SINGLE SIDEBAND RECEPTION
AN ADAPTER TO CONVERT A SUPERHET INTO A TRUE SINGLE SIDEBAND RECEIVER
Matterially Reduces QRM When Receiving AM, PM, CW or SSB Signals

The single-sideband adapter, shown in Fig. 1 from a rear view, when attached to a superhet receiver will permit reception of single-sideband signals. Further, this combination will receive amplitude modulated phone signals, phase modulated signals, and c-w signals in a fashion which will enable the user to reduce the qrm on any frequency by at least fifty percent.

In the case of reception of true single sideband signals with attenuated or suppressed carrier, the adapter furnishes a carrier against which the sidebands may be demodulated. By selecting the proper sideband with a switch, the modulation may be read. For reception of AM phone signals, this SSB receiver (adapter plus superhet) makes the carrier component of the phone signal, making it effectively stronger than it would otherwise have been, and thus allows reception of both sidebands, or either sideband singly. If qrm exists on one sideband, it can be avoided by receiving only the sideband on which the qrm does not exist. Where qrm exists on both sidebands, one is selected which is greatest in the least.

Phase modulated or NBFM signals may be received in the same manner as AM signals. No special detection equipment need be added to the SSB receiver.

For the reception of c-w signals, the SSB receiver furnishes the heterodyning signal so that the EBO in the superhet is not needed. True single-signal reception of c-w signals is achieved.

GENERAL PERFORMANCE
A single sideband receiver is not necessarily a "sharp" receiver, although the results obtained are usually superior to those obtainable with a receiver with strip-shaped IF curves. This means that if a signal has modulation with good audio fidelity, the SSB receiver will receive the full audio band, limited principally by the bandwidth of the IF transformers in the superhet itself. Of course it is desirable to limit the audio range, both in transmission and reception,
to narrow a range as possible, consistent with intelligibility. However, signals characteristic by variable-frequency-random, variable-frequency
and, or modulated FM will be immediately apparent. The amateur using a SSR receiver is thus able to spot distortions of these sorts on any signal.

This SSR receiver does not cut out one sideband completely, but it attenuates it by approximately 40 dB. This is the same as about 7 dB on the average receiver. Attenuation is such that signals which are no closer than 75 cycles and as far away as 5400 cycles from the carrier are attenuated at least 40 dB. However, sufficient attenuation takes place between zero and 76 cycles so that an interfering signal is practically zero level it can be elimi-
nated in most cases sufficiently well to allow the desired signal to be copied.

The SSR receiver thus allows reception of all of the usual types of signals found on the band, in- cluding single-sideband signals. The principal advan-
tage is that it allows the user to receive only one side-
band at a time so that qrm is reduced by at least 50%.

**ELECTRICAL DETAILS**

The SSR adapter described here may be switched in any one of four types of reception by switch S (see Fig. 2). Positions 1 and 2 allows reception of one sideband of any type of signal described above. This will be either the upper or lower sideband, depending on which side of the selected frequency the superhet oscillator operates. Position 3 is a locked-oscillator position. This means that the adapter is an artificial crack, or as it does also on positions 1 and 2) which augment (correct) the carrier being received. It has a providing with an strong non-

drasing carrier. The result is to reduce distortion on

Position 4 of switch S allows the receiver to function normally. The SSR adapter is not completely out of the circuit, since audio connections with the receiver require that audio be fed through the adapter. Experience has shown that position 4 is

voided sonic once the operator is familiar with the operation of a SSR receiver.

The circuit diagram, in Fig. 2, follows the principles set forth by D. B. Longford in his article "Practical Single-sideband Reception" in the July [1957].

With reference to Fig. 2, the second 687 is the oscillator which generates the artificial carrier. Its frequency is the same as that of the received IF. Coil L and condenser C5, along with the first 687 (reactance tube), are the frequency determining elements. Transformer L5 is a 90 degree phase shift circuit. The 687 tubes act as demodulators. The IF signal from the receiver is applied through the 6AK5 tube (which functions as an impedance matching device) to both 687 tubes. The output of the 687 oscillator is also coupled to these 687 tubes. A portion of the output of the upper 687 is fed back through a low-pass filter (Rs, R2, Cs, Cs) and acts on the 687 reactance tube so that automatic carrier synchronization is achieved.

