National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

JPL Spec ZPP-2061-PPL

JPL PREFERRED PARTS LIST

RELIABLE ELECTRONIC COMPONENTS

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THE JPL PREFERRED PARTS LIST IS CURRENTLY BEING REVISED. THE CURRENT VERSION (JPL Spec ZPP-2061-PPL) WILL BECOME OBSOLETE AT THE TIME THE REVISION IS PUBLISHED.

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Space Administration

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JPL PREFERRED PARTS LIST

RELIABLE ELECTRONIC COMPONENTS

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PREFACE

PURPOSE

The JPL Preferred Parts List has been prepared to provide a basis for selection of electronic parts for JPL spacecraft programs. Supporting tests for the listed parts have been designed to comply with specific JPL spacecraft environmental requirements. Since it has been designed specifically for JPL programs, availability of this specification to personnel working on projects not related to JPL efforts is limited to an "Information Only" basis.

The Preferred Parts List tabulates the electronic, magnetic, and electromechanical parts applicable to all JPL electronic equipment wherein reliability is a major consideration. The parts listed are relevant to equipment supplied by subcontractors as well as that fabricated at the laboratory.

Packaging and cabling hardware (including connectors) is beyond the scope of this list. See JPL STD00009 for preferred packaging and cabling hardware.

There is no intent to exclude any manufacturer from this Preferred Parts List; however, all entries shall be qualified to JPL requirements prior to listing. Qualification is normally a Laboratory function except when a part is deemed beyond the scope of Preferred Parts List effort. In these cases the burden of qualification to JPL requirements shall rest with the manufacturer.

Parts not listed for which a substantial usage is anticipated should be brought to the attention of the Electronic Parts Engineering Section.

JPL has agreed to implement use of the NASA Standard Parts List (NSPL), MIL-STD-975. The parts contained in MIL-STD-975 are listed herein in the section entitled MIL-STD-975. Appendix B from MIL-STD-975 is also added to guide the reader to upgrading Grade 2 devices to Grade 1 devices. Grade 1 parts, as defined in MIL-STD-975, are intended for critical flight and mission-essential ground support applications. Grade 2 parts are for use in non-critical flight and mission-essential ground support applications.

PREFACE

SELECTION

Parts are added to the white sheets of the Preferred Parts List only with the knowledge of their capabilities and reliability potential as determined from qualification testing. A minimum practicable number of part types is selected for qualification in the interest of maximum efficiency and conservation of resources. Each year candidates for the Preferred Parts List are selected in an effort to satisfy: 1) requirements resulting from current usage of parts which have unknown reliability histories, 2) requirements for alternate source of currently approved parts, and 3) anticipation of future usage of new state-of-the art devices. After corroborative data originating from sources such as the Government-Industry Data Exchange Program (GIDEP), industry, and parts manufacturers are carefully examined, qualification tests are carried out and the qualified parts are entered on the white sheets of the Preferred Parts List.

In the interests of standardization, certain of the qualified parts on the white sheets have been selected for their overall excellence, high usage history, and availability. These recommended standards are designated by an asterick (*) before the part number.

The blue sheets in each section of the Preferred Parts List are provided when the parts on the white sheets do not satisfy all design requirements. The parts so listed are JPL recommendations but have not been fully qualified. They are classified as acceptable parts because some evaluation has been accomplished and no outstanding faults are in evidence.

A section entitled MIL-STD-975 has been added giving summaries of MIL-STD-975 parts; some in detail. The Parts Specialists can be contacted for more explicit information.

ORDER OF PREFERENCE

The following order of preference for parts selection has been established.

1. Both PPL Qualified and NSPL Grade 1.
2. Either PPL Qualified or NSPL Grade 1.
3. Either PPL Acceptable or NSPL Grade 2.
4. Commercial Grade (all parts not listed in this document). Consultation with Parts Specialist is advised.

PREFACE

REMOVAL OF PARTS FROM THE PREFERRED PARTS LIST

Parts are removed from the Preferred Parts List when: 1) they fail to comply with existing specifications, 2) they can be replaced by superior parts, or 3) they are found to have very limited applications.

QUALIFICATION AND EVALUATION

The objective of qualification testing is to confirm through both destructive and nondestructive tests that the devices are capable of withstanding spacecraft environments without degradation and have stable parametric characteristics during operational life. It is also intended to assess the effects of levels, sequence, combinations and time durations of electrical, environmental, and mechanical stresses and to determine inherent failure modes and necessary safety margins.

If the part design has been satisfactorily qualified by other agencies or programs, all available data from central infor mation gathering facilities are utilized to avoid needless duplication. Parts which lack complete qualification to the JPL functional and environmental requirements are evaluated and supplemental testing is conducted to complete the qualification.

Approval of manufacturer's materials, processes, quality control, and engineering and production capabilities are also required for part approval.

In qualification and evaluation testing, each device must undergo a design appraisal in which device construction and processing are examined to obtain identity of the part for future reference and comparison, to identify probable failure modes, and to assist in the subsequent design of optimum screening specifications.

PREFACE

SCREENING

A screening test is a nondestructive process designed to identify potential failures and eliminate defective, marginal and damaged components. JPL requires that all electronic/electromechanical/ magnetic parts used in the assembly of spacecraft hardware be 100 percent screened prior to their assembly into flight-rated spacecraft hardware.

From thorough analysis of previous qualification and screening test data, JPL has defined certain parameters, sensitive to degradation or change, which are indicative of device failure or tendency toward failure. Tests are monitored to assess the effectiveness of screening specification limits.

The Preferred Parts List tabulates the released screening specifications covering each of the listed devices.

REVISIONS

As new information becomes available, revised pages will be issued. They will be dated and their dates reflected on the "Revision" pages of this Preface (starting on page 5, with additional pages added as necessary). A new "Revision" page(s) will accompany each package of revised pages. As the new pages are issued, insert them into this document and destroy the superseded pages.

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FORMAT OF PREFERRED PARTS LIST

This format is designed to facilitate the selection of highly reliable qualified parts by the component part users. In listing the parts, several columns of information of interest are provided as follows:

1. Part Number: Lists Electronic Industries Association - registered, Government Standard, or vendor part number.

2. Vendor: The vendor codes are defined in Table I, Vendor Identification.

3. Type: Lists the general type of part with the preferred standard, qualified, or approved parts within that type.

4. Characteristics: The most characterizing parameters are indicated. The ratings provided are the nominal ratings at room temperature unless otherwise stated. For applications near the limit of any parameter rating, the part specialist should be consulted for pertinent modifying factors. For example, a resistor may be rated at 10 watts at room temperature with an infinite heat sink. At higher temperatures, or lesser heat sinks, derating factors must be considered.

5. Screening Specifications: The screening specifications covering the components are listed. The latest revisions are indexed in JPL Electronic Parts Engineering Reliability Engineering Document (RED) Number 23 entitled "Index of Screening Specifications for Electronic and Electromechanical Parts".

6. Drawings: All parts included on the white sheets of the Preferred Parts List, except specially fabricated parts, are specified for procurement purposes by JPL Standard (ST) Drawings. The parts on the blue sheet may or may not have drawings. For information contact the appropriate Part Specialist.

PARTS INFORMATION DIRECTORY

The parts specialists identified below are available to assist the parts users in all parts matters such as selection of the proper parts for their specific applications, part derating, procurement and screening specifications, part limitations, etc.

CATEGORY	PART SPECIALIST	EXTENSION
Capacitors	J. McKinney	3553
Connectors and Accessories	Section 352	6003
Controlled Rectifiers	E. Powell/C. Simmons	6175
Controlled Switches	E. Powell/C. Simmons	6175
Crystals	W. Mallen	5598
Diodes	E. Powell/C. Simmons	6175
Discrete Parts, SSI/MSI System Components	J. T. R. Wilson	6246
Filters (EMI)	J. McKinney	3553
Fuses	C. Simmons	6175
Hardware, Electronic Packaging	Section 352	6003
LSI, LSI Peripherals, Memory, Microprocessors	L. M. Hess	5527
Indicators	W. Mallen	5598
Magnetic Devices, Transformer/Inductor Screening	C. Simmons	6175
Microcircuits, Analog Switches	R. L. Weesner	7609
Microcircuits, A/D and D/A	R. L. Weesner	7609
Microcircuits, Digital	S. Agarwal/J. T. R. Wilson	4008/6246
Microcircuits, Linear	R. L. Weesner	7609
Microcircuits, LSI System Components	L. M. Hess	5527
Microcircuits, LSI Peripherals	B. Drotman	5622
Microcircuits, Memory	K. Soliman	5622
Microprocessors	F. R. Stott	3070
Relays	J. T. R. Wilson	6246
Resistors	J. McKinney	3553
Switches	W. Mallen	5598
Thermistors	J. McKinney	3553
Transistors	E. Powell/C. Simmons	6175
Wire and Cabling Accessories	Section 352	6003
General Information and Inquiries	W. R. Scott, Parts Engineering Group Supervisor	5750

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CAPACITORS

APPLICATION NOTES

1. Reduction in physical size for a given capacitance and voltage rating can be expected to exhibit a decrease in stability.
2. Capacitors having low volumetric efficiency and high capacitance ratings should be avoided where possible. Such devices are prone to failure due to vibration and shock due to the large mass of the capacitor element. This is particularly true in the case of metallized dielectrics.
3. Capacitors not having a glass-to-metal hermetic seal are subject to degradation where moisture is an environmental factor.
4. The internal series resistance of a capacitor limits the current carrying capabilities of the device. For this reason, capacitors having high dissipation factors should be avoided where possible.
5. Capacitors having high dielectric constants can be expected to exhibit poor stability.
6. Packaging geometry, ambient temperatures, and atmospheric pressure are major factors to be considered when establishing the current carrying capability of a capacitor.
7. Specification limits for capacitors are usually established at 1 kHz. For high frequency operation appropriate limits must be determined.
8. Life expectancy for a capacitor is inversely proportional to the applied stress. Choose voltage ratings that allow the maximum derating within the confines of packaging restrictions.

PAPER

Paper capacitors have extensive capacitance and voltage ranges, a long history of reliable operation, and are low in cost. Their major disadvantage is low volumetric efficiency. Typical applications include: by-pass, suppression, filtering, coupling, blocking, timing, wave shaping and pulse forming.

MYLAR/PAPER METALLIZED

Electrical characteristics, and application of these devices are similar to those given for conventional paper capacitors. An increase in volumetric efficiency is realized as a result of the metallization techniques.

CAPACITORS

MYLAR

Mylar, in general, exhibits superior characteristics to those of paper at temperatures below 85°C. Mylar exhibits a large positive shift in capacitance above 85°C. The applications are essentially those listed for paper. The major advantages are low cost and a relatively high volumetric efficiency.

TEFLON, METALLIZED

The applications for teflon include those listed for paper, as well as those associated with precision networks. This dielectric has extremely good characteristics, and is capable of operation at high temperatures. Teflon is normally reserved for those applications requiring low temperature coefficient, high stability, and high insulation resistance. The metallized dielectric has a self-healing characteristic. Since the self-healing phenomenon is dependent on energy surges to clear the defect, use of this device should be avoided where high impedance and low voltage are circuit factors, as well as those circuits whose performance would be degraded by the presence of occasional transients. Teflon has the disadvantage of high cost and poor volumetric efficiency.

POLYCARBONATE, METALLIZED

The applications for polycarbonate dielectric are similar to those of paper. In general, the characteristics are superior to those of Mylar, but do not exceed those found in teflon. Operating temperature is 125°C, usually with some derating. Size and cost are moderate. The remarks regarding metallization (see Teflon) are applicable here.

MICA/GLASS

Capacitors in this group are particularly suitable for applications in high frequency filtering, coupling, and by pass, as well as applications in delay lines and tuned circuitry. This group exhibits high insulation resistance, high "Q", high dielectric strength, and high stability. Temperature coefficients, depending on the specific type, range from 0 ppm/°C to 200 ppm/°C. Selection within this group is usually determined by cost, and required temperature coefficient. The poor volumetric efficiency of this group limits the practical capacitance range to approximately 10,000 pF. Where long life is a design factor, the silvered mica capacitor should be protected from moisture to prevent degradation.

CAPACITORS

POLYSULFONE, METALLIZED

The characteristics for polysulfone are similar to those for polycarbonate; operating temperature is extended to 150°C.

MICA, RECONSTITUTED

This group of capacitors has characteristics similar to those of conventional mica devices. The volumetric efficiency is enhanced at high voltage levels due to the versatility of the refabricated dielectric.

CERAMIC

This group of capacitors is quite popular due to its high volumetric efficiency. Applications include by-pass, suppression, filtering, coupling and blocking. Ceramics have an extensive temperature and voltage range. Cost is low. Capacitance, dissipation factor are quite dependent on the applied voltage and frequency, and operating temperature range. Loss of capacitance will occur during shelf life storage. Dielectric constants in the order of 1800 exhibit piezoelectric properties. Mechanical forces exerted on the dielectric will produce noise voltages. In general, the characteristics are considerably inferior to the mica/glass group. The cost per microfarad is relatively low.

TANTALUM, FOIL, WET, SOLID

Due to the extreme volumetric efficiency of Tantalum capacitors, the major applications are in low frequency filtering. The cost per microfarad is low. Leakage current and dissipation factor are high and stability is poor. Polar devices should not be operated where dc voltage reversal is possible, or where the applied ac peak voltage exceeds the applied dc voltage. Solid tantalum capacitors having the maximum capacitance/voltage product for a given can size tend to exhibit higher failure rates. Loss of electrolyte can occur in those devices having compression seals causing high impedance and loss of capacitance. The electrolyte in most wet devices is highly corrosive.

CAPACITORS

TANTALUM CAPACITOR COMPARISON

STYLE	ADVANTAGE	DISADVANTAGE
FOIL	1. Highest voltage range 2. Adaptable to nonpolar construction. 3. Most tolerant to voltage reversals. 4. Wide range of capacitance.	1. Low volumetric efficiency. 2. Poor low temperature stability. 3. Cost. 4. External welds. 5. High dissipation factor.
WET	1. Highest volumetric efficiency. 2. Low leakage current. 3. High voltage range.	1. Limited or no reverse voltage capability. 2. Poor low temperature stability. 3. Corrosive electrolyte.
SOLID	1. Best temperature characteristic. 2. Lowest dissipation factor. 3. No external welds. 4. Cost.	1. Limited voltage range. 2. Limiting series resistor advisable.

VARIABLE

These devices are particularly useful where high circuit "Q" must be maintained. Change of capacitance is accomplished by the intermeshing of concentric cylinders. The dielectric is air. Extreme care must be exercised to prevent the entry or generation of conducting foreign material into the dielectric cavity.

QUALIFIED CAPACITORS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS		SCREEN SPEC. ZPP-2073-	DRAWINGS
		Ceramic	Capacitance (μF)	Voltage at 125°C		
848	ERI	Disk, Radial Leads	0.000047 - 0.0038	1-6 kV at 85°C	0121	ST11939
CKR05	AVX, UCC	Rectangular, Radial Leads	0.00001 - 0.1	50/100/200	0105	ST11560
CKR06	AVX, UCC	Rectangular, Radial Leads	0.0012 - 1.0	50/100/200	0105	ST11561
CKR11	AVX, UCC	Cylindrical, Axial Leads	0.000010 - 0.01	50/100	0157	ST11845
CKR12	AVX, UCC	Cylindrical, Axial Leads	0.0056 - 0.047	50/100	0144	ST11562
CKR14	AVX, UCC	Cylindrical, Axial Leads	0.012 - 0.27	50/100	0157	ST11846
C052E/CCR05	UCC	NPO Rectangular, Radial Leads	0.000001 - 0.0033	50/100/200	0167	ST11905
C062E/CCR06	UCC	NPO Rectangular, Radial Leads	0.00036 - 0.018	50/100/200	0167	ST11906
		Glass				
CYFR10	CCW	Rectangular, Axial Leads	0.0000005 - 0.00030	300/500	0107	ST11565
CYFR15	CCW	Rectangular, Axial Leads	0.00022 - 0.0012	300/500	0107	ST11566
CYFR20	CCW	Rectangular, Axial Leads	0.00056 - 0.0051	300/500	0107	ST11567
CYFR30	CCW	Rectangular, Axial Leads	0.00036 - 0.01	300/500	0107	ST11568
		Mylar/Paper Metallized				
118P	SPR	Hermetic, Cylindrical, Axial Leads	0.001 - 12.0	200-1000	0113	ST11583
		Polycarbonate Metallized				
CRH01-05	CRC	Hermetic, Cylindrical, Axial Leads	0.001 - 22	30 - 400 at 100°C	0134	ST11585

QUALIFIED CAPACITORS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS		SCREEN SPEC. ZPP-2073-	DRAWINGS
		Tantalum, Foil	Capacitance (μF)	Voltage at 85°C		
CLR25	MEP, SPR	Hermetic, Cylindrical, Polar, Etched, Axial Leads	1.0 - 580	15 - 150	0141	ST11896
CLR27	MEP, SPR	Hermetic, Cylindrical, Non-Polar, Etched, Axial Leads	0.5 - 350	15 - 150	0141	ST11897
CLR35	MEP, SPR	Hermetic, Cylindrical, Polar, Plain, Axial Leads	0.15 - 160	15 - 450	0141	ST11896
CLR37	MEP, SPR	Plain, Hermetic, Cylindrical, Non-Polar, Axial Leads	0.1 - 100	15 - 375	0141	ST11897
		Tantalum, Solid				
CSR13	SPR, UCC	Hermetic, Cylindrical, Axial Leads, Polar	0.0047 - 330	6 - 100	0142	ST11700
		Tantalum, Wet				
135D/CLR79	SPR	Hermetic, Cylindrical, Axial Leads, Polar	1.7 - 1200	6 - 150	0143	ST11875
		Teflon Metallized				
J11B	CRC	Hermetic, Cylindrical, Axial Leads	0.001 - 2.0	50 at 125°C	0118	ST11584

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DIODES

APPLICATION NOTES

This list does not cover the entire spectrum of diodes available but is intended to apply to devices used for JPL projects. Diodes can be classified in use-oriented categories. These categories are:

1. General purpose rectifiers.
2. Power rectifiers.
3. Signal or switching diodes.
4. Voltage regulators.
   a. Zener.
   b. Precision reference.
5. Special purpose.
   a. Microwave.
   b. Optical.
   c. Current regulating.
6. Silicon controlled rectifier and silicon controlled switch.

The diode is a simple unilateral electrical device, analogous to a switch, conducting freely in the forward direction but very poorly in the reverse direction. Like the switch, the diode is frequently used as an isolation or disconnect device. The rectifier action, too, can be likened to a rapidly opening and closing switch, commutating an alternating current signal into a direct current signal.

Early construction and device materials were varied. The early radio detector of catwhisker and Galena crystal (the first point contact device widely used) was defined as a detector, not as a diode. The early power devices, in some cases still available, were of copper oxide or Selenium and were designated rectifiers, not diodes. The designation of diode stems from the two-element vacuum tube bearing that name. Materials and construction methods have rapidly become more sophisticated and the results accomplished today have greatly enhanced the usefulness of this simple device. Common among today's construction materials are Germanium, Silicon, Gallium Arsenide and Silicon Carbide. These basic materials are diffused or alloyed with other elements to achieve the desired operational results.

GENERAL PURPOSE RECTIFIERS

The general purpose rectifier diode is exactly what the name implies, a low-power rectifier with no special characteristics. The power capability of this type of part is equal to, or less than one watt. There is no specification of recovery time or of junction capacitance. This type of diode is usually inexpensive, though the quality and reliability may be excellent. In an application requiring merely a low-power rectification or low to medium voltage isolation in a circuit not sensitive to accumulated capacitance, this is a suitable device.

POWER RECTIFIERS

This classification covers a broad spectrum of part characteristics. One end of this distribution has parts with relatively low Peak Inverse Voltage (PIV), usually less than 1,000 volts, but with forward current capability of over 1,000 amperes. Conversely, there are parts with PIV as great as 200,000 volts but with only 100 milliamperes of forward current capability.

It must be remembered that the power rectifier will dissipate only a rated amount of power within its structure. This is manifested in the form of heat which must be conducted out of the part to avoid catastrophic part failure. The power dissipated is always the product of voltage and current. The sum of the high forward current-low forward voltage product, and the PIV-low leakage current product over the full cycle of rectification generates the heat involved.

Power rectifiers are not necessarily slow-recovery devices. Some devices within this classification recover within 10 nanoseconds and upwards. These parts can easily be classified as switching diodes and are frequently so listed.

DIODES

SIGNAL OR SWITCHING DIODES

Generally speaking, these are low operating voltage, low current, low junction capacitance and relatively fast recovery devices. Initially the DO7 package dominated the field in this type of diode. However, the trend in the manufacturing industry is now away from this package. Many manufacturers are now using the DO34 and DO35 package, with double heatsinks, no 'S' spring and, in some cases, no void within the package. This shift in packaging is being accomplished without degrading the operating characteristics of the diode. This new process produces diodes that tend to be, mechanically, a more reliable device.

VOLTAGE REGULATORS

Voltage regulator diodes, commonly known as Zener diodes have a useful reverse current-reverse voltage relationship. When reverse voltage less than the clamping voltage is applied to the junction, it behaves in the same manner as a normal diode with a low reverse leakage current. In this operating region the diode presents a high impedance. At a specified point in the voltage-current relationship, the impedance decreases greatly, the reverse current increases greatly and the diode clamps the voltage at this point. An increase or decrease of current, within reason, will have only minimal effect on the voltage appearing across the device. Usually, diode junctions which clamp at five volts or less are alloyed junctions. High voltage junctions are usually diffused. The lower voltage units have a negative temperature coefficient, while the diffused junctions have a positive temperature coefficient. The clamping voltage can be shifted slightly by varying the current through the diode; an increase in current will produce a slightly higher voltage.

The temperature compensated reference diode is constructed by combining a diffused zener chip and one to three standard diffused rectifier chips. The positive temperature coefficient of the zener and the negative temperature coefficient of the rectifier combine to reduce the overall temperature effect. Normally, the specified zener test current is placed at the crossover point and the result is zero, or very low, temperature coefficient over a given temperature range. Here, again, the clamped voltage may be shifted by adjusting current but this will move the operation away from the best temperature coefficient point. Extremely low current reference devices come in forms other than those described, often being either an integrated circuit or a transistor with the base lead disabled.

Power dissipation in zener diodes is the product of the voltage and the current. Each diode has a power rating dependent upon the thermal resistance of the package. The zener test current specified by the manufacturer is well below the capability of the package which will tolerate the specified maximum zener current, a much higher value. The zener diode can be derated in the conventional manner by following the manufacturer's published linear derating curve.

SPECIAL PURPOSE

The category of special purpose diodes includes low-usage devices, with good promise for future application. Prominent among these are the microwave families. Less well-know, but increasing in importance are the optical devices, both light emitting and light sensitive. Additionally, there is a certain interest in current limiting devices.

Microwave devices in general use are the Step-Recovery diode, the Hot-Carrier diode, the Gunn-effect diode, the Impatt diode, the Varactor diode, the Tunnel diode, the PIN diode and the Paramp diode. This is not an all-inclusive list, only a fair sample. The step-Recovery diode finds its greatest useable as a frequency multiplier. Great care is exercised to assure that this is a very non-linear device with a harmonic-rich output. The Varian Company refers to this type of device as a Bimode diode.

The Hot-carrier diode is a Schottky-barrier, silicon-metal junction device. This construction enables a majority-carrier operation with recovery time in the picosecond range. These devices are used as low-noise mixers, high-sensitivity small and large signal detectors, limiters, discriminators and balanced modulators. They work equally well from low to high frequencies well into the microwave range.

The Gunn-effect and Impatt diodes are basically oscillator or frequency-generator devices. The Gunn-effect is probably more flexible in application. The Impatt device operates in the avalanche mode of reverse-bias and will convert direct current energy directly into radio frequency energy.

The Tunnel diode is useful in low-power operations. It has a broad range of applications from basic oscillator through switching operations and on into amplification. This diode is characterized by a negative-resistance voltage-current portion of its operating curve. The Varactor and Paramp devices are variable capacitor devices. The junction capacity in any diode is an inverse function of reverse bias, however, this effect is emphasized in the varactor family and high Q tuning devices result.

DIODES

The PIN diode is a control and switching device. By proper adjustment of the direct current bias, the impedance of the device can be varied from the one-ohm region to the 15,000 ohm region, providing signal control over a broad range of frequencies. The diode is characterized by nanosecond turn-on and turn-off times, low junction capacitance and low series resistance.

Normally, optical devices are diodes as emitters, transistors as sensors. This, again, is subject to exception. The light source is ordinarily a Gallium-Arsenide junction, doped with Phosphorus. The light sensor is usually a silicon transistor with no base lead, the base current being supplied by incident photons.

The current limiting device resembles a diode only in that it has two leads. The internal structure is an N-channel field effect transistor with the gate electrically connected to the source, $V_{GS} = 0$. When operated within specified limits, the device appears as a constant-current direct current source in parallel with a high value resistance.

SILICON CONTROLLED RECTIFIERS AND SILICON CONTROLLED SWITCHES

These are four-layer devices which maintain both forward and reverse blocking when in an inoperative state. Both devices act in a manner similar to a relay, a small signal being capable of controlling large anode to cathode energy. The Silicon Controlled Rectifier (SCR) when turned on by the gate, will remain on until the anode to cathode current drops below a specified level known as the holding current. At this point conduction ceases and the device goes into a blocking state.

The Silicon Controlled Switch (SCS) operates in an identical manner. However, the provision of an additional gate allows turn off at any anode to cathode current. Usually, the SCS has only a small-signal capability in contrast to the SCR.

DIODES
RECTIFIER SELECTION CHART

PEAK INVERSE VOLTAGE (VOLTS) \ FORWARD CURRENT (AMPERES)	② 0.125 (0.14 DIA, 0.41 LONG)	① 1.0 SMALL A109	① 3.0 GLASS BODY	4.0 GLASS BODY	① 6.0 CATHODE STUD	① 7.5 CATHODE STUD	① 9.0 CATHODE STUD	① 12.0 CATHODE STUD	② 25-50 CATHODE STUD	75.0 CATHODE STUD
50			UTR3305	UTR4305	UTR4405	UTR5405	UTR6405	UT8105 1N1199A	1N1183 30FQ045	75HQ045
100			UTR3310	UTR4310	UTR4410	UTR5410	UTR6410	UT8110 1N1220A	1N1184	
150								1N1201A	1N1185	
200		1N5614	UTR3320	UTR4320	UTR4420	UTR5420	UTR6420	UT8120 1N1202A	1N1186 STF2	
300								1N3892 1N1203A	1N1187	
400		1N5616	UTR3340	UTR4340	UTR4440	UTR5440	UTR6440	UT8140 1N1204A	1N1188	
500			UTR3350	UTR4350				1N1205A	1N1189	
600		1N5618	UTR3360	UTR4360				UT8160 1N1206A	1N1190	
800		1N5620								
1000		1N5622								
4000	SCE 40									
5000	SCE 50									
7500	SCE 75									
10000	SCE 100									

Notes: ① For Qualified Parts Listing, see pages 12-21..
② Acceptable parts - not qualified, see pages 23-26.

DIODES

SCR AND SCC SELECTION GUIDE

PRV (VOLTS) \ TEMPERATURE / CURRENT I_F AVG (AMPERES)	T_A = 75°C		T_A = 100°C	T_C = 60°C	T_C = 65°C
	0.15	0.25		4.7	16
15	2N892 2N893		2N1875		
25				C11U (2N1770)	C35U (2N681)
30	2N894 2N895	2N3030	2N1876 2N1870A		
50				C11F (2N1771)	C35F (2N682)
60	2N896 2N897	2N3031	2N1877 2N1871A		
100	2N898 2N899	2N3032	2N1878 2N1872A	C11A (2N1772)	C35A (2N683)
150			2N1879	C11G (2N1773)	C35G (2N684)
200	2N900 2N901		2N1880 2N1874A	C11B (2N1774)	C35B (2N685)
250				C11H (2N1775)	C35H (2N686)
300				C11C (2N1776)	C35C (2N687)
400				C11D (2N1777)	C35D (2N688)
500				C11E (2N1778)	C35E (2N689)
600				C11M (2N2619)	C35M (2N690)
700					C35S (2N691)
800					C35N (2N692)

Note: For Qualified Parts Listing, see pages 12-21.

DIODES
ZENER SELECTION CHART

NOMINAL VOLTAGE \ WATTS	0.25 ALL DO-7 PKG	0.4 ALL DO-7 PKG	1.0 ALL DO-13 PKG	1.5 TRANSISTOR CAN	5.0 GLASS PKG	10.0 ① CS OR AS	50.0 ANODE STUD
1.8	MZ4614						
2.0	MZ4615						
2.2	MZ4616						
2.4	MZ4617						
2.7	MZ4618						
3.0	MZ4619						
3.3	MZ4620	1N746,A	1N3821,A				
3.6	MZ4621	1N747,A	1N3822,A				
3.9	MZ4622	1N748,A	1N3823,A				
4.3	MZ4623	1N749,A	1N3824,A				
4.7	MZ4624	1N750,A	1N3825,A				
5.1	MZ4625	1N751,A	1N3826,A				
5.6	MZ4626	1N752,A	1N3827,A				
6.2	MZ4627	1N753,A	1N3828,A				
6.8	1N4099,	1N754,A 1N957,A,B	1N3829,A 1N3016,A,B		UZ5706,806,906	UZ7706,806 CS 1N2970A,B AS	1N3305A,B
7.5	1N4100	1N755,A 1N958,A,B	1N3830,A 1N3017,A,B		UZ5707,807,907	UZ7707,807 CS 1N2971A,B AS	1N3306A,B
8.2	1N4101	1N756,A 1N959,A,B	1N3018,A,B		UZ5708,808,908	UZ7708,808 CS 1N2972A,B AS	1N3307A,B
8.7	1N4102						
9.1	1N4103	1N757,A 1N960,A,B	1N3019,A,B		UZ5709,809,909	UZ7709,809, CS 1N2973A,B AS	1N3308A,B
10.0	1N4104	1N758,A 1N961,A,B	1N3020,A,B		UZ5710,810,910	UZ7710,810 CS 1N2974A,B AS	1N3309A,B

① CS = cathode stud, AS = anode stud.

Note: For Qualified Parts Listing, see pages 12-21.

DIODES
ZENER SELECTION CHART (contd)

NOMINAL VOLTAGE \ WATTS	0.25 ALL DO-7 PKG	0.4 ALL DO-7 PKG	1.0 ALL DO-13 PKG	1.5 TRANSISTOR CAN	5.0 GLASS PKG	10.0 (1) CS OR AS	50.0 ANODE STUD
11.0	1N4105	1N962,A,B					1N3310A,B
12.0	1N4106	1N759,A 1N963,A,B	1N3021,A,B		UZ5712,812,912	UZ7712,812 CS 1N2975A,B AS	1N3311A,B
13.0	1N4107	1N964,A,B	1N3022,A,B		UZ5713,813,913	UZ7713,813 CS 1N2977A,B AS	1N3312A,B
14.0	1N4108		1N3023,A,B		UZ5714,814,914	UZ7714,814 CS 1N2978A,B AS	1N3313A,B
15.0	1N4109	1N965,A,B	1N3024,A,B		UZ5715,815,915	UZ7715,815 CS 1N2979A,B AS	1N3314A,B
16.0	1N4110	1N966,A,B	1N3025,A,B		UZ5716,816,916	UZ7716,816 CS 1N2980A,B AS	1N3315A,B
17.0	1N4111						1N3316A,B
18.0	1N4112	1N967,A,B	1N3026,A,B		UZ5718,818,918	UZ7716,818 CS 1N2892A,B AS	1N3317A,B
19.0	1N4113						1N3318A,B
20.0	1N4114	1N968,A,B	1N3027,A,B		UZ5720,820,920	UZ7720,820 CS 1N2984A,B AS	1N3319A,B
22.0	1N4115	1N969,A,B	1N3028,A,B		UZ5722,822,922	UZ7722,822 CS 1N2985A,B AS	1N3320A,B
24.0	1N4116	1N970,A,B	1N3029,A,B		UZ5724,824,924	UZ7724,824 CS 1N2986A,B AS	1N3321A,B
25.0	1N4117						
27.0	1N4118	1N971,A,B	1N3030,A,B		UZ5727,827,927	UZ7727,827 CS	
28.0	1N4119						
30.0	1N4120	1N972,A.B	1N3031,A,B	1N3800A,B	UZ5730,830,930	UZ7730,830 CS	
33.0	1N4121	1N973,A,B	1N3032,A,B	1N3801A,B	UZ5733,833,933	UZ7733,833 CS	
36.0	1N4122	1N974,A,B	1N3033,A,B	1N3802A,B	UZ5736,836,936	UZ7736,836 CS	
39.0	1N4123	1N975,A,B	1N3034,A,B	1N3803A,B			
40.0					UZ5740,840,940	UZ7740,840 CS	

(1) CS = cathode stud; AS = anode stud.

Note: For Qualified Parts Listing, see pages 12-21.

DIODES
ZENER SELECTION CHART (contd)

NOMINAL VOLTAGE \ WATTS	0.25 ALL DO-7 PKG	0.4 ALL DO-7 PKG	1.0 ALL DO-13 PKG	1.5 TRANSISTOR CAN	5.0 GLASS PKG	10.0 ① CS OR AS	50.0 ANODE STUD
43.0	1N4124	1N976,A,B	1N3035,A,B	1N3804A,B			
45.0					UZ5745,845,945	UZ7745,845 CS	
47.0	1N4125	1N977,A,B	1N3036A,B	1N3805A,B			
50.0					UZ5750,850,950	UZ7750,850 CS	
51.0	1N4126	1N978,A,B	1N3037,A,B	1N3806A,B			
56.0	1N4127	1N979,A,B	1N3038,A,B	1N3807A,B	UZ5756,856,956	UZ7756,856 CS	
60.0	1N4128				UZ5760,860,960	UZ7760,860 CS	
62.0	1N4129	1N980,A,B	1N3039,A,B	1N3808A,B			
68.0	1N4130	1N981,A,B	1N3040,A,B	1N3809A,B			
70.0					UZ5770,870,970	UZ7770,870 CS	
75.0	1N4131	1N982,A,B	1N3041,A,B	1N3810,A,B	UZ5775,875,975	UZ7775,875 CS	
80.0					UZ5780,880,980	UZ7780,880 CS	
82.0	1N4132	1N983,A,B	1N3042,A,B	1N3811A,B			
87.0	1N4133						
90.0					UZ5790,890,990	UZ7790,890 CS	
91.0	1N4134	1N983,A,B	1N3043,A,B	1N3812A,B			
100.0	1N4135		1N3044,A,B	1N3813A,B	UZ5110,210,310	UZ7110,210 CS	
110.0			1N3045,A,B	1N3814A,B	UZ5111,211,311		
120.0			1N3046A,B	1N3815A,B	UZ5112,212,312		
130.0			1N3047A,B	1N3816A,B	UZ5113,213,313		
140.0					UZ5114,214,314		
150.0			1N3048A,B	1N3817A,B	UZ5115,215,315		
160.0			1N3049A,B	1N3818A,B	UZ5116,216,316		
170.0					UZ5117,217,317		
180.0			1N3050A,B	1N3819A,B	UZ5118,218,318		
190.0					UZ5119,219,319		
200.0			1N3051A,B	1N3820A,B	UZ5120,220,320		
220.0					UZ5122,222,322		
240.0					UZ5124,224,324		

① CS = cathode stud; AS = anode stud.

Note: For Qualified Parts Listing, see pages 12-21.

DIODES
TEMPERATURE COMPENSATED PRECISION REFERENCE SELECTION CHART

VOLTS \ WATTS	0.25	0.4	0.5	0.6	0.75
6.0	5.90	6.08		6.365	
	1N821A, 23A 25A, 27A, 29A DO-7	1N4565, A through 1N4584, A DO-7		FCT 1021, 22, 25 FCT 1121, 22, 25 TO-18	
7.0	6.50	6.72		7.035	
8.0			8.55		8.835
9.0			1N935, A, B through 1N940, A, B DO-7		1N2620, A, B through 1B2624, A, B DO-13
10.0			9.45		9.765
11.0			11.12		
			1N941, A, B through 1N946, A, B DO-7		
12.0			12.28		

Note: For Qualified Parts Listing, see pages 12-21.

DIODES
QUALIFIED DIODES

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS				SCRN SPEC ZPP-2073-	DRAWINGS
		Computer and Signal	I_0 (mA)	PIV (Volts)	I_R at PIV (μA)	Case		
*FD306	FAS		150	125	1.0 (1)	Glass, Subminiature	0330	ST 11705
*FD643	FAS		200	60	100 (1)	Glass, Subminiature	3007	ST 11706
*DJ1896	GEC		200	60	100 (1)	Glass, Subminiature	3007	ST 11707
*1N662	FAS		40	100		Glass, Subminiature	3054	ST 11708
		Switching						
1N4148	FAS, GEC		150	75	25 nA	Glass, Subminiature	0305	PT 40015
1N5711	HPA	Schottky	33	50	200 nA	Glass, Subminiature	3082	PT 40427
B2D914	TIX	Beam Lead	75	75			--	--
		Step Recovery						
*5082-0180	HPA			50				ST 11730
*5082-0181	HPA			65			Vendor	ST 11730
*5082-0240	HPA			65			Screened	ST 11730
*5082-0241	HPA			65				ST 11730

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

(1) At 150°C ambient temperature.

DIODES
QUALIFIED DIODES (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS: I_0 at 55°C (Amps)	CHARACTERISTICS: PIV (Volts)	CHARACTERISTICS: I_R at PIV (µA)	CHARACTERISTICS: Case	SCRN SPEC ZPP-2073-	DRAWINGS
		General Purpose Rectifier						
*1N5614	SET		1.0	200	0.5	Metoxilite	3046	ST 11841
*1N5616	SET		1.0	400	0.5	Metoxilite	3046	ST 11841
*1N5618	SET		1.0	600	0.5	Metoxilite	3046	ST 11841
*1N5620	SET		1.0	800	0.5	Metoxilite	3046	ST 11841
*1N5622	SET		1.0	1000	0.5	Metoxilite	3046	ST 11841
*1N5550	SET		3.0	200	0.5	Metoxilite	3078	ST 11862
*1N5551	SET		3.0	400	0.5	Metoxilite	3078	ST 11862
*1N5552	SET		3.0	600	0.5	Metoxilite	3078	ST 11862
*1N5553	SET		3.0	800	0.5	Metoxilite	3078	ST 11862
*1N5554	SET		3.0	1000	0.5	Metoxilite	3078	ST 11862
*1N1199A through 1N1206A	GEC		12.0 (1)	50-600	1.0 mA (1)	Stud	3017	ST 11711
*UT8100 Series	UTR		12.0 at 25°C	50-600	10	Stud	3004	ST 11557
		Fast Recovery Rectifier						
*UTR3300 Series	UTR		3.0 at 25°C	50-600	5	Body B	3013	ST 11714
*UTR6400 Series	UTR		9.0 at 25°C	50-400	10	Stud	3014	ST 11552
*UTR4300 Series	UTR		4.0 at 25°C	50-600	5	Body B	3074	ST 11592

Notes:

(1) At 150°C case temperature.

* Indicate choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

DIODES
QUALIFIED DIODES (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS				SCRN SPEC ZPP-2073-	DRAWINGS
		Fast Recovery Rectifier	I_O at 55°C (Amps)	PIV (Volts)	I_R at PIV (μA)	Case		
*1N5415	SET		3.0	50	1.0	Metoxilite	3059	ST 11864
*1N5416	SET		3.0	100	1.0	Metoxilite	3059	ST 11864
*1N5417	SET		3.0	200	1.0	Metoxilite	3059	ST 11864
*1N5418	SET		3.0	400	1.0	Metoxilite	3059	ST 11864
*1N5419	SET		3.0	500	1.0	Metoxilite	3059	ST 11864
*1N5615	SET		1.0	200	0.5	Metoxilite	3058	ST 11863
*1N5617	SET		1.0	400	0.5	Metoxilite	3058	ST 11863
*1N5619	SET		1.0	600	0.5	Metoxilite	3058	ST 11863
*1N5621	SET		1.0	800	0.5	Metoxilite	3058	ST 11863
*1N5623	SET		1.0	1000	0.5	Metoxilite	3058	ST 11863
*1N3892A	MOT		12.0	300	3.0 mA (1)	Stud	3006	ST 11712

Notes:

(1) At 100°C case temperature.

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

DIODES
QUALIFIED DIODES (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS			SCRN SPEC ZPP-2073-	DRAWINGS
		Radiation Tolerant Rectifier	I_O at 55°C (Amps)	PIV (Volts)	I_R at PIV (μA)		
UR105	UTR		1.0	50	3	--	
UR110	UTR		1.0	100	3	--	
UR115	UTR		1.0	150	3	--	
UR120	UTR		1.0	200	3	--	
UR125	UTR		1.0	250	3	--	
UR205	UTR		2.0	50	3	--	
UR210	UTR		2.0	100	3	--	
UR215	UTR		2.0	150	3	--	
UR220	UTR		2.0	200	3	--	
UR225	UTR		2.0	250	3	--	
		Radiation Tolerant Rectifier Fast Recovery					
UR710	UTR		1.0	100	0.5	--	
UR720	UTR		1.0	200	0.5	--	

DIODES
QUALIFIED DIODES (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS			SCRN SPEC ZPP-2073-	DRAWINGS
		Reference	V_Z (Volts)	I_Z (mA)			
*1N821A through 1N827A and 1N829A	MOT MOT	Precision	6.2	7.5	See note (2)	0306	ST 11724
1N935, A, B and 1N940, A, B	MOT	Precision	9.0	7.5	See note (2)	0368	ST 11725
*1N2620, A, B through 1N2624, A,B	MOT	Precision	9.3	10.0	See note (2)	0310	ST 11726
					Power Dissipation (mW)		
*1N941, A, B through 1N946 A, B	SIE	Precision	11.7	7.5	500	3019	ST 11727
*1N4565, A through 1N4584 A	MOT	Precision	6.4	0.5-4.0	400	0398	ST 11728
*FCT1021, FCT1022, FCT1025	FAS	Precision	6.7	0.1	See note (1)	0379	ST 11722
FCT1121 FCT1122, FCT1125	FAS	Precision	6.2	0.1	See note (2)	0379	ST 11722
*PC1 300A through PS1 314A	TRW	Precision	6.5	50/100/250		3040	ST 11861

Notes:

(1) Over temperature range of 0 to 100°C.

(2) Over temperature range of -55 to 100°C.

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

DIODES
QUALIFIED DIODES (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS			SCRN SPEC ZPP-2073-	DRAWINGS
		Zener	V_Z (Volts)	I_Z (mA)	Power Dissipation (Watts)		
*1N746A through 1N759A	MOT	Voltage Regulator	3.3-12.0	20	400 mW	0304	ST 11715
*1N957A, B through 1N984A, B	MOT	Voltage Regulator	6.8-91.0	1.4-18.5	400 mW	0377	ST 11716
*1N2970A, B through 1N2986A, B	MOT	Voltage Regulator	6.8-24	105-370	10.0	3012	ST 11718
*1N3016A, B through 1N3051A, B	MOT	Voltage Regulator	6.8-200	1.2-37	1.0	0320	ST 11717
*1N3305A, B through 1N3321A, B	MOT	Voltage Regulator	6.8-24	520-1850	50.0	3010	ST 11719
*1N3800 B through 1N3820A, B	MOT SIE	Voltage Regulator	30-200	1.9-12	1.5	3022	ST 11720
*1N3821A, through 1N3830A	MOT	Voltage Regulator	3.3-7.5	34-76	1.0	3020	ST 11721
1N4614 through 1N4627	MOT	Voltage Regulator	1.8-6.2	250 μA	0.250	3032	PT 40434
1N4099 through 1N4135	MOT	Voltage Regulator	6.8-100	250 μA	0.250	3032	ST 11860
*UZ5806 through UZ5890 and UZ5210 through ① UZ5240	UTR	Voltage Regulator	6.8-400	3-175	5	3005	ST 11729
*UZ7806 through UZ7890 and UZ7210 ①	UTR	Voltage Regulator	6.8-100	20-350	10	3081	ST 11558

Notes:

① UZ5806 and UZ7210 are 10% parts. For 5% tolerance reduce second digit in the part number by 1, UZ5806 becomes UZ5706, UZ7210 becomes UZ7110. Conversely, for 20% parts increase the second digit in the part number by 1. For example, UZ5806 becomes UZ5906 for a 20% part.

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

DIODES
QUALIFIED DIODES (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS				SCRN SPEC ZPP-2073-	DRAWINGS
		Field Effect	V_T (Volts)	I_P max (mA)	P_D max (mW)			
*1N5283 through 1N5314	MOT	Current Regulating	25	0.242-5.17	600		3048	ST 11731
		Diode Array	I_O (mA)	PIV (Volts)	I_R at PIV at 25°C (nA)	Case		
BC996 ①	TIX		15	30	100	TO-84	3043	ST 11880
BC997 ①	TIX		28	30	100	TO-84	3043	ST 11678
BC1042 ①	TIX		15	40	100	TO-84	3066	ST 11881
BC1043 ①	TIX		15	40	100	TO-84	3066	ST 11882
TID23A ①	TIX		25	40	100	TO-89	3044	ST 11879

Notes:

① Values given are for each diode in the array.

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

DIODES
QUALIFIED CONTROLLED RECTIFIERS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
			P_{RV} & V_{BO} (Volts)	I_R at P_{RV} & I_S at V_{BO} (max)	I_H (mA)	V_{GT} (Volts)	I_{GT} (μA max)	Case		
*2N3030 through *2N3032	UTR	Silicon PNPN	30-100	100 nA	0.3 to 4.0 ①	0.44 to 0.6	-5 to 20	TO-18	0717	ST 11555
*2N1870A *2N1871A *2N1872A and *2N1874A	UTR	Silicon PNPN	30-200	10 μA	0.3 to 5.0	0.4 to 0.8	200	TO-9	0716	ST 11553
*2N1770 through *2N1778 and *2N2619 (C11 Series)	GEC	Silicon PNPN	25-600	9 mA to 2 mA	8.0 max	2.0 max	15 mA max	TO-64	0719	ST 11703
*2N681 through *2N692 (C35 Series)	GEC	Silicon PNPN	25-800	13 mA to 4 mA	100 max	3.0 max	40 mA max	TO-48	0718	ST 11704
*2N1875 through *2N1880	UTR	Silicon PNPN	15-200	10 μA	3.0	0.6	20	TO-9	0716	ST 11554

① I_C = -150 μA

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

DIODES
QUALIFIED CONTROLLED RECTIFIERS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS					SCRN SPEC ZPP-2073-	DRAWINGS
			PRV (Volts)	I_{RX}/I_{FX} (μA)	I_{H} max (μA)	V_{GT} max (Volts)	I_{GT} max (μA)		
*2N892 through *2N901	UTR	Silicon PNPN	15-200	10	--	0.70	50	0701	ST 11556
*3N86	GEC	Silicon PNPN	65	1.0	200	0.65	1.0	0715	ST 11842

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

DIODES
QUALIFIED OPTICAL DEVICES

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS	SCRN SPEC ZPP-2073-	DRAWINGS
* TIL23	TIX	Optical	I_F = 50 mA, P_o = 0.4 mW min	3037	ST 11732
* TIL24	TIX	Optical	I_F = 50 mA, P_o = 1.0 mW min	3037	ST 11732

Note:

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

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DIODES
ACCEPTABLE DIODES

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS				SCRN SPEC ZPP-2073-	DRAWINGS
		Power	I_O (Amps)	PIV (Volts)	I_R at PIV (mA)	Case		
1N1183	GEC		35	50	10 *	Stud	3008	ST 11710
1N1184	GEC		35	100	10 *	Stud	3008	ST 11710
1N1185	GEC		35	150	10 *	Stud	3008	ST 11710
1N1186	GEC		35	200	10 *	Stud	3008	ST 11710
1N1187	GEC		35	300	10 *	Stud	3008	ST 11710
1N1188	GEC		35	400	10 *	Stud	3008	ST 11710
1N1189	GEC		35	500	10 *	Stud	3008	ST 11710
1N1190	GEC		35	600	10 *	Stud	3008	ST 11710
STF2	SET		50	200	13 µA	Stud	3086	PT 40488
SCE 40	SET		100 mA	4000	1.0 µA	Axial	3042	
SCE 50	SET		100 mA	5000	1.0 µA	Axial	3042	
SCE 75	SET		100 mA	7500	1.0 µA	Axial	3042	
SCE 100	SET		100 mA	10000	1.0 µA	Axial	3042	
		Schottky Power						
30FQ045	IRC		30	45	8 **	Stud	3111	
75HQ045	IRC		75	45	15 **	Stud	3111	

* At $T_C = 140^\circ C$

** At $T_J = 100^\circ C$

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DIODES
ACCEPTABLE DIODES (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS				SCRN SPEC ZPP-2073-	DRAWINGS
		Rectifier Fast Recovery	I_O 25° C Amps	PIV (Volts)	I_R at PIV (mA)	T_{rr} (ns)		
1N6073	SET		1.5	50	1.0	30	3105	
1N6074	SET		1.5	100	1.0	30	3105	
1N6075	SET		1.5	150	1.0	30	3105	
1N6076	SET		3.0	50	5.0	30	3105	
1N6077	SET		3.0	100	5.0	30	3105	
1N6078	SET		3.0	150	5.0	30	3105	
1N6079	SET		5.0	50	10.0	30	3105	
1N6080	SET		5.0	100	10.0	30	3105	
1N6081	SET		5.0	150	10.0	30	3105	
		Optical						
OP133	OPI		I_F = 100 mA, P_o = 5.0 mW min				3101	

DIODES
ACCEPTABLE CONTROLLED RECTIFIERS

PART NUMBER	VENDOR	TYPE				SCRN SPEC ZPP-2073-	DRAWINGS
		Varactor	V_{BR} (Volts)	Capacitance (pF)	P_D 25° C (mW)		
1N4801B	TRW		100	6.8	600	3097	
1N4802B	TRW		100	8.2	600	3097	
1N4803B	TRW		100	10.0	600	3097	
1N4804B	TRW		100	12.0	600	3097	
1N4805B	TRW		100	15.0	600	3097	
1N4806B	TRW		90	18.0	600	3097	
1N4807B	TRW		90	22.0	600	3097	
1N4808B	TRW		65	27.0	600	3097	
1N4809B	TRW		60	33.0	600	3097	
1N4810B	TRW		55	39.0	600	3097	
1N4811B	TRW		50	47.0	600	3097	
1N4812B	TRW		40	56.0	600	3097	
1N4813B	TRW		30	68.0	600	3097	
1N4814B	TRW		20	82.0	600	3097	
1N4815B	TRW		20	100.0	600	3097	

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DIODES

ACCEPTABLE DIODES

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		SCR	P_{RV} & V_{BO} (Volts)	I_R at P_{RV} & I_S at V_{BO} (max)	I_H (mA)	V_{GT} (Volts)	I_{GT} (μA max)	Case		
C11DR491	GEC		400	2 mA	10-25	2.0 max	15 mA	Stud	0720	PT 40023
C35DR999	GEC		400	8 mA	10 min	0.25-3.0	40 mA	Stud	0721	PT 40022

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INDEX OF FILTERS

Part Number	Page
APPLICATION NOTES	1 - 2
1250 - 700	3
3112 - 001F	3

FILTERS, EMI/RFI

APPLICATION NOTES

There are basically four types of filters in this category. The devices are usually designed for bulkhead mounting (feedthrough), with the body used as the ground terminal. The common types are:

a. Single element (L or C).

b. Two element (L and C). This device is available in both LC, and CL configurations. It is defined by the input reactance element.

c. Three element (C, L, C) "Pi" type.

d. Three element (L, C, L) "T" type.

Selection of a filter depends primarily on the desired slope of the insertion loss/frequency curve. It should be remembered that the standard method of measuring insertion loss (MIL-STD-220) is comparing the input voltage of a 50-ohm line to the input voltage measured when the filter is inserted in the line. Such a measurement does not indicate actual performance in the applications where the matched impedances are greater, or less than 50 ohms, or the input and output impedances are unbalanced. For a given set of conditions, the performance of a filter can be determined by measuring the attenuation of the device at the operating frequency. Attenuation is determined by the ratio of the input/output voltage.

TYPICAL APPLICATIONS

Single element (C). This device is used where a steep attenuation slope is not required and where source impedances are relatively high. The slope of the insertion loss/frequency curve approximates 20 dB per decade.

FILTERS

TYPICAL APPLICATIONS (contd)

Two element (LC or CL). This device is useful in systems where the source and load impedance are unbalanced, or where a low source or load impedance exists. Maximum attenuation is obtained when the device is installed with the inductive element toward the low impedance. The slope of the insertion loss/frequency curve approximates 40 dB per decade.

Three element "Pi" filters are used in relatively high impedance systems. They are also useful where the source and load impedances vary from low to high values as a function of circuit performance. The effectiveness of a Pi filter is quite dependent on the design frequency. The slope of the insertion loss/frequency curve approximates 60 dB per decade.

Three element "T" filters are used in relatively low impedance systems. Unbalance between source and load impedance has little effect. Insertion loss measurement in a 50-ohm system is somewhat irrelevant since the device has a much higher effectiveness in impedance systems nearer 1 ohm. The slope of the insertion loss/frequency curve approximates 60 dB per decade.

NOTES

At frequencies in and above the MHz range, attached leads add inductance to the network and alter the filter characteristics.

It is particularly important when the part is fastened to the ground plane by mechanical means to miminize any series resistance that may exist at that point. Resistances in the order of 2 milliohms can have a significant effect on the characteristic of the device.

FILTERS
QUALIFIED FILTERS EMI/RFI

Part Number	Vendor	Type	Characteristics	Screen Spec ZPP-2073-	Drawings
1250-700	ERI	Feed Thru	Pi Section	0153	TBA
3112-001F	SCL	Feed Thru	L Type	0153	PT 40752

INDEX OF FUSES

Part Number	Vendor	Page
APPLICATION NOTES		1 through 12
GPN	Bussman	13
265 Series	Littlefuse	13

FUSES

APPLICATION NOTES

CURRENT RATING

A fuse, operating at its rated current, consumes some electrical power which it must dissipate in the form of heat. When operating above its rated current, a fuse must operate or "blow", which simply means that the fuse element has melted because of the additional heat. Fuses, therefore, are heat operated and heat sensitive devices.

Assuming the rated current of a fuse as 100 percent, then the performance of fuses at "percent of rated current" conditions can conveniently be described. All fuses in most catalogs are rated so that at 110 percent of rating the temperature rise (from room temperature) at the hottest point on the fuse will not exceed $70^{\circ}C$. This temperature rise measurement is made in a single clip mounting as shown on Figure 1, and with the mounted fuse open to convection currents of air. The clips in the fuse mounting are silver plated and tight, and the temperature rise may be measured with a thermocouple as shown on Figure 2. Under other conditions of mounting, or at other ambient environments, the rating of a fuse must be adjusted up or down to allow for the added or subtracted heat provided by the mounting or environment conditions. We call this uprating or derating and provide more information in a later section.

Fuses in most catalogs can be operated at rated current for long periods of time and will blow at 135, 150 or 200 percent of rating, depending on the particular fuse as shown in the catalog tables. The time required for the fuse to blow at the "will blow" currents may be as long as one hour, but will usually be within 15 minutes. Other blowing time characteristics of fuses are described in a later section.

