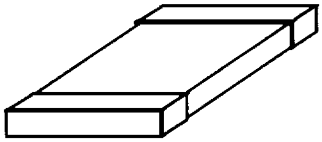
HARRIS SEMICONDUCTOR

ML Series

Multilayer Surface Mount Transient Surge Suppressors

January 1995



ML SERIES

Features

- Leadless Chip Form - "Zero" Lead Inductance
- Multilayer Construction Technology
- -55°C to +125°C Operating Temperature Range
- Wide Operating Voltage Range $V_{M(DC)}$ = 3.5V to 68V
- Broad Range of Energy Handling Capabilities
- Low Profile, Compact Industry Standard Chip Sizes
- Inherent Bidirectional Clamping
- No Plastic or Epoxy Packaging Assures Better than 94V-0 Flammability Rating
- Low Capacitance Models Available

Applications

- On-Board Transient Voltage Protection for ICs and Transistors
- ESD Protection for Components Sensitive to IEC 801-2, MIL-STD-3015.7, etc.
- Replace Larger Surface Mount Zener Diodes

Description

ML series transient surge suppressors are designed to protect sensitive electronic devices from destruction by high voltage transients. These suppressors are designed to fail short when overstressed and protect the associated equipment. The ML suppressor is manufactured from semiconducting ceramics which offer rugged protection, excellent transient energy absorption and increased internal heat dissipation.

The devices are in chip form, eliminating lead inductance and assuring fast speed of response to transient surges. These transient suppression devices have significantly smaller footprints and lower profiles than traditional TVS diodes or radial MOV's (metal oxide varistors), thus allowing designers to reduce size and weight while increasing system reliability.

Absolute Maximum Ratings For ratings of individual members of a series, see device ratings and Characteristics chart.

	ML SERIES	UNITS
Continuous:		
Steady State Applied Voltage:		
DC Voltage Range ($V_{M(DC)}$)	3.5 to 68	V
AC Voltage Range ($V_{M(AC)RMS}$)	2.5 to 50	V
Transient:		
Non-Repetitive Surge Current, 8/20µs Waveform, (I_{TM})	40 to 250	A
Non-Repetitive Surge Energy, 10/1000µs Waveform, (W_{TM})	0.1 to 1.2	J
Operating Ambient Temperature Range (T_A)	-55 to +125	°C
Storage Temperature Range (T_{STG})	-55 to +150	°C
Temperature Coefficient (αV) of Clamping Voltage (V_C) at Specified Test Current	<0.01	%/°C

Device Ratings and Characteristics

MODEL NUMBER	MAXIMUM RATINGS (+125°C)					CHARACTERISTICS (+25°C)		
	MAXIMUM CONTINUOUS WORKING VOLTAGE		MAXIMUM NON-REPETITIVE SURGE CURRENT (8/20μs)	MAXIMUM NON-REPETITIVE SURGE ENERGY (10/1000μs)	MAXIMUM CLAMPING VOLTAGE AT 10A (OR AS NOTED) (8/20μs)	NOMINAL VOLTAGE AT 1mA DC TEST CURRENT		TYPICAL CAPACITANCE AT f = 1MHz
	$V_{M(DC)}$	$V_{M(AC)}$	I_{TM}	W_{TM}	V_C	$V_{N(DC)}$ MIN	$V_{N(DC)}$ MAX	C
	(V)	(V)	(A)	(J)	(V)	(V)	(V)	(pF)
V3.5MLA0805	3.5	2.5	120	0.3	10 at 5A	3.7	5.5	2750
V3.5MLA0805L	3.5	2.5	40	0.1	10 at 2A	3.7	5.5	1200
V3.5MLA1206	3.5	2.5	100	0.3	14	5.0	7.0	6000
V5.5MLA0805	5.5	4.0	120	0.3	15.5 at 5A	7.1	9.3	2500
V5.5MLA0805L	5.5	4.0	40	0.1	15.5 at 2A	7.1	9.3	1100
V5.5MLA1206	5.5	4.0	150	0.4	15.5	7.1	8.7	4500
V14MLA0805	14	10	120	0.3	30 at 5A	15.9	20.3	1200
V14MLA0805L	14	10	40	0.1	30 at 2A	15.9	20.3	450
V14MLA1206	14	10	150	0.4	30	16.4	20	2100
V18MLA0805	18	14	120	0.3	40 at 5A	22.5	28.0	650
V18MLA0805L	18	14	40	0.1	40 at 2A	22.5	28.0	350
V18MLA1206	18	14	150	0.4	40	22	27	1700
V18MLA1210	18	14	250	0.8	40	22	27	1900
V26MLA1206	26	20	150	0.6	56	29.5	38.5	800
V26MLA1210	26	20	250	1.2	54	29.5	38.5	1000
V33MLA1206	33	26	180	0.8	72	38	45	500
V42MLA1206	42	30	180	0.8	86	46	56	450
V56MLA1206	56	40	180	1.0	110	61	76	350
V68MLA1206	68	50	180	1.0	130	76	90	150

