



# IMPORTANT NOTICE

10 December 2015

## 1. Global joint venture starts operations as WeEn Semiconductors

Dear customer,

As from November 9th, 2015 NXP Semiconductors N.V. and Beijing JianGuang Asset Management Co. Ltd established Bipolar Power joint venture (JV), **WeEn Semiconductors**, which will be used in future Bipolar Power documents together with new contact details.

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Thank you for your cooperation and understanding,

WeEn Semiconductors



# 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

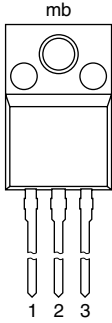
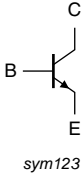
### 1.4 Quick reference data

Table 1. Quick reference

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

## 2. Pinning information

**Table 2. Pinning information**

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

## 3. Ordering information

**Table 3. Ordering information**

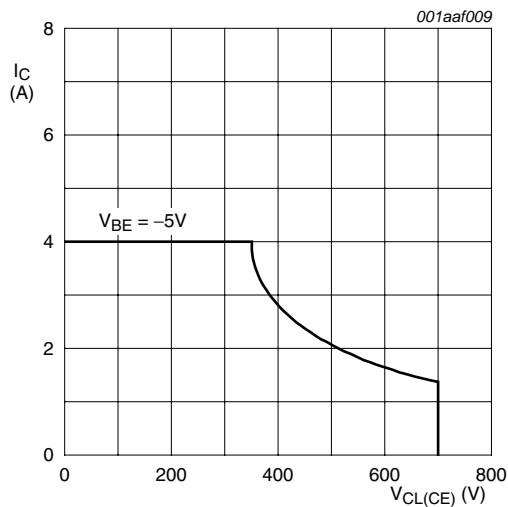
Type number	Package		Version
	Name	Description	
PHE13005X	TO-220F	plastic single-ended package; isolated heatsink mounted; 1 mounting hole; 3-lead TO-220 "full pack"	SOT186A

## 4. Limiting values

**Table 4. Limiting values**

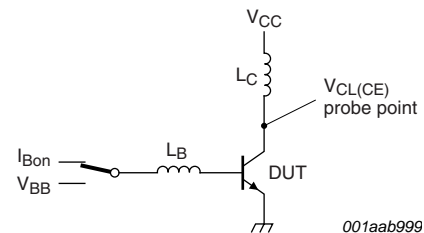
In accordance with the Absolute Maximum Rating System (IEC 60134).

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 <a href="#">Figure 3, 1</a> and <a href="#">2</a>	-	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 <a href="#">Figure 4</a>	-	26	W
$T_{stg}$	storage temperature		-65	150	°C
$T_j$	junction temperature		-	150	°C



$$T_j = T_{j(max)}\text{ °C}$$

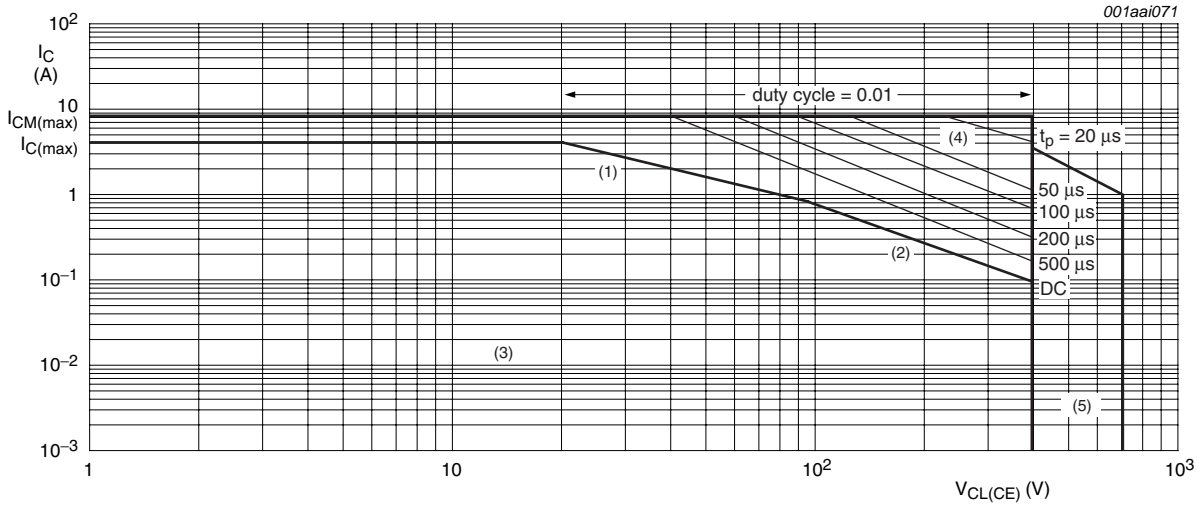
**Fig 1. Reverse bias safe operating area**