FUSES

VOLTAGE RATING

A fuse can be operated at any circuit voltage as long as the fuse is able to blow without suffering arc damage, and as long as it is mounted in a sufficiently well insulated holder. When a fuse blows, there is always a sharp break in the ciruit current which causes full circuit voltage to appear across the blown fuse, and in circuits where inductance is present, the voltage across the fuse may be substantially increased by inductive "kick". Under these conditions, a destructive electric arc may be formed within the fuse and continue to grow in size until the intense heat and pressure within the fuse cause it to literally explode.

All 125 and 250 volt fuses in most catalogs are given a very conservative voltage rating, referred to as "approved voltage". This means that the fuses can be subjected to a full short circuit test at this voltage when connected with heavy copper conductors to a generator which can supply at least 10,000 amperes of current, and under these conditions the fuses will not shatter or emit flame or molten metal. In many practical circuit applications the amount of short circuit current which can flow through a fuse is limited by connector plugs, circuit wires, switches, transformers, or other components to values which are not destructive to the fuse.

BLOWING TIME CHARACTERISTICS

When a current larger than the rating is suddenly applied to a fuse, it begins to heat up and, after a period of time it "blows". This "blowing time" depends on the percent of rated current and on the thermal inertia of the fuse. "Slo-Blo" fuses are constructed with the thermal inertia of the fuse element made large so that the blowing time of the fuse is increased. Fast blowing or instrument fuses are made with the smallest, lightest possible fuse element to reduce the thermal inertia and speed up the blowing time. Other fuses with rather bulky fuse elements or powder filled fuses will have medium blowing times.

FUSES

The following figures are typical of the blowing time ranges to be expected of the three classes of fuses when tested at 200 percent of rating.

a. Fast - Less than one second.
b. Medium - 1 to 10 seconds.
c. Slow - Over 10 seconds.

The curves shown on Figure 3 are also typical of these three classes of fuses. Curves for the fuses qualified to this Preferred Parts List are shown in Figures 5 to 8. These fuses are "Fast Blowing" types.

SELECTION OF BLOWING TIME

In selecting the blowing time characteristic of a fuse, the transient or surge characteristics of the circuit as well as the steady state values must be considered. If currents of 200-400 percent of normal can flow during periods of 1 to 10 seconds, then a Slo-Blo fuse should be used to avoid nuisance blowing. Typical applications for Slo-Blo fuses include circuits involving motor starting currents, capacitor charging currents, or switching transients.

If normal currents in the circuit are limited to 200 percent of rating and can flow for less than one second, then a medium blowing fuse can be used. If the circuit requires fast protection on any current above normal, then the best choice is a fast acting fuse. Typical applications are meter protection and for protecting power transistors.

DERATING OR UPRATING

Figure 4 gives data on the change in fuse rating which will occur (at sea level) at various ambient temperatures, as explained in the section on fuse current rating. The three characteristic curves, A, B and C apply to fuses that use low, medium or high melting temperature elements. It is often desirable to have a fuse uprate or derate at various temperatures because the equipment protected by a fuse will similarly uprate or derate in its ability to dissipate heat safely.

FUSES

Further derating from sea level ratings may be required for vacuum operation of fuses. Figure 9 gives data on vacuum blowing of Bussman GPN (GFA) fuses.

The best practice for applications at sea level is to select a fuse rating which allows for a 50 percent derating in the expected environment and for increased reliability. In other words, a fuse should normally be operated at about 50 percent of its rating or expected blow value, and it will then provide the best balance between protection and reliability.

MILITARY SPECIFICATIONS

A complete line of military approved fuses and holders are available in accordance with the following specifications:

a.	MIL-F-15160D	Fuses (Navy)
b.	MIL-F-19207	Fuseholders (Navy)
c.	MIL-F-23419	Fuses Miniature
d.	MIL-F-19207/27, `28, `29	Fuseholders Miniature
e.	MIL-F-21346	Clips

These specifications govern the construction and performance of fuses and fuseholders so they are generally suitable for military applications.

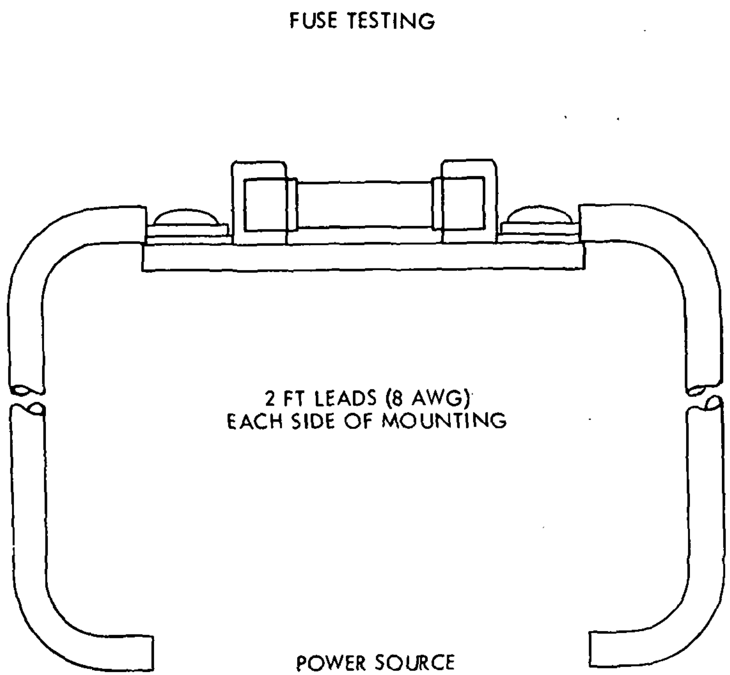

Figure 1. Temperature Rise Measurement

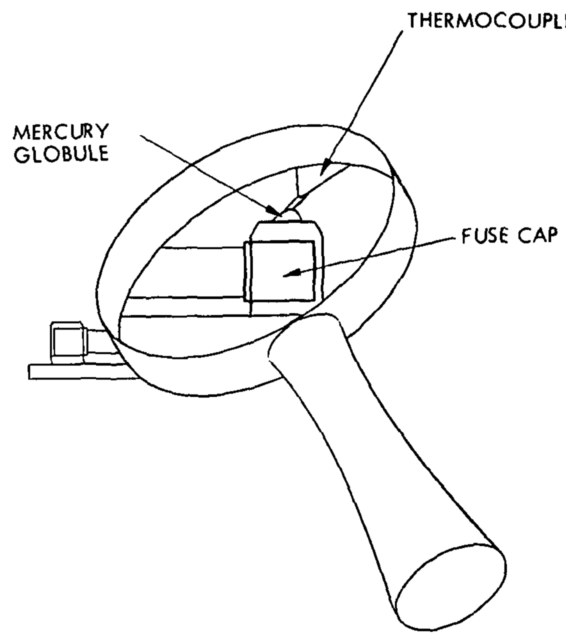

Figure 2. Thermocouple Measurement

FUSES

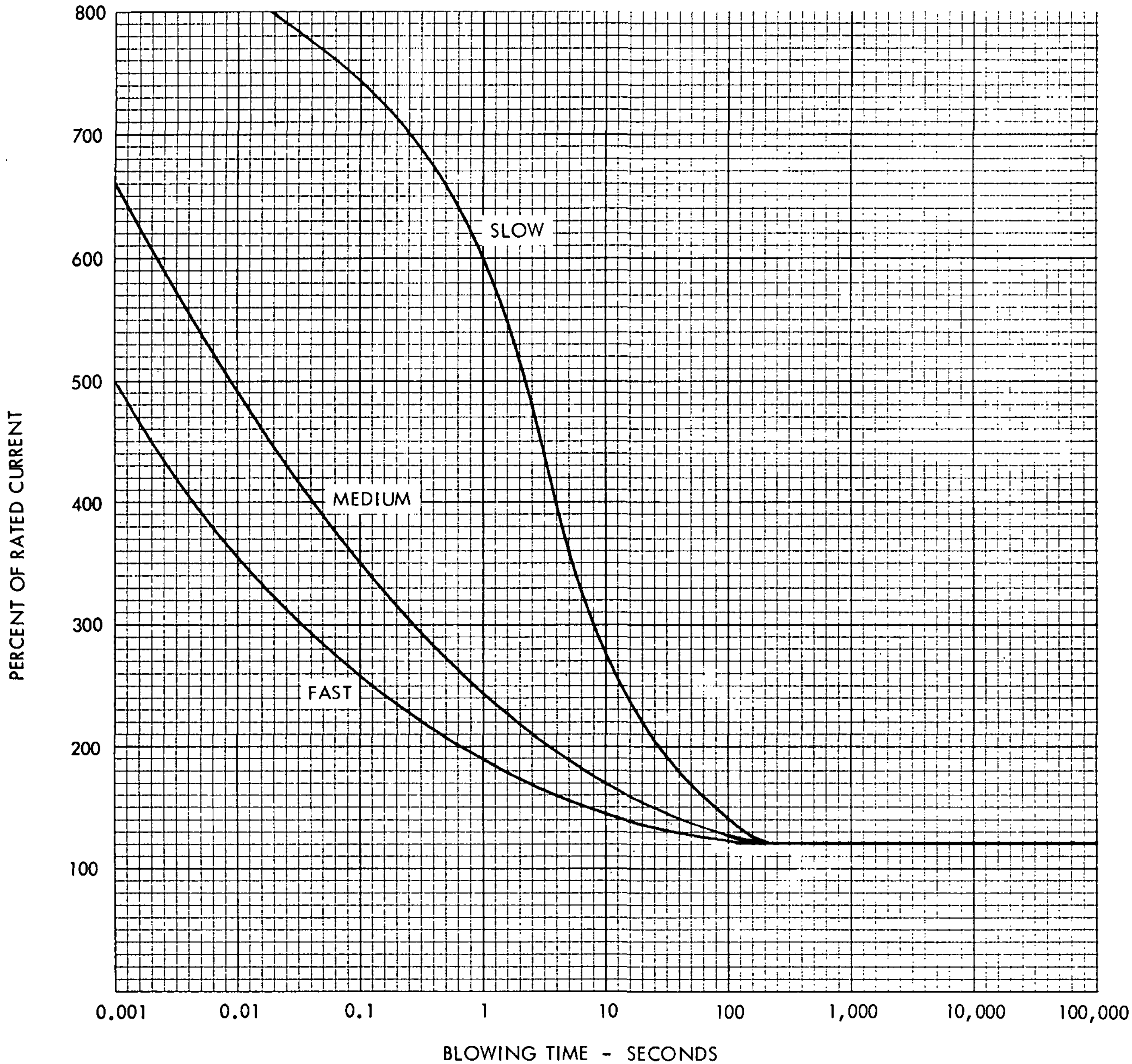

Figure 3. Fast, Medium and Slow Blowing Fuses

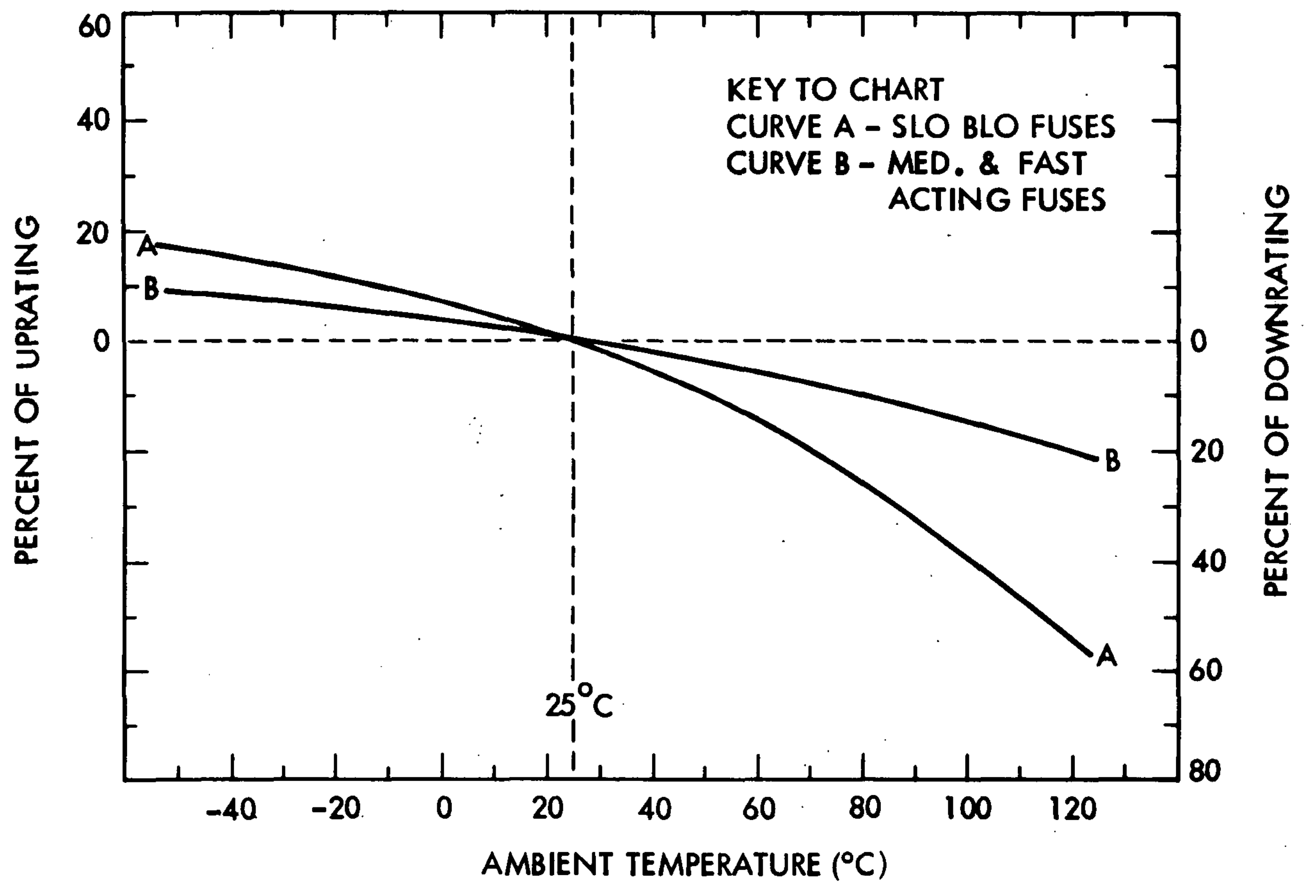

Figure 4. Chart Showing Effect of Ambient Temperature on Current-Carrying Capacity

FUSES

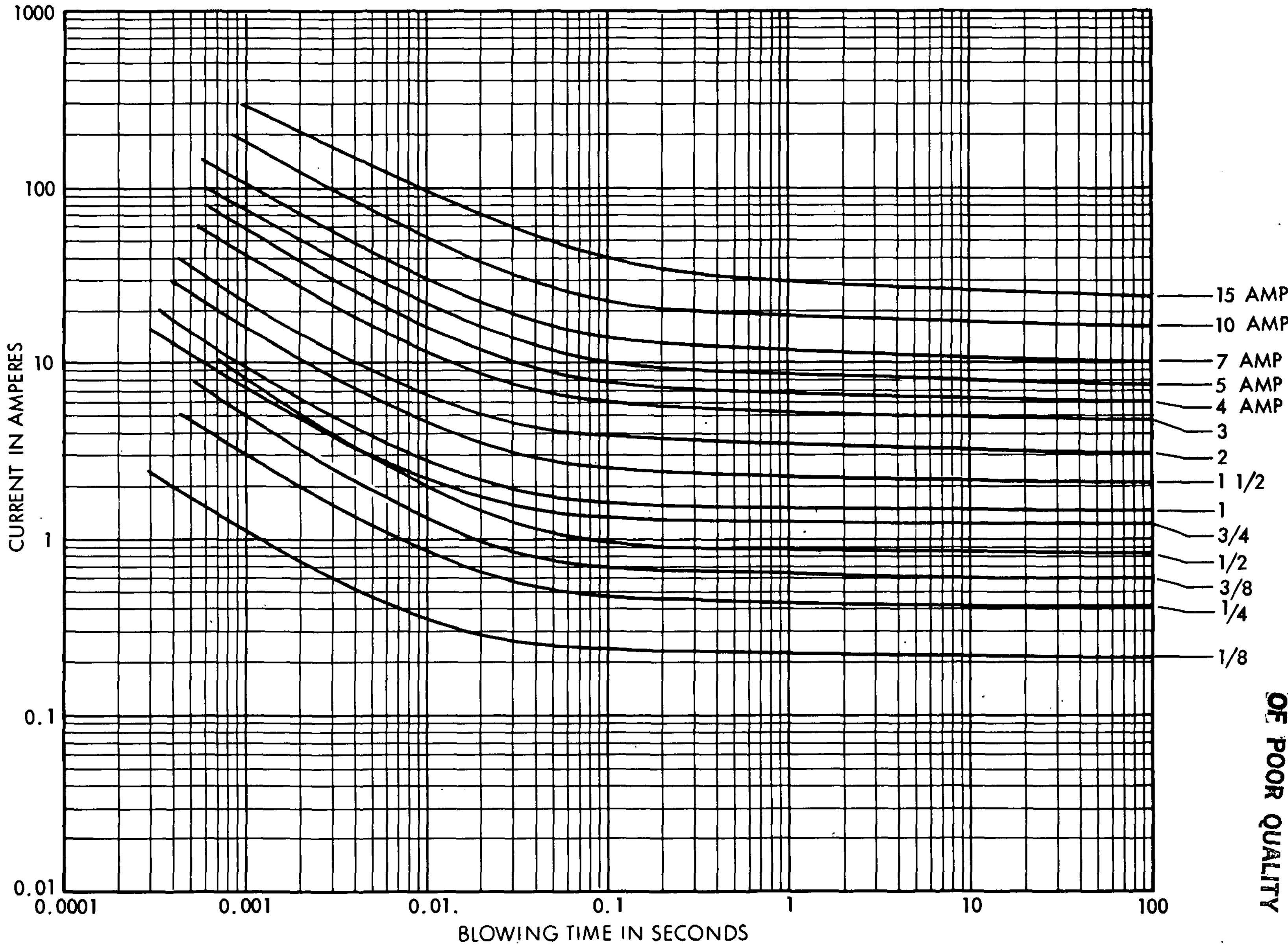

Figure 5. Pico Fuses, Series 265 (Littlefuse)

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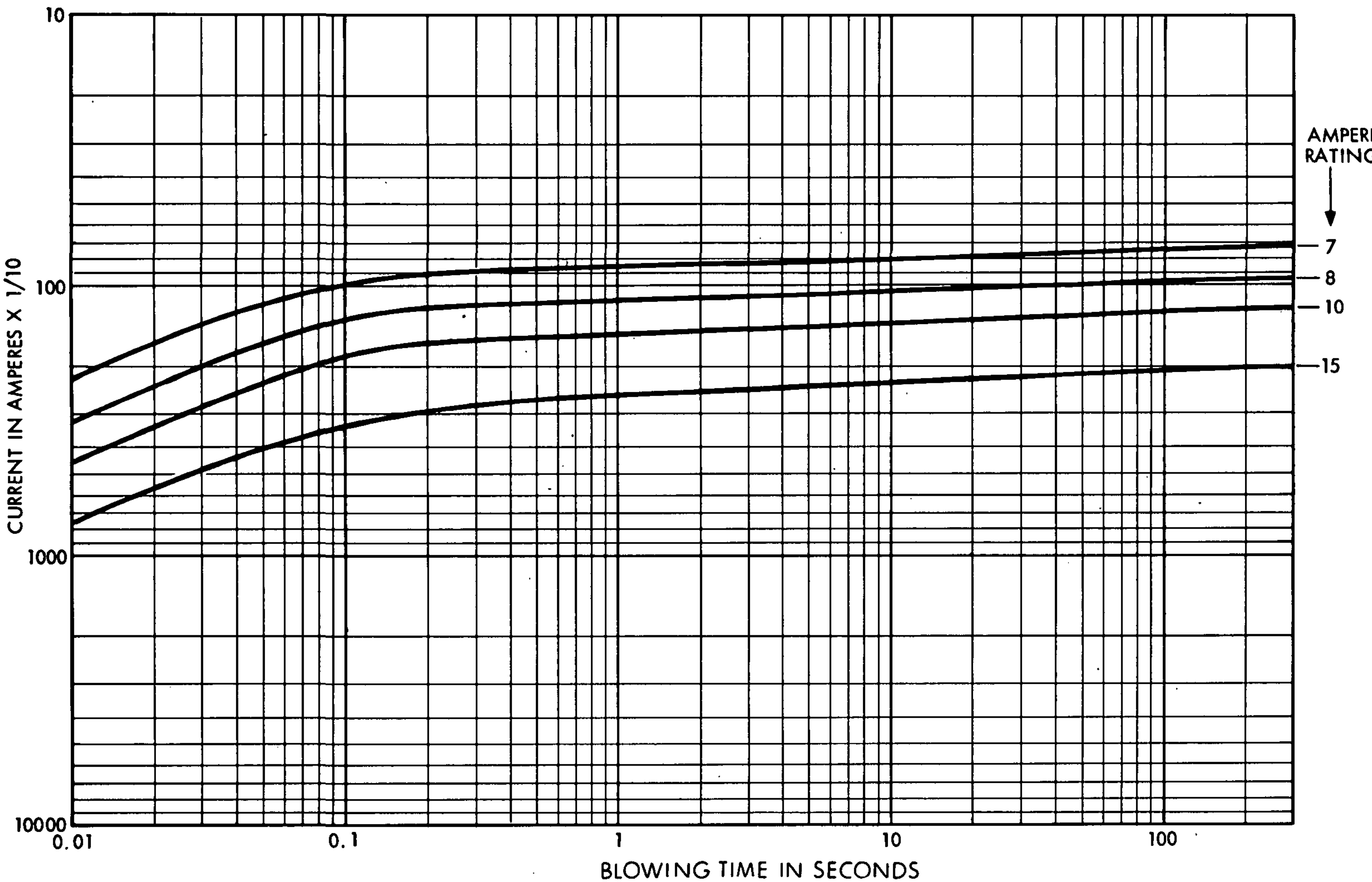

Figure 6. GPN (Bussman)

FUSES

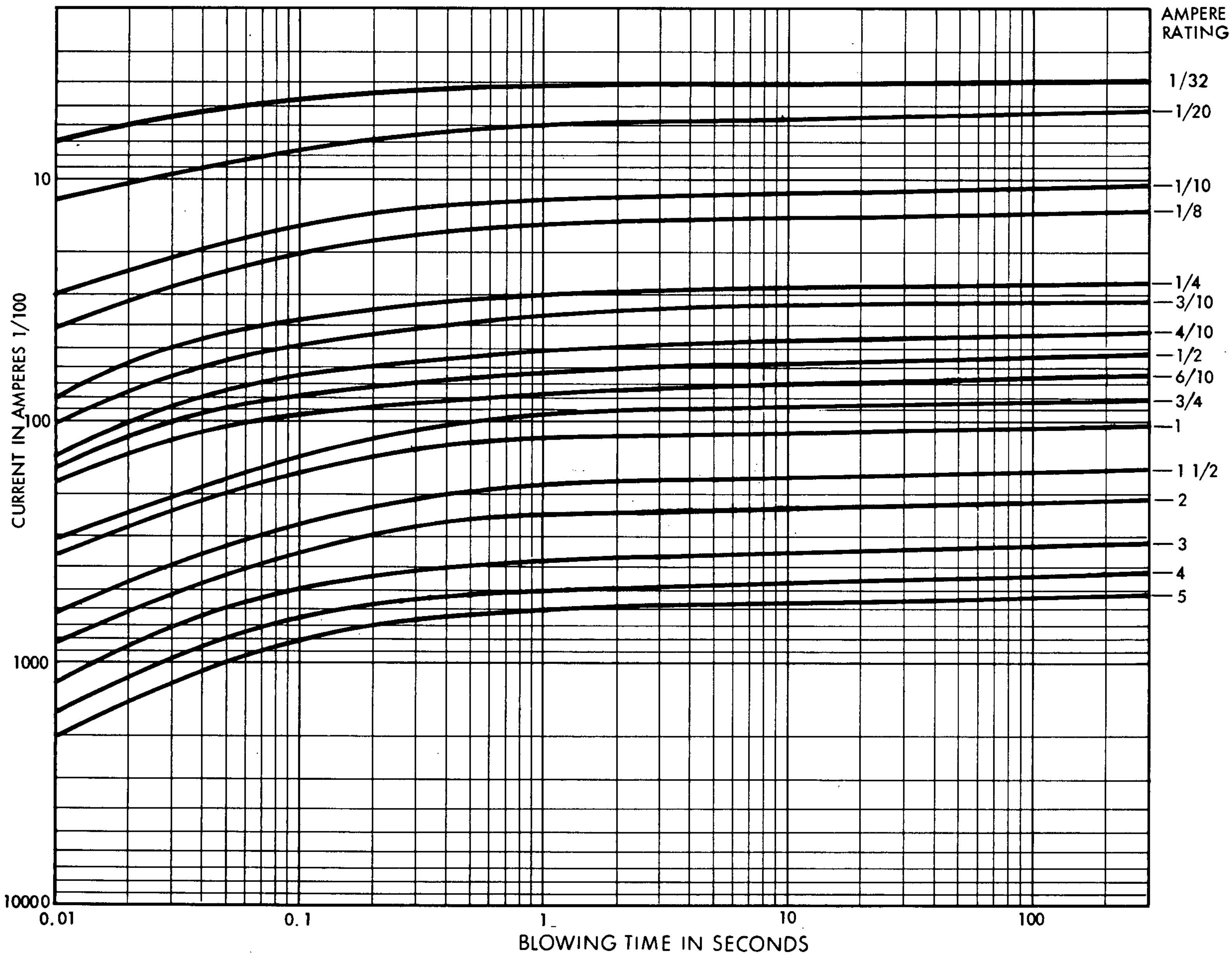

Figure 7. GPN (Bussman)

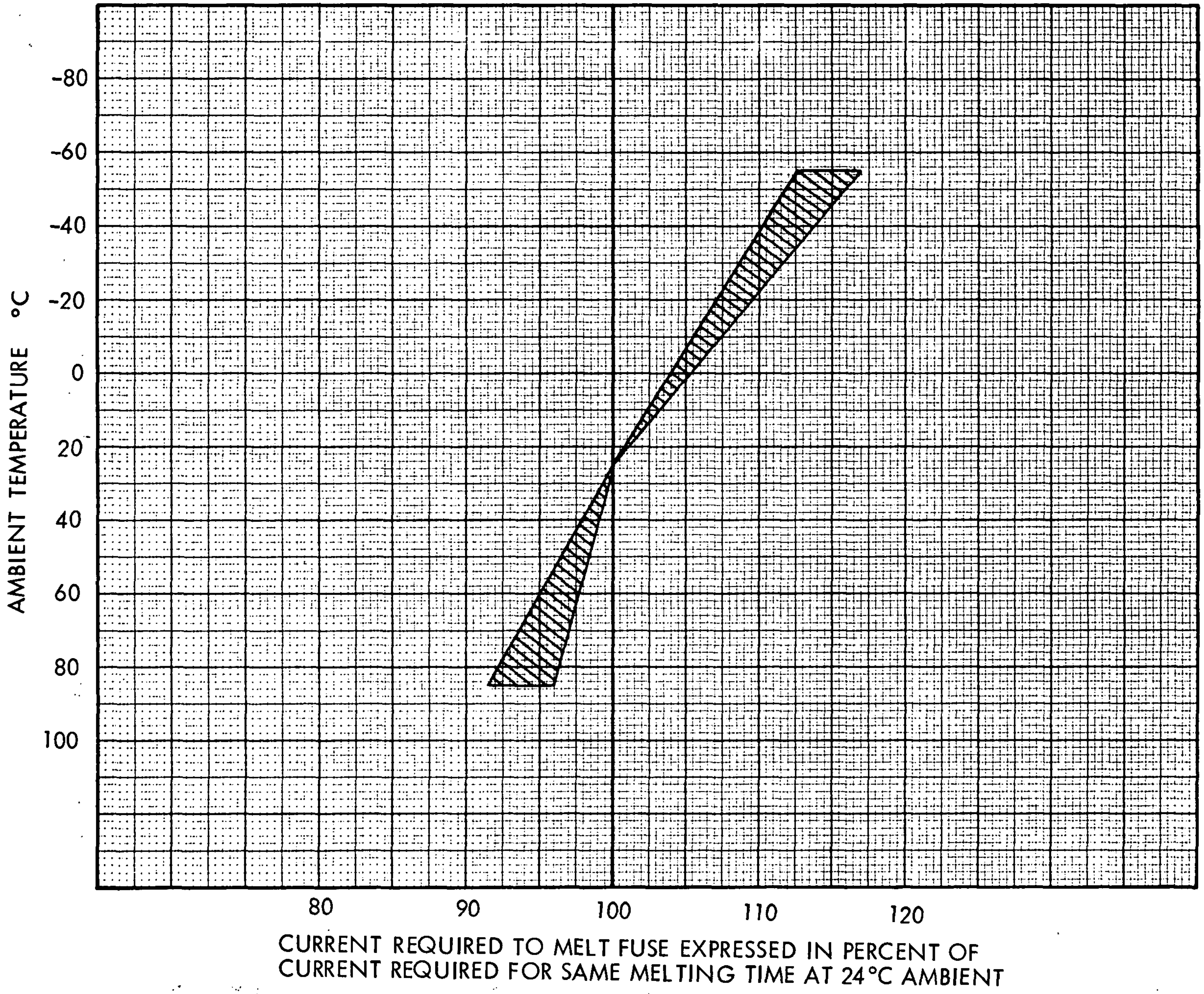

Figure 8. Ambient Temperature Effect on Normal Blowing Fuses (Littlefuse)

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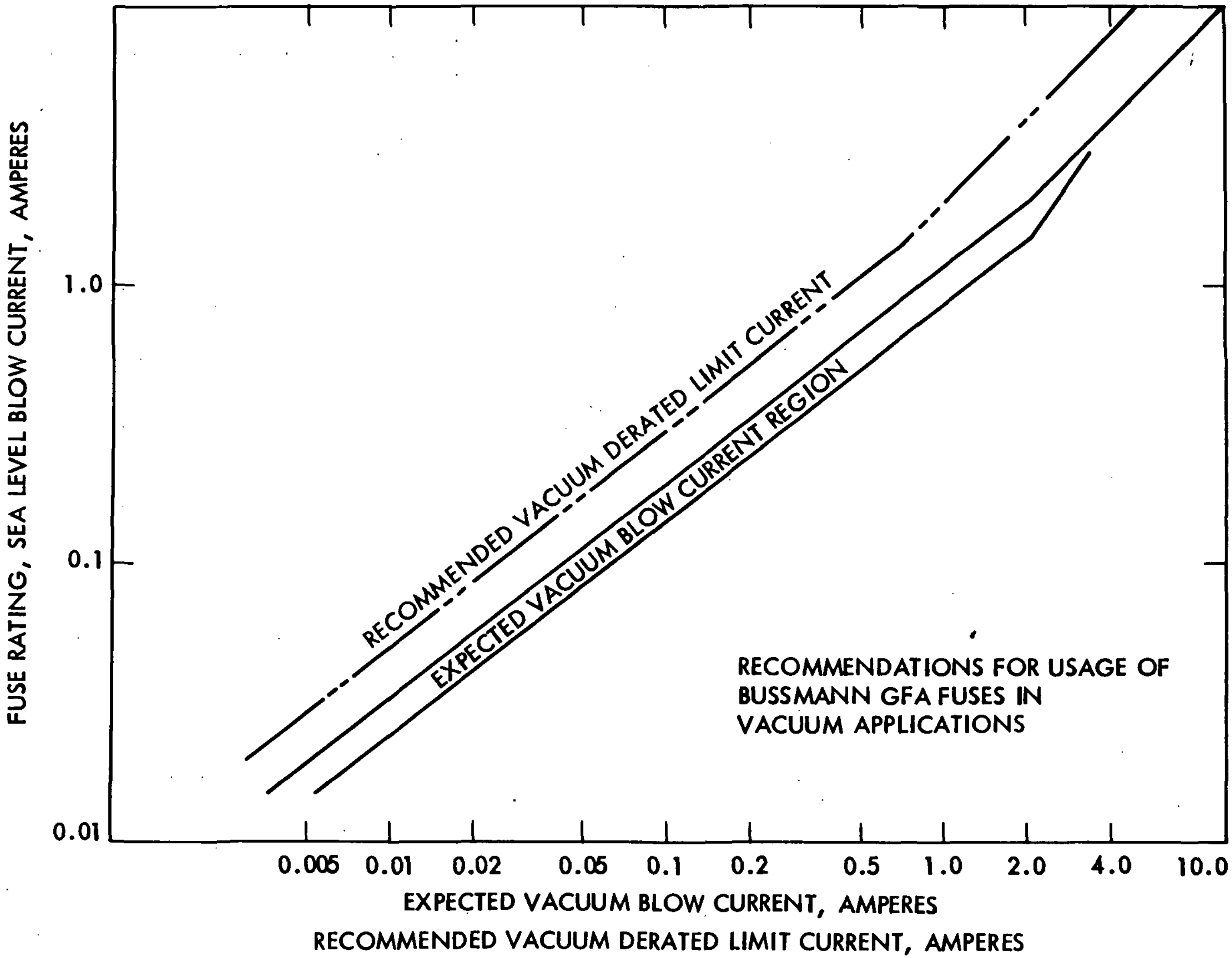

PLOTTED FROM TABLES 3 AND 4 OF "EVALUATION OF FUSE OPERATING CHARACTERISTICS IN A VACUUM($I \leq 5A$)", GIDEP ACCESS NO. E330-1360, 21 DEC. 1981

Figure 9. Recommendation for Usage of Bussman GFA (GPN) Fuses in Vacuum Applications

FUSES
QUALIFIED FUSES

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS ① ②		SCRN SPEC ZPP-2073-	DRAWINGS
			Current (Amps)	Voltage (max)		
*GPN	BUS	Subminiature Axial	1/32 to 5	125	1017	ST 11735
			7 to 15	32		
265 Series	LTF	Subminiature Axial	1/16 to 10	125	1024	ST 11736
			15	32		

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

① De-rating required for reliability. See Table II in the Parts Derating section.

② Voltage rating is very conservative. Designed to protect users. See Application Notes on page 2 of of this section.

INDEX OF MAGNETIC DEVICES

Part Number	Vendor	Page
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BIT Series	TRW	8
D Series	PII	8
DOT Series	TRW	8
G Series	PII	8
IM-2 Series	DAL	8
IM-4 Series	DAL	8
PGV and PV Series	PII	8
Special Devices	HAD	8
ST Series	PII	8
TT Series	PII	8
51, 52 and 61 Series	VAN	8
71 Series	VAN	8
155 Series	API	8
1025, 1537, 1537-700, 1840, 2150, and 2500 Series	API	8
Transformers		
BIT 250 Series	TRW	9
Blue Chip 2, 3, 4, 5, 6, and 7	ADC	9
DOT Series	TRW	9
GHRT Series	TEE	9

MAGNETIC DEVICES

TRANSFORMERS AND INDUCTORS

GENERAL APPLICATION NOTES

A large percentage of transformers used by JPL for space applications are specially designed and specially constructed units. In order for them to be designed and constructed, the transformer engineer must be furnished certain electrical and mechanical information. The attached sheets (samples of JPL Forms 2665, 2666, 2667, 2668, 2673 and 2674) indicate information needed for four different categories of magnetic components. Studies and design calculations by the Magnetic Parts Specialist will determine whether the unit is possible or practical to wind and assemble.

Transformers and inductors purchased to catalogue values should be derated 25 percent in the maximum current and test voltage values. Certain constraints must be observed in the use of quasi-catalog items. When using RF inductors of the non-shielded types, care must be exercised in the mounting, as two units too close together may exhibit a mutual inductance which may be detrimental to proper circuit operation. Care must also be taken not to subject the units to a higher voltage than that for which they were designed. Excess current through the inductors results in a lower inductance, heating and subsequent damage. Further, care must be taken in selecting items from catalogs, not to exceed catalog ratings. Assistance in selecting proper catalog items may be obtained from the Magnetics Part Specialist.

Sample of JPL Form 2665

JPL SPECIFICATION ____________
(FOR COMPONENT ENGINEERING USE ONLY)

ELECTRICAL CHARACTERISTICS
AUDIO TRANSFORMER

	PRI	PRI-TAP	SEC	SEC-TAPS
IMPEDANCE				
RESISTANCE				

INDUCTANCE PRI ________ @ ________ VOLTS RMS ________ ADC ________ CPS

INSERTION LOSS ____________

	VOLTAGE	RESISTANCE
CENTER TAP BALANCE PRI	______ %,	______ %
CENTER TAP BALANCE SEC	______ %,	______ %

FREQUENCY RESPONSE ____________ ($\frac{\omega L}{R_p}$) FOR LOWER CORNER

TURNS RATIO ____________

SELF RESONANT FREQUENCY ____________

MAXIMUM SIGNAL LEVEL ________ VAC @ ________ CPS WITH ________ ADC

LEAKAGE INDUCTANCE ________ @ ________ VAC, ________ CPS.

WINDING ________ TO WINDING ________

WINDING TO WINDING CAPACITANCE ________ PF MAX. ________ TO

WINDING ______ TO CORE / CASE / GROUND ____________ PF MAX.

SHIELD ATTENUATION ________ Db MINIMUM. WINDING ________ ENERGIZED

WITH ______ V ______ CPS, SHIELD TIED TO ________ RETURN, WINDING

________ LOADED WITH ________ PF / OHMS RETURNED TO ________

MAGNETIC ATTENUATION ________ V MAXIMUM ACROSS WINDING ________ WITH ________

GAUSS FIELD APPLIED ________ TO (MAJOR / ANY) AXIS OF TRANSFORMER.

VENDOR NAME
VENDOR PART #
JPL SKETCH #

JPL 2665 JAN 66

Sample of JPL Form 2666

JPL SPECIFICATION ____________
(FOR COMPONENT ENGINEERING USE ONLY)

ELECTRICAL CHARACTERISTICS

PULSE TRANSFORMER

PRIMARY IMPEDANCE ____________

SECONDARY IMPEDANCE ____________

TURNS RATIO ____________

	VOLTAGE	RESISTANCE
CENTER TAP BALANCE PRI	________ %,	________ %
CENTER TAP BALANCE SEC	________ %,	________ %

PRIMARY PULSE INDUCTANCE ____________ (OCL) MEASURED: PULSE ______

PULSE WIDTH ____________ SINEWAVE ____ CPS ____ V

REPETITION RATE ____________

PRIMARY DCR ____________

SECONDARY DCR ____________

OVERSHOOT ____________

DROOP ____________

RISE TIME ____________

PRIMARY VOLTAGE ____________

MIN VOLTAGE TO GROUND (PRI) ____________

MIN VOLTAGE TO GROUND (SEC) ____________

UNBALANCED DC PRI ________ SEC ________

LEAKAGE INDUCTANCE ________ @ ________ V ________ CPS. WINDING ______ TO

WINDING ________.

PRIMARY VOLT SECONDS ____________

INTERWINDING CAPACITANCE ________ TO ________ . ________ PF MAX.

TEMPERATURE RISE ________ °C/F MAX.

VENDOR NAME
VENDOR PART #
JPL SKETCH #

MAGNETIC DEVICES

JPL 2666 JAN 66

Sample of JPL Form 2667

JPL SPECIFICATION________________
(FOR COMPONENT ENGINEERING USE ONLY)

ELECTRICAL CHARACTERISTICS

INDUCTOR

INDUCTANCE ________ @ ________ V RMS ________ ADC ________ CPS

RESISTANCE ________ Ω ± ______ %

INDUCTANCE LINEARITY ________ : SIGNAL LEVEL RANGE ________ TO ________.

CURRENT RANGE ______ TO ______ @ ______ V ______ CPS.

TEMPERATURE RANGE ________ TO ________ °C/°F

MAXIMUM LEVEL ________ V, ________ CPS, ________ ADC

SELF RESONANT FREQUENCY ________ @ ________ V

STRAY (EXTERNAL) MAGNETIC FIELD:

DC. ________ GAUSS MAX @ ________ INCHES WITH ________ ADC APPLIED.

AC. ________ GAUSS MAX @ ________ INCHES WITH ________ VRMS CPS APPLIED.

VOLTAGE COIL TO CORE ________ TO GROUND ________

VENDOR NAME
VENDOR PART #
JPL SKETCH #

JPL 2667 JAN 66

MAGNETIC DEVICES

Sample of JPL Form 2668

JPL SPECIFICATION ____________
(FOR COMPONENT ENGINEERING USE ONLY)

ELECTRICAL CHARACTERISTICS

POWER TRANSFORMER

PRIMARY: ______ VOLTS RMS P/P AVERAGE ______ CPS ACROSS (—) SWITCHING TIME ______

EXCITING CURRENT ______ @ ______ VOLTS ______ CPS. TERMINALS ______ TO ______

NO LOAD WATTS ______ @ ______ VOLTS ______ CPS. TERMINALS ______ TO ______

	VOLTS	AMPS	WORKING VOLTS	% REGULATION
SECONDARY #1				
SECONDARY #2				
SECONDARY #3				
SECONDARY #4				
SECONDARY #5				
SECONDARY #6				
SECONDARY #7				
SECONDARY #8				
SECONDARY #9				
SECONDARY #10				

BALANCE ______ % VOLTAGE ______ % RESISTANCE WINDING ______ ______

STRAY FIELD (EXTERNAL):

DC. ______ GAUSS MAX @ ______ INCHES WITH ______ TO ______ ADC IN

WINDING ______.

AC. ______ GAUSS MAX @ ______ INCHES WITH ______ VRMS ______ CPS

______ WAVEFORM IN WINDING ______.

VENDOR NAME
VENDOR PART #
JPL SKETCH #

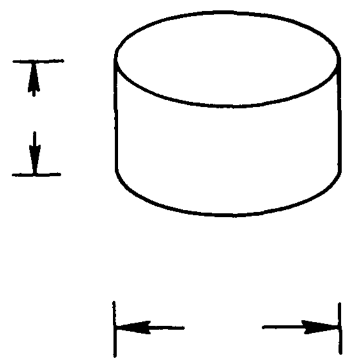
JPL 2668 JAN 66

Sample of JPL Form 2673

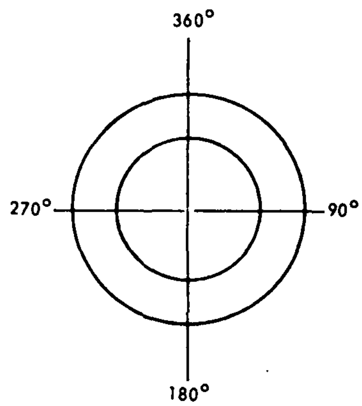
JPL SPECIFICATION ____________
(FOR COMPONENT ENGINEERING USE ONLY)

TOROID TYPE
MECHANICAL CONFIGURATION

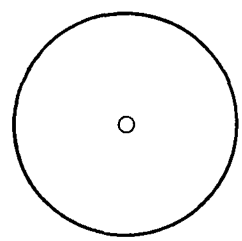
OUTLINE



WINDING INFORMATION

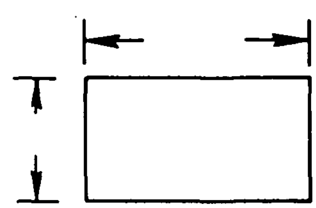


LEAD BREAKOUT



STUD: ________
TUBE: ________
HOLE: ________

SCHEMATIC



MINIMUM IDENTIFICATION:

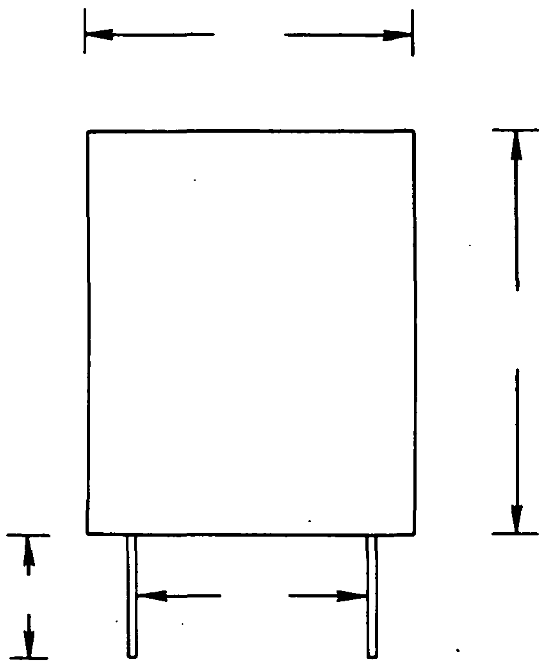
1. SCHEMATIC DESIGNATION
2. JPL #
3. VENDOR #
4. SERIAL #

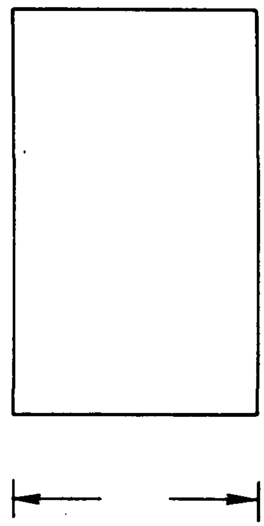
VENDOR NAME
VENDOR PART #
JPL SKETCH #

Sample of JPL Form 2674

LAYER TYPE MECHANICAL CONFIGURATION

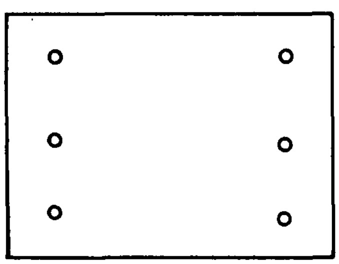
JPL SPECIFICATION ____________________
(FOR COMPONENT ENGINEERING USE ONLY)





SCHEMATIC

INDICATE ALTERNATE LEAD BREAKOUT



MINIMUM IDENTIFICATION:

1. SCHEMATIC DESIGNATION
2. JPL #
3. VENDOR #
4. SERIAL #

VENDOR NAME
VENDOR PART #
JPL SKETCH #

JPL 2674 JAN 66

MAGNETIC DEVICES
QUALIFIED MAGNETIC DEVICES

INDUCTORS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS	SCRN SPEC ZPP-2073-	DRAWINGS
DOT Series	TRW	Low Frequency	DOT Series acceptable only when ordered under special high reliability number	9214	ST 11818
BIT Series 250	TRW	Low Frequency		9215	ST 11853
	HAD	Low Frequency	Acceptable sources for special devices ①		
1025, 1537,1537-700, 1840, 2150 and 2500 Series	API	High Frequency	All values	9112, 9113, 9242 9181, 9213 and 9222	ST 11820
155 Series	API	High Frequency	Values of 20 microhenries (μH) or less	9240	ST 11856
51, 52, and 61 Series	VAN	High Frequency	RF variable, magnetically-shielded ③	9262	ST 11925
71 Series	VAN	High Frequency	RF variable magnetically and electrostatically shielded ③	9262	ST 11925
G Series	PII	High Frequency		9241 ②	ST 11857
D Series	PII	High Frequency		9242 ②	ST 11858
PV Series	PII	High Frequency		9243 ②	ST 11859
TT Series	PII	High Frequency Variable	Values to 20 μH or less	9120	
TT and B Series PGV and ST	PII	High Frequency	RF variable values of 680 μH, or less	9120	ST 11918
IM-2 Series	DAL	High Frequency	Molded RF Inductor, Fixed All values to 120 μH	④	④
IM-4 Series	DAL	High Frequency	Molded RF Inductor, Fixed All values to 240 μH	④	④

① Special devices fabricated and tested on piece-part basis

② Due to extreme hazard of part damage in handling the G, D & PV Series Piconics, high frequency Inductors cannot be screened to ZPP-2073-9241, -9242 & -9243 without provisions for special handling. Contact the Parts Specialist for additional information

③ All values to 1000 μH maximum.

④ Screening spec and drawing not released. Contact the Parts Specialist for current status before buying or screening these parts.

MAGNETIC DEVICES
QUALIFIED MAGNETIC DEVICES

TRANSFORMERS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS	SCRN SPEC ZPP-2073-	DRAWINGS
Blue Chip 2, 3, 4, 5 6 and 7 Series	ADC	Audio	To be purchased to ADC Spec DM12178	9216	ST 11621
DOT Series	TRW	Audio	DOT Series acceptable only when ordered under special high reliability part number ①	9217	ST 11822
	HAD	Power	Acceptable sources for special devices ②		
BIT 250 Series	TRW	Audio		9218	ST 11823
G, H, R, T Series	TEE	Pulse	Series	9219	ST 11824

① Contact the Transformer specialist for hi-rel part numbers.

② Special devices fabricated and tested on a piece-part basis.

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MICROCIRCUITS

APPLICATION NOTES

Handling and operating conditions for microcircuits must be given special attention due to the small physical size, low thermal capacity, and high level of complexity of these devices. They are generally also low voltage, low power devices. For these reasons, some microcircuits can be easily damaged by voltage or current transients, or by electrostatic discharge (ESD). Suggestions for ESD protection can be found in JPL Design Requirement DM509306, Volume II. Specific operating and handling procedures vary according to the type of microcircuit. For those devices covered by JPL CS specifications, the recommended operating conditions in the specification should be followed. Information on operating and handling restrictions for other devices can be obtained from the manufacturer's device manuals and data sheets. Additional information can be obtained by contacting the specialist listed in the Parts Information Directory section of the PPL.

ORGANIZATION AND TABLE OF CONTENTS

The microcircuit section of the PPL is arranged in subsections covering the various major categories. The larger subsections contain tabulations to assist designers in part selection as well as detailed listings of qualified and acceptable parts as defined in the Preface of the PPL. The following listing outlines the categories of microcircuits and types of information included.

		Pages
I.	Digital	
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	b. Detailed Listings	9-18
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MICROCIRCUITS

DIGITAL MICROCIRCUIT FUNCTIONAL SELECTION GUIDE

Part numbers in parentheses are acceptable; see blue pages for details.

All other part numbers are qualified; see white pages for details.

