Note: Some illustrations have been reduced in this sample to shrink the file size, but are often full pages in the actual books. The text may also refer to pages or figures that are not included in this sample. These graphics were scanned using greatly compressed JPG files and do not represent the real picture quality in the books.

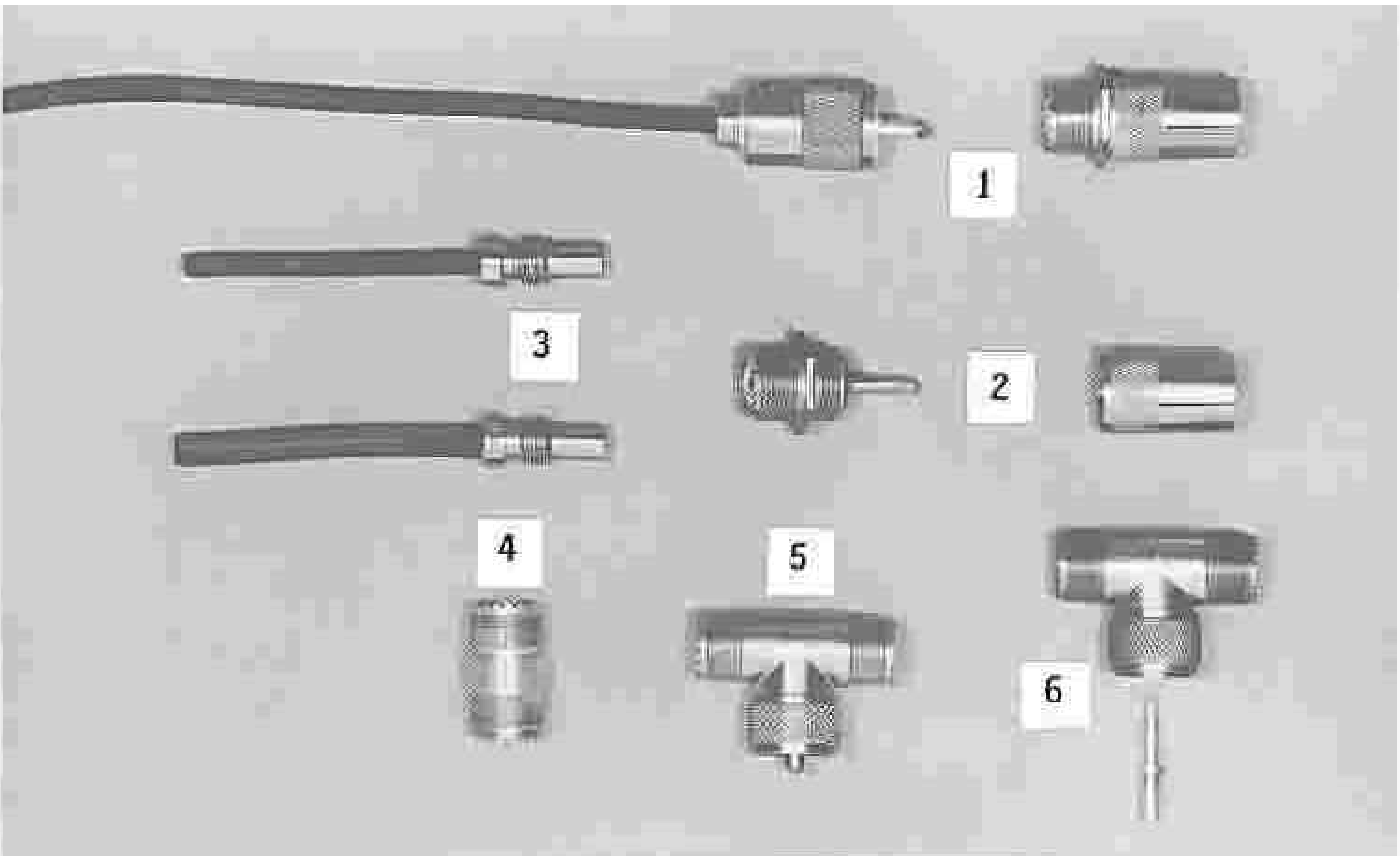
TABLE OF CONTENTS

…from Pages 9-12
(Chapter 1, INTRODUCTION TO CB SERVICING)

NOTES:
We didn't include any text from Chapter 1, just the following three photos which are fully described in the book anyway. The photos do have brief descriptions underneath them, which you can read if you zoom in with your JPG viewer program. These photos show some of our more useful and inexpensive do-it-yourself CB testers. This whole chapter contains detailed information about the meaning of various technical specs, setting up a CB repair shop, and a large section with names and numbers to get yourself started. The rest of this sample does contain text and illustrations.

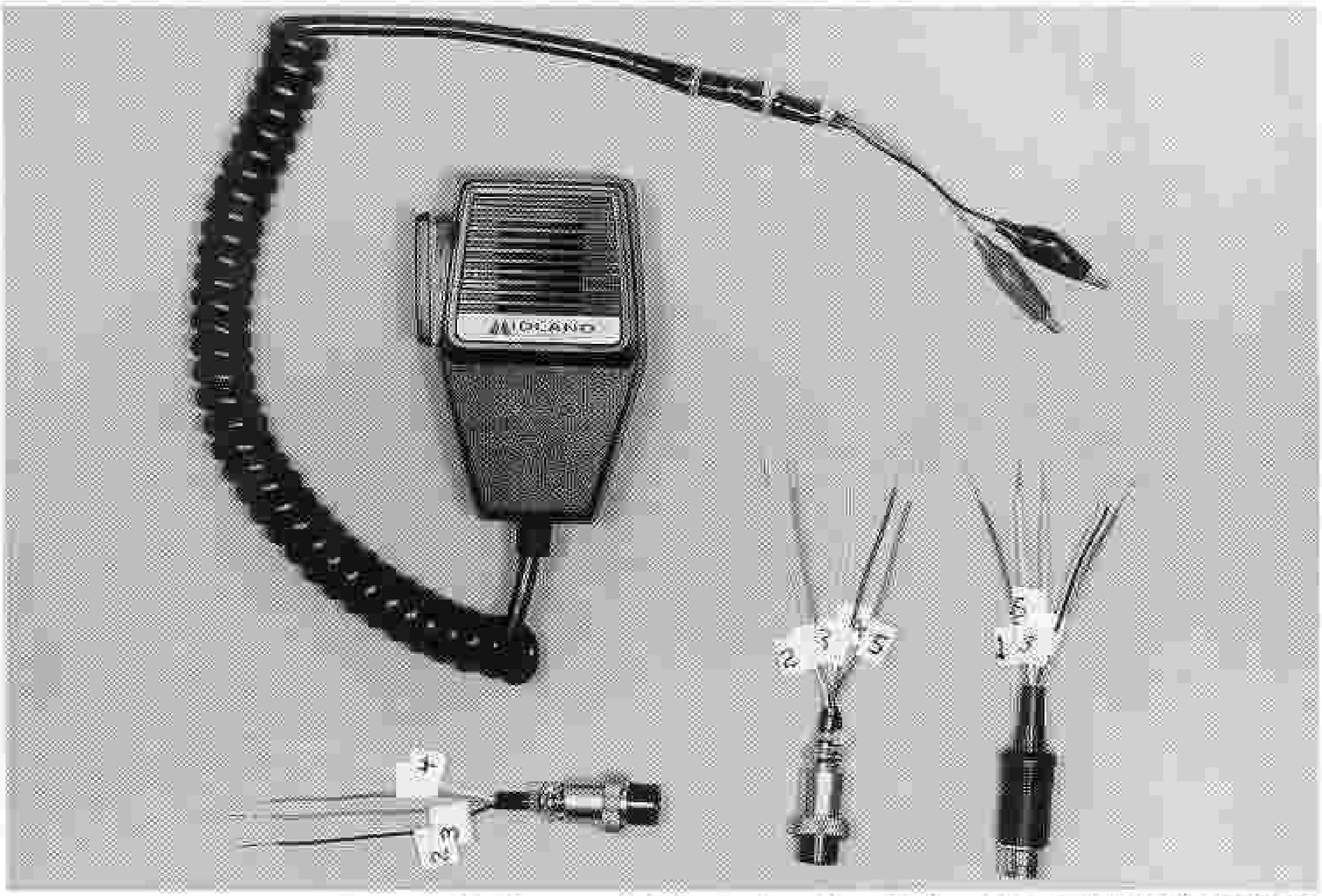
At the end of this sample file we've included the complete subject index; it's nine pages of small 3-column print covering thousand of entries, to give you an idea of this book's thorough coverage!

Photo from Page 9:



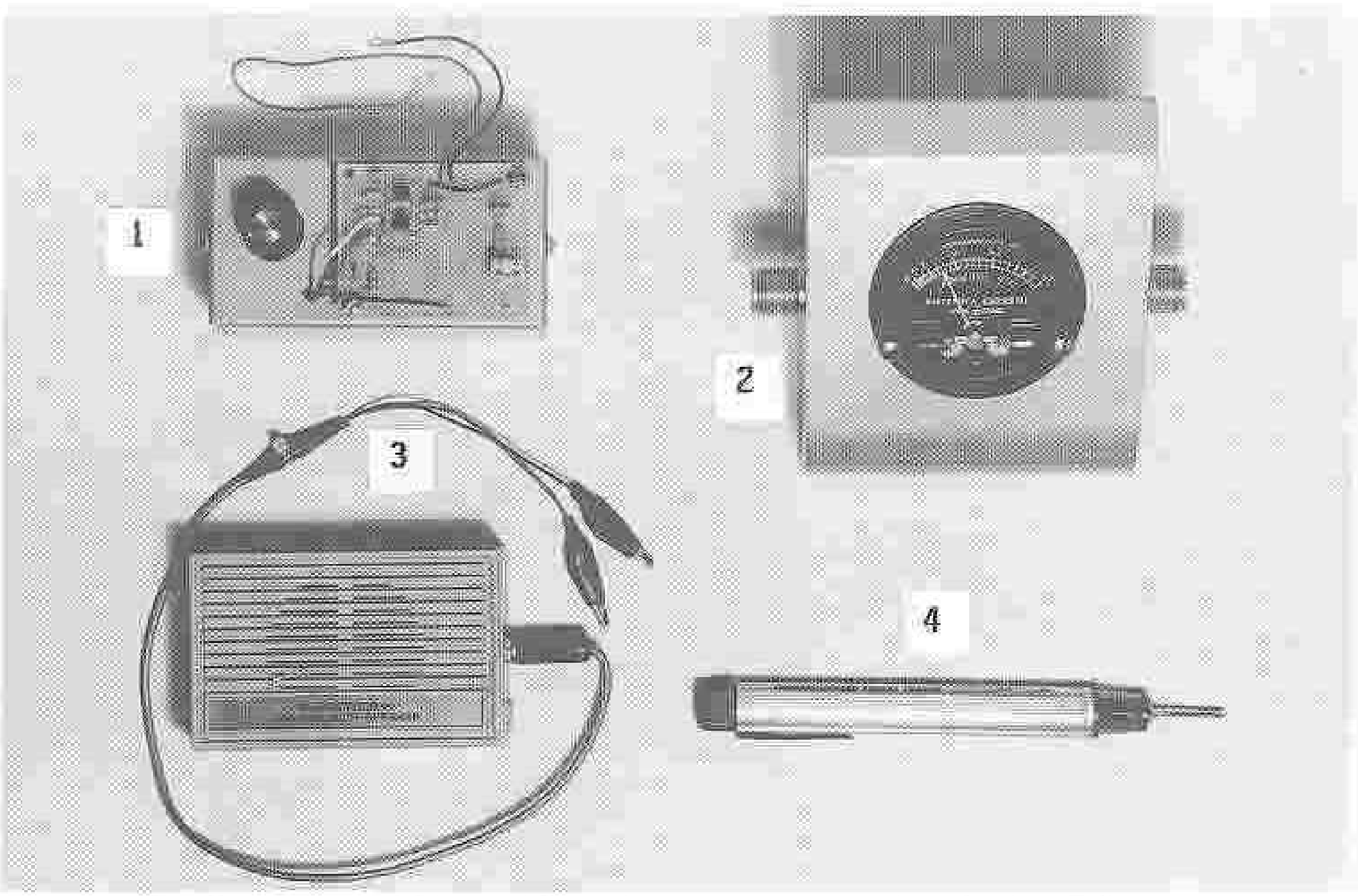
COAX CONNECTOR HARDWARE: #1 shows how a standard PL259 plug can be adapted to a push-fit plug (Gold Line #GL259-PF, Amphenol 83-55P) for quick hookups on the bench. #2 shows the two threaded pieces that make up this special plug. #3 shows the reducing adapters used with the PL259 plug; the UG175/U is for RG58 coax, and the UG176/U is for RG59 coax. #4 is the double-female "barrel" connector (PL258) used to splice cables with PL259 plugs. #5 is the "T" connector (M358) often used in test set-ups; #6 shows it with the center pin removed to make the RF sampler described in CHAPTER 5.

Photo from Page 10:



MIKE TESTERS: A standard dynamic CB mike is often convenient for tracing mike-related problems. Jumper the PTT switch so the audio is always hot, and remove the T/R wires. Also shown are three common mike plugs which can be used to figure out mike socket functions without a schematic. Connect colored wires to each pin, and number each pin as shown. (See text for details.)

Photo from Page 12:



MISCELLANEOUS TESTERS: #1 is the Colpitts oscillator whose schematic appeared in Figure 1-3. This was made from one of our EXPANDER 160 crystal oscillator boards. The DC power wires and a hooked test point for a 'scope or frequency counter are located along the top edge. The knob allows simultaneous switching of the divider capacitor values to test a wide range of crystal frequencies. The socket at its lower right will hold either the HC/18 or HC/25 crystal types. #2 is an RF Ammeter used for power measurements. It's mounted in a standard aluminum Bud meter box with SO-239 coax sockets on each side. The indicated reading of 0.75 RFA equals about 28 watts across 50 ohms. #3 is a 200 mW Radio Shack audio amp used for audio signal tracing. (See text.) #4 is an inexpensive "buzz-it" type RF signal generator.

…from Pages 51–57 (Chapter 3, GENERATING THE SIGNAL FREQUENCIES)

CRYSTAL SYNTHESIZERS

As CB radios gained popularity, all of the original 23 channels were quickly filled up. Crystals are very expensive relative to other components and it wasn't practical to use 46 separate crystals to cover the band, let alone 80 crystals when the band was expanded to 40 channels. And as overcrowding became the rule, more selective receiver circuits were needed.

The answer to the problems of cost, physical space and greater selectivity was a process called "crystal synthesis" or "crystal-plexing." This allowed complete 23-channel AM coverage with as few as twelve crystals, and the more selective dual-conversion receiver circuits. Let's see how they did it.

The Crystal Mixing Process

Figure 3-9 shows that when two signals are mixed in the heterodyning process, sum and difference frequencies result along with the two originals. For example, mixing signals of 15 MHz and 10 MHz results in 15 MHz – 10 MHz = 5 MHz, and 15 MHz + 10 MHz = 25 MHz, besides the original signals. Tuned circuits then select only the sum or difference frequency for further processing. In CB synthesizers both sum and difference signals may be used.