The outputs from the two 687 demodulators are fed independently to two audio-frequency phase- shift networks. The upper two 657-A7T tubes with their associated components act as one network and the lower pair of 657-A2T tubes with their circuit components act as the other phase-shift network. The audio outputs of these two networks are mixed by resistors R6 and R7 to that emanate from side-

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The 6CA4 is an audio amplifier tube. The power supply circuit and the voltage regulator tube circuit are conventional. A large amount of capacitance is required because the two audio phase-shift networks must be supplied from a low impedance source of voltage.

**CONSTRUCTIONAL DETAILS**

Before starting the constructional work, it is wise to have all the necessary components on hand. Some of the required components at this point. Resistors RP through R6 are specified as 1/2 watt precision, or, with a tolerance of ±1%. These are an important part of the SSR adapter. Quantities

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of this type are available at low prices. Naturally, one watt resistors may be used if $.25 watt ones are not available. It is possible to measure regular tolerance resistors until suitable values are found. This is not advisable unless the resistors chosen are certain to hold their measured values. A better alternative is to use stable resistors and pair them. For example, RP5 and RP8 need not be exactly 480 ohms so long as they are the same value (within 40 or 50 ohms). Similarly, other pairs are RP7, RP5, RP6, RP8, RP5, RP6, RP7, RP8, RP5, and RP6.

Resistors RB, through RB4 are listed separately because it is desirable for them to be very stable although their exact value is not important as long as they hold their value. Precision resistors are usually stable types, and for this reason they are recommended although not required. Ordinary resistors are suitable, although the performance of the unit may suffer if their resistors change value with time.

Condensers CA, through CA4 are shown as single condensers, but except for CA4, they are all multiple units. For example, CA3 is listed as a 125-500 microfarad adjustable condenser. This was made up by paralleling a 0.002 mf cond and a 15微法 muf cond at each end.

Each of these specified condensers consists of a 150-200 muf unit with one condensers. CA5 is simply a 105-500 muf trimmer. The objective sought here is to permit adjustment of the RC products (RR7 times CA7, RB times CA6, etc.) to the proper values. This will be covered more thoroughly under "Tune-up Adjustments."

A Miller IF transformer is specified for LA. Other types will undoubtedly work, although difficulty may be experienced in obtaining the correct coupling between the primary and the secondary windings. Generally speaking, high stability air tuned IF transformers of the proper frequency are suitable. Switch SB is specified as a shorting type switch in order to provide smooth switching action.

Inductance LA should be approximately 0.15 millirem, for use with receivers having 450-470 kc IF amplifiers. This value of inductance was obtained from a 4 piez 3.5 microh, by removing 3 of the pies, then taking 3 more off the remaining pie. The particular choke used was a Miller No. 3405.

The lead is supposed to be on a .050 inch chassis and uses a .83 inch relay rack panel. The GA69 probe (Fig. 3 and 4) is built into a 2-1/4 inch diameter by 4 inch long shield can (Miller No. 86000). It is assumed that the layout as shown in Fig. 1 indicates the general placement of parts, and Fig. 7 shows the actual layout of the chassis. For the lead from the GA69, with the layout of the chassis, referring to Fig. 1, is drilled for the two nuts used to mount the chassis on the back of the cabinet. Fig. 3 is drilled with four holes for the on-off switch, oscillator tuning control, control switch (S), and the pilot light. All holes are in a center line 1/2 inch up from the bottom of the panel, and the side dimensions are three inches and four inches, respectively, in from either side of the panel.

The under-chassis view (Fig. 4) clearly shows the layout of parts. Note the shield which encloses the wiring for the two 68J7 and two 68M tubes. In order to better balance the layout in this shield compartment, the IF transformer could be moved toward the 68J7 oscillator tube.

