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LB-1058

MICROWAVE NOISE SOURCE

MODULATOR AND POWER SUPPLY

RADIO CORPORATION OF AMERICA

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Approved

Stuart Wm Seeley

Secondary standards of noise power at microwave frequencies are available in the form of gaseous discharge tubes, similar in form to commercial fluorescent lamps. These tubes require either hot-cathode starting, or else a high initial voltage pulse to break down the gas. They also require a current-limited power supply of fairly high current capacity. The circuit described here fulfills both of these requirements, and uses a minimum number of components. With an 'inductive kick' type of initiation circuit, all dc supply voltages are limited to less than 250 volts. An adjustable series resistor allows the supply to deliver currents ranging from about 50 to 250 ma. Provision is made for external square-wave modulation of the noise source, or internal 60 cycle modulation. Modulation can be effected by opening and closing a low-voltage circuit, in or external to the modulator. A voltage is available for synchronization of other circuits.

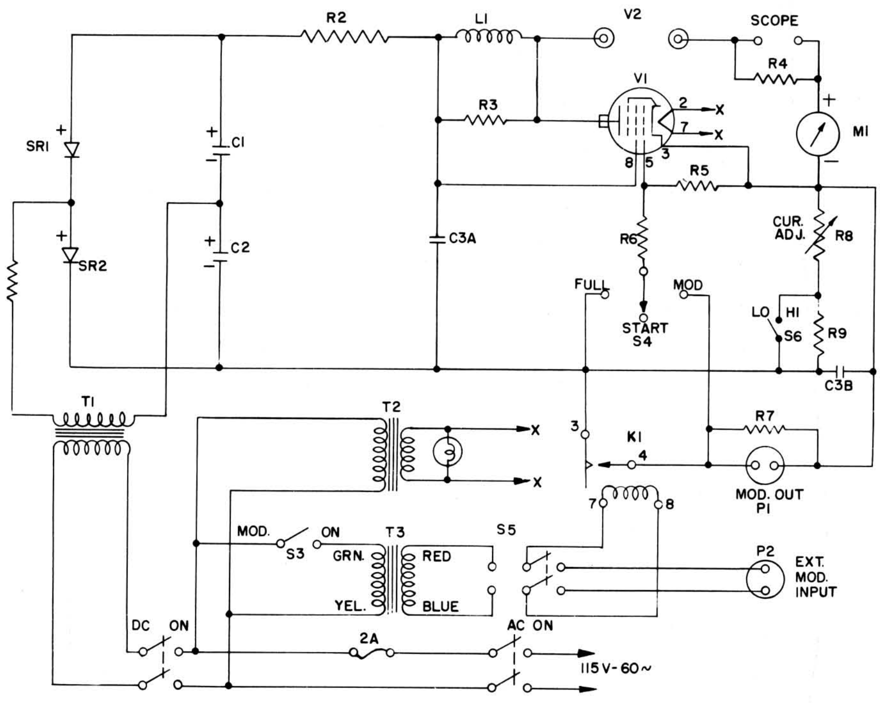
Introduction

Low-pressure gas discharge tubes and some types of commercial fluorescent lamps make excellent secondary standards of microwave power[1], generating spectrally 'white' noise at a level of about 15 decibels above ambient thermal noise. The noise output, in addition, is not critically dependent on the discharge current. The operation of certain types of noise-measuring circuits[2] requires square-wave modulation of the discharge tube. The circuit described here can operate either continuously or square-wave modulated, any commercial noise-source tube operating at currents less than 250 ma. It provides 60-cycle square-wave modulation by means of an internal relay; the relay may also be operated from an external synchronizing source, at somewhat different modulation frequencies.

Principles of Operation

The voltage required to maintain the gas discharge in a noise-source tube is usually less than 100 volts, but that required for ignition is as much as 1000 volts. Most such tubes have a directly-heated cathode to reduce the voltage required for starting; after starting, the tube can maintain a cold-cathode discharge. The present circuit eliminates the need for a heated cathode in starting, and thereby should extend the useful life of the discharge tube in modulated operation. Some earlier modulators have used a relay-switched high-voltage supply with large series resistance; this would necessitate a 1000-volt supply capable of handling 250 ma of current, which would be rather expensive, as well as inefficient. The present circuit uses a low-voltage power supply, and by means of an electronically-switched inductance provides a large starting voltage pulse. The switching relay itself does not carry the discharge current, but controls only the grid circuit of the switching tube.