Function		Standard TTL	Low Power TTL	Low Power Schottky	CMOS
NAND Gates:	Quad 2-input	5400	54L00	(54LS00)	(CD4011B)
	Quad 2-input with open collector outputs	5401	54L01	(54LS01)	
	Triple 3-input	5410	54L10	(54LS10)	(CD4023B)
	Dual 4-input	5420	54L20	(54LS20)	(CD4012B)
	8-input	5430	54L30	(54LS30)	
NOR Gates:	Quad 2-input	5402	54L02	(54LS02)	(CD4001B)
	Triple 3-input				(CD4025B)
AND Gates:	Quad 2-input			(54LS08)	(CD4081B)
	Triple 3-input				(CD4073B)
OR Gates:	Quad 2-input			(54LS32)	(CD4071B)
	Triple 3-input				(CD4075B)

MICROCIRCUITS

DIGITAL MICROCIRCUIT FUNCTIONAL SELECTION GUIDE (contd)

Function		Standard TTL	Low Power TTL	Low Power Schottky	CMOS
Complex Gates:	Quad 2-Input Exclusive - OR	5486	54L86		(CD4070B)
	Dual 2-wide 2-input AND-OR-Invert	(5451)	54L51	(54LS51)	
	4-wide 3-2-2-3 input AND-OR-Invert		54L54	(54LS54)	
	2-wide 4-input AND-OR-Invert		54L55	(54LS55)	
	Quad AND/OR-Select				(CD4019B)
Inverters:	Hex Inverter	5404	54L04	(54LS04)	
	Hex Inverter with Open Collector Outputs			(54LS05)	
Buffers:	Hex Inverting				(CD4049UB)
	Hex Inverting Buffer/Driver with Open Collector Outputs	5406			
	Hex Non-Inverting				(CD4050B)
	Quad 2-input NAND	5437			
	Quad 2-input NAND, with Open Collector Outputs	5438			
	Dual 4-input NAND	5440			

MICROCIRCUITS

DIGITAL MICROCIRCUIT FUNCTIONAL SELECTION GUIDE (contd)

Function		Standard TTL	Low Power TTL	Low Power Schottky	CMOS
Flip-Flops:	Dual D-Type, Edge-Triggered, with Preset & Clear (Set & Reset)	5474	54L74	(54LS74A)	(CD4013B)
	Gated J-K, Edge-Triggered, with Preset & Clear	5470			
	Gated J-K, Master-Slave, with Non-Inverting Inputs	5472	54L72		
	Dual J-K, Master-Slave, with Clear	(5473)	54L73	(54LS73)	
	Dual J-K, Master-Slave, with Preset & Clear (Set & Reset)		54L78	(54LS78)	(CD4027B)
	Gated R-S, Master-Slave, with Preset & Clear		54L71		
	Dual J-K, with Preset & Clear			(54LS76)	
Latches:	Quad Clocked D (4-bit Bistable)	(5477)	54L77		(CD4042B)
	8-bit Addressable				(CD4099B)
Multivibrators:	Monostable	54121			
	Retriggerable Monostable with Clear		54L122		

MICROCIRCUITS

DIGITAL MICROCIRCUIT FUNCTIONAL SELECTION GUIDE (contd)

Function		Standard TTL	Low Power TTL	Low Power Schottky	CMOS
Schmitt Triggers:	Dual 4-input NAND	(5413)			
Shift Registers:	4-bit Parallel-Access (Right/Left Shift)		54L95		
	4-bit Parallel/Serial In, Parallel Out, (Right/Left Shift) with J-K Serial Inputs		54L99		(CD4035B)
	8-Stage Parallel/Serial In, Serial Out, With Synchronous Inputs				(CD4014B)
	8-bit Serial		54L91		
	Dual 4-Stage and Dual 5-Stage Serial				(CD4006B)
	64-Stage Serial				(CD4031B)
	Dual 4-Stage, Serial In, Parallel Out				(CD4015B)
	8-bit Serial In, Parallel Out		54L164		
Misc. Registers:	4-bit D-Type Parallel Register with Input & Output Disable				(CD4076B)
	4-bit Data Selector/Storage Register		54L98		
	8-Stage Bidirectional Parallel/Serial Input/Output Bus Register				(CD4034B)

MICROCIRCUITS

DIGITAL MICROCIRCUIT FUNCTIONAL SELECTION GUIDE (contd)

Function		Standard TTL	Low Power TTL	Low Power Schottky	CMOS
Counters:	Decade, with BCD/Bi-Quinary Outputs		54L90		
	Decade, with 10 Decoded Outputs				(CD4017B)
	4-bit Binary		54L93		
	7-Stage Binary				(CD4024B)
	12-Stage Binary				(CD4040B)
	Synchronous Up/Down, Dual Clock 4-bit Binary with Clear		54L193		
	4-Stage Presettable Up-Down, Binary or BCD-Decade				(CD4029B)
	Presettable Divide-by-N, 2 ≤N ≤10				(CD4018B)
Adders:	4-bit Binary, with Carry	5483		54LS83	(CD4008B)
Magnitude Comparators:	4-bit		(54L85)	(54LS85)	(CD4063B)
Decoders:	BCD-to-Decimal or Binary-to-Octal				(CD4028B)
Multiplexers:	Dual 4-line to 1-line Data Selector		54L153		
	Dual 8-channel Analog				(HI507)
	Dual 4-channel Analog				(HI509)

MICROCIRCUITS

DIGITAL MICROCIRCUIT FUNCTIONAL SELECTION GUIDE (contd)

Function		Bipolar	Bipolar/JFET	Bipolar/MOS	CMOS
Switches:	2-channel SPST		DG133, DG141	DGM111	(HI200)
	2-channel DPST		DG129		
	5-channel SPST			DG125	
Interface Circuits:	Triple Line Transmitter	HD245			
	Triple Line Receiver	HD246			
	4-channel Driver for MOS-FET Switches, with Decode	(D129)			

QUALIFIED MICROCIRCUITS (DIGITAL)

PART NO.	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS
5400	SGN	Quad 2-Input Positive-NAND Gates (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5401	SGN	Quad 2-Input Positive-NAND Gates with Open Collector Outputs (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5402	SGN	Quad 2-Input Positive-NOR Gates (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5404	SGN	Hex Inverters (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5406	SGN	Hex Inverter Buffers/Drivers with Open Collector Outputs (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5410	SGN	Triple 3-Input Positive-NAND Gates (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5420	SGN	Dual 4-Input Positive-NAND Gates (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5430	SGN	8-Input Positive-NAND Gate (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5437	SGN	Quad 2-Input Positive-NAND Buffers (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5438	SGN	Quad 2-Input Positive-NAND Buffers with Open Collector Outputs 14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5440	SGN	Dual 4-Input Positive-NAND Buffers (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5470	SGN	AND-Gated J-K Positive-Edge-Triggered Flip-Flop with Preset and Clear (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5472	SGN	AND-Gated J-K Master-Slave Flip-Flops with Preset and Clear (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5474	SGN	Dual D-Type Positive-Edge-Triggered Flip-Flops with Preset and Clear (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5483	SGN	4-Bit Binary Full Adder with Fast Carry (16-Pin Flatpack)	
5486	SGN	Quad 2-Input Exclusive-OR Gates (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
54121	SGN	Monostable Multivibrator (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495

MICROCIRCUITS

QUALIFIED MICROCIRCUITS (DIGITAL) (contd)

PART NO.	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS
54L00	TIX NSC	Quad 2-Input Positive-NAND Gates, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L01	TIX	Quad 2-Input Positive-NAND Gates with Open Collector Outputs, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L02	TIX	Quad 2-Input Positive-NOR Gates, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L04	TIX	Hex Inverters, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L10	TIX NSC	Triple 3-Input Positive-NAND Gates, Low Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L20	TIX NSC	Dual 4-Input Positive-NAND Gates, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L30	TIX NSC	8-Input Positive-NAND Gate, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L51	TIX	Dual 2-Wide 2-Input AND-OR-Invert Gates, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L54	TIX NSC	4-Wide 3-2-2-3 Input AND-OR-Invert Gate, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L55	TIX NSC	2-Wide 4-Input AND-OR-Invert Gate, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L71	TIX NSC	AND-Gated R-S Master-Slave Flip-Flop with Preset and Clear, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L72	TIX NSC	AND-Gated J-K Master-Slave, Flip-Flop with Preset and Clear, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L73	TIX NSC	Dual J-K Flip-Flops with Clear, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494

MICROCIRCUITS

QUALIFIED MICROCIRCUITS (DIGITAL) (contd)

PART NO.	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS
54L74	TIX	Dual D-Type Positive-Edge-Triggered Flip-Flops with Preset and Clear, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L77	TIX	4-Bit Bistable Latch, Low-Power (14-Pin, 1/4 x 1/4 Flatpack	ST 11494
54L78	TIX NSC	Dual J-K Flip-Flops with Preset, Common Clear and Common Clock, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L86	TIX	Quad 2-Input Exclusive-OR Gates, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L90	TIX	Decade Counter, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L91	TIX	8-Bit, Serial, Shift Register, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L93	TIX	4-Bit Binary Counter, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L95	TIX NSC	4-Bit Parallel-Access Shift Register, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L98	TIX	4-Bit Data Selector/Storage Register, Low-Power (16-Pin, Flatpack)	--
54L99	TIX	4-Bit Right-Shift Left-Shift Register, Low-Power (16-Pin, Flatpack)	--
54L122	TIX	Retriggerable Monostable Multivibrator with Clear, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L153	TIX	Dual 4-Line-to-1-Line Data Selectors/Multiplexers, Low-Power (16-Pin, Flatpack)	ST 11494
54L164	TIX	8-Bit Parallel-Out Serial Shift Register, Low-Power (14-Pin, 1/4 x 1/4 Flatpack)	ST 11494
54L193	TIX	Synchronous 4-Bit Up/Down Binary Counters (Dual Clock with Clear), Low-Power (16-Pin, Ceramic Dip)	--
54LS83	TIX	4-Bit Binary Full Adder, Low-Power Schottky (16-pin, Flatpack)	--

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MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS (DIGITAL)

PART NO.	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS
5413	SGN	Dual 4-Input NAND Schmitt Trigger (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5451	SGN	Dual 2-Wide 2-Input AND-OR-Invert Gates (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5473	SGN	Dual J-K Flip-Flops with Clear (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
5477	SGN	Quad Bistable Latch (14-Pin, 1/4 x 3/8 Flatpack)	ST 11495
54L85	NSC	4-Bit Magnitude Comparator, Low-Power (16-Pin, 1/4 x 3/8 Flatpack)	PT 40354

MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS (DIGITAL) (contd)

PART NO.	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS
54LS00	TIX/SGN	Quad 2-Input NAND Gate	PT 40764
54LS01	TIX/SGN	Quad 2-Input NAND Gate (Open-Collector Outputs)	PT 40765
54LS02	TIX/SGN	Quad 2-Input NOR Gate	PT 40766
54LS04	TIX/SGN	Hex Inverter	PT 40764
54LS05	TIX/SGN	Hex Inverter (Open-Collector Outputs)	PT 40764
54LS08	TIX/SGN	Quad 2-Input AND Gate	PT 40768
54LS10	TIX/SGN	Triple 3-Input NAND Gate	PT 40764
54LS20	TIX/SGN	Dual 4-Input NAND Gate	PT 40764
54LS30	TIX/SGN	8-Input NAND Gate	PT 40764
54LS32	TIX/SGN	Quad 2-Input OR Gate	
54LS51	TIX/SGN	2-Wide 3 Input, 2-Wide 2-Input, AND- OR-INVERT Gates	PT 40779
54LS54	TIX/SGN	4-Wide, 3-2-2-3 Input, AND- OR-INVERT Gate	PT 40779
54LS55	TIX/SGN	2-Wide, 4-Input, AND- OR-INVERT GATE	PT 40779
54LS73	TIX/SGN	Dual J-K Flip-Flops With Clear	PT 40780
54LS74A	TIX/SGN	Dual D Flip-Flops With Clear and Preset	PT 40780
54LS76	TIX/SGN	Dual J-K Flip-Flops With Clear and Preset	PT 40780
54LS78	TIX/SGN	Dual J-K Flip-Flops With Preset, Common Clear and Common Clock	PT 40780
54LS85	TIX/SGN	4-Bit Magnitude Comparator	PT 40767

MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS (CMOS DIGITAL)

PART NUMBER	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS	REMARKS (SEE NOTES)
CD4001BD	RCA	Quad 2-Input NOR Gate	PT 40703	(1) (2)
CD4001BK		Quad 2-Input NOR Gate	PT 40703	
CD4006BD		Dual 4-Stage and Dual 5-Stage Serial Shift Register	PT 40717	
CD4006BK		Dual 4-Stage and Dual 5-Stage Serial Shift Register	PT 40717	
CD4011BD		Quad 2-Input NAND Gate	PT 40700	
CD4011BK		Quad 2-Input NAND Gate	PT 40700	
CD4012BD		Dual 4-Input NAND Gate	PT 40718	
CD4012BK		Dual 4-Input NAND Gate	PT 40718	
CD4013BD		Dual D-Type Flip Flop with Set and Reset	PT 40701	
CD4013BK		Dual D-Type Flip Flop With Set and Reset	PT 40701	
CD4014BD		8-Stage, Parallel/Serial In, Serial Out Shift Register	PT 40716	
CD4014BK		8-Stage, Parallel/Serial In, Serial Out Shift Register	PT 40716	
CD4015BD		Dual 4-Stage, Serial In, Parallel Out Shift Register	PT 40716	
CD4015BK		Dual 4-Stage, Serial In, Parallel Out Shift Register	PT 40716	
CD4017BD		Decade Counter With 10 Decoded Outputs	PT 40706	
CD4017BK		Decade Counter With 10 Decoded Outputs	PT 40706	
CD4018BD		Presettable Divide-by-N Counter, 2 <N <10	PT 40706	
CD4018BK	RCA	Presettable Divide-by-N Counter, $2 \leq N \leq 10$	PT 40706	(1) (2)

Notes:

(1) The last letter of the RCA part number denotes the package type: D = ceramic dual-in line, K = ceramic flatpack.

(2) For applications with greater than 400 k rad (Si) total ionization dose, contact the CMOS specialist for the latest radiation hardening information on these part types.

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MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS (CMOS DIGITAL) (contd)

PART NUMBER	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS	REMARKS (SEE NOTES)
CD4019BD	RCA	Quad AND-OR Select Gate	PT 40704	(1) (2)
CD4019BK	↓	Quad AND-OR Select Gate	PT 40704	↓
CD4023BD	↓	Triple 3-Input NAND Gate	PT 40700	↓
CD4023BK	↓	Triple 3-Input NAND Gate	PT 40700	↓
CD4024BD	↓	7-Stage Binary Counter	PT 40706	↓
CD4024BK	↓	7-Stage Binary Counter	PT 40706	↓
CD4025BD	↓	Triple 3-Input NOR Gate	PT 40703	↓
CD4025BK	↓	Triple 3-Input NOR Gate	PT 40703	↓
CD4027BD	↓	Dual J-K Type Flip-Flop With Set and Reset	PT-40701	↓
CD4027BK	↓	Dual J-K Type Flip-Flop With Set and Reset	PT 40701	↓
CD4028BD	↓	BCD-to-Decimal or Binary-to-Octal Decoder	PT 40709	↓
CD4028BK	↓	BCD-to-Decimal or Binary-to-Octal Decoder	PT 40709	↓
CD4029BD	↓	4-Stage, Presettable Up/Down Counter, Binary or BCD-Decade	PT 40707	↓
CD4029BK	↓	4-Stage, Presettable Up/Down Counter, Binary or BCD-Decade	PT 40707	↓
CD4031BD	↓	64-Stage Serial Shift Register	PT 40708	↓
CD4031BK	↓	64-Stage Serial Shift Register	PT 40708	↓
CD4034BD	↓	8-Stage Static Bidirectional Parallel/Serial, Input/Output Bus Register	PT 40708	↓
CD4034BK	RCA	8-Stage Static Bidirectional Parallel/Serial, Input/Output, Bus Register	PT 40708	(1) (2)

Notes:

(1) The last letter of the RCA part number denotes the package type: D = ceramic dual-in-line, K = ceramic flatpack.

(2) For applications with greater than 400 k rad (Si) total ionization dose, contact the CMOS specialist for the latest radiation hardening information on these part types.

MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS (CMOS DIGITAL) (contd)

PART NUMBER	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS	REMARKS (SEE NOTES)
CD4035BD	RCA	4-Stage, Parallel/Serial In. Parallel Out Shift Register	PT 40708	(1) (2)
CD4035BK		4-Stage, Parallel/Serial In. Parallel Out Shift Register	PT 40708	
CD4040BD		12-Stage Binary Counter	PT 40725	
CD4040BK		12-Stage Binary Counter	PT 40725	
CD4042BD		Quad Clocked D Latch	PT 40702	
CD4042BK		Quad Clocked D Latch	PT 40702	
CD4049UBD		Hex Inverting Buffer	PT 40705	
CD4049UBK		Hex Inverting Buffer	PT 40705	
CD4050BD		Hex Non-Inverting Buffer	PT 40705	
CD4050BK		Hex Non-Inverting Buffer	PT 40705	
CD4070BD		Quad Exclusive-OR Gate	PT 40712	
CD4070BK		Quad Exclusive-OR Gate	PT 40712	
CD4071BD		Quad 2-Input OR Gate	PT 40711	
CD4071BK		Quad 2-Input OR Gate	PT 40711	
CD4073BD		Triple 3-Input AND Gate	PT 40710	
CD4073BK		Triple 3-Input AND Gate	PT 40710	
CD4075BD		Triple 3-Input OR Gate	PT 40711	
CD4075BK	RCA	Triple 3-Input OR Gate	PT 40711	(1) (2)

Notes:

(1) The last letter of the RCA part number denotes the package type: D = ceramic dual-in-line, K = ceramic flatpack.

(2) For applications with greater than 400 k rad (Si) total ionization dose, contact the CMOS specialist for the latest radiation hardening information on these part types.

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MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS (CMOS DIGITAL) (contd)

PART NUMBER	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS	REMARKS (SEE NOTES)
CD4076BD	RCA	4-Bit, D-Type Parallel Register, with Input and Output Disable	PT 40713	① ②
CD4076BK	↓	4-Bit, D-Type Parallel Register, with Input and Output Disable	PT 40713	↓ ↓
CD4081BD	↓	Quad 2-Input AND Gate	PT 40710	↓ ↓
CD4081BK	↓	Quad 2-Input AND Gate	PT 40710	↓ ↓
CD4099BD	↓	8-Bit Addressable Latch	PT 40714	↓ ↓
CD4099BK	↓	8-Bit Addressable Latch	PT 40714	↓ ↓
CD4510BD	↓	Presettable Up/Down Counters, BCD	PT 40707	↓ ↓
CD4510BK	↓	Presettable Up/Down Counters, BCD	PT 40707	↓ ↓
CD4516BD	↓	Presettable Up/Down Counter, Binary	PT 40707	↓ ↓
CD4516BK	↓	Presettable Up/Down Counter, Binary	PT 40707	↓ ↓
CD4518BD	↓	Dual BCD Up-Counter	PT 40707	↓ ↓
CD4518BK	↓	Dual BCD Up-Counter	PT 40707	↓ ↓
CD4520BD	↓	Dual Binary Up-Counter	PT 40707	↓ ↓
CD4520BK	↓	Dual Binary Up-Counter	PT 40707	↓ ↓
CD40192BD	↓	Presettable BCD Up-Down Counter	PT 40707	↓ ↓
CD40192BK	↓	Presettable BCD Up-Down Counter	PT 40707	↓ ↓
CD40193BD	↓	Presettable Binary Up-Down Counter	PT 40707	↓ ↓
CD40193BK	RCA	Presettable Binary Up-Down Counter	PT 40707	① ②

Notes:

① The last letter of the RCA part number denotes the package type: D = ceramic dual-in-line, K = ceramic flatpack.

② For applications with greater than 400 k rad (Si) total ionization dose, contact the CMOS specialist for the latest radiation hardening information on these part types.

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MICROCIRCUITS

QUALIFIED MICROCIRCUITS (LINEAR)

DESIGNER'S CHECK SHEET FOR OPERATIONAL AMPLIFIERS

	HA2520	HA2600	HA2620	HA2700	LM101A	LM108	LM108A	LM124(1/4)	LF155	ICL8007	UNITS
Input Offset Voltage (Max)	8.0	4.0	4.0	3.0	2.0	2.0	0.5	5.0	2.0	20.0	mV
Input Offset Current (Max)	10.0	15.0	15.0	10.0	10.0	0.2	0.2	30.0	0.01	0.0005	m/A
Bias Current (Max)	200.0	15.0	15.0	20.0	75.0	2.0	2.0	15.0	0.05	0.02	m/A
Gain (min)	10. k	100 k	100 k	400 k	50 k	50 k	80 k	50 k	50 k	50 k	V/V
Slew Rate (Min)	100.0	4.0	25.0	15.0	10.0	0.1	0.1	--	3.0	6.0	V/us
Unity Gain Bandwidth	15.0	6.0	20.0	0.6	1.0	1.0	1.0	--	2.5	--	MHz
Supply Current (Max)	6.0	3.7	3.7	0.15	3.0	0.6	0.6	2.0	4.0	5.2	mA
Offset Input Voltage Drift	--	--	--	--	15.0	15.0	5.0	--	5.0	75.0	μV/°C
Offset Input Current Drift	--	--	--	--	200.0	2.5	2.5	--	--	--	pA/°C

DESIGNER'S CHECK SHEET FOR COMPARATORS

PARAMETER	LM106	LM111	LM139(1/4)	LM139A(1/4)	LM710	LM119(1/2)	UNITS
Input Offset Voltage (Max)	3	3	5	2	3	4	mV
Input Offset Current (Max)	7	0.02	25	25	7	0.075	μV
Input Bias Current (Max)	45	0.150	100	100	45	0.5	μV
Supply Voltage	V+ = +12	±15	±18 or +36 GND	±18 or +36 GND	V+ = +12	V+ = 18	V
	V- = -3 to -12	to +5 and GND			V- = -6	V- = 25	V
Supply Current (Max)	10	6	2	2	9	8	mA
Voltage Gain (Min)	40 k	40 k	50 k	50 k	1250	40 k	V/V
Response Time (Max)	40	275	2000	2000	50	80	ns
T^2L Fanout (Max)	10	5	6	6	1	--	

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MICROCIRCUITS

QUALIFIED MICROCIRCUITS (LINEAR)

DESIGNER'S CHECK SHEET FOR VOLTAGE FOLLOWERS

Parameter	LM102	LM110A	UNITS
Offset Voltage (Max)	4.0	4.0	mV
Input Current (Max)	3.0	3.0	A
Input Resistance (Min)	10^{10}	10^{10}	Ω
Output Resistance (Max)	2.5	2.5	Ω
Gain (Min)	0.999	0.999	-
Supply Current (Max)	4.0	4.0	μA
Slew Rate	10	30	V/μs

DESIGNER'S CHECK SHEET FOR VOLTAGE REGULATORS

PARAMETER	LM103	LM104	LM105	LM723
Input Voltage	—	-50 to -8 V	8.5 to 50 V	9.5 to 40 V
Output Voltage	1.8 to 5.6 V	-40 to -0.015 V	4.5 to 40 V	2.0 to 37 V
Output-Input Voltage Differential	--	-50 V	40 V	40 V
Load Regulator	--	5 mV	0.05%	0.6% Vout
Line Regulator	--	0.1%	0.87%	0.3% Vout
Temperature Stability	-7.0 mV/°C	1.0%	1.0%	0.015%/°C
Standby Current Drain	--	5.0 mA	2.5 mA	4.0 mA
Type	Reference Diode	Negative	Positive	Negative or Positive

MICROCIRCUITS

QUALIFIED MICROCIRCUITS (LINEAR)

PART NUMBER	VENDOR	CIRCUIT DESCRIPTION	PACKAGE	DRAWINGS (SEE NOTES)
		Operational Amplifiers		
HA-2-2520-2	HAR	High Slew Rate, Uncompensated	TO-99	ST 11498
HA-9-2520-2	HAR	High Slew Rate, Uncompensated	TO-86	ST 11498
HA-2-2530-2	HAR	High Slew Rate, Wideband Inverter	TO-99	(2)
HA-2-2600-2	HAR	High Inpedance Wide Bandwidth	TO-99	ST 11498
HA-9-2600-2	HAR	High Impedance Wide Bandwidth	TO-91	ST 11498
HA-2-2620-2	HAR	Very Wide Band, Uncompensated	TO-99	ST 11498
HA-9-2620-2	HAR	Very Wide Band, Uncompensated	TO-91	ST 11498
*HA-2-2700-2	HAR	Low Power, High Gain, General Purpose	TO-99	ST 11498
*HA-9-2700-2	HAR	Low Power, High Gain, General Purpose	TO-91	ST 11498
ICL8007	INL	FET Input	TO-99	PT 40695
LF155, 6	NSC	FET Input	TO-99	ST 11980
*LM101 AH, AF	NSC INL	General Purpose	TO-99, TO-86	ST 11499
*LM108H, F, AF	NSC INL	High Impedance, Low Offset Low Drift	TO-99, TO-86	ST 11499
*LM108AH	NSC INL	High Impedance, Low Offset, Low Drift	TO-99	ST 11499
LM118H	NSC	High Slew Rate, Wide Bandwidth	TO-99	(1)
LM124F	NSC	Quad General Purpose	Flatpack	ST 11869
89159	RCA	Radiation Hardened, High Slew Rate	Flatpack	ST 11963

Notes:

* * Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.
* (1) No drawings issued. Consult specialist for drawing status prior to procurement of this part.
* (2) Do not use above $85^{\circ}C$. See Alert #E3-A-02. Consult specialist before using.

MICROCIRCUITS

QUALIFIED MICROCIRCUITS (LINEAR) (contd)

PART NUMBER	VENDOR	CIRCUIT DESCRIPTION	PACKAGE	DRAWINGS (SEE NOTES)
		<u>RF Devices</u>		
*MIC76T	MOT	RF Amplifier	TO-99	ST 11903
*MIC236	MOT	RF Mixer	TO-99	ST 11903
*MIC336	MOT	RF Mixer, Phase Detector	TO-99	ST 11903
2PH3	MOT	Beam Leaded Chip, RF Amplifier	Chip only	
		<u>Phase Locked Loop</u>		
XR-215	EXR	High Frequency (0.5 - 35 MHz)	DIP	PT 40425 (2)
		<u>Comparators</u>		
LM106H, F	NSC	Comparator, Logic or Strobe	TO-99 and Flatpack	ST 11502
LM111H, F	NSC INL AMD	Voltage Comparator	TO-99 and Flatpack	ST 11499
LM119F	NSC	High Speed, Dual	Flatpack	PT 40350
LM139(A)F	NSC AMD	Low Offset Voltage Quad Comparator	Flatpack	ST 11869
LM161 F	NSC	High Speed Differential Input, TTL Compatible	Flatpack	(1)
LM710H, F	NSC	Fast Voltage Comparator	TO-99, TO-86	ST 11500
LF111H, F	NSC	BIFET Voltage Comparator	TO-99 and Flatpack	(1)

Notes:

* Only a "Q" part if internal leads are ultrasonically bonded. Parts of this type with the internal leads thermo-compression bonded are rated "X".

(1) No drawings issued. Consult specialist for drawing status prior to procurement of this part.

(2) Check with specialist before using.

MICROCIRCUITS

QUALIFIED MICROCIRCUITS (LINEAR) (contd)

PART NUMBER	VENDOR	CIRCUIT DESCRIPTION	PACKAGE	DRAWINGS (SEE NOTES)
		<u>Voltage Follower</u>		
LM110H, F	NSC	Voltage Follower	TO-99, TO-86	ST 11891
		<u>Voltage Regulators</u>		
*LM103H	NSC	Precision Reference, Low Voltage Sharp Breakdown	TO-46	ST 11506
LM104H	NSC	Voltage Regulator, Negative	TO-99	ST 11499
LM105F	NSC	Voltage Regulator, Positive	Flatpack	ST 11499
LM105H	NSC	Precision Regulator, Positive	TO-99	ST 11499
LM723H	NSC MOT	Precision Regulator	TO-99	ST 11499
SG1524	SLG	Switching Regulator	DIP	(3)
		<u>Function Generators</u>		
ICL8038	INL	Waveform Generator and VCO	DIP	PT 40432
XR2207	EXR	VCO	DIP	(1)
		<u>Sample and Hold</u>		
HA2420	HAR	Monolithic	DIP	PT 40357 (2)

Notes:

* Indicates choice for standardization. Refer to explanation in second paragraph on page 6 of the Preface.

(1) No Drawings issued. Consult specialist for drawing status prior to procurement of this part.

(2) Consult specialist before using. Use parts with data code 7806 or newer.

(3) Qualification performed by Ford Aerospace. See specialist for details.

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ACCEPTABLE MICROCIRCUITS (LINEAR)

PART NUMBER	VENDOR	TYPE - CHARACTERISTICS	SCRN SPEC ZPP-2073	DRAWINGS	REMARKS (SEE NOTES)
		<u>Operational Amplifiers</u>			
OP15, 16, 17	PMI	FET Input			(1) (2)
HA-2-2620-2	INL	Wide Bandwidth, Uncompensated		ST 11498	(1) (7)
HA-2-2600-2	INL	High Impedance, Wide Bandwidth		ST 11498	(1) (6)
CA3140	RCA	MOSFET Input Overload Protected			(1)
HA-2-2520-2	INL	High Slew Rate Wide Bandwidth		ST 11498	(1) (5)
LM250H	NSC	Programmable			(2)
		<u>Comparators</u>			
ICL8001	INL	Low Power	2833	PT 40344	(3) (4)
		<u>Phase Locked Loop</u>			
CD4046	RCA NSC	Low Frequency (0.3 - 2.4 MHz)		PT 40726	(1)
		<u>Timer</u>			
LM555H	NSC	General Purpose			(1)
		<u>Multiplexer</u>			
HI 1-1818A	HAR	8 Channel; Analog			(1)
		<u>Regulators</u>			
LM117	NSC	Variable Voltage, 3 Terminal			(1) (2)
LM129	NSC	Precision Reference (6.9 V)			(1) (2)

Notes:

(1) Limited evaluation. JPL qualification planned
(2) Standard (ST) planned or written.
(3) Check with specialist before using.
(4) Do not use parts with Date Code earlier than 7601.
(5) Second source for Harris HA-2-2520-2.
(6) Second source for Harris HA-2-2600-2.
(7) Second source for Harris HA-2-2620-2.

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MICROCIRCUITS

QUALIFIED MICROCIRCUITS (CONVERTER)

PART NUMBER	VENDOR	CIRCUIT DESCRIPTION	PACKAGE	DRAWINGS
MN 90227	MNC	±12 V Supply	Special	CS 512650
		-5 to +5 V Analog Input Conversion	1.25 x 0.8 in.	
		12 µs	Dip	
MN 90228	MNC	A/D Converter		CS 512651
		±15 V Supply	Special	
		-5 to +5 V Analog Input	1.25 x 0.8 in.	
		12 µs Conversion	Dip	

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MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS (D/A AND A/D CONVERTERS)

PART NUMBER	VENDOR	TYPE - CHARACTERISTICS	SCRN SPEC ZPP-2073-	DRAWINGS	REMARKS (SEE NOTES)
		<u>D/A Converters</u>			
8018 and Series	INL	Quad Current Switch, for use in D/A Converter	2853A	ST 11871	(1)
AD571KD	ADI	A/D Converter 10 bit ±15 V Supply	--	--	--

Note:

(1) JPL qualification/screening test in progress

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MICROCIRCUITS

QUALIFIED MICROCIRCUITS - ANALOG SWITCHES

PART NO.	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS
DG125	SIL	5-Channel SPST PMOS Switches with Drivers (14-Pin, 1/4 x 1/4 Flatpack)	ST 11496
DG129	SIL	2-Channel Drivers with DPST N-Channel JFET Switches (14-Pin, 1/4 x 1/4 Flatpack)	ST 11496
DG133	SIL	2-Channel Drivers with SPST N-Channel JFET Switches (14-Pin, 1/4 x 1/4 Flatpack)	ST 11496
DG141	SIL	2-Channel Driver with SPST N-Channel JFET Switches (14-Pin, 1/4 x 1/4 Flatpack)	ST 11496
DG181	SIL	2-Channel High Speed Driver with SPST N-Channel JFET Switches	ST 11496
DGM111	SIL	2-Channel SPST PMOS Switch with Driver (14-Pin, 1/4 x 1/4 Flatpack)	ST 11496

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MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS - ANALOG SWITCHES

PART NO.	VENDOR	TYPE - CHARACTERISTICS	DRAWINGS	REMARKS (SEE NOTES)
D129	SIL	4-Channel MOS FET Switch Driver with Decode	ST 11496	
DG300 thru DG303	SIL	Various Switching Configurations CMOS - TTL Compatible		
DG304 thru DG307	SIL	Various Switching Configurations CMOS - CMOS Compatible		

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MICROCIRCUITS

QUALIFIED MICROCIRCUITS

(MICROPROCESSORS AND PERIPHERALS)

Evaluation of various large scale integration (LSI) devices is currently in process. When sufficient information is available, these devices will be included under the appropriate headings. For the current status, contact the specialists listed in the Parts Information Directory section of the PPL for LSI System Components, Microprocessors or LSI Peripherals.

(LSI/VLSI CUSTOM AND SEMI-CUSTOM)

Custom VLSI - Development of design, fabrication and product assurance methodologies for a VLSI is currently being pursued at JPL for support of future JPL system applications.

Semi-Custom LSI - Evaluation of LSI gate arrays, for near term JPL system applications, is being planned for FY 83.

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MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS – (MICROPROCESSORS AND PERIPHERALS)

PART NUMBER	VENDOR	TYPE – CHARACTERISTICS	SPECIFICATION	REMARKS (SEE NOTES)
		Microprocessors		
G1802	SNL	8-Bit Microprocessor (CMOS)	CS512295	(1)
AM 2901A	AMD	4-Bit Microprocessor Slice (Low Power Schottky TTL)	MIL-M-38510/440	
AM 2901B	AMD	4-Bit Microprocessor Slice (Low Power Schottky TTL)	--	--
		Microprocessor Peripherals		
G1852	SNL	8-Bit Input/Output Port	CS512297	(1)
G1856	SNL	4-Bit Bus Buffer/Separator	CS512298	(1)
AM 2902	AMD	Look-Ahead Carry Generator	--	--
AM 2909	AMD	Microprogram Sequencer	--	--
AM 2914	AMD	Vectored Priority Interrupt Controller	--	--

Note:

(1) Radiation hardened 2×10^5 rad (Si) version to be qualified by Project Galileo.

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MICROCIRCUITS

QUALIFIED MICROCIRCUITS (MEMORIES)

PART NUMBER	VENDOR	TYPE - CHARACTERISTICS	DRAWING	REMARKS
CD4061 AD,AK	RCA	CMOS 256X1 Static RAM	PT 40355	

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MICROCIRCUITS

ACCEPTABLE MICROCIRCUITS (MEMORIES)

PART NUMBER	VENDOR	TYPE - CHARACTERISTICS	DRAWING	REMARKS (SEE NOTES)
TCC244	SNL	CMOS 256X4 Static RAM	CS512299	(1)
HS6508RH	HAR	CMOS 1024X1 Static RAM		
HS6504RH	HAR	CMOS 4096X1 Static RAM		(3)
93L415M	FAS	Bipolar 1024X1 RAM		(2)
G1834	SNL	CMOS 1024X8 Static ROM	CS512296	(1)
AM27S29	AMD	Bipolar PROM		
82S100	SGN	Bipolar FPLA		

Notes:

(1) JPL Qualification test planned.

(2) Qualified per JPL Contract 953958

(3) Under development per JPL P/O No. JS-727887

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RELAYS

APPLICATION NOTES

The following is a brief definition of major relay parameters, together with some application considerations and characteristics data.

OPERATING POWER

The operating power of a relay is expressed in watts, usually at 25°C, and it expresses the power required to "just operate" the relay. Since this represents a marginal operating condition, additional power must be applied in order to insure proper operation in the application. As a general rule, four times the "just operate" power (twice pull-in voltage or current) is provided at 25°C to insure proper operation under all circuit and environmental conditions.

COIL RESISTANCE

This is the ohmic value of the relay drive coil. It is usually specified at 25°C, with a tolerance of ±10 percent to allow for variations in winding and wire diameter. Since the coil is wound with copper wire, the resistance value will vary with temperature. It should also be noted that the coil resistance is not only subject to the surrounding ambient, but also to the self-heating effect resulting from the power dissipation within the coil.

PULL-IN CURRENT

This is the current level, usually expressed in milliamperes, that is required to "just operate" the relay. In order to avoid marginal operating conditions and environmental exposures, it is customary to provide a nominal coil current of twice the operate current. The relay is dependent upon ampere turns for its operation, and since the number of turns in a given relay remains constant, the operate current also remains reasonably constant regardless of temperature variation.

RELAYS

DROP-OUT CURRENT

Drop-out current, usually expressed in milliamperes, is the value at which the relay coil releases and contacts return to the de-energized condition. As in the case of pull-in current, drop-out current is relatively independent of ambient temperature. This value should be expressed as approximately 6 to 10 percent of the pull-in current, minimum.

PULL-IN VOLTAGE

The pull-in voltage is that required to "just operate" the relay, and is usually expressed in volts, at 25°C. While the pull-in current remains constant (as explained above), the coil resistance is subject to change depending upon the ambient temperature and coil temperature rise. Therefore, the pull-in voltage will vary directly with temperature, approximating the normal temperature resistance characteristic of copper. Since coil energization will produce self heat in the coil, it will also affect the pull-in voltage. Pull-in voltage increases with temperature.

DROP-OUT VOLTAGE

This is the voltage level at which the drive coil has insufficient magnetic power to hold the armature in the closed condition and the contacts return to the de-energized state. As with pull-in voltage, the value of drop-out voltage will be dependent to the same extent upon ambient temperature. Drop-out voltage increases with temperature.

OPERATE TIME

This is the time interval between the application of coil voltage and the closure of normally-open contacts. It is usually based upon the application of nominal coil voltage, at a temperature of 25°C. Operate time is made up of two essential components, the electrical lag which is dependent upon the coil inductance (which retards the current build up within the coil) and a mechanical lag which is dependent upon the inertia of the armature and contact system. Of these two, the electrical lag is by far the greatest, representing 90 to 95 percent of the operate time. It should also be noted that relay operate time is dependent upon energizing voltage and temperature: that is, inversely proportional to both voltage and temperature.

RELAYS

RELEASE TIME

Release time is the interval between the removal of coil voltage and closure of the normally-closed contacts. Again, this is usually specified under the test conditions of nominal voltage, at 25°C. The release time is essentially independent of ambient temperature and coil voltage. It is, however, heavily dependent upon parallel circuitry included in the coil circuit; such circuitry provides a path for that current which is generated during the magnetic field collapse. This collapsing field current tends to hold the relay in the energized position and can multiply the release time by as much as one order of magnitude.

CONTACT BOUNCE

This is the contact interruptions which may result from the elastic rebound of the contacts, on either the operate or release cycles. Usually, contact bounce is more predominant during the release cycle. It is also noteworthy that contact bounce is dependent upon the current carried by the contacts under test. Bounce is normally specified at the rated load for the contacts. However, it should be remembered that this usually represents the shortest bounce time period, while the low level loads provide the longest periods. Since bounce is usually an elastic rebound condition, it is dependent to a great extent on contact impact velocity. Thus, at lower velocities, contact bounce will be reduced. As might be expected, arc quenching or parallel circuits across the relay coil, which increase dropout time, also reduce contact velocity and hence, bounce time.

CONTACT RESISTANCE

This is the measured electrical resistance through the contact circuitry of the relay, and represents the total resistance developed at the contact interface (plus any ohmic resistance of the contact terminals, contact springs, and internal wiring). This value is usually expressed in ohms or milliohms for relays rated at two amperes or less, and in terms of voltage drop across the contacts at current ratings above two amperes. It is customary to require 50 milliohms (0.050 ohm) on units rated two amperes or less, and a 100 millivolt-drop at rated current for contacts rated above two amperes (before life testing). After life testing it is customary to double these values, as a degradation allowance.

RELAYS

CONTACT LIFE

The life rating of a relay is generally specified in terms of contact life, i.e., the minimum number of contact operations that can be expected with high confidence level, under a given contact load and specified ambient conditions. While the relay is capable of switching a wide range of contact loads, this basic rating system provides a means for standardizing test procedures and providing reasonable comparative data.

CONTACT LOADS

GENERAL

Contact loads fall into one of six types: resistive, inductive, lamp, motor, capacitance, and low level. Each of these load conditions is discussed separately in the following paragraphs, outlining the special requirements and considerations.

RESISTIVE LOAD

The resistive load condition has been generally accepted as the basic load specification item for relay contacts. Life tests are normally conducted at maximum operating temperature, at a cycling frequency of 20 cpm, with a 50 percent duty cycle, with the relays actuated at their nominal coil voltage or current.

INDUCTIVE LOAD

When the current in an inductive circuit is broken by the relay contacts, the collapse of the magnetic field of the inductor induces a voltage of a polarity tending to maintain the current flow. This inducted voltage increases the voltage across the contacts, thereby adding considerably to the arc activity and physical wear upon the contact system. Some circuit elements, such as solenoids, contactors, transformers and heavy relays, provide a sufficiently high inductance to be of concern to the circuit designer because of their impact upon the contact performance of the controlling relay, as well as the RFI that they may develop. It is generally desirable, therefore, when such devices are incorporated in circuits, to provide means of transient suppression for protection of the relay contacts and for reduction of generated RFI.

RELAYS

It is recommended that the circuit design engineer specify relays under the actual application requirements. Where optimum transient suppression can be applied, the load condition will approach that of a resistive nature, and the relay capability will almost be that of the pure resistive load. When transient suppression cannot be employed, current derating will be necessary, generally, to 35 percent of the rated resistive load.

Where inductive loads do exist, transient suppression should be applied to reduce the stress upon the relay contacts and to minimize RFI. Where suppression circuitry is not desirable or feasible, the exact nature of the inductive load should be specified and carefully evaluated. Consultation with a JPL Parts Specialist will be most helpful to the circuit designer in selecting the best relay design for the particular requirement.

LAMP LOADS

Tungsten filament lamps are normally rated at their steady state current, i.e., after the filaments have reached full temperature. When cold, the lamp filament presents a resistance approximately one-tenth of the value that will exist in the stabilized heated condition. This results in a severe current in-rush at the time of initial contact closure and tends to produce an unusual contact burning condition. In many instances, it is necessary to derate the relay under lamp load conditions to a value of 10 to 30 percent of its rated resistive load. In some cases, it may be feasible and desirable to add a series resistor, or an inductor of small value, to limit the in-rush current; here, the derating need not be as severe. Again, consultation with a JPL Parts Specialist will be invaluable to the circuit designer.

MOTOR LOADS

Motor loads combine the undesirable features of the inductive and lamp loads, since they are both inductive and possess a high in-rush current condition. Ordinarily, it is necessary to derate the relay under motor load conditions to 20 percent of its rated resistive load. Therefore, it is necessary that each application be carefully evaluated, and where critical in nature, the exact condition be specified and the relay be evaluated under this specific condition.

RELAYS

CAPACITIVE LOADS

Capacitive load ratings are seldom seen in relay specifications. They do occur, however, in some circuit requirements, and should be given special consideration to insure proper handling by the relay contacts.

Upon initial closure of the relay contacts, the capacitor will usually present an extremely high in-rush current, tapering off as capacitor approaches the steady state charge or discharge condition. In application where the capacity represents a fairly high value, or the circuit resistance is extremely low, attention must be given to the magnitude of the in-rush current to insure that it is within the safe handling capability of the relay contacts. Usually, it is possible to add a small series resistor to limit the current surge and thereby insure against contact damage.

DRY CIRCUIT LOADS

Those low-level loads which fall within the millivolt/milliampere range, typically encountered in signal switching service, are sometimes referred to as dry circuit switching. This is because the voltage and current conditions are so low that they do not impose electrical wear upon the contacts. Actually, such usage is a misnomer, since "dry circuit" defines a switching condition under which contacts are operated with no voltage applied during the switching function. Under dry circuit conditions, contact load is imposed only when the relay contacts have been closed, and it is removed before the contacts are open. "Low-level" is the true definition of this load condition, and for test purposes, the National Association of Relay Manufacturers (NARM) has established 50 millivolts and one milliampere as maximum values.

LOW-LEVEL LOAD

Low level load conditions are unique in that they present insufficient voltage to break through a barrier film, and insufficient current to provide arc activity which might burnish or cleanse contact areas. Therefore, special provisions are necessary for relays intended for this type of service to insure against the presence of barrier films and the contamination which might produce them. Most relays are manufactured under the design and process controls necessary to insure reliable service in low level applications.

RELAYS

INTERMEDIATE RANGE LOADS

The intermediate range load (or minimum current) usually covers the area from 5 to 20 percent of the nominal current rating of a contact system. This type of load requires special consideration by the circuit designer because contact resistance may run higher than is generally anticipated.

Under normal rated load switching conditions, arc activity in the contact area provides a cleansing and burnishing action which constantly reforms the contact surfaces and provides a uniform contact condition (with low contact resistance). Under intermediate range switching conditions, the current density and arc activity are sufficient to aggravate the normal galling action of reforming contact surfaces. Therefore, the contact resistance under these load conditions tends to be higher than under the normal rated condition. While contact resistance levels in this load service may appear excessive at first glance, they represent a relatively small voltage loss in such circuit applications.

CONTACT LOAD/LIFE RATING CURVES

Based upon laboratory load life testing on many hundreds of relays, the curves shown on Figure 1 have been developed. These curves depict the life expectancy which may be anticipated under various load levels, based upon the rated resistive load condition of the relay type.

ENVIRONMENTAL CONDITIONS

Environmental requirements imposed upon the relay have a pronounced effect upon other parameters, such as contact rating and sensitivity, and therefore, the specification of environmental requirements should be applied realistically without undue safety factors.

TEMPERATURE RATINGS

The most commonly specified temperature rating for military and space application relays is -65 to +125°C. There are, of course, other standardized temperature ranges such as -55 to +85°C and -65 to +200°C. (The latter poses some stringent requirements and should be avoided wherever possible).

RELAYS

Generally speaking, temperature has its greatest effect upon the relay by increasing the coil resistance and thereby reducing the coil current available at any given voltage. For example, a crystal can relay designed for 26.5 volt service will normally have a coil resistance of approximately 700 ohms, and in order to insure its proper operation under a minimum circuit voltage condition of 18 volts, it must have a pull-in voltage of approximately 13 volts, at 25°C. In this case, pull-in voltage will not exceed 18 volts at 125°C, including the self heat of the relay coil. The relay will then have an operating power of approximately 210 milliwatts, at 25°C. Now, if the same relay were to be specified for operation at a maximum of 85°C ambient, the 25°C pull-in voltage could be increased during the relay adjustment to approximately 14 volts and still assure that its pull-in voltage would not exceed 18 volts at the 85°C level. Under this adjustment, the relay would have an operating power availability at 25°C of almost 300 milliwatts. This additional power could be utilized to provide additional contact spacing for higher contact ratings or greater pressures for higher vibration levels. Therefore, the value of specifying the operating temperature realistically is clearly evident.

In some instances, it may be necessary for the relay to be exposed to a high temperature (without operational requirements, such as might be incurred during storage or installation processing). In such cases, these should be specified as storage temperatures. With such guidance, the relay designer will then be able to provide the materials and processing necessary for the unit to survive the imposed environment while maintaining the operating advantages available under the lower temperature specified for functional conditions. In circuit package designs, it is often necessary to give consideration to the temperature produced by the relay as a result of the power dissipated in its coil.

VIBRATION AND SHOCK

All relays are ruggedly constructed to withstand rigorous vibration and shock loading without mechanical damage. Most of these relays are rated for a minimum of 20 g's to 2,000 Hz, based upon a failure criterion of 10 μsec of contact chatter, maximum. Many have standard rating of 30 g's to 3,000 Hz with the same failure criterion. Special units with vibration characteristics far in excess of those noted, are available on special order from several manufacturers.

When specifying vibration or shock, it should be recognized that a trade-off exists between these parameters and sensitivity or switching capability. This is due, in many instances, to the necessity of providing contact pressures, i.e., the force holding the movable contact against the normally closed contact, to a value higher than is required for proper contact resistance, to insure against contact chatter under the stress of vibration or shock loading. In many cases, reduction of vibration or shock levels below standard requirements will permit an improvement in sensitivity and switching capability.

In some applications, it may be necessary for the relay to sustain exposure to high vibration or shock loads where contact chatter, or even contact transfer, may not be a consideration. This should be noted in the specifications. The condition may often be met, without sacrificing other performance characteristics.

RELAYS

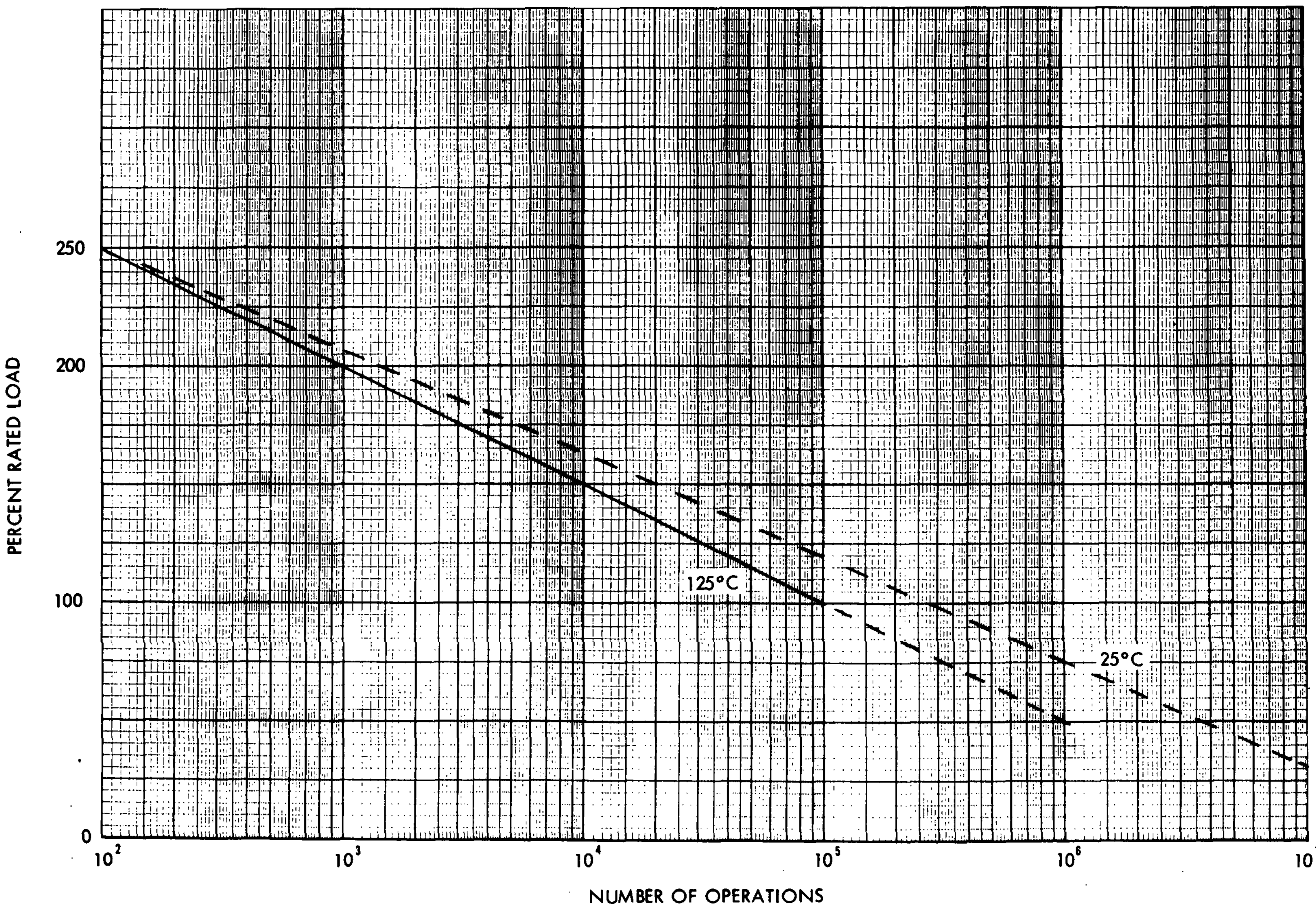

Figure 1. Life Expectancy

RELAYS

QUALIFIED RELAYS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS (1)		SCRN SPEC ZPP-2073-	DRAWINGS
		<u>Miniature</u>	<u>Contacts</u>	<u>Case</u>		
*3 SAM Series	GEC	DPDT Magnetic Latching	2 A at 28 Vdc resistive	Crystal	0410	ST 11739
*BRJ Series	DEU	DPDT Nonlatching	2 A at 28 Vdc resistive	Crystal	Vendor screened (2)	ST 11741
3 SAF Series	GEC	DPDT Nonlatching	3 A at 28 Vdc resistive	Crystal	0407	ST 11742
BR13 Series	BAB	DPDT Nonlatching	3 A at 28 Vdc resistive	Crystal	Vendor screened (2)	ST 11743
		<u>Sub-Miniature</u>				
*BRDJL Series	DEU	DPDT Magnetic Latching	2 A at 28 Vdc resistive	1/2 Crystal	Vendor screened (2)	ST 11744
BR17-S492	BAB	DPDT Magnetic Latching	2 A at 28 Vdc resistive	1/2 Crystal	Vendor screened (2)	ST 11745
		<u>Ultra-Miniature</u>				
*412 Series	TEL	DPDT Nonlatching	1 A at 28 Vdc resistive	TO-5	Vendor screened (2)	ST 11748
*420 Series	TEL	DPDT Magnetic Latching	1 A at 28 Vdc resistive	TO-5	Vendor screened (2)	ST 11749
*421 Series	TEL	SPDT Magnetic Latching	0.5 A at 28 Vdc resistive	TO-5	Vendor screened (2)	ST 11750

(1) All relays on this list are available with various coil voltage ratings. See Part Specialist for proper part number.

(2) Part screening not required if purchased to special Hi-Rel part numbers since screening is performed by the manufacturer. Consult the JPL Part Specialist for verification of special part numbers and part information. Parts screened to JPL screening tests are acceptable. JPL screening test numbers may be obtained from the Part Specialist or Research Engineering Document No. 23.

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

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RELAYS

ACCEPTABLE RELAYS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS (1) Contacts	Case	SCRN SPEC ZPP-2073-	EVALUATION	DRAWINGS
		Contactor-High-Load Capability					
KC-A2A-013	LEA	3PDT, Polarized, Nonlatching	25 A resistive at 28 Vdc 25 A at 115-200 Vac, 400 Hz, 3Φ	1.000 x 1.015 x 1.015 in.	Vendor screened (2)	(3)	See Part Specialist
KCL-A2A-015	LEA	3PDT, Magnetic, Latching	25 A resistive at 28 Vdc 25 A resistive at 115-200 Vac, 400 Hz, 3Φ	1.000 x 1.015 x 1.015 in.	Vendor screened (2)	(3)	See Part Specialist
K-A2A-012	LEA	4PDT, Polarized, Nonlatching	10 A resistive at 28 Vdc	1.015 x 1.000 x 1.015 in.	Vendor screened (2)	Similar to KC-4PDT, 10 A	See Part Specialist
KL-A2A-015	LEA	4PDT, Magnetic Latching	12 A resistive at 28 Vdc	1.015 x 1.000 x 1.015 in.	Vendor screened (2)	Similar to KCL-4PDT, 10 A	See Part Specialist
BR15-S159	BAB	4PDT, Nonlatching	10 A resistive at 28 Vdc	1.075 x 1.3 x 1 in.	Vendor Screened (2)	(3)	See Part Specialist
BR23-S80	BAB	4PDT, Magnetic Latching	10 A resistive at 28 Vdc	1.075 x 1.3 x 1 in.	Vendor Screened (2)	(3)	See Part Specialist
BR19-S555	BAB	2PDT Nonlatching	10 A resistive at 28 Vdc	1.075 x 1.3 x 0.515 in.	Vendor Screened (2)	(3)	See Part Specialist
BR20-S496	BAB	2PDT Magnetic Latching	10 A resistive at 28 Vdc	1.075 x 1.3 x 0.515 in.	Vendor Screened (2)	(3)	See Part Specialist
		Subminiature					
3SBH	GEC	4PDT, Nonlatching	2 A resistive at 28 Vdc	0.61 x 0.61 x 0.32 in.	0430	(3)	See Part Specialist
3SBM	GEC	4PDT, Magnetic, Latching	2 A resistive at 28 Vdc	0.61 x 0.61 x 0.32 in.	0431	(3)	See Part Specialist

Notes: (1) All relays on this list are available with various coil voltage ratings. See Part Specialist for proper part number.

(2) Part screening not required if purchased to special Hi-Rel part numbers since screening is performed by the manufacturer. Consult JPL Part Specialist for verification of special part numbers and part information. Parts screened to JPL screening tests are acceptable. JPL screening test numbers may be obtained from the Part Specialist or Research Engineering Document No. 23.

(3) Qualification test cancelled, but completed sufficiently to evaluate these parts as being acceptable.

INDEX OF RESISTORS AND THERMISTORS

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AGS-10/RWR84	46	HR12/RBR55	47	RER70	46	# 33A5	49
ARH-5/RER60	46	HR14/RBR54	47	RER75	46	# 35A2	49
ARH-10/RER65	46	HR32	47	RLR05	45	# 118AKP	49
ARH-25/RER70	46	HR41	47	RLR07	45	# 118AKR	49
ARH-50/RER75	46			RLR20	45	# 118AKT	49
		MG650	48	RNC50	44	# 146DV	49
BB/RCR05	43	MG660	48	RNC55	44		
		MG680	48	RNC60	44	811 Series	48
CB/RCR07	43	MG721	48	RNC65	44		
		MG750	48	RNC70	44	# 44004	49
EB/RCR20	43	MG780	48	RWR80	46	# 44005	49
				RWR81	46	# 44006	49
				RWR82	46	# 44008	49

Thermistor

RESISTORS

GENERAL APPLICATION NOTES

Resistors generate heat, and their power rating is based on the amount of heat they can dissipate and remain within some specified tolerance. Anything which increases the amount of heat the part can dissipate, such as low ambient temperature, good heat sinking or forced air convection, increases the power handling capability. Anything which decreases the heat dissipation such as high ambient temperature or operation in vacuum, decreases the power rating. Power ratings of resistors are, unfortunately, not all based on the same ambient temperature, but vary depending on device type with ratings at 25, 70, and 125°C. All ratings assume free air with a heat sink available to the resistor leads within one inch of the body, typically a terminal or a printed wiring board. Termination as close as practicable to the resistor body will obviously help its heat dissipation. Attention to basic thermodynamics will greatly aid in the proper application of resistors.

METAL FILM (DALE EMF/RNC Series)

These resistors should be used for general purpose applications if the carbon composition types cannot be used. Power rating is based on an ambient temperature of 125°C. Impedance remains relatively constant to frequencies of 1 MHz. Resistance normally increases and the primary failure mode is open.

WIREWOUND, PRECISION (Shallcross HR/RBR Series)

These devices are for use whenever extremely close tolerances or excellent stability are needed. Initial tolerance can be 0.01 percent and drift will be about 0.05 percent per year. Power rating is based at 125°C.

THICK FILM, HIGH VALUE, HIGH VOLTAGE (Cad MG Series)

The Caddock MG resistors are special thick film devices intended for use whenever high voltages or high resistance values are required. They are not for general purpose use.

NETWORKS (DALE TKR Series)

These parts have 7 to 13 resistors in a flat pack, and are designed for general purpose applications where multiple resistors of the same and different values are needed, such as pull-up resistors. Resistance tolerance is 2 percent.

RESISTORS

LADDER NETWORKS (BEK 811 Series)

The 811 ladder is a R-2R type of ladder and includes three application resistors. Resistance values available for R are 5, 10 and 20 k ohms. Compensation is made in the first four bits for a switch resistance of 5 ohms.

POWER WIREWOUND RESISTORS

The power wirewound resistors listed herein are suitable for spacecraft flight equipment. These resistors are general purpose types for dc and low frequency ac use, with wattage ratings of 1 to 30 watts.

