Basic Operating Needs of the Radio Shack

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Looking at the shack as a *place,* we can begin the process of transforming it into a center of activity. Amateur radio is a very broad name for many activities. To sort out what may be most relevant to each of us as *individual* hams, we must go back to basics. In this article, we will look at the basics from a perspective which differs somewhat from our usual view of Hamming: one of being deeply involved in one or another part of it. Perhaps the most fundamental aspect of amateur radio is *communications,* so let's start there.

Communication is a two-way process. Whether talking face-to-face or exchanging information with a station on the moon, both sides must be able to transmit information and to receive it.

Radio communication differs from ordinary conversation only insofar as the information we put into the transmitter does not emerge in the same form, nor does the information intercepted by our receiving system come out the same way. Transmitters and receivers change the form of the information to make possible long distance transmission.

Therefore, every communications system and station consists of certain fundamental elements which permit it to fulfill its function of transmitting and receiving information.

The elements—in the abstract—are simple. As shown in **Fig. 1**, the transmitting and receiving ends contain at least the following elements:

Transmitting:
Input device: converts information into energy patterns;
RF generator: creates radio frequency energy;
Modulator: combines energy patterns with RF energy;
Antenna: radiates modulated RF energy.

Receiving:
Antenna: intercepts modulated RF energy;
Demodulator: converts modulated RF energy into non-RF energy patterns;
Output device: converts energy patterns into intelligible information.

The information input and output of the system may consist of audible sound, visible light patterns, pulses, or any number of other forms which we as human beings take to be "natural" forms for information. What is natural may be relative. Morse code is unnatural until we master it. And, some have argued that no one is truly the master of human speech.

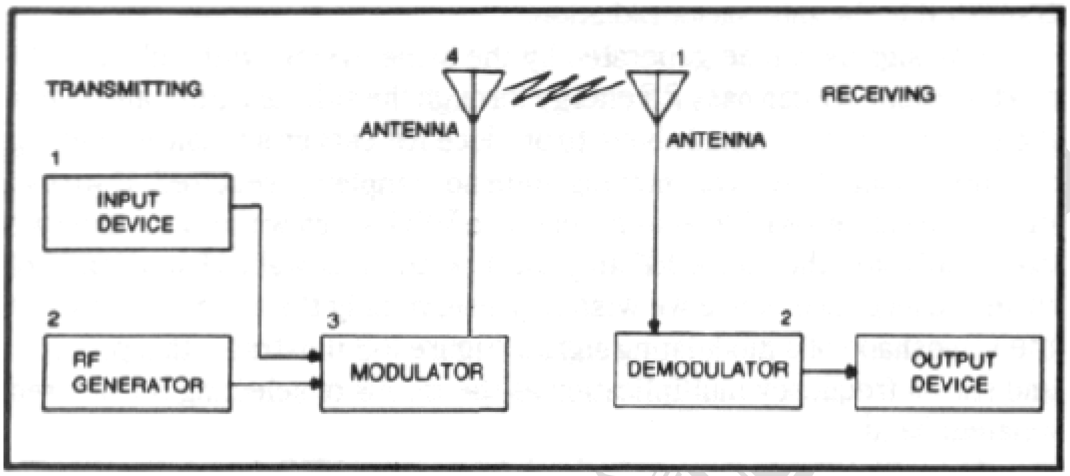


Fig. 1 Basic elements of a radio communications system

The conversion device for the input side may be a key to create on-off periods, a microphone to generate electrical patterns following the patterns created by our voices in air, cameras to create electrical patterns of visual scenes, or special code-creating devices such as an RTTY generator. At the output side, we can recreate sounds, pictures, or letters by reversing the input process, sometimes with the same instrument.

The receiving process, which we call demodulation, consists of separating intelligence patterns from the RF energy. On the transmitting side, we create RF energy and combine it with the intelligence patterns in a process generally called modulation. What passes between antennas is the modulated RF energy in the form of radiation.

Every ham station must have the elements listed above. They are fundamental and part of every radio communications link. But they are not what I mean by the article heading *BASIC.* While it may be possible in the abstract to have only these elements, this is not very practical in today's world. A keyed oscillator and a crystal receiver, fed to and by a single wire antenna may permit successful communication on some occasions, but such a station is little more than a curiosity.

More truly basic are the primary materials we must have to take advantage of today's communications opportunities, and we should look at these according to their major properties.

CW AND SSB

In the high-frequency bands, where the vast majority of amateur operators conduct their communications, the primary modes are CW and single sideband (SSB). Because so much work is now done with commercial transmitter-receiver combinations or transceivers which have the capability for both modes, the basic station looks much like the sketch in **Fig. 2**. It consists of these elements:

- A keying device which may be a hand key, a mechanical keyer or bug, an electronic keyer, or a code typewriter;
- A microphone;
- A transmitter to generate RF energy and modulate it;
- A receiver to demodulate incoming signals;
- An antenna changeover switch or relay;
- Transmission cable to transfer the energy to or from the antenna;
- An antenna.

Of course, the transmitter and receiver functions may be combined into a single unit called a *transceiver.* In fact, transceivers now probably outnumber separate transmitter-receiver combinations in use. The chief advantage of a transceiver is that it occupies only about one cubic foot of space on the operating table, rather than the two or more cubic feet needed by a transmitter-receiver combination.

For single sideband, the process by which we create a suitable RF signal to radiate is necessarily complex. Generating an RF signal, modulating it via AM methods, eliminating or suppressing the carrier, and filtering out one sideband usually take place at a frequency outside the ham bands. Providing stable but continuously-variable RF signals in any portion of any ham band is a second process and is usually started in a VFO in a separate frequency band, again outside the ham bands. The next steps can take place in one of two usual ways. Either we can mix the filtered signal with the variable frequency signal and then mix once more with a third signal source to place the SSB signal on the desired ham frequency. Or we can premix the variable signal with the new third signal, and then mix the product with the filtered SSB signal to end up in the desired ham band. Whichever way we go, the final task is to amplify the SSB signal to the desired power level (usually 200 to 300 watts PEP) with minimum distortion in a so-called linear amplifier. Then we are ready to transfer it to the antenna for radiation.

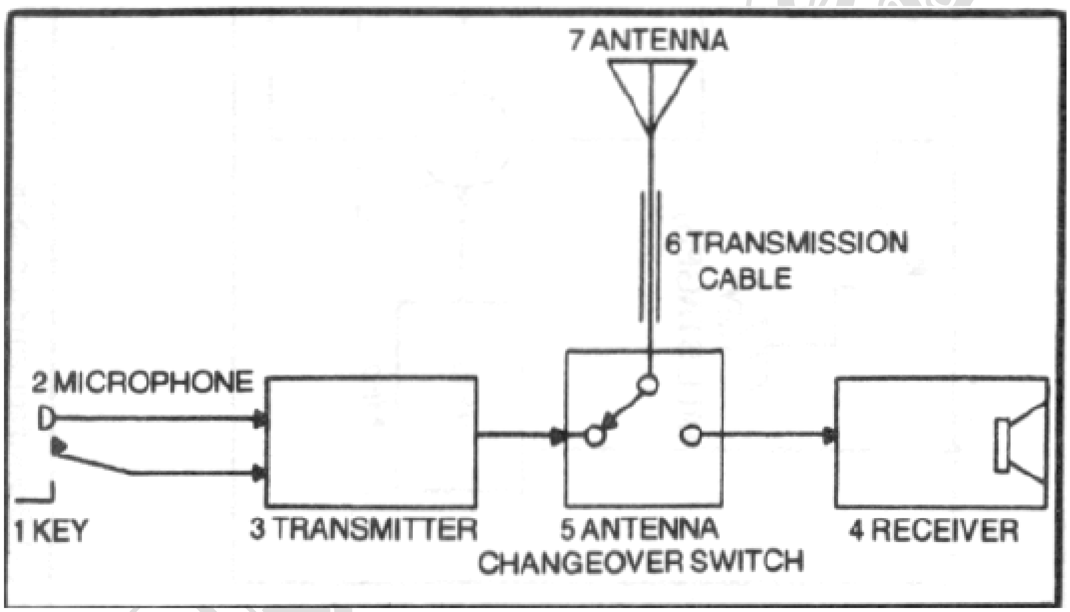
CW signals can be generated by the same system with only a slight modification. We can pass RF energy through the sideband filter and follow the mixing schemes listed above to produce RF energy suitable for keying in Morse Code. However, nothing quite so complex is required. If we can develop a stable variable energy source, a VFO which we can key, then we can simply key the entire RF amplification train as well. Distortion is of little consequence, since we wish to preserve only the on-off periods, not the wave shape of a modulating signal. **Fig. 3** illustrates this process, and shows frequency multiplication as the means of selecting the desired amateur band.

