6-METER RECEIVER

Economical Six-tube Superhet for DX, Mobile or CD Use

A receiver designed and built for a single amateur band may seem like a luxury to many amateurs, but this is not the case when the high-frequency bands are considered. Hand-switching can be accomplished on frequencies between 10 and 120 megacycles. In fact, many commercial hand-switching receivers include the six-meter band. However, inclusion of more than one set of bands and controls results in too many knobs and switches. This receiver is a compromise, and the greater the frequency coverage, the greater the complexity.

This does not mean that it is simple to design a single-band receiver. Yet it does mean that the design is simple, efficient, and somewhat universal. Usually this means a superior receiver and, strangely enough, a simpler receiver.

This six-meter receiver about to be described is simple, has low current drain, and yet has a noise figure of between 5 and 7 db. Most important of all, it is not difficult to build. The average amateur should have no trouble putting it together and making it work properly.

DESIGN CONSIDERATIONS

Basically, the idea was to get a six-meter receiver that was sensitive enough to do serious DX work, and yet be simple to build and low in cost. Since this receiver might be used for civil-defense work or mobile work, power-supply drift became a consideration.

Six miniature tubes are used, two of them twin-triods and one a twin-plate. This gives the receiver the equivalent of nine tubes. All of the popular superhet functions are included: AVC, BFO and noise limiter. In order to keep the design simple, no trick
circuits are employed. Sensitivity is achieved by the proper choice of the input circuit and r-f amplifier tubes.

The idea of double-conversion, that is, the use of two different r-f frequencies, was discarded because it would add to the complexity of the receiver. The receiver as designed could use more selectivity—most receivers can—but until the six-meter band becomes more heavily populated, the selectivity achieved in this receiver is adequate.

In order to keep the six-meter receiver independent of the a-c line, the power supply has been eliminated. For home use a separate a-c power supply can be employed, and for mobile or civil-defense use a vibrator power supply is adequate. The voltage required is not critical (25 to 36 volts) and the current drain is low (50 to 63 ma).

**MOBILE AND CP ASPECT**

It might seem strange to say that a receiver which is housed in a 10 by 7 by 4 inch cabinet is suitable for mobile work, but such is the case. Recent trends in mobile and emergency work have been to keep the transmitting and receiving equipment as an integral unit, yet one which is not mounted in any particular car.

This system has several advantages. For example, assume that the receiver, transmitter and vibrator power supply are mounted on a piece of wood which will fit comfortably on the front seat beside the driver. Two dip leads can be used for the battery connections, or a special lead can be used which will plug into the cigarette lighter socket. Alto that is needed now is an antenna (assuming a relay is used to switch the antenna from transmitter to receiver).

The antenna may be mounted on the car, or the antenna may be mounted on an insulating board which fits or clips over the glass on one of the car windows. In the latter case, the entire station is completely independent of the automobile.

Only an independent station installation of this sort can be considered to be a true emergency station. Any car which is available serves as the home for a station of this sort. Any six-volt car battery serves as a prime source of power. Thus the station can be used in an attic, in a medical center, or even in the top of a tree. A mobile rig mounted in a car can only go where a car can go, while an independent station can go anywhere that human hands can carry it.

**CIRCUIT DETAILS**

Refer to the circuit diagram, Fig. 2. The 6AK5 miniature tube serves as a pentode i-f amplifier. The input circuit is broad-band; that is, when L1 is correctly tuned, the r-f stage will operate properly over the range 50-54 megacycles. In order to maintain a low noise figure and broad-band characteristics, it is vital that the proper antenna be used. For the const-"ants shown a 50 ohm antenna is correct. A 75 ohm antenna can also be used if some change in the band-pass characteristics can be tolerated.

