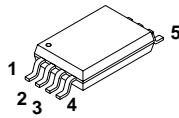


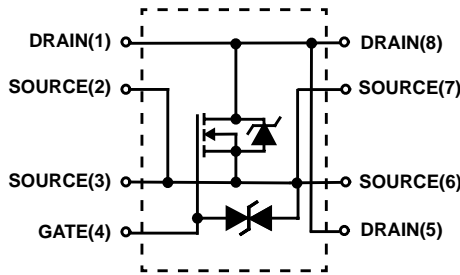
**10A, 30V, 0.012 Ohm, N-Channel, Logic Level, Power MOSFET**

**Packaging**

TSSOP8



**Symbol**



**Features**

- Ultra Low On-Resistance
  - $r_{DS(ON)} = 0.012\Omega, V_{GS} = 10V$
  - $r_{DS(ON)} = 0.016\Omega, V_{GS} = 4.5V$
- Gate to Source Protection Diode
- Simulation Models
  - Temperature Compensated PSPICE™ and SABER Electrical Models
  - Spice and SABER Thermal Impedance Models
  - www.intersil.com
- Peak Current vs Pulse Width Curve
- Transient Thermal Impedance Curve vs Board Mounting Area
- Switching Time vs  $R_{GS}$  Curves

**Ordering Information**

PART NUMBER	PACKAGE	BRAND
ITF86116SQT	TSSOP-8	86116

NOTE: When ordering, use the entire part number. ITF86116SQT2 is available only in tape and reel.

**Absolute Maximum Ratings**  $T_A = 25^\circ C$ , Unless Otherwise Specified

	ITF86116SQT	UNITS
Drain to Source Voltage (Note 1) . . . . .	30	V
Drain to Gate Voltage ( $R_{GS} = 20k\Omega$ ) (Note 1) . . . . .	30	V
Gate to Source Voltage . . . . .	$\pm 20$	V
Drain Current		
Continuous ( $T_A = 25^\circ C, V_{GS} = 10V$ ) (Figure 2) (Note 2) . . . . .	10.0	A
Continuous ( $T_A = 25^\circ C, V_{GS} = 4.5V$ ) (Note 2) . . . . .	9.0	A
Continuous ( $T_A = 100^\circ C, V_{GS} = 4.5V$ ) (Note 2) . . . . .	5.0	A
Pulsed Drain Current . . . . .	Figure 4	A
Power Dissipation (Note 2) . . . . .	2	W
Derate Above $25^\circ C$ . . . . .	16	mW/ $^\circ C$
Operating and Storage Temperature . . . . .	-55 to 150	$^\circ C$
Maximum Temperature for Soldering		
Leads at 0.063in (1.6mm) from Case for 10s. . . . .	300	$^\circ C$
Package Body for 10s, See Technical Brief TB370 . . . . .	260	$^\circ C$

NOTES:

1.  $T_J = 25^\circ C$  to  $125^\circ C$ .
2.  $62.5^\circ C/W$  measured using FR-4 board with  $1.00\text{ in}^2$  ( $645.2\text{ mm}^2$ ) copper pad at 10 second.

**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

## ITF86116SQT

### Electrical Specifications $T_A = 25^\circ\text{C}$ , Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS	
<b>OFF STATE SPECIFICATIONS</b>							
Drain to Source Breakdown Voltage	$BV_{DSS}$	$I_D = 250\mu\text{A}$ , $V_{GS} = 0\text{V}$ (Figure 11)	30	-	-	V	
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 30\text{V}$ , $V_{GS} = 0\text{V}$	-	-	10	$\mu\text{A}$	
Gate to Source Leakage Current	$I_{GSS}$	$V_{GS} = \pm 20\text{V}$	-	-	$\pm 10$	$\mu\text{A}$	
<b>ON STATE SPECIFICATIONS</b>							
Gate to Source Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}$ , $I_D = 250\mu\text{A}$ (Figure 10)	1.0	-	2.5	V	
Drain to Source On Resistance	$r_{DS(ON)}$	$I_D = 10.0\text{A}$ , $V_{GS} = 10\text{V}$ (Figures 8, 9)	-	0.0086	0.012	$\Omega$	
		$I_D = 5.0\text{A}$ , $V_{GS} = 4.5\text{V}$ (Figure 8)	-	0.011	0.016	$\Omega$	
<b>THERMAL SPECIFICATIONS</b>							
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	Pad Area = 1.00 in <sup>2</sup> (645.2 mm <sup>2</sup> ) (Note 2)	-	-	62.5	$^\circ\text{C/W}$	
		Pad Area = 0.035 in <sup>2</sup> (22.4 mm <sup>2</sup> ) (Figure 20)	-	-	165.4	$^\circ\text{C/W}$	
		Pad Area = 0.0045 in <sup>2</sup> (2.88 mm <sup>2</sup> ) (Figure 20)	-	-	206.8	$^\circ\text{C/W}$	
<b>SWITCHING SPECIFICATIONS (<math>V_{GS} = 4.5\text{V}</math>)</b>							
Turn-On Delay Time	$t_{d(ON)}$	$V_{DD} = 15\text{V}$ , $I_D = 5.0\text{A}$ $V_{GS} = 4.5\text{V}$ , $R_{GS} = 8.2\Omega$ (Figures 14, 18, 19)	-	21.5	-	ns	
Rise Time	$t_r$		-	82	-	ns	
Turn-Off Delay Time	$t_{d(OFF)}$		-	29	-	ns	
Fall Time	$t_f$		-	31	-	ns	
<b>SWITCHING SPECIFICATIONS (<math>V_{GS} = 10\text{V}</math>)</b>							
Turn-On Delay Time	$t_{d(ON)}$	$V_{DD} = 15\text{V}$ , $I_D = 10.0\text{A}$ $V_{GS} = 10\text{V}$ , $R_{GS} = 9.1\Omega$ (Figures 15, 18, 19)	-	12	-	ns	
Rise Time	$t_r$		-	63	-	ns	
Turn-Off Delay Time	$t_{d(OFF)}$		-	47	-	ns	
Fall Time	$t_f$		-	46	-	ns	
<b>GATE CHARGE SPECIFICATIONS</b>							
Total Gate Charge	$Q_{g(TOT)}$	$V_{GS} = 0\text{V}$ to $10\text{V}$	$V_{DD} = 15\text{V}$ , $I_D = 9.0\text{A}$ , $I_{g(REF)} = 1.0\text{mA}$ (Figures 13, 16, 17)	-	34	-	nC
Gate Charge at 5V	$Q_{g(5)}$	$V_{GS} = 0\text{V}$ to $5\text{V}$		-	18.6	-	nC
Threshold Gate Charge	$Q_{g(TH)}$	$V_{GS} = 0\text{V}$ to $1\text{V}$		-	2	-	nC
Gate to Source Gate Charge	$Q_{gs}$			-	6.4	-	nC
Gate to Drain "Miller" Charge	$Q_{gd}$			-	7.2	-	nC
<b>CAPACITANCE SPECIFICATIONS</b>							
Input Capacitance	$C_{ISS}$	$V_{DS} = 25\text{V}$ , $V_{GS} = 0\text{V}$ , $f = 1\text{MHz}$ (Figures 12)	-	1770	-	pF	
Output Capacitance	$C_{OSS}$		-	390	-	pF	
Reverse Transfer Capacitance	$C_{RSS}$		-	163	-	pF	

