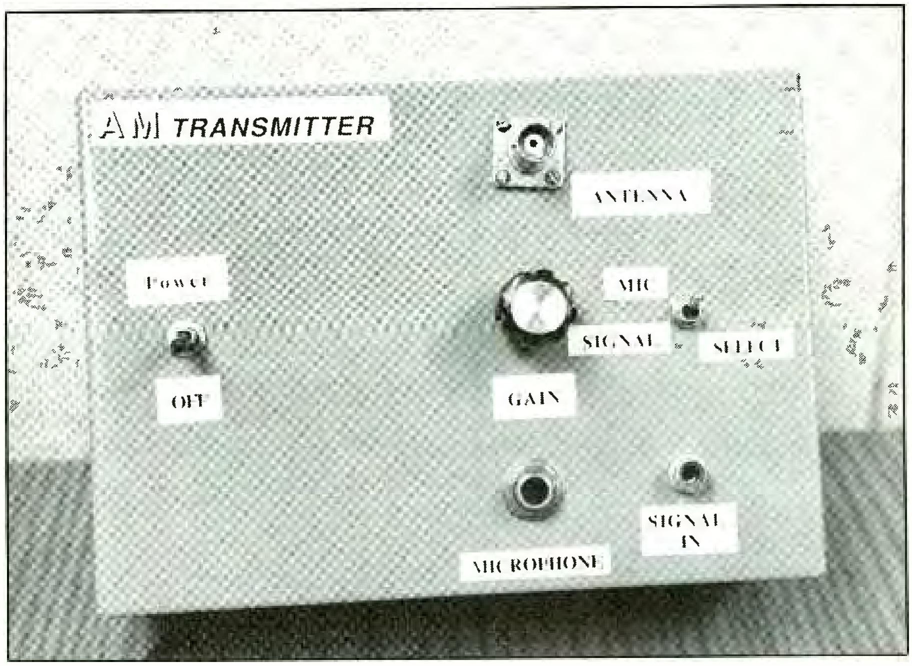
AM Radio Transmission

How AM radio transmission works and a mini-power AM transmitter you can build and use for experimenting

By Bob Mostafapour



You may have wondered how radio waves are transmitted or why transmission is done in a certain way. Or perhaps you shied away from building a radio transmitter because you thought such a project would be difficult, requires a special FCC license and requires hard-to-find costly components. Actually, a radio transmitter—especially an amplitude-modulated one—is one of the easiest circuits to build, using only readily available low-cost components. In fact, building an AM transmitter is a major focus of this article. And you don't need a license for this one!

We begin here with a discussion of AM radio transmission in all its guises. Then we present full details for building a low-power, license-free AM transmitter that broadcasts a signal that can be received with any AM broadcast-band radio. Because the transmitter radiates less than 1 milliwatt of power from its short antenna, no FCC license is required to build and operate it. You can voice-modulate the transmitter through a microphone or from a higher-level source like a tape deck or compact disc player simply by flipping a switch.

AM Transmission

Amplitude modulation, or AM, is a means by which two signals are combined so that one modulates the other. The signal to be modulated, called a carrier, is usually constant and much greater frequency than the modulating signal. The modulating signal can also be fixed in frequency, though it's usually variable and in the audio range so that voice, music and other sounds can be heard after demodulation at the receiving location.

Though an audio-frequency signal can be transmitted directly, economics (among other reasons) dictate that it be impressed on a carrier. This is because transmission and reception of a signal depend on antenna length. The lower the frequency to be transmitted, the longer the antenna needed at both ends. If an audio signal of, say, 5 kHz were to be transmitted directly, the antenna would be an impractical length. Its length is calculated using the wavelength formula:

$$\lambda = c/f$$

where λ is wavelength in meters, c is the speed of light (considered to be a constant 300,000,000 meters per second) and f is frequency in Hertz (Hz). Since we already know two of the unknowns for this formula—the speed of light and frequency—antenna wavelength is calculated as follows:

$$\lambda = c/f$$
$$\lambda = 300{,}000{,}000/5{,}000$$
$$\lambda = 60{,}000 \text{ meters}$$

As you can see, 60,000 meters (60 km) is an exceedingly long antenna length. The cost of building such an antenna would be prohibitive, as would be installing it.

Using a high carrier frequency, such as 1.5 MHz, to convey the 50-kHz signal considerably shortens the effective length of the antenna needed to transmit it. This reduces both cost and real estate on which to mount the antenna. When a carrier signal of a considerably greater frequency than that of the modulating signal is used, only the frequency of the carrier need be considered in the wavelength formula used to calculate antenna length.

