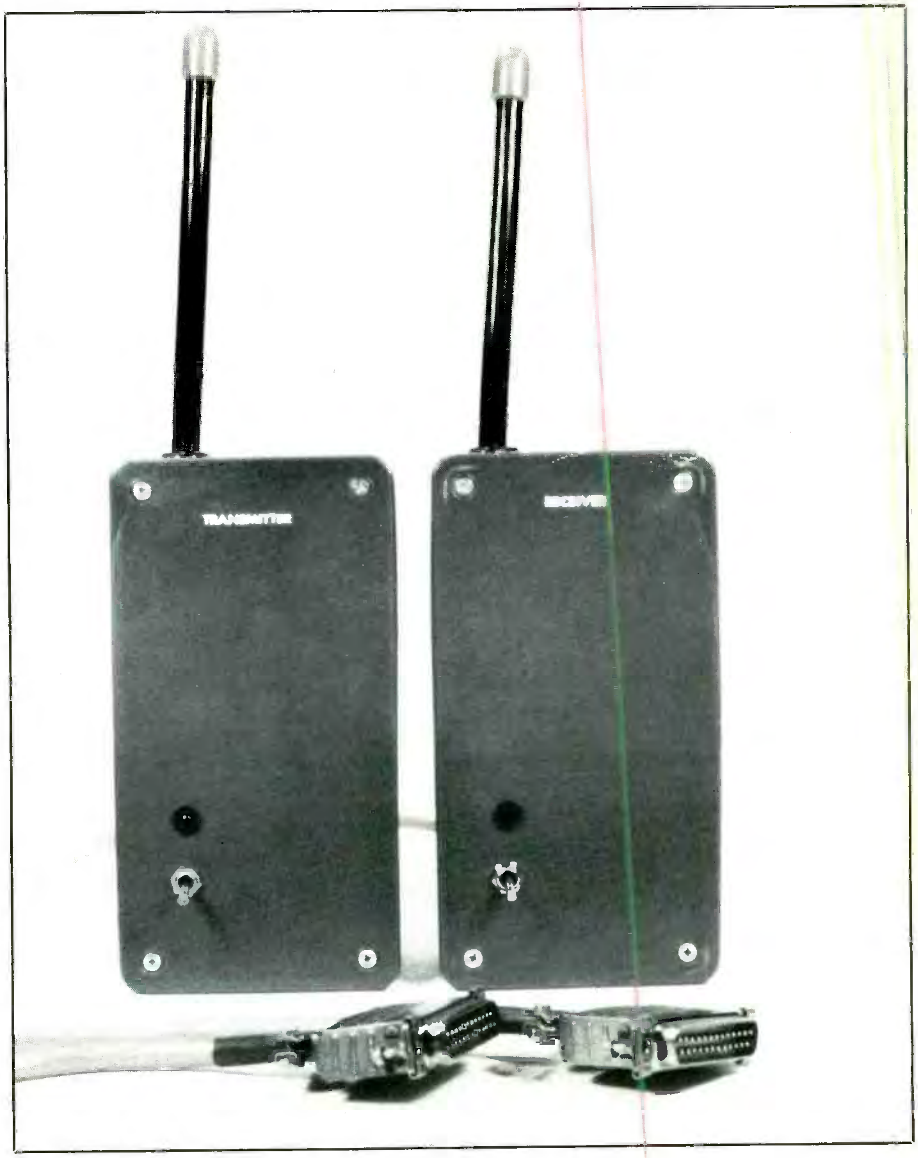
A Wireless Data Link

This 300-baud accessory eliminates the need for long cable runs when connecting serial peripherals to a computer

By Jan Axelson & Jim Hughes



The RS232 serial interface has become a popular way to send data from a computer to another computer, remote terminal, printer, or other serial device. However, when the devices to be interconnected are located in different rooms or are on different floors, running a cable between them isn't always convenient or even practical. For situations like these, you need a device like the Wireless Data Link to be described. This handy device does away with the need for the connecting cable, using radio waves instead of physical cables to link together RS232 data transmit/receive devices. It operates at a transmission speed of 300 baud.

About the circuit

Design of the circuitry for this project was greatly simplified due to use of two convenient building blocks. One is National Semiconductor's 74HC943 single-chip modems that convert digital data into audio-frequency tones that can easily be transmitted on an r-f carrier and, at the receiving end, converts the tones back into digital data square waves. The other building block is Radio Shack's Space Patrol walkie-talkies that are used here as transmitters and receivers of the audio signals. These operate on the 49-MHz citizens band.

Portability isn't a criterion for this project. Therefore, the circuits are powered by ac-operated 9-volt dc power supplies or batteries. Whichever powering option is used, the system can accept and generate bipolar RS232-compatible signals, at a communication speed of 300 bits per second.

