PAK40F65F

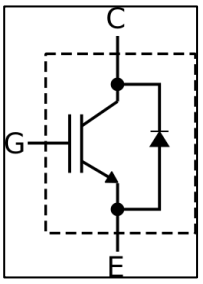
40A / 650V Trench-Gate IGTO
IGBT Drop-in Upgrade

Features

- Pakal's Proprietary Trench IGTO Technology
- Integrated SuperBallast™ Technology
  - Safe, Simple Paralleling
- Very Low $V_{CE,SAT}$
- Excellent E_{TS}
- Square Turn-Off SOA at >3x Rated Current

40A / 650V IGTO

40 A V_{CEsat} = 1.40V @T_J=100°C



Applications

- Uninterruptible Power Supplies (UPS)
- Welding Equipment
- Inverters
- Power Factor Correction (PFC)

Product Highlights

Current (A)	Voltage (V)	Temp (C)	VCEsat (V)	Ets (mJ)	Package
20	650	100°	1.11	.872	TO-247

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Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability; operation at conditions that exceed 80% of the absolute maximum rating conditions is not recommended. T_A = 25°C, unless otherwise specified.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Collector-Emitter Voltage	V_{CE}				650	V
DC Collector Current (Note 1)	$I_{C,DC}$	T_J = 25°C T_J = 100°C			120 52	A
Pulsed Collector Current (Note 1)	$I_{C,P}$				120	A
Diode Forward Current (Note 1)	$I_{D,DC}$	T_J = 25°C T_J = 100°C			90 30	A
Diode Pulsed Current (Note 1)	$I_{D,P}$				TBD	A
Turn-off Safe Operating Area		$V_{CE} \leq$ 650V, $T_J \leq$ 150°C, t_p = 1µs			90	A
Gate-Emitter Voltage	V_{GE}	DC Transient ($t_p \leq$ 10µs, D<0.010)	-20 -30		20 30	V
Power Dissipation	P_{MAX}	T_J = 25°C T_J = 100°C			205 100	W
Operating Junction Temperature	T_J		-40		175	°C
Storage Temperature	T_{STG}		-55		150	°C

Note 1: Limited by $T_{J,MAX}$.

Thermal Resistance

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
IGTO, Junction-Case	$R_{TH(JC)}$				0.65	K/W
Diode, Junction-Case	$R_{TH(JC)}$				0.80	K/W

Electrical Specifications

Static Characteristics

T_A = 25°C, unless otherwise specified. Items in **Bold** are production tested, other specifications are guaranteed by characterization.

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Collector-Emitter Breakdown Voltage	$V_{CE,BR}$	V_{GE}=0, I_C=250 µA		650			V
Collector-Emitter Saturation Voltage	$V_{CE,SAT}$	V_{GE}=15 V	I_C=20 A		1.11		V
			I_C=40 A		1.43	**1.80**	V
			T_j=150°C, I_C=40 A		1.38		V
Diode Forward Voltage	V_F	V_{GE}=0 V	I_F=2 A		1.17		V
			I_F=20 A		1.92		V
			T_j=150°C, I_F=20 A		1.43		V
Gate-Emitter Voltage Threshold	V_{TH}	I_C=40 mA, V_{CE}=20 V		3.3	4.4	5.4	V
Collector Leakage Current	I_{CES}	V_{CE}=650 V	T_j=25°C		0.1	60	µA
		V_{GE}=0 V	T_j=150°C		1000		µA
Gate-Emitter Leakage Current	I_{GES}	V_{CE}=0 V, V_{GE}=20 V			0.1	150	nA

Dynamic Characteristics

T_A = 25°C, unless otherwise specified. Items in **Bold** are production tested, other specifications are guaranteed by characterization.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Capacitance	C_{IES}	V_{GE}=0 V, V_{CE}=25 V, f=1 MHz		5662		pF
Output Capacitance	C_{OES}	V_{GE}=0 V, V_{CE}=25 V, f=1 MHz		62		pF
Reverse Transfer Capacitance	C_{RES}	V_{GE}=0 V, V_{CE}=25 V, f=1 MHz		8		pF
Gate Charge	Q_G	V_{CC}=400 V, I_C=40 A, V_{GE}=15 V		292		nC

Switching Characteristics

T_A = 25°C, unless otherwise specified. Items in **Bold** are production tested, other specifications are guaranteed by characterization.

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Turn-on Delay Time	$t_{d,on}$	T_J=25°C	I_C=40 A, V_{CC}=400 V, V_{GE}=15 V/0 V, R_G=20 Ω, (Note 1)		63		ns
Rise Time	t_r				24		ns
Turn-off Delay Time	$t_{d,off}$				555		ns
Fall time	t_f				89		ns
Turn-on Energy	E_{ON}				380		µJ
Turn-off Energy	E_{OFF}				1122		µJ
Total Switching Energy	E_{TS}				1502		µJ
Turn-on Delay Time	$t_{d,on}$	T_J=25°C	I_C=20 A, V_{CC}=400 V, V_{GE}=15 V/0 V, R_G=20 Ω (Note 1)		72		ns
Rise Time	t_r				18		ns
Turn-off Delay Time	$t_{d,off}$				641		ns
Fall time	t_f				39		ns
Turn-on Energy	E_{ON}				215		µJ
Turn-off Energy	E_{OFF}				535		µJ
Total Switching Energy	E_{TS}				750		µJ

Note 1: Energy losses include “tail” and diode reverse recovery.

Diode Characteristics, at T_J = 25 °C

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Diode reverse recovery time	T_{rr}	T_J=25°C	V_R=400 V, I_F=20 A, di_F/dt=1000 A/µs		47		ns
Diode reverse recovery charge	Q_{rr}				0.40		µC
Diode peak reverse recovery current	I_{rrm}				13.6		A
Diode peak rate of fall of reverse recovery current	di_{rr}/dt				-790		A/µs
Diode reverse recovery time	t_{rr}	T_J=25°C	V_R=400 V, I_F=5 A, di_F/dt=1000 A/µs		46		ns
Diode reverse recovery charge	Q_{rr}				0.34		µC
Diode peak reverse recovery current	I_{rrm}				10.0		A
Diode peak rate of fall of reverse recovery current	di_{rr}/dt				-880		A/µs

Switching Characteristics

T_A = 25°C, unless otherwise specified. Items in **Bold** are production tested, other specifications are guaranteed by characterization.