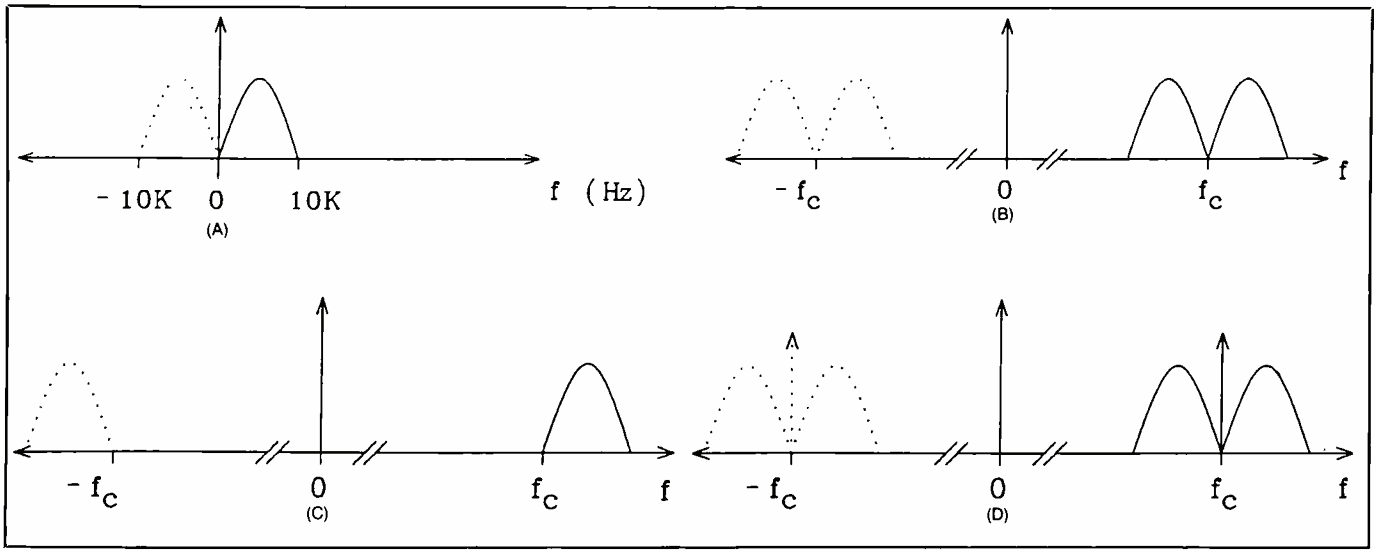


Fig. 1. Frequency distribution details for: (A) speech range profile; (B) modulated spectrum showing both negative and positive frequency components; (C) SSB spectrum; and (D) DSB-C (standard AM) spectrum.

Thus, for a 1.5-MHz (1,500,000-Hz) carrier, effective antenna length is calculated as follows:

$\lambda = c/f$
$\lambda = 300{,}000{,}000/1{,}500{,}000$
$\lambda = 200$ meters

At 200 meters in length, this a considerable improvement over the 60,000-meter antenna length needed to transmit the 5-kHz signal directly. If the carrier frequency is further increased to 30 MHz, only a 10-meter-long antenna would be needed for transmission and reception of the signal.

Modulation is the key to transmitting useful low-frequency information on a high-frequency carrier. This is done by electronically combining the two frequencies so that they produce a composite signal that's then radiated from the transmitting antenna.

Amplitude Modulation

Many forms of modulation are currently used for transmission and reception of radio waves, including amplitude modulation (AM), frequency modulation (FM), pulse modulation (PM), pulse-code modulation (PCM), etc. Our focus here is on AM, which includes such techniques as single sideband (SSB), double sideband (DSB), and double sideband with carrier (DSB-C). Each technique has its advantages to recommend it as well as its unique drawbacks. To understand the differences between these techniques, we'll discuss each in turn.

• Single Sideband. SSB is a type of signal that's transmitted with only one of its "side bands" present. To understand what is meant by sidebands, visualize the audio spectrum in terms of frequency. This can be represented in a graphic manner in much the same way as audio equipment frequency-response curves are presented.

Speech can be simplified into a frequency curve that has a "hump" centered around 5 kHz, as in Fig. 1. Although the hump appears to be symmetrical in Fig. 1(A), it isn't. It's shown like this for simplicity. As shown, speech consists of a range of frequencies, with greatest concentration in the middle of the range and a tapering off at both ends of the curve.

A phantom curve that depicts *negative* frequency is also shown in Fig. 1(A). Negative frequency is an important concept in gaining understanding of the modulation and transmission process.

A spectrum analysis of the human speech reveals a range of frequencies that can be divided into fundamental

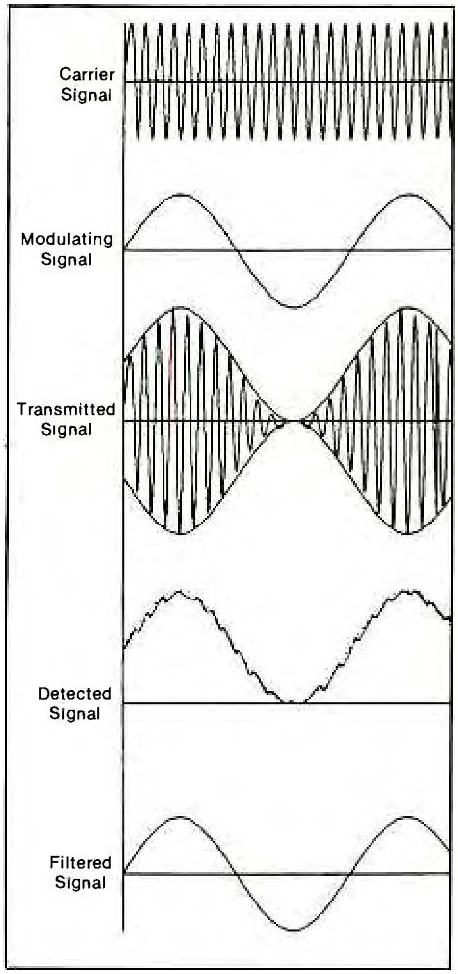


Fig. 2. Representations of modulation, transmission, detection and filtering of a signal.

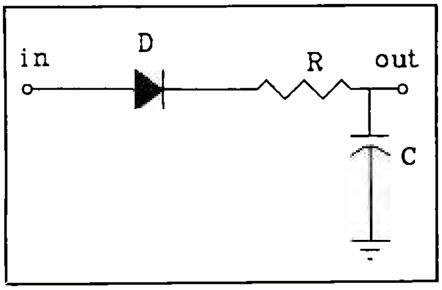


Fig. 3. A simple AM detector circuit arrangement.

parts as a summation of sinusoids. Mathematician Fourier hypothesized that any continuous function can be represented as a summation of sine waves, starting at a fundamental frequency and adding to it higher frequencies (harmonics, which are multiples of the fundamental). These frequencies have phase relationships that can be shown, through trigonometric identities, to be "negative" frequencies.

When the desired signal that contains the information to be transmitted is multiplied by a high-frequency carrier, modulation is the result. During modulation, the baseband signal being shifted up in frequency, centered at the carrier frequency (f_c). Modulation also creates a copy of this signal, shifting it in the negative direction as a negative frequency, as shown in Fig. 1(B).

Notice that the modulated signal at f_c contains both upper and lower sidebands. Recall that the shifted spectrum at f_c has what was once the negative and positive profiles of the speech spectrum. Consequently, it contains redundant information, since only one profile is needed to convey the desired information. Therefore, filtering out one of these humps won't diminish the transmitted information.

The process of filtering out one of the humps is where single sideband gets its name from. After filtering is accomplished, only one sideband remains to be transmitted, as illustrated in Fig. 1(C).

