CHAPTER 2

RADIO

The word "radio" can be defined briefly as the transmission of signals through space by means of electromagnetic waves. Usually, the term is used in referring to the transmission of intelligence code and sound signals, although television (picture signals) and radar (pulse signals) also depend on electromagnetic waves.

Of the several methods of radio communications available, those utilized most commonly by the Navy are radiotelegraphy, radiotelephony, radioteletype, radiofacsimile, and digital data. These modes are defined as follows:

1. RADIOTELEGRAPHY: The transmission of intelligence coded radiofrequency waves in the form of short transmissions (dots) and long transmissions (dashes).
2. RADIOTELEPHONY: The transmission of sound intelligence (voice, music, or tones) by means of radiofrequency waves.
3. RADIOTELETYPE: The transmission of messages from a teletypewriter or coded tape over a radiofrequency channel by means of coded combinations of mark and space impulses.
4. RADIOFACSIMILE: The transmission of still images (weather maps, photographs, sketches, typewritten pages, and the like) over a radiofrequency channel.
5. DIGITAL DATA: The transmissions of data from a computer in serial or parallel format of binary numbers and zero. The radiofrequency transmission is usually by a series of pulse code modulations or sidetone modulations.

Radio equipment can be divided into two broad categories: transmitting equipment and receiving equipment. Both transmitting and receiving equipments consist basically of electronic power supplies, amplifiers, and oscillators.

A basic radio communication system may consist of only a transmitter and a receiver, which are connected by the medium through which the electromagnetic waves travel (fig. 2-1). The transmitter comprises an oscillator (which generates a basic radiofrequency), radiofrequency (RF) amplifiers, and the stages (if any) required to place the audio intelligence on the RF signal (modulator).

The electromagnetic variations are propagated through the medium (space) from the transmitting antenna to the receiving antenna.

The receiving antenna converts that portion of the transmitted electromagnetic energy received by the antenna into a flow of alternating radiofrequency currents. The receiver converts these current changes into the intelligence that is contained in the transmission.

FREQUENCY SPECTRUM

Radio transmitters operate on frequencies ranging from 10,000 hertz to several thousand megahertz. These frequencies are divided into eight bands as shown in table 2-1.

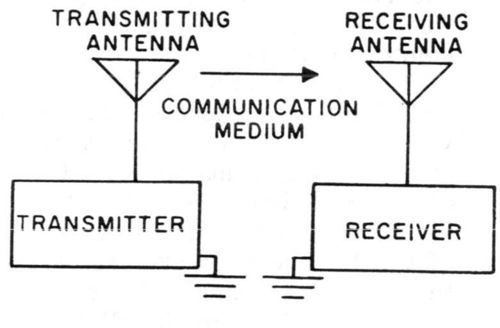

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Figure 2-1.—Basic radio communication system.

Table 2-1.—Bands of Frequencies

Abbreviation	Frequency band	Frequency range
VLF	Very low frequency	below 30 kHz
LF	Low frequency	30-300 kHz
MF	Medium frequency	300-3000 kHz
HF	High frequency	3000-30,000 kHz
VHF	Very high frequency	30-300 MHz
UHF	Ultrahigh frequency	300-3000 MHz
SHF	Superhigh frequency	3000-30,000 MHz
EHF	Extremely high frequency	30-300 GHz

Because the VLF and LF bands require great power and long antennas for efficient transmission, the Navy normally uses these bands mostly for shore station transmissions. (The antenna length varies inversely with frequency.)

Only the upper and lower ends of the MF band have naval use because of the commercial broadcast band extending from about 550 kHz to 1700 kHz.

Most shipboard radio communications are conducted in the HF band. Consequently, a large percentage of shipboard transmitters and receivers are designed to operate in this band. The HF band lends itself well for long-range communications.

A large portion of the lower end of the VHF band is assigned to the commercial television industry and is used by the Armed Forces only in special instances. The upper portion of the VHF band (225 MHz to 300 MHz) and the lower portion of the UHF band (300 MHz to 400 MHz) are used extensively by the Navy for their UHF communications. The frequencies above 400 MHz in the UHF band through the SHF and EHF bands are normally used for radar and special equipment.

ANTENNAS AND PROPAGATION

An antenna is a conductor or system of conductors that radiates or intercepts energy in the form of electromagnetic waves. In its elementary form, an antenna may be simply a length of elevated wire. For communication and radar work, however, other considerations make the design of an antenna system a more complex problem. For instance, the height of the radiator above ground, the conductivity of the earth below the radiator, and the shape and dimensions of an antenna all affect the radiated field pattern in space.

When RF current flows through a transmitting antenna, radio waves are radiated from the antenna in much the same way that waves travel on the surface of a pond into which a rock is thrown. Part of each radio wave moves outward in contact with the ground to form the groundwave, and the rest of the wave moves upward and outward to form the skywave. The ground and sky portions of the radio wave are responsible for two different methods of carrying signals from transmitter to receiver.

Commonly, the groundwave is considered to be made up of two parts: a surface wave and a direct wave. The surface wave travels along the surface of the earth, whereas the direct wave travels in the space immediately above the surface of the earth. The groundwave is used both for short-range communications at high frequencies with low power and for long-range communications at low frequencies with very high power.