The 6AK5 tube feeds a 12AT7, one half of which serves as the local oscillator, and the other half acting as the mixer. Both the oscillator and mixer have tuned circuits, with C6 tuning the mixer grid and C5 tuning the oscillator grid. The oscillator section is a Colpitts oscillator. This type of circuit is used so that a col tap is not required. The r-f choke required in the cathode circuit is relatively simple to provide at this frequency. The oscillator is designed to work on the high side of the received signal, for reasons which will be discussed subsequently.
A single 4836 acts as the LF amplifier, operating at 3.5 megacycles. This is chosen through the frequency is worth discussing at this point. As previously mentioned, double conversion was discarded in the design of this receiver. The receiver must tune over a range of four megacycles. If the intermediate frequency is lower than two megacycles, images will be found in the 30-54 megacycle band. What about using an intermediate frequency of 2500 megacycles? This could be done, but it presents problems. For example, the oscillator would be on 53.5 megacycles when the receiver was tuned to 50 megacycles. The r-f section is broadband, so that any leakage of signal from the oscillator into the r-f stage would affect the tuning of the receiver and make it insensitive to 50 megacycle signals. Another problem is that of coupling the oscillator to the mixer grid. It was felt that the average ham would have some difficulty with tracking if 2.5 megacycles were to be used as the intermediate frequency. It would be possible to use ten megacycles as an intermediate frequency, but the receiver would have much less selectivity than one using five megacycles. To sum up, 5.5 megacycles was selected because the image problem, overload problem and coupling problem were minimized, and because it is possible to get reasonable selectivity and gain with only one r-f stage. The frequency of exactly 2500 megacycles has much to recommend it. For one thing, the r-f stage can be adjusted to this frequency by the use of WWV. Second, in most cases WWV does not have a sufficiently strong signal to cause interference. At least, you know what is on 5000 megacycles! In the event that this receiver is used in an area where WWV is too strong, the actual intermediate frequency may be changed plus or minus fifty megacycles without affecting the tracking.

It is possible to add a second r-f stage and achieve additional selectivity. This was not done because the advantages were outweighed by the disadvantages. Another r-f stage would be required, and the plate current for this tube, added to the current already required, would bring the total current requirements for the receiver well above the fifty milliamperes figure desired. The additional gain would not be sufficient to permit the use of only one audio stage, and if the second r-f stages were used more care would be needed to keep the I-f system adequately shielded. A bias source is used in this receiver for the noise limiting circuit. This bias is obtained by rectifying the 6.3 volt filament supply with a small germanium diode which works from either an a-c or a d-c source, so that mobile operation is possible. An explanation of this will be given later.

The use of such a bias system permits the r-f gain of the receiver to be reduced to zero (this is not true of a self-biased r-f gain system). The I-f stage uses a remote-control tube, which means that the gain of the r-f system decreases faster than the gain of the I-f system, when the r-f gain control, Re, is adjusted to progressively lower gain settings. The effect keeps the front-end from overloading. It would be desirable, from the cross-modulation standpoint, to have a remote-control tube in the r-f amplifier stage, but such a tube would give a poorer noise figure, so the sharp-cut tube is used.

One section of a 5AL5 acts as the diode section detector, and the other half acts as the diode for the noise limiter circuit. The limiter is a parallel clipper circuit whose clipping level is adjusted by means of the potentiometer, R5. The bias voltage available is

CIRCUIT CONSTANTS

References unless specified otherwise!  

C, C6, C6: 100 microfarads or greater. 

C1, C2, C3: 500,000 volt, paper or high-K ceramic. 

C1o, C11, C12: 0.01 microfarad, paper or high-K ceramic. 

C13: 50 microfarads, paper or high-K ceramic. 

C14: 500 microfarads, paper or high-K ceramic. 

C15: 1 uf, paper or high-K ceramic. 

C16: 1 uf, paper or high-K ceramic. 

C17: 1 uf, paper or high-K ceramic. 

D1, D2, D3: 1N34 or similar germanium diode. 

D4: General Radio No. 1560-A. 

D5: 1N914. 

D6: 1N914. 

D7: 1N103. 

F1: 6.3 volt filament, 115 volt, 400 ma. 

F2: 6.3 volt filament, 115 volt, 400 ma. 

F3: 6.3 volt filament, 115 volt, 400 ma. 

F4: 6.3 volt filament, 115 volt, 400 ma. 

F5: 6.3 volt filament, 115 volt, 400 ma. 

F6: 6.3 volt filament, 115 volt, 400 ma. 

