

## 600V, 40A, Trench FS II Fast IGBT

### General Description

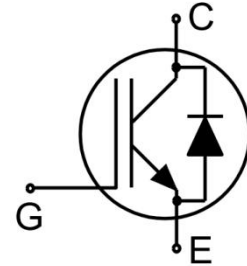
Using NCE's proprietary trench design and advanced FS (Field Stop) second generation technology, the 600V Trench FS II IGBT offers superior conduction and switching performances, and easy parallel operation;

### Features

- Trench FSII Technology offering
- Very low  $V_{CE(sat)}$
- High speed switching
- Positive temperature coefficient in  $V_{CE(sat)}$
- Very tight parameter distribution
- High ruggedness, temperature stable behavior

### Application

- Air Condition
- Inverters
- Motor drives



Schematic diagram

### Package Marking and Ordering Information

Device	Device Package	Device Marking
NCE40TD60BT	TO-247	NCE40TD60BT



TO-247

### Absolute Maximum Ratings ( $T_C=25^\circ\text{C}$ unless otherwise noted)

Symbol	Parameter	Value	Units
$V_{CES}$	Collector-Emitter Voltage	600	V
$V_{GES}$	Gate- Emitter Voltage	$\pm 30$	V
$I_C$	Collector Current	80	A
	Collector Current @ $T_C = 100^\circ\text{C}$	40	A
$I_{Cpuls}$	Pulsed Collector Current, $t_p$ limited by $T_{jmax}$	160	A
-	Turn off safe operating area, $V_{CE}=600\text{V}$ , $T_j=175^\circ\text{C}$	160	A
$I_F$	Diode Continuous Forward Current @ $T_C = 100^\circ\text{C}$	40	A
$I_{FM}$	Diode Maximum Forward Current	160	A
$P_D$	Power Dissipation @ $T_C = 25^\circ\text{C}$	288	W
	Power Dissipation @ $T_C = 100^\circ\text{C}$	144	W
$T_J, T_{stg}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
$T_L$	Maximum Temperature for Soldering	260	$^\circ\text{C}$
$t_{sc}$	Short circuit withstand time $V_{GE}=15\text{V}$ , $V_{CC}\leq 400\text{V}$ , Allowed number of short circuits<1000Time between short circuits: $\geq 1.0\text{s}$ , $T_j\leq 150^\circ\text{C}$	5	us

**Thermal Characteristic**

Symbol	Parameter	Value	Units
$R_{\theta JC}$	Thermal Resistance, Junction to case for IGBT	0.52	$^{\circ}\text{C}/\text{W}$
$R_{\theta JC}$	Thermal Resistance, Junction to case for Diode	0.99	$^{\circ}\text{C}/\text{W}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	40	$^{\circ}\text{C}/\text{W}$

**Electrical Characteristics ( $T_C=25^{\circ}\text{C}$  unless otherwise noted)**

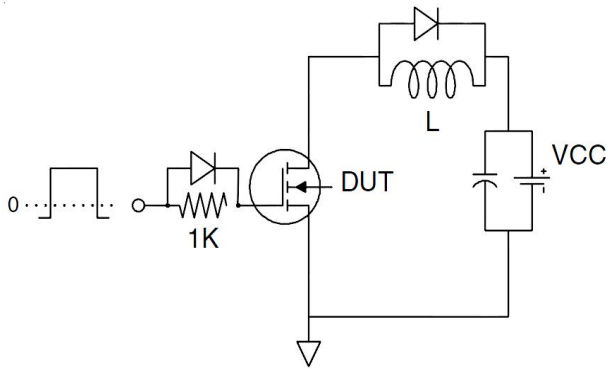
Symbol	Parameter	Conditions	Value			Units	
			Min.	Typ.	Max.		
<b>Static Characteristics</b>							
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	$V_{GE}=0\text{V}, I_{CE}=1\text{mA}$	600	--	--	V	
$I_{CES}$	Collector-Emitter Leakage Current	$V_{GE}=0\text{V}, V_{CE}=600\text{V}$	--	--	40	$\mu\text{A}$	
$I_{GES(F)}$	Gate to Emitter Forward Leakage	$V_{GE}=+30\text{V}, V_{CE}=0\text{V}$	--	--	200	nA	
$I_{GES(R)}$	Gate to Emitter Reverse Leakage	$V_{GE}=-30\text{V}, V_{CE}=0\text{V}$	--	--	200	nA	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C=40\text{A}$	--	1.7	1.9	V	
		$V_{GE}=15\text{V}$	--	1.9	--	V	
$V_{GE(th)}$	Gate Threshold Voltage	$I_C=1\text{mA}, V_{CE}=V_{GE}$	4.0	5.0	6.0	V	
<b>Dynamic Characteristics</b>							
$C_{ies}$	Input Capacitance	$V_{CE}=25\text{V}, V_{GE}=0\text{V},$ $f=1\text{MHz}$	--	4894	--	pF	
$C_{oes}$	Output Capacitance		--	136	--		
$C_{res}$	Reverse Transfer Capacitance		--	94	--		
$Q_g$	Total Gate Charge	$V_{CC}=480\text{V}, I_C=40\text{A},$ $V_{GE}=15\text{V}$	--	176	--	nC	
$Q_{ge}$	Gate to Emitter Charge		--	38	--		
$Q_{gc}$	Gate to Collector Charge		--	73	--		
$I_{C(SC)}$	Short circuit collector current Max.1000 short circuits Time between short circuits: $\geq 1.0\text{s}$	$V_{GE}=15\text{V}, V_{CC}\leq 400\text{V},$ $t_{SC}\leq 5\mu\text{s}, T_J\leq 150^{\circ}\text{C}$	--	235	--	A	
<b>Switching Characteristics</b>							
$t_{d(ON)}$	Turn-on Delay Time	$V_{CC}=400\text{V}, I_C=40\text{A},$ $V_{GE}=0/15\text{V}, R_g=5\Omega,$ Inductive Load	--	19	--	ns	
$t_r$	Rise Time		--	17	--		
$t_{d(OFF)}$	Turn-Off Delay Time		--	168	--		
$t_f$	Fall Time		--	16	--	mJ	
$E_{on}$	Turn-On Switching Loss		--	0.58	--		
$E_{off}$	Turn-Off Switching Loss		--	0.48	--		
$E_{ts}$	Total Switching Loss		--	1.06	--	mJ	
$E_{on}$	Turn-On Switching Loss		$V_{CC}=400\text{V}, I_C=40\text{A},$	--	0.70		--
$E_{off}$	Turn-Off Switching Loss		$V_{GE}=0/15\text{V}, R_g=5\Omega,$	--	0.65		--
$E_{ts}$	Total Switching Loss	$T_J=175^{\circ}\text{C}$	--	1.35	--		