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Turn-on Delay Time	$t_{d,on}$	T_J=150°C	I_C=40 A, V_{CC}=400 V, V_{GE}=15 V/0 V, R_G=20 Ω (Note 1)		64		ns
Rise Time	t_r				26		ns
Turn-off Delay Time	$t_{d,off}$				541		ns
Fall time	t_f				101		ns
Turn-on Energy	E_{ON}				708		µJ
Turn-off Energy	E_{OFF}				1520		µJ
Total Switching Energy	E_{TS}				2228		µJ
Turn-on Delay Time	$t_{d,on}$	T_J=150°C	I_C=20 A, V_{CC}=400 V, V_{GE}=15 V/0 V, R_G=20 Ω (Note 1)		72		ns
Rise Time	t_r				24		ns
Turn-off Delay Time	$t_{d,off}$				684		ns
Fall time	t_f				60		ns
Turn-on Energy	E_{ON}				398		µJ
Turn-off Energy	E_{OFF}				771		µJ
Total Switching Energy	E_{TS}				1169		µJ

Note 1: Energy losses include “tail” and diode reverse recovery.

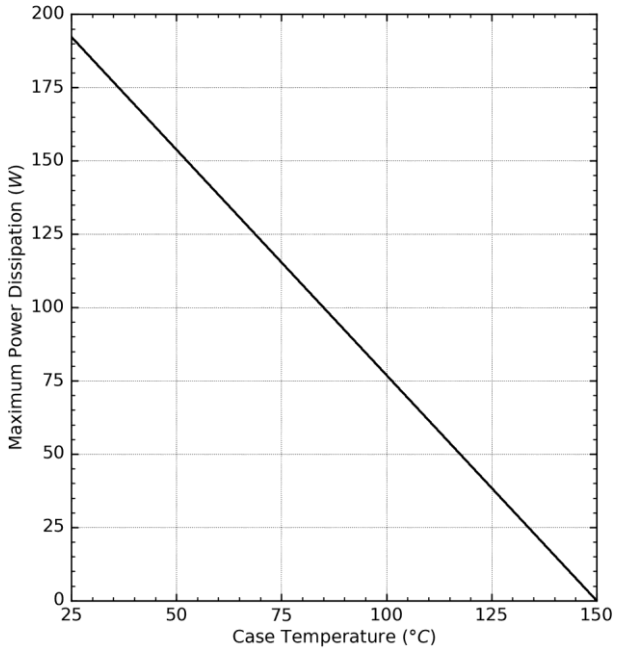
Diode Characteristics, at T_J = 150 °C

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Diode reverse recovery time	t_{rr}	T_J=150°C	V_R=400 V, I_F=20 A, di_F/dt=1000 A/µs		87		ns
Diode reverse recovery charge	Q_{rr}				1.32		µC
Diode peak reverse recovery current	I_{rrm}				26.4		A
Diode peak rate of fall of reverse recovery current	di_{rr}/dt				-530		A/µs
Diode reverse recovery time	t_{rr}	T_J=150°C	V_R=400 V, I_F=5 A, di_F/dt=1000 A/µs		48		ns
Diode reverse recovery charge	Q_{rr}				0.58		µC
Diode peak reverse recovery current	I_{rrm}				16.0		A
Diode peak rate of fall of reverse recovery current	di_{rr}/dt				-860		A/µs

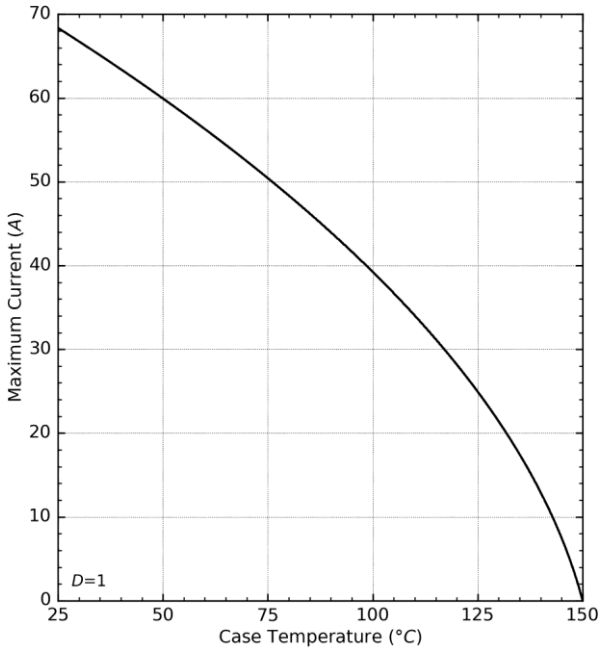
Typical Operating Characteristics

T_A = 25°C, unless otherwise specified.

