Amplitude Modulation (AM)
Double Side Band Full Carrier (DSBFC)
Percent of Modulation (%OM)

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The degree of modulation is defined in terms of the maximum permissible amount of modulation. Thus, a fully modulated wave is said to be 100-Percent Modulated. The modulation envelope in **figure 1-1(A)** shows the conditions for 100-percent sine-wave modulation. **For this degree of modulation, the peak audio signal wave voltage must be equal to the DC supply voltage to the final power amplifier. Under these conditions, the RF output signal wave voltage, will reach '0' on the negative peak of the modulating signal wave and the RF output signal wave voltage, will rise to twice the amplitude of the positive peak of the unmodulated carrier wave.**

When analyzed, the **modulation envelope** consists of the **unmodulated RF carrier wave voltage and the combined voltage of the two sidebands.** The combined sideband voltages are approximately equal to the RF carrier wave voltage since **each sideband audio signal wave voltage contains one-half the carrier wave voltage,** as shown in view **figure 1-1(B)**. This condition is known as 100-percent modulation and **the maximum modulated RF voltage wave is twice the carrier wave voltage.**

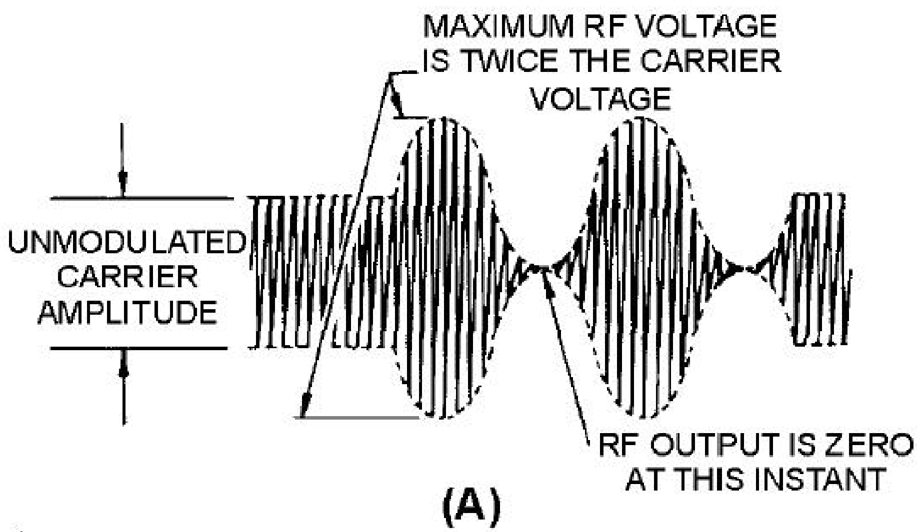


Figure 1-1A. Conditions for 100-percent modulation.

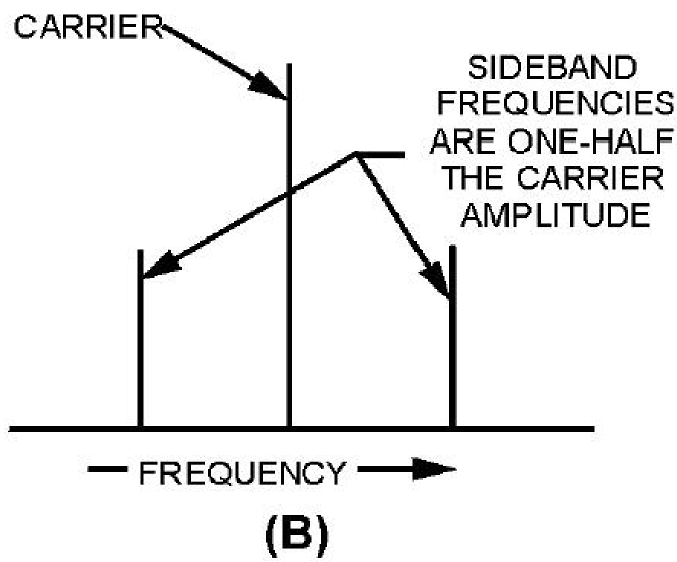
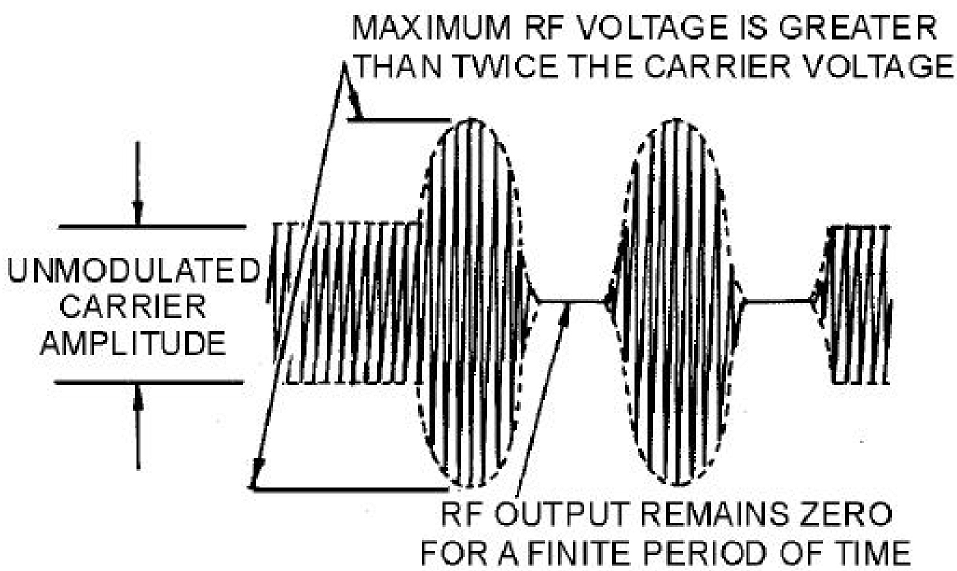


