



Use of the RCA-7558 and RCA-7551 VHF Beam Power Tubes in RF-Amplifier, Frequency-Multiplier, and AF-Modulator Service

This Note discusses the application of the RCA-7558 and RCA-7551 beam power tubes in class C rf-amplifier and frequency-multiplier service at frequencies up to 175 megacycles and in af modulator and power-amplifier service. Circuits illustrating the use of these tubes in a "straight-through" amplifier and in various types of frequency multipliers are described.

The RCA-7558 and RCA-7551 are beam power tubes of the nine-pin miniature type. Although primarily designed for vhf service, both tubes also provide excellent performance in audio-frequency modulator and power-amplifier applications. In typical operation at 175 megacycles, both tubes can deliver useful power output of 8.5 watts under CCS conditions and 10 watts under ICAS conditions. In af modulator service, two tubes in push-pull can provide 20.5 watts of audio power with less than 5 per cent total harmonic distortion.

Tube Design Features

The 7558 and 7551 have identical electrical characteristics except for heater-voltage requirements. The 7558 has a 6.3-volt heater and is designed primarily for continuous service in fixed-station communications equipment in which the normal heater-voltage variation does not exceed ± 10 per cent. The 7551 has a 12-to-15-volt heater and provides reliable service in mobile communications equipment operating from a 6-cell storage battery system.

Although the heater of the 7551 is designed to operate over a voltage range of from 12 to 15 volts, it will withstand momentary excursions from 11 to 17 volts. During manufacture, the 7551 is subjected to rigid controls and tests for heater-cathode leakage, interelectrode leakage, low-frequency-vibration performance, and intermittent shorts, as well as a 500-hour intermittent life test at a heater voltage of 15 volts and a heater-cycling life test at a heater voltage of 17 volts. As a result, the rugged heater design and the careful testing ensure dependable performance in mobile equipment under operating conditions encountered during battery charging and discharging.

Features which contribute to the efficient performance of both these tubes at 175 megacycles are low lead inductances, low interelectrode



capacitances, and low rf losses. Low lead inductances for both cathode and grid No.2 (screen grid) are achieved by the use of two pin connections for each of these electrodes. If the two pin connections for the cathode are arranged so that the rf input current flows through one and the rf output current through the other, degeneration in the cathode circuit is reduced. The two base-pin connections for the grid No.2 facilitate rf bypassing and aid in cooling. The low rf losses and high input resistance permit the use of relatively high values of grid-No.1-circuit resistance (100,000 ohms) to minimize loading of the driver stage. In addition, high grid-No.1-circuit resistance makes it possible to obtain the high value of grid bias required for good frequency-multiplier plate-circuit efficiency with low values of dc grid current.

The maximum permissible temperature of the bulb is 225 degrees centigrade. Within reasonable ambient temperatures, no artificial means of cooling are required for most applications. However, a heat-dissipating tube shield may be used as an aid in reducing bulb temperature when necessary.

RF-Power-Amplifier Service

Fig.1 shows a circuit in which the 7551 or 7558 is used as a "straight-through" amplifier at 175 megacycles. In this single-ended amplifier, C_1 and C_8 effectively simulate the input and output capacitances, respectively, of the other section of a push-pull circuit. Thus, the tube input and output capacitances are in series with C_1 and C_8 . This arrangement optimizes tube performance at higher frequencies because it provides a higher L/C ratio in the resonant circuits than would be possible with a conventional parallel-tuned tank circuit.

At vhf, the rf grounding of the heater circuit is important because of its effect on the stability of the amplifier. The most satisfactory method of grounding the heater circuit is achieved when one of the heater pins is connected directly to the chassis at the socket and the other is bypassed to the chassis through a low-inductance capacitor.

As mentioned previously, degeneration in the cathode circuit is minimized when the two pin connections, 1 and 9, are used to separate the input and output rf currents. These pins should be grounded by the shortest possible connections to the chassis to reduce the external cathode-lead inductance.

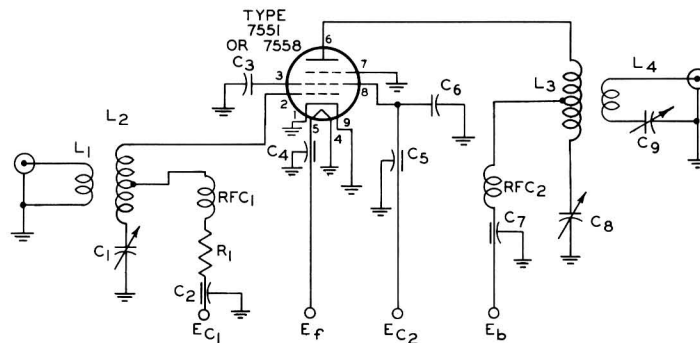
If a socket shield is required to prevent rf feedback from the plate circuit to the grid-No.1 circuit (usually at frequencies above 100 megacycles), the shield should be placed across the socket in the plane of pins 4 and 9 so that the heater (pin 4) and cathode (pin 9) can utilize the shield as a low-inductance ground connection.

