Home-Brew Design and Construction

L. B. Cebik, W4RNL (SK)

Not every amateur wishes to purchase equipment. Some amateurs prefer to build rather than buy the basic equipment which goes into the shack. On the chance that thoughts of this nature have entered your immediate or future plans, we should look at some of the design and construction features of home-brew equipment in at least enough detail to permit some decisions.

In the beginning of amateur radio, everything was home-brew. In fact, many components emerged from the basement shop simply because no manufacturer existed to produce them. By the twenties, home-brew largely confined itself to the construction of circuits from existing parts, although in many cases hams modified components to make them work in ham circuits. Slowly the wooden breadboard gave way to the metal chassis base and finally a metal case surrounded the entire circuit. With television came shielding and filtering. SSB brought on the tabletop KW station. Transistors added the first step toward miniaturization, and modern solid state, in all its varieties, has shrunk equipment to the limits of comfortable human use.

Solid state has now displaced tubes in virtually all arenas except power amplifiers. With current commercial production of transistor RF amplifiers at the 200-watt level, the practical solid-state linear is a logical step. Many hams still build tube-type equipment, and for many different reasons. However, the dominance of solid state is complete, and the new builder often enters amateur radio knowing more about transistors and integrated circuits than about tubes. Thus, the discussion here will largely focus in solid state construction and design.

Our purpose will not be to provide a complete manual. That task belongs to the extensive handbooks on the market. Rather, we will look for some basic ideas and some basic problems in home-brewing. And, while we will look mostly at the construction of the basic station in this article, the ideas and the problems will apply to nearly every home-brew project we might dream up, from simple accessories to complete computers.

One of the key ideas that the new home-brewer should try to get rid of is that his construction projects must emulate commercial design to the last detail. This one idea more than any other may be the cause of frustrated home-brewers. Home-brew equipment should be designed to meet your needs, your skills, and your desires. Although commercially designed equipment can provide many good ideas for the functions, circuitry, and packaging of your construction project, it should not dictate what you build.

The second idea to give up is that you must either be a design engineer or give up home-brewing altogether. There are many levels of construction open to you. The easiest is kit building, through which you can save money in exchange for the labor of assembly. Next, there are numerous good designs in the handbooks and magazines which you can copy. A third level is to design your equipment using tried and true circuits taken from a variety of sources and adapted to your needs. Finally, there is the level of basic engineering in which you design from scratch. In fact, few engineers do this since where accessible good circuits exist there is little sense in reinventing them. Their circuit invention and development is limited to cases where they must design to new advanced standards or with new devices or new functions in mind. Somewhere in the spectrum, there is a place for everyone.

With the belief that home-brewing holds something for everyone and that everyone can do it, let's look at some basic design considerations. To give us a focal point, we will look at some of the ways home-brew designs can profitably differ from commercial designs.

HOME-BREW TRANSMITTER DESIGN

Previous articles provided a survey of some basic design elements of commercial equipment. One option open to us is simply to build a transmitter which reproduces those design elements. This will usually involve us in complex band switching. Too, we will have to tackle the problem of achieving equal stage gain everywhere within the transmitter across the ham bands. These requirements are not easy to meet with home construction and test methods, for most of us lack access to engineering laboratories.

A Home-built transmitter, however, does not have to do everything that a commercial unit does. The manufacturer builds the most versatile rig possible to appeal to the most amateurs and widen the market. Usually this includes five or six bands of operation (80 or 160 through 10 meters), two to five modes (CW, SSB—with upper and lower sideband selection—plus possibly AM and FSK), and numerous operating convenience options. There may be dual digital and analog readouts, choice of VOX or push-to-talk, and other extras.

Unless a feature is important to your operating needs and wishes, do not design it into your transmitter. If you work 80 meters and 40 meters exclusively, five-band and six-band capability might be superfluous. If you never work CW, then sidetone keying might present more trouble than it is worth. The first task in designing your own transmitter is to evaluate carefully your needs and build to them. Figure 1 compares a commercial type of transmitter with the product of a 75-meter SSB operator who built to meet his own needs.

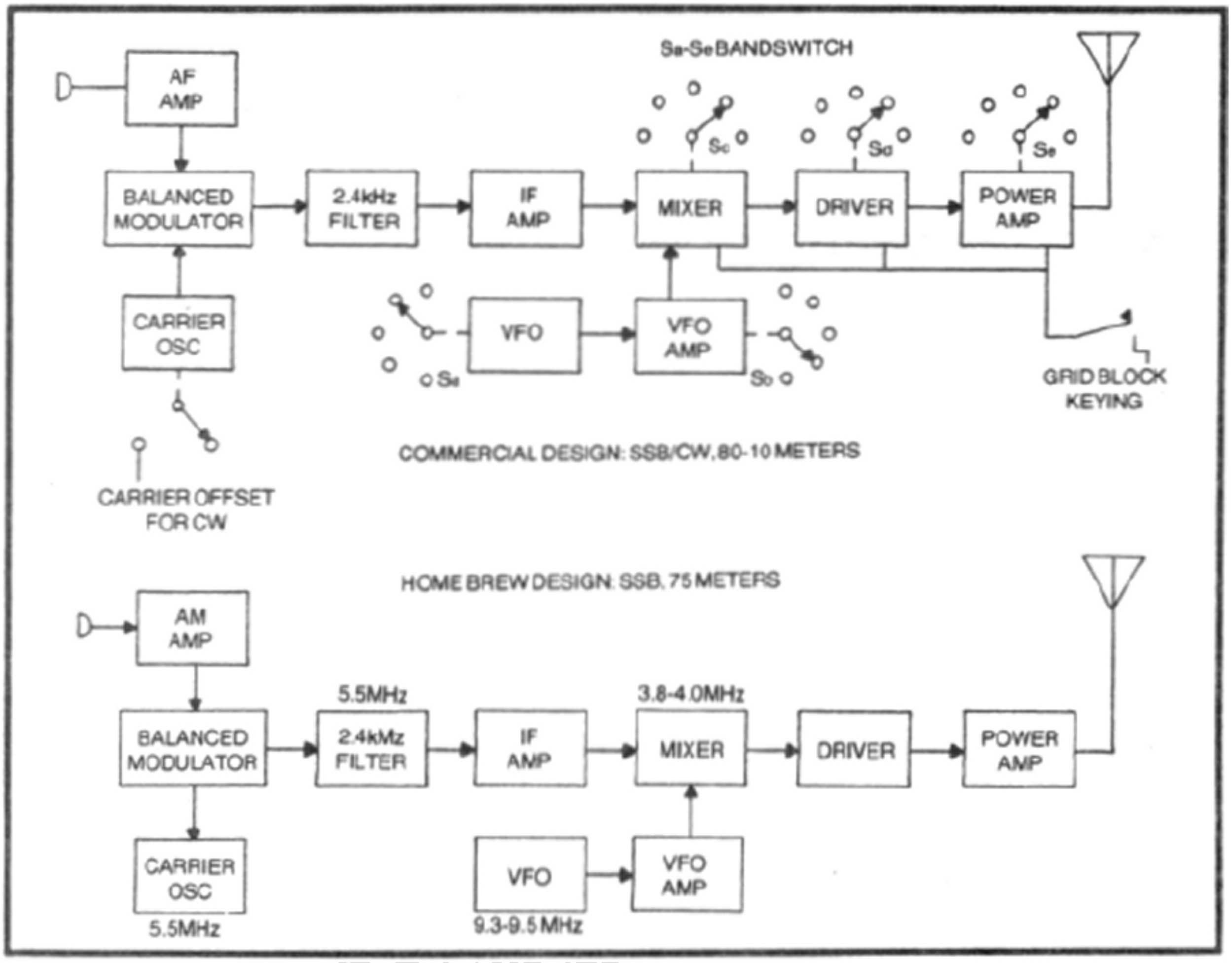


Fig. 1: The commercial transmitter designed compared to a home-brew transmitter according to designed specific needs.

The operating needs of many hams do not stay the same for all time. Having built a 75-meter SSB transmitter, they suddenly take an interest in 20-meter RTTY. When they build the new rig, they suddenly realize that they have reproduced some of the circuits for each. This apparent waste can be overcome by pre-thinking our packaging design. It is not necessary to put everything into one box for each project Modular design permits the construction of smaller assemblies so that they can be combined to function in many modes and bands. Figure 2 breaks up the common CW-SSB transmitter into units which a builder might perfect and install in separate cases. If there is room on the operating table, each case can sit by itself. However, it is also possible to begin with a case large enough to hold all the modules, plus others which might be built in the future.

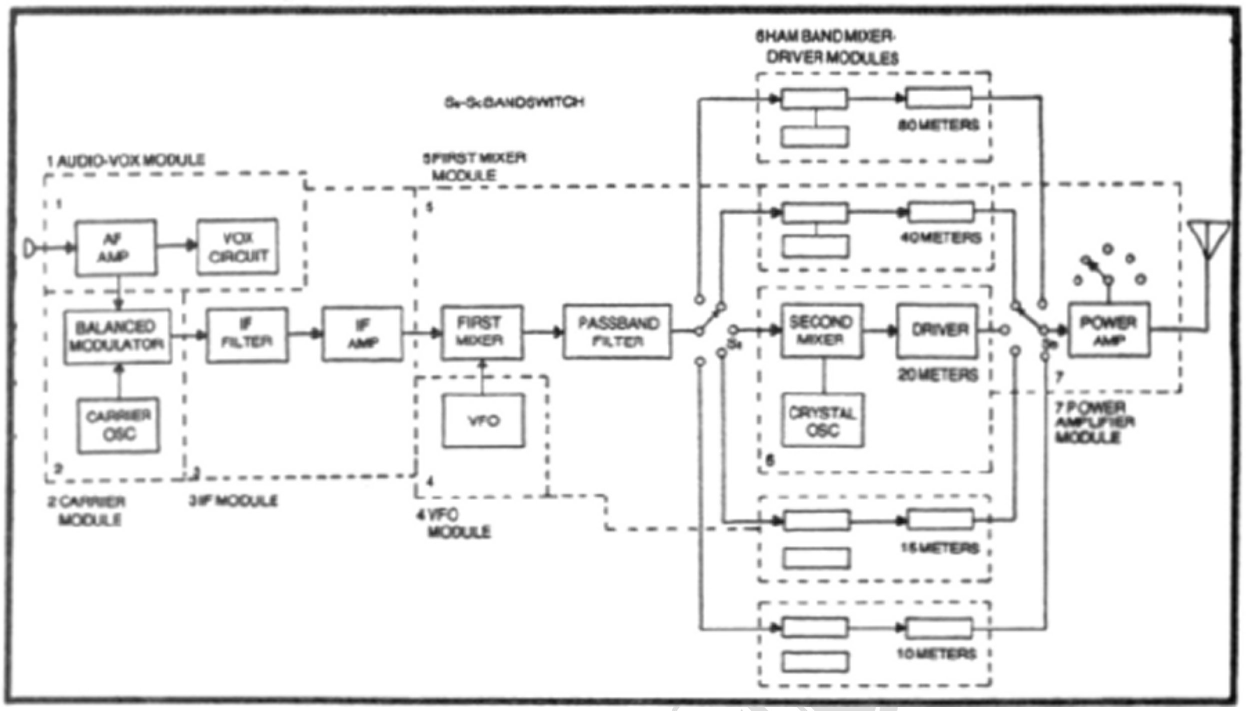


Fig. 2: Modularizing a SSB HF transmitter for systematic construction

Notice in Fig. 2, the RF section is subdivided by frequency conversion sections with separate mixers, HFOs and drivers for each band of interest This type of design is often more successful and less expensive for the home-brewer than copies of the band-switching designs used commercially. Compare Fig. 3 with Fig. 4. In the first diagram, notice that the switch requires many sections to change tuned circuits for each band. Most of these circuits are high impedance, and this increases the chances for unwanted capacitive coupling and introduces stray capacitance values into the circuit, lowering Q. In Fig. 4, only the dc voltage, the low-impedance input and the low-impedance output are switched, overcoming most of the potential problems. The only extra components required are transistors, biasing resistors, and bypass capacitors for each band. The extra cost might be a couple of dollars per band, and this often will be less than the cost of the high quality switch called for in Fig. 3. There are two special advantages offered by the circuit in Fig. 4: first, if one band goes bad, the others are still available for use; and second, each circuit group can be adjusted for optimum results without concern for what it might do on another frequency. Thus, the circuits for 80 meters and for 10 meters might look very different.