Figure 1-1B. Conditions for 100-percent modulation.

The audio-modulating wave voltage can be increased beyond the amount required to produce 100-percent modulation. When this happens, the negative peak of the modulating signal wave becomes larger in amplitude than the DC plate-supply voltage to the final power amplifier. This causes the plate, base or drain voltage to be negative for a short period of time near the negative peak of the modulating wave signal. For the duration of the negative plate, base or drain voltage, no RF energy is developed across the plate, base or drain tank circuit and the RF output wave voltage remains at '0', as shown in **figure 1-2(A).**

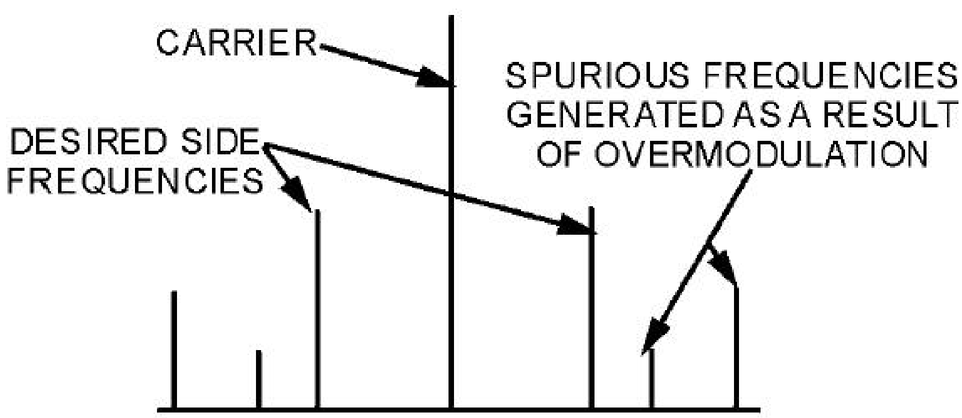
Look carefully at the modulation envelope in view (A). It shows that the negative peak of the modulating wave signal has effectively been limited. If the signal were demodulated (detected in the receiver), it would have an appearance somewhat similar to a square wave. This condition, known as **Overmodulation,** causes the signal to sound severely distorted (although this will depend on the degree of overmodulation). Overmodulation will generate unwanted (SPURIOUS) sideband frequencies. This effect can easily be detected by tuning a receiver near, but somewhat outside the desired frequency. You would likely be able to tune to one or more of these undesired sideband frequencies, but the reception would be severely distorted, possibly unintelligible. (Without overmodulation, no such unwanted sideband frequencies would exist and you would be able to tune only to the desired frequency.) These unwanted frequencies will appear for a considerable range both above and below the desired frequency. This effect is sometimes called SPLATTER. These spurious frequencies, shown in **figure 1-**

2(B), cause interference with other stations operating on adjacent frequencies. **You should clearly understand that overmodulation, and its attendant distortion and interference is to be avoided**.



(A)

Figure 1-2A. Overmodulation conditions.



(B)

Figure 1-2B. Overmodulation conditions.

In addition to the above problems, overmodulation also causes abnormally large voltages and currents to exist at various points within the transmitter. Therefore, sufficient overload protection by circuit breakers and fuses should be provided. When this protection is not provided, **the excessive voltages can cause arcing between transformer windings and between the**

plates of capacitors, which will permanently destroy the dielectric material. Excessive currents can also cause overheating of tubes and other components.

Ideally, you will want to operate a transmitter at 100-percent modulation so that you can provide the maximum amount of energy in the sideband. However, because of the large and rapid fluctuations in amplitude that these signals normally contain, this ideal condition is seldom possible. When the modulation gain is properly adjusted, the loudest parts of the transmission will produce 100-percent modulation. The quieter parts of the signal then produce lesser degrees of modulation.