CASE TEMPERATURE VERSUS POWER DISSIPATION

Power ratings are based on 25°C free air ambient temperature, and a heat sink available at the resistor termination within 3/8 inch from the body. The JPL derating figure is to use the resistors at 50 percent of the rated power. From the temperature rise curves, it should be noted that in some cases this will bring the part to an operating temperature of 150°C. The resistor will operate reliably at this temperature, but it may adversely affect surrounding parts which are not capable of surviving the high temperature. The resistor must be further derated for ambient temperatures above 25°C. Additionally, they must be derated for operation in a vacuum, since they depend on convection cooling to a great extent. It is recommended that the parts be derated to 25 percent of the rated power for vacuum operation. Refer to Figures 1, 2, 3, and 4. The resistors may be ultrasonically cleaned. The following maximum resistance-temperature characteristics must be observed:

Below 1 ohm	$\pm$90 ppm/$^{\circ}$C
1 to below 10 ohms	$\pm$50 ppm/$^{\circ}$C
10 ohms and above	$\pm$20 ppm/$^{\circ}$C

ELECTRICAL CHARACTERISTICS

The resistors are inductively wound (refer to Figure 5), and the reactive components for the various types are listed in Table 1.

RESISTORS

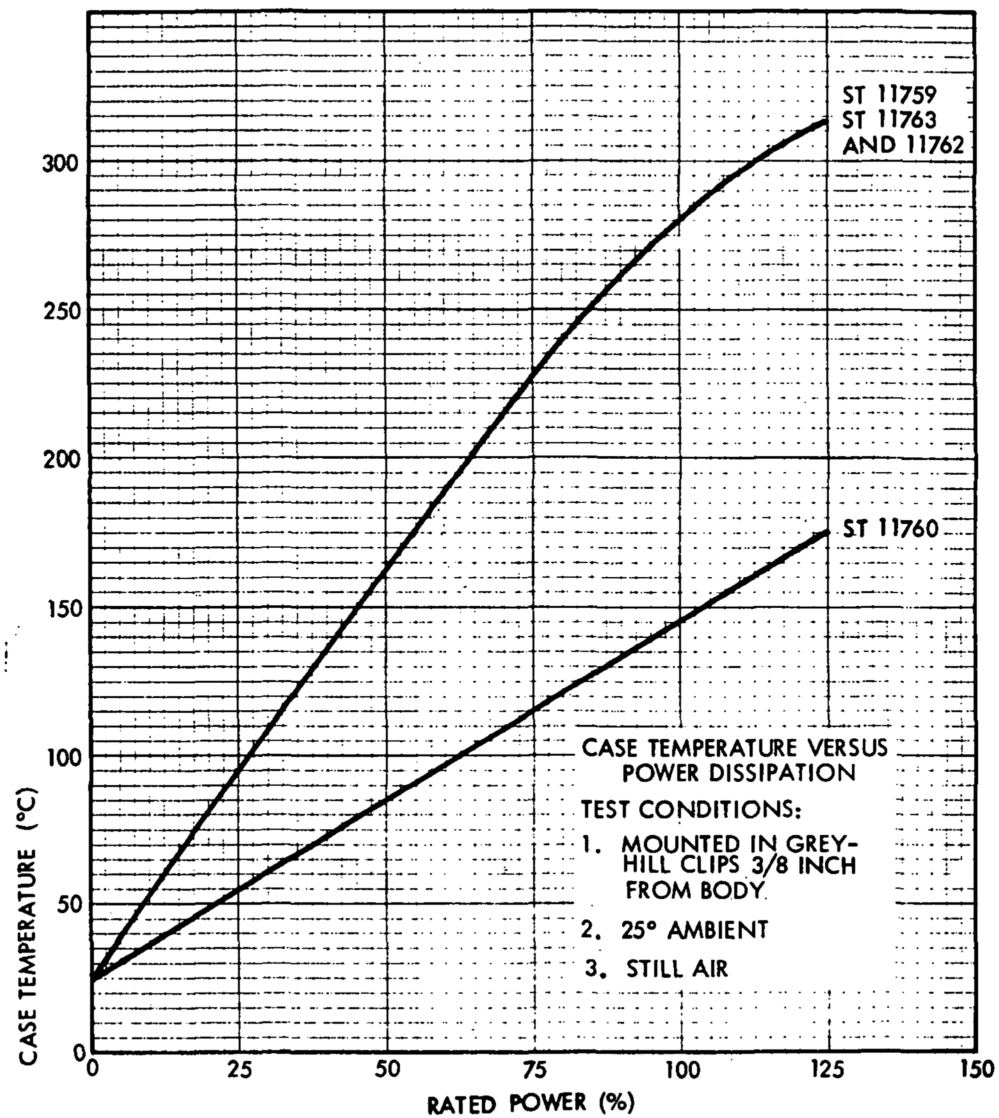

Figure 1

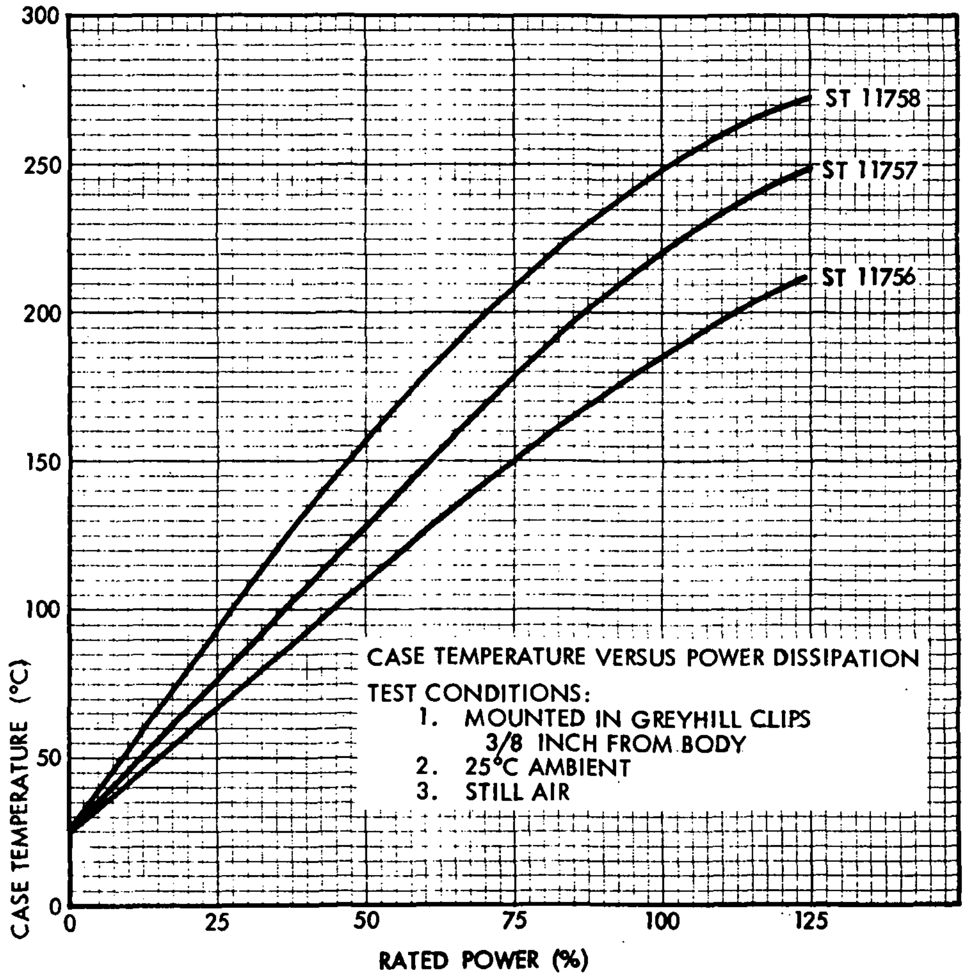
300
250
200
150
100
50
0
CASE TEMPERATURE (°C)
0
25
50
75
100
125
RATED POWER (%)
ST 11758
ST 11757
ST 11756
CASE TEMPERATURE VERSUS POWER DISSIPATION
TEST CONDITIONS:
1. MOUNTED IN GREYHILL CLIPS 3/8 INCH FROM BODY
2. 25°C AMBIENT
3. STILL AIR

Figure 2

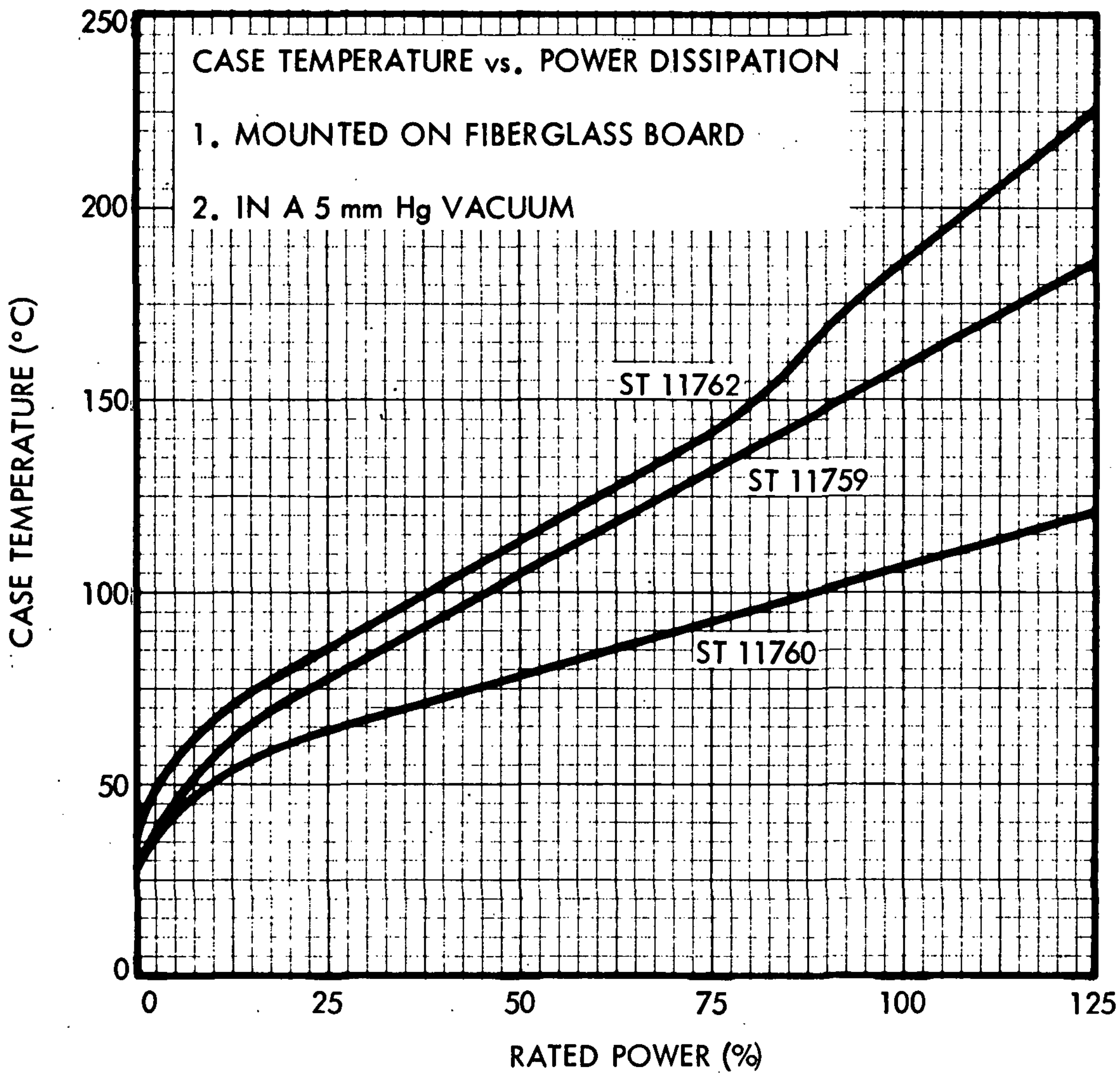

Figure 3

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RESISTORS

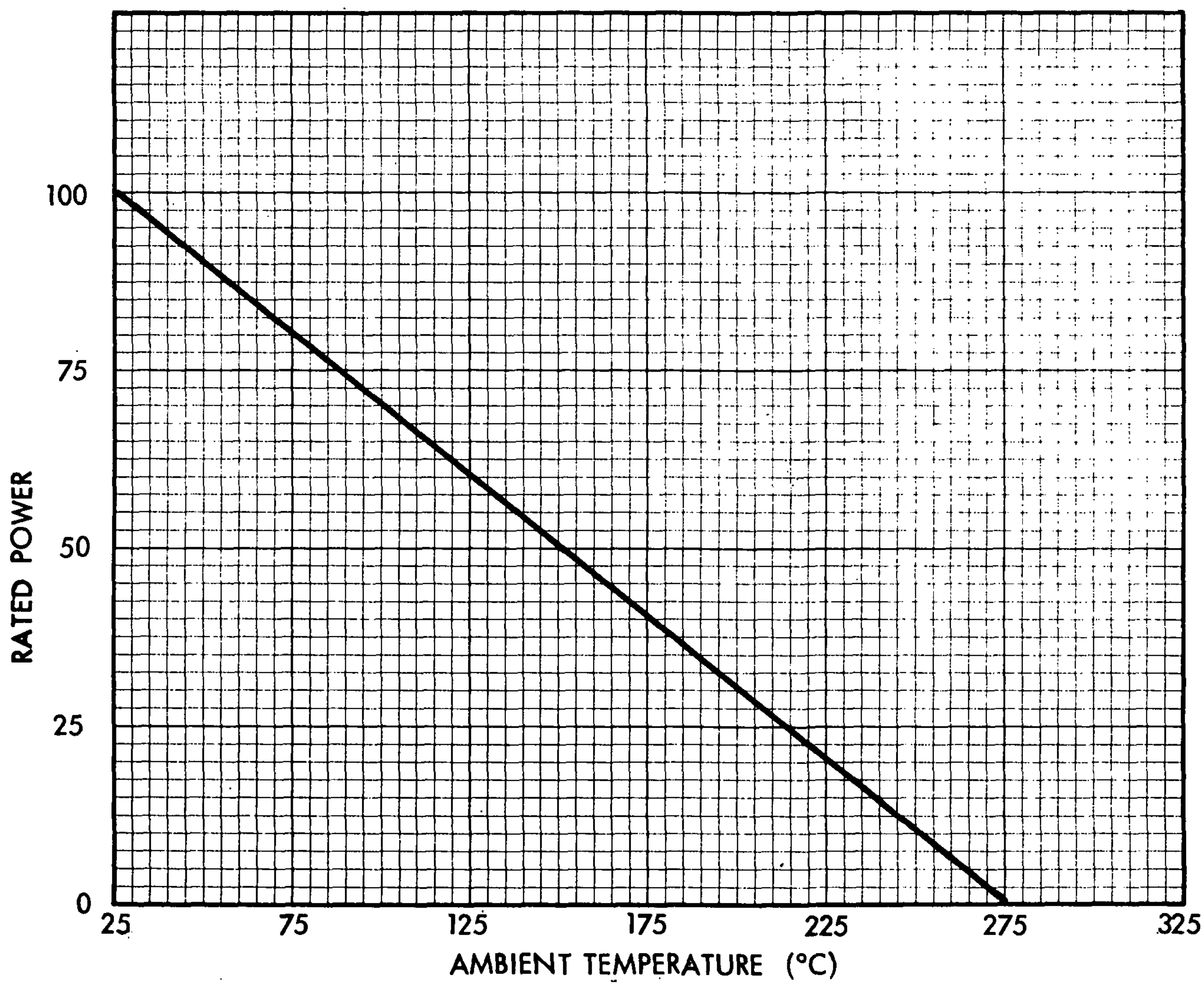


Figure 4. High Temperature Derating Curve

RESISTORS

Table I. Reactive Components (Sheet 1 of 3)

ST11760			ST11759		
Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)
0.5	0.1	0.014	0.5	0.1	0
	10.0	0.047		10.0	0.202
	100.0	0.20		100.0	0.50
	1 k	0.936		500.0	1.575
				1 k	2.809
1.0	0.5	0.09	1.0	0.1	0.05
	10.0	0.15		10.0	0.25
	100.0	0.40		100.0	0.50
	1 k	1.30		500.0	1.60
				1 k	2.1
4.0	0.5	0.09	4.0	0.1	0.05
	10.0	0.14		10.0	0.25
	100.0	0.40		100.0	0.55
	1 k	1.30		500.0	1.6
				1 k	2.2
10.0	0.5	0.08	10.0	0.1	0.06
	10.0	0.12		10.0	0.25
	100.0	0.40		100.0	0.50
	1 k	1.40		500.0	1.7
				1 k	2.3

RESISTORS

Table I. Reactive Components (Sheet 2 of 3)

ST11762			ST11756		
Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)
0.5	10.0	0.56	0.5	0.5	0.066
	100.0	1.24		1.0	0.070
	500.0	3.06		10.0	1.29
	1 k	5.88		100.0	3.40
	3 k	8.6		500.0	6.66
				1 k	7.28
				5 k	10.4
1.0	10.0	0.8	1.0	1.0	0.110
	100.0	1.4		10.0	1.07
	500.0	3.1		100.0	2.45
	1 k	5.4		500.0	6.30
	2.5 k	8.9		1 k	8.45
				4 k	28.2
4.0	10.0	0.7	4.0	1.0	0.100
	100.0	1.4		10.0	1.10
	500.0	3.1		100.0	2.42
	1 k	5.4		500.0	6.27
	2.5 k	8.6		1 k	10.9
				4 k	25.8
10.0	10.0	0.8	10.0	1.0	0.14
	100.0	1.4		10.0	1.10
	500.0	3.1		100.0	2.36
	1 k	5.7		500.0	6.12
	2.5 k	8.6		1 k	9.36
				4 k	20.3

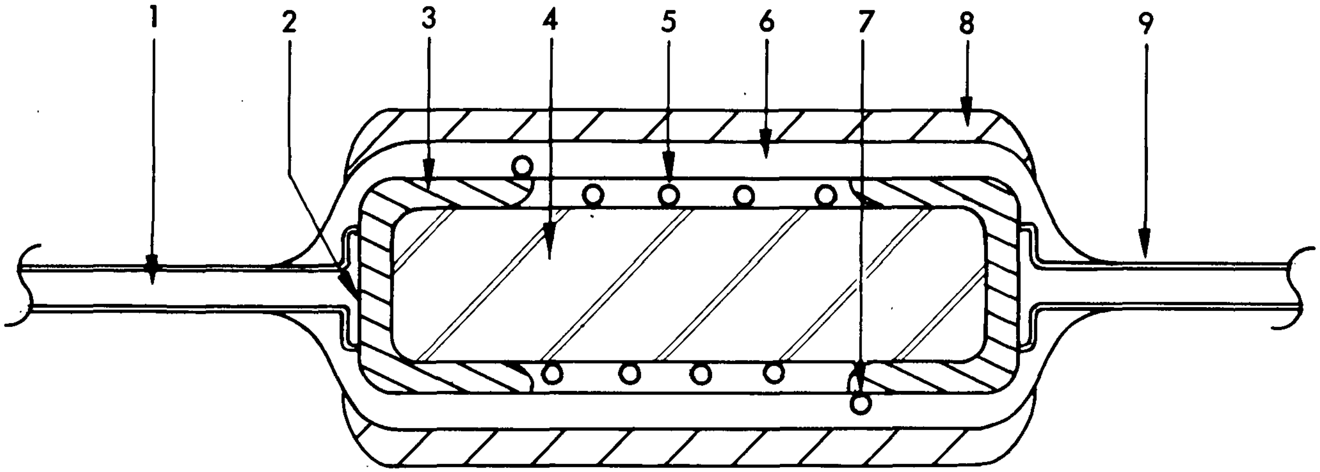
RESISTORS

Table I. Reactive Components (Sheet 3 of 3)

ST11757 and ST11763			ST11758		
Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)
0.5	10.0	2.19	0.5	1.0	0.307
	100.0	8.02		10.0	0.860
	500.0	9.37		100.0	15.40
	1 k	18.21		500.0	21.2
	3 k	27.30		1 k	28.6
	5 k	24.15		5 k	130.0
				10 k	44.0
1.0	10.0	1.3	1.0	1.0	0.220
	100.0	6.7		10.0	2.65
	500.0	9.6		100.0	0.560
	1 k	11.3		500.0	24.2
	2.5 k	22.0		1 k	34.3
				4 k	94.3
				14 k	14.50
4.0	10.0	1.6	4.0	1.0	0.240
	100.0	7.0		10.0	2.71
	500.0	9.6		100.0	0.590
	1 k	11.4		500.0	24.4
	2.5 k	21.9		1 k	33.6
	5 k	25.4		4 k	98.7
				14 k	15.7
10.0	10.0	1.4	10.0	1.0	0.24
	100.0	6.7		10.0	2.69
	500.0	9.8		100.0	0.57
	1 k	15.4		500.0	28.3
	2.5 k	23.0		1 k	36.9
	7.5 k	23.4		4 k	7.66
				14 k*	

*Net Capacitance: 0.08 pF

RESISTORS



1. NICKEL LEAD WIRE
2. LEAD WIRE TO END CAP WELD: RESISTANCE BUTT WELD
3. NICKEL-IRON END CAP
4. CERAMIC CORE: ALUMINA IN ST 11756, ST 11757, AND ST 11758 AND BERYLLIA IN ST 11759, ST 11760, ST 11761, ST 11762, AND ST 11763
5. RESISTANCE WIRE: NICKEL-COPPER IN LOW RESISTANCE VALUES AND NICKEL-CHROMIUM IN HIGH RESISTANCE VALUES
6. BODY: CONFORMAL COATED HIGHLY FILLED MODIFIED SILICONE
7. RESISTANCE WIRE TO END CAP WELD
8. POLYTETRAFLUORETHYLENE SLEEVE
9. GOLD PLATE OR SOLDER PLATE ON LEAD WIRE SURFACES

Figure 5. Construction

RESISTORS

PULSE HANDLING CAPABILITY

Power wirewound resistors have steady-state power and voltage ratings which limit the temperature of the unit to less than 275°C. For pulses of several seconds, these ratings are satisfactory, however, the resistors are capable of handling much higher levels of power and voltage for very short periods of time. It is the product of power and time, energy, that creates heat, not just power alone. Figures 6 and 7 show the maximum power the resistors are capable of enduring for relatively short periods of time without significant changes in resistance or other parameters. The uses and limitations of these curves are as follows:

1. Determine the maximum pulse power rating for:

   a. Non-repetitive pulses.

      1) Calculate the pulse power: $P = \frac{V^2}{R}$

         P = Pulse power (watts)
         V = Pulse voltage (volts)
         R = Resistance (ohms)

      2) The maximum pulse power rating is not exceeded, if the intersection of the pulse power line and pulse width line is on or below the appropriate curve.

   b. Repetitive pulses.

      1) Calculate the pulse power and check the curve as in a. above, to determine if the maximum pulse power rating is exceeded.

      2) If the maximum pulse power rating is not exceeded, determine the average pulse power: $P_{avg} = P \frac{t}{T}$.

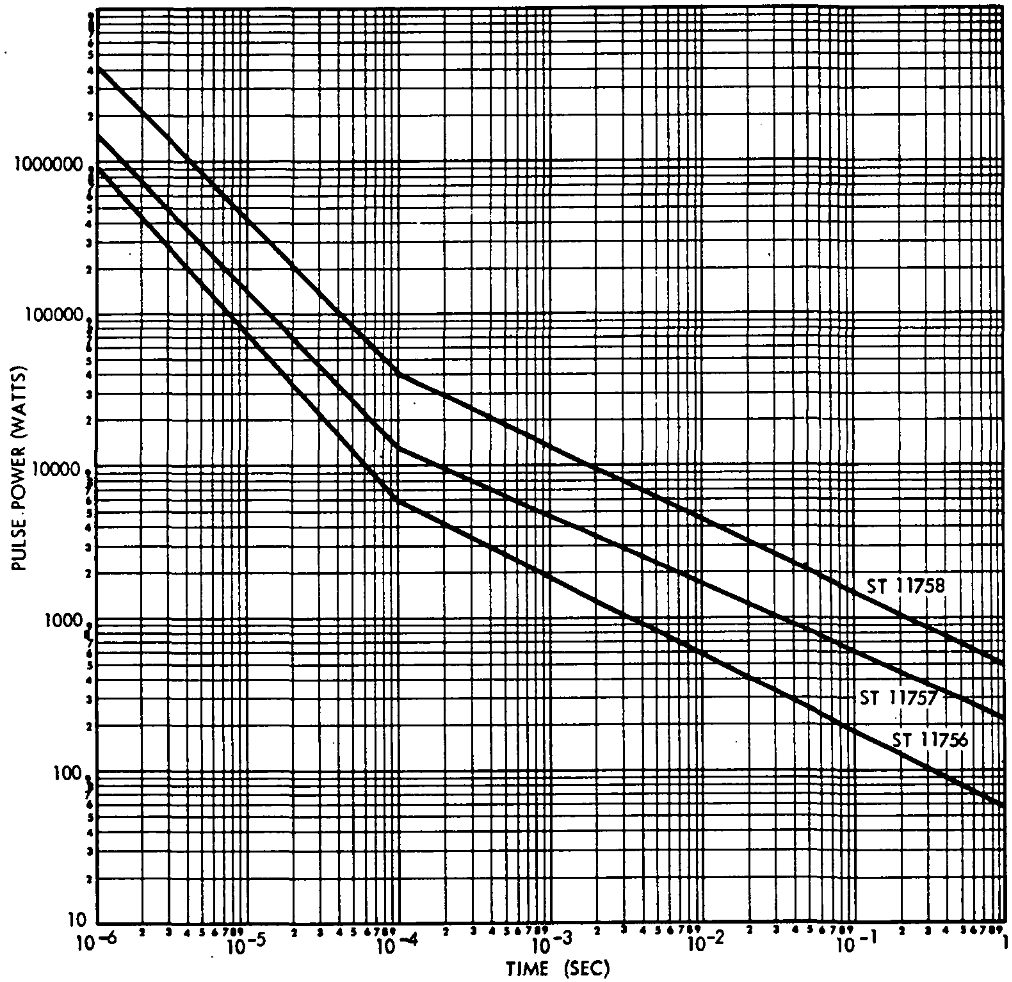

PULSE POWER (WATTS)
1000000
100000
10000
1000
100
10
ST 11758
ST 11757
ST 11756
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
TIME (SEC)

Figure 6

RESISTORS

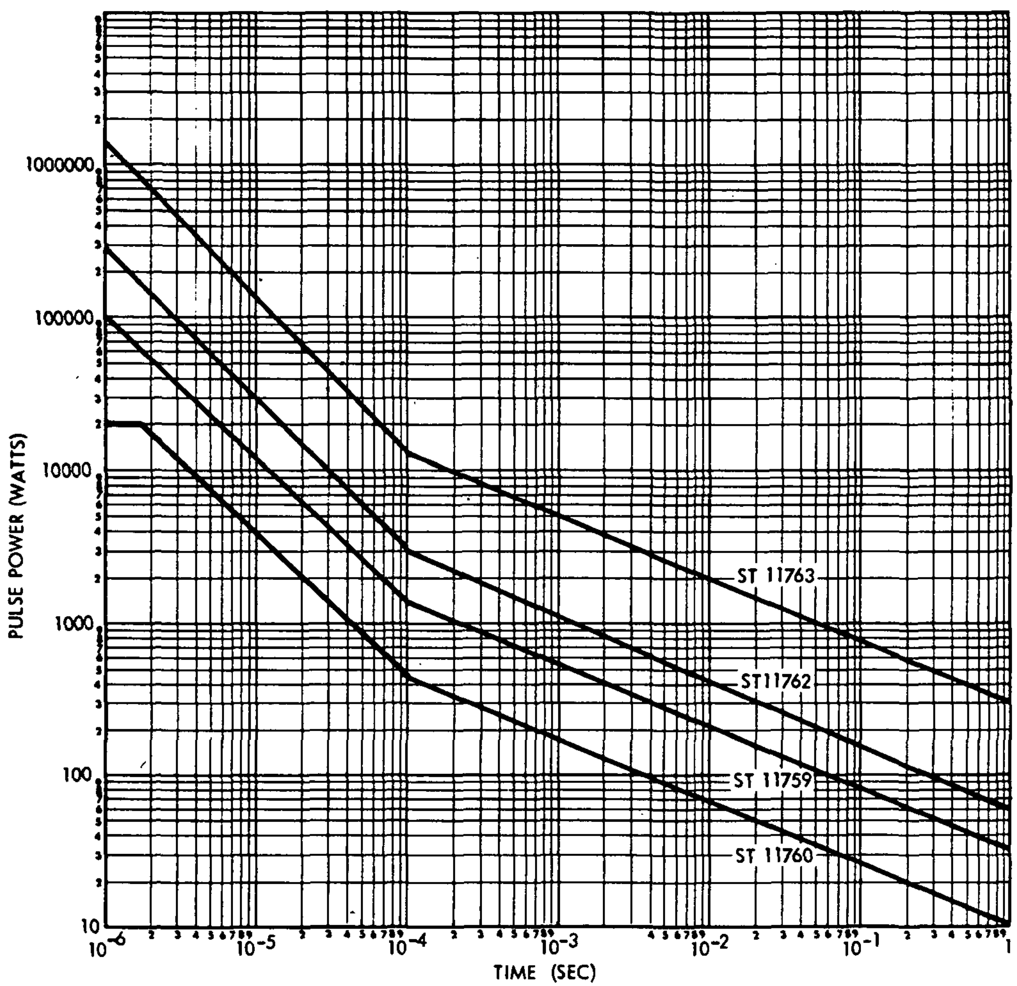


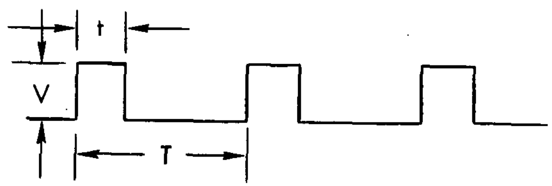
Figure 7

P_{avg} = Average pulse power (watts)

P = Pulse power (watts)

t = Pulse width (seconds)

T = Time of sequence - pulse width plus off time of one cycle (seconds)



The average pulse power should not exceed 50 percent of the steady-state power rating.

2. The maximum pulse voltage shall be:

ST11760	175 V	ST11763	750 V
ST11759	275 V	ST11757	750 V
ST11762	450 V	ST11758	1400 V
ST11756	550 V		

3. Limitations.

a. Under reduced pressure conditions, the voltage shall not exceed the values shown due to reduced dielectric strength of the air:

ST11760	200 V	ST11762	200 V
ST11759	200 V	ST11763	500 V

b. When the resistors are operated above 25°C, the pulse power rating must be derated, just as it is for steady-state ratings. Derate linearly from 100 percent of the pulse power at 25°C to 0 percent at 275°C.

c. When the resistors are operating under steady-state conditions and a pulse is applied, the pulse power rating must be derated. Derate linearly from 100 percent of the pulse power at 0 percent steady-state power to 0 percent of the pulse power at 100 percent steady-state power.

RESISTORS

CARBON COMPOSITION RESISTORS

The carbon composition resistors listed herein are suitable for spacecraft flight equipment. These resistors are general purpose types for use where variations in resistance due to temperature, moisture and life can be tolerated.

CASE TEMPERATURE VERSUS POWER DISSIPATION

Power ratings are based on 70°C free air ambient temperature. However, the resistors may be operated at 70 percent of rated power if the ambient temperature is maintained at less than 50°C. The JPL derating figure is to use the resistors at 50 percent of the rated power. They must be further derated at ambient temperatures above 70°C. Additionally, they must be derated for operation in a vacuum, since they depend on convection cooling to a great extent. Curves are not presently available for this percentage; however, it is recommended that the parts be derated to 75 percent of the rated power for vacuum operation. Refer to Figures 8 and 9. Construction is shown on Figure 10.

RESISTANCE TEMPERATURE CHARACTERISTICS

The minimum and maximum allowable change in resistance for each ohmic value is shown in Table II.

ELECTRICAL CHARACTERISTICS

The reactive components are given in two types of curves:

1. The ratio of impedance ($|Z|/R_{dc}$) versus dc resistance (Rdc) for frequencies from 0.1 to 100 MHz.
2. The phase angle (θ) versus Rdc for frequencies from 0.1 to 100 MHz. Refer to Figures 11 through 18.

MOISTURE ABSORPTION

The resistors will absorb moisture and shift positively in resistance value; however, such action takes months and the resistance shift is temporary and completely reversible. When the resistors are dried out, they will return to their original value.

RESISTORS

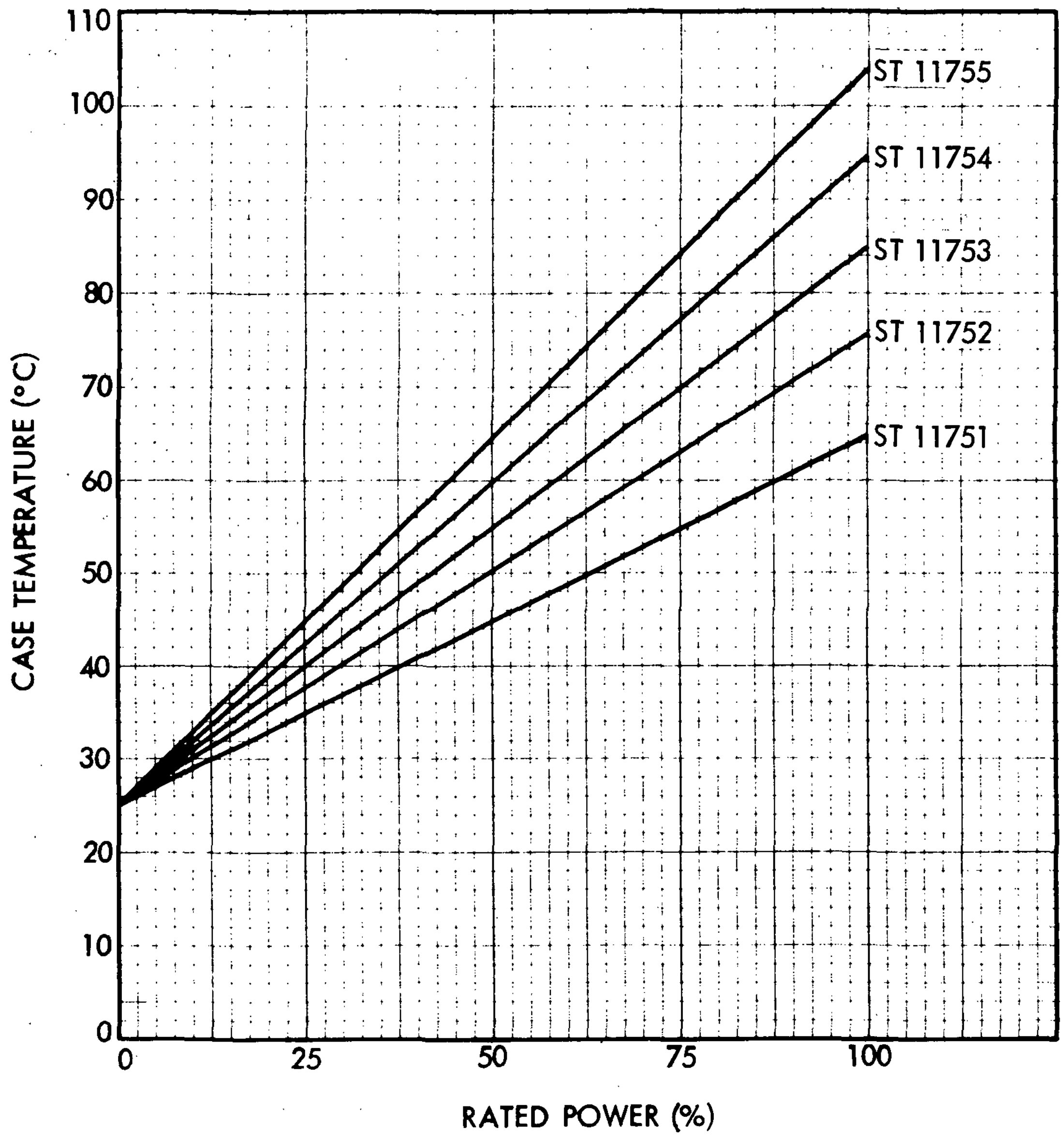


Figure 8

RESISTORS

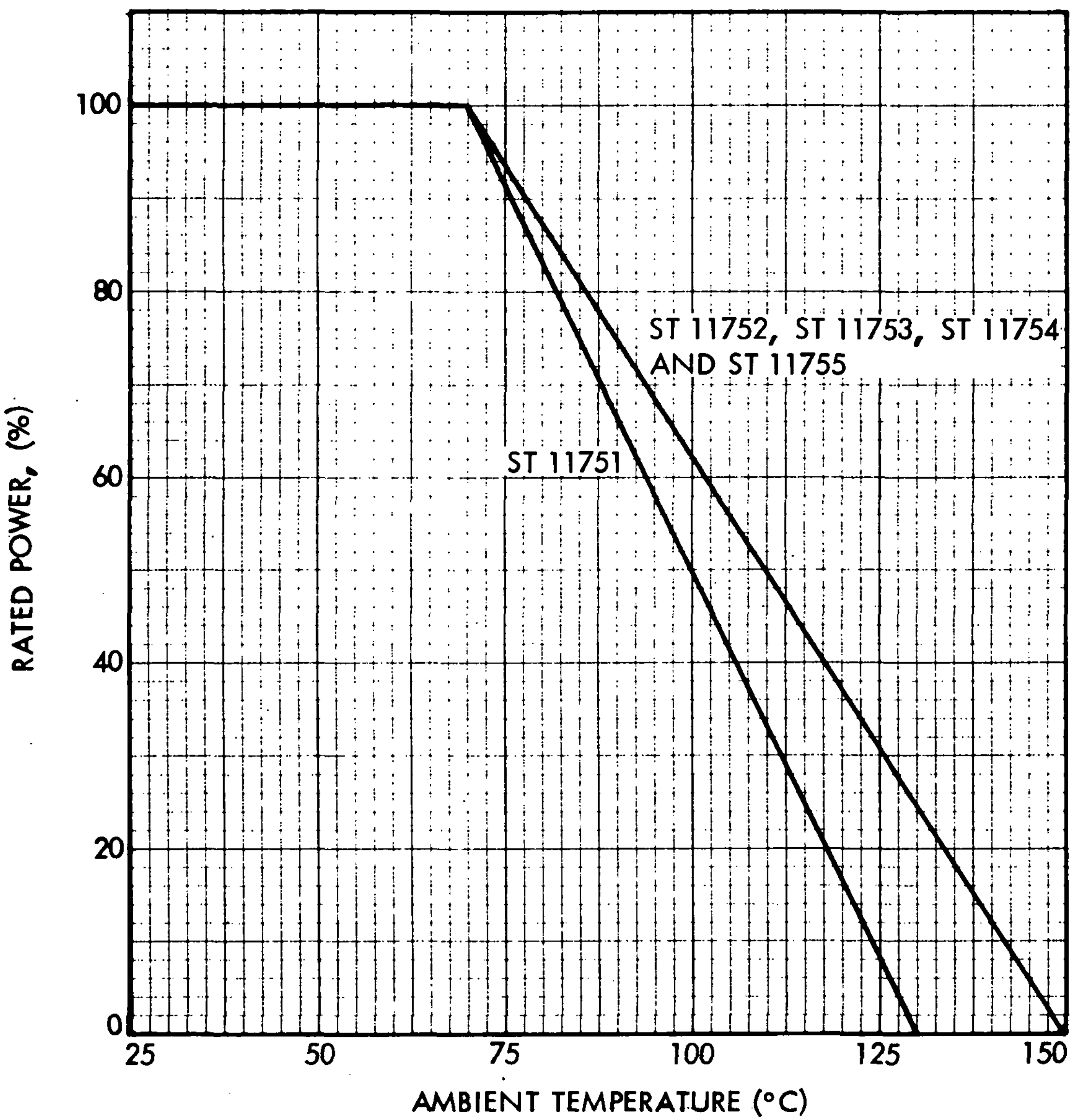


Figure 9. High Temperature Derating Curve

Table II. Resistance Temperature Characteristics

Nominal Resistance (Ohms)	Allowable Change in Resistance From Resistance at Ambient Temperature of 25°C			
	At -55°C (Ambient) (Percent)		At +105°C (Ambient) (Percent)	
	Minimum	Maximum	Minimum	Maximum
1 k and under	+0.3	+6.4	-1.0	+5.0
1.1 to 10 k	+0.4	+7.7	-1.2	+6.0
11 to 100 k	+0.5	+8.9	-1.4	+7.1
110 k to 22 M	+0.6	+11.9	-1.9	+9.4
24 to 100 M	+0.7	+12.8	-2.0	+10.1

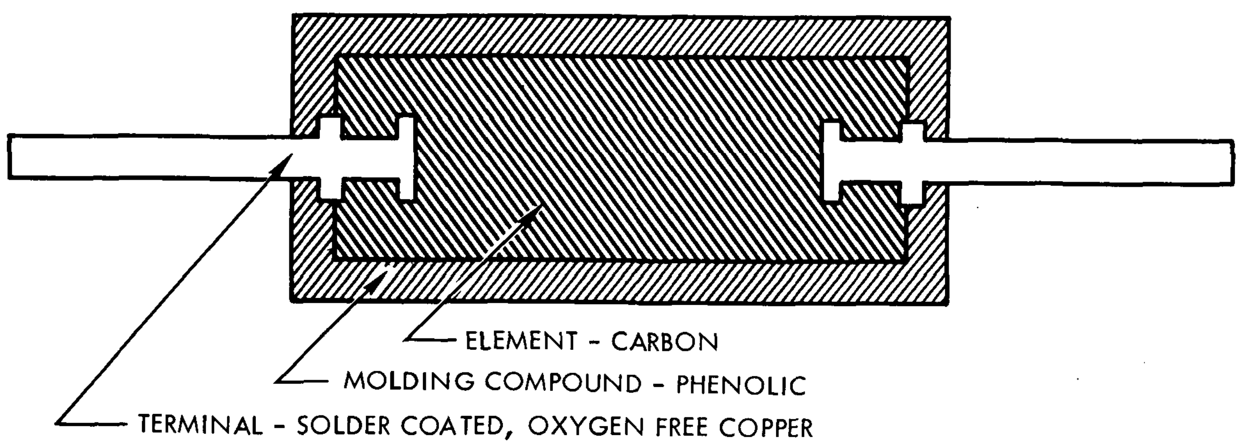


Figure 10. Construction

ST11751
ST11752

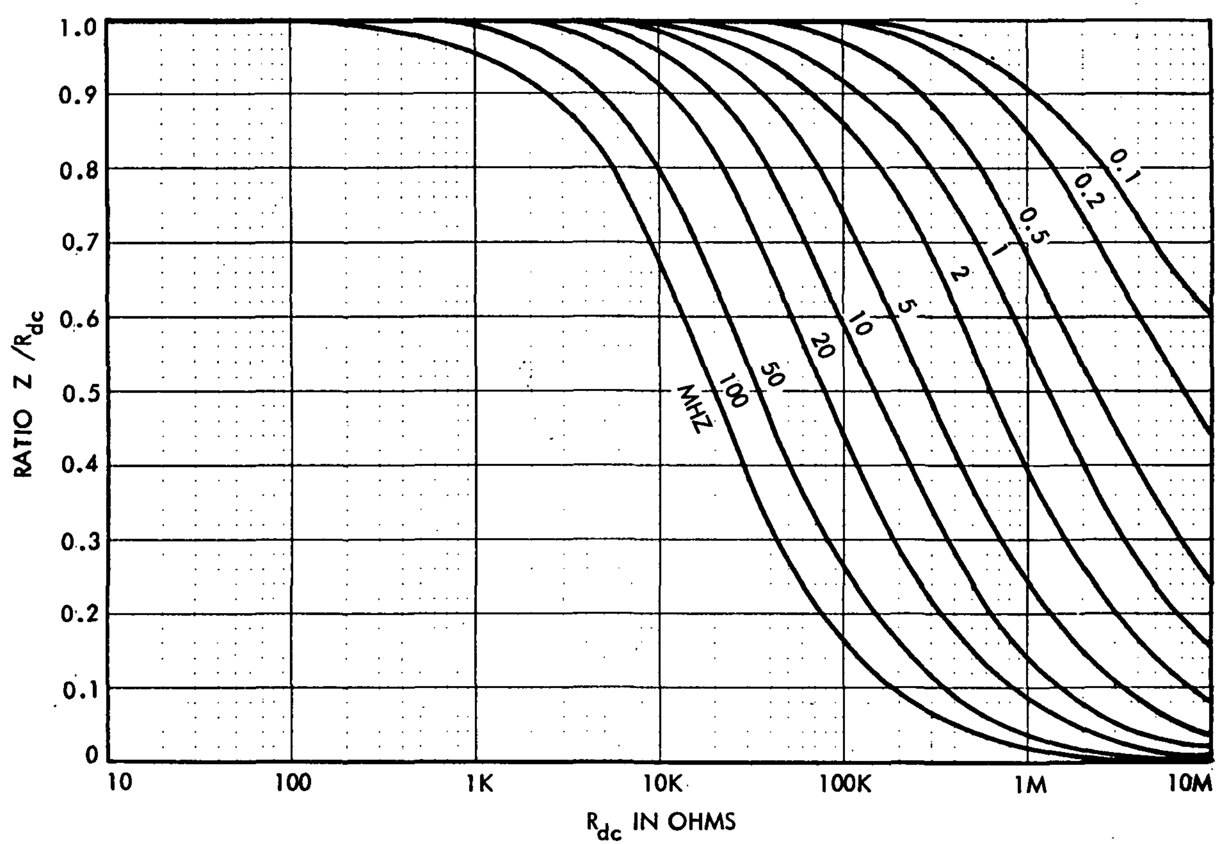


Figure 11

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RESISTORS

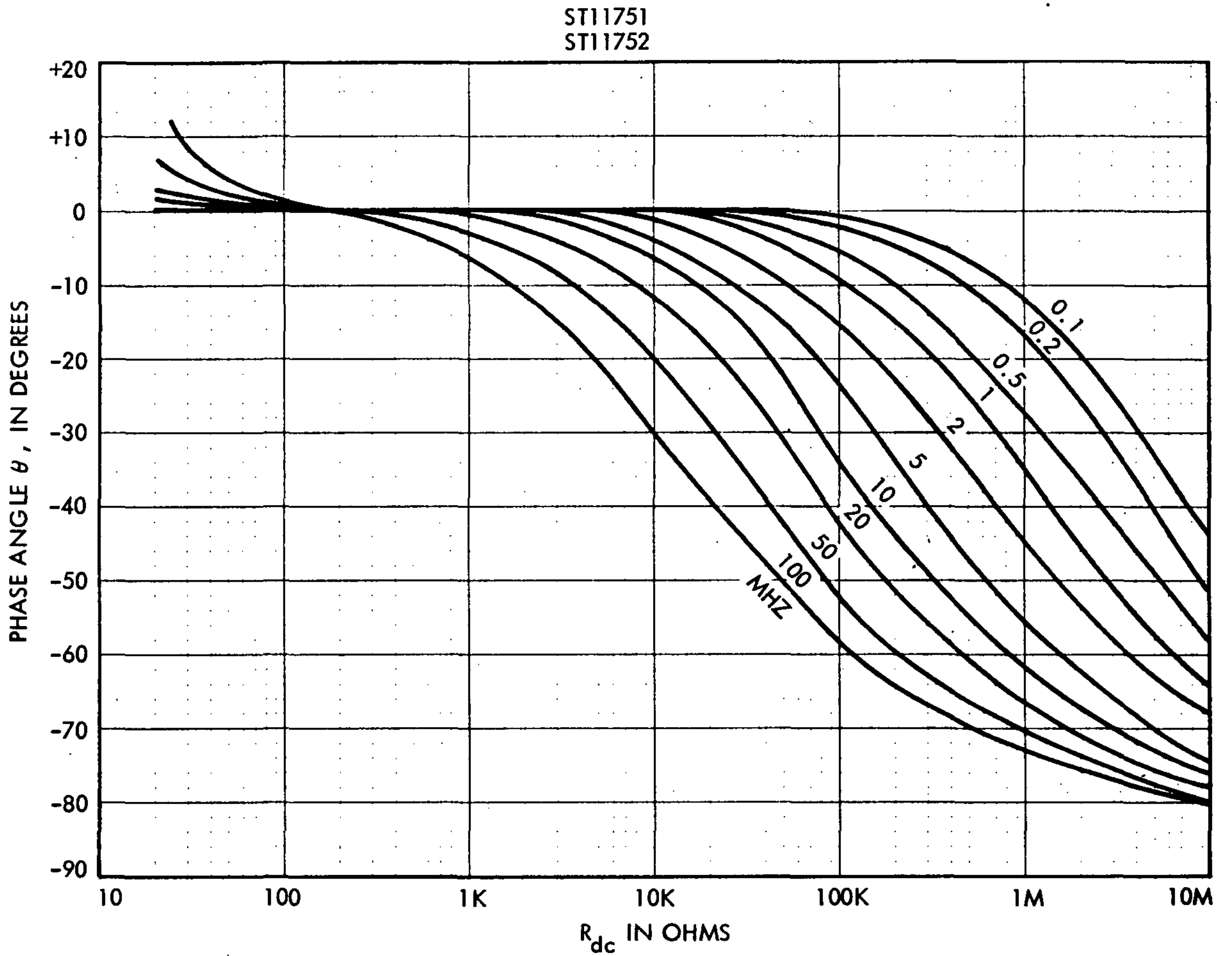


Figure 12

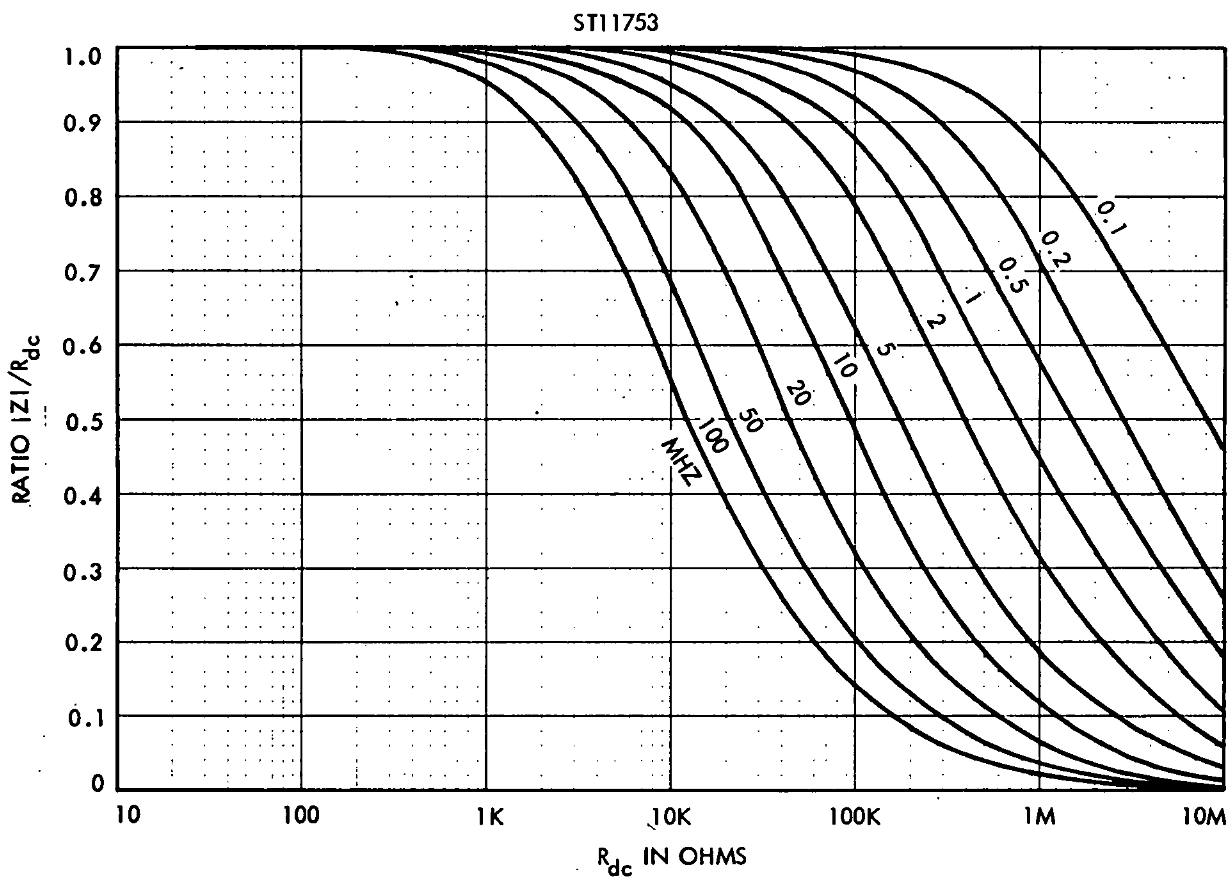

ST11753
RATIO |Z|/R_{dc}
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
100
1K
10K
100K
1M
10M
R_{dc} IN OHMS
0.1
0.2
0.5
1
2
5
10
20
50
100
MHZ

Figure 13

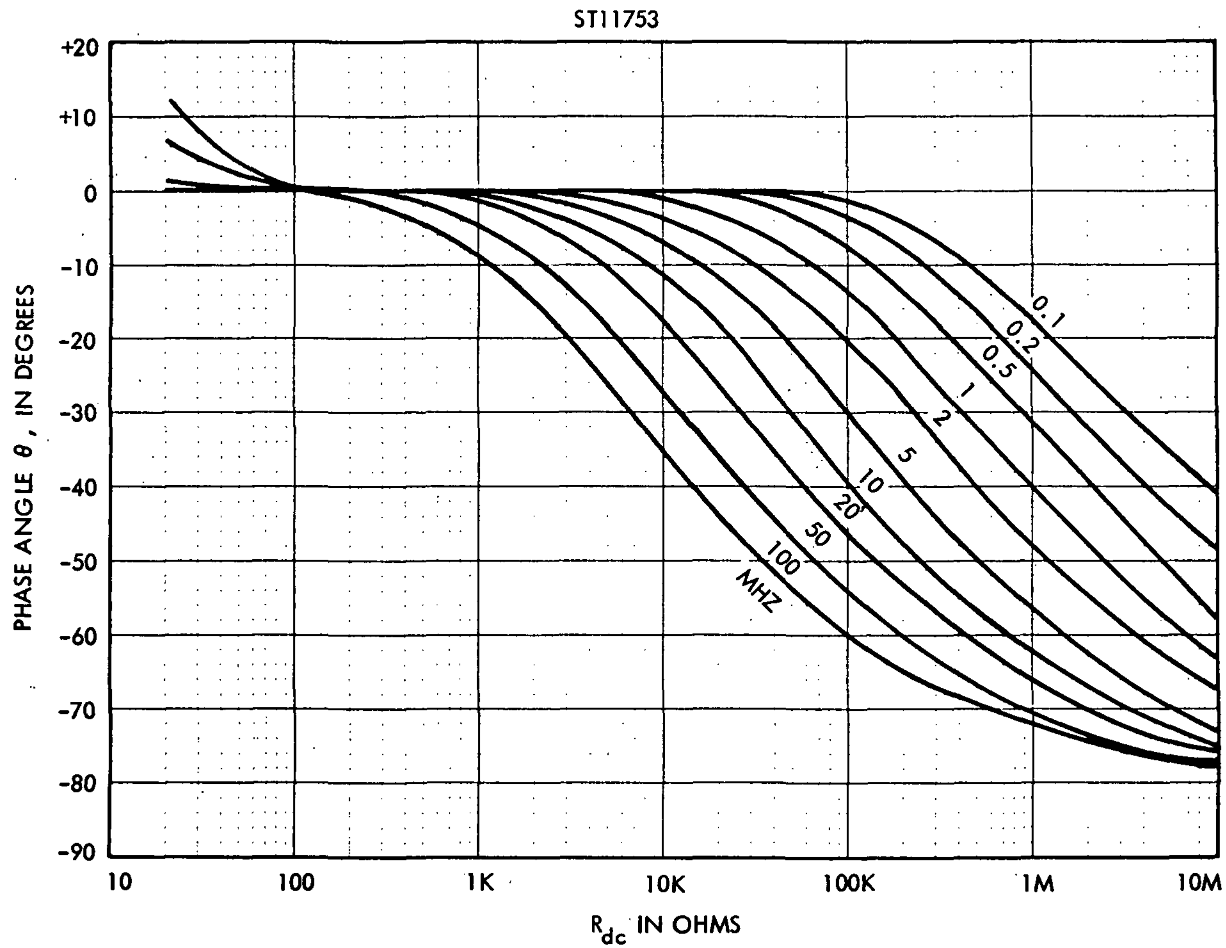

ST11753
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
PHASE ANGLE θ, IN DEGREES
10
100
1K
10K
100K
1M
10M
Rdc IN OHMS
0.1
0.2
0.5
1
2
5
10
20
50
100
MHZ

