International Rectifier

IOR

Quarterly Reliability Report

for

T0247 / T0220 Products Manufactured at

IRGB

IGBT / CoPack

ISSUE.3.

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Introduction

The reliability report is a summary of the test data collated since the implementation of the reliability programme. This report will be periodically updated typically on a quarterly basis. Future publications of this report will also include as appropriate additional information to assist the user in the interpretation of the data provided. The programme covers only IGBT / CoPack manufactured products at IRGB, Holland Road, Oxted. The reliability data provided in this report are for the package types TO247 and TO220.

Further information regarding reliability data is available in the IR data book IGBT-3, pages E-65-E-72. This also, is available from the Oxted office.

Reliability Engineering ______________________________

Quality Manager ______________________________

Date ______________________________

Section

2

Reliability Information

Fit Rate / Equivalent Device Hours

Traditionally, reliability results have been presented in terms of Mean-Time-To-Failure or Median-Time-To-Failure. While these results have their value, they do not necessarily tell the designer what he most needs to know. For example, the Median-Time-To-Failure tells the engineer how long it will take for half a particular lot of devices to fail. Clearly no designer wishes to have a 50% failure rate within a reasonable equipment lifetime. Of greater interest, therefore, is the time to failure of a much smaller percentage of devices say 1% or 0.1%. For example, in a given application one failure per hundred units over five years is an acceptable failure rate for the equipment, the designer knows that time to accumulate 1% failure of that components per unit, then no more than 0.1% of the components may fail in five years. Therefore, the IGBT / CoPack reliability or operating-life data is presented in terms of the time it will take to produce a prescribed number of failures under given operating conditions.

To obtain a perspective of failure rate from an example, let us assume that an electronic system contains 1,000 semiconductor devices, and that it can tolerate 1% system failures per month. The equation for the device failure is:

$$\lambda = \frac{\text{Proportion allowed system failures}}{\text{Time period}} \times \frac{1}{\text{No. of devices}} \times 10^9 = \text{FITS}$$

In the case of the example,

$$\lambda = \frac{0.01\ \text{Failures}}{720\ \text{Hours}} \times \frac{1}{1000\ \text{Devices}} = 10^9 = 14\ \text{FITS}$$

or 14 FITs or 14 failures per 10^9 devices hours.

Using IGBT Reliability Information

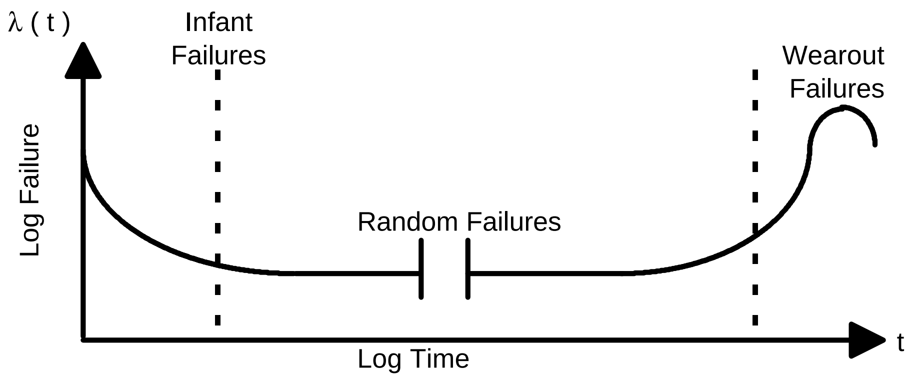
Reliability is the probability that a semiconductor device will perform its specified function in a given environment for a specified period of time. Reliability is quality over time & environmental conditions.

Reliability can be defined as a probability of failure-free performance of a required function, under a specified environment, for a given period of time. The reliability of semiconductors has been extensively studied and the data generated from these works is widely used in industry to estimate the probabilities of system lifetimes. The reliability of a specific semiconductor device is unique to the technology process used in fabrication and to the external stress applied to the device.

In order to understand the reliability of specific product like the IGBT it is useful to determine the failure rate associated with each environmental stress that IGBT's encounter.

The values reported in this report are at a 60% upper confidence limit and the equivalent device hours at state of working temperature of 90°C. It has been shown that the failure rate of semiconductors in general. when followed for a long period of time, exhibits what has been called a "Bathtub Curve" when plotted against time for a given set of environmental conditions.

Classic Bathtub Curve for failure rate of solid state devices



The IGBT Structure

The silicon cross-section of an Insulated Gate Bipolar Transistor (IGBT), the terminal called Collector is, actually, the Emitter of the PNP. In spite of its similarity to the cross-section of a power MOSFET, operating of the two transistors is fundamentally different, the IGBT being a minority carrier device. Except for the P + substrate is virtually identical to that of a power MOSFET, both devices share a similar polysilicon gate structure and P wells with N + source contacts. In both devices the N-type material under the P wells is sized in thickness and reistivity to sustain the full voltage rating of the device.

However, in spite of the many similarities, he physical operation of the IGBT is closer to that of a bipolar transistor than to that of a power MOSFET. This is due to the P + substrate which is responsible for the minority carrier injection into the N regtion and the resulting conductivity modulation, a significant share of the conduction losses occur in the N region, typically 70% in a 500v device.

The part number itself contains in coded form the key features of the IGBT. An explanation of the nomenclature in contained below.