That part of the radio wave that moves upward and outward, but is not in contact with the ground, is called the skywave. An ionized belt, found in the rarefied atmosphere approximately 40 to 350 miles above the earth, is known as the ionosphere. It refracts (bends) some of the energy of the skywave back toward the earth. A receiver in the vicinity of the returning skywave receives strong signals even though the receiver is several hundred miles beyond the range of the groundwave. The skywave is used for long-range, high-frequency, daylight communications. It also provides a means for long-range contacts at somewhat lower frequencies at night.

The direct wave is that portion of radiated energy which contains no sky or ground wave components. It attempts to travel in a straight line, however, it is refracted (bent) slightly downward due to atmospheric density. All

VHF and UHF communications are conducted via the direct wave.

CONTINUOUS-WAVE TRANSMITTER

One of the simplest types of radio transmitters is the continuous-wave (CW) transmitter (fig. 2-2). This CW transmitter is designed to send short or long pulse of RF energy to form the dots and dashes of the Morse code characters. Morse code transmission is also known as ICW (interrupt continuous wave).

A CW transmitter has four essential components: (1) a generator of RF oscillations, (2) a means of amplifying, and, if necessary, multiplying the frequencies of these oscillations, (3) a method of turning the RF output on and off (keying) in accordance with the code to be transmitted, and (4) a power supply to provide the operating potential to the various electron tubes and transistors. Although not actually a part of the transmitter, an antenna is required to radiate the keyed output of the transmitter.

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.

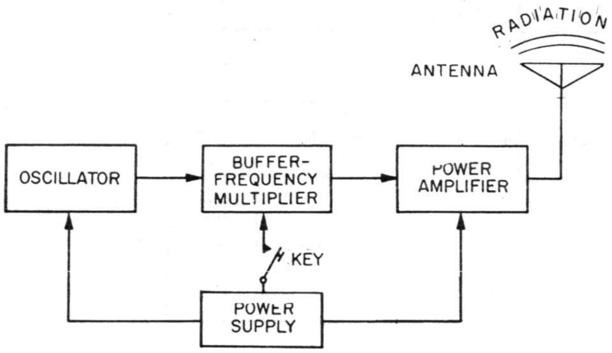

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Figure 2-2.—Continuous-wave transmitter.

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 usually is 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 such instances, the frequency-determining components 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, these 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 operated in such a manner that it greatly increases the magnitude of the RF current and voltage. The output from the PA is fed to the antenna via RF transformers and transmission lines. The PA is simply another RF amplifier. The last stage of RF amplification in a transmitter is usually referred to as the power amplifier.

POWER SUPPLY

Transmitters (and many other types of electronic equipment) require DC voltages ranging from a minus hundreds of volts to plus thousands of volts. Additionally, they need AC voltages at smaller values than those available from the ship's normal power source. It is the function of the power supply to furnish these voltages at the necessary current ratings. Usually, this is accomplished through transformer-rectifier-filter action, with the ship's power as the source of supply.

VOICE MODULATION

Because it is impractical to transmit electromagnetic waves at sound frequencies (15 hertz to 20,000 hertz), the intelligence, by means of modulation, is impressed upon a higher frequency for transmission. Modulation is the process of varying the amplitude or the frequency of a carrier signal (RF output of the transmitter) at the rate of an audio signal. The composite wave thus contains radiofrequency and audiofrequency components. The audio portions of the modulation are removed before transmission leaving the audio effect (envelope) on the RF wave for transmission. A receiver that is within reception range and tuned to the carrier frequency accepts the transmitter signal and removes the audio component from the carrier. This process is called demodulation or detection. The audio signal is then fed to a loudspeaker or headset which reproduces the original sound.

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. This process can be accomplished by removing the key and modifying the continuous-wave transmitter (fig. 2-2) so that the audio output from a microphone (and necessary amplifiers) is impressed on the carrier frequency. The required changes are incorporated in the block diagram of a basic AM radiotelephone transmitter, as shown in figure 2-3. The top row of blocks produces and amplifies the RF carrier frequency; the lower row produces and amplifies the audiofrequency. The speech amplifier driver, and modulator stages provide the voltage and power amplification required in the modulation process.