The circuit shown in Fig.1 was found to be very stable when tested for oscillation at reduced plate and screen-grid voltages without fixed bias. With the plate circuit unloaded and no grid drive, the amplifier did not oscillate with any combination of settings of the plate and grid-No.1-tank capacitors.

When more rf power is required than a single 7558 or 7551 can deliver, two tubes may be used. At frequencies below 60 megacycles, the tubes may



be connected in parallel; at higher frequencies (up to 175 megacycles), a push-pull circuit is recommended to reduce the effective input and output capacitances.



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- C_1, C_9 : 7-45 μmf , ceramic disc. C_1 for doubler: 4-30 μmf ceramic disc
 C_2, C_4, C_5, C_7 : 1000 μmf , feed-through, silver button mica
 C_3, C_6 : 1000 μmf , bypass, silver button mica
 C_8 : 3.6-15 μmf , midget, double spaced (Hammarlund HF-15-X or equivalent)
 L_1 : 2 turns of No.18 Enam. wound on 1/2" diameter form
 L_2 : No.18 Enam. wound on 1/2" diameter form: 5 turns center tapped for amplifier; 7 turns center tapped for doubler; 8 turns center tapped for tripler
 L_3 : 4 turns center tapped No.18 Enam. wound on 1/2" diameter form
 L_4 : 3 turns No.18 Enam. wound on 1/2" diameter form
 R_1 : 22,000 ohms, 0.5 watt for amplifier; 47,000 ohms, 0.5 watt for doubler; 68,000 ohms, 0.5 watt for tripler.
 $\text{RFC}_1, \text{RFC}_2$: 1.8 $\mu\text{h.}$, 1000 ma., 80-200 Mc. (Ohmite Z-144 or equivalent)
 RFC_1 for doubler and tripler: 7.0 $\mu\text{h.}$, 1000 ma., 35-110 Mc. (Ohmite Z-50 or equivalent)

Fig.1 - Basic circuit for 175-Mc amplifier, 87.5/175-Mc. doubler, and 58.5/175-Mc. tripler.

Grid-Driving Power

The grid-No.1-driving power given in the published data for the tube is the power which must be delivered by the previous stage. This value is the actual total power input required by the grid-No.1 circuit, and includes the power delivered to the grid No.1, the power dissipated in the grid-bias resistor, the losses in the tube caused by transit-time loading, and the rfl losses in the tube, tank circuit, socket, and wiring. The driver stage should be designed to provide reserve power to allow for variations in line voltage, components, and tube characteristics.

If the tube is to be operated under conditions differing from the suggested typical operating conditions, the performance can be checked as follows: First, load the amplifier to the desired value of plate current.



Then vary the grid-driving power slowly (tank-circuit tuning remains unchanged) and note the change in output. If the change in output is approximately proportional to the change in grid-No.1 drive, the stage is underdriven. The drive should be increased until very little increase in power output results from a large increase in drive. However, the maximum rated value of dc grid-No.1 current should not be exceeded.

If the stage is underdriven, low power output and low efficiency will result. In plate-modulated service, underdriving causes severe distortion at high levels of modulation. This condition is readily recognizable as downward modulation; it is evidenced by a decrease in the average plate current as the modulation level is increased.

Because overdriving the 7558 or 7551 may cause the grid-No.2 input rating to be exceeded before the maximum control-grid rating is reached, it is recommended that the grid-No.2 current be metered to determine whether the power input is within ratings.

The grid-No.1 bias voltage may be obtained from a grid-No.1 resistor or from a combination of grid-No.1 resistor with either a cathode resistor or fixed supply. The use of a bias supply or a cathode resistor will provide protective bias in the event of loss of excitation.

Plate-Modulated RF Power-Amplifier Service

For high-level modulation in plate-modulated telephony service, both the plate and grid No.2 must be modulated. The rf impedance between grid No.2 and cathode must be kept low by means of a suitable bypass capacitor. The value of bypass capacitor used should be kept as small as possible to avoid excessive af bypassing. If the capacitance value is too small, however, feedback may occur between the plate and grid No.1, with subsequent instability. If the grid-No.2 bypass capacitor is replaced by a series-resonant circuit tuned to resonate at the operating frequency, the rf impedance between grid No.2 and ground is low at this frequency and high at audio frequencies.

