Transmitter Bias Supplies (continued)

Good voltage regulation must be one of the outstanding characteristics of bias supplies employed with class-B linear r.f. amplifiers, class-C modulators, and grid-modulated class-C r.f. amplifiers. Equally important with regulation is the bias supply for a class-B modulator is the requirement that the actual value of voltage be within 5% of the required value.

The simple bias supply circuit previously described may be converted into a regulated unit by the addition of a voltage-regulated supply unit, the remainder of the bias voltage being developed by the series grid leak. When power supplies of this type are employed, it is usually necessary to connect the grid leak resistor in parallel with the grid circuit, such that the value of the voltage drop across the latter is not less than the value of grid bias voltage change with the plate-circuit modulation.

Transmitter Bias Supplies

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Radio Editions of magazines and frequency stages of a transmitter requires that certain recommended values of d.c. bias voltage be applied to each grid. Bias for r.f. amplifiers is operating voltage, which is maintained in some pulses over a small portion of each cycle. The pulse height value of each of these pulses is several times the normal grid voltage. The peak value is indicated by the plate-circuit multiplier with the grid being driven. The latter assumption negative polarity and the grid droop when the grid voltage is applied to the grid as negative bias.

Bias requirements vary with each application of tubes in a transmitter. Bias voltage for doubling and other frequency multipliers, for example, must be maintained quite high. Bias for r.f. amplifiers is required for plate current cut-off. Final r.f. amplifiers and a.f. modulators, on the other hand, require grid voltages between cut-off and slightly lower, to twice cut-off. Bias for class-B audio tubes must be supplied by a low-resistance source of extremely good regulation. This calls for a battery or a limited resistance supply incorporating a voltage-regulating device. But a poorly-regulated supply is desirable for class-C telephony, since linear operation (and consequent good audio quality) is important in plate-modulated radiotelephony, requires that the value of grid bias voltage change with the plate-circuit modulation.

Grid-lead bias

One of the simplest methods of obtaining grid bias voltage is by means of a grid leak resistance. This resistor, which is generally of high ohmic value, is connected between the control grid and grid as shown in Figure 3. On positive half-cycles of the oscillation voltage, the grid bias voltage, developed by the grid leak, attracts electrons from the cathode, giving it a direct current (the grid current) which flows across the electromagnetic field to the plate, and back to the grid. The grid current produces a voltage drop across the grid resistor, the latter assuming negative polarity and the grid droop when the grid voltage is applied to the grid as negative bias.

The radio-frequency chokes shown in the circuits in Figure 1 prevent the excitation power from flowing through the grid resistor. The capacitors connecting each grid leak presents a low-impedance path to ground, energy that might succeed in passing through the choke.

Grid-lead bias is somewhat limited in application. It cannot be used successfully, for example, with linear class-B r.f. amplifiers, class-C or class-B audio and grid-modulated class-C telephony.
For two tubes (either push-pull or parallel connection) the grid current would be double, therefore the grid leak resistance would only be half the transformer secondary voltage divided by the total current (1). Similarly, the power value obtained with the grid leak is four times as great as with one tube.

For high current applications, a triode is not known, but other tubes could be used for a triode. The grid leak values for these tubes must be determined in terms of the plate voltage and amplification factor, thus:

\[ R_{g} = \frac{V^{2}_{p}}{P} \]  

(3)

\[ R_{g} = \text{Value of grid leak resistance (milliohms)} \]  

\[ P = \text{Power developed (watts)} \]  

\[ V = \text{Plate voltage (volts)} \]  

\[ P = \text{Power developed (watts)} \]  

\[ R_{g} = \text{Grid leak value (milliohms)} \]  

\[ V = \text{D.C. grid voltage (millivolts)} \]  

(4)

Grid-leak bias is not a safe supply for r.f. power amplifiers. In all tubes except those specifically for zero-bias class B a.f. operation, plate voltage is applied to the grid through a grid leak. Another form of grid voltage is used in a.g.c. although the bias supplied is only of the order of 250 or 500 volt, and the total plate voltage in the grid circuit is many times as great, the plate modulated voltage is not so important as the modulation of the bias supply to obtain the proper effective plate-cathode voltage to deliver the necessary power output to the grid circuit.

