1 of 1

Development of Environmentally Conscious Cleaning Process for Leadless Chip Carrier Assemblies

Kansas City Division

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DEVELOPMENT OF ENVIRONMENTALLY CONSCIOUS CLEANING PROCESS FOR LEADLESS CHIP CARRIER ASSEMBLIES

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Published April 1995

Final Report
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Abstract

A cross-functional team of process, product, quality, material, and design lab engineers was assembled to develop an environmentally friendly cleaning process for leadless chip carrier assemblies (LCCAs). Using flush and filter testing, Auger surface analysis, GC-Mass spectrophotometry, production yield results, and electrical test results over an extended testing period, the team developed an aqueous cleaning process for LCCAs. The aqueous process replaced the Freon vapor degreasing/ultrasonic rinse process.

Summary

A cross-functional team of process, product, quality, material, and design lab engineers was assembled to investigate the cleaning issues for leadless chip carrier assemblies (LCCAs). The purpose for this investigation was to develop an environmentally friendly cleaning process for LCCAs to eliminate the use of Freon. Using the TQ process, the team analyzed the current process, brainstormed possible alternatives, and then investigated their feasibility. To identify the root causes of contamination, all storage conditions and handling procedure for all components and assemblies from stores through production were investigated. The major contaminants of concern were ionic, particulate, and human debris.

The testing methods used to determine component and assembly cleanliness included flush and filter testing, Auger surface analysis, and GC-Mass spectrophotometry. Flush and filter testing was used to determine the quantity of particles that were 0.45 microns and larger on a part. The procedure was to ultrasonically clean (40 KHz) a part for 2 minutes. The part was contained in a test tube filled with 20 ml of DI water filtered to 0.2 micron. The contents of the test tube were then vacuum filtered through 0.45-micron filter paper. The paper was examined under 640X microscope to look for particles. All work was done in a class 100 clean bench. Several blanks and base line runs were done before and during the testing to determine background particle contamination. Auger surface analysis was run to base line the organic contamination level and measure the cleaning ability of several solvents. GC-Mass spectrophotometry was used to identify the organic contaminants.

The results of the flush and filter testing showed that the most grossly contaminated parts were packages after die attach and the die attach collets. A high number of silicon, gold, ceramic, eutectic, and white foreign material particles were found in the packages and on the collets. No particle contamination was removed from Kovar lids. Auger surface analysis revealed LCC packages were not contaminated by organic materials. Auger of the Kovar lids did reveal organic materials present. Cleaning the lids by alcohol or oxygen plasma removed the organic material. GC-Mass spectrophotometry identified the contaminants as oleamide, erucamide (slip agents used on polyethylene bags), and trace amounts of polyethylene. On the average, 0.01 mg of residue was on each lid. From these results it was determined that LCCAs should be ultrasonically cleaned in DI water before and after die attach to remove particles and ionic.

A DI water flush in a cascading tank was recommended for assemblies prior to sealing. The small amount of contamination on lids was considered insignificant, and lids were not to be cleaned.

With a new aqueous process developed, verification of product producibility and reliability was required. To measure producibility, sample parts from excess material were assembled and production yields were measured. To measure reliability, six lots of common radar parts were assembled and tested. Three lots were assembled using WR procedures and cleaned with CFC-113. Three identical lots were assembled following the WR procedures and substituting the new aqueous cleaning process for the CFC-113. The lots were tested to the following requirements.

- The assemblies were tested to the requirements of their respective product specifications.
- Twenty pieces from each lot underwent high temperature reverse bias (HTRB) for 500 hours at 175°C. No failures could occur when electrically tested.
- Moisture analysis of five of each set of twenty parts was run. Moisture level must be below 3000 ppm.
- Comparison was made between the data collected on aqueous-cleaned and CFC-cleaned parts.

Results of the producibility experiments, in Table 1, showed production yields to be equal for Freon- and aqueous-cleaned parts. The comparison of electrical data between Freon-cleaned LCCAs and aqueous-cleaned LCCAs showed no statistical difference. Residual gas analysis indicated that average moisture in Freon-cleaned LCCAs was 392 ppm and for aqueous cleaned LCCAs was 498 ppm after 500-hour life test.

Table 1. Yield Data for LCCAs Cleaned by Aqueous and Freon Processes

	Aqueous	Freon (Historical)
PIND (5 Runs)	24/25 (96%)	96.4%
NDPT	150/150 (100%)	99.5%
Sealing	140/140 (100%)	99.7%

The conclusion drawn from the data gathered was that aqueous cleaning of LCCAs can replace the Freon vapor degreasing process with no detrimental consequences.

Discussion

Scope and Purpose

The purpose of this project was to develop an environmentally friendly cleaning process for LCCA production to eliminate vapor degreasing with Freon. In developing a new, environmentally friendly cleaning process the following points were considered critical.

- Product reliability must remain at present level.
- Product yields must maintain current level.
- New cleaning must meet or exceed all environmental regulations.

Activity

Background

The passing of the Montreal Protocol requiring the elimination of CFCs led to the opportunity to closely evaluate the cleaning and handling procedures for semiconductor packaging. For the past ten years, cleaning had been done by vapor degreasing and ultrasonic rinsing in trichlorotrifluoroethane (CFC-113). This cleaning method was originally chosen because of the benign nature of the solvent coupled with the aggressive ultrasonic power to remove particles.

A cross-functional team of process, product, quality, material, and design lab engineers was assembled to investigate the cleaning issues for LCCAs. Using the TQ process, the team analyzed the current process, brainstormed possible alternatives, and then investigated their feasibility. To identify the root causes of contamination, investigation of stores packaging material and handling procedure for all components and assemblies was done. The major contaminants of concern were ionic, particulate, and human debris.

To develop a new cleaning procedure, the group began by listing cleaning solutions based upon the environmental impact, operator safety, and cost of material. The cleaning solution ranking from most to least environmentally friendly was as follows:

1. No clean
2. Carbon dioxide snow (specifically for particulate)
3. DI water
4. DI water with surfactant
5. DI water with detergent
6. Organic solvent

The process list was then established, based upon the mechanical agitation the process would impart on the product. Ranking from most mild to most aggressive was as follows:

1. Immersion
2. Immersion with stirring or dipping
3. Spray
4. Ultrasonic
5. Carbon dioxide snow

Combining the cleaning solution list with the mechanical agitation list gave 19 cleaning alternatives to potentially replace CFC vapor degreasing.

Experimentation

Phase One

The general cleanliness of the LCC packages in stores was investigated first to determine the best cleaning process for that component. Packages were stored in groups of 100 in polypropylene containers. The containers were stored in nitrogen cabinets in the clean room. As jobs were released to the manufacturing floor, a container of 100 packages was removed from the nitrogen cabinet and sent with the die and lids. The packages were not typically handled individually by the storekeeper. If the storekeeper was required to handle any packages, a vacuum pencil or tweezers were used.

Two tests were run on the packages to measure their cleanliness as received on the manufacturing floor from stores. First was a flush and filter test to determine particulate contamination level. Second, Auger surface analysis was run to determine the surface condition and measure the cleaning ability of different cleaning processes. Concurrently with empty package testing, packages with die attached (having gone through eutectic die attach process) were being run through the same battery of tests.

Flush and filter testing was used to determine the quantity of particles 0.45 microns and larger which were present on a part. The procedure was to ultrasonically clean (40 KHz) a part for 2 minutes. The part was contained in a test tube filled with 20 ml of DI water filtered to 0.2 micron. The contents of the test tube are then vacuum filtered through 0.45-micron filter paper. The paper is examined under 640X microscope to look for particles. All the work was done in a class 100 clean bench. Several blanks and base line runs were done before and during the testing to determine background particle contamination.

The general cleanliness of the combo lids in stores was investigated next. Combo lids were stored in groups of 100 in polyethylene bags inside polyethylene boxes and tightly packed with low-density polypropylene foam. The boxes of lids were stored in nitrogen cabinets in the clean room. As jobs were released to the manufacturing floor, a bag of 100 lids was removed from one of the polyethylene boxes and sent with the die and packages. The lids were not handled individually by the storekeeper.

Three tests were run on the combo lids to measure the cleanliness of lids as received on the manufacturing floor from stores. First was a flush and filter test to determine particulate contamination level. Next, Auger surface analysis was used to determine thickness of contaminating material and measure the cleaning ability of different cleaning processes. Third, GC-Mass spectrophotometry and gravimetric analysis were run using methylene chloride as the solvent to determine the type and quantity of contaminating organics.

Lastly, the equipment, handling, and the assembly process flow through lidding were investigated for contamination. Items such as die collets used on a die attach machine, waffle packs, conductive boxes, and handling fixtures were run through flush and filter testing. Assemblies were retested after die attach, wire bonding, pull testing, and storage, looking for particulate contamination.

Phase Two

From the results obtained in Phase 1 of the experimentation, the following cleaning processes were proposed for testing by the team.

1. Empty packages and packages containing die would be ultrasonically cleaned for two minutes in DI water, followed by a DI water spray rinse for 30 seconds, nitrogen blow off, and oven drying. To maintain the water integrity during the ultrasonic step, a cascading tank was used and the flow rate of the DI water was set at 0.5 gpm.

2. Packages with wire bonds attached would be flushed by flowing DI water in a cascading tank. The flow rate of the water was to be 2.0 gpm.

3. The contamination on the lids was considered minute, and lids were not to be cleaned.

With a new cleaning process established that met the environmentally friendly issue, test parts were run to verify that the process met with the established yield requirement. The yield requirements assessed were wire pull testing (NDPT), sealing, particle-induced noise detection (PIND) testing, and residual gas analysis (RGA). Also, to verify the reliability and to qualify the process for production, six lots of LCCAs were assembled and electrically and mechanically tested. Three lots were assembled using the current WR process with CFC-113 cleaning, and three lots were assembled by the WR process, substituting the new aqueous cleaning process for the CFC-113 process. The LCCAs contained a sample of all dice used for the common radar program. Testing included the following requirements.

1. The products were tested to the requirements of their respective product specifications.

2. Twenty pieces from each lot underwent high temperature reverse bias for 500 hours at 175°C. No failures could occur when electrically tested.

3. Moisture analysis of five of each set of twenty parts was run. Moisture level must be below 3000 ppm.

4. The electrical data was analyzed for trends. Comparison of the data between aqueous-cleaned and CFC-cleaned parts was done. Assuming no statistical difference between the two groups of data, aqueous cleaning was approved.

Results

Phase One

The overall results of the flush and filter testing can be seen in Table 2.

Table 2. Number of Particles Captured During Flush and Filter Testing (Particle Size 0.45 Micron and Larger)

Test Item	Quantity Tested	Gold (#/cm^2)	Ceramic (#/cm^2)	Silicon (#/cm^2)	Eutectic (#/cm^2)	Fibers (#/cm^2)	Other (#/cm^2)
Empty package	10	100±25	10±5	ND	ND	2±2	10±5
Die attach package	10	50±15	10±5	15±10	10±10	ND	170±25
Wire bond package	10	50±15	ND	ND	ND	ND	1±1
Lids	12	ND	ND	ND	ND	ND	ND
Collets	4	170±50	80±30	140±50	50±25	ND	Infinite
Waffle packs	3	ND	ND	ND	ND	ND	400±100
Handling fixture	3	ND	ND	ND	ND	ND	5±5

Table 2 represents average numbers of particles per square centimeter of filter paper recovered from each item, with an estimated range based on data collected from multiple runs. As can be seen from the table, the most grossly contaminated parts were packages after die attach and the die attach collets. The particles listed under the other category for die attach packages were a white foreign material. The possible sources of the material were residual adhesive on the die, waffle pack debris, or human debris.

A larger number of gold flakes were shed from the packages during the ultrasonic cleaning. Subsequent ultrasonic cleaning (up to five runs) continued to yield very high gold flake counts, indicating that the package will continually shed gold plating during ultrasonic cleaning. Repeat cleaning of any package (empty, die attached, wire bonded) would result in only gold flakes being recovered. All other particles were removed during the first run.

Surface analysis of packages received from stores was run to determine the organic contamination level. A sample of 16 LCCs was pulled from stores. Four were not cleaned, four were cleaned in alcohol, four were cleaned in DI water, and four were vapor degreased in CFC-113 (base line). The results shown in Figure 1 indicate that packages were free of organic contamination. All had carbon-to-gold ratios between 0.765 and 1.17, indicating a clean surface. A carbon-to-gold peak ratio of zero (0) would indicate an absolutely clean surface. The only way to achieve an absolutely clean surface is to plasma clean and never remove the part from the vacuum. Once exposed to factory air, carbon will deposit on the surface of the part. A carbon-to-gold ratio below 2.0 has less than 100 Å of organic contamination.

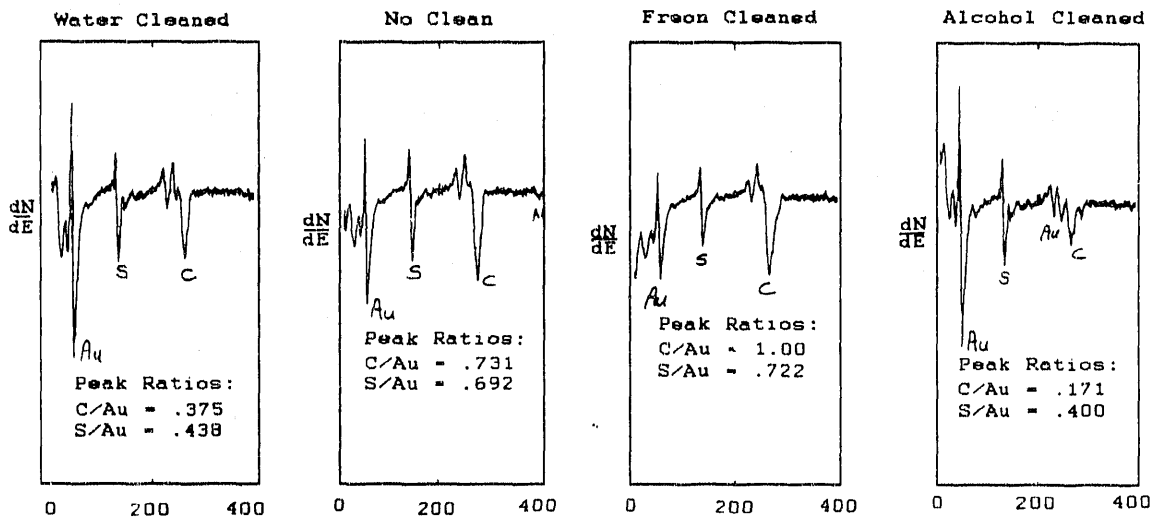


Figure 1. Auger Results for Ceramic Packages

Auger analysis was also run on a sample of nine lids, three uncleaned, three cleaned in alcohol, and three oxygen plasma cleaned. The results of the Auger analysis can be seen in Figure 2. Uncleaned lids showed a relatively large carbon peak and smaller sulfur peak. The low energy gold peak is masked because of the carbon thickness. This is an indication of the organic contamination which was identified by GC-Mass spec. Lids which were alcohol cleaned showed great improvement over the uncleaned lids, and the oxygen plasma cleaned lids showed the best cleaning results. Carbon-to-gold peak ratios for the three samples of lids were 8.0 for uncleaned, 1.36 for alcohol cleaned, and 0.09 for oxygen plasma cleaned.

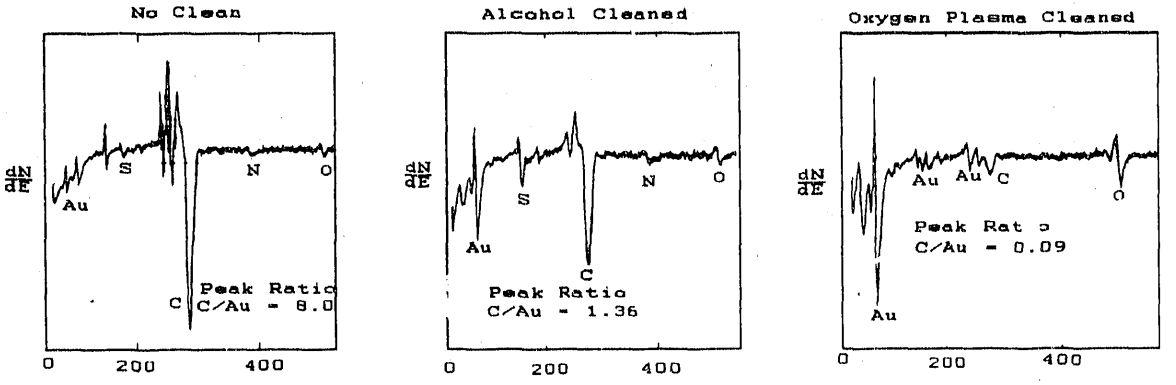


Figure 2. Auger Results for Kovar Lids

Two hundred lids were washed in methylene chloride. A very small sample of the solvent extract was analyzed and found to contain oleamide and erucamide (slip agents used on polyethylene bags). Also, trace amounts of low molecular weight polyethylene were found. The remainder of the solvent was evaporated, and gravimetric analysis of the residue was run. On the average, 0.01 mg of residue is on each lid. This equates to a residue of 150 ppm per lid by weight.

Phase Two

A sample of 150 LCCAs was assembled from excess material to test the yield potential for the new proposed cleaning process. The yield for critical processes is shown in Table 3.

Table 3. Yield Data for LCCAs Cleaned by Aqueous and Freon Processes

	Aqueous	Freon (Historical)
PIND (5 Runs)	24/25 (96%)	96.4%
NDPT	150/150 (100%)	99.5%
Sealing	140/140 (100%)	99.7%

The residual gas analysis (RGA) results of five of the above parts is shown in Table 4.

Table 4. Internal Moisture Results for Aqueous- and Freon-Cleaned LCCAs Sealed the Same Day

Sample	Aqueous	Freon
1	1,311	1,432
2	1,494	1,268
3	1,773	1,346
4	1,114	888
5	964	863
Avg.	1,331	1,159
Std	284	238

Based on these results, the 600 LCCAs were assembled and tested as outlined above. Table 5 shows the results of the processing yields and Tables A1 through A36 in the appendix show all the electrical test results and comparisons.

Table 5. Production Yields at Critical Points for Aqueous- and Freon-Cleaned LCCAs

	Aqueous	Freon
PIND (5 Runs)	216/217 (99.5%)	239/240 (99.6%)
Sealing	216/217 (99.5%)	239/242 (98.8%)
NDPT	100%	100%

The RGA results for these six lots of LCCAs are shown in Table 6.

Table 6. Internal Moisture Results for Freon- and Aqueous-Cleaned LCCAs After 500-Hour HTRB

P/N	Aqueous (ppm H_2O)	Freon (ppm H_2O)
391289-01	452	604
	168	<100
	971	471
	510	226
	1,146	531
391291-01	332	535
	383	323
	381	319
	317	165
	547	672
391376-01	427	356
	365	194
	331	442
	706	295
	439	361
Avg.	498	392
Std	259	155

Accomplishments

The overall results of the phase one testing indicate cleaning of empty packages and assemblies after die attach was required to remove particulate contamination. Organic contamination on packages was minute at most. Cleaning packages with an organic solvent gave no improvement to the surface condition. Therefore, the recommended cleaning process for packages was ultrasonic cleaning in DI water followed by a DI water spray rinse. However, ultrasonic cleaning of LCCAs containing wire bonds was NOT recommended. If cleaning was required after wire bonding, then assemblies should be flushed by flowing DI water in a

cascading tank. DI water is the safest, most environmentally friendly solvent and has the added benefit of removing ionic contamination if it is present.

There was no sign of ionic or particulate contamination on the lids, only small amounts of organic residues. Oxygen plasma cleaning the lids or alcohol rinsing would remove the small amounts of contamination. However, the results of the assembly testing during phase two indicated that cleaning of lids was optional. Identical yield results were obtained for assemblies when the lids were cleaned or not. The sealing yield for cleaned and uncleaned lids, determined by fine and gross leak testing, had no statistically significant difference.

Based upon the mechanical assemblies built in phase two, aqueous cleaning of LCCAs was an acceptable process. No detrimental effects on product yields or reliability were found. The comparison of electrical data from the six lots of LCCAs in the appendix further proved that the aqueous cleaning process was a viable replacement for the CFC-113 vapor degreasing process.

Based on all the results of these experiments, it is recommended that the cleaning process for LCCAs with eutectically attached die be the following:

1. Empty packages and packages containing die would be ultrasonically cleaned for two minutes in DI water, followed by a DI water spray rinse for 30 seconds, nitrogen blow off and oven drying. To maintain the water integrity during the ultrasonic step, a cascading tank was used and the flow rate of the DI water was set at 0.5 gpm.

2. Packages with wire bonds attached would be flushed by flowing DI water in a cascading tank. The flow rate of the water was to be 2.0 gpm.