IR G 4 B C 4 0 S D

- **IR** – International Rectifier
- **G** – IGBT
- **4** – Generation
- **B** – Package Designator
  - B T0220
  - P T0247
- **C** – Voltage Designator
  - C 600v, E 800v
  - F 900v, G 1000v
  - H 1200v
- **4** – Die Size
- **0** – Modifier
- **S** – Speed Designator
  - S Standard
  - F Fast
  - M Short Cicuit Fast
  - U UltraFast
  - K Short Circuit UltraFast
- **D** – Diode

Basic IGBT Structure

Section

3

Environmental Test Results

HIGH TEMPERATURE REVERSE BIAS (HTRB)

T0247 Package

Junction Temperature : Tj = as specified below
Applied Bias: Vge = 0V
Vce = 80% of maximum rated BVces

N Channel	MID FREQUENCY (Fast)								
DEVICE TYPE	DATE CODE	TEMP (deg C)	VOLTAGE MAX (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	FAILURES MODE (note b)	EQUIVALENT DEV-HRS @ 90°C	FAILURE RATE @ 90°C & 60% UCL FITs (note a)
IRGPC30FD2	9344	150	600	20	1080	0		2.01E+06	456
IRGPC50FD2	9237	150	600	59	2008	0		1.10E+07	83
TOTALS				79	3088	0		1.30E+07	70

N Channel	HIGH FREQUENCY (Ultra-Fast)								
DEVICE TYPE	DATE CODE	TEMP (deg C)	VOLTAGE MAX (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	FAILURES MODE (note b)	EQUIVALENT DEV-HRS @ 90°C	FAILURE RATE @ 90°C & 60% UCL FITs (note a)
IRGPC40U	9538	150	600	20	2008	0		3.73E+06	245
IRGPC40U	9620	150	600	20	2008	0		3.73E+06	245
IRGPC40UD2	9237	150	600	20	1008	0		1.87E+06	489
IRG4PC40UD2	9643	150	600	20	2030	0		3.78E+06	243
IRGPC50UD2	9346	150	600	20	1080	0		2.01E+06	456
IRGPH60UD2	9450	150	1200	10	1008	0		9.37E+05	977
TOTALS				110	9142	0		1.61E+07	57

NOTES

a. One FIT represents one failure in one billion (1.0E+09) hours.

b. FAILURE MODES:

HIGH TEMPERATURE REVERSE BIAS (HTRB)

T0220 Package

Junction Temperature: Tj = as specified below
Applied Bias: Vge = 0V
Vce = 80% of maximum rated BVces

N Channel					LOW FREQUENCY (Standard)				
DEVICE TYPE	DATE CODE	TEMP (deg C)	VOLTAGE MAX (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	FAILURES MODE (note b)	EQUIVALENT DEV-HRS @ 90°C	FAILURE RATE @ 90°C & 60% UCL FITs (note a)
IRGBC20S	9544	150	600	20	2008	0		3.73E+06	245
IRGBC40S	9606	150	600	20	2008	0		3.73E+06	245
TOTALS				40	4016	0		7.47E+06	123

N Channel					MID FREQUENCY (Fast)				
DEVICE TYPE	DATE CODE	TEMP (deg C)	VOLTAGE MAX (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	FAILURES MODE (note b)	EQUIVALENT DEV-HRS @ 90°C	FAILURE RATE @ 90°C & 60% UCL FITs (note a)
IRGBC30F	9537	150	600	20	2008	0		3.73E+06	245
IRGNC30FD2	9640	150	600	20	2007	0		3.73E+06	245
IRGBF30F	9613	150	900	20	2008	0		3.73E+06	245
TOTALS				60	6023	0		1.12E+07	82

NOTES

a. One FIT represents one failure in one billion (1.0E+09) hours.

b. FAILURE MODES:

HIGH TEMPERATURE REVERSE BIAS (HTRB)

T0220 Package

Junction Temperature:	Tj = as specified below
Applied Bias:	Vge = 0V
	Vce = 80% of maximum rated BVces

N Channel	HIGH FREQUENCY (Ultra-Fast)								
DEVICE TYPE	DATE CODE	TEMP (deg C)	VOLTAGE MAX (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	FAILURES MODE (note b)	EQUIVALENT DEV-HRS @ 90°C	FAILURE RATE @ 90°C & 60% UCL FITs (note a)
IRGBC20K	9613	150	600	20	2008	0		3.73E+06	245
IRGBC30U	9605	150	600	20	2008	0		3.73E+06	245
IRGB440U	9643	150	400	20	2008	0		3.73E+06	245
TOTALS				60	6024	0		1.12E+07	82

NOTES

a. One FIT represents one failure in one billion (1.0E+09) hours.

b. FAILURE MODES:

HIGH TEMPERATURE GATE BIAS (HTGB)

Junction Temperature: Tj = as specified below
Vc = Ve = 0V
Vg = as specified

N Channel	MID FREQUENCY (Fast)								
DEVICE TYPE	DATE CODE	TEMP (deg C)	GATE BIAS (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	FAILURES MODE (note b)	DEV-HRS @ 90°C	FAILURE RATE @ 90°C & 60% UCL FITs (note a)
IRGPF30F	9642	150	20	20	2007	0		2.46E+05	3724
IRGPC50FD2	9237	150	20	20	2088	0		2.56E+05	3579
TOTALS				40	4095	0		5.02E+05	1825

