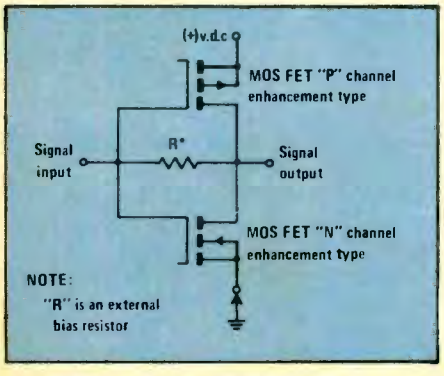
Easy-to-build CMOS radio receiver

Fun for tonight! Build our easy receiver and learn how to handle CMOS integrated circuits.

by Charles Green

One of the most fun things you can build always is a new and different version of the good old fashioned am broadcast radio.

Everybody loved the crystal sets of the Twenties; the one-tube jobs of the Forties; the two-transistor rigs of the Sixties. As we head into the Exciting Eighties, here's a new version of the old favorite, built around the latest electronic technology available to experimenters. It's easy to build and will provide hours of entertainment fun.



The basic CMOS amplifier consists of a pair of complimentary p– and n–channel MOS enhancement type FETS.

CMOS integrated circuits (ICs) are being used with increasing frequency today because, in digital circuits, they use less power, operate over a wider voltage range and require a higher input impedance.

CMOS ICs are fabricated with *Complementary MOS* field-effect transistors (FETs) and have certain very interesting features, including the use of both *P* and *N* types of semiconductors in the same IC package.

In fact, there's one type of CMOS IC which can be used in *linear* circuits, such as am broadcast radio receivers!

It's the CD4007A dual complementary pair plus inverter IC. It has six FETs inside. You can experiment with this IC by building our simple receiver project.

We'll use the 4007 as an audio amplifier fed by a germanium diode detector and a loopstick antenna tuned circuit for the broadcast band.

The receiver is housed in a compact metal cabinet with a 9-volt battery for power, and can drive a small speaker or low impedance headphones.

The receiver circuit

Signals from the antenna are fed through J1 and tuned by the broadcast-band tuned circuit of L1 and C3. The signals are detected by the germanium diode D1 and coupled through C2 to the input of the first section of the CD4007A (IC1A).

This section is biased by the two series resistors R1-R2 and the amplified signal is coupled through C6 to the volume control R4 and to the input of the second IC section (IC1B).

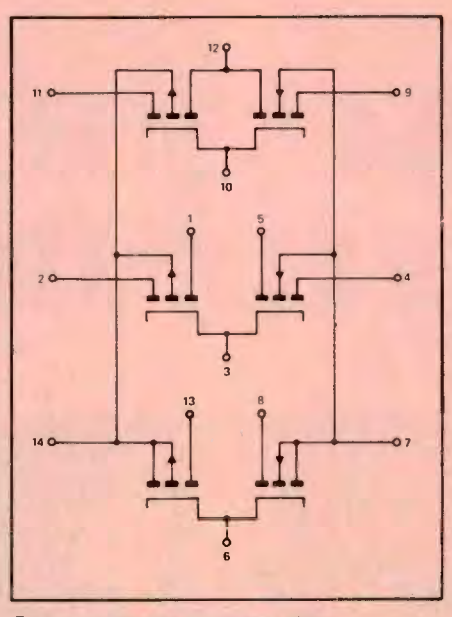
The CMOS IC

The complementary metal-oxide semiconductor (CMOS) IC employs both p-channel and n-channel FET's on the same silicon substrate as shown in the basic schematic. Only one of the FET's is operational at a time as each of the devices are enhancement mode types.

The gate voltage input signal swing will only turn on the FET that will operate in the same polarity direction as the signal. For example, the n-channel device will conduct on a positive going signal, and the p-channel device will conduct on a negative going signal. At zero input, neither device will conduct.

As each of the FETs conduct, the CMOS output is connected to either the power supply, or to ground, depending upon the input signal polarity. The circuit operates as an inverter as the output signal is the logical complement of the input.

As the FET devices are insulated gate types, the input resistance of the CMOS is very high, in the millions of megohms. The power consumption of the CMOS (when used in digital applications) is very low, as only one of the



FETs are turned on at one time.

When CMOS are biased in the linear portion of their voltage transfer characteristics, they can be used in linear applications as well as the more common digital uses. The simplest way of biasing is to connect a high value resistance (R in the schematic) between the input and the output of the CMOS.

The CMOS IC used in our receiver circuit is an RCA CD4007A in a 14-pin dual in-line plastic package. It is listed as a dual complementary pair plus inverter device.

As shown in the IC schematic, the CD4007A has six FETs fabricated on its substrate; three p-channel and three n-channel types.

Two of the p-channel and two of the n-channel FETs are connected with separate outputs (pins 8-13 and 1-5). These are the complementary pairs.

