# INCREASING EFFECTIVE AMPLIFIER OUTPUT POWER USING AUDIO COMPRESSION

By: Joel Bump, President/Director of Engineering, RDL

## INTRODUCTION

The power rating for audio power amplifiers used in commercial installations must deliver the average speech or music power plus reserve power headroom sufficient to handle audio peaks. The average power demanded from an amplifier is only ever a fraction of the total rated power because the average power in either speech or music signals is much less than the peak power. This article examines the relationship between required amplifier power and the dynamic content of speech.

Amplifiers used in commercial installations are typically rated in Watts RMS, a term that describes the essentially unclipped RMS voltage an amplifier can deliver continuously into a resistive load. This is commonly referred to as RMS power.

RDL produces several audio power amplifiers that are rated for a specific RMS power “plus compression”. The qualifier “plus compression” is used to indicate that the continuous average usable output power will be *greater* than that available from a conventional amplifier (without compression). The amount of additional power the compressor makes available can substantially reduce the required amplifier power output.

The amplifier used for the measurements in this report is the RDL FP-PA20. The integral compressor, using only a nominal amount of compression, will increase the output power of speech by 2.2 times. Therefore, the FP-PA20 type amplifiers, rated for 20 Watts (RMS) “plus compression” will deliver the same unclipped output power on dynamic speech content as a standard power amplifier rated at 2.2 x 20 W, or 44 Watts RMS. In addition to the economy of using the FP-PA20 in place of a much larger amplifier, the FP-PA20 compressor has sufficient headroom to afford an additional 10 dB of input overload protection.

## COMPRESSION CHARACTERISTICS

Typically, audio compressors allow instantaneous overshoot on high dynamic content peaks, which are common in speech. The overshoot is a result of the attack time of the compressor. The delay from the time the compressor detects the peak energy until it reduces the gain defines the duration of the overshoot. The peak amplitude of the overshoot can be equal to the uncompressed input signal amplitude. If such a compressor is installed prior to an audio power amplifier input with the peak output of the compressor calibrated to the clipping threshold of the power amplifier, the compressor may produce no measurable increase in average amplifier output power. RDL compressors include circuitry to prevent attack time overshoot.