NOTES:

1. L suffix is a low capacitance and energy version.
2. Typical leakage at +25°C < 50μA, maximum leakage 100μA.
3. Average power dissipation of transients for 0805, 1206 and 1210 sizes not to exceed 0.10W, 0.10W and 0.15W, respectively.
4. Devices specifically characterized for automotive applications also available. (See AUML Series).

Power Dissipation Ratings

Continuous power dissipation capability is not an applicable requirement for a suppressor, unless transients occur in rapid succession. Under this condition, the average power dissipation required is simply the energy (watt-seconds) per pulse times the number of pulses per second. The power so developed must be within the specifications shown on the Device Ratings and Characteristics table for the specific device. Furthermore, the operating values need to be derated at high temperatures as shown in Figure 1.

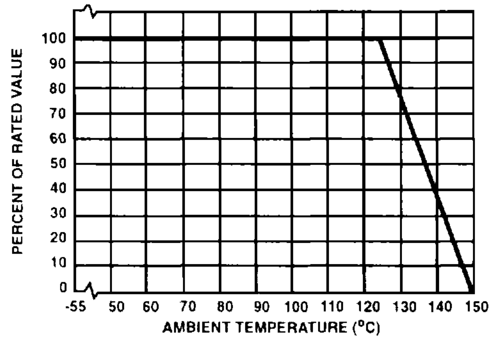
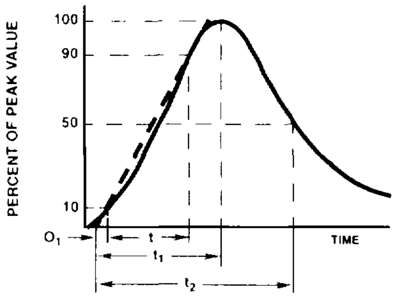


FIGURE 1. CURRENT, ENERGY AND POWER DERATING CURVE



O_1 = VIRTUAL ORIGIN OF WAVE
t = TIME FROM 10% TO 90% OF PEAK
t_1 = VIRTUAL FRONT TIME = 1.25 x t
t_2 = VIRTUAL TIME TO HALF VALUE (IMPULSE DURATION)