N Channel	HIGH FREQUENCY (Ultra-Fast)								
DEVICE TYPE	DATE CODE	TEMP (deg C)	GATE BIAS (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	FAILURES MODE (note b)	EQUIVALENT DEV-HRS @ 90°C	FAILURE RATE @ 90°C & 60% UCL FITs (note a)
IRGPC40U	9538	150	20	20	2008	0		2.46E+05	3722
IRGPC40U	9620	150	20	20	2008	0		2.46E+05	3722
IRG4PC50U	9721	150	20	20	2213	0		2.71E+05	3377
IRG4PC40UD2	9643	150	20	20	2039	0		2.50E+05	3665
TOTALS				80	8268	0		1.01E+06	904

NOTES

a. One FIT represents one failure in one billion (1.0E+09) hours.

b. FAILURE MODES:

HIGH TEMPERATURE GATE BIAS (HTGB)

Junction Temperature: Tj = as specified below
Vc = Ve = 0V
Vg = as specified

N Channel				LOW FREQUENCY (Standard)				
DEVICE TYPE		TEMP (deg C)	GATE BIAS		ACTUAL TEST TIME (hours)	FAILURES # (note b)	DEV-HRS	FAILURE RATE @ FITs
IRGBC20S	9544		20	20		0	2.46E+05	
IRGBC40S	9605		20	20		0	2.46E+05	
TOTALS				40		0	4.92E+05	

N Channel				MID FREQUENCY (Fast)				
TYPE	DATE	TEMP	BIAS (V)	QTY	ACTUAL TIME (hours)	MODE	EQUIVALENT DEV-HRS @ 90°C	FAILURE RATE @ 90°C & 60% UCL FITs (note a)
IRGBC30F		150	20		2008	0		3722
IRGBC30FD2		150	20		2095	0		3567
IRGBC30FD2		150	20		2007	0		3724
IRGBF30F		150	20		2008	0		3722
TOTALS					8118	0		921

NOTES

b. FAILURE MODES:

HIGH TEMPERATURE GATE BIAS (HTGB)

T0220 Package

Junction Temperature: Tj = as specified below
Applied Bias: Vc = Ve = 0V
Vg = as specified

N Channel					HIGH FREQUENCY (Ultra-Fast)				
DEVICE TYPE	DATE CODE	TEMP (deg C)	GATE BIAS (V)	QTY	ACTUAL TEST TIME (hours)	#	MODE	EQUIVALENT DEV-HRS @ 90°C	FAILURE RATE @ FITs
	9613	150	20	20	2008	0			3722
	9605	150	20	20	2008	0			3722
	9641	150	20	20	2007	0			3724
	9643	150	20	20	2054	0			3639
TOTALS				80	8077	0			925

NOTES

a. One FIT represents one failure in one billion (1.0E+09) hours.

b. FAILURE MODES:

TEMPERATURE & HUMIDITY (THB)

T0247 Package

Junction Temperature:	85°C
Relative Humidity:	85% rh
Applied Bias:	Vge = 0V
	Vce = as specified

N Channel	MID FREQUENCY (Fast)					
DEVICE TYPE	DATE CODE	COLLECTOR VOLTAGE (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	MODE (note b)
IRGPF30F	9642	100	20	2000	0	
TOTALS			20	2000	0	

N Channel	HIGH FREQUENCY (Ultra-Fast)					
DEVICE TYPE	DATE CODE	COLLECTOR VOLTAGE (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	MODE (note b)
IRGPC40U	9538	500	20	1504	3	1
IRGPC40U	9620	500	20	1504	4	1
IRG4PC40UD2	9643	100	20	2051	0	
IRGPH60UD2	9450	500	10	1008	0	
TOTALS			70	6067	7	

NOTES

b. FAILURE MODES:

1. 3 devices failed @ 1504hrs 85/85 and 4 devices failed @ 1552 HRS 85/85 all the failures were due to termination structure corrosion, caused by moisture ingression.

TEMPERATURE & HUMIDITY (THB)

T0220 Package

Junction Temperature: 85°C
Relative Humidity: 85% rh
Applied Bias: Vge = 0V
Vce = as specified

N Channel	LOW FREQUENCY (Standard)					
DEVICE TYPE	DATE CODE	COLLECTOR VOLTAGE (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	MODE (note b)
IRGBC20S	9544	500	20	1008	0	
IRGBC30S	9643	100	20	2051	0	
IRGBC40S	9606	500	20	1008	0	
TOTALS			60	4067	0	

N Channel	MID FREQUENCY (Fast)					
DEVICE TYPE	DATE CODE	COLLECTOR VOLTAGE (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	MODE (note b)
IRGBC30F	9537	600	20	1008	1	1
IRGBF30F	9613	900	20	1008	0	
IRGBC30FD2	9640	100	20	2051	0	
TOTALS			60	4067	1	

NOTES

b. FAILURE MODES:

1 1 device failed @ 1008hrs 85/85 it was due to termination structure corrosion, caused by moisture ingression.

TEMPERATURE & HUMIDITY (THB)

T0220 Package

Junction Temperature:	85°C
Relative Humidity:	85% rh
Applied Bias:	Vge = 0V
	Vce = as specified

N Channel	HIGH FREQUENCY (Ultra-Fast)					
DEVICE TYPE	DATE CODE	COLLECTOR VOLTAGE (V)	QTY	ACTUAL TEST TIME (hours)	FAILURES #	FAILURES MODE (note b)
IRG4BC30U	9641	100	20	2000	0	
IRGB440U	9643	100	20	2051	0	
IRGBC20K	9613	500	20	1008	3	1
TOTALS			60	5059	3	

NOTES

b. FAILURE MODES:

1 3 devices failed @ 1008hrs 85/85 all the failures were due to termination structure corrosion, caused by moisture ingression.

