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WIRED-RADIO CONTROL CIRCUITS

Wired-radio, or carrier-current, systems are used in both communications and control applications. The r-f signals are transmitted and received over the power lines. Since the signals normally are not radiated, no transmitting license is required. Wired radio has both serious and hobby applications.

Wired-radio communications covers a wide field ranging from the "over-the-line" telephone systems of the electric power companies to the simple intercoms, used in homes and offices, for which no special lines need be strung. Similarly, wired-radio control systems permit a wide variety of remotely-located devices to be turned on or off from a convenient control point. This article is concerned only with the non-commercial control function of wired radio.

In simple control systems, the standby receiver operates a relay when energized by the control signal. The relay, in turn, switches the a-c power to the controlled device. When the power required by the controlled device exceeds the contact ratings of the receiver relay, the latter is made to actuate a heavier slave relay. For interaction, the transmitter and receiver simply are plugged into the same power line.

Some of the jobs which can be done with simple wired-radio control include door and gate opening, lamp switching, receiver switching, operation of remote counter, alarm operation, motor control, etc. In short, the scope of application includes virtually any operation which can be performed through the opening and closing of a relay.

The radio frequency employed in carrier-current operation must be low enough to prevent appreciable radiation from the power lines or interference to radio reception by transmission through receiver power supplies. Frequencies in the range 40 to 200 kc commonly are used. All equipment described in this article is designed for 50-kc operation, although the transmitters and receivers each may be tuned somewhat lower and higher than this frequency.

Two simple transmitter and two receiver circuits are described in this article. The r-f power output of the transmitters is low enough to forestall unauthorized radiation of signals from the power line, but high enough to operate the receivers reliably under average conditions of use. While these are not the only circuits which may be employed for wired-radio control, their simplicity and reliability are to be recommended.

Transmitter Circuits

Transformer - Coupled Circuit. See Figure 1. This transmitter employs a triode-connected 6AQ5 tube in a self-excited Hartley oscillator circuit. A fixed tank capacitor (C_2) and slug-tuned tank coil (L_2) are provided. Radio-frequency output is delivered to the power line by the coupling coil, L_1, which consists of 5 turns of insulated hookup wire wound tightly around the outside of L_2. Blocking capacitor C_1 prevents short-circuit of

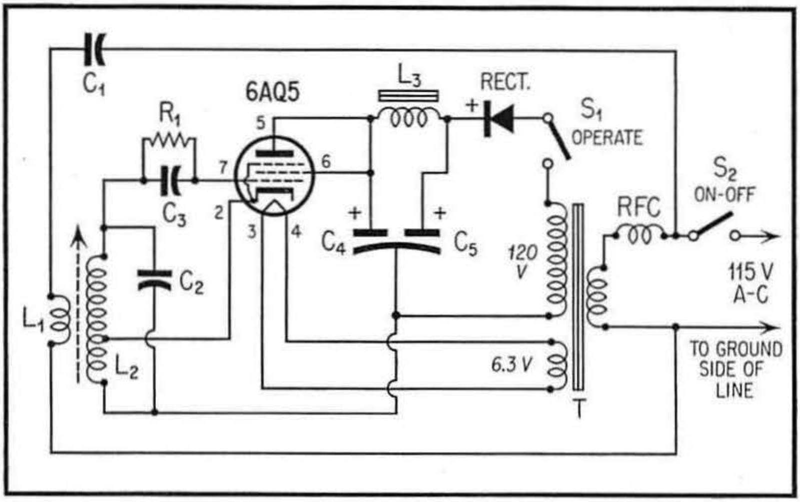

Fig. 1. Transformer-Coupled Wired-Radio Transmitter.

the power line by L_1 while providing easy transmission of the 50-kc energy. (The 60-cycle reactance of C_1 is 26,000 ohms, while the 50-kc reactance is only 26 ohms). The line radio-frequency choke coil, RFC, blocks the path of the r-f output currents back through the primary of power transformer T.

