AVX 528-900 TO 529-047

TransGuard®

Transient Voltage Suppressors

GENERAL DESCRIPTION

The AVX TransGuard® Transient Voltage Suppressors (TVS) with unique high-energy multilayer construction represents state-of-the-art overvoltage circuit protection. Monolithic multilayer construction provides protection from voltage transients caused by ESD, lightning, NEMP, inductive switching, etc. True surface mount product is provided in industry standard packages. Thru-hole components are supplied as conformally coated axial devices.

FEATURES

- Small Size
- Low Voltage
- Excellent Clamping Ratio
- High Transient Current Capability
- Response Time: Less than 1 nsec

TYPICAL APPLICATIONS

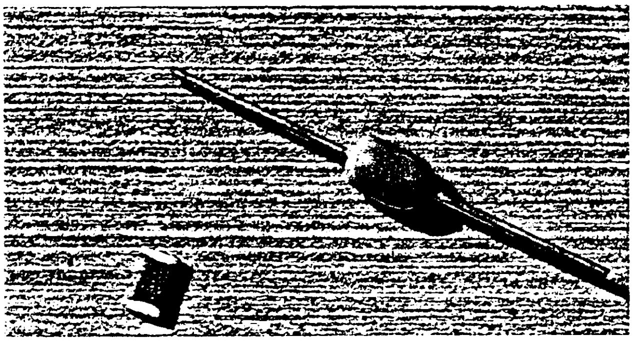
- Computer ESD and I/O Protection
- Automotive Transient Protection
- ESD/EMP Protected Connectors
- Data Line Protection
- Telecommunication Transient Protection
- Avionic Transient Protection

TRANSGUARD® DESCRIPTION

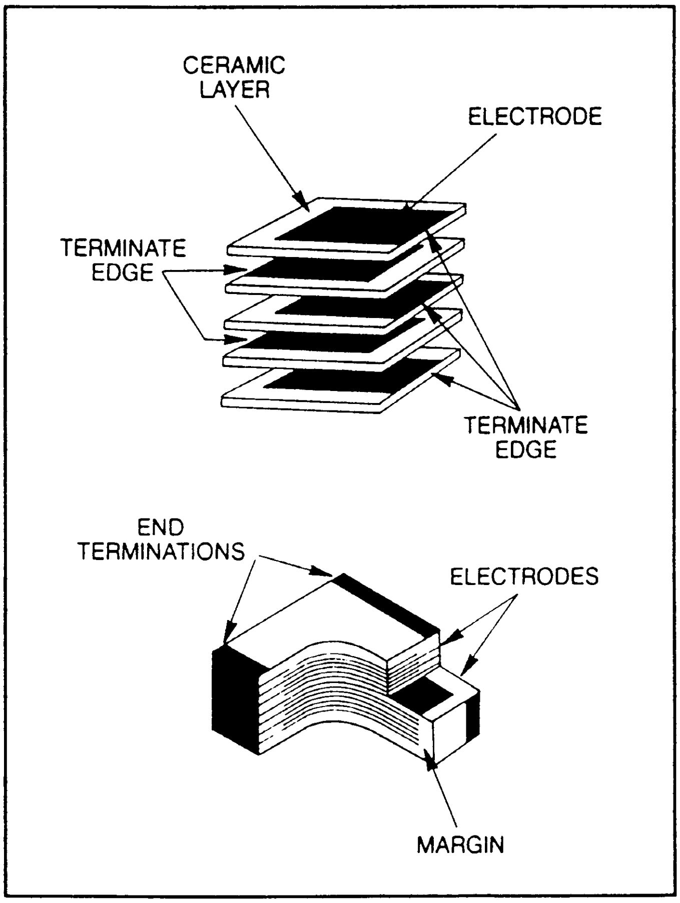
TransGuard® products are zinc oxide (ZnO) based ceramic semi-conductor devices with non-linear current-voltage characteristics similar to back-to-back zener diodes. They have the added advantage of greater current and energy handling capabilities. Devices are fabricated by a ceramic sintering process that yields a structure of conductive ZnO grains surrounded by electrically insulating barriers, creating varistor-like behavior.

The number of grain-boundary interfaces between conducting electrodes determines "Breakdown Voltage" of the device. High voltage applications such as AC line protection require many grains between electrodes while low voltage requires few grains to establish the appropriate breakdown voltage. Single layer ceramic disc processing proved to be a viable production method for thick cross section devices with many grains, but attempts to address low voltage suppression needs by processing single layer ceramic disc formulations with huge grain growth has had limited success.

AVX, the world leader in the manufacture of multilayer ceramic capacitors, now offers the low voltage transient protection marketplace a true multilayer, monolithic surface mount varistor. Technology leadership in processing thin dielectric materials and patented processes for precise ceramic grain growth have yielded superior energy dissipation in the smallest size. Now a varistor has voltage characteristics determined by design and not just cell sorting whatever falls out of the process.



Multilayer ceramic varistors are manufactured by mixing ceramic powder in an organic binder (slurry) and casting it into thin layers of precision thickness. Metal electrodes are deposited onto the green ceramic layers which are then stacked to form a laminated structure. The metal electrodes are arranged so that their terminators alternate from one end of the varistor to the other. The device becomes a monolithic block during the sintering (firing) cycle providing uniform energy dissipation in a small volume.



AVX

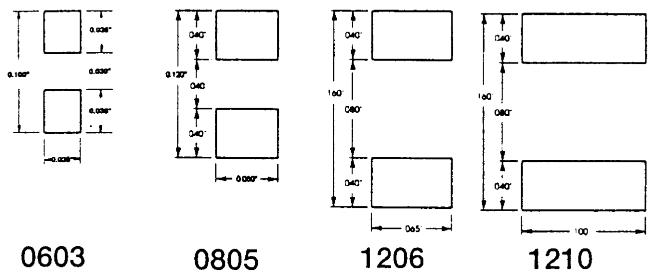
TransGuard®

Transient Voltage Suppressors

SMT APPLICATIONS

The move to surface mount assembly is driven by size, weight and increased functionality of electronic systems. AVX TransGuard® chips are small by design, fitting the standard 0603, 0805, 1206 and 1210 case sizes and are available in 8mm tape. This is contrasted by disc varistors in large non-standard resin molded packages or zener diodes in molded cylinders or large gull-wing packages.

The small size of the TransGuard® product allows maximum board density and protection but requires special attention to land design to assure minimum defects during soldering. The recommended solder pads (lands) have a proven low defect rate (<1 ppm) in production with a solder paste wet laydown of 10-12 mils.

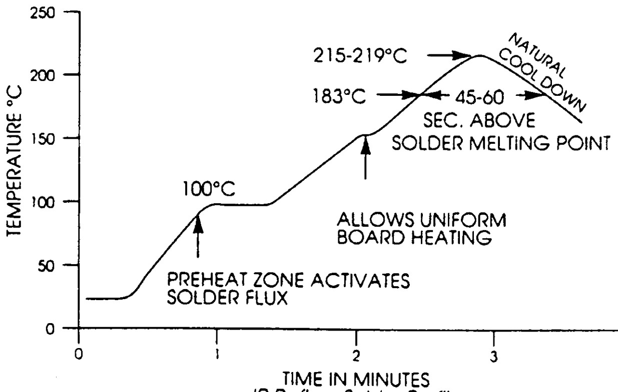


Recommended TransGuard® Reflow Solder Pads

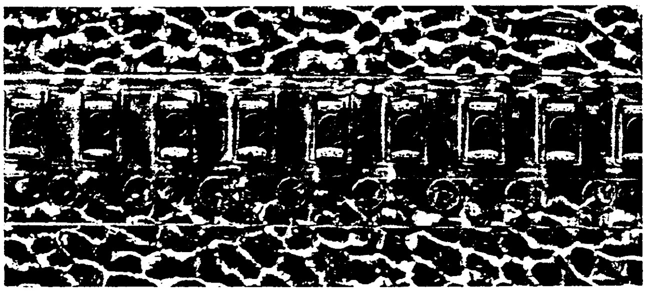
AVX TransGuard® voltage suppressors are easy to process with less restrictions than MLC capacitors, chip resistors and other surface mount components. The following solderability profiles are suggested for the different soldering techniques.

INFRARED REFLOW SOLDERING (IR)

Soldering with IR has the highest yields due to controlled heating rates and solder liquidus times. Only the dwell time and peak temperature limitations of resin-molded components need to be considered. Typical recommended solder paste wet laydown is 10-15 mils.

