A KYOCERA GROUP COMPANY

AVX TransGuard®/StaticGuard/MultiGuard Multilayer Ceramic Transient Voltage Suppressors

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors

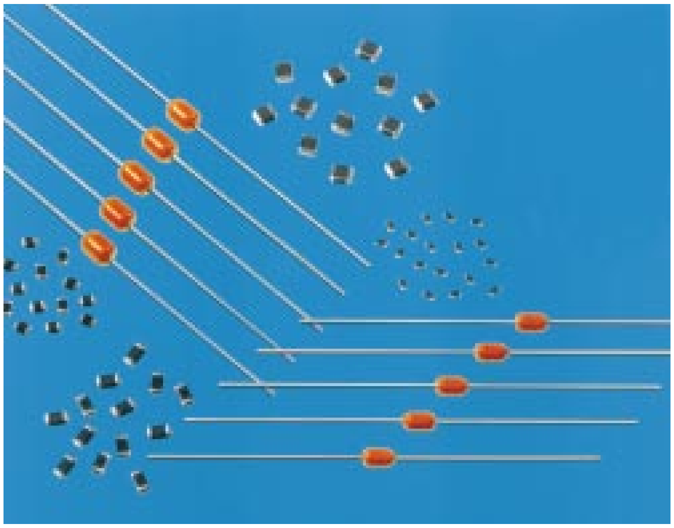
The contents of this catalog are entitled and located on the pages noted below:

TransGuard®

AVX Multilayer Ceramic 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 EIA industry standard packages. Thru-hole components are supplied as conformally coated axial devices.



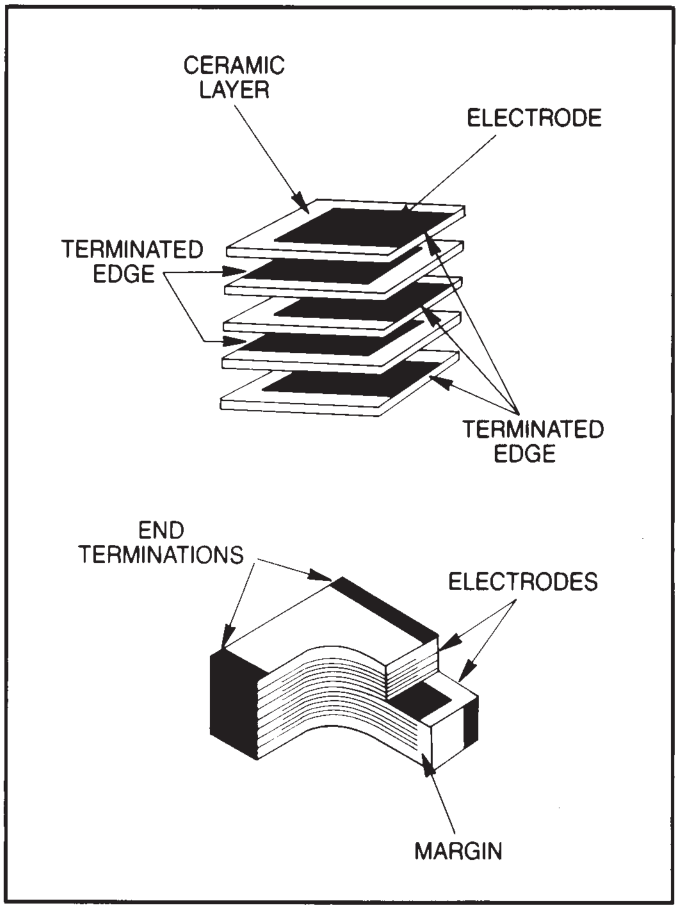
TRANSGUARD® DESCRIPTION

TransGuard® products are zinc oxide (ZnO) based ceramic semiconductor devices with non-linear voltage-current characteristics (bi-directional) similar to back-to-back zener diodes. They have the added advantage of greater current and energy handling capabilities as well as EMI/RFI attenuation. 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 sites 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 terminations 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.



PART NUMBER IDENTIFICATION

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 3-8) for the correct electrical ratings.

V C 1206 05 D 150 R

PACKAGING (Pcs/Reel):

STYLE	"D"	"R"	"T"
VC0402	N/A	4,000	10,000
VC0603	1,000	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	500 = 50.0V
150 = 15.5V	560 = 56.0V
200 = 20.0V	580 = 58.0V
250 = 25.0V	620 = 62.0V
300 = 30.0V	650 = 65.0V
390 = 39.0V	101 = 100.0V
400 = 40.0V	121 = 120.0V

ENERGY:

Where:

A = 0.1J	H = 1.2J
C = 0.3J	J = 1.5J
D = 0.4J	P = 3.0J
F = 0.7J	V = 0.02J
G = 0.9J	X = 0.05J

WORKING VOLTAGE:

Where:

03 = 3.3 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	
0402	1.00±0.10mm	(0.040"±0.004")	0.5±0.10mm	(0.020"±0.004")
0603	1.60±0.15mm	(0.063"±0.006")	0.8±0.15mm	(0.032"±0.006")
0805	2.01±0.2mm	(0.079"±0.008")	1.25±0.2mm	(0.049"±0.008")
1206	3.20±0.2mm	(0.126"±0.008")	1.60±0.2mm	(0.063"±0.008")
1210	3.20±0.2mm	(0.126"±0.008")	2.49±0.2mm	(0.098"±0.008")

CASE STYLE:
C = Chip

PRODUCT DESIGNATOR:
V = Varistor

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.

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, page 9) 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
D = 0.4J
K = 2.0J

WORKING VOLTAGE:

Where:

03 = 3.3 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

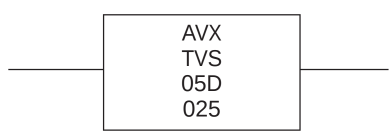
CASE SIZE DESIGNATOR:

SIZE	LENGTH	DIAMETER
1000	4.32mm (0.170")	2.54mm (0.100")
2000	4.83mm (0.190")	3.56mm (0.140")

CASE STYLE:
A = Axial

PRODUCT DESIGNATOR:
V = Varistor

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 and Energy Rating (Joules)
Where: 05 = 5.6 VDC, D = 0.4J
025 = Three Digit Date Code
Where: 0 = Last digit of year (2000)
25 = Week of year

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors

VOLTAGES = 5.6, 9, 14 OR 18 VDC
0402 SURFACE MOUNT

Dimensions: **Actual Size:**

Length	1.0 ± 0.10mm (0.040" ± 0.004")
Width	0.5 ± 0.10mm (0.020" ± 0.004")
Thickness	0.6mm Max. (0.024")
Termination Band Width	0.25 ± 0.15mm (0.010" ± 0.006")
Termination Separation	0.3mm Min. (0.012")
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 @: 1MHz	di/dt = 100mA/nS
VC040205X150	5.6	7.6 - 9.3	15.5	20	0.05	360	<1.0
VC040209X200	9.0	11.0 - 14.0	20.0	20	0.05	230	<1.0
VC040214X300	14.0	16.5 - 20.3	30.0	20	0.05	120	<1.0
VC040218X400	18.0	22.9 - 28.0	40.0	20	0.05	90	<1.0
VC04LC18V500	See pages 14-15 for specification and performance details.						

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
<0.05 Joule	1A 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 1MHz

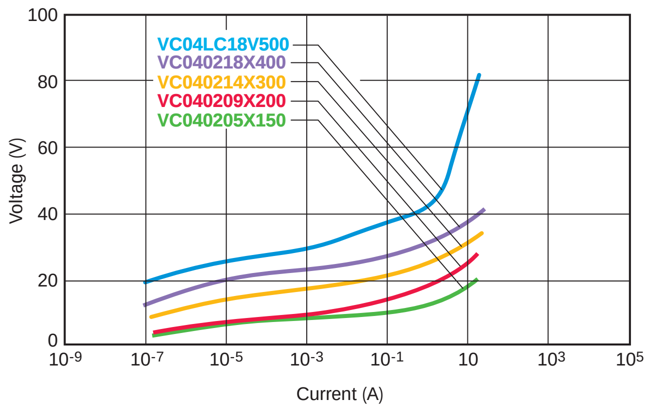
L—Device inductance measured with a current edge rate of 100 mA/nS

Dimensions: Millimeters (Inches)

TYPICAL PERFORMANCE CURVES (0402 CHIP SIZE)

VOLTAGE/CURRENT CHARACTERISTICS

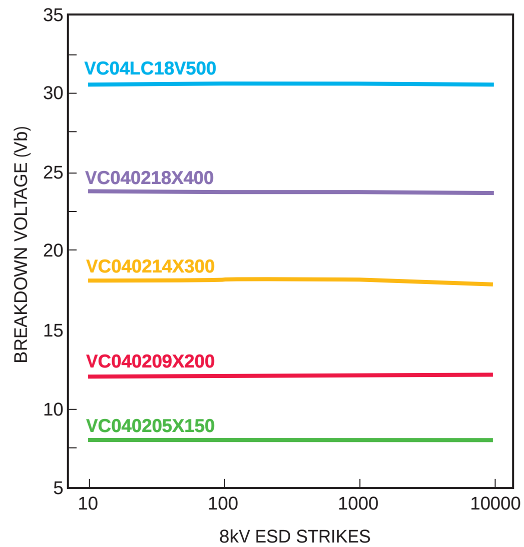
Multilayer construction and improved grain structure result in excellent transient clamping characteristics up to 20 amps peak current, while maintaining very low leakage currents under DC operating conditions. The VI curves below show the voltage/current characteristics for the 5.6V, 9V, 14V, 18V and low capacitance StaticGuard parts with currents ranging from parts of a micro amp to tens of amps.



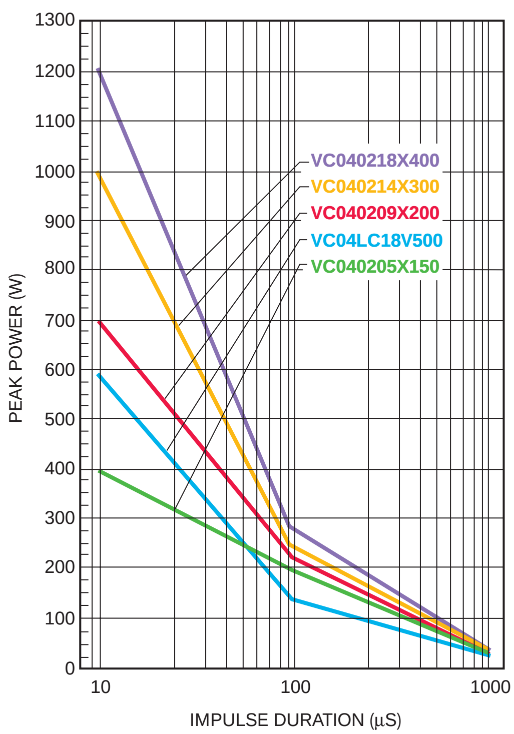
PULSE DEGRADATION

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 TransGuard transient voltage suppressors with 150Amp peak 8 x 20µS waveforms 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.

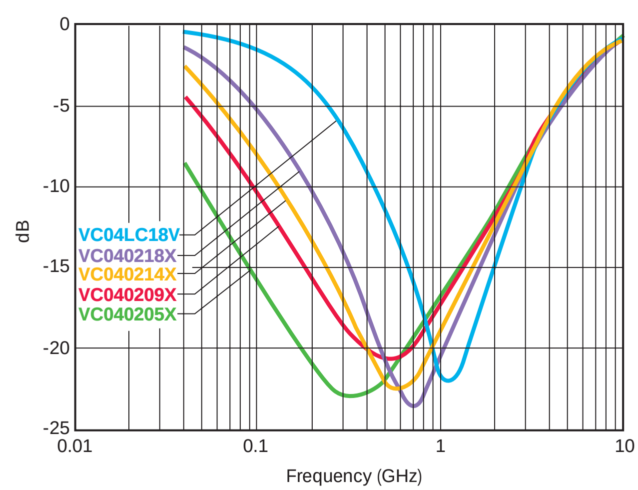
ESD TEST OF 0402 PARTS



PEAK POWER VS PULSE DURATION



INSERTION LOSS CHARACTERISTICS



TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors

VOLTAGES = 3.3, 5.6, 9, 14, 18, 26 OR 30 VDC
0603 SURFACE MOUNT

Dimensions: **Actual Size:**

Length	1.6 ± 0.15mm (0.063" ± 0.006")
Width	0.50 ± 0.15mm (0.032" ± 0.006")
Thickness	0.9mm Max. (0.035")
Termination Band Width	0.35 ± 0.15mm (0.014" ± 0.006")
Termination Separation	0.7mm Min. (0.028")
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	0.5Vrms @: 1 MHz	di/dt = 100mA/nS
VC060303A100	3.3#	4.1 - 6.0	10	30	0.1	1800	1230	<1.0
VC060305A150	5.6	7.6 - 9.3	15.5	30	0.1	1000	825	<1.0
VC060309A200	9.0	11.0 - 15.0	20	30	0.1	650	550	<1.0
VC060314A300	14.0	16.5 - 20.3	30	30	0.1	500	424	<1.0
VC060318A400	18.0	22.9 - 28.0	40	30	0.1	275	225	<1.0
VC060326A580	26.0	31.0 - 38.0	58	30	0.1	200	160	<1.0
VC060330A650	30.0	37.0 - 46.0	65	30	0.1	175	150	<1.0
VC06LC18X500	See pages 14-15 for specification and performance details.							

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
0.1 Joule	2A 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: Millimeters (Inches)

#Test condition <100µA

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors

VOLTAGES = 3.3, 5.6, 9, 12, 14, 18, 26 OR 30 VDC
0805 SURFACE MOUNT

Dimensions: **Actual Size:**

Length	2.01 ± 0.2mm (0.079" ± 0.008")
Width	1.25 ± 0.2mm (0.049" ± 0.008")
Thickness	1.02mm Max. (0.040")
Land Length	0.71mm Max. (0.028")
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	0.5Vrms @: 1 MHz	di/dt = 100mA/nS
VC080503A100	3.3#	4.1 - 6.0	10	40	0.1	1300	930	<1.5
VC080503C100	3.3#	3.7 - 5.6	10	120	0.3	5500	4000	1.5
VC080505A150	5.6	7.6 - 9.3	15.5	40	0.1	1250	860	<1.5
VC080505C150	5.6	7.1 - 8.7	15.5	120	0.3	3500	2400	1.5
VC080509A200	9	11.0 - 14.0	20	40	0.1	780	585	<1.5
VC080512A250	12	14.0 - 18.3	25	40	0.1	525	400	<1.5
VC080514A300	14	16.5 - 20.3	30	40	0.1	375	280	<1.5
VC080514C300	14	15.9 - 19.4	30	120	0.3	1100	820	1.5
VC080518A400	18*	22.9 - 28.0	40	30	0.1	350	275	<1.5
VC080518C400	18*	22.5 - 27.5	40	100	0.3	650	500	1.5
VC080526A580	26	31.0 - 37.9	58	30	0.1	140	110	<1.5
VC080526C580	26	30.5 - 37.3	58	100	0.3	250	190	1.5
VC080530A650	30	37.0 - 46.0	65	30	0.1	100	80	<1.5
VC08LC18A500	See pages 14-15 for specification and performance details.							

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
0.1 Joule	2A 8/20µS
0.2 - 0.3 Joules	5A 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: Millimeters (Inches)

#Test condition <100µA

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors

VOLTAGES = 3.3, 5.6, 14, 18, 26, 30 OR 48 VDC
1206 SURFACE MOUNT

Dimensions:	**Actual Size:**	
	Length	3.20 ± 0.2mm (0.126" ± 0.008")
	Width	1.60 ± 0.2mm (0.063" ± 0.008")
	Thickness	1.02mm Max. (0.040")
	Land Length	0.71mm Max. (0.028")
	Termination Finish	Pt/Pd/Ag0

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	0.5Vrms @: 1 MHz	di/dt = 100mA/nS
VC120603A100	3.3#	4.1 - 6.0	10	40	0.1	2000	1500	<1.7
VC120603D100	3.3#	3.7 - 5.6	10	150	0.4	4700	3800	1.7
VC120605A150	5.6	7.6 - 9.3	15.5	40	0.1	1200	870	<1.7
VC120605D150	5.6	7.1 - 8.7	15.5	150	0.4	3000	2300	1.7
VC120614A300	14	16.5 - 20.3	30	40	0.1	600	500	<1.7
VC120614D300	14	15.9 - 19.4	30	150	0.4	1200	900	1.7
VC120618A400	18*	22.9 - 28.0	40	30	0.1	350	270	<1.7
VC120618D400	18*	22.5 - 27.5	40	150	0.4	800	635	1.7
VC120626D580	26	30.5 - 37.3	58	120	0.4	550	450	1.7
VC120630D650	30	36.0 - 45.0	65	120	0.4	500	400	1.7
VC120648D101	48	56.0 - 68.0	100	100	0.4	225	185	1.7
VC12LC18A500	See pages 14-15 for specification and performance details.							

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
0.1 Joule	2A 8/20µS
≥0.4 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: Millimeters (Inches)

#Test condition <100µA

VOLTAGES = 18, 26, 30, 48 OR 60 VDC
1210 SURFACE MOUNT

Dimensions: **Actual Size:** 

Length	3.20 ± 0.2mm (0.126" ± 0.008")
Width	2.49 ± 0.2mm (0.098" ± 0.008")
Thickness	1.70mm Max. (0.067")
Land Length	0.71mm Max. (0.028")
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	0.5Vrms @: 1 MHz	di/dt = 100mA/nS
VC121018J390	18*	21.5 - 26.5	39	500	1.5	3100	2400	2.0
VC121026H560	26	29.7 - 36.3	56	300	1.2	2150	1675	2.0
VC121030G620	30	35.0 - 43.0	62	220	0.9	1900	1530	2.0
VC121030H620	30	35.0 - 43.0	62	280	1.2	1975	1575	2.0
VC121048G101	48	54.5 - 66.5	100	220	0.9	500	430	2.0
VC121048H101	48	54.5 - 66.5	100	250	1.2	525	450	2.0
VC121060J121	60	67.0 - 83.0	120	250	1.5	450	375	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 ≥0.4 Joules — Pulse Current & Waveform 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: Millimeters (Inches)

VOLTAGES = 3.3, 5.6, 14, 18, 26, 30, 48, 60 VDC
AXIAL LEADED

Dimensions:

		VA1000	VA2000
Body Length	(L)	= 4.32mm Max. (0.170")	4.83mm Max. (0.190")
Body Diameter	(D)	= 2.54mm Max. (0.100")	3.56mm Max. (0.140")
Lead Diameter		= 0.51 ± .05mm (0.020 ± 0.002)	0.51 ± .05mm (0.020 ± 0.002)
Lead Length		= 25.4mm Min. (1")	25.4mm Min. (1")

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	1 MHz	di/dt = 100mA/nS
VA100003A100	3.3#	4.1 - 6.0	10	40	0.1	1500	1100	3.5
VA100003D100	3.3#	3.7 - 5.6	10	150	0.4	4700	3800	3.5
VA100005A150	5.6	7.6 - 9.3	15.5	40	0.1	1000	750	3.5
VA100005D150	5.6	7.1 - 8.7	15.5	150	0.4	2800	2150	3.5
VA100014A300	14	16.5 - 20.3	30	40	0.1	400	300	3.5
VA100014D300	14	15.9 - 19.4	30	150	0.4	1200	900	3.5
VA100018A400	18	22.9 - 28.0	40	40	0.1	350	270	3.5
VA100018D400	18	22.5 - 27.5	40	150	0.4	900	700	3.5
VA100026D580	26	30.5 - 37.3	58	120	0.4	700	550	3.5
VA100030D650	30	36.0 - 45.0	65	120	0.4	600	500	3.5
VA100048D101	48	56.0 - 68.0	100	100	0.4	200	165	3.5
VA200060K121	60	67.0 - 83.0	120	300	2.0	400	340	3.5
VA10LC18A500	See pages 14-15 for specification and performance details.							

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
0.1 Joule	2A 8/20µS
≥0.4 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: Millimeters (Inches)

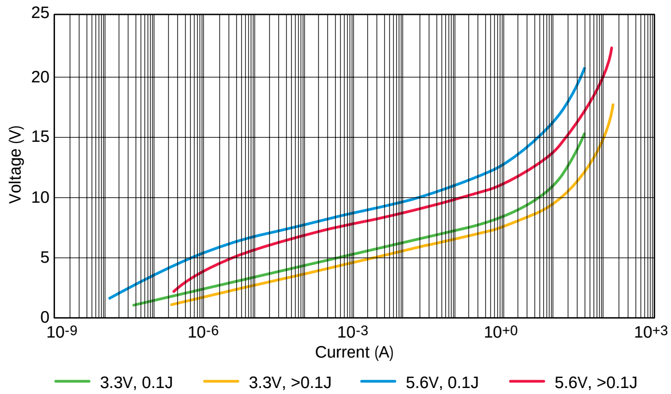
#Test condition <100µA

TYPICAL PERFORMANCE CURVES (0603, 0805, 1206 & 1210 CHIP SIZES)

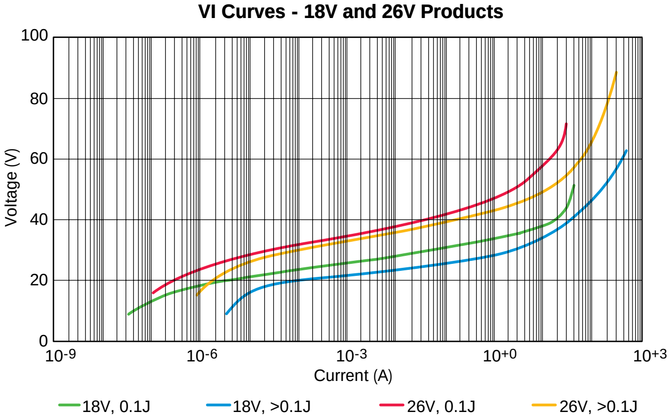
VOLTAGE/CURRENT CHARACTERISTICS

Multilayer construction and improved grain structure result in excellent transient clamping characteristics up to 500 amps peak current, depending on case size and energy rating, while maintaining very low leakage currents under DC operating conditions. The VI curve below shows the voltage/current characteristics for the 3.3V, 5.6V, 12V, 14V, 18V, 26V, 30V, 48V and 60VDC parts with currents ranging from parts of a micro amp to tens of amps.