Shown in Fig. 1 is the schematic diagram of the very simple (in terms of component count) transmitter modem circuit. It is designed to reside between the computer's or other device's RS232 interface and the input to transmitting walkie-talkie. Regulated 5 volts dc for modem chip

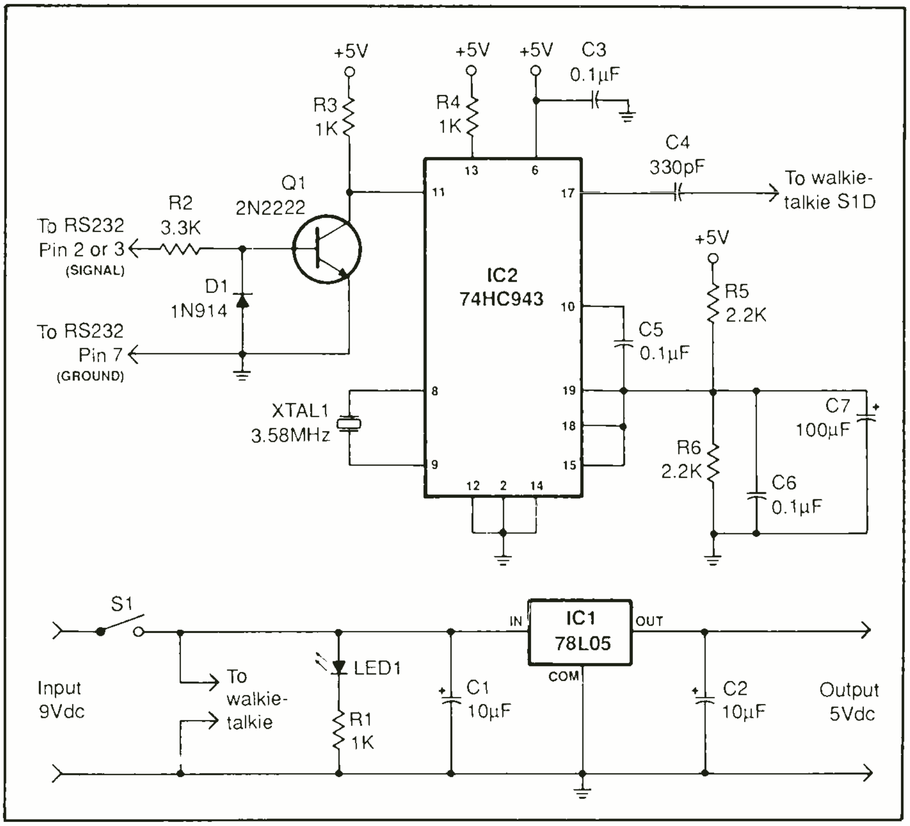


Fig. 1. Schematic diagram of the transmitter unit from the RS232 interface to the input to the walkie-talkie.

PARTS LIST

Semiconductors

D1—1N914 or similar silicon diode
D2,D3—1N270 germanium diode
IC1,IC3—78L05 +5-volt regulator
IC2,IC6—74HC943 300-baud modem (National Semiconductor)
IC4—555 timer
IC5—1488 quad line driver for RS232
LED1,LED2—Light-emitting diode (high-intensity recommended)
Q1—2N2222 or similar npn transistor

Capacitors (16 WV minimum)

C1,C2,C8,C9,C11,C12—10-µF electrolytic
C3,C5,C6,C13,C14,C15,C16—0.1-µF ceramic
C4—330-pF ceramic
C7,C17—100-µF electrolytic
C10—0.001-µF ceramic

Resistors (¼-watt, 10% tolerance)

R1,R3,R4,R7—1,000 ohms
R2—3,300 ohms
R5,R6,R9,R10—2,200 ohms
R8—68,000 ohms

Miscellaneous

XTAL1,XTAL2—3.579545-MHz crystal
S1,S2—Spst toggle or slide switch
Printed-circuit boards (2) or perforated board with holes on 0.1" centers and suitable Wire Wrap or soldering hardware; two Archer Space Patrol walkie-talkies (Radio Shack Cat. No. 60-4015); DIP sockets for IC2, IC4, IC5, and IC6; suitable enclosures (2); two subminiature D-type RS232 connectors; rubber grommets; two 9-volt batteries and battery clips or two 9-volt dc power supplies and connecting jacks (see text); panel clips for LEDs (2); 2-conductor cable; machine hardware; hookup wire; solder; etc.

IC2 is provided from the 9-volt dc source by regulator *IC1*. Light-emitting diode *LED1* serves as a convenient POWER-on indicator.

Data to be transmitted is fed from the RS232 interface through resistor *R3* to the base of transistor *Q1* in the Fig. 1 circuit. According to the RS232 standard for bipolar data signals, a transmitted logic 1 is represented by a potential between −5 and −15 volts, a logic 0 between +5 and +15 volts. Transistor *Q1*, diode *D1*, and resistor *R3* convert the bipolar signal to the TTL-compatible levels required by *IC2*. The transistor also inverts the signal, converting negative inputs to high voltage levels and positive inputs to low voltage levels.

Modem chip *IC2* receives the digital signal at pin 11 and uses frequency-shift-keyed (fsk) modulation to code the digital information as an analog signal. Being a single-chip modem in the high-speed CMOS family of circuit devices, the 74HC943 is designed primarily for use in telephone communications. It contains on-chip analog-to-digital (A/D) and digital-to-analog (D/A) converters, as well as timing and control circuits. This is a sophisticated chip and, needless to say, our Wireless Data Link project uses only some of the chip's capabilities.

