TVS 13

HIGH RELIABILITY SERIES MECHANICAL AND ENVIRONMENTAL TESTING FOR AEROSPACE, MILITARY, AND HIGH RELIABILITY APPLICATIONS

The high-reliability Harris varistor is the latest step in increased product performance, and is available for applications requiring quality and reliability assurance levels consistent with military or other standards. (Mil-Std-19500, Mil-S-750, Method 202)

This series of high-reliability varistors involves five categories:

13.1 DESC Qualified Parts List (QPL) Mil-R-83536.
4 types presently available.

13.2 DESC Source Control Drawings based on Mil-R-83530.
83 types presently available:
ZA Series - Drawing #87063
DB Series - Drawing #90065
PA Series - Drawing #88063

13.3 Harris high reliability series offers TX equivalents.
29 types presently available.

13.4 Custom types processed to customer-specific requirements - (SCD) or to standard military flow.

13.5 Radiation hardened varistors.

Credentials

Harris varistors and quality management systems are:

- DESC approved
- QPL listed
- CECC approved
- ISO approved
- UL approved
- CSA approved.

13.1 DESC QUALIFIED PARTS LIST (QPL) MIL-R-83530

Table 13.1. MIL-R-83530/1 Ratings and Characteristics

PART NUMBER M83530/	NOMINAL VARISTOR VOLTAGE (V)	TOLERANCE (%)	VOLTAGE RATING (V) (RMS)	VOLTAGE RATING (V) (DC)	ENERGY RATING (J)	CLAMPING VOLTAGE AT 100A (V)	CAPACITANCE AT 1MHz (pF)	CLAMPING VOLTAGE AT PEAK CURRENT RATING (V)	I_{TM} (A)	NEAREST COMMERCIAL EQUIVALENT
1-2000B	200	±10	130	175	50	325	3800	570	6000	V130LA20B
1-2200D	220	+10, -5	150	200	55	360	3200	650	6000	V150LA20B
1-4300E	430	+5, -10	275	369	100	680	1800	1200	6000	V275LA40B
1-5100E	510	+5, -10	320	420	120	810	1500	1450	6000	V320LA40B

This series of varistors are screened and conditioned in accordance with MIL-R-83530 as outlined in Table 13.2. Manufactur-

Table 13.2. MIL-R-83530 Group A, B, and C Inspections

Group A Inspection

INSPECTION	AQL (PERCENT DEFECTIVE)	
SUBGROUP 1		
High Temperature Life (stabilization bake)	100%	
Thermal Shock		
Power Burn-In		
Clamping Voltage		
Nominal Varistor Voltage		
SUBGROUP 2	MAJOR	MINOR
Visual and Mechanical Examination		
Body Dimensions		-
Diameter and Length of	1.0% AQL	-
Leads	7.6% LQ	-
Marking		
Workmanship		25% AQL
		13.0% LQ

Group B Inspection

INSPECTION
SUBGROUP I
Dielectric Withstanding Voltage
SUBGROUP II
Solderability
Resistance to Solvents
SUBGROUP III
Terminal Strength (lead fatigue)
Moisture Resistance
Peak Current
Energy

Group C Inspection

INSPECTION	NUMBER OF SAMPLE UNITS	FAILURES ALLOWED
EVERY 3 MONTHS		
High Temperature Storage	10	0
Operating Life (steady state)	10	0
Pulse Life	10	0
Shock	10	0
Vibration	10	0
Constant Acceleration	10	0
Energy	10	0

