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DIODE

STEP STRESS TESTING PROGRAM

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FINAL REPORT
FOR
JANTX1N972B

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Prepared
For

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FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transisters, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the zener diode JANTX1N972B manufactured by Siemens and Motorola.

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-Speed Computer-Controlled Tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all the test devices during the power/temperature stress conditions. The voltage was set by V_Z and the current was varied in order to comply with the specified power rating for the device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were

subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power (MRP) for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot

failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Siemens. The Siemens sample lot completed the entire 2500 hours of Group I Testing with two catastrophic failures. The two failures occurred 50 hours into the 175% MRP step. Serial number 5010 failed the maximum ^{B}V limit. Serial number 5015 failed the minimum ^{B}V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for ^{I}R changed 459.8nA from an initial mean of 2.377nA to a final mean of 462.2nA.
2) The mean value for ^{B}V changed 190.0mV from an initial mean of 30.40V to a final mean of 39.59V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Motorola. The Motorola sample lot completed the entire 2500 hours of Group I Testing with one catastrophic failure. The failure occurred 50 hours into the 175% MRP step. Serial number 4962 failed the maximum ^{I}R and minimum ^{B}V limits. Typical characteristics of this sample lot's performance were:

1) The mean value for ^{I}R changed 5.585nA from an initial mean of 7.839nA to

a final mean of 2.254nA.

2) The mean value for ^{B}V changed 100.0mV from an initial mean of 30.20V to a final mean of 30.30V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I. Table 4 outlines the results of Group I - Power Stress Process for each of the electrical parameters and all measurement points for both Siemens and Motorola.

3.2 Group II - Temperature Stress I

3.2.1 Siemens. The Siemens sample lot completed the entire 1600 hours of Group II Testing with 13 catastrophic failure. The first failures occurred 160 hours into the 275°C-temperature step. Serial numbers 5017, 5019, 5020, 5022 and 5046 failed the maximum ^{I}R and minimum ^{B}V limits. The last failures occurred 160 hours into the 300°C-temperature step. Serial numbers 5018, 5021, 5023, 5044, 5045, 5048, 5049 and 5050 failed the maximum ^{I}R and minimum ^{B}V limits. Typical characteristics of this sample lot's performance were:

1) The mean value for ^{I}R changed 72.66μA from an initial mean of 1.857nA to a final mean of 72.66 μA.

2) The mean value for ^{B}V changed 21.32V from an initial mean of 30.45V to a final mean of 9.135V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Motorola. The Motorola sample lot completed the entire 1600 hours of Group II Testing with seven catastrophic failures. The first failure occurred 160 hours into the 125°C-temperature step. Serial number 4978 failed due to excessive I_R leakage. The next failure occurred 160 hours into the 275°C-temperature step. Serial number 4982 failed the minimum B_V limit. The last failures occurred 160 hours into the 300°C-temperature step. Serial numbers 4977, 4979, 4933, 4984 and 4985 failed because of excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 35.68μA from an initial mean of 2.392nA to a final mean of 35.68μA.
2) The mean value for B_V changed 60.00mV from an initial mean of 30.37V to a final mean of 30.31V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 of this report outlines the results of Group II - Temperature Stress I Testing, for each of the electrical parameters and all of the measurement points pertaining to both Siemens and Motorola.

3.3 Group III - Temperature Stress II

3.3.1 Siemens. The Siemens sample lot completed the entire 112 hours of Group III Testing with three catastrophic failures. The failures occurred 16 hours into the 300°C-temperature step. Serial

numbers 5053, 5054 and 5057 failed due to excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 18.73µA from an initial mean of 2.679nA to a final mean of 18.73µA.
2) The mean value for B_V changed 1.830V from an initial mean of 28.80V to a final mean of 30.63V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Motorola. The Motorola sample lot completed the entire 112-hour Group III Testing with one catastrophic failure. The failure occurred 16 hours into the 275°C-temperature step. Serial number 4991 failed the maximum I_R and minimum B_V limits. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 2.980µA from an initial mean of 3.040nA to a final mean of 2.983µA.
2) The mean value for B_V changed 80.00mV from an initial mean of 30.09V to a final mean of 30.01V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II Testing, for each of the electrical parameters and all of the measurement points for both Siemens and Motorola.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 were used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in Figures 3 and 5, respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

The only step stress that did any notable damage to both manufacturers was the Group II - Temperature Stress I Testing. Many of the Siemens devices failed possibly because of the thermal expansion of the center contact rods being greater than that of the glass body. This would increase the force being exerted against the die at high temperature, causing the silicon to crack. The dice of the Motorola parts were electrically damaged due to alloying with molten metal during the long test periods at high temperatures which exceeded the designed capability of the devices.

A plot showing the cumulative failure distribution for Groups II and III was drawn for Siemens and Motorola sample lots (Figures 2 and 3, and 4 and 5, respectively). Figures 2 and 3 display the data for the Siemens sample lot used to calculate an activation energy of 2.91eV. Figures 4 and 5 display the data for the Motorola sample lot used to calculate an activation energy of 1.04eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated main failure point. The regression line was calculated using the least squares method.

Because of visual defects caused by the extreme heat of the stress tests, serial numbers 5017, 5048, 5049, 5018, 5044 and 5050 were not calculated as part of the regression line.