D-C power for the plate and screen of the tube is provided by a simple half-wave power supply (T-RECT-L_3-C_4-C_5). The transmitter is placed into operation to control the distant receiver by depressing pushbutton switch S_1.

The transmitter is tuned to 50 kc by adjustment of the slug of coil L_2. A wavemeter, heterodyne frequency meter, or low-frequency c-w receiver may be used to check the operating frequency. For 50 kc, the inductance of L_2 is set approximately to 2 millihenries.

Transformerless Circuit. See Figure 2. The power transformer is dispensed with in this Hartley oscillator circuit. D-C power for the plate and screen of the triode-connected 50C5 tube is obtained from the selenium rectifier, RECT, operated directly from the a-c power line. Filtration is provided by resistor R_3 and capacitor C_3. The 50-volt filament of the tube is operated from the line through dropping resistor R_4.

This transmitter employs the principal outlined by Warner Clements.[1] Here, the power line and the input circuit of the remote receiver are included in the series-resonant tank circuit (L-C_1) of the transmitter. The circulating r-f tank current thus flows over the line and through the receiver. The transmitter is tuned by adjustment of the slug of coil L. The frequency 50 kc is reached when the inductance of L is set approximately to 2 millihenries. The transmitter is placed into operation to control the remote receiver by depressing pushbutton switch S_1.

Radio-frequency choke coil RFC_1 blocks the path of transmitted energy back into the d-c power supply section. Similarly, radio-frequency choke coil RFC_2 blocks the path of transmitter output back through the filament of the tube.

Since this circuit is transformerless, it can constitute a shock hazard. For this reason, no part of the circuit should be connected to the chassis or metal housing of the transmitter. In some instances, the greater simplicity and smaller size of this transmitter will cause it to be preferred to the bulkier transformer-type unit shown in Figure 1.

Receiver Circuits

Both receivers use semiconductor elements rather than tubes. This promotes greater reliability by removing the possibility of tube burnout. The diode-type circuit (Figure 3) draws no standby current at all. The diode-and-transistor circuit (Figure 4) draws very little standby current.

Diode-Type. This circuit employs a simple crystal detector and a sensitive, microammeter-type d-c relay. The diode is a high-conductance type (Hughes HD2150).

The circuit is pre-tuned by means of the slug-type coil, L. Tuning is broad, since the power line is connected across the tuned circuit through blocking capacitor C_2. The circuit is tuned roughly to 50 kc when the inductance of L is set to 5 millihenries.

The high sensitivity of this circuit is provided by the sensitivity of the relay, RY. The latter is a "Sensitrol" type relay having a permanent-magnet stationary contact. The magnetic contact attracts the movable contact and holds it in closure until the contacts

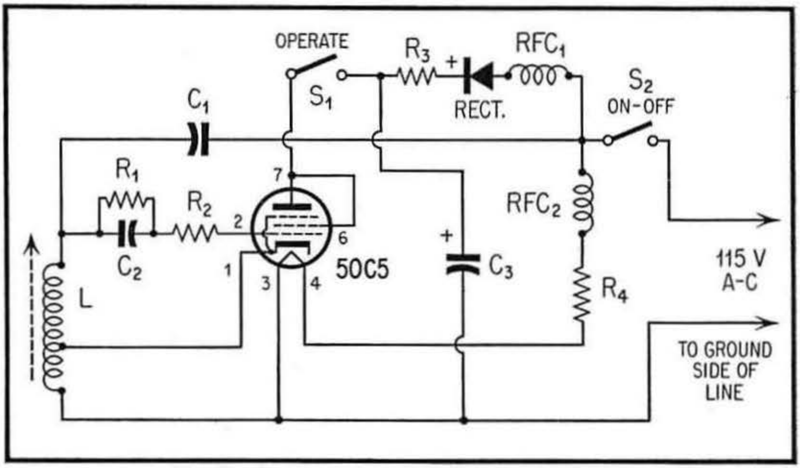

Fig. 2. Transformerless Wired-Radio Transmitter.