3. The contamination on the lids was considered minute, and lids were not to be cleaned.

Appendix

Electrical Test Data for Common Radar LCCAs

TABLE A1: MINIMUM AND MAXIMUM VALUES OF INITAL ELECTRICAL TEST DATA FOR M-53						
TEST	MINIMUM VALUE			MAXIMUM VALUE		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB=60V	0.4	0.51	-0.11	3.8	7.7	-3.9
ICBO (nA) @ VCB=75V	0.35	0.5	-0.15	6.8	18	-11.2
IEBO (nA) @ VEB=4V	0.05	0.01	0.05	9.3	2.1	7.2
ICER (nA) @ VC=50V, R=5K	0.29	0.34	-0.05	2.5	6.9	-4.4
ICES (nA) @ VCE= -50V	0.09	0.18	-0.1	2.3	6.7	-4.4
HFE @ VCE=10V, IC=0.1mA	143.8	162.7	-18.9	194.4	183.3	11.1
HFE @ VCE=10V, IC=1mA	167.1	167.8	-0.7	201	183.8	17.2
HFE @ VCE=10V, IC=10mA	175.7	169.8	5.9	210	187.8	22.2
HFE @ VCE=10V, IC=150mA	173.6	167.4	6.2	213	186.6	26.4
HFE @ VCE=10V, IC=500mA	95.7	94.1	1.6	117.5	104.5	13
VCES(mV)@IC=150mA, IB=15mA	147	151.5	-4.5	161	164.5	-3.5
VCES(mV)@IC=500mA,IB=50mA	365.5	367	1.5	395	392.5	2.5
VBEON(mV)@VCE=10V,IC=20mA	706	716	-10	715.5	720	-4.5
VBEON(mV)@VCE=10V,IC=50mA	730.5	740.5	-10	740.5	745	-4.5
VBES(mV)@IC=150mA,IB=15mA	865.5	872	-6.5	875	878.5	-3.5
VBES(mV)@IC=500mA,IB=50mA	1,082.5	1,086.5	-4	1,105.5	1,103	2.5
ICBO (nA) @ VCB=-50V	0.55	0.62	-0.07	0.64	0.65	-0.01
ICBO (nA) @ VCB=-60V	0.4	0.5	-0.1	0.7	0.6	0.1
ICER (nA) @ VC=-50V, R=5K	0.3	0.32	-0.02	0.42	0.36	0.06
IEBO (nA) @ VEB=-4V	0.4	0.4	0	0.59	0.51	0.08
HFE @ VCE=-10V, IC=-0.1mA	97.7	103.3	-5.6	107	111.6	-4.6
HFE @ VCE=-10V, IC=-1mA	113.3	121.2	-7.9	124.7	131.2	-6.5
HFE @ VCE=-10V, IC=-10mA	125	136.4	-11.4	139.6	147.7	-8.1
HFE @ VCE=-10V, IC=-150mA	130.2	143.7	-13.5	146.5	156.3	-9.8
HFE @ VCE=-10V, IC=-500mA	83.3	91.7	-8.4	94.3	103.5	-9.2
VCES(mV)@IC=-150mA,IB=-15mA	161	156	5	169.5	165.5	4
VCES(mV)@IC=-500mA,IB=-50mA	407.5	391	16.5	441	421	20
VBEON(mV)@VCE=-10V,IC=-20mA	711.5	715.5	-4	718.5	720	1.5
VBEON(mV)@VCE=-10V,IC=-50mA	735.5	738.5	-3	742.5	743	-0.5
VBES(mV)@IC=-150mA,IB=-15mA	879.5	880.5	-1	886	884.5	1.5
VBES(mV)@IC=-500mA,IB=-50mA	1,081.5	1,072.5	9	1,094.5	1,083.5	11
IR (μA) @VR = 6V	1.09	0.87	0.22	2.24	1.79	0.45
IR (μA) @ VR= 36V	4.47	3.67	0.8	13.8	16	-2.2
VF (mV) @ IF = 2 mA	196.5	212.5	-16	214	218	-4
VF (mV) @ IF = 10 mA	240	255.5	15.5	256.5	261.5	-5
VF (mV) @ IF = 100 mA	313	327.5	-14.5	330.5	333	-2.5
VF (mV) @ IF = 1A	486.5	493	-6.5	517.5	524.5	-7
VF (mV) @ IF = 2A	629.5	629.5	0	678	692	-14
IR (μA) @ VR = 6V	1.18	0.85	0.33	2.75	1.54	1.21
IR (μA) @ VR = 36V	4.56	3.6	0.96	15.3	20.4	-5.1
VF (mV) @ IF=2mA	192	204	-12	211.5	219	-7.5
VF (mA) @ IF = 10 mA	235.5	247	-11.5	255.5	262	-6.5
VF (mV) @ IF= 100 mA	307.5	318.5	-11	327.5	333.5	-6
VF (mV) @ IF = 1A	479.5	486.5	-7	524.5	505.5	19
VF (mV) @ IF = 2A	621.5	625.5	-4	688	650.5	37.5

TABLE A2: AVERAGE AND STANDARD DEVIATION OF INITAL ELECTRICAL TEST DATA FOR M-53						
TEST	AVERAGE			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB=60V	0.51	0.77	-0.26	0.4	1	-0.6
ICBO (nA) @ VCB=75V	0.59	1.2	-0.61	0.74	2.7	-1.96
IEBO (nA) @ VEB=4V	0.23	0.06	0.17	1.1	0.29	0.81
ICER (nA) @ VC=50V, R=5K	0.38	0.52	-0.14	0.25	0.78	-0.53
ICES (nA) @ VCE= -50V	0.22	0.37	0.15	0.25	0.78	-0.53
HFE @ VCE=10V, IC=0.1mA	179.64	176.2	3.44	10.96	4.16	6.8
HFE @ VCE=10V, IC=1mA	188.75	175.42	13.33	8.95	4.35	4.6
HFE @ VCE=10V, IC=10mA	198.54	177.88	20.66	10.77	4.83	5.94
HFE @ VCE=10V, IC=150mA	198.75	175.88	22.87	11.5	5.25	6.24
HFE @ VCE=10V, IC=500mA	106.44	98.3	8.14	5.91	2.7	3.21
VCES(mV)@IC=150mA, IB=15mA	153.77	159.45	-5.68	3.53	3.54	-0.01
VCES(mV)@IC=-500mA,IB=-50mA	382.07	383.23	-1.16	6.05	6.32	-0.27
VBEON(mV)@VCE=10V,IC=20mA	709.24	718.1	-8.86	2.44	0.86	1.58
VBEON(mV)@VCE=10V,IC=50mA	734.13	742.75	-8.62	2.52	0.98	1.54
VBES(mV)@IC=150mA,IB=15mA	870.61	875.28	-4.67	1.98	1.24	0.74
VBES(mV)@IC=500mA,IB=50mA	1,095.1	1,096.1	-1	4.8	3.16	1.64
ICBO (nA) @ VCB=-50V	0.61	0.63	-0.02	0.02	0.01	0.01
ICBO (nA) @ VCB=-60V	0.56	0.57	-0.01	0.06	0.04	0.02
ICER (nA) @ VC=-50V, R=5K	0.37	0.33	0.04	0.03	0.01	0.01
IEBO (nA) @ VEB=-4V	0.53	0.46	0.07	0.04	0.02	0.01
HFE @ VCE=-10V, IC=-0.1mA	104.26	108.69	-4.43	1.76	1.74	0.02
HFE @ VCE=-10V, IC=-1mA	120.77	127.27	-6.5	2.21	.05	0.16
HFE @ VCE=-10V, IC=-10mA	134.59	143.09	-8.5	2.73	2.4	0.32
HFE @ VCE=-10V, IC=-150mA	140.84	150.44	-9.6	3.1	3.5	-0.4
HFE @ VCE=-10V, IC=-500mA	91.82	99.81	-7.99	2.76	2.9	-0.14
VCES(mV)@IC=-150mA,IB=-15mA	164.3	159.49	4.81	1.87	2.1	-0.23
VCES(mV)@IC=-500mA,IB=-50mA	419.24	402.25	16.99	7.59	6.45	1.14
VBEON(mV)@VCE=-10V,IC=-20mA	714.8	717.61	2.81	1.29	0.88	0.42
VBEON(mV)@VCE=-10V,IC=-50mA	738.09	740.32	-2.23	1.31	0.85	0.46
VBES(mV) @IC=-150mA,IB=-15mA	882.38	882.4	-0.02	1.29	0.86	0.43
VBES(mV) @IC=-500mA,IB=-50mA	1,087.6	1,077.6	10	3.28	2.37	0.91
IR (μA) @VR=6V	1.6	1	0.6	0.21	0.12	0.09
IR (μA) @ VR=36V	6.36	4.29	2.07	1.48	1.63	-0.15
VF (mV) @IF=2mA	205.26	215.41	-10.15	2.99	1.13	1.86
VF (mA) @ IF = 10 mA	248.63	258.27	-9.64	2.96	1.35	1.61
VF (mV) @ IF=100mA	321.42	329.8	-8.38	2.94	1.3	1.64
VF (mV) @ IF=1A	497.33	500.11	-2.78	4.82	3.76	1.06
VF (mV) @ IF=2A	645.68	642.08	3.6	8.1	7.23	0.87
IR (μA) @ VR=6V	1.62	1.01	0.61	0.31	0.12	0.18
IR (μA) @VR=36V	6.42	4.52	1.9	1.98	1.95	0.03
VF (mV) @ IF=2mA	204.84	214.79	-9.95	3.93	2.83	1.1
VF (mV) @ IF=10mA	248.25	257.75	-9.5	3.88	2.83	1.05
VF (mV) @ IF=100mA	320.7	329.27	-8.57	3.8	2.87	0.93
VF (mV) @ IF=1A	494.27	499.01	-4.74	5.94	4.19	1.75
VF (mV) @ IF=2A	639.25	640.16	-0.91	9.05	6.14	2.91

TABLE A3: MINIMUM AND MAXIMUM VALUES OF POST HTRB ELECTRICAL TEST DATA FOR M-53						
TEST	MINIMUM VALUE			MAXIMUM VALUE		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB=60V	0.36	3	-2.64	3	7.7	-4.7
ICBO (nA) @ VCB=75V	0.3	0.5	-0.2	5.5	18	-12.5
IEBO (nA) @ VEB=4V	0.01	0.01	0	8.7	2.1	6.6
ICER (nA) @ VC=50V, R=5K	0.18	0.34	0.16	1.9	6.9	-5
ICES (nA) @ VCE= -50V	0.11	0.18	-0.07	1.7	6.7	-5
HFE @ VCE=10V, IC=0.1mA	140.8	162.7	-21.9	192.5	183.3	9.2
HFE @ VCE=10V, IC=1mA	163.5	167.8	-4.3	199.2	183.8	15.4
HFE @ VCE=10V, IC=10mA	173.6	169.8	3.8	209	187.8	21.2
HFE @ VCE=10V, IC=150mA	173.6	167.4	6.2	213	186.6	26.4
HFE @ VCE=10V, IC=500mA	95.6	94.1	1.5	117	104.5	12.5
VCES (mV) @ IC=150mA, IB=15mA	146.5	151.5	-5	160.5	164.5	-4
VCES(mV)@IC=500mA,IB=50mA	363.5	367	-3.5	394	392.5	1.5
VBEON(mV)@VCE=10V,IC=20mA	705	716	-11	719	720	-1
VBEON(mV)@VCE=10V,IC=50mA	729	740.5	-11.5	745	745	0
VBES(mV)@IC=150mA,IB=15mA	864.5	872	-7.5	877.5	878.5	-1
VBES(mV)@IC=500mA,IB=50mA	1,081.5	1,086.5	-5	1104.5	1,103	1.5
ICBO (nA) @ VCB=-50V	0.56	0.62	-0.06	0.64	0.65	-0.01
ICBO (nA) @ VCB=-60V	0.4	0.5	-0.1	0.65	0.6	0.05
ICER (nA) @ VC=-50V, R=5K	0.32	0.32	0	0.4	0.36	0.04
IEBO (nA) @ VEB=-4V	0.42	0.4	0.02	0.57	0.51	0.06
HFE @ VCE=-10V, IC=-0.1mA	96.4	103.3	-6.9	106.2	111.6	-5.4
HFE @ VCE=-10V, IC=-1mA	111.4	121.2	-9.8	123.3	131.2	-7.9
HFE @ VCE=-10V, IC=-10mA	123.6	136.4	-12.8	137.9	147.7	-9.8
HFE @ VCE=-10V, IC=-150mA	130.2	143.7	-13.5	144.2	156.3	-12.1
HFE @ VCE=-10V, IC=-500mA	82.2	91.7	-9.5	93.9	103.5	-9.6
VCES(mV)@IC=-150mA,IB=-15mA	162	156	6	170.5	165.5	5
VCES(mV)@IC=-500mA,IB=-50mA	408.5	391	17.5	445	421	24
VBEON(mV)@VCE=-10V,IC=-20mA	711.5	715.5	-4	721	720	1
VBEON(mV)@VCE=-10V,IC=-50mA	735	738.5	-3.5	744.5	743	1.5
VBES(mV) @IC=-150mA,IB=-15mA	879.5	880.5	-1	887.5	884.5	3
VBES(mV) @IC=-500mA,IB=-50mA	1,082	1,072.5	9.5	1096	1,083.5	12.5
IR (μA) @VR=6V	0.92	2.07	-1.15	2.07	1.79	0.28
IR (μA) @ VR=36V	3.94	3.67	0.27	15	16	-1
VF (mV) @ IF = 2mA	198	212.5	-14.5	217.5	218	-0.5
VF (mV) @ IF=10mA	241.5	255.5	-14	260	261.5	-1.5
VF (mV) @ IF=100mA	314.5	327.5	-13	332.5	333	-0.5
VF (mV) @ IF=1A	492.5	493	-0.5	507.5	524.5	-17
VF (mV) @ IF=2A	639.5	629.5	10	659.5	692	-32.5
IR (μA) @ VR=6V	1.04	0.85	0.19	2.48	1.54	0.94
IR (μA) @VR=36V	4.23	3.6	0.63	13.5	20.4	-6.9
VF (mV) @ IF=2mA	194	204	-10	215	219	-4
VF (mV) @ IF=10mA	237.5	247	-9.5	257.5	262	-4.5
VF (mV) @ IF=100mA	309.5	318.5	-9	329.5	333.5	-4
VF (mV) @ IF=1A	479.5	486.5	-7	520	505.5	14.5
VF (mV) @ IF=2A	617	625.5	-8.5	690.5	650.5	40

TABLE A4: AVERAGE AND STANDARD DEVIATION OF POST HTRB ELECTRICAL TEST DATA FOR M-53						
TEST	AVERAGE VALUE			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB=60V	0.49	0.77	-0.28	0.32	1	-0.68
ICBO (nA) @ VCB=75V	0.58	1.2	-0.62	0.62	2.7	-2.08
IEBO (nA) @ VEB=4V	0.21	0.06	0.15	1.1	0.29	0.81
ICER (nA) @ VC=50V, R=5K	0.35	0.52	-0.17	0.2	0.78	-0.58
ICES (nA) @ VCE= -50V	0.2	0.37	-0.17	0.21	0.78	-0.57
HFE @ VCE=10V, IC=0.1mA	177.89	176.2	1.69	11.18	4.16	7.02
HFE @ VCE=10V, IC=1mA	186.77	175.42	11.35	9.15	4.35	4.8
HFE @ VCE=10V, IC=10mA	196.67	177.88	18.79	10.72	4.83	5.88
HFE @ VCE=10V, IC=150mA	197.28	175.88	21.4	11.73	5.25	6.48
HFE @ VCE=10V, IC=500mA	106.42	98.3	8.12	5.96	2.7	3.26
VCES(mV)@IC=150mA, IB=15mA	153.08	159.45	-6.37	3.52	3.54	-0.02
VCES(mV)@IC=500mA,IB=50mA	380.4	383.23	-2.83	6.03	6.32	-0.29
VBEON(mV)@VCE=10V,IC=20mA	711.23	718.1	-6.87	3.28	0.86	2.42
VBEON(mV)@VCE=10V,IC=50mA	736.09	742.75	-6.66	3.33	0.98	2.35
VBES(mV)@IC=150mA,IB=15mA	871.67	875.28	-3.61	2.56	1.24	1.32
VBES(mV)@IC=500mA,IB=50mA	1,095	1,096.1	-1.1	4.89	3.16	1.73
ICBO (nA) @ VCB = -50V	0.58	0.63	-0.05	0.02	0.01	0.01
ICBO (nA) @ VCB=-60V	0.53	0.57	-0.04	0.07	0.04	0.03
ICER (nA) @ VC=-50V, R=5K	0.35	0.33	0.02	0.03	0.01	0.02
IEBO (nA) @ VEB=-4V	0.51	0.46	0.05	0.03	0.02	0.01
HFE @ VCE=-10V, IC=-0.1mA	102.85	108.69	-5.84	1.9	1.73	0.17
HFE @ VCE=-10V, IC=-1mA	119.26	127.27	-8.01	2.3	2.05	0.25
HFE @ VCE=-10V, IC=-10mA	132.88	143.09	-10.21	2.8	2.4	0.4
HFE @ VCE=-10V, IC=-150mA	138.85	150.44	-11.59	3.07	3.5	-0.43
HFE @ VCE=-10V, IC=-500mA	90.82	99.81	-8.99	2.83	2.9	-0.07
VCES(mV)@IC=-150mA,IB=-15mA	164.86	159.49	5.37	1.88	2.1	-0.22
VCES(mV)@IC=-500mA,IB=-50mA	421.03	402.25	18.78	7.99	6.45	1.54
VBEON(mV)@VCE=-10V,IC=-20mA	716.58	717.61	-1.03	2.37	0.88	1.51
VBEON(mV)@VCE=-10V,IC=-50mA	740.11	740.32	-0.21	2.33	0.85	1.48
VBES(mV) @IC=-150mA,IB=-15mA	883.65	882.4	1.25	1.9	0.86	1.04
VBES(mV) @IC=-500mA,IB=-50mA	1,088.8	1,077.6	11.2	3.49	2.37	1.12
IR (μA) @VR=6V	1.47	1	0.47	0.23	0.12	0.11
IR (μA) @ VR=36V	5.97	4.29	1.68	1.46	1.63	-0.17
VF (mV) @IF=2mA	207.13	215.41	-8.28	3.46	1.13	2.33
VF (mV) @ IF=10mA	250.49	258.27	-7.78	3.29	1.35	1.94
VF (mV) @ IF=100mA	323.26	329.8	-6.54	3.15	1.3	1.85
VF (mV) @ IF=1A	500.15	500.11	0.04	3.49	3.76	-0.27
VF (mV) @ IF=2A	650.35	642.08	8.27	5.24	7.23	-1.99
IR (μA) @ VR=6V	1.51	1.01	0.5	0.3	0.12	0.17
IR (A) @ VR = 36V	6.1	4.52	1.58	1.83	1.95	-0.12
VF (mV) @ IF=2mA	206.69	214.79	-8.1	4.26	2.83	1.43
VF (mV) @ IF=10mA	249.96	257.75	-7.79	4.09	2.83	1.26
VF (mV) @ IF=100mA	322.18	329.27	-7.09	3.98	2.87	1.11
VF (mV) @ IF=1A	494.17	499.01	-4.84	5.69	4.19	1.5
VF (mV) @ IF=2A	637.79	640.16	-2.37	9.41	6.14	3.27

TABLE A5: MINIMUM AND MAXIMUM VALUES OF POST EXTENDED HTRB ELECTRICAL TEST DATA FOR M-53						
TEST	MINIMUM VALUE			MAXIMUM VALUE		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB=60V	0.49	0.45	0.04	3.2	5.8	-2.6
ICBO (nA) @ VCB=75V	0.45	0.45	0	13	18	-5
IEBO (nA) @ VEB=4V	0.01	0.01	0	1.7	0.01	1.69
ICER (nA) @ VC=50V, R=5K	0.32	0.27	0.05	2	5.4	-3.4
ICES (nA) @ VCE= -50V	0.15	0.11	0.04	1.8	5.3	-3.5
HFE @ VCE=10V, IC=0.1mA	138.4	163.5	-25.1	191.6	182.8	8.8
HFE @ VCE=10V, IC=1mA	161.3	167.8	-6.5	198	183.5	14.5
HFE @ VCE=10V, IC=10mA	182.1	169.8	12.3	207	187.6	19.4
HFE @ VCE=10V, IC=150mA	180.3	167.4	12.9	210	186.6	23.4
HFE @ VCE=10V, IC=500mA	96.3	93.9	2.4	115.6	104.4	11.2
VCES(mV)@IC=150mA, IB=15mA	147	152	-5	158	163.5	-5.5
VCES(mV)@IC=500mA,IB=50mA	363	368	-5	386	391	-5
VBEON (mV) @ VCE=10V, IC=20mA	705.5	716.5	-11	712.5	720.5	-8
VBEON(mV)@VCE=10V,IC=50mA	730	741	-11	737.5	745	-7.5
VBES(mV)@IC=150mA,IB=15mA	886.5	873	-6.5	872	877.5	-5.5
VBES(mV)@IC=500mA,IB=50mA	1,081.5	1089.5	-8	1,099	1,101	-2
ICBO (nA) @ VCB=-50V	0.74	0.65	0.09	0.83	0.68	0.15
ICBO (nA) @ VCB=-60V	0.6	0.55	0.05	0.8	0.7	0.1
ICER (nA) @ VC=-50V, R=5K	0.44	0.36	0.08	0.52	0.4	0.12
IEBO (nA) @ VEB=-4V	0.48	0.46	0.02	0.56	0.54	0.02
HFE @ VCE=-10V, IC=-0.1mA	97.7	103.1	-5.4	106.1	110.1	-4
HFE @ VCE=-10V, IC=-1mA	112.4	120.6	-8.2	122.9	129	-6.1
HFE @ VCE=-10V, IC=-10mA	124.6	135.5	-10.9	137.2	145.4	-8.2
HFE @ VCE=-10V, IC=-150mA	130.2	142	-11.8	142	153.7	-11.7
HFE @ VCE=-10V, IC=-500mA	81.3	90.7	-9.4	93.3	102.5	-9.2
VCES(mV)@IC=-150mA,IB=-15mA	162	157	5	170.5	163.5	7
VCES(mV)@IC=-500mA,IB=-50mA	411	396	15	447.5	418.5	29
VBEON(mV)@VCE=-10V,IC=-20mA	712.5	716	-3.5	716.5	719.5	-3
VBEON(mV)@VCE=-10V,IC=-50mA	736	739	-3	740.5	741.5	-1
VBES(mV) @IC=-150mA,IB=-15mA	881	880.5	0.5	884.5	883.5	1
VBES(mV) @IC=-500mA,IB=-50mA	1,083.5	1,073	10.5	1,094.5	1,081	13.5
IR (μA) @VR=6V	1.3	0.92	0.38	1.97	4.73	-2.76
IR (μA) @ VR=36V	5.14	3.87	1.27	8.63	31.7	-23.07
VF (mV) @IF=2mA	200.5	211.5	-11	209.5	217.5	-8
VF (mV) @ IF=10mA	244	255	-11	253.5	260	-6.5
VF (mV) @ IF = 100mA	316.5	326	-9.5	326	332	-6
VF (mV) @ IF=1A	489	494.5	-5.5	502.5	504	-1.5
VF (mV) @ IF=2A	633	633	0	652	648	4
IR (μA) @ VR=6V	1.25	0.9	0.35	2.44	1.08	1.36
IR (μA) @VR=36V	5.11	3.84	1.27	15.6	5.87	9.73
VF (mV) @ IF=2mA	198	212.5	-14.5	211.5	217.5	-6
VF (mV) @ IF=10mA	241.5	255.5	-14	255	260.5	-5.5
VF (mV) @ IF=100mA	314	327.5	-13.5	327	332	-5
VF (mV) @ IF=1A	485	495.5	-10.5	511	504.5	6.5
VF (mV) @ IF=2A	626.5	633	-6.5	674	649	25