Figure 14

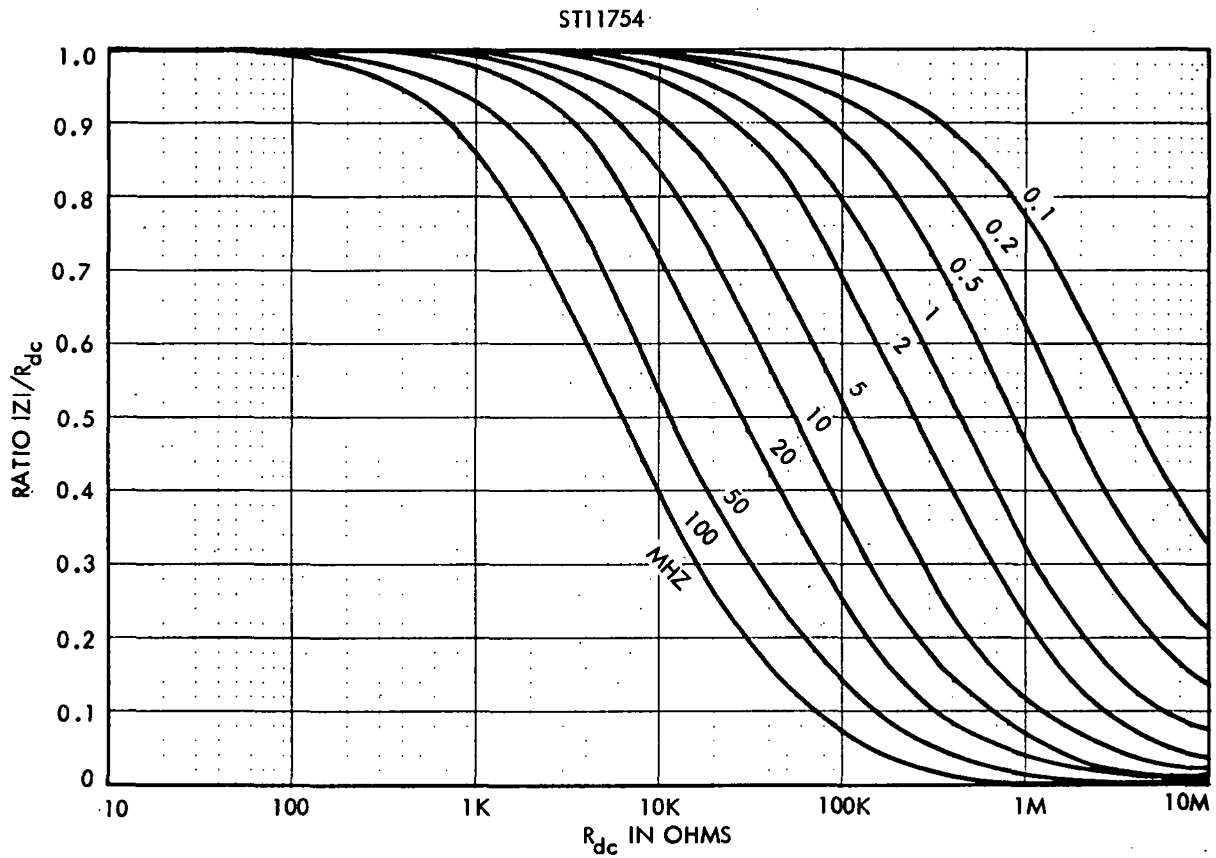

ST11754
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RATIO IZI/Rdc
10
100
1K
10K
100K
1M
10M
Rdc IN OHMS
0.1
0.2
0.5
1
2
5
10
20
50
100
MHZ

Figure 15

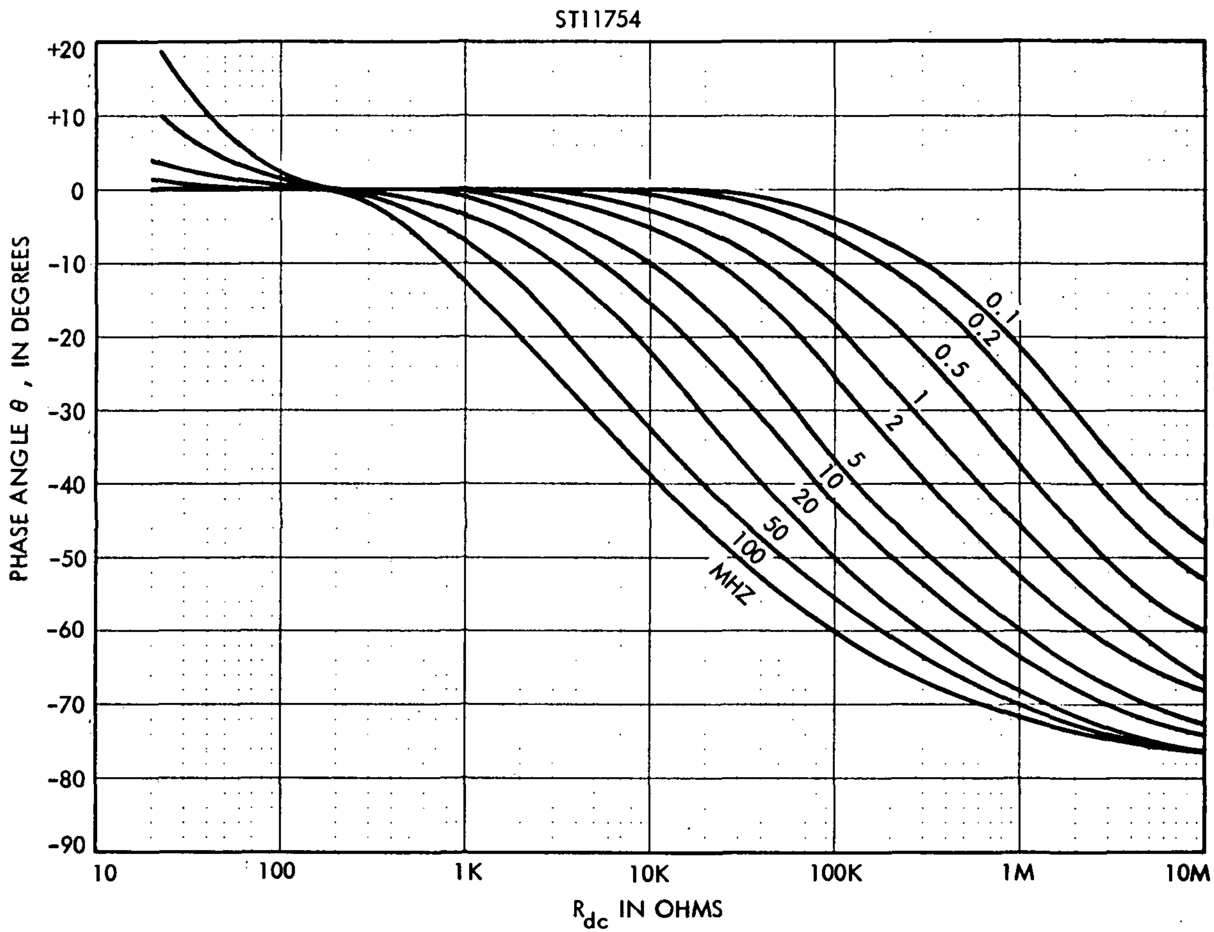

ST11754
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
PHASE ANGLE θ, IN DEGREES
10
100
1K
10K
100K
1M
10M
Rdc IN OHMS
0.1
0.2
0.5
1
2
5
10
20
50
100
MHZ

Figure 16

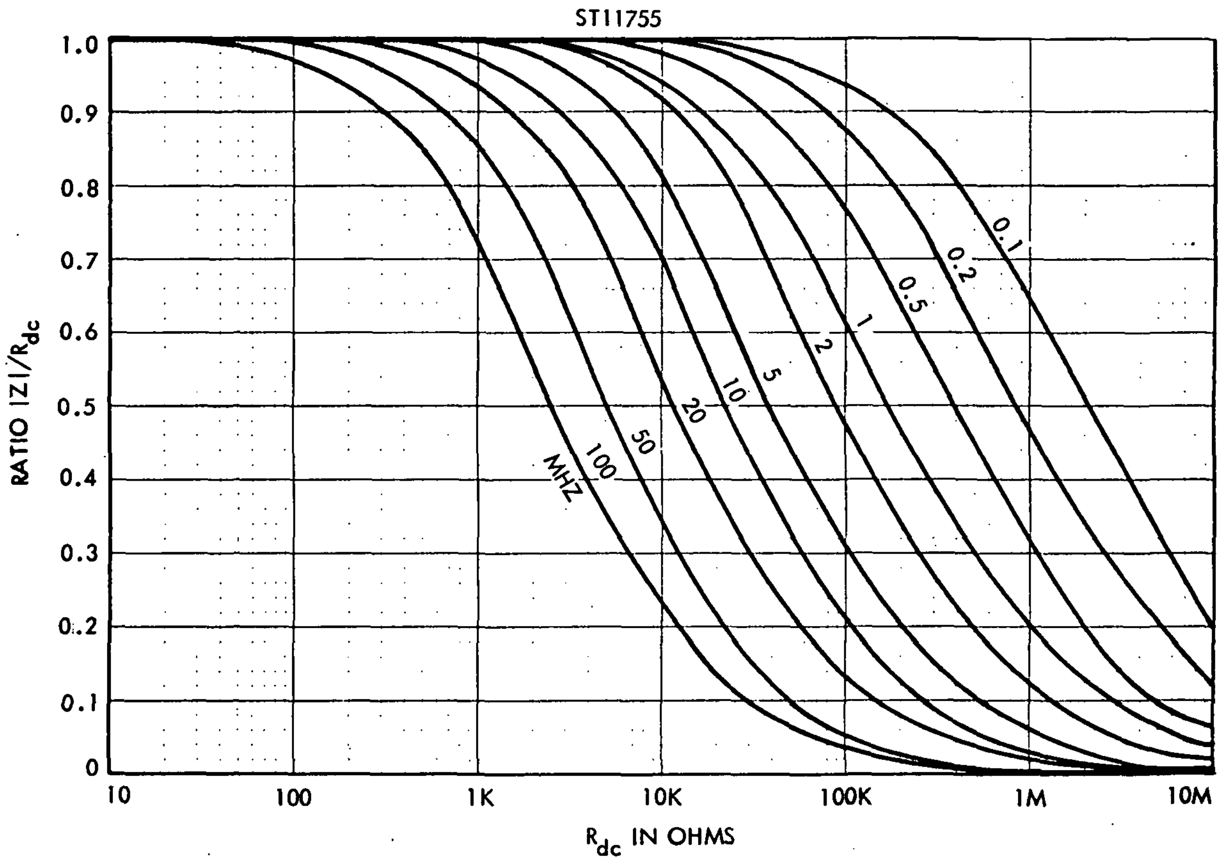

ST11755
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RATIO IZI/R_{dc}
10
100
1K
10K
100K
1M
10M
R_{dc} IN OHMS
0.1
0.2
0.5
1
2
5
10
20
50
100
MHZ

Figure 17

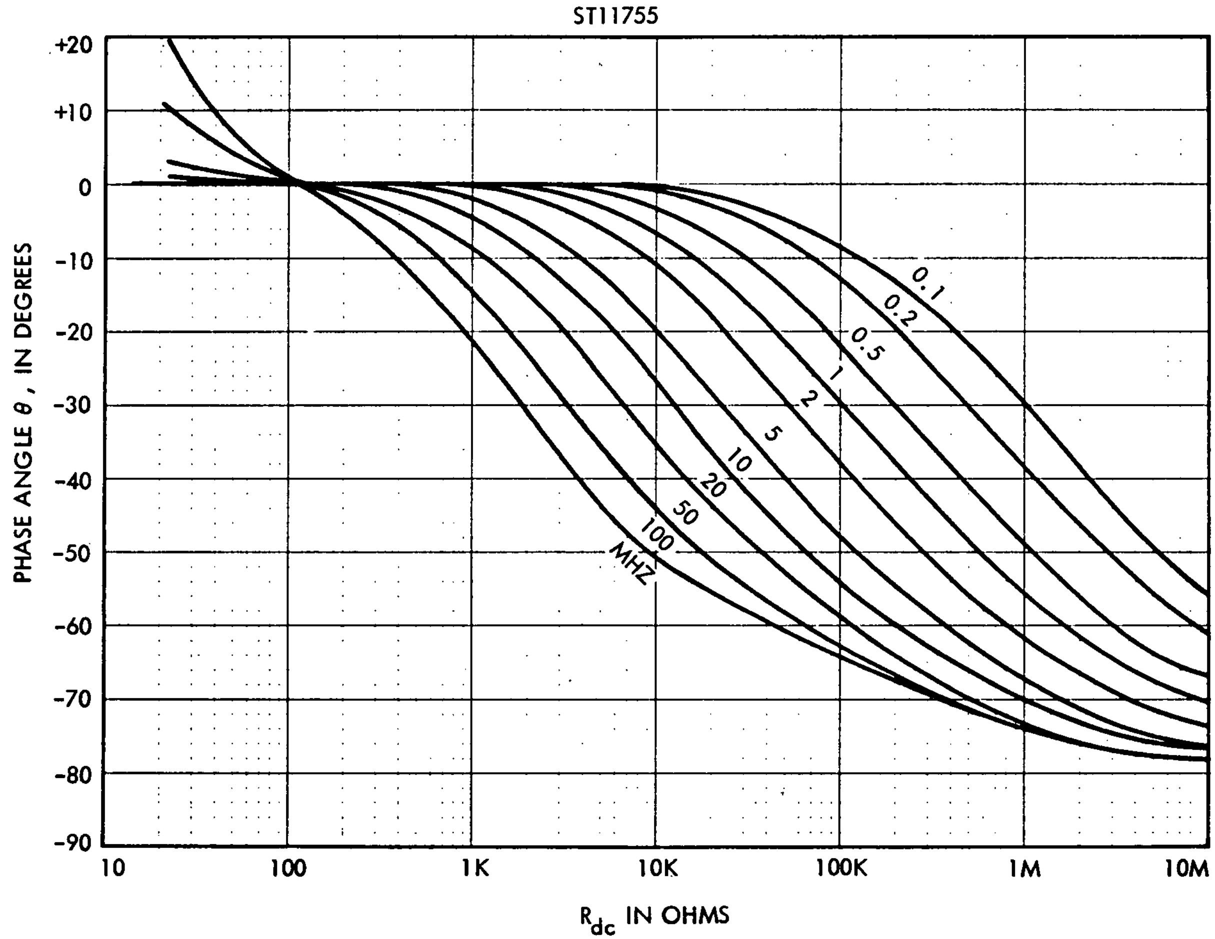

ST11755
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
PHASE ANGLE θ, IN DEGREES
10
100
1K
10K
100K
1M
10M
Rdc IN OHMS
0.1
0.2
0.5
1
2
5
10
20
50
100
MHZ

Figure 18

PULSE HANDLING CAPABILITY

Carbon composition resistors have steady-state power and voltage ratings which limit the temperature of the device to less than 150°C. For pulses of several seconds, these ratings are satisfactory, however, the resistors are capable of handling much higher levels of power for very short periods of time. It is the product of power and time, energy, that creates heat, not just power alone. Table III lists the watt-seconds the resistors are capable of enduring for relatively short periods of time without opening.

Table III. Pulse Capability

JPL Part Number	Power Rating (Watts)	Probability That The Resistor Will Open After The Indicated Number of Pulses (Watt-Seconds)				Thermal Time Constant (Seconds)
		50% After Multiple Pulses	10% After 1 Pulse	50% After 1 Pulse	90% After 1 Pulse	
ST11751	0.125	0.14	0.72	0.90	1.08	4
ST11752	0.250	0.56	2.80	3.50	4.20	8
ST11753	0.500	2.24	11.20	14.00	16.80	16
ST11754	1.000	8.90	44.00	55.00	66.00	32
ST11755	2.000	12.80	64.00	80.00	96.00	64

The uses and limitation of Table III are:

1. First calculate the pulse power:

$$P = \frac{V^2}{R}$$

P = pulse power (watts)

V = pulse voltage (volts) (Testing has been done to 5000 volts)

R = resistance (ohms)

Then calculate the watt-seconds:

Ws = PT

Ws = watt-seconds

t = pulse width (seconds)

If the calculated watt-seconds are equal to or less than the watt-seconds under the proper probability in Table III, the applied pulse power is acceptable.

2. For repetitive pulses, the pulsed power should be averaged over a time period (T) that is less than the thermal time constant. The average power (P_{avg}) of repetitive pulses should not exceed rated power. The calculation for average power is:

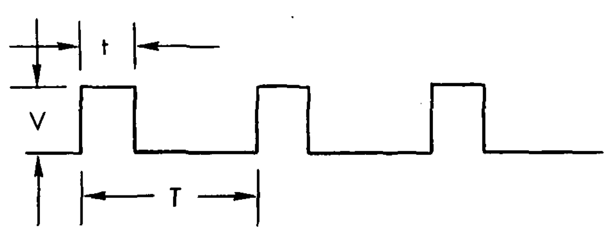
$$P_{avg} = P \frac{t}{T}$$

P_{avg} = average pulse power (watts)

$P = \frac{V^2}{R}$ = pulse power (watts)

t = pulse width (seconds)

T = time period of one cycle - pulse width plus off time of one cycle (seconds)



3. When the resistors are operated above 70°C, the pulse power rating must be derated just as it is for rated power. Derate linearly from 100 percent of the pulse power at 70°C to 0 percent at:

   a. 125°C for ST11751.
   b. 150°C for ST11752, ST11753, ST11754, and ST11755.

4. When the resistor is operating under a steady-state condition (a percentage of rated power is being applied) and a pulse is applied, the pulse power rating must be derated. Derate linearly from 100 percent of the pulse power at 0 percent steady-state power to 0 percent of the pulse power at 100 percent steady-state power.

CHASSIS MOUNTED POWER WIREWOUND RESISTORS

The chassis mounted power wirewound resistors listed herein are suitable for spacecraft flight equipment. These resistors are general purpose types for dc and low frequency ac use.

CASE TEMPERATURE VERSUS POWER DISSIPATION

Power ratings are based on 25°C free air ambient temperature. The JPL derating figure is to use the resistors at 50 percent of the rated power. The resistors must further be derated for ambient temperatures above 25°C. Additionally, they must be derated for operation in a vacuum, since they depend on convection cooling to a great extent. It is recommended that the parts be derated to 40 percent of the rated power for vacuum operation. Refer to Figures 19, 20, 21 and 22.

The following resistance-temperature characteristics (maximum) must be observed:

Below 1 ohm	±100 ppm/°C
1 to 19.6 ohms	±50 ppm/°C
20 ohms and above	±30 ppm/°C

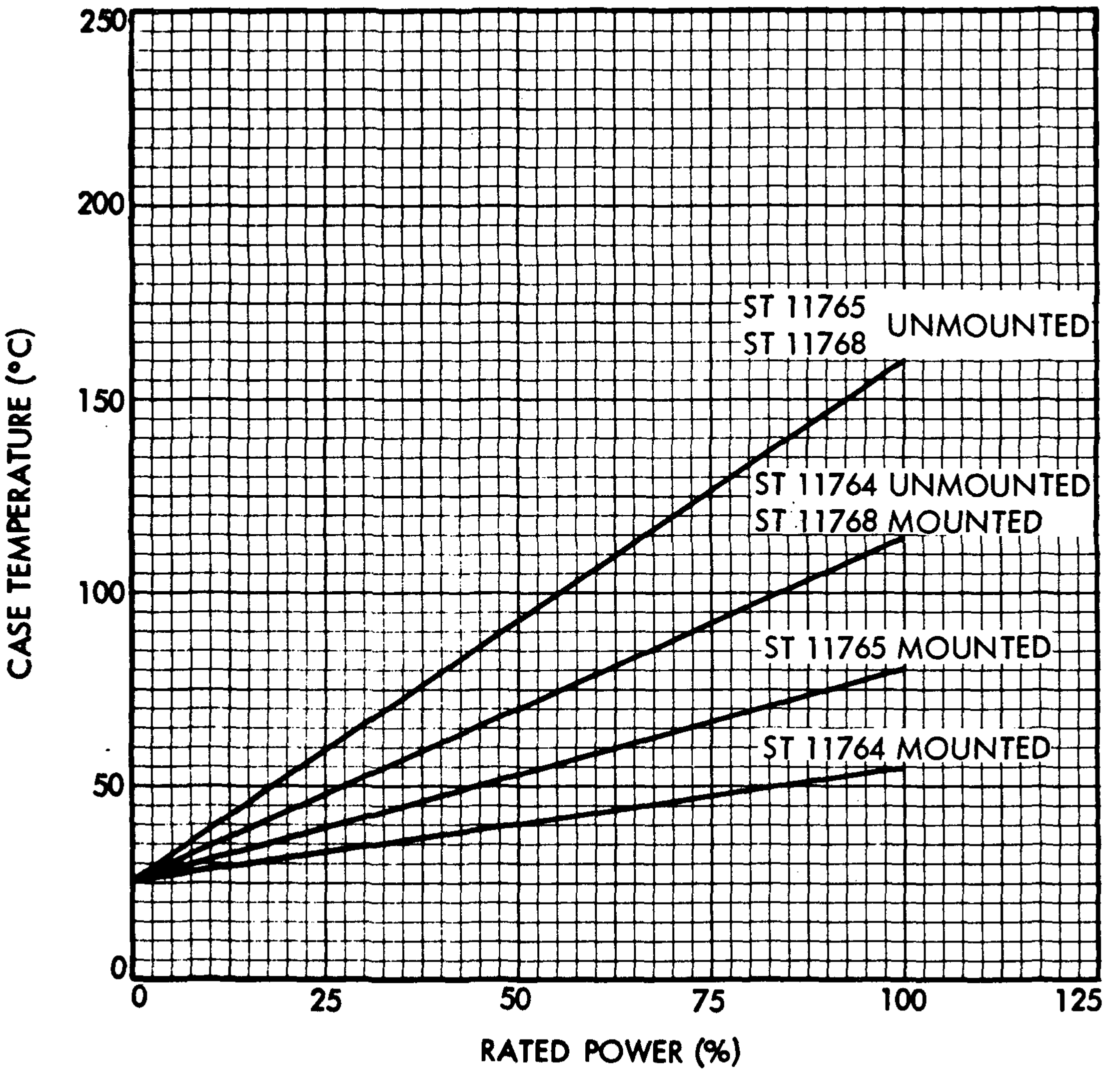

CASE TEMPERATURE (°C)
250
200
150
100
50
0
0
25
50
75
100
125
RATED POWER (%)
ST 11765
ST 11768
UNMOUNTED
ST 11764 UNMOUNTED
ST 11768 MOUNTED
ST 11765 MOUNTED
ST 11764 MOUNTED

Figure 19

RESISTORS

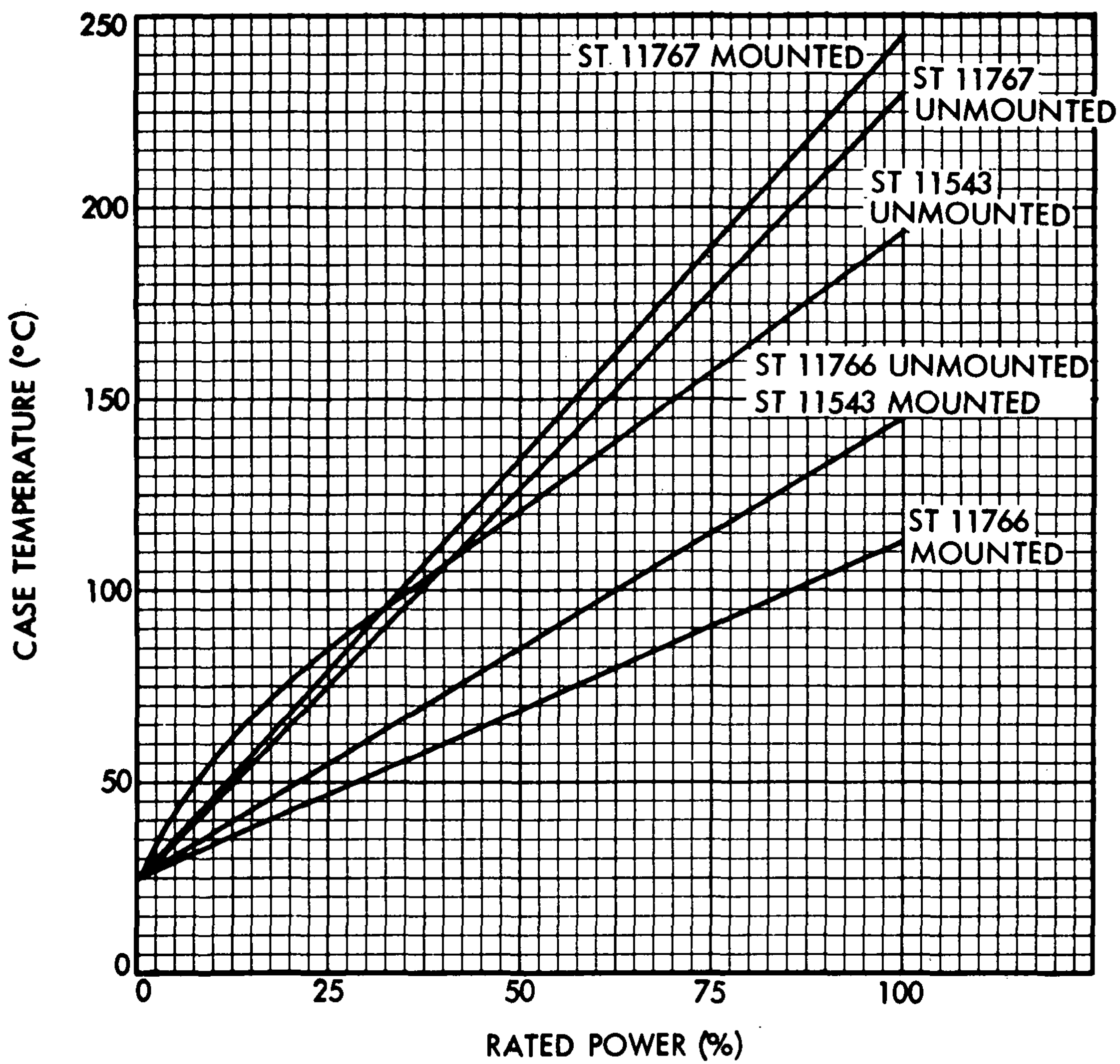


Figure 20

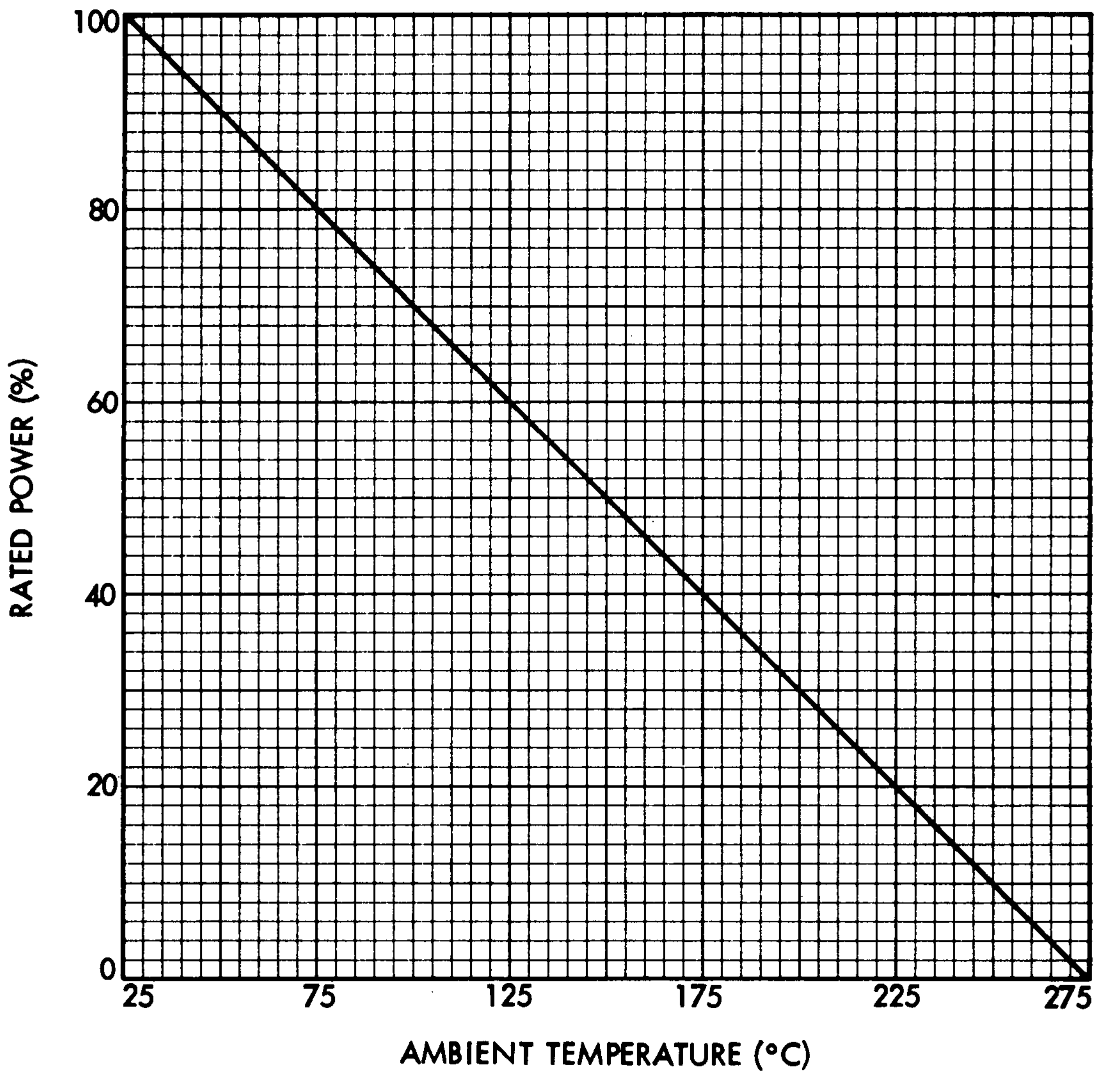


Figure 21. High Temperature Derating Curve

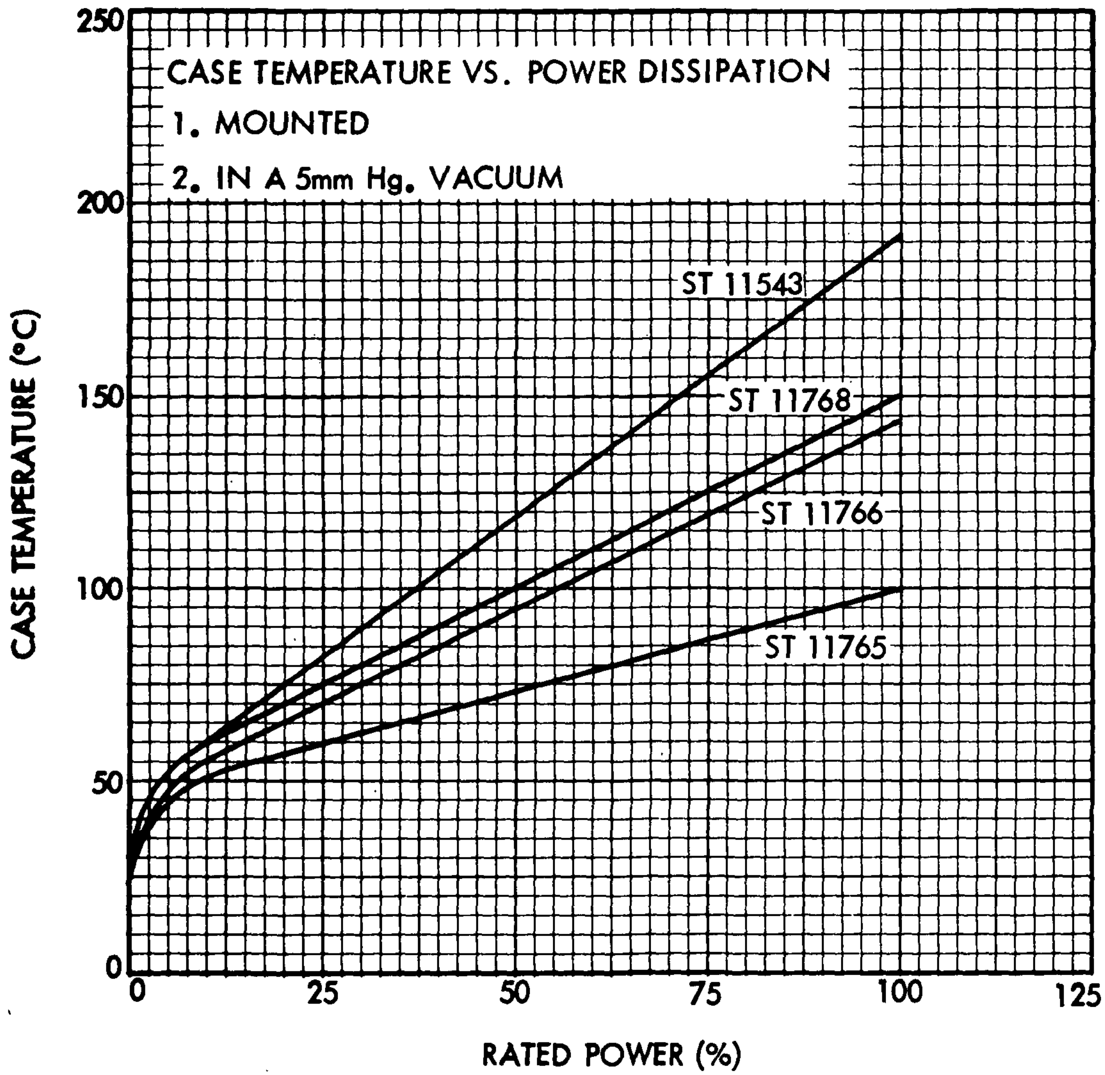


Figure 22

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RESISTORS

ELECTRICAL CHARACTERISTICS

The resistors are inductively wound (refer to Figure 22) and the reactive components for the various types are listed in Table IV.

MOUNTING CONSIDERATIONS

The resistors should be mounted on aluminum chassis of the following dimensions:

ST	Dimensions (Inches)
11764, 11765, and 11768	6 x 4 x 2 x 0.04
11766, 11767, and 11543	7 x 5 x 2 x 0.04

When the resistors are mounted on materials other than aluminum, the difference in thermal properties between the aluminum and other material must be taken into consideration. Also, if the chassis area is reduced, the wattage must be derated (refer to Figures 23 and 24).

PULSE HANDLING CAPABILITY

Power wirewound resistors have steady-state power and voltage ratings which limit the temperature of the unit to less than 275°C. For pulses of several seconds, these ratings are satisfactory, however, the resistors are capable of handling much higher levels of power and voltage for very short periods of time. It is the product of power and time, energy, that creates heat, not just power alone.

Figure 25 shows the maximum power the resistors are capable of enduring for relatively short periods of time without significant changes in resistance or other parameters. The uses and limitations of these curves are as follows:

1. Determine the maximum pulse power rating for:

   a. Non-repetitive pulses:

      1) Calculate the pulse power: $P = \frac{V^2}{R}$

RESISTORS

Table IV. Reactive Components (Sheet 1 of 3)

ST11764				ST11765 and ST11768			
Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Net Capacitance (pF)	Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Net Capacitance (pF)
0.5	10	0.23		0.5	10	0.39	
	90	0.63			100	1.73	
	499	1.92			499	2.86	
	1000	3.66			1000	4.88	
	4000		1.50		4120		1.50
1.0	10	0.27		1.0	10	0.46	
	90	0.69			100	1.71	
	499	2.16			499	3.00	
	1000	3.56			1000	3.15	
	4000		1.70		4120		1.60
4.0	10	0.26		4.0	10	0.47	
	90	0.67			100	1.71	
	499	2.10			499	2.92	
	1000	3.43			1000	2.90	
	4000		1.90		4120		1.75
10.0	10	0.29		10.0	10	0.49	
	90	0.64			100	1.72	
	499	2.08			499	2.92	
	1000	1.33			1000	2.85	
	4000	1.72			4120		1.90

RESISTORS

Table IV. Reactive Components (Sheet 2 of 3)

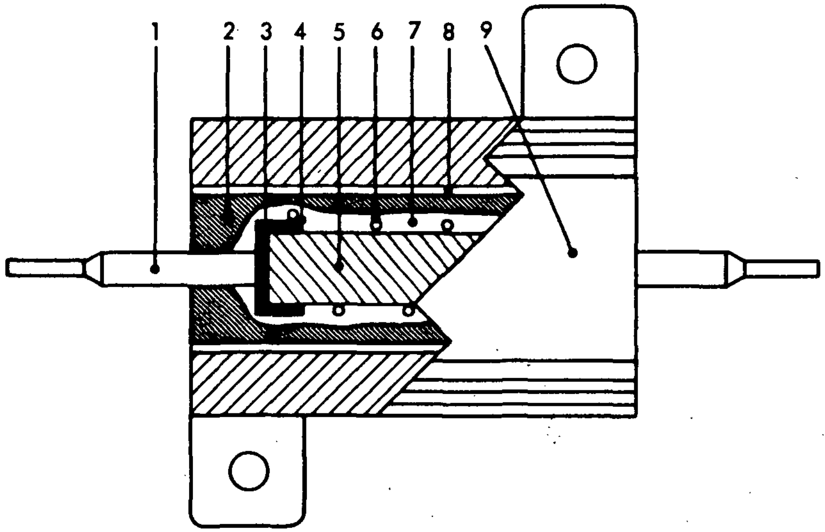
ST11766 and ST11543				ST11767			
Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Net Capacitance (pF)	Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Net Capacitance (pF)
0.5	11	0.66		0.5	10	1.20	
	100	2.47			124	7.40	
	487	4.20			619	7.02	
	1000	8.96			1000	10.46	
	7500		2.80		7870		4.50
	12,000		2.70		12,000		3.50
1.0	11	0.76		1.0	10	1.21	
	100	2.62			124	7.42	
	487	4.37			619	7.22	
	1000	8.70			1000	10.24	
	7500		3.00		7870		4.50
	12,100		3.10		12,000		4.00
4.0	11	0.74		4.0	10	1.21	
	100	2.53			124	7.54	
	487	4.25			619	7.40	
	1000	8.31			1000	9.58	
	7500		3.15		7870		4.60
	12,100		3.10		12,000		4.00

RESISTORS

Table IV. Reactive Components (Sheet 3 of 3)

ST11766 and ST11543				ST11767			
Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Net Capacitance (pF)	Frequency (MHz)	Resistance (Ohms)	Net Inductance (μH)	Net Capacitance (pF)
10.0	11	0.82		10.0	10	1.22	
	100	2.58			124	12.66	
	487	4.39			619	7.49	
	1000	9.19			1000	4.57	
	7500		3.20		7870		4.60
	12,100		3.15		12,000		4.00

RESISTORS



1. TERMINAL - TINNED COPPERWELD
2. MOLDING COMPOUND - DOW CORNING 307
3. END CAP - STAINLESS 305
4. RESISTANCE WIRE TO END CAP WELD
5. CORE - ALUMINA OR BERYLLIUM OXIDE DEPENDING ON STYLE
6. RESISTANCE WIRE - COPPER-NICKEL OR NICKEL-CHROME ALLOY DEPENDING ON RESISTANCE VALUE
7. COATING - SILICONE
8. INSULATING FILM - DUPONT KAPTON TYPE H
9. HOUSING - ANODIZED ALUMINUM

Figure 23. Construction

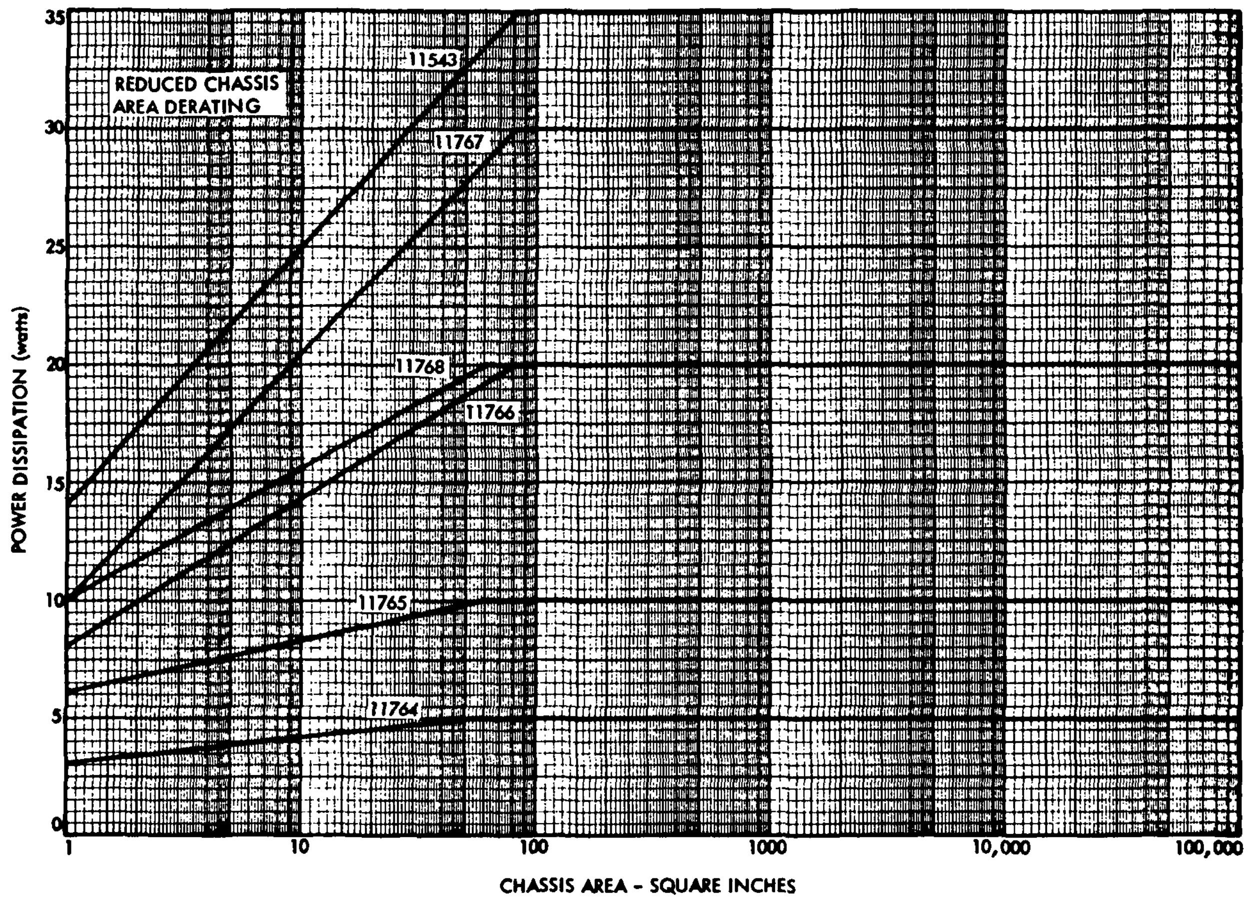

REDUCED CHASSIS
AREA DERATING
11543
11767
11768
11766
11765
11764
35
30
25
20
15
10
5
0
POWER DISSIPATION (watts)
1
10
100
1000
10,000
100,000
CHASSIS AREA - SQUARE INCHES

Figure 24

RESISTORS

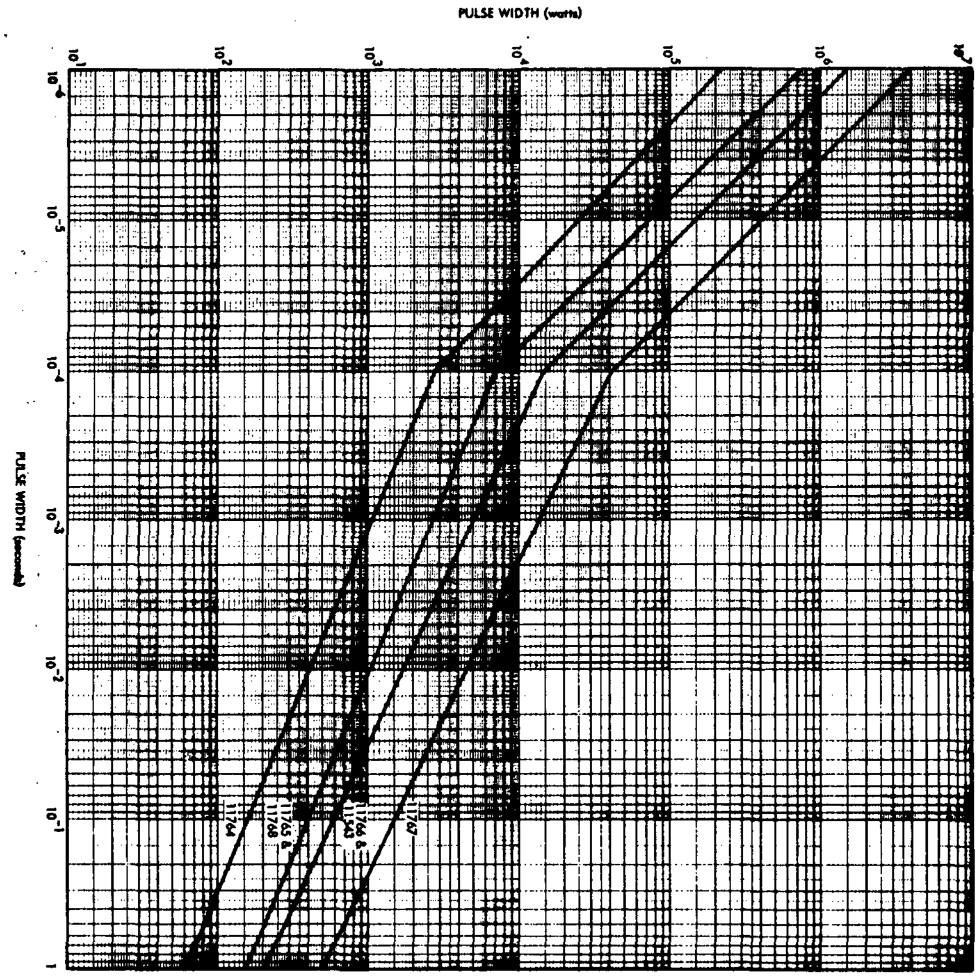


Figure 25

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P = pulse power (watts)

V = pulse voltage (volts)

R = resistance (ohms)

2) The maximum pulse power rating is not exceeded, if the intersection of the pulse power line and pulse width line is on or below the appropriate curve.

b. Repetitive pulses:

1) Calculate the pulse power and check the curve as in a. above to determine if the maximum pulse power rating is exceeded.

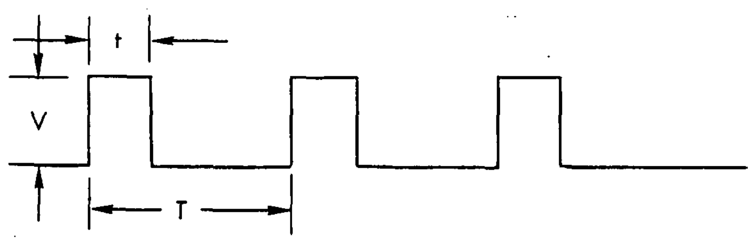
2) If the maximum pulse rating is not exceeded, determine the average pulse power: $P_{avg} = P \frac{t}{T}$.

P_{avg} = average pulse power (watts)

P = pulse power (watts)

t = pulse width (seconds)

T = time of sequence - pulse width plus off time of one cycle (seconds)



The average pulse power should not exceed 50 percent of the steady-state power rating.

RESISTORS

2. The maximum pulse voltage shall be:

ST11764	450 V
ST11765, ST11768	640 V
ST11766, ST11543	750 V
ST11767	1400 V

3. Limitations:

a. Under reduced pressure conditions, the voltage shall not exceed the values shown due to reduced dielectric strength of the air:

ST11764	200 V
ST11765, ST11768	200 V
ST11766, ST11543	500 V
ST11767	750 V

b. When the resistors are operated above 25°C, the pulse power rating must be derated, just as it is for steady-state ratings. Derate linearly from 100 percent of the pulse power at 25°C to 0 percent at 275°C.

c. When the resistors are operating under steady-state conditions and a pulse is applied, the pulse power rating must be derated. Derate linearly from 100 percent of the pulse power at 0 percent steady-state power to 0 percent of the pulse power at 100 percent steady-state power.

RESISTORS

QUALIFIED RESISTORS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS (AT 70°C)			SCREEN SPEC ZPP-2073-	DRAWINGS
			Watts	Range (ohms)	Description		
BB	ABC	Carbon Composition	1/8	2.7-100 meg	General Purpose 5% tol	0507	ST 11751
RCR05	ABC	Carbon Composition	1/8	2.7-22 meg	General Purpose 5% tol	0507	ST 11751
CB	ABC	Carbon Composition	1/4	2.7-100 meg	General Purpose 5% tol	0507	ST 11752
RCR07	ABC	Carbon Composition	1/4	2.7-22 meg	General Purpose 5% tol	0507	ST 11752
EB	ABC	Carbon Composition	1/2	1-100 meg	General Purpose 5% tol	0507	ST 11753
RCR20	ABC	Carbon Composition	1/2	2.7-22 meg	General Purpose 5% tol	0507	ST 11753
GB	ABC	Carbon Composition	1	2.7-100 meg	General Purpose 5% tol	0507	ST 11754
RCR32	ABC	Carbon Composition	1	1.0-22 meg	General Purpose 5% tol	0507	ST 11754
HB	ABC	Carbon Composition	2	10-100 meg	General Purpose 5% tol	0507	ST 11755
RCR42	ABC	Carbon Composition	2	10-22 meg	General Purpose 5% tol	0507	ST 11755

RESISTORS

QUALIFIED RESISTORS (Contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS (AT 125°C)			SCREEN SPEC ZPP-2073-	DRAWINGS
			Watts	Range (ohms)	Description		
EMF50	DAL	Metal Film, Molded	1/20	49.9-200 k	To 25 ppm/°C and 0.1% tol	0501	ST 11547
RNC50	DAL	Metal Film, Molded	1/20	10.0 - 796 k	To 25 ppm/°C and 0.1% tol	0501	ST 11547
EMF55	DAL	Metal Film, Molded	1/10	49.9 - 499 k	To 25 ppm/°C and 0.1% tol	0501	ST 11546
RNC55	DAL	Metal Film, Molded	1/10	10.0 - 1.21 meg	To 25 ppm/°C and 0.1% tol	0501	ST 11548
EMF60	DAL	Metal Film, Molded	1/8	49.9 - 604 k	To 25 ppm/°C and 0.1% tol	0501	ST 11549
RNC60	DAL	Metal Film, Molded	1/8	10.0-3.01 meg	To 25 ppm/°C and 0.1% tol	0501	ST 11549
EMF65	DAL	Metal Film, Molded	1/4	49.9 - 1.5 meg	To 25 ppm/°C and 0.1% tol	0501	ST 11550
RNC65	DAL	Metal Film, Molded	1/4	49.9 - 3.01 meg	To 25 ppm/°C and 0.1% tol	0501	ST 11550
EMF70	DAL	Metal Film, Molded	1/2	49.9 - 4.02 meg	To 25 ppm/°C and 0.1% tol	0501	ST 11551
RNC70	DAL	Metal Film, Molded	1/2	29.9 - 2.49 meg	To 25 ppm/°C and 0.1% tol	0501	ST 11551

RESISTORS

QUALIFIED RESISTORS (Contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS (AT 70°C)			SCREEN SPEC ZPP-2073-	DRAWINGS
			Watts	Range (ohms)	Description		
HC3	CGW	Tin Oxide Film, Coated	1/8	10 - 150 k	General Purpose, 2% tol	0529	ST 11865
RLR05	CGW	Tin Oxide Film, Coated	1/8	10 - 150 k	General Purpose, 2% tol	0529	ST 11865
HC4	CGW	Tin Oxide Film, Coated	1/4	10 - 300 k	General Purpose, 2% tol	0529	ST 11866
RLR07	CGW	Tin Oxide Film, Coated	1/4	10 - 300 k	General Purpose, 2% tol	0529	ST 11866
HC5	CGW	Tin Oxide Film, Coated	1/2	10 - 1 meg	General Purpose, 2% tol	0529	ST 11867
RLR20	CGW	Tin Oxide Film, Coated	1/2	10 - 1.0 meg	General Purpose, 2% tol	0529	ST 11867

RESISTORS

QUALIFIED RESISTORS (Contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS (AT 25°C) Watts	Range (ohms)	Description	SCREEN SPEC ZPP-2073-	DRAWINGS
AGS-1	DAL	Wirewound, Power	1	0.1 - 1 k	General Purpose 1% tol	CS505918 (1)	ST 11760
RWR81	DAL	Wirewound, Power	1	0.1 - 464	General Purpose 1% tol	CS505918 (1)	ST 11760
AGS-2	DAL	Wirewound, Power	1.5	0.1 - 1.3 k	General Purpose 1% tol	CS505918 (1)	ST 11761
RWR82	DAL	Wirewound, Power	1.5	0.1 - 1.3 k	General Purpose 1% tol	CS505918 (1)	ST 11761
AGS-3	DAL	Wirewound, Power	2	0.1 - 2.67 k	General Purpose 1% tol	CS505918 (1)	ST 11759
RWR80	DAL	Wirewound, Power	2	0.1 - 1.40 k	General Purpose 1% tol	CS505918 (1)	ST 11759
AGS-5	DAL	Wirewound, Power	3	0.1 - 4.12 k	General Purpose 1% tol	CS505918 (1)	ST 11762
RWR89	DAL	Wirewound, Power	3	0.1 - 3.57 k	General Purpose 1% tol	CS505918 (1)	ST 11762
AGS-10	DAL	Wirewound, Power	7	0.1 - 12.4 k	General Purpose 1% tol	CS505918 (1)	ST 11763
RWR84	DAL	Wirewound, Power	7	0.1 - 12.4 k	General Purpose 1% tol	CS505918 (1)	ST 11763
ARH-5	DAL	Wirewound, Power, Chassis Mounted	5	0.1 - 3.32 k	General Purpose 1% tol	CS506084 (1)	ST 11764
RER60	DAL	Wirewound, Power, Chassis Mounted	5	0.1 - 3.32 k	General Purpose 1% tol	CS506084 (1)	ST 11764
ARH-10	DAL	Wirewound, Power, Chassis Mounted	10	0.1 - 5.62 k	General Purpose 1% tol	CS506084 (1)	ST 11765
RER65	DAL	Wirewound, Power, Chassis Mounted	10	0.1 - 5.62 k	General Purpose 1% tol	CS506084 (1)	ST 11765
ARH-25	DAL	Wirewound, Power, Chassis Mounted	20	0.1 - 12.1 k	General Purpose 1% tol	CS506084 (1)	ST 11766
RER70	DAL	Wirewound, Power, Chassis Mounted	20	0.1 - 12.1 k	General Purpose 1% tol	CS506084 (1)	ST 11766
ARH-50	DAL	Wirewound, Power, Chassis Mounted	30	0.1 - 39.2 k	General Purpose 1% tol	CS506084 (1)	ST 11767
RER75	DAL	Wirewound, Power, Chassis Mounted	30	0.1 - 39.2 k	General Purpose 1% tol	CS506084 (1)	ST 11767

Note: (1) Parts bought to JPL procurement specification are screened by the manufacturer, and do not require additional screening.

