

S-PAC Instruction Manual Supplementary Equipment



Instruction Manual SUPPLEMENTARY S-PAC MODULES AND EQUIPMENT

April 16, 1968



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SUPPLEMENTARY S-PAC EQUIPMENT

TABLE OF CONTENTS

Paragraph		Page
	SECTION I	
	INTRODUCTION	
1 – 1	Scope	1 - 1
1 - 2	S-PAC Line	1 - 1
1-3	Supplementary PACs and Equipment	1 - 5
1 - 4	Logic Symbol Stickers	1-5
	SECTION II SPECIFICATIONS AND CIRCUITRY	
2-1	Logic and Voltage Levels	2-1
2-2	Product Specifications	2-1
2-3	Product Line Features	2-2
2-4	Compatibility of Different Frequency Lines	2-4
	SECTION III DESCRIPTIONS OF S-PAC MODULES AND EQUIPMENT	
3-1	BL-30 through BL-33, S-BLOCs	3-1
3-2	BP-30, Blank PAC	3-9
3-3	BP-31, Blank PAC (Universal Polarization)	3-11
3 - 4	BS-34 through BS-39, Split Drawer Units	3-13
3 - 5	BT-32 and BT-33, Tilt Drawer Units	3-13
3 - 5A	CA-30, Converter Clock PAC	3-21 3-28A
3 - 6	CD-30, Analog Comparator PAC	3-20A 3-29
3 - 7	CI-20, Counter-Indicator PAC	3-27
3-8	CI-21, Counter-Indicator (High Level) PAC	3 - 45
3-9	CP-20, Counter-Converter PAC	3-51
3-10	CP-21, Counter-Converter (High Level) PAC	3-59
3-11	CU-30, Cooling Unit	3-65
3-12	DD-31, Display Driver PAC	3-69
3-13	DI-21, Signal Adapter PAC	3-75
3-14	DI-31, Signal Adapter PAC	3-81
3-15	DI-36, Signal Adapter PAC	3-87
3-15A	ES-31, Electrostatic Shield PAC	3 - 92A
3-16	IP-30, Indicator-Converter PAC	3-93
3-17	JL-30, Jumper Lead Set	3-101
3-17A	LC-35, Positive Logic Level Converter PAC	3-102A
3-18	LD-30, Lamp Driver PAC	3-103
3-19	LN-30, Digital Attenuator PAC	3-107
3-20	LN-30A, Adjustable Digital Attenuator PAC	3-115
3-21	LP-30, Precision Digital-to-Analog Converter PAC (Four Bit)	3-121

SUPPLEMENTARY S-PAC EQUIPMENT

TABLE OF CONTENTS (Cont)

Paragraph		Page
3-22	LP-31, Precision Digital-to-Analog Converter PAC (Six Bit)	3-133
3-23	MS-30, Gate/Shaper PAC	3-141
3-23A	MX-30, Multiplexer Switch PAC	3 - 150A
3-24	ND-31, Nixie Driver PAC	3-151
3-24A	OA-30, Operational Amplifier PAC	3 - 156A
3-25	PB-30, Plug-In Power Supply	3-157
3-26	PD-30, IDCU Power Supply	3-165
3-26A	PR-30, Precision Reference PAC	3-170A
3-26B	PR-31, Precision Reference (Slave) PAC	3-170H
3-27	RP- Power Supplies (RP-30 up to and including Serial No. 280334; RP-31 up to and including Serial No. 239541; RP-32 up to and including Serial No. 198197 and/or models with "A" prefix; and Serial No. 201050 through 220253)	3-171
3-27A	RP- Power Supplies (RP-30 bearing Serial No. 280335 and beyond; RP-31 No. 239542 and beyond; RP-32 No. 220254 and beyond)	3 - 182A
3-27B	RP-31E through RP-33E, Power Supplies	3-1820
3-28	RV-30, Vertical Relay PAC	3-183
3-28A	SA-30, Analog Switch PAC	3 - 186A
3-29	SD-30, Solenoid Driver PAC	3-187
3-30	SI-30, Storage-Indicator PAC	3-191
3-31	SN-30, System Normalizer PAC	3-197
3-32	SP-30, Storage-Converter PAC	3-201
3-33	ST-30, Schmitt Trigger PAC	3-207
3-34	ST-35, Schmitt Trigger PAC	3-215
3-35	TD-30, Timing Distributor PAC	3-223
3-35A	TD-32, Timing Distributor PAC	3-234
3-36	UI-10, Transistorized Unit Indicator	3-235
3-37	UI-30, Transistorized Unit Indicator	3-237
3-38	UI-31, Transistorized Unit Indicator	3-239
3-39	UT-30, Utility PAC	3-241
3-40	XP-30, PAC Extender	3-243
	SECTION IV PARTS LIST FOR SUPPLEMENTARY S-PAC EQUIPMENT	4-1
	SECTION V S-PAC LOGIC AND APPLICATIONS	5-1

SECTION I INTRODUCTION

1-1 SCOPE

This instruction manual provides complete descriptive and reference material for the supplementary S-PAC Digital Modules and other supplementary S-PAC equipment of Computer Control Company, Inc. A section on logic application notes is also included in this manual. The supplementary modules include circuits with input-output capability for interface equipment, indicating decimal counting PACs, analog-digital PACs, and other assorted PACs to fulfill specialized requirements. Auxiliary S-PAC equipment includes power supplies, BLOCs for mounting the PACs, wiring equipment, and other mechanical products. Refer to table 1-1.1. Information on the basic digital logic modules can be found in the appropriate instruction manual for each of the different S-PAC frequency lines: 200 KC, 1 MC, and 5 MC. The basic series of S-PACs includes gates, flip-flops, power amplifiers, one-shots, and clocks. Refer to table 1-1.2.

1-2 S-PAC LINE

The S-PAC series of digital modules are standard products that provide the complete capability for building computer and data processing systems. All S-PACs use static logic and all three S-PAC frequency series (200 KC, 1 MC, and 5 MC) are mechanically and electrically compatible. Each series shares the same circuit arrangements and performs identical logic functions. They use a common system of model names, pin numbers, color coding, and connector polarization. The power supply voltages and logic levels are the same in each series.

Figure 1-2.1 shows the mechanical dimensions of a standard S-PAC. All S-PAC components are dip-soldered onto etched circuit boards that provide uniformity, ruggedness, and dimensional stability. Metal frames are added to the card to provide rigidity and to facilitate proper guidance into the mating connector. The PAC type is clearly indicated on the frame by model number and color code. All S-PACs are individually polarized by type and mating connectors can be polarized to accept only one type of S-PAC. The 34 pin connectors used are gold-plated with a spring-contact, self-wiping action.

The S-PAC series employs negative logic, with the following nominal voltage levels:

Logic ONE: -6 volts
Logic ZERO: 0 volts

These levels are used on all S-PACs, unless stated otherwise.

3/2/64

SUPPLEMENTARY S-PAC EQUIPMENT

Table 1-1.1. Types of Supplementary S-PACS and Equipment

	Description	Model No.
Input-Output PACs Signal Adapter PACs		DI-21,31,36
Ì	Display Driver PAC	
	Positive Logic Level Converter PAC	LC-35
	Lamp Driver PAC	LD-30
	Gate/Shaper PAC	MS-30
	Nixie Driver PAC	ND-31
	Vertical Relay PAC	RV-30
	Solenoid Driver PAC	SD-30
	System Normalizer PAC	SN-30
	Schmitt Trigger PACs	ST-30,35
	Timing Distributor PACs	TD-30,32
Analog-Digital PACs	Converter Clock PAC	CA-30
	Analog Comparator PAC	CD-30
	Digital Attenuator PAC	LN-30
	Adjustable Digital Attenuator PAC	LN-30A
	Precision Digital-to-Analog Converter PAC (4 Bit)	LP-30
	Precision Digital-to-Analog Converter PAC (6 Bit)	LP-31
	Multiplexer Switch PAC	MX-30
	Operational Amplifier PAC	OA-30
	Precision Reference PAC	PR-30
	Precision Reference (Slave) PAC	PR-31
	Analog Switch PAC	SA-30
Indicating Decimal	Counter-Indicator PAC	CI-20
Counting Unit PACs	Counter-Indicator (High Level) PAC	CI-21
1	Counter-Converter PAC	CP-20
	Counter-Converter (High Level) PAC	CP-21
	Indicator-Converter PAC	IP-30
	Storage Indicator PAC	SI-30
	Storage-Converter PAC	SP-30
Consist Down and DAC	Dlaula DA Ca	BP-30,31
Special Purpose PACs	_	
	Electrostatic Shield PAC	
	Transistorized Unit Indicators	UI-10,30,31
	Utility PAC	UT-30
	PAC Extender	XP-30

1-2 4/16/68

SUPPLEMENTARY S-PAC EQUIPMENT

Table 1-1.1. Types of Supplementary S-PACS and Equipment (Cont)

	Description	Model No.
Power Supplies	Plug-In Power Supplies	PB-30
	IDCU P ower Supply	PD-30
	Power Supplies (Rack Mounted)	RP-30,31,32 RP-31E,32E, 33E
BLOCs	S-BLOCs Split Drawer Units	BL-30 thru 33 BS-34 thru 39
	Tilt Drawer Units	BT-32,33
Auxiliary Equipment	Cooling Unit	CU-30
	Jumper Lead Set	JL-30

Table 1-1.2. Types of 1-MC S-PACS

	Description	Model No.
Gate PACs Diode PAC		DC-30
	Parallel Gate PAC	DF-30
	NAND PAC	DI-30
	Parallel NAND PAC	DJ-30
	NAND PAC	DL-30
	Gate PAC	DN-30
Flip-Flop PACs	Counter PAC	BC-30
	Gated Flip-Flop PAC	FA-30
	Basic Flip-Flop PAC	FF-30
	Multi-Purpose Flip-Flop PAC	MF-30
	Shift Register PAC	SR-30
	Universal Flip-Flop PAC	UF-30
Power Amplifier PACs	Power Amplifier PAC	PA-30
_	Non-Inverting Power Amplifier PAC	PN-30
Delay Multivibrator PACs	Delay Multivibrator/Pulse Shaper PAC	DM-30
	Adjustable Delay Multivibrator PAC	DM-30A
	Delay Pulse PAC	DS-30
	Adjustable Delay Pulse PAC	DS-30A
Clock PACs	Master Clock PAC	MC-30
	Master Clock PAC (Special precision)	MC-30X
	Multivibrator Clock PAC	MV-30
Serial Memory PACs	Serial Memory PACs Serial Memory PAC	
·	Serial Memory PAC (Long Line)	SM-30L
Special Purpose PAC	Octal/Decimal Decoder PAC	OD-30
	Transmission Line Driver PAC	XD-30

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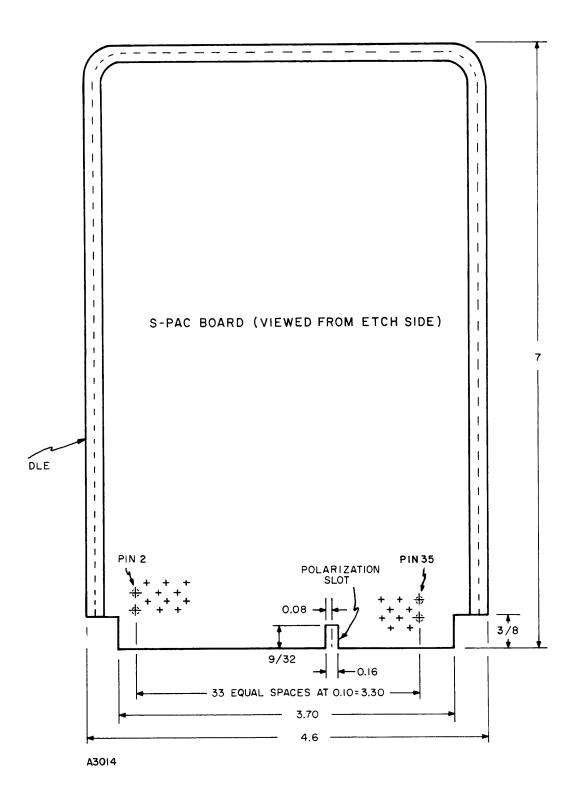


Figure 1-2.1. Standard S-PAC Mechanical Dimensions

1-3 SUPPLEMENTARY PACS AND EQUIPMENT

Input-Output PACs

These PACs are used for interface with equipment other than S-PACs. There are PACs available for driving lamps, relays, Nixie tubes, and other peripheral equipment. A Schmitt Trigger PAC is available for converting nonstandard signals to S-PAC levels.

Analog-Digital PACs

The Analog-Digital PACs are used for systems requiring analog computations or analog-to-digital conversion. PACs are available for digital-to-analog conversions and the processing of analog signals.

IDCU Equipment

The Indicating Decimal Counting Unit PACs combine the functions of counting, storage, and display. One of the ten numbers 0 through 9 is illuminated on the vertical faceplate of a PAC or on a remote indicator PAC to provide visual indication of the BCD state of the four-stage counter or register.

S-BLOCs

Several different types of S-BLOCs are used to mount the S-PACs in standard 19-inch racks. The S-BLOCs can be wired with soldered wires or with taper pin leads. A high-density S-BLOC holds 28 S-PACs and a low-density S-BLOC holds 19.

The Split Drawer Unit and the Tilt Drawer Unit are used for mounting S-PACs. These units feature unique mechanical arrangements to allow high packaging density and easy accessibility to the PACs and the connector wiring.

Power Supplies

There are six standard rack-mounted power supplies and two plug-in power supplies, Models PB-30 and PD-30 (120 V) for driving S-PAC equipment. The rack-mounted power supplies and plug-in supply, Model PB-30, provide current at the standard S-PAC voltages of +12 volts, -6 volts, and -18 volts. The Plug-In Power Supplies, Models PB-30 and PD-30, mount directly in an S-BLOC.

Other Products

Jumper lead sets with taper pin connectors are available for wiring taper pin S-BLOCs. A variety of lead lengths and colors provides a convenient assortment for use in system wiring. Cooling units are also available for cooling BLOCs of S-PACs.

1-4 LOGIC SYMBOL STICKERS

To aid in the use of S-PACs, an S-PAC Logic Symbol Kit, Model SK-30 (figure 1-4.1), is available. This kit contains symbol stickers as well as detailed technical information on individual PAC connections and applications. Using the symbol kit greatly simplifies system logic design and wiring and effectively minimizes the drafting requirements for the production of final engineering drawings. The logic symbol, applicable pin connections, and circuit identification are printed directly on each sticker. In addition, space is provided for designating the physical location of the PAC in the respective S-BLOC.

The entire kit is assembled as a booklet and includes symbol sheets and applicable instructions for use. Individual sheets of logic symbols are also available. 1/12/66

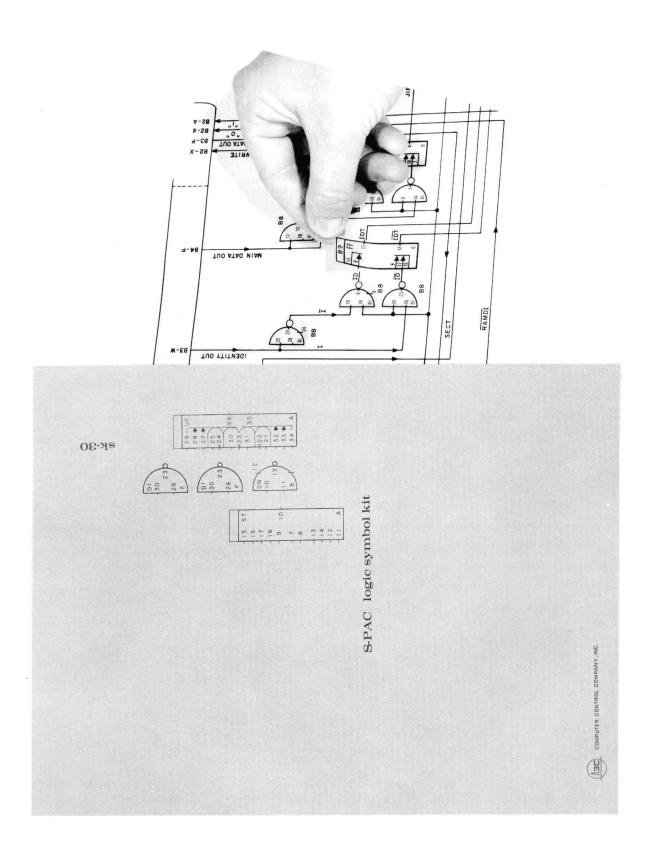


Figure 1-4.1. Application of S-PAC Stick-On Symbols

SECTION II SPECIFICATIONS AND CIRCUITRY

2-1 LOGIC AND VOLTAGE LEVELS

In general the following input and output specifications apply.

Input Logic Levels Output Logic Levels

Logic ONE: -4.5 to -8.0 V Logic ONE: -6.0 to -6.6 V

Logic ZERO: 0.0 to -1.5 V Logic ZERO: 0.0 to -0.5 V

2-2 PRODUCT SPECIFICATIONS

Temperature Range

Operating: -20°C to $+55^{\circ}\text{C}$ Storage: -55°C to $+85^{\circ}\text{C}$

Input Loading

The power required to drive a 1 MC NAND gate is defined as a standard 1 MC unit load (1 U load). For standard inputs and outputs, all circuits are specified in terms of U loads for input loading and output drive capability. This system makes it easy to determine fan-out capability when many different types of circuits are used.

Current Requirements

The current requirements are listed in the specifications for each individual PAC. The requirements are calculated on a nominal worst case basis, in which the inputs of the circuits are assumed to be in the condition capable of causing the maximum current drain for that particular voltage. In most cases, it is impossible for the PAC to draw the maximum rated current for each supply voltage simultaneously.

The nominal worst case is chosen instead of the extreme worst case to provide a more realistic figure for power requirements and therefore drive more equipment from a power supply. Since it is inconceivable that all gates in a system would be on at the same time, nominal worst case calculations provide a considerable safety factor.

The current specifications include only the current used in the specific PAC and do not reflect the current going to an external load. However, since the input load current is included in the specification, a simple summation of all currents for the PACs used in a system gives the total power requirements.

Power Specifications

The power dissipation of each PAC is listed in the individual PAC specifications. The specifications are calculated assuming that the circuits are in their highest dissipation state.

WARNING

DC power must be off prior to insertion or removal of S-PACs from S-BLOCs.

2-3 PRODUCT LINE FEATURES

The S-PAC series of modules provides maximum reliability and flexibility to the logic design engineer. A wide variety of versatile S-PACs is available to meet data processing applications. Long and extensive experience by Computer Control Company, Inc. in the design and application of digital and analog circuits provides the S-PAC line with optimum circuits which use transistors and other semiconductor elements.

The metal frame on each S-PAC is color coded to identify the PAC type by model number. In addition, each PAC is provided with two polarizing slots. The mating connectors on the S-BLOC can also be polarized so that only the corresponding S-PAC can be seated in any one position of the S-BLOC. Table 2-3.1 lists the color code and polarization pins for each type of S-PAC and figure 2-3.1 illustrates the S-PAC handle identification.

Handle Color Code Polarization Pin No. PAC Type Long Bar Short Bar Pin No. BP-30 (universal polarization) BP-31 18 CD-30 White Red CI-20 4 20 4 20 CI - 21 CP-20 Orange Brown 14 18 Brown 14 18 CP-21 Orange LD-30 Red 18 30 Brown LN-30 Green 6 32 Purple Green 6 32 LN-30A Purple 22 LP-30 Purple White 18 4 28 LP-31 White Purple 4 22 White ND-31 Orange PB-30 SD-30 20 32 Orange Orange 4 18 SI-30 28 16 SN-30 White Brown SP-30 Orange Green 4 16 ST-30 Purple Purple 8 28 Purple 8 28 ST-35 Purple 6 30 TD-30 White Green

Table 2-3.1. S-PAC Color Code and Polarization

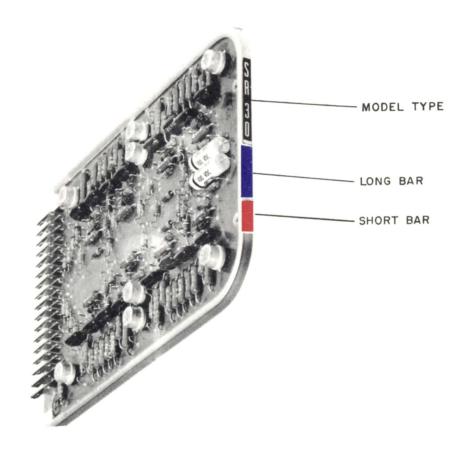


Figure 2-3.1. Handle Identification

2-4 COMPATIBILITY OF DIFFERENT FREQUENCY LINES

The three S-PAC lines (200 KC, 1 MC, and 5 MC) use the same voltage and logic levels and are electrically compatible. This compatibility permits the design of systems that use any combination of different frequency types.

The standard NAND gate requires input power to keep the transistor OFF (condition when an input is at ground). The output is then at -6 volts. The gate does not require input power to turn the transistor ON (condition when all inputs are at -6 volts or not connected). Ratings are therefore given for an output at ground, which is the power driving state. The static current requirements to drive 200-KC, 1-MC, and 5-MC gates are 1.8, 2.4, and 3.2 milliamperes, respectively.

The unit loads for the various frequency lines (200 KC, 1 MC, and 5 MC) are noted as W, U, and V loads, respectively. A W load represents the amount of power required to drive a 200-KC NAND gate, a U load for a 1-MC NAND gate, and a V load for a 5-MC gate. Input loading and output drive capability are rated in terms of these units. An input loading of 3 W loads corresponds to about 5.4 milliamperes of current required, while an output drive capability of 2 V loads corresponds to about 6.4 milliamperes available.

An S-PAC can drive both the standard DC input of any other S-PAC directly or the standard AC input of any S-PAC on the same frequency line or in a lower frequency line. When driving the AC input of a higher frequency S-PAC from any lower frequency PAC, a gate circuit of the higher frequency must be interposed to reshape the waveform. Any of the standard NAND gate PACs can be used for this purpose.

The conversion factors for connecting S-PACS of different frequency series are listed in table 2-4.1.

		Input Loading		
Output Dri	ve Capability	W Loads	U Loads	V Loads
200 KC	l W load	1.0	0.7	0.5
l MC	l U load	1.4	1.0	0.7
5 MC	l V load	2.0	1.4	1.0
		1		

Table 2-4.1. Mixed Loading Conversion

EXAMPLE: Determine how many circuits rated with an input loading of 2 W loads can be driven from a circuit rated with an output drive capability of 4 U loads.

$$4 U = (4) (1.4) = 5.6 W capability.$$

Hence

$$\frac{5.6 \text{ W}}{2 \text{ W}}$$
 = 2.8 circuits that can be driven.

2-4

SECTION III DESCRIPTIONS OF S-PAC MODULES AND EQUIPMENT

3-1 S-BLOCS, MODELS BL-30 THROUGH BL-33

GENERAL DESCRIPTION

Four standard S-BLOCs, Models BL-30 through BL-33, are available for mounting S-PACs. These S-BLOCs offer a choice of soldered or taper pin interconnections and are available in 19 S-PAC/S-BLOC or 28 S-PAC/S-BLOC versions. Refer to table 3-1.1. All S-BLOCs are 19 inches wide, 5-1/4 inches high, and 9-1/2 inches deep, and have prewired power and ground. The S-BLOCs provide a built-in ground bus which mounts 19 test points and quick-disconnect power terminals (figures 3-1.1 and 3-1.2). Power leads are bypassed at the power connectors on each S-BLOC as well as on each S-PAC. A protective diode is provided between the -6-volt bus and ground to prevent accidental short circuits from causing equipment damage. Included with each S-BLOC is a kit for isolating the electrical ground from the BLOC frame. The kit includes parts and instructions to electrically separate the BLOC grounding channel from the BLOC housing.

S-BLOC WIRING

Four ground clips are provided with each S-BLOC. Two clips are used for general purpose cable connection (flag type terminal C52, Thomas & Betts) and two for direct connection to a flat braid for system ground (ground clip A000 231 001, Computer Control Company).

The S-BLOCs are constructed so that the connector plane and ground bus can be removed from the S-BLOC as a single assembly to permit convenient bench wiring.

INSTALLATION OF S-PACS

S-PAC insertion is accomplished by engaging the S-PAC in the appropriate slot of the S-BLOC and pressing the S-PAC into position until the connector is engaged and seated. The S-PAC is inserted with the components at the left.

S-PAC removal from the S-BLOCs is accomplished by engaging the two holes at the handle end of the S-PAC, using the S-PAC extractor tool supplied with each S-BLOC. A 20-pound force is sufficient to disengage an S-PAC from its mating connector and the S-PAC can then be removed with the fingers. The extractor tool must be engaged from the component side of the S-PAC to present damage to the etched wiring.

WARNING

DC power must be off prior to insertion or removal of S-PACs from S-BLOCs.

A hold-down bar is also provided with each S-BLOC. This bar is used to clamp the S-PACs in place in all S-BLOC types. The bar is equipped with a quick-release thumb latch and bears against the S-PACs with a spongerubber pad. A plastic baffle can be fastened to the rubber pressure pad for use with models BL-32 and BL-33.

POLARIZATION

Polarization of the connectors should be performed after the final S-PAC locations have been determined. Polarization is accomplished by inserting two nylon pegs into the appropriate slots of the connector, which prevents any but the desired S-PAC typed from being inserted into that slot. Sufficient polarizing pegs for the connectors in any S-BLOC

are supplied in a plastic package with the S-BLOC. The allowable position of polarizing pegs (figure 3-1.3) for the various S-PACs is given in table 2-3.1 in Section II of this manual and the method of insertion is illustrated in figure 3-1.4.

BLOC COOLING

In applications of the 19-connector S-BLOCs, convection cooling is adequate in stacks of up to 10 S-BLOCs for ambient temperatures of a maximum of 40°C if free bottom-to-top airflow is provided. For higher ambient temperatures, forced air from cooling unit model CU-30 is sufficient up to a maximum rated S-PAC ambient temperature.

In applications of the 28-connector S-BLOCs (BL-32 or BL-33) convection cooling is adequate for one S-BLOC up to an ambient temperature of 40°C. For stacks of 28-connector S-BLOCs, forced air cooling from a CU-30 is recommended. To insure uniform airflow through a stack of S-BLOCs, the special plastic baffle, mounted on the hold-down bar of each S-BLOC, must be in position to prevent leakage of air from the S-PAC insertion face of the S-BLOC. Small polyfoam gaskets prevent leakage between connectors on the BL-32 and BL-33. In applications where it is desired to use the high-density, 28-connector S-BLOCs, it is recommended that these S-BLOCs be used throughout any one stack to provide uniform airflow channels. When mixing 19- and 28-connector S-BLOCs in the same stack is desired, it is recommended that a 1-3/4-inch gap be left at the junction between the 19- and 28-connector S-BLOCs to insure free airflow in all package slots. In addition, it is recommended that the 28-connector S-BLOCs be mounted below the 19-connector S-BLOCs.

An S-BLOC channel detail assembly and schematic diagram are illustrated in figure 3-1.5.

Table 3-1.1. S-BLOC Connector Types

BL-30	Solder-Tab, 19-Connector, Prewired Power
BL-31	Taper-Pin, 19-Connector, Prewired Power
BL-32	Solder-Tab, 28-Connector, Prewired Power
BL-33	Taper-Pin, 28-Connector, Prewired Power

SPECIFICATIONS

BL-30 and BL-32:

Connectors:

Elco, Type 7008-35-5-2

Power:

- -18 V wired to pin 2, bypassed with 22 μf
- -6 V wired to pin 3, bypassed with 22 uf
- +12 V wired to pin 4, bypassed with 3.3 μf

Ground wired to pin 5

BL-31 and BL-33:

Connectors:

Elco, Type 7009-34-5-2

Power:

- -18 V wired to pin 2, bypassed with 22 μf to ground
- -6 V wired to pin 3, bypassed with 22 µf to ground
- +12 V wired to pin 4, bypassed with 3.3 μf to ground

Ground wired to pin 5

SPECIFICATIONS (Continued)

BL-30, BL-31, BL-32, and BL-33

Power Connectors:

Three mating connectors are supplied with each S-BLOC for quick-disconnect power connectors. (Heyco 202-1 receptacle, 3C part number 941 307 112; Heyco 202-SS terminal, 3C part number 937 201 004)

Mating connector (Thomas & Betts No. RB-250. 3C part number 937 200 001)

Test Points:

19 supplied (Sealectro SKT-14, receptacle) Mating piece (Sealectro PR-10, plug or No. 18 wire)

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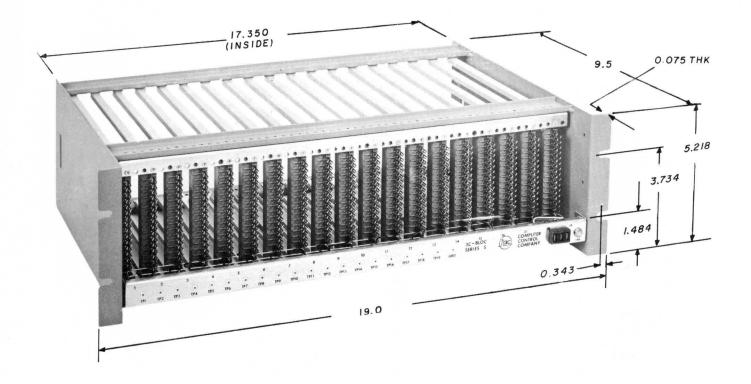


Figure 3-1.1. S-BLOC Model BL-30

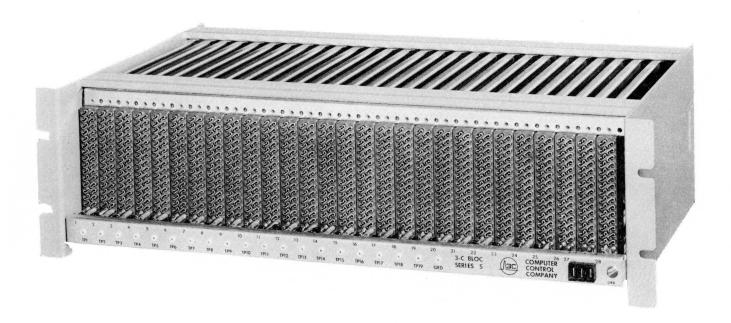


Figure 3-1.2. S-BLOC, Model BL-33

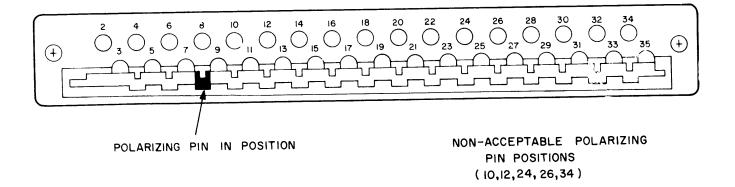


Figure 3-1.3. Position of Polarizing Pegs

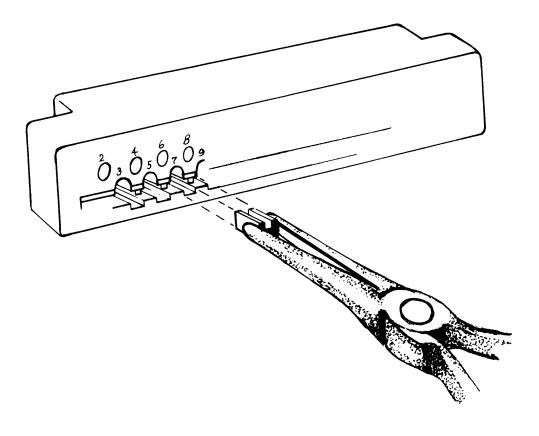


Figure 3-1.4. Method of Pin Insertion

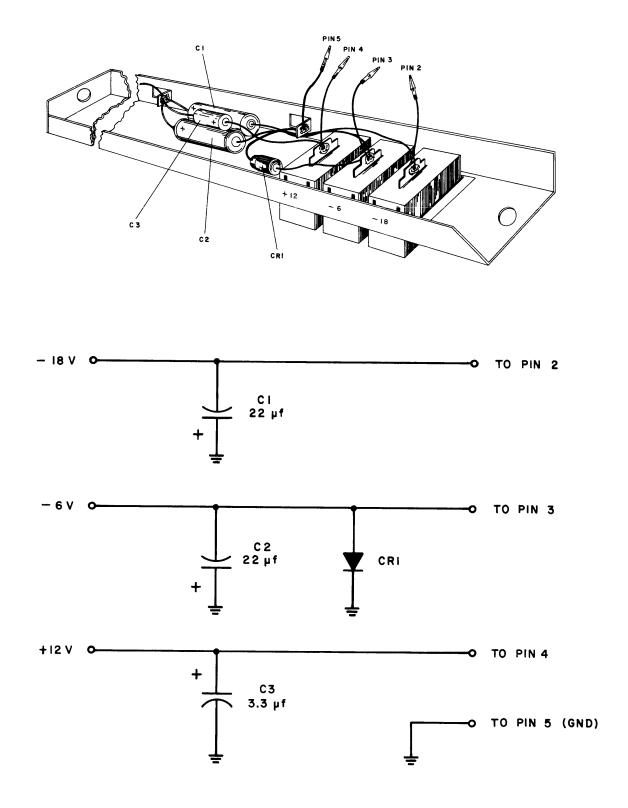


Figure 3-1.5. S-BLOC Channel Detail Assembly and Schematic Diagram

3-2 BLANK PAC, MODEL BP-30

GENERAL DESCRIPTION.

The Blank PAC, Model BP-30 (figure 3-2.1), is a standard S-PAC card with etched power and ground buses from the appropriate connector terminals about its periphery. Most of the card is blank to facilitate the mounting of any special circuits or components using standard component lugs and point-to-point wiring. The usable area is 23 square inches.

PAC-to-PAC spacing in the BL-30 and BL-31 is 0.9 inch and in the BL-32 and BL-33 0.6 inch. The maximum height of the special circuit components on the BP-30 is 0.375 inch for 0.6-inch spacing and 0.675 inch for 0.9-inch spacing. If adjacent S-PAC slots are left vacant, any component height can be attained.

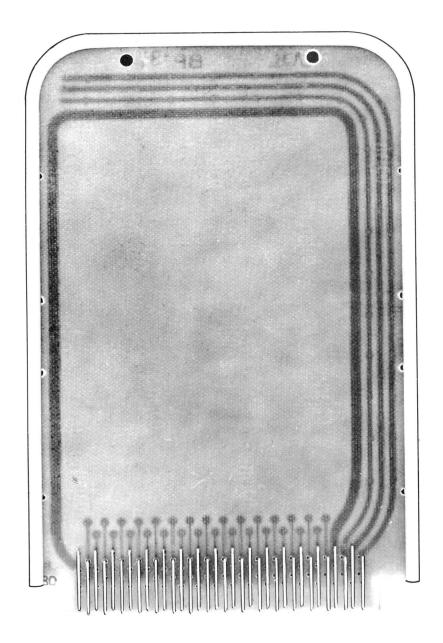


Figure 3-2.1. Blank PAC, Model BP-30

3-3 BLANK PAC (UNIVERSAL POLARIZATION), MODEL BP-31

GENERAL DESCRIPTION

The Blank PAC, Model BP-31 (figure 3-3.1), is a standard S-PAC card with etched power and ground buses from the appropriate connector terminals about its periphery. The BP-31 has universal polarization slots, whereas the BP-30 has no polarization slots. (Universal polarization allows the PAC to be inserted into a slot polarized to accept any standard S-PAC.)

Most of the BP-31 card is blank to permit the convenient mounting of any special circuits or components using standard component lugs and point-to-point wiring. The usable area is 23 square inches.

When the BP-31 occupies a single PAC slot in an S-BLOC, the maximum component height allowable is 0.375 inch for the high-density BLOCs (BL-32 and BL-33) and 0.675 inch for the low-density BLOCs (BL-30 and BL-31). When adjacent PAC slots remain empty, the additional space is available for component height.

3/2/64

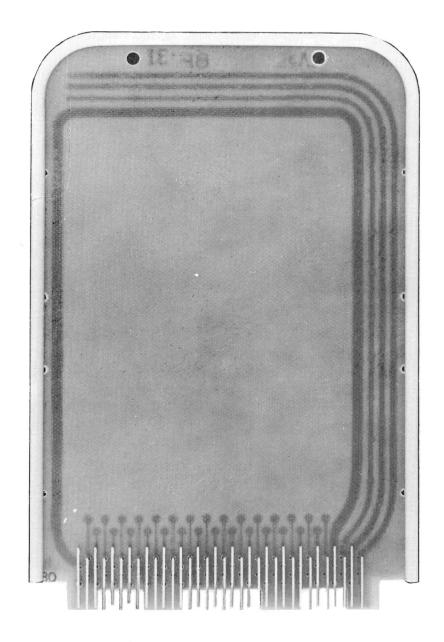


Figure 3-3.1. Blank PAC, Model BP-31

3-4 SPLIT DRAWER UNITS, MODELS BS-34 THROUGH BS-39

GENERAL DESCRIPTION

The Split Drawer Unit, Models BS-34 through BS-39 (figure 3-4.1), is a high-density assembly for mounting S-PACs in which access to the PACs is obtained by sliding the drawer out of the mounting rack (figure 3-4.2). The two halves of the split drawer can then be spread apart by rotation on the vertical pivot shafts to provide access to the PAC connectors (figure 3-4.3).

There are six standard split drawer units with either solder or taper pin connectors and a capacity for 100, 150, or 200 S-PACs (table 3-4.1). The units consist of two stacks of special S-BLOCs mounted in an enclosure with the PACs parallel to the front panel. The stacks are supported on pivot shafts. Each stack can be separated from the unit for bench wiring by removing the pivot shafts, using the removal tool (3C Part No. 917 050 001) supplied with each unit. The BLOC stacks roll out of the enclosure locked together, with the connector planes facing each other. A pushbutton on the front panel releases the stacks from each other and the stacks can then be swung apart approximately 90 degrees to permit access to the connector wiring and test points. By closing the stacks together and re-engaging the latch, the unit becomes rigid to permit the insertion and removal of the S-PACs (figure 3-4.4).

The split drawer units are 19 inches wide and 21 inches deep. The height and weight of the units depends upon the model (table 3-4.1). The units are designed for mounting in standard RETMA cabinets. (The RETMA cabinet is not included with the split drawer units.)

SPLIT DRAWER WIRING

Each S-BLOC has prewired power and ground connections and contains a built-in ground bus which mounts 19 test points. Power leads are bypassed at the power connectors on each BLOC as well as on each PAC. A protective diode is provided between the -6-volt bus and ground to prevent accidental short circuits from causing equipment damage.

Power and ground connections are internally wired from the connector plane to a terminal block at the rear of each S-BLOC assembly. External power and ground connections can be tied to the screw type terminals on the terminal block with a spade lug suitable for a No. 5-40 machine screw. Each S-BLOC is constructed so that the connector plane and ground bus can be removed as a single assembly for convenient bench wiring.

INSTALLATION OF S-PACS

S-PAC insertion is accomplished by engaging the S-PAC in the appropriate slot of the S-BLOC and pressing the S-PAC into position until the connector is engaged and seated. The S-PAC is inserted with the components at the left.

S-PAC removal from the S-BLOCs is accomplished by engaging the two holes at the handle end of the S-PAC, using the S-PAC extractor tool supplied with each drawer unit. A 20-pound force is sufficient to disengage an S-PAC from its mating connector and the S-PAC can then be removed with the fingers. The extractor tool must be engaged from the component side of the S-PAC to prevent damage to the etched wiring.

3/2/64

WARNING

DC power must be off prior to insertion or removal of S-PACs from S-BLOCs.

POLARIZATION

Polarization of the connectors should be performed after the final S-PAC locations have been determined. Polarization is accomplished by inserting two nylon pegs into the appropriate slots of the connector, which prevents any but the desired S-PAC type from being inserted into that slot. Sufficient polarizing pegs for the connectors are supplied in a plastic package with the drawer unit. The position of the polarizing pegs for the various S-PACs is given in table 2-3-1 in Section II of this manual.

COOLING

The split drawer units are cooled by a unit composed of four axial flow fans with reusable filters. The cooling unit is located beneath the BLOCs and is easily removable for servicing. Air is drawn in through the bottom of the drawer unit, circulated up through the S-BLOC stacks, and exhausted through the open frame at the top of the unit. The fans are prewired in parallel to a terminal strip at the center of the cooling unit. An external 115-volt AC, 60-cycle source should be attached to the terminal strip.

SPLIT DRAWER UNIT MOUNTING

The split drawer is shipped as an assembled unit. In addition to the unit, there are eight mounting brackets and a hardware kit for mounting the frame of the drawer in any RETMA rack with sufficient height, as specified in table 3-4.1.

Before mounting the frame, the left and right S-BLOC assemblies must be removed from the cast yoke. This is done by removing the 5/8-inch diameter pivot pins.

The eight mounting brackets are attached to the front and rear vertical mounting rails. For flush mounting, the front rails should be countersunk for No. 10-32 flathead screws. The frame assembly is then mounted between the eight brackets and the left and right S-BLOC assemblies are reinstalled. The front panels should be aligned in the rack by loosening the hardware and repositioning the frame.

7,1					
Model	Connector Type	S-PAC Capacity	No. of BLOCs	Panel Height (inches)	Weight (approx pounds)
BS-34	Solder pin	100	4	14	65
BS-35	Taper pin	100	4	14	65
BS-36	Solder pin	150	6	19-1/4	100
BS-37	Taper pin	150	6	19-1/4	100
BS-38	Solder pin	200	8	24-1/2	130
BS-39	Taper pin	200	8	24-1/2	130

Table 3-4.1. Split Drawer Types

SPECIFICATIONS

BS-34, BS-36, BS-38:

Connectors:

Elco, type 7008-35-2

Power:

-18 V wired to pin 2, bypassed with 22 $\mu\mathrm{f}$

-6 V wired to pin 3, bypassed with 22 μf

+12 V wired to pin 4, bypassed with 3.3 μf

Ground wired to pin 5

BS-35, BS-37, BS-39:

Connectors:

Elco, type 7009-34-5-2

Power:

-18 V wired to pin 2, bypassed with 22 μf

-6 V wired to pin 3, bypassed with 22 μf

+12 V wired to pin 4, bypassed with 3.3 μf

Ground wired to pin 5

BS-34 through BS-39:

Power Connectors:

Each S-BLOC in the split drawer unit has its own power input terminal (Cinch Jones No. 5-140/3/4 W) which is prewired to the BLOC and wired in parallel with all other power input terminal strips in the unit. Incoming power lines should be terminated with a spade lug suitable for a No. 5-40 machine screw.

Test Points:

19 supplied (Sealectro SKT-14 receptacle) Mating piece (Sealectro PR-10, plug or No. 18 wire)

NOTE

BS units do not require hold-down bars or air barriers.

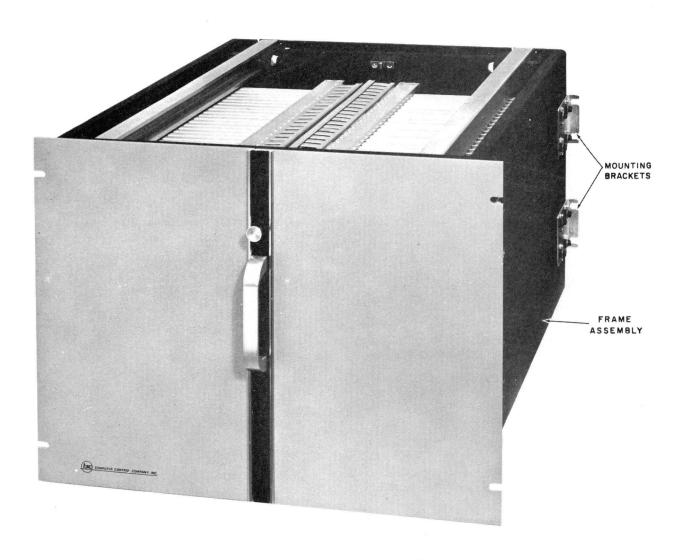


Figure 3-4.1. Split Sliding Drawer, Model BS-35 (Closed Position)

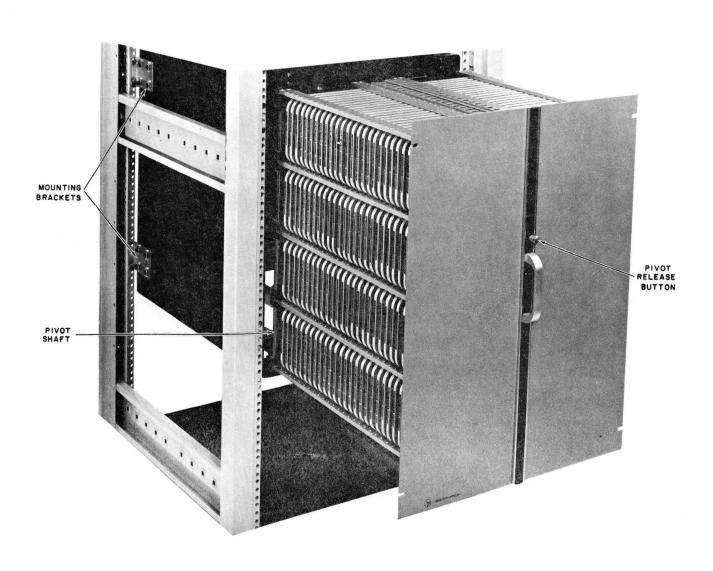


Figure 3-4.2. Split Sliding Drawer, Model BS-39 (PAC Access)

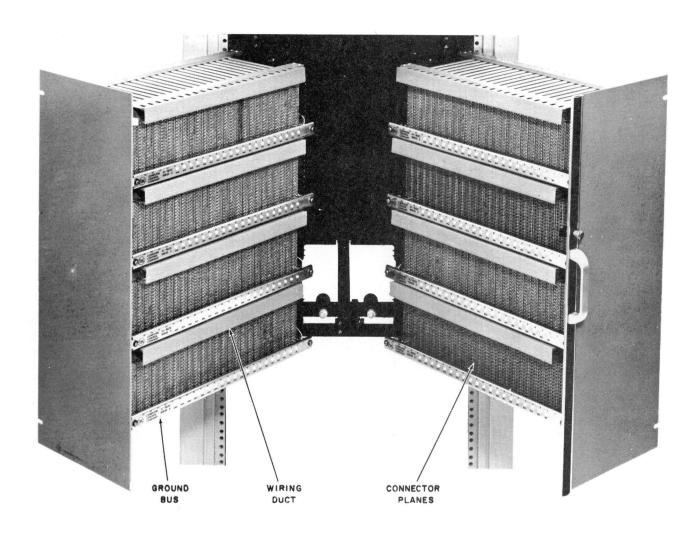


Figure 3-4.3. Split Sliding Drawer, Model BS-39 (Connector Plane Access)

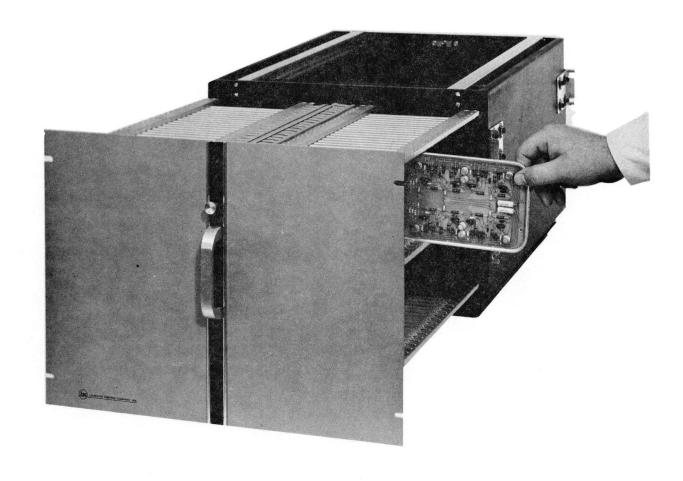


Figure 3-4.4. Split Sliding Drawer, Model BS-35 (S-PAC Accessibility)

3-5 TILT DRAWER UNITS, MODELS BT-32 AND BT-33

GENERAL DESCRIPTION

The Tilt Drawer Unit, Models BT-32 and BT-33 (figures 3-5.1 and 3-5.2), is a high-density assembly for mounting S-PACs in which access to both the PACs and the connectors is obtained by sliding the drawer out of the mounting rack and then rotating the unit horizontally about the side pivots. The unit rolls out on slides and contains a detent plate which holds the unit in the desired tilted position. The detent plate has seven stops: 0, 45, 90, and 105 degrees on either side of the horizontal.

The standard tilt drawer units (Models BT-32 and BT-33) have solder and taper pin connectors, respectively (table 3-5.1). The units contain three modified S-BLOCs which can hold 80 S-PACs arranged in 27, 26, 27 PAC capacities. The S-BLOCs are assembled as shown in figure 3-5.3, with all connectors lying in the same plane for convenient interwiring. The front panel is 12-1/4 inches high and is located 2-7/8 inches in front of the first S-BLOC to provide component mounting space. Attached to the rear S-BLOC is an angle bracket for mounting connectors. Circulating fans provide convection cooling and are included as an integral part of the unit.

The tilt drawer units are designed to mount in standard RETMA cabinets having a 19-inch panel width and a depth of 24 inches or more. A cabinet is not included with the tilt drawer units.

TILT DRAWER WIRING

Each S-BLOC has prewired power and ground connections and contains a built-in ground bus which mounts 19 test points and quick-disconnect power terminals. Power leads are bypassed at the power connectors on each S-BLOC as well as on each S-PAC. A protective diode is provided between the -6-volt bus and ground to prevent accidental short circuits from causing equipment damage.

Twelve mating terminals are provided to wire power and ground to the quick-disconnect terminals on each S-BLOC and three flag-type terminal lugs and three ground clips are supplied for use in other grounding methods. The quick-disconnect terminals accommodate wire ranging from AWG No. 14 and No. 18 and mate with the pins of the power connector. The S-PAC power voltages (+12, -6, and -18 volts) and ground are marked on the ground channel adjacent to the connector. The flag-type terminals take wire size AWG No. 10 or No. 12 and the ground clips are used to clamp ground braids between the ground channels.

INSTALLATION OF S-PACS

S-PAC insertion is accomplished by engaging the S-PAC in the appropriate slot of the S-BLOC and pressing the S-PAC into position until the connector is engaged and seated. The S-PAC is inserted with the components at the left.

S-PAC removal from S-BLOCs is accomplished by engaging the two holes at the handle end of the S-PAC, using the S-PAC extractor tool supplied with each drawer unit.

1/12/66 3-21

A 20-pound force is sufficient to disengage an S-PAC from its mating connector and the S-PAC can then be removed with the fingers. The tool must be engaged from the component side of the S-PAC to prevent damage to the etched wiring.

WARNING

DC power must be off prior to the insertion or removal of S-PACs from S-BLOCs.

A hold-down bar featuring a quick-release thumb latch clamps the S-PACs to the BLOC. A sponge rubber pad on the bar presses against the PACs to lock them in position.

POLARIZATION

The connectors should not be polarized until after final S-PAC locations have been determined. Polarization is accomplished by inserting two nylon pegs into the appropriate slots of the connector, which prevents any but the desired PAC type from being inserted into that slot. Sufficient polarizing pegs for the connectors are supplied with the drawer unit. Polarizing pegs are inserted in specific locations for each S-PAC as listed in table 2-3.1 in Section II of this manual.

COOLING

The tilt drawer units are cooled by a unit composed of three axial flow fans equipped with suitable filters. The circulating air is drawn into the unit from the rear of the cabinet, passed horizontally forward through the S-BLOCs, and exhausted through the space between the forward S-BLOC and the front panel.

To insure uniform air flow through the unit, the special plastic baffle mounted on the hold-down bar of each S-BLOC must be in a position to prevent the leakage of air through the PAC insertion face of the S-BLOC. A small Polyfoam gasket prevents the leakage of air between the connectors.

TILT DRAWER UNIT MOUNTING

The BT-32 and BT-33 units are supplied with a set of detent slides. The inner rails, detent plates, and detent latch assemblies are mounted to the drawer at the factory. The intermediate rails and outer rails are mounted to the vertical rails of the cabinet (figure 3-5.4), with the top hole in the slide mounting bracket 6-1/8 inches from the top of the front panel. The tilt drawer is installed by sliding the inner rails of the slide into the intermediate rails, depressing the locking buttons on the inner rail, and captivating them within the intermediate rail. The unit can be secured within the cabinet by bolting the front panel to the front vertical rails (figure 3-5.5). The front panel will extend 27-11/16 inches from the front vertical mounting rails of the cabinet and will rotate up to 105 degrees from the horizontal plane in either direction.

Model Connector Type S-PAC Capacity
BT-32 Solder pin 80
BT-33 Taper pin 80

Table 3-5.1. Tilt Drawer Types

SPECIFICATIONS

BT-32:

Connectors:

Elco, type 7008-35-5-2

Power:

-18 V wired to pin 2, bypassed with 22 $\mu\,\mathrm{f}$

-6 V wired to pin 3, bypassed with 22 μf

+12 V wired to pin 4, bypassed with 3.3 μf

Ground wired to pin 5

BT-33:

Connectors:

Elco, type 7009-034-193-101

Power:

-18 V wired to pin 2, bypassed with 22 μf to ground

-6 V wired to pin 3, bypassed with 22 μf to ground

+12 V wired to pin 4, bypassed with 3.3 μf to ground

Ground wired to pin 5

BT-32 and BT-33:

Power Terminals:

Mating terminals (Thomas & Betts No. RB-250, 3C part number 937 200 001) are supplied with each drawer for the quick-disconnect power connectors. (Heyco 202-1 receptacle, 3C part number 941 307 112; Heyco 202-SS terminal, 3C part number 937 201 004)

Test Points:

19 supplied (Sealectro SKT-14 receptacle)

Mating piece (Sealectro PR-10, plug or No. 18 wire)

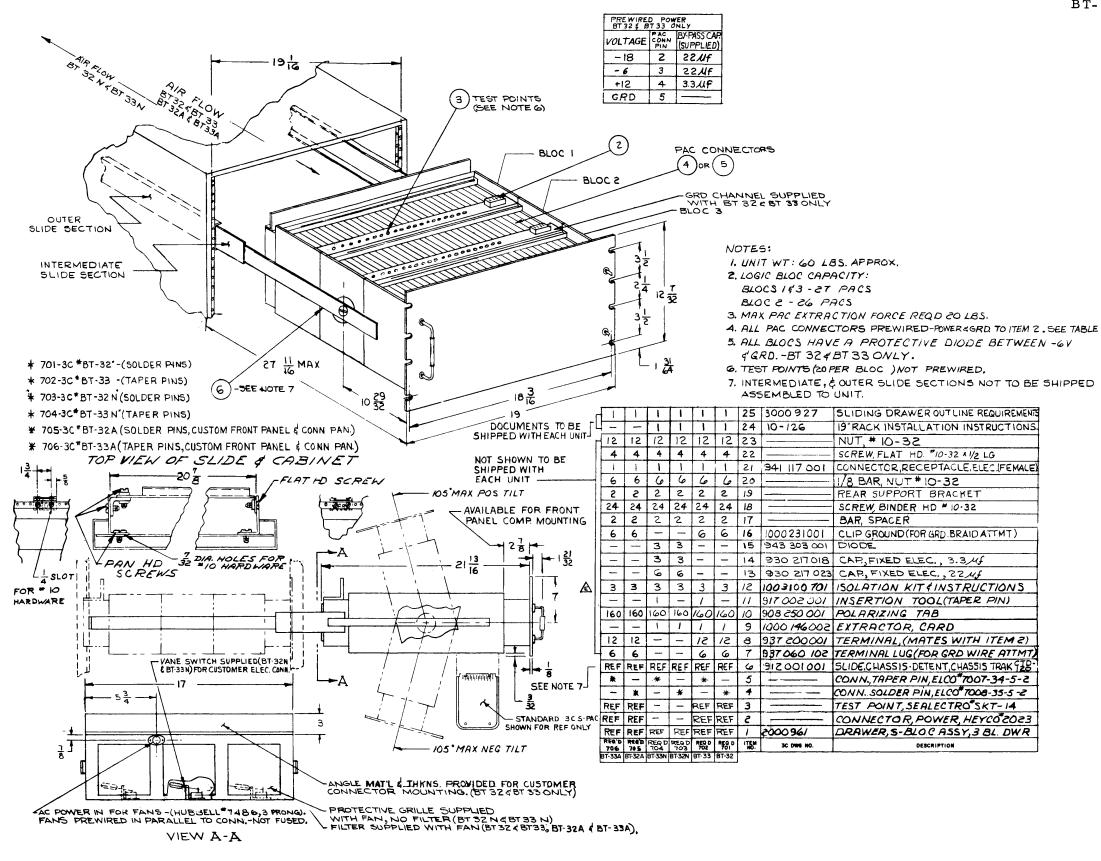


Figure 3-5.2. Sliding Drawer Outline Requirements 3C Dwg. No. 3000927

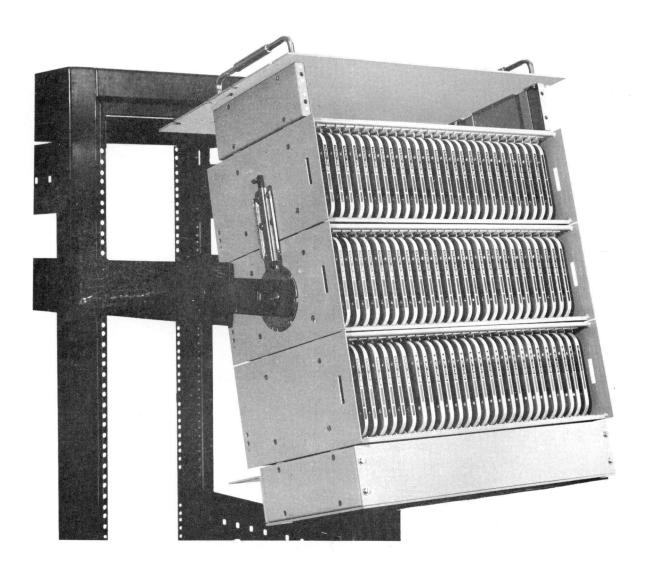
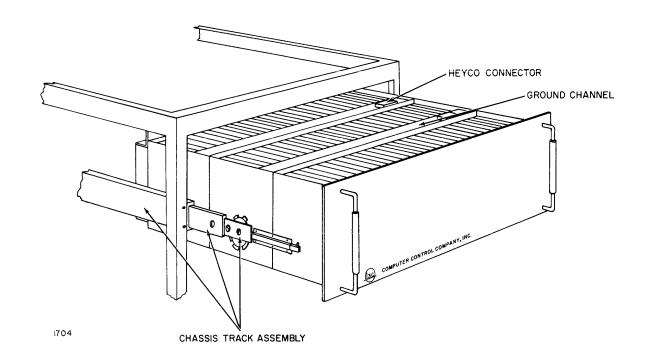


Figure 3-5.1. Tilt Drawer Unit, Models BT-32 and BT-33 Assembly



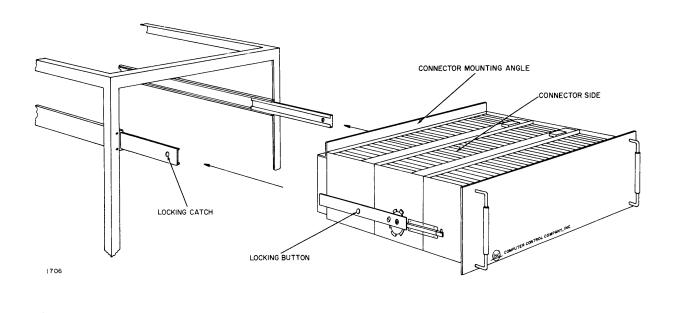


Figure 3-5.3. Tilt Drawer Unit Installation (Sheet 1 of 2)

1/12/66 3-25

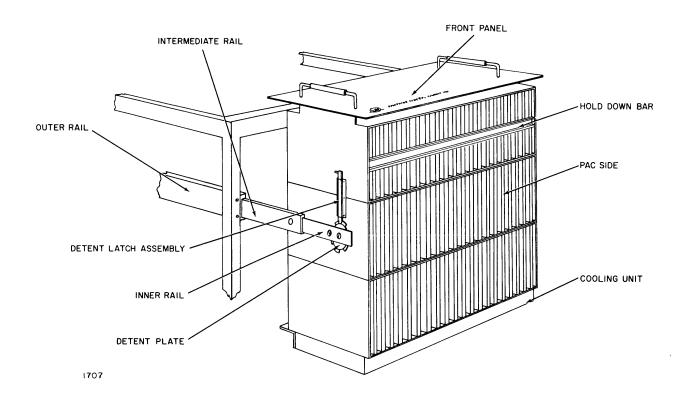


Figure 3-5.3. Tilt Drawer Unit Installation (Sheet 2 of 2)

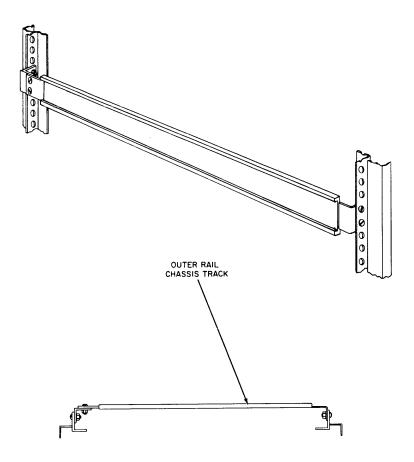


Figure 3-5.4. Tilt Drawer Unit, Outer Mounting Rail

3-5A CONVERTER CLOCK PAC, MODEL CA-30

GENERAL DESCRIPTION

The Converter Clock PAC, Model CA-30 (Figures 3-5A. 1 and 3-5A. 2), is a special purpose PAC for generating timing and control signals for an S-PAC analog-to-digital converter that uses the successive bit approximation method. The CA-30 is used with other S-PACs to construct a bipolar or unipolar A/D converter of up to 11 bits.

The CA-30 PAC (Figure 3-5A. 3) contains three sections: start pulse generator, clock pulse generator, and least bit circuit. The start pulse generator converts an external trigger voltage to a pulse capable of initiating the conversion in the A/D equipment. The clock pulse generator contains a controlled, free-running multivibrator and other circuitry for generating three timing signals which control the converter. The least bit circuit contains the least significant bit switch for the converter, and also provides a means of offsetting the converter by 1/2 bit, to change the range of quantizing error from 0 to -1 bit, to $\pm 1/2$ bit.

CIRCUIT FUNCTION

Start Pulse Generator. A positive- or negative-going signal can be used to trigger the start pulse. When driven from S-PACs, a positive transition should be used. If the feedback output (pin 20) is connected to the positive trigger input (pin 15), the generator will free run at approximately 400 pps.

Clock Pulse Generator. Three timing control signals (preclock, clock, and reset) are generated synchronously from a free-running multivibrator. The time period is variable from 5 to 10 µsec by adjusting the potentiometer on the PAC. The preclock signal interrogates the state of the comparator, which sends a signal back to the reset enable input. The clock signal sets successive flip-flops (puts ONEs in the converter register). The reset signal, which is the gated result of the clock and the reset enable, is used to reset the previous flip-flop in the converter register. A 0-volt signal applied to the stop input inhibits the timing pulses.

Least Bit Circuit. This is an optional circuit which is not necessary in an A/D converter. The circuit can be used to extend the capability of an LP-31 PAC from 6 to 7 bits. The termination resistor (R20) on the LP-31 must be removed when the least bit circuit is used. A transistor switch controlled by the 2° input connects a weighted resistor from the LP-31 summing junction to either ground or the negative reference voltage for handling the seventh bit.

For offsetting the converter, the sign test input controls another transistor switch which can provide offset current to the LP-31 summing junction. The pin connections between the CA-30 and the LP-31 for various configurations are shown in Figure 3-5A. 4.

APPLICATIONS

The CA-30 PAC (Figure 3-5A. 5) is used with other S-PACs in a bipolar A/D converter. An external start signal generates a start pulse which resets the converter register and initiates conversion. The polarity of the analog input is determined without the converter being offset. Thereafter, the converter is offset 1/2 bit when making

4/15/64 3-28A

comparisons with respect to ground. Successive ONEs are put in the converter register, most significant bit first, and comparisons are made to determine if the bit is accepted or rejected. At the end of the conversion cycle, a stop signal is sent to the CA-30.

SPECIFICATIONS

Start Pulse Generator

Positive Trigger Input (Use with S-PACs)

Positive-going pulse, - 6 V to 0 V; rise time (max), 5 μ sec; pulse width (min), 2 μ sec; signal must be at -6 V for 30 μ sec (min) before going positive.

If at 0 V, it inhibits the negative trigger input; if at -6 V or not connected, it enables. Signal must be at -6 V for 30 μsec (min) after being inhibited by the negative trigger input.

Loading: l U load

Negative Trigger Input (Should not be driven by S-PACs)

Negative-going pulse, 0 V to -6 V; fall time (max), 5 μ sec; pulse width (min), 2 μ sec; signal must be at 0 V for 30 μ sec (min) before going negative.

If at -6 V, it inhibits the positive trigger input; if at 0 V or not connected, it enables. Signal must be at 0 V for 30 μ sec (min) after being inhibited by the positive trigger input.

Loading: 1 U load + 150 pf capacitance

Noise protection: 0.6 V (min)

	Start Output	Aux Start Output				
Positive pulse	-18 V to 0 V	-6 V to 0 V				
Rise time	0.1 μsec (typ)	0.1 μsec (typ)				
Pulse width	l μsec	l μsec				
Output drive capability	20 U loads (total)					

Feedback Output

Connect to positive trigger input to make start pulse generator free run at 400 CPS (approx).

Clock Pulse Generator

Stop Input

-6 V enables; 0 V inhibits; clock pulse generator will start or stop approximately l μsec after application of signal.

Rise and fall time: 1 µsec (max)

Pulse width: 2 µsec (min)

Loading: 1/2 U load

Reset Enable Input

-6 V enables: 0 V inhibits

Loading: 1 U load

SPECIFICATIONS (Cont)

Preclock Output

Positive pulse: -6 V to 0 V

Rise time: $0.1~\mu sec$ Pulse width: l µsec

Output drive capability: 16 U loads

Clock Output and Reset Output (Same as preclock output)

Least Bit Circuit

Sign Test Input

-6 V offsets the converter (13 µamps to LP-31 summing junction). 0 V or not connected, no offset

Loading: 1/2 U load

2° Input

At 0 V a weighted resistor is connected to the -Ref voltage.

At -6 V the resistor is connected to ground.

Loading: 1/2 U load

Reference Input

Connect to the -10 V reference voltage used on the LP's.

Loading: 0.12 ma (reverse)

LP-31 Summing Junction Output

Connect to the LP-31 summing junction (R20 on the LP-31 must be disconnected).

Termination

Connect to signal ground when using the 2° input (seventh bit on the LP-31). Connect to the 1/2 bit output when the 2° input is not used.

1/2 Bit Output

Leave unconnected when using the 2° input. Connect to the termination output when not using the 2° input.

CA-30 PAC

Operating Temperature Range Polarization 0°C to +55°C Pins 8 and 14

Current Requirements

Color Code 35 ma +12 V: Long: Blue - 6 V: 30 ma Short: Yellow -18 V: 26 ma

Power

1.0 watt

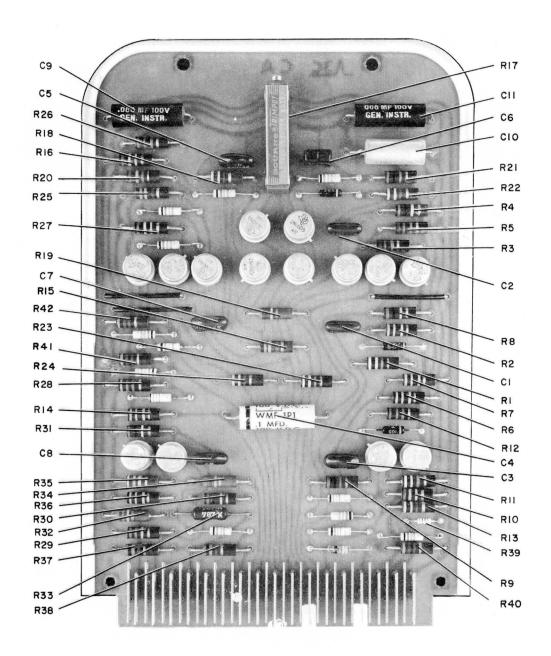


Figure 3-5A.1. Converter Clock PAC, Model CA-30, Parts Location (Capacitors and Resistors)

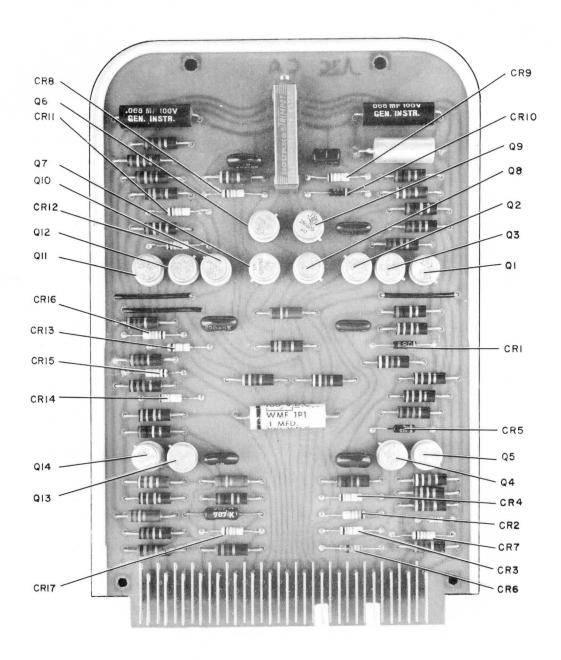


Figure 3-5A.2. Converter Clock PAC, Model CA-30, Parts Location (Diodes and Transistors)

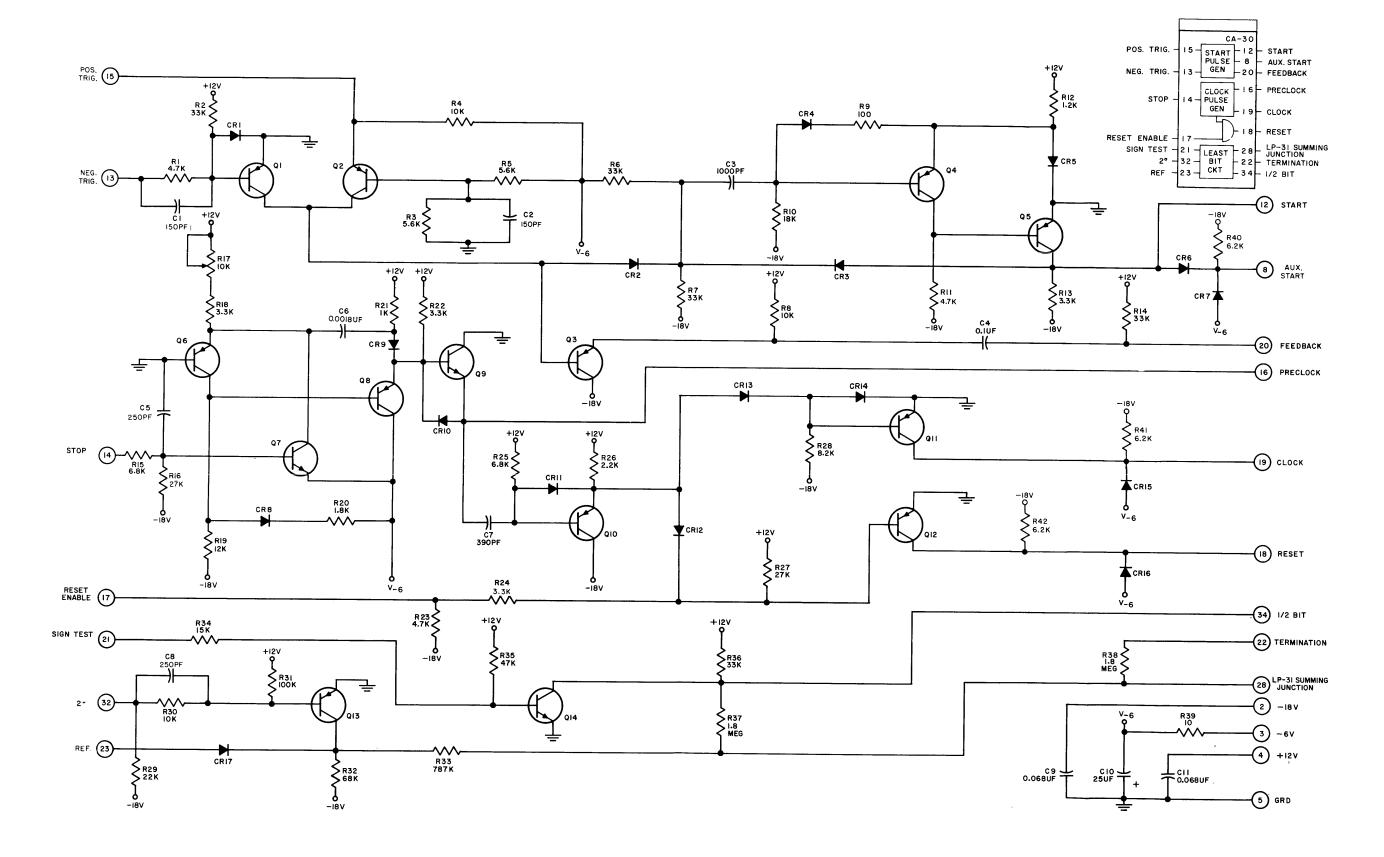
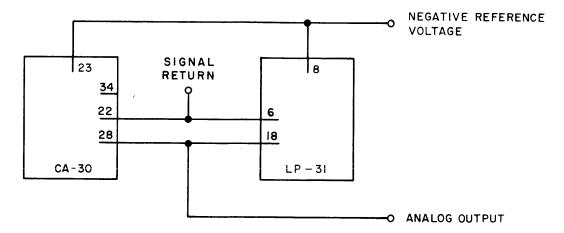
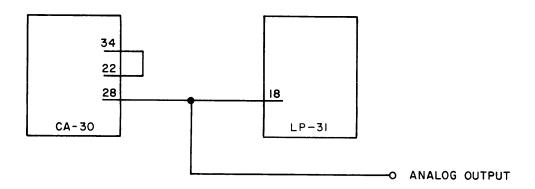


Figure 3-5A.3. Converter Clock PAC, Model CA-30, Schematic and Logic Diagram

7 BIT LP-31 PAC WITH OR WITHOUT OFFSET



6 BIT LP-31 PAC WITH OFFSET



6 BIT LP-31 PAC WITH NO OFFSET

NO CONNECTIONS BETWEEN CA-30 AND LP-31 PACS.
DISREGARD THE LEAST BIT CIRCUIT.

Figure 3-5A.4. Offset Interconnections

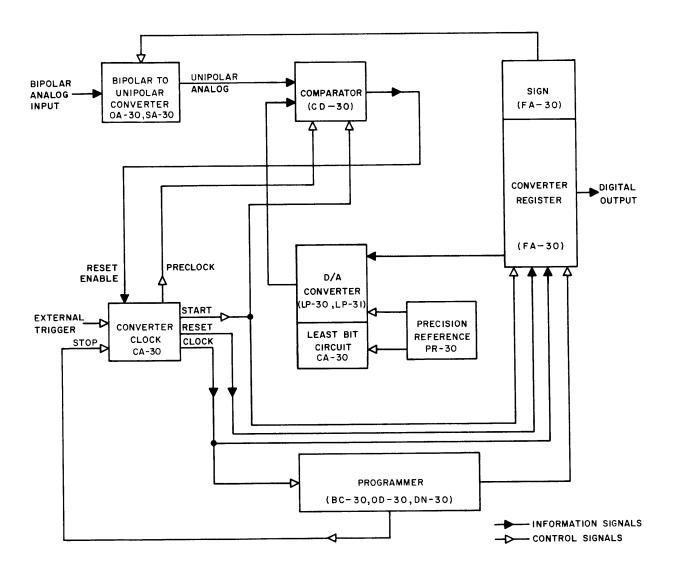


Figure 3-5A. 5. S-PAC A/D Converter Block Diagram

3-6 ANALOG COMPARATOR PAC, MODEL CD-30

GENERAL DESCRIPTION

The Analog Comparator PAC, Model CD-30 (figure 3-6.1), is a high-sensitivity, high-speed, analog null detecting device. This PAC can be used for any application where it is desired to know the polarity of a signal to within a few millivolts of ground or the polarity of the sum of two analog voltages to within a few millivolts. Typical applications of the CD-30 are as a comparator in an analog-to-digital converter and as a digital servo null detector on a crossover detector for converting the output of a resolver to digital signals.

The CD-30 consists essentially of a low-drift, high-gain, DC differential amplifier whose output is periodically sampled by the system clocks and stored in an output flip-flop stage. At the maximum sampling rate of 300 kilocycles, sensitivity for a direct input is better than 1 millivolt, with signal ground as the input reference. The set and reset outputs of the CD-30 provide standard S-PAC levels.

CIRCUIT FUNCTION

The CD-30 circuit (figure 3-6.2) can be separated into the following areas:

- a. Low-level differential amplifier (Q3, Q4, Q5, and Q6)
- b. Sampled differential amplifier (Q2, Q7, and Q8)
- c. Interrogation pulse shaper (Q1)
- d. Differential steering circuit (Q9 and Q10)
- e. Current switch output flip-flop (Qll and Ql2)

The input differential amplifier has been designed to provide minimum drift. The gains of transistor pair Q3 and Q4 have been carefully matched so that their base currents will be equal at balance over the temperature range. The CD-30 is provided with a 3-kilohm impedance at the reference base and a pair of 6-kilohm resistors at the input side. When performing analog summing at other than a 1 to 1 basis, the values of R6 and R7 can be changed, provided their parallel impedance is equal to 3 kilohms. Diodes CR3 and CR4 prevent the voltage at the base of Q3 from exceeding ±0.6 volt. This serves two functions: It prevents large input transients from damaging the input stages and limits the voltage acquired by the input capacitance, thus allowing fast recovery from large input swings. If the diodes are to perform their function, a low-impedance voltage source must not be connected directly to the summing point. Sources such as the output of the LP-30 Digital-to-Analog Converter PAC can be connected directly to the summing point because of their high internal impedances (6 kilohms). Transistors Q5 and Q6 provide additional low-level amplification before the signal is applied to the differential sampler.

The differential sampler is a differential amplifier with a pulsed current source drifting its emitters. Normally, no current is supplied to the emitters and the collector potentials are at -6 volts. To sample, a 3-milliampere current pulse is applied to the emitters of Q7 and Q8. The current splits between the transistors according to the voltage difference between the bases. At balance, the current splits equally and equal size pulses appear at the collectors of the differential amplifier. As an imbalance occurs, the amplitude of one pulse increases and that of the other pulse decreases (figure 3-6.3).

3/2/64 3-29/3-30

When input pulses of equal amplitude appear at the base of differential steering amplifier Q9 and Q10, there is no output at either collector. If the input pulses do not balance, pulses of opposite polarity appear at the collectors of these transistors. The pulses on the collectors of Q9 and Q10 are capacitively coupled to the bases of Q11 and Q12, respectively. These transistors form a current switch flip-flop which requires a differential input of only 2 volts to switch reliably from one stage to the other. The output of CD-30 is taken from the collectors of this flip-flop. The phasing from the input to output is such that when the summing of the input voltage is positive, the reset output (pin 14) goes to 0 and the set output (pin 13) goes to -6 volts.

SPECIFICATIONS

Polarization

Pins 18 and 28

Direct Input	Output							
Impedance: 5 K (assuming no diode clipping) Sensitivity: 1 mv (min) with DC input 4 mv at 10 KC	Levels:	Positive Voltage at Input	Negative Voltage at Input					
Drift: ±2 mv (max)	Set output: Reset output:	-6 V	0 V -6 V					
Summing Inputs Impedance: 6 K each input (standard)	Drive capability: 2 unit loads each and 100 pf of stray capacitance							
Parallel resistance of R6 and R7 in any nonstandard configuration should equal	Circuit delay: 0.5 μsec (max) Waveforms:							
3 K Sample Command Input	Rise time: 0.2 μsec (typ) Fall time: 0.2 μsec (typ)							
Sampling rate: 300 KC (max) Pulse requirements: 0.6 µsec (min) at -6 V before a positive transition to ground	Operating Temper		e -					
Rise time: 0.2 µsec (max)	Current Requirements							
Sampling: Takes place at -6 V to 0 V positive transition Total Power	-18 V 36 ma -6 V 12 ma (reverse current) -12 V 14 ma							
0.8 watts	Handle Color Code	e						

Long: Red

Short: White

4/16/68

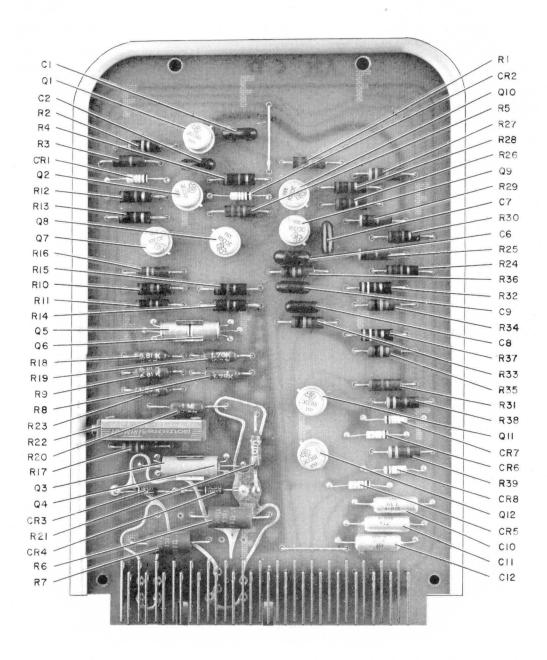


Figure 3-6.1. Analog Comparator PAC, Model CD-30, Parts Location

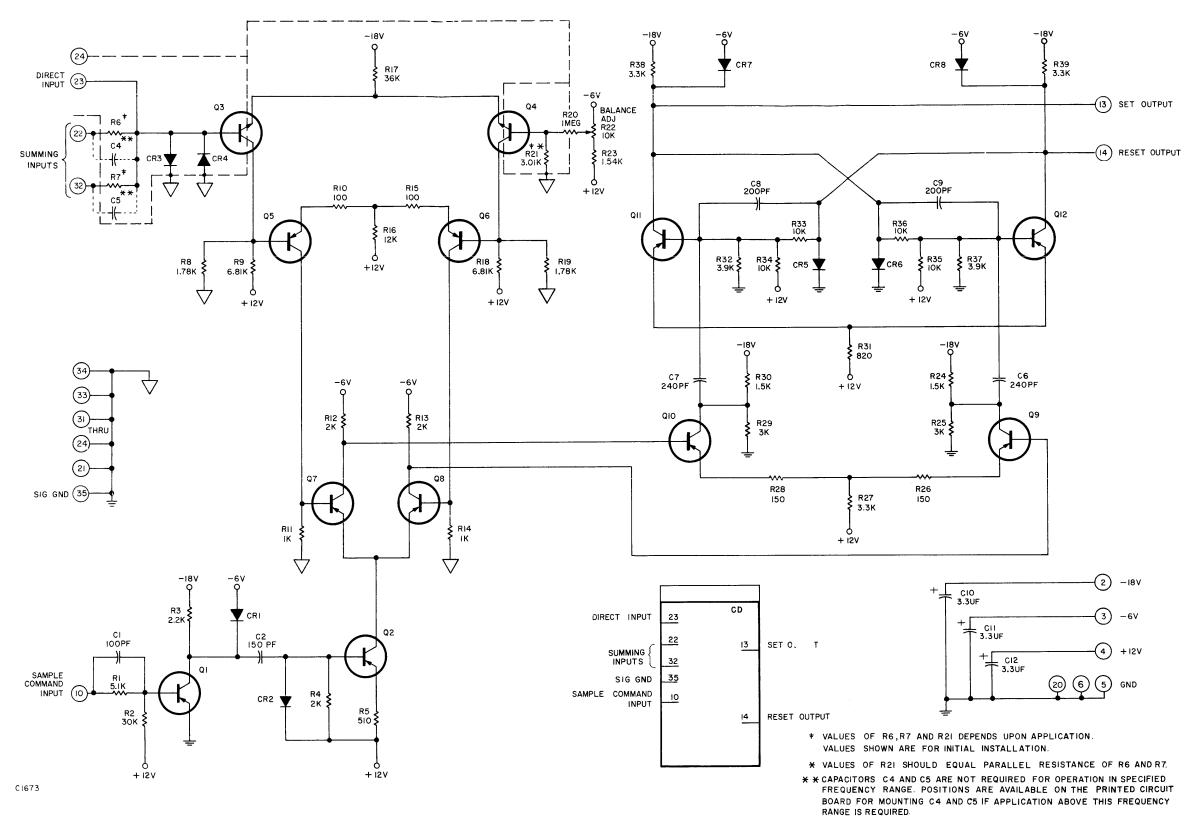


Figure 3-6.2. Analog Comparator PAC, Model CD-30, Schematic and Logic Diagram

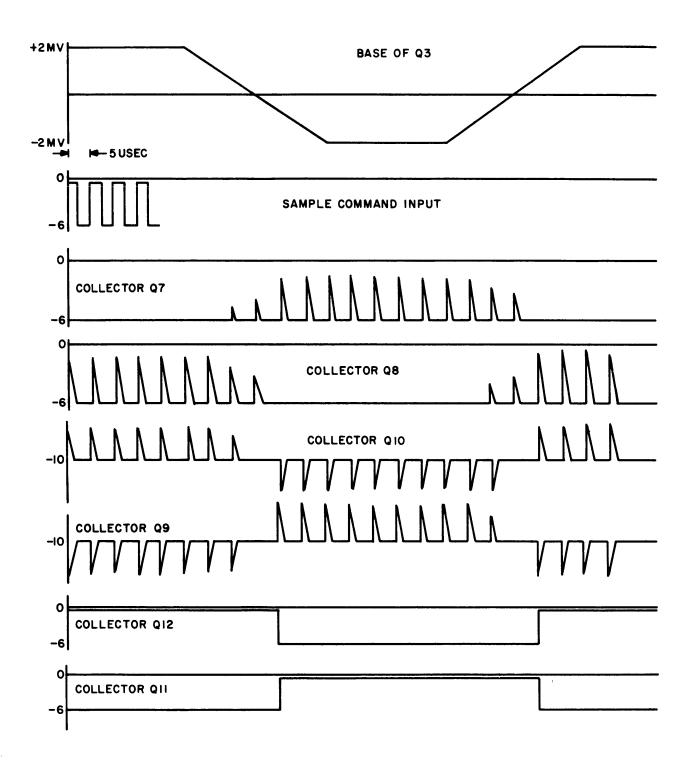


Figure 3-6.3. Analog Comparator PAC, Model CD-30, Waveforms

3-7 COUNTER-INDICATOR PAC, MODEL CI-20

GENERAL DESCRIPTION

The Counter-Indicator PAC, Model CI-20 (figures 3-7.1 and 3-7.2), is a decimal counting unit containing a four-stage BCD counter and a converter-indicator. The counter consists of four flip-flops internally connected to count input pulses in an 8-4-2-1 binary-coded-decimal (BCD) mode at frequencies from DC to 100 kilocycles. The converter-indicator decodes the BCD information from the counters and displays the decimal equivalent by lighting one of the 10 neon indicator lamps mounted on the vertical display panel.