TABLE A6: AVERAGE AND STANDARD DEVIATION OF POST EXTENDED HTRB ELECTRICAL TEST DATA FOR M-53						
TEST	AVERAGE			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB=60V	0.64	0.93	-0.29	0.61	1.3	-0.69
ICBO (nA) @ VCB=75V	0.78	1.6	-0.82	1.2	3.1	-1.9
IEBO (nA) @ VEB=4V	0.11	0.01	0.1	0.38	0	0.38
ICER (nA) @ VC=50V, R=5K	0.41	0.64	-0.23	0.37	1.2	-0.83
ICES (nA) @ VCE= -50V	0.25	0.51	-0.26	0.37	1.2	-0.83
HFE @ VCE=10V, IC=0.1mA	176.91	174.87	2.04	15.38	4.77	10.61
HFE @ VCE=10V, IC=1mA	186.59	174.9	11.69	10.52	4.52	6
HFE @ VCE=10V, IC=10mA	198.15	178.03	20.12	9.23	4.92	4.3
HFE @ VCE=10V, IC=150mA	199.75	176.91	22.84	9.95	5.2	4.75
HFE @ VCE=10V, IC=500mA	107.32	98.86	8.46	5.5	3.05	2.44
VCES(mV)@IC=150mA, IB=15mA	152.25	158.03	-5.78	3.01	3.72	-0.71
VCES(mV)@IC=500mA,IB=50mA	378.75	380.73	-1.98	5.29	6.71	-1.42
VBEON(mV)@VCE=10V,IC=20mA	708.68	718.78	-10.1	2.01	0.88	1.13
VBEON(mV)@VCE=10V,IC=50mA	733.35	743.33	-9.98	2.05	1.04	1.01
VBES(mV)@IC=150mA,IB=15mA	869.55	875.5	-5.95	1.63	1.32	0.31
VBES(mV)@IC=500mA,IB=50mA	1,092.1	1,095.2	-3.1	4.42	3.55	0.87
ICBO (nA) @ VCB=-50V	0.75	0.66	0.09	0.02	0.01	0.01
ICBO (nA) @ VCB=-60V	0.67	0.59	0.08	0.05	0.04	0.01
ICER (nA) @ VC=-50V, R=5K	0.45	0.37	0.08	0.02	0.01	0.01
IEBO (nA) @ VEB=-4V	0.52	0.49	0.03	0.02	0.02	0
HFE @ VCE=-10V, IC=-0.1mA	102.97	107.98	-5.01	2.09	1.61	0.48
HFE @ VCE=-10V, IC=-1mA	118.62	126.37	-7.75	2.59	2	0.59
HFE @ VCE=-10V, IC=-10mA	131.96	142.03	-10.07	3.13	2.4	0.73
HFE @ VCE=-10V, IC=-150mA	137.39	148.13	-10.74	3.66	3.37	0.29
HFE @ VCE=-10V, IC=-500mA	89.63	98.93	-9.31	3.17	2.85	0.33
VCES(mV)@IC=-150mA,IB=-15mA	165	159.18	5.82	1.98	1.76	0.22
VCES(mV)@IC=-500mA,IB=-50mA	423.33	403.08	20.25	8.89	5.95	2.94
VBEON(mV)@VCE=-10V,IC=-20mA	714.68	717.58	-2.9	0.91	0.85	0.06
VBEON(mV)@VCE=-10V,IC=-50mA	738.28	740.25	-1.97	1.03	0.73	0.3
VBES(mV) @IC=-150mA,IB=-15mA	882.25	882.18	0.07	0.98	0.77	0.21
VBES(mV) @IC=-500mA,IB=-50mA	1,087.9	1,077.7	10.2	3.05	2.2	0.85
IR (μA) @ VR=6V	1.61	1.18	0.43	0.16	0.84	-0.67
IR (μA) @ VR=36V	6.28	5.49	0.79	0.76	6.17	-5.41
VF (mV) @IF=2mA	205.13	215.2	-10.07	2.3	1.41	0.89
VF (mV) @ IF=10mA	248.38	258.13	-9.75	2.29	1.49	0.8
VF (mV) @ IF=100mA	321.23	329.6	-8.37	2.31	1.5	0.81
VF (mV) @ IF=1A	496.73	499.05	-2.32	3.48	2.7	0.78
VF (mV) @ IF=2A	644.28	639.75	4.53	5.66	4.32	1.34
IR (μA) @ VR=6V	1.68	0.99	0.69	0.27	0.05	0.23
IR (μA) @VR=36V	7.04	4.35	2.69	2.8	0.41	2.39
VF (mV) @ IF=2mA	204.25	215.5	-11.25	3.23	1.18	2.05
VF (mV) @ IF=10mA	247.68	258.4	-10.72	3.11	1.33	1.78
VF (mV) @ IF=100mA	320.2	329.95	-9.75	3.01	1.29	1.72
VF (mV) @ IF=1A	493.58	499.85	-6.27	5.34	2.52	2.82
VF (mV) @ IF=2A	638.68	641.03	-2.35	10.31	4.55	5.76

TABLE A7: MINIMUM AND MAXIMUM VALUES OF POST 500 HOUR HTRB ELECTRICAL TEST DATA FOR M-53						
TEST	MINIMUM VALUE			MAXIMUM VALUE		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB=60V	0.46	0.43	0.03	0.59	3.5	-2.91
ICBO (nA) @ VCB=75V	0.45	0.35	0.1	0.65	14	-13.35
IEBO (nA) @ VEB=4V	0.01	0.01	0	9.2	0.13	9.07
ICER (nA) @ VC=50V, R=5K	0.32	0.25	0.07	0.42	0.87	-0.45
ICES (nA) @ VCE = -50V	0.16	0.11	0.05	0.25	0.74	-0.49
HFE @ VCE=10V, IC=0.1mA	145.8	165.7	-19.9	190.1	178.7	11.4
HFE @ VCE=10V, IC=1mA	167.5	165.6	1.9	196.8	178.3	18.5
HFE @ VCE=10V, IC=10mA	175.6	167.8	7.8	207	182.1	24.9
HFE @ VCE=10V, IC=150mA	174.4	165.9	8.5	210	180.3	29.7
HFE @ VCE=10V, IC=500mA	95.6	93.6	2.3	114.8	102.7	12.1
VCES(mV)@IC=150mA, IB=15mA	147.5	151.5	-4	160.5	164.5	-4
VCES(mV)@IC=500mA,IB=50mA	371.5	367.5	4	390	393.5	-3.5
VBEON(mV)@VCE=10V,IC=20mA	706.5	719.5	-13	717.5	722.5	-5
VBEON(mV)@VCE=10V,IC=50mA	732	743	-11	742.5	747	-4.5
VBES(mV)@IC=150mA,IB=15mA	868	874	-6	874.5	879	-4.5
VBES(mV)@IC=500mA,IB=50mA	1,088	1,089.5	-1.5	1,102	1,102.5	-0.5
ICBO (nA) @ VCB=-50V	0.7	0.64	0.06	0.74	0.66	0.08
ICBO (nA) @ VCB=-60V	0.6	0.55	0.05	0.7	0.6	0.1
ICER (nA) @ VC=-50V, R=5K	0.4	0.36	0.04	0.46	0.4	0.06
IEBO (nA) @ VEB=-4V	0.43	0.45	-0.02	0.56	0.53	0.03
HFE @ VCE=-10V, IC=-0.1mA	100.7	101.6	-0.9	105.7	109.4	-3.7
HFE @ VCE=-10V, IC=-1mA	116.1	119.1	-3	122.9	128.5	-5.6
HFE @ VCE=-10V, IC=-10mA	128.9	133.9	-5	137.6	144.9	-7.3
HFE @ VCE=-10V, IC=-150mA	133.9	139.9	-6	144.2	153.7	-9.5
HFE @ VCE=-10V, IC=-500mA	82.6	89.03	-6.43	93.3	102.5	-9.2
VCES(mV)@IC=-150mA,IB=-15mA	162.5	156	6.5	168	165.5	2.5
VCES(mV)@IC=-500mA,IB=-50mA	415	392.5	22.5	441.5	425	16.5
VBEON(mV)@VCE=-10V,IC=-20mA	714.5	718	-3.5	721	721.5	-0.5
VBEON(mV)@VCE=-10V,IC=-50mA	738	740	-2	744	744	0
VBES(mV) @IC=-150mA,IB=-15mA	881.5	881.5	0	888	885	3
VBES(mV) @IC=-500mA,IB=-50mA	1,083	1073	10	1,095.5	1,084	11.5
IR (μA) @VR=6V.	0.98	0.83	0.15	2.04	1	1.04
IR (μA) @ VR=36V	4.09	3.35	0.74	15.6	4.07	11.53
VF (mV) @IF=2mA	199.5	214	-14.5	216	218	-2
VF (mV) @ IF=10mA	243.5	257	-13.5	259	261	-2
VF (mV) @ IF=100mA	316.5	328.5	-12	331	332.5	-1.5
VF (mV) @ IF=1A	491.5	496	-4.5	512	505	7
VF (mV) @ IF=2A	633	633.5	-0.5	671	649.5	21.5
IR (μA) @ VR=6V	1.12	0.82	0.3	2.63	1.18	1.45
IR (μA) @VR=36V	4.45	3.58	0.87	12.8	5.46	7.34
VF (mV) @ IF=2mA	192.5	210	-17.5	213	219.5	-6.5
VF (mV) @ IF=10mA	236	252.5	-16.5	256	262	-6
VF (mV) @ IF=100mA	308.5	324	-15.5	328.5	333.5	-5
VF (mV) @ IF=1A	479	490	-11	501	506	-5
VF (mV) @ IF=2A	621.5	627	-5.5	646	651	-5

TABLE A8: AVERAGE AND STANDARD DEVIATION OF POST 500 HOUR HTRB ELECTRICAL TEST DATA FOR M-53

TEST	AVERAGE			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB=60V	0.51	0.64	-0.13	0.03	0.64	-0.61
ICBO (nA) @ VCB=75V	0.53	1.3	-0.77	0.04	2.9	-2.86
IEBO (nA) @ VEB=4V	0.61	0.02	0.59	2.1	0.04	2.06
ICER (nA) @ VC=50V, R=5K	0.35	0.33	0.02	0.02	0.12	-0.1
ICES (nA) @ VCE= -50V	0.19	0.2	-0.01	0.02	0.13	-0.11
HFE @ VCE=10V, IC=0.1mA	176.74	172.78	3.96	10.99	4.36	6.63
HFE @ VCE=10V, IC=1mA	183.71	171.99	11.72	9.14	4.3	4.88
HFE @ VCE=10V, IC=10mA	192.79	174.71	18.08	11.59	4.46	7.13
HFE @ VCE=10V, IC=150mA	193.64	173.55	20.09	13.2	4.71	8.49
HFE @ VCE=10V, IC=500mA	104.55	98.66	5.89	6.4	2.94	3.46
VCES(mV)@IC=150mA, IB=15mA	153.93	159.59	-5.66	4.03	3.48	0.55
VCES(mV)@IC=500mA,IB=50mA	380.95	383.66	-2.71	5.28	6.75	-1.47
VBEON(mV)@VCE=10V,IC=20mA	710.68	720.64	-9.96	3.04	0.93	2.11
VBEON(mV)@VCE=10V,IC=50mA	735.63	745.02	-9.39	3.04	1.01	2.03
VBES(mV)@IC=150mA,IB=15mA	871.35	877.2	-5.85	2.15	1.21	0.94
VBES(mV)@IC=500mA,IB=50mA	1,094.8	1,097.2	-2.4	3.62	3.06	0.56
ICBO (nA) @ VCB=-50V	0.72	0.64	0.08	0.01	0.01	0
ICBO (nA) @ VCB=-60V	0.65	0.6	0.05	0.05	0.02	0.03
ICER (nA) @ VC=-50V, R=5K	0.43	0.37	0.06	0.02	0.01	0.01
IEBO (nA) @ VEB=-4V	0.49	0.48	0.01	0.04	0.02	0.02
HFE @ VCE=-10V, IC=-0.1mA	103.16	106.15	-2.99	1.55	1.97	-0.42
HFE @ VCE=-10V, IC=-1mA	119	124.51	-5.51	2.04	2.36	-0.32
HFE @ VCE=-10V, IC=-10mA	132.45	140.04	-7.59	2.69	2.73	-0.04
HFE @ VCE=-10V, IC=-150mA	138.53	146.36	-7.83	3.02	3.05	-0.03
HFE @ VCE=-10V, IC=-500mA	89.65	97.89	-8.24	3.55	3.45	0.1
VCES(mV)@IC=-150mA,IB=-15mA	164.53	159.09	5.44	1.7	2.5	-0.8
VCES(mV)@IC=-500mA,IB=-50mA	423.15	403.16	19.99	8.47	7.96	-0.51
VBEON(mV)@VCE=-10V,IC=-20mA	716.6	719.55	-2.95	1.68	0.9	0.78
VBEON(mV)@VCE=-10V,IC=-50mA	740.08	742.02	-1.94	1.6	1.03	0.57
VBES(mV) @IC=-150mA,IB=-15mA	883.88	883.36	0.52	1.37	0.9	0.47
VBES(mV) @IC=-500mA,IB=-50mA	1,089.2	1,078.1	11.1	2.78	2.4	0.38
IR (μA) @VR=6V	1.48	0.9	0.58	0.27	0.04	0.23
IR (μA) @ VR=36V	6.43	3.78	2.65	2.57	0.2	2.37
VF (mV) @IF=2mA	206.85	216.64	-9.79	4.14	1.1	3.04
VF (mV) @ IF=10mA	250.2	259.34	-9.14	3.88	1.06	2.82
VF (mV) @ IF=100mA	322.8	330.75	-7.95	3.83	1.18	2.65
VF (mV) @ IF=1A	498.5	499.57	-1.07	5.51	2.33	3.18
VF (mV) @ IF=2A	646.48	639.86	6.62	9.08	4.07	5.01
IR (μA) @ VR=6V	1.43	0.94	0.49	0.31	0.1	0.21
IR (μA) @VR=36V	5.64	4.02	1.62	1.76	0.4	1.36
VF (mV) @ IF=2mA	207.5	215.98	-8.48	4.21	2.62	1.59
VF (mV) @ IF=10mA	250.65	258.73	-8.08	4.18	2.62	1.56
VF (mV) @ IF=100mA	322.75	330.2	-7.45	4.13	2.71	1.42
VF (mV) @ IF=1A	493.85	500.36	-6.51	4.88	4.27	0.61
VF (mV) @ IF=2A	636.45	641.93	-5.48	6.43	6.32	0.11

TABLE A9: MINIMUM AND MAXIMUM VALUES OF ELECTRICAL TEST DATA AT -55°C FOR M-53						
TEST	MINIMUM VALUE			MAXIMUM VALUE		
	Freon	DI Water	Delta	Freon	DI Water	Delta
HFE @ VCE = 10V, IC = 10mA	93.3	90.6	2.7	111.6	102.5	9.1
HFE @ VCE = 10V, IC = 20mA	91.7	89.1	2.6	111.1	101.1	10
HFE @ VCE = 10V, IC = 50mA	91.2	88.3	2.9	111.6	101.1	10.5
VBEON (mV) @VCE=10V, IC=20mA	852.5	854.5	-2	862	863	-1
VBEON (mV)@VCE=-10V,IC=-50mA	870.5	872.5	-2	880.5	881.5	-1
HFE @ VCE=-10V, IC=-1mA	58.6	64.3	-5.7	65.4	69.8	-4.4
HFE @ VCE=-10V, IC=-20mA	67.3	74.5	-7.2	75.8	81.6	-5.8
HFE @ VCE=-10V, IC=-50mA	71.7	79.4	-7.7	81	86.8	-5.8
VBEON (mV)@VCE=-10V,IC=-20mA	853.5	851	2.5	862.5	859	3.5
VBEON (mV)@VCE=-10V,IC=-50mA	871	868	3	880	875.5	4.5
VF (mV) @ IF = 2mA	332	341	-9	351.5	349	2.5
VF (mV) @ IF = 10mA	366	375	-9	384.5	383.5	1
VF (mV) @ IF = 100mA	420	429.5	-9.5	438.5	437	1.5
VF (mV) @ IF = 1A	536.5	543	-6.5	555	552	3
VF (mV) @ IF = 2A	629	631	-2	653.5	645.5	8
VF (mV) @ IF = 2mA	326	335	-9	348.5	348.5	0
VF (mV) @ IF = 10mA	359.5	368	-8.5	382	383	-1
VF (mV) @ IF = 100mA	413	422	-9	436.5	437	-0.5
VF (mV) @ IF = 1A	528	534	-6	553	554.5	-1.5
VF (mV) @ IF = 2A	618	622.5	-4.5	647	649.5	-2.5

TABLE A10: AVERAGE AND STANDARD DEVIATION OF ELECTRICAL TEST DATA AT -55°C FOR M-53						
TEST	AVERAGE VALUE			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
HFE @ VCE = 10V, IC = 10mA	104.63	95.52	9.11	5.83	2.85	2.98
HFE @ VCE = 10V, IC = 20mA	103.56	94.25	9.31	5.83	2.82	3.01
HFE @ VCE = 10V, IC = 50mA	103.81	93.49	10.32	6.18	2.84	3.34
VBEON (mV) @VCE=10V, IC=20mA	856.78	857.99	-1.21	2.17	1.76	0.41
VBEON (mV)@VCE=-10V,IC=-50mA	875.35	876.67	-1.32	2.22	1.72	0.5
HFE @ VCE=-10V, IC=-1mA	62.59	67.57	-4.98	1.31	1.2	0.11
HFE @ VCE=-10V, IC=-20mA	72.15	78.58	-6.43	1.64	1.55	0.09
HFE @ VCE=-10V, IC=-50mA	76.81	83.87	-7.06	1.73	1.64	0.09
VBEON (mV)@VCE=-10V,IC=-20mA	857.14	853.9	3.24	1.85	1.73	0.12
VBEON (mV)@VCE=-10V,IC=-50mA	874.47	870.62	3.85	1.84	1.66	0.18
VF (mV) @ IF = 2mA	342.19	344.36	-2.17	3.59	1.51	2.08
VF (mV) @ IF = 10mA	375.55	378.38	-2.83	3.51	1.64	1.87
VF (mV) @ IF = 100mA	429.52	432.78	-3.26	3.42	1.53	1.89
VF (mV) @ IF = 1A	545.67	547.68	-2.01	3.55	2.03	1.52
VF (mV) @ IF = 2A	638.41	638.74	-0.33	4.45	3.18	1.27
VF (mV) @ IF = 2mA	341.44	343.64	-2.2	4.27	2.57	1.7
VF (mV) @ IF = 10mA	375.01	377.59	-2.58	4.23	2.84	1.39
VF (mV) @ IF = 100mA	428.79	432.06	-3.27	4.36	2.95	1.41
VF (mV) @ IF = 1A	543.16	546.57	-3.41	4.66	3.79	0.87
VF (mV) @ IF = 2A	633.94	637.28	-3.34	5.74	5.24	0.5

TABLE A11: MINIMUM AND MAXIMUM VALUES OF ELECTRICAL TEST DATA AT 100°C FOR M-53						
TEST	MINIMUM VALUE			MAXIMUM VALUE		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB = 60V	15	16	-1	124	74	50
IEBO (nA) @ VEB = 4V	0.06	1.2	-1.14	28	18	10
ICER (nA) @ VC = 50V, R = 5K	17	18	-1	109	65	44
HFE @ VCE = 10V, IC = 20 mA	253	246	7	305	276	29
HFE @ VCE = 10V, IC = 50 mA	244	236	8	295	265	30
VBEON (mV) @ VCE=10V, IC=20mA	539	545	-6	574.5	551.5	23
VBEON (mV) @ VCE=10V, IC=50mA	571	576.5	-5.5	605	583.5	21.5
ICBO (nA) @ VCB = -50V	7	4.9	2.1	23	24	-1
IEBO (nA) @ VEB = -4V	1.8	1.7	0.1	4.3	3	1.3
ICER (nA) @ VC = -50V, R = 5K	9.8	6.8	3	33	32	1
HFE @ VCE = -10V, IC = -20 mA	187.2	207	-19.8	211	225	-14
HFE @ VCE = -10V, IC = -50 mA	186.6	206	-19.4	210	225	-15
VBEON (mV) @VCE=-10V, IC=-20mA	550.5	547	3.5	580	553	27
VBEON (mV) @VCE=-10V, IC=-50mA	580.5	576	4.5	609.5	582	27.5
IR (μA) @ VR = 6V	372	687	-315	1090	880	210
IR (μA) @ VR = 36V	872	1580	-708	2610	2030	580
VF (mV) @ IF = 2 mA	48.5	53.5	-5	76	60	16
VF (mV) @ IF = 10 mA	98	103.5	-5.5	127.5	111.5	16
VF (mV) @ IF = 100 mA	190.5	196	-5.5	217	203.5	13.5
VF (mV) @ IF = 450 mA	298.5	302.5	-4	321	311	10
IR (μA) @ VR = 6V	365	665	-300	1300	1040	260
IR (μA) @ VR = 36V	868	1520	-652	3090	2360	730
VF (mV) @ IF = 2 mA	44	49.5	-5.5	76	60.5	15.5
VF (mV) @ IF = 10 mA	92	98	-6	127.5	112	15.5
VF (mV) @ IF = 100 mA	183	189.5	-6.5	216.5	204.5	12
VF (mV) @ IF = 450 mV	289	295	-6	320.5	312.5	8

TABLE A12: AVERAGE AND STANDARD DEVIATION OF ELECTRICAL TEST DATA AT 100°C FOR M-53						
TEST	AVERAGE VALUE			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
ICBO (nA) @ VCB = 60V	31	41	-10	13	13	0
IEBO (nA) @ VEB = 4V	3.3	2.8	0.5	4	2.3	1.7
ICER (nA) @ VC = 50V, R = 5K	34	41	-7	12	12	0
HFE @ VCE = 10V, IC = 20 mA	286.61	259.71	26.9	15.72	7.5	8.12
HFE @ VCE = 10V, IC = 50 mA	276.69	249.25	27.44	15.83	7.49	8.34
VBEON (mV) @ VCE=10V, IC=20mA	547.44	549.19	-1.75	6.74	1.48	5.26
VBEON (mV) @ VCE=10V, IC=50mA	579.44	580.74	-1.3	6.39	1.48	4.91
ICBO (nA) @ VCB = -50V	14	7.1	6.9	3.3	2.8	0.5
IEBO (nA) @ VEB = -4V	3	2.3	0.7	0.54	0.27	0.27
ICER (nA) @ VC = -50V, R = 5K	20	9.9	10.1	5.1	3.4	1.7
HFE @ VCE = -10V, IC = -20 mA	200.31	218 39	-18.08	4.55	3.84	0.71
HFE @ VCE = -10V, IC = -50 mA	199.68	217.61	-17.93	4.59	3.83	.76
VBEON (mV) @VCE=-10V, IC=-20mA	556.69	550.78	5.91	6.26	1.33	4.93
VBEON (mV) @VCE=-10V, IC=-50mA	586.62	579.86	6.76	6.11	1.26	4.85
IR (μA) @ VR = 6V	804	747	57	145	41.6	103.4
IR (μA) @ VR = 36V	1840	1720	120	323	95.2	227.8
VF (mV) @ IF = 2 mA	56.57	57.69	-1.12	5.42	1.58	3.84
VF (mV) @ IF = 10 mA	106.99	108.58	-1.59	5.94	1.71	4.23
VF (mV) @ IF = 100 mA	199.06	200.55	-1.49	5.3	1.68	3.62
VF (mV) @ IF = 450 mA	306.9	307.59	-0.69	4.51	2.08	2.43
IR (μA) @ VR = 6V	812	759	53	154	65.2	88.8
IR (μA) @ VR = 36V	1870	1750	120	340	145	195
VF (mV) @ IF = 2 mA	56.18	57.37	-1.19	5.64	2.2	3.44
VF (mV) @ IF = 10 mA	106.47	108.13	-1.66	6.12	2.53	3.59
VF (mV) @ IF = 100 mA	198.18	200.06	-1.88	5.62	2.68	2.94
VF (mV) @ IF = 450 mV	304.61	306.82	-2.21	5.14	3.25	1.89

