

Fig. 1—SSB-5 Transceiver; only five controls are needed for complete operation.



SSB TRANSCEIVER FOR FIXED OR MOBILE APPLICATIONS

This compact, inexpensive transceiver realizes many of the advantages of SSB transmission. Use of the RCA 7360 beam-deflection tube simplifies design and maintenance by replacing the three tubes usually required to generate the basic SSB signal. For mobile operation, a pretuned antenna may be selected to match the frequency range, thus eliminating bulky antenna tuning units.

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TABLE I—SSB vs. AM TRANSMISSION^{4,5}

Advantages	Disadvantages
Up to 9 db power savings; i.e., a 125-watt SSB unit can replace a 1000-watt AM system.	The SSB transmission must justify its use in terms of cost factors and economics in operation, if existing users of radio communications are to change from AM operation. This transition requires compatibility between AM and SSB operation. Standardization of SSB technique is required.
Primary power cost is less.	The SSB receiver must have suitable demodulating carrier with highly stable frequency control of transmitter and receiver.
Transmission line and antenna costs can be reduced because peak voltages are less.	The r-f parts of an SSB transmitter generally cause a moderate increase in the number of components, stages and vacuum tubes over that of an AM transmitter of comparable power rating.
Cost of transmitter buildings is lower, since less floor space is required and weight is lower.	The SSB operation requires critically designed sideband separation filter, either crystal or mechanical. High-performance filter results in minimum bandwidth.
Total radiated power may be reduced to accomplish a given communication function.	
Higher efficiency of sideband power generation.	
High-power SSB suppressed carrier transmission equipment compares favorably to similar high-power AM equipment.	
Conservation of frequency spectrum because only $\frac{1}{2}$ the bandwidth of an AM system is required.	
Narrow bandwidth results in improved signal-to-noise ratio.	
Man-made interference is minimized.	

DURING THE PAST few years the trend in the radio communications field has been toward increased use of single-sideband (SSB) transmission and reception.¹⁻³ Although some disadvantages do exist, the many advantages of SSB operation far outweigh them, as may be seen in Table I. The RCA Radiomarine SSB-5 Transceiver is an application of SSB transmission; many of the advantages shown in Table I are included in the design, the obvious one being its small size. Table II lists detailed specifications. The SSB-5 Transceiver, which may be used in either a mobile or fixed station, has a transmitter output power of 125 watts and a receiver output of 4.5 watts. Use of either of two external power supplies allows for mobile or fixed station operation. As depicted in Fig. 1, the Transceiver requires only five front-panel controls.

The *channel selector* permits selection of any one of four available channels. Channels 1 and 2 cover the frequencies of 3 to 6.7 Mc, while channels 3 and 4 allow operation at frequencies between 6.7 and 15 Mc. This same control also provides channel switching information for possible use of a remote antenna tuner or other auxiliary equipment. The *sideband selector* switches from upper or lower sideband, with or without full carrier. The *trim* control is a "fine" frequency adjustment (described below in more detail). Receiver *volume*, power *off*, and *transmitter gain* comprise the remaining front-panel controls.

Fig. 1 also illustrates one means of attaching the carbon microphone. Antennas for mobile operation consist of separate pre-tuned helical whips, approximately 8 feet long for each operating frequency. For fixed station operation, a single antenna may be used for up to four channels by employing an external antenna tuner; again, separate antennas may be used for each output frequency.

TRANSMITTER CIRCUITRY

The transmitter of the SSB-5 Transceiver is comprised of only seven tubes (Fig. 2): a microphone amplifier, an audio amplifier, two RCA 7360 tubes used in balanced modulators, an r-f amplifier, a driver, and two power amplifier tubes in parallel.