13.2 DESC SOURCE CONTROLLED DRAWING # 87063

Based on MIL-R-83530 ZA Package Series

Table 13.3 Ratings and Characteristics

87063 DASH NO.	NEAREST COMM. NO.	SIZE*	MAXIMUM RATINGS (+85°C) CONTINUOUS RMS $V_{M(AC)}$ (V)	CONTINUOUS DC $V_{M(DC)}$ (V)	TRANSIENT ENERGY (10/1000µs) W_{TM} (J)	TRANSIENT PEAK CURRENT (8/20µs) I_{TM} (A)	CHARACTERISTICS (+25°C) VARISTOR VOLTAGE @ 1mA DC TEST CURRENT MIN (V)	$V_{N(DC)}$ (V)	MAX (V)	MAXIMUM CLAMPING VOLTAGE V_C @ TEST CURRENT (8/20µs) V_C (V)	I_C (A)	TYPICAL CAPACITANCE f = 1MHz (pF)
001	V22ZA05	1	14	18	0.2	35	18.7	22	26	51	2	400
002	V22ZA1	2	14	18	0.9	150	18.7	22	26	47	5	1600
003	V22ZA2	3	14	18	2.0	350	18.7	22	26	43	5	4000
004	V22ZA3	4	14	18	4.0	750	18.7	22	26	43	10	9000
005	V24ZA50	5	14	18	6.5	1500	19.2	24†	26	43	20	18000
006	V27ZA05	1	17	22	0.25	35	23	27	31.1	59	2	300
007	V27ZA1	2	17	22	1.0	150	23	27	31.1	57	5	1300
008	V27ZA2	3	17	22	2.5	350	23	27	31.1	53	5	3000
009	V27ZA4	4	17	22	5.0	750	23	27	31.1	53	10	7000
010	V27ZA60	5	17	22	8.0	1500	23	27†	31.1	50	20	15000
011	V33ZA05	1	20	26	0.3	35	29.5	33	38	67	2	250
012	V33ZA1	2	20	26	1.2	150	29.5	33	36.5	68	5	1100
013	V33ZA2	3	20	26	3.0	350	29.5	33	36.5	64	5	2700
014	V33ZA5	4	20	26	6.0	750	29.5	33	36.5	64	10	6000
015	V33ZA70	5	21	27	9.0	1500	29.5	33†	36.5	58	20	13000
016	V36ZA80	5	23	31	10.0	1500	32	36†	40	63	20	12000
017	V39ZA05	1	25	31	0.35	35	35	39	46	79	2	220
018	V39ZA1	2	25	31	1.5	150	35	39	43	79	5	900
019	V39ZA3	3	25	31	3.5	350	35	39	43	76	5	2200
020	V39ZA6	4	25	31	7.2	750	35	39	43	76	10	5000
021	V47ZA05	1	30	38	0.4	35	42	47	55	90	2	200
022	V47ZA1	2	30	38	1.8	150	42	47	52	92	5	800
023	V47ZA3	3	30	38	4.5	350	42	47	52	89	5	2000
024	V47ZA7	4	30	38	8.8	750	42	47	52	89	10	4500
025	V56ZA05	1	35	45	0.5	35	50	56	66	108	2	180
026	V56ZA2	2	35	45	2.3	150	50	56	62	107	5	700
027	V56ZA3	3	35	45	5.5	350	50	56	62	103	5	1800
028	V56ZA8	4	35	45	10.0	750	50	56	62	103	10	3900
029	V68ZA05	1	40	56	0.6	35	61	68	80	127	2	150
030	V68ZA2	2	40	56	3.0	150	61	68	75	127	5	600
031	V68ZA3	3	40	56	6.5	350	61	68	75	123	5	1500
032	V68ZA10	4	40	56	13.0	750	61	68	75	123	10	3300
033	V82ZA05	1	50	66	1.2	70	73	82	97	145	2	120
034	V82ZA2	2	50	66	3.5	300	73	82	91	135	10	500
035	V82ZA4	3	50	66	7.3	750	73	82	91	135	25	1100
036	V82ZA12	4	50	66	13.0	1500	73	82	91	145	50	2500
037	V100ZA05	1	60	81	1.5	70	90	100	117	175	2	90
038	V100ZA3	2	60	81	4.3	300	90	100	110	165	10	400
039	V100ZA4	3	60	81	8.9	750	90	100	110	165	25	900
040	V100ZA15	4	60	81	16.0	1500	90	100	110	175	50	2000
041	V120ZA05	1	75	102	1.8	100	108	120	138	205	2	70
042	V120ZA1	2	75	102	5.3	400	108	120	132	205	10	300
043	V120ZA4	3	75	102	11.0	1000	108	120	132	200	25	750
044	V120ZA6	4	75	102	19.0	2000	108	120	132	210	50	1700
045	V150ZA05	1	92	127	2.3	100	135	150	173	240	2	60
046	V150ZA1	2	95	127	6.5	400	135	150	165	250	10	250
047	V150ZA4	3	95	127	13.0	1000	135	150	165	250	25	600
048	V150ZA8	4	95	127	23.0	2000	135	150	165	255	50	1400
049	V180ZA05	1	110	153	2.7	150	162	180	207	290	2	50
050	V180ZA1	2	115	153	7.7	500	162	180	198	295	10	200
051	V180ZA5	3	115	153	16.0	1500	162	180	198	300	25	500
052	V180ZA10	4	115	153	27.0	3000	162	180	198	300	50	1100