The PAC has three types of count inputs and two types of reset inputs for different signal voltage levels. The counter outputs are available for driving other circuits. A carry pulse output is provided which can be applied as a high-level count input to a similar counter for cascading stages.

CIRCUIT FUNCTION

The counter (figure 3-7.3) contains four flip-flops which are permanently connected to count in the 8-4-2-1 BCD mode. The set and reset outputs of each flip-flop are connected to the converter-indicator, which generates and displays the decimal equivalent of the binary information stored in the flip-flops. The converter-indicator consists of a network of converter lamps, indicator lamps, and resistors connected in a matrix to allow only one indicator lamp to light on a specific count. Several of the converter lamps will light, thereby inhibiting the remaining nine indicator lamps. Refer to table 3-7.1 for the condition of the converter and indicator lamps in each decimal state.

High Level Count Input. The high level count input accepts carry pulses from a previous counter or other high level count sources. The input is driven by the positive-going edge of a 60-volt pulse. The minimum positive or negative pulse width is 3 microseconds, allowing a variation in the duty cycle of 30 to 70 percent at the maximum input frequency of 100 kilocycles.

Auxiliary Count Input. The auxiliary count input accepts fixed-amplitude pulses of 10 to 80 volts when used with the properly valued input capacitor for that amplitude. Provisions are made on the PAC for the insertion of the required capacitor. The value of capacitor C3 can be determined from the following equation:

$$C = [15, 500/V] - 40$$

where C is in micromicrofarads and V is the pulse amplitude in volts.

Count Inputs. A count input is activated by the negative-going edge of a pulse (0 to -6 volt transition). The minimum positive or negative pulse width is 3 microseconds. With one input connected to a pulse source, the other count input can be used as a count enable input. An open circuit or -6 volts on that input will enable; ground will disable.

Reset Input. The reset input permits a logic reset of the counter to decimal 0 or the reset state. A -6 volt level applied to the input resets the counter; ground allows the counter to advance.

<u>Direct Reset Input.</u> The direct reset input permits resetting of the counter by grounding the input through a relay, switch, or the reset driver of the IDCU power supply, Model PD-30. The external switching to the input must be capable of handling a maximum current of 25 milliamperes when closed and a voltage of 80 volts when open.

<u>Carry Output.</u> The carry output provides a high-level pulse capable of driving a high-level count input of another decimal counting unit (such as a CI-20, CI-21, CP-20, or CP-21) to allow cascading.

BCD Data Outputs. The set and reset outputs of each flip-flop are available to drive other S-PACs.

Table 3-7.1. IDCUIndicator, Proper Conditions for Correct Decoding

	Indicator Lamps	Converter Lamps DS11-DS20									
Decimal State	DS1-DS10	11	12	13	14	15	16	17	18	19	20
0	1				X		Х	Х	Х		X
1	2				X		Х	Х	Х		X
2	3	X				X	Х		x		X
3	4	x				X	Х		Х		X
4	5		X	Х	X			Х			X
5	6		Х	Х	X			Х			Х
6	7	X	X	X		X					X
7	8	X	X	X		X					X
8	9				X		X	Х	Х	Х	
9	10				X		Х	X	X	X	

NOTE

X indicates lamp is lighted.

SPECIFICATIONS

Frequency of Operation

DC to 100 KC (max)

Circuit Delay

6.0 μsec (typ)

10.0 µsec (max)

Input Requirements

High Level Count Input

Voltage: $60 \text{ V} \pm 10 \text{ V}$ positive-going pulse

Rise time: 2.5 µsec (max)

Pulse width: 3 µsec (min) at

either level

Auxiliary Count Input

Voltage: 10 V to 80 V amplitude

(positive-going pulse)

Rise time: Same as high level

count input

Pulse width: Same as high level

count input

Count Input

Voltage: Ground to -6 V (negative-

going S-PAC pulse)

Fall time: 2.5 µsec (max)

Pulse width: $3 \mu sec$ (min) at

either level

Direct Reset Input

Counter enable: Open circuit or more negative than -80 V

Counter reset: Ground, 3.5 µsec

(min) duration

Reset Input

Counter enable: Ground

Counter reset: -6 V or open circuit,

3.5 µsec (min) duration

Input Loading

High Level Count Input

220 pf to ground

Auxiliary Count Input

C3 to ground

Count Input

l W load

Direct Reset Input

25 ma (max)

Reset Input

l W load

Output Drive Capability

BCD Data Outputs

1 V load and 50 pf stray

capacitance

Carry Output

l high level count input and

50 pf stray capacitance

Output Levels

BCD Data Outputs

Ground and -60 V when unloaded

S-PAC compatible ONES and

ZEROS when loaded

Carry Output

Ground and -60 V

Current Requirements

-18 V

ll ma

+12 V

2 ma

-120 V

25 ma

Total Power

3.2 watts

Polarization

Pins 4 and 20

PAC Length

7-3/4 inches (includes 5/16 in. extraction stud)

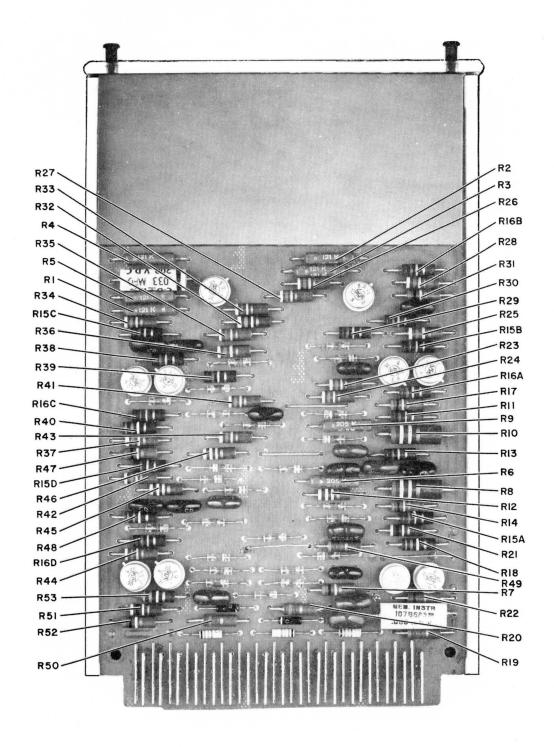


Figure 3-7.1. Counter-Indicator PAC, Model CI-20, Parts Location (Resistors)

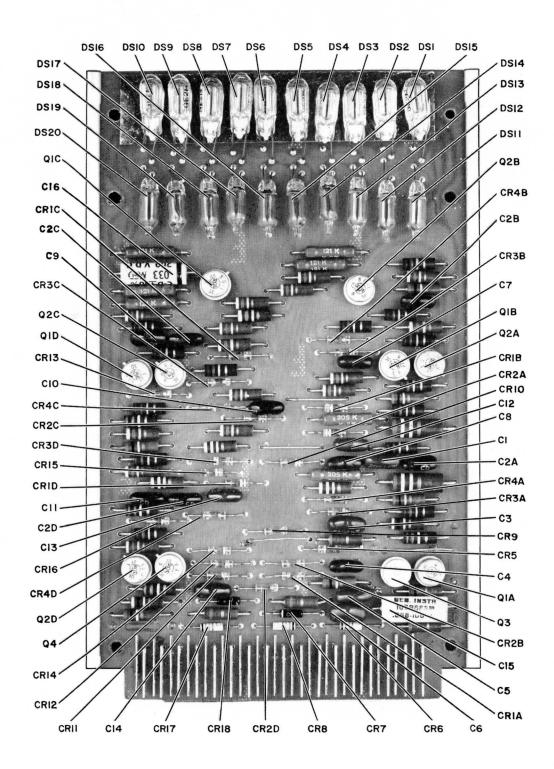


Figure 3-7.2. Counter-Indicator PAC, Model CI-20, Parts Location (Capacitors, Diodes, Transistors, and Lamps)

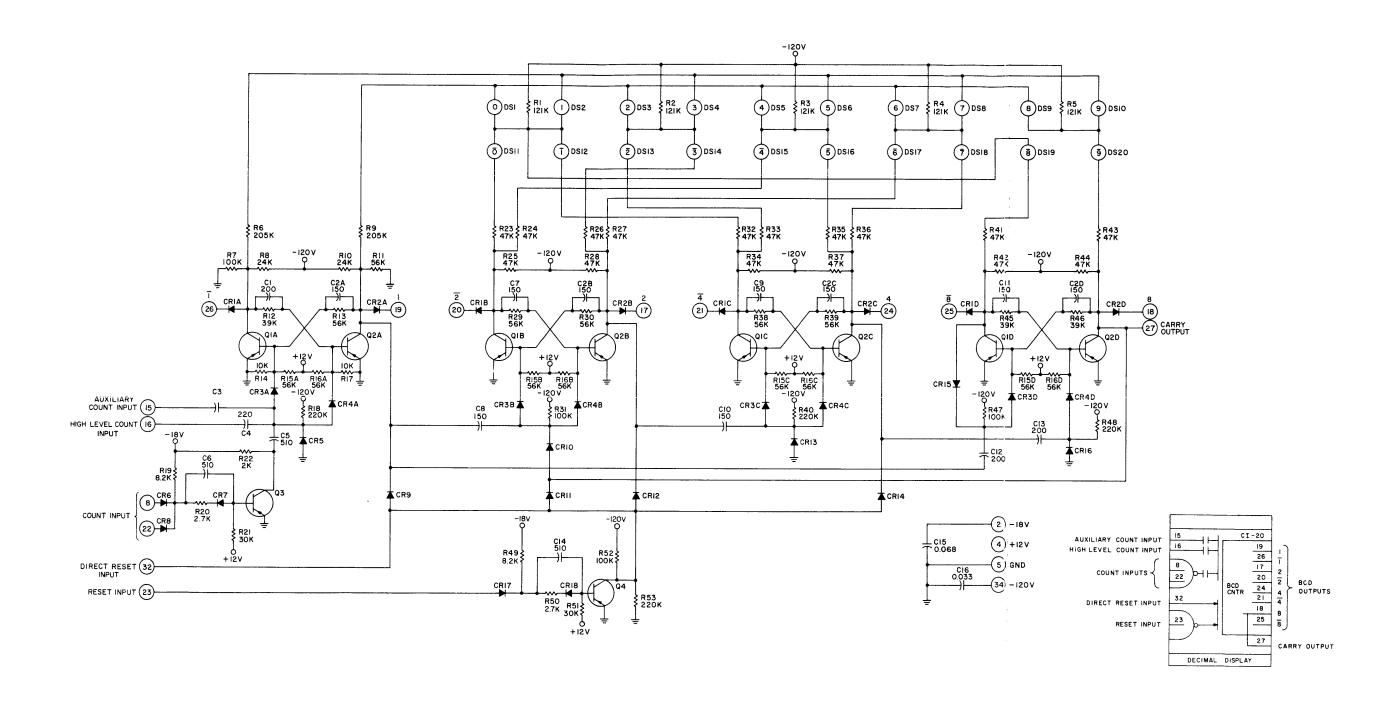


Figure 3-7.3. Counter-Indicator PAC, Model CI-20, Schematic and Logic Diagram

3-8 COUNTER-INDICATOR (HIGH LEVEL) PAC, MODEL CI-21

GENERAL DESCRIPTION

The Counter-Indicator (High Level) PAC, Model CI-21 (figures 3-8.1 and 3-8.2) is a decimal counting unit containing a four-stage BCD counter and a converter-indicator. The counter consists of four flip-flops internally connected to count input pulses in an 8-4-2-1 binary-coded-decimal (BCD) mode at frequencies from DC to 100 kilocycles. The converter-indicator decodes the BCD information from the counters and displays the decimal equivalent by lighting one of the 10 neon indicator lamps mounted on the vertical display panel.

The PAC has a high-level count input and a direct reset input. A carry pulse output is provided which can be applied as a high level count input to a similar counter for cascading stages.

CIRCUIT FUNCTION

The counter (figure 3-8.3) contains four flip-flops which are permanently connected to count in the 8-4-2-1 BCD mode. The set and reset outputs of each flip-flop are connected to the converter-indicator, which generates and displays the decimal equivalent of the binary information stored in the flip-flops. The converter-indicator consists of a network of converter lamps, indicator lamps, and resistors connected in a matrix to allow only one indicator lamp to light on a specific count. Several of the converter lamps will light, thereby inhibiting the remaining nine indicator lamps. Refer to table 3-8.1 for the condition of the converter and indicator lamps in each decimal state.

High Level Count Input. The high level count input accepts carry pulses from a previous counter or other high level count sources. The input is driven by the positive-going edge of a 60-volt pulse. The minimum positive or negative pulse width is 3 microseconds, allowing a variation in the duty cycle of 30 to 70 percent at the maximum input frequency of 100 kilocycles.

<u>Direct Reset Input</u>. The direct reset input permits resetting of the counter by grounding the input through a relay, switch, or the reset driver of the IDCU Power Supply, Model PD-30. The external switching to the input must be capable of handling a maximum current of 25 milliamperes when closed and a voltage of 80 volts when open.

<u>Carry Output</u>. The carry output provides a high level pulse capable of driving a high level count input of another decimal counting unit (such as a CI-20, CI-21, CP-20, or CP-21) to allow cascading.

Table 3-8.1. IDCU Indicator, Proper Conditions for Correct Decoding

	Indicator Lamps	Converter Lamps DS11-DS20					3.0				
Decimal State	DS1-DS10	11	12	13	14	15	16	17	18	19	20
0	1				Х		Х	Х	Х		X
1	2				Х		Х	Х	X		X
2	3	Х				X	Х		Х		Х
3	4	Х				X	X		Х		X
4	5		X	Х	X			X			X
5	6		Х	X	X			X			X
6	7	Х	Х	Х		X					X
7	8	Х	Х	Х		X					X
8	9				X		Х	Х	Х	Х	
9	10				X		X	X	Х	Х	

NOTE

X indicates lamp is lighted.

SPECIFICATIONS

Frequency	of	Operation	
·			

DC to 100 KC (max)

Circuit Delay

(Four stages)

6.0 μsec (typ)

10.0 µsec (max)

Input Requirements

High Level Count Input

Voltage: 60 V ± 10 V positive-going

pulse

Rise time: 2.5 µsec (max)

Pulse width: 3 µsec (min) at either

level

Direct Reset Input

Counter enable: Open circuit or more negative than -80 V

8

Counter reset: Ground, 3.5 µsec

(min) duration

Input Loading

High Level Count Input

220 pf to ground

Direct Reset Input

25 ma (max)

Output Drive Capability

Carry Output

l high level count input and 50 pf stray capacitance

Output Levels

Carry Output

Ground and -60 V

Current Requirements

+12 V 2 ma

-120 V 24 ma

Total Power

3.0 watts

Polarization

Pins 4 and 20

PAC Length

7-3/4 inches (includes 5/16 in. extraction stud)

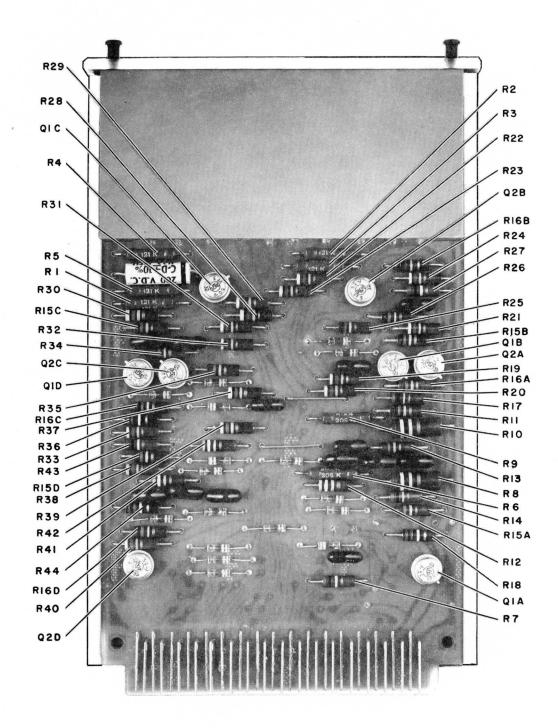


Figure 3-8.1. Counter-Indicator (High Level) PAC, Model CI-21, Parts Location (Resistors and Transistors)

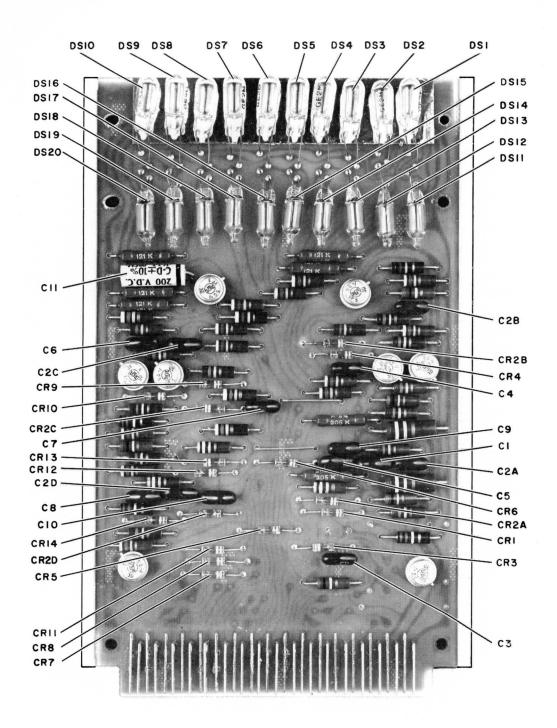


Figure 3-8.2. Counter-Indicator (High Level) PAC, Model CI-21, Parts Location (Capacitors, Diodes, and Lamps)

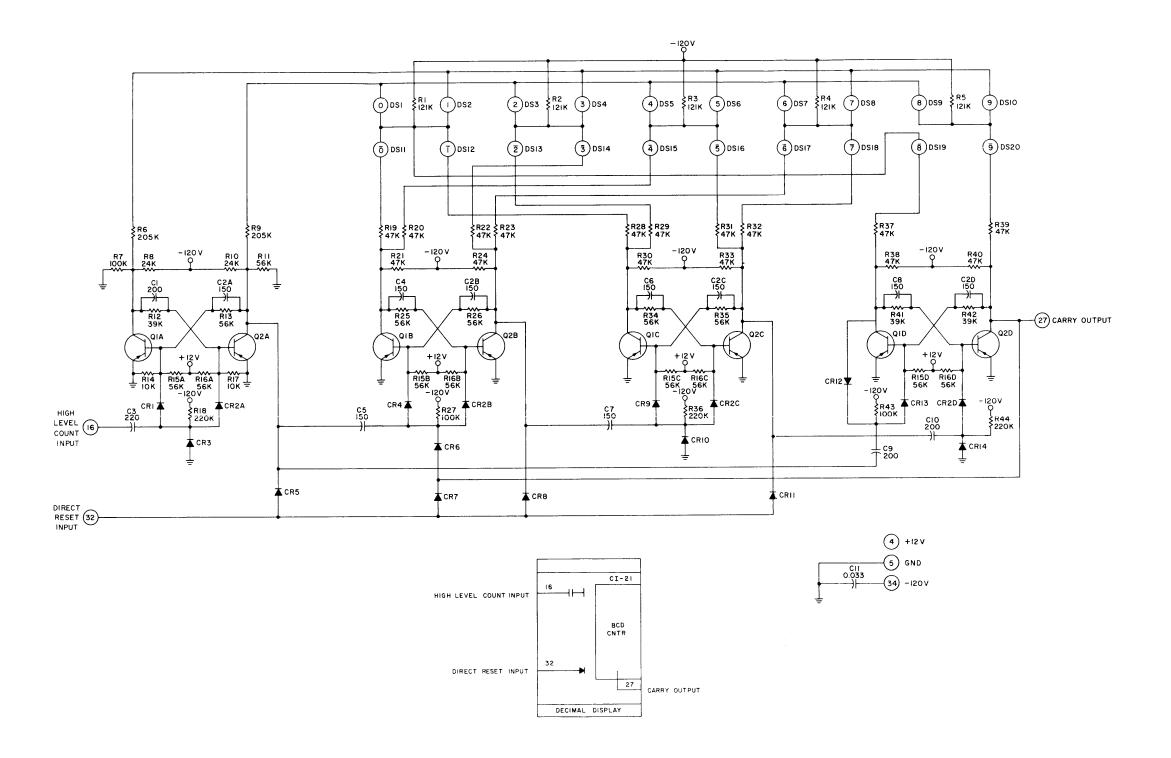


Figure 3-8.3. Counter-Indicator (High Level) PAC, Model CI-21, Schematic and Logic Diagram

3-49/3-50

3-9 COUNTER-CONVERTER PAC, MODEL CP-20

GENERAL DESCRIPTION

The Counter-Converter PAC, Model CP-20 (figures 3-9.1 and 3-9.2), is a decimal counting unit containing a four-stage BCD counter and part of a binary-to-decimal converter. The counter consists of four flip-flops internally connected to count input pulses in an 8-4-2-1 binary-coded-decimal (BCD) mode at frequencies from DC to 100 kilocycles. The part of the binary-to-decimal converter contained in the PAC converts the BCD information into a special 12-line output capable of driving an Indicator-Converter PAC, Model IP-30. The IP-30 PAC completes the conversion and displays the decimal equivalent.

The CP-20 has three types of count inputs and two types of reset inputs for different signal voltage levels. The counter outputs are available for driving other circuits. A carry pulse output is provided which can be applied as a high level count input to a similar counter for cascading stages. The CP-20 and IP-20 PACs can be separated by several hundred feet to allow remote display of the counter.

CIRCUIT FUNCTION

The counter (figure 3-9.3) contains four flip-flops which are permanently connected to count in the 8-4-2-1 BCD mode. The set and reset outputs of each flip-flop are connected to a resistor network which provides the 12-line output for driving the IP-30 PAC. The IP-30 PAC converts the 12-line input data to a decimal display.

High Level Count Input. The high level count input accepts carry pulses from a previous counter or other high level count sources. The input is driven by the positive-going edge of a 60-volt pulse. The minimum positive or negative pulse width is 3 microseconds, allowing a variation in the duty cycle of 30 to 70 percent at the maximum input frequency of 100 kilocycles.

Auxiliary Count Input. The auxiliary count input accepts fixed-amplitude pulses of 10 to 80 volts when used with the properly valued input capacitor for that amplitude. Provisions are made on the PAC for the insertion of the required capacitor. The value of the capacitor C3 can be determined from the following equation:

$$C = [15, 500/V] - 40$$

where C is in micromicrofarads and V is the pulse amplitude in volts.

Count Inputs. A count input is activated by the negative-going edge of a pulse (0 to -6 volt transition). The minimum positive or negative pulse width is 3 microseconds. With one input connected to a pulse source, the other count input can be used as a count enable input. An open circuit or -6 volts on that input will enable; ground will disable.

Reset Input. The reset input permits a logic reset of the counter to decimal 0 or the reset state. A -6 volt level applied to the input resets the counter; ground allows the counter to advance.

3/2/64

<u>Direct Reset Input.</u> The direct reset input permits resetting of the counter by grounding the input through a relay, switch, or the reset driver of the IDCU Power Supply. Model PD-30. The external switching to the input must be capable of handling a maximum current of 25 milliamperes when closed and a voltage of 80 volts when open.

<u>Carry Output.</u> The carry output provides a high level pulse capable of driving a high level count input of another decimal counting unit (such as a CI-20, CI-21, CP-20, or CP-21) to allow cascading.

BCD Data Outputs. The set and reset outputs of each flip-flop are available to drive other S-PACs.

Decimal Display Outputs. The 12-line output from the resistor network provides drive for an IP-30 PAC. With the 12 outputs connected to the 12 inputs of an IP-30 PAC, the BCD information of the counter is converted to a decimal display.

SPECIFICATIONS

Frequency of Operation
DC to 100 KC (max)

Input Requirements

High Level Count Input

Will do we want input

Voltage: 60 V ± 10 V positive-

going pulse

Rise time: $2.5 \mu sec (max)$

Pulse width: $3 \mu sec (min) at$

either level

Auxiliary Count Input

Voltage: 10 V to 80 V amplitude

(positive-going pulse)

Rise time: Same as high level

count input

Pulse width: Same as high level

count input

Count Input

Voltage: Ground to -6 V, negative-

going S-PAC pulse

Fall time: 2.5 µsec (max)

Pulse width: 3 µsec (min) at either

level

Direct Reset Input

Counter enable: Open circuit or more negative than -80 V

Counter reset: Ground, 3.5 µsec

(min) duration

Reset Input

Counter enable: Ground

Counter reset: -6 V or open circuit,

3.5 µsec (min) duration

Circuit Delay

(Four stages)

6.0 μsec (typ)

10.0 μsec (max)

Input Loading

High Level Count Input

220 pf to ground

Auxiliary Count Input

C3 to ground

Count Input

l W load

Direct Reset Input

25 ma (max)

Reset Input

1 W load

Output Drive Capability

BCD Data Output

1 V load and 50 pf stray capacitance

Carry Output

1 high level count input and 50 pf

stray capacitance

Decimal Display Outputs

l Indicator-Converter PAC, Model

IP-30

3-52 3/2/64

SPECIFICATIONS (Continued)

Output Levels

BCD Data Outputs

Ground -60 V when unloaded

S-PAC compatible ONES and ZEROS

when loaded

Carry Output

Ground and -60 V

Decimal Display Outputs

Compatible with IP-30 PAC

Current Requirements

-18 V 11 ma +12 V 2 ma -120 V 23 ma

Total Power

3.2 watts

Polarization

Pins 14 and 18

Handle Color Code

Long: Orange Short: Brown

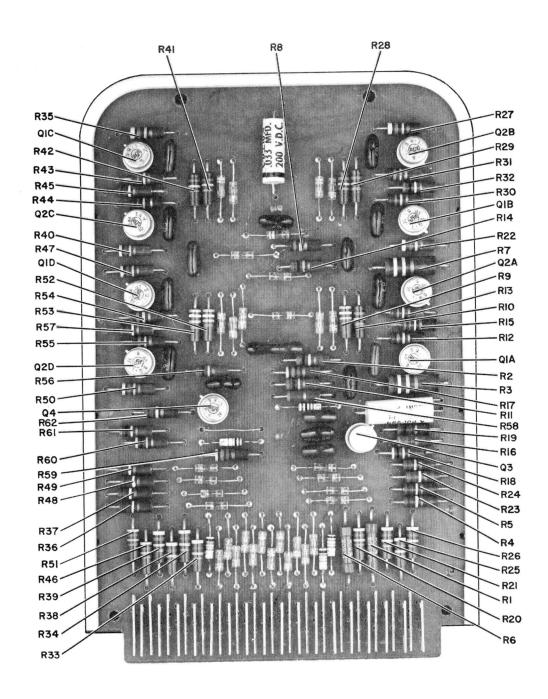


Figure 3-9.1. Counter-Converter PAC, Model CP-20, Parts Location (Resistors and Transistors)

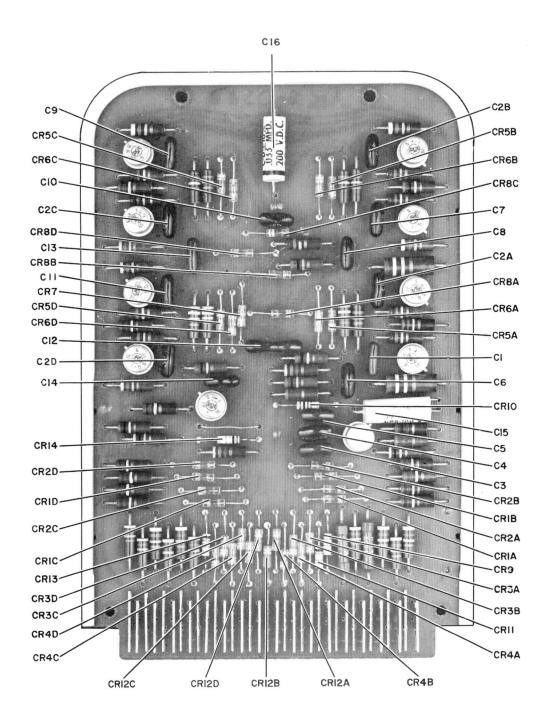


Figure 3-9.2. Counter-Converter PAC, Model CP-20, Parts Location (Capacitors and Diodes)

3-56

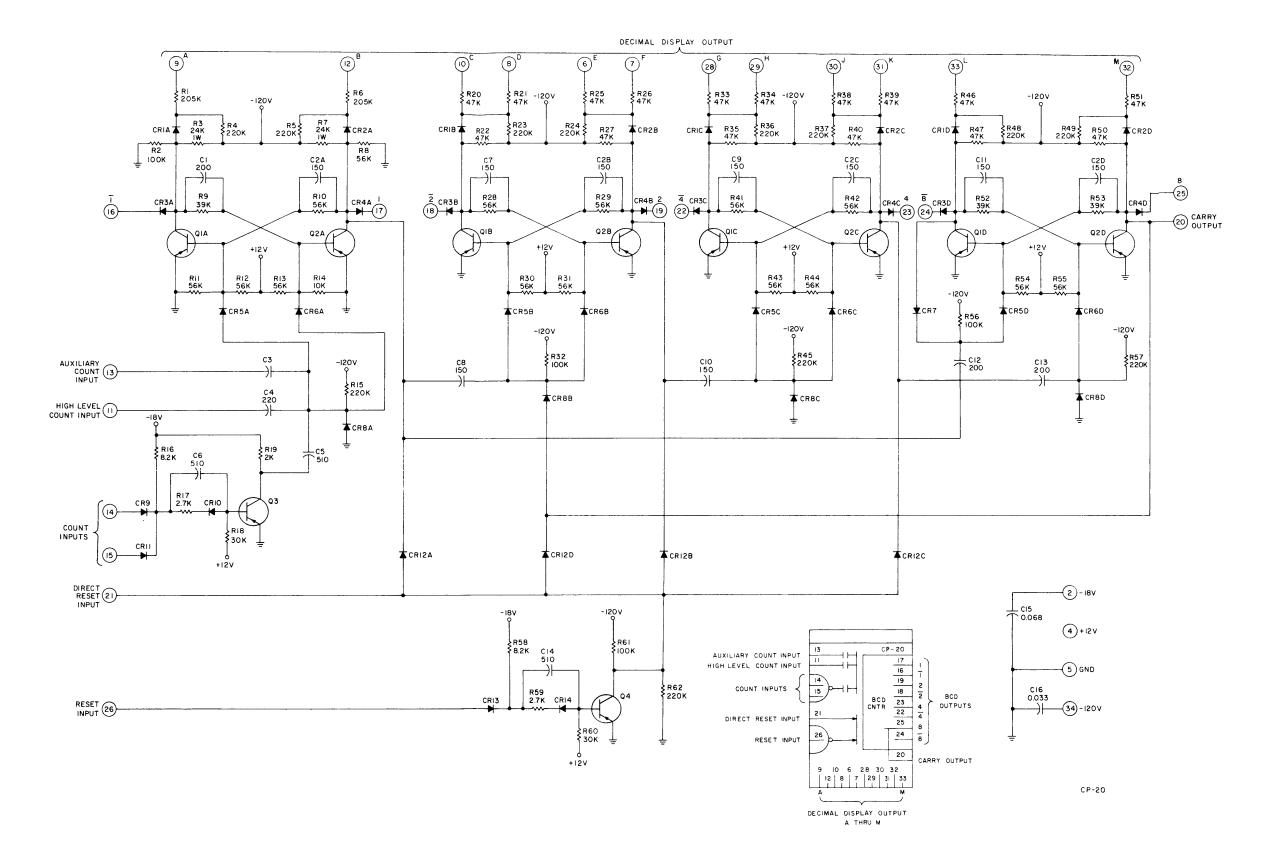


Figure 3-9.3. Counter-Converter PAC, Model CP-20, Schematic and Logic Diagram

3-10 COUNTER-CONVERTER (HIGH LEVEL) PAC, MODEL CP-21

GENERAL DESCRIPTION

The Counter-Converter (High Level) PAC, Model CP-21 (figures 3.10.1 and 3.10.2), is a decimal counting unit containing a four-stage BCD counter and part of a binary-to-decimal converter. The counter consists of four flip-flops internally connected to count input pulses in an 8-4-2-1 binary-coded-decimal (BCD) mode at frequencies from DC to 100 kilocycles. The part of the binary-to-decimal converter contained in the PAC converts the BCD information into a special 12-line output capable of driving an Indicator-Converter PAC, Model IP-30. The IP-30 PAC completes the conversion and displays the decimal equivalents.

The CP-21 has a high level count input and a direct reset input. A carry pulse is provided which can be applied as a high level count input to a similar counter for cascading stages. The CP-21 and IP-30 PACs can be separated by several hundred feet to allow remote display of the counter.

CIRCUIT FUNCTION

The counter (figure 3-10.3) contains four flip-flops which are permanently connected to count in the 8-4-2-1 BCD mode. The set and reset outputs of each flip-flop are connected to a resistor network which provides the 12-line output for driving the IP-30 PAC. The IP-30 PAC converts the 12-line input data to a decimal display.

High Level Count Input. The high level count input accepts carry pulses from a previous counter or other high level count sources. The input is driven by the positive-going edge of a 60-volt pulse. The minimum positive or negative pulse width is 3 microseconds, allowing a variation in the duty cycle of 30 to 70 percent at the maximum input frequency of 100 kelocycles.

Direct Reset Input. The direct reset input permits resetting of the counter by grounding the input through a relay, switch, or the reset driver of the IDCU Power Supply, Model PD-30. The external switching to the input must be capable of handling a maximum current of 25 milliamperes when closed and a voltage of 80 volts when open.

Carry Output. The carry output provides a high level pulse capable of driving a high level count input of another decimal counting unit (such as a CI-20, CI-21, CP-20, or CP-21) to allow cascading.

Decimal Display Outputs. The 12-line output from the resistor network provides drive for an IP-30 PAC. With the 12 outputs connected to the 12 inputs of an IP-30 PAC, the BCD information of the counter is converted to a decimal display.

Frequency of Operation

DC to 100 KC (max)

Circuit Delay

(Four stages)

6.0 μsec (typ)

10.0 µsec (max)

Input Requirements

High Level Count Input

Voltage: 60 V + 10 V positive-

going pulse

Rise time: 2.5 µsec (max)

Pulse width: 3 µsec (min) at either

level

Direct Reset Input

Counter enable: Open circuit or

more negative than -80 V

Counter reset: Ground 3.5 µsec

(min) duration

Input Loading

High Level Count Input

220 pf to ground

Direct Reset Input

25 ma (max)

Output Drive Capability

Carry Output

l high level count input and $50~\mathrm{pf}$

stray capacitance

Decimal Display Outputs

1 Indicator-Converter PAC, Model

IP-30

Output Levels

Carry Output

Ground and -60 V

Decimal Display Outputs

Compatible with IP-30 PAC

Current Requirements

+12 V 2 ma

-120 V 24 ma

Total Power

2.7 watts

Polarization

Pins 14 and 18

Handle Color Code

Long: Orange

Short: Brown

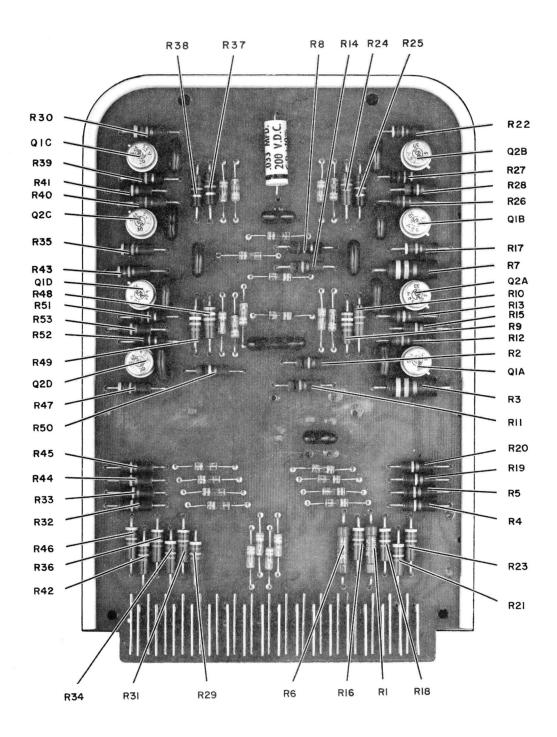


Figure 3-10.1. Counter-Converter (High Level) PAC, Model CP-21, Parts Location (Resistors and Transistors)

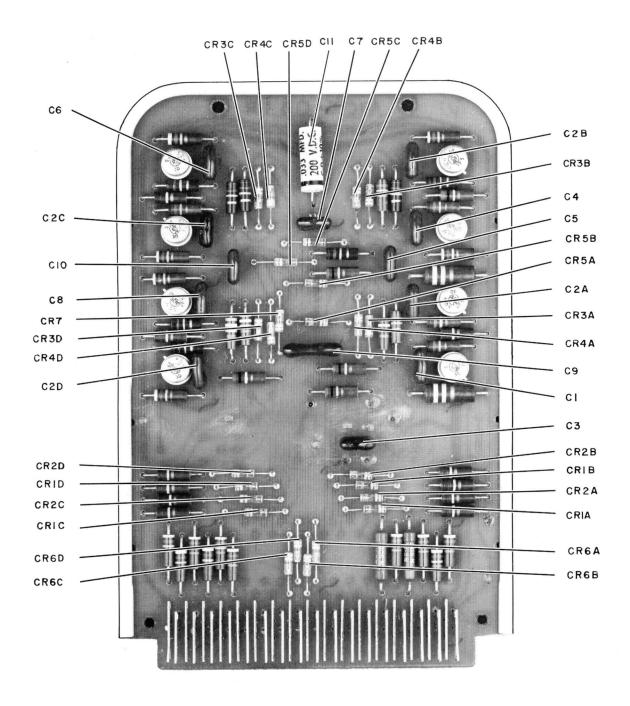


Figure 3-10.2. Counter-Converter (High Level) PAC, Model CP-21, Parts Location (Capacitors and Diodes)

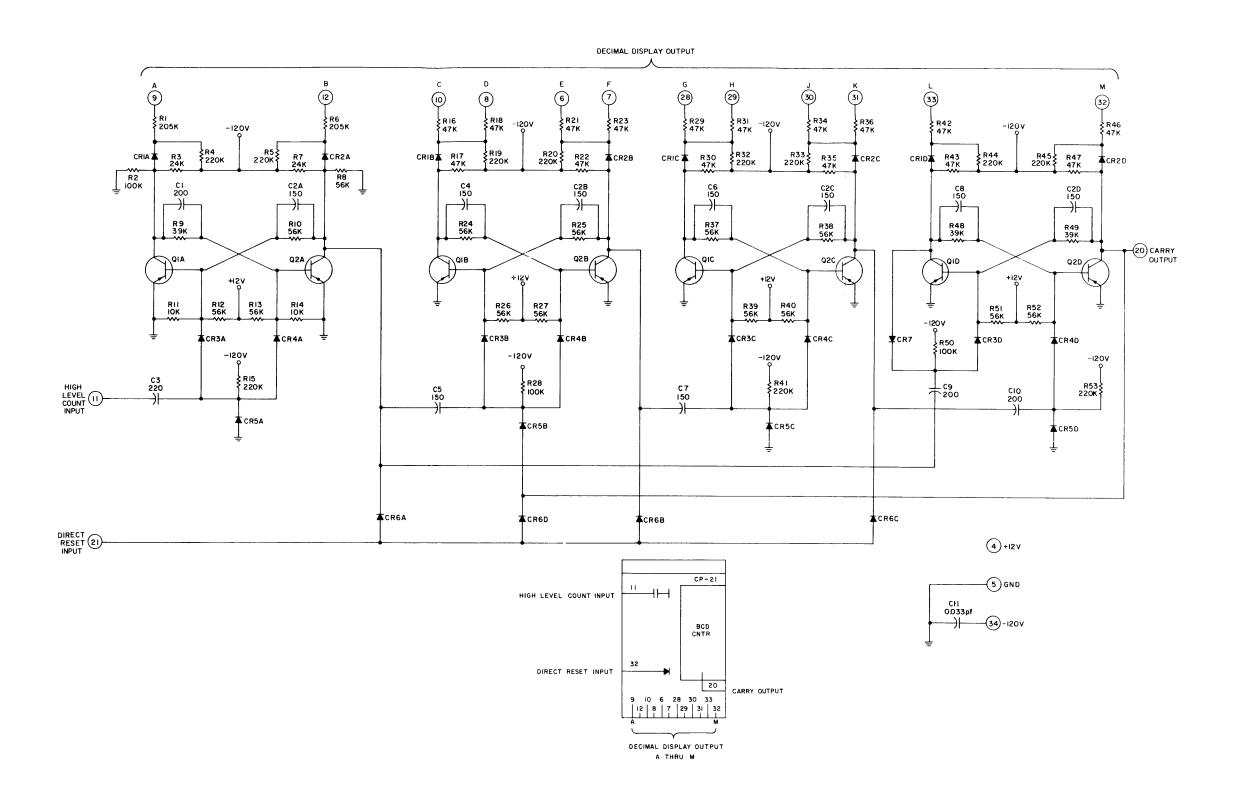


Figure 3-10.3. Counter-Converter (High Level) PAC, Model CP-21, Schematic and Logic Diagram

3-11 COOLING UNIT, MODEL CU-30

GENERAL DESCRIPTION

The Cooling Unit, Model CU-30 (figure 3-11.1), is designed for use with high density BLOCs in closed systems. The unit contains an air filter and three axial fans mounted in venturi rings and provides filtered cooling air for S-BLOCs BL-32 and BL-33.

A 1/2-ampere fuse provides overload protection and a neon indicator detects and indicates fuse and power failures. Unit grounding is accomplished through a three-prong power plug.

When mounted at the bottom of a column of S-BLOCs and equipped with a clean filter, a single CU-30 unit discharges air from the BLOC uppermost in the column in the approximate quantities listed in table 3-11.1.

Column Height in S-BLOCs	Air Quantity (cfm)
1	160
2	135
3	120
4	110
5	100
6	90
7	85
8	80

Table 3-11.1. CU-30 Quantity of Air Flow through S-BLOCs

AIR FLOW DIRECTION

The normal direction of air flow in the CU-30 is intake air from the bottom and exhaust air from the top. However, if a heat-dissipating source is mounted beneath the CU-30 to prevent the CU-30 from recirculating preheated air, an air duct and cover are supplied to regulate the intake air flow. When properly fastened to the underside of the CU-30, the duct directs intake air from either the front or rear of the unit.

When power supplies RP-30, RP-31, or RP-32 are mounted immediately below the CU-30, the air duct should be oriented to the front of the unit. However, it is preferable to mount the air duct to the rear if air induction from the front is obstructed or impeded; that is, operation with the cabinet doors closed.

The special plastic baffle normally mounted on the S-BLOC holddown bar must be in position to prevent air from leaking out of the PAC insertion face of the S-BLOC.

Two filter types are available for use in the CU-30 unit: a lowcost, disposable fiberglass type (supplied with each unit) or a permanent filter that can be cleaned by washing in water.

Input Power Requirements

42 W, 110-115 V, 50-60 cps, single-phase

Air Duct Panel Size

1-3/4 inches high by 19 inches wide

Unit Size

3-1/2 inches high by 19 inches wide by 8 inches deep

Exterior Finish

Jade green, Coritex texture

3-66

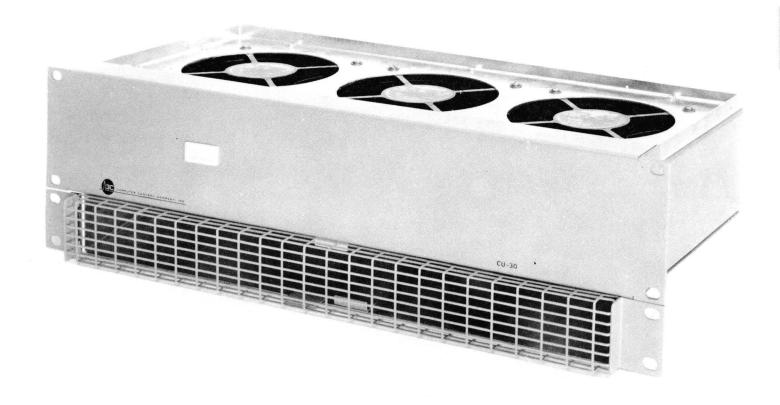


Figure 3-11.1. Cooling Unit, Model CU-30

3-12 DISPLAY DRIVER PAC, MODEL DD-31

GENERAL DESCRIPTION

The Display Driver PAC, Model DD-31 (figures 3-12.1 and 3-12.2), can decode a four-bit, binary-coded-decimal (BCD) input, store the result, and drive a projection type digital display device. The BCD input information is applied to the PAC, strobed, and then decoded to a decimal number. The result is stored and retained until a clear signal is applied.

The circuit is designed around the silicon-controlled rectifier (SCR), which provides both storage and power amplification. The use of an AC supply voltage for the incandescent lamps of the display unit is essential for the proper operation of the circuit, since resetting of the SCRs is accomplished during the negative half-cycle of this supply voltage.

CIRCUIT FUNCTION

The circuit of the DD-31 PAC (figure 3-12.3) is discussed in the following paragraphs.

BCD Data Input. The DD-31 uses diode gating which selects one of the 10 SCR switches in accordance with the BCD input data. Both polarities of the BCD inputs, assertion and negation, are required. One input to each gate is a strobe signal. Because S-PAC convention defines -6 volts as the logic ONE and ground as the logic ZERO, the inputs of the PAC are defined to be consistent with this convention, although the internal logic of the gating structure is reversed because of the positive polarity gate used to control the SCRs.

Output. Ten identical output circuits are provided, each associated with one of the decimal numbers 0 to 9. The SCR and its associated number is turned on when all of its gate inputs are at 0 volt. This places a positive bias on the SCR and turns the SCR and its associated decimal number on. Any inputs at -6 volts will inhibit the gate and keep the SCR biased off.

The anode of each SCR is connected to its associated lamp filament. The common side of the lamp filaments is connected to pin 6 of the PAC. The AC supply voltage is connected between pins 18 and 5 (ground) and reaches the lamp common through a single diode. This diode acts as a halfwave rectifier when one SCR switch is on. The voltage of the AC supply depends upon the requirements of the display device. (Refer to the AC supply calculation under Specifications.)

CLEAR Input. The clear circuit is a direct-coupled transistor switch. The CLEAR input is inactive when at -6 volts, since the transistor is biased off and holding current flows into the ON SCR. A positive reset pulse is required to clear previous information prior to the insertion of a new decimal digit. When the CLEAR input is at 0 volt, the transistor is switched on, the collector drives toward -6 volts, the coupling diode is reverse-biased, and the current to the SCR is removed. The SCR should also be reverse-biased at this time by deactivating the STROBE input to insure turn-off. The CLEAR signal must take place during the negative half-cycle of the AC supply voltage.

When the signal is not synchronized externally to the supply, its width must be greater than one-half of the AC supply voltage; if it is externally synchronized, the width must be a minimum of 80 microseconds.

STROBE Input. A STROBE input is provided to allow strobing of the information gates so that the time of insertion of the data can be controlled. The strobe amplifier is a standard S-PAC NAND circuit which is used to minimize the load requirements for this signal. A negative pulse (40 microseconds or more in width) is required to activate the input and allow the SCRs to turn on. The STROBE signal is effective at the -6-volt level and ineffective at the 0-volt level.

SPECIFICATIONS

Input Loading

BCD data: 1 unit load each
CLEAR: 1 unit load
STROBE: 1 unit load

Activation of Inputs	Active	Inactive
BCD	-6 V	Ground
CLEAR:	Ground, 80 µsec width (min) 0.5 sec width (max)	-6 V
STROBE:	-6 V, 40 µsec width (min)	Ground

Output Drive Capability

20 V (peak) at 300 ma

Current Requirements

-18 VDC 33 ma

+12 VDC 13 ma

- 6 VDC 9 ma (reverse current into supply)

AC supply: Current rating of display device

Anode Voltage Rate Limit

20 V/µsec (max)

AC Supply Calculation

 $v_S \le 2v_L$

V_S - supply voltage (RMS)

V_I - lamp voltage (DC rating)

NOTE

For example, with an IEE series 10,000 display using a No. 44 lamp (6.3 V, 250 ma) or a Burroughs Spherical Optical Display series SD-12 using an L6 lamp (6 V, 200 ma), use an AC supply of 10 V RMS.

Total Power:

0.8 watt (max)

Polarization:

Pins 8 and 20

Handle Color Code:

Long: Red Short: Orange

3-70

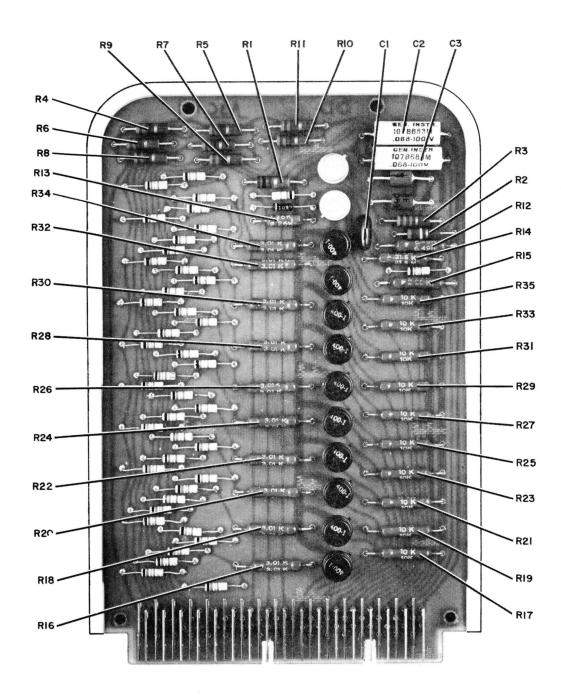


Figure 3-12.1. Display Driver PAC, Model DD-31, Parts Location (Resistors and Capacitors)

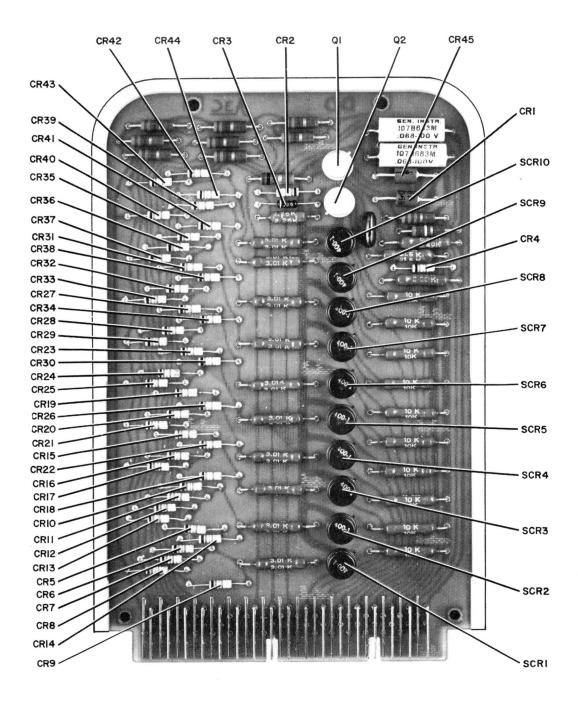


Figure 3-12.2. Display Driver PAC, Model DD-31, Parts Location (Diodes and Rectifiers)

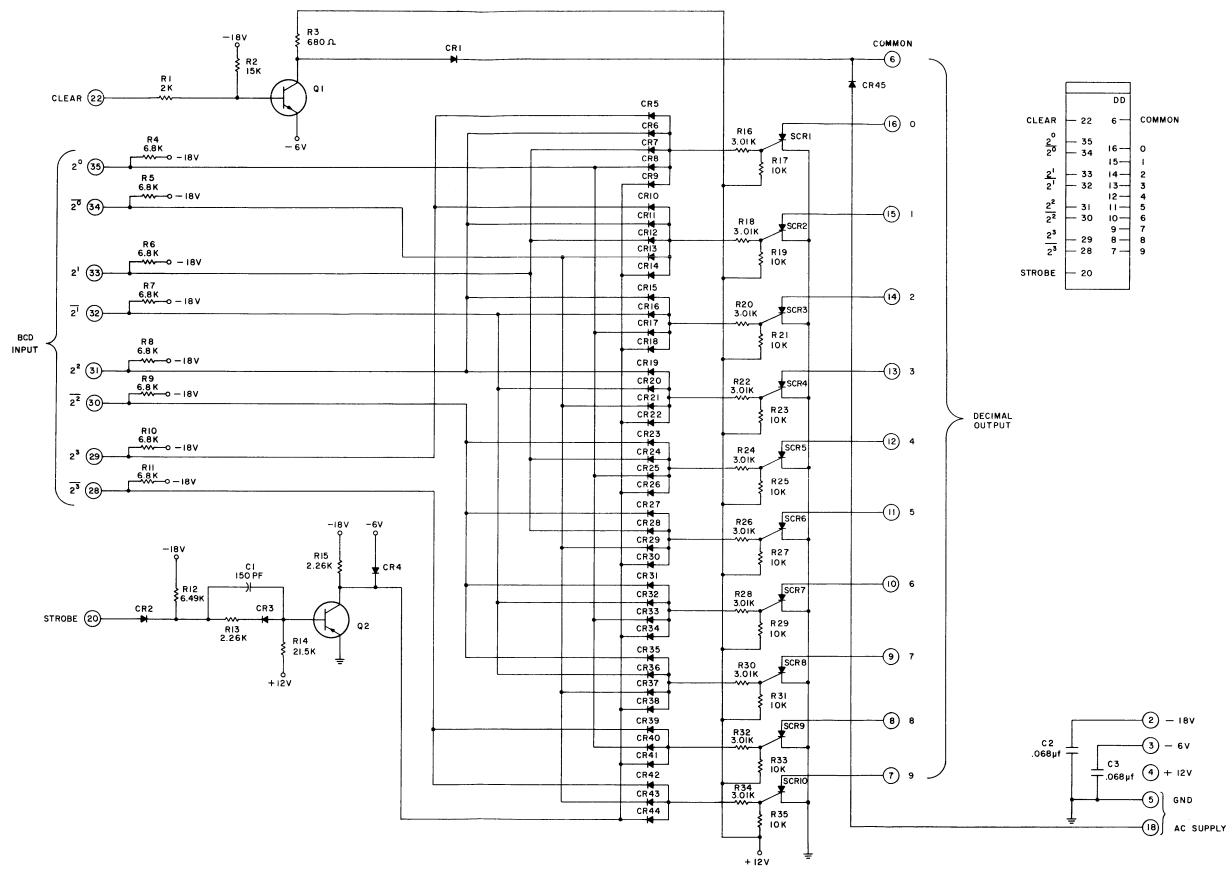


Figure 3-12.3 Display Driver PAC, Model DD-31, Schematic and Logic Diagram

3-13 SIGNAL ADAPTER PAC, MODEL DI-21

GENERAL DESCRIPTION

The Signal Adapter PAC, Model DI-21 (figure 3-13.1), contains eight 2-input NAND gates with increased input sensitivity for use with other than S-PAC systems. The number of inputs to each circuit can be expanded to a maximum of 10 by using the diode clusters on either the DC or DN PACs. Five of the eight gates have input nodes provided for connection with diode clusters. The remaining three gates are expandable by using one of the diode inputs as an input node. When this is done, the noise margins on the expanded inputs are reduced by 0.3 volt.

Each NAND gate performs the NAND function for negative logic (ONE = -3 V) or the NOR function for positive logic (ONE = 0 V). The gates operate on levels, pulses, or with a combination of both. Two DI-21 NAND circuits form a flip-flop when the inputs and outputs are cross-coupled.

CIRCUIT FUNCTION

Each DI-21 (figure 3-13.2) NAND circuit consists of a two-input diode gate followed by a transistor inverter amplifier. When all inputs are at ONE (-3 V), the gate turns the transistor on and the output is clamped through the transistor to 0 volt. When an input goes to ZERO (0 V), the transistor is turned off and the output falls to the clamp voltage of -6 volts.

The increased input sensitivity (-3 volts) of the DI-21 gate, when compared with the standard S-PAC NAND gate sensitivity (-6 volts), results in a reduction in noise protection. If the input nodes are used to expand the five DI-21 gate circuits, the gate circuits offer a noise margin of 0.7 volt when an input is 0 volt. If the inputs to each of the three remaining circuits are expanded by adding a diode cluster to a diode input, each circuit offers a noise margin of 0.4 volt when an input is 0 volt.

NOTE

In all applications of the DI-21, pin 35 should be connected to pin 5 (ground). The jumper attenuates noise picked up by distributed impedance of the etched circuit.

Input Loading

1 W load each

Circuit Delay

(Measured at -3 V, averaged over two stages)

0.6 µsec (max)

0.3 µsec (typ)

Output Drive Capability

7 W loads and 500 pf stray capacitance each

Total Power

0.6 watts

Polarization

Pins 28 and 32

Frequency of Operation

DC to 200 KC (max)

Output Waveform Characteristics

Rise time: $0.5 \mu sec (typ)$

Fall time: 0.8 µsec (typ)

Current Requirements

-18 V 30 ma

-6 V 12 ma (reverse current

into supply)

+12 V 3.5 ma

Handle Color Code

Long: Red

Short: Yellow

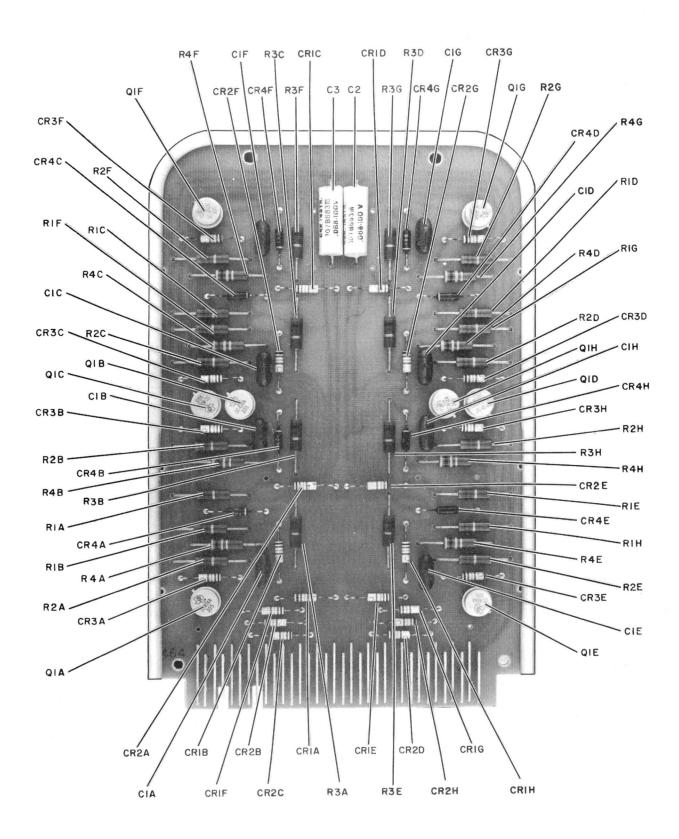


Figure 3-13.1. Signal Adapter PAC, Model DI-21, Parts Location

3-78

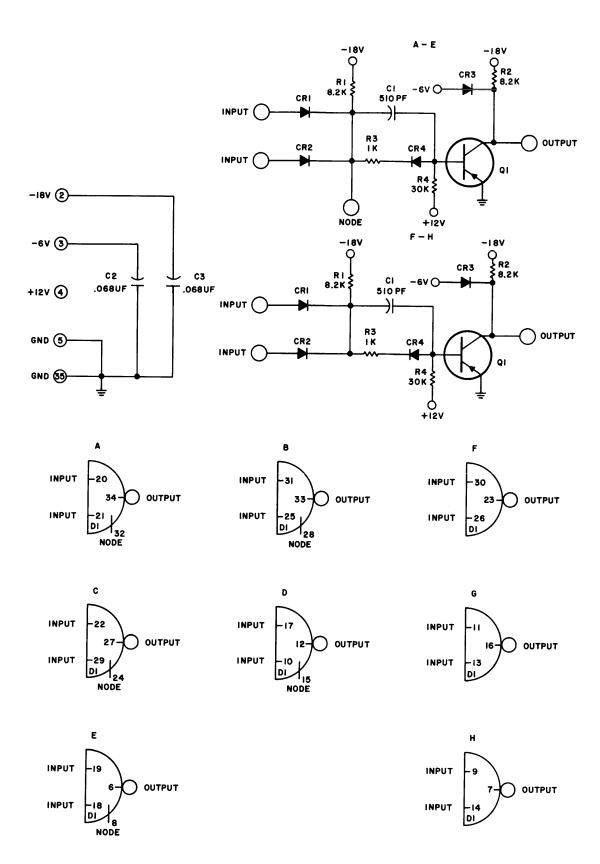


Figure 3-13.2. Signal Adapter PAC, Model DI-21, Schematic and Logic Diagram

3-14 SIGNAL ADAPTER PAC, MODEL DI-31

GENERAL DESCRIPTION

The Signal Adapter PAC, Model DI-31 (figure 3-14.1), contains eight 2-input NAND gates with increased input sensitivity for use with other than S-PAC systems. The number of inputs to each circuit can be expanded to a maximum of 10 by using the diode clusters on either the DC or DN PACs. Five of the eight gates have input nodes provided for connection with diode clusters. The remaining three gates are expandable by using one of the diode inputs as an input node. When this is done, the noise margins on the expanded inputs are reduced by 0.3 volt.

Each NAND gate performs the NAND function for negative logic (ONE = -3 V) or the NOR function for positive logic (ONE = 0 V). The gates operate on levels, pulses, or with a combination of both. Two DI-31 NAND circuits form a flip-flop when the inputs and outputs are cross-coupled.

CIRCUIT FUNCTION

Each DI-31 (figure 3-14.2) NAND circuit consists of a two-input diode gate followed by a transistor inverter amplifier. When all inputs are at ONE (-3 V), the gate turns the transistor on and the output is clamped through the transistor to 0 volt. When an input goes to ZERO (0 V), the transistor is turned off and the output falls to the clamp voltage of -6 volts.

The increased input sensitivity (-3 volts) of the DI-31 gate, when compared with the standard S-PAC NAND gate sensitivity (-6 volts), results in a reduction in noise protection. If the input nodes are used to expand the five DI-31 gate circuits, the gate circuits offer a noise margin of 0.7 volt when an input is 0 volt. If the inputs to each of the three remaining circuits are expanded by adding a diode cluster to a diode input, each circuit offers a noise margin of 0.4 volt when an input is 0 volt.

NOTE

In all applications of the DI-31, pin 35 should be connected to pin 5 (ground). The jumper attenuates noise picked up by distributed impedance of the etched circuit.

Input Loading

1 U load each

Circuit Delay

(Measured at -3 V averaged over two stages)

0.1 µsec (max)

0.06 μsec (typ)

Output Drive Capability

7 U loads and 400 pf stray capacitance

Total Power

1.4 watts

 $\underline{\textbf{Polarization}}$

Pins 28 and 32

Frequency of Operation

DC to 1 MC (max)

Output Waveform Characteristics

Rise time: 0.1 µsec (typ)

Fall time: 0.15 µsec (typ)

Current Requirements

-18 V 80 ma

-6 V 42 ma (reverse current

into supply)

+12 V 5 ma

Handle Color

Long: Red

Short: Yellow

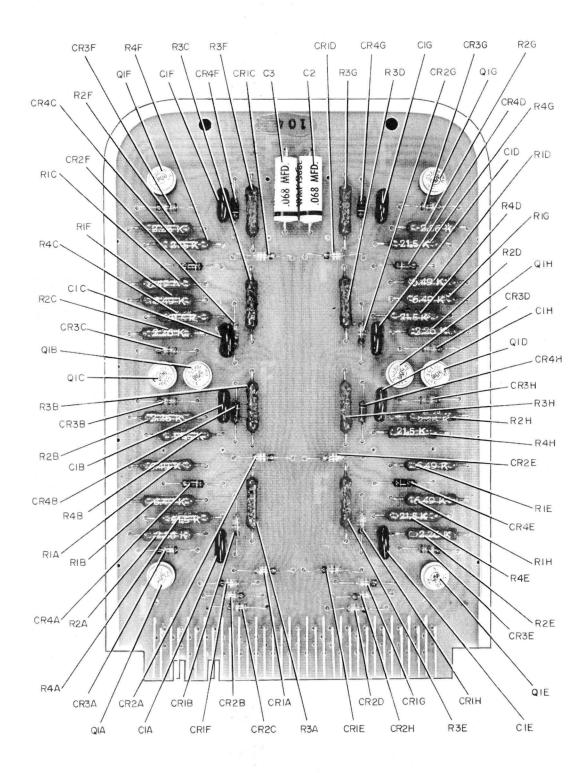


Figure 3-14.1. Signal Adapter PAC, Model DI-31, Parts Location

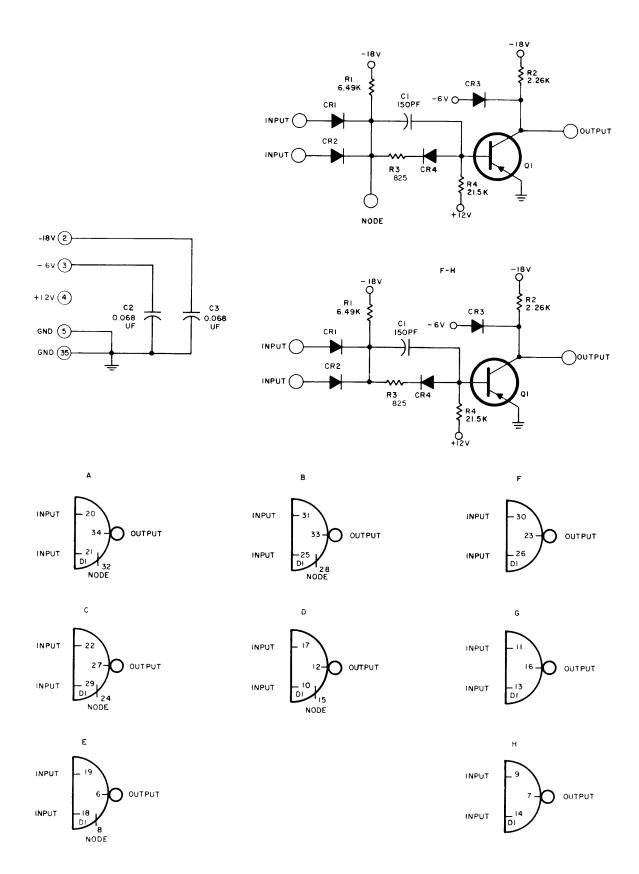


Figure 3-14.2. Signal Adapter PAC, Model DI-31, Schematic and Logic Diagram

3-15 SIGNAL ADAPTER PAC, MODEL DI-36

GENERAL DESCRIPTION

The Signal Adapter PAC, Model DI-36 (figure 3-15.1), contains eight 2-input NAND gates with increased input sensitivity for use with other than S-PAC systems. The number of inputs to each circuit can be expanded to a maximum of 10 by using the diode clusters on either the DC or DN PACs. Five of the eight gates have input nodes provided for connection with diode clusters. The remaining three gates are expandable by using one of the diode inputs as an input node. When this is done, the noise margins on the expanded inputs are reduced by 0.3 volt.

Each NAND gate performs the NAND function for negative logic (ONE = -3 V) or the NOR function for positive logic (ONE = 0 V). The gates operate on levels, pulses, or with a combination of both. Two DI-36 NAND circuits form a flip-flop when the inputs and outputs are cross coupled.

CIRCUIT FUNCTION

Each DI-36 (figure 3-15.2) NAND circuit consists of a two-input diode gate followed by a transistor inverter amplifier. When all inputs are at ONE (-3 V), the gate turns the transistor on and the output is clamped through the transistor to 0 volt. When an input goes to ZERO (0 V), the transistor is turned off and the output falls to the clamp voltage of -6 volts.

The increased input sensitivity (-3 volts) of the DI-36 gate, when compared with the standard S-PAC NAND gate sensitivity (-6 volts), results in a reduction in noise protection. If the input nodes are used to expand the five DI-36 gate circuits, the gate circuits offer a noise margin of 0.7 volt when an input is 0 volt. If the inputs to each of the three remaining circuits are expanded by adding a diode cluster to a diode input, each circuit offers a noise margin of 0.4 volt when an input is 0 volt.

NOTE

In all applications of the DI-36, pin 35 should be connected to pin 5 (ground). The jumper attenuates noise picked up by distributed impedance of the etched circuit.

Input Loading

l V load each

Circuit Delay

(Measured at -3 V, averaged over two

stages)

0.02 µsec (max)

0.015 µsec (typ)

Output Drive Capability

5 V loads and 50 pf stray capacitance

each

Total Power

2.0 watts

Polarization

Pins 28 and 32

Frequency of Operation

DC to 5 MC (max)

Output Waveform Characteristics

Rise time: $0.025 \mu sec (typ)$

Fall time: 0.05 µsec (typ)

Current Requirements

-18 V 112 ma

-6 V 59 ma (reverse current into

supply)

+12 V 7 ma

Handle Color Code

Long: Red

Short: Yellow

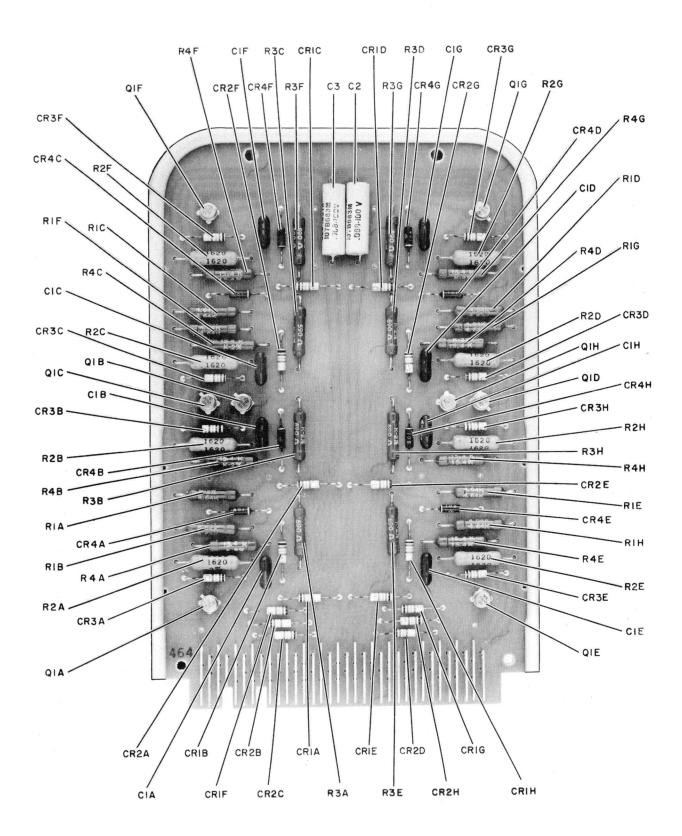


Figure 3-15.1. Signal Adapter PAC, Model DI-36, Parts Location

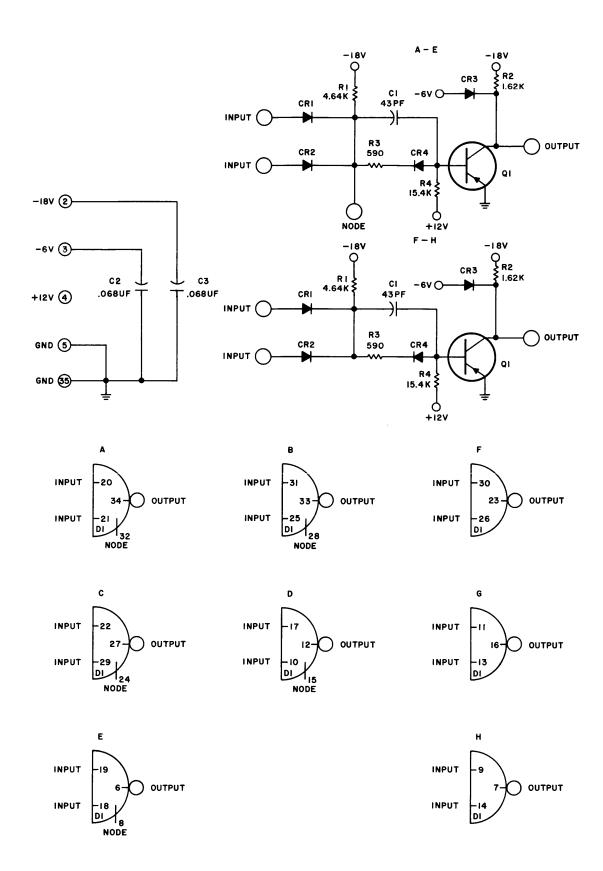


Figure 3-15.2. Signal Adapter PAC, Model DI-36, Schematic and Logic Diagram

3-15A ELECTROSTATIC SHIELD PAC, MODEL ES-31

GENERAL DESCRIPTION

Electrostatic Shield PAC, Model ES-31 (Figures 3-15A. 1 and 3-15A. 2), is a standard S-PAC board with an etched copper plate connected to the output pins. The PAC is used to reduce electrostatic noise on S-PACs with low level signals, which are mounted close to S-PACs with high level signals. The ES-31 PAC should be placed in an S-BLOC between the low level and high level PACs, with the ES-31 output connected to signal ground.

A single row of connector pins is used on the PAC, with all even pin numbers 8 through 34 connected to the copper shield. There is no connection between the shield and the frame handle.

SPECIFICATIONS

Polarization

Pins 6 and 14

Color Code

Long: Green

Short: Blue

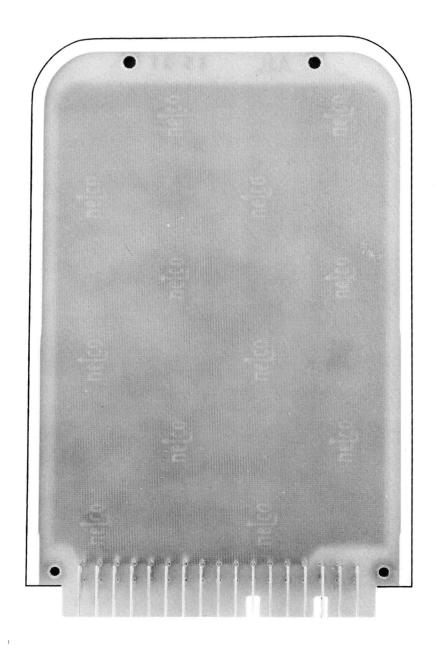


Figure 3-15A.1. Electrostatic Shield PAC, Model ES-31, Parts Location

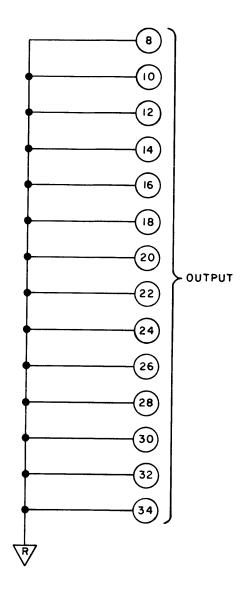


Figure 3-15A.2. Electrostatic Shield PAC, Model ES-31, Schematic Diagram

4/15/64

3-16 INDICATOR-CONVERTER PAC, MODEL IP-30

GENERAL DESCRIPTION

The Indicator-Converter PAC, Model IP-30 (figure 3-16.1), is a decimal counting unit which contains a decimal display and part of a binary-to-decimal converter. The PAC permits remote display of the decimal information contained in a Counter-Converter PAC, Model CP-20 or CP-21, or a Storage-Converter PAC, Model SP-30.

The part of the binary-to-decimal converter contained in the PAC decodes the special 12-line input data and displays the decimal equivalent of the BCD information by lighting one of the 10 neon indicator lamps on the vertical display panel.

CIRCUIT FUNCTION

The IP-30 (figure 3-16.2) consists of a network of converter lamps, indicator lamps, and resistors connected in a matrix to allow only one indicator neon to light on a specific count. Several of the converter neons will light, thereby inhibiting the remaining nine indicator neons. Refer to table 3-16.1 for the condition of the converter and indicator in each decimal state.

INSTALLATION

The IP-30 is designed for mounting behind a front panel, with a cutout provided for viewing the numbers. The PAC is attached to the panel by means of two 6-32 screws which fit into the tapped holes of the lamp cover. When mounting a PAC (figure 3-16.3), a screw should first be inserted through the top panel hole and the loose faceplate placed through the screw and next to the panel. The lamp cover hole should then be lined up and the entire assembly joined together.

A special connector that accommodates soldered wire is provided with each PAC. The connector is keyed to mate with the etched fingers of the PAC in only one orientation.

Figure 3-16.3 shows the dimensions of the faceplate and the recommended panel mounting arrangement of the panel cutout and holes. Countersinking of the panel holes will permit covering the screw heads with a bezel.

Indicator Lamps	Table 3-10.1. IDGO indicator, Froper Conditions for Correct Decoding											
Decimal State DS1-DS10 11 12 13 14 15 16 17 18 19 20		Indicator Lamps Converter Lamps DS11-DS20										
	Decimal State	DS1-DS10	11	12	13	14	15	16	17	18	19	20
1 2 3 4 X X X X X X X X X X X X X X X X X X	0 1 2 3 4 5 6 7 8	1 2 3 4 5 6 7 8 9	X X	X X	X X	X X X	X	X X X	X X X	X X X		X X X X X

Table 3-16.1. IDCU Indicator, Proper Conditions for Correct Decoding

NOTE

X indicates lamp is lighted.

Input Requirements

Must be driven from 12-line BCD data output of a Model CP-20, CP-21, or SP-30. The IP-30 and driving source can be separated by a maximum of 300 feet.

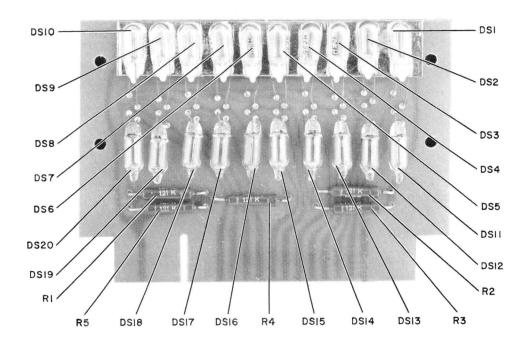
Current Requirements

-120 V

1.9 ma

Total Power

0.23 watts



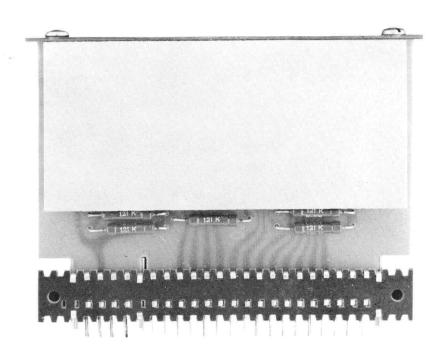
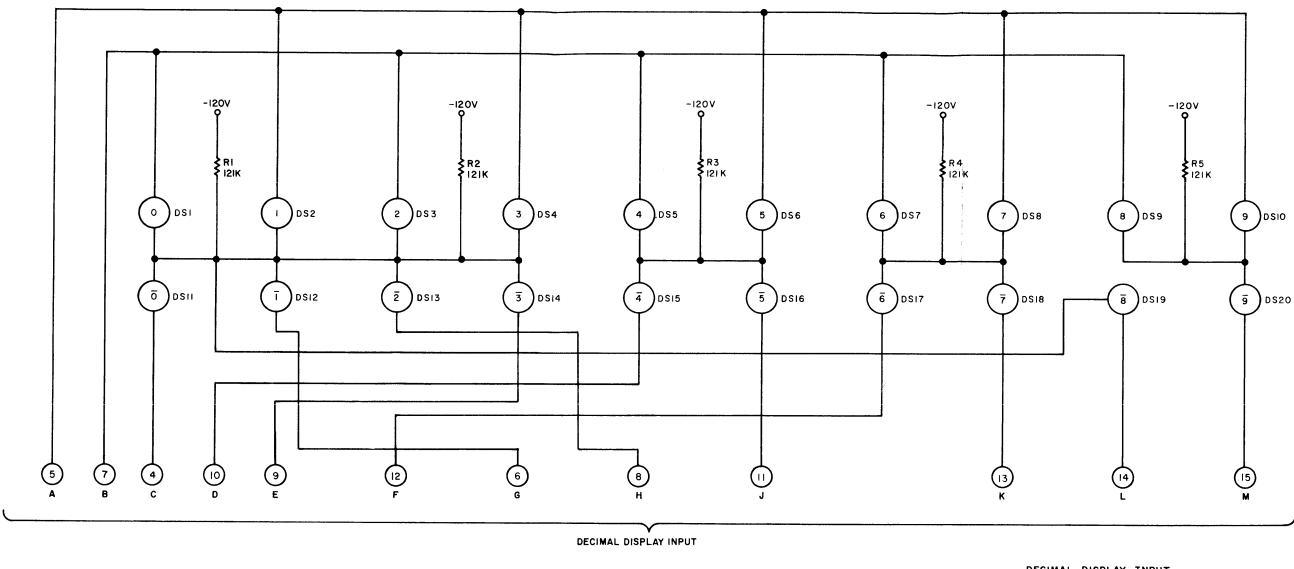


Figure 3-16.1. Indicator-Converter PAC, Model IP-30, Parts Location



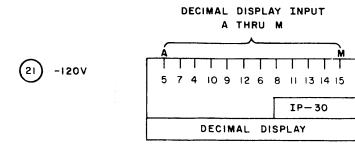


Figure 3-16.2. Indicator-Converter PAC, Model IP-30, Schematic and Logic Diagram

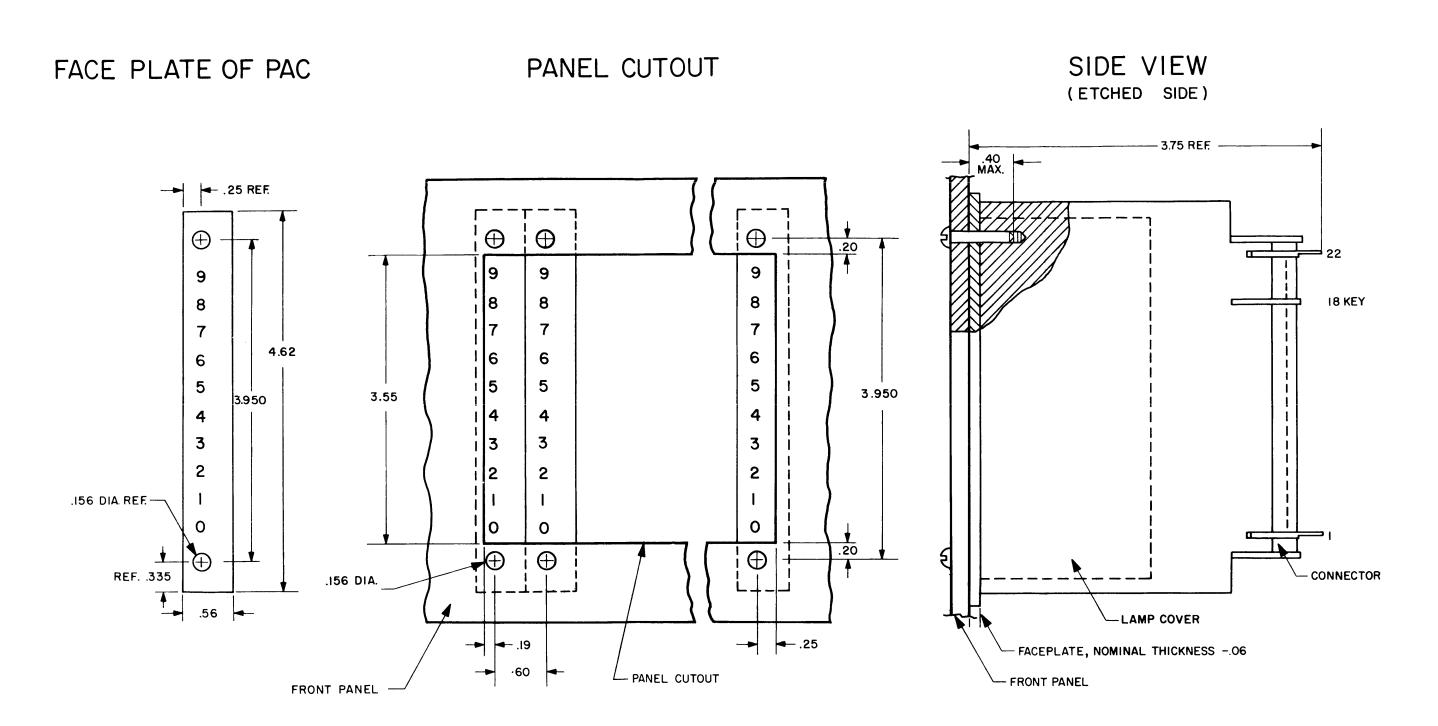


Figure 3-16.3. Indicator-Converter PAC, Model IP-30, Panel Mounting Drawings

3-99/3-100

3-17 JUMPER LEAD SET, MODEL JL-30

GENERAL DESCRIPTION

The Jumper Lead Set, Model JL-30, contains 420 assorted jumper leads for use on S-BLOCs with taper-pin connectors. The leads are composed of plastic insulated No. 22 stranded wire with gold plated AMP No. 53 series taper pins at each end.