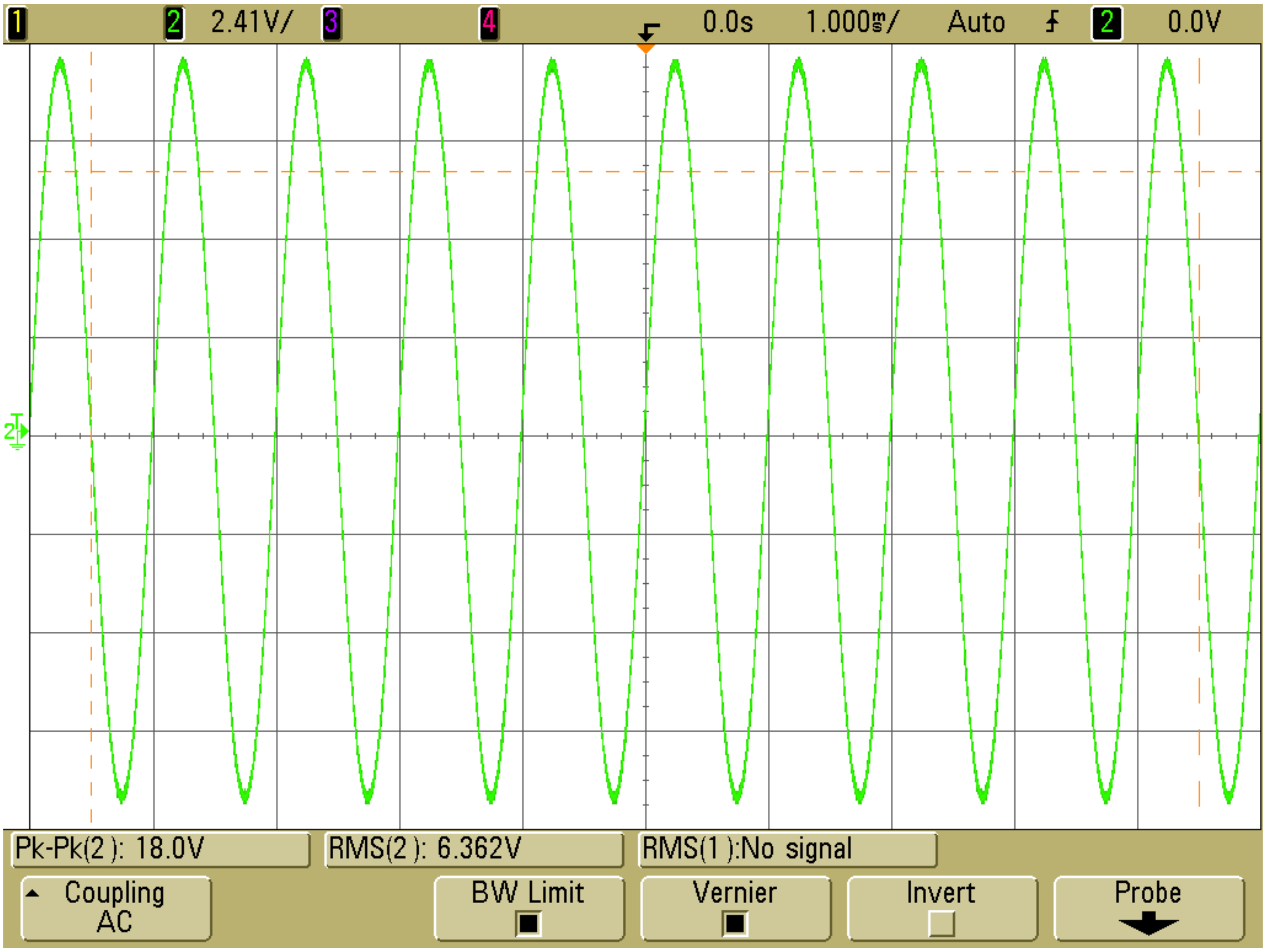
It is important to note that the RDL compressors automatically adjust to different program material, preserving aural dynamics while providing effective peak overshoot control. The results from this study do not extend to OEM compressors, but they are relevant to the RDL ST-CL2. The ST-CL2 Compressor/Limiter module is commonly installed prior to power amplifier inputs. When the module is calibrated to the amplifier, it can provide the same power and overload benefits as the FP-PA20 compressor evaluated in this report.

## MEASUREMENTS

The continuous power produced by an amplifier is determined by the average audio input level over time, which is much lower than the peak-to-peak input level. The RMS level of the sine wave signal used to determine the power rating of the amplifier is equal to 0.707 times the peak voltage of the sine wave. (The peak voltage is ½ the peak-to-peak value.) Complex speech and music waveforms, compared to a sine wave, have a much lower RMS voltage for an equal peak voltage. This lower RMS voltage determines the amount of power the amplifier will actually have to deliver. The rest of the amplifier's rated power is simply used to provide the headroom required to prevent clipping audio peaks.

The RMS value of most music content, and of all compressed audio, is greater than that of uncompressed speech. Speech patterns themselves can vary in RMS content depending on how "choppy" or "sing-song" the person's voice is. A worst-case voice recording was created in the RDL voice-over booth, using a choppy delivery and no audio compression. A short phrase was repeated continuously so the RMS amplifier output voltage could be measured accurately over a period of time with consistent results from repeated measurements. The peak and RMS values of the waveforms were measured using the math functions provided in an Agilent DSO6034A Digital Storage Oscilloscope connected from ground to one amplifier output leg. Speech signals were sampled for five seconds. For each measurement, the peak-to-average (RMS) ratio is calculated in decibels. The uncompressed speech recording has an RMS voltage about 15 dB below the peak voltage, which is typical of speech.