• *Double Sideband.* As its name indicates, DSB transmits both sidebands intact, as in Fig. 1(B). Although the transmitted signal contains redundant information, the design of the DSB transmitter is simpler than the SSB transmitter. Without sideband filtering, the transmitter is less costly and easier to build. At the destination, though, the receivers for DSB and SSB are fairly complex.

• *Double Sideband With Carrier.* DSB-C is the technical designation for standard AM, which is what commercial AM broadcasters use to deliver music, news, weather, sports, etc. to their audiences. The frequency spectrum of DSB-C looks much like that of DSB, except that it contains a spike at carrier frequency f_c, with both bands along for the ride, as in Fig. 1(D).

The tradeoff between these AM modulation techniques is a matter of efficiency *versus* ease of implementation and cost of demodulation. Because consumers want low-cost receivers, the sacrifice made is lower efficiency. Greater efficiency is realized in SSB and DSB systems, but cost is much greater for receivers because a synchronous modulator is needed for reception and demodulation of DSB and SSB signals.

To be able to hear the information contained in an incoming signal, the receiver must use circuitry that multiplies the incoming signal by a sinewave signal of exactly the same frequency as the carrier. Multiplying the incoming signal again shifts the spectrum. But now the negative-going spectrum falls into the place it started from but is at twice the original carrier frequency, making it easy to filter out. The spectrum shifted to the original position allows you to hear the information. The circuitry required to achieve this is expensive and requires many components to implement.

AM Radio Detection

Graphic examination of DSB-C transmission and reception demonstrates the economy of this format. Referring to Fig. 2, carrier signal (A)

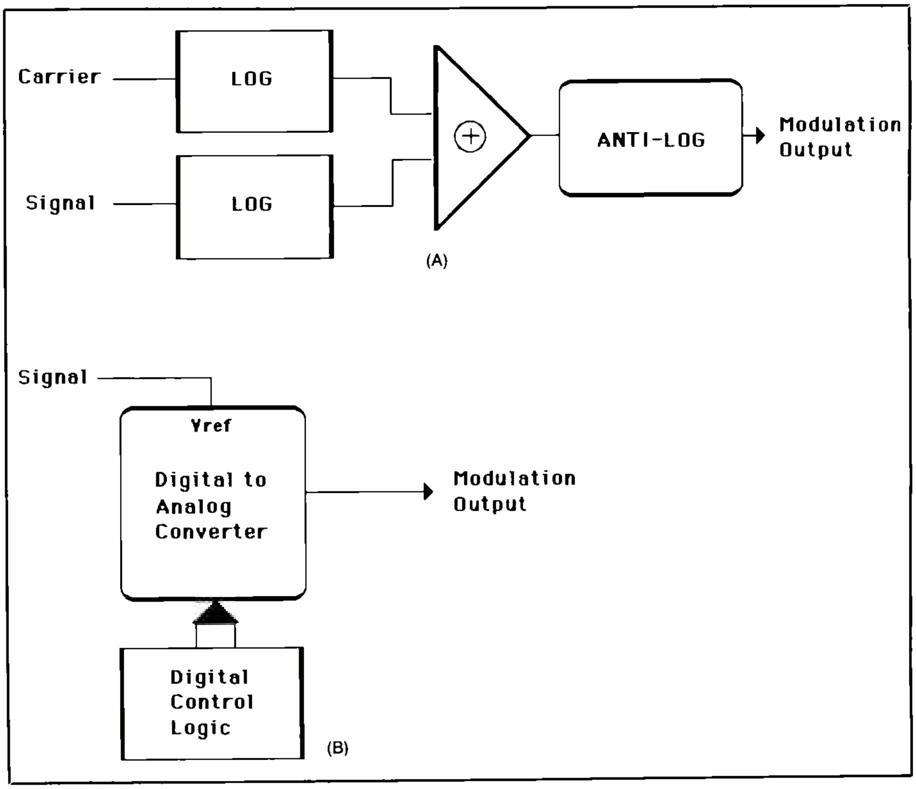


Fig. 4. Ways of achieving amplitude modulation by the (A) logarithmic method and (B) the analog-to-digital method.

is multiplied by dc-offset modulating signal (B) to yield transmitted composite (modulated) signal (C). Signal (C) is received and input to the detector arrangement shown in Fig. 3. The simple diode/resistor/capacitor circuit shown is all that's needed to retrieve the transmitted signal. Of course, a receiver would also contain a preceding r-f amplifier and an amplifier to drive a speaker.

The demodulated signal exiting the detector is usually ragged, as shown in Fig. 2(D). After final filtering, raggedness is removed, producing a clean signal like that in Fig. 2(E).

Recall that the double sidebands contain the same information. Hence, efficiency can be measured as the ratio of the power of one sideband to total transmitted power. From this, it's easy to see that SSB is most efficient and DSB-C is least efficient. The DSB-C transmitter uses power to transmit both sidebands *and* the carrier. This being the case, efficiency is a maximum of only 33 percent.

Modulation Methods

To build an AM transmitter, you need a modulator to multiply a carrier frequency by a modulating signal that contains useful information. You can do this electronically with logarithmic conversion and addition, use of digital-to-analog (D/A) converters, etc. Because it's readily available, low in cost and easy to implement, the project to be described employs the D/A circuit for its modulator.

Operational amplifiers can be configured to integrate, differentiate and amplify signals, each function implemented by feedback elements. An integrator, for example, requires a capacitor in the feedback loop. If the feedback element is a nonlinear device like a diode or transistor, you can design a logarithmic converter like that depicted in Fig. 4(A). With such a circuit, adding the log of two signals and then taking the antilog produces the equivalent multiplied signal. In theory, this would work, but putting it into practice can be a real nightmare. The bandwidth consideration of the op amps would make this implementation prohibitively expensive, and a large number of op amps would be needed to implement such an arrangement.

With support circuitry, D/A converters can be used for modulation, as in Fig. 4(B). A D/A converter can be used as a programmable attenuator by feeding the signal into its voltage-reference pin. Digital control logic switches the attenuation of the signal at a high rate (creating the carrier) to produce modulation. This implementation is limited by the bandwidth of the D/A converter and requires extensive support logic.

