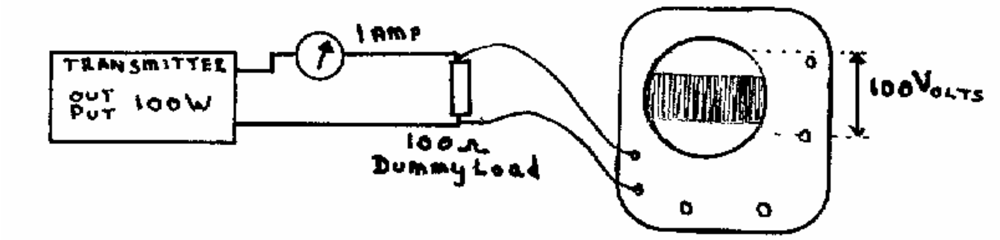
Moving on from "DC input"

The original way to lay down the *maximum permitted power* was in terms of "DC input" to the *final stage.* This also made the assumption that the final valve or transistor would not exceed certain operating efficiencies (Class A 50%; Class B 66.6% and Class C 80%)



The above transmitter is being operated at the "old fashioned limit" of *150 watts DC input*. It is either a FM or CW (key down) transmitter.

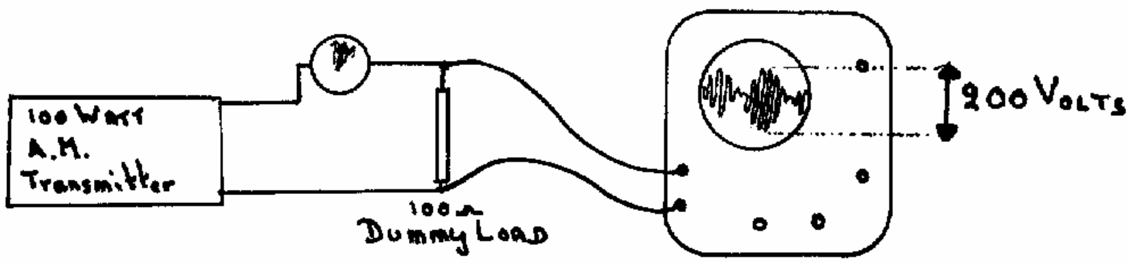
[FM= frequency modulated; CW = carrier wave (Morse)]

More precise measurements can now be made using a calibrated oscilloscope. It shows the transmitter connected to a 100Ω dummy load. The oscilloscope is displaying the RF waveform by connecting it across the dummy load.

The display shows the carrier wave. Being FM or CW (with the key held down) is has constant amplitude.

The RF power out from the transmitter is 100 Watts. This results in 1 Amp flowing through the 100Ω dummy load resistor. The RF voltage across this dummy load, as indicated by the oscilloscope, is 100 volts.

Amplitude modulation



The 100 watt carrier is then fully amplitude modulated.(100%) by a sine wave audio tone. The resultant RF output is displayed on the oscilloscope. The radio frequency is very high compared with the audio frequency and the individual RF cycles may merge into each other on the screen and just appear as a green "modulation envelope".

The carrier now varies between zero and **twice** the amplitude of the original (unmodulated) carrier.

The ammeter now vibrates, with the modulation and gives a fairly meaningless reading.

In this example the *peak to peak* voltage is 200 volts. The power in the 100Ω dummy load is therefore:

$W = V^2/R = 200^2/100 = 400$ Watts pep (*peak envelope power).* This equates to 26 dBW.

In other words: *the power at the peak of the modulation envelope is 400 watts*

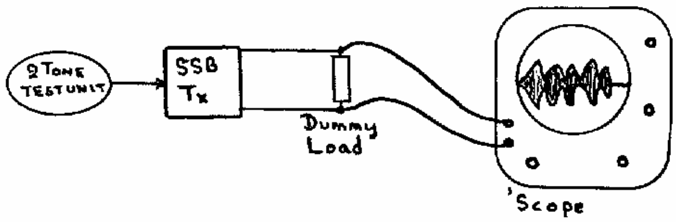
Remember:

It is <u>very important to avoid *over modulation*</u>. Therefore it is better to aim for, say 80% modulation when using speech.

