

PHE13005X

Silicon diffused power transistor

Rev. 02 — 20 November 2009

Product data sheet

1. Product profile

1.1 General description

High-voltage, high-speed planar-passivated, NPN power switching transistor in a full pack plastic package for use in high frequency electronic lighting ballast applications

1.2 Features and benefits

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

1.3 Applications

- Electronic lighting ballasts

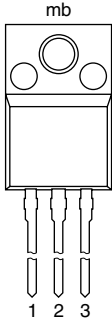
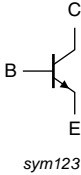
1.4 Quick reference data

Table 1. Quick reference

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

2. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	B	base	 <p>SOT186A (TO-220F)</p>	 <p><i>sym123</i></p>
2	C	collector		
3	E	emitter		
mb	n.c.	isolated		

3. Ordering information

Table 3. Ordering information

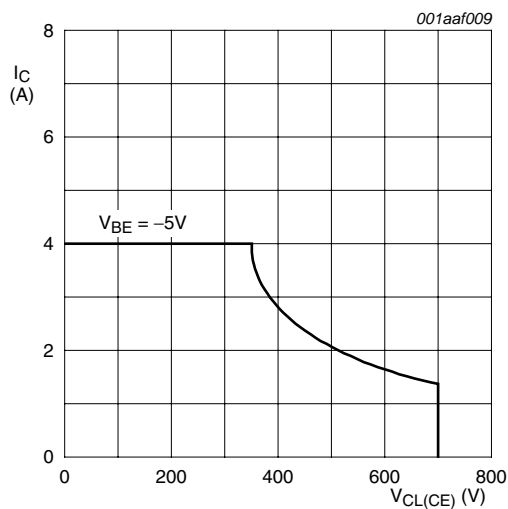
Type number	Package		Version
	Name	Description	
PHE13005X	TO-220F	plastic single-ended package; isolated heatsink mounted; 1 mounting hole; 3-lead TO-220 "full pack"	SOT186A

4. Limiting values

Table 4. Limiting values

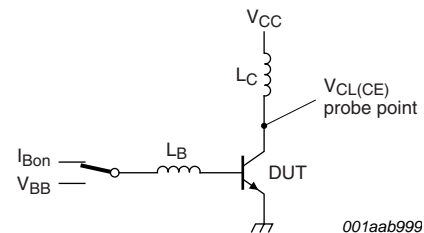
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	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; see Figure 3, 1 and 2	-	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	$T_h \leq 25\text{ °C}$; see Figure 4	-	26	W
T_{stg}	storage temperature		-65	150	°C
T_j	junction temperature		-	150	°C