TEMPERATURE CYCLING (T/C) Unbiased

T0247 Package

Temperature Cycle: Tmin = - 55°C, Tmax = + 150°C
Cycle time: 25 minutes
Bias None

N Channel	MID / HIGH FREQUENCY				
DEVICE TYPE	DATE CODE	QTY	ACTUAL CYCLES	FAILURES	
				#	MODE (note b)
IRGPC30FD2	9344	39	1000	0	
IRGPC50FD2	9237	80	2174	0	
IRGPC40U	9538	20	2008	0	
IRGPC40U	9620	20	2055	0	
IRGPC40UD2	9237	40	1087	0	
IRG4PC40UD2	9643	20	1496	0	
IRG4PC50U	9721	20	2086	0	
IRGPC50UD2	9346	38	1000	0	
IRGPF30F	9642	20	2015	0	
IRGPH60UD2	9450	10	1044	0	
TOTALS		307	15965	0	

NOTES

b. FAILURE MODES:

TEMPERATURE CYCLING (T/C) Unbiased

T0220 Package

Temperatre Cycle:	Tmin = - 55°C, Tmax = + 150°C
Cycle Time	25 minutes
Bias	None

N Channel	LOW / MID / HIGH FREQUENCY				
DEVICE TYPE	DATE CODE	QTY	ACTUAL CYCLES	FAILURES	
				#	MODE (note b)
IRGBC20S	9544	20	2062	0	
IRGBC40S	9606	20	2008	0	
IRGBC30S	9643	20	2017	0	
IRGBC30F	9537	20	2008	0	
IRGBF30F	9613	20	2032	0	
IRGBC20K	9613	20	2032	0	
IRGBC30U	9605	20	2008	0	
IRG4BC30U	9614	20	2015	0	
IRGB440U	9643	20	2107	0	
IRGBC30FD2	9640	20	2077	0	
IRGBC30FD2	9643	20	2043	0	
TOTALS		220	22409	0	

NOTES

b. FAILURE MODES:

POWER CYCLING (P/C) unbiased

T0247 Package

Bias:	Set to give Δ T = 100°C
Temperature:	Tj = Δ 100°C
Duration:	10000 Cycles
Test Points:	2500, 5000, 10000 Nominal

N Channel	HIGH FREQUENCY (Ultra-Fast)				
DEVICE TYPE	DATE CODE	QTY	ACTUAL (hours)	FAILURES	
				#	MODE (note b)
IRGPC40U	9620	20	10000	0	
TOTALS		20	10000	0	

NOTES

b. FAILURE MODES:

ACCELERATED MOISTURE RESISTANCE (A/C) Unbiased

T0247 Package

Pressure:	15 lbs psig
Temperature:	121°C
Humidity:	100%
Bias:	None

N Channel	MID / HIGH FREQUENCY				
DEVICE TYPE	DATE CODE	QTY	ACTUAL (hours)	FAILURES	
				#	MODE (note b)
IRGPF30F	9642	20	96	0	
IRGPC40U	9538	20	96	0	
IRGPC40U	9620	20	96	0	
IRG4PC40UD2	9643	20	96	0	
IRG4PC50U	9721	20	96	0	
TOTALS		100	480	0	

NOTES

b. FAILURE MODES:

ACCELERATED MOISTURE RESISTANCE (A/C) Unbiased

T0220 Package

Pressure:	15 Ibs psig
Temperature:	121°C
Humidity:	100%
Bias:	None

N Channel	LOW / MID / HIGH FREQUENCY				
DEVICE TYPE	DATE CODE	QTY	ACTUAL (hours)	FAILURES	
				#	MODE (note b)
IRGBC20S	9544	20	96	0	
IRGBC30S	9643	20	96	0	
IRGBC40S	9606	20	96	0	
IRGBC30F	9537	20	96	0	
IRGBF30F	9613	20	96	0	
IRGBC20K	9613	20	96	0	
IRGBC30U	9606	20	96	0	
TOTALS		140	672	0	

NOTES

b. FAILURE MODES:

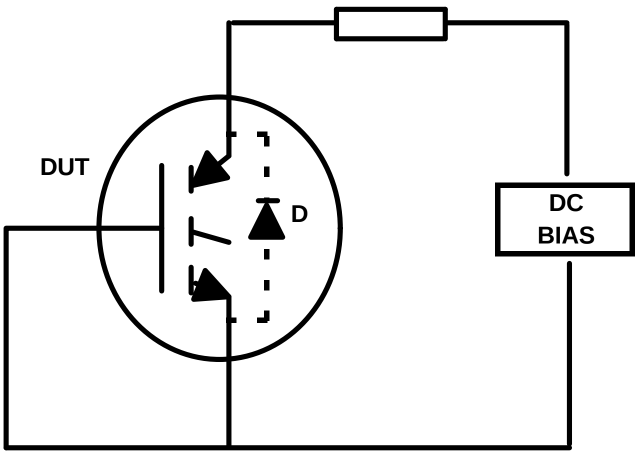
Section

4

Environmental Test Conditions / Schematics

HIGH TEMPERATURE REVERSE BIAS (HTRB)

Test circuit



D = Diode for CoPack devices only

Conditions

Bias:	Vce = As required
Temperature:	Tmax
Duration:	2000 Hours nominal
Test points:	168, 500, 1000, 1500, 2000, Hours nominal

Purpose

High temperature reverse bias (HTRB) burn-in is to stress the devices with the applied voltage in the blocking mode while elevating the junction temperature. This will accelerate any blocking voltage degradation process.