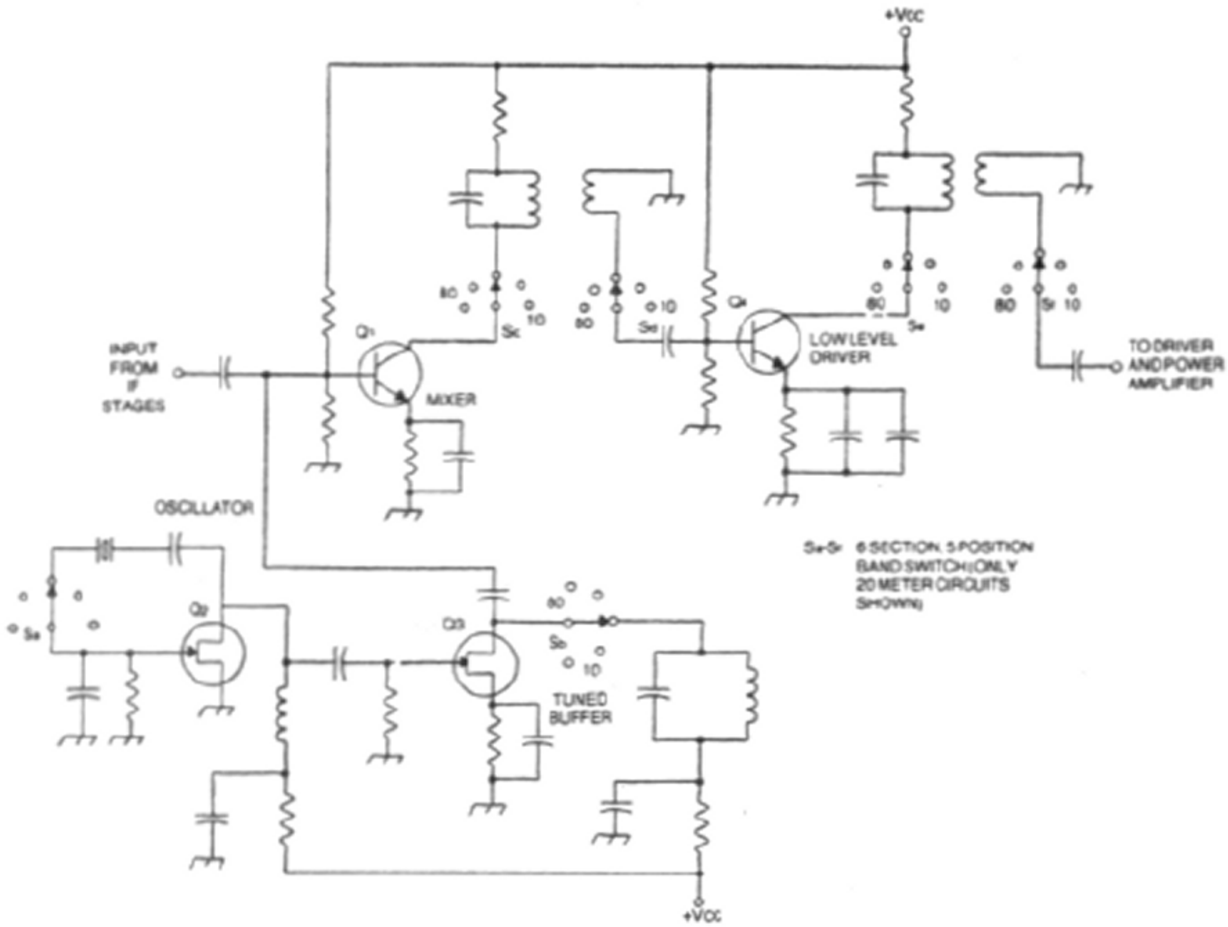


Fig. 3: Multi-band HFO-mixer-driver module

Certainly there is no need to reproduce circuits which use common or frequencies for every band or mode. Commercial equipment often requires unnecessary double duty from some circuits. A SSB VOX amplifier is often also a sidetone oscillator for CW. These can be separated easily so that you can perfect each one independently. In home-brewing, especially for the newcomer, one good function per circuit is usually preferable to two functions, neither of which works quite up to specifications.

Perhaps the only place it makes sense to bandswitch within a circuit is in the power amplifier. Here components are too large and expensive to duplicate conveniently. Hence, the standard tube amplifier of Fig. 5 and the transistor power amplifier of Fig. 6 bandswitch some circuits. In fact, only the tube amplifier bandswitches in the amplifier, the transistor unit switches half wave filters to suppress harmonics generated in the broadband transistor stage.

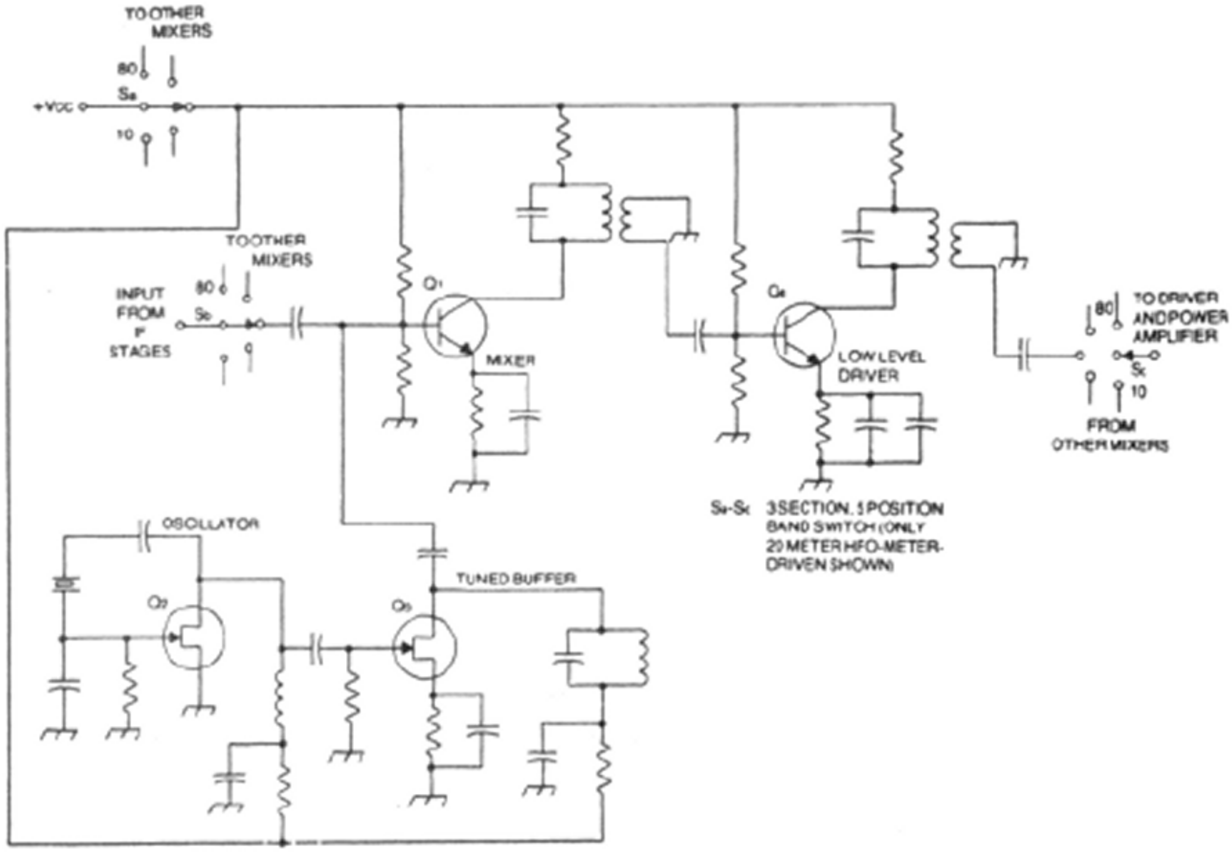


Fig. 4: Figure 3 redrawn as one of the five single-band HFO-mixer-driver modules.

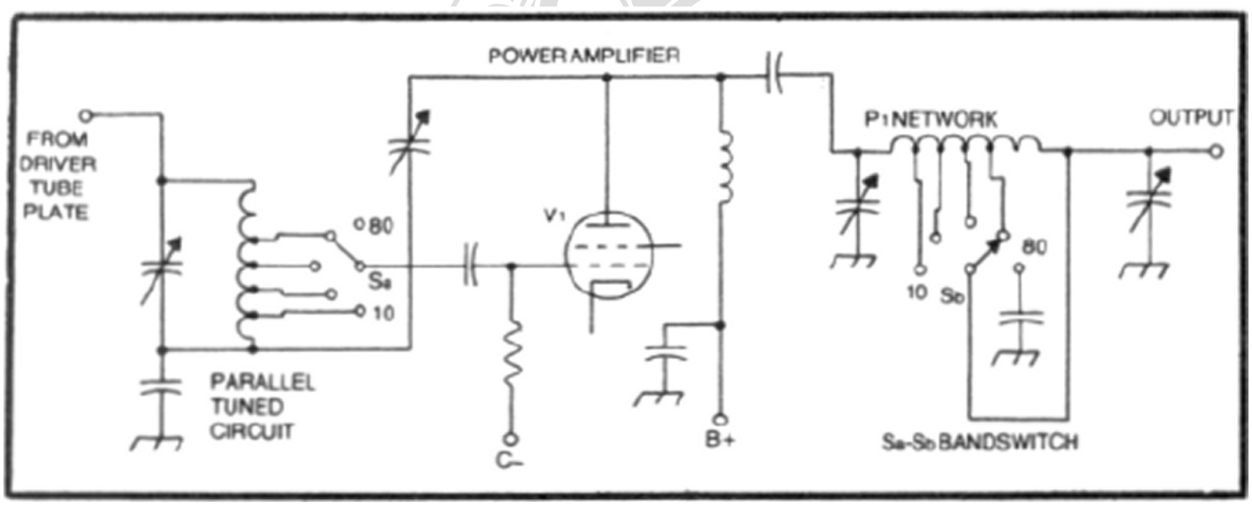


Fig. 5: Bandswitching in a vacuum tube power amplifier.

Whether or not you actually construct your transmitter in modules, the modular way of thinking can assist the design process by separating functions into blocks for ease of design and testing. In addition, you can add into your own transmitter features hardly ever found in commercial transmitters but common as accessories. The CW operator can put the key jack on the front panel and build a keyer into the transmitter. The SSB operator can incorporate speech processing. The RTTY enthusiast can incorporate all he needs for complete FSK options.