The activation energy was calculated from the formula:

$$E = \left[\ell n \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{eV}$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in $^{\circ}$C of 16% failure for Group II.

T_2 = temperature in $^{\circ}$C of 16% failure for Group III.

NOTE:

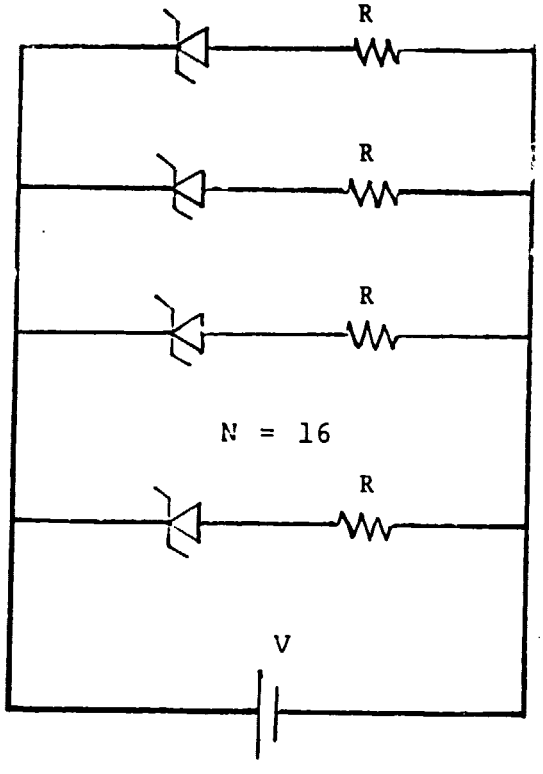
* Conditions for failure:

A) Open or short

B) Leakage exceeds the maximum limit by 100 times.

C) Other parameters exceed MIL limits by 50% or more.