### Source to Drain Diode Specifications

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Source to Drain Diode Voltage	$V_{SD}$	$I_{SD} = 9.0\text{A}$	-	0.81	-	V
Reverse Recovery Time	$t_{rr}$	$I_{SD} = 9.0\text{A}$ , $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	27	-	ns
Reverse Recovered Charge	$Q_{RR}$	$I_{SD} = 9.0\text{A}$ , $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	13.5	-	nC

Typical Performance Curves

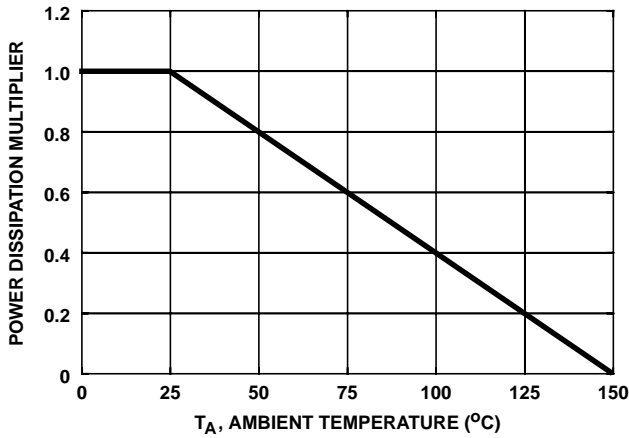


FIGURE 1. NORMALIZED POWER DISSIPATION vs AMBIENT TEMPERATURE

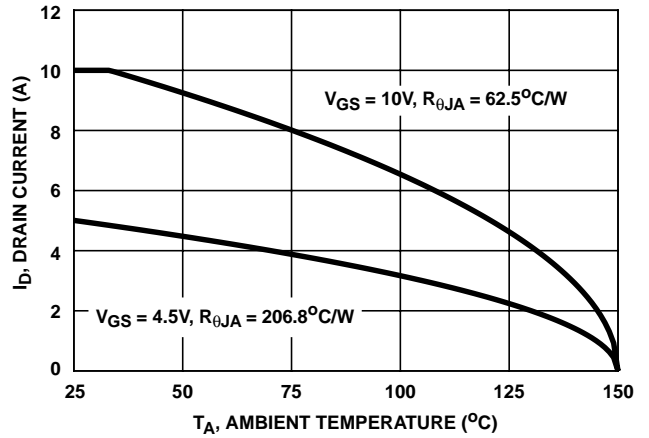


FIGURE 2. MAXIMUM CONTINUOUS DRAIN CURRENT vs AMBIENT TEMPERATURE

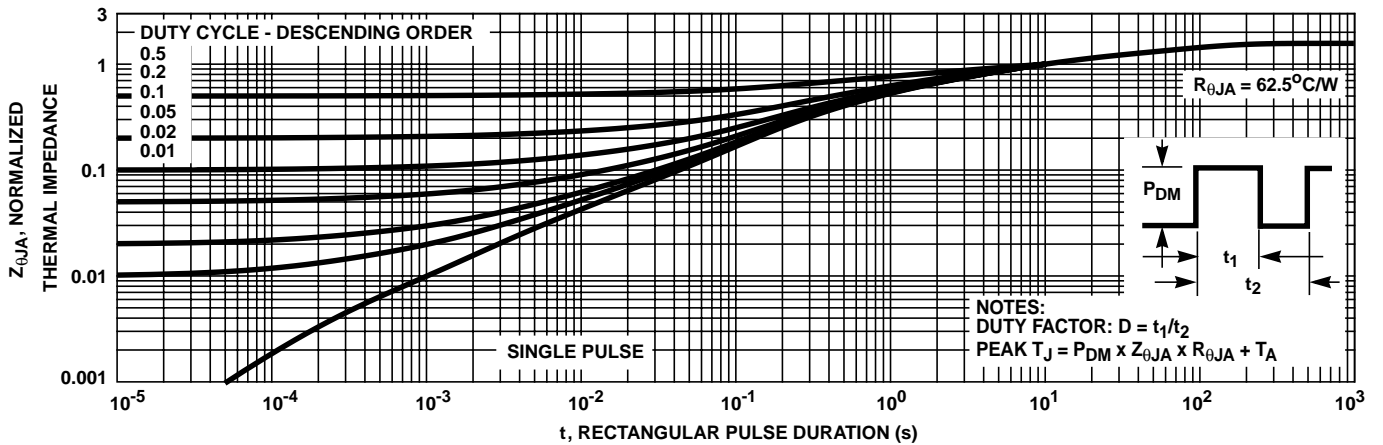


FIGURE 3. NORMALIZED MAXIMUM TRANSIENT THERMAL IMPEDANCE

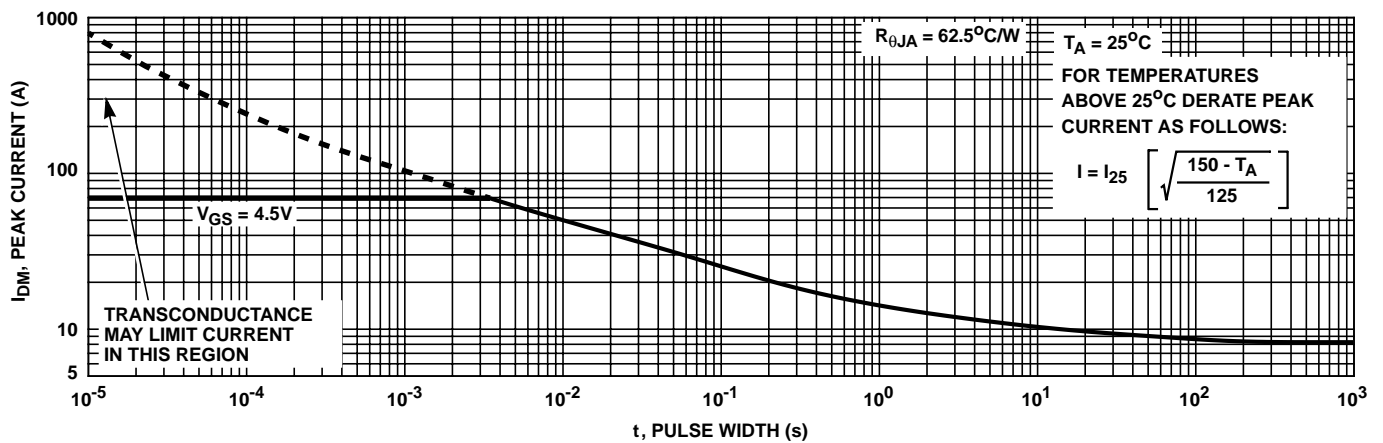


FIGURE 4. PEAK CURRENT CAPABILITY

Typical Performance Curves (Continued)