J1, J2: A4S0-80 amplifier tube or equivalent. 

L1: 12 turns No. 26 enameled wire, wound on 1.5 in. diameter form. The turns are uniformly wound on the outside of the bobbin and cemented (Motorola No. 1232-A). 

L2: 1 turn No. 26 enameled wire, wound on a generous form, 1 in. diameter, uniformly wound, 8 turns per inch. 

L3: 1 turn No. 26 enameled wire, wound on a generous form, 1 in. diameter, uniformly wound, 8 turns per inch. 

L4: 1 turn No. 26 enameled wire, wound on a generous form, 1 in. diameter, uniformly wound, 8 turns per inch.
CONSTRUCTIONAL DETAILS

It is recommended that the mechanical layout shown in the photographs and sketches be followed exactly. A receiver operating on the six-meter band is capable of developing a lot of trouble unless care is taken with parts placement and lead length. The layout shown was used only after a great deal of thought had been put into getting an efficient and well-planned layout of parts.

The cabinet selected for the 6-meter receiver is shown in the "side view" drawings. It is 11 inches wide and eight inches deep. The chassis used is a standard seven by nine by two-inch chassis. In order to maintain the panel layout and yet have correct parts placement, the chassis is attached to the panel so that the top of the chassis is three inches from the top of the panel. This leaves two inches below the bottom of the chassis, on the panel, for mounting of parts, and places the main tuning dial high enough so that tuning is convenient.

The exact placement of parts is indicated by the layout sketches and the photographs. Small tubes are not indicated on the sketches, but the location of the major components is shown. The position of the main transformer is not indicated, because this will depend upon the type of variable condenser used (C3 and the type of dial used. The dial shown is a Miller No. 15519.

Inasmuch as five-microcycle 1-F transformers of the desired type are practically unobtainable, it is necessary to purchase five-cycle 1-F transformers and convert them. Practically any low-frequency 1-F transformer is such which does not have an iron-cored form. Buried-out transformers would be ideal, as long as they are of the iron-core type.

The transformers used in this receiver are Meissner "Plastic," 1-F Transformers. The transformers are 5½ inches square and 2½ inches high and are rated for frequency range from 400 to 550, and capacity of 2500 micro-µfd. They are provided with a dial for tuning and a nut for setting, any of which can be used because you are going to remove the coils anyway. The numbers of these three transformers are: 16-6658, 16-6659 and 16-6660.

Regardless of the type of transformer you procure, make certain that you do not get an iron-cored transformer. Furthermore, try to get transformers that have a coil form of ½ inch in diameter. The form is necessary in the Meissner transformers just described has a 5 inch diameter. It is necessary to reduce the radius ab to 1½ inches but this is easily done by winding the form with paper until it is the right diameter, three times if necessary, on a final layer of transparent tape. Now, follow the sketch of the winding diagram, and make up each coil with 40 turns of No. 30 silk or enamelled wire. The
sparking between coils is ½ inch, as shown, and the wire is close-wound. The 40 turns of close-wound No. 30 wire should just take up the ½ inch winding space shown. For proper connections, follow the color coding shown in the circuit diagram and that shown in Fig. 8. After the coils are wound a small amount of cement may be applied to them to hold the wire in place.

The capacitor which couples the oscillator energy into the mixer, C54, and the capacitor used for BFO injection, C64, are specified as 2 mmf ceramic condensers. It is possible to use a pair of twisted wires in place of the ceramic condensers. This might even be preferred in the case of C64, because the BFO injection can be started by means of the twisted-wire condenser until injection is optimum. Some experimentation may be needed on C64 also, although this is not as critical as C54.

The bottom view of the receiver, Fig. 3, shows that the shielded wire has been used for the leads that go to the earphone jack and to the volume control, R5. This wire connection is not shown in the top view of the receiver. A shielded wire also is used for the connections to the noise limiter switch, P5, as may be seen in the top view of the receiver, Fig. 4.

If the cabinet used has a solid back it will be necessary to drill two clearance holes in this back to pass the coaxial connector and the wire leads going to the terminal block.