EXAMPLE:
FOR AN 8/20μs CURRENT WAVEFORM:
8μs = t_1 = VIRTUAL FRONT TIME
20μs = t_2 = VIRTUAL TIME TO HALF VALUE

FIGURE 2. PEAK PULSE CURRENT TEST WAVEFORM

Maximum Transient V-I Characteristic Curves

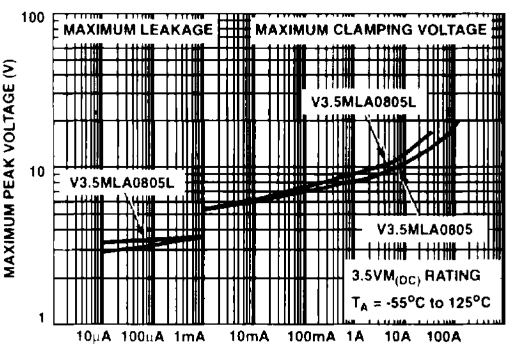


FIGURE 3. V3.5MLA0805/L MAXIMUM V-I CHARACTERISTICS CURVES

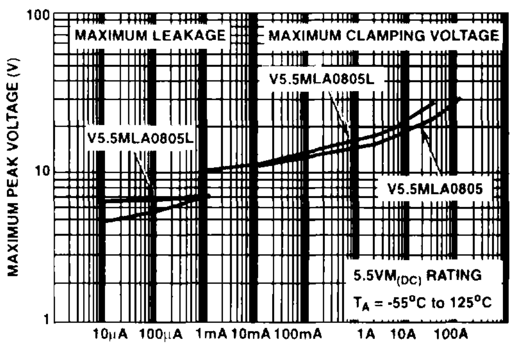


FIGURE 4. V5.5MLA0805/L MAXIMUM V-I CHARACTERISTICS CURVES

Maximum Transient V-I Characteristic Curves (Continued)