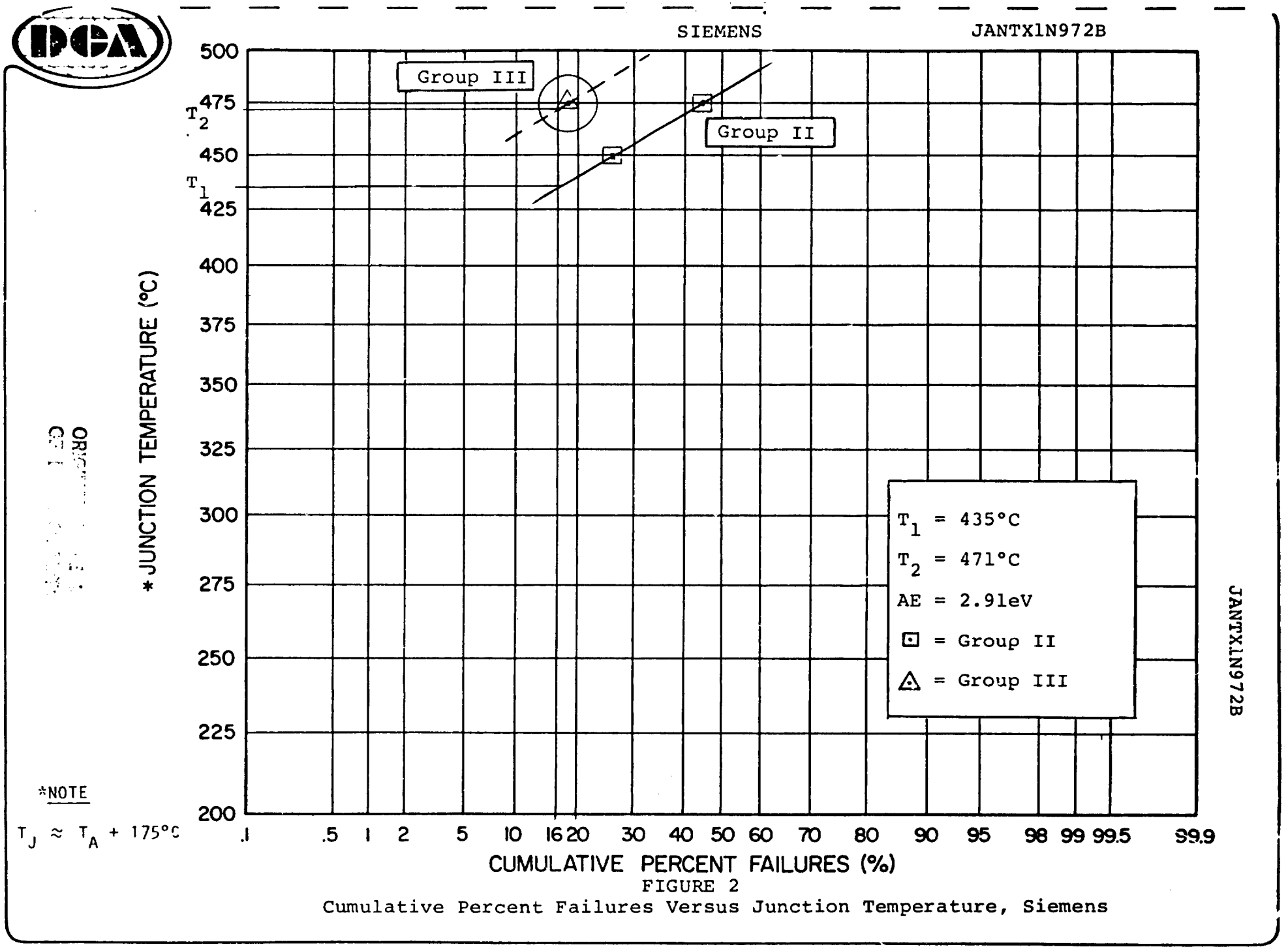
ZENER DIODES



$R = VZ \div 1.75\ IZ_{MAX} \pm 50\%$

$P_d = VZ^2 \div R$

FIGURE 1
Power/Stress Circuit
For JANTX1N972B

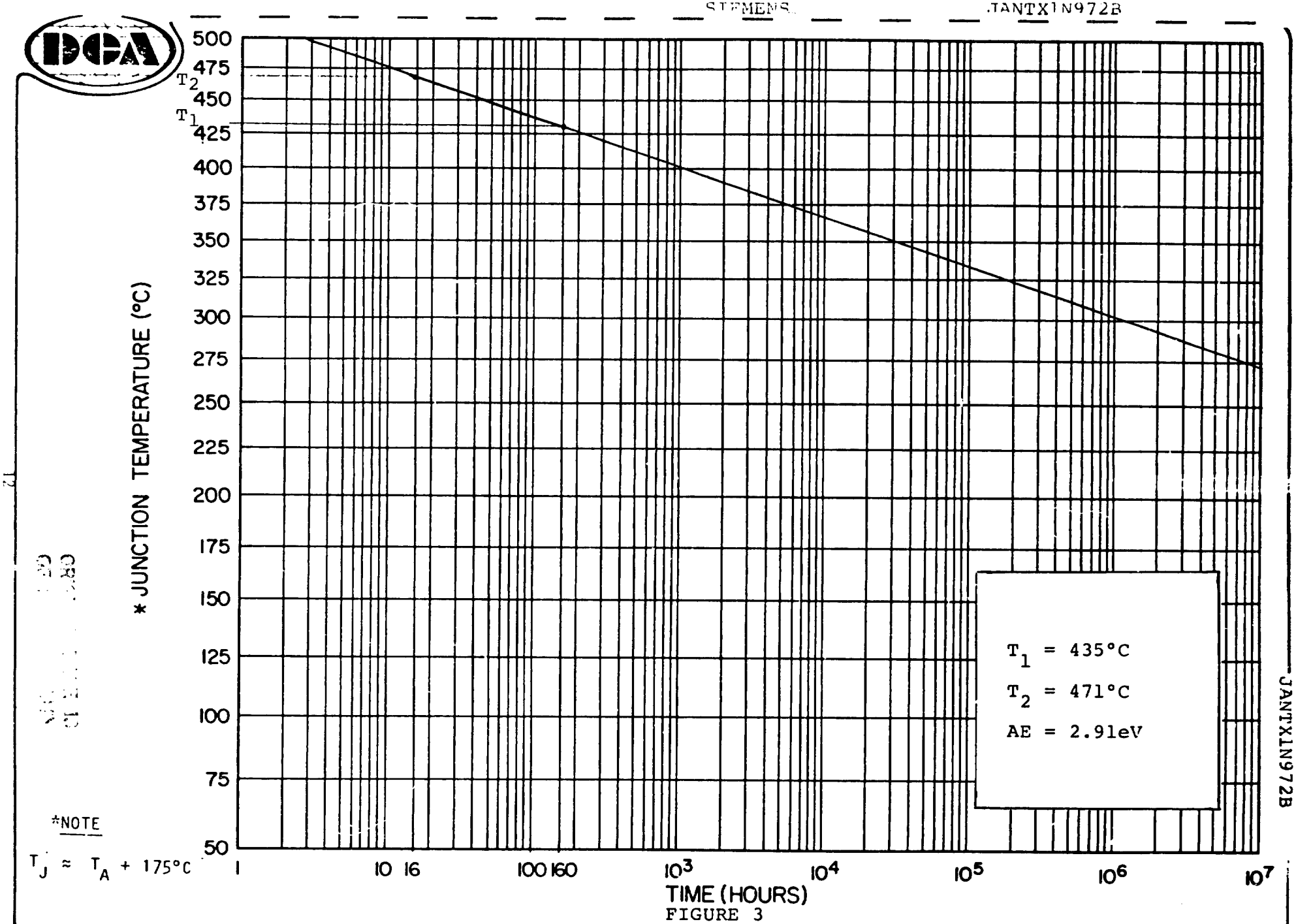