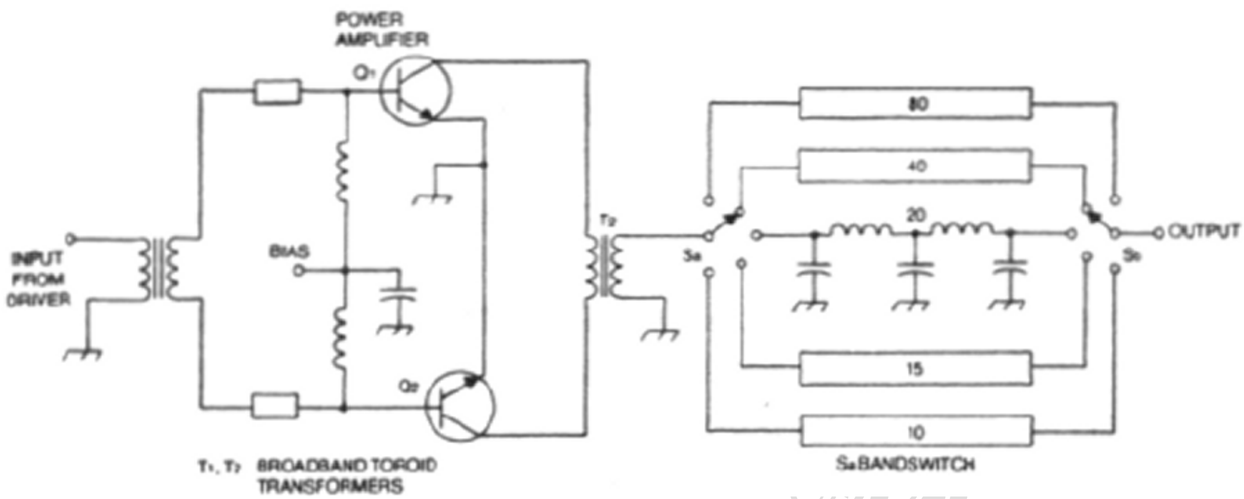


Fig. 6: Bandswitching in a broad-band transistor power amplifier

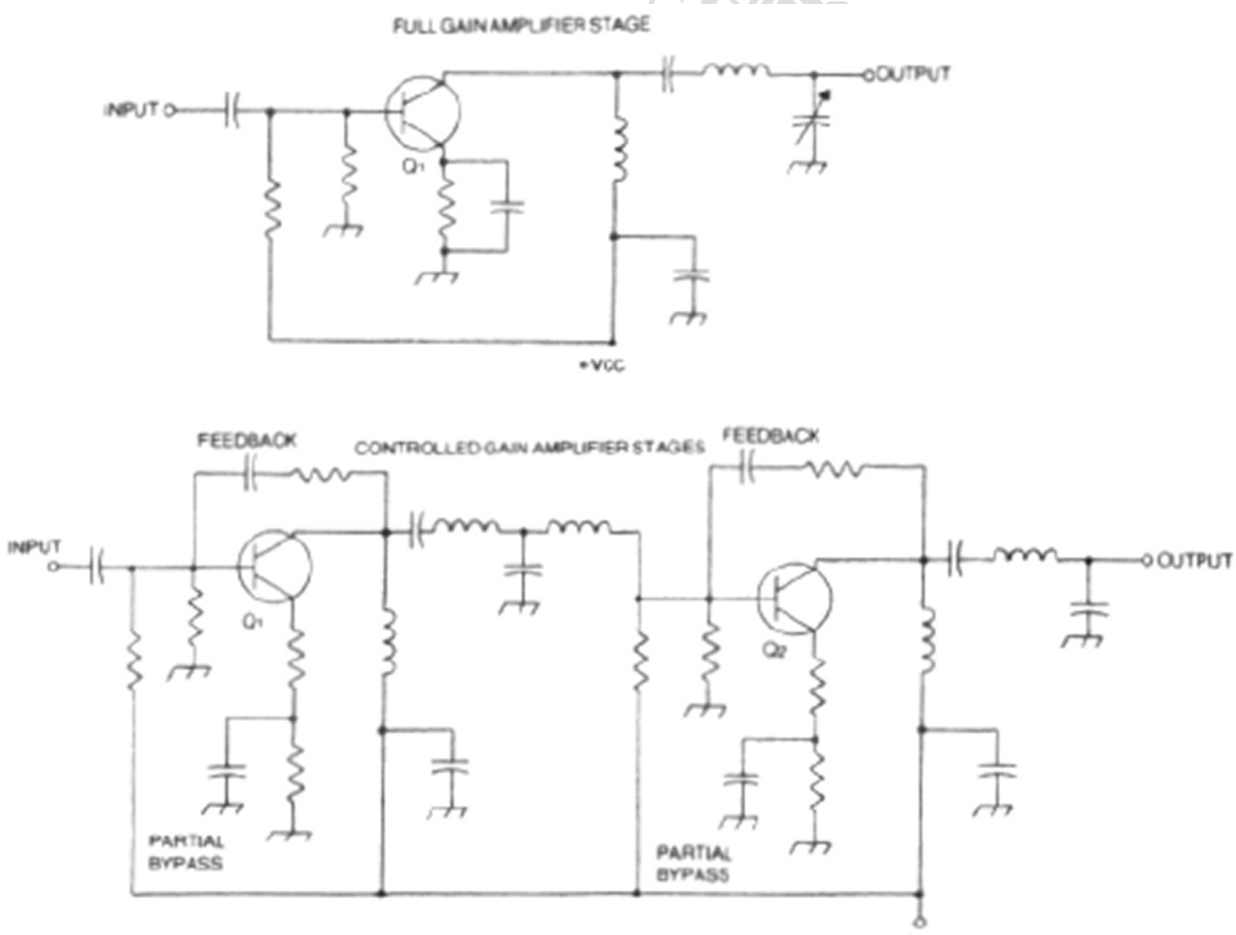


Fig. 7: Comparison of a single stage and a two-stage controlled gain amplifier

The concept of modularization includes the idea of optimizing each circuit. Perhaps the most common hangover from the days of tubes is the attempt to achieve maximum output from each individual circuit in order to minimize the number of tubes. The benefits of this way of thinking were a savings of space and power and a reduction in the adverse effects of heat—in solid state, low power stages, this makes no sense. The rule should be to achieve from each circuit the correct output, with impedance and signal purity. Figure 7 contrasts a one-stage amplifier with marginal output with a two-stage amplifier adjusted for optimal output. The possible instability of the first circuit is overcome through the use of two control-led gain stages. The partial rather than full bypassing of the emitters introduces degeneration, as does the feedback loop. Thus, we achieve controlled gain and stability, and we do so at a cost of a few dollars.

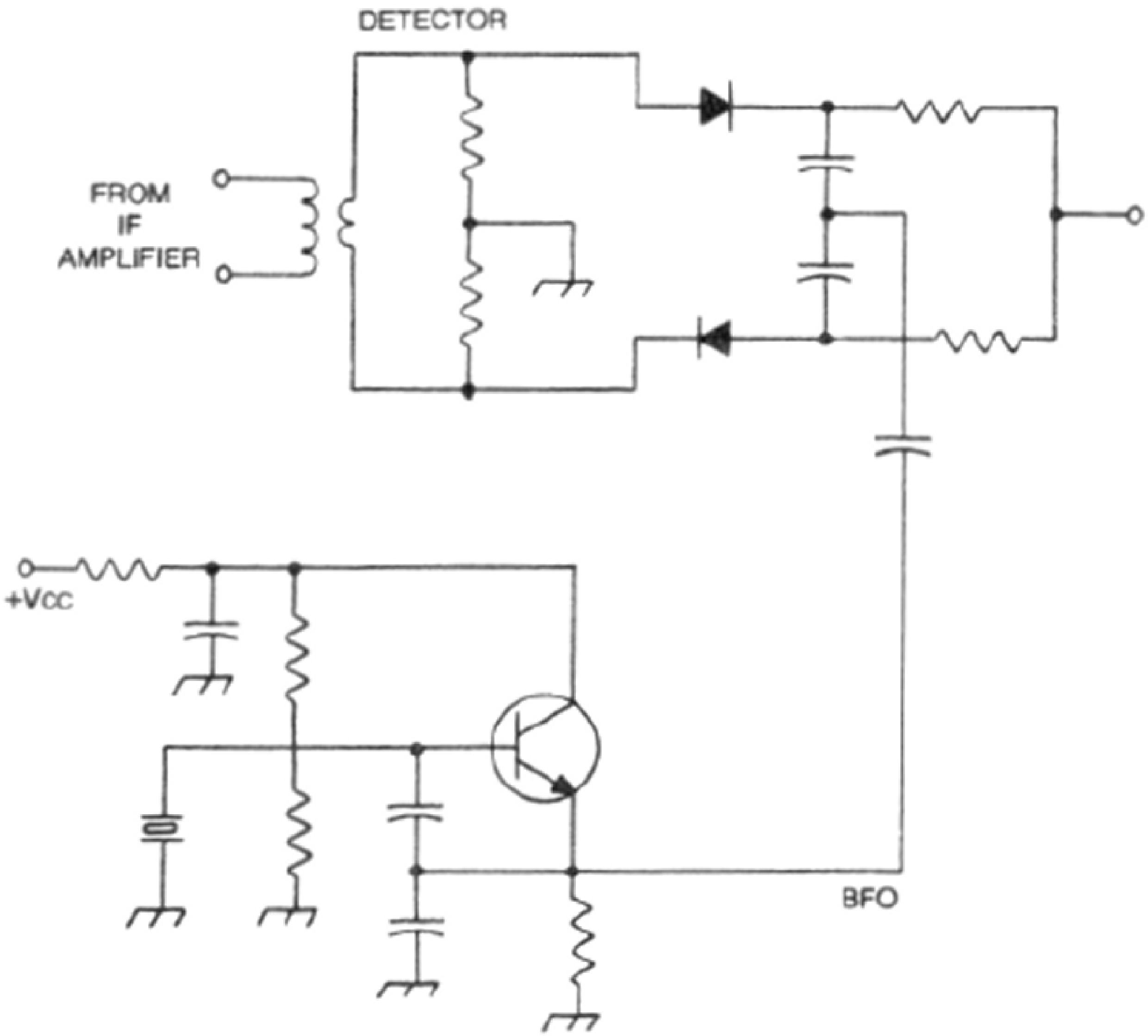
Every transmitter builder understands the effects of insufficient output: the following circuits simply do not receive the needed drive level of signal desired. Too many of us, perhaps, fail to realize that too much gain is equally troublesome. In amplifiers, it increases harmonic content. In mixers, it often causes feed-through of the local oscillator or RF input signals. In SSB, il can introduce distortion. Modular thinking can help us develop circuits which perform Just as we need them to.

HOME-BREW RECEIVER DESIGN

Effective home-brewing of receivers requires much the same thinking as successful transmitter construction. Transmitter design begins with the RF generator, the oscillator. In SSB we must simultaneously begin with audio. We proceed to develop the CW or SSB signal toward the final amplifier. Receivers begin at the opposite end, with the audio output stages, find proceed back toward the RF input stages. The procedure permits us to optimize every stage so that it accomplishes exactly what it should. In addition, it allows us to more easily optimize the relationship between stages.

Suppose we have an audio amplifier and have just built a product detector, in designing the product detector, we paid attention to the ratio of BFO injection to anticipated signal strength from the IF stages. At this point, we connect the detector to the audio amplifier, as shown in Fig. 8. If we should not achieve the performance we desire, adjustments are easy. If the detector output drives the amplifier to distortion, we can cut the detector gain or reduce the input to the AF preamplifier. If the output is insufficient, we can add another stage of preamplification.

DETECTOR SECTION



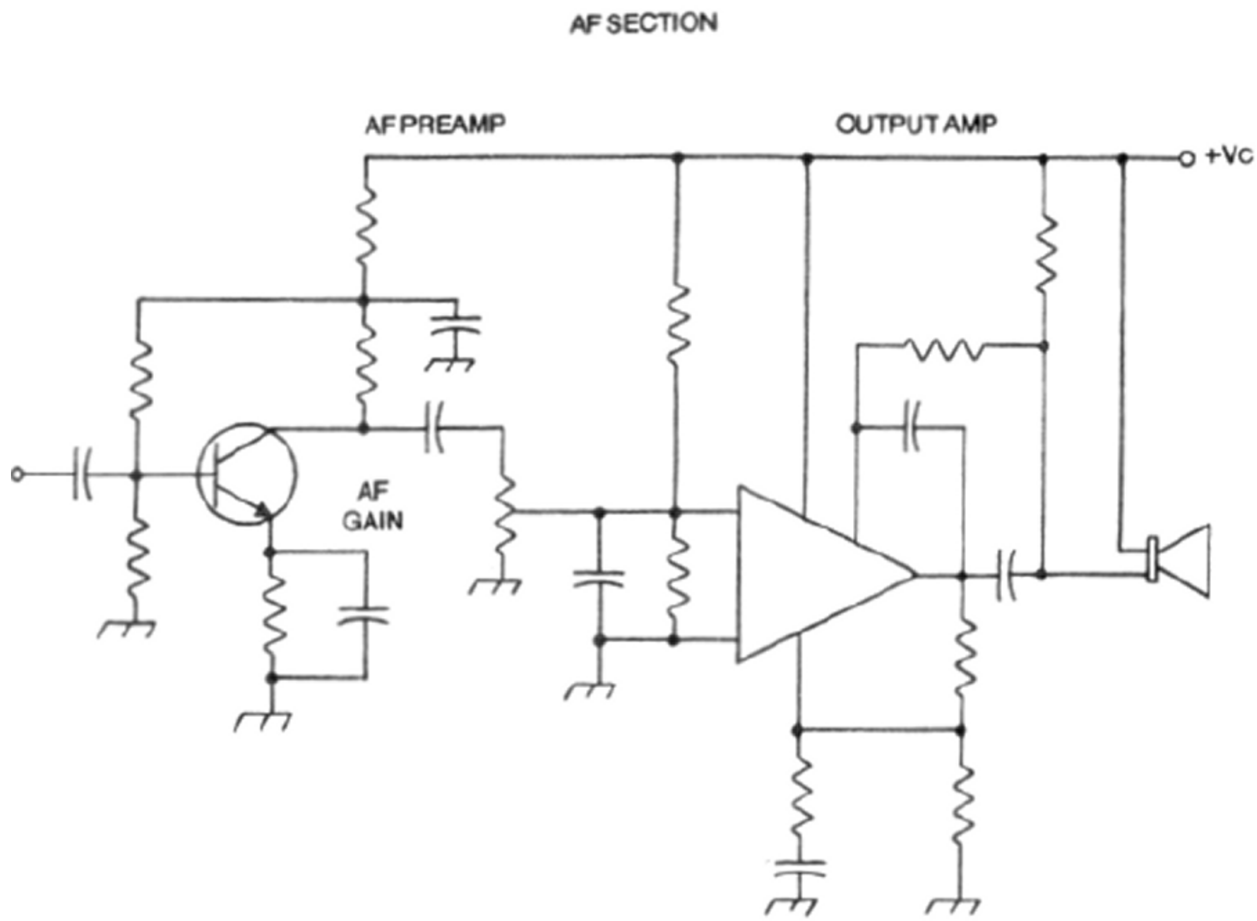


Fig. 8: Connecting a detector to the audio section of a receiver

The IF requirements are similar, perhaps the two most common errors committed by home-brewers are: 1. introducing the filters after stages with considerable gain, and 2. designing-in too much gain from the IF stages, thus overloading the detector. Crystal and mechanical filters, while requiring enough signal to overcome losses, should not be installed too late in the IF chain. The chances for spurious outputs and signal distortion increase, and the chances that out-of-band signals will sneak through also go up. Figure 9 shows a preferred set-up, although it is not the only one which will work well.