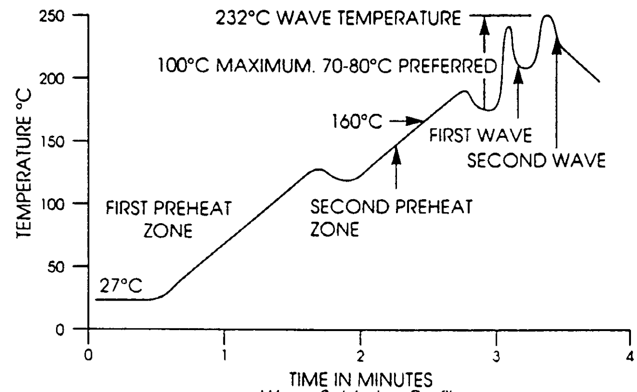


IR Reflow Solder Profile



WAVE SOLDERING

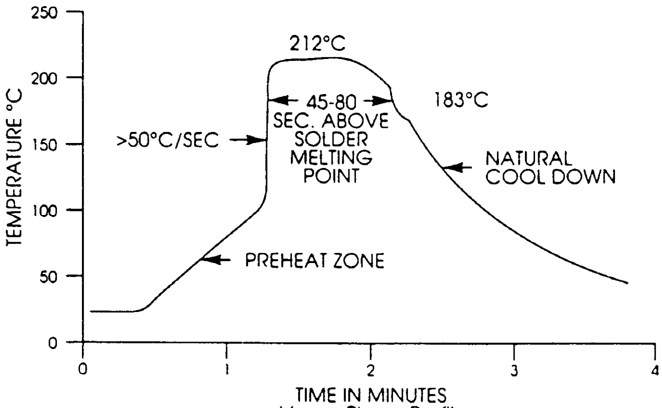
Wave soldering has the highest solder temperatures and heat transfer rates whose temperature limits are determined by parts like transistors and integrated circuits. The profile has a short dwell time in the solder pot and requires a high preheat to minimize thermal shock in ceramic components and temperature problems with resin-molded parts.



Wave Soldering Profile

VAPOR PHASE REFLOW SOLDERING

Vapor phase soldering has the second highest heat transfer rate so care must be used. Preheating the assembly and minimizing the dwell time above the solder liquidus temperature are needed to help reduce defects.



Vapor Phase Profile

Transient Voltage Suppressors

Disc or pressed pill varistor construction is ideal for high voltages due to low manufacturing cost but large irregular grains in low voltage devices limit mechanical integrity and electrical performance. In low voltage applications, many disadvantages exhibited by disc varistor construction is eliminated with the multilayer construction of TransGuard® suppressors. (Figure 1)

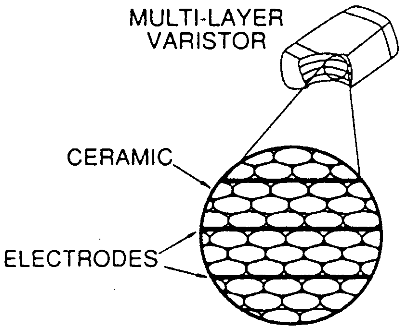
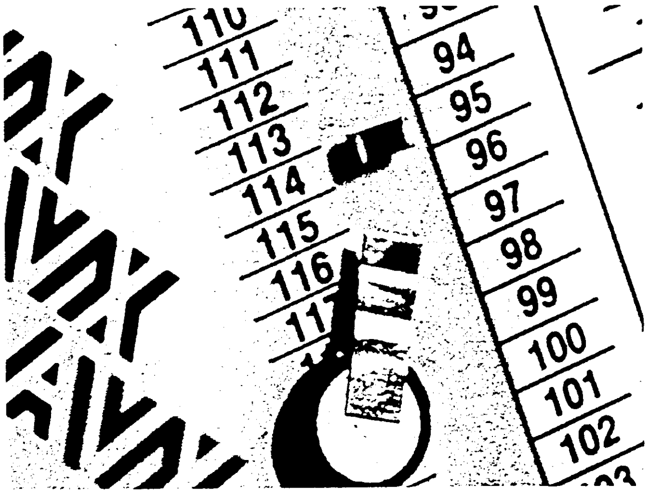
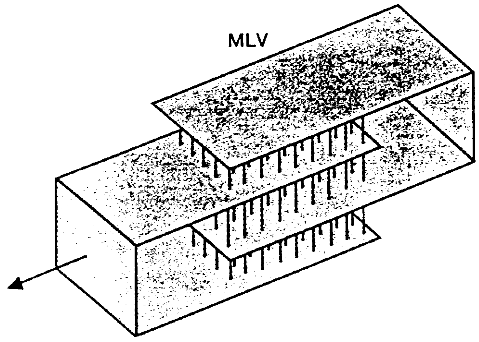


Figure 1



TransGuard® vs. Disc Varistor

Varistors or semiconducting ceramics are in reality series/parallel combinations of Schottky diodes that also support significant energy dissipation in the thin depletion regions at each Schottky barrier. Zener diodes have only a single thin depletion region at the surface while varistors have many in series/parallel combinations distributed throughout the whole ceramic volume as seen in Figure 2. This results in superior energy dissipation per unit volume without having to resort to internal package heat sinks found in high peak current zener diode suppressors.



Energy is dissipated in the total volume between electronics
Figure 2

COMPARISON OF SURFACE MOUNT TRANSIENT SUPPRESSORS

SUPPRESSOR TYPE			5.6 VDC			14 VDC		
			TransGuard®	MOV	ZENER	TransGuard®	MOV	ZENER
Dimensions	LxW	Inch	1206	1812	1812	1206	1812	1812
Breakdown Voltage	V_B	Volt	8.7	11	7.3	19.4	21.6	19.1
Clamping Voltage	V_C	Volt	15.5	30	9.6	30	44	25.8
Peak Current	I_{peak}	Amp	150	25	62.5	150	50	23.3
Transient Energy	E_{tran}	Joule	.4	.1	.5	.4	.2	.5
Capacitance	C	nF	3	.7	5	1.4	.4	1.1
Inductance	L	nH	1.7	4	4	1.7	4	4

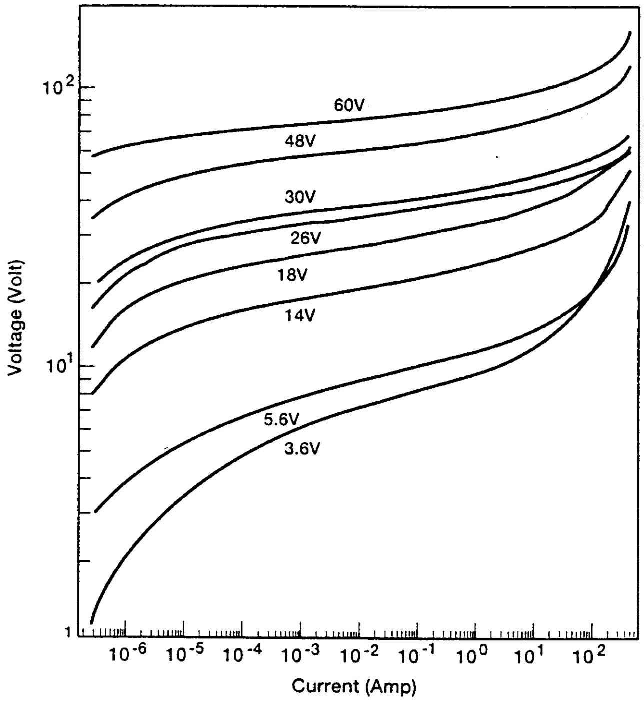
Transient Voltage Suppressors

TYPICAL PERFORMANCE CURVES

VOLTAGE/CURRENT CHARACTERISTICS

Multilayer construction and improved grain structure result in excellent transient clamping characteristics in excess of 150 amps peak current while maintaining very low leakage currents under DC operating conditions. The IV curve below shows the voltage/current characteristics for the 3.6V, 5.6V, 14V, 18V, 26V, 30V, 48V and 60VDC parts with currents ranging from parts of a micro amp to tens of amps.