The third pair of FETs are internally strapped and has a single output pin (12). This section is the inverter.

The other two sections are strapped externally in our receiver circuit to also function as inverting amplifiers. Protective diodes for electrostatic punctures are included in the circuits.

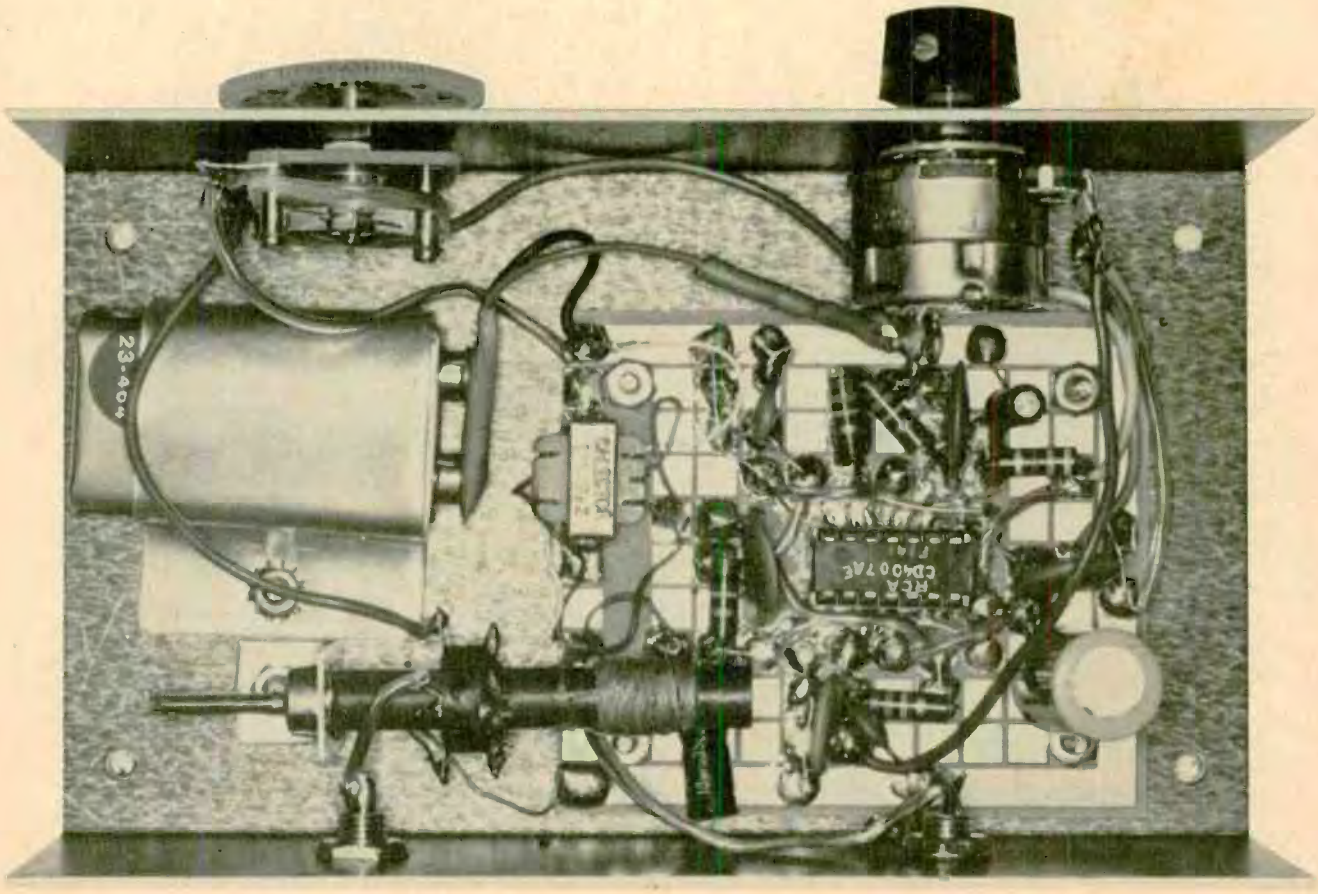
This section is biased by R5 and the amplified output is fed through C9 to IC1C and further amplified.