* Size 1-5mm, 2-7mm, 3-10mm, 4-14mm, 5-20mm

† Denotes 10mA DC test current.

13.2 DESC STANDARD MILITARY DRAWING # 90065

Based on MIL-R-83530 DB Package Series

Table 13.4 Ratings and Characteristics

90065 DASH NO.	VOLTAGE RATING MAX. (RMS)	ENERGY MAX (J)	PEAK CURRENT (A)	NOMINAL VARISTOR VOLTAGE (V)		MAX CLAMPING VOLTAGE AT TEST CURRENT (V)	(I)	TYPICAL CAPACITANCE (pF)
012	130	170	22500	200	+28, -16	345	200	10000
013	150	200	22500	240	±28	405	200	8000
014	250	270	22500	390	+39, -36	650	200	5000
015	275	300	22500	430	±43	730	200	4500
016	320	350	22500	510	+29, -48	830	200	3800
017	420	460	28800	680	+68, -70	1130	200	3000
018	480	510	28800	750	+74, -80	1240	200	2700
019	510	550	28800	820	+91, -85	1350	200	2500
020	575	600	28800	910	+95, -105	1480	200	2200
021	660	690	28800	1050	±110	1720	200	2000
022	750	810	28800	1200	±120	2000	200	1800

13.2 DESC STANDARD MILITARY DRAWING # 88063

Based on MIL-R-83530 PA Package Series

Table 13.5 Ratings and Characteristics

80063 DASH NO.	VOLTAGE RATING MAX. (RMS)	(DC)	ENERGY MAX (J)	PEAK CURRENT (A)	NOMINAL VARISTOR VOLTAGE (V)		MAX CLAMPING VOLTAGE AT TEST CURRENT (V)	(I)	TYPICAL CAPACITANCE (pF)
001	130	175	70	6500	200	+43, -16	360	100	1900
002	130	175	70	6500	200	+20, -16	325	100	1900
003	150	200	80	6500	240	+44, -28	420	100	1600
004	150	200	80	6500	240	+3, -28	360	100	1600
005	250	330	130	6500	390	+63, -36	675	100	1000
006	250	330	130	6500	390	+23, -36	620	100	1000
007	275	369	140	6500	430	+64, -41	740	100	900
008	275	369	140	6500	430	+23, -41	680	100	900
009	320	420	160	6500	510	+55, -48	850	100	750
010	320	420	160	6500	510	+30, -48	800	100	750
011	420	560	160	6500	680	+110, -70	1160	100	600
012	420	560	160	6500	680	+10, -70	1050	100	600
013	480	640	180	6500	750	+110, -80	1280	100	550
014	480	640	180	6500	750	+40, -80	1160	100	550
015	510	675	190	6500	820	+143, -85	1410	100	500
016	510	675	190	6500	820	+40, -85	1280	100	500
017	575	730	220	6500	910	+140, -105	1560	100	450
018	575	730	220	6500	910	+50, -105	1410	100	450
019	660	850	250	6500	1050	+160, -110	1820	100	400
020	660	850	250	6500	1050	+50, -110	1650	100	400