To measure degrees of modulation less than 100 percent, you can use a MODULATION FACTOR (M) to indicate the relative magnitudes of the RF carrier and the audio-modulating signal. Numerically, the modulation factor is:

$$M = \frac{E_m}{E_c}$$

Where:

M = the modulation factor

E_m = the peak, peak-to-peak, or rms value of the modulating voltage

E_c = the peak, peak-to-peak,

To illustrate this use of the equation, assume that a carrier wave with a peak amplitude voltage of 400 volts is modulated by a 3-kilohertz sine wave with a peak amplitude voltage of 200 volts. The modulation factor is figured as follows:

$$M = \frac{E_m}{E_c}$$

$$M = \frac{200}{400}$$

$$M = 0.5$$

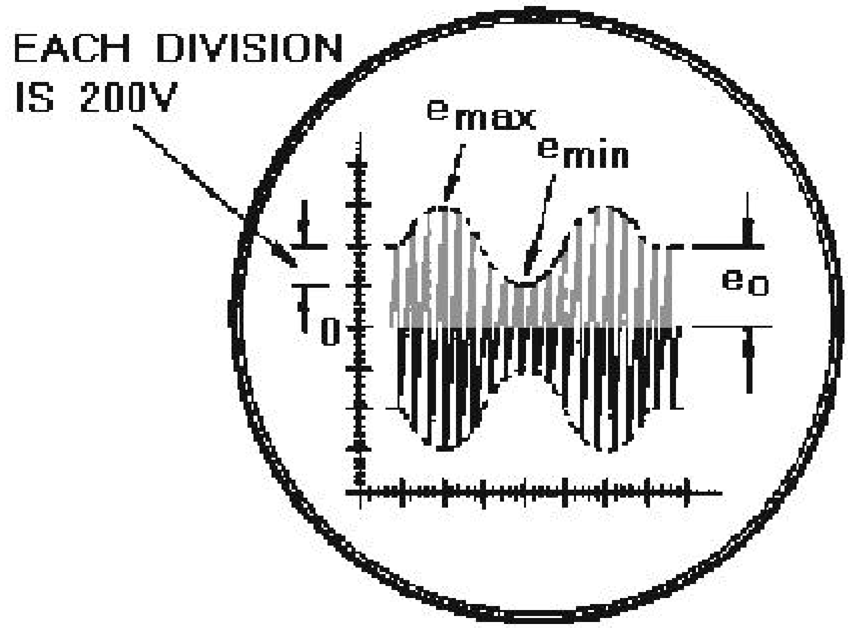
If the modulation factor were multiplied by 100, the resultant quantity would be the PERCENT OF MODULATION (%M):

$$\%M = \frac{E_m}{E_c} \times 100$$

$$\%M = \frac{200}{400} \times 100$$

$$\%M = 50 \text{ percent}$$

By using the correct equation, you can determine the percent of modulation from the modulation envelope pattern. This method is useful when the percent of modulation is to be determined using the pattern on the screen of an oscilloscope. For example, assume that your oscilloscope is connected to the output of a modulator circuit and produces the screen pattern shown in **figure 1-3.** According to the setting of the calibration control, each large division on the vertical scale is equal to 200 volts. By using this scale, you can see that the peak carrier amplitude (unmodulated portion) is 400 volts. The peak amplitude of the carrier is designated as e_o in **figure 1-3**.



$$\%M = \frac{e_{max} - e_{min}}{2e_0} \times 100$$

-OR-

$$\%M = \frac{e_{max} - e_{min}}{e_{max} + e_{min}} \times 100$$

Figure 1-3. Computing percent of modulation from the modulation envelope.

The amplitude of the audio-modulating signal voltage can also be determined from amplitude variations in the envelope pattern. Notice that the peak-to-peak variations in envelope amplitude ($e_{max} - e_{min}$) are equal to 400 volts on the scale. Note then that the peak amplitude of the audio signal voltage is 200 volts. If these RF and audio signal voltage values are inserted into the equation, the pattern in figure 1-3 is found to represent 50-percent modulation.

If E_m and E_c in the equation are assumed to represent peak-to-peak values, the following formula results:

$$\%M = \frac{E_m}{E_c} \times 100$$

Since the peak-to-peak value of E_m in **figure 1-3** is $e_{max} - e_{min}$, we can substitute as follows:

$$\%M = \frac{e_{max} - e_{min}}{E_c} \times 100$$

Also, since the peak-to-peak value of the carrier E_c is 2 times e_o, we can substitute $2e_o$ for E_c as follows:

$$\%M = \frac{e_{max} - e_{min}}{2e_o} \times 100$$

Linear vertical distance represents voltage on the screen of a cathode-ray tube. Vertical distance units can be used in place of voltage in equations. Thus, if only the percent of modulation is required, the oscilloscope need not be calibrated and the actual circuit voltages are not required. In **figure 1-3**, e_{max} represents 600 volts (3 large divisions); e_{min} is 200 volts (1 division); and e_o is 400 volts (2 divisions). Using the equation and the dimensions of the screen pattern, you can figure the percent of modulation as follows:

$$\%M = \frac{e_{max} - e_{min}}{2e_o} \times 100$$

$$\%M = \frac{3 - 1}{2 \times 2} \times 100$$

$$\%M = \frac{2}{4} \times 100$$

$$\%M = 50 \text{ percent}$$

When e_o of the equation is difficult to measure, an alternative solution can be obtained with the equation below:

$$\%M = \frac{e_{max} - e_{min}}{e_{max} + e_{min}} \times 100$$