Failure Modes

The primary failure mode for HTRB stress is a gradual degradation of the breakdown characteristics or $\mathbf{V}_{(BR)CES}$. This degradation has been attributed to the presence of foreign materials and polar/ionic contaminants. These materials, migrating under application of electric field at high temperature, can perturb the electric field termination structure.

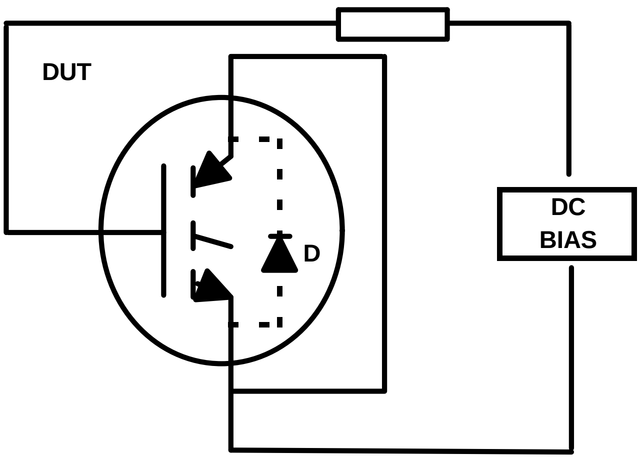
Extreme care must be exercised in the course of a long term test to avoid potential hazards such as electrostatic discharge or electrical overstress to the gate during test. Failures arising from this abuse can be virtually indistinguishable from true HTRB failures which results from the actual stress test.

Sensitive Parameters

$\mathbf{V}_{(BR)CES}$, $\mathbf{I}_{CES}$, $\mathbf{I}_{GES}$, $\mathbf{V}_{GE(th)}$

HIGH TEMPERATURE GATE BIAS (HTGB)

Test circuit



D = Diode for CoPack devices only

Conditions

Bias:	Vge = As required
Temperature:	Tmax
Duration:	2000 Hours nominal
Test points:	168, 500, 1000, 1500, 2000 Hours nominal.

Purpose

The purpose of High Temperature Gate Bias is to stress the devices with the applied bias to the gate while at elevated junction temperature to accelerate time dependent dielectric breakdown of the gate structure.

Failure Modes

The primary failure modes for long term gate stress is a rupture of the gate oxide, causing either a resistive short between gate-to-emitter or gate-to-collector or what appears to be a low breakdown diode between the gate and source.

The oxide breakdown has been attributed to the degradation in time of existing defects in the thermally grown oxide. These defects can take form of localized thickness variations, structural anomalies or the presence of sub-micron particulate, within the oxide.

As with HTRB, extreme care must be exercised in the course of a long term test to avoid potential hazards such as electrostatic discharge or electrical overstress to the gate during test. Failures arising from this abuse are virtually indistinguishable from true oxide breakdown which result from the actual stress test.

Sensitive Parameters

$I_{CES}, V_{GE(th)}$

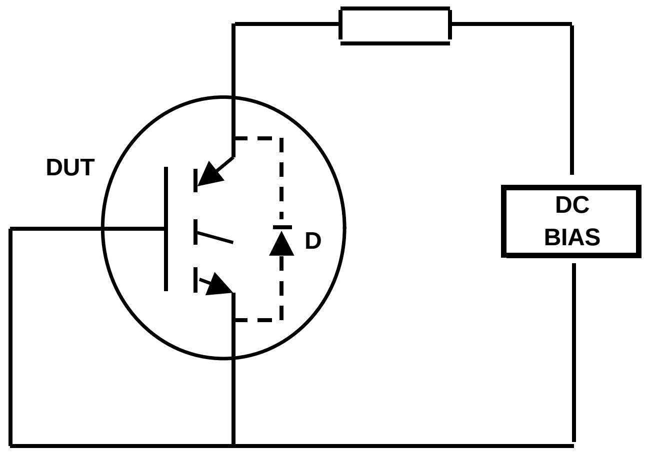
TEMPERATURE & HUMIDITY (THB)

Conditions

Bias: Vce = 100% of maximum rated $\mathbf{V}_{(BR)CES}$ up to 500V: 500V for all devices with rated $\mathbf{V}_{(BR)CES}$ greater than 500V *
Temperature: 85°C
Relative Humidity: 85%
Duration: 2000 Hours nominal
Test points: 168, 500, 1000, 1500, 2000 Hours nominal.

* Devices manufactured since week code 9640 the applied bias: $\mathbf{V}_{(BR)CES}$ = Vmax or 100v which ever the lesser

Test circuit



D = Diode for CoPack devices only

Purpose

Temperature and Humidity bias testing for non-hermetic packages is to subject the devices to extremes of temperature and humidity to examine the ability of the package to withstand the deleterious effect of the humid environment.

Failure Modes

There are two primary failure modes which have been observed. The first failure mode comes about as a result of the ingression of water molecules into the active area on the surface of the die. Once sufficient water has accumulated in the region of the electric field termination structure on the die, the perturbation of that field begins to degrade the breakdown characteristics of the device.

