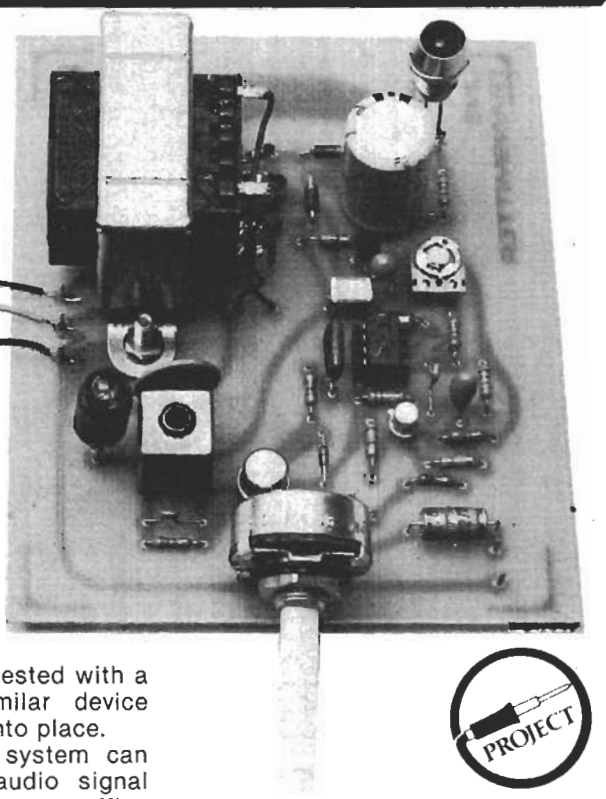
WIRED SOUND

A system for distributing a Hi-Fi or other audio signal to any number of remotely-located speakers, using the power lines as the communication link.



THIS UNUSUAL PROJECT is designed to distribute an audio signal to any number of speakers that are remotely-located throughout a house or office building, using the power lines as the communication link. The system has an overall audio frequency response that extends to 20 kHz, with typically less than 0.5% total harmonic distortion and is designed to deliver a maximum of about 2 watts to each speaker. The system rejects all unwanted noise and has an overall audio sensitivity of about 10 mV for 2 watts output on each speaker.

The system comprises a single transmitter unit and any required number of remotely-located receiver/amplifier units. The transmitter unit generates a 200 kHz carrier signal, which is frequency modulated by the audio input signal and which the transmitter superimposes on the neutral line of the 120 volt AC wiring. At each receiver unit, this FM signal is picked up from the lines, is amplified, demodulated and the resulting audio signal is then fed to an external eight ohm speaker via a 2 watt power amplifier IC.

The transmitter and each receiver unit is provided with its own volume control. Each receiver unit is also provided with an automatic mute facility, which disables its audio output when the transmitter is turned off. All units are line powered and simply plug into existing wall sockets, no other interconnections being required. All units incorporate a variety of safety features, but it is essential for correct operation that the sockets be wired in the correct polarity: each socket should thus be tested with a neon indicator or similar device before plugging a unit into place.

The Wired Sound system can readily distribute an audio signal throughout an entire house or office building and has a variety of practical applications. In the home, it can be used to transmit the output of a music centre or other audio source to all rooms in the building. Alternatively, the transmitter can be fitted with a microphone and pre-amp and used as a baby alarm, enabling the baby to be heard from any part of the house.

In an office, the transmitter can be coupled to a mixer unit and used to distribute music signals and announcements throughout the entire building without the expense of having to fit additional wiring.

Construction: The Transmitter

The entire transmitter unit, including the power transformer, is assembled on a single PCB. Construction should present few problems if the usual precautions are taken to ensure that all semiconductor devices and electrolytics are fitted in the correct polarity.

When construction is complete, set the core of L2 and the slider of RV1 to mid position. If you have a 'scope, give the unit a functional check by checking that a signal of a few hundred mV at about 200 kHz is present across the output terminals of T2: set the frequency to precisely 200 kHz via RV1 and trim the core of T2 for maximum output.

You can, if you wish, case the complete unit; our own prototype is uncased, as it is intended to be built into an existing audio amplifier system.