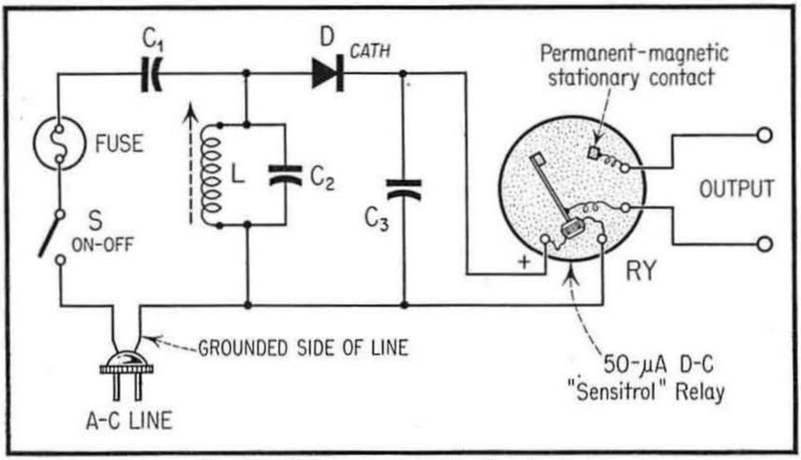

Fig. 3. Diode-Type Wired-Radio Receiver.

are separated by a manual or electrical re-set mechanism. This circuit is satisfactory only for non-repetitive applications such as door-opening, where the subsequent manual closing of the door can be used to re-set the relay.

While the magnetic hold-in, meter-type relay is high-priced (unless found in surplus), its use is justified by the reliability of this device and its high sensitivity which replaces amplifiers in the circuit. An additional advantage is the positive hold-in action which resists vibration, a feature which would not be obtained in a conventional meter-type relay without the magnetic stationary contact.

Diode-Transistor Circuit. See Figure 4. In this receiver circuit, a heavier, milliampere-type d-c relay is operated by a single transistor d-c amplifier which receives its d-c signal excitation from the output of a diode detector. The relay, RY, is a 2-ma, 8000-ohm unit.

Here, tuning is accomplished by adjustment of the slug of coil L_2. R-F energy transmitted over the power line is coupled into the tuned circuit, L_2-C_2, through L_1 which consists of 10 turns of No. 20 d. c. c. wire close-wound around the outside of L_2. Blocking capacitor C_1 prevents short circuit of the power line through L_1, while affording relatively easy passage to the r-f signal current. Resistor R_1 and capacitor C_3 form a simple filter for attenuation of any line-frequency energy which might be coupled in from the power line along with the received r-f signal.

Collector d-c voltage is furnished by a line-operated power supply consisting of 6.3-volt transformer T, diodes D_2 and D_3, and capacitors C_4 and C_5. The power supply circuit is a voltage doubler which, at the low drain of the transistor, has an output of approximately 17 volts dc. Until the actuating signal is received and diode D_1 delivers current, the transistor collector current is only a few microamperes.

When the relay closes, 6.3 volts ac from transformer T are delivered to the OUTPUT terminals. This voltage may be employed to operate an auxiliary heavy-duty relay or directly to sound an alarm or operate any other 6-volt a-c device.

R-F choke coil, RFC, prevents short circuit of the r-f signal by blocking the passage of r-f currents into the primary winding of transformer T.