If multiplication is not desired (since any VFO instability is also multiplied), we can use a simplified mixing scheme, giving us a stable CW signal on every band with the need for one less step of mixing than the SSB transmitter required. Of course, if we desire to work only one band, then even this much mixing may be superfluous.

These differences we should keep in mind when deciding whether to build or buy a rig. A one-band CW operator may spend too much money if he or she buys a modem transceiver for SSB and CW. The money might be better spent in additional receiving capability.

The transceiver has fairly well determined that modem receivers will just reverse the transmitting process. **Fig. 4** and **Fig. 5** contrast a transceiver demodulation chain with that of a separate receiver, both of commercial design. Note that the separate receiver permits the use of additional intermediate frequencies to add to the selectivity capabilities of the overall design. Fig. 3-6 shows the demodulation chain of a third receiver, much simpler than the others, yet one which performs quite well. It represents perhaps the most basic receiver which meets modem requirements of sensitivity, selectivity, stability, the three "S's" of most concern to ham operators. Notice that the three receivers, if equipped with a filter of suitable width for CW and for SSB, are equally suited for both modes of reception. As a rule of thumb, current equipment should be capable of at least 0.5 microvolt sensitivity for 10 dB S + N/N, 2.1 to 2.4 kHz SSB selectivity with a 2:1 shape factor and 0.5 kHz selectivity with a 4:1 or better shape factor for CW. and stability of less than 100 Hz per hour drift after warm-up.

This brief scan of the very basic requirements of modern CW and SSB work is not a technical discussion of how to generate signals in each mode. Instead it is a review of the functional elements in HF CW and SSB operating systems. Each system will have to have either a keying mechanism or a microphone, or both. In addition, the station requires one or more antennas with associated transmission lines. The common wire antenna will provide successful communications in either mode, and the half wave dipole is perhaps the most common of wire antennas. Very common also are the multi-band dipole and the multi-band quarter wave vertical antenna, either of which can be designed to operate from a single coaxial cable transmission line (if the operator is certain that his transmitter output is sufficiently free of harmonics).