Construction: The Receiver

Most of the receiver unit (except T1, RV2, SW1 and LED 1) is wired up on a single PCB. Construction should present few problems if the overlay is followed with care. When construction is complete, fit the PCB and remaining components into a suitable case and complete the interconnections to T1, RV2, SW1 and LED 1, as indicated on the overlay and the circuit diagram.

When construction is complete, set the core of T2 and the slider of RV1 to their mid position, connect the output of the unit to an eight ohm speaker and switch the unit on. With mute switch SW1 on, little noise should come from the speaker: with SW1 off, lots of 'white' noise should come from the speaker, indicating that the system is functional. If you have a 'scope, monitor pins 4-5 of IC1 and adjust RV1 to obtain a frequency of about 400 kHz.

Setting Up The System

Access to a 'scope is needed when initially setting up the system, as follows.

Switch on both units and apply a suitable audio (music) signal to the input of the transmitter. Turn the transmitter volume control to zero,

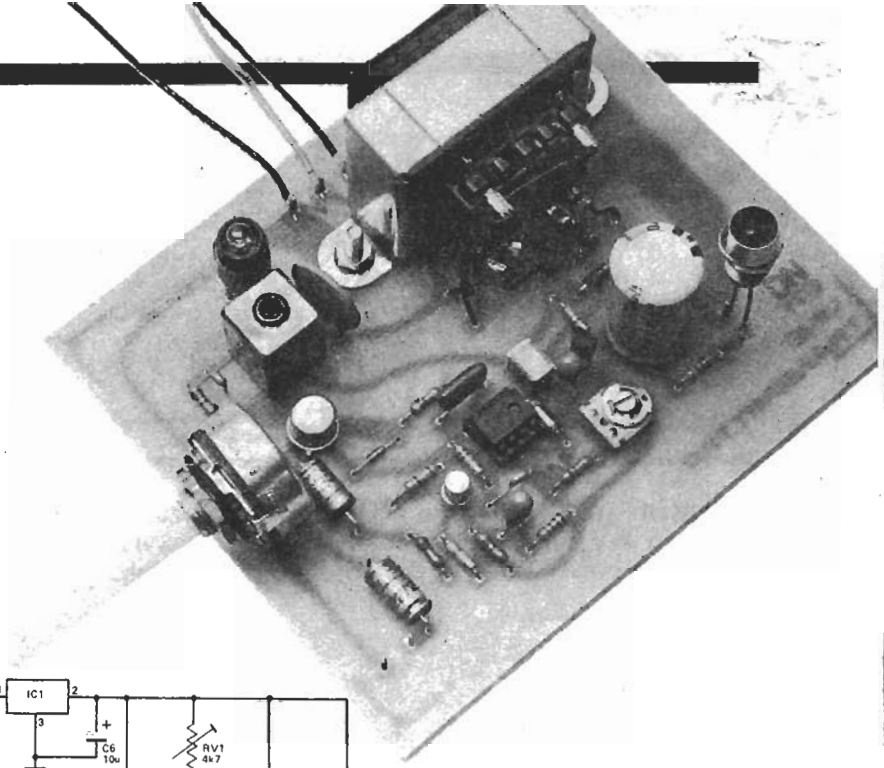
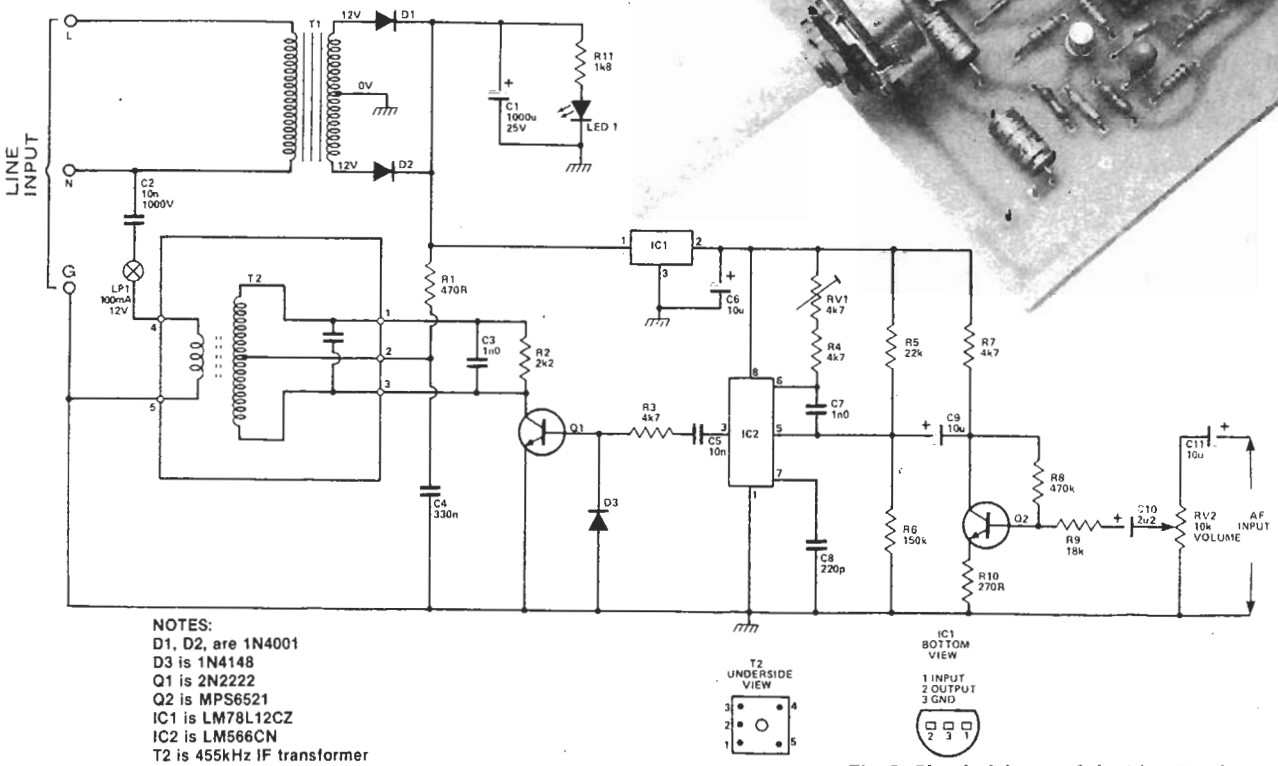
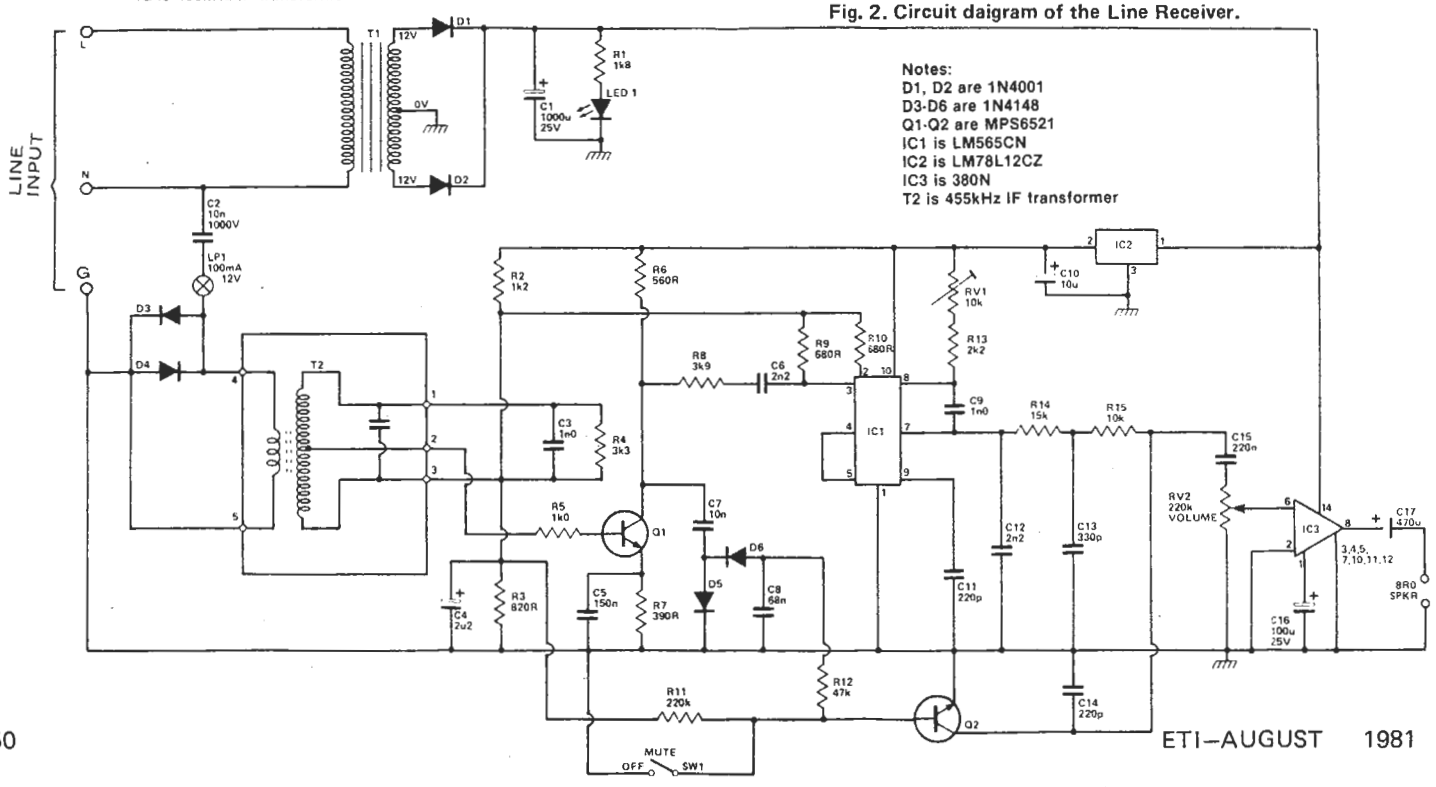


