Lightning/EMP Arrestor

Note: *Nothing can protect totally against a direct lightning strike* – it vaporizes wires! However, this inexpensive system provides significant hardening against nearby strikes with induced voltages and also hardens against EMP – a part of Level II DHS EMP hardening. Ref: http://qsl.net/nf4rc/2018/DHSEMPRec.pdf Grounding is not required for EMP hardening but is strongly suggested for lightning hardening --- by the shortest, straightest, largest conductor possible.

by Gordon Gibby KX4Z NCS521

Back decades ago, the only lightning arrestor components were a “spark gap” with a ground wire. Probably took thousands of volts to jump the gap!

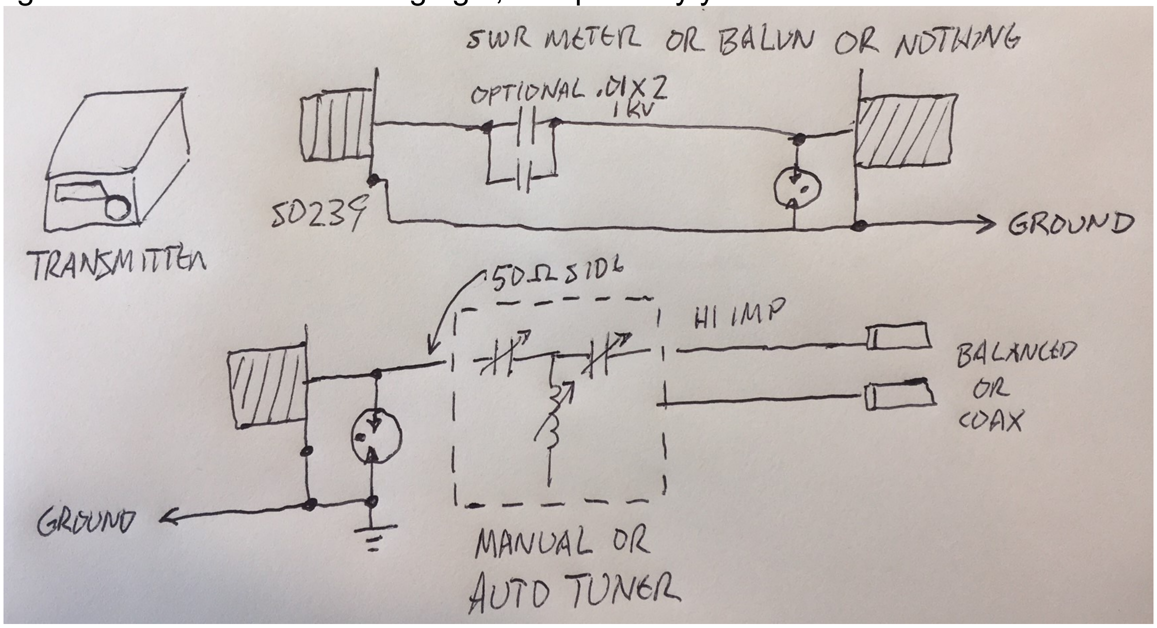
Anyone who is familiar with an older neon lamp knows that it takes a certain voltage to ionize the gas and make it conduct --- older voltage regulator tubes like the OA2 worked this way. The same principle is now widely used in electrostatic damage protection for radios and solid state devices --- “gas discharge tubes” are everywhere in the modern house, protecting dishwasher, air conditioners etc.

The lowly gas discharge tube is exactly what is inside an expensive ham radio Lightning Arrestor. While the GDT only costs $2-$3, the machining and final produce raise the price of typical commercial lightning arrestor devices above $60 --- but you can build your own far less expensively. They can be added to devices you already have --- like an antenna tuner or SWR meter. The Gas Discharge Tube simply goes between the center conductor and the shield conductor at a place where the RF voltage is normally predictable --- a 50ohm portion of your system, such as the transmitter end of a matching device, or inside an SWR meter. If you don't have any of those devices, you can put two female coax connectors (SO-239) in a plastic electrical handi-box and just wire the connections to pass the RF --- and put the gas discharge tube from the center connector to the shield. The gas discharge device has no polarity, so it can be connected either way.