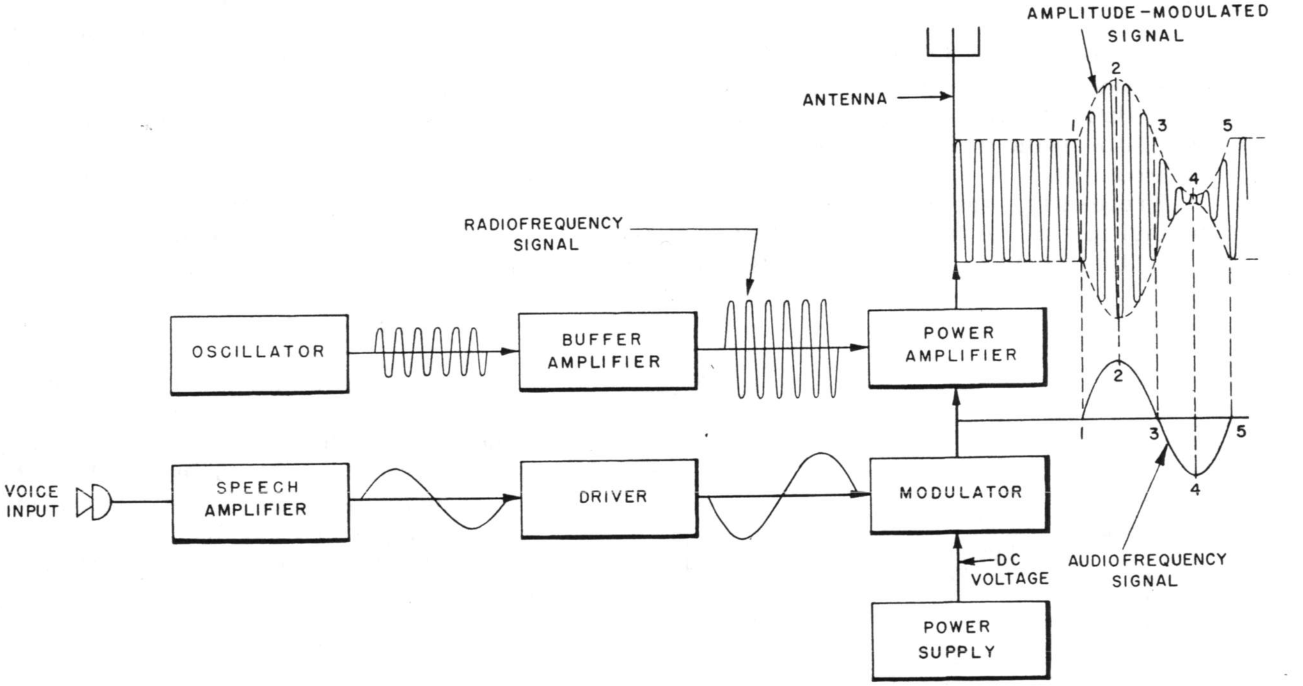

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Figure 2-3.—An AM radiotelephone transmitter.

Assume that the modulating audio signal is of constant frequency. The audio voltage is fed into the RF power amplifier stage so that it alternately adds to and subtracts from the DC 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 field at the antenna to increase gradually in strength during the time the audio voltage is increasing (from 1 to 2 on the waveforms, fig. 2-3). It also results in a decrease in strength during the time the audio output is decreasing (from 2 to 3). Similar variations in RF power output occur throughout each audio cycle. The waveform produced at the antenna thus contains the sum and difference frequencies combined with the carrier to produce a composite radio signal from which the audio may be extracted in a receiver.

Actually, the two frequencies introduced in the PA during the modulation process combine to produce two additional frequencies called sideband frequencies. The sideband frequencies are always related to the original two frequencies as sum and difference frequencies, respectively. The sum frequency, i.e., the sum of the RF carrier and audio-modulating frequencies, is called the upper sideband; the difference frequency is the lower sideband. At 100 percent modulation, one-sixth of the total power (RF plus audio power) appears in each of the sidebands.

The relationship of the carrier, audio, and sideband frequencies is illustrated in figure 2-4. Assume that the carrier frequency is 1000 kHz at 100 watts, and that the audio-modulating frequency is a single 1-kHz tone at 50 watts. Then, 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 sideband is 1,000,000 hertz +1000 hertz = 1,001,000 Hz (or 1001 kHz). The power in each sideband (25 watts) is one-sixth the total transmitter output power (150 watts).

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 (signal). This envelope is in the shape of the output waveform shown in figure 2-3.

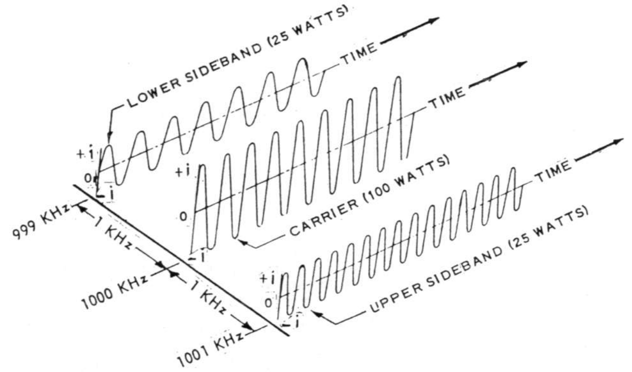

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Figure 2-4.—Carrier wave and its sideband frequencies.

During modulation, the peak voltages and currents on 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 transmitter power output for radiotelephone operation.

FREQUENCY MODULATION

Intelligence can be transmitted by varying the frequency of a carrier signal of constant amplitude. The carrier frequency can be varied a small amount on either side of its average or assigned frequency by means of the AF modulating signal. The amount the carrier is varied depends on the magnitude of the modulating signal. The rate with which the carrier is shifted depends on the frequency of the modulating signal. With or without modulation, the amplitude of the RF carrier remains substantially constant.