Balanced Modulator Chip

The versatile low-cost and readily available LM1496 balanced modulator IC can be used for DSB-C, SSB and DSB modulation. Choice of modulation depends on how you bias this chip. In operation, the LM1496 circuit modulates two signals by chopping the modulated signal at the rate of the carrier frequency, in effect using the chopping operation as a multiplier (see Fig. 5).

Internally, the LM1496 uses two sets of transistors configured as differential pairs and only a small voltage to switch at the carrier frequency. The differential pairs are fed by constant-current sources biased by external resistors and the modulating signal. Therefore, the dc offsets applied to the input determine the type of transmitter configured.

Close examination of Fig. 5 reveals that chopping is, indeed, multiplying. For example, look at the input signal at the top of the illustration at any time along the axis when in its

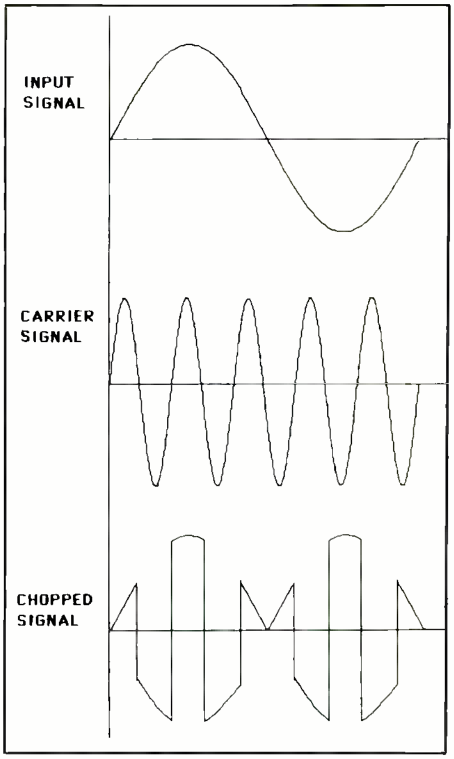


Fig. 5. How signal chopping results in amplitude modulation.

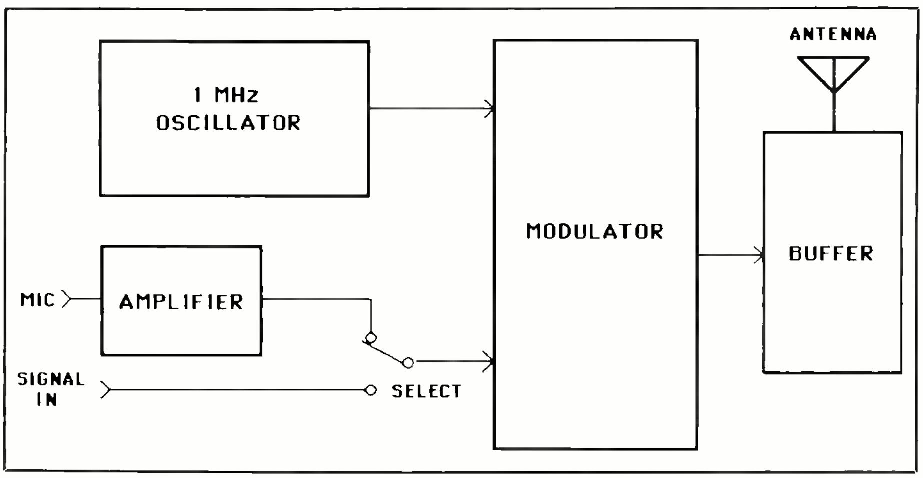


Fig. 6. Block diagram of the circuitry used in the AM Transmitter project.

