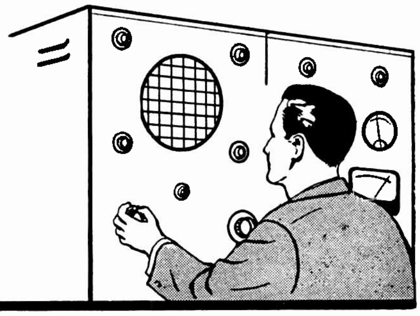
AEROVOX RESEARCH WORKER



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Voltage-Variable Capacitors

Part 2

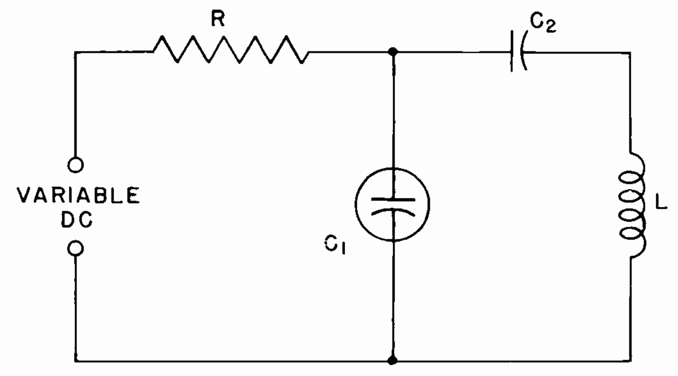
By the Engineering Department, Aerovox Corporation

This second part of the series of two on voltage-variable capacitors is devoted to typical applications of these units.

Typical Applications

Within its capacitance, voltage, and power dissipation limits, the semiconductor voltage-variable capacitor may be used in any application requiring a variable capacitor. Most of the voltage-variable capacitors are small-sized, having approximately the same dimensions as a ¼ watt resistor and requiring much less space than even a miniature trimmer capacitor. The following describes a number of practical applications. See also cited references 7, 8, 9.

Voltage-Tuned Tank. Figure 4 shows a voltage-tuned tank circuit employing a semiconductor capacitor C_1. Blocking capacitor C_2 prevents short circuit of the dc source by inductor L. The series resistor, R, is several megohms and increases the radio-frequency impedance. There is practically no d-c voltage drop across this resistor. The LC_1 combination may be the tank of a tube or transistor oscillator, wavemeter, or similar device. This principle of voltage tuning has been employed for remote control and for fine tuning in television receivers.



BASIC VOLTAGE-TUNED TANK

FIG. 4

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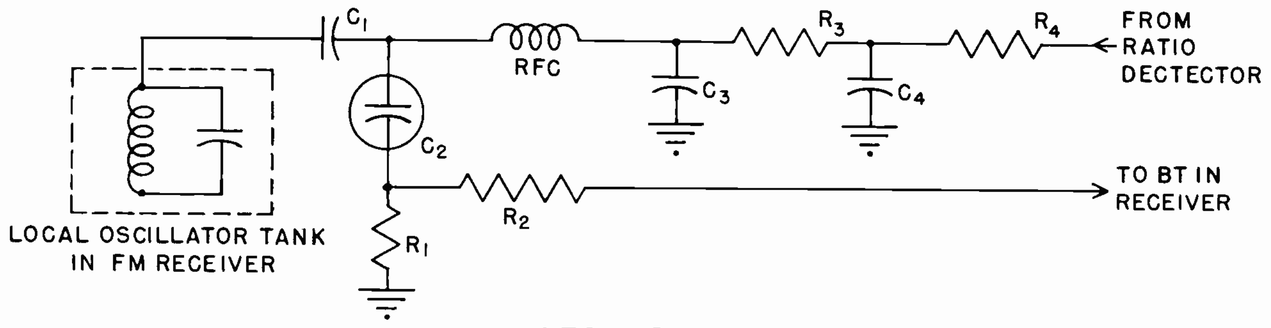