Some lightning arrestor systems further cut out very low frequency components of the lightning by interposing a series capacitance in the system, designed to produce very little reactance at HF frequencies (like 1 ohm) and to be big enough to handle the power. Two 0.01 uf ceramic capacitors 1kV in parallel will fill that bill. There is a possible issue however with static charges if you do this --- so add a 100K ohm bleeder resistor from center conductor to ground if you put in the capacitor. Might be smart to put one on both sides of the capacitor (to ground on each side) to discharge any static within a few seconds.

The diagram below shows how to wire the gas discharge tube.

Note: It is important to put the GDT on the 50-ohm TRANSMITTER side of a matching network if you're installing it in an antenna tuner. The voltages on the ANTENNA side of such a matching system might normally be far far higher and inappropriately cause the gas discharge tube to conduct --- damaging it, and possibly your transceiver.



NOTE: If you do use the optional series capacitor, it is recommended to add a bleed resistor to ground on the transmitter side, such as 100K ohms, ½ watt.

http://www.dcitech.com/slides/slide/lightning-arrestor-application-note-82/pdf_content

Possible Sites of the Gas Discharge Tube
On the antenna side of a 1:1 current balun or SWR meter
On the antenna side of a blocking capacitor
On the transmitter side of a manual or automated tuner

CHOOSING AN APPROPRIATE BREAKDOWN VOLTAGE

Gas Discharge Tubes begin to conduct at an approximate voltage. Their accuracy is typically +/-10-20% The peak voltage of an RMS waveform is 1.41 x RMS. The RMS voltage for a given power level on a perfect 1:1 50 ohm line is equal to the square root of (50 x Watts). However, as the SWR rises, that voltage can be much much greater. For a brief moment they can conduct thousands of amperes, but are damaged by repetitive conductions.

It is suggested that the voltage of the Gas Discharge Tube be chosen based on this table:

Power / SWR extremes	Gas Discharge Voltage
<=100 watts, 2:1 or better SWR	230 V

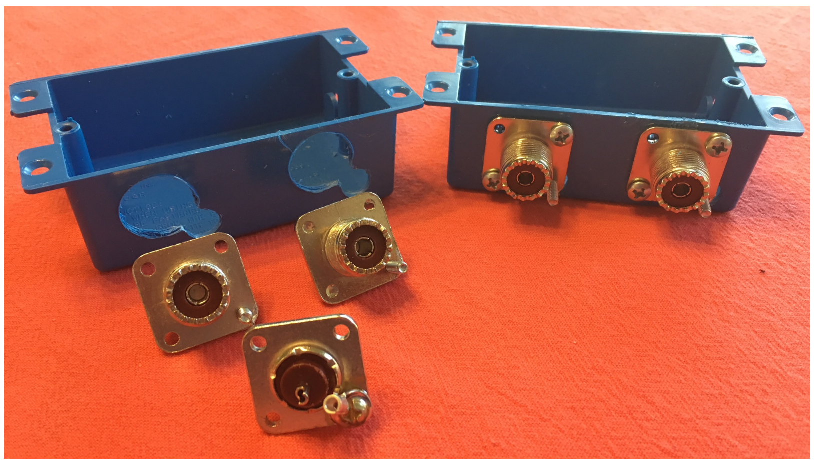
<=100 watts, 3:1 or better SWR	350 V
500 watts or more	two 350V in series

Suggested devices:
230 V: $3.06 20,000 amps https://www.digikey.com/product-detail/en/littelfuse-inc/CG2230L/F2735-ND/950216