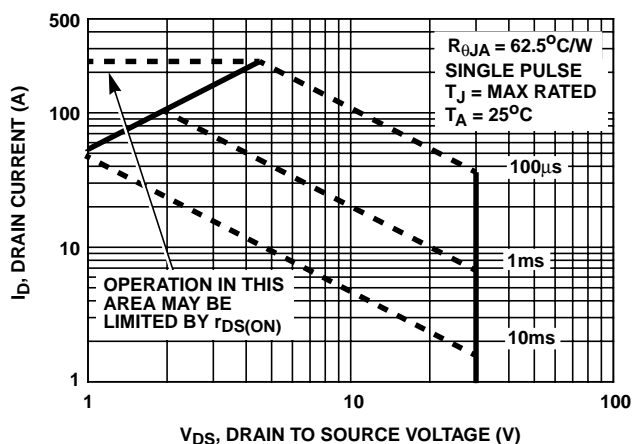


FIGURE 5. FORWARD BIAS SAFE OPERATING AREA

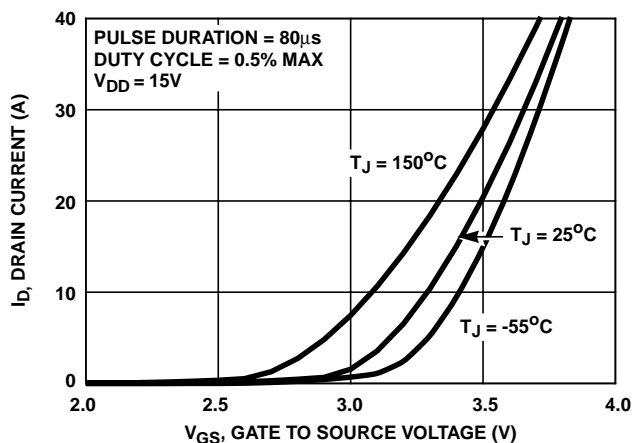


FIGURE 6. TRANSFER CHARACTERISTICS

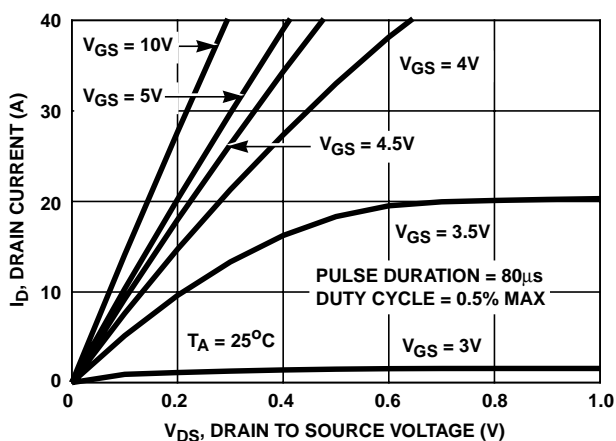


FIGURE 7. SATURATION CHARACTERISTICS

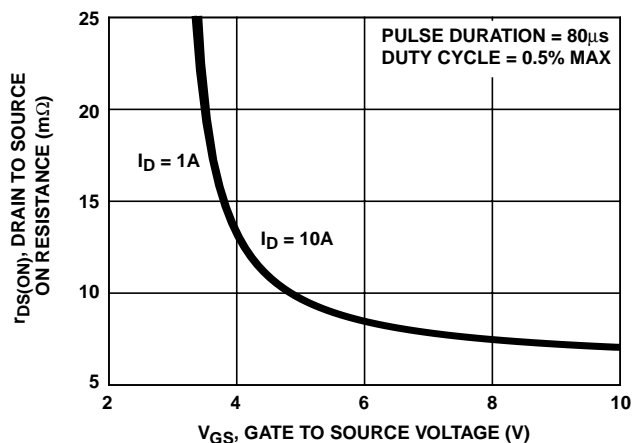


FIGURE 8. DRAIN TO SOURCE ON RESISTANCE vs. GATE VOLTAGE AND DRAIN CURRENT

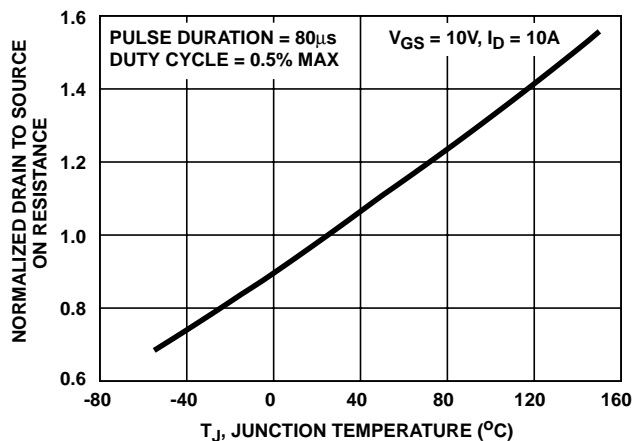


FIGURE 9. NORMALIZED DRAIN TO SOURCE ON RESISTANCE vs. JUNCTION TEMPERATURE

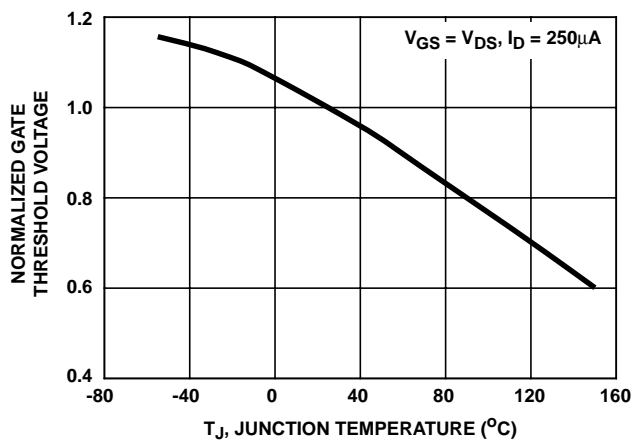


FIGURE 10. NORMALIZED GATE THRESHOLD VOLTAGE vs. JUNCTION TEMPERATURE

Typical Performance Curves (Continued)

