CHAPTER 4

THE TRANSMIT AND RECEIVE SUBSYSTEMS

The following chapter describes the operating principles of typical transmitters and receivers. The equipments described are only representative of the types that the CTM is most likely to encounter.

TRANSMIT SUBSYSTEM

The transmit subsystem consists of the carrier systems (discussed in Chapter 5), transmitters, and transmitting antennas which are used to transmit the processed information or data to the cognizant activities or commands. Although Radiomen or Electronics Technicians usually control and maintain the transmitting equipments, you are required to be familiar with the operation and maintenance of this subsystem because in some instances you may be required to operate or perform maintenance on the equipments which comprise the transmit subsystem. A basic knowledge of this subsystem will also give you an insight into the overall operation of the Naval Security Group Electronics System, and enhance your ability to perform systems analysis.

TRANSMITTERS

As stated above, you will not normally be required to maintain transmitters. However, it is important that you know how transmitters relate to the remainder of the electronics system. The following is a brief description of the transmitter and its relationship to the transmit subsystem.

Oscillator

The oscillator is the basic frequency determining element of the transmitter. It is here that the RF signal is generated. If the oscillator fails to function, no RF signals will be produced.

Frequently, the oscillator operates on a submultiple of the transmitter output frequency. When this occurs, a process called frequency multiplication is used to increase the transmitter frequency as desired. This action is particularly desirable when the output frequency is so high that stable oscillations are difficult to obtain.

Present-day transmitters may contain several oscillators to perform various functions. In general, only one of these is used to generate the basic transmitter radiofrequency. This oscillator is usually called the master oscillator (MO) to distinguish it from any other oscillator circuit in the transmitter.

Transmitters capable of transmitting over a wide frequency range normally have the total frequency coverage divided into separate bands. In this arrangement, components that will produce the desired frequency in the oscillator (and other stages as necessary) are selected by means of a band switch.

Buffer-Frequency Multiplier

The buffer stage is situated between the oscillator and subsequent stages to isolate the oscillator from load reflections. When the transmitter is keyed, the associated changes in the condition of the transmitter stages may cause undesired voltage or current reflections. If permitted to reach the oscillator, the reflections would cause the oscillator frequency to change.

As stated previously, the oscillator may be operated at a submultiple of the transmitter output frequency. With this mode of operation, the buffer stage usually performs the additional function of frequency multiplication in all but single-sideband equipment.

Power Amplifier

The power amplifier (PA) is simply another RF amplifier used to greatly increase the magnitude of the RF current and voltage. The output from the PA, the final stage of amplification in the transmitter, is fed to the antenna via RF transformers and transmission lines.

Power Supply

Transmitters require negative and postive d.c. voltages ranging from minus to plus thousands of volts. Additionally, they need a.c. voltages at smaller values than those available from the normal power source. The power supply functions to furnish these voltages at the necessary current ratings. Usually, this is accomplished through transformer-rectifier-filter action, with normal power as the source of supply.

MODULATION

Modulation is the process of varying some characteristic of a periodic wave with an external signal. In voice communications, this means that the carrier frequency will be varied at the voice or audio rate. The voice frequencies 15 - 3,000 Hz are contained in the audio frequency spectrum 15 - 20,000 Hz. In naval communications, the terms "voice communications" and "audio communications" are sometimes used interchangeably. The audio signal is impressed upon the radio frequency carrier because it is impractical to transmit frequencies in the audio range. This is due in part to the excessive wavelength. As an example, the wavelength at 3,000 Hz is 10,000,000 cm. The physical size of circuit components at these frequencies is too large to be practical.

There are three characteristics of the carrier wave that may be varied at an external signal rate; amplitude, frequency, and phase.

Amplitude Modulation

Amplitude modulation (AM) is the process of combining audiofrequency and radiofrequency signals in a manner which causes the amplitude of the radiofrequency waves to vary at an audiofrequency rate. The speech amplifier, driver, and modulator stages provide the voltage and power amplification required in the modulation process.

Assume that the modulating audio signal is of constant frequency (e.g., 1 kHz tone). The audio voltage is fed into the RF power amplifier stage so that it alternately adds to, and subtracts from, the d.c. plate supply voltage in the amplifier. An increase in voltage in the PA increases the RF power output. Conversely, a decrease in voltage decreases the RF power. The presence of the audio voltage in series with the supply voltage causes the overall amplitude of the RF signal to increase gradually during the time of audio voltage increase (from 1 to 2 on the waveforms of figure 4-1). A decrease in RF signal amplitude also occurs during the time the audio output is decreasing (From 2 to 3 on the waveforms of figure 4-1). These RF signal amplitude changes in turn govern the instantaneous levels of the electromagnetic field radiated from the antenna.

Variations in RF power output similar to the compression and rarefaction of sound occur throughout each audio cycle. The waveform at the antenna thus contains three major frequencies: (1) the carrier frequency, (2) the carrier frequency plus the audiofrequency (sum frequency), and (3) the carrier frequency minus the audiofrequency (difference frequency). The sum frequency is called the upper sideband; the difference frequency, the lower sideband. The sideband frequencies are always related to the carrier frequency by the sum and difference of the modulation frequency.

The relationship of the carrier, audio, and sideband frequencies is illustrated in figure 4-2. Assume that the carrier frequency is 1000 kHz and that the audio-modulating frequency is a single 1 kHz tone. Each of the sidebands is displaced 1000 hertz from the carrier frequency. The lower sideband is 1,000,000 hertz - 1000 hertz = 999,000 hertz (or 999 kHz). The upper

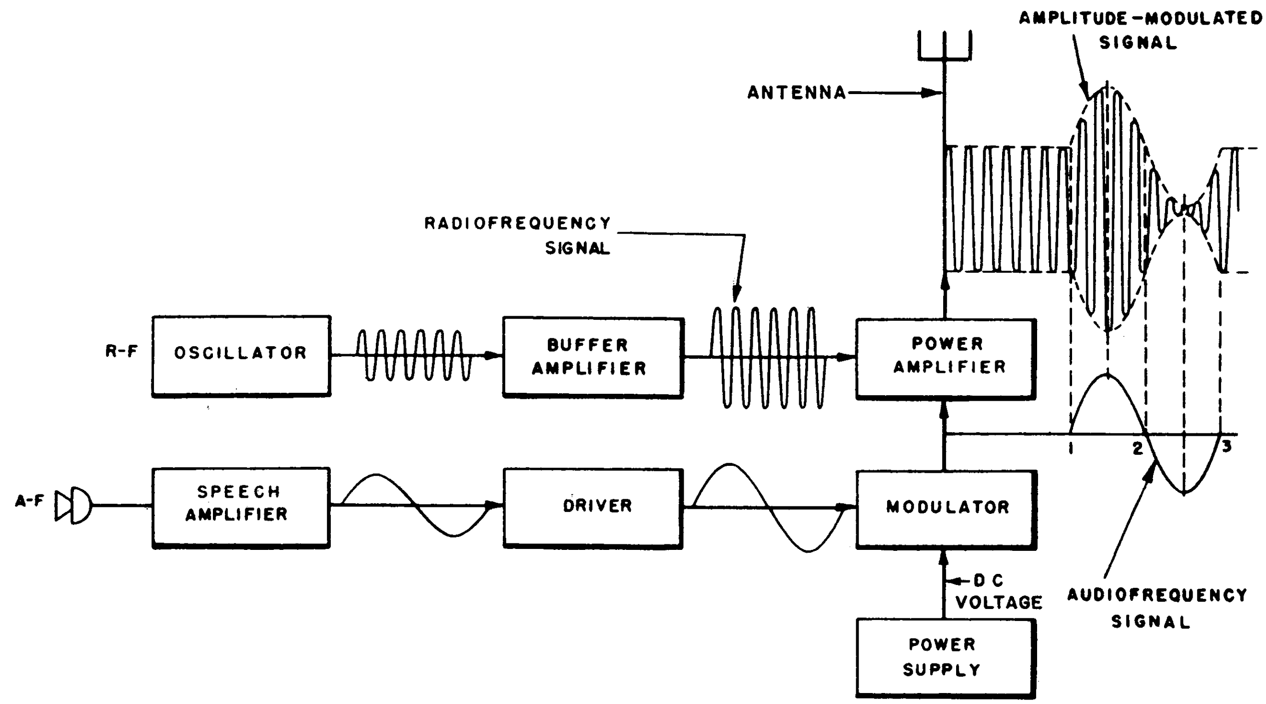

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Figure 4-1.–An AM Radiotelephone Transmitter.

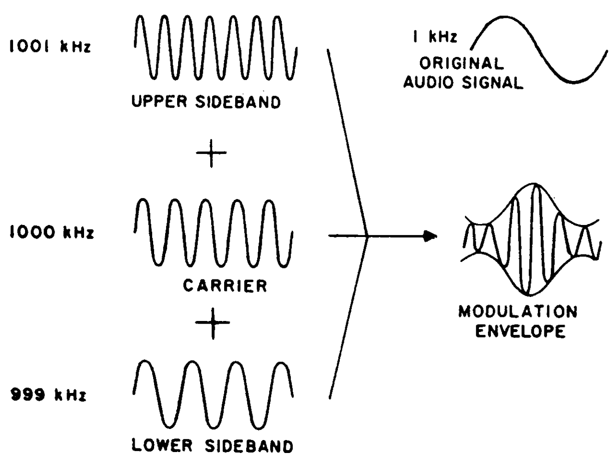

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Figure 4-2.–Formation of the Modulation Envelope.

sideband is 1,000,000 hertz + 1000 hertz = 1,001,000 Hz(or 1001 kHz).

Note that the amplitude of each of the three frequencies is constant when considered alone. But, because these frequencies appear simultaneously at the output, they add to form one composite envelope (single). This envelope is in the shape of the output waveform shown in figure 4-2.

During modulation, the peak voltages and currents of the RF power amplifier stage are greater than values that occur when the stage is not modulated. To prevent damage to the equipment, a transmitter, designed to transmit both CW and radiotelephone signals, is provided with controls that reduce the power output for radiotelephone operation.

FREQUENCY AND PHASE MODULATION

Frequency modulation (FM) is the process of combining audio and carrier signals in a manner which causes the frequency of the carrier waves to vary at an audio rate while the amplitude of the carrier waves remains essentially constant. The carrier frequency can be varied a small amount on either side of its average or assigned frequency by means of the audio frequency (AF) modulating signal.

The relationship between the audio modulating signal and the FM signal is shown in figure 4-3. The horizontal axis represents a linear time base, and the vertical axis represents relative amplitude. During T_0 in figure 4-3A, there is no audio modulation and the FM signal is at the carrier or rest frequency. As the audio modulating signal goes in the positive direction during T_1, it causes a change in the FM signal. The amplitude of the audio modulating signal determines the amount of change (increase) in the frequency of the FM signal. The greater the audio signal amplitude (i.e. louder the sound in voice modulation), the greater the increase in frequency of the FM signal. To show this, the audio signal in figure 4-3A, is increased in amplitude to form the audio signal shown in figure 4-3B. A comparison of the FM signals in figures 4-3A and 4-3B shows a discernable change in frequency of the FM signal.

During T_2 in figure 4-3A, the audio signal passes through zero amplitude, and the FM signal returns to the carrier frequency (rest frequency). At T_3 the audio signal swings in the negative direction, causing a change (decrease) in the FM carrier frequency. Again the amplitude of the audio signal determines the amount of change in the FM signal frequency (i.e., the louder the sound in voice modulation, the greater the change in frequency of the FM signal).

If figure 4-3, this relationship is shown with a time base reference. Since time is inversely proportional to frequency ($T = \frac{1}{f}$); time for a complete cycle is decreased as frequency is increased. For example, at T_0 in figure 4-3A, the FM signal is at the carrier frequency and the time for a complete cycle (point A to point B) is a certain amount of time. During T_1 the amplitude of the audio signal increases, causing the frequency of the FM signal to increase and the time (point C to point D) of a complete cycle to decrease when compared to time AB. At time T_3 the amplitude of the audio signal is decreased, causing the frequency of the FM signal to decrease and the time for a complete cycle (point E to point F) to increase when compared to time AB. In other words, the FM signal is compressed during T_1 and rarefied during T_3.

The time required for a complete audio cycle is represented by points G and H along the time axis in figure 4-3B. When the frequency of the audio signal is doubled, as shown by points G and H along the time axis of figure 4-3C, a comparison of the modulated signals of figures 4-3B and 4-3C shows that the shift from compression to rarefaction is correspondingly reduced in time. Thus the rate at which variations in the assigned carrier, or resting, frequency occur, has increased.

It may now be stated that the amount of variation from the carrier frequency depends on the magnitude of the modulating signal and the rate of variations in carrier frequency depends on the frequency of the modulating signal.

Frequency modulation and phase modulation (PM) are essentially the same. The difference lies in the physical method of accomplishing the frequency shift in the transmitter. Botn FM and PM can be received on FM receivers, and both are commonly referred to as FM.

A block diagram of a representative FM transmitter, in which frequency modulation is accomplished by a phase-shift system, is shown in figure 4-4. The transmitter oscillator is maintained at a constant frequency by means of a quartz crystal. This constant-frequency signal passes through an amplifier that increases the amplitude of the RF subcarrier. The audio signal is applied to this carrier in phase-shift network in such a manner as to cause the frequency of the carrier to shift according to the variations of the audio signal. The FM output of the phase-shift network is fed into a series of frequency multipliers that raise the signal to the desired output frequency. Then the signal is amplified in the power amplifier and coupled to the antenna for radiation.