**Electrical Characteristics of the Diode ( $T_c=25^{\circ}\text{C}$  unless otherwise specified)**

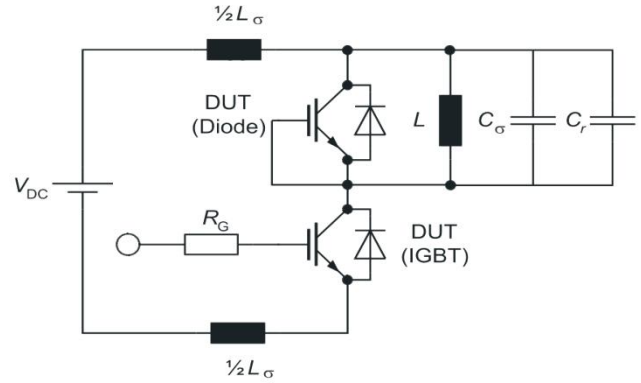
Symbol	Parameter	Conditions	Rating			Units	
			Min.	Typ.	Max.		
$V_{FM}$	Diode Forward Voltage	$I_F=40\text{A}$	$T_j=25^{\circ}\text{C}$	--	1.75	2.40	V
			$T_j=175^{\circ}\text{C}$	--	1.40	--	V
$T_{rr}$	Reverse Recovery Time	$V_R=400\text{V}, I_F=40\text{A},$ $di/dt=200\text{A}/\mu\text{s}$	--	242	--	ns	
$I_{RRM}$	Diode Peak Reverse Recovery Current		--	3.9	--	A	
$Q_{rr}$	Reverse Recovery Charge		--	0.44	--	$\mu\text{C}$	
$T_{rr}$	Reverse Recovery Time	$V_R=400\text{V}, I_F=40\text{A},$ $di/dt=200\text{A}/\mu\text{s},$ $T_j=175^{\circ}\text{C}$	--	452	--	ns	
$I_{RRM}$	Diode Peak Reverse Recovery Current		--	5.5	--	A	
$Q_{rr}$	Reverse Recovery Charge		--	1.21	--	$\mu\text{C}$	