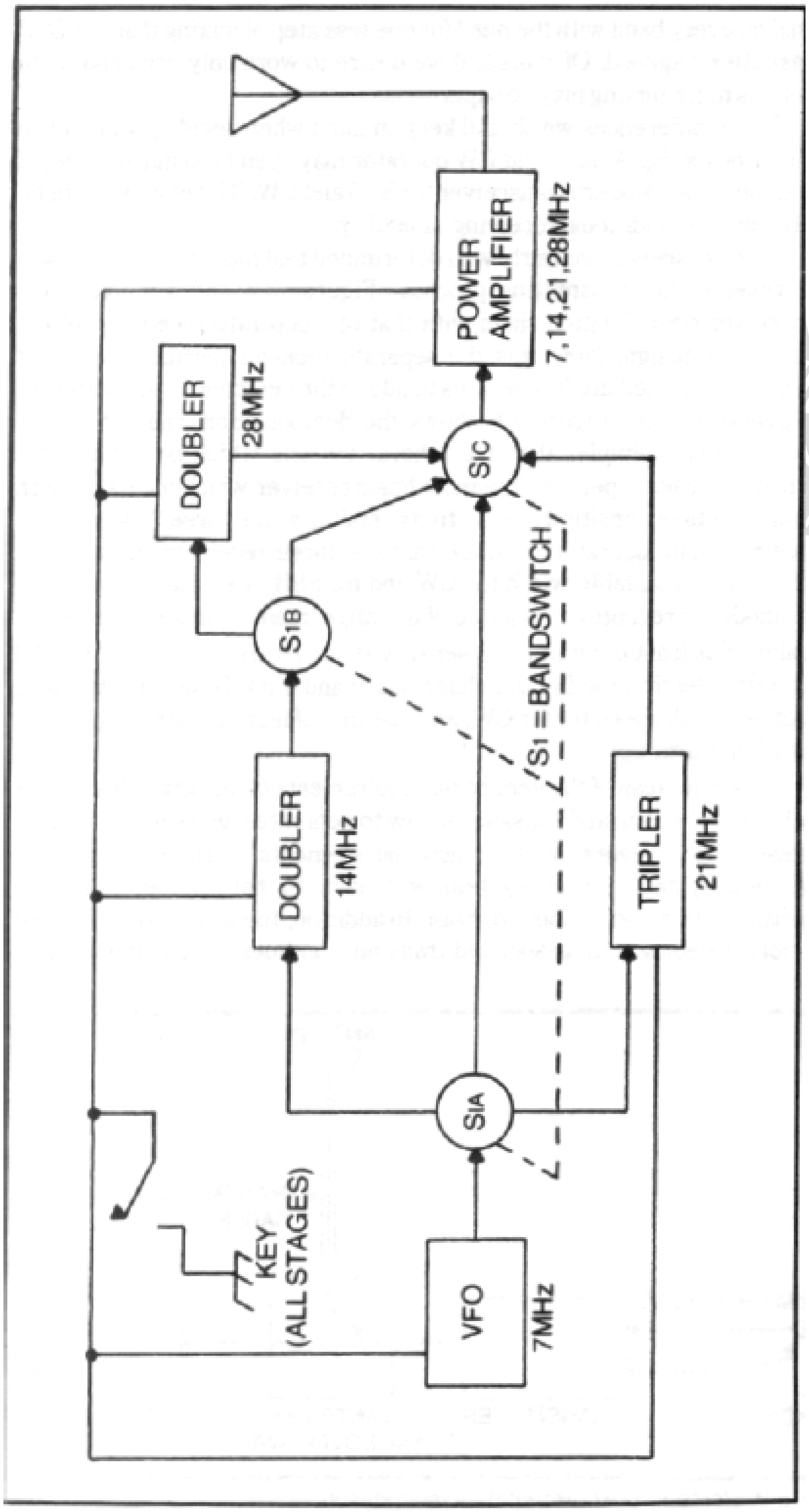


Fig. 3 Block diagram of a multi-band CW transceiver

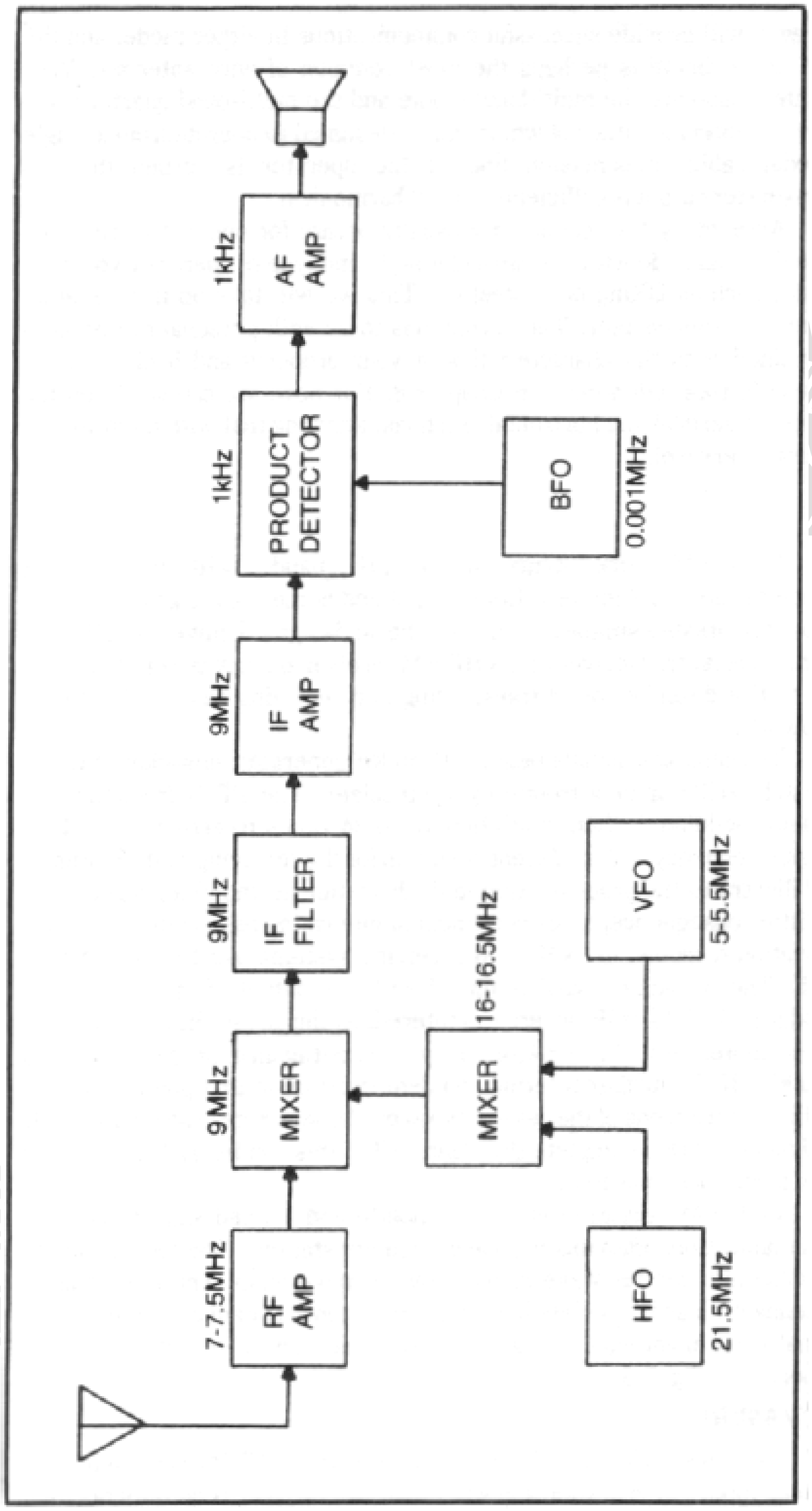


Fig. 4 Block diagram of a typical receiving section of a transceiver

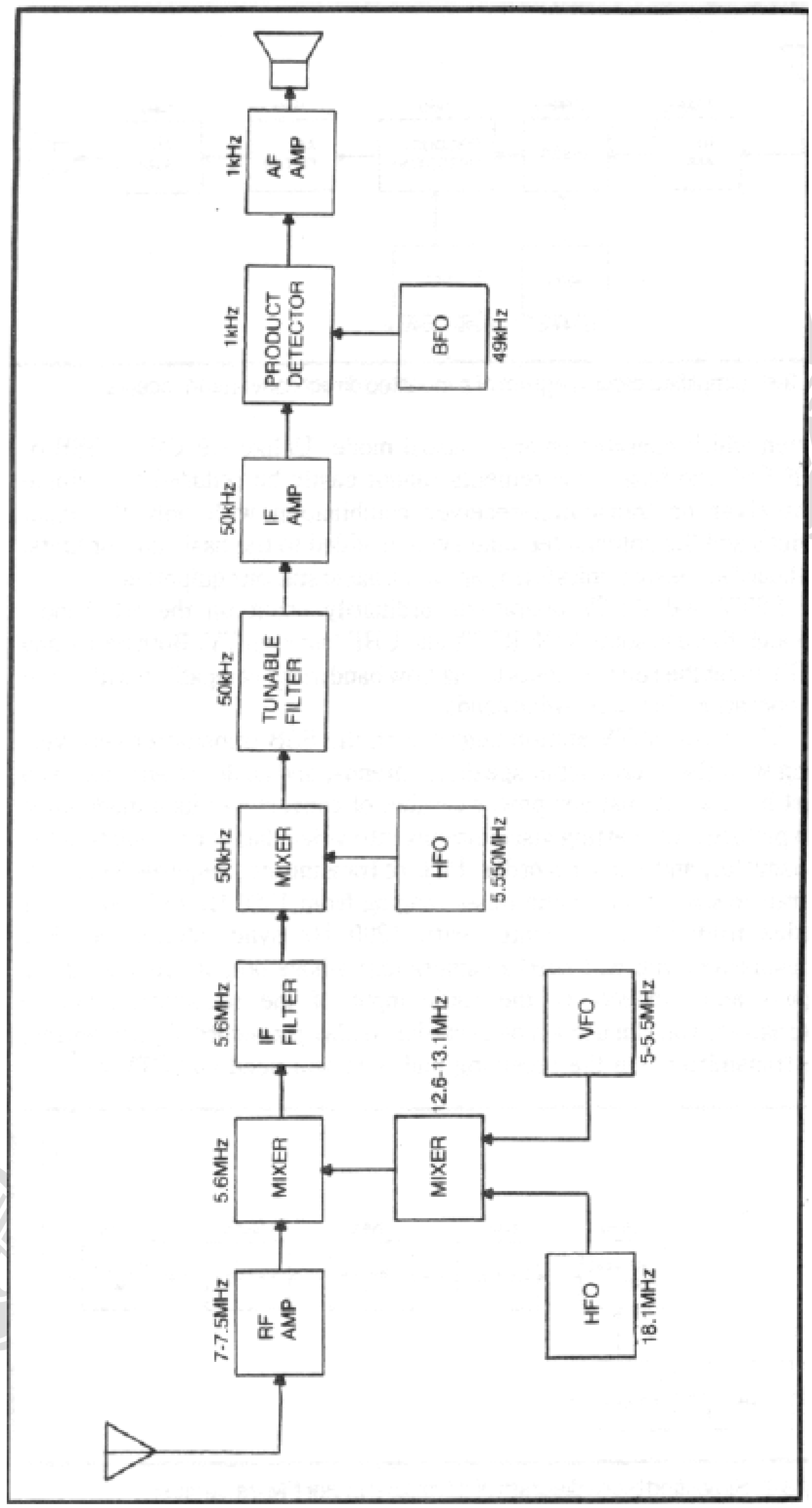


Fig. 5 Simplified block diagram of a typical separate receiver

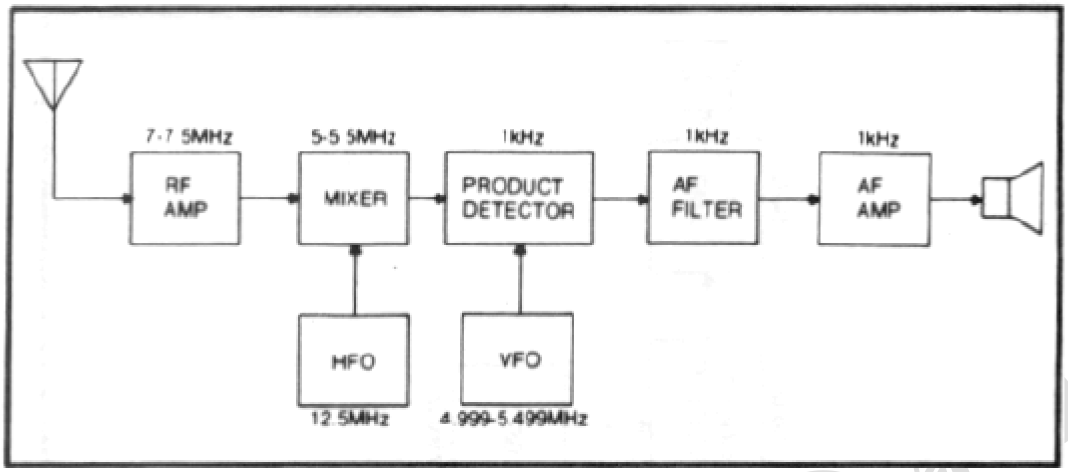


Fig. 6 Simplified block diagram of a modified direct conversion receiver.

Antenna system complexity usually occurs for one of two reasons. The first has to do with the particular style and type of operating you wish to do, such as DXing or contesting. This we will take up in a separate section of this article. The second has to do with personal preferences combined with the characteristics of your property and bank account. For now, we can settle on the simplest vertical and horizontal antennas, knowing that with them we can operate very well.

FM

Most FM work occurs in the VHF bands, with the greatest concentration on 2 meters. Commercial and home brew rigs abound and show remarkable similarities in their basic designs. Unlike HF CW-SSB transceivers, transceivers for VHF FM rarely make any circuit do double duty. The descriptions of transmitting and receiving basics will clearly show why.