Single sideband (SSB)
As you will remember, a SSB transmission only contains one side band. The other sideband has been eliminated and the carrier has been suppressed.
It is very important to ensure that the various frequencies contained in the remaining sideband do **not** intermodulate (mix) with each other. If this did occur, other unwanted frequencies (intermodulation products) would be generated and transmitted…. This is very undesirable and must be avoided at all costs otherwise considerable interference will be caused.
It is therefore important that there is a means of ensuring that the power amplifier is functioning correctly. It is **not** just a case of adjusting the amplifier for maximum output……..It must be adjusted to give a "clean" output. IE No intermodulation products.

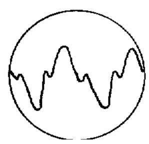
Note that if a single frequency is connected to the microphone input, then the transmitter output will be a single radio frequency. Thus a single tone will not be an adequate test for the presence of intermodulation products.
If, however, two audio frequencies are applied the microphone input the result should be just two radio frequencies at the transmitter output. If the transmitter power amplifier is faulty or incorrectly adjusted, then its non-linearity would result in extra intermodulation products.
The "Two Tone Test" has been developed so that this important check can be carried out by the Radio Amateur with easily available test equipment.

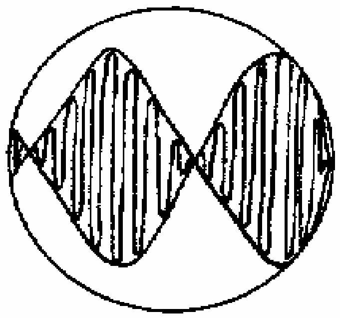
Two Tone Test



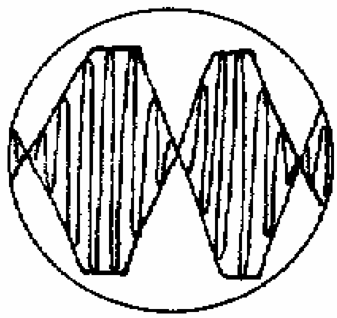
The *two tone generator* comprises two audio oscillators whose out puts are combined into a single output to be connected to the *microphone input* of the transmitter under test.
Both of the frequencies must be in the normal microphone input frequency range.
The tones should have the same amplitude but must not be harmonically related.
700Hz and 2kHz would be suitable frequencies.

The combined output of the *two tone generator* would look like this.

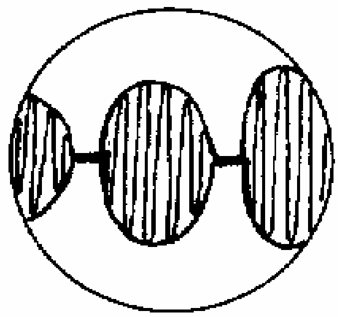




This is the "good" waveform. The peaks are correctly rounded and the crossover is sharp and straight.
No intermodulation
Indicates a fault.



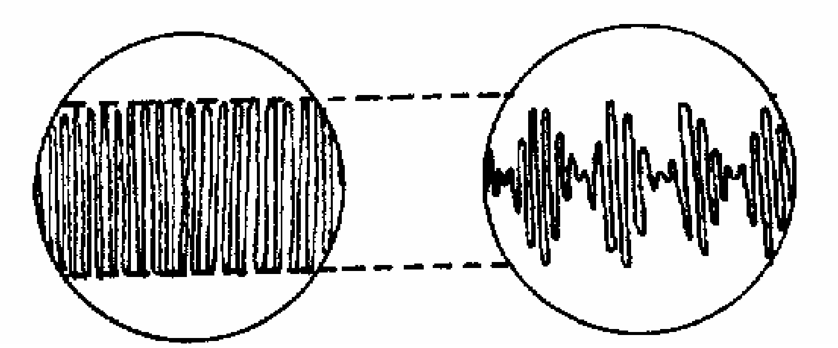
Could be the result of *over driving* the Power Amplifier stage of the transmitter. There is intermodulation.
Indicates a fault.