RESISTORS

QUALIFIED RESISTORS (Contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS (AT 125°C)			SCREEN SPEC ZPP-2073-	DRAWINGS
			Watts	Range (ohms)	Description		
HR10	SHA	Wirewound, Precision	0.125	10-350 k	To 5 ppm/°C and 0.01% tol	0505	ST 11769
RBR56	SHA	Wirewound, Precision	0.125	10-100 k	To 5 ppm/°C and 0.01% tol	0505	ST 11769
HR12	SHA	Wirewound, Precision	0.15	10-525 k	To 5 ppm/°C and 0.01% tol	0505	ST 11770
RBR55	SHA	Wirewound, Precision	0.15	10-332 k	To 5 ppm/°C and 0.01% tol	0505	ST 11770
HR14	SHA	Wirewound, Precision	0.25	10-850 k	To 5 ppm/°C and 0.01% tol	0505	ST 11772
RBR54	SHA	Wirewound, Precision	0.25	10-150 k	To 5 ppm/°C and 0.01% tol	0505	ST 11772
HR32	SHA	Wirewound, Precision	0.25	10-1.5 meg	To 5 ppm/°C and 0.01% tol	0505	ST 11771
HR41	SHA	Wirewound, Precision	0.05	10-125 k	To 5 ppm/°C and 0.01% tol	0505	ST 11828

RESISTORS

QUALIFIED RESISTORS (Contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS			SCREEN SPEC ZPP-2073-	DRAWINGS
			At 125°C Watts	Range (ohms)	Description		
MG650	CAD	Film, High Value, High Voltage	0.5	499 k - 5.11 meg	600 V	0518	ST 11773
MG660	CAD	Film, High Value, High Voltage	0.6	1.0 meg - 10 meg	1000 V	0518	ST 11831
MG680	CAD	Film, High Value, High Voltage	0.8	1.0 meg - 15 meg	1500 V	0518	ST 11774
MG721	CAD	Film, High Value, High Voltage	2	1.0 meg - 30.1 meg	2500 V	0518	ST 11832
MG750	CAD	Film, High Value, High Voltage	3	3.0 meg - 150 meg	3000 V	0518	ST 11776
MG780	CAD	Film, High Value, High Voltage	5	3.92 meg - 226 meg	4000 V	0518	ST 11833
811 Series	BEK	12 Bit R-2R Ladder	N/A	5 k - 20 k	0.012% at 20 V	CS508914	ST 11540
			At 70°C				
PVC60	KDI	Thick Film, Molded	1/4	10 k - 100 meg	1%	0518	
PVC100	KDI	Thick Film, Molded	1.5	10 k - 1000 meg	1%	0518	
			At 25°C				
TKR-178	DAL	13 Resistor Network	0.6	21.5 - 100 k	2%	CS506217 (1)	ST 11541
TKR-217	DAL	7 Resistor Network	0.6	21.5 - 100 k	2%	CS506217 (1)	ST 11542
TKR-220	DAL	11 Resistor Network	0.6	5 k - 51 k	2%	CS506217 (1)	ST 11672
TKR-221	DAL	8 Resistor Network	0.6	21.5 - 100 k	2%	CS506217 (1)	ST 11830
TKR-233	DAL	8 Resistor Network	0.6	47 - 100 k	2%	CS506217 (1)	ST 11693
TKR-234	DAL	7 Resistor Network	0.6	665 and 5.11 k	2%	CS506217 (1)	ST 11894

(1) Parts bought to the JPL procurement specification are screened by the manufacturer, and do not require additional screening.

RESISTORS

QUALIFIED THERMISTORS AND TEMPERATURE TRANSDUCERS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS Resistance (ohms)	CHARACTERISTICS Description	SCREEN SPEC ZPP-2073-	STANDARDS
44004	YSI	Precision, negative TC, Disc Type	2252	1 mw/°C dissipation constant	CS506974 (1)	ST 11983
44005	YSI	Precision, negative TC, Disc Type	3000	1 mw/°C dissipation constant	CS506974 (1)	ST 11834
44006	YSI	Precision, Negative TC, Disc Type	10 k	1 mw/°C dissipation constant	CS506974 (1)	ST 11825
44008	YSI	Precision, Negative TC, Disc Type	30 k	1 mw/°C dissipation constant	CS506974 (1)	ST 11826
35A2	VEC	Negative TC, Bead Type	5 k	0.35 mw/°C dissipation constant, Axial Lead	0506	ST 11780
32A101	VEC	Negative TC, Bead in Glass Rod	2 k	1 mw/°C dissipation constant, Axial Lead	0506	ST 11781
33A5	VEC	Negative TC, Glass Probe	5 k	1 mw/°C dissipation constant Radial Lead	0506	ST 11782
TC 1/8	TIX	Positive TC, Silicon Resistor	10 - 5.6 k	1/8 watt, hermetic seal, Axial Leads	0510	ST 11763
118AKP, R	REC	Platinum Resistance	125, 500	Square, platinum encased	CS506099 (1)	ST 11786
118AKT	REC	Platinum Resistance	125, 500	Square, miniature, surface sensor	CS506099 (1)	ST 11784
146DV	REC	Platinum Resistance	125, 500	Cylindrical surface sensor	CS506099 (1)	ST 11765

(1) Parts bought to the JPL procurement specification are screened by the manufacturer, and do not require additional screening.

INDEX OF SWITCHES

Part Number	Vendor	Page
1HM1	HON	1
6HM1	HON	1

SWITCHES
QUALIFIED SWITCHES

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS	SCRN SPEC ZPP-2073-	QUAL TEST NO.	DRAWINGS
1HM1	HON	Precision, SPDT, Snap Action, Hermetically Sealed	5 A at 28 Vdc, resistive	1005	791.00-00 (619)	ST 11733
6HM1	HON	Precision, SPDT, Snap Action, Hermetically Sealed	5 A at 28 Vdc, resistive	1005	791.00-00 (619)	ST 11835

INDEX OF TRANSISTORS

Part Type	Page	Part Type	Page	Part Type	Page
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		2N222A	11	2N3866	15
MA42979	17	2N2369A	11	2N3947	11
MQ2905	16	2N2405	14	2N3980	13
MQ3725	16	2N2432A	12	2N3997	19
MRD300	21	2N2484	11	2N4391	13
MRD370	21	2N2605	11	2N4392	20
MRF904	17	2N2608	13	2N4393	20
MSC3001	17	2N2658	11	2N4856	20
MSC80264	17	2N2814	12	2N5117	16
MT1061A	17	2N2880	12	2N5154	16
		2N2905A	11	2N5196	13
PA7443	16	2N2907A	11	2N5250	18
PT3526	19	2N2920	12	2N5520	20
PT4500	19	2N2946A	12	2N5663	16
PT4503	19	2N3066	20	2N6137	20
		2N3251	11	2N6138	20
SA2267	16	2N3331	13	2N6483	20
SDT3303	12	2N3350	12		
SDT4925	15	2N3375	19	3N75	12
SDT5005	15	2N3382	13		
SDT5553	11	2N3437	13	6N140	21
SDT8304	18	2N3467	11		
		2N3495	15	14BB101	18
2N910	11	2N3497	11		
2N918	11	2N3501	11	79BB128	18
2N2060	12	2N3507	15		
2N2193A	11	2N3637	15	96EJ103	18
				96SV107	18

TRANSISTORS

APPLICATION NOTES

The transistors listed in this document are silicon devices, and have been limited to a small number of types for standardization. These types are classified as follows:

1. NPN.
2. Dual and Quad NPN.
3. PNP.
4. Dual and Quad PNP.
5. N-channel JFET.
6. Dual N-channel JFET.
7. P-channel JFET.
8. Specials, which consist of PN Unijunction and NPN, Double Emitter.

POWER CYCLING USAGE GUIDELINES

Transistors fabricated with 1.0 mil aluminum wire, which is thermocompression wedge bonded to the semiconductor chip, are highly susceptible to thermal fatigue near the bond due to power cycling. A power cycle is one cycle of operating frequency when the frequency is less than 100 Hz, and also a power cycle may be considered a turn-on and turn-off of the transistor.

The product of the transistor on-power, on-current, and estimated power cycles during operating life gives an index to power cycling failure. When the transistor is fabricated with 1.0 mil (0.001 inch) diameter aluminum wire and is thermocompression wedge bonded to the chip, index numbers exceeding five million mW-mA-Hz are suspect, and the application should be discussed with the transistor specialist. Other types of wire and bonded techniques are less susceptible to such fatigue failure. Cunsult the transistor specialist when operating frequencies are below 100 Hz and when the index number exceeds five million mW-mA-Hz.

TRANSISTORS

DEGRADATION OF h_{FE} DUE TO REVERSE BREAKDOWN OF BASE-EMITTER

The h_{FE} of transistors can be changed, generally degraded, by reverse current following through the emitter-base junction. This phenomena has been reported in literature and verified by JPL tests. The amount of h_{FE} degradation is a function of the reverse current magnitude and the integrated time the reverse current flows. Operation should be confined below the reverse breakdown voltage of the base-emitter junction.

TRANSISTORS
PNP POWER/FREQUENCY CHART, SELECTION GUIDE

MAXIMUM POWER 25° AMBIENT WATTS / MIN f_t (MHz)	0.18	0.3	0.4	0.5	0.5 to 15 W T_C = 100°C
5	2N2946A I_C = 0.05 A TO-46				
30	2N2605 I_C =0.015 A TO-46				
60					SDT3303 I_C = 2.5 A TO-111/I
100	2N3799 I_C = 0.025 A TO-18				
150	2N3497 I_C = 0.05 A TO-18	2N3495 I_C = 0.05 A TO-5			
175			2N3467 I_C = 0.5 A TO-5		
200	2N2907A I_C = 0.3 A TO-18	2N2905A I_C = 0.3 A TO-5		2N3637 I_C = 0.5 A TO-5	
300	2N3251A I_C = 0.1 A TO-18				

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TRANSISTORS
NPN POWER/FREQUENCY CHART, SELECTION GUIDE

MAXIMUM POWER 25°C AMBIENT WATTS / MIN f_t (MHz)	0.1	0.18	0.4	0.5	1.0	1.0 to 15 T_C = 100°C	15 to 25 T_C = 100°C	25 to 50 T_C = 100°C
10, Typical								96SV107 I_C = 50 A TO-63
20		2N2432A I_C = 0.05 A TO-18			2N5663 I_C = 1.0 A TO-5	14BB101 I_C = 10 A TO-61	SDT8304 I_C = 15 A TO-63	
40		2N910 I_C = 0.025 A TO-18				2N3997 I_C = 2.5 A Stud		
50, Typical			2N2193A I_C = 0.5 A TO-5				2N2814 I_C = 5 A TO-61	
60		2N2484 I_C = 0.025 A TO-18	2N2658 I_C = 2.5 A TO-5	2N3507 I_C = 1.5A TO-5	2N5154 I_C = 1.0 A TO-39	2N2880 I_C = 2.5 A TO-111		
80		SDT5005 I_C = 1 A TO-46	SDT5553 I_C = 1 A TO-5					
150			2N3501 I_C = 0.15 A TO-5	2N2405 I_C = 0.5 A TO-39				
300		2N2222A I_C = 0.25 A TO-18	2N2219A I_C = 0.4 A TO-5 2N3947 I_C = 0.1 A TO-18					
500			2N2369A I_C = 0.1 A TO-18	2N3866 I_C = 0.4 A TO-39	2N3375 I_C = 0.25 A TO-60			
600	2N918 I_C = 0.01 A TO-72							

TRANSISTORS

SELECTION GUIDE FOR BIPOLAR AMPLIFIERS

NPN

- **LOW CURRENT** 1 µA to 30 mA
  - 2N2484
  - 2N910
  - 2N918
- **MEDIUM CURRENT** 100 µA to 500 mA
  - 2N2219A
  - 2N2222A
  - 2N3947
  - 2N2405
  - 2N3866
- **HIGH CURRENT** 10 mA to 1 A
  - 2N3501
  - 2N2193A
  - 2N5154
  - 2N5663
- **VERY HIGH CURRENT** 1 to 50 A
  - SDT5553
  - 2N2658
  - SDT5005
  - SDT4925
  - 2N3507
  - 96SV107
  - 2N5250
  - 2N3997
  - SDT8304
  - 14BB101
  - 79BB128
  - 96EJ103

PNP

- **LOW CURRENT** 1 µA to 30 mA
  - 2N3799
  - 2N2605
  - 2N3251A
- **MEDIUM CURRENT** 100 µA to 500 mA
  - 2N3495
  - 2N3497
  - 2N2907A
  - 2N2905A
- **HIGH CURRENT** 10 mA to 1 A
  - 2N3467
  - 2N3637
- **VERY HIGH CURRENT** 1 to 5 A
  - SDT3303

TRANSISTORS

SELECTION GUIDE FOR BIPOLAR SWITCHES

NPN

LOW CURRENT
1 μA to 50 mA

- 2N3947 T_{on} 70 ns, T_{off} 450 ns
- 2N2369A T_{on} 12 ns, T_{off} 18 ns

MEDIUM CURRENT
1 mA to 500 mA

- 2N3501 T_{on} 55 ns, T_{off} 380 ns
- 2N2222A, 2N2219A T_{on} 35 ns, T_{off} 285 ns

HIGH CURRENT
100 mA to 5 A

- 2N2658 T_{on} 0.1 μs, T_{off} 1.5 μs
- 2N3507 T_{on} 45 ns, T_{off} 90 ns

PNP

LOW CURRENT
1 μA to 50 mA

- 2N3497 T_{on} 300 ns, T_{off} 450 ns
- 2N3251A T_{on} 70 ns, T_{off} 250 ns

MEDIUM CURRENT
1 mA to 500 mA

- 2N2907A, 2N2905A T_{on} 50 ns, T_{off} 100 ns
- 2N3495 T_{on} 300 ns, T_{off} 1000 ns

HIGH CURRENT
10 mA to 1 A

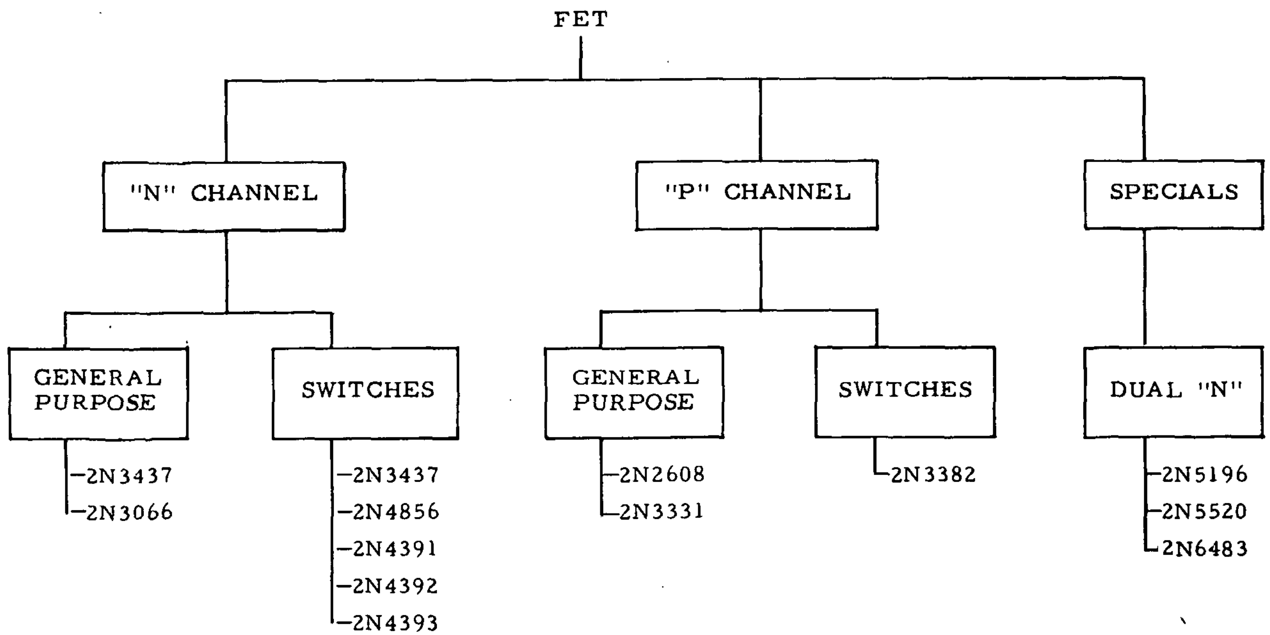
- 2N3467 T_{on} 40 ns, T_{off} 90 ns
- 2N3637 T_{on} 400 ns, T_{off} 600 ns

VERY HIGH CURRENT
1 to 5 A

- SDT3303

TRANSISTORS

SELECTION GUIDE FOR FIELD EFFECT TRANSISTORS



TRANSISTORS

SELECTION GUIDE FOR SPECIAL DEVICES

DUAL TRANSISTORS

- 2N2060 (NPN similar to 2N910 chip)
- 2N2920 (NPN similar to 2N2484 chip)
- 2N3350 (PNP similar to 2N2605 chip)
- 2N5117 (PNP)

SPECIAL

- PA7443 Quad (similar to 2N2222 chip)
- SA2267 Quad (similar to 2N2907 chip)
- MQ2905 Quad (similar to 2N2907 chip)
- MQ3725 Quad (similar to 2N3725 chip)

CHOPPERS

- 2N2432A NPN
- 2N2946A PNP
- 3N75 NPN

NPN POWER

- 2N2280 2.5 A - 80 V (V_{CE})
- 2N2814 5 A - 80 V (V_{CE})
- 96SV107 50 A - 180 V (V_{CE})
- 2N3997 2.5 A - 80 V (V_{CE})
- 14BB101 10 A - 300 V (V_{CE})

UNIJUNCTION

- 2N3980
- 2N6137
- 2N6138

PNP POWER

- SDT3303 2.5 A - 80 V (V_{CE})

RF

- 2N3375 NPN
- 2N3866 NPN
- MRF904 NPN
- MT1061A NPN
- MA42979 NPN

TRANSISTORS
BIPOLAR TRANSISTORS/MANUFACTURERS VOLTAGE RATINGS

VOLTAGE RATING (Volts)	BV_{CBO}		BV_{CEO}	
	NPN P/N	PNP P/N	NPN P/N	PNP P/N
325	SDT4925			
300			SDT4925	
225	SDT5553			
200	96SV107		SDT5553	
180	SDT5005		96SV107	
175		2N3637		2N3637
150	2N3501		2N3501	
120	2N2814	2N3497 2N3495	SDT5005	2N3497
100	2N910 2N2658 2N2880 2N3997 2N2060 (Dual)		2N5250 96EJ103	
80	2N2193A 2N3507	SDT3303	2N910 2N2658 2N2814 2N2880 2N3997	SDT3303
75	2N2219A 2N2222A			

TRANSISTORS
BIPOLAR TRANSISTORS/MANUFACTURERS VOLTAGE RATINGS

VOLTAGE RATING (Volts)	BV_{CBO}		BV_{CEO}	
	NPN P/N	PNP P/N	NPN P/N	PNP P/N
65	MQ3725 (Quad) 2N3375			
60	2N2484 2N2920 (Dual) 2N3947	MQ2905 (Quad) 2N2605 2N2905A 2N2907A 2N3251A 2N3799 2N3350 (Dual)	2N2484 2N2060 (Dual) 2N2920 (Dual)	MQ2905 (Quad) 2N2905A 2N2907A 2N3251A 2N3799
55	2N3866			
50	3N75 PA7443 (Quad)		2N2193A 2N3507	
45	2N2432A	2N5117	2N2432A	2N2605, 2N5117
40	2N2369A	2N3467 2N2946A SA2267 (Quad)	2N2219A 2N2222A 2N3375 2N3947 MQ3725 (Quad)	2N3467 SA2267 (Quad)
35				2N2946A 2N3350
30	2N918		2N3866 PA7443 (Quad)	
18			3N75	
15			2N918 2N2369A	

TRANSISTORS
QUALIFIED TRANSISTORS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		Small Signal	V_{CEO} max (Volts)	h_{FE} min	$V_{CE}sat$ max (Vdc)	I_c ① max (mA)	P_A 25°C ① (mW)	Case		
2N910	TIX	NPN	80	75	1.2	500	250	TO-18	0815	ST 11787
* 2N918 ②	MOT	NPN	15	20	0.4	25	100	TO-72	8122	ST 11788
2N2193A	MOT	NPN	50	40	0.25	500	400	TO-5	8030	ST 11789
2N2219A	TIX, MOT	NPN	40	100	0.3	400	400	TO-5	8037	ST 11892
* 2N2222A	TIX, MOT	NPN	40	100	0.3	400	250	TO-18	8037	ST 11790
* 2N2369A ②	MOT	NPN	15	40	0.25	100	180	TO-18	0863	ST 11791
* 2N2484	TIX	NPN	60	100	0.35	25	180	TO-18	0885	ST 11792
* 2N2605	TIX	PNP	45	100	0.5	15	200	TO-46	0842	ST 11793
* 2N2658	SOD	NPN	80	40	0.5	2.5 A	500	TO-5	8056	ST 11794
2N2905A	TIX, MOT	PNP	60	100	0.4	300	300	TO-5	0898	ST 11890
* 2N2907A	TIX, MOT	PNP	60	100	0.4	300	200	TO-18	0898	ST 11795
* 2N3251A	MOT	PNP	60	100	0.25	100	180	TO-18	8028	ST 11797
* 2N3467	MOT	PNP	40	40	0.5	500	500	TO-5	8087	ST 11798
* 2N3497	MOT	PNP	120	40	0.35	50	200	TO-18	8085	ST 11799
2N3799 ②	MOT	PNP	60	300	0.25	25	180	TO-18	8110	ST 11800
* 2N3501	MOT	NPN	150	100	0.4	150	500	TO-5	8059	ST 11801
* 2N3947 ②	MOT	NPN	40	100	0.3	100	180	TO-18	8111	ST 11802
* SDT5553	SOD	NPN	200	50	0.3	1 A	500	TO-5	8095	ST 11803

Notes: All values listed are maximum permissible under operating conditions and do not include safe operation criteria required for 1.0 mil aluminum wedge bond construction.

① These power and current ratings have been derated from manufacturer's values by the JPL Specialist, and are applicable at 25°C ambient temperature. Derate to zero power at 110°C junction temperature.

② Highly susceptible to thermal fatique failure during power cycling, due to 1.0 mil aluminum wedge bond construction. Refer to application notes and consult specialist for additional information.

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

TRANSISTORS
QUALIFIED TRANSISTORS (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		Power	V_{CEO} max (V)	h_{FE} min	$V_{CE}sat$ max (Vdc)	I_c (1) max	P_A 25^oC (1) (mW)	Case		
* 2N2814	SOD	NPN	80	40	0.5	5 A	25 W (2)	3/4 in. Hex Stud	8032	ST 11804
* 2N2880	SOD	NPN	80	40	0.25	2.5 A	15 W (2)	7/16 in. Hex Stud	8040	ST 11805
SDT3303	SOD	PNP	80	40-120 (2 A)	0.75 (2 A)	2.5 A	15 W (2)	TO-111/I	8109	ST 11889
		Special Devices Choppers								
* 2N2432A	TIX	NPN	45	50	0.15	50 mA	180	TO-18	0851	ST 11807
* 2N2946A	TIX	PNP	35	30	0.25	50 mA	200	TO-46	8046	ST 11808
* 3N75	TIX	NPN	18			10 mA	150	TO-72	8094	ST 11809
		Special Devices Dual	V_{CEO} max (V)	h_{FE1}/h_{FE2}	(V_{BE1}/V_{BE2})		P_A (1) 25^oC (mW)	Case		
* 2N2060	TIX	NPN	60	0.9	5 mV		300	TO-78	0838	ST 11810
* 2N2920	TIX	NPN	60	0.9	3 mV		250	TO-78	8015	ST 11811
* 2N3350	TIX	PNP	45	0.9	5 mV		300	TO-5	8074	ST 11812

Notes: All values listed are maximum permissible under operating conditions and do not include safe operation criteria required for 1.0 mil aluminum wedge bond construction. Consult specialist.

(1) These power and current ratings have been derated from manufacturer's values by the JPL Specialist, and are applicable at 25°C ambient temperature. Derate to zero power at 110°C junction temperature.

(2) With infinite heat sink and T_C = 25°C. Derate at zero power at T_C = 110°C.

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

TRANSISTORS

QUALIFIED TRANSISTORS (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		Special Devices Field Effect	BV_{DGS} (Volts)	G_m (µmhos)	I_{GSS} max (nA)	V_P max (Volts)	I_{DSS} (mA)	Case		
2N2608	SIL	P-Channel	30	1000	10.0	4.0	0.9-4.5	TO-18	8021	ST 11813
* 2N3331	SIL	P-Channel	20	2000-4000	10.0	8.0	5.0-15.0	TO-72	8115	ST 11843
* 2N3382	SIL	P-Channel	30	4500-12000	15.0	5.0	3.0-30.0	TO-72	8020	ST 11837
* 2N3437	SIL	N-Channel	50	1500-6000	0.5	4.8	0.8-4.0	TO-18	8081	ST 11836
* 2N4391	SIL, INL	N-Channel	40	[$r_{ds(on)}$ 30Ω]	0.1	10.0	50-150	TO-18	8117	ST 11815
* 2N5196	SIL	N-Channel (Dual)	50	1000-4000	0.025	4.0	0.7-7.0	TO-71	8119	ST 11844
		Special Devices Unijunction	R_{BBO}	n	V_{EB2}	P_A 25°C (mW)		Case		
* 2N3980	TIX MOT		4-8 k	0.68-0.82	30	180 (1)		TO-18	8107	ST 11817

Notes: (1) These power ratings have been derated from the manufacturer's values by the JPL specialist, and are applicable at 25°C ambient temperature. Derate to zero power at 110°C junction temperature.

* Indicates choice for standardization. Refer to explanation in second paragraph on page 2 of the Preface.

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TRANSISTORS

ACCEPTABLE TRANSISTORS

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		Small Signal	V_{CEO} max (Vdc)	h_{FE} min (@ I_c mA)	$V_{CE}sat$ max Vdc (@ I_c mA)	I_c (1) max (mA)	P_A (1) 25°C (mW)	Case		
SDT4925	SOD	NPN	300	20-60 (1 A)	0.4 (1 A)	2.5 A	180	TO-5	8056	
SDT5005	SOD	NPN	120	50-150 (500)	0.35 (500)	1.0 A	180	TO-46	8095	
2N3495	MOT	PNP	120	40 (50 mA)	0.35 (10)	50	300	TO-5	8085	
2N3507	MOT	NPN	50	30-150 (1.5 A)	1.0 (1.5 A)	1.5 A	500	TO-5	8120	
2N3637	MOT	PNP	175	100-300 (50)	0.5 (50)	500	500	TO-5	8065	
2N2405	RCA	NPN	90	35 (10)	0.2 (50)	500	500	TO-39	8171	
2N3866	RCA	NPN	30	10 (50)	1.0 (100)	200	500	TO-39	8141	

Note: (1) These power and current ratings have been derated from manufacturer's values by JPL Specialist, and are applicable at 25°C ambient temperature. Derate to zero power at 110°C junction temperature per Figure 1.

TRANSISTORS

ACCEPTABLE TRANSISTORS (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		Small Signal	V_{CEO} max (Vdc)	h_{FE} min (@ I_c mA)	V_{CE}sat max Vdc (@ I_c mA)	I_c (1) max (mA)	P_A 25°C (1) (mW)	Case		
2N5154	SOD	NPN	80	70-200 (2.5 A)	0.75 (2.5)	1 A	500	TO-39		
2N5663	SOD	NPN	300	25-75 (500)	0.4 (1 A)	1 A	600	TO-5		
		Dual								
2N5117	INL	PNP	45	100-400 (0.5)	0.35 (1.0)	10	375	TO-78	8158	PT 40694
		Quads								
PA7443	RAY (3)	NPN	60	50-150 (100)	0.52 (500)	250	30	TO-86	8133	ST 11885
SA2267	RAY (4)	PNP	60	50-150 (100)	1.3 (500)	250	30	TO-86	8130	PT 40282
MQ2905	MOT (4)	PNP	60	100-300 (150)	0.4 (150)	250	30	TO-86	8155	PT 40674
MQ3725	MOT (5)	NPN	40	50-150 (100)	0.26 (100)	250	30	TO-86	8156	PT 40688

Notes: (1) These power and current ratings have been derated from manufacturer's values by JPL Specialists, and are applicable at 25°C ambient temperature.

(3) These are four 2N2222 type chips. Values listed are for each chip.

(4) These are four 2N2907A type chips. Values listed are for each chip.

(5) These are four 2N3725 type chips. Values listed are for each chip.

TRANSISTORS

ACCEPTABLE TRANSISTORS (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS					SCRN SPEC ZPP-2073-	DRAWINGS
		High Frequency	BV_{cer} min (Vdc)	h_{FE} min (@ I_C A)	F_T min (MHz)	P_D 25°C (1) (mW)	Case		
MA42979	MAI	NPN, UHF	15	70-100 (8)	1300	250	TO-72	8185	
MRF904	MOT	NPN, UHF	15	30-200 (5)	4000	100	TO-72	8176	
MSC3001	MSC	NPN, UHF	50	15-120 (100)	3500	500	STRIPAC	8177	
MSC80264	MSC	NPN, UHF	20	15-120 (100)	3700	250	STRIPAC	8184	PT 40825
MT1061A	FAS	NPN, UHF	30	40-185 (5)	1300	125	TO-72	8174	

Note (1) These power ratings have been derated from manufacturer's values by the JPL Specialist, and are applicable at 25°C ambient temperature. Derate to zero power at 110°C junction temperature.

TRANSISTORS

ACCEPTABLE TRANSISTORS (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		Power	V_{CEO} max (Vdc)	h_{FE} min (@ I_c A)	$V_{CE}sat$ max Vdc (@ I_c A)	I_c (1) max (A)	P_D (1)(2) 25°C (W)	Case		
SDT8304	SOD	NPN	80	100 (10)	0.6 (10)	15	85	TO-63	8043	
2N5250	SOD	NPN	100	10-40 (70)	2.5 (70)	45	175	TO-114	8190	
14BB101	SOD	NPN	300	15-60 (10)	0.70 (10)	10	50	TO-61	8152	PT 40669
79BB128	SOD	NPN	80	80-300 (1)	0.07 (1)	25	85	TO-61	8151	PT 40579
96EJ103	SOD	NPN	100	40 (30)	0.25 (8)	12	110	TO-228	8043	PT 40828
96SV107	SOD	NPN	180	25-75 (25)	1.0 (25)	50	50	TO-63	8043	

Notes: (1) These power and current ratings have been derated from manufacturer's values by the JPL Specialist.

(2) With infinite heat sink and T_c = 25°C. Derate to zero power at T_c = 110°C.

TRANSISTORS

ACCEPTABLE TRANSISTORS (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		Power	V_{CEO} max (Vdc)	h_{FE} min (@ I_C A)	$V_{CE}sat$ max Vdc (@ I_C A)	I_c (1) max (A)	P_D (1)(2) 25°C (W)	Case		
PT3526	PTI	NPN	600	10 (20 A)	0.5 (20 A)	20	325	TO-63	8170	
PT4500	PTI	NPN	200	20-60 (50)	0.4 (50)	100	350	TO-114	8170	
PT4503	PTI	NPN	400	10 (60)	0.75 (60)	60	350	TO-114	8170	
2N3375	RCA	NPN	40	15-150 (150 mA)	1.0 (500 mA)	0.25	5	TO-60	8142	
2N3997	TIX	NPN	80	80-240 (1)	0.25 (1)	2.5	15	TO-111	8084	PT 40017

Notes: (1) These power and current ratings have been derated from manufacturer's values by the JPL Specialist.

(2) With infinite heat sink and T_c = 25°C. Derate to zero power at T_c = 110°C.

TRANSISTORS

ACCEPTABLE TRANSISTORS (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS						SCRN SPEC ZPP-2073-	DRAWINGS
		FETS	BV_{DGS} (Vdc)	G_m (μmhos)	I_{GSS} max (nA)	V_P max (Vdc)	I_{DSS} (mA)	Case		
2N3066	SIL	N Channel	50	400-1000	1.0	9.5	0.8-4.0	TO-18	8116	
2N4392	SIL	N Channel	40	r_{ds} 60	0.1	5	25-75	TO-18	8117	
2N4393	SIL	N Channel	40	r_{ds} 100	0.1	3	5-30	TO-18	8117	
2N4856	SIL	N Channel	40	r_{ds} 25	0.25		50 (min)	TO-18	8099	ST 11816
		Dual FET								
2N5520	SIL	N Channel	40	1000-4000	0.25	0.7-4	0.5-7.5	TO-71	8137	PT 40018
2N6483	INL	N Channel	50	1000-4000	0.20	0.7-4	0.5-7.5	TO-71	8188	
		Unijunction	V_{AK} max (Vdc)		I_{GAO} max (nA)	V_F max (Vdc)	P_A (1) (mW)	Case		
2N6137	UTR	Programmable	40		10	1.0	150	TO-18	8169	
2N6138	UTR	Programmable	100		10	1.0	150	TO-18	8169	

Note: (1) These power ratings have been derated from manufacturers values by JPL specialist and are applicable at 25° ambient temperature.

TRANSISTORS

ACCEPTABLE TRANSISTORS (contd)

PART NUMBER	VENDOR	TYPE	CHARACTERISTICS					SCRN SPEC ZPP-2073-	DRAWINGS
		Photo Transistors	BV_{CEO} min (Vdc)	I_D max (nA)	I_L min (mA)	P_D (1) 25°C (mW)	Case		
MRD 300	MOT	NPN	50	25	4.0	125	TO-18	8168	
MRD 370	MOT	NPN	40	100	3.0	125	TO-18	8168	
		Opto-coupler	I_{FL} max (μA)	I_{FH} (mA)	VF max (Vdc)	P_o (1) max (mW)	Case		
6N140	HPA	QUAD	2.0	0.5-5	1.7	25 (2)	DIP	3110	

Notes: (1) These power ratings have been derated from manufacturer's values by the JPL Specialist, and are applicable at 25°C ambient temperature. Derate to zero power at 110°C junction temperature.

(2) Each channel.

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TABLE I. VENDOR IDENTIFICATION CODES

JPL Alphabetical Code	FSCM Number	*Vendor
ABC	01121	Allen-Bradley Co., Milwaukee, WI
ACD	08742	ACDC Electronics, Div. of Emerson Electric Co., Oceanside, CA
ADC	70674	ADC Products, Div. of Magnetic Controls Co., Minneapolis, MN (Audio Development Corp.)
ADI	24355	Analog Devices, Inc., Norwood, MA
AMD	34335	Advanced Micro Devices, Inc., Sunnyvale, CA
ANA	31855	Analog Technology Corp., Pasadena, CA
ANG	17745	Angstrohm Precision, Inc., Hagerston, MD
API	99800	American Precision Industries, Inc., Delevan Electronics Div., East Aurora, NY
ATC	29990	American Technical Ceramics, Div. of Phase Ind., Huntington Station, NY
AVX	04222	AVX Ceramics, Div. of AVX Corp., Myrtle Beach, SC (Hi-Q)
AVX	96095	AVX Ceramics, Div. of AVX Corp., Olean, NY (Hi-Q)
BAB	09026	Babcock Electronics Corp., Control Products Div., Costa Mesa, CA
BEK	80740	Beckman Instruments, Inc., Fullerton, CA
BOU	32997	Bourns, Inc., Trimpot Products Div., Riverside, CA
BUS	71400	Bussman Mfg. Co., Div. of McGraw-Edison Co., St. Louis, MO
CAD	19647	Caddock Electronics, Inc., Riverside, CA
CEN	71590	Centralab Electronics, Div. of Globe-Union, Fort Dodge, IA
CGW	24546	Corning Glass Works, Electronic Components Div., Bradford, PA
CHI	54294	Cutler-Hammer, Inc., Shallcross Resistor Products, Smithfield, NC
CRC	12517	Component Research Co., Inc., Santa Monica, CA
CTC	71279	Cambridge Thermionic Corp., Cambridge, MA
CUS	23280	Custom Electronics, Inc., Oneonta, NY

JPL Alphabetical Code	FSCM Number	*Vendor
DAL	91637	Dale Electronics, Inc., Columbus, NE
DEU	99699	Deutsch Relays, Inc., East Northport, NY (Filters)
ELM	72136	Electro Motive Corp., Subs. of International Electric, Florence, SC (El-Menco Capacitor Prod)
ERI	72982	Erie Technological Products, Inc., Erie, PA
EXR	52063	Exar Integrated Systems, Inc., Sunnyvale, CA
FAS	07263	Fairchild Camera and Instrument Corp., Semiconductor Div., Mountain View, CA
FRQ	14844	Frequency Electronics, New Hyde Park, NY
GEC	01002	General Electric Co., Capacitor Dept., Hudson Falls, NY
GEC	09214	General Electric Co., Semiconductor Products Dept., Auburn, NY
GEC	01526	General Electric Co., Data Communication Product Dept., Waynesboro, VA
HAD	72964	Hadley, Robert M. Co., Los Angeles, CA
HAR	91417	Harris Semiconductor, Div. of Harris Corp., Melbourne, FL (Radiation, Inc.)
HON	91929	Honeywell, Inc., Microswitch Div., Freeport, IL
HPA	28480	Hewlett-Packard Co., Palo Alto, CA
HUG	53670	Hughes Aircraft Co., Micro Circuit Division, Newport Beach, CA
INL	32293	Intersil Inc., Cupertino, CA
IRC	81483	International Rectifier Corp., El Segundo, CA
JFD	73899	JFD Electronics Corp., Oxford, NC
JOH	91293	Johanson Manufacturing Co., Boonton, NJ
KDI	03888	KDI Pyrofilm Corp., Whippany, NJ
KEL	07088	Kelvin Electric Co., Van Nuys, CA

*Former names of Vendors are shown in parentheses for information only.

TABLE I. VENDOR IDENTIFICATION CODES (contd)

JPL Alphabetical Code	FSCM Number	*Vendor
LEA	35344	Leach Corp., Relay Div., Los Angeles, CA
LTF	75915	Littlefuse, Inc., Desplaines, IL
MAI	96341	Microwave Associates, Inc., Burlington, MA
MCA	90201	Mallory Capacitor, Div. of P.R. Mallory, Co., Indianapolis, IN
MEP	80031	Mepco/Electra, Inc., Morristown, NJ
MNC	50507	Micro Networks Corp., Worchester, MA
MOT	04713	Motorola, Inc., Semiconductor Products Div., Phoenix, AZ
MSC	32421	Microwave Semiconductor Corp., Sumerset, NJ
NSC	27014	National Semiconductor Corp., Santa Clara, CA
PII	26618	Piconics, Inc., Tynsburo, MA
PMI	06665	Precision Monolithics, Inc., Santa Clara, CA
PTI	32953	Powertech Inc., Clifton, NJ
RAY	49956	Raytheon Co., Lexington, MA
RCA	02735	RCA Corp., Solid State Div., Somerville, NJ
REC	04274	Rosemount Inc., Eden Prairie, NM
SET	14099	Semtech Corp., Newbury Park, CA
SGN	18324	Signetics Corp., Sunnyvale, CA
SIE	12954	Siemens Corp., Components Group, Scottsdale, AZ (Dickson)
SIL	17856	Siliconix, Inc., Santa Clara, CA
SLG	34333	Silicon General, Inc., Westminster, CA
SNC	87991	Sandia National Laboratories, Albuquerque, NM
SOD	21845	Solitron Devices, Inc., Transistor Div., Riviera Beach, FL
SPR	56289	Sprague Electric Co., North Adams, MA
TEE	90095	Technitrol, Inc., Philadelphia, PA
TEL	11532	Teledyne Relays, Hawthorne, CA
TIX	01295	Texas Instruments, Inc., Semiconductor Group, Dallas, TX
TRI	81095	Triad-Utrad, Div. of Litton Systems, Inc., National City, CA
TRW	07716	TRW Electronic Components, IRC Fixed Resistor Div., Burlington, IA
TRW	01281	TRW Electronic Components, Semiconductor Div., Lawndale, CA (PSI)
TRW	84411	TRW Electronic Components, TRW Capacitors, Ogallala, NE
TRW	80223	TRW Electronic Components, United Transformer Div., New York, NY
UCC	31433	Union Carbide Corp., Component Dept., Greenville SC (Kemet)
UTR	12969	Unitrode Corp., Watertown, MA
VAN	03550	Vanguard Electronics, Inglewood, CA
VEC	83186	Victory Engineering Corp., Springfield, NJ
VIT	95275	Vitramon, Inc., Bridgeport, CT
VOL	18736	Voltronics Corp., Hanover, NJ
VRN	88236	Varian Associates, Varian/Beverly, Beverly, MA
WEC	05277	Westinghouse Electric Corp., Semiconductor Div., Youngwood, PA
YSI	97794	Yellow Springs Instrument Co., Inc., Yellow Springs, OH

*Former names of Vendors are shown in parentheses for information only.

TABLE II. PART DERATING FACTORS

It is generally recognized that part failure rates are increasing functions of the stress applied in operation. Furthermore, it is realized that even the best parts, when operated at maximum rated stress levels, do not have sufficiently low failure rates to allow the synthesis of highly reliable complex systems. Therefore, the need to derate parts in application is clearly established.

Part derating factors are based on the part reliability at various stress levels. Once the necessary part reliability is established, one might immediately determine the maximum stress level at which the part could be operated without violating the reliability requirement. Unfortunately, curves of Reliability versus Stress exist for only a very few parts and are generally not well-proven even for these. In the remainder of the cases, historical information based on field data obtained from various equipments operating under conditions similar to those of interest must be used.

The recommended derating factors are based on a survey of the best information currently available. Failure rates in application will vary widely due to the particular circuit's tolerance of part drift; therefore, to assure low failure rates the designer should strive to achieve the greatest possible circuit tolerance.

TABLE II. PART DERATING FACTORS (contd)

Part	Derating Factor *	Stress	Remarks
CAPACITORS		Voltage	
Ceramic Disc			
Less than 1000 Vdc	0.7		
1000 Vdc or greater	0.5		
Ceramic, Low Voltage			
0.1 μF or less	0.7		
Greater than 0.1 μF	0.6		
Glass			
CYFR10 and CYFR15	0.7		
CYFR20 and CYFR30	0.6		
High K	*		*Same derating factors as Ceramic, Low Voltage Capacitors
Porcelain	0.7		
Mica			
Less than 1000 Vdc	0.7		
1000 Vdc or greater	0.5		
Plastic Film			
1.0 μF or less	0.7		
Greater than 1.0 μF	0.5		
Paper	0.8		
Metalized Film			
1.0 μF or less	0.6		
Greater than 1.0 μF			

$$\text{*Derating Factor} = \frac{\text{Maximum Stress for Reliable Operation}}{\text{Rated Stress}}$$

TABLE II. PART DERATING FACTORS (contd)

Part	Derating Factor *	Stress	Remarks
CAPACITORS (contd)		Voltage	
Tantalum, Solid			
18 and 22 μF at 50 Vdc	0.5		
39 and 47 μF at 35 Vdc	0.5		
82 and 100 μF at 20 Vdc	0.5		
All others	0.7		
Tantalum, Wet Slug	0.7		
Tantalum, Foil	0.7		
SILICON DIODES			Current and voltage derating factors shall be applied simultaneously.
General Purpose, Switching,	0.5	PIV	
Signal, Rectifier, SCR	0.5	I_o	
Varactors	0.75	PIV	
	0.75	Current	
Zener	0.75	Power	

*Derating Factor = $\frac{\text{Maximum Stress for Reliable Operation}}{\text{Rated Stress}}$

TABLE II. PART DERATING FACTORS (contd)

Part	Derating Factor *	Stress	Remarks
FILTERS			
EMI/RFI	0.7	Voltage/ Current	Current and voltage derating factors shall be applied simultaneously.
FUSES	0.50 at sea level	Current	If temperature extremes or vacuum operations are involved, further derating may be required. See Figures 4 and 9 in the Fuse Section.
MICROCIRCUITS			Recommended derating factors for integrated circuits used in high reliability applications are listed under Microcircuits (page 6 of this table). These factors shall be applied to the device manufacturer's published maximum ratings except where the device is screened for a higher rating. In the latter case, the derating factors shall be applied to the screened parameters. For circuit types not listed, a general derating factor of 0.80 is recommended for output currents, applied voltages and power dissipation.
RELAYS	0.8	Current	Applies to contact load current at rated load voltage. Coil voltage and current should be rated values. Contact derating given here is minimal for average type loads. See application notes in the Relay section for additional derating information.
RESISTORS		Power	
Composition	0.5		If local ambient is maintained at less than 50°C, parts may be operated at 70 percent of rated power.
Film	0.5		
Wirewould	0.5		
SWITCHES	0.8	Current	Applies to contact load current at rated load voltage.

$$\text{*Derating Factor} = \frac{\text{Maximum Stress for Reliable Operation}}{\text{Rated Stress}}$$

TABLE II. PART DERATING FACTORS (contd)

Part	Derating Factor *	Stress	Remarks
TRANSFORMERS	0.4	Power	
TRANSISTORS			
Silicon, All types, TO-5 Case Outline and Smaller Packages	0.5 [1]	Power	Derate to 110°C maximum junction temperature. Use ambient temperature conditions. (See Figure 1 following.)
Silicon, All types Larger Case Outline Than TO-5	0.5 [1]	Power	Derate to 110°C maximum junction temperature. Case temperature conditions permissible to use. (See Figure 2 following.)
Silicon, All types	0.75	Voltage	The voltage across any junction or group of junctions shall not exceed 75 percent of the manufacturer's rated voltage.
Silicon, All types	0.5	Current	300 mA maximum for 1.0 mil and smaller aluminum internal connect wire.
Silicon, All types	Consult transistor specialist	ON-OFF Cycling	ON-OFF cycling at rates less than 100 Hz may result in catastrophic opens. Consult transistor specialist for recommendations.

* Derating Factor = $\frac{\text{Maximum Stress for Reliable Operation}}{\text{Rated Stress}}$

(1) Manufacturers often overrate transistor power ratings. The PPL power listing has taken this into account anu reflects maximum permissible power.

TABLE II. PART DERATING FACTORS (contd)

MICROCIRCUITS	Linear					Converters			Digital					Processors, Peripherals and Memories	
Parameters	Diff'l. Ampl.	Compara-tors	Sense Ampl.	Current Ampl.	Voltage Reg.	A/D	D/A	Analog Switches	Std. TTL	Schottky TTL	LP TTL	LP Schottky TTL	CMOS	CMOS	TTL
1. Supply voltages.	0.80	0.90	0.80	0.80		⑤	⑤	0.90	⑤	⑤	⑥	⑤	0.70	⑧	⑤
2. Power dissipation (Percent of rated power at maximum operating temperature).	0.75	0.75	0.75	0.75	0.80	1.00	1.00	0.80	0.80 ⑥	0.80 ⑥	0.80 ⑥	0.80 ⑥	0.80 ⑦	0.80 ⑦	0.80
3. Ac input voltage (percent of rated ac voltage at actual supply voltage).	1.00	1.00	1.00	1.00		1.00									
4. Differential dc input voltage.	0.30 ③	0.30 ③	0.80												
5. Single-ended dc input voltage.				0.80	0.80		1.00		1.00	1.00	1.00 ①	1.00 ⑨	0.70	⑧	0.80
6. Signal voltage referenced to negative supply voltage.								0.90							
7. Input-output voltage differential.					0.80										
8. Output ac voltage.	1.00			1.00											
9. Open collector (or drain) dc output voltage		0.90	0.90						0.75	0.75	0.75	0.75			
10. Operating ac or dc output current.	0.80	0.80	0.80	0.80	0.80 ②	1.00	1.00	0.80	0.80 ④	0.80 ④	0.80 ④	0.80 ④	0.80 ④	0.80	0.80
11. Maximum short-circuit output current set by external means.	0.90	0.90	0.90	0.90	0.90										

NOTES: ① Transient input currents caused by the below-zero portion of ring waveforms shall be limited to 2 mA. This condition may occur where LPTTL is driven by standard TTL.

② 50% of rated current for two terminal regulators.

③ Should not exceed the BV_{EBO} of the transistors in the input circuit.

④ Further derating may be required for radiation environments.

⑤ Manufacturer's recommended operating voltages should be used.

⑥ Derating factor applicable to 85°C maximum.

⑦ See Figure 3 following for temperature derating. Power dissipation for CMOS devices is a function of operating frequency; consult the manufacturer's data sheet or contact the device specialist for detailed information.

⑧ For rad-hard 1800 series and 244, the continuous and transient voltages shall be between 7.0 and 11.00 volts, and continuous and transient input voltages shall not exceed the supply voltage. For other devices, the manufacturer's recommended operating voltages shall be used.

⑨ This rating applies to devices with $V_{IN} \leq V_{CCi}$; when $V_{INMAX} > V_{CC}$ (e.g. 15 volt inputs) change derating factor to 0.8.