The second failure mode that has been observed is due to cathodic corrosion of the aluminum emitter bonding pad. As with first failure mode, water will ingress to the top of the die. There, in the presence of applied bias, an electric current through the few monolayers of water will begin to cause the bond pad to dissolve. Eventually. the corrosion will proceed to the point where the current capability of the device is increased and become unstable.

The dominance of either of these failure modes is basically determined by the amount of bias present during test. Under low bias conditions, the corrosion proceeds slowly, so the first failure mode will proceed very rapidly and the device will fail due to on-resistance before the breakdown characteristics can degrade.

Sensitive Parameters

$\mathbf{V}_{(BR)CES}$, $\mathbf{V}_{CE(on)}$

TEMPERATURE CYCLING (T/C) Unbiased

Conditions

Temperature:	Tmin = - 55°C
	Tmax = + 150°C
Bias:	Unbiased
Duration:	2000 Cycles
Test points:	250,500,1000,1500,2000 Nominal

Purpose

Temperature Cycling simulates the extremes of thermal stresses which devices will encounter in the actual circuit applications in combination with potentially extreme operating ambient temperatures. Some equipment is destined to be used in extreme environments, and subject to daily temperature cycles.

Failure Modes

The primary failure mode for temperature cycling is a thermal fatigue of the silicon / metal interfaces and metal / metal interfaces. The fatigue results from thermomechanical stresses due to heating and cooling and will cause electrical or thermal performance to degrade.

If the degradation occurs at the header / die interface, then the thermal impedance, $\mathbf{R}_{\theta JC}$ will begin to increase well before any electrical effect is seen.

If the degradation occurs at the wire bond / die interface or the wire bond / bond post interface, then on resistance, $\mathbf{V}_{CE(on)}$, will slowly increase or become unstable with time. The thermal impedance, when measured during this time, may appear to decrease or change erratically.

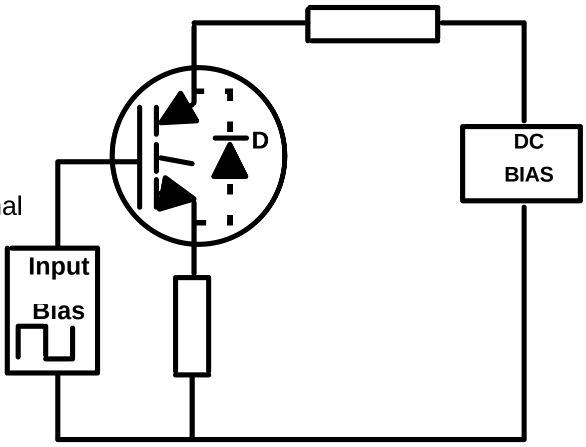
The mechanical stresses from the temperature can also propagate fractures in the silicon when the die is thermally mismatched to the solder / heat sink system. These fractures will manifest themselves in the form of shorted gates or degraded breakdown characteristics ($\mathbf{V}_{(BR)CES}$)

Sensitive Parameters

$\mathbf{I}_{CES}$, $\mathbf{V}_{(BR)CES}$, $\mathbf{R}_{\theta JC}$, $\mathbf{V}_{CE(on)}$

POWER CYCLING (P/C) Unbiased

Test circuit



D = Diode for CoPack devices only

Conditions

Bias	Set to give Δ T = 100°C
Temperature	Tj = Δ 100°C
Duration	10000 Cycles
Test points	2500, 5000, 7500, 10000 Nominal

Purpose

The purpose of Power Cycling is to simulate the thermal and current pulsing stresses which devices will encounter in actual circuit applications when either the equipment is turned on and off or power is applied to the device in short bursts interspersed with quiescent, low power periods. The simulation is achieved by the on/off application of power to each device while they are in the active linear region.

Failure Modes

The primary failure mode for power cycling is a thermal fatigue of the silicon/metal interfaces and metal/metal interfaces. The fatigue, due to the thermomechanical stresses from the heating and cooling, will cause electrical or thermal performance or degrade.

If the degradation occurs at the header/die interface, then the thermal impedance $\mathbf{R\theta}_{JC}$, will begin to increase well before any electrical effect is seen. If the degradation occurs at the wire bond/die interface or the wire bond/post interface, then on resistance, $\mathbf{V}_{CE(on)}$, will slowly increase or become unstable with time. The thermal impedance, when measured during this time may appear to decrease or change erratically.

The mechanical stresses from the application of power can also propagate fractures in the silicon when the die is thermally mismatched to the solder/heat sink system. These fractures will manifest themselves in the form of shorted gates or degraded breakdown characteristics ($\mathbf{V}_{(BR)CES}$).

Sensitive Parameters

$\mathbf{I}_{CES}$, $\mathbf{V}_{(BR)CES}$, $\mathbf{R\theta}_{JC}$, $\mathbf{V}_{CE(on)}$

ACCELERATEDMOISTURE RESISTANCE (A/C)Unbiased

Conditions

Temperature:	121°C
Pressure:	15Ibs psig
Bias:	None
Duration:	96 Hours nominal
Test points:	96 Hours

Purpose

Accelerated Moisture Resistance test is performed to evaluate the moisture resistance of non-hermetic packages. Severe conditions of pressure, humidity and temperature are applied that accelerate the penetration of moisture through the interface of the encapsulant and the conductors that pass through it.