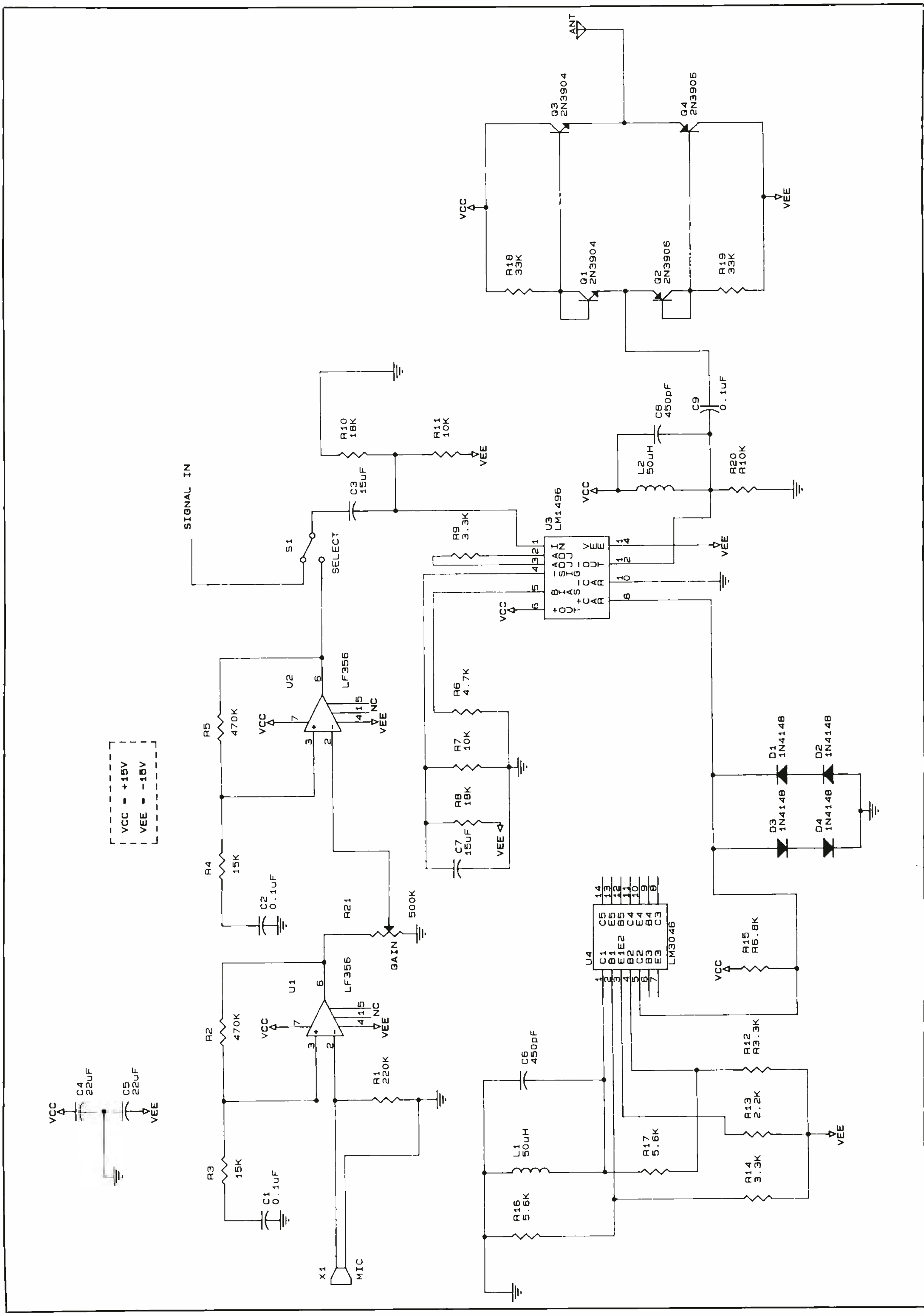

ANT
Q3 2N3904
Q4 2N3906
VCC
VEE
R18 33K
Q1 2N3904
Q2 2N3906
R19 33K
C9 0.1uF
C8 450pF
L2 50uH
R20 R10K
R10 18K
R11 10K
SIGNAL IN
S1
SELECT
C3 15uF
R9 3.3K
U3 LM1496
U2 LF356
R5 470K
NC
VCC = +15V
VEE = -15V
R6 4.7K
R7 10K
R8 18K
C7 15uF
D1 1N4148
D2 1N4148
D3 1N4148
D4 1N4148
R4 15K
C2 0.1uF
R21 500K
GAIN
U1 LF356
R2 470K
U4 LM3046
R15 R6.8K
C4 22uF
C5 22uF
R1 220K
C6 450pF
R12 R3.3K
R13 2.2K
L1 50uH
R17 5.6K
R3 15K
C1 0.1uF
R14 3.3K
R16 5.6K
X1
MIC

Fig. 7. Schematic diagram of basic AM Transmitter circuitry.

PARTS LIST

Semiconductors
BR1—200-volt, 1-ampere bridge-rectifier module
D1 thru D4—1N4148 or similar small-signal diode
Q1,Q3—2N3904 silicon npn transistor
Q2,Q4—2N3906 silicon pnp transistor
U1,U2—LF356 operational amplifier
U3—LM1496 balanced modulator
U4—LM3046 transistor array
U5—LM7816 +15-volt fixed regulator
U6—LM7915 −15-volt fixed regulator
Capacitors
C1,C2,C9—0.1-μF ceramic disc
C3,C7—15-μF, 25-volt electrolytic
C4,C5—22-μF, 25-volt electrolytic
C6,C8—450-pF ceramic disc
C10,C11—2,200-μF, 25-volt electrolytic
C12,C13—0.1-μF tantalum
C14,C15—0.22-μF tantalum
Resistors (¼-watt, 5% tolerance)
R1—220,000 ohms
R2,R5—470,000 ohms
R3,R4—15,000 ohms
R6—4,700 ohms
R7,R11,R20—10,000 ohms
R8,R10—18,000 ohms
R9,R12,R14—3,300 ohms
R13—2,200 ohms
R15—6,800 ohms
R16,R17—5,600 ohms
R18,R19—33,000 ohms
R21—500,000-ohm panel-mount linear-taper potentiometer
Miscellaneous
F1—0.5-ampere slow-blow fuse
L1,L2—50-μH inductor
S1—Spdt toggle or slide switch
S2—Spst toggle or slide switch
T1—24-volt, 300-mA center-tapped power transformer
Perforated board with holes on 0.1 inch centers and suitable soldering hardware (see text); suitable enclosure (see text); sockets for all DIP ICs; fuse holder; ac line cord with plug; microphone; panel-mount connectors; lettering kit; clear acrylic spray; ½-inch spacers; machine hardware; hookup wire; solder; etc.

positive excursion. Select a point and draw an imaginary line down to the carrier signal. You'll notice that if the carrier signal is positive, the chopped signal is also positive, and *vice-versa*. In essence, the carrier signal is multiplying the chopped signal by +1 and −1. To create true multiplication, the chopped signal must be fed through a filter to smooth out sharp edges. This is accomplished in the final circuit.

Project Circuitry

Shown in Fig. 6 is the block diagram of a transmitter circuit you can build and use for experimental purposes. A microphone, the low-level signal from which is amplified by an on-board preamplifier stage, or a high-level signal that doesn't undergo preamplification can be used as the modulating signal source. The carrier signal comes from a 1-MHz oscillator for easy tuning of the transmitted signal on a standard AM broadcast-band radio.

The modulator in this transmitter chops and filters the carrier and modulating-source signals. The final stage buffers the modulator and delivers the output from the transmitter to the antenna.

As shown in Fig. 7, the preamplifier section is the straightforward two-stage (*U1* and *U2*) noninverting op-amp circuit. It's selected by setting *S1* to the alternate position shown. The purpose of the preamplifier section is to match the impedance of the microphone to the impedance of the *U3* balanced modulator. The gain of each stage in the preamplifier is 30, yielding an overall gain of 900 (30 × 30). Two stages were used in the preamplifier because of the limited gain bandwidth product of inexpensive op amps. Though extremely high gain is possible with one op amp, a narrower bandwidth would have resulted.

Capacitors *C1* and *C2* in the noninverting amplifier configuration limits dc gain to about 1. This eliminates the possibility of saturation of either amplifier at dc. The JFET op amps provide immunity to noise at high input impedance.

The *U4* oscillator section is the familiar Colpitts configuration. It's simply a differential pair with an LC tank and feedback to provide regeneration. The modulating frequency can be changed here with ease. The values of capacitor *C6* and inductor *L1* in parallel determine carrier frequency using the formula: $f_c = 1/(2\pi\sqrt{LC})$.