TABLE A13: MINIMUM AND MAXIMUM VALUES OF INITIAL ELECTRICAL TEST DATA FOR M-48						
	MINIMUM VALUE			MAXIMUM VALUE		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	7.4	7	0.4	12	9.5	2.5
VF (mV) @ IF = 1 mA	615.5	621.5	-6	620	628.5	-8.5
VF (mV) @ IF = 10 mA	742	747.5	-5.5	756.5	755.5	1
IR (nA) @ VR = 55V	7.3	6.8	0.5	12	9.4	2.6
VF (mV) @ IF = 1 mA	615.5	621.5	-6	620	629.5	-9.5
VF (mV) @ IF = 10 mA	739.5	748	-8.5	750	755.5	-5.5
IR (pA) @ VR = 10V	0	1	-1	2.2	2.5	-0.3
IR (pA) @ VR = 30V	1.5	0.8	0.7	4.5	2	2.5
VF (mV) @ IF = 1 mA	747	751	-4	749	756	-7
VF (mV) @ IF = 10 mA	824	827	-3	826	831.5	-5.5
VF (mV) @ IF = 100 mA	997.5	976.5	21	986.5	985.5	1
IR (pA) @ VR = 10V	0	0	0	1.7	1.1	0.6
IR (pA) @ VR = 30V	1.4	1.3	0.1	3.4	2.6	0.8
VF (mV) @ IF = 1mA	747.5	751	-3.5	749	756	-7
VF (mV) @ IF = 10 mA	824	827.5	-3.5	826	832.5	-6.5
VF (mV) @ IF = 100 mA	978	979.5	-1.5	985.5	1005.5	-20

TABLE A14: AVERAGE AND STANDARD DEVIATION OF INITIAL ELECTRICAL TEST DATA FOR M-48						
	AVERAGE VALUE			STANDARD DEVIATION		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	10	8.3	1.7	0.93	0.76	0.17
VF (mV) @ IF = 1 mA	618.08	624.31	-6.23	1.01	2.2	-1.19
VF (mV) @ IF = 10 mA	746.45	751.22	-4.77	2.1	1.88	0.22
IR (nA) @ VR = 55V	9.7	8.2	1.5	1.1	0.73	0.37
VF (mV) @ IF = 1 mA	618.2	624.54	-6.34	1.14	2.29	-1.15
VF (mV) @ IF = 10 mA	745.76	751.15	-5.39	2.27	1.91	0.36
IR (pA) @ VR = 10V	0.53	1.5	-0.97	0.44	0.24	0.2
IR (pA) @ VR = 30V	2.6	1.5	1.1	0.49	0.25	0.24
VF (mV) @ IF = 1 mA	748.12	753.04	-4.92	0.33	1.68	-1.35
VF (mV) @ IF = 10 mA	824.63	828.72	-4.09	0.53	1.44	-0.91
VF (mV) @ IF = 100 mA	980.52	980.48	0.04	1.78	2.23	-0.45
IR (pA) @ VR = 10V	0.55	0.16	0.39	0.35	0.16	0.19
IR (pA) @ VR = 30V	2	2	0	0.35	0.28	0.07
VF (mV) @ IF = 1mA	748.15	752.88	-4.73	0.26	1.62	-1.36
VF (mV) @ IF = 10 mA	825.21	829.35	-4.14	0.50	1.47	-0.97
VF (mV) @ IF = 100 mA	982.3	984.35	-2.05	1.78	3.66	-1.88

TABLE A15: MINIMUM AND MAXIMUM VALUES OF POST HTRB ELECTRICAL TEST DATA FOR M-48						
	MINIMUM VALUE			MAXIMUM VALUE		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	8.9	7.2	1.7	15	9.9	5.1
VF (mV) @ IF = 1 mA	617.5	624	-6.5	624	629.5	-5.5
VF (mV) @ IF = 10 mA	742	750	-8	751.5	755.5	-4
IR (nA) @ VR = 55V	8	7.1	0.9	16	9.8	6.2
VF (mV) @ IF = 1 mA	616.5	625	-8.5	622	629.5	-7.5
VF (mV) @ IF = 10 mA	741.5	751.5	-10	751.5	755.5	-4
IR (pA) @ VR = 10V	0	1.1	-1.1	0.6	1.8	-1.2
IR (pA) @ VR = 30V	1.7	0.8	0.9	3.5	1.8	1.7
VF (mV) @ IF = 1 mA	748	753.5	-5.5	752	756.5	-4.5
VF (mV) @ IF = 10 mA	842.5	829	13.5	828	831.5	-3.5
VF (mV) @ IF = 100 mA	977.5	978.5	-1	986.5	986	0.5
IR (pA) @ VR = 10V	0	0	0	0.6	0.5	0.1
IR (pA) @ VR = 30V	1.5	1.1	0.4	2.4	2.1	0.3
VF (mV) @ IF = 1mA	748	753.5	-5.5	752	756	-4
VF (mV) @ IF = 10 mA	824.5	830	-5.5	828.5	832	-3.5
VF (mV) @ IF = 100 mA	978	981	-3	986.5	988.5	-2

TABLE A16: AVERAGE AND STANDARD DEVIATION OF POST HTRB ELECTRICAL TEST DATA FOR M-48						
	AVERAGE VALUE			STANDARD DEVIATION		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	12	9.3	2.7	1.4	0.61	0.79
VF (mV) @ IF = 1 mA	619.48	627.16	-7.68	1.25	0.98	0.27
VF (mV) @ IF = 10 mA	747.43	753.29	-5.86	1.85	1.11	0.74
IR (nA) @ VR = 55V	11	8.2	2.8	1.7	0.58	1.12
VF (mV) @ IF = 1 mA	619.69	627.26	-7.57	1.14	0.95	0.19
VF (mV) @ IF = 10 mA	746.86	753.29	-6.43	2.24	0.98	1.26
IR (pA) @ VR = 10V	0.3	1.4	-1.1	0.18	0.15	0.03
IR (pA) @ VR = 30V	2.3	1.4	0.9	0.29	0.19	0.1
VF (mV) @ IF = 1 mA	749.39	755.11	-5.72	0.93	0.69	0.24
VF (mV) @ IF = 10 mA	825.67	830.53	-4 86	0.69	0.66	0.03
VF (mV) @ IF = 100 mA	980.98	981.82	-0.84	1.8	1.85	-0.05
IR (pA) @ VR = 10V	0.14	0.15	-0.01	0.12	0.11	0.01
IR (pA) @ VR = 30V	1.9	1.6	0.3	0.24	0.19	0.05
VF (mV) @ IF = 1mA	749.47	755.01	-5.54	0.91	0.68	0.23
VF (mV) @ IF = 10 mA	826.23	831.21	-4.98	0.88	0.59	0.59
VF (mV) @ IF = 100 mA	982.88	985.03	-2.15	1.84	1.54	0.3

TABLE A17: MINIMUM AND MAXIMUM VALUES OF POST EXTENDED HTRB ELECTRICAL TEST DATA FOR M-48						
	MINIMUM VALUE			MAXIMUM VALUE		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	9.2	8.6	0.6	14	11	3
VF (mV) @ IF = 1 mA	619	621.5	-2.5	625.5	627.5	-2
VF (mV) @ IF = 10 mA	745.5	747	-1.5	752	753.5	-1.5
IR (nA) @ VR = 55V	8	8.5	-0.5	14	11	3
VF (mV) @ IF = 1 mA	618	624	-6	624	627	-3
VF (mV) @ IF = 10 mA	743	751.5	-8.5	752.5	753	-0.5
IR (pA) @ VR = 10V	0.5	1.3	-0.8	3.3	2.4	0.9
IR (pA) @ VR = 30V	0.6	0.5	0.1	5.7	1.4	4.3
VF (mV) @ IF = 1 mA	748.5	752.5	-4	753	755	-2
VF (mV) @ IF = 10 mA	825	828	-3	829	831	-2
VF (mV) @ IF = 100 mA	979	978	1	985	984.5	0.5
IR (pA) @ VR = 10V	0	0.6	-0.6	2.3	1.7	0.6
IR (pA) @ VR = 30V	1.1	0.5	0.6	2.7	1.4	1.3
VF (mV) @ IF = 1mA	749.5	752.5	-3	753	755	-2
VF (mV) @ IF = 10 mA	826	828.5	-2.5	830	831.5	-1.5
VF (mV) @ IF = 100 mA	981	981	0	987	987.5	-0.5

TABLE A18: AVERAGE AND STANDARD DEVIATION OF POST EXTENDED HTRB ELECTRICAL TEST DATA FOR M-48						
	AVERAGE VALUE			STANDARD DEVIATION		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	12	9.3	2.7	1.3	0.76	0.54
VF (mV) @ IF = 1 mA	621.48	625.15	-3.67	1.62	1.36	0.26
VF (mV) @ IF = 10 mA	749.28	751.85	-2.57	1.94	1.45	0.49
IR (nA) @ VR = 55V	11	9.3	1.7	1.8	0.8	1
VF (mV) @ IF = 1 mA	621.25	625.48	-4.23	1.47	0.94	0.53
VF (mV) @ IF = 10 mA	748.03	752.1	-4.07	2.68	0.36	2.32
IR (pA) @ VR = 10V	1.9	1.9	0	0.69	0.36	0.33
IR (pA) @ VR = 30V	2.1	.76	1.34	1	0.23	0.77
VF (mV) @ IF = 1 mA	750.68	753.48	-2.8	1.23	0.84	0.39
VF (mV) @ IF = 10 mA	826.85	829.1	-2.25	1.09	0.85	0.24
VF (mV) @ IF = 100 mA	981.48	981.69	-0.21	1.63	2.12	-0.49
IR (pA) @ VR = 10V	0.58	0.87	-0.29	0.75	0.23	0.52
IR (pA) @ VR = 30V	1.9	0.94	0.96	0.41	0.26	0.15
VF (mV) @ IF = 1mA	750.98	753.21	-2.23	1.04	0.66	0.38
VF (mV) @ IF = 10 mA	827.65	830.06	-2.41	0.99	0.67	0.32
VF (mV) @ IF = 100 mA	984.35	984.35	0	1.62	1.65	-0.03

TABLE A19: MINIMUM AND MAXIMUM VALUES OF POST 500 HOUR HTRB ELECTRICAL TEST DATA FOR M-48						
	MINIMUM VALUE			MAXIMUM VALUE		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	8.7	7.4	1.3	12	9.7	2.3
VF (mV) @ IF = 1 mA	621	627	-6	625	630	-5
VF (mV) @ IF = 10 mA	748	752	-4	753.5	756	-2.5
IR (nA) @ VR = 55V	7.4	7.4	0	13	9.3	3.7
VF (mV) @ IF = 1 mA	622	628.5	-6.5	625	630	-5
VF (mV) @ IF = 10 mA	744.5	754	-9.5	754	755.5	-1.5
IR (pA) @ VR = 10V	1.4	0.8	0.6	2.3	2.5	-0.2
IR (pA) @ VR = 30V	1.5	0.2	1.3	2.1	1.9	0.2
VF (mV) @ IF = 1 mA	752	756	-4	752.5	756.5	-4
VF (mV) @ IF = 10 mA	828	831.5	-3.5	828.5	832	-3.5
VF (mV) @ IF = 100 mA	980.5	980.5	0	986	986.5	-0.5
IR (pA) @ VR = 10V	0	0.2	-0.2	0.4	1.4	-1
IR (pA) @ VR = 30V	1.7	0	1.7	2.8	1.5	1.3
VF (mV) @ IF = 1mA	752	756	-4	753	757	-4
VF (mV) @ IF = 10 mA	828	831.5	-3.5	830	833	-3
VF (mV) @ IF = 100 mA	981	983.5	-2.5	987.5	989.5	-2

TABLE A20: AVERAGE AND STANDARD DEVIATION OF POST 500 HOUR HTRB ELECTRICAL TEST DATA FOR M-48						
	AVERAGE VALUE			STANDARD DEVIATION		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	10	8.6	1.4	1.1	0.75	0.35
VF (mV) @ IF = 1 mA	623.73	629.13	-5.4	0.97	0.86	0.11
VF (mV) @ IF = 10 mA	750.65	754.93	-4.28	1.42	1.05	0.37
IR (nA) @ VR = 55V	10	8.5	1.5	1.5	0.6	0.9
VF (mV) @ IF = 1 mA	623.85	629.65	-5.8	0.78	0.49	[illegible]29
VF (mV) @ IF = 10 mA	750.43	755.18	-4.75	2.46	0.55	1.91
IR (pA) @ VR = 10V	1.8	1.5	0.3	0.21	0.36	-0.15
IR (pA) @ VR = 30V	1.7	0.82	0.88	0.21	0.49	-0.28
VF (mV) @ IF = 1 mA	752.1	756.48	-4.38	0.21	0.11	0.10
VF (mV) @ IF = 10 mA	828.15	831.6	-3.45	0.24	0.21	0.03
VF (mV) @ IF = 100 mA	982.9	983.03	-0.13	1.49	1.93	-0.44
IR (pA) @ VR = 10V	0.12	0.58	-0.46	0.11	0.28	-0.17
IR (pA) @ VR = 30V	2.2	0.9	1.3	0.3	0.39	-0.09
VF (mV) @ IF = 1mA	752.15	756.45	-4.3	0.29	0.22	0.07
VF (mV) @ IF = 10 mA	828.75	832.25	-3.5	0.6	0.38	0.22
VF (mV) @ IF = 100 mA	984.93	985.75	-0.82	1.64	1.56	0.08

TABLE A21: MINIMUM AND MAXIMUM VALUES OF ELECTRICAL TEST DATA AT -55°C FOR M-48						
	MINIMUM VALUE			MAXIMUM VALUE		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
VF (mV) @ IF = 1 mA	778	771.5	6.5	785	786	-1
VF (mV) @ IF = 10 mA	872	867	5	879	879	0
VF (mV) @ IF = 25 mA	930	925	5	938	935.5	2.5
VF (mV) @ IF = 1 mA	778	771.5	6.5	785.5	786	-0.5
VF (mV) @ IF = 10 mA	870	867	3	879	879	0
VF (mV) @ IF = 25 mA	926	925	1	938	936	2
VF (mV) @ IF = 1 mA	876	870	6	881.5	881.5	0
VF (mV) @ IF = 10 mA	935	928.5	6.5	940	940	0
VF (mV) @ IF = 1 mA	876	870	6	882	881.5	0.5
VF (mV) @ IF = 10 mA	935.5	929.5	6	977.5	939.5	38

TABLE A22: AVERAGE AND STANDARD DEVIATION OF ELECTRICAL TEST DATA AT -55°C FOR M-48						
	AVGERAGE VALUE			STANDARD DEVIATION		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
VF (mV) @ IF = 1 mA	781.92	780.7	1.22	1.5	2.08	-0.58
VF (mV) @ IF = 10 mA	875.32	874.01	1.31	1.34	1.85	-0.51
VF (mV) @ IF = 25 mA	933.11	931.56	1.55	1.55	1.84	-0.29
VF (mV) @ IF = 1 mA	781.91	780.86	1.05	1.7	1.98	-0.28
VF (mV) @ IF = 10 mA	875.06	874.02	1.04	1.96	1.77	0.19
VF (mV) @ IF = 25 mA	932.74	931.56	1.18	2.6	1.64	0.96
VF (mV) @ IF = 1 mA	878.68	877.49	1.19	1.4	1.69	-0.29
VF (mV) @ IF = 10 mA	936.84	935.51	1.33	1.18	1.42	-0.24
VF (mV) @ IF = 1 mA	878.69	877.38	1.31	1.47	1.67	-0.2
VF (mV) @ IF = 10 mA	937.68	935.97	1.71	5.12	1.35	3.77

TABLE A23: MINIMUM AND MAXIMUM VALUES OF ELECTRICAL TEST DATA AT 100°C FOR M-48						
	MINIMUM VALUE			MAXIMUM VALUE		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	5.05	5.53	-0.48	17.6	7.91	9.69
VF (mV) @ IF = 1 mA	404.5	404.5	0	415.5	415.5	0
VF (mV) @ IF = 10 mA	572	572.5	-0.5	582	582	0
IR (nA) @ VR = 55V	4.44	5.57	-1.13	8.76	8.26	0.5
VF (mV) @ IF = 1 mA	407	404.5	2.5	417.5	415.5	2
VF (mV) @ IF = 10 mA	575.5	574	1.5	580.5	582	-1.5
IR (pA) @ VR = 10V	0.17	0.15	0.02	1.3	0.51	0.79
IR (pA) @ VR = 30V	0.78	0.32	0.46	4.3	1.7	2.6
VF (mV) @ IF = 1 mA	574	572	2	579.5	582	-2.5
VF (mV) @ IF = 10 mA	674	672.5	1.5	679.5	700	-20.5
IR (pA) @ VR = 10V	0.2	0.13	0.07	3	1.7	1.3
IR (pA) @ VR = 30V	1.2	0.32	0.88	9.8	5.3	4.5
VF (mV) @ IF = 1mA	574	572	2	580	582	-2
VF (mV) @ IF = 10 mA	675.5	673	2.5	680.5	682	-1.5

TABLE A24: AVERAGE AND STANDARD DEVIATION OF ELECTRICAL TEST DATA AT 100°C FOR M-48						
	AVERAGE VALUE			STANDARD DEVIATION		
TEST	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ vr = 55V	7.46	6.76	0.7	1.51	0.53	0.98
VF (mV) @ IF = 1 mA	410.73	409.81	0.92	2.01	1.95	0.06
VF (mV) @ IF = 10 mA	578.71	577.75	0.96	1.59	1.74	-0.15
IR (nA) @ VR = 55V	6.78	6.75	0.03	1.04	0.55	0.49
VF (mV) @ IF = 1 mA	411.8	410.29	1.51	2.29	1.89	0.4
VF (mV) @ IF = 10 mA	578.82	577.9	0.92	1.21	1.55	-0.34
IR (pA) @ VR = 10V	0.48	0.3	0.18	0.2	0.06	0.14
IR (pA) @ VR = 30V	1.5	0.85	0.65	0.67	0.18	0.49
VF (mV) @ IF = 1 mA	577.24	576.85	0.39	1.21	1.57	-0.36
VF (mV) @ IF = 10 mA	677.57	677.16	0.41	1.15	3.01	-1.86
IR (pA) @ VR = 10V	1.1	0.35	0.75	0.74	0.25	0.49
IR (pA) @ VR = 30V	3.3	1	2.3	2.3	0.78	1.52
VF (mV) @ IF = 1mA	577.42	576.76	0.66	1.2	1.57	-0.37
VF (mV) @ IF = 10 mA	678.22	677.7	0.52	1.14	1.59	-0.45

TABLE A25: MINIMUM AND MAXIMUM VALUES OF INITIAL ELECTRICAL TEST FOR M-50						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ VR = 55V	6.2	7.3	-1.1	12	12	0
VF (mV) @ IF = 1mA	616	614	2	631	631	0
VF (mV) @ IF = 10mA	743.5	740	3.5	761.5	763	-1.5
ICBO (nA) @ VCB = -50V	0.71	0.78	-0.07	0.87	0.82	0.05
ICBO (nA) @ VCB = -70V	0.7	0.75	-0.05	0.85	0.8	0.05
ICES (nA) @ VCE = -50V	0.45	0.44	0.01	0.6	0.48	0.12
ICER (nA) @ VC = -50V, R=1K	0.37	0.34	0.03	0.48	0.4	0.08
IEBO (nA) @ VEB = -5V	0.04	0.01	0.03	0.08	0.01	0.07
VCES (mV) @ IC = -10mA, IB=-500μA	79.5	83	-3.5	83.5	85	-1.5
VBES (mV) @ IC=-10mA, IB=-500μA	761.5	764	-2.5	768	768	0
VBEON (mV) @ VCE=-5V, IC=-5mA	700.5	700	0.5	708.5	704	4.5
VBEON (mV) @ VCE=-5V, IC=-20mA	744	743	1	751.5	747	4.5
1+HFE @ VCB=-5V, IE=-10μA	225	257	-32	246	273	-27
HFE @ VCE=-5V, IC=-500μA	219	249	-30	239	264	-25
HFE @ VCE=-5V, IC=-10mA	206	233	-27	223	247	-24
HFE @ VCE=-5V, IC=-20mA	193	218	-25	209	231	-22
ICBO (nA) @ VCB=20V	2	1.9	0.1	5	3.5	1.5
IEBO (nA) @ VEB=4V	12	12	0	146	178	-32
ICER (nA) @ VCE=13V, R=1K	1.8	1.7	0.1	2.7	2.1	0.6
HFE @ VCE=5V, IC=1mA	51.6	54.2	-2.6	109.2	89.8	19.4
HFE @ VCE=5V, IC=10mA	70.1	71.3	-1.2	133.7	113.6	20.1
HFE @ VCE=5V, IC=100mA	54.2	55.6	-1.4	95.4	82.8	12.6
VCES (mV) @ IC =10mA, IB=1mA	135.5	137.5	-2	148.5	152	-3.5
VBES (mV) @ IC=10mA, IB=1mA	798	799.5	-1.5	808	807.5	0.5
VCES (mV) @ IC =100mA, IB=10mA	415.5	427	-11.5	498	519	-21
VBES (mV) @ IC=100mA, IB=10mA	1119	1113.5	5.5	1154.5	1195.5	-41
VBEON (mV) @ VCE=5V, IC=5mA	717.5	718	-0.5	733.5	731	2.5
VBEON (mV) @ VCE=5V, IC=10mA	768.5	772	-3.5	791.5	788	3.5
ICBO (nA) @ VCB=-50V	0.48	0.59	-0.11	2.8	0.62	2.18
ICBO (nA) @ VCB=-70V	0.55	0.6	-0.05	2.8	0.7	2.1
ICES (nA) @ VCE =-50V	0.075	0.2	-0.125	2.4	0.25	2.15
ICER (nA) @ VC=-50V, R=1K	0.18	0.28	-0.1	2.5	0.32	2.18
IEBO (nA) @ VEB=-5V	0.01	0.01	0	1.8	0.01	1.79
VCES (mV) @ IC =-10mA, IB=-500μA	79.5	83	-3.5	83	84.5	-1.5
VBES (mV) @ IC=-10mA, IB=-500μA	762	764	-2	768.5	767.5	1
VBEON (mV) @ VCE=-5V, IC=-5mA	701	700	1	709	704.5	4.5
VBEON (mV) @ VCE=-5V, IC=-20mA	744	743	1	751.5	747	4.5
1+HFE @ VCB=-5V, IE=-10μA	224	254	-30	256	271	-15
HFE @ VCE=-5V, IC=-500μA	219	246	-27	239	263	-24
HFE @ VCE=-5V, IC=-10mA	206	230	-24	223	245	-22
HFE @ VCE=-5V, IC=-20mA	192.7	215	-22.3	209	229	-20
IR (nA) @ VR = 55V	6.4	7.3	-0.9	28	11	17
VF (mV) @ IF = 1mA	620.5	617.5	3	632	631	1
VF (mV) @ IF = 10mA	747.5	745.5	2	761.5	761.5	0
ICBO (nA) @ VCB = -50V	0.68	0.76	-0.08	0.82	0.79	0.03
ICBO (nA) @ VCB = -70V	0.65	0.65	0	0.85	0.8	0.05
ICES (nA) @ VCE = -50V	0.42	0.44	-0.02	0.56	0.48	0.08
ICER (nA) @ VC = -50V, R=1K	0.32	0.34	-0.02	0.46	0.4	0.06
IEBO (nA) @ VEB = -5V	0.01	0.01	0	0.06	0.04	0.02
VCES (mV) @ IC = -10mA, IB=-500μA	79.5	83.5	-4	82	86	-4
VBES (mV) @ IC=-10mA, IB=-500μA	762	764	-2	769	767	2