13.3 HARRIS HIGH RELIABILITY SERIES TX EQUIVALENTS

Table 13.6. Available TX Model Types

TX MODEL	MODEL SIZE	DEVICE MARK	NEAREST COMMERCIAL EQUIVALENT
V8ZTX1	7mm	8TX1	V8ZA1
V8ZTX2	10mm	8TX2	V8ZA2
V12ZTX1	7mm	12TX1	V12ZA1
V12ZTX2	10mm	12TX2	V12ZA2
V22ZTX1	7mm	22TX1	V22ZA1
V22ZTX3	14mm	22TX3	V22ZA3
V24ZTX50	20mm	24TX50	V24ZA50
V33ZTX1	7mm	33TX1	V33ZA1
V33ZTX5	14mm	33TX5	V33ZA5
V33ZTX70	20mm	33TX70	V33ZA70
V68ZTX2	7mm	68TX2	V68ZA2
V68ZTX10	14mm	68TX10	V68ZA10
V82ZTX2	7mm	82TX2	V82ZA2
V82ZTX12	14mm	82TX12	V82ZA12

TX MODEL	MODEL SIZE	DEVICE MARK	NEAREST COMMERCIAL EQUIVALENT
V130LTX2	7mm	130TX	V130LA2
V130LTX10A	14mm	130TX10	V130LA10A
V130LTX20B	20mm	130TX20	V130LA20A
V150LTX2	7mm	150TX	V150LA2
V150LTX10A	14mm	150TX10	V150LA10A
V150LTX20B	20mm	150TX20	V150LA20B
V250LTX4	7mm	250TX	V250LA4
V250LTX20A	14mm	250TX20	V250LA20A
V250LTX40B	20mm	250TX40	V250LA40B
V420LTX20A	14mm	420TX20	V420LA20A
V420LTX40B	20mm	420TX40	V420LA40B
V480LTX40A	14mm	480TX40	V480LA40A
V480LTX80B	20mm	480TX80	V480LA80B
V510LTX40A	14mm	510TX40	V510LA40A
V510LTX80B	20mm	510TX80	V510LA80B

This series of varistors are 100% screened and conditioned in accordance with MIL-STD-750. Tests are as outlined in Table 13.7.

Table 13.7. TX Equivalents Series 100% Screening

SCREEN	MIL-STD-750 METHOD	CONDITION	TX REQUIREMENTS
High Temperature Life (stabilization bake)	1032	24 hours min. at max. rated storage temperature.	100%
Thermal Shock (temperature cycling)	1051	No dwell is required at 25°C. Test condition A1, 5 cycles - 55° C to +125°C (extremes). > 10 minutes	100%
Humidity Life		85°C, 85% R.H., 168 hours.	100%
Interim Electrical $V_{N(DC)}$ V_C (Note 1)		As specified, but including delta parameter as a minimum.	100% Screen
Power Burn-In	1038	Condition B, 85°C, Rated $V_{M(AC)}$, 72 hours mmin	100%
Final Electrical $+V_{N(DC)}$ V_C (Note 1)		As specified — All parameter measurements must be completed within 96 hours after removal from burn-in conditions.	100% Screen
External Visual Examination	2071	To be performed after complete marking.	100%

NOTE:

1. Delta Parameter - $V_{N(DC)}$
   Maximum allowable shift ±10% Max.
   Applicable lot PDA - 10% Max.
   Peak current and energy ratings are derated by 10% and 30%, respectively, from standard parts.

13.3 HARRIS HIGH RELIABILITY SERIES TX EQUIVALENTS (Continued)

Table 13.8. Quality Assurance Acceptance Test

	MIL-STD-105		
	LEVEL	AQL	LTPD
Electrical (Bi-directional) $V_{N(DC)}$, V_C (Per characteristics table)	II	0.1	-
Dielectric Withstand Voltage MIL-STD-202, Method 301, 2500V min. at 1.0μAdc	-	-	15
Solderability MIL-STD-202, Method 208, no aging, non-activated	-	-	15

13.4 CUSTOM TYPES

In addition to our comprehensive high-reliability series as referenced above, Harris can screen and condition to customer-specific requirements.