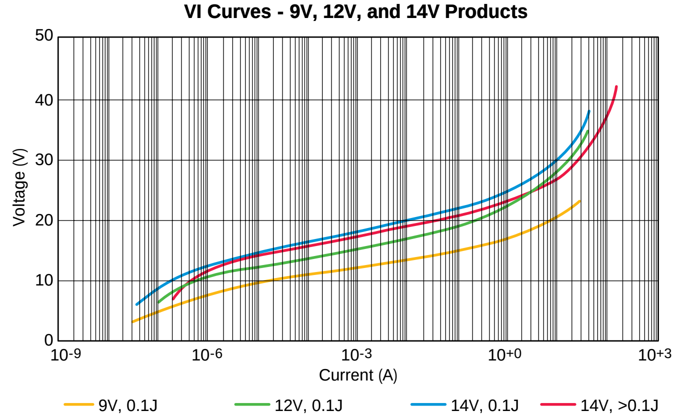
VI Curves - 3.3V and 5.6V Products



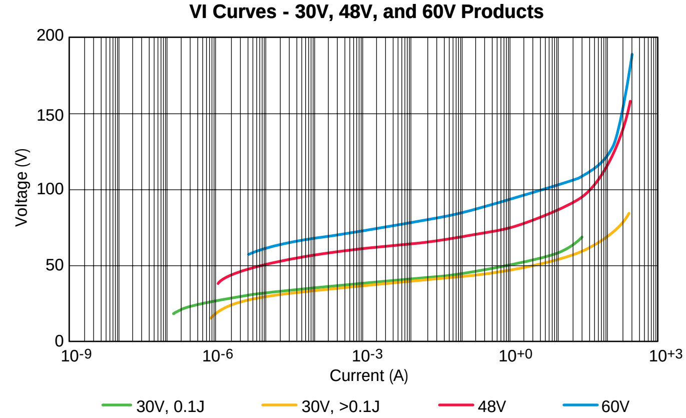
VI Curves - 18V and 26V Products



VI Curves - 9V, 12V, and 14V Products



VI Curves - 30V, 48V, and 60V Products

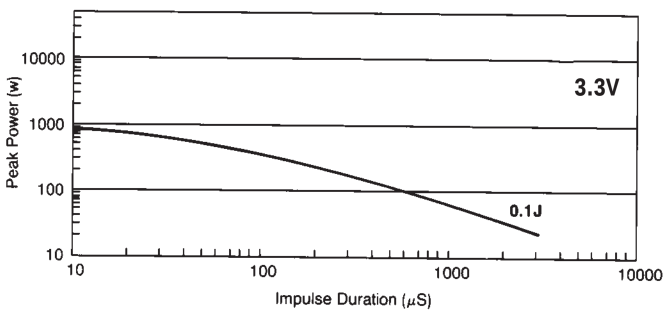


TransGuard®

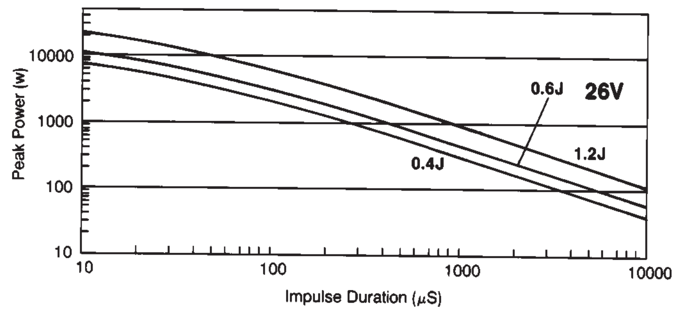
AVX Multilayer Ceramic Transient Voltage Suppressors

TYPICAL PERFORMANCE CURVES (0603, 0805, 1206 & 1210 CHIP SIZES)

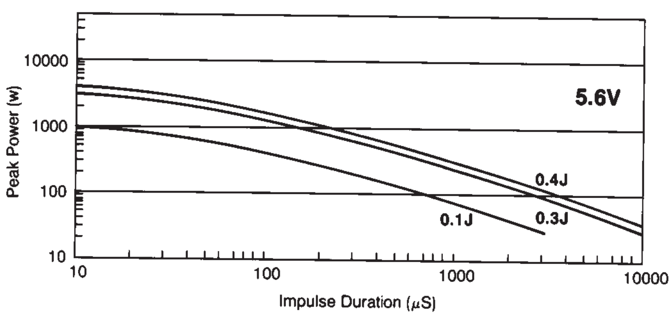
TYPICAL PULSE RATING CURVE
3.3V MULTILAYER TRANSGUARD®



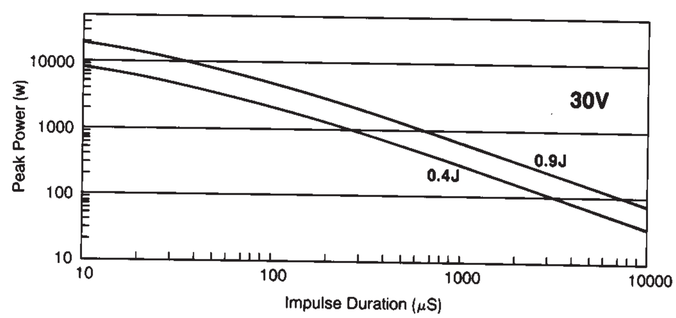
TYPICAL PULSE RATING CURVE
26V MULTILAYER TRANSGUARD®



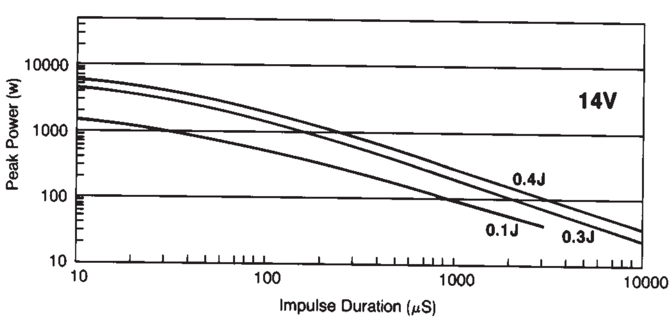
TYPICAL PULSE RATING CURVE
5.6V MULTILAYER TRANSGUARD®



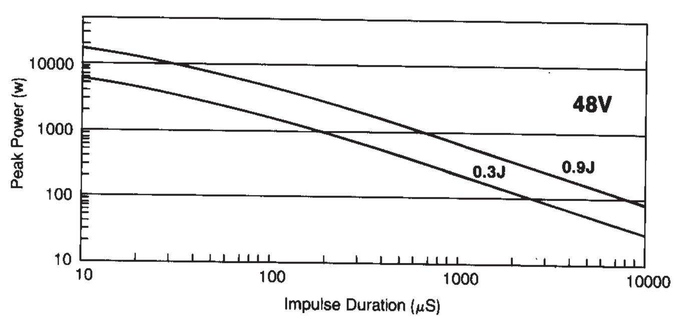
TYPICAL PULSE RATING CURVE
30V MULTILAYER TRANSGUARD®



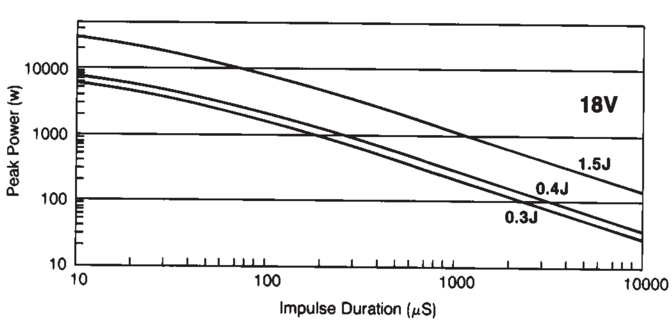
TYPICAL PULSE RATING CURVE
14V MULTILAYER TRANSGUARD®



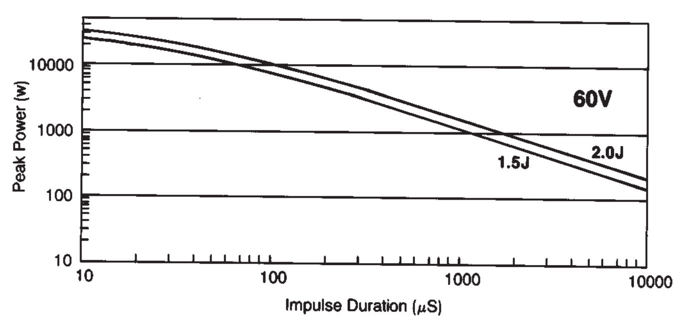
TYPICAL PULSE RATING CURVE
48V MULTILAYER TRANSGUARD®



TYPICAL PULSE RATING CURVE
18V MULTILAYER TRANSGUARD®



TYPICAL PULSE RATING CURVE
60V MULTILAYER TRANSGUARD®

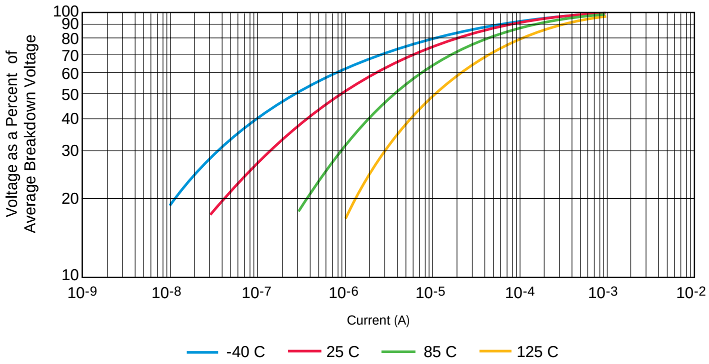


TYPICAL PERFORMANCE CURVES (0603, 0805, 1206 & 1210 CHIP SIZES)

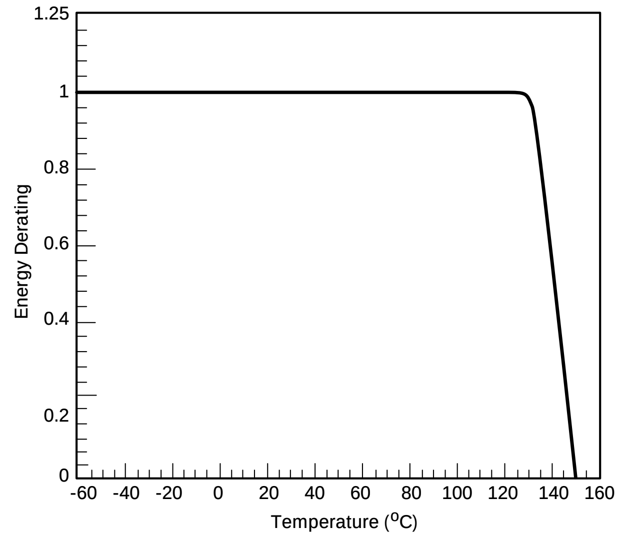
TEMPERATURE CHARACTERISTICS

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.

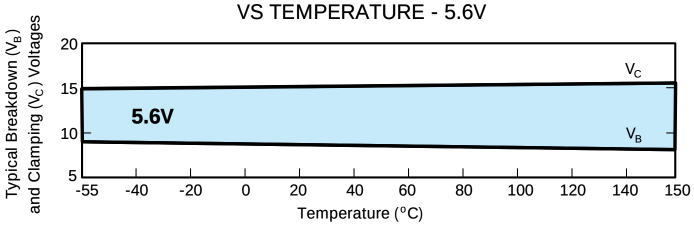
Temperature Dependence of Voltage



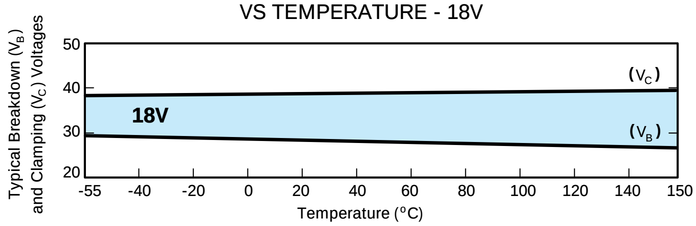
TYPICAL ENERGY DERATING VS TEMPERATURE



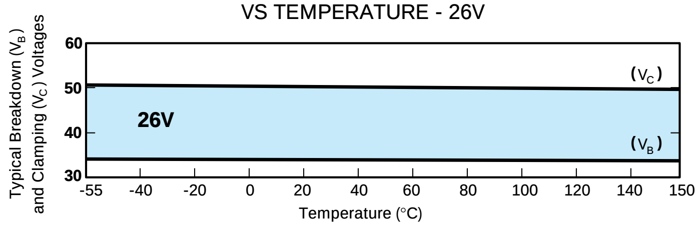
TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 5.6V



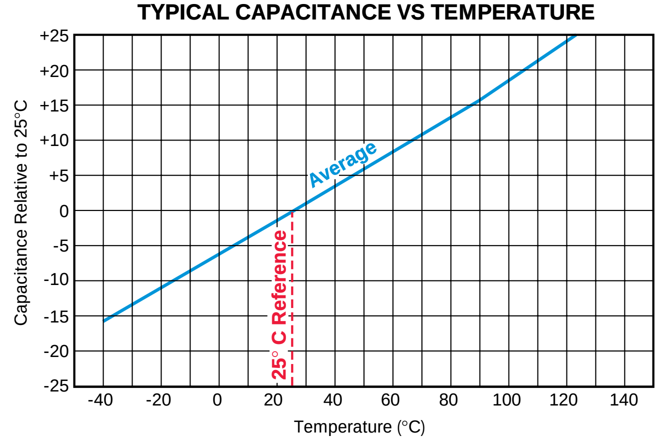
TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 18V



TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 26V



TYPICAL CAPACITANCE VS TEMPERATURE



TYPICAL PERFORMANCE CURVES (0603, 0805, 1206 & 1210 CHIP SIZES)

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 waveforms 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 are shown below.

Repetitive Peak Current Strikes
TransGuard 1206 0.4J Product

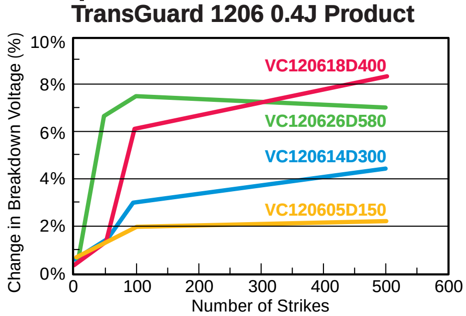


Figure 1

Repetitive Peak Current Strikes
TransGuard 1210 1.5J Product

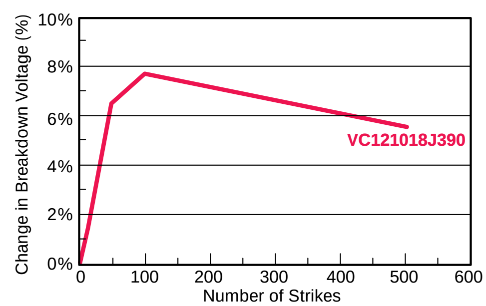


Figure 3

Repetitive Peak Current Strikes
TransGuard 0805 0.1J and 0.3J Products

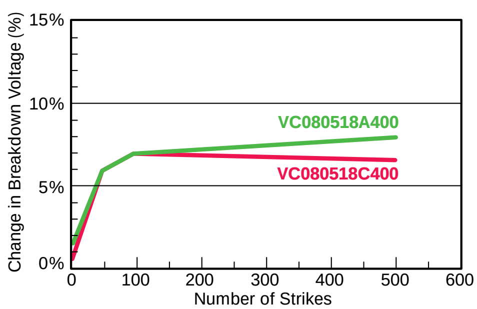


Figure 2

Repetitive Peak Current Strikes
StaticGuard 0805 0.1J Product

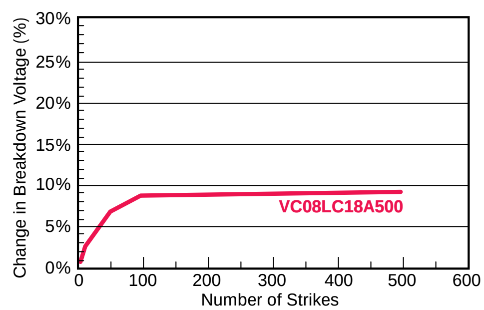
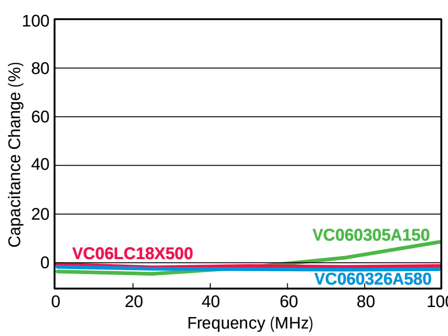


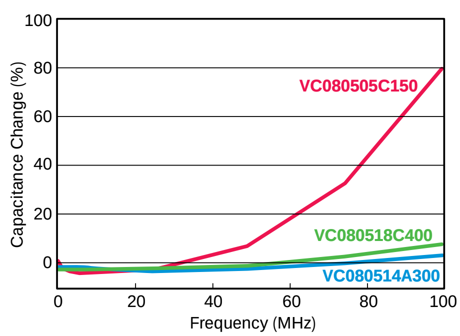
Figure 4

CAPACITANCE/FREQUENCY CHARACTERISTICS

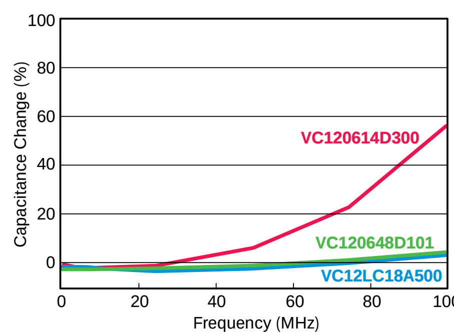
TransGuard Capacitance vs Frequency 0603



TransGuard Capacitance vs Frequency 0805



TransGuard Capacitance vs Frequency 1206



StaticGuard

AVX Multilayer Ceramic Transient Voltage Suppressors ESD Protection for CMOS and Bi Polar Systems

GENERAL INFORMATION

- Typical ESD failure voltage for CMOS and/or Bi Polar is ≥ 200V.
- 15kV ESD pulse (air discharge) per IEC 1000-4-2, Level 4, generates < 20 millijoules of energy.
- Low capacitance (<200pF) is required for high-speed data transmission.
- Low leakage current (I_L) is necessary for battery operated equipment.

PART NUMBER IDENTIFICATION (See page 2 for details)

Chips

V C 08 LC 18 A 500 R

- V — PRODUCT DESIGNATOR
- C — CASE STYLE
- 08 — CASE SIZE DESIGNATOR
- LC — LOW CAPACITANCE DESIGN
- 18 — WORKING VOLTAGE (0-18V)
- A — ENERGY RATING
- 500 — CLAMPING VOLTAGE
- R — PACKAGING (Pcs/Reel)

Axials

V A 10 LC 18 A 500 R

- V — PRODUCT DESIGNATOR
- A — CASE STYLE
- 10 — CASE SIZE DESIGNATOR
- LC — LOW CAPACITANCE DESIGN
- 18 — WORKING VOLTAGE (0-18V)
- A — ENERGY RATING
- 500 — CLAMPING VOLTAGE
- R — PACKAGING (Pcs/Reel)

AVX Part Number	Working Voltage	Clamping Voltage	Peak Current	Transient Energy	Capacitance	Inductance
Symbol	V_{WM}	V_C	I_{peak}	E_{trans}	C	L
Units	Volts (max.)	Volts (max.)	Amp (max.)	Joules (max.)	pF (typ.)	nH (typ.)
Test Condition	<10µA	8/20µS†	8/20µs	10/1000µS	0.5Vrms @: 1 MHz	di/dt = 100mA/ns
VC04LC18V500	≤18.0	<50.0	15	0.02	40	<1.0
VC06LC18X500	≤18.0	50	20	.05	75	<1.0
VC08LC18A500	≤18.0	50	30	0.1	100	<1.5
VC12LC18A500	≤18.0	50	30	0.1	200	<1.7
VA10LC18A500	≤18.0	50	30	0.1	200	<3.5

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

†Transient Energy Rating	Pulse Current & Waveform
<0.05 Joule	1A 8/20µS
0.1 Joule	2A 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 1MHz

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

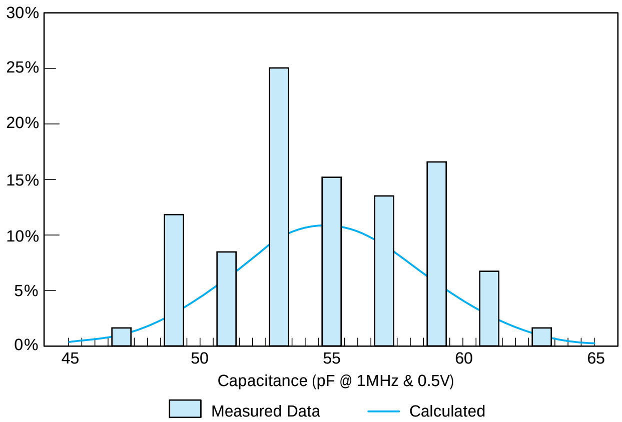
Dimensions: Millimeters (Inches)

StaticGuard

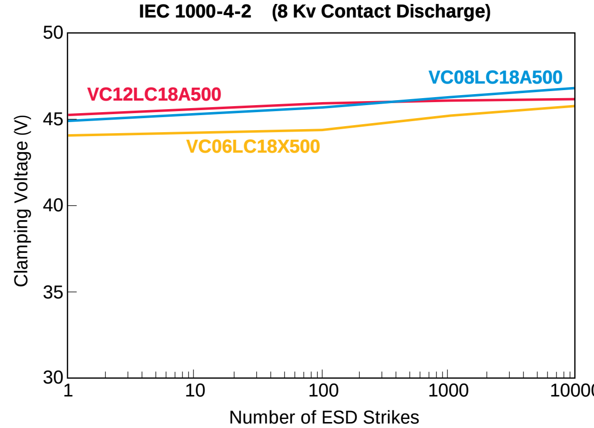
AVX Multilayer Ceramic Transient Voltage Suppressors
ESD Protection for CMOS and Bi Polar Systems

TYPICAL PERFORMANCE DATA

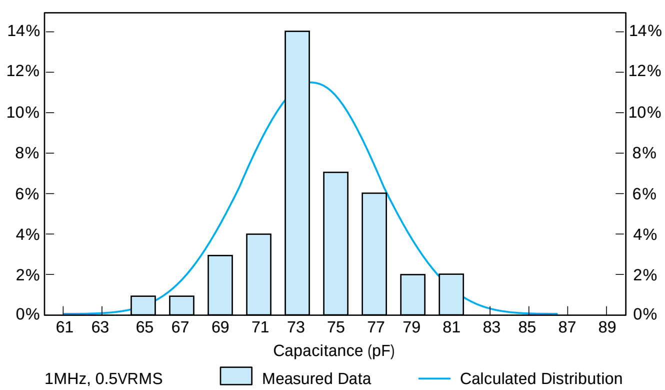
VC06LC18X500 Capacitance Histogram



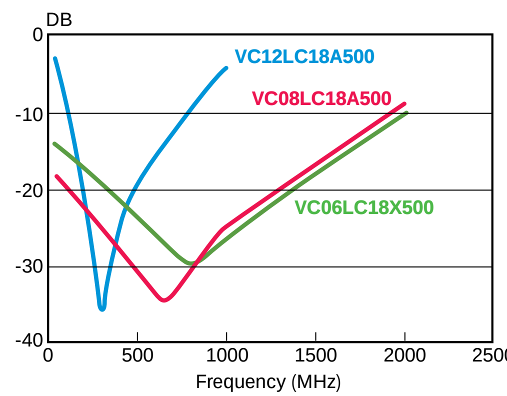
StaticGuard ESD RESPONSE
IEC 1000-4-2 (8 Kv Contact Discharge)