## Test Circuit

### 1) Gate Charge Test Circuit

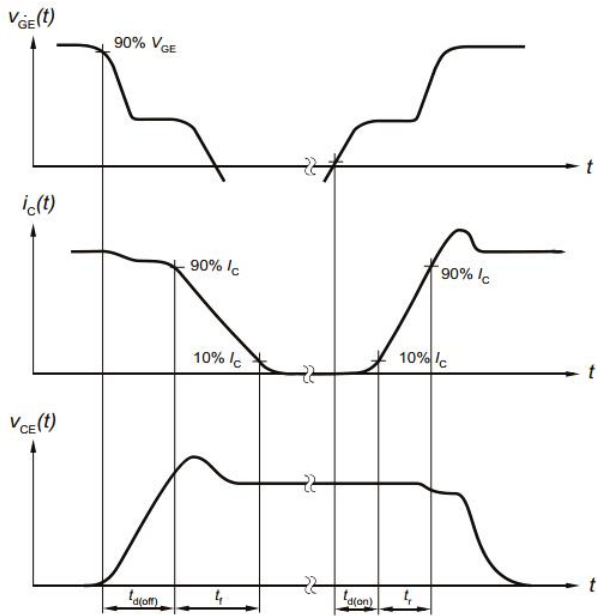


### 2) Switch Time Test Circuit

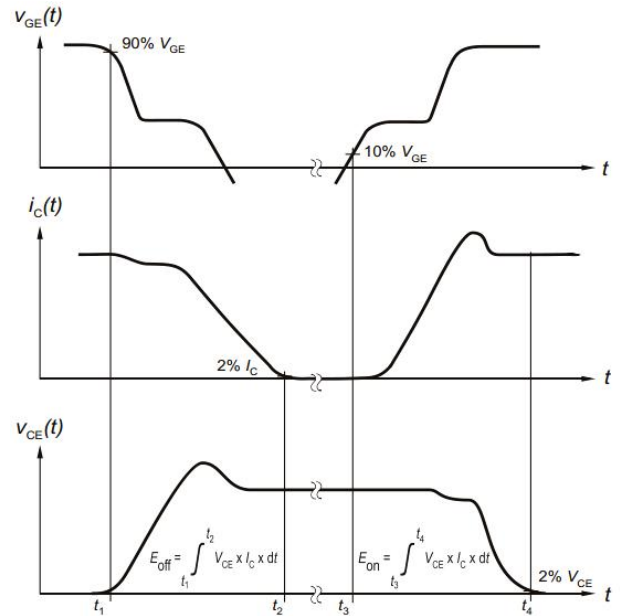


## Switching characteristics

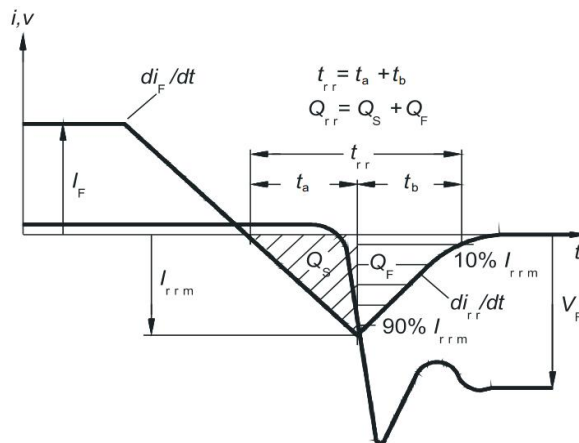
### 1) Definition of switching times



### 2) Definition of switching losses

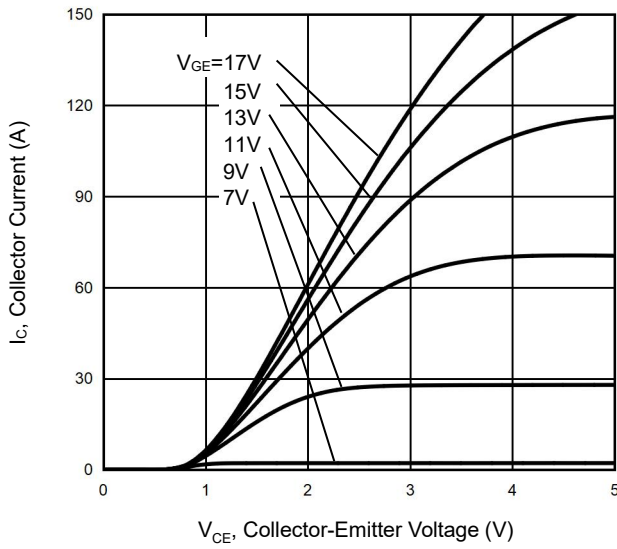


### 3) Definition of diode switching characteristics

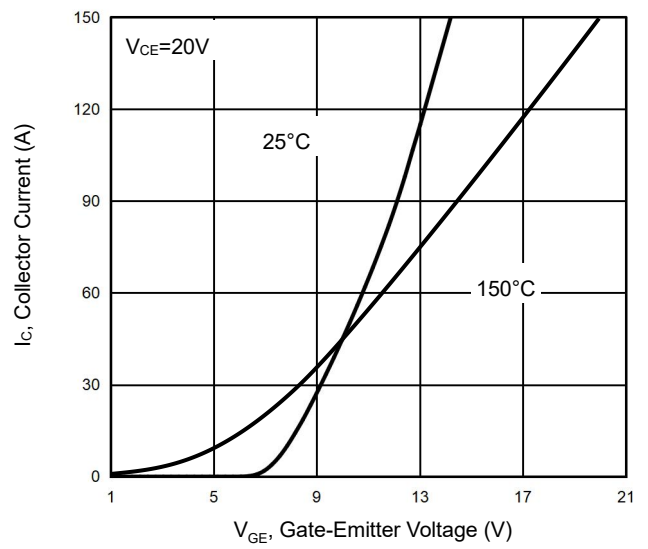