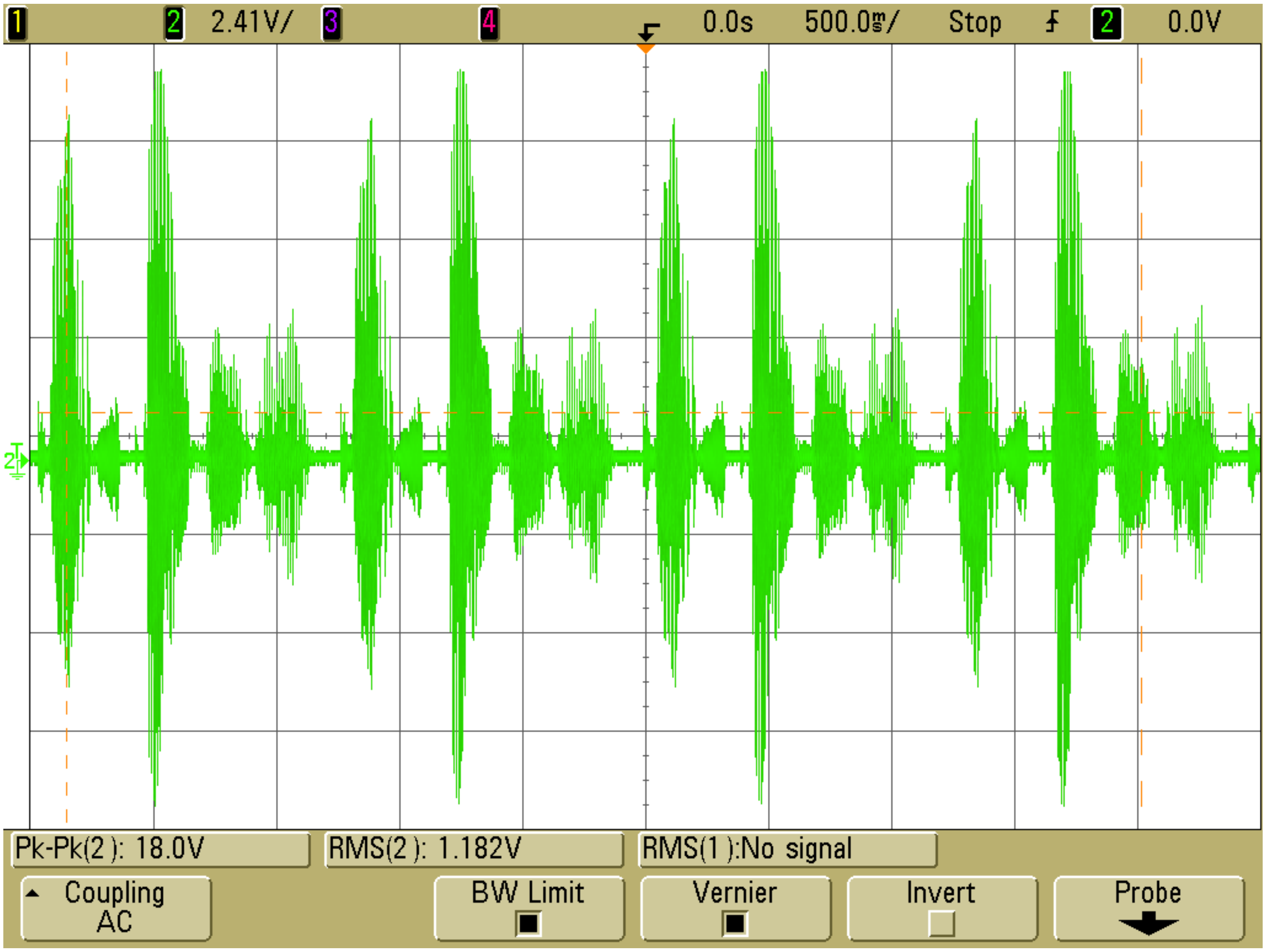
MEASUREMENT SETUP




Prior to applying the speech source, the amplifier was first fed with a sine wave. The vertical input sensitivity was set to maximize the waveform on the screen. Peak-to-peak and RMS automatic measurements were selected and the cursor was enabled to indicate the amplitude of the calculated RMS voltage. The applied tone produced the following reference readings to be used in subsequent speech audio tests:

| | |
|---|---|
| Peak-to-peak (P-P) voltage: | 18.0 V |
| Calculated RMS equivalent of P-P voltage: | 6.36 V |
| Measured RMS signal voltage: | 6.36 V |