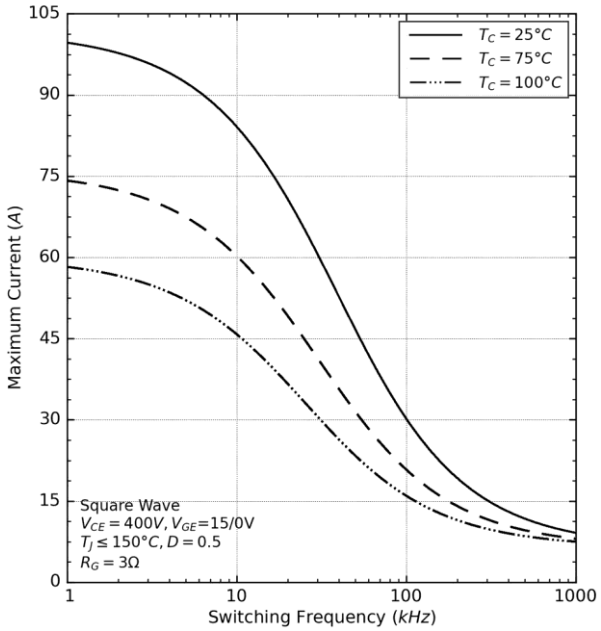
Maximum Power Dissipation



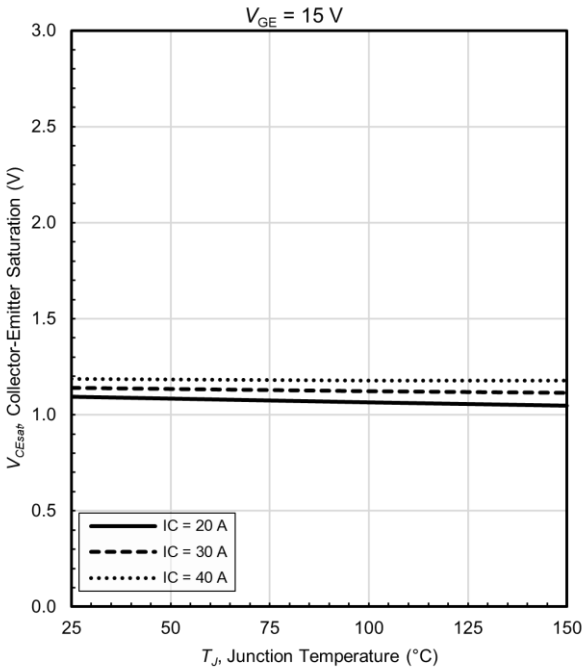
Thermally-Limited Maximum Current



Thermally-Limited Current vs Frequency



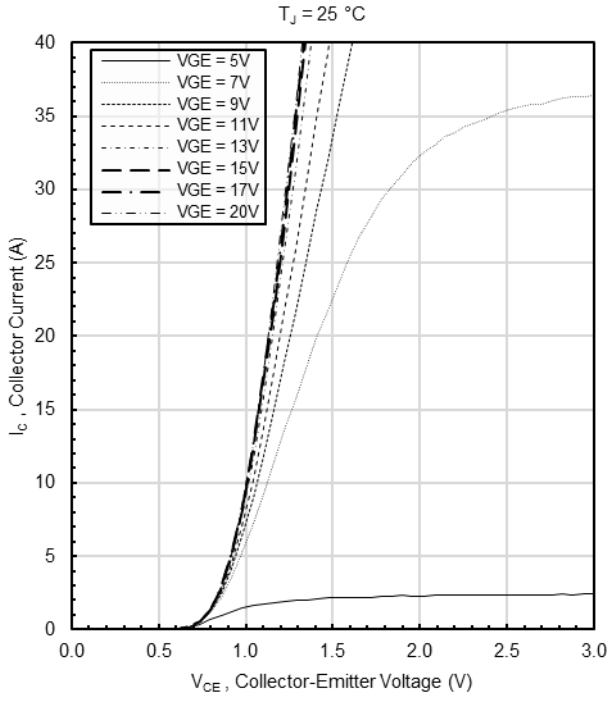
V_{CEsat} vs Junction Temperature



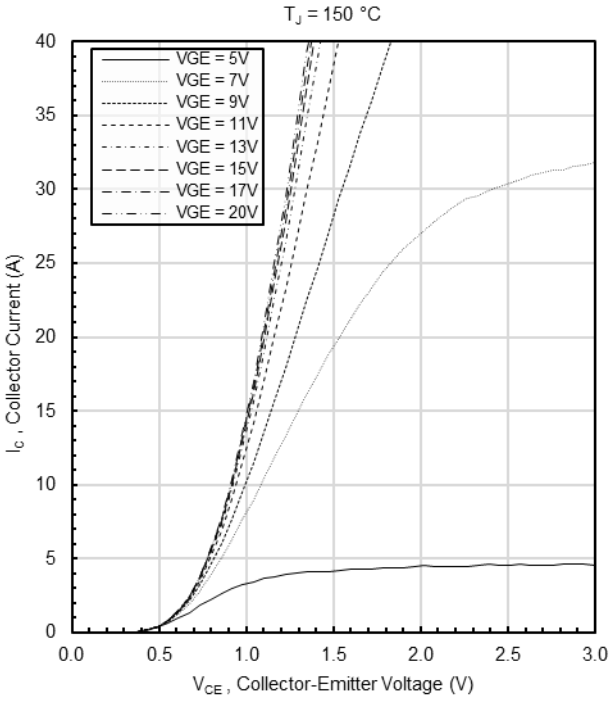
Typical Operating Characteristics

T_A = 25°C, unless otherwise specified.