TELEVISON STATION IMMUNITY

If a television station in your locality operates on channel three, you will receive an image of the sound carrier at 53.75 megacycles, but since this is outside the 6-meter band, it should not be troublesome. The video carrier, however, which is centered at 62.35 megacycles may cause a television image at 52.15 megacycles. If this is the case, you may wish to install a rejection filter in the receiver antenna circuit. The A-B-C-L Handbook gives design details on such a filter. It is not advisable to move the oscillator frequency below that of the incoming signal, because the tracking of the receiver will be seriously affected. Further, the image problem is probably more serious with the oscillator running in the range 45-49 megacycles.

COMPONENT PARTS

Practically none of the parts used in this receiver are critical. Five resistors are specified with a tolerance of ten percent, but all other parts carry a twenty-five percent tolerance. The manufacturer's name and part number are shown in the Circuit Constants list. The two resistors specified as 1500 ohms are 1500 ohms ± 25%. The pilot-needle lamp is 100 volts 1 milliamperes. This lamp is specified because it permits you to maintain short load lengths in the wiring. Further, they take up very little space.

When purchasing these new the ceramic condensers be in mind that they come in three general types:
1) those suitable for biasing applications (and some coupling applications) where the capacitance specified is a guaranteed minimum value only; 2) those suitable for general purpose use as alternates for filament condensers; and 3) those suitable for use in resonant or frequency-determining circuits. The information given under Circuit Constants should enable you to obtain the right condenser for each particular job. The capacitor type numbers given are those of the condensers actually used in the receiver pictured.

The Miller coil form specified for coils L30, L31 and L32 uses a powdered-iron slug. Brass-drawn coil form can be used, but the coils will probably require a different number of turns if this is done.

(Final Adjustments)

Terminal "B" on the terminal board supplies either an a-c or a d-c voltage to the bias rectifier. If the receiver is to be used with arc on the filament, connect the 6.3 volts a-c to terminals "P" and "Q". If a 4.5 volt battery is to be used for the filament power, terminal "B" can be connected to terminal "P" if the negative of the battery is connected to the junction of terminals "B" and "F", and the positive terminal of the battery is connected to terminal "Q".

It is essential that a negative d-c voltage be applied to terminal "B" in order that the bias rectifier will pass the direct current and supply bias for the c-f gain control and the noise limiter. If the receiver is used in a car where the negative of the battery is connected to
Receiver Noise Figures

The purpose of this article is to explain in simple language the term "noise figure" and "signal-to-noise ratio." Admittedly this is a bit of a load, but it will be attempted here because as the writer has a keen concept of what noise actually is.

There are four general types of noise, and we are concerned primarily with one type in this discussion. Basic is one type of noise. It is produced primarily by lighting devices. A second type of noise originates from our planet Earth, and is called atmospheric noise. We have here that well-known phenomenon, man-made noise, which is, in a sense, just light noise on a lower level. This noise is also called ionospheric noise which sounds like a series of machine-gun shots. The three types of noise just mentioned are interesting, and they will help us to understand receiver noise problems, but they have absolutely nothing to do with the actual receiver or any equipment that we are interested in. In fact, if it is the only one we can do anything about.

This type of noise is better called by another name, which is "thermal noise." This name describes rather accurately the cause of this type of noise, because it is due to the temperature. There are in every bit of matter, the electrons are moving back and forth, and this motion causes noise. The only way to stop this noise is to cool the electrons down to absolute zero. If this is not possible, it is very reasonable to try to reduce the noise. Thermal noise, in other words, depends upon the temperature affecting other things, and the hotter the electronics, the greater the noise.

What does this noise exactly mean for one thing? It means that, in a noise source, there is an input signal, there is the input circuit of your receiver generator noise, and there is the input tube generator noise, all of which are due to the random motion of the electrons in the electron tube or stage, or in fact, practically everything in the receiver generator noise, but generally in the receiver we have a condition where we have an antenna connected to it. Since we are connected to the antenna, and then the antenna is generating noise, what we actually measure is the noise in the antenna. So let's see what it means to signal-to-noise ratio.