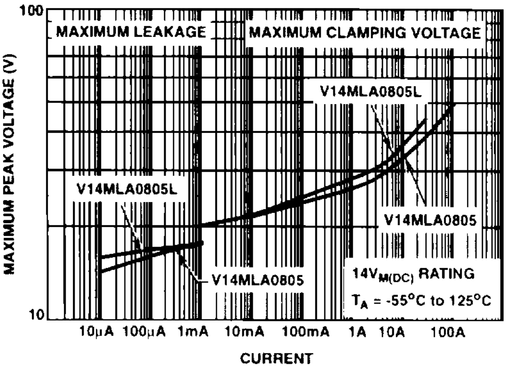


FIGURE 5. V14MLA0805/L MAXIMUM V-I CHARACTERISTICS CURVES

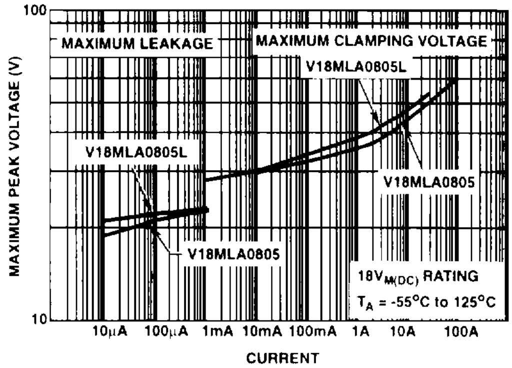


FIGURE 6. V18MLA0805/L MAXIMUM V-I CHARACTERISTICS CURVES

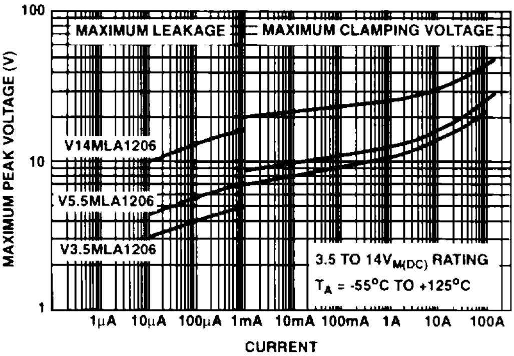


FIGURE 7. V3.5MLA1206 TO V14MLA1206 MAXIMUM V-I CHARACTERISTIC CURVES

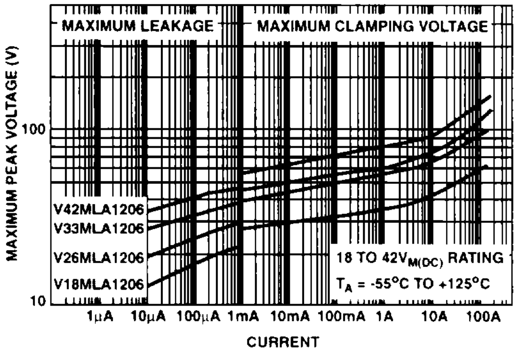


FIGURE 8. V18MLA1206 TO V42MLA1206 MAXIMUM V-I CHARACTERISTIC CURVES

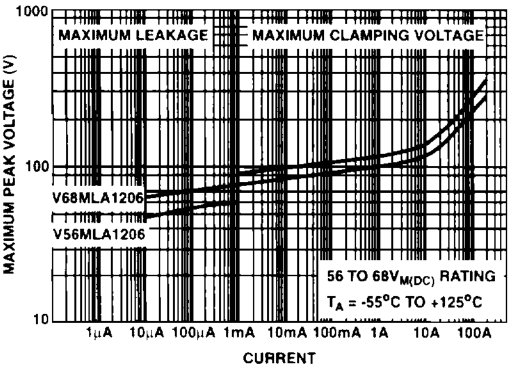


FIGURE 9. V56MLA1206 TO V68MLA1206 MAXIMUM V-I CHARACTERISTIC CURVE

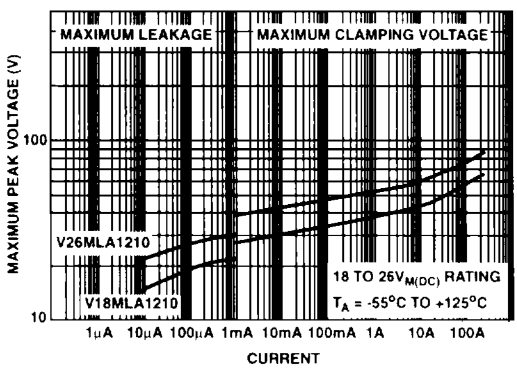


FIGURE 10. V18MLA1210 TO V26MLA1210 MAXIMUM V-I CHARACTERISTIC CURVES

Device Characteristics

At low current levels, the V-I curve of the multilayer transient voltage suppressor approaches a linear (ohmic) relationship and shows a temperature dependent affect (Figure 11). The suppressor is in a high resistance mode (approaching $10^9\Omega$) and appears as a near open circuit. This is equivalent to the leakage region in a traditional zener diode. Leakage currents at maximum rated voltage are in the microamp range and in most cases below 50μA.

When clamping transients at higher currents, at and above the 10mA range, the multilayer suppressor approaches a 1Ω -10Ω characteristic. Here, the multilayer becomes virtually temperature independent (Figure 12).

Speed of Response

Traditional transient suppressors, e.g. metal oxide varistors and zener diode type devices, have finite lead inductance, device capacitance and resistance. Thus these suppressors have their response times limited (slowed) by parasitic lead impedances. These difficulties have been recognized by the IEEE committees on transient suppressors concluding that response time of a suppressor is influenced by lead configuration and length. Unlike the leaded packages offered for surface mounting (Gull-wing and J-bend) the multilayer suppressor is a true surface mount device. As the multilayer has no leads it therefore has virtually zero inductance and the major factor controlling response time is eliminated.

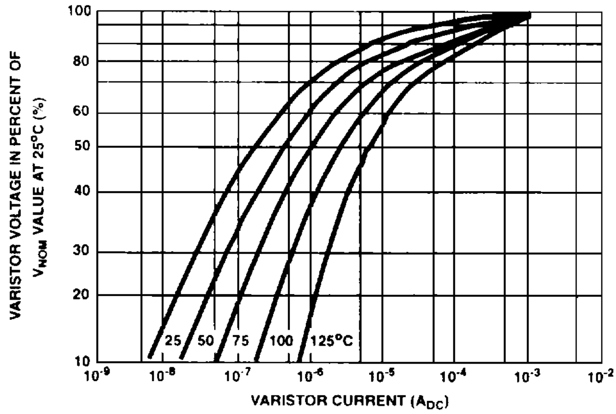


FIGURE 11. TYPICAL TEMPERATURE DEPENDENCE OF THE CHARACTERISTIC CURVE IN THE LEAKAGE REGION

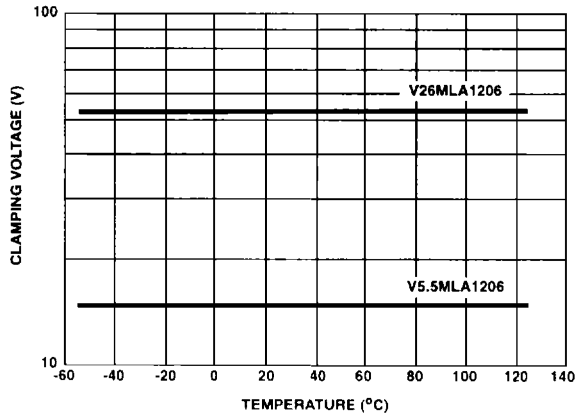


FIGURE 12. CLAMPING VOLTAGE OVER TEMPERATURE (V_C AT 10A)