## Typical Electrical and Thermal Characteristics

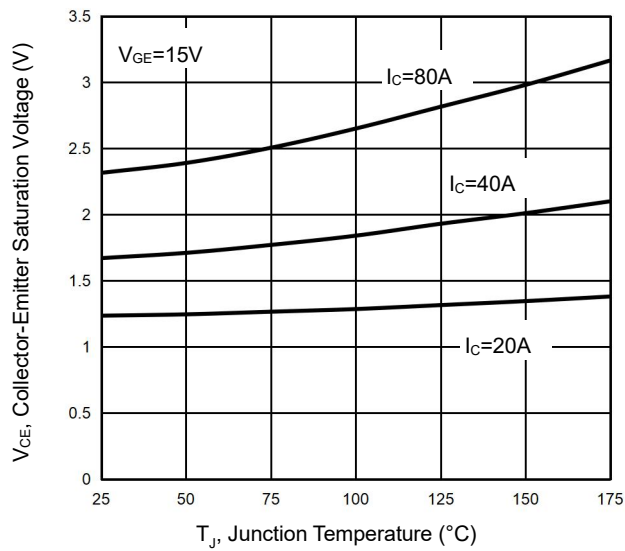
**Figure 1 Output Characteristics**



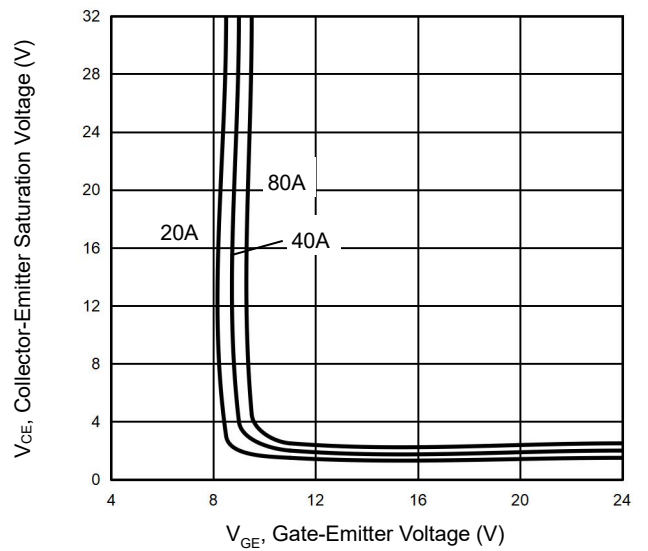
**Figure 2 Transfer Characteristics**



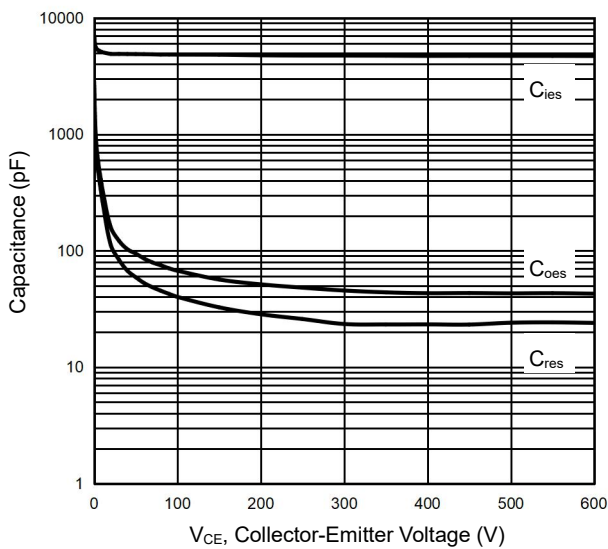
**Figure 3  $V_{CE(sat)}$  vs. Temperature**



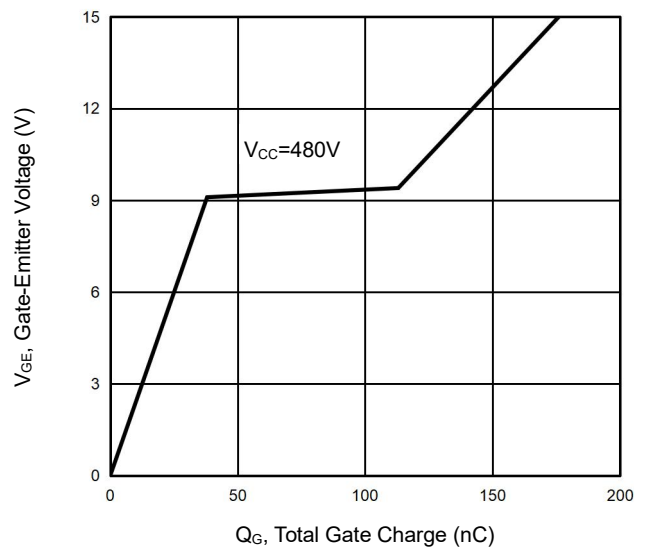
**Figure 4 Saturation Voltage vs.  $V_{GE}$**



