December 1997

RR-1K

# Product Reliability Report

*This report presents the product reliability data for Maxim's analog products. The data was acquired from extensive reliability stress testing performed in 1996. It is separated into seven fabrication processes: 1) Standard Metal-Gate CMOS (SMG); 2) Medium-Voltage Metal-Gate CMOS (MV1); 3) Medium-Voltage Silicon-Gate CMOS (MV2); 4) 3µm Silicon-Gate CMOS (SG3); 5) 5µm Silicon-Gate CMOS (SG5); 6) 1.2µm Silicon-Gate CMOS; and 7) Bipolar (BIP) processes.*

*Over 8,967,000 device hours have been accumulated for products stressed at an elevated temperature (135°C) during this period. The data in this report is considered typical of Maxim's production. As you will see, Maxim's products demonstrate consistently high reliability.*

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## Fabrication Processes

Maxim is currently running the following seven major fabrication processes:

SMG (Standard Metal-Gate CMOS)
MV1 (Medium-Voltage Metal-Gate CMOS)
MV2 (Medium-Voltage Silicon-Gate CMOS)
SG3 (3-Micron Silicon-Gate CMOS)
SG5 (5-Micron Silicon-Gate CMOS)
SG1.2 (1.2-Micron Silicon-Gate CMOS)
Bipolar (18/12-Micron)

### *SMG*

SMG is a 6-micron, 24V, metal-gate CMOS process. It has conservative design rules, but is appropriate for many SSI and MSI circuit designs. This very popular fabrication process is used to produce many of Maxim's products.

### *MV1*

MV1 is a 12-micron, 44V, metal-gate CMOS process, used exclusively to produce our analog switch product line.

### *MV2*

MV2 is a 5-micron, 44V, silicon-gate CMOS process, also used in our analog switch production line.

### *SG3, SG5, and SG1.1*

SG3 is a 3-micron, 12V, silicon-gate CMOS process. SG5 is a 5-micron, 20V, silicon-gate CMOS process. SG1.2 is a 1.2-micron, 6V, silicon-gate CMOS process. SG3, SG5, and SG1.2 have become our future process standards.

### *Bipolar*

Bipolar is an 18-micron, 44V or 12-micron, 24V bipolar process, used chiefly for precision references, op amps, and A/D converters.

## Reliability Methodology

Maxim's quality approach to reliability testing is conservative. Each of the seven fabrication processes has been qualified using the following industry-standard tests: Life Test, 85/85, Pressure Pot, HAST, High-Temperature Storage Life, and Temperature Cycling (Table 1). Each process has been qualified and proven to produce inherently high-quality product.

Maxim's early conservative approach included burn-in as a standard stage of our production flow. Burn-in ensured that our customers were receiving a quality product. Now, with the addition of our own sophisticated fabrication facility, we have improved the innate product quality to the point where burn-in adds little reliability value.

Each time a new fabrication process is introduced at Maxim, an Infant Mortality evaluation (burn-in evaluation) is initiated at the same time as process qualification. Through this Infant Mortality evaluation we can identify fabrication process defects at an early stage of production. Using the data in Table 2 (Infant Mortality Evaluation Results) and Figure 9 (Infant Mortality Pareto Chart) we can identify which category should next be improved. The data shown demonstrates the positive direction of Maxim's quality standards. It illustrates our continued dedication to providing the lowest overall-cost solution to our customers, through superior quality products.

Maxim's SMG, MV1, MV2, SG3, SG5, SG1.2, and Bipolar processes clearly meet or exceed the performance and reliability expectations of the semiconductor industry. These processes are qualified for production. Cross-sectional views of these seven processes are shown in Figures 1–7.

## Reliability Program

**TABLE 1. MAXIM PROCESS RELIABILITY TESTS**

| TEST NAME | CONDITIONS | SAMPLING PLAN ACC/SS |
|---|---|---|
| Life Test | +135°C/1000 hrs. | 1/77 |
| 85/85 | +85°C, 85% R.H.,<br>1000 hrs. with Bias | 1/77 |
| Pressure Pot | +121°C, 100% R.H.,<br>2 ATM, 168 hrs. | 0/77 |
| Temperature Cycling | -65°C to +150°C<br>Air-to-Air/1000 Cycling | 1/77 |
| High-Temp. Storage Life | +150°C/1000 hrs. | 1/77 |

Maxim has implemented a series of Quality and Reliability programs aimed at building the highest quality, most reliable analog products in the industry.

### *Reliability Program Steps*

All products, processes, packages, and changes in

## Process Technologies

This section defines the layer-by-layer construction steps used in the fabrication of each process.

**(1) SMG** (Refer to Figure 1)

| Layer | Description | Dimension |
|---|---|---|
| 1 | P-Well Diffusion | 10µm |
| 2 | P+ Diffusion | 2µm |
| 3 | N+ Diffusion | 2µm |
| 4 | Gate-Oxide Growth | 900Å |
| 5 | Threshold Implant | |
| 6 | Contact Etch | |
| 7 | Metallization | 1µm (Al, Si-1%) |
| 8 | Passivation | 0.8µm ($Si_3N_4$ over $SiO_2$) |

**(2) MV1** (Refer to Figure 2)

| Layer | Description | Dimension |
|---|---|---|
| 0 | Buried Layer | 10µm |
| 1 | EPI Deposit | 19µm |
| 2 | P-Well Diffusion | 10µm |
| 3 | P+ Diffusion | 3µm |
| 4 | N+ Diffusion | 3µm |
| 5 | Gate-Oxide Growth | 1975Å |
| 6 | Threshold Implant | |
| 7 | Contact | |
| 8 | Metallization | 1µm (Al, Si-1%) |
| 9 | Passivation | 0.8µm ($Si_3N_4$ over $SiO_2$) |

**(3) MV2** (Refer to Figure 3)

| Layer | Description | Dimension |
|---|---|---|
| 1 | Buried Layer | 24.0µm |
| 2 | P Well | 10.0µm |
| 3 | P+ Diffusion | 1.5µm |
| 4 | N+ Diffusion | 1.5µm |
| 5 | Gate-Oxide Growth | 1000Å |
| 6 | P-Ch Threshold Adjust | |
| 7 | Polysilicon | 4500Å |
| 8 | NLDD | |
| 9 | PLDD | |
| 10 | N+ Ohmic | |
| 11 | Contact | |
| 12 | Metal | 1.0µm |
| 13 | Passivation | 0.8µm |

**(4) SG3** (Refer to Figure 4)

| Layer | Description | Dimension |
|---|---|---|
| 1 | P Well | 6.0µm |
| 2 | PNP Base | |
| 3 | Zener Implant | |
| 4 | Active Area | 1.5µm |
| 5 | P Guard | |
| 6 | N Guard | |
| 7 | P-Ch Threshold Adjust | |
| 8 | Poly 2 | 7000Å |
| 9 | Poly 1 | 4000Å |
| 10 | N+ Block | |
| 11 | P+ Select | |
| 12 | Thin Film | |
| 13 | CrSi Contact | |
| 14 | Contact | |
| 15 | Metal | 1.0µm |
| 16 | Passivation | 0.8µm ($Si_3N_4$ over $SiO_2$) |

**(5) SG5** (Refer to Figure 5)

| Layer | Description | Dimension |
|---|---|---|
| 1 | P-Well Diffusion | 8µm |
| 2 | PNP Base Drive | |
| 3 | Zener Implant | |
| 4 | Active Area/Field Ox | 1µm |
| 5 | N Guard | |
| 6 | P Guard | |
| 7 | Threshold Adjust | |
| 8 | Gate-Oxide Growth | 750Å |
| 9 | Polysilicon 1 | 4400Å |
| 10 | Cap Oxide | 1000Å |
| 11 | Polysilicon 2 | 4400Å |
| 12 | N+ Implant (Source/Drain) | |
| 13 | P+ Implant (Source/Drain) | |
| 14 | Chrome/Si Thin-Film Deposit | |
| 15 | Contact | |
| 16 | Metallization | 1µm |
| 17 | Passivation | 0.8µm ($Si_3N_4$ over $SiO_2$) |

**(6) SG1.2** (Refer to Figure 6)

| Layer | Description | Dimension |
|---|---|---|
| 0 | Mark Layer on P Substrate | |
| 1 | N+ Buried Layer | 4µm |
| 2 | P+ Buried Layer | 6µm |
| 3 | P Well | 2.8µm |
| 4 | NPN Base | |
| 5 | PNP Base | |
| 6 | Active Area | |
| 7 | P Guard | |
| 8 | N Guard | |
| 9 | Gate-Oxide Growth | 230Å |
| 10 | Poly 1 | 4200Å |
| 11 | Poly 2 | 4200Å |
| 12 | NMOS LDD | |
| 13 | N+ Implant (Source/Drain) | 0.3µm |
| 14 | P+ Implant (Source/Drain) | 0.3µm |
| 15 | Thin Film (Chrome/Si) | |
| 16 | Contact | |
| 17 | TF Contact | |
| 18 | Metal 1 | 6000Å |
| 19 | Metal 1 Options | |
| 20 | Via | |
| 21 | Metal 2 | 1.0µm |
| 22 | Passivation | 8000Å |

**(7) BIP** (Refer to Figure 7)

| Layer | Description | Dimension |
|---|---|---|
| 1 | N+ Buried Layer | 4.5µm |
| 2 | P+ Isolation | 20µm |
| 3 | P Base | 3µm |
| 4 | N+ Emitter | 2.5µm |
| 5 | Capacitor | 1500Å |
| 6 | Contact Etch | |
| 7 | Aluminum | 11kÅ (Al, Si-1%) |
| 8 | Passivation | 8kÅ ($Si_3N_4$ over $SiO_2$) |