Forget the additional crystals used in SSB equipment for the moment, since this is completely covered in CHAPTER 6. This leaves basically two crystal synthesis methods for most AM radios: the 12-crystal scheme, and the 14-crystal scheme. In both cases, three oscillators are used: a Master Oscillator, a Transmit Oscillator, and a Receive Oscillator. There are subtle differences between the two mixing methods, and each was used about equally in 23-channel AM equipment.

The 14-Crystal (6-4-4) System

Figure 3-10 and the accompanying chart show this basic system. There are six crystals in the Master Oscillator, and four each in the Receive and Transmit oscillators. In this system only the difference frequencies are used; a quick glance shows that 37 MHz – 10 MHz = the 27 MHz needed for CB operation. Notice the 37 MHz oscillator runs for both Receive and Transmit, which means a problem here affects both modes. A problem only on Receive or only on Transmit means you should consider the separate Transmit and Receive oscillators, not the Master Oscillator.

FIGURE 3-9
BASIC SIGNAL MIXING PROCESS

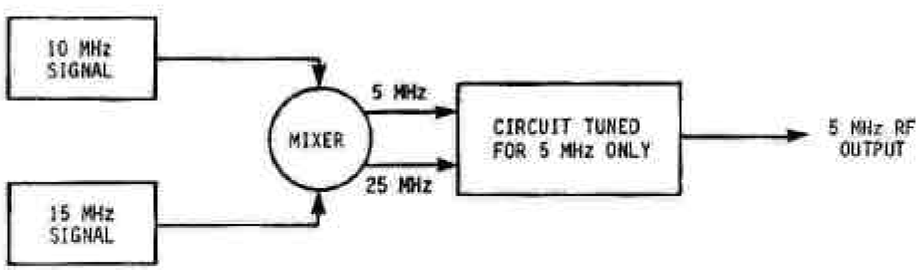
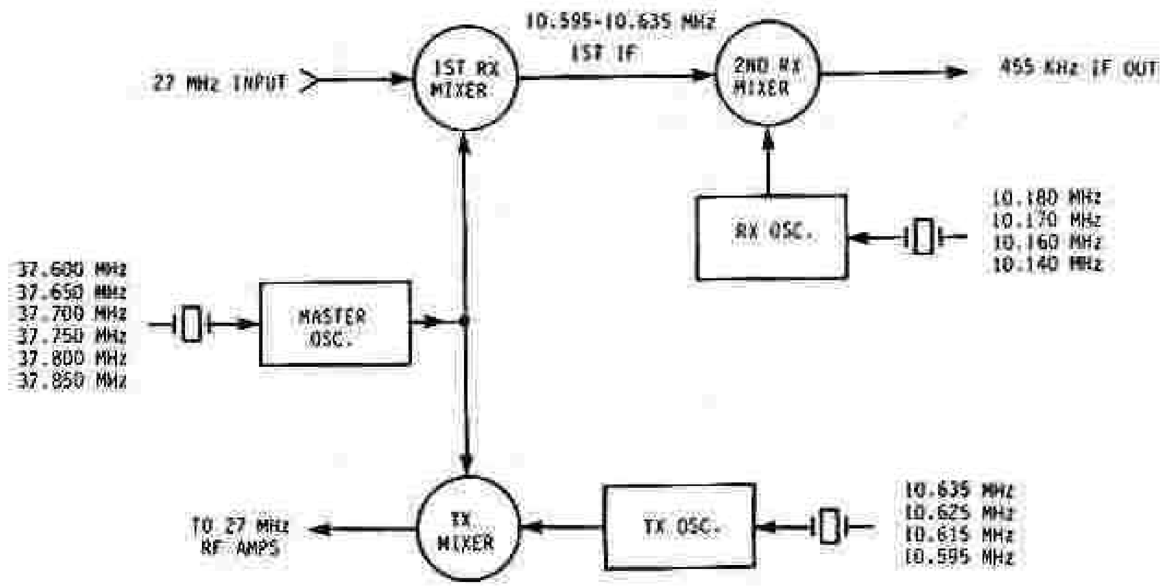


FIGURE 3-10
THE 14-CRYSTAL (6-4-4) AM MIXING SYSTEM



THE 14-CRYSTAL AM SYNTHESIZER

	BOTH RX&TX "A"	RX ONLY "B"	TX ONLY "C"		BOTH RX&TX "A"	RX ONLY "B"	TX ONLY "C"
Ch. 1 (26.965)	37.600	10.180	10.635	Ch.13 (27.115)	37.750	10.180	10.635
Ch. 2 (26.975)	"	10.170	10.625	Ch.14 (27.125)	"	10.170	10.625
Ch. 3 (26.985)	"	10.160	10.615	Ch.15 (27.135)	"	10.160	10.615
Ch. 4 (27.005)	"	10.140	10.595	Ch.16 (27.155)	"	10.140	10.595
Ch. 5 (27.015)	37.650	10.180	10.635	Ch.17 (27.165)	37.800	10.180	10.635
Ch. 6 (27.025)	"	10.170	10.625	Ch.18 (27.175)	"	10.170	10.625
Ch. 7 (27.035)	"	10.160	10.615	Ch.19 (27.185)	"	10.160	10.615
Ch. 8 (27.055)	"	10.140	10.595	Ch.20 (27.205)	"	10.140	10.595
Ch. 9 (27.065)	37.700	10.180	10.635	Ch.21 (27.215)	37.850	10.180	10.635
Ch.10 (27.075)	"	10.170	10.625	Ch.22 (27.225)	"	10.170	10.625
Ch.11 (27.085)	"	10.160	10.615	Ch.23 (27.255)	"	10.140	10.595
Ch.12 (27.105)	"	10.140	10.595				

Synthesis: "A" - "C" = direct on-channel TX frequency;
"A" - "B" = RX frequency (offset by 455 KHz)

This system is divided into six major groups. The last group (Ch.21/22/23) has one less frequency than the others; we only need 23 channels, and the missing combination would generate the 24th channel. The jump of 30 KHz between Ch.22 and Ch.23 later became Ch.24 and Ch.25 in the expanded 40-channel FCC band.

For example, Ch.1 (26.965 MHz) mixes the 37.600 MHz crystal with both the 10.180 MHz crystal on Receive, and the

10.635 MHz crystal on Transmit. The transmitter mixing produces the direct channel frequency of 37.600 MHz – 10.635 MHz = 26.965 MHz. However the receiver mixing results in 37.600 MHz – 10.180 MHz = 26.510 MHz. Note this is 455 KHz lower, which provides the required 2nd IF for the dual-conversion receiver circuit.

Use this information whenever you suspect oscillator-related problems. The most common causes will be faulty crystals, a faulty mixer, poor soldering of a particular crystal, or poor contact(s) for a particular crystal at the Channel Selector switch.

Symptoms of the 6-4-4 synthesizer failure are:

1. No Transmit or Receive on any channel. (Check the active devices, mixer, and switch wiring.)
2. No Transmit or Receive on four consecutive channels. (Check the associated 37 MHz crystal.)
3. No Receive on every fourth channel. (Check the associated 10 MHz crystal.)
4. No Transmit on every fourth channel. (Check the associated 10 MHz crystal.)

There are some variations on the 6-4-4 crystal system using frequencies other than the common 37-10-10 MHz scheme, and you may occasionally encounter these. Examples are most Johnson radios, which use 32-6-6 MHz, and the SBE scheme of 17-9-9 MHz. The principle is the same, although both sum and difference mixing frequencies may be chosen.

At the end of this chapter I've listed most of the other common AM mixing schemes for your reference.

The 12-Crystal (6-4-2) System

This system differs in the way the mixing signals are generated. See Figure 3-11 and the accompanying chart.

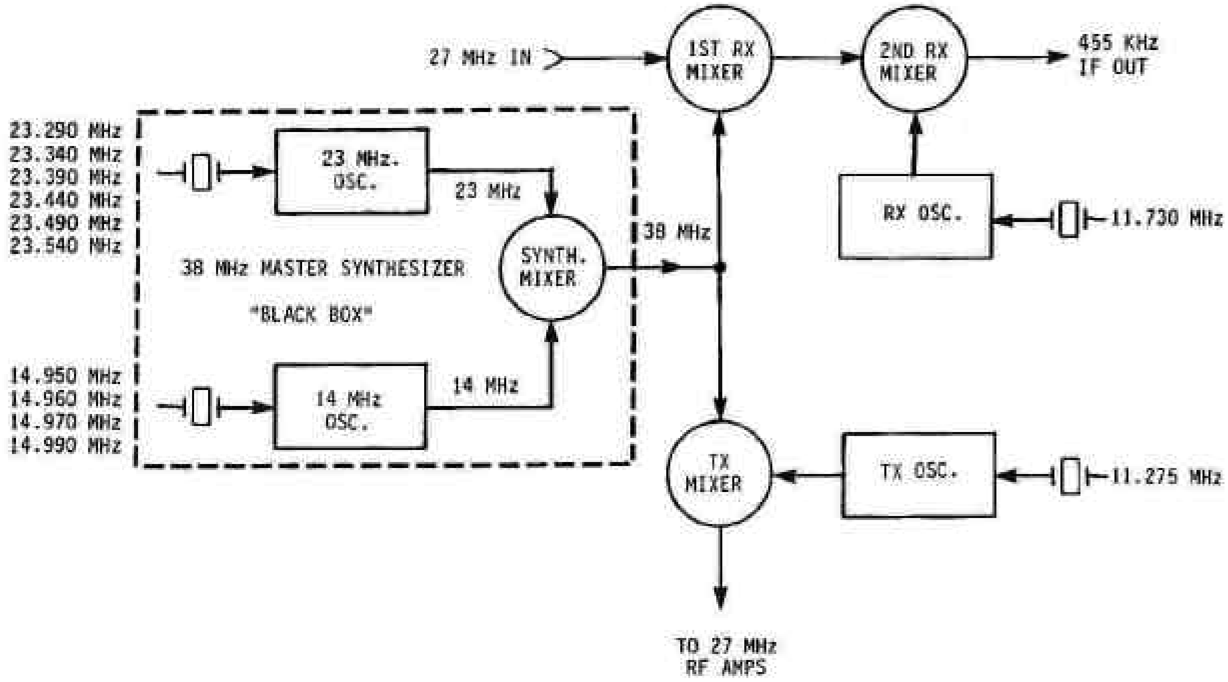
There are now two Master Oscillators running at 14 MHz and 23 MHz. The resulting sum of 38 MHz is chosen and then mixed with separate 11 MHz Receive and Transmit oscillators. When subtracted from the 38 MHz composite signal, we get the required 27 MHz. Like the 14-crystal system with its 10 MHz Receive/Transmit crystal pairs that are separated by 455 KHz, in this system the 11 MHz crystals are also separated by 455 KHz to generate the required offset for dual- conversion receivers.

Example: For CB Channel 1 (26.965 MHz) the 23.290 MHz crystal mixes with the 14.950 MHz crystal. This gives 23.290 MHz + 14.950 MHz = 38.240 MHz. The Transmit oscillator is always 11.275 MHz, which results in 38.240 MHz – 11.275 MHz = 26.965 MHz, the channel frequency. For Receive, the result will be 38.240 MHz – 11.730 MHz = 26.510 MHz. This is the same as the 14-crystal scheme; we simply got there by a different route. This 6-4-2 synthesizer method was very popular in Uniden AM radios sold under the Cobra, Courier, HyGain, Lafayette, Midland, and Realistic names, among many others.

Symptoms of the 6-4-2 synthesizer failure are:

1. No Transmit, all 23 channels. (Check the 11.275 MHz oscillator circuit.)
2. No Receive, all 23 channels. (Check the 11.730 MHz oscillator circuit.)
3. No Transmit or Receive, all 23 channels. (Check the 38 MHz mixer stage.)
4. No Transmit or Receive on four consecutive channels. (Check the associated 23 MHz crystal.)
5. No Transmit or Receive on every fourth channel. (Check associated 14 MHz crystal.)

FIGURE 3-11
THE 12-CRYSTAL (6-4-2) AM MIXING SYSTEM



THE 12-CRYSTAL AM SYNTHESIZER

	RX/TX "A"	RX/TX "B"		RX/TX "A"	RX/TX "B"
Ch. 1 (26.965)	23.290	14.950	Ch.13 (27.115)	23.440	14.950
Ch. 2 (26.975)	"	14.960	Ch.14 (27.125)	"	14.960
Ch. 3 (26.985)	"	14.970	Ch.15 (27.135)	"	14.970
Ch. 4 (27.005)	"	14.990	Ch.16 (27.155)	"	14.990
Ch. 5 (27.015)	23.340	14.950	Ch.17 (27.165)	23.490	14.950
Ch. 6 (27.025)	"	14.960	Ch.18 (27.175)	"	14.960
Ch. 7 (27.035)	"	14.970	Ch.19 (27.185)	"	14.970
Ch. 8 (27.055)	"	14.990	Ch.20 (27.205)	"	14.990
Ch. 9 (27.065)	23.390	14.950	Ch.21 (27.215)	23.540	14.950
Ch.10 (27.075)	"	14.960	Ch.22 (27.225)	"	14.960
Ch.11 (27.085)	"	14.970	Ch.23 (27.255)	"	14.990
Ch.12 (27.105)	"	14.990			

Synthesis: "A" + "B" - 11.275 = direct on-channel TX frequency;
"A" + "B" - 11.730 = RX frequency (offset by 455 KHz)

THE PHASE-LOCKED-LOOP (PLL) SYNTHESIZER

The PLL synthesizer is the only type now used for CB radios worldwide. Any CB having 40 (or more) channels just wouldn't be practical any other way. (One exception: the Tram D201A, which simply added a few more synthesizer crystals to convert the D201 23-channel radio to the 40-channel version. It had enough room!) A handful of 23-channel American radios like the SBE Formula "D," Royce 601 "Gyro-Lock," and Realistic TRC57 did use early PLL circuits composed of many discrete ICs. Today IC technology reduces this circuit to one or two chips and a few external components. With digital technology the whole radio needs only one to seven crystals. Besides the obvious advantages of cost and space, performance is improved because every channel has the same degree of accuracy, since the same crystal(s) generates every mixing frequency.