Modular thinking comes into its own at the home-brew receiver front-end. Here, the complex bandswitching of commercial design defies reproduction by most builders. However, there are many other good routes to successful front-end design which are far simpler— a series of individual front-end conveners is one way. Figure 10 illustrates the principle. A series of converters, perhaps designed differently for each band, precedes the IF. The only necessary switching consists of low impedance input and output lines and the dc supply voltage. Depending upon specific design, AGC voltage might be supplied to all stages or be switched. In such a scheme, we might intentionally design the converters for 80 and 40 to have lower gain, since the basic noise level is so high. The high-gain converters are reserved for 20, 15, and 10 meters. In short, modular thinking not only saves us the problem of tracking multiple stages, it also permits some easier routes to custom design.

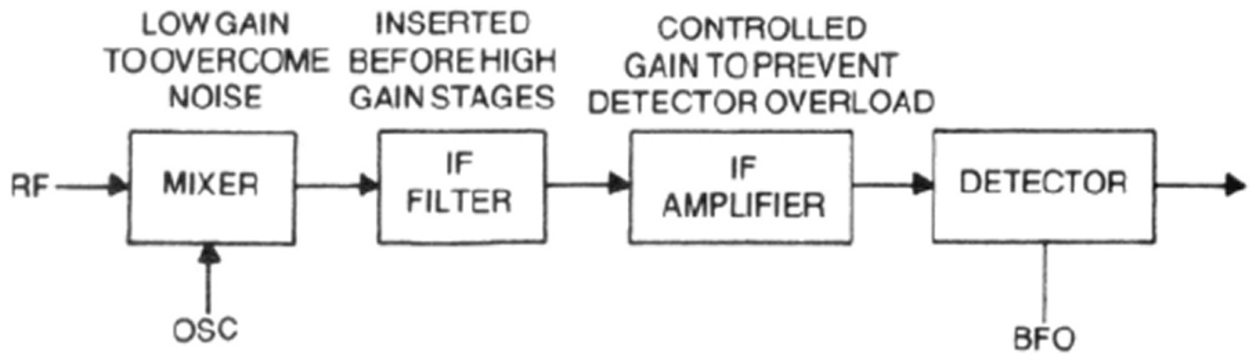


Fig. 9: IF filter and amplifier considerations

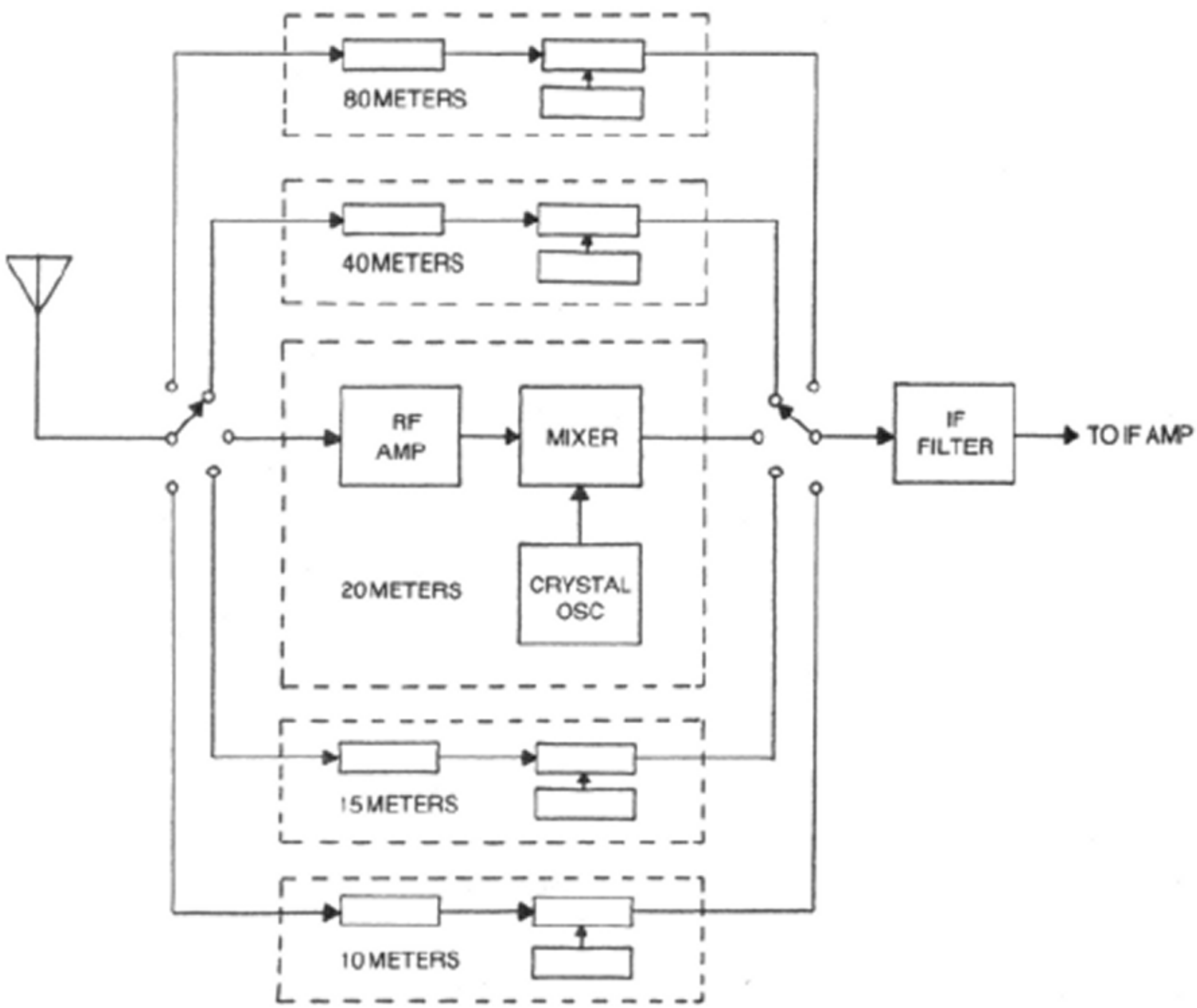


Fig. 10: Modular front-end design for home-brew receivers

In the scheme of Fig. 10, there is a compromise. Each converter requires a relatively wideband front end since the input to each is fixed tuned. We can add ganged front end filters, such as the one shown in Fig. 11, to provide narrower bandpass characteristics. A filter per band would require only mechanical ganging or linkage.

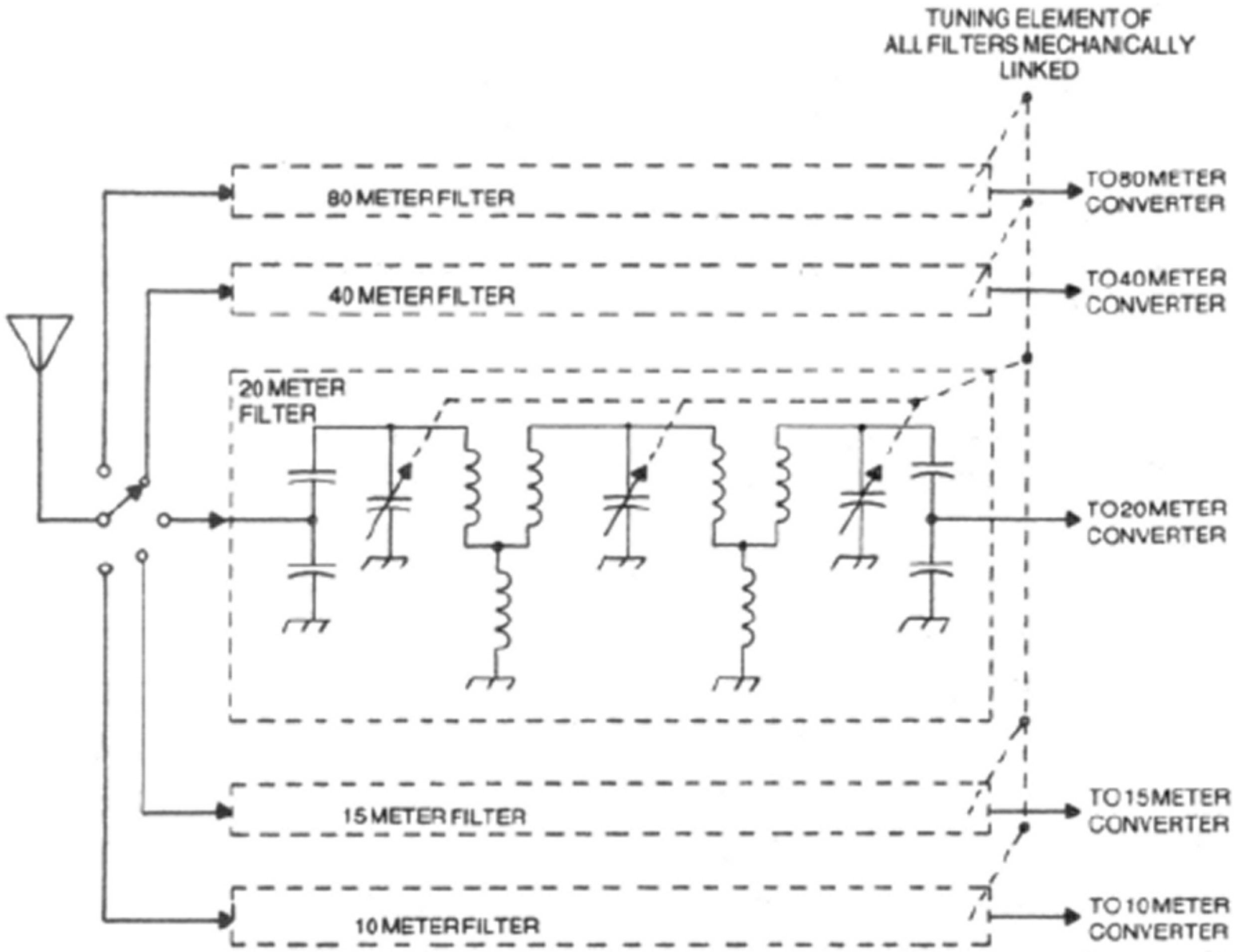


Fig. 11: Adding tunable front-end filters to converter modules

In these basic notes about home-brewing receivers, we have made no attempt to suggest what features your receiver should have or which specific circuits you should use. Your operating desires will provide most of the answers to those questions, and your abilities to design and build will produce the rest. Many home-brewers purchase crystal filters and design around them. Others begin with a basic SSB or CW filter and design-in additional filtration in the form of Q-multipliers, single-crystal filters, or audio filters. The design of a receiver can give you the opportunity to try several filter combinations, as well as to try out some new circuits or save an older one from oblivion. As with constructing transmitters, building your own receiver gives you the chance to design-in only what you want *and everything* you want. With receivers, where power consumption is little problem, there is the added advantage of being able to add circuit functions just to experiment, with little added cost in most cases.

These notes assume that you are building the main station receiver and that space is no special problem. Of course, home-brewers build for many other purposes. Among the functions a home-brew receiver might have are these: to serve as a back-up for the commercial main receiver; to serve special reception needs, such as a net or WWV monitor; to be a compact portable unit for field day or other uses; to be a permanent experiment in receiving techniques. It is clear that purpose and design are closely related. The miniaturized portable receiver will likely not have as many band, mode, or filter options as the main station receiver. Likewise, the special monitor receiver need have only one band and mode, and may not even require tuning. The station back-up, however, should be full-featured to the degree that you require for adequate operating when the commercial main receiver goes down. All of these relationships, whether in transmitters or receivers, have a bearing on the construction techniques we will use, and our construction capabilities will in turn affect the nature of our designs. Let's spend a little time therefore on the physical aspects of home-brewing.

MECHANICAL CONSTRUCTION

Mechanical skills do not come automatically with the amateur license. For some of us sheet metal, hole punches, and screwdrivers never seem to produce the perfection we desire. For others, the skills come naturally or by training and are the easiest part of equipment construction. In this section, I will assume limited mechanical skill in order to suggest some ideas which may make the mechanical part of the construction process somewhat less forbidding. Not every idea may be relevant to you but perhaps one or more of them will start a chain of thought which will make the seemingly impossible task of building your own gear easier.