It is necessary to make a small change in the IF transformer, assuming that the Miller No. 645J6 is used. The blue lead should be considered from the terminal post on the end of the coil form (which is a tap on the 68M) and soldered instead to the stator of the primary tuning condenser. Also, the 24 muf padding condenser across the primary coil should be removed.

The tune-up process will be simplified if a small piece of tape is used to solder the eight cathode connections of the four 68J7-6Q tubes. This wire should be soldered to the cathode lead and arranged so that a clip lead may be attached to it. The 68M tubes use all the 6.3 volt tubes except the 6A6S which is wired to the 6.3 volt winding on the power transformer.

The 6A6S tube is mounted in the probe chassis. The mounting plate is made of aluminum to fit the shield can. See Figs. 3 and 4. The coaxial lead which comes out the rear of this can connects to the receiver by means of a coaxial connector. The two filament leads and the coaxial line to the receiver are brought out the side of the can.

TUNE-UP ADJUSTMENTS

When the SSB adapter has been completed, it is necessary to check the alignment carefully. In particular, the amount of attenuation obtainable on either sideband depends upon how well these adjustments are made.

Connect the adapter to the receiver in the following manner. The connection with the GA69 tubes should be placed as close as possible to the last IF transformer in the receiver. The load marked "receiver IF" should be soldered to the "hot" end of the secondary winding for the IF transformer. The load wire should be the lead from this point going to the second detector. The shielding brass on the coaxial cable should be stripped back only as far as necessary and then attached to ground (receiver chassis). The 6.3 volt filament leads should be wired into a 6.3 volt a-c source in the receiver.

If the IF alignment of the receiver is questionable, it is possible to slightly adjust the primary coupling to the stator of factor's directions. In any event, it is necessary to adjust the tuning of the secondary of the last IF transformer to compensate for the addition of the 6A6S stage.
The other two connections are those marked "audio in" and "audio out." The audio connection to the input of the first audio amplifier must be opened. If the receiver has a photo input jack which accomplishes this, the two leads may be connected at this point. The "audio in" lead should be connected to the receiver connection which carries the voltage from the second detector tube, and the "audio out" lead should be connected so that the audio signals on this lead is fed to the remainder of the audio system of the receiver. It is important to note that because the adapter may be connected to a wide variety of receivers.

Turn on the receiver and the adapter. Allow both units to reach operating temperature. Turn off the aec on the receiver and set the adapter switch S to position 0 (normal). Turn a to a static signal, such as a 400 Kc broadcast station. Adjust Ra and the receiver control until an adequate volume level is obtained. Change S to position 3. Adjust condenser C1, which tunes the oscillator, until a beat note is heard. Adjust for zero beat. If no beat is heard, the oscillator is either not oscillating or is not able to reach the correct frequency. With the constants shown, the oscillator will operate in the 450 kc to 465 kc IF range. For higher or lower frequencies it may be necessary to change La and C6.

Next, detune the receiver slightly so that a beat note is audible. Set the rf gain on the receiver to ensure that no overloading is taking place. Adjust condenser C8 until this beat note is as loud as possible. If the receiver does not use a 430-465 kc IF, it may be necessary to change L2, C4, and C5 in order to achieve resonance.

Turn the receiver to a low frequency beat note, being sure not to hold a low-frequency beat note that is audible, that the rf gain control should be reduced. Insert a 0.250 volt voltmeter (approximation), adjust the tuning condenser in the primary of L1 for a maximum reading of this meter. This adjustment probably will cause the oscillator to change frequency, but the IF section will change frequency. If so, adjust C1 to get the original low-frequency beat note again after adjusting the tuning condenser. After adjusting the tuning condenser, readjust if necessary.

Remove the meter and repeat for another point between R10 and ground in the exact way. Adjust the tuning of the secondary of L8 for maximum meter reading. If the beat note changes, adjust C2 as before.