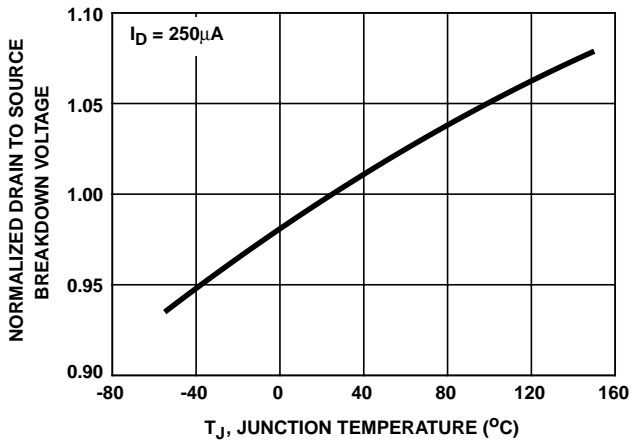


FIGURE 11. NORMALIZED DRAIN TO SOURCE BREAKDOWN VOLTAGE vs JUNCTION TEMPERATURE

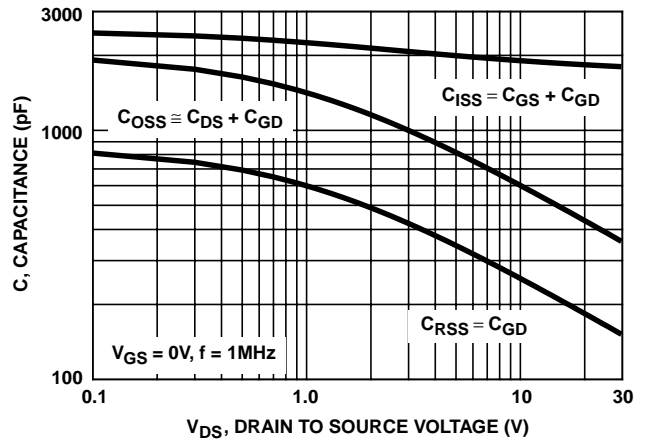
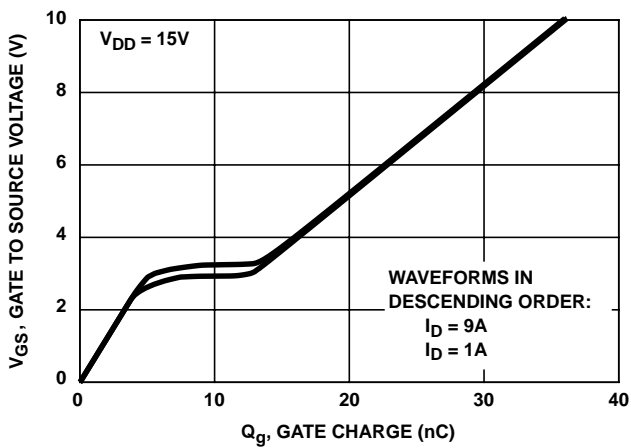


FIGURE 12. CAPACITANCE vs DRAIN TO SOURCE VOLTAGE



NOTE: Refer to Intersil Application Notes AN7254 and AN7260.