TABLE A25: MINIMUM AND MAXIMUM VALUES OF INITIAL ELECTRICAL TEST FOR M-50 (CONTINUED)						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VBEON (mV) @ VCE=-5V, IC=-20mA	744	743	1	752	747	5
VBEON (mV) @ VCE=-5V, IC=-5mA	701	700	1	710	704	6
1+HFE @ VCB=-5V, IE=-10μA	225	253	-28	246	274	-28
HFE @ VCE=-5V, IC=-500μA	219	245	-26	239	265	-26
HFE @ VCE=-5V, IC=-10mA	206	229	-23	223	248	-25
HFE @ VCE=-5V, IC=-20mA	192.5	214	-21.5	209	232	-23
ICBO (nA) @ VCB=20V	1.9	1.9	0	4.4	5.7	-1.3
IEBO (nA) @ VEB=4V	12	12	0	212	165	47
ICER (nA) @ VCE=13V, R=1K	1.5	1.7	-0.2	2.3	2.2	0.1
HFE @ VCE=5V, IC=1mA	55.7	56	-0.3	129.5	94.6	34.9
HFE @ VCE=5V, IC=10mA	73.5	73.4	0.1	153.6	119.3	34.3
HFE @ VCE=5V, IC=100mA	56.1	56.6	-0.5	105	86.5	18.5
VCES (mV) @ IC =10mA, IB=1mA	131.5	138	-6.5	147.5	152	-4.5
VBES (mV) @ IC=10mA, IB=1mA	796	799.5	-3.5	807.5	806	1.5
VCES (mV) @ IC =100mA, IB=10mA	410	436.5	-26.5	498.5	535	-36.5
VBES (mV) @ IC=100mA, IB=10mA	1112.5	1112.5	0	1167	1177	-10
VBEON (mV) @ VCE=5V, IC=5mA	713.5	716.5	-3	732	731	1
VBEON (mV) @ VCE=5V, IC=20mA	764.5	770.5	-6	788.5	788	0.5
ICBO (nA) @ VCB=-50V	0.72	0.63	0.09	0.77	0.66	0.11
ICBO (nA) @ VCB=-70V	0.75	0.65	0.1	0.9	0.8	0.1
ICES (nA) @ VCE =-50V	0.32	0.28	0.04	0.46	0.32	0.14
ICER (nA) @ VC=-50V, R=1K	0.4	0.32	0.08	0.44	0.36	0.08
IEBO (nA) @ VEB=-5V	0.01	0.01	0	0.01	0.01	0
VCES (mV) @ IC =-10mA, IB=-500μA	79.5	83	-3.5	83	86	-3
VBES (mV) @ IC=-10mA, IB=-500μA	762	764	-2	768.5	767	1.5
VBEON (mV) @ VCE=-5V, IC=-5mA	702	700	2	709.6	704	5.6
VBEON (mV) @ VCE=-5V, IC=-20mA	744.5	743	1.5	751.5	747	4.5
1+HFE @ VCB=-5V, IE=-10μA	225	255	-30	245	272	-27
HFE @ VCE=-5V, IC=-500μA	219	247	-28	238	264	-26
HFE @ VCE=-5V, IC=-10mA	206	230	-24	222	247	-25
HFE @ VCE=-5V, IC=-20mA	192.9	215	-22.1	208	231	-23

TABLE A26: AVGERAGE AND STANDARD DEVIDATION OF INITIAL ELECTRICAL TEST FOR M-50						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ VR = 55V	9.7	9.7	0	1.1	1.1	0
VF (mV) @ IF = 1mA	623.94	625.45	-1.51	2.91	3.24	-0.33
VF (mV) @ IF = 10mA	753.16	755.48	-2.32	4.24	4.36	-0.12
ICBO (nA) @ VCB = -50V	0.81	0.79	0.02	0.035	0.005	0.03
ICBO (nA) @ VCB = -70V	0.8	0.78	0.02	0.031	0.025	0.006
ICES (nA) @ VCE = -50V	0.51	0.46	0.05	0.024	0.014	0.01
ICER (nA) @ VC = -50V, R=1K	0.41	0.36	0.05	0.015	0.014	0.001
IEBO (nA) @ VEB = -5V	0.054	0.0052	0.0488	0.014	0.0009	0.0131
VCES (mV) @ IC = -10mA, IB=-500μA	80.9	83.95	-3.05	1	0.416	0.584
VBES (mV) @ IC=-10mA, IB=-500μA	763.81	765.23	-1.42	1.58	1.15	0.43
VBEON (mV) @ VCE=-5V, IC=-5mA	703.29	701.92	1.37	1.77	1.45	0.32
VBEON (mV) @ VCE=-5V, IC=-20mA	746.13	744.68	1.45	1.7	1.17	0.53
1+HFE @ VCB=-5V, IE=-10μA	235.11	265.58	-30.47	5.5389	3.8763	1.6626
HFE @ VCE=-5V, IC=-500μA	228.41	256.93	-28.52	5.0732	3.5531	1.5201
HFE @ VCE=-5V, IC=-10mA	213.79	240.24	-26.45	4.4219	3.2884	1 1335
HFE @ VCE=-5V, IC=-20mA	200.34	224.73	-24.39	4.1062	3.0274	1.0788
ICBO (nA) @ VCB=20V	2.8	2.4	0.4	0.61	0.25	0.36
IEBO (nA) @ VEB=4V	28	19	9	29	23	6
ICER (nA) @ VCE=13V, R=1K	2.2	1.8	0.4	0.16	0.1	0.06
HFE @ VCE=5V, IC=1mA	71.014	75.209	-4.195	15.806	9.5693	6.2367
HFE @ VCE=5V, IC=10mA	91.455	97.445	-5.99	18.255	11.303	6.952
HFE @ VCE=5V, IC=100mA	67.98	73.14	-5.16	11.77	7.3149	4.4551
VCES (mV) @ IC =10mA, IB=1mA	144.38	142.49	1.89	4.02	4	0.02
VBES (mV) @ IC=10mA, IB=1mA	802.61	802.61	0	2.2	1.84	0.36
VCES (mV) @ IC =100mA, IB=10mA	470.33	469.55	0.78	26.32	20.58	5.74
VBES (mV) @ IC=100mA, IB=10mA	1133.9	1144.1	-10.2	8.73	19.78	-11.05
VBEON (mV) @ VCE=5V, IC=5mA	725.15	722.48	2.67	3.34	3.18	0.16
VBEON (mV) @ VCE=5V, IC=10mA	780.64	777.31	3.33	5.05	4.01	1.04
ICBO (nA) @ VCB=-50V	0.61	0.6	0.01	0.3	0.0065	0.2935
ICBO (nA) @ VCB=-70V	0.69	0.66	0.03	0.29	0.004	0.286
ICES (nA) @ VCE =-50V	0.22	0.23	-0.01	0.3	0.013	0.287
ICER (nA) @ VC=-50V, R=1K	0.32	0.31	0.01	0.3	0.008	0.292
IEBO (nA) @ VEB=-5V	0.037	0.005	0.032	0.24	0	0.24
VCES (mV) @ IC =-10mA, IB=-500μA	80.82	83.93	-3.11	0.783	0.413	0.37
VBES (mV) @ IC=-10mA, IB=-500μA	763.95	765.24	-1.29	1.51	1.1	0.41
VBEON (mV) @ VCE=-5V, IC=-5mA	703.5	701.97	1.53	1.85	1.44	0.41
VBEON (mV) @ VCE=-5V, IC=-20mA	746.31	744.76	1.55	1.83	1.13	0.7
1+HFE @ VCB=-5V, IE=-10μA	234.46	263.49	-29.03	6.4497	4.2682	2.1815
HFE @ VCE=-5V, IC=-500μA	227.86	255.6	-27.74	5.3477	3.8132	1.5345
HFE @ VCE=-5V, IC=-10mA	213.34	239.02	-25.68	4.7684	3.5875	1.1809
HFE @ VCE=-5V, IC=-20mA	199.94	223.64	-23.7	4.375	3.3019	1.0731
IR (nA) @ VR = 55V	9.6	9.2	0.4	2.8	0.87	1.93
VF (mV) @ IF = 1mA	625.75	626.85	-1.1	2.42	2.68	-0.26
VF (mV) @ IF = 10mA	755.7	757.2	-1.5	3.31	3.71	-0.4
ICBO (nA) @ VCB = -50V	0.77	0.77	0	0.038	0.0077	0.0303
ICBO (nA) @ VCB = -70V	0.78	0.75	0.03	0.046	0.044	0.002
ICES (nA) @ VCE = -50V	0.5	0.47	0.03	0.027	0.0078	0.0192
ICER (nA) @ VC = -50V, R=1K	0.4	0.36	0.04	0.03	0.015	0.015
IEBO (nA) @ VEB = -5V	0.034	0.0062	0.0278	0.014	0.0054	0.0086
VCES (mV) @ IC = -10mA, IB=-500μA	80.8	84.12	-3.32	0.724	0.49	0.234
VBES (mV) @ IC=-10mA, IB=-500μA	964.05	765.17	198.88	1.54	0.992	0.548

TABLE A26: AVERAGE AND STANDARD DEVIATION OF INITIAL ELECTRICAL TEST FOR M-50 (CONTINUED)						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VBEON (mV) @ VCE=-5V, IC=-5mA	703.46	701.98	1.48	1.89	1.42	0.47
VBEON (mV) @ VCE=-5V, IC=-20mA	746.21	744.75	1.46	1.79	1.12	0.67
1+HFE @ VCB=-5V, IE=-10μA	236.88	263.82	-26.94	5.7463	4.8078	0.9385
HFE @ VCE=-5V, IC=-500μA	230.13	255.38	-25.25	5.4608	4.4409	1.0199
HFE @ VCE=-5V, IC=-10mA	215.27	238.73	-23.46	4.6417	4.2751	0.3666
HFE @ VCE=-5V, IC=-20mA	201.58	223.22	-21.64	4.3693	3.9379	0.4314
ICBO (nA) @ VCB=20V	2.7	2.7	0	0.48	0.81	-0.33
IEBO (nA) @ VEB=4V	35	26	9	42	29	13
ICER (nA) @ VCE=13V, R=1K	2	1.9	0.1	0.17	0.12	0.05
HFE @ VCE=5V, IC=1mA	91.209	65.247	25.962	22.944	9.2094	13.735
HFE @ VCE=5V, IC=10mA	113.3	84.822	28.478	25.418	11.071	14.347
HFE @ VCE=5V, IC=100mA	81.225	64.607	16.618	15.605	7.1912	8.4138
VCES (mV) @ IC =10mA, IB=1mA	138.79	147.65	-8.86	4.43	3.73	0.7
VBES (mV) @ IC=10mA, IB=1mA	801.56	802.55	-0.99	2.63	1.33	1.3
VCES (mV) @ IC =100mA, IB=10mA	439.1	494.8	-55.7	24.57	19.32	5.25
VBES (mV) @ IC=100mA, IB=10mA	1134.2	1125.2	9	12.39	13.4	-1.01
VBEON (mV) @ VCE=5V, IC=5mA	722.38	726.6	-4.22	4.38	3.4	0.98
VBEON (mV) @ VCE=5V, IC=20mA	776.32	782.35	-6.03	6.44	4.18	2.26
ICBO (nA) @ VCB=-50V	0.73	0.65	0.08	0.017	0.0064	0.0106
ICBO (nA) @ VCB=-70V	0.81	0.75	0.06	0.03	0.051	-0.021
ICES (nA) @ VCE =-50V	0.38	0.31	0.07	0.026	0.013	0.013
ICER (nA) @ VC=-50V, R=1K	0.4	0.33	0.07	0.013	0.014	-0.001
IEBO (nA) @ VEB=-5V	0.005	0.005	0	0	0	0
VCES (mV) @ IC =-10mA, IB=-500μA	80.76	84.55	-3.79	0.792	0.571	0.221
VBES (mV) @ IC=-10mA, IB=-500μA	764.1	765.35	-1.25	1.42	1.12	0.3
VBEON (mV) @ VCE=-5V, IC=-5mA	703.48	702.02	1.46	1.77	1.41	0.36
VBEON (mV) @ VCE=-5V, IC=-20mA	746.2	744.84	1.36	1.72	1.06	0.66
1+HFE @ VCB=-5V, IE=-10μA	237.3	264.22	-26.92	4.9135	3.4838	1.4297
HFE @ VCE=-5V, IC=-500μA	230.68	255.84	-25.16	4.6441	3.3097	1.3344
HFE @ VCE=-5V, IC=-10mA	215.66	239.31	-23.65	3.9232	3.0844	0.8388
HFE @ VCE=-5V, IC=-20mA	201.99	223.75	-21.76	3.7006	2.9327	0.7679

TABLE A27: MINIMUM AND MAXIMUM VALUES OF POST HTRB ELECTRICAL TEST DATA FOR M-50						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ VR = 55V	9.5	13	-3.5	16	21	-5
VF (mV) @ IF = 1mA	620	610	10	631	627.5	3.5
VF (mV) @ IF = 10mA	747	736	11	762	760	2
ICBO (nA) @ VCB = -50V	1.9	0.71	1.19	2	0.79	1.21
ICBO (nA) @ VCB = -70V	1.8	0.65	1.15	2	0.8	1.2
ICES (nA) @ VCE = -50V	1	0.38	0.62	1	0.47	0.53
ICER (nA) @ VC = -50V, R=1K	0.76	0.3	0.46	0.8	0.36	0.44
IEBO (nA) @ VEB = -5V	0.01	0.01	0	0.01	0.01	0
VCES (mV) @ IC = -10mA, IB=-500μA	80	83.5	-3.5	84	86	-2
VBES (mV) @ IC=-10mA, IB=-500μA	761.5	762	-0.5	767	766	1
VBEON (mV) @ VCE=-5V, IC=-5mA	673.5	699	-25.5	690	704	-14
VBEON (mV) @ VCE=-5V, IC=-20mA	666.5	741.5	-75	716	746.5	-30.5
1+HFE @ VCB=-5V, IE=-10μA	221	253	-32	239	266	-27
HFE @ VCE=-5V, IC=-500μA	215	246	-31	232	258	-26
HFE @ VCE=-5V, IC=-10mA	202	229	-27	217	240	-23
HFE @ VCE=-5V, IC=-20mA	268	215	53	391	225	166
ICBO (nA) @ VCB=20V	2.8	2.9	-0.1	4.7	4.7	0
IEBO (nA) @ VEB=4V	13	13	0	131	106	25
ICER (nA) @ VCE=13V, R=1K	2.1	2.3	-0.2	3.1	3.3	-0.2
HFE @ VCE=5V, IC=1mA	50.9	54.4	-3.5	108.8	90.4	18.4
HFE @ VCE=5V, IC=10mA	69.2	71.4	-2.2	133.2	114.8	18.4
HFE @ VCE=5V, IC=100mA	53.7	55.6	-1.9	95.8	83.6	12.2
VCES (mV) @ IC =10mA, IB=1mA	135.5	139	-3.5	148.5	153.5	-5
VBES (mV) @ IC=10mA, IB=1mA	798	797.5	0.5	807	804.5	2.5
VCES (mV) @ IC =100mA, IB=10mA	416	428.5	-12.5	498.5	521	-22.5
VBES (mV) @ IC=100mA, IB=10mA	1116.5	1111.5	5	1151	1179.5	-28.5
VBEON (mV) @ VCE=5V, IC=5mA	716	716	0	732	729.5	2.5
VBEON (mV) @ VCE=5V, IC=10mA	768	769.5	-1.5	790	787	3
ICBO (nA) @ VCB=-50V	1.5	0.52	0.98	1.5	0.59	0.91
ICBO (nA) @ VCB=-70V	1.6	0.55	1.05	1.8	0.7	1.1
ICES (nA) @ VCE =-50V	0.68	0.31	0.37	0.88	0.36	0.52
ICER (nA) @ VC=-50V, R=1K	0.65	0.24	0.41	0.72	0.32	0.4
IEBO (nA) @ VEB=-5V	0.01	0.01	0	0.01	0.01	0
VCES (mV) @ IC =-10mA, IB=-500μA	80.5	84.5	-4	83.5	87	-3.5
VBES (mV) @ IC=-10mA, IB=-500μA	761.5	762	-0.5	766	768	-2
VBEON (mV) @ VCE=-5V, IC=-5mA	700.5	699	1.5	707.5	75.5	2
VBEON (mV) @ VCE=-5V, IC=-20mA	742	742	0	748	748	0
1+HFE @ VCB=-5V, IE=-10μA	213	242	-29	237	256	-19
HFE @ VCE=-5V, IC=-500μA	207	235	-28	230	248	-18
HFE @ VCE=-5V, IC=-10mA	193.4	219	-25.6	216	231	-15
HFE @ VCE=-5V, IC=-20mA	181.7	206	-24.3	202	216	-14
IR (nA) @ VR = 55V	8.5	12	-3.5	15	20	-5
VF (mV) @ IF = 1mA	623.5	615.5	8	631	631.5	-0.5
VF (mV) @ IF = 10mA	749.5	743.5	6	761.5	763	-1.5
ICBO (nA) @ VCB = -50V	1.9	0.68	1.22	2	0.76	1.24
ICBO (nA) @ VCB = -70V	1.9	0.6	1.3	2	0.8	1.2
ICES (nA) @ VCE = -50V	1	0.39	0.61	1	0.48	0.52
ICER (nA) @ VC = -50V, R=1K	0.76	0.3	0.46	0.8	0.36	0.44
IEBO (nA) @ VEB = -5V	0.01	0.01	0	0.01	0.01	0
VCES (mV) @ IC = -10mA, IB=-500μA	80.5	84	-3.5	83.5	87	-3.5
VBES (mV) @ IC=-10mA, IB=-500μA	761.5	762	-0.5	767	768	-1

TABLE A27: MINIMUM AND MAXIMUM VALUES OF POST HTRB ELECTRICAL TEST DATA FOR M-50 (CONTINUED)						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VBEON (mV) @ VCE=-5V, IC=-5mA	700.5	699	1.5	707.5	705.5	2
VBEON (mV) @ VCE=-5V, IC=-20mA	737.5	742	-4.5	744	748	-4
1+HFE @ VCB=-5V, IE=-10μA	224	249	-25	239	367	-128
HFE @ VCE=-5V, IC=-500μA	217	242	-25	232	258	-26
HFE @ VCE=-5V, IC=-10mA	203	226	-23	216	241	-25
HFE @ VCE=-5V, IC=-20mA	190.7	212	-21.3	203	226	-23
ICBO (nA) @ VCB=20V	2.5	2.7	-0.2	4.3	6.3	-2
IEBO (nA) @ VEB=4V	12	13	-1	234	141	93
ICER (nA) @ VCE=13V, R=1K	1.9	2.3	-0.4	3.1	3.1	0
HFE @ VCE=5V, IC=1mA	54.7	56	-1.3	127	94.7	32.3
HFE @ VCE=5V, IC=10mA	72.3	73.4	-1.1	150.9	119.4	31.5
HFE @ VCE=5V, IC=100mA	55.2	56.8	-1.6	103.4	86.5	16.9
VCES (mV) @ IC =10mA, IB=1mA	131.5	139	-7.5	147.5	152.5	-5
VBES (mV) @ IC=10mA, IB=1mA	798.5	798	0.5	806	805.5	0.5
VCES (mV) @ IC =100mA, IB=10mA	410	438.5	-28.5	499.5	536.5	-37
VBES (mV) @ IC=100mA, IB=10mA	1112.5	1110.5	2	1160.5	1166	-5.5
VBEON (mV) @ VCE=5V, IC=5mA	716.5	716	0.5	731	732	-1
VBEON (mV) @ VCE=5V, IC=20mA	768	769.5	-1.5	789.5	788	1.5
ICBO (nA) @ VCB=-50V	1.4	0.58	0.82	1.5	0.65	0.85
ICBO (nA) @ VCB=-70V	1.6	0.6	1	1.8	0.8	1
ICES (nA) @ VCE =-50V	0.72	0.32	0.4	0.88	0.4	0.48
ICER (nA) @ VC=-50V, R=1K	0.62	0.28	0.34	0.72	0.34	0.38
IEBO (nA) @ VEB=-5V	0.01	0.01	0	0.01	0.01	0
VCES (mV) @ IC =-10mA, IB=-500μA	81	84.5	-3.5	83.5	88	-4.5
VBES (mV) @ IC=-10mA, IB=-500μA	761.5	762	-0.5	766	768	-2
VBEON (mV) @ VCE=-5V, IC=-5mA	700.5	699	1.5	707	706	1
VBEON (mV) @ VCE=-5V, IC=-20mA	741.5	742	-0.5	747.5	749	-1.5
1+HFE @ VCB=-5V, IE=-10μA	212	240	-28	227	261	-34
HFE @ VCE=-5V, IC=-500μA	207	233	-26	220	253	-33
HFE @ VCE=-5V, IC=-10mA	193.8	217	-23.3	206	237	-31
HFE @ VCE=-5V, IC=-20mA	181.8	204	-22.2	193.2	221	-27.8

