PULSE TRANSFORMER CIRCUIT AND PULSE FORMING NETWORK

INTRODUCTION

These notes describe the simulation of a pulse forming network used as part of a radar system with a PACE ® TR-20 desk-top-size general purpose analog computer. In the actual system, the pulses occur, unequally spaced, at a repetition frequency of approximately 50 mc. Suitable time scaling on the computer, however, permits "slowing down" this high speed so that transient and steady state circuit performance and the rise time, overshoot and sag of individual pulses can be studied accurately and conveniently, without having to build an actual radar system.

Resolutions on the order of 1 nanosecond are obtainable using this method.

BENEFITS

This low cost simulation provides several important benefits to engineers and designers. In particular, the computer permits an entire engineering design study to be performed right at the desk. There need not be the considerable expense in time and money involved in building model circuits.

The ease with which parameters can be changed--it is necessary only to manipulate hand - set potentiometers to change values of circuit components--is especially convenient, also. The effects of circuit components--inductances, tubes, etc.--can be studied in detail merely by changing a few potentiometer settings. In this way, most of the practical hardships involved in HF circuit design can be avoided, and the time spent in building and modifying an actual model considerably reduced, since after the computer analysis, one final test model is usually sufficient.

In addition, simulating a circuit provides the engineer-designer with an extremely versatile tool which can be changed gradually from an "ideal" to an "actual" circuit. In the process, the engineer can gain a deeper insight into circuit behavior.

In general, the analog computer permits the simulation of very sophisticated equivalent circuits, the transfer functions (or differential equations) of which may be exceedingly complex and defy solution by hand, or require a large digital computer.

Circuit elements which are described by experimental data rather than analytic expressions (such as Tunnel Diodes) present no particular problem to the analog computer. (Of particular interest, in this regard, is Application Study: 8.4.3a, Analog Computer Study of the Transient Behavior of a High-Speed Tunnel-Diode Switching Circuit. Please write for Bulletin No. ALAC 6348-1ab.)

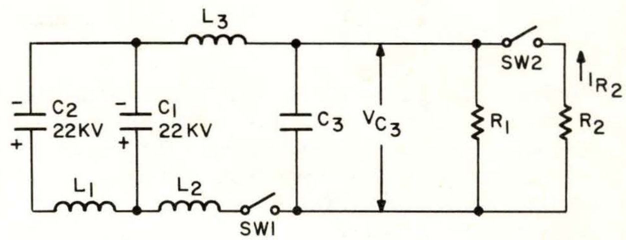

Figure 1: Equivalent Circuit Showing Reactances

SYSTEM EQUATIONS

Figure 1 shows the equivalent circuit for the system, with circuit reactances taken into account. This equivalent circuit satisfies the following system equations:

$$\dot{I}_{L_1} L_1 = V_{C_1} - V_{C_2} \quad (1)$$

$$\dot{I}_{L_2} (L_2 + L_3) = -(V_{C_1} - V_{C_3}) \quad (2)$$

$$\dot{V}_{C_1} C_1 = I_{L_2} - I_{L_1} \quad (3)$$

$$\dot{V}_{C_2} C_2 = I_{L_1} \quad (4)$$

$$\dot{V}_{C_3} C_3 = I_{L_2} - I_R \quad (5)$$

MECHANIZATION OF PROBLEM

The block diagram of Figure 2 shows the two main areas mechanized in the simulation: the differential equations and the decision network comparator.

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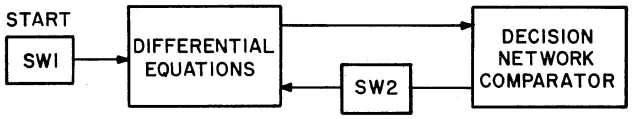

Figure 2: Block Diagram of Computer Program

The differential equations, (1) through (5), are used to simulate the system on the computer. Capacitors C_1 and C_2 are assumed to be charged initially. When switch SW1 is closed, capacitor C_3 acquires charge. Now, switch SW2 closes whenever V_{C_3} exceeds a certain level. If $R_2 \leq R_1$, current I_R will be pulsed on SW2 closed.

Damping, and the passive character of the circuit will give a finite number of unequally-spaced pulses. The task is to investigate the performance of I_R and V_{C_3}.

RESULTS AND CONCLUSIONS

Figure 3 is a plot of I_R and V_{C_3} vs time over a 2 minute computer period. The problem was slowed down by a factor of 10^8. Thus, 10^{-8} seconds of problem time correspond to 1 second of computer time. The resolution obtained approaches 10^{-9} seconds.

It can be seen from Figure 3 that the time scaling possible in this TR-20 computer simulation achieves two goals of importance. One of these is clearly defined resolution, extremely valuable in the study of the fine structure of pulses; the other is evidence of genuine overshoot of the pulse forming system, a phenomena which may not be accurately studied on any but the most sensitive oscilloscopes.

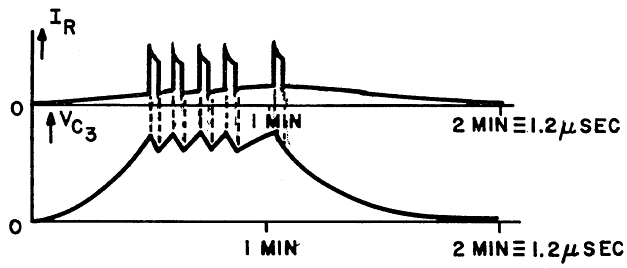

Figure 3: Graphic Plot Showing Changes in Current and Voltage vs. Time Over 2 Minute Pulsing Cycle

For complete details on this simulation, please write for Application Study: 8.4.5a, Bulletin No. ALAC 64057.

COMPLEMENT OF EQUIPMENT

Major pieces of equipment required for this simulation include:

- 5 integrators
- 1 high gain amplifier
- 2 summing amplifiers
- 3 inverting amplifiers
- 16 potentiometers
- 2 diodes
- 1 comparator
- 1 integrator } used only when generting a 2-minute time axis for plotting
- 1 potentiometer }

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