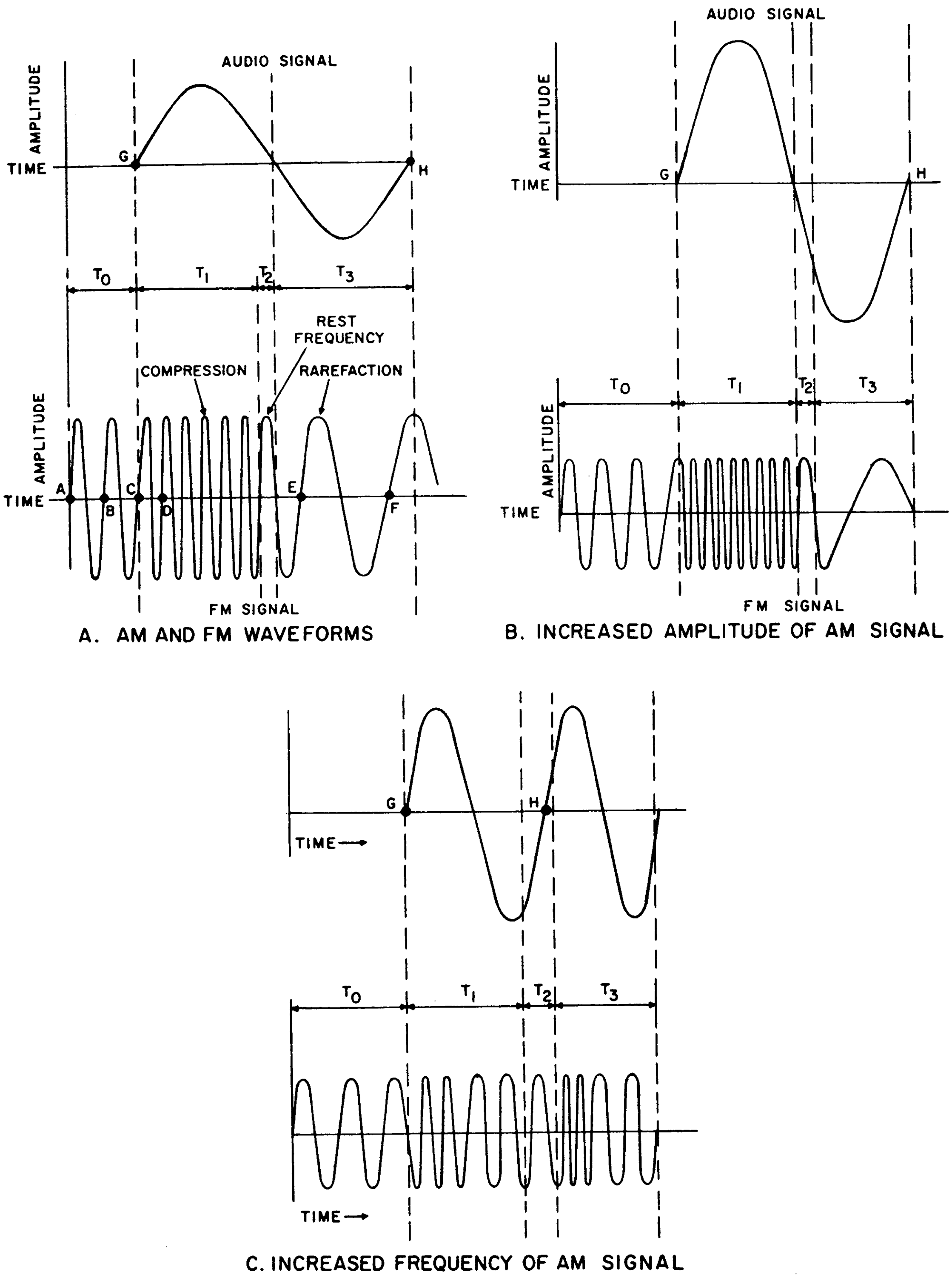

Figure 4-3.–FM Waveform Compared to an AM Signal.

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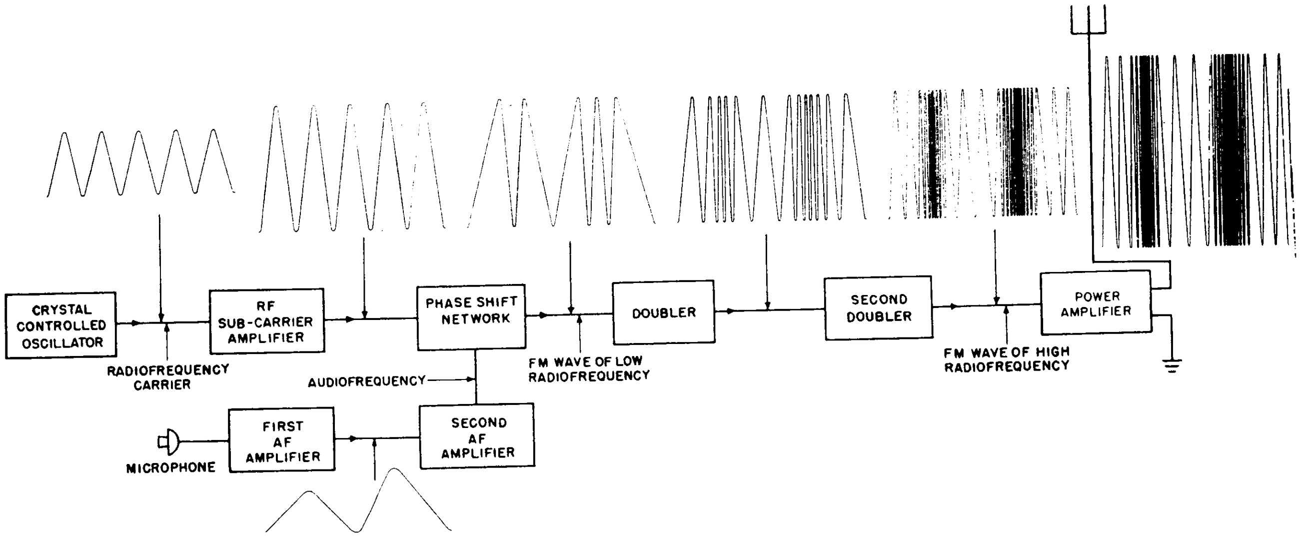

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Figure 4-4.—Block Diagram of an FM Transmitter and Waveforms.

TRANSMITTING ANTENNAS

Transmitters and transmitting antennas must be properly matched to each other to ensure maximum RF signal output with a minimum RF loss. This match is imperative in order to obtain optimum performance during all transmissions.

As such, the transmitting antenna's parameters and physical characteristics are much more critical than that of a receiving antenna, as discussed in chapter 3.

Transmitting antennas are also under the cognizance of the radiomen who operate the transmit system's equipment.

After the signal is processed by the transmitter, it is passed to the antenna distribution panel where it is switched or patched to the required antenna for transmission.

THE RECEIVE SUBSYSTEM

The Receive Subsystem consists of many different types of receiving equipment. The following section reviews the basic theory and operation of radio receivers and describes several representative types.

RADIO RECEIVERS

A radio receiver processes signals received by its antenna and delivers, as an output, a reproduction of the original signal that modulated the RF carrier at the transmitter. The signal can then be applied to some reproducing device such as a loudspeaker or a terminal device such as a teletypewriter. Actual receivers vary widely in complexity. Some are very simple, others contain a relatively large number of complex circuits.

Whatever its degree of sophistication, a receiver must perform certain basic functions in order to be useful. These functions, in order of their performance, are: reception, selection, detection, and reproduction.

Reception occurs when a transmitted electromagnetic wave passes through the receiver antenna in such a manner as to induce a voltage in the antenna.

Selection is the ability to select a particular station's frequency from all other frequencies appearing at the receiver's antenna. Detection is the action of separating the low (audio) frequency intelligence from the high (radio) frequency carrier and is accomplished in a detector circuit.

Reproduction is the action of converting the electrical signals to sound waves which can then be interpreted by the ear as speech, music, etc.

RECEIVER CHARACTERISTICS

Receiver characteristic measurements are useful in determining operational conditions and as an aid for comparison to other units. Important receiver characteristics are sensitivity, selectivity, fidelity, and noise.

The ability of a receiver to reproduce very weak signals is a function of the receiver's sensitivity. The weaker a signal that can be applied to a receiver and still produce a certain value of signal output, the better that receiver's sensitivity rating. Sensitivity of a receiver is measured under standardized conditions and is expressed in terms of the signal voltage, usually in microvolts, that must be applied to the antenna input terminals to give an established level of the output. The output may be an a.c. or d.c. voltage measured at the detector output or a power measurement at the loudspeaker or headphone terminals.

All receivers generate a certain amount of noise which must be taken into account. Noise is a limiting factor on the minimum usable signal that the receiver can process and still deliver a usable output. Therefore, the measurement is made by determining the amplitude of the signal at the receiver input required to give a signal-plus-noise output at a predetermined ratio above the static noise output of the receiver.

Selectivity is the degree of distinction made by the receiver between the desired signal and unwanted signals. The better the receiver's ability to exclude unwanted signals, the better its selectivity. The degree of selection is determined by the sharpness of resonance to which the frequency determining circuits have been engineered and tuned. Measurement of selectivity is usually by a series of sensitivity readings in which the input signal is stepped along a band of frequencies above and below resonance of the receivers circuit (e.g. 100 kHz below to 100 kHz above tuned frequency). As the frequency to which the receiver is tuned is approached, the input level required to maintain a given output level will fall. As the frequency is passed, the required input level will rise. Input voltage levels are then plotted against frequency. The steepness of the curve at the tuned frequency indicates the selectivity of the receiver.

The fidelity of a receiver is its ability to accurately reproduce, in its output, the signal that appears at its input. In general, the broader the band passed by frequency selection circuits, the greater the fidelity. It may be measured by modulating an input frequency with a series of audio frequencies; then plotting the output measurements at each step against the audio input frequencies. The resulting curve will show the limits of reproduction.

It may be remembered that good selectivity requires that a receiver pass a narrow frequency band. Good fidelity, on the other hand, requires that the receiver pass a broader band in order to amplify the outermost frequencies of the sidebands. Therefore, receivers in general use are a compromise between good selectivity and high fidelity.

SUPERHETERODYNE (AM) RECEIVER

The superheterodyne receiver is pre-tuned to one fixed frequency, called the intermediate frequency (IF).

The intermediate frequency is obtained through the principle of frequency conversion by heterodyning a signal generated in a local oscillator of the receiver with the incoming signal in a mixer stage. Thus, an incoming signal is converted to the fixed intermediate frequency, and the IF amplifier operates with uniform selectivity and sensitivity over the entire tuning range of the receiver.

A block diagram of a representative superheterodyne receiver is shown in figure 4-5. Although not illustrated, a superheterodyne receiver may have more than one frequency converting stage and as many amplifiers as needed to obtain the desired power output.

Heterodyning

The intermediate frequency is developed by a process called heterodyning. This action takes place in the mixer stage, which is sometimes

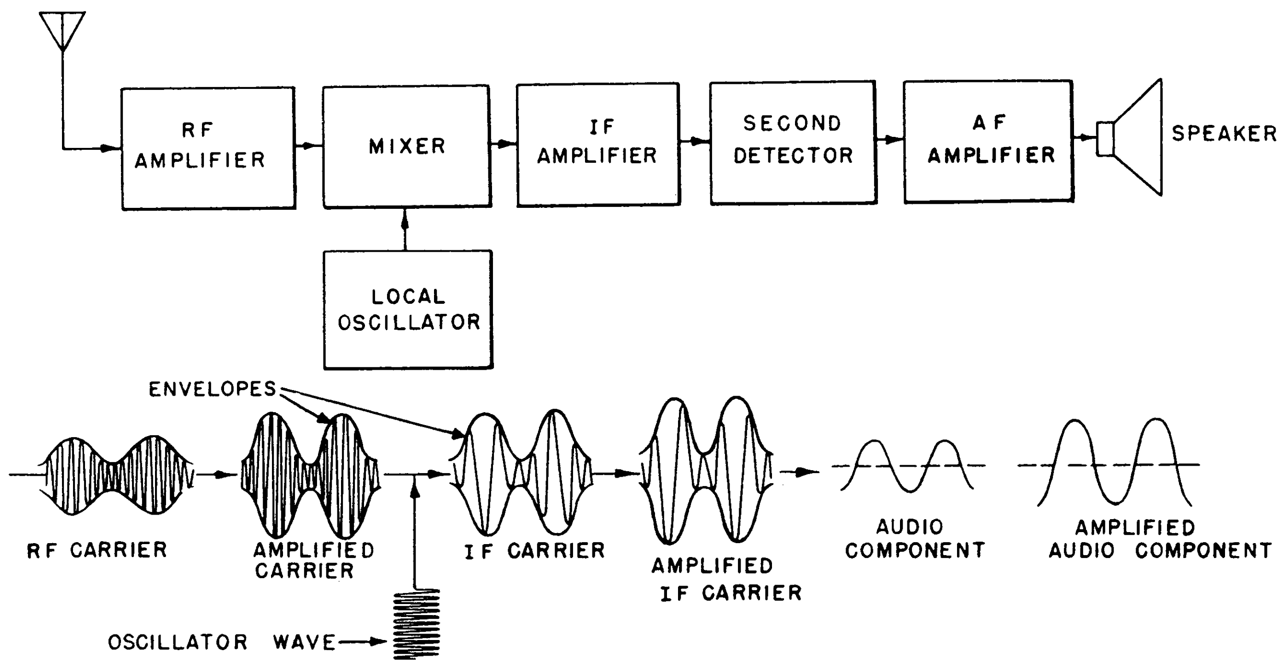

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Figure 4-5.—Block diagram of an AM superheterodyne receiver and waveforms.

called a converter or first detector depending upon how the heterodyning action is viewed. It may be described as combining (mixing) the incoming signal with the local oscillator signal; changing (converting) the input signal from its RF carrier frequency to an intermediate frequency (IF); or extracting (detecting) the intermediate frequency from the combined frequencies. In any case, the incoming signal from the RF amplifier is combined in the mixer stage with a locally generated, unmodulated RF signal of constant amplitude from the local oscillator.

The local oscillator is set to track with the tuning of the incoming signal so that it produces a frequency greater or less than the frequency of the incoming signal by the exact amount of the fixed IF frequency. By combining (heterodyning) the incoming signal and locally produced signal in the mixer stage, four frequencies appear at the mixer output. They are: (1) the incoming RF signal, (2) the local oscillator signal, (3) the sum of the incoming RF signal and the local oscillator signal and (4) the difference in these frequencies. Although the sum frequency is present, it is the difference frequency to which the IF amplifier is tuned. A typical intermediate frequency for communication receivers is 455kHz.