**Figure 5 Capacitance Characteristics**



**Figure 6 Gate Charge Wave Form**



Typical Electrical and Thermal Characteristics

Figure 7 Forward Characteristics

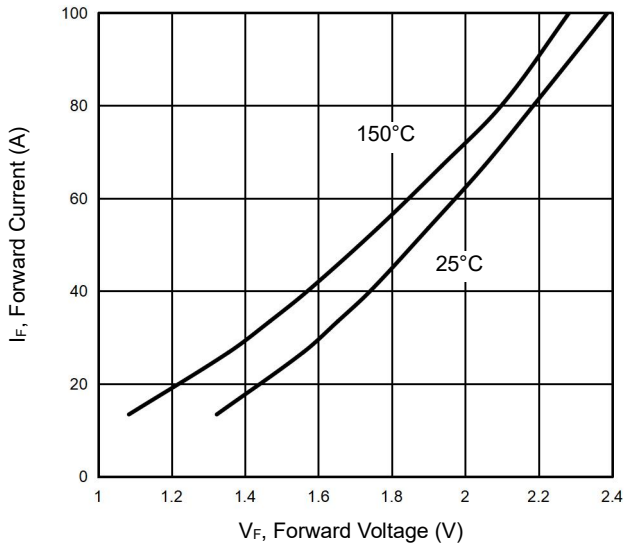


Figure 8  $V_F$  vs. Temperature

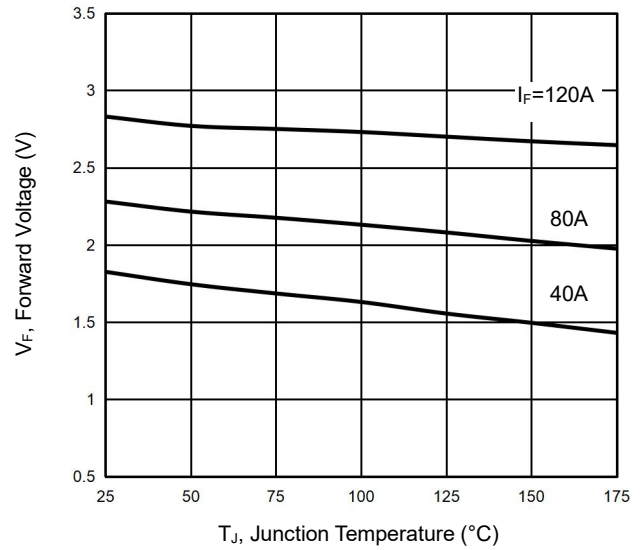


Figure 9 Switching Loss vs.  $R_G$

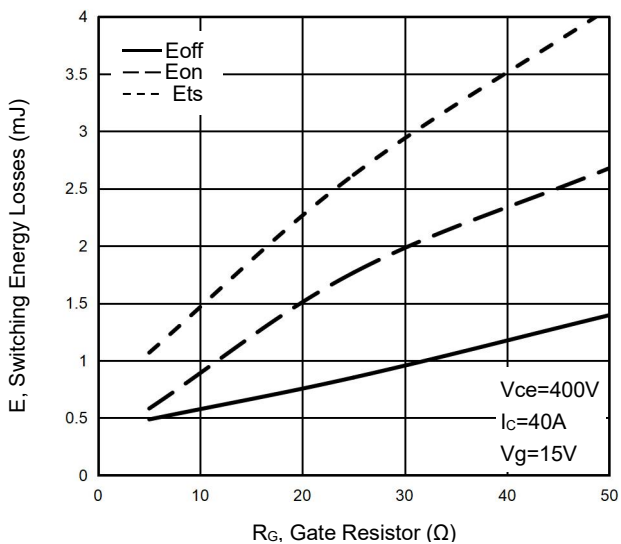


Figure 10 Switching Energy vs. Temperature

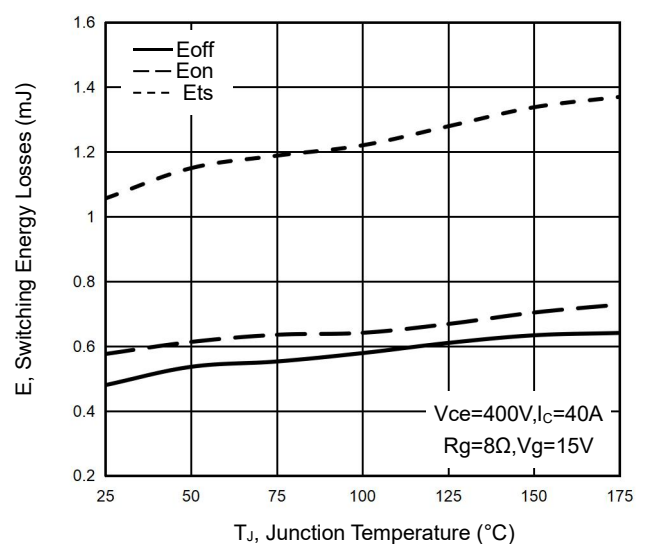


Figure 11 Switching Loss vs. Collector Current

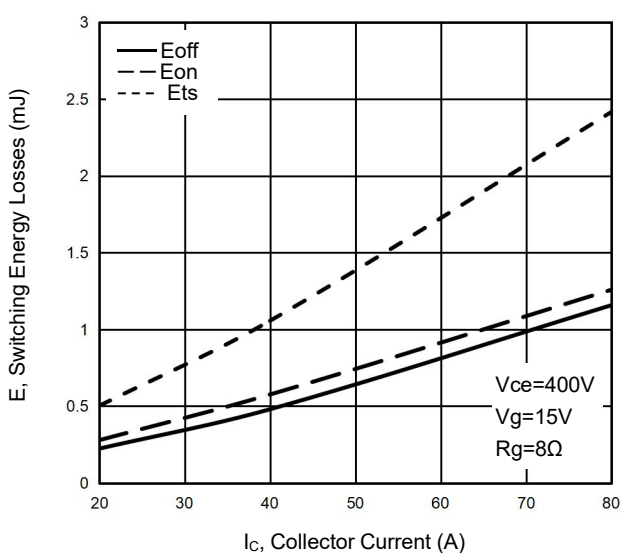
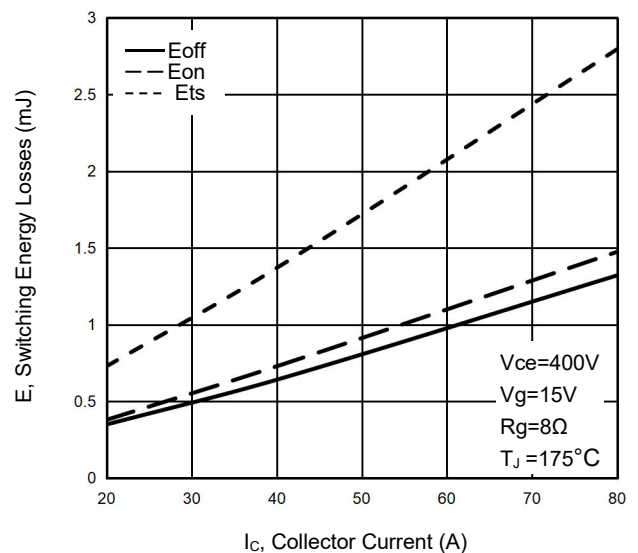