The first balanced modulator is a combination modulator-oscillator (Fig. 4). The oscillator circuit generates a 1400-kc signal which is heterodyned with the audio signal applied to one of the deflection electrodes. A capacitor diode in the oscillator circuit is varied by adjusting the *trim* control on the front panel. This capacitance variation, of one

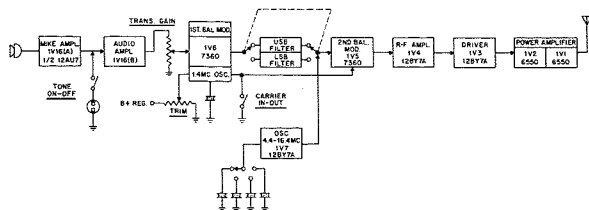


Fig. 2—Simplified block diagram of the SSB-5 transmitter.

of the oscillator circuits constants, will vary the crystal frequency over a frequency range of $1400 \text{ kc} \pm 75$ cycles. This frequency variation permits compensation for slight frequency differences that may exist in a circuit with other stations. The output of the first balanced modulator consists of the sum and difference frequencies of 1400 kc and the audio or modulating frequency. The 1400-kc carrier is balanced out in the RCA 7360 plate circuit.

USE OF RCA 7360 SIMPLIFIES DESIGN

Use of the RCA 7360 tubes in the balanced modulator circuits has greatly simplified the design and reduced the cost and the maintenance problem.

Normally, up to three tubes are required to generate the basic SSB signal. The RCA-7360 beam-deflection tube is so constructed that it performs the required function of these three tubes thus conserving valuable space and components.

The RCA 7360 is a dual controlled beam-deflection tube having a cathode, control grid, screen grid, two deflection electrodes and two output plates.

The design features provide balanced, push-pull output from a single-ended input, improved performance, and simple circuits when used as a balanced modulator. Long-term stability is achieved because the electron flow to each plate is derived from a single beam of electrons. High transconductance, high deflection sensitivity, and low interelectrode capacitance are features.

When used as a balanced modulator (Fig. 5), it provides a carrier suppression of 60 db or more, with third-order distortion of at least -47 db . The total

beam current is controlled by the bias on the control and screen grids. When balanced, the gain between the control grid and each plate will be equal. The total beam current will remain constant but the division of beam current between the two plates is controlled by the potential difference between the deflection electrodes. When the plate current in one plate circuit is decreased, the plate current in the other plate circuit is increased. Therefore, if there is an a-c current in one plate circuit, there will be an equal a-c current in the other plate circuit, but of the opposite phase. This provides a balanced push-pull output from a single-ended input.

The sideband filters are switched into the output of the first balance modulator to select the sideband to be transmitted (Fig. 2). These crystal-lattice filters require no adjustment and operate in the 1400-kc range.

Operation of the second balance modulator is similar to the first balance modulator, i.e., it also uses a 7360 and heterodynes the "single-sideband" signal developed at the filter output, with a suitable "channel-oscillator" signal to produce a signal at the desired r-f output frequency. This signal is then amplified in two amplifier stages (1V4 and 1V3).

The power amplifier consists of two type 6550 tubes in parallel and a π -type plate circuit; it operates in class AB-1. This results in a linear amplifier with 125-watt-PEP output and an over-all third-order distortion of better than -35 db below the level of either tone of a two-tone test signal.

RECEIVER CIRCUITRY

For SSB reception, the receiver design

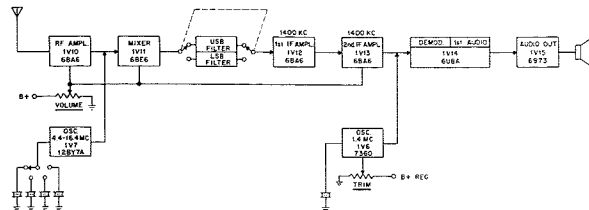


Fig. 3—Simplified block diagram of the SSB-5 receiver.

principles are conventional (Fig. 3) although as shown in Table I and below, frequency control is of great importance. The main difference from an AM receiver is the selection of either the upper or lower sideband (selectivity) and the reinsertion of the carrier at the proper level and point for demodulation. Stability is also a prime consideration. Drift and difference in frequency should not be more than 30 cycles.

The SSB signal is applied through the proper antenna coils to the r-f amplifier (1V10), from where it is coupled through another set of r-f coils to the grid of 1V11 to be combined with the local oscillator frequency for an intermediate frequency output of 1400 kc . This i-f frequency is then applied to either of the highly selective upper- or lower-sideband crystal filters. These filters are fixed-tuned to reject the unwanted sideband (when present) and any extraneous signals. (Refer to Fig. 6 for selectivity characteristics). To keep the cost of this equipment to a minimum, only one set of filters is required for the transmitter and receiver through the use of a simple coupling and isolating arrangement common to both.