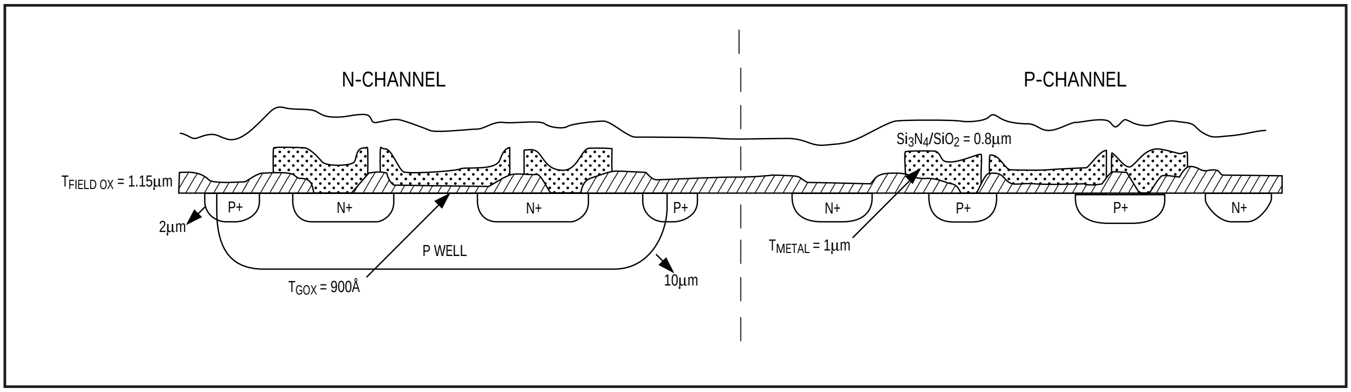

*Figure 1. SMG Process*

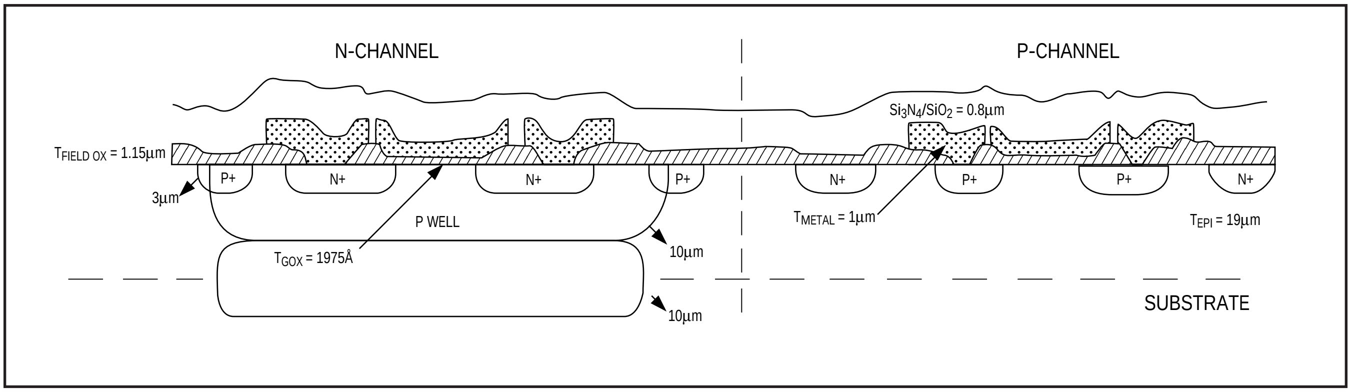

*Figure 2. MV1 Process*

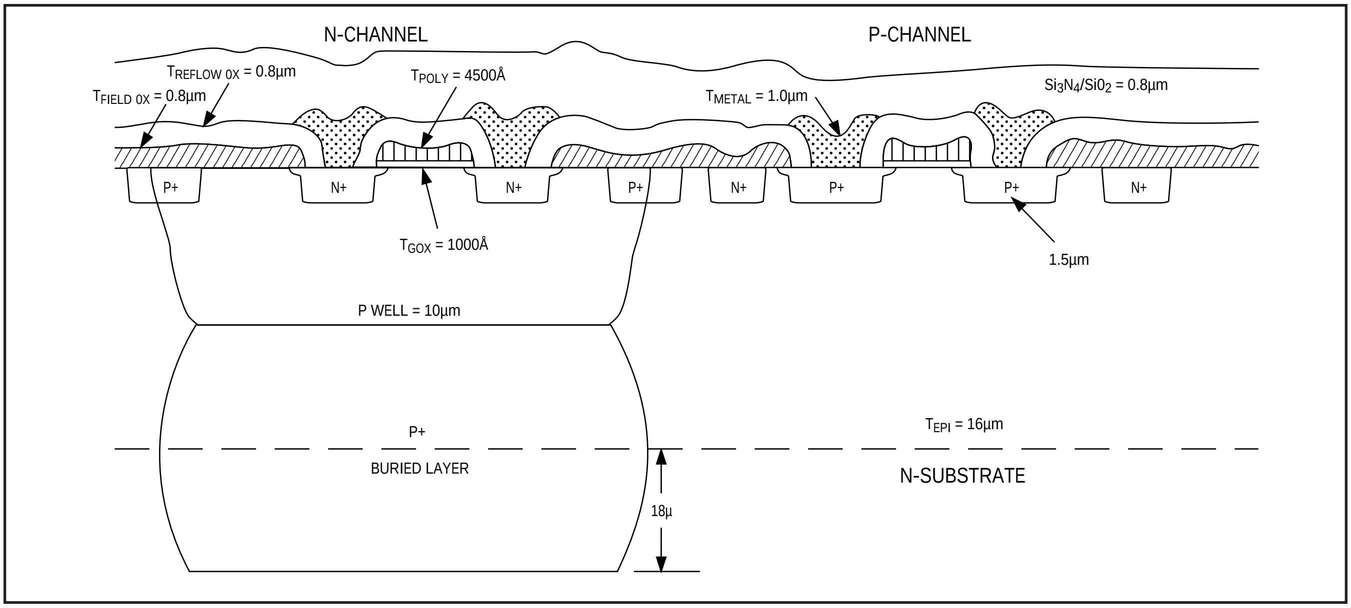

*Figure 3. MV2 Process*

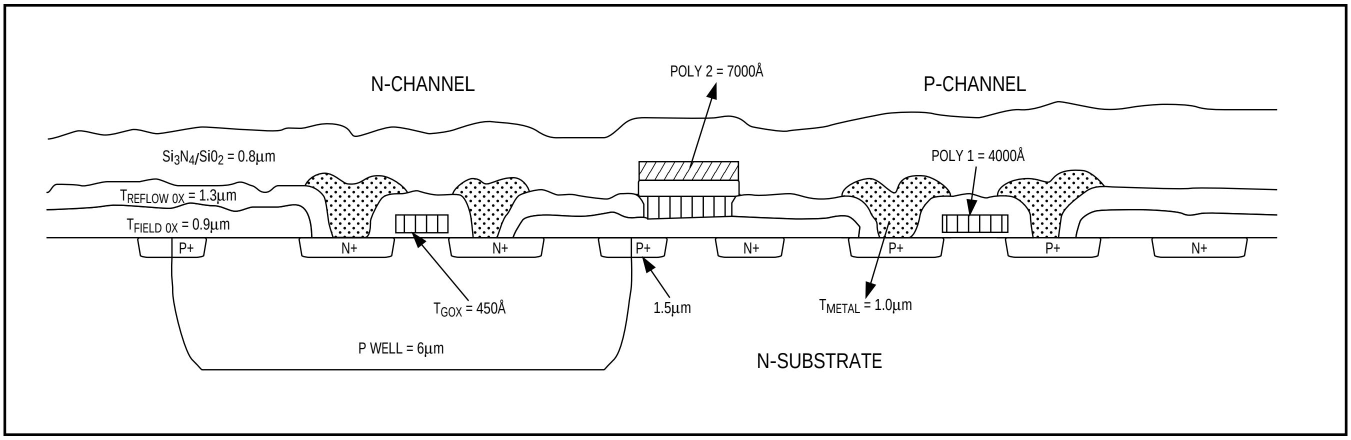

*Figure 4. SG3 Process*

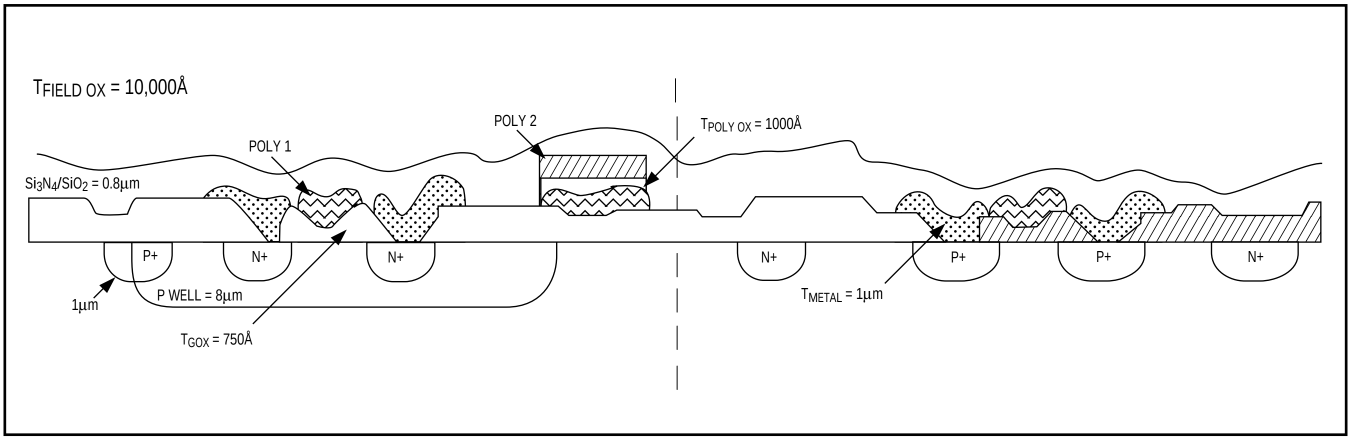

*Figure 5. SG5 Process*

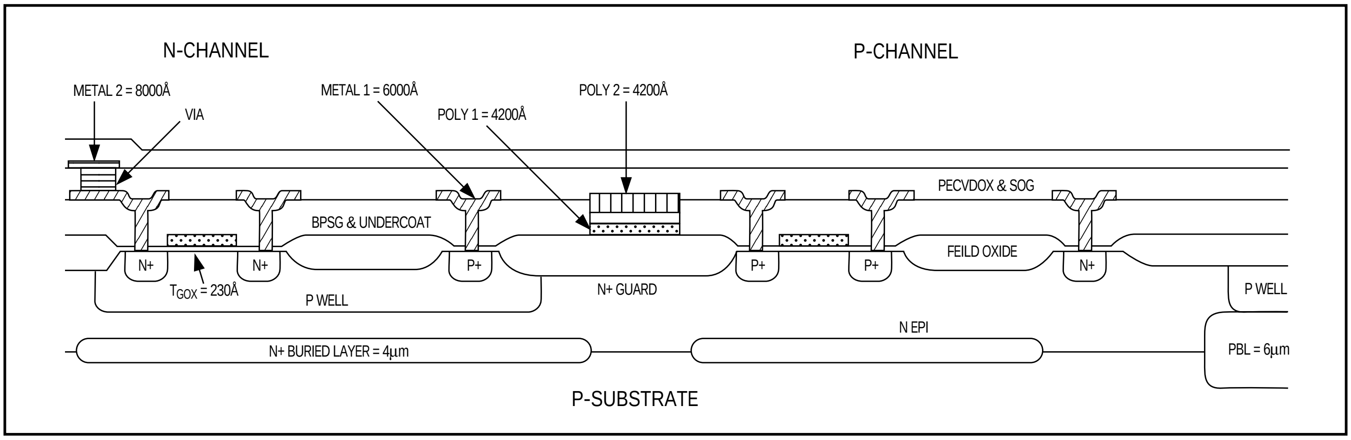

*Figure 6. SG1.2 Process*

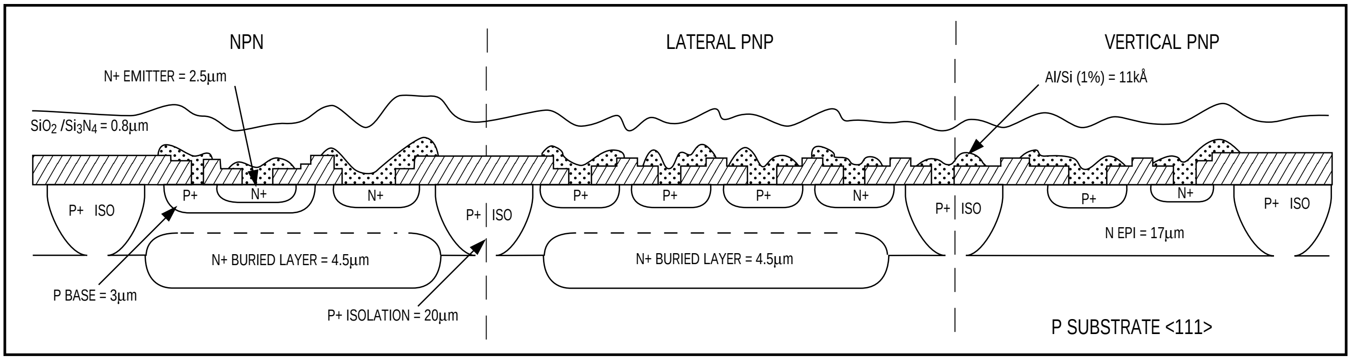

*Figure 7. Bipolar Process*

manufacturing steps must be subjected to Maxim's reliability testing before release to manufacturing for mass production. Our reliability program includes the following steps:

Step 1: Initial Reliability Qualification Program
Step 2: Ongoing Reliability Monitor Program
Step 3: In-Depth Failure Analysis and Corrective Action

Tables 5–11 show the results of long-term Life Tests by process and device type. Tables 12–16 show the results of the 85/85, Pressure Pot, HAST, Temperature Cycling, and High-Temperature Storage Life tests, by device type. Tables 17 and 18 show hybrid product reliability.

### *Step 1: Initial Reliability Qualification Program*

Maxim's product reliability test program meets EIA-JEDEC standards and most standard OEM reliability test requirements.

Table 1 summarizes the qualification tests that are part of Maxim's reliability program. Before releasing products, we require that three consecutive manufacturing lots from a new process technology successfully meet the reliability test requirements.

### *Step 2: Ongoing Reliability Monitor Program*

Each week Maxim identifies three wafer lots per process per fab to be the subjects of reliability monitor testing. Each lot is Pressure Pot tested, and tested to 192 hours of High-Temperature Life (at 135°C). On a quarterly basis, one wafer lot per process per fab is identified and subjected to the same long-term reliability tests as defined in Table 1. Test results are fed back into production.

### *Step 3: In-Depth Failure Analysis and Corrective Action*

Our technical failure-analysis staff is capable of analyzing every reliability test failure to the device level. If an alarming reliability failure mechanism or trend is identified, the corrective action is initiated automatically. This proactive response and feedback ensures that discrepancies in any device failure mechanism are corrected before becoming major problems.

### *Designed-In High Reliability*

A disciplined design methodology is an essential ingredient of manufacturing a reliable part. No amount of finished-product testing can create reliability in a marginal design.

To design-in reliability, Maxim began by formulating a set of physical layout rules that yield reliable products even under worst-case manufacturing tolerances. These rules are rigorously enforced, and every circuit is subjected to computerized Design Rule Checks (DRCs) to ensure compliance.

Special attention is paid to Electrostatic Discharge (ESD) protection. Maxim's goal is to design every pin of every product to withstand ESD voltages in excess of 2000V, through a unique protection structure. In the case of our RS-232 interface circuits, products can even withstand ±15kV ESD using the human-body model, ±8kV ESD using IEC1000-4-2 contact discharge, or ±15kV ESD using IEC1000-4-2 air-gap discharge. Maxim tests each new product for designed 50mA latchup protection.

Designs are extensively simulated (using both circuit and logic simulation software) to evaluate performance under worst-case conditions. Finally, every design is checked and rechecked by independent teams before being released to mask making.

### *Wafer Inspection*

All wafers are fabricated using stable, proven

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processes with extremely tight control. Each wafer must pass numerous in-process checkpoints (such as oxide thickness, alignment, critical dimensions, and defect densities), and must comply with Maxim's demanding electrical and physical specifications.

Finished wafers are inspected optically to detect any physical defects. They are then parametrically tested to ensure full conformity to Maxim's specifications. Our parametric measurement system is designed to make the precision measurements that will ensure reliability and reproducibility in analog circuits.