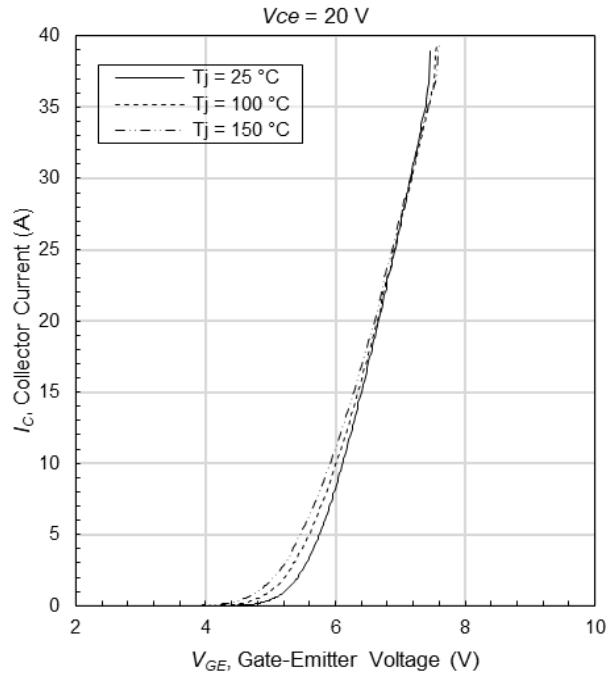
Typical Output Characteristic



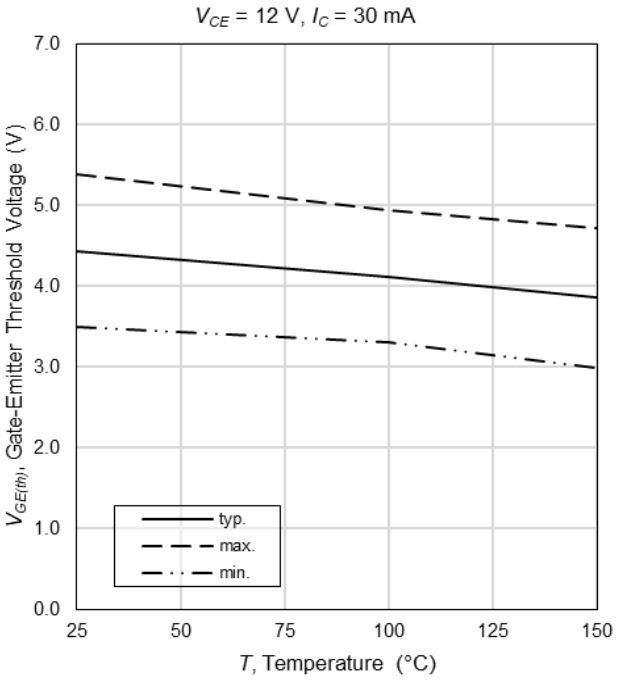
Typical Output Characteristic



Typical Transfer Characteristics



Threshold Voltage vs. Junction Temperature



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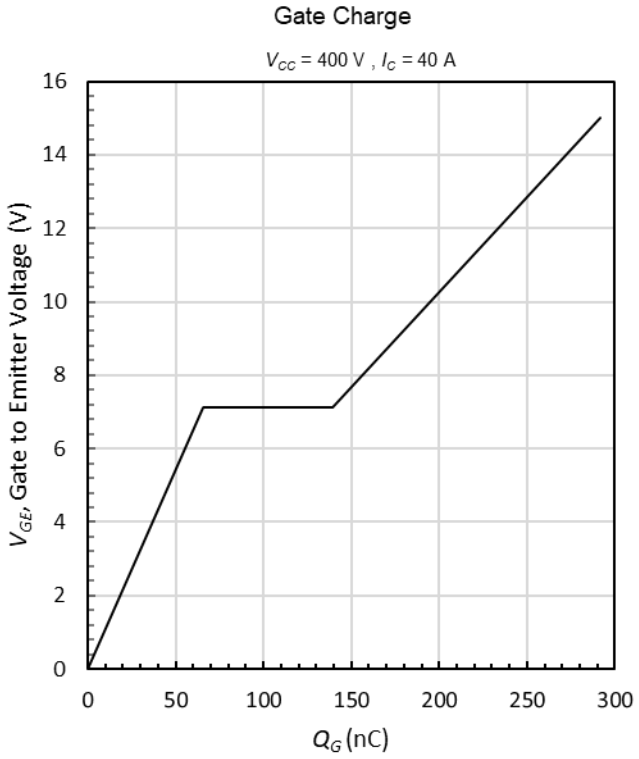

