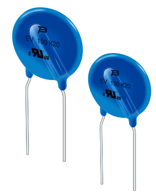
APPLICATION NOTE

Don’t Get Fooled by Overvoltage Protector Joule Ratings



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Introduction

A ‘joule’ is defined as a unit of work, energy, and heat. For surge protection, a joule is a measure of energy released over a period of time, and its associated joule rating indicates how much energy it can absorb before it fails. The assumption is – the higher the number of joules, the greater the surge protection. An average lightning strike releases about one billion joules of energy over a fraction of a second.

Below is the formula to calculate joules:

Joule = Watt (energy) x Time

By many accounts, customers and end-users just look at the joule rating listed in the data sheet and think that the higher the joule rating, the better the protection. However, the joule rating is only half of the story when looking for an effective component that can deliver the level of protection needed. Equally important is the clamping voltage of the protector, which is not always considered. If the joule rating is the only basis to make a decision, or even used as a comparison between products, then the resulting answer may not help the designer to select the right protection solution.

In this paper, a surge current of 8/20 μs is used to compare the energy capabilities of a variety of protection components. For purposes of evaluation, energy is calculated by using the Math Function built into the scope used in Bourns’ testing, INTG(Ch1 x Ch2), where Ch1 is voltage and Ch2 is current.

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Why is the Joule Rating Not a Complete Answer?

The various standards committees (UL, IEC, IEEE, ITU, etc.), do not typically use an energy rating to compare surge suppression devices. It is acknowledged that many countries don't trust joule ratings, believing them to be more of a marketing scheme rather than an actual tested number that can be used to gauge energy absorption between products. A common practice among power strip manufacturers is to advertise their protection capabilities based on the sum of the individual joule ratings of their internal MOVs. For example, a power strip with 10 MOVs, each rated at 200 joules, might be marketed as having a total protection rating of 2000 joules. With this high number of joules, would the power strips' circuit breaker survive a transient that comes close to this joule rating?

When specifying a surge protector's rating, it is the surge current and the clamping voltage that are more critical. In this paper, a standard Metal Oxide Varistor (MOV), Bourns® EdgMOV™ Varistor,, and a Power Transient Voltage Suppressor (PTVS) Diode will be used to illustrate the deficiency in only evaluating energy ratings.

MOV and PTVS Diode Comparison

Most MOV data sheets provide a joule rating and a V_{clamp} at a very low current rating (hundreds of amps) instead of at the maximum current rating, which is what would truly be needed for a proper design. The clamping voltage of an MOV is not constant but increases as the surge current increases (see Figure 1).

Figure 1. | MOV clamping voltage

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Why is the Joule Rating Not a Complete Answer? (Continued)

The clamping voltage of a PTVS Diode is much lower and will change much less as the surge current increases (see Figure 2).