Energy Absorption/Peak Current Capability

This rating serves as a figure of merit for the ML suppressor. Energy is calculated by multiplying the clamping voltage, transient current and transient duration. An important advantage of the multilayer TVS interdigitated construction is its mass of transient suppressor material available to absorb energy. As a result, the peak temperature per energy absorbed is very low. The matrix of semiconducting grains combine to absorb and distribute transient energy (heat) (Figure 13). This dramatically reduces peak temperature, thermal stresses and enhances device reliability.

As a measure of the device capability in energy handling and peak current, the V26MLA1206A23 part was tested with multiple pulses at its peak current rating (150A, 8/20 μs). As this level of current is far in excess of anything the device is exposed to in an IC protection application it is taken as measure of the ruggedness and inherent capability. At the end of the test, 10,000 pulses later, the device voltage characteristics are still well within specification (Figure 14).

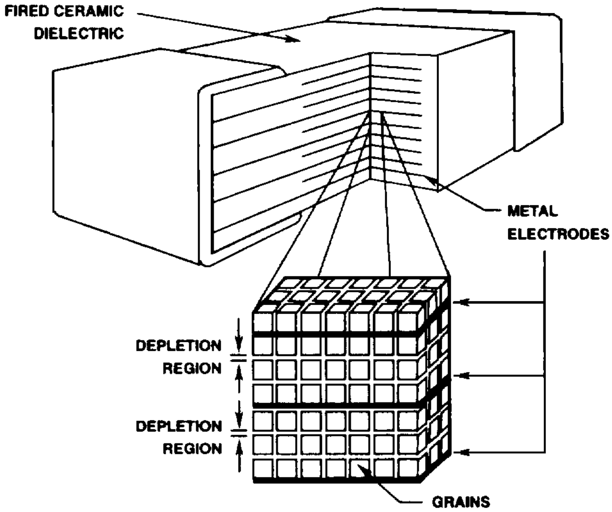


FIGURE 13. MULTILAYER TVs INTERNAL CONSTRUCTION

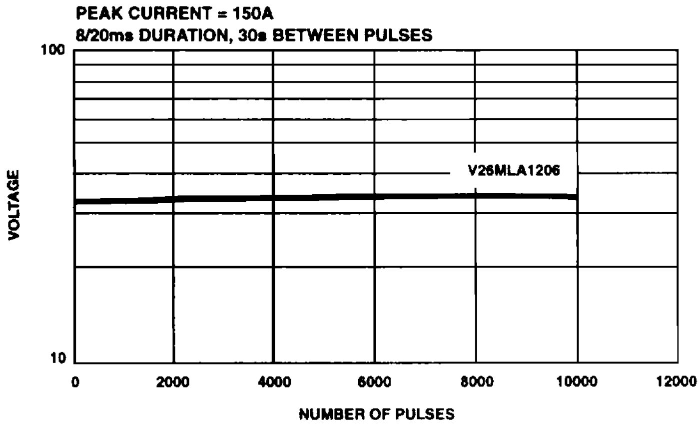


FIGURE 14. REPETITIVE PULSE CAPABILITY

Soldering Recommendations

The principal techniques used for the soldering of components in surface mount technology are Infra Red (IR) Reflow, Vapour Phase Reflow and Wave Soldering. When wave soldering, the ML suppressor is attached to the substrate by means of an adhesive. The assembly is then placed on a conveyor and run through the soldering process. With IR and Vapour Phase Reflow the device is placed in a solder paste on the substrate. As the solder paste is heated it reflows, and solders the unit to the board.