The i-f signal (1400 kc) after passing through the sideband filter, is amplified and applied to the demodulator along with the carrier reinsertion frequency of 1400 kc (1V6) for demodulation. The 1400-kc oscillator is also common to the transmitter for proper generation of the transmitted sideband signal. The trim control is used for compensating or slight frequency differences of the received signal (other transmitter) should they exist. The demodulated signal is

Fig. 4—First balanced modulator, a combination modulator and oscillator.

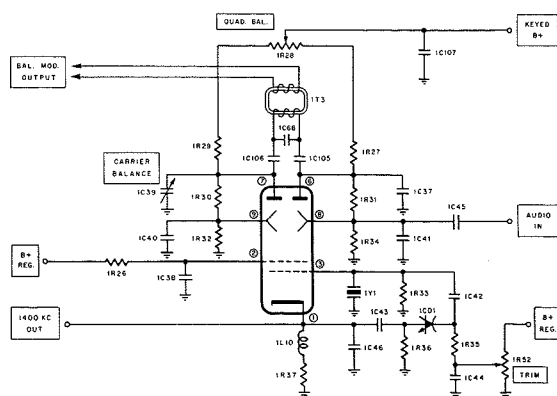
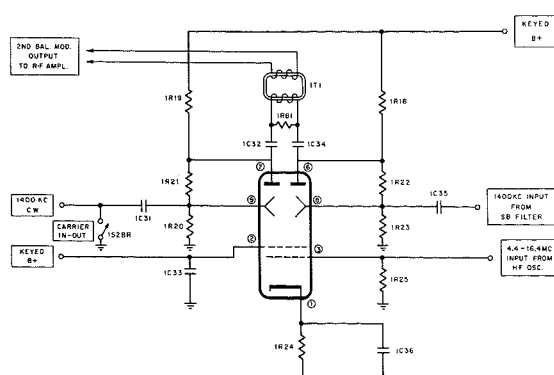


Fig. 5—Balanced push-pull output circuit provided from a single-ended or unbalanced input.



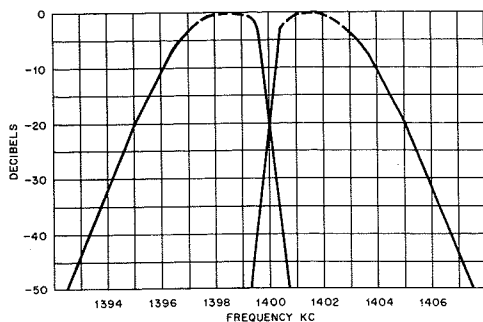


Fig. 6—Highly selective upper or lower sideband crystal filters reject extraneous or unwanted sideband signals. The above curves show the receiver's sharp selectivity characteristic.

next amplified to the proper level to drive the audio output tube to a maximum of 4.5-watt output.

All oscillators in the SSB-5 are crystal controlled and common to both receiver and transmitter to conserve space. Volume is adjusted by manually varying the bias on the r-f stage, mixer, and first i-f amplifier. To keep the cost at a minimum, conserve space, and simplify operation, it was decided not to include an agc system. Adequate frequency stability is realized by the use of precision channel crystals, maintained at a constant oven-controlled temperature.

ANTENNA SYSTEMS

The π -network output circuit of the SSB-5 Transceiver will match an antenna impedance of 10 to 80 ohms resistive. For fixed station operation, a single antenna may be used for up to four channels through the use of an external antenna tuner, such as the RCA type AAT-100. Separate matched transmission line antennas or separate quarter-wavelength antennas may be used for each channel.

In mobile operation, separate pre-tuned helical whip antennas are used which are approximately 8 feet long. A series of fifteen antennas are available

to cover the range of frequencies and slight trimming will put an antenna on the exact operating frequency within its range. This results in greater efficiency of operation and eliminates the need for bulky antenna tuning units.

POWER SUPPLIES

The power supply for fixed station operation is connected to a 115-230-volt, 50-60-cycle power line. All rectifiers are of the silicon diode type, thus providing instant voltages when the power is applied. Available output voltages are -100, +300, +800 and 12.6 volts.

