

1. General description

High-voltage, high-speed planar-passivated, NPN power switching transistor in SOT186A (TO-220F) plastic package for use in high frequency electronic lighting ballast applications

2. Features and benefits

- Fast switching
- High voltage capability of 700 V
- Low thermal resistance
- Isolated package

3. Applications

- Electronic lighting ballasts

4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Values			Unit
Absolute maximum rating						
V_{CESM}	collector-emitter peak voltage	$V_{BE} = 0\text{ V}$	700			V
I_C	collector current	DC; Fig. 1 ; Fig. 2 ; Fig. 3	4			A
P_{tot}	total power dissipation	$T_h \leq 25\text{ °C}$; Fig. 4	26			W
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Static characteristics						
h_{FE}	DC current gain	$I_C = 1\text{ A}$; $V_{CE} = 5\text{ V}$; $T_h = 25\text{ °C}$; Fig. 11	12	20	40	
		$I_C = 2\text{ A}$; $V_{CE} = 5\text{ V}$; $T_h = 25\text{ °C}$; Fig. 11	10	17	28	

5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	B	base		
2	C	collector		
3	E	emitter		
mb	n.c.	isolated		

6. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
PHE13005X	TO-220F	plastic single-ended package; isolated heatsink mounted; 1 mounting hole; 3-lead TO-220 "full pack"	SOT186A

7. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Values	Unit
V_{CESM}	collector-emitter peak voltage	$V_{BE} = 0\text{ V}$	700	V
V_{CBO}	collector-base voltage	$I_E = 0\text{ A}$	700	V
V_{CEO}	collector-emitter voltage	$I_B = 0\text{ A}$	400	V
I_C	collector current	DC; Fig. 1 ; Fig. 2 ; Fig. 3	4	A
I_{CM}	peak collector current		8	A
I_B	base current		2	A
I_{BM}	peak base current		4	A
P_{tot}	total power dissipation	$T_h \leq 25\text{ °C}$; Fig. 4	26	W
T_{stg}	storage temperature		-65 to 150	°C
T_j	junction temperature		150	°C