TYPICAL IV CURVES OF TRANSGUARD®



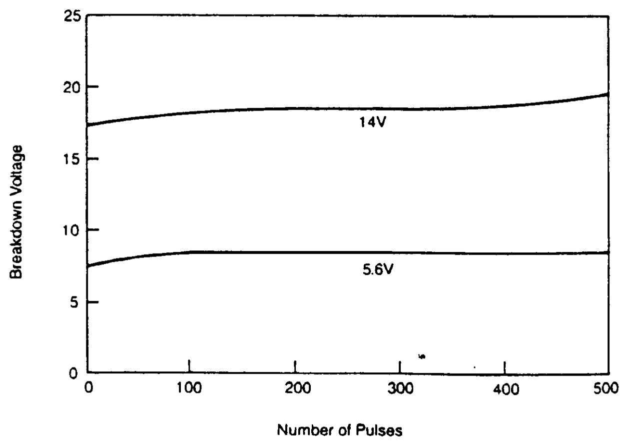
CAPACITANCE/FREQUENCY CHARACTERISTICS

Capacitance changes typically between -6 to -8% per decade of increasing frequency between 1 kHz and resonance.

PULSE DEGRADATION

Traditionally varistors have suffered degradation of electrical performance with repeated high current pulses resulting in decreased breakdown voltage and increased leakage current. It has been suggested that irregular intergranular boundaries and bulk material result in restricted current paths and other non-Schottky barrier paralleled conduction paths in the ceramic. Repeated pulsing of both 5.6 and 14V TransGuard® transient voltage suppressors with 150Amp peak 8 x 20µS wave forms shows negligible degradation in breakdown voltage and minimal increases in leakage current. This does not mean that TransGuard® suppressors do not suffer degradation, but it occurs at much higher current. The plots of typical breakdown voltage vs number of 150A pulses shown in the adjacent figure is for devices that are only one-eighth of an inch long (3.18mm) and a sixteenth of an inch wide (1.59mm).

TYPICAL PULSE DEGRADATION FOR
8 × 20 MICROSECOND
150 AMP PEAK CURRENT PULSE



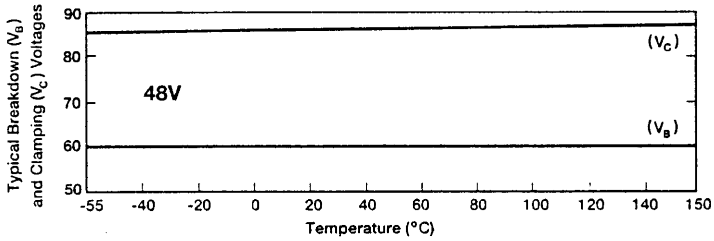
Transient Voltage Suppressors

TYPICAL PERFORMANCE CURVES

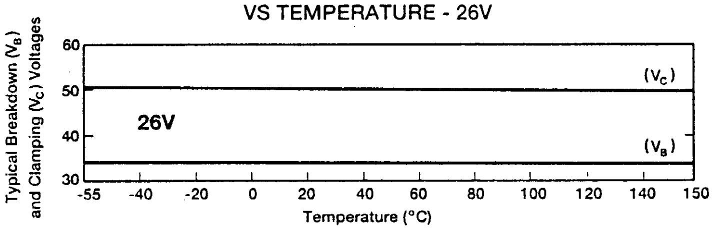
TEMPERATURE CHARACTERISTICS

TransGuard® suppressors are designed to operate over the full temperature range from -55°C to +125°C. This operating temperature range is for both surface mount and axial leaded products.

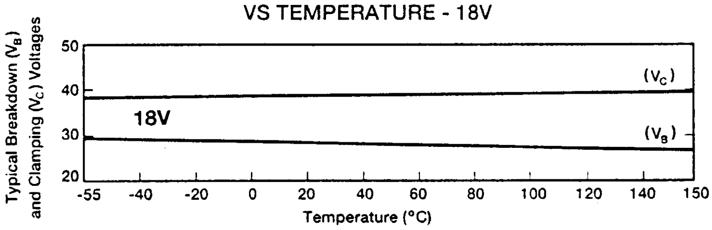
TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 48V



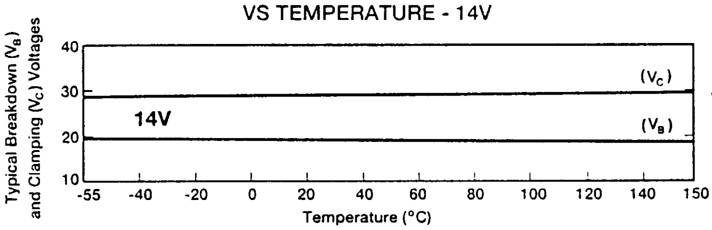
TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 26V



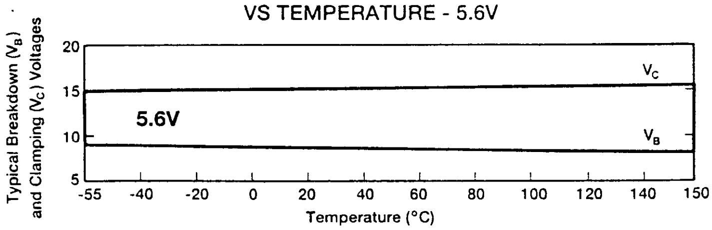
TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 18V



TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 14V



TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 5.6V



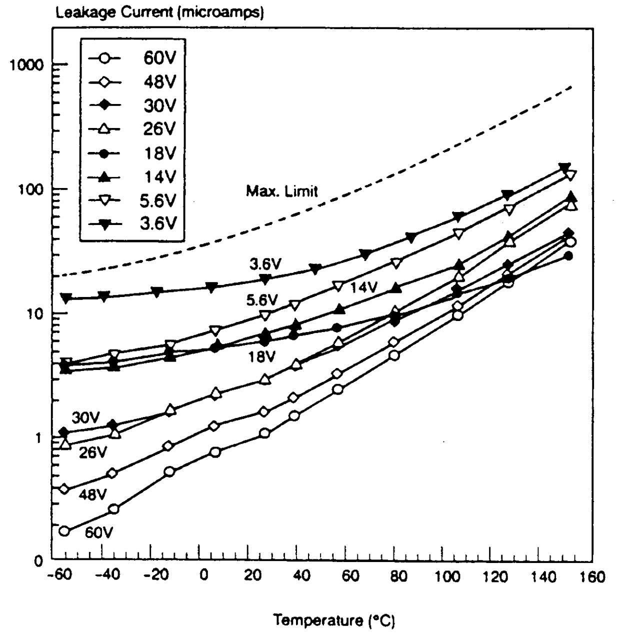
Transient Voltage Suppressors

TYPICAL PERFORMANCE CURVES

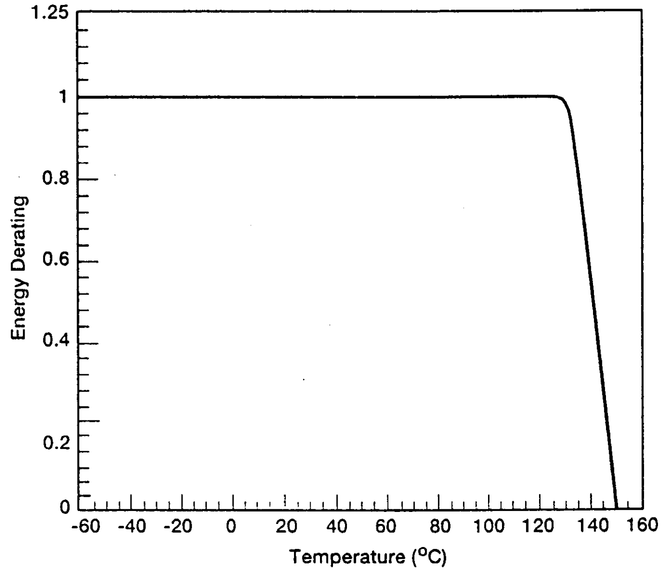
TEMPERATURE CHARACTERISTICS

TransGuard® suppressors are designed to operate over the full temperature range from -55°C to +125°C. This operating temperature range is for both surface mount and axial leaded products.