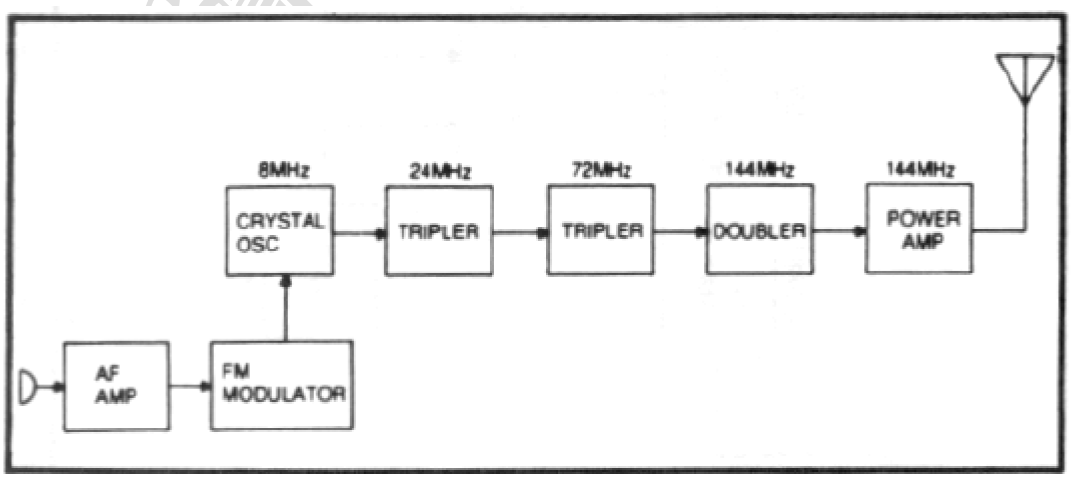


Fig. 7 Simplified block diagram of a typical 2-meter FM transmitter.

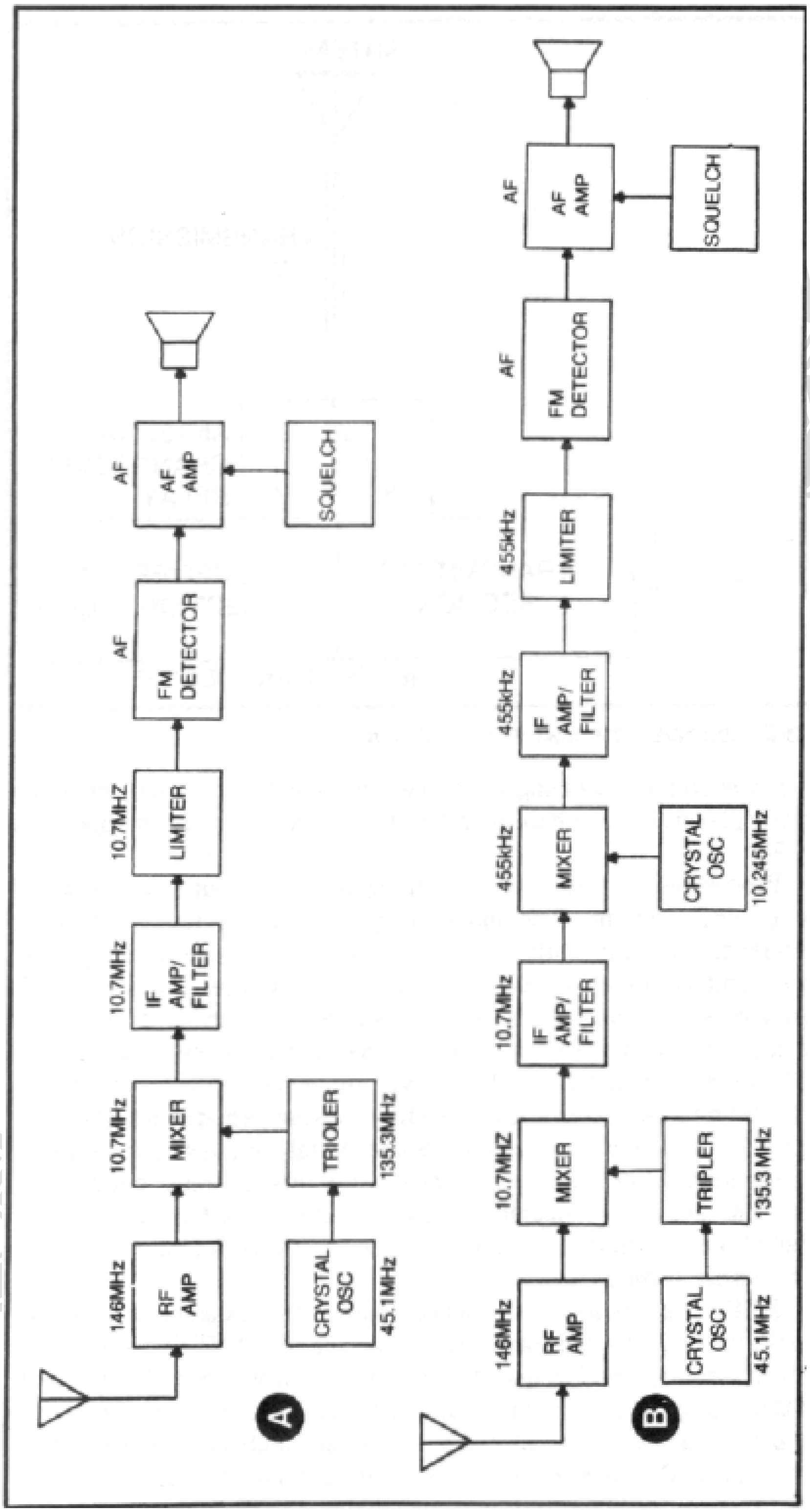


Fig. 8 Simplified block diagram of typical 2-Meter FM receiver

Transmitters usually begin with an RF generator, nowadays either a crystal oscillator or a frequency synthesizer. The RF is frequency (or phase) modulated then multiplied 12 to 24 times to arrive at the final output frequency with sufficient deviation for the receiving system. **Fig. 7** illustrates the process. Amplitude distortion in amplifiers is generally of little consequence, since non-linear amplification retains the frequency deviation components. VHF FM receiving systems usually take another tack. The incoming signal is mixed with the output of an oscillator to produce a 10.7 MHz IF, where it is filtered. At this point, the signal may be demodulated, as in **Fig. 8A**, or it may be mixed again to produce perhaps a 455 kHz IF for further filtering and demodulation at that point as in **Fig. 8B**. A limiter, one of the several types of FM detectors, a squelch circuit, and audio system complete the chain. All of this can be packaged in less than a third of a cubic foot.

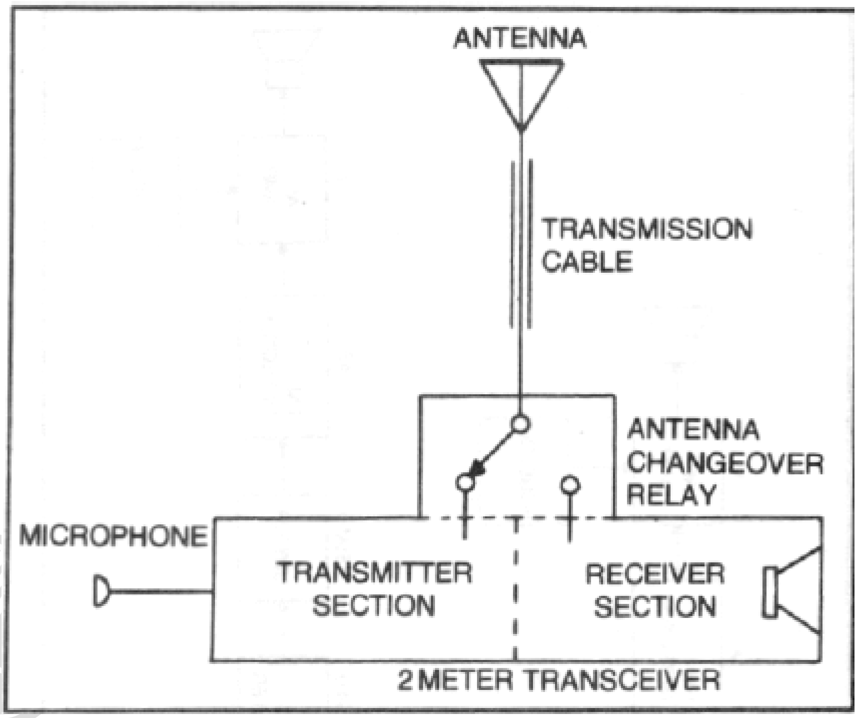


Fig. 9 Elements of the basic VHF FM station

VHF FM operation is both a mobile and a fixed station mode of communication, often making use of repeater stations. The typical mobile antenna is a quarter-wave or five-eighths wave whip. The fixed station antenna ordinarily consists of a vertically oriented beam or an omnidirectional vertical antenna with gain. Overall, the basic VHF FM station will appear as in **Fig. 3-9**.