Detection

Once the IF stages have amplified the intermediate frequency to a sufficient level, it is fed to the detector (or second detector when considering the mixer as first detector) to extract the modulating audio signal. The detector stage consists of a rectifying device and filter which respond only to the amplitude variations of the IF signal to develop an output voltage varying at an audio frequency rate. The output from the detector is further amplified in the audio amplifier and used to drive a speaker or earphones.

SUPERHETERODYNE (FM) RECEIVER

The function of a frequency modulated (FM) receiver is the same as an AM superheterodyne receiver. There are certain important differences in component construction and circuit design however, because of differences in the modulating technique. The comparison of block diagrams (figures 4-5 and 4-6) shows that in both AM and FM receivers, the amplitude of the incoming signal is increased in the RF stages. The mixer combines the incoming RF with the local oscillator RF signals to produce the intermediate frequency which is then amplified by one or more IF amplifier stages. Note that the FM receiver has a wide-band IF amplifier. Since the band-width for any type of modulation must be wide enough to receive and pass all the side-frequency components of the modulated signal without distortion, the IF amplifier in an FM receiver must have a broader passband than an AM receiver.

Sidebands created by FM and phase-modulated (PM) systems differ from the AM system. They occur at integral multiples of the modulating frequency on either side of the carrier wave. Recall that the AM system consists of a single set of side frequencies for each radiofrequency signal that is modulated. An FM or phase-modulated signal inherently occupies a wider band than AM and the number of these extra sidebands that occur in FM transmisison is related to the amplitude and frequency of the audio signal.

Beyond the IF stage there is a marked difference between the two receiver diagrams (figures 4-5 and 4-6). While AM demodulation involves the detection of variations in the amplitude of the signal, FM demodulation is the process of detecting variations in the frequency of the signal. In FM receivers, a "discriminator" is designed to respond to frequency shift variations. A discriminator is preceded by a limiter, which limits all signals to the same amplitude level to minimize noise interference. The audiofrequency component is then extracted by the discriminator, amplified in the AF amplifier, and used to drive the speaker.

Electrically, there are only two fundamental sections of the FM receiver which are different from the AM receiver; the discriminator (second detector) and the accompanying limiter.

Some Advantages of FM Receivers

In normal reception, FM signals are totally absent of static while AM signals are subject to cracking noises and whistles. FM followed AM in

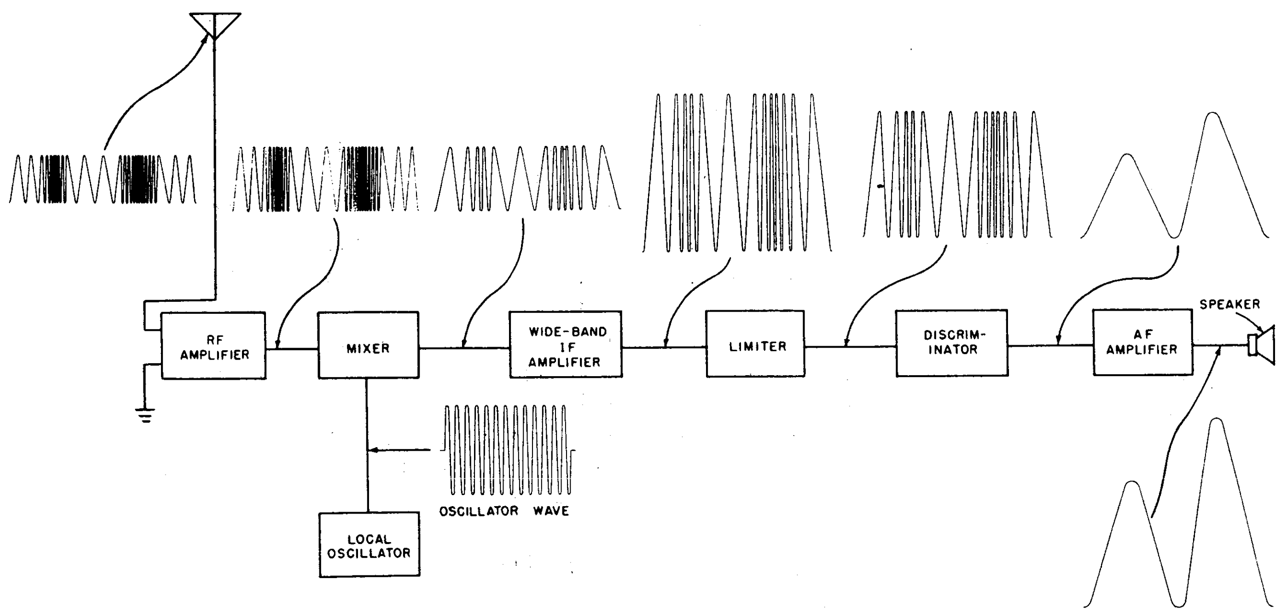

Figure 4-6.–Block Diagram of an FM Receiver and Waveforms. 13.67

The carrier reinsertion oscillator frequency will be set to the IF frequency that would have resulted had the carrier been present. For example, assume that a transmitter, with a suppressed carrier frequency of 3 MHz, is radiating a USB signal. Also assume that the intelligence consists of a 1 kHz tone. The transmitted sideband frequency will be 3,001 kHz. If the receiver has a 500 kHz IF, the correct local oscillator frequency should be 3,500 kHz. The output of the mixer to the IF stages will be the difference frequency, 499 kHz, which is in the IF passband. The missing carrier would have been based on an IF frequency of 500 kHz, therefore, the carrier reinsertion oscillator frequency should be 500 kHz, in order to preserve the frequency relationship of carrier to sideband at 1 kHz.

Recall that 1 kHz is the modulating signal. If the local oscillator frequency should drift to 3500.5 kHz, then the IF output of the mixer will become 499.5 kHz. The carrier reinsertion oscillator, however, will still be operating at 500 kHz. This will result in an incorrect audio output of .5 kHz rather than the original 1 kHz tone. If the intelligence transmitted was a complex signal, such as speech, it would be unintelligible, due to the displacement of the side frequencies caused by the local oscillator deviation. It is, therefore, very important that the local oscillator and carrier reinsertion oscillator be extremely stable.

RADIO RECEIVER R-390A/URR

Model R-390A/URR (figure 4-9) is a high-performance, general-purpose radio receiver used aboard ships and at shore stations throughout the Navy. It provides reception of CW, mcw, conventional amplitude-modulated, frequency-shift radio-actuated teletype (RATT) Facsimile (FAX), and single-sideband signals (when used in conjunction with the SSB converter, CV-591A/URR), within the frequency range of 0.5 to 32 MHz. The receiver is a superheterodyne type with multiple

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Figure 4-9.—Radio Receiver, R-390A/URR.

frequency conversion. Double conversion is used when the receiver is operating in the 8 to 32 MHz range, and triple conversion is used in the 0.5 to 8 MHz range.

Tuning is accomplished by the insertion of powdered-iron cores into the RF and variable IF coils at a rate controlled by a complex mechanical arrangement of gears, shafts, and cams. Frequency is indicated by a mechanical counter that, when calibrated, is accurate to within 300 Hz; an accuracy that permits use of the receiver as a relatively accurate frequency meter. Calibration of the frequency dial is accomplished by a crystal-controlled calibration oscillator and, if required, may be performed at every 100 kHz position.

Receiver Block Diagram

Figure 4-10 shows the path of the received signals from the antenna input to the audio and IF outputs. Since this block diagram is self-explanatory, a block-by-block description is not provided. However, the CTM 3 and 2 should become familiar with the R-390's operation.

Receiver Front Panel Controls

The front panel of an R-390A/URR receiver is shown in figure 4-11. Although controls on other receivers may vary somewhat in their nomenclature, their basic function will be the same as those on the R-390A/URR.

FUNCTION SWITCH.–The FUNCTION switch, which serves several purposes, has a number of positions, each of which will be discussed. The OFF position, which is self-explanatory, simply turns off power to the receiver.

STAND BY – When the FUNCTION switch is in the STAND BY position, the filament supply voltages are energized, but the plate supply voltages are not applied to the tubes. This condition readies the receiver for instant use without a long warmup time.

AGC AND MGC – The abbreviation AGC stands for automatic gain control. When the FUNCTION switch is placed in the AGC position, the circuitry which automatically

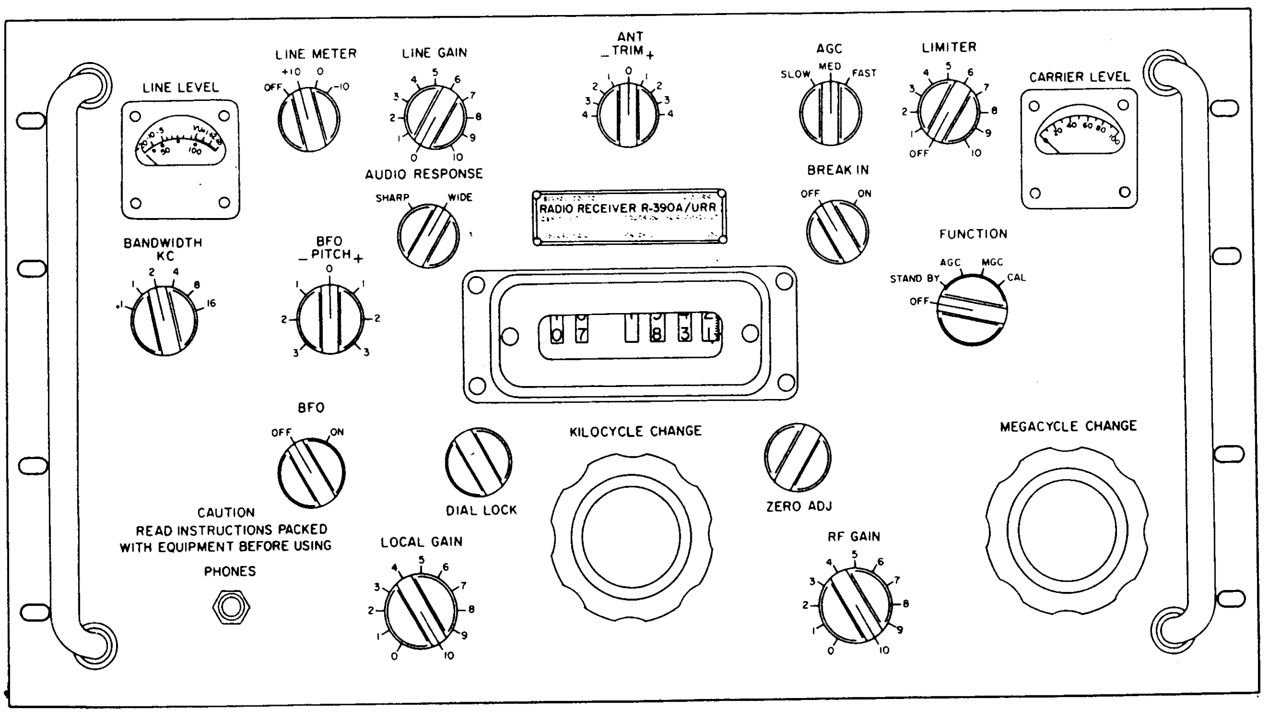


Figure 4-11.–Front Panel of Radio Receiver, R-390A/URR. 13.68

adjusts the RF and IF amplifier gain to compensate for variations in the level of the incoming signal is activated. In connection with the AGC function, notice the AGC switch at the top of the panel which has three positions marked SLOW, MED, and FAST. This AGC switch adjusts the rate at which the AGC circuitry responds to a change in the signal level. The correct position of the AGC switch is that position that most effectively compensates for fading RF signals. The abbreviation MGC, which identifies the next position of the function switch, stands for manual gain control. When the FUNCTION switch is in the MGC position, the agc circuitry is not activated, and the gain is controlled manually by means of the RF GAIN control.

CAL – When the FUNCTION switch is in the CAL (calibrate) position, a stable crystal oscillator introduces a signal at the input circuitry of the receiver. This signal allows the operator to calibrate his receiver; that is, to ascertain that the reading of the tuning dial corresponds to the frequency being received. The calibration circuitry of the R-390A permits the operator to calibrate the receiver at each 100 kHz point throughout the tuning range of the receiver. In connection with calibration, notice the ZERO ADJ knob near the frequency dial. When turned clockwise, this knob disengages the frequency indicator from the tuning control (KILOCYCLE CHANGE). Detailed calibration procedure is contained in the technical manual for this receiver.

TUNING CONTROLS.–Two front panel knobs provide the tuning control of the R-390A, the MEGACYCLE CHANGE knob and the KILOCYCLE CHANGE know. The MEGACYCLE CHANGE knob selects any 1 MHz bandwidth of the tuning range. Turning this knob changes the reading of the first two digits of the frequency indicator. The KILOCYCLE CHANGE knob tunes the receiver to any desired frequency within the megahertz band selected by the MEGACYCLE CHANGE control. The last three digits of the frequency indicator dial provide the kilohertz reading. The tuning controls actually adjust the tuned circuits in the RF stages, local oscillator, and first crystal oscillator; in order to select the desired station frequency and to provide simultaneously the desired IF signal to the IF portion of the receiver. The DIAL LOCK knob is associated with the tuning controls. This knob locks the KILOCYCLE CHANGE control so that the frequency setting will not be accidentally changed.

BANDWIDTH CONTROL.–Some transmissions use narrower bandwidths in the RF spectrum than others. Therefore, receivers are provided with a control which allows the operator to adjust the bandpass of the receiver so that only the desired bandwidth is received. On the R-390A receiver, this control is achieved by the BANDWIDTH KC switch, which adjusts the tuned circuits and selects the appropriate mechanical filter of the IF portion of the receiver, thereby controlling receiver selectivity. Proper adjustment of this control helps to eliminate noise and interfering signals. Of course, if the bandwidth is set too narrow, part of the incoming signal will be lost.