Fig. 1. Circuit diagram of the Line Transmitter.



NOTES:
D1, D2, are 1N4001
D3 is 1N4148
Q1 is 2N2222
Q2 is MPS6521
IC1 is LM78L12CZ
IC2 is LM566CN
T2 is 455kHz IF transformer

Fig. 2. Circuit daigram of the Line Receiver.



Notes:
D1, D2 are 1N4001
D3-D6 are 1N4148
Q1-Q2 are MPS6521
IC1 is LM565CN
IC2 is LM78L12CZ
IC3 is 380N
T2 is 455kHz IF transformer

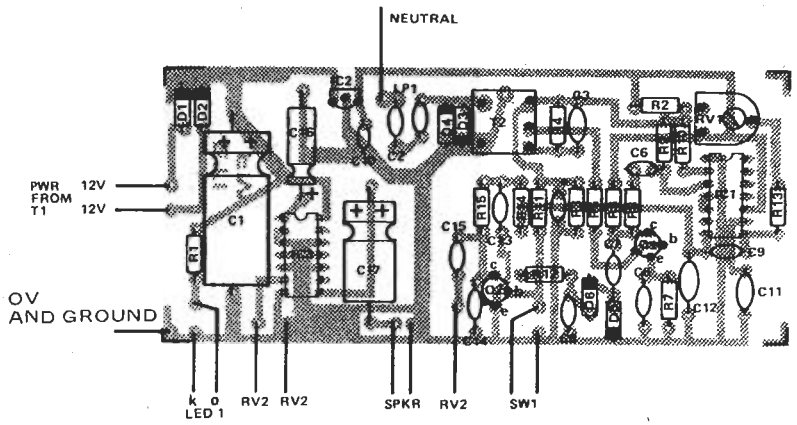


Fig. 3. Component overlay for the transmitter board.

use the 'scope to monitor pin 2 of T2 in the receiver and adjust T2 core for maximum signal. Next, monitor pins 4-5 of IC1 in the receiver and set RV1 to the mid position at which locking to the 200 kHz carrier occurs. Finally, set the receiver volume control to mid value and adjust the transmitter volume control so that the music signal is heard at the receiver without apparent clipping. The system is then complete and ready for use throughout the house or office. ●