SSTV AND RTTY
Slow-Scan TV (SSTV) and Radio Teletype (RTTY) represent two special modes of operation and will illustrate the basic requirements for a station which operates on any unusual mode. Unlike HF CW or SSB or VHF FM, the basic requirements cannot easily be reduced to a single transceiver or transmitter-receiver combination with only the input devices and the antenna-feedline system added to the basic unit or units. Outboard accessory units form pan of the basic station equipment.

SSTV and RTTY operations ordinarily count on the HF bands, although there is some VHF RTTY and UHF fast scan TV. Both SSTV and RTTY meet the requirements for narrow bandwidth compatible with other HF operations in the crowded bands.

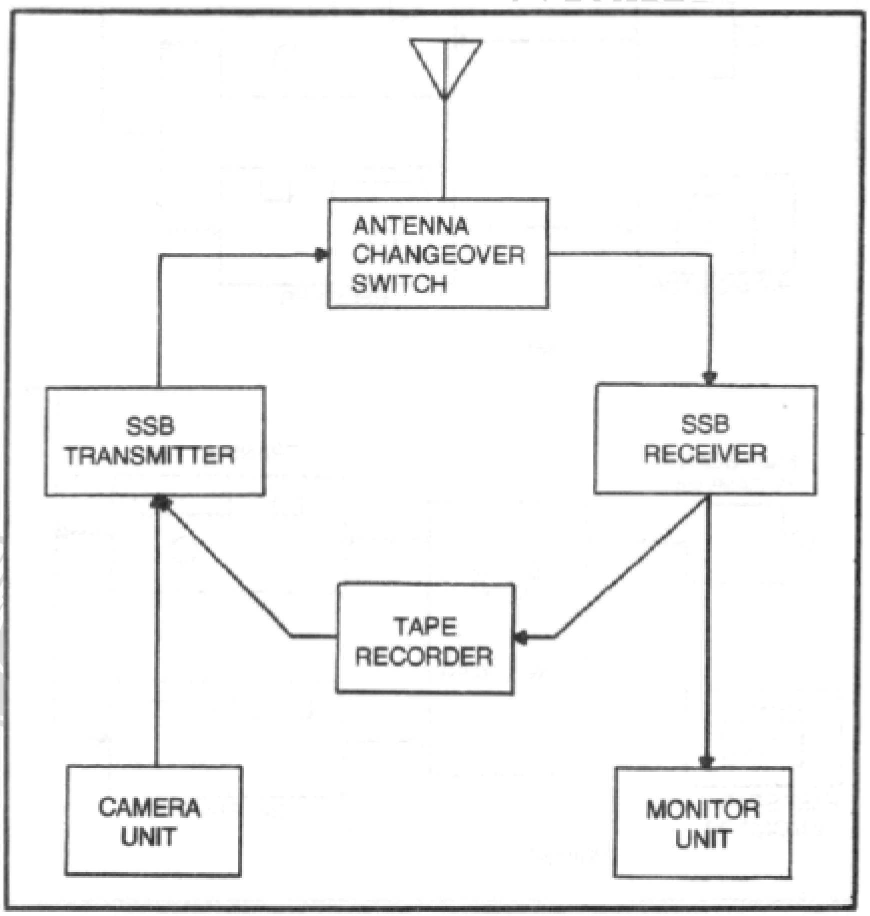


Fig. 10 Basic elements of a SSTV station

The basic SSTV station begins with the SSB transmitter-receiver, along with the microphone, speaker, antenna, and cable. In addition, you must have additional equipment capable of converting video modulation into pictures, converting visual scenes into video data for modulating the transmitter, and a tape recorder. Picture transmission requires 8 seconds of transmission time, using tones ranging from 1500 Hz to 2300 Hz for shades from black to white, with 1200 Hz sync information. For transmission, you will need a camera unit whose output provides these signals and connects to the audio input of the transmitter. As an alternative, you can use a tape (or DVD) recorder to play prerecorded pictures into the transmitter. On the receiving end, you will need an SSTV monitor which converts the incoming audio tones into a picture, or a tape (or DVD) recorder for later playback through the monitor. The overall basic station appears in **Fig. 10**.

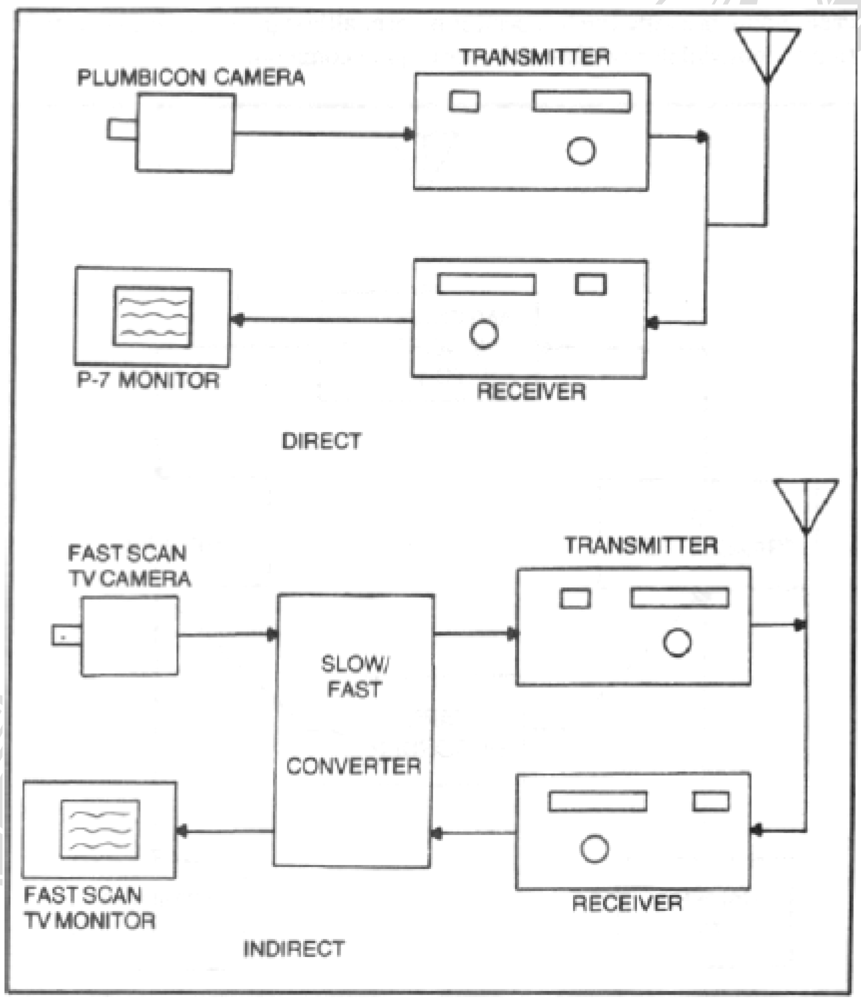


Fig. 11 Direct and indirect systems for SSTV

Processing the video signals coming in or going out requires one of two general systems. The more straightforward system uses direct conversion. The transmitter-modulating camera may use a long persistence plumbic on for slow scan of a static scene. The receiving monitor will make use of a P-7 long persistence cathode ray tube and build the picture one line at a time. The second or indirect system makes use of slow-to-fast scan conversion techniques. On receive, the monitor samples and stores the incoming pulses, converting them to a fast scan format compatible with regular TV sets or video monitors. Some digital circuitry permits use of less expensive short-persistence cathode ray tubes. Similar but reverse operations occur on transmit, where the output of a fast scan tube is sampled and transmitted in the slow scan rate. **Fig. 11** blocks out the elements of the two systems.

RTTY requires a different set of equally complex additional units to go with the basic station transmitter- receiver. Most RTTY work on the HF bands makes use of frequency shift keying consisting of 2125 Hz mark and 2295 Hz space signals (or the older 2125 Hz mark and 2975 Hz space). The input and output devices will be teleprinter units or a storage device such as perforated tape. Between the input-output device must be special units to convert device signals into modulation or vice versa.