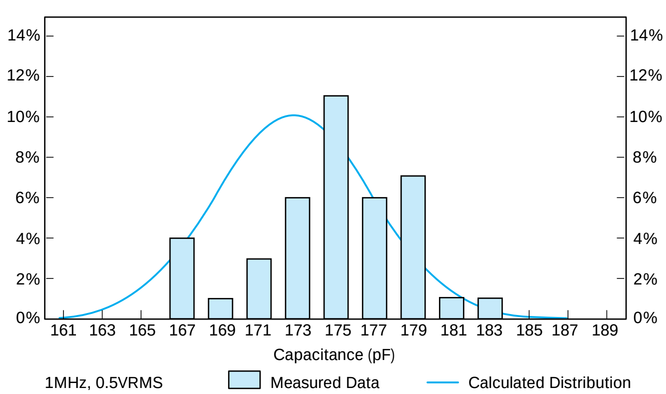
VC08LC18A500 Capacitance Histogram



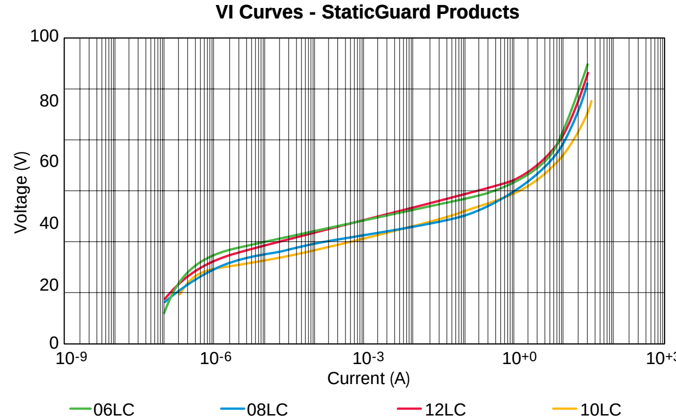
StaticGuard S21



VC12LC18A500 Capacitance Histogram



VI Curves - StaticGuard Products

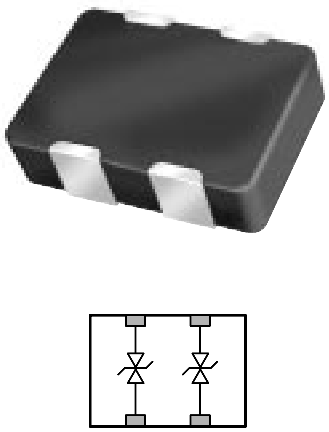


MultiGuard (2&4 Elements)
AVX Multilayer Ceramic
Transient Voltage Suppression Arrays
ESD Protection for CMOS and Bi Polar Systems

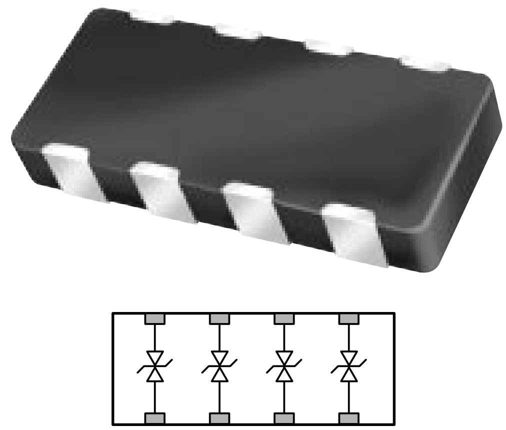
GENERAL DESCRIPTION AND COMMENTS

AVX's Transient Voltage Suppressor (TVS) Arrays address three trends in today's electronic circuits: (1) mandatory ESD protection, (2) PCB downsizing, and (3) reduced component placement costs. Where multiple lines require ESD protection, the 4-element 0612 chip is an ideal solution. If less than 4 lines of protection is needed and/or if space will not permit the use of the larger 0612 chip, the latest 2-element 0508 chip may offer the answer. In either configuration, 5.6, 9, 14 and 18 volts, with 0.1 joule energy rating are available. The StaticGuard series (≤18V, and low capacitance) is also available, rated at 0.05 joules energy.

AVX's MultiGuard products consume less than half the PCB real estate required for the equivalent number of discrete chips. This size advantage, coupled with the savings associated with placing only one chip, makes MultiGuard the TVS component of choice for ESD protection of I/O lines.



SIZE: 0508



SIZE: 0612

ELECTRICAL CHARACTERISTICS PER ELEMENT

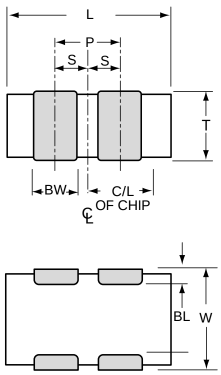
AVX Part Number	Working Voltage	Breakdown Voltage	Clamping Voltage	Peak Current	Transient Energy	Capacitance	Inductance
Symbol	V_{WM}	V_B	V_C	I_{peak}	E_{trans}	C	L
Units	Volts (max.)	Volts	Volts (max.)	Amp (max.)	Joules (max.)	pF (typ.)	nH (typ.)
Test Condition	<50µA	1mA DC	8/20µS	8/20µs	10/1000µS	0.5Vrms @: 1 MHz	di/dt = 100mA/nS
2 ELEMENT 0508 CHIP							
MG052S05A150	5.6	6.8 - 9.3	15.5	30	0.1	825	<1.0
MG052S09A200	9.0	10.0 - 14.0	20	30	0.1	550	<1.0
MG052S14A300	14.0	14.7 - 20.3	30	30	0.1	425	<1.0
MG052S18A400	18.0	20.4 - 28.0	40	30	0.1	225	<1.0
MG052L18X500	≤18.0	N/A	50	20	0.05	<75	<1.0
4 ELEMENT 0612 CHIP							
MG064S05A150	5.6	6.8 - 9.3	15.5	30	0.1	825	<1.0
MG064S09A200	9.0	10.0 - 14.0	20	30	0.1	550	<1.0
MG064S14A300	14.0	14.7 - 20.3	30	30	0.1	425	<1.0
MG064S18A400	18.0	20.4 - 28.0	40	30	0.1	225	<1.0
MG064L18X500	≤18.0	N/A	50	20	0.05	<75	<1.0

MultiGuard (2 & 4 Elements)

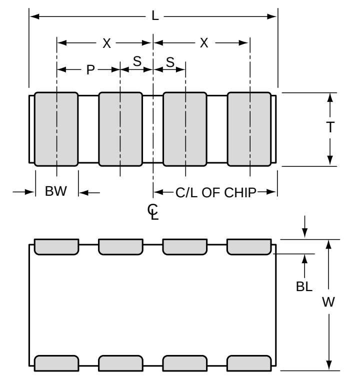
AVX Multilayer Ceramic
Transient Voltage Suppression Arrays
ESD Protection for CMOS and Bi Polar Systems

PHYSICAL DIMENSIONS AND PAD LAYOUT

2-ELEMENT MULTIGUARD



4-ELEMENT MULTIGUARD



PART DIMENSIONS mm (inches)

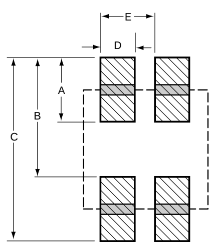
L	W	T	BW	BL	P	S
2.01±0.2 (0.079±0.008)	1.25±0.2 (0.049±0.008)	1.02 MAX (0.040 MAX)	0.41±0.1 (0.016±0.004)	$0.18^{+0.25}_{-0.08}$ $(0.007^{+.010}_{-.003})$	0.76 REF (0.030 REF)	0.38±0.1 (0.015±0.004)

PART DIMENSIONS mm (inches)

L	W	T	BW	BL	P	X	S
3.20±0.2 (0.126±0.008)	1.60±0.2 (0.063±0.008)	1.22 MAX (0.048 MAX)	0.41±0.1 (0.016±0.004)	$0.18^{+0.25}_{-0.08}$ $(0.007^{+.010}_{-.003})$	0.76 REF (0.030 REF)	1.14±0.1 (0.045±0.004)	0.38±0.1 (0.015±0.004)

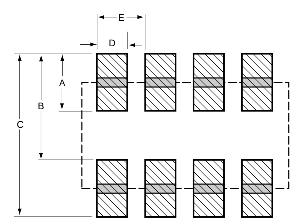
PAD LAYOUT DIMENSIONS mm (inches)

A	B	C	D	E
0.89 (0.035)	1.27 (0.050)	2.16 (0.085)	0.46 (0.018)	0.76 (0.030)



PAD LAYOUT DIMENSIONS mm (inches)

A	B	C	D	E
0.89 (0.035)	1.65 (0.065)	2.54 (0.100)	0.46 (0.018)	0.79 (0.030)



PART NUMBERING SYSTEM

MG 06 4 S 14 A 300 T

MULTIGUARD — MG

CHIP SIZE
- 05 = 0508
- 06 = 0612

CONFIGURATION
- 2 = 2 Elements
- 4 = 4 Elements

STYLE
- S = Standard Construction
- L = Low Capacitance

WORKING VOLTAGE
- 05 = 5.6V
- 09 = 9.0V
- 14 = 14.0V
- 18 = 18.0V

PACKAGING
(PCS/REEL)
- D = 1,000
- R = 4,000
- T = 10,000

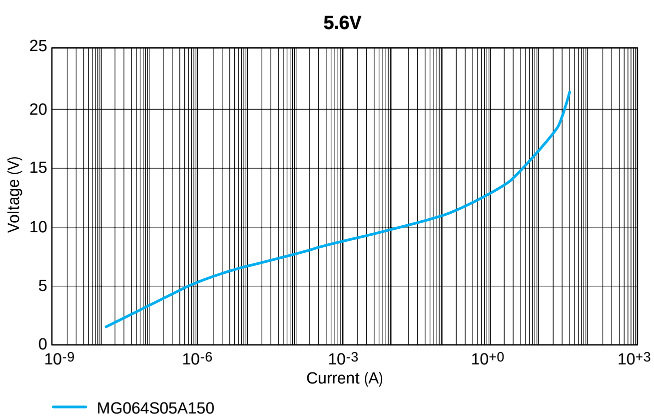
CLAMPING VOLTAGE
- 150 = 15.5V
- 200 = 20.0V
- 300 = 30.0V
- 400 = 40.0V
- 500 = 50.0V

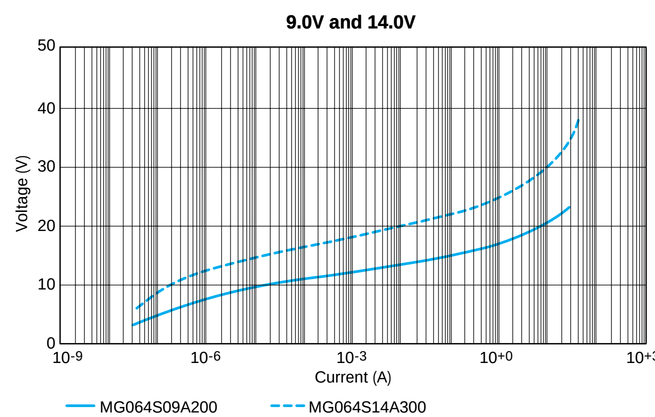
ENERGY RATING
- A = 0.10 Joules
- X = 0.05 Joules

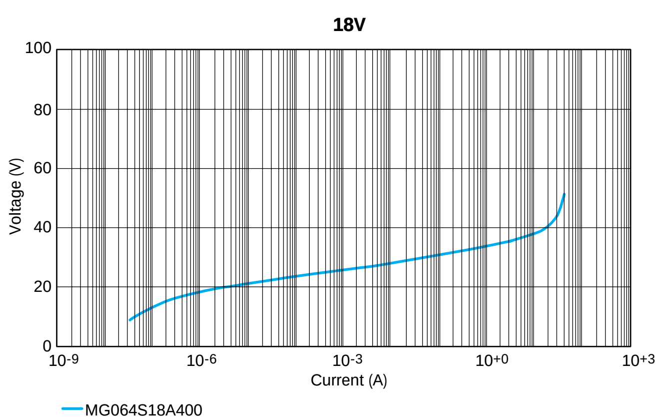
TYPICAL PERFORMANCE CURVES

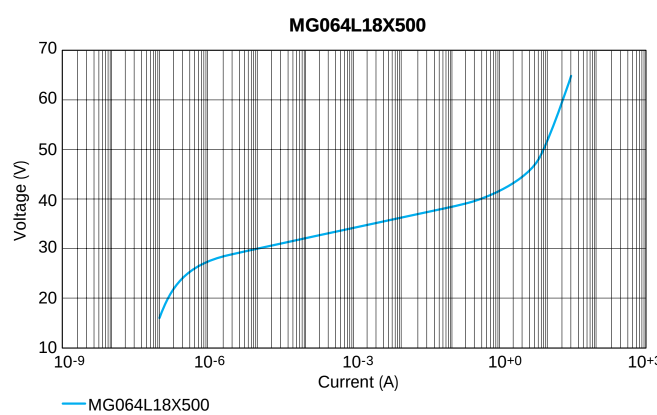
VOLTAGE/CURRENT CHARACTERISTICS

Multilayer construction and improved grain structure result in excellent transient clamping characteristics in excess of 30 amps (20 amps on MG064L18X500) peak current while maintaining very low leakage currents under DC operating conditions. The VI curves below show the voltage/current characteristics for the 5.6V, 9V, 14V and 18V parts with currents ranging from fractions of a micro amp to tens of amps.









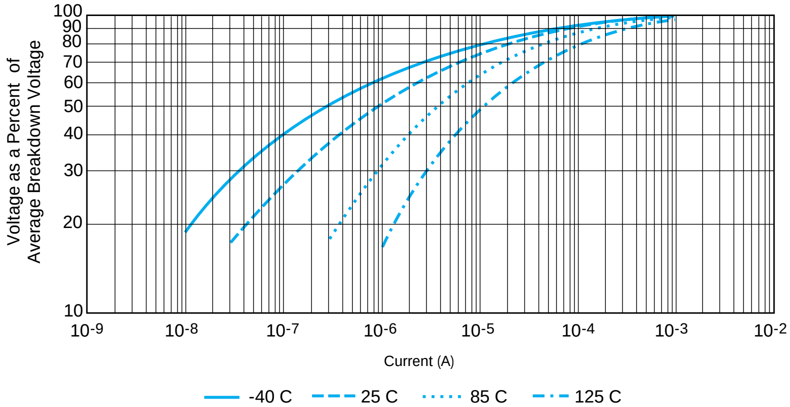
MultiGuard (2 & 4 Elements)
AVX Multilayer Ceramic
Transient Voltage Suppression Arrays
ESD Protection for CMOS and Bi Polar Systems

TYPICAL PERFORMANCE CURVES

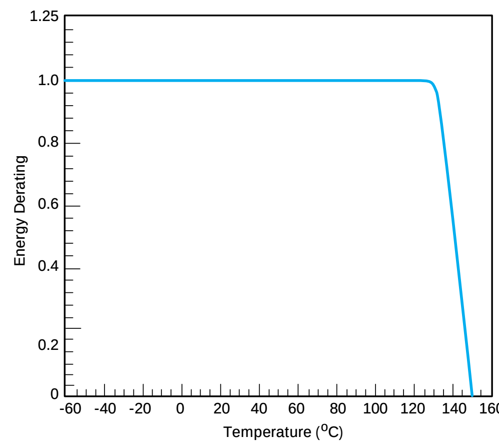
TEMPERATURE CHARACTERISTICS

MultiGuard suppressors are designed to operate over the full temperature range from -55°C to +125°C.

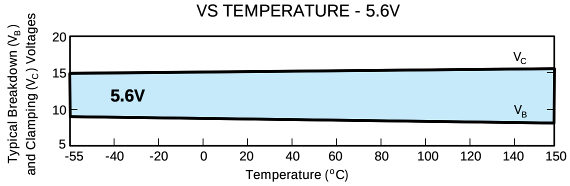
Temperature Dependence of Voltage



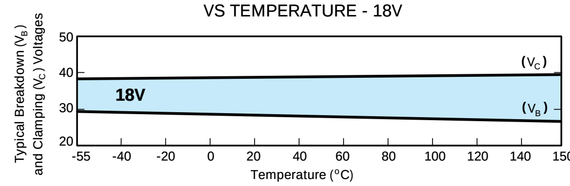
TYPICAL ENERGY DERATING VS TEMPERATURE



TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 5.6V



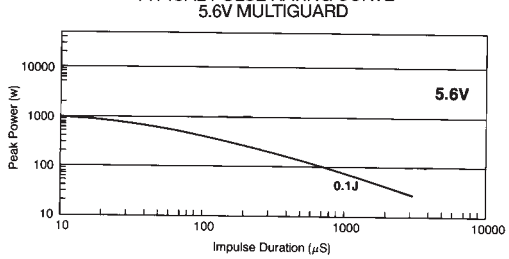
TYPICAL BREAKDOWN AND CLAMPING VOLTAGES VS TEMPERATURE - 18V



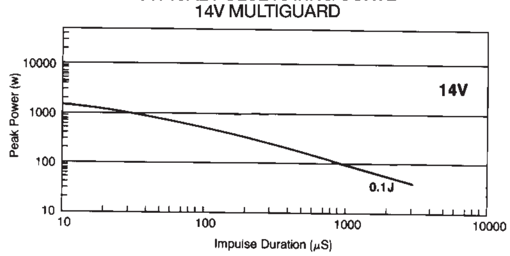
TRANSIENT VOLTAGE SUPPRESSORS

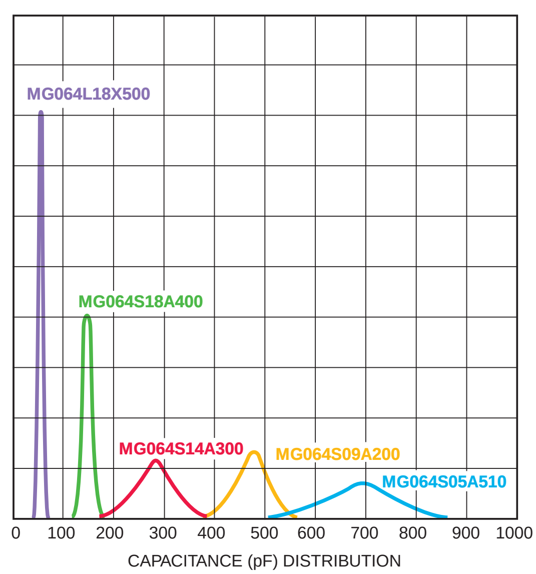
TYPICAL PERFORMANCE CURVES

TYPICAL PULSE RATING CURVE
5.6V MULTIGUARD



TYPICAL PULSE RATING CURVE
14V MULTIGUARD





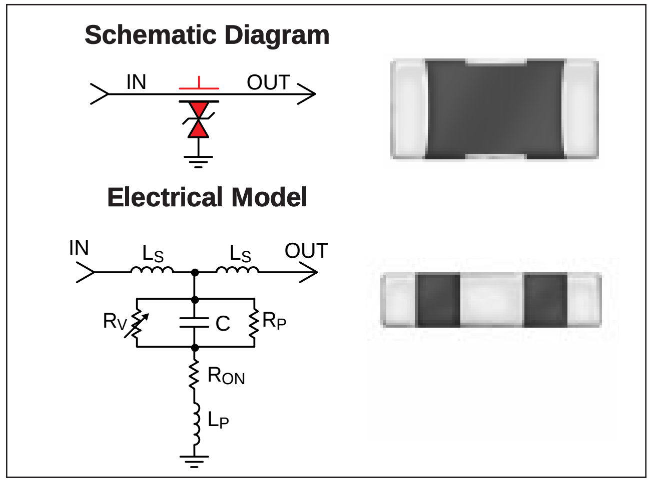
TransFeed

AVX Multilayer Ceramic Transient Voltage Suppressors
TVS Protection and EMI Attenuation in a Single 0805 Chip - V2F Series

GENERAL DESCRIPTION

AVX has combined the best electrical characteristics of its TransGuard Transient Voltage Suppressors (TVS) and its Feedthru Capacitors into a single chip for state-of-the-art overvoltage circuit protection and EMI reduction over a broad range of frequencies. This unique combination of multilayer ceramic construction in a feedthru configuration gives the circuit designer a single 0805 chip that responds to transient events faster than any TVS device on the market today, and provides significant EMI attenuation when in the off-state.

The reduction in parallel inductance, typical of the feedthru chip construction when compared to the construction of standard TVS or ceramic capacitor chips, gives the TransFeed product two very important electrical advantages: (1) faster "turn-on" time. Calculated response times of <200 pSec are not unusual with this device, and measured response times range from 200 – 250 pSec. The TransFeed "turn-on" characteristic is less than half that of an equivalent TransGuard part — and TransGuards clamp transient voltages faster than any other bipolar TVS solution such as diodes; (2) the second electrical advantage of lower parallel inductance, coupled with optimal series inductance, is the enhanced attenuation characteristics of the TransFeed product. Not only is there significantly greater attenuation at a higher self-resonance frequency, but the roll-off characteristic becomes much flatter, resulting in EMI filtering over a much broader frequency spectrum. Typical applications include filtering/protection on Microcontroller I/O Lines, Interface I/O Lines, Power Line Conditioning and Power Regulation.



Where designers are concerned with both transient voltage protection and EMI attenuation, either due to the electrical performance of their circuits or due to required compliance to specific EMC regulations, the TransFeed product is an ideal choice.