UNCOMPRESSED AUDIO (Reference)

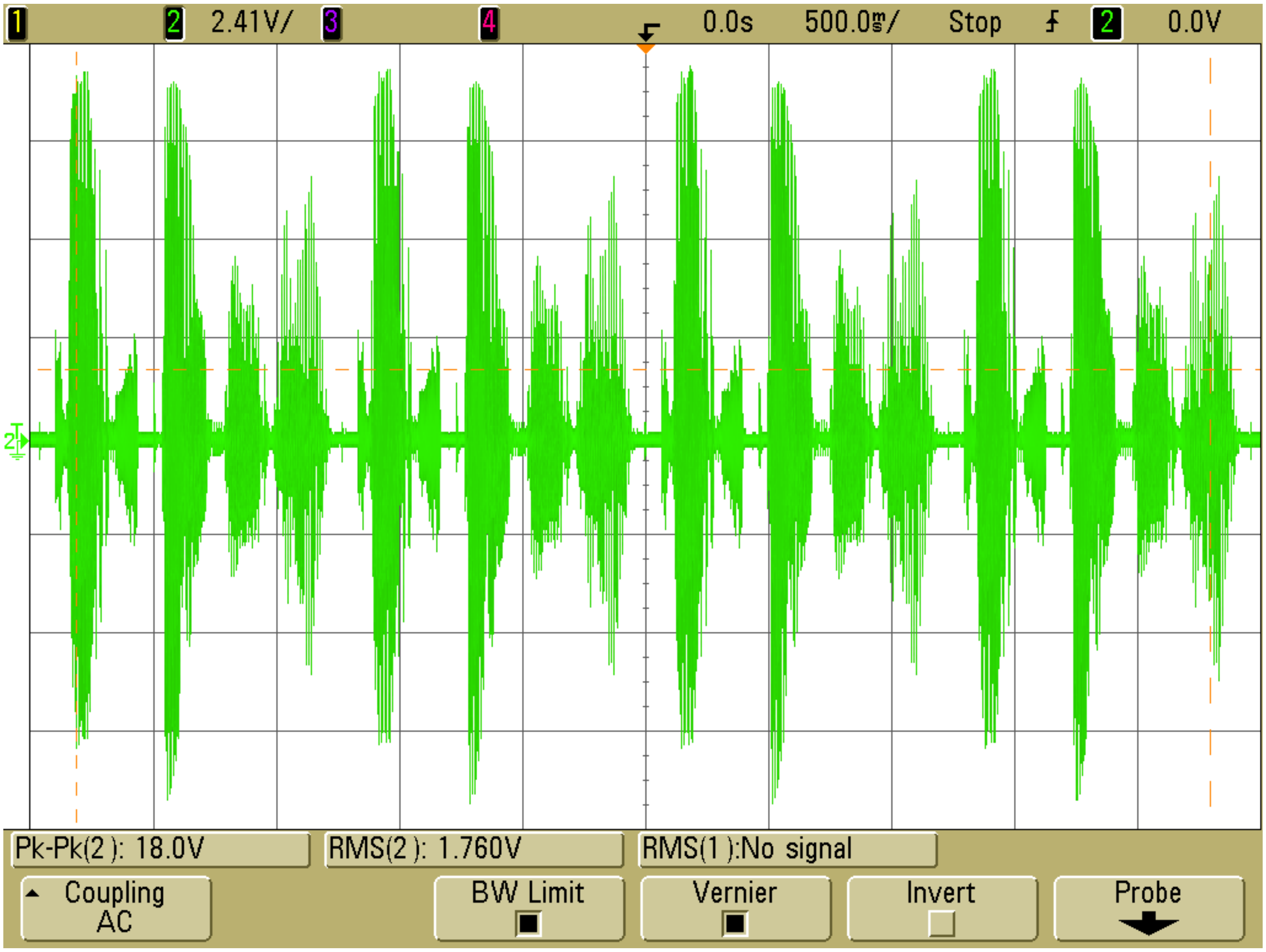



| | |
|---|---|
| Peak-to-peak (P-P) voltage: | 18.0 V |
| Calculated RMS equivalent of P-P voltage: | 6.36 V |
| Measured RMS signal voltage: | 1.182 V |
| RMS to Peak-to-peak output voltage ratio: | 14.62 dB |

The recorded speech pattern was fed into the power amplifier and the compression was defeated in the amplifier. (The compression was defeated by a factory modification; no user control is provided for this purpose.) The screen image shows the uncompressed speech pattern, the measured voltages (P-P and RMS) and the RMS voltage cursor.

