INTEGRA
RF POWER DEVICES

Measurement of Peak Pulse Power and Droop

INTRODUCTION

A frequent question that is asked is "How do you measure peak RF output power and power droop within the pulse for pulsed signals"? The situation can be quite complex for some of the signals used in today's radar systems, especially for waveforms such as those used in IFF/SSR or Link 16 systems that use pulse bursts.

Before the advent of peak power meters such as those made by Boonton, the common method was to measure the average power and divide the result by the duty cycle. However, this method gives inaccurate results for several reasons such as the fact that the power isn't constant within the pulse but generally decreases with time, and because the pulse has finite rise and fall times. Also, it is inherently impossible to measure the pulse droop by just using an average power meter. Accordingly, it is now universal practice to use a peak power meter such as Boonton's model 4500B [1] which simultaneously allows measurement of both peak pulse power and droop. However, since the RF output power within the pulse isn't constant, then at what point in the pulse is the power measured when Integra specifies a value?

MEASUREMENT OF PEAK PULSE POWER AND PULSE DROOP FOR REPETITIVE SINGLE PULSES

Integra Technologies transistors have to handle a very wide range of pulse conditions from short pulse length, low duty cycle such as 250µs and 1% duty cycle up to 3ms and 30% duty cycle, or even longer pulse length and higher duty cycle. For the 250µs and 1% duty cycle situation, then the ideal RF output waveform is that shown in Figure 1.
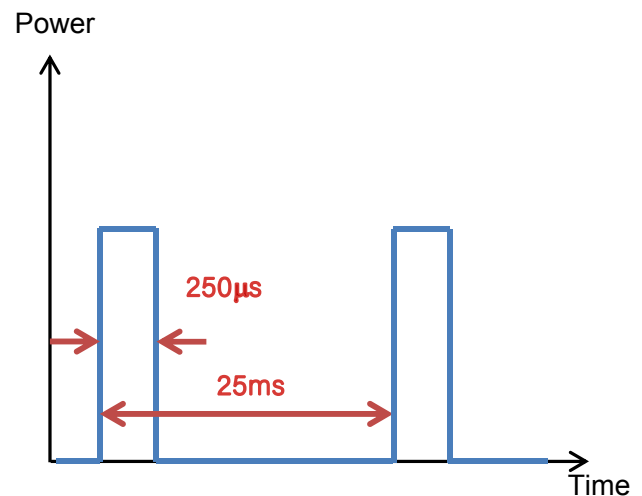

FIGURE 1: Ideal Repetitive Single Pulse Waveform

The actual RF output power for the 450W GaN on SiC transistor used in this pulse application is shown in Figure 2. This particular transistor has virtually no droop at all, but the amount of droop is strongly dependent on the location and value of the drain storage capacitor. Nevertheless, Figure 2 shows the points in time between which we measure pulse droop and peak power. Integra measures the power at the 10% and 90% points in time of the pulse waveform and averages these two values to provide a value for peak pulse power. Similarly, Integra measures the pulse power droop between these two same points to determine a value for pulse power droop. For this particular 450W GaN on SiC transistor tested in Integra's standard production test fixture with optimized location and value of drain storage capacitor then the part would be recorded as having a peak pulse power of 58.76dBm (the average of the peak pulse power at the 10% and 90% points in time) and having a pulse droop of 0.05dB (the difference in power output between the 10% and 90% points in time).
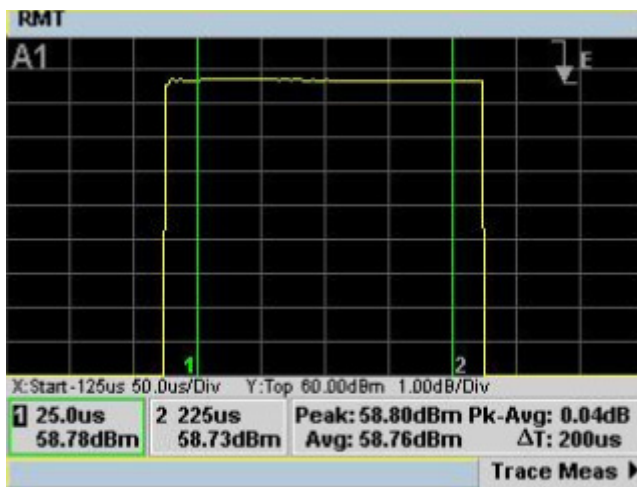

FIGURE 2: Real Pulse Shape for Integra Technologies 450W GaN on SiC Transistor

A key point to note about most repetitive single pulse radar applications is that the pulse off period is in the ms region so that the transistor junction temperature cools down in the off period to the initial ambient temperature. Consequently, each RF pulse starts from the same junction temperature and so each RF pulse is the same as every other pulse – a situation that is not true for pulse bursts that are considered next.

