Engineering News

ALTEC LANSING

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TECHNICAL LETTER NO. 172

PEAK FACTOR DEMONSTRATION TEST SET

This demonstration was designed to visually illustrate the differences between the effective (or RMS) voltage as measured on a VOM and the true peak voltage encountered in complex waveforms of music and speech.

1. 70V Input

   From a signal generator, recorded tape, or other suitable source, a sinewave signal is fed into a power amplifier having a 70 Volt output, the input being sufficient to drive the amplifier to full output. This output is then monitored on the test set. The VU meter, calibrated for 70V at "0 VU" will read "0"; the two remaining meters will directly indicate 70 Volts. This is illustrated in Figure 1.

2. Complex Waveforms

   The recorded signal will then change from a pure sinewave to speech and music. The difference in the meter readings becomes immediately apparent. Both the VU meter and the average responding meter (on the right) will indicate a level considerably lower than the center meter, which responds to the peak value of the waveform. The reasons for this difference are explained in the appendix section, but the apparent discrepancy in the readings has a very real meaning. This relates directly to the "peak factor", or peak-to-RMS ratio.

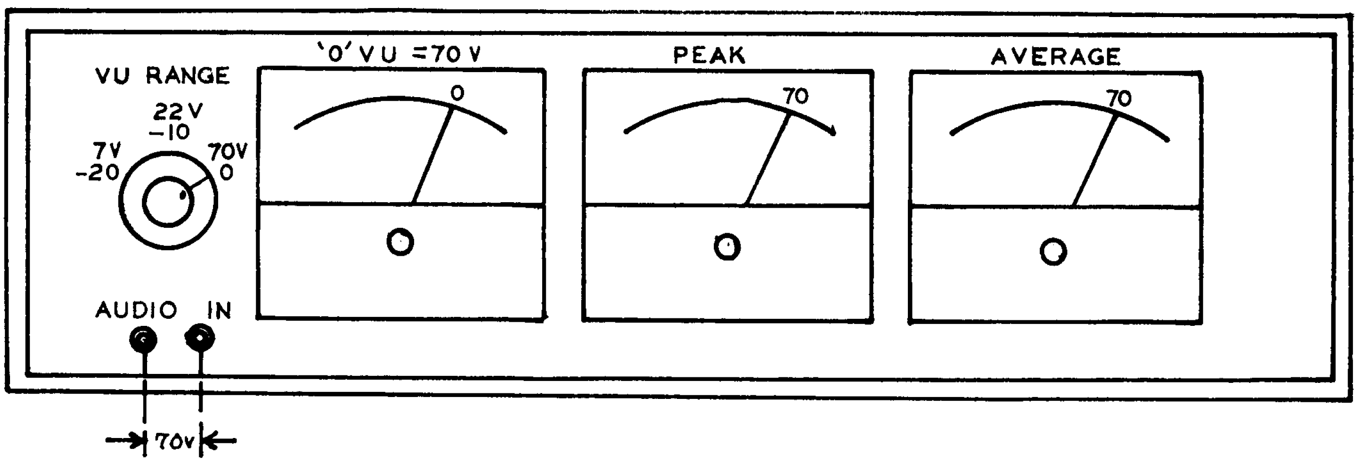


Figure 1.

APPENDIX

This test set was fabricated for the purpose of demonstrating the often confused "peak factor" prevalent in audio frequency complex waveforms. This peak factor, which is referred to so frequently in discussions of amplifier power and overdrive requirements, remains a subject which is often misunderstood.

The front panel of this test set, illustrated in Figure 1, contains three separate meters. On the left is a standard VU meter, whose ballistics conforms to the accepted ASA standard for VU indicators. Associated with it is a switch providing two attenuation steps of 10 dB each, 0 Vu indicating 70V, -10 indicating 22 Volts, and -20 indicating 7 Volts.

In the center is a meter calibrated in RMS Volts, 100 Volts full scale, but whose circuitry is such that it responds to the PEAK of the waveform. At the right is a second meter calibrated in RMS Volts, 100 Volts full scale, but whose circuitry responds to the AVERAGE value of the waveform.

When a 70 Volt (RMS) sinewave signal, shown in Figure 2, is applied to the test set, both the peak and average responding instruments will indicate 70 Volts. This is the same voltage which would be read on an external piece of test equipment, such as a VOM. The test set's VU meter is adjusted to indicate "0 VU" with this 70V sinewave signal. The meter readings are shown in Figure 1. The sine waveform in Figure 2 is labeled to indicate the four values normally associated with a waveform. Although a normal rectifier-type instrument, such as a VOM, actually responds to the AVERAGE value of the waveform, its scale is calibrated in EFFECTIVE (or RMS) Volts. It should be noted that this reading is correct only with a sine waveform, as will be shown below.