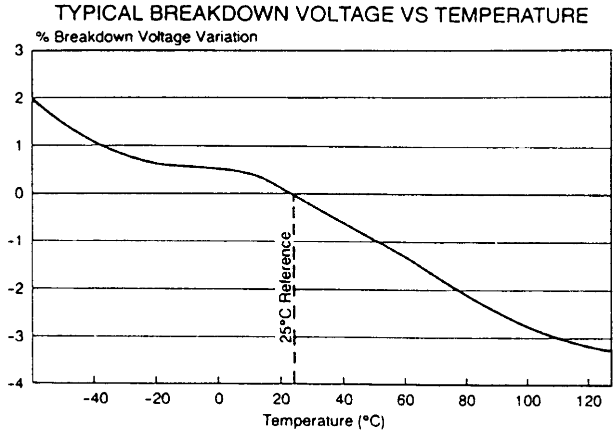
TYPICAL LEAKAGE CURRENTS VS TEMPERATURE



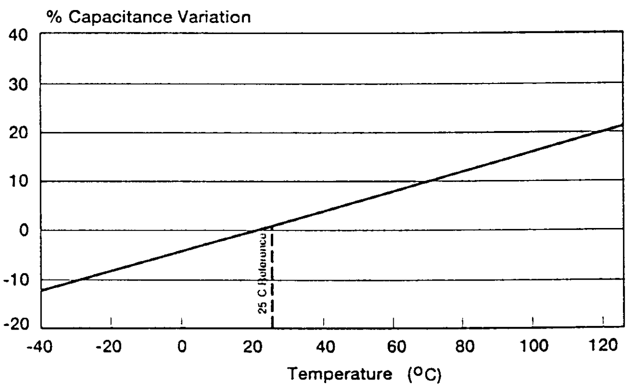
TYPICAL ENERGY DERATING VS TEMPERATURE



TYPICAL BREAKDOWN VOLTAGE VS TEMPERATURE



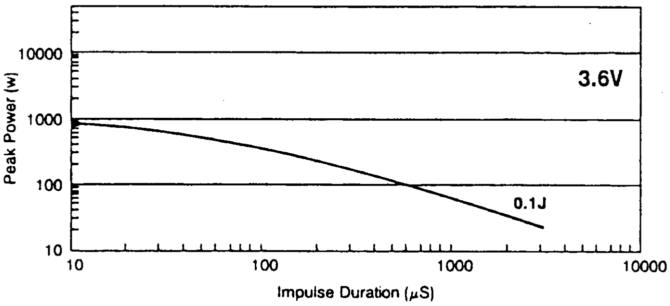
TYPICAL CAPACITANCE VS TEMPERATURE



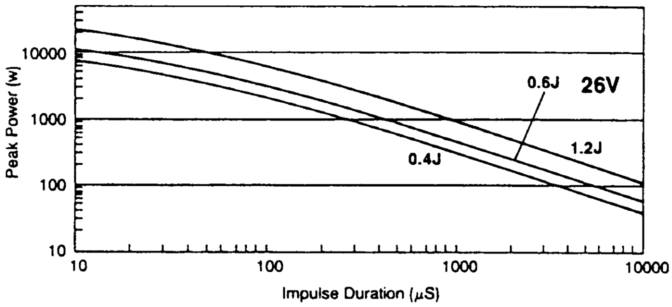
Transient Voltage Suppressors

TYPICAL PERFORMANCE CURVES

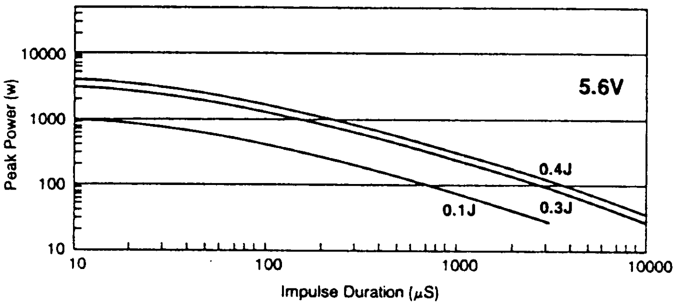
TYPICAL PULSE RATING CURVE
3.6V MULTILAYER TRANSGUARD®



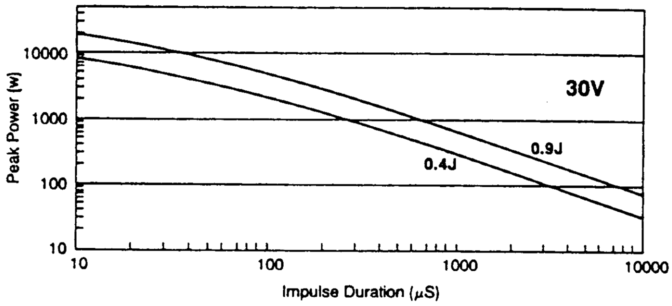
TYPICAL PULSE RATING CURVE
26V MULTILAYER TRANSGUARD®



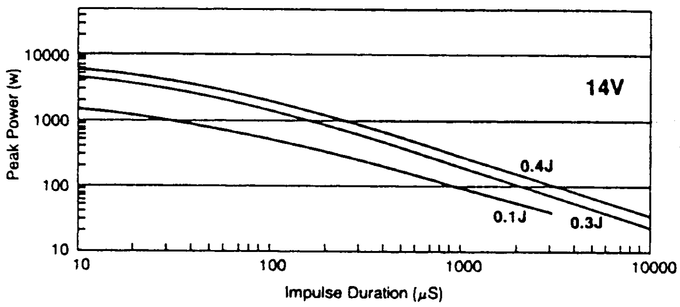
TYPICAL PULSE RATING CURVE
5.6V MULTILAYER TRANSGUARD®



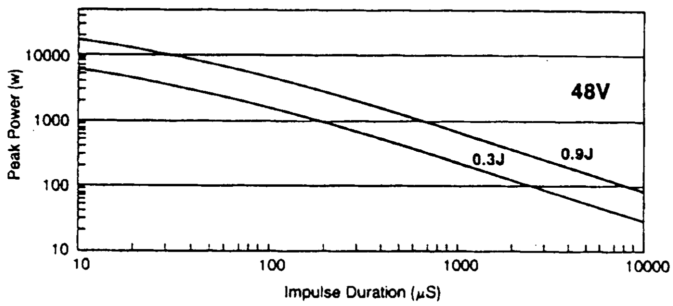
TYPICAL PULSE RATING CURVE
30V MULTILAYER TRANSGUARD®



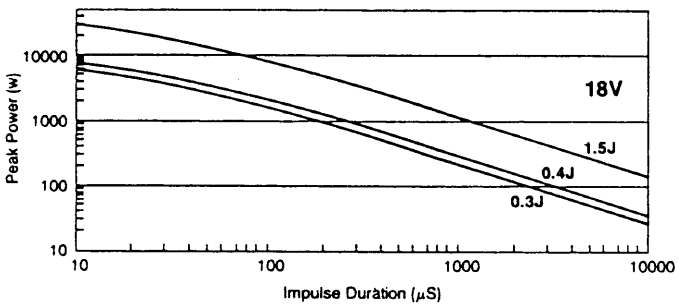
TYPICAL PULSE RATING CURVE
14V MULTILAYER TRANSGUARD®



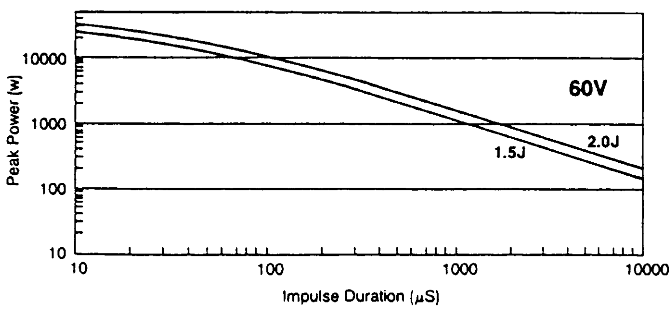
TYPICAL PULSE RATING CURVE
48V MULTILAYER TRANSGUARD®



TYPICAL PULSE RATING CURVE
18V MULTILAYER TRANSGUARD®



TYPICAL PULSE RATING CURVE
60V MULTILAYER TRANSGUARD®



AVX

TransGuard®

Transient Voltage Suppressors

HOW TO ORDER
Surface Mount Devices

Important: For part number identification only, not for construction of part numbers.
The information below only defines the numerical value of part number digits, and cannot be used to construct a desired set of electrical limits. Please refer to the TransGuard® part number data (blue section, pages 9-13) for the correct electrical ratings.