TABLE A28: AVGERAGE AND STANDARD DEVIATION OF POST HTRB ELECTRICAL TEST DATA FOR M-50						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ VR = 55V	12	18	-6	1.3	2	-0.7
VF (mV) @ IF = 1mA	626.01	622.71	3.3	2.85	3.16	-0.31
VF (mV) @ IF = 10mA	754.75	753.15	1.6	4.22	4.4	-0.18
ICBO (nA) @ VCB = -50V	1.9	0.75	1.15	0.01	0.021	-0.011
ICBO (nA) @ VCB = -70V	1.9	0.71	1.19	0.038	0.048	-0.01
ICES (nA) @ VCE = -50V	1	0.43	0.57	0	0.022	-0.022
ICER (nA) @ VC = -50V, R=1K	0.79	0.32	0.47	0.01	0.011	0.001
IEBO (nA) @ VEB = -5V	0.01	0.01	0	0	0	0
VCES (mV) @ IC = -10mA, IB=-500μA	81.67	85.62	-3.95	0.911	0.623	0.288
VBES (mV) @ IC=-10mA, IB=-500μA	764.71	763.23	1.48	0.914	0.907	0.007
VBEON (mV) @ VCE=-5V, IC=-5mA	677.74	700.01	-22.27	3.66	1.09	2.57
VBEON (mV) @ VCE=-5V, IC=-20mA	707.89	742.83	-34.94	9.4	1.01	8.39
1+HFE @ VCB=-5V, IE=-10μA	229.33	260.95	-31.62	5.0395	2.7245	2.315
HFE @ VCE=-5V, IC=-500μA	222.89	252.53	-29.64	4.757	2.3793	2.3777
HFE @ VCE=-5V, IC=-10mA	208.76	235.87	-27.11	4.0837	2.2448	1.8389
HFE @ VCE=-5V, IC=-20mA	369.74	220.84	148.9	21.398	2.0884	19.31
ICBO (nA) @ VCB=20V	3.6	3.6	0	0.41	0.27	0.14
IEBO (nA) @ VEB=4V	28	19	9	28	16	12
ICER (nA) @ VCE=13V, R=1K	2.7	2.8	-0.1	0.15	0.16	-0.01
HFE @ VCE=5V, IC=1mA	70.77	74.975	-4.205	15.848	9.8259	6.0221
HFE @ VCE=5V, IC=10mA	91.12	97.136	-6.016	18.315	11.641	6.674
HFE @ VCE=5V, IC=100mA	67.748	72.953	-5.205	11.791	7.5656	4.2254
VCES (mV) @ IC =10mA, IB=1mA	144.47	143.52	0.95	4.06	3.95	0.11
VBES (mV) @ IC=10mA, IB=1mA	803.83	800.57	3.26	1.86	1.63	0.23
VCES (mV) @ IC =100mA, IB=10mA	470.77	472.31	-1.54	26.49	20.95	5.54
VBES (mV) @ IC=100mA, IB=10mA	1131.8	1137.8	-6	8.35	17.07	-8.72
VBEON (mV) @ VCE=5V, IC=5mA	726.78	720.76	6.02	3.28	3.66	-0.38
VBEON (mV) @ VCE=5V, IC=10mA	782.28	775.9	6.38	5.09	4.5	0.59
ICBO (nA) @ VCB=-50V	1.5	0.56	0.94	0	0.018	-0.018
ICBO (nA) @ VCB=-70V	1.7	0.63	1.07	0.045	0.046	-0.001
ICES (nA) @ VCE =-50V	0.84	0.34	0.5	0.027	0.017	0.01
ICER (nA) @ VC=-50V, R=1K	0.69	0.29	0.4	0.015	0.023	-0.008
IEBO (nA) @ VEB=-5V	0.01	0.01	0	0	0	0
VCES (mV) @ IC =-10mA, IB=-500μA	82.31	86.03	-3.72	0.785	0.445	0.34
VBES (mV) @ IC=-10mA, IB=-500μA	764.45	763.39	1.06	0.859	1.32	-0.461
VBEON (mV) @ VCE=-5V, IC=-5mA	704.87	700.43	4.44	1.17	1.35	-0.18
VBEON (mV) @ VCE=-5V, IC=-20mA	746.03	743.31	2.72	1.13	1.37	-0.24
1+HFE @ VCB=-5V, IE=-10μA	220.3	249.87	-29.57	4.9929	3.8637	1.1292
HFE @ VCE=-5V, IC=-500μA	213.67	241.91	-28.24	4.8252	3.4441	1.3811
HFE @ VCE=-5V, IC=-10mA	200.23	225.65	-25.42	4.4751	3.2954	1.1797
HFE @ VCE=-5V, IC=-20mA	187.66	211.35	-23.69	3.9734	2.8689	1.1045
IR (nA) @ VR = 55V	12	17	-5	1.5	1.8	-0.3
VF (mV) @ IF = 1mA	627.56	625.17	2.39	2.17	2.99	-0.82
VF (mV) @ IF = 10mA	757.16	756.05	1.11	3.32	4.05	-0.73
ICBO (nA) @ VCB = -50V	1.9	0.72	1.18	0.0091	0.02	-0.011
ICBO (nA) @ VCB = -70V	1.9	0.7	1.2	0.035	0.05	-0.015
ICES (nA) @ VCE = -50V	1	0.44	0.56	0	0.024	-0.024
ICER (nA) @ VC = -50V, R=1K	0.78	0.33	0.45	0.01	0.014	-0.004
IEBO (nA) @ VEB = -5V	0.01	0.01	0	0	0	0
VCES (mV) @ IC = -10mA, IB=-500μA	81.75	85.66	-3.91	0.805	0.601	0.204
VBES (mV) @ IC=-10mA, IB=-500μA	764.83	763.77	1.06	0.962	1.24	-0.278

TABLE A28: AVERAGE AND STANDARD DEVIATION OF POST HTRB ELECTRICAL TEST DATA FOR M-50 (CONTINUED)						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VBEON (mV) @ VCE=-5V, IC=-5mA	704.72	700.59	4.13	1.11	1.5	-0.39
VBEON (mV) @ VCE=-5V, IC=-20mA	741.77	743.37	-1.6	1.11	1.44	-0.33
1+HFE @ VCB=-5V, IE=-10μA	231.28	259.31	-28.03	4.7679	3.7311	1.0368
HFE @ VCE=-5V, IC=-500μA	224.7	251.18	-26.48	4.3595	3.1334	1.2261
HFE @ VCE=-5V, IC=-10mA	210.22	234.38	-24.16	3.8494	3.052	0.7974
HFE @ VCE=-5V, IC=-20mA	196.92	219.53	-22.61	3.5799	2.8209	0.759
ICBO (nA) @ VCB=20V	3.3	3.7	-0.4	0.4	0.65	-0.25
IEBO (nA) @ VEB=4V	34	26	8	43	26	17
ICER (nA) @ VCE=13V, R=1K	2.5	2.8	-0.3	0.25	0.18	0.07
HFE @ VCE=5V, IC=1mA	91.344	65.835	25.509	22.318	9.643	12.675
HFE @ VCE=5V, IC=10mA	113.42	85.502	27.918	24.751	11.551	13.2
HFE @ VCE=5V, IC=100mA	81.298	65.007	16.291	15.237	7.4442	7.7928
VCES (mV) @ IC =10mA, IB=1mA	138.69	148.28	-9.59	4.33	3.97	0.36
VBES (mV) @ IC=10mA, IB=1mA	802.67	800.92	1.75	2.29	1.6	0.69
VCES (mV) @ IC =100mA, IB=10mA	438.79	496.16	-57.37	24.14	19.96	4.18
VBES (mV) @ IC=100mA, IB=10mA	1131.9	1122.4	9.5	11.53	11.39	0.14
VBEON (mV) @ VCE=5V, IC=5mA	723.79	725.06	-1.27	4.01	3.72	0.29
VBEON (mV) @ VCE=5V, IC=20mA	777.7	780.94	-3.24	6.31	4.46	1.85
ICBO (nA) @ VCB=-50V	1.5	0.62	0.88	0.022	0.018	0.004
ICBO (nA) @ VCB=-70V	1.7	0.72	0.98	0.054	0.059	-0.005
ICES (nA) @ VCE =-50V	0.81	0.38	0.43	0.048	0.023	0.025
ICER (nA) @ VC=-50V, R=1K	0.66	0.31	0.35	0.02	0.012	0.008
IEBO (nA) @ VEB=-5V	0.01	0.01	0	0	0	0
VCES (mV) @ IC =-10mA, IB=-500μA	82.14	86.54	-4.4	0.736	0.679	0.057
VBES (mV) @ IC=-10mA, IB=-500μA	764.57	763.88	0.69	0.939	1.32	-0.381
VBEON (mV) @ VCE=-5V, IC=-5mA	704.61	700.75	3.86	1.19	1.58	-0.39
VBEON (mV) @ VCE=-5V, IC=-20mA	745.54	743.63	1.91	1.26	1.51	-0.25
1+HFE @ VCB=-5V, IE=-10μA	223.09	249.67	-26.58	3.8767	3.4105	0.4662
HFE @ VCE=-5V, IC=-500μA	216.37	242.02	-25.65	3.5358	3.1298	0.406
HFE @ VCE=-5V, IC=-10mA	202.68	115.82	86.86	3.3104	2.9001	0.4103
HFE @ VCE=-5V, IC=-20mA	189.65	211.33	-21.68	2.8728	2.539	0.3338

TABLE A29: MINIMUM AND MAXIMUM VALUES OF POST EXTENDED HTRB ELECTRICAL TEST DATA FOR M-50						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ VR = 55V	12	7.7	4.3	12	16	-4
VF (mV) @ IF = 1mA	620	619	1	630	633.5	-3.5
VF (mV) @ IF = 10mA	748	743.5	4.5	761.5	764	-2.5
ICBO (nA) @ VCB = -50V	1.6	0.8	0.8	1.7	0.81	0.89
ICBO (nA) @ VCB = -70V	1.5	0.7	0.8	1.8	0.8	1
ICES (nA) @ VCE = -50V	0.84	0.48	0.36	0.94	0.48	0.46
ICER (nA) @ VC = -50V, R=1K	0.64	0.38	0.26	0.77	0.4	0.37
IEBO (nA) @ VEB = -5V	0.005	0.035	-0.03	0.005	0.055	-0.05
VCES (mV) @ IC = -10mA, IB=-500μA	80.5	83.5	-3	83	85.5	-2.5
VBES (mV) @ IC=-10mA, IB=-500μA	764.5	767	-2.5	766	768.5	-2.5
VBEON (mV) @ VCE=-5V, IC=-5mA	704	704	0	706	707	-1
VBEON (mV) @ VCE=-5V, IC=-20mA	727.5	747	-19.5	740	749	-9
1+HFE @ VCB=-5V, IE=-10μA	219	246	-27	235	258	-23
HFE @ VCE=-5V, IC=-500μA	214	239	-25	227	251	-24
HFE @ VCE=-5V, IC=-10mA	201	223	-22	212	234	-22
HFE @ VCE=-5V, IC=-20mA	208	209	-1	245	219	26
ICBO (nA) @ VCB=20V	3	2.2	0.8	4.9	3	1.9
IEBO (nA) @ VEB=4V	13	12	1	66	150	-84
ICER (nA) @ VCE=13V, R=1K	2.6	1.8	0.8	2.9	2.1	0.8
HFE @ VCE=5V, IC=1mA	50.9	56.4	-5.5	104.2	84.9	19.3
HFE @ VCE=5V, IC=10mA	69.2	73.5	-4.3	129.2	108.1	21.1
HFE @ VCE=5V, IC=100mA	53.6	57.1	-3.5	93.3	79.4	13.9
VCES (mV) @ IC =10mA, IB=1mA	135.5	139.5	-4	148.5	152	-3.5
VBES (mV) @ IC=10mA, IB=1mA	800.5	803.5	-3	806	809.5	-3.5
VCES (mV) @ IC =100mA, IB=10mA	419.5	448	-28.5	499	520	-21
VBES (mV) @ IC=100mA, IB=10mA	1119	1115	4	1146	1181.5	-35.5
VBEON (mV) @ VCE=5V, IC=5mA	720	723.5	-3.5	731	732.5	-1.5
VBEON (mV) @ VCE=5V, IC=10mA	772	777	-5	789.5	790.5	-1
ICBO (nA) @ VCB=-50V	1.5	0.6	0.9	1.6	0.63	0.97
ICBO (nA) @ VCB=-70V	1.5	0.6	0.9	1.9	0.8	1.1
ICES (nA) @ VCE =-50V	0.8	0.38	0.42	0.9	0.4	0.5
ICER (nA) @ VC=-50V, R=1K	0.64	0.32	0.32	0.76	0.34	0.42
IEBO (nA) @ VEB=-5V	0.01	0.01	0	0.005	0.03	-0.025
VCES (mV) @ IC =-10mA, IB=-500μA	81.5	83.5	-2	83.5	86	-2.5
VBES (mV) @ IC=-10mA, IB=-500μA	764	766	-2	765.5	768	-2.5
VBEON (mV) @ VCE=-5V, IC=-5mA	704	704	0	705.5	706	-0.5
VBEON (mV) @ VCE=-5V, IC=-20mA	747.5	747	0.5	749	748.5	0.5
1+HFE @ VCB=-5V, IE=-10μA	210	238	-28	223	256	-33
HFE @ VCE=-5V, IC=-500μA	204	230	-26	216	248	-32
HFE @ VCE=-5V, IC=-10mA	191.2	215	-23.8	202	231	-29
HFE @ VCE=-5V, IC=-20mA	179.5	202	-22.5	189.7	216	-26.3
IR (nA) @ VR = 55V	10	7.9	2.1	14	15	-1
VF (mV) @ IF = 1mA	624	626	-2	631	634	-3
VF (mV) @ IF = 10mA	750	752	-2	761.5	764	-2.5
ICBO (nA) @ VCB = -50V	1.6	0.77	0.83	1.6	0.79	0.81
ICBO (nA) @ VCB = -70V	1.5	0.65	0.85	1.7	0.8	0.9
ICES (nA) @ VCE = -50V	0.87	0.48	0.39	0.92	0.49	0.43
ICER (nA) @ VC = -50V, R=1K	0.66	0.38	0.28	0.71	0.4	0.31
IEBO (nA) @ VEB = -5V	0.002	0.015	-0.01	0.005	0.055	-0.05
VCES (mV) @ IC = -10mA, IB=-500μA	80.5	83.5	-3	83	85.5	-2.5

TABLE A29: MINIMUM AND MAXIMUM VALUES OF POST EXTENDED ELECTRICAL TEST DATA FOR M-50 (CONTINUED)						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VBES (mV) @ IC=-10mA, IB=-500μA	764.5	767	-2.5	765.5	768.5	-3
VBEON (mV) @ VCE=-5V, IC=-5mA	704.5	704	0.5	705.5	706	-0.5
VBEON (mV) @ VCE=-5V, IC=-20mA	744	746.5	-2.5	746	749	-3
1+HFE @ VCB=-5V, IE=-10μA	221	251	-30	236	257	-21
HFE @ VCE=-5V, IC=-500μA	215	243	-28	230	249	-19
HFE @ VCE=-5V, IC=-10mA	202	227	-25	215	232	-17
HFE @ VCE=-5V, IC=-20mA	189	212	-23	201	217	-16
ICBO (nA) @ VCB=20V	2.7	2.3	0.4	4.1	3.2	0.9
IEBO (nA) @ VEB=4V	12	12	0	101	49	52
ICER (nA) @ VCE=13V, R=1K	2.1	1.8	0.3	3	2.1	0.9
HFE @ VCE=5V, IC=1mA	53.7	56.2	-2.5	125.6	92.3	33.3
HFE @ VCE=5V, IC=10mA	72.5	74.1	-1.6	149.3	116.7	32.6
HFE @ VCE=5V, IC=100mA	56.2	57.3	-1.1	102.7	84.5	18.2
VCES (mV) @ IC =10mA, IB=1mA	132.5	137.5	-5	148	152	-4
VBES (mV) @ IC=10mA, IB=1mA	799.5	804	-4.5	806	807.5	-1.5
VCES (mV) @ IC =100mA, IB=10mA	412.5	437.5	-25	495.5	535	-39.5
VBES (mV) @ IC=100mA, IB=10mA	1112.5	1114	-1.5	1154.5	1168	-13.5
VBEON (mV) @ VCE=5V, IC=5mA	718	723.5	-5.5	729.5	733.5	-4
VBEON (mV) @ VCE=5V, IC=20mA	769	776	-7	787	789.5	-2.5
ICBO (nA) @ VCB=-50V	1.3	0.66	0.64	1.3	0.68	0.62
ICBO (nA) @ VCB=-70V	1.4	0.7	0.7	1.6	0.8	0.8
ICES (nA) @ VCE =-50V	0.68	0.41	0.27	0.82	0.46	0.36
ICER (nA) @ VC=-50V, R=1K	0.64	0.36	0.28	0.68	0.38	0.3
IEBO (nA) @ VEB=-5V	0.01	0.01	0	0.01	0.01	0
VCES (mV) @ IC =-10mA, IB=-500μA	81.5	83.5	-2	83.5	87	-3.5
VBES (mV) @ IC=-10mA, IB=-500μA	764	767	-3	765.5	768.5	-3
VBEON (mV) @ VCE=-5V, IC=-5mA	704	704	0	705.5	707	-1.5
VBEON (mV) @ VCE=-5V, IC=-20mA	747	747	0	748.5	749.5	-1
1+HFE @ VCB=-5V, IE=-10μA	213	239	-26	224	251	-27
HFE @ VCE=-5V, IC=-500μA	207	232	-25	217	243	-26
HFE @ VCE=-5V, IC=-10mA	193.8	216	-22.2	204	227	-23
HFE @ VCE=-5V, IC=-20mA	182	203	-21	190.2	213	-22.8

TABLE A30: AVERAGE AND STANDARD DEVIATION OF POST EXTENDED HTRB ELECTRICAL TEST FOR M-50						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ VR = 55V	13	14	-1	1.1	1.9	-0.8
VF (mV) @ IF = 1mA	626.19	629.61	-3.42	2.64	3.27	-0.63
VF (mV) @ IF = 10mA	754.81	759.31	-4.5	3.91	4.53	-0.62
ICBO (nA) @ VCB = -50V	1.7	0.8	0.9	0.023	0.0029	0.0201
ICBO (nA) @ VCB = -70V	1.6	0.78	0.82	0.1	0.031	0.069
ICES (nA) @ VCE = -50V	0.88	0.48	0.4	0.03	0	0.03
ICER (nA) @ VC = -50V, R=1K	0.68	0.39	0.29	0.039	0.0078	0.0312
IEBO (nA) @ VEB = -5V	0.005	0.039	-0.034	0	0.0059	-0.0059
VCES (mV) @ IC = -10mA, IB=-500μA	81.59	84.19	-2.6	0.821	0.489	0.332
VBES (mV) @ IC=-10mA, IB=-500μA	765	767.67	-2.67	0.516	0.485	0.031
VBEON (mV) @ VCE=-5V, IC=-5mA	704.97	704.94	0.03	0.591	0.856	-0.265
VBEON (mV) @ VCE=-5V, IC=-20mA	734.72	747.69	-12.97	4.72	0.667	4.053
1+HFE @ VCB=-5V, IE=-10μA	226.94	255.28	-28.34	5.4708	2.6746	2.7962
HFE @ VCE=-5V, IC=-500μA	220.63	247.22	-26.59	4.7592	2.6247	2.1345
HFE @ VCE=-5V, IC=-10mA	206.63	230.61	-23.98	4.0476	2.3798	1.6678
HFE @ VCE=-5V, IC=-20mA	224.69	216.06	8.63	11.649	2.2089	9.4401
ICBO (nA) @ VCB=20V	3.6	2.5	1.1	0.48	0.18	0.3
IEBO (nA) @ VEB=4V	25	24	1	16	32	-16
ICER (nA) @ VCE=13V, R=1K	2.7	2	0.7	0.081	0.0081	0.0729
HFE @ VCE=5V, IC=1mA	74.425	69.428	4.997	18.011	9.046	8.965
HFE @ VCE=5V, IC=10mA	95.6	90.633	4.967	21.133	11.009	10.124
HFE @ VCE=5V, IC=100mA	70.65	68.839	1.811	13.693	7.3454	6.3476
VCES (mV) @ IC =10mA, IB=1mA	143.31	144.17	-0.86	4.99	4.35	0.64
VBES (mV) @ IC=10mA, IB=1mA	803.59	805.86	-2.27	1.58	1.74	-0.16
VCES (mV) @ IC =100mA, IB=10mA	463.22	478.11	-14.89	31.67	21.92	9.75
VBES (mV) @ IC=100mA, IB=10mA	1129.9	1139.8	-9.9	8.08	20.04	-11.96
VBEON (mV) @ VCE=5V, IC=5mA	726.34	727.47	-1.13	3.43	3.53	-0.1
VBEON (mV) @ VCE=5V, IC=10mA	781.41	782.78	-1.37	5.77	4.48	1.29
ICBO (nA) @ VCB=-50V	1.5	0.61	0.89	0.025	0.0079	0.0171
ICBO (nA) @ VCB=-70V	1.6	0.68	0.92	0.12	0.059	0.061
ICES (nA) @ VCE =-50V	0.85	0.39	0.46	0.033	0.0051	0.0279
ICER (nA) @ VC=-50V, R=1K	0.7	0.33	0.37	0.028	0.0071	0.0209
IEBO (nA) @ VEB=-5V	0.005	0.0075	-0.003	0	0.0065	-0.0065
VCES (mV) @ IC =-10mA, IB=-500μA	82.28	85.19	-2.91	0.752	0.689	0.063
VBES (mV) @ IC=-10mA, IB=-500μA	764.56	767.42	-2.86	0.403	0.575	-0.172
VBEON (mV) @ VCE=-5V, IC=-5mA	705.09	705.03	0.06	0.523	0.776	-0.253
VBEON (mV) @ VCE=-5V, IC=-20mA	748.16	747.78	0.38	0.397	0.624	-0.227
1+HFE @ VCB=-5V, IE=-10μA	217.25	243.5	-26.25	3.9412	4.5794	-0.638
HFE @ VCE=-5V, IC=-500μA	210.81	235.83	-25.02	3.6918	4.5407	-0.849
HFE @ VCE=-5V, IC=-10mA	197.54	220.17	-22.63	3.4727	4.033	-0.56
HFE @ VCE=-5V, IC=-20mA	185.05	206.44	-21.39	3.1123	3.6335	-0.521
IR (nA) @ VR = 55V	13	13	0	1.3	1.7	-0.4
VF (mV) @ IF = 1mA	628	630.92	-2.92	2.06	2.2	-0.14
VF (mV) @ IF = 10mA	757.56	760.47	-2.91	3.45	3.32	0.13
ICBO (nA) @ VCB = -50V	1.6	0.78	0.82	0	0.0067	-0.0067
ICBO (nA) @ VCB = -70V	1.6	0.76	0.84	0.055	0.037	0.018
ICES (nA) @ VCE = -50V	0.88	0.48	0.4	0.011	0.0038	0.0072
ICER (nA) @ VC = -50V, R=1K	0.68	0.39	0.29	0.014	0.0062	0.0078
IEBO (nA) @ VEB = -5V	0.005	0.036	-0.031	0	0.009	-0.009
VCES (mV) @ IC = -10mA, IB=-500μA	81.44	84.42	-2.98	0.629	0.522	0.107