BEAT FREQUENCY OSCILLATOR.–Some radio transmissions, such as Morse telegraphy and fsk teletype, contain no audio frequency information when they are received. If it is necessary or desirable to produce an audio output, some method must be provided to convert the incoming RF signal to an af signal. This requirement is fulfilled by the beat frequency oscillator (BFO). In a superheterodyne receiver, the BFO is installed in such a manner that, when activated, the signal produced by the BFO heterodynes with the IF signal, producing an audio frequency output signal. On the R-390A, the BFO is activated by the BFO ON-OFF switch, and the pitch of the audio output can be adjusted by the BFO PITCH knob.

GAIN CONTROL.–The R-390A has three front panel gain controls. The RF GAIN control, which was mentioned earlier, permits manual adjustment of the gain of the RF and IF portions of the receiver. The LOCAL GAIN and LINE GAIN knobs control the gain of the audio circuitry. The LOCAL GAIN control adjusts the level of the output to the phone jack and the LOCAL AUDIO terminals on the rear panel of the receiver. The LINE GAIN controls the level of the audio output used to operate terminal equipment.

ANTENNA TRIMMER.—The front panel control, labeled ANT TRIM, adjusts the input circuit in such a manner that optimum coupling from the antenna to the receiver can be achieved at each frequency.

AUDIO RESPONSE.—The AUDIO RESPONSE control, which adjusts the bandwidth of the audio circuits, has two settings, SHARP, and WIDE. The setting of this control will depend on the type of signal being received.

LIMITER.—When the control labeled LIMITER is activated, the operator can control the maximum amplitude of the signal to the audio output circuits. The setting of the LIMITER control is dependent upon the type of signals being received; for example, a low setting of the control may be desirable to prevent loud crashes of static in the output when monitoring voice signals. Or, if the received signal is fsk modulated, it may be desirable to remove all amplitude variations by using a high setting on the LIMITER control. However, for many types of reception, the LIMITER should not be activated.

BREAK IN.—The ON-OFF switch labeled BREAK IN is used when a receiver and transmitter are used together as a radio set. When in the ON position, circuits are activated which will remove the antenna from the receiver and ground the antenna and receiver audio circuits whenever the transmitter is energized.

Receiver Front Panel Indicators

The R-390A has three indicators on the front panel. The frequency indicator dial indicates the frequency to which the receiver is tuned. The dial is of the digital-counter type which permits the frequency to be read directly with little chance of misreading.

The CARRIER LEVEL indicator is a meter which measures a voltage equivalent to the level of the incoming signal when in the AGC and CAL functions. The operator will find this meter valuable in tuning to the exact frequency which will give the strongest signal. It is also used to indicate proper adjustment of the ANT TRIM (antenna trimmer).

The indicator labeled LINE LEVEL is a meter which may be used to monitor the level of the line audio output used to drive terminal equipment. This meter is placed across the output circuit by the LINE METER switch. The three available ranges of meter sensitivity (voltage required for full-scale deflection) are determined by the setting of the LINE METER switch. This meter is valuable in maintaining the proper output level, by means of the LINE GAIN control, when making tape recordings or driving other external equipment.

Receiver Rear Panel

The rear panel of an R-390A/URR receiver is shown in figure 4-12. Various connectors, terminals, fuses, and tools are illustrated along with their appropriate function labels. Note that holders are provided for storage of spare fuses.

SSB CONVERTER, CV-561A/URR

The CV-591A/URR single sideband converter (fig. 4-13) is used to convert standard communication receivers such as the R-390/URR for SSB use.

The use of SSB communications results in the selectivity of most receiving systems being greatly sharpened, by the rejection of unwanted adjacent signals or interference with little or no detrimental effect to the desired signal. The tuning of single-sideband signals is greatly simplified since the final tuning is done at the converter, not the receiver. A mechanical and electrical bandspread tunes over the IF bandpass. This effective vernier easily tunes SSB or exalted carrier AM signals within cycles of correct tone. Either sideband is selectable, either with the bandpass tuning feature or by inverting the oscillator separation. Continuous wave (CW), mcw, and fsk signals are easily tunable with the bandspread feature.

For extreme stability, the first oscillator is switched to crystal control for both upper and lower sideband positions.

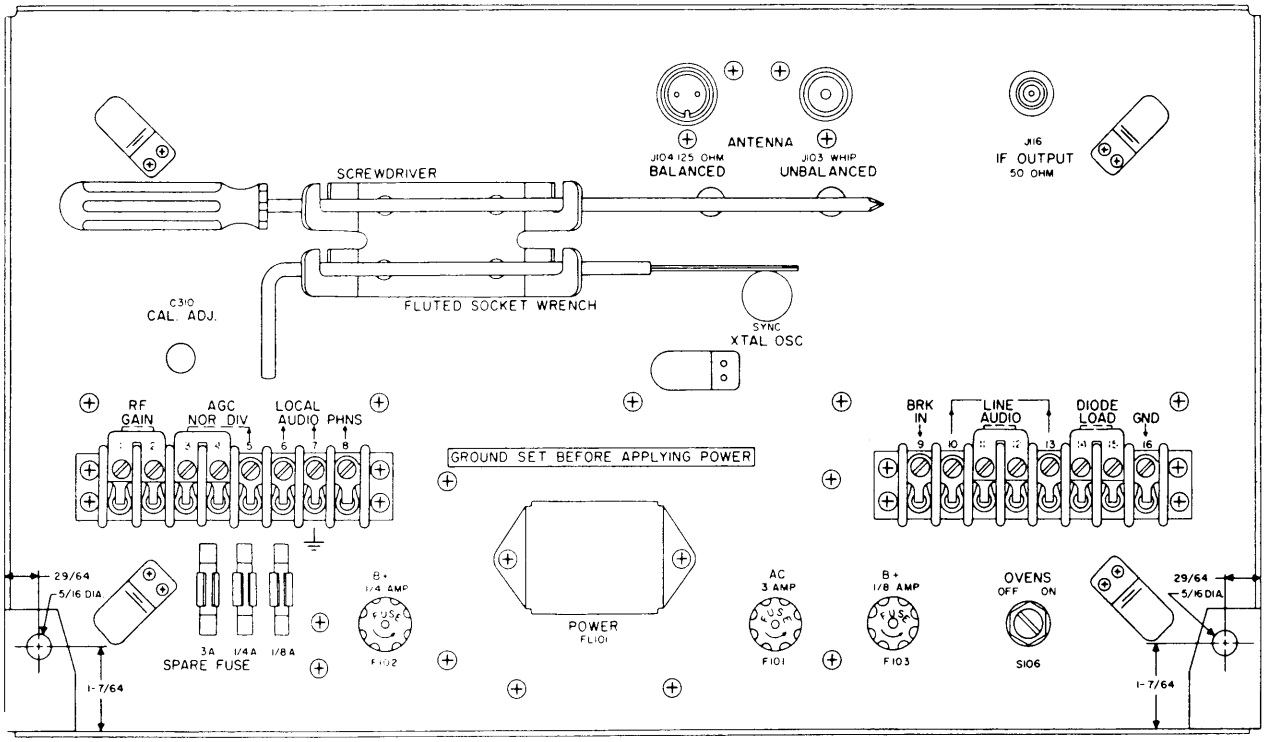


Figure 4-12.—Rear Panel of Radio Receiver, R-390A/URR. 1.347

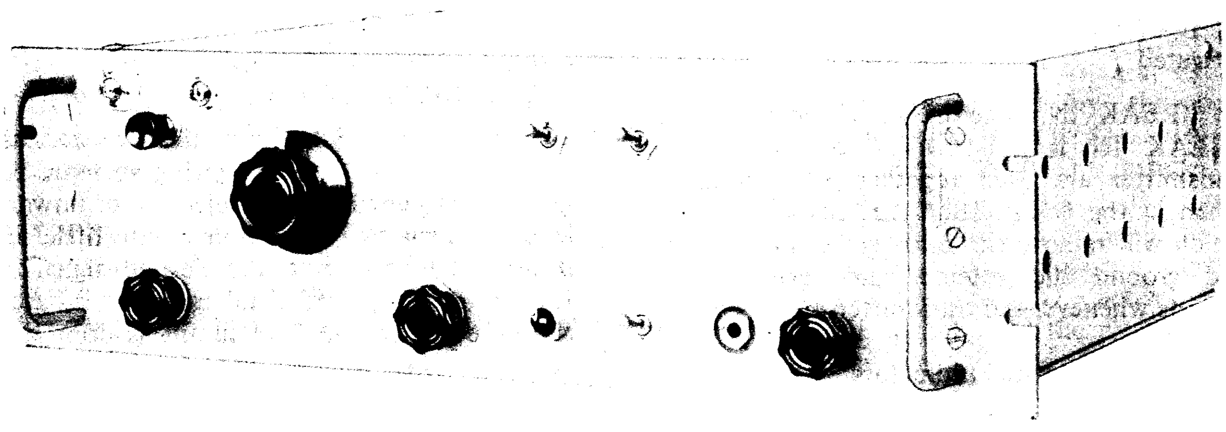


Figure 4-13.—SSB Converter, CV-591A/URR, Front View. 109.30

The local or remote-tuned VFO feature of the converter permits operation with any receiver having an IF nominally centered at 455 kHz. When the oscillator is switched to crystal control and the proper crystals inserted however, most any receiver IF may be accommodated.

All operational controls are located on the front panel. These controls are similar in function and effect to those found on any receiver. The BANDSPREAD control tunes the converter over a limited frequency range. A MANUAL/XTAL switch sets the first oscillator to either variable or fixed crystal operation. The BFO, AVC and AUDIO GAIN controls perform similar functions as on a receiver.

Terminals at the rear panel provide simple connections for remote control of the main features of the converter without modifications or the use of additional lines or tones.

By this means it is possible to remotely or locally tune the converter across the receiver IF bandpass, select sidebands with a remote indication of which sideband is in use, and still retain all of the control features without modification.

CONVERTER BLOCK DIAGRAM

The block diagram (fig 4-14) presents a simplified outline of the functions of the converter and how they are accomplished. Since this block diagram is self explanatory a block-by-block description is not provided.

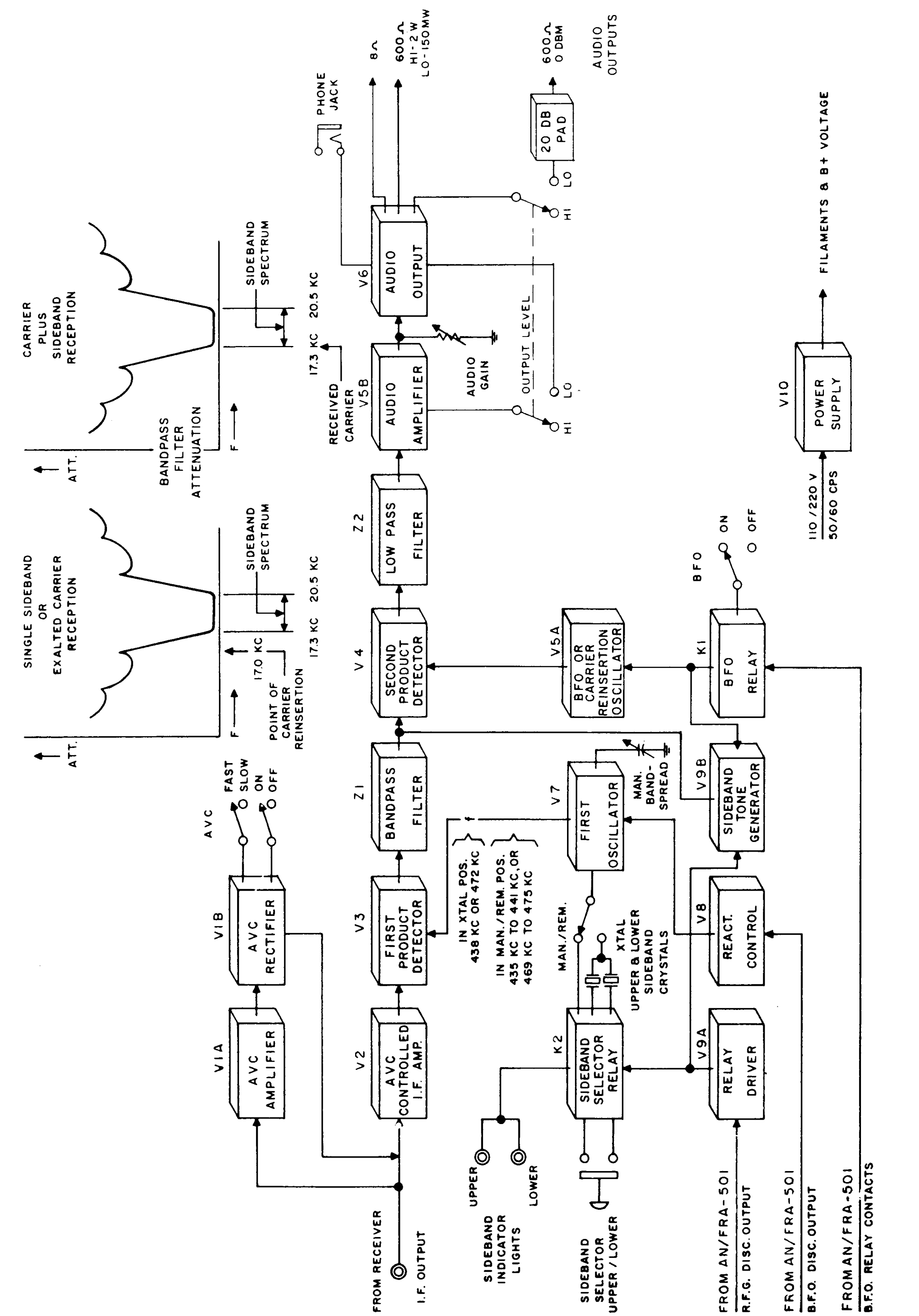
RADIO RECEIVER R-1051/URR

Radio Receiver R-1051/URR is a triple-conversion superheterodyne receiver, tunable over the high frequency range from 2 to 30 MHz. Tuning of the R-1051/URR is accomplished digitally by five controls (MCS and KCS) and a switch (CPS) located on the front panel (fig. 4-15). A display window directly above each control provides a digital readout of the digits to which the controls are set. The displayed frequency can be changed in 1 kHz increments. The front panel switch allows the operating frequency to be changed in 500 Hz increments, or 100 Hz increments depending on the model. This tuning provides 56,000 discrete frequencies in which the receiver is locked to a very accurate frequency standard. Each 1 kHz increment can be continuously tuned through by selecting the VERNIER position of the CPS switch. When using the vernier, the full accuracy of the frequency standard is sacrified. The R-1051/URR demodulates and provides audio outputs for the following types of received signals: LSB, USB, ISB, CW, fsk, and AM. A functional block diagram of the receiver is shown in figure 4-16.