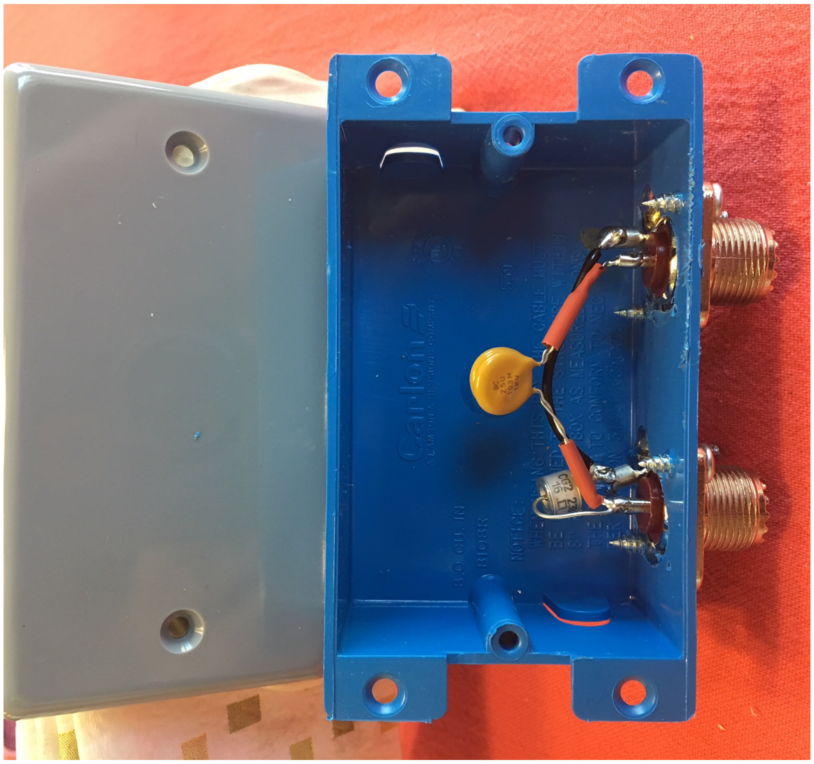
350V: (20%) 20,000 Amps: https://www.digikey.com/product-detail/en/epcos-tdk/B88069X2380S102/495-4271-ND/2269480

Construction in a plastic handibox:

1. Screw 6-32 x 1/2" machine screw into one mounting hole of a chassis-mount SO-239, with a crimp terminal on the chassis side, to allow for easy connection of the shield wire. (It is really difficult to solder directly to the case of a SO-239). If possible, use a 200+ watt iron to solder the head of the 6-32 screw to the case of the SO-239.
2. Drill a 3/8" hole to provide clearance for the head of the screw
3. Drill a hole at least 5/8" and <= 3/4" for the main body to fit.
4. Pilot drill small holes for at least two #6 x 3/8 sheet metal screws.



A DC blocking capacitor is optional. It may provide additional protection against lightning or EMP. In ordinary amateur radio usage, it appears as a very slight reactance and needs less than 50V rating – however, a much higher rating is used to provide sufficient current carrying capacity and to reduce the chance that it will be destroyed by even slight nearby lightning strikes.



EMP PROTECTION: This is the best there is....
The rise time of a Gas Discharge Tube isn't fast enough to capture the leading edge of the military spec of an E1 High Altitude EMP attack waveform---which has signal power all the way up to 1 GHz. However, your antenna and coax aren't that good either!!! So the actual spectrum of the power that will reach to your station is much less scary and the risetime of the resulting signal isn't that fast. The Gas Discharge Tube is one of the only available solutions for EMP protection of operating gear, providing voltage clamping with negligible capacitance to disturb your antenna system. Thus is is the mainstay of the Level II protection against EMP.

For further details see:

DHS: Electromagnetic Pulse (EMP) Protection and Restoration Guidelines for Equipment and Facilities (2016) http://qsl.net/nf4rc/2018/DHSEMPRec.pdf

QST: Electromagnetic Pulse and the Radio Amateur (1986 4-part article) http://qsl.net/kx4z/QST-Electromagnetic_Pulse_and_the_Radio_Amateur.pdf