First, draw a complete mechanical sketch of the equipment you wish to build. Many hams draw complete schematics and then try to guess the size and mechanical layout of parts. The resulting construction often yields a perfectly good circuit which will not work due to the location of components. There are two types of drawings needed for the mechanical side of the task. One is a scale drawing of the parts layout so that you can evaluate the physical aspects of the circuits for potential problems such as lead length and coupling. The other is a set of drawings of the entire mechanical set up, including chassis or main frame arrangement and the front panel layout. With this latter set of sketches in hand, you may even be able to enlist aid in the heavier metal work.

Although linear amplifiers and heavy power supplies still use the old standard chassis and cabinet arrangement, using solid state circuitry for the bulk of equipment offers several alternatives. Figure 11 shows a simple circuit sketched out for circuit board, pert board, and tie point construction. Although there are many convenient ways to etch circuit boards, they still require more messy work than many builders wish to do. As a substitute, some builders use commercially-made boards with pre-etched patterns, replacing copper lines with juniper wires. Perf board construction offers similar advantages. Perhaps only high-power solid state stages require the large copper areas of etched boards, and these can be produced with a minimum of problem compared, say, to a board with a dozen integrated circuits on it.

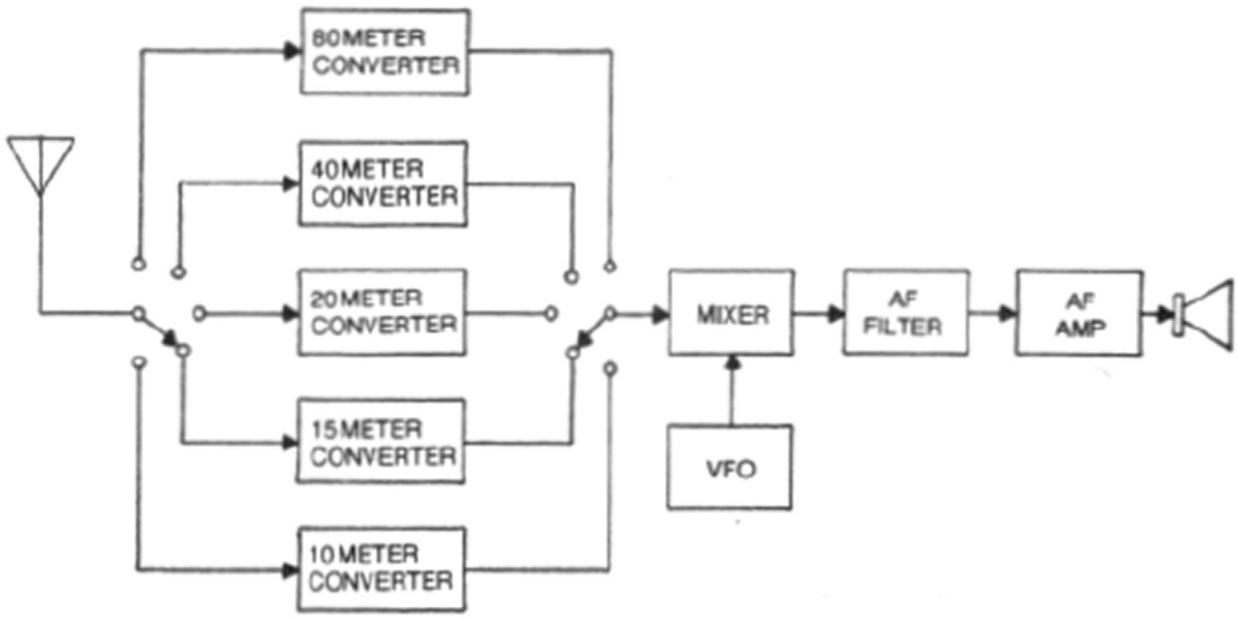


Fig. 12: Modified direct-conversion receiver for home-brew construction

Third, with solid state design do not put too much circuitry on any one board. Modularity is the key to the effective design of home-brew projects. It is also the key to successful construction. Sometimes the design will appear to be logically devisable into modules, at other times you will have to make decisions based upon what you can build and test as a unit. The hypothetical receiver in Fig. 12 has several natural divisions. Figure 13 shows how this translates into one type of construction—a series of boards, each either isolated from others by shields or encased in a separate aluminum box. Note that all the interconnections are made with shielded cable to minimize interaction. With a simple set of RF and audio signal sources, as well as a general coverage receiver to check the oscillators, testing of this receiver is easy.

From the construction in Fig. 13, it is an easy move to more sophisticated techniques. Plug-in boards on a main frame with interstage shielding are a useful type of construction used in computers. Figure 14 shows a sample. If you use those precautions necessary in RF work, the technique can provide easy mechanical assembly and maximum flexibility. Any time you get the urge to try a new circuit, you can plug it in for the test without undoing any other circuit. If it does not work out, the change of a board will restore equipment to its previous functional condition.

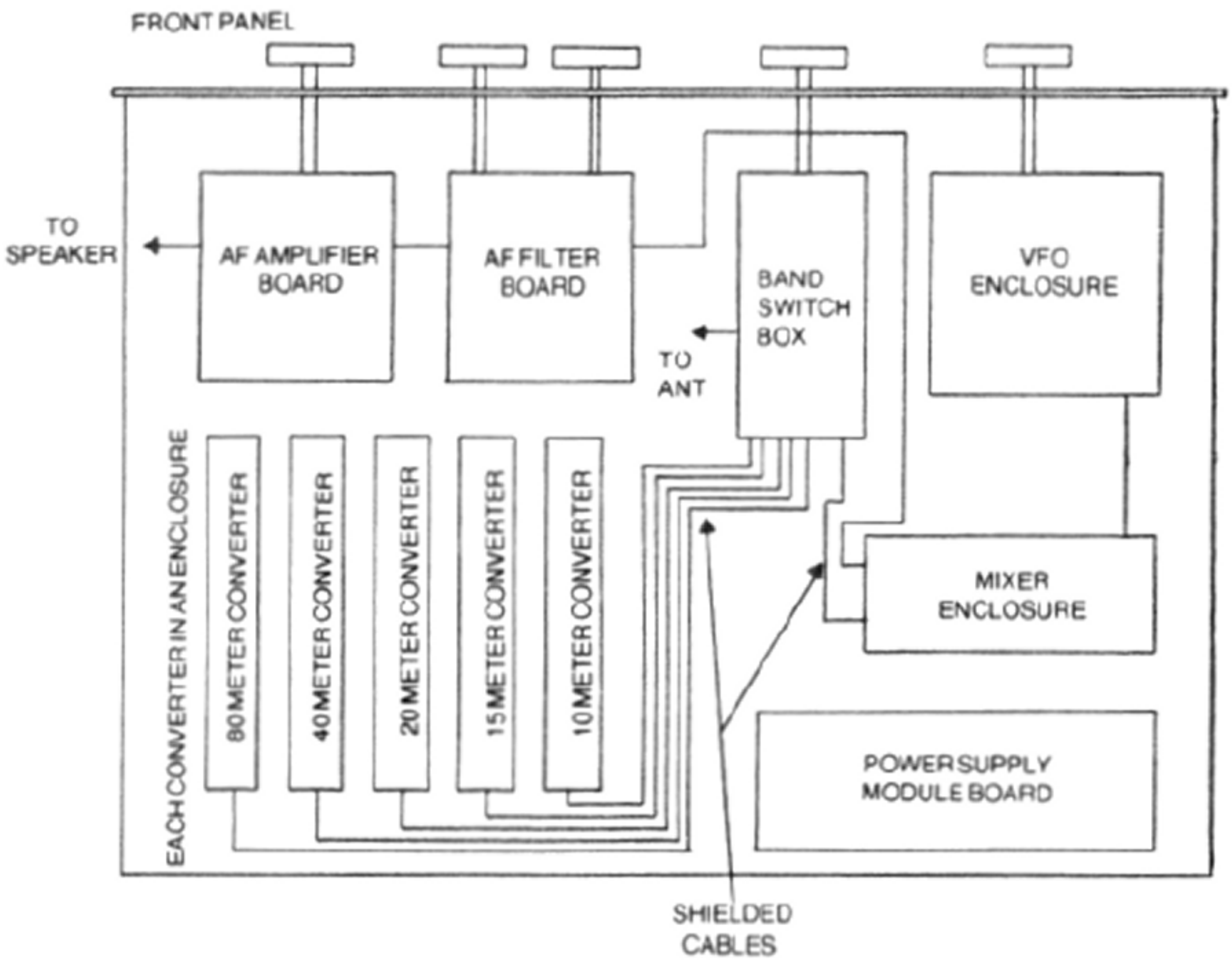


Fig. 13: Modular construction of the receiver in Fig. 12

Fourth, the case construction can be as flexible as the circuit construction. No rule tells us that we cannot use every surface of a cabinet for controls—the tops and sides of a cabinet can be as eligible as the front panel. Many modern cabinets break down into separate panels for easy access. Nor does our cabinet have to be perfectly rectangular. New styles are emerging, many with sloping panels. If the cabinet suits our needs, the smaller size of solid state circuits may make such cabinets the perfect choice. In short, do not look to the commercial manufacturers as the last word in cabinetry. Rather, analyze your needs and explore all the possibilities in commercial and home-brew cabinets before you make a final selection.

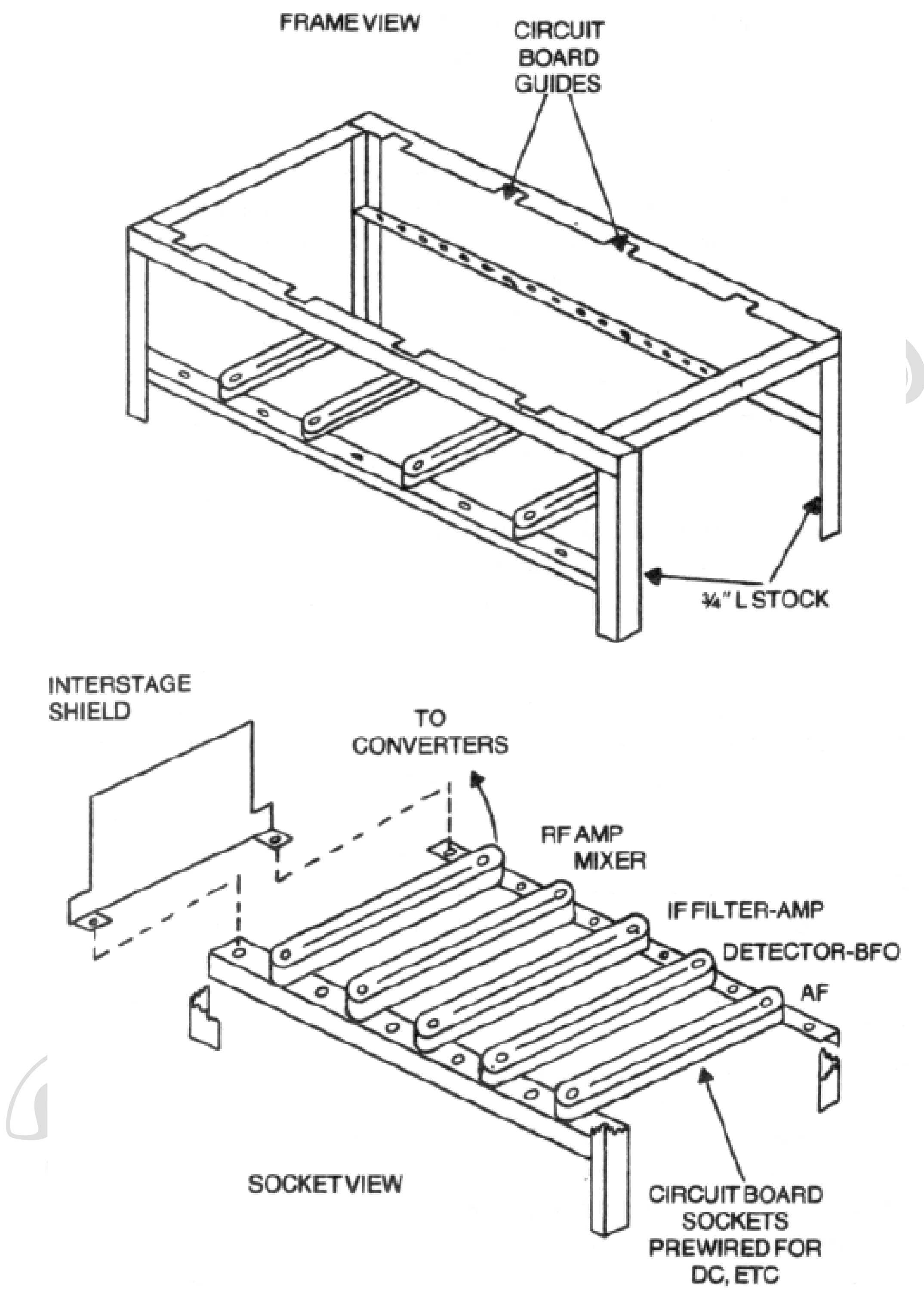


Fig. 14: Circuit board socket and main frame construction for Ham gear

These considerations are far from complete. A survey of the latest techniques used by commercial builders and by hams can be found in recent issues of magazines. The idea of this section is to open a set of considerations for planning the mechanical side of home-brewing. Whatever the techniques you choose as appropriate to your work, you must equip yourself to be able to perform them. Later articles will take a long look at the test and construction benches, but here let's just sample what is involved. For circuit construction, you will need space and those tools that fit the methods you favor. Parts storage, lighting, and comfortable seating must also be part of the plan. For perforated or pre-etched boards, you may need only wiring room. Etching your own boards will require more working area, part of which will have to be in a place that spilled etching fluids cannot harm. If you buy cabinets, you will need tools to drill or punch round or rectangular holes. Bending your own cabinets may require a metal brake or other equipment to permit precise shaping, but cabinets can also be built using metal sheets attached to L-stock at the comers, eliminating the need for fancy bending equipment.

