RCA Application Note

AN-192

Use of the RCA-6939 UHF Twin Power Pentode In RF-Amplifier and Frequency-Tripler Service

This Note discusses the application of the RCA-6939 twin power pentode in Class C rf-amplifier and frequency-tripler service at frequencies up to 500 megacycles. Circuits illustrating the use of this tube in a "straight-through" amplifier stage and in frequency-tripler service are described.

The RCA-6939 is a twin power pentode of the nine-pin miniature type. At 500 megacycles, the 6939 can deliver an average of 5 watts of useful power under CCS conditions and 6 watts under ICAS conditions. In frequency-tripler service, it can deliver an average of 1.8 watts of useful power under CCS conditions and 2.2 watts under ICAS conditions.

Tube Design Features

The 6939 uses frame-type control grids (grids No.1) wound with gold-plated lateral wires, zirconium-sprayed molybdenum plates, and a screen grid (grid No.2) which is carbon-coated to minimize secondary emission and increase heat-dissipation capabilities. The cathode and screen grid are common to both pentode units. In addition, the 6939 features an internal neutralizing system.

Extremely close spacing between the cathode and grid No.1 makes possible a transconductance of 10,500 micromhos for each unit. The tube is especially useful in a push-pull output amplifier, driver, or frequency tripler because its design minimizes problems of instability and cathode degeneration often encountered in push-pull systems using separate tubes.

The cathode of the 6939 is indirectly heated; the heater is center-tapped for use with either a 6.3-volt, 0.6-ampere heater supply or a 12.6-volt, 0.3-ampere heater supply.

Stable amplifier operation over a relatively wide frequency range is assured by the internal capacitive neutralizing system which compensates for the capacitive feedback from plate to grid No.1. The neutralizing capacitors consist of metal tabs mounted on the top mica spacer near each plate. Each tab is connected to the grid of the opposite unit of the tube.

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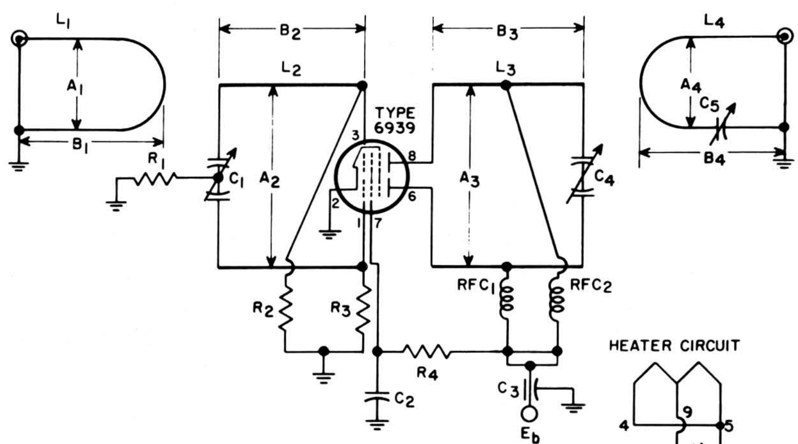
Basic RF-Amplifier Considerations

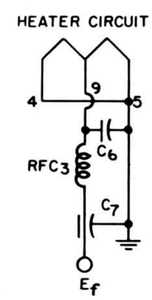
The maximum useful operating frequency of a conventional rf-amplifier tube is determined by the natural resonant frequency of the internal inductances and capacitances. In a push-pull circuit the input capacitances of the two tubes are in series across the input tuned circuit. This arrangement halves the effective input capacitance of the circuit and thus makes it possible to achieve much higher operating frequencies than in a single-ended circuit. The same considerations apply for the output capacitances of push-pull circuits.

At high frequencies, two separate tubes operating in push-pull have certain disadvantages. For example, the separate lead inductances of the tubes introduce degeneration, and the separate screen-grid leads often cause circuit instability. The 6939 overcomes these difficulties by incorporating in one envelope two pentodes having a common cathode and a common screen grid. Low lead inductances and freedom from cathode degeneration are achieved, and the other disadvantages of separate tubes are avoided.