When a complex waveform (non-sinusoidal), such as speech or music, is monitored with the test set, both the VU and average responding instruments show a reading much lower than the peak responding instrument. Therefore, while an average responding meter will indicate a relatively low power level, the peak reading meter will indicate a level considerably higher due to the inherent electrical characteristics of the complex waveforms. Then, the difference in readings will relate directly to the peak factor (or crest factor), which is the peak-to-effective (or RMS) ratio. Therefore, if the peak of a complex waveform has 3.15 times the amplitude of the effective value, the peak factor is 3.15, or in more commonly used terms, 10 dB. This means that the peak voltage appearing across the load is actually 10 dB greater than that read on an external VOM. At high power levels, therefore, while the effective power is well below the amplifier's capabilities, the waveform peaks may be driving the amplifier well into the overdrive, or clipping, region. This is illustrated in Figure 3.

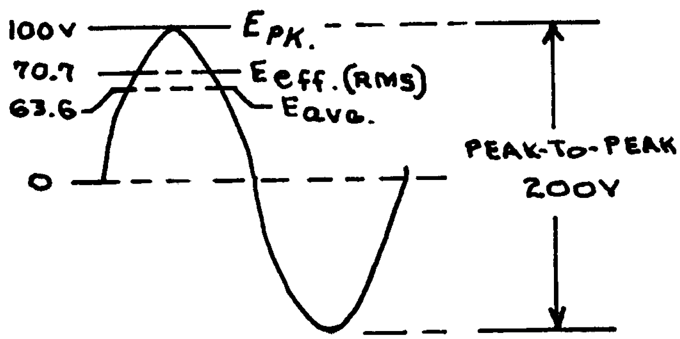


Figure 2.

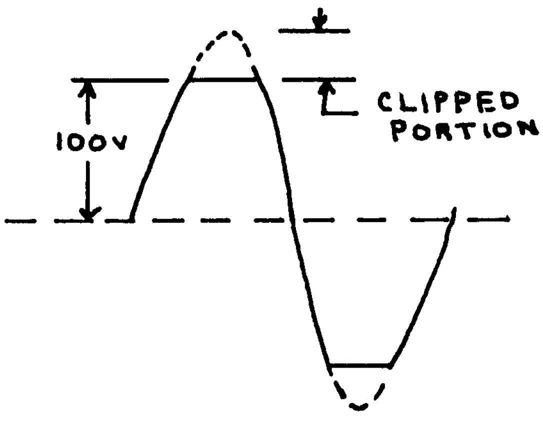
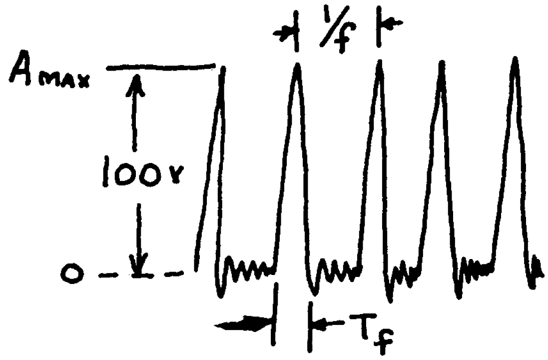


Figure 3.

Figure 3 shows a sinusoidal waveform driven into the clipping region. However, it should be noted that a pure sine waveform is obtained from signal generators, and very rarely occurs in either speech or music; the closest approximation of a sinusoidal is obtained from an organ. Normally, the waveforms encountered are complex. This is particularly true in music, where precussion instruments produce a very high peak factor, the wavefronts resembling narrow pulses. In this type of waveform, the effective level is low, but the peak factor may be 10 or more. To illustrate this, let's look at the case of a precussive instrument, such as a roll on a snare drum, at the rate of 5 beats per second. Figure 4 illustrates this (drawing is exaggerated for clarity).

From this, we see that although the peaks attain the 100V level, the effective, or RMS, value is 18.25V while the average is only 2.5 Volts. This represents a peak factor of 14.8 dB (peak-to-RMS), and is not an unrealistic case.

Where continuous speech is the input, the peak factor may not be as high, depending on the amount of clipping which can be tolerated. The chart in Figure 5 presents the required peak factor vs clipping for continuous speech. Referring to this chart, it can be seen that by using an amplifier with a 10 dB peak factor power reserve, the probability of clipping is 3% of full time. A 15 dB peak factor reserve would reduce the