FIGURE 13. GATE CHARGE WAVEFORMS FOR CONSTANT GATE CURRENT

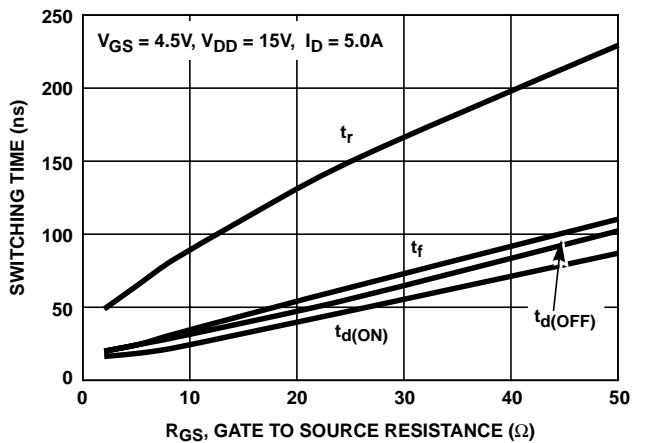


FIGURE 14. SWITCHING TIME vs GATE RESISTANCE

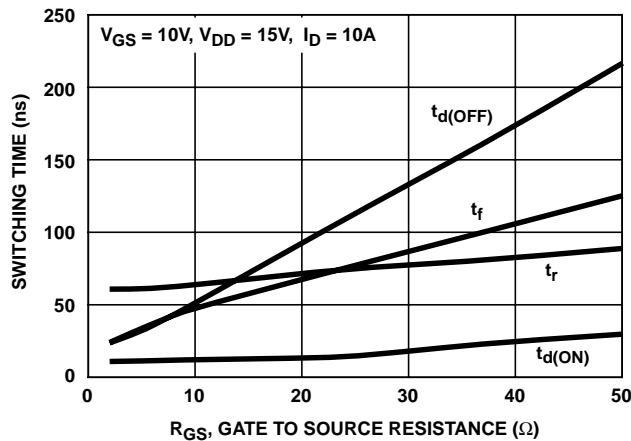


FIGURE 15. SWITCHING TIME vs GATE RESISTANCE

**Test Circuits and Waveforms**

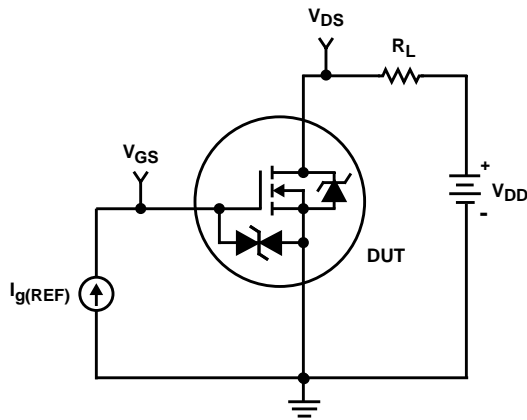


FIGURE 16. GATE CHARGE TEST CIRCUIT

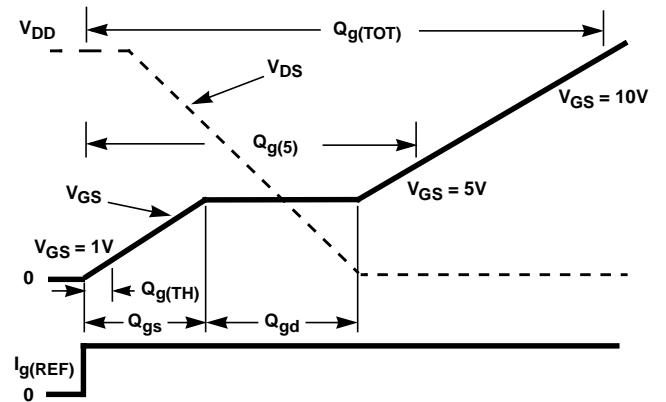


FIGURE 17. GATE CHARGE WAVEFORMS

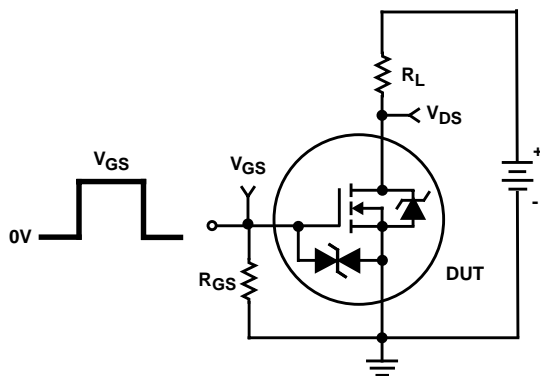


FIGURE 18. SWITCHING TIME TEST CIRCUIT

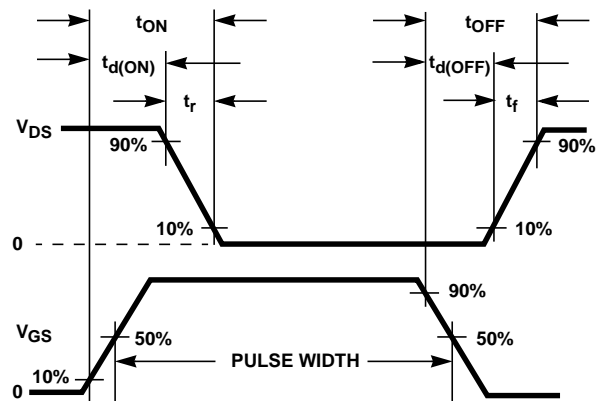


FIGURE 19. SWITCHING TIME WAVEFORM

**Thermal Resistance vs Mounting Pad Area**

The maximum rated junction temperature,  $T_{JM}$ , and the thermal resistance of the heat dissipating path determines the maximum allowable device power dissipation,  $P_{DM}$ , in an application. Therefore the application's ambient temperature,  $T_A$  ( $^{\circ}C$ ), and thermal resistance  $R_{\theta JA}$  ( $^{\circ}C/W$ ) must be reviewed to ensure that  $T_{JM}$  is never exceeded. Equation 1 mathematically represents the relationship and serves as the basis for establishing the rating of the part.

$$P_{DM} = \frac{(T_{JM} - T_A)}{Z_{\theta JA}} \quad (EQ. 1)$$

In using surface mount devices such as the TSSOP-8 package, the environment in which it is applied will have a significant influence on the part's current and maximum power dissipation ratings. Precise determination of  $P_{DM}$  is complex and influenced by many factors:

1. Mounting pad area onto which the device is attached and whether there is copper on one side or both sides of the board.
2. The number of copper layers and the thickness of the board.
3. The use of external heat sinks.
4. The use of thermal vias.
5. Air flow and board orientation.
6. For non steady state applications, the pulse width, the duty cycle and the transient thermal response of the part, the board and the environment they are in.

Intersil provides thermal information to assist the designer's preliminary application evaluation. Figure 20 defines the  $R_{\theta JA}$  for the device as a function of the top copper (component side) area. This is for a horizontally positioned FR-4 board with 1oz copper after 1000 seconds of steady state power with no air flow. This graph provides the

necessary information for calculation of the steady state junction temperature or power dissipation. Pulse applications can be evaluated using the Intersil device Spice thermal model or manually utilizing the normalized maximum transient thermal impedance curve.

Displayed on the curve are  $R_{\theta JA}$  values listed in the Electrical Specifications table. The points were chosen to depict the compromise between the copper board area, the thermal resistance and ultimately the power dissipation,  $P_{DM}$ .

Thermal resistances corresponding to other copper areas can be obtained from Figure 20 or by calculation using Equation 2.  $R_{\theta JA}$  is defined as the natural log of the area times a coefficient added to a constant. The area, in square inches is the top copper area including the gate and source pads.

$$R_{\theta JA} = 97.5 - 20.2 \ln(\text{Area}) \quad (\text{EQ. 2})$$

The transient thermal impedance ( $Z_{\theta JA}$ ) is also effected by varied top copper board area. Figure 21 shows the effect of copper pad area on single pulse transient thermal impedance. Each trace represents a copper pad area in square inches corresponding to the descending list in the graph. Spice and SABER thermal models are provided for each of the listed pad areas.

Copper pad area has no perceivable effect on transient thermal impedance for pulse widths less than 100ms. For pulse widths less than 100ms the transient thermal impedance is determined by the die and package. Therefore, C THERM1 through C THERM5 and R THERM1 through R THERM5 remain constant for each of the thermal models. A listing of the model component values is available in Table 1.