TABLE A30: AVERAGE AND STANDARD DEVIATION OF POST EXTENDED HTRB ELECTRICAL TEST DATA FOR M-50 (CONTINUED)						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VBES (mV) @ IC=-10mA, IB=-500μA	764.81	767.69	-2.88	0.359	0.598	-0.239
VBEON (mV) @ VCE=-5V, IC=-5mA	704.88	705	-0.12	0.465	0.786	-0.321
VBEON (mV) @ VCE=-5V, IC=-20mA	744.72	747.64	-2.92	0.632	0.782	-0.15
1+HFE @ VCB=-5V, IE=-10μA	229.94	254.67	-24.73	4.9996	1.5339	3.4657
HFE @ VCE=-5V, IC=-500μA	223.38	246.67	-23.29	4.8973	1.4951	3.4022
HFE @ VCE=-5V, IC=-10mA	209.13	229.94	-20.81	4.1932	1.3921	2.8011
HFE @ VCE=-5V, IC=-20mA	195.64	215.39	-19.75	3.8196	1.195	2.6246
ICBO (nA) @ VCB=20V	3.3	2.6	0.7	0.41	0.25	0.16
IEBO (nA) @ VEB=4V	27	19	8	24	11	13
ICER (nA) @ VCE=13V, R=1K	2.6	2	0.6	0.25	0.075	0.175
HFE @ VCE=5V, IC=1mA	92.844	65.339	27.505	23.511	10.316	13.195
HFE @ VCE=5V, IC=10mA	116.16	84.794	31.366	26.646	12.189	14.457
HFE @ VCE=5V, IC=100mA	83.25	64.489	18.761	16.479	7.8785	8.6005
VCES (mV) @ IC =10mA, IB=1mA	138.16	147.33	-9.17	5.03	4.13	0.9
VBES (mV) @ IC=10mA, IB=1mA	802.41	805.69	-3.28	2.12	1.1	1.02
VCES (mV) @ IC =100mA, IB=10mA	436.38	494.42	-58.04	26.75	22.87	3.88
VBES (mV) @ IC=100mA, IB=10mA	1129.8	1126.4	3.4	11.19	12.84	-1.65
VBEON (mV) @ VCE=5V, IC=5mA	723.38	730.25	-6.87	4.18	2.91	1.27
VBEON (mV) @ VCE=5V, IC=20mA	776.97	785.83	-8.86	6.51	3.91	2.6
ICBO (nA) @ VCB=-50V	1.3	0.66	0.64	0	0.0084	-0.0084
ICBO (nA) @ VCB=-70V	1.5	0.77	0.73	0.064	0.039	0.025
ICES (nA) @ VCE =-50V	0.77	0.43	0.34	0.045	0.014	0.031
ICER (nA) @ VC=-50V, R=1K	0.65	0.36	0.29	0.01	0.007	0.003
IEBO (nA) @ VEB=-5V	0.005	0.005	0	0	0	0
VCES (mV) @ IC =-10mA, IB=-500μA	81.94	85.72	-3.78	0.727	0.79	-0.063
VBES (mV) @ IC=-10mA, IB=-500μA	764.59	767.69	-3.1	0.417	0.489	-0.072
VBEON (mV) @ VCE=-5V, IC=-5mA	704.78	705.08	-0.3	0.547	0.827	-0.28
VBEON (mV) @ VCE=-5V, IC=-20mA	747.81	747.94	-0.13	0.443	0.662	-0.219
1+HFE @ VCB=-5V, IE=-10μA	220.25	242.39	-22.14	3.8557	3.0125	0.8432
HFE @ VCE=-5V, IC=-500μA	213.5	235.06	-21.56	3.5777	2.6892	0.8885
HFE @ VCE=-5V, IC=-10mA	199.78	219.44	-19.66	3.2196	2.5257	0.6939
HFE @ VCE=-5V, IC=-20mA	187.01	205.67	-18.66	2.7325	2.3764	0.3561

TABLE A31: MINIMUM AND MAXIMUM VALUES OF POST 500 HOUR HTRB ELECTRICAL TEST DATA FOR M-50						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ VR = 55V	12	11	1	20	19	1
VF (mV) @ IF = 1mA	615.5	620	-4.5	627	632	-5
VF (mV) @ IF = 10mA	745.5	748.5	-3	759	764	-5
ICBO (nA) @ VCB = -50V	0.8	0.79	0.01	0.82	0.81	0.01
ICBO (nA) @ VCB = -70V	0.75	0.74	0.01	0.85	0.75	0.1
ICES (nA) @ VCE = -50V	0.48	0.46	0.02	0.48	0.48	0
ICER (nA) @ VC = -50V, R=1K	0.36	0.36	0	0.4	0.4	0
IEBO (nA) @ VEB = -5V	0.005	0.025	-0.02	0.015	0.05	-0.035
VCES (mV) @ IC = -10mA, IB=-500μA	80.5	83.5	-3	84.5	85.5	-1
VBES (mV) @ IC=-10mA, IB=-500μA	759	764	-5	764.5	768	-3.5
VBEON (mV) @ VCE=-5V, IC=-5mA	697	701	-4	704.5	705.5	-1
VBEON (mV) @ VCE=-5V, IC=-20mA	740.5	744	-3.5	748	748	0
1+HFE @ VCB=-5V, IE=-10μA	221	250	-29	238	258	-20
HFE @ VCE=-5V, IC=-500μA	215	243	-28	121	250	-129
HFE @ VCE=-5V, IC=-10mA	201	227	-26	216	233	-17
HFE @ VCE=-5V, IC=-20mA	188.8	212	-23.2	203	219	-16
ICBO (nA) @ VCB=20V	3.3	2.6	0.7	5.6	4	1.6
IEBO (nA) @ VEB=4V	13	12	1	143	64	79
ICER (nA) @ VCE=13V, R=1K	2.7	2.1	0.6	3.7	2.6	1.1
HFE @ VCE=5V, IC=1mA	53.4	54	-0.6	102	89.5	12.4
HFE @ VCE=5V, IC=10mA	71.7	70.9	0.8	131.2	112.9	18.3
HFE @ VCE=5V, IC=100mA	54.7	55.3	-0.6	93.3	82.7	10.6
VCES (mV) @ IC =10mA, IB=1mA	140.5	139	1.5	152	153.5	-1.5
VBES (mV) @ IC=10mA, IB=1mA	796.5	800.5	-4	803.5	807	-3.5
VCES (mV) @ IC =100mA, IB=10mA	441.5	428.5	13	519	520.5	-1.5
VBES (mV) @ IC=100mA, IB=10mA	1119	1117.5	1.5	1147.5	1179	-31.5
VBEON (mV) @ VCE=5V, IC=5mA	714.5	719.5	-5	728.5	732	-3.5
VBEON (mV) @ VCE=5V, IC=10mA	767	773	-6	787	789	-2
ICBO (nA) @ VCB=-50V	0.61	0.6	0.01	0.63	0.61	0.02
ICBO (nA) @ VCB=-70V	0.65	0.6	0.05	0.75	0.7	0.05
ICES (nA) @ VCE =-50V	0.38	0.38	0	0.4	0.4	0
ICER (nA) @ VC=-50V, R=1K	0.32	0.32	0	0.33	0.34	-0.01
IEBO (nA) @ VEB=-5V	0.005	0.005	0	0.005	0.035	-0.03
VCES (mV) @ IC =-10mA, IB=-500μA	81.5	84	-2.5	83.5	86	-2.5
VBES (mV) @ IC=-10mA, IB=-500μA	758	764	-6	764	768	-4
VBEON (mV) @ VCE=-5V, IC=-5mA	696.5	701.5	-5	704	706	-2
VBEON (mV) @ VCE=-5V, IC=-20mA	740	744.5	-4.5	747.5	748.5	-1
1+HFE @ VCB=-5V, IE=-10μA	210	236	-26	227	247	-20
HFE @ VCE=-5V, IC=-500μA	204	229	-25	220	239	-19
HFE @ VCE=-5V, IC=-10mA	191.6	214	-22.4	206	223	-17
HFE @ VCE=-5V, IC=-20mA	179.9	201	-21.1	192.8	209	-16.2
IR (nA) @ VR = 55V	12	12	0	20	17	3
VF (mV) @ IF = 1mA	616.5	624.5	-8	625.5	632	-6.5
VF (mV) @ IF = 10mA	745.5	754	-8.5	756	762	-6
ICBO (nA) @ VCB = -50V	0.78	0.76	0.02	0.8	0.87	-0.07
ICBO (nA) @ VCB = -70V	0.75	0.7	0.05	0.8	0.8	0
ICES (nA) @ VCE = -50V	0.48	0.48	0	0.49	0.57	-0.08
ICER (nA) @ VC = -50V, R=1K	0.36	0.38	-0.02	0.4	0.48	-0.08
IEBO (nA) @ VEB = -5V	0.005	0.015	-0.01	0.005	0.14	-0.135
VCES (mV) @ IC = -10mA, IB=-500μA	80.5	83.5	-3	83.5	85	-1.5

TABLE A31: MINIMUM AND MAXIMUM VALUES OF POST 500 HOUR HTRB ELECTRICAL TEST DATA FOR M-50 (CONTINUED)						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VBES (mV) @ IC=-10mA, IB=-500μA	759	764.5	-5.5	764.5	768	-3.5
VBEON (mV) @ VCE=-5V, IC=-5mA	697.5	702	-4.5	704.5	705.5	-1
VBEON (mV) @ VCE=-5V, IC=-20mA	740.5	744.5	-4	747.5	748.5	-1
1+HFE @ VCB=-5V, IE=-10μA	218	247	-29	239	259	-20
HFE @ VCE=-5V, IC=-500μA	218	238	-20	232	259	-20
HFE @ VCE=-5V, IC=-10mA	206	222	-16	216	234	-18
HFE @ VCE=-5V, IC=-20mA	192.8	209	-16.2	202	219	-17
ICBO (nA) @ VCB=20V	3	2.5	0.5	5	4.4	0.6
IEBO (nA) @ VEB=4V	14	13	1	188	122	66
ICER (nA) @ VCE=13V, R=1K	2.3	2.1	0.2	3.6	2.6	1
HFE @ VCE=5V, IC=1mA	58.2	55.6	2.6	120.2	82.1	38.1
HFE @ VCE=5V, IC=10mA	76.7	72.9	3.8	145.8	105.5	40.3
HFE @ VCE=5V, IC=100mA	59	56.6	2.4	101.1	77.9	23.2
VCES (mV) @ IC =10mA, IB=1mA	134	140.5	-6.5	150.5	152	-1.5
VBES (mV) @ IC=10mA, IB=1mA	793.5	801.5	-8	803	806.5	-3.5
VCES (mV) @ IC =100mA, IB=10mA	414	460	-46	512	521	-9
VBES (mV) @ IC=100mA, IB=10mA	1115	1115.5	-0.5	1146	1154.5	-8.5
VBEON (mV) @ VCE=5V, IC=5mA	711	720.5	-9.5	726	732	-6
VBEON (mV) @ VCE=5V, IC=20mA	763	774.5	-11.5	783	789.5	-6.5
ICBO (nA) @ VCB=-50V	0.66	0.66	0	0.69	0.68	0.01
ICBO (nA) @ VCB=-70V	0.75	0.7	0.05	0.85	0.8	0.05
ICES (nA) @ VCE =-50V	0.4	0.4	0	0.44	0.46	-0.02
ICER (nA) @ VC=-50V, R=1K	0.34	0.34	0	0.37	0.36	0.01
IEBO (nA) @ VEB=-5V	0.005	0.005	0	0.005	0.005	0
VCES (mV) @ IC =-10mA, IB=-500μA	81.5	84.5	-3	84	86	-2
VBES (mV) @ IC=-10mA, IB=-500μA	758	764.5	-6.5	764.5	768	-3.5
VBEON (mV) @ VCE=-5V, IC=-5mA	696.5	702	-5.5	704.5	706	-1.5
VBEON (mV) @ VCE=-5V, IC=-20mA	740.5	744.5	-4	747.5	749	-1.5
1+HFE @ VCB=-5V, IE=-10μA	213	235	-22	225	246	-21
HFE @ VCE=-5V, IC=-500μA	207	227	-20	219	238	-19
HFE @ VCE=-5V, IC=-10mA	193.8	213	-19.2	205	223	-18
HFE @ VCE=-5V, IC=-20mA	181.8	199.6	-17.8	191.5	209	-17.5

TABLE A32: AVERAGE AND STANDARD DEVIATION OF POST 500 HOUR HTRB ELECTRICAL TEST DATA FOR M-50						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (nA) @ VR = 55V	16	15	1	1.9	2.4	-0.5
VF (mV) @ IF = 1mA	620.5	626.28	-5.78	3.09	2.99	0.1
VF (mV) @ IF = 10mA	750.55	755.9	-5.35	4.36	3.84	0.52
ICBO (nA) @ VCB = -50V	0.81	0.8	0.01	0.0071	0.0032	0.0039
ICBO (nA) @ VCB = -70V	0.79	0.77	0.02	0.028	0.024	0.004
ICES (nA) @ VCE = -50V	0.48	0.47	0.01	0	0.0047	-0.0047
ICER (nA) @ VC = -50V, R=1K	0.37	0.39	-0.02	0.015	0.012	0.003
IEBO (nA) @ VEB = -5V	0.006	0.037	-0.031	0.0026	0.006	-0.003
VCES (mV) @ IC = -10mA, IB=-500μA	82.08	84.33	-2.25	0.963	0.52	0.443
VBES (mV) @ IC=-10mA, IB=-500μA	760.65	765.7	-5.05	1.61	1.37	0.24
VBEON (mV) @ VCE=-5V, IC=-5mA	699.68	703	-3.32	2.24	1.35	0.89
VBEON (mV) @ VCE=-5V, IC=-20mA	742.95	745.6	-2.65	2.09	1.3	0.79
1+HFE @ VCB=-5V, IE=-10μA	230.35	255.2	-24.85	5.2643	2.6278	2.6365
HFE @ VCE=-5V, IC=-500μA	224.05	246.9	-22.85	4.9148	2.49	2.4248
HFE @ VCE=-5V, IC=-10mA	209.75	230.4	-20.65	4.2162	2.21	2.0062
HFE @ VCE=-5V, IC=-20mA	196.45	215.95	-19.5	3.9808	2.0641	1.9167
ICBO (nA) @ VCB=20V	4.2	3	1.2	0.57	0.29	0.28
IEBO (nA) @ VEB=4V	32	17	15	36	12	24
ICER (nA) @ VCE=13V, R=1K	3.3	2.4	0.9	0.32	0.14	0.18
HFE @ VCE=5V, IC=1mA	67.78	75.11	-7.33	11.757	11.02	0.737
HFE @ VCE=5V, IC=10mA	87.71	96.875	-9.165	13.525	13.053	0.472
HFE @ VCE=5V, IC=100mA	65.55	72.51	-6.96	8.632	8.5292	0.1028
VCES (mV) @ IC =10mA, IB=1mA	147.1	143.4	3.7	2.94	4.53	-1.59
VBES (mV) @ IC=10mA, IB=1mA	799.58	803.6	-4.02	1.92	1.77	0.15
VCES (mV) @ IC =100mA, IB=10mA	486	471.58	14.42	21.35	24.89	-3.54
VBES (mV) @ IC=100mA, IB=10mA	1131.4	1137.6	-6.2	8.12	17.98	-9.86
VBEON (mV) @ VCE=5V, IC=5mA	721.98	724.4	-2.42	2.68	3.79	-1.11
VBEON (mV) @ VCE=5V, IC=10mA	778.45	779.28	-0.83	3.66	4.75	-1.09
ICBO (nA) @ VCB=-50V	0.62	0.6	0.02	0.0074	0.0041	0.0033
ICBO (nA) @ VCB=-70V	0.69	0.68	0.01	0.028	0.03	-0.002
ICES (nA) @ VCE =-50V	0.39	0.39	0	0.0077	0.0047	0.003
ICER (nA) @ VC=-50V, R=1K	0.32	0.32	0	0.0033	0.0091	-0.006
IEBO (nA) @ VEB=-5V	0.005	0.017	-0.012	0	0.008	-0.008
VCES (mV) @ IC =-10mA, IB=-500μA	83	85.38	-2.38	0.562	0.666	-0.104
VBES (mV) @ IC=-10mA, IB=-500μA	760.3	765.78	-5.48	1.87	1.35	0.52
VBEON (mV) @ VCE=-5V, IC=-5mA	699.68	703.2	-3.52	2.23	1.36	0.87
VBEON (mV) @ VCE=-5V, IC=-20mA	743.1	745.93	-2.83	2.02	1.33	0.69
1+HFE @ VCB=-5V, IE=-10μA	216.25	241.8	-25.55	4.7559	3.563	1.1929
HFE @ VCE=-5V, IC=-500μA	210.4	234.4	-24	4.2227	3.4853	0.7374
HFE @ VCE=-5V, IC=-10mA	197.43	218.95	-21.52	3.9651	2.982	0.9831
HFE @ VCE=-5V, IC=-20mA	185.1	205.35	-20.25	3.4596	2.7391	0.7205
IR (nA) @ VR = 55V	17	14	3	2.3	1.7	0.6
VF (mV) @ IF = 1mA	620.95	629.08	-8.13	2.51	2	0.51
VF (mV) @ IF = 10mA	751.98	759.43	-7.45	3.21	2.16	1.05
ICBO (nA) @ VCB = -50V	0.79	0.78	0.01	0.004	0.022	-0.018
ICBO (nA) @ VCB = -70V	0.77	0.77	0	0.0024	0.03	-0.028
ICES (nA) @ VCE = -50V	0.48	0.418	0	0.0029	0.02	-0.017
ICER (nA) @ VC = -50V, R=1K	0.38	0.39	-0.01	0.016	0.022	-0.006
IEBO (nA) @ VEB = -5V	0.005	0.038	-0.033	0	0.023	-0.023
VCES (mV) @ IC = -10mA, IB=-500μA	82.43	84.3	-1.87	0.922	0.377	0.545

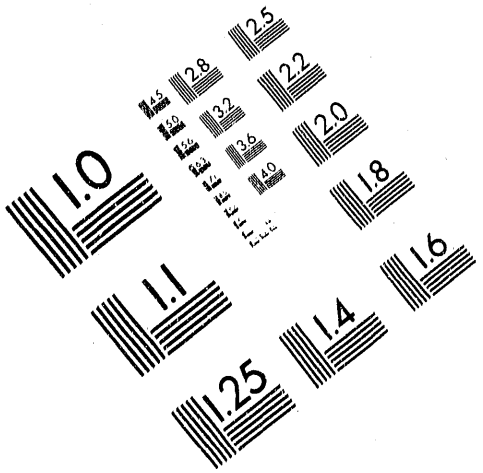
TABLE A32: AVERAGE AND STANDARD DEVIATION OF POST 500 HOUR HTRB ELECTRICAL TEST DATA FOR M-50 (CONTINUED)						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VBES (mV) @ IC=-10mA, IB=-500μA	760.55	766.1	-5.55	1.69	1.18	0.51
VBEON (mV) @ VCE=-5V, IC=-5mA	699.53	703.33	-3.8	2.18	1.28	0.9
VBEON (mV) @ VCE=-5V, IC=-20mA	742.78	746	-3.22	2	1.31	0.69
1+HFE @ VCB=-5V, IE=-10μA	230.5	253.4	-22.9	4.9151	3.5748	1.3403
HFE @ VCE=-5V, IC=-500μA	224.25	245.35	-21.1	3.9454	3.4985	0.4469
HFE @ VCE=-5V, IC=-10mA	209.95	229	-19.05	3.4101	3.1119	0.2982
HFE @ VCE=-5V, IC=-20mA	196.53	214.55	-18.02	3.0485	2.9996	0.0489
ICBO (nA) @ VCB=20V	3.9	3.1	0.8	0.53	0.36	0.17
IEBO (nA) @ VEB=4V	34	29	5	43	27	16
ICER (nA) @ VCE=13V, R=1K	3	2.3	0.7	0.38	0.14	0.24
HFE @ VCE=5V, IC=1mA	90.23	63.045	27.185	21.281	6.2276	15.053
HFE @ VCE=5V, IC=10mA	112.06	82.14	29.92	23.465	7.7372	15.728
HFE @ VCE=5V, IC=100mA	80.625	62.77	17.855	14.404	5.1791	9.2249
VCES (mV) @ IC =10mA, IB=1mA	140.5	148.7	-8.2	4.76	3.05	1.71
VBES (mV) @ IC=10mA, IB=1mA	798.23	804.2	-5.97	2.63	1.35	1.28
VCES (mV) @ IC =100mA, IB=10mA	443.73	498.68	-54.95	28.16	15.5	12.66
VBES (mV) @ IC=100mA, IB=10mA	1128	1124.4	3.6	9.34	13.23	-3.89
VBEON (mV) @ VCE=5V, IC=5mA	718.88	728.8	-9.92	4.24	3.09	1.15
VBEON (mV) @ VCE=5V, IC=20mA	773.18	784.95	-11.77	5.89	3.55	2.34
ICBO (nA) @ VCB=-50V	0.67	0.66	0.01	0.006	0.0069	-0.0009
ICBO (nA) @ VCB=-70V	0.78	0.77	0.01	0.03	0.034	-0.004
ICES (nA) @ VCE =-50V	0.41	0.43	-0.02	0.013	0.017	-0.004
ICER (nA) @ VC=-50V, R=1K	0.35	0.35	0	0.01	0.0062	0.0038
IEBO (nA) @ VEB=-5V	0.005	0.005	0	0	0	0
VCES (mV) @ IC =-10mA, IB=-500μA	82.75	85.83	-3.08	0.786	0.406	0.38
VBES (mV) @ IC=-10mA, IB=-500μA	760.33	766.18	-5.85	1.8	1.21	0.59
VBEON (mV) @ VCE=-5V, IC=-5mA	699.35	703.4	-4.05	2.21	1.29	0.92
VBEON (mV) @ VCE=-5V, IC=-20mA	742.7	746.28	-3.58	1.96	1.26	0.7
1+HFE @ VCB=-5V, IE=-10μA	220.5	241.4	-20.9	3.9403	3.0157	0.9246
HFE @ VCE=-5V, IC=-500μA	214.6	234.1	-19.5	3.5004	2.7891	0.7113
HFE @ VCE=-5V, IC=-10mA	201.04	218.85	-17.81	3.2809	2.5189	0.762
HFE @ VCE=-5V, IC=-20mA	188.14	205.23	-17.09	2.8572	2.3631	0.4941