We believe our quality-control technology is the best in the industry, capable of resolving current levels below 1pA, and of producing less than 1pF capacitance. Maxim's proprietary software allows automatic measurement of subthreshold characteristics, fast surface-state density, noise, and other parameters crucial to predicting long-term stability and reliability. Every Maxim wafer is subject to this rigorous screening at no premium to our customers.

### *Failure-Rate History*

The graph below (Figure 8) illustrates Maxim's Failures-in-Time (FIT) rate performance. It also highlights the progressive improvements made in this FIT rate, a trend that we expect to see continue, thanks to our established continuous-improvement methodology.

### *Infant Mortality Evaluation*

Maxim evaluates each process and product family's Infant Mortality rate immediately after achieving qualified status. Through Infant Mortality analysis, we can identify the common defects for each process or product family. For an illustration of Maxim's low Infant Mortality rate, refer to Table 2. Figure 9 is an Infant Mortality pareto chart showing each category of failures; categories are prioritized based on relative frequency.

## Reliability Data

### *Merits of Burn-In*

Figure 10 plots Failure Rate versus Time for the metal-gate CMOS process. The plot is based on Table 3's Life Test data and Table 2's Infant Mortality evaluation data, both applied to a General Reliability model. From this data, the benefit of production burn-in can be derived.

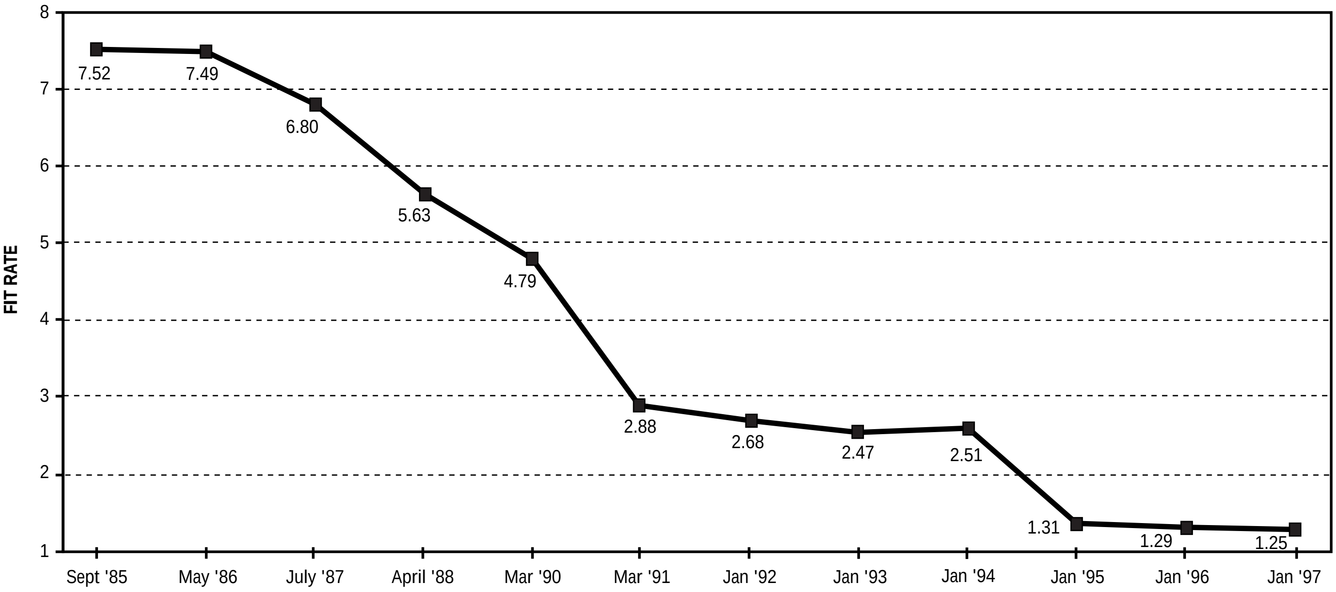

*Figure 8. Maxim FIT Rates Over Time*

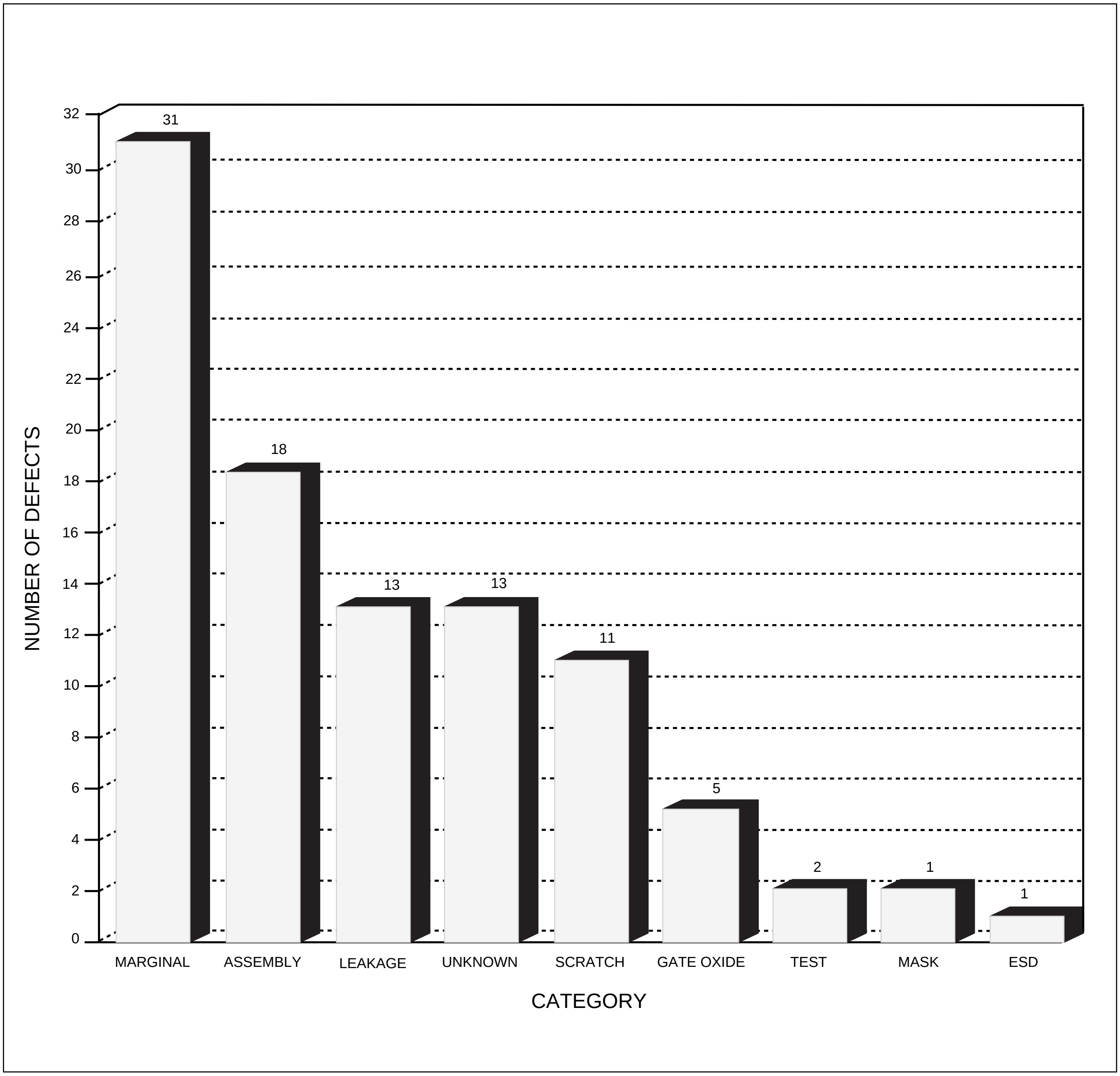

*Figure 9. Infant Mortality Pareto Chart*

### TABLE 2. INFANT MORTALITY EVALUATION RESULTS

| PRODUCT | LOT | BI TEMP (°C) | SS | FAILURES | PPM | ANALYSIS |
|---|---|---|---|---|---|---|
| **MV1 PROCESS** | | | | | | |
| DG201ACJ | XRCAAB184C | 135 | 11,698 | 1 | 85 | 1-MARGINAL LEAKAGE |
| DG211CJ | XRCAAB217Q | 135 | 9642 | 4 | 414 | 4-MARGINAL LEAKAGE |
| DG212CJ | XRCBAA208Q | 135 | 11,834 | 2 | 169 | 2-MARGINAL LEAKAGE |
| DG509ACJ | XROCAA045Q | 135 | 12,629 | 11 | 871 | 7-$IS_{OFF}$ CONTAMINATION, 1-HIGH $I_{CC}$, 3 TIMING |
| DG508ACJ | XROBAB029Q | 135 | 10,216 | 2 | 195 | 1-$ID_{ON}$, $ID_{OFF}$ |
| DG508ACJ | XROBAC030Q | 135 | 7912 | 0 | 0 | |
| Subtotals | | | 63,931 | 20 | 312.8 | |
| **MV2 PROCESS** | | | | | | |
| DG411DY | XRLADB016A | 135 | 10,338 | 1 | 97 | 1-MARGINAL LEAKAGE |
| | XRLADB017B | 135 | 10,482 | 0 | 0 | |
| | XRLADB018B | 135 | 10,068 | 2 | 199 | 2-MARGINAL LEAKAGE |
| Subtotals | | | 30,888 | 3 | 97 | |
| **SMG PROCESS** | | | | | | |
| ICM7218CIPI | XDDCAA096A | 135 | 6886 | 0 | 0.0 | |
| | XDDCAA102A | 135 | 6824 | 2 | 293 | 1-MARGINAL LEAKAGE, 1-UNKNOWN |
| ICM7218AIPI | XDDAAA097A | 135 | 6694 | 0 | 0.0 | |
| | XDDAAA098A | 135 | 6927 | 0 | 0.0 | |
| ICM7218BIPI | XDDBAA099B | 135 | 6959 | 0 | 0.0 | |
| Subtotals | | | 34,290 | 2 | 58.3 | |
| ICM7218AIPI | BDDACZ012Q | 135 | 11,674 | 1 | 85 | 1-UNKNOWN |
| | BDDACA015B | 135 | 3101 | 1 | 322 | 1-UNKNOWN |
| ICM7218BIPI | BDDBCZ010Q | 135 | 12,355 | 1 | 80 | 1-UNKNOWN |
| Subtotals | | | 27,130 | 3 | 110 | |
| MAX1232CPA | XPPAJQ003BR | 135 | 844 | 0 | 0.0 | |
| | XPPAJQ003C | 135 | 6447 | 2 | 310 | 1-DIE SCRATCH, 1-PACKAGE CRACK |
| | XPPAJQ006A | 135 | 12,390 | 0 | 0.0 | |
| | XPPAJQ007B | 135 | 13,330 | 0 | 0.0 | |
| Subtotals | | | 33,011 | 2 | 60.6 | |
| MAX232CPE | XPWAAA039AA | 150 | 5324 | 0 | 0.0 | |
| | XPWAAA040AA | 150 | 5627 | 1 | 177.7 | 1-INTERMITTENT BOND WIRE OPEN (HEEL OF WEDGE BOND) |
| | XPWAAA044AB | 150 | 5831 | 0 | 0.0 | |
| | XPWAAA048AB | 125 | 5575 | 2 | 358.7 | 2-BOND WIRE SHORT FAILURES |
| | XPWAAA050AA | 125 | 5768 | 2 | 346.7 | 1-MECHANICAL DAMAGE, 1-GATE-OXIDE DEFECT |
| | XPWAAA074AA | 150 | 4643 | 3 | 646.1 | 1-INTERMITTENT BOND OPEN (HEEL OF WEDGE BOND),<br>1-GATE-OXIDE DEFECT,<br>1-MARG. HIGH $R_{IN}$ THRESHOLD (CAUSE UNKNOWN) |
| | XPWAAA147A | 150 | 10,372 | 2 | 192.8 | 1-BOND WIRE OPEN WEDGE BONDS @ LEADFRAME,<br>1-HIGH $I_{EE}$ DUE TO GATE-OXIDE DEFECT |
| | XPWAAA147B | 150 | 10,789 | 0 | 0.0 | |
| | XPWBAA012A | 150 | 10,070 | 3 | 297.9 | 1-LOW R1IN RESISTANCE SCRATCH ON DIE,<br>1-HIGH $I_{EE}$ GATE-OXIDE DEFECT,<br>1-HIGH $R2_{IN}$ RESISTANCE ERR. FUSE BLOWN |
| | XPWBAA012B | 150 | 10,929 | 3 | 274.5 | 1-HIGH $R1_{IN}$ RESISTANCE ERR. FUSE BLOWN,<br>1-$T1_{OUT}$ STUCK HIGH UNKNOWN DAMAGE IN FA,<br>1-$R2_{IN}$ INPUT THRESHOLD MARG. FAIL |
| MAX232CPE | XKMAAA005Q | 135 | 15,727 | 2 | 127 | 2-UNKNOWN |
| MAX202CPE | XKMCAA007A | 135 | 6277 | 1 | 159 | 1-UNKNOWN |
| MAX232CPE | XKMAAA008A | 135 | 30,888 | 1 | 32 | 1-UNKNOWN |
| Subtotals | | | 128,330 | 20 | 155.8 | |
| MAX690CPA | XPYAJA208A | 150 | 9443 | 4 | 423.6 | 1-AC FAILURE NO SCRATCH,<br>2-MARGINAL HIGH RESET THRESHOLD NO SCRATCH,<br>1-FUNCTIONAL FAILURE DUE TO DIE SCRATCH |
| | XPYAJA208BA | 150 | 4702 | 3 | 638.0 | 2-DIE SCRATCH ON SILICON SUBSTRATE,<br>1-DIE SCRATCH ON METAL LINES |
| | XPYAJA209A | 150 | 9873 | 3 | 303.9 | 1-RESET THRESHOLD DUE TO DIE SCRATCH,<br>1-MARGINAL $I_{BAT}$ NO SCRATCH,<br>1-GATE-OXIDE RUPTURE POSSIBLY ESD DAMAGE |
| | XPYAJA208B | 150 | 4295 | 0 | 0.0 | |
| Subtotals | | | 28,313 | 10 | 353.2 | |
| MAX1044CPA | NEAABZ003B | 135 | 2010 | 1 | 497 | 1-UNKNOWN |
| | NEAAVN020B | 135 | 3191 | 0 | 0 | |
| | NEAABZ003A | 135 | 5511 | 2 | 363 | 2-UNKNOWN |
| Subtotals | | | 10,712 | 3 | 280 | |