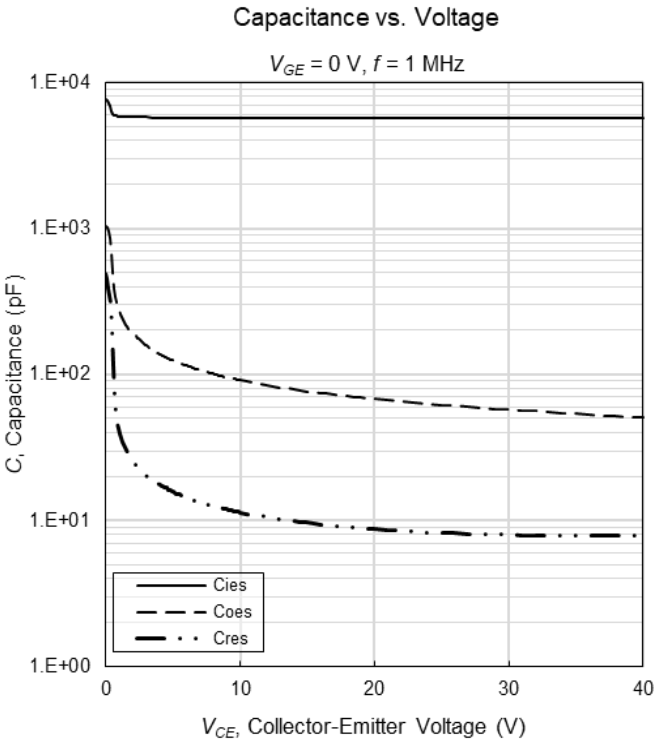

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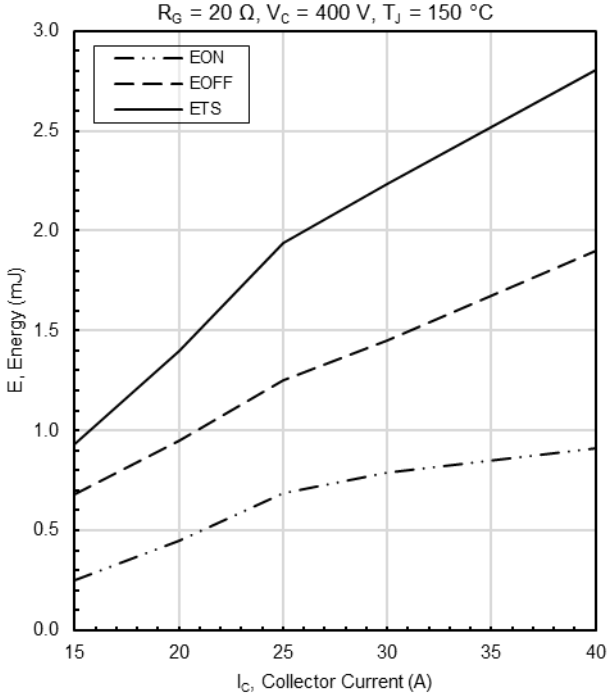
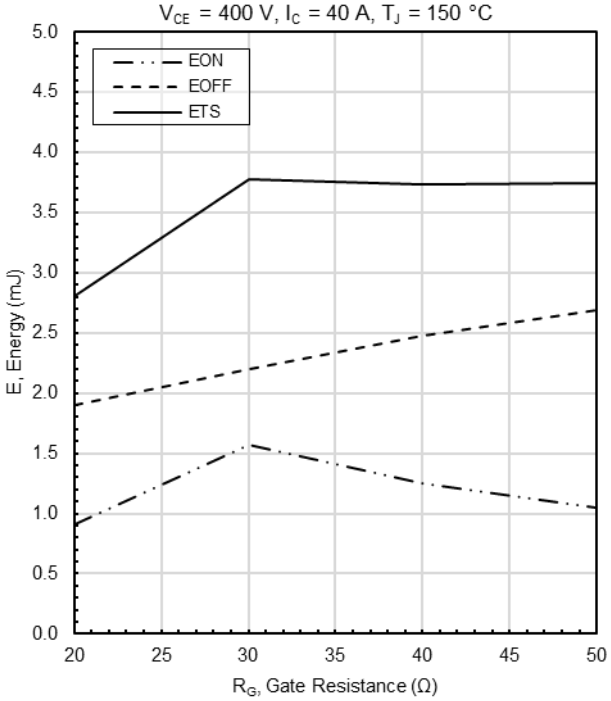
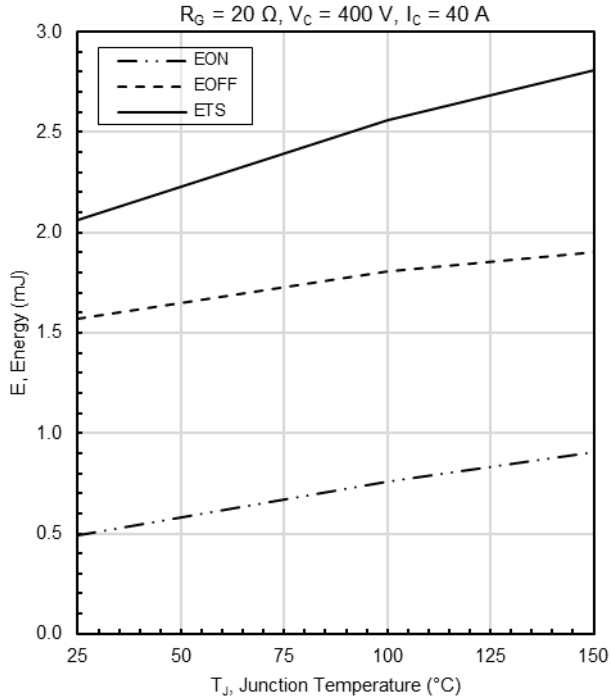
Switching Energy vs Collector Current



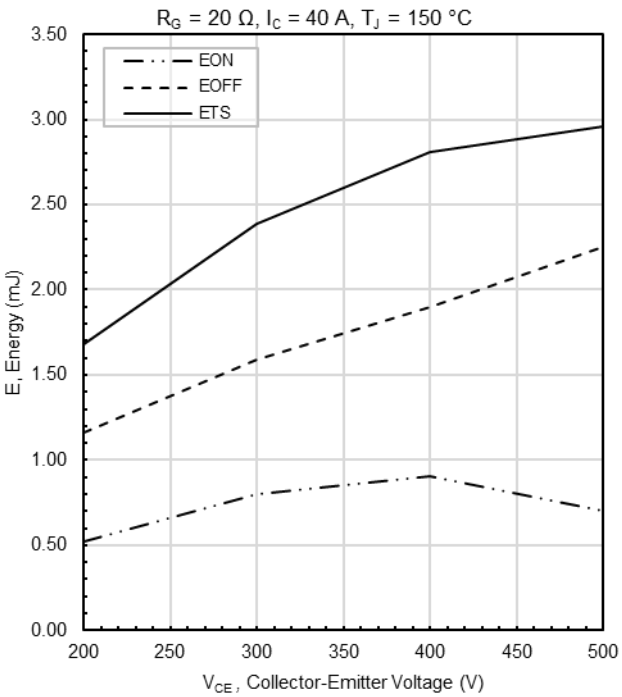
Switching Energy vs Gate Resistance



Switching Energy vs Junction Temperature

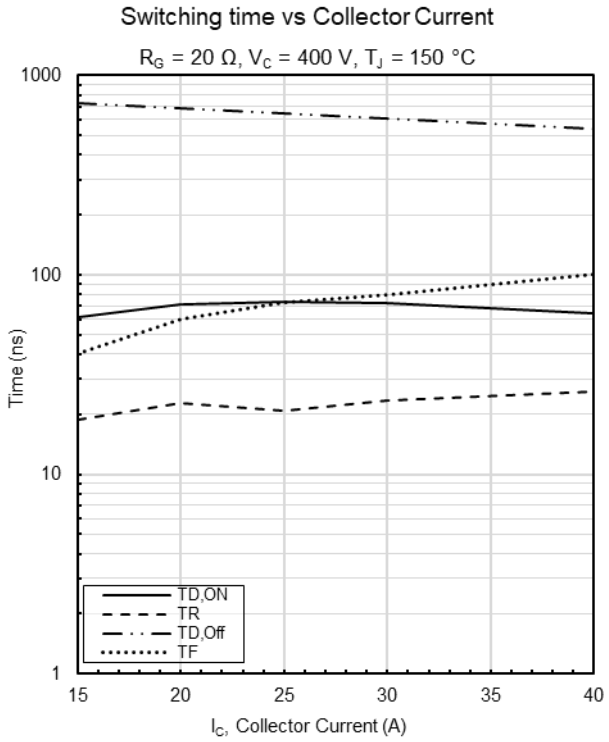


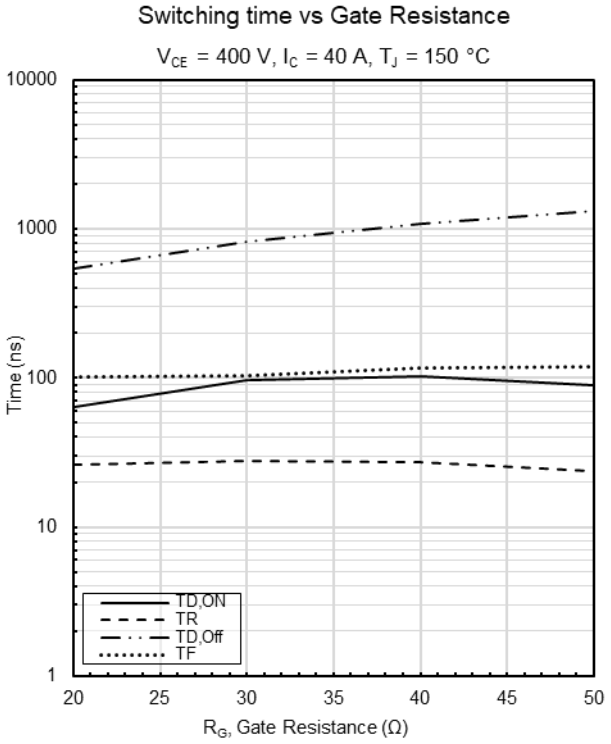
Switching Energy vs Collector-Emitter Voltage