MAIN SIGNAL FLOW

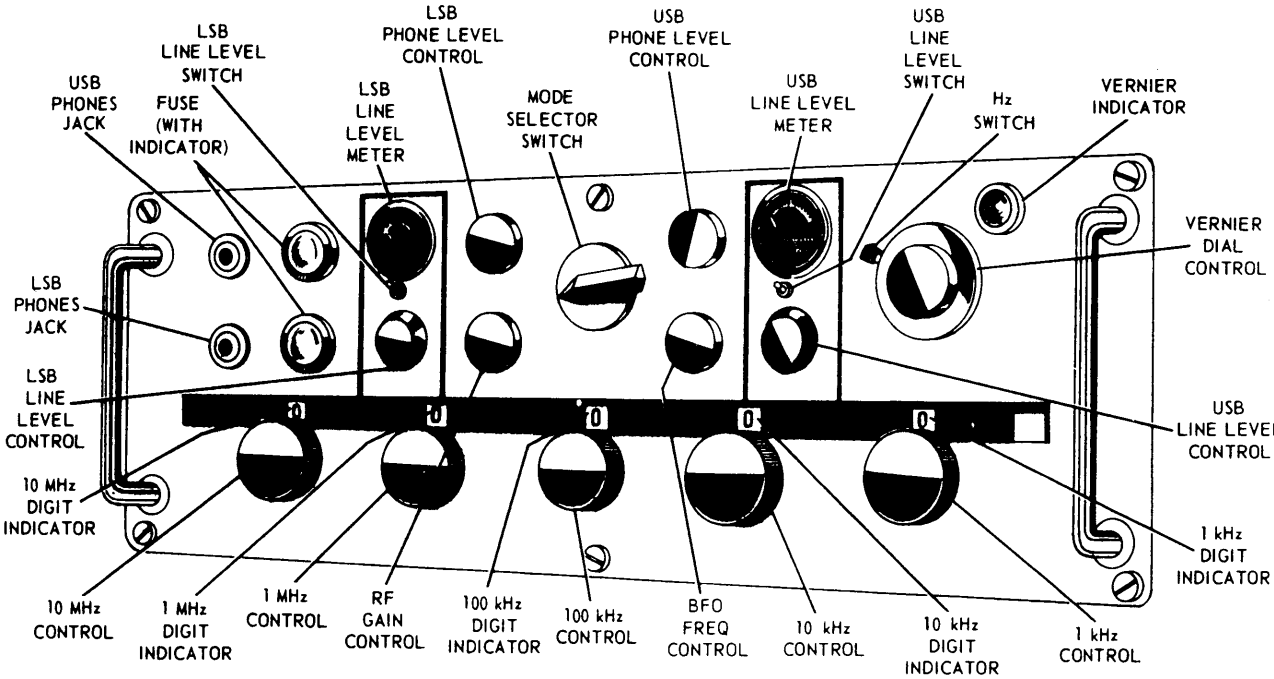
A received signal from the antenna passes through closed relay contacts in the antenna overload circuit to the RF amplifiers (fig. 4-16). If a signal in excess of 15 volts appears at the receiver input, the antenna overload circuit will open the relay contacts. The excessive voltage is thereby prevented from being applied to the RF amplifiers, which form a part of Assembly A2A4. Within the RF amplifiers, the signal passes through a double-tuned input circuit, two RF amplifier stages, a single-tuned interstage circuit, and output circuits. All of the resonant tuned circuits are tuned by the MCS, 100 kHz (KCS), and 10 kHz (KCS) frequency controls on the front panel (fig. 4-15) The MCS controls operate a code generator, which activates a motor-driven turret containing 28 strips. Each strip contains a tuned transformer and a portion of the capacitance required by each of the four tuned circuits. For each megahertz increment, a different tuned transformer and capacitor are switched into the four tuned circuits by the 100 kHz (KCS) and 10 kHz (KCS) controls on the front panel (fig. 4-15).

The output from the RF amplifiers is applied to the mixers, which form a part of Subassembly A2A6A6 (fig. 4-16). The mixers consist of three transistor mixer stages, with interstage coupling provided by selective filters. The first mixer receives the injection frequencies from Subassembly A2A6A1. The injection frequency is determined by the megahertz band selected by the MCS controls on the front panel. The desired output frequency from the first mixer always falls within two frequency bands, either 19.5 to 20.5 MHz or 29.5 to 30.5 MHz. The high or low band is also determined by the megahertz band to which the R-1051/URR is tuned. The output from the first mixer is gated through the appropriate 20 or 30 MHz filter. This signal is mixed in the second mixer stage with the injection frequencies supplied from 100 kHz Synthesizer Electronic Subassembly A2A6A2. The desired frequency band from the second mixer is 2.8 to 2.9 MHz. This signal is coupled through a 2.85 MHz filter to the third



109.31

Figure 4-14.—SSB Converter, CV-591A/URR, Block Diagram.



76.63

Figure 4-15.–Radio Receiver, R-1051/URR.

mixer. The injection frequencies for the third mixer are supplied by Subassembly A2A6A3. The output from the third mixer is a 500 kHz IF signal.

The 500 kHz IF output from the third mixer is applied to the mode gates. Three parallel paths are presented to the signal. The path that passes through the LSB mechanical filter (also used in ISB) is not gated since it has an independent output from the mode selector electronic assembly. Because the outputs from the USB mechanical filter (also used in fsk and ISB) and the AM mechanical filter (also used in cw) are paralleled for a common output, the input paths to these two filters must be gated so that only one path is open at any given time. Application of the correct gating potentials is determined by the mode of operation selected at the front panel.

The output from the LSB filter is applied to the IF amplifiers in Assembly A2A3. The common output of the USB and AM filters is also applied to the IF amplifiers in Assembly A2A2. The operating d.c. voltage is applied to the proper electronic assembly according to the mode of operation selected at the front panel. In the ISB mode of operation, a d.c. operating voltage is applied to both IF amplifiers. AGC voltage from the step AGC circuit controls the overall gain of the IF amplifiers by varying the attenuation of the input and the gain of the second IF amplifier stage. The input to the step AGC circuit is derived from the output of the second IF amplifier stage.

The output of the IF amplifiers is applied to the detector circuits, consisting of a product detector and an AM detector. Depending on the mode of operation selected at the front panel, either the balanced product detector or the AM detector is powered by d.c. operating voltage. The product detector demodulates the USB, LSB, fsk, and ISB signals. In these modes of operation, a 500 kHz injection frequency originating at a multiplier-divider in Assembly A2A5 is applied to the product detector for carrier reinsertion. This 500 kHz injection passes through 500 kHz gate in Assembly A2A1 with little attenuation in these modes of operation. In AM and CW modes, this gate presents a high attenuation, since no carrier reinsertion is required by the AM detector. In the CW mode of operation, the BFO assembly is Assembly A2A1 is turned on, and a variable 500 kHz output is applied to the input of the AM detector in assembly A2A2. The output frequency from the BFO circuit is controlled by the BFO FREQ control on the front panel.

The audio derived from the detector circuits in Assembly A2A2 is applied to the USB LINE LEVEL control on the front panel, which controls the audio level prior to its application to the audio amplifiers. The LSB LINE LEVEL control sets the audio level from the product detector in Assembly A2A3. Assemblies A2A2 and A2A3 each have two outputs. One is a 600 ohm remote output, which is applied to a connector at the rear of the case. The second output is to the PHONES jacks on the front panel. The PHONES output passes through a PHONE LEVEL control on the front panel, which adjusts the phone signal amplitude without altering the level of the remote output. Each remote output is monitored at the front panel by a LINE LEVEL meter, which has two scale ranges controlled by the LINE LEVEL switch on the front panel.

STEP AGC SIGNAL FLOW

The step AGC circuit, which forms a part of Assemblies A2A2 and A2A3, controls the gain of the RF amplifiers and IF amplifiers according to the received RF signal strength. The output from the IF amplifiers is applied to the step AGC circuits, where it is converted to a d.c. voltage that is applied to both the RF and IF amplifiers. The gain of the RF and IF amplifiers may be manually controlled by applying a d.c. voltage on the AGC lines with the RF GAIN control. This manual action overrides the normal AGC voltages.

FREQUENCY STANDARD

The 5 MHz frequency standard (Assembly A2A5, fig. 4-16) produces an accurate, stable reference frequency upon which all frequencies used in the R-1051/URR are based. The circuit is housed in an oven assembly maintained at a nearly constant temperature of 85 °C by the oven control circuit. The accurate output from the 5 MHz frequency standard is applied to a switching-and-compare circuit. An external 5 MHz frequency may also be applied to this circuit. The switching-and-compare circuit routes the internal or external 5 MHz signal to the multiplier-divider circuits or to the compare circuit. The compare circuit compares the internal 5 MHz frequency with the external 5 MHz frequency for an indication of the accuracy of the internal frequency standard.

The 5 MHz output from the switching-and-compare circuit is applied to the multiplier-divider circuit, where it is converted to frequencies of 500 kHz, 1 MHz, and 10 MHz. These three outputs are used in the mixing processes required to produce the injection frequencies used in the RF conversion process. The 500 kHz output is also applied to the 500 kHz gate circuit for insertion into the product detector for demodulation.

FREQUENCY GENERATION

The injection frequencies used in the first frequency conversion in the mixers circuit are generated within Subassembly A2A6A1. This circuit consists of a phase-locked crystal oscillator that is automatically tuned to produce one of seventeen frequencies between 2.5 MHz and 23.5 MHz. The output is applied to the high frequency mixer. The output frequency depends on the setting of the front panel MCS controls.

The injection frequencies used in the second frequency conversion in the mixers circuit are generated within Subassembly A2A6A2. This circuit consists of a crystal oscillator, the output of which is one of ten frequencies spaced at 100 kHz intervals between 4.553 and 5.453 MHz. The output frequency is determined by the setting of the front panel 100 kHz (KCS) control. If a lo-band injection frequency is required, the 17.847 MHz output from the 17.847 MHz mixer is additively mixed in the lo-band mixer with the output from the 100 kHz oscillator (4.553 MHz to 5.453 MHz, in 100 kHz steps) to provide a frequency in the 22.4 to 23.3 MHz range. If a hi-band injection frequency is required, the 27.847 MHz output from the 27.847 MHz mixer is additively mixed in the hi-band mixer with the output from the 100 kHz oscillator (4.553 MHz to 5.453 MHz, in 100 kHz steps) to provide a frequency in the 32.4 to 33.3 MHz range. In either case, the resultant frequency is applied to the mid-frequency mixers.

The injection frequencies used in the third frequency conversion in the mixers circuit are generated with Subassembly A2A6A3. This circuit consists of two crystal oscillators, each of which has ten possible output frequencies. The output from the 1 kHz oscillator (1.850 MHz to 1.859 MHz, in 1 kHz steps) is determined by the setting of the front panel 1 kHz (KCS) control, and the output from the 10 kHz oscillator (5.25 MHz to 5.16 MHz, in 10 kHz steps) is determined by the setting of the front panel 10 kHz (KCS) control. The outputs from the two oscillators are subtractively mixed to provide one of 100 possible output frequencies spaced at 1 kHz intervals between 3.301 MHz and 3.400 MHz. The output is applied to the low frequency mixer.

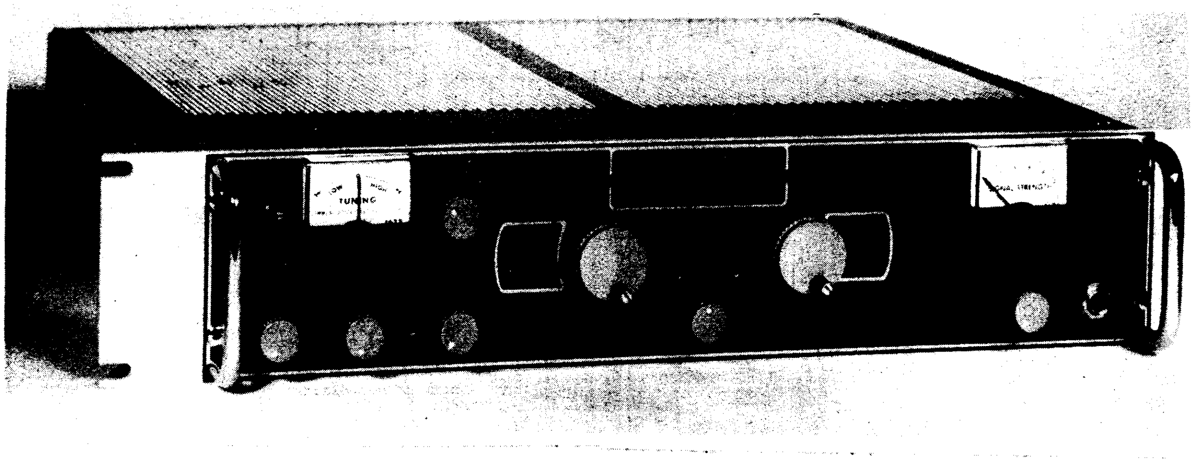
A combination of error canceling loops and phase-locked loops is used in the frequency synthesizer circuits of the R-1051/URR to ensure that the injection frequencies applied to the mixers are correct.

POWER SUPPLIES

The operating voltages for all circuits in the R-1051/URR are produced by the Power Supply Assembly A2A8 (fig. 4-16). The 105 to 125v. a.c. primary power is converted to d.c. voltages of 110 volts (RF amplifier tubes plate and screen supply), 30 volts (RF amplifier tubes bias), and 28 volts (general use). The 28v. d.c. is also regulated to 20v. d.c. for use in all semiconductor circuits of the R-1051/URR.