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2

Cumulative Percent Failures Versus Junction Temperature, Siemens

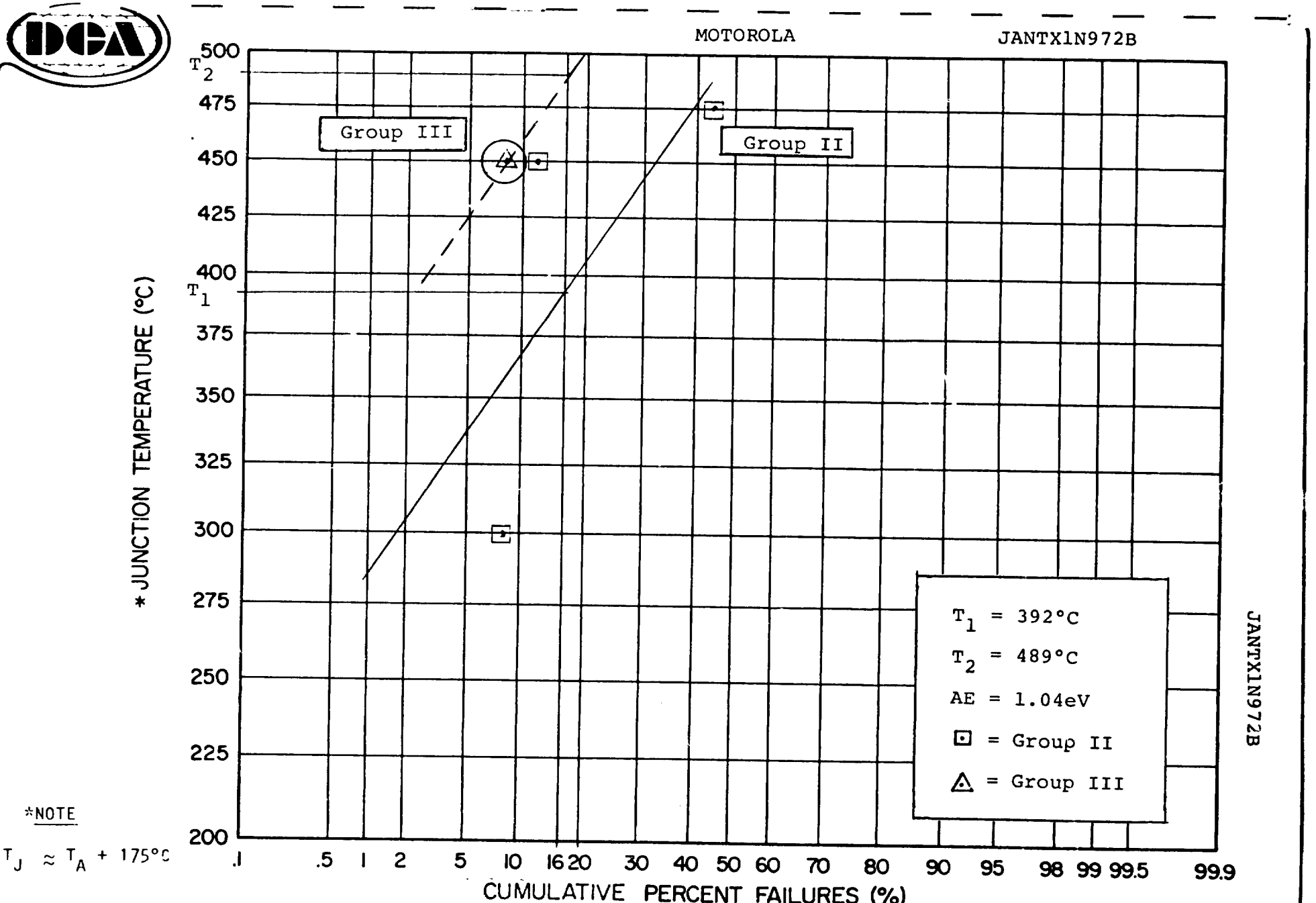


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 3