V C 1206 05 D 150 R

PACKAGING (Pcs/Reel):

STYLE	"D"	"R"	"T"
VC0603	N/A	4,000	10,000
VC0805	1,000	4,000	10,000
VC1206	1,000	4,000	10,000
VC1210	1,000	2,000	10,000

CLAMPING VOLTAGE:
Where:
100 = 10.0V, 560 = 56.0V
150 = 15.5V, 580 = 58.0V
200 = 20.0V, 620 = 62.0V
250 = 25.0V, 650 = 65.0V
300 = 30.0V, 101 = 100.0V
390 = 39.0V, 121 = 120.0V
400 = 40.0V

Energy:
Where:
A = 0.1J, G = 0.9J
B = 0.2J, H = 1.2J
C = 0.3J, J = 1.5J
D = 0.4J, K = 2.0J
E = 0.6J, V = 0.02J
F = 0.7J, X = 0.05J

WORKING VOLTAGE:
Where:
03 = 3.6 VDC, 18 = 18.0 VDC
05 = 5.6 VDC, 26 = 26.0 VDC
09 = 9.0 VDC, 30 = 30.0 VDC
12 = 12.0 VDC, 48 = 48.0 VDC
14 = 14.0 VDC, 60 = 60.0 VDC

CASE SIZE DESIGNATOR:

SIZE	LENGTH	WIDTH
0603	.063"±.006" (1.60±0.15mm)	.032"±.006" (0.8±0.15mm)
0805	.079"±.008" (2.01±0.2mm)	.049"±.008" (1.25±0.2mm)
1206	.126"±.008" (3.20±0.2mm)	.063"±.008" (1.60±0.2mm)
1210	.126"±.008" (3.20±0.2mm)	.098"±.008" (2.49±0.2mm)

CASE DESIGNATOR:
C = Chip

PRODUCT DESIGNATOR:
V = TransGuard®

MARKING:
All standard surface mount TransGuard® chips will **not** be marked. Marked chips will be considered a special; contact factory for minimum order requirement and price adder.

HOW TO ORDER
Axial Leaded Devices

Important: For part number identification only, not for construction of part numbers.
The information below only defines the numerical value of part number digits, and cannot be used to construct a desired set of electrical limits. Please refer to the TransGuard® part number data (blue section, pages 9-13) for the correct electrical ratings.

V A 1000 05 D 150 R

PACKAGING (Pcs/Reel):

STYLE	"D"	"R"	"T"
VA1000	1,000	3,000	7,500
VA2000	1,000	2,500	5,000

CLAMPING VOLTAGE:
Where:
100 = 10.0V, 580 = 58.0V
150 = 15.5V, 650 = 65.0V
300 = 30.0V, 101 = 100.0V
400 = 40.0V, 121 = 120.0V

ENERGY:
Where:
A = 0.1J, G = 0.9J
B = 0.2J, H = 1.2J
C = 0.3J, J = 1.5J
D = 0.4J, K = 2.0J
E = 0.6J, X = 0.05J
F = 0.7J

WORKING VOLTAGE:
Where:
03 = 3.6 VDC, 26 = 26.0 VDC
05 = 5.6 VDC, 30 = 30.0 VDC
14 = 14.0 VDC, 48 = 48.0 VDC
18 = 18.0 VDC, 60 = 60.0 VDC

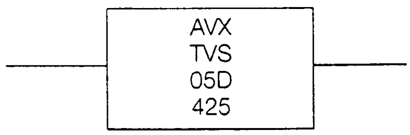
CASE SIZE DESIGNATOR:

SIZE	LENGTH	DIAMETER
1000	.170" (4.32mm)	.100" (2.54mm)
2000	.190" (4.83mm)	.140" (3.56mm)

CASE DESIGNATOR:
A = Axial

PRODUCT DESIGNATOR:
V = TransGuard®

MARKING:
All axial TransGuards® are marked with vendor identification, product identification, voltage/energy rating code and date code (see example below):



Where: AVX = Always AVX (Vendor Identification)
TVS = Always TVS (Product Identification - Transient Voltage Suppressor)
05D = Working VDC
Where: 05 = 5.6 VDC, D = 0.4J
425 = Three Digit Date Code
Where: 4 = Last digit of year (1994)
25 = Week of year

Transient Voltage Suppressors

Voltages = 3.6, 5.6, 9, 14, 18, 26 or 30VDC
0603 Surface Mount

Dimensions:

Actual Size:	
Length	.063" ± .006" (1.6 ± 0.15mm)
Width	.032" ± .006" (0.8 ± 0.15mm)
Thickness	.035" Max. (0.9mm)
Termination Band Width	.014" ± .006" (0.35 ± 0.15mm)
Termination Separation	.028" Min. (0.7mm)
Termination Finish	Pt/Pd/Ag

AVX Part Number	Working Voltage	Breakdown Voltage	Clamping Voltage	Peak Current	Transient Energy	Capacitance	Inductance
Symbol	V_{WM}	V_B	V_C	I_{peak}	E_{trans}	C	L
Units	Volts (max.)	Volts	Volts (max.)	Amp (max.)	Joules (max.)	pF (typ.)	nH (typ.)
Test Condition	<50µA	1mA DC	8/20µS†	8/20µs	10/1000µS	0.5Vrms @: 1kHz	di/dt = 100mA/nS
VC060303A100	3.6*	4.0 - 5.5	10	30	0.1	1500	<1.0
VC060305A150	5.6	7.6 - 9.3	15.5	30	0.1	1000	<1.0
VC060309A200	9.0	11.0 - 14.0	20	30	0.1	650	<1.0
VC060314A300	14.0	16.5 - 20.3	30	30	0.1	500	<1.0
VC060318A400	18.0	22.9 - 28.0	40	30	0.1	275	<1.0
VC060326A580	26.0	31.0 - 38.0	58	30	0.1	200	<1.0
VC060330A650	30.0	37.0 - 46.0	65	30	0.1	175	<1.0

V_{WM}—Maximum steady-state DC operating voltage the varistor can maintain and not exceed 50µA leakage current
V_B—Voltage across the device measured at 1mA DC current
V_C—Maximum peak voltage across the varistor measured at a specified pulse current and waveform

†Transient Energy Rating	Pulse Current & Waveform
.1 Joule	2A 8/20µS
.2 - .3 Joules	5A 8/20µS
≥.4 Joules	10A 8/20µS

I_{peak}—Maximum peak current which may be applied with the specified waveform without device failure

E_{tran}—Maximum energy which may be dissipated with the specified waveform without device failure

C—Device capacitance measured with zero volt bias 0.5Vrms and 1kHz

L—Device inductance measured with a current edge rate of 100 mA/nS

Dimensions: Inches (Millimeters)

*Test condition <100µA

AVX TransGuard®

Transient Voltage Suppressors

Voltages = 3.6, 5.6, 12, 14, 18, 26 or 30VDC
0805 Surface Mount

Dimensions:	**Actual Size:**	
	Length	.079" ± .008" (2.01 ± 0.2mm)
	Width	.049" ± .008" (1.25 ± 0.2mm)
	Thickness	.040" Max. (1.02mm)
	Land Length	.028" Max. (0.71mm)
	Termination Finish	Pt/Pd/Ag

AVX Part Number	Working Voltage	Breakdown Voltage	Clamping Voltage	Peak Current	Transient Energy	Capacitance	Inductance
Symbol	V_{WM}	V_B	V_C	I_{peak}	E_{trans}	C	L
Units	Volts (max.)	Volts	Volts (max.)	Amp (max.)	Joules (max.)	pF (typ.)	nH (typ.)
Test Condition	<50µA	1mA DC	8/20µS†	8/20µs	10/1000µS	0.5Vrms @: 1kHz	di/dt = 100mA/nS
VC080503A100	3.6	4.0 - 5.5	10	40	0.1	1775	<1.5
VC080503C100	3.6	3.7 - 5.1	10	120	0.3	5200	1.5
VC080505A150	5.6	7.6 - 9.3	15.5	40	0.1	1100	<1.5
VC080505C150	5.6	7.1 - 8.7	15.5	120	0.3	2750	1.5
VC080512A250	12	14.0 - 18.3	25	40	0.1	525	<1.5
VC080514A300	14	16.5 - 20.3	30	40	0.1	430	<1.5
VC080514C300	14	15.9 - 19.4	30	120	0.3	1200	1.5
VC080518A400	18	22.9 - 28.0	40	30	0.1	350	<1.5
VC080518C400	18	22.5 - 27.5	40	100	0.3	650	1.5
VC080526A580	26	31.0 - 37.9	58	30	0.1	150	<1.5
VC080526C580	26	30.5 - 37.3	58	100	0.3	200	1.5
VC080530A650	30	37.0 - 46.0	65	30	0.1	100	<1.5

V_{WM}—Maximum steady-state DC operating voltage the varistor can maintain and not exceed 50µA leakage current
V_B—Voltage across the device measured at 1mA DC current
V_C—Maximum peak voltage across the varistor measured at a specified pulse current and waveform

†Transient Energy Rating	Pulse Current & Waveform
.1 Joule	2A 8/20µS
.2 - .3 Joules	5A 8/20µS
≥.4 Joules	10A 8/20µS

I_{peak}—Maximum peak current which may be applied with the specified waveform without device failure
E_{tran}—Maximum energy which may be dissipated with the specified waveform without device failure
C—Device capacitance measured with zero volt bias 0.5Vrms and 1kHz
L—Device inductance measured with a current edge rate of 100 mA/nS