HOW TO ORDER

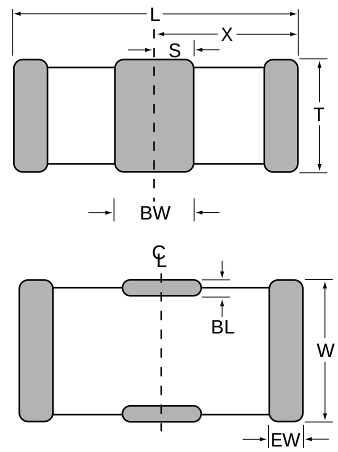
V 2 F 1 05 A 150 Y 2 E D

- **V** – **Varistor**
- **2** – **Chip Size**: 2 = 0805
- **F** – **Feedthru Capacitor**
- **1** – **No. of Elements**
- **05** – **Voltage**: 05 = 5.6V; 09 = 9.0V; 14 = 14.0V; 18 = 18.0V
- **A** – **Energy Rating**: X = 0.05J; A = 0.1J; C = 0.3J
- **150** – **Varistor Clamping Voltage**: 150 = 15.5V; 200 = 20.0V; 300 = 30.0V; 400 = 40.0V; 500 = 50.0V
- **Y** – **Capacitance Tolerance**: Y = +100/-50%
- **2** – **DC Resistance**: 1 = 0.150 Ohms; 2 = 0.200 Ohms; 3 = 0.250 Ohms
- **E** – **Feedthru Current**: D = 500 mA; E = 750 mA; F = 1.0 Amp
- **D** – **Packaging Code Pcs./Reel**: D = 1,000; R = 4,000; T = 10,000

DIMENSIONS

millimeters (inches)

	L	W	T	BW	BL	EW	X	S
0805	2.01 ± 0.20 (0.079 ± 0.008)	1.25 ± 0.20 (0.049 ± 0.008)	0.76 ± 0.03 (0.030 ± 0.003)	0.46 ± 0.10 (0.018 ± 0.004)	0.18 + 0.25 -0.08 (0.007 + 0.010 -0.003)	0.25 ± 0.13 (0.010 ± 0.005)	1.02 ± 0.10 (0.040 ± 0.004)	0.23 ± 0.05 (0.009 ± 0.002)

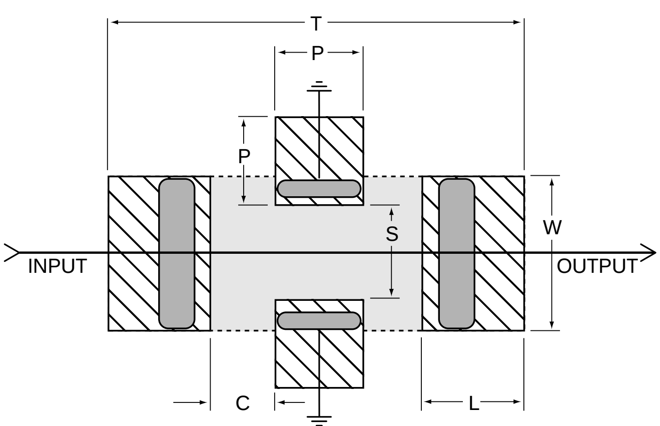


RECOMMENDED SOLDER PAD LAYOUT (Typical Dimensions)

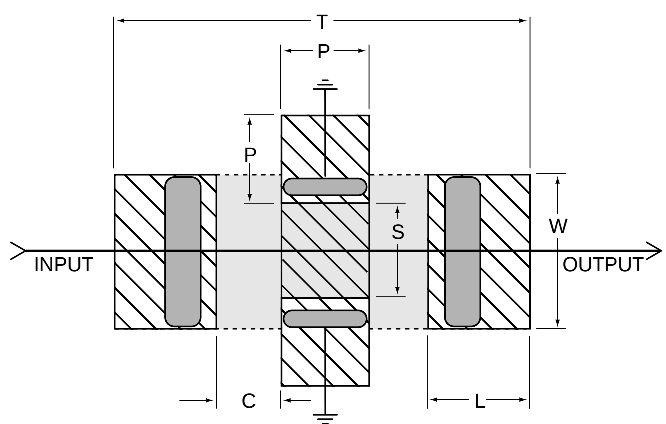
millimeters (inches)

	T	P	S	W	L	C
0805	3.45 (0.136)	0.51 (0.020)	0.76 (0.030)	1.27 (0.050)	1.02 (0.040)	0.46 (0.018)

4 Pad Layout



3 Pad Layout



Note: It is only necessary to ground one center terminal. However, AVX recommends that both side terminals be connected.

TRANSFEED ELECTRICAL SPECIFICATIONS (0805 CHIP SIZE)

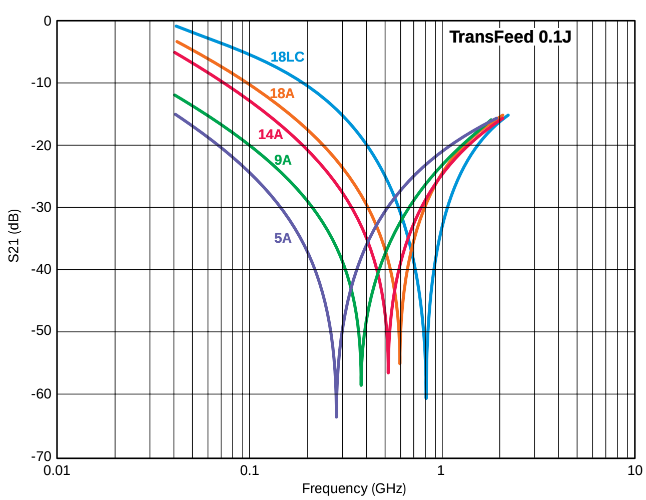
AVX Part Number	Working Voltage	Breakdown Voltage	Clamping Voltage	Peak Current	Transient Energy	Capacitance	DC Resistance Ohms	Feedthru Current
Symbol	V_{WM}	V_B	V_C	I_{peak}	E_{trans}	C	Ohms	I
Units	Volts (max.)	Volts	Volts (max.)	Amp (max.)	Joules (max.)	pF (typ.)	Ω	Amp.
Test Condition	<50µA	1mA DC	8/20µS†	8/20µs	10/1000µS	0.5Vrms @: 1 MHz		
V2F105A150Y2E	5.6	7.6 - 9.3	15.5	30	0.1	800	0.200	750 mA
V2F109A200Y2E	9.0	11.0 -14.0	20.0	30	0.1	575	0.200	750 mA
V2F114A300Y2E	14.0	16.5 -20.3	30.0	30	0.1	300	0.200	750 mA
V2F118A400Y2E	18.0	22.9 -28.0	40.0	30	0.1	200	0.200	750 mA
V2F118X500Y3D	<18.0	N/A	<50.0	20	0.05	<100	0.250	500 mA
V2F105C150Y1F	5.6	7.1 - 8.7	15.5	120	0.3	2500	0.150	1 Amp
V2F109C200Y1F	9.0	10.5 -13.5	20.0	120	0.3	1800	0.150	1 Amp
V2F114C300Y1F	14.0	15.9 -19.4	30.0	120	0.3	900	0.150	1 Amp
V2F118C400Y1F	18.0	22.5 -27.5	40.0	120	0.3	500	0.150	1 Amp

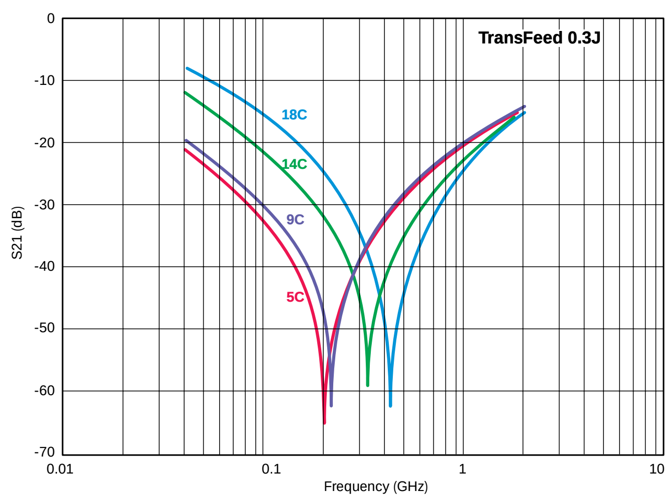
V_C—Maximum peak voltage across the varistor measured at a specified pulse current and waveform

†Transient Energy Rating	Pulse Current & Waveform
0.05 Joule	1A 8/20µS
0.01 Joule	2A 8/20µS
0.2 - 0.3 Joules	5A 8/20µS

PERFORMANCE CHARACTERISTICS

dB Attenuation vs Frequency

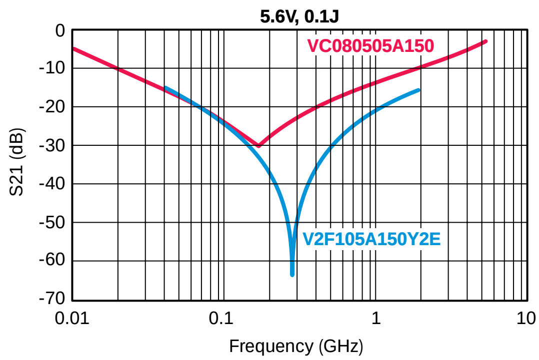


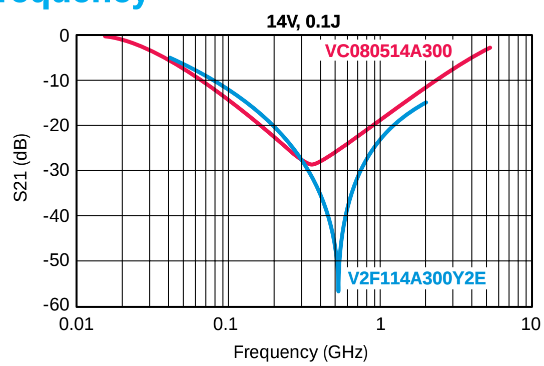


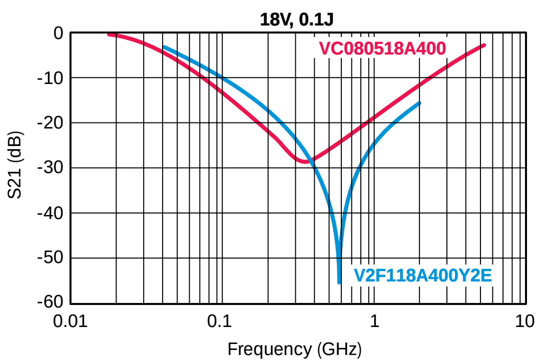
PERFORMANCE CHARACTERISTICS

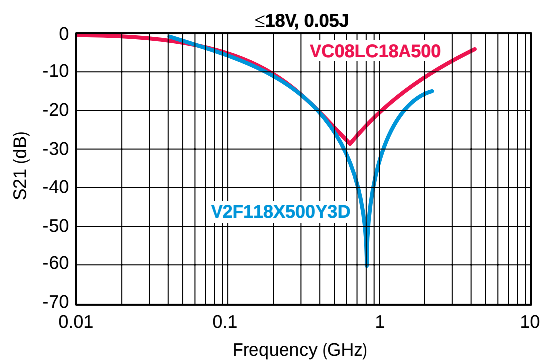
INSERTION LOSS COMPARISON (TransFeed vs TransGuard)

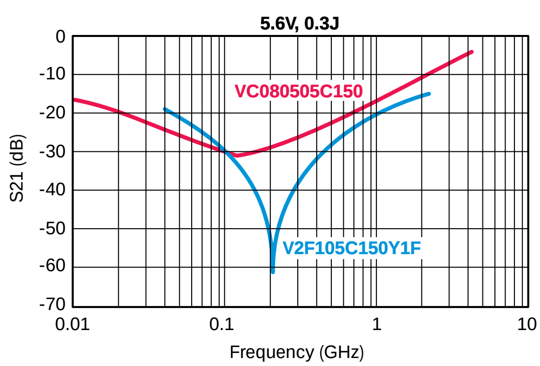
0805 – dB vs Frequency

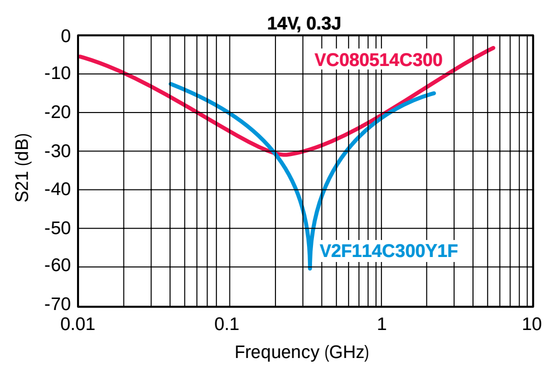


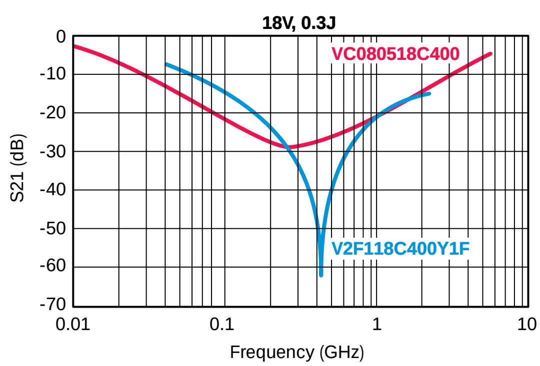








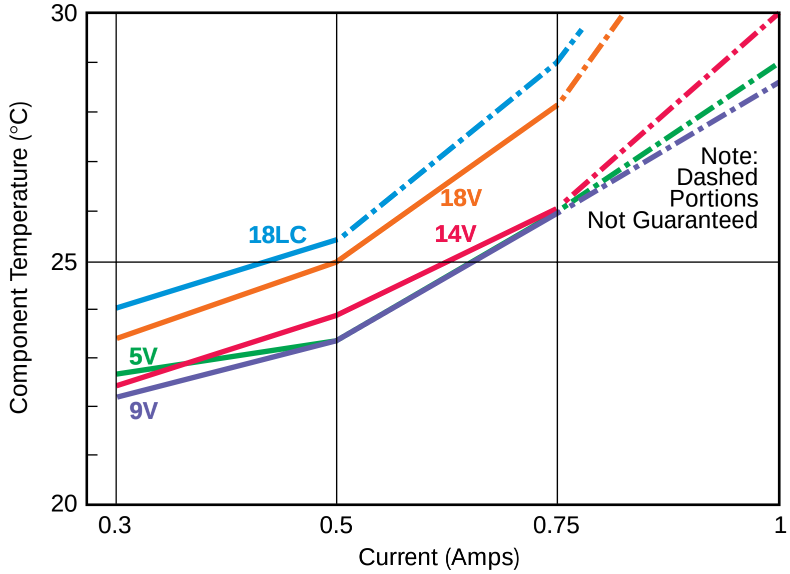




PERFORMANCE CHARACTERISTICS

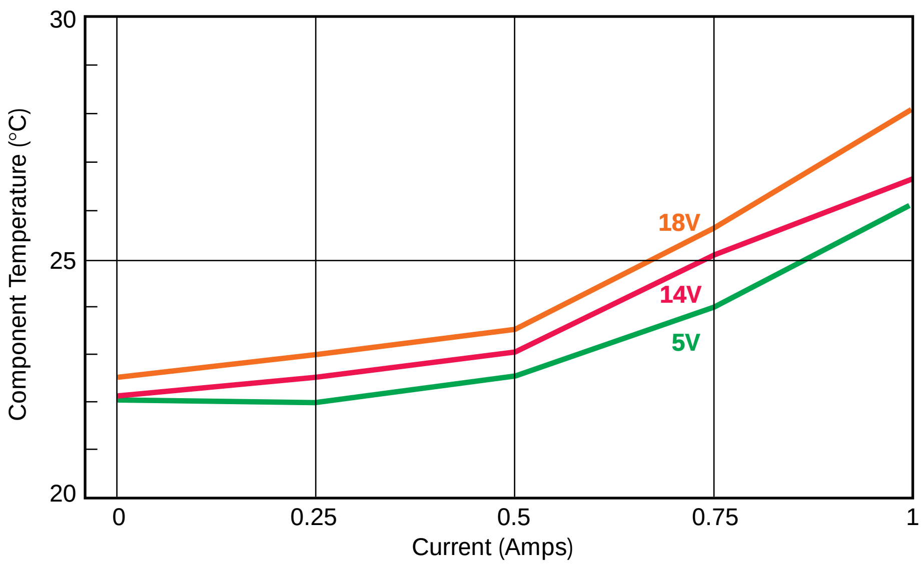
CURRENT vs TEMPERATURE

0805 – 0.1 Joule



CURRENT vs TEMPERATURE

0805 – 0.3 Joule



PERFORMANCE CHARACTERISTICS

FEEDTHRU VARISTORS

AVX Multilayer Feedthru Varistors (MLVF) are an ideal choice for system designers with transient strike and broadband EMI/RFI concerns.

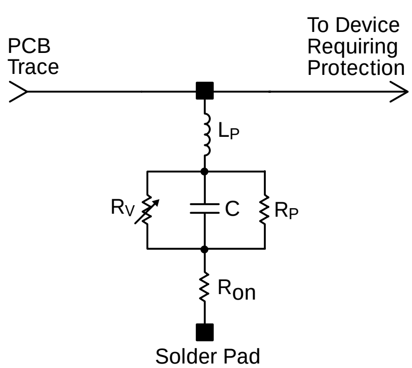
Feedthru Varistors utilize a ZnO varistor material and the electrode pattern of a feedthru capacitor. This combination allows the package advantage of the feedthru and material advantages of the ZnO dielectric to be optimized.

ZnO MLV Feedthrus exhibit electrical and physical advantages over standard ZnO MLVs. Among them are:

1. Faster Turn on Time
2. Broadband EMI attenuation
3. Small size (relative to discrete MLV and EMI filter schemes)

The electrical model for a ZnO MLV and a ZnO Feedthru MLV are shown below. The key difference in the model for the Feedthru is a transformation in parallel to series inductance. The added series inductance helps lower the injected transient peak current (by $2\pi fL$) resulting in an additional benefit of a lower clamping voltage. The lowered parallel inductance decreases the turn on time for the varistor to <250ps.

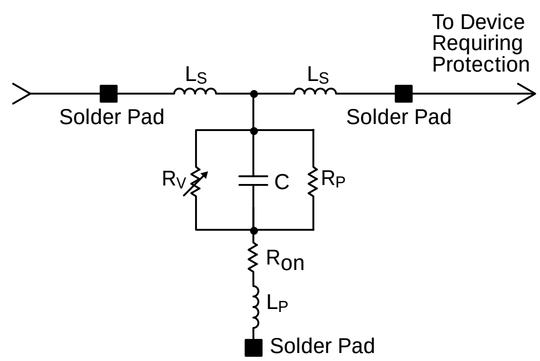
Discrete MLV Model



Where:

R_V	=	Voltage Variable resistance (per VI curve)
R_P	≥	$10^{12}\ \Omega$
C	=	defined by voltage rating and energy level
R_{on}	=	turn on resistance
L_P	=	parallel body inductance

Discrete MLVF Model



Where:

R_V	=	Voltage Variable resistance (per VI curve)
R_P	=	Body IR
C	=	defined by voltage rating and energy level
R_{on}	=	turn on resistance
L_P	=	minimized parallel body inductance
L_S	=	series body inductance

TransFeed

AVX Multilayer Ceramic Transient Voltage Suppressors
TVS Protection and EMI Attenuation in a Single 0805 Chip - V2F Series

PERFORMANCE CHARACTERISTICS

APPLICATIONS

- EMI Suppression
- Broadband I/O Filtering
- Vcc Line Conditioning

FEATURES

- Small Size
- Low ESR
- Ultra-fast Response Time
- Broad S21 Characteristics

MARKET SEGMENTS

- Computers
- Automotive
- Power Supplies
- Multimedia Add-On Cards
- Bar Code Scanners
- Remote Terminals
- Medical Instrumentation
- Test Equipment
- Transceivers
- Cellular Phones / Pagers

TYPICAL CIRCUITS REQUIRING TRANSIENT VOLTAGE PROTECTION AND EMI FILTERING

The following applications and schematic diagrams show where TransFeed TVS/ EMI filtering devices might be used:

- System Board Level Interfaces: (Fig. 1)
  - Digital to RF
  - Analog to Digital
  - Digital to Analog
- Voltage Regulation (Fig. 2)
- Power Conversion Circuits (Fig. 3)
- GaAs FET Protection (Fig. 4)

Fig. 1 – System Interface

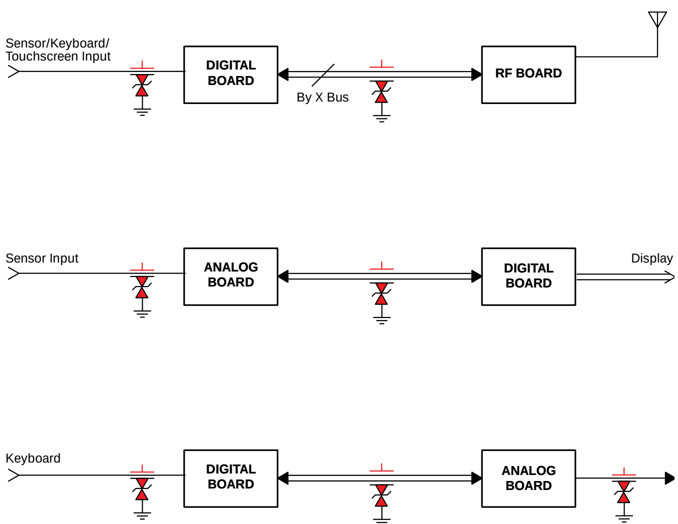


Fig. 2 – Voltage Regulators

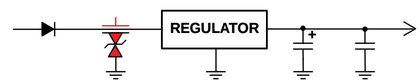


Fig. 3 – Power Conversion Circuits/Power Switching Circuits

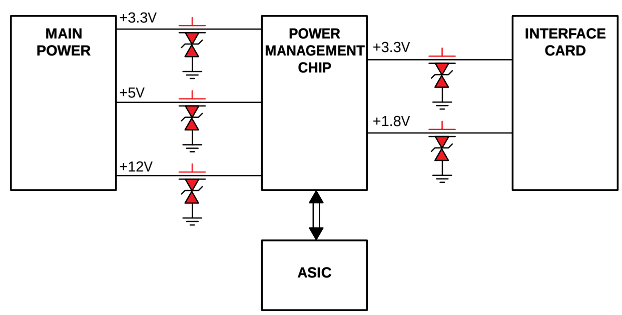
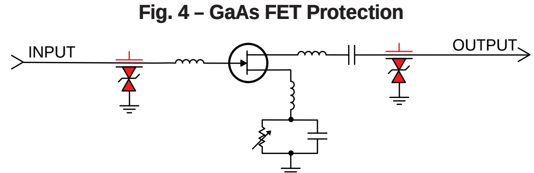


Fig. 4 – GaAs FET Protection



SPECIFICATION COMPARISON

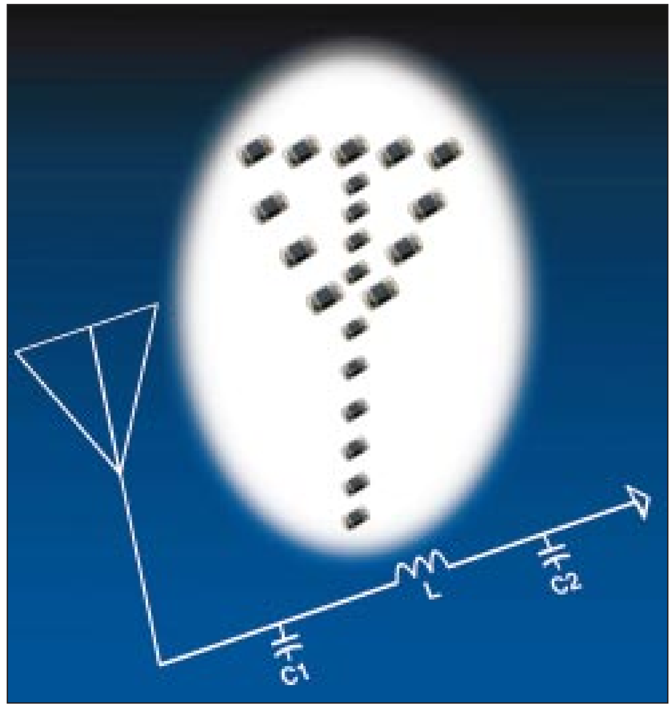
MLVF 0805	PARAMETER		MLV 0805
5ph	L_S	typical	N/A
<600nh	L_P	typical	<1.5nh
<0.025Ω	R_{on}	typical	<0.1Ω
100pf to 2.5nf	C	typical	100pf to 5.5nf
see VI curves	R_V	typical	see VI curves
>0.25 x 10^{12}Ω	R_P	typical	>1 x 10^{12}Ω
<250ps	Typical turn on time Typical frequency response		<500ps

A comparison table showing typical element parameters and resulting performance features for MLV and MLVF is shown above.