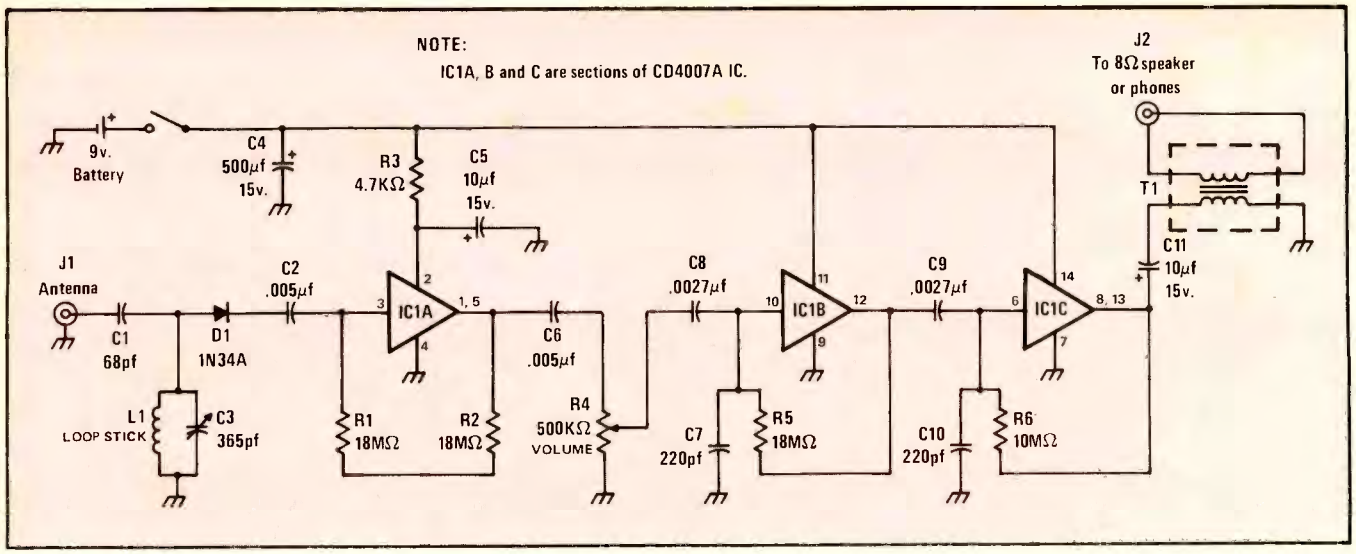
The output is coupled through C11 to the output transformer T1 to J2 and external 8-ohm speaker or headphones.

C4 and R3-C5 act as RC decoupling circuits to minimize any audio feedback through the dc power circuit from B1. S1 is the on-off switch and is coupled to R4. C7-C10 are rf bypass capacitors.

Most of the receiver components are mounted on a 2⅞-inch by 2½-inch section of Radio Shack experimenter's printed circuit board (part number 276-151). As shown in the wiring diagram, this particular pc board is composed of copper foil squares used for soldering component lead connections, and solder pads for mounting an IC socket.

If desired, the circuit can be wired





with a perf-board and push-in solder pins in place of the pc board section.

As shown in the photos, the pc board is mounted on the bottom of a Radio Shack 2¾ by 6 by 4-inch metal cabinet (part number 270-260) with 4 screws and spacing nuts. The cabinet size is not critical, and you can use any convenient size cabinet to fit your components.

Begin construction by cutting the pc board to size. Inasmuch as both sections of the pc circuits are identical, either side can be used, and the remaining section cut-off. For convenience, the section used in our model was cut one vertical line of copper foil squares past the pc board center line.

This line of squares is used to mount T1 and the connections of the leads to B–, GND, and J2. Check the wiring diagram before cutting the pc board.

Before soldering the IC socket to the pc board pads, check its position; the pc pattern has pads for a 16 pin-socket and the IC used in our model is a 14 pin type.

The unused two pads can be peeled off the board with a sharp knife or razor to prevent possible confusion in wiring the board. The unused pads are the ones located near R6 and C9 connection foil squares.

Wire the pc board with small diameter solid wire (#24) and lengths of insulated tubing to prevent any possible shorts. Mount the components vertically on the foil squares with short leads to minimize movement, except for C11 which should be laid horizontally to prevent any interference with L1.

Bend out the tabs of T1 and solder them to the foil squares to hold the transformer securely in place, and cut the leads to size before connecting them to the foil squares to keep them away from the IC1 circuits to prevent any possible feed-back coupling. After mounting the pc board components, set the board aside.

Locate and mount the cabinet components, R4 and C3, on the front panel in the approximate locations shown in the photos. Then mount J1 and J2 on the rear panel and install a ground lug on J2. Use lockwashers under the mounting nuts to prevent accidental movement of the components. Position the pc board on the bottom of the cabinet and locate the four corner mounting holes.

Drill the holes and mount the pc board with machine screws and spacing nuts to keep the board bottom approximately 1/16-inch up from the cabinet bottom.