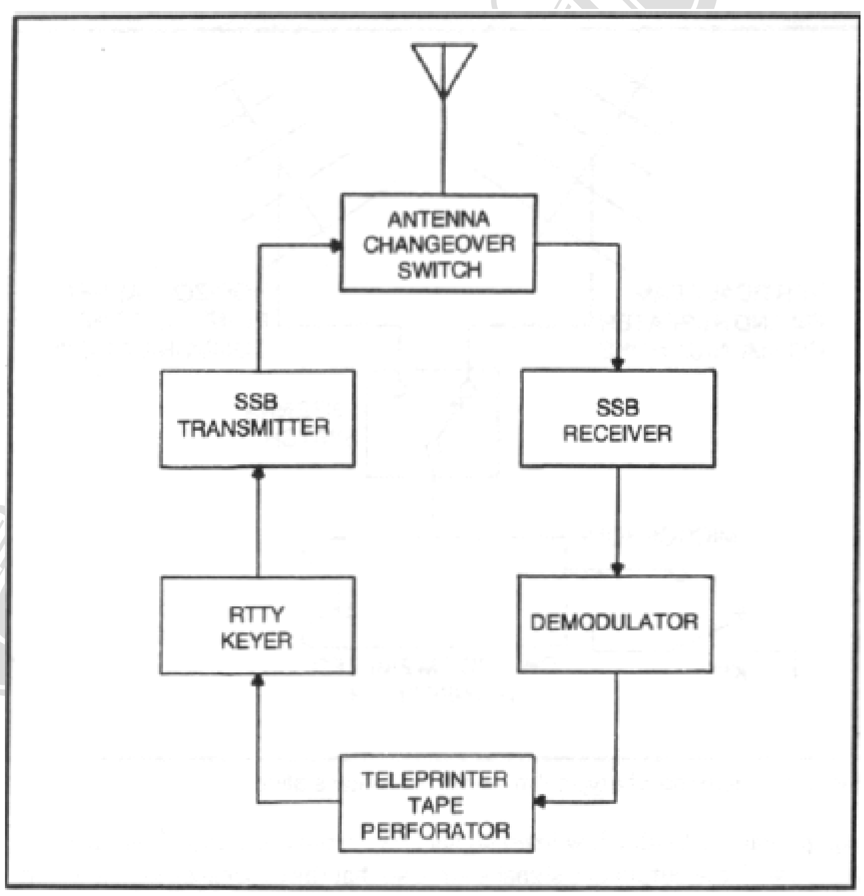


Fig. 12 Basic elements of an amateur RTTY stations

A typical basic station contains the units shown in **Fig. 12**. Between the receiver and the teleprinter is a demodulator (also called a terminal unit, TU, or receiving convener). The unit converts the series of mark and space signals into a series of pulses capable of properly triggering the teleprinter. On the transmit side, a small keying unit converts the usual mark-space/voltage-no voltage printer or tape signals into either a precisely spaced frequency shift of the transmitter oscillator or into two tones fed into the audio input of a single sideband transmitter. In the latter case, since the carrier and other sideband are suppressed, what emerges is two RF signals properly spaced.

The section of **Fig. 12** labeled teleprinter-tape perforator is shown combined because most RTTY operators buy ready-made units. Mechanical printers and perforators appear on the surplus market and thus require only maintenance by the operator. A newer breed of electronic units with cathode ray tube readout is attracting some RTTY operators. In either case, home brewing the teleprinter is rare, although design and construction of demodulators and modulators is quite common.

These very brief descriptions of the basic requirements for RTTY and SSTV illustrate the fact that choosing a mode of operation determines what is basic. Similar complexities arise for fast scan UHF amateur TV and for satellite operation. It is possible for an amateur or a manufacturer to build all these special basic units into a single transceiver or transmitter-receiver combination. However, the fact that smaller numbers of amateurs use these modes than use CW and SSB dictates that commercial gear for HF will usually not contain the extra basics. Perhaps habit more than anything else keeps the home brewer from putting his entire RTTY or SSTV equipment in one cabinet, even though he may build a SSB-CW transceiver from scratch.

UHF AND VHF OPERATION

Although VHF FM operation is the most common form of VHF communications, other modes are used by many operators. In recent years, manufacturers have begun to produce transceiving units capable of CW, SSB, and FM. Thus, a 2-meter station in its basic form, might look little different from **Fig. 13**. Some manufacturers even provide for multi-UHF-band operation.

Equally common are the use of converters to reach the VHF and UHF portions of the spectrum. Receiving converters are by far the most common. A converter consists usually of only two or four sections: the mixer and the oscillator chain (which may contain frequency multipliers as well as an oscillator) are essential, but many units add one or more RF and IF amplifiers. These are shown in **Fig. 14**. Further processing of the signal is done in the HF receiver.

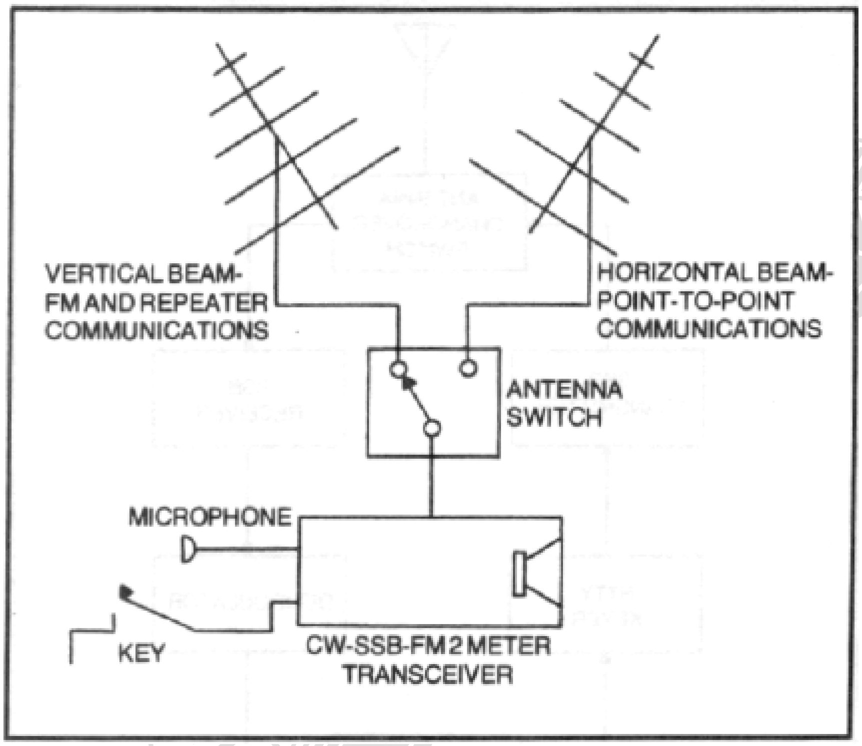


Fig. 13 Elements of a typical multi-mode 2-Meter station

Transmission is accomplished in one of two ways. Until the last few decades, most VHF and UHF operators built a complete transmitter from scratch. In principle, these units vary little from units designed for the HF bands, except for additional multiplier stages and special precautions as common components reached their frequency limits. Some builders and manufacturers have realized, however, that the basic SSB signal processing sections of transmitters need not be replicated in VHF and UHF equipment. Instead, a low level signal taken from the transmitter could be mixed with the output of a signal source so that the processed signal would appear on the proper VHF or UHF band. The only needed extra stage would be a power amplifier for adequate output. Thus was born the transmitting converter, such as the basic unit shown in **Fig. 15**. Combined with a receiving converter in the same case, the unit becomes a transverter, a one-package method of reaching one or more VHF-UHF bands from HF.