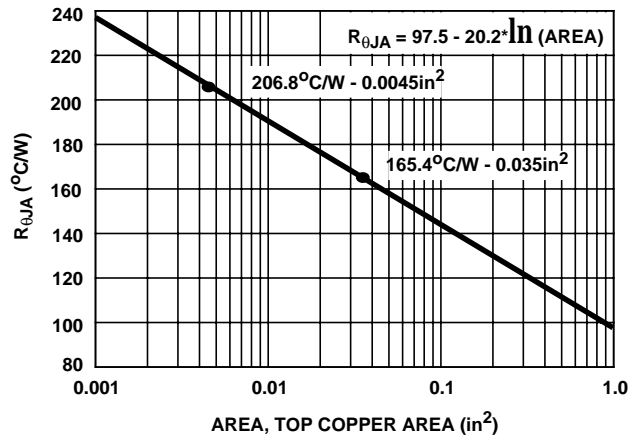


FIGURE 20. THERMAL RESISTANCE vs MOUNTING PAD AREA

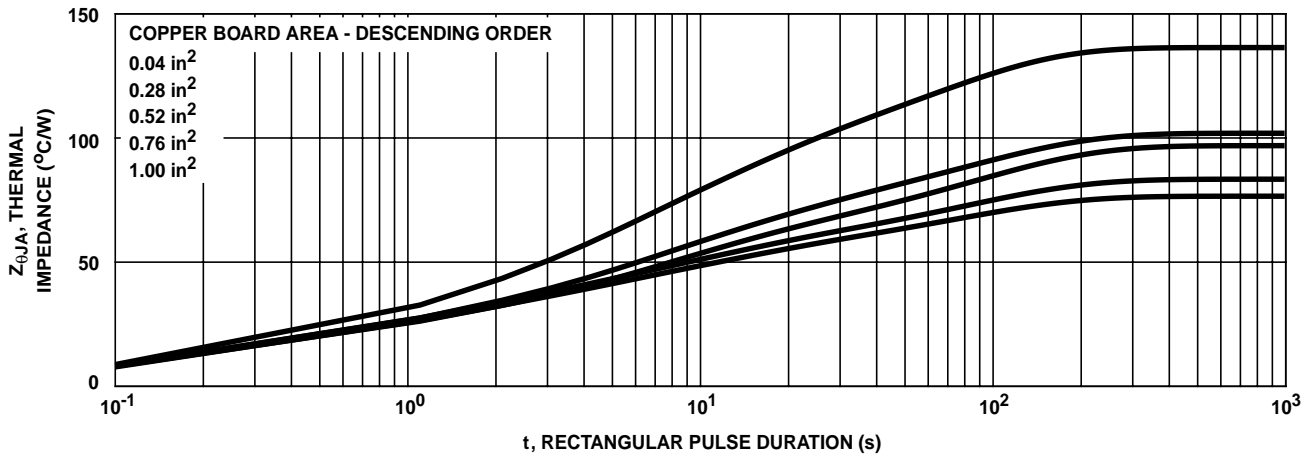


FIGURE 21. THERMAL IMPEDANCE vs MOUNTING PAD AREA

# ITF86116SQT

## PSPICE Electrical Model

.SUBCKT ITF86116SQT 2 1 3 ; REV 29 Dec 1999

CA 12 8 1.55e-9  
 CB 15 14 1.65e-9  
 CIN 6 8 1.65e-9

DBODY 7 5 DBODYMOD  
 DBREAK 5 11 DBREAKMOD  
 DESD1 91 9 DESD1MOD  
 DESD1 91 7 DESD2MOD  
 DPLCAP 10 5 DPLCAPMOD

EBREAK 11 7 17 18 38.78  
 EDS 14 8 5 8 1  
 EGS 13 8 6 8 1  
 ESG 6 10 6 8 1  
 EVTHRES 6 21 19 8 1  
 EVTEMP 20 6 18 22 1

IT 8 17 1

LDRAIN 2 5 1.00e-9  
 LGATE 1 9 1.04e-9  
 LSOURCE 3 7 1.29e-10

MMED 16 6 8 8 MMEDMOD  
 MSTRO 16 6 8 8 MSTROMOD  
 MWEAK 16 21 8 8 MWEAKMOD

RBREAK 17 18 RBREAKMOD 1  
 RDRAIN 50 16 RDRAINMOD 2.40e-3  
 RGATE 9 20 1.37  
 RLDRAIN 2 5 10  
 RLGATE 1 9 9 10.4  
 RLSOURCE 3 7 1.29  
 RSLC1 5 51 RSLCMOD 1e-6  
 RSLC2 5 50 1e3  
 RSOURCE 8 7 RSOURCEMOD 3.50e-3  
 RVTHRES 22 8 RVTHRESMOD 1  
 RVTEMP 18 19 RVTEMPMOD 1

S1A 6 12 13 8 S1AMOD  
 S1B 13 12 13 8 S1BMOD  
 S2A 6 15 14 13 S2AMOD  
 S2B 13 15 14 13 S2BMOD

VBAT 22 19 DC 1

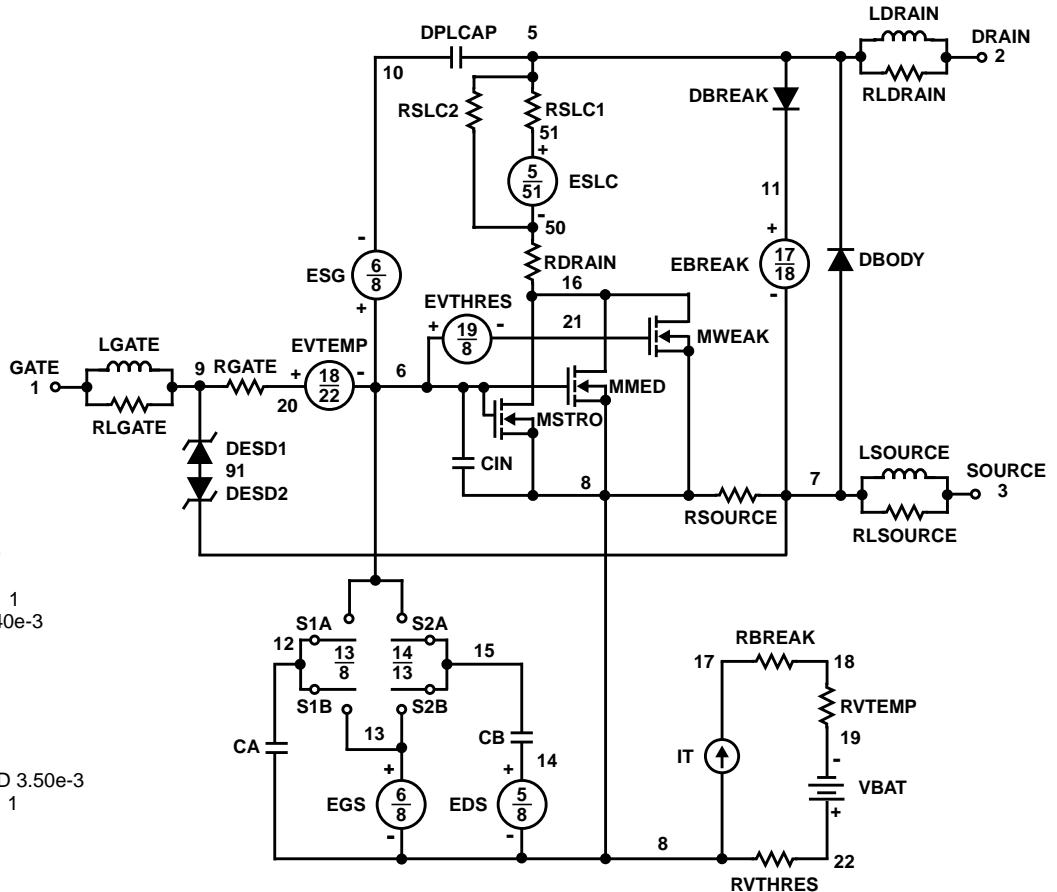
ESLC 51 50 VALUE={{(V(5,51)/ABS(V(5,51)))\*(PWR(V(5,51))/(1e-6\*320),2))}}