Failure Modes

There are two failure modes which have been observed. The first mode, degradation of the breakdown characteristics of the devices, can occur.

The second failure mode that has been observed is due to cathodic corrosion of aluminum emitter bonding pad. Water will ingress to the top of the die. It is possible for contaminants to work their way into the active area of the device while under pressure in the presence of water. For that reason, the devices and test board are cleaned prior to use. Then, throughout the course of the testing, the parts and the test boards are never brought into contact with human contaminant.

Sensitive Parameters

$V_{(BR)CES}$, $V_{CE(on)}$

Section

5

Device Package and Frequency Listings

T0247 Generation III Package

Part Number	Channel	Voltage	Speed	Hex Size	Frequency Family
IRGPC30S	N	600	Standard	3	Low Frequency
IRGPC40S	N	600	Standard	4	Low Frequency
IRGPC50S	N	600	Standard	5	Low Frequency
IRGPH20S	N	1200	Standard	2	Low Frequency
IRGPH30S	N	1200	Standard	3	Low Frequency
IRGPH40S	N	1200	Standard	4	Low Frequency
IRGPH50S	N	1200	Standard	5	Low Frequency
IRGPC20F	N	600	Fast	2	Mid Frequency
IRGPC20M	N	600	Short Circuit Rated Fast	2	Mid Frequency
IRGPC20MD2	N	600	Short Circuit Rated Fast	2	Mid Frequency
IRGPC30F	N	600	Fast	3	Mid Frequency
IRGPC30M	N	600	Short Circuit Rated Fast	3	Mid Frequency
IRGPC30FD2	N	600	Fast	3	Mid Frequency
IRGPC30MD2	N	600	Short Circuit Rated Fast	3	Mid Frequency
IRGPC40F	N	600	Fast	4	Mid Frequency
IRGPC40M	N	600	Short Circuit Rated Fast	4	Mid Frequency
IRGPC40FD2	N	600	Fast	4	Mid Frequency
IRGPC40MD2	N	600	Short Circuit Rated Fast	4	Mid Frequency
IRGPC50F	N	600	Fast	5	Mid Frequency
IRGPC50M	N	600	Short Circuit Rated Fast	5	Mid Frequency
IRGPC50FD2	N	600	Fast	5	Mid Frequency
IRGPC50MD2	N	600	Short Circuit Rated Fast	5	Mid Frequency
IRGPF20F	N	900	Fast	2	Mid Frequency
IRGPF30F	N	900	Fast	3	Mid Frequency
IRGPF40F	N	900	Fast	4	Mid Frequency
IRGPF50F	N	900	Fast	5	Mid Frequency
IRGPH20M	N	1200	Short Circuit Rated Fast	2	Mid Frequency
IRGPH30MD2	N	1200	Short Circuit Rated Fast	3	Mid Frequency
IRGPH40F	N	1200	Fast	4	Mid Frequency
IRGPH40M	N	1200	Short Circuit Rated Fast	4	Mid Frequency
IRGPH40FD2	N	1200	Fast	4	Mid Frequency
IRGPH40MD2	N	1200	Short Circuit Rated Fast	4	Mid Frequency
IRGPH50F	N	1200	Fast	5	Mid Frequency
IRGPH50M	N	1200	Short Circuit Rated Fast	5	Mid Frequency
IRGPH50FD2	N	1200	Fast	5	Mid Frequency
IRGPH50MD2	N	1200	Short Circuit Rated Fast	5	Mid Frequency

IRGP420U	N	500	Ultra-Fast	2	High Frequency
IRGP430U	N	500	Ultra-Fast	3	High Frequency
IRGP440U	N	500	Ultra-Fast	4	High Frequency
IRGP440UD2	N	500	Ultra-Fast	4	High Frequency
IRGP450U	N	500	Ultra-Fast	5	High Frequency
IRGP450UD2	N	500	Ultra-Fast	5	High Frequency
IRGPC20K	N	600	Short Circuit Rated Ultra-Fast	2	High Frequency
IRGPC20U	N	600	Ultra-Fast	2	High Frequency
IRGPC20KD2	N	600	Short Circuit Rated Ultra-Fast	2	High Frequency
IRGPC30K	N	600	Short Circuit Rated Ultra-Fast	3	High Frequency
IRGPC30U	N	600	Ultra-Fast	3	High Frequency
IRGPC30KD2	N	600	Short Circuit Rated Ultra-Fast	3	High Frequency
IRGPC30UD2	N	600	Ultra-Fast	3	High Frequency
IRGPC40K	N	600	Short Circuit Rated Ultra-Fast	4	High Frequency
IRGPC40U	N	600	Ultra-Fast	4	High Frequency
IRGPC40KD2	N	600	Short Circuit Rated Ultra-Fast	4	High Frequency
IRGPC40UD2	N	600	Ultra-Fast	4	High Frequency
IRGPC50K	N	600	Short Circuit Rated Ultra-Fast	5	High Frequency
IRGPC50U	N	600	Ultra-Fast	5	High Frequency
IRGPC50KD2	N	600	Short Circuit Rated Ultra-Fast	5	High Frequency
IRGPC50UD2	N	600	Ultra-Fast	5	High Frequency
IRGPH50K	N	1200	Short Circuit Rated Ultra-Fast	5	High Frequency
IRGPH50KD2	N	1200	Short Circuit Rated Ultra-Fast	5	High Frequency