The dynamic content of the speech shows an RMS value 14.62 dB below the peak-to-peak value.

COMPRESSED AUDIO (7.5 dB Sine Wave Gain Reduction)

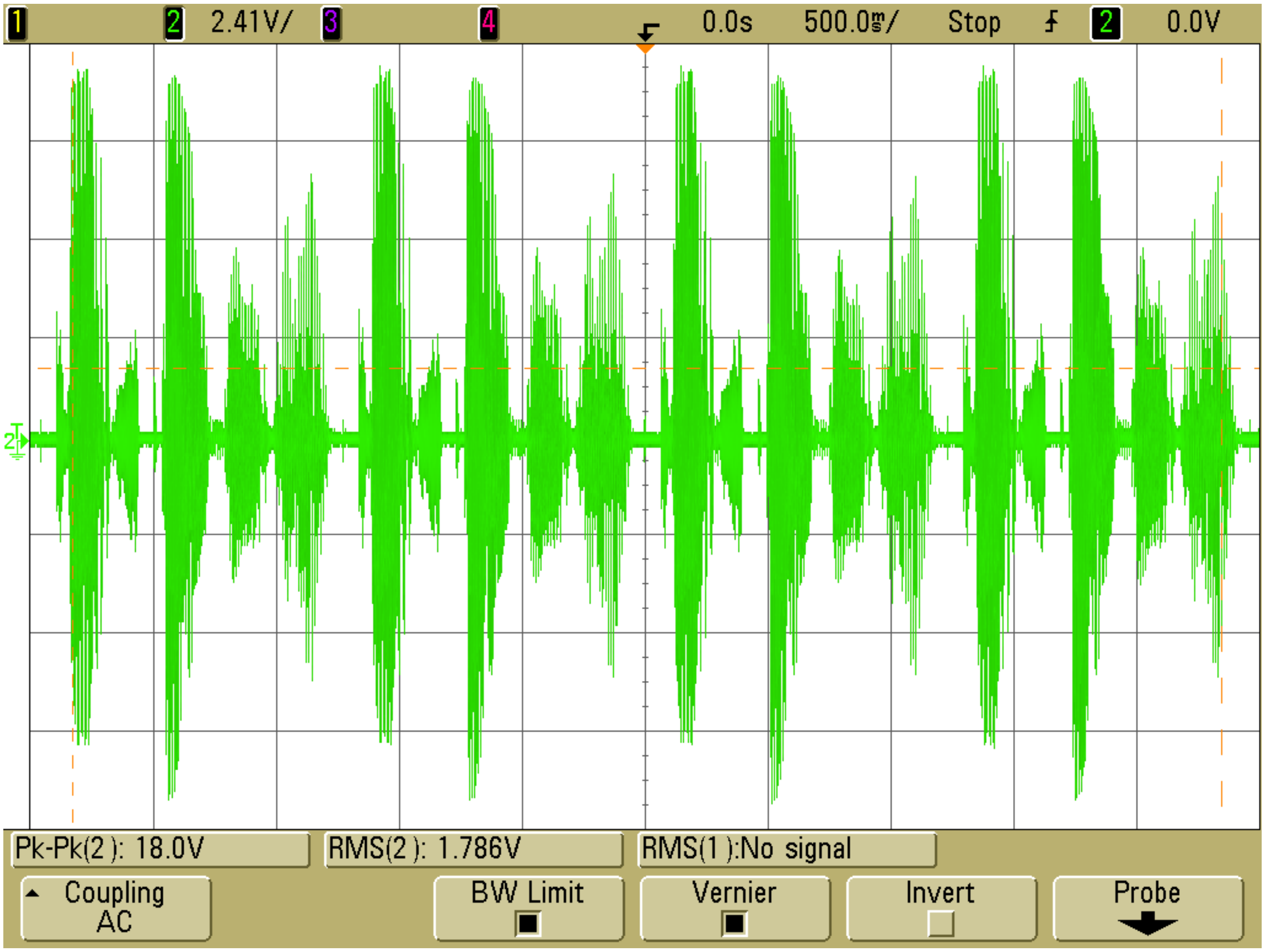



| | |
|---|---|
| Peak-to-peak (P-P) voltage: | 18.0 V |
| Calculated RMS equivalent of P-P voltage: | 6.36 V |
| Measured RMS signal voltage: | 1.76 V |
| RMS to Peak-to-peak output voltage ratio: | 11.16 dB |
| Compression (uncompressed ref. -14.62 dB): | 3.46 dB |

The input signal connected to the amplifier was increased in level by 7.5 dB as measured using a sine wave tone. This is considered moderate compression and is indicated by repetitive flashing of the compression LED on the amplifier. The screen image shows the compressed speech pattern, the measured voltages (P-P and RMS) and the RMS voltage cursor.

The dynamic content of the speech shows an RMS value 11.16 dB below the peak value. The difference between the 14.62 dB (uncompressed) and 11.16 dB (compressed) values is the amount of compression applied to the speech signal. The 3.46 dB of compression is less than the 7.5 dB increase in the input signal, as measured using a tone, because speech has more dynamic content than sine waves.

COMPRESSED AUDIO  (15 dB Sine Wave Gain Reduction)




| | |
|---|---|
| Peak-to-peak (P-P) voltage: | 18.0 V |
| Calculated RMS equivalent of P-P voltage: | 6.36 V |
| Measured RMS signal voltage: | 1.786 V |
| RMS to Peak-to-peak output voltage ratio: | 11.03 dB |
| Compression (uncompressed ref. -14.62 dB): | 3.59 dB |

The input signal connected to the amplifier was increased in level by an additional 7.5 dB (for a total of 15 dB) as measured using a sine wave tone. This level constitutes a substantial overload of the amplifier input, which is not uncommon in paging and certain other applications.  The compression shows only a slight increase over the prior test, from 3.46 dB to 3.59 dB.  The compressor is now acting only to suppress the input overload without adding additional compression to the actual audio signal.