Figure 12 Switching Loss vs. Collector Current



Typical Electrical and Thermal Characteristics

Figure 13  $V_{GE(th)}$  vs. Junction Temperature

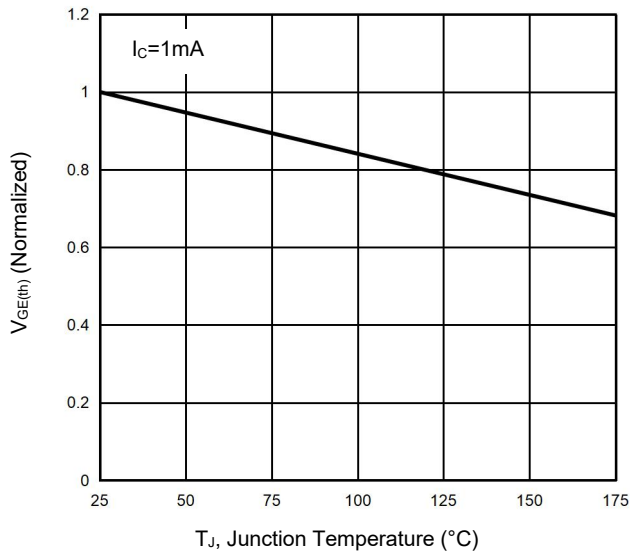


Figure 14  $V_{CE(SAT)}$  vs. Collector Current

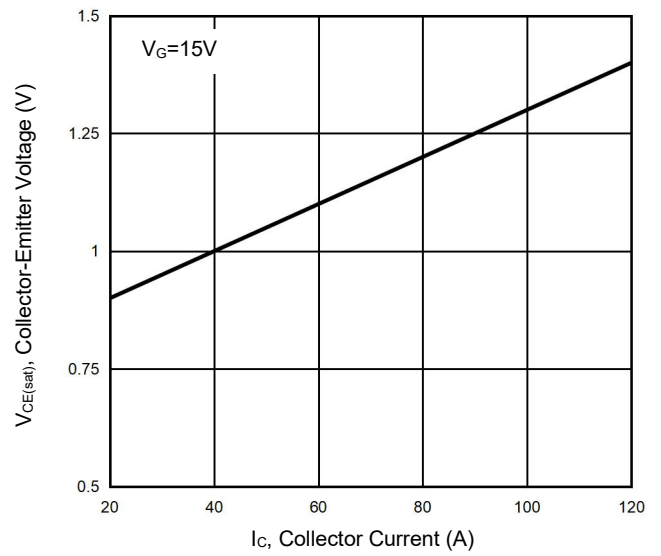


Figure 15 Forward Bias Safe Operating Area

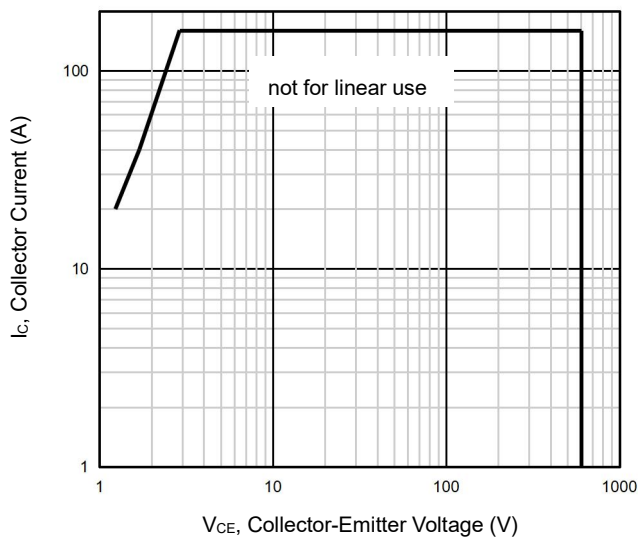


Figure 16  $P_{tot}$  vs. Case Temperature

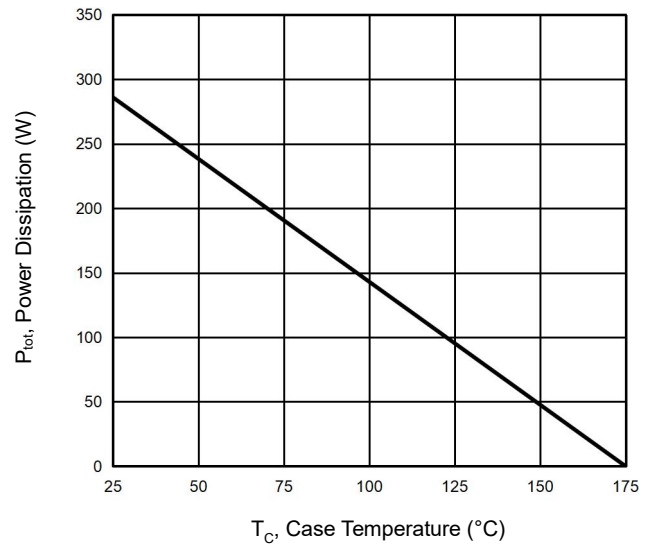


Figure 17  $V_{CES}$  vs. Temperature

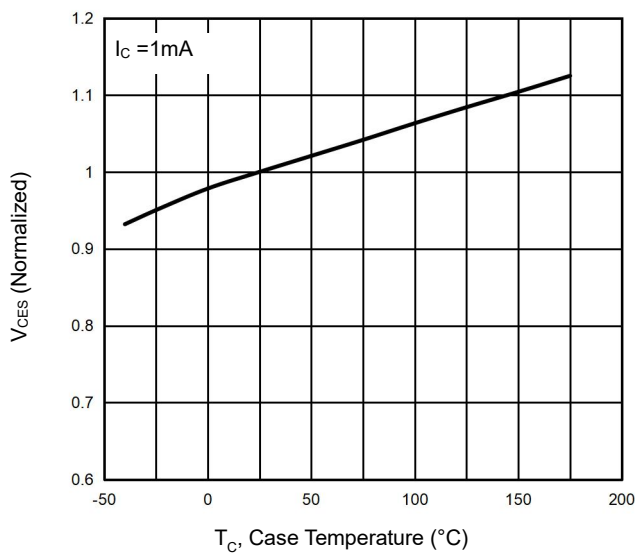
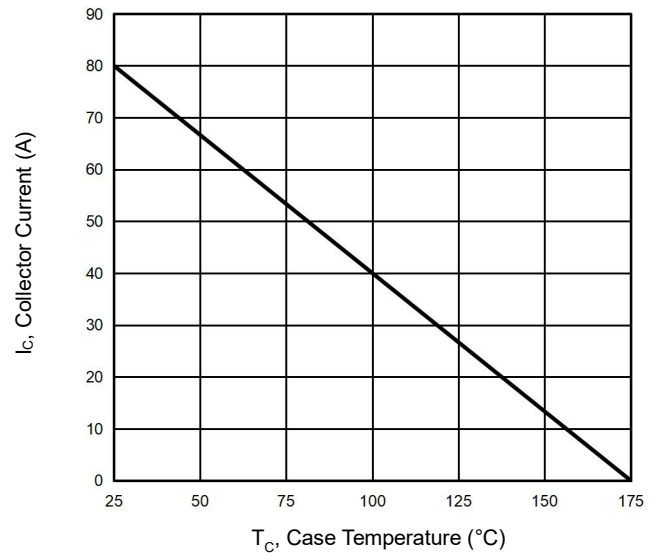
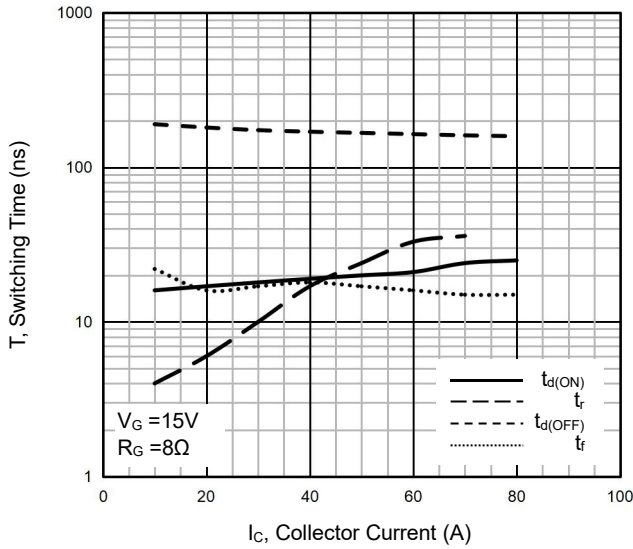