Operating Notes

The first question usually asked about amateur wired-radio control equipment is: "What is the operating range?" Unfortunately, there is no pat answer. The power line represents a low and variable impedance. It is particularly low when several appliances or lamps are in operation simultaneously. The greater the number of such appliances in use, the more difficult it becomes to develop a useful r-f voltage across the line. However, tests indicate that any combination of the transmitter and receiver circuits shown in this article will give consistently reliable operation throughout a small building. How far the range can be extended down the neighborhood depends upon many variables such as the length of the intervening line, whether the power lines are overhead or underground (overhead lines tend to give longer-distance operation, probably because

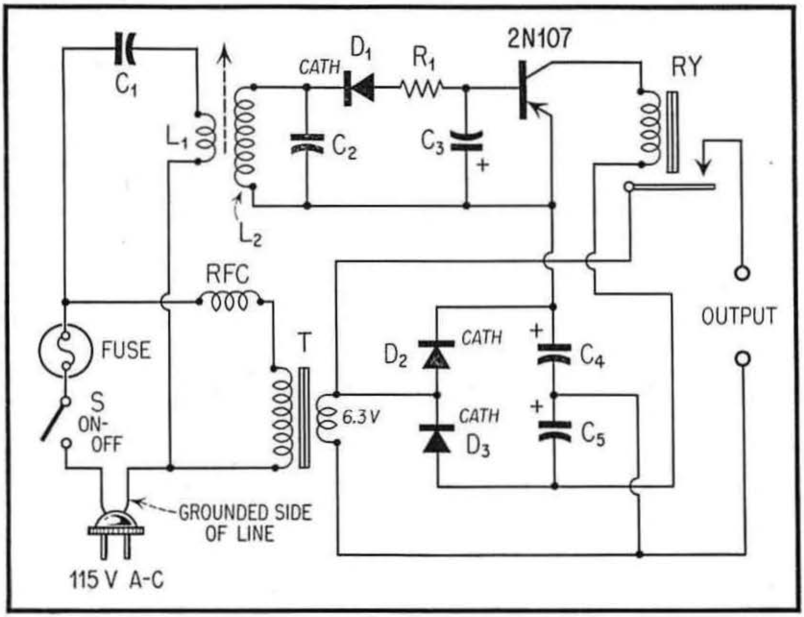

Fig. 4. Diode-Transistor-Type Wired-Radio Receiver.

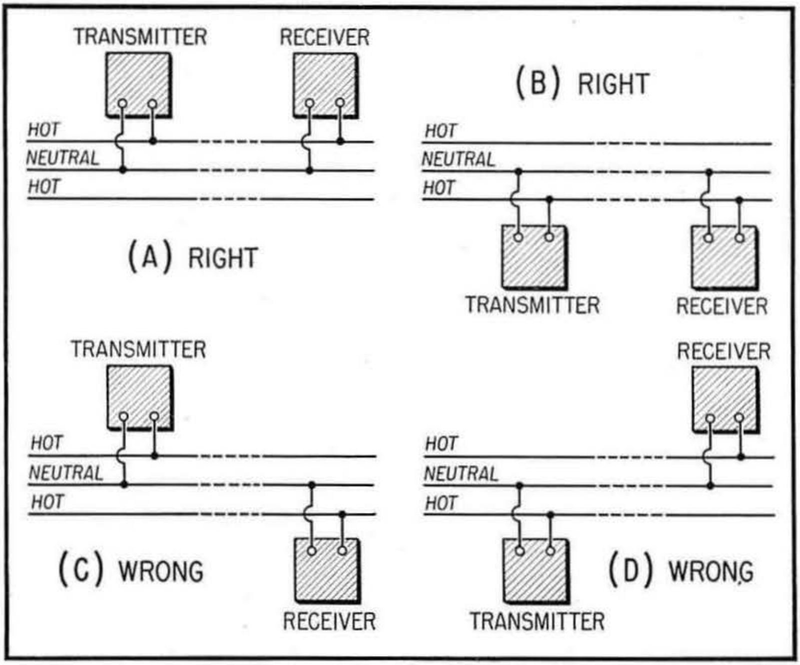

Fig. 5. Connections To 3-Wire Service.

of lower shunting capacitance), the number of appliances in operation in other buildings along the route, and whether separate distribution transformers are encountered. (It is seldom possible to transmit a useful amount of signal through a transformer when using low-powered amateur equipment.)