AFC CIRCUIT

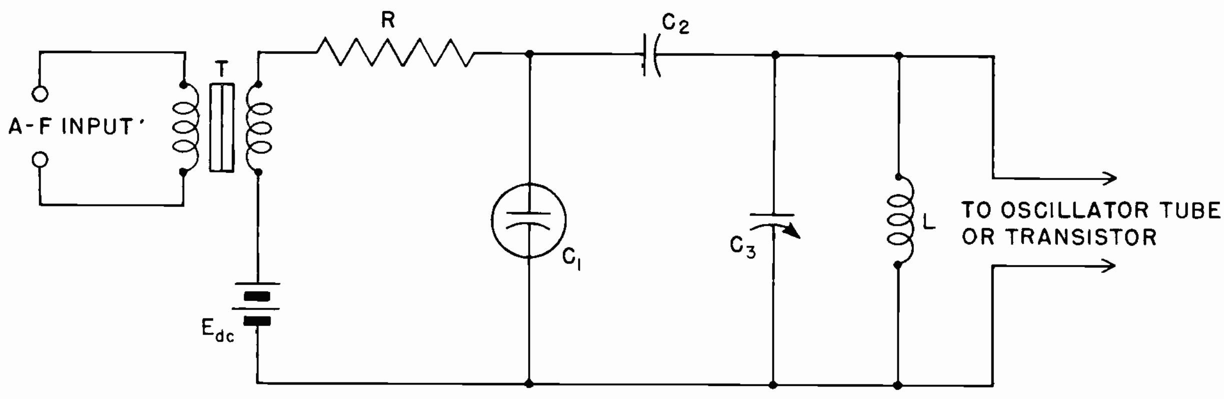
FIG. 5

Automatic Frequency Control. Figure 5 shows an afc circuit for fm receivers. The semiconductor capacitor, C_2, is connected across the tank circuit of the local oscillator in the receiver through a blocking capacitor, C_1. The semiconductor capacitor is biased by a d-c voltage derived from the receiver power supply and set by the voltage divider, R_1-R_2. Capacitor tuning voltage is obtained from the ratio detector in the receiver through an r-f filter comprised by RFC, R_3, R_4, C_3, and C_4. As the receiver drifts, the control voltage increases, shifting the capacitance, C_2, and tuning the oscillator tank back to frequency.

Frequency Modulator. When a semiconductor capacitor shunts an oscillator tank, the capacitor may be biased by an a-c signal in series with a d-c voltage. The capacitance then will fluctuate at the a-c rate above and below the capacitance determined by the d-c bias voltage, and the oscillator will be frequency modulated. Figure 6 shows a circuit for obtaining such performance. The tank circuit, LC_3, may be part of a tube or transistor oscillator. C_2 is a blocking capacitor for d-c isolation. Voltage E_{dc} is chosen to bias the semiconductor capacitor, C_1, to a point within the linear portion of its voltage - capacitance characteristic. The fm swing is then proportional to the amplitude of the a-c signal voltage.

Dieletric (Resonant-Slope) A-F Amplifier. Appreciable a-f gain may be obtained with the circuit shown in Figure 7(A). Here the r-f oscillator serves as a high-frequency power supply. The semiconductor capacitor, C_1, tunes the inductor, L, to the oscillator frequency, under the influence of a d-c bias voltage, E_{dc}. This d-c voltage is selected so that C_1 is biased within the linear portion of the capacitance-voltage characteristic, and the tank is detuned to one side of the resonance curve (see Figure 7B). The a-f input voltage, E_{ac}, swings the capacitance above and below the operating point, as shown in Figure 7(B) and thus amplitude modulates the r-f voltage. Amplification results, because of the steepness of the resonance curve at the operating point. The modulation envelope is recovered by diode D, and the amplified a-f signal is delivered to the A-F OUTPUT terminals.