Time Steps Versus Junction Temperature, Siemens



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, Motorola

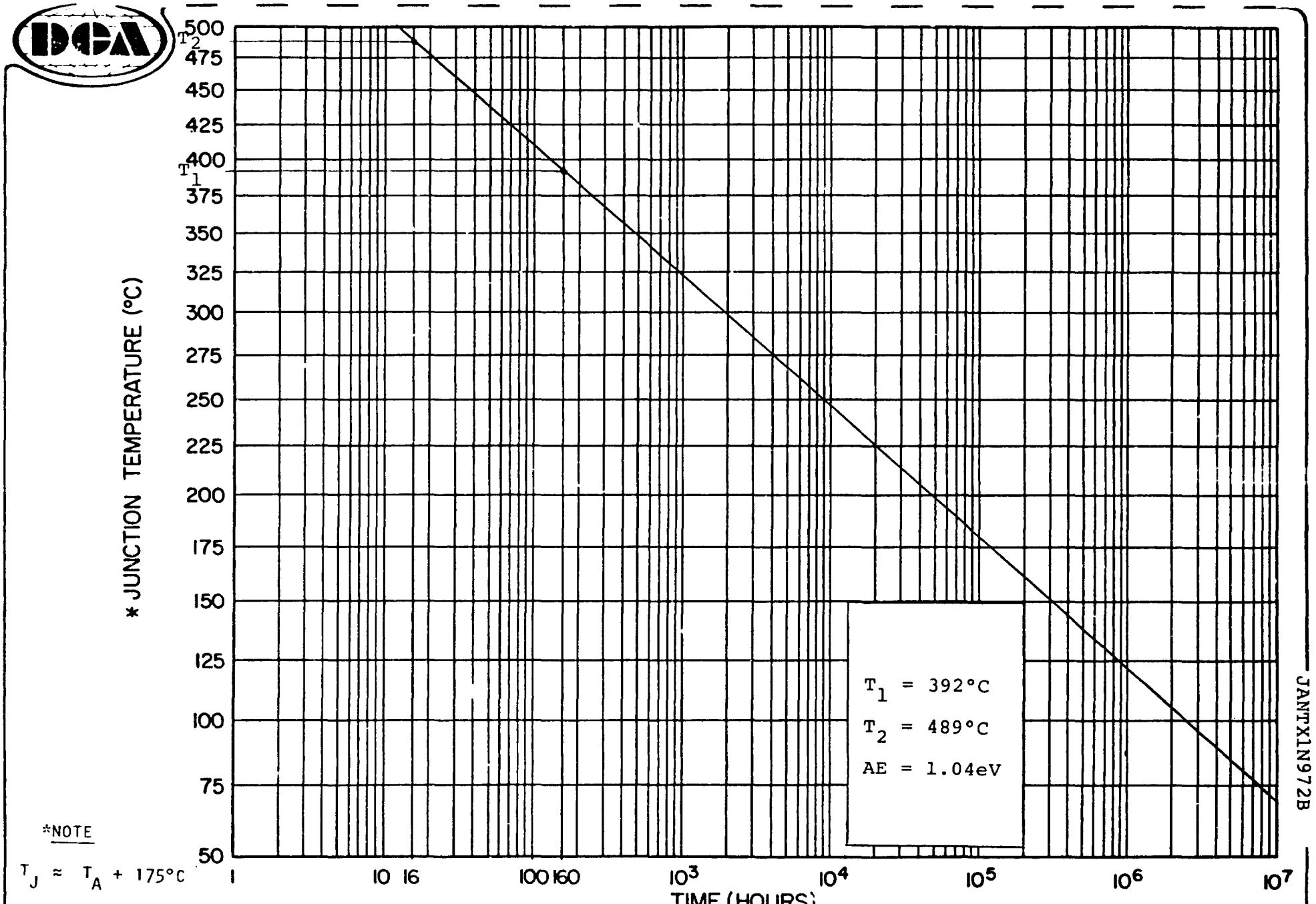
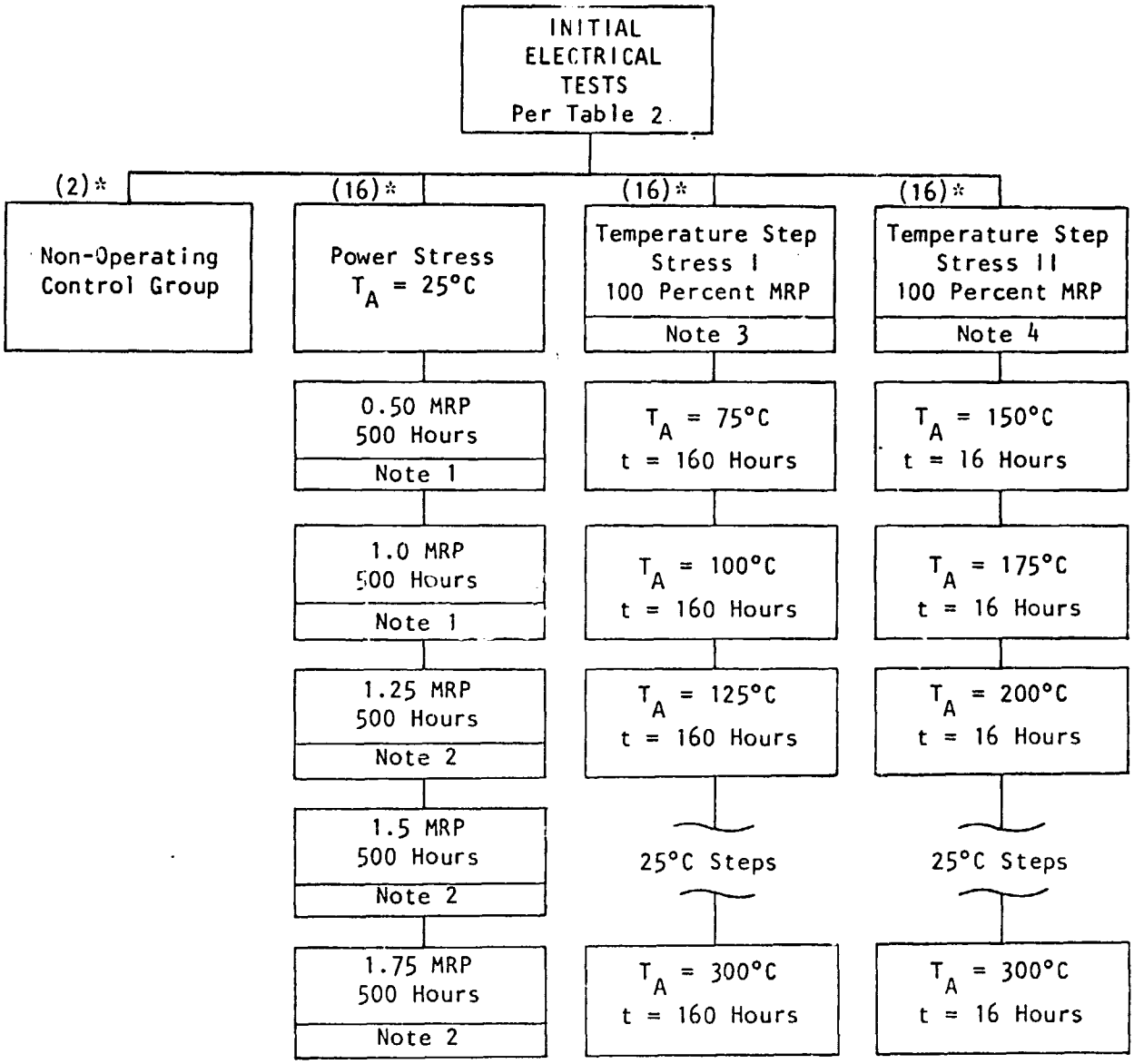