Additional mechanical and environmental capabilities are defined in Table 13.9.

Table 13.9. Mechanical and Environmental Capabilities (Typical Conditions)

TEST NAME	TEST METHOD	DESCRIPTION
Terminal Strength	MIL-STD-750-2036	3 bends, 90° arc, 16 oz. weight
Drop Shock	MIL-STD-750-2016	1500 g's, 0.5ms, 5 pulses, X_1, V_1, Z_1
Variable Frequency Vibration	MIL-STD-750-2056	20 g's, 100-2000Hz, X_1, V_1, Z_1
Constant Acceleration	MIL-STD-750-2006	V_2, 20,000 g's min
Salt Atmosphere	MIL-STD-750-1041	35° C, 24 hrs, 10-50 g/m^2 day
Soldering Heat/Solderability	MIL-STD-750-2031/2026	260° C, 10s, 3 cycles, test marking
Resistance to Solvents	MIL-STD-202-215	permanence, 3 solvents
Flammability	MIL-STD-202-111	15s torching, 10s to flameout
Flammability	UL1414	3 x 15s torching
Cyclical Moisture Resistance	MIL-STD-202-106	10 days
Steady-State Moisture Resistance		85/85 96 hrs.
Biased Moisture Resistance		Not recommended for high-voltage types
Temperature Cycle	MIL-STD-202-107	-55 to +125°C, 5 cycles
High-Temperature Life (Nonoperating)	MIL-STD-750-1032	125° C, 24 hrs.
Burn-In	MIL-STD-750-1038	Rated temperature and V_{RMS}
Hermetic Seal	MIL-STD-750-1071	Condition D

13.5 RADIATION HARDNESS

For space applications, an extremely important property of a protection device is its response to imposed radiation effects.

Electron Irradiation

A Harris MOV and a silicon transient suppression diode were exposed to electron irradiation. The V-I Curves, before and after test, are shown in Figure 13.1.

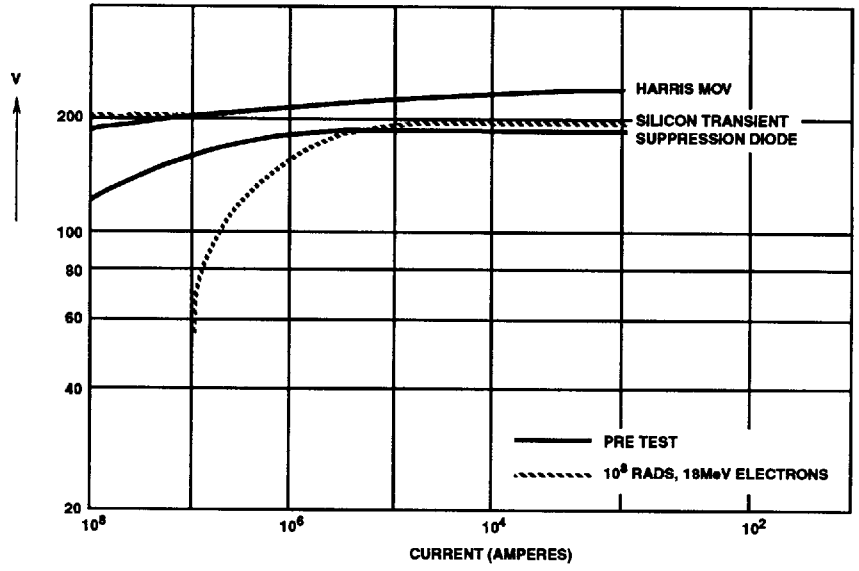

Figure 13.1. Radiation Sensitivity of Harris V130LA1 and Silicon Transient Suppression Diode

It is apparent that the Harris MOV was virtually unaffected, even at the extremely high dose of 10^8 rads, while the silicon transient suppression diode showed a dramatic increase in leakage current.

Neutron Effects

A second MOV-Zener comparison was made in response to neutron fluence. The selected devices were equal in area.