Parametric R-F Amplifier. At ultra-high and microwave frequencies, semiconductor capacitors (varactors) provide r-f amplification at noise levels considerably lower than ever observed with the best vacuum-tube amplifiers. In this device, the **parametric amplifier,** the high-frequency power supply (oscillator) delivers a reverse voltage to the varactor at a frequency multiple of the r-f signal frequency, usually 2 times. This h-f supply potential is termed the **pumping voltage.**



FREQUENCY MODULATOR

FIG. 6

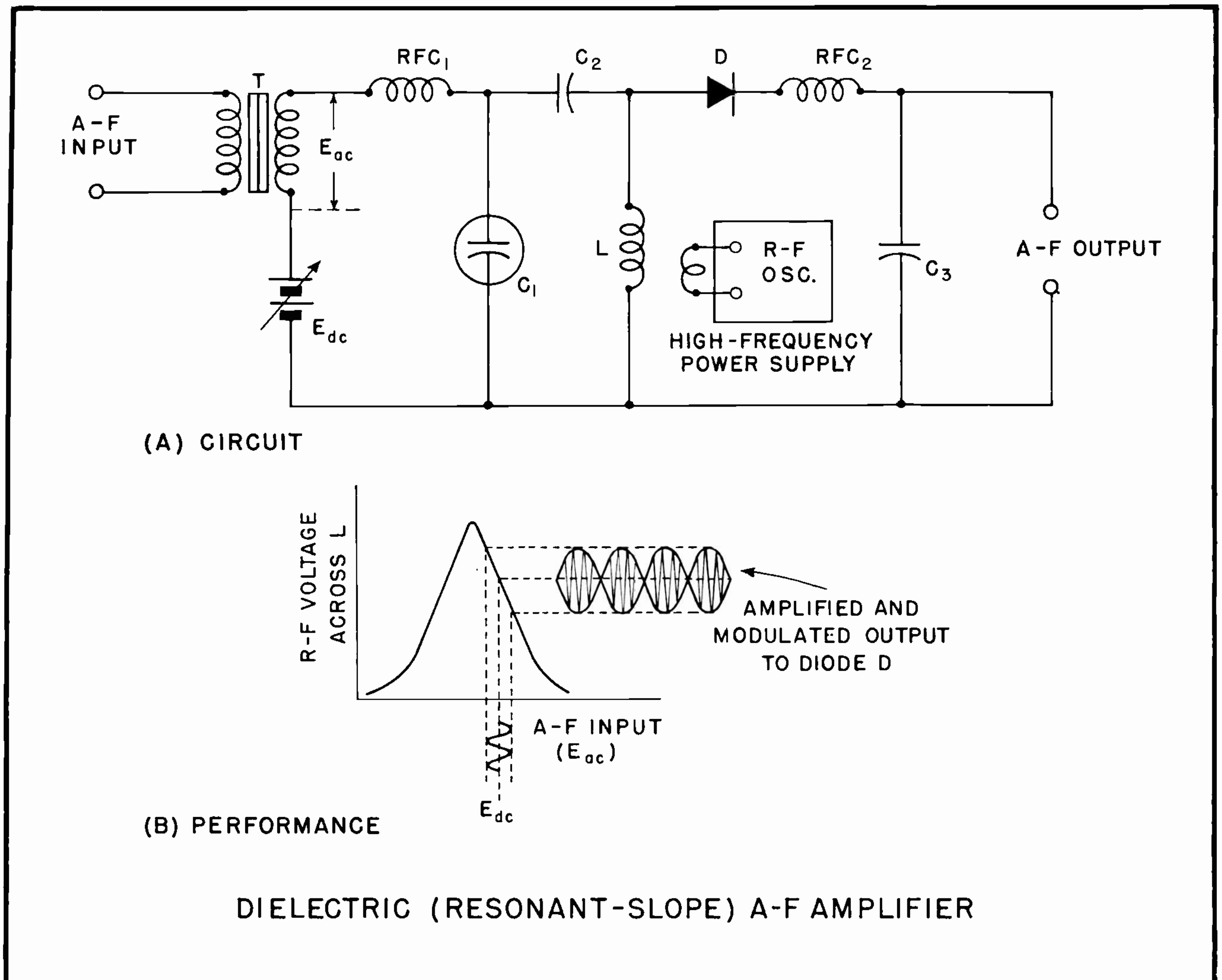


FIG. 7

The pumping voltage alternately pumps the varactor capacitance low (h-f voltage high) and high (h-f voltage low). The pump and signal voltages are so phased that the high pump voltage arrives at each instant when the varactor charge has been maximized by the signal voltage. This causes the capacitance to decrease, but simultaneously (since $E=Q/C$ and the charge remains constant) the varactor voltage increases and so does the power in the varactor circuit. (The extra power is, of course, supplied by the h-f oscillator.) Power gain of 18 db at a signal frequency of 485 Mc and pump frequency of 970 Mc is typical.[10]

Outlook and Prospects

The simplicity, small size, and dependability of the semiconductor types of voltage-variable capacitors and the advantages they have already afforded in various communications, control, and computer circuits, point to the increased utilization of these solid