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

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

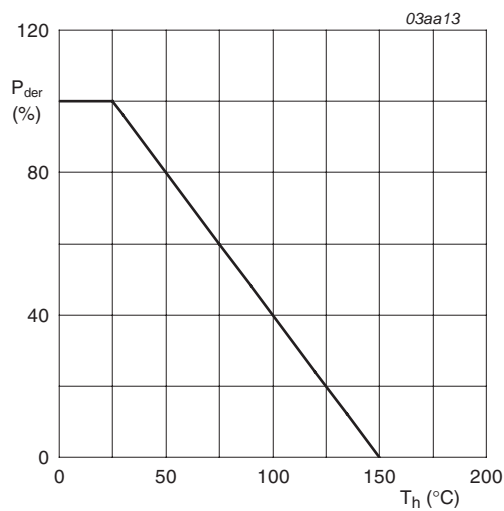
**Fig 2. Test circuit for reverse bias safe operating area**



$T_h \leq 25^\circ C$  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



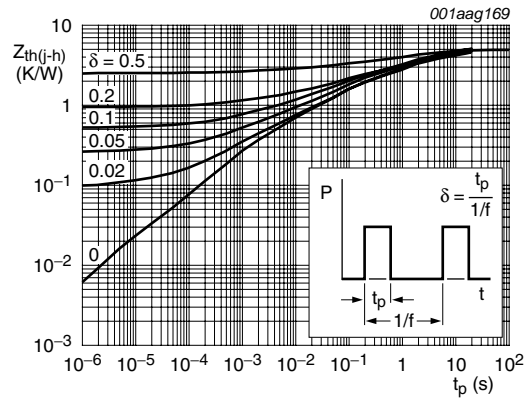
$$P_{der} = \frac{P_{tot}}{P_{tot(25^\circ C)}} \times 100\%$$

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 <a href="#">Figure 5</a>	-	-	4.8	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient		-	55	-	K/W