The IF transformer L9 is now tuned approximately to the receiver IF. It is next necessary to adjust the coupling of this transformer. The approximate small signal voltages are fed to the two Leads. This condition is satisfied when the voltages fall from "a" to ground and "s." to ground are equal. (These voltages are those that were measured with the 0.1 millimeter.) It may be desirable to connect a closed circuit jack between Ra and ground and R5 and ground. Inserting a 0.1 mill. dc meter in the jack between R5 and ground reads voltage "s" and between R4 and ground reads voltage "a". Normally "a" will be greater than "s".itating that there is not sufficient coupling between the primary and the secondary. If the coupling is too low, the coil gain of the Miller 4H transformer with a soldering iron, through the lead held in the coil opening, the coil, and the bottom coil can be pushed slightly toward the top coil. After this adjustment, rotate C8 to obtain the low-frequency beat note if this note changes frequency.

Next measure voltages "a" and "s" by plugging the 0.1 millimeter into the two temporary jacks. Voltage "s" should increase as the coupling is increased. Several adjustments should be required as this process should be taken in easy steps to avoid too much coupling. Each time the coupling is ad-justed the oscillator frequency should be adjusted to reach the low frequency beat with the signal in the receiver. Also the primary and secondary tuning condensers should be checked for proper tuning by adjustment of a peak reading of the 0.4 mill. dc meter. (Peak the primary and read correct in R10 and peak the secondary by reading current in R10.)

When voltages "a" and "s" are within 0.1 per cent of one another the coupling adjustment may be considered complete. These voltages should normally be between about 100 volts half-scale on the 0.1 millimeter. The next step is to determine that transformer L1, is at 90 degrees phase-shift. An oscil-lator is required for this and the following adjust-ments. The horizontal and vertical amplifiers in the scope are set to a low frequency, so it is necessary to check for this condition.

Connect the "high lead" inputs of the horizontal and vertical amplifiers of the scope to pin 1 of the first 6SN7GT (tube pin 1). The ground connections of the scope should be tied to the chassis of the 6SN7GT. A scope with an auxiliary horizontal sweep with approximately 600 cycles is obtained as seen in the receiver IF section when a signal is applied. Adjust the coupling of the secondary of L1 to cause uniformity of the scope until a straight line at 45 degree angle is obtained when a small signal is applied. Adjust the coupling of the secondary of L1 until a straight line at 45 degree angle is obtained. If the phase shift is not 90 degrees, the trace will be a circle instead of an ellipse.

In order to connect this phase shift insert a 50,000 ohm potentiometer in the "high lead" of either the horizontal or vertical input at the scope. Adjust this potentiometer until the line becomes a solid line. If this is not performed, the trace drifts to the other "high lead." It should now be possible to adjust the resistance to 45 degree angle on the scope.

Next, remove one scope lead from pin 1 and connect it to point J in the cathode of another first 6SN7GT tube in the lower network. Do not remove the potentiometer or do not change the gain con-trol on the scope.

Changing receiver tuning to get a beat note of approximately 100 cycles. A circle should now appear on the scope when the receiver is tuned. The scope may now be checked, but it should resemble a circle. Adjust the condenser in the secondary of L1 until a clear circle is obtained. If the best adjustment does not give a perfect circle it is possible that horizontal or vertical coupling should be adjusted to give equal horizontal and vertical lines. This may be checked by a drift compensation test as shown in the receiver manual and readjust the 50,000 ohm potentiometer if necessary. Now repeat 5
the check for the circle by adjustment of the secondary tuning of L2. Detune the receiver to provide a 6600 cycle beat note. The circle may change size but it should hold its shape reasonably well. If not, the fault will probably lie in one or more of C1, C2, C3, C4, C5, C6, or resistors R4, R8, R9, R10, R11. Ideally C1 and C2 should be the same value, that is, equal in capacitance. Allen, C3 and C5 should be equal, and C4 and C6 should be equal. Further, R7 and R10 should be equal, R8 and R9 equal, and R1 and R2 should be equal. It may be necessary to measure them in order to point them in the way which makes them as close to equal values as possible.

The fine-drift adjustment concerns the two audio frequency phase shift networks. In addition to the scope, an audio oscillator is required. This oscillator should be as good an instrument as can be obtained, since accurate calibration and good waveforms are required in order to permit adjustment of the audio-frequency phase shift networks for optimum performance. This audio oscillator is required to generate the ten audio frequencies shown in the circuit diagram (Fig. 2).