AntennaGuard 0402/0603

AVX Multilayer Ceramic Transient Voltage Suppressors
ESD Protection for Antennas

GENERAL DESCRIPTION



RF antenna/RF amplifier protection against ESD events is a growing concern of RF circuit designers today, given the combination of increased signal "gain" demands, coupled with the required downsizing of the transistor package. The ability to achieve both objectives is tied to a reduced thickness of the SiO_2 gate insulator layer within the semiconductor. The corresponding result of such a change increases the transistor's vulnerability to ESD strikes — a common event with handheld electronic products with RF transmitting and/or receiving features.

AVX's 0402/0603 AntennaGuard products are an ultra-low capacitance extension of the proven TransGuard TVS (transient voltage suppression) line of multilayer varistors. RF designers now have a single chip option over conventional protection methods (passive filters or diode clamps), which not only gives superior performance over traditional schemes, but also provides the added benefits of reduced PCB real estate and lower installation costs.

AVX's AntennaGuard products are available in capacitance ratings of ≤3pF (0402 & 0603 chips) and ≤12pF (0603 chip). These low capacitance values maintain RF signal strength at acceptable levels, as well as give other TransGuard advantages such as small size, sub-nanosecond response time, low leakage currents and unsurpassed reliability (FIT Rate of 0.2) compared to diodes.

FEATURES

- Smallest TVS Component
- Standard EIA Chip Sizes
- Chip Placement Compatible
- Fastest Response Time to ESD Strikes
- Two Cap Values (≤3 and ≤12pF)

APPLICATION

- ESD Protection for RF Amplifiers

HOW TO ORDER

VC	04	AG	18	3R0	Y	A	1	x	x
Varistor Chip	**Chip Size** 04 = 0402 06 = 0603	**Varistor Series** AntennaGuard	**Working Voltage** (DC)	**Capacitance** 3pF = 3R0 12pF = 120	**Non-Std. Cap Tolerance** (Maximum)	**Not Applicable**	**Termination** 1 = PtPdAg T = Plated Ni and Solder	**Reel Size** 1 = 7" 3 = 10"	**Reel Quantity** A = 4,000 or 10,000 (i.e., 1A = 4,000 3A = 10,000)

CATALOG PART NUMBERS/ELECTRICAL VALUES

AVX Part Number	Working Voltage I_L < 100nA	Capacitance Value 1 MHz, 0.5V RMS	Cap Tolerance	Inductance (Typical) di/dt = 0.1 A/nS
VC04AG183R0YA1	18 VDC	3 pF	Maximum	< 1.0
VC06AG183R0YA1	18 VDC	3 pF	Maximum	< 1.0
VC06AG18120YA1	18 VDC	12 pF	Maximum	< 1.0

PHYSICAL DIMENSIONS

millimeters (inches)

	0402	0603
Length	1.0 (0.039") ±0.1 (0.004")	1.6 (0.063") ±0.15 (0.006")
Width	0.5 (0.020") ±0.1 (0.004")	0.8 (0.031") ±0.15 (0.006")
Thickness	0.6 Max. (0.024")	0.9 Max. (0.035")
Termination Band Width	0.25 (0.010") ±0.15 (0.006")	0.35 (0.014") ±0.15 (0.006")
Termination Separation	0.3 Min. (0.012")	0.7 Min. (0.028")

AntennaGuard 0402/0603
AVX Multilayer Ceramic Transient Voltage Suppressors
ESD Protection for Antennas

Antenna Varistors

AVX announces a series of 0402 and 0603 chip varistors, designated the AntennaGuard series, for RF antenna/RF amplifier protection. These devices offer ultra-low capacitance (<3pF in 0402 chips, and ≤3pF & ≤12pF in 0603 packages), as well as low insertion loss. Antenna varistors can replace output capacitors and provide ESD suppression in cell phones, pagers and wireless LANs.

It is very common to employ some form of a FET in many types of efficient/miniature RF amplifiers. Typically, these RF transistors have nearly ideal input gate impedance and outstanding noise figures. However, FETs are very susceptible to ESD damage due to the very thin layer of SiO_2 uses as the gate insulator. The ultra-thin SiO_2 layer is required to improve the gain of the transistor. In other words, the upside of the performance enhancement becomes the downside of the transistors survival when subjected to an ESD event.

ESD damage to the RF Field Effect Transistors (FETs) is a growing concern among RF designers due to the following trends: (1) RF amplifiers continue to shrink in size, and (2) FET gains figures continue to increase. Both trends relate to decreasing gate oxide thickness, which in turn, is directly proportional to increased ESD sensitivity. As miniaturization trends accelerate, the traditional methods to protect against ESD damage (i.e., PC board layout, passive filters, and diode clamps) are becoming less and less effective.

AVX's AntennaGuard varistor can be used to protect the FET and offer superior performance to the previously mentioned protection methods given above. The standard EIA 0603 chip size, and particularly the 0402 chip, offer designers an ESD protection solution consistent with today's downsizing trend in portable electronic products. Savings in component volume up to 86%, and PC board footprint savings up to 83% are realistic expectations. These percentages are based upon the following table and Figures 1A and 1B.

millimeters (inches)

Suppression Device	Pad Dimensions				
	D1	D2	D3	D4	D5
0402 TransGuard	1.79 (0.070)	0.51 (0.020)	0.51 (0.020)	0.51 (0.020)	0.51 (0.020)
0603 TransGuard	2.29 (0.090)	0.76 (0.030)	0.76 (0.030)	0.76 (0.030)	0.76 (0.030)
SOT23 Diode	See Below				

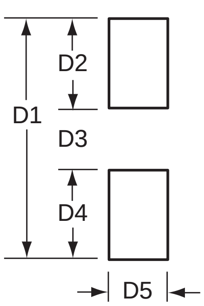


Figure 1A. 0402/0603 IR Solder Pad Layout

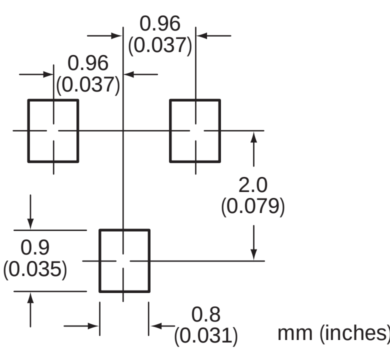


Figure 1B. SOT23 - Solder Pad Layout

AntennaGuard 0402/0603

AVX Multilayer Ceramic Transient Voltage Suppressors
ESD Protection for Antennas

Antenna varistors offer excellent ESD repetitive strike capability compared to a SOT23 diode when subjected to IEC 1000-4-2 8kV contact discharge. A performance summary is shown in Figure 2.

ESD TEST OF ANTENNAGUARD RATINGS

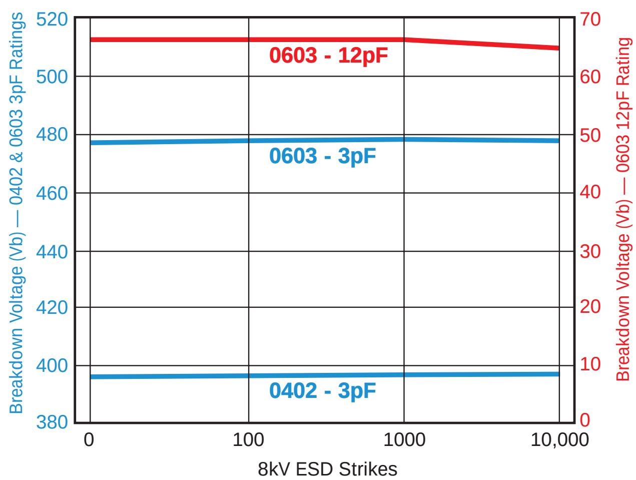


Figure 2. Repetitive 8kV ESD Strike

Antenna varistors also turn on and divert ESD overvoltages at a much faster rate than SOT23 devices (typically 300pS vs 1500pS - 5000pS). See Figure 3.

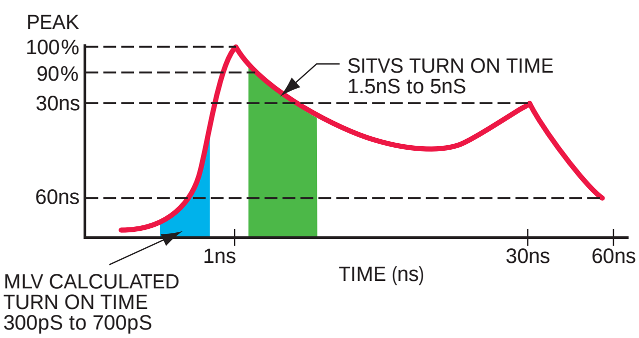
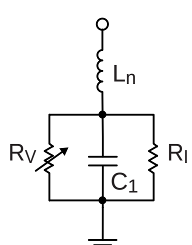


Figure 3. Turn On Time

The equivalent circuit model for a typical antenna varistor is shown in Figure 4.



L_n = 100V INDUCTANCE

C_1 = DEVICE CAPACITANCE

R_V = VOLTAGE VARIABLE RESISTOR

R_I = INSULATION RESISTANCE

Figure 4. Antenna Varistor

The varistor shown exhibits a capacitance of ≤3pF which can be used to replace the parallel capacitance typically found prior to the antenna output of an RF amplifier. In the off state, the varistor acts as a capacitor and helps to filter RF output. The varistor is not affected by RF output power or voltage and has little insertion loss. See Figure 5.

ANTENNA VARISTOR S21

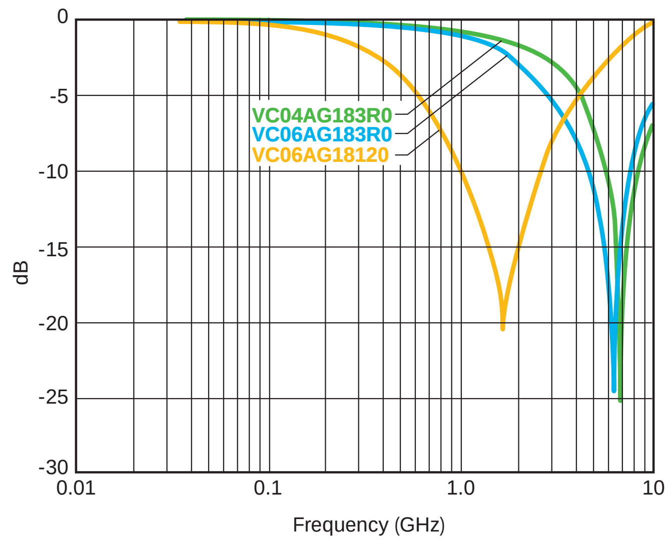


Figure 5. Attenuation vs Frequency

Typical implementations of the antenna varistors are shown for use in cell phone, pager and wireless LAN applications in Figures 6A, 6B and 6C.

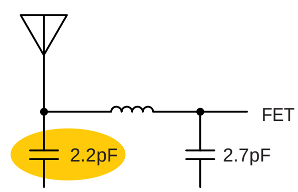


Figure 6A. Cell Phone

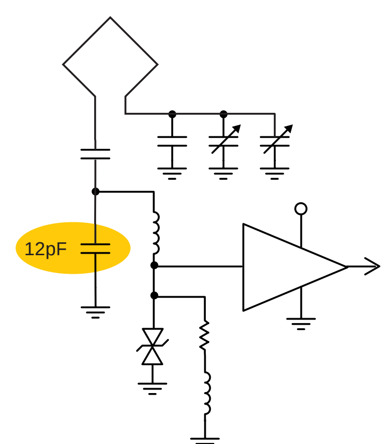
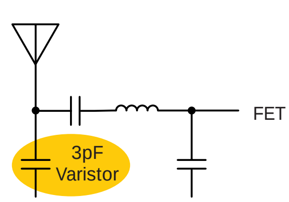


Figure 6B. Pager



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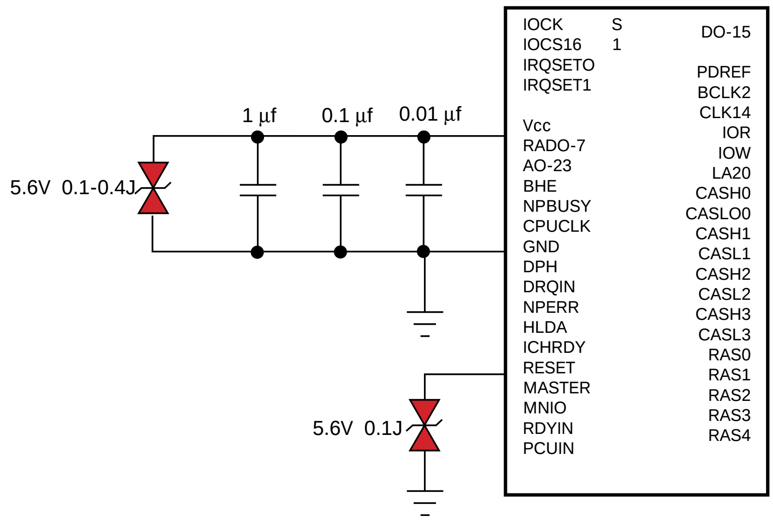
TYPICAL CIRCUITS REQUIRING PROTECTION

The following applications and schematic diagrams show where TransGuards might be used to suppress various transient voltages:

- ASIC Reset & Vcc Protection
- Micro Controllers, Relays, DC Motors
- I/O Port Protection
- Keyboard Protection
- Modem Protection
- Sensor Protection
- Preamplifier Protection
- Audio Circuit Protection
- LCD Protection
- Optics Protection

ASIC RESET & Vcc PROTECTION

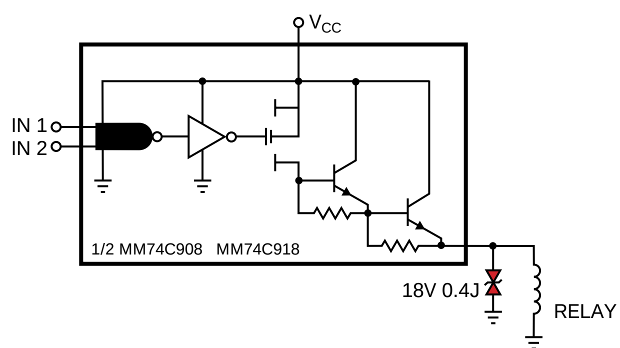


MICRO CONTROLLERS RELAYS, DC MOTORS

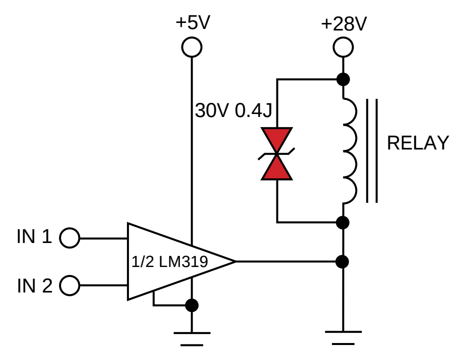
TRANSGUARD CHARACTERISTICS

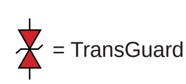
WORKING VOLTAGE ≥ RELAY OR MOTOR VOLTAGE
ENERGY RATING TYPICALLY > 0.3J
CAPACITANCE IS OF NO CONCERN

CMOS RELAY DRIVER



LM319 RELAY DRIVER



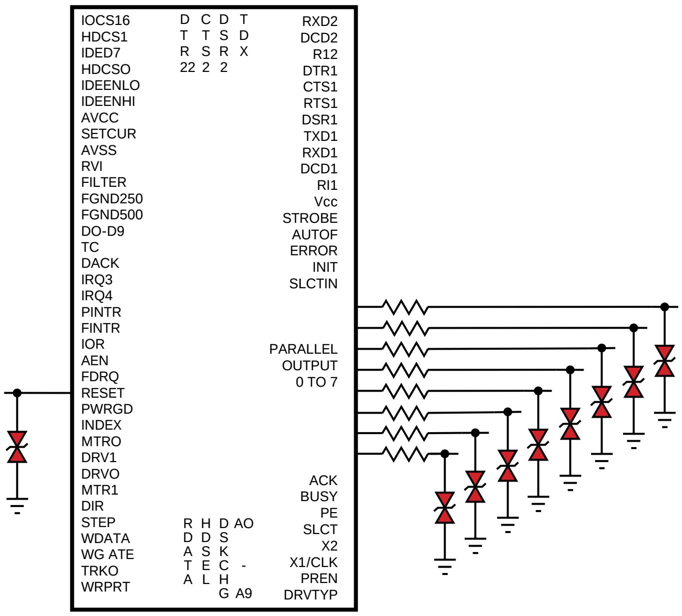


I/O PORT PROTECTION

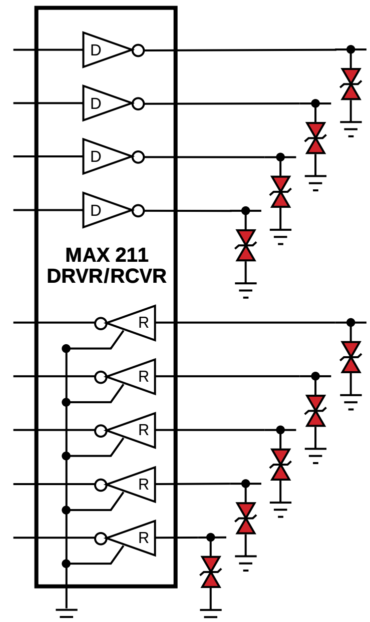
TRANSGUARD CHARACTERISTICS

WORKING VOLTAGE TYPICALLY 14V - 18V
ENERGY RATING TYPICALLY 0.05J - 0.1J
CAPACITANCE SHOULD BE MINIMIZED

SUB NOTEBOOK & PDA'S



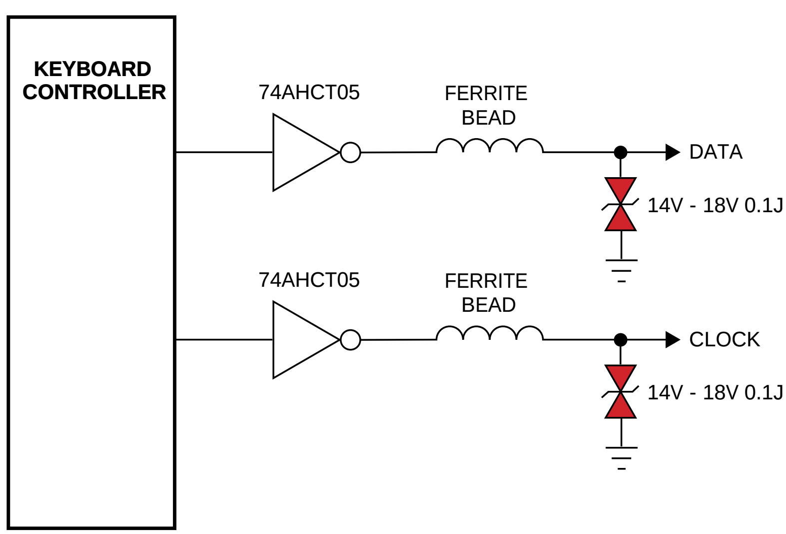
NOTEBOOK & WORK STATION



KEYBOARD PROTECTION

TRANSGUARD CHARACTERISTICS

WORKING VOLTAGE >5.6V
ENERGY RATING TYPICALLY <0.4J
CAPACITANCE PREFERRED TO BE MINIMUM



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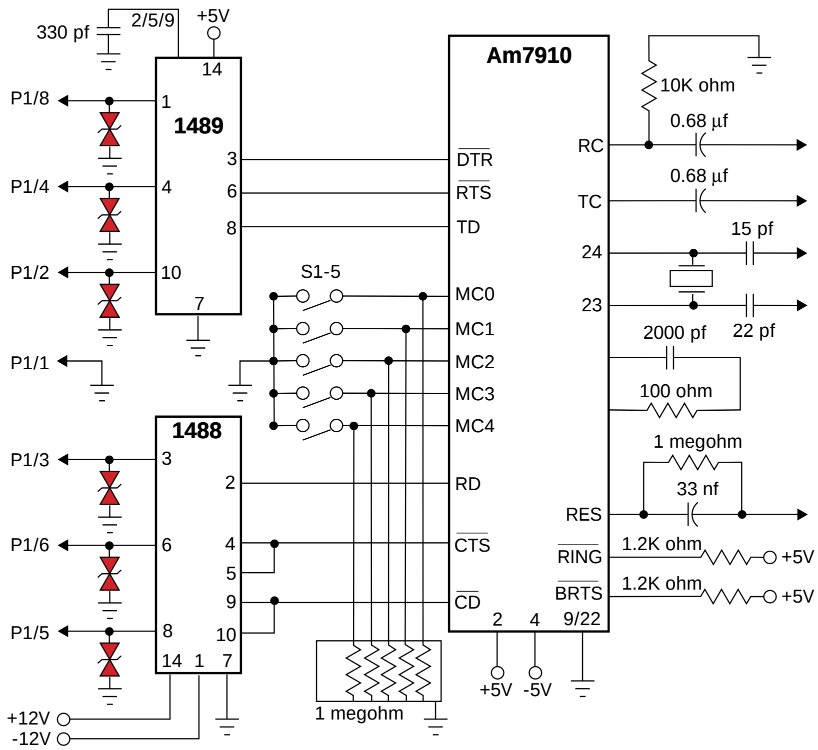
MODEM PROTECTION