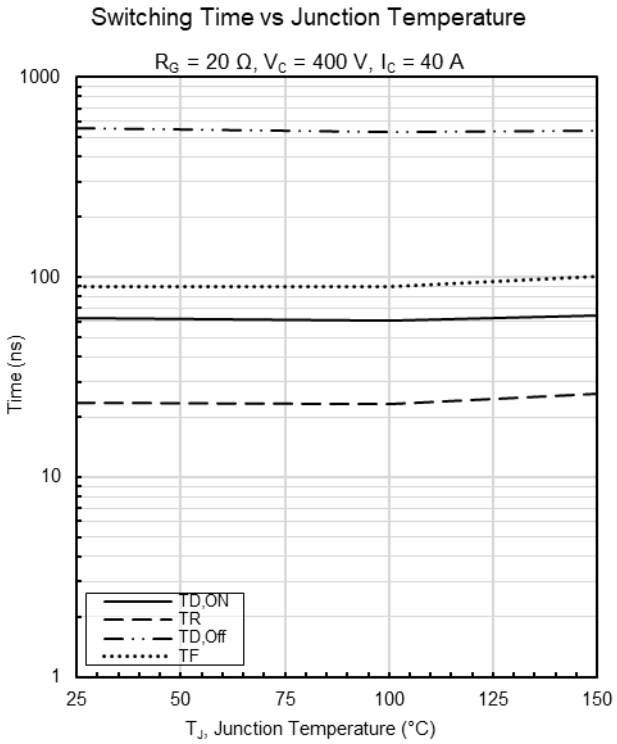


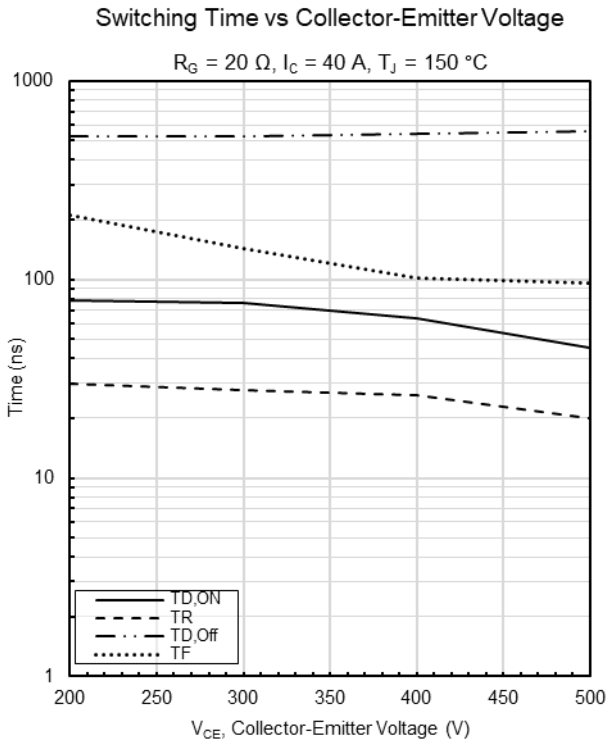
Typical Operating Characteristics

T_A = 25°C, unless otherwise specified.









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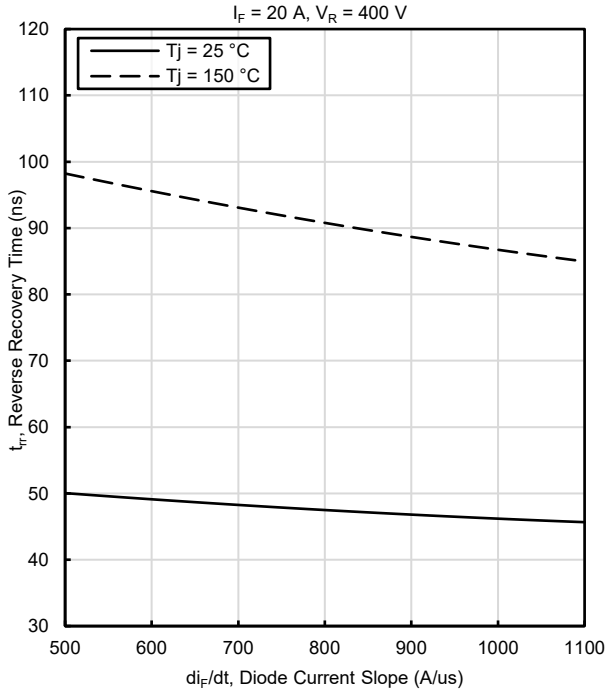
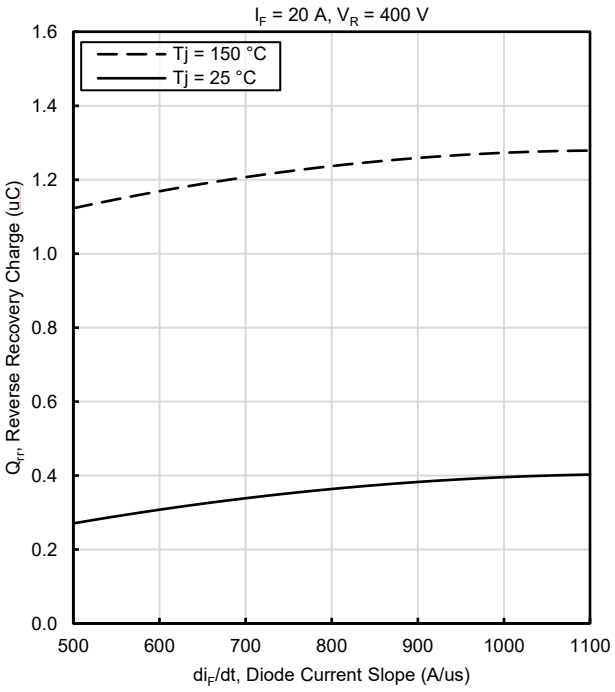
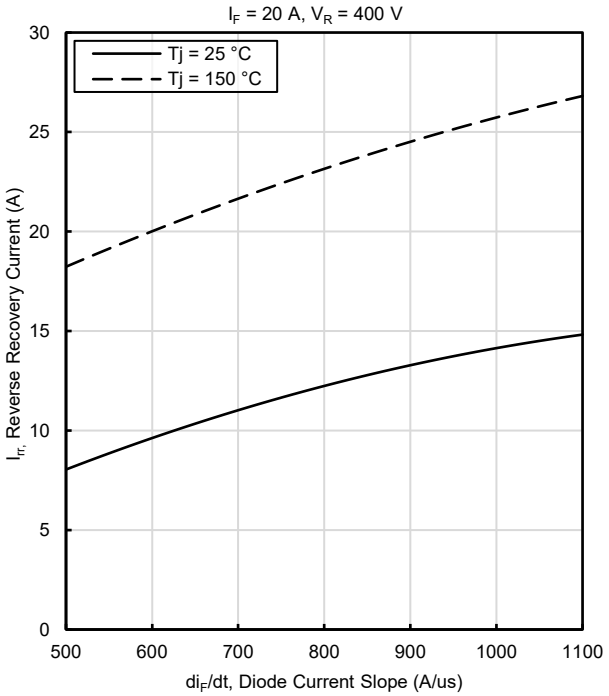
Reverse Recovery Time
as a Function of Diode Current Slope