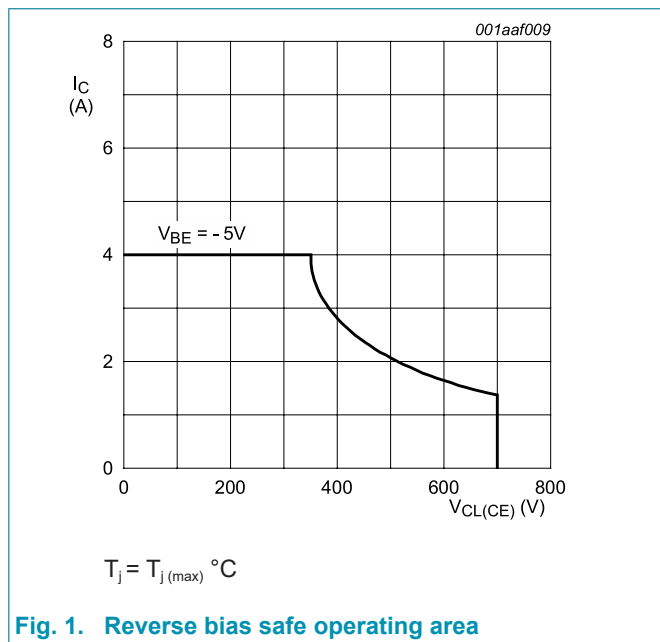


Fig. 1. Reverse bias safe operating area

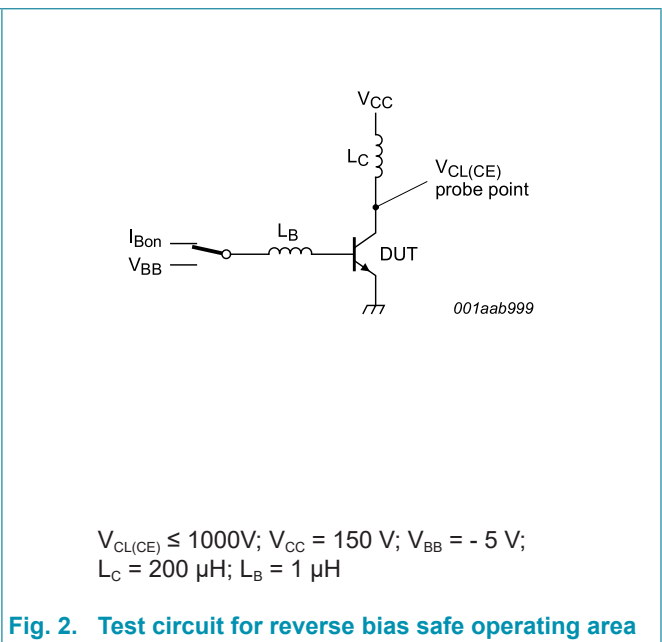
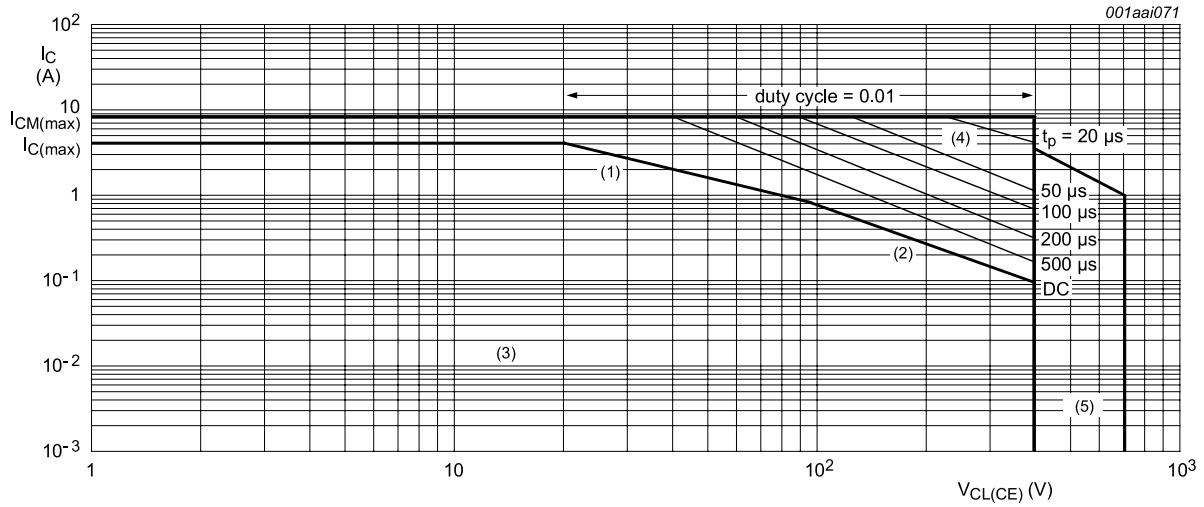


Fig. 2. Test circuit for reverse bias safe operating area

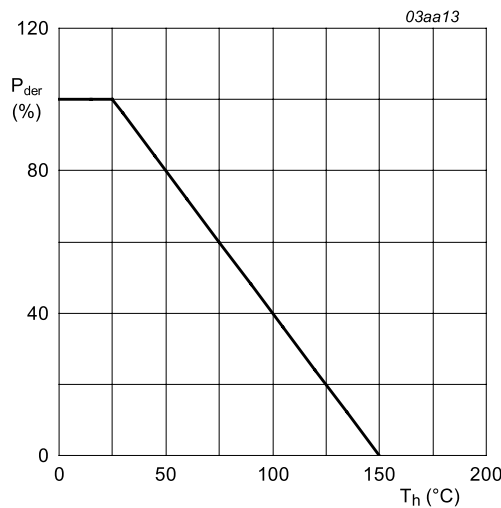


$T_h \leq 25^\circ\text{C}$

Mounted with heatsink compound and (30 ± 5) N force on the center of the envelope

- (1) P_{tot} maximum and P_{tot} peak maximum lines
- (2) Second breakdown limits
- (3) Region of permissible DC operation
- (4) Extension of operating region for repetitive pulse operation
- (5) Extension of operating region during turn-on in single transistor converters provided that $R_{BE} \leq 100 \Omega$ and $t_p \leq 0.6 \mu\text{s}$.