$$T_j = T_{j(max)}\text{ °C}$$

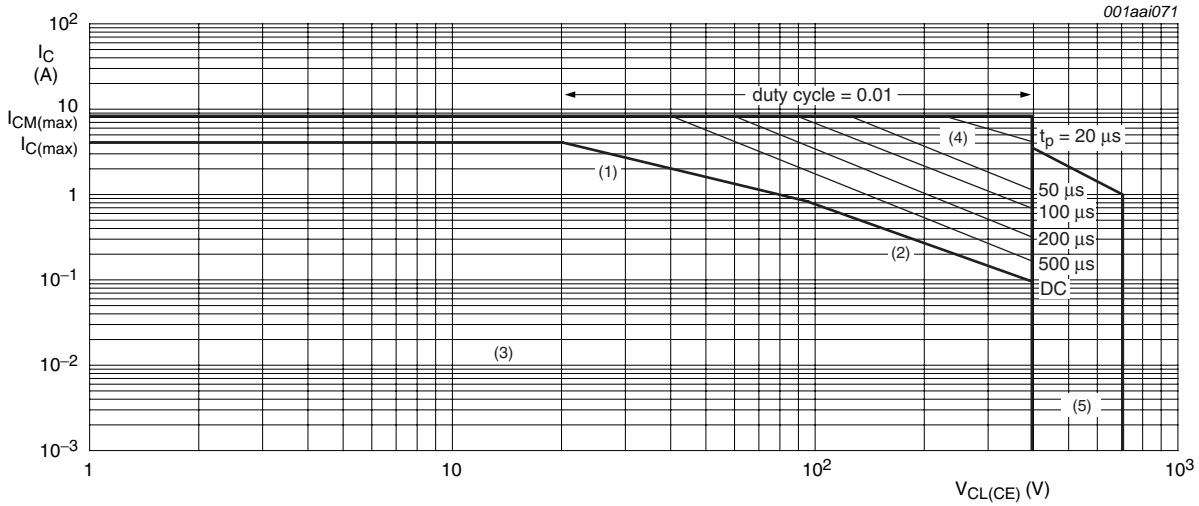
Fig 1. Reverse bias safe operating area



$$V_{CL(CE)} \leq 1000\text{ V}; V_{CC} = 150\text{ V}; V_{BB} = -5\text{ V};$$

$$L_B = 1\text{ }\mu\text{H}; L_C = 200\text{ }\mu\text{H}$$

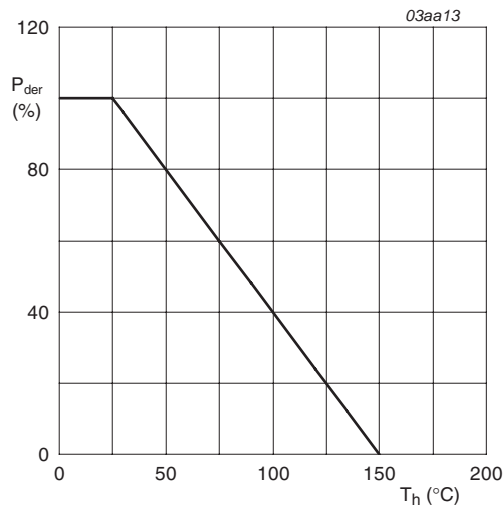
Fig 2. Test circuit for reverse bias safe operating area



$T_h \leq 25^\circ C$ Mounted with heatsink compound and $(30 \pm 5)N$ force on the centre 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 $t_p \leq 0.6 \mu s$

Fig 3. Forward bias safe operating area



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

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

5. Thermal characteristics

Table 5. Thermal characteristics

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

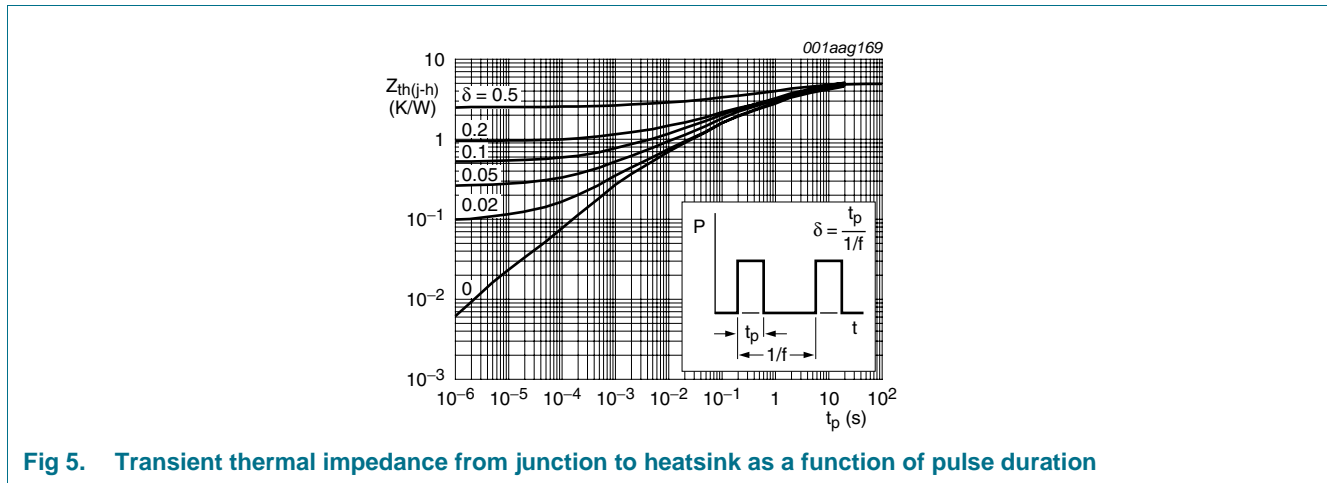


Fig 5. Transient thermal impedance from junction to heatsink as a function of pulse duration