Evaluating the mechanical aspects of construction thus requires a three step process:

1.) Assess your skills in comparison to the available circuit and mechanical construction techniques and select the methods most suited to you;

2.) Plan space in the shack or in another part of the house for the work required by the techniques you have chosen;

3.) Plan to equip the space with the tools needed to do the work properly.

There is no one way to good mechanical construction, but the evaluation process will help assure that the way you choose will produce good results.

PARTS AND SUPPLIES

One of the most agonizing aspects of building for the home-brewer just getting into the business is obtaining parts for the equipment Old timers have their proverbial "bottomless" junk boxes. What cannot be found there is obtained by judicious swapping with other old timers, often at ham fests. The new builder has little to trade and a skimpy junk box.

The junk box is not always the safest place to find parts for complex circuits. Parts removed from equipment may have changed value from the heat of desoldering. Lead lengths may not be correct. The general rule is that the more critical a circuit, the wiser it is using new parts. This rule, of course, does not apply to large, expensive, and relatively simple components, such as surplus rotary coils and wide-spaced variable capacitors. With miniature and inexpensive components, however, it is better to buy unless you are sure of the quality of the component you have on hand.

Purchasing components can be a complex process. No one dealer carries everything, and for good reason. The number of different components makes it impossible for a dealer to maintain stocks of everything. In addition, the cost of doing business has risen to the point that the order for one resistor or capacitor is too expensive to handle. Thus, many dealers sell only in minimum quantities; others have minimum dollar order levels; still others have both.

Putting together a parts order requires careful planning. You may need several orders to separate dealers to complete the parts list. Each may have differing requirements for ordering. The research required to obtain all parts with minimum duplication or ordering of unneeded extras may rival the research you will have done on the rig design.

The first step in the process is to list all the parts you will need for a building project. If you can combine the lists for several small projects together, then you may be able to buy more economically. This list is the prelude to searching the catalogs and brochures.

The second step consists of listing dealers and creating a matrix, such as shown in Table 1. Each entry should show the price and any special ordering information, such as minimum quantity. Keep on searching catalogs until every need has a source to fill it. Make sure there is an entry for each dealer who can supply the component.

		Dealers and Prices		
		Smith	Jones	Adams
Part	Quantity	$10 Minimum	$1 Svc. Chg. Under $15	$8 Minimum
IC 74193	3	1.14	1.65	1.20
IC 74164	1	1.65	1.65	1.60
IC 7400	4	10/2.00	.20	.15
IC LM373	2	---	4.00	---
100 pf mini vari C	2	2.50	---	---
1000 mf/35 v C	4	.40	---	.39
5000 ohm/10 w R	1	---	1.00	---
⅛" red LED	10	5/1.00	.20	.15
⅛" amber LED	5	5/1.00	---	.20
2N5139	4	2.00	---	---
2N2222	3	4/1.00	.20	---

Table 1: Sample Parts Ordering Matrix for Mail Orders

The third step is to analyze your lists and make up orders to obtain every component while meeting all requirements for minimum orders. In some cases, you might not order from the dealer with the most pans if a number of others can collectively supply all of them and the first dealer is lacking some critical part. It is all a question of matching-supplies, order requirements, and your needs. The matrix tells all.

A few decades ago, the parts situation was worse than today. Fewer dealers handled small parts, and RF components began to disappear entirely. Today, there are some dealers specializing in RF components. For the rest, the advent of ICs has rekindled the small parts business, since besides the integrated circuits, the dealer will usually also carry a variety of related parts.

Experience with a few projects will provide you with data on the dependability and trustworthiness of the dealers from whom you order. How they perform on small orders (which still meet their minimum purchase requirements) will be a guide to whether they have a place in your future parts list matrices. You may also want to keep track of how long it takes them to fill orders and how well they perform in correcting problems and errors. Price is the other factor which will complete your evaluation of dealers.

Whatever your home-brew project, you can expect that at least one vital part will not be available from any known dealer. The only alternatives are either to redesign to eliminate the part or to try a substitute. There are both easy and difficult substitutions. If temperatures stay fairly constant a silver mica capacitor may often substitute for a polystyrene unit—that is an example of an easy substitution. One the other hand, moving from a ferrite-core toroid coil to a linear-wound coil can have consequences in circuit resistance, Q, shielding, and other aspects of performance.

Going through the intensive search for components and making substitutions is not too painful a task. There is much to be learned from parts catalogs about component characteristics and limits. The changing state of the art is often first chronicled in catalogs and only later in magazines and handbooks. The process of making a substitution can be a good way to learn about or review the differences between component types. In the end, the entire process of building one's own equipment can teach us a great deal about electronics—even the parts order contributes to our knowledge.

THE HOME-BREWER'S STANDARDS

Designing entire transmitters and receivers appeals to perhaps a minority of amateurs—however, there are some types of equipment which have far wider appeal. Perhaps the three most popular home-brew projects are the power amplifier, the electronic keyer, and the audio filter.

The power amplifier, in the 1 KW DC or 2 KW PEP input range, is a popular home construction project due to the expense of commercial units. All components are large, and each is costly. However, by judicious searching of ham test flea markets or swaps with other hams, you can gradually acquire the needed parts—even the tubes. Power supply components may often be purchased from surplus dealers.

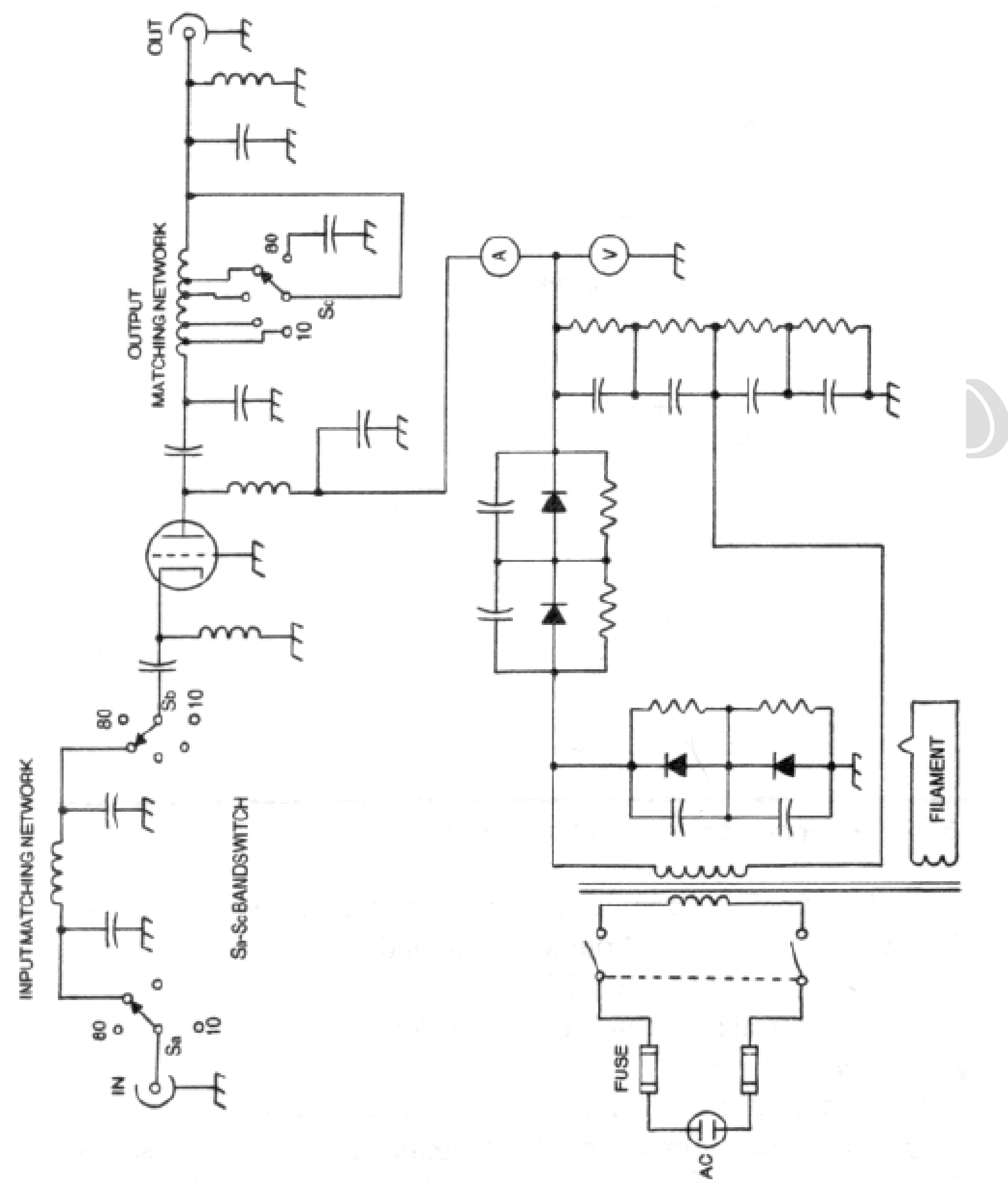


Fig. 15: Simplified schematic of a linear amplifier and power supply

Figure 15 shows a simplified diagram of a linear amplifier. Beyond the savings from obtaining used or surplus components, the schematic shows the second appeal of power amplifiers: they are relatively simple electronically. But they are not so simple that we can take their successful construction for granted. They require attention to matching, operating conditions, and most of all to safety. Burning up components is also burning up money. Putting a hand in the wrong place without safety precautions can be fatal.

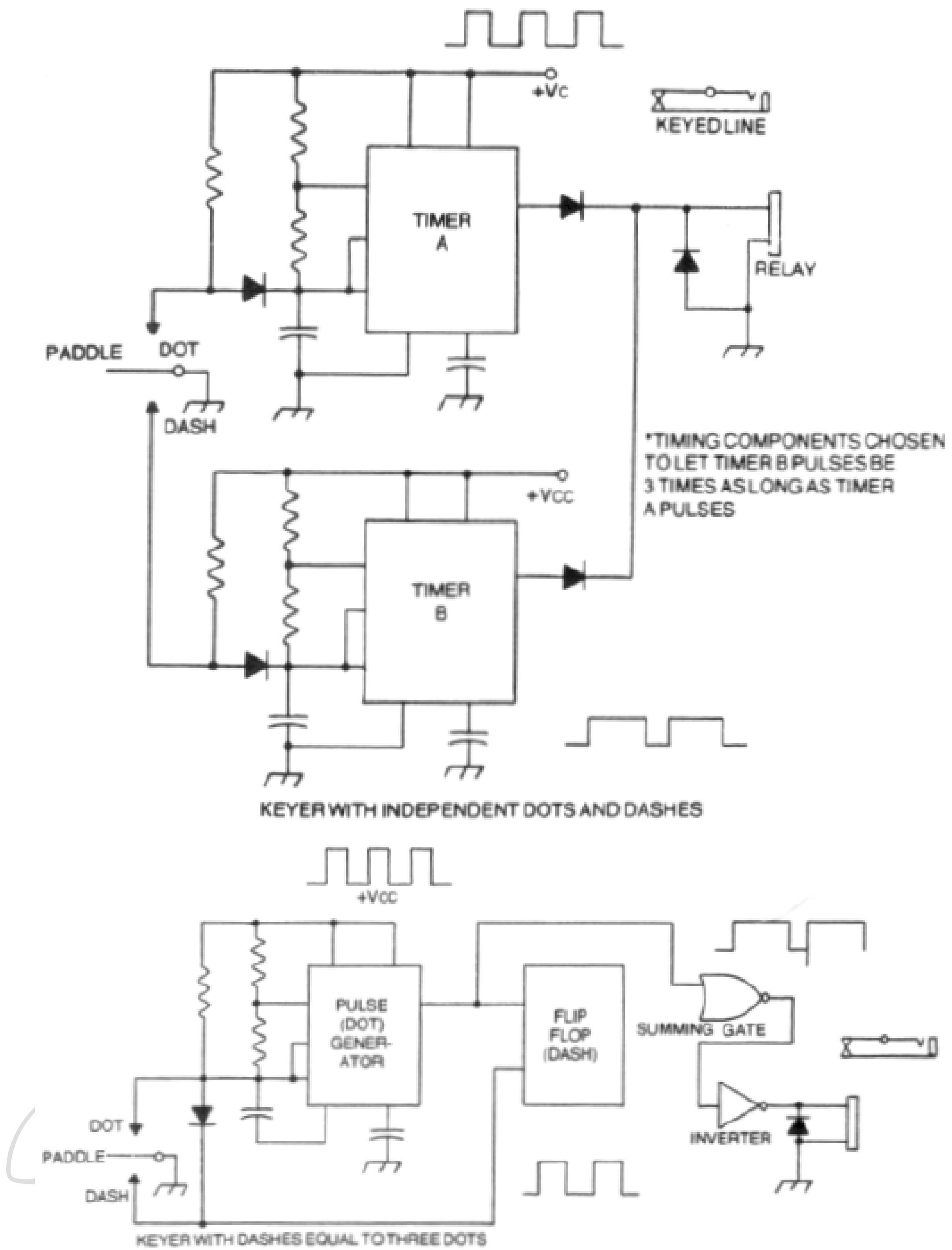


Fig. 16: Two approaches to electronic keyers

When we turn to the electronic keyer the picture changes. Keyers can be as simple or complex as we desire to make them. The basic electronic keyer consists of a means to make dots and dashes on command by the press of a paddle. Figure 16 shows two ways of going about this, one using independent pulse generators for dots and dashes, the other using a flip-flop to add to the dots for perfect dashes three times as long as the dots. Finishing out these sketches is reasonably simple.