Fig. 3. Forward bias safe operating area



$$P_{der}(\%) = \frac{P_{tot}}{P_{tot(25^\circ\text{C})}} \times 100\%$$

Fig. 4. Normalized total power dissipation as a function of heatsink temperature

8. Thermal characteristics

Table 5. Thermal characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$R_{th(j-mb)}$	thermal resistance from junction to heatsink	with heatsink compound; Fig. 5	-	-	4.8	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient		-	55	-	K/W

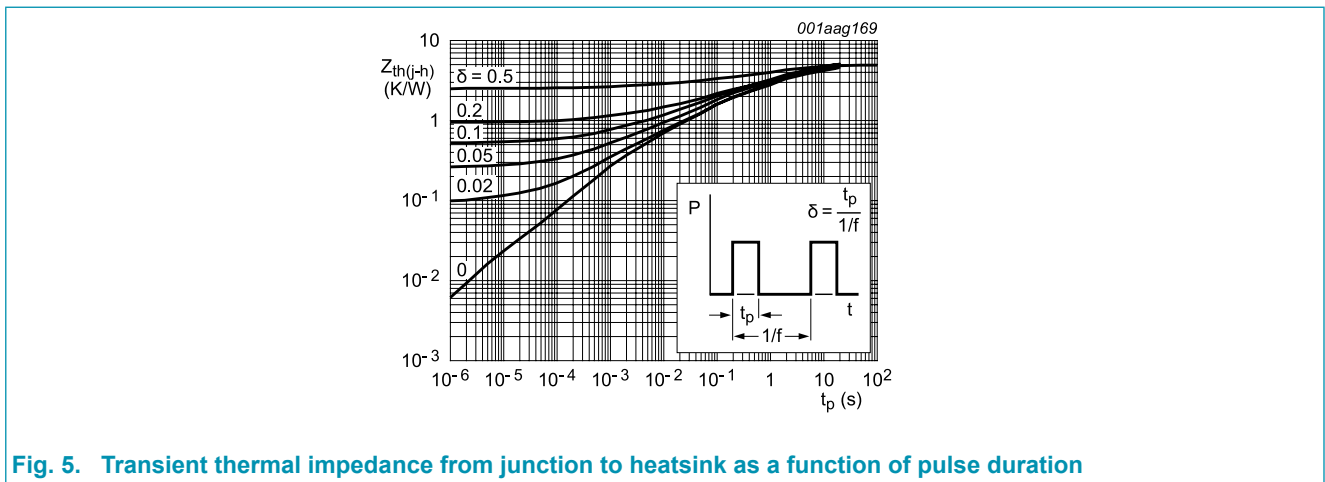


Fig. 5. Transient thermal impedance from junction to heatsink as a function of pulse duration

