RADIO AM & FM
LEARNING OUTCOME

- Understand the basic principle of radio receiver
  - Basic principle of AM and FM radio receiver
  - Function of each block in AM and FM radio block diagram.

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Basic Principle of AM & FM Radio

- A radio receiver is an electronic device that picks up electromagnetic signals from the air, amplifies them, extracts the intelligence, and reproduces the sound.

- The receiver must match the type of transmitter. The type of receiver is specified by the type of modulation the receiver is designed to handle: amplitude modulation (AM), frequency modulation (FM), frequency multiplexing (FM MUX), stereo, etc.

- Range: AM ➔ 540 kHz – 1600 kHz.
  
  FM ➔ 88 MHz 108 MHz

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AM Fundamentals
A high-frequency continuous wave produced by an oscillator is mixed with the low-frequency audio wave.

This produces a modulated wave used to transmit the intelligence from the transmitter to the receiver.

Figure 7.1 illustrates the amplitude modulation principle in which the intelligence, or low audio frequencies, varies the amplitude of the carrier.
AM Fundamentals

Figure 7.1: The two waves that form a modulated RF wave

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The AM wave or signal is a composite of the carrier and the upper and lower sidebands.

Most AM receivers are called superheterodyne receivers because of the mixer stage.

Figure 7.2 shows a block diagram of an AM receiver with the signals that are processed at each stage.

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AM Fundamentals

Figure 7.2: An AM receiver block diagram. (Courtesy Howard W. Sams & Co., Inc.)

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The antenna receives many radio frequencies within its frequency band.

The tuner, which consists of a variable capacitor and a coil, selects a desired band of frequencies and passes them on to the mixer stage.

At the mixer stage, the incoming RF signal is combined with a constant-amplitude continuous wave which oscillates at a frequency of (generally) 455 kHz [the usual intermediate frequency (IF)] above the incoming RF signal.

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The beating of the signals together produces many frequencies composed of the sums and differences of these signals.

The output of the mixer passes through a tank circuit tuned to 455 kHz.

Suppose that the RF tuning circuit is set to receive a signal at 1000 kHz and the IF circuit is set at 455 kHz.

Then the local oscillator (LO) will be set at 1455 kHz so that the new intermediate difference frequency of 455 kHz will be created.

The 455 kHz intermediate frequency (IF) is the difference between the incoming frequency of 1000 and 1455 kHz. Note that 455 kHz is the most common intermediate frequency; many receivers are designed to operate at other intermediate frequencies.

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The next stage of signal processing is a single stage or multiple stages (up to three) of **IF amplification**.

Each IF stage is tuned to the receiver's specific intermediate frequency for improving selectivity.

The function of the **detector** stage is to separate the audio intelligence from the IF carrier.

It does this in two steps. **First**, the composite signal is rectified, which leaves the upper envelope of the composite AM signal.

**Then** the IF carrier component is filtered through a capacitor to ground, and only the low-frequency audio signal is passed.

The **automatic gain control (AGC)** circuit feeds back a portion of the signal to provide control for constant volume.

The audio signal from the detector is passed through an **audio-frequency (AF) amplifier stage**.
FM Fundamentals
The frequency modulation (FM) technique of transmission begins with an RF carrier wave and an audio frequency called the modulating signal.

When the RF carrier is modulated with the audio signal, the frequency of the RF carrier varies with the amplitude of the modulating signal.

Figure 7.3 illustrates the principles of frequency modulation.
Figure 7.3: Frequency modulation principle—an audio wave mixed with a carrier wave, producing frequency variations.  
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Figure 7.4 : FM receiver block diagram.

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A block diagram of an FM receiver is shown in Fig. 7.4.

The **antenna** receives FM signals within its band, and the tuner stage selects a specific band of frequencies.

The **RF amplifier** strengthens the FM signal.

The **local oscillator** (LO) generates a constant-amplitude RF signal which is mixed with the FM signal, producing an intermediate frequency.

The **IF** stages are generally tuned to 10.7 MHz. The IF stage or stages pass as well as amplify the IF carrier.

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The **FM detector** stage is different from the AM detector stage. The **FM detector** must convert the frequency variations to its audio representation.

Then the detected audio signal is fed through a de-emphasis network.

The de-emphasis network restores the relative amplitudes of the signal's frequency components.

At the **transmitter**, the high frequencies are further amplified-called *pre-emphasis* to improve the signal-to-noise ratio for transmission. Therefore, at the receiver, a reverse process must be done.

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After de-emphasis processing, the audio signal is amplified to drive the speaker at the audio amplifier stage.

Notice that there is an automatic frequency control (AFC) which keeps the receiver oscillator properly tuned.

Some of the AM circuit can be used by an FM receiver. Figure 7.5 illustrates a block diagram of a combination AM-and-FM receiver.

When you switch from AM to FM reception, the unique circuits are all switched in simultaneously. 

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Figure 7.5: AM/FM receiver block diagram.