RADIO RECEIVER R-1279/URR

The model R-1279/URR (figure 4-17) is a widely used superheterodyne VHF receiver covering the frequency range of 30 to 300 MHz in two bands. It provides for reception of AM, FM, and CW signals with a wide variety of output options. The receiver uses semiconductor components in all but the RF tuners. The two RF tuners use nuvistor tubes which are small vacuum tubes. One tuner covers the 30 to 90 MHz band and the other covers the 60 to 300 MHz band. Three IF bandwidths are available: 20 kHz, 200 kHz, and 2 MHz. Either 20 kHz or 200 kHz is available from one IF strip while the 2 MHz bandwidth is continuously available from



93.90

Figure 4-17.—Radio Receiver, R-1279/URR.

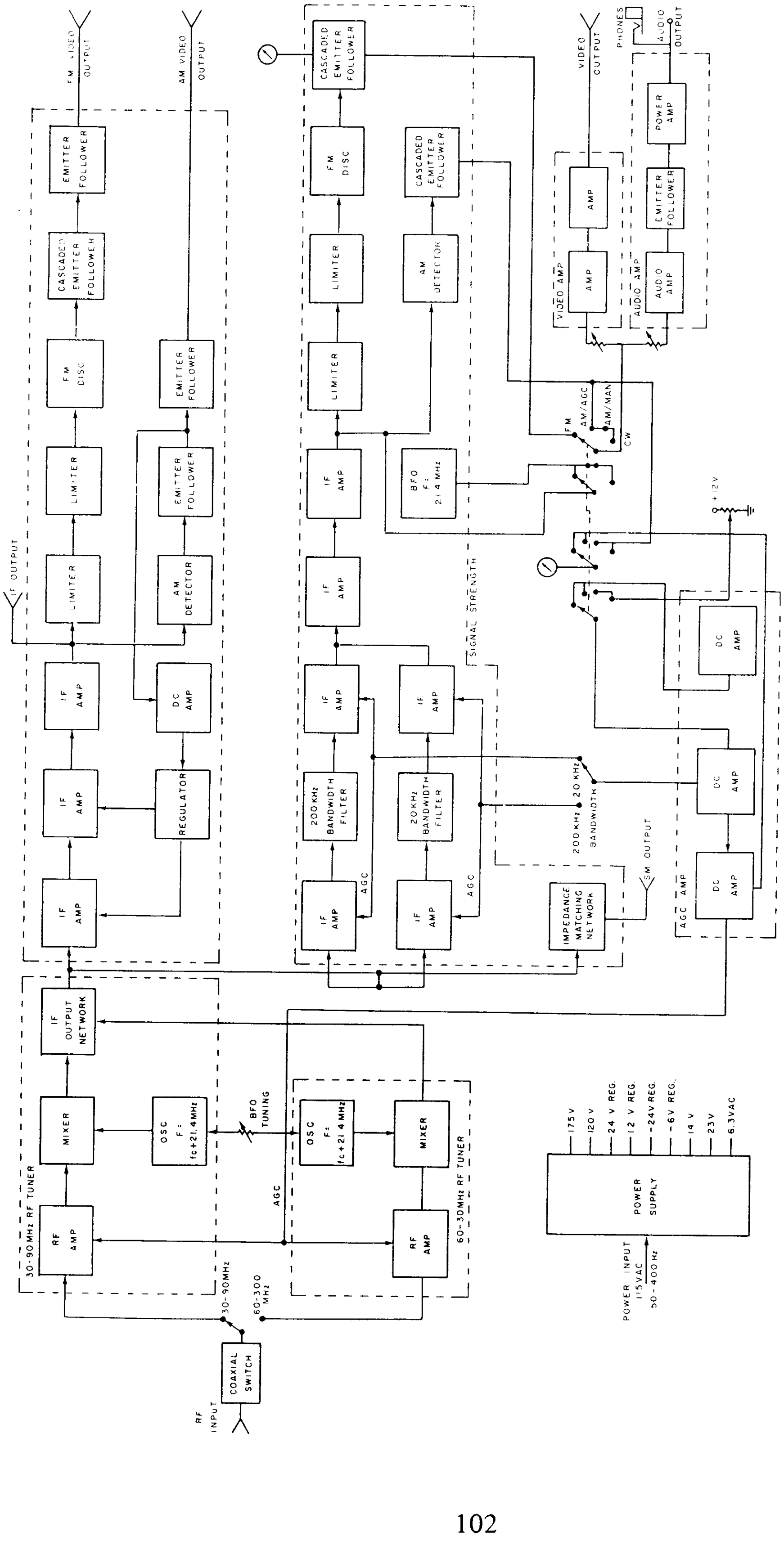


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Figure 4-18.—Radio Receiver, R-1279/URR Block Diagram.

a separate IF strip. The 2 MHz bandwidth IF strip has an IF, an FM video, and an AM video output. The 20/200 kHz bandwidth IF strip (some models of the R-1279 have a different bandwidth IF strip, e.g. 20/300 kHz) has an IF output and also feeds circuits which provide audio and video outputs. The front panel FUNCTION switch selects either the 20/200 kHz detected FM or AM signals, cuts on the BFO for CW reception and switches either Manual or Automatic Gain control into use when AM detection has been selected. A signal monitor output is also available which is essentially the unfiltered IF output of the tuners.

RECEIVER BLOCK DIAGRAM

Figure 4-18 is a self-explanatory block diagram showing the signal paths from the antenna input to the various outputs. For a block-by-block description, the technical manual should be consulted.

RADIO RECEIVER R-1401A/G

The R-1401A/G Radio Receiver shown in figure 4-19 and figure 4-20, was designed to cover the 1 kHz to 600 kHz VLF frequency range in one band.

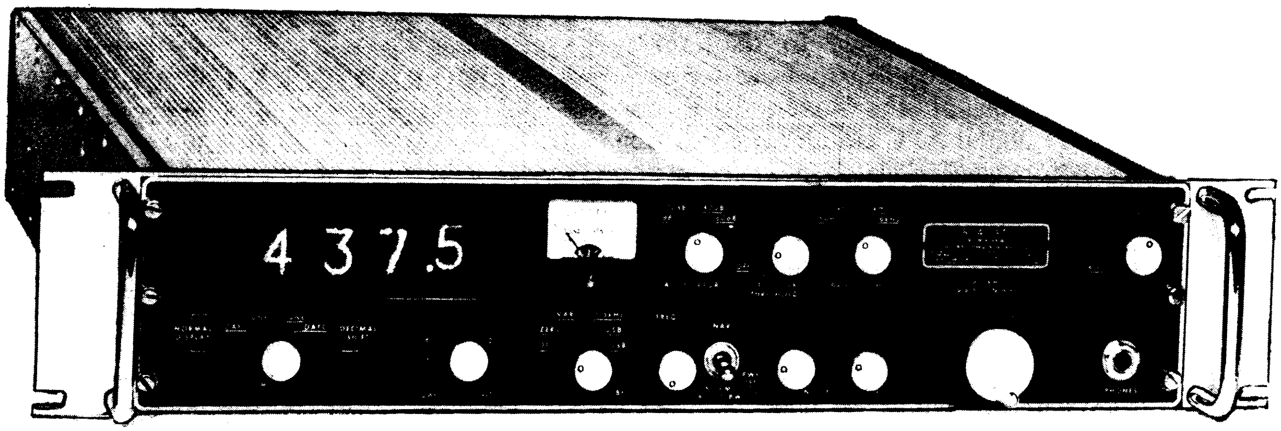

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Figure 4-19.–Radio Receiver, R-1401A/G.

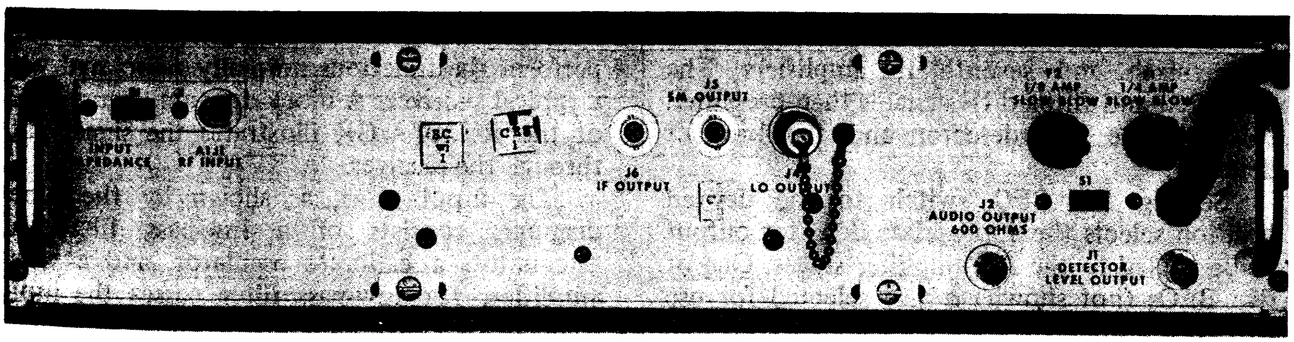

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Figure 4-20.–Radio Receiver, R-1401A/G, Rear View.

It receives AM, CW, SSB, mcw or fsk signals. The tuned frequency is normally displayed with an accuracy of ±100 Hz by direct-reading electronic digital readout. A front panel switch permits expanding the readout by a factor of 10, so that the frequency may be read to an accuracy of ±10 Hz. The receiver is of all solid-state superheterodyne design.

RECEIVER BLOCK DIAGRAM.

Tracing the input signal from the antenna through the bandpass filter and attenuator, it enters the input amplifier (figure 4-21) for amplification. The output of the input amplifier is fed to the mixer.

The local oscillator provides a frequency 2 MHz above the tuned frequency. The local oscillator output is presented to the Limiter where it is converted to a square-wave for more efficient operation of the mixer. It is also applied to the digital AFC circuit for correction of the oscillator signal to match incoming carrier frequency shifts. The limited local oscillator signal is amplified by the local oscillator amplifier. The RF amplifier again amplifies the local oscillator signal and presents it to the mixer.

The input signal and the local oscillator outputs are heterodyned in the mixer, producing the 2 MHz IF signal. The 2 MHz signal is amplified by the first RF amplifier. This amplification is controlled by the AGC circuit if the receiver is in the AM mode of operation. The second and third IF amplifiers provide further amplification and pass the IF signal to the selected IF bandwidth filter. After passing through the filter, the IF signal is passed through four more stages of amplification in the fourth, fifth, sixth and seventh IF amplifiers. The amplified and filtered IF signal is then presented to both the AM detector and the product detector.

Setting the BFO switch to the desired position selects the appropriate detector output to be passed to the AF amplifier stages. One of five BFOs (not shown) is also selected for use with the product detector. These BFOs are the zero-beat oscillator, the 5.5 kHz offset oscillator, a variable frequency oscillator, a USB oscillator, and a LSB oscillator. In the OFF position, the AM detector output is used. In any other position, the product detector output is used.

An audio bandwidth filter is available for use at the output of the detector circuits. The AUDIO BANDWIDTH switch selects this filter in the NARROW position and bypasses it in the NORMAL position. When selected, the filter passes 875 - 1175 Hz of the AF signal.

The AF signal is simultaneously passed through two stages of amplification in each of two AF amplifier circuits. One AF amplifier circuit amplifies the AF signal and presents it for use on the 600 ohm AUDIO OUTPUT connector. The other circuit amplifies the AF signal and presents it to the PHONES jack for monitoring purposes.

RADIO RECEIVER R-1307A/GR (RYCOM)

The radio receiver (R-1307A/GR) (RYCOM) (figure 4-22) is highly sensitive and unique in that it is capable of splitting multiplex signals for detection and reproduction. This receiver covers the frequency range of 3 kHz to 810 kHz in five bands. Most types of signals are demodulated by the R-1307A/GR receiver, these include AM, CW, mcw, SSB, FM, and fsk.

All operator controls are located on the front panel. A speaker and headset jack on the front panel permit monitoring.

RECEIVER BLOCK DIAGRAM

The R-1307A/GR (RYCOM) receiver consists of five basic stages, excluding the power supply. With the exception of a video amplifier stage in place of an RF amplifier, these circuits perform the functions normally associated with a typical receiver. A block diagram (figure 4-23) of the R-1307A/GR illustrates the signal path through the receiver.

