Amplifier Overshoot-Drive Protection
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Introduction

Some transceivers overshoot to full power on the first "dit" even when set to a lower output power. This can occur as 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 WARC bands, and eliminated full-power overshoot since the radio was already at full power. However, it turns out that some transceivers overshoot well over 100 watts regardless of power setting - even when set to their full power 100 watt setting. As an example, according to my PowerMaster peak-reading wattmeter my IC-706MKII overshoots to 130-145 watts on the first "dit" of any new transmission regardless of output power setting. While my current transceiver has no overshoot (Elecraft K3), my IC-706MKII is my back-up transceiver and I wanted to make sure I wouldn't damage my ALS-600 amplifier should I put the Icom 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 2GB/s digital sampling oscilloscope. So the first thing I did was to examine the RF output waveform of my IC-706MKII. Figure 1 below shows the oscilloscope trace of the first dit leading edge.

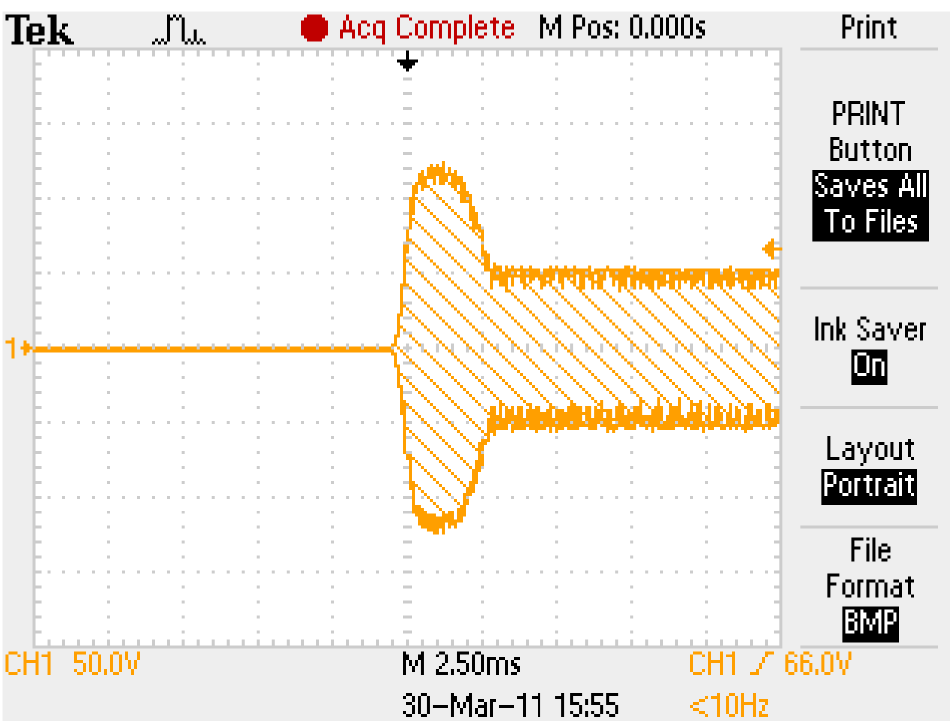

Figure 1: Vpk ≈ 115V. PowerMaster peak power measured = 132 watts.

The IC-706MKII transmit power had been set to 25 watts. Note that the power spike is very short in duration – less than 2-milliseconds. 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 holds the RF output to the output power set level for about 5-seconds after key-up. Then an overshoot pulse occurs again. So 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. Therefore, I began to think that a properly chosen GDT might also be applicable for limiting an intermittent RF transmitter overshoot. Further, GDTs have extremely low capacitance, typically less than 1-pf, so they will not present an impedance problem on HF-6 meters. A commonly available GDT is the Littlefuse CG75L (Mouser part number 576-CG75L). DC spark-over is 75V spec (spec'd at 100V/sec rise-time). Impulse spark-over is much higher, but for very fast impulses. I.e., spark-over is 400V at 100V/usec. I suspected that the typical 3-8ms 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 is shown in Figure 2 below. I added series resistance to the GDT in order to change the spark-over point. For the resistors, I paralleled three 51 ohm 2-watt 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 dissipated power in the resistors will be very low.