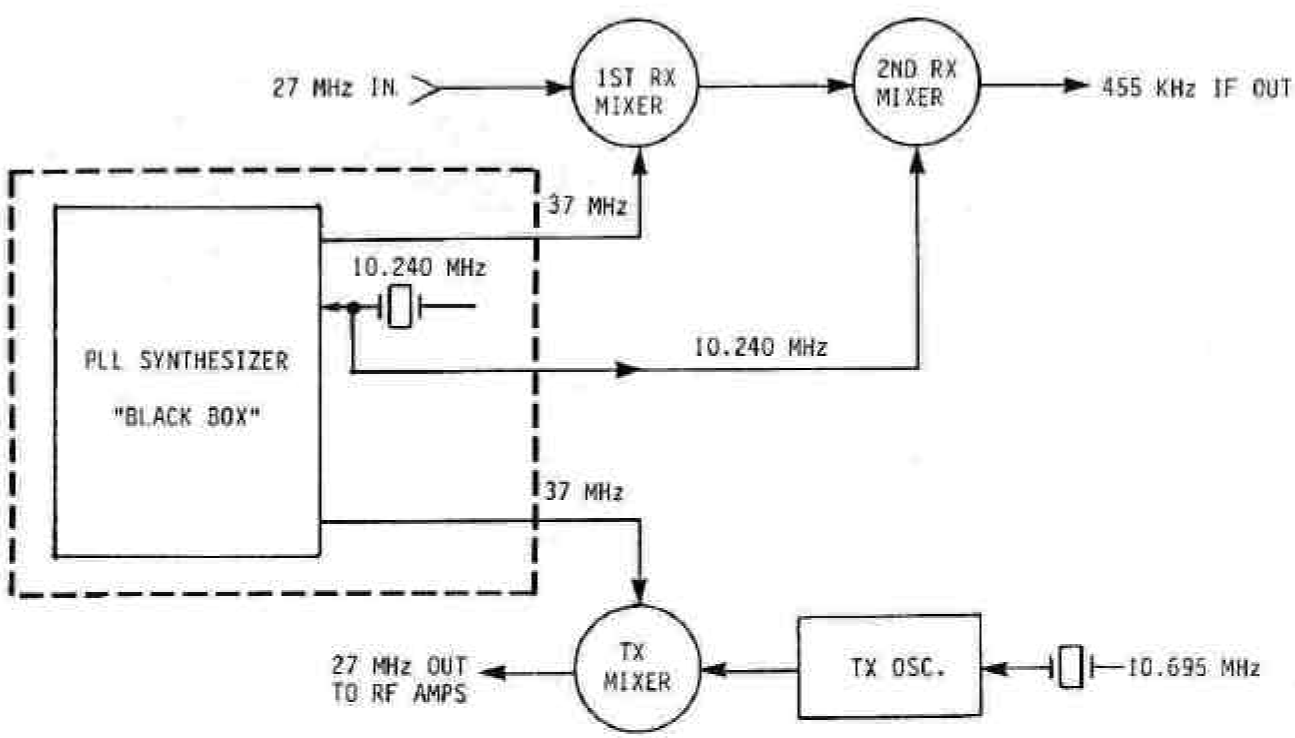
PLL circuits look more complicated than crystal synthesizers, but really aren't when you compare their end results; i.e., generating a specific set of mixing signals. The main distinction is that the PLL is a digital rather than analog system. Let's compare both in a very general way to see how they evolved.

Comparison of PLL and Crystal Synthesizers

Return to the 12-crystal 6-4-2 synthesizer on the preceding page. For the moment ignore whatever's going on inside the dotted lines. The important point is that coming from this area is a set of 38 MHz frequencies, one for each CB channel, which when mixed with the associated 11 MHz Receive/Transmit oscillators will produce the required signal frequencies.

Now compare this to the equivalent PLL synthesizer of Figure 3-12. Again, the area inside the dotted lines can be considered a "black box" for the moment. Its output is a group of 37 MHz frequencies, plus a 10.240 MHz signal. When mixed with the appropriate Receive/Transmit circuits, the same signal frequencies are generated. Note the 10.240 MHz oscillator is sampled and also used to supply the injection for the 2nd receiver IF. This eliminates the extra cost and complexity of another crystal oscillator, and also helps reduce the number of spurious signals generated within the radio. Except for some other minor changes for SSB, there's little difference between the function of either "black box."

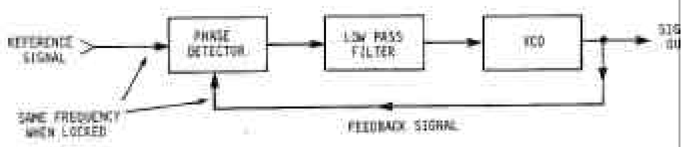
FIGURE 3-12
EQUIVALENT SYNTHESIZER OF FIG. 3-11 USING A PLL



ELEMENTS OF THE PLL SYSTEM

Now let's dissect the PLL "black box" to see what's happening inside that makes it produce the needed mixing signals. Figure 3-13 shows its three basic elements: a VCO or Voltage-Controlled Oscillator, a Low-Pass Filter, and a Phase Detector or Phase Comparator.

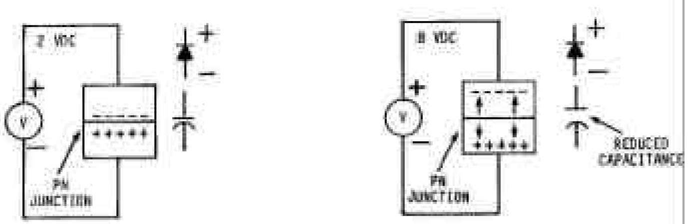
FIGURE 3-13
BASIC PLL SYSTEM



The VCO

The VCO is an oscillator whose frequency change depends not upon coils, capacitors, or quartz crystals, but on a special semiconductor device called a "varactor," "varicap," or "VVC" (Voltage-Variable Capacitance) diode. This has the ability to change its capacitance at a predictable rate as its reverse-bias voltage changes. The concept makes more sense when you consider the construction of a typical silicon PN junction. See Figure 3-14.

FIGURE 3-14
CAPACITANCE EFFECT OF SILICON JUNCTION
AS A FUNCTION OF REVERSE BIAS



The two halves of the PN junction can be thought of like the two plates of a capacitor separated by the junction barrier. Near the junction are [+] and [–] charged particles. The varactor diode always operates with reverse-bias, and as this bias increases the charged particles separate further from the junction, reducing the capacitance. In other words, the capacitance is inversely proportional to the diode's reverse bias. Actually all diodes have this property, but without special manufacturing techniques, the back resistance could be low enough to damp the oscillations completely and keep it from working.

It doesn't matter how the reverse bias is made to change. In Figure 3-15A, the varactor's cathode voltage can be increased, which is the usual case in most PLLs. Or its anode voltage can be decreased as in Figure 3-15B. Many common PLL ICs like the PLL02A, SM5104, and MC145106 use a negative-going Phase Detector output in which the higher the input frequency, the lower the DC output voltage to the varactor.

The most common varactor diodes for CBs are the 22 pF or 33 pF types. (1S2339G, ITT310, ECG613, ECG614, etc.) This is the capacitance value at a specific reverse bias, typically 4.0VDC. In practice a fixed DC bias is first applied to establish operation in the diode's linear range, and the changing control voltage is added to this. Figure 3-15A on the next page shows a VCO circuit using a discrete varactor. Many newer chassis use ICs containing most of the VCO circuit, and often part of the mixer too. Examples are the TA7310/AN103/C3001, and the UHIC005 or UHIC007. The TA7310 type requires an external varactor, while the UHIC types have internal varactors.

Because diode junction capacitance also changes with temperature, the varactor or IC and the surrounding VCO components are buried in wax for greater stability against temperature and vibration. When repairing this circuit, always reseal the area. They used beeswax; candle wax is OK too. Figure 3-15B shows the Cybernet SSB (and some of their late AM/FM) chassis, which have a sealed plastic VCO block that's completely encapsulated for stability and must be replaced rather than repaired.

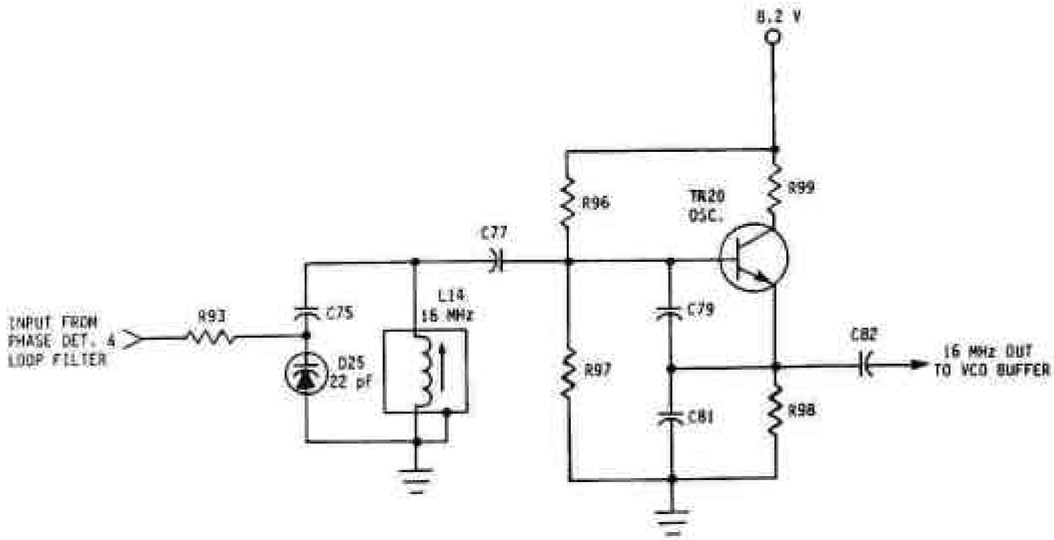
The VCO is typically a Colpitts oscillator where the varactor and a tunable shunt coil form its parallel-resonant tank circuit. With a varactor in the oscillator tank circuit (Figure 3-15A), any change in its reverse bias changes the capacitance, which in turn changes the frequency. The higher the applied voltage, the smaller the capacitance and hence the higher the frequency, and vice-versa. This is precisely the circuit idea used in the Delta Tune or Clarifier control of a modern CB radio.

Note that the [+] shift is always clockwise from the center knob position and the [–] shift is counterclockwise. Clockwise rotation increases the varactor control voltage and counterclockwise decreases it. The same principle is used for FM, where a sample of the mike audio is applied to the VCO varactor and causes it to change frequency at an audio rate.

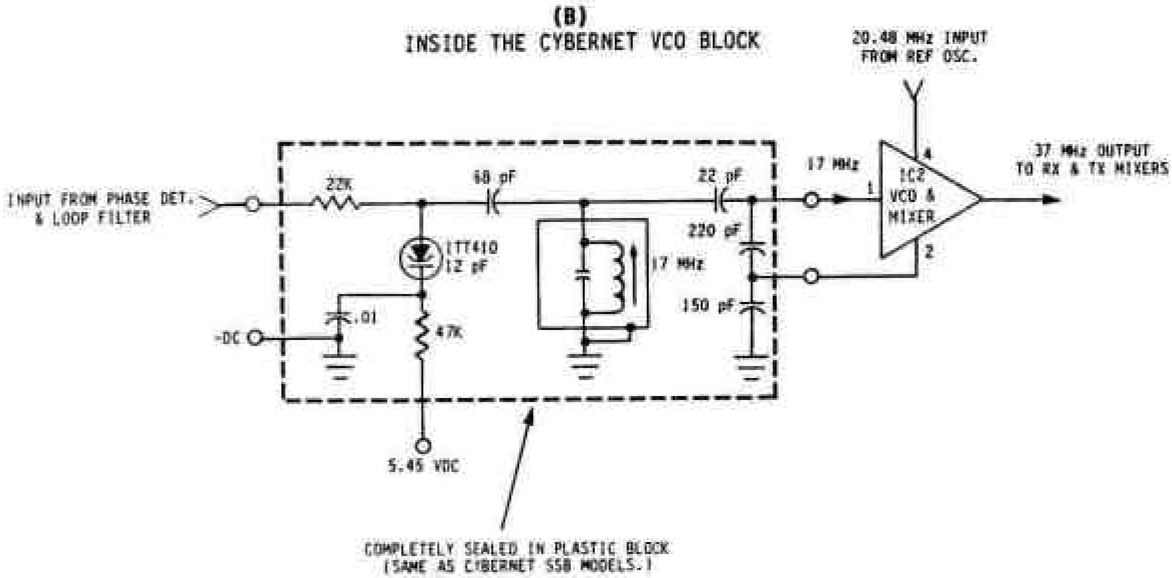
(continued on next page)

FIGURE 3-15
VCO CIRCUITS

(A)
COLPITTS VCO USING DISCRETE COMPONENTS
(Cobra 146GTL, President AR144, Realistic TRC451, Uniden PC244, etc.)



(B)
INSIDE THE CYBERNET VCO BLOCK



…from Pages 182–187 (Chapter 5, TRANSMITTER CIRCUITS)

MODULATION LIMITERS & COMPRESSORS

Circuits to prevent overmodulation are found in most speech audio chains. There were some radios from the 23-channel era that had absolutely no limiting at all, causing bleedover interference to other stations. This was especially true when combined with power mikes. During the 40-channel expansion in l976 the FCC tightened its technical requirements, and all models had to limit modulation under 100% before they could legally be sold. Other countries followed, with the result that all radios now have a modulation limiter circuit.

It's desirable to have such circuits for more reasons than the obvious interference problem. If the transmitter is adjusted so the average voice just hits 100% peaks, which only happens over a relatively small amount of the time, the remaining modulation will average only about 30%. Speech processing can raise this average value considerably, giving a stronger signal with more range. Modulation limiters are a simple form of such processing.

The circuit which controls modulation is called the Automatic Modulation Control, or AMC. Often it's incorrectly called ALC (Automatic Load Control), which is a similar circuit for SSB that operates on RF rather than audio stages. In AM/SSB radios the AMC is sometimes referred to or labelled "AF ALC" to distinguish it from the RF ALC used for SSB limiting.

AMC is a means of volume compression working on exactly the same principle as receiver AGC. A feedback loop samples the modulation from the audio power amplifier and applies it to a control circuit at the speech amplifier, where it adjusts gain as required. Most AMC circuits have internal trimmers to set the 100% limit, although a few use fixed component values.

AMC circuits are <u>not</u> true speech processors in the sense that modulation power is increased substantially. They only control peak levels, and can do nothing about low levels that may be caused by a soft voice or a weak mike. Since manufacturers never give anything away, they only do enough to pass the legal requirements. Any extra built-in processing (like that in the CPI rigs) or external add-on accessories (like our own **DYNAMIC SPEECH PROCESSOR**) cost extra.

There are two basic types of AMC. In the "bias" circuit, the sampled feedback voltage is applied to the emitter of the mike amplifier to control its gain. In the "shunt" AMC circuit a transistor, acting like a variable resistance, is shunted directly across the mike input to ground. The more it conducts, the more mike voltage is bypassed to ground. The shunt method is the most common, found in perhaps 80% of all CB transceiver models.

Figure 5-35 (next page) is a simple bias type AMC circuit. C50 couples a sample of the high-level audio to D9, the limiter. This particular circuit uses a germanium diode for its lower conduction voltage, but silicon diodes are also common.

There's no adjustment other than the fixed resistance values set by trial-and-error when designed. Since D9 is shunted across the feedback loop, a positive DC voltage will develop across R58. This voltage is filtered by C49 and R57. At normal modulation levels the bias on Mike Amp TR9 remains unaffected. As modulation becomes excessive, the rectified feedback voltage raises its emitter higher above ground, reducing the conduction of TR9 and therefore its gain. C41 and C42 roll off the higher undesired audio frequencies.