Class C 500-Mc Push-Pull RF Power Amplifier

Fig.1 shows a circuit diagram of a 500-megacycle push-pull rf power amplifier using the 6939. In this circuit, the open-ended resonant lines in the grid-No.1 and plate circuits are both electrically one-half-wave-





C_1 C_4: capacitors, 2.2–8 $\mu\mu$f
C_2 C_6: capacitors, 250 $\mu\mu$f
C_3 C_7: capacitors, 1000 $\mu\mu$f
C_5: capacitor, 1.5–5 $\mu\mu$f

L_1: #10 tinned copper wire; A_1 = 1/2 inch, B_1 = 2 inches
L_2: #10 tinned copper wire; A_2 = 1/2 inch, B_2 = 3 inches
L_3: #10 tinned copper wire; A_3 = 3/4 inch, B_3 = 3 inches
L_4: #10 tinned copper wire; A_4 = 3/4 inch, B_4 = 1-1/2 inches

R_1: 220 ohms
R_2, R_3: 27000 ohms
R_4: 100 ohms
RFC_1, RFC_2: 0.2 μh
RFC_3: 20 turns #26 enamel-covered wire (3/16-inch diameter x 1/2-inch long)

Fig.1 - 500-megacycle push-pull rf power-amplifier circuit using the 6939.

length long. For applications involving stringent space limitations, it is possible to obtain a resonant plate circuit by use of a quarter-wave-length closed-end resonant line. With such an arrangement, the plate voltage is applied through an rf choke to the center of the closed end. Under these conditions, however, coupling losses may prevent full utilization of the rf power developed by the tube.

It should be noted that the plate capacitor C_4 is ungrounded. The two rf chokes in the plate-voltage supply are connected at points on the transmission line where the rf voltage is at a minimum, i.e., at approximately the mid-point of each leg. Care should be used in determining the location of these points to avoid loss of output power and excessive heating of the chokes.

Pins 4 and 5 of the 6939 are grounded as close as possible to the socket to minimize absorption of rf power by the heater circuit. Isolation of the ungrounded heater terminal (pin 9) is provided by an rf choke (RFC_3) and a low-inductance bypass capacitor (C_6). Any rf in the heater supply lead is bypassed by a feedthrough capacitor (C_7) located at the point at which the heater lead passes through the chassis.

The cathode terminal (pin 2) is grounded directly to the chassis by the shortest possible connection to minimize series inductance.

In this push-pull rf-amplifier circuit, the screen-grid and plate voltages are obtained from the same source. The screen grid is bypassed to ground by a low-inductance capacitor (C_2). In addition, a 100- or 200-ohm resistor (R_4) is connected in series with the screen-grid supply lead at the tube socket to minimize parasitic oscillations. To minimize self-oscillation due to parallel resonance in the grid-No.1 circuit, the rotor of the input tuning capacitor (C_1) is connected to ground through a 220-ohm resistor (R_1).

	CCS	ICAS	
DC Plate Voltage	180	200	volts
DC Grid-No.2 Voltage	180	200	volts
DC Grid-No.1 Voltage	-20	-20	volts
DC Plate Current	55	60	ma
DC Grid-No.2 Current	12.5	14	ma
DC Grid-No.1 Current	1.5	1.5	ma
Plate Input	10	12	watts
Plate Dissipation	4.2	5.2	watts
Grid-No.2 Input	2.25	2.8	watts
Driving Power	1.2	1.2	watts
Useful Power Output	5	6	watts

Table I - Typical operating values for 500-megacycle rf-amplifier circuit shown in Fig. 1.

The grid-bias resistors are connected to the input transmission line at points where the rf voltage is a minimum. The point of minimum rf voltage in this circuit is at the tube socket. The use of separate grid resistors is advisable for circuit symmetry.

A grounded shielding strip is mounted across the tube socket to prevent feedback of rf power from the plate to the grid No.1. This shield is installed so that it crosses the socket between pins 4 and 5 and between pins 1 and 9.