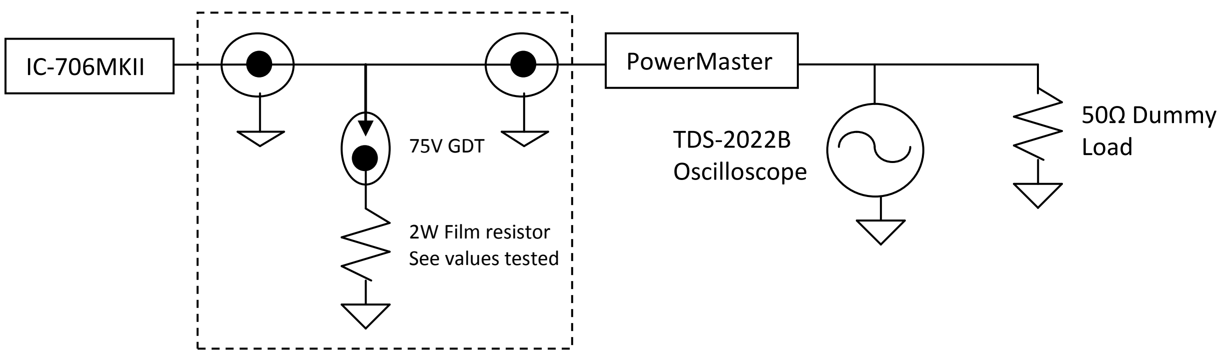

Figure 2: GDT Test Circuit

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

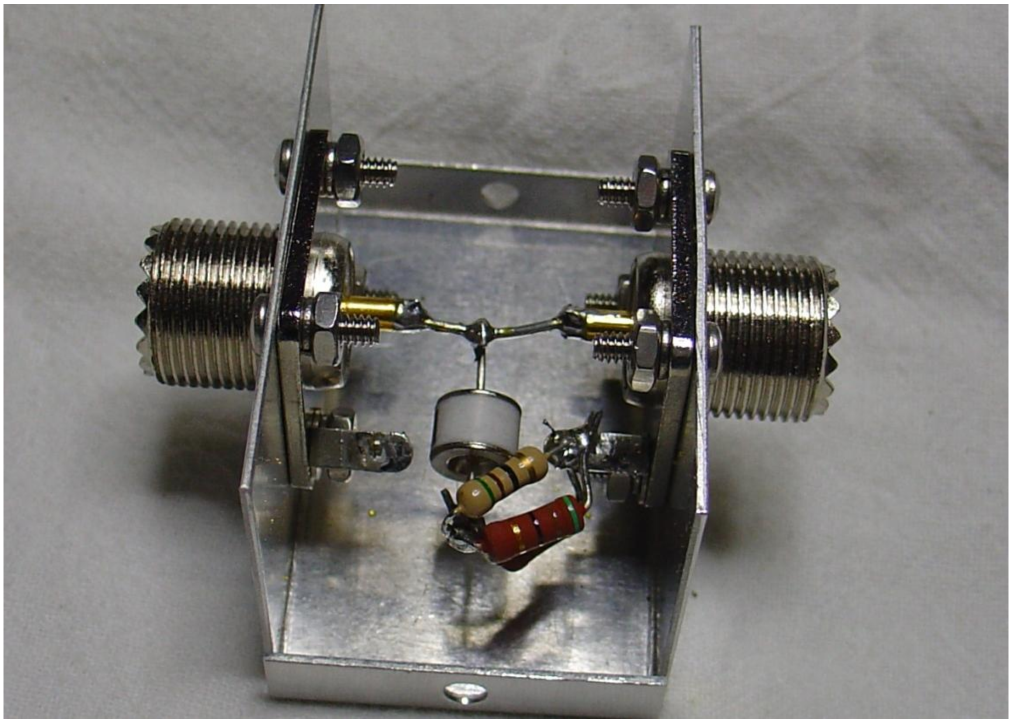

Figure 3: GDT transmitter limiter ready for test

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

Table 1 – GDT/Transceiver power limiting tests

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

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

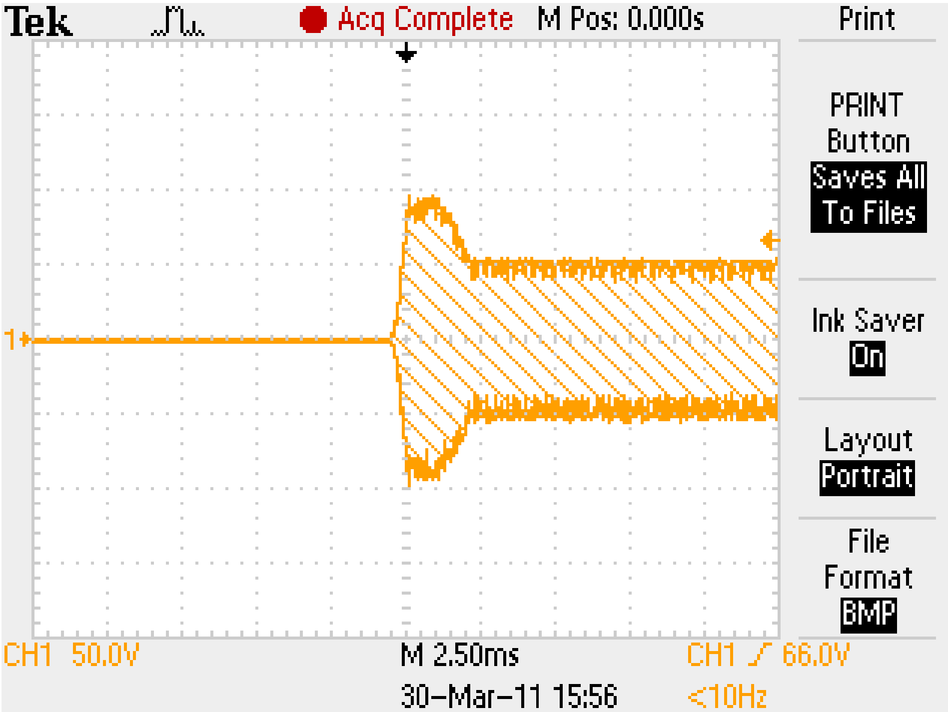

Figure 4: Vpk ≈ 85V. GDT/16Ω resistor. PowerMaster peak power = 73 watts.

Depending on your amplifier's drive requirements, you can pick your series resistor accordingly. Or you may want to go with a higher voltage-rated GDT. As an example, a 90V GDT with some series resistance would probably be perfect for vacuum tube amplifiers that require closer to 100-watts 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. I.e., 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 in order 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 problem does occur on other models and other brands of equipment. To see if you have a potential problem, you should buy or borrow a good peak reading wattmeter for transceiver overshoot evaluation.