Perhaps due to incorrect bias of the power Amplifier stage of the transmitter. There is intermodulation.

SSB Transmitter Power Measurement

RF out put with 1 tone at mike input RF output with 2 tones at mike input



The waveform on the left is the display of the RF output of a SSB transmitter that has a single tone injected at the microphone input. As mentioned before, a single tone input will result in a single Radio Frequency output.

However, the display on the right, shows the RF out put from the same transmitter when it has *two tones* injected at the microphone input.

Both displays show waveforms of equal amplitude, but the power contained is very different!

In fact, the RF power output from a transmitter fed with the *two tone input* will have **half** the **mean power** of the RF output resulting from a *single tone* input.
Or, to put it another way:- the *mean power output* of an SSB transmitter fed with two tones will be 50% of the *Peak Envelope Power*.
The oscilloscope screen is then marked with two lines to indicate the voltage across the dummy load that represents 400 watts PEP (equivalent to a Mean power of 200 watts).

The transmitter output power is then increased until the display just meets the calibration lines. The display should then be carefully examined to ensure that no distortion has taken place occurred.
For example, if "flat topping" occurs, then the drive should be reduced until a perfect waveform returns.

The Two tones are then replaced with speech and the *mike gain* (or drive) is adjusted so that the above limits are not exceeded. IE do not exceed the lines to mark maximum permitted power or a lower level to avoid distortion.

Sample calculation
The following question appeared in a RAE manual:-

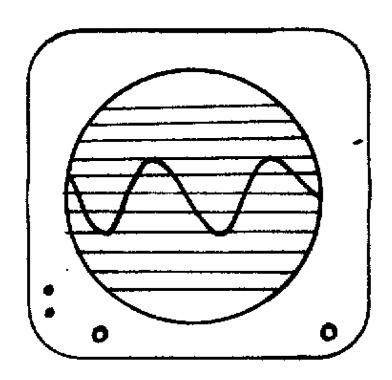
> A transmitter is connected to a 50Ω dummy load. With a two tone input there is a 2 cm deflection on an oscilloscope connected across the load while it is dissipating 72 Watts
> What is the peak envelope power output when the two tones are replaced with speech whose peaks cause a deflection of 3cm?.

Answer to sample problem.

With the two tone signal the power in the load will be half of that for a single tone.
Thus the true power output is 72 x 2 = 144 Watts. (this results in the 2 cm deflection)
It is important to note that the power is proportional to the *square of the voltage*.
$W=V^2/R$
The speech results in a 3cm voltage deflection whereas the 144Watts only gave a 2cm deflection.
Thus the P.E.P. output (from 3cm speech deflection) is $144 \times (3^2/2^2)$
$= 144 \times 9/4 =$ **324 Watts**

Questions.

Q1
This oscilloscope is displaying a waveform that is 80 volts peak to peak.
The "Y" amplifier would be set to a sensitivity of:-



- (a) 20 volts per division
- (b) 10 volts per division
- (c) 40 Volts per division
- (d) 5 volts per division

Q2
The main purpose of the *two tone test* is to:
- (a) check their frequencies when combined
- (b) measure the depth of modulation
- (c) measure the output power
- (d) check for intermodulation

Q3
What is "effective radiated power
- (a) The amount of power from the supply that is not given off as heat
- (b) The product of the power supplied to the antenna and its gain in the direction of maximum radiation.
- (c) The product of the power supplied to the transmitter and the gain of the last valve or transistor.
- (d) The amount of power from the supply that is given off as heat

Q4
What is Peak Envelope Power
- (a) The average power supplied to the antenna by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken during maximum operating conditions
- (b) The peak power supplied to the antenna by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken during normal operating conditions
- (c) The average power supplied to the antenna by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken during normal operating conditions
- (d) The mean power supplied to the antenna by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken during normal operating conditions