TRANSGUARD CHARACTERISTICS

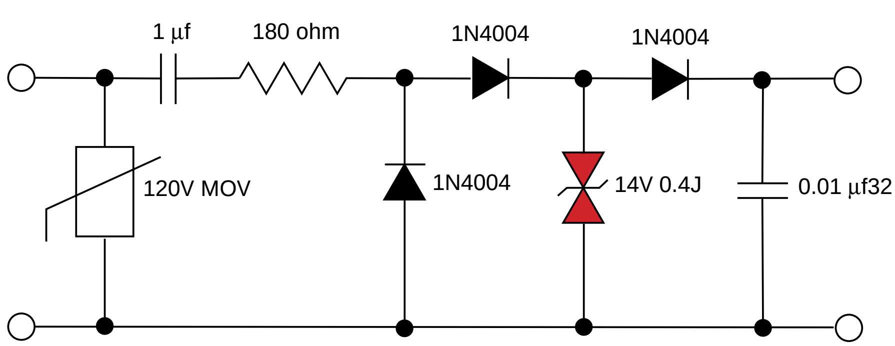
WORKING VOLTAGE <26V
ENERGY RATING ≥ 0.1J



SENSOR PROTECTION

TRANSGUARD CHARACTERISTICS

WORKING VOLTAGE TYPICALLY >14V
ENERGY RATING > 0.4J
CAPACITANCE IS NO CONCERN



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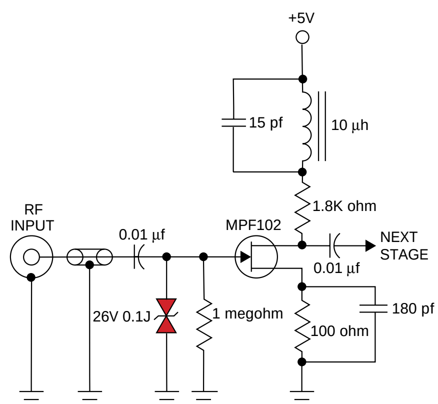
ANTENNA AND PREAMPLIFIER PROTECTION

TRANSGUARD CHARACTERISTICS

WORKING VOLTAGE TYPICALLY 18V - 26V
ENERGY RATING 0.05J - 0.9J
CAPACITANCE OF CONCERN ON MANY DESIGNS

PREAMPLIFIER PROTECTION

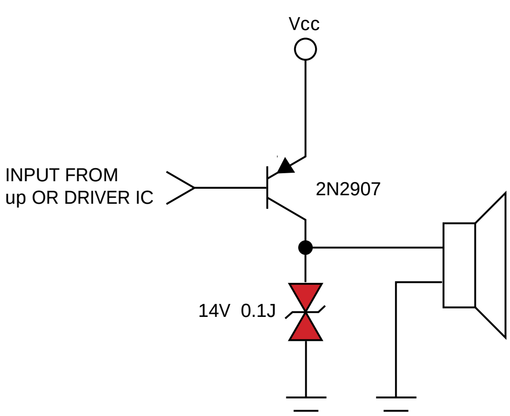


AUDIO CIRCUIT PROTECTION

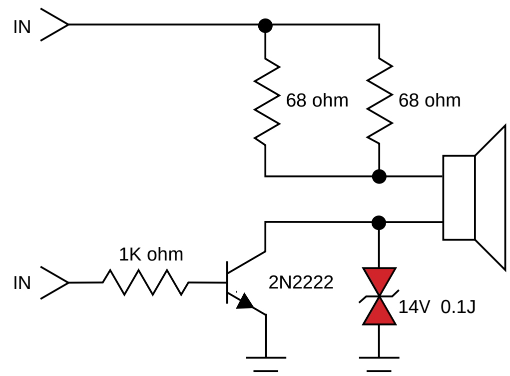
TRANSGUARD CHARACTERISTICS

WORKING VOLTAGE TYPICALLY 14V - 18V
ENERGY RATING 0.1J

PAGER AUDIO PROTECTION



NOTEBOOK, WORK STATION AUDIO PROTECTION



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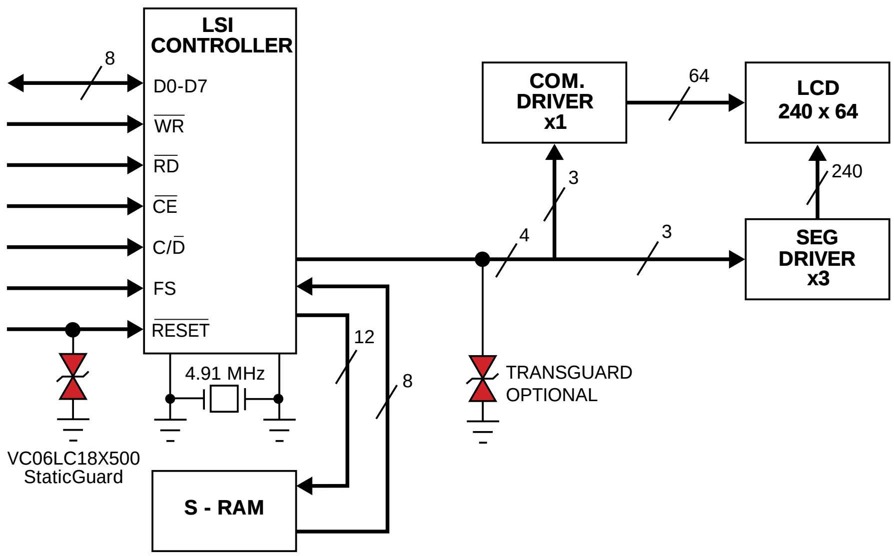
LCD PROTECTION

TRANSGUARD CHARACTERISTICS

WORKING VOLTAGE < 5.6V
ENERGY RATING < 0.1J

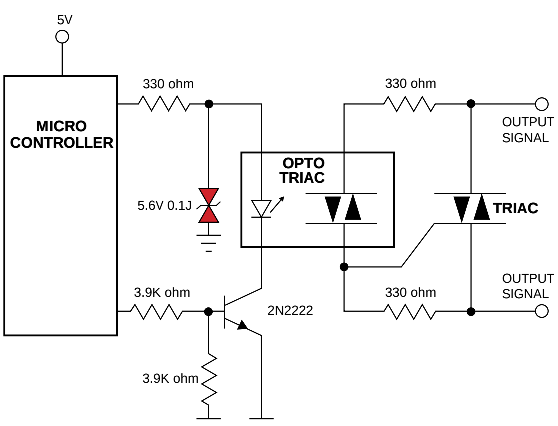


OPTICS PROTECTION

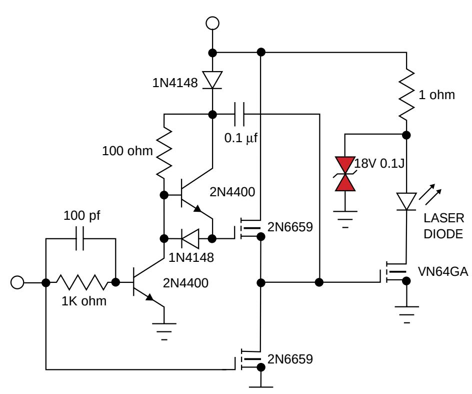
TRANSGUARD CHARACTERISTICS

WORKING VOLTAGE ≤ 18V
ENERGY RATING 0.1J
CAPACITANCE SHOULD BE MINIMIZED

OPTO ISOLATER PROTECTION



LASER DIODE PROTECTION

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APPLICATION NOTES

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AVX Multilayer Ceramic Transient Voltage Suppressors
Application Notes: SMT Process Characteristics of AVX TransGuards

TRANSGUARD SURFACE MOUNT DEVICES

The move toward SMT assembly of Transient Voltage Suppressors (TVS) will continue accelerating due to improved long-term reliability, more efficient transient voltage attenuation and size/functionality/cost issues.

TransGuards are uniquely suited for wide-scale usage in SMT applications. TransGuards exhibit many advantages when used in SMT assemblies. Among them are:

- Available in standard EIA chip sizes 0402/0603/0805/ 1206/1210.
- Placed with standard equipment (8mm tape and reel).
- Processed with fewer guidelines than either ceramic chip or resistor chip devices.
- Exhibit the highest energy/volume ratio of any EIA size TVS.

This general guideline is aimed at familiarizing users with the characteristics of soldering multilayer SMT ZnO TransGuards.

TransGuards can be processed on wave or infrared reflow assembly lines. For optimum performance, EIA standard solder pads (land areas) shown in Figure 1 are recommended regardless of the specific attachment method.

Dimensions: millimeters (inches)

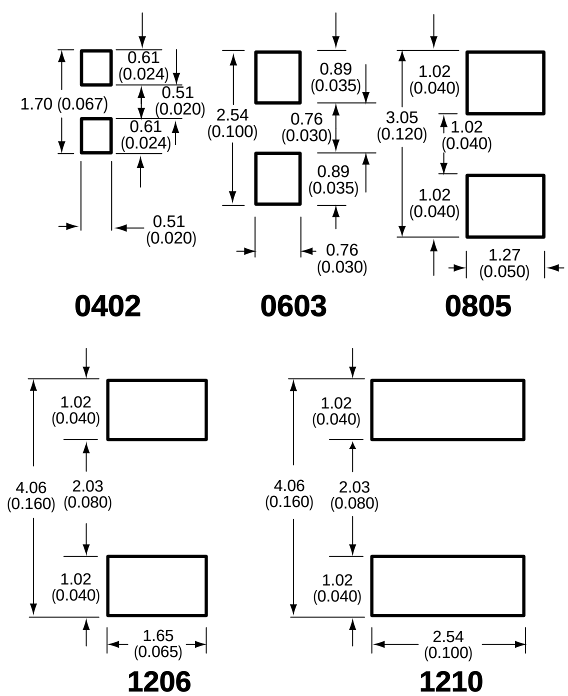

Figure 1: TransGuard Solder Pad Dimensions

TRANSGUARD PROCESS GUIDELINES

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.

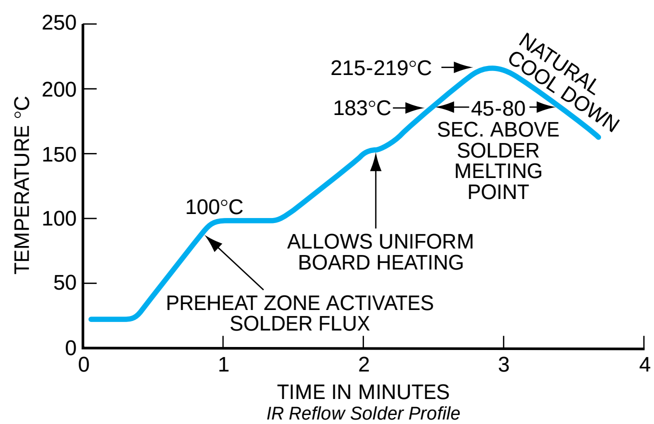

Figure 2: Infrared Reflow Temperature Profile

WAVE SOLDERING
(Not Recommended for 0402)

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.

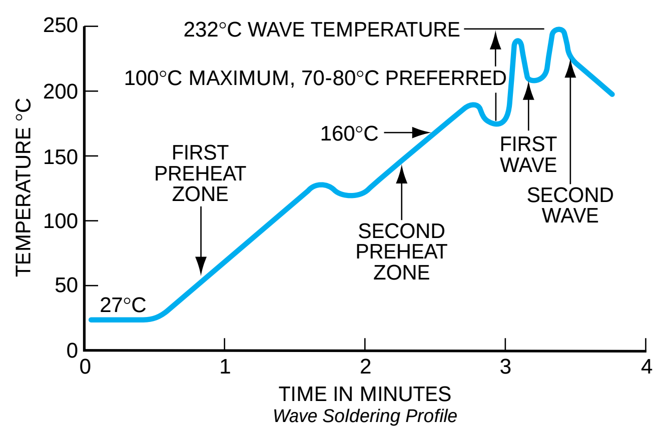

Figure 3: Wave Soldering Temperature Profile

WHAT IS IEC 1000-4?

The International Electrotechnical Commission (IEC) has written a series of specifications, IEC 1000-4, which mandate the performance of all electronic devices in a variety of transient and incident RF conditions. This specification requirement resulted as part of Europe's move toward a single market structure and a desire to formalize and harmonize current member countries' requirements. As of January 1, 1996, all electronic and electrical items sold to Europe must meet IEC 1000-4 series specifications.

WHY IS IEC 1000-4 REQUIRED BY EUROPE?

The various regulatory agencies within Europe feel that the IEC 1000-4 series of specifications is necessary to insure acceptable performance of electronic equipment in a world filled with increasingly more Electromagnetic Interference - EMI. Furthermore, as electronic systems become more portable, and the transient susceptibility of semiconductors increases, government regulations are essential to maintain a minimum level of performance in all equipment. Europe is so serious about the problem that they require that equipment be certified via testing to meet IEC 1000-4 series specifications after 1/1/96 to avoid fines and prosecution.

HOW DO COMPANIES SELLING ELECTRONIC SYSTEMS MEET IEC 1000-4 PARTS 2-5 SPECIFICATIONS?

Companies and design engineers must now use protective circuits or devices to meet these requirements. First, a description of IEC 1000-4/2-6 is in order:

IEC 1000-4-2 ESD TESTING REQUIREMENTS

All equipment destined for Europe must be able to withstand 10 strikes of ESD waveforms with Tr < 1ns in contact discharge mode (preferred) at pre-selected points accessible during normal usage or maintenance. Testing shall be performed at one or more of four (4) severity levels, depending upon equipment category.

Level	Contact Discharge[1] Mode Test Voltage kV	Air Discharge Mode Test Voltage kV
1	2	2
2	4	4
3	6	8
4	8	15

1000-4-2 Test Conditions

[1]Preferred mode of testing due to repeatability.

WAVEFORM PARAMETERS

Level	Test Voltage Level kV	First Peak of Discharge Current Amps ± 10%	TR nS	30 nS Current Amps ± 30%	60 nS Current Amps ± 30%
1	2	7.5	0.7 -1	4	2
2	4	15	0.7 -1	8	4
3	6	22.5	0.7 -1	12	6
4	8	30	0.7 -1	16	8

Upon completion of the test, the system must not experience upset (data or processing errors) or permanent damage. The waveforms are to be injected at or along the DUT's body which is accessible in normal set-up and operation.

IEC 1000-4-3 ELECTROMAGNETIC COMPATIBILITY IMPACT TESTING (EMC)

This test is concerned with the susceptibility of equipment when subjected to radio frequencies of 27 MHz to 500 MHz. The system must be able to withstand three (3) incident radiation levels:

Level 1 1V/m field strength
Level 2 3V/m field strength
Level 3 10V/m field strength
Level X User defined > 10V/m field strength

The system must not experience upset (data or processing errors) or permanent errors.

IEC 1000-4-4 ELECTRICAL FAST TRANSIENT (EFT) TESTING

The EFT test is modeled to simulate interference from inductive loads, relay contacts and switching sources. It consists of coupling EFT signals on I/O parts, keyboard cables, communication lines and power source lines. The system, depending upon appropriate severity level, must be able to withstand repetition rates of 2.5 kHz to 5 kHz for ≥ 1 minute as follows:

Open Circuit Output Voltage/10%

	On Power Supply	On I/O, Signal, Data, Control lines
Level 1	0.5kV	0.25kV
Level 2	1kV	0.5kV
Level 3	2kV	1kV
Level 4	4kV	2kV

IEC 1000-4-5 UNIDIRECTIONAL POWER LINE SURGE TEST

The details of this specification for high energy disturbances are being addressed in several drafts under discussion within the EC at this time.

IEC 1000-4-4-6 - CONDUCTED RF TEST FROM 9kHz TO 80MHz

The details of this specification for conducted broad band RF signals are being addressed in a first edition draft within the EC at this time.

Designers have the option of using AVX TransGuards to meet IEC 1000-4-2, 3 and 4.

In the case of IEC 1000-4-2 TransGuards can be used to suppress the incoming Transient just like a Zener diode would. TransGuards, however, exhibit bipolar characteristics, a faster turn-on-time (<1nS), a better repetitive strike capability and superior thermal stability to the Zener suppression device. Furthermore, TransGuards are typically smaller and lighter when placed on SMT circuit boards. See Figure 1 for data illustrating IEC 1000-4-2 repetitive strike capability.

The TransGuards effective capacitance allows the device to be used to meet IEC 1000-4-3 and 1000-4-4. The device's parallel capacitance can be used as effectively as a capacitor to block low level incident and conducted RF energy. If in the case of some levels of IEC 1000-4-3 and IEC 1000-4-4 when the intensity of pulse is greater than the device's breakdown capability it will then turn on and suppress via MOV means rather than capacitance (as in the small signal case). Effectiveness hinges upon the proper placement of the device within the PCB (which is usually easily accomplished since TransGuards are so small).

SUMMARY

AVX TransGuards are exceptionally suited to meet the defined portions of the IEC 1000-4 document. Experimentation is critical to proper choice and selection of devices to suppress 1000-4-3/4. Samples are available from your local sales representative.

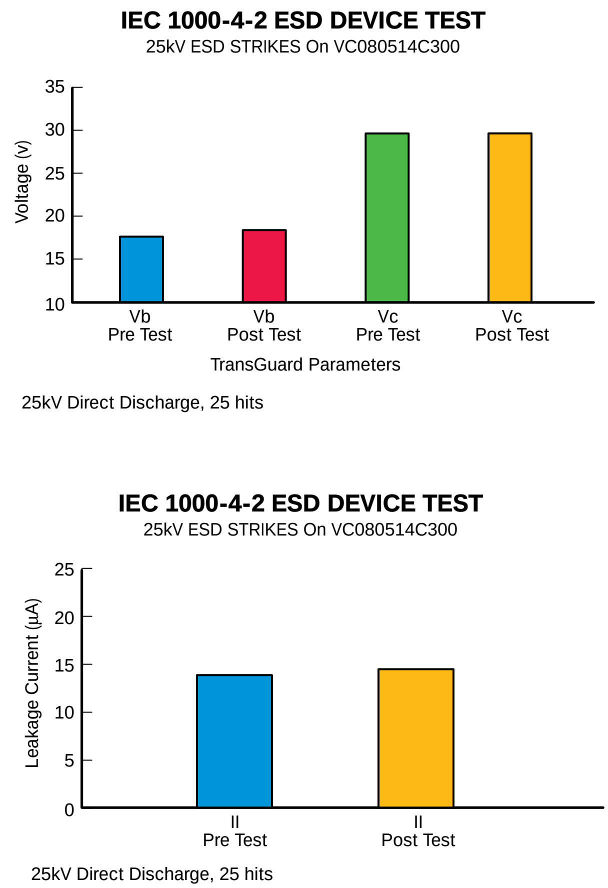

Figure 1

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors
Application Notes: Turn on Time Characteristics of AVX Multilayer Varistors

(MLVs - TRANSGUARDS)

INTRODUCTION

Due to the growing importance of ESD immunity testing, as required by the EMC Directive, proper selection of voltage suppressor devices is critical. The proper selection is a function of the performance of the device under transient conditions. An ideal transient voltage suppressor would reach its "clamping voltage" in zero time. Under the conditions imposed by the 1991 version of IEC 1000-4-2, the actual turn-on-time must be less than one nanosecond to properly respond to the fast leading edge of the waveform defined in the standard.

It has been found during testing of transient suppressors that the response time is very closely dictated by the packaging of the device. Inductance that is present in the connection between the silicon die and the leads of the device creates an impedance in series with the suppressor device; this impedance increases the overall device response time, reducing the effectiveness of the suppressor device.

The purpose of this paper is to present the Turn on Time characteristics of Multilayer Varistors (MLVs) and to compare the MLV Turn on Time to that of various silicon transient voltage suppressors (SiTVs).

The Turn on Time of a transient voltage suppressor (TVS) is of growing importance since IEC 1000-4-2 now specifies ESD waveform with a rise time < 1 ns. Therefore, TVS's must have a turn on time < 1 ns to effectively suppress ESD. In many, if not all, ESD suppression applications, TVS turn on time can be of more importance than absolute clamping voltage (Vc) of the TVS (assuming that the TVS clamping voltage is less than the damage voltage of the circuit or IC).

To measure the turn on time of today's TVS's, a broad cross section of MLVs and SiTVs were chosen. Only surface mount devices were chosen in order to best represent today's TVS current usage/trends and to keep the test matrix to a reasonable level of simplicity. The following devices were tested:

SMT MLV	SiTVS
	MA141WA
0603	BAV 99
0805	SOT 23 type
1206	SMB - 500W gull-wing SM device
1210	SMC - 1500W gull-wing SM device

TEST PROCEDURE

The TVS device under test (DUT) was placed on a PCB test fixture using SN60/40 solder. The test fixture (see Figure 1) was designed to provide an input region for an 8kV contact ESD discharge waveform (per IEC 1000-4-2 level 4 requirements). In addition, the fixture was designed to provide low impedance connections to the DUTs.

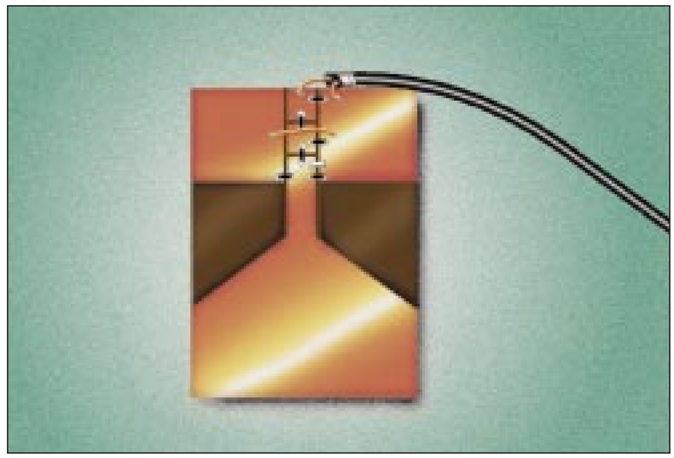

Figure 1. DUT Test Fixture

The ESD pulse was injected to the PCB from a Keytek mini-zap ESD simulator. Additionally, the fixture was to channel the ESD event to a storage oscilloscope to monitor the suppressor's response. Six resistors were used on the PCB to provide waveshaping and an attenuated voltage to the storage scope (see Figure 2):

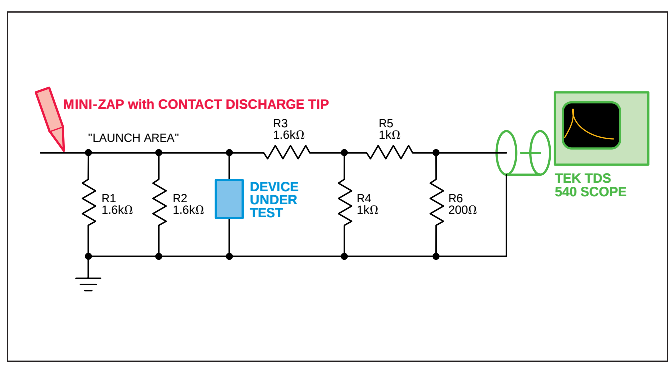

Figure 2. Schematic of Test Set Up

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors Application Notes: Turn on Time Characteristics of AVX Multilayer Varistors

The functions of the resistors are as follows: The resistor values were adjusted in "open circuit" conditions to obtain best open circuit response.