In fsk modulation, logic 1s and 0s are represented by different frequencies, rather than by different voltage levels. The frequencies used by *IC2* are those defined by the Bell 103 standard for modem transmission. To permit full-duplex (two-way) transmission over telephone lines, the Bell 103 standard specifies two sets of frequencies, one for transmitting in each direction. Figure 2 shows both sets.

The simplex (one-way) circuit presented here uses just one of these pairs. To select the "originate" frequencies for transmitting, pin 11 of *IC2* is tied high. When the input at pin 11 is low, pin 17 outputs a 1,070-Hz sine wave; when pin 11 is high, pin 17 outputs 1,270 Hz.

Figure 3 shows the square-wave input to the modem and the frequency-shift-keyed output that results. If you carefully examine the photo, you can see that the frequency of the sine wave changes slightly as the voltage of the square wave goes high and low.

The clock for the modem chip is provided by *XTAL1*, a 3.58-MHz crystal (a standard TV color-burst type). Resistors *R5* and *R6* and capacitors *C6* and *C7* provide an analog ground midway between the +5-volt supply and circuit ground rails. Capacitor *C4* couples the fsk signal to the audio input of the walkie-talkie, in place of the speaker.

The fsk input to the walkie-talkie consists of sine waves in the voice, or audio, frequency band. The walkie-talkie, which is designed for voice communication, can easily transmit such a signal. It uses FM (frequency modulation) to carry the signal over the 49-MHz radio band.

Unused pins on *IC2* are tied to ground as recommended by the IC's data sheet. Pins 14 (squelch transmitter) and 2 (analog loop-back) are grounded for normal operation. Pins 15 (receive analog #2) and 18 (external input) are tied to analog ground, and pin 10 (filter test input) is analog-grounded through a 0.1-microfarad capacitor.

On the other end of the data link, another walkie-talkie receives and demodulates the FM signal. A second modem chip converts the frequency-shift-keyed signal back to digital pulses, and an RS232 driver and 555 timer provide an RS232-compatible signal for the end receiving device. The receive unit also includes a 5-volt regulator like the one in the transmitter. The receiver's schematic diagram is shown in Fig. 4.

The speaker output of the receiving walkie-talkie is coupled to the input of receive modem chip *IC6* by capacitor *C14*.

The receive modem is configured much like the transmit modem, except that pin 13 of the modem chip is grounded to identify it as an "answer" device. The modem converts the fsk input at pin 17 back to digital pulses, which appear at pin 5. (These digital pulses should match those at pin 11 of the transmitting modem.)

	Originate	Answer
Space (logic 0)	1,070 Hz	1,070 Hz
Mark (logic 1)	1,270 Hz	1,270 Hz
Direction of Transmission →		
Space (logic 0)	2,025 Hz	2,025 Hz
Mark (logic 1)	2,225 Hz	2,225 Hz
← Direction of Transmission		

Fig. 2. In the Bell 103 standard for modem transmission, different frequencies are designated for communicating in each direction.

The pulses are inverted and level-shifted to a bipolar RS232-compatible signal by RS232 driver chip *IC5*. The negative voltage supply for *IC5* is generated at *C12* by timer *IC4*. In the timer circuit, adapted from a circuit in *IC Timer Cookbook* by Walter Jung, the 555 is configured as an astable oscillator, whose frequency of about 10,000 Hz is set by *C10* and *R8*.

Several oscillator cycles are required to fully charge *C12*. When power is first applied to the circuit and pin 3 of *IC4* goes high, *C11* charges through *D2* to approximately 7 volts, which is limited by the output characteristics of the 555 and the voltage drop across *D2*. When pin 3 goes low, *C11* "shares" its charge with *C12*, which charges to about −3 volts through *D3*.

When pin 3 again goes high, *C11* recharges to 7 volts. Then when pin 3 goes low again, *C11* charges *C12* until the two are at equal potential once more, with about 5 volts across each. The potential across *C12* increases in this manner, cycle-by-cycle, until it levels out at about −6.5 volts. Use of germanium devices holds the limiting effect of the diode drops to a minimum.

The output at pin 3 of *IC5*, the RS232 driver, is a bipolar signal with positive peaks of about +7 volts and negative peaks of about −5 volts. These fall within the "legal" levels specified by the RS232 standard.

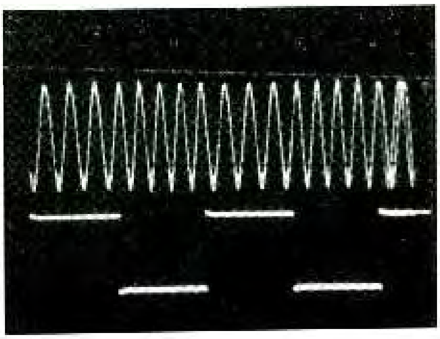


Fig. 3. The bottom trace shows the digital RS232 signal. The top trace is the frequency-shift-keyed output at the modem chip.