6. 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	$V_{CE} = 400\text{ V}; I_B = 0\text{ A}; T_h = 25\text{ }^\circ\text{C}$	-	-	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_{CE0sus}	collector-emitter sustaining voltage	$I_B = 0\text{ A}; I_C = 10\text{ mA}; L_C = 25\text{ mH}; T_h = 25\text{ }^\circ\text{C}$; see Figure 6 and 7	400	-	-	V
V_{CEsat}	collector-emitter saturation voltage	$I_C = 1\text{ A}; I_B = 0.2\text{ A}; T_h = 25\text{ }^\circ\text{C}$; see Figure 8 and 9	-	0.1	0.5	V
		$I_C = 2\text{ A}; I_B = 0.5\text{ A}; T_h = 25\text{ }^\circ\text{C}$; see Figure 8 and 9	-	0.2	0.6	V
		$I_C = 4\text{ A}; I_B = 1\text{ A}; T_h = 25\text{ }^\circ\text{C}$; see Figure 8 and 9	-	0.3	1	V
V_{BEsat}	base-emitter saturation voltage	$I_C = 1\text{ A}; I_B = 0.2\text{ A}; T_h = 25\text{ }^\circ\text{C}$; see Figure 10	-	0.85	1.2	V
		$I_C = 2\text{ A}; I_B = 0.5\text{ A}; T_h = 25\text{ }^\circ\text{C}$; see Figure 10	-	0.92	1.6	V
h_{FE}	DC current gain	$I_C = 1\text{ A}; V_{CE} = 5\text{ V}; T_h = 25\text{ }^\circ\text{C}$; see Figure 11	12	20	40	
		$I_C = 2\text{ A}; V_{CE} = 5\text{ V}; T_h = 25\text{ }^\circ\text{C}$; see Figure 11	10	17	28	
Dynamic characteristics						
t_s	storage time	$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; I_{B0f} = -0.4\text{ A}; R_L = 75\text{ }\Omega; T_h = 25\text{ }^\circ\text{C}$; resistive load; see Figure 12 and 13	-	2.7	4	μs
		$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 25\text{ }^\circ\text{C}$; inductive load; see Figure 14 and 15	-	1.2	2	μs
		$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 100\text{ }^\circ\text{C}$; inductive load; see Figure 14 and 15	-	1.4	4	μs
t_f	fall time	$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; I_{B0f} = -0.4\text{ A}; R_L = 75\text{ }\Omega; T_h = 25\text{ }^\circ\text{C}$; resistive load; see Figure 13 and 12	-	0.3	0.9	μs
		$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 25\text{ }^\circ\text{C}$; inductive load; see Figure 14 and 15	-	0.1	0.5	μs
		$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 100\text{ }^\circ\text{C}$; inductive load; see Figure 14 and 15	-	0.16	0.9	μs

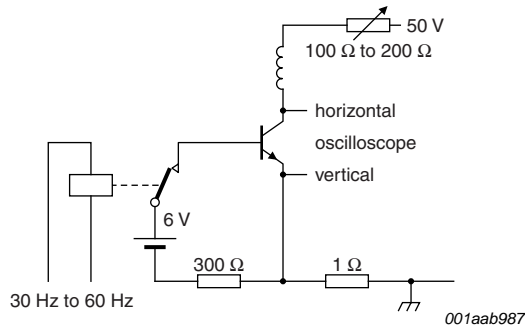


Fig 6. Test circuit for collector-emitter sustaining voltage

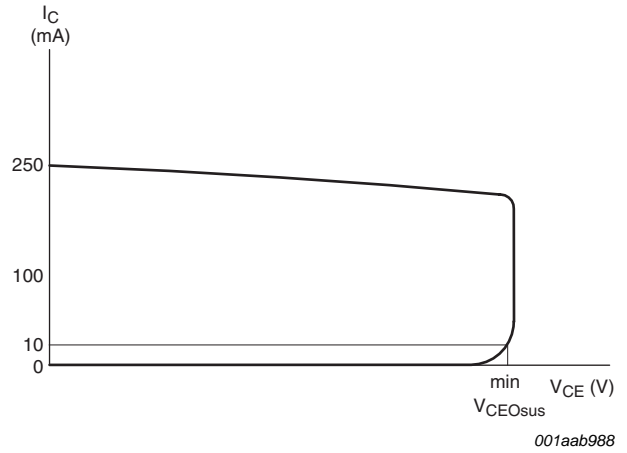


Fig 7. Oscilloscope display for collector-emitter sustaining voltage test waveform