All AMC circuits are carefully designed with time constants in mind, just like receiver AGC. These are determined by the RC values chosen, like R58/C49/R57 in Figure 5-35. If the time constant is made about one second, the system will follow the average modulation well, giving a fairly constant modulation percentage. If not long enough, the faster attack time results in some overshoot before settling down. This is often noticeable on your 'scope, where a loud whistle into the mike may overshoot the 100% limit momentarily before settling. The AMC is therefore a compromise between effective limiting and high average modulation.

A common Uniden shunt limiter is shown in Figure 5-36. TR27 is the shunt element; the harder it turns on, the more the mike audio is grounded. The conduction of TR27 is controlled in turn by the conduction of TR28 and TR29. Note the mixed use of NPN and PNP transistors to take advantage of polarity differences. The high-level audio is sampled at TR44, the main AM modulator. VR5 sets the standing bias on TR29, while D43 establishes a minimum forward bias of about 0.6VDC. As the sample voltage increases, TR29's emitter is raised higher, turning it off more. As it turns off more, its collector voltage rises. This turns off TR28 more, raising its collector voltage. The higher collector voltage is applied to the base of TR27, which conducts harder to limit the mike audio. C123/R154 sets the appropriate time delay. C119 reduces the higher frequencies.

This circuit is somewhat sophisticated, using three transistors. The extra amplification allows greater sensitivity and control range. It can be done more simply but less effectively using only one or two transistors and a diode detector to control the shunt element. Shunt AMC always requires a transistor to act as the variable resistance element. The more complicated circuits like this are generally reserved for AM/SSB equipment, where the feedback sample is often combined with the ALC for improved SSB modulation control as well. In such radios, additional switching transistors or diodes are used to gate the feedback path to the appropriate AM or SSB circuits.

FIGURE 5-35
BIAS TYPE AMC CIRCUIT
(Pearce-Simpson Bobcat 23C)

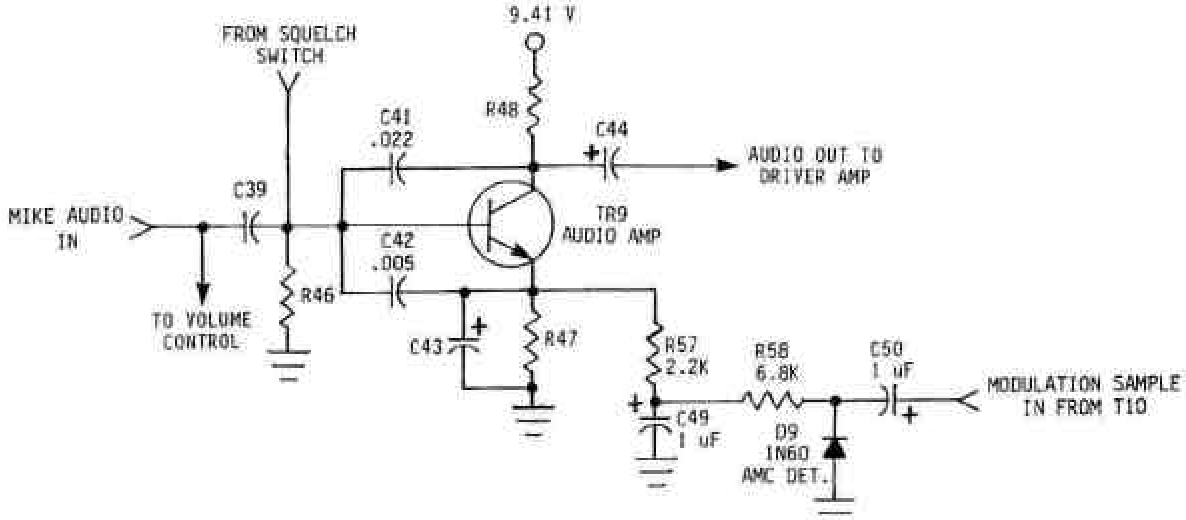
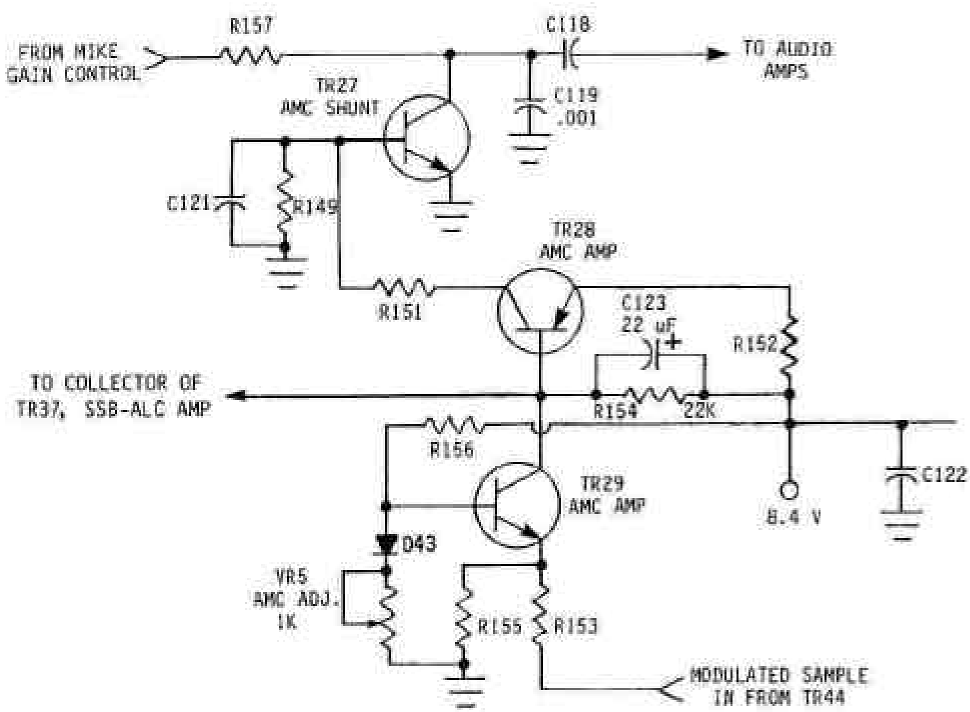


FIGURE 5-36
UNIDEN AMPLIFIED SHUNT AMC CIRCUIT
(Cobra 146GTL, President AX144, Realistic TRC451, Uniden PC244, etc.)



In tube-type equipment there isn't always an AMC circuit, since most of these were made before the tighter FCC rules. When present, the bias method is used to change the bias on the control grid of the speech amplifier tube and therefore its audio gain. The AMC sample typically comes from a pair of diodes in a voltage doubler configuration. The only special precaution when replacing them is to use high PIV silicon types like the 1N4004, 1N4005, etc.

MEASURING MODULATION CHARACTERISTICS

Maintaining modulation levels just under 100% is essential for maximum talk power and prevention of interference. The only proper way to accomplish this is with the oscilloscope. Modulation meters sold as CB accessories are grossly inaccurate, and obviously can't show distortion. You need a visual picture of the transmitted signal, and the 'scope provides this. No serious repairman would ever attempt AM transmitter alignment without one!

Ideally you'll have a 'scope with a minimum bandwidth of 30 MHz in the vertical amplifier. This allows you to view the 27 MHz modulation envelope directly. It's also possible to use a less expensive instrument by connecting it as described shortly.

There are two ways to view the modulated transmitter signal: the envelope method, and the trapezoidal method. The envelope method shown in the earlier photos and on the cover of this book is the most familiar. The RF signal is displayed as a function of the 'scope's internal horizontal time base, which means you can control how many cycles are displayed.

In the trapezoidal method, the scope's internal horizontal sweep is disconnected, and a sample is coupled in externally from the modulator. The display is then an RF signal graphed as a function of the audio signal itself rather than some fixed time base. The display resembles a triangle or trapezoid, depending upon the modulation percentage. The trapezoidal method is better for catching the more subtle problems such as non-linearity, since it's easier to interpret straight lines than curves.

Test Equipment Set-Ups

Figure 5-37 shows the two set-up procedures. The only difference between the envelope and trapezoidal methods is the source of the horizontal time base, from internal to external respectively. You can pick off the audio sample from any high-level area, like the output pin of the audio power IC, secondary of the audio output transformer, plate of the modulator tube, etc. Make sure it's capacitively coupled though. A 'scope probe is convenient for this.

Without a 30 MHz 'scope, it's still possible to get the trapezoidal pattern. See Figure 5-38. Basically this involves connecting an RF detector circuit across the antenna socket and connecting the other end to the 'scope's vertical amplifier. This produces a rectified DC voltage that changes with modulation. When this modulated DC is plotted against the sampled audio at the horizontal input, a trapezoid results. The sketch shows two diodes used in a voltage doubler, and a 47KΩ load resistor to get the largest possible signal sample for the 'scope input.

An even simpler trapezoidal measurement method, assuming the vertical amplifier has enough sensitivity, is to couple its input directly to the radio's S/RF Meter, since that circuit already has an RF detector handy. However the metering circuit is generally only a half-wave rectifier, which might not produce enough voltage sample for a good display even with the 'scope set to its maximum vertical sensitivity. In such cases you'll still need the higher output of the doubler type circuit.

FIGURE 5-37
MODULATION MEASUREMENT TEST SET-UPS

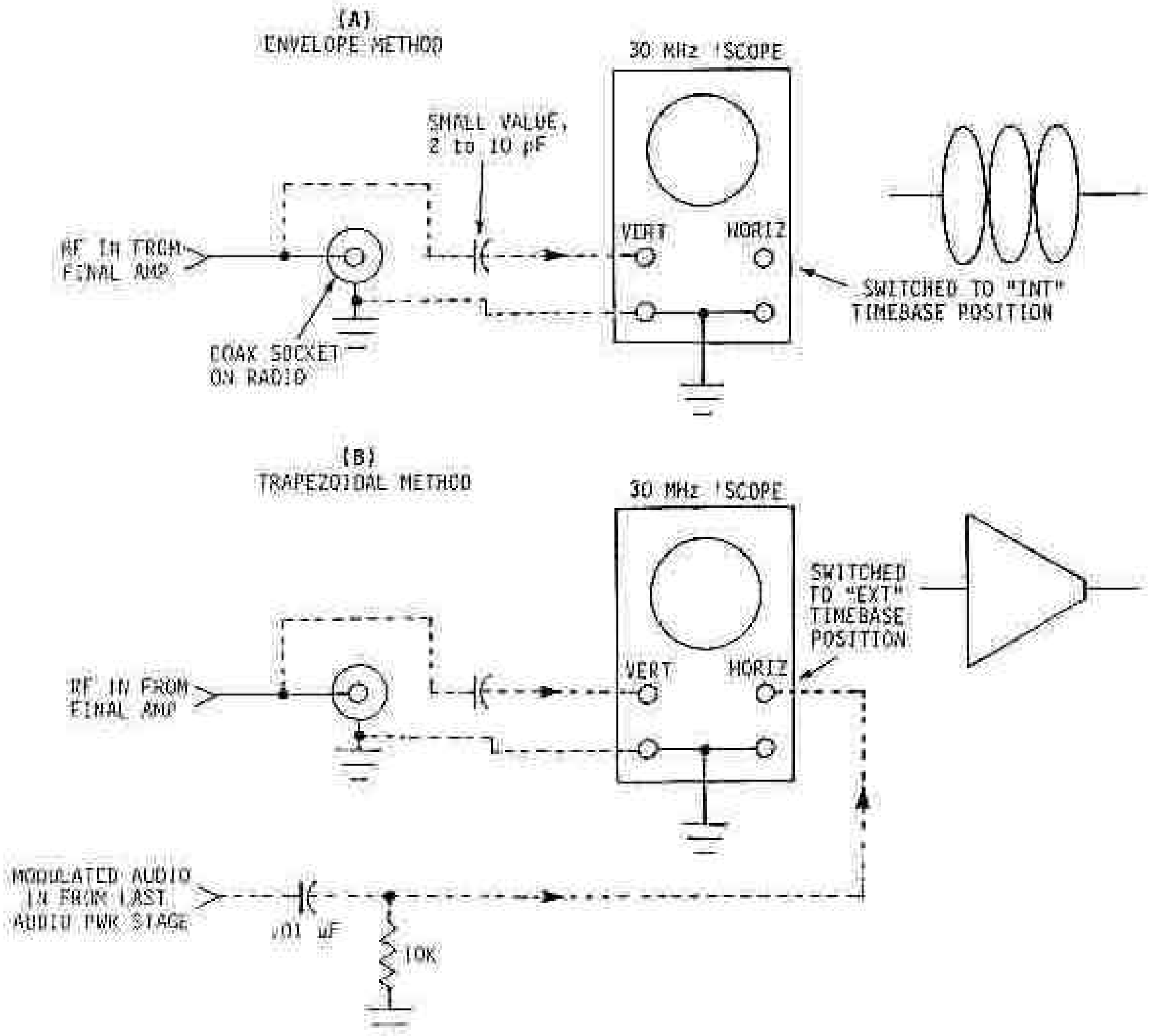
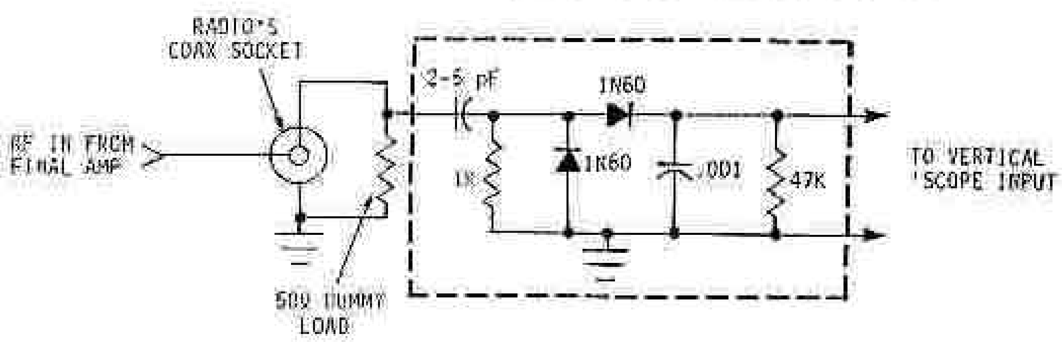


FIGURE 5-38
RF DETECTOR FOR USE WITH LOW BANDWIDTH 'SCOPE



To view the modulated RF envelope on a 30 MHz 'scope, a small RF sample is coupled from the coax socket and dummy load. Figure 5-39 shows one clever way to do this. Take an ordinary coax "T" connector (Amphenol M-358, etc.) and remove its center pin with a nutdriver or needle-nose pliers; the pin is screwed in. (See the first photo, #6.) Hacksaw off most of the pin so when you rethread it, the remaining pin section is flush with the plastic dielectric. (If you should ruin the pin, a piece of 4/40 or 6/32 machine screw also works.) This formerly male section now becomes a capacitive pickoff point. The two female ends of the "T" become a series feed-thru from radio to dummy load.