Construction

Since the two units are quite similar in design, you can build them side-by-side, following essentially the same procedures. Figure 5 contains the actual-size etching-and-drilling guides for both printed-circuit boards. Figure 6 shows component layout and orientations and off-board connections for both circuit-board assemblies.

Though printed-circuit construction is recommended for ease of assembly and virtual elimination of chance wiring errors, if you prefer, you can build the circuits on perforated board that has holes on 0.1-inch centers. If you do this, use suitable Wire Wrap or soldering hardware and arrange the components approximately the same as in Fig. 6, but refer to Fig. 1 for wiring the transmitter and Fig. 4 for wiring the receiver boards.

Begin construction by installing

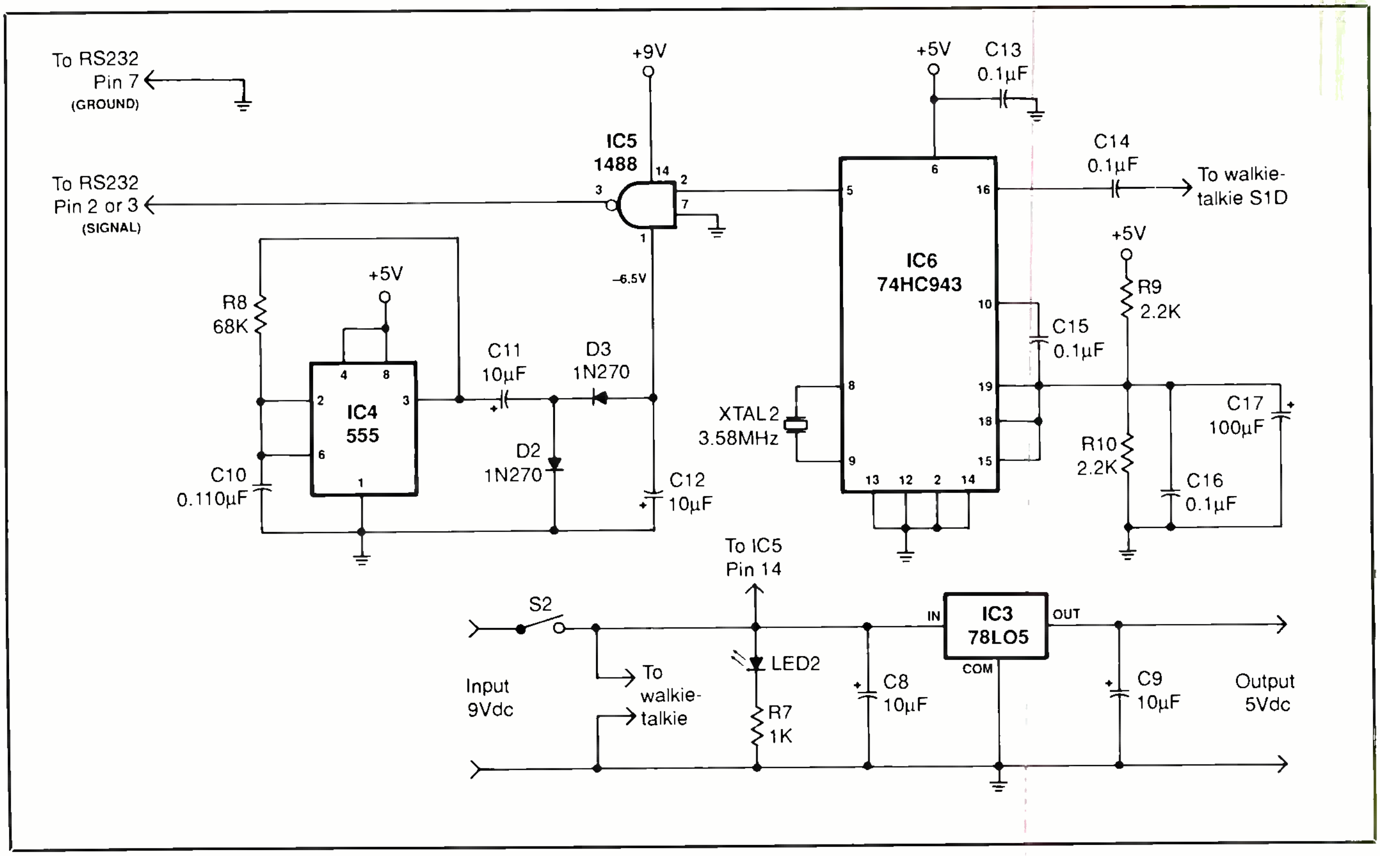


Fig. 4. Schematic diagram of the receiver unit from the output of the walkie-talkie to the RS232 interface.

and soldering into place DIP sockets for *IC2*, *IC4*, *IC5* and *IC6*. Do not install the ICs themselves at this time. Then install and solder into place all resistors, capacitors, diodes, the transistor, crystals and voltage-regulator ICs. Observe proper orientation for electrolytic capacitors, diodes, transistor and the three-terminal voltage regulators. Note that the positive (+) lead of *C12* connects to circuit *ground*.