## TABLE 2. INFANT MORTALITY EVALUATION RESULTS *(continued)*

| PRODUCT | LOT | BI TEMP (°C) | SS | FAILURES | PPM | ANALYSIS |
|---|---|---|---|---|---|---|
| **SMG PROCESS (continued)** | | | | | | |
| MAX667CPA | XEVAJA035A | 135 | 9823 | 1 | 102 | 1-PARAMETRIC |
| | XEVANA046A | 135 | 8201 | 5 | 610 | 1-PARAMETRIC, 4-FUNCTIONAL |
| | XEVANB048B | 135 | 5015 | 0 | 0 | 1-UNKNOWN |
| Subtotals | | | 23,039 | 6 | 260 | |
| MAX202CPE | NHUABO013A | 135 | 7262 | 2 | 275 | 2-FUNCTIONAL, UNKNOWN |
| | NHUABO007A | 135 | 9450 | 2 | 212 | 1-MASKING DEFECT, 1-UNKNOWN |
| | NHUABO004B | 135 | 9977 | 0 | 0 | |
| Subtotals | | | 26,689 | 4 | 150 | |
| MAX202ECPE | NDOBCO005A | 135 | 4257 | 1 | 235 | 1-DIE SCRATCH |
| | NDOBCO005J | 135 | 4630 | 3 | 648 | 1-BAUD CRATER, 2-UNKNOWN |
| | NDOBCO006A | 135 | 4255 | 0 | 0 | |
| | NDOBCN009A | 135 | 13,440 | 0 | 0 | |
| Subtotals | | | 26,582 | 4 | 152 | |
| **SG3 PROCESS** | | | | | | |
| MAX485CPA | XKNACA009A | 135 | 8654 | 1 | 115 | 1-LEAKAGE |
| | XKNACA011A | 135 | 9689 | 2 | 206 | 2-UNKNOWN |
| | XKNACB016C | 135 | 6239 | 1 | 160 | 1-UNKNOWN |
| Subtotals | | | 24,582 | 4 | 162 | |
| MAX705CPA | XTOACZ010A | 135 | 7026 | 1 | 142 | 1-HIGH $I_{CC}$ |
| | XTOACA014Q | 135 | 6759 | 2 | 295 | 2-PARAMETRIC |
| | XTOACB015B | 135 | 4895 | 0 | 0 | |
| Subtotals | | | 18,680 | 3 | 160 | |
| MAX712CPE | XAABCA009A | 135 | 12,505 | 3 | 239 | 3-PARAMETRIC |
| MAX713CPE | XAAACA013A | 135 | 11,873 | 2 | 168 | 2-PARAMETRIC |
| | XAAACA016A | 135 | 10,530 | 2 | 189 | 1-FUNCTIONAL, 1-PARAMETRIC |
| Subtotals | | | 34,908 | 7 | 200 | |
| MAX692ACPA | NTABGO01O | 135 | 12,033 | 2 | 166 | 2-PARAMETRIC |
| Subtotals | | | 12,033 | 2 | 166 | |
| MAX488ECPA | XIKGBA037A | 135 | 4590 | 1 | 217 | 1-UNKNOWN |
| MAX490ECPA | XIKDBB028C | 135 | 3347 | 0 | 0 | |
| MAX491EEPD | XIKEBB033B | 135 | 6470 | 1 | 154 | 1-UNKNOWN |
| MAX489EEPD | XIKHBB036B | 135 | 749 | 0 | 0 | |
| Subtotals | | | 15,156 | 2 | 131 | |
| **SG5 PROCESS** | | | | | | |
| MAX232ACPE | XETAZZ063Q | 135 | 10,016 | 6 | 599 | 2-BOND WIRE SHORT TO DIE EDGE,<br>1-BOND WIRE SMASH, 1-DIE SCRATCH,<br>1-HIGH $I_{CC}$, 1-LOW SLEW RATE |
| MAX232ACPE | XETAZZ058Q | 135 | 10,181 | 1 | 98 | 1-OXIDE DEFECT |
| MAX202ACPE | XETAZA075A | 135 | 14,977 | 4 | 267 | 2-DIE SCRATCH, 2-UNKNOWN |
| MAX232ACPE | XETAZA099Q | 135 | 10,425 | 3 | 288 | 3-HIGH $I_{CC}$ |
| Subtotals | | | 45,599 | 14 | 307 | |
| MAX452CPA | XFPAUB004A | 135 | 5592 | 2 | 358 | 2-$V_{OS}$ |
| MAX454CPD | XFPAVA011Q | 135 | 6565 | 0 | 0 | |
| MAX455CPP | XFPAVA009Q | 135 | 16,236 | 5 | 308 | 4-$V_{OS}$, 1-FUNCTIONAL FAILURE |
| Subtotals | | | 28,393 | 7 | 246.5 | |
| MAX732CPA | XPKABB254A | 135 | 10,848 | 2 | 184 | 1-AC FAILURE, 1-UNKNOWN |
| | XPKABB261A | 135 | 11,657 | 1 | 86 | 1-AC FAILURE |
| | XPKABB263A | 135 | 12,333 | 2 | 162 | 1-AC FAILURE |
| Subtotals | | | 34,838 | 5 | 143 | |
| **SG1.2 PROCESS** | | | | | | |
| MAX7219CN | BDRAAZ014A | 135 | 10,091 | 3 | 297 | 3-UNKNOWN |
| | BDRAAZ026B | 135 | 16,648 | 3 | 180 | 3-UNKNOWN |
| | BDRAAZ029A | 135 | 11,347 | 1 | 88 | 1-UNKNOWN |
| Subtotals | | | 38,086 | 7 | 184 | |
| **BIP PROCESS** | | | | | | |
| MAX901BCPE | VWHABB074C | 135 | 4100 | 1 | 243 | 1-LEAKAGE |
| | VWHABB079D | 135 | 4650 | 1 | 215 | 1-HIGH $I_{CC}$ |
| | VWHABB083A | 135 | 6415 | 0 | 0 | |
| | VWHABB083B | 135 | 4587 | 2 | 436 | 2-PARAMETRIC |
| Subtotals | | | 19,752 | 4 | 202 | |
| **Combined Totals** | | | **704,942** | **132** | **187** | |

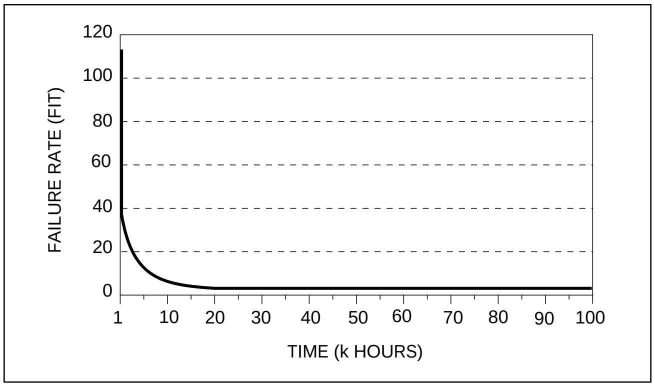

*Figure 10. Failure Rate at the Field (55°C for Metal-Gate CMOS Process)*

**TABLE 3. LIFE TEST RESULT OF MAXIM PRODUCTS FOR EACH PROCESS (Combined Test Conditions: 135°C and 1000 Hrs.)**

| PROCESS | SAMPLE SIZE | REJECTS | FIT@ 25°C | FIT@ 55°C |
|---|---|---|---|---|
| SMG | 2250 | 0 | 0.09 | 1.59 |
| MV1 | 385 | 0 | 0.54 | 9.23 |
| MV2 | 467 | 0 | 0.45 | 7.68 |
| SG3 | 1602 | 0 | 0.13 | 2.24 |
| SG5 | 846 | 1 | 0.54 | 9.36 |
| SG1.2 | 1618 | 2 | 0.28 | 4.89 |
| BIP | 1799 | 1 | 0.26 | 4.4 |
| Total | 8967 | 4 | 0.13 | 2.3 |

**TABLE 4. LIFE TEST DATA SUMMARY**

| PRODUCT FAMILY | NUMBER OF LOTS | NUMBER OF FAILURES | TOTAL UNITS TESTED | DEGREE OF FREEDOM | $X^2$ 60% VALUE | $X^2$ 90% VALUE | FIT @ 25°C | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 60% CONF. LEVEL | 90% CONF. LEVEL |
| Converters (Note 1) | 73 | 11 | 5399 | 24 | 24.7 | 32.5 | 1.21 | 1.60 |
| Linear (Note 2) | 251 | 46 | 19,530 | 94 | 96.4 | 111.3 | 1.31 | 1.51 |
| Timers/Counters/ Display Drivers | 3 | 0 | 240 | 2 | 1.38 | 3.62 | 1 .52 | 4.0 |
| Sum Total of All Product Lots | 327 | 57 | 25,169 | 116 | 118.8 | 135.3 | 1.25 | 1.42 |

**Note 1:** *A/D Converters, D/A Converters*

**Note 2:** *Voltage References, Operational Amplifiers, Power-Supply Circuits, Interface, Filters, Analog Switches, and Multiplexers*

Table 3's data summarizes the reliability effect of production burn-in. Essentially, only four units out of 8,967 were found to be outside the specification after 1000 hrs of operation at 135°C. This is equal to an FIT rate of 0.13 at 25°C.

In comparison, the Infant Mortality rate is equal to 132 units out of 704,942 after 12 hrs at 135°C, which has an equivalent FIT rate of approximately 0.794. In practical terms, 0.019%/six years (or 0.003%/year) of the total population would be found as defective through the first six years of operation, with an additional 0.009%/year failing over the remaining life of the product.

### *Life Test at 135°C*

Life Test is performed using biased conditions that simulate a real-world application. This test estimates the product's field performance. It establishes the constant failure-rate level and identifies any early wearout mechanisms. The tested product is kept in a controlled, elevated-temperature environment, typically at 135°C. This test can detect design, manufacturing, silicon, contamination, metal integrity, and assembly-related defects.

| | |
|---|---|
| Test Used: | High-Temperature Life and Dynamic Life Test (DLT) |
| Test Conditions: | 135°C, 1000 hrs., inputs fed by clock drivers at 50% duty cycle |
| Failure Criteria: | Must meet data sheet specifications |
| Results: | See Tables 5–11 |

### *Humidity Test*

The most popular integrated circuit (IC) packaging material is plastic. Plastic packages are not hermetic; therefore, moisture and other contaminants can enter the package. Humidity testing measures the contaminants present and the product's resistance to ambient conditions. Contaminants can be introduced during both wafer fabrication and assembly, and they can negatively affect product performance. Pressure Pot, 85/85, and HAST tests are used for this evaluation.