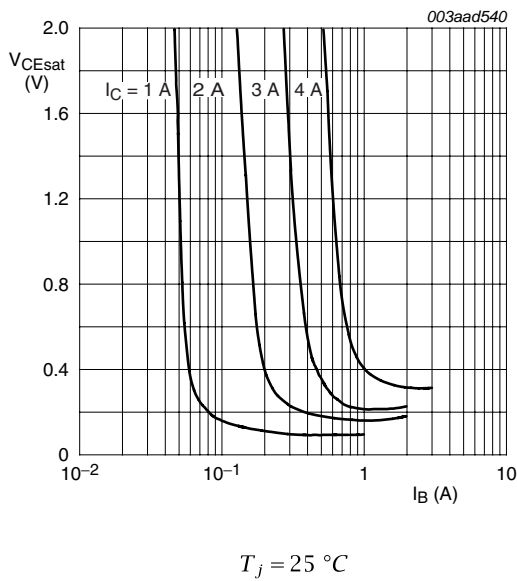


Fig 8. Collector-emitter saturation voltage; typical values

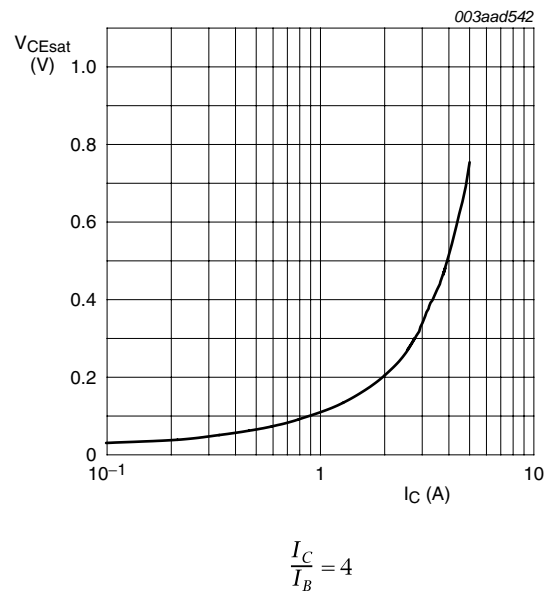
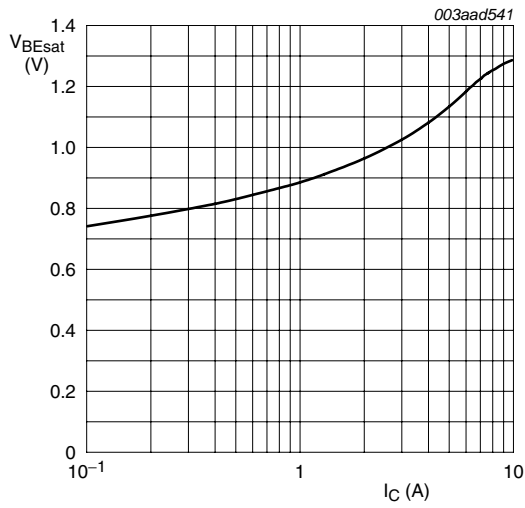
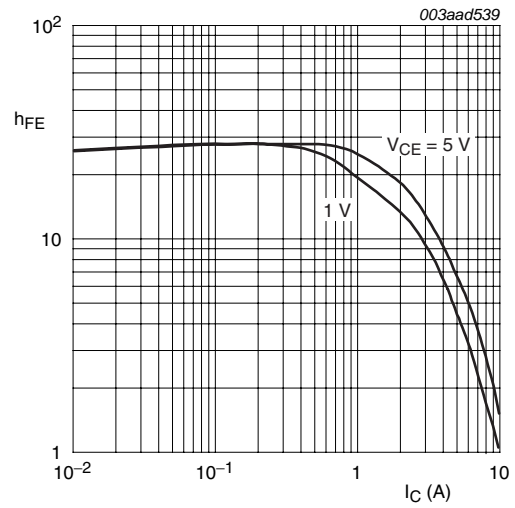


