XI. TRANSISTOR CIRCUITS

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A. TRANSISTOR CIRCUITRY

1. Voltage-Tuned RC Active Filters

In the Quarterly Progress Report of January 15, 1956, a voltage-tuned amplifier that employed twin-T networks with a Q of 8 was described. During the past quarter, tuned amplifiers employing twin-T networks and Wien-bridge networks with a range of Q's as high as 30 were considered. The current gain of a tuned amplifier employing a Wien-bridge network is related to Q in the following manner:

$$Q \approx \frac{|A_i|}{3} \tag{1}$$

where A_i is the current gain of the amplifier. To obtain a Q of 25, a current gain of approximately 75 is required. Thus, two stages of current amplification, together with other stages, are necessary to provide the proper drive and load impedance to the RC network. Except at the center frequency, the amplifier has highly degenerate feedback. This feedback, coupled with the high gain and multistage form of the amplifier, causes stability problems. To provide stable operation, single, dominant time-constants were included externally at both low and high frequencies. A study of the effects of the location of these dominant time-constants showed that a ratio of dominant cut-off frequency to maximum or minimum center frequency of 5 or 1/5, respectively, produced negligible effects on the magnitude or phase characteristics of the amplifier.

A voltage-tuned amplifier with a Q of 30 was constructed and tested. Two interesting observations are worth mentioning. The first is the observation of phase jitter at the output of the amplifier that was caused by resistance modulation of the diodes. An approximate relation between the phase jitter, Q, and the resistance fluctuation per diode in a tuned amplifier that employs a Wien-bridge network is

$$\theta_N \approx 60\, Q\, \frac{\Delta R}{R} \tag{2}$$

where θ_N is the rms phase shift in degrees, and $\Delta R/R$ is the rms deviation in the diode resistance caused by resistance modulation. The second observation is one of conditional stability. Manual tuning of the oscillator, monotonically in one direction, occasionally induced transient oscillation. This oscillation can be stopped by interrupting the loop in order to establish equilibrium conditions in the RC network. Tests of sinusoidal voltage tuning have not yet been made.

2. Voltage-Tuned Oscillator

The major factors that limit the frequency stability of a voltage-tuned Wien-bridge oscillator were studied. The long-time frequency stability is influenced primarily by the temperature dependence of the incremental resistance of the junction diodes that are employed, and also by the temperature dependence of the capacitors. The temperature dependence of the diodes is approximately 0.3 per cent per degree centigrade. Since the capacitors that are required can be in the range of 0.1 to 1.0 μf, a temperature dependence of ±500 parts per million per degree centigrade can be expected. The major cause of short-time instability of the frequency of oscillation is, apparently, a resistance modulation of the junction diodes that are employed. Several tests with different diodes under different bias conditions indicate an rms fluctuation in diode resistance from 1 part in 1000 to 1 part in 10,000. The rms fluctuation increases with direct bias current. The measurements that have been made are not of sufficient accuracy for us to state the dependence specifically; it is not, however, a linear relationship.

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