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Audio Transients

• The program audio signal can meet with many mishaps which can distort the signal on its journey through the audio system. Some of these distortions also produce side effects that will further degrade the audio. One such side effect is transient distortion that can be added to the signal. Transients can be created by a number of conditions or by some operating practices, such as signal peak clipping. This month we will take a look at this type of transient and ways it can affect the operation.

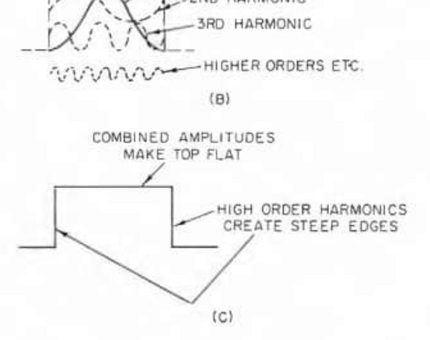
THE SQUARE WAVE

Perhaps we can better understand the audio transient if we consider it from the viewpoint of square waves and the behavior of these pulse signals in a system.

The square wave is a pulse signal that is very rich in many related signal components. These cover a wide frequency range from d.c. to many times the basic frequency of the pulse. The basic frequency of a pulse signal is its repetition rate, which can be reduced to a sine wave signal with the proper filtering.

The perfect pulse is a gold mine of harmonic signals that have the proper phase and amplitude relationship to the fundamental sine wave of the pulse. The great number of harmonics present give rise to the steep leading and trailing edges of the pulse. When phasing is correct, then so is the waveshape of each of these harmonics. All of the amplitudes will combine with the fundamental sine wave to produce a perfectly flat top to the pulse. Since the pulse amplitude does not change during the time of the flat top passage. this flat top represents a d.c. component in the signal.

Figure 1. The square wave is made up of many related signal components.



THE CIRCUIT PATH

If the pulse is to retain its shape and amplitude, each frequency component of the pulse must see the correct impedance, and there must be no phase shifts among the various components in the pulse. It is quite obvious that a pulse signal places tremendous demands upon every circuit or stage through which the pulse passes. How well the circuit can accomplish this is really a figure of merit for that circuit. This is why square wave testing of non-pulse type circuits, such as audio circuits, is popular in some quarters. The pulse signal as it appears at the output of an amplifier or a system can indicate many factors about that system. all at the same time.

But to be more specific, beginning at the very low end of the frequency spectrum, the circuit must be able to pass the d.c. component (flat top) or the pulse will be tilted. As we move up the spectrum to the lower frequency component, if the circuit response is poor, the top of the pulse may be either rounded or cupped—depending upon the circuit conditions. When we get to the upper limits of the system bandpass, this will determine how many of the harmonic components will pass. Removal of a number of these harmonics will round off the leading and trailing edge of the pulse. If phase shifts also occur, this leads to transients.

THE PULSE TRANSIENT

Although the impedances the various components of the pulse "see" enter into the results, perhaps the largest factor in producing transients is phase shift.

When phase shifts are different for different harmonics, they move from their normal positions in the pulse and the individual shape of the harmonic also changes. The disturbed harmonics tend to pile up at the leading and trailing edges of the pulse and

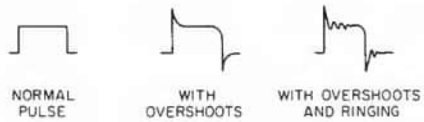


Figure 2. A transient appears as an overshoot, sometimes wtih ringing.

produce large overshoots at these two edges. The overshoots may be followed by an oscillatory waving of the pulse top that appears similar to a damped wave. This particular aspect is called *ringing*.

The amplitude of the overshoot can be rather high in relation to the normal pulse amplitude. Just how much greater the amplitude is depends upon the factors creating the transient. In some cases, the overshoot amplitude can be several times that of the pulse.

All the foregoing has been a rather simplified explanation of pulses and what can happen to them as they pass through a system. The actual process can be demonstrated more accurately by complicated mathematics. Suffice to say that it is difficult to pass pulse signal through *any* electronic system—even those designed for pulse! And needless to say, the audio system is designed for audio signals—not pulse.

AUDIO TRANSIENTS

Although the audio system is not designed for pulse, the system is often called upon to pass pulse-like signals. This can happen inadvertently when the system lacks headroom, for example, and the signal peaks become clipped. In some operational practices, signal peaks are deliberately clipped, for example, when peak limiters clip signal peaks to prevent the overmodulation of the transmitter.

Whatever the reason for the peak clipping, the clipped signal peak becomes a square wave-type signal. Once created, this clipped signal will have most of the same characteristics as the square wave and places the same demands upon the system.

TRANSIENT RESPONSE

A term appearing more often these days in equipment specifications is *transient* response. This term refers to the equipment unit's ability to pass a variety of audio signals, and more specifically, square wave signals, without creating transients.

To pass a square wave the equipment must have a superior response curve that starts at d.c. and extends far up the frequency spectrum—all without phase shift. Actually, the equipment designer has many other

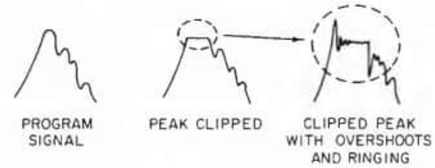


Figure 3. The clipped signal peak takes on the same characteristics as the square wave.

conditions to consider in the design besides transient response, keeping in mind that the finished unit must also be commercially competitive. So consequently, the finished unit will involve many compromises. This does not mean that it is a poor unit; it only means that it isn't perfect. As far as transient response is concerned, the unit may have either a good or a poor transient response characteristic, depending upon what compromises were made to arrive at the finished product.