When three-wire service is used, both transmitter and receiver must be connected to the same side of the service. Figure 5 shows the right and wrong ways of making these connections.

Wired-radio transmitters and receivers should be adequately fused. When working with this equipment, the operator should take care to protect himself from line-voltage shocks and should build his equipment carefully to prevent accidental short circuits which could cause a fire as well as blowing the service fuses.

Before placing any type of carrier-current equipment into use, the operator should check with his local power company to ascertain if his intended frequency is being used already by the company in its operations. Some power companies employ carrier-current switching devices, and amateur transmitters could cause interference to these services. When this is determined, the amateur transmitter should be tuned far enough out of the range of such commercially-used frequencies to prevent interference.

Reference

1. **Carrier-Controlled Switching.** Warner Clements. RADIO & TELEVISION NEWS, February 1955, p. 68.

PARTS LIST FOR FIGURE 1

C_1—0.1 ufd 600 v tubular — (C-D PM 6P1)

C_2—0.0051 ufd 500 wvdc mica — (C-D 1A5D51)

C_3—100 uufd mica — (C-D 5W5T1)

C_4-C_5—Dual 2-ufd 250 dcwv electrolytic — (C-D BBRD 2225)

L_1—5 turns insulated hookup wire closewound around L_2

L_2—0.5-5-mh tunable inductor (tapped) — Miller 6323

L_3—8 hy 100 ma filter choke — Merit C-2995

R_1—10,000 ohms 2 watts

RECT—75-ma selenium rectifier

RFC—Line filter choke: 0.6 mh, 2 amps — Miller 7825

S_1—Spst, normally-open pushbutton switch

S_2—Spst toggle switch

T—Midget power transformer: 120 v, 50 ma; 6.3 v, 2 A — Merit P-3045

PARTS LIST FOR FIGURE 2

C_1—0.005 ufd 500 v mica — (C-D 1W5D5)

C_2—150 uufd mica — (C-D 5W5T15)

C_3—50 ufd 250 dcwv electrolytic — (C-D BR 5025)

L—0.5-5-mh tunable inductor (tapped) — Miller 6323

R_1—10,000 ohms 2 watts

R_2—120 ohms 1 watt

R_3—33 ohms 1 watt

R_4—400 ohms 20 watts wirewound (Ohmite Brown Devil)

RECT—75-ma selenium rectifier

RFC_1, RFC_2—2½ mh, 200 ma r-f chokes — Miller 5222

S_1—Spst, normally-open pushbutton switch

S_2—Spst toggle switch

PARTS LIST FOR FIGURE 3

C_1—0.005 ufd silvered mica — (C-D 1DR5D5)

C_2—0.002 ufd silvered mica — (C-D 1R5D2)

C_3—0.01 ufd mica — (C-D 1D3S1)

D—High-current germanium diode — Hughes HD2150

L—1.5-10-mh tunable inductor — Miller 6322

RY—50-microampere, magnetic hold-in, meter-type d-c relay — Weston Sensitrol or equivalent

S—Spst toggle switch

PARTS LIST FOR FIGURE 4

C_1—0.1 ufd 600 v tubular — (C-D PM 6P1)

C_2—0.002 ufd silvered mica — (C-D 1R5D2)

C_3—1 ufd 6 dcwv subminiature electrolytic — (C-D NL 1-6)

C_4, C_5—50 ufd 25 v tubular electrolytics — (C-D BBR 50-25)

D_1, D_2, D_3—1N34 germanium diodes

L_1—10 turns No. 20 d. c. c. wire closewound around outside of L_2

L_2—1.5-10-mh tunable inductor — Miller 6322

R_1—1000 ohms ½ watt

RFC—2½ mh, 200 ma r-f choke — Miller 5222

RY—2-ma, 8000-ohm d-c relay — Sigma 4-F

S—Spst toggle switch

T—6.3-volt 1-ampere filament transformer — Merit P-3074