However, simplicity is not always the hallmark of keyers, since we can also make them extremely complex. Figure 17 shows a complicated keyer having a memory and other special features. And, if paddle keyers become too tame, we can always try code typewriters. The beauty of electronic keyers as home-brew projects is that succeed or fail, we have not harmed the main rig and we have not wasted a great deal of cash. With the advent of ICs, parts are readily available. Those with a strong mechanical bent can construct paddles for the keyer. Many others buy a commercial paddle.

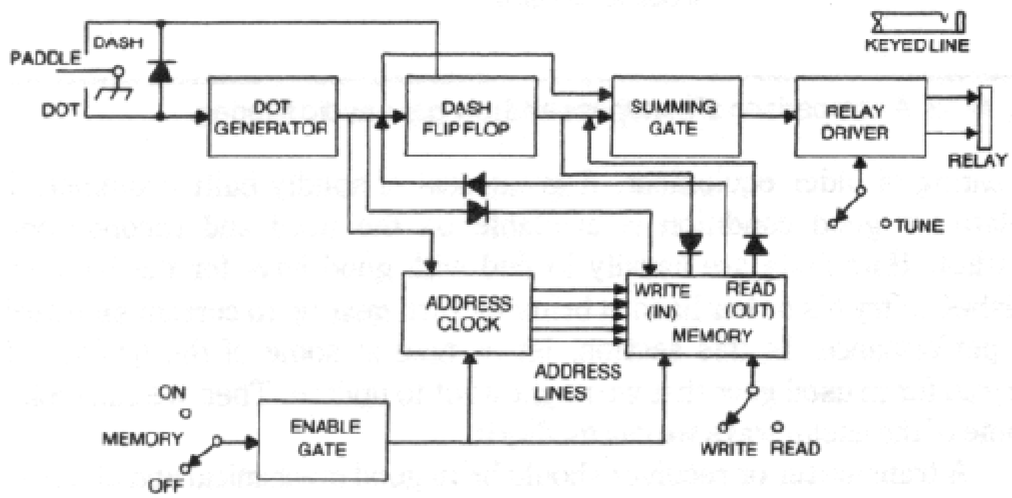


Fig. 17: Simplified block diagram of a keyer with memory

The audio filter has come to represent the same type of project for many builders. Most designs begin by taking output from the speaker and end with an audio amplifier to drive a speaker. Therefore, the current crop of AF filters requires no modifications to the main receiver. Like keyers, they are also relatively inexpensive and can be made in several degrees of complexity.

Unlike the keyer, the AF filter provides real benefits to the SSB as well as the CW fan. The filter bandwidth can be made adjustable continuously or in steps from less than 100 Hz up to a few kHz. The center frequency can be preset or made adjustable throughout the audio range. In addition to the usual band pass filtration methods, as shown in Fig. 18, we can add low pass shaping. Many SSB operators prefer this mode, since it eliminates most high frequency noises while preserving the low frequency components of the voice.

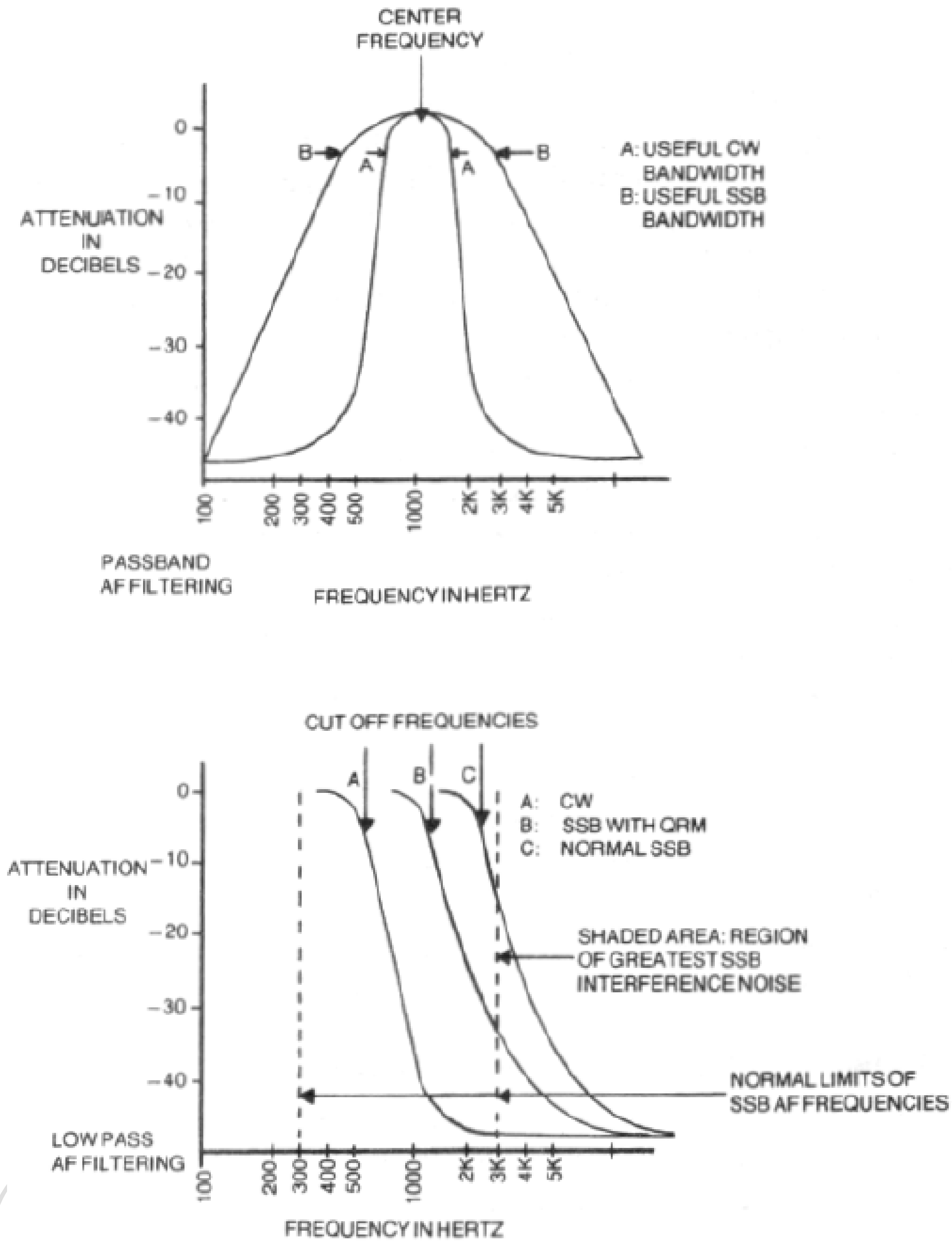


Fig. 18: A comparison of bandpass and low-pass audio filtering

A typical block diagram of an audio filter is shown in Fig. 20, and complete schematics abound in magazines and handbooks.