With values of 50 μH and 450 pF for *L1* and *C6*, respectively, f_c factors out to 1,060 kHz, or 1.06 MHz. This frequency is in the middle of the AM broadcast band. If you use a different transmit frequency, recalculate the values of *C6* and *L1* using the above formula.

LM3046 *U4* is simply four npn transistors on the same piece of silicon inside the chip. The oscillator could be built using discrete components, but the LM3046 approach is better because its matched transistors are on the same substrate and withstand the same processing parameters. The transistors also heat and cool together for more stability.

LM1496 *U3* is configured for DSB-C transmission by offsetting the dc component applied to the input using *R10* and *R11*. The potential at the junction of these two resistors is −9.6 volts. The values of *R8* and *R9* are the same as those of *R11* and *R10* but their arrangement provides a potential of −5.4 volts that's applied to pin 3 of *U3*. These dc offsets create the envelope needed for DSB-C transmission.

The output of the oscillator at pin 12 of *U3* is clamped at two diode drops of approximately 1.2 volts by *D1* through *D4*.

The switching mechanism inside *U3* is a differential transistor pair that requires only a small voltage to switch states. The smoothing filter that rounds out the sharp edges created by the chopping action is made up of *C8* and *L2*. Without this filter, the transmitter would be less efficient because it would waste power on harmonic frequencies. If you change the carrier frequency, you must also recalculate the values of *C8* and *L2*.

Capacitor *C3* buffers the dc applied to pin 1 of *U3* and prevents back feeding to *U2*. Capacitor *C7* shorts to

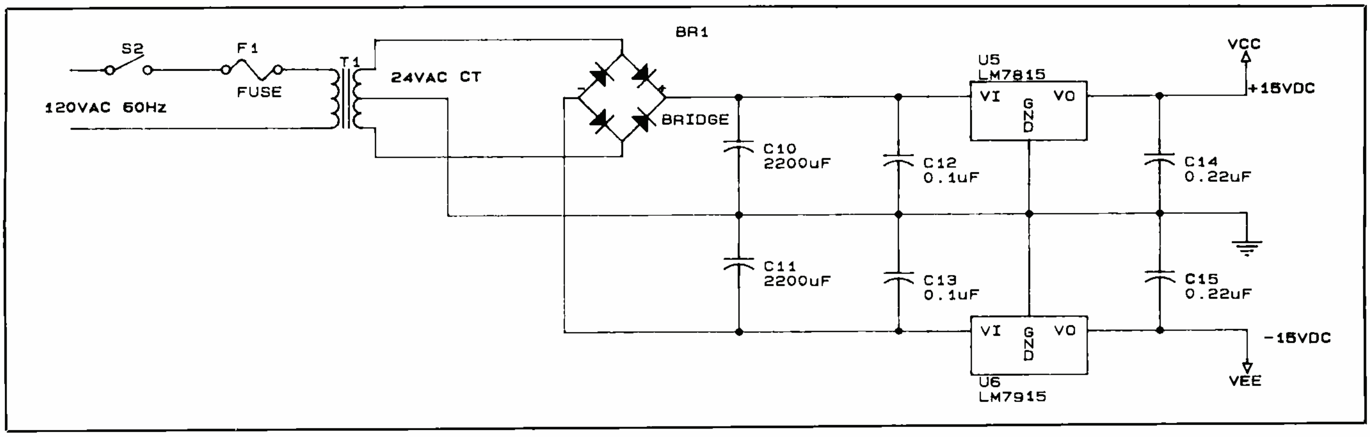


Fig. 8. Schematic diagram of power supply for the AM Transmitter.

ground high frequencies at pin 4 of *U3*, allowing proper bias to be applied to this pin. Bridging resistor *R9* sets the internal bias for *U3*. Internally, the two emitters of the differential transistor pair meet at *R9*. Thus, the modulating voltage creates a current through *R9* and, consequently, a voltage across this resistor.

The output of *U3* is a current that's fed through *R20* to obtain a voltage for transmission. The high output impedance of *U3* requires a buffering stage to accomplish transmission. The buffering stage is a straightforward emitter-follower arrangement that has a gain of 1.

Since ±15 volts is available, a class-AB circuit was devised. Front-end transistors *Q1* and *Q2* are connected as diodes that bias output transistors *Q3* and *Q4*.

An antenna not longer than 2 to 3 feet must be used with this transmitter to assure the broadcasting range is limited to the immediate area.

Power for the transmitter is provided from the 117-volt ac line by the circuit shown schematically in Fig. 8. This circuit arrangement provides regulated ±15 volts. Regulators *U5* and *U6* reduce the incoming dc voltages and regulate them to +15 and −15 volts because the biasing voltages in various stages is based on ±15 volts dc. Center-tapped power transformer *T1* provides outputs for the positive and negative voltages required by the transmitter circuitry.

Construction

The simplest approach to construction is to wire together the components on perforated board that has holes on 0.1-inch centers using soldering hardware. Use sockets for *U1* through *U4*. Two points to keep in mind when building the transmitter: keep all wire runs and component leads as short as possible and mount the power supply on a separate board.

A suggested layout for the main board is shown in Fig. 9. The *U1/U2* preamp is on the end, the *U3* modulator is in the center and the *U4* oscillator is on the left. The output section (*Q1* through *Q4*, *D1* through *D4* and their support components) are at the far left and along the top of the board. The modulator is fed from both sides, and the output is at a corner of the board away from the microphone preamplifier circuit.

Begin assembly by mounting into place the four IC sockets. Do *not* plug the ICs into the sockets until you're directed to do so. Then mount the other components in the locations shown for them. Some resistors and the diodes mount on-end to conserve board space.