FIGURE 5
Time Steps Versus Junction Temperature, Motorola

TABLE 1
TEST FLOW DIAGRAM



*Quantity per manufacturer (Siemens and Motorola)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were made at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_R	V_R = 23V	-	5		500	µA
B_V	I_Z = 4.2mA	28.5	31.5	14.25	47.25	V

NOTES:
1/ In addition, any open or short shall be considered catastrophic

TABLE 3
POWER STRESS BURN-IN CONDITIONS

V_Z = 30V	
I_Z	Percent P_D
6.5mA	50
13.0mA	100
16.2mA	125
19.5mA	150
22.7mA	175

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I – POWER STRESS DATA SUMMARY

PARAMETER	I_R = 5µA (MAX)		B_V = 28.5(MIN)31.5(MAX)					
CONDITIONS AND LIMIT	V_R = 23V		I_Z = 4.2mA					
IDENTIFICATION	SIE	MOT	SIE	MOT				
INITIAL DATA								
MIN VALUE	30.00pA	40.00pA	29.57V	28.94V				
MAX VALUE	18.50nA	98.70nA	31.04V	31.05V				
MEAN	2.377nA	7.839nA	30.40V	30.20V				
STD DEV	4.385nA	23.50nA	459.8mV	513.2mV				
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 HRS	2.346nA	-4.107nA	-10.00mV	0.000V				
150 HRS	1.556nA	-4.435nA	0.000V	10.00mV				
250 HRS	215.0pA	-4.480nA	0.000V	0.000mV				
500 HRS	227.0pA	-5.092nA	-30.00mV	-10.00mV				
100% POWER								
550 HRS	-662.0pA	-5.962nA	-10.00mV	-10.00mV				
650 HRS	155.0pA	-5.705nA	-30.00mV	-10.00mV				
750 HRS	319.0pA	-5.810nA	10.00mV	-10.00mV				
1000 HRS	277.0pA	-5.664nA	60.00mV	40.00mV				
125% POWER								
1010 HRS	-305.0pA	-5.907nA	20.00mV	10.00mV				
1025 HRS	-353.0pA	-5.557nA	-10.00mV	-20.00mV				
1050 HRS	-47.00pA	-5.767nA	10.00mV	-10.00mV				
1150 HRS	-753.0pA	-5.844nA	10.00mV	10.00mV				
1250 HRS	6.875µA	-5.845nA	-30.00mV	10.00mV				
1500 HRS	6.750µA	-5.663nA	30.00mV	30.00mV				

(continued on second sheet)

TABLE 4 (Cont'd)

(continued from first sheet) GROUP I — POWER STRESS DATA SUMMARY

PARAMETER	I_R = 5μA		B_V=28.5V(MIN) 31.5V(MAX)					
CONDITIONS AND LIMITS	V_R = 23V		I_Z = 4.2mA					
IDENTIFICATION	SIE	MOT	SIE	MOT				
INITIAL DATA								
MIN VALUE	30.00pA	40.00pA	29.57V	28.94V				
MAX VALUE	18.50nA	98.70nA	31.04V	31.05V				
MEAN	2.377nA	7.839nA	30.40V	30.20V				
STD DEV	4.385nA	23.50nA	459.8mV	513.2mV				
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 HRS	4.356μA	-5.797nA	20.00mV	0.000V				
1525 HRS	-349.0pA	-5.627nA	10.00mV	10.00mV				
1550 HRS	-523.0pA	-5.640nA	20.00mV	10.00mV				
1650 HRS	-67.00pA	-5.872nA	20.00mV	10.00mV				
1750 HRS	472.6nA	-5.933nA	10.00mV	-20.00mV				
2000 HRS	123.6nA	-5.706nA	70.00mV	40.00mV				
175% POWER								
2010 HRS	6.818μA	-5.615nA	40.00mV	80.00mV				
2025 HRS	5.789nA	-5.557nA	90.00mV	90.00mV				
2050 HRS	3.184nA	* 624.4μA	*130.0mV	90.00mV				
2150 HRS	119.6nA	-5.636nA	60.00mV	150.0mV				
2250 HRS	107.4nA	-5.650nA	120.0mV	100.0mV				
2500 HRS	459.8nA	-5.585nA	190.0mV	100.0mV				
FINAL DATA								
MIN VALUE	120.0pA	180.0pA	29.70V	28.71V				
MAX VALUE	6.450μA	5.050nA	31.12V	31.15V				
MEAN	462.2nA	2.254nA	30.59V	30.30V				
STD DEV	1.661μA	1.578nA	459.8mV	588.2mV				