PARTS LIST

TRANSMITTER

Resistors All ¼W, 5%

R 1	470R
R 2	2k2
R 3 , 4 , 7	4k7
R 5	22k
R 6	150k
R 8	470k
R 9	18k
R 1 0	270R
R 1 1	1k8

Potentiometers

R V 1	4k7 min horiz preset
R V 2	10k log

Capacitors

C 1	1000u 25V PCB electrolytic
C 2	10n 1000V disc ceramic
C 3	1n0 polester
C 4	330n polycarbonate
C 5	10n polyester
C 6 , 9	10u 16V tantalum
C 7	1n0 ceramic
C 8	220p polystyrene'
C 1 0	2u2 16V electrolytic
C 1 1	10u 16V electrolytic

Semiconductors

I C 1	78L12
I C 2	LM566CN
D 1 , 2	1N4001
D 3	1N4148
Q 1	2N2222
Q 2	MPS6521
L E D 1	0.2 in red LED

Miscellaneous

T1 12-0-12 6VA transformer, 12V 100mA bulb. TR-103 IF Transformer, Armaco 12-0-12 transformer 6VA, 12V 100 mA .

RECEIVER

Resistors All ¼W, 5%

R 1	1k8
R 2	1k2
R 3	820R
R 4	3k3
R 5	1k0
R 6	560R
R 7	390R
R 8	3k9
R 9 , 1 0	680R
R 1 1	220k
R 1 2	47k
R 1 3	2k2
R 1 4	15k
R 1 5	10k

Potentiometers

R V 1	10k min horiz preset
R V 2	220k

Capacitors

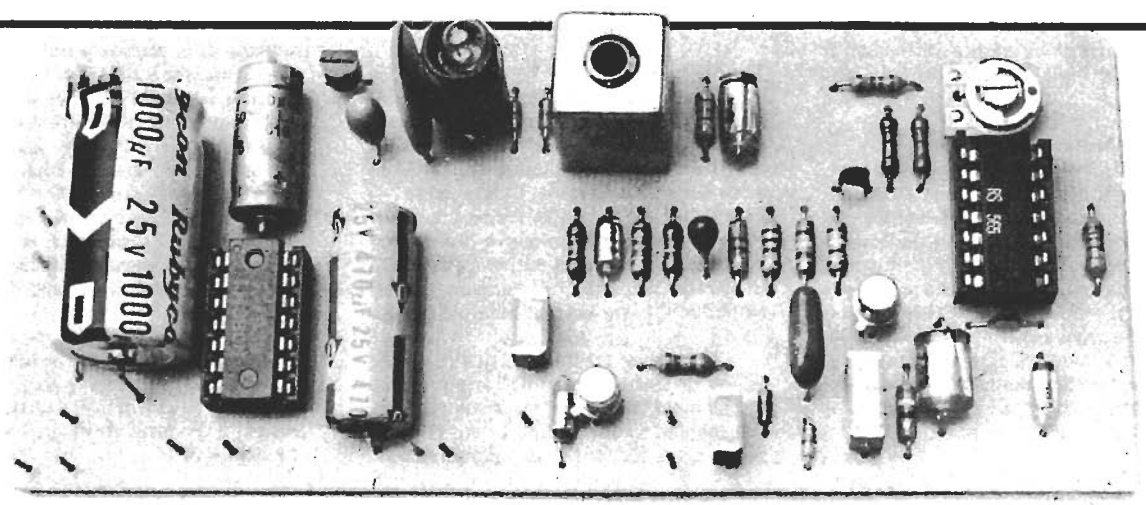
C 1	1000u 25V electrolytic
C 2	10n 250V AC ceramic
C 3	1n0 polystyrene
C 4	2u2 tantalum
C 5	150n polycarbonate
C 6	2n2 ceramic
C 7	10n polyester
C 8	68n polycarbonate
C 9	1n0 ceramic
C 1 0	10u tantalum
C 1 1 , 1 4	220p polystyrene
C 1 2	2n2 polystyrene
C 1 3	330p polystyrene
C 1 5	220n polycarbonate
C 1 6	100u 25V electrolytic
C 1 7	470u electrolytic