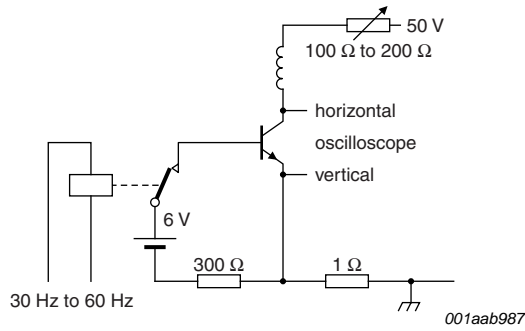


**Fig 5. Transient thermal impedance from junction to heatsink as a function of pulse duration**

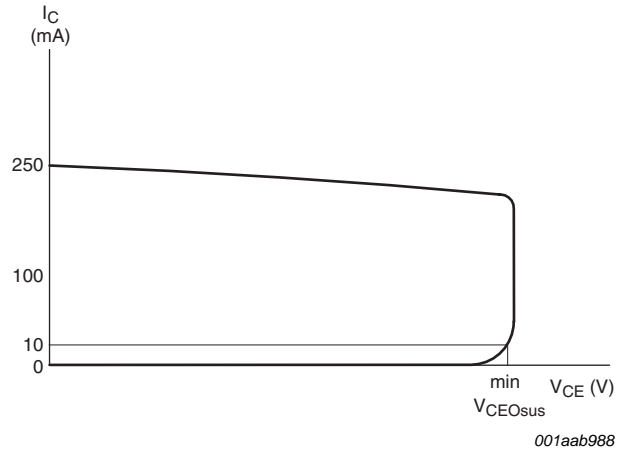
## 6. Characteristics

**Table 6. Characteristics**

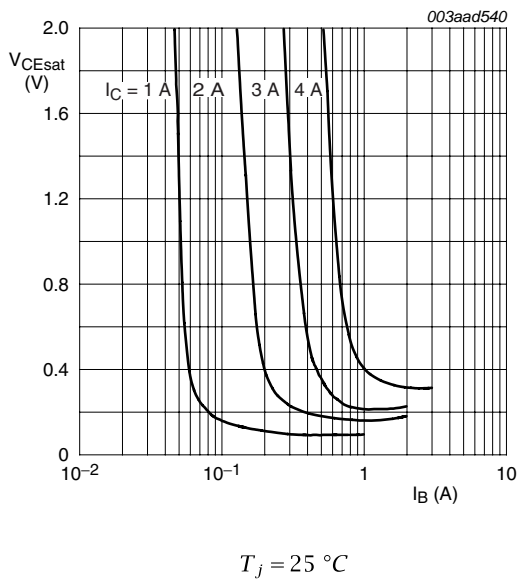
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics</b>						
$I_{CES}$	collector-emitter cut-off current	$V_{BE} = 0\text{ V}; V_{CE} = 700\text{ V}; T_j = 25\text{ }^\circ\text{C}$	-	-	1	mA
		$V_{BE} = 0\text{ V}; V_{CE} = 700\text{ V}; T_j = 100\text{ }^\circ\text{C}$	-	-	5	mA
$I_{CBO}$	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 <a href="#">Figure 6</a> and <a href="#">7</a>	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 <a href="#">Figure 8</a> and <a href="#">9</a>	-	0.1	0.5	V
		$I_C = 2\text{ A}; I_B = 0.5\text{ A}; T_h = 25\text{ }^\circ\text{C}$ ; see <a href="#">Figure 8</a> and <a href="#">9</a>	-	0.2	0.6	V
		$I_C = 4\text{ A}; I_B = 1\text{ A}; T_h = 25\text{ }^\circ\text{C}$ ; see <a href="#">Figure 8</a> and <a href="#">9</a>	-	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 <a href="#">Figure 10</a>	-	0.85	1.2	V
		$I_C = 2\text{ A}; I_B = 0.5\text{ A}; T_h = 25\text{ }^\circ\text{C}$ ; see <a href="#">Figure 10</a>	-	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 <a href="#">Figure 11</a>	12	20	40	
		$I_C = 2\text{ A}; V_{CE} = 5\text{ V}; T_h = 25\text{ }^\circ\text{C}$ ; see <a href="#">Figure 11</a>	10	17	28	
<b>Dynamic characteristics</b>						
$t_s$	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 <a href="#">Figure 12</a> and <a href="#">13</a>	-	2.7	4	$\mu\text{s}$
		$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 25\text{ }^\circ\text{C}$ ; inductive load; see <a href="#">Figure 14</a> and <a href="#">15</a>	-	1.2	2	$\mu\text{s}$
		$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 100\text{ }^\circ\text{C}$ ; inductive load; see <a href="#">Figure 14</a> and <a href="#">15</a>	-	1.4	4	$\mu\text{s}$
$t_f$	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 <a href="#">Figure 13</a> and <a href="#">12</a>	-	0.3	0.9	$\mu\text{s}$
		$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 25\text{ }^\circ\text{C}$ ; inductive load; see <a href="#">Figure 14</a> and <a href="#">15</a>	-	0.1	0.5	$\mu\text{s}$
		$I_C = 2\text{ A}; I_{B0n} = 0.4\text{ A}; V_{BB} = -5\text{ V}; L_B = 1\text{ }\mu\text{H}; T_h = 100\text{ }^\circ\text{C}$ ; inductive load; see <a href="#">Figure 14</a> and <a href="#">15</a>	-	0.16	0.9	$\mu\text{s}$