The selection of lead lengths and colors is based upon the experience of the Computer Control Company in wiring, tracing signals, and troubleshooting S-PAC equipment.

The assorted jumper leads are described in table 3-17.1 together with a recommended color code for each PAC type. The colors apply to the PAC outputs.

		Quantity	(Per Lead				
Wire Color	2-1/2 (inches)	4-1/2 (inches)	6 (inches)	7-1/2 (inches)	9 (inches)	Quantity (Per Color)	Recommended PAC Type
Blue	36	36	24	12	12	120	Flip-flops
Red	36	36	24	12	12	120	Gates
Yellow	27	27	18	9	9	90	Amplifiers, Input/output circuits
Orange	9	9	6	3	3	30	Clocks, One-shots
White	9	9	6	3	3	30	Miscellaneous
Black	-	30	-	-	-	30	(Ground)
Total	117	147	78	39	39	420	

Table 3-17.1. Jumper Lead Set

^{*}Lead length denotes overall length from tip to tip of taper pins.

3-17A POSITIVE LOGIC LEVEL CONVERTER PAC, MODEL LC-35

GENERAL DESCRIPTION

The Positive Logic Level Converter PAC, Model LC-35 (Figures 3-17A.1 and 3-17A.2), contains 10 independent converter circuits. The P input accepts a positive logic signal (i.e. logic ONE is a positive voltage) for conversion into a standard S-PAC negative logic signal. The S input uses an S-PAC signal to control or gate the positive logic signal. When the circuit is enabled, there is no logic inversion from the converting input to the output. The operation of the circuit is summarized in Tables 3-17A.1 and 3-17A.2.

TABLE 3-17A.1. LOGIC TRUTH TABLE

Positive Logic	Negative Logic				
P	S	Output			
0	0	1			
0	1	0			
1	0	l,			
l	1	1			

For the P input: Logic ZERO = 0.0 V to +1.5 V

Logic ONE = +2.8 V to 15 V (or not connected)

For the S input:

Logic ZERO = 0.0 V to -1.5 V

Logic ONE = -4.5 V to -8.0 V (or not connected)

TABLE 3-17A.2. VOLTAGE TRUTH TABLE

Р	S	Output
0 V	0 V	-6 V
0 V	-6 V	0 V
+6 V	0 V	-6 V
+6 V	-6 V	-6 V

CIRCUIT FUNCTION

Each level converter consists of a standard S-PAC NAND gate and a level shifter (Figure 3-17A. 3). The converting input (P) drives the emitter of a common base transistor

whose base is referenced to +2 volts. When a logic ZERO (0 V) is applied to this input, the emitter of transistor Q1 becomes more negative than the base and Q1 is turned off. This is interpreted as a logic ONE at the NAND gate input. When the converting input is a ONE (positive voltage or not connected), Q1 is turned on, causing the NAND gate output to be +6 volts.

SPECIFICATIONS

Frequency of Operation

DC to 5 MC (max)

Input Logic Levels

Refer to Table 3-17A.1

Input Loading

P input: 4.5 ma

S input: 1 V load

Current Requirements

-18 V: 140 ma

- 6 V: 70 ma (reverse current

into supply)

+12 V: 56 ma

Total Power

3.1 watts

Polarization

Pins 16 and 20

Output Drive Capability

5 V loads and 50 pf stray capacitance each

Conversion Circuit Delay

(measured from +1.5 volt of the input

to -1.5 volt of the output)

Positive-going input: 40 nsec (max) Negative-going input: 60 nsec (max)

Output Waveform Characteristics

Rise time: $0.025 \mu sec (typ)$

Fall time: $0.05 \mu sec (typ)$

Handle Color Code

Long: Brown

Short: Green

APPLICATIONS

The LC-35 PAC can be used when converting signals from a μ -PAC or Silicon S-PAC system to a standard S-PAC system. This is accomplished by applying the external signal to the P input; an S-PAC signal will appear at the output. A control signal from within the S-PAC system can be applied to the S input to gate the external signal (a ONE enables and a ZERO inhibits). If no control is required, the S input should be left disconnected.

 $\mbox{Each circuit can be used as an inverter for S-PAC signals by using the S input and grounding the P input. } \\$

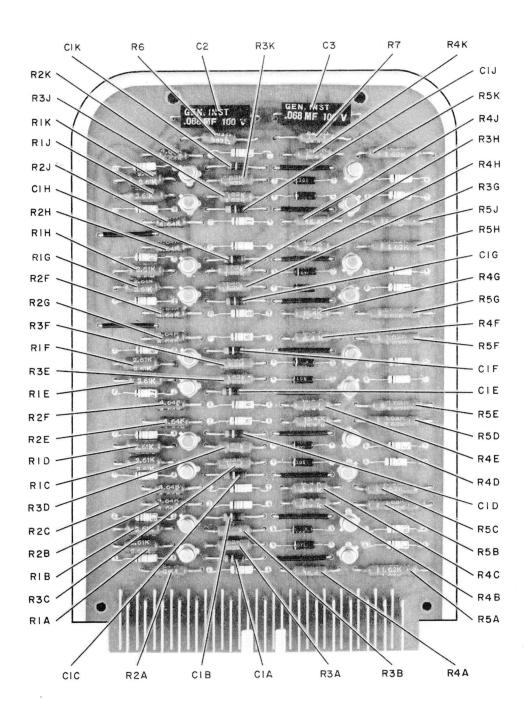


Figure 3-17A.1. Positive Level Converter PAC, Model LC-35, Parts Location (Resistors and Capacitors)

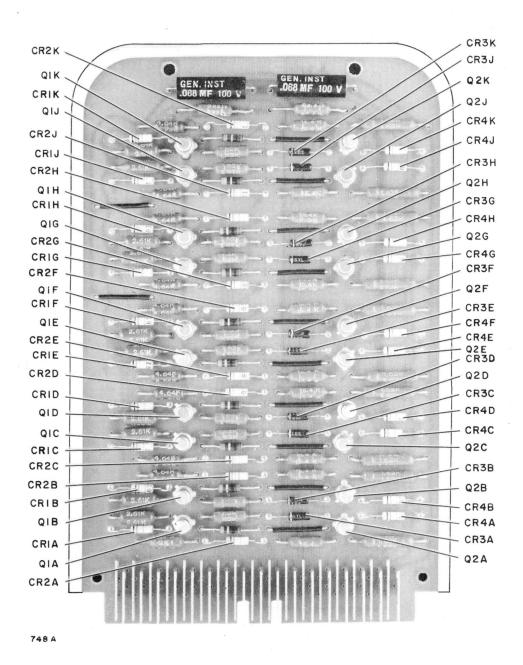


Figure 3-17A.2. Positive Level Converter PAC, Model LC-35, Parts Location (Transistors and Diodes)

3-102D

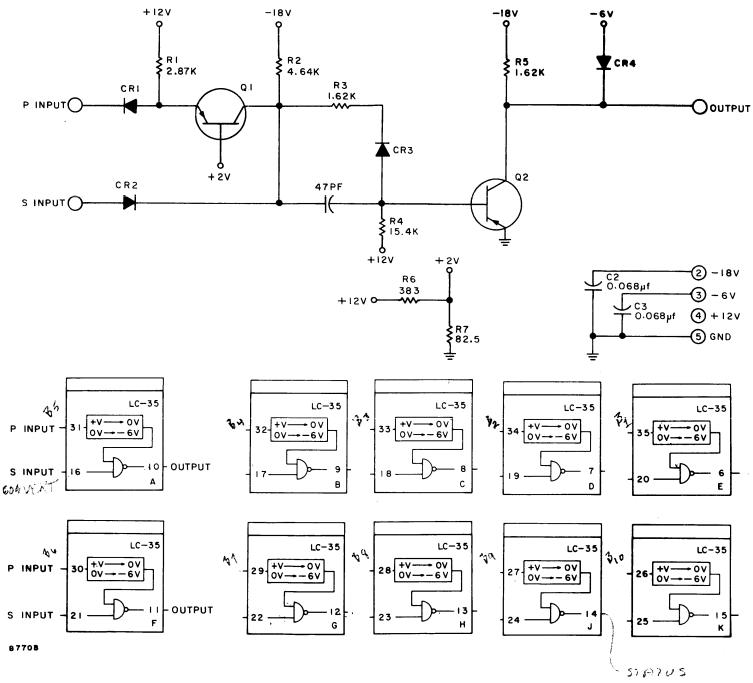


Figure 3-17A.3. Positive Level Converter PAC, Model LC-35, Schematic and Logic Diagram

3-18 LAMP DRIVER PAC, MODEL LD-30

GENERAL DESCRIPTION

The Lamp Driver PAC, Model LD-30 (figure 3-18.1), contains 14 identical and independent transistor-driver circuits for use with indicator lamps. The circuit operates from standard S-PAC levels. Each circuit can deliver 70 milliamperes to an external indicator lamp with a rated operating voltage of -6 to -24 volts.

The -18 volts from a standard S-PAC power supply can drive any lamp rated from -18 to -28 volts. The use of a 28-volt bulb at 18 volts provides durability and low power consumption with adequate illumination for most applications.

CIRCUIT FUNCTION

The lamp is connected in series between the collector of the transistor and the negative supply voltage (figure 3-18.2). When the input to the circuit is a ONE (-6 V) or an open circuit, the transistor is turned on and the lamp illuminated. When the input is a ZERO (0 V), the transistor is biased off and the lamp extinguished.

Each LD-30 circuit is provided with a bleeder resistor (R4) which provides warmup current to the incandescent lamp during its OFF condition so that transient current when going from a cold to warm bulb is greatly reduced.

When the circuit drives loads other than incandescent lamps, R4 should be removed to reduce total circuit current drain.

NOTE

The negative supply voltage return should be connected to pin 35 on this PAC.

SPECIFICATIONS

Input Loading

2 U loads each

Current Requirements

(Assuming all circuits are used)

-18 V 84 ma (max)

+12 V 16 ma

Polarization

Pins 18 and 30

Frequency of Operation

DC to 10 KC

Output Drive Capability

70 ma at any lamp supply voltage between -6 V and -24 V

Total Power

(Assuming all circuits are used)

1.7 watts

Handle Color Code

Long: Brown Short: Red

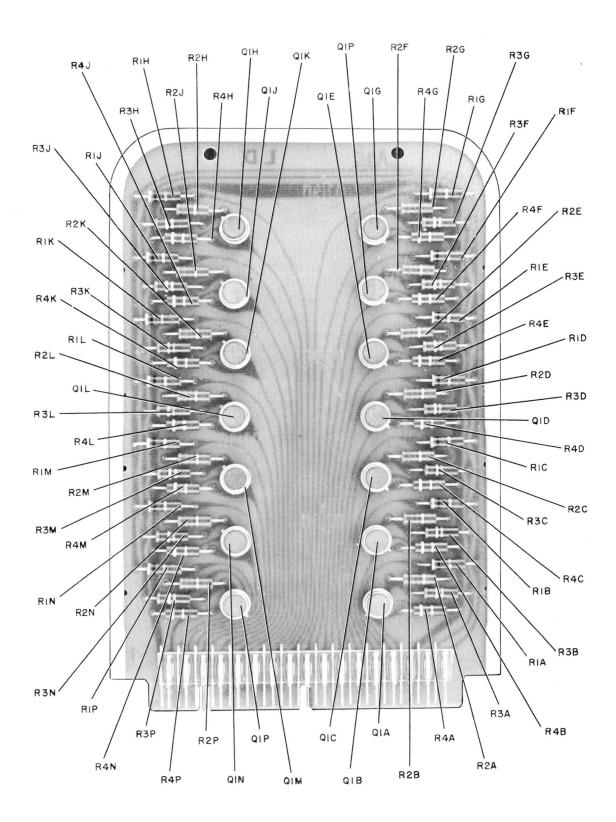


Figure 3-18.1. Lamp Driver PAC, Model LD-30, Parts Location

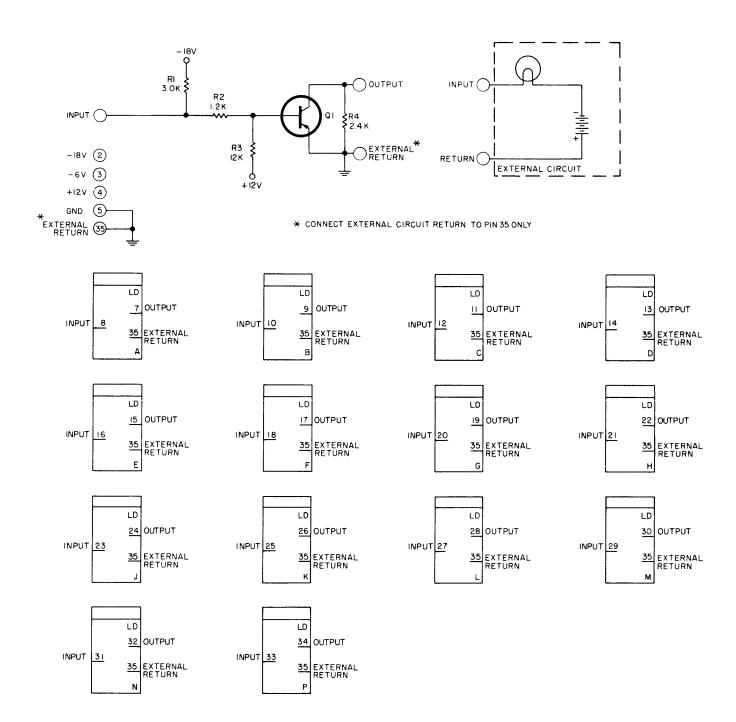


Figure 3-18.2. Lamp Driver PAC, Model LD-30, Schematic and Logic Diagram

3-105/3-106

3-19 DIGITAL ATTENUATOR PAC, MODEL LN-30

GENERAL DESCRIPTION

The Digital Attenuator PAC, Model LN-30 (figure 3-19.1), contains two independent resistor networks which function as digital-to-analog converters. Each network can accommodate a maximum of four bits and each resistor in the network is individually weighted so that the current contributed to the summing line is proportional to the significance of the associated input bit. Either network can function as a four-bit binary converter or as a BCD converter. In addition, both networks on the LN-30 can be coupled to expand the conversion facilities.

Each LN-30 PAC contains additional resistors for coupling and terminating each of the two summing lines. Bipolar operation is possible in any mode by using the appropriate output terminations and 2's complement codes for negative numbers, with a zero in the MSB (sign) bit representing a negative number.

Space is provided on the PAC for mounting one capacitor per network. These capacitors can be used to smooth the analog function.

The following applications are indicative of LN-30 PAC uses:

- a. LN-30 PAC can serve as an oscilloscope display for monitoring digital storage or readout devices.
- b. An LN-30 PAC and an associated S-PAC flip-flop register can be programmed to operate as a function generator.
- c. The LN-30 PAC in various closed loop systems can serve as a digital error signal generator.

CIRCUIT FUNCTION

The LN-30 networks (figure 3-19.2) of circuits A and B each contain four weighted input resistors connected to a common summing line. Each input resistor value is selected to provide a current in the summing line which is proportional to the significance of the associated digital bit.

The output voltage levels from the digital driver are approximately -0.2 volt or -6.4 volts. However, these levels are dependent upon the transistor saturation voltage and the forward resistance of the clamp diode of the drive circuit. The effects of the saturation voltage can be minimized in circuit A (for circuits A and B coupled together) by saturating the driving circuits and adjusting a 330 kilohm potentiometer (R5) for 0 volt at the LN output.

NOTE

The summing line of circuit A must be terminated by the appropriate resistance before potentiometer R5 is adjusted.

Unlike circuit A, circuit B has no adjustment available to compensate for saturation voltage variation. However, a 150-kilohm resistor (R19) between the summing line and +12 volts offers some compensation for the transistor saturation voltage offset.

To compensate for the clamp voltage variations, the -REF input should be connected to -6 volts by inserting a jumper on the PAC. If the required output voltage from the

LN-30 must be more negative than -6 volts, the -6-volt input to the drive PAC (pin 3) should be disconnected and the desired negative voltage reconnected to both the drive PAC and the -REF input (pin 7) of the LN-30 PAC.

NOTE

The negative voltage used must not exceed -10 volts.

When the desired output voltage level is to be less negative than the reference potential, additional resistors connected between the summing line (circuit A or circuits A and B coupled together) and ground can provide adjustment of the output voltage scaling. The LN-30 PAC contains mounting space for these components. However, adding resistance to the summing line in this way to adjust the output voltage scale causes the output impedance to change from the specified 3 kilohms. Therefore, the input reference potential and the desired full-scale output voltage should be held to the same value to avoid changing the output impedance.

To maintain proportional attenuation and output impedance (3 kilohms), the resistor networks must be terminated correctly. Each PAC includes resistors for terminating each summing line and the mode of operation determines which terminating resistor is selected. The terminating resistance for binary attenuation is 48 kilohms and for BCD attenuation 28.8 kilohms. In either case, a 3-kilohm output impedance is maintained through the use of a proper terminating resistor.

Circuits A and B used separately are always terminated in this manner. However, if circuits A and B are combined, the value of the coupling resistor must maintain the proper termination impedance (48 and 28.8 kilohms) for circuit A when the input impedance of circuit B is added (figure 3-19.3). Table 3-19.1 specifies the correct pin connections between circuits A and B and their coupling resistors.

Any unused inputs (digit) must be grounded to pin 6 and the PAC connector. When a fixed ONE is required to implement a specific logic requirement, the input requiring the ONE can be connected to pin 8.

Converter Mode	Pin Connections at PAC Connector	Output Pin(s)
Two 4-bit binary	15 to 10, 9 to 19, 22 to ground	12, 14
One 8-bit binary	15 to 10, 9 to 19, 23 to 9	1 2
Two single decade (BCD)	16 to 10, 9 to 18, 20 to ground	11, 13
One 2-decade (BCD)	16 to 10, 9 to 18, 22 to 9	1 1

Table 3-19.1. PAC Connector Pin Connections for Different Converter Modes

Bipolar Operation. Bipolar operation permits the output voltage to swing positive or negative with respect to ground. Bipolar operation is possible for binary or BCD conversion by connecting R4 or R3, respectively, between +12 volts and the summing line.

This effectively offsets the summing line to a positive potential so that the output voltage swings equally positive and negative around ground. Refer to figure 3-19.4 for bipolar waveforms.

The following procedures must be conducted to set up for bipolar operation.

Binary Conversion

One or two 4-bit:

- a. Make jumper connections as indicated in table 3-19.1.
- b. In the driving registers, set the most significant bit and reset the remaining three bits.
- c. Jumper pin 25 to pin 10 (circuit A) or pin 26 to pin 9 (circuit B).
- d. Set the output of circuit A to 0.0 volt with R5.
- e. Bipolar output appears at pin 12 (circuit A) or pin 14 (circuit B).

One 5 to 8 bit:

- a. Make jumper connections as indicated in table 3-19.1.
- b. Jumper pin 25 to 10.
- c. In the driving register, set the most significant bit and reset the remaining bits.
- d. For the unused inputs to the LN-30, apply ZERO (0 V).
- e. Set the output, pin 12, to 0.0 volt with R5.

BCD 4-Bit Conversion

- a. Set number 5 into the flip-flop register.
- b. Jumper pin 24 to pin 10 for circuit A or pin 27 to 9 for circuit B.
- c. If circuit A is used, adjust R5 to obtain 0.0 volt at pin 11.

BCD 8-Bit Conversion

- a. Set number 50 into the flip-flop register.
- b. Jumper pin 24 to pin 10
- c. Adjust R5 to obtain 0.0 volt at pin 11.

SPECIFICATIONS

Input Loading	Resolution
1/2 U load each	8 bits or 2 decimal digits
Output Impedance	Zeroing
3 K $\pm 2\%$ (independent of input code)	Output can be ZERO set within

Current Requirements

Curren	t Requirements	
-18 V	0.3 ma	Accuracy
-66 V +12 V	4.0 ma (current into supply) 2.0 ma	Approximately 5%, using -6 volt reference from any S-PAC power
Timing	(Settling)	supply (RP-30, RP-31, RP-32), or 2% relative to reference voltage.
Settling	time of the driving source	m

±20 my

plus 0.5 µsec plus effect of output stray capacitance

Total Power 0.1 Watt

The converter modes are indicated in tables 3-19.2 through 3-19.5.

Table 3-19.2. Four-Bit Binary Mode

	Input	.6 3-			Output (wi	th -6 V reference)
Number	2 ³	2 ²	2 ¹	20	Nom	inal Voltage
0	0	0	0	0	0.00 V	Ground
1	0	0	0	1	-0.38	$1/16 \times V_{REF}$
2	0	0	1	0	-0.75	1/8 x V _{REF}
1						
1						
1						
8	1	0	0	0	-3.00	
1						
1						
1						
1						
13	1	1	0	1	-4.88	
14	1	1	1	0	-5, 25	
15	1	1	1	1	-5,63	15/16 x V _{REF}

Table 3-19.3. Three-Bit Plus Sign Binary Bipolar Mode

	Input	Output (with -6 V reference)			
Number	(Sign) 2 ³	22	21	20	Nominal Voltage
-8	0	0	0	0	+2.4 V
-7	0	0	0	1	+2.1
-6	0	0	1	0	+1.8
1					
1					
-1	0	1	1	1	+0.3
+0	1	0	0	0	0.0
+1	1	0	0	1	-0.3
1					
1					
1					
+5	1	1	0	1	-1.5
+6	1	1	1	0	-1.8
+7	1	1	1	1	-2.1

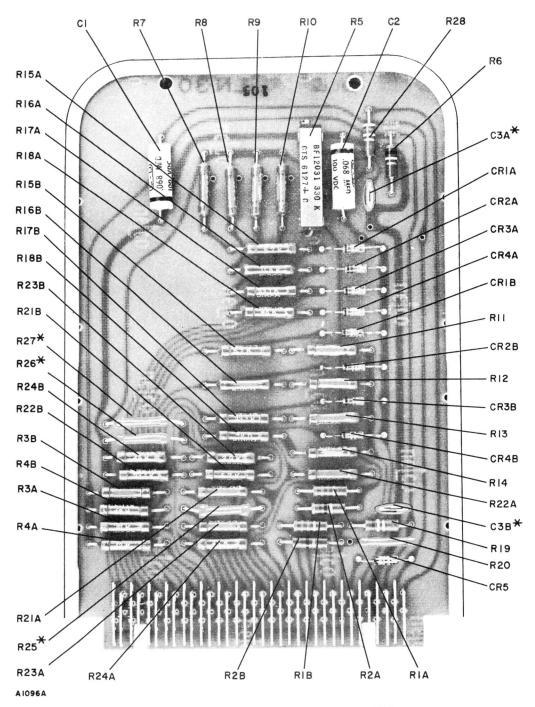
Use 2's comple-ment for encoding numbers

Table 3-19.4. Four-Bit BCD Mode

	Input				Output (with -6 V reference)
Number	23	22	2 ¹	20	Nominal Voltage
0	0	0	0	0	0.00 V
1	0	0	0	1	-0.36
2	0	0	1	0	-0.72
1					
1					
5	0	1	0	1	-1.80
1					
1					
8	1	0	0	0	-2.88
9	1	0	0	1	-3.24
10	1	0	1	0	-3.60
15	1	1	1	1	-5.40

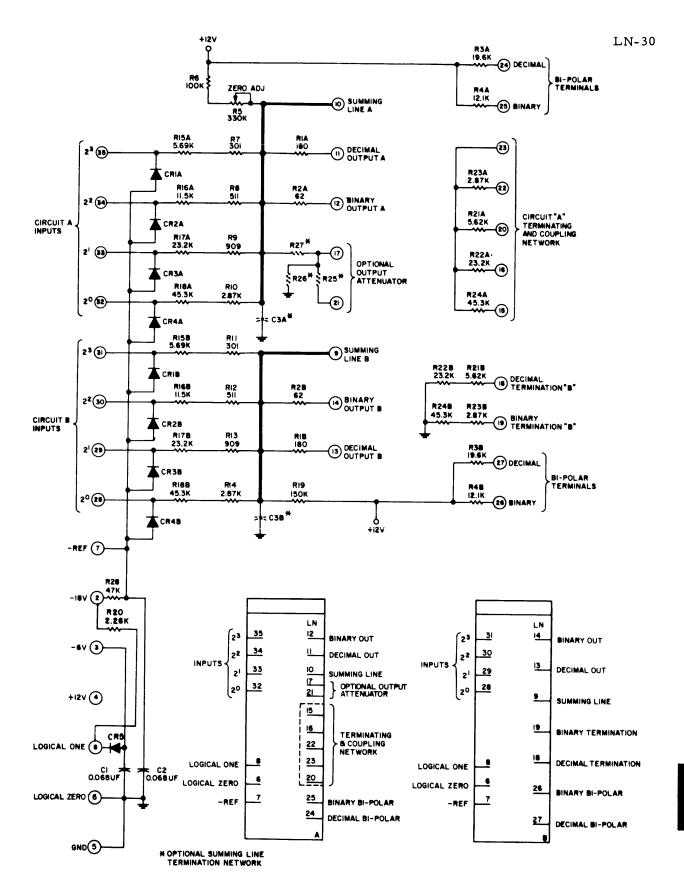
Table 3-19.5. Four-Bit BCD Bipolar Mode

	Inpu			Output (with -6 V reference)	
Number	23	22	21	20	Nominal Voltage
0	0	0	0	0	+1.56 V
1	0	0	0	1	+1.25
2	0	0	1	0	+ .94
4	0	1	0	0	+0.31
5	0	1	0	1	0.00
6	0	1	1	0	-0.31
I					
8	1	0	0	0	94
9	1	0	0	1	-1.25
10	1	0	1	0	-1.56



* OPTIONAL COMPONENTS FOR SUMMING LINE TERMINATION

Figure 3-19.1. Digital Attenuator PAC, Model LN-30, Parts Location



A3031

Figure 3-19.2. Digital Attenuator PAC, Model LN-30, Schematic and Logic Diagram

1/12/66 3-113

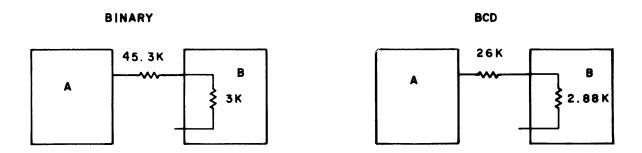
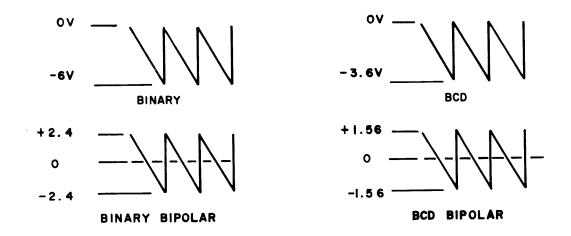


Figure 3-19.3. Coupling Between Circuits A and B $\,$



NOTE: THESE WAVEFORMS ARE REPRESENTATIVE OF AN UP COUNTER AND FOR -6 VOLTS REFERENCE

Figure 3-19.4. Output Waveforms

3-20 ADJUSTABLE DIGITAL ATTENUATION PAC, MODEL LN-30A

GENERAL DESCRIPTION

The operation of the Adjustable Digital Attenuator PAC, Model LN-30A (figure 3-20.1), is similar to that of the LN-30. The main difference is that the LN-30A contains variable trimming resistors in circuit A to increase the output accuracy. These variable resistors adjust the level of the output voltage steps for monotonic operation, which guarantees output accuracies of approximately ±1 percent.

CIRCUIT FUNCTION

The circuit function of the LN-30A PAC (figure 3-20.2) is similar to that of the LN-30. For additional descriptive information, refer to paragraph 3-19 covering the LN-30.

Each LN-30A is factory adjusted for monotonic operation. However, when readjustment of resistors R7 through R10 becomes necessary for monotonic operation, the adjustment should be performed using an oscilloscope and a binary counter with S-PAC compatible outputs.

Monotonic operation signifies an increasing positive- or negative-going output in equal incremental steps (figure 3-20.3). Progression is always in equal steps; unequal output steps signify maladjustment.

SPECIFICATIONS

Input Loading

	0	1,0001401011			
1/2 U 1	oad each input	8 bits or 2 decimal digits			
Output	Impedance	Zeroing			
3 K ± 2%	% (independent of input code)	Output can be ZERO set within ±20 mv			
Curren	t Requirements	Accuracy			
-18 V	0.3 ma	Approximately 5%, using -6 volt			
-6 V	4.0 ma (current into supply)	reference from any S-PAC power supply (RP-30, RP-31, RP-32),			
+12 V	2.0 ma	or 1% relative to reference voltage.			
Timing	(Settling)	G			
	g time of the driving source	Total Power			
_	5 µsec plus effect of output apacitance	0.1 watt			

Resolution

The converter modes are indicated in tables 3-20.1 through 3-20.4.

Table 3-20.1. Four-Bit Binary Mode

	Inpu	t			Output (with -6 V reference)
Number	23	22	21	20	Nominal Voltage
0	0	0	0	0	0.00 V Ground
1	0	0	0	1	$-0.38 1/16 \times V_{REF}$
2	0	0	1	0	$-0.75 1/8 \times V_{REF}$
1					
1					
8	1	0	0	0	-3.00
1	•				
1					
1					
13	1	1	0	1	-4.88
14	1	1	1	0	-5.25
15	1	1	1	1	-5.63 15/16 x V _{REF}

Table 3-20.2. Three-Bit Plus Sign Binary Bipolar Mode

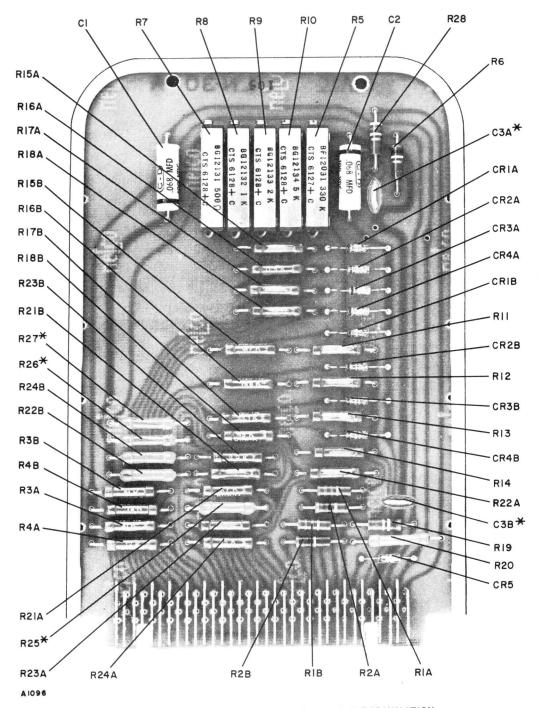
		Input		Output (with -6 V reference)
	Number	(Sign) 2 ³	2 ² 2 ¹ 2 ⁰	Nominal Voltage
,	-8	0	0 0 0	+2.4 V
Use 2's	-7	0	0 0 1	+2.1
comple-	-6	0	0 1 0	+1.8
ment for encoding numbers	1			
Hambers	ı			
/	- 1	0	1 1 1	+0.3
	+ 0	1	0 0 0	0.0
	+ 1	1	0 0 1	- 0.3
	1			
	l			
	l			
	+ 5	1	1 0 0	-1.5
	+6	1	1 1 0	-1.8
	+ 7	1	1 1 1	-2.1

Table 3-20.3. Four-Bit BCD Mode

	Input			Output (with -6 V reference)	
Number	23	22	21	20	Nominal Voltage
0	0	0	0	0	0.00 V
1	0	0	0	1	-0.36
2	0	0	1	0	-0.72
1					
5	0	1	0	1	-1.80
1					
1					
8	1	0	0	0	-2.88
9	1	0	0	1	-3.24
10	1	0	1	0	-3.60
1					
1					
15	1	1	1	1	-5.40

Table 3-20.4. Four-Bit BCD Bipolar Mode

	Input				Output (with -6 V reference)
Number	23	2 ²	2 ¹	20	Nominal Voltage
0	0	0	0	0	+1.56 V
1 2	0	0		1 0	+1.25 + .94
4	0	1	0	0	+0.31
5 6	0 0	1 1	0 1	1 0	0.00
1					
8 9	1 1	0	0	0	94 -1.25
10	1	0	1	0	-1.56



* OPTIONAL COMPONENTS FOR SUMMING LINE TERMINATION

Figure 3-20.1. Digital Attenuator PAC, Model LN-30A, Parts Location

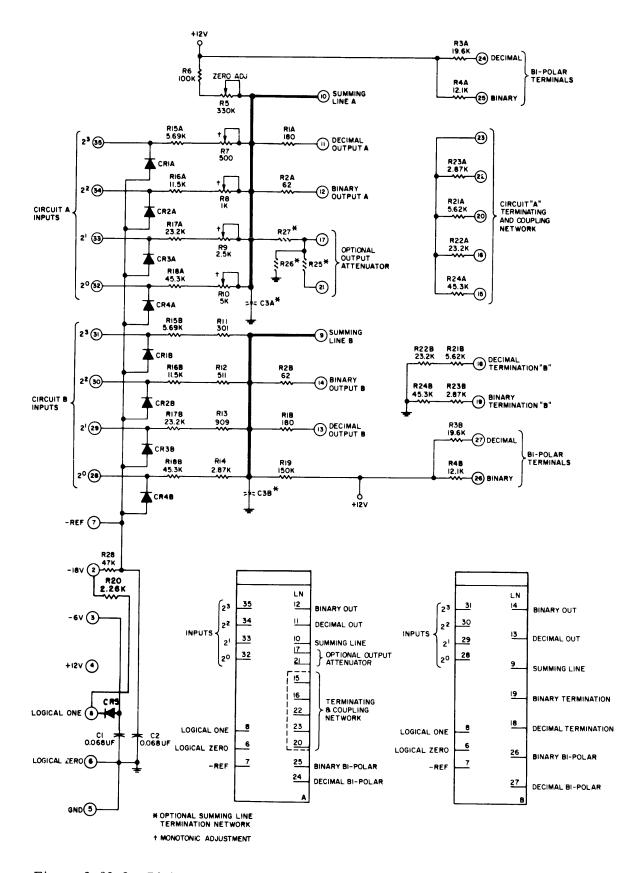
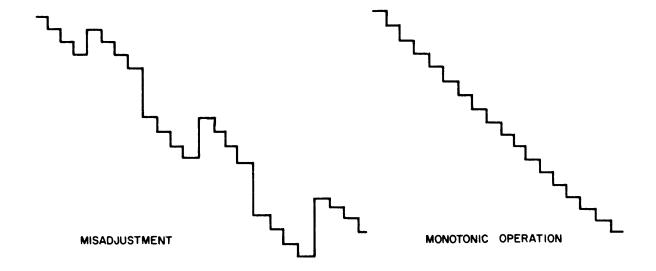


Figure 3-20.2. Digital Attenuator PAC, Model LN-30A, Schematic and Logic Diagram



NOTE

These waveforms are produced by an LN-30A when driven by a binary counter operating in the forward direction.

Figure 3-20.3. LN-30A Waveforms

3-21 PRECISION DIGITAL-TO-ANALOG CONVERTER PAC (FOUR BIT), MODEL LP-30

GENERAL DESCRIPTION

The Precision Digital-to-Analog Converter PAC, Model LP-30 (figure 3-21.1), transforms any four-bit binary number or BCD number into a corresponding analog voltage. The LP-30 requires an input reference potential between -1 and -10 volts. The full-scale output voltage of the converter is proportional to the input reference potential. Therefore, it is possible to perform various mathematical functions such as multiplication or division by modulating the reference level.

Each LP-30 can be connected with the LP-31 S-PAC to perform binary conversion with an output accuracy of a maximum of 10 bits. The LP-30s can be cascaded to supply multiple decade conversion for binary or BCD inputs. Coupling resistors are provided on each S-PAC for any expansion of conversion facilities in the manner described previously.

The conversion accuracy of the LP-30 is 0.04 percent relative to the input reference when used as a single unit and 0.05 percent when used in conjunction with other S-PAC converter modules. The LP-30 output settles within the specified accuracy 5 microseconds after the input signals complete switching.

CIRCUIT FUNCTION

Each LP-30 (figure 3-21.2) consists of four precision, single-pole, double-throw, transistor switches, with a precision resistor connected to the pole of each switching circuit. In performing the conversion function, each switching circuit alternately connects its precision resistor to the reference potential or 0 volt, depending upon the state of the input signal. When the input signal to a particular switch is a ONE (-6 V), the precision resistor is connected to 0 volt; when the input is a ZERO (0 V), the precision resistor is connected to the reference potential. Each precision resistor is of a value correlated to the significance of the binary input to the particular switch with which it is associated (figure 3-21.3). In addition, all four precision binary-weighted resistors are tied to a common summing point which requires proper termination to preserve the conversion accuracy. When properly terminated, the voltage at the summing point is that portion of the reference signal determined by the status of the input digital signals. Resistor R16 (binary termination) or R17 (decimal termination) can be used to terminate the summing point of the converter when a single LP-30 is used. Resistor R20 (decimal coupling) or R19 (binary coupling) can provide coupling between PACs to implement various converter configurations (figures 3-21.4, 3-21.5, and 3-21.6).

The PAC connector pin 8 is used for signal ground. This connection must be made to the external -REF return and to the ground return of any external load circuit.

NOTE

Signal ground must be connected to system ground at one point.

Reference Requirements. Any reference potential from -1 to -10 volts can be used. The reference current required is negative and is a function of the reference potential used and the operational mode of the unit. An equivalent circuit of the load presented to the reference source is shown in figure 3-21.7. The 2000-ohm resistor, in

series with the equivalent 12-volt battery, is a static load and represents a current being driven against the reference. Generator I_{v} produces an additional current which is a function of the reference potential, the terminating impedance into which the converter is operating, and of the state of the control signals operating the converter. Under worst case conditions, I_{v} is a maximum of 1.6 milliamperes. I_{v} is at a minimum (approximately 0.2 milliampere) when a reference potential of -1 volt is used and the output of the converter is operated into a zero impedance point, such as the summing point of an operational amplifier.

If the reference source cannot accept back current, a shunt resistor must be connected across the reference terminals to bias out the back current. A mounting position with eyelet holes is provided on each PAC which accommodates a shunting resistor, shown as R23 in figures 3-21.1 and 3-21.2. The value of the shunting resistor is calculated from the following formula:

$$R_{S} = \frac{24 - 2V_{R}}{12 + V_{R}}$$

where R_S is the value of the shunt resistor in kilohms and V_R^* is the reference potential in volts.

An example calculation using the previously given formula is as follows:

Assume:
$$V_{R1} = -10 \text{ V}$$
 $R_S = \frac{24 - (2)(-10)}{12 - 10} = 22 \text{ K}$

The reference potential can be modulated to perform various analog manipulations such as multiplication or division. However, to modulate the reference the S-PAC must be modified by removing capacitors C4 and C2.

Bipolar Operation. Bipolar operation is defined as a mode of operation that permits the output voltage to swing either positive or negative with respect to ground. The application of only the most significant bit causes an output equal to 0 volt.

Bipolar operation requires that the summing point be offset in voltage and can be implemented by connecting a precision resistance between the summing point and a positive reference voltage. Bipolar operation causes the output voltage and impedance to be modified. Typical parameters concerning bipolar operation are shown in the equivalent circuit diagram (figure 3-21.8).

Space is provided on each LP-30 for mounting two bipolar terminating resistors (R21 and R22) in series. This allows the terminating resistors to be trimmed to an exact value. If the LP-30 is used with other S-PAC converter modules (LP-30 or LP-31, for example), the bipolar terminating resistors should be used on only the LP-30, converting the most significant digits.

^{*}In the case of a variable reference potential, the lowest value should be used for the term V_R in the formula; that is, if the reference REF potential varies between -1 V and -10 V, -1 V should be used for V_R .

NOTE

Connect resistors R21 and R22 as shown in figures 3-21.1 and 3-21.2. If a single resistor is used, connect it between points C and D (R22). If two resistors are used, remove the jumper between A and B and install resistor R21 in its place.

The offset resistor value is determined by the following equation:

$$R_{X} = 12 \frac{V_{P}}{-V_{R}}$$

where:

$$R_X = R_{21} + R_{22}$$
 in kilohms

 V_{D} = positive reference voltage in volts

 V_{R} = negative reference voltage in volts

With bipolar operation, the output can swing approximately ${}^{\pm V}O$, with ${}^{V}O$ given by the following equation:

$$V_O = \frac{6 V_P}{R_X + 6}$$

where:

V_O = magnitude of output voltage in volts

 $V_{\mathbf{p}}$ = positive reference voltage in volts

 $R_{X}^{}$ = offset resistor in kilohms

For example: for a positive reference ($V_{\rm P}$) of +10 volts and a negative reference ($V_{\rm R}$) of -10 volts:

$$R_X = 12 \frac{(10 \text{ V})}{-(-10 \text{ V})} = 12 \text{ kilohms}$$

$$V_O = \frac{(6)(10)}{(12+6)} = 3.333 \text{ volts}$$

SPECIFICATIONS

Input Loading Output Impedance

1 U load each 6 K ±5 ohms

Settling Time Output Drive

5 μsec (max) after input signals
complete quitables
1.6 ma (full scale)

complete switching

Reference Requirements Accuracy

Voltage Current 0.04% relative to reference or 4 mv,

whichever is greater

-1 to -10 VDC 0 to 6 ma

(reverse current into supply) Polarization

(Refer to paragraph on

Bipolar Operation) Pins 18 and 22

Current Requirements Total Power

-18 V 43 ma 0.8 watt

-6 V (not used)

+12 V 4 ma Handle Color Code

Frequency of Operation Long: Purple

200 KC (max) Short: White

The PAC connector pin connections for different converter modes are given in table 3-21.1. The converter modes are indicated in tables 3-21.2 through 3-21.6.

Table 3-21.1. PAC Connector Pin Connections for Different Converter Modes

Converter Mode	Pin Connections at PAC Connector	Output Pin
4-bit binary	18 to 19 8 to signal ground or 6 9 to negative reference (V_R)	17
4-bit binary bipolar	18 to 19 8 to signal ground or 6 9 to negative reference (V _R) 12 to positive reference (V _P)	17
4-bit BCD	18 to 11 8 to signal ground or 6 9 to negative reference (V_R)	29

SPECIFICATIONS (Continued)

Input Output (with -10 V reference) 23 22 20 Number Nominal Voltage 15/16 x V_{REF} 15 0 0 0 0 -9.375 V 14 0 0 0 1 -8.750 13 0 0 1 0 -8.125 Use l's complement for < 8 0 1 -5.000 1 encoding numbers $1/8 \times V_{REF}$ 2 1 0 1 -1.250 $1/16 \times \overline{V}_{REF}$ 1 l 0 -0.625 0 1 1 1 Ground 1 0.000

Table 3-21.2. Four-Bit Binary Mode

Table 3-21.3. Three-Bit Plus Sign Binary Bipolar Mode

		Input		Output (with -10 V and +10 V references)				
	Number	(Sign) 2 ³	22	21	20	Nominal Voltage		
	+ 7	0	0	0	0	-2.917 V	-7/8 x V _O	
Use l's	+ 6	0	0	0	1	-2.501		
comple-	+ 5	0	0	1	0	-2.085		
ment for < encoding								
numbers	1							
	+ 1	0	1	1	0	-0.416	-1/8 x V _O	
	+ 0	0	1	1	1	0.000	Ground	
	-1	1	0	0	0	+0.416	+ 1/8 x V	
Subtract	-2	1	0	0	1	+0.832	+ 1/8 x V _O + 1/4 x V _O	
1 bit for							O	
encoding numbers								
numbers	-6	1	1	0	1	+ 2.501		
	-7	1	1	1	0	+ 2.917		
	-8	1	1	l	1	+ 3, 333	v _O	

SPECIFICATIONS (Continued)

Table 3-21.4. Four-Bit BCD Mode

		In	put		Output (with -10 V reference)			
	Number		23	22	21	20	Nominal Voltage	
	15		0	0	0	0	-9.00 V	
	I							
	I							
	10	1	0	1	0	1	-6.00	
	9		0 '	1	1	0	-5.40	
Use l's	8		0	1	1	1	-4.80	
comple- ment for	1							
encoding	-							
numbers	-							
	5		1	0	1	0	-3.00	
	l							
	2		1	l	0	1	-1.20	
	l		1	l	l	0	-0.60	
	0		1	1	<u>l</u>	l	0.00	

Table 3-21.5. Eight-Bit Binary Mode

					Output (with -10 V reference)							
		Number	27	26	2 ⁵	24	23	22	21	20	Nom	inal Voltage
		255	0	0	0	0	0	0	0	0	-9.961 V	255/256 x V _{REF}
		254	0	0	0	0	0	0	0	1	-9.922	1.31
		240	0	0	0			1		1	-9.375	15/16 x V _{REF}
Use l's		239	0	0	0	1	0	0	0	0	-9.336	
comple- ment for	\prec											
encoding numbers		17	1	1	1	0	1	1	1	0	-0.664	
numbers		16			l	0	1	l	1	1	-0.625	 1/16 v V
		10	1	1	1	U	1	1	1	1	-0.025	1/16 x V _{REF}
		2	1	l	l		1	1	0	1	-0.078	$1/128 \times V_{REF}$
		1	1	1	l	1	1	1	1	0	-0.039	1/256 x V _{REF}
		0	1	1	1	l	1	1	1	1	0.000	Ground

SPECIFICATIONS (Continued)

Table 3-21.6. Eight-Bit BCD Mode

					Inp	ut			Output (with -10 V reference)			
	Number	27	26	25	24	23	22	2 ¹	20	Nominal Voltage		
	150	0	0	0	0	1	1	1	1	-9.00 V		
	100	0	1	0	1	1	1	1	1	-6.00		
	99	0	1	1	0	0	l	1	0	-5.94		
Use l's comple-	50	1	0	1	0	1	1	l	l	-3.00		
ment for { encoding	11	1	l	1	0	l	1	1	0	-0.66		
numbers	10	l	1	1	0	l	1	l	1	-0.60		
	9	1	1	1	1	0	1	1	0	-0.54		
	1	1	1	1	1	l	1	1	0	-0.06		
	0	1	l	1	1	1	1	1	1	0.00		

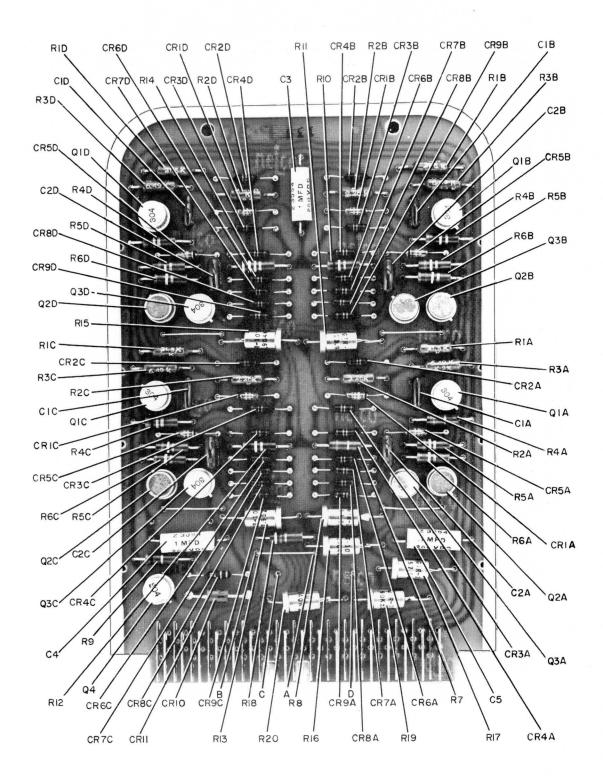


Figure 3-21.1. Precision Digital-to-Analog Conversion PAC (Four Bit),
Model LP-30, Parts Location

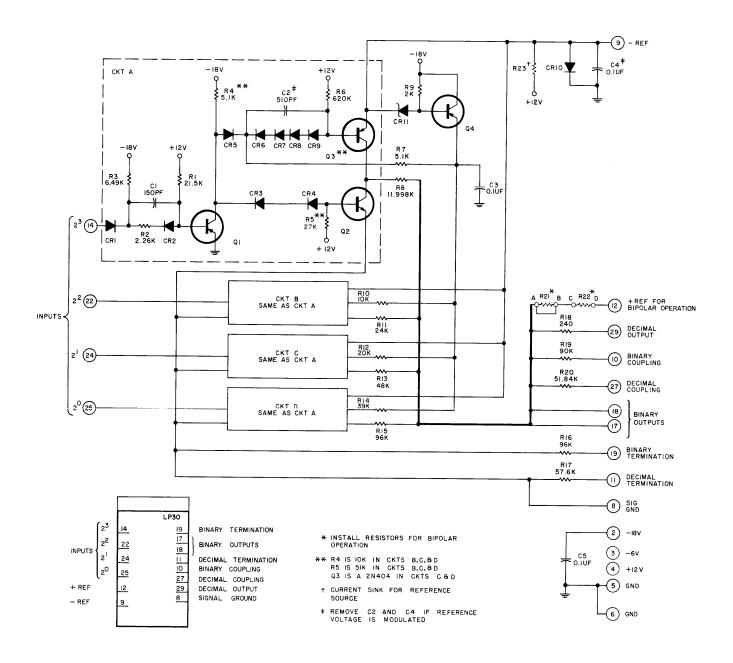


Figure 3-21.2. Precision Digital-to-Analog Conversion PAC (Four Bit), Model LP-30, Schematic and Logic Diagram

3/2/64

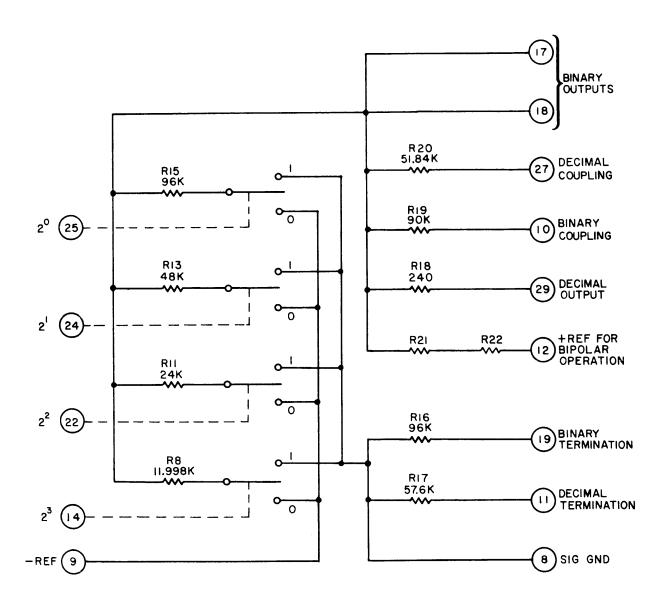


Figure 3-21.3. Precision Digital-to-Analog Conversion PAC (Four Bit), Model LP-30, Equivalent Schematic Diagram

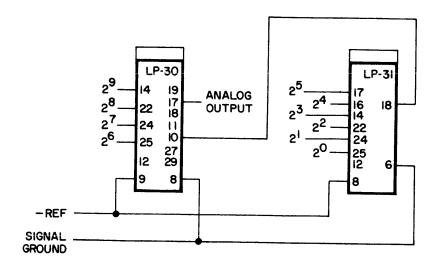


Figure 3-21.4. Ten-Bit Binary-to-Analog Converter

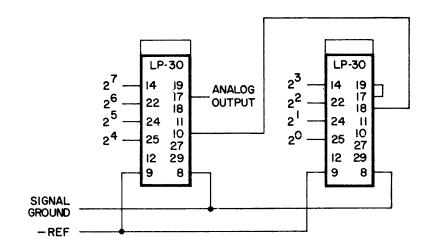


Figure 3-21.5. Eight-Bit Binary-to-Analog Converter

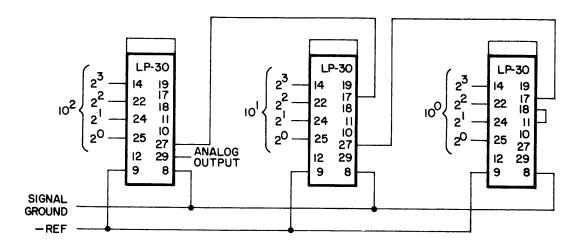


Figure 3-21.6. Three-Decade BCD-to-Analog Converter

3/2/64

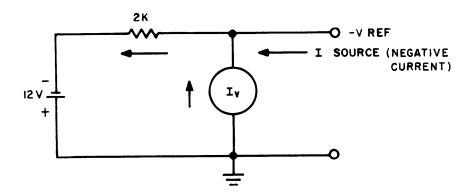
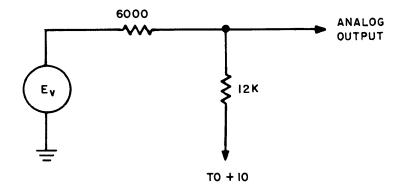


Figure 3-21.7. Equivalent Circuit of Load Presented to Reference Source



 E_{V} is the equivalent LP-30 analog voltage generator

Figure 3-21.8. Bipolar Equivalent Circuit Diagram

3-22 PRECISION DIGITAL-TO-ANALOG CONVERTER PAC (SIX BIT), MODEL LP-31

GENERAL DESCRIPTION

The method of operation of the Precision Digital-to-Analog Converter PAC, Model LP-31 (figures 3-22.1 and 3-22.2), is similar to that of the LP-30. However, the LP-31 S-PAC contains six precision conversion switches instead of four. Because of this basic distinction, the LP-31 is not suited to BCD operation. However, the LP-31 can be used as either a 6-bit binary converter; or, in conjunction with the LP-30, to accept the six least significant bits in a 10-bit digital-to-analog converter.

CIRCUIT FUNCTION

The circuit function of the LP-31 (figure 3-22.3) is similar to that of the LP-30 covered in paragraph 3-21. The LP-31 can function in the bipolar mode of operation (figure 3-22.4) as discussed under Bipolar Mode in paragraph 3-21.

SPECIFICATIONS

Input Loading		Current Requirements				
l U load each		-18 V 54 ma				
Output Impedance	e	- 6 V (not used) +12 V 6 ma				
$6 \text{ K} \pm 30 \text{ ohms}$		E				
Output Drive		Frequency of Operation				
Output Diive		200 KC (max)				
1.6 ma (full scal	e)	,				
Reference Requi	rements	Settling Time				
Voltage	Current	5 μsec (max) after input signals				
-1 to -10 VDC	0 to 6 ma	complete switching				
	(current into supply) (Refer to paragraph 3-21)	Accuracy				
Total Power		0.1% relative to the reference or 10 mv, whichever is greater`				
1.0 watt		•				
		Handle Color Code				
Polarization		Long: Purple				
Pins 4 and 28		Short: White				

The PAC connector pin connections for different converter modes are given in table 3-22.1. The converter modes are indicated in tables 3-22.2 and 3-22.3.

Table 3-22.1. PAC Connector Pin Connections for Different Converter Modes

Converter Mode	Pin Connections at PAC Connector	Output Pin
6-bit binary	6 to signal ground 8 to negative reference ($V_{ m R}$)	18
6-bit binary bipolar	6 to signal ground 8 to negative reference (V_R) 12 to positive reference (V_P)	18

Table 3-22.2. Six-Bit Binary Mode

		Inp	out					Output (with -	·10 V reference)	
	Number	2 ⁵	24	23	22	21	20	Nominal Voltage		
(63	0	0	0	0	0	0	-9.844 V	63/64 x V _{REF}	
	62	0	0	0	0	0	1	-9.688		
	l									
	1									
Use l's										
comple- ment for	32	0	1	1	1	1	1	-5.000		
encoding numbers										
	1									
	2	1	1	1	1	0	1	-0.312	$1/32 \times V_{REF}$	
	1	1	1	1	1	1	0	-0.156	1/64 x V _{REF}	
ĺ	0	1	1	1	1	1	1	0.000	Ground	

Table 3-22.3. Five-Bit Plus Sign Binary Bipolar Mode

		Inpu	Output (with -10 V and +10 V references)								
	Number	(Sign) 2 ⁵	24	2 ³	22	21	20	Nominal Voltage			
1	+31	0	0	0	0	0	0	-3.229	-31/32 x V _o		
Use l's	+30	0	0	0	0	0	1	-3.125			
comple-	1										
ment for encoding	I										
numbers	+1	0	1	1	1	1	0	-0.104	-1/32 x V _o		
Ì	+0	0	1	1	1	1	1	0.000	Ground		
	-1	1	0	0	0	0	0	+0.104	+1/32 x V _o		
Subtract											
l bit for) encoding (ĺ				
numbers	ı										
()	-31	1	1	1	1	1	0				
\	-32	1	1	1	1	1	1	+3.333	Vo		
]											

3/2/64 3-135/3-136

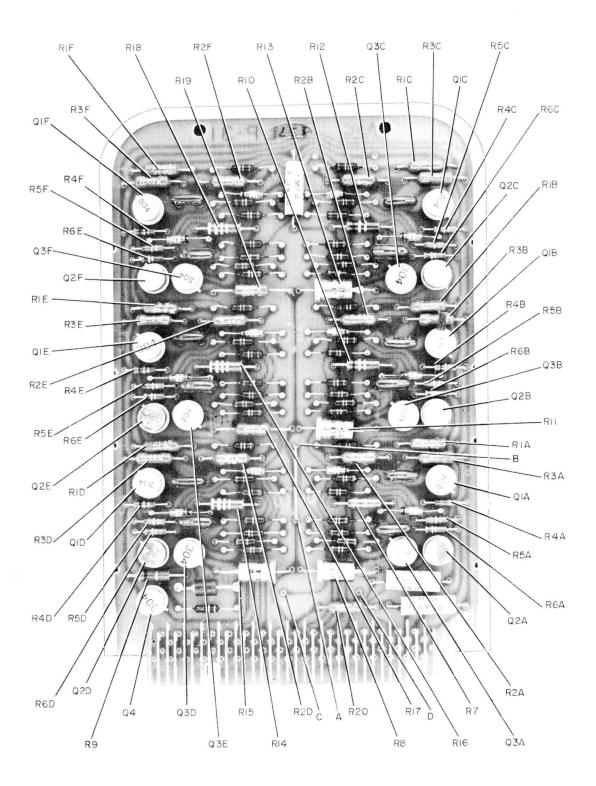


Figure 3-22.1. Precision Digital-to-Analog Converter PAC, Model LP-31, Parts Location (Resistors and Transistors)

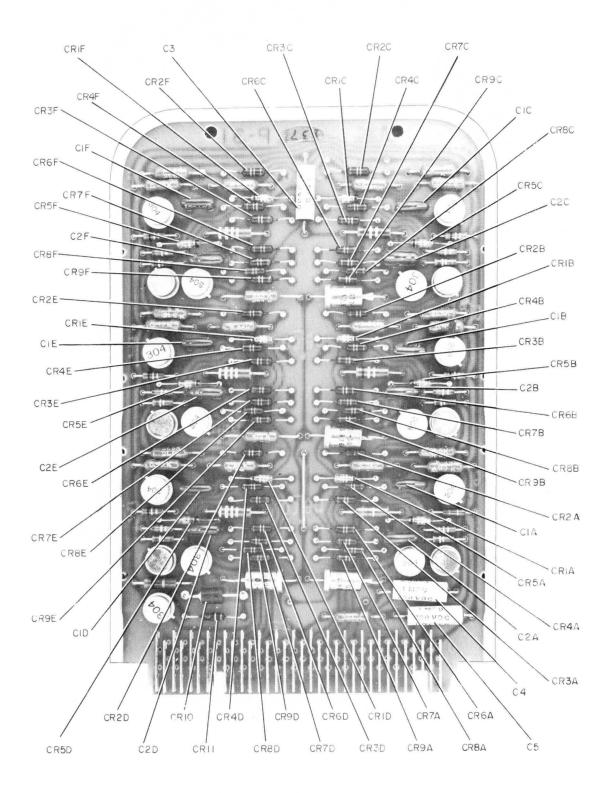


Figure 3-22.2. Precision Digital-to-Analog Converter PAC, Model LP-31, Parts Location (Capacitors and Diodes)

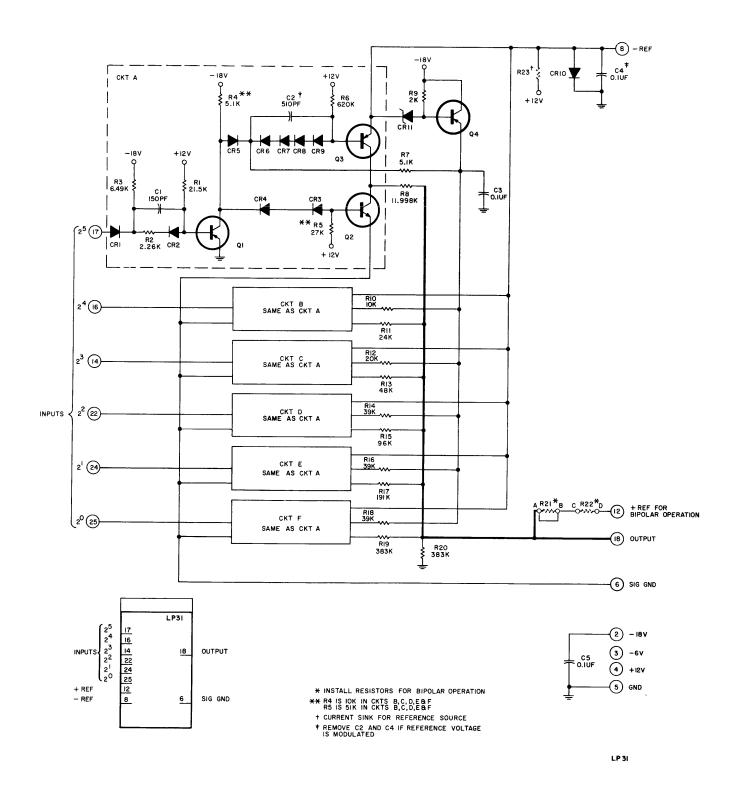


Figure 3-22.3. Precision Digital-to-Analog Converter PAC, Model LP-31, Schematic and Logic Diagram

3-23 GATE/SHAPER PAC, MODEL MS-30

GENERAL DESCRIPTION

The Gate/Shaper PAC, Model MS-30, (figure 3-23.1) contains six independent circuits: two pulse shaping circuits and four special gating circuits. Both pulse shapers are identical AC coupled inverter circuits which convert positive input signal transitions to output pulses of predetermined width. The standard output pulse width is 0.24 microsecond but can be set to 0.6 microsecond by jumpering the pin connections at the PAC connector. Other pulse widths are obtainable by connecting an external capacitor to the proper pins at the PAC connector. Only assertion pulses are available at the outputs of the pulse shaping circuits. The pulse shaper input circuitry has a single input and a node for expanding the number of inputs.

The four special gate circuits are identical NAND gates that can function either as standard S-PAC NAND gates or can provide increased input sensitivity from the standard -6 volts to -3 volts. The special gates are particularly useful for converting negative logic signals at -3 volts or more negative (i.e., 3C T-PAC assertion pulses) to S-PAC compatible logic signals.

CIRCUIT FUNCTION

Pulse Shaper. The pulse shaper is an AC coupled inverter circuit that provides negative output pulses. The output pulse width is determined by an RC time constant. The normal output pulse width is 0.24 microsecond. However, this pulse width can be increased to 0.6 microsecond by adding parallel-connected capacitance. This is accomplished by jumpering pin connections at the PAC as indicated in table 3-23.1.

In the pulse shapers, pin 32 of circuit A and pin 9 of circuit B condition the circuits for various functions. Because these circuits are identical, this discussion concerns only circuit A.

When connected to an external diode cluster, pin 32 provides a multi OR input for positive logic signals; when jumpered with pin 35, it provides an output pulse width of 0.6 microsecond. When an external capacitor is connected between pins 32 and 33 (figure 3-28.3), output pulse widths greater than 0.6 microsecond are obtainable.

Pin 32 can be connected in any one of these three configurations, or in any combination. The external capacitance required for a specific output pulse width is calculable from the following equation:

$$C = (PW - 0.24) \times 1.07 \times 10^3$$

where PW is the pulse width in microseconds, and C is the capacitance in picofarads (pf). For example, if a 10-microsecond pulse is required:

C =
$$(10 - 0.24) \times 1.07 \times 10^3$$

= $9.78 \times 1.07 \times 10^3$
= $10,400 \text{ pf}$
= $0.01 \mu \text{f}$

The input waveform which establishes the governing limitations upon the output pulse width must conform to the following two rules:

The input waveform must be positive for a time equal to, or greater than the desired output pulse width.

The input waveform must be negative, prior to going positive, for a time equal to or greater than the desired output pulse width.

Minimal cases require that the input waveform be symmetrical. Examples of input waveforms required are shown in figure 3-23.4.

Special Gate. The special gate is a standard NAND gate with an additional input identified in figure 3-23.2 as a special node. This special node input allows the gate input sensitivity to be increased. The sensitivity is increased by jumpering the special node to the node connection at the PAC connector. This modification reduces the value of the base series resistor. Consequently, the input triggering voltage is reduced from -6 volts to -3 volts, where -3 volts is a ONE. If the two node points are not connected, the circuit remains a standard S-PAC NAND gate.

Increasing the input sensitivity reduces noise protection when the input is at ZERO. In a standard NAND gate, noise protection is 1.5 volts. When the circuit is connected as a special gate (figure 3-23.6), noise protection is reduced to 0.7 volt.

SPECIFICATIONS

Input Loading

Pulse shaper input: 2 U loads each

Special gate input:

load each

Output Waveform Characteristics

Rise time: 0.1 µsec (typ)

Fall time: 0.15 µsec (typ)

Current Requirements

-18 V 79 ma

- 6 V 35 ma (reverse current into supply)

+12 V 15 ma

Total Power

1.75 watts

Frequency of Operation

Pulse shaper: $f(max) = \frac{1}{2 PW}$

where f is frequency in mc, and PW is pulse width in $\mu\text{sec.}$

Special gate: 1 mc (max)

Output Drive Capability

Pulse shaper (assertion output pulse only): 5 Ū loads and 100 pf stray capacitance each.

Special gate: 7 U loads and 400 pf stray capacitance each.

Polarization

Pins 18 and 32

Handle Color Code

Long: Purple

Short: Orange

Table 3-23.1. MS-30 PAC Connector Jumper Connections

Pulse Shaper Connections			
l. For 0.6 μsec output pulse width (circuit A)	Jumper pin 32 to pin 35		
2. For other pulse widths (circuit A)	Connect external capacitor between pins 32 and 33		
3. For 0.6 μsec output pulse width (circuit B)	Jumper pin 9 to pin 6		
4. For other pulse widths (circuit B)	Connect external capacitor between pins 8 and 9		
Special Gate Connections			
1. For -3 volt sensitivity	Connect pin 26 to pin 31, circuit C pin 15 to pin 10, circuit D pin 27 to pin 29, circuit E pin 14 to pin 12, circuit F		
2. For standard -6 volt sensitivity	No jumper connection on circuits C through F		

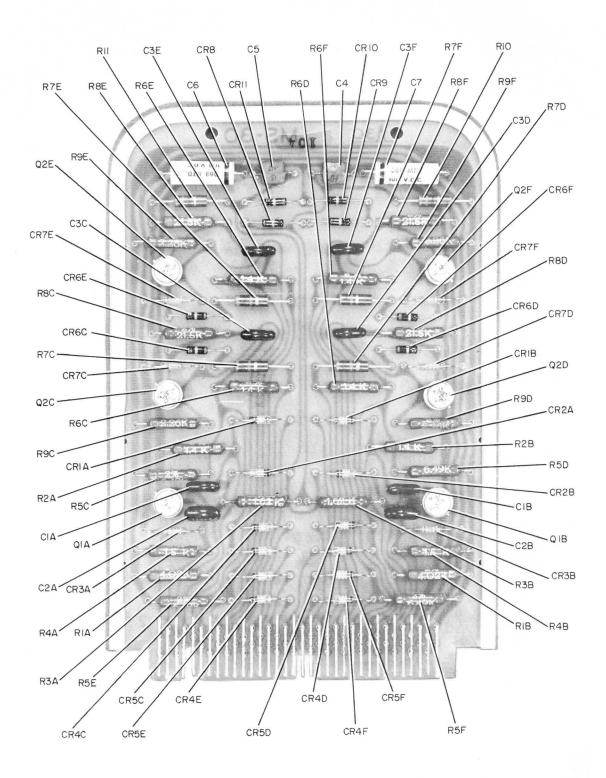


Figure 3-23.1. Gate Shaper PAC, Model MS-30, Parts Location

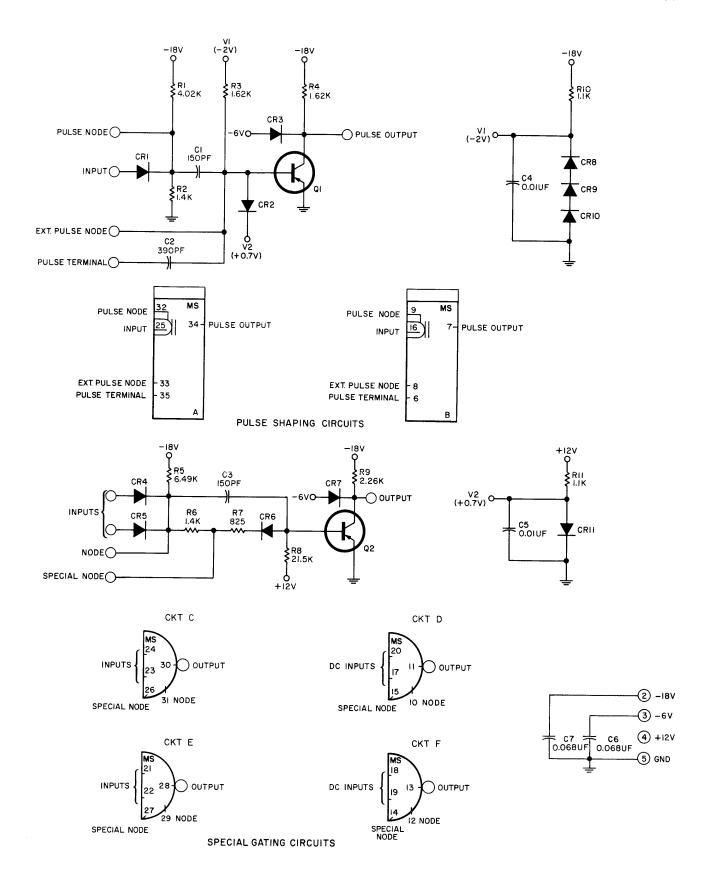
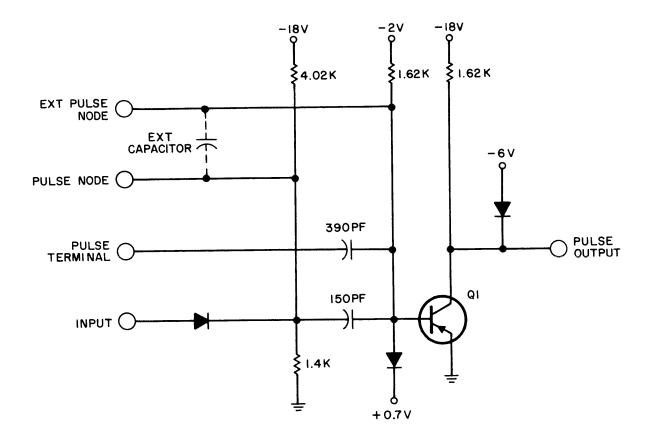


Figure 3-23.2. Gate Shaper PAC, Model MS-30, Schematic and Logic Diagram

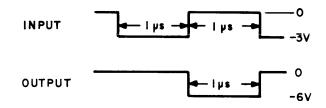


THE VALUE OF THE EXTERNAL CAPACITOR CAN BE CALCULATED FROM THE FOLLOWING EQUATION:

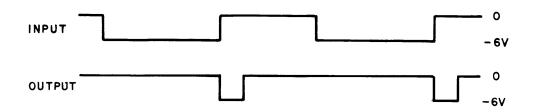
FOR EXAMPLE: A 10 USEC PULSE IS REQUIRED: $C = (10 - .24) \times 1.07 \times 10^{3} = 9.76 \times 1.07 \times 10^{3} = 10,400 \text{ PF} = 0.01 \text{UF}$

Figure 3-23.3. Pulse Shaper (Using External Capacitor), Simplified Schematic Diagram

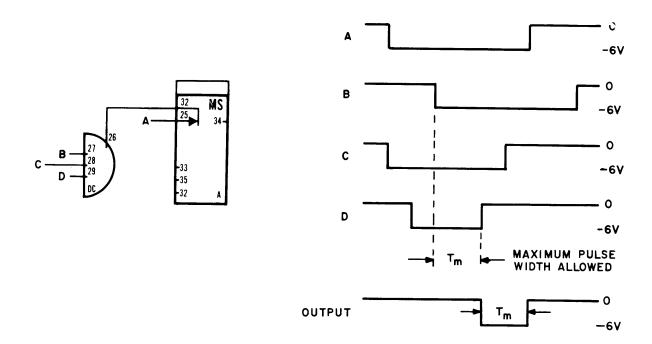
3-146



MINIMUM INPUT REQUIRED FOR A Iµs PULSE OUTPUT



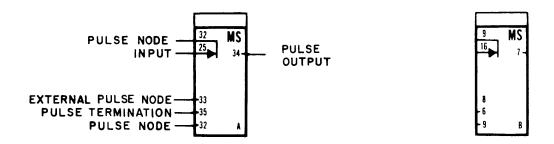
TYPICAL INPUT-OUTPUT WAVEFORMS



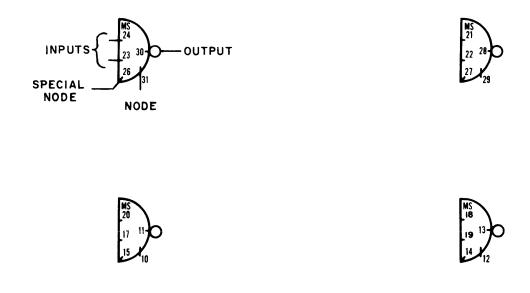
TYPICAL MULTIPLE INPUT WAVEFORMS REQUIRED FOR MAXIMUM OUTPUT PULSE WIDTH

Figure 3-23.4. Pulse Shaper Waveforms

3/2/64

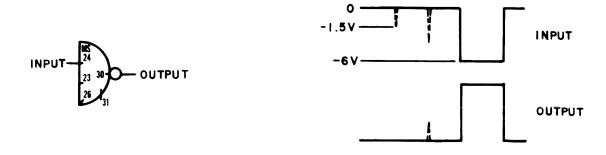


PULSE SHAPERS

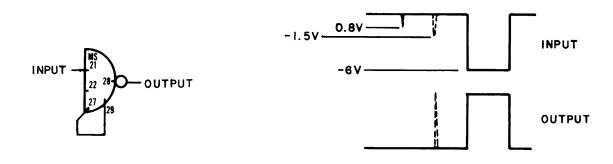


SPECIAL GATES

Figure 3-23.5. MS-30 Block Diagram



STANDARD NAND GATE



SPECIAL GATE

Figure 3-23.6. Comparison Waveforms Showing Gate Noise Protection

3/2/64 3-149/3-150

3-23A MULTIPLEXER SWITCH PAC, MODEL MX-30

GENERAL DESCRIPTION

The Multiplexer Switch PAC, Model MX-30 (Figure 3-23A.1), contains ten solid-state switching elements for use in a ten-channel multiplexer. A complete multiplexer consists of an MX-30 PAC enclosed within the feedback loop of an operational amplifier such as the OA-30 PAC (Figure 3-23A.3).

Each channel consists of a precision input resistor, a precision feedback resistor, and a quasi-error point switch. When a channel is not selected, its input resistor is shorted to the signal return; when selected, its input resistor is connected to the summing junction of an operational amplifier.

CIRCUIT FUNCTION

Each encapsulated switch module (Figure 3-23A.2) contains a solid-state, single-pole, double-throw, voltage-controlled switch. The select input is DC coupled, so there are no restrictions on maximum channel select interval or minimum channel select rate.

A select input at 0 volt causes the corresponding drive transistor to saturate, and connect the analog signal to the output. When a select input is at -6 volts, the associated channel signal is connected to the signal return.

When a channel is not selected, both its input resistor and feedback resistor are grounded. When a channel is selected, the input resistor is connected to the operational amplifier summing junction, a virtual ground. In both cases, there is a constant and precise input impedance. For the selected channel, the switch resistance is enclosed within the amplifier feedback loop, minimizing the effect of the resistance in the multiplexer. Critical circuitry is protected against surface leakage by guarding the summing junction with grounded printed circuit etch.

APPLICATIONS

The location of the MX-30 PAC with respect to the operational amplifier must be carefully considered. The lead from the multiplexer output to the amplifier input should be direct and as short as possible. In addition, the lead should be protected from noise pickup by shielding all wiring in the immediate vicinity that carry high-frequency signals, rather than using a shielded lead for the error point connection. Crosstalk can be minimized by using shielded wiring for the analog inputs and by dressing the leads away from the output terminal. From the wiring standpoint, the multiplexer and amplifier should be as close as possible. However, if the analog inputs contain high levels of high-frequency components, an Electrostatic Shield PAC, Model ES-31, should be used between the PAC and the operational amplifier.

The operational amplifier should be protected from input overloads if the amplifier recovery time cannot be tolerated. The amplifier may be overloaded by an excessive analog input amplitude or by leaving the feedback loop open for more than one microsecond.

4/15/64 3-150A

To prevent the latter case, one channel must be selected at all times, with a maximum of one microsecond between the end of one select input signal and the start of another.

The select inputs can be driven directly from an Octal/Decimal Decoder PAC, Model OD-30.

The power ground and the reference return are not connected on the PAC so that an optimum grounding system may be implemented. However, the ground and the return must be connected together at one point.

SPECIFICATIONS

The performance of the MX-30 is primarily a function of the characteristics of the associated operational amplifier. The specifications below apply to the MX-30 only.

Channe.	l Input
---------	---------

Voltage: ±10 volts (max)
Impedance: 100 K ±0.01%

Select Input

Select: 0 volt
Not select: -6 volts
Loading: 1 U load

Feedback Input

Connect to the output of an operational amplifier.

Impedance: 10 K (Each of the 10 feedback resistors is 100 K \pm 0.01%).

Output

Connect to the summing junction of an operational amplifier.

Delay: $5 \mu sec$ (approx) excluding operational amplifier.

Current Requirements

+12 V: 16 ma - 6 V: 16 ma

Crosstalk

DC: -100 db (typ)
100 CPS: -86 db (typ)
1 KC: -66 db (typ)
10 KC: -46 db (typ)

Offset (referred to full scale)

Channel to channel: 0.02%

Drift: 0.005%(typ) 0.08% (max)

Operating Temperature Range

0°C to +55°C

Power

0.3 watt

Polarization

Pins 4 and 20

Color Code

Long: Orange Short: Yellow

3-150B 4/15/64

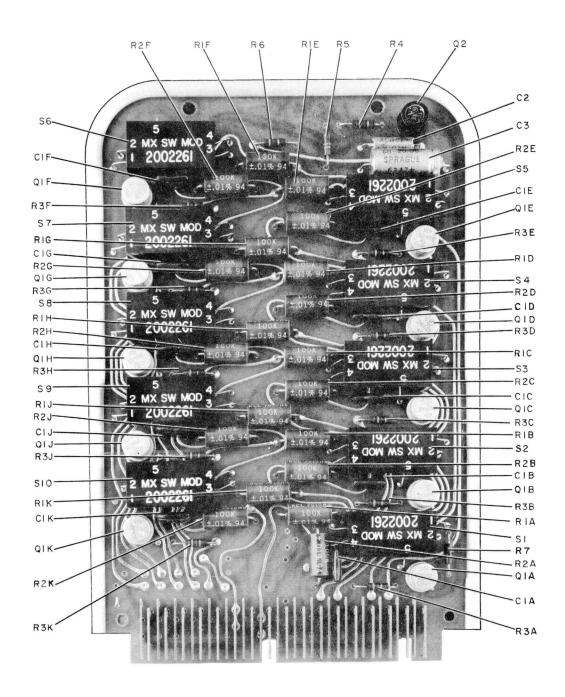


Figure 3-23A.1. Multiplexer Switch PAC, Model MX-30, Parts Location

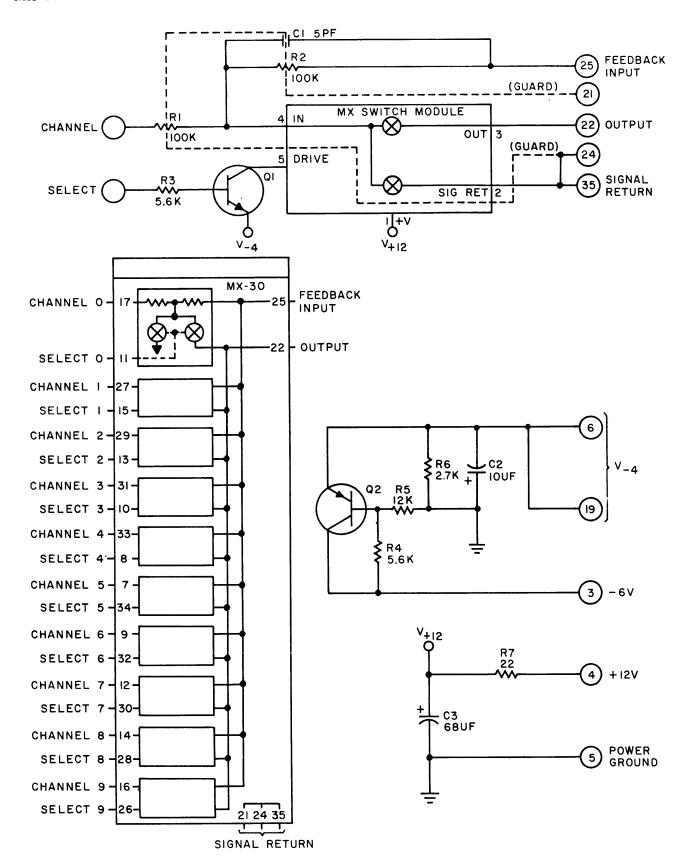


Figure 3-23A.2. Multiplexer Switch PAC, Model MX-30, Schematic and Logic Diagram

3-150D 4/15/64

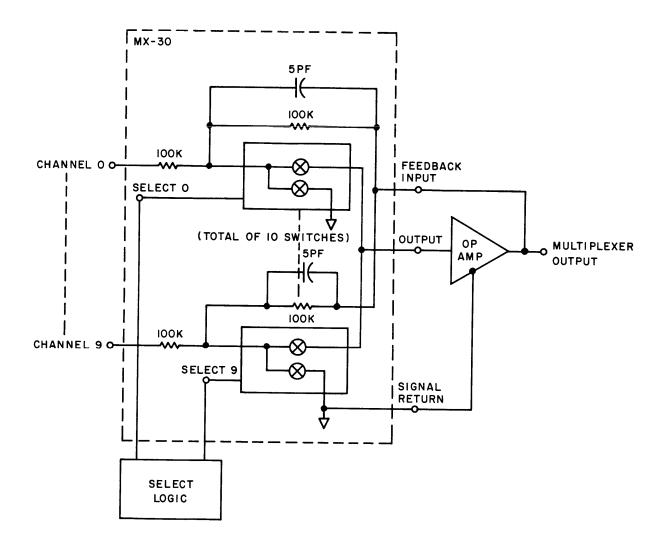


Figure 3-23A.3. Multiplexer Functional Block Diagram

3-24 NIXIE DRIVER PAC, MODEL ND-31

GENERAL DESCRIPTION

The Nixie Driver PAC, Model ND-31, (figures 3-24.1 and 3-24.2) can decode a four-bit binary coded decimal (BCD) input, store the result, and drive a Nixie display device. The BCD input information is applied to the PAC, strobed, and then decoded to a decimal number. The result is stored and retained until a clear signal is applied. The circuit is designed around the silicon controlled rectifier (SCR), which provides storage and power amplification. Two external supply voltages of +175 volts and +80 volts are required in addition to the regular S-PAC voltages.

The PAC is coated with a layer of epoxy on the etched side of the board to provide protection from dust or moisture, and prevent shorting between etches or contact with the Nixie tube high voltage.

CIRCUIT FUNCTION

BCD Data Input. Diode gating is utilized to select one of the ten SCR switches in accordance with the BCD input information. Both polarities of the inputs, assertion and negation, are required. One input to each gate is a strobe signal. The S-PAC convention defines -6 volts as a logic ONE and ground as the logic ZERO. The inputs to the ND-31 are consistent with this convention. The internal logic of the gating structure is reversed, due to the positive polarity gate used to control the SCRs.

Output. The ND-31 (figure 3-24.3) contains ten identical output circuits, each one associated with one of the decimal numbers from 0 to 9. The SCR and its associated number is turned on when all its gate inputs are at 0 volt. This puts a positive bias on the SCR, which turns it and its associated decimal number on. Any input at -6 volts will inhibit the gate and keep the SCR biased off.

The Nixie anode is connected through a limiting resistor to +175 volts and each Nixie cathode is connected to an SCR anode. The ON SCR will have its anode voltage near ground, allowing one section of the Nixie to illuminate.

CLEAR input. The clear circuit is a direct-coupled transistor switch. The CLEAR input is inactive at -6 volts since the transistor is biased off, allowing current to flow into the ON SCR. A positive reset pulse is needed to clear previous information prior to insertion of a new decimal digit. When the CLEAR input is at 0 volt, the transistor is switched on. The collector heads towards -6 volts, and the current to the SCR is removed. The SCR should also be reverse-biased at this time by deactivating the STROBE input, to ensure turnoff. The width of the CLEAR signal should be 80 μ sec minimum to 10 μ sec maximum.

STROBE Input. A STROBE input is provided to control the timing of data insertion to the diode gates. The strobe amplifier is a standard S-PAC NAND circuit and is used to minimize load requirements for this signal. The STROBE input is activated by a negative pulse of 40 μ sec or more in width which allows the SCR to turn on. The STROBE signal is effective at the -6-volt level and ineffective at 0 volt.

3/2/64

Non-Standard Supply Voltages. The current requirements for the +175-volt and +80-volt supplies are given in the specifications. The peak current is required only when the CLEAR signal is applied. In normal operation one number is lit and the circuit requires the average current; the minimum current is used when no numbers are lighted. With a low clearing duty cycle, a power supply with a well-filtered output would only have to supply the average current.

