



DOES SIZE REALLY MATTER? – AN EXPLORATION OF THE UTILIZATION OF A SINGLE HIGHER ENERGY RATED MOV VS. PARALLELING MULTIPLE LOWER ENERGY MOVS

By

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ABSTRACT

This paper compares the merits of selecting either a single large MOV or the paralleling of smaller MOVs for AC line application. Recommended practices for the matching process of paralleled MOVs is presented through characterization testing examples and mathematical modeling. The paper also examines the effects of current, and therefore, energy sharing between parallel MOV arrays.

1. Introduction

The metal oxide varistor or MOV is commonly chosen as the first line of defense against transient over-voltages occurring on the AC mains. As a clamping device, much of the energy of the voltage transient itself is dissipated within the ceramic material of which the MOV is comprised. Thus the selection process of a MOV requires some knowledge of the expected transient in terms of available energy and surge current. Generally speaking, as available transient energy increases, a physically larger MOV would be required for higher rated energy. At the same time, designers of products such as TVSS devices, UPS systems or AC Panel protection devices may face physical space constraints or other dimensional form factor limitations. One route to solve this size issue is to compare the usage of a single, large MOV vs. that of using ganged (electrically paralleled) smaller MOVs to achieve equivalent ratings. This paper discusses trade-offs between these alternatives and presents a recommended procedure for the paralleling of MOVs should that choice be made.

2. Size Matters for Energy and Current Ratings

Essentially, the entire volume of material of an MOV is “active area” which accounts for its high energy rating. This is an appropriate characteristic for AC mains operation where available transient energy varies from a few joules to hundreds of joules. Likewise, the MOV’s surge current rating increases with the surface area or diameter of the metalized surface of the MOV. AC Line lightning surge currents can reach 500A to 10kA depending upon the service, source, and location. Observations of higher currents have been cited, for example, to 40kA. Again, for this reason MOVs are chosen over other technologies.

Table 1 compares Energy and Surge Current parameters for typical 14, 20, 32 and 40mm diameter radial devices and a 34mm square device.

Table 1 – Surge Current and Energy Ratings of Various Size MOVs at Typical Voltage Ratings

| Nominal Diameter | Voltage Rating (AC) | Maximum Surge Current (8x20 μ Sec, 1 pulse) | Maximum Energy (2 mSec) |
|------------------|---------------------|---|-------------------------|
| 14mm | 130 | 6,000 A | 50 J |
| 20mm | 130 | 1,000 A | 100 J |
| 32mm | 130 | 25,000 A | 200 J |
| 34mm | 130 | 30,000 A | 270 J |
| 40mm | 130 | 30,000 A | 270 J |
| 14mm | 275 | 6,000 A | 110 J |
| 20mm | 275 | 10,000 A | 190 J |
| 32mm | 275 | 25,000 A | 360 J |
| 34mm | 275 | 40,000 A | 400 J |
| 40mm | 275 | 40,000 A | 400 J |

3. Physical Comparisons of Common Disc Size MOVs

While common disc sizes range from 5mm to 60mm, for the purpose of this discussion, a large MOV is defined as one incorporating a 32mm, 34mm square, or 40mm disc (Figure 1). A small varistor is defined as a 14 or 20mm disc since these are usually the smallest practical size for most commercial AC Mains equipment. A first-order comparison of these disc sizes is made in Table 2 for the 250VAC (RMS) working voltage types.



Figure 1 – Various MOV Packages available

TABLE 2 – Comparison of available 250 V_{AC} MOV packages

| NOMINAL DIAMETER | MAXIMUM THICKNESS | MAXIMUM SEATING HEIGHT | MAXIMUM ENERGY | MAXIMUM SURGE CURRENT |
|------------------|-------------------|------------------------|----------------|-----------------------|
| 14mm | 5.6 mm | 20 mm | 100 J | 6,000 A |
| 20mm | 5.6 mm | 26.5 mm | 170 J | 10,000 A |
| 32mm | 9 mm | 52 mm | 330 J | 25,000 A |
| 40mm | 9 mm | 57 mm | 370 J | 40,000 A |
| 34mm | 6.1 mm | 44.5 mm | 370 J | 40,000 A |

4. Connecting MOVs in Parallel

MOVs with radial leads – the familiar “lollipop” device are generally available in diameters from 5mm to 20mm. These devices can handle up to 10kA peak surge current and dissipate up to 170 Joules of energy. For larger current and energy handling capability, larger diameter MOVs are available. These come in diameters from 32mm to 60mm and commonly have soldered tabs or are housed in plastic cases with screw terminals (see Figure 1). The physical size and the mounting arrangements make these larger components unsuitable for applications where space – especially headroom - is restricted. The only alternative in such cases is to gang or electrically parallel a number of smaller radial MOVs (Figure 2). The idea being that their energy capabilities like their capacitance will add, ($Energy_{Total} = Energy_{MOV1} + Energy_{MOV2}$, etc.). Another attraction of paralleling four 20mm MOVs – a commodity product - is that their cost is less than an equivalent 40mm device. Despite the attractions of paralleling, there are difficulties that must be addressed - current sharing is one such pitfall. For very high energy applications requiring more capability than even a 60mm device can deliver, then there is no option but to gang devices.

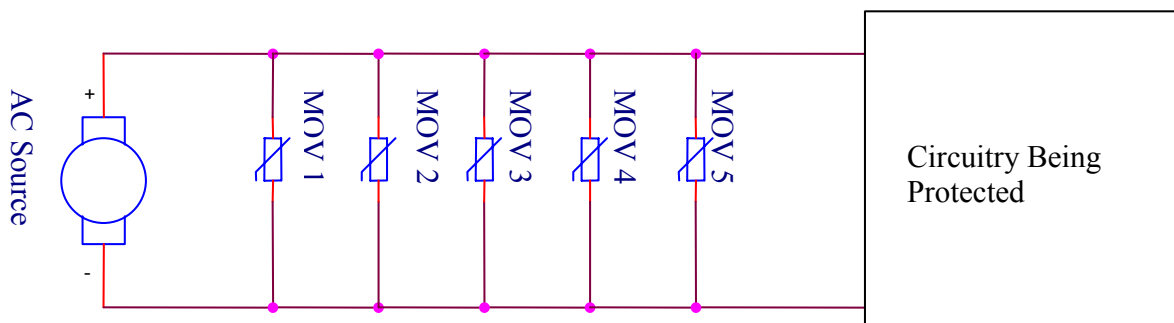


Figure 2 – Electrical arrangement of MOVs in parallel

The effects of sharing (mismatch) is not as dramatic under high level short circuit transients and it is possible to screen MOVs to a tighter V_{nom}^1 tolerance level. Still to obtain a 40 kA rating for the classic 8x20µSec lighting transient, 4 – 20mm discs would be required to perform the same job as a single 40mm

¹ V_{nom} (or Nominal Voltage) is the voltage drop of the MOV with 1mA DC forced current applied. It is the electrical characteristic region where the MOV transitions to the non-linear resistance (clamping) under higher applied currents.