For linear modulation characteristics, the use of a combination of grid resistor and fixed supply in the grid-No.1 circuit has the advantage of providing the desired variations in bias voltage as the modulating voltage varies.

Frequency-Multiplier Service

Doubler Operation: With the input modifications given in the parts list, the circuit shown in Fig.1 may be used for frequency-doubler service to provide a power output of three watts CCS and 4.5 watts ICAS at an output frequency of 175 megacycles. A pair of tubes in "push-push" may be used to obtain greater power output in doubler service. In this case, the plates are connected in parallel and the inputs in push-pull. With this arrangement, the even-order harmonics are accentuated and the odd-order harmonics suppressed.

Tripler Operation: The input of the basic circuit shown in Fig.1 can also be modified as shown in the parts list to permit frequency-tripler operation. This circuit provides a power output of 1.4 watts CCS and



2.3 watts ICAS at an output frequency of 175 megacycles. For high-order multiplication, a single tube used as a frequency tripler can provide more than adequate driving power for the push-push frequency doubler or straight-through amplifier. For additional power output, a pair of tubes may be used in a push-pull arrangement. This circuit accentuates the odd-order harmonics and suppresses even-order harmonics, making it suitable as a frequency tripler.

No socket shield is necessary for either doubler or tripler operation.

AF Power Amplifier and Modulator — Class AB₁ Service

Two 7558 or 7551 tubes connected as a class AB₁ amplifier with 300 volts applied to the plates and 250 volts to grid No.2 can furnish a power output of approximately 20 watts with 5 per cent distortion. The power output and distortion also depend on the characteristics of the driver tube, the input transformer, and the regulation of the power-supply units.

Because the source of plate and grid-No.2 supply voltage of a class AB amplifier has internal resistance, the dc voltages applied to the plates and screen grids decrease as power output increases. However, when plate and grid-No.2 voltages are reduced, power output is also reduced, and a change in load resistance may be necessary to maintain a reasonably low level of distortion.

Fig.2 shows power output as a function of the internal power-supply resistance over a range of 0 to 700 ohms in series with the plate supply

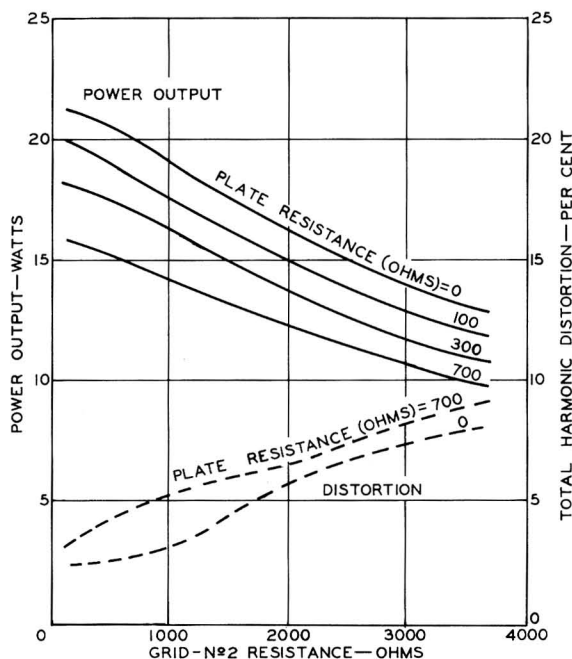


Fig.2 - Power output and harmonic distortion as a function of internal power-supply resistance.

and 0 to 3500 ohms in series with the grid-No.2 supply. Fig.2 also includes a typical curve (dashed line) of total harmonic distortion as a function of internal power-supply resistances. The curves indicate that with zero plate and grid-No.2 supply resistance, the typical power output



is 20.5 watts with a total distortion of 2.5 per cent. With the poorest power-supply regulation measured (i.e., 700 ohms of series plate-circuit resistance and 3500 ohms of series grid-No.2 resistance), the power output drops to 10.5 watts and total distortion increases to 9.3 per cent. Consequently, good voltage-supply regulation is essential for efficient operation.

Transformers having poor audio-frequency response characteristics will degrade the over-all performance of the circuit. The transformer characteristics which are important in modulator applications include the primary and secondary leakage inductance, the capacitances between windings and from each winding to ground, core loss, and winding resistance. Excessive values of any of these factors can cause loss of frequency response, phase distortion, generation of nonlinear distortion products, and reduced power output.

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