Microcircuit Derating

This section details derating requirements for microcircuits.

Derating is the method of reducing stress and/or making numerical allowances for functional degradation in microcircuit performance. Non-military parts used in military applications need to be derated more conservatively than military parts. The microcircuits must meet the performance and reliability criteria established for their application when used in military applications. When using microcircuits of different temperature ranges, reliability levels, and performance characteristics, it is crucial to derate them properly. Two methods of derating are (1) by reducing heat and electrical stress and (2) by compensating for functional loss. Heat and electrical stress derating is applied to the voltage, current, and power stresses of the microcircuit. Functional loss and/or performance degradation over the part's life requires a degree of parametric derating. Derating should be applied knowledgeably and singly only enough to improve reliability, and only once throughout the application cycle. The severity of an application and its environment may require an additional degree of derating.

Tables 1A through 1E detail the type (technology-product), package (hermetic or plastic), derating parameters, and maximum allowable limits (percentage and/or temperature) of operation (in specific environment) for the microcircuit. Tables 1A through 1E are grouped by type of microcircuit: Table 1A MOS and Bipolar Digital, Table 1B MOS and Bipolar Linear, Table 1C MOS and Bipolar Microprocessor, Table 1D MOS and Table 1E Bipolar Memory and GaAs Digital microcircuits.

Table 1A. Digital MOS and Bipolar Microcircuit Derating Requirement

Type			**Environment**		
Digital	Package	Derating Parameter	Protected	Normal	Severe
MOS	Hermetic	Supply Voltage	/3	/3	/3
		Frequency	90%	90%	90%
		Output Current	90%	85%	80%
		Fanout	100%	90%	90%
		Junction Temperature (T_J)	125°C	110°C	100°C
	Plastic 1/	Supply Voltage	/3	/3	
		Frequency	90%	80%	
		Output Current	90%	80%	
		Fanout	100%	90%	

		Junction Temperature (T_J)	90°C	85°C	
	Plastic 2/	Supply Voltage	/3		
		Frequency	80%		
		Output Current	70%		
		Fanout	80%		
		Junction Temperature (T_J)	70°C		
Bipolar	Hermetic	Supply Voltage	/3	/3	/3
		Frequency	100%	90%	85%
		Output Current	90%	85%	80%
		Fanout	90%	85%	80%
		Junction Temperature (T_J)	125°C	110°C	100°C
	Plastic 1/	Supply Voltage	/3	/3	
		Frequency	100%	90%	
		Output Current	90%	80%	
		Fanout	90%	80%	
		Junction Temperature (T_J)	90°C	85°C	
	Plastic 2/	Supply Voltage	/3		
		Frequency	75%		
		Output Current	70%		
		Fanout	70%		
		Junction Temperature (T_J)	70°C		

Table 1B. Linear MOS and Bipolar Microcircuit Derating Requirements

Type			**Environment**		
Linear	Package	Derating Parameter	Protected	Normal	Severe
MOS	Hermetic	Supply Voltage	/3	/3	/3
		Input Voltage	80%	80%	70%
		Frequency	90%	90%	90%
		Output Current	90%	85%	80%
		Fanout	100%	90%	90%
		Junction Temperature	125°C	110°C	100°C

		(T_J)			
	Plastic 1/	Supply Voltage	/3	/3	
		Input Voltage	80%	70%	
		Frequency	90%	80%	
		Output Current	90%	80%	
		Fanout	100%	90%	
		Junction Temperature (T_J)	90°C	85°C	
	Plastic 2/	Supply Voltage	/3		
		Input Voltage	60%		
		Frequency	80%		
		Output Current	70%		
		Fanout	80%		
		Junction Temperature (T_J)	70°C		
Bipolar	Hermetic	Supply Voltage	/3	/3	/3
		Input Voltage	80%	80%	70%
		Frequency	100%	90%	85%
		Output Current	90%	85%	80%
		Fanout	90%	85%	80%
		Junction Temperature (T_J)	125°C	110°C	100°C
	Plastic 1/	Supply Voltage	/3	/3	
		Input Voltage	80%	70%	
		Frequency	100%	90%	
		Output Current	90%	80%	
		Fanout	90%	80%	
		Junction Temperature (T_J)	90°C	85°C	
	Plastic 2/	Supply Voltage	/3		
		Input Voltage	60%		
		Frequency	75%		
		Output Current	70%		
		Fanout	70%		
		Junction Temperature (T_J)	70°C		

Table 1C. Microprocessor MOS and Bipolar Derating Requirements

Type			Environment		
Microprocessor	Package	Derating Parameter	Protected	Normal	Severe
MOS	Hermetic	Supply Voltage	/3	/3	/3
		Frequency	90%	90%	90%
		Output Current	90%	85%	80%
		Fanout	100%	90%	90%
		Junction Temperature (T_J)	125°C	110°C	100°C
	Plastic 1/	Supply Voltage	/3	/3	
		Frequency	90%	80%	
		Output Current	90%	80%	
		Fanout	100%	85%	
		Junction Temperature (T_J)	85°C	75°C	
	Plastic 2/	Supply Voltage	/3		
		Frequency	80%		
		Output Current	70%		
		Fanout	80%		
		Junction Temperature (T_J)	70°C		
Bipolar	Hermetic	Supply Voltage	/3	/3	/3
		Frequency	90%	80%	75%
		Output Current	80%	75%	70%
		Fanout	80%	75%	70%
		Junction Temperature (T_J)	125°C	110°C	100°C
	Plastic 1/	Supply Voltage	/3	/3	
		Frequency	80%	90%	
		Output Current	75%	80%	
		Fanout	75%	80%	
		Junction Temperature (T_J)	85°C	75°C	
	Plastic 2/	Supply Voltage	/3		
		Frequency	75%		
		Output Current	70%		
		Fanout	70%		