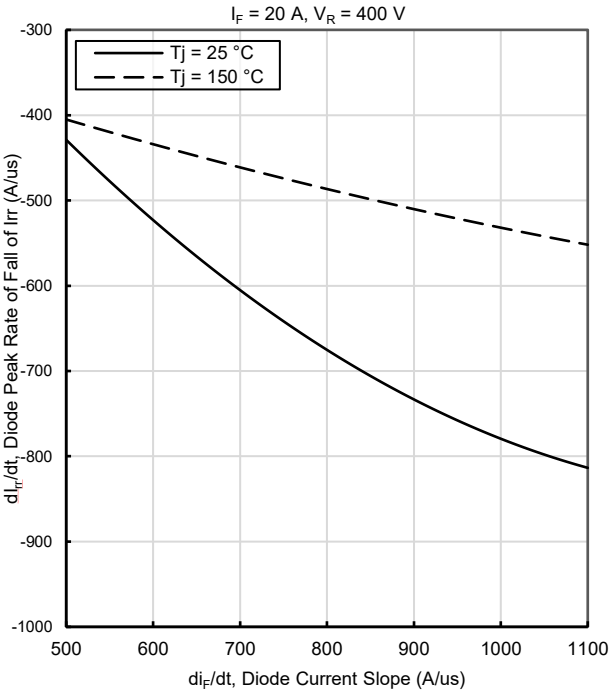
Reverse Recovery Charge
as a Function of Diode Current Slope



Reverse Recovery Current
as a Function of Diode Current Slope



Peak Rate of Fall of Reverse Recovery
as a Function of Diode Current Slope



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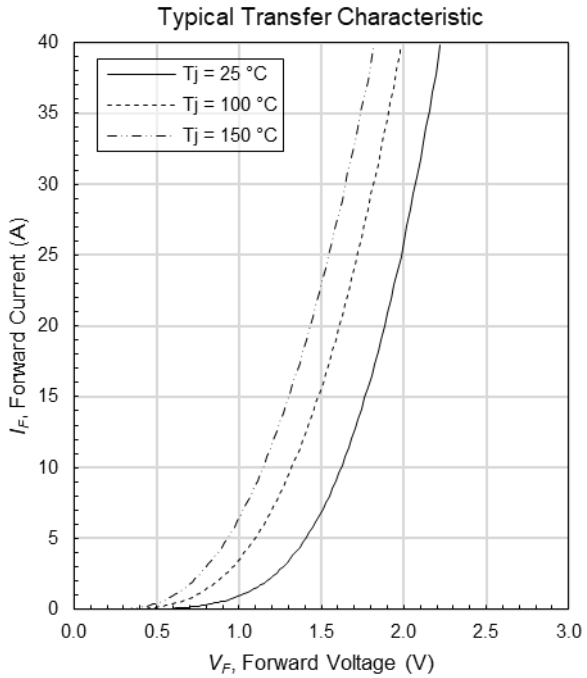
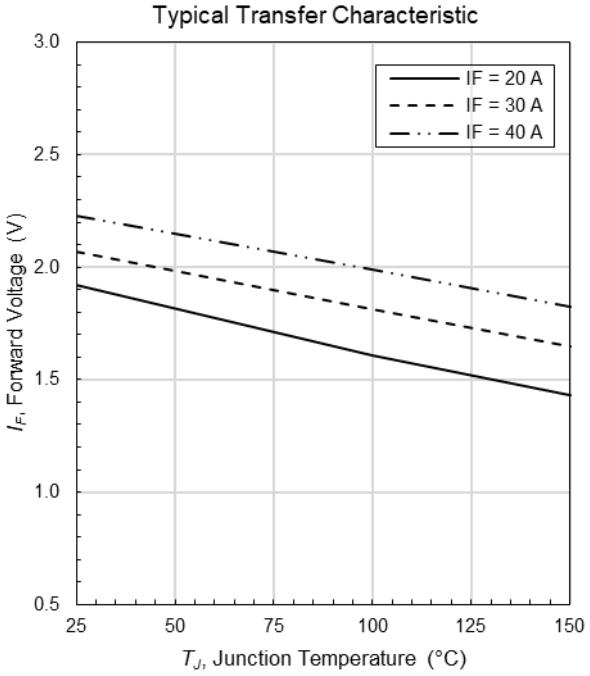
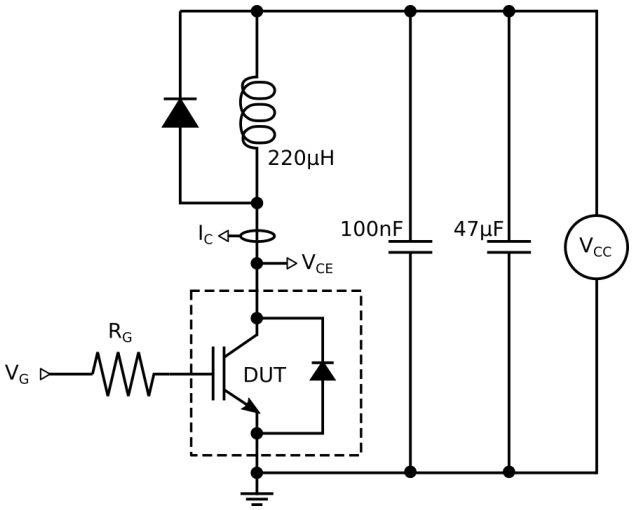
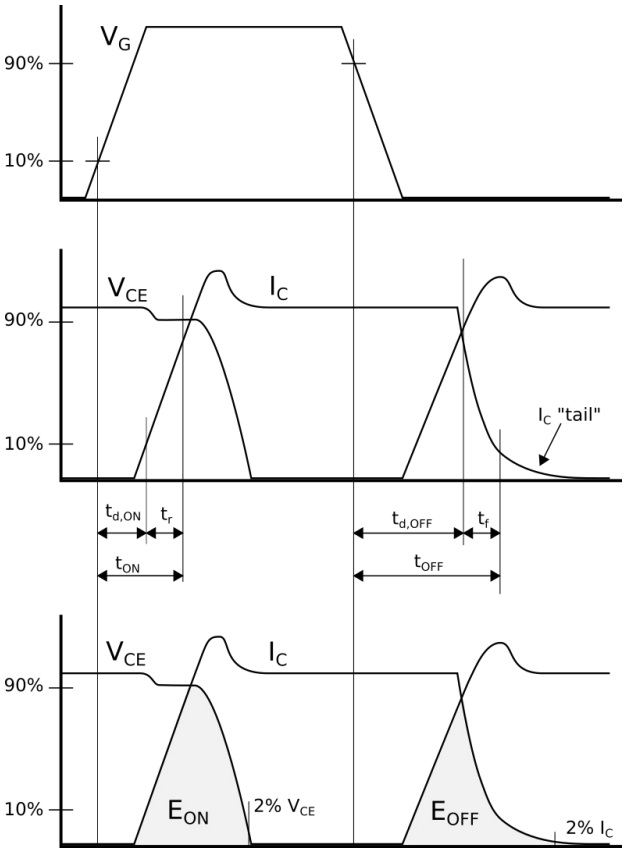