Dimensions: Inches (Millimeters)

Transient Voltage Suppressors

Voltages = 3.6, 5.6, 14, 18, 26, 30 or 48 VDC
1206 Surface Mount

Dimensions:

Actual Size:	
Length	.126" ± .008" (3.20± 0.2mm)
Width	.063" ± .008" (1.60 ± 0.2mm)
Thickness	.040" Max. (1.02mm)
Land Length	.028" Max. (0.71mm)
Termination Finish	Pt/Pd/Ag

AVX Part Number	Working Voltage	Breakdown Voltage	Clamping Voltage	Peak Current	Transient Energy	Capacitance	Inductance
Symbol	V_{WM}	V_B	V_C	I_{peak}	E_{trans}	C	L
Units	Volts (max.)	Volts	Volts (max.)	Amp (max.)	Joules (max.)	pF (typ.)	nH (typ.)
Test Condition	<50μA	1mA DC	8/20μS†	8/20μs	10/1000μS	0.5Vrms @: 1kHz	di/dt = 100mA/nS
VC120603A100	3.6	4.0 - 5.5	10	40	0.1	2000	<1.7
VC120603D100	3.6	3.7 - 5.1	10	150	0.4	4700	1.7
VC120605A150	5.6	7.6 - 9.3	15.5	40	0.1	1150	<1.7
VC120605D150	5.6	7.1 - 8.7	15.5	150	0.4	3000	1.7
VC120614A300	14	16.5 - 20.3	30	40	0.1	600	<1.7
VC120614D300	14	15.9 - 19.4	30	150	0.4	1400	1.7
VC120618A400	18	22.9 - 28.0	40	30	0.1	350	<1.7
VC120618D400	18*	22.5 - 27.5	40	150	0.4	1000	1.7
VC120626D580	26	30.5 - 37.3	58	120	0.4	550	1.7
VC120630D650	30	36.0 - 45.0	65	120	0.4	500	1.7
VC120648D101	48	56.0 - 68.0	100	100	0.4	225	1.7

V_{WM}—Maximum steady-state DC operating voltage the varistor can maintain and not exceed 50μA leakage current
V_B—Voltage across the device measured at 1mA DC current
V_C—Maximum peak voltage across the varistor measured at a specified pulse current and waveform

†Transient Energy Rating	Pulse Current & Waveform
.1 Joule	2A 8/20μS
.2 - .3 Joules	5A 8/20μS
≥.4 Joules	10A 8/20μS

I_{peak}—Maximum peak current which may be applied with the specified waveform without excessive leakage
E_{tran}—Maximum energy which may be dissipated with the specified waveform without device failure
C—Device capacitance measured with zero volt bias 0.5Vrms and 1kHz
L—Device inductance measured with a current edge rate of 100 mA/nS
*Withstands 24.5 VDC for 5 minutes (automotive applications)

Dimensions: Inches (Millimeters)

AVX

TransGuard®

Transient Voltage Suppressors

Voltages = 18, 26, 30, 48 or 60 VDC
1210 Surface Mount

Dimensions:	Actual Size:	
	Length	.126"± .008" (3.20 ± 0.2mm)
	Width	.098" ± .008" (2.49 ± 0.2mm)
	Thickness	.067" Max. (1.70mm)
	Land Length	.028" Max. (0.71mm)
	Termination Finish	Pt/Pd/Ag

AVX Part Number	Working Voltage	Breakdown Voltage	Clamping Voltage	Peak Current	Transient Energy	Capacitance	Inductance
Symbol	V_{WM}	V_B	V_C	I_{peak}	E_{trans}	C	L
Units	Volts (max.)	Volts	Volts (max.)	Amp (max.)	Joules (max.)	pF (typ.)	nH (typ.)
Test Condition	<50μA	1mA DC	8/20μS†	8/20μs	10/1000μS	0.5Vrms @: 1kHz	di/dt = 100mA/nS
VC121018J390	18*	21.5 - 26.5	39	500	1.5	3100	2.0
VC121026H560	26	29.7 - 36.3	56	300	1.2	2150	2.0
VC121030G620	30	35.0 - 43.0	62	220	0.9	1600	2.0
VC121030H620	30	35.0 - 43.0	62	280	1.2	1975	2.0
VC121048G101	48	54.5 - 66.5	100	220	0.9	500	2.0
VC121048H101	48	54.5 - 66.5	100	250	1.2	650	2.0
VC121060J121	60	67.0 - 83.0	120	250	1.5	450	2.0

V_{WM}—Maximum steady-state DC operating voltage the varistor can maintain and not exceed 50μA leakage current
V_B—Voltage across the device measured at 1mA DC current
V_C—Maximum peak voltage across the varistor measured at a specified pulse current and waveform

†Transient Energy Rating	Pulse Current & Waveform
.1 Joule	2A 8/20μS
.2 - .3 Joules	5A 8/20μS
≥.4 Joules	10A 8/20μS

I_{peak}—Maximum peak current which may be applied with the specified waveform without device failure
E_{tran}—Maximum energy which may be dissipated with the specified waveform without device failure
C—Device capacitance measured with zero volt bias 0.5Vrms and 1kHz
L—Device inductance measured with a current edge rate of 100 mA/nS
*Withstands 24.5 VDC for 5 minutes (automotive applications)

Dimensions: Inches (Millimeters)

Transient Voltage Suppressors

Voltages = 3.6, 5.6, 14, 18, 26, 30, 48, 60 VDC
Axial Leaded

Dimensions:

		VA1000	VA2000
Body Length	(L)	= .170" Max. (4.32mm)	.190" Max. (4.83mm)
Body Diameter	(D)	= .100" Max. (2.54mm)	.140" Max. (3.56mm)
Lead Diameter		= .020 ± .002 (0.51 ± .05mm)	.020 ± .002 (0.51 ± .05mm)
Lead Length		= 1" Min. (25.4mm)	1" Min. (25.4mm)

AVX Part Number	Working Voltage	Breakdown Voltage	Clamping Voltage	Peak Current	Transient Energy	Capacitance	Inductance
Symbol	V_{WM}	V_B	V_C	I_{peak}	E_{trans}	C	L
Units	Volts (max.)	Volts	Volts (max.)	Amp (max.)	Joules (max.)	pF (typ.)	nH (typ.)
Test Condition	<50µA	1mA DC	8/20µS†	8/20µs	10/1000µS	0.5Vrms @: 1kHz	di/dt = 100mA/nS
VA100003A100	3.6	4.0 - 5.5	10	40	0.1	1200	3.5
VA100003D100	3.6	3.7 - 5.1	10	150	0.4	3400	3.5
VA100005A150	5.6	7.6 - 9.3	15.5	40	0.1	1100	3.5
VA100005D150	5.6	7.1 - 8.7	15.5	150	0.4	2800	3.5
VA100014A300	14	16.5 - 20.3	30	40	0.1	500	3.5
VA100014D300	14	15.9 - 19.4	30	150	0.4	1400	3.5
VA100018A400	18	22.9 - 28.0	40	40	0.1	350	3.5
VA100018D400	18	22.5 - 27.5	40	150	0.4	1000	3.5
VA100026D580	26	30.5 - 37.3	58	120	0.4	700	3.5
VA100030D650	30	36.0 - 45.0	65	120	0.4	600	3.5
VA100048D101	48	56.0 - 68.0	100	100	0.4	200	3.5
VA200060K121	60	67.0 - 83.0	120	300	2.0	400	3.5

V_{WM}—Maximum steady-state DC operating voltage the varistor can maintain and not exceed 50µA leakage current
V_B—Voltage across the device measured at 1mA DC current
V_C—Maximum peak voltage across the varistor measured at a specified pulse current and waveform

†Transient Energy Rating	Pulse Current & Waveform
.1 Joule	2A 8/20µS
.2 - .3 Joules	5A 8/20µS
≥.4 Joules	10A 8/20µS

I_{peak}—Maximum peak current which may be applied with the specified waveform without device failure
E_{tran}—Maximum energy which may be dissipated with the specified waveform without device failure
C—Device capacitance measured with zero volt bias 0.5Vrms and 1kHz
L—Device inductance measured with a current edge rate of 100 mA/nS

Dimensions: Inches (Millimeters)

AVX Limited
A Kyocera Group Company

Electrostatic discharge suppression with multilayer varistors

Scott Tripp, Manager of Technology Development at AVX, Europe

Extract from Electronic Engineering
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AVX Limited
Admiral House
Harlington Way
Fleet, Hants GU13 8BB
Tel: 01252 770000
Fax: 01252 770001

AVX S.A.
Zone d'Activities de Courtaboeuf
Boite Postale 213
91941 Les Ulis Cedex, France
Tel: (1) 69184600
Fax: (1) 69287387

AVX GmbH
Postfach 1110
Liebigstr. 1A
85749 Karlsfeld, Germany
Tel: 08131 9004-0
Fax: 08131 9004-44

AVX s.r.l.
Via Marconi, 28
20091 Bresso (Milano)
Italy
Tel: 02-66500116
Fax: 02-6142576

AVX Corporation
3900 Electronics Drive
Raleigh, North Carolina 27604
USA
Tel: 919 878 6200
Fax: 919 878 6218

Electrostatic discharge suppression with multilayer varistors

Scot Tripp, Manager of Technology Development at AVX, describes how electronic discharge suppression (ESD) has become an important one of the many problems that must now be solved for a successful design solution. He makes a strong case, through a description of the characteristics and structure, for the use of MLV (Multi Layer Varistor) as the device of choice.