$$1/f = 0.2 \text{ SEC.}$$

$$T_f = .02 \text{ SEC.}$$

$$RMS = A_{MAX}\sqrt{\frac{f}{3}(T_f)}$$
$$= 18.25\text{ V}$$

$$AVG = A_{MAX}(f)\left(\frac{T_f}{2}\right)$$
$$= 2.5\text{ V}$$

Figure 4

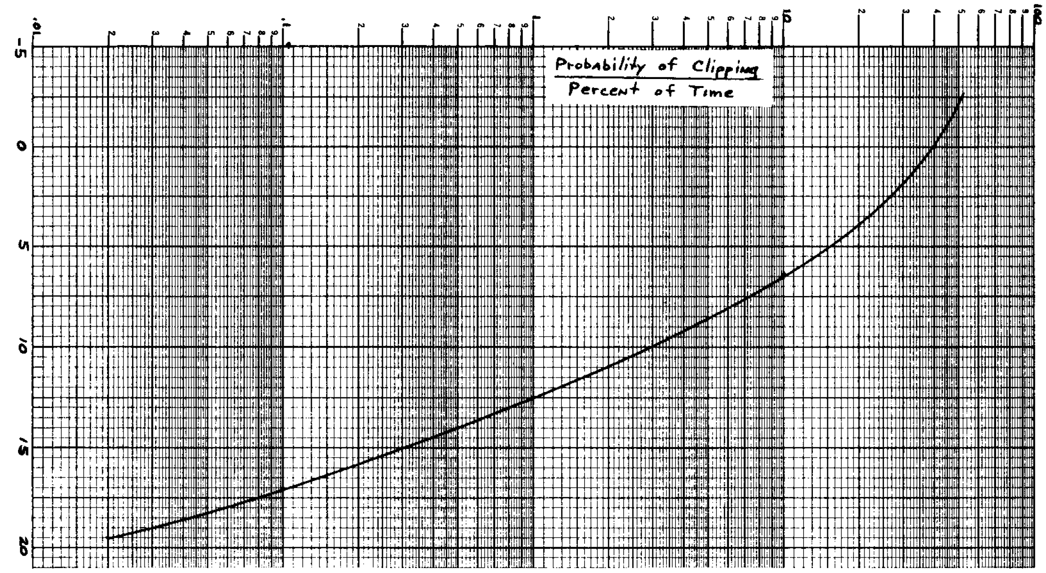


Figure 5.

probability of clipping to only 0.3% or, for all practical purposes, would eliminate clipping. Thus, to produce an effective (or RMS) power level of 5 Watts with only a 3% probability of clipping, a 50 Watt capability is needed (10 dB above 5 Watts).

The waveforms presented in Figures 6 and 7 are oscilloscope photographs of normal speech.

These photographs show the peak excursion of the waveform, and also illustrate that the waveforms extend in both positive and negative directions from a zero reference. Figure 6 shows the words "ONE-TWO-THREE", while Figure 7, the words "AMPLIFIER PEAK-FACTOR" are displayed. Figure 7 in particular provides a graphic example of peak factor. It should be noted that in both of these examples, the horizontal scale is 100 milliseconds per division and that unlike a sine-wave, the positive and negative excursions of the waveform are not symmetrical.

These examples are illustrated in more convenient and readable form through the use of the Peak Factor Test Set.

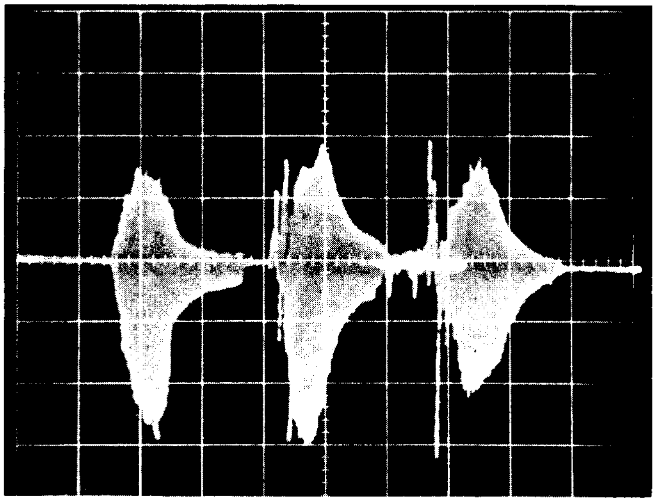


Figure 6.

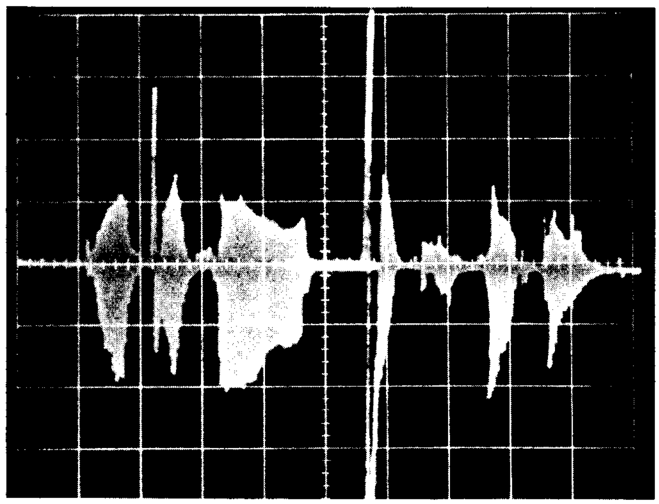


Figure 7.

By Lou Garner