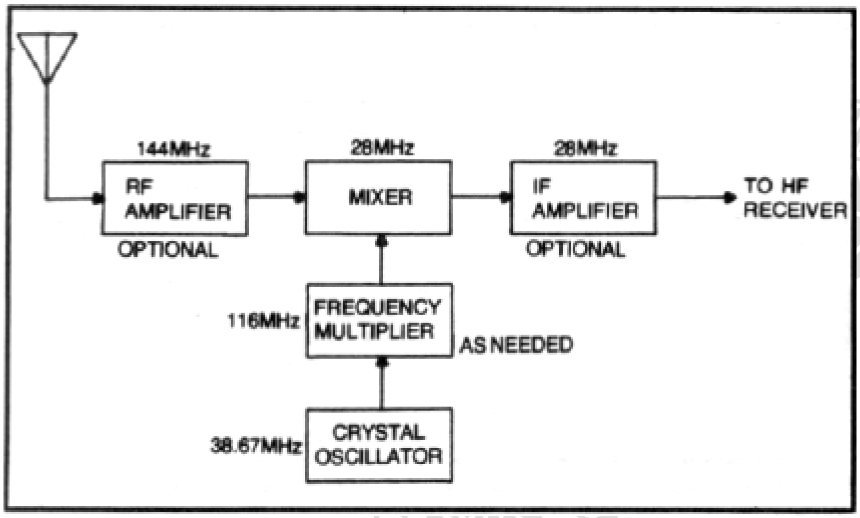


Fig. 14 Elements of a VHF / UHF receiving converter for VHF / UHF

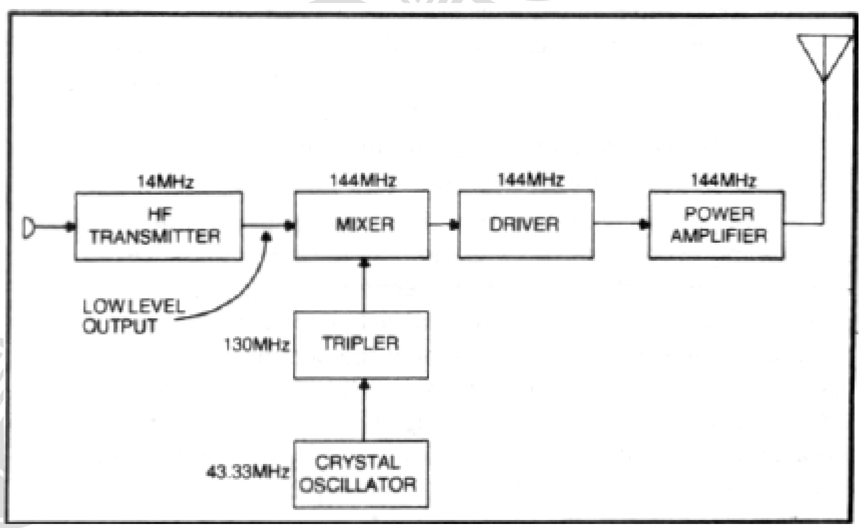


Fig. 15 Elements of a typical VHF transmitting converter

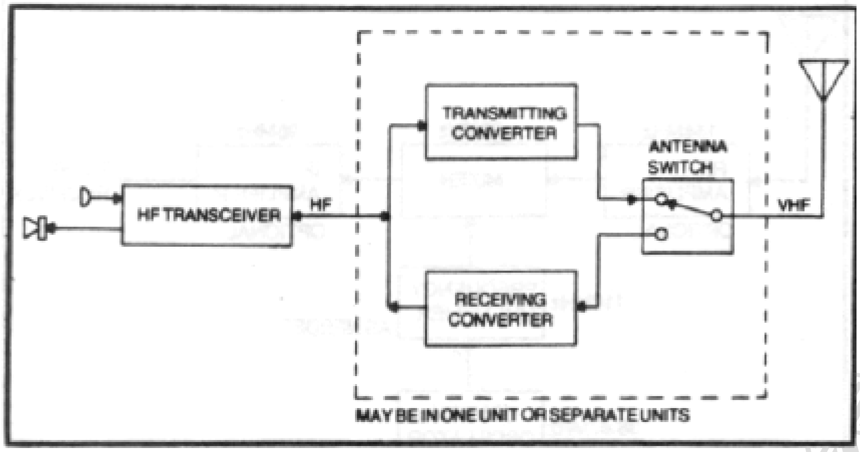


Fig. 16 Elements of a VHF station using a HF station as a foundation

Fig. 16 displays the elements of both systems of using HF as a foundation for VHF and UHF operation.

Not to be neglected at VHF and UHF are the antenna needs of a station. Unlike an HF station, for which a simple wire antenna may provide successful communications, the VHF and UHF station demands a beam for anything more than local contacts. Most usual are rotatable Yagi antennas, horizontally-polarized for point-to-point communications and erected on steel or aluminum towers of considerable height. Although an omnidirectional vertical antenna suffices for the ham who prefers good area coverage via FM repeaters; the CW, SSB, OR AM VHF enthusiast will need as a basic element in his station a high-gain directional antenna system elevated as much as he can afford or maintain. If he also happens to be an amateur satellite operator, he may well add an elevation rotator to the one he uses for azimuth.

The basic elements for a VHF-UHF station are considerably more complex than for HF operation. Too, they differ from those for SSTV and RTTY. Thus, if you are a VHF RTTY fan, your basic station may look like **Fig. 17** on the next page. The sketch is inserted at this point only to show how basic building blocks of the ham shack can add up to produce a complex station, even without frills. The combination of mode and frequency you choose for your operations will determine to a large measure what counts as basic for you.

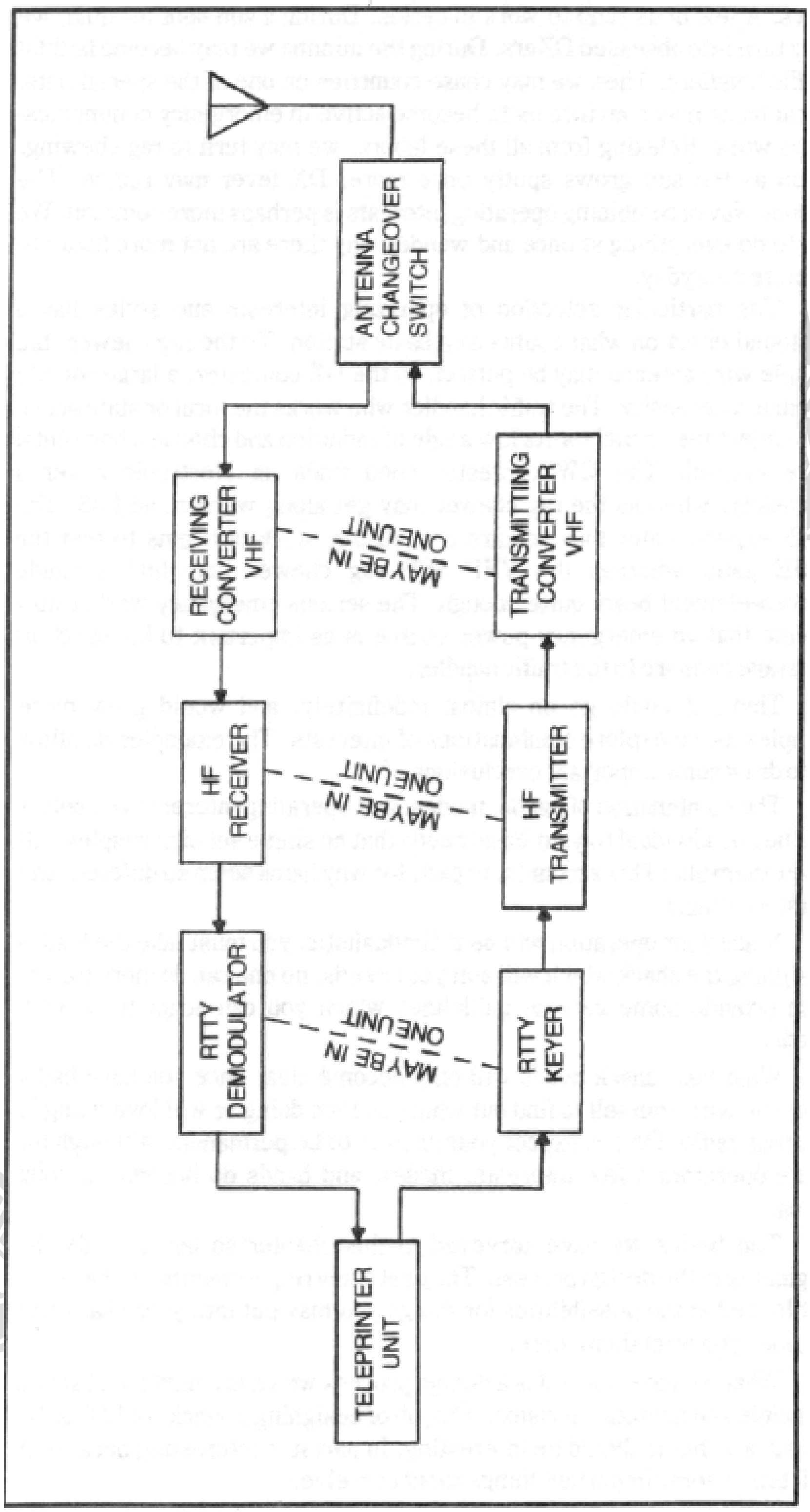


Fig. 17 Basic elements of a VHF RTTY station

OPERATING STYLES AND INTERESTS

Besides your choice of bands and modes, one more operating factor will influence what you consider basic to your shack—the style or type of operating you wish to do. In itself, the operating style you choose may not change all the elements of a basic shack, but when combined with the other choices, the influence may be considerable. There are many types of amateur operations:

- *DXing:* attempting to *work* as many foreign countries as possible or attempting to work mostly foreign stations;
- *Contesting:* engaging in amateur band operating contests such as Sweepstakes, state QSO parties, and the like;
- *Traffic handling:* participating in nets in order to relay messages;
- *Rag chewing:* holding informal conversations with random or select stations;
- *Special purpose net participation:* checking into nets to exchange contacts, information, or other matters;
- *Experimenting:* operating in order to discover or uncover facts about radio ranging from the success of a new building project to the effectiveness of an unusual communications path;
- *Emergency operating:* engaging in emergency communications including regular preparation exercises.