Semiconductors

I C 1	LM565CN
I C 2	LM78L12CZ
I C 3	LM380N
Q 1 , 2	MPS6521
D 1 , 2	1N4001
D 3 , 4 , 5 , 6	1N4148
L E D 1	any LED

Miscellaneous

12-0-12 transformer 6VA, 12V 100 mA bulb, 8 ohm loudspeaker, TR-103 IF Transformer (Armaco)



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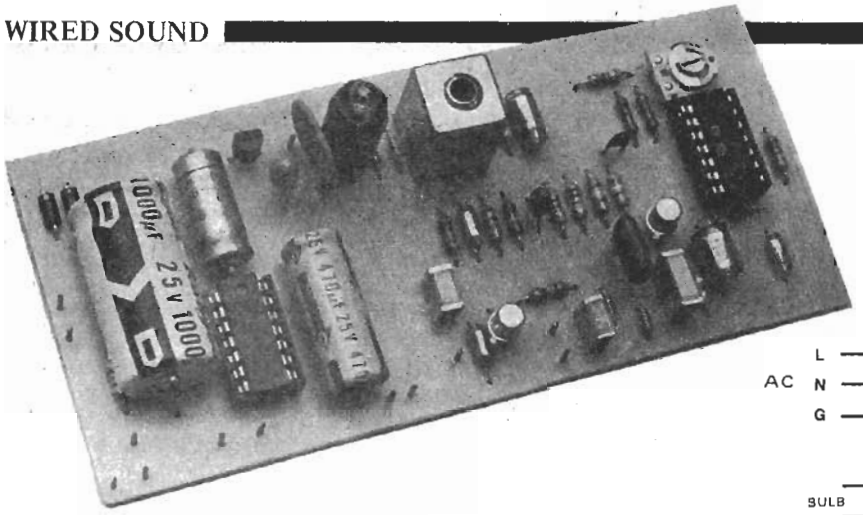

A fully assembled line receiver PCB. Note the polarity of the ICs and polarised components.

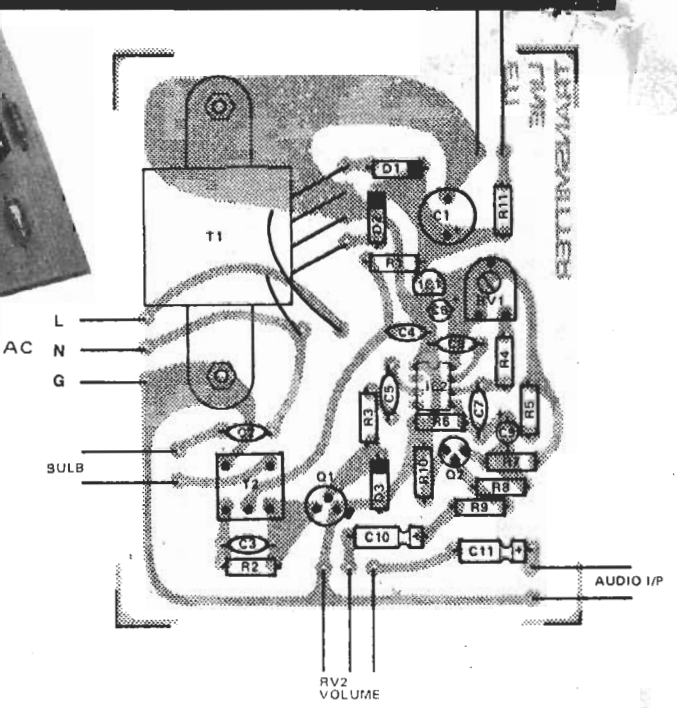

Fig. 4. Component overlay of the receiver.

HOW IT WORKS

The system is designed to transmit an audio signal to any number of remotely-located receiver/speaker units, using the AC wiring as the communication link. The transmitter produces a low-level 200 kHz carrier signal, frequency modulated by the audio signal, which it superimposes on the neutral side of the power lines. At each receiver unit, the carrier signal is picked up from the wall plug amplified, demodulated and the resulting audio signal is passed on to a speaker via a 2 watt audio amplifier IC. The use of an FM link ensures a good audio response and excellent noise rejection.