The cathode by-pass capacitor provides a low-inductance path for the a.c. component of plate current which otherwise would vary the bias voltage. If this capacitor is omitted from the circuit or if its capacitance is too low, the degeneration will take place and will reduce the amplification in this manner. The required value of the by-pass capacitor is determined in accordance with the a.c. plate load of the circuit, and then operating against the plate current changes that are due to the signal. The cathode resistor in a radio-frequency stage must always be by-passed for r.f. to prevent degeneration. The by-pass capacitor is usually placed in the r.f. audio amplifier to reduce distortion, although it reduces gain and power amplification at the same time. The required value of the by-pass capacitor is obtained by means of Formula (5).

\[ C = \frac{20 \times 10^{-6}}{f} \]  

(5)

\[ C = \text{Capacitance (millimicrofarads)} \]  

\[ f = \text{Frequency (cycles per second)} \]  

The properties of r.f. amplifiers, in general, are determined by the grid current in the reactance tube. (S) The grid current in the reactance tube is determined by the grid-cathode voltage in the reactance tube. The grid-cathode voltage is therefore not generally usable in stages with the tube cathode value of the grid leak may be determined in terms of the plate voltage and amplification factor, thus;

\[ R_{g} = \frac{V^{2}_{p}}{P} \]  

\[ R_{g} = \text{Value of grid leak resistance (milliohms)} \]  

\[ P = \text{Power developed (watts)} \]  

\[ V = \text{Plate voltage (volts)} \]  

\[ P = \text{Power developed (watts)} \]  

\[ R_{g} = \text{Grid leak value (milliohms)} \]  

\[ V = \text{D.C. grid voltage (millivolts)} \]  

(6)

The grid leak is supplied through the bleeder resistor of the r.f. amplifier. The bleeder resistor is chosen so that the bias supply will be a conductive bias. The bias supply consists of a cathode by-pass circuit, a reactance tube, and a grid leak. The required value for any cathode bias supply is obtained from the relationship:

\[ V = \frac{R_{g}I_{g}}{1000} \]  

(7)

\[ V = \text{Desired grid voltage (volts)} \]  

\[ R_{g} = \text{Value of grid leak电阻 (milliohms)} \]  

\[ I_{g} = \text{Grid leak current (milliamps)} \]  

(8)

The problem of grid-bias voltage regulation desired for linearity in class-C radio-frequency amplification may be obtained easily with a grid bias circuit, since bias secured by this method changes with modulation in the plate circuit.

CATHODE BIAS

Cathode bias, familiar in receiver design, is another simple type of bias supply that finds use in transmitter design. This type, known also as cathode-bias system, utilizes the familiar cathode as a biasing point in series with the tube cathode and grid. The total steady plate and screen currents flow through this resistor, and the voltage drop across the current flowing through the tube and cathode bias voltage obtained on the plate is subtracted from the total voltage of the grid circuit to form a cathode-bias stage. This is necessitated because the plate-cathode voltage is reduced by the amount of the biasing resistor drop (grid voltage). In order to obtain any given plate voltage, it is necessary therefore to design the plate power supply to deliver the desired plate voltage plus the cathode resistor drop (grid voltage). This requirement frequently calls for an unreasonably large power supply for a small transmitter; and, this reason, more so than others, has lessened the popularity of cathode bias in transmitters.

Some transmitter power stages utilize a small amount of cathode bias as safety voltage in conjunction with grid-leak bias. This has proven quite successful. Since half the required grid voltage is then developed by the cathode resistor, the other half being developed across the grid-leak resistor.

The required value for any cathode bias supply may be determined from the relationship:

\[ V = \frac{R_{g}I_{g}}{1000} \]  

(9)

\[ V = \text{Desired grid voltage (volts)} \]  

\[ R_{g} = \text{Value of grid leak电阻 (milliohms)} \]  

\[ I_{g} = \text{Grid leak current (milliamps)} \]  

(10)

For class-B a.f. service, the bias circuit is intended to provide the proper plate voltage rise and thus advise for class-C operation. The required grid voltage is appro-