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Radio Troubleshooting
Radio Troubleshooting

- Several techniques are used in troubleshooting radio and sound equipment.

- For example, when you are troubleshooting a superheterodyne receiver, start with a visual and hearing inspection.

- Look for obvious signs of damage. If the receiver has a hum, most likely it has a defective filter capacitor. Test the suspected filter capacitor by bridging it with a known good one of equal value or by using a capacitor substitution box, as shown in Fig. 7.19.

- If the hum disappears, replace the filter.

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Radio Troubleshooting

Figure 7.6: Using a substitution box to bridge a capacitor.

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Radio Troubleshooting

- In a dead set, check the switch with an ohmmeter.
- Naturally, this should only be done with the unit disconnected from the power line.
- Also, use the ohmmeter to check the fuse, power supply diode, thermistor (Fig 7.7), and filter coil (Fig. 7.8).
- Any one of these components could cause an open circuit. A simple power supply showing the above components is seen in Fig. 7.9.

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Radio Troubleshooting

Figure 7.7 : Thermistor

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Radio Troubleshooting

Figure 7.8: Filter Coil

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Radio Troubleshooting

Figure 7.9: Simple power supply.

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Radio Troubleshooting

- If a radio or stereo plays for a while, then stops and comes back on later, check for thermally intermittent components.
- Using a combination hot-and-cool blower, carefully heat the suspected transistors or ICs.
- When the defective component is heated, the receiver will stop playing or become badly distorted.
- Now cool off the transistor, using the cool-air blower or a chemical freeze mist.
- The receiver should once again operate normally.
- When the thermally intermittent transistor has been found, replace it with a recommended model.

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If a receiver has power but fails to produce sound, first try to isolate the defective stage.

Signal injection can be used to locate the faulty stage, as shown in Fig. 7.10.

First, using an AF signal generator or a noise generator, connect the ground lead to the chassis ground and the other lead to each stage of the receiver.

Start by injecting an AF signal around 1 kHz or 400 Hz into the speaker; this should produce a tone.

If you hear a tone, the speaker is operating, proceed to the amplifier stage, and inject a signal into the base of this transistor.

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Radio Troubleshooting

- If a tone is heard, proceed to the next stage toward the detector.
- When you inject a signal into the detector stage or back to the antenna, use an RF signal.
- If no tone is heard when the RF signal is injected into the detector stage, you can assume this is the faulty stage.
- At this time, proceed to make resistance checks of each component until the faulty component is located.

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Radio Troubleshooting

Figure 7.10: Stereo multiplex separator test setup

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LASER DISK PLAYERS
Laser Disk Players

- Laser disk players (compact disks) are now the standard for music and are becoming more popular again for video recordings.
- The major advantage of the laser disk is that the information is digitally recorded.
- This means that the voltage of the signal coming from a microphone or video camera is sampled at regular intervals, and the value of the signal at that instant in time is stored as a binary (digital) number.
- These digital numbers are stored by burning pits in the surface of a disk, using a laser beam.
The circuitry necessary to reproduce sound or video images from digital information is very sophisticated.

A semiconductor laser reflects its beam off the surface of the disk as it rotates.

As the beam strikes the pits, the light does not reflect, and this change is sensed by the circuitry.

Combinations of these reflecting and nonreflecting points are used to represent numbers, and a sequence of these numbers represents the original analog signal (audio or video).

Digital signal processing in the CD player's circuitry is able to minimize noise and distortion while reproducing a signal very similar to the original analog input.
The actual circuitry that makes up the spindle speed control, the pickup carriage control, and the audio signal processing on a CD player is not generally repairable.

It must be replaced if it is found to be defective.

The input and output actuators such as switches, sensors, and motors should be checked.
**LASER DISK PLAYERS**

- Laser disk players, in many respects, have similar mechanical components to those of CD and tape players.

- Typical problems involve the mechanical parts, such as the loading mechanism, spindle motor elevator mechanism, lever assembly, tilt sensor, tilt motor and cam gear, drive gear, and other limit switches, levers, and brackets.

- For example, if the disk is not loading, consider the loading mechanism or whether the trigger switch is engaging.

- Poor playback may be a result of misaligned or defective tilt sensor, pickup carriage, spindle, drive assembly, or circuit problem.

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Laser Disk Players

- Foreign material can also be a problem. Check the pickup lens for dust and dirt.
- Clean the lens and surrounding components, using a cotton swab and isopropyl alcohol.
- Gently wipe the lens in a spiral motion from the center of the lens to the outer edges.
- Never use other types of alcohol, or else damage may result.

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The basic test for a multiplex unit is to measure the decibel (dB) separation between the L and R signals that it produces.

The setup for a stereo multiplex separation test is illustrated in Fig. 7.10.

A stereo multiplex signal generator supplies the L and R signals, which are the same but different in phase relationship.

Therefore, when the R signal is applied to the multiplex unit, the R output channel should be maximum, while the L channel should theoretically be zero.
Figure 7.10: Stereo multiplex separator test setup

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