Now prepare the walkie-talkies as follows. Begin by removing their back covers. Figure 7 is an interior view of one of the Radio Shack Space Patrol walkie-talkies specified for this project. Remove the screws that hold in place the printed-circuit assemblies and antennas in both walkie-talkies.

Cut off the red and black wires leading to the circuit boards at the battery snap connectors. Then cut

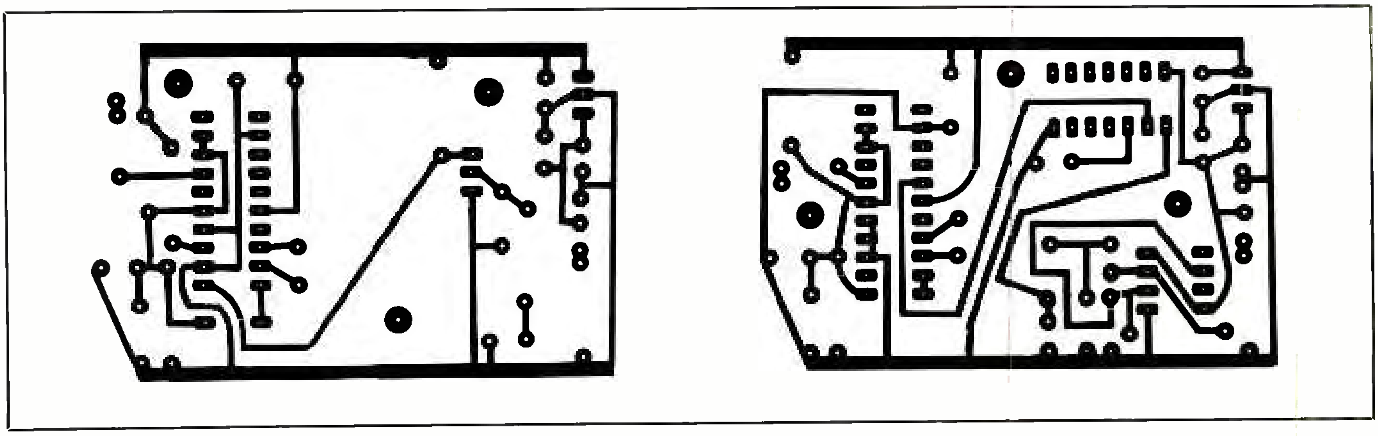


Fig. 5. Actual-size etching-and-drilling guides for the transmitter's (A) and receiver's (B) printed-circuit boards.

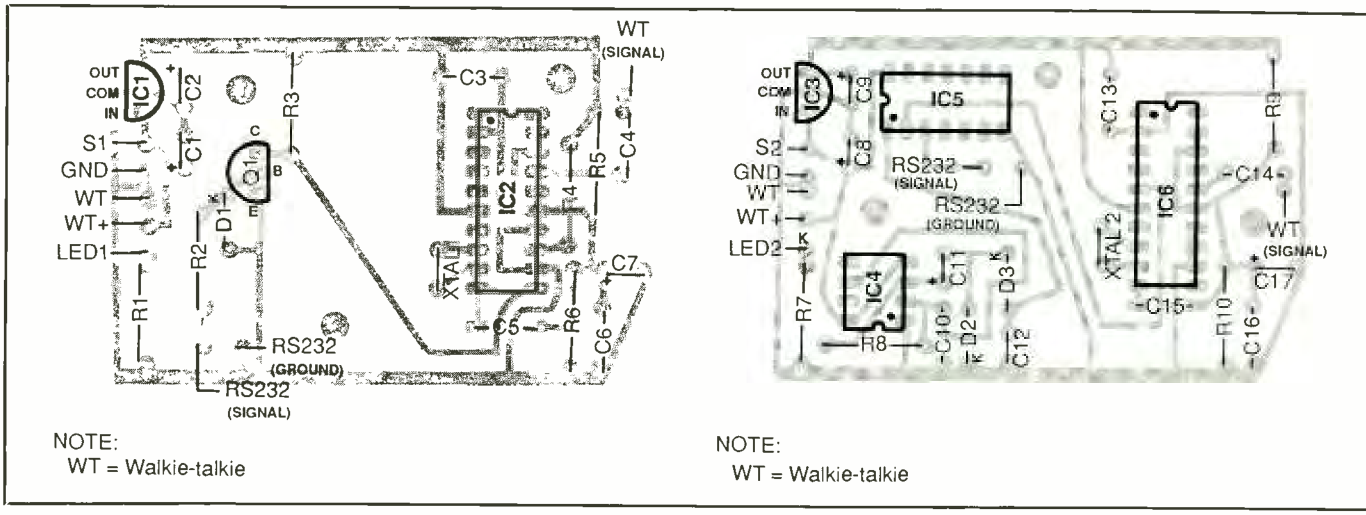


Fig. 6. Wiring guides for the transmitter (A) and receiver (B) pc boards. Use these as rough guides to component layout if you wire the circuits on perforated board.

the two speaker wires on each unit near the lugs of the speakers. Lift out of the cases the circuit-board assemblies and set the cases aside.