### *85/85 Test*

Maxim tests plastic-encapsulated products with an 85/85 test to determine the moisture resistance capability of our products under bias conditions. This test can detect the failure mechanisms found in Life Test. In addition, it can detect electrolytic and chemical corrosion.

| | |
|---|---|
| Test Used: | 85/85 |
| Test Conditions: | 85°C, 85% Relative Humidity, biased,1000 hrs. |
| Failure Criteria: | Must meet all data sheet parameters |
| Results: | See Table 12 |

### *Pressure Pot Test*

This test simulates a product's exposure to atmospheric humidity, which can be present during both wafer fabrication and assembly. Although an IC is covered with a nearly hermetic passivation layer (upper-surface coat), the bond pads must be exposed during bonding. Pressure Pot testing quickly determines if a potentially corrosive contaminant is present.

| | |
|---|---|
| Test Used: | Pressure Pot |
| Test Conditions: | 121°C, 100% RH, no bias, 168 hrs. |
| Failure Criteria: | Any opened bond or visual evidence of corrosion |
| Results: | See Table 13 |

### *HAST Test*

Highly Accelerated Steam and Temperature (HAST) testing is quickly replacing 85/85 testing. It serves the same basic function as 85/85 in typically 10% of the time, making HAST tests useful for immediate feedback and corrective action.

| | |
|---|---|
| Test Used: | HAST |
| Test Conditions: | 120°C, 85% RH, biased,100 hrs. |
| Failure Criteria: | Must meet all data sheet specifications |
| Results: | See Table 14 |

### *Temperature Cycling Test*

This test measures a component's response to temperature changes and its construction quality. The test cycles parts through a predetermined temperature range (usually -65°C to +150°C). Both fabrication and assembly problems can be discovered using Temperature Cycling, but the test typically identifies assembly quality.

| | |
|---|---|
| Test Used: | Temperature Cycling |
| Test Conditions: | -65°C to +150°C, 1000 cycles |
| Failure Criteria: | Must meet all data sheet specifications |
| Results: | See Table 15 |

### *High-Temperature Storage Life Test*

This test evaluates changes in a product's performance after being stored for a set duration (1000 hrs.) at a high temperature (150°C). It is only useful for failure mechanisms accelerated by heat.

| | |
|---|---|
| Test Used: | High-Temperature Storage Life |
| Test Conditions: | 150°C, 1000 hrs. unbiased |
| Failure Criteria: | Must meet all data sheet specifications |
| Results: | See Table 16 |

## ***Hybrid Products Reliability Data***

Maxim's hybrid product reliability data is presented in Tables 17 and 18. Table 17 is the Life Test data for products tested in 1996. Table 18 is the Temperature Cycling test data for hybrid products.

## ***Process Variability Control***

Reliability testing offers little value if the manufacturing process varies widely. A standard assumption, which is often false, is that test samples pulled from production are representative of the total population. Sample variability can be lessened by increasing the number of samples pulled. However, unless a process is kept "in control," major variations can invalidate reliability test results, leading to incorrect conclusions and diminishing the integrity of failure-rate estimates. Uncontrolled processes also make it difficult to prove failure rates of less than 10 FIT.

Maxim monitors the stability of critical process parameters through the use of computerized Statistical Process Control (SPC). Over 125 charts are monitored in-line during wafer production. Additionally, over 100 process parameters are monitored at Wafer Acceptance. Maxim has a target Capability Coefficient (Cpk) goal of 1.5, which is equivalent to 7ppm. In addition to SPC, Maxim uses Design of Experiments (DOE) to improve process capability, optimize process targeting, and increase robustness.

## *Reliability Test Results*

### TABLE 5. LIFE TEST AT 135°C/1000 HRS. FOR THE METAL-GATE CMOS PROCESS (SMG)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 |
| MAX634 | 9551 | 8 PDIP | 77 | 0 | 0 | 0 |
| ICM7555 | 9551 | TO99 | 77 | 0 | 0 | 0 |
| MAX8211 | 9552 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX421 | 9552 | 14 PDIP | 77 | 0 | 0 | 0 |
| MAX232 | 9553 | 16 PDIP | 74 | 0 | 0 | 0 |
| MAX232 | 9602 | 16 WSO | 400 | 0 | 0 | 0 |
| MAX202E | 9603 | 16 PDIP | 75 | 0 | 0 | 0 |
| MAX8211 | 9612 | 8 SO | 77 | 0 | 0 | 0 |
| MAX232 | 9613 | 8 SO | 77 | 0 | 0 | 0 |
| MAX850 | 9616 | 16 PDIP | 78 | 0 | 0 | 0 |
| MAX202E | 9622 | 16 PDIP | 80 | 0 | 0 | 0 |
| MAX202E | 9623 | 16 PDIP | 80 | 0 | 0 | 0 |
| MAX850 | 9623 | 8 SO | 77 | 0 | 0 | 0 |
| MAX8211 | 9624 | 8 SO | 77 | 0 | 0 | 0 |
| MAX232 | 9626 | 16 PDIP | 74 | 0 | 0 | 0 |
| MAX211E | 9627 | 28 SSOP | 65 | 0 | 0 | 0 |
| MAX211E | 9631 | 28 SSOP | 80 | 0 | 0 | 0 |
| MAX8212 | 9633 | 8 SO | 77 | 0 | 0 | 0 |
| MAX232 | 9634 | 16 PDIP | 80 | 0 | 0 | 0 |
| MAX850 | 9635 | 8 SO | 80 | 0 | 0 | 0 |
| MAX211 | 9635 | 28 SSOP | 76 | 0 | 0 | 0 |
| MAX844 | 9636 | 8 SO | 79 | 0 | 0 | 0 |
| MAX232 | 9638 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX667 | 9640 | 8 PDIP | 80 | 0 | 0 | 0 |
| MAX654 | 9641 | 14 PDIP | 79 | 0 | 0 | 0 |
| Totals | | | 2250 | 0 | 0 | 0 |

**Note:** *Products included in this Life Test data are: A/D Converters, Operational Amplifiers, Power-Supply Circuits, Interface, and Display Drivers/Counters.*

### TABLE 6. LIFE TEST AT 135°C/1000 HRS. FOR THE MEDIUM-VOLTAGE METAL-GATE CMOS PROCESS (MV1)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 |
| DG201 | 9612 | 16 PDIP | 74 | 0 | 0 | 0 |
| DG302 | 9626 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX359 | 9637 | 16 PDIP | 80 | 0 | 0 | 0 |
| DG509 | 9638 | 16 PDIP | 77 | 0 | 0 | 0 |
| DG301 | 9638 | 16 PDIP | 77 | 0 | 0 | 0 |
| Totals | | | 385 | 0 | 0 | 0 |

**Note:** *Products included in this Life Test data are: Analog Switches and Analog Multiplexers.*

### TABLE 7. LIFE TEST AT 135°C/1000 HRS. FOR THE MEDIUM-VOLTAGE SILICON-GATE CMOS PROCESS (MV2)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 |
| DG411 | 9553 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX305 | 9611 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX303 | 9626 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX319 | 9637 | 8 SO | 79 | 0 | 0 | 0 |
| MAX303 | 9637 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX333 | 9638 | 20 PDIP | 80 | 0 | 0 | 0 |
| Totals | | | 467 | 0 | 0 | 0 |

### TABLE 8. LIFE TEST AT 135°C/1000 HRS. FOR THE 3µm SILICON-GATE CMOS PROCESS (SG3)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 |
| MAX708 | 9551 | 8 PDIP | 79 | 0 | 0 | 0 |
| MAX706 | 9552 | 8 PDIP | 76 | 0 | 0 | 0 |
| MXD1210 | 9606 | 8 PDIP | 79 | 0 | 0 | 0 |
| MAX4501 | 9611 | 8 PDIP | 78 | 0 | 0 | 0 |
| MAX4502 | 9611 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX3222 | 9613 | 18 PDIP | 80 | 0 | 0 | 0 |
| MAX707 | 9613 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX4503 | 9615 | 8 PDIP | 70 | 0 | 0 | 0 |
| MAX4504 | 9615 | 8 PDIP | 70 | 0 | 0 | 0 |
| MAX4514 | 9615 | 8 PDIP | 79 | 0 | 0 | 0 |
| MAX4516 | 9615 | 8 PDIP | 70 | 0 | 0 | 0 |
| MAX4517 | 9615 | 8 PDIP | 50 | 0 | 0 | 0 |
| MAX4518 | 9615 | 14 PDIP | 79 | 0 | 0 | 0 |
| MAX4519 | 9615 | 14 PDIP | 79 | 0 | 0 | 0 |
| MAX4515 | 9616 | 8 PDIP | 80 | 0 | 0 | 0 |
| MAX797 | 9616 | 16 SO | 77 | 0 | 0 | 0 |
| MAX785 | 9623 | 28 SSOP | 65 | 0 | 0 | 0 |
| MAX782 | 9624 | 36 SSOP | 65 | 0 | 0 | 0 |
| MAX797 | 9624 | 16 SO | 80 | 0 | 0 | 0 |
| MAX705 | 9626 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX785 | 9630 | 28 SSOP | 38 | 0 | 0 | 0 |
| MAX706 | 9640 | 8 PDIP | 77 | 0 | 0 | 0 |
| Totals | | | 1602 | 0 | 0 | 0 |

### TABLE 9. LIFE TEST AT 135°C/1000 HRS. FOR THE 5µm SILICON-GATE CMOS PROCESS (SG5)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | | NOTES |
|---|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 | |
| MAX232A | 9552 | 16 PDIP | 77 | 0 | 0 | 0 | |
| TSC427 | 9606 | 8 PDIP | 80 | 0 | 0 | 0 | |
| MAX528 | 9607 | 18 PDIP | 221 | 1 | 0 | 0 | Gate oxide defect |
| MAX232A | 9613 | 16 PDIP | 77 | 0 | 0 | 0 | |
| MX7534 | 9619 | 20 PDIP | 79 | 0 | 0 | 0 | |
| MAX232A | 9619 | 16 PDIP | 79 | 0 | 0 | 0 | |
| MAX232A | 9629 | 16 PDIP | 77 | 0 | 0 | 0 | |
| MAX232A | 9639 | 16 PDIP | 76 | 0 | 0 | 0 | |
| MAX232A | 9648 | 16 PDIP | 80 | 0 | 0 | 0 | |
| Totals | | | 846 | 1 | 0 | 0 | |

**Note:** *Products included in this Life Test data are: A/D Converters, D/A Converters, Interface, and Switched Capacitor Filters.*

### TABLE 10. LIFE TEST AT 135°C/1000 HRS. FOR THE 1.2µm SILICON-GATE CMOS PROCESS (SG1.2)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | | NOTES |
|---|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 | |
| MAX619 | 9546 | 8 SO | 77 | 0 | 0 | 0 | |
| MAX619 | 9548 | 8 SO | 77 | 0 | 0 | 0 | |
| MAX7219 | 9553 | 24 PDIP | 77 | 0 | 0 | 0 | |
| MAX7219 | 9601 | 24 PDIP | 77 | 0 | 0 | 0 | |
| MAX8864S | 9601 | 5 SOT23 | 69 | 0 | 0 | 0 | |
| MAX8864T | 9602 | 5 SOT23 | 68 | 0 | 0 | 0 | |
| MAX8863T | 9602 | 5 SOT23 | 58 | 0 | 0 | 0 | |
| MAX811L | 9604 | 8 PDIP | 79 | 0 | 0 | 0 | |
| MAX1600 | 9613 | 28 SSOP | 77 | 0 | 0 | 1 | Mask defect |
| MAX8864S | 9621 | 5 SOT23 | 68 | 0 | 0 | 0 | |
| MAX8863T | 9622 | 5 SOT23 | 58 | 0 | 0 | 0 | |
| MAX1247 | 9624 | 16 PDIP | 51 | 0 | 0 | 0 | |
| MAX7219 | 9630 | 24 PDIP | 80 | 0 | 0 | 0 | |
| MAX7219 | 9633 | 24 PDIP | 80 | 0 | 0 | 0 | |
| MAX1600 | 9633 | 28 SSOP | 75 | 0 | 0 | 0 | |
| MAX1604 | 9640 | 28 SSOP | 77 | 0 | 0 | 0 | |
| MAX7219 | 9641 | 24 PDIP | 79 | 0 | 0 | 0 | |
| MAX7219 | 9642 | 24 PDIP | 77 | 0 | 0 | 0 | |
| MAX7219 | 9643 | 24 PDIP | 80 | 0 | 0 | 0 | |
| MAX7219 | 9644 | 24 PDIP | 77 | 0 | 0 | 0 | |
| MAX7219 | 9645 | 24 PDIP | 77 | 0 | 0 | 0 | |
| MAX7219 | 9646 | 24 PDIP | 80 | 1 | 0 | 0 | Threshold shift |
| Totals | | | 1618 | 1 | 0 | 1 | |

### TABLE 11. LIFE TEST AT 135°C/1000 HRS. FOR THE BIPOLAR PROCESS (BIPOLAR)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | | NOTES |
|---|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 | |
| MX580 | 9549 | TO52 | 77 | 0 | 0 | 0 | |
| MAX477 | 9601 | 8 PDIP | 79 | 0 | 0 | 0 | |
| MXL1013 | 9603 | 8 PDIP | 80 | 0 | 0 | 0 | |
| MAX400 | 9604 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX471 | 9607 | 8 SO | 45 | 0 | 0 | 0 | |
| REF02 | 9608 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX471 | 9609 | 8 PDIP | 80 | 0 | 0 | 0 | |
| MAX724 | 9612 | TO220 | 80 | 0 | 0 | 0 | |
| MAX872 | 9612 | 8 PDIP | 76 | 0 | 0 | 0 | |
| MAX4111 | 9613 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX471 | 9614 | 8 PDIP | 80 | 0 | 0 | 0 | |
| MXL1013 | 9618 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX675 | 9618 | 8 PDIP | 77 | 0 | 0 | 0 | |
| REF02 | 9621 | 8 PDIP | 75 | 0 | 0 | 0 | |
| REF02 | 9623 | 8 PDIP | 73 | 0 | 0 | 0 | |
| MAX872 | 9624 | 8 PDIP | 80 | 0 | 0 | 0 | |
| MAX471 | 9625 | 8 PDIP | 73 | 1 | 0 | 0 | Lifted bond |
| MAX492 | 9627 | 8 PDIP | 80 | 0 | 0 | 0 | |
| MX636 | 9631 | 14 PDIP | 80 | 0 | 0 | 0 | |
| MAX4102 | 9637 | 8 SO | 79 | 0 | 0 | 0 | |
| REF02 | 9638 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MXL1001 | 964 | 18 PDIP | 20 | 0 | 0 | 0 | |
| Totals | | | 1799 | 1 | 0 | 0 | |