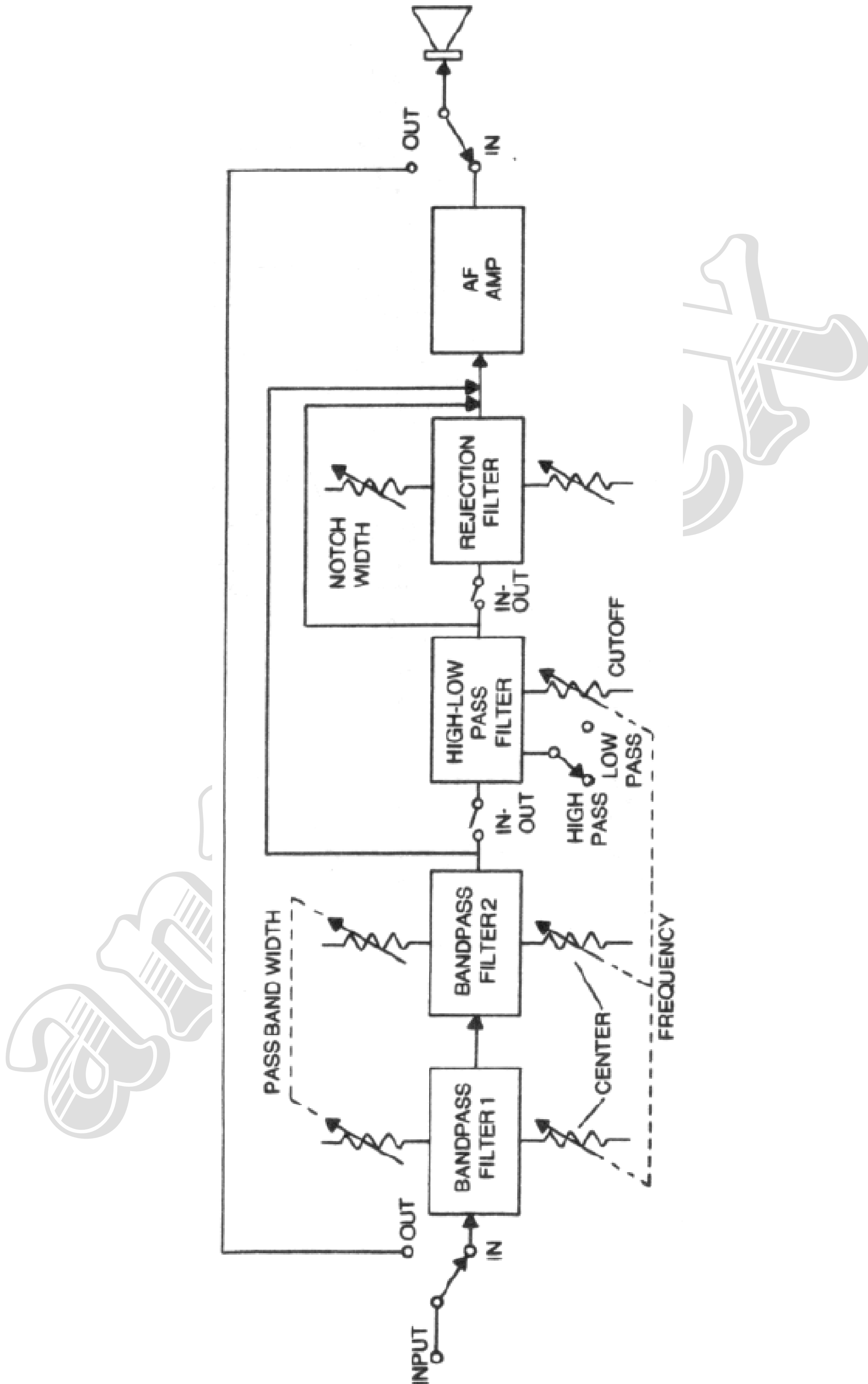


Fig. 19: Simplified block diagram of the modern op-amp audio filter

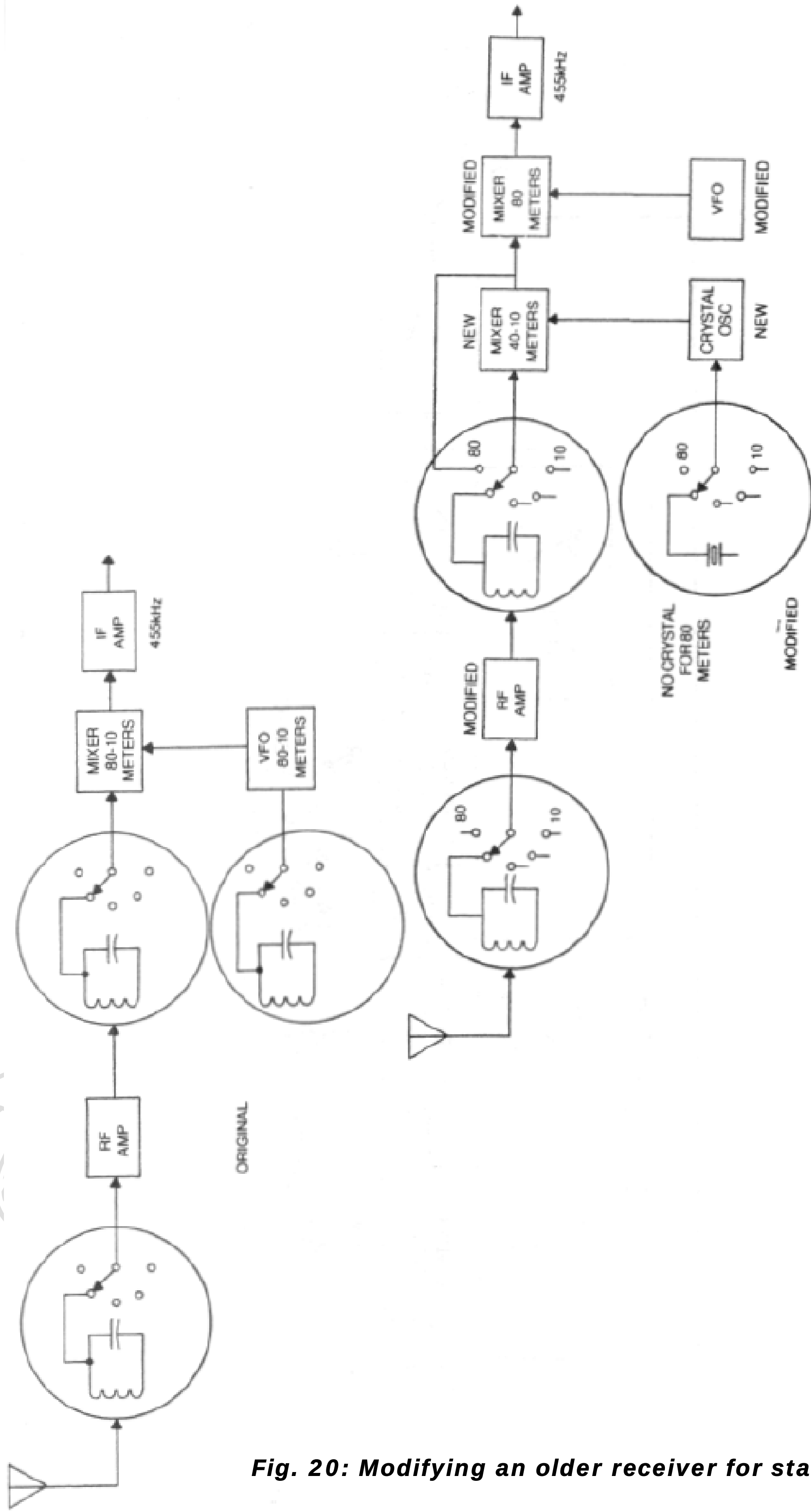


Fig. 20: Modifying an older receiver for stability

These three most popular home-brew projects illustrate a different type of construction urge than that which goes with building the entire station. The key factors, beyond the desire to build and to learn electronic design and construction, are these:

- ❑ Economics: the desire to improve the station at less than commercial costs:
- ❑ Confidence: the desire to build without threatening basic station functions;
- ❑ Simplicity: the desire to build with reasonable chances of success and minimal construction and parts procurement problems;
- ❑ Interest: the curiosity which prompts us to build just to see if we can make something work.

Although such motives as these may not make engineers of us, they are all good reasons to try our hands at design and construction.

UPDATING OLDER TRANSMITTERS AND RECEIVERS

Economics and interest, two main items from the list of building motives, can lead us to another type of building: the modification and updating of older equipment. A great deal of solidly built equipment in relatively good condition is available on the used and reconditioned market. Ham fests are usually loaded with good buys for the ham who wishes to try his or her hand at bringing such gear up to current standards of performance. In this section, let us take at some of the qualities to search for in used gear that we might want to update. Then we can look at some of the useful ways we can modify it.

A transmitter or receiver should be in good mechanical and electrical condition, unless we are only going to use the basic mechanical structure as a foundation for a completely new design. This means that the metal work should be in good physical condition, hopefully free of excessive corrosion and with the paint intact. Moving mechanical parts, such as the tuning drive assembly should work smoothly and require no more than the simplest lubrication. Major parts should be perfect. The multi-gang variable capacitor of a receiver, for example, should not be modified or damaged, since getting a replacement to fit the chassis may be impossible. In addition, unless you plan to strip the chassis, the wiring should show no signs of mildew or other organic growth.

The transmitter or receiver should work. If it is not perfect, you should know what is wrong. If the rig is electrically "shot," modification may demand rebuilding from end to end. Additionally, some older rigs use tubes. You should verify that replacements are available, unless your modification consists of replacing most of the tubes with solid state devices.

If possible, obtain at least a schematic and preferably the entire manual on the equipment. The information will make modification much simpler.

There are numerous modifications we can make to older equipment. and the following list is only a start.

For receivers, we might consider the following steps:

1. *Replace the AM detector with a product detector* (or add the product detector if there is a convenient way to switch modes): This is perhaps the most basic modification. Once a suitable circuit is chosen and built, adjustment usually consists of providing the right level of BFO injection and equalizing the output to that of the AM detector.

2. *Provide steep-sided filtration for SSB reception:* Most older methods of selectivity were suitable for CW, but distort voice frequencies when receiving SSB. Building or buying a crystal filter for the IF frequency of the receiver is a common practice. Four-pole crystal filters are not too difficult to fabricate and cost little more than the crystals themselves. While not the equal of current commercial 8-pole filters, they do a good job in conjunction with the filtering methods already in the receiver.

3. *Stabilize the tuning:* This modification may consist of a number of different modifications. If the VFO is fairly stable, cleaning up and tightening the mechanical portions of the system may suffice. Adding voltage regulation or going to solid state may help. The more drastic solutions consist of redesigning the front end of the receiver. Figure 20 shows a receiver with 455 kHz IF and a standard multiband VFO. Below is one way to modify the design for stability. The tuned circuits for 40 through 10 meters are used with a converter to bring the signal to 80 meters. Band switching is removed from the VFO, which now tunes only for 80 meters. A simpler way to achieve the same end is to use an outboard converter for all but 80 meters—the disadvantage is the need for more than one cabinet for the receiver.

In addition to these basic modifications there are numerous improvements which might be useful for some receivers. A preamplifier may be needed on 20 through 10 meters for added sensitivity. Modification of the filter system in the receiver may produce better selectivity in combination with an added crystal filter. A crystal-controlled BFO permits sideband selection, if the receiver does not have a variable BFO. Some or most of the tubes may be replaced with solid state circuits or, in a few cases, with solid state replacement "tubes." In most receivers, there will be room enough for all these modifications.

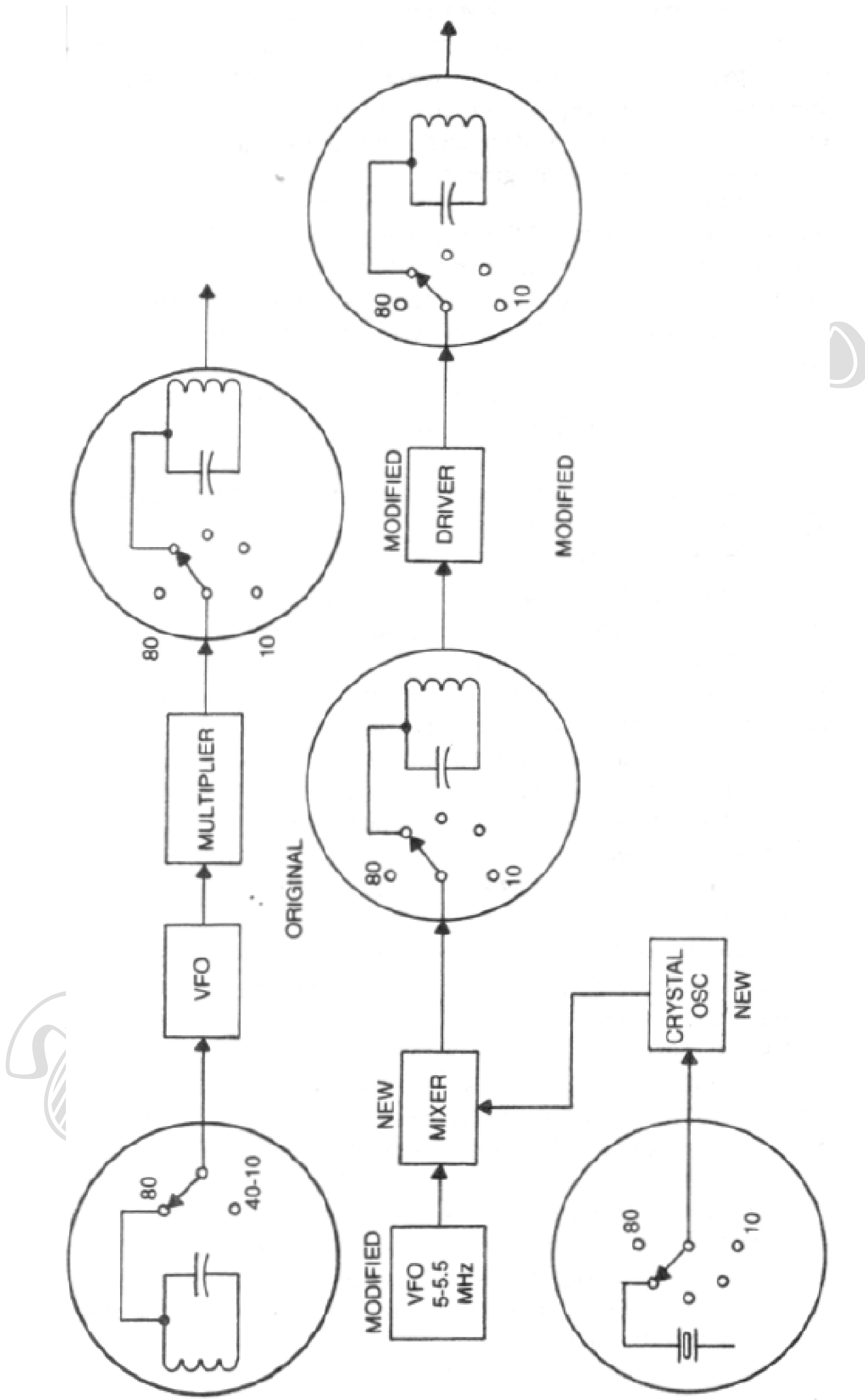


Fig. 21: Modifying an older CW-AM transmitter for stability

Transmitters provide different challenges, depending upon whether they are older SSB units or AM-CW rigs.

1. The older SSB transmitters may require addition of CW capability, which may mean the introduction of a single tone oscillator and a monitor oscillator.

2. Automatic level control (ALC), which limits drive to the final amplifier, may be required on some rigs.

3. AM-CW transmitters probably are not good choices for conversion to SSB, and for good CW performance may require frequency stabilization—simple mechanical cleaning, voltage regulation, and other first order modifications may not suffice. It may be easier to modify the VFO to a single frequency range, say 5.0 to 5.5 MHz and add a mixer and HFO to produce the ham band output Figure 21 shows such a scheme. In rigs which use a multiplier stage as the driver, you may have to neutralize the stage since it will now operate straight through on all bands. In general, since most of these rigs were designed to operate with high drive levels throughout, conversion of the lower power stages to solid state is not advisable past the VFO and HFO. Moreover, to assure stability, you may need good thermal isolation and electrical compensation of the VFO.

4. In any cathode keyed rig, we should seriously consider converting to a blocked grid system of keying to better control the keyed wave shape and to remove high voltages and currents from the key contacts.

In this article we have looked at some of the basic elements in many different kinds of home construction, seeking out the positive steps we can take and paying heed to the dangers involved. The decision to build part or all of the equipment in the shack is an important one which demands thorough evaluation. For most, the best advice may be to begin small or to begin with equipment other than the main station. When your confidence in your abilities matches your desire to try the whole station, then forge ahead.