Fig 9. Collector-emitter saturation voltage as a function of collector current; typical values



$$\frac{I_C}{I_B} = 4$$

Fig 10. Base-emitter saturation voltage; typical values



$$T_j = 25 \text{ }^\circ\text{C}$$

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

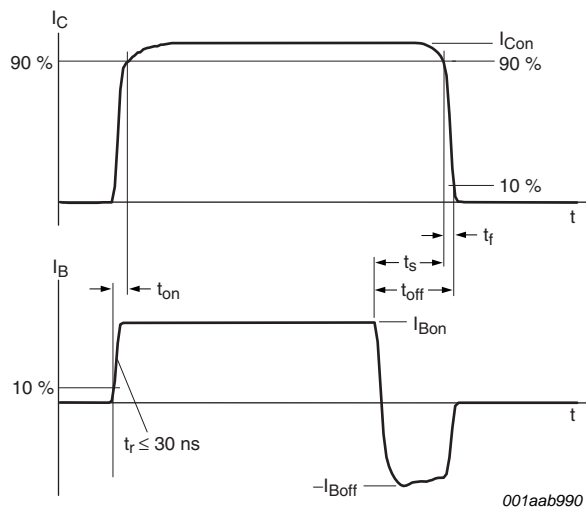
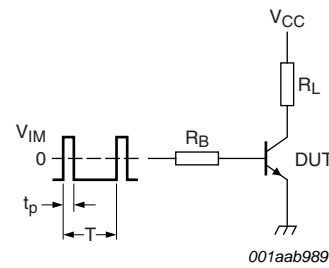


Fig 12. Switching times waveforms for resistive load



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

Fig 13. Test circuit for resistive load switching

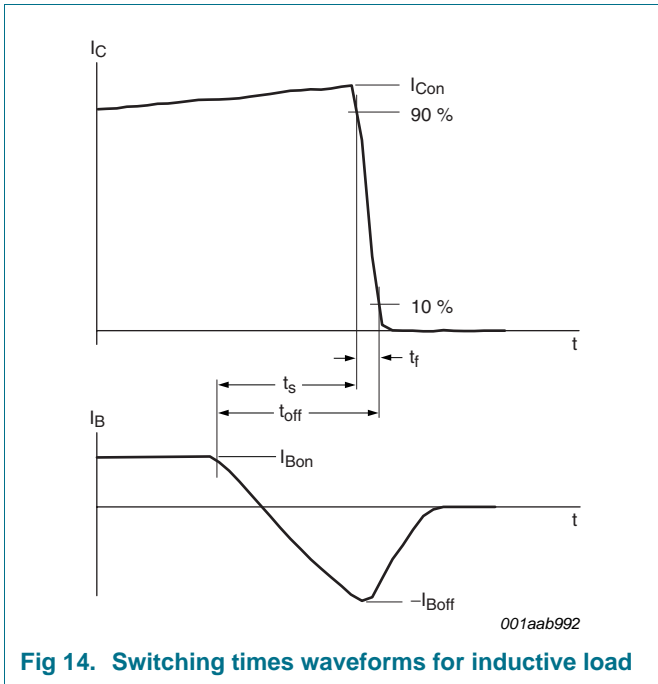
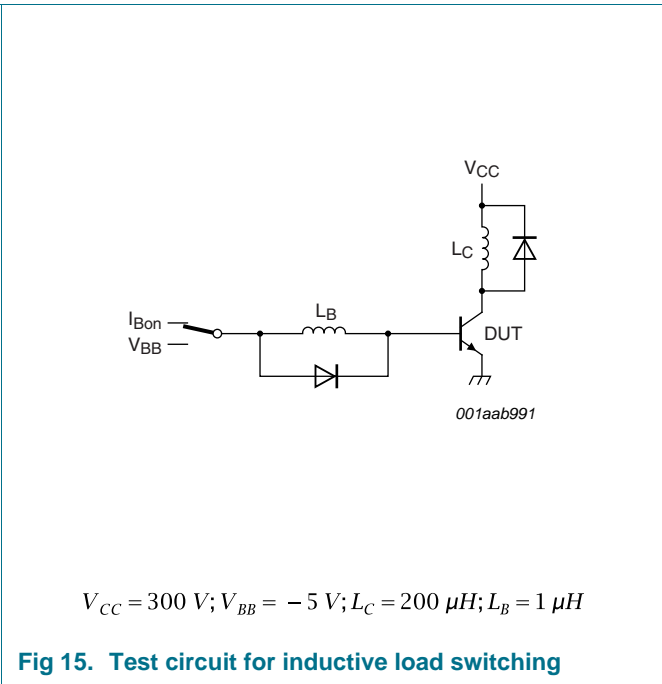


Fig 14. Switching times waveforms for inductive load



$V_{CC} = 300\text{ V}; V_{BB} = -5\text{ V}; L_C = 200\ \mu\text{H}; L_B = 1\ \mu\text{H}$