SPECIFICATIONS

Input Loading

BCD data: 1 U load each

Clear: 1 U load Strobe: 1 U load

Activation of Inputs

	<u>Active</u>	<u>Inactive</u>
BCD data:	-6 V	Ground
Clear:	Ground, 80 µsec width (min) 10 ms width (max)	- 6 V
Strobe:	-6 V, 40 µsec width (min)	Ground

Output Drive Capability

B5031 Nixie tube or equivalent

Nonstandard S-PAC Voltage Requirements

	Peak	Average	Minimum
+175 V: +5%	25 ma	14 ma	10 ma
+80 V: +10%	10 ma	6 ma	-2 ma

Standard S-PAC Voltage Requirements

+12 V: 13 ma
-18 V: 33 ma
- 6 V: 9 ma (reverse current into supply)

Total Power

3.0 watts (average)

Polarization

Pins 4 and 22

Handle Color Code

Long: Orange Short: White

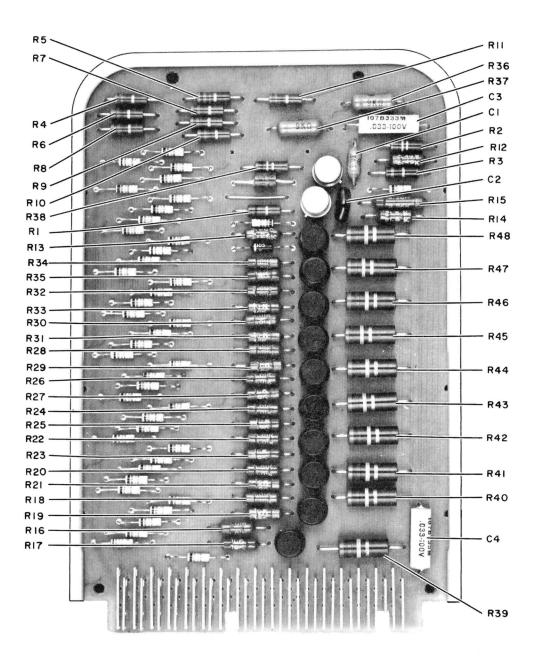


Figure 3-24.1. Nixie Driver PAC, Model ND-31, Parts Location (Resistors and Capacitors)

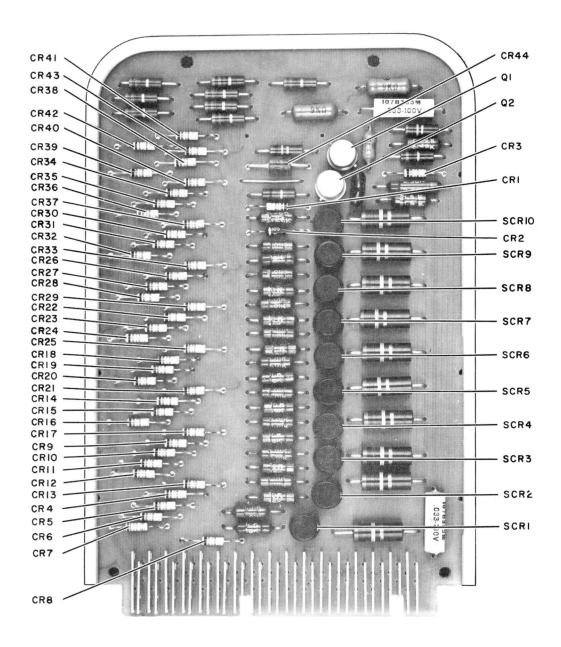


Figure 3-24.2. Nixie Driver PAC, Model ND-31, Parts Location (Diodes, Silicon Controlled Rectifiers and Transistors)

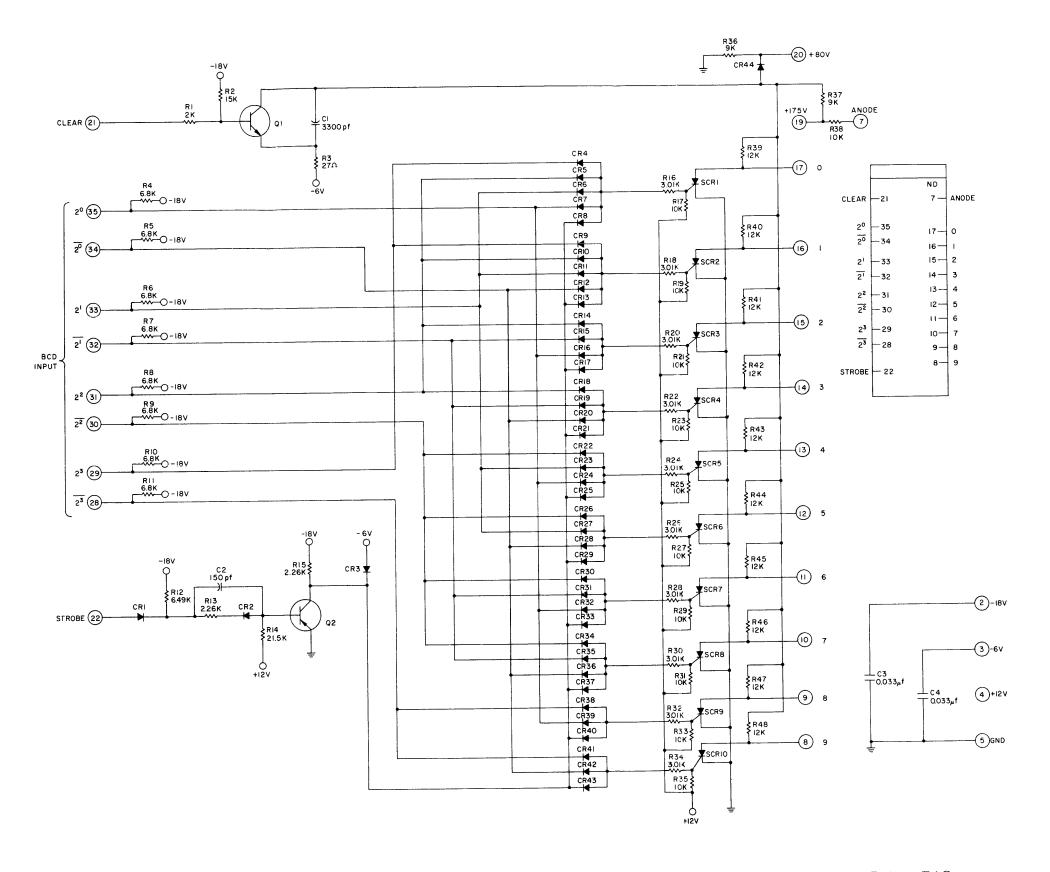


Figure 3-24.3. Nixie Driver PAC, Model ND-31, Schematic and Logic Diagram

3-24A OPERATIONAL AMPLIFIER PAC, MODEL OA-30

GENERAL DESCRIPTION

The Operational Amplifier PAC, Model OA-30 (Figures 3-24A.1 and 3-24A.2) is a solid-state, chopper-stabilized, high-gain, wide-band, DC amplifier. The amplifier has an open loop DC gain of 7.5 x 10^7 , and a -6 db/octave rolloff to less than unity gain at 3 MC. The PAC features excellent stability (5000 pf capacitance at the output will not cause oscillation), high rate of change output capability (10 volts/ μ sec at full load), high gain, and low noise.

With the standard input and feedback networks the PAC is a minus unity gain amplifier with output capability of ±10 volts at 20 ma. In this configuration, the frequency response of the circuit will be flat to 160 KC, then roll off at -6 db/octave.

CIRCUIT FUNCTION

The PAC (Figure 3-24A.3) contains a transistor chopper, a multivibrator operating at 750 CPS, a chopper amplifier, a wide-band DC amplifier, a 10 K precision input resistor (R_{IN}) and a 10 K precision feedback resistor (R_{F}). A feedback capacitor (C_{F}) is used to roll off the gain such that the maximum rate of change at the output is achieved without rate limiting when a full-scale step input is applied. Several gain configurations and suggested input and feedback component values are listed below. These components can be mounted on standoffs to facilitate customer selection. The OA-30 is shipped with the standard values indicated below.

	Gain	$\frac{R_{IN}}{}$	$\frac{R_{F}}{}$	$\frac{c_F}{}$
(standard)	1	10 K	10 K	68 pf
	1	100 K	100 K	8 pf
	10	10 K	100 K	8 pf
	1/10	100 K	10 K	68 pf

Input signals are chopped, amplified, and then synchronously full-wave demodulated in the chopper section, before being applied to the main wide-band amplifier. A unique push-pull output stage is used which produces high output current capability, low output impedance, and minimal crossover distortion. A smooth -6 db/octave rolloff is assured by closely controlled frequency break points.

A zero-adjust potentiometer is provided to compensate for chopper offset. With the input (pin 16) connected to the signal return (pin 19), the potentiometer is used to adjust the voltage between the output (pin 34) and the signal return (pin 35) to 0 volt ± 0.5 MV.

Critical circuitry is protected against surface leakage by guarding the summing junction with grounded printed circuit etch.

Standoffs are provided for customer mounting of two additional input resistors.

4/16/68 3-156A

APPLICATIONS

The PAC can be used to perform a wide variety of functions by changing the input and feedback networks. To realize maximum accuracy and performance, the full scale input and feedback currents should be between 0.1 ma and 1.0 ma, corresponding to resistances between 10 K and 100 K for a 10-volt signal.

The power ground and the signal return are not connected on the PAC so that an optimum grounding system may be implemented. However, the ground and the return must be connected together at one point.

Note

The amplifier is not short-circuit protected and care must be taken to prevent shorting the output to ground.

SPECIFICATIONS

Gain	Noise (referred to input)	
DC: -7.5 X 10 ⁷ (approx)	0.5 MV peak to peak (typ)	
AC: -3 X 10 ⁴ (approx)	1.0 MV peak to peak (max)	
Input Impedance (Error Point)	Zero Stability	
DC: 200 K (approx)	4 μ volts per °C (typ)	
AC: 14 K (approx)	20 μ volts per °C (max)	
Operating Temperature Range	Recovery From Overload	
0°C to +55°C	10 sec (approx)	
Temperature Drift (referred to 10 V	Polarization	
output, 0°C to +55°C)	Pins 14 and 28	
0.002% (typ)	Color Code	
0.020% (max)	Long: Green	
Output Signal	Short: Red Current Requirements	
Voltage: ±10 volts (max)		
Current: 20 ma (max)		
Time rate of change: $dv/dt = 10 \text{ volts/}\mu\text{sec}$ at full load	+12 V: 35 ma (plus the positive load current)	
*Full load: 500 ohms and 500 pf to ground	- 6 V: 6 ma	
Capacitive load: 5000 pf (max) for stability	-18 V: 30 ma (plus the negative load current)	
Frequency Response	Power	
Gain-bandwidth product: 3.0 MC (with	1.4 watts	

a -6 db/octave rolloff)

^{*}Excessive loads could severely damage the amplifier.

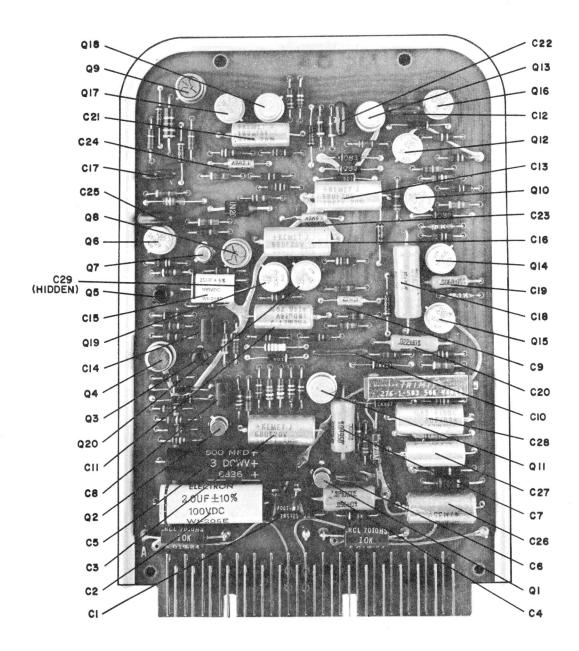
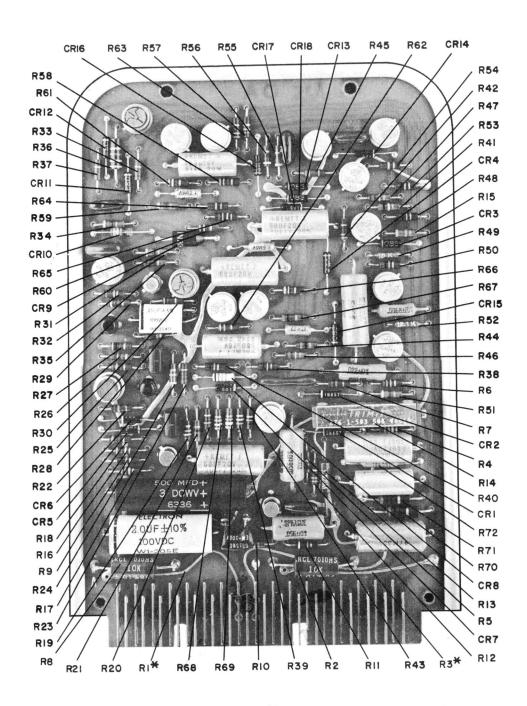


Figure 3-24A.1. Operational Amplifier PAC, Model OA-30, Parts Location (Capacitors and Transistors)



* OPTIONAL COMPONENT

Figure 3-24A.2. Operational Amplifier PAC, Model OA-30, Parts Location (Diodes and Resistors)

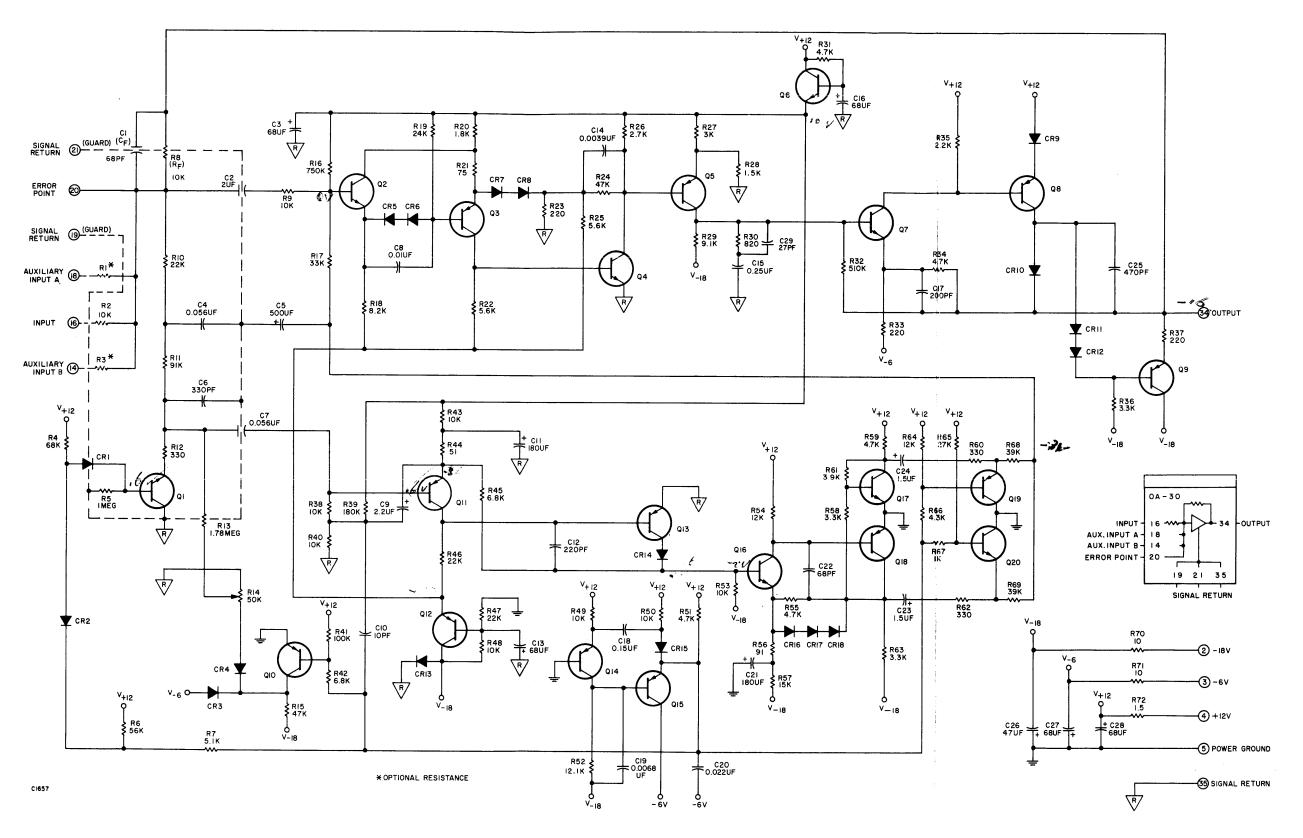


Figure 3-24A.3. Operational Amplifier PAC, Model OA-30, Schematic and Logic Diagram

3-25 PLUG-IN POWER SUPPLY, MODEL PB-30

GENERAL DESCRIPTION

The Plug-In Power Supply, Model PB-30 (figures 3-25.1 through 3-25.3), is a small, integrally packaged unit that can be mounted directly in an S-BLOC. The supply occupies 5 PAC slots from a total of 19 slots in a low-density BLOC (BL-30, BL-31), or 7 of 28 slots in a high-density BLOC (BL-32, BL-33).

The PB-30 supplies current at the three S-PAC digital voltage levels (+12 V, -6 V, and -18 V) and can drive approximately one BLOC of S-PACs. The number of PACs that can be powered from the supply depends on the current requirements of the PACs used.

Line voltage is applied and S-PAC voltages are taken through the printed circuit board pin connections. No additional output power wiring is needed since output power pin numbers correspond to the standard S-PAC input power pin numbers, and the power pins are jumpered together on the BLOC. Pin 2 on the power supply and pin 2 on any S-PAC represent -18 V.

An adapter kit is included to allow the AC input power to be controlled from the wiring side of the block. The kit consists of a prewired TV-type connector, a line cord, and a toggle switch mounted in a bracket which attaches to the side of the BLOC.

The front panel includes the following features:

- 1. ON/OFF AC power switch
- 2. Power on lamp
- 3. Two fuses. Protection provided for the ac input (1A), and negative voltage outputs (3 A).
 - 4. Four test points for three voltage levels and ground.
 - 5. Voltage adjustment potentiometers for -18 V and -6 V outputs.

CIRCUIT DESCRIPTION

The PB-30 (figure 3-25.4) contains two dynamically regulated circuits and one Zener regulated circuit, which combine to provide the three S-PAC voltage levels. The rated current output for each voltage is proportional to the relative currents required in a system.

The -18 V supply section consists of a full-wave rectifier, filter, output sampler, error detector, control circuit, and a series regulated output stage. The voltage adjustment potentiometer allows a variable portion of the output voltage to be sampled and compared in the feedback circuitry, and produce an adjustable output voltage.

The -6 V supply section is similar to the -18 V section, except that a parallel regulated output stage is used. This type of regulation allows the supply to furnish the reverse current flow (clamp current) required by an S-PAC system.

A 12-volt Zener diode is used to provide the regulated \pm 12 V output. The supply GND is connected internally to the chassis.

SPECIFICATIONS

Input Powe	er Requirements	Stability	
Voltage: 1	17 V <u>+</u> 5% (Pins 31 and 34)	Better than +1%	
Frequency	: 55 to 65 cps	Ripple	•
Current:	0.8 A (max)	-18 VDC	75 mv (max)
		-6 VDC	75 mv (max)
Output		+12 VDC	110 mv (max)
-18 VDC	0 to 1.5 A		
-6 VDC	0 to 0.8 A (reverse	Operating	Temperature Range
+12 VDC	current) 0 to 0.2 A	0°C to 50°C at full load	
Voltage Ac	liustment	Size	
		4-5/8" hig	h x 3-7/8" wide x 7-1/2" deep
-18 VDC	<u>+5%</u>	Occupies five slots in a low-density BLC	
-6 VDC	±5%	seven slots in a high-density BLOC	
+12 VDC	None		
Regulation	1	Weight	
-18 VDC	±2%	5 lbs. (ma	x)
-6 VDC	±2%		
+12 VDC	+12%, -6%		

CAUTION

Due to the magnitude of the ripple in the 12-volt supply, it is not recommended that the PB-30 be used with Serial Memory S-PACs.

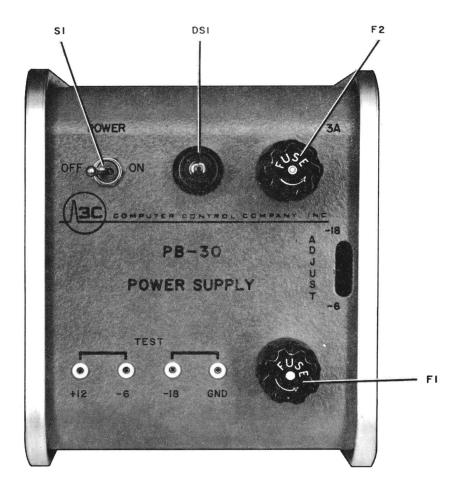


Figure 3-25.1. Plug-In Power Supply, Model PB-30

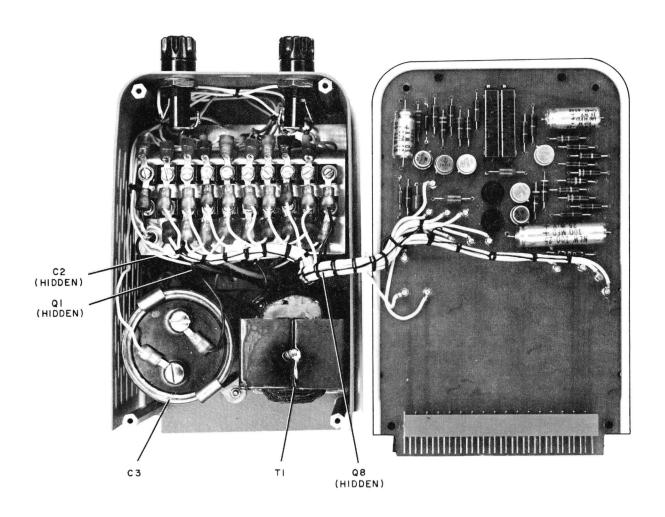


Figure 3-25.2. Plug-In Power Supply, Model PB-30, Disassembly

3/2/64 3-161

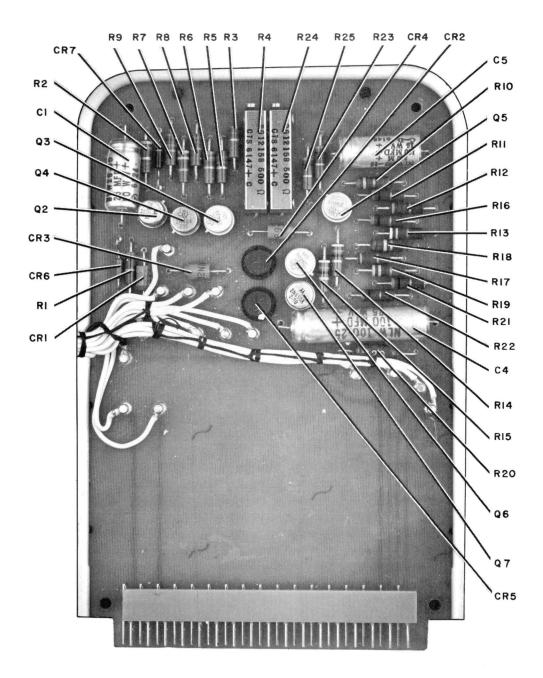


Figure 3-25.3. Plug-In Power Supply, Model PB-30, Parts Location

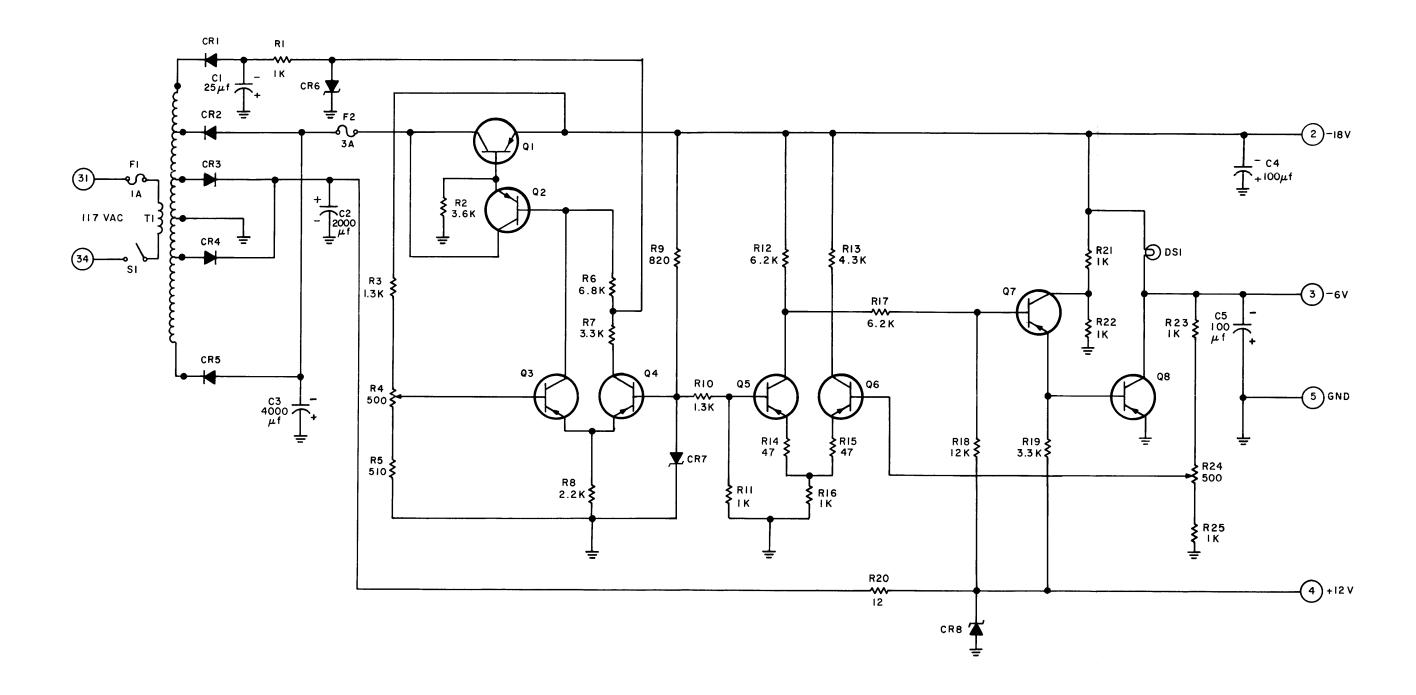


Figure 3-25.4. Plug-In Power Supply Model PB-30, Schematic Diagram

3-26 IDCU POWER SUPPLY, MODEL PD-30

GENERAL DESCRIPTION

The IDCU Power Supply, Model PD-30 (Figures 3-26.1 through 3-26.4), is a small, integrally packaged unit that mounts directly in an S-BLOC. The supply occupies 5 of the 19 slots in a low-density BLOC (BL-30, BL-31), or 7 of the 28 slots in a high-density BLOC (BL-32, BL-33).

The PD-30 consists of a high-voltage power supply and two independent reset driver circuits for use with Indicating Decimal Counting Unit (IDCU) PACs. The power supply section supplies current at -120 VDC and can drive 16 IDCU PACs. Each of the reset driver circuits permits simultaneous clearing to ZERO of eight IDCU counters when the driver output is connected to the direct reset inputs of the counters. Use of the driver circuits provides a convenient logic reset of the counters.

The front panel includes the following features.

- 1. ON/OFF POWER switch
- 2. POWER ON lamp
- 3. Fuses (2). Protection for the AC input (3A) and the -120 VDC output (3/4A)
- 4. Test points (2) for -120 VDC and ground
- 5. Voltage adjustment potentiometer

CIRCUIT DESCRIPTION

The power supply section of the PD-30 (Figure 3-26.5) consists of a full-wave bridge rectifier, an RC filter, and a series regulator. Voltage adjustment potentiometer R13 allows a variable portion of the output voltage to be sampled and compared in the feedback circuitry, thus producing an adjustable output voltage. Supply ground is connected internally to the chassis.

The reset driver section consists of two independent amplifier circuits that allow standard S-PAC signals to control the high-level direct reset inputs of IDCU counters. If either or both inputs of a reset driver are at ground, the counter is allowed to advance. If both inputs are at -6 volts or are not connected, the counter is reset to the ZERO state. Pin 32 must be connected to pin 34 when the reset driver is used.

An adapter kit is provided to allow the AC input power to be controlled from the wiring side of the BLOC. The kit consists of a prewired TV-type connector, a line cord, and a toggle switch mounted in a bracket which attaches to the side of the BLOC.

SPECIFICATIONS

Power Supply Section

Input Power Requirements

Voltage: 117 V ±5% (pins 26 and 29)

Frequency: 55 to 65 CPS

Current: 0.75 amp (max)

Output

-120 VDC 0 to 0.42 amp (pin 34)

3/15/64

SPECIFICATIONS (Continued)

Voltage Adjustment

±5%

Regulation

Better than ±2%

Stability

Better than ±2%

Ripple

200 MV (max)

Reset Drivers

Frequency of Operation

DC to 10 KC

Input Loading

1 W load each

Input Pulse Width

To reset: 3 μsec (min) pulse at -6 V

Circuit Delay

Reset action: 0.3 µsec (typ), 1 µsec (max) Non-reset action: 2.0 µsec (typ), 5 µsec (max)

Output Drive Capability

8 IDCU direct reset inputs each

Output Voltages

GND (reset)

-80 V

Current Requirements

-18 V: 4 ma +12 V: 2 ma

-120 V: 7 ma (connect pins 32 and 34)

PD-30 PAC

Operating Temperature Range

0°C to 45°C at full load

Size

4-5/8" high x 4-1/8" wide x 7-5/8" deep

Occupies five slots in a low-density BLOC; seven slots in a high-density BLOC.

Weight

6-1/2 lb (max)

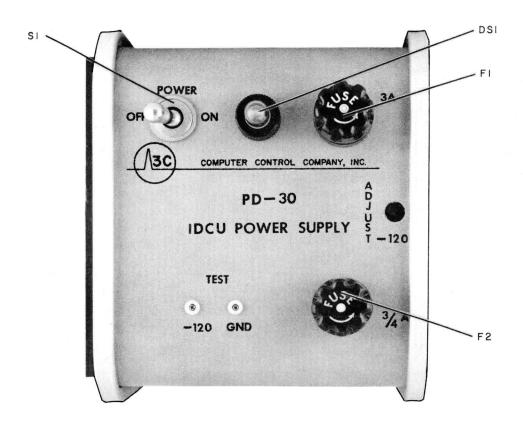


Figure 3-26.1. Plug-In Power Supply, Model PD-30, Front Panel

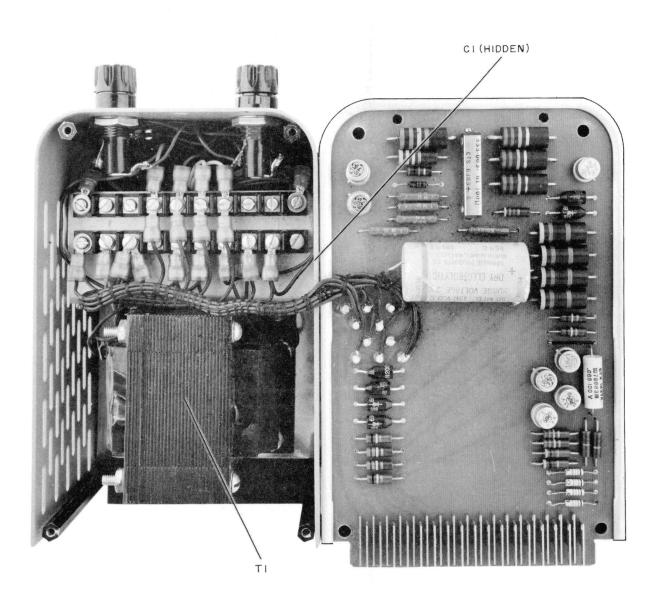


Figure 3-26.2. Plug-In Power Supply, Model PD-30, Disassembly

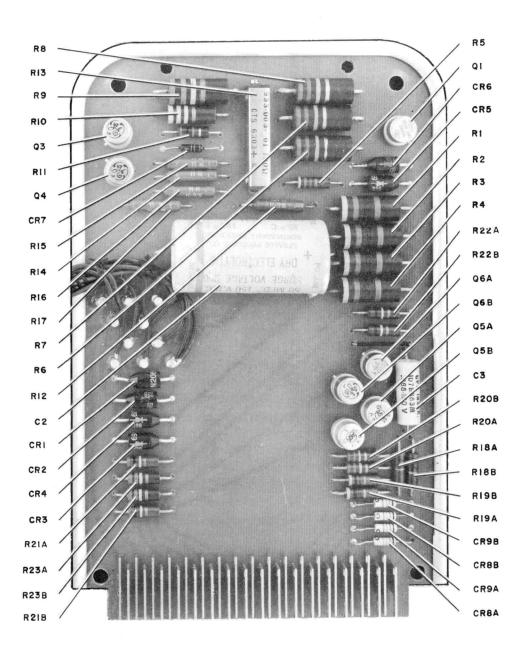


Figure 3-26.4. Plug-In Power Supply, Model PD-30, Parts Location

3-169A

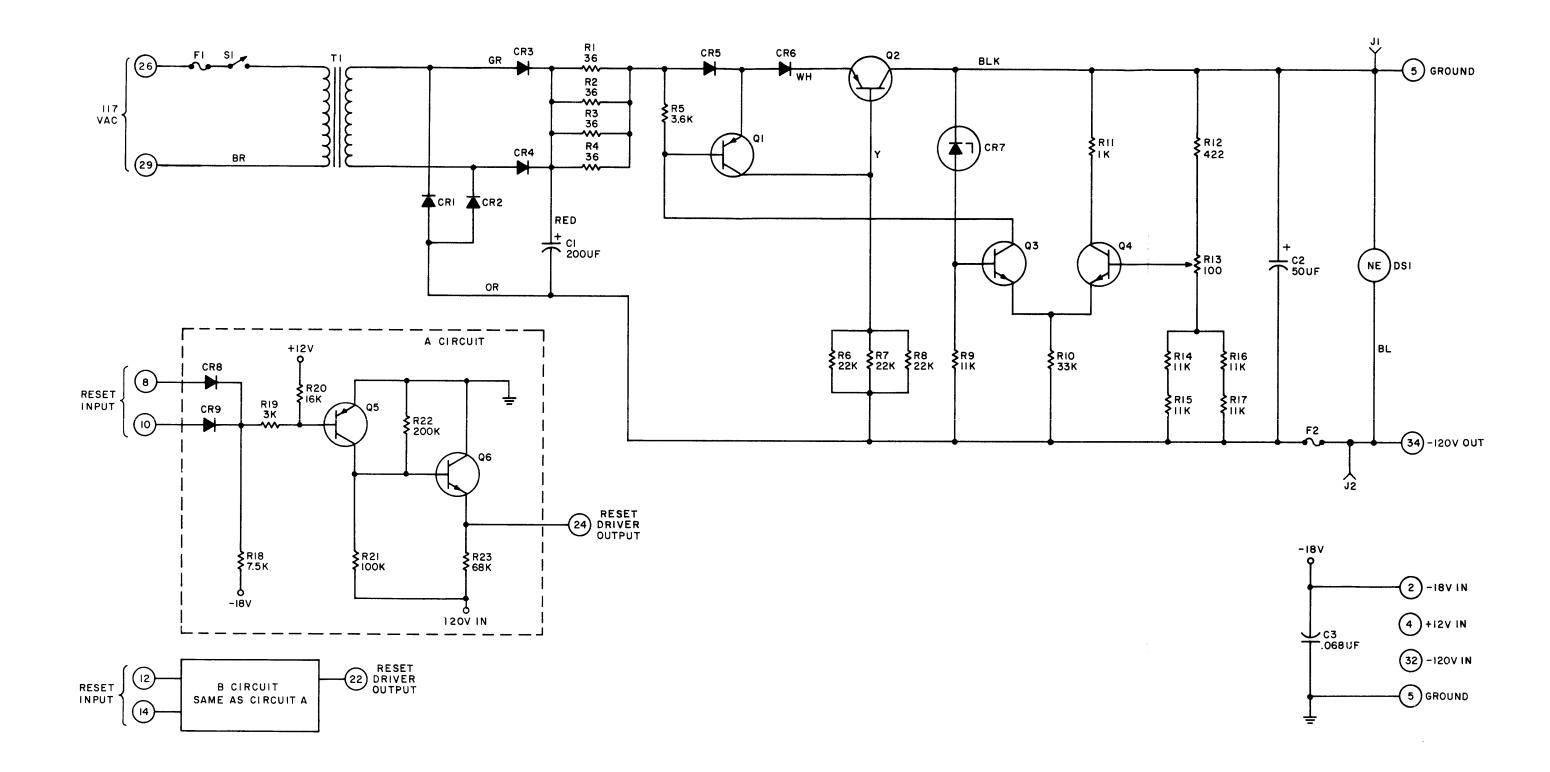


Figure 3-26.5. Plug-In Power Supply, Model PD-30, Schematic Diagram

3-169B/3-170

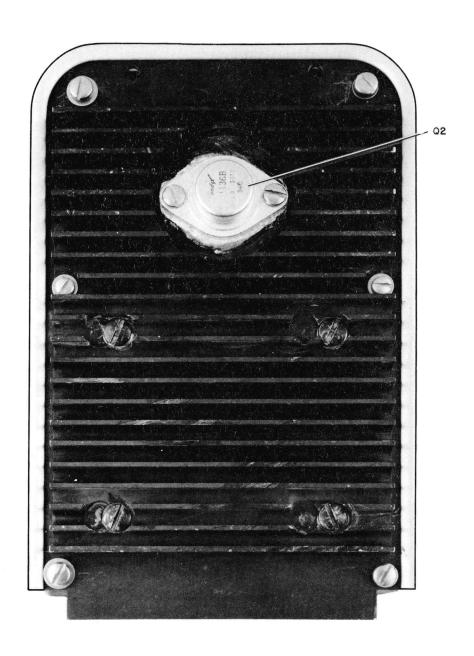


Figure 3-26.3. Plug-In Power Supply, Model PD-30, Parts Location

3/15/64

3-26A PRECISION REFERENCE PAC, MODEL PR-30

GENERAL DESCRIPTION

The Precision Reference PAC, Model PR-30 (Figures 3-26A.1 and 3-26A.2), is a precision, shunt-regulated, voltage supply. The PAC provides an output of either +10 volts or -10 volts, and is intended for use with equipment which requires reverse current from a reference supply. The PAC can absorb 90 ma of reverse current.

The PAC has an ultra-stable, internal reference standard but it can also be referenced to an external voltage or current (Figure 3-26A.4 and 3-26A.5). The unique design ensures excellent stability (10 μ f capacitance at the output will not cause oscillation), fast recovery time from load transients (1.5 μ sec approx), and low intrinsic output impedance (0.00016 ohm at DC).

CIRCUIT FUNCTION

The PAC (Figure 3-26A.3) contains a transistor chopper, a multivibrator operating at 750 CPS, a chopper amplifier, a DC amplifier, and a regulated reference standard. The ultra-stable internal reference standard is the voltage across a current regulated Zener diode. This Zener voltage is then used to reference the output voltage (see Table 3-26A.1).

Any errors at the error point are chopped, amplified, and synchronously demodulated in the chopper amplifier, and then amplified by the DC amplifier. This combination provides high DC loop gain and, therefore, high regulation and low output impedance. Excellent stability, low AC output impedance, and fast recovery time from load transients are assured by closely controlled minor feedback loops.

A potentiometer is provided for fine adjustment of the output to 10 volts. To calibrate, connect a high accuracy digital voltmeter between the output (pin 24) and the reference return (pin 9). Apply power and adjust the potentiometer for the desired output voltage in the range of 10 ± 0.05 volts.

Critical circuitry is protected against surface leakage by guarding the summing junction with grounded printed-circuit etch.

APPLICATIONS

The PAC can be used as a reference supply for digital-to-analog converters or other equipment that requires reverse current. It is recommended for use with the Precision Digital-to-Analog Converter PACs, Models LP-30 and LP-31. It can also be used as the reference for the Precision Reference (Slave) PAC, Model PR-31.

The power ground and the reference return are not connected on the PAC so that an optimum grounding system may be implemented. However, the ground and the return must be connected together at one point.

When used with an analog-to-digital or digital-to-analog converter, the PR-30 calibration adjustment should be considered as part of the converter calibration, rather than as an absolute voltage adjustment.

Note

The reference PAC is not short-circuit protected and care must be taken to prevent shorting the output to ground.

SPECIFICATIONS

Voltage:

Output

ment

Current: 90 ma reverse (max) at 25°C

50 ma reverse (max) at 55°C

±10 volts ±0.05 voltadjust-

2 ma forward (max)

Intrinsic Output Impedance

DC: $160 \times 10^{-6} \text{ ohms (typ)}$

AC: 10 X 10⁻³ ohms (typ)

Standard Input

(1) ±6 volts from internally provided standard

(2) An external standard with a magnitude between 1 and 100 volts, and with $R_{\mbox{\scriptsize IN}}$ changed. (Refer to

figure 3-26A.4)

Drift

0.0025% per °C (typ)

0.0060% per °C (max)

Stability (8 hours) 0.005% (typ)

Regulation with Power Supply

Variations

5% change in +12 volts: 0.003% (max)

5% change in -6 volts and -18 volts: 0.001% (max)

Operating Temperature Range

0°C to +55°C

Current Requirements

+12 V: 60 ma

- 6 V: 3 ma (reverse current

into supply)

-18 V: 20 ma

Power

2.0 watts

Polarization

Pins 8 and 16

Color Code

Long: Brown

Short: Blue

TABLE 3-26A. I CONNECTIONS WHEN USING THE INTERNAL STANDARD

Jumper Connections		
+10 V at Reference Output	-10 V at Reference Output	
Pins 22 and 34	Pins 22 and 30	
Pins 18 and 6	Pins 18 and 7	
Pins 10 and 28	Pins 10 and 26	
Pins 15 and 30	Pins 15 and 34	
Pins 32 and 7	Pins 32 and 6	

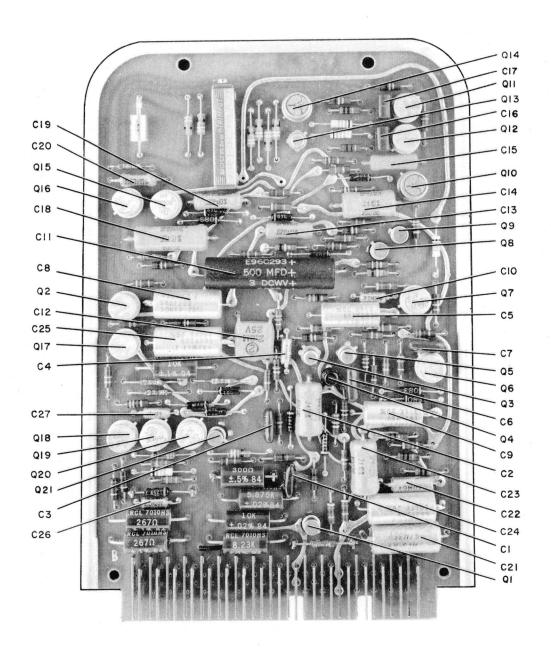


Figure 3-26A.1. Precision Reference PAC, Model PR-30, Parts Location (Capacitors and Transistors)

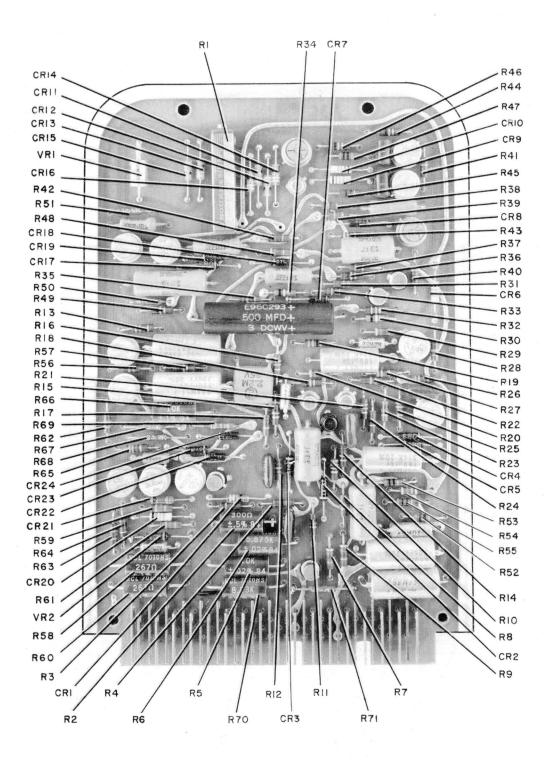


Figure 3-26A.2. Precision Reference PAC, Model PR-30, Parts Location (Diodes and Resistors)

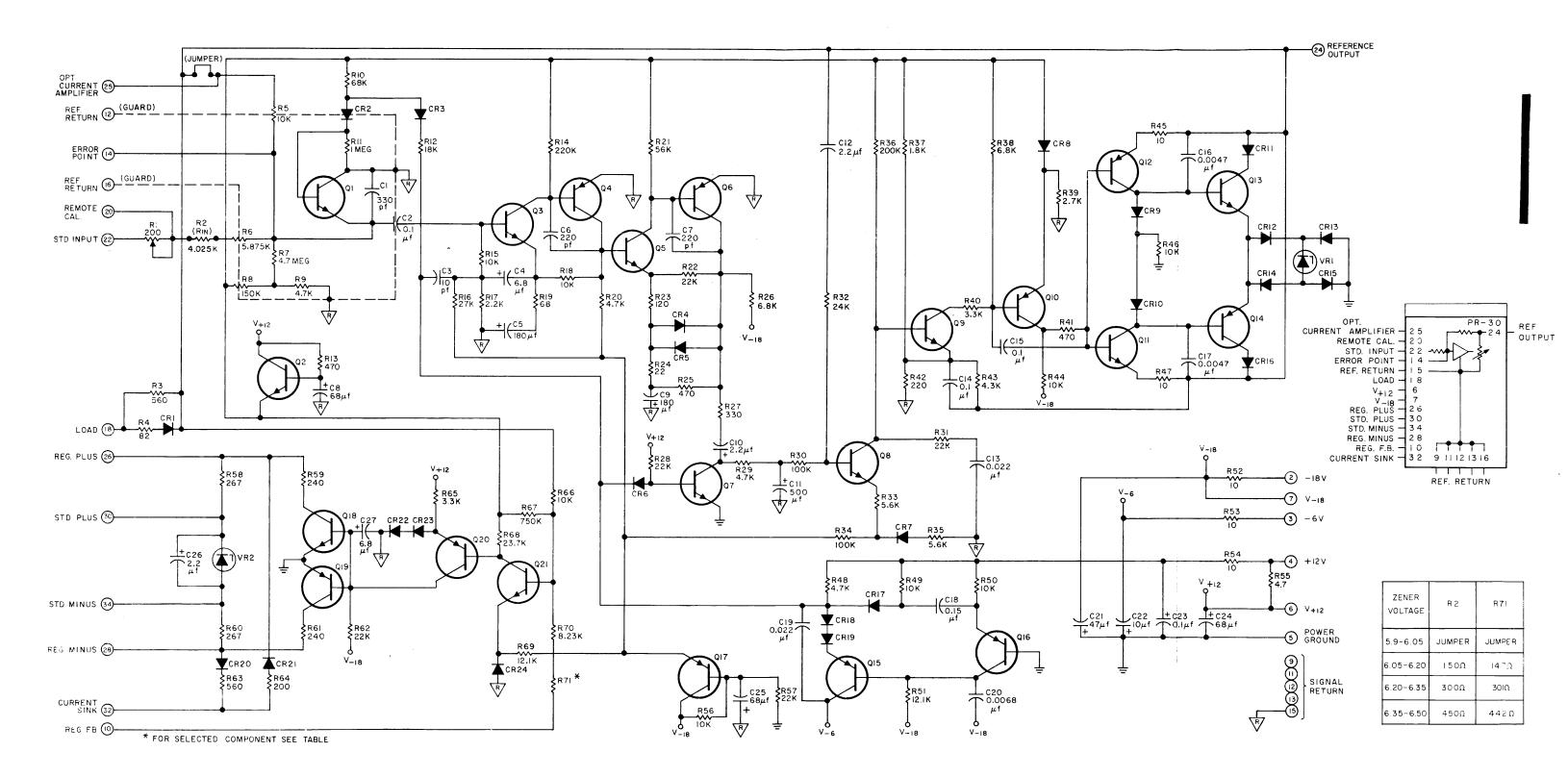
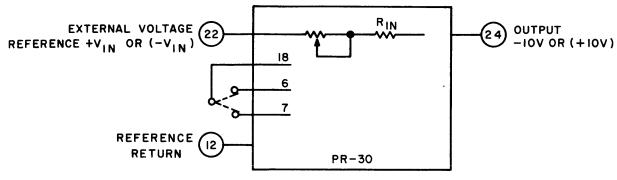


Figure 3-26A.3. Precision Reference PAC, Model PR-30, Schematic and Logic Diagram



THE VALUE OF RIN IS DETERMINED BY:

WHERE: R_{IN} = RESISTANCE IN KILOHMS $|V_{IN}|$ = MAGNITUDE IN VOLTS

PR-30 INPUT	PR-30 OUTPUT	CONNECT PIN 18 TO
+٧	-10V	PIN 7
-v	+10 V	PIN 6

Figure 3-26A. 4. Using an External Voltage Reference

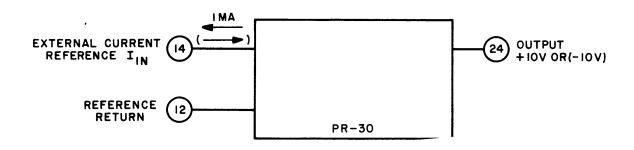


Figure 3-26A. 5. Using an External Current Reference

3-26B PRECISION REFERENCE (SLAVE) PAC, MODEL PR-31

GENERAL DESCRIPTION

The Precision Reference (Slave) PAC, Model PR-31 (Figures 3-26B.1 and 3-26B.2) is a precision shunt regulated voltage supply that is slaved to an external reference. The PAC provides an output of either +10 volts or -10 volts and is intended for use with equipment which requires reverse current from a reference supply. The PAC can absorb 90 ma of reverse current.

The PAC must be referenced to an external voltage or current (Figures 3-26B.5 and 3-26B.6), such as the output of a Precision Reference PAC, Model PR-30 (Figure 3-26B.4). The unique design ensures excellent stability ($10\,\mu f$ of capacitance at the output will not cause oscillation), fast recovery from load transients (1.5 μ sec approximately), and low intrinsic output impedance (0.00016 ohm at DC).

CIRCUIT FUNCTION

The PAC (Figure 3-26B.3) contains a transistor chopper, a multivibrator operating at 750 CPS, a chopper amplifier, and a DC amplifier.

Any errors at the error point are chopped, amplified, and synchronously demodulated in the chopper amplifier, and then amplified by the DC amplifier. This combination provides high DC loop gain and, therefore, high regulation and low output impedance. Excellent stability, low AC output impedance, and fast recovery time from load transients are assured by closely controlled minor feedback loops.

A potentiometer is provided for fine adjustment of the output to 10 volts. To calibrate, connect a high accuracy digital voltmeter between the output, pin 24, and the reference return, pin 9. Apply power and adjust the potentiometer for the desired output voltage in the range of 10 ± 0.05 volts.

Critical circuitry is protected against surface leakage by guarding the summing junction with grounded printed circuit etch.

APPLICATIONS

The PAC can be used as a reference supply for D/A converters or other equipment that requires reverse current. It is recommended for use with Precision Digital-to-Analog Converter PACs, Models LP-30 and LP-31.

The power ground and the reference return are not connected on the PAC so that an optimum grounding system may be implemented. However, the ground and the return must be connected at one point.

When used with an analog-to-digital or digital-to-analog converter, the PR-31 calibration adjustment should be considered as part of the converter calibration, rather than as an absolute voltage adjustment.

Note

The reference PAC is not short-circuit protected and care must be taken to prevent shorting the output to ground.

4/15/64 3-170H

SPECIFICATIONS

Output

Voltage: ±10 volts ±0.05 volt adjust-

ment

Current: 90 ma reverse (max) at

25 °C

50 ma reverse (max) at

55°C

2 ma forward (max)

Intrinsic Output Impedance

DC: 160×10^{-6} ohms (typ)

AC: 10×10^{-3} ohms (typ)

Standard Input

1. ± 10 volts with no change in $R_{\mbox{\footnotesize{IN}}}$

 An external standard with a magnitude between 1 and 100 volts, and with R_{IN} changed (refer to

figure 3-26B. 5)

Drift

0.0025% per °C (typ)

0.0060% per °C (max)

Stability (8 hours) 0.005% (typ)

Regulation with Power Supply Variations

5% change in +12 volts: 0.003% (max)

5% change in -6 volts

and -18 volts: 0.001% (max)

Operating Temperature Range

 $0^{\circ}C$ to $+55^{\circ}C$

Current Requirements

+12 V: 60 ma

-6 V: 3 ma (reverse current into

supply)

-18 V: 20 ma

Power

1.8 watts

Polarization

Pins 8 and 16

Color Code

Long: Brown

Short: Blue

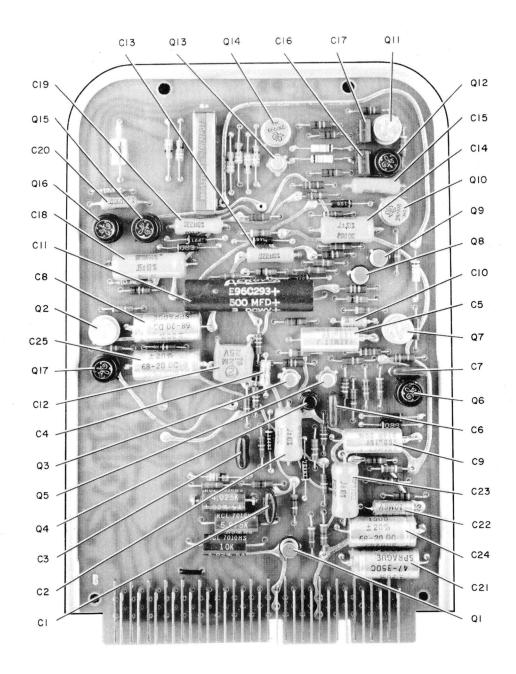


Figure 3-26B.1. Precision Reference (Slave) PAC, Model PR-31, Parts Location (Capacitors and Transistors)

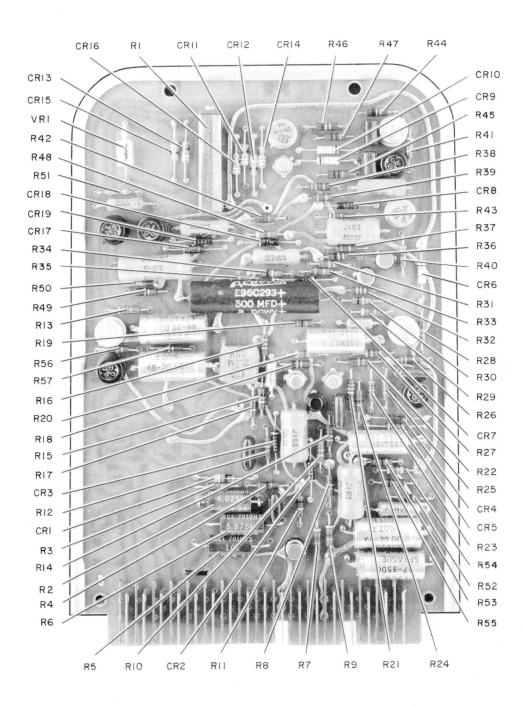


Figure 3-26B.2. Precision Reference (Slave) PAC, Model PR-31, Parts Location (Diodes and Resistors)

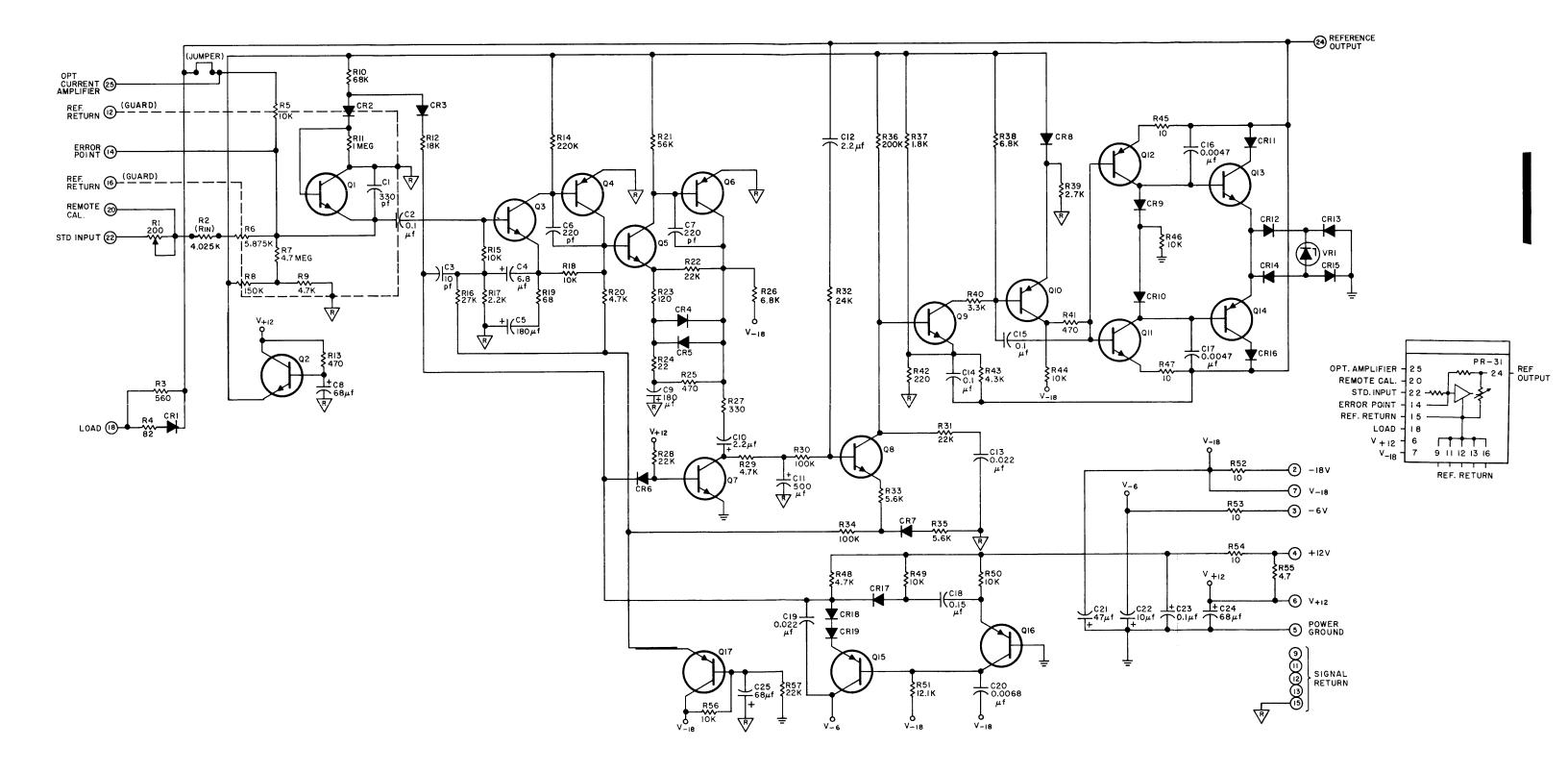
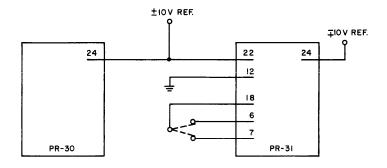


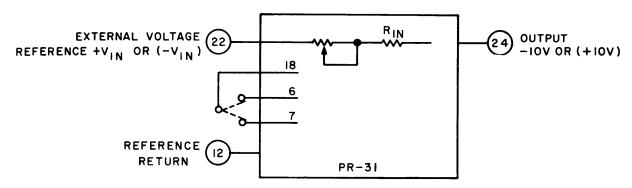
Figure 3-26B.3. Precision Reference (Slave) PAC, Model PR-31, Schematic and Logic Diagram

4/16/68 3-170M/3-170N



PR-31 INPUT	PR-3I OUTPUT	CONNECT PIN 18 TO
+10V	-10 V	PIN 7
-10 V	+10V	PIN 6

Figure 3-26B. 4. Using a PR-30 as the Standard Input



THE VALUE OF RIN IS DETERMINED BY:

 $R_{IN} = |V_{IN}| - 6$

WHERE: R_{IN} = RESISTANCE IN KILOHMS $|V_{IN}|$ = MAGNITUDE IN VOLTS

PR-30 INPUT	PR-30 OUTPUT	CONNECT PIN 18 TO
+٧	-10V	PIN 7
-v	+10 V	PIN 6

Figure 3-26B. 5. Using an External Voltage Reference

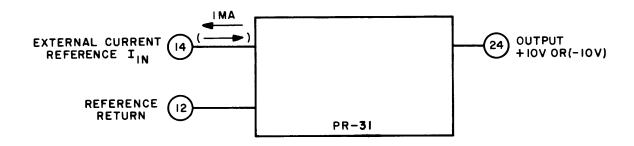


Figure 3-26B. 6. Using an External Current Reference

4/15/64 3-170 P

3-27 POWER SUPPLIES, MODELS RP-30 THROUGH RP-32 *

GENERAL DESCRIPTION

The S-PAC Power Supplies, Models RP-30, RP-31, and RP-32 (figures 3-27.1, 3-27.2, and 3-27.3), are integrally packaged, regulated power sources containing three S-PAC voltages with proportioned current capability. These supplies are substantially derated at rated load and can be operated safely at full load over their specified environmental temperature range. In specific cases, it may also be possible to operate a supply slightly beyond its ratings when used in an air-conditioned laboratory environment. The supplies employ ferroresonant transformers to minimize the effects of line voltage variations and use high-gain, solid-state regulator circuits to achieve the excellent ripple, regulation, and stability specified.

The power supplies are stacked to provide the -6-volt reverse current required by the S-PACs. The power supply schematics are shown in figures 3-27.4 through 3-27.7.

SPECIFICATIONS

NOTE

The following specifications are applicable to all three power supplies, except when otherwise noted.

Input Power Requirements

Input voltage: 105 to 125 V rms

Frequency: 58 to 62 cps, single phase (400 cps on special order)

Output

Model RP-30	Voltage and Load Current -18 VDC, 0 to 2 amp	Input Line Current
1(1 50	-	1.0 amp (max)
	-6 V, 0 to 2 amp (reverse)	
	+12 VDC, 0 to 0.8 amp	
RP-31	-18 VDC, 0 to 8 amp	2.6 amp (max)
	-6 V, 0 to 8 amp (reverse)	
	+12 VDC, 0 to 1.6 amp	
RP-32	-18 VDC, 0 to 20 amp	6.2 amp (max)
	-6 V, 0 to 20 amp (reverse)	
	+12 VDC, 0 to 3 amp	

Regulation

Better than 0.75% for load (0 to maximum) and line voltage change

Stability

0.03%/°C from 10°C to 50°C

^{*}RP-30 supplies bearing serial numbers up to and including No. 280334, RP-31 supplies bearing serial numbers up to and including No. 239541, RP-32 supplies bearing serial numbers up to and including No. 198197, and/or models with "A" prefix and serial No. 201050 - 220253.

SPECIFICATIONS (Continued)

Ripple

Less than 75 mv peak-to-peak at full load

Source Impedance

Consistent with regulation: $Z = \frac{\Delta e}{I_L}$

Ambient Temperature

Rated operation is from 10°C to 50°C at full load. All semiconductors are rated not to exceed junction temperature of 80°C at full load and maximum ambient temperature. When mounted in a relay rack, there must be a 2-inch vertical clearance above or below the supplies.

Size

RP-30: 5-1/4 inches high x 13 inches deep x 19 inches wide (relay rack mounting)

RP-31: 5-1/4 inches high x 15 inches deep x 19 inches wide (relay rack mounting)

RP-32: 8-3/4 inches high x 15 inches deep x 19 inches wide (relay rack mounting)

Weight

RP-30: 30 pounds RP-31: 45 pounds RP-32: 90 pounds

General

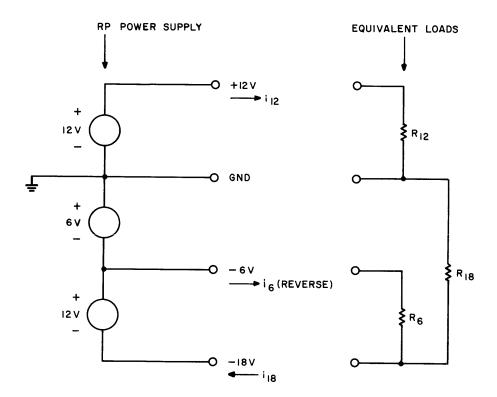
AC and DC power-on indicators are provided.

DC outputs are protected by fast-acting circuit breakers and an indicator is provided to indicate DC power failure.

All supplies are factory preset. Screwdriver adjustment is provided for recalibration if necessary. (Range of adjustment is 2%).

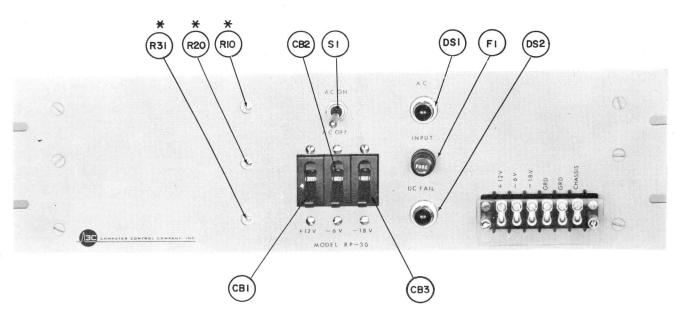
Provision is made for one output terminal on each supply per 2-ampere rating of -18-volt supply. This allows individual power wiring to each S-BLOC, if desired.

Supplies are floating with respect to chassis. Chassis ground terminal is provided.



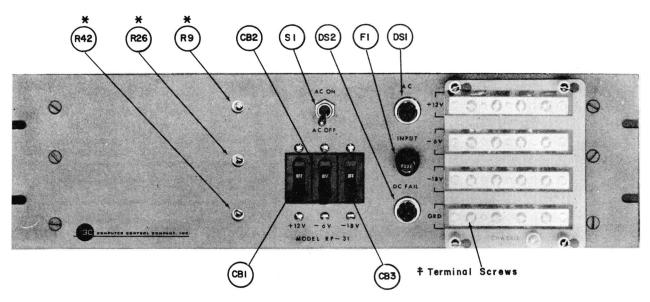
S-PAC EQUIVALENT LOADS TO RP POWER SUPPLY STACKED SUPPLIES

3/2/64



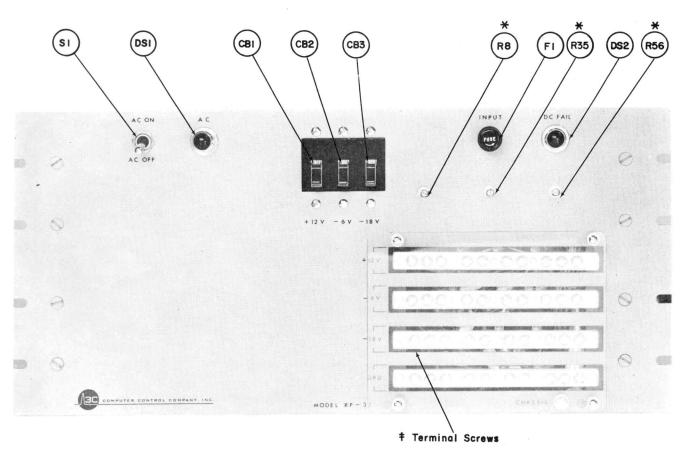
 \bigstar All voltages are factory set within the tolerances specified, and further adjustment is not recommended. However, if it becomes absolutely necessary to perform a field adjustment, do not use measuring equipment that has less than $\pm 0.5\%$ full scale accuracy.

Figure 3-27.1. Power Supply, Model RP-30, Front Panel



- * All voltages are factory set within the tolerances specified, and further adjustment is not recommended. However, if it becomes absolutely necessary to perform a field adjustment, do not use measuring equipment that has less than ±0.5% full scale accuracy.
- Parallel wiring should be used to maintain equal current distribution and voltage stability when the RP-31 is used to supply a group of S-BLOCs. To facilitate parallel connections, screw-taps are provided on the current buss of each available voltage and ground.

Figure 3-27.2. Power Supply, Model RP-31, Front Panel



- * All voltages are factory set within the tolerances specified, and further adjustment is not recommended. However, if it becomes absolutely necessary to perform a field adjustment, do not use measuring equipment that has less than ±5% full scale accuracy.
- Parallel wiring should be used to maintain equal current distribution and voltage stability when the RP-32 is used to supply a group of S-BLOCs. To facilitate parallel connections, screw-taps are provided on the current buss of each available voltage and ground.

Figure 3-27.3. Power Supply, Model RP-32, Front Panel

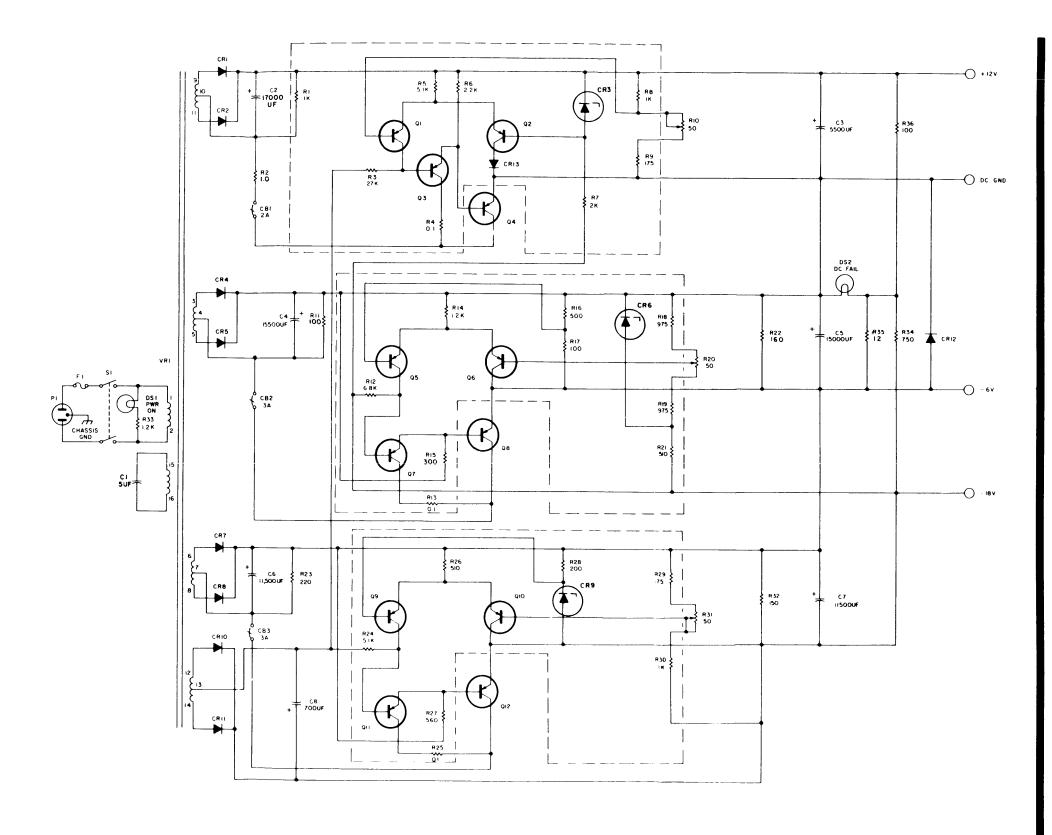


Figure 3-27.4. Power Supply, Model RP-30, Schematic Diagram

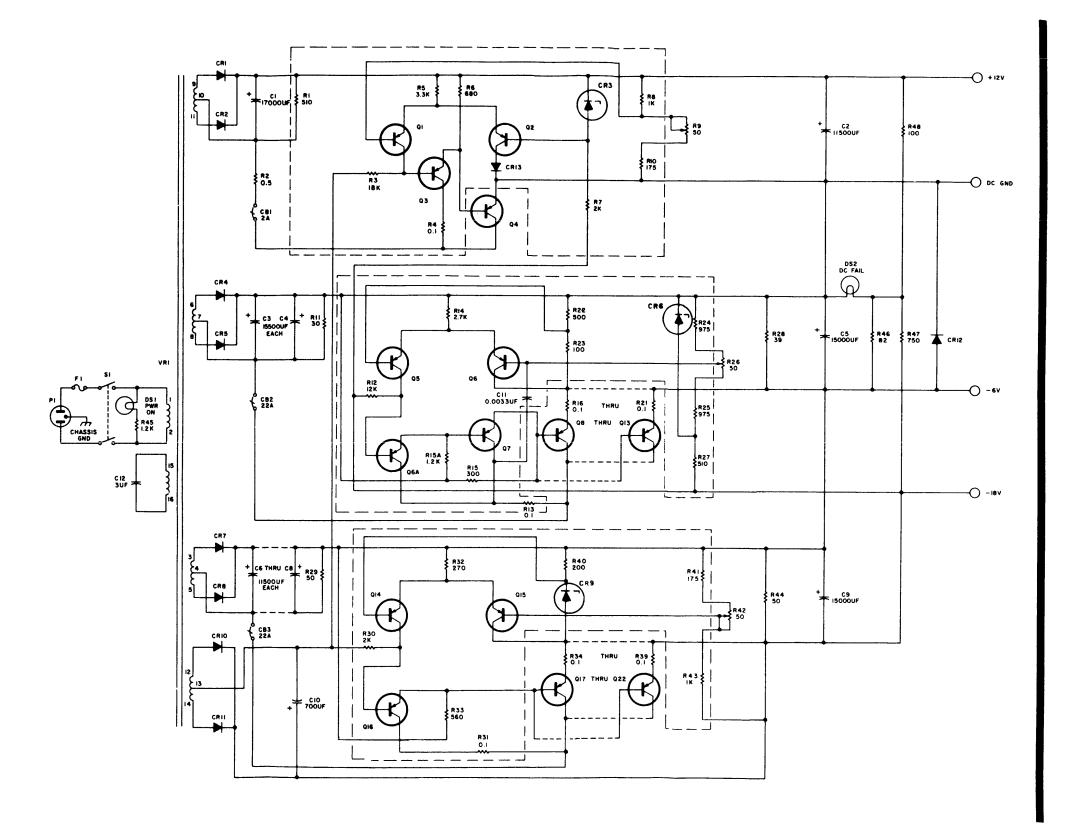


Figure 3-27.5. Power Supply, Model RP-31, Schematic Diagram

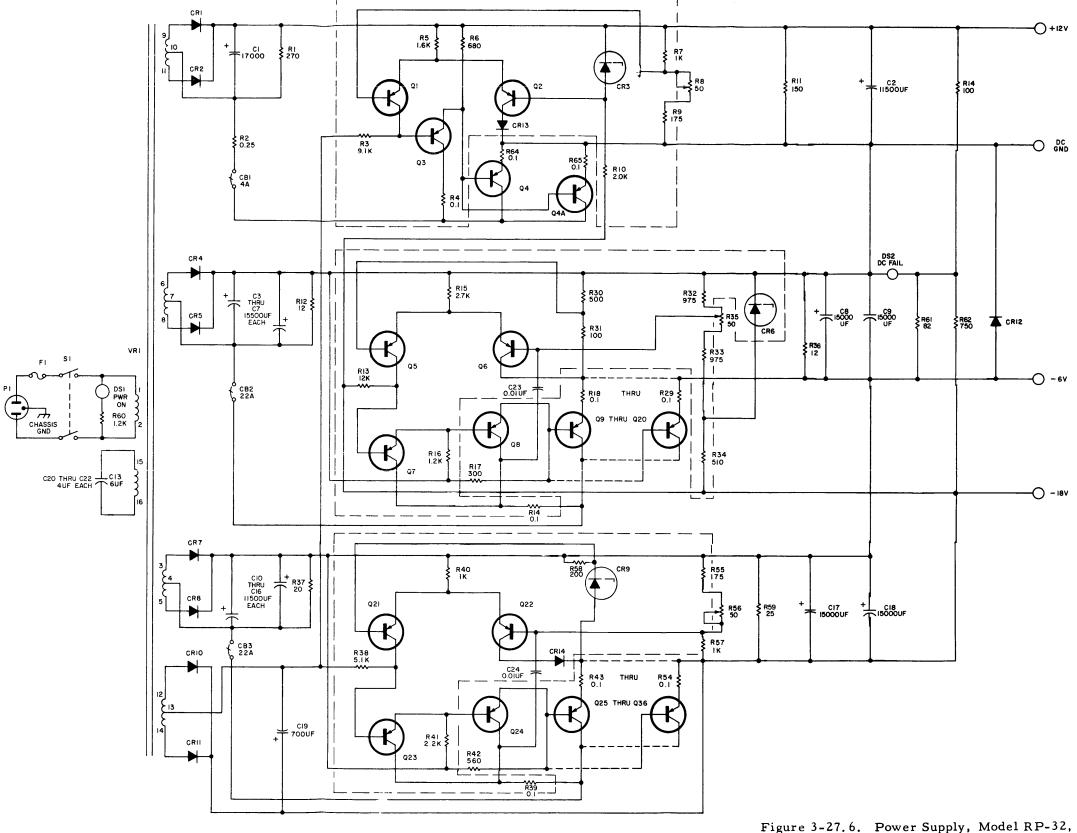
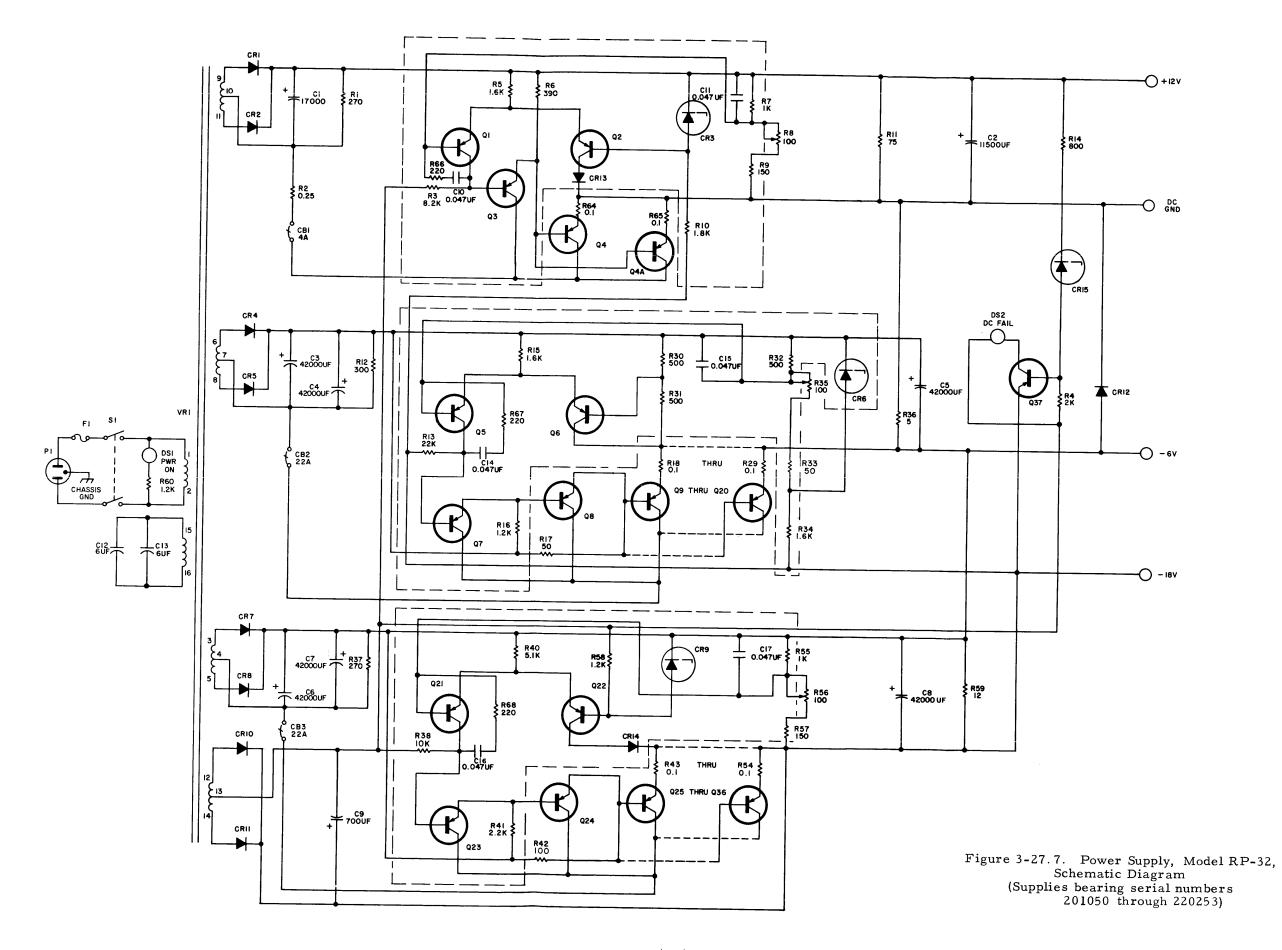


Figure 3-27.6. Power Supply, Model RP-32,
Schematic Diagram
(Supplies bearing serial numbers up to and including No. 198197 and/or models with prefix "A".)



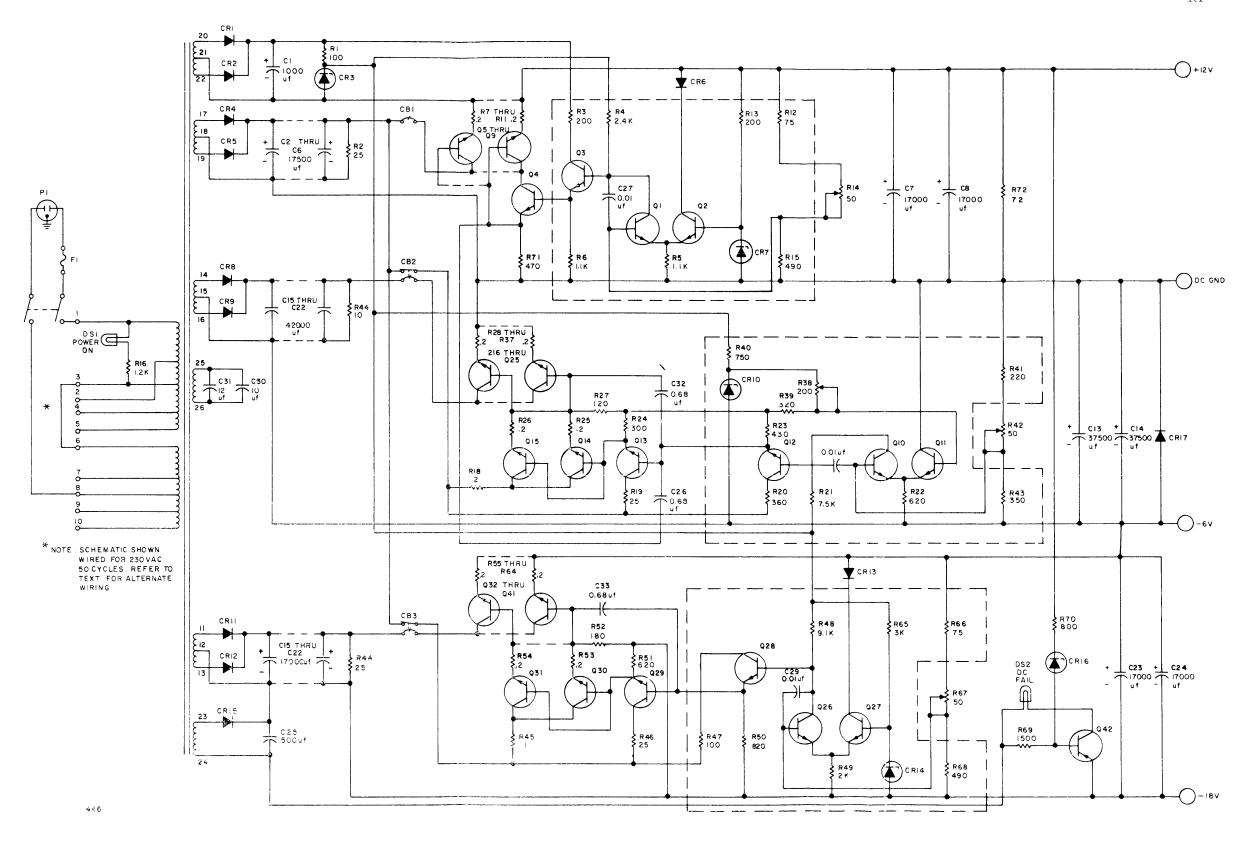


Figure 3-27B.7. Power Supply, Model RP-33E, Schematic Diagram

3-27A POWER SUPPLIES, MODELS RP-30 THROUGH RP-32*

GENERAL DESCRIPTION

The S-PAC Power Supplies, Models RP-30, RP-31 and RP-32 (figures 3-27A. 1, 3-27A.2, and 3-27A.3) are integrally packaged, regulated power sources containing three S-PAC voltages with proportioned current capability. The single phase input transformers have been designed to operate at 50 or 60 cycles on a line-voltage range extending between 100 and 240 volts.

These supplies are substantially derated at rated load and can be operated safely at full load over their specific environmental temperature range. In specific cases, it may also be possible to operate a supply slightly beyond its ratings when used in an air-conditioned laboratory environment. The supplies employ ferroresonant transformers to minimize the effects of line voltage variations and use high-gain, solid-state regulator circuits to achieve the excellent ripple regulation, and stability specified.