9. Characteristics

Table 6. Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Static characteristics						
I_{CES}	collector-emitter cut-off current	$V_{BE} = 0\text{ V}; V_{CE} = 700\text{ V}; T_j = 25\text{ }^\circ\text{C}$	-	-	1	mA
		$V_{BE} = 0\text{ V}; V_{CE} = 700\text{ V}; T_j = 100\text{ }^\circ\text{C}$	-	-	5	mA
I_{CBO}	collector-base cut-off current	$V_{CB} = 700\text{ V}; I_E = 0\text{ A}; T_h = 25\text{ }^\circ\text{C}$	-	-	1	mA
I_{CEO}	collector-emitter cut-off current	$V_{CEO} = 400\text{ V}; I_B = 0\text{ A}; T_h = 25\text{ }^\circ\text{C}$	-	-	0.1	mA
I_{EBO}	emitter-base cut-off current	$V_{EB} = 9\text{ V}; I_C = 0\text{ A}; T_h = 25\text{ }^\circ\text{C}$	-	-	1	mA
V_{CEOsus}	collector-emitter sustaining voltage	$I_B = 0\text{ A}; I_C = 10\text{ mA}; L_C = 25\text{ mH}; T_h = 25\text{ }^\circ\text{C};$ Fig. 6 ; Fig. 7	400	-	-	V
V_{CEsat}	collector-emitter saturation voltage	$I_C = 1\text{ A}; I_B = 0.2\text{ A}; T_h = 25\text{ }^\circ\text{C};$ Fig. 8 ; Fig. 9	-	0.1	0.5	V
		$I_C = 2\text{ A}; I_B = 0.5\text{ A}; T_h = 25\text{ }^\circ\text{C};$ Fig. 8 ; Fig. 9	-	0.2	0.6	V
		$I_C = 4\text{ A}; I_B = 1\text{ A}; T_h = 25\text{ }^\circ\text{C};$ Fig. 8 ; Fig. 9	-	0.3	1	V
V_{BEsat}	base-emitter saturation voltage	$I_C = 1\text{ A}; I_B = 0.2\text{ A}; T_h = 25\text{ }^\circ\text{C};$ Fig. 10	-	0.85	1.2	V
		$I_C = 2\text{ A}; I_B = 0.5\text{ A}; T_h = 25\text{ }^\circ\text{C};$ Fig. 10	-	0.92	1.6	V
h_{FE}	DC current gain	$I_C = 1\text{ A}; V_{CE} = 5\text{ V}; T_h = 25\text{ }^\circ\text{C};$ Fig. 11	12	20	40	
		$I_C = 2\text{ A}; V_{CE} = 5\text{ V}; T_h = 25\text{ }^\circ\text{C};$ Fig. 11	10	17	28	
Dynamic characteristics						
t_s	storage time	$I_C = 2\text{ A}; I_{Bon} = 0.4\text{ A}; I_{Boff} = -0.4\text{ A}; R_L = 75\text{ }\Omega; T_h = 25\text{ }^\circ\text{C};$ resistive load; Fig. 12 ; Fig. 13	-	2.7	4	μs
		$I_C = 2\text{ A}; I_{Bon} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 25\text{ }^\circ\text{C};$ inductive load; Fig. 14 ; Fig. 15	-	1.2	2	μs
		$I_C = 2\text{ A}; I_{Bon} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 100\text{ }^\circ\text{C};$ inductive load; Fig. 14 ; Fig. 15	-	1.4	4	μs
t_f	fall time	$I_C = 2\text{ A}; I_{Bon} = 0.4\text{ A}; I_{Boff} = -0.4\text{ A}; R_L = 75\text{ }\Omega; T_h = 25\text{ }^\circ\text{C};$ resistive load; Fig. 12 ; Fig. 13	-	0.3	0.9	μs
		$I_C = 2\text{ A}; I_{Bon} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 25\text{ }^\circ\text{C};$ inductive load; Fig. 14 ; Fig. 15	-	0.1	0.5	μs
		$I_C = 2\text{ A}; I_{Bon} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 100\text{ }^\circ\text{C};$ inductive load; Fig. 14 ; Fig. 15	-	0.16	0.9	μs

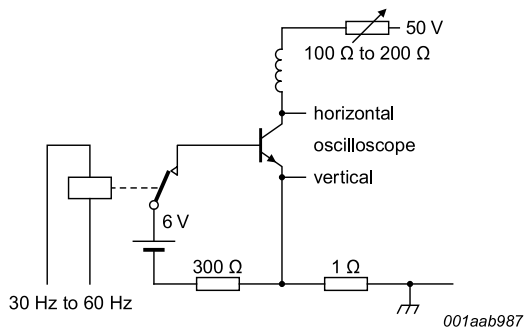


Fig. 6. Test circuit for collector-emitter sustaining voltage

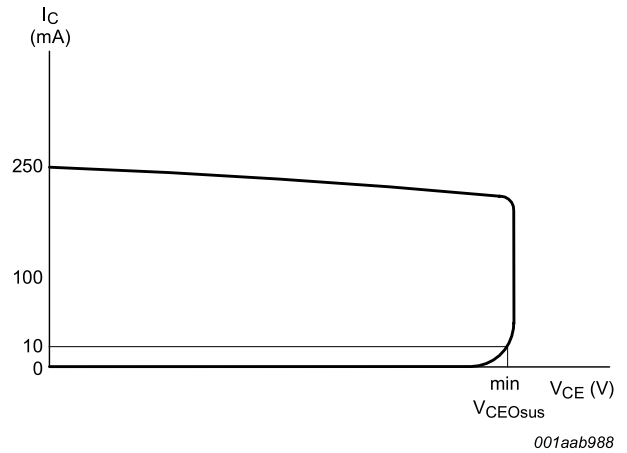


Fig. 7. Oscilloscope display for collector-emitter sustaining voltage test waveform