Figure 13.2 shows the clamping voltage response of the MOV and the zener to neutron irradiation to as high as 10^{15} N/cm^2. It is apparent that in contrast to the large change in the zener, the MOV is unaltered. At higher currents where the MOV's clamping voltage is again unchanged, the zener device clamping voltage increases by as much as 36%.

Counterclockwise rotation of the V-I characteristics is observed in silicon devices at high neutron irradiation levels; in other words, increasing leakage at low current levels and increasing clamping voltage at higher current levels.

The solid and open circles for a given fluence represent the high and low breakdown currents for the sample of devices tested. Note that there is a marked decrease in current (or energy) handling capability with increased neutron fluence.

Failure threshold of silicon semiconductor junctions is further reduced when high or rapidly increasing currents are applied. Junctions develop hot spots, which enlarge until a short occurs if current is not limited or quickly removed.

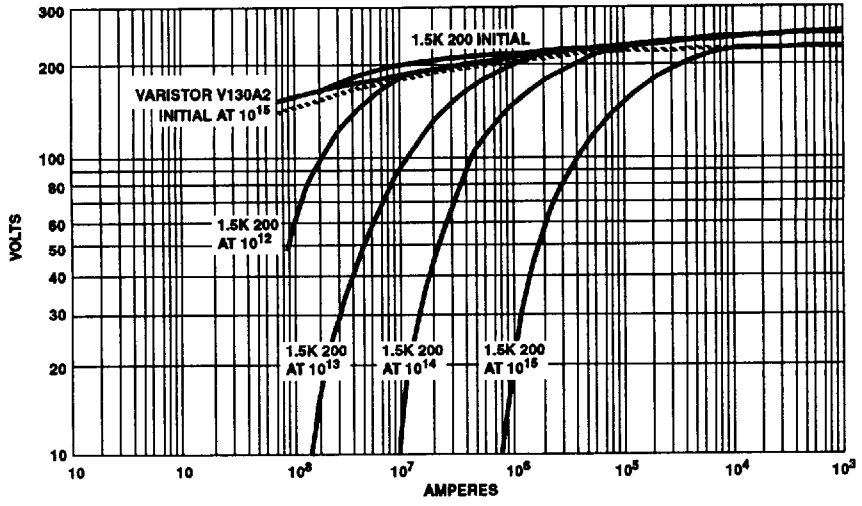

Figure 13.2. V-I Characteristic Response to Neutron Irradiation for MOV and Zener Diode Devices

The characteristic voltage current relationship of a PN-Junction is shown in Figure 13.3.

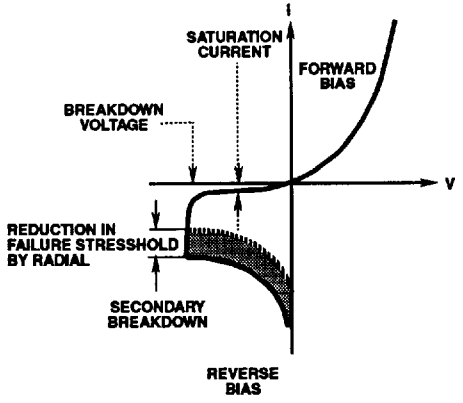

Figure 13.3. V-I Characteristic of PN-Junction

At low reverse voltage, the device will conduct very little current (the saturation current). At higher reverse voltage V_{BO} (breakdown voltage), the current increases rapidly as the electrons are either pulled by the electric field (Zener effect) or knocked out by other electrons (avalanching). A further increase in voltage causes the device to exhibit a negative resistance characteristic leading to secondary breakdown.

This manifests itself through the formation of hotspots, and irreversible damage occurs. This failure threshold decreases under neutron irradiation for zeners, but not for Zinc Oxide Varistors.

Gamma Radiation

Radiation damage studies were performed on type V-I 30LA2 varistors. Emission spectra and V-I characteristics were collected before and after irradiation with 10^6 rads Co^{60} gamma radiation.

Both show no change, within experimental error, after irradiation.