Each power supply uses electrically stacked voltage supply sections to provide the -6-volt reverse current required by the S-PACs (refer to figure 3-27A. 4). The power supply schematics are shown in figures 3-27A. 5 through 3-27A. 7. Each schematic is shown wired for 230-volt, 50 cycle operation. Alternate transformer primary and secondary connections for input voltage and frequency of operation are listed in tables 3-27A. 1 and 3-27A. 2 Supplies are factory wired for 115 VAC, 60 cps.

SPECIFICATIONS

NOTE

The following specifications are applicable to all three power supplies, except when otherwise noted.

Input Power Requirements

Input voltages: 100, 115, 120, 127, 200, 220, 230, and 240 V $rms \pm 10\%$

Frequency: 50 or 60 cps, single phase, ±2 cycles

Output

Model	Voltage and Load Current	Input Load Current
RP-30	-18 VDC, 0 to 2 amp	1.5 amp (max)
	-6 VDC, 0 to 2 amp (reverse)	
	+12 VDC, 0 to 0.8 amp	
RP-31	-18 VDC, 0 to 8 amp	3.7 amp (max)
	-6 VDC, 0 to 8 amp (reverse)	
	+12 VDC, 0 to 1.6 amp	
RP-32	-18 VDC, 0 to 20 amp	8.4 amp (max)
	-6 VDC, 0 to 20 amp (reverse)	
	+12 VDC, 0 to 3 amp	

^{*}RP-30 supplies bearing serial numbers 280335 and beyond, RP-31 supplies bearing serial numbers 239542 and beyond and RP-32 supplies bearing serial numbers 220254 and beyond.

SPECIFICATIONS (Continued)

Regulation

Better than 0.75% for load (0 to maximum) and line voltage change

Stability

0.03% °C from -20°C to 50°C. (When mounted in a relay rack, there must be a vertical clearance of 2 inches above or below the supplies.)

Ripple

Less than 75 mv peak-to-peak at full load

Size

RP-30: 5-1/4 inches high x 13 inches deep x 19 inches wide (relay rack mounting)

RP-31: 5-1/4 inches high x 15 inches deep x 19 inches wide (relay rack mounting)

RP-32: 8-3/4 inches high x 15 inches deep x 19 inches wide (relay rack mounting)

Weight

RP-30: 35 pounds

RP-31: 50 pounds

RP-32: 95 pounds

General

AC and DC power-on indicators are provided.

DC outputs are protected by fast-acting circuit breakers.

All supplies are factory preset. Screwdriver adjustment is provided for recalibration if necessary. (Range of adjustment is 2%.)

Supplies are floating with respect to chasis. Chassis ground terminal is provided. Supplies are factory wired for 115 VAC, 60 cps.

Terminal boards located inside the power supplies provide connections for the desired input voltage and frequency of operation (refer to tables 3-27A. 1 through 3-27A.3).

Example: To convert the operation of the RP-31 power supply from 115 VAC, 60 cps to 220 VAC, 50 cps, remove the lead from terminal 12 and connect it to terminal 13; remove lead from terminal 15 and connect it to terminal 14, etc. Remove jumper wire from terminals 3 and 8; remove lead from terminal 1 and connect it to terminal 4, and remove lead from terminal 3 and connect it to terminal 8.

Mating female connector for P1 (Hubbel 7082G Part No. 3650159) is shipped with each supply.

CAUTION

Do not remove the lamp indicator DS1 and its associated series resistor from pins 1 and 3 when altering the primary input connections for the desired voltage.

Table 3-27A.1. Transformer Primary Connections for Power Supplies, Model RP-30 through RP-32

Input Voltage	Connect Input Line Voltage To Terminals	Connect Jumper Wire Between Terminals	
100 VAC 60 cps	l and 2	1 and 6; 2 and 7	
115 VAC 60 cps	1 and 3	1 and 6; 3 and 8	
120 VAC 60 cps	1 and 3	1 and 6; 3 and 8	
100 VAC 50 cps	1 and 3	l and 6; 3 and 8	
115 VAC 50 cps	l and 4	l and 6; 4 and 9	
120 VAC 50 cps	1 and 4	1 and 6; 4 and 9	
127 VAC 50 cps	l and 5	l and 6; 5 and 10	
200 VAC 50 cps	l and 8	3 and 6	
220 VAC 50 cps	l and 8	4 and 6	
230 VAC 50 cps	1 and 8	5 and 6	
240 VAC 50 cps	1 and 9	4 and 6	

Table 3-27A.2. Transformer Secondary Connections for Power Supplies, Model RP-30 through RP-32

50-Cycle Operation		60-Cycle Operation	
RP-31 Terminal	RP-30 and RP-32 Terminal	RP-31 Terminal	RP-32 Terminal
13	11	12	12
14	15	15	14
18	16	17	17
19	20	20	19
23	21	22	22
24	25	25	24
28	26	27	27
29	30	30	29
33	33	32	32

4/16/68

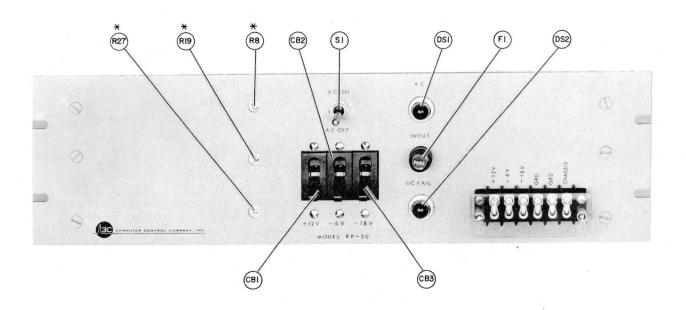
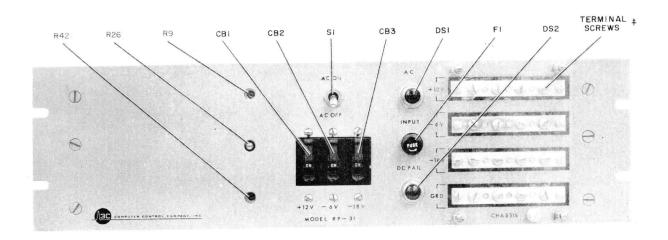


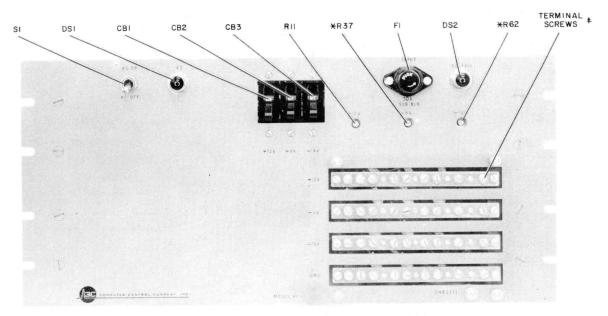
Figure 3-27A.1. Power Supply, Model RP-30, Front Panel



- * ALL VOLTAGES ARE FACTORY SET WITHIN THE TOLERANCES SPECIFIED, AND FURTHER ADJUSTMENT IS NOT RECOMMENDED. HOWEVER, IF IT BECOMES ABSOLUTELY NECESSARY TO PERFORM A FIELD ADJUSTMENT, DO NOT USE MEASURING EQUIPMENT THAT HAS LESS THAN ±0.5% FULL SCALE ACCURACY.
- † PARALLEL WIRING SHOULD BE USED TO MAINTAIN EQUAL CURRENT DISTRIBUTION AND VOLTAGE STABILITY WHEN THE RP-31 IS USED TO SUPPLY A GROUP OF S-BLOCS. TO FACILITATE PARALLEL CONNECTIONS, SCREW-TAPS ARE PROVIDED ON THE CURRENT BUSS OF EACH AVAILABLE VOLTAGE AND GROUND.

122

Figure 3-27A.2. Power Supply, Model RP-31, Front Panel



- * ALL VOLTAGES ARE FACTORY SET WITHIN THE TOLERANCES SPECIFIED, AND FURTHER ADJUSTMENT IS NOT RECOMMENDED. HOWEVER, IF IT BECOMES ABSOLUTELY NECESSARY TO PERFORM A FIELD ADJUSTMENT, DO NOT USE MEASURING EQUIPMENT THAT HAS LESS THAN ±5% FULL SCALE ACCURACY.
- + PARALLEL WIRING SHOULD BE USED TO MAINTAIN EQUAL CURRENT DISTRIBUTION AND VOLTAGE STABILITY WHEN THE RP-32 IS USED TO SUPPLY A GROUP OF S-BLOCS. TO FACILITATE PARALLEL CONNECTIONS, SCREW-TAPS ARE PROVIDED ON THE CURRENT BUSS OF EACH AVAILABLE VOLTAGE AND GROUND.

Figure 3-27A.3. Power Supply, Model RP-32, Front Panel

86

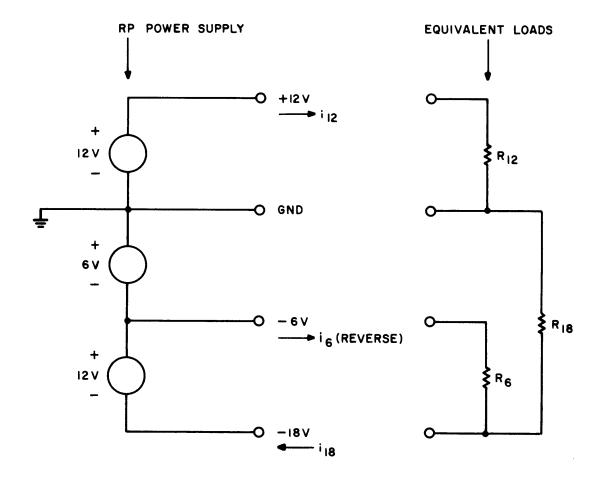


Figure 3-27A. 4. S-PAC Equivalent Loads to RP Type Power Supply Stacked Voltage Sections

4/16/68 3-182G/3-182H

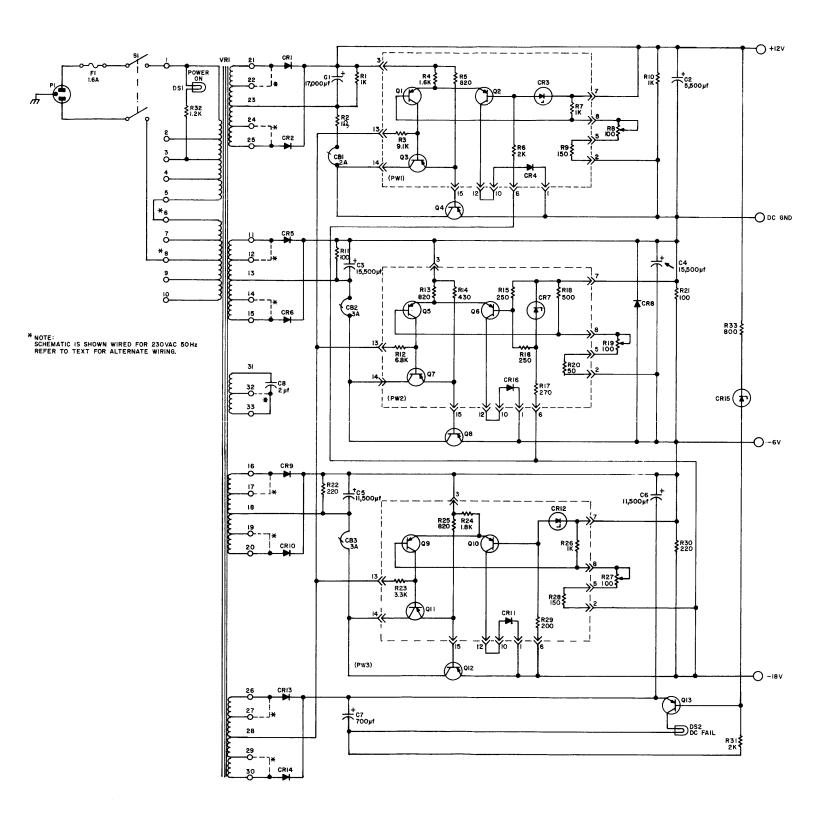


Figure 3-27A.5. Power Supply Model RP-30, Schematic Diagram

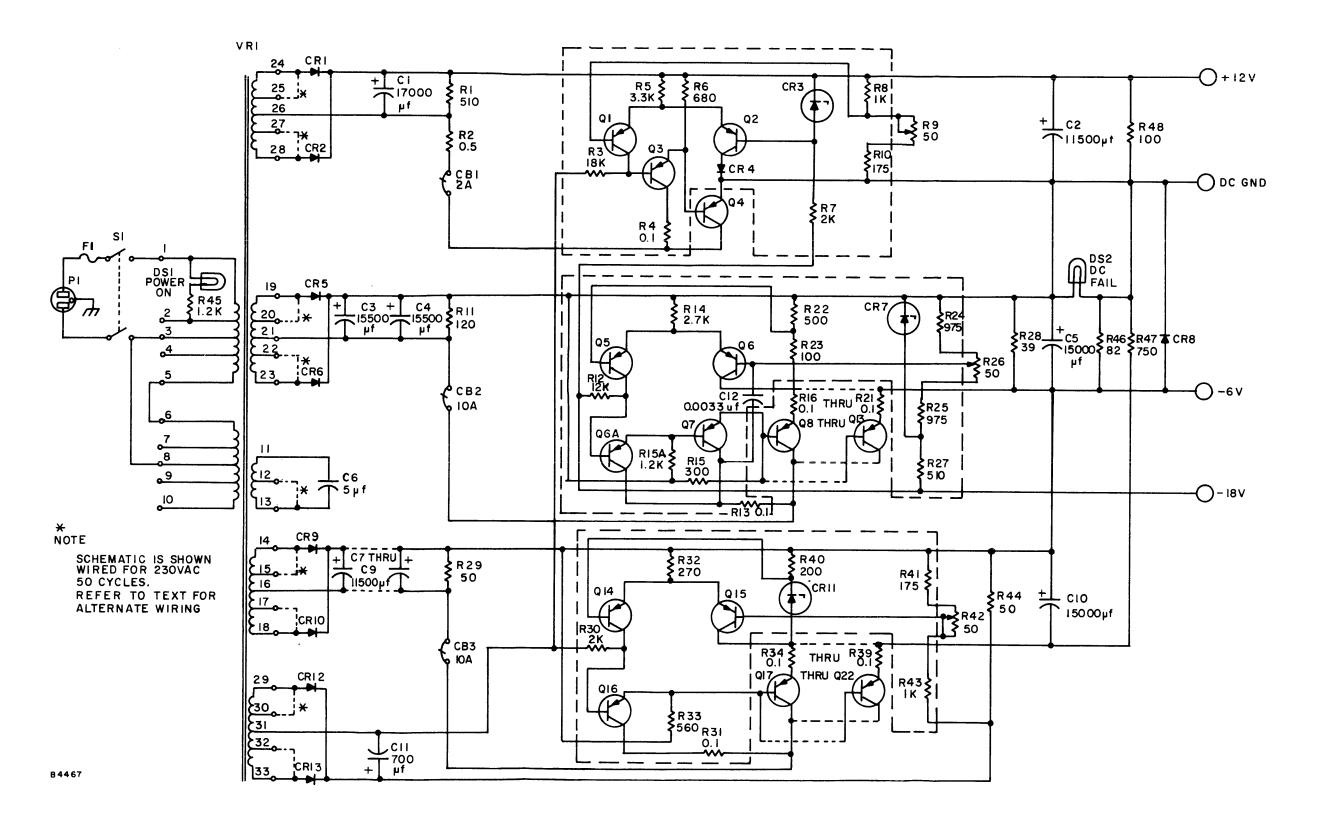


Figure 3-27A.6. Power Supply, Model RP-31, Schematic Diagram

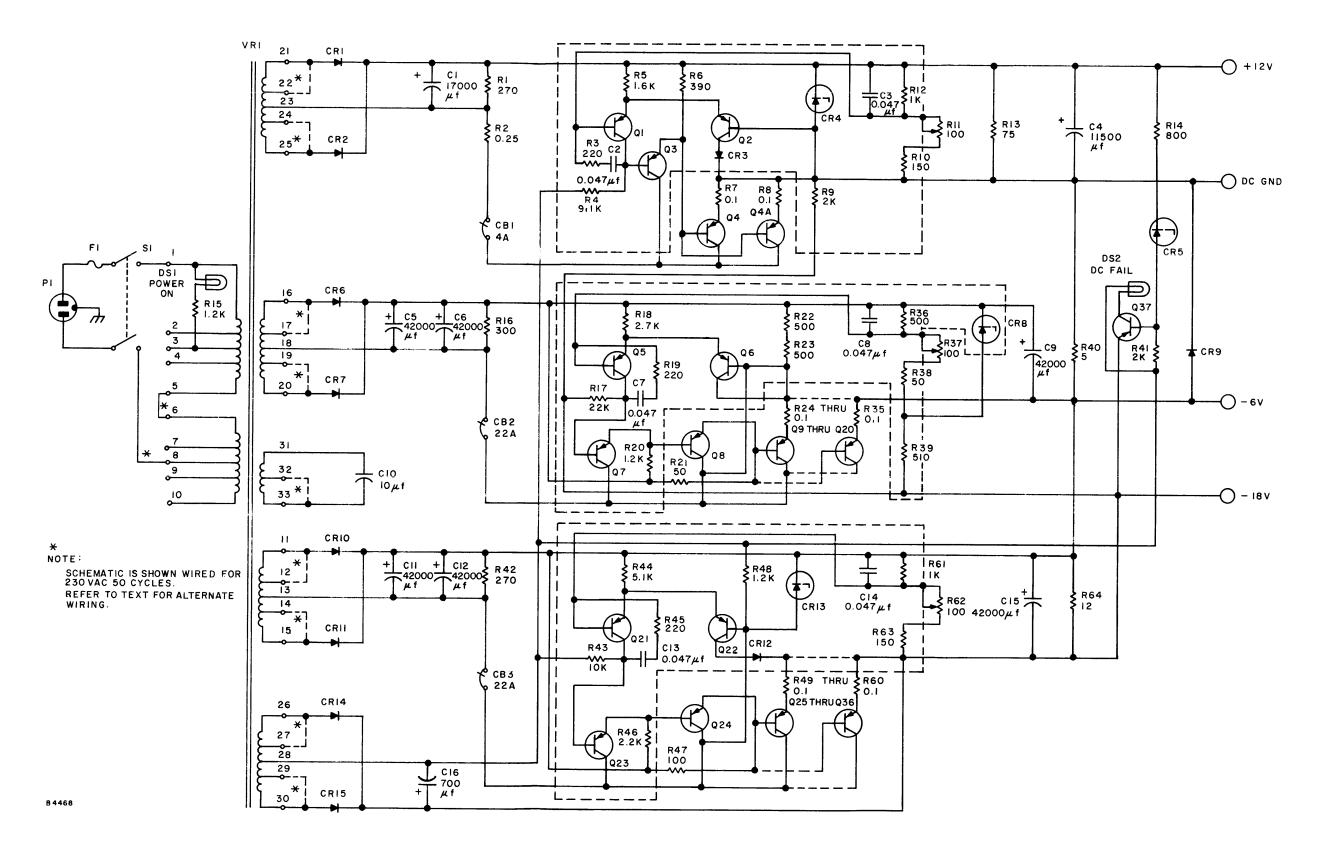


Figure 3-27A.7. Power Supply, Model RP-32, Schematic Diagram

3-27B POWER SUPPLIES, MODELS RP-31E THROUGH RP-33E

GENERAL DESCRIPTION

The S-PAC Power Supplies, Models RP-31E, RP-32E, and RP-33E (figures 3-27B.1, 3-27B.2, and 3-27B.3) are integrally packaged, regulated power sources containing three S-PAC voltages with proportioned current capability. With the exception of input power requirements, each model is mechanically and electrically compatible to the RP-31, RP-32, and RP-33 power supplies. The single phase input transformers have been designed to operate at 50 or 60 cycles (RP-33E, 50 cycle only) on a line-voltage range extending between 100 and 240 volts.

These supplies are substantially derated at rated load and can be operated safely at full load over their specific environmental temperature range. In specific cases, it may also be possible to operate a supply slightly beyond its ratings when used in an air-conditioned laboratory environment. The supplies employ ferroresonant transformers to minimize the effects of line voltage variations and use high-gain, solid-state regulator circuits to achieve the excellent ripple regulation, and stability specified.

Each power supply uses electrically stacked voltage supply sections to provide the -6-volt reverse current required by the S-PACs (refer to figure 3-27B.4). The power supply schematics are shown in figures 3-27B.5 through 3-27B.7. Each schematic is shown wired for 230-volt, 50 cycle operation. Alternate transformer primary and secondary connections for input voltage and frequency of operation are listed in tables 3-27B.1 through 3-27B.3. RP-31E and RP-32E are factory wired for 115 VAC, 60 cycles, and RP-33E is factory wired for 230 VAC, 50-cycle operation.

SPECIFICATIONS

NOTE

The following specifications are applicable to all three power supplies, except when otherwise noted.

Input Power Requirements

Input voltages: 100, 115, 120, 127, 200, 220, 230, and 240 V rms $\pm 10\%$ Frequency: RP-31E and RP-32E - 50 or 60 cps ± 2 cycles, single phase RP-33E - 50 cps ± 2 cycles only, single phase

Output

\underline{Model}	Voltage and Load Current	Input Load Current
RP-31E	-18 VDC, 0 to 8 amp	3.7 amp (max)
	-6 VDC, 0 to 8 amp (reverse)	
	+12 VDC, 0 to 1.6 amp	
RP-32E	-18 VDC, 0 to 20 amp	8.4 amp (max)
	-6 VDC, 0 to 20 amp (reverse)	
	+12 VDC, 0 to 3 amp	
RP-33E	-18 VDC, 0 to 40 amp	21.0 amp (max)
	-6 VDC, 0 to 40 amp (reverse)	
	+12 VDC, 0 to 15 amp	

SPECIFICATIONS (Continued)

Regulation

Better than 0.75% for load (0 to maximum) and line voltage change

Stability

0.03% C from -20°C to 50°C. (When mounted in a relay rack, there must be a vertical clearance of 2 inches above or below the supplies.)

Ripple

Less than 75 mv peak-to-peak at full load

Size

RP-31E: 5-1/4 inches high x 15 inches deep x 19 inches wide (relay rack mounting)

RP-32E: 8-3/4 inches high x 15 inches deep x 19 inches wide (relay rack mounting)

RP-33E: 10-1/4 inches high x 22 inches deep x 19 inches wide (relay rack mounting)

Weight

RP-31E: 50 pounds RP-32E: 95 pounds RP-33E: 150 pounds

General

AC and DC power-on indicators are provided.

DC outputs are protected by fast-acting circuit breakers.

All supplies are factory preset. Screwdriver adjustment is provided for recalibration if necessary. (Range of adjustment is 2%.)

RP-31E and RP-32E are factory wired for 115 VAC, 60 cps RP-33E is factory wired for 230 VAC, 50 cps

Supplies are floating with respect to chassis. Chassis ground terminal is provided.

Mating female connector for P1 (Hubbel 7082G Part No. 3650159) is shipped with each power supply.

Terminal boards located inside the power supplies provide connections for the desired input voltage and frequency of operation (refer to tables 3-27B. 1 through 3-27B. 3).

Example: To convert the operation of the RP-31E power supply from 115 VAC, 60 cps to 220 VAC, 50 cps, remove the lead from terminal 12 and connect it to terminal 13; remove lead from terminal 15 and connect it to terminal 14, etc. Remove jumper wire from terminals 3 and 8; remove lead from terminal 1 and connect it to terminal 4, and remove lead from terminal 3 and connect it to terminal 8.

CAUTION

Do not remove the lamp indicator DS1 and its associated series resistor from pins 1 and 3 when altering the primary input connections for the desired voltage.

3-182P 4/16/68

Table 3-27B.1. Transformer Primary Connections for Power Supplies, Model RP-31E and RP-32E

Input Voltage	Connect Input Line Voltage To Terminals	Connect Jumper Wire Between Terminals
100 VAC 60 cps	l and 2	1 and 6; 2 and 7
115 VAC 60 cps	l and 3	l and 6; 3 and 8
120 VAC 60 cps	l and 3	l and 6; 3 and 8
100 VAC 50 cps	l and 3	l and 6; 3 and 8
115 VAC 50 cps	l and 4	l and 6; 4 and 9
120 VAC 50 cps	l and 4	l and 6; 4 and 9
127 VAC 50 cps	l and 5	l and 6; 5 and 10
200 VAC 50 cps	l and 8	3 and 6
220 VAC 50 cps	l and 8	4 and 6
230 VAC 50 cps	l and 8	5 and 6
240 VAC 50 cps	l and 9	4 and 6

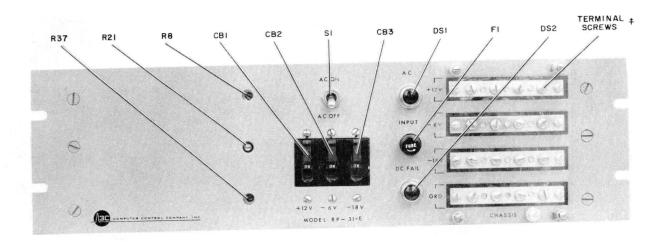
Table 3-27B.2. Transformer Primary Connections for Power Supply, Model RP-33E

Input Voltage	Connect Input Line Voltage To Terminals	Connect Jumper Wire Between Terminals
100 VAC	l and 2	1 and 6; 2 and 7
115 VAC	l and 3	l and 6; 3 and 8
120 VAC	l and 4	l and 6; 4 and 9
127 VAC	l and 5	l and 6; 5 and 10
200 VAC	l and 7	2 and 6
220 VAC	l and 9	2 and 6
230 VAC	l and 8	3 and 6
240 VAC	l and 9	4 and 6

Table 3-27B.3. Transformer Secondary Connections for Power Supplies, Model RP-31E and RP-32E

50-Cycle	Operation	60-Cycle Operation			
RP-31E	RP-32E	RP-31E	RP-32E		
Terminal	Terminal	Terminal	Terminal		
13	11	12	12		
14	15	15	14		
18	16	17	17		
19	20	20	19		
23	21	22	22		
24	25	25	24		
28	26	27	27		
29	30	30	29		
33	33	32	32		

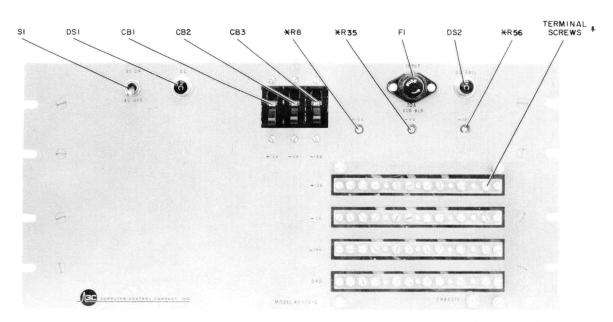
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- * ALL VOLTAGES ARE FACTORY SET WITHIN THE TOLERANCES SPECIFIED, AND FURTHER ADJUSTMENT IS NOT RECOMMENDED. HOWEVER, IF IT BECOMES ABSOLUTELY NECESSARY TO PERFORM A FIELD ADJUSTMENT, DO NOT USE MEASURING EQUIPMENT THAT HAS LESS THAN ±0.5% FULL SCALE ACCURACY.
- † PARALLEL WIRING SHOULD BE USED TO MAINTAIN EQUAL CURRENT DISTRIBUTION AND VOLTAGE STABILITY WHEN THE RP-3IE IS USED TO SUPPLY A GROUP OF S-BLOCS. TO FACILITATE PARALLEL CONNECTIONS, SCREW-TAPS ARE PROVIDED ON THE CURRENT BUSS OF EACH AVAILABLE VOLTAGE AND GROUND.

122

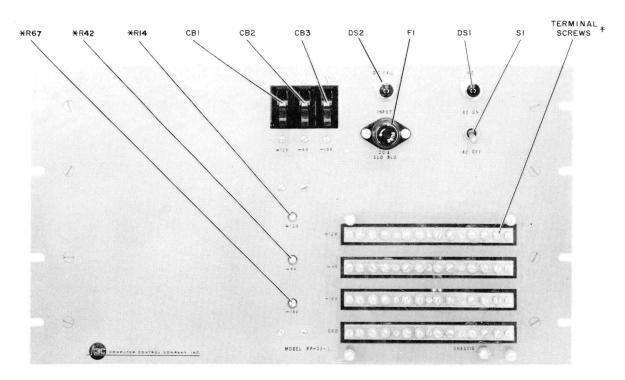
Figure 3-27B.1. Power Supply, Model RP-31E, Front Panel



- * ALL VOLTAGES ARE FACTORY SET WITHIN THE TOLERANCES SPECIFIED, AND FURTHER ADJUSTMENT IS NOT RECOMMENDED. HOWEVER, IF IT BECOMES ABSOLUTELY NECESSARY TO PERFORM A FIELD ADJUSTMENT, DO NOT USE MEASURING EQUIPMENT THAT HAS LESS THAN ±5% FULL SCALE ACCURACY.
- + PARALLEL WIRING SHOULD BE USED TO MAINTAIN EQUAL CURRENT DISTRIBUTION AND VOLTAGE STABILITY WHEN THE RP-32E IS USED TO SUPPLY A GROUP OF S-BLOCS. TO FACILITATE PARALLEL CONNECTIONS, SCREW-TAPS ARE PROVIDED ON THE CURRENT BUSS OF EACH AVAILABLE VOLTAGE AND GROUND.

86

Figure 3-27B.2. Power Supply, Model RP-32E, Front Panel



- * ALL VOLTAGES ARE FACTORY SET WITHIN THE TOLERANCES SPECIFIED, AND FURTHER ADJUSTMENT IS NOT RECOMMENDED. HOWEVER, IF IT BECOMES ABSOLUTELY NECESSARY TO PERFORM A FIELD ADJUSTMENT, DO NOT USE MEASURING EQUIPMENT THAT HAS LESS THAN ±5% FULL SCALE ACCURACY.
- + PARALLEL WIRING SHOULD BE USED TO MAINTAIN EQUAL CURRENT DISTRIBUTION AND VOLTAGE STABILITY WHEN THE RP-33E IS USED TO SUPPLY A GROUP OF S-BLOCS. TO FACILITATE PARALLEL CONNECTIONS, SCREW-TAPS ARE PROVIDED ON THE CURRENT BUSS OF EACH AVAILABLE VOLTAGE AND GROUND.

87

Figure 3-27B.3. Power Supply, Model RP-33E, Front Panel

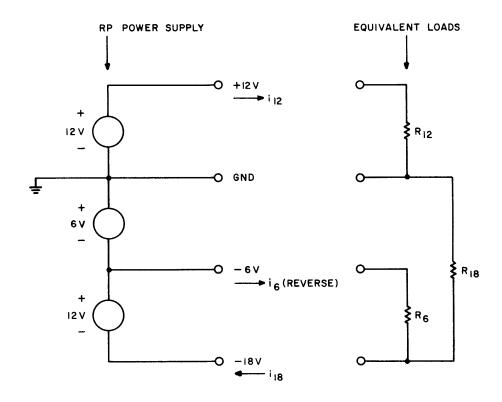


Figure 3-27B.4. S-PAC Equivalent Loads to RP Type Power Supply Stacked Voltage Sections

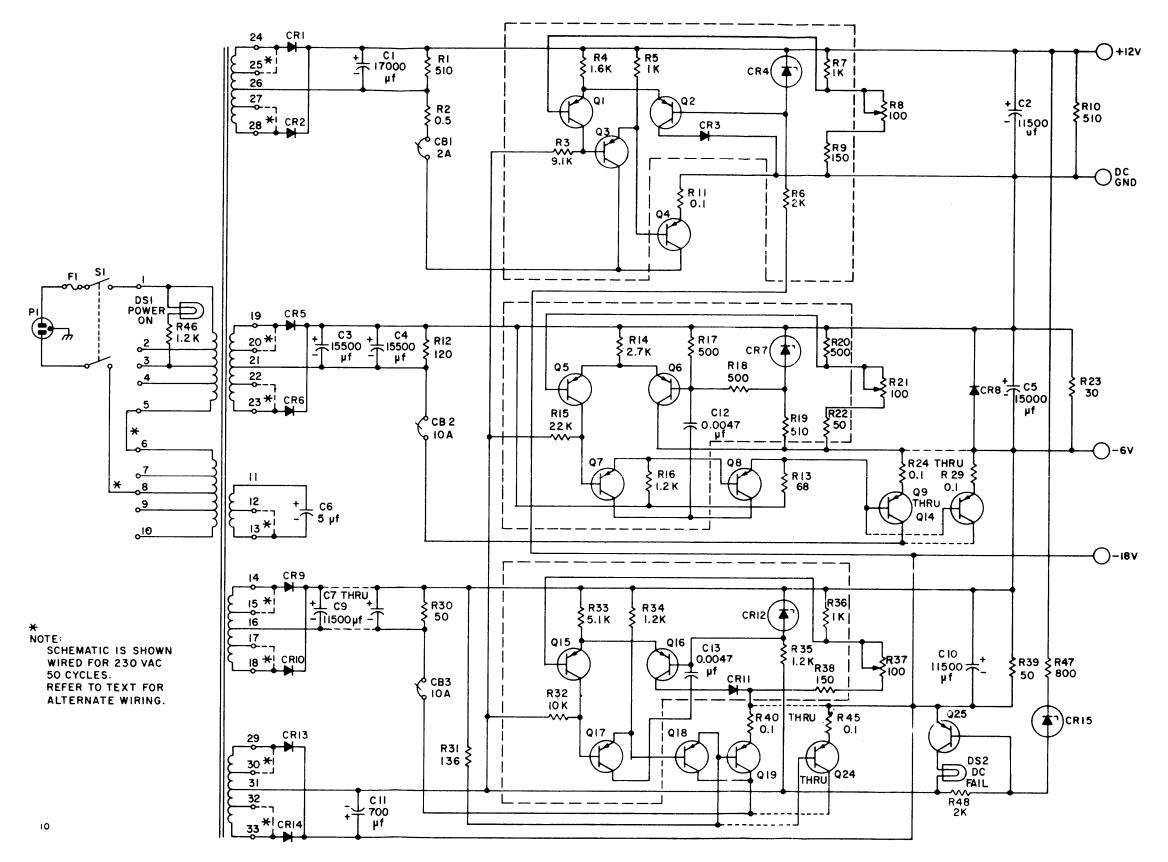


Figure 3-27B.5. Power Supply, Model RP-31E, Schematic Diagram

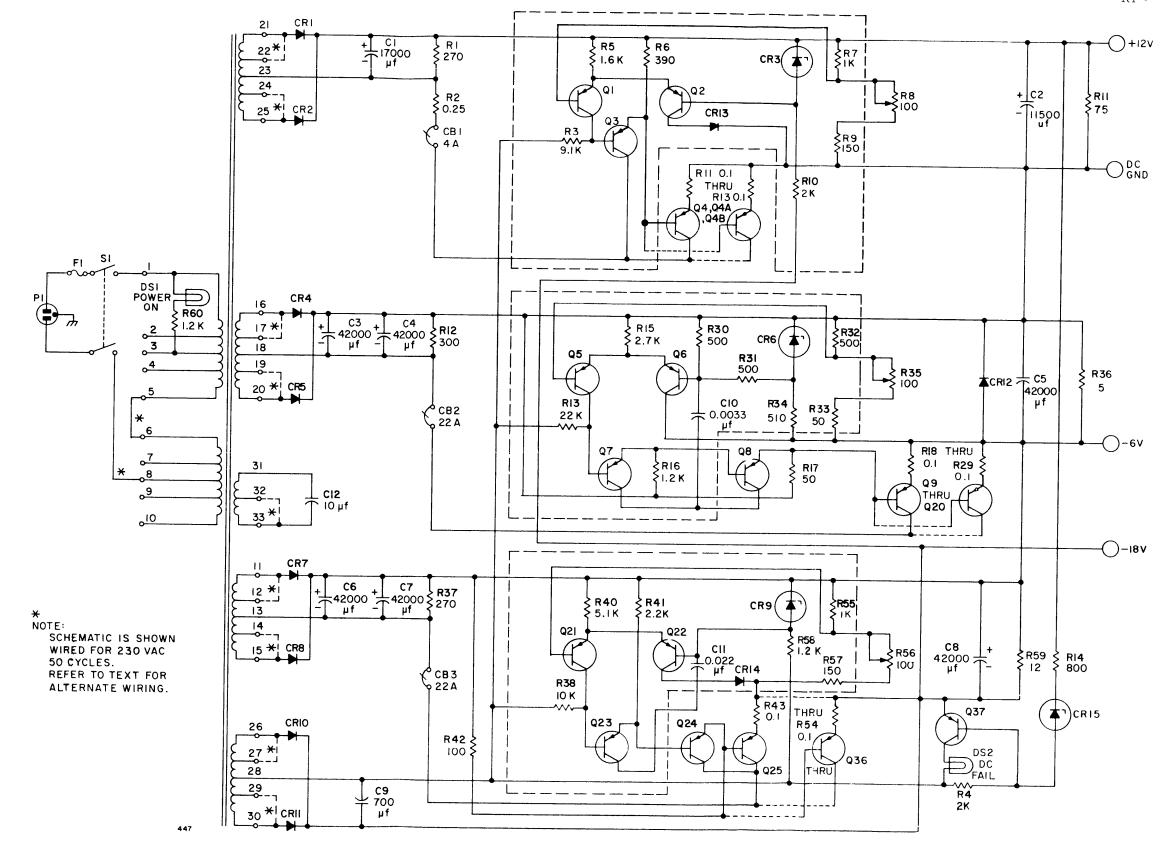


Figure 3-27B. 6. Power Supply, Model RP-32E, Schematic Diagram

3-183

3-28 VERTICAL RELAY PAC, MODEL RV-30

GENERAL DESCRIPTION

The Vertical Relay PAC, Model RV-30 (figure 3-28.1), contains six independent, single-pole, double-throw, mercury-wetted relays with form C (break-before-make) contacts. The mercury-wetted relays must be mounted in an upright position with the arrows on the relays pointed upward. The RV-30 is used only when the PAC is mounted in the normal vertical position. The position of the relay can only deviate from the vertical by a maximum of 30 degrees with a negligible change in operating characteristics.

The relays can safely switch up to 1 ampere of current and can handle contact loads as high as 100 volt-amperes. The relays will follow driving signals up to 200 cycles per second.

The PAC plugs into a single connector of an S-BLOC. The PAC occupies one card slot in a low-density S-BLOC (BL-30 or BL-31) and two slots in a high-density S-BLOC (BL-32 or BL-33).

CIRCUIT FUNCTION

Each relay circuit (figure 3-28.2) consists of a single-pole, double-throw relay, two RC contact protection networks, and a damping diode to reduce backswing across the coil. All relay connections are brought out to the connector so that the relays can be wired separately or together to form a wide variety of switching control functions.

The relay coil can be operated from the -18 volts of the S-PAC power supply or with voltage amplitudes 14 to 45 volts. The relay card can be driven directly from the output of Lamp Driver PAC, Model LD-30, or Solenoid Driver PAC, Model SD-30. However, when using the LD-30 PAC to drive the RV-30, the shunt resistor, R4, should be removed from each driver. This resistor is required for filament lamp applications.

Care must be taken to wire the coil with the correct polarity. Refer to the schematic diagram (figure 3-28.2).

SPECIFICATIONS

Operating Frequency	Output Switching Capability					
DC to 200 cps	l amp (max)					
Input Voltage Requirements	500 V (max)					
14 V to 45 V, swing	(The product must not exceed 100 volt-amperes.)					
Input Resistance	1					
1.4 K (approx)	Handle Color Code					
Polarization	Long: Blue					
6 and 22	Short: Purple					

1/12/66

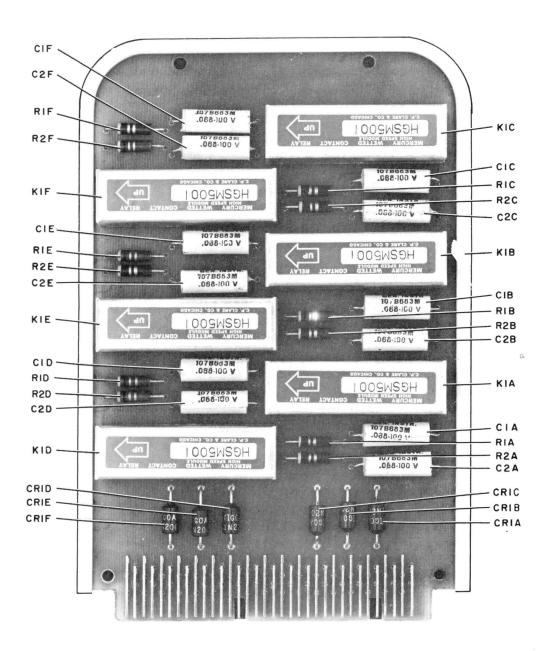


Figure 3-28.1. Vertical Relay PAC, Model RV-30, Parts Location

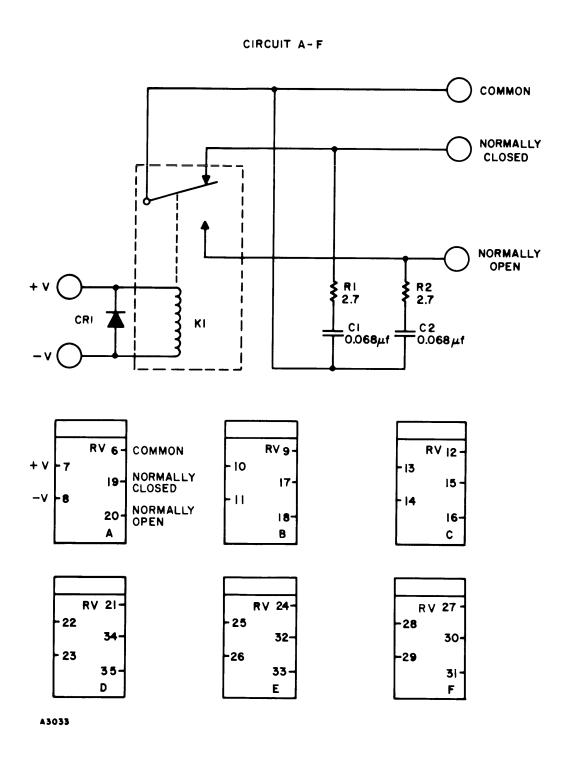


Figure 3-28.2. Vertical Relay PAC, Model RV-30, Schematic and Logic Diagram

1/12/66

3-28A ANALOG SWITCH PAC, MODEL SA-30

GENERAL DESCRIPTION

Analog Switch PAC, Model SA-30 (Figure 3-28A.1), is a solid-state circuit equivalent of a single-pole, double-throw relay switch. The PAC can accept and transfer input voltages up to ± 10.5 volts but is normally used to switch positive voltages. Each switch section has a typical offset voltage of 0.1 MV and an equivalent series resistance of 5 ohms.

There are two control inputs for selecting which analog input is connected to the output. These control inputs use standard S-PAC signal voltages and must be complements. CIRCUIT FUNCTION

Transistors Q1, Q2, and Q10, Q11 (Figure 3-28A.2) form the two sections of the analog switch. To ensure low offset voltage between the input and output, high gain transistors are used back-to-back in an inverted configuration, such that the collector-emitter voltages of each transistor tend to cancel.

With -6 volts applied to control input A, the analog voltage on signal input A will be transferred to the output. Ground on control input A will disconnect that section of the switch. Switch section B operates in a similar manner.

Transistors Q8 and Q9 are part of an adjustable current source which must be terminated with an external load of 10 K to ground for proper operation. (A CD-30 with a modified input resistor network may be used.) Potentiometer R10 adjusts the output for 0 volt when the input is 0 volt, and potentiometer R13 adjusts for correspondence between input and output when the input is at maximum voltage.

CALIBRATION

The Analog Switch PAC is calibrated in the following manner.

- 1. Connect a 10 K, 0.02% resistor from pin 10 (output) to ground.
- 2. Connect -6 volts to pin 14 (control input A) and ground to pin 22 (control input B).
 - 3. Connect pin 12 (signal input A) to +10 volts.
- $4.\,\,$ Connect a floating micro-voltmeter or an oscilloscope with 1 MV/CM sensitivity between pins 10 and 12.
- $\,$ 5. Adjust potentiometer R13 until the meter nulls when in the 1MV full scale position.
 - 6. Remove +10 volts from pin 12; connect pin 12 to ground.
 - 7. Adjust potentiometer R10 until the meter nulls.
- 8. Repeat the above steps until the meter remains nulled with pin 12 at either +10 volts or ground.
- 9. Reverse the voltages applied to pins 14 and 22, connecting ground to pin 14 and -6 volts to pin 22.
- 10. With the voltmeter or oscilloscope connected between pin 32 (signal input B) and pin 10 (output), and pin 32 alternately set to ± 10 volts and ground, the voltage should read between $\pm 1/2$ MV with no further adjustment of the potentiometers.

4/15/64 3-186A/B

APPLICATIONS

The intended application for this PAC is at the front end of a bipolar A/D converter to select either the analog signal or the inverted analog signal, whichever is positive. The SA-30 PAC is then the load for the operational amplifiers. (See Figure 3-28A.3.) The individual offset voltages of the two switch sections are balanced by the zero adjustment on the operational amplifiers. The intercept error is now the differential offset voltage which appears over time and temperature between the two sections of the switch. The converter may be scaled such that the apparent series resistances in the switch cause minimum error. There is no compensation for the difference between the apparent series resistances in each section of the switch. However, this difference is reduced substantially by a negative resistance circuit paralleling the external load, resulting in a total switch load of extremely high resistance:

(-10 K in parallel with +10 K =
$$\frac{(10)(-10)}{10-10} = \infty$$
).

SPECIFICATIONS

Signal Input

Voltage: ±10.5 volts (max)
Voltage to be transferred: 0 to +10.5 volts
Current: 1/2 ma (max)

Control Input

Transfer: -6 volts
Disconnect: 0 volts
Input loading: 1 U load

Output

External load required: 10 K ±1% to ground

Offset voltage: 1.0 MV (typ) 2.0 MV (max)

Drift: 0.05 MV per °C (typ) 0.25 MV per °C (max)

Nonlinearity: 0.005% (max)

Slope: 0.003% (typ) 0.01% (max)

Switching speed: $4 \mu sec$ to within $\pm 0.005\%$ of full scale

Operating Temperature Range

 $0^{\circ}C$ to $+55^{\circ}C$

Current Requirements Polarization
+12 V: 20 ma Pins 6 and 20

-6 V: 2 ma

-18 V: 5 ma

Long: Purple

Power Short: Brown

0.5 watt

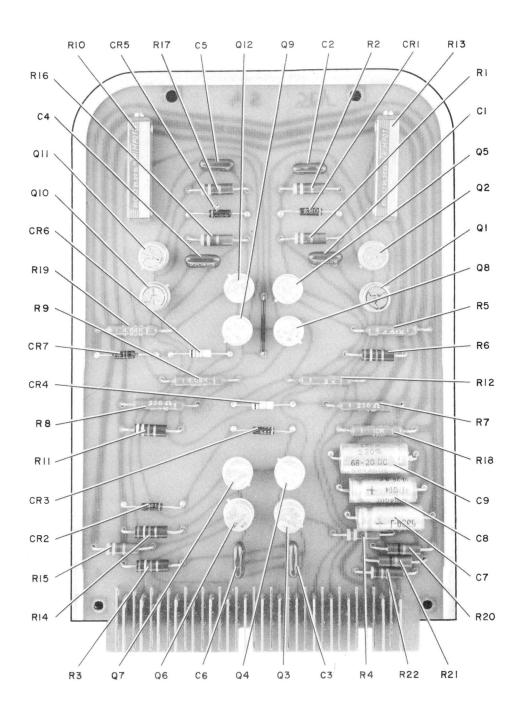


Figure 3-28A.1. Analog Switch PAC, Model SA-30, Parts Location

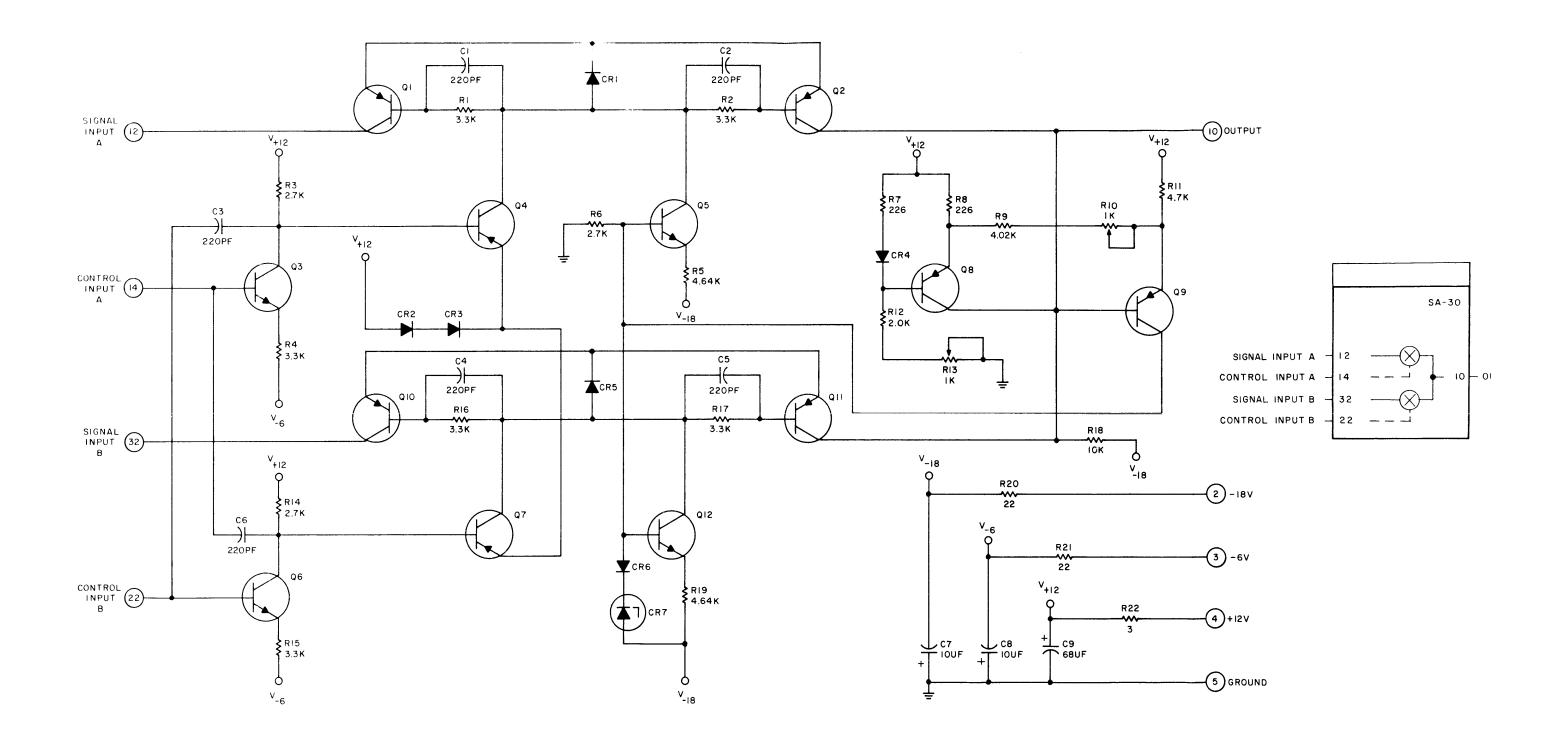


Figure 3-28A. 2. Analog Switch PAC, Model SA-30, Schematic and Logic Diagram

4/15/64 3-186E/F

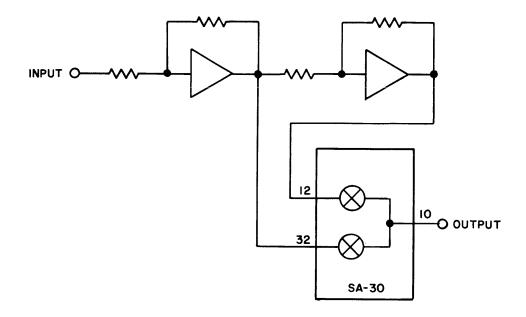


Figure 3-28A. 3. Analog Switch PAC Application

3-29 SOLENOID DRIVER PAC, MODEL SD-30

GENERAL DESCRIPTION

The Solenoid Driver PAC, Model SD-30 (figure 3-29.1), contains four independent, two-input solenoid driver circuits. Each circuit is capable of switching a maximum of one-half ampere of solenoid current from a supply voltage of up to -48 volts DC or as much as 1 ampere from a -28-volt DC source. The number of inputs is expandable to a maximum of 10 by connecting diode clusters contained in DC or DN S-PACs. The solenoid driver circuit is noninverting; therefore, when an input is at ZERO (0 V), the solenoid is energized and when all inputs are at ONE (-6 V), the solenoid is de-energized.

CIRCUIT FUNCTION

Each SD-30 circuit (figure 3-29.2) consists of a two-input diode gate followed by a two-stage noninverting transistor amplifier. When all inputs are at ONE, the gate turns on the first transistor. This transistor then turns off the output transistor, and the solenoid is not energized. When an input goes to ZERO, the first transistor is turned off, the output transistor is turned on, and a current path is provided through the solenoid to its power supply. A diode-resistor combination provides damping for energy stored in the solenoid when the output transistor is turned off and protects the transistor from excessive voltage resulting from this turn-off transient. Figure 3-29.3 shows a typical solenoid connection.

NOTE

To eliminate ground noise, the ground return for the external solenoid supply must not be connected directly to the S-PAC ground. The external return should be connected only to pin 18 of each SD-30 PAC.

SPECIFICATIONS

	Input :	Loading
--	---------	---------

2 U loads each

Frequency of Operation

DC to 500 cps (max)

Output Drive Capability

l amp at -28 V

0.5 amp at -48 V

Total Power

4.5 watts

Polarization

Pins 20 and 32

Current Requirements

-18 V 220 ma

-6 V 0 ma

+12 V 45 ma

(Plus external solenoid supply of l amp max at -28 V; 0.5 amp max at -48 V)

Damping

10-ohm resistor (mounted on lugs) is provided. If faster recovery is required, resistor value should be increased. (Collector voltage must not exceed -55 V peak.)

Handle Color Code

Long: Orange Short: Orange

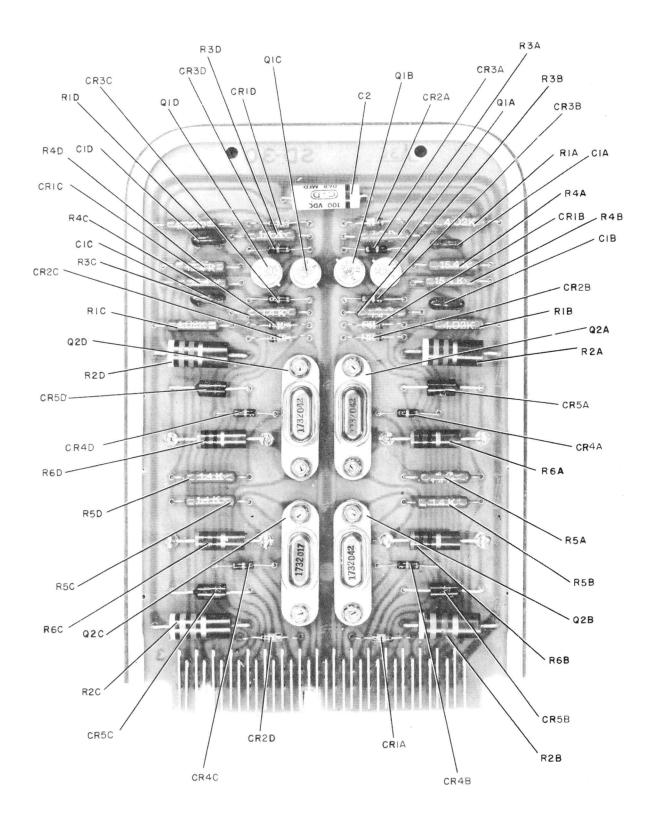


Figure 3-29.1. Solenoid Driver PAC, Model SD-30, Parts Location

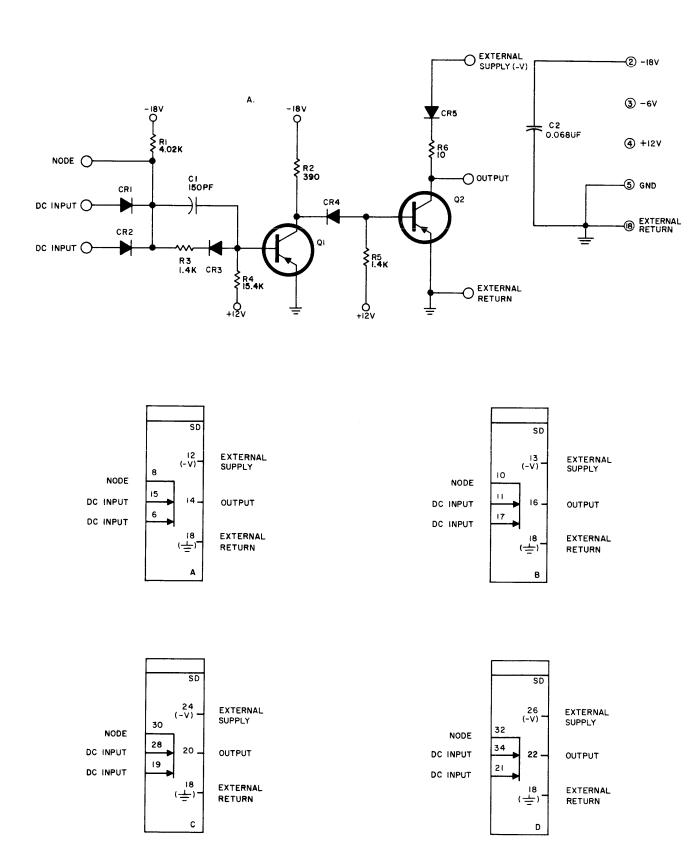


Figure 3-29.2. Solenoid Driver PAC, Model SD-30, Schematic and Logic Diagram

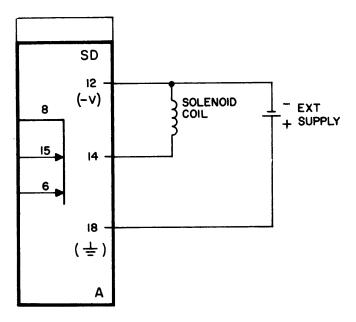


Figure 3-29.3. Typical Solenoid Connection

3-190

3-30 STORAGE-INDICATOR PAC, MODEL SI-30

GENERAL DESCRIPTION

The Storage-Indicator PAC, Model SI-30 (figures 3-30.1 and 3-30.2), is a decimal-counting unit which contains a four-stage BCD storage register and a converter-indicator. The storage element consists of a four flip-flop register, with each flip-flop having both a set and a reset input. The outputs from an 8-4-2-1 BCD counter or register drive these inputs. The PAC can follow the counter to which it is connected or the count can be transferred from the counter at any time and stored until the next transfer. The converter-indicator decodes the BCD information from the register and displays the decimal equivalent by lighting one of the 10 neon indicator lamps on the vertical display panel.

The set and reset outputs from each flip-flop permit the parallel operation of several PACs as well as binary readout.

CIRCUIT FUNCTION

The PAC (figure 3-30.3) receives input data from a counter to set or reset the corresponding storage register stages. Each input is gated with a transfer input which allows the register to follow the input data or remain in a static state. A ONE (-6 V) enables the gates and permits the register to follow the counter, while a ZERO (0 V) disables the gates and prevents a transfer of information to the register. The set and reset outputs of each flip-flop are connected to the converter-indicator which generates and displays the decimal equivalent of the binary information stored in the flip-flops. The converter-indicator consists of a network of converter lamps, indicator lamps, and resistors connected in a matrix to allow only one indicator lamp to light on a specific count. Several of the converter lamps will light, thereby inhibiting the remaining nine indicator lamps. Refer to table 3-30.1 for the condition of the converter and indicator lamps in each decimal state.

BCD Data Input. The DC levels of the input data are applied to the set and reset inputs of the flip-flop register. With a ONE on the set (TRUE) input and a ZERO on the reset (FALSE) input, the application of a ONE on the TRANSFER input will set the corresponding register flip-flop.

Transfer Input. The transfer input controls the transfer of data to the storage register. A ONE input enables the register to follow the state of the counter, while a ZERO input prevents the register from changing state. The transfer input must be at the ONE level for a minimum of 1 microsecond after the last data input has changed state to insure a transfer.

BCD Data Outputs. The set and reset outputs of each flip-flop are available to drive other S-PACs.

Table 3-30.1. IDCU Indicator, Proper Conditions for Correct Decoding

Indicator Decimal Lamps		Converter Lamps DS11-DS20									
State	DS1-DS10	11	12	13	14	15	16	17	18	19	20
0	1				X		Х	Х	Х		х
1	2				Х		X	Х	Х		Х
2	3	Х				X	Х		Х		Х
3	4	Х				Х	Х		Х		X
4	5		Х	X	Х			Х			Х
5	6		Х	X	Х			Х			Х
6	7	Х	Х	X		Х					Х
7	8	Х	Х	X		Х					Х
8	9				Х		х	X	Х	X	
9	10				Х		Х	X	Х	X	

NOTE

X indicates lamp is lighted.

SPECIFICATIONS

Frequency of Operation	Output Levels					
DC to 1 MC (max)	BCD Data Outputs					
	Ground and -60 V when unloaded					
Input Loading	S-PAC compatible ONES and ZEROS when loaded					
BCD data inputs: l W load						
Transfer input: 4 W loads	Decimal Display Outputs					
	Compatible with IP-30 PAC					
Output Drive Capability						
BCD Data Outputs	Current Requirements					
l V load and 50 pf stray capacitance	+12 V 3 ma					
Decimal Display Outputs	-120 V 30 ma					
l Indicator-Converter PAC,						
Model IP-30	Circuit Delay					
	l.5 μsec (typ)					
Total Power	2.5 μsec (max)					
3.6 watts						
	Transfer Pulse Width					
Polarization Pins 4 and 18	l µsec (min) at -6 V or open circuit					
PAC Length						

3-192

7-3/4 in. (includes 5/16 in. extraction stud)

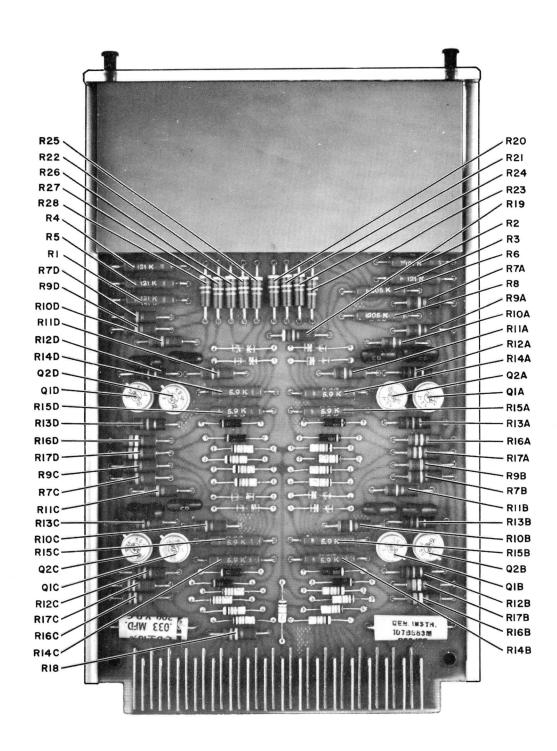


Figure 3-30.1. Storage-Indicator PAC, Model SI-30, Parts Location (Resistors and Transistors)

3/2/64

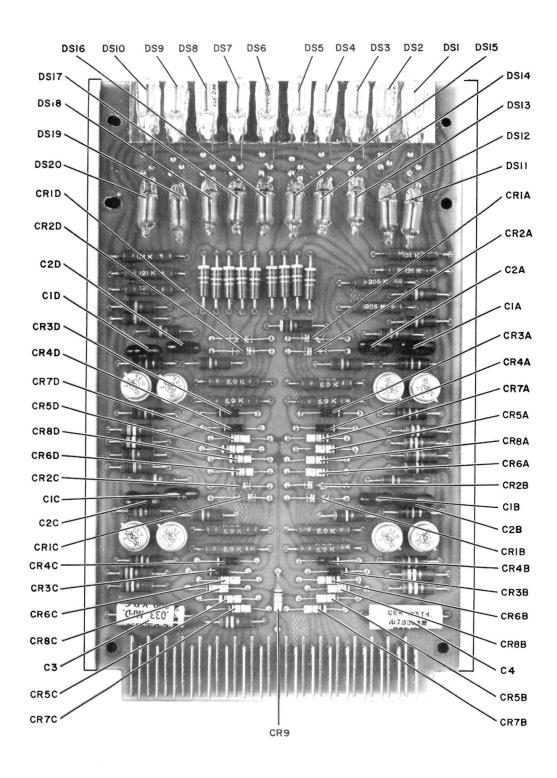


Figure 3-30.2. Storage-Indicator PAC, Model SI-30, Parts Location (Capacitors, Diodes and Lamps)

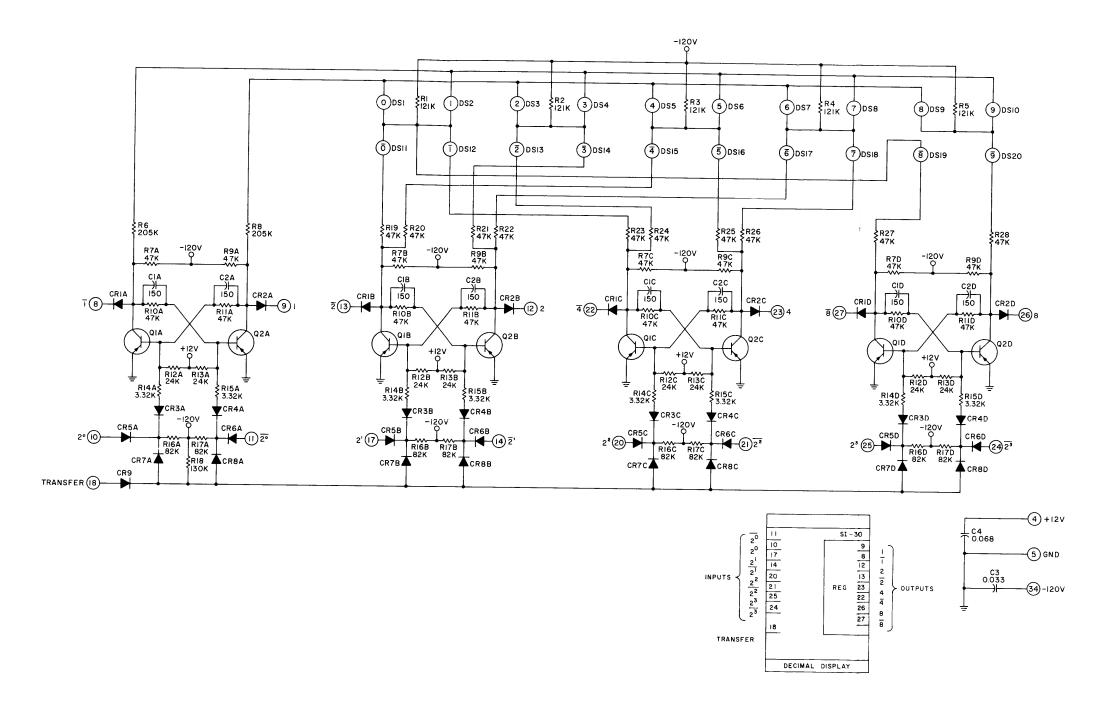


Figure 3-30.3. Storage-Indicator PAC, Model SI-30, Schematic and Logic Diagram

3-31 SYSTEM NORMALIZER PAC, MODEL SN-30

GENERAL DESCRIPTION

The System Normalizer PAC, Model SN-30 (figure 3-31.1) contains a time delay circuit used to normalize system control flip-flops when the power is turned on; that is, initially condition the flip-flops to the proper state. The SN-30 has 8 diode-coupled outputs and 3 direct outputs which are capable of driving a total of 8 U loads.

The PAC normally drives a few critical control flip-flops to insure initial operation in the proper state.

CIRCUIT FUNCTION

The SN-30 circuit (figure 3-31.2) has a single form A relay contact and an RC delay in the coil circuit. The relay is normally open, permitting a positive current source, clamped to ground, to be supplied to the output terminals. After a delay of approximately 0.1 second, during which all supply voltages become stabilized, the relay contact closes. The voltage of the output terminals then falls to -6 volts, freeing the control flip-flops for normal operation.

SPECIFICATIONS

Output Drive Capability

8 U loads (total)

Power Requirements

-18 V 55 ma

- 6 V 9 ma (reverse current into supply)

+12 V 34 ma

Total Power (Static Dissipation)

1.3 watts

Polarization

Pins 16 and 28

Handle Color Code

Long: White

Short: Brown

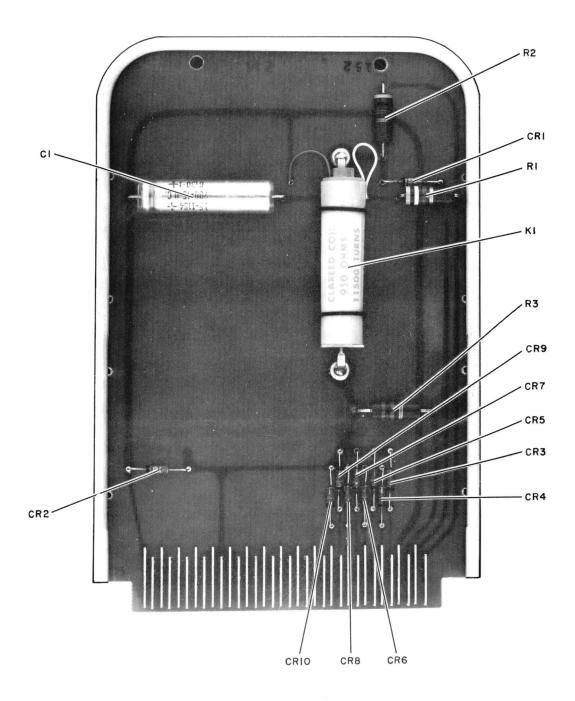


Figure 3-31.1. System Normalizer PAC, Model SN-30, Parts Location

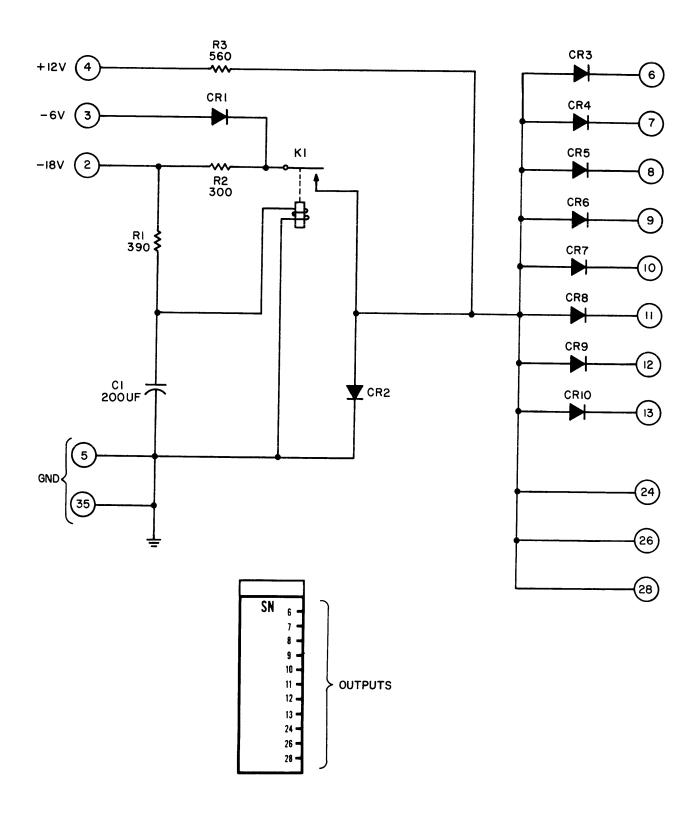


Figure 3-31.2. System Normalizer PAC, Model SN-30, Schematic Diagram

3-32 STORAGE-CONVERTER PAC, MODEL SP-30

GENERAL DESCRIPTION

The Storage-Converter PAC, Model SP-30 (figures 3-32.1 and 3-32.2), is a decimal-counting unit which contains a four-stage BCD storage register and part of a binary-to-decimal converter. The storage element consists of a four flip-flop register, with each flip-flop having both a set and a reset input. The outputs from an 8-4-2-1 BCD counter or register drive these inputs. The PAC can follow the counter to which it is connected or the count can be transferred from the counter at any time and stored until the next transfer. The part of the binary-to-decimal converter contained in the PAC converts the BCD information from the register into a special 12-line output capable of driving a Converter-Indicator PAC, Model IP-30. The IP-30 PAC completes the conversion and displays the decimal equivalent.

The set and reset outputs from each flip-flop permit parallel operation of several PACs as well as binary readout. The SP-30 and IP-30 PACs can be separated by several hundred feet to allow remote display of the register.

CIRCUIT FUNCTION

The SP-30 PAC (figure 3-32.3) receives input data from a counter to set or reset the corresponding storage register stages. Each input is gated with a transfer input which allows the register to follow the input data or remain in a static state. A ONE (-6 V) enables the gates and permits the register to follow the counter. A ZERO (0 V) disables the gates and prevents a transfer of information to the register. The set and reset outputs of each flip-flop are connected to a resistor network which provides the 12-line output for driving the IP-30 PAC. The IP-30 PAC converts the 12-line input data to a decimal display.

BCD Data Inputs. The DC levels of the input data are applied to the set and reset inputs of the flip-flop register. With a ONE on the set (TRUE) input and ZERO on the reset (FALSE) input, the application of a ONE on the TRANSFER input will set the corresponding register flip-flop.

Transfer Input. The transfer input controls the transfer of data to the storage register. A ONE input enables the register to follow the state of the counter, while a ZERO input prevents the register from changing state. The transfer input must be at the ONE level for a minimum of 1 microsecond after the last data input has changed state to guarantee a transfer.

BCD Data Outputs. The set and reset outputs of each flip-flop are available to drive other S-PACs.

Decimal Display Outputs. The 12-line output from the resistor network provides drive for an IP-30 PAC. With the 12 outputs connected to the 12 inputs of an IP-30 PAC, the BCD information of the register is converted to a decimal display.

3/2/64

SPECIFICATIONS

Input Loading

BCD data inputs: | W load

Transfer input: 4 W loads

Frequency of Operation

DC to 1 MC (max)

Output Drive Capability

BCD Data Outputs

1 V load and 50 pf stray

capacitance

Total Power

3.4 watts

Polarization

Pins 4 and 16

Output Levels

Ground and -60 V when unloaded

S-PAC compatible ONES and ZEROS

when loaded

Circuit Delay

1.5 µsec (typ)

2.5 µsec (max)

Transfer Pulse Width

1 μsec (min) at -6 V or open circuit

Current Requirements

+12 V 3 ma

-120 V 28 ma

Handle Color Code

Long: Orange

Short: Green

3-202

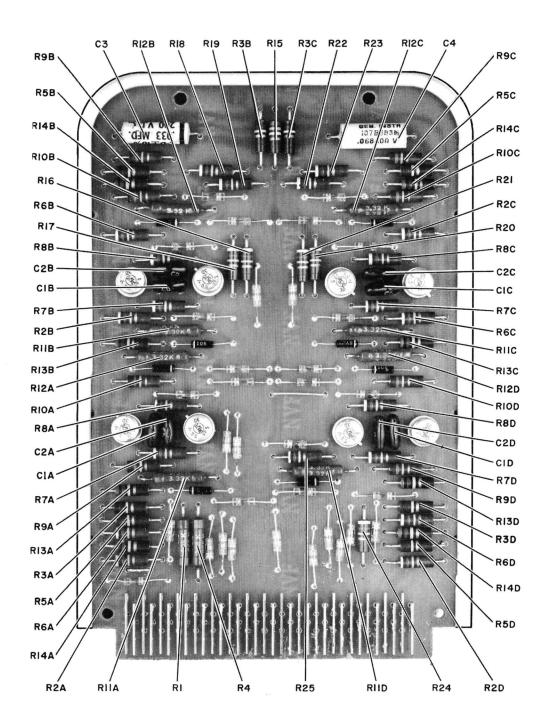


Figure 3-32.1. Storage-Converter PAC, Model SP-30 Parts Location (Resistors and Capacitors)

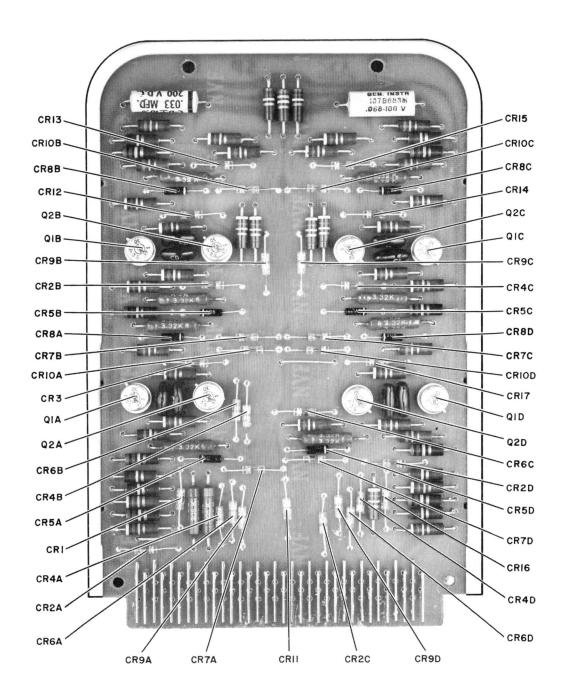


Figure 3-32.2. Storage-Converter PAC, Model SP-30, Parts Location (Diodes and Transistors)

3-204

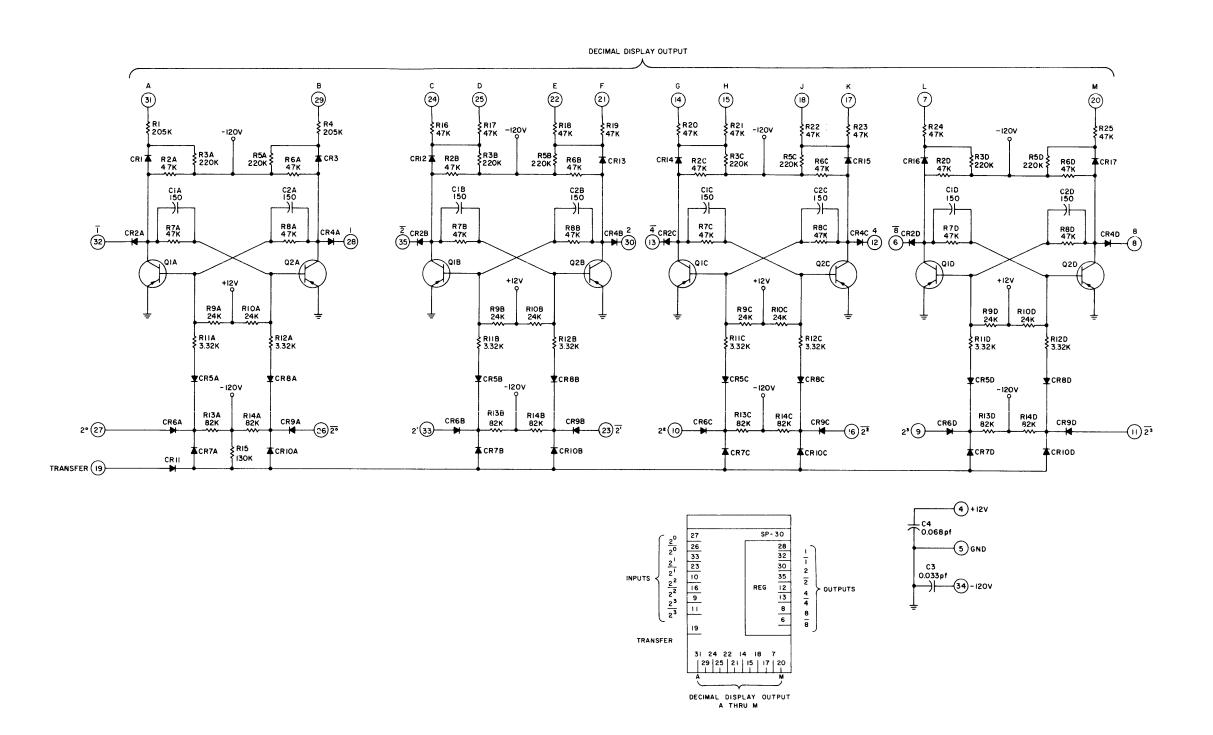


Figure 3-32.3. Storage-Converter PAC, Model SP-30, Schematic and Logic Diagram

3-33 SCHMITT TRIGGER PAC, MODEL ST-30

GENERAL DESCRIPTION

The Schmitt Trigger PAC, Model ST-30 (figures 3-33.1 through 3-33.3), contains two identical, independent Schmitt trigger circuits, each capable of converting arbitrarily shaped inputs to S-PAC compatible outputs. The Schmitt trigger is versatile and can be used for such applications as pulse shaping, waveform restoration, signal level shifting, and DC level detection. This versatility is achieved by employing several input networks to accommodate many differently shaped input signals. In addition, RC networks are provided to permit attenuation, differentiation, integration, level shifting, and filtering of the input signal, as required. Provision is also made for adjusting the sensitivity from below 0.2 volt to 4.0 volts. The threshold is variable from +2.0 to -2.0 volts with options to extend this range.

The output of the Schmitt trigger is a ONE (-6 V) for a positive-going threshold crossing (figure 3-33.1). Conversely, the output is a ZERO (0 V) for a negative-going threshold crossing. The polarity of the output is independent of the threshold voltage. The output of the Schmitt trigger with no signal input depends upon the setting of potentiometer R18 as described under Operating Threshold.

CIRCUIT FUNCTION

The ST-30 Schmitt trigger (figure 3-33.4) is a regenerative bistable circuit whose operation depends upon the input voltage. The shape of the output signal is not governed by the shape of the input signal; therefore, the Schmitt trigger is useful for pulse shaping, waveform restoration, signal shifting, and DC level detection.

Transistors Q1 and Q2 comprise a conventional Schmitt trigger circuit. Transistor Q5, connected to the emitters of both Q1 and Q2, insures that a constant current of approximately 8 milliamperes is switched between Q1 and Q2. Emitter follower Q4 and its associated circuit provide a means of varying the threshold of the Schmitt trigger. Transistor Q3 is an inverter whose output is S-PAC compatible in voltage levels and transition times.

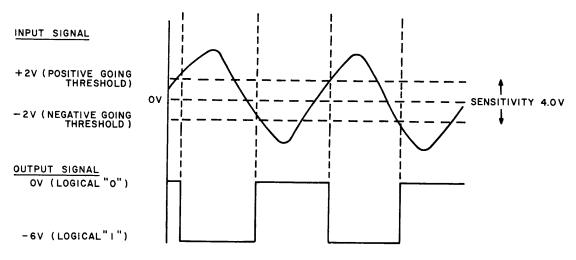


Figure 3-33.1. Schmitt Trigger PAC, Model ST-30, Typical Waveforms

Inputs. The ST-30 has five inputs: one direct, two resistive, and two capacitive. The variety of inputs provides a choice of attenuation, differentiation, integration, or filtering by connecting the input signal to the appropriate input pin. Table 3-33.1 provides two typical variations that can be obtained with the various input options.

Table 3-33.1. Typical Input Variat

	Ground Pins		Input on Pins	
Variation	A Circuit	B Circuit	A Circuit	B Circuit
10:1 attenuation DC to 3.1 KC low-pass	17 16	20 21	18	19 19
filter (-3 db)				

NOTE

To achieve optimum timing, the input voltage should not exceed ± 2.5 volts.

Level Shifting. Although the threshold is variable to ± 2.0 volts, an additional $\pm 1.9*$ volts can be obtained. A positive shift allows for more negative threshold settings, while a negative shift allows for more positive threshold settings. A positive shift can be obtained by connecting pin 8 to pin 9 for circuit A and pin 29 to pin 28 for circuit B. Similarly, a negative shift can be obtained by connecting pin 7 to pin 9 for circuit A and pin 30 to pin 28 for circuit B. The degree of level shift (ΔE) depends upon the driving source impedance (R_s) and the DC level of the source e_{dc}). Equation 1 shows this relationship for a negative level shift and equation 2 the relationship for a positive level shift.

NOTE

The value of R_s must be given in kilohms in equations 1 through 4.

$$\Delta E_{(-)} = \frac{-18 R_{s}}{1.17 R_{c} + 8.2} + \frac{7.0 \times e_{dc}}{7.0 + R_{s}}$$
(1)

$$\Delta E_{(+)} = \frac{12 R_{s}}{1.11 R_{s} + 5.1} + \frac{4.6 \times e_{dc}}{4.6 + R_{s}}$$
 (2)

Equation 3 shows the attenuation of the input signal for a negative level shift. The attenuation of the input signal for a positive level shift is shown in equation 4.

Attenuation (-) =
$$\frac{e_{base}}{e_{source}}$$
 = $\frac{7.0}{7.0 + R_s}$ (3)

Attenuation (+) =
$$\frac{e_{base}}{e_{source}}$$
 = $\frac{4.6}{4.6 + R_s}$ (4)

3-208

^{*}An increase of ±1.9 volts is possible provided the source impedance is 1 kilohm or greater and the DC level of the source is 0 volt.

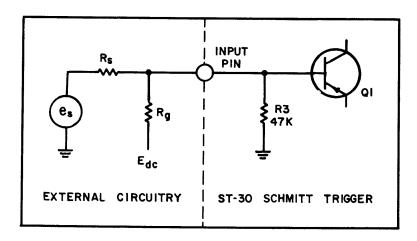
External Level Shifting and Attenuation Networks. The versatility of the ST-30 Schmitt trigger can be increased by the addition of external level shifting and attenuation networks. Figure 3-33.2 illustrates one method by which this can be accomplished.