* NOTE: Catastrophic reject(s) removed from data after this point

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	I_R = 5μA(MAX)		B_V=28.5V(MIN) 31.5V(MAX)					
CONDITIONS AND LIMITS	V_R = 23V		I_Z = 4.2mA					
IDENTIFICATION	SIE	MOT	SIE	MOT				
INITIAL DATA								
MIN VALUE	680.0pA	500.0pA	29.27V	28.88V				
MAX VALUE	4.550nA	4.930nA	31.10V	31.04V				
MEAN	1.859nA	2.392nA	30.45V	30.37V				
STD DEV	1.294nA	1.456nA	573.5mV	540.6mV				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP(T_A)								
160 / 75°C	686.0pA	3.947nA	-20.00mV	90.00mV				
320 / 100°C	658.0pA	390.4nA	40.00mV	120.0mV				
480 / 125°C	301.0pA	62.44μA	-10.00mV	90.00mV				
640 / 150°C	438.0pA	385.0pA	10.00mV	110.0mV				
800 / 175°C	792.0pA	677.0pA	-10.00mV	90.00mV				
960 / 200°C	568.0pA	296.0pA	50.00mV	90.00mV				
1120 / 225°C	444.2nA	474.0pA	90.00mV	130.0mV				
1240 / 250°C	63.92nA	66.73nA	90.00mV	170.0mV				
1440 / 275°C	*43.75μA	66.74nA	*-6.430V	*-1.780V				
1600 / 300°C	*72.66μA	*35.68μA	*-21.32V	-60.00mV				
FINAL DATA								
FINAL TEMP (T_A)	300°C	300°C	300°C	300°C				
MIN VALUE	1.930nA	1.200nA	110.0mV	26.51V				
MAX VALUE	99.90μA	99.90μA	30.83V	31.19V				
MEAN	72.66μA	35.68μA	9.135V	30.31V				
STD DEV	44.49μA	47.87μA	13.10V	1.263V				

* NOTE: Catastrophic reject(s) removed from data after this point

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	I_R = 5μA(MAX)		B_V=28.5V(MIN) 31.5(MAX)					
CONDITIONS AND LIMITS	V_R = 23V		I_Z = 4.2mA					
IDENTIFICATION	SIE	MOT	SIE	MOT				
INITIAL DATA								
MIN VALUE	540.0pA	450.0pA	0.000V	28.86V				
MAX VALUE	6.900nA	6.910nA	31.14V	30.88V				
MEAN	2.679nA	3.040nA	28.80V	30.09V				
STD DEV	2.325nA	1.909nA	7.007V	579.3mV				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP (T_A)								
16 / 150°C	-472.0pA	-284.0pA	1.790V	0.000V				
32 / 175°C	52.00pA	265.0pA	1.800V	20.00mV				
48 / 200°C	521.0pA	272.0pA	1.790V	-10.00mV				
64 / 225°C	820.0pA	310.0pA	1.770V	40.00mV				
80 / 250°C	287.0pA	40.00pA	1.800V	10.00mV				
96 / 275°C	7.068nA	3.208nA	1.740V	*-1.930V				
112 / 300°C	*18.73μA	2.980μA	1.830V	-80.00mV				
FINAL DATA								
FINAL TEMP (T_A)	300°C	300°C	300°C	300°C				
MIN VALUE	840.0pA	1.630nA	29.39V	28.84V				
MAX VALUE	99.90μA	44.70μA	31.15V	30.87V				
MEAN	18.73μA	2.983μA	30.63V	30.09V				
STD DEV	38.99μA	11.15μA	443.4mV	584.8mV				

* NOTE: Catastrophic reject(s) removed from data after this point

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			SIE	MOT	SIE	MOT	SIE	MOT
I_R	-	5	μA		+1.0036	+24.010 *	*+11.692	*+9.8650	*+2.6769	+.42626
B_V	28.5	31.5	V		+.03077 *	+.02692	-2.7510 *	-.09500 *	+1.7886	*-.27857

*NOTE: Catastrophic reject(s) removed from data

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N972B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
100% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
125% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
150% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
175% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	1 \ 1	A \ B	1	C
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	–	0	–
100° C	0	–	0	–
125° C	0	–	1	D
150° C	0	–	0	–
175° C	0	–	0	–
200° C	0	–	0	–
225° C	0	–	0	–
250° C	0	–	0	–
275° C	5	C	1	E
300° C	8	C	4 \ 1	D \ E

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150° C	0	–	0	–
175° C	0	–	0	–
200° C	0	–	0	–
225° C	0	–	0	–
250° C	0	–	0	–
275° C	0	–	1	C
300° C	3	D	0	–

MFR "A" - SIEMENS

MFR "B" - MOTOROLA

NOTES: A - B_V > 47.25V

B - B_V < 14.25V

C - B_V < 14.25V and I_R > 500μA

D - I_R > 500μA

E - SHORT (verified by failure analysis)

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JANTX1N972B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
100% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
125% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	1	A	0	–
250 hr.	0	–	0	–
150% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
175% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	1	A	0	–

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	–	0	–
100° C	0	–	1	A
125°C	0	–	0	–
150°C	0	–	0	–
175°C	0	–	0	–
200°C	0	–	0	–
225°C	1	A	0	–
250°C	0	–	0	–
275°C	1	A B	0	–
300°C	0	–	0	–

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	–	0	–
175°C	0	–	0	–
200°C	0	–	0	–
225°C	0	–	0	–
250°C	0	–	0	–
275°C	0	–	0	–
300°C	0	–	1	A

MFR "A" - SIEMENS

MFR "B" - MOTOROLA

NOTES: A - I_R limit failure

B - B_V minimum limit failure

APPENDIX

FAILURE ANALYSIS

TEMPERATURE STRESS I

FAILURE ANALYSIS

TEMPERATURE STRESS I

Date 16 November 1978

J/N 2CN242-30B **P/N** 1N972 **MFR** MOTOROLA

End point limits: 14.25-47.25
End point limit: 500μA Max.