System operation relies on the fact that the AC wiring is highly inductive and acts as a fairly high impedance to a 200 kHz signal. At this frequency, the wiring can be regarded as an inductive potential divider, with the power sub-station at its 'low' end. This 'divider' normally produces relatively little signal attenuation between power points that are separated by dozens or hundreds of metres of wiring and can be used as an excellent built-in 'data link' in any home.

The Transmitter

IC2 is a voltage-controlled oscillator, or VCO. Its operating frequency is determined by the values of RV1-4 and C8 and by the voltage on pin 5. With the component values shown, the VCO operates at a centre frequency of 200 kHz and produces a square wave output at pin 3. This output is used to drive common emitter amplifier Q1, which uses a standard IF transformer (T2) as its collector load; the centre frequency of T2 is shifted to 200 kHz by C3 and its 'Q' is reduced to a fairly low value (to give a broad-band response) by R2. The output signal on T2 secondary (pins 4 and 5) has an amplitude of a few hundred mV rms.

Audio input signals to the unit are fed to volume control RV2 via C11 and then subjected to about 20 dB of amplification via Q2. The output of Q2 is used to frequency modulate the VCO via C9 and pin 5. Consequently, the output of T2 is a 200 kHz 'carrier' signal frequency modulated by the audio signal. This output is coupled into the neutral line of the AC wiring via low-value capacitor C2 and current-limiting 'fuse' LP1. Note that one side of T2 output is wired to the ground side of the line, thereby ensuring that standing DC potentials of only a few volts exist between the primary and secondary windings of the transformer. C2 and LP1 ensure that the system will not be damaged if the output signal is accidentally fed to the live, rather than the neutral, side of the line.

Q2 and IC2 are powered from a regulated supply via IC1, a 12 volt regulator.

The Receiver

The 200 kHz frequency-modulated line signal is picked up on the input of T2 via C2 and current-limiting 'fuse' LP1; D3 and D4 are used to limit the T2 signal amplitudes to a few hundred millivolts. T2 is tuned to 200 kHz via C3 and has its 'Q' reduced to a fairly low value via R4, to give a broad-band response. The isolated output signal of T2 is fed to the base of common emitter amplifier Q1 via current-limiting resistor R5.

The base of Q1 is biased to 4V5 via the R2-R3 divider network. Q1 is overdriven by the input signal and has its output clipped at about 6 volts peak-to-peak. The output of Q1 is fed to the pin 3 input terminal of IC1 via R8-C6-R9. IC1 is a phase locked loop and is used to demodulate the 200 kHz FM carrier signal. This IC contains a reference oscillator, which is set to the same centre frequency as the carrier via RV1-R13 and C11. The demodulated audio signal appears at pin 7 of IC1. C12-R14-C13-R15-C14 are used to filter out any vestiges of the carrier and the resulting 'clean' audio signal is passed on to volume control RV2 via C15. The output of the volume control is fed to 2-watt audio amplifier IC3 and is then passed on to an external eight ohm speaker via C17. Most of the circuit (other than IC3) is powered from a stabilised supply via IC2, a 12 volt regulator.

The receiver unit is provided with an automatic 'mute' facility, which kills the audio output in the absence of a carrier signal, via Q2 and its associated network. Q2 is wired across the input to the volume control and kills the audio signal when biased on. Q2 is biased from two independent sources. It is positively biased (biased on) via R11 and the R2-R3 potential divider and can also be negatively biased (biased off) from the output of Q1 via the C7-D5-D6-C8-R12 rectifier network. The values of R11 and R12 are chosen so that the negative bias is predominant and Q2 is turned off in the presence of a carrier signal in excess of about 1V5 at Q1 collector. In the absence of a suitable carrier signal the negative bias falls to a negligible value and Q2 is turned on via R11.

The automatic mute circuit can be disabled by closing SW1, in which case the phase-locked loop tries to lock on to noise signals in the absence of a carrier and consequently produces very high noise levels at the output of IC3.

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