Referring to the circuit diagram Fig. 1, a power transformer (T_1), of 1-to-1 ratio, isolates the circuit from the 110-volt line. A voltage-doubler supply employing solenium rectifiers provides up to 300 ma at about 250 volts. The supply is connected in series with the inductance L_1, the noise tube (V_2) a current meter (M_1), monitoring resistor R_4 (10 ohms), and a current-limiting circuit consisting of a 1K variable resistor R_8, and an additional 2250-ohm resistor R_9 (used with low-current tubes). A switch (S_5) shorts this additional resistor for currents over 100 ma. A 6CD6 beam power tube (V_1) is connected with cathode and plate across the discharge tube terminals. When the switch S_4 is in the START position, the grid of V_1 assumes approximately cathode potential; because the screen is connected to B^+, the 6CD6 conducts strongly. The voltage across the 6CD6 is therefore less than the extinction voltage of the discharge tube. When S_4 is moved to the FULL position, the grid of V_1 is connected to -B. This applies suddenly a large negative bias; V_1 is cut off, thereby producing an 'inductive kick' across L_1 (and the discharged tube V_2). Since it is designed for this type of operation, the 6CD6 does not conduct at this time, even with 1000 volts of positive plate voltage. The voltage pulse ignites the discharge tube, which then operates at a current fixed by the resistors



R1-5-4W
R2-100-10W
R3-8200-1W
R4-10-1W
R5-470K-1W
R6-51K-1W
R7-100K-1W
R8-1000W-50WATT-WW
R9-2250W-25WATT WW
C1-90MFD/450V ELEC CAP
C2-90MFD/450V ELEC CAP
C3A-50MFD/450V ELEC CAP
C3B-40MFD/450V ELEC CAP
S1-DPDT SWITCH (AC)
S2-DPDT SWITCH (DC)
S3-SPST SWITCH (MOD)
S4-DPDT SWITCH (LAMP)
S5-DPDT (MOD 60~-EXT)
S6-SPST (HI-LO)
T1-STANCOR P6160 (ISOLATION 1:1 100 WATT)
T2-STANCOR P5014 (FILAMENT 6.3V/3A)
T3-RCA-208T2 (VERTICAL. BLOCKING OSC.)
M1-0-300MA METER
K1-W.E. 276E RELAY
SR1-FTR-1090A SEL. REC. T (300MA)
SR2-FTR-1090A SEL. RECT. (300MA)
L1-THORDARDSON 20C54
V1-6CD6G TUBE
V2- GAS DISCHARGE LAMP

ALL WIRING TO BE FOR 1000V

Fig. 1 – Schematic diagram of modulator and power supply for microwave noise source.

R_8 and R_9. If the switch S_4 is moved again to the START position, the 6CD6 conducts, pulling the voltage down below the extinction voltage of the discharge tube and cutting off the discharge.

In the MOD. (modulated) position of S_4, the relay K_1 performs the switching function just described, but at a more rapid rate. Because there is very little delay in the starting and stopping operations, modulation may be applied at any frequency up to at least 80 c.p.s. The limit is largely due to the dionization time of the discharge in V_2.

In the modulated condition, there is very little change in the discharge tube current during the 'on' time, largely because of the large capacitance across the current-adjusting resistor. The 8200-ohm resistor across the inductance is chosen to minimize the change in current during the conduction time; if this resistance is made too small, the tube will fail to ignite.

The choice of the 6CD6 as the switch tube V_1 came about for two reasons: 1) it can supply enough current at low plate and screen voltages to extinguish the discharge tube, and 2) it can be cut off by a relatively small negative bias. At the time this circuit was designed, the 6CD6 was the only receiving tube meeting these requirements, but it is probable that beam-power tubes developed for horizontal-output service in color television receivers would also operate successfully. The 470 K resistor R_5 in the grid circuit of V_1 limits grid current to develop a square wave voltage which can be used for synchronizing another circuit with the discharge tube.

The RCA 208T2 transformer T_3 (a television receiver vertical-blocking oscillator type) reduces the 110-volt 60-cycle line voltage to a value suitable for operating the relay.

A high-impedance square-wave voltage applied between 6CD6 cathode and grid (across the P_1 terminals, with K_1 removed) could also be used for modulation. The relay is used here only as a convenient means for converting the sine-wave line voltage to a square wave.

A note of caution: The circuit should not be operated without a discharge lamp connected, as the peak available ignition voltage is sufficient to break down the insulation of the inductance and the terminals; this could be avoided by the addition of a spark gap. The circuit as shown in the diagram is not grounded. This may be convenient if the MOD OUT (P_1) voltage is to be used to control another circuit since the other circuit may not be grounded. The left-hand P_1 terminal must not be connected to a highly capacitive circuit, otherwise an insufficiently high ignition voltage will be produced.

Conclusions

The circuit described satisfies the requirements for starting, running, and modulating a gas-discharge noise-source tube over a wide range of discharge currents. It is highly efficient, and employs only readily-available components.

Circuits of this type have been in use without breakdowns for nearly two years at RCA Laboratories, operating with three different types of noise-source tubes operating in the frequency range from 3000 to 12000 N, and with discharge currents of 70 to 200 ma.

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R. D. Hughes

References

1. H. Johnson and K. R. DeRemer, 'Gaseous Discharge Super-High-Frequency Noise Sources', *Proc. IRE* 39 pp. 908-914, Aug., 1951.

2. R. W. Peter, 'Direct-Reading Noise-Factor Measuring System' *RCA Review* XII, pp. 269-281, June 1951.