Unsolder and save the red battery wires that connect to the on/off switches in both cases. These switches and the orange transmit/receive switches on the walkie-talkies can now be unsoldered and removed. You will replace the on/off switches with a master switch for each unit; the transmit/receive functions will be hard-wired later.

Use a vacuum-type desoldering tool or wicking-type desoldering braid to remove the solder from the pins of the switches and carefully work the switches free. After removing the on/off switches, resolder one end of the red wires to the 9-volt trace on each board. This trace is located one pin up from where the wire was originally fastened. For double-checking locations on the walkie-talkie's circuit board, Radio Shack supplies schematic diagrams with its Space Patrol units.

After removing the transmit/receive switches, their functions can be wired at each walkie-talkie. Designate and so label one walkie-talkie as the transmitter, the other as the receiver, and use short jumper wires to solder the connections at the switch locations, as shown in Fig. 8. The removed switches and speakers can be saved for use in other projects.

Prepare 12 8-inch or so lengths of hook-up wire by stripping from each end ¼ inch of insulation. If you are using stranded wire, tightly twist together the fine conductors at both ends and sparingly tin with solder. Use these wires for interconnecting the circuit-board assemblies and switches. Though the following instructions describe the procedure for wiring one unit, follow the same procedure for both transmitter and receiver.

First, solder a wire from the negative (−) terminal on the power supply connector or battery clip to GND on the circuit board. Figure 6 shows the circuit board connection locations. Next, solder a wire from the positive (+) terminal on the power supply connector or battery clip to one lug of *S1*. Then solder two wires to the other lug of *S1* and connect one to the anode of the LED and the other to the +9V pad on the circuit board. Solder a wire from the LED's cathode to the LED1 K pad on the circuit board.

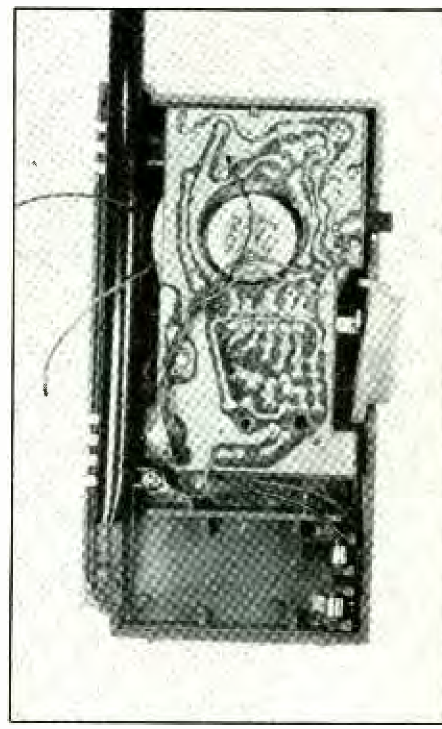


Fig. 7. Interior view of one of the walkie-talkies used in this project.

Solder a wire from the WT signal pad on the circuit board to the jumper at *S1D* on the walkie-talkie, as shown in 8. Solder the red- and black-insulated battery wires on the walkie-talkie to the WT+ and WT−

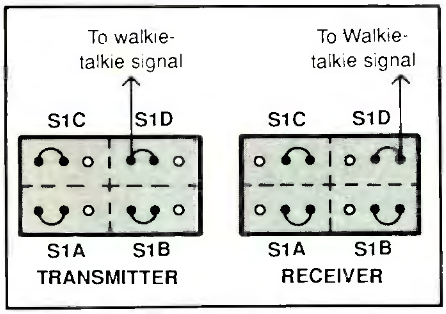


Fig. 8. Wiring guide for transmit/receive switch in walkie-talkies. Switch is shown in same orientation as in Fig. 7.

pads on the circuit board, making sure to observe proper polarity.

To prepare the enclosures used for the project, drill appropriate-size holes for the antenna, on/off switch, LED, and power supply jack (if used). The antenna should mount on one side of the enclosure at the rear. This way, its top will rise out of the case. Mount the walkie-talkie board at the bottom of the enclosure so it can easily connect to the bottom of the antenna. Use ½-inch spacers to provide clearance for the antenna when mounting the circuit boards.

Make a hole for inserting a two-wire cable for the RS232 interface and line the cable and antenna holes with rubber grommets. If you prefer, you can mount the RS232 connector directly on the enclosure and use a separate cable. If you do this, prepare an appropriate-size and shape cutout for the connector. Drill mounting holes for the circuit boards. Slide the antenna through its hole and insert and fasten the power supply jack, if used.

A few words about the RS232 standard might be helpful here. The standard specifies RS232 devices as being either DTE (Data Terminal Equipment) with male connectors, or DCE (Data Communications Equipment) with female connectors. Most RS232 interfaces use subminiature D-type connectors. The standard also specifies that DTE devices transmit data on pin 2 and receive on pin 3 at the connector, with DCE devices transmitting on pin 3 and receiving on pin 2.