Fig 15. Test circuit for inductive load switching

7. Isolation characteristics

Table 7. Isolation characteristics

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

8. Package outline

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

SOT186A

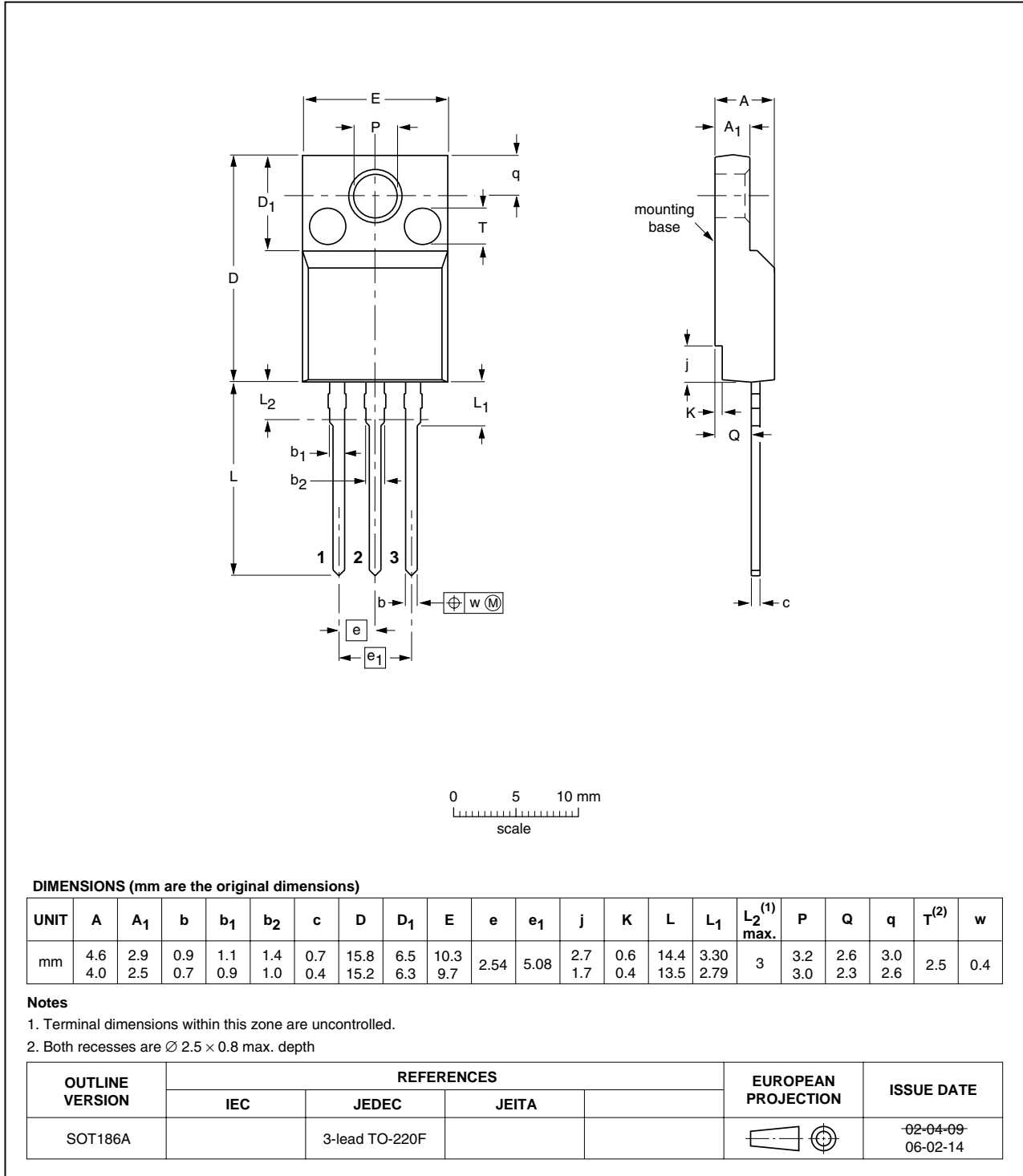


Fig 16. Package outline SOT186A (TO-220F)

9. Revision history

Table 8. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
PHE13005X_2	20091120	Product data sheet	-	PHE13005X_1
Modifications:	• Various changes to content.			
PHE13005X_1	20080515	Product data sheet	-	-

10. Legal information

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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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