## SUMMARY

The average level of a normal uncompressed speech audio signal is 14 to 15 dB below its peak-to-peak voltage, 14.6 dB in our example. The amplified peak-to-peak audio voltage cannot exceed the available power supply voltage in an amplifier; otherwise clipping will occur, producing severe distortion. Applying Ohm's law, the rated amplifier power for an uncompressed speech signal must be 28.6 times the RMS power of the amplified speech.

Applying 3.5 dB of compression *with peak overshoot control* produces an average speech level 11.2 dB below its peak-to-peak value. Again applying Ohm's law, the amplifier power for the compressed speech signal need only be 13 times the RMS power of the amplified speech. With effective, calibrated audio compression, required rated amplifier power is reduced to 45% (28.6 / 13) of that required for uncompressed voice sources. The effective equivalent rated output power of an amplifier using calibrated audio compression is 2.2 (1 / 45%) times the amplifier's actual rated power. An effective compressor design must include peak overshoot control and should incorporate substantial additional level overload protection to accommodate the range of levels expected in the field.

## CONCLUSION

These measurements clearly show that a properly designed compression circuit with effective peak overshoot control can effectively reduce the rated amplifier power requirement by 50% in installations with speech or other high dynamic program content.

The FP-PA20 (8 Ohm, 70/100 V, 25 V output models) can be effectively utilized in paging installations otherwise requiring an amplifier rated at 44 Watts RMS. An RDL ST-PA18 18 Watt RMS "plus compression" power amplifier can be used where a 40 watt RMS paging amplifier would normally be required. This same principle applies to other amplifier powers. If an RDL ST-CL2 module is calibrated to the clipping level of OEM power amplifiers, a similar result can be expected. Paging systems that otherwise would require a 100 Watt amplifier can be equipped with a 50 Watt model; a 200 Watt requirement may be fulfilled using a 100 Watt amplifier and a calibrated compressor module.