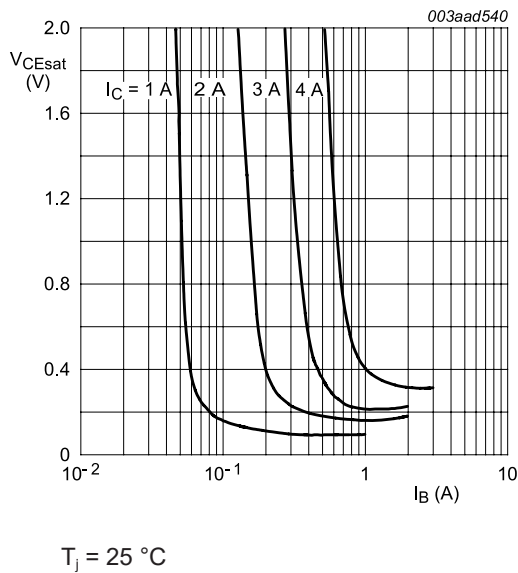


Fig. 8. Collector-emitter saturation voltage; typical values

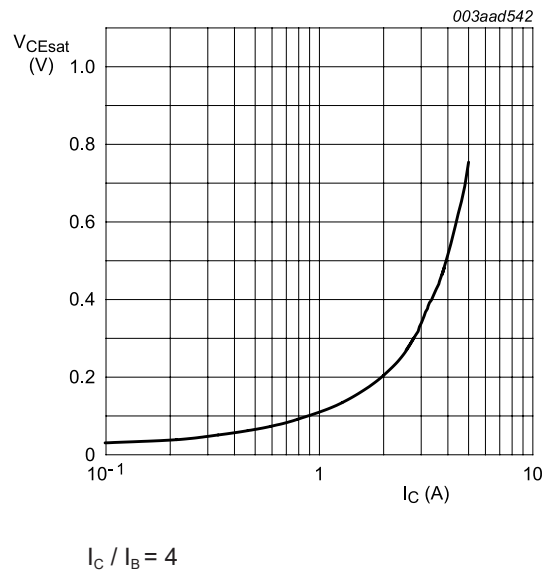


Fig. 9. Collector-emitter saturation voltage as a function of collector current; typical values