R1, R2 (1.6K) - provide wave shaping during the ESD discharge event

R3 (1.6K), R4 (1K), R5 (1K) - Form a 60 dB Attenuator (1000:1 ratio) for input of Tektronix TDS 540 1 giga sample/second storage oscilloscope

R6 (200 Ω) - provides matching to the 50 ohm coax feeding the TDS 540 oscilloscope.

The open circuit response of the ESD test fixture with a 9kV ESD pulse is shown in Figure 3.

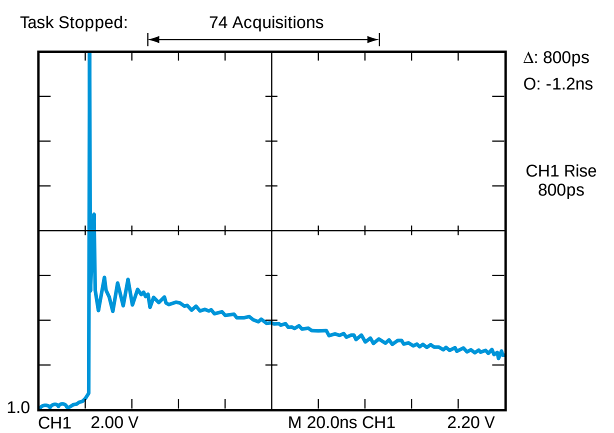

Figure 3. Open Circuit Response of Test Fixture to an Injected ESD Waveform

The graph shows the voltage attenuated by a factor of 1000, with a 800ps risetime for the ESD waveform (this agrees with typical data given by Keytek for equipment performance). It should be noted that only the positive polarity was tested. Prior testing showed turn on time was not dependent upon waveform polarity (assuming that DUTs are bidirectional).

TEST RESULTS

MLV TURN ON TIME TRANSGUARDS

The turn on time test results for AVX TransGuards showed that all case sizes were capable of a sub-nanosecond turn on response. This corresponds favorably with the calculated turn on time of less than 1 ns. Specific performance data follows:

AVX TransGuard	
CASE SIZE	TURN ON SPEED
0603	< 0.7 ns
0805	< 0.9 ns
1206	< 0.9 ns
1210	< 0.8 ns

TVS TURN ON TIME

Test results for SiTVs varied widely depending upon the physical size and silicon die mounting configuration of the device. The results agree with several SiTVs manufacturers papers indicating that the absolute response from the silicon die could be < 1 ns. However, when the die is placed in a package, the turn on time delay increases dramatically. The reason for this is the series inductance of the SiTVs packaging decreases the effective response time of the device. Reports of 1-5 ns are frequently referred to in SiTVs manufacturers publications. Further, the turn on times for SiTVs vary dramatically from manufacturer to manufacturer and also vary within a particular manufacturers lot. The data provided in the following table generally agreed with these findings:

SiTVS	
CASE SIZE	TURN ON SPEED
MA141WA	0.8ns
BAV 99	0.9ns to 1.2ns
SOT 23 Type	0.8ns
SMB	1.5ns to 2.2ns
SMC	1.5ns to 3ns

SUMMARY

This test confirms calculations that show that AVX TransGuards have a true sub-nanosecond turn on time. Although the silicon die of a SiTVs has a sub-nanosecond response, the packaged SiTVs typically has a response time much slower than a TransGuard. If the two devices were directly compared on a single graph (see Figure 4), it could be shown that the TransGuard diverts significantly more power than even the fastest SiTVs devices. Additionally, TransGuards have a multiple strike capability, high peak inrush current, high thermal stability and an EMI/RFI suppression capability which diodes do not have.

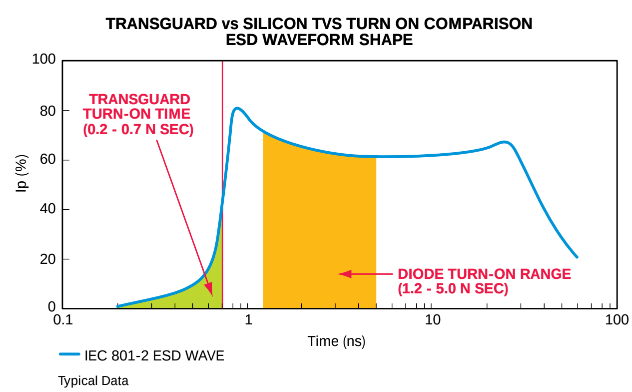

Figure 4.

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AVX Multilayer Ceramic Transient Voltage Suppressors

Application Notes: The Impact of ESD on Insulated Portable Equipment

The purpose of this discussion is to recap the impact ESD has on portable, battery powered equipment. It will be shown that ESD can cause failures in "floating ground systems" in a variety of ways. Specifically, ESD induced failures can be caused by one or more of its complex components:

Predischarge	-	Corona Generated RF
Predischarge	-	E Field
Discharge	-	Collapsing E Field
Discharge	-	Collapsing H Field
Discharge	-	Current Injection...Voltage...Additional Fields

With this in mind it will be shown that the only way to insure equipment survivability to ESD is to use a Transient Voltage Suppressor (in addition to proper circuit layout, decoupling, and shielding).

In order to get a better understanding of what happens in an ESD event the charge developed by a human body should be defined. The ESD schematic equivalent of the human body model is shown in Figure 1. Typically, the charge developed on a person can be represented by a 150pF capacitor in series with a resistance of 330 ohms. The energy of an ESD waveform generated from this model is $Q = 1/2\ CV^2$ where Q = total energy in Joules, C = capacitance of the human body model in farads and V = charging voltage in volts.

Voltages can be as high as 25 kV, however typical voltages seen are in the 8 to 15 kV regions.

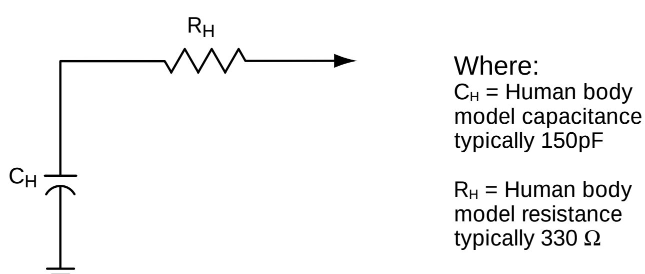


Figure 1. Human Body Model

PREDISCHARGE E FIELD FAILURES

Now that we have a definition of the basic ESD human body model we can discuss the predischarge E field failure mode.

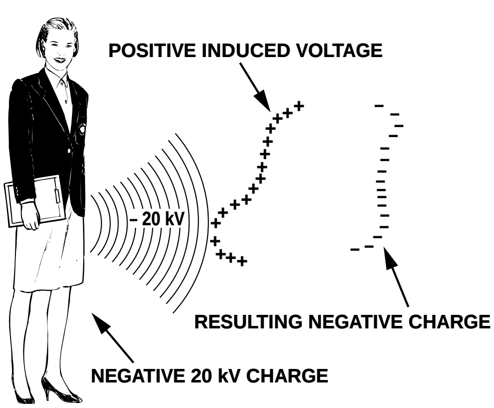


Figure 2. Pre-Discharge Scenario

In the predischarge scenario (Figure 2) a human charged to –20 kV may approach a battery powered "system" on a table. As the person reaches toward the system electrostatics dictate that the system will have an equal and opposite charge on the system's surface nearest to the person. SInce the system we are approaching is isolated from ground, the charge is only redistributed among the device. (If the system were grounded a current would be generated by the loss of electrons to ground. The system would then become positive relative to ground). The rate of approach of the human body model affects the charging current to a small extent. However, most importantly, it is the electrostatic field and the unequal voltages which developed across the equipment that cause the destruction of components within the system. In general, unprotected IC's (particularly CMOS) are susceptible to damage due to induced E field voltages. This problem is further complicated by the device type and complexity and the fact that the breakdown voltage of a generic IC will vary greatly from manufacturer to manufacturer (Figure 3). This brief discussion should be adequately convincing that electrostatically induced E field can impact system reliability. IC protection can be achieved by placing a transient suppressor on the most susceptible pins of the sensitive IC's (e.g., Vcc and I/O pins, etc.).

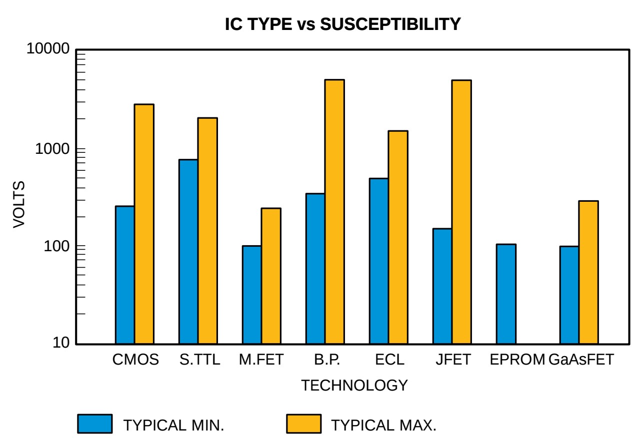


Figure 3. IC Type E Field Susceptibility

CONTACT DISCHARGE FAILURES

As the charged person gets closer to the system, the situation is more complex. First a much more detailed human body model is needed to represent the complex transmission line which will transport energy to the system (see Figure 4). In this discussion we will only consider the case of a single contact discharge. In the real world, however, multiple discharges will likely occur (possibly caused by a person's hand reacting to an ESD spark and then touching the system again, etc.).

In contact discharge, when a charged person approaches the system, E fields are induced. As the person gets closer to the system, the field intensity becomes greater, eventually reaching a point large enough to draw an arc between the person and the system. In contrast to the noncontrast E field example, the speed of approach is of great importance in the contact discharge model. A fast approach causes a more intensive discharge and faster current rise times and peaks.

The model shown on Figure 4 can be broken up into 4 sections for the sake of simplification. The first section is the human body model input voltage. This section is identical to the simplified human body model shown in Figure 1.

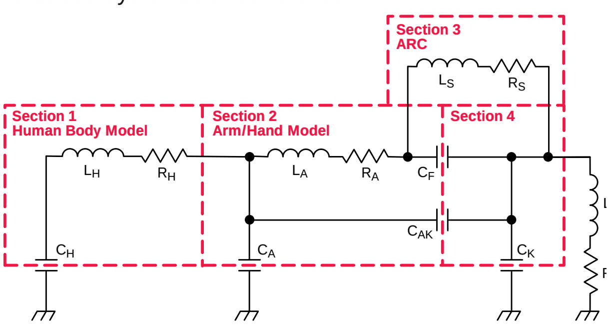
Section 2 takes into account how the human body model gets the energy to the system. This section considers the inductance, resistance and capacitance of the human's arm and finger and its capacitance relative to ground and the system.

The third section is the inductance and resistance of the arc which is created as section 2 approaches the system (Section 4).

Section four is the system itself.

The combination of the capacitances and inductances in these sections form a complex network of LC tank circuits which will inject a variety of waveforms (transients) into the system. These waveforms will range in frequency from very high (5 GHz) to high (100 MHz) to low (20-50 MHz) plus a variety of under damped and over damped waveforms.

Finally, in addition to current/voltage injection occurring as a result of the discharge, there will be collapsing E and H fields and significant high frequency RF waveforms. Many times these waveforms propagate into shielded equipment and cause system/device failures.



Where: C_H = Lumped capacitance between the human body and earth
R_H = Lumped resistance of the human body
L_H = Lumped inductance of the human body
C_A = Lumped capacitance between the person's arm and earth
C_{AK} = Lumped capacitance between the person's arm (and near portions of the body) and the keyboard
R_A = Lumped resistance of the person's arm's discharge path
L_A = Lumped inductance of the person's arm's discharge path
C_F = Capacitance between person's finger, hand, and the keyboard
C_K = Lumped capacitance of the keyboard to earth
R_K = Lumped resistance of the keyboard earth ground path
L_K = Lumped inductance of the keyboard earth ground path

Figure 4. Contact Discharge Model

SUMMARY

Designers may be inclined to think that E field variation due to near field electrostatics (as in the person being close to the system but not touching it) can be eliminated by shielding. This is usually not the case because it is difficult to get a tight columbic shield around internal circuitry without incurring significant additional manufacturing costs. Additionally, the shielding will likely have seams, ventilation holes, or I/O ports which represent a significant portion of a wavelength (at 5 GHz). Therefore, E fields and corona generated RF can be a problem. Finally, if the system has I/O connectors, keyboards, antennas, etc., care must be taken to adequately protect them from direct/and indirect transients. The most effective resolution is to place a TransGuard as close to the device in need of protection as possible.These recommendations and comments are based upon case studies, customer input and Warren Boxleitner's book *Electrostatic Discharge and Electronic Equipment - A Practical Guide for Designing to Prevent ESD Problems.*

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors
Application Notes: Motor and Relay Application Study

PURPOSE

A significant number of end customers have experienced failures of circuitry in and around low voltage relays and motors. Additionally, EMI problems have been associated with running motors.

This study is aimed at evaluating how TransGuards can reduce EMI from running motors and clamp transients generated from relays and motors during power off.

DESCRIPTION

Three different motors and two different relays were chosen to represent the wide range of possible devices used by designers. Device choices were as follows:

MOTORS

Cramer 8001 series Geared Motor
12V, 30rpm (4800 RPM armature speed) 170ma
Start/Run Torque 30oz

Comair Rotron DC Biscut Fan - 24V, 480ma

Comair Rotron DC Biscut Fan - 12V, 900ma

RELAYS

Potter and Brumfield 24V Relay
⅓ HP 120V AC, 10A 240 VAC Rating

Potter and Brumfield 12V Relay
⅓ HP 120V AC, 10A 240 VAC Rating

A Tektronix TDS 784A four channel 1GHz 4G S/s digitizing storage scope was used to capture the -1⁄2 LI2 transient peak from the relays and motors. A x10 probe was connected to the scope and one leg of the relay/motor coil; the probe's ground was connected to the other relay coil/motor wire. The scope was triggered on the pulse and waveforms printed.

When suppression was introduced into the circuit, it was placed directly on the relay coils/motor lead wires. The axial TransGuard and capacitors had a 19mm (3⁄4") total lead length in each case. Upon careful consideration, it was determined that this was a fairly common lead length for such applications.

SUMMARY

GEARED MOTOR

The Cramer geared motor was tested while running (under load) to determine its "on state" noise as well as under loaded turn off conditions. Both TransGuards and ceramic capacitors were tested to determine the level of protection they offer.

A 14V axial TransGuard provided the best protection during running and turn off. The VA100014D300 TransGuard cut the 60V unprotected turn off voltage spike to 30V. It also cut the on state noise to 4.0V pk-pk due to its internal capacitance. The following is a summary of measured voltages (scope traces are shown in Figures 1, 1A, 2, 2A).

Test Condition	Transient without Protection	Transient with .1µF cap	Transient with .01µF cap	Transient with 14v TransGuard
Geared motor at turn off	60V	32V	48V	30V
Geared motor during running	12V pk-pk	4.0V pk-pk	4.0V pk-pk	4.0V pk-pk

Fig. 1. Geared Motor Transient at Turnoff without protection 60 V Gear Motor 20 V/Division

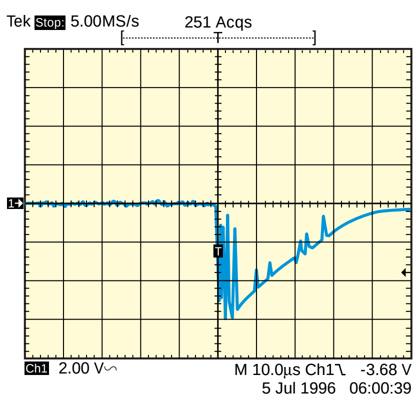


Fig. 1A. Geared Motor Transient at Turnoff with 14 V TransGuard 30 V 10 V/Division

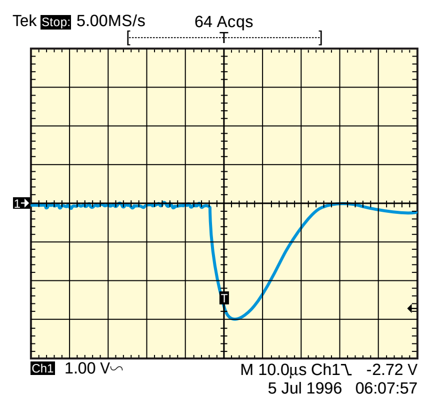


Fig. 2. Geared Motor Running noise without protection 12 V pk-pk 2 V/Division

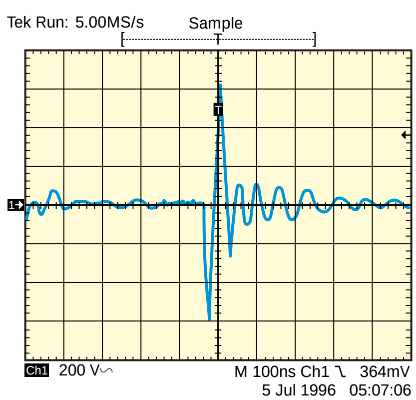
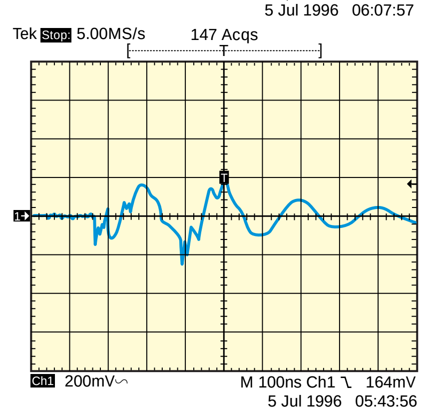


Fig. 2A. Geared Motor Running with 14 V TransGuard 4 V pk-pk 2 V/Division



BISCUT FAN

The Comair 24V and 12V biscut fans were tested only for transients at turn off. Results of those tests are shown in the table at the right (as well as slope traces 3, 3A, 4, 4A).

Motor Type	Transient without Protection	Transient with .1µF cap	Transient with .01µF cap	Transient with TransGuard
24V Fan	165V	120V	140V	65V(1)
12V Fan	60V	52V	64V	30V(2)

(1) VA100030D650 TransGuard / (2) VA100014D300 TransGuard

Fig. 3. 24 V Biscut Fan without protection 165 V Biscut 50 V/Division

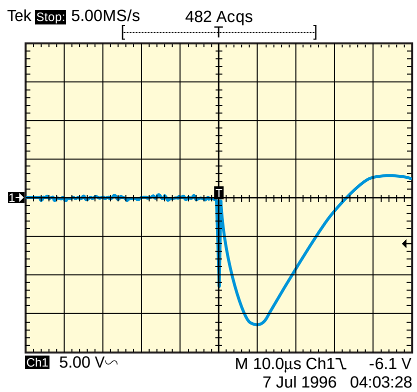


Fig. 3A. 24 V Biscut Fan with 30 V TransGuard 65 V 50 V/Division

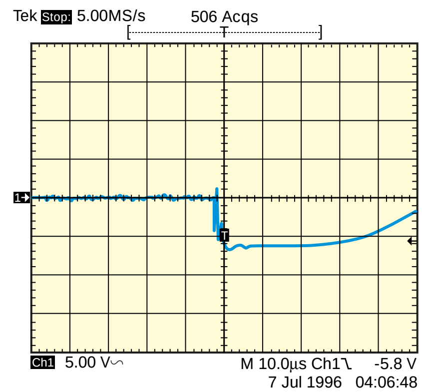


Fig. 4. 12 V Biscut Fan without protection 60 V 20 V/Division

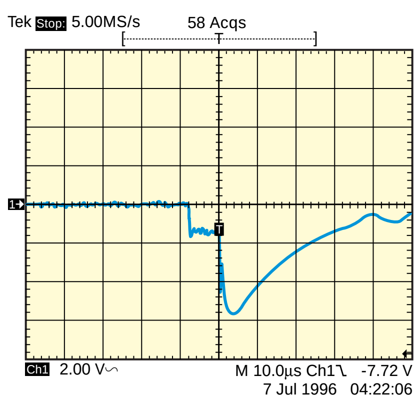
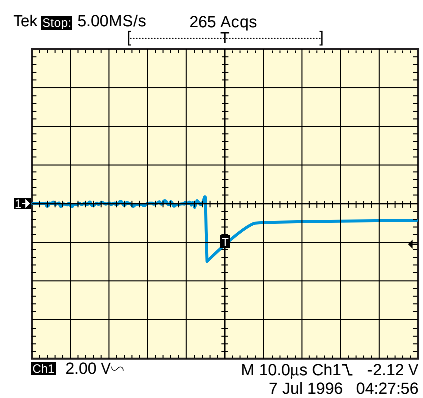


Fig. 4A. 12 V Biscut Fan with 14 V TransGuard 30 V 20 V/Division



RELAYS

The 12V and 24V relays were tested only for transients at turn off. The results of those tests are shown in the table at the right (as well as scope traces 5, 5A, 6, 6A).