A block diagram of a representative FM transmitter, in which frequency modulation is accomplished by a phase-shift system, is shown in figure 2-5. 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 a 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.

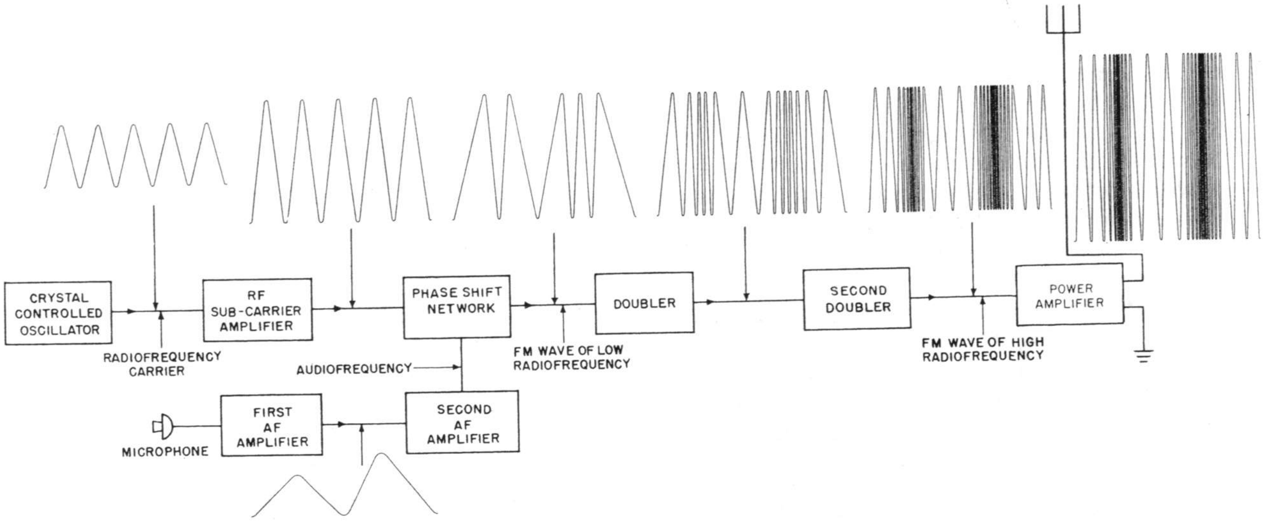

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Figure 2-5.—Block diagram of FM transmitter and waveforms.

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.

RECEIVERS

The modulated RF carrier wave produced at the transmitter travels through space as an electromagnetic wave. When the wave passes across a receiving antenna, it induces small RF voltages (and associated currents) in the antenna wire at the frequency of the transmitted signal. The signal voltage is coupled to the receiver input via an antenna coil or antenna transformer.

Electromagnetic energy is received from several transmitters simultaneously by the receiving antenna. The receiving circuits must select the desired transmitter signal from those present at the antenna and amplify this signal. The RF stages must isolate the internally generated frequencies within the receiver from the antenna which is necessary in observing radio silence. Further, the receiver must extract the audio component from the carrier frequency by a process called demodulation, or detection, and amplify the audio component to the proper magnitude to operate a loudspeaker or earphones.

TUNED RADIOFREQUENCY RECEIVER

The tuned radiofrequency (TRF) receiver is the forerunner of the modern military receiver. It is of the simplest design, and lends itself well for the purpose of explaining basic receiver principles. Although not used extensively in the Navy, it has advantages and may come back again due to improvements in solid state devices.

The TRF receiver (fig. 2-6) consists of one or more RF amplifier stages, a detector (demodulator) stage, one or more stages of audio amplification, a power supply, and a reproducer (usually loudspeaker or earphones). Waveforms that appear at the input and output of each stage are shown in the illustration.

Radiofrequency Stages

Radiofrequency stages of the receiver are designed to select and amplify the desired signal. The relative ability of a receiver to select a particular frequency and to reject all others is called the selectivity of the receiver. The relative ability of the receiver to amplify small signal voltages is called the sensitivity of the receiver. Both of these values can be improved within limits, by increasing the number of RF stages.