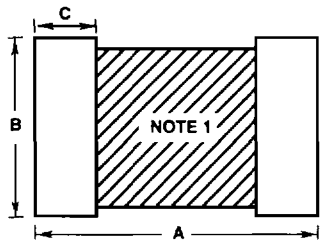
With the ML suppressor, the recommended solder is a 62/36/2 (Sn/Pb/Ag) silver solder paste. While this configuration is best, a 60/40 (Sn/Pb) or a 63/37 (Sn/Pb) solder paste can also be used. In soldering applications, the ML suppressor is held at elevated temperatures for a relatively long period of time. With the wave soldering operation is the most strenuous of the processes. To avoid the possibility of generating stresses due to thermal shock, a preheat stage in the soldering process is recommended, and the peak temperature of the solder process should be rigidly controlled.

When using a reflow process, care should be taken to ensure that the ML chip is not subjected to a thermal gradient steeper than 4 degrees per second; the ideal gradient being 2 degrees per second. During the soldering process, preheating to within 100 degrees of the solders peak temperature is essential to minimize thermal shock. Examples of the soldering conditions for the ML series of suppressors are given in the table below.

Once the soldering process has been completed, it is still necessary to ensure that any further thermal shocks are avoided. One possible cause of thermal shock is hot printed circuit boards being removed from the solder process and subjected to cleaning solvents at room temperature. The boards must be allowed to cool to less than 50°C before cleaning.

SOLDERING OPERATION	TIME (SECONDS)	PEAK TEMPERATURE (°C)
IR Reflow	5 - 10	220
Vapour Phase Reflow	5 - 10	222
Wave Solder	3 - 5	260

Recommended Pad Outline



NOTE 1: Avoid metal runs in this area.

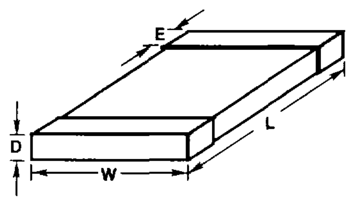
SYMBOL	CHIP SIZE					
	1210		1206		0805	
	IN	MM	IN	MM	IN	MM
A	0.219	5.53	0.203	5.15	0.105	2.65
B	0.147	3.73	0.103	2.62	0.058	1.45
C	0.073	1.85	0.065	1.65	0.032	0.80

Soldering Recommendations

Material - 62/36/2 Sn/Pb/Ag or equivalent

Temperature - 230°C, 5 seconds max Flux - nonactivated

Dimensional Outline



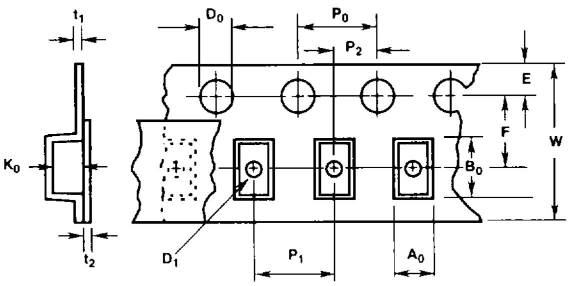
SYMBOL	CHIP SIZE					
	1210		1206		0805	
	IN	MM	IN	MM	IN	MM
D Max.	0.113	2.87	0.071	1.80	0.043	1.1
E	0.02 ±0.01	0.50 ±0.25	0.02 ±0.01	0.50 ±0.25	0.01 to 0.029	0.25 to 0.75
L	0.125 ±0.012	3.20 ±0.30	0.125 ±0.012	3.20 ±0.03	0.079 ±0.008	2.01 ±0.2
W	0.10 ±0.012	2.54 ±0.30	0.06 ±0.011	1.60 ±0.28	0.049 ±0.008	1.25 ±0.2

Tape and Reel Specifications

- **Conforms to EIA - 481, Revision A**
- **Can be Supplied to IEC Publication 286 - 3**