There are some other special operating possibilities, such as transmitting code practice or bulletins. However, these seven basic interests cover most of the common territory. Just these seven multiply into a much larger number once we realize that we can combine them. The resultant combinations sometimes yield the one major interest of some operators. There are DX contesters who do little else. Likewise, there are DX rag chewers who prefer this to rag chewing with U.S. stations or to working DX to add to the countries list. There are DX nets. The combinations, while not endless, are rather lengthy.

Most of us tend to do a combination of operating; that is, we like to do more than one of the things on the list. We go about this in two general ways. A few of us tend to work in cycles. During sunspot maxima we may turn into obsessed DXers. During the minima we may become faithful traffic handlers. Then we may chase countries on one of the special nets. Local hams may convince us to become active in emergency communications work. Relaxing from all these labors, we may turn to rag chewing. Then as the sun grows spotty once more, DX fever may return. The second way of combining operating interests is perhaps more common. We try to do everything at once and wonder why there are not more hours to operate every day.

The particular selection of operating interests and styles has a profound effect on what counts as a basic station. To the rag chewer, the simple wire antenna may be perfect; to the DX contester, a large rotatable beam is a necessity. The traffic handler who works the local or state scene may reject the vertical for its low angle of radiation and choose a horizontal wire instead. The CW contester soon finds an electronic keyer a necessity, whereas the rag chewer may get along with an old J-38. The VHF experimenter may require a multi-bay stack of beams to test the EME path, whereas the VHP SSB rag chewer may find a single eleven-element beam quite enough. The serious emergency worker may decide that an emergency power source is as important to his shack as message pads are to the traffic handler.

This list could go on almost indefinitely, and would grow more complex as we explore combinations of interests. The examples do allow us to draw some important conclusions.

The combination of bands, modes, and operating interests you select will be so individual to your basic needs that no single set of principles will cover them all. (This accounts, in part, for why hams seem so different and so interesting.)

Since your operation will be individualistic, you must take the lead in designing the shack which will suit your needs; no one can do more for you than provide some general guidelines which you can adapt to fit your needs.

What your shack needs will only become clear once you have had a long talk with yourself to find out what you love doing or will love doing in amateur radio. Do not expect your answer to be permanent, although for some operators a few interests, modes, and bands do become lifelong loves.

The basics we have surveyed in this article so far are only the beginning of the design process. They set a few requirements; we have not looked at the possibilities for things you may put into your shack just because you want them there. That will be discussed in the future.

What we have started here is a design process which is a mixture of sound principle and personal decision. The job of designing a shack could thus be a long one, but it should be interesting. In part it is interesting because it will tell us some important things about ourselves.

OTHER NEEDS: TEST, REPAIR, AND CONSTRUCTION

Let us look for a moment at some non-operating needs. These we can call testing, repairing, and building, and all three have to do with the creation and maintenance of our operating equipment and accessories, in this arena, we find a continuum of hams ranging from those who wish only to operate and rely upon manufacturers and service departments to provide working equipment, to those for whom anything other than equipment designed and built by themselves has no place in the shack. Where we fit on this continuum will determine our basic requirements for test and construction benches. Whether we have space, time and money for them will also help in the decision.

We all do *some* testing, even if we own no test equipment. The best test instrument we have is the human brain. The second best instrument is the ailing piece of equipment itself. Even if we do not take the case off the rig, we do some basic testing when we think it is malfunctioning. We may check other modes of operation, other bands, and other control settings. We attempt to fathom the unusual reading on the station meters, including the plate current, output, and SWR meters which help us adjust the rig in ordinary operation. If it is the receiver going bad, we analyze with both our eyes and ears: weaker audio and lower S-meter readings provide some information. We also check to see that all cables, including the AC line cord are properly connected. The nose may get into the analysis by detecting smells suspiciously like burning insulation or leaking electrolyte. What we learn contributes to our estimate of what may be wrong and where to go to get it fixed—to the factory or dealer if matters are serious or to a knowledgeable ham friend if the problem sees simpler.

How much testing we do or wish to do will determine what we need in the way of a test bench. The test bench is not only a place to put ailing gear; it is also a collection of test equipment arranged to be of most use to us. The more testing and checking we do, the more equipment we are likely to have, and the models we purchase may cost more. Likewise, if we specialize in certain modes of operation or certain bands, then our equipment on the test bench may reflect this specialization. The FM operator may have a deviation meter, whereas the SSB operator has no use for one. The UHF experimenter may have a noise generator to test converter performance; the HF operator rarely finds use for one.

To many hams the construction bench is a luxury; to others it is superfluous.

For some, it is as necessary as breathing. Whether or not we need a construction bench depends in part on how much and what type of construction we do or plan to do. If we build only kits and simple projects, then the test bench may be able to do double duty. If, on the other hand, we want to do the mechanical as well as the electronic construction of major projects, we may need a separate workbench for construction. Depending on where the shack is located, we may want to locate the construction bench near the test and operating positions, or we may want certain work to go on in separate rooms. If we are lucky enough to have a basement or garage workshop, we may have the solution to the problem of where to cut and drill metal. Then, depending upon the nature of the project and of the shop, we may do our wiring on the same bench or take the project into the shack for the building and testing of circuits.

The subjects of testing and building will come under detailed scrutiny in the future. The principle here is that the process of shack design must include consideration of them from the beginning. If we leave the test and construction benches until after the operating position are complete, we face the danger of having neither space nor money for them. If we treat them as afterthoughts, we deny ourselves the satisfaction of being able to do these jobs as well as we may want to do them.

At this point, the chief questions to ask are these:

- How much testing and/or building do I want to do?
- How does building and/or testing stack up against operating as a chief interest?
- Am I willing or able to reserve space for testing and/or building in my shack or elsewhere?

Most of us are not 100 percent happy with any part of the present shack. If we are planning to create one from scratch or planning to make some major revisions of the present shack, this discussion should have laid a foundation for extensive consideration. We have looked at the room for the shack and the basic functions we wish to have go on there. Checklists for your shack should give a good feel for the parameters within which we will refine the shack design. With this much we can turn to the details, the first of which will be an evaluation of the equipment we need and want at our operating position.

Basic Operating Needs Checklist

Note: some of the items below suggest that you make some sketches. For convenience in referring to them later, you may want to file them here with this checklist.

1. Ham bands of interest (Check or list specific bands if not all are of interest to you.) HF VHF UHF Other
2. Modes of interest CW AM SSB FM Other
3. Special modes of interest SSTV ATV RTTY OSCAR FAX Other
4. From items 1. through 3., list all combinations of mode and bands interests, for example, HF, SSB, VHF, RTTY, 40 CW, etc.

________________________________ ________________________________
________________________________ ________________________________
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5. Operating interests DX Contests Traffic Rag chewing Special nets Experimenting Emergency
6. Below each entry in 5, list the bands and modes preferred, for example,

   DX
   20, 15
   SSB
7. List any special combinations of interests, for example, DX contesting, net operations, rag chewing, etc.

________________________________ ________________________________
________________________________ ________________________________

8. To the list in item 7, add band and mode preferences.
9. The checklist items 1-8 provide a profile of your operating interests and supply you with information about what the basic station needs are. At this point, you should make some sketches of basic station needs for each major combination of band, mode, special mode, operating interest, and special combination of interests. Use some of the simple figures in the article as models for your sketches.
10. Evaluate the sketches:
    A. Can two or more sketches be combined into one set of basic needs? If so, work toward the smallest number of sketches.

    How does your present station measure up to these needs? If any deficiencies appear, list them for future reference.

11. What test capabilities do you wish to have?
    a. Basic checks ______________
    b. Simple repairs and alignment ______________
    c. Complex repairs and alignment ______________
    d. Design and construction work ______________
12. What level of test work, if any, is as important to you as operating? ________________________________
13. Does your present test bench meet the needs of the answers to items 11 and 12? If not, note the difference for future reference.____________
14. What level of construction capability do you wish to have?
    a. Kits and simple circuits _______
    b. Modification of existing gear _______
    c. Building moderately complex gear with minimal mechanical work _______
    d. Building complex gear with moderate mechanical work _______
    e. Building (in principle) the entire station to standards equal to those of manufactured gear _______
15. At what level can you build with your present construction bench? If there is a difference between desires and capabilities, note it for future reference.____________________________