MEASUREMENT OF PEAK PULSE POWER AND PULSE DROOP FOR PULSE BURSTS

IFF (Identify Friend or Foe) and SSR (Secondary Surveillance Radar) systems typically transmit an ELM (Extended Length Message) signal in addition to standard Mode S signals. The ELM waveform consists of a burst of 48 pulses, each being 32μs on with an 18μs off period i.e. the duration of the pulse burst is 2.4ms. The duty cycle within the pulse burst is thus 64%. This pulse burst is repeated every 24ms giving a LTDC (Long Term Duty Cycle) of 6.4% (total on time of 48 x 32μs =1.536ms divided by 24ms). The problem with this pulse burst waveform for the transistor is that the 18μs off period between pulses is too short for the transistor junction temperature to cool down to ambient between pulses and hence the junction temperature steadily increases for each successive pulse. This results in the RF output power not only drooping within each pulse but also from pulse to pulse as well. Consequently, specifying a peak pulse power for the transistor is problematic and there is no universally accepted standard for defining either peak pulse power or pulse droop for the ELM waveform.

Link 16 is another pulse burst waveform that is used in

military data exchange networks. In this case the waveform consists of a burst of 444 pulses, each being 7µs on with an off period of 6µs. The duty cycle within the pulse burst is thus 53.8% and the pulse burst duration is 5.772ms. The LTDC in this case is 22.7%. The 6µs pulse off period is even shorter than for the ELM waveform and so the transistor junction temperature steadily climbs during the pulse burst leading once more to pulse droop not just within the pulse but also from pulse to pulse.
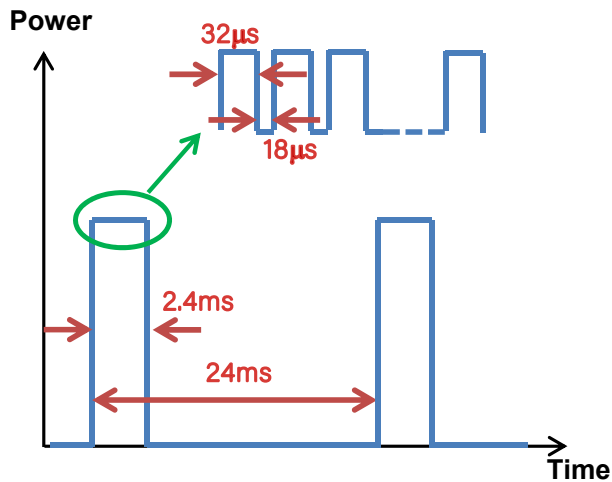

FIGURE 3: ELM Pulse Burst Waveform.

Figure 3 shows the ideal ELM waveform while Figure 4 shows real measured data for Integra's 1200W GaN on SiC transistor IGN1011L1200. This figure clearly shows not only the droop within the pulse but also the pulse to pulse droop. Integra measures the peak power in the 5th pulse at 202µs and 230µs and averages these two values to record the peak pulse power for the transistor. Droop is defined by the difference in output power 10µs after the start of the 5th and 44th pulses, i.e. at 210µs and 2160µs. In both cases the sample window is set to 2µs. Thus the pulse droop value quoted in Integra's data sheets is the

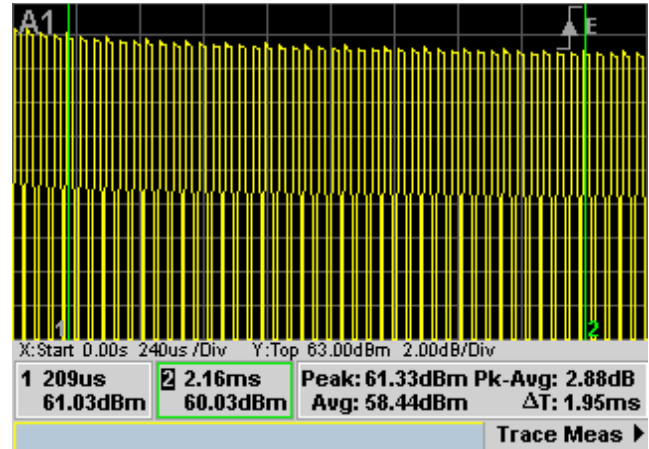droop across the pulse train and not the droop within an individual pulse.

FIGURE 4: IGN1011L1200 Measured ELM Pulse Burst Waveform.

For Link 16 Integra measures and averages the power between 560µs and 565µs during the 44th pulse which starts at 559µs and ends at 566µs to determine the peak pulse power. For pulse droop measurement Integra records the power 1µs after the start of the 44th and 400th pulse using a 2µs window, the difference between these two values being the pulse droop value.

CONCLUSION

This Application Note has described the problems associated with peak power and droop measurement for RF power transistors and has provided details of how Integra performs these measurements on its RF power transistors. If additional information is required then please contact Integra Technologies.

REFERENCE

1.   www.boonton.com

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