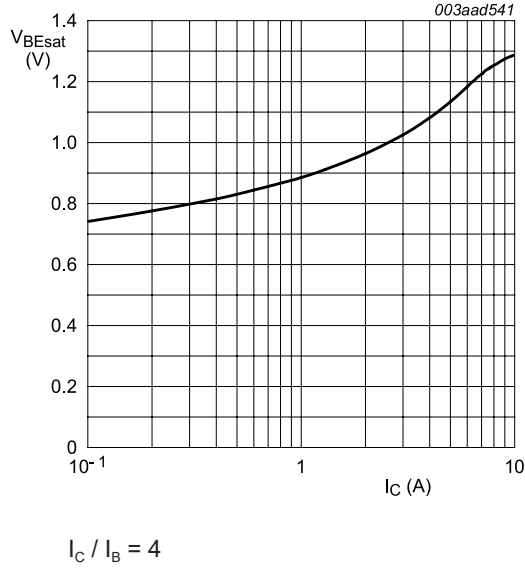


Fig. 10. Base-emitter saturation voltage; typical values

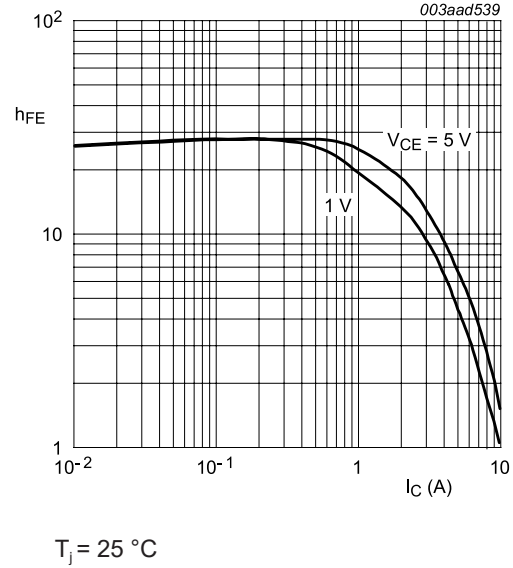


Fig. 11. DC current gain as a function of collector current; typical values

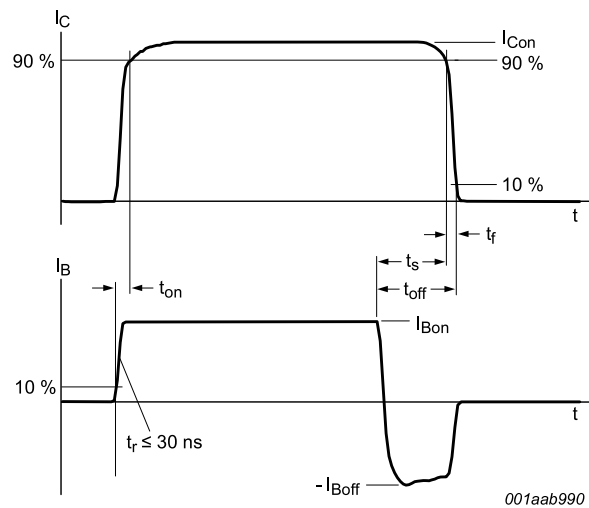
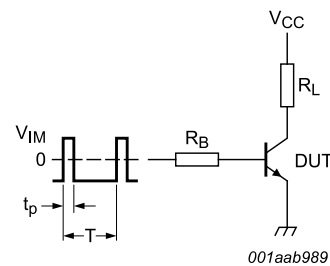


Fig. 12. Switching times waveforms for resistive load



$V_{IM} = -6$ to $+8$ V; $V_{CC} = 250$ V; $t_p = 20$ μ s;
 $\delta = t_p / T = 0.01$
 R_B and R_L calculated from I_{Con} and I_{Bon} requirements.