External resistor R_g is connected to pin 9 for circuit A or to pin 28 for circuit B. An external DC power source is connected to the other end of R_g . Equation 5 explains how to calculate the positive level shift for a particular value of R_g and E_{dc} and equation 6 explains how to calculate a negative level shift. The attenuation resulting from either a positive or negative level shift can be calculated by the use of equation 7.

$$\Delta E_{(+)} = \frac{e_{dc} + \frac{E_{dc} R_{s}}{R_{g}}}{\frac{R_{s}}{R_{g}} + \frac{R_{s}}{47} + 1}$$
(5)

$$\Delta E_{(-)} = \frac{e_{dc} + \frac{E_{dc} R_{s}}{R_{g}} + 0.2R_{s}}{\frac{R_{s}}{R_{g}} + \frac{R_{s}}{47} + 1}$$
(6)

Attenuation (+ or -) =
$$\frac{e_{base}}{e_{base}}$$
 = $\frac{1}{\frac{R_s}{R_g} + \frac{R_s}{47} + 1}$ (7)



es = source voltage

R_s = SOURCE IMPEDANCE IN K OHMS

Rg = EXTERNAL RESISTANCE IN K OHMS

Edc = EXTERNAL DC VOLTAGE

Figure 3-33.2. External Level Shifting and Attenuation Network, Simplified Schematic Diagram

Operating Threshold. The ST-30 has a variable threshold which is adjustable from +2.0 to -2.0 volts. Potentiometer R18 is used to adjust either the positive or the negative threshold (figure 3-33.1). The other threshold depends upon sensitivity. However, both thresholds can be controlled by certain sensitivity adjustments as described under Sensitivity.

To adjust the negative threshold, proceed as follows:

NOTE

The following adjustment procedure is described using the pin numbers for circuit A. The corresponding pin numbers for circuit B are shown in parentheses.

- a. Select the desired sensitivity and make the proper connections (table 3-33.2).
- b. Connect a variable DC power source to pin 9 (28).
- c. Adjust the variable DC power source for the desired threshold voltage.
- d. Measure the output voltage at pin 10 (27). The voltage at pin 10 (27) must be -6.0 volts. If the output voltage is not at this level, adjust R18 until -6.0 volts is obtained.
 - e. Slowly adjust R18 until the output voltage at pin 10 (27) switches to 0 volt.

The procedure for adjusting the positive threshold is similar to that of the negative threshold with the following exceptions:

- a. The output voltage at pin 10 (27) must be 0 volt.
- b. Potentiometer R18 must be slowly adjusted until the output voltage at pin 10 (27) switches to -6.0 volts.

NOTE

The accuracy of either threshold adjustment depends upon the fine adjustment of R18 and the precision of the instruments used. An accuracy of 20 millivolts is easily obtainable. When the adjustment is made, the input voltage changes because of the base current in the source impedance. This change is of no consequence and can be ignored if the preceding procedure is followed carefully.

Sensitivity. The ST-30 provides four options for sensitivity control. Three of these options are preset and the fourth is variable. The four options are shown in table 3-33.2.

	Table 3-33.2.	Sensitivity	Options f	or Schmitt	Trigger,	Model ST-30
--	---------------	-------------	-----------	------------	----------	-------------

Connection of Variable Level Control*		
Circuit A	Circuit B	Sensitivity**
Open	Open	4.0 V preset***
14	23	1.0 V preset
13	24	0.6 V preset
12	25	< 0.2 to 0.25 V variable

^{*}Variable level control is the signal on pin 11 of circuit A and pin 26 on circuit B.

^{**}Refer to figure 3-33.1.

^{***}Note that when this sensitivity option is used, the operating thresholds are preset at ±2.0 volts. All of the other options allow a ±2.0-volt variable threshold.

The sensitivity of the ST-30 can be modified by the addition of external fixed-resistors or potentiometers. For example, a 500-ohm potentiometer connected between pins 11 and 12 of circuit A (pins 26 and 25 of circuit B) produces a variable sensitivity of from less than 0.2 to 1.0 volt.

To determine the sensitivity of the ST-30 Schmitt Trigger, proceed as follows:

- $\ensuremath{\mathtt{a}}_{\bullet}$ Adjust one of the operating thresholds as described under Operating Thresholds.
- b. Determine the other operating threshold by slowly varying the input voltage and observing the output voltage at pin 10 (27). The point at which the transition occurs determines the other threshold.
- $c_{\:\raisebox{1pt}{\text{\circle*{1.5}}}}$ Calculate the sensitivity by taking the algebraic difference between the two operating thresholds.

Multiple Triggering. When the input signal is more negative than the operating threshold, base current from transistor Q1 flows into the source. With some combinations of sensitivity and source impedance, this current affects sensitivity and causes multiple triggering because of the voltage shift at the base of Q1. The magnitude of this voltage shift is equal to the product of the base current and the source impedance. The sensitivity must be less than the voltage shift to prevent multiple triggering.

The ST-30 is provided with a 0.01-microfarad capacitor (input pin 16 on circuit A and input pin 21 on circuit B) which can be used to filter the level change.

SPECIFICATIONS

Input Impedance

Applied voltage positive with respect to threshold 47 K. Applied voltage negative with respect to threshold 47 K (max base current into source is 200 µa).

Input Sensitivity

Refer to table 3-33.2.

Frequency of Operation

DC to 1 MC (max)

Circuit Delay

0.15 μsec (typ)

Total Power

2.0 watts

Polarization

8 and 28

Output Waveform Characteristics

Rise time: 0.1 µsec (typ) Fall time: 0.15 µsec (typ)

Output Drive Capability

7 U loads and 400 pf stray capacitance each

Current Requirements

-18 V 47 ma

-6 V 32 ma (reverse current into supply)

+12 V 64 ma

Handle Color Code

Long: Purple
Short: Purple

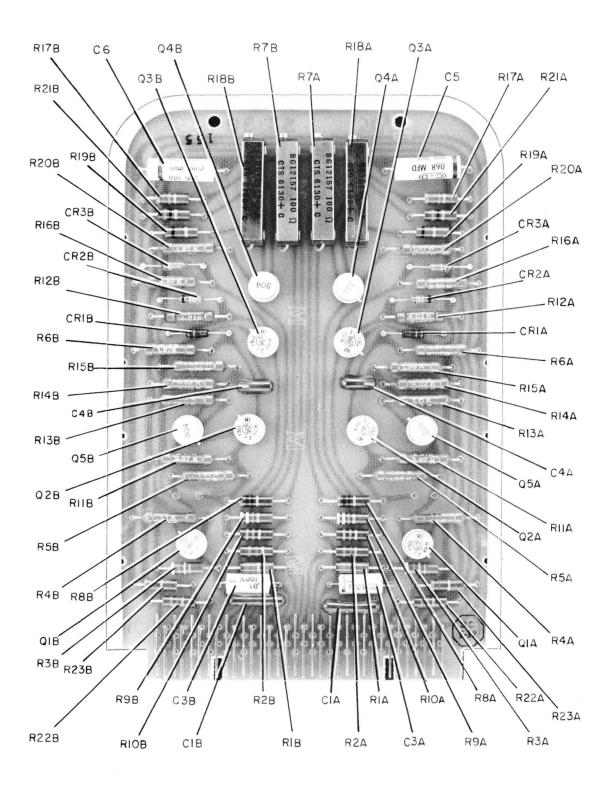


Figure 3.33.3. Schmitt Trigger PAC, Model ST-30, Parts Location

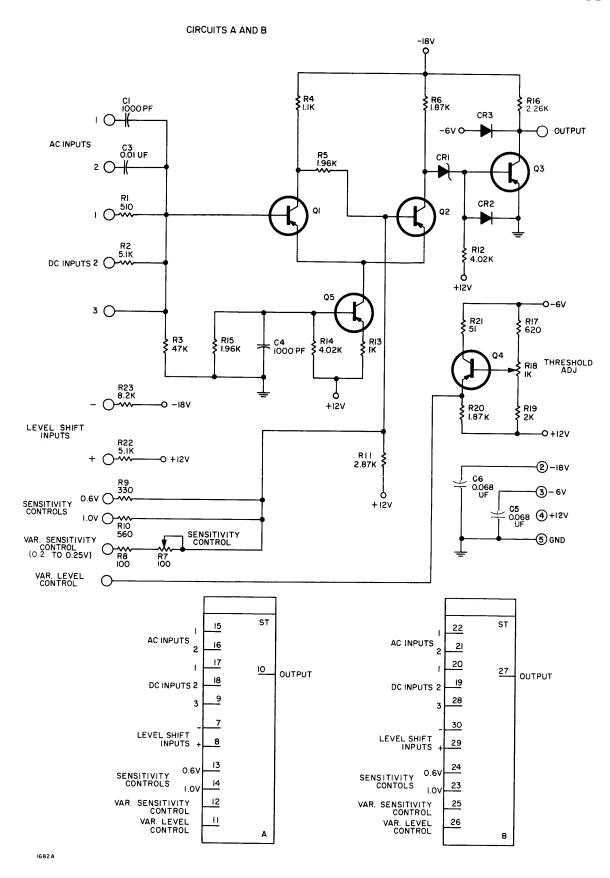


Figure 3-33.4. Schmitt Trigger PAC, Model ST-30, Schematic and Logic Diagram

3-34 SCHMITT TRIGGER PAC, MODEL ST-35

GENERAL DESCRIPTION

The Schmitt Trigger PAC, Model ST-35 (figures 3-34.1 through 3-34.3) contains two identical, independent Schmitt trigger circuits, each capable of converting arbitrarily shaped inputs to S-PAC compatible outputs. The Schmitt trigger is versatile and can be used for such applications as pulse shaping, waveform restoration, signal level shifting, and DC level detection. This versatility is achieved by employing several input networks to accommodate many differently shaped input signals. In addition, RC networks are provided to permit attenuation, differentiation, integration, level shifting, and filtering of the input signal, as required. Provision is also made for adjusting the sensitivity from below 0.2 volt to 4.0 volts. The threshold is variable from +2.0 to -2.0 volts with options to extend this range.

The output of the Schmitt trigger is a ONE (-6 V) for a positive-going threshold crossing (figure 3-34.1). Conversely, the output is a ZERO (0 V) for a negative-going threshold crossing. The polarity of the output is independent of the threshold voltage. The output of the Schmitt trigger with no signal input depends upon the setting of potentiometer R18. Model ST-35 is shown in figure 3-34.3.

CIRCUIT FUNCTION

The ST-35 Schmitt trigger (figure 3-34.4) is a regenerative bistable circuit whose operation depends upon the input voltage. The shape of the output signal is not governed by the shape of the input signal; therefore, the Schmitt trigger is useful for pulse shaping, waveform restoration, signal shifting, and DC level detection.

A schematic of the ST-35 is shown in figure 3-34.4. Transistors Ql and Q2 comprise a conventional Schmitt trigger circuit. Transistor Q5, connected to the emitters of both Ql and Q2, insures that a constant current of approximately 8 milliamperes is switched between Ql and Q2. Emitter follower Q4 and its associated circuit provide a means of varying the threshold of the Schmitt trigger. Transistor Q3 is an inverter whose output is S-PAC compatible in voltage levels and transition times.

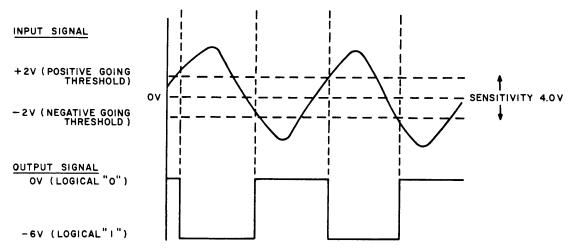


Figure 3-34.1. Schmitt Trigger PAC, Model ST-35, Typical Waveforms

3/2/64

<u>Inputs</u>. The ST-35 has five inputs: one direct, two resistive, and two capacitive. The variety of inputs provides a choice of attenuation, differentiation, integration, or filtering by connecting the input signal to the appropriate input pin. Table 3-34.1 gives two typical variations that can be obtained with the various input options.

Table	3-34.1.	Typical	Input	Variations
-------	---------	---------	-------	------------

	Ground Pins		Input on Pins	
Variation	A Circuit	B Circuit	A Circuit	B Circuit
10:1 attenuation	17	20	18	19
DC to 3.1 KC low-pass filter (-3 db)	16	21	18	19

NOTE

To achieve optimum timing, the input voltage should not exceed ± 2.5 volts.

Level Shifting. Although the threshold is variable to ± 2.0 volts, an additional $\pm 1.9*$ volts can be obtained. A positive shift allows for more negative threshold settings, while a negative shift allows for more positive threshold settings. A positive shift can be obtained by connecting pin 8 to pin 9 for circuit A and pin 29 to pin 28 for circuit B. A negative shift can be obtained by connecting pin 7 to pin 9 for circuit A and pin 30 to pin 28 for circuit B. The degree of level shift (ΔE) depends on the driving source impedance (R_s) and the DC level of the source (e_{dc}). Equation 1 shows this relationship for a negative level shift and equation 2 the relationship for a positive level shift.

NOTE

The value of R_s must be given in kilohms in equations 1 through 4.

$$\Delta E_{(-)} = \frac{-18 R_{s}}{1.17 R_{s} + 8.2} + \frac{7.0 \times e_{dc}}{7.0 + R_{s}}$$
(1)

$$\Delta E_{(+)} = \frac{12 R_s}{1.11 R_s + 5.1} + \frac{4.6 \times e_{dc}}{4.6 + R_s}$$
 (2)

Equation 3 shows the attenuation of the input signal for a negative level shift. The attenuation of the input signal for a positive level shift is shown in equation 4.

Attenuation (-) =
$$\frac{e}{e} \frac{base}{source} = \frac{7.0}{7.0 + R_s}$$
 (3)

Attenuation (+) =
$$\frac{e_{\text{base}}}{e_{\text{source}}} = \frac{4.6}{4.6 + R_{\text{s}}}$$
 (4)

^{*}An increase of ±1.9 volts is possible provided the source impedance is 1 kilohm or greater and the DC level of the source is 0 volt.

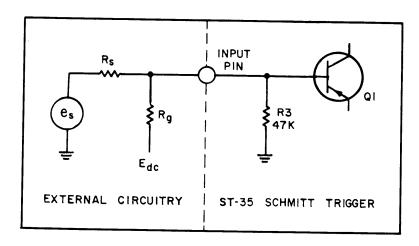
External Level Shifting and Attenuation Networks. The versatility of the ST-35 Schmitt trigger can be increased by the addition of external level shifting and attenuation networks. Figure 3-34.2 illustrates one method by which this can be accomplished.

External resistor R_g is connected to pin 9 for circuit A or to pin 28 for circuit B. An external DC power source is connected to the other end of R_g . Equation 5 explains how to calculate the positive level shift for a particular value of R_g and E_{dc} and equation 6 explains how to calculate a negative level shift. The attenuation resulting from either a positive or negative level shift can be calculated by the use of equation 7.

$$\Delta E_{(+)} = \frac{e_{dc} + \frac{E_{dc} R_{s}}{R_{g}}}{\frac{R_{s}}{R_{g}} + \frac{R_{s}}{47} + 1}$$
(5)

$$\Delta E_{(-)} = \frac{e_{dc} + \frac{E_{dc} R_{s}}{R_{g}} + 0.2R_{s}}{\frac{R_{s}}{R_{g}} + \frac{R_{s}}{47} + 1}$$
(6)

Attenuation (+ or -) =
$$\frac{e}{e} \frac{base}{base}$$
 = $\frac{1}{\frac{R_s}{R_g} + \frac{R_s}{47} + 1}$ (7)



es = source voltage

Rs = SOURCE IMPEDANCE IN KOHMS

Rg = EXTERNAL RESISTANCE IN K OHMS

Edc = EXTERNAL DC VOLTAGE

Figure 3-34.2. External Level Shifting and Attenuation Network, Simplified Schematic Diagram

3/2/64

Operating Threshold. The ST-35 has a variable threshold which is adjustable from +2.0 to -2.0 volts. Potentiometer R18 is used to adjust either the positive or the negative threshold (figure 3-34.1). The other threshold depends upon sensitivity. However, both thresholds can be controlled by certain sensitivity adjustments.

To adjust the negative threshold, proceed as follows.

NOTE

The following adjustment procedure is described using the pin numbers for circuit A. The corresponding pin numbers for circuit B are shown in parentheses.

- a. Select the desired sensitivity and make the proper connections (Table 3-34.2.)
- b. Connect a variable DC power source to pin 9 (28).
- c. Adjust the variable DC power source for the desired threshold voltage.
- d. Measure the output voltage at pin 10 (27). The voltage at pin 10 (27) must be
- -6.0 volts. If the output voltage is not at this level, adjust R18 until -6.0 volts is obtained.
 - e. Slowly adjust R18 until the output voltage at pin 10 (27) switches to 0 volt.

The procedure for adjusting the positive threshold is similar to that of the negative threshold with the following exceptions:

- a. The output voltage at pin 10 (27) must be 0 volt.
- b. Potentiometer R18 must be slowly adjusted until the output voltage at pin 10 (27) switches to -6.0 volts.

NOTE

The accuracy of either threshold adjustment depends upon the fine adjustment of R18 and the precision of the instruments used. An accuracy of 20 millivolts is easily obtainable. When the adjustment is made, the input voltage changes because of the base current in the source impedance. This change is of no consequence and can be ignored if the preceding procedure is followed carefully.

Sensitivity. The ST-35 provides four options for sensitivity control. Three of these options are preset and the fourth is variable. The four options are shown in table 3-34.2.

Table 3-34.2.	Sensitivity	Options	for Schmitt	Trigger,	Model ST-35
---------------	-------------	---------	-------------	----------	-------------

Connection of Variable Level Control*		
Circuit A	Circuit B	Sensitivity**
Open	Open	4.0 V preset***
14	23	1.0 V preset
13	24	0.6 V preset
12	25	⟨ 0. 2 to 0. 25 V variable

^{*}Variable Level Control is the signal on pin 11 of circuit A and pin 26 on circuit B.

^{**}Refer to figure 3-34.1.

^{***}Note that when this sensitivity option is used, the operating thresholds are preset at ±2.0 volts. All of the other options allow a ±2.0-volt variable threshold.

The sensitivity of the ST-35 can be modified by the addition of external fixed-resistors or potentiometers. For example, a 500-ohm potentiometer connected between pins 11 and 12 of circuit A (pins 26 and 25 of circuit B) produces a variable sensitivity of from less than 0.2 to 1.0 volt.

To determine the sensitivity of the ST-35 Schmitt Trigger, proceed as follows.

- a. Adjust one of the operating thresholds as described under Operating Thresholds.
- b. Determine the other operating threshold by slowly varying the input voltage and observing the output voltage at pin 10 (27). The point at which the transition occurs determines the other threshold.
- c. Calculate the sensitivity by taking the algebraic difference between the two operating thresholds.

Multiple Triggering. When the input signal is more negative than the operating threshold, base current from transistor Ql flows into the source. With some combinations of sensitivity and source impedance, this current effects sensitivity and causes multiple triggering because of the voltage shift at the base of Ql. The magnitude of this voltage shift is equal to the product of the base current and the source impedance. The sensitivity must be less than the voltage shift to prevent multiple triggering.

The ST-35 is provided with a 0.01-microfarad capacitor (input pin 16 on circuit A and input pin 21 on circuit B) which can be used to filter the level change.

SPECIFICATIONS

Input Impedance

Applied voltage positive with respect to threshold 47 K. Applied voltage negative with respect to threshold 47 K (max base current into source is $200 \ \mu a$).

Input Sensitivity

Refer to table 3-34.2.

Frequency of Operation

DC to 3 MC (max)

Circuit Delay

 $0.05 \, \mu sec (typ)$

Total Power

2.0 watts

Polarization

8 and 28

Output Waveform Characteristics

Rise time: 0.025 μsec (typ) Fall time: 0.05 μsec (typ)

Output Drive Capability

5 V loads and 50 pf stray

capacitance each

Current Requirements

-18 V: 47 ma

- 6 V: 32 ma (reverse current into supply)

+12 V: 64 ma

Handle Color Code

Long: Purple

Short: Purple

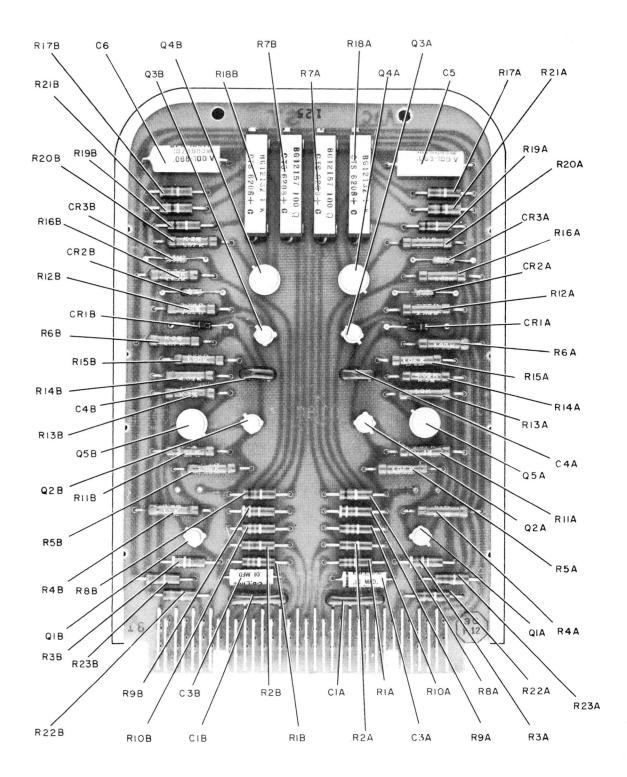


Figure 3-34.3. Schmitt Trigger PAC, Model ST-35, Parts Location

3-220

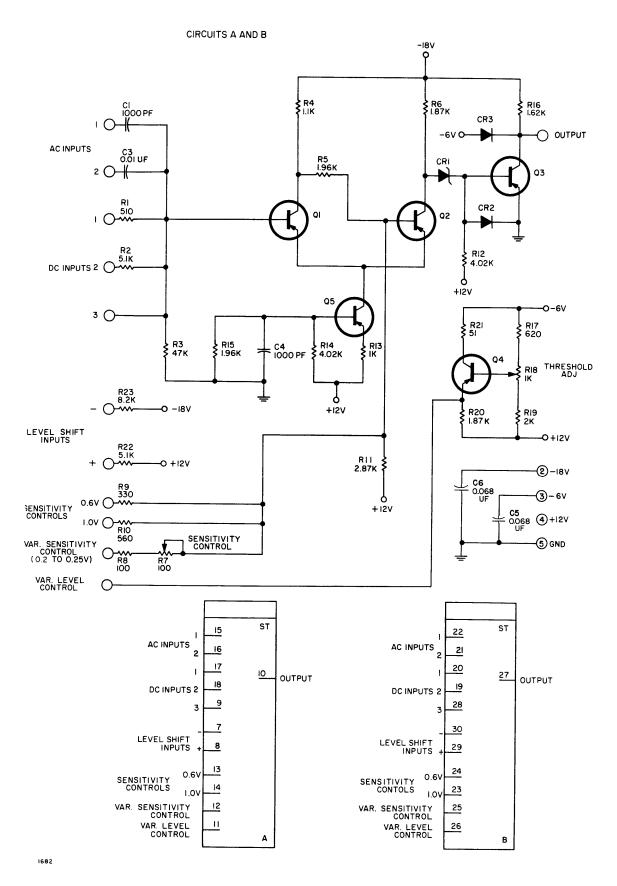


Figure 3-34.4. Schmitt Trigger PAC, Model ST-35, Schematic and Logic Diagram

1/12/66

3-35 TIMING DISTRIBUTOR PAC, MODEL TD-30

GENERAL DESCRIPTION

The Timing Distributor PAC, Model TD-30 (figure 3-35.1), provides an accurately timed positive pulse sequence after application of an input signal. Output pulses are selectable from delay line taps. The TD-30 contains a gated input pulse generator, a 4-microsecond passive delay line, and six independent amplifiers. The input to each amplifier can be connected to different taps on the delay line to provide the desired output pulse sequence. The TD-30 is directly replaceable by the improved Model TD-32.

CIRCUIT FUNCTION

For standard S-PAC logic signals, the input stage consists of a pair of AND gates (two-legged and three-legged) which are buffered through an OR gate to the base of gating transistor Ql. A transition from logic ZERO (0 V) to logic ONE (-6 V) on either AND gate output with the other AND gate output at ground, turns on transistor Ql. This transistor then triggers blocking oscillator Q2, sending a negative pulse down the 4-microsecond delay line. Table 3-35.1 shows the values of delay that can be obtained using this PAC.

Each delay line tapped output can be amplified and inverted to provide an accurately timed, 0.6-microsecond positive output pulse capable of driving five S-PAC unit loads. Input connection points for each amplifier are located on the printed circuit board to allow jumper connections to the delay line tap points (figure 3-35.2, sheets 1 and 2). Amplifiers A and B have AND gate inputs that can be connected to any two separate points on the delay line to provide narrow output pulses. The width of these pulses is determined by the overlap of the two pulse inputs. A typical jumper connection arrangement is shown on sheet 3 of figure 3-35.2.

NOTE

One leg of an unused AND gate must be tied to ground, for proper operation.

SPECIFICATIONS

Amplifier Output Drive Capability		
5 U loads and 300 pf stray capacitance each		
Output Waveform Characteristics		
Rise time: 0.5 µsec (typ) Fall time: 0.8 µsec (typ) Positive pulse width: 0.6 µsec (nom)		
, , , , , , , , , , , , , , , , , , , ,		
Amplifier Delay		
40 ns (typ)		

4/16/68

SPECIFICATIONS (Continued)

Power Requirements

Quiescent Cycling at
Maximum Rate

+12 V 45 ma 45 ma
- 6 V 31 ma (rev) 28 ma (rev)
-18 V 50 ma 73 ma

Total power:
1.2 watts Total power:
1.8 watts

 $\frac{\text{Polarization}}{\text{Pins 6 and 30}}$

Input Delay

100 ns (typical delay from input to first delay line tap)

Delay Line Taps Refer to table 3-35.1

Handle Color Code

Long: White Short: Green

3-224

Table 3-35.1. Delay Line Tap Points with Corresponding Delay Line Delays (Refer to figure 3-35.2)

Delay Line Jumper Connection NR	Delay Line Delay (ns)	Delay Line Jumper Connection NR	Delay Line Delay (ns)
1	0	32	2036
2	36	33	2107
3	107	34	21 7 9
4	179	35	2250
5	250	36	2322
6	322	37	2393
7	393	38	2465
8	465	39	2536
9	536	40	2608
10	608	41	2679
11	679	42	2751
1 2	751	43	2822
1 3	822	44	2894
14	894	45	2965
15	965	46	3000
16	1000	47	3036
17	1036	48	3107
18	1107	49	3179
19	1179	50	3250
20	1 250	51	3322
21	1322	52	3393
22	1393	53	3465
23	1 465	54	3536
24	1536	55	3608
25	1608	56	3679
26	1679	57	3751
27	1751	58	3822
28	1822	59	3894
29	1894	60	3965
30	1965	61	4000
31	2000		

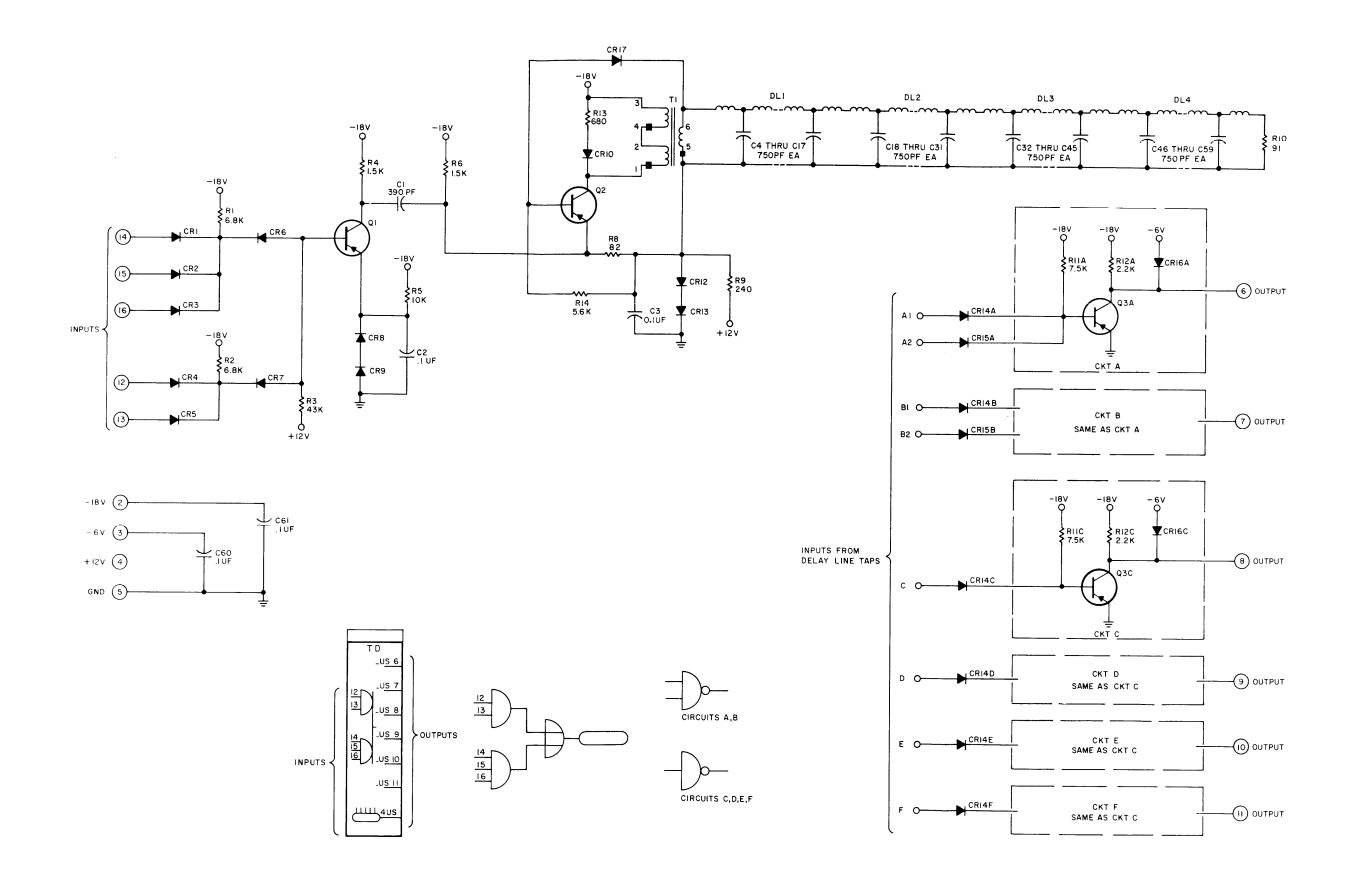


Figure 3-35.1. Timing Distributor PAC, Model TD-30, Schematic and Logic Diagram

3/2/64 3-227/3-228

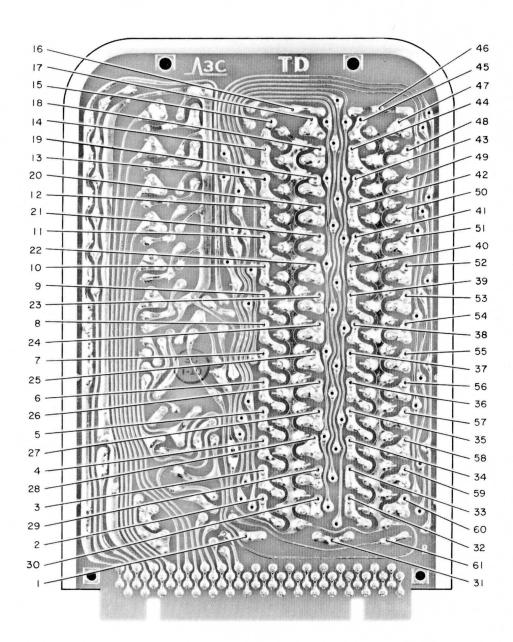


Figure 3-35.2. Timing Distributor PAC, Model TD-30, Jumper Interconnection Diagram (Sheet 1 of 3)

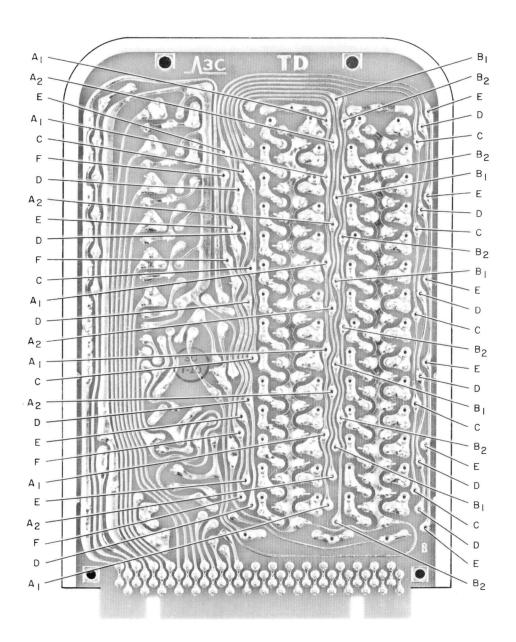


Figure 3-35.2. Timing Distributor PAC, Model TD-30, Jumper Interconnection Diagram (Sheet 2 of 3)

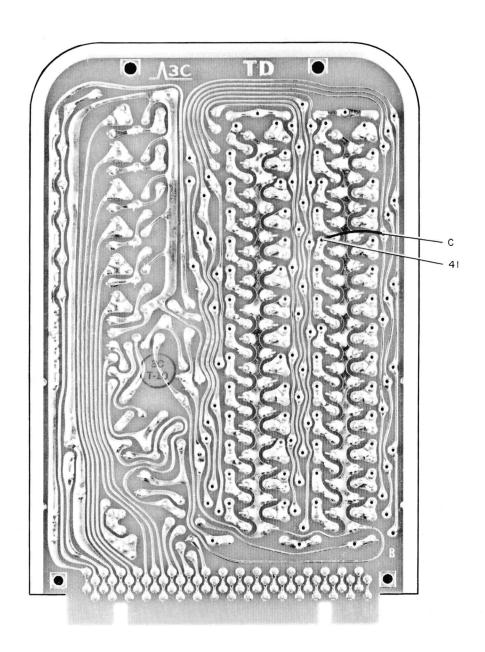


Figure 3-35.2. Timing Distributor PAC, Model TD-30, Jumper Interconnection Diagram (Sheet 3 of 3)

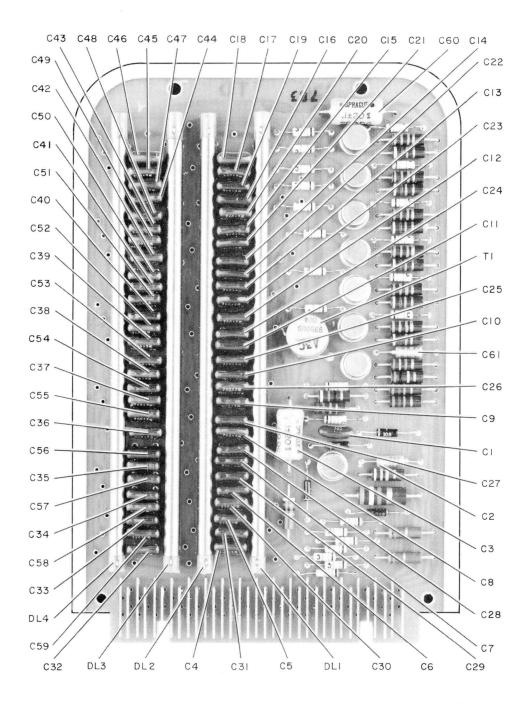


Figure 3-35.3. Timing Distributor PAC, Model TD-30, Parts Location (Capacitors, Delay Lines, and Transformers)

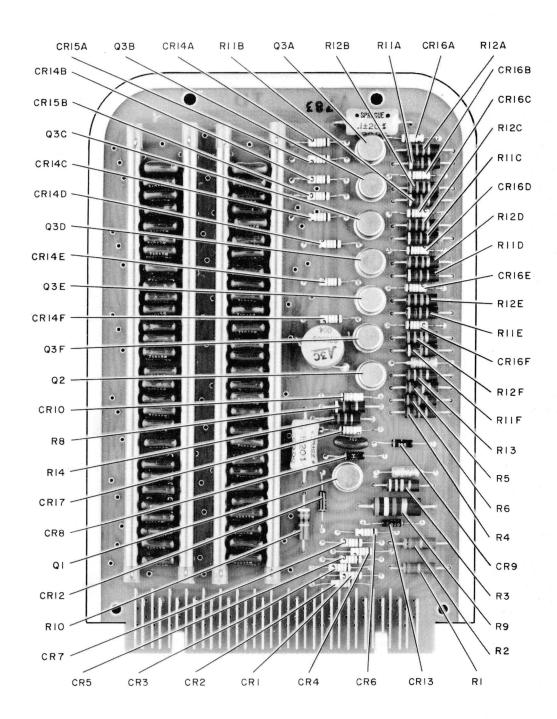


Figure 3-35.4. Timing Distributor PAC, Model TD-30, Parts Location (Resistors, Diodes, and Transistors)

3-35A TIMING DISTRIBUTOR PAC, MODEL TD-32

GENERAL DESCRIPTION

The Timing Distributor PAC, Model TD-32 (figures 3-35A.1 and 3-35A.2), provides accurately timed positive pulse sequences to drive S-PACs. The positive pulses are selected from a delay line. The TD-32 contains a gated input pulse generator, a $4\,\mu$ sec passive delay line, and six independent amplifiers. The input to each amplifier can be connected to taps on the delay line to provide output pulse sequences.

CIRCUIT FUNCTION

Input negative logic signals activate a pair of AND gates (2-legged and 3-legged) which are buffered through an OR gate to the base of gating transistor Q6 (figure 3-35A.5). A logic ONE (-6V) at the base of Q6 turns it on which, in turn, sets flip-flop Q2 and Q3. The reset output from Q3 (a logical zero) will cause Q4 to cut-off and Q5 to start conduction. This causes a pulse to be sent down the 4-µsec delay line. The pulse width may be adjusted by selecting taps on the delay line. Flip-flop reset is also dependent on the delay line tap. Values of delay from the delay line can be obtained from Table 3-35A.1 and Figure 3-35A.3. Each delay line tapped output can be amplified and inverted to provide an accurately timed, positive output pulse capable of driving five S-PAC unit loads. Input connection points for each amplifier are located on the PAC to facilitate jumper connections to delay line tap points (figures 3-35A.3 and 3-35A.4). Amplifiers A and B have AND gate inputs that can be connected to any two separate points on the delay line. This will provide arbitrarily narrow output pulses. A typical jumper connection arrangement is illustrated in figure 3-35A.4.

SPECIFICATIONS

Input Loading

1/2 U load (each gate)

Output

5 U loads (each output)

Output Pulse Width

(Max. pulse width not to exceed 49% of the duty cycle). Adjustable from 0.1 to 1.0 μ sec. Two of six channels can provide narrower pulses.

Frequency of Operation

500 KC (max)

Input Delay

100 nsec, typical delay from input to first delay line tap

Power Requirements

Quiescent:

+12V 6 ma

- 6V 35 ma (rev)

-18V 120 ma

Total Power: 1.2 watts

Cycling at maximum rate:

65 ma

35 ma (rev)

120 ma

Total Power: 1.75 watts

Table 3-35A.1. Delay Line Tap Points With Corresponding Delay Line Delays (Refer to Figure 3-35A.3).

Delay Line Jumper Connection NR	Delay Line Delay (ns ±3%)	Delay Line Jumper Connection NR	Delay Line Delay (ns ±3%)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	0 36 107 179 250 322 393 465 536 608 679 751 822 894 965 1000 1036 1107 1179 1250 1322 1393 1465 1536 1608 1679 1751 1822 1894 1965 2000	32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61	2036 2107 2179 2250 2322 2393 2465 2536 2608 2679 2751 2822 2894 2965 3000 3036 3107 3179 3250 3322 3393 3465 3536 3608 3679 3751 3822 3894 3965 4000

3-234B 4/16/68

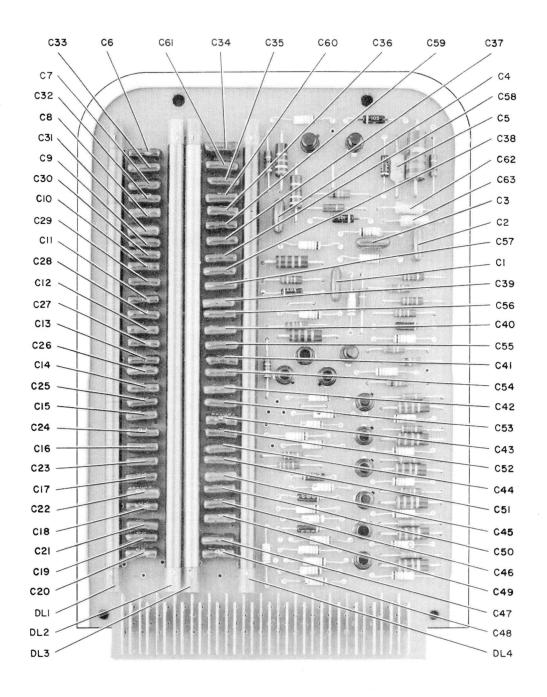


Figure 3-35A.1. Timing Distributor PAC, Model TD-32, Parts Location (Capacitors and Delay Lines)

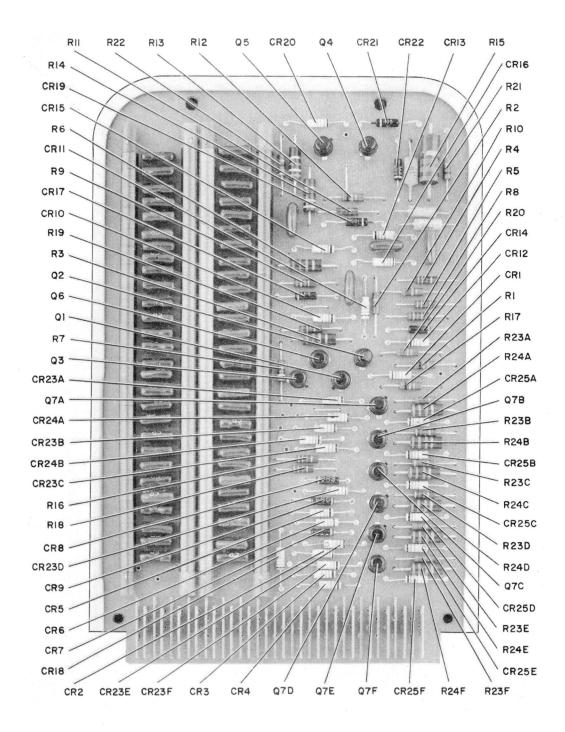


Figure 3-35A.2. Timing Distributor PAC, Model TD-32, Parts Location (Transistors, Diodes and Resistors)

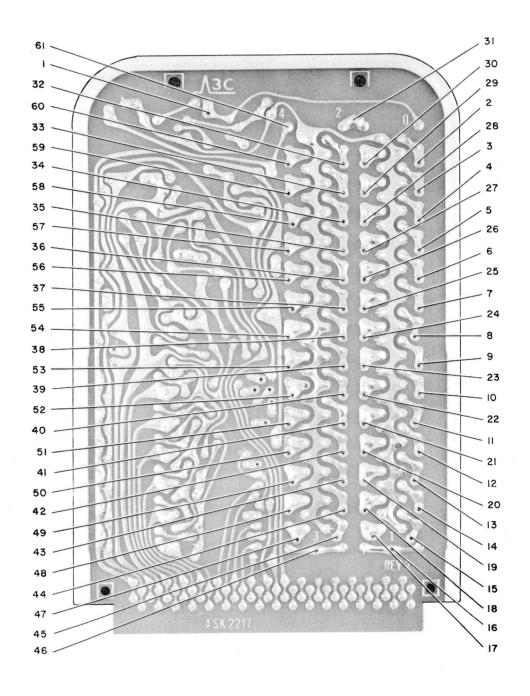


Figure 3-35A.3. Timing Distributor PAC, Model TD-32, Jumper Interconnection Diagram

4/16/68 3-234E

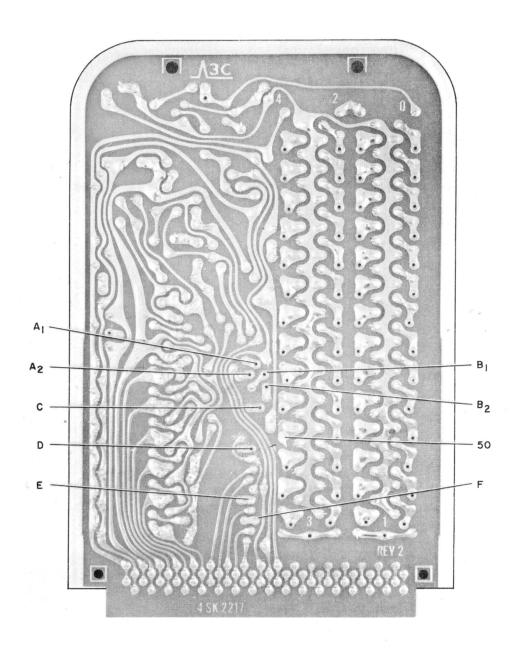


Figure 3-35A.4. Timing Distributor PAC, Model TD-32, Jumper Interconnection Diagram

3-234F 4/16/68

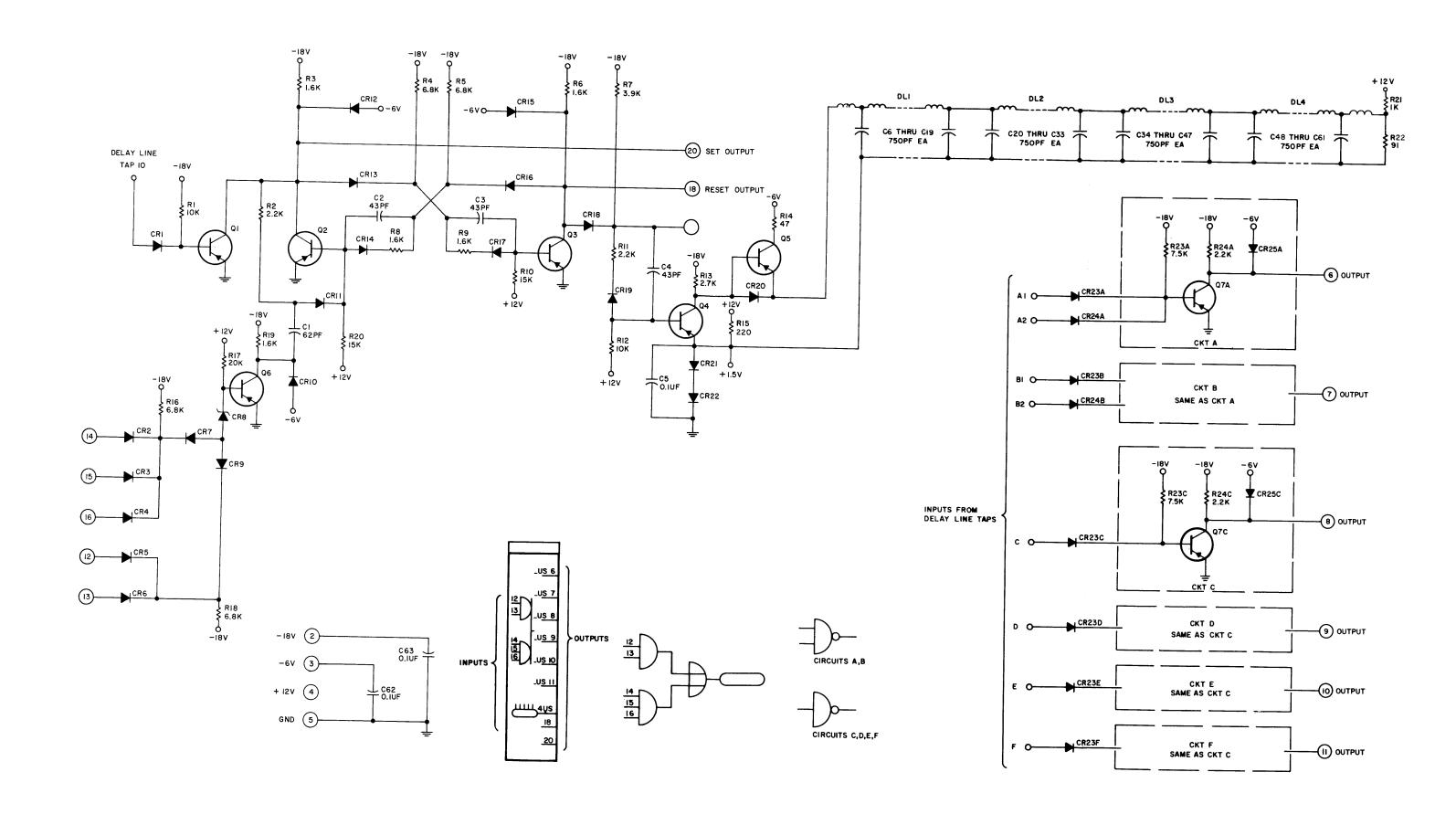


Figure 3-35A.5. Timing Distributor PAC, Model TD-32, Schematic and Logic Diagrams

3-36. TRANSISTORIZED UNIT INDICATOR, MODEL UI-10

GENERAL DESCRIPTION

The Transistorized Unit Indicator, Model UI-10 (figure 3-36.1), is a low-power visual indicator that monitors S-PAC logic levels. The UI-10 contains a transistorized neon indicator circuit. When a ONE (-6 V) is applied to the input circuit, the neon indicator ignites. The UI-10 is powered from a -90-volt supply and is driven by standard S-PAC logic signals.

Each standard UI-10 is equipped with a clear plastic lens and taper pin connections and has provision for driving an external indicator. The UI-10 mounts in a 3/8-inch diameter hole, 5/8 inch on center, and projects a maximum of 1-15/16 inches behind the panel.

CIRCUIT FUNCTION

In normal operation, the transistor is biased to cutoff (figure 3-36.1). Application of a -6 volt level permits the transistor to light the indicator lamp. Input logic levels are -applied to pin 2 or pin 3 of the UI-10 connector. The internal 68-kilohm resistor between pin 3 and the base of the transistor provides effective circuit isolation between the UI-10 and the driving source. Pin 2 is provided for the application of dynamic assertion signals to the indicators.

CAUTION

Do not apply power to a UI-10 unit unless pin 2 is connected to an appropriate input signal or ground.

SPECIFICATIONS

Input Loading	Input Voltage Margins			
l U load each		Indicator	Indicator	
Frequency of Operation		On	Off	
DC to 50 KC	Voltono	0.0.4	-0.4 to	
Total Power 162 mw	Voltage: (Pin 2) Current:	-0.8 to -1.5 VDC 0.1 to 1.0 ma	+5.0 VDC 0 ma	
Current Requirements	Voltage: (Pin 3)	-3.5 to	-1.6 to	
-90 VDC 2.3 ma with remote lamp 1.8 ma without remote lamp	Current:	-20 VDC 0.2 to 1.0 ma	+5.0 VDC 0 ma	

1/12/66



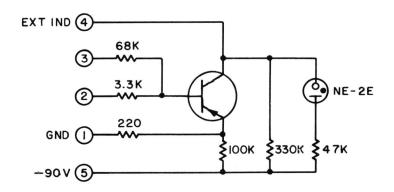


Figure 3-36.1. Transistorized Unit Indicator, Model UI-10

3-37 TRANSISTORIZED UNIT INDICATOR, MODEL UI-30

GENERAL DESCRIPTION

The Transistorized Unit Indicator, Model UI-30 (figure 3-37.1), is a low-power visual indicator that monitors S-PAC logic levels. The UI-30 contains a neon indicator and a transistor blocking oscillator circuit which functions as a high-voltage AC generator. When a ONE (-6 V) is applied to the input circuit, the oscillator ignites the neon indicator. The UI-30 is powered from the -18-volt line of any S-PAC power supply and is driven by standard S-PAC logic signals.

Each standard UI-30 is equipped with a clear plastic lens and taper pin connections. However, colored plastic lenses and solder pin connections are available by special order. The UI-30 mounts in a 3/8-inch diameter hole, 5/8 inch on center, and projects a maximum of 2-1/8 inches behind the panel.

CIRCUIT FUNCTION

In normal operation, the blocking oscillator is biased to cutoff (figure 3-37.1). Application of a -6-volt level permits the blocking oscillator to generate a large AC voltage through the secondary of the transformer to light the indicator lamp. Input logic levels are applied to pin 2 or pin 3 of the UI-30 connector. The internal 10-kilohm resistor between pin 3 and the base of the blocking oscillator provides effective circuit isolation between the UI-30 and the driving source. Pin 2 is a direct connection to the base of the blocking oscillator and provides a connection for a 10-kilohm base current-limiting resistor located at the output terminals of the driving source. This arrangement isolates any circuit wiring capacitance.

NOTE

If pin 2 is used, a 10-kilohm resistor must be connected in series with the driver.

SPECIFICATIONS

Input Loading	Input Voltage Signals
l U load each Frequency of Operation	Lamp on: -5 to -10 V
Total Power	Current Requirements
117 mw	-18 V 6.5 ma (max)



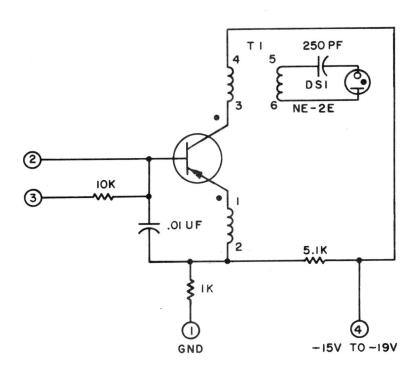


Figure 3-37.1. Transistorized Unit Indicator, Model UI-30

3-38 TRANSISTORIZED UNIT INDICATOR, MODEL UI-31

GENERAL DESCRIPTION

The Transistorized Unit Indicator, Model UI-31 (figure 3-38,1), is a transistorized visual indicator that monitors S-PAC logic levels. The UI-31 contains a low-power incandescent lamp driven by a switching transistor. Each standard indicator is supplied with a replaceable bulb, a replaceable translucent white lens (available in colors by special order), a nut, a lockwasher, and four taper pin connections. The unit mounts in a 3/8-inch diameter hole, 5/8 inch on center, and has an overall length of 2-7/16 inchs.

CIRCUIT FUNCTION

When the input of the UI-31 (figure 3-38.1) is a logic ONE (-6 V) or an open circuit, the transistor is turned on and current flows in the collector circuit, illuminating the indicator lamp. When the input is a logic ZERO (0 V), the transistor is biased off and the lamp is extinguished. A keep-alive resistor, connected between the collector of the transistor and ground, provides a low current through the indicator lamp during nonindicating periods and permits the lamp filament to remain warm. This action increases the lamp and transistor life by eliminating high current turn-on transients.

The indicator should not be operated faster than 10 kilocycles to prevent damage to the transistor.

SPECIFICATIONS

Input Loading

	Gail ent redail entents
Input: 1 U load	+12 V 1.8 ma
Input Voltage Signals	-18 V 50 ma
Lamp on: -5 V to -10 V	Total Power
Lamp off: $-1.5 \text{ V to } +3 \text{ V}$	800 mw
Frequency of Operation	Lamp Type
DC to 10 KC	GE Type No. 370 (18 V at 40 ma

Current Requirements



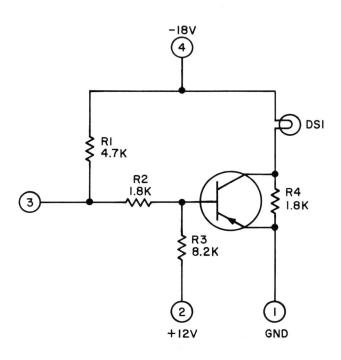


Figure 3-38.1. Transistorized Unit Indicator, Model UI-31

3-39 UTILITY PAC, MODEL UT-30

GENERAL DESCRIPTION

The Utility PAC, Model UT-30 (figure 3-39.1), is a standard S-PAC card designed for component mounting. This PAC is particularly suited for mounting large capacitors for DM PACs and special circuits. Etched power and ground buses are provided as well as predrilled holes and corresponding etched wiring. A reproducible layout sheet, which can be used as an assembly drawing, is furnished with each PAC for planning component placement and wiring. A silk screen on the component side of the PAC and etched numbers on the wiring side simplify final layout and construction.

When the UT-30 occupies a single PAC slot in an S-BLOC, the maximum component height allowable is 0.375 inch for the BL-32 and BL-33 BLOCs and 0.675 inch for the BL-30 and BL-31 BLOCs. If an adjacent PAC slot remains empty, the additional space is available for component height.

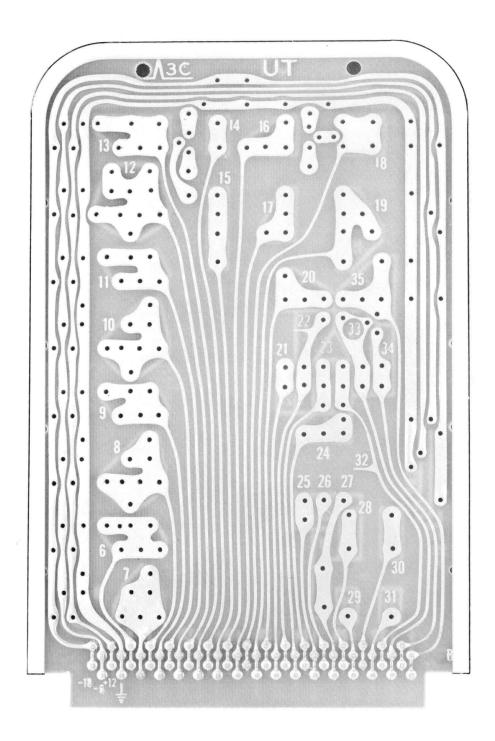


Figure 3-39.1. Utility PAC, Model UT-30

3-40 PAC EXTENDER, MODEL XP-30

GENERAL DESCRIPTION

The PAC Extender, Model XP-30 (figure 3-40.1), provides unobstructed access to any S-PAC while it is electrically mounted in its appropriate S-BLOC connector. The connector terminals at the front end of the XP-30 mount into any S-BLOC connector and the connector at the rear of the XP-30 accepts the S-PAC it is displacing. Front and rear terminals are directly tied together electrically.

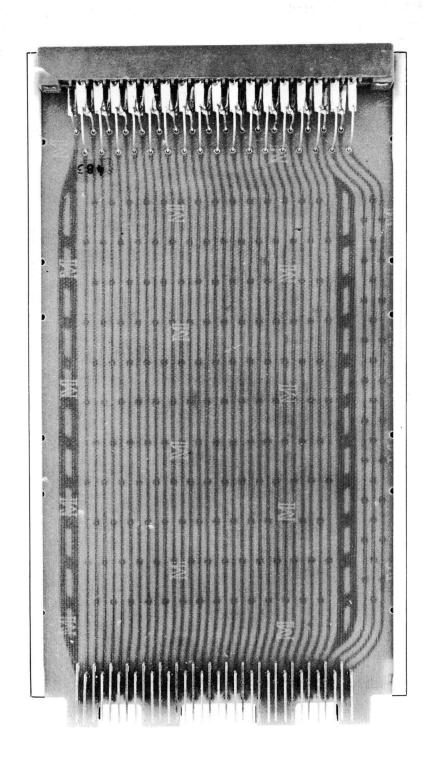


Figure 3-40.1. PAC Extender, Model XP-30

SECTION IV PARTS LIST FOR SUPPLEMENTARY S-PAC EQUIPMENT

The parts lists below are applicable to the supplementary S-PAC equipment in Section III.

Model		Page
BL-30,31,32,33	3	4-3
CA-30		4-5
CD-30		4-7
CI-20		4-9
CI-21		4-11
CP-20		4-13
CP-21		4-15
CU-30		4-17
DD-31		4-19
DI-21		4-21
DI-31		4-23
DI-36		4-25
IP-30		4-27
LC-35		4-29
LD-30		4-31
LN-30		4-33
LN-30A		4-35
LP-30		4-37
LP-31		4-39
MS-30		4-41
MX-30		4-43
ND-31		4-45
OA-30		4-47
PB-30		4-51
PD-30		4-53
PR-30		4-55
PR-31		4-59
RP-30 *		4-63
RP-31 **		4-67
RP-32 ***		4-71
RP-30 thru 32	(Spares)	4-77

^{*}Supplies bearing serial numbers up to and including No. 280334. **Supplies bearing serial numbers up to and including No. 239541.

^{***}Supplies bearing serial numbers up to and including No. 198197 and/or models with "A" prefix; and Serial No. 201050 through 220253.

Model	Page
RP-30*	4-80A
RP-31**	4-80E
RP-32***	4-80J
RP-31E	4-81
RP-32E	4-85
RP-33E	4-89
RV-30	4-93
SA-30	4-95
SD-30	4-97
SI-30	4-99
SN-30	4-101
SP-30	4-103
ST-30	4-105
ST-35	4-107
TD-30	4-109
TD-32	4-111

*Supplies bearing serial numbers 280335 and beyond. **Supplies bearing serial numbers 239542 and beyond. ***Supplies bearing serial numbers 220254 and beyond.

BL-30, 31, 32, 33 S-BLOCs, PARTS LIST

	BL-30, 31, 32, 33 S-BLOCs, PARTS LIST	
Ref. Desig.	Description	3C Part No.
C1, C2	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 22 µf ±20%, 35 VDC	930 217 023
C3	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 3.3 µf ±20%, 35 VDC	930 217 018
CRI	DIODE: Replacement Type 1N2069	943 303 001

A/D CONVERTER CLOCK PAC, MODEL CA-30, PARTS LIST

	D CONVERTER CLOCK PAC, MODEL CA-30, PARTS L	T
Ref. Desig.	Description	3C Part No.
C1,C2	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C3	CAPACITOR, FIXED, MICA DIELECTRIC: 1000 pf ±5%, 100 VDC	930 011 153
C4	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 µf ±10%, 100 VDC	930 301 117
C5, C8	CAPACITOR, FIXED, MICA DIELECTRIC: 250 pf ±5%, 100 VDC	930 011 137
C6	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.0018 µf ±10%, 100 VDC	930 310 217
C7	CAPACITOR, FIXED, MICA DIELECTRIC: 390 pf ±5%, 100 VDC	930 011 142
C9,C11	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
C10	CAPACITOR, FIXED, ELECTROLYTIC: 25 µf +75% -10%, 12 VDC	930 220 211
CR1-CR4, CR7-CR9, CR11-CR17	DIODE: Replacement Type 1N695	943 023 001
CR5, CR10	DIODE: Replacement Type 1N816	943 105 001
CR6	DIODE:	943 021 001
Q1, Q2, Q4, Q8, Q11, Q12	TRANSISTOR: Replacement Type 2N1301	943 535 002
Q3, Q5, Q6, Q10, Q13	TRANSISTOR: Replacement Type 2N404	943 519 002
Q7, Q9, Q14	TRANSISTOR: Replacement Type 2N1605	943 545 001
R1, R11, R23	RESISTOR, FIXED, COMPOSITION: $4.7 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 065
R2, R6, R7, R14, R36	RESISTOR, FIXED, COMPOSITION: $33 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 085
R3, R5	RESISTOR, FIXED, COMPOSITION: 5.6 K ±5%, 1/2 W	932 004 067
R4, R8, R30	RESISTOR, FIXED, COMPOSITION: 10 K $\pm 5\%$, 1/2 W	932 004 073
R9	RESISTOR, FIXED, COMPOSITION: 100 ohms ±5%, 1/2 W	932 004 025
R10	RESISTOR, FIXED, COMPOSITION: $18 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 079
R12	RESISTOR, FIXED, COMPOSITION: 1.2 K ±5%, 1/2 W	932 004 051
R13, R18, R22, R24	RESISTOR, FIXED, COMPOSITION: $3.3 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 061
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A/D CONVERTER CLOCK PAC, MODEL CA-30, PARTS LIST (Cont)

A/D C	ONVERTER CLOCK PAC, MODEL CA-30, PARTS LIS	T (Cont)
Ref. Desig.	Description	3C Part No.
R15, R25	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/2 W	932 004 069
R16, R27	RESISTOR, FIXED, COMPOSITION: 27 K ±5%, 1/2 W	932 004 083
R17	RESISTOR, VARIABLE WIREWOUND: 10 K ±10%, 1/4 W	933 201 010
R19	RESISTOR, FIXED, COMPOSITION: 12 K ±5%, 1/2 W	932 004 075
R20	RESISTOR, FIXED, COMPOSITION: 1.8 K ±5%, 1/2 W	932 004 055
R21	RESISTOR, FIXED, COMPOSITION: 1 K ±5%, 1/2 W	932 004 049
R26	RESISTOR, FIXED, COMPOSITION: 2.2 K ±5%, 1/2 W	932 004 057
R28	RESISTOR, FIXED, COMPOSITION: 8.2 K ±5%, 1/2 W	932 004 071
R29	RESISTOR, FIXED, COMPOSITION: 22 K ±5%, 1/2 W	932 004 081
R31	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/2 W	932 004 097
R32	RESISTOR, FIXED, COMPOSITION: 68 K ±5%, 1/2 W	932 004 093
R33	RESISTOR, FIXED, FILM: 787 K ±2%, 1/4 W	932 102 444
R34	RESISTOR, FIXED, COMPOSITION: 15 K ±5%, 1/2 W	932 004 077
R35	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/2 W	932 004 089
R37, R38	RESISTOR, FIXED, COMPOSITION: 1.8 meg ±5%, 1/2 W	932 004 127
R39	RESISTOR, FIXED, COMPOSITION: 10 ohms ±10%, 1/10 W	932 003 004
R40, R41, R42	RESISTOR, FIXED, COMPOSITION: 6.2 K ±5%, 1/2 W	932 004 068
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ANALOG COMPARATOR PAC, MODEL CD-30, PARTS LIST

Ref. Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, MICA DIELECTRIC: 100 pf ±5%, 100 VDC	930 011 127
C2	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C6, C7	CAPACITOR, FIXED, MICA DIELECTRIC: 240 pf ±5%, 100 VDC	930 011 136
C8, C9	CAPACITOR, FIXED, MICA DIELECTRIC: 200 pf ±5%, 100 VDC	930 011 134
C10-C12	CAPACITOR, FIXED, ELECTROLYTIC: 3.3 µf ±20%, 35 VDC	930 217 018
CR1, CR2, CR5-CR8	DIODE: Replacement Type 1N276	943 023 001
CR3, CR4	DIODE: Replacement Type JAN 1N457	943 080 001
Q1,Q2,Q7-Q12	TRANSISTOR: Replacement Type 2N1301	943 535 002
Q3,Q4	TRANSISTOR: Replaced as Matched Pair	943 220 001
Q5,Q6	TRANSISTOR: Replaced as Matched Pair	943 250 001
R1	RESISTOR, FIXED, COMPOSITION: 5.1 K ±5%, 1/2 W	932 004 066
R2	RESISTOR, FIXED, COMPOSITION: 30 K ±5%, 1/2 W	932 004 084
R3	RESISTOR, FIXED, COMPOSITION: $2.2 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 057
R4, R12, R13	RESISTOR, FIXED, COMPOSITION: 2 K $\pm 5\%$, 1/2 W	932 004 056
R5	RESISTOR, FIXED, COMPOSITION: 510 ohms $\pm 5\%$, $1/2$ W	932 004 042
R6, R7	RESISTOR, FIXED, WIREWOUND: 6.0 K ±0.1%, 1/3 W	932 204 108
R8, R19	RESISTOR, FIXED, FILM: 1.78 K ±2%, 1/4 W	932 102 213
R9, R18	RESISTOR, FIXED, FILM: 6.81 K ±2%, 1/4 W	932 102 241
R10, R15	RESISTOR, FIXED, COMPOSITION: 100 ohms ±5%, 1/2 W	932 004 025
R11, R14	RESISTOR, FIXED, COMPOSITION: $1 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 049
R16	RESISTOR, FIXED, COMPOSITION: 12 K ±5%, 1/2 W	932 004 075
R17	RESISTOR, FIXED, COMPOSITION: 36 K ±5%, 1/2 W	932 004 086
R20	RESISTOR, FIXED, FILM: 1 meg ±2%, 1/4 W	932 102 501
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4/16/68

ANALOG COMPARATOR PAC, MODEL CD-30, PARTS LIST (Cont)

	LOG COMPARATOR PAC, MODEL CD-30, PARTS LIST	
Ref. Desig.	Description	3C Part No.
R21	RESISTOR, FIXED, FILM: 3.01 K ±2%, 1/4 W	932 102 224
R22	RESISTOR, VARIABLE, WIREWOUND: 10 K ±20%, 1/4 W	933 201 010
R23	RESISTOR, FIXED, COMPOSITION: 1.54 K ±2%, 1/4 W	932 102 210
R24, R30	RESISTOR, FIXED, COMPOSITION: 1.5 K ±5%, 1/2 W	932 004 053
R25, R29	RESISTOR, FIXED, COMPOSITION: 3 K ±5%, 1/2 W	932 004 060
R26, R28	RESISTOR, FIXED, COMPOSITION: 150 ohms ±5%, 1/2 W	932 004 029
R27, R38, R39	RESISTOR, FIXED, COMPOSITION: 3.3 K ±5%, 1/2 W	932 004 061
R31	RESISTOR, FIXED, COMPOSITION: 820 ohms ±5%, 1/2 W	932 004 047
R32, R37	RESISTOR, FIXED, COMPOSITION: 3.9 K ±5%, 1/2 W	932 004 063
R33-R36	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/2 W	932 004 073

COUNTER-INDICATOR PAC, MODEL CI-20, PARTS LIST

	I PARTS LIST	·
Ref. Desig.	Description	3C Part No.
C1, C12, C13	CAPACITOR, FIXED, MICA DIELECTRIC: 200 pf ±5%, 100 VDC	930 011 134
C2A-C2D, C7-C11	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C3	Customer Installed Option	
C4	CAPACITOR, FIXED, MICA DIELECTRIC: 220 pf ±5%, 100 VDC	930 011 135
C5, C6, C14	CAPACITOR, FIXED, MICA DIELECTRIC: 510 pf ±5%, 100 VDC	930 011 146
C15	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
C16	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.033 µf ±20%, 200 VDC	930 300 019
CR1A-CR1D, CR2A-CR2D, CR3A-CR3D, CR4A-CR4D, CR5, CR9-CR16	DIODE	943 003 001
CR6, CR8, CR17	DIODE: Replacement Type 1N276	943 023 001
CR7, CR18	DIODE: Replacement Type 1N816	943 105 001
DS1-DS10	LAMP, NEON	945 007 002
DS11-DS20	LAMP, NEON	945 007 001
Q1A-Q1D, Q2A-Q2D,Q4	TRANSISTOR	943 508 001
Q3	TRANSISTOR: Replacement Type 2N404	943 519 001
R1-R5	RESISTOR, FIXED, FILM: 121 K ±2%, 1/2 W	932 103 405
R6, R9	RESISTOR, FIXED, FILM: 205 K ±2%, 1/2 W	932 103 416
R7, R31, R47, R52	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/2 W	932 004 097
R8, R10	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1 W	932 005 082
R11, R13, R15A-R15D, R16A-R16D, R29, R30, R38, R39	RESISTOR, FIXED, COMPOSITION: 56 K ±5%, 1/2 W	932 004 091
R12, R45, R46	RESISTOR, FIXED, COMPOSITION: 39 K ±5%, 1/2 W	932 004 087
R14, R17	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/2 W	932 004 073

COUNTER-INDICATOR PAC, MODEL CI-20, PARTS LIST (Cont)

COUNTER-INDICATOR PAC, MODEL CI-20, PARTS LIST (Cont)			
Ref. Desig.	Description	3C Part. No.	
R18, R40, R48, R53	RESISTOR, FIXED, COMPOSITION: 220 K ±5%, 1/2 W	932 004 105	
R19, R49	RESISTOR, FIXED, COMPOSITION: 8.2 K ±5%, 1/2 W	932 004 071	
R20, R50	RESISTOR, FIXED, COMPOSITION: 2.7 K ±5%, 1/2 W	932 004 059	
R21, R51	RESISTOR, FIXED, COMPOSITION: 30 K ±5%, 1/2 W	932 004 084	
R22	RESISTOR, FIXED, COMPOSITION: 2 K ±5%, 1/2 W	932 004 056	
R23-R28, R32-R37, R41-R44	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/2 W	932 004 089	

COUNTER-INDICATOR (HIGH LEVEL) PAC, MODEL CI-21, PARTS LIST

	ER-INDICATOR (HIGH LEVEL) PAC, MODEL CI-21, PAR	12 [2]
Ref. Desig.	Description	3C Part No.
C1, C9, C10	CAPACITOR, FIXED, MICA DIELECTRIC: 200 pf ±5%, 100 VDC	930 011 134
C2A-C2D, C4-C8	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C3	CAPACITOR, FIXED, MICA DIELECTRIC: 220 pf ±5%, 100 VDC	930 011 135
C11	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.033 µf ±20%, 200 VDC	930 300 019
CR1, CR2A-CR2D, CR3-CR14	DIODE	943 003 001
DS1-DS10	LAMP, NEON	945 007 002
DS11-DS20	LAMP, NEON	945 007 001
Q1A-Q1D, Q2A-Q2D	TRANSISTOR	943 508 001
R1-R5	RESISTOR, FIXED, FILM: 121 K ±2%, 1/2 W	932 103 405
R6, R9	RESISTOR, FIXED, FILM: 205 K ±2%, 1/2 W	932 103 416
R7, R27, R43	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/2 W	932 004 097
R8, R10	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1 W	932 005 082
R11, R13, R15A-R15D, R16A-R16D, R25, R26, R34, R35	RESISTOR, FIXED, COMPOSITION: 56 K ±5%, 1/2 W	932 004 091
R12, R41, R42	RESISTOR, FIXED, COMPOSITION: 39 K $\pm 5\%$, $1/2$ W	932 004 087
R14, R17	RESISTOR, FIXED, COMPOSITION: $10 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 073
R18, R36, R44	RESISTOR, FIXED, COMPOSITION: 220 K $\pm 5\%$, $1/2$ W	932 004 105
R19-R24, R28-R33, R37-R40	RESISTOR, FIXED, COMPOSITION: 47 K $\pm 5\%$, 1/2 W	932 004 089

COUNTER-CONVERTER PAC, MODEL CP-20, PARTS LIST

	COUNTER-CONVERTER PAC, WODEL CF-20, PARTS LIS.	<u> </u>
Ref. Desig.	Description	3C Part No.
C1, C13	CAPACITOR, FIXED, MICA DIELECTRIC: 200 pf ±5%, 100 VDC	930 011 134
C2A-C2D, C7-C11	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C3	Customer Installed Option	5
C4	CAPACITOR, FIXED, MICA DIELECTRIC: 220 pf ±5%, 100 VDC	930 011 135
C5, C6, C14	CAPACITOR, FIXED, MICA DIELECTRIC: 510 pf ±5%, 100 VDC	930 011 146
C12	CAPACITOR, FIXED, MICA DIELECTRIC: 200 pf ±5%, 100 VDC	930 006 134
C15	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 μf ±20%, 100 VDC	930 301 015
C16	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.033 µf ±20%, 200 VDC	930 300 019
CR1A-CR1D, CR2A-CR2D, CR3A-CR3D, CR4A-CR4D, CR5A-CR5D, CR6A-CR6D, CR7, CR8A-CR8D, CR12A-CR12D	DIODE	943 003 001
CR9, CR11, CR13	DIODE: Replacement Type 1N276	943 023 001
CR10, CR14	DIODE: Replacement Type 1N816	943 105 001
Q1A-Q1D, Q2A-Q2D,Q4	TRANSISTOR	943 508 001
Q3	TRANSISTOR	943 519 001
R1, R6	RESISTOR, FIXED, FILM: 205 K ±2%, 1/2 W	932 103 416
R2, R32, R56, R61	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/2 W	932 004 097
R3, R7	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1 W	932 005 082
R4, R5, R15, R23, R24, R36, R37, R45, R48, R49, R57, R62	RESISTOR, FIXED, COMPOSITION: 220 K ±5%, 1/2 W	932 004 105
R8, R10, R12, R13, R28-R31, R41-R44, R54, R55	RESISTOR, FIXED, COMPOSITION: 56 K ±5%, 1/2 W	932 004 091

COUNTER-CONVERTER PAC, MODEL CP-20, PARTS LIST (Cont)

	r	MODEL CF-20, PARTS LIST (C	· · · · · · · · · · · · · · · · · · ·
Ref. Desig.	De	scription	3C Part No.
R9, R52, R53	RESISTOR, FIXED, COM 39 K ±5%, 1/2 W	POSITION:	932 004 087
R11, R14	RESISTOR, FIXED, COM	POSITION:	932 004 073
R16, R58	RESISTOR, FIXED, COM 8.2 K ±5%, 1/2 W	POSITION:	932 004 071
R17, R59	RESISTOR, FIXED, COM 2.7 K ±5%, 1/2 W	POSITION:	932 004 059
R18, R60	RESISTOR, FIXED, COM 30 K ±5%, 1/2 W	POSITION:	932 004 084
R19	RESISTOR, FIXED, COM 2 K ±5%, 1/2 W	POSITION:	932 004 056
R20-R22, R25-R27, R33-R35, R38-R40, R46, R47, R50, R51	RESISTOR, FIXED, COM 47 K ±5%, 1/2 W	IPOSITION:	932 004 089

COUNTER-CONVERTER (HIGH LEVEL) PAC, MODEL CP-21, PARTS LIST

COUNTE	CR-CONVERTER (HIGH LEVEL) PAC, MODEL CP-21, PAI	RTS LIST
Ref. Desig.	Description	3C Part No.
C1, C10	CAPACITOR, FIXED, MICA DIELECTRIC: 200 pf ±5%, 100 VDC	930 011 134
C2A-C2D, C4-C8	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C3	CAPACITOR, FIXED, MICA DIELECTRIC: 220 pf ±5%, 100 VDC	930 011 135
C9	CAPACITOR, FIXED, MICA DIELECTRIC: 200 pf ±5%, 100 VDC	930 006 134
C11	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.033 μf ±20%, 200 VDC	930 300 019
CRIA-CR6A, CRIB-CR6B, CRIC-CR6C, CRID-CR6D, CR7	DIODE	943 003 001
Q1A-Q1D, Q2A-Q2D	TRANSISTOR	943 508 001
R1, R6	RESISTOR, FIXED, FILM: 205 K ±2%, 1/2 W	932 103 416
R2, R28, R50	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/2 W	932 004 097
R3, R7	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1 W	932 005 082
R4, R5, R15, R19, R20, R32, R33, R41, R44, R45, R53	RESISTOR, FIXED, COMPOSITION: 220 K ±5%, 1/2 W	932 004 105
R8, R10, R12, R13, R24-R27, R37-R40, R51, R52	RESISTOR, FIXED, COMPOSITION: 56 K ±5%, 1/2 W	932 004 091
R9, R48, R49	RESISTOR, FIXED, COMPOSITION: 39 K $\pm 5\%$, $1/2$ W	932 004 087
R11, R14	RESISTOR, FIXED, COMPOSITION: $10 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 073
R16-R18, R21-R23, R29-R31, R34-R36,R42, R43,R46,R47	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/2 W	932 004 089

COOLING UNIT, MODEL CU-30, PARTS LIST

<u> </u>	COOLING UNIT, MODEL CU-30, PARTS LIST	
Ref. Desig.	Description	3C Part No.
B1, B2, B3	FAN, AXIAL	964 001 002
DS1	LIGHT, INDICATOR	935 057 001
Fl	FUSE, CARTRIDGE	960 002 006
FLI	FILTER, AIR	911 002 004
XF1	FUSEHOLDER	935 002 001
L		

DISPLAY DRIVER PAC, MODEL DD-31, PARTS LIST

Ref.		
Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C2, C3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
CR1, CR45	DIODE: Replacement Type 1N2069	943 303 001
CR2, CR4-CR44	DIODE: Replacement Type 1N276	943 023 001
CR3	DIODE: Replacement Type 1N816	943 105 001
Q1	TRANSISTOR	943 550 001
Q2	TRANSISTOR	943 519 001
R1	RESISTOR, FIXED, COMPOSITION: 2 K ±5%, 1/2 W	932 004 056
R2	RESISTOR, FIXED, COMPOSITION: 15 K ±5%, 1/2 W	932 004 077
R3	RESISTOR, FIXED, COMPOSITION: 680 ohms ±5%, 1/2 W	932 004 045
R4-R11	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/2 W	932 004 069
R12	RESISTOR, FIXED, FILM: 6.49 K ±2%, 1/2 W	932 103 240
R13	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/4 W	932 102 218
R14	RESISTOR, FIXED, FILM: 21.5 K ±2%, 1/2 W	932 103 317
R15	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/2 W	932 103 218
R16, R18, R20, R22, R24, R26, R28, R30, R32, R34	RESISTOR, FIXED, FILM: 3.01 K ±2%, 1/2 W	932 103 224
R17, R19, R21, R23, R25, R27, R29, R31, R33, R35	RESISTOR, FIXED, FILM: 10 K ±2%, 1/2 W	932 103 301
SCR1-SCR10	RECTIFIER, SILICON CONTROLLED	943 402 001
		<u> </u>

SIGNAL ADAPTER PAC, MODEL DI-21, PARTS LIST

Ref. Desig.	SIGNAL ADAPTER PAC, MODEL DI-21, PARTS LIST Description	3C Part No.
C1	CAPACITOR, FIXED, MICA DIELECTRIC:	
	510 pf ±5%, 100 VDC	930 011 146
C2, C3	CAPACITOR, FIXED, MICA DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
CR1-CR3	DIODE: Replacement Type 1N276	943 023 001
CR4	DIODE: Replacement Type 1N816	943 105 001
Q1	TRANSISTOR	943 519 002
R1, R2	RESISTOR, FIXED, COMPOSITION: 8.2 K ±5%, 1/2 W	932 004 071
R3	RESISTOR, FIXED, COMPOSITION: 1.0 K ±5%, 1/2 W	932 004 049
R4	RESISTOR, FIXED, COMPOSITION: 30 K ±5%, 1/2 W	932 004 084

SIGNAL ADAPTER PAC, MODEL DI-31, PARTS LIST

<u></u>	SIGNAL ADAPTER PAC, MODEL DI-31, PARTS LIST	
Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 131
C2, C3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC; Pyramid Type 107; Cornell-Dubilier Type WMF	930 301 015
CR1-CR3	DIODE: Replacement Type 1N276	943 023 001
CR4	DIODE: Replacement Type 1N816	943 105 001
Q1	TRANSISTOR: Replacement Type 2N1301	943 535 002
Rl	RESISTOR, FIXED, FILM: 6.49 K ±2%, 1/2 W	932 103 240
R3	RESISTOR, FIXED, FILM: 825 ohms ±2%, 1/2 W	932 103 145
R4	RESISTOR, FIXED, FILM: 21.5 K ±2%, 1/2 W	932 103 317
R2	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/2 W	932 103 218

SIGNAL ADAPTER PAC, MODEL DI-36, PARTS LIST

<u> </u>	SIGNAL ADAPTER PAC, MODEL DI-30, PARTS LIST	
Ref. Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, MICA DIELECTRIC: 43 pf ±5%, 100 VDC	930 011 117
C2, C3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
CR1-CR3	DIODE: Replacement Type 1N276	943 023 001
CR4	DIODE: Replacement Type 1N816	943 105 001
Q1	TRANSISTOR	943 543 004
R1	RESISTOR, FIXED, FILM: 4.64 K ±2%, 1/2 W	932 103 233
R2	RESISTOR, FIXED, FILM: 1.62 K ±2%, 1/2 W	932 103 211
R3	RESISTOR, FIXED, FILM: 590 ohms ±2%, 1/2 W	932 103 138
R4	RESISTOR, FIXED, FILM: 15.4 K ±2%, 1/2 W	932 103 310

INDICATOR-CONVERTER PAC, MODEL IP-30, PARTS LIST

Ref. Desig.	Description	3C Part No.
DS1-DS10	LAMP, NEON	945 008 002
DS11-DS20	LAMP, NEON	945 008 001
R1-R5	RESISTOR, FIXED, FILM: 121 K ±5%, 1/2 W	932 103 405
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POSITIVE LEVEL CONVERTER PAC, MODEL LC-35, PARTS LIST

Ref.	Description	2C D- 4 N
Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 47 pf ±10%, 100 VDC	930 173 211
C2, C3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
CR1, CR2, CR4	DIODE: Replacement Type 1N276	943 023 001
CR3	DIODE: Replacement Type 1N816	943 105 001
Q1, Q2	TRANSISTOR: Replacement Type 2N965	943 543 014
R1	RESISTOR, FIXED, FILM: 2.87K ±2%, 1/4 W	932 111 223
R2	RESISTOR, FIXED, FILM: 4.64K ±2%, 1/4 W	932 102 233
R3	RESISTOR, FIXED, FILM: 1.62K ±2%, 1/4 W	932 102 211
R4	RESISTOR, FIXED, FILM: 15.4K ±2%, 1/4 W	932 102 310
R5	RESISTOR, FIXED, FILM: 1.62K ±2%, 1/2 W	932 103 211
R6	RESISTOR, FIXED, FILM: 383 ohms ±2%, 1/4 W	932 111 129
R7	RESISTOR, FIXED, FILM: 82.5 ohms ±2%, 1/4 W	932 111 045

LAMP DRIVER, MODEL LD-30, PARTS LIST

	LAMP DRIVER, MODEL LD-30, PARTS LIST	
Ref. Desig.	Description	3C Part No.
Q1-Q14	TRANSISTOR: Replacement Type 2N404	943 519 001
Rl	RESISTOR, FIXED, COMPOSITION: $3 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 060
R2	RESISTOR, FIXED, COMPOSITION: 1.2 K ±5%, 1/2 W	932 004 051
R3	RESISTOR, FIXED, COMPOSITION: 12 K ±5%, 1/2 W	932 004 075
R4	RESISTOR, FIXED, COMPOSITION: 2.4 K ±5%, 1/2 W	932 004 058