Relay Type	Transient without Protection	Transient with .1µF cap	Transient with .01µF cap	Transient with TransGuard
24V	44V	24V	28V	28V[3]
12V	105V	63V	100V	30V[4]

[3] VA100026D580 TransGuard / [4] VA100014D300 TransGuard

Fig. 5. 24 V Relay Transient without protection 44 V 10 V/Division

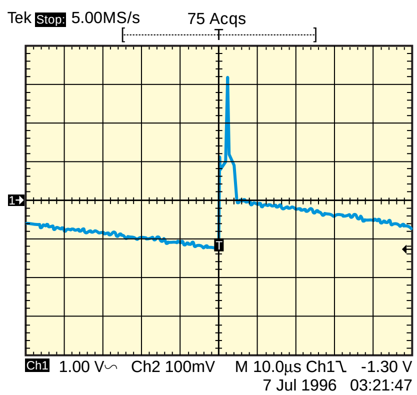


Fig. 5A. 24 V Relay Transient with 26 V TransGuard 10 V/Division

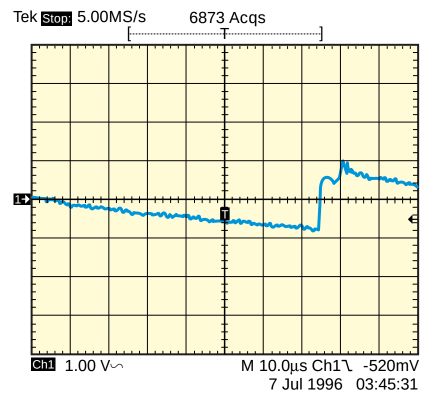


Fig. 6. 12 V Relay Transient without protection 105 V 50 V/Division

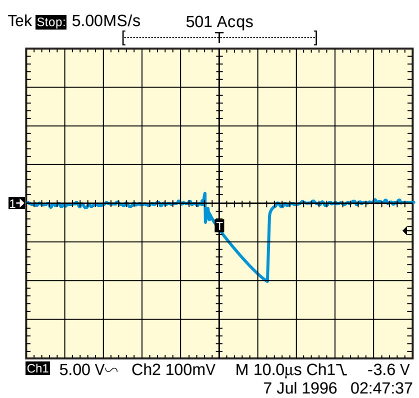
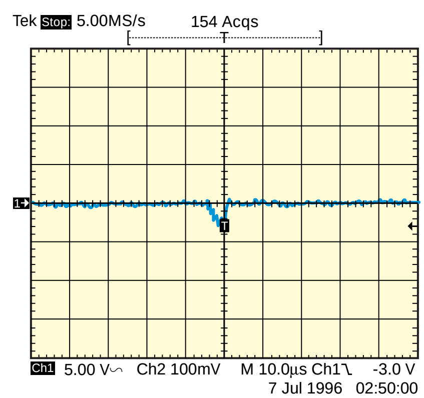


Fig. 6A. 12 V Relay Transient with 14 V TransGuard 30 V 50 V/Division



CONCLUSIONS

TransGuards can clamp the wide range of voltages coming from small/medium motors and relays due to inductive discharge. In addition, TransGuards capacitance can help reduce EMI/RFI. Proper selection of the TransGuards voltage is critical to clamping efficiency and correct circuit operation.

Application Notes: Multilayer Varistors In Automobile MUX Bus Applications

The current trend in automobiles is towards increased performance, comfort and efficiency. To achieve these goals, automobile companies are incorporating an ever increasing array of electronics into cars. As the electronic content within cars increases, auto manufacturers are utilizing multiplex bus designs to network all the sensors to a central point (usually the engine control unit [ECU]). Multiplex lines save wiring harness weight and decrease the harness' complexity, while allowing higher communication speeds. However, the multiplex structure tends to increase the occurrence and severity of Electromagnetic Interference (EMC) and Electrostatic Discharge (ESD).

Multilayer varistors (MLVs) are a single component solution for auto manufacturers to utilize on multiplex nodes to eliminate both ESD and EMC problems. MLVs also offer improved reliability rates (FIT rates <1 failure/billion hours) and smaller designs over traditional diode protection schemes.

TYPICAL MUX NODE APPLICATION

There are a variety of SAE recommended practices for vehicle multiplexing (J-1850, J-1939, J-1708, J-1587, CAN). Given the number of multiplexing specifications, it is easy to understand that bus complexity will vary considerably.

Each node has an interface circuit which typically consists of a terminating resistor (or sometimes a series limiting resistor), back to back Zener diodes (for over voltage protection) and an EMC capacitor. Such a method is compared to that of a multilayer varistor in Figure 1.

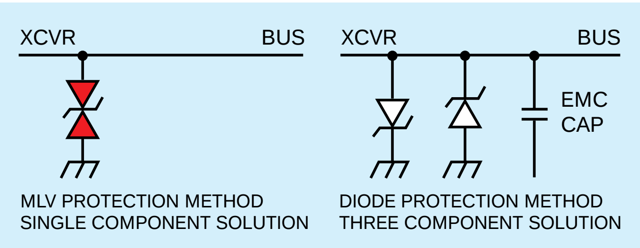


Figure 1. Comparison of past node protection methods to MLV node protection methods.

To more clearly understand the functional structure of a MLV, see the equivalent electrical model shown in Figure 2.

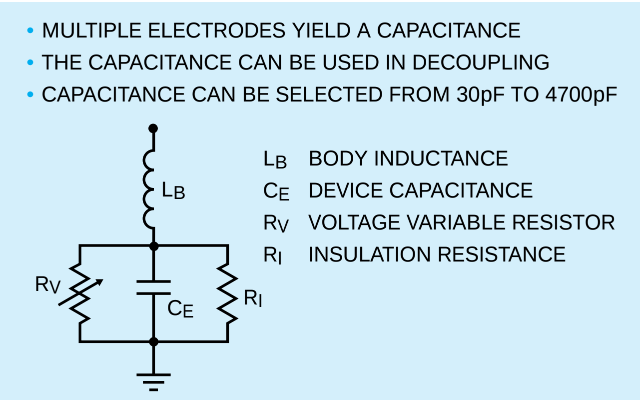


Figure 2. TransGuard Equivalent Model.

As the schematic in Figure 1 illustrates, the implementation of MLV protection methods greatly simplifies circuit layout, saves PCB space and improves system reliability. The MLV offers many additional electrical improvements over the Zener/passive schemes. Among those advantages are higher multiple strike capability, faster turn on time and larger transient overstrike capability. Further clarification on the types of varistors compared to the performance of Zener diodes follows.

CONSTRUCTION AND PHYSICAL COMPARISON

The construction of Zinc Oxide (ZnO) varistors is a well known, relatively straightforward process in which ZnO grains are doped with cobalt, bismuth, manganese and other oxides. The resulting grains have a Schottky barrier at the grain interface and a typical grain breakdown voltage (V_b) of approximately 3.6V per grain.

Currently, there are two types of varistors. Single layer varistors (SLVs) - an older technology referred to as "pressed pill," typically are larger, radial leaded components designed to handle significant power. Multilayer varistors (MLVs) are a relatively new technology packaged in true EIA SMT case sizes.

Beyond the ZnO material system and grain breakdown similarity, MLVs and SLVs have little in common. That is, to design a low voltage SLV, the grains must be grown as large as possible to achieve a physically large enough part to be handled in the manufacturing process. Typically it is very difficult to obtain a consistent grain size in a low voltage SLV process.

The electrical performance of SLV is affected by inconsistent grain size in two ways. First, low voltage SLVs often exhibit an inconsistent V_b and leakage current (I_L) from device to device within a particular manufacturing lot of a given rating. This contributes to early high voltage repetitive strike wear out.

Secondly, SLVs with similar voltage and energy ratings as MLVs typically exhibit a lower peak current capability due in part to increased resistance of the long current path of the large grains. This contributes to early repetitive high current wear out.

At higher voltages, the grain size variations within SLVs play a much smaller percentage role in V_b and leakage current values. As a result, SLVs are the most efficient cost effective way to suppress transients in high voltages (e.g., 115 VAC, 220 VAC).

MLV MANUFACTURE

The construction of a MLV was made possible by employing a variety of advanced multilayer chip capacitors (MLCC) manufacturing schemes coupled with a variety of novel and proprietary ZnO manufacturing steps. In the MLCC process, thin dielectrics are commonly employed to obtain very large capacitance values. It is that capability to design and manufacture multilayer structures with dielectric thicknesses of ≤1 mil that allows MLVs to be easily made with operating/working voltages (V_{wm}) as low as 3.3V (for use in next generation silicon devices).

Once a particular working voltage has been determined (by altering the ZnO dielectric thickness), the multilayer varistor's transient energy capability is determined by the number of layers of dielectric and electrodes. It is, therefore, generally easy to control the grain size and uniformity within a MLV due to the relative simplicity of this process.

MLVs exhibit capacitance due to their multiple electrode design and the fact that ZnO is a ceramic dielectric. This capacitance can be utilized with the device's series inductance to provide a filter to help limit EMI/RFI. The equivalent model of a MLV is shown in Figure 2.

MLVs are primarily used as transient voltage suppressors. In their "on" state, they act as a back-to-back Zener, diverting to ground any excess, unwanted energy above their clamping voltage. In their "off" state, they act as an EMC capacitor (capacitance can be minimized for high speed applications). A single MLV, therefore, can replace the diode, capacitor and resistor array on multiplex node applications.

Any TVS will see a large number of transient strikes over its lifetime. These transient strikes will result from different events such as well known ESD HBM, IC MM, alternator field decay, load dump models and uncontrolled random events. It is because of the repetitive strikes that all TVS suppressors should be tested for multiple strike capability. Typically, a TVS will fail due to high voltage, high current or over-energy strikes.

High voltage repetitive strikes are best represented by IEC1000-4-2 8kV waveforms. MLVs demonstrate a greatly superior capability to withstand repetitive ESD high voltage discharge without degradation.

High current repetitive strikes are represented by 8x20µs 150A waveforms. A comparison between MLVs, SLVs and SiTVS is shown in Figures 3A, B, C respectively.

SILICON TVS MANUFACTURE

The construction of a silicon TVS departs dramatically from that of either single layer varistor or multilayer varistor construction. Devices are generally produced as Zener diodes with the exception that a larger junction area is designed into the parts and additional testing was likely performed. After the silicon die is processed in accordance to standard semi-conductor manufacturing practice, the TVS die is connected to a heavy metal lead frame and molded into axial and surface mount (SMT) configuration.

MLVs COMPARED TO DIODES

The response time for a silicon diode die is truly sub-nanosecond. The lead frame into which the die is placed and the wire bonds used for die connections introduce a significant amount of inductance. The large inductance of this packaging causes a series impedance that slows the response time of SiTVS devices. A best case response time of 8nS on SOT23 and a 1.5nS to 5nS response time on SMB and SMC products respectively are rather typical. MLVs turn on time is <7nS. MLVs turn on time is faster than SiTVS and that fast turn on time diverts more energy and current away from the IC than any other protection device available.

CONCLUSION

The technology to manufacture MLVs exists and allows the manufacture of miniature SMT surge suppressors. MLVs do not have the wear out failure mode of first generation (single layer) varistors. In fact, MLVs exhibit better reliability numbers than that of TVS diodes. MLVs are a viable protection device for auto multiplex bus applications.

Written by Ron Demcko

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150 AMP Current Repetitive Strike Comparison

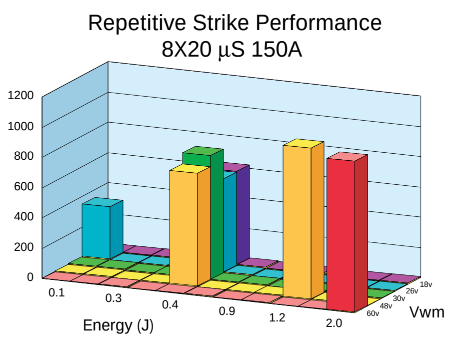


Figure 3A. Multilayer Varistor.

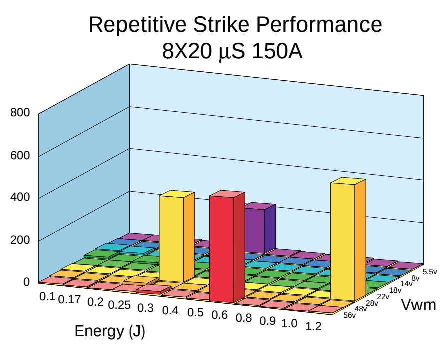


Figure 3B. Single Layer Varistor.

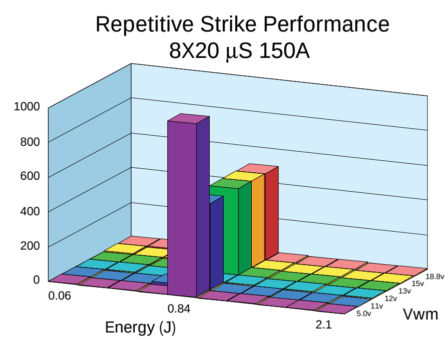
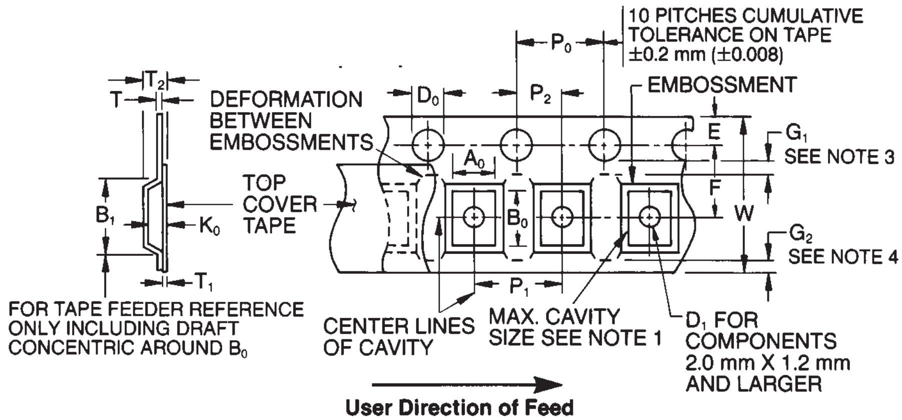


Figure 3C. Silicon TVS.

AVX TransGuard®

PACKAGING

- Chips
- Axial Leads



8mm Embossed Tape
Metric Dimensions Will Govern

CONSTANT DIMENSIONS

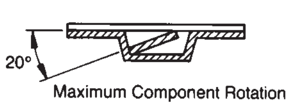
Tape Size	D_0	E	P_0	P_2	T Max.	T_1	G_1	G_2
8mm	$8.4^{+0.10}_{-0.0}$ $(0.059^{+0.004}_{-0.0})$	1.75 ± 0.10 (0.069 ± 0.004)	4.0 ± 0.10 (0.157 ± 0.004)	2.0 ± 0.05 (0.079 ± 0.002)	0.600 (0.024)	0.10 (0.004) Max.	0.75 (0.030) Min. See Note 3	0.75 (0.030) Min. See Note 4

VARIABLE DIMENSIONS

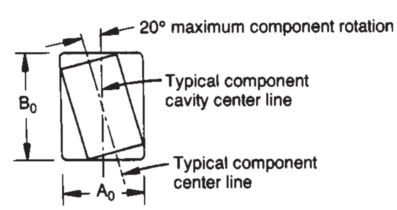
Tape Size	B_1 Max. See Note 6	D_1 Min. See Note 5	F	P_1	R Min. See Note 2	T_2	W	A_0 B_0 K_0
8mm	4.55 (0.179)	1.0 (0.039)	3.5 ± 0.05 (0.138 ± 0.002)	4.0 ± 0.10 (0.157 ± 0.004)	25 (0.984)	2.5 Max. (0.098)	$8.0^{+0.3}_{-0.1}$ $(0.315^{+.012}_{-0.004})$	See Note 1

NOTES:

1. A_0, B_0, and K_0 are determined by the max. dimensions to the ends of the terminals extending from the component body and/or the body dimensions of the component. The clearance between the end of the terminals or body of the component to the sides and depth of the cavity (A_0, B_0, and K_0) must be within 0.05 mm (0.002) min. and 0.50 mm (0.020) max. The clearance allowed must also prevent rotation of the component within the cavity of not more than 20 degrees (see sketches C & D).
2. Tape with components shall pass around radius "R" without damage.
3. G_1 dimension is the flat area from the edge of the sprocket hole to either the outward deformation of the carrier tape between the embossed cavities or to the edge of the cavity whichever is less.
4. G_2 dimension is the flat area from the edge of the carrier tape opposite the sprocket holes to either the outward deformation of the carrier tape between the embossed cavity or to the edge of the cavity whichever is less.
5. The embossment hole location shall be measured from the sprocket hole controlling the location of the embossment. Dimensions of embossment location and hole location shall be applied independent of each other.
6. B_1 dimension is a reference dimension for tape feeder clearance only.



Side or Front Sectional View
Sketch "C"

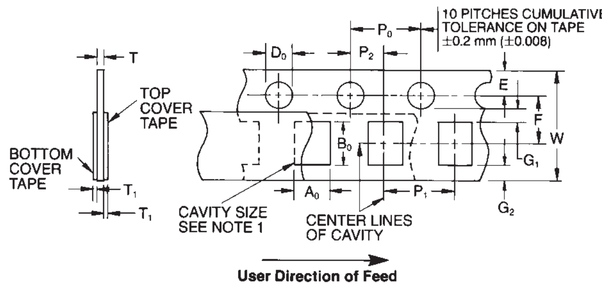


Top View
Sketch "D"

TransGuard®

AVX Multilayer Ceramic Transient Voltage Suppressors
Packaging - Chips / Punched Carrier Configuration 8mm Tape Only

8mm Punched Tape
Metric Dimensions Will Govern



CONSTANT DIMENSIONS

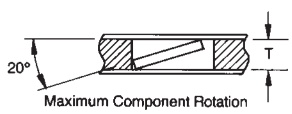
Tape Size	D_0	E	P_0	P_2	T_1	G_1	G_2	R MIN.
8mm	1.5 $^{+0.1}_{-0.0}$ (0.059 $^{+0.004}_{-0.000}$)	1.75 ± 0.10 (0.069 ± 0.004)	4.0 ± 0.10 (0.157 ± 0.004)	2.0 ± 0.05 (0.079 ± 0.002)	0.10 (0.004) Max.	0.75 (0.030) Min.	0.75 (0.030) Min.	25 (0.984) See Note 2

VARIABLE DIMENSIONS

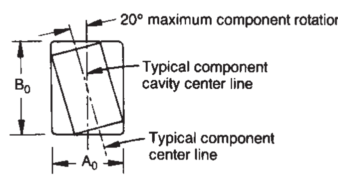
Tape Size	P_1	F	W	A_0 B_0	T
8mm	4.0 ± 0.10 (0.157 ± 0.004)	3.5 ± 0.05 (0.138 ± 0.002)	8.0 $^{+0.3}_{-0.1}$ (0.315 $^{+0.012}_{-0.004}$)	See Note 1	See Note 3

NOTES:

1. A_0, B_0, and T are determined by the max. dimensions to the ends of the terminals extending from the component body and/or the body dimensions of the component. The clearance between the ends of the terminals or body of the component to the sides and depth of the cavity (A_0, B_0, and T) must be within 0.05 mm (0.002) min. and 0.50 mm (0.020) max. The clearance allowed must also prevent rotation of the component within the cavity of not more than 20 degrees (see sketches A & B).
2. Tape with components shall pass around radius "R" without damage.
3. 1.1 mm (0.043) Base Tape and 1.6 mm (0.063) Max. for Non-Paper Base Compositions.

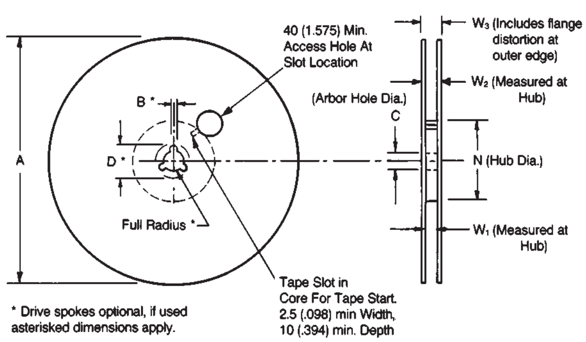


Side or Front Sectional View
Sketch "A"



Top View
Sketch "B"

REEL DIMENSIONS



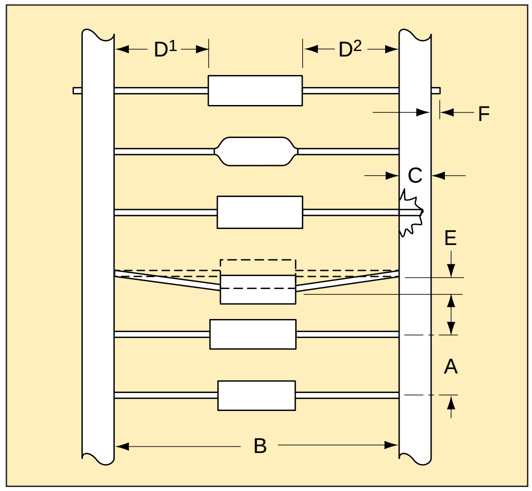
Tape Size	A Max.	B* Min.	C	D* Min.	N Min.	W_1	W_2 Max.	W_3
8mm	330 (12.992)	1.5 (0.059)	13.0±0.20 (0.512±0.008)	20.2 (0.795)	50 (1.969)	8.4 $^{+1.0}_{-0.0}$ (0.331 $^{+0.060}_{-0.0}$)	14.4 (0.567)	7.9 Min. (0.311) 10.9 Max. (0.429)

Metric dimensions will govern.
English measurements rounded and for reference only.

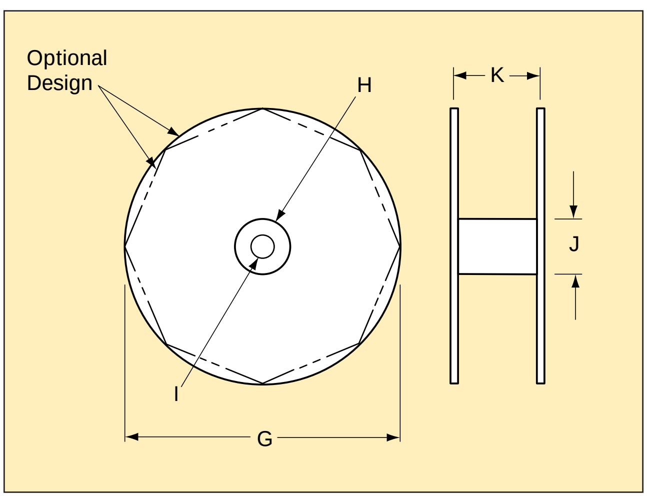
BAR CODE LABELING STANDARD

AVX bar code labeling is available and follows latest version of EIA-556.

CLASS I / RS-296	
A.	5mm ± 0.5mm (0.200" ± 0.020")
B*.	52.4mm ± 1.5mm (2.063" ± 0.059")
C.	6.35mm ± 0.4mm (0.250" ± 0.016")
D[1]-D[2].	1.4mm (0.055" MAX.)
E.	1.2mm (0.047" MAX.)
F.	1.6mm (0.063" MAX.)
G.	356mm (14.00")
H.	76mm (3.000")
I.	25.4mm (1.000")
J.	84mm (3.300")
K.	70mm (2.750")



Leader Tape: 300mm min. (12")
Splicing: Tape Only
Missing Parts: 0.25% of component count max.- No consecutive missing parts



AVX TECHNICAL SERVICES AND TESTING FACILITY

The AVX test lab has the capability to perform ESD and a variety of other fast wave form tests on finished assemblies, subassemblies and components for performance to ESD per IEC 1000-4-2 contact/air discharge and a number of other transient voltage specifications.

Components can be tested for:

- Pre/post current draw
- Pre/post output driving voltage
- Pre/post receiver sensitivity levels
- TVS turn on time characterization

Finished assemblies and subassemblies can be tested for:

- System functionality under repetitive ESD strikes
- Pre/post output voltages
- Pre/post receiver sensitivity levels

For details on specific lab test capabilities and costs, contact: Jack Bush @ (843) 946-0244

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