Fig. 13. Test circuit for resistive load switching

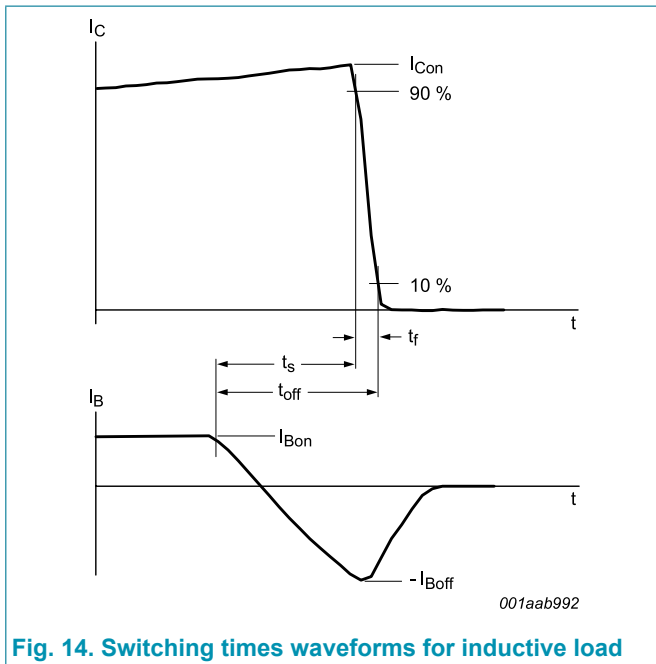


Fig. 14. Switching times waveforms for inductive load

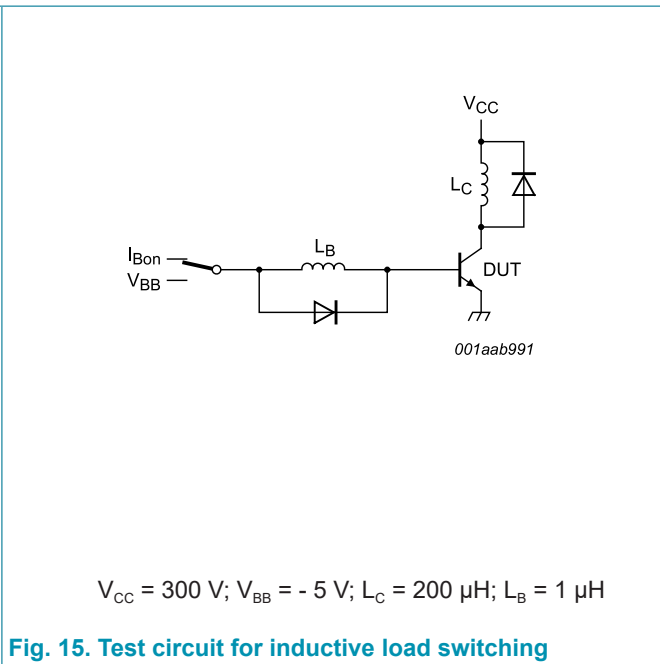


Fig. 15. Test circuit for inductive load switching

10. Isolation characteristics

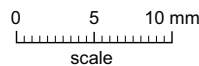
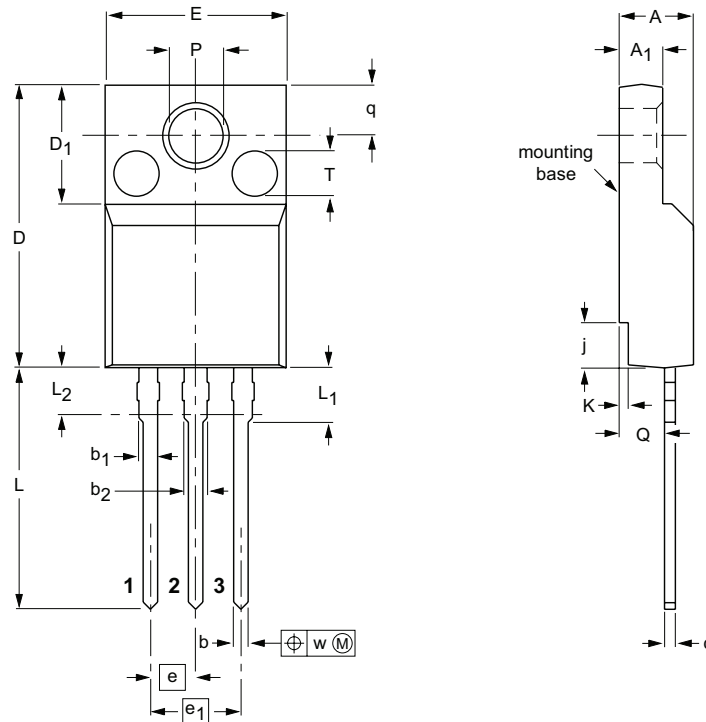
Table 8. Isolation characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{isol(RMS)}$	RMS isolation voltage	from all terminals to external heatsink; clean and dust free; $50\text{ Hz} \leq f \leq 60\text{ Hz}$; $RH \leq 65\%$; $T_h = 25\text{ }^\circ\text{C}$	-	-	2500	V
C_{isol}	isolation capacitance	from collector to external heatsink; $f = 1\text{ MHz}$; $T_h = 25\text{ }^\circ\text{C}$	-	10	-	pF

11. Package outline

Plastic single-ended package; isolated heatsink mounted;
1 mounting hole; 3-lead TO-220 'full pack'

SOT186A



DIMENSIONS (mm are the original dimensions)

UNIT	A	A ₁	b	b ₁	b ₂	c	D	D ₁	E	e	e ₁	j	K	L	L ₁	L ₂ ⁽¹⁾ max.	P	Q	q	T ⁽²⁾	w
mm	4.6 4.0	2.9 2.5	0.9 0.7	1.1 0.9	1.4 1.0	0.7 0.4	15.8 15.2	6.5 6.3	10.3 9.7	2.54	5.08	2.7 1.7	0.6 0.4	14.4 13.5	3.30 2.79	3	3.2 3.0	2.6 2.3	3.0 2.6	2.5	0.4

Notes

- 1. Terminal dimensions within this zone are uncontrolled.
- 2. Both recesses are $\square 2.5 \times 0.8$ max. depth

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT186A		3-lead TO-220F				02-04-09 06-02-14

12. Revision history

Table 9. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
PHE13005X v.3	20180426	Product data sheet	-	PHE13005X_2
Modifications:	Change from NXP version to WeEn version			
PHE13005X_2	2091120	Product data sheet	-	PHE13005X_1
Modifications:	Various changes to content.			
PHE13005X_1	20080515	Product data sheet	-	-

13. Legal information

Data sheet status

Document status [1][2]	Product status [3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

- [1] Please consult the most recently issued document before initiating or completing a design.
- [2] The term 'short data sheet' is explained in section "Definitions".
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