Diagrams

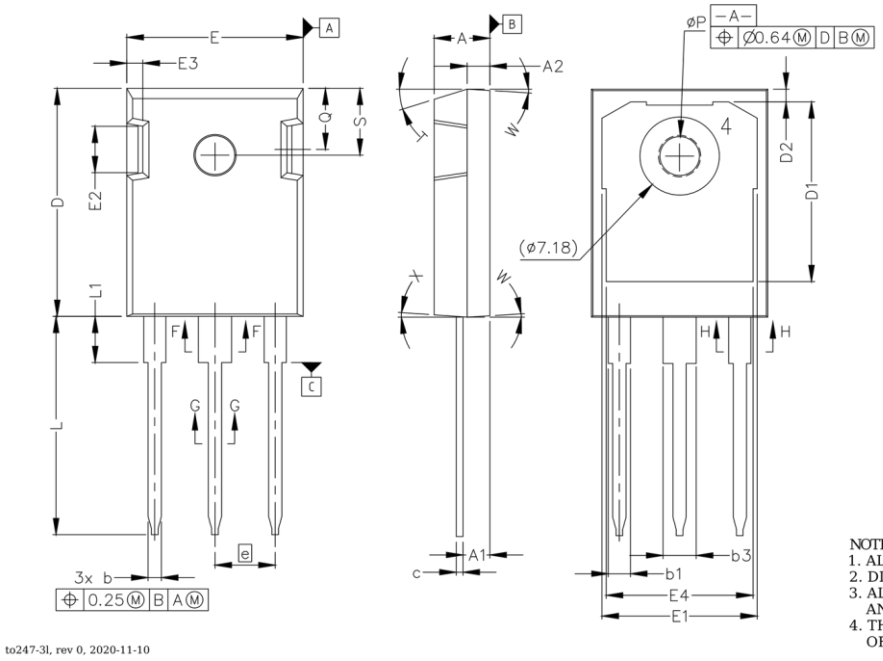


Switching Test Circuit



Switching Waveforms

Package Drawing



to247-3l, rev 0, 2020-11-10

SYMBOL	MIN	MAX
A	4.83	5.21
A1	2.29	2.54
A2	1.91	2.16
b'	1.07	1.28
b	1.07	1.33
b1	1.91	2.41
b2	1.91	2.16
b3	2.87	3.38
b4	2.87	3.13
c'	0.55	0.65
c	0.55	0.68
D	20.80	21.10
D1	16.25	17.65
D2	0.95	1.25
E	15.75	16.13
E1	13.10	14.15
E2	3.68	5.10
E3	1.00	1.90
E4	12.38	13.43
e	5.44 BSC	
N	3	
L	19.81	20.32
L1	4.10	4.40
P	3.51	3.65
Q	5.49	6.00
S	6.04	6.30
T	17.5°REF.	
W	3.5°REF.	
X	4°REF.	

NOTE;
1. ALL METAL SURFACES: TIN PLATED,EXCEPT AREA OF CUT
2. DIMENSIONS & TOLERANCES CONFORM TO ASME Y14.5M-1994
3. ALL DIMENSIONS ARE IN MILLIMETERS.
   ANGLES ARE IN DEGREES.
4. THIS DRAWING MEETS ALL DIMENSION REQUIREMENTS
   OF JEDEC OUTLINES TO-247 AD.

Pin Configuration

PIN NUMBER	DESCRIPTION
1	Gate
2	Collector
3	Emitter

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Pakal Technologies, Inc.

50 Osgood, Suite 340
San Francisco, CA
94133