TRANSISTOR DERATING CURVES

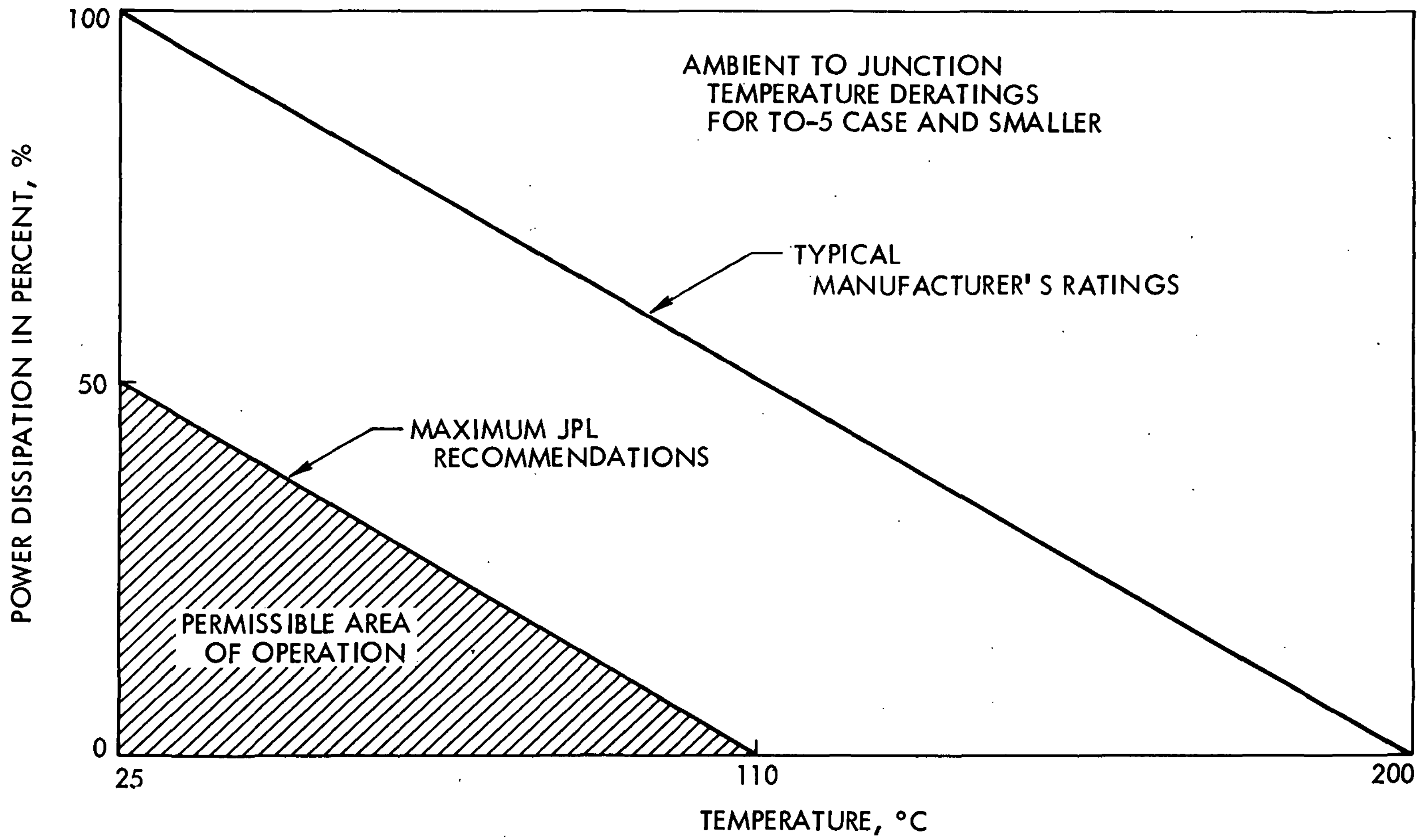

Figure 1. Derating, TO-5 Case and Smaller

TRANSISTOR DERATING CURVES

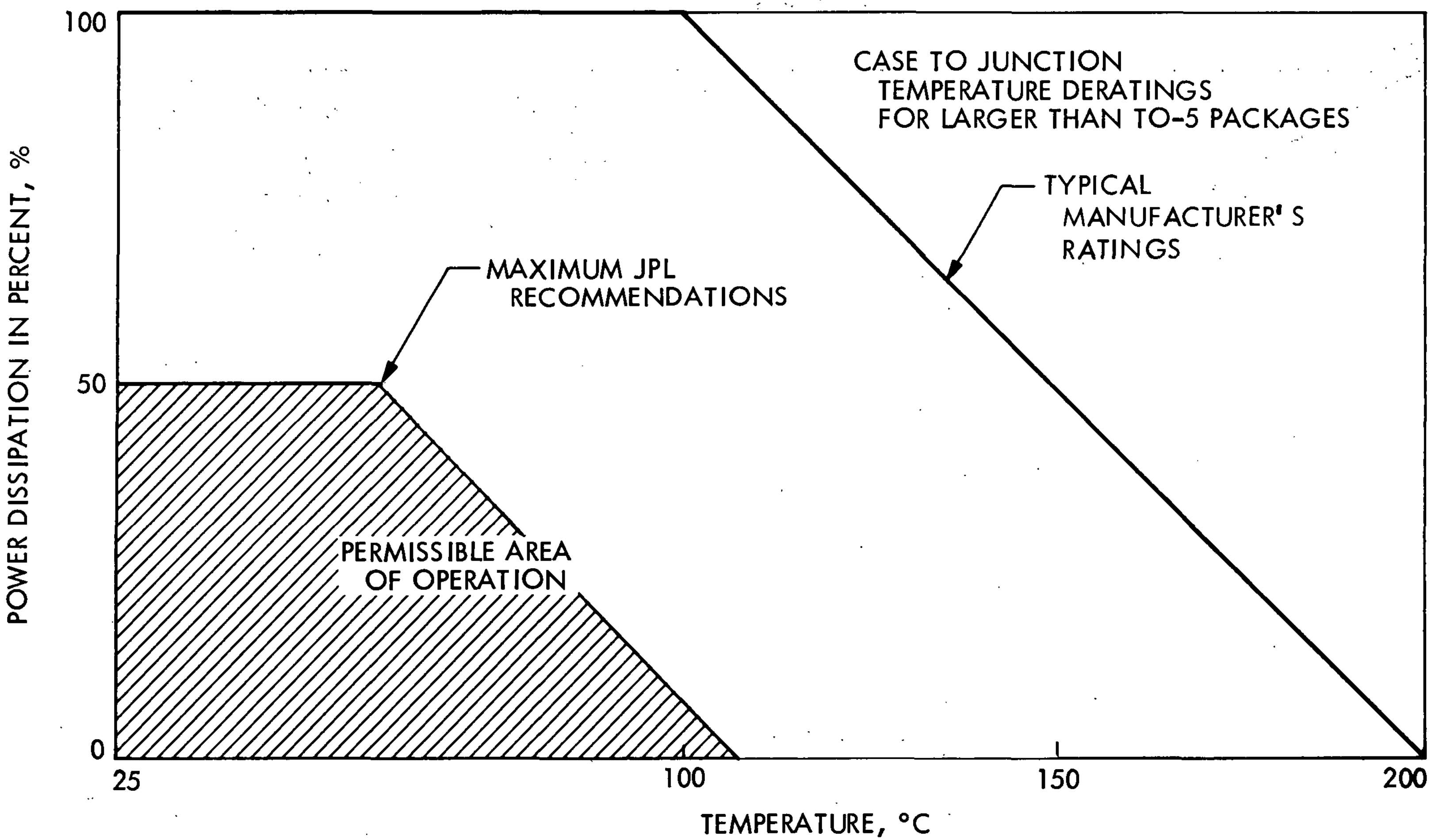

Figure 2. Derating, Larger Than TO-5 Case

CMOS MICROCIRCUIT DERATING CURVES

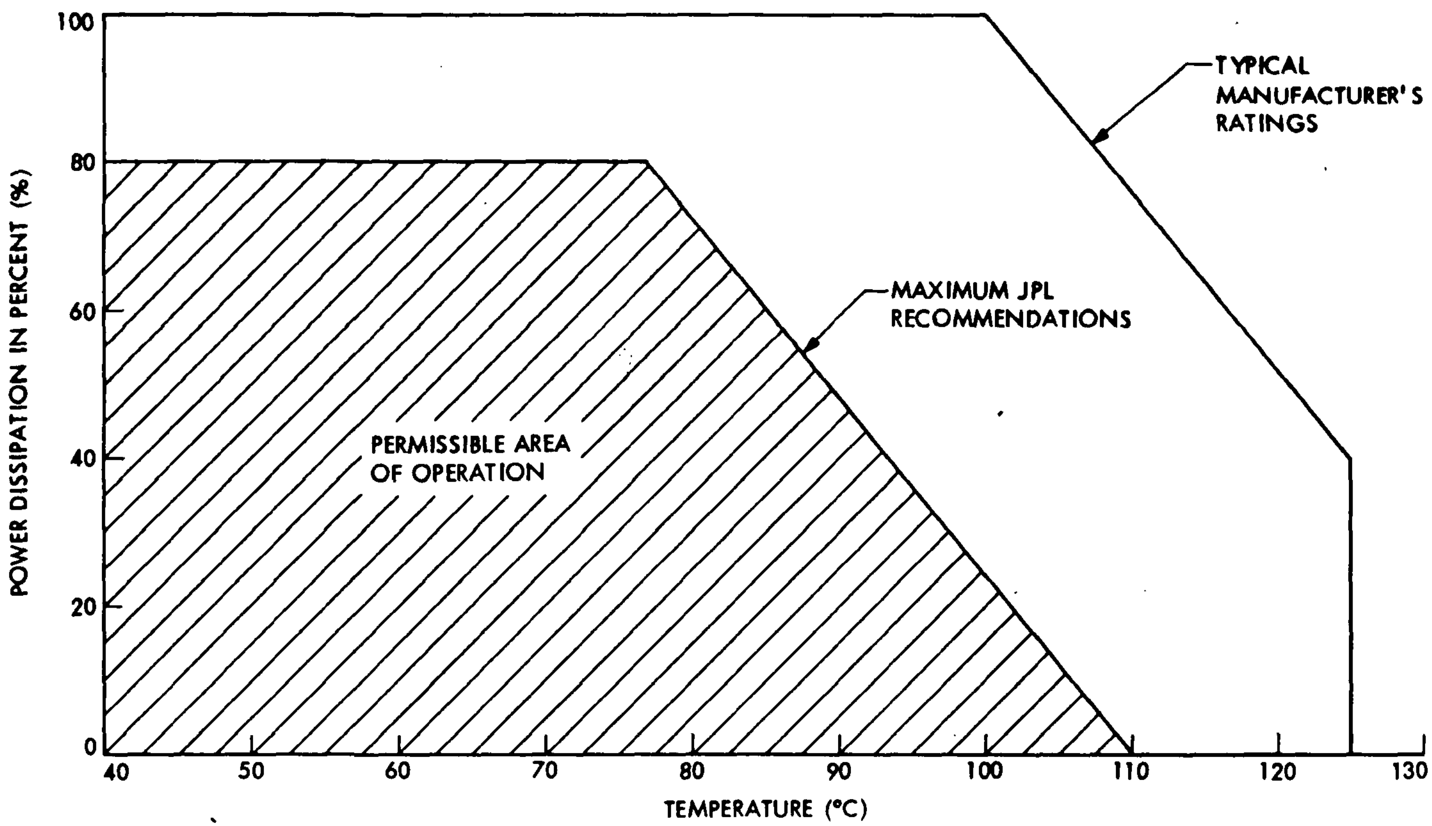

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Figure 3. Derating for CMOS Digital Microcircuits, Microprocessors, Peripherals and Memories

TABLE III. TORQUE LIMITS

Type	Thread Size	Torque (Inch-Pounds, Unless Noted) Minimum	Maximum
DIODE			
1N1183A through 1N1190A	1/4-28	20	30
1N1199A through 1N1206A	10-32	12	15
1N2970A, B through 1N2986A, B	10-32	12	15
1N3305A, B through 1N3321A, B	1/4-28		30
1N3889 through 1N3893	10-32	12	15
UT8105, 10, 20, 40, 60	4-40		28 in.-oz
UTR 4405 / UTR 5405 / UTR 6405 } 10, 20, 40	4-40		28 in.-oz
UZ7706 / UZ7806 } through 10, 12	4-40		28 in.-oz
SCR			
2N681 through 2N692	1/4-28		30
2N1770 through 2N1779	10-32		15
FILTER			
1250-700 (ERIE)	8-32	3	5
1250-003 (ERIE)	8-32	3	5
TRANSISTOR			
2N2814	1/4-28	12	18
2N2880	10-32	10	12
2N3997	10-32		15
SDT3303	10-32	10	12

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1. SCOPE

1.1 General. This standard establishes a list of Standard Electronic Parts for use in the selection, procurement, and application for flight and mission-essential ground support equipment. The listings are limited to the following Federal Stock Classes -

- 5905 - resistors (inc. thermistors).
- 5910 - capacitors.
- 5915 - filters.
- 5920 - protective devices.
- 5935 - connectors.
- 5945 - relays.
- 5950 - inductors and transformers.
- 5955 - crystals.
- 5961 - diodes and transistors.
- 5962 - microcircuits.
- 6145 - wire and cable.

1.2 Purpose. The purpose of this standard is as follows:

a. To provide equipment designers and manufacturers with a list of electronic parts having two quality levels considered to be most acceptable for flight and mission-essential ground support equipment.

b. To control and minimize the variety of electronic parts used by Government activities in order to maximize economic support of, to concentrate improvement on, and to facilitate effective logistic support of the electronic parts listed in this standard.

1.3 Classification. Two levels of quality are used in this standard. Grade 1 parts are higher quality, government specification controlled parts intended for critical flight and mission-essential ground support applications. Grade 2 parts are high quality, government specification controlled parts for use in non-critical flight and non-mission essential ground support applications.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on the date of invitation for bids or request for proposal form a part of this standard to the extent specified herein.

SPECIFICATIONS - MILITARY

CAPACITORS - FSC 5910

MIL-C-20	-	Capacitors, Fixed, Ceramic Dielectric, Temperature Compensating, ER and Non ER, General Specification for.
MIL-C-23269	-	Capacitors, Fixed, Glass Dielectric, ER, General Specification for.
MIL-C-39003	-	Capacitors, Fixed, Electrolytic (Solid Electrolyte), Tantalum, ER, General Specification for.
MIL-C-39006	-	Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum, ER, General Specification for.
MIL-C-39014	-	Capacitors, Fixed, Ceramic Dielectric (General Purpose), ER, General Specification for.
MIL-C-55681	-	Capacitor, Chip, Multiple Layer, Fixed, Unencapsulated, Ceramic Dielectric, Established Reliability, General Specification for.
MIL-C-83421	-	Capacitors, Fixed, Supermetallized Plastic Film Dielectric, Hermetically Sealed, ER, General Specification for.

CONNECTOR - FSC 5935

MSFC 40M38277	-	Connectors, Electrical, Circular, Miniature, High Density, Environment Resisting, Specification for.
MSFC 40M39569	-	Connectors, Electrical, Miniature Circular, Environment Resisting, 200°C, Specification for.
GSFC S-311-P-4	-	Connectors (and Contacts), Electrical, Rectangular, For Space Flight Use, General Specification for.

GSFC S-311-P-10	-	Connectors, Subminiature, Electrical and Coaxial Contact, For Space Flight Use.
MIL-C-5015	-	Connector, Electrical, Circular Threaded, AN Type, General Specification for.
MIL-C-22992	-	Connector, Plugs and Receptacles, Electrical, Waterproof, Quick Disconnect, Heavy Duty Type, General Specification for.
MIL-C-24308	-	Connector, Electric, Rectangular, Miniature Polarized Shell, Rack and Panel, General Specification for.
MIL-C-26482	-	Connector, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting) Receptacles And Plugs, General Specification for.
MIL-C-38999	-	Connector, Electrical, Circular, Miniature, High Density, Quick Disconnect, (Bayonet, Threaded and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for.
MIL-C-39012	-	Connector, Coaxial, Radio Frequency, General Specification for.

<u>CRYSTALS</u> - FSC 5955

MIL-C-3098	-	Crystal Unit, Quartz, General Specification for.
MIL-O-55310	-	Oscillators, Crystal, General Specification for.

<u>DIODES</u> - FSC 5961

MIL-S-19500	-	Semiconductor Devices, General Specification for.

<u>FILTERS</u> - FSC 5915

MIL-F-18327	-	Filters, High Pass, Low Pass, Band Pass, Band Suppression, and Dual Functioning, General Specification for.

INDUCTORS -		FSC 5950
MIL-T-27	-	Transformers and Inductors (Audio, Power, and High-Power Pulse). General Specification for.
MIL-C-15305	-	Coil, Fixed and Variable, Radio Frequency, General Specification for.
MIL-C-39010	-	Coils, Fixed, Radio Frequency, Molded Established Reliability, General Specification for.
MICROCIRCUITS -		FSC 5962
MIL-M-38510	-	Microcircuits, General Specification for.
PROTECTIVE DEVICES -		FSC 5920
MIL-F-23419	-	Fuses, Instrument Type, General Specification for.
RELAYS -		FSC 5945
MIL-R-39016	-	Relays, Electromagnetic, Established Reliability, General Specification for.
RESISTORS -		FSC 5905
MIL-R-39005	-	Resistors, Fixed, Wire - Wound (Accurate) ER, General Specification for.
MIL-R-39007	-	Resistors, Fixed, Wire-Wound (Power Type), ER, General Specification for.
MIL-R-39008	-	Resistors, Fixed, Composition (Insulated), ER, General Specification for.
MIL-R-39009	-	Resistors, Fixed, Wire-Wound (Power Type, Chassis Mounted), ER, General Specification for.
MIL-R-39015	-	Resistors, Variable, Wire-Wound (Lead Screw Actuated), ER, General Specification for.
MIL-R-39017	-	Resistors, Fixed, Film (Insulated), ER, General Specification for.
MIL-R-39035	-	Resistors, Variable, Nonwire-Wound (Adjustment Type), ER, General Specification for.
MIL-R-55182	-	Resistors, Fixed, Film, ER, General Specification for.
MIL-R-83401	-	Resistor Networks, Fixed, Film, General Specification for.

THERMISTORS -	FSC 5905	
GSFC S-311-P-18	-	Thermistors.
MIL-T-23648	-	Thermistor, (Thermally Sensitive Resistor) Insulated, General Specification for.
TRANSFORMERS -	FSC 5950	
MIL-T-27	-	Transformers and Inductors (Audio, Power, and High-Power Pulse), General Specification for.
MIL-T-21038	-	Transformers, Pulse, Low Power, General Specification for.
TRANSISTORS -	FSC 5961	
MIL-S-19500	-	Semiconductor Devices, General Specification for.
WIRE & CABLE -	FSC 6145	
MIL-C-17	-	Cable, Radio Frequency, Flexible and Semirigid, General Specification for.
MIL-W-5086	-	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy.
MIL-W-16878	-	Wire, Electrical, Insulated, High Temperature.
MIL-W-22759	-	Wire, Electric, Fluorocarbon Insulated, Copper or Copper Alloy
MIL-C-27500	-	Cable, Electrical, Shielded and Unshielded, Aerospace.
MIL-W-81381	-	Wire, Electric, Polyimide-Insulated Copper and Copper Alloy.

NOTE: Additional information on specific performance, use, and application can be found in MIL-HDBK-978 and MIL-HDBK-979.

NASA Publications

SP6507	-	Parts, Materials, and Processes Experience Summary, Vols. I and II.

(Copies of specifications, standards, drawings, and publications requested by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

NOTE: Additional copies may be obtained from the following center:

COMMANDING OFFICER
NAVAL PUBLICATIONS & FORMS CENTER
5801 TABOR AVE.
PHILADELPHIA, PA 19120

3. DEFINITIONS

3.1 Standard part. An electronic part approved for listing in this standard.

3.2 Non-standard part. An electronic part that is not approved for listing in this standard.

3.3 Grade 1. The classification used for higher quality standard parts intended for applications where either:

a. Maintenance or replacement is extremely difficult or impossible and failure would cause major mission degradation.

b. Part performance is critical to mission success, or

c. Part performance is critical to safety.

3.3.1 Capacitors, Grade 1. This grade contains military established reliability (ER) parts purchased to "S" failure rate (0.001%/1000 hours). When no source is listed on the Qualified Products List (QPL) to "S" failure rate level, level "R" (0.01%/1000 hours) may be substituted for Grade 1 application.

3.3.2 Connectors, Grade 1. This grade contains connectors that are procurable to NASA Marshall's "40M" and Goddard's S-311 specifications.

3.3.3 Crystals, Grade 1. There are no Grade 1 crystals listed in this standard.

3.3.4 Diodes, Grade 1. This grade contains diodes that are MIL-S-19500 Class JANS qualified. When Grade 1 (JANS) parts are not on the Qualified Products List (QPL), Grade 2 (JANTXV) may be upgraded in accordance with Appendix B for use in Grade 1 applications.

3.3.5 Filters, Grade 1. There are no Grade 1 filters listed in this standard.

3.3.6 Inductors & Coils, Grade 1. This grade contains military established reliability (ER) parts purchases to "R" failure rate (0.01%/1000 hours). Inductors and coils covered by MIL-T-27 & MIL-C-15305 may be upgraded in accordance with Appendix B for use in Grade 1 applications.

3.3.7 Microcircuits, Grade 1. This grade contains MIL-M-38510 qualified Class "S" devices. When Grade 1 (Class "S") parts are not on the Qualified Products List (QPL), Grade 2 (Class B) parts may be upgraded in accordance with Appendix B for use in Grade 1 applications.

3.3.8 Protective Devices, Grade 1. There are no Grade 1 protective devices listed in this standard.

3.3.9 Resistors, Grade 1. This grade contains military established reliability (ER) parts purchased to "S" failure rate (0.001%/1000 hours). When no source is listed on the Qualified Products List (QPL) to "S" failure rate level, level "R" (0.01%/1000 hours) may be substituted for Grade 1 applications.

3.3.10 Thermistors, Grade 1. This grade contains thermistors that are procurable to NASA/GSFC specification S-33-P-18.

3.3.11 Transformers, Grade 1. Presently there are no Grade 1 transformers available. Grade 2 transformers may be upgraded in accordance with Appendix B for use in Grade 1 application.

3.3.12 Transistors, Grade 1. This grade contains transistors that are MIL-S-19500 Class JANS qualified. When Grade 1 (JANS) parts are not on the Qualified Products List (QPL), Grade 2 (JANTXV) may be upgraded in accordance with Appendix B for use in Grade 1 applications.

3.3.13 Wire & Cable, Grade 1. This grade contains wire qualified to MIL-W-22759 or MIL-W-81381, and cable qualified to MIL-C-17 and MIL-C-27500, excluding silver coated types within each specification. The outgassing properties of these wire and cable are not controlled and must be evaluated for compliance to project outgassing requirements.

3.3.14 Relays, Grade 1. There are no GRADE 1 relays listed in this standard.

3.4 Grade 2. The classification used for standard parts which meet the criteria for inclusion in this standard and are intended for applications not requiring Grade 1 parts.

3.4.1 Capacitors, Grade 2. This grade contains military established reliability (ER) parts purchased to a minimum "P" failure rate level (0.01%/1000 hours).

3.4.2 Connectors, Grade 2. This grade contains connectors that are procurable to NASA/MSFC "40M", NASA/GSFC "S-311", MIL-C-5015, MIL-C-24308, MIL-C-26482, MIL-C-38999 and MIL-C-39012 specifications. The outgassing properties of the

NASA specifications are controlled within the document, however, the MIL-C outgassing properties are not controlled and must be evaluated for compliance to project outgassing requirements.

3.4.3 Crystals, Grade 2. This grade contains crystals and oscillators qualified to MIL-O-3098 and MIL-O-55310.

3.4.4 Diodes, Grade 2. This grade contains diodes that are MIL-S-19500 Class JANTX or JANTXV qualified.

3.4.5 Filters, Grade 2. This grade contains filters that are qualified to MIL-F-18327.

3.4.6 Inductors & Coils, Grade 2. This grade contains inductors and coils that are procurable to military control specifications. In those cases where established reliability (ER) parts are applicable, this grade contains "P" failure rate level parts as a minimum.

3.4.7 Microcircuits, Grade 2. This grade contains microcircuits which are qualified to MIL-M-38510 class B or to NASA/MSFC "40M" specifications.

3.4.8 Protective Devices, Grade 2. This grade contains devices that are qualified to MIL-F-23419/8.

3.4.9 Resistors, Grade 2. This grade contains military established reliability (ER) parts purchased to a minimum "P" failure rate level (0.01%/1000 hours).

3.4.10 Thermistors, Grade 2. This grade contains thermistors that are procurable to military control specification MIL-T-23648/19.

3.4.11 Transformers, Grade 2. This grade contains transformers that are procurable to military control specification MIL-T-27 and MIL-T-21038.

3.4.12 Transistors, Grade 2. This grade contains transistors that are MIL-S-19500 Class JANTXV qualified.

3.4.13 Wire & Cable, Grade 2. This grade contains wire qualified to MIL-W-22759 or MIL-W-81381, and cable qualified to MIL-C-17 and MIL-C-27500. The outgassing properties of these wire and cable are not controlled and must be evaluated for compliance to project outgassing requirements.

3.4.14 Relays, Grade 2. This grade contains parts qualified to MIL-R-39016 failure rate level (FRL)P.

SECTION 1: SUMMARY OF STANDARD CAPACITORS

Page	Control Specification	Military Style	Description	Seal	Capacitance Range Min	Capacitance Range Max	DC Voltage Range (Volts) Min	DC Voltage Range (Volts) Max	Operating Temperature Range (°C) Min	Operating Temperature Range (°C) Max	GRADE 1 1/ FRL	GRADE 2 FRL
10	MIL-C-20	CCR	Fixed, Ceramic, Temperature Compensating.	Non-Hermetic	1.0 pF	0.082 µF	50	200	-55	+125	S, R	P
11	MIL-C-23269	CYR	Fixed, Glass.	Hermetic	0.5 pF	0.01 µF	100		-55	+125	S	S
12	MIL-C-39003	CSR	Fixed, Tantalum (solid) electrolytic.	Hermetic	.0047 µF	560 µF	10	75	-55	+85	S	P
13	MIL-C-39006	CLR	Fixed, Tantalum (non-solid) electrolytic.	Hermetic	0.39 µF	750 µF	15	375	-55	+125	S, R	P
14	MIL-C-39014	CKR	Fixed, Ceramic.	Non-Hermetic	10 pF	1 µF	50	200	-55	+125	S	P
15	MIL-C-55681	CDR	Chip, Fixed, Ceramic, Dielectric.	Unencapsulated	0.0012 µF	0.47 µF	50	200	-55	+125	S, R	P
16	MIL-C-83421	CRH	Fixed, Supermetallized plastic film.	Hermetic	0.001 µF	22 µF	30	400	-65	+100	S	P

1/ Failure Rate Levels (FRLs), defined in %/1000 hours, are specified as follows: S = 0.001, R = 0.01, and P = 0.1.

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MIL-C-20, CAPACITORS

Fixed, Ceramic Dieletric, Temperature Compensating, Established Reliability

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Part number example: CCRXX CX XXX X X

STYLE - "CCR" identifies an established reliability, ceramic-dielectric, temperature-compensating, fixed capacitor; "XX" identifies the shape and dimensions of the capacitor.

CHARACTERISTICS - C identifies the nominal temperature coefficient (0 ppm/°C) while X identifies the approximate tolerance envelope for the temperature coefficient. Characteristics available are:

X	±ppm/C
G	30
H	60

CAPACITANCE - nominal value expressed in picofarads. 1/

CAPACITANCE TOLERANCE - is specified in accordance with the following table:

X	Tolerance (±)	X	Tolerance (±)
C	0.25pF	G	2%
D	0.5 pF	J	5%
F	1%	K	10%

FAILURE RATE LEVEL -
"P" = 0.1%/1000 hours
"R" = 0.01%/1000 hours

Part Number	Control Specification MIL-C-20	Style	Capacitance Range (pF)	Capacitance Tolerances Available	Rated Voltage (volts dc)	Dissipation Factor (%)	Temperature Range °C	Temperature Characteristics Available	Minimum I.R. (Megohms) @ Temperature +25°C	Minimum I.R. (Megohms) @ Temperature +125°C	Configuration Case Type	Configuration Lead Type 2/	GRADE 1 3/	GRADE 2
CCR05CX XXX X X	/35	CCR05	1.0-3,300	C,D,F,G,J	50, 100 200	0.15	-55 to +125	CG, CH	100K	10K	Rect. molded	Radial	S, R	P
CCR06CG XXX X X	/36	CCR06	390-10,000	F,G,J,K				CG						
CCR07CG XXX X X	/37	CCR07	2,200-22,000											
CCR08CG XXX X X	/38	CCR08	3,900-68,000	G,J,K										
CCR75GC XXX X X	/27	CCR75	1.0-680	C,D,F,G,J							Tubular molded	Axial		
CCR76GC XXX X X	/28	CCR76	82-1,000	F,G,J,K										
CCR77CG XXX X X	/29	CCR77	150-5,600											
CCR78CG XXX X X	/30	CCR78	820-27,000											
CCR79CG XXX X X	/31	CCR79	3,900-82,000											

1/ For values ≥10pF the first two digits are significant, and the last signifies the number of zeros to follow. For values <10pF, the letter "R" is used to indicate the decimal point and succeeding digit(s) represent significant figures(s); e.g., 1R0 indicates 1.0pF; R75 indicates 0.75pF; and 0R5 indicates 0.5pF

2/ MIL-C-20 specifies that leads be solderable, but the lead material itself is not specified. When leads are to be welded, copper leads and solder or tin-plate finish are not preferred and are not recommended. Consult the project engineer for recommendations for parts procurement.

3/ For space flight use, wax impregnates or other volatile materials must not be used.

MIL-C-23269, CAPACITORS

Fixed, Glass Dielectric, Established Reliability

Part Number example: M23269 /XX XXXX

M-Number - identifies "CYR" fixed, glass dielectric, established reliability capacitors conforming to MIL-C-23269.

/XX - identifies the appropriate military specification sheet that uniquely specifies the capacitor family.

XXXX - uniquely specifies the nominal capacitance value, capacitance tolerance, rated dc voltage, and failure rate level (%/1000 hours).

Part Number	Control Specification	Style 1/,3/	Capacitance		Working Voltage Vdc 2/	Dissipation Factor (%)	Temperature		Insulation Resistance (megohms)	GRADE/FRL	
			Range (pF)	Tolerance (±)			Range (°C)	Coefficient (ppm/°C)		1 FRL	2 FRL
M23269/01-XXXX	MIL-C-0023269/1 (USAF)	CYR10	0.5-300	0.25pf,1,2,5%	100	0.1	-55 to +125	140 ±25	100K	S	S
M23269/02-XXXX	MIL-C-0023269/2 (USAF)	CYR15	220-1200	1,2,5%						S	S
M23269/03-XXXX	MIL-C-0023269/3 (USAF)	CYR20	560-5100							S	S
M23269/04-XXXX	MIL-C-0023269/4 (USAF)	CYR30	3600-10,000							S	S

1/ See atached table listing standard capacitors for this style.
2/ Capacitors operate at full rated voltage at temperatures up to +125°C.
3/ All styles listed are in rectangular-glass, hermetic cases with axial leads. Lead material and coating are specified in the detailed specification sheet for each device type. However, not all lead materials listed are preferred and recommended for welding. Consult the project parts engineer for recommendations for part procurement.

MIL-C-39003, CAPACITORS

Fixed, Tantalum (solid) Electrolytic, Established Reliability

Part Number example: M39003 /XX XXXX

M-NUMBER - identifies "CSR" fixed tantalum, electrolytic (solid electrolyte), established reliability capacitors that are hermetically sealed in metal cases. The metal cases are insulated.

/XX - identifies the appropriate military specification sheet that uniquely specifies the capacitor family.

XXXX - uniquely specifies the nominal capacitance value, capacitance tolerance, rated voltage, maximum dc leakage and dissipation factor, and failure rate level (%/1000 hours).

Part Number	Control Specification	Style	Capacitance		Rated 1/ Voltage (Vdc)	Operating Temperature Range (°C)	Configuration			GRADE/FRL	
			Range (μF)	Tolerance (±%)			Case Type	Lead Type	Lead Material	1 2/ FRL	2 FRL
M39003/01-XXXX	MIL-C-39003/1 Polarized 3/	CSR13	.0047-220.0	10,20	10-75	-55 to +85	Tubular	Axial	Tin-lead coated Nickel	S	P
M39003/02-XXXX	MIL-C-39003/2 Polarized 3/	CSR09	0.047-15.0	10	10-75	-55 to +85	Tubular	Axial	Nickel-iron alloy	S	P
M39003/06-XXXX	MIL-C-39003/6 Polarized 3/	CSR33	1.2-560.0	10,20	10-50	-55 to +85	Tubular	Axial	Tin-lead coated Nickel	4/	P

1/ Refer to MIL-C-39003; Parts are useable to a maximum operating temperature of +125°C but must be derated linearly above +85°C to 50% of the +125°C rated voltage.
2/ All parts must be subjected to the surge current screen as specified by Appendix B, paragraph 4.0 of MIL-STD-975.
3/ Parts should see an effective current limiting series resistance of at least 3 ohms per volt. See Appendix A for derating guidelines.
4/ CSR33 capacitors are listed as GRADE 2 only, due to poor failure rates.

MIL-C-39006, CAPACITORS
Fixed, Tantalum (non-solid) Electrolytic, Hermetically Sealed, Established Reliability

Part Number example:

M39006 **/XX** **XXXX**

M NUMBER - identifies "CLR" tantalum, electrolytic (nonsolid electrolyte); fixed capacitors (polarized and non-polarized), hermetically sealed in metal cases, with insulating sleeves.

/XX - identifies the appropriate military specification sheet that uniquely specified the capacitor family.

XXXX - uniquely specifies the nominal capacitance value, capacitance tolerance, rated dc voltage, dc leakage, and failure rate level (%/1000 hours).

Part Number	Control Specification	Style 1/	Capacitance Range µf	Capacitance Tolerance ±%	Working Voltage Vdc 3/	Operating Temperature Range °C	GRADE/FRL 1 FRL 4/	GRADE/FRL 2 FRL
M39006/**01**-XXXX	MIL-C-39006/1 Polarized/Etched Foil	**CLR25**	40 to 580 12 to 150 4 to 70	+75, -15 +50, -15 +30, -15	15,25 or 30 50 or 75 100 or 150	-55 to +125	S,R	P
M39006/**02**-XXXX	MIL-C-39006/2 Nonpolarized/Etched Foil	**CLR27**	18 to 350 6 to 80 2 to 35	+75, -15 +50, -15 +30, -15	15,25 or 30 50 or 75 100 or 150	-55 to +125	S,R	P
M39006/**03**-XXXX	MIL-C-39006/3 Polarized/Plain Foil	**CLR35**	18 to 160 12 to 100 10 to 85 68 6 to 55 4 to 40 3 to 30 2 to 20 1.5 to 15 1 to 10	±20 (18 to 160 through 2 to 20) ±15 ±15	15 25 30 35 50 75 100 150 200 300	-55 to +125	S,R	P
M39006/**04**-XXXX	MIL-C-39006/4 Nonpolarized/Plain Foil	**CLR37**	10 to 100 6 to 60 5.5 to 45 3 to 30 2 to 20 1.5 to 15 1 to 10 .75 to 7.5 .6 to 6 .47 to 4.7 .39 to 3.9	±20 (10 to 100 through 1 to 10) ±15 (.75 to 7.5 through .39 to 3.9)	15 25 30 50 75 100 150 200 250 300 375	-55 to +125	S,R	P
M39006/**22**-XXXX	MIL-C-39006/22 Polarized/Sintered Slug	**CLR79**	20 to 750 15 to 540 8 to 300 5 to 160 3.5 to 110 2.5 to 86 1.7 to 56	±5, ±10, ±20	10 20 30 50 75 100 125	-55 to +125	S,R	P

1/ See attached table listing standard capacitors for this style.
2/ CLR25, CLR27, CLR35 and CLR37 are susceptible to vibration failures. Consult the project parts engineer for recommendations.
3/ For operation above 85°C, operating voltage shall be derated per MIL-C-39006/1, /2, /3, /4 or /22 as applicable.
4/ When no source is listed on QPL to Level "S" failure rate, alternate FRL "R" shall be used.

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MIL-C-39014, CAPACITORS
Fixed, Ceramic Dielectric, Established Reliability

Part Number example: **M39014** **/XX** **- XXXX**

M-NUMBER - identifies "CKR" fixed, ceramic, insulated, general purpose, established reliability capacitors conforming to MIL-C-39014.

/XX - identifies the appropriate military specification sheet that uniquely specifies the capacitor family.

XXXX - uniquely specifies the nominal capacitance value, capacitance tolerance, rated dc voltage, and failure rate level (FRL) in %/1000 hours.

Part Number	Control Specification	Style	Capacitance Range 6/ (pF)	Capacitance Tolerance (±%)	Working Voltage (Vdc)	Dissipation Factor (%)	Insulation Resistance @ +25°C	Operating Temperature Range (°C)	Configuration CASE Type	Configuration LEAD Type 3/	GRADE/FRL 1 1/ FRL 2/	GRADE/FRL 2 FRL
M39014/**01**-XXXX	MIL-C-39014/1	**CKR05**	10-100,000		50,100 200				Rect.	Radial	S	P
M39014/**02**-XXXX	MIL-C-39014/2	**CKR06**	1,500-1,000,000				100K megohm for C < 10 nf				S	P
M39104/**05**-XXXX	MIL-C-39014/5	**CKR11**	10-10,000	10,20		2.5		-55 to +125			S	P
M39014/**05**-XXXX	MIL-C-39014/5	**CKR12**	5,600-47,000		50,100		1K megohm -µf for C ≥ 10 nf 4/		5/ Tubular	Axial	S	P
M39014/**05**-XXXX	MIL-C-39014/5	**CKR14**	12,000-100,000								S	P
M39014/**05**-XXXX	MIL-C-39014/5	**CKR15**	68,000-1,000,000								S	P

1/ For space flight use, wax impregnates or other volatile materials must not be used.
2/ Until the effectivity of Amendment 5 to MIL-C-39014 in screening out lots with dielectric delamination and voids is determined, parts purchased for use in Grade 1 applications shall be rescreened as specified in Appendix B.
3/ MIL-C-39014 specifies that leads be solderable, but the lead material itself is not specified. When leads are to be welded, copper leads and solder or tin-plate finish are not preferred and are not recommended. Consult the proect parts engineer for recommendations for part procurement.
4/ Insulation Resistance = X/C, where X = 1K megohm-µF and C is the capacitance expressed in µF.
5/ Glass encased capacitors should not be potted in hard materials. If potting in a hard material is required, then a resilient material shall be applied to the capacitor as a buffer.
6/ Capacitance values above .33µF are not recommended for use in critical applications because they are more susceptible to delaminations and cracks due to the thinness of the dielectric material.

MIL-C-55681, CAPACITORS, CHIP
Multiple Layer, Fixed, Unencapsulated, Ceramic Dielectric, Established Reliability

Part number example:

CDRYY BY YYY Y Y Y Y

- CDRYY — Style
- BY — Rated Temperature and voltage Temperature limits
  - BP = 0 ±30 ppm
  - BX = ±15%
- YYY — Capacitance
- Y — Rated Voltage (Vdc)
  - A = 50
  - B = 100
  - C = 200
  - D = 300
  - E = 500
- Y — Capacitance Tolerance
  - J = ±5%
  - K = ±10%
  - M = ±20%
- Y — Termination finish 2/
- Y — Failure Rate Level
  - "P" - 0.1%/1000 hours
  - "R" - 0.01%/1000 hours
  - "S" - 0.001%/1000 hours

Part Number 1/	Control Specification	Style	Capacitance		Rated Voltage (volts, dc)	Rated Temperature and voltage-temperature limits	GRADE 1	GRADE 2
			Range (pF)	Tolerances Available				
CDR04BYYYYYYYY	MIL-C-55681/1	CDR04	1,200-180,000	J, K, M	50, 100, 200	BP, BX	S	R
CDR05BYYYYYYYY	MIL-C-55681/2	CDR05	3,900-330,000		50, 100		S, R	P
CDR06BYYYYYYYY	MIL-C-55681/3	CDR06	6,800-470,000				S, R	P

1/ Complete Part Number must conform to that shown in Part Number Example.
2/ Available termination finishes: S - Solder-coated, final.
M - Palladium - silver.
N - Silver-nickel-gold.

MIL-C-83421, CAPACITORS
Fixed, Supermetallized Plastic Film Dielectric, Hermetically Sealed, Established Reliability

Part Number example: M83421 /01 X XXX X

M83421 — M-NUMBER - identifies "CRH" established reliability, fixed, supermetalized plastic film dielectric capacitors that are hermetically sealed in metal cases.

/01 — /01 - identifies the appropriate specification sheet that uniquely specifies the capacitor family.

X — X - specifies the capacitor style e.g.,
1 = CRH01
2 = CRH02
3 = CRH03
4 = CRH04
5 = CRH05

XXX — XXX - uniquely specifies the capacitance value, capacitance tolerance, ac ratings, and physical dimensions of the capacitor.

X — FAILURE RATE LEVEL -
"P" - 0.1%/1000 hours
"S" - 0.001%/1000 hours

Part Number	Control Specification	Style 1/	Capacitance Range (µF)	Capacitance Tolerance (±%)	Rated Voltage (Vdc)	Dissipation Factor (%, Max)	Dielectric Absorption (%, Max)	Operating Temperature Range (°C) 2/	GRADE/FRL 1 FRL	GRADE/FRL 2 FRL
M83421/01-XXXXX	MIL-C-83421/1	CRH01	0.001-22.0	1,5,10	30	0.15	0.1	-65 to +100	S 3/	P
		CRH02	0.001-10.0		50					
		CRH03	0.001-10.0		100					
		CRH04	0.001- 3.9		200					
		CRH05	0.001- 2.0		400					

1/ All styles listed are in tubular cases with axial leads. Lead material and coating are specified in MIL-C-83421/1. However, not all lead materials listed are preferred and recommended for welding. Consult the NASA project parts engineer for recommendations for part procurement.

2/ Parts may be used in a maximum operating temperature of +125°C but must be derated linearly above +100°C, to 50% of the +100°C rated voltage.

3/ This capacitor is not approved for use in circuits where the energy is less than 500 µjoules.

SECTION 3: SUMMARY OF STANDARD CRYSTALS

Page	Control Specification	Description	Frequency Range (Hz)		GRADE 1	GRADE 2
			Min	Max		
3.2	MIL-C-3098	Crystal unit, quartz	0.8	62 M	1/	
3.3	MIL-O-55310	Crystal oscillators, I.C. technology	0.01	25 M	1/	

1/ MIL-C-3098 and MIL-O-55310 parts are not available for Grade 1 applications.

MIL-C-3098, CRYSTAL UNITS
Quartz

Part Number Example: CR -XX X /U (X------X)

- CR — COMPONENT IDENTIFIER
- -XX — NUMBER - Crystal Type
- X — LETTER MODIFICATION STATUS
- /U — BASIC INDICATOR (Application) U = General Utility
- (X------X) — OUTPUT FREQUENCY

Part Number		Control Specification	frequency (Hz)			Mode of Oscilation	Antiresonance Load Capacitance (pF)	Operating Temperature Range (°C)	
GRADE 1	GRADE 2		Range Min	Range Max	Tolerance (PPM)			Min	Max
1/	CR-18A/U	MIL-C-3098/03	0.8M	20M	±50	Fundamental	32.0 ±0.5	-55	+105
1/	CR-19A/U	MIL-C-3098/04	0.8M	20M	±50	Fundamental	shunt = 7.0 max.	-55	+105
1/	CR-55A/U	MIL-C-3098/33	17M	62M	±50	Third Mechanical Overtone	shunt = 7.0 max.	-55	+105
1/	CR-78A/U	MIL-C-3098/62	2.2M	20M	±50	Fundamental	30.0 ±0.5	-55	+105
1/	CR-157/U	MIL-C-3098/137	0.8M	20M	±50	Fundamental	shunt = 7.0 max.	-55	+105

1/ Presently there are no Grade 1 parts available.

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SUMMARY OF MIL-STD-975 DIODES

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C			Package
			I_o (mA)	PIV (Vdc)	I_R at V_R (max)	
Small Signal						
Rectifiers	1N645-1		400	225	25 nA	
	1N647-1	/240	400	440	25 nA	A1
	1N649-1		400	600	50 nA	
Fast Switching	1N4148-1	/116	150	75	5 µA	DO35
	TX1N5719	/443	70	100	250 nA	A1
Schottky	1N5711	/444	33	50	200 nA	A1
	1N5712	/445	33	16	150 nA	
Power Diodes						
Rectifiers	1N5550 through 1N5554	/420	3 A	200-1000	1 µA	A1
	1N5614			200		
	1N5616			400		
	1N5618	/427	1 A	600	0.5 µA	A248
	1N5620			800		
	1N5622			1000		
	TX1N1202A	/260	12 A	200	50 µA	DO4

SUMMARY OF MIL-STD-975 DIODES (contd)

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C			Package
			I_o (mA)	PIV (Vdc)	I_R at V_R (max)	
Power Diodes						
Fast Switching	1N5415 through 1N5420	/411	3 A	50-600	1 µA	A248
	1N5615 1N5617 1N5619 1N5621 1N5623	/429	1 A	200 400 600 800 1000	0.5 µA	A248
	1N3891 1N3893	/304	12 A	200 400	15 µA 25 µA	DO4
Fast Recovery	1N5814 1N5816	/478	20 A	100 150	10 µA	DO4
Schottky	TX1N5829 TX1N5830 TX1N5831	/490	25 A	20 30 40	20 mA	DO4

SUMMARY OF MIL-STD-975 DIODES (contd)

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C			Package
			V_Z (Vdc)	I_{ZT} (mA)	P_D (W)	
Zener Diodes Voltage Regulators	1N746A through 1N759A	/127	3.3-12	20	400 mW	D07
	1N962B through 1N992B	/117	11-200	0.65-11.5	400 mW	D07
	1N3016B through 1N3051B	/115	6.8-200	1.2-37	1.0	A31
	1N3821A through 1N3828A	/115	3.3-6.2	41-76	1.0	A31
	1N4460 through 1N4496	/406	6.2-200	1.2-40	1.5	A1
	1N4370A through 1N4372A	/127	2.4-3.0	20	400 mW	D07

SUMMARY OF MIL-STD-975 DIODES (contd)

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C			Package
			V_Z (Vdc)	I_{ZT} (mA)	P_D (W)	
Zener Diodes						
Power	1N2970B through 1N3015B	/124	6.8-200	12-370	10	DO4
	1N4954 through 1N4996	/356	6.8-390	3-175	5	A248
Temperature Compensated	1N823 1N827 1N829	/159	6.2	7.5	250 mW	DO7
	1N937B through 1N940B	/156	9.0	7.5	500 mW	DO7
	1N4570A through 1N4574A	/452	6.4	1.0	400 mW	DO7

SUMMARY OF MIL-STD-975 DIODES (contd)

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C			Package
Zener			V_Z (Vdc)	I_{ZT} (mA)	P_D (W)	
Voltage Suppressors	1N5629A through 1N5665A 1N5907	/500	6.0-210	1-10	1.0	DO13
Voltage Suppressors (Bi-Polar)	1N6102,A through 1N6173,A	/516	6.12-210	5-175	2.0-3.0	A298
Zener			V_T (Vdc)	I_P max (mA)	P_D (mW)	
Current Regulators	1N5285 through 1N5314	/463	25	0.242-5.17	600	DO7

SUMMARY OF MIL-STD-975 DIODES (contd)

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C				Package
Diode Arrays			I_o (mA)	P_{IV} (Vdc)	I_R at V_R (max)		
	1N5768	/474	300	60	100 nA		TO85
	1N5770						TO85
	1N5772						TO85
	1N5774						TO86
Thyristors			V_{RM} (Vdc)	I_H (mA)	V_{GT} (Vdc)	I_{GT} max (µ Adc)	
	2N2323A	/276	50	2.0	0.35-0.60	20	TO5
	2N2324A		100				
	2N2326A		200				
	2N2328A		300				
Light Emitting Diodes			Color	I_{V1} (mcd)	V_F at I_F = 20 mA (Vdc)		
	TX1N5765	/467	Red	0.5-3.0	2.0		TO18
	TX1N6092	/519	Red				
	TX1N6093	/520	Yellow				
	TX1N6094	/521	Green				

SECTION 5: SUMMARY OF STANDARD FILTERS

Page	Control Specification	Description	Frequency Range (Hz)		Grade 1	Grade 2
			Min	Max		
5.2	MIL-F-18327	Band Pass	228	18.6 M	1/	

1/ These parts are to be used in Grade 2 applications only. Presently there are no Grade 1 parts available.

MIL-F-18327, FILTERS
High Pass, Low Pass, Band Pass, Band Suppression, and Dual Functioning

Part Number Example:

M18327	/XXX	-XXX
Military Specification Sheet	Military Slash Sheet	Dash Number

Part Number	Dash Number		Type Designation	Control Specification	Impedance (ohms)		Reference Frequency (Hz)	Insertion Loss (dB)	Frequency Range (Hz)	Discrimination (dB)		DC Operating Voltage (volts)
	Grade 1	Grade 2			Input	Output				Min	Max	
M18327/027-001	1/	001	FR6QX22YY2 (Band Pass)		2K	2K	18.6 M	3 max	18.45 M 18.578 M 18.622 M 18.655 M	60 60	 6 6 	zero
M18327/046-00X	1/	001	FR7RX22221 (Band Pass)	MIL-F-18327	10K	10K	400	8 max	228 300 370 430 500 700	40 15 15 40	 4 4 	zero
	1/	002			10K	10K	7,350	8 max	4,190 5,512 6,799 7,901 9,188 12,863	40 15 15 40	 4 4 	zero

1/ These parts are to be used in GRADE 2 applications only.

MIL-F-23419/8, STYLE FM08 FUSES

Instrument Type, (Subminiature - High Performance)

Part Number Example: **FM08- A XXXV XXXA**

- FM08- : STYLE
- A : CHARACTERISTIC, A = normal interrupt time
- XXXV : VOLTAGE RATING followed by letter V
- XXXA : CURRENT RATING followed by letter A

Part Number 4/ GRADE 2	Control Specification	Style	Current Rating (Amps)	Overload Interrupt Time -55°C to +125°C (sec) max. 200% 1/	Overload Interrupt Time -55°C to +125°C (sec) max. 300% 1/	Maximum Voltage Rating (Volts)	Cold Resistance Max 2/ (Ohms)	Voltage drop (volts) 3/ Min	Voltage drop (volts) 3/ Max
FM08-125V 1/8A	MIL-F-23419/8	FM08	1/8	5	0.1	125	2.31	.85	1.15
FM08-125V 1/4A			1/4				.781	.59	.80
FM08-125V 3/8A			3/8				.462	.572	.713
FM08-125V 1/2A			1/2				.308	.488	.660
FM08-125V 3/4A			3/4				.187	.145	.197
FM08-125V 1A			1				.138	.157	.213
FM08-125V 1-1/2A			1-1/2				.088	.153	.207
FM08-125V 2A			2				.0605	.144	.196
FM08-125V 2-1/2A			2-1/2				.0462	.125	.169
FM08-125V 3A			3				.0388	.139	.187
FM08-125V 4A			4				.0253	.110	.150
FM08-125V 5A			5				.0154	.087	.118
FM08-125V 7A			7				.0110	.087	.118
FM08-125V 10A			10				.0066	.073	.099
FM08-32V 15A			15	10.0	0.3	32	.0044	.065	.087

1/ Percentage of nominal current rating.
2/ Cold resistance is measured at 10% or less of rated current.
3/ Voltage drop is measured after the fuse has been subjected to rated current for not less than 5 minutes, no more than 10.
4/ These parts are to be used in GRADE 2 applications only.

SECTION 6: SUMMARY OF STANDARD INDUCTORS

Page	Control Specification	Description	Inductance Range (H)		Q Range		Grade 1 FRL	Grade 2 FRL
			Min	Max	Min	Max		
6.2	MIL-T-27	High Q	1.0 m	60	16	70	1/	
6.5	MIL-C-15305	Fixed, Molded, Radio Frequency	0.015	1.0 m	32	65	1/	
6.9	MIL-C-39010	Fixed, Molded, Radio Frequency	0.1µ	0.1	18	75	R	R

1/ No Grade 1 version of this part is yet available. Grade 2 parts can be used in Grade 1 applications when screened per MIL-STD-975, Appendix B.

SECTION 7: SUMMARY OF STANDARD MICROCIRCUITS

Page	Control Specification	Description	GRADE 1	GRADE 2
7.2		Microcircuit Information		
7.3		Digital, TTL		
7.4		Digital, Low Power TTL		
7.5-7.6		Digital, Schottky, Low Power TTL		
7.7	MIL-M-38510	Digital, CMOS	1/	QPL-38510
7.8		Digital, Memories		
7.9		Microprocessors		
7.10		Peripheral/Microprocessors		
7.11		Linear		

1/ When Grade 1 (Class S) parts are not QPL listed, Grade 2 (Class B) parts may be upgraded for use in Grade 1 applications in accordance with MIL-STD-975, Appendix B.

MICROCIRCUIT INFORMATION

MIL-M-38510 SPECIFICATION

MIL-M-38510 specification parts are the only microcircuits referenced in this standard. For Grade 1 parts only JAN S devices are listed. However, due to the limitation of available JANS parts an option of upgrading Grade 2 parts, (JAN B), so that they may be used in Grade 1 application is given in Appendix "B".

The part numbers listed in the tables are not complete. It is necessary to reference to the following coding system to develop the complete part number.

JANM38510	/YYY	YY	X	X	X
Military Designator	Detail Specification	Device Type	Device Class	Case Outline	Lead Finish

Detail Specification: Establishes the general requirements, quality and reliability requirements, detail requirements and specific characteristics of the microcircuits.

Device Type: Determines the specific circuit or device type. (See detail specification for list.)

Device Class: Three levels of microcircuit quality and reliability assurance are provided. Class "S" is for higher reliability applications, Class "B" is for general applications, and Class "C" commercial applications. 3/

CASE OUTLINE

A — Flat Pack, 1/4" x 1/4", 14 leads
B — Flat Pack, 1/4" x 3/16", 14 leads
C — Dual-In-Line Pack, 14 leads
D — Flat Pack, 1/4" x 3/8", 14 leads
E — Dual-In-Line Pack, 16 leads
F — Flat Pack, 1/4" x 3/8", 16 leads
G — TO-5 Can, 8 leads
H — Flat Pack, 1/4" x 1/4", 10 leads
I — TO-5 Can, 8 leads
J — Dual-In-Line Pack, 24 leads
K — Flat Pack, 3/8" x 1/2", 24 leads
Z — Flat Pack, 1/4" x 3/8", 24 leads
Q — Dual-In-Line Pack, 40 leads

2/

LEAD FINISH

A — Kovar or Alloy 42 with Hot Solder Dip
B — Kovar or Alloy 42 with Acid Tin Plate
C — Kovar or Alloy 42 with Gold Plate

IMPORTANT NOTICE

When systems are to be fabricated by welding, the recommended lead finishes are gold plate or acid tin plate. A hot solder dip lead finish can be welded, but only by using special equipment and welding techniques.

1/ The detail specification and QPL must be consulted to determine the availability of various packages (case outline) and lead finishes. All variations are not available on all part types.

2/ Case outlines listed are not all-inclusive. Check QPL for case outlines available.

3/ Class "C" shall not be used in NASA applications.

MIL-M-38510, MICROCIRCUITS
MICROPROCESSORS

Commerical Part No. 1/	BIT Size	Fixed Instruction	Technology	Case Size	Clock Frequency (Max)	JAN Part Number 2/ 3/		
						M38510/	GRADE 1	GRADE 2
2901A	4	No	Schottky	40-Pin Dip	10 MHz	44001	2/	BQX
1802	8	Yes	CMOS	40-Pin Dip	3.8 MHz	47001	4/ SQX 2/	BQX 4/
8080A	8	Yes	NMOS	40-Pin Dip	800 KHz	42001	2/	BQX

Notes:

1/ Use the JANM38510 part number for ordering.
2/ When GRADE 1 (Class S) parts are not QPL listed, GRADE 2 (Class B) parts may be upgraded for use in GRADE 1 applications in accordance with Appendix B.
3/ The "X" is for choice of lead finish. Refer to QPL-38510 specific choices available.
4/ Until a MIL-M-38510 QPL part is established, this part shall be procured and upgraded to the applicable grade requirements of MSFC-SPEC-662.

MIL-M-38510, MICROCIRCUITS
PERIPHERAL/MICROPROCESSORS

COMMERCIAL PART NO. 1/	BIT SIZE	SYSTEM FAMILY	DEVICE DESCRIPTION	JAN Part Number 2/3/		
				M38510/	GRADE 1	GRADE 2
1852	8	1800	INPUT-OUTPUT PORT	47301	SJX 2/4/	BJX 4/
1853	N-1/8	1800	DECODER	47401	SEX 2/4/	BEX 4/
1856	4	1800	BUFFER/SEPARATOR	47601	SEX 2/4/	BEX 4/
1857	4	1800	BUS BUFFER/SEPARATOR	47602	SEX 2/4/	BEX 4/
2906	4	2901	BUS TRANSCEIVERS	44102	2/	B*X
2916	4	2901	BUS TRANSCEIVERS	44105	2/	B*X
2918	4	2901	QUAD "D" REGISTERS	44201	2/	B*X
8212	8	8080	INPUT/OUTPUT	42101	2/	B*X

1/ Use the JANM38510 Part Number for ordering.

2/ When GRADE 1 (Class S) parts are not QPL listed, GRADE 2 (Class B) parts may be upgraded for use in GRADE 1 applications in accordance with Appendix B.

3/ The "*" is for choice of package style. The "X" is for choice of lead finish. Refer to QPL-38510 for specific choices available.

4/ Until a MIL-M-38510 QPL part is established, this part shall be procured and upgraded to the applicable grade requirements of MSFC-SPEC-662.

SECTION 14: SUMMARY OF STANDARD RELAYS

Page	Control Specification	Description	GRADE 1 FRL	GRADE 2 FRL
14.2	MIL-R-39016	Non-Latching	1/	P
14.2		Latching		

1/ Presently there are no GRADE 1 parts available.

MIL-R-39016, RELAYS
Electromagnetic, Non-Latching

Part Number Example:

M39016	/XX	-XXX	-XX
MIL DOCUMENT NUMBER	SPECIFICATION SHEET NO.	DASH NUMBER	FAILURE RATE LEVEL

Part Number GRADE 2	Control Specification	Contract Rating 1/ (Amps)	Coil		Contract Configuration	Pkg.	Dash No. Solderable leads only		Failure Rate Level	
			Voltage (nominal) (volts)	Resistance (ohms ±10%)			Wire leads	Printed Wire (PW) leads	GRADE 1	GRADE 2
M39016/9-XXX-X	MIL-R-39016	1 1	26.5 5.0	1560 50	DPDT	T05 2/	042 037	048 043	3/	P
M39016/11-XXX-X		1 1	26.5 5.0	3300 100		T05	023 017	024 018		
M39016/15-XXX-X		1 1	26.5 4/ 5.0	1560 50		T05 2/	045 046	051 052		
M39016/20-XXX-X		1 1	26.5 4/ 5.0	1560 39		T05 2/	024 019	048 043		

Electromagnetic, Latching

M39016/12-XXX-X	MIL-R-39016	1 1	26.5 5.0	2000 61	DPDT	T05 2/	031 036	043 048	3/	P

1/ Contact Rating at 28 V dc, Resistive.
2/ See Figure 2 (Dimensions and Configuration) of applicable slash sheet.
3/ Presently there are no GRADE 1 parts available. See Appendix B for upgrading.
4/ Internal diode for coil transient suppression and polarity reversal protection.