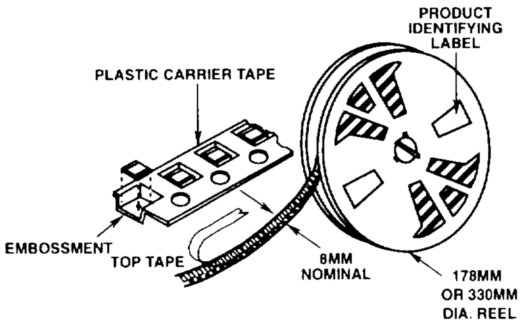
SYMBOL	DESCRIPTION	MILLIMETERS
A_0	Width of Cavity	Dependent on Chip Size to Minimize Rotation.
B_0	Length of Cavity	Dependent on Chip Size to Minimize Rotation.
K_0	Depth of Cavity	Dependent on Chip Size to Minimize Rotation.
W	Width of Tape	8 ± 0.2
F	Distance Between Drive Hole Centers and Cavity Centers	3.5 ± 0.5
E	Distance Between Drive Hole Centers and Tape Edge	1.75 ± 0.1
P_1	Distance Between Cavity Center	4 ± 0.1
P_2	Axial Distance Between Drive Hole Centers and Cavity Centers	2 ± 0.1
P_0	Axial Distance Between Drive Hole Centers	4 ± 0.1
D_0	Drive Hole Diameter	1.55 ± 0.05
D_1	Diameter of Cavity Piercing	1.05 ± 0.05
t_1	Embossed Tape Thickness	0.3 max
t_2	Top Tape Thickness	0.1 max

NOTE: Dimensions in millimeters.



Standard Packaging

The ML Series of transient suppressors are always shipped in tape and reel. The standard 330 millimeter (13 inch) reel utilized contains 8000 pieces for the 1210 and 10000 pieces for the 1206 and 0805 chip. To order add "T23" to the standard part number, e.g. V5.5MLA1206T23 or V68MLA1206T23.



Special Packaging

Option 1: 178 millimeter (7 inch) reels containing 2000 or 2500, depending on chip size, pieces are available. To order add "H23" to the standard part number, e.g. V5.5MLA1206H23 or V68MLA1206H23.

Option 2: For small sample quantities (less than 100 pieces) the units are shipped bulk pack. To order add "A23" to the standard part number, e.g. V5.5MLA1206A23 or V68MLA1206A23.

4

VARISTOR PRODUCTS

Terms and Descriptions

Rated DC Voltage ($V_{M(DC)}$)

This is the maximum continuous DC voltage which may be applied up to the maximum operating temperature of the device. The rated DC operating voltage (working voltage) is also used as the reference point for leakage current. This voltage is always less than the breakdown voltage of the device. Unlike the zener diode all multilayer TVS devices have a maximum leakage current of less than 100μA.

Rated AC Voltage ($V_{M(AC)RMS}$)

This is the maximum continuous sinusoidal rms voltage which may be applied. This voltage may be applied at any temperature up to the maximum operating temperature of the device.

Maximum Non-Repetitive Surge Current (I_{TM})

This is the maximum peak current which may be applied for an 8/20μs impulse, with rated line voltage also applied, without causing device failure. The pulse can be applied to the device in either polarity with the same confidence factor. See Figure 2 for waveform description.

Maximum Non-Repetitive Surge Energy (W_{TM})

This is the maximum rated transient energy which may be dissipated for a single current pulse at a specified impulse duration (10/1000μs), with the rated DC or RMS voltage applied, without causing device failure.

Leakage (I_L) at Rated DC Voltage

In the nonconducting mode, the device is at a very high impedance (approaching $10^9\Omega$) and appears as an almost open circuit in the system. The leakage current drawn at this level is very low (<50μA at ambient temperature) and, unlike the zener diode, the multilayer TVS has the added advantage that, when operated up to its maximum temperature, its leakage current will not increase above 500μA.

Nominal Voltage ($V_{N(DC)}$)

This is the voltage at which the device changes from the off state to the on state and enters its conduction mode of operation. The voltage is usually characterized at the 1mA point and has a specified minimum and maximum voltage listed.

Clamping Voltage (V_C)

This is the peak voltage appearing across the suppressor when measured at conditions of specified pulse current and specified waveform (8/20μs). It is important to note that the peak current and peak voltage may not necessarily be coincidental in time.

Capacitance (C)

This is the capacitance of the device at a specified frequency (1MHz) and bias ($1V_{P-P}$).