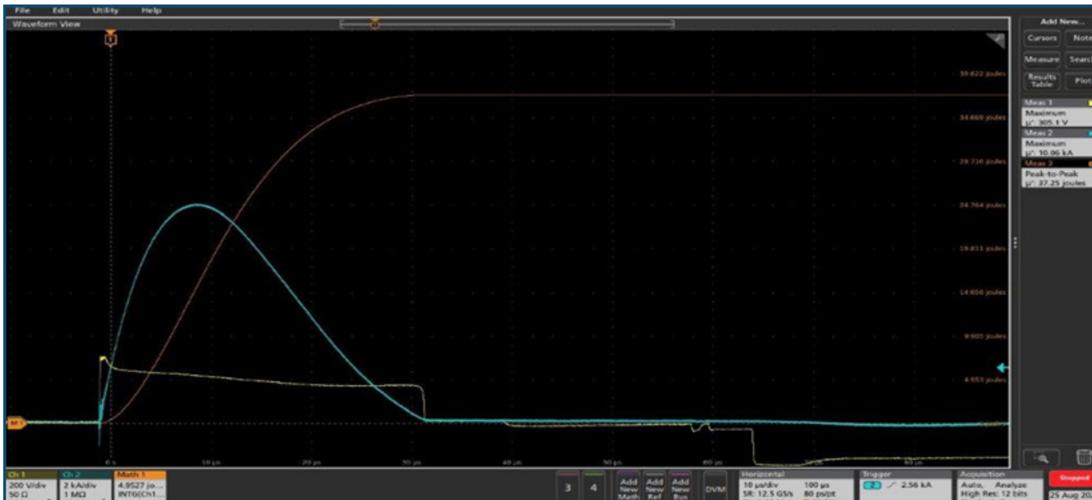

Figure 2. PTVS Clamping voltage

Both the MOV and PTVS components are rated at a maximum of 10 kA. Based on these measurements, the MOV is showing 145 joules compared to the PTVS Diode, which has only 37 joules. That is more than 100 joules lower than the MOV! In addition, the PTVS Diode's surge life rating is almost unlimited at 10 kA while the MOV is only rated at a single surge. The PTVS has a lower joule rating because it has a clamping voltage that is much lower than the MOV. In this example between the MOV and the PTVS Diode, the PTVS Diode has almost 2.6 times lower clamping voltage (798 / 305 = 2.6) and, therefore, will provide much better protection.

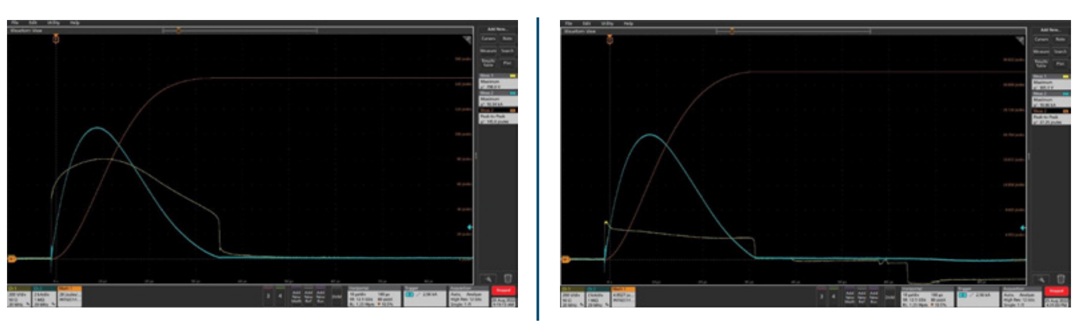

Figure 3.

MOV
$V_{clamp} = 798$
$I_{max} = 10$ kA
$J = 145$

PTVS DIODE
$V_{clamp} = 305$
$I_{max} = 10$ kA
$J = 37$

The above example shows that the PTVS Diode is much better while the joule rating is much lower. This is in opposition to the belief that higher joule ratings are better.

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Why is the Joule Rating Not a Complete Answer? (Continued)

Multiple MOV Comparisons

It is also important to compare a variety of MOV types.

First, a 14 mm MOV is tested on a surge with a maximum current of 8 kA. It needs to be rated at 130 joules (or more) to survive this surge.

