PERFORMANCE TESTING OF 7 & 10 MODE PROTECTORS

Some vendors claim significant performance advantage in TVSS protection can be provided for three phase WYE systems by using TVSS with 10 protection Modes rather than 7. To provide a clear understanding of the true differences, simple 10 Mode and 7 Mode protectors were constructed and tested.

- The 7 Mode protector used standard EPCOS 150Vrms 20mm disk MOVs L-N, L-G and N-G (8kA 8/20µs rated).
- The 10 Mode protector was based on the 7 Mode protector, but with 300Vrms MOVs added Line to Line.

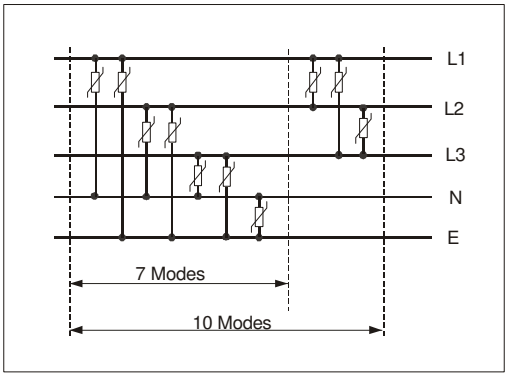

Figure 1. 7 and 10 Mode Protection Circuit Diagram

The 7 and 10 Mode MOV circuits were constructed to allow just the effect of the added Modes to be identified. Had 7 and 10 Mode products from different manufacturers been used, the performance differences may have included technology, MOV clamping voltage, surge rating, TVSS layout and filter performance differences.

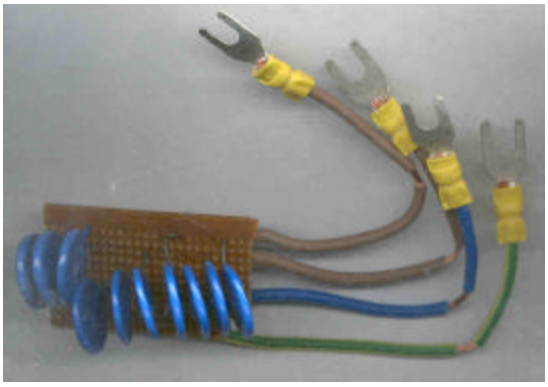

Figure 2. 10 Mode Protection Circuit Construction

To simulate performance at a branch panel location, tests as detailed in Table 1 were completed. The circuit design for each of the three phases is identical and initial testing confirmed L1-N let-through voltages matched that of L2-N and L3-N. Similarly L1-L2 let-through voltage performance matched L1-L3 and L2-L3. For clarity, the results of these phases were not recorded.

Explanation of results (Table 1)**:**
The main performance difference between the two protectors is evident in setup 5 to 8 where L-L performance is measured. The 10 Mode circuit performance was approximately 5% better. However, to achieve this 5% improvement, a 42% increase in component count was required.

Although setup #2 and #10 show a large performance improvement for the 10 Mode protector, simple comparison between the 7 and 10 Mode performance would lead to a false conclusion. The important point is that all the let-through voltages are below the results obtained for setup #6 (L-L tests).

Setup 14 also shows a low let-through voltage but large percentage change. The difference is likely noise and generator/measurement accuracy and should be ignored.

Test Condition			Let-through Voltage				
Setup #	Applied Impulse Current (8/20µs)*	Mode of Applied Impulse	Mode of Let-through Voltage Measured	10 Mode Protector (Volts)	7 Mode Protector (Volts)	Difference (Volts)	Difference (%)
1	3kA	L1 – N	L1 - N	538	531	-7	-1.3%
2	3kA	L1 – N	L1 - L2	350	438	88	20%
3	3kA	L1 – N	L1 - G	316	328	12	3.6%
4	3kA	L1 – N	N - G	247	247	0	0%
5	**3kA**	**L1 – L2**	**L1 - N**	**450**	**469**	**19**	**4.0%**
6	**3kA**	**L1 – L2**	**L1 - L2**	**906**	**953**	**47**	**4.9%**
7	**3kA**	**L1 – L2**	**L1 - G**	**456**	**475**	**19**	**4.0%**
8	**3kA**	**L1 – L2**	**N - G**	**18.4**	**19.4**	**1**	**5.0%**
9	3kA	L1 – G	L1 - N	322	328	6	1.8%
10	3kA	L1 – G	L1 - L2	375	456	81	17%
11	3kA	L1 – G	L1 - G	562	562	0	0%
12	3kA	L1 – G	N - G	272	275	3	1.0%
13	3kA	N-G	L1 - N	288	288	0	0%
14	3kA	N-G	L1 - L2	27.8	33.1	5.3	16%
15	3kA	N-G	L1 - G	297	300	3	1.0%
16	3kA	N-G	N - G	569	569	0	0%
*Applied Impulse: ANSI/IEEE C62.41 Cat B3/C1 Impulse 6kV 1.2/50µs / 3kA 8/20µs							

Table 1. Let-through Comparison for 10 and 7 Mode Protector at Branch Panel

Summary:
The results show a small L-L performance improvement when the additional Modes are added. However:
1) Even though the 7 Mode protector does not have MOVs directly connected Line to Line, test setup 2, 6, 10 and 14 prove that L-L protection is provided.
2) The let-through voltages of the 7 Mode protector (including L-L protection) are more than adequate for effective equipment protection.
3) The marginal performance improvement of a 10-mode is not justified technically or economically compared to the 42% increase in components and associated costs.

Not shown by the simple circuit construction is that when a 10 Mode protector is laid out in a TVSS, additional component space is required. Lead-length is a major influence on TVSS let-through voltage performance. The additional space required can have a detrimental affect on the overall performance - beyond the reported gains of the extra three Modes. Using the accepted value of let-through voltage adding 165V per foot of wiring (at 3kA 8/20µs), the 19V L-N performance improvement of the 10 mode protector would be eroded if this product was designed or installed with an additional 1.5" of lead-length. Putting it into perspective the difference between 7 and 10 Mode protectors is secondary to good design and installation practices.

TVSS's are installed to protect equipment from two main transient sources: 1) the rare but large destructive energies of a direct or induced lightning strike, and 2) the more common smaller electrical switching impulse.
The lightning impulses are predominately attempting to find a path to ground (not to another line) while the switching surges may be predominately L-N or L-L events. Those manufacturers of 10 Mode products generally construct all 10 Modes with identical surge ratings. However, ERICO recommends that the protection in the L-L Mode would provide far better value if added to the L-N, L-G Modes where the larger stresses are to be encountered. The smaller switching surges that may have a L-L component can be adequately protected by the L-N-L Mode.

The 10 Mode versus 7 Mode is primarily a marketing gimmick that is unfortunately given consideration due to human nature's "bigger is better" mentality. Well-designed 7 Mode TVSS's have successfully provided protection for many thousands of sites for numerous years.

In conclusion, the number of Modes should not be a determining factor in the selection of a TVSS. Important selection parameters are:

- Maximum Continuous Operating Voltage
- Let-through voltages
- Surge Rating
- Ease of optimal installation
- Standards compliance, alarms and indicators, warranty, etc.

A "good" 7 Mode protector will always be better than a "poor" 10 Mode protector.