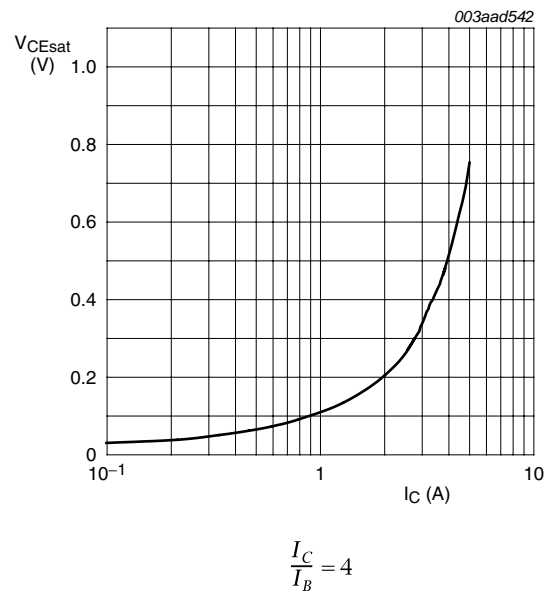
**Fig 6. Test circuit for collector-emitter sustaining voltage**



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

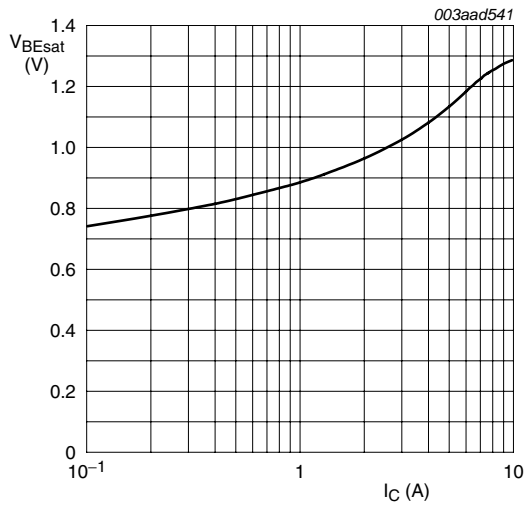


**Fig 8. Collector-emitter saturation voltage; typical values**



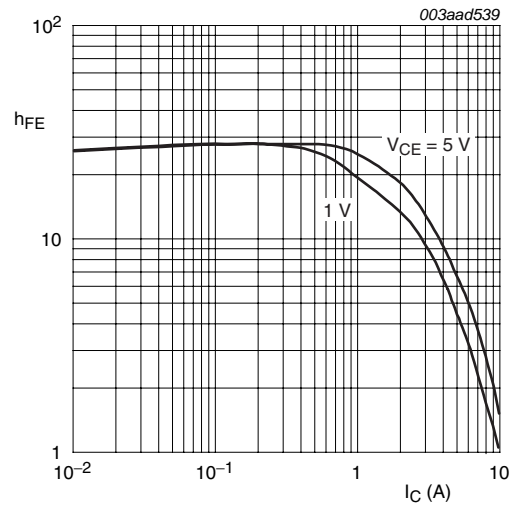
**Fig 9. Collector-emitter saturation voltage as a function of collector current; typical values**