**Note:** *Products included in this Life Test data are: Voltage References and Operational Amplifiers.*

### TABLE 12. TEMPERATURE AND HUMIDITY (85/85) TEST RESULTS

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | | NOTES |
|---|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 | |
| MAX619 | 9546 | 8 PDIP | 73 | 0 | 0 | 0 | |
| MAX921 | 9547 | 8 SO | 39 | 0 | 0 | 0 | |
| MAX619 | 9548 | 8 PDIP | 74 | 0 | 0 | 0 | |
| REF01 | 9550 | 8 SO | 77 | 0 | 0 | 0 | |
| DG411 | 9553 | 16 PDIP | 77 | 0 | 0 | 0 | |
| MAX8211 | 9552 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX706 | 9552 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX7219 | 9553 | 24 PDIP | 44 | 0 | 0 | 0 | |
| MAX478 | 9548 | 8 SO | 42 | 0 | 0 | 0 | |
| MAX202E | 9604 | 16 WSO | 26 | 0 | 0 | 0 | |
| MAX7219 | 9601 | 24 PDIP | 45 | 0 | 0 | 0 | |
| MAX400 | 9604 | 8 PDIP | 45 | 0 | 0 | 0 | |
| MAX471 | 9607 | 8 SO | 45 | 0 | 0 | 0 | |
| REF02 | 9608 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX707 | 9613 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX305 | 9611 | 16 PDIP | 77 | 0 | 0 | 1 | Leakage |
| MAX8211 | 9612 | 8 SO | 77 | 0 | 0 | 0 | |
| MAX675 | 9618 | 8 PDIP | 45 | 0 | 0 | 0 | |
| MAX1247 | 9624 | 16 PDIP | 77 | 0 | 0 | 0 | |
| REF02 | 9623 | 8 PDIP | 45 | 0 | 0 | 0 | |
| MAX705 | 9626 | 8 PDIP | 77 | 0 | 0 | 0 | |
| MAX303 | 9626 | 16 PDIP | 77 | 0 | 0 | 1 | High bias current |
| MAX8211 | 9624 | 8 SO | 76 | 0 | 0 | 0 | |
| MAX8212 | 9636 | 8 SO | 38 | 0 | 0 | 0 | |
| MAX692 | 9637 | 8 SO | 45 | 0 | 0 | 0 | |
| MAX8212 | 9633 | 8 SO | 77 | | | 0 | |
| MAX706 | 9640 | 8 PDIP | 77 | | | 0 | |
| MAX303 | 9637 | 16 PDIP | 72 | | | 0 | |
| REF02 | 9638 | 8 PDIP | 45 | | | 0 | |
| Totals | | | 1800 | 0 | 0 | 2 | |

### TABLE 13. PRESSURE POT TEST AT 121°C/100% RH 15 PSIG/168 HRS. (ALL PLASTIC PACKAGES)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) 168 | NOTES |
|---|---|---|---|---|---|
| MX7574 | 9528 | 16 PDIP | 45 | 0 | |
| MAX619 | 9546 | 8 SO | 45 | 0 | |
| MAX619 | 9548 | 8 SO | 45 | 0 | |
| MAX478 | 9548 | 8 SO | 43 | 0 | |
| MAX246 | 9549 | 40 PDIP | 45 | 0 | |
| MAX245 | 9549 | 40 PDIP | 45 | 0 | |
| MAX247 | 9549 | 40 PDIP | 45 | 0 | |
| REF01 | 9550 | 8 SO | 36 | 0 | |
| MAX8211 | 9552 | 8 PDIP | 45 | 0 | |
| MAX706 | 9552 | 8 PDIP | 45 | 0 | |
| DG411 | 9553 | 16 PDIP | 45 | 0 | |
| MAX232 | 9553 | 16 PDIP | 45 | 0 | |
| MAX7219 | 9553 | 24 PDIP | 45 | 0 | |
| DG303 | 9601 | 16 WSO | 45 | 0 | |
| MAX726 | 9601 | TO220 | 20 | 0 | |
| MAX7219 | 9601 | 24 PDIP | 45 | 0 | |
| MAX1600 | 9601 | 28 SSOP | 45 | 0 | |
| MAX232 | 9602 | 16 WSO | 76 | 0 | |
| MAX8863T | 9602 | 5 SOT23 | 60 | 0 | |
| MAX8864S | 9602 | 5 SOT23 | 53 | 0 | |
| MAX202E | 9603 | 16 PDIP | 45 | 0 | |
| MAX400 | 9604 | 8 PDIP | 45 | 0 | |
| MAX811L | 9604 | 8 PDIP | 45 | 0 | |
| MAX471 | 9604 | 8 SO | 77 | 0 | |
| MAX850 | 9607 | 8 SO | 77 | 0 | |
| MAX232A | 9608 | 16 PDIP | 45 | 0 | |
| MAX850 | 9611 | 8 SO | 77 | 0 | |
| MAX8211 | 9611 | 8 SO | 42 | 0 | |
| MAX809L | 9611 | 3 SOT23 | 43 | 0 | |
| MAX8864T | 9612 | 5 SOT23 | 59 | 0 | |
| MAX305 | 9612 | 16 PDIP | 45 | 0 | |
| MAX471 | 9612 | 8 PDIP | 77 | 0 | |
| MAX872 | 9612 | 8 PDIP | 77 | 0 | |
| MAX786 | 9612 | 28 SSOP | 45 | 0 | |
| REF02 | 9613 | 8 PDIP | 45 | 0 | |
| MAX232 | 9613 | 16 PDIP | 45 | 0 | |
| MAX707 | 9613 | 8 PDIP | 45 | 0 | |
| DG201 | 9613 | 16 PDIP | 45 | 0 | |
| MAX809L | 9613 | 3 SOT23 | 45 | 0 | |
| MAX724 | 9614 | TO220 | 77 | 0 | |
| MAX809L | 9614 | 3 SOT23 | 44 | 0 | |
| MAX243 | 9615 | 16 SO | 45 | 0 | |
| MXL1013 | 9618 | 8 PDIP | 45 | 0 | |
| MAX675 | 9618 | 8 PDIP | 45 | 0 | |
| MAX243 | 9621 | 16 SO | 44 | 0 | |
| MAX511 | 9621 | 14 SO | 73 | 0 | |
| REF02 | 9621 | 8 PDIP | 77 | 0 | |
| MAX8864S | 9621 | 5 SOT23 | 77 | 0 | |
| MAX8863T | 9622 | 5 SOT23 | 77 | 0 | |
| MAX4501 | 9622 | 5 SOT23 | 72 | 0 | |
| REF02 | 9623 | 8 PDIP | 45 | 0 | |
| MAX1247 | 9624 | 16 PDIP | 25 | 0 | |
| MAX8211 | 9624 | 8 SO | 45 | 0 | |
| MAX872 | 9624 | 8 PDIP | 76 | 0 | |
| MAX471 | 9625 | 8 PDIP | 77 | 0 | |
| MAX232A | 9626 | 16 SO | 45 | 0 | |

### TABLE 13 *(continued)*

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) 168 | NOTES |
|---|---|---|---|---|---|
| MAX232 | 9626 | 16 PDIP | 45 | 0 | |
| MAX705 | 9626 | 8 PDIP | 45 | 0 | |
| DG302 | 9626 | 16 PDIP | 45 | 0 | |
| MAX303 | 9626 | 16 PDIP | 45 | 0 | |
| MAX809L | 9626 | 3 SOT23 | 45 | 0 | |
| MAX492 | 9627 | 8 PDIP | 77 | 0 | |
| MAX1630 | 9627 | 28 SSOP | 45 | 0 | |
| MAX211E | 9627 | 28 SSOP | 45 | 0 | |
| MAX809L | 9628 | 3 SOT23 | 45 | 0 | |
| MAX232A | 9629 | 16 PDIP | 45 | 0 | |
| MAX232A | 9630 | 16 SO | 42 | 0 | |
| MAX7219 | 9630 | 24 PDIP | 77 | 0 | |
| MAX620 | 9633 | 18 PDIP | 77 | 0 | |
| MAX734 | 9633 | 8 SO | 77 | 0 | |
| MAX8212 | 9633 | 8 SO | 45 | 0 | |
| MAX203 | 9635 | 20 WSO | 45 | 0 | |
| MAX211 | 9635 | 28 SSOP | 77 | 0 | |
| MX7226 | 9636 | 20 WSO | 77 | 0 | |
| MAX487 | 9636 | 8 PDIP | 77 | 0 | |
| MAX8212 | 9636 | 8 SO | 45 | 0 | |
| MAX232 | 9636 | 16 PDIP | 77 | 0 | |
| MAX488 | 9636 | 8 SO | 45 | 0 | |
| DG301 | 9636 | 16 PDIP | 45 | 0 | |
| MAX692A | 9637 | 8 SO | 45 | 0 | |
| MAX519 | 9637 | 16 SO | 77 | 0 | |
| MAX203 | 9637 | 20 WSO | 45 | 0 | |
| MAX303 | 9637 | 16 PDIP | 45 | 0 | |
| MAX797 | 9638 | 16 SO | 77 | 0 | |
| MAX232 | 9638 | 16 PDIP | 45 | 0 | |
| REF02 | 9638 | 8 PDIP | 45 | 0 | |
| MAX232A | 9639 | 16 PDIP | 45 | 0 | |
| MAX492 | 9639 | 8 PDIP | 77 | 1 | High input offset voltage |
| MAX817L | 9639 | 8 PDIP | 77 | 0 | |
| MAX1604 | 9640 | 28 SSOP | 77 | 0 | |
| MAX232A | 9640 | 16 SO | 45 | 0 | |
| MAX706 | 9640 | 8 PDIP | 45 | 0 | |
| MAX1604 | 9640 | 28 SSOP | 77 | 0 | |
| MAX782 | 9641 | 36 SSOP | 80 | 0 | |
| MAX7219 | 9642 | 24 PDIP | 77 | 0 | |
| MAX797 | 9642 | 16 SO | 77 | 0 | |
| MAX7219 | 9643 | 24 PDIP | 77 | 0 | |
| MAX7219 | 9644 | 24 PDIP | 77 | 0 | |
| MAX235 | 9644 | 24 PDIP | 77 | 0 | |
| MAX211 | 9644 | 28 SSOP | 77 | 0 | |
| MAX7219 | 9645 | 24 PDIP | 77 | 0 | |
| MAX203 | 9645 | 20 PDIP | 77 | 1 | Capacitor open |
| MAX235 | 9645 | 24 PDIP | 77 | 0 | |
| MAX235 | 9646 | 24 PDIP | 77 | 0 | |
| MAX7219 | 9646 | 24 PDIP | 45 | 0 | |
| MAX233 | 9646 | 20 DIP | 77 | 0 | |
| MAX233A | 9649 | 20 WSO | 77 | 0 | |
| MAX233A | 9650 | 20 WSO | 77 | 0 | |
| Totals | | | 6167 | 2 | |

### TABLE 14. HAST TEST RESULTS 120°C/85% RH/BIASED/100 HRS.

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) 100 | NOTES |
|---|---|---|---|---|---|
| MAX8864S | 9601 | 5 SOT23 | 24 | 0 | |
| MAX232 | 9602 | 16 WSO | 25 | 0 | |
| MAX8864T | 9602 | 5 SOT23 | 25 | 0 | |
| MAX8863T | 9602 | 5 SOT23 | 25 | 0 | |
| MAX811 | 9604 | 8 PDIP | 25 | 0 | |
| MX636 | 9607 | 16 WSO | 25 | 0 | |
| MX636 | 9611 | 14 PDIP | 25 | 0 | |
| DG201 | 9612 | 16 PDIP | 25 | 0 | |
| MAX724 | 9612 | TO220 | 25 | 0 | |
| MAX872 | 9612 | 8 PDIP | 25 | 0 | |
| MAX471 | 9614 | 8 PDIP | 25 | 0 | |
| MAX786 | 9617 | 28 SSOP | 25 | 0 | |
| MAX4123 | 9618 | 8 SO | 25 | 0 | |
| MAX4125 | 9620 | 8 SO | 25 | 0 | |
| MAX202 | 9620 | 16 WSO | 25 | 0 | |
| MAX8864S | 9621 | 5 SOT23 | 25 | 0 | |
| MAX8863T | 9622 | 5 SOT23 | 25 | 0 | |
| MAX4501 | 9622 | 5 SOT23 | 25 | 0 | |
| MAX872 | 9624 | 8 PDIP | 25 | 0 | |
| MAX471 | 9625 | 8 PDIP | 25 | 0 | |
| MAX235 | 9626 | 24 PDIP | 25 | 0 | |
| MAX492 | 9627 | 8 PDIP | 23 | 0 | |
| MAX211E | 9627 | 28 SSOP | 25 | 0 | |
| MAX232A | 9629 | 16 PDIP | 25 | 0 | |
| MAX233A | 9629 | 20 PDIP | 25 | 0 | |
| MAX203 | 9635 | 20 WSO | 25 | 0 | |
| MAX211 | 9635 | 28 SSOP | 25 | 0 | |
| MAX488 | 9636 | 8 SO | 25 | 0 | |
| MAX203 | 9637 | 20 WSO | 25 | 1 | Capacitor open |
| MAX232 | 9638 | 16 PDIP | 25 | 0 | |
| MAX232A | 9639 | 16 PDIP | 25 | 0 | |
| MAX203 | 9640 | 20 WSO | 25 | 0 | |
| MAX235 | 9644 | 24 PDIP | 25 | 0 | |
| MAX7219 | 9645 | 24 PDIP | 25 | 0 | |
| MAX235 | 9645 | 24 PDIP | 25 | 0 | |
| MAX235 | 9646 | 24 PDIP | 25 | 0 | |
| MAX7219 | 9646 | 24 PDIP | 24 | 0 | |
| MAX233A | 9651 | 20 WSO | 25 | 0 | |
| Totals | | | 946 | 1 | |