Electrostatic Discharge (ESD) suppression has become a key issue for many engineers, not only because of a plethora of regulatory specifications (EEC Directive 89/336 EMC; ETSI Spec pr ETS 300 339; ISO/CD10 605/E-ESD in Road Vehicles etc), but also because of the growing awareness of the real-world damage ESD can cause to microprocessors, ASICs, sensors and other vital components.

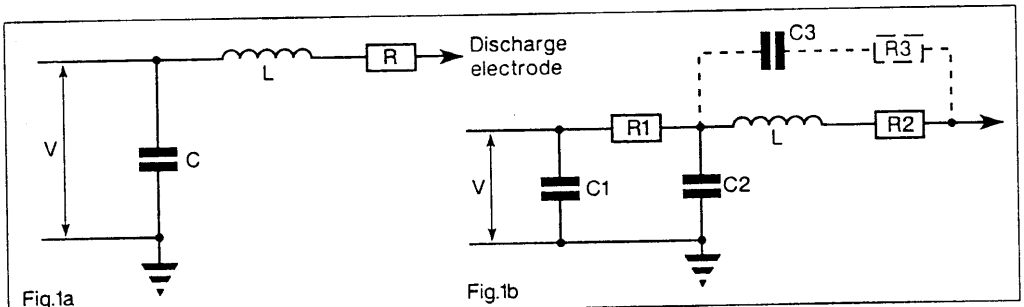


Figure 1(a) above left: Single RC ESD model for the human body (IEC specified values, R=150Ω, C=150pF). Figure 1(b) above right: Multiple-discharge model for an upper/lower body configuration.

ESD characteristics

A typical human body as illustrated in figure 1 for single RC and upper/lower body models can become electrostatically charged to between 8kV and 15kV, dependent upon such factors as materials worn, shoe thickness, humidity, etc. The discharge of this voltage by contact or via the ionization of a small air gap is characterised by an extremely rapid rise of current — in typically ≤1ns and dependent upon the contact areas being sharp (eg, probes) or blunt (eg human fingers) by high peak currents up to >20A.

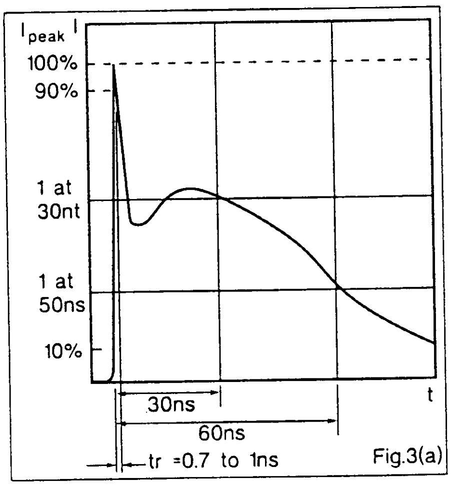
As ICs have, in the very best case, an overvoltage immunity of some 3kV (figure 2), the imbalance between this and the 8kV + human body ESD must inevitably lead to failure of the EIC, either catastrophic or the potentially even more dangerous latent failure.

Device Family	Range of ESD vulnerability (volts)
CMOS	250 - 3000
VMOS	30 - 1800
MOSFET	100 - 200
EPROM	100
ECL	500 - 1500
SCHOTTKY TTL	1000 - 2500
GAASFET	100 - 300
SAW	150 - 500
OP-AMP	<200 - 3000
FILM RESISTORS	300 - 3000
THYRISTOR	650 - 1000
Scaling will reduce the above limits. Remember — typical ESD voltage is 15000V	

Figure 2: Comparison by device of range of ESD vulnerability

ESD test specifications

Most national and international ESD immunity test specifications are based upon IEC801-2 (figures 3a and 3b). Note that the rise time (tr) is specified as 0.7 to 1.0ns. In the case of EuroNorms (such as EN55024 — Immunity of Information Technology Equipment), this test



Level	Indicated Voltage kV	First peak current of discharge A	Rise time tr with discharge switch ns	Current (±30% %) at 30ns A	Current (±30% %) at 30ns A
1	2	7,5	0,7 to 1	4	2
2	4	15	0,7 to 1	8	4
3	6	22,5	0,7 to 1	12	6
4	8	30	0,7 to 1	16	8

Figure 3(a) left: IEC801-2 test impulse waveforms. Figure 3(b) above: IEC801-2 waveform parameters.

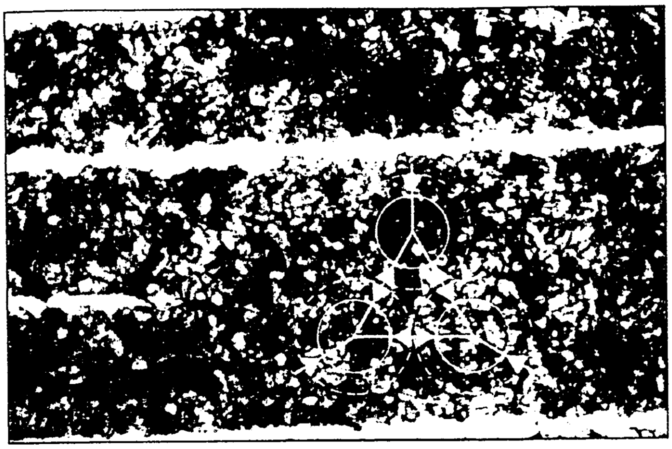
pulse must be applied with both positive and negative polarities, therefore, any suppression device must be bipolar by nature.

It is therefore clear that an acceptable ESD suppression device must meet the following criteria:

1. Be bipolar in action
2. Have a response time ≤0.7ns
3. Be capable of handling repetitive peak currents in excess of 20A
4. Be undamaged by repetitive ESD strikes of 15kV.

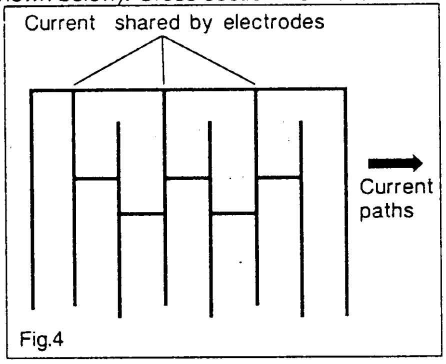
Additional desirable features include: small size and SMT compatibility, intrinsic high reliability and optional capacitance values (eg, low for high speed lines or higher for RFI suppression).

Of all the transient suppression devices available today, the MLV most completely fulfils these criteria. An examination of the mechanics of operation and the equivalent electrical circuit of the MLV shows why the device is so good at suppressing multiple ESD strikes.



Picture 1 (shown above): Equivalent circuit of ZnO grains in contact.

Figure 4 (shown below): Cross section view of an MLV chip



MLV structure and operation

Figure 4 represents a cross-section through part of an MLV chip. For simplicity only 3 electrodes/counter electrode sets are show; 10 sets would be more typical.

In the case of a transient having a peak current of, say 30A, it can be seen that the multiple internal electrode system very efficiently divides the current so that in a 10 electrode system, each electrode only has to carry, on average, 3A. Compare this to a MOV or TVS diode which have only a single pair of external electrodes, these having to accept the full 30A peak current.