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SECTION 9: SUMMARY OF STANDARD RESISTORS

Page	Control Specification	Style	Description	Resistance Range (ohms)		Power Range (W)		GRADE 1 1/ FRL	GRADE 2 FRL
				Min	Max	Min	Max		
9.2	MIL-R-39005	RBR	Fixed, Wirewound (Accurate), ER	10	1.37 M	0.5	0.75	S, R	P
9.4	MIL-R-39007	RWR	Fixed, Wirewound (Power Type), ER	0.1	39.2 K	1	10	S	R
9.6	MIL-R-39008	RCR	Fixed, Composition (Insulated), ER	1.0	22 M	0.125	2	S	P
9.8	MIL-R-39009	RER	Fixed, Wirewound (Power Type, Chassis Mounted), ER	0.1	39.2 K	5	30	S, R	P
9.10	MIL-R-39017	RLR	Fixed, Film (Insulated), ER	4.3	3.01 M	0.125	1.0	S, R	P
9.12	MIL-R-39015	RTR	Variable, Wirewound (Lead Screw Actuated), ER	10	20 K	0.75		S, R	P
9.14	MIL-R-39035	RJR	Variable, Non-Wirewound (Adjustment Type), ER	10	1.0 M	0.25	0.5	2/	P
9.16	MIL-R-55182	RNC	Fixed, Film, ER	10	1.5 M	0.05	0.5	S, R	P
9.18	MIL-R-83401	RZO	Fixed, Film, Networks	10	1 M	0.025	0.2	2/	3/

1/ When no source is listed on QPL to level S, alternate FRL "R" shall be used.
2/ Presently there are no Grade 1 parts available.
3/ Parts may be used in Grade 2 applications only.

MIL-R-39005, RESISTORS
Fixed Wirewound (Accurate) Established Reliabilty

Part Number Example: RBR XX X XXXX X X X

- RBR = MIL-R-39005; XX = SIZE (together: STYLE)
- X = TERMINAL CHARACTERISTIC: L-SOLDERABLE, U-WELDABLE
- XXXX = SIGNIFICANT FIGURES; X = NUMBER OF ZEROS (together: RESISTANCE 1/)
- X = RESISTANCE TOLERANCE (±%): T = .01, Q = .02, A = .05, B = .10, F = 1.0
- X = FAILURE RATE: P = 0.1%/1000 hr., R = 0.01%/1000 hr., S = 0.001%/1000 hr.

Part Number	Control Specification	Style Size 2/	Characteristics: Rated Power (Watts) 3/	Range (ohms) 4/ Min	Range (ohms) 4/ Max 5/	Tolerance (±%) 6/	Max Volts	Failure Rate Level: GRADE 1 7/	GRADE 2	Substitute GRADE 1
RBR52XXXXXXXTX	MIL-R-39005/1	RBR52	1/2	10	806 K	T = 0.01	$E = \sqrt{PR}$	S	P	R
RBR54XXXXXXXTX	MIL-R-39005/3	RBR54	1/4	10	255 K	T = 0.01	$E = \sqrt{PR}$	S	P	R
RBR56XXXXXXXTX	MIL-R-39005/5	RBR56	1/8	10	100 K	T = 0.01	$E = \sqrt{PR}$	S	P	R
RBR57XXXXXXXTX	MIL-R-39005/7	RBR57	3/4	10	1.370 M	T = 0.01	$E = \sqrt{PR}$	S	P	R

1/ For R≥ 1000Ω, expressed by five digits, the first four are significant and the fifth is the number of zeros. For < 1000Ω, the letter "R" replaces one of the digits and is used as a decimal point and all digits are significant.
2/ These resistors are encased in non-metallic materials. The possibility of outgassing at low pressures must be considered in their application.
3/ Maximum operating temperature, at full rated power, shall not exceed 125°C.
4/ Resistance range applicable for tolerance T.
5/ Maximum values are for element wire diameter of 0.001 inch minimum, as permitted by MIL-R-39005.
6/ A resistance tolerance of ±.01% (T) is recommended. The resistance values may be at any value within the limits of the specification, but it is preferred that the values be chosen from the 192-series decode specified on pg. 9.3.
7/ When no source is listed on QPL to level S, alternate FRL "R" shall be used.

MIL-R-39007, RESISTORS

Fixed, Wirewound, (Power Type), Established Reliabilty

Part Number Example: RWR XX X XXX X X X

RWR	XX	X	XXX	X	X	X
MIL-R-39007 STYLE	SIZE	TERMINAL CHARACTERISTIC W = WELDABLE, INDUCTIVELY WOUND S = SOLDERABLE, INDUCTIVELY WOUND N = SOLDERABLE, NON-INDUCTIVE	SIGNIFICANT FIGURES	NUMBER OF ZEROS	RESISTANCE TOLERANCE B = ±0.1% D = ±0.5% F = ±1.0% 2/	FAILURE RATE R = 0.01%/1000 hr. S = 0.001%/1000 hr.
			RESISTANCE 1/			

Part Number	Control Specification	Style Size 3/ 4/	Characteristics					Failure Rate Level	
			Rated Power (Watts) 5/	Range (ohms) 7/ Min	Max 6/	Tolerance (±%)	Max Volts	GRADE 1	GRADE 2
RWR74XXXXXFX	MIL-R-39007/6	RWR74	5	.1	12.1 K	F = 1.0	$E = \sqrt{PR}$	S	R
RWR78XXXXXFX	MIL-R-39007/7	RWR78	10	.1	39.2 K	F = 1.0	$E = \sqrt{PR}$	S	R
RWR80XXXXXFX	MIL-R-39007/8	RWR80	2	.1	1.21 K	F = 1.0	$E = \sqrt{PR}$	S	R
RWR81XXXXXFX	MIL-R-39007/9	RWR81	1	.1	.464 K	F = 1.0	$E = \sqrt{PR}$	S	R
RWR84XXXXXFX	MIL-R-39007/10	RWR84	7	.1	12.4 K	F = 1.0	$E = \sqrt{PR}$	S	R
RWR89XXXXXFX	MIL-R-39007/11	RWR89	3	.1	3.57 K	F = 1.0	$E = \sqrt{PR}$	S	R

1/ For R ≥ 100Ω, the first three digits, out of four, are significant and the fourth is the number of zeros. For R <100Ω, the letter "R" replaces one of the digits and is used as a decimal point. All digits are significant.
2/ A resistance tolerance of 1.0% (F) is recommended.
3/ These resistors are encased in non-metallic materials. The possibility of outgassing at low pressures must be considered in their application.
4/ Certain coating materials used in fabricating resistors to this specificaiton may be subjected to "outgassing" of volatile material when operated at surface temperatures over 200°C. This phenomena should be taken into consideration for equipment design.
5/ Maximum operating temperature, at full rated power, shall not exceed 25°C. Maximum no load temperature is at 275°C.
6/ Maximum values are for element wire diameter of 0.001 inches minimum (0.0009 absolute minimum diameter) as permitted by MIL-R-39007.
Application note: Resistors should not be used in circuits involved in high frequency applications (above 20 kHz) where ac performance is of critical importance to the proper application of the circuit.
7/ For terminal "N" min value = 10Ω; max value = 1/2 max for terminal S and W.

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MIL-R-39008, RESISTORS
Fixed, Composition (Insulated), Established Reliabilty

Part Number Example:

RCR XX G XX X X X

- RCR — MIL-R-39008
- XX — SIZE
- (MIL-R-39008 + SIZE = STYLE)
- G — CHARACTERISTIC 1/
- XX — SIGNIFICANT FIGURES
- X — NUMBER OF ZEROS
- (SIGNIFICANT FIGURES + NUMBER OF ZEROS = RESISTANCE 2/)
- X — RESISTANCE TOLERANCE: J = ±5%, K = ±10%
- X — FAILURE RATE: P = 0.1%/1000 hr., S = 0.001%/1000 hr.

Part Number	Control Specification	Style Size 3/	Characteristics					Failure Rate Level	
			Rated Power (Watts) 4/	Range (ohms)		Tolerance (±%) 5/	Max Volts	GRADE 1	GRADE 2
				Min	Max				
RCR05GXXXJX	MIL-R-39008/4	RCR05	1/8	2.7	22.0 M	5, 10	150	S	P
RCR07GXXXJX	MIL-R-39008/1	RCR07	1/4	2.7	22.0 M	5, 10	250	S	P
RCR20GXXXJX	MIL-R-39008/2	RCR20	1/2	1.0	22.0 M	5, 10	350	S	P
RCR32GXXXJX	MIL-R-39008/3	RCR32	1.0	2.7	22.0 M	5, 10	500	S	P
RCR42GXXXJX	MIL-R-39008/5	RCR42	2.0	10.0	22.0 M	5, 10	500	S	P

1/ Characteristic G only available, 100% rated wattage at 70°C ambient. Derate linearly to zero watts at +130°C.
2/ For $R < 10\Omega$, all digits are significant and the letter "R" is substituted for one of the digits indicating a decimal point.
3/ These resistors are encased in a phenolic sleeve and are extremely sensitive to moisture. It is recommended that these resistors be baked for a period of 48 hours at 100°C (with no power applied) prior to usage and after a storage period in the order of six months.
4/ Maximum operating temperature, at full rated power, shall not exceed 70°C.
5/ A resistance tolerance of ±5% (J) is recommended.

MIL-R-39009, RESISTORS

Fixed, Wirewound, (Power Type, Chassis Mounted), Established Reliabilty

Part Number Example: RER XX F XXX X X

- RER XX — MIL-R-39009 SIZE — STYLE
- F — RESISTANCE TOLERANCE F =±1.0% 1/
- XXX X — SIGNIFICANT FIGURES, NUMBER OF ZEROS — RESISTANCE 2/
- X — FAILURE RATE
  - P = 0.1%/1000 hr.
  - R = 0.01%/1000 hr.
  - S = 0.001%/1000 hr.

Part Number	Control Specification	Style Size	Characteristics: Rated Power (Watts) 3/4/	Characteristics: Range (ohms) Min	Characteristics: Range (ohms) Max 5/	Characteristics: Tolerance (±%) 1/	Characteristics: Max Volts	Failure Rate Level: GRADE 1 6/	Failure Rate Level: GRADE 2	Failure Rate Level: Substitute GRADE 1
RER60FXXXXX	MIL-R-39009/1	RER 60	5.0	0.10	3.32 K	F = 1.0	$E = \sqrt{PR}$	S	P	R
RER65FXXXXX		RER 65	10.0	0.10	5.62 K	F = 1.0	$E = \sqrt{PR}$	S	P	R
RER70FXXXXX		RER 70	20.0	0.10	12.1 K	F = 1.0	$E = \sqrt{PR}$	S	P	R
RER75FXXXXX		RER 75	30.0	0.10	39.2 K	F = 1.0	$E = \sqrt{PR}$	S	P	R
RER40FXXXXX	MIL-R-39009/2	RER 40	5.0	1.0	1.65 K	F = 1.0	$E = \sqrt{PR}$	S	P	R
RER45FXXXXX		RER 45	10.0	1.0	2.80 K					
RER50FXXXXX		RER 50	20.0	1.0	6.04 K					
RER55FXXXXX		RER 55	30.0	1.0	19.60 K					

1/ Resistance tolerance of ±1.0%(F) is the only available.
2/ For R ≥ 100Ω, the first three digits are significant and the fourth signifies the number of zeros. For R < 100Ω, all digits are significant, the letter "R" is substituted for one of the digits indicating a decimal point.
3/ These aluminum housed chassis mounted styles are assigned power ratings when mounted on test chassis areas of a specific size at an ambient temperature of 25°C.
4/ Maximum operating temperature, at full rated power, shall not exceed 25°C.
5/ Maximum values are for element wire diameter of 0.001 inch minimum as permitted by MIL-R-30009.
6/ When no source is listed on QPL to level S, alternate FRL "R" shall be used.

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MIL-R-39017, RESISTORS
Fixed, Film, (Insulated), Established Reliabilty

Part Number Example: RLR XX C XXX X X X

- RLR — MIL-R-39017; XX — SIZE; together: STYLE
- C — CHARACTERISTIC 1/
- XXX — SIGNIFICANT FIGURES; X — NUMBER OF ZEROS; together: RESISTANCE 2/
- X — RESISTANCE TOLERANCE: F = ±1.0%, G = ±2.0%
- X — FAILURE RATE: P = 0.1%/1000 hr., R = 0.01%/1000 hr., S = 0.001%/1000 hr.

Part Number	Control Specification	Style Size 3/	Characteristics: Rated Power (Watts) 4/	Range (ohms) Min	Range (ohms) Max	Tolerance (±%) 5/	Max Volts	Failure Rate Level: GRADE 1 6/	GRADE 2	Substitute GRADE 1
RLR05CXXXXFX	MIL-R-39017/5	RLR05	1/8	4.7	.300 M	1.0, 2.0	200	S	P	R
RLR07CXXXXFX	MIL-R-39017/1	RLR07	1/4	10.0	2.49 M	1.0, 2.0	250	S	P	R
RLR20CXXXXFX	MIL-R-39017/2	RLR20	1/2	4.3	3.01 M	1.0, 2.0	350	S	P	R
RLR32CXXXXFX	MIL-R-39017/3	RLR32	1	10.0	1.0M	1.0, 2.0	500	S	P	R

1/ Characteristic C, solderable/weldable terminal, is the only available.
2/ For R ≥ 100Ω, the first three digits are significant and the fourth is the number of zeros. For R < 100Ω, the letter "R" replaces one of the digits and represents a decimal point. All digits are significant.
3/ These resistors are encased in non-metallic materials; sensitivity to moisture and possible outgassing at low pressure must be considered in their application.
4/ Maximum operating temperature, at full rated power, shall not exceed 70°C.
5/ A resistance tolerance of ±1.0%(F) is recommended.
6/ When no source is listed on QPL to level S, alternate FRL "R" shall be used.

MIL-R-39015, RESISTORS

Variable, Wirewound (Lead Screw Actuated), Established Reliability

Part Number Example: M39015 /X XXX X X

- M39015 — DOCUMENT NUMBER
- /X — SPECIFICATION SHEET NUMBER
- XXX — DASH NUMBER
- X — TERMINAL TYPE 1/
- X — FAILURE RATE
  - M = 1.0%/1000 hrs.
  - P = 0.1%/1000 hrs
  - R = 0.01%/1000 hrs.
  - S = 0.001%/1000 hrs.

Part Number	Control Specification	Style Size	Rated Power 2/ (Watts)	Tolerance (±%)	Characteristics: Resistance Range (ohms) Min	Resistance Range (ohms) Max	Resolution Range (%) Min	Resolution Range (%) Max	Voltage Range 3/ (Volts) Min	Voltage Range 3/ (Volts) Max	Failure Rate Level: GRADE1 4/	GRADE2	Substitute GRADE 1
M39015/2-XXXXX	MIL-R-39015/3	RTR22	0.75	5.0	10	20 K	0.11	1.3	2.7	122.0	S	P	-
M39015/3-XXXXX	MIL-R-39015/2	RTR24			10	10 K	0.19	1.3	2.7	86.7	S	P	R

1/ Terminal types available:
- L - Flex insulated wire leads
- P - Printed circuit pin (base mount)
- W - Printed circuit pin (edge mount)
- X - Printed circuit pin (edge mount - alternate configuration)

2/ The power rating given is for the whole element and is directly proportional to the length of the element actually active in the circuit. If 50% of the element is in the circuit after adjustment, the power must be derated to 50% in order to limit the dissipation to a safe value. Maximum operating temperature, at full rated power, shall not exceed 85°C.

3/ The actual voltage which may be impressed across these resistors is determined by

$$E = \sqrt{PR}$$

Where: E = Maximum applied voltage (dc or rms) (in volts)
P = Derated power (in watts)
R = The resistance of that portion of he element actually active in the circuit.

Under no conditions shall the applied voltage exceed the values specified.

4/ When no source is listed on QPL to level S, substitute FRL "R" shall be used.

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MIL-R-39035, RESISTORS

Variable, Non-Wirewound (Adjustment Type), Established Reliability

Part Number Example: RJR XX X X XXX X

- RJR XX: MIL-R-39035, SIZE — STYLE
- X: RESISTANCE TEMPERATURE CHARACTERISTICS:
  C = ±0.025%/°C, ±250 PPM
  F = ±0.01%/°C, ±100 PPM
- X: TERMINAL CONFIGURATION 1/
- XXX: RESISTANCE: Expressed by two significant digits and a third for the number of zeros
- X: FAILURE RATE
  P = 0.1%/1000 hr.
  R = 0.01%/1000 hr.
  S = 0.001%/1000 hr.

Part Number	Control Specification	Style Size	Characteristics: Rated Power 2/ (watts)	Tolerance (±%)	Res. Temp. Char.	Resistance Range (ohms) Min	Resistance Range (ohms) Max	Voltage Range (volts) Min	Voltage Range (volts) Max	Failure Rate Level: GRADE 1 4/	GRADE 2	Substitute Grade 1
RJR24X X XXX X	M39035/2	RJR24	0.50	10	C, F	10	1.0M	2.23	300	S	P	R
RJR26X X XXX X	M39035/3	RJR26	0.25		F	10	1.0M	1.58	200	S	P	R

1/ P = Printed circuit pins.
W = Printed circuit pins, (edge mounted).
X = Printed circuit pins, (edge mounted, alternate configuration).

2/ Power ratings are applicable only when the maximum resistance is engaged in the circuit. The power rating is reduced in the same proportion as the resistance. Maximum operating temperature, at full-rated power, shall not exceed 85°C.

3/ The actual voltage which may be impressed across these resistors is determined by

$$E = \sqrt{PR}$$

Where

E = Maximum applied voltage (dc or rms) (in volts).
P = Derated power (watts).
R = The resistance of that portion of the element actually active in the circuit. Under no conditions shall the applied voltage exceed the values specified on page 9.15.

4/ When no source is listed on QPL to level S, alternate FRL "R" shall be used.

MIL-R-55182, RESISTORS
Fixed, Film, Established Reliability

Part Number Example: RNC XX X XXX(XX) X X X

RNC	XX	X	XXX(XX)	X	X	X
MIL-R-55182 STYLE	SIZE	CHARACTERISTIC E = HERMETIC ±25 PPM/°C H = NONHERMETIC ±50 PPM/°C Y = NONHERMETIC ±5 PPM/°C up to +125°C, ±10 PPM/°C, +125°C to +175°C	SIGNIFICANT FIGURES RESISTANCE 1/	NUMBER OF ZEROS	RESISTANCE TOLERANCE T = ±0.01% B = ±0.1% F = ±1.0%	FAILURE RATE P = 0.1%/1000 hr. R = 0.01%/1000 hr. S = 0.001%/1000 hr.

Part Number	Control Specification	Style 5/ Size	Rated Power (Watts) 2/	Characteristics: Range (ohms) Min	Range (ohms) Max	Tolerance (±%) 3/	Max Volts	Failure Rate Level: GRADE 1	GRADE 2	Substitute GRADE 1
RNC50HXXXXFX	MIL-R-55182/7	RNC50H	1/20	10.0	796 K	0.1, 1.0	200	S	P	-
RNC55EXXXXFX	MIL-R-55182/1	RNC55E	1/10	24.9	200.0 K	0.1, 1.0	200	S	P	-
RNC60EXXXXFX	MIL-R-55182/3	RNC60E	1/8	24.9	499.0 K	0.1, 1.0	250	S	P	-
RNC65EXXXXFX	MIL-R-55182/5	RNC65E	1/4	10.0	1.0 M	0.1, 1.0	300	S	P	-
RNC70EXXXXFX	MIL-R-55182/6	RNC70E	1/2	24.9	1.5 M	0.1, 1.0	350	S	P	-
RNC90YXXXXXX 6/	MIL-R-55182/9	RNC90Y	1/3	36.5	0.1 M	0.01, 0.1	300	S 4/	P	R

1/ All styles except RNC90, expressed by four digits; for R ≥ 100Ω, the first three digits are significant and the fourth is the number of zeros. For R < 100Ω, the letter "R" replaces one of the digits and represents a decimal point. Style RNC90, expressed as five significant digits and a letter. For < 1000Ω, the letter "R" is used as a decimal point. For values > 1000Ω but < 1.0 MΩ the letter "K" is used to represent a decimal point and multiplier. All digits preceding and following the letter (R, or K) of the group, represent significant figures.
2/ Maximum operating temperature, at full rated power, shall not exceed +125°C.
3/ A resistance tolerance of ±1.0%(F) is recommended. For tolerances T and B, resistance values within the limits of the specification may be ordered. .01% tolerance only available in RNC 90 style.
4/ When no source is listed on QPL to level S, substitute FRL "R" shall be used. When FRL "R" is not listed on QPL, consult the project parts engineer for recommendations.
5/ Hollow core devices shall not be used.
6/ Use only "S555" type.

MIL-R-83401, RESISTORS

Networks, Fixed, Film

Part Number Example: M83401 /XX X XXXX X X

- M83401 — DETAIL SPEC. NUMBER
- /XX — SPECIFICATION SHEET NO.
- X — CHARACTERISTIC: K = ±100 PPM/°C; M = ±300 PPM/°C (non-hermetic)
- XXXX — RESISTANCE 2/
- X — TOLERANCE: F = ±1.0%; G = ±2.0%; J = ±5.0%
- X — SCHEMATIC: A, B, C, G 4/

Part Number 1/	Control Specification	Style GRADE 1	Style GRADE 2	Pins/ Package	4/ Schematic	Power Rating Element (Watts)	Power Rating Network (Watts)	Resistance Range (ohms) Min	Resistance Range (ohms) Max	Tolerance (±%)	Maximum Working Voltage/element (volts) 3/
M83401/01-X XXXX X X	MIL-R-83401/1	1/	RZ010	14/DIP	A B	0.2 0.1	1.4 1.3	10	1.0M	1, 2, 5	100
M83401/02-X XXXX X X	MIL-R-83401/2	1/	RZ020	16/DIP	A B	0.2 0.1	1.6 1.5	10	1.0M	2, 5	100
M83401/03-X XXXX X X	MIL-R-83401/3	1/	RZ030	14/FP	A B	0.05 0.025	0.35 0.325	10	1.0M	1, 2, 5	50
M83401/04-X XXXX X X	MIL-R-83401/4	1/	RZ040	6/SIP	C G	0.2 0.2	1.0 0.6	10	1.0M	1, 2, 5	50
M83401/05-X XXXX X X	MIL-R-83401/5	1/	RZ050	8/SIP	C G	0.2 0.2	1.4 0.8	10	1.0M	1, 2, 5	50

1/ Presently there are no GRADE 1 parts available.
2/ For R≥ 100Ω, the first three digits, of four, are significant and the fourth signifies the number of zeros. For R <100Ω, all digits are significant, the letter "R" is substituted for one of the digits indicating a decimal point.
3/ The actual voltage which may be impressed across each resistor element is determined by

$$E = \sqrt{PR}$$

where: E = Maximum applied voltage (dc or rms) (in volts).
P = Derated power (watts).
R = The resistance of that portion of the element actually active in the circuit.
Under no conditions shall the applied voltages exceed the values specified.
4/ See Control Specification for applicable schematic diagram.

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SECTION 10: SUMMARY OF STANDARD THERMISTORS

Page	Control Specification	Description	Resistance Range (ohms) Min	Max	GRADE 1	GRADE 2
10.2	MIL-T-23648/19	Positive Temperature Coefficient	10	10K	1/	
10.4	GSFC S-311-P-18	Negative Temperature Coefficient	2252	30 K	2/	

1/ Presently there are no GRADE 1 parts available. Parts may be used in GRADE 2 applications only.

2/ Parts may be used in GRADE 1 and GRADE 2 applications.

MIL-T-23648, THERMISTORS, INSULATED

Part Number Example: RTHXX (STYLE) X (RESISTANCE RATIO) S (LEAD TYPE S = SOLDERABLE (S only)) XXX (ZERO POWER RESISTANCE 2/) X (RESISTANCE TOLERANCE J = ±5% K = ±10%)

Part Number		Control Specification	Style	Temp. Coefficient	Seal	Resistance Ratio 3/	Resistance Values (ohms)		Thermal Time Constant (sec) max.	Dissipation Constant Min. (mw/°C)	Power Rating @ 25°C (Watts)
GRADE 1	GRADE 2						Min	Max			
1/	RTH42ES XXXX	MIL-T-23648/19	RTH42	Positive	Hermetic	E = 0.55	10	10K	60	2.5	0.25

1/ Presently there are no GRADE 1 parts available. Consult procuring activity for direction.
2/ Expressed in ohms and identified by a three-digit number. The first two digits represent significant figures, and the last digit specifies the number of zeros to follow.
3/ Resistance ratio is specified from +25°C to +125°C.

GSFC S-311-P-18, THERMISTORS

Part Number Example:

311P18- / XX / X / XXX

- 311P18-: GSFC Control Specification
- XX: Dash Number
- X: Lead Style:
  - S = 32 AWG, Type C per MIL-STD-1276
  - T = 28 AWG, Type ET per MIL-W-16876
  - N = 32 AWG, Type N-2 per MIL-STD-1276
  - E = Insulated lead (TFE), 32 AWG per MIL-I-22129; Bare lead, Style S; Tubing (FEP), M23053/11-105c.
- XXX: Lead Length: (cm) 1R0 = 1.0, 10R = 10,101 = 100. Minimum length is 7.6 cm.

Part Number 1/ GRADE 1	GRADE 2	Control Specification	Temp. Coefficient	Seal	Resistance Ratio 2/ 70°C	90°C	Resistance (ohms)	25°C Tolerance (±%)	Thermal Time Constant (sec.) max.	Dissipation Constant Min. (mw/°C)
311P18-01 XXXX		GSFC S-311-P-18	Negative	Non Hermetic	5.71	10.93	2252	1	10.0 3/	1.0
311P18-02 XXXX							2252	0.5		
311P18-03 XXXX					5.71	10.91	3000	1		
311P18-04 XXXX							3000	0.5		
311P18-05 XXXX					5.71	10.91	5000	1		
311P18-06 XXXX							5000	0.5		
311P18-07 XXXX					5.03	9.23	10000	1		
311P18-08 XXXX							10000	0.5		
311P18-09 XXXX					5.60	10.72	30000	1		
311P18-10 XXXX							30000	0.5		

1/ These parts have been successfully tested and used in space applications but not formally qualified. No published QPL exists, therefore, see the control specification for recommended suppliers.
2/ Resistance Ratio is specified from +25°C to +70°C or +90°C.
3/ For a thermistor suspended in still air.

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SUMMARY OF MIL-STD-975 TRANSISTORS

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C					Package
			V_{CEO} Max (Vdc)	h_{FE} Min (@I_C mA)	V_{CE} SAT Max Vdc (@I_C mA)	I_C Max (mA)	P_D 25°C (mW)	
Low Power NPN								
	2N2219A	/251	50	100-300 (150)	1.0 (500)	800	800	TO-39
	2N2222A	/255	50	100-300 (150)	1.0 (500)	800	500	TO-18
	2N2369A	/317	15	40-120 (10)	0.2 (10)	200	360	TO-18
	2N2484	/376	60	200-500 (10)	0.3 (1)	50	360	TO-18
	2N3700	/391	80	100-300 (150)	0.2 (150)	1 A	500	TO-18
	2N918	/301	15	20-200 (3)	0.4 (10)	50	300	TO-72
Low Power PNP								
	2N2905A	/290	60	100-300 (150)	0.4 (150)	600	600	TO-39
	2N2907A	/291	60	100-300 (150)	0.4 (150)	600	400	TO-18
	2N2605	/354	60	100-300 (10 µA)	0.5 (10)	30	400	TO-46
	2N5416	/485	300	30-120 (50)	2.0 (50)	1 A	750	TO-5
	2N4957	/426	30	30-150 (5)	—	30	200	TO-72

SUMMARY OF MIL-STD-975 TRANSISTORS (contd)

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C					Package
			V_{CEO} Max (Vdc)	h_{FE} Min (@I_C mA)	V_{CE} SAT Max Vdc (@I_C A)	I_C Max (A)	P_D 25°C (W)	
High Power NPN								
	2N3749	/315	80	40-120 (1)	0.25 (1)	5	30*	MT-53
	2N4150	/394	80	40-120 (5)	0.60 (5)	10	1.5	TO-5
	2N5666	/455	200	40-120 (1)	0.40 (3)	5	1.2	TO-5
	2N5667	/455	300	25-75 (5)	0.40 (3)	5	1.2	TO-5
	2N5672	/488	120	20-100 (15)	0.75 (15)	30	8	TO-3
	2N6308	/498	350	12-60 (3)	5.0 (8)	8	62.5*	TO-3
	2N3996	/374	80	40-120 (1)	2.0 (5)	10	2	TO-111
High Power PNP								
	2N3637	/357	175	100-300 (50 mA)	0.6 (50 mA)	1.0	1.0	TO-5
	2N4399	/433	60	15-60 (10)	1.0 (15)	30	115*	TO-3

*AT T_C = 100°C

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SUMMARY OF MIL-STD-975 TRANSISTORS (contd)

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C					Package
			V_{CEO} Max (Vdc)	h_{FE} Min (@I_C mA)	V_{CE} SAT Max Vdc (@I_C mA)	I_C Max (mA)	P_D 25°C (mW)	
Dual NPN								
	2N2060	/270	60	40-120 (1.0)	1.2 (50)	500	600	TO-78
	2N2920	/355	60	175-600 (10 µA)	0.3 (1.0)	30	500	TO-78
Dual PNP								
	2N3810	/336	60	150-450 (1.0)	0.25 (1.0)	50	600	TO-78
	2N3811	/336	60	300-900 (1.0)	0.25 (1.0)	50	600	TO-78
Chopper NPN								
	2N2432A	/313	45	80-400 (1.0)	—	100	300	TO-18
	2N2945A	/382	25	70 (1.0)	—	100	400	TO-46
			V_{B2E} Max (Vdc)	V_{B2B1} (Vdc)	n @V_{B2B1} (Ratio)	I_E (mA rms)	P_D 25°C (mW)	
Unijunction								
	2N4948	/388	30	3.0	0.55-0.82 (10 V)	50	360	TO-18

SUMMARY OF MIL-STD-975 TRANSISTORS (contd)

Description	Part Type	MIL-S-19500	Electrical Characteristics, T_A = 25°C					Package
			BV_{DGS} Min (Vdc)	G_M Min-Max (µs)	I_{GSS} Max (nA)	V_P Max (Vdc)	I_{DSS} Min-Max (mA)	
N-Chan J-FET								
	2N3823	/375	30	3500-6500	0.50	8	4-20	TO-72
	2N4856	/385	40	—	0.25	10	50	TO-18
P-Chan J-FET								
	2N5114	/476	30	—	0.50	10	30-90	TO-18
	2N3330	/378	20	1500-3000	10	6	2-6	TO-72
			V_{CEO} Max (Vdc)	I_F Max (mA)	I_C Max (mA)	$V_{CE}SAT$ (Vdc) (@I_C mA)	P_D 25°C (mW)	
Photo Coupler								
	4N23,A	/486	35	40	50	0.3 (5)	300	PH-13
	4N24,A	/486	35	40	50	0.3 (10)	300	PH-13

SECTION 11: SUMMARY OF STANDARD TRANSFORMERS

<table>
<tr><th>Page</th><th>Control Specification</th><th>Description</th><th>Grade 1</th><th>Grade 2</th></tr>
<tr><td>11.2</td><td>MIL-T-27</td><td>Audio Frequency</td><td colspan="2" rowspan="2">1/</td></tr>
<tr><td>11.7</td><td>MIL-T-21038</td><td>Pulse, Low Power</td></tr>
</table>

1 These transformers are suitable for Grade 2 applications only. See MIL-STD-975, Appendix B for upgrade guidelines to a Grade 1.

MIL-T-27 TRANSFORMERS

Audio Frequency

Part Number Example: M27 /XXX - XX

- M27 — MILITARY SPECIFICATION SHEET
- /XXX — MILITARY SLASH SHEET
- - XX — DASH NUMBER

Part Number	Control Specification	Type Designation GRADE 1	Type Designation GRADE 2	Primary Impedance Range (ohms) 2/ Min	Primary Impedance Range (ohms) 2/ Max	Secondary Impedance Range (ohms) 2/ Min	Secondary Impedance Range (ohms) 2/ Max	Power Level Range at 1 kHz (mW) Min	Power Level Range at 1 kHz (mW) Max	Resonance, Secondary Resonant Freqeuncy Range (kHz) Min	Resonance, Secondary Resonant Freqeuncy Range (kHz) Max
M27/103-XX	MIL-T-27	1/	TF5R21ZZ	80 CT	30K CT	32 Split	12K CT	50	500	500	1000
M27/165-XX	MIL-T-27	1/	TF5R21ZZ	50 CT	100K	32 Split	250K	10	250	20	
M27/166-XX	MIL-T-27	1/	TF4R21YY	50	20K CT	8	1M	3	250	3	20
M27/197-XX	MIL-T-27	1/	TF4R21YY	20 CT	30K Split	4	100K CT	4	10K	20	

1/ These transformers are suitable for Grade 2 applications only. See MIL-STD-975, Appendix B for upgrade guidelines for Grade 1 applications.
2/ Where windings are listed as Split, one-fourth of the listed impedance is available by paralleling the windings.

APPENDIX A

STANDARD PARTS DERATING GUIDELINES

1. STANDARD PARTS DERATING GUIDELINES

1.1 Guidelines for the derating of Standard Parts listed in this standard.

1.2 Introduction. Derating is the reduction of electrical, thermal, and mechanical stresses to a part to decrease the degradation rate and prolong the expected life of the part. By derating, the margin of safety between the operating stress level and the actual failure level for the part is increased, providing added protection from system anomalies unforeseen by the designer. The following guidelines give basic information for the derating of Standard Parts. The specified derating percentages and notes will assist the designer in obtaining reliable operation of parts used in space equipment. It must be emphasized that the user should evaluate all parts to the project requirements and assure that adequate deratings are accomplished. These recommended derating factors are based on the best information currently available.

1.3 Derating Factors. The derating factors contained herein, when multiplied by the maximum rating, indicate the maximum recommended stress values and do not preclude further derating. When derating, the designer must first take into account the specification environmental and operating condition rating factors, consider the actual environmental and operating conditions of the application, then apply the recommended derating factor contained herein. Parts not appearing in these guidelines are lacking in empirical data and failure history. Since the operating characteristics for such parts cannot be guaranteed, it is a good policy to derate generously so as to provide an additional margin of safety. Where parts are listed, but are not given a specific derating value, a good practice should also be to derate generously.

1.4 Derating Guidelines Factors. The derating guidelines factors are listed for each commodity in the following paragraphs.

1.4.1 Capacitors. The derating guidelines factors for capacitors are tabulated below:

Type	Derating Factor	Parameter	Applicable Notes
Ceramic (CKR and CDR)	.60	voltage	1,2,5
Glass (CYR)	.50	voltage	1,2,5
Film (CRH)	.60	voltage	1,2,5
Tantalum			
Foil (CLR)	.50	voltage	1,2,4,5
Wetslug (CLR)	.60	voltage	1,2,5
Solid (CSR)			
>1 ohm/volt	.50	voltage	1,2,3,5
<1 ohm/volt, <20 volts	.40	voltage	1,2,3,5
<1 ohm/volt, >20 volts	.30	voltage	1,2,3,5

NOTES:

1/ The current derating factor should be 70 percent of specified maximum in-rush limit.

2/ The derating factors should be applied to the maximum rating of the applicable ER specification.

3/ Ambient temperature should not exceed 50°C.

4/ Ambient temperature should not exceed 70°C.

5/ The derated voltage applies to the sum of the peak ac voltage and the dc polarizing voltage.

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1.4.2 Microcircuits. The derating guidelines factors for microcircuits are tabulated below:

MICROCIRCUIT DERATING FACTORS

MICROCIRCUITS / Parameters	Diff'l. Ampl. (Oper'l)	Compara-tors	Sense Ampl.	Current Ampl.	Voltage Reg.	Analog Switches	Digital			
							TTL	LP TTL	NMOS CMOS	Line Drivers and Receivers
1. Supply voltages	0.80	0.90	0.80	0.80		0.90	[5]	[5]	0.70[4]	1.00[7]
2. Power dissipation (Percent of rated power at maximum operating temperature)	0.75	0.75	0.75	0.75	0.80	0.80	0.80[6]	0.80[6]	0.80	0.80
3. Ac input voltage (percent of rated ac voltage at actual supply voltage)	1.00	1.00	1.00	1.00						
4. Differential dc input voltage	0.30[3]	0.30[3]	0.70							1.00[7]
5. Single-ended dc input voltage				0.80	0.80		1.00	[7] [1] 1.00	0.50[4]	1.00[7]
6. Signal voltage referenced to negative supply voltage						0.80				
7. Input-output voltage differential					0.80					
8. Output ac voltage	1.00			1.00						
9. Open collector (or drain) dc output voltage		0.90	0.90				0.80	0.80		.75
10. Operating ac or dc output current	0.80	0.80	0.80	0.80	0.80[2]	0.80	0.80[4]	0.80[4]	0.80[4]	0.80
11. Maximum short-circuit output current sent by external means	0.90	0.90	0.90	0.90	0.90					

NOTES:
1. Transient input currents caused by the below-zero portion of ringing waveforms shall be limited to 2 mA. This condition may occur where LPTTL is driven by standard TTL.
2. 50% of rated current for two terminal regulators.
3. Should not exceed the BV_{EBO} of the transistors in the input circuit.
4. Further derating may be required for radiation environments (i.e., minimum Voc to insure minimum dc reference for transients).
5. Manufacturer's recommended operating voltages should be used.
6. Derating factor applicable to 85°C maximum, or Junction temperature less than 125°C.
7. Use 1.00 when used with digital logic families, and 0.75 when used with analog logic families.

1.4.3 Resistors. Derating guidelines factors for resistors are tabulated below:

Type	Derating Factor 6/	Parameter	Applicable Notes
Fixed			
Carbon Composition	.60	power	1,2
Film (High Stability and Metal)	.60	power	1,2
Wirewound power Chassis mount	.60	power	1,2
Wirewound, Precision			
1.0%	.60	power	1,2
0.1%	.25	power	1,2
0.01%	.25	power	1,2
Wirewound, Power	.60	power	1,2
Adjustable			
Wirewound	.70	rated current	1,2,4,5
Non-wirewound	.70	rated current	1,2,4,5
Networks	.60	power	1,2
Thermistors	.50	power	1,2,3

NOTES:

1/ The maximum voltage for all resistors should be no more than 80% of the MIL-ratings or 80% of $E = \sqrt{PR}$, whichever is less, where:

E = Max applied voltage (dc or rms) (in volts)
P = Derated power (in watts)
R = The resistance of that portion of the element actually active in the circuit

2/ High density packaging may require further derating if ambient temperatures are increased.

3/ Thermistors used in other than zero power applications should also have minimum wattage specified for the application.

4/ Rated current is defined as: $I_R = \sqrt{\frac{P_{max}}{R_{max}}}$ and by limiting the current to .70 rated current, power is limited to .5 maximum power.

5/ Adjustable resistors - The actual voltage which may be impressed across these resistors is determined by $E = \sqrt{PR}$.

6/ Under no conditions should the applied voltage exceed the values specified.

1.4.4 Semiconductors. The derating guidelines factors for semiconductors (diodes and transistors) are tabulated below:

Type	Derating Factors	Parameter	Applicable Notes
Diodes			
General Purpose	.50	PIV	1
Rectifiers, Switching	.50	Surge current	
SCR	.50	Forward current	
Varactor	.75	PIV	
	.75	Forward current	
Zener V. Reg. & V. Ref		Zener current	1,2
Transistors			
General Purpose Power and Switching	.50	Power	1,3
	.75	Current	
	.75	Voltage	

NOTES:

1/ Junction temperature should not exceed +125°C.

2/ Zener current should be limited to no more than $I_Z = I_Z$ nom. $+ .5\,(I_Z \text{ max} - I_Z \text{ nom})$

3/ Worst-case combination at dc, ac, and transient voltages should be no greater than the derated limit.

1.4.5 Transformers. The derating guideline factors for transformers are tabulated below.

Class		Maximum Operating	
MIL-T-27	MIL-T-21038	Temperature 1/	Voltage
Q	Q	65°C	50% of maximum rated voltage
R	R	85°C	
S	S	105°C	

NOTES:

1/ a) Maximum operating temperature equals ambient temperature + temperature rise +10°C (allowance for hot spot). Compute temperature rise as follows:

$$\text{Temperature rise } (°C) = \frac{R-r}{r}(T + 234.5) - (T - t)$$

Where R = Winding resistance under load.
r = No load winding resistance at ambient temperature T (°C).
t = Specified initial ambient temperature (°C).
T = Maximum ambient temperature (°C) at time of power shutoff. (T) shall not differ from (t) by more than 5°C.

b) The insulation classes of MIL style inductive parts have maximum operating temperature ratings which are generally based upon a life expectancy of at least 10,000 hrs. The maximum operating temperatures in this table are selected to extend the life expectancy to 50,000 hrs.

c) Custom made inductive devices shall be evaluated on a materials basis and stressed at levels below the maximum rated operating temperature for the materials used. Devices having a maximum rated operating temperature in the range of 85°C to 130°C, shall be derated to: Maximum Operating Temperature (°C) = .75 x Maximum Rated Operating Temperature (°C). For devices with maximum rated temperatures outside this temperature interval consult the project parts engineer for temperature derating recommendations.

1.4.6 Inductors/Coils. The derating guidelines factors for Inductors/Coils are tabulated below:

Class		Maximum Operating	
MIL-C-39010	MIL-C-15305	Temperature 1/	Voltage
-	O	65°C	50% of maximum rated voltage
A	A	85°C	
B	B	105°C	

NOTES:

1/ a) Maximum operating temperature equals ambient temperature + temperature rise +10°C (allowance for hot spot). Compute temperature rise as follows:

$$\text{Temperature rise } (^\circ C) = \frac{R-r}{r}(T + 234.5)$$

Where R = Winding resistance under load
r = No load winding resistance at ambient temperature T(°C)

b) The insulation classes of MIL style inductive parts have maximum operating temperature ratings which are generally based upon a life expectancy of at least 10,000 hrs. The maximum operating temperatures in this table are selected to extend the life expectancy to 50,000 hrs.

c) Custom made inductive devices shall be evaluated on a material basis and stressed at levels below the maximum rated operating temperature for the materials used. Devices having a maximum rated operating temperature in the range of 85°C to 130°C, shall be derated to: Maximum Operating Temperature (°C) = .75 x Maximum Rated Operating Temperature (°C). For devices with maximum rated temperatures outside this temperature interval consult the project parts engineer for temperature derating recommendations.

1.4.7 EMI Filters. The derating guidelines factors for EMI Filters are tabulated below:

Class	Derating Factor	Maximum Ambient Temperature
All	.50 of Rated Current .50 of Rated Voltage	85°C

1.4.8 Connectors. The derating guidelines factor for connectors are tabulated below:

Number of Contacts Used in Connector	Contact Size	Maximum Current Per Contract1/ (Amperes)							Maximum Operating Voltage
		Wire Size (AWG)							
		16	18	20	22	24	26	28	
1 to 4	16	13.0	9.2	6.5					.25 of Rated Dielectric With Standby Voltage
1 to 4	20			6.0	4.5	3.3			
1 to 4	22				4.5	3.3	2.5	1.8	
5 to 14	16	9.0	7.0	5.0					
5 to 14	20			5.0	3.5	2.7			
5 to 14	22				3.5	2.7	1.9	1.4	
15 or more	16	6.5	5.0	3.7					
15 or more	20			3.7	2.5	2.0			
15 or more	22				2.5	2.0	1.4	1.0	

NOTE:

1/ Maximum current may be carried 10% of the contacts at one time. At such time, other contacts should be limited to 100 mA.

1.4.9 Fuses. The derating guidelines factors for fuses are tabulated below:

Fuse Current Rating (Amperes)	Derating Factor	Parameter	Remarks
15	.50	Rated Amperes1/	Derating of fuses allows for possible loss of pressure, which lowers the blow current rating and allows for a decrease of current capability with time.
10	.50		
5	.50		
2	.50		
1	.45		
1/2	.40		
3/8	.35		
1/4	.30		
1/8	.25		

NOTE:

1/ Derating factors are based on data from fuses mounted on printed circuit boards and conformally coated. For other type mountings, consult the project parts engineer for recommendations.

1.4.10 <u>Wire & Cable</u>. The derating guideline factors for wire and cable are tabulated below:

Wire Size	Derate To - Amperes Maximum		Remarks
	Bundle or Cable	Single	
30	0.7	1.3	1. Current ratings for bundles or cables are based on bundles of 15 or more wires at 70°C in a hard vacuum. For smaller bundles the allowable current may be proportionally increased as the bundle approaches a single wire. 2. Ratings are based on Teflon insulated wire (Type TFE).
28	1.0	1.8	
26	1.4	2.5	
24	2.0	3.3	
22	2.5	4.5	
20	3.7	6.5	
18	5.0	9.2	
16	6.5	13.0	
14	8.5	19.0	
12	11.5	25.0	
10	16.5	33.0	
8	23.0	44.0	
6	30.0	60.0	
4	40.0	81.0	
2	50.0	108.0	
0	75.0	147.0	
00	87.5	169.0	

APPENDIX B

REQUIREMENTS FOR UPGRADING GRADE 2 DEVICES TO BE USED IN GRADE 1 APPLICATIONS

1.0 SCOPE

1.1 This appendix contains guidelines for upgrading Grade 2 parts to be used in Grade 1 applications.

2.0 GENERAL

2.1 Introduction. To support the designs required by NASA Programs, this Standard Parts List includes parts that are only available as Grade 2. Before the parts can be used in a Grade 1 application (see paragraph 3 of introduction), they must be screened to the requirement specified in this appendix for that commodity. If a commodity is not referenced in this appendix, no upgrading of quality levels in that commodity is allowed.

The requirements listed are minimum requirements to reduce the risk of using parts in the system that initially do not meet Grade 1 requirements. Therefore, the specified screens must be fully compliant in order to upgrade a part to Grade 1.

On completion of the screening requirements, the parts shall be marked uniquely so that they may be easily identified once assembled into the equipment.

2.2 Marking. Upon successful completion of these upgrading requirements, each part shall be permanently and legibly marked with a "NU" (NASA Upgrade), except when the contractor utilizes a Specification Control Drawing (SCD) to implement these requirements and specifies an unique marking, so that the part may be identified and controlled. The marking shall be legible (with a contrasting color), non-toxic, and permanent such that it meets the resistance to solvents requirements of MIL-STD-883, Method 2015.

Part documentation shall reflect the successful completion of the upgrading requirements.

Alternate methods of part upgrading identification shall be approved by the NASA Project Engineer.

3.0 REQUIREMENTS FOR UPGRADING GRADE 2 TO GRADE 1 PARTS

3.1 Transistors & Diodes: The guidelines for upgrading Transistors and Diodes are tabulated in Table 3.1.

3.2 Microcircuits: The guidelines for upgrading Microcircuits are tabulated in Table 3.2.

3.3 Transformers: The guidelines for upgrading Transformers are tabulated in Table 3.3.

3.4 Resistor Networks: The guidelines for upgrading Resistor Networks (MIL-R-83401) are tabulated in Table 3.4.

4.0 ADDITIONAL SCREENING REQUIREMENTS

4.1 Capacitors, Fixed, Tantalum (Solid) Electrolytic, (CSR): Each part shall be subjected to a surge current test of five charge-discharge surge current cycles at 25°C, -55°C and +85°C and rated voltage. The surge current test circuit shall comply with the following conditions:

A. A D.C. power supply with a minimum 15 ampere capability shall be used.

B. 100,000 uF aluminum electrolyte capacitors shall be placed across the D.C. power supply.

C. A 30 ampere mercury relay shall be used to switch the capacitor under test to the energy bank for charge and into a short circuit for discharge.

D. Wiring resistance between the energy bank capacitors and the capacitors under test shall be equal to or less than .25 ohm.

E. A one ampere fast blow fuse shall be placed in series with each capacitor under test.

F. A capacitor under test will be considered a failure when either a fuse blows or the D.C. leakage current is exceeded for both.

TABLE 3.1. Requirements for Upgrading Grade 2 Transistors and Diodes
To be used in Grade 1 applications

DPA

Destructive Physical Analysis (DPA) 3/ 4/	5 pieces for JANTXV - with zero rejects. 10 pieces for JANS - with zero rejects

SCREENING PER MIL-STD-19500 (test 100%)

Screen	MIL-STD-750 Method	Requirement
1. Particle impact noise detection (for all devices with an internal cavity)	2052	Condition A or B
2. Radiography	2076	
3. Serialization	-	
4. Interim electrical parameters	-	JANS interim electrical parameters per detail spec.
5. High temperature reverse bias (HTRB) 1/	-	48 hrs. min. at T_A = 150°C min. and min. applied voltage as follows:
Burn-in (for transistors)	1039	Transistor - 80% min of rated V_{CB} (bipolar) or V_{GS} (FET), V_{GS} (MFET), as applicable.
Burn-in (for diodes and rectifiers)	1038	Diodes (except zeners) and rectifiers rated ≤ 10 amps at T_C ≥ 100°C -80% (min) of rated V_R. For all others, use test condition "A" (rated working peak reverse voltage).
6. Interim electrical and delta parameters	-	JANS interim electrical parameters and deltas per detail spec except a PDA of 5% on electricals and deltas.
7. Power burn-in 2/	-	Per JANS detail spec. except 96 hrs.
Burn-in (for transistors)	1039	Transistors.
Burn-in (for diodes and rectifiers)	1038	Diodes (including zeners) and all rectifiers.
Burn-in (for thyristor controlled rectifiers).	1040	Thyristors
8. Final electrical test	-	Per JANS electrical and delta.
(a) Interim electrical and delta (parameters) for PDA		All parameter measurements must be completed within 96 hrs. after removal from burn-in conditions.
9. Hermetic seal		
(a) Fine 3/	1071	(a) Test conditions G or H, max. leak rate = 5 x 10^{-8} atm cc/s except 5 x 10^{-7} atm cc/s for devices with internal cavity > 0.3cc.
(b) Gross		(b) Test condition, A, C, E, or F.

GROUP B PER MIL-STD-19500

The following subgroups of Table IVa shall be performed per the LTPD specified:

Subgroup 4, Intermittent Operating Life and the electrical parameters per JANS Detail Spec.

MARKING

A unique marking to signify compliance with these requirements. See para. 2.2.

NOTES:

1/ Zener diodes shall be subject to HTRB at 80% of nominal V_Z for V_Z ≥ 10V. Omit test for devices with V_Z < 10V.

2/ Reverse blocking test shall replace power burn-in for power rectifiers at ≥ 10 amp rating at T_C ≥ 100°C and all thyristors.

3/ Omit this test for metallurgically bonded, double plug diodes.

4/ Use of MIL-STD-883, Method 5009 and the applicable test methods of MIL-STD-750.

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Table 3.2. Requirements for Upgrading Grade 2 Microcircuit To Be Used in Grade 1 Applications

SCREENING PER MIL-STD-883, METHOD 5004 test to 100%)

Screen	Method	Requirements
1. Particle Impact Noise Detection (PIND)	2020	Test condition A or B
2. Radiographic	2012	Two views
3. Serialization	-	100%
4. Interim (Pre Burn-In) Electrical Parameters	1/	Per detail spec class "S" requirements.
5. Burn-In Test	1015 2/ 160 hrs	Per applicable MIL-M-38510 detail spec.
6. Interim (Post Burn-In) Electrical Parameters	1/	Per detail spec class "S" requirements and deltas. PDA of 5% on electricals.
7. Reverse Bias Burn-In	1015	Per applicable MIL-M-38510 detail spec. Test condition A or C, 72 hrs. at 150°C min 2/
8. Final Electrical and Deltas	1/	Per applicable detail spec class "S" requirements.
9. Seal Test (a) Fine (b) Gross	1014	Reject criteria per test method.

DPA

Destructive Physical Analysis (DPA) MIL-STD-883, Method 5009

GROUP B PER MIL-STD-883, METHOD 5005

Subgroup	Method	Requirements
1(b) Internal Water-Vapor Content	1018	On GLASS-FRIT-SEALED packages only.
6(a) Electrical Parameters	-	Per detail spec class "S" requirements.
6(b) Temp cycling	1010	
6(c) Constant Acceleration	2001	
6(d) Seal - Fine and Gross	1014	
6(e) Electrical Parameters	-	Per detail spec class "S" requirements.

MARKING

A unique marking to signify compliance with these requirements. See para. 2.2.

NOTES:

1/ Electrical parameters shall be read and recorded.
2/ Test condition "F" of Method 1015 shall not apply.

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TABLE 3.3. Requirements for Upgrading Grade 2 Transformers to be used in Grade 1 applications

AUDIO AND POWER

Screen	Method	Requirement
1. Initial Measurements	-	1. Visual Examination 2. Dielectric Withstanding Voltage (DWV) 3. Induced Voltage 4. Insulation Resistance (IR) 5. D.C. Resistance (DCR) of each winding 6. Primary inductance (L) 7. Turns Ratio
2. Thermal Shock	MIL-STD-202, Method 107, Test Condition A-1.	Use maximum temperature specified for transformer as maximum temperature. Transformer should be monitored for continuity on the last two cycles.
3. Burn-In	Not Required	
4. Seal Leak Test NOTE: Do not perform these tests on encapsulated units.	MIL-STD-202, Method 112. Test Condition C for Fine Leak. Test Condition D for Gross Leak.	Use maximum temperature specified for transformer as bath temperature.
5. Final Measurement and Tests	-	Repeat initial examinations, and measurements. Reject criteria: L> ±3% (powder core and toroids) DCR > ±3% DWV < min. specified IR < min. specified Turns ratio must equal specified value.

MARKING

A unique marking to signify compliance with these requirements. See para. 2.2.

PULSE, LOW POWER

1. Initial Measurements	-	1. Visual Examination 2. Dielectric Withstanding Voltage (DWV) 3. Induced Voltage 4. Insulation Resistance (IR) 5. DC Resistance (DCR) 6. Open Circuit Inductance (OCL) 7. Leakage Inductance 8. Turns Ratio
2. Thermal Shock	-	Not Required
3. Burn-In	MIL-T-21038 Para. 4.7.2	
4. Seal Leak Test	MIL-T-21038 Para. 4.7.5 (Gross Leak Test)	
5. Final Measurements and Tests	-	Repeat initial measurements and examinations. Measure turns ratio and waveform (rise time, overshoot, droop, backswing, decay time). Reject criteria: DCR < ±3% DWV < min. specified, IR < min. specified. Turns ratio must equal specified value. Waveform parameters must not exceed the specified maximums.

MARKING

A unique marking to signify compliance with these requirements. See para. 2.2.

TABLE 3.4. Requirements for upgrading GRADE 2 Resistor Networks (MIL-R-83401) to be used in GRADE 1 applications.

Screening per MIL-STD-202 (100%)

Screen	Method	Requirements
Thermal Shock	107 T.C. B-1	Paragraph 4.6.3 of MIL-R-83401
Burn-In	108	MIL-R-83401 (150 hours)
Electrical	MIL-R-83401 Group A	Shall be within spec. limits before and after screen.

MARKING

A unique marking to signify compliance with these requirements. See para. 2.2.

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