If the available oscillator is not accurately calibrated, it is not too difficult to calibrate it for the six frequencies involved. This can be done by means of a piano, if the piano is in tune. Using the proper key on the piano it is possible to produce a frequency which may be used as a calibration point, or in some cases as a sub-multiple of a required calibration. Of course, any other calibration means which is accurate may also be used.

When the oscillator is ready for use, turn on the adapter and remove both 6806 tubes and set I6 to position 1. Usually the receiver need not be turned on. Connect the audio oscillator output to pin 8 of the 6806 tube. The red lead on the audio oscillator output going to the adapter channel. Connect the green lead of the audio oscillator output to jack J. Set the audio oscillator at 10,846 cycles and adjust its output to approximately one volt.

The scope tube should now show a line at a 45° degree angle, or the gain controls should be adjusted.
so that it does. If the line is thin and not split the phase compensation is correct. If not, adjust the 50,000 ohm potentiometer which should still be in series with one scope lead, as explained before. Next, move one lead from point J to point K. A square which resembles a circle should now appear on the scope. Adjust the variable condenser CA3 until a perfect circle is obtained. If this is not possible, then neither the correct RC product (CA3 times RS) is outside the range of adjustments as the gain controls on the scope are set in the wrong position. As before, adjust the gain controls so that equal horizontal and vertical deflection is obtained. Then, check phase compensation again. This must always be done whenever the gain controls are adjusted. If the RC product is wrong change CA3, RS, or both in order to obtain the required values.

The next five steps are repetitions of the above as follows. Remove the scope lead from J and place it on K. Adjust the oscillator to 140 cycles. The chaging adjustment to get a single line, if it is required, may call for a condenser in series with one of the scope leads, as in the 50,000 ohm condenser. Turn values between 0.001 and 0.1 mF. When phase compensation is correct, move one lead from K and place it on P. Adjust CA3 until a perfect circle is obtained.

Next, move the lead that is on K to point P. Adjust oscillator frequency to 947 cycles. Check for phase compensation by getting a straight line as before. Move one of the leads on P to point Q. Adjust CA3 until a perfect circle is obtained. This completes the upper network adjustment.

The oscillator output so that it connects to pin 8 of the lower 555 is in the circuit diagram. Connect both scope leads to pin 8 and set the audio oscillator to 2170 cycles. Check for phase compensation as before, using either capacitor or resistor as required. Move one lead from 8 and place it on P. Adjust CA3 until a perfect circle is obtained.

Change the oscillator to 35 cycles and move the lead from 8 to 7. Check for phase compensation. Move one lead from 7 to point J. Adjust RQ and CA3 until a perfect circle is obtained. Usually adjustment of RQ alone is all that is required, but if a perfect circle cannot be obtained, try adjusting CA3 again with RQ. Repeat until you get a perfect circle.

Change oscillator frequency to 2170 cycles and move the lead from 7 to point J. Check for phase compensation. Move one lead from 1 to point J. Adjust RQ, CA3, and CA2. Repeat with RQ and CA2. Then, repeat the above steps until all four frequencies are correct.

The adjustment of the networks, and the balancing adjustments of RQ and R1 are next. Set the grid of the RF tube, replace the 555 tube in the adapter and allow the receiver to reach operating temperature. Set RQ and R1 to approximate mid-position. Connect the vertical input to the scope to the "blackout" lead. Set the horizontal plates to 500 cycles per volt and sweep frequency to 100 cycles. Look for any frequency complications on the scope. After the 1000 cycle sweep is completed, look for any frequency changes on the scope. The frequency is now adjusted to 1000 cycles. This completes the setup of the SS 20 adapter.

Finally, check the receiver through zero beat, to the opposite side of the signal until a 1000 cycle heterodyne note is obtained. Change switch SK to the other of the two sidetones positions. Then adjust the other poten- tiometer (which was not touched before) for a mini- mum, checking both by the scope and by ear.