state devices in applications calling for continuously variable capacitance at negligible (if not zero) consumption of control power. Characteristic of recent progress is the development of a 250-Mc varactor frequency multiplier which doubles at 80% efficiency and triples at 70%.

1—"The Dielectric Amplifier," **Aerovox Research Worker,** August 1952.

2—"Tubeless Amplifiers," **Aerovox Research Worker,** July- August 1956.

3—"Voltage Sensitive Capacitors," **Electronic Design,** July 1954.

4—J. R. Anderson, "Ferroelectric Storage Elements for Digital Computers and Switching Systems, **"Electrical Engineering,** October 1952 p. 916.

5—J. F. Fink, "Introducing the Dielectric Amplifier," **Radio-Electronics,** February 1954, p. 92.

6—A. M. Vincent, "Dielectric Amplifier Fundamentals," **Electronics,** December 1951.

7—Rufus P. Turner, "Using the Varicap," **Radio - Electronics,** May 1958, p. 57.

8—Rufus P. Turner, "Tuning with DC, **"Western Radio Amateur,** August 1958, p. 9.

9—Rufus P. Turner, **Semiconductor Devices,** New York, Holt, Rinehart and Winston, Inc., 1961, pp. 230-238.

10—Richard J. Mayer, "Degenerate Parametric Amplifier," **Electronics** December 15,1961, p. 74.

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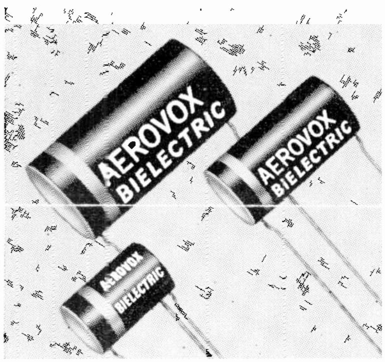
PRODUCT NEWS FROM AEROVOX



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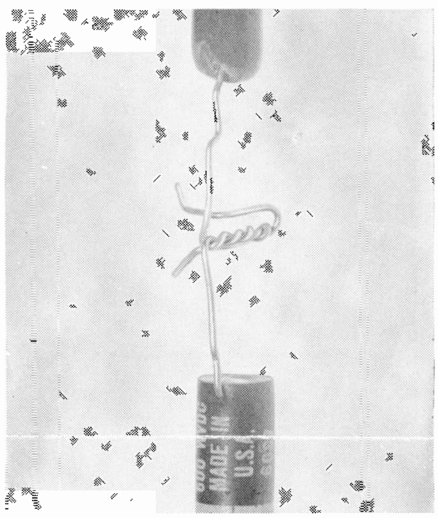

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