DIGITAL ATTENUATOR PAC, MODEL LN-30, PARTS LIST

Ref. Desig.	Description	2C D- 1 N
	Description	3C Part No.
C1,C2	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC; Pyramid Type 107; Cornell-Dubilier Type WMF	930 301 015
CR1-CR5	DIODE: Replacement Type 1N276	943 023 001
Rl	RESISTOR, FIXED, COMPOSITION: 180 ohm ±5%, 1/2 W	932 004 031
R2	RESISTOR, FIXED, COMPOSITION: 62 ohms ±5%, 1/2 W	932 004 020
R3	RESISTOR, FIXED, FILM: 19.6 K ±1%, 1/2 W	932 106 329
R4	RESISTOR, FIXED, FILM: 12.1 K ±1%, 1/2 W	932 106 309
R5	RESISTOR, VARIABLE, COMPOSITION: 330 K $\pm 10\%$, $1/4$ W	933 003 116
R6	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/2 W	932 004 097
R7, R11	RESISTOR, FIXED, FILM: 301 ohms ±1%, 1/2 W	932 106 147
R8, R12	RESISTOR, FIXED, FILM: 511 ohms ±2%, 1/2 W	932 103 135
R9, R13	RESISTOR, FIXED, FILM: 909 ohms ±2%, 1/2 W	932 103 147
R10, R14, R23	RESISTOR, FIXED, FILM: 2.87 K ±2%, 1/2 W	932 103 223
R15	RESISTOR, FIXED, FILM: 5.69 K ±0.5%, 1/2 W	932 101 273
R16	RESISTOR, FIXED, FILM: 11.5 K ±1%, 1/2 W	932 106 307
R17, R22	RESISTOR, FIXED, FILM: $23.2 \text{ K} \pm 1\%$, $1/2 \text{ W}$	932 106 336
R18, R24	RESISTOR, FIXED, FILM: 45.3 K $\pm 1\%$, 1/2 W	932 106 364
R19	RESISTOR, FIXED, COMPOSITION: 150 K ±5%, 1/2 W	932 004 101
R20	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/2 W	932 103 218
R21	RESISTOR, FIXED, FILM: 5.62 K $\pm 2\%$, $1/2$ W	932 103 237
R28	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/2 W	932 004 089

ADJUSTABLE DIGITAL ATTENUATOR PAC, MODEL LN-30A, PARTS LIST

D - f	TIBEL BIGITAL ATTENDATOR TAC, MODEL EN-30A, PA	THE DIST
Ref. Desig.	Description	3C Part No.
C1,C2	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC; Pyramid Type 107; Cornell-Dubilier Type WMF	930 301 015
CR1-CR5	DIODE: Replacement Type 1N276	943 023 001
Rl	RESISTOR, FIXED, COMPOSITION: 180 ohms ±5%, 1/2 W	932 004 031
R2	RESISTOR, FIXED, COMPOSITION: 62 ohms ±5%, 1/2 W	932 004 020
R3	RESISTOR, FIXED, FILM: 19.6 K ±1%, 1/2 W	932 106 329
R4	RESISTOR, FIXED, FILM: 12.1 K ±1%, 1/2 W	932 106 309
R5	RESISTOR, VARIABLE, COMPOSITION: 330 K ±20%, 1/4 W	933 003 016
R6	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/2 W	932 004 097
R7	RESISTOR, VARIABLE, COMPOSITION: 500 ohms ±20%, 1/4 W	933 003 003
R8	RESISTOR, VARIABLE, COMPOSITION: 1 K ±20%, 1/4 W	933 003 004
R9	RESISTOR, VARIABLE, COMPOSITION: 2.5 K ±20%, 1/4 W	933 003 005
R10	RESISTOR, VARIABLE, COMPOSITION: 5 K ±20%, 1/4 W	933 003 006
Rll	RESISTOR, FIXED, FILM: 301 ohms ±1%, 1/2 W	932 106 147
R12	RESISTOR, FIXED, FILM: 511 ohms ±2%, 1/2 W	932 103 135
R13	RESISTOR, FIXED, FILM: 909 ohms ±2%, 1/2 W	932 103 147
R14, R23	RESISTOR, FIXED, FILM: 2.87 K ±2%, 1/2 W	932 103 223
R15	RESISTOR, FIXED, FILM: 5.69 K $\pm 0.5\%$, $1/4$ W	932 101 273
R16	RESISTOR, FIXED, FILM: 11.5 K $\pm 1\%$, 1/2 W	932 106 307
R17, R22	RESISTOR, FIXED, FILM: $23.2 \text{ K} \pm 1\%$, $1/2 \text{ W}$	932 106 336
R18, R24	RESISTOR, FIXED, FILM: 45.3 K $\pm 1\%$, 1/2 W	932 106 364
R19	RESISTOR, FIXED, COMPOSITION: 150 K ±5%, 1/2 W	932 004 101

ADJUSTABLE DIGITAL ATTENUATOR PAC, MODEL LN-30A, PARTS LIST (Cont)

ADJUSTADE	E DIGITAL ATTENUATOR PAC, MODEL LN-30A, PARTS	1
Ref. Desig.	Description	3C Part No.
R20	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/2 W	932 103 218
R21	RESISTOR, FIXED, FILM: 5.62 K ±2%, 1/2 W	932 103 237
R28	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/2 W	932 004 089
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PRECISION DIGITAL-TO-ANALOG CONVERTER PAC (4-BIT), MODEL LP-30, PARTS LIST

	PARTS LIST	
Ref.	D	j
Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 131
C2	CAPACITOR, FIXED, MICA DIELECTRIC: 510 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 146
C3-C5	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 µf ±20%, 100 VDC	930 304 001
CR1, CR5	DIODE: Replacement Type 1N276	943 023 001
CR2-CR4, CR6-CR9	DIODE: Replacement Type 1N816	943 105 001
CR10	DIODE: Replacement Type 1N2069	943 303 001
CRII	DIODE, ZENER: Replacement Type 1N706	943 102 001
Q1,Q3C,Q3D, Q4	TRANSISTOR: Replacement Type 2N404	943 519 001
Q2	TRANSISTOR: Replacement Type 2N1605	943 545 001
Q3A, Q3B	TRANSISTOR: Replacement Type 2N522A	943 546 001
Rl	RESISTOR, FIXED, FILM: 21.5 K ±2%, 1/4 W	932 102 317
R2	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/4 W	932 102 218
R3	RESISTOR, FIXED, FILM: 6.49 K ±2%, 1/4 W	932 102 240
R4A, R7	RESISTOR, FIXED, COMPOSITION: 5.1 K ±5%, 1/2 W	932 004 066
R4B, R4C, R4D, R10	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/2 W	932 004 073
R5A	RESISTOR, FIXED, COMPOSITION: 27 K ±5%, 1/2 W	932 004 083
R5B, R5C, R5D	RESISTOR, FIXED, COMPOSITION: 51 K ±5%, 1/2 W	932 004 090
R6	RESISTOR, FIXED, COMPOSITION: 620 K ±5%, 1/2 W	932 004 116
R8	RESISTOR, FIXED, WIREWOUND: 11.998 K ±0.02%, 1/3 W	932 204 001
R9	RESISTOR, FIXED, COMPOSITION: 2 K ±5%, 1/2 W	932 004 056
R11	RESISTOR, FIXED, WIREWOUND: 24.0 K ±0.02%, 1/3 W	932 204 002
R12	RESISTOR, FIXED, COMPOSITION: 20 K $\pm 5\%$, $1/2$ W	932 004 080
R13	RESISTOR, FIXED, WIREWOUND: 48.0 K ±0.02%, 1/3 W	932 204 003
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PRECISION DIGITAL-TO-ANALOG CONVERTER PAC (4-BIT), MODEL LP-30, PARTS LIST (Cont)

PARTS LIST (Cont)		
Ref. Desig.	Description	3C Part No.
R14	RESISTOR, FIXED, COMPOSITION: 39 K ±5%, 1/2 W	932 004 087
R15, R16	RESISTOR, FIXED, WIREWOUND: 96.0 K ±0.02%, 1/3 W	932 204 007
R17	RESISTOR, FIXED, WIREWOUND: 57.6 K ±0.02%, 1/3 W	932 204 005
R18	RESISTOR, FIXED, FILM: 240 ohms ±0.5%, 1/4 W	932 110 020
R19	RESISTOR, FIXED, WIREWOUND: 90 K ±0.02%, 1/3 W	932 204 006
R20	RESISTOR, FIXED, WIREWOUND: 51.84 K ±0.02%, 1/3 W	932 204 004

PRECISION DIGITAL-TO-ANALOG CONVERTER PAC (6-BIT), MODEL LP-31, PARTS LIST

	PARTS LIST	
Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 131
C2	CAPACITOR, FIXED, MICA DIELECTRIC: 510 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 146
C3-C5	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 µf ±20%, 100 VDC	930 304 001
CR1, CR5	DIODE: Replacement Type 1N276	943 023 001
CR2-CR4, CR6-CR9	DIODE: Replacement Type 1N816	943 105 001
CR10	DIODE: Replacement Type 1N2069	943 303 001
CR11	DIODE, ZENER: Replacement Type 1N706	943 102 001
Q1,Q3,Q4	TRANSISTOR: Replacement Type 2N404	943 519 001
Q2	TRANSISTOR: Replacement Type 2N1605	943 545 001
R1	RESISTOR, FIXED, FILM: 21.5 K ±2%, 1/4 W	932 102 317
R2	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/4 W	932 102 218
R3	RESISTOR, FIXED, FILM: 6.49 K ±2%, 1/4 W	932 102 240
R4A	RESISTOR, FIXED, COMPOSITION: 5.1 K ±5%, 1/4 W	932 007 066
R4B-R4F	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/4 W	932 007 073
R5A	RESISTOR, FIXED, COMPOSITION: 27 K ±5%, 1/4 W	932 007 083
R5B-R5F	RESISTOR, FIXED, COMPOSITION: 51 K ±5%, 1/4 W	932 007 090
R6	RESISTOR, FIXED, COMPOSITION: 620 K ±5%, 1/4 W	932 007 116
R7	RESISTOR, FIXED, COMPOSITION: 5.1 K ±5%, 1/2 W	932 004 066
R8	RESISTOR, FIXED, WIREWOUND: 11.998 K ±0.1%, 1/3 W	932 204 101
R9	RESISTOR, FIXED, COMPOSITION: 2 K ±5%, 1/2 W	932 004 056
R10	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/2 W	932 004 073
Rll	RESISTOR, FIXED, WIREWOUND: 24.0 K ±0.1%, 1/3 W	932 204 102
R12	RESISTOR, FIXED, COMPOSITION: $20 \text{ K} \pm 5\%$	932 004 080

PRECISION DIGITAL-TO-ANALOG CONVERTER PAC (6-BIT), MODEL LP-31, PARTS LIST (Cont)

	PARTS LIST (Cont)	
Ref. Desig.	Description	3C Part No.
R13	RESISTOR, FIXED, WIREWOUND: 48.0 K ±0.1%, 1/3 W	932 204 103
R14, R16, R18	RESISTOR, FIXED, COMPOSITION: 39 K ±5%, 1/2 W	932 004 087
R15	RESISTOR, FIXED, WIREWOUND: 96.0 K ±0.1%, 1/3 W	932 204 107
R17	RESISTOR, FIXED, FILM: 191 K ±1%, 1/2 W	932 106 428
R19, R20	RESISTOR, FIXED, FILM: 383 K ±2%, 1/2 W	932 103 429
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GATE SHAPER PAC, MODEL MS-30, PARTS LIST

	GATE SHAPER PAC, MODEL MS-30, PARTS LIST	.
Ref. Desig.	Description	3C Part No.
C1, C3	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC; Elmenco Type DM.15; Cornell-Dubilier Type CD-15	930 011 131
C2	CAPACITOR, FIXED, MICA DIELECTRIC: 390 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 142
C4, C5	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 0.01 µf GMV, 75 VDC; Glenco Type K-6000	930 156 301
C6, C7	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 μ f ±20%, 100 VDC; Pyramid Type 107; Cornell-Dubilier Type WMF	930 301 015
CR1-CR5,CR7	DIODE: Replacement Type 1N276	943 023 001
CR6,CR8-CR11	DIODE: Replacement Type 1N816	943 105 001
Q1, Q2	TRANSISTOR: Replacement Type 2N1301	943 535 002
Rl	RESISTOR, FIXED, FILM: 4.02 K ±2%, 1/2 W	932 103 230
R2, R6	RESISTOR, FIXED, FILM: 1.4 K ±2%, 1/2 W	932 103 208
R3, R4	RESISTOR, FIXED, FILM: 1.62 K ±2%, 1/2 W	932 103 211
R5	RESISTOR, FIXED, FILM: 6.49 K ±2%, 1/2 W	932 103 240
R7	RESISTOR, FIXED, FILM: 825 ohms ±2%, 1/2 W	932 103 145
R8	RESISTOR, FIXED, FILM: 21.5 K ±2%, 1/2 W	932 103 317
R9	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/2 W	932 103 218
R10, R11	RESISTOR, FIXED, COMPOSITION: 1.1 K ±5%, 1/2 W	932 004 050

MULTIPLEXER SWITCH PAC, MODEL MX-30, PARTS LIST

	DETIT BEXER SWITCH FAC, MODEL MX-30, PARTS I	
Ref. Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, MICA DIELECTRIC: 5 pf ±10%, 100 VDC	930 011 004
C2	CAPACITOR, FIXED, TANTALUM: 10 µf ±20%, 6 VDC	930 213 011
C3	CAPACITOR, FIXED, TANTALUM: 68 μf ±20%, 20 VDC	930 216 026
Q1	TRANSISTOR: Replacement Type 2N1605	943 545 001
Q2	TRANSISTOR: Replacement Type 3C404A	943 519 002
R1, R2	RESISTOR, FIXED, WIREWOUND: 100 K ±0.01%, 1/3 W	932 204 022
R3, R4	RESISTOR, FIXED, COMPOSITION: 5.6 K ±5%, 1/4 W	932 007 067
R5	RESISTOR, FIXED, COMPOSITION: 12 K ±5%, 1/4 W	932 007 075
R6	RESISTOR, FIXED, COMPOSITION: 2.7 K ±5%, 1/4 W	932 007 059
R7	RESISTOR, FIXED, COMPOSITION: 22 ohms ±5%, 1/4 W	932 007 009
S1-S10	MX Switch Module	B 2 002 261 701
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NIXIE DRIVER PAC, MODEL ND-31, PARTS LIST

Ref. Desig.	Description	2C Don't No
		3C Part No.
CI	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 3300 µµf ±10%, 100 VDC	930 301 105
C2	CAPACITOR, FIXED, MICA DIELECTRIC: 150 μμf ±5%, 100 VDC	930 011 131
C3, C4	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.033 µf ±20%, 100 VDC	930 301 013
CR1, CR3-CR43	DIODE: Replacement Type 1N276	943 023 001
CR2	DIODE: Replacement Type 1N816	943 105 001
CR44	DIODE: Replacement Type 1N2069	943 303 001
Q1	TRANSISTOR	943 701 002
Q2	TRANSISTOR	943 519 001
RI	RESISTOR, FIXED, COMPOSITION: 2 K ±5%, 1/2 W	932 004 056
R2	RESISTOR, FIXED, COMPOSITION: 15 K ±5%, 1/2 W	932 004 077
R3	RESISTOR, FIXED, COMPOSITION: 27 ohms ±5%, 1/2 W	932 004 011
R4-R11	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/2 W	932 004 069
R12	RESISTOR, FIXED, FILM: 6.49 K ±2%, 1/4 W	932 102 240
R13	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/4 W	932 102 218
R14	RESISTOR, FIXED, FILM: 21.5 K ±2%, 1/4 W	932 102 317
R15	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/2 W	932 103 218
R16, R18, R20, R22, R24, R26, R28, R30, R32, R34	RESISTOR, FIXED, FILM: 3.01 K ±2%, 1/4 W	932 102 224
R17, R19, R21, R23,R25,R27, R29,R31,R33, R35	RESISTOR, FIXED, FILM: 10 K ±2%, 1/4 W	932 102 301
R36, R37	RESISTOR, FIXED, WIREWOUND: 9 K ±5%, 3 W	932 206 135
R38	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1 W	932 004 073
R39-R48	RESISTOR, FIXED, COMPOSITION: 12 K ±5%, 1 W	932 005 075
SCR1-SCR10	RECTIFIER, SILICON CONTROLLED	943 401 001

OPERATIONAL AMPLIFIER PAC, MODEL OA-30, PARTS LIST

Ref.	EMITIONIE MILIER I NO, MODEL CA-30, FARTS	
Desig.	Description	3C Part No.
Cl	CAPACITOR, SELECTED VALUE (see text)	
C2	CAPACITOR, FIXED, PAPER DIELECTRIC: 2 µf ±10%, 100 VDC	930 400 006
C3, C13, C16, C28	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 68 µf ± 20%, 20 VDC	930 216 026
C4, C7	CAPACITOR, FIXED, PAPER DIELECTRIC: 0.056 µf ±10%, 200 VDC	930 306 026
C5	CAPACITOR, FIXED, ELECTROLYTIC: 500 µf ±20%, 3 VDC	930 215 001
C6	CAPACITOR, FIXED, MICA DIELECTRIC: 330 pf ±5%, 100 VDC	930 011 140
C8	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.01 µf ±10%, 100 VDC	930 310 226
C9	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 2.2 µf ±20%, 6 VDC	930 213 007
C10	CAPACITOR, FIXED, MICA DIELECTRIC: 10 pf ±5%, 100 VDC	930 006 105
C11, C21	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: $180~\mu f~\pm 20\%$, 6 VDC	930 213 021
C12	CAPACITOR, FIXED, MICA DIELECTRIC: 220 pf ±5%, 100 VDC	930 011 135
C14	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.0039 µf ±5%, 100 VDC	930 310 121
C15	CAPACITOR, FIXED, PAPER DIELECTRIC: 0.25 µf ±5%, 100 VDC	930 400 005
C17	CAPACITOR, FIXED, MICA DIELECTRIC: 200 pf ±5%, 100 VDC	930 011 134
C18	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.15 μ f \pm 10%, 200 VDC	930 306 031
C19	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.0068 µf ±10%, 200 VDC	930 306 015
C20	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.022 μf ±10%, 200 VDC	930 306 021
C22	CAPACITOR, FIXED, MICA DIELECTRIC: $68 \text{ pf } \pm 5\%$, 100 VDC	930 011 123
C23, C24	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 1.5 μf ±20%, 6 VDC	930 213 006
C25	CAPACITOR, FIXED, MICA DIELECTRIC: 470 pf ±5%, 100 VDC	930 011 144
C26	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: $47 \mu f \pm 20\%$, 35 VDC	930 217 025
C27	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: $68~\mu f~\pm 20\%,~15~VDC$	930 209 016
C29	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 27 pf ±10%, 100 VDC	930 173 208

1/12/66 4-47

OPERATIONAL AMPLIFIER PAC, MODEL OA-30, PARTS LIST (Cont)

OPERA	ATIONAL AMPLIFIER PAC, MODEL OA-30, PARTS LIST	(Cont)
Ref. Desig.	Description	3C Part No.
CR1, CR2	DIODE: Replacement Type 1N457	943 080 002
CR3, CR4, CR11-CR13, CR15, CR18	DIODE	943 083 001
CR5-CR7, CR14 CR16, CR17	DIODE: Replacement Type 1N816	943 105 001
CR8	DIODE: Replacement Type 1N695	943 023 001
CR9	DIODE: Replacement Type 1N2069	943 303 001
CR10	DIODE	943 004 001
Ql	TRANSISTOR: Replacement Type 3C214	943 711 001
Q2	TRANSISTOR: Replacement Type 3C306-1	943 714 002
Q3, Q5	TRANSISTOR: Replacement Type 2N965	943 543 004
Q4	TRANSISTOR: Replacement Type 2N447A	943 534 001
Q6, Q16, Q17, Q20	TRANSISTOR: Replacement Type 2N1605	943 545 001
Q7	TRANSISTOR: Replacement Type 3C710	943 710 001
Q8, Q9	TRANSISTOR: Replacement Type 2N1998	943 558 001
Q10, Q12, Q14 Q15, Q19	TRANSISTOR	943 519 002
Q11, Q13, Q18	TRANSISTOR	943 560 001
Rl	RESISTOR, OPTIONAL	
R2, R8	RESISTOR, FIXED, WIREWOUND: 10 K ±0.01%, 1/3 W	932 204 020
R3	RESISTOR, OPTIONAL	
R4	RESISTOR, FIXED, COMPOSITION: $68 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 093
R5	RESISTOR, FIXED, COMPOSITION: 1 megohm ±5%, 1/4 W	932 007 121
R6	RESISTOR, FIXED, COMPOSITION: 56 K \pm 5%, 1/4 W	932 007 091
R7	RESISTOR, FIXED, COMPOSITION: 5.1 K \pm 5%, 1/4 W	932 007 066
R9, R38, R40, R43, R48, R50, R53	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/4 W	932 007 073
R10, R46, R47	RESISTOR, FIXED, COMPOSITION: 22 K ±5%, 1/4 W	932 007 081
Rll	RESISTOR, FIXED, COMPOSITION: 91 K \pm 5%, 1/4 W	932 007 096
R12, R60, R62	RESISTOR, FIXED, COMPOSITION: 330 ohms ±5%, 1/4 W	932 007 037
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OPERATION AMPLIFIER PAC, MODEL OA-30, PARTS LIST (Cont)

012.	T THE PAC, MODEL OA-30, PARTS LIST	(Cont)
Ref. Desig.	Description	3C Part No.
R13	RESISTOR, FIXED, FILM: 1.78 megohms ±2%, 1/4 W	932 102 513
R14	RESISTOR, VARIABLE, COMPOSITION: 50 K ±20%, 1/4 W	933 003 009
R15, R24	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/4 W	932 007 089
R16	RESISTOR, FIXED, COMPOSITION: 750 K $\pm 5\%$, 1/4 W	932 007 118
R17	RESISTOR, FIXED, COMPOSITION: 33 K ±5%, 1/4 W	932 007 085
R18	RESISTOR, FIXED, COMPOSITION: 8.2 K ±5%, 1/4 W	932 007 071
R19	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1/4 W	932 007 082
R20	RESISTOR, FIXED, COMPOSITION: 1.8 K ±5%, 1/4 W	932 007 055
R21	RESISTOR, FIXED, COMPOSITION: 75 ohms ±5%, 1/4 W	932 007 022
R22, R25	RESISTOR, FIXED, COMPOSITION: 5.6 K ±5%, 1/4 W	932 007 067
R23, R33, R37	RESISTOR, FIXED, COMPOSITION: 220 ohms ±5%, 1/4 W	932 007 033
R26	RESISTOR, FIXED, COMPOSITION: 2.7 K ±5%, 1/4 W	932 007 059
R27	RESISTOR, FIXED, COMPOSITION: 3 K ±5%, 1/4 W	932 007 060
R28	RESISTOR, FIXED, COMPOSITION: 1.5 K \pm 5%, 1/4 W	932 007 053
R29	RESISTOR, FIXED, COMPOSITION: 9.1 K \pm 5%, 1/4 W	932 007 072
R30	RESISTOR, FIXED, COMPOSITION: 820 ohms ±5%, 1/4 W	932 007 047
R31, R34, R51, R55, R59	RESISTOR, FIXED, COMPOSITION: 4.7 K \pm 5%, 1/4 W	932 007 065
R32	RESISTOR, FIXED, COMPOSITION: 510 K \pm 5%, 1/4 W	932 007 114
R35	RESISTOR, FIXED, COMPOSITION: 2.2 K ±5%, 1/4 W	932 007 057
R36	RESISTOR, FIXED, COMPOSITION: 3.3 K \pm 5%, 1/2 W	932 004 061
R39	RESISTOR, FIXED, COMPOSITION: 180 K ±5%, 1/4 W	932 007 103
R41	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/4 W	932 007 097

OPERATION AMPLIFIER PAC, MODEL OA-30, PARTS LIST (Cont)

OPI	ERATION AMPLIFIER PAC, MODEL OA-30, PARTS	LIST (COIL)
Ref. Desig.	Description	3C Part No.
R42, R45	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/4 W	932 007 069
R44	RESISTOR, FIXED, COMPOSITION: 51 ohms ±5%, 1/4 W	932 007 018
R49	RESISTOR, FIXED, FILM: 10 K ± 2%, 1/8 W	932 105 301
R52	RESISTOR, FIXED, FILM: 12.1 K ±2%, 1/8 W	932 105 305
R54, R64	RESISTOR, FIXED, COMPOSITION: 12 K ±5%, 1/4 W	932 007 075
R56	RESISTOR, FIXED, COMPOSITION: 91 ohms ±5%, 1/4 W	932 007 024
R 57	RESISTOR, FIXED, COMPOSITION: 15 K ±5%, 1/4 W	932 007 077
R58, R63	RESISTOR, FIXED, COMPOSITION: $3.3 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 061
R61	RESISTOR, FIXED, COMPOSITION: 3.9 K ±5%, 1/4 W	932 007 063
R65	RESISTOR, FIXED, COMPOSITION: 27 K ±5%, 1/4 W	932 007 083
R66	RESISTOR, FIXED, COMPOSITION: 4.3 K ±5%, 1/4 W	932 007 064
R67	RESISTOR, FIXED, COMPOSITION: 1 K ±5%, 1/4 W	932 007 049
R68, R69	RESISTOR, FIXED, COMPOSITION: 39 K ±5%, 1/4 W	932 007 087
R70, R71	RESISTOR, FIXED, COMPOSITION: 10 ohms ±5%, 1/2 W	932 004 001
R72	RESISTOR, FIXED, WIREWOUND: 1.5 ohms ±5%, 1 W	932 208 103
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PLUG-IN POWER SUPPLY, MODEL PB-30, PARTS LIST

Ref. Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, ELECTROLYTIC:	930 222 611
C2	25 μf ± %, 50 VDC CAPACITOR, FIXED, ELECTROLYTIC:	930 205 001
C3	2000 μf ± %, 25 VDC CAPACITOR, FIXED, ELECTROLYTIC: 4000 μf ± %, 40 VDC	930 204 006
C4	CAPACITOR, FIXED, ELECTROLYTIC: 100 μf ± %, 25 VDC	930 222 513
C5	CAPACITOR, FIXED, ELECTROLYTIC: 100 μf ± %, 15 VDC	930 222 414
CR1, CR3, CR4		943 303 001
CR2, CR5	DIODE	943 308 001
CR6	DIODE	943 110 022
CR7	DIODE	943 110 009
CR8	DIODE	943 112 001
DS1	LAMP, INCANDESCENT	945 002 001
Fl	FUSE, CARTRIDGE	960 001 019
F2	FUSE, CARTRIDGE	960 001 027
J1-J4		
J1-J4	JACK, TIP	941 501 008
Q1, Q8	TRANSISTOR	943 520 001
Q2, Q7	TRANSISTOR	943 551 001
Q3-Q6	TRANSISTOR	943 519 001
R1, R11, R16, R21, R22, R23, R25	RESISTOR, FIXED, COMPOSITION: 1 K $\pm 5\%$, 1/2 W	932 004 049
R2	RESISTOR, FIXED, COMPOSITION: 3.6 K $\pm 5\%$, 1/2 W	932 004 062
R3	RESISTOR, FIXED, COMPOSITION: 1.3 K±5%, 1/2 W	932 004 05 2
R4, R24	RESISTOR, VARIABLE, COMPOSITION: 500 ohms ±2%, 1/4 W	933 003 003
R5	RESISTOR, FIXED, COMPOSITION: 510 ohms ±5%, 1/2 W	932 004 042
R6	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/2 W	932 004 069
R7, R19	RESISTOR, FIXED, COMPOSITION: 3.3 K $\pm 5\%$, 1/2 W	932 004 061
R8	RESISTOR, FIXED, COMPOSITION: 2.2 K $\pm 5\%$, 1/2 W	932 004 057

4/16/68

PLUG-IN POWER SUPPLY, MODEL PB-30, PARTS LIST (Cont)

	UG-IN POWER SUPPLY, MODEL PB-30, PARTS LIST (C	John
Ref. Desig.	Description	3C Part No.
R9	RESISTOR, FIXED, COMPOSITION: 820 ohms ±5%, 1/2 W	932 004 047
R10	RESISTOR, FIXED, COMPOSITION: 1.3 K ±5%, 1/2 W	932 004 052
R12, R17	RESISTOR, FIXED, COMPOSITION: 6.2 K ±5%, 1/2 W	932 004 068
R13	RESISTOR, FIXED, COMPOSITION: 4.3 K \pm 5%, 1/2 W	932 004 064
R14, R15	RESISTOR, FIXED, COMPOSITION: 47 ohms ±5%, 1/2 W	932 004 017
R18	RESISTOR, FIXED, COMPOSITION: 12 K ±5%, 1/2 W	932 004 075
R20	RESISTOR, FIXED, WIREWOUND: 12 ohms ±2%, 3 W	932 206 339
S1	SWITCH, TOGGLE	934 002 001
Tl	TRANSFORMER	938 154 001

IDCU POWER SUPPLY, MODEL PD-30, PARTS LIST

	IDCU POWER SUPPLY, MODEL PD-30, PARTS LIST	
Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 200 µf, 150 VDC	930 226 001
C2	CAPACITOR, FIXED, ELECTROLYTIC: 50 µf, 150 VDC	930 214 001
C3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
CR1-CR6	DIODE: Replacement Type 1N2069	943 303 001
CR7	DIODE	943 113 109
CR8, CR9	DIODE: Replacement Type 1N695	943 023 001
Fl	FUSE: 3 amp, SLO-BLOW	960 001 027
F2	FUSE: 3/4 amp, CARTRIDGE	960 002 006
J1, J2	JACK, TIP	941 501 008
DS1	LAMP, NEON	935 061 002
Q1	TRANSISTOR: Replacement Type 2N404	943 519 001
Q2	TRANSISTOR: Replacement Type 2N1136B	943 538 001
Q3, Q4, Q6	TRANSISTOR: Replacement Type 2N699	943 701 002
Q5	TRANSISTOR: Replacement Type 2N398A	943 508 001
R1-R4	RESISTOR, FIXED, COMPOSITION: 36 ohms ±5%, 2 W	932 006 014
R5	RESISTOR, FIXED, COMPOSITION: 3.6 K ±5%, 1/2 W	932 004 062
R6-R8	RESISTOR, FIXED, COMPOSITION: 22 K ±5%, 2 W	932 006 081
R9	RESISTOR, FIXED, COMPOSITION: 11 K ±5%, 2 W	932 006 074
R10	RESISTOR, FIXED, COMPOSITION: 33 K ±5%, 1 W	932 005 085
RII	RESISTOR, FIXED, COMPOSITION: 1.0 K ±5%, 1/2 W	932 004 049
R12	RESISTOR, FIXED, FILM: 422 ohms ±2%, 1/2 W	932 103 131
R13	RESISTOR, VARIABLE, COMPOSITION: 100 ohms ±10%, 1/4 W	933 003 101
R14-R17	RESISTOR, FIXED, FILM: 11 K ±2%, 1/2 W	932 103 303
R18	RESISTOR, FIXED, COMPOSITION: 7.5 K ±5%, 1/2 W	932 004 070

IDCU POWER SUPPLY, MODEL PD-30, PARTS LIST (Cont)

1100	CU POWER SUPPLY, MODEL PD-30, PARTS LIST (Cont)	
Ref. Desig.	Description	3C Part No.
R19	RESISTOR, FIXED, COMPOSITION: 3.0 K $\pm 5\%$, 1/2 W	932 004 060
R20	RESISTOR, FIXED, COMPOSITION: 16 K ±5%, 1/2 W	932 004 078
R21	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/2 W	932 004 097
R22	RESISTOR, FIXED, COMPOSITION: 200 K $\pm 5\%$, $1/2$ W	932 004 104
R23	RESISTOR, FIXED, COMPOSITION: 68 K ±5%, 1/2 W	932 004 093
Sl	SWITCH, TOGGLE	934 011 001
Tl	TRANSFORMER	938 200 001
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REFERENCE SUPPLY PAC, MODEL PR-30, PARTS LIST

	REFERENCE SUPPLY PAC, MODEL PR-30, PARTS LIS	<u> </u>
Ref. Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, MICA DIELECTRIC: 330 pf ±5%, 100 VDC	930 011 140
C2, C14, C23	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 µf ±10%, 200 VDC	930 306 029
C3	CAPACITOR, FIXED, MICA DIELECTRIC: 10 pf ±5%, 100 VDC	930 011 105
C4, C27	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 6.8 µf ±20%, 6 VDC	930 213 010
C5, C9	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 180 µf ±20%, 6 VDC	930 213 021
C6, C7	CAPACITOR, FIXED, MICA DIELECTRIC 220 pf ±5%, 100 VDC	930 011 135
C8, C24, C25	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 68 µf ±20%, 20 VDC	930 216 026
C10, C26	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 2.2 μf ±20%, 20 VDC	930 216 017
C11	CAPACITOR, FIXED, ELECTROLYTIC: 500 µf ±20%, 3 VDC	930 215 001
C12	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 2.2 µf ±20%, 25 VDC	930 174 006
C13,C19	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.022 µf ±10%, 200 VDC	930 306 021
C15	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 µf ±20%, 200 VDC	930 304 001
C16, C17	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.0047 µf ±10%, 100 VDC	930 310 222
C18	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.15 μ f ±10%, 200 VDC	930 306 031
C20	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.0068 µf ±10%, 200 VDC	930 306 015
C21	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 47 μf ± 20%, 35 VDC	930 217 025
C22	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 10 μf ± 20%, 6 VDC	930 213 011
CR1, CR11-CR16	DIODE	943 004 001
CR2, CR3	DIODE: Replacement Type 1N457	943 080 002
CR4, CR5, CR17	DIODE	943 083 001
CR6, CR9, CR10, CR20	DIODE: Replacement Type 1N695	943 023 001
CR7, CR8, CR18, CR19, CR22, CR23, CR24	DIODE: Replacement Type 1N816	943 105 001
CR21	DIODE	943 021 001
VRl	DIODE: Replacement Type 1N3828A	943 114 002
VR2	DIODE: ZENER	943 115 001

REFERENCE SUPPLY PAC, MODEL PR-30, PARTS LIST (Cont)

REFE.	RENCE SUPPLY PAC, MODEL PR-30, PARTS LIST (Conti
Ref.	December	3C Part No.
Desig.	Description	oc Part No.
Ql	TRANSISTOR: Replacement Type 3C214	943 711 001
Q2, Q7,Q11, Q18	TRANSISTOR: Replacement Type 2N1605	943 545 001
Q3, Q5, Q13	TRANSISTOR: Replacement Type 3C710	943 710 001
Q4	TRANSISTOR: Replacement Type 2N965	943 543 004
Q6, Q12, Q15-Q17, Q19, Q20	TRANSISTOR: Replacement Type 3C404A	943 519 002
Q8, Q9	TRANSISTOR: Replacement Type 3C306-1	943 714 002
Q10, Q14	TRANSISTOR: Replacement Type 2N1998	943 558 001
Q21	TRANSISTOR: Replacement Type 3C306-2	943 714 003
Rl	RESISTOR, VARIABLE WIREWOUND: 200 ohms ±10%	933 203 005
R2	RESISTOR, SELECTED VALUE (see text)	
R3, R63	RESISTOR, FIXED, COMPOSITION: 560 ohms ±5%, 1/4 W	932 007 043
R4	RESISTOR, FIXED, COMPOSITION: 82 ohms $\pm 5\%$, 1/4 W	932 007 023
R 5	RESISTOR, FIXED, WIREWOUND: 10 K ±0.02%, 1/3 W	932 204 018
R6	RESISTOR, FIXED, WIREWOUND: 5.875 K \pm 0.02%, 1/3 W	932 204 015
R7	RESISTOR, FIXED, COMPOSITION: $4.7 \text{ megohms } \pm 5\%$, $1/4 \text{ W}$	932 007 137
R8	RESISTOR, FIXED, COMPOSTION: 150 K ±5%, 1/4 W	932 007 101
R9, R20, R29, R48	RESISTOR, FIXED, COMPOSITION: $4.7 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 065
R10	RESISTOR, FIXED, COMPOSITION: 68 K ±5%, 1/4 W	932 007 093
Rll	RESISTOR, FIXED, COMPOSITION: 1 megohm $\pm 5\%$, $1/4$ W	932 007 121
R12	RESISTOR, FIXED, COMPOSITION: 18 K ±5%, 1/4 W	932 007 079
R13, R25, R41	RESISTOR, FIXED, COMPOSITION: 470 ohms ±5%, 1/4 W	932 007 041
R14	RESISTOR, FIXED, COMPOSITION: 220 K \pm 5%, 1/4 W	932 007 105
R15, R18, R44, R46, R49, R56	RESISTOR, FIXED, COMPOSITION: $10 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 073
R16	RESISTOR, FIXED, COMPOSITION: 27 K \pm 5%, $1/4$ W	932 007 083
R17	RESISTOR, FIXED, COMPOSITION: 2.2 K ±5%, 1/4 W	932 007 057

4-56 4/15/64

REFERENCE SUPPLY PAC, MODEL PR-30, PARTS LIST (Cont)

	TERENCE SUPPLY PAC, MODEL PR-30, PARTS LIST (C	
Ref. Desig.	Description	3C Part No.
R19	RESISTOR, FIXED, COMPOSITION: 68 ohms ±5%, 1/4 W	932 007 021
R21	RESISTOR, FIXED, COMPOSITION: 56 K ± 5%, 1/4 W	932 007 091
R22, R28, R31, R57, R62	RESISTOR, FIXED, COMPOSITION: 22 K ± 5%, 1/4 W	932 007 081
R23	RESISTOR, FIXED, COMPOSITION: 120 ohms ±5%, 1/4 W	932 007 027
R24	RESISTOR, FIXED, COMPOSITION: 22 ohms ±5%, 1/4 W	932 007 009
R26, R38	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/4 W	932 007 069
R27	RESISTOR, FIXED, COMPOSITION: 330 ohms ±5%, 1/4 W	932 007 037
R30, R34	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/4 W	932 007 097
R32	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1/4 W	932 007 082
R33, R35	RESISTOR, FIXED, COMPOSITION: 5.6 K ±5%, 1/4 W	932 007 067
R36	RESISTOR, FIXED, COMPOSITION: 200 K ±5%, 1/4 W	932 007 104
R 37	RESISTOR, FIXED, COMPOSITION: 1.8 K ±5%, 1/4 W	932 007 055
R 39	RESISTOR, FIXED, COMPOSITION: 2.7 K ±5%, 1/4 W	932 007 059
R40, R65	RESISTOR, FIXED, COMPOSITION: 3.3 K ±5%, 1/4 W	932 007 061
R42	RESISTOR, FIXED, COMPOSITION: 220 ohms ±5%, 1/4 W	932 007 033
R43	RESISTOR, FIXED, COMPOSITION: 4.3 K ±5%, 1/4 W	932 007 064
R45, R47, R52-R54	RESISTOR, FIXED, COMPOSITION: 10 ohms ±5%, 1/4 W	932 007 001
R 50	RESISTOR, FIXED, FILM: 10 K ±2%, 1/8 W	932 105 301
R51, R69	RESISTOR, FIXED, FILM: $12.1 \text{ K} \pm 2\%$, $1/8 \text{ W}$	932 105 305
R 55	RESISTOR, FIXED, COMPOSITION: 4.7 ohms ±5%, 1/4 W	932 007 160
R58, R60	RESISTOR, FIXED, WIREWOUND: 267 ohms ±0.1%, 1/3 W	932 204 011
R59, R61	RESISTOR, FIXED, COMPOSITION: 240 ohms ±5%, 1/4 W	932 007 034

REFERENCE SUPPLY PAC, MODEL PR-30, PARTS LIST (Cont)

REI	FERENCE SUPPLY PAC, MODEL PR-30, PARTS LIST	(Cont)
Ref.		
Desig.	Description	3C Part No.
R64	RESISTOR, FIXED, COMPOSITION: 200 ohms ±5%, 1/4 W	932 007 032
R66	RESISTOR, FIXED, WIREWOUND: 10 K ±0.01%, 1/3 W	932 204 017
R67	RESISTOR, FIXED, FILM: 750 K ±2%, 1/8 W	932 105 443
R68	RESISTOR, FIXED, FILM: 23.7 K ±2%, 1/8 W	932 105 319
R70	RESISTOR, FIXED, WIREWOUND: 8.23 K ±0.01%, 1/3 W	932 204 016
R71	RESISTOR, SELECTED VALUE (see text)	

REFERENCE SUPPLY PAC, MODEL PR-31, PARTS LIST

	REFERENCE SUPPLY PAC, MODEL PR-31, PARTS LIST	
Ref. Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, MICA DIELECTRIC: 330 pf ±5%, 100 VDC	930 011 140
C2, C14, C23	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 µf ±10%, 200 VDC	930 306 029
C3	CAPACITOR, FIXED, MICA DIELECTRIC: 10 pf ±5%, 100 VDC	930 011 105
C4	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 6.8 µf ±20%, 6 VDC	930 213 010
C5,C9	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 180 µf ±20%, 6 VDC	930 213 021
C6, C7	CAPACITOR, FIXED, MICA DIELECTRIC: 220 pf ±5%, 100 VDC	930 011 135
C8, C24, C25	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 68 µf ±20%, 20 VDC	930 216 026
C10	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 2.2 µf ±20%, 20 VDC	930 216 017
Cll	CAPACITOR, FIXED, ELECTROLYTIC: 500 µf ±20%, 3 VDC	930 215 001
C12	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 2.2 µf ±20%, 25 VDC	930 174 006
C13,C19	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.022 µf ±10%, 200 VDC	930 306 021
C15	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 µf ±20%, 200 VDC	930 304 001
C16, C17	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.0047 µf ±10%, 100 VDC	930 310 222
C18	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.15 µf ±10%, 200 VDC	930 306 031
C20	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.0068 μf ±10%, 200 VDC	930 306 015
C21	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: $47 \mu f \pm 20\%$, 35 VDC	930 217 025
C22	CAPACITOR, FIXED, TANTALUM ELECTROLYTIC: 10 µf ±20%, 6 VDC	930 213 011
CR1, CR11-CR16	DIODE	943 004 001
CR2, CR3	DIODE: Replacement Type 1N457	943 080 002
CR4, CR5, CR17	DIODE	943 083 001
CR6, CR9, CR10	DIODE: Replacement Type 1N695	943 023 001
CR7, CR8, CR18, CR19	DIODE: Replacement Type 1N816	943 105 001
VRl	DIODE: Replacement Type 1N3828A	943 114 002
Ql	TRANSISTOR: Replacement Type 3C214	943 711 001
Q2, Q7, Q11	TRANSISTOR: Replacement Type 2N1605	943 711 001

REFERENCE SUPPLY PAC, MODEL PR-31, PARTS LIST (Cont)

Ref. Desig.	Description	3C Part No.
Q3, Q5, Q13	TRANSISTOR: Replacement Type 3C710	943 710 001
Q3, Q3, Q13	TRANSISTOR: Replacement Type 2N965	943 543 004
Q6, Q12, Q15-Q17	TRANSISTOR: Replacement Type 3C404A	943 519 002
Q8, Q9	TRANSISTOR: Replacement Type 3C306-1	943 714 002
Q10, Q14	TRANSISTOR: Replacement Type 2N1998	943 558 001
Rl	RESISTOR, VARIABLE WIREWOUND: 200 ohms ±10%	933 203 005
R2	RESISTOR, FIXED, WIREWOUND: $4.025 \text{ K} \pm 0.02 \%$, $1/3 \text{ W}$	932 204 014
R3	RESISTOR, FIXED, COMPOSITION: 560 ohms $\pm 5\%$, $1/4$ W	932 007 043
R4	RESISTOR, FIXED, COMPOSITION: 82 ohms ±5%, 1/4 W	932 007 023
R5	RESISTOR, FIXED, WIREWOUND: 10 K ±0.02 %, 1/3 W	932 204 018
R6	RESISTOR, FIXED, WIREWOUND: $5.875 \text{ K} \pm 0.02 \%$, $1/3 \text{ W}$	932 204 015
R7	RESISTOR, FIXED, COMPOSITION: 4.7 megohms ±5%, 1/4 W	932 007 137
R8	RESISTOR, FIXED, COMPOSITION: $150 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 101
R9, R20, R29, R48	RESISTOR, FIXED, COMPOSITION: $4.7 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 065
R10	RESISTOR, FIXED, COMPOSITION: 68 K ±5%, 1/4 W	932 007 093
Rll	RESISTOR, FIXED, COMPOSITION: 1 megohm ±5%, 1/4 W	932 007 121
R12	RESISTOR, FIXED, COMPOSITION: $18 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 079
R13, R25, R41	RESISTOR, FIXED, COMPOSITION: 470 ohms ±5%, 1/4 W	932 007 041
R14	RESISTOR, FIXED, COMPOSITION: 220 K $\pm 5\%$, $1/4$ W	932 007 105
R15, R18, R44 R46, R49, R56	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/4 W	932 007 073
R16	RESISTOR, FIXED, COMPOSITION: $27 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 083
R17	RESISTOR, FIXED, COMPOSITION: $2.2 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 057
R19	RESISTOR, FIXED, COMPOSITION: 68 ohms ±5%, 1/4 W	932 007 021

REFERENCE SUPPLY PAC, MODEL PR-31, PARTS LIST (Cont)

	EKENCE SUPPLI FAC, MODEL PR-31, PARTS LIST (C	T T
Ref. Desig.	Description	3C Part No.
R21	RESISTOR, FIXED, COMPOSITION: 56 K ±5%, 1/4 W	932 007 091
R22, R28, R31, R57	RESISTOR, FIXED, COMPOSITION: 22 K ±5%, 1/4 W	932 007 081
R23	RESISTOR, FIXED, COMPOSITION: 120 ohms ±5%, 1/4 W	932 007 027
R24	RESISTOR, FIXED, COMPOSITION: 22 ohms ±5%, 1/4 W	932 007 009
R26, R38	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/4 W	932 007 069
R27	RESISTOR, FIXED, COMPOSITION: 330 ohms ±5%, 1/4 W	932 007 037
R30, R34	RESISTOR, FIXED, COMPOSITION: 100 K ±5%, 1/4 W	932 007 097
R32	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1/4 W	932 007 082
R33, R35	RESISTOR, FIXED, COMPOSITION: 5.6 K ±5%, 1/4 W	932 007 067
R36	RESISTOR, FIXED, COMPOSITION: 200 K ±5%, 1/4 W	932 007 104
R37	RESISTOR, FIXED, COMPOSITION: 1.8 K ±5%, 1/4 W	932 007 055
R39	RESISTOR, FIXED, COMPOSITION: 2.7 K ±5%, 1/4 W	932 007 059
R40	RESISTOR, FIXED, COMPOSITION: $3.3 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 061
R42	RESISTOR, FIXED, COMPOSITION: 220 ohms ±5%, 1/4 W	932 007 033
R43	RESISTOR, FIXED, COMPOSITION: $4.3 \text{ K} \pm 5\%$, $1/4 \text{ W}$	932 007 064
R45, R47, R52-R54	RESISTOR, FIXED, COMPOSITION: 10 ohms ±5%, 1/4 W	932 007 001
R50	RESISTOR, FIXED, FILM: 10 K ±2%, 1/8 W	932 105 301
R51	RESISTOR, FIXED, FILM: 12.1 K ±2%, 1/8 W	932 105 305
R55	RESISTOR, FIXED, COMPOSITION: $4.7 \text{ ohms } \pm 5\%, 1/4 \text{ W}$	932 007 160

POWER SUPPLY, MODEL RP-30, PARTS LIST*

Ref. Desig.	Description	1
		3C Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 5 μf, 330 VAC	3040855
C2	CAPACITOR, FIXED, ELECTROLYTIC: 17000 µf, 19 VDC	3040854
C3	CAPACITOR, FIXED, ELECTROLYTIC: 5500 μ f, 19 VDC	3040705
C4, C5	CAPACITOR, FIXED, ELECTROLYTIC: $15,500 \mu f$, 10 VDC	3040742
C6, C7	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
C8	CAPACITOR, FIXED, ELECTROLYTIC: 700 μf , 15 VDC	3040758
CBl	CIRCUIT BREAKER: 2 amp	3050117
CB2, CB3	CIRCUIT BREAKER: 3 amp	3050118
CR1, CR2	DIODE: Replacement Type 1N218	3370903
CR3, CR6, CR9	DIODE, ZENER, VOLTAGE REFERENCE: Replacement Type 102659A	3370924
CR4, CR5, CR7, CR8	DIODE: Replacement Type 1N3209	3370998
CR10, CR11, CR13	DIODE: Replacement Type 1N1217	3370906
CR12	DIODE: Replacement Type 1N199A	3370895
DS1	LAMP, INDICATOR, POWER ON: Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAILURE: Replacement Type GE-49	3220036
Fl	FUSE: 1.6 amp, 125 volt, Replacement Type MDX	3150267
Pl	CONNECTOR, ELECTRIC: Replacement Type; Hubbel 5278	3330123
Q1,Q2,Q5,Q6, Q9,Q10	TRANSISTOR: Replacement Type 2N527	3700029
Q3	TRANSISTOR: Replacement Type 2N1038	3700028
Q4,Q8,Q12	TRANSISTOR: Replacement Type 2N277	3700050
Q7,Q11	TRANSISTOR: Replacement Type 2N1544	3700044
Rl	RESISTOR, FIXED: 1 K ±5%, 1/2 W	3400153
R2	RESISTOR, FIXED: l ohm ±10%, 5 W	3407001
R3	RESISTOR, FIXED: 27 K ±5%, 1/2 W	3400187
R4,R13,R25	RESISTOR, FIXED: 0.1 ohm ±5%	3408103

^{*}Supplies bearing serial numbers up to and including No. 280334.

POWER SUPPLY, MODEL RP-30, PARTS LIST (Cont)

<u> </u>	POWER SUPPLY, MODEL RP-30, PARTS LIST (Cont)	1
Ref. Desig.	Description	Part No.
R5, R24	RESISTOR, FIXED: 5.1 K ±5%, 1/2 W	3400170
R6	RESISTOR, FIXED: 2.2 K ±5%, 1/2 W	3400161
R7	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3400160
R8, R30	RESISTOR, FIXED: 1 K ±1%, 3 W	3405051
R9, R29	RESISTOR, FIXED: 175 ohms ±1%, 3 W	3405071
R10, R20, R31	RESISTOR, VARIABLE: 50 ohms ±1%, 2 W	3410414
R11	RESISTOR, FIXED: 100 ohms ±5%, 2 W	3900824
R12	RESISTOR, FIXED: 6.8 K ±5%, 2 W	3400173
R14	RESISTOR, FIXED: 1.2 K ±5%, 1/2 W	3400155
R15	RESISTOR, FIXED: 300 ohms ±5%, 1/2 W	3400140
R16	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3405013
R17	RESISTOR, FIXED: 100 ohms ±1%, 3 W	3405004
R18, R19	RESISTOR, FIXED: 975 ohms ±1%, 3 W	3405010
R21, R26	RESISTOR, FIXED: 510 ohms ±5%, 1/2 W	3400146
R22	RESISTOR, FIXED: 160 ohms ±5%, 1/2 W	3400133
R23	RESISTOR, FIXED: 220 ohms ±5%, 2 W	3400832
R27	RESISTOR, FIXED: 560 ohms ±5%, 1/2 W	3400147
R28	RESISTOR, FIXED: 200 ohms ±5%, 1/2 W	3400136
R32	RESISTOR, FIXED: 150 ohms ±5%, 2 W	3400828
R33	RESISTOR, FIXED: 1.2 K ±5%, 5 W	3401673
R34	RESISTOR, FIXED: 750 ohms ±5%, 1 W	3400622
R35	RESISTOR, FIXED: 12 ohms ±5%, 1 W	3400579

POWER SUPPLY, MODEL RP-30, PARTS LIST (Cont)

ſ	POWER SUPPLY, MODEL RP-30, PARTS LIST (Cont)	1
Ref. Desig.	Description	Part No.
R36	RESISTOR, FIXED: 100 ohms ±5%, 5 W	3408018
Sl	SWITCH, TOGGLE, DPST	3660251
VRl	TRANSFORMER, REGULATED, FERROMAGNETIC	6123197

POWER SUPPLY, MODEL RP-31, PARTS LIST*

	POWER SUPPLY, MODEL RP-31, PARTS LIST*	
Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
C2, C6-C8	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
C3, C4	CAPACITOR, FIXED, ELECTROLYTIC: 15,500 µf, 10 VDC	3040742
C5, C9	CAPACITOR, FIXED, ELECTROLYTIC: 15,000 µf, 12 VDC	3040566
C10	CAPACITOR, FIXED, ELECTROLYTIC: $700 \mu f$, 15 VDC	3040758
C11	CAPACITOR, FIXED, 0.0033 µf, 100 VDC	3040835
C12	CAPACITOR, FIXED: 3 µf, 600 VAC	3040682
CB1	CIRCUIT BREAKER: 2 amp	3050117
CB2, CB3	CIRCUIT BREAKER:	3050120
CR1,CR2,CR4, CR5,CR7,CR8	DIODE: Replacement Type 1N3209	3370998
CR3,CR6,CR9	DIODE: Replacement Type 102659A	3370924
CR10,CR11,CR13	DIODE: Replacement Type 1N1217	3370906
CR12	DIODE: Replacement Type 1N1199A	3370895
DS1	LAMP, INDICATOR, POWER ON: Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAILURE: Replacement Type GE-49	3220036
Fl	FUSE: 4 amp, 125 volt, Replacement Type MDX	3150157
P1	CONNECTOR, ELECTRIC: Replacement Type; Hubbel 5278	3330123
Q1, Q2, Q5, Q6, Q6A,Q14,Q15	TRANSISTOR: Replacement Type 2N527	3700029
Q3, Q7, Q16	TRANSISTOR: Replacement Type 2N1544	3700044
Q4, Q8-Q13, Q17-Q22	TRANSISTOR: Replacement Type 2N277	3700050
R1	RESISTOR, FIXED: 510 ohms ±5%, 1 W	3400618
R2	RESISTOR, FIXED: 0.5 ohm ±10%, 10 W	3402011
R3	RESISTOR, FIXED: 18 K $\pm 5\%$, 1/2 W	3400183
L		L

^{*}Supplies bearing serial numbers up to and including No. 239541.

POWER SUPPLY, MODEL RP-31, PARTS LIST (Cont)

	POWER SUPPLY, MODEL RP-31, PARTS LIST (Cont)	1
Ref. Desig.	Description	Part No.
R4, R13, R16-R21,R31, R34-R39	RESISTOR, FIXED: 0.l ohm ±5%, 5 W	3408103
R5	RESISTOR, FIXED: 3.3 K ±5%, 1/2 W	3400165
R6	RESISTOR, FIXED: 680 ohms ±5%, 1 W	3400621
R7	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3400160
R8, R43	RESISTOR, FIXED: 1 K ±1%, 3 W	3405051
R9, R26, R42	RESISTOR, VARIABLE: 50 ohms, 2 W	3410414
R10, R41	RESISTOR, FIXED: 175 ohms ±1%, 3 W	3405071
R11	RESISTOR, FIXED: 30 ohms ±5%, 5 W	3407013
R12	RESISTOR, FIXED: 12 K ±5%, 1/2 W	3400179
R14	RESISTOR, FIXED: 2.7 K ±5%, 1/2 W	3400163
R15	RESISTOR, FIXED: 300 ohms ±5%, 1/2 W	3400140
R15A	RESISTOR, FIXED: 1.2 K ±5%, 1/2 W	3400155
R22	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3405013
R23	RESISTOR, FIXED: 100 ohms ±1%, 3 W	3405009
R24, R25	RESISTOR, FIXED: 975 ohms ±1%, 3 W	3405070
R27	RESISTOR, FIXED: 510 ohms ±5%, 1/2 W	3400146
R28	RESISTOR, FIXED: 39 ohms ±5%, 2 W	3400814
R29, R44	RESISTOR, FIXED: 50 ohms ±5%, 10 W	3407216
R30	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3400160
R32	RESISTOR, FIXED: 270 ohms ±5%, 1/2 W	3400139
R33	RESISTOR, FIXED: 560 ohms ±5%, 1/2 W	3400147
R40	RESISTOR, FIXED: 200 ohms ±5%, 1/2 W	3400136
L		L

POWER SUPPLY, MODEL RP-31, PARTS LIST (Cont)

	POWER SUPPLY, MODEL RP-31, PARTS LIST (Cont)	
Ref. Desig.	Description	Part No.
R45	RESISTOR, FIXED: 1.2 K ±5%, 5 W	3401673
R46	RESISTOR, FIXED: 82 ohms ±5%, 1 W	3400599
R47	RESISTOR, FIXED: 750 ohms ±5%, 1 W	3400622
R48	RESISTOR, FIXED: 100 ohms ±5%, 5 W	3408018
Sl	SWITCH, TOGGLE, DPST	3660251
VRI	TRANSFORMER, REGULATED, FERROMAGNETIC	6123248
	,	

POWER SUPPLY, MODEL RP-32, PARTS LIST *

Ref.	TOWER BOTTET, MODELE RT-32, TAKEN DIST	
Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
C2, C10-C16	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
C3-C7	CAPACITOR, FIXED, ELECTROLYTIC: 15,500 µf, 10 VDC	3040742
C8, C9, C17, C18	CAPACITOR, FIXED, ELECTROLYTIC: 15,500 µf, 12 VDC	3040566
C19	CAPACITOR, FIXED, ELECTROLYTIC: $700\mu f$, 15 VDC	3040758
C20-C22	CAPACITOR, FIXED: 4 µf, 660 VAC	3040605
C23, C24	CAPACITOR, FIXED: 0.01 µf, 100 VDC	3040716
CB1	CIRCUIT BREAKER: 4 amp	3050118
CB2, CB3	CIRCUIT BREAKER: 22 amp	3050121
CR1, CR2, CR12	DIODE: Replacement Type 1N3209	3370998
CR3, CR6, CR9	DIODE, ZENER, VOLTAGE REFERENCE: Replacement Type 102659A	3370924
CR4, CR5, CR7, CR8	DIODE: Replacement Type 1N1188	3370905
CR10, CR11, CR13	DIODE: Replacement Type 1N1217	3370906
DS1	LAMP, INDICATOR, POWER ON: Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAILURE: Replacement Type GE-49	3220036
Fl	FUSE: 7 amp, 125 volt; Replacement Type MDX	31 50333
Pl	CONNECTOR, ELECTRIC: Replacement Type; Hubbel 5278	3330123
Q1,Q2,Q5-Q7, Q21-Q23	TRANSISTOR: Replacement Type 2N527	3700029
Q3,Q8,Q24	TRANSISTOR: Replacement Type 2N1544	3700044
Q4,Q4A,Q9-Q20, Q25-Q36	TRANSISTOR: Replacement Type 2N277	3700050
R1	RESISTOR, FIXED: 200 ohms ±5%, 5 W	3407021
R2	RESISTOR, FIXED: 0.25 ohms ±10%, 10 W	3402010
R3	RESISTOR, FIXED: 9.1 K ±5%, 1/2 W	3400176

^{*}Supplies bearing serial numbers up to and including No. 198197 and/or models with "A" prefix.

POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)

	POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)	
Ref. Desig.	Description	Part No.
R4,R14,R18- R29,R39,R43- R54,R64,R65	RESISTOR, FIXED: 0.1 ohm ±5%, 1/2 W	3408103
R5	RESISTOR, FIXED: 1.6 K ±5%, 1/2 W	3400158
R6	RESISTOR, FIXED: 680 ohms ±5%, 1 W	3400621
R7, R57	RESISTOR, FIXED: 1 K ±1%, 3 W	3405051
R8, R35, R56	RESISTOR, VARIABLE: 50 ohms, 2 W	3410414
R9, R55	RESISTOR, FIXED: 175 ohms ±1%, 3 W	3405071
R10	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3400160
R11	RESISTOR, FIXED: 150 ohms ±5%, 2 W	3400828
R12	RESISTOR, FIXED: 12 ohms ±10%, 25 W	3402917
R13	RESISTOR, FIXED: 12 K±5%, 1/2 W	3400179
R15	RESISTOR, FIXED: 2.7 K ±5%, 1/2 W	3400163
R16	RESISTOR, FIXED: 1.2 K ±5%, 1/2 W	3400155
R17	RESISTOR, FIXED: 300 ohms ±5%, 1/2 W	3400140
R30	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3405013
R31	RESISTOR, FIXED: 100 ohms ±1%, 3 W	3405009
R32, R33	RESISTOR, FIXED: 975 ohms ±1%, 3 W	3405070
R34	RESISTOR, FIXED: 510 ohms ±5%, 1/2 W	3400146
R36	RESISTOR, FIXED: 12 ohms ±10%, 10 W	3407209
R37	RESISTOR, FIXED: 20 ohms ±10%, 25 W	3407409
R38	RESISTOR, FIXED: 10 K±5%, 1/2 W	3400177
R40	RESISTOR, FIXED: 1 K ±5%, 1/2 W	3400153
R41	RESISTOR, FIXED: 2.2 K ±5%, 1/2 W	3400161

POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)

	POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)	
Ref. Desig.	Description	Part No.
R42	RESISTOR, FIXED: 560 ohms ±5%, 1/2 W	3400147
R58	RESISTOR, FIXED: 200 ohms ±5%, 1/2 W	3400136
R59	RESISTOR, FIXED: 25 ohms ±10%, 10 W	3407212
R60	RESISTOR, FIXED: 1.2 K±5%, 5 W	3401673
R61	RESISTOR, FIXED: 82 ohms ±5%, 1 W	3400599
R62	RESISTOR, FIXED: 750 ohms ±5%, 1 W	3400622
R63	RESISTOR, FIXED: 100 ohms ±5%, 5 W	3408018
Sl	SWITCH, TOGGLE, DPST	3660251
VR1	TRANSFORMER, REGULATED, FERROMAGNETIC	6123249

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POWER SUPPLY, MODEL RP-32, PARTS LIST*

	POWER SUPPLY, MODEL RP-32, PARTS EBT	
Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
C2	CAPACITOR, FIXED, ELECTROLYTIC: $11,500\mu f,\ 18\ VDC$	3 0 4 0 5 7 2
C3,C4,C5,C8	CAPACITOR, FIXED, ELECTROLYTIC: $42,000\mu f,\ 15\ VDC$	3 0 4 1 0 9 9
C6,C7	CAPACITOR, FIXED, ELECTROLYTIC: $42,000 \mu f$, 20 VDC	3 0 4 1 1 2 5
C 9	CAPACITOR, FIXED, ELECTROLYTIC: 700 µf, 35 VDC	3 0 4 0 9 6 3
C10,C11, C13-C16	CAPACITOR, FIXED: 0.0047 μf, 100 VDC	3040933
C12, C17	CAPACITOR, FIXED: 6 μf, 660 VAC	3 0 4 1 0 0 7
CB1	CIRCUIT BREAKER: 4 amp	3 0 5 0 1 7 1
CB2,CB3	CIRCUIT BREAKER: 22 amp	3050121
CR1,CR2	DIODE: Replacement Type 367A	3371185
CR3, CR6, CR9	DIODE, ZENER, VOLTAGE REFERENCE: Replacement Type 102659A	3371230
CR4, CR5, CR7, CR8	DIODE: Replacement Type 1N1183	3371205
CR10, CR11, CR13, CR14	DIODE: Replacement Type 1N4001	3371266
CR12	DIODE: Replacement Type 368B	3371222
CR15	DIODE, ZENER: Replacement Type 1N3028A	0529643
DS1	LAMP, INDICATOR, POWER ON: Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAILURE: Replacement Type GE-49	3220036
Fl	FUSE: 7 amp, 125 volt; Replacement Type MDX	3150333
Pl	CONNECTOR, ELECTRIC: Replacement Type; Hubbel 5278	3330123
Q1,Q2,Q5-Q7, Q21-Q23,Q37	TRANSISTOR: Replacement Type 2N527	3700029
Q3	TRANSISTOR: Replacement Type 2N1038	3700028
Q4, Q4A, Q9-Q20, Q25-Q36	TRANSISTOR: Replacement Type 2N277	3700050
Q8,Q24	TRANSISTOR: Replacement Type 2N1544	3700044
R1,R37	RESISTOR, FIXED: 270 ohms ±5%, 2 W	3400834

^{*}Supplies bearing serial numbers beginning with 201050 through 220253.

POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)

D (
Ref. Desig.	Description	3C Part No.
R2	RESISTOR, FIXED: 0.25 ohm ±10%, 10 W	3402022
R3	RESISTOR, FIXED: 9.1 K ±5%, 1/2 W	3400176
R4	RESISTOR, FIXED: 2 K ±1%, 3 W	3405052
R5	RESISTOR, FIXED: 1.6 K ±5%, 1/2 W	3400158
R6	RESISTOR, FIXED: 390 ohms ±5%, 2 W	3400838
R7, R55	RESISTOR, FIXED: 1 K ±1%, 3 W	3405051
R8,R35,R56	RESISTOR, VARIABLE: 100 ohms, 2 W	3410573
R9,R57	RESISTOR, FIXED: 150 ohms ±1%, 3 W	3405102
R10	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3400160
R11	RESISTOR, FIXED: 75 ohms ±5%, 10 W	3407217
R12	RESISTOR, FIXED: 300 ohms ±5%, 1 W	3400612
R13	RESISTOR, FIXED: 22 K ±5%, 1/2 W	3400185
R14	RESISTOR, FIXED: 800 ohms ±1%, 3 W	3405276
R15	RESISTOR, FIXED: 2.7 K ±5%, 1/2 W	3400163
R16, R58	RESISTOR, FIXED: 1.2 K ±5%, 1/2 W	3400155
R17, R33	RESISTOR, FIXED: 50 ohms ±1%, 3 W	3405126
R18-R29, R43-R54, R64,R65	RESISTOR, FIXED: 0.1 ohm ±5%, 3 W	3405158
R30-R32	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3405013
R34	RESISTOR, FIXED: 510 ohms ±5%, 1/2 W	3400146
R36	RESISTOR, FIXED: 5 ohms ±10%, 25 W	3407405
R38	RESISTOR, FIXED: 10 K ±5%, 1/2 W	3400177
R40	RESISTOR, FIXED: 5.1 K ±5%, 1/2 W	3400170

POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)

Ref.	POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)	
Desig.	Description	3C Part No.
R41	RESISTOR, FIXED: 2.2 K ±5%, 1/2 W	3400161
R42	RESISTOR, FIXED: 100 ohms ±1%, 3 W	3405009
R59	RESISTOR, FIXED: 12 ohms ±10%, 25 W	3402917
R60	RESISTOR, FIXED: 1.2 K ±5%, 5 W	3401673
R66-68	RESISTOR, FIXED: 220 ohms ±5%, 1/2 W	3400137
S1	SWITCH, TOGGLE, DPST	3600251
VRl	TRANSFORMER, REGULATED, FERROMAGNETIC	6113707
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RECOMMENDED SPARE PARTS KIT LIST FOR POWER SUPPLIES, MODELS RP-30, RP-31, AND RP-32

	MODEL RP-30	
Quantity	Description	Part No.
1	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
1	CAPACITOR, FIXED, ELECTROLYTIC: 5,500 µf, 19 VDC	3040705
1	CAPACITOR, FIXED, ELECTROLYTIC: $15,500\mu f,\ 10\ VDC$	3040742
1	CAPACITOR, FIXED, ELECTROLYTIC: 5 µf, 330 VAC	3040855
1	CAPACITOR, FIXED, ELECTROLYTIC: 700 µf, 15 VDC	3040758
1	DIODE: Replacement Type 1N1199A	3370895
1	DIODE: Replacement Type MR313	3370998
1	DIODE: Replacement Type 320B	3370903
1	DIODE: Replacement Type 320A	3370906
1	DIODE, ZENER: Replacement Type 102659A	3370924
1	LAMP, INDICATOR, DC FAILURE	3220036
1	LAMP, INDICATOR, POWER ON	3220026
6	FUSE: 1.5 amp, 125 volt	3150144
1	TRANSISTOR: Replacement Type 2N527	3700029
1	TRANSISTOR: Replacement Type 2N1544	3700044
1	TRANSISTOR: Replacement Type 2N277	3700050
	MODEL RP-31	
1	CAPACITOR, FIXED, ELECTROLYTIC: 5,500 µf, 19 VDC	3040705
1	CAPACITOR, FIXED, ELECTROLYTIC: 15,500 µf, 10 VDC	3040742
1	CAPACITOR, FIXED, ELECTROLYTIC: 15,000 µf, 12 VDC	3040566
1	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
1	CAPACITOR, FIXED, ELECTROLYTIC: 700 µf, 15 VDC	3040758
1	CAPACITOR, FIXED, ELECTROLYTIC: 3 µf, 660 VAC	3040682
1	DIODE: Replacement Type MR313	3370998

4/16/68

	MODEL RP-31 (Cont)	
Quantity	Description	Part No.
1	DIODE: Replacement Type 320A	3370906
1	DIODE: Replacement Type 1N1199A	3370895
1	DIODE, ZENER: Replacement Type 102659A	3370924
1	LAMP, INDICATOR, DC FAILURE	3220036
1	LAMP, INDICATOR, POWER ON	3220026
6	FUSE: 4 amp, 125 volt	3150157
1	TRANSISTOR: Replacement Type 2N527	3700029
1	TRANSISTOR: Replacement Type 2N1544	3700044
2	TRANSISTOR: Replacement Type 2N277	3700050
	MODEL RP-32	
	(Supplies bearing serial numbers up to and including No. 198197 and/or models with "A" prefix)	
1	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
1	CAPACITOR, FIXED, ELECTROLYTIC: 15,500 µf, 10 VDC	3040742
1	CAPACITOR, FIXED, ELECTROLYTIC: 15,000 μf , 12 VDC	3040566
1	CAPACITOR, FIXED, ELECTROLYTIC: 700 µf, 15 VDC	3040758
1	CAPACITOR, FIXED, ELECTROLYTIC: $4\mu f$, 660 VAC	3040605
1	DIODE: Replacement Type 302A	3370905
1	DIODE: Replacement Type 320A	3370906
1	DIODE: Replacement Type MR313	3370998
1	DIODE, ZENER: Replacement Type 102659A	3370924
1	LAMP, INDICATOR, DC FAILURE	3220036
1	LAMP, INDICATOR, POWER ON	3220026
6	FUSE: 7 amp, 125 volt	3150333
1	TRANSISTOR: Replacement Type 2N527	3700029
1	TRANSISTOR: Replacement Type 2N1544	3700044
2	TRANSISTOR: Replacement Type 2N277	3700050
	MODEL RP-32	
	(Supplies with Serial No. 201050 through 220253)	
1	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
1	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572

4/16/68

	MODEL RP-32 (Cont)	
	(Supplies with Serial No. 201050 through 22)253)	
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Quantity	Description	Part No.
1	CAPACITOR, FIXED, ELECTROLYTIC: 42,000 µf, 15 VDC	3 041 099
1	CAPACITOR, FIXED, ELECTROLYTIC: 42,000 µf, 20 VDC	3041125
1	CAPACITOR, FIXED, ELECTROLYTIC: 700 µf, 35 VDC	3040963
1	CAPACITOR, FIXED, ELECTROLYTIC: 6 µf, 660 VAC	3041007
1	DIODE: Replacement Type 367A	3371185
1	DIODE: Replacement Type 1N1183	3371205
1	DIODE: Replacement Type 1N4001	3371266
1	DIODE: Replacement Type 368B	3371222
1	DIODE, ZENER: Replacement Type 102659A	3371230
1	DIODE, ZENER: Replacement Type 1N3028A	0529643
1	LAMP, INDICATOR, DC FAILURE	3220037
1	LAMP, INDICATOR, POWER ON	3220026
6	FUSE: 7 amp, 125 volt	3150333
1	TRANSISTOR: Replacement Type 2N527	3700029
1	TRANSISTOR: Replacement Type 2N1038	3700028
2	TRANSISTOR: Replacement Type 2N2082	3700103
1	TRANSISTOR: Replacement Type 2N1544	3700044
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POWER SUPPLY, MODEL RP-30, PARTS LIST*

Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
C2	CAPACITOR, FIXED, ELECTROLYTIC: 5,500 µf, 19 VDC	3040705
C3, C4	CAPACITOR, FIXED, ELECTROLYTIC: 15,500 µf, 10 VDC	3040742
C5, C6	CAPACITOR, FIXED, ELECTROLYTIC 11,500 µf, 18 VDC	3040572
C7	CAPACITOR, FIXED, ELECTROLYTIC 700 μf, 35 VDC	3040963
C8	CAPACITOR, FIXED: 2 µf, 660 VAC	3041019
CB1	CIRCUIT BREAKER: 2 amp, Replacement Type Heineman AM12	3050117
CB2, CB3	CIRCUIT BREAKER: 3 amp, Replacement Type Heineman AM12	3050118
CR1, CR2	DIODE: Replacement Type 1N1218	3371174
CR3, CR7 CR12	DIODE, ZENER:	3371230
CR4, CR11, CR13, CR14, CR16	DIODE: Replacement Type 1N4001	3371266
CR5, CR6, CR9, CR10	DIODE:	3371185
CR8	DIODE: Replacement Type, Westinghouse 368B	3371222
CR15	DIODE, ZENER: Replacement Type 1N3028A	0529643
DS1	LAMP, INDICATOR, POWER ON: Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAIL: Replacement Type GE-1813	3220037
Fl	FUSE: 1.6 amp, Replacement Type Bussman MDX	3150267
PW1	PRINTED CIRCUIT BOARD ASSEMBLY: +12V	6186187
PW2	PRINTED CIRCUIT BOARD ASSEMBLY: -6V	6186188

^{*}Supplies bearing serial numbers 280335 and beyond.

POWER SUPPLY, MODEL RP-30, PARTS LIST (Cont)

Ref. Desig.	Description	3C Part No.
PW3	PRINTED CIRCUIT BOARD ASSEMBLY: -18 V	6186189
Q1, Q2, Q5, Q6, Q9, Q10, Q13	TRANSISTOR: Replacement Type 2N527	3700029
Q3, Q7, Q11	TRANSISTOR: Replacement Type 2N1038	3700028
Q4, Q8, Q12	TRANSISTOR: Replacement Type 2N2082	3700103
R1, R10	RESISTOR, FIXED: 1K ±1%, 1/2 W	3400153
R2	RESISTOR, FIXED: 1 ohm ±5%, 5 W	3408109
R3	RESISTOR, FIXED: 9.1K ±5%, 1/2 W	3400176
R4	RESISTOR, FIXED: 1.6K ±5%, 1/2 W	3400158
R5	RESISTOR, FIXED: 820 ohms ±5%, 1/2 W	3400151
R6	RESISTOR, FIXED: 2K ±5%, 1/2 W	3400160
R7, R26	RESISTOR, FIXED: 1K ±1%, 3 W	3405051
R8, R19, R27	RESISTOR, VARIABLE: 100 ohms, 2 W	3410573
R9, R28	RESISTOR, FIXED: 150 ohms ±1%, 3 W	3405102
R11, R21	RESISTOR, FIXED: 100 ohms ±5%, 2 W	3400824
R12	RESISTOR, FIXED: 6.8K ±5%, 1/2 W	3400173
R13	RESISTOR, FIXED: 820 ohms ±5%, 1/2 W	3400151
R14	RESISTOR, FIXED: 430 ohms ±5%, 1/2 W	3400144
R15, R16	RESISTOR, FIXED: 250 ohms ±1%, 3 W	3405005

POWER SUPPLY, MODEL RP-30, PARTS LIST (Cont)

Ref.		
Desig.	Description	3C Part No.
R17	RESISTOR, FIXED: 270 ohms ±5%, 1/2 W	3400139
R18	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3405013
R20	RESISTOR, FIXED: 50 ohms ±1%, 3 W	3405126
R22, R30	RESISTOR, FIXED: 220 ohms ±5%, 2 W	3400832
R23	RESISTOR, FIXED: 3.3K ±5%, 1/2 W	3400165
R24	RESISTOR, FIXED: 1.8K ±5%, 1/2 W	3400159
R25	RESISTOR, FIXED: 820 ohms ±5%, 1/2 W	3400151
R29	RESISTOR, FIXED: 200 ohms ±5%, 2 W	3400831
R31	RESISTOR, FIXED: 2K ±1%, 3 W	3405052
R32	RESISTOR, FIXED: 1.2K ±5%, 5 W	3401673
R33	RESISTOR, FIXED: 800 ohms ±1%, 3 W	3405276
S1	SWITCH, TOGGLE, DPST:	3660251

POWER SUPPLY, MODEL RP-31, PARTS LIST *

Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 μf, 19 VDC	3 0 4 0 8 5 4
C2, C7-C9	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
C3,C4	CAPACITOR, FIXED, ELECTROLYTIC: 15,500 µf, 12 VDC	3 04 0 7 4 2
C5,C10	CAPACITOR, FIXED, ELECTROLYTIC: 15,000 µf, 12 VDC	3040566
C6	CAPACITOR, FIXED: 5 µf, 660 VAC	3 041 020
Cll	CAPACITOR, FIXED, ELECTROLYTIC: 700 µf, 35 VDC	3 040963
C12	CAPACITOR, FIXED: 0.0033 µf, 100 VDC	3040835
CB1	CIRCUIT BREAKER: 2 amp	3050117
CB2,CB3	CIRCUIT BREAKER: 10 amp	3 05 01 2 0
CR1, CR2, CR5, CR6, CR9, CR10	DIODE: Replacement Type 1N3209	3370998
CR3,CR7, CR11,	DIODE: Replacement Type 102659A	3370924
CR4	DIODE: Replacement Type 1N1217	3370906
CR8	DIODE: Replacement Type 1N1199A	3370895
CR12, CR13	DIODE: Replacement Type 1N4001	3371266
DS1	LAMP, INDICATOR, POWER ON Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAILURE Replacement Type GE-49	3220036
Fl	FUSE: 4 amp, 125 volt, Replacement Type MDX	3150157
Pl	CONNECTOR, ELECTRIC: Replacement Type, Hubbel 7808G	3330031
Q1,Q2,Q5,Q6, Q6A,Q14,Q15	TRANSISTOR: Replacement Type 2N527	3700029
Q3,Q7,Q16	TRANSISTOR: Replacement Type 2N1544	3700044
Q4,Q8-Q13, Q17-Q22	TRANSISTOR: Replacement Type 2N277	3700050

^{*}Supplies bearing serial numbers 239542 and beyond.

POWER SUPPLY, MODEL RP-31, PARTS LIST (Cont)

Ref. Desig.	Description	3C Part No.
Rl	RESISTOR, FIXED:	3 4 0 0 6 1 8
R2	510 ohms ±5%, 1 W RESISTOR, FIXED:	3402011
R3	0.5 ohm ±10%, 10 W RESISTOR, FIXED:	3400183
R4,R13, R16-R21, R31,R34-R39	18 K ±5%, 1/2 W RESISTOR, FIXED: 0.1 ohm ±5%, 5 W	3 4081 03
R5	RESISTOR, FIXED: 3.3 K ±5%, 1/2 W	3400165
R6	RESISTOR, FIXED: 680 ohms ±5%, 1 W	3 4 0 0 6 2 1
R7	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3400160
R8,R43	RESISTOR, FIXED: 1 K ±1%, 3 W	3 4 0 5 0 5 1
R9,R26,R42	RESISTOR, VARIABLE: 50 ohms, 2 W	3410414
R10,R41	RESISTOR, FIXED: 175 ohms ±1%, 3 W	3405071
R11	RESISTOR, FIXED: 120 ohms ±5%, 1 W	3 4 0 0 6 0 3
R12	RESISTOR, FIXED: 12 K ±5%, 1/2 W	3 4001 79
R14	RESISTOR, FIXED: 2.7 K ±5%, 1/2 W	3 4001 63
R15	RESISTOR, FIXED: 300 ohms ±5%, 1/2 W	3 4001 40
R15A	RESISTOR, FIXED: 1.2 K ±5%, 1/2 W	3 4001 55
R22	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3 40501 3
R23	RESISTOR, FIXED: 100 ohms ±1%, 3 W	3405009
R24,R25	RESISTOR, FIXED: 975 ohms ±1%, 3 W	3405070
R27	RESISTOR, FIXED: 510 ohms ±5%, 1/2 W	3 4 0 0 1 4 6
R28	RESISTOR, FIXED: 39 ohms ±5%, 2 W	3 4 0 0 8 1 4
R29,R44	RESISTOR, FIXED: 50 ohms ±5%, 10 W	3 4 0 7 2 1 6
R30	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3 4 0 0 1 6 0

POWER SUPPLY, MODEL RP-31, PARTS LIST (Cont)

Ref. Desig.	Description	3C Part No.
R32	RESISTOR, FIXED: 270 ohms ±5%, 1/2 W	3400139
R33	RESISTOR, FIXED: 560 ohms ±5%, 1/2 W	3 4 0 0 1 4 7
R40	RESISTOR, FIXED: 200 ohms ±5%, 1/2 W	3400136
R45	RESISTOR, FIXED: 1.2 K ±5%, 5 W	3 4 0 1 6 7 3
R46	RESISTOR, FIXED: 82 ohms ±5%, 1 W	3400599
R47	RESISTOR, FIXED: 750 ohms ±5%, 1 W	3400622
R48	RESISTOR, FIXED: 100 ohms ±5%, 5 W	3408018
Sl	SWITCH, TOGGLE, DPST	3660251
VR1	TRANSFORMER, REGULATED, FERROMAGNETIC	6123761

POWER SUPPLY, MODEL RP-32, PARTS LIST*

D. C		
Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
C2, C3, C7, C8, C13, C14	CAPACITOR, FIXED: 0.047 µf	3040933
C4	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
C5,C6,C9,C15	CAPACITOR, FIXED, ELECTROLYTIC: 42,000 µf, 15 VDC	3 041 099
C10	CAPACITOR, FIXED: 10 µf, 660 VAC	3 0 4 1 0 2 3
C11,C12	CAPACITOR, FIXED, ELECTROLYTIC: 42,000 µf, 20 VDC	3041125
C16	CAPACITOR, FIXED, ELECTROLYTIC: 700 µf, 35 VDC	3040963
CB1	CIRCUIT BREAKER: 4 amp	3050171
CB2, CB3	CIRCUIT BREAKER: 22 amp	3050121
CR1, CR2	DIODE: Replacement Type 367A	3371185
CR3, CR12, CR14, CR15	DIODE: Replacement Type 1N4001	3371266
CR4, CR8, CR13	DIODE, ZENER, VOLTAGE REFERENCE: Replacement Type 102659A	3371230
CR5	DIODE, ZENER: Replacement Type 1N3028A	0529643
CR6, CR7, CR10, CR11	DIODE: Replacement Type 1N1183	3371205
CR9	DIODE: Replacement Type 368B	3371222
DS1	LAMP, INDICATOR, POWER ON: Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAILURE: Replacement Type GE-49	3220036
Fl	FUSE: 10 amp, 125 volt; Replacement Type MDX	3150145
Pl	CONNECTOR, ELECTRIC: Replacement Type; Hubbel 7808G	3330031
Q1,Q2,Q5-Q7, Q21-Q23,Q37	TRANSISTOR: Replacement Type 2N527	3700029
Q3	TRANSISTOR: Replacement Type 2N1038	3700028
Q4,Q4A,Q9-Q20, Q25-Q36	TRANSISTOR: Replacement Type 2N277	3700050
Q8,Q24	TRANSISTOR: Replacement Type 2N1544	3700044
R1,R42	RESISTOR, FIXED: 270 ohms ±5%, 2 W	3400834

^{*}Supplies bearing serial numbers beginning with 220254 and beyond.

POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)

Ref. Desig	Description	3C Part No.
R2	RESISTOR, FIXED: 0.25 ohm ±10%, 10 W	3 402022
R3,R19,R45	RESISTOR, FIXED: 220 ohms ±5%, 1/2 W	3 4 0 0 1 3 7
R4	RESISTOR, FIXED: 9.1 K ±5%, 1/2W	3400176
R5	RESISTOR, FIXED: 1.6 K ±5%, 1/2 W	3 4 0 0 1 5 8
R6	RESISTOR, FIXED: 390 ohms ±5%, 2 W	3400838
R7,R8,R24-R35, R49-R60	RESISTOR, FIXED: 0.1 ohm ±5%, 3 W	3405158
R9	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3 4 0 0 1 6 0
R10,R63	RESISTOR, FIXED: 150 ohms ±1%, 3 W	3 4 0 5 1 0 2
R11,R37,R62	RESISTOR, VARIABLE: 100 ohms, 2 W	3 41 0573
R12,R61	RESISTOR, FIXED: 1 K ±1%, 3 W	3 4 0 5 0 5 1
R13	RESISTOR, FIXED: 75 ohms ±5%, 10 W	3407217
R14	RESISTOR, FIXED: 800 ohms ±1%, 3 W	3405276
R15	RESISTOR, FIXED: 1.2 K ±5%, 5 W	3 4 0 1 6 7 3
R16	RESISTOR, FIXED: 300 ohms ±5%, 1 W	3 4 0 0 6 1 2
R17	RESISTOR, FIXED: 22 K ±5%, 1/2 W	3 4 0 0 1 8 5
R18	RESISTOR, FIXED: 2.7 K ±5%, 1/2 W	3 4 0 0 1 6 3
R20,R48	RESISTOR, FIXED: 1.2 K ±5%, 1/2 W	3 4 0 0 1 5 5
R21,R38	RESISTOR, FIXED: 50 ohms ±1%, 3 W	3 4 0 5 1 2 6
R22, R23, R36	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3 4 0 5 0 1 3
R39	RESISTOR, FIXED: 510 ohms ±5%, 1/2 W	3 4 0 0 1 4 6
R 40	RESISTOR, FIXED: 5 ohms ±10%, 25 W	3 4 0 7 4 0 5
R 41	RESISTOR, FIXED: 2 K ±1%, 3 W	3405052

POWER SUPPLY, MODEL RP-32, PARTS LIST (Cont)

Ref. Desig.	Description	2C Don't No
		3C Part No.
R 43	RESISTOR, FIXED: 10 K ±5%, 1/2 W	3400177
R44	RESISTOR, FIXED: 5.1 K ±5%, 1/2 W	3400170
R46	RESISTOR, FIXED: 2.2 K ±5%, 1/2 W	3 4 0 0 1 6 1
R47	RESISTOR, FIXED: 100 ohms ±1%, 3 W	3405009
R64	RESISTOR, FIXED: 12 ohms ±10%, 25 W	3402917
S1	SWITCH, TOGGLE, DPST	3600251
VR1	TRANSFORMER, REGULATED, FERROMAGNETIC	6113707

POWER SUPPLY, MODEL RP-31E, PARTS LIST

Ref.	POWER SUPPLY, MODEL RP-31E, PARTS LIST	
Desig.	Description	Part No.
.C1	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
C2, C7-C10	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 µf, 18 VDC	3040572
C3, C4	CAPACITOR, FIXED, ELECTROLYTIC: 15,500 µf, 12 VDC	3040742
C5	CAPACITOR, FIXED, ELECTROLYTIC: 15,000 µf, 12 VDC	3040566
C6	CAPACITOR, FIXED: 5 µf, 660 VAC	3041020
C11	CAPACITOR, FIXED, ELECTROLYTIC: 700 μf, 35 VDC	3040963
C12, C13	CAPACITOR, FIXED: 0.0047 µf, 100 VDC	3040715
CBl	CIRCUIT BREAKER: 2 amp	3050117
CB2, CB3	CIRCUIT BREAKER: 10 amp	3050120
CR1, CR2, CR5, CR6, CR9, CR10		3370998
CR3, CR11, CR13, CR14	DIODE: Replacement Type 1N4001	3371266
CR4, CR7, CR12	DIODE: Replacement Type Hoffman 102659A	3371230
CR8	DIODE: Replacement Type Westinghouse 368B	3371222
CR15	DIODE: Replacement Type 1N3028A	0529643
DS1	LAMP, INDICATOR, POWER ON: Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAILURE: Replacement Type GE-1813	3220037
Fl	FUSE: 4 amp, 125 volt, Replacement Type MDX	3150157
Pl	CONNECTOR, ELECTRIC: Replacement Type, Hubbel 7808G	3330031
Q1, Q2, Q5-Q7. Q15-Q17, Q25	TRANSISTOR: Replacement Type 2N527	3700029
Q3	TRANSISTOR: Replacement Type 2N1038	3700028
Q4, Q9-Q14, Q19-Q24	TRANSISTOR: Replacement Type 2N2082	3700103
Q8, Q18	TRANSISTOR: Replacement Type 2N1544	3700044
R1, R10	RESISTOR, FIXED: 510 ohms ±5%, 1 W	3400618
R2	RESISTOR, FIXED: 0.5 ohm ±10%, 10 W	3402019

POWER SUPPLY, MODEL RP-31E, PARTS LIST (Cont)

<u></u>	POWER SUPPLY, MODEL RP-31E, PARTS LIST (Co.	1111
Ref. Desig.	Description	Part No.
R3	RESISTOR, FIXED: 9.1 K ±5%, 1/2 W	3400176
R4	RESISTOR, FIXED: 1.6 K ±5%, 1/2 W	3400158
R5	RESISTOR, FIXED: 1 K ±5%, 1/2 W	3400153
R6	RESISTOR, FIXED: 2 K ±5%, 1/2 W	3400160
R7, R36	RESISTOR, FIXED: 1 K, 1%, 3 W	3405051
R8, R21, R37	RESISTOR, VARIABLE: 100 ohms, 2 W	3410573
R9,R38	RESISTOR, FIXED: 150 ohms, 1%, 3 W	3405102
R11,R24-R29, R40-R45	RESISTOR, FIXED: 0.1 ohm ±5%, 3 W	3405158
R12	RESISTOR, FIXED: 120 ohms ±5%, 1 W	3400603
R13	RESISTOR, FIXED: 68 ohms ±5%, 2 W	3400820
R14	RESISTOR, FIXED: 2.7 K ±5%, 1/2 W	3400163
R15	RESISTOR, FIXED: 22 K ±5%, 1/2 W	3400185
R16, R35	RESISTOR, FIXED: 1.2 K ±5%, 1/2 W	3400155
R17, R18, R20	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3405013
R19	RESISTOR, FIXED: 510 ohms ±5%, 1/2 W	3400146
R22	RESISTOR, FIXED: 50 ohms ±1%, 3 W	3405126
R 23	RESISTOR, FIXED: 30 ohms ±5%, r %	3407013
R 23	RESISTOR, FIXED: 30 ohms ±5%, 5 W	3407013
R30, R39	RESISTOR, FIXED: 50 ohms ±5%, 10 W	3407216
R31	RESISTOR, FIXED: 136 ohms ±1%, 3 W	3405110
R32	RESISTOR, FIXED: 10 K ±5%, 1/2 W	3400177
R33	RESISTOR, FIXED: 5.1 K ±5%, 1/2 W	3400170

POWER SUPPLY, MODEL RP-31E, PARTS LIST (Cont)

Ref. Desig.	Description	Part No.
R34	RESISTOR, FIXED: 1.2 K ±5%, 1/2 W	3400155
R46	RESISTOR, FIXED: 1.2 K ±5%, 5 W	3401673
R47	RESISTOR, FIXED: 800 ohms ±1%, 3 W	3405276
R48	RESISTOR, FIXED: 2 K ±1%, 3 W	3405052
Sl	SWITCH, TOGGLE, DPST	3660251
VRl	TRANSFORMER, REGULATED, FERROMAGNETIC	6123761

POWER SUPPLY, MODEL RP-32E, PARTS LIST

	POWER SUPPLY, MODEL RP-32E, PARTS LIST	
Ref. Desig.	Description	Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
C2	CAPACITOR, FIXED, ELECTROLYTIC: 11,500 μf, 18 VDC	3040572
C3-C5, C8	CAPACITOR, FIXED, ELECTROLYTIC: 42,000 µf, 15 VDC	3041099
C6, C7	CAPACITOR, FIXED, ELECTROLYTIC: 42,000 µf, 20 VDC	3041125
C9	CAPACITOR, FIXED, ELECTROLYTIC: 700 µf, 35 VDC	3040963
C10	CAPACITOR, FIXED: 0.0033 µf, 100 VDC	3041047
C11	CAPACITOR, FIXED: 0.022 µf, 100 VDC	3040981
C12	CAPACITOR, FIXED: 10 µf, 660 VAC	3041023
CB1	CIRCUIT BREAKER: 4 amp	3050171
CB2, CB3	CIRCUIT BREAKER: 22 amp	3050121
CR1, CR2	DIODE: Replacement Type 367A Westinghouse	3371185
CR3, CR6, CR9		3371230
CR4, CR5, CR7, CR8		3371205
CR10, CR11, CR13, CR14	DIODE: Replacement Type 1N4001	3371266
CR12	DIODE: Replacement Type 368B Westinghouse	3371222
CR15	DIODE: Replacement Type 1N3028A	0529643
DS1	LAMP, INDICATOR, POWER ON: Replacement Type GE-1835	3220026
DS2	LAMP, INDICATOR, DC FAILURE: Replacement Type GE-1813	3220037
F1	FUSE: 10 amp, 125 volt, Replacement Type FNN Bussman	3150145
Pl	CONNECTOR, ELECTRIC: Replacement Type Hubbel 7808G	3331031
Q1, Q2, Q5-Q7, Q21-Q23, Q37	TRANSISTOR: Replacement Type 2N527	3700029
Q3	TRANSISTOR: Replacement Type 2N1038	3700028
Q4, Q4A, Q4B, Q9-Q20, Q25-Q36	TRANSISTOR: Replacement Type 2N2082	3700103
Q8, Q24	TRANSISTOR: Replacement Type 2N1544	3700044

4/16/68

POWER SUPPLY, MODEL RP-32E, PARTS LIST (Cont)

Ref.		
Desig.	Description	Part No.
R1, R37	RESISTOR, FIXED: 270 ohms ±5%, 2 W	3400834
R2	RESISTOR, FIXED: 0.25 ohm ±10%, 10 W	3402022
R 3	RESISTOR, FIXED: 9.1 K ±5%, 1/2 W	3400176
R4	RESISTOR, FIXED: 2 K ± 1%, 3 W	3405052
R5	RESISTOR, FIXED: 1.6 K ±5%, 1/2 W	3400158
R6	RESISTOR, FIXED: 390 ohms ±5%, 2 W	3400838
R7, R55	RESISTOR, FIXED: 1 K ±1%, 3 W	3405051
R8, R35, R56	RESISTOR, VARIABLE: 100 ohms, 2 W	3410573
R9, R57	RESISTOR, FIXED: 150 ohms ±1%, 3 W	3405102
R10	RESISTOR, FIXED: 2 K ± 5%, 1/2 W	3400160
R11	RESISTOR, FIXED: 75 ohms ±5%, 10 W	3407217
R12	RESISTOR, FIXED: 300 ohms ±5%, 1 W	3400612
R13	RESISTOR, FIXED: 22 K ±5%, 1/2 W	3400185
R14	RESISTOR, FIXED: 800 ohms ±1%, 3 W	3405276
R15	RESISTOR, FIXED: 2.7 K ±5%, 1/2 W	3400163
R16, R58	RESISTOR, FIXED: 1.2 K ± 5%, 1/2 W	3400155
R17, R33	RESISTOR, FIXED: 50 ohms ±1%, 3 W	3405126
R18-R29, R43-R54, R63-R65	RESISTOR, FIXED: 0.1 ohm ±5%, 3 W	3405158
R30-R32	RESISTOR, FIXED: 500 ohms ±1%, 3 W	3405013
R34	RESISTOR, FIXED: 510 ohms ±5%, 1/2 W	3400146
R36	RESISTOR, FIXED: 5 ohms ±10%, 25 W	3407405
R38	RESISTOR, FIXED: 10 K ±5%, 1/2 W	3400177

POWER SUPPLY, MODEL RP-32E, PARTS LIST (Cont)

	POWER SUPPLY, MODEL RP-32E, PARTS LIST (Cont)	
Ref. Desig.	Description	Part No.
R40	RESISTOR, FIXED: 5.1 K ±5%, 1/2 W	3400170
R41	RESISTOR, FIXED: 2.2 K ±5%, 1/2 W	3400161
R42	RESISTOR, FIXED: 100 ohms ±1%, 3 W	3405009
R59	RESISTOR, FIXED: 12 ohms ±10%, 25 W	3402917
R60	RESISTOR, FIXED: 1.2 K ±5%, 5 W	3401673
Sl	SWITCH, TOGGLE, DPST	3660251
VRI	TRANSFORMER, REGULATED, FERROMAGNETIC	6123775

POWER SUPPLY, MODEL RP-33E, PARTS LIST

	POWER SUPPLY, MODEL RP-33E, PARTS LIST	
Ref. Desig.	Description	Part No.
C1	CAPACITOR, FIXED, ELECTROLYTIC: 1000 µf, 25 VDC	3041140
C2-C6	CAPACITOR, FIXED, ELECTROLYTIC: 17,500 µf, 24 VDC	3041084
C7, C8, C15-C24	CAPACITOR, FIXED, ELECTROLYTIC: 17,000 µf, 19 VDC	3040854
C9-C12	CAPACITOR, FIXED, ELECTROLYTIC: 42,000 µf, 15 VDC	3041099
C13, C14	CAPACITOR, FIXED, ELECTROLYTIC: 37,500 µf, 10 VDC	3041073
C25	CAPACITOR, FIXED, ELECTROLYTIC: 500 µf, 25 VDC	3040761
C26, C32, C33	CAPACITOR, FIXED: 0.68 μf, 200 VDC	3041176
C27-C29	CAPACITOR, FIXED: 0.01 µf, 100 VDC	3040716
C30	CAPACITOR, FIXED: 10 µf, 660 VAC	3041023
C31	CAPACITOR, FIXED: 12 µf, 660 VAC	3041024
CB1	CIRCUIT BREAKER: 17 amp	3050254
CB2, CB3	CIRCUIT BREAKER: 42 amp	3050255
CR1, CR2, CR6 CR13, CR15	DIODE: Replacement Type 1N4001	3371266
CR3	DIODE: Replacement Type 1N3789B	3371290
CR4, CR5	DIODE: Replacement Type 1N248A	3371246
CR7, CR14	DIODE: Replacement Type 102659A	3370924
CR8, CR9, CR11, CR12	DIODE	3371293
CR10	DIODE: Replacement Type 1N752A	3371092
CR16	DIODE: Replacement Type 1N3028A	0529643
CR17	DIODE: Replacement Type Westinghouse 368B	3371222
DS1	LAMP, INDICATOR, POWER ON:	3220026
	Replacement Type GE-1835	
DS2	LAMP, INDICATOR, DC FAILURE:	3220037
	Replacement Type GE-1813	3220031
Fl	FUSE:	
	20 amp, 125 volt, Replacement Type BAF20 Bussman	3150187
Pl	CONNECTOR, ELECTRIC: Replacement Type Hubbel 3321G	3330141

POWER SUPPLY, MODEL RP-33E, PARTS LIST (Cont)

P	OWER SUPPLY, MODEL RP-33E, PARTS LIST (Cont)	
Ref. Desig.	Description	Part No.
Q1-Q3, Q10-Q12, Q26-Q28	TRANSISTOR: Replacement Type 2N1613	3700072
Q4-Q9, Q14-Q25, Q30-Q41	TRANSISTOR: Replacement Type 2N3235	3700135
Q13, Q29	TRANSISTOR: Replacement Type 2N1483	3700115
Q42	TRANSISTOR: Replacement Type 2N3133	3700144
Rl	RESISTOR, FIXED: 100 ohms ±1%, 2 W	3401096
R2, R19, R44	RESISTOR, FIXED: 25 ohms ±5%, 25W	3402806
R3	RESISTOR, FIXED: 200 ohms ±5%, 2 W	3400831
R4	RESISTOR, FIXED: 2.4K ±5%, 1/2 W	3400162
R5, R6	RESISTOR, FIXED: 1.1 K ±5%, 1/2 W	3400154
R7-R11, R25, R26, R53, R54	RESISTOR, FIXED: 0.2 ohms ±5%, 5 W	3401659
R12, R66	RESISTOR, FIXED: 75 ohms ±5%, 3 W	3405066
R13	RESISTOR, FIXED: 200 ohms ±5%, 1/2 W	3400608
R14, R42, R67	RESISTOR, VARIABLE: 50 ohms, 2 W	3410414
R15, R68	RESISTOR, FIXED: 490 ohms ±1%, 3 W	3405320
R16	RESISTOR, FIXED: 1.2 K ±5%, 5 W	3401673
R17	RESISTOR, FIXED: 10 ohms ±5%, 25 W	3402808
R18	RESISTOR, FIXED: 2 ohms ±10%, 160 W	3404032
R20	RESISTOR, FIXED: 360 ohms ±5%, 1 W	3400614
R21	RESISTOR, FIXED: 7.5 K ±5%, 1/2 W	3400373
R22, R51	RESISTOR, FIXED: 620 ohms ±5%, 1/2 W	3400148
R23	RESISTOR, FIXED: 430 ohms ±5%, 1/2 W	3400144
R24	RESISTOR, FIXED: 300 ohms ±5%, 1/2 W	3400140

POWER SUPPLY, MODEL RP-33E, PARTS LIST (Cont)

Ref.		
Desig.	Description	Part No.
R27	RESISTOR, FIXED: 120 ohms ±5%, 1 W	3400603
R28-R37 R55-R64	RESISTOR, FIXED: 0.2 ohms ±1%, 10 W	3402062
R38	RESISTOR, VARIABLE: 200 ohms ±10%, 1/4 W	3410563
R39	RESISTOR, FIXED: 320 ohms $\pm 1\%$, 1 W	3405520
R40	RESISTOR, FIXED: 750 ohms $\pm 1\%$, 3 W	3405091
R41	RESISTOR, FIXED: 220 ohms ±5%, 3 W	3405193
R43	RESISTOR, FIXED: 350 ohms $\pm 1\%$, 3 W	3405112
R45	RESISTOR, FIXED: l ohm ±5%, 100 W	3403600
R46	RESISTOR, FIXED: 25 ohms ±10%, 10 W	3407212
R47	RESISTOR, FIXED: 100 ohms ±5%, 1 W	3400772
R48	RESISTOR, FIXED: 9.1 K ±5%, 1/2 W	3400176
R49	RESISTOR, FIXED: 2 K ± 5%, 1/2 W	3400160
R 50	RESISTOR, FIXED: 820 ohms ±5%, 1/2 W	3400151
R 52	RESISTOR, FIXED: 180 ohms ± 5%, 2 W	3400830
R65	RESISTOR, FIXED: 3 K ± 5%, 1 W	3400636
R69	RESISTOR, FIXED: 1500 ohms ±1%, 3 W	3405277
R70	RESISTOR, FIXED: 800 ohms ±1%, 3 W	3405276
R71	RESISTOR, FIXED: 470 ohms ±5%, 1/2 W	3400145
R72	RESISTOR, FIXED: 72 ohms ±1%, 7 W	3405345
S1	SWITCH, TOGGLE, DPST	3660031
VRl	TRANSFORMER, REGULATED, FERROMAGNETIC	6113792

VERTICAL RELAY PAC, MODEL RV-30 PARTS LIST

Ref. Desig.	Description	3C Part No.
C1, C2	CAPACITOR, FIXED, PLASTIC: 0.068 µf ±20%, 600 VDC	930 400 007
CRl	DIODE: 1N2069	943 303 001
Kl	RELAY	963 003 001
R1, R2	RESISTOR, FIXED, COMPOSITION: 2.7 ohms ±5%, 1/2 W	932 004 230

ANALOG SWITCH PAC, MODEL SA-30, PARTS LIST

	ANALOG SWITCH PAC, MODEL SA-30, PARTS LIST	
Ref. Desig.	Description	3C Part No.
C1-C6	CAPACITOR, FIXED, MICA DIELECTRIC: 220 pf ±5%, 100 VDC	930 011 135
C7, C8	CAPACITOR, FIXED, ELECTROLYTIC: 10 μf, 25 VDC	930 220 408
C9	CAPACITOR, FIXED, TANTALUM: 68 µf ± 20%, 20 VDC	930 216 026
CR1, CR5	DIODE	943 083 001
CR2, CR3	DIODE: Replacement Type 1N816	943 105 001
CR4, CR6	DIODE: Replacement Type 1N695	943 023 001
CR7	DIODE, ZENER: Replacement Type 1N705	943 102 002
Q1, Q2, Q10,Q11	TRANSISTOR: Replacement Type 2N1998	943 558 001
Q3, Q5, Q6, Q12	TRANSISTOR: Replacement Type 2N1605	943 545 001
Q4, Q7-Q9	TRANSISTOR: Replacement Type 3C404A	943 519 002
R1, R2, R4 R15-R17	RESISTOR, FIXED, COMPOSITION: 3.3 K \pm 5%, 1/2 W	932 004 061
R3, R6, R14	RESISTOR, FIXED, COMPOSITION: 2.7 K ±5%, 1/2 W	932 004 059
R5, R19	RESISTOR, FIXED, FILM: 4.64 K ±2%, 1/2 W	932 103 233
R7, R8	RESISTOR, FIXED, FILM: 226 ohms ±2%, 1/2 W	932 103 118
R9	RESISTOR, FIXED, FILM: 4.02 K ±2%, 1/2 W	932 103 230
R10, R13	RESISTOR, VARIABLE, WIREWOUND: 1 K ±10%, 1/4 W	933 201 007
R11	RESISTOR, FIXED, COMPOSITION: 4.7 K ±5%, 1/2 W	932 004 065
R12	RESISTOR, FIXED, FILM: $2.05 \text{ K} \pm 2\%$, $1/2 \text{ W}$	932 103 216
R18	RESISTOR, FIXED, FILM: 10 K ±2%, 1/2 W	932 103 301
R20, R21	RESISTOR, FIXED, COMPOSITION: 22 ohms ±5%, 1/2 W	932 004 009
R22	RESISTOR, FIXED, COMPOSITION: 3 ohms ±5%, 1/2 W	932 004 231

4/15/64 4-95/4-96

SOLENOID DRIVER PAC, MODEL SD-30, PARTS LIST

<u></u>	SOLENOID DRIVER PAC, MODEL SD-30, PARTS LIST	
Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 131
C2	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC; Pyramid Type 107; Cornell-Dubilier Type WMF	930 301 015
CR1, CR2	DIODE: Replacement Type 1N276	943 023 001
CR3, CR4	DIODE: Replacement Type 1N816	943 105 001
CR5	DIODE: Replacement Type 1N2069	943 303 001
Q1	TRANSISTOR: Replacement Type 2N1301	943 535 002
Q2	TRANSISTOR, POWER: Replacement Type CTP-1732	943 522 001
Rl	RESISTOR, FIXED, FILM: 4.02 K ±2%, 1/2 W	932 103 230
R2	RESISTOR, FIXED, COMPOSITION: 390 ohms ±5%, 2 W	932 006 039
R3, R5	RESISTOR, FIXED, FILM: 1.4 K ±2%, 1/2 W	932 103 208
R4	RESISTOR, FIXED, FILM: 15.4 K ±2%, 1/2 W	932 103 310
R6	RESISTOR, FIXED, COMPOSITION: 10 ohms ±5%, 1 W	932 005 001

STORAGE-INDICATOR PAC, MODEL SI-30, PARTS LIST

	STORAGE-INDICATOR PAC, MODEL SI-30, PARTS LIST	
Ref. Desig.	Description	3C Part No.
C1A-C1D, C2A-C2D	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.033 µf ±20%, 200 VDC	930 300 019
C4	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
CR1A-CR1D, CR2A-CR2D, CR5A-CR5D, CR6A-CR6D, CR7A-CR7D, CR8A-CR8D, CR9	DIODE	943 ∪03 001
CR3A-CR3D, CR4A-CR4D	DIODE: Replacement Type 1N816	943 105 001
DS1-DS10	LAMP, NEON	945 008 002
DS11-DS20	LAMP, NEON	945 008 001
Q1A-Q1D, Q2A-Q2D	TRANSISTOR	943 508 001
R1-R5	RESISTOR, FIXED, FILM: 121 K ±2%, 1/2 W	932 103 405
R6, R8	RESISTOR, FIXED, FILM: 205 K ±2%, 1/2 W	932 103 416
R7A-R7D, R9A-R9D, R10A-R10D, R11A-R11D, R19-R28	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/2 W	932 004 089
R12A-R12D, R13A-R13D	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1/2 W	932 004 082
R14A-R14D, R15A-R15D	RESISTOR, FIXED, FILM: 3.32 K±2%, 1/2 W	932 103 226
R16A-R16D, R17A-R17D	RESISTOR, FIXED, COMPOSITION: 82 K ±5%, 1/2 W	932 004 095
R18	RESISTOR, FIXED, COMPOSITION: 130 K ±5%, 1/2 W	932 004 100

SYSTEM NORMALIZER, MODEL SN-30, PARTS LIST

SISTEM NORMALIZER, MODEL SN-30, PARTS LIST	
Description	3C Part No.
CAPACITOR, FIXED, ELECTROLYTIC: 200 µf, 15 VDC; Sprague Type 30D174A1	930 220 317
DIODE: Replacement Type 1N695	943 023 001
RELAY: Replacement Type CLAREED CR2 1056	963 002 001
RESISTOR, FIXED, COMPOSITION: 390 ohms ±5%, 1/2 W	932 004 039
RESISTOR, FIXED, COMPOSITION: 300 ohms ±5%, 1 W	932 005 036
RESISTOR, FIXED, COMPOSITION: 560 ohms ±5%, 1 W	932 005 043
	Description CAPACITOR, FIXED, ELECTROLYTIC: 200 µf, 15 VDC; Sprague Type 30D174A1 DIODE: Replacement Type 1N695 RELAY: Replacement Type CLAREED CR2 1056 RESISTOR, FIXED, COMPOSITION: 390 ohms ±5%, 1/2 W RESISTOR, FIXED, COMPOSITION: 300 ohms ±5%, 1 W RESISTOR, FIXED, COMPOSITION:

STORAGE-CONVERTER PAC, MODEL SP-30, PARTS LIST

	STORAGE-CONVERTER PAC, MODEL SP-30, PARTS LIST	L
Ref. Desig.	Description	3C Part No.
C1A-C1D, C2A-C2D	CAPACITOR, FIXED, MICA DIELECTRIC: 150 pf ±5%, 100 VDC	930 011 131
C3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.033 µf ±20%, 200 VDC	930 300 019
C4	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC	930 301 015
CR1, CR3, CR2A-CR2D, CR4A-CR4D, CR6A-CR6D, CR7A-CR7D, CR9A-CR9D, CR10A-CR10D, CR11, CR12-CR17	DIODE	943 003 001
CR5A-CR5D, CR8A-CR8D	DIODE: Replacement Type 1N816	943 105 001
Q1A-Q1D, Q2A-Q2D	TRANSISTOR	943 508 001
R1, R4	RESISTOR, FIXED, FILM: 205 K $\pm 2\%$, 1/2 W	932 103 416
R2A-R2D, R6A-R6D, R7A-R7D, R8A-R8D, R16-R25	RESISTOR, FIXED, COMPOSITION: 47 K $\pm 5\%$, 1/2 W	932 004 089
R3A-R3D, R5A-R5D	RESISTOR, FIXED, COMPOSITION: 220 K±5%, 1/2 W	932 004 105
R9A-R9D, R10A-R10D	RESISTOR, FIXED, COMPOSITION: 24 K ±5%, 1/2 W	932 004 082
R11A-R11D, R12A-R12D	RESISTOR, FIXED, FILM: 3.32 K ±2%, 1/2 W	932 103 226
R13A-R13D, R14A-R14D	RESISTOR, FIXED, COMPOSITION: 82 K ±5%, 1/2 W	932 004 095
R15	RESISTOR, FIXED, COMPOSITION: 130 K±5%, 1/2 W	932 004 100

SCHMITT TRIGGER, MODEL ST-30, PARTS LIST

SCHMITT TRIGGER, MODEL ST-30, PARTS LIST		
Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, MICA DIELECTRIC: 1000 pf ±10%, 100 VDC; Elmenco Type DM-16	930 006 053
C 3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.01 µf ±10%, 100 VDC; Pyramid Type 107; Cornell-Dubilier Type WMF	930 301 109
C4	CAPACITOR, FIXED, MICA DIELECTRIC: 1000 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 053
C5,C6	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC; Pyramid Type 107; Cornell-Dubilier Type WMF	930 301 015
CR1	DIODE, ZENER: Replacement Type 1N706	943 102 001
CR2, CR3	DIODE: Replacement Type 1N276	943 023 001
Q1-Q3	TRANSISTOR: Replacement Type 2N1301	943 535 002
Q4,Q5	TRANSISTOR: Replacement Type 2N404	943 519 001
Rl	RESISTOR, FIXED, COMPOSITION: 510 ohms ±5%, 1/2 W	932 004 042
R2, R22	RESISTOR, FIXED, COMPOSITION: 5.1 K ±5%, 1/2 W	932 004 066
R3	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/2 W	932 004 089
R4	RESISTOR, FIXED, FILM: 1.1 K ±2%, 1/2 W	932 103 203
R5, R15	RESISTOR, FIXED, FILM: 1.96 K ±2%, 1/2 W	932 103 215
R6, R20	RESISTOR, FIXED, FILM: 1.87 K ±2%, 1/2 W	932 103 214
R7	RESISTOR, VARIABLE, COMPOSITION: 100 ohms ±20%, 1/4 W	933 003 001
R8	RESISTOR, FIXED, COMPOSITION: 100 ohms ±5%, 1/2 W	932 004 025
R9	RESISTOR, FIXED, COMPOSITION: 330 ohms ±5%, 1/2 W	932 004 037
R10	RESISTOR, FIXED, COMPOSITION: 560 ohms ±5%, 1/2 W	932 004 043
Rll	RESISTOR, FIXED, FILM: 2.87 K ±2%, 1/2 W	932 103 223
R12, R14	RESISTOR, FIXED, FILM: 4.02 K ±2%, 1/2 W	932 103 230
R13	RESISTOR, FIXED, FILM: 1.0 K ±2%, 1/2 W	932 103 201
R16	RESISTOR, FIXED, FILM: 2.26 K ±2%, 1/2 W	932 103 218

SCHMITT TRIGGER, MODEL ST-30, PARTS LIST (Cont)

Ref. Desig.	Description	3C Part No.
R17	RESISTOR, FIXED, COMPOSITION: 620 ohms ±5%, 1/2 W	932 004 044
R18	RESISTOR, VARIABLE, COMPOSITION: 1 K ±20%, 1/4 W	933 003 004
R19	RESISTOR, FIXED, COMPOSITION: $2 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 056
R21	RESISTOR, FIXED, COMPOSITION: 51 ohms ±5%, 1/2 W	932 004 018
R23	RESISTOR, FIXED, COMPOSITION: 8.2 K ±5%, 1/2 W	932 004 071
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SCHMITT TRIGGER, MODEL ST-35, PARTS LIST

Ref.	Dogoristics	2C David No
Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, MICA DIELECTRIC: 1000 pf ±10%, 100 VDC; Elmenco Type DM-16	930 006 053
C3	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.01 µf ±10%, 100 VDC; Pyramid Type 107; Cornell-Dbuilier Type WMF	930 301 109
C4	CAPACITOR, FIXED, MICA DIELECTRIC: 1000 pf ±10%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 053
C5, C6	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.068 µf ±20%, 100 VDC; Pyramid Type 107; Cornell-Dubilier Type WMF	930 301 015
CR1	DIODE, ZENER: Replacement Type 1N706	943 102 001
CR2, CR3	DIODE: Replacement Type 1N276	943 023 001
Q1-Q3	TRANSISTOR: Replacement Type 2N965	943 543 004
Q4, Q5	TRANSISTOR: Replacement Type 2N404	943 519 001
R1	RESISTOR, FIXED, COMPOSITION: 510 ohms ±5%, 1/2 W	932 004 042
R2, R22	RESISTOR, FIXED, COMPOSITION: 5.1 K ±5%, 1/2 W	932 004 066
R3	RESISTOR, FIXED, COMPOSITION: 47 K ±5%, 1/2 W	932 004 089
R4	RESISTOR, FIXED, FILM: 1.1 K ±2%, 1/2 W	932 103 203
R5, R15	RESISTOR, FIXED, FILM: 1.96 K ±2%, 1/2 W	932 103 215
R6, R20	RESISTOR, FIXED, FILM: 1.87 K ±2%, 1/2 W	932 103 214
R7	RESISTOR, VARIABLE, COMPOSITION: 100 ohms ±20%, 1/4 W	933 003 001
R8	RESISTOR, FIXED, COMPOSITION: 100 ohms ±5%, 1/2 W	932 004 025
R9	RESISTOR, FIXED, COMPOSITION: 330 ohms ±5%, 1/2 W	932 004 037
R10	RESISTOR, FIXED, COMPOSITION: 560 ohms ±5%, 1/2 W	932 004 043
R11	RESISTOR, FIXED, FILM: 2.87 K ±2%, 1/2 W	932 103 223
R12, R14	RESISTOR, FIXED, FILM: 4.02 K ±2%, 1/2 W	932 103 230
R13	RESISTOR, FIXED, FILM: 1.0 K ±2%, 1/2 W	932 103 201
R16	RESISTOR, FIXED, FILM: 1.62 K ±2%, 1/2 W	932 103 211

SCHMITT TRIGGER, MODEL ST-35, PARTS LIST (Cont)

Ref. Desig.	Description	3C Part No.
R17	RESISTOR, FIXED, COMPOSITION: 620 ohms ±5%, 1/2 W	932 004 044
R18	RESISTOR, VARIABLE, COMPOSITION: 1 K $\pm 20\%$, 1/4 W	933 003 004
R19	RESISTOR, FIXED, COMPOSITION: $2 \text{ K} \pm 5\%$, $1/2 \text{ W}$	932 004 056
R21	RESISTOR, FIXED, COMPOSITION: 51 ohms ±5%, 1/2 W	932 004 018
R23	RESISTOR, FIXED, COMPOSITION: 8.2 K ±5%, 1/2 W	932 004 071

TIMING DISTRIBUTOR PAC, MODEL TD-30, PARTS LIST

Ref.		
Desig.	Description	3C Part No.
Cl	CAPACITOR, FIXED, MICA DIELECTRIC: 390 pf ±5%, 100 VDC; Elmenco Type DM-15; Cornell-Dubilier Type CD-15	930 011 142
C2, C61	CAPACITOR, FIXED, ELECTROLYTIC, TANTALUM: 0.1 \muf \pm 20\%, 35 VDC; Sprague 150D	930 217 009
C3, C60	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 µf ±20%, 200 VDC; Sprague Type 192P	930 306 129
C4-C59	CAPACITOR, FIXED, MICA DIELECTRIC: 750 pf ±2%, 100 VDC; Elmenco Type DM-15	930 001 001
CR1-CR7, CR10, CR14-CR17	DIODE: Replacement Type 1N276	943 023 001
CR8, CR9, CR12, CR13	DIODE: Replacement Type 1N816	943 105 001
DL1, DL2, DL3, DL4	COIL, DELAY LINE	991 005 001
Q1,Q2	TRANSISTOR: Replacement Type 2N1499A	943 552 001
Q3A-Q3F	TRANSISTOR: Replacement Type 2N1754	943 532 002
R1,R2	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/2 W	932 004 069
R3	RESISTOR, FIXED, COMPOSITION: 43 K ±5%, 1/2 W	932 004 088
R4,R6	RESISTOR, FIXED, COMPOSITION: 1.5 K ±5%, 1/2 W	932 004 053
R5	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/2 W	932 004 073
R8	RESISTOR, FIXED, COMPOSITION: 82 ohms ±5%, 1/2 W	932 004 023
R9	RESISTOR, FIXED, COMPOSITION: 240 ohms ±5%, 1 W	932 005 034
R10	RESISTOR, FIXED, COMPOSITION: 91 ohms ±5%, 1/2 W	932 004 024
RllA-RllF	RESISTOR, FIXED, COMPOSITION: 7.5 K ±5%, 1/2 W	932 004 070
R12A-R12F	RESISTOR, FIXED, COMPOSITION: 2.2 K ±5%, 1/2 W	932 004 057
R13	RESISTOR, FIXED, COMPOSITION: 680 ohms ±5%, 1/2 W	932 004 045
R14	RESISTOR, FIXED, COMPOSITION: 5.6 K ±5%, 1/2 W	932 004 067
Tl	TRANSFORMER, PULSE	938 009 003
L		

1/12/66

TIMING DISTRIBUTOR PAC, MODEL TD-32, PARTS LIST

Ref. Desig.	Description	3C Part No.
C1	CAPACITOR, FIXED, MICA DIELECTRIC: 62 pf ±5%, 100 VDC	930 011 122
C2,C3,C4	CAPACITOR, FIXED, MICA DIELECTRIC: 43 pf ±5%, 100 VDC	930 011 116
C5	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 0.1 \mu f \pm 20%, 25 VDC	930 171 007
C6-C61	CAPACITOR, FIXED, MICA DIELECTRIC: 750 pf ±2%, 100 VDC	930 001 001
C62,C63	CAPACITOR, FIXED, PLASTIC DIELECTRIC: 0.1 \mu f \pm 20\%, 35 VDC	930 217 009
CR1-CR6, CR10-CR13, CR15,CR16, CR18-CR20, CR23A-CR23F, CR25A-CR25F	DIODE: Replacement Type 1N695	943 023 001
CR7,CR9	DIODE	943 083 001
CR8	DIODE: Replacement Type 1N702A	943 102 004
CR14, CR17, CR19, CR21, CR22	DIODE: Replacement Type 1N816	943 105 001
DL1-DL4	COIL, DELAY LINE	991 005 001
Q1-Q7A-Q7F	TRANSISTOR: Replacement Type 2N965	943 543 004
R1,R12	RESISTOR, FIXED, COMPOSITION: 10 K ±5%, 1/4 W	932 007 073
R2,R11	RESISTOR, FIXED, COMPOSITION: 2.2 K ±5%, 1/4 W	932 007 057
R3,R6	RESISTOR, FIXED, COMPOSITION: 1.6 K ±5%, 1/2 W	932 004 054
R4,R5,R16,R18	RESISTOR, FIXED, COMPOSITION: 6.8 K ±5%, 1/4 W	932 007 069
R7	RESISTOR, FIXED, COMPOSITION: 3.9 K ±5%, 1/4 W	932 007 063
R8,R9,R19	RESISTOR, FIXED, COMPOSITION: 1.6 K ±5%, 1/4 W	932 007 054
R10,R20	RESISTOR, FIXED, COMPOSITION: 15 K $\pm 5\%$, 1/4 W	932 007 077
R13	RESISTOR, FIXED, COMPOSITION: 2.7 K ±5%, 1/2 W	932 004 059
R14	RESISTOR, FIXED, COMPOSITION: 47 ohms ±5%, 1/2 W	932 004 017
R15	RESISTOR, FIXED, COMPOSITION: 220 ohms ±5%, 1 W	932 005 033
R17	RESISTOR, FIXED, COMPOSITION: 20 K ±5%, 1/4 W	932 007 080

TIMING DISTRIBUTOR PAC, MODEL TD-32, PARTS LIST (Cont)

Ref. Desig.	Description	3C Part No.
R21	RESISTOR, FIXED, COMPOSITION: 1 K ±5%, 1/4 W	932 007 049
R22	RESISTOR, FIXED, COMPOSITION: 91 ohms ±5%, 1/4 W	932 007 024
R23A-R23F	RESISTOR, FIXED, COMPOSITION: 7.5 K ±5%, 1/4 W	932 007 070
R24A-R24F	RESISTOR, FIXED, COMPOSITION: 2.2 K ±5%, 1/2 W	932 004 057

The information contained in Section V is furnished only to suggest possible uses of 3C S-PACs. This information should not be used to replace customer engineering or without proper reference to the individual PAC specifications and to other information contained in this manual. In all cases, the aforementioned specifications govern and take precedence over the Application Notes.

SECTION V

S-PAC LOGIC AND APPLICATIONS

5-1 INTRODUCTION

The entire line of S-PAC modules has been designed around one basic circuit. This circuit consists of a diode gating structure followed by an inverting transistor amplifier. The operation of the circuit is such that if <u>any</u> input is zero volts, the transistor is nonconducting and the output is -6 volts; conversely, if all the inputs are -6 volts, the transistor is saturated and the output is zero volts.

Thus, for positive logic (i. e., where 0 volts = TRUE and -6 volts = FALSE), this circuit performs the NOR (not OR) function; for negative logic (i. e., where -6 volts = TRUE and 0 volts = FALSE) it performs the NAND (not AND) function. * If $X_1, X_2, X_3, \ldots X_n$ are the inputs and Y is the output, then

NOR function,
$$Y = \overline{X_1 + X_2 + X_3 \dots + X_n}$$

NAND function, $Y = \overline{X_1 \dots X_2 \dots X_n}$

Although the basic S-PAC logic circuit can serve as either a NOR or NAND function, the following discussion will deal with the NAND function applications.

There are two fundamental approaches to logical design with S-PACs. The first is a method of synthesizing NAND logical networks directly from Boolean expressions. The second is a method of converting the familiar AND-OR logic block diagram to a NAND equivalent. Either or both of these design techniques are useful in various system applications of using S-PACs. Section 6.0 is devoted entirely to S-PAC applications. Examples are presented of Forward-Backward Counters, Parity Generators, Gray-to-Binary Converters, Serial Adders, Parallel Accumulators, and many others.

5-2 LOGIC DESIGN WITH THE NAND FUNCTION

5-2. l Relationship of the NAND function to AND-OR-NOT Functions

Digital computing and control operations are usually designed by deriving the logical equations which describe the operation using the AND-OR-NOT functions and then implementing these equations with practical circuits or standard building blocks such as the S-PAC NAND circuit. The block diagram of the NAND circuit is shown in figure 5-1.

5/11/62 5-1

^{*}The NOR and NAND functions are directly equivalent to the Peirce function and Sheffer Stroke, respectively. See Appendix A.

⁺Refer 3C T-PAC Instruction Manual.

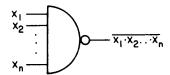


Figure 5-1. NAND Circuit Block Diagram

The AND, OR and NOT functions are implemented as follows:

NOT Function

A device which performs the NOT function must produce as an output the negation, or opposite value of its input. Thus, a TRUE (-6 volts) input signal is changed to a FALSE (0 volts) signal; and a FALSE input is changed to a TRUE signal. A single NAND circuit performs this function. (figure 5-2).

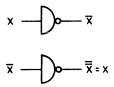


Figure 5-2. NOT Function

OR Function

A device which performs the OR function must have a TRUE output when <u>any</u> of its inputs are TRUE; and a FALSE output when <u>all</u> of its inputs are FALSE. To accomplish the OR function with NAND circuits, each signal is first inverted and then applied to a NAND circuit. Thus, a NAND circuit performs the OR function if its inputs are the negation of the signals that are to be ORed together. This is illustrated in figure 5-3.

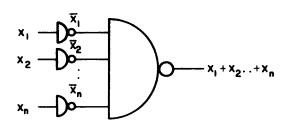


Figure 5-3. OR Function

AND Function

A device which performs the AND function must have a TRUE output when all of its inputs are TRUE, and a FALSE output when any of its inputs are FALSE. By definition,

5-2 5/11/62

the NAND circuit produces the negation of the AND function. A second NAND can be used to remove this negation and thus form the pure AND function as shown in figure 5-4.

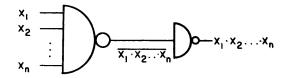


Figure 5-4. AND Function

Because a single NAND stage produces the negation of the AND function and because the OR function requires the negation as inputs, AND-OR logic networks are directly implemented by substitution of the NAND circuit. This logic form is obtained by writing the logical equations in disjunctive form. *

Truth tables and minimization aids such as Veitch charts, are extremely useful in seeking the minimal statements of a given function. **

The logical equation $(A \cdot B) + (\overline{C} \cdot D) + (\overline{C} \cdot F)$ is an example of the disjunctive form. This equation is implemented by using a NAND to perform each of the three AND operations and a fourth NAND for the OR operation. The block diagram of this equation is shown in figure 5-5.

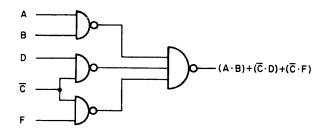


Figure 5-5. Implementing the OR Function

It should be noted that the NAND circuit can be applied to logic statements of any level.

5-2.2 Reduction of Logical Equations to NAND Form

Any logical equation can be reduced to a form that can be directly implemented by the NAND function simply by using logical identities to remove all OR connectives. The result will be a "bar product" Boolean equation. Each "bar" (NOT) in the

5/11/62

^{*}An expression consisting entirely of large terms connected by the symbol + (OR) is known as a disjunction. The terms are called fidisjuncts. "The disjuncts may contain still lesser terms connected by the symbol. (AND).

^{**}Symbolic Logic, Boolean Algebra and Design of Digital Systems, Technical Staff of Computer Control Company, Inc.

equation is equivalent to a NAND function, because the NAND function is a "bar product", $Y = X_1 \cdot X_2 \cdot ...$ etc. In a complex expression, the terms X_1 , X_2 , etc., may be in themselves complex "bar products". An example of this technique is as follows:

to remove the remaining +

Given:
$$f_{1} = (A \cdot B) + \left[\overline{C} \cdot (D + F)\right]$$

$$Using$$

$$DeMorgan's theorem:*
$$f_{1} = (A \cdot B) + (\overline{C} \cdot \overline{D} \cdot \overline{F})$$

$$to remove the + in (D + F)$$

$$Again Using$$

$$DeMorgan's theorem:
$$f_{1} = (\overline{A \cdot B} \cdot \overline{\overline{C} \cdot \overline{D} \cdot \overline{F}})$$$$$$

This equation is of the NAND form:

$$f_1 = \overline{X_1 \cdot X_2}$$
where $X_1 = \overline{A \cdot B}$
and $X_2 = \overline{\overline{C} \cdot \overline{D} \cdot \overline{F}}$

Furthermore, X₂ is of the NAND form:

$$X_{2} = \overline{X_{3} \cdot X_{4}}$$
where
$$X_{3} = \overline{C}$$
and
$$X_{4} = \overline{\overline{D} \cdot \overline{F}}$$

The NAND circuit implementation is therefore one NAND for each bar as shown in figure 5-6.

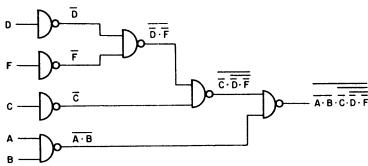


Figure 5-6. Reducing to NAND Form

The NAND that produces \overline{C} , \overline{D} and \overline{F} of course would not be necessary if the negations were available as inputs. This implementation is not the only solution nor necessarily the minimal form. Another approach would be:

- -

^{*}See Appendix A for description of DeMorgan's theorem.

$$f_1 = (A \cdot B) + [\overline{C} \cdot (D + F)]$$

$$f_1 = (A \cdot B) + (\overline{C} \cdot D) + (\overline{C} \cdot F)$$

Expansion by the distributive law.

$$f_1 = \overline{\overline{A \cdot B} \cdot \overline{\overline{C} \cdot D} \cdot \overline{\overline{C} \cdot F}}$$

Removal of three +'s by DeMorgan's theorem.

The resulting NAND implementation shown in figure 5-7 is:

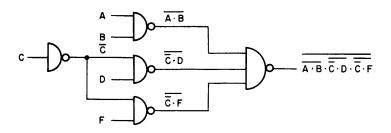


Figure 5-7. Reducing to NAND Form

In some cases it may be necessary to apply the identity $A \equiv \overline{\overline{A}}$ to reduce the equation to bar product form. For example:

Given:
$$f = A \cdot B \cdot (\overline{C} + D + E)$$

Using $f = A \cdot B \cdot \overline{C \cdot \overline{D} \cdot E}$ to remove +'s

DeMorgan's theorem:

Applying $f = A \cdot B \cdot \overline{C \cdot D} \cdot E$ to place bars over entire expression

This NAND implementation is shown in figure 5-8.

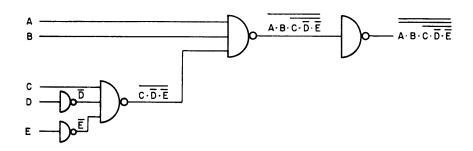


Figure 5-8. Implementing Identity to Reduce Equation to Bar Product

Additional logical equivalents, useful in converting logical equations to the minimal form are contained in the Appendix A.

5/11/62

5-2. 3 Rules for Converting AND and OR Gates to NAND Gates

In many cases the systems designer, when designing a digital system, does not wish to use Boolean algebra, or logical expressions. He simply creastes a logical block diagram using AND and OR gates, flip-flops, etc. The following techniques enable direct conversion of such a design to an S-PAC NAND circuit design.

The NAND circuit in addition to performing the AND operation on input signals and producing an inverted output, also performs the OR operation provided that the inverse of each input's signal is applied. With these facts in mind, consider the following examples.

The AND, OR implementation of the function $(A \cdot B \cdot C) + D$ shown in figure 5-9.

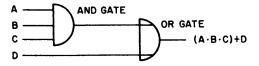


Figure 5-9. AND-OR Implementation

The NAND implementation is shown in figure 5-10.

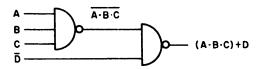


Figure 5-10. NAND Implementation

The negation of D, when applied to the second NAND, implements the OR function. To show on a diagram that the second NAND serves as an OR gate, it can be drawn as shown in figure 5-11.

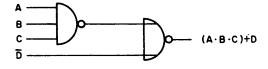


Figure 5-11. NAND Implementation

As another example, the conventional AND, OR implementation of the function $[(A + B) \cdot C] + D$ of figure 5-12.

5-6 5/11/62

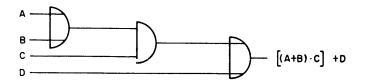


Figure 5-12. Conventional AND - OR

The NAND implementation is shown in figure 5-13.

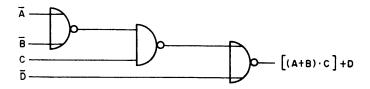


Figure 5-13. NAND Implementation of AND - OR

As a final example, the conventional AND, OR implementation of the function $[(A \cdot B) + C] \cdot D$ is shown in figure 5-14.

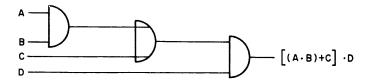


Figure 5-14. Conventional AND - OR

The NAND implementation is shown in figure 5-15.

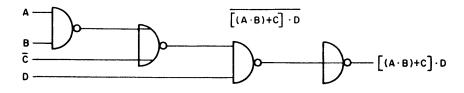


Figure 5-15. NAND Implementation of AND - OR

In this example, the fourth NAND gate simply inverts the output of the third NAND. These examples help to illustrate a set of rules that permit direct substitution of NAND gates for both AND and OR gates.

5/11/62

- 1. A NAND gate (used as an inverter) must be inserted between any AND gate that drives another AND gate and between any OR gates that drives another OR gate.
- 2. All inputs to OR gates that are not from within the logic network must be inverted. (If the negation is not available as an input, a NAND gate can be used to perform the inversion.)
- 3. The last gate should be an OR gate. If not, a NAND gate must be added to obtain the assertion of the function being implemented.

Using these three rules, all AND and OR gates can be replaced with NAND gates.

5-3 SPECIAL FEATURES OF NON-LOGIC S-PACS

In addition to logic elements, the implementation of digital systems requires the use of storage and timing devices such as flip-flops and delay multivibrators. Again, the basic NAND circuit has served in construction of these S-PAC devices.

5-3.1 Basic Flip-Flop

 $\label{eq:two-nand} Two\ NAND\ circuits\ are\ cross-coupled\ to\ form\ a\ basic\ flip-flop\ as\ shown\ in$ figure 5-16.

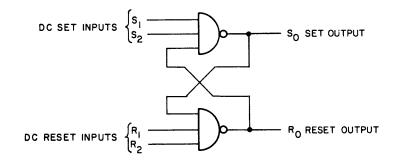


Figure 5-16. Basic Flip-Flop

In any flip-flop circuit the cross-coupling network controls the state of the flip-flop when it is in the static condition. For the static condition of the NAND circuit flip-flop, all DC inputs are normally TRUE (-6 volts) because the flip-flop responds to 0 volt (FALSE) input signals. Thus, assuming the static condition and the Set output is TRUE and all inputs to the Reset NAND are TRUE, then the Reset output must be FALSE (0 volts). This cross-coupled FALSE input to the true Set NAND maintains the Set output, which was the assumed static condition. If any DC Reset input becomes FALSE, the Reset output will become TRUE and remain TRUE when this input returns to -6 volts. If any DC Set input becomes FALSE, the Set output will becomes TRUE and remain TRUE when this input returns to -6 volts If both a Set and a Reset input are FALSE (0 volts), both Set and Reset outputs will be TRUE (-6 volts). This event creates a third output state for the flip-flop in which both outputs are identical (TRUE). The designer may use this condition advantageously if

5-8 5/11/62

he chooses. The final static condition of the flip-flop will depend on which input returns to the TRUE condition last. The NAND flip-flop action, stated logically, follows:

$$S_0 = \overline{S_1 \cdot S_2 \cdot R_0} = \overline{S_1} + \overline{S_2} + \overline{R_0}$$
, is the Set NAND gate equation

and $R_0 = \overline{R_1 \cdot R_2 \cdot S_0}$, is the Reset NAND gate equation by

substitution

$$S_0 = \overline{S_1} + \overline{S_2} + (R_1 \cdot R_2 \cdot S_0)$$

In turn;

$$R_0 = \overline{R_1} + \overline{R_2} + (S_1 \cdot S_2 \cdot R_0)$$

The terms $(R_1 \cdot R_2 \cdot S_0)$ and $(S_1 \cdot S_2 \cdot R_0)$ in these flip-flop equations represent the cross-coupling or feedback connections. The multiple DC Set inputs and DC Reset inputs to S-PAC flip-flops form OR functions. Thus, to set the flip-flops when $(A \cdot B)$ is TRUE, or $(C \cdot D)$ is TRUE, external NAND circuits are used as shown in figure 5-17.

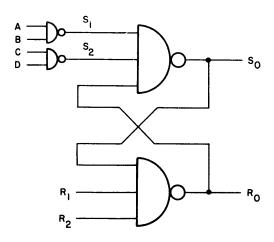


Figure 5-17. Flip-Flop Inputs

5-3.2 AC Coupled Inputs

Complementing, shifting, counting pulse, dodging, etc., are economically implemented with S-PACs by using AC coupled inputs. A typical AC coupled input and accompanying waveforms are shown in figure 5-18.

5/11/62

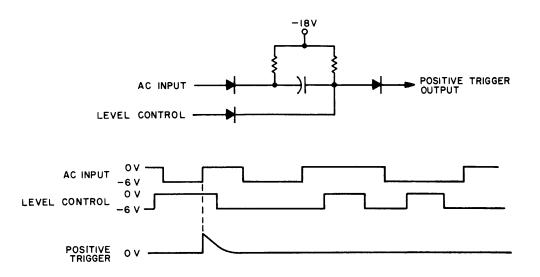


Figure 5-18. Waveforms For AC Coupled Input

All circuits having AC coupled inputs trigger on the positive going edge of the input waveform. Therefore, to pulse-dodge (trigger on the trailing edge) the assertion of the input pulse should be applied. Conversely, if a negation is used as an AC input, the circuit triggers on the leading edge. Each AC input has an associated Level Control. The purpose of the Level Control is to form an AND gate with the positive going edge of the AC input waveform. The signal on the AC input leg of this AND gate will decree when the gate shall respond (i.e., when the AC signal positive going edge appears). The signal on the Level Control leg of this AND gate will decree if the gate shall respond at all. The Level Control must be at 0 volt (FALSE) for the positive edge of the AC input to trigger the circuit. The continuation of a typical AC input signal and a level control signal in the foregoing sketch show the various input conditions that might be imposed on this AND gate and its resulting output.

5-3.3 Diode Clusters

Additional flexibility for system implementation using S-PACs can be obtained by adding diode clusters (contained in DN-30 and DC-30 packages) to the AC input and/or level control input. A diode cluster added to the AC input forms a rather unusual gate. All inputs to this cluster first must become TRUE (-6 volts). Then, if any one of the inputs becomes FALSE, a positive trigger pulse is produced. Thus, if the inputs are normally FALSE (0 volt), a trailing edge triggering AND gate is formed; if the inputs are normally TRUE (-6 volts), a leading edge triggering OR gate is formed. A diode cluster added to the Level Control input forms an OR gate, that is, if any input to this cluster is FALSE, the Level Control will be FALSE and therefore activated. An example of the use of diode

5-10 5/11/62

clusters follows:

It is desired to trigger a flip-flop with the trailing edge of timing pulse A when signals B and C are TRUE and when either D, E or F is also TRUE. Logically this can be stated:

$$(A . B . C) . (D + E + F) = trigger to flip-flop$$

This is accomplished by applying A, B and C to a diode cluster that is attached to the AC input and applying \overline{D} , \overline{E} , and \overline{F} to a diode cluster attached to the Level Control input. Diode clusters are also used to expand the available inputs to NAND gates.

5-4 S-PAC SYMBOLS

5-4.1 NAND Gates. The standard NAND gate symbol is shown in figure 5-19.

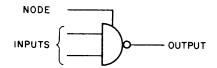


Figure 5-19. NAND Gate Symbol

The node allows the addition of diode clusters for expanding the number of available inputs. Diode clusters are represented by an AND gate symbol and connected to the NAND gate symbol as in figure 5-20.

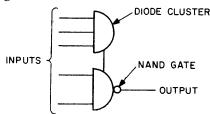


Figure 5-20. NAND Gate with Diode Cluster

Some system designers prefer to construct their logical block diagrams so that the function of AND and OR are easily distinguishable. This is accommodated by drawing the NAND gate symbol differently depending on how it is used. The use of a plus (+) or minus (-) sign in the center of the NAND gate is sometimes used for this purpose. However, with such symbology, the AND and OR functions do not "stand out" on a block diagram. A more easily recognized symbol for the NAND used to implement an OR function is shown in figure 5-21.

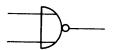


Figure 5-21. OR Function

5/11/62

With this symbol representing the OR function, the standard NAND symbol can represent the AND function. However, as a precautionary note, there is only one basic logic circuit in the S-PAC line. For negative logic (-6 volts = TRUE, 0 volt = FALSE) this circuit performs only the NAND function. Under no conditions can the proposed symbology be considered two different circuits, one for NAND and one for NOR.

 $\,$ A diode cluster added to a NAND gate performing the OR function $\,$ is shown in figure 5-22.

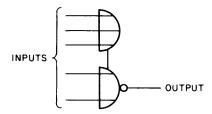


Figure 5-22. OR Function with Diode Clusters

5-5 S-PAC APPLICATIONS

5-5.1 Binary Up-Down Counter. The binary counter shown in figure 5-23 employs a "gated ripple" carry (or borrow). Two gates are provided at each binary stage, for carry propagation and borrow propagation. The input count pulse "ripples" through the carry gates for UP counting or the borrow gates for DOWN counting. Propagation of a carry will continue through the carry gates as long as the preceding stage is set. Propagation of a borrow will continue through the borrow gates as long as the preceding stage is reset. Pulse dodging is achieved by using the complement input of the BC-30 stages which provide trailing edge triggering. Thus, the counter stages do not change state until after the carry or borrow gates have been sensed.

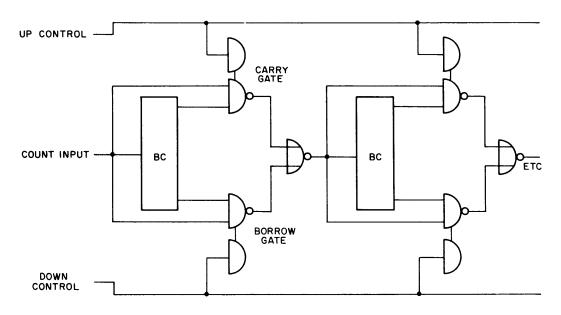


Figure 5-23. Binary Up-Down Counter

5-12

5-5.2 "Equal To" or "Greater Than". The parallel comparator shown in figure 5-24, will determine if two binary numbers $(A_n A_{n-1} \dots A_0 \text{ and } B_n B_{n-1} \dots B_0)$ are equal, and if not, which is greater.

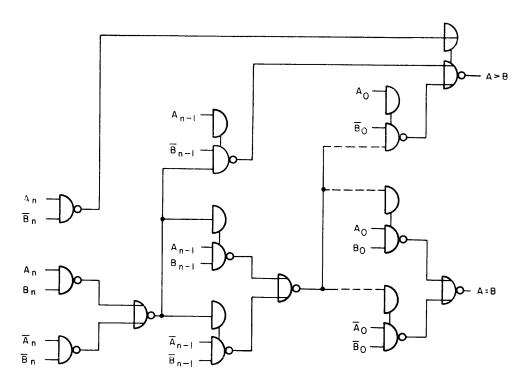


Figure 5-24. Parallel Comparator

A pair of gates sense for equality of the bits at each stage of the two numbers. Starting with the high order bit, if equality exists, the result senses the next pair of equality gates. If the two numbers are equal, the equality signal passes through all stages and indicates complete equality of all bits when the A = B output is ONE (-6 V). In addition, a gate at each stage is used to sense for "greater than". Starting with the high order bit, if A_n is a ONE and B_n is a ZERO then A > B. If not, but A_n is equal to B_n , then the second "greater than" gate is sensed by this equality signal. In the second stage, if A_{n-1} is a ONE and B_{n-1} is a ZERO then A>B, etc. A "greater than" signal is generated at any stage where the A bit is a ONE and the B bit a ZERO providing all preceding high order bits are equal, and the A > B output is ONE.

5-5.3 Parallel Odd Parity Generator (6 Bits, figure 5-25). The Parity Generator shown in figure 5-25 produces an output whenever there is an odd number of ONEs in the 6-bit word. Two steps are used: (1) form two 3-bit odd-even parities for each half of the word; (2) form the final whole word odd parity from the result of each half. The logical equations are:

Low order 3-bit odd parity

$$P_{L} = (A_0 \cdot \overline{A}_1 \cdot \overline{A}_2) + (\overline{A}_0 \cdot A_1 \cdot \overline{A}_2) + (\overline{A}_0 \cdot \overline{A}_1 \cdot A_2) + (A_0 \cdot A_1 \cdot A_2)$$

High order 3-bit odd parity

$$\mathbf{P}_{\mathbf{H}} = (\mathbf{A}_3 \ . \ \overline{\mathbf{A}}_4 \ . \ \overline{\mathbf{A}}_5) + (\overline{\mathbf{A}}_3 \mathbf{A}_4 \overline{\mathbf{A}}_5) + (\overline{\mathbf{A}}_3 \overline{\mathbf{A}}_4 \mathbf{A}_5) + (\mathbf{A}_3 \mathbf{A}_4 \mathbf{A}_5)$$

6-bit odd parity = $(P_L \cdot \overline{P}_H) + (P_H \cdot \overline{P}_L)$

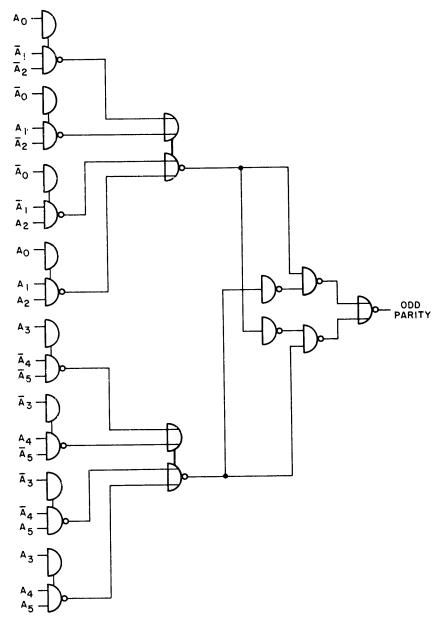


Figure 5-25. Odd Parity Generator

5-5.4 Serial Adder (figure 5-26). The Serial Adder shown in figure 5-26 accepts two binary numbers (low order first) from two shift registers, performs an addition, and delivers the sum to a result shift register. The logical equation for the sum is:

Sum =
$$(A \cdot \overline{B} \cdot \overline{C})+(\overline{A} \cdot B \cdot \overline{C})+(\overline{A} \cdot \overline{B} \cdot C)+(A \cdot B \cdot C)$$

Where A - Augend

B = Addend

C = Carry from previous lower order addition

This sum equation is implemented directly with NAND gates and the output applied to the level control inputs of the result shift register. Each shift pulse transfers the sum into the result register and advances the addend and augend registers and a new sum is generated.

The logical equation for the carry is as follows:

$$Carry = (A . B)+(B . C)+(C . A)$$

The carry equation is implemented directly with NAND gates, and the output is applied to the level control inputs of a shift register stage which effectively delays the carry one bit time. The output of this shift register stage is the carry from the previous bit addition.

An alternate carry generator employs a complementing flip-flop (BC-30). The logic of this carry generator can be stated as "Complement the carry flip-flop whenever the present carry differs from the previous carry." The logical equation is:

Complement when
$$(A . B . \overline{C}) + (\overline{A} . \overline{B} . C)$$

Shift pulses are used to time the NAND implementation of the complement equation and trailing edge triggering, at the complement input to the flip-flop, provides an effective one bit delay.

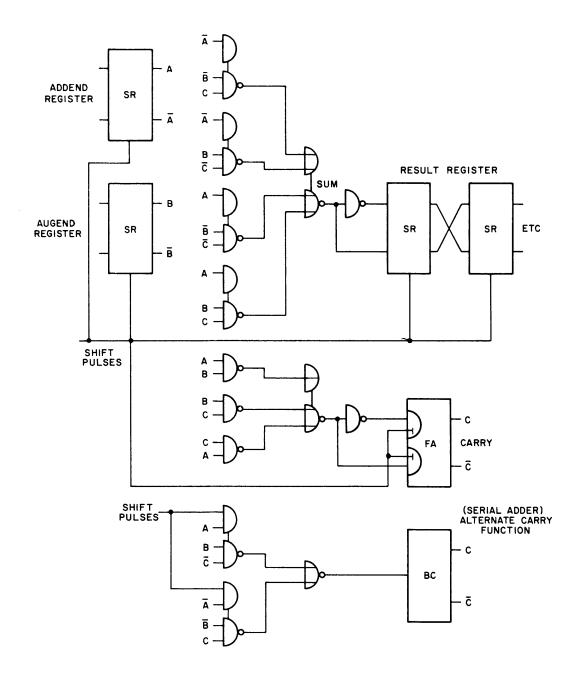


Figure 5-26. Serial Adder

5-5.5 Parallel Gray Code to Binary Converter (figure 5-27). Gray code is a reflected code in which only one bit changes value every time the number is increased one unit. The following table shows the Binary code and its equivalent Gray code.

Table 5-1. Binary-Gray Codes

В2	В	В ₀	G ₂	G ₁	G ₀
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	1
0	1	1	0	1	0
1	0	0	1	1	0
1	0	1	1	1	1
1	1	0	1	0	1
l	1	1	1	0	0

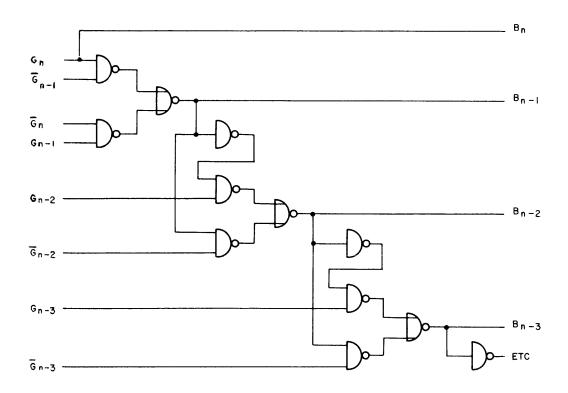
Let:

$$B_n = n^{th}$$
 Binary Bit
 $G_n = n^{th}$ Gray Code Bit

The highest order Binary bit is equal to the highest order Gray code bit. All succeeding lower order Binary bits are expressed logically as:

$$B_{n-1} = (\overline{B}_n \cdot G_{n-1}) + (B_n \cdot \overline{G}_{n-1})$$

This is the expression for an exclusive OR function. The NAND gate implementation of the exclusive OR is used to implement the Gray-to-Binary Converter.



BASIC NETWORK IS EXCLUSIVE OR

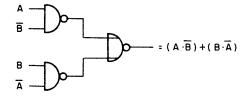


Figure 5-27. Gray-To-Binary Converter

5-5.6 "Greater Than" or "Less Than" (figure 5-28). The parallel comparator shown in figure 5-28 determines if two numbers $(A_n A_{n-1} \dots A_o \text{ and } B_n B_{n-1} \dots B_o)$ are unequal, and if so which is the greater. Two gates at each stage determine if the A bit is greater than or less than the B bit. The final "greater than" output is produced if at any stage the A bit is a ONE, the B bit is a ZERO and all higher order stages were not "less than". Similarly, the final "less than" output is produced if at any stage the A bit is a ZERO and the B bit is a ONE and all higher order stages were not "greater than".

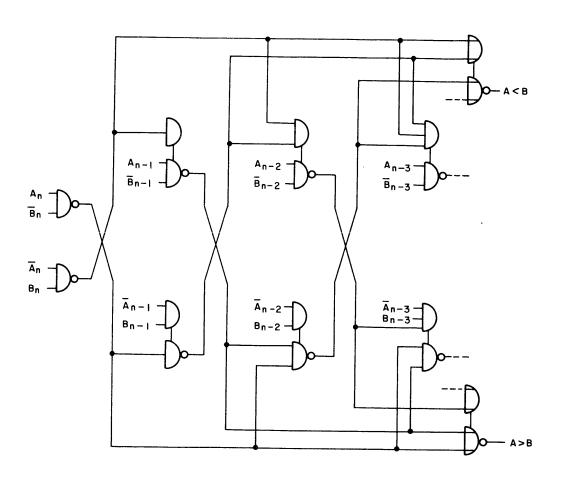


Figure 5-28. Parallel Comparator

The loading on the high order comparator gates will be at a maximum for a seven bit comparator. Larger comparators can be implemented by adding an inverter to the "greater than" and "less than" outputs and starting over with the second stage of the illustrated logical network.

5-5.7 Shift Register With Right and Left Shift. The universal flip-flop (UF-30) can be used to form a shift register as shown in figure 5-29 that will shift either to the right or to the left. This is made possible by the multiple ac coupled inputs on each universal flip-flop. As shown in the diagram below, one set of ac inputs is connected to the shift right buss with the associated level controls attached to the outputs of the preceding stage;

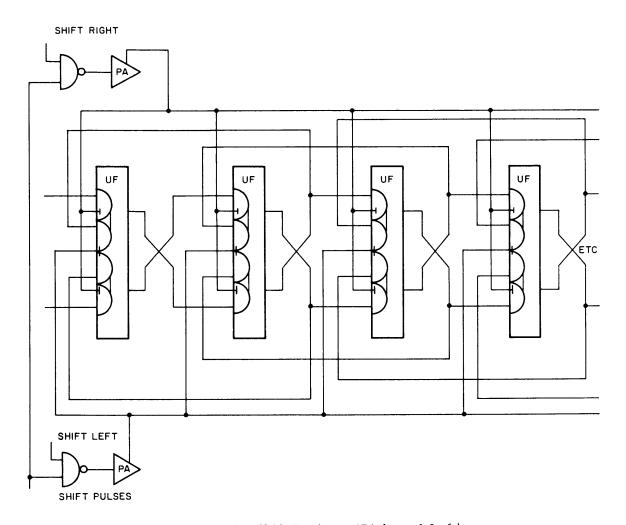


Figure 5-29. Shift Register (Right and Left)

the common ac input is connected to the shift left buss with the associated level controls attached to the outputs of the following stage.

Information can be entered in parallel through the dc inputs, or in serial from either end. The dc reset inputs can serve to clear the register.

5-5.8 Parallel Input Accumulator. A parallel input accumulator for binary numbers is constructed as shown in figure 5-30. The ac inputs on the universal flip-flop (UF-30) are connected to provide dual complement inputs. One complement input receives the parallel input. The other complement input receives the carry when generated by the previous stage.

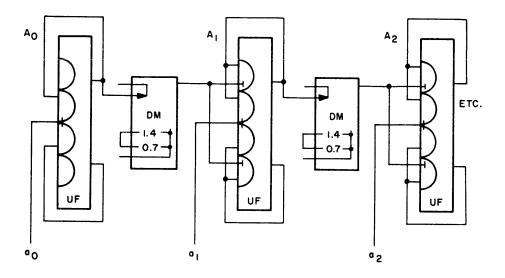


Figure 5-30. Parallel Input Accumulator

A delay multivibrator (DM-30), inserted in the carry line between each stage, allows the flip-flop to respond completely to the parallel input before applying the carry. The maximum accumulation rate is determined by the carry propagation delay. With the DM-30 wired for 2 μ sec delay, the time between inputs must be \geq 2.2n microseconds (n = number of bits in input binary number).

- 5-5.9 Binary Count/Shift Register. The illustration of figure 5-31 depicts a register that will both binary count and shift. The multiple ac inputs on the universal flip-flop serve to perform these functions. One set of ac inputs is connected to the shift buss and the associated level controls are attached to the outputs of the preceding stage. The common ac input is connected as a complement input by attaching the associated level controls to the outputs of the same stage. A gate counter is formed by the following connections:
 - 1. The count pulses are fed directly to the first stage common ac input.
 - 2. A diode cluster, added to the second stage common ac input, forms an AND gate for the count pulses and the Set output of the first stage.
 - 3. A diode cluster, added to the third stage common ac input, forms an AND gate for the count pulses and the Set output of both the first and second stages.

4. The count pulses and the Set output of the first, second, and third stages are connected to a NAND gate, and inverted by a second NAND gate, to form the carry into the fourth stage and count pulses for succeeding stages. NAND gates are used instead of another diode cluster to limit the loading on the output of the first stage.

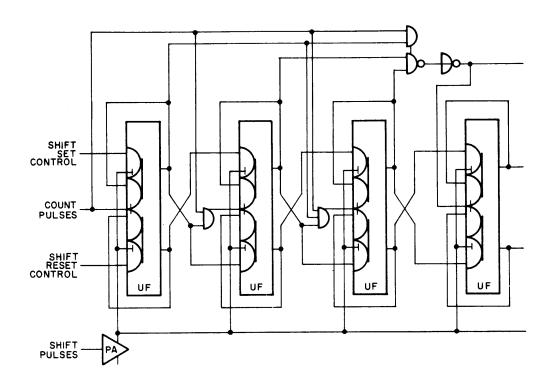


Figure 5-31. Binary Counter-Shift Register

5-5.10 Up-Down BCD Counter. The Up-Down BCD Counter shown in figure 5-32 operates in a similar manner to the counter described in paragraph 5-5.1. Additional connections are made to the carry and borrow gates to make the counter operate as an 8421 binary coded decimal counter. When counting UP, the transition from 9 (1001) to 0 (0000) is accomplished by preventing the carry from entering the second stage and forcing a carry into the fourth stage. When counting DOWN, the transition from 0 (0000) to 9 (1001) is accomplished by preventing the borrow from entering the second stage and forcing a borrow into the fourth stage.

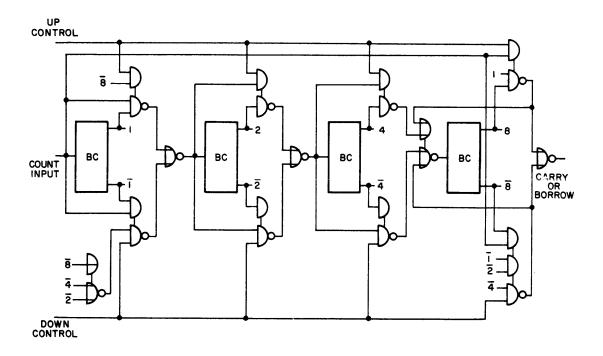


Figure 5-32. Up-Down BCD Counter

5-5.11 <u>Binary Counter with Instantaneous Carry</u>. All stages of the Binary Counter of figure 5-33 are sensed simultaneously by the input count pulses. The carry logic is implemented by diode clusters attached to the complement inputs of a BC-30.

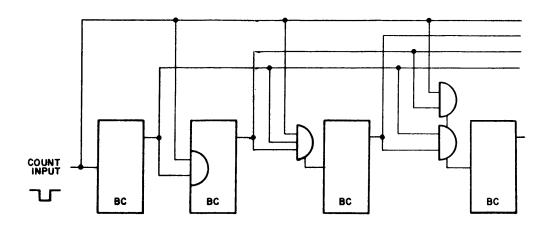


Figure 5-33. Binary Counter

5-5.12 BCD Counter with Instantaneous Carry Within Each Decade. Added diode clusters provide the means for sensing all stages of the BCD Counter (BC-30) of figure 5-34 simultaneously. The decade carry is implemented with NAND gates.

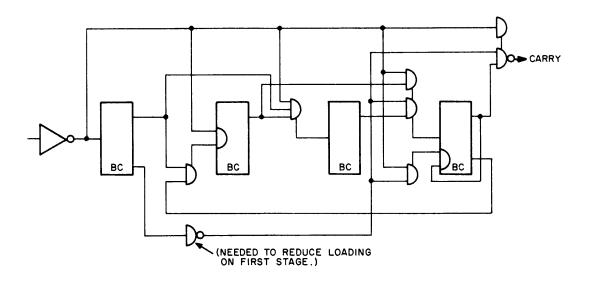


Figure 5-34. BCD Counter

5-5.13 Combined BCD Counter-Shift Register (figure 5-35).

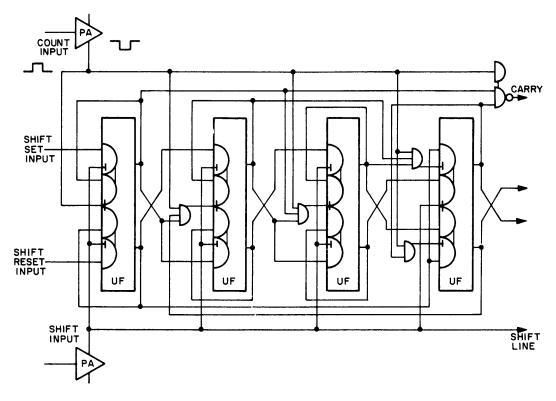


Figure 5-35. BCD Counter-Shift Register

5-5.14 Synchronizer. The trailing edge of the asynchronous input sets flip-flop 1 of figure 5-36. The trailing edge of the first clock pulse that occurs after flip-flop 1 is set, sets flip-flop 2. The next clock pulse is gated by flip-flop 2 to produce the synchronized output. This output resets flip-flop 1; the trailing edge of the second clock pulse resets flip-flop 2; and the synchronizer is ready for the next input.

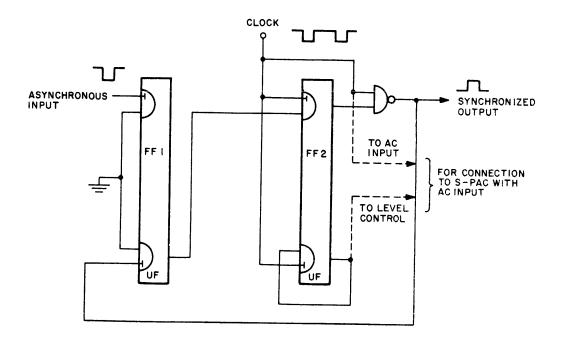


Figure 5-36. Synchronizer Circuit

5-5.15 <u>Binary to BCD Converter (figure 5-37)</u>. "Double-Dabble" method of conversion.

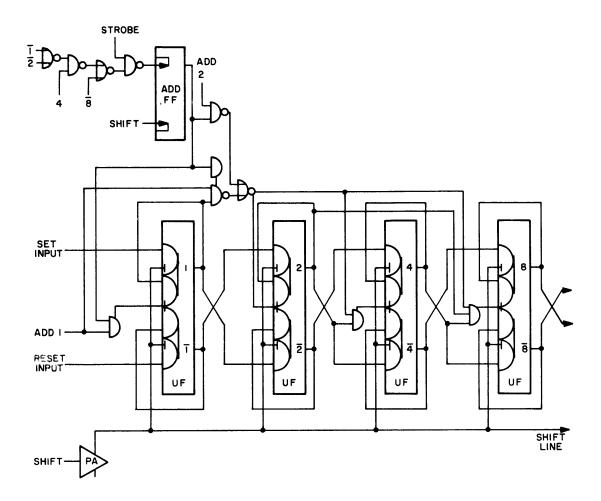


Figure 5-37. Binary to BCD Converter

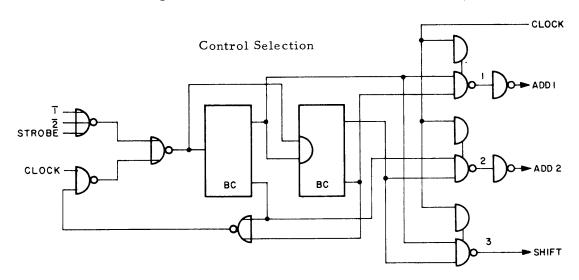


Figure 5-38. Four Bit Shift Register Adder

5-26 5/11/62

SUPPLEMENTARY S-PAC EQUIPMENT

Figures 5-37 and 5-38 present the implementation of a binary-to-BCD converter using S-PACs. Given an N bit pure binary number, the conversion method is as follows:

- 1. Begin with the most significant bit.
- 2. If the next bit is ZERO, double the accumulated sum.
- 3. If the next bit is ONE, double the accumulated sum and add 1.
- 4. Continue this process for all succeeding bits, carrying along the accumulated sum.

The $\overline{1}$ and $\overline{2}$ inputs enable operation at a maximum rate. The properties of binary numbers are such that a number may be doubled or halved simply by shifting one place left or right. A BCD number has the same property, but numbers which are doubled must be adjusted because a radix of ten is imposed. Thus doubling any 4-bit digit which is 5 or greater results in a digit (10 or greater) that is outside the limits of constraint. By adding 6 to any number greater than 9, which results from doubling, a 2-digit number is created within the constrained radix of ten.

A convenient method of implementing the "add 6 correction" is to detect 4-bit digits that are 5 or greater and add 3 to them before doubling. This, in effect, is equivalent to adding 6 to the doubled number, but eliminates the need for carry generation between decades. Doubling and doubling and adding 2 are accomplished automatically by shifting.

The diagram shows a 4-bit shift register adder which may be cascaded, one 4-bit register per BCD digit, to form a code converter. This register inspects its contents, and if the number is 5 or greater, adds 3 to the contents and then shifts.

Each strobe pulse strobes each decade register of the converter to test its contents for a number of 5 or greater. If the number is 5 or greater, the add flip-flop associated with that decade is set. The strobe pulse also turns on the two-stage control counter.

The next three clock pulses are counted by the control counter, and the Add 1, Add 2, and Shift pulses are generated. Each add flip-flop, if set, allows the Add 1 and Add 2 pulses to add a total of 3 counts to their associated decade; then, the entire decade register is shifted.

This converter performs a binary to BCD conversion at a maximum rate of $4\,\mu \rm sec$ per binary bit. The control logic illustrated in the above diagram is for synchronous clock operation and requires the strobe pulse to be in synchronism with the clock. For asynchronous operation, the strobe pulse can be connected to a series of Delay Multivibrators (DM-30 or DS-30) that provide the sequential Add 1, Add 2, and Shift commands.

5-5.16 BCD Backward Counter. To implement the BCD backward counter of figure 5-39, the set and reset functions of the BC-30 are inverted (i.e., the common reset becomes a common set, etc.). Normal borrows between stages are connected as in a binary backward counter. After the count of zero is reached, the second stage borrow input is inhibited and a set input to the fourth stage is conditioned so that the next count

input sets the first stage to a ONE, prevents a borrow from changing the state of the second stage, and a borrow from the first stage sets the fourth stage to a ONE. Thus, the counter changes from zero (0000) to nine (1001).

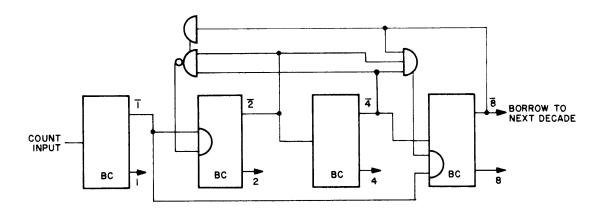


Figure 5-39. BCD Backward Counter

The BC-30 common reset input, when used in this application, conditions the counter to all ONEs. Parallel drop-in of information can be accomplished by entering the "complement" of the desired count. This is desirable in that no borrows are produced during parallel drop-in.

SUPPLEMENTARY S-PAC EQUIPMENT

APPENDIX A

DeMORGAN's THEOREM

DeMorgan's theorem states that any Boolean expression is equal to the negation of the expression obtained by changing all conjunctions to disjunctions and the converse of this, and by replacing each variable with its negation. As examples:

 $A+B+C = \overline{A} \cdot \overline{B} \cdot \overline{C}$ $\overline{A+B+C} = \overline{A} \cdot \overline{B} \cdot \overline{C}$ $A \cdot B \cdot C = \overline{A} + \overline{B} + \overline{C}$ $\overline{A \cdot B \cdot C} = \overline{A} + \overline{B} + \overline{C}$

PEIRCE AND SHEFFER STROKE FUNCTIONS

The complete set of Boolean elements that is usually used in the logical design of digital computers consists of AND, OR and NOT. However, a lesser known Peirce function (represented by the symbol "\dagger"), and its dual, the Sheffer Stroke (represented by the symbol"/"), are each complete logical operators and can be used to form all logical Boolean functions.

The Peirce function can be stated as:

 \mathbf{X}_1 $\downarrow \mathbf{X}_2$ is true if both \mathbf{X}_1 and \mathbf{X}_2 are FALSE.

Thus, the Boolean equivalent of $X_1 \downarrow X_2$ is $\overline{X}_1 \cdot \overline{X}_2$. The NOR function, $\overline{X_1 + X}_2$ is directly equivalent (DeMorgan's Theorem) to $\overline{X}_1 \cdot \overline{X}_2$. Therefore, it follows that the Peirce function is the same as the NOR function.

The Sheffer Stroke can be stated as:

 X_1/X_2 is true if either X_1 or X_2 or both are FALSE.

Thus, the Boolean equivalent of X_1/X_2 is $\overline{X}+\overline{X}_2$. The NAND function, $\overline{X_1\cdot X_2}$ is directly equivalent to $\overline{X}_1+\overline{X}_2$. Therefore, the Sheffer Stroke is the same as the NAND function.

LOGICAL EQUIVALENTS

Provided below is a convenient reference list of common logical equivalences. The statements use the symbols:

 $\cdot = AND$

+ = OR

- = NOT

Statements using these symbols are true in the following cases (see the truth table below).

SUPPLEMENTARY S-PAC EQUIPMENT

Table A-1. Truth Table

WHEN A IS	WHEN B IS	A.BIS	A+B IS	A IS	BIS
Т	Т	Т	Т	F	F
Т	F	F	Т	F	Т
F	Т	F	Т	Т	F
F	F	F	F	Т	Т

Using the truth table the following statements can be shown to be equivalent. Brackets are used to define the terms that are connected by the various connective symbols.

$$\overline{(\overline{A})} = A$$

$$A \cdot A = A$$

$$A+A = A$$

$$\overline{(A.B)} = \overline{A}+\overline{B}$$

$$A \cdot (B+C) = (A \cdot B) + (A:C)$$

$$A+(B\cdot C) = (A+B).(A+C)$$

$$A+B = B+A$$

 $\overline{(A+B)} = \overline{A} \cdot \overline{B}$

$$A \cdot B = B \cdot A$$

$$A \cdot (B \cdot C) = (A \cdot B) C$$

$$A+(B+C) = (A+B)+C$$

$$A+B = (\overline{A} \cdot \overline{B})$$

$$A B = (\overline{A} + \overline{B})$$

$$(A \overline{A}) = Always FALSE$$

$$(A+\overline{A}) = Always TRUE$$

$$(\overline{A \cdot B}) + \overline{C} = \overline{A} + \overline{A \cdot B \cdot C}$$

$$(\overline{A \cdot (B+C)}) = \overline{A} + (\overline{B+C})$$

$$((\overline{A \cdot B}) + C) = (\overline{A \cdot B}) \cdot \overline{C}$$

$$((\overline{A \cdot B}) + \overline{C}) = A + B + C$$

$$(A \cdot B) + (\overline{A} \cdot B) + (\overline{A} \cdot \overline{B}) = (\overline{A \cdot B})$$

$$(A \cdot B) + (A \cdot \overline{B}) + (\overline{A} \cdot \overline{B}) = (\overline{A} \cdot B)$$

$$(A \cdot B) + (\overline{A} \cdot B) + (A \cdot \overline{B}) = (\overline{A} \cdot \overline{B}) = (A+B)$$

$$(\overline{A} \cdot B) + (A \cdot \overline{B}) + (\overline{A} \cdot \overline{B}) = (\overline{A} \cdot \overline{B}) = \overline{A} + \overline{B}$$

$$(A \cdot B)+(C \cdot D) = (A+(C.D) \cdot B+(C.D)$$