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

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

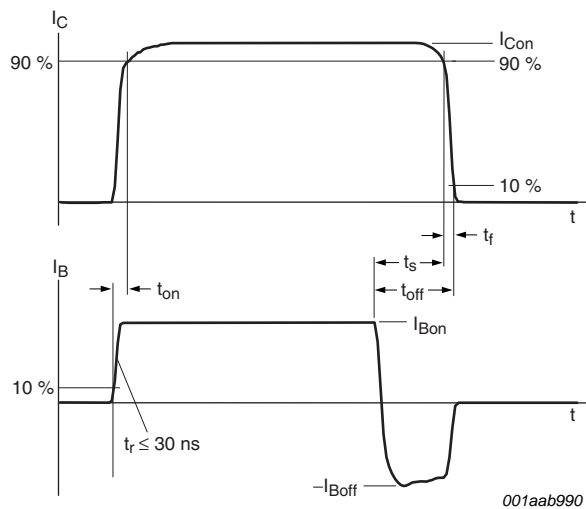
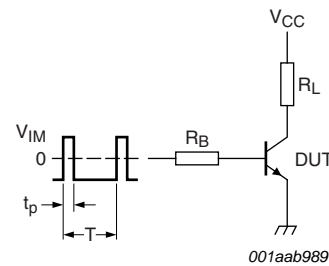


Fig 12. Switching times waveforms for resistive load



$V_{IM} = -6$  to  $+8$  V;  $V_{CC} = 250$  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

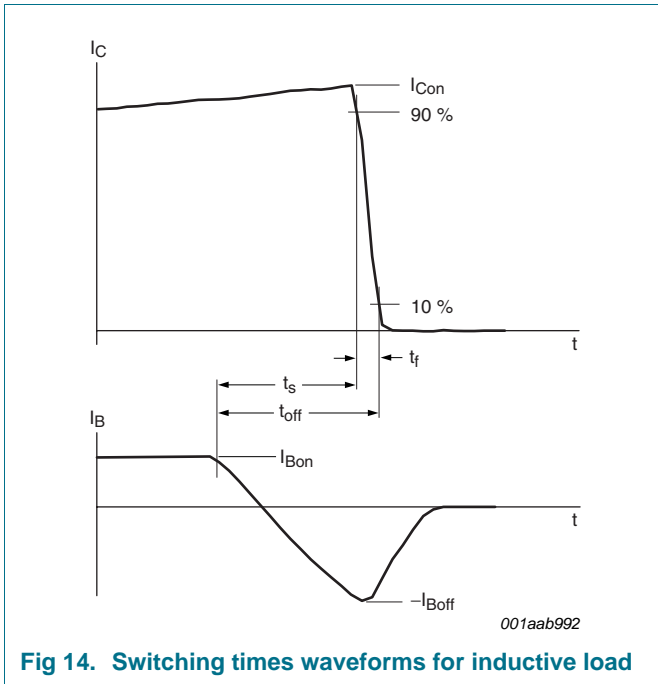
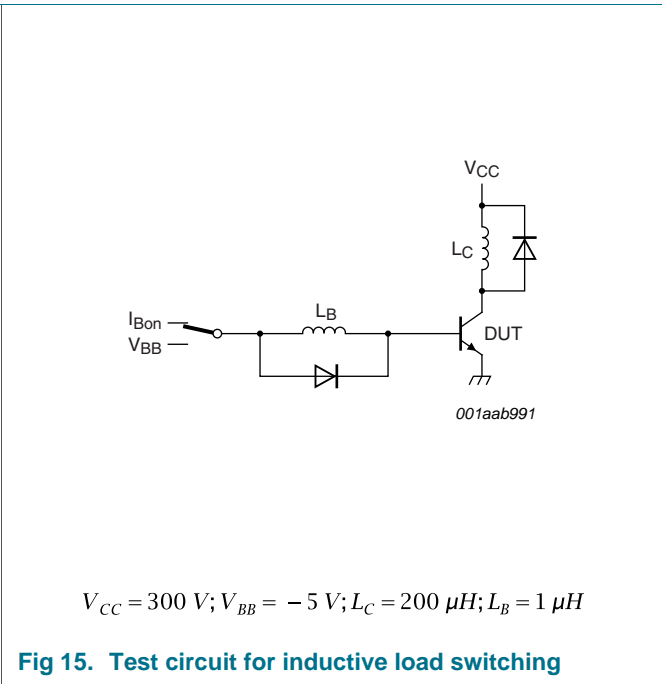


Fig 14. Switching times waveforms for inductive load



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

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
$C_{\text{isol}}$	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