TABLE A33: MINIMUM AND MAXIMUM VALUES OF ELECTRICAL TEST DATA FOR M-50 AT -55°C						
TEST	MINIMUM VALUE			MAXIMUM VALUE		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VF (mV) @ IF = 1mA	775.5	773	2.5	788.5	791.5	-3
VF (mV) @ IF = 10mA	870	866	4	883.5	884.5	-1
1+HFE @VCB=-5V, IE=-10μA	117.2	133.9	-16.7	151.9	146.4	5.5
HFE @ VCE=-5V, IC=-5mA	121.4	126.3	-4.9	111.6	137.7	-26.1
HFE @ VCE=-5V, IC=-20mA	98.8	110.3	-11.5	113.4	126	-12.6
VBEON (mV) @ VCE=-5V, IC=-5mA	843.5	842	1.5	848	848.5	-0.5
VBEON (mV) @ VCE=-5V, IC=-20mA	792	797	-5	880.5	878.5	2
HFE @ VCE=5V, IC=5mA	35.1	35.3	-0.2	63.6	56.4	7.2
HFE @ VCE=5V, IC=20mA	36	35.8	0.2	62.5	56.2	6.3
VBEON (mV) @ VCE=5V, IC=5mA	864	862	2	873.5	876	-2.5
VBEON (mV) @ VCE=5V, IC=20mA	911	911	0	928	928.5	-0.5
1+HFE @VCB=-5V, IE=-10μA	106.7	127.4	-20.7	164.5	158.7	5.8
HFE @ VCE=-5V, IC=-5mA	106.8	119.9	-13.1	116.4	130.9	-14.5
HFE @ VCE=-5V, IC=-20mA	100.4	112.3	-11.9	109.1	122.2	-13.1
VBEON (mV) @ VCE=-5V, IC=-5mA	843	842	1	848.5	849	-0.5
VBEON (mV) @ VCE=-5V, IC=-20mA	875.5	874.5	1	881	881	0
VF (mV) @ IF = 1mA	779.5	779	0.5	788.5	790	-1.5
VF (mV) @ IF = 10mA	873.5	872	1.5	883.5	884.5	-1
1+HFE @VCB=-5V, IE=-10μA	119.1	134.5	-15.4	213	186.7	26.3
HFE @ VCE=-5V, IC=-5mA	111.6	127.1	-15.5	212.7	140.1	-18.4
HFE @ VCE=-5V, IC=-20mA	104.7	118.8	-14.1	113.9	130.8	-16.9
VBEON (mV) @ VCE=-5V, IC=-5mA	843	842	1	848	848.5	-0.5
VBEON (mV) @ VCE=-5V, IC=-20mA	875.5	874.5	1	881	881	0
HFE @ VCE=5V, IC=5mA	35.8	57.2	-21.4	72.4	35.8	36.6
HFE @ VCE=5V, IC=20mA	36.1	35.8	0.3	70.2	56.7	13.5
VBEON (mV) @ VCE=5V, IC=5mA	861.5	864	-2.5	873.5	876	-2.5
VBEON (mV) @ VCE=5V, IC=20mA	907.5	913.5	-6	931	928.5	2.5
1+HFE @VCB=-5V, IE=-10μA	113.9	99.5	14.4	173.6	216	-42.4
HFE @ VCE=-5V, IC=-5mA	107.6	120.2	-12.6	116.1	132.6	-16.5
HFE @ VCE=-5V, IC=-20mA	101	112.6	-11.6	108.7	123.9	-15.2
VBEON (mV) @ VCE=-5V, IC=-5mA	843	842	1	847.5	848.5	-1
VBEON (mV) @ VCE=-5V, IC=-20mA	875.5	875	0.5	880	881	-1

TABLE A34: AVERAGE AND STANDARD DEVIATION OF ELECTRICAL TEST DATA FOR M-50 AT -55°C						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
VF (mV) @ IF = 1mA	782.88	784.02	-1.14	2.39	2.84	-0.45
VF (mV) @ IF = 10mA	877.38	878.77	-1.39	2.79	3.04	-0.25
1+HFE @VCB=-5V, IE=-10μA	124.39	140.73	-16.34	4.79	2.14	2.65
HFE @ VCE=-5V, IC=-5mA	116.69	132.75	-16.06	2.65	2.01	0.64
HFE @ VCE=-5V, IC=-20mA	104.38	117.41	-13.03	3.73	3.81	-0.08
VBEON (mV) @ VCE=-5V, IC=-5mA	845.89	844.81	1.08	1.31	1.35	-0.04
VBEON (mV) @ VCE=-5V, IC=-20mA	852.7	851.86	0.84	24.16	20.01	4.15
HFE @ VCE=5V, IC=5mA	43.9	47.83	-3.93	7.99	5.64	2.35
HFE @ VCE=5V, IC=20mA	43.9	47.99	-4.09	7.54	5.44	2.10
VBEON (mV) @ VCE=5V, IC=5mA	869.81	867.74	2.07	2.65	3.32	-0.67
VBEON (mV) @ VCE=5V, IC=20mA	922.37	919.2	3.17	4.79	4.49	0.3
1+HFE @VCB=-5V, IE=-10μA	119.28	133.27	-13.99	9.37	4.40	4.97
HFE @ VCE=-5V, IC=-5mA	110.79	125.36	-14.57	2.19	2.32	-0.13
HFE @ VCE=-5V, IC=-20mA	103.85	117.25	-13.4	1.95	2.12	-0.17
VBEON (mV) @ VCE=-5V, IC=-5mA	845.9	844.88	1.02	1.26	1.42	-0.16
VBEON (mV) @ VCE=-5V, IC=-20mA	878.35	877.19	1.16	1.15	1.35	-0.2
VF (mV) @ IF = 1mA	783.6	784.53	-0.93	2.08	2.31	-0.23
VF (mV) @ IF = 10mA	878.77	879.69	-0.92	2.38	2.56	-0.18
1+HFE @VCB=-5V, IE=-10μA	126.3	141.39	-15.09	11.83	7.26	4.57
HFE @ VCE=-5V, IC=-5mA	117.49	132.13	-14.64	2.48	2.35	0.13
HFE @ VCE=-5V, IC=-20mA	110.03	123.43	-13.4	2.25	2.14	0.11
VBEON (mV) @ VCE=-5V, IC=-5mA	845.64	844.75	0.89	1.3	1.42	-0.12
VBEON (mV) @ VCE=-5V, IC=-20mA	878	877.03	0.97	1.25	1.34	-0.09
HFE @ VCE=5V, IC=5mA	55.06	41.67	13.39	11.12	5.27	5.85
HFE @ VCE=5V, IC=20mA	54.30	41.89	12.41	10.39	5.14	5.25
VBEON (mV) @ VCE=5V, IC=5mA	866.7	870.85	-4.15	3.38	2.91	0.47
VBEON (mV) @ VCE=5V, IC=20mA	916.78	923.12	-6.34	6.29	3.68	2.61
1+HFE @VCB=-5V, IE=-10μA	121.9	134.24	-12.34	8.92	12.53	-3.61
HFE @ VCE=-5V, IC=-5mA	112.38	125.6	-13.22	1.89	2.11	-0.23
HFE @ VCE=-5V, IC=-20mA	105.18	117.45	-12.27	1.68	1.94	-0.26
VBEON (mV) @ VCE=-5V, IC=-5mA	845.55	844.84	0.71	1.3	1.4	-0.1
VBEON (mV) @ VCE=-5V, IC=-20mA	877.99	877.21	0.78	1.18	1.28	-0.1

TABLE A35: MINIMUM AND MAXIMUM VALUES OF ELECTRICAL TEST DATA FOR M-50 AT 100°C						
TEST	MINIMUM VALUES			MAXIMUM VALUES		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (μA) @ VR = 55V	6.55	7.56	-1.01	11.3	11.8	-0.5
VF (mV) @ IF = 1mA	401.5	400.5	1	415.5	414	1.5
VF (mV) @ IF = 10mA	572	567	5	586	585.5	0.5
ICBO (nA) @ VCB = -50V	17	19	-2	82	31	51
ICER (nA) @ VCE = -50V, R=1K	24	24	0	98	40	58
IEBO (nA) @ VEB = -4V	3.3	1.3	2	12	7.2	4.8
HFE @ VCE=-5V, IC=-5mA	325	360	-35	347	373	-26
HFE @ VCE=-5V, IC=-20mA	287	315	-28	305	326	-21
VBEON (mV) @ VCE=-5V, IC=-5mA	504.5	503	1.5	514	508	6
VBEON (mV) @ VCE=-5V, IC=-20mA	562.5	560.5	2	571.5	566	5.5
ICER (nA) @ VCE=13V, R=1K	1220	1130	90	3320	2820	500
IEBO (nA) @ VEB=4V	120	118	2	648	380	268
HFE @ VCE=5V, IC=5mA	110.9	114.7	-3.8	229	193.1	35.9
HFE @ VCE=5V, IC=20mA	114.3	116.6	-2.3	216	186	30
VBEON (mV) @ VCE=5V, IC=5mA	522.5	520.5	2	539.5	539	0.5
VBEON (mV) @ VCE=5V, IC=20mA	586.5	587	-0.5	608.5	607.5	1
VCES (mV) @ IC =10mA, IB=1mA	156	161.5	-5.5	175.5	179.5	-4
ICBO (nA) @ VCB=-50V	22	19	3	93	52	41
ICER (nA) @ VC=-50V, R=1K	27	23	4	322	166	156
IEBO (nA) @ VEB=-4V	2.4	1.6	0.8	9.4	4.9	4.5
HFE @ VCE=-5V, IC=-5mA	315	351	-36	336	366	-30
HFE @ VCE=-5V, IC=-20mA	278	308	-30	296	320	-24
VBEON (mV) @ VCE=-5V, IC=-5mA	504.5	502	2.5	514	508.5	5.5
VBEON (mV) @ VCE=-5V, IC=-20mA	563	560.5	2.5	571.5	566.5	5
IR (μA) @ VR = 55V	6.2	7.41	-1.21	24.1	11.8	12.3
VF (mV) @ IF = 1mA	407	404.5	2.5	417.5	414	3.5
VF (mV) @ IF = 10mA	577.5	572.5	5	588.5	586	2.5
ICBO (nA) @ VCB=-50V	20	18	2	57	30	27
ICER(nA) @ VCE =-50V, R=1K	27	22	5	101	41	60
IEBO (nA) @ VEB = -4V	3.6	2	1.6	14	7.2	6.8
HFE @ VCE=-5V, IC=-5mA	324	359	-35	348	375	-27
HFE @ VCE=-5V, IC=-20mA	286	315	-29	305	328	-23
VBEON (mV) @ VCE=-5V, IC=-5mA	504.5	502	2.5	515	508.5	6.5
VBEON (mV) @ VCE=-5V, IC=-20mA	562.5	560.5	2	572	566.5	5.5
ICER (nA) @ VCE=13V, R=1K	832	1130	-298	1580	1510	70
IEBO (nA) @ VEB=4V	112	117	-5	536	373	163
HFE @ VCE=5V, IC=5mA	116.8	117.9	-1.1	269	199.6	69.4
HFE @ VCE=5V, IC=20mA	119.2	120	-0.8	247	193.1	53.9
VBEON (mV) @ VCE=5V, IC=5mA	518	521.5	-3.5	538	538.5	-0.5
VBEON (mV) @ VCE=5V, IC=20mA	581.5	587	-5.5	606.5	607.5	-1
VCES (mV) @ IC =10mA, IB=1mA	152	161.5	-9.5	175.5	179	-3.5
ICBO (nA) @ VCB=-50V	23	18	5	61	35	26
ICER (nA) @ VC=-50V, R=1K	30	23	7	78	46	32
IEBO (nA) @ VEB=-4V	3.6	1.5	2.1	10	6.4	3.6
HFE @ VCE=-5V, IC=-5mA	316	352	-36	337	371	-34
HFE @ VCE=-5V, IC=-20mA	279	309	-30	295	324	-29
VBEON (mV) @ VCE=-5V, IC=-5mA	504.5	502	2.5	512.5	508.5	4
VBEON (mV) @ VCE=-5V, IC=-20mA	562.5	560.5	2	570.5	566.5	4

TABLE A36: AVERAGE AND STANDARD DEVIATION OF ELECTRICAL TEST DATA FOR M-50 AT 100°C						
TEST	AVERAGE VALUES			STANDARD DEVIATION		
	Freon	DI Water	Delta	Freon	DI Water	Delta
IR (μA) @ VR = 55V	9.02	10.1	-1.08	0.993	1.01	-0.017
VF (mV) @ IF = 1mA	410.48	409.98	0.5	2.48	2.75	-0.27
VF (mV) @ IF = 10mA	580.23	580.94	-0.71	2.99	3.5	-0.51
ICBO (nA) @ VCB = -50V	30	23	7	9.5	2.4	7.1
ICER (nA) @ VCE = -50V, R=1K	40	28	12	13	2.9	10.1
IEBO (nA) @ VEB = -4V	5.5	3.8	1.7	1.6	0.72	0.88
HFE @ VCE=-5V, IC=-5mA	335.37	368.69	-33.32	6.75	2.81	3.94
HFE @ VCE=-5V, IC=-20mA	295.28	322.54	-27.26	5.49	2.15	3.34
VBEON (mV) @ VCE=-5V, IC=-5mA	508.77	506.48	2.29	1.75	1.39	0.36
VBEON (mV) @ VCE=-5V, IC=-20mA	566.43	564.16	2.27	1.62	1.22	0.4
ICER (nA) @ VCE=13V, R=1K	1500	1380	120	257	279	-22
IEBO (nA) @ VEB=4V	175	143	32	85	43	42
HFE @ VCE=5V, IC=5mA	147.64	159.85	-12.21	32.92	20.76	12.16
HFE @ VCE=5V, IC=20mA	146.2	158.59	-12.39	28.56	18.55	10.01
VBEON (mV) @ VCE=5V, IC=5mA	531.78	527.63	4.15	3.49	4.51	-1.02
VBEON (mV) @ VCE=5V, IC=20mA	599.28	594.27	5.01	5.22	5.23	-0.01
VCES (mV) @ IC =10mA, IB=1mA	168.28	166.55	1.73	5.07	5.1	-0.03
ICBO (nA) @ VCB=-50V	36	23	13	11	4.6	6.4
ICER (nA) @ VC=-50V, R=1K	52	33	19	42	21	21
IEBO (nA) @ VEB=-4V	6	3.8	2.2	1.5	0.71	0.79
HFE @ VCE=-5V, IC=-5mA	324.42	358.33	-33.91	6.28	3.97	2.31
HFE @ VCE=-5V, IC=-20mA	286.08	313.81	-27.73	4.99	3.17	1.82
VBEON (mV) @ VCE=-5V, IC=-5mA	508.84	506.45	2.39	1.73	1.43	0.3
VBEON (mV) @ VCE=-5V, IC=-20mA	566.45	564.2	2.25	1.61	1.22	0.39
IR (μA) @ VR = 55V	9.55	9.5	0.05	2.59	1.03	1.56
VF (mV) @ IF = 1mA	410.84	411.53	-0.69	1.97	2.1	-0.13
VF (mV) @ IF = 10mA	581.73	582.63	-0.9	2.23	2.42	-0.19
ICBO (nA) @ VCB=-50V	31	23	8	7.3	2.2	5.1
ICER(nA) @ VCE =-50V, R=1K	42	28	14	12	3.6	8.4
IEBO (nA) @ VEB = -4V	6	4	2	1.7	0.74	0.96
HFE @ VCE=-5V, IC=-5mA	338.3	367.89	-29.59	6.37	3.12	3.25
HFE @ VCE=-5V, IC=-20mA	297.77	322	-24.23	5.17	2.52	2.65
VBEON (mV) @ VCE=-5V, IC=-5mA	508.39	506.54	1.85	1.71	1.5	0.21
VBEON (mV) @ VCE=-5V, IC=-20mA	566.09	564.19	1.9	1.63	1.19	0.41
ICER (nA) @ VCE=13V, R=1K	1340	1320	20	211	82	129
IEBO (nA) @ VEB=4V	185	161	24	87	52	35
HFE @ VCE=5V, IC=5mA	194.37	137.55	56.82	46.34	20.01	26.33
HFE @ VCE=5V, IC=20mA	185.97	137.9	48.07	39.35	17.98	21.37
VBEON (mV) @ VCE=5V, IC=5mA	527.72	533.13	-5.41	4.8	4.46	0.34
VBEON (mV) @ VCE=5V, IC=20mA	593.38	600.73	-7.35	6.8	5.14	1.66
VCES (mV) @ IC =10mA, IB=1mA	159.39	173.15	-13.76	5.2	4.75	0.45
ICBO (nA) @ VCB=-50V	38	23	15	7.4	3	4.4
ICER (nA) @ VC=-50V, R=1K	50	29	21	10	3.8	6.2
IEBO (nA) @ VEB=-4V	6.7	3.9	2.8	1.5	1.1	0.4
HFE @ VCE=-5V, IC=-5mA	329.82	358.74	-28.92	4.88	3.34	1.54
HFE @ VCE=-5V, IC=-20mA	290.17	314.11	-23.94	3.86	2.74	1.12
VBEON (mV) @ VCE=-5V, IC=-5mA	508.18	506.48	1.7	1.6	1.4	0.2
VBEON (mV) @ VCE=-5V, IC=-20mA	565.97	564.34	1.63	1.51	1.19	0.32



AIIM

Association for Information and Image Management

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Centimeter

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 mm

1 2 3 4 5

Inches

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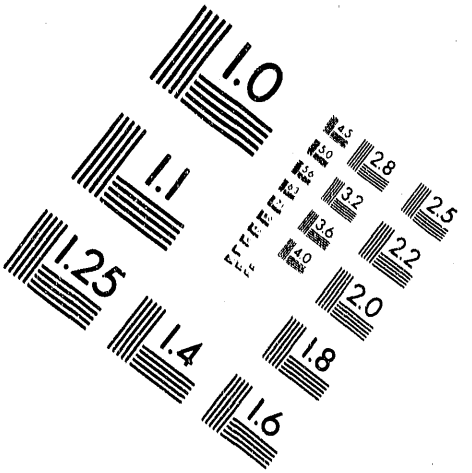

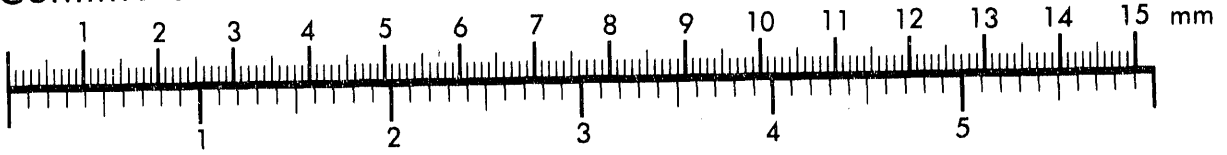

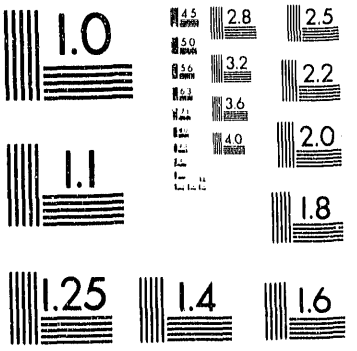

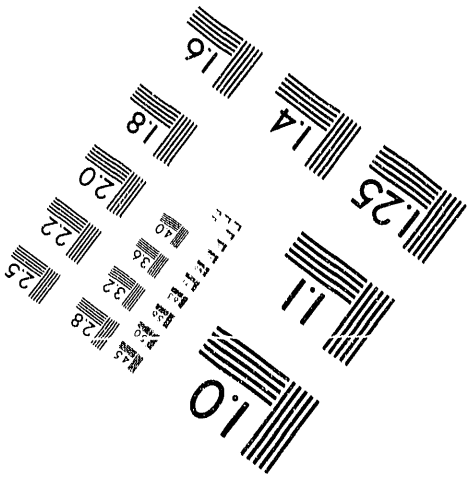

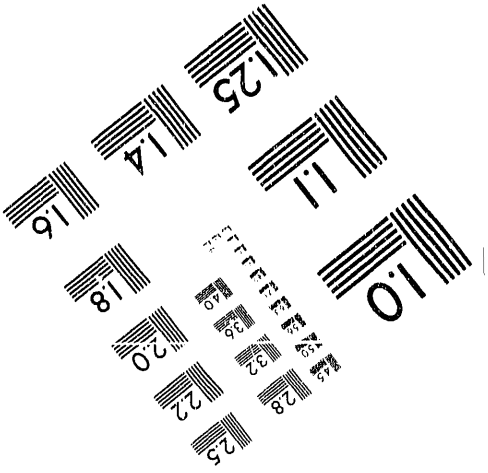

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