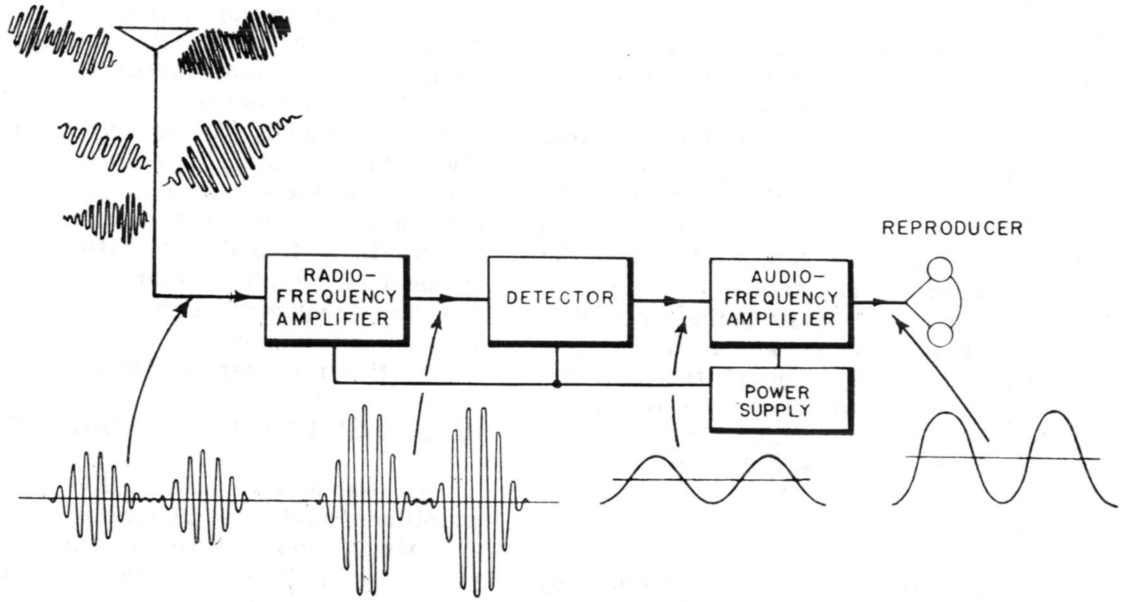

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Figure 2-6.—Block diagram of TRF receiver and waveforms.

Detector

In the detector stage, the intelligence component of the modulated wave is separated from the RF carrier. The separation process, called detection or demodulation, consists of rectifying the AM envelope and removing (filtering out) the RF carrier.

As seen earlier, amplitude modulation of an RF carrier with audio intelligence causes both the positive and the negative half cycles of RF to vary in amplitude. The resultant amplitude variations are a replica of the modulating audio signal. The detector stage accepts the RF amplitude variations at its input, and produces audio variations at its output.

Audio Amplifier

The function of the audiofrequency section of the receiver is to amplify the audio signal from the detector. In most instances, the amount of audio amplification necessary depends on the type of reproducer. If the reproducer is earphones, only one stage of amplification may be required.

Disadvantages of TRF Receiver

The principal disadvantages of the TRF receiver has been its inability to reject unwanted frequencies, and its inability to amplify desired frequencies uniformly. In other words, the selectivity and the sensitivity of the receiver are not uniform over its frequency range. As the TRF receiver is being tuned from the low-frequency end of its range towards the high-frequency end, the selectivity of the receiver will decrease; conversely, the sensitivity will increase. Solid state microminiature circuits are helping to minimize these disadvantages.

SUPERHETERODYNE (AM) RECEIVER

The superheterodyne receiver was developed to overcome the disadvantages of TRF receivers. The essential difference between the two types of receivers is in the amplifier stage(s) preceding the detector. Whereas the RF amplifier preceding the detector in the TRF receiver is tunable, the corresponding amplifier in the superheterodyne receiver is pretuned 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 2-7. 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 produced by a process called heterodyning. This action takes place in the mixer, so called because it receives and combines (mixes) two frequencies. These two frequencies are the incoming signal from the RF amplifier, and a locally generated, unmodulated RF signal of constant amplitude from the local oscillator.

The heterodyning action in the mixer (also called the first detector) produces four frequencies at the mixer output. These frequencies are (1) the incoming RF signal, (2) the local oscillator signal, (3) the sum of the incoming RF and local oscillator signals, and (4) the difference of these signals. Both the sum and difference frequencies contain the amplitude modulation. Usually, the difference-frequency is used as the intermediate frequency, although the sum-frequency can be used equally as well. A common intermediate frequency for communication receivers is 455 kHz.

SINGLE-SIDEBAND COMMUNICATIONS

As explained earlier, the intelligence of amplitude-modulated signals is contained in the sidebands, and for normal amplitude modulation, the intelligence in both sidebands is the same. Radio intelligence can be conveyed by removing the carrier and one sideband and transmitting only the remaining sideband if