The input stage, as shown by the block diagram, consists of a low-pass filter, an attenuator, a calibrate oscillator, and a video amplifier. The low-pass filter passes the input frequencies below 900 kHz. These frequencies are passed to the attenuator to set the proper level to drive the mixer for minimum noise and distortion. The calibrate oscillator produces a 250 kHz output used to calibrate the receiver

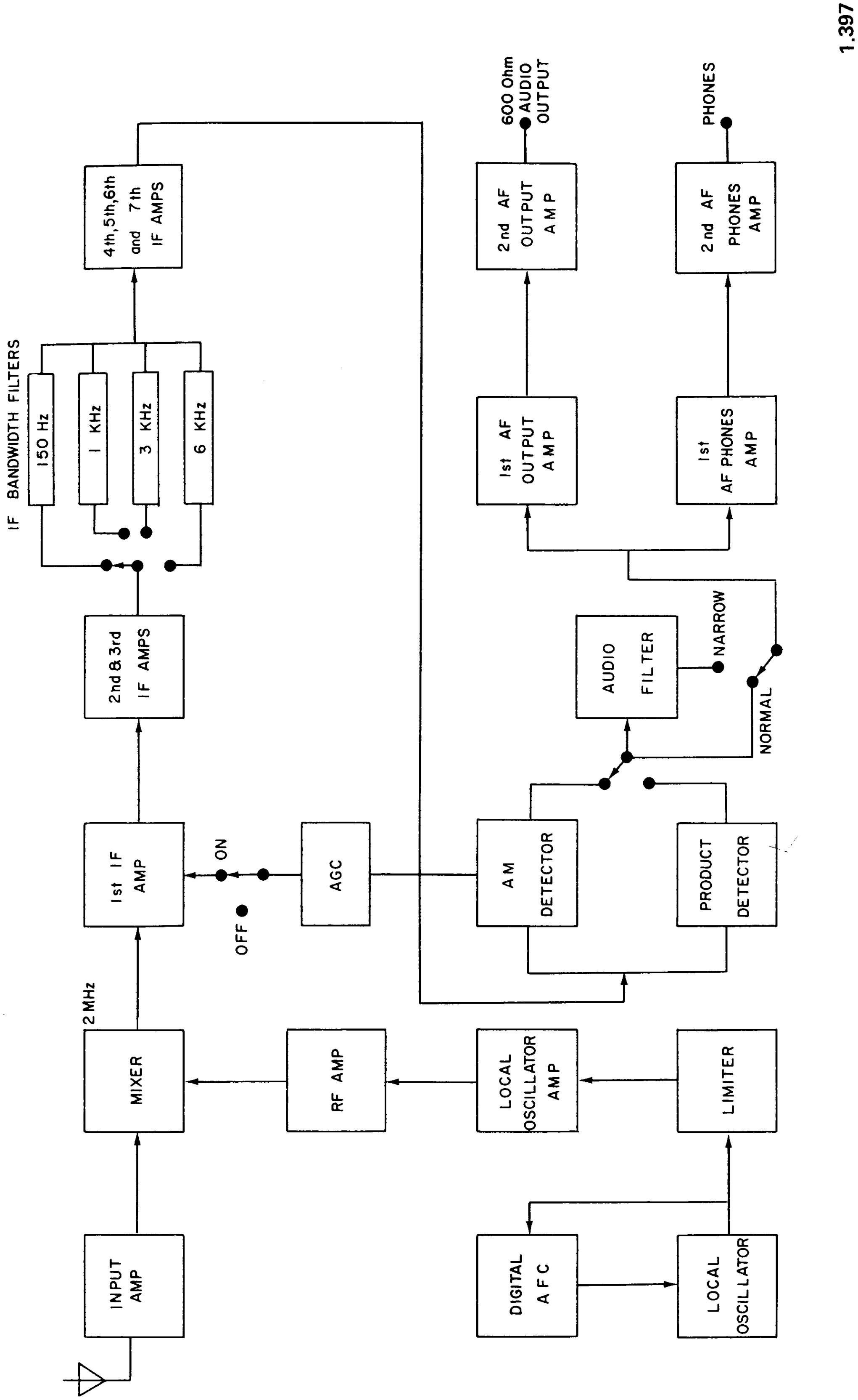

Figure 4-21.–Radio Receiver, R-1401A/G, Block Diagram.

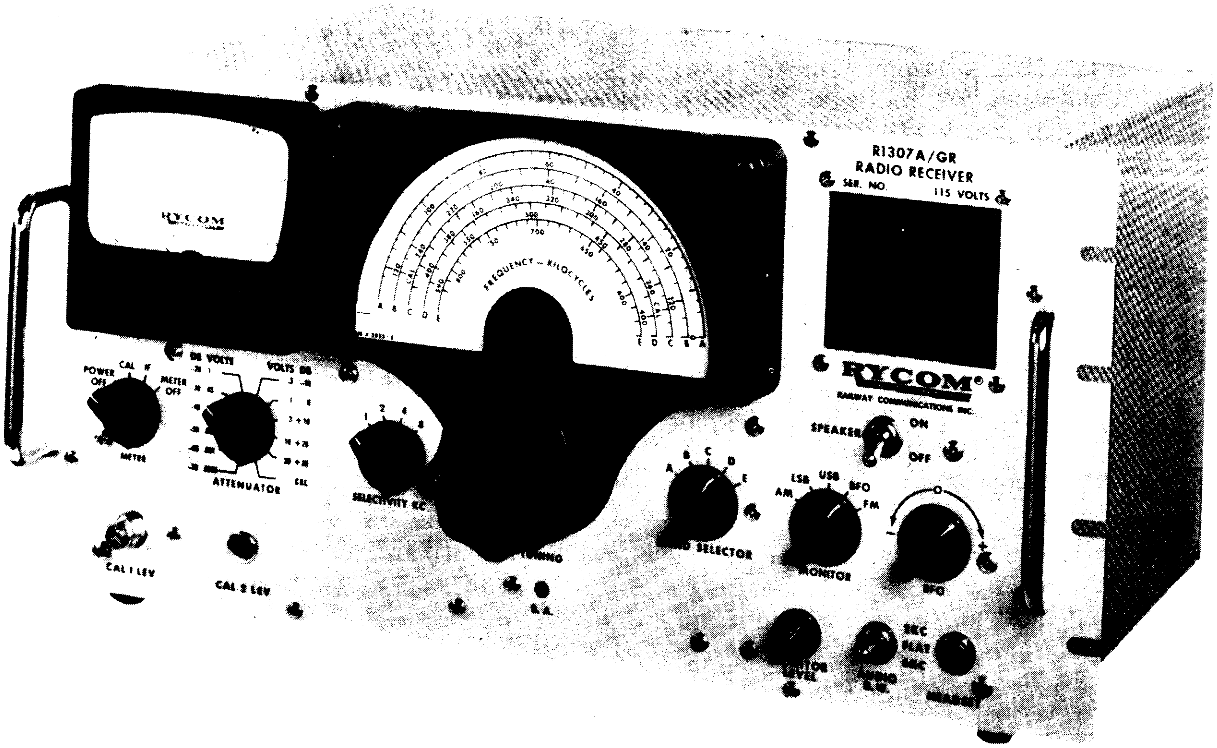

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Figure 4-22.—Radio Receiver, R-1307A/GR.

level and to check for dial accuracy. The input signal, which is direct-coupled from the attenuator, is amplified by the video amplifier, a cathode follower, and acts as a broad band constant impedance driver for the mixer.

The oscillator-mixer stage consists of a mixer, phase splitter, local oscillator, and frequency stabilization circuits.

A grounded-plate Hartley configuration is used for the local oscillator. The local oscillator's output frequency is equal to the tuned frequency plus 2.215 MHz. Two voltage-variable capacitors are used in the tuned-grid circuit of the local oscillator or stabilize small variations of the local oscillator frequency. A phase splitter is used to drive the mixer diodes into conduction during half of the local oscillator cycle.

The mixer circuit is of the balanced-shunt type using two diodes to heterodyne the input signal with the local oscillator injection from the phase splitter. The diodes short the signal to ground during half the local oscillator cycle.

The IF amplifier stages consists of the mixer amplifier four selectable bandwidth filter, first, second, and third IF amplifiers, and an IF buffer amplifier.

The output of the mixer is direct coupled to the mixer amplifier for amplification. The IF signal is then directed through one of four bandwidth filters to the first IF amplifier. The IF signal proceeds through the first, second, and third IF amplifiers for further amplification prior to demodulation. An IF buffer amplifier is used to pass the IF signal to the IF OUT jack. This amplifier also isolates the IF OUT jack from the receiver circuitry.

Three demodulators are used in this receiver. These are an AM detector, a product detector, and an FM detector. The AM detector is used to

1.399

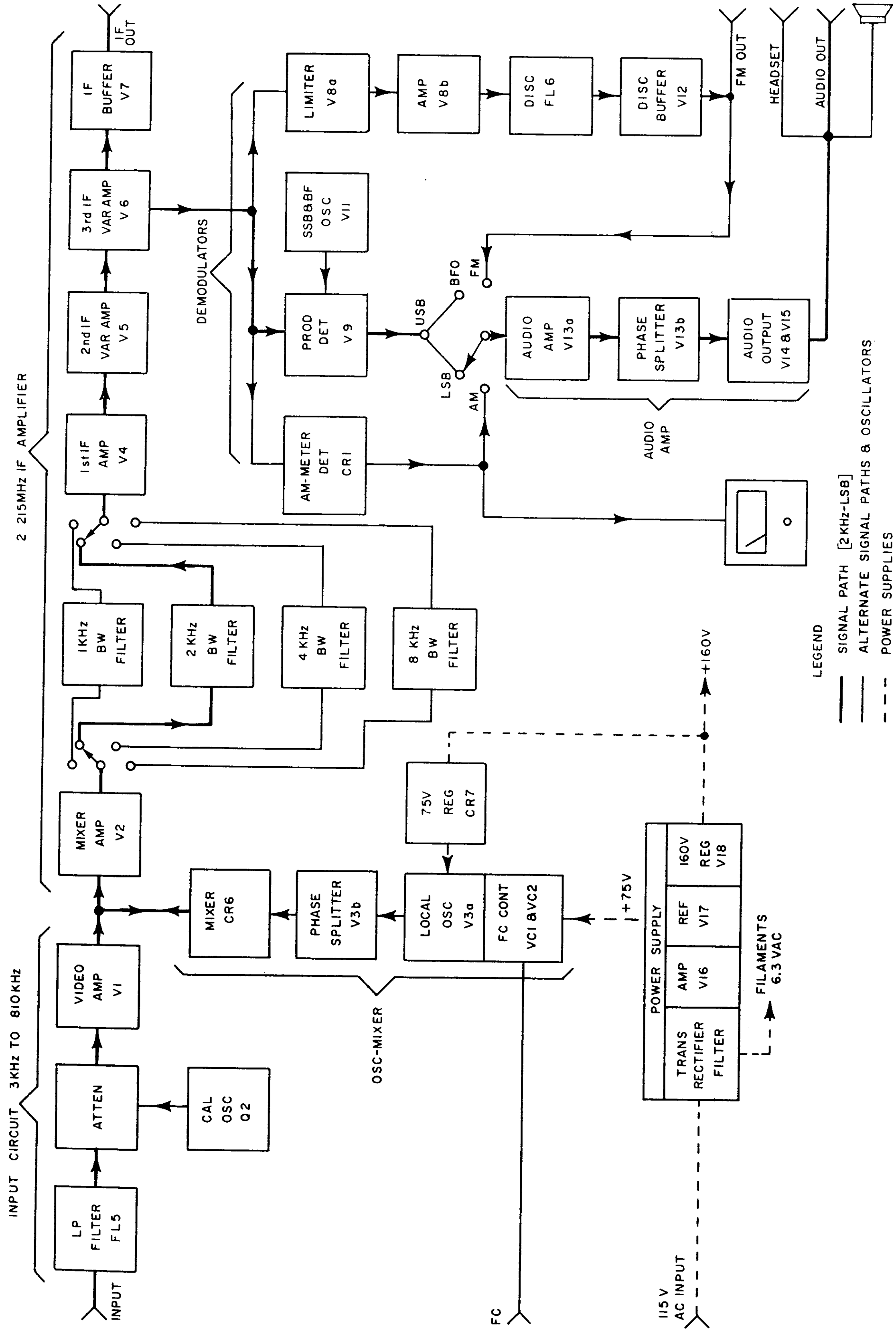

Figure 4-23.—Radio Receiver, R-1307A/GR, Block Diagram.

demodulate AM and mcw signals; the product detector demodulates SSB, CW, and fsk signals; and the FM detector is used for demodulation of FM signals only. An output from the FM detector is provided on the FM OUT jack for use as required.

The output from the selected demodulator circuit is amplified by the audio amplifier and presented to the HEADSET jack, AUDIO OUT terminal, and the speaker simultaneously.

RECEIVER FRONT PANEL CONTROLS

The following is a description of the use of the front panel controls:

AUDIO B. W. – Determines audio "roll off" frequency –– 2 kHz, 6kHz, or flat. ATTENUATOR – Controls input level to receiver in 10 dB steps. Also inserts calibrate oscillator output into the video amplifier in CAL position. B.A. – Adjusts bias on oscillator frequency stabilization circuitry. BAND SELECTOR – Selects band of frequencies to be tuned. BFO – Controls BFO frequency. CAL 1 LEV – Adjusts IF gain to determine gain of the receiver. CAL 2 LEV – Sets calibrate frequency level. METER – Turns a.c. power on. Turns on calibrate oscillator and reads out average IF output. SPEAKER – Turns speaker on or off. MONITOR LEVEL – Controls audio amplifier gain. SELECTIVITY KC – Selects appropriate bandwidth filter in IF section of receiver. MONITOR – Selects mode of detection. TUNING – Determines operating frequency. HEADSET – Provides monitor output.

RECEIVER REAR PANEL CONNECTIONS

INPUT – Signal input. IF OUTPUT – Provides output from IF stages. FM OUTPUT – Provides FM detector output. AUDIO OUTPUT – Provides 600-ohm audio output. F.C. – Frequency control input.