Refer to Fig. 7. Wire together the components. Take care in making connections to the IC sockets, elec-

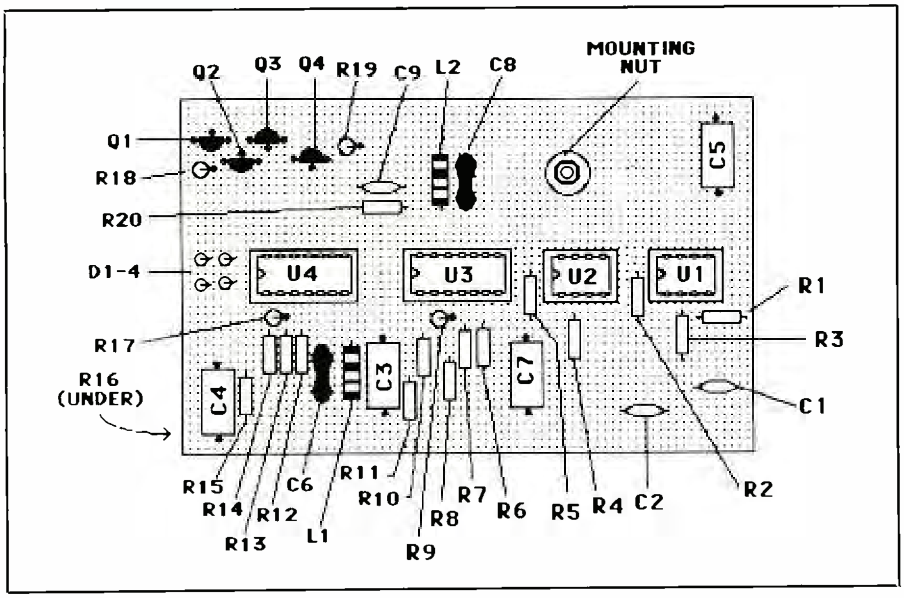


Fig. 9. Suggested component layout for main transmitter circuitry on perforated board.

trolytic capacitors, diodes and transistors. The microphone and signal inputs, antenna output, GAIN control *R21* and MIC/SIGNAL selector switch *S1* mount off the board.

Provide solder-post pins on the board for circuit ground, +15 and −15 volts, the microphone and signal inputs, antenna output, MIC/SIGNAL selector switch and GAIN control. These will be connected later, during the final assembly stages. Temporarily set aside the main transmitter circuit-board assembly.

As shown in Fig. 10, the power supply is best wired on two small pieces of perforated board. Mount the power transformer, bridge rectifier and filter capacitors on the larger of the two boards, the remainder of the power-supply circuitry on the smaller board. Refer to Fig. 9 to wire the power-supply circuit, making sure to observe correct capacitor polarities and regulator and bridge-rectifier pin identifications.

Use solder posts with which to make interconnections between all three boards and the primary circuitry of *T1*. Label each pin on all circuit-board assemblies according to its function for easy identification.

Use any size metal enclosure that accommodates the circuitry and provides sufficient panel space on which to mount the connectors and controls (see lead photo for a suggested layout for the panel). Drill mounting holes for the circuit-board assemblies and fuse holder and an entry hole for the ac line cord through the rear panel. Then drill mounting holes for the connectors and controls through the front panel. When done, deburr all holes to remove sharp edges.

Use a dry-transfer lettering kit or tape labeler to apply appropriate legends on the front panel. If you use dry-transfer lettering, spray two or more light coats of clear acrylic over them. Allow each coat to dry before spraying on the next.

Line the ac cord entry hole with a rubber grommet. Then mount the fuse holder and circuit-board assemblies in place, using suitable machine hardware and ½-inch spacers for the boards. Referring to Fig. 7 and Fig. 8, wire together the circuit boards.

Route the ac power cord into the enclosure through its grommet-lined entry hole and tie a knot in it about 10 inches from the end inside the enclo-

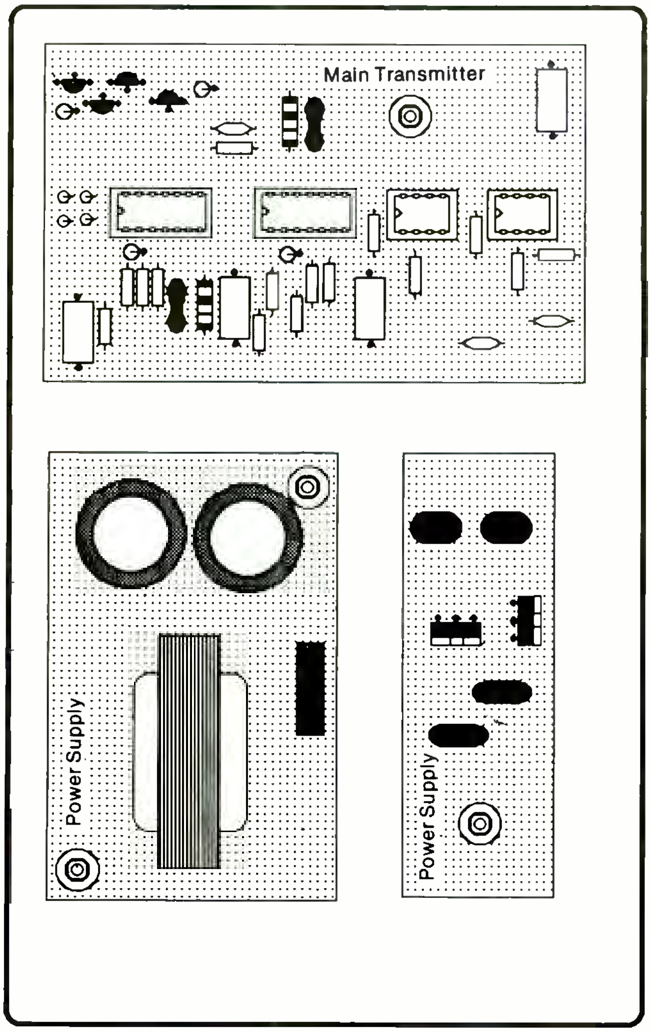
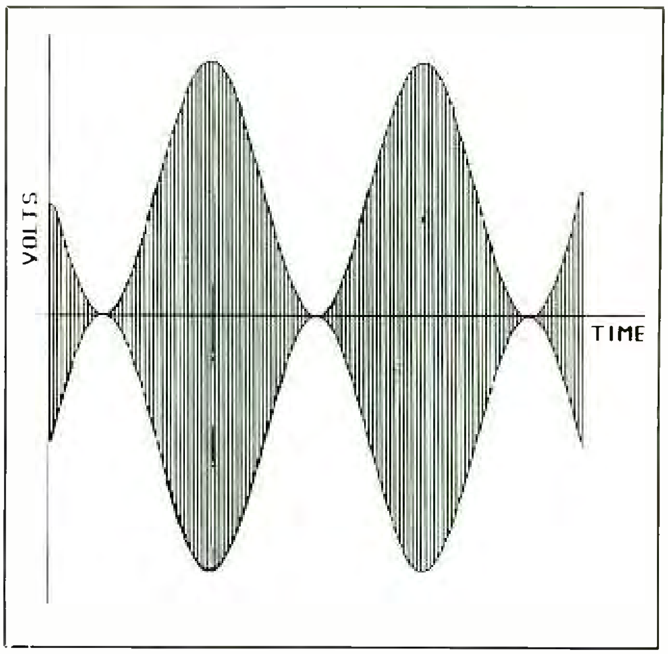