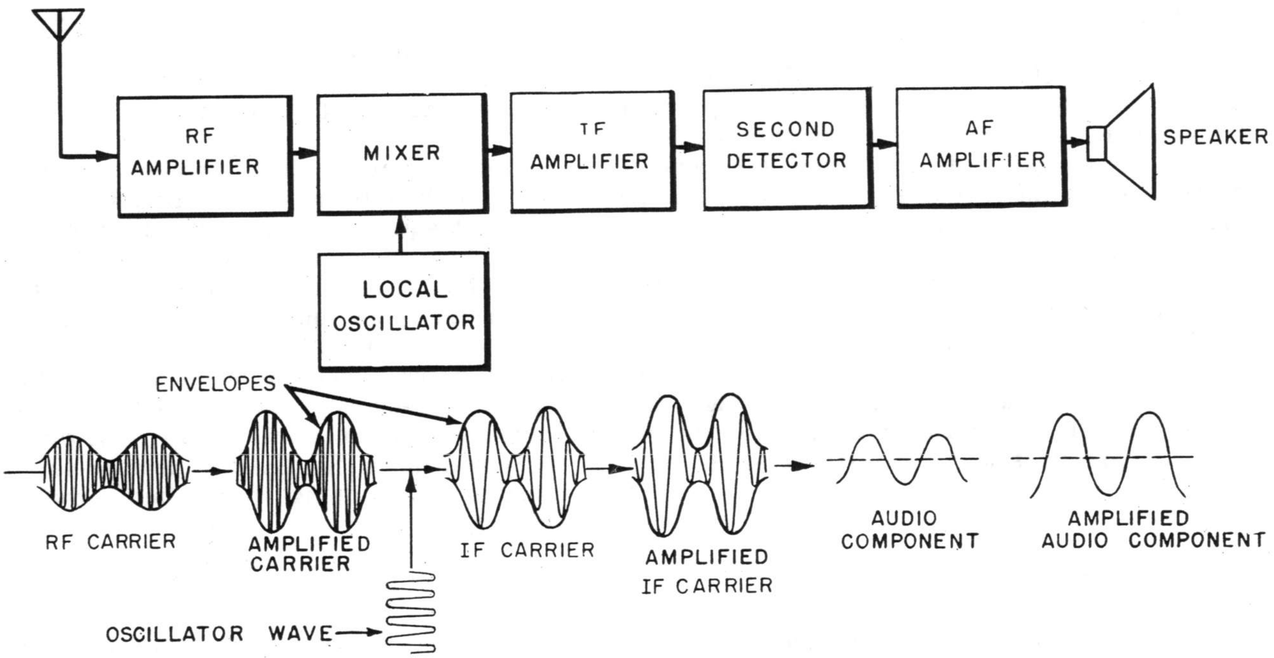

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Figure 2-7.—Block diagram of an AM superheterodyne receiver and waveforms.

some method of carrier reinsertion is used at each receiving station. This type of communications is called single-sideband (SSB) communications---all transmitting power is concentrated in the one sideband. The RF carrier, which has been either partially or entirely suppressed at the transmitter, must be reinserted at the receiver to combine with the received single sideband. The result is a waveform identical to the one produced in the transmitter before suppression of the carrier and one sideband.

Single-sideband communications has several advantages over the conventional AM system. One of the major advantages is that all of the radiated power is utilized in conveying the intelligence, and no power is lost in transmitting the carrier or duplicate sideband. A second advantage is that the bandwidth necessary for single-sideband reception is narrower than that required to receive both sidebands for the same contained intelligence; therefore, more single-sideband channels can be accommodated in a given band of frequencies. Third, the AM signal is less affected by selective fading or by manmade interferences.

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 waveform design. Compare block diagrams (figs. 2-7 and 2-8). In both AM and FM sets 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. This is necessary, since the bandwidth requirements for any type of modulation is that it must be wide enough to receive and pass all the side-frequency components of the modulated signal without distortion.

Sidebands created by FM and phase-modulated (PM) systems differ from those of the AM system. They occur at integral multiples of the modulating frequency on either side of the carrier wave. Remember that the AM system consists of a single set of side frequencies for each radiofrequency signal that is modulated. An FM or phase-modulated