For a working data link, the transmit pin of the sending device must connect to RS232 signal on the transmitting modem board, and RS232 signal on the receive modem board must connect to the receive pin of the receiving device. Figure 9 illustrates the wiring for different combinations of equipment. A transmitting computer with a DTE interface, for example, requires a female connector on the transmitter unit, with RS232 signal wired to pin 2 of the connector. A printer with a DCE interface needs a male connector on the receive unit, with RS232 signal again wired to pin 2.

Because not all equipment rigidly adheres to the specifications of the RS232 standard, you should double-check which pin is used as the transmit pin before wiring the connector. To do this, turn on the device and measure with a dc voltmeter or multimeter set to the dc voltage function at the connector from pin 2 (signal) to pin 7 (ground) and then from pin 3 (signal) to pin 7 (ground). When no data is being transmitted, the transmit pin should provide a reading of

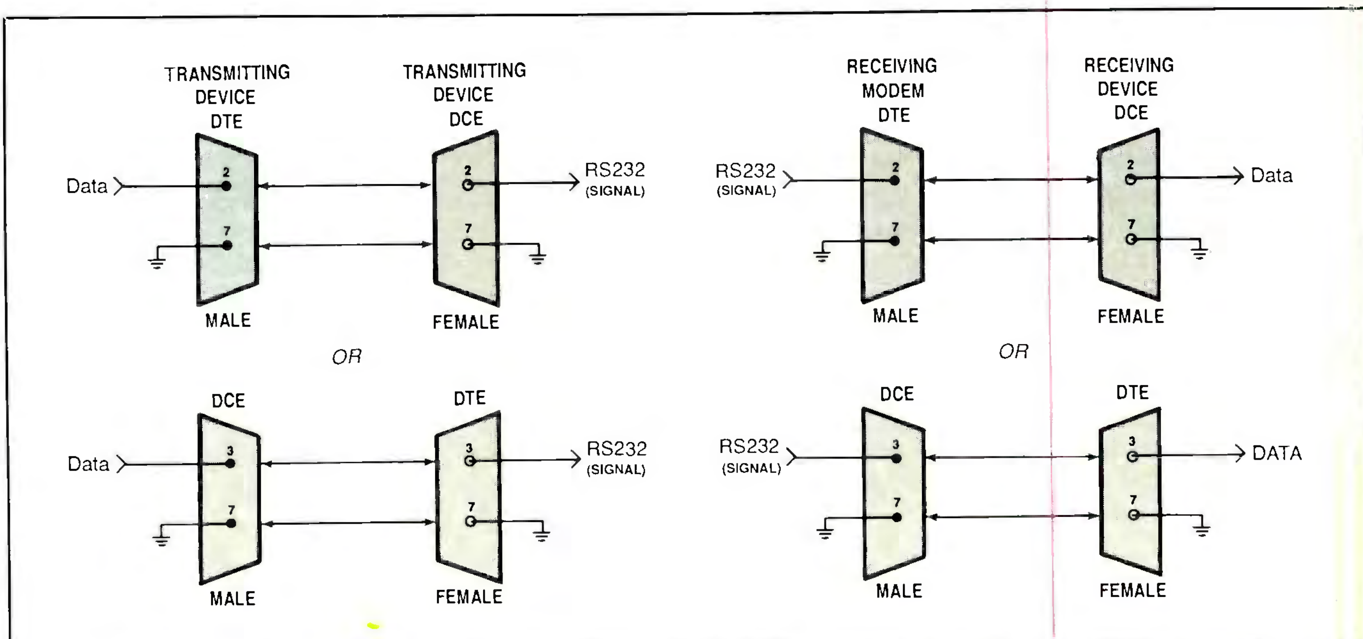


Fig. 9. The RS232 connectors must be wired to be compatible with the equipment they connect to. DTE devices have male connectors and transmit on pin 2. DCE devices have female connectors and transmit on pin 3. Pin 7 is signal ground.

−5 to −15 volts, while the reading at the receive pin should should be 0 volt.

To wire the RS232 connector, cut a length of two-conductor cable long enough to conveniently reach from the end equipment to the wireless link. Remove 2 inches of the outer plastic jacket from both ends of the cable and strip ¼ inch of insulation from each conductor. Tightly twist together the fine wires at each conductor end and sparingly tin with solder.

Solder the conductors at one end of the cable to the GND and RS232 signal pads on the modem board. Tie a strain-relieving knot in the cable a few inches from the soldered end and pass the free end of the cable from the inside of the enclosure through its rubber-grommet-lined hole. At the free end of this cable, connect and solder the GND conductor to pin 7 of the RS232 connector and the RS232 signal conductor to pin 2 or 3 on the connector, which is used depending on your particular setup. (See Fig. 9 for wiring details.)

Mount the modem board in the enclosure. Then, with a screw and nut, connect the antenna to the antenna lug at the walkie-talkie board. Mount the walkie-talkie board in the case and insert and fasten the on/off switch and LED in its holder.

Finally, label the two enclosures according to function (transmitter and receiver). If you use dry-transfer lettering, spray onto them two or more light coats of clear acrylic to protect from scratching. The completed project, just before closing the enclosures, is shown in Fig. 10.