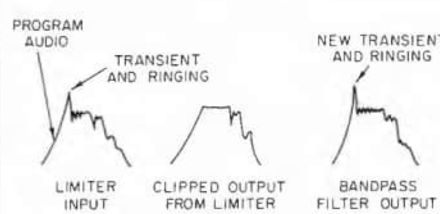
Aside from compromises in equipment design, the manner in which the equipment is operated in the broadcast chain will also have a direct bearing upon transients that may appear in the reproduced program signal. An equipment unit that does not have a good transient response characteristic, for example, will not produce transients if we don't try to force that unit to pass square wave type signals!

HOW IT HAPPENS

When signal peaks are clipped, the signal is automatically distorted since it no longer has its original shape, and intermodulation distortion can also occur. The clipping also creates many harmonics that are related to the frequency or frequencies of the signal peak that is clipped. Along with these harmonics, another component is added to the signal—a d.c. component. Aside from the initial distortions, every circuit from this stage onward must have excellent transient response if further degradation of the signal is to be avoided.

Much depends upon where the clipping is taking place in the system. If this is in an early unit of the system, then the transients can be amplified, intensified, or reshaped as each following unit contributes its share of

Figure 4. Limiter clippers can remove the positive overshoots, but filters can recreate them.



phase shifts and impedance irregularities. By the time the signal arrives at the transmitter, the transient may be rather severe. Perhaps we may feel confident that the peak limiter and the system bandpass or bandpass filter will remove the transients and the harmonics, so there is little cause to worry. Not so! The bandpass filter (if used) can in itself further intensify the transient. To be sure, the peak clippers will lop off the transient overshoot and thus produce a nice, but very flat top, square signal peak again. When that squared peak hits the bandpass filter in the stereo generator, for example, that filter can *recreate* the very transients we thought were removed! These *new* transients will now cause overmodulation of the transmitter. Our "final filter" simply sowed the seeds of its own undoing.

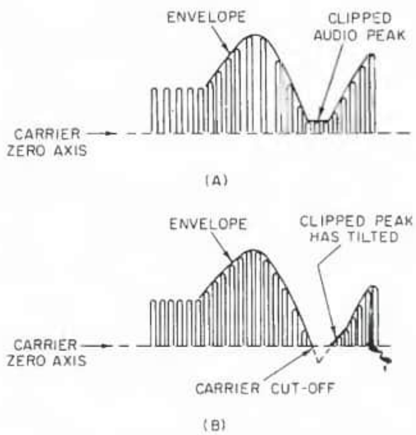


Figure 5. The flat top of a clipped peak can tilt and overmodulate the a.m. carrier in the negative modulation direction. (Only the upper half of the modulated waveform is shown.)

AT THE TRANSMITTER

Transients can affect the actual transmitter modulation as well as the modulation monitor indications. When the limiter clips signal peaks, the stages which follow those clippers and the audio section of the a.m. transmitter or the stereo generator of the f.m. station must have excellent transient response. If they do not, transient overshoots that may be typically 2 or 3 dB higher than the signal peaks will occur. Two dB is approximately 20 to 25 per cent modulation. If the levels are such that the normal peak will produce 100 per cent modulation, this added 2 dB overshoot will push the true modulation to 125 per cent. But unless there are several of these peak overshoots in quick succession, the modulation meter will not indicate the true modulation because of its characteristics. The peak flasher however, will catch the overmodulating peaks. All this may have the operator wondering what is wrong with the monitor. To keep the flasher from indicating overmodulation, he might pull back the signal level to the transmitter so the peaks indicate about 80 per cent on the modulation meter. The transient in this case is actually robbing the system of 2 dB modulation capability for its program signal!

TILT

The clipped signal peak also contains a d.c. component that must pass through the audio stages and modulator in the a.m. transmitter, for example, or the flat top will tilt. To pass the d.c. component, the stages should all be d.c. coupled—but very few are. Although the operator may have the transmitter modulator set up for tight 99 per cent negative peak modulation, the clipped peak may tilt and push this past 100 per cent modulation and carrier cutoff. This can produce channel "splatter" and spurious radiations.

NEW EQUIPMENT

The new breed of transmitters and stereo generators today have a better transient response than their predecessors. Designers are now aware of the effects of transients in signal degradation and modulation. The Harris MW-1 all solid state a.m. transmitter, for example, uses d.c. coupling of the audio stages and no modulation transformer. On the f.m. front, the Orban stereo generator is actually a combined automatic gain control limiter/stereo generator in one unit, all designed as an integral unit—and thereby achieves superior transient response. Still other units contain "soft" clippers in limiters. These clippers produce less audible distortion on the air than "hard" clippers.

OTHER TRANSIENTS

I don't want to leave the reader with the impression that peak clipping is the only way in which transients can be created. Transients can be caused by parasitics, spurious oscillations, intermittent positive feedback, rfi feedback, and a host of other factors. But with signal clipping a very predominant part of many signal processors today, this is perhaps the largest cause of audio transients.

SUMMARY

The clipped signal peak has most of the characteristics of a square wave signal, and places the same demands upon system performance in terms of transient response. Transient overshoots can cause overmodulation or rob the system of program modulation capability. If you must clip—clip with care! ■