Now make up a piece of RG58/U coax with a BNC plug on one end and a female UHF on the other; this can be done directly with the solderless female Amphenol 83-58FCJ, or indirectly with a PL259 and a double-female (PL258) connector. This makes a coupler having a few picofarads of capacitance between the center of the female connector and the cutoff pin; when screwed together, they come very close but don't actually touch. (Confirm by DC ohmmeter checks.) If your frequency counter is sensitive enough it might read on this too. Another bonus is the fact that it's shielded.

Another sampling method involves making a 20:1 voltage divider. See Figure 5-40. Solder one lead of a 1KΩ, 2-watt resistor into a PL259 plug. Using a piece of RG58/U with a BNC for the 'scope end, strip back the other end and solder the center conductor to the loose resistor lead, and the shield to the body of the PL259. Shunt a 47Ω, 2-watt resistor from the center conductor splice to the body of the PL259 plug.

FIGURE 5-39
CAPACITIVE SIGNAL SAMPLER USING COAX "T" CONNECTOR

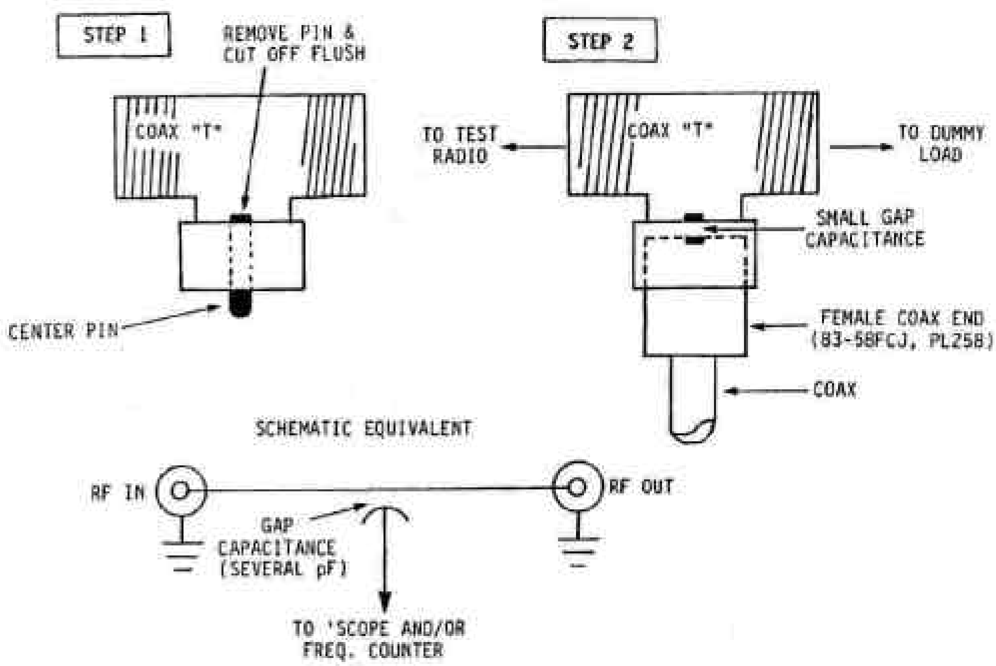
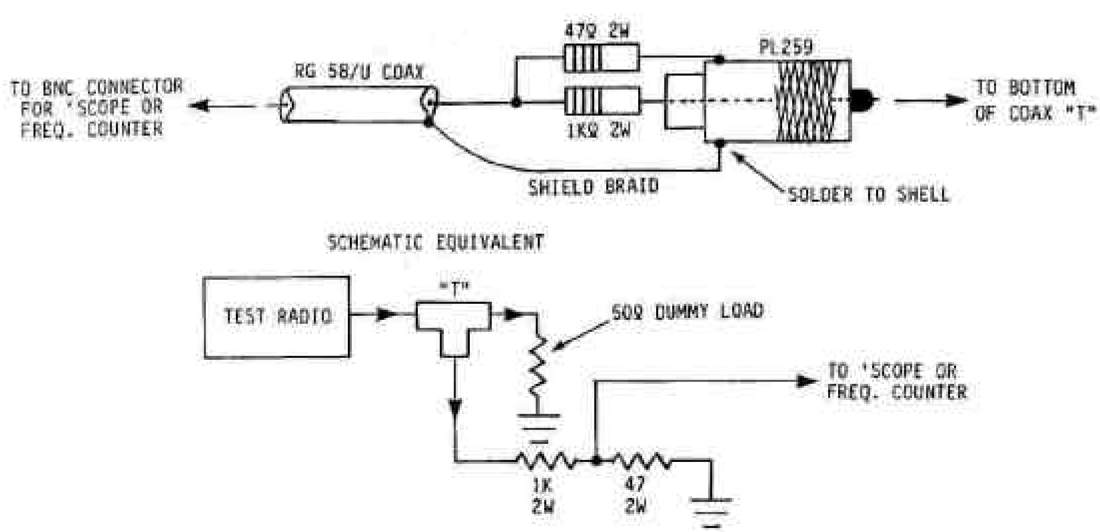


FIGURE 5-40
20:1 VOLTAGE DIVIDER RF SAMPLER



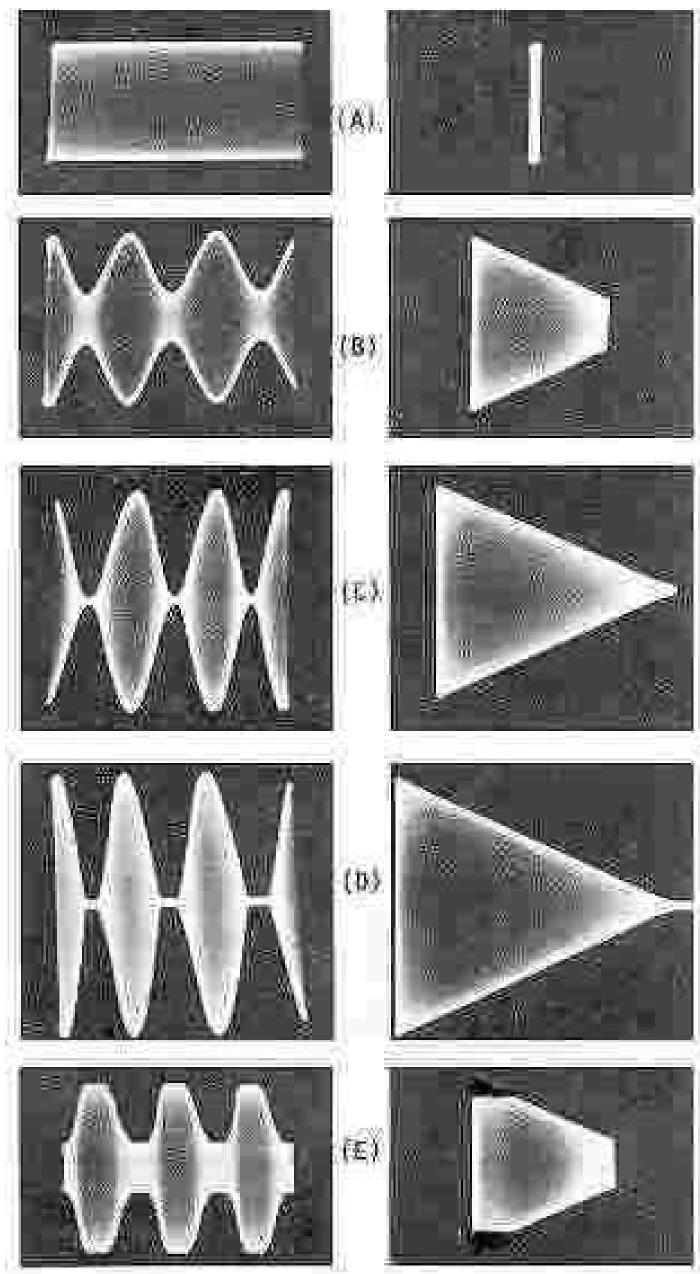
Now you can use various "T" connectors and UHF adapters to sample directly rather than capacitively from the dummy load; the 1KΩ presents a high enough impedance so normal RF output power isn't affected. With a typical 4 W output you'll get about 2 V P-P, which should be enough to drive both the 'scope and a frequency counter together.

Modulation Display Patterns

The 'scope photos on this page show various modulation conditions using both envelope and trapezoidal methods. The unmodulated carrier is seen in Photo "A." Note with the trapezoid only a vertical bar appears, since there's no audio yet at the horizontal input to spread it out. In Photo "B" you see 50% modulation. With the trapezoidal method, the right-hand vertical edge is exactly half as long (50%) as the left-hand edge. Photo "C" shows 100% modulation.

Photo "D" shows overmodulation; with either method a bright horizontal line appears where the modulation went to zero and stayed there for a finite time. Photo "E" shows the common problem of insufficient audio; the envelope shows peak clipping ("flat-topping"), while the trapezoid shows less than 100% modulation combined with clipping of the triangle's points. The cure is to reduce the carrier power or to increase the audio drive by realignment.

Problems of non-linearity would easily be seen as a rounding of the straight-line trapezoid edges; proper biasing is the usual cure, unless the modulating waveform itself is distorted.



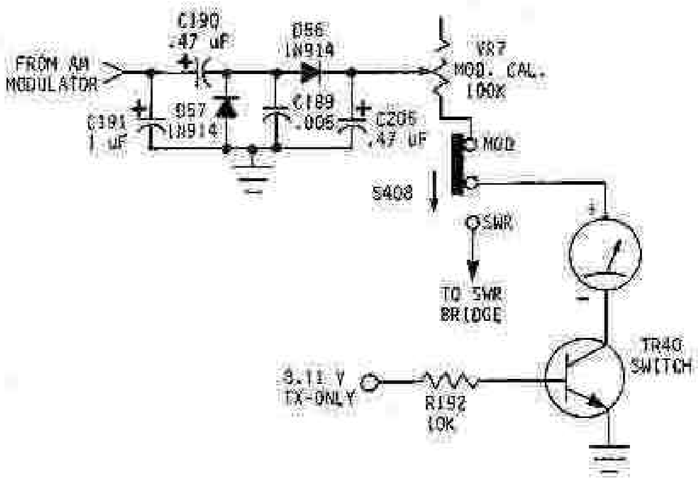
(Courtesy ARRL RADIO AMATEUR'S HANDBOOK)

…from Pages 194–200 (Chapter 5, TRANSMITTER CIRCUITS)

MODULATION METERING

This is basically the same as RF metering. The difference is that the sample is picked off a modulated audio stage and has a time constant more suitable for audio, since now we want the meter to bounce around. Unless the radio uses low-level modulation, the sample comes from the high-level modulator. In Figure 5-49 the audio is sampled via C190, an audio value, from the same modulator bus that feeds the AMC/ALC and RF power amps. This is a common method. C191 and C205 provide filtering and a small delay while C189 filters RF. VR7 is calibrated for a 100% indication during transmitter alignment. D57/D56 form a voltage doubler type rectifier for maximum DC sampling levels.

FIGURE 5-49
MODULATION METERING CIRCUIT
(Cobra 2000GTL, Uniden Madison)

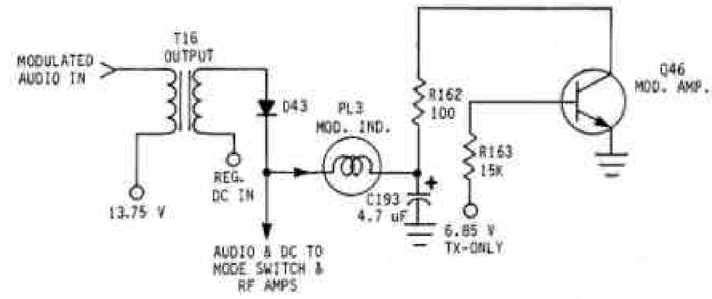


Because this meter also functions for SWR, the [–] meter terminal is grounded only on Transmit by switch TR40 rather than being hard-wired to ground. This prevents possible DC rectification in the "SWR" position from the bridge diodes on strong received signals; otherwise the meter might also deflect during reception.

Many radios use a simple LED or lamp for a modulation indicator. The stronger the audio, the brighter it lights. In Figure 5-50 the modulation LED is in series with high-level audio from output transformer T16 and ground, via Q46. The conduction of Q46 controls current flow through PL3 and therefore its brightness.

Q46 is biased just at the turn-on point with no modulation; the additional audio voltage makes it conduct harder. C193/R162 establish a time constant which is slow enough to make the changing brightness easy to see.

FIGURE 5-50
LAMP OR LED MODULATION INDICATOR CIRCUIT
(Cybernet PTBM048 chassis: Boman CB950, GE 3-5825A, RCA 14T302, etc.)



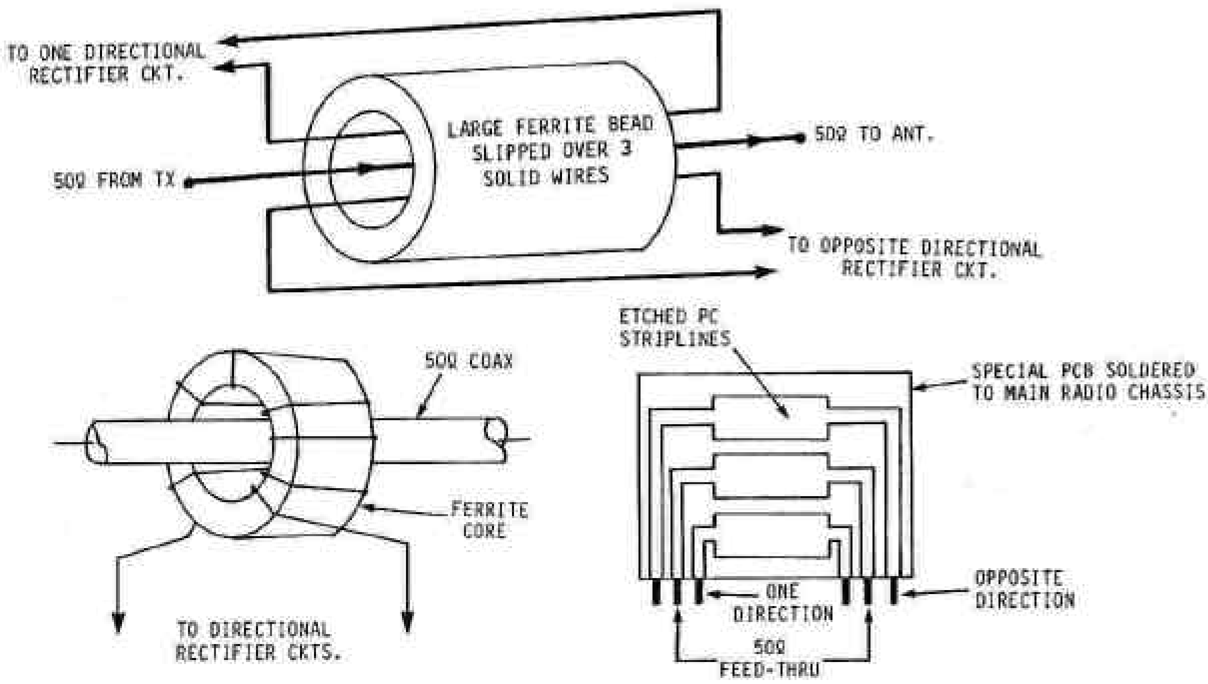
SWR METERING

The SWR metering circuit gives the operator an indication of proper antenna matching and performance. It consists of a directional sampling loop that measures the RF input/output power balance (or imbalance) at the antenna socket. This balance is the Standing Wave Ratio or SWR. The RF power moving outward from transmitter to antenna is called the "forward" or "incident" power; that returning from the antenna is called the "reflected" power. The SWR meter is also called a Reflectometer. A calibration control on the front panel lets the operator set the full-scale forward meter reading so that the reflected reading will be correct. CHAPTER 8 discusses SWR in detail.