.MODEL DBODYMOD D (IS = 2.15e-12 RS = 4.73e-3 TRS1 = 1.51e-3 TRS2 = 1.06e-6 CJO = 1.16e-9 TT = 2.19e-8 M = 0.50)  
 .MODEL DBREAKMOD D (RS = 8.99e-2 TRS1 = -1.74e-3 TRS2 = 2.86e-5)  
 .MODEL DESD1MOD D (BV = 9.7 Tbv1 = -2.72e-3 N = 16 RS = 25)  
 .MODEL DESD2MOD D (BV = 15.6 Tbv1 = -2.17e-3 N = 13 RS = 25)  
 .MODEL DPLCAPMOD D (CJO = 8.50e-10 IS = 1e-30 M = 0.50)  
 .MODEL MMEDMOD NMOS (VTO = 2.30 KP = 3.50 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 1.37)  
 .MODEL MSTROMOD NMOS (VTO = 2.89 KP = 125 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u)  
 .MODEL MWEAKMOD NMOS (VTO = 2.05 KP = 0.10 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 13.7 RS = 0.1)  
 .MODEL RBREAKMOD RES (TC1 = 7.98e-4 TC2 = -9.15e-7)  
 .MODEL RDRAINMOD RES (TC1 = 8.78e-3 TC2 = 8.98e-6)  
 .MODEL RSLCMOD RES (TC1 = 9.15e-4 TC2 = 1.22e-6)  
 .MODEL RSOURCEMOD RES (TC1 = 1.00e-3 TC2 = 0)  
 .MODEL RVTHRESMOD RES (TC1 = -3.55e-3 TC2 = -6.24e-6)  
 .MODEL RVTEMPMOD RES (TC1 = -1.66e-3 TC2 = 0)

.MODEL S1AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -4.0 VOFF = -2.8)  
 .MODEL S1BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -2.8 VOFF = -4.0)  
 .MODEL S2AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -2.5 VOFF = 0)  
 .MODEL S2BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 0 VOFF = -2.5)

.ENDS

NOTE: For further discussion of the PSPICE model, consult **A New PSPICE Sub-Circuit for the Power MOSFET Featuring Global Temperature Options**; IEEE Power Electronics Specialist Conference Records, 1991, written by William J. Hepp and C. Frank Wheatley.