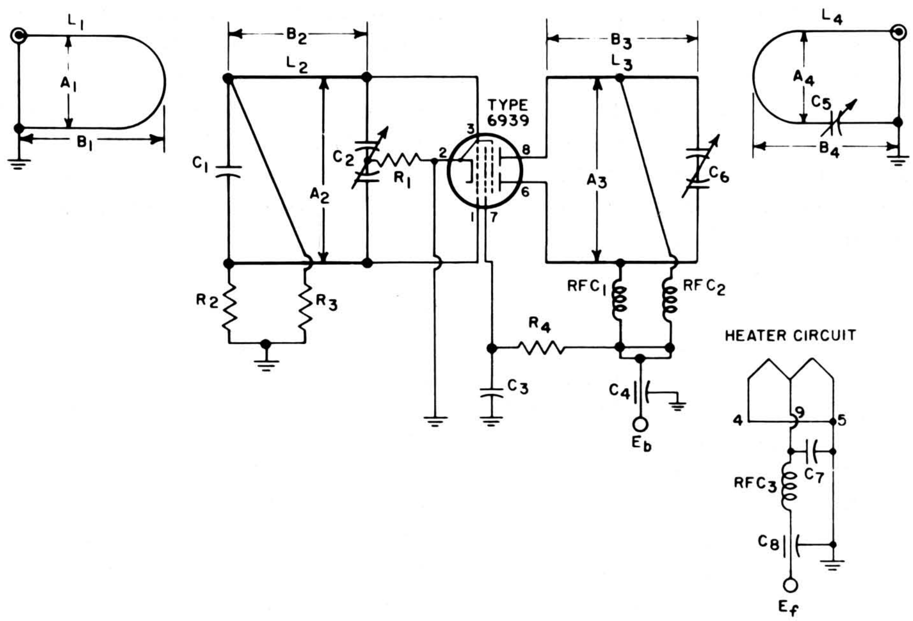
Optimum coupling to the single-ended input and output loops (L_1 and L_4) is obtained when the closed end of the coupling loop faces the tuning capacitors. The separation between the resonant lines and the coupling loop is generally between one-half and three-quarters of an inch.

Because the maximum permissible bulb temperature of the 6939 is 225 degrees centigrade, normal convection cooling is sufficient for all operating conditions. The 6939 should never be operated in a closed tube shield unless the shield has a mat black internal finish and is either corrugated or finned.

Table I lists typical operating values for the amplifier.

166.6-Mc to 500-Mc Push-Pull Frequency Tripler

Fig.2 shows the diagram of a 166.6-megacycle to 500-megacycle frequency tripler circuit using the 6939. In this circuit, the 6939 is capable of delivering 1.8 watts of drive to the following stage. The



C_1, C_4, C_8: capacitors, 1000 $\mu\mu f$
C_2, C_6: capacitors, 2.2-8 $\mu\mu f$
C_3, C_7: capacitors, 250 $\mu\mu f$
C_5: capacitor, 1.5-5 $\mu\mu f$

L_1: #10 tinned copper wire; A_1 = 1/2 inch, B_1 = 2 inches
L_2: #10 tinned copper wire; A_2 = 1/2 inch, B_2 = 3 inches
L_3: #10 tinned copper wire; A_3 = 3/4 inch, B_3 = 3 inches
L_4: #10 tinned copper wire; A_4 = 3/4 inch, B_4 = 1-1/2 inches

R_1: 100 ohms
R_2, R_3: 82000 ohms
R_4: 1200 ohms

RFC_1, RFC_2: 0.2 μh
RFC_3: 20 turns #26 enamel-covered wire (3/16-inch diameter x 1/2-inch long)

Fig.2 - 166.6-Mc to 500-Mc frequency-tripler circuit using the 6939.

design considerations given previously for the 500-megacycle amplifier circuit also apply when the tube is used in a frequency-tripler circuit, except that the shield across the tube socket is not required for tripler operation. The input resonant line (L_2) is a quarter wavelength at 166.6 megacycles. The grid-bias resistors (R_2 and R_3) are connected at the end of the input resonant line where the rf voltage is a minimum. Because the closed end of L_2 is terminated by a high-value capacitor (C_1) which does not change the rf characteristic of L_2, two separate grid resistors are used to provide a symmetrical push-pull input circuit.

Table II lists typical operating values for the frequency-tripler circuit.

	CCS	ICAS	
DC Plate Voltage	180	200	volts
DC Grid-No.2 Voltage	180	190	volts
DC Grid-No.1 Voltage	-74	-74	volts
DC Plate Current	40	46	ma
DC Grid-No.2 Current	9.7	11	ma
DC Grid-No.1 Current	1.8	1.8	ma
Plate Input	7.2	9.2	watts
Plate Dissipation	4.9	6.1	watts
Grid-No.2 Input	1.65	2.05	watts
Driving Power	1.1	1.1	watts
Useful Power Output	1.8	2.2	watts

Table II - Typical operating values for frequency-tripler circuit shown in Fig.2.