The forward and reflected RF voltages must be sampled in a particular way. Figure 5-51 shows several methods. The RF is coupled to the meter circuit through a special transformer using a ferrite bead or core, or by a special PC board having parallel striplines and soldered to the main chassis. (The sketch shows only the striplines present, although the other bridge components may also be placed there.) Regardless of method, each simulates a section of 50Ω transmission line to prevent mismatches and their inaccurate readings. Coupling occurs through the mutual inductance and capacitance between the main center conductor and the wires or PC foils placed near it. The PC board is a simplified version of the top bead sketch using three striplines as the wires; it evolved as a labor saving step. The coax cable method is actually not found in CBs, but is used in some external SWR meters and helps illustrate the directional sampling idea.

Like all transmission lines, the coupler has a characteristic impedance which affects the RF voltages, currents, and phases in both directions, and these can be measured. In CB circuits the SWR meter measures the relative input/output RF voltages, or VSWR. Each sampling input is terminated in a rectifier diode at one end and a resistor at the other which establishes the characteristic impedance of the transmission line. You'll see various resistor values used in CB SWR

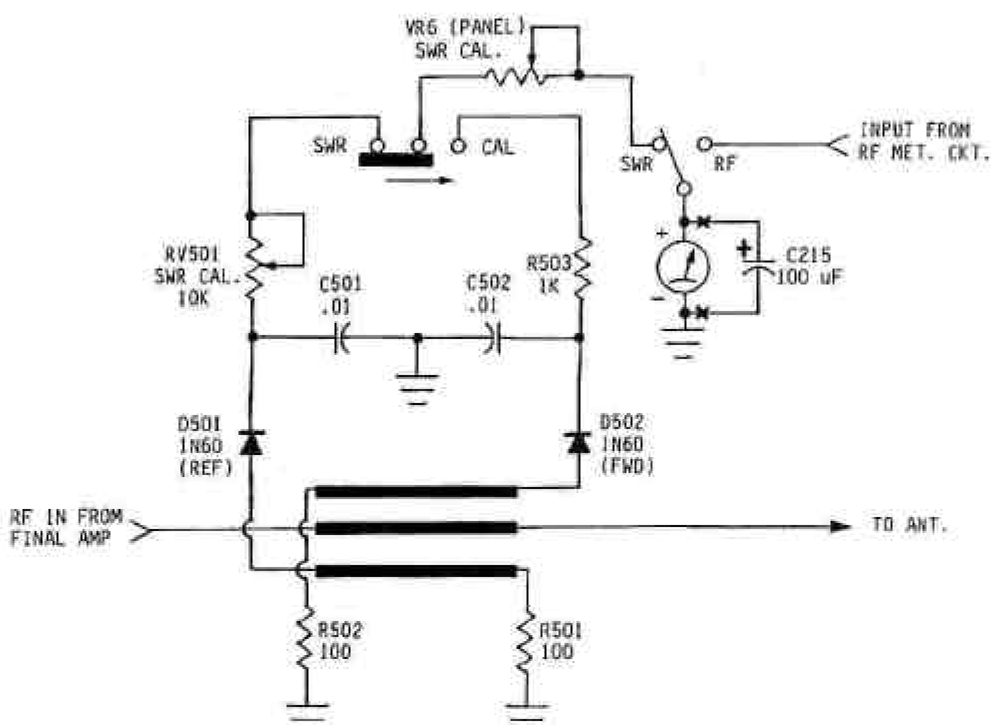
FIGURE 5-51
DIRECTIONAL RF SAMPLING METHODS



meters but since complex impedances are involved, all that matters is the eventual 50Ω transformation at each end for proper matching.

In Figure 5-52, the RF current flowing outward induces a voltage in the top stripline proportional to the forward transmission line voltage. The bottom stripline senses the reflected voltage component. Each stripline is sampled at opposing ends, where voltages and phases are also opposite; the SWR will simply be the net [+] and [–] total. The bridge is normally balanced by C501/C502, R501/R502, and R503/RV501; any reflected voltage will upset this balance

FIGURE 5-52
SWR BRIDGE METERING CIRCUIT
(Cybernet PTBM048 chassis: Boman CB950, Lafayette SSB140, RCA 14T302, etc.)



and be seen on the meter. Forward voltage is rectified by D502 and reflected voltage by D501, with appropriate RF filtering by C502 and C501. Since CBs are designed for a 50Ω resistive load, RV501 calibrates the reflected voltage using a 100Ω (2:1 SWR) or 150Ω (3:1 SWR) noninductive load resistor during initial transmitter alignment. This is done only after setting VR6 to the full-scale meter mark to establish bridge balance.

To read the proper ratio, the operator first calibrates the FORWARD voltage reading by adjusting VR6 to the "SET" or "CAL" meter mark. Then switching to the "SWR" position shows how much the bridge is unbalanced. The FORWARD voltage reading changes with reactive loads and small component variations, which is why a calibration control must be included on the radio's front panel. Internal trimmers like RV501 aren't always included though. Initial accuracy is calibrated using several known resistive load values; diode non-linearity and poorly-matched components could affect the true relative voltage readings.

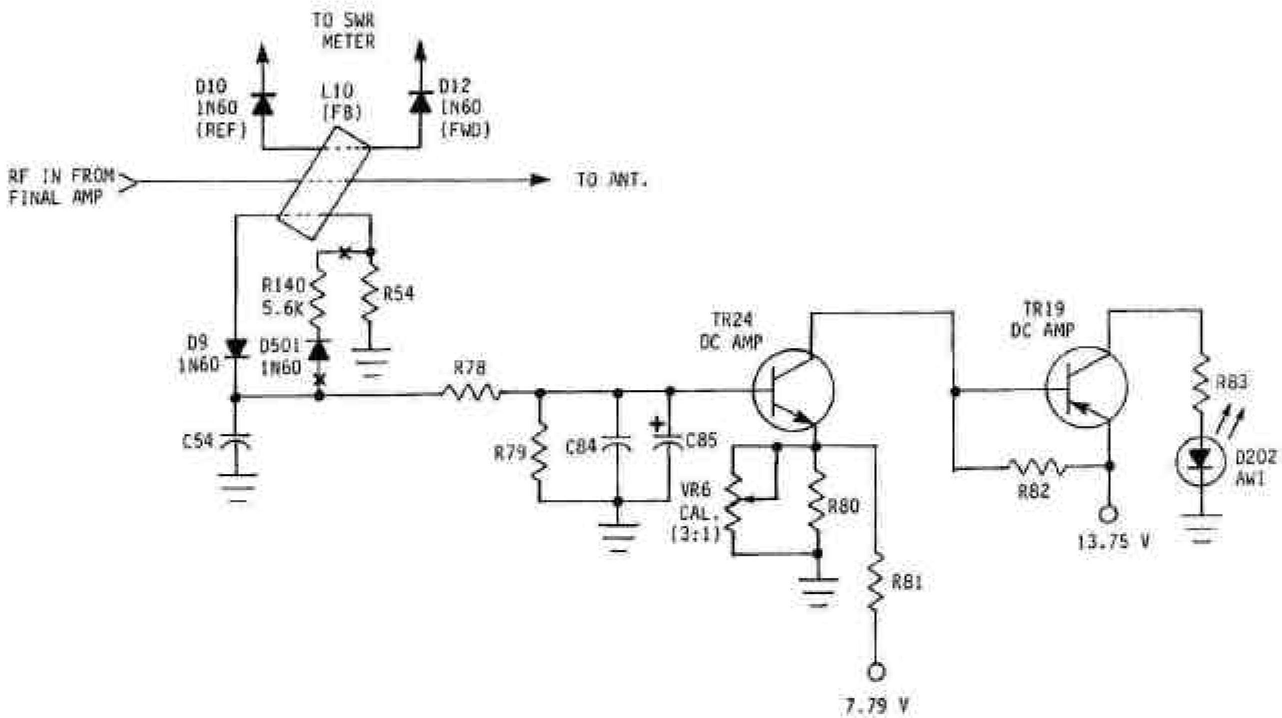
ANTENNA WARNING INDICATOR (AWI)

This is an LED circuit that lights when the VSWR reaches a predetermined level, usually 3:1. Many inexpensive radios use this circuit instead of the SWR Meter, while others have both metering and the LED. Even if just the LED is used, a directional transmission line coupler is still needed to drive it.

A circuit using both is shown in Figure 5-53. Note either wire in the FB can be used for both forward and reflected voltages, since RF voltage and phase along a transmission line is always changing; it's not necessary to have a separate wire for each direction. Instead, the bottom wire is used only to drive the AWI LED. The two left-hand wire ends will sense the reflected voltage, and the two right-hand ends will sense the forward voltage.

D9 rectifies RF, with filtering by C54, R79, C84, and C85. D501/R140 is sometimes added to clamp excessive RF

FIGURE 5-53
ANTENNA WARNING INDICATOR (AWI) CIRCUIT
(Cobra 29GTL, 29LTD, etc.)



voltages from the Final amp to a safe level. TR24 is cut off via R80/R81/VR6 and will only conduct when the SWR reaches 3:1. Increasing reflected voltages develop enough base bias to overcome the cutoff emitter bias on TR24. The more the base voltage, the harder it conducts. As it turns on it pulls the base of TR19 lower, turning TR19 on harder too. As TR19 conducts more, current flows through it to turn on the LED.

NOTE: SAMS #217 and #218 show an FET for TR24, but they actually used a bipolar transistor (2SC945) with its leads crossed to fit the original FET PC holes; it's cheaper!

VR6 is set during alignment. A resistive dummy load of the wrong impedance is purposely used for calibration. SWR is the ratio of voltages, currents, or impedances between source and load. Since the antenna jack is 50Ω by design, a non-inductive resistor of say, 150Ω connected across it gives,

$$SWR = 150 \div 50 = 3.0 \text{ or } 3:1$$

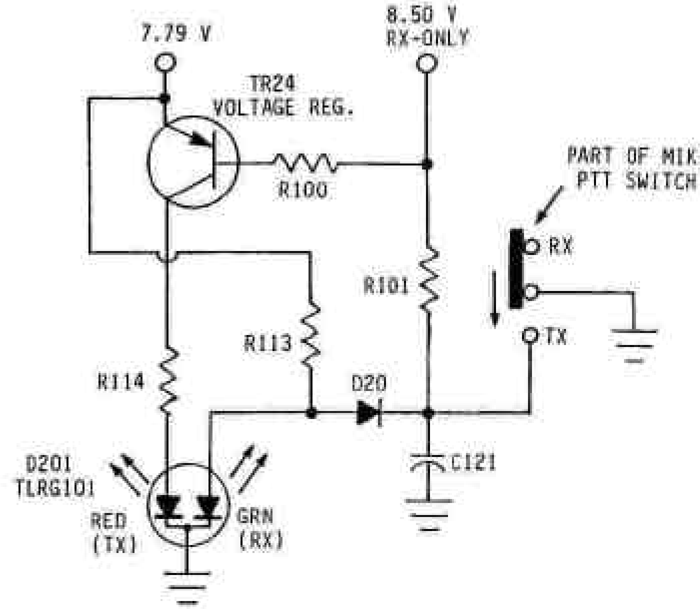
Troubleshooting the metering or AWI/LED circuit amounts to backtracking the driving DC towards its source until lost. The most obvious faults are bad diodes, transistors, or the LED itself.

Incidentally, the practice of adding an SWR or AWI circuit after the output low-pass filter is frowned upon by most serious designers, since rectifier diodes can easily generate harmonics. But it's done in CBs because the transmission line coupler needs a 50Ω impedance and the filter provides this. If such a radio has a particularly bad harmonic radiation problem, suspect the diode rectifiers. Add an external low-pass filter, using a double-male coax connector directly rather than a coax patch cord to minimize potential coax radiation.

T/R LEDs

Many CBs use LEDs to indicate T/R switching. These may be two individual diodes (RED for Transmit, GREEN for Receive), a RED Transmit only, or a two-color LED with GREEN for Receive and RED for Transmit. The dual-color types have two LEDs in a single package with a common cathode. Each anode goes to the appropriate switched voltage source. See Figure 5-54. The GREEN segment is normally conducting via R113 and the 7.79VDC source. On Receive, switch D20 is cut off by R101, keeping its cathode about 0.7V higher (8.50VDC) than its anode. On Transmit, this source and the base of TR24 are simultaneously grounded, allowing D20 and TR24 to conduct. The GREEN diode loses its voltage source and turns off, but TR24 can now supply current to light the RED diode section instead. All such circuits work exactly the same way.

FIGURE 5-54
T/R LED CIRCUIT
(Cobra 29GTL, 29LTD, etc.)



Troubleshooting amounts to checking for the presence of the correct anode voltage in the correct mode, and working backwards until that voltage source is lost. When transistor-driven like Figure 5-53 or 5-54, suspect the active device. In the case of bi-color LEDs where only one color lights but both anodes are receiving the correct switched mode voltages, you'll have to replace the LED itself.

"ROGER BEEP" OSCILLATOR

This circuit causes a short audible beep to be transmitted when the mike button is released. A listener knows the transmission is over and he can now transmit, without taking his cue from the traditional "Over" or "Go Ahead" spoken by the other station. With AM and FM this function isn't really needed, since the end of a transmission is obvious when the carrier drops out. However it's quite useful for SSB, which has no carrier and the end of speech isn't so obvious. The radio sometimes has a switch to disable the RB when not desired. Only the export radios have included this feature so far, but there are some add-on RB units sold as accessories to modify standard CBs.

All RB circuits work the same way. A separate audio oscillator is connected across the mike bus and generates a tone of about 1200-2000 Hz. The transmitter remains keyed after release of the mike button for about 150 mS. To accomplish this, several things must happen at once. The oscillator must have operating voltage, but its output must be kept disconnected until the mike PTT button is released. And the T/R switching voltages must be delayed slightly after the button release so the carrier stays on the air just long enough to be modulated by the tone.

Figure 5-55 shows the Uniden circuit, which has a slightly more complicated switching scheme than the Cybernet version. TR33 is a simple audio oscillator using a "T" network RC phase shift for low cost and simplicity. The tone frequency is set by the values of C156 and C154. The output is about 8 V P-P and couples through R217 to the mike audio line. R217 is a very high impedance to minimize loading.