### TABLE 15. TEMPERATURE CYCLING -65°C TO +150°C 1000 CYCLES (ALL PACKAGE TYPES)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 168 | 168 | 168 |
| MAX619 | 9546 | 8 SO | 74 | 0 | 0 | 0 |
| MAX619 | 9548 | 8 SO | 75 | 0 | 0 | 0 |
| MAX478 | 9548 | 8 SO | 45 | 0 | 0 | 0 |
| MX580 | 9549 | TO52 | 45 | 0 | 0 | 0 |
| REF01 | 9550 | 8 SO | 77 | 0 | 0 | 0 |
| ICM7555 | 9551 | TO99 | 45 | 0 | 0 | 0 |
| MAX8211 | 9552 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX232A | 9552 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX706 | 9552 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX421 | 9552 | 14 PDIP | 45 | 0 | 0 | 0 |
| DG411 | 9553 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX203 | 9553 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX7219 | 9553 | 24 PDIP | 45 | 0 | 0 | 0 |
| DG303 | 9601 | 16 WSO | 77 | 0 | 0 | 0 |
| MAX7219 | 9601 | 24 PDIP | 45 | 0 | 0 | 0 |
| MAX8864S | 9601 | 5 SOT23 | 47 | 0 | 0 | 0 |
| MAX232 | 9602 | 16 WSO | 77 | 0 | 0 | 0 |
| MAX8864T | 9602 | 5 SOT23 | 44 | 0 | 0 | 0 |
| MAX8863T | 9602 | 5 SOT23 | 60 | 0 | 0 | 0 |
| MAX202E | 9603 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX202E | 9604 | 16 WSO | 44 | 0 | 0 | 0 |
| MAX400 | 9604 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX811L | 9604 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX471 | 9607 | 8 SO | 45 | 0 | 0 | 0 |
| REF02 | 9608 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX305 | 9611 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX809L | 9611 | 3 SOT23 | 44 | 0 | 0 | 0 |
| DG201 | 9612 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX8211 | 9612 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX724 | 9612 | TO220 | 77 | 0 | 0 | 0 |
| MAX872 | 9612 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX232A | 9613 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX232 | 9613 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX707 | 9613 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX471 | 9614 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX809L | 9614 | 3 SOT23 | 44 | 0 | 0 | 0 |
| MXL1013 | 9618 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX675 | 9618 | 8 PDIP | 44 | 0 | 0 | 0 |
| REF02 | 9621 | 8 PDIP | 44 | 0 | 0 | 0 |
| MAX8864S | 9621 | 5 SOT23 | 72 | 0 | 0 | 0 |
| MAX8863T | 9622 | 5 SOT23 | 77 | 0 | 0 | 0 |
| MAX4501 | 9622 | 5 SOT23 | 67 | 0 | 0 | 0 |
| REF02 | 9623 | 8 PDIP | 44 | 0 | 0 | 0 |
| MAX1247 | 9624 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX8211 | 9624 | 8 SO | 77 | 0 | 0 | 0 |
| MAX872 | 9624 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX471 | 9625 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX232 | 9626 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX705 | 9626 | 8 PDIP | 77 | 0 | 0 | 0 |
| DG302 | 9626 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX303 | 9626 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX492 | 9627 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX1630 | 9627 | 28 SSOP | 45 | 0 | 0 | 0 |
| MAX232A | 9629 | 16 PDIP | 77 | 0 | 0 | 0 |
| MX636 | 9631 | 14 PDIP | 77 | 0 | 0 | 0 |
| MAX8212 | 9633 | 8 SO | 77 | 0 | 0 | 0 |
| MAX211 | 9635 | 28 SSOP | 76 | 0 | 0 | 0 |
| MAX488 | 9636 | 8 SO | 45 | 0 | 0 | 0 |
| DG301 | 9636 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX692A | 9637 | 8 SO | 45 | 0 | 0 | 0 |
| MAX303 | 9637 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX232 | 9638 | 16 PDIP | 77 | 0 | 0 | 0 |
| REF02 | 9638 | 8 PDIP | 77 | 0 | 0 | 0 |
| MAX232A | 9639 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX492 | 9639 | 8 PDIP | 75 | 0 | 0 | 0 |
| MAX706 | 9640 | 8 DPIP | 77 | 0 | 0 | 0 |
| MAX7219 | 9644 | 24 PDIP | 45 | 0 | 0 | 0 |
| MAX7219 | 9645 | 24 PDIP | 45 | 0 | 0 | 0 |
| MAX7219 | 9646 | 24 PDIP | 45 | 0 | 0 | 0 |
| Totals | | | 4436 | 0 | 0 | 0 |

## TABLE 16. HIGH-TEMPERATURE STORAGE LIFE TEST 150°C/1000 HRS. (ALL PACKAGE TYPES)

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 |
| MAX3480 | 9538 | 28 PDIP | 45 | 0 | 0 | 0 |
| MAX619 | 9548 | 8 SO | 77 | 0 | 0 | 0 |
| MAX478 | 9548 | 8 SO | 43 | 0 | 0 | 0 |
| MX580 | 9549 | TO52 | 45 | 0 | 0 | 0 |
| REF01 | 9550 | 8 SO | 45 | 0 | 0 | 0 |
| MAX634 | 9551 | 8 PDIP | 45 | 0 | 0 | 0 |
| ICM7555 | 9551 | TO99 | 45 | 0 | 0 | 0 |
| MAX8211 | 9552 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX232A | 9552 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX706 | 9552 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX421 | 9552 | 14 PDIP | 45 | 0 | 0 | 0 |
| DG411 | 9553 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX232 | 9553 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX7219 | 9553 | 24 PDIP | 45 | 0 | 0 | 0 |
| DG303 | 9601 | 16 WSO | 45 | 0 | 0 | 0 |
| MAX7219 | 9601 | 24 PDIP | 45 | 0 | 0 | 0 |
| MAX8864S | 9601 | 5 SOT23 | 45 | 0 | 0 | 0 |
| MAX8864T | 9602 | 5 SOT23 | 44 | 0 | 0 | 0 |
| MAX8863T | 9602 | 5 SOT23 | 42 | 0 | 0 | 0 |
| MAX202E | 9603 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX202E | 9604 | 16 WSO | 45 | 0 | 0 | 0 |
| MAX400 | 9604 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX811L | 9604 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX471 | 9607 | 8 SO | 45 | 0 | 0 | 0 |
| REF02 | 9608 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX305 | 9611 | 16 PDIP | 43 | 0 | 0 | 0 |
| DG201 | 9612 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX8211 | 9612 | 8 SO | 45 | 0 | 0 | 0 |
| MAX724 | 9612 | TO220 | 45 | 0 | 0 | 0 |
| MAX872 | 9612 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX232A | 9613 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX232 | 9613 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX707 | 9613 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX471 | 9614 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX233A | 9617 | 20 WSO | 14 | 0 | 0 | 0 |
| MAX233A | 9618 | 20 WSO | 14 | 0 | 0 | 0 |
| MAX675 | 9618 | 8 PDIP | 45 | 0 | 0 | 0 |
| REF02 | 9621 | 8 PDIP | 44 | 0 | 0 | 0 |
| MAX8864S | 9621 | 5 SOT23 | 73 | 0 | 0 | 0 |
| MAX8863T | 9622 | 5 SOT23 | 42 | 0 | 0 | 0 |
| REF02 | 9623 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX8211 | 9624 | 8 SO | 45 | 0 | 0 | 0 |
| MAX872 | 9624 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX471 | 9625 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX705 | 9626 | 8 PDIP | 45 | 0 | 0 | 0 |
| DG302 | 9626 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX303 | 9626 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX492 | 9627 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX232A | 9629 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX8212 | 9633 | 8 SO | 45 | 0 | 0 | 0 |
| MAX203 | 9635 | 20 WSO | 45 | 0 | 0 | 0 |
| MAX211 | 9635 | 28 SSOP | 45 | 0 | 0 | 0 |
| DG301 | 9636 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX203 | 9637 | 20 WSO | 45 | 0 | 0 | 0 |
| MAX303 | 9637 | 16 PDIP | 41 | 0 | 0 | 0 |
| MAX232 | 9638 | 16 PDIP | 45 | 0 | 0 | 0 |
| REF02 | 9638 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX233 | 9638 | 20 PDIP | 45 | 0 | 0 | 0 |
| MAX232A | 9639 | 16 PDIP | 45 | 0 | 0 | 0 |
| MAX706 | 9640 | 8 PDIP | 45 | 0 | 0 | 0 |
| MAX203 | 9640 | 20 WSO | 45 | 0 | 0 | 0 |
| MAX233 | 9641 | 20 PDIP | 45 | 0 | 0 | 0 |
| MAX7219 | 9644 | 20 PDIP | 45 | 0 | 0 | 0 |
| MAX681 | 9644 | 14 PDIP | 77 | 0 | 0 | 0 |
| MAX235 | 9644 | 24 PDIP | 45 | 0 | 0 | 0 |

## TABLE 16 *(continued)*

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 |
| MAX211 | 9644 | 28 SSOP | 45 | 0 | 0 | 0 |
| MAX203 | 9644 | 20 PDIP | 45 | 0 | 0 | 0 |
| MAX203 | 9645 | 20 PDIP | 45 | 0 | 0 | 0 |
| MAX235 | 9645 | 24 PDIP | 45 | 0 | 0 | 0 |
| MAX235 | 9646 | 24 PDIP | 44 | 0 | 0 | 0 |
| MAX7219 | 9646 | 24 PDIP | 45 | 0 | 0 | 0 |
| MAX233 | 9646 | 20 PDIP | 45 | 0 | 0 | 0 |
| Totals | | | 3253 | 0 | 0 | 0 |

## TABLE 17. HYBRID PRODUCTS LIFE TEST 135°C/1000 HRS

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 192 | 500 | 1000 |
| MAX246 | 9549 | 40 PDIP | 75 | 0 | 0 | 0 |
| MAX245 | 9549 | 40 PDIP | 77 | 0 | 0 | 0 |
| MAX247 | 9549 | 40 PDIP | 75 | 0 | 0 | 0 |
| MAX233A | 9617 | 20 WSO | 63 | 0 | 0 | 0 |
| MAX233A | 9618 | 20 WSO | 63 | 0 | 0 | 0 |
| MAX203 | 9635 | 20 WSO | 77 | 0 | 0 | 0 |
| MAX233 | 9638 | 20 PDIP | 77 | 0 | 0 | 0 |
| MAX203 | 9640 | 20 WSO | 77 | 0 | 0 | 0 |
| MAX233 | 9641 | 20 PDIP | 77 | 0 | 0 | 0 |
| MAX681 | 9644 | 14 PDIP | 76 | 0 | 0 | 0 |
| MAX235 | 9644 | 24 PDIP | 77 | 0 | 0 | 0 |
| MAX203 | 9644 | 20 PDIP | 77 | 0 | 0 | 0 |
| MAX203 | 9645 | 20 PDIP | 76 | 0 | 0 | 0 |
| MAX235 | 9645 | 24 PDIP | 76 | 0 | 0 | 0 |
| MAX235 | 9646 | 24 PDIP | 77 | 0 | 0 | 0 |
| MAX233 | 9646 | 20 PDIP | 77 | 0 | 0 | 0 |
| Totals | | | 1197 | 0 | 0 | 0 |

