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Amplifier Overshoot-Drive Protection

Protect the input of your amplifier from potentially damaging power transients.

Some transceivers overshoot to full power on the first "dit" even when set to a lower output power. This can occur because it may take a finite amount of time for the transceiver's detector circuitry to sense the actual power and then apply a compensating ALC voltage. High peak-power pulses can be hard on amplifiers, and can even damage solid-state amplifiers. In an earlier article (*QST* August 2010 p. 39) I proposed using an input in-line attenuator when using an amplifier so the driving transceiver could always be left at its full power setting. This simplified using the amplifier as you wouldn't have to re-adjust drive power, improved the amplifier input match especially when using older amplifiers on the more recent 12 and 17 m bands, and eliminated full-power overshoot since the radio was already at full power. However, it turns out that some transceivers overshoot to well over 100 W regardless of power setting, even when set to their full power 100 W setting. As an example, according to a PowerMaster peak-reading wattmeter my Icom IC-706MKII overshoots to 130-145 W on the first "dit" of any new transmission regardless of output power setting.

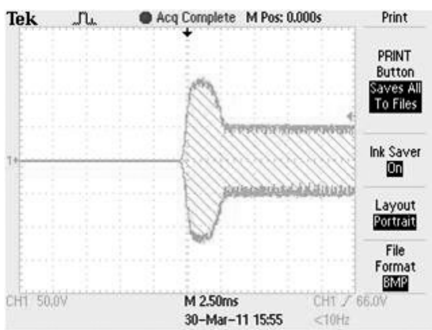

Figure 1 — Oscilloscope trace of the first "dit" shows a peak voltage of about 115 V. The PowerMaster peak power measured 132 W.

While my current transceiver, an Elecraft K3, has no overshoot, I wanted make sure that my back-up IC-706MKII transceiver wouldn't damage my ALS-600 amplifier should I put the IC-706MKII on-line.

Examining The Problem

I am fortunate to posses some very good NIST-calibrated test equipment, namely an Array Solutions PowerMaster wattmeter and a Tektronix TDS-2022B 2 Gbit/s digital sampling oscilloscope. So I examined the RF output waveform of my IC-706MKII. Figure 1 shows the oscilloscope trace of the first "dit".

The IC-706MKII transmit power had been set to 25 W. Note that the power spike is very short in duration – less than 2 ms. So while the energy in the pulse is very low due to the short duration, the peak voltage is high. After the overshoot the IC-706MKII ALC

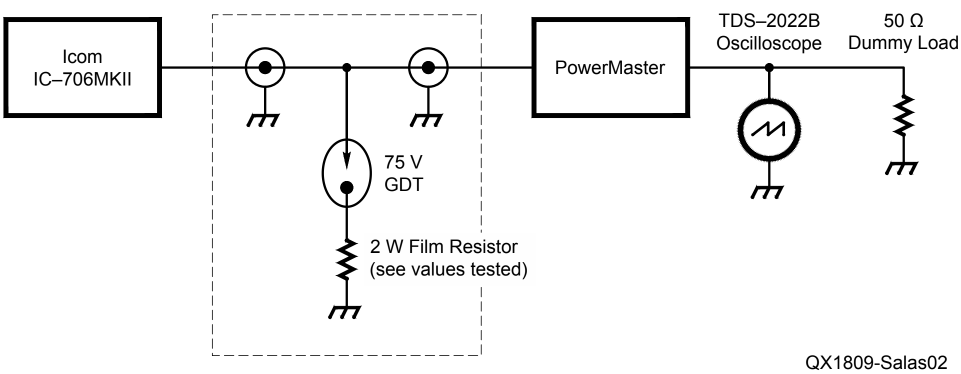

Figure 2 — GTD test circuit.

Table 1.

GDT/Transceiver power limiting tests.

GDT/Resistor	Overshoot Power Result
None	130-145 W
GDT/50Ω resistor	90 W max, 80 W typ.
GDT/25Ω resistor	80 W max, 75 W typ.
GDT/16Ω resistor	73 W max, 65 W typ.

holds the RF output to the output power set level for about 5 seconds after key-up. Then an overshoot pulse occurs again. The question is – what can we do about this?

The Solution

Gas discharge tubes (GDTs) are often used to protect receiver input circuits and data transmission lines from large static discharges. I began to think that a properly chosen GDT might also be applicable for limiting an intermittent RF transmitter overshoot. Furthermore, GDTs have extremely low capacitance, typically less than 1 pF, so they will not present an impedance problem in the 160 through 6 m bands. A commonly available GDT is the Littlefuse CG75L (Mouser part number 576-CG75L). The dc spark-over carries a 75 V spec (spec'd at 100 V/s rise-time). Impulse spark-over is much higher, but for very fast impulses. That is, spark-over is 400 V at 100 V/µs. I suspected that the typical 3-8 ms rise-time of a CW signal is closer to the dc spark-over spec, but I needed to experiment.