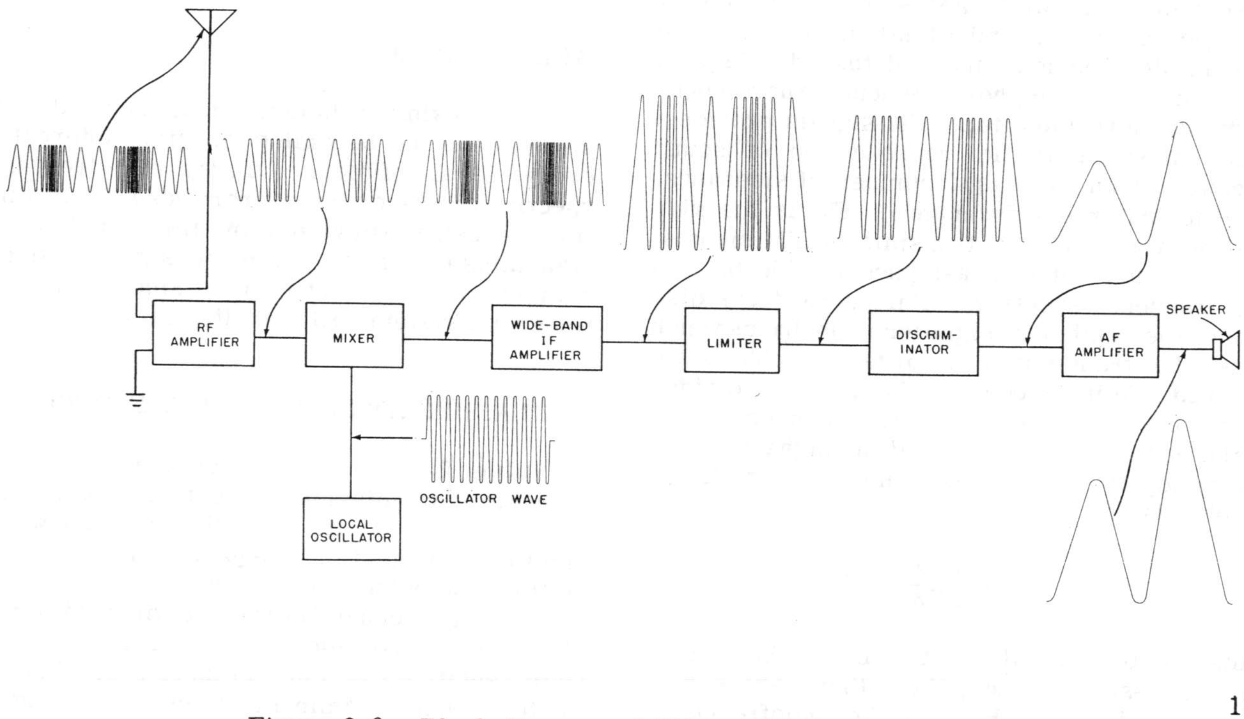

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Figure 2-8.—Block diagram of FM receiver and waveforms.

signal inherently occupies a wider band than AM and the number of these extra sidebands that occur during FM transmission is related to the amplitudes and frequencies of the audio signal.

Now we begin to see a marked difference between the two receiver diagrams (figs. 2-7 and 2-8). 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. Thus, in AM superheterodyne receivers, the "detector" is designed to respond to amplitude variations of the signal and 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 removed by the discriminator. This audio signal is amplified in the AF amplifier and sent to 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 development and had the advantage of operating at the higher frequency where spectrum is more plentiful. FM signals provide a much more realistic reproduction of sound because of an increased number of sidebands.

The major disadvantage of FM is the wide bandpass required to transmit the FM signals. Each station must be assigned a wide band in the frequency spectrum. During FM transmissions, the number of significant sidebands which must be transmitted in order to obtain the desired fidelity is equal to the deviation divided by the highest audiofrequency to be used. Thus, if the deviation is 40 kHz and the highest audiofrequency is 10 kHz, the number of significant sidebands is

$$\frac{40 \text{ kHz}}{10 \text{ kHz}} = 4$$

This number of sidebands exists on both sides of the rest frequency; thus, there are 8 significant sidebands. Because the audiofrequency is 10 kHz, and there are 8 sidebands, and bandwidth must accommodate an 80 kHz signal. This is considerably wider than the 10- to 15-kHz bandpass for AM transmitting stations.

Because of the wide bandwidth requirements, the Navy uses very little FM equipment. One type of FM equipment presently being used by the Navy is a series of walkie-talkie transceivers which provide voice communications for amphibious operations.

Frequency Conversion

Frequency conversion is accomplished by employing the heterodyne principle of beating two frequencies together to get an intermediate frequency. We have been studying this principle which is sometimes called single conversion.

Some receivers use double or triple conversion, sometimes referred to as double or triple heterodyning or detection. These receivers are more selective since they suppress image signals in order to yield sharp signal discrimination. (The image frequency is an undesired modulated carrier frequency that differs from the frequency to which a superheterodyne receiver is tuned by twice the intermediate frequency.) Double and triple conversion receivers also have better adjacent channel selectivity than can be realized in single conversion sets.

MULTIPLEXING

Multiplexing techniques used in naval communications is becoming of vital interest to every naval officer. Today our frequency spectrum is becoming overcrowded. This situation is being alleviated by the simultaneous transmission of two or more signals using a common carrier wave or a single path in a telegraph system called multiplexing.

CLASSIFICATION OF RADIO EMISSIONS

Table 2-2 is a reference table pertaining to radio transmission. The three main classifications of radio emission are shown as amplitude modulation, frequency or phase modulation, and pulse modulation.

To better acquaint ourselves with radio emissions, let us consider a few combinations and representative examples in table 2-2. A1 refers to telegraphic communications by keying an

Table 2-2.—Classification of Radio Emissions.

Symbol	Type of transmission
	Amplitude modulated
A0	Continuous wave (CW) no modulation.
A1	Continuous-wave (CW) telegraphy. On-off keying.
A2	Telegraphy by keying of a modulated emission.
A3	Telephony—Double sideband, full carrier.
A3A	Telephony—Single sideband, reduced carrier.
A3B	Telephony—Two independent sidebands with reduced carrier.
A3J	Telephony—Single sideband, suppressed carrier.
A4	Facsimile.
A5	Television.
A7	Telegraphy Multichannel Audiofrequency Tone Shift. (AFTSRATT).
A7B	Telegraphy Multichannel Audiofrequency Tone Shift. Two Independent Sidebands.
A7J	Telegraphy Multichannel Audiofrequency Tone Shift. Single Sideband Suppressed Carrier.
A9	Composite transmissions and cases not covered by above classifications of emissions.
A9A	Composite transmissions, reduced carrier.
A9B	Composite transmissions, two independent sidebands.
	Frequency (or phase) modulated
F0	Absence of modulation
F1	Telegraphy by Radio Frequency Carrier Shift. (RFCSRATT). No modulation.
F2	Telegraphy by keying of a modulating audiofrequency. Also by keying of modulated emission.
F3	Telephony.
F4	Facsimile.
F5	Television.
F9	Composite transmissions and cases not covered by above classification of emissions.
	Pulse modulated
P0	Absence of modulation intended to carry information (such as radar).
P1	Telegraphy—No modulation of audiofrequency.
P2D	Telegraphy by keying an audiofrequency which modulates the pulse in its amplitude.
P2E	Telegraphy by keying an audiofrequency which modulates the pulse in its width.
P2F	Telegraphy by keying an audiofrequency which modulates the pulse in its phase (or position).
P3D	Telephony—Amplitude modulated.
P3E	Telephony—Width modulated.
P3F	Telephony—Phase (or position) modulated.
P9	Composite transmissions and cases not covered by above classification of emissions.