Bend a ½-inch wide by 1¼-inch high (with a ½-inch foot) bracket from the sheet aluminum and cut a hole near the top to fit L1. Mount the bracket on the box bottom with a machine screw and nut so that the L1

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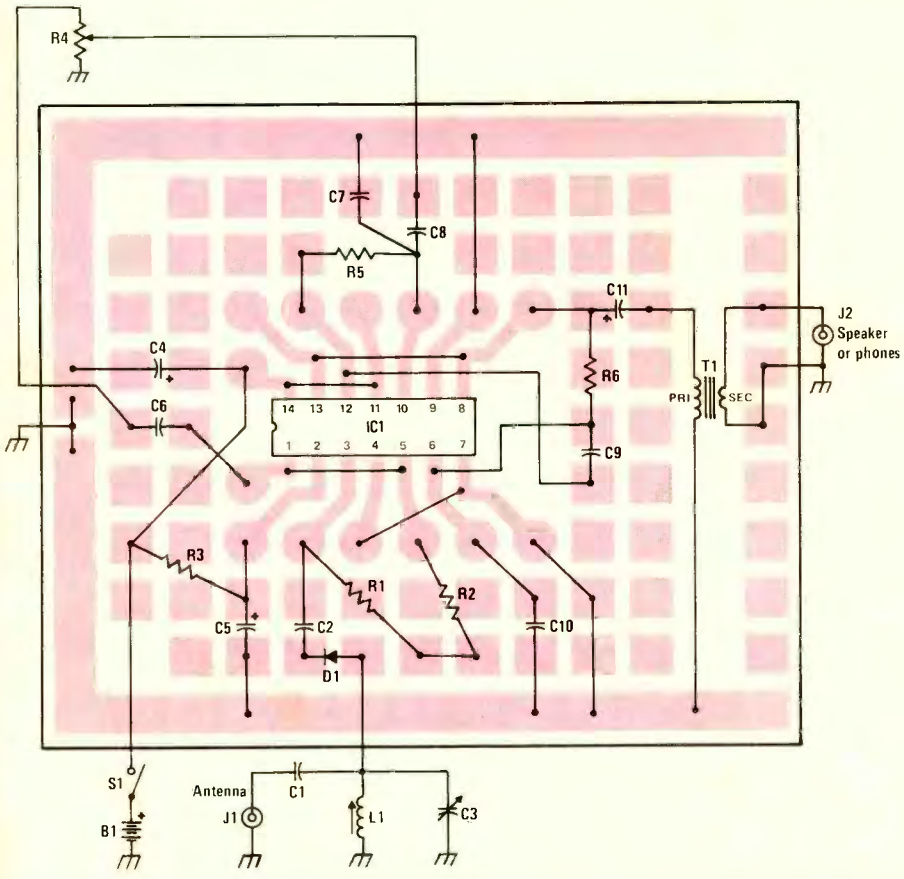

The Radio Shack 276-151 experimenter PC board is ideal for building the CMOS receiver. You'll only need one section of the board. The parts layout shown is neat and provides ample clearance between components.

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lugs are near J1 and connect C1 between J1 and L1 as shown in the schematic.

Bend a section of sheet aluminum around B1 to form a mounting bracket for the battery and install it with a machine screw and nut on the box bottom. Complete and check the wiring of the receiver, and then install IC1 into its socket.

Parts List

Part number	Description	Radio Shack number
B1	Nine-volt battery	23-151
C1	68 pf capacitor	*
C2,C6	.005 mfd disk ceramic	272-130
C3	365 pf variable capacitor	*
C4	470 mfd, 16 V electrolytic	*
C5,C11	10 mfd, 16 V electrolytic	272-952
C7,C10	220 pf disk ceramic	272-124
C8,C9	.0027 mfd capacitor	*
D1	1N34A germanium diode	276-1123
IC1,IC2	CD4007A integrated circuit	*
J1,J2	RCA phono jacks	*
L1	Loopstick antenna	270-1430
R3	4.7K resistor	*
R1,R2,R5	18M resistor	*
R4	500K volume control w/switch	*
R6	10M resistor	*
T1	Output transformer—500 ohm primary to 8 ohm secondary	*

Notes: All resistors, except R4, can be ¼-watt composition type such as Radio Shack's 271-1300 series. You'll also need a cabinet, such as Radio Shack's 270-260, tuning knob, a section of Radio Shack's 276-151 Experimenter's Board, a 14-pin DIP IC socket such as Radio Shack's 276-1999, and miscellaneous hardware.

For best results a good external antenna and a ground connection are required. Connect the antenna to the center connector of J1 and the ground connection to the outside shell or cabinet. Connect either a small 8-ohm speaker or a pair of 8-ohm headphones to J2, and turn the receiver on by rotating R4 clockwise (actuating S1).

Tune C3 for a station, and adjust the volume with R4. If the volume lowers as the control is turned clockwise, change the connections to the outside terminals of R4 (connections to the resistance element).

The selectivity of the receiver will not be very great because it has only one tuned circuit, but improvement can be made by adjusting the antenna loading by changing the value of C1. A smaller capacity will have lighter loading, more selectivity, but less sensitivity. Adjust the inductance of L1 as required to tune for stations on the low end of the band.