## TABLE 18. HYBRID PRODUCTS TEMPERATURE CYCLING -65°C TO +150°C/1000 CYCLES

| DEVICE TYPE | DATE CODE | PKG. | SAMPLE SIZE | FAILURES (HRS) | | |
|---|---|---|---|---|---|---|
| | | | | 200 | 500 | 1000 |
| MAX3480 | 9538 | 28 PDIP | 45 | 0 | 0 | 0 |
| MAX252 | 9543 | 40 PDIP | 44 | 0 | 0 | 0 |
| MAX625 | 9544 | 24 PDIP | 45 | 0 | 0 | 0 |
| MAX246 | 9549 | 40 PDIP | 77 | 0 | 0 | 0 |
| MAX245 | 9549 | 40 PDIP | 75 | 0 | 0 | 0 |
| MAX247 | 9549 | 40 PDIP | 75 | 0 | 0 | 0 |
| MAX233A | 9617 | 20 WSO | 74 | 0 | 0 | 0 |
| MAX233A | 9618 | 20 WSO | 77 | 0 | 0 | 0 |
| MAX203 | 9635 | 20 WSO | 43 | 0 | 0 | 0 |
| MAX203 | 9637 | 20 WSO | 43 | 0 | 0 | 0 |
| MAX233 | 9638 | 20 PDIP | 77 | 0 | 0 | 0 |
| MAX203 | 9640 | 20 WSO | 45 | 0 | 0 | 0 |
| MAX233 | 9641 | 20 PDIP | 77 | 0 | 0 | 0 |
| MAX681 | 9644 | 16 PDIP | 77 | 0 | 0 | 0 |
| MAX235 | 9644 | 24 PDIP | 76 | 0 | 0 | 0 |
| MAX203 | 9644 | 20 PDIP | 77 | 0 | 0 | 0 |
| MAX203 | 9645 | 20 PDIP | 77 | 0 | 0 | 0 |
| MAX235 | 9645 | 24 PDIP | 77 | 0 | 0 | 0 |
| MAX235 | 9646 | 24 PDIP | 76 | 0 | 0 | 0 |
| MAX233 | 9646 | 20 PDIP | 77 | 0 | 0 | 0 |
| Totals | | | 1334 | 0 | 0 | 0 |

## *Appendix 1: Determining Acceleration Factor*

### *Definition of Terms*

An acceleration factor is a constant used in reliability prediction formulas that expresses the enhanced effect of temperature on a device’s failure rate. It is usually used to show the difference (or acceleration effect) between the failure rate at two temperatures. In simple terms, a statement such as, “The failure rate of these devices operating at 150°C is five-times greater than the failure rate at 25°C,” implies an acceleration factor of 5.

The acceleration factor used in the semiconductor industry is a result of the Arrhenius equation stated below:

Where:

$$\text{Acceleration Factor} = Ke^{\frac{Ea}{k}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

K = an experimentally determined constant

Ea = the activation energy

k = Boltzmann’s constant

$T_1$ = actual use temp. in degrees Kelvin

$T_2$ = test temp. in degrees Kelvin

### *How to Use the Arrhenius Equation*

The first step in using the Arrhenius equation given above is to determine an activation energy (Ea), which may be done in one of two ways.

The first method involves using failure analysis techniques to determine the actual failure mechanism. The activation energies for many failure mechanisms have already been determined, and tabulated in published literature. Although all processes are not exactly the same, the activation energy of a particular failure mechanism is mainly determined by physical principles. A published activation energy will not be the exact figure associated with a particular process, but it will be a very close approximation.

The dominant failure mechanisms in Maxim’s Life Tests have activation energies in the range of 0.8eV to 1.2eV. We have conservatively chosen 0.8eV for the purposes of computing the acceleration factors used in this report. Actual acceleration factors are probably greater than those quoted.

The second method of determining an activation energy is empirical. Two groups of devices are tested at different temperatures, and the difference between their failure rates is measured. An example is shown below:

Group 1 = 9822 failures after 100 hrs. of operation at 150°C.

Group 2 = 1 failure after 100 hrs. of operation at 25°C.

The acceleration factor for this particular failure mechanism between these two temperatures is, therefore, 9822.

Where:

$$9822 = e^{\frac{Ea}{k}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

Ea = the unknown activation energy

k = $8.63 \times 10^{-5}$eV/°K

$T_1$ = 25°C + 273°C or 298°K

$T_2$ = 150°C + 273°C or 423°K

Substituting:

$$9822 = e^{\frac{Ea}{8.63 \times 10^{-5}}\left(\frac{1}{298} - \frac{1}{423}\right)}$$

$$9822 = e^{Ea \times 11.49}$$

Taking the natural log of both sides:

$$\text{Log}_e 9822 = Ea \times 11.49$$

$$\frac{\text{Log}_e 9822}{11.49} = Ea$$

Therefore, Ea = 0.8eV

Assuming that this activation energy represents the dominant failure mechanism of the device under consideration, it may then be used to determine the acceleration factor between any two temperatures as follows:

Between 150°C and 70°C, for example:

$$\text{Acceleration Factor} = e^{\frac{0.8}{8.63 \times 10^{-5}}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

Where:

$T_1 = 70°C + 273°C = 343°K$
$T_2 = 150°C + 273°C = 423°K$

Substituting for $T_1 + T_2$ and solving for e yields the result:

Acceleration Factor = 165

The acceleration factor between 150°C and 70°C is 165.

## Appendix 2: Determining Failure Rate

### Definition of Terms

The Mean Time Between Failures (MTBF) is the average time it takes for a failure to occur. For example, assume a company tests 100 units for 1000 hrs. The total device-hours accrued would be 100 x 1000, or 100,000 device-hours. Now assume two units were found to be failures. Roughly, it could be said that the MTBF would equal:

$$\text{MTBF} = \frac{\text{Total Device Hrs.}}{\text{Total No. of Failures}} = \frac{100{,}000}{2} = 50{,}000 \text{ hrs.}$$

The Failure Rate (FR) is equal to the reciprocal of the MTBF, or:

$$\text{FR} = \frac{1}{\text{MTBF}} = \frac{1}{50{,}000} = 0.00002$$

If this number is multiplied by 1 x $10^5$, the failure rate in terms of percent per 1000 hrs. is obtained; i.e., 2%.

A common reliability term also used to express the failure rate is Failures-in-Time, or FIT. This is the number of failures per billion device-hours, and is obtained by dividing the Failure Rate by $10^{-9}$:

$$\frac{\text{FR}}{10^{-9}} = \text{FIT.}$$

Using the above example:

$$\begin{aligned} \text{FIT} &= 0.00002/10^{-9} \\ &= 20{,}000 \end{aligned}$$

The FIT rate is, therefore, shorthand for the number of units predicted to fail in a billion ($10^{-9}$) device-hours at the specified temperature.

### Calculating Failure Rates and FITs

The failure rate can be expressed in terms of the following four variables:

A = The number of failures observed after test
B = The number of hours the test was run
C = The number of devices used in the test
D = The temperature acceleration factor (see Appendix 1)

Using data in Table 2, a failure rate at 25°C can now be calculated:

A = 57
B = 192
C = 25,169
D = 9822 (Assuming Ea = 0.8eV, and a test temperature of 150°C)

Substituting:

$$\text{FR} = \frac{57}{192 \times 25{,}169 \times 9822} = 1.20 \times 10^{-9}$$

Expressing this in terms of the FIT rate:

FIT = 1.20

To determine the FIT rate at a new temperature, the acceleration factor (D) must be recalculated from the Arrhenius equation given in Appendix 1.

### Including Statistical Effects in the FIT Calculation

Because a small random sample is being chosen from each lot, the statistical effects are significant enough to mention. With most published failure rate figures, there is an associated confidence level number. This number expresses the confidence level that the actual failure rate of the lot will be equal to or lower than the predicted failure rate.

The failure rate calculation, including a confidence level, is determined as follows:

$$\text{FR} = \frac{X^2}{2DH}$$

Where:

$X^2$ = the Chi square value
2DH = 2 times the total device hours
= 2 x (B x C x D)

The Chi square value is based on a particular type of statistical distribution. However, all that is required to arrive at this value is knowing the number of failures. In this example, there were 57 failures. The Chi square value is found using a standard $X^2$ distribution table. The tabular values are found using the factors (1 - CL), where CL is the desired confidence level, and 2(N + 1) is the degree of freedom.

The value of (1 - CL) for a 60% confidence level is (1 - 0.60) = 0.40.

The number of degrees of freedom is 2(57 + 1) = 116.

The Chi square value found under the values of 0.40 and 116 degrees of freedom is 119.

Therefore, the failure rate found using a 60% confidence level is:

$$FR = \frac{119}{9.49 \times 10^{10}} = 1.25 \times 10^{-9}$$

Expressed as Failure-in-Time rate:

$$FIT = 1.25$$

Referring to Table 2, one can see that for Maxim's product, there is a 60% confidence level that no more than 1.25 units will fail per billion ($10^9$) device-hours of operation at 25°C.

NOTES

**NOTES**

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YEL SRL
(1) 372 7163
***Australia***
Veltek Australia Pty., Ltd.
(Victoria)
(03) 9574 9300
(Western Australia)
(08) 9472 3855
(New South Wales)
(02) 9745 1400
(Queensland)
(07) 3216 0770
(South Australia)
(08) 8232 3922
***Austria***
Maxim GmbH
(Germany)
0660-5954 (Toll Free)
***Belgium***
Master Chips
(02) 219 5862
***Brazil***
Intectra (U.S.A.)
(415) 967-8818
***Canada***
Maxim Integrated
Products
(Western)
1-800-241-4813
(Central)
1-800-416-7237
(Eastern)
1-800-416-7237
***Canada Distributors***
Arrow
(514) 421-7411
(613) 226-6903
(418) 871-7500
(416) 670-7769
(604) 421-2333
Bell/Milgray
(905) 678-0958
(514) 426-5900
(604) 291-0044
Hamilton Hallmark
(604) 420-4101
(416) 564-6060
(514) 335-1000
(613) 226-1700
***China***
Maxim China
(10) 620 10598
***China Distributor***
P & S
27 7493500-6
(Wuhan)
27 7862631
(Beijing)
10 62549897
(Shanghai)
21 64712494
(Shenzhen)
755 3245517
(Chengdu)
28 5575657
(Nanjing)
25 6618571
(Xi'an)
29 5214247
***Czech Republic***
Spezial-Electronic KG
42 2 24342200
***Denmark***
Arrow-Exatec A/S
44 92 70 00
98 64 11 11
***Finland***
Berendsen Components Oy
8 (0)9 4130 800
***France***
Maxim France
01 30 60 91 60
***France Distributors***
Maxim Distribution
0800 05 04 27
ASAP
01 30 12 20 20
***Germany***
Maxim GmbH
(0130) 827925 (Toll Free)
49 (089) 857 99-0
***Germany Distributors***
Maxim Distribution
(0130) 827925 (Toll Free)
49 (089) 857 99-0
Spezial-Electronic GmbH
(05722) 203-0
***Hong Kong***
Maxim Integrated
Products, Inc.
2376 3000
***India***
Sritech Information
Technology Pvt Ltd.
(Bangalore)
80-640661
(New Delhi)
11-6162313
(Pune)
212-541484
(Secunderabad)
7741623
(Trivandrum)
471-331376
***Ireland***
FMG Electronics
03-56-64002
***Israel***
Tritech, Ltd.
(09) 917 277
***Italy***
Maxim Italy
(039) 6058555
***Italy Distributor***
Esco Italiana Electronics
Supply
(02) 26 27 011
***Japan***
Maxim Japan Co., Ltd.
(03) 3232-6141
***Japan Distributors***
Easton Co., Ltd.
(03) 3279-1922
Internix, Inc.
(03) 3369-1101
Marubun Corp.
(03) 3639-0677
***Korea***
Maxim Korea
(02) 508 1170
***Mexico***
Hamilton Hallmark (USA)
1-(210) 412-2047
***Netherlands***
Koning En Hartman
(015) 2609906
***New Zealand***
Power Technology
Components Ltd.
00649 8366-744
***Norway***
Berendsen Electronics
22 08 85 00
***Poland***
Uniprod, Ltd.
(48) 32376459
***Portugal***
ADM Electronics, S.A.
(2) 9736957
***Russia***
Spezial-Electronic KG
(Moscow)
007/095-433-2582/83
007/095-438-7343/59
(St. Petersburg)
007/812-275-3860
***Singapore/Malaysia/ Thailand***
Maxim Integrated Products,
Inc. (Singapore)
841-7117
Electronic Resources Limited
(Singapore)
(65) 298-0888
Electronic Resources
(Thailand) Co., Ltd.
(Bangkok)
(66) 02 370 1280-90
Electronic Resources
(Malaysia) Sdn. Bhd.
(Petaling Jaya)
(60) 03-703 7274
Electronic Resources
(Malaysia) Sdn. Bhd.
(Penang)
(60) 04-656 2895
***South Africa***
Fairmont Electronics (Pty),
Ltd.
(011) 886 2920
***Spain***
Maxim Distribution
900 99 44 44 (Tel. gratuito)
ADM Electronics S.A.
1-5304121
***Sweden***
Egevo AB
(08) 795 9650
***Switzerland***
Laser & Electronics AG
(01) 947 50 70
***Taiwan***
Maxim Taiwan
(2) 2558-6801
***Turkey***
Interex (U.S.A.)
(415) 254-0627
***U.K.***
Maxim Integrated Products
(U.K.), Ltd.
0800 585 048 (Toll Free)
(0118) 9303388
***U.K. Distributors***
Maxim Distribution
(0118) 9303388
2001 Electronic Components
(01438) 742001
Eurodis HB Electronics
(01204) 555100
***Ukraine***
Spezial-Electronic KG
0038/044-290-04-21
0038/044-290-99-05