The Transmit keyline of all CB mikes works by the grounding of a voltage when the PTT button is pushed. When the mike is keyed here, D91 and D92 are pulled down near ground and conduct. Grounding D92 kills the oscillator's output, even though the Transmit-only voltage source is still being applied. One section of dual op-amp IC4 is a voltage comparator. It compares two separate voltage inputs, and the output is their difference multiplied by the op-amp gain. (The other 4558 IC section is the Mike Preamp.)

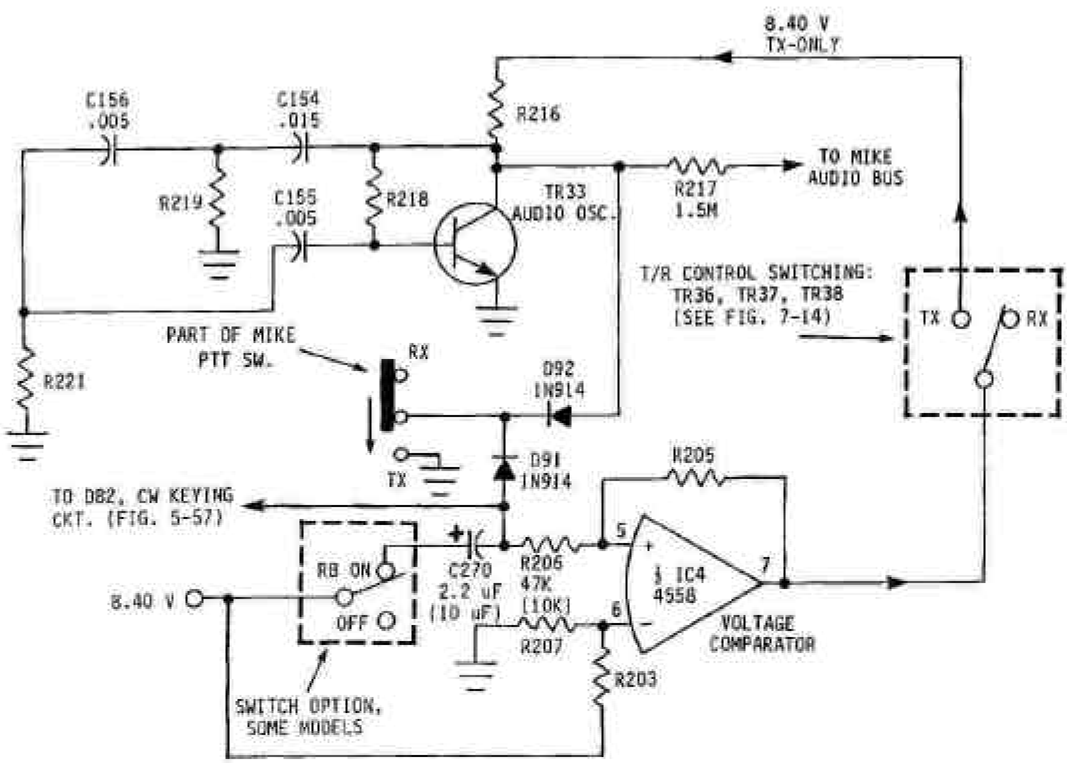
IC4 Pin 6 has a fixed bias from voltage divider R203/R207. Pin 5 has a switchable bias, which changes between Receive and Transmit. D91 when grounded on Transmit switches the comparator, which in turn controls the T/R switching voltages of TR36, TR37, and TR38. (Represented here by a simple toggle switch for simplicity; see CHAPTER 7 for a complete discussion of this circuit.) On the PB010 chassis, the CW keyline is also connected to IC4 to control T/R modes.

C270/R206 form an RC time delay. On some models the charging voltage to C270 is switchable (dotted lines) to disable the RB when desired. Note alternate parts values used in some models which still result in the same time constant. After the button release, there's a delay of about 150 mS before the comparator switches, which keeps the radio in the Transmit mode for that amount of time. At the same time D92 turns off, which allows the tone to couple into the mike line and be heard on the air.

The Cybernet circuit works on exactly the same principle, using discrete transistors for T/R switching. The same kind of RC time delay will be found in its switching circuits. The RB is located on a small PC board (PCZS001) in the NATO 2000. Most older Ham International models used a separate "Roger Beep" unit with a 5-wire interconnect to the main PC board chassis.

Troubleshooting can be logically divided among the oscillator itself, the delay circuit, and the T/R switching. You can 'scope the collector of the oscillator transistor to see if it's running when the mike is unkeyed. The active device is the most likely failure point, with a shorted switching diode like D92 another possibility. Check the T/R switching by measuring appropriate DC operating voltages between modes. It's also possible for the timing capacitor (C270) to be leaky or open so there's virtually no time delay. This would make it appear that there's no oscillator output on the 'scope, because it didn't stay on long enough to be seen.

FIGURE 5-55
"ROGER BEEP" CIRCUIT
(Uniden PB010 chassis: Cobra 148GTL-DX, Superstar 360FM)



Omnidirectional Mobile Antennas

Most mobile and base CB antennas consist of a single vertical radiating element. The horizontal radiation is equal in all compass directions, assuming there aren't any nearby objects or irregular ground conditions to distort the pattern. (In practice there always are.)

Figure 8-17 shows the ideal horizontal pattern of such antennas. Note it's also a perfect circle like the ideal dipole, but this time it's rotated 90° so you're looking down on its top instead of horizontally end-on.

In a real installation this pattern will be distorted. The worst distortion occurs in mobile operations when the whip is mounted somewhere other than the exact center of the roof; i.e., the "ground plane" is irregular. The strongest field will generally be in the direction of the greatest mass of vehicle body. With the antenna in the center of the roof the mass is roughly equal in all compass directions and this is usually the best location, although not always practical with long whips or low garages. With the whip on the trunk lid or a corner of the rear bumper, the pattern is distorted. Figure 8-18 shows this effect.

<u>Never</u> mount the whip on the bumper of a van or camper; the close proximity to the body not only distorts the pattern, but the coupling capacitance between the whip and vehicle body causes a serious SWR mismatch. Mount the whip up as high as possible. See Figure 8-19.

FIGURE 8-19
WHIP MOUNTING ON A VAN

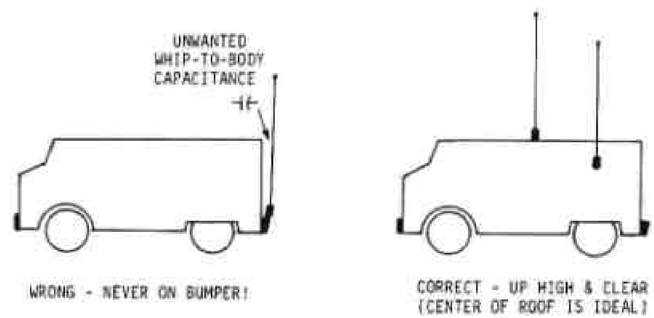


FIGURE 8-17
OMNIDIRECTIONAL RADIATION PATTERN
OF VERTICAL ANTENNA

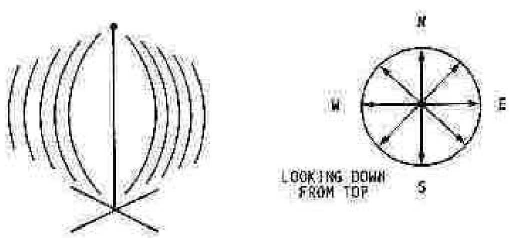
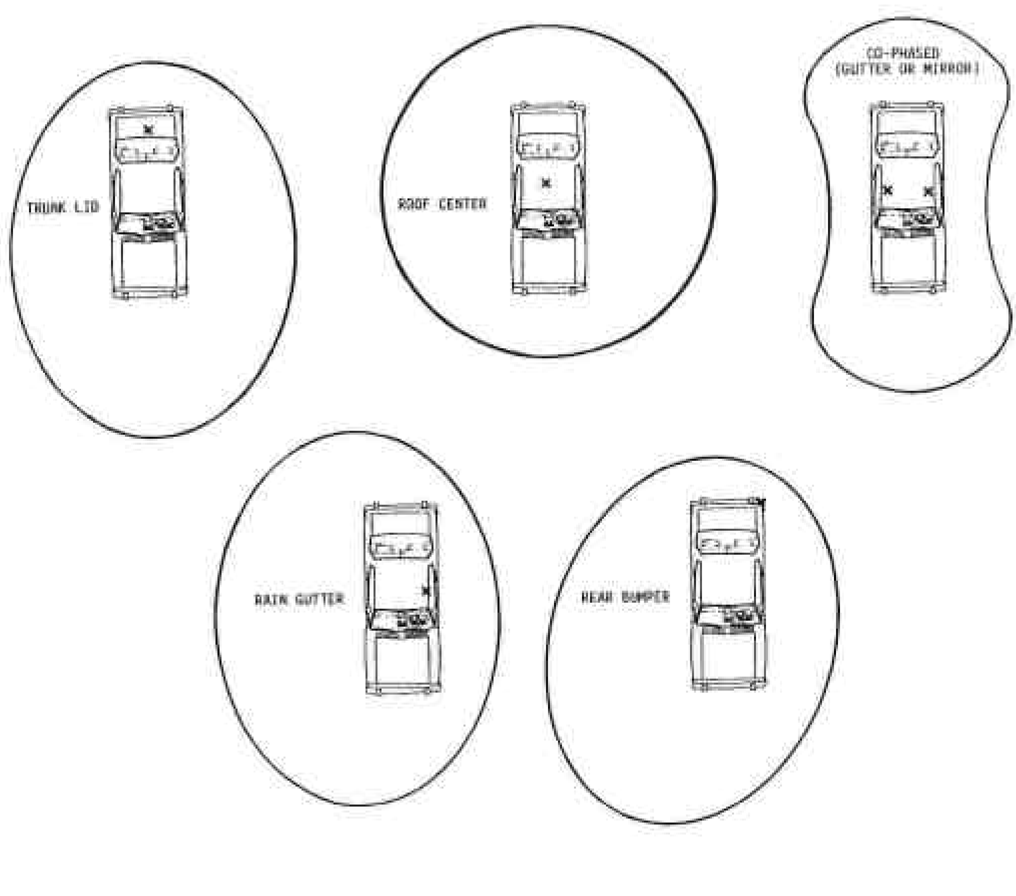


FIGURE 8-18
RADIATION PATTERNS OF MOBILE ANTENNAS
BY MOUNTING LOCATION



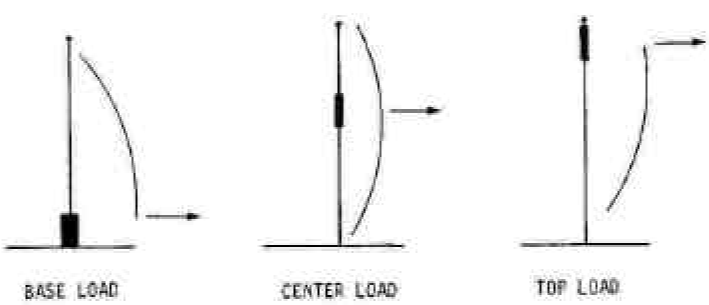
Effect Of Loading Coils On Field Strength

Loading coils are added to most mobile CB antennas to compensate for capacitive reactance; i.e., the antenna is physically shorter than the required electrical length. In addition to the whip mounting location, the location of the loading coil on the whip can have a marked effect on performance.

The larger the antenna current, the greater the field strength. Since reactance limits current flow, the only part of a loaded antenna that carries a significant current is that section <u>before</u> the loading coil. Thus with base loading there's very little current in the rod. With center loading there's current from the center down, and with top loading (or the full-size steel or fiberglass whip), current flows along the entire length. ("Top-loaded" fiberglass CB whips aren't truly top-loaded; the wire's concentrated at the top, but is continuously or helically wound along the entire length. This effects its current distribution.)

The straight length before the coil also affects radiation resistance, being higher with center or top loading than with base loading. This makes it easier to transfer power, since from Ohm's Law, $P = I^2R$, and "R" is higher with top loading.

FIGURE 8-20
RF CURRENT DISTRIBUTION AS A FUNCTION OF LOADING COIL LOCATION



<u>All other things being equal</u>, top loading would have the best range of loaded whips, since the main lobe is highest above ground and therefore sees the furthest horizon. This is like seeing further from the roof of a building than from the ground floor. Figure 8-20 illustrates this effect. Of course the full-size 102" whip has the advantages of full radiation <u>and</u> no coil losses. But these advantages are offset by wind loading at high speeds, bending the whip away from pure vertical polarization.

Before dismissing base-loaded antennas as poor performers, consider this: in loaded whips, the capacitance of just that section above the loading coil appears across its coil. With base loading, the capacitive reactance is a function of the entire whip length. As the loading coil is raised though, the amount of whip remaining above the coil is shorter, increasing the capacitive reactance. This means more inductive reactance will be needed to resonate it, and that means a bigger coil. A bigger coil means more turns and thinner wire, increasing the DC resistance and therefore losing some of its advantage. You could always make the coil physically bigger to offset these losses, but then there's the problem of increased wind drag! Antenna Specialists makes at least one center-loaded whip model using oversize loading coils, called “beer cans” by many truckers, to minimize such losses.

Selecting a good mobile antenna is therefore a compromise between available mounting location and hardware, physical size, type of loading, wind drag, looks, and of course price. For every guy who says his K-40 works best, there's another guy claiming the same for his PAL Firestik. As a general rule, I recommend mobile antennas at least 40" or longer. Any of the better brands like A/S, Wilson, Francis, Hustler, K-40, PAL Firestik, and Shakespeare will meet this criterion and give excellent and comparable results. Avoid antenna "bargains" when you buy!

The cover of this book shows me adjusting a Hustler HQ-27 center-loaded whip on my car. Except for the mounting hardware, this is the very same whip that's used in the Hustler "Twin Huskies" popular with truckers. I use a bayonet type 3/8" x 24 quick-disconnect with a special two-piece hideaway mount. Unlike standard trunk lid mounts, everything shown in the picture can be removed and thrown in the trunk when not needed, leaving no exposed mounting base visible to would-be thieves. The HQ-27 is sold with many types of mounts. It's 55" long and works quite well. (For example, I've worked Alaska from Phoenix on 4 W when the skip's in!)

Omnidirectional Base Antennas

CB communication involves both ground-wave and sky-wave or skip propagation. Both give the best range when the vertical radiation angle is low; i.e., close to the earth. The lower this elevation angle, the better the range. With ground waves the lower angle causes them to hug the ground so they cover more distance before fading out. The same is true for skip waves; but instead of hugging the ground, the wave travels further towards the horizon before striking the earth's atmosphere and bouncing back to earth. The effect of both types is shown in Figure 8-21. Note that the sky waves are reflected at the same angle they originally struck the atmosphere, which means the lower angles result in the greatest skip range.

We've seen how the location of whip loading coils affects their vertical radiation angles. Similar effects occur on vertical base antennas. The location of the current loop still depends on the radiator length, which can be controlled to change the vertical radiation angle. But losses are much smaller on base antennas, since it's physically practical to use full-size radiators with no loading needed.