S/N	PIV -volts- @ 4.2mA	I_R @ 23 V.dc	V_F @ ____dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
4982	short	>100mA		19 (275°C - 1440 Hrs. Tot)	B_V
4983	short	>100mA		21 (300°C - 1600 Hrs. Tot)	I_R
4985	4.5	>100mA		21 (300°C - 1600 Hrs. Tot)	I_R

INTERNAL VISUAL INSPECTION

All three Motorola samples exhibit flow of melted metal up the internal lead and away from the top of the die (see Figure A-1). S/N 4983 also has a consensed smoky film inside the glass.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

FAILURE ANALYSIS

TEMPERATURE STRESS II

Date 16 November 1978

J/N 2CN242-30B **P/N** 1N972 **MFR** SIEMENS

End point Limits: 14.25-47.25 End point Limit: 500μA Max.

S/N	PIV -volts- @4.2mA	I_R @ 23 V.dc	V_F @ ____dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
5017	5.1 (S)	>100mA		19 (275° C - 1440 Hrs. Tot)	I_R
5048	7.0 (S)	>100mA		21 (300° C- 1600 Hrs. Tot)	I_R
5049	2.0 (R)	>100mA		21 (300°C - 1600 Hrs. Tot)	I_R

INTERNAL VISUAL INSPECTION

All three Siemens samples exhibit cracked dice (see Figure A-2). There are no other significant visual anomalies.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

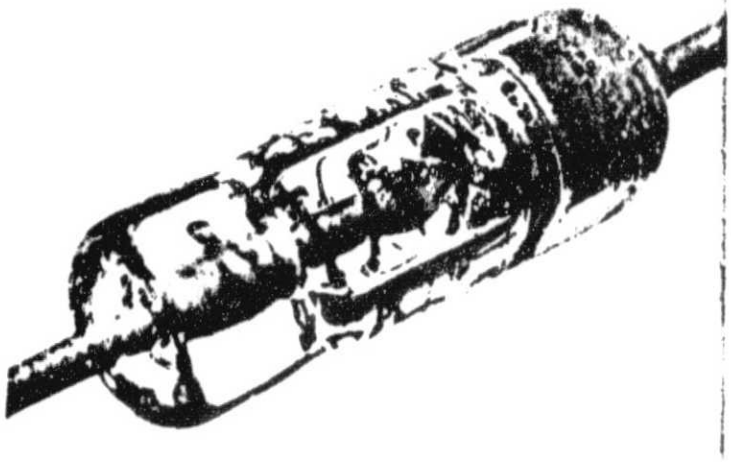


FIGURE A-1
S/N 4982, Typical Motorola Diode, 14X.
There has been melting metal and
flow beneath the die, and up the internal lead.

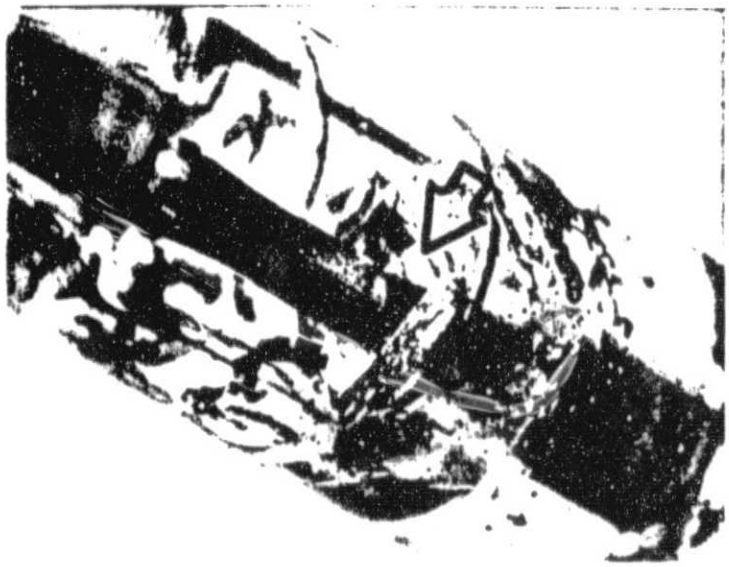


FIGURE A-2
S/N 5048, Typical Siemens Diode, 24X.
Arrow indicates cracked die.

CONCLUSIONS

The Siemens devices all failed, possibly due to the thermal expansion of the center contact rods being greater than that of the glass body. This resulted in increased force being exerted against the die at high temperature, until the silicon finally cracked. This could have possibly been avoided if there were some flexing capability built into the top contact. For normal temperatures, however, his improvement would not be necessary.

All the dice of the Motorola parts are electrically damaged due to alloying with molten metal during the long test periods at high temperatures which exceeded the designed capability of the devices.