By a diffusion process, every grain of zinc oxide material in the MLV is converted into a Schottky diode (picture 1); when the transient voltage across the device reaches and exceeds the zener level of millions of P-N junctions packed into a series parallel configuration, the current increases very rapidly, flowing from electrode to counter electrode, across the "ceramic diodes" and hence to the ground. In this "on" mode, the whole volume of ceramic grain Schottky diode between the outermost electrodes, is dissipating energy, hence the extremely high energy density characteristics of the MLV. Additionally, whilst an overrated transient could easily destroy the single or power line being protected, it is clear that such a high current impulse will only short circuit a relatively small proportion of the vast number of P-N junctions in the MLV. Hence, the result of such a transient impacting the MLV would be a minor increase in the leakage current and the circuit being protected would continue to function. Therefore, the MLV automatically belongs in the "Hi-Rel" category.

From the electrical model of a TransGuard MLV (figure 5), several interesting points emerge viz:

- The very low inductance of the small chip package is the prime factor in a response time of some 0.2-0.5ns, fast enough to protect from ESD. Whilst silicon diode TVSs are theoretically high speed in operation, package inductance means that clamping of transient voltages takes some 5ns in the case of bipolar devices (1).

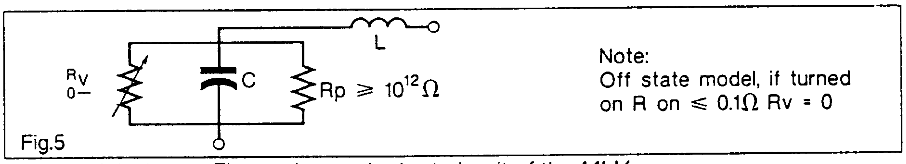


Figure 5(a) above: First order equivalent circuit of the MLV.

Figure 5(b) below: Typical parameters of chip MLVs.

Case size	Voltage rating (V)	Energy level (J)	Capacitance (pF)	Inductance (nH)
0603	3.3	0.1	1200	1.5
0603	5.6	0.1	1100	1.5
0603	14.0	0.1	430	1.5
0805	3.3	0.1	1200	1.5
0805	5.6	0.3	3000	1.5
0805	14.0	0.3	1200	1.2
0805	14.0	0.1	430	1.2
0805	18.0	0.3	650	1.2
0805	18.0	0.1	350	1.2
1206	3.3	0.1	1200	1.5
1206	5.6	0.4	2800	1.5
1206	14.0	0.4	1400	1.7
1206	14.0	0.1	500	1.5
1206	18.0	0.4	1000	1.7
1206	26.0	0.6	550	1.9
1206	30.0	0.4	500	1.5
1206	48.0	0.3	150	1.5
1210	18.0	1.5	4000	2.5
1210	26.0	1.2	2500	2.0
1210	30.0	0.9	800	2.0
1210	48.0	0.9	500	2.0
1210	60.0	1.5	350	1.5

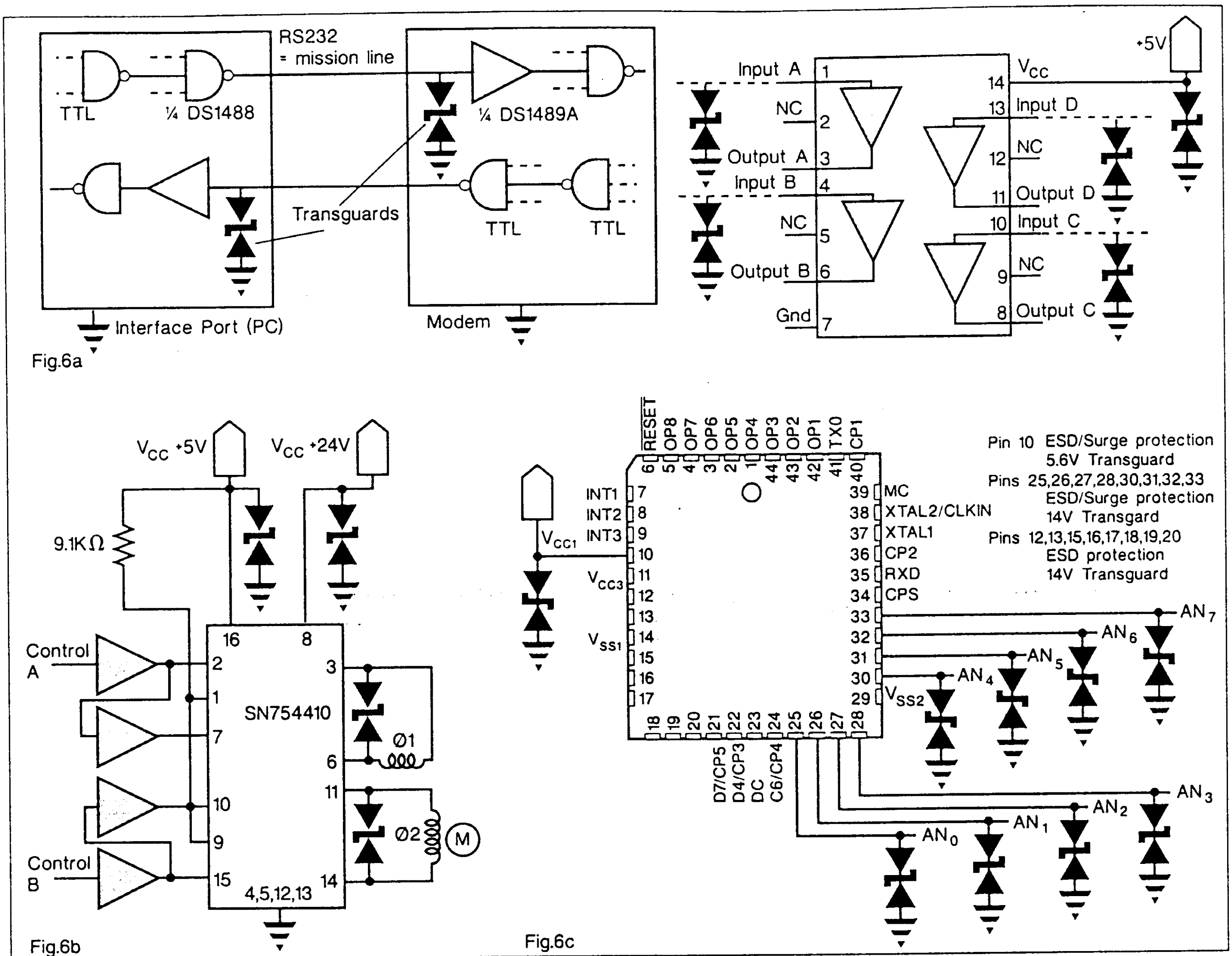


Figure 6(a): (shown top) Typical RS232 application, (b), (shown bottom left) typical inductive load chip protection and (c), (shown bottom right) typical microprocessor protection.

- By adding or removing electrodes, both the capacitance and energy level of a given chip size may be increased or decreased.

Consider the 0805 14V rated TransGuard; it can be seen that the 0.3J device has a typical capacitance of 1200pF whereas the 0.1J part exhibits only 430pF. Because zinc oxide is much more "lossy" than the typical barium titanate based MLC dielectrics, the attenuation of RFI is also much better; dependent upon frequency, the equivalent attenuation pF for pF could easily be 3:1, (ie, 1nF of zinc oxide based capacitance could equal 3nF or more of barium titanate MLV).

MLV selection/applications

Correct selection of an MLV is quite straightforward and identical to selecting a suppression diode. To ensure that the device is normally "off", a rated voltage (VWM) slightly above the line operating voltage should be chosen, eg, a 5.6V rated device for a 5V line, a 14V device for a 12V line etc.

Secondly, the clamping voltage must be below the vulnerability voltage level of the circuitry or device to be protected. Finally, the power handling capability of the MLV must exceed the power levels contained in anticipated transients. In the case of ESD protection, an energy rating of 50 or 100mJ is very adequate. Figure 6 shows several common circuit applications for MLVs.

Summary

The MLV as typified by AVX's TransGuard is a comprehensive solution to the very serious problems posed to equipment designers by "real-world" ESD and also the various immunity specifications currently being mandated or proposed. In addition to the necessary very high speed operation to protect from sub-nanosecond transients, MLV's also offer small SMT standard formats and very high reliability.

It is hardly surprising therefore that their use is becoming very widespread as the preferred ESD protection device in such products as cellular and other mobile phones, PCs, LANs, computer peripheral, security systems, automotive circuits (particularly EMUs, ABS and keyless entry), portable T&M equipment, etc.

Acknowledgement

The author wishes to acknowledge the input and data kindly provided by Ron C Demcko of AVX Ceramics Inc, Raleigh, NC, USA. □

References

[1] Protection Devices handbook, pp308, SGS-Thomson Microelectronics.