My test circuit and test set-up are shown in Figure 2. I added series resistance to the GDT in order to change the spark-over point. For the resistors, I paralleled three 51 Ω 2 W resistors (Mouser 594-5083NW51R00J). In that way I could clip out one or two resistors to give different series resistance to ground. Remember that the pulse duration is less than 2 ms, so power dissipated in the resistors will be very low.

I built the circuit into a Mouser 563-CU-3000A aluminum box. The UHF connectors are Amphenol (Mouser 594-5083NW51R00J). Figure 3 shows the complete assembly ready for testing. Note the three paralleled 51 Ω resistors.

For testing, I set the IC-706MKII to 25 W to ensure that the radio output was set below the firing point of the GDT. The test power meter, an Array Solutions PowerMaster, has a detector charge time constant of about 15 µs, which does a very good job catching the 2 ms peak pulse. Tests were repeated at least 50 times for each experiment. Table 1 lists the results. Notice how the series resistor values affect the GDT firing point voltage.

I also took an oscilloscope measurement

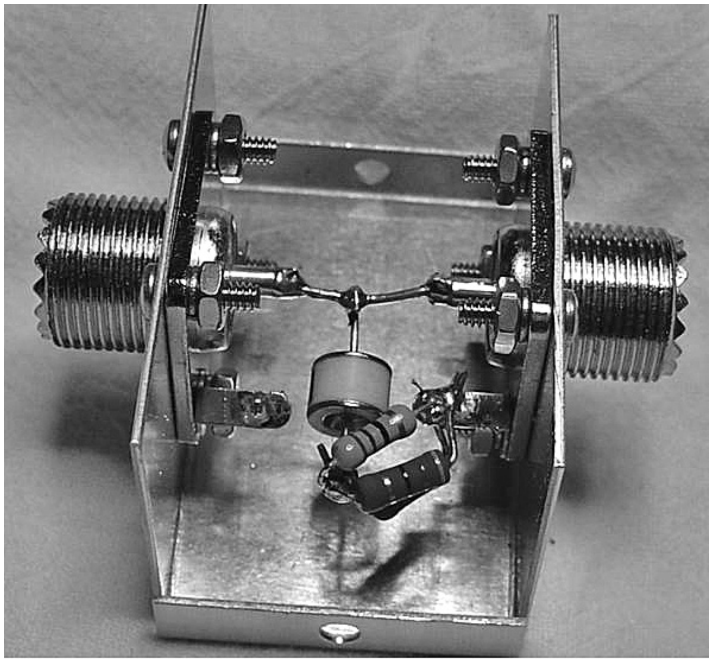

Figure 3 — GDT transmitter limiter in an aluminum housing ready for testing.

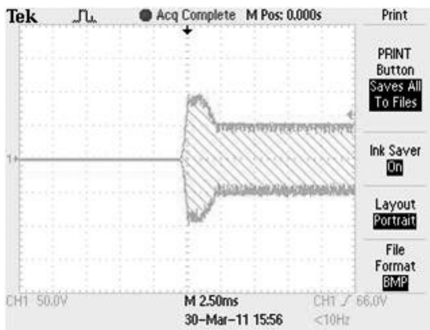

Figure 4 — The GDT and 16 W resistor significantly reduced the amplitude of the overshoot to about 85 V. The PowerMaster peak power reading was 73 W.

with the GDT and 16 Ω resistor, as this was perfect for the 60 W drive requirement of my ALS-600 amplifier. As you can see in Figure 4, the GDT and 16 Ω resistor significantly reduced the amplitude of the overshoot as expected from the PowerMaster measurements. Notice the clipping of the peak; it is not as nicely rounded as the trace shown in Figure 1.

Depending on your amplifier drive requirements, you can pick your series resistor accordingly, or you may want to go with a higher voltage rated GDT. For example, a 90 V GDT with some series resistance would probably be perfect for vacuum tube amplifiers that require closer to 100 W of drive power.

Finally, this limiter is designed specifically for protecting against overshoot from a transceiver that has the output properly set for driving an amplifier. That is, you must *not* use this to limit normal transceiver output power in order to drive an amplifier, as the continuous clipping will cause distortion products. Always properly set your drive power to that required by the amplifier.

Conclusion

This article discussed a method for limiting the first "dit" overshoot of a transceiver to protect an amplifier input circuit – and especially the input circuit of a solid-state amplifier. While I specifically considered the Icom IC-706MKII transceiver, I have been told that the significant overshoot problems also occur on other models and other brands of equipment. To see if you have a potential problem, buy or borrow a good peak reading wattmeter for transceiver overshoot evaluation.

Phil Salas, AD5X , an ARRL Life Member, has been licensed continuously since becoming a Novice in 1964. His interest in ham radio led him to pursue BSEE and MSEE degrees from Virginia Tech and Southern Methodist University respectively. He is now retired from a 33 year career in microwave and light-wave new product development, where he held positions from design engineer to vice-president of engineering. Phil enjoys tinkering with ham radio projects.