The total noise is referred to as the noise figure, and it is measured as a factor for every frequency. The noise figure is measured in a unit of power. For instance, a 1 dB noise figure means that the receiver is 1 dB better than the receiver without the noise figure. The receiver with a 1 dB noise figure is 3 dB better than the receiver without the noise figure.

The noise figure is the ratio of the noise power in the output of the receiver to the noise power in the input of the receiver. The noise figure is always measured in dB. The noise figure of a receiver is the ratio of the noise power in the output of the receiver to the noise power in the input of the receiver. The noise figure of a receiver is the ratio of the noise power in the output of the receiver to the noise power in the input of the receiver.

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I wonder how many of you have had the experience of forming up a new high-frequency transmitter or receiver, only to find that they would not work! This has always been the case in a new receiver. The tunings have been set to give the best signal and the set has been tuned all the way through. The result has been more of a process of learning than of use. It is not that I insist on the band having a signal; I insist on its being usable. If you have tried that with trouble, maybe the six-meter recovery will help to solve the problem of the Ham News will break the charm for you, just as it did for me.

The first time I used my 9JL I had a relation that I had planned a 9JL calling CQ. I was excited that I used the receiver, and for the next half-hour I listened in on various six-meter openings. When I got off, after thirty minutes, the band was still active, and I was discouraged to see all the knobs and switches the receiver, I considered it a most successful evening.

The receiver worked just like the lab instruments said it would. Sensitivity seemed excellent, even when compared to another receiver of the same age, and the noise limiter had a fine workout when a neighbor drove his car in the driveway and kept the motor idling while he opened the garage doors. It must be human nature to insist on an actual listening test with a receiver, when you know the receiver has been thoroughly aligned on the bench. What appears in the Ham News are always given on the-air tests, by the way. That's a policy.

The amateurs in this area have had their share of trouble with television, but in typical ham fashion most of us have eliminated TVI and now we are using television for our own purposes. It's strictly a monkey-dog story. By carefully aligning the XYL to watch for certain disturbances in the TV picture, we can tell when the six-meter band is open. Because the XYL is usually an avid TV viewer, this works out perfectly.

In case you would like to try this system, here is how to do it: When propagation conditions are just right for a six-meter opening, it is unusual to have any bad interference. By watching the reception, you may know when the six-meter band is open. Because the XYL is an avid TV viewer, this system works perfectly. When you get ready to listen under these conditions, it makes a break for the rig, because the chances are good that six-meter is in red hot. You, without knowing that your six-meter rig must be on TVI'd—after all, you have to keep on the good side of the XYL if you want her to watch for those important bands.

One of my readers in Detroit, Glenn Ross, writes to remind me that the new Novice Class license should provide a number of operators for the civil-defense setup. This is a good thought, Glenn, and one that I'm happy to pass along. Of course, the Novice Class license includes operation on 2 to 3700 to 3770 kc. and 35,000 to 50,000 kc. and phone between 145 and 137 megacycles, but the six-meter band may work into some civil-defense setup.

In the last issue, I mentioned some facts about the Schoeneck General Electric plant, and several readers have written in to say they would like to hear more about it. With a cutie like that, I can't refuse.

For one thing, Schoeneck is the headquarters of an inter-works trucking service which does all the long-distance hauling between the eastern plants of the Company, carrying G-E mail and packages. This fleet of heavy-duty trucks plays a big part in keeping business going—in effect it makes it just as if these plants and offices were all in one spot, because it's all overnight service. In 1950 this fleet of trucks covered 1,155,791 miles.

Schoeneck is also the location of one of General Electric's eight television-switching centers. A very elaborate arrangement transfers messages between circuits by the simple operation of a push button. Everything that can be done to make the system automatic is being done, because the message load is very heavy. In an average day, the T-D television-switching network handles 15,000 telegrams, all of them concerning G-E business.

A seemingly simple operation as the mailing of dividend checks to G-E stockholders can be handled by computer on the General Electric. Among other things, this involves the signing of the dividend checks. It is no secret, in fact this is handled by a special machine; otherwise someone would be bound to get a glass arm.

—Lothorn E. Wans

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