Fig. 10. Layout details for circuit-board assemblies inside enclosure. Large board at top is main transmitter circuitry. Power supply circuitry is on two smaller boards shown at bottom.

Fig. 11. Typical DSB-C AM-modulated signal as displayed on the CRT screen of an oscilloscope.



sure. Tightly twist together the fine wires in one conductor and sparingly tin with solder. Determine how long the other conductor must be to reach one of the solder posts connected to the power transformer primary, leaving some slack. Cut this conductor to length, strip ⅜ inch of insulation from it, tightly twist together the fine wires and sparingly tin with solder. Connect this conductor to either transformer primary solder post.

Mount the GAIN control, POWER and MIC/SIGNAL switches and ANTENNA, MICROPHONE and SIGNAL IN connectors in their respective locations. Place a control knob on the shaft of the GAIN control.

Crimp and solder the free end of the other ac line cord conductor to one lug of the POWER switch. Then use hookup wire to bridge from the other lug of the switch to one lug of the fuse holder and another wire to bridge from the other lug of the fuse holder to the unused transformer primary solder post. Place a fuse in the fuse holder.

Interconnect the circuit assemblies and components mounted on the front panel as needed, using hookup wire. Make sure each connection goes to the proper pins on the circuit-board assemblies.

Checkout & Use

Make sure *U1* through *U4* are not plugged into their sockets. Connect the common lead of a dc voltmeter or multimeter set to the dc-volts function to any convenient point in the circuit that is supposed to be at ground potential. Plug the line cord of the transmitter into an ac outlet and set the POWER switch to "on."

Touching the "hot" probe of the meter to pin 7 of the *U1* and *U2* sockets and pin 6 of the *U3* socket should yield a reading of + 15 volts. Similarly, touching the "hot" probe to pin 4 of the *U1* and *U2* sockets and pins and pins 4 and 14 of the *U3* should yield a reading of − 15 volts.

When you're certain that your wiring is correct, power down the Transmitter and plug the ICs into their respective sockets on the main board.

Temporarily disconnect the links between the oscillator, microphone preamplifier, modulator and output buffer sections. Power up the Transmitter and check the input section with a low-level signal from a signal generator. Use an oscilloscope to verify that proper gain is obtained at pin 6 of *U2*. If you observe saturation (flattening of the signal waveform peaks), you may have to install a voltage divider to correct for this.

After verifying that the preamp circuit is working properly, power down the Transmitter and generator. Disconnect the latter and plug into the MICROPHONE jack a microphone. Power up the Transmitter once again and speak into the microphone as you observe the scope display. You should see a variable amplitude/frequency waveform displayed with peak-to-peak excursions amounting to a few volts.

Next, check out the oscillator section. Touch the input probe of your scope to the anode of *D3* and note that there should be at this point a square waveform of approximately 1.06 MHz (unless you chose a different frequency for the carrier). Peak excursion of this signal should be approximately 1.2 volts. If the signal obtained is considerably off-frequency, change the value of *C6* to bring it in line. Tolerance here may affect frequency.

Restore the links between the microphone preamp, oscillator and modulator circuits, but don't restore the link between the modulator and output buffer circuits just yet. Check the output of *C9* while feeding a low-level signal from your signal generator into the MICROPHONE input jack. Set the panel switch to MIC during this test. The scope should display a waveform similar to Fig. 11.

If you fail to obtain a modulated-signal display, check the connections to *U3*. Use your meter to check the dc bias at pins 1 and 4 for presence of − 9.6 volts and − 5.4 volts, respectively. If you obtain different readings, resistor connections are incorrect.

When the output signal from the modulator looks okay, power down the Transmitter and restore the link between it and the buffer section. Powering up the Transmitter, there should be no difference in signal at the input and output of the buffer.

Now plug your antenna into the connector on the Transmitter. You should observe no change in the signal displayed on your scope. If everything works as described, you're ready to go on the air.

Plug the output cable from a tape deck or CD player into the SIGNAL IN and a 2- to 3-foot length of solid hookup wire (strip ⅜ inch of insulation from one end first) ANTENNA jacks. Turn on your transmitter, a nearby table or portable AM radio and tape deck or CD player and start a tape or disc playing. Set the SELECT switch on the panel to SIGNAL. Then carefully tune through the middle of the band on the radio until you hear the program being played on the tape deck or CD player from the radio.

Having verified that the high-level input works, power down the transmitter and unplug the tape deck or CD player from it. Plug your microphone into the MICROPHONE jack and set the SELECT switch to MIC. Power up the transmitter and speak into the microphone. If you fail to hear your voice coming from the AM radio or the signal sounds distorted, adjust the GAIN control until the signal sounds clean.

Experimenting

This Transmitter project serves well as a basis for studying DSB-C amplitude modulation. The LM1496 balanced modulator can easily be configured for DSB and SSB modulation, though additional filtering is needed to complete the design. However, the buffer, oscillator and input stages remain as they are shown. Implementation of SSB and DSB also requires a suitable receiver to pick up and demodulate the transmitted signal.

DSB-C modulation simplifies things because just about everyone already has a standard AM broadcast-band radio to receive its transmissions. If you have a shortwave receiver that can tune SSB transmissions, you can experiment with the SSB and DSB transmission. **ME**