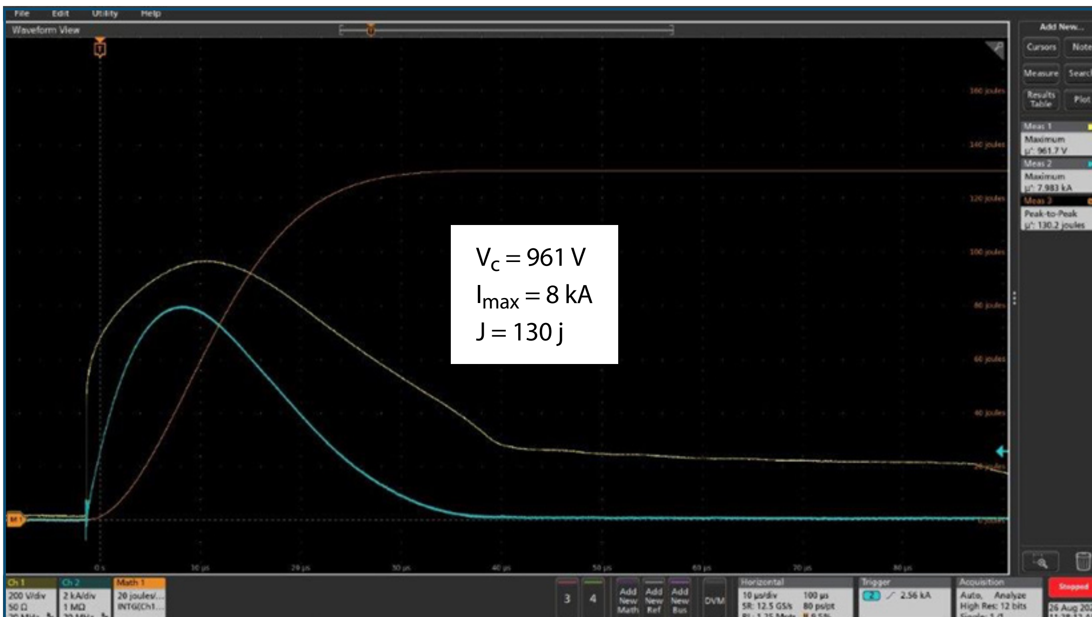

Figure 4. | *MOV test, rated at 130 joules*

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Why is the Joule Rating Not a Complete Answer? (Continued)

Next, a 20 mm Bourns® EdgMOV™ varistor is tested at the same 8 kA surge level. Because of its innovative design, this device only needs to be rated at 89 joules (or more) to survive the same surge current pulse! Bourns® EdgMOV™ varistors deliver comparable surge ratings of the next larger size of conventional MOV components.

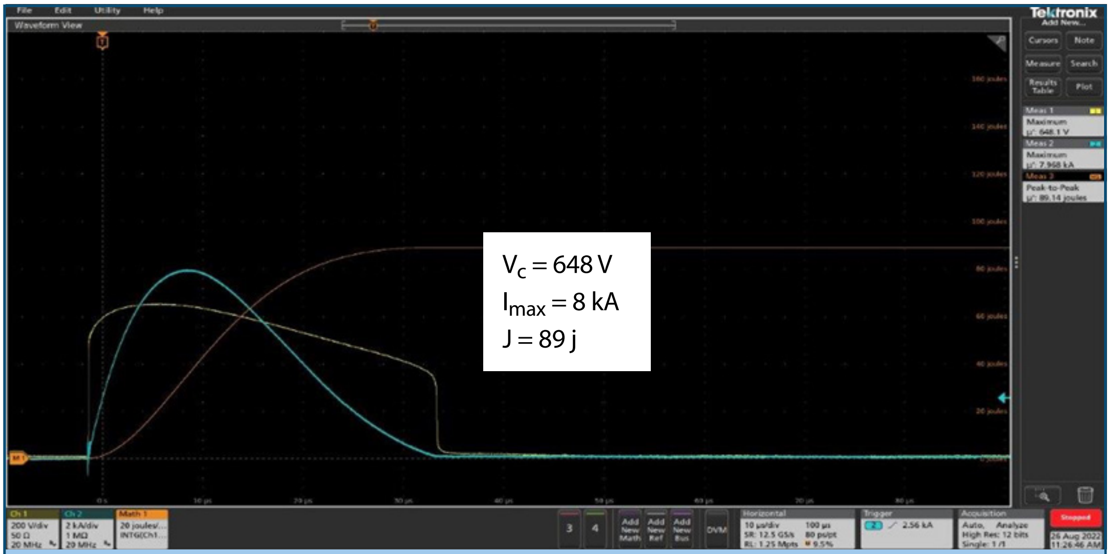

Figure 5. | Bourns® EdgMOV™ varistor test, rated at 89 joules

If the surge current is increased to 10 kA, this same 20 mm EdgMOV™ surge protector can support 122 joules, which is still lower than the 130 joule energy requirement of the 14 mm MOV at 8 kA.