Figure 18  $I_C$  vs. Temperature

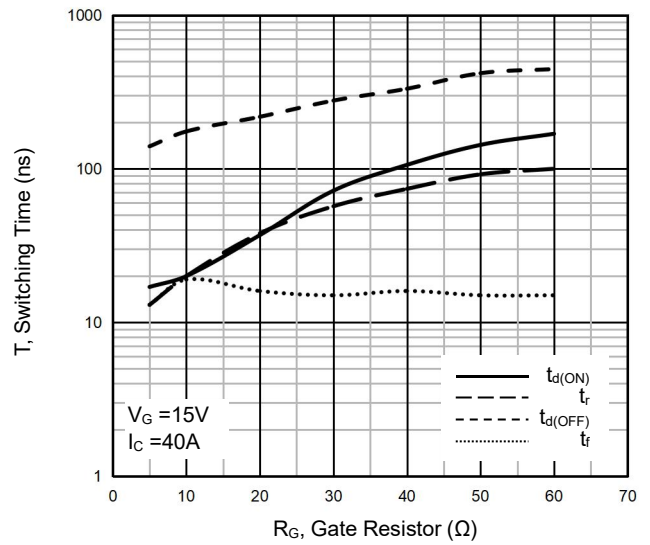


## Typical Electrical and Thermal Characteristics

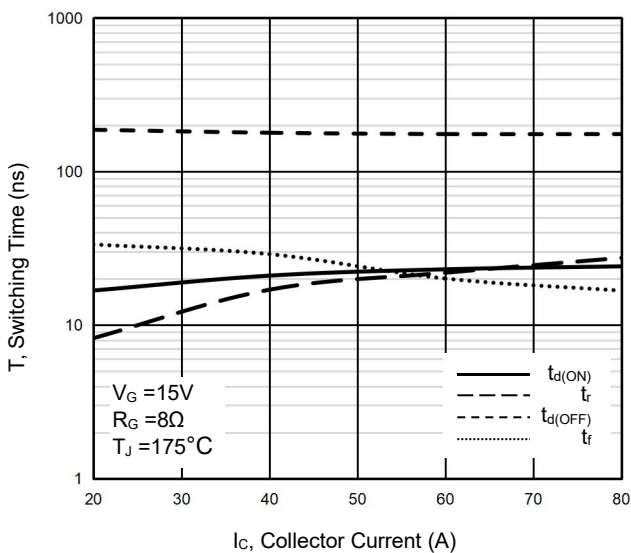
**Figure 19 Switching Time vs.  $I_C$**



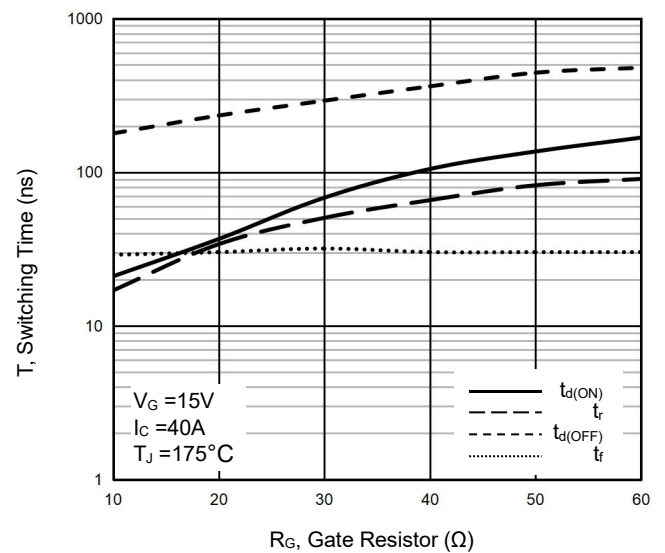
**Figure 20 Switching Time vs.  $R_G$**



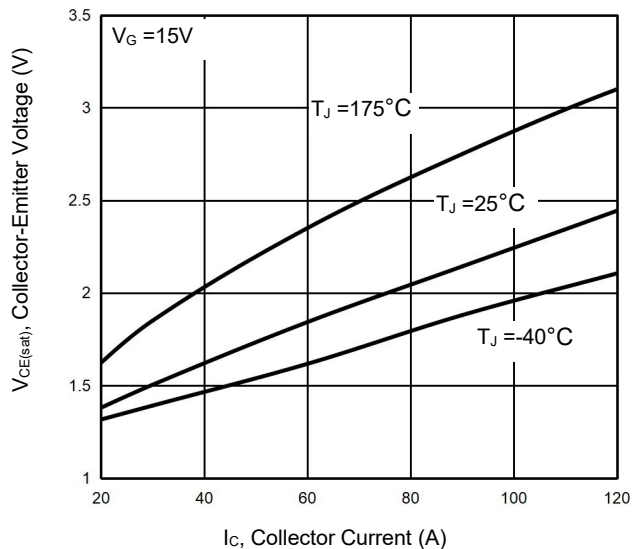
**Figure 21 Switching Time vs.  $I_C$**



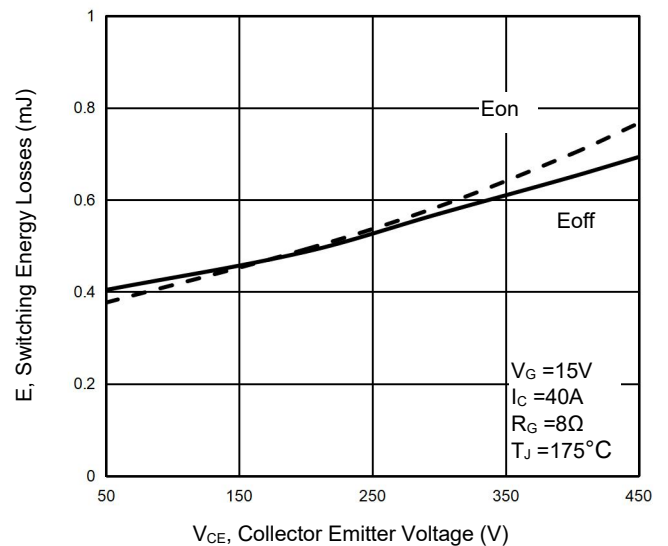
**Figure 22 Switching Time vs.  $R_G$**



**Figure 23  $V_{CE(sat)}$  vs. Collector Current**

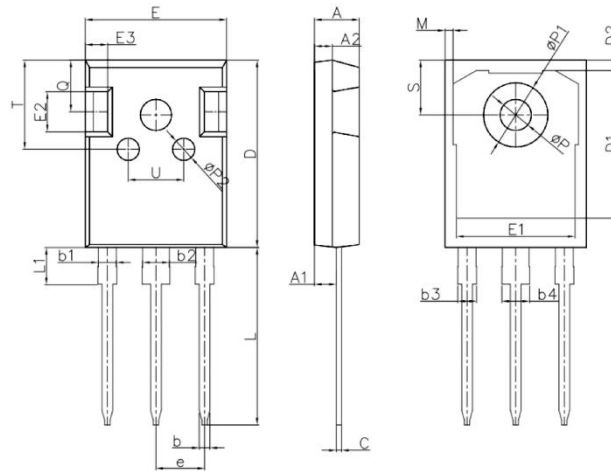


**Figure 24 Switching Loss vs.  $V_{CE}$**



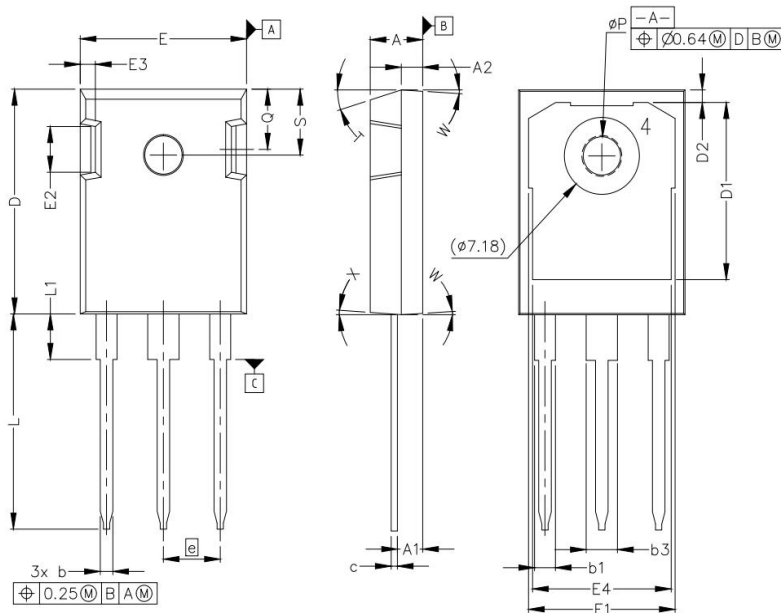


## TO-247-E Package Information



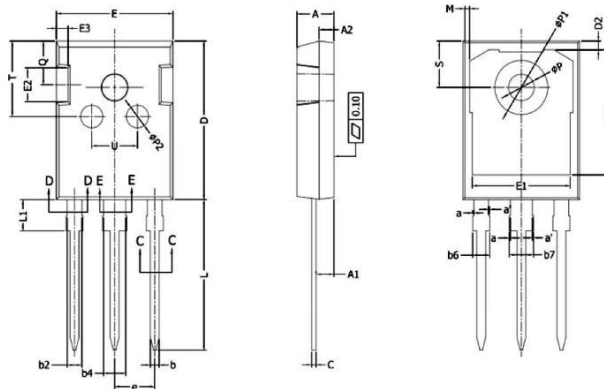
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	4.90	5.10	0.19	0.20
A1	2.31	2.51	0.09	0.10
A2	1.90	2.10	0.07	0.08
b	1.16	1.26	0.05	0.06
b1	1.96	2.06	0.08	0.09
b2	2.96	3.06	0.12	0.13
b3	--	2.25	--	0.09
b4	--	3.25	--	0.13
c	0.59	0.66	0.02	0.03
D	20.90	21.10	0.82	0.83
D1	16.25	16.85	0.64	0.66
D2	1.05	1.35	0.04	0.05
E	15.70	15.90	0.62	0.63
E1	13.10	13.50	0.52	0.53
E2	4.40	4.60	0.17	0.18
E3	2.40	2.60	0.09	0.10
e	5.436 BSC		0.214 BSC	
L	19.80	20.10	0.78	0.79
L1	--	4.30	--	0.17
M	0.35	0.95	0.01	0.04
P	3.40	3.60	0.13	0.14
P1	7.00	7.40	0.28	0.29
P2	2.40	2.60	0.09	0.10
Q	5.60	6.00	0.22	0.24
S	6.05	6.25	0.24	0.25
T	9.80	10.20	0.39	0.40
U	6.00	6.40	0.24	0.25

## TO-247-B Package Information



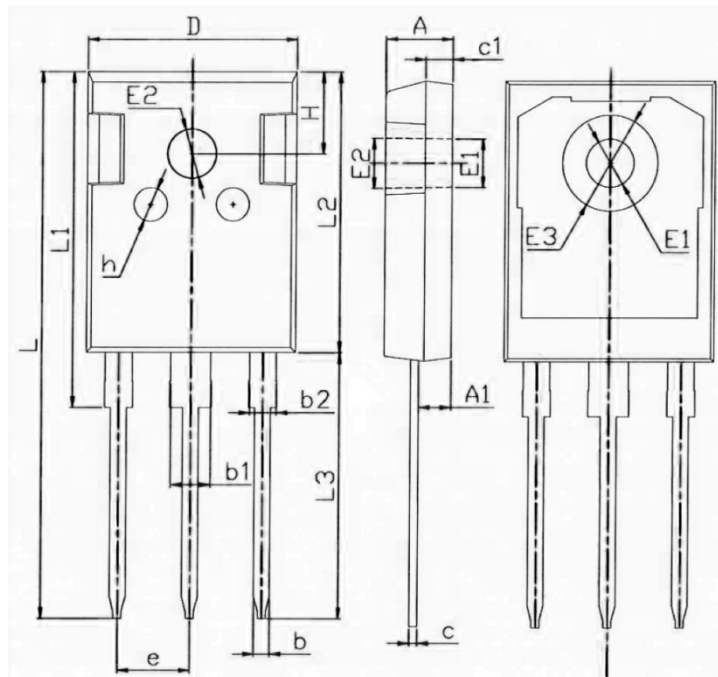
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	4.83	5.21	0.19	0.21
A1	2.29	2.54	0.09	0.10
A2	1.91	2.16	0.08	0.09
b	1.07	1.33	0.04	0.05
b1	1.91	2.41	0.08	0.10
b3	2.87	3.38	0.11	0.13
c	0.55	0.68	0.02	0.03