For mobile operation, the input power is obtained from the vehicle's 12-volt d-c system. Four germanium power transistors are employed in a conventional over-driven push-pull transformer-coupled oscillator. The input power terminal board provides simple connections to permit operation from either a positive or negative grounded source of 12 volts d-c. A relay is provided in the transistor circuit to permit reduced source current in the receive position, thus conserving battery power. (Receive or transmit is controlled by the push-to-talk button on the microphone.) By-passing and decoupling reduces the "birdies" commonly generated in this type of supply.

Careful transformer design further reduced the usual audible whistle (1500 cycles) to a negligible value. The efficiency is approximately 80 percent under full load. The type of rectifiers and the available output voltages are identical to those for the d-c power supply. If desired, this power supply may also be used for a fixed installation.

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Radiomarine Engineering, for the basic specifications and helpful suggestions.

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CHARLES E. SCHNEIDER joined the Radiomarine Corporation in March, 1941, to work in radio and radar receiver and transmitter test and development. He graduated from the RCA Institutes in 1941 and the Capital Radio Engineering Institute in 1951. From 1943 to 1946 Mr. Schneider served in the U. S. Air Force as Communications Officer in the Pacific Theater, and from 1951 to 1952 as Communications Officer in Korea. After his release from active duty in 1952 he entered the RCA Transmitter Division and designed marine radio telephone and telegraph transmitters. His primary interest in the past few years has been single-sideband transmission, co-designing the SSB-1, designing the SSB-30M, SSB-1 Mark IIA, and co-designing the ET-8063, ET-8063A and SSB-5. Mr. Schneider is now Systems Engineer of the Radiomarine Engineering group, Broadcast and Communications Products Division.

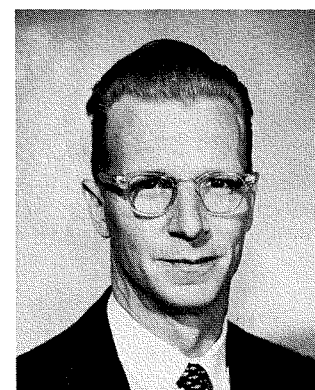


TABLE II—Specifications, SSB-5 Transceiver

Designed around RCA 7360 dual-controlled beam deflection tube; common revr-xmtr circuitry in oscillators, sideband filters, crystals and ovens, switches, and controls.
 Xmtr-revr: 16 lbs, 7½ x 12½ x 13 inches; 16 tubes, 8 diodes.
 115-230 pwr sply: 23 lbs, 6½ x 5¼ x 13½ inches; 9 diodes.
 12v-dc pwr sply: 8 lbs, 7½ x 11 x 7½ inches; 10 diodes, 4 transistors.
 Channels 1 & 2.....3.0-6.7 Mc
 Channels 3 & 4.....6.7-15.0 Mc
 Antenna Impedance ..10-80 ohms
 Crystals, four CR-27/U; channel crystals 1400 kc higher than desired operating frequency; same crystal serves xmtr and revr.
 Freq. stability±0.0002%
 Emission A3J sss suppressed carrier; A3H sss with full carrier

TRANSMITTER:
 Power output 125 watts PEP
 Transmitted sideband, upper or lower; selectable sideband output available if both upper and lower sideband filters are installed
 Unwanted sideband suppression 50 db
 Carrier suppression ...50 db
 Audio fidelity±3 db, 400-2900 cps

Speech clipping 12 db
 Distortion products ...35 db below either tone of two-tone test signal at PEP output

RECEIVER:
 Sensitivity Better than 1 µv for 50-mw output with 10-db signal-to-noise/noise
 Selectivity 2.5-kc nom. bandwidth for 3-db attenuation
 7.5-kc bandwidth for 40-db attenuation

Audio output 4.5 watts max in ldspr
 Audio fidelity±3 db, 400-2900 cps
 Audio distortion 2.5% (1 kc at 50-mw output)

POWER:
 115-230 v, 60 c, single-phase power-supply line supply:
 Power load, revr only...135 watts
 Power load, xmtr & revr:
 no sig, pwr on 160 watts
 avg voice modulation 290 watts
 12-v-dc power supply (battery):
 Drain, revr only 12 amps
 Drain, revr & xmtr:
 no sig, pwr on 17 amps
 avg voice modulation 25 amps