RADIO RECEIVING SET AN/URR-52B

The Radio Receiving Set, AN/URR-52B (figure 4-24), is designed to provide AM, FM, and CW reception including a visual spectrum display over the 30 to 1000 MHz frequency range in four bands: 30-60 MHz, 60-300 MHz, 235-500 MHz, and 490-1000 MHz. Switching of these four tuners is controlled by the RANGE switch on the front panel. A digital automatic frequency control (DAFC) circuit provides the capability of stabilizing these tuners to within ± 1 kHz by use of an external frequency counter. A single FINE TUNING control provides fine frequency adjustments for the operating tuner when the DAFC is not used. Two IF amplifiers are operating at all times. One is a 2 MHz bandwidth amplifier which provides

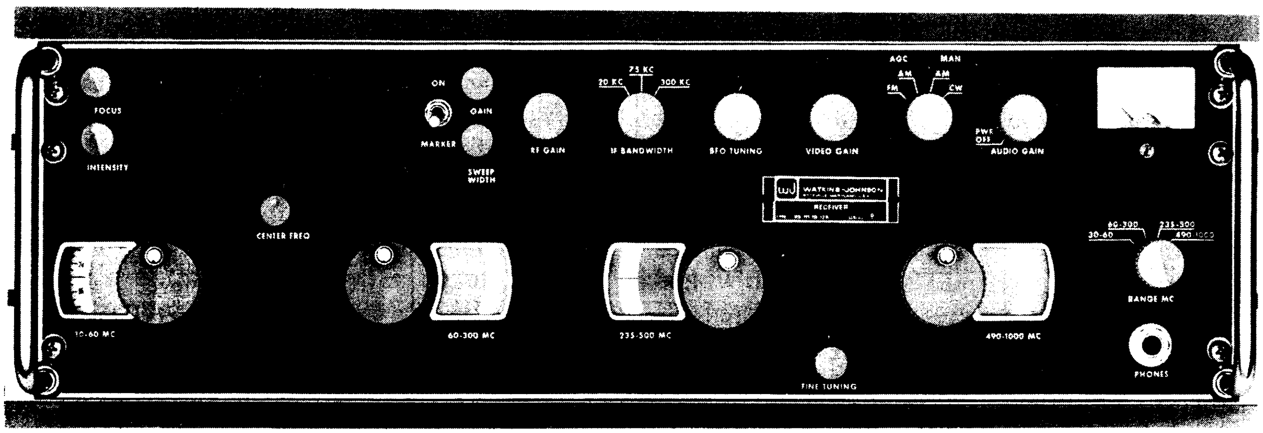

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Figure 4-24.—Radio Receiving Set, AN/URR-52B.

simultaneous AM and FM video output. The other IF amplifier provides either 20 kHz, 75 kHz, or 300 kHz bandwidth, depending on the setting of the front panel IF BANDWIDTH switch. Predetection outputs are available from both these sources. From the 20/75/300-kHz bandwidth IF amplifier, either an AM or FM video output also is available, depending on the setting of the front panel function switch. In either case, audio is available at a 600-ohm audio output and a headphone jack. The 20/75/300 kHz bandwidth IF amplifier contains a beat frequency oscillator (BFO) which operates in the CW position of the function switch in all three bandwidths. A signal monitor, which is an integral part of the receiving system, provides the visual signal display. Center frequency indication is available for tuning when a 21.4 MHz marker is turned on.

FUNCTIONAL DESCRIPTION.—Figure 4-25 is a functional block diagram of the AN/URR-52B Receiving System. The AN/URR-52B has RF inputs for two frequency ranges: 30-500 MHz (J1) and 490-1000 MHz (J2). Signals from the 30-500 MHz input are routed through K2 to either 235-500 MHz tuner A3 or to relay K1. Relay K1 routes the signals to tuner Al (30-60 MHz) or A2 (60-300 MHz). The two relays are controlled by the front panel RANGE MC switch.

Signals for the 490-1000 MHz tuner are routed from rear panel jack J2 to jack J1 on the tuner. Within the tuner, the signal is applied to a tuned preselector stage. Signals from the tuned preselector are combined in the crystal mixer with an injection signal from the oscillator stage (A4V1). This oscillator always operates 60 MHz higher in frequency than the signals from the tuned preselector. A portion of the oscillator signal is coupled through jack J3 to the coupling network A14. The 60 MHz difference frequency from the crystal mixer is amplified by the 60 MHz IF amplifier and coupled to the 60-21.4 MHz converter (A6).

Signals for the 235-500 MHz tuner (A3) are routed from relay K2 to the tuner input jack J1. Signals entering the tuner are amplified by the RF amplifier of A3 before being combined with the local oscillator signal in the mixer stage of A3. The oscillator stage of A3 operates 60 MHz higher in frequency than the signal from the RF amplifier of A3. A portion of the oscillator signal is applied to the coupling network A14. The 60 MHz difference signal from the mixer is coupled to the 60-21.4 MHz converter (A6).

The 60-21.4 MHz converter (A6) contains two identical 60 MHz input stages. As discussed above, signals from the 235-500 MHz tuner and the 490-1000 MHz tuner enter the converter at jacks J1 and J2 of A6 respectively. Although not shown on the functional block diagram, the RANGE MC switch energizes the proper stage for the tuner in use. If neither one of these tuners has been selected the converter is disabled. The 60 MHz output from either amplifier stage of A6 is coupled to the mixer stage where it is combined with an 81.4 MHz signal from the crystal controlled oscillator in A6. The 21.4 MHz difference frequency output of A6 is coupled to the 30-60 MHz tuner (A1).

When the 60-300 MHz tuner (A2) is selected by the RANGE MC switch, signals from the 30-500 MHz RF input jack (J1) are routed through relays K1 and K2 to the input of the RF amplifier stage of A2. The signals are amplified before being combined with the local oscillator signal in the mixer stage of A2. The oscillator stage of A2 operates 21.4 MHz higher in frequency than the signals from the RF amplifier stage. The 21.4 MHz difference signals from the mixer stage of A2 are routed to the 30-60 MHz tuner A1.

There are three RF inputs to the 30-60 MHz tuner (A1); however, only one of these is an antenna input. When this tuner is selected by the RANGE MC switch, signals from the 30-500 MHz RF input jack (J1) on the rear panel of the receiver are routed through relays K1 and K2 to tuner jack J1 of A1. Signals from J1 in the range of 30-60 MHz are amplified by the RF amplifier and combined with the local oscillator signal in the mixer stage of A1. The oscillator stage of A1 operates 21.4 MHz higher in frequency than the signals from the RF amplifiers. Also, a portion of the oscillator signal is coupled through output J5 to coupling network A13. The 21.4 MHz difference signals from the mixer stage are coupled to the 21.4 MHz mixer output network, from which signals are routed to the 2 MHz IF amplifier stage A7. The other two RF inputs to A1 are also coupled into this output network. Input jack J4 of A1 receives 21.4 MHz signals from the 60-21.4 MHz converter (A6) when either A3 or A5 is activated. The remaining RF input to the tuner (A1) is from the mixer stage of A2 when this tuner is activated. Therefore, the 21.4 MHz IF output network of A1 receives the output from the mixer stages of A1, A2, and A6, depending on the setting of the RANGE MC switch. This network provides impedance matching of the outputs of the tuners to the inputs of the IF amplifiers A7 and A8.

The 21.4 MHz IF output from jack J3 of the 30-60 MHz tuner (A1) is distributed to three assemblies. From J3 to A1 the signals are routed to input jack J1 of the 2MHz IF amplifier (A7). A portion of the signal to this IF amplifier (A7) is rerouted back out of the A7 module through output jack J2 to the input jack (J1) of the 20/75/300 kHz IF amplifier (A8). A portion of the 21.4 MHz signal entering this IF amplifier (A8) is passed through a matching network to the signal monitor assembly (A5). These three assemblies: the signal monitor, the 20/75/300 kHz IF amplifier, and the 2 MHz IF amplifier, receive the 21.4 MHz signal simultaneously.

The 2MHz IF amplifier (A7) provides three stages of amplification for the 21.4 MHz IF entering at jack J1. This amplified signal from A7Q3 is distributed to three circuits. A portion of the amplified IF is passed through to the wide band IF output (WB IF OUTPUT) jack, J23. A second portion of the IF is coupled to the AM detector stage. The detected output is applied to an emitter-follower stage, located on the Video/AGC amplifier circuit board (A2). The output of the emitter-follower is distributed to both the AGC amplifier stage and another emitter follower stage. The signal from the second emitter-follower stage (A2Q4) is connected to the AM Video Output Jack, J5. A convenient test point from the AGC amplifier stage is routed to the assembly exterior by way of a feedthrough capacitor (C33). This test point can be used to apply a fixed bias for test and alignment purposes. The remaining portion of the RF signal from the IF amplifier stage A7Q3 is coupled to two symmetrical limiter stages located on the limiter/demodulator board (A1). These two limiter stages remove amplitude variations from the 21.4 MHz IF passing through them. The output from the second limiter stage is applied to the discriminator stage which demodulates the FM signal and applies it to the d.c. amplifier stage. The video signal from the d.c. amplifier stage is coupled to emitter follower stage A1Q7. The output of this stage is routed through to the FM Video Output Jack (J3) located on the rear of the receiver.

Signals entering the 20/75/300 - kHz IF amplifier (A8) are applied to three IF stages. All three paths are similar, each containing two IF amplifiers separated by bandpass filters. The circuits in two paths are disabled by the IF BANDWIDTH switch while the circuits in the third path are activated, depending on whether this switch is placed in the 300 KC, 75 KC, or 20 KC position. The bandpass filter in the 300 kHz bandwidth path is a conventional LC circuit. Crystal filters are used in the 75 kHz and 20 kHz paths. Signals from the path in operation receive additional amplification in stages A8Q7 and A8Q8. The amplified signal from A8Q7-A8Q8 are applied to three circuits. The signal is connected through jack J3 to the narrow band IF output (NB IF OUTPUT) jack J24 and also to a limiter/demodulator stage and an AM detector stage.

The limiter/demodulator subassembly A1 receives a portion of the amplified IF signals entering this subassembly which are applied to symmetrical limiter stage Q1-Q2. This stage in turn is connected to the symmetrical limiter stage Q3-Q4. These two stages remove amplitude variations from the 21.4 MHz IF passing through them. The output from limiter stage Q3-Q4 is applied to the discriminator stage which demodulates FM signals and applies them to the d.c. amplifier stage. From the d.c. amplifier stage, the demodulated signals are applied to the FM contact of the MODE switch. The third position of the IF output from amplifier stage A8Q7 - A8Q8 is routed to the AM detector stage CR3. The detected output from CR3 is applied to a d.c. amplifier stage. The output of the d.c. amplifier stage is applied to the MODE switch and the AGC amplifier (A8Q11). Thus, either AM video or FM video signals from the MODE switch are applied to the video amplifier (A9) and the audio amplifier (A10). The second portion of the detected signal from the AM detector stage (CR3) is coupled through the d.c. amplifier to the AGC amplifier (A8Q11). The AGC amplifier output voltage is connected through the feedback capacitor C71 to the FM and AM/AGC contacts of the MODE switch.

Contacts 10 and 12 of this switch (AM MAN and CW, respectively) are supplied with voltage from the RF GAIN control located on the front panel. When the MODE switch is in the FM or AM/AGC positions, the voltage from the AGC amplifier Q11 is routed back into the IF assembly through feedback capacitor C72. The voltage entering the assembly at C72 is applied to the d.c. amplifier stage. A portion of the output voltage from this stage is routed out of the assembly through feedthrough capacitor C76. The voltage from C76 is applied to the B input of the AGC monitor amplifier (A15) and also to the IF BANDWIDTH switch, mounted on the front panel. Selection of either 20, 75, or 300 kHz on the IF BANDWIDTH switch returns the voltage back into the IF assembly (A8) via feedthrough capacitors. Voltages from these capacitors supply gain control to the 20, 75, and 300 kHz amplifiers. The d.c. amplifier (A8Q12) also provides a signal voltage to the d.c. amplifier and AGC delay stage (A8Q13). The output of A8Q13 is supplied to four other assemblies: AGC amplifier A15, 30-60 MHz tuner A1, 60-300 MHz tuner A2, and 60-21.4 MHz converter A6.

Video from the MODE switch (S2A-W) is applied through the VIDEO GAIN and AUDIO GAIN controls to the video and audio amplifiers, A9 and A10 respectively. Signals entering the video amplifier (A9) are amplified and passed to the AM-FM VIDEO OUT jack J4.

Signals entering the audio amplifier (A10) are amplified by A10Q1 before being coupled to emitter follower stage A10Q2 which drives the power amplifier stage A10Q3. The power amplifier (A10Q3) output is applied to transformer T1, the output impedance of which is 600 ohms. This 600-ohm output is applied to terminal strip TB1 (600-ohm audio output) located on the rear of the receiver. It is also applied to the PHONES jack J10 located on the front panel of the receiver.

Coupling network assemblies A13 and A14 are identical. Coupling network A13 receives local oscillator signals from either the 30-60 MHz tuner (A1)or the 60-300 MHz tuner (A2), if one or the other tuners is in operation. Likewise, coupling network A14 receives local oscillator signals from the 235-500 MHz tuner (A3) or the 490-1000 MHz tuner (A4), if one or the other tuner is in operation. The output of A13 (J3) is accessible on the rear panel of the receiver and is labeled LO OUTPUT 30-300 MC. The output of A14 (J3) is accessible on the rear panel of the receiver and is labeled LO OUTPUT 235-1000 MC.

The AFC amplifier (A16) provides FINE TUNING, BFO TUNING, and AFC tuning voltage for the four tuners Because the BFO is crystal controlled, the local oscillator frequency in the operating tuner must be varied to provide a pitch change in the CW audio signal. There are two inputs to the AFC amplifier. A voltage variation at either one of these two inputs changes the output voltage of the driver stage (A16Q1); however, if a DAFC voltage is present, any voltage variation on the FINE TUNING/BFO TUNING input will be opposed by the AFC/DAFC voltage until it is finally pulled out of range. Voltage from the driver stage (A16Q1) is applied to the four oscillator stage inputs of the tuners.

Signal monitor assembly A5 (See figure 4-26) consists of the cathode ray tube (CRT) and five subassemblies. These subassemblies are: IF amplifiers (A1 and A2), sweep generator (A3), crystal oscillator (A4), and the bandpass filter (A5). The operation of the signal monitor can be summarized as follows:

Signals centered near 21.4 MHz are applied to the first mixer stage (A1Q1). Also coupled to the first mixer is a signal from the sweep oscillator (A1Q5), which varies in frequency from 32.9 MHz to 35.9 MHz. The output of the first mixer is coupled to the 13 MHz amplifier (A2Q1), which accepts only signals very close to 13 MHz. As the sweep frequency applied to the first mixer increases from 32.9 MHz to 35.9 MHz, it beats in turn with each signal in the range of 19.9 MHz to 22.9 MHz to produce difference signals at 13 MHz. Each one of these 13 MHz signals is ultimately detected and applied to the vertical deflection plates of the CRT. To have these detected vertical signals presented on the CRT screen corresponding to the originals present in the range of 19.9 MHz to

22.9 MHz, the horizontal plates of the CRT must be swept in relation to the sweep of the first mixer (A1Q4). This relationship is established by having the sawtooth generator (A3Q1) provide the sweep voltage for the sweep oscillator (A1Q5) and the sweep voltage for the horizontal plates of the CRT. This synchronization provides a visual display on the CRT corresponding to the input signals centered on 21.4 MHz coupled to the signal monitor.