D	20.80	21.10	0.82	0.83
D1	16.25	17.65	0.64	0.70
D2	0.95	1.25	0.04	0.05
E	15.75	16.13	0.62	0.64
E1	13.10	14.15	0.52	0.56
E2	3.68	5.10	0.15	0.20
E3	1.00	1.90	0.04	0.08
E4	12.38	13.43	0.49	0.53
e	5.44 BSC		0.21 BSC	
L	19.81	20.32	0.78	0.80
L1	4.10	4.40	0.16	0.17
ØP	3.51	3.65	0.14	0.15
Q	5.49	6.00	0.22	0.24
S	6.04	6.30	0.24	0.25
T	17.5° REF			
W	3.5° REF			
X	4° REF			

## TO-247-P Package Information



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	4.90	5.10	0.19	0.20
A1	2.31	2.51	0.09	0.10
A2	1.90	2.10	0.08	0.09
a	0.00	0.15	0.00	0.01
a'	0.00	0.15	0.00	0.01
b	1.16	1.26	0.05	0.06
b2	1.96	2.06	0.08	0.09
b4	2.96	3.06	0.12	0.13
b6	-	2.25	-	0.09
b7	-	3.25	-	0.13
C	0.59	0.66	0.02	0.03
D	20.90	21.10	0.82	0.83
D1	16.25	16.85	0.64	0.66
D2	1.05	1.35	0.04	0.05
E	15.70	15.90	0.62	0.63
E1	13.10	13.50	0.52	0.53
E2	4.40	4.60	0.17	0.18
E3	2.40	2.60	0.09	0.10
e	5.436 BSC		0.214 BSC	
L	19.80	20.10	0.78	0.79
L1	-	4.30	-	0.17
M	0.35	0.95	0.01	0.04
P	3.40	3.60	0.13	0.14
P1	7.00	7.40	0.28	0.29
P2	2.40	2.60	0.09	0.10
Q	5.60	6.00	0.22	0.24
S	6.05	6.25	0.24	0.25
T	9.80	10.20	0.39	0.40
U	6.00	6.40	0.24	0.25

## TO-247-L Package Information



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	4.80	5.20	0.19	0.20
A1	2.26	2.56	0.09	0.10
b	1.10	1.30	0.04	0.05
b1	2.85	3.15	0.11	0.12
b2	1.85	2.15	0.07	0.08
c	0.50	0.70	0.02	0.03
c1	1.85	2.15	0.07	0.08
D	15.60	16.00	0.61	0.63
E1	3.45	3.75	0.14	0.15
E2	3.55	3.85	0.14	0.15
E3	7.04	7.34	0.28	0.29
L	40.67	41.17	1.60	1.62
L1	24.80	25.10	0.98	0.99
L2	20.80	21.20	0.82	0.83
L3	19.72	20.12	0.78	0.79
e	5.29	5.59	0.21	0.22
H	6.00	6.30	0.24	0.25
h	2.35	2.65	0.09	0.10

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