Omnidirectional base antennas come in three popular heights: the 1/4-wave, the 1/2-wave, and the 5/8-wave, corresponding to about 9', 18', and 22' respectively. Figure 8-22 shows the current distribution pattern for each. ("Height" in a vertical antenna means the same as "length" in a horizontal antenna.)

FIGURE 8-21
EFFECT OF VERTICAL RADIATION ANGLE ON COMMUNICATIONS DISTANCE

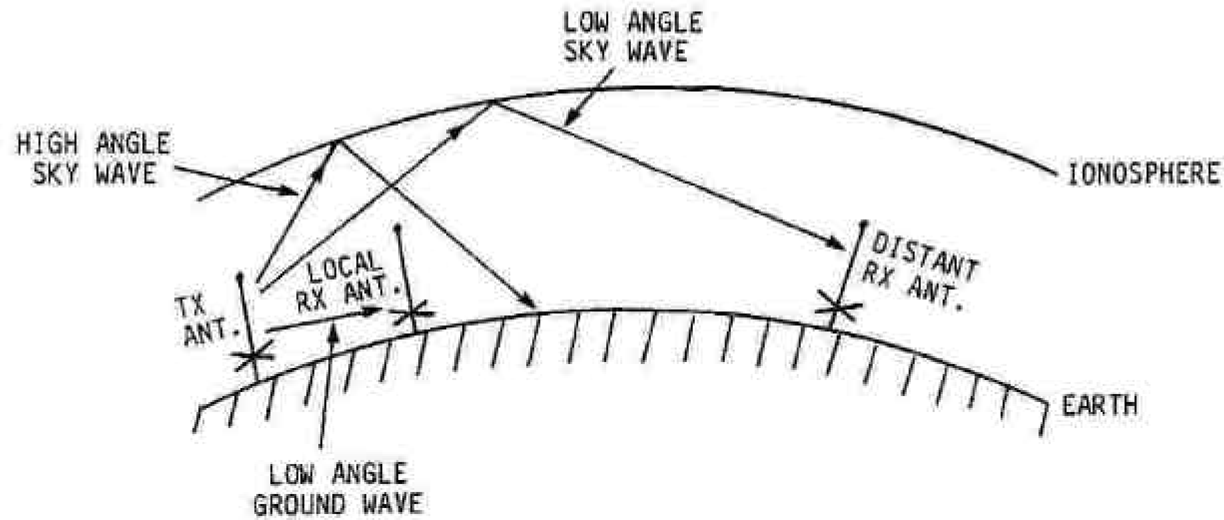
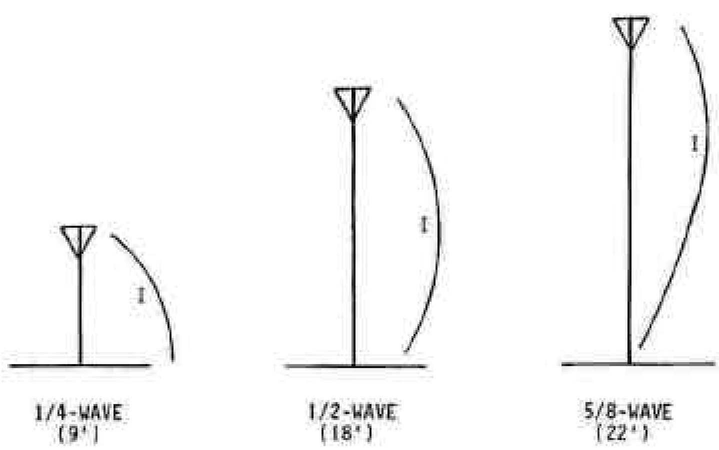


FIGURE 8-22
CURRENT LOOP LOCATION AS A FUNCTION OF VERTICAL RADIATOR LENGTH



As the radiator height increases, the current loop moves up the antenna, always reaching a peak a 1/4-wavelength below the top.

Raising the current loop lowers the vertical radiation angle, so the 5/8-wave antenna has the lowest angle and the ¼-wave the highest. The lower the angle, the less radiation lost towards the sky. See Figure 8-23. Visualize this in three dimensions by starting with a perfectly round balloon; squeezing it from the top spreads it out further horizontally while maintaining the same volume or "field."

Up to about 5/8-wavelength, the main lobe angle is low and theoretically has about 2 dBd gain over a 1/4-wave radiator. Beyond this height, minor high-angle lobes begin to appear at the expense of the lower lobes. Thus the 1/2-wave and 5/8-wave antennas are the most effective omnidirectional types; 5/8-wave is the best you can do with just a single vertical element.

Since verticals are base-fed but the base isn't always the low impedance point, the 1/2-wave and 5/8-wave antennas generally need matching circuits to compensate for their higher base impedances. The 1/4-wave vertical can be fed directly by 50Ω coax with no special matching.

Directional Mobile Antennas

The most popular directional mobile antennas are the dual "trucker" mirror-mount whips. These come under the general category of driven arrays, where both whips are directly driven by the transmitter. The pattern is bidirectional like a dipole. This system was developed to solve the problem of field distortion caused by the large metal trailer, and the fact that truckers are most interested in communications up and down the road they're traveling. The field is usually strongest towards the front and back, although it's just as easy to make it perpendicular to the vehicle. Figure 8-24 shows both possible patterns.

FIGURE 8-23
VERTICAL RADIATION ANGLE AS A FUNCTION OF VERTICAL ANTENNA LENGTH

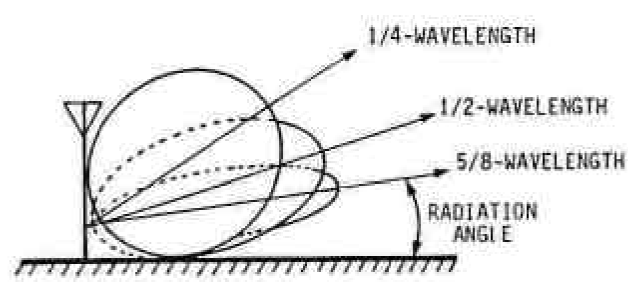
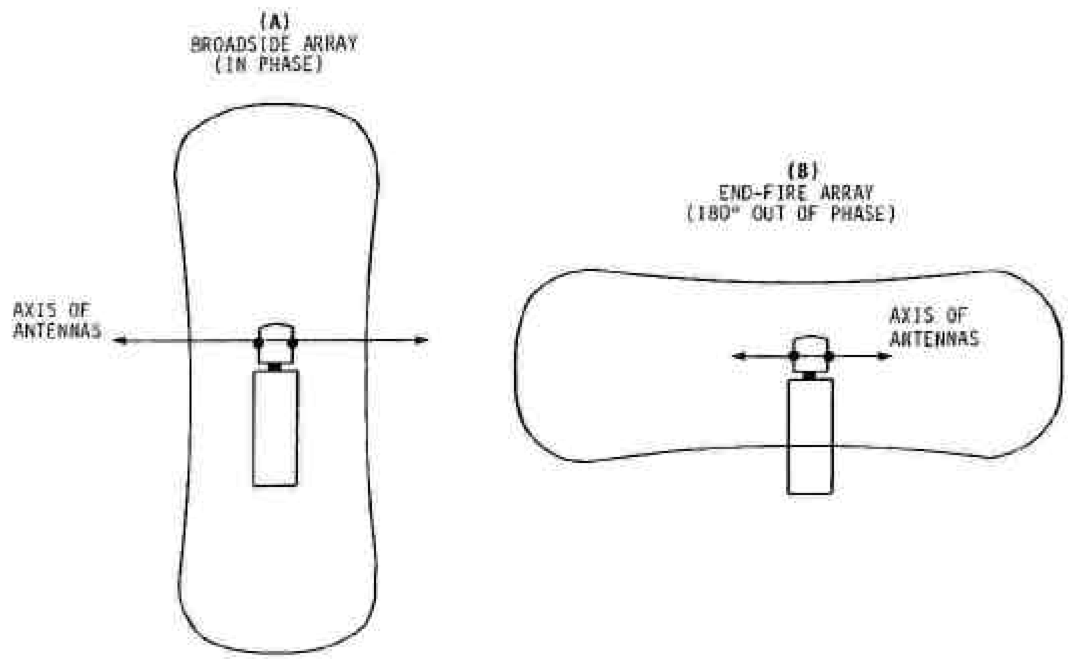
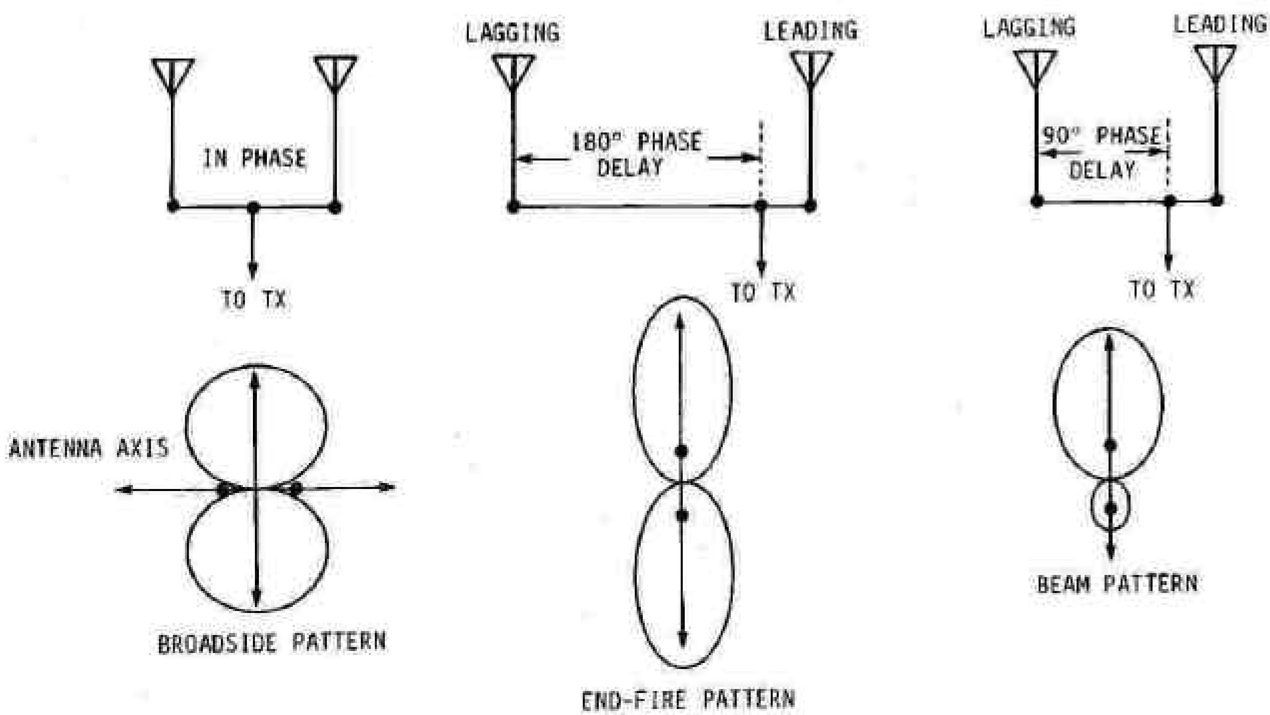


FIGURE 8-24
HORIZONTAL RADIATION PATTERN OF CO-PHASED MOBILE WHIPS



These antennas work on the phasing principle. See Figure 8-25. If two vertical antennas are spaced a 1/2-wavelength apart and fed equal currents in phase, the radiation will be perpendicular to the line of the antennas. This is called a "broadside array" and is the usual case with truck installations. When the same whips are fed 180° out of phase, the radiation will be in line with the antennas and is known as an "end fire" array. Theoretically dual antennas have

FIGURE 8-25
USE OF PHASING TO CONTROL RADIATION PATTERN



(THE DOTS ARE THE TWO VERTICALS AS VIEWED FROM ABOVE, SPACED 1/2-WAVELENGTH APART)

3 dB gain over a single vertical radiator. The phasing is accomplished by controlling the whip spacing, and by feeding them with a special coax "phasing harness."

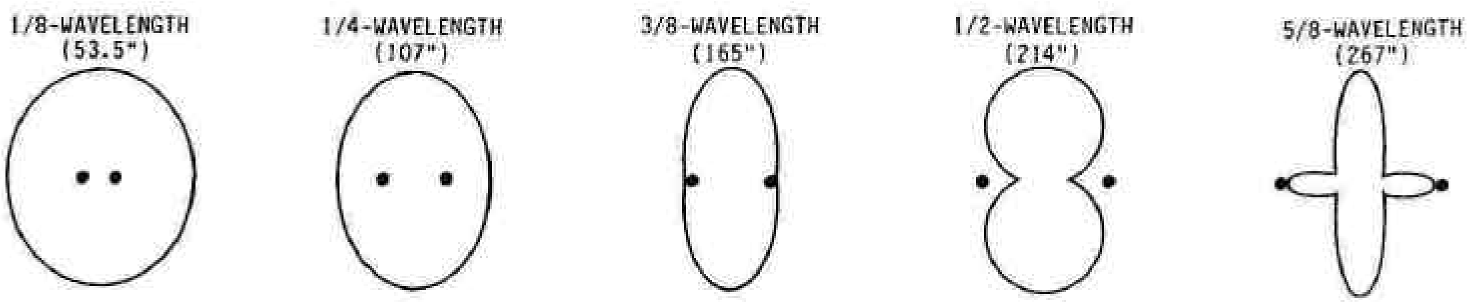
For the end-fire pattern, a 1/2-wave "phase delay" section using an extra 12' of coax could be added to one side of the balanced feedpoint, as shown. (12' is a 1/2-wavelength including the coax Velocity Factor.) This means the whip with the extra coax lags the leading whip by 180°, since its signal is delayed by that amount of time. To carry this a step further, a 90° phase delay produces a unidirectional beam antenna with the major lobe in the direction of the leading antenna. These principles have been applied for years in most directional AM broadcasting towers, and were simply copied for use in CB antennas.

In practice it's nearly impossible to get a 17' whip spacing even on an 18-wheeler. On a car or pickup trunk it's more like 1/4-wave spacing! You could do it on a bus using front and rear whips and end-fire phasing. The effect of the different whip spacings is to distort the horizontal signal patterns. See Figure 8-26. Notice the 1/4-wavelength spacing adds only a tiny improvement over that of a single whip, and by 5/8-wavelength minor side lobes begin to appear, which degrade the directional effects.

I never recommend dual antennas except on big trucks or buses, where a distance close to the correct 1/2-wavelength spacing of 17' can be realized. On smaller vehicles they're a total waste of money. But you'll still see them!

(continued with INDEX on next page)

FIGURE 8-26
HORIZONTAL RADIATION PATTERNS OF CO-PHASED WHIPS
AS A FUNCTION OF THEIR SPACING



(DOTS ARE THE WHIPS AS VIEWED FROM ABOVE)

(Note: This is the <u>complete</u> subject index, to give you an idea of this book's scope!)

INDEX

A

B

C

D

E

F

G

H

I

L

M

N

O

T

U

V

W

Y

Z