Sampling of Transmitter Equipment

DESIGNATOR	TYPE OF EMISSION	SAMPLE EQUIPMENT
2.04A2	1020 Hz AFT Beacon	AN/WRT-1 (MF)
36F3	Telephony (FM)	AN/PRC-10 (VHF)

For further reference on radiofrequency emission, see JANAP 195.

unmodulated carrier wave (CW). A2 is also a form of telegraphy, but in this case, the transmitted signal is a keyed modulated carrier wave, generally referred to as MCW. In figure 2-9A and B, note that many more signal waves are involved in forming the DASH than in forming the DOT. This results from the time difference in the keying operation.

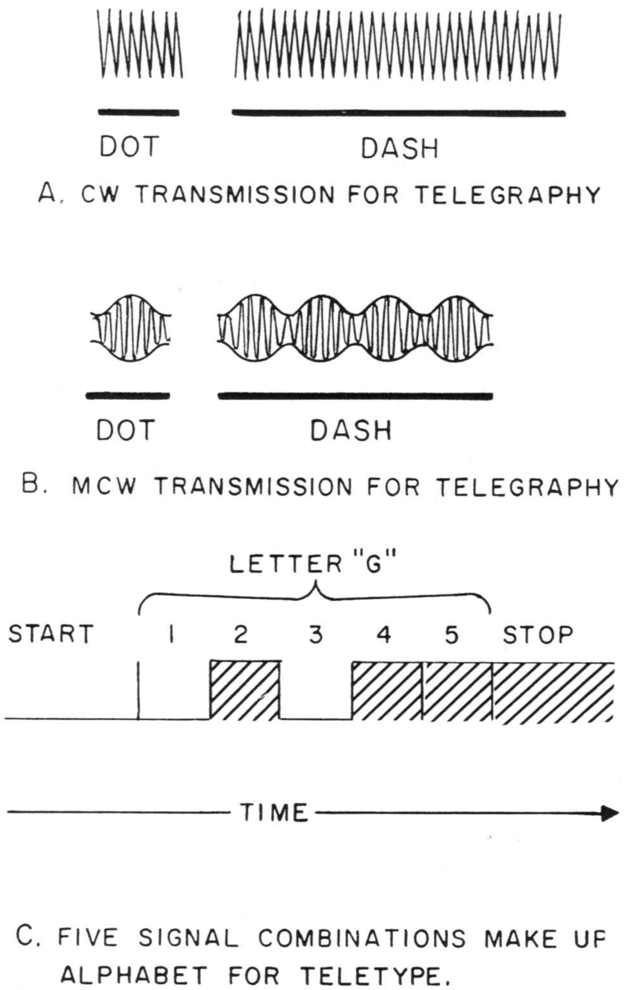

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Figure 2-9.—Representative types of special transmissions.

Various combinations of dots and dashes are used to form the alphabet by Morse code. The term "continuous wave" (CW) refers to the fact that the amplitude is continuous and does not vary. It does not refer to the interruption rate.

The advantage of CW over MCW is the narrow frequency band type of transmission involved for CW. CW is also advantageous for long range transmissions under severe noise conditions. Intelligence is easily encrypted for security using CW (A1) transmissions. A1 radio receivers, however, require a beat frequency oscillator (BFO) input to the IF stage to heterodyne with the continuous wave code so that audible tones can be reproduced at the second detector. This is not required for A2 reception since the incoming wave is modulated (MCW). A2 transmission is not often used for telegraphy, however, because a wider frequency band is required.

In recent years, the Navy has vastly improved its radio teletype (RATT) capabilities with new equipment that uses two types of RATT emissions (FM and AM). Both require the use of two discrete radiofrequencies to produce one channel of radioteletype; one frequency for the MARK signal and the other for the SPACE signal (fig. 2-9C). The START signals are always SPACE, and the STOP signals are always MARK. Combinations of 5 marks and/or spaces make up the various letters of the code.

The AN/WRT-1 (mentioned as a sample equipment at the bottom of Table 2-2) is a medium frequency range AM transmitter. In this example it is being used as a 1020 Hz audiofrequency tone homing beacon. 2.04A2 indicates the Navy's assigned bandwidth and type of transmission; 2.04 designates the "necessary bandwidth" in kHz and A2 represents telegraphy by keying of amplitude modulated emission.

The AN/PRC-10, another sample equipment, is an FM transmitter operating in the very high frequency range. In the designator 36F3 the 36 indicates the Navy's assigned bandwidth for the transmitter (36 kHz) and F3 denotes frequency modulated telephony.