Two more adjustments must now be made before the SS 20 receiver is really ready for use. Disconnect the scope. With SK in position 3, tune in a station. Be sure the loop signal is small. Return to position 4. If the audio level changed, adjust RQ until no change in audio level is noted when going from position 3 to 4 or vice versa. (When in position 1 or 2 receiving AM fidelity the audio level will be lower by 6 db than the level observed in positions 3 and 4. This is normal.)

Lastly, tune in a signal zero beat in position 3 of SK. Make sure the unit is at operating temperature. Reduce r-f gain as far as practicable. Switch to position 4, wait five seconds and switch to position 3. If a sidetone frequency is heard as the oscillator is pulling in, RQ needs adjustment. Make a slight adjustment, return to position 4, wait five seconds, then switch to 3. If the frequency change is less con- tinue the adjustment process in this direction until no change of frequency is heard. If the frequency change was worse, adjust RQ in the other direction and follow the above steps until no frequency change is heard.

The SS 20 adapter is now completely aligned and set up for operation. It is possible to check some of the receiver circuits at some future date some of the previous steps in this adjustment. However, the parts of the circuit which will have to be set for the new 1F of the receiver and transmitter may have changed. The values of RQ, R1, R2, and R3 will probably need readjustment. It is advisable to be familiar with the settings of RQ, R1, R2, and R3 in the manner previously described. The chart of audio phase shift settings should not require any re-adjustment at any time unless the component values have changed. This might be a good place to mention that the adjustments which have been described may seem very complicated, but they are much easier to perform than to describe in writing.

Fig. 7. Layout Guide for SS 20 Adapter
USE OF THE SSB RECEIVER

A person using a SSB receiver for the first time will be in a position very similar to that of a young child taking his first steps. That is to say, the child does not know how to walk until he has learned, and since a SSB receiver will not be able to use the SSB receiver to full advantage until he has had some experience with it. (And he is due for as big a thrill as the child gets—Editor's note.) However, there are some basic rules to keep in mind. The smaller the r-f input, that is to say, the more the r-f gain can be turned down and still have a readable signal, the more certain one will be of obtaining maximum unwanted-sideband rejection. Always use the receiver with the set off.

When the SSB receiver is used for the reception of c-w signals, it is not necessary to use the receiver LFO, as the necessary beat note is supplied by the oscillator in the adapter. Of course, since switch S4 is in position 4 the BFO is used as usual with the receiver. Tuning is usually done in the locked oscillator position when the receiver is first in use, although with experience a c-w man will develop his own tuning patterns. For example, if the receiver is set to reject the high frequency sideband, and tuning is done from a low to a high frequency, then signals are not heard (unless they are very strong) until you have passed them frequency-wise.

For AM reception, the oscillator in the adapter will produce a heterodyne when tuning across phone signals, when in position 1, 2, or 3. This heterodyne disappears when the received signal is tuned to zero beat. It thus acts as a signal locator and is a real tuning aid.

For phase-modulated signals and narrow-band FM signals reception is carried out in positions 1 or 2, assuming that the frequency swing is not excessive. It is not necessary to tune to one side of the signal to receive it. It might be well to emphasize that reception of PM and FM signals requires only the SSB adapter and a regular superhet—no special limiting device or FM adapter is necessary, or desirable, on the receiver. Merely tune in the signal to zero beat to position 3, and switch to either sideband (position 1 or 2) for reception.

Reception of single-sideband signals is obviously possible, whatever the signal is transmitting a carrier or not. If a carrier is transmitted the SSB receiver will lock on to the carrier of sufficient amplitude. If this is not true, it is only necessary to ensure that the receiver is kept properly tuned. After tuning in the signal, make certain that you listen on the sideband being transmitted.

Finally, the receiver LFO is not used, but that he switches back and forth between positions 1 and 2 rather often, during a QSO, whenever necessary to dodge QRM which comes up. (Unless he is listening to a single-sideband signal.) In this connection, the adapter must be adjusted to whatever interference is heard may also be further reduced by means of the crystal filter, assuming that the supertet has such a device.

For best results, the receiver to which this adapter is connected and the signals which are tuned, should have reasonably good frequency stability. The more perfect the receiver, the better the results will be.

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