		Junction Temperature (T_J)	70°C		

Table 1D. Microcircuit Memory MOS and Bipolar Derating Requirements

Type			**Environment**		
Memory	Package	Derating Parameter	Protected	Normal	Severe
MOS	Hermetic	Supply Voltage	/3	/3	/3
		Frequency	100%	90%	90%
		Output Current	90%	85%	80%
		Junction Temperature (T_J)	125°C	110°C	100°C
	Plastic 1/	Supply Voltage	/3	/3	
		Frequency	100%	90%	
		Output Current	90%	80%	
		Junction Temperature (T_J)	90°C	85°C	
	Plastic 2/	Supply Voltage	/3		
		Frequency	80%		
		Output Current	70%		
		Junction Temperature (T_J)	70°C		
Bipolar	Hermetic	Supply Voltage	/3	/3	/3
		Frequency	100%	100%	90%
		Output Current	90%	85%	80%
		Junction Temperature (T_J)	125°C	110°C	100°C
	Plastic 1/	Supply Voltage	/3	/3	
		Frequency	100%	95%	
		Output Current	90%	80%	
		Junction Temperature (T_J)	90°C	85°C	
	Plastic 2/	Supply Voltage	/3		
		Frequency	80%		
		Output Current	70%		
		Junction Temperature (T_J)	70°C		

Table 1E. GaAs Microcircuit Derating Requirements

Type			**Environment**		
GaAs	Package	Derating Parameter	Protected	Normal	Severe
Digital	Hermetic	Channel Temperature	150°C	125°C	90°C
	Plastic 1/	Channel Temperature	125°C	90°C	
	Plastic 2/	Channel Temperature	90°C		<P <p>

Notes for Tables 1A through 1E

1/ Plastic packaged microcircuit with heat dissipating mechanisms (e.g. thermal fillers, thermal conductivity plate or a type of metal substrate) built-in.

2/ Low-power plastic packaged microcircuits with no heat dissipating mechanism other than through the leads.

3/ The supply voltage must be kept within the microcircuit specification sheets minimum and maximum limit.

Examples of parameters that may need derating are:

a. Junction temperature. The microcircuit's maximum junction temperature should not go over 115°C. For example, IBM uses 85°C as its design guideline and Intel uses 90°C as the maximum junction temperature specification for the Pentium processor. Temperature drop between the junction and the ambient is typically 50°C with an ambient of 40°C (113°F) inside an enclosure. Designers should try to design-derate junction temperatures below 90°C while maintaining, at most, a temperature difference of 50°C. Junction temperatures increase as energy builds up. The greater the temperature-difference, the higher the energy flow out of the part. The maximum temperature of a junction is reached when the heat flow out to the ambient is able to keep up with the energy being produced by the junction. Performance risks and speed concerns are associated with increasing junction temperatures. In addition, all failure mechanisms have activation energy associated with accelerated increased temperature. For an activation energy, for the failure mechanism of 0.5eV, typical of punch-through failures for example, every 10°C increase in junction temperature results in the lifetime of a microcircuit cut roughly in half. This is diagramed in Figure 1.

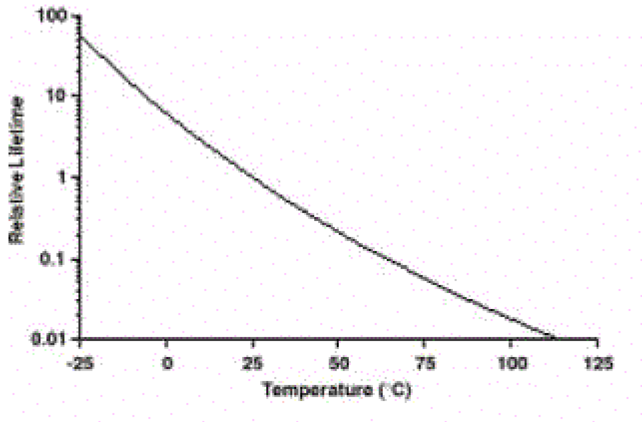

Figure 1. Relative MTBF with Activation Energy of 0.5eV

b. Examples of parametric derating:

1. Use a digital circuit at less than full fanout. Historically, fanout has been derated by a factor of 20%.

2. Design for extra noise margin and sacrifice some for derating.

3. Applying the performance level below guaranteed by the manufacturer.

4. Parameters that depend directly on transistor beta, resistor value, or junction leakage are more prone to shifting during the life of the microcircuit. These are detailed in the derating Table 8-5.

5. Parameters that depend directly on the saturation voltages of junctions and on the ratios of resistors are likely to remain stable through the life of the microcircuit.

6. Logic noise-margin levels have been derated by a factor of 10%.

7. AC parameters such as delay times or rates are usually not derated, as these parameters do not vary greatly over the life of a microcircuit. The delay times of separate gates within one microcircuit may vary

greatly in many cases. In addition, these parameters are not normally measured on 100% of the microcircuits, and as such, this variation should be allowed for in the designing of microcircuits.