# ITF86116SQT

## SPICE Thermal Model

REV 27 Dec 1999

ITF86116SQT

Copper Area = 0.04 in<sup>2</sup>

CTHERM1 th 8 1.50e-3

CTHERM2 8 7 5.00e-3

CTHERM3 7 6 1.00e-2

CTHERM4 6 5 2.00e-2

CTHERM5 5 4 5.00e-2

CTHERM6 4 3 1.20e-1

CTHERM7 3 2 2.50e-1

CTHERM8 2 tl 1.30

RTHERM1 th 8 0.15

RTHERM2 8 7 0.50

RTHERM3 7 6 1.25

RTHERM4 6 5 8.00

RTHERM5 5 4 12.00

RTHERM6 4 3 26.00

RTHERM7 3 2 39.00

RTHERM8 2 tl 49.5

## SABER Thermal Model

Copper Area = 0.04 in<sup>2</sup>

template thermal\_model th tl

thermal\_c th, tl

{

ctherm.ctherm1 th 8 = 1.50e-3

ctherm.ctherm2 8 7 = 5.00e-3

ctherm.ctherm3 7 6 = 1.00e-2

ctherm.ctherm4 6 5 = 2.00e-2

ctherm.ctherm5 5 4 = 5.00e-2

ctherm.ctherm6 4 3 = 1.20e-1

ctherm.ctherm7 3 2 = 2.50e-1

ctherm.ctherm8 2 tl = 1.30

rtherm.rtherm1 th 8 = 0.15

rtherm.rtherm2 8 7 = 0.50

rtherm.rtherm3 7 6 = 1.25

rtherm.rtherm4 6 5 = 8.00

rtherm.rtherm5 5 4 = 12.00

rtherm.rtherm6 4 3 = 26.00

rtherm.rtherm7 3 2 = 39.00

rtherm.rtherm8 2 tl = 49.50

}

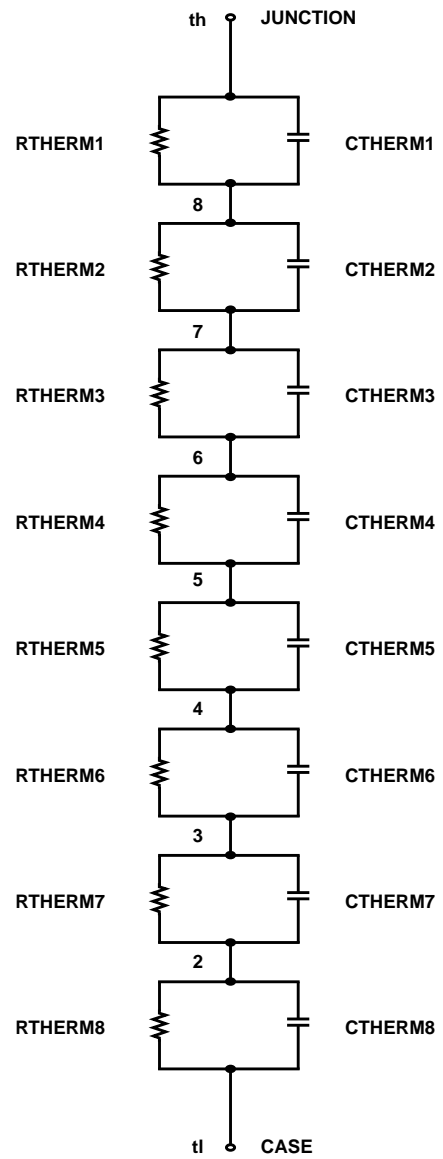


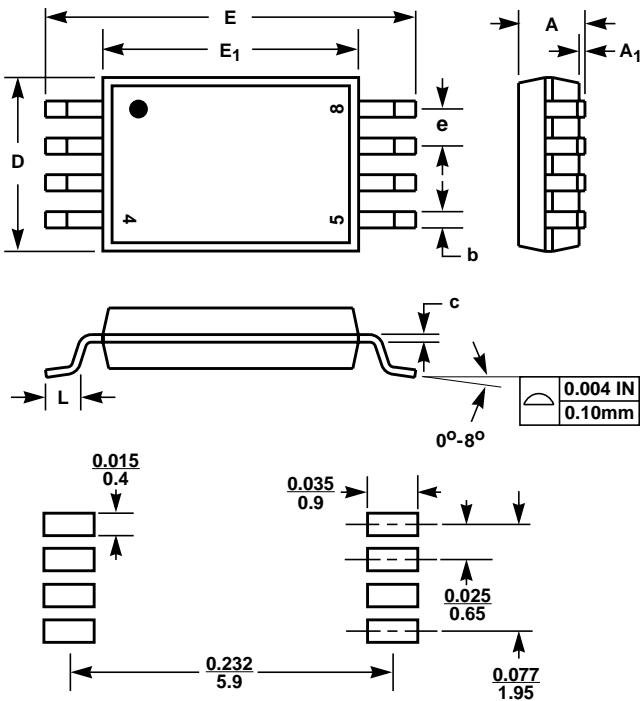
TABLE 1. THERMAL MODELS

COMPONANT	0.04 in <sup>2</sup>	0.28 in <sup>2</sup>	0.52 in <sup>2</sup>	0.76 in <sup>2</sup>	1.0 in <sup>2</sup>
CTHERM6	1.20e-1	2.00e-1	2.80e-1	1.90e-1	2.00e-1
CTHERM7	2.50e-1	4.80e-1	4.50e-1	3.90e-1	5.00e-1
CTHERM8	1.30	2.30	2.20	2.70	3.00
RTHERM6	26	20	15	11	12
RTHERM7	39	24	21	21	18
RTHERM8	49.5	36.8	39	29.5	25

# ITF86116SQT

## MO-153AA (TSSOP-8)

8 LEAD JEDEC MO-153AA TSSOP PLASTIC PACKAGE



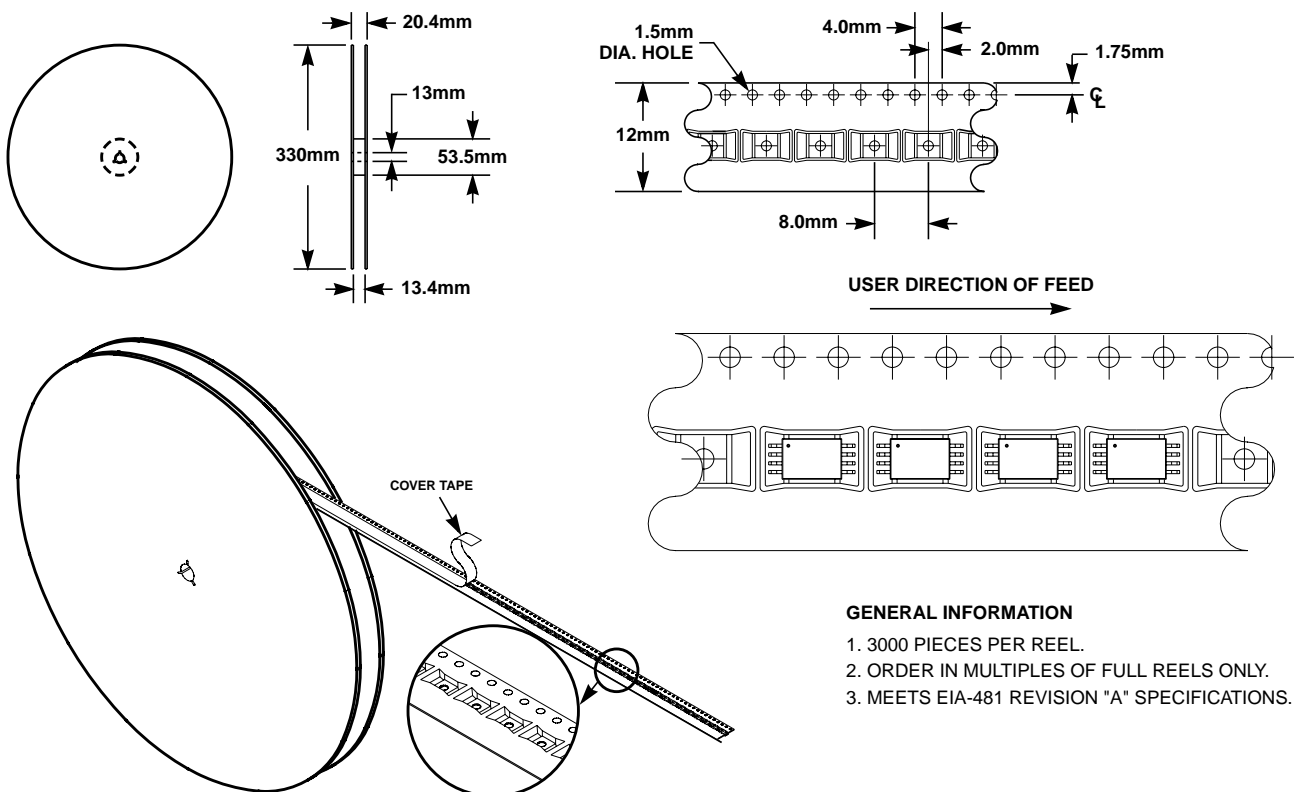
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.041	0.047	1.05	1.20	-
A <sub>1</sub>	0.002	0.006	0.05	0.15	-
b	0.010	0.012	0.25	0.30	-
c	0.005		0.127		-
D	0.114	0.122	2.90	3.10	2
E	0.244	0.260	6.20	6.60	-
E <sub>1</sub>	0.170	0.177	4.30	4.50	3
e	0.025 BSC		0.65 BSC		-
L	0.020	0.028	0.50	0.70	4

**NOTES:**

1. These dimensions are within allowable dimensions of Rev. E of JEDEC MO-153AA outline dated 10-97.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.006 inches (0.15mm) per side.
3. Dimension "E<sub>1</sub>" does not include inter-lead flash or protrusions. Interlead flash and protrusions shall not exceed 0.010 inches (0.25mm) per side.
4. "L" is the length of terminal for soldering.
5. Controlling dimension: Millimeter
6. Revision 2 dated: 1-00.

## MO-153AA (TSSOP-8)

12mm TAPE AND REEL



**GENERAL INFORMATION**

1. 3000 PIECES PER REEL.
2. ORDER IN MULTIPLES OF FULL REELS ONLY.
3. MEETS EIA-481 REVISION "A" SPECIFICATIONS.

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