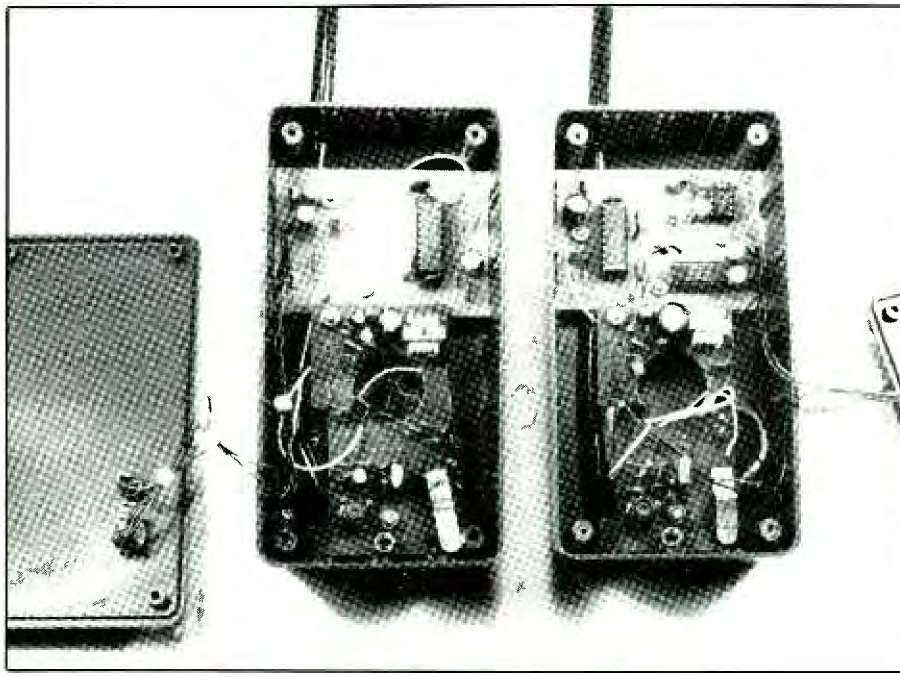


Fig. 10. Interior views of completed transmitter (left) and receiver (right) ends of project.

Checkout & Use

The first step in checking out the circuit is to make sure the power supplies are operating properly. Connect the power supply or 9-volt battery to and turn on the transmitter. (Note: The DIP ICs should still *not* be installed in their sockets at this time!) Now use a dc voltmeter or a multimeter set to the dc voltage function to take voltage readings as follows.

First, connect the meter's common probe to any convenient circuit-ground point and leave it there for the duration of the tests. Working on first the transmitter portion of the project, touch the meter's "hot" probe to the IN pin of *IC1* and note that the reading should be +9 volts. Then touch the "hot" probe to the OUT pin of *IC1* and socket pin 6 of *IC2*; this time, the readings should both be +5 volts. If you do not obtain the appropriate reading at any of these three points, power down the circuit and correct the problem before proceeding.

Repeat the tests for the receiving end of the project. This time, you should obtain the same readings at the IN and OUT pins of *IC3* as you did for *IC1*, and +5 volts should be available at socket pins 4 and 8 of *IC4* and pin 6 of *IC5*. Once again, if you do not obtain the proper reading at any point, power down the circuit and correct the problem before proceeding.

When you are satisfied that both boards have been correctly wired, power down both and carefully install the ICs in their respective sockets. Make sure that each is properly oriented and that no pins overhang the sockets or fold under between IC and socket as you push each home. Use safe-handling procedures for MOS devices when installing *IC2* and *IC6* in their sockets.

With the ICs installed in their sockets, power up the receiver portion of the project. Connect the meter's common probe to circuit ground and touch its "hot" probe to pin 1 of *IC5*. If all is okay, you should obtain a reading of about −6.5 volts.

If all looks okay, you're ready to proceed with system checkout. Connect the Wireless Data Link units to the devices that will be transmitting and receiving data in your system. As always, set up the communications protocol so it is the same at both

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Wireless Data Link *(from page 27)*

ends, including baud rate, number of data and stop bits, and parity. The Wireless Data Link will operate at 300 baud or slower if desired.

Turn on the system, including both Wireless Data Link units. When the system is set up properly, data sent by the transmitting end will appear at the receiving end just as it would if you were using a hard-wired cable link. If you have set up a computer-to-printer link, the printer should operate just as if it were simply cable-connected to the computer. Since the Link communicates in only one direction, the printer must be able to keep up at 300 baud, or it should have a buffer that is large enough to hold the entire transmission. Most dot-matrix printers can easily keep up at this rate (300 baud translates to about 30 characters per second).

If you are receiving data that is garbled or otherwise not intelligible, double-check the communications protocol. If possible, cable-link the two devices, without using the Wireless Data Link to first make certain that the system is properly set up and operating as it should. This will confirm that the two ends can communicate and eliminates the end devices as sources of error. When you have the cable-link arrangement working, replace it with the wireless link and you are ready to transmit. **ME**