T0247 Generation IV Package

Part Number	Channel	Voltage	Speed	Hex Size	Frequency Family
IRG4P254S	N	250	Standard	5	Low Frequency
IRG4PC30S	N	600	Standard	3	Low Frequency
IRG4PC40S	N	600	Standard	4	Low Frequency
IRG4PC50S	N	600	Standard	5	Low Frequency
IRG4PC30F	N	600	Fast	3	Mid Frequency
IRG4PC30FD	N	600	Fast	3	Mid Frequency
IRG4PC40F	N	600	Fast	4	Mid Frequency
IRG4PC40FD	N	600	Fast	4	Mid Frequency
IRG4PC50F	N	600	Fast	5	Mid Frequency
IRG4PC50FD	N	600	Fast	5	Mid Frequency
IRG4PC30U	N	600	Ultra-Fast	3	High Frequency
IRG4PC30UD	N	600	Ultra-Fast	3	High Frequency
IRG4PC30K	N	600	Short Circuit Rated Ultra-Fast	3	High Frequency
IRG4PC40U	N	600	Ultra-Fast	4	High Frequency
IRG4PC40UD	N	600	Ultra-Fast	4	High Frequency
IRG4PC40K	N	600	Short Circuit Rated Ultra-Fast	4	High Frequency
IRG4PC40KD	N	600	Short Circuit Rated Ultra-Fast	4	High Frequency
IRG4PC50U	N	600	Ultra-Fast	5	High Frequency
IRG4PC50UD	N	600	Ultra-Fast	5	High Frequency
IRG4PH50U	N	1200	Ultra-Fast	5	High Frequency
IRG4PH50UD	N	1200	Ultra-Fast	5	High Frequency

T0220 Generation III Package

Part Number	Channel	Voltage	Speed	Hex Size	Frequency Family
IRGBC20S	N	600	Standard	2	Low Frequency
IRGBC30S	N	600	Standard	3	Low Frequency
IRGBC40S	N	600	Standard	4	Low Frequency
IRGBC20F	N	600	Fast	2	Mid Frequency
IRGBC20M	N	600	Short Circuit Rated Fast	2	Mid Frequency
IRGBC20FD2	N	600	Fast	2	Mid Frequency
IRGBC20MD2	N	600	Short Circuit Rated Fast	2	Mid Frequency
IRGBC30F	N	600	Fast	3	Mid Frequency
IRGBC30M	N	600	Short Circuit Rated Fast	3	Mid Frequency
IRGBC30FD2	N	600	Fast	3	Mid Frequency
IRGBC30MD2	N	600	Short Circuit Rated Fast	3	Mid Frequency
IRGBC40F	N	600	Fast	4	Mid Frequency
IRGBC40M	N	600	Short Circuit Rated Fast	4	Mid Frequency
IRGBF20F	N	900	Fast	2	Mid Frequency
IRGBF30F	N	900	Fast	3	Mid Frequency
IRGB420U	N	500	Ultra-Fast	2	High Frequency
IRGB420UD2	N	500	Ultra-Fast	2	High Frequency
IRGB430U	N	500	Ultra-Fast	3	High Frequency
IRGB430UD2	N	500	Ultra-Fast	3	High Frequency
IRGB440U	N	500	Ultra-Fast	4	High Frequency
IRGBC20K	N	600	Short Circuit Rated Ultra-Fast	2	High Frequency
IRGBC20U	N	600	Ultra-Fast	2	High Frequency
IRGBC20KD2	N	600	Short Circuit Rated Ultra-Fast	2	High Frequency
IRGBC20UD2	N	600	Ultra-Fast	2	High Frequency
IRGBC30K	N	600	Short Circuit Rated Ultra-Fast	3	High Frequency
IRGBC30U	N	600	Ultra-Fast	3	High Frequency
IRGBC30KD2	N	600	Short Circuit Rated Ultra-Fast	3	High Frequency
IRGBC30UD2	N	600	Ultra-Fast	3	High Frequency
IRGBC40K	N	600	Short Circuit Rated Ultra-Fast	4	High Frequency
IRGBC40U	N	600	Ultra-Fast	4	High Frequency

T0220 Generation IV Package

Part Number	Channel	Voltage	Speed	Hex Size	Frequency Family
IRG4BC20S	N	600	Standard	2	Low Frequency
IRG4BC30S	N	600	Standard	3	Low Frequency
IRG4BC40S	N	600	Standard	4	Low Frequency
IRG4BC20F	N	600	Fast	2	Mid Frequency
IRG4BC20FD	N	600	Fast	2	Mid Frequency
IRG4BC30F	N	600	Fast	3	Mid Frequency
IRG4BC30FD	N	600	Fast	3	Mid Frequency
IRG4BC40F	N	600	Fast	4	Mid Frequency
IRG4BC20U	N	600	Ultra-Fast	2	High Frequency
IRG4BC20UD	N	600	Ultra-Fast	2	High Frequency
IRG4BC30U	N	600	Ultra-Fast	3	High Frequency
IRG4BC30UD	N	600	Ultra-Fast	3	High Frequency
IRG4BC30K	N	600	Short Circuit Rated Ultra-Fast	3	High Frequency
IRG4BC40U	N	600	Ultra-Fast	4	High Frequency
IRG4BC40K	N	600	Short Circuit Rated Ultra-Fast	4	High Frequency