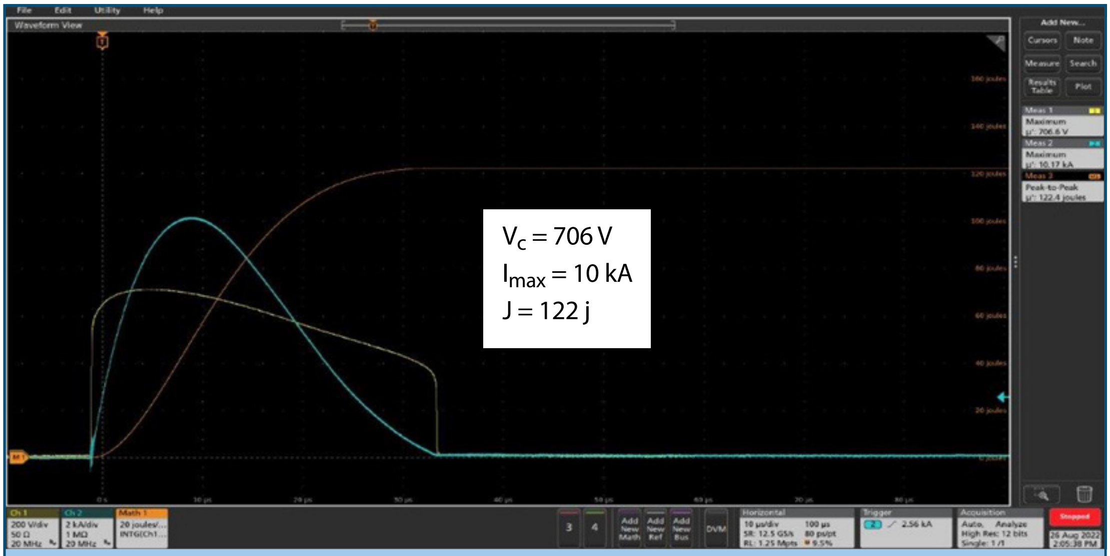

Figure 6. | Bourns® EdgMOV™ varistor test, rated at 122 joules — V_c = 706, I_n = 10, J = 122

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Conclusion

Based on the test results provided in this paper, even at higher surge currents, the joule requirement is lower for protection devices designed with advanced technology features. For easy comparison, the table below summarizes the measurements:

Product	Size (mm)	Clamping Voltage (V)	Surge Current (kA)	Joules (j)
Standard MOV	14	961	8	130
Bourns® EdgMOV™ Varistor	20	648	8	89
Bourns® EdgMOV™ Varistor	20	706	10	122
PTVS Diode	—	305	10	37

At face value, if the joule rating alone is used to gauge which component is better, the 14 mm MOV would immediately be chosen because it must have a higher joule rating at 8 kA compared to the 20 mm MOV. But this is in contrast to the common knowledge that a 20 mm MOV is better than a 14 mm MOV. The reason why the 20 mm energy measurement is lower is because it has a lower clamping voltage (648 V vs. 961 V).

In conclusion, a lower joule rating does not necessary mean that the component is inferior. As shown, it is more meaningful for a design engineer to select a surge protection device based on the clamping voltage at the required surge current than simply looking at the joule rating. The myth that higher joule ratings give better protection is busted. This paper was developed to give designers a better understanding that the joule rating is not the complete answer.

Americas: *Tel* +1-951 781-5500
Email americus@bourns.com

EMEA: *Tel* +36 88 520 390
Email eurocus@bourns.com

BOURNS®

Asia-Pacific: *Tel* +886-2 256 241 17
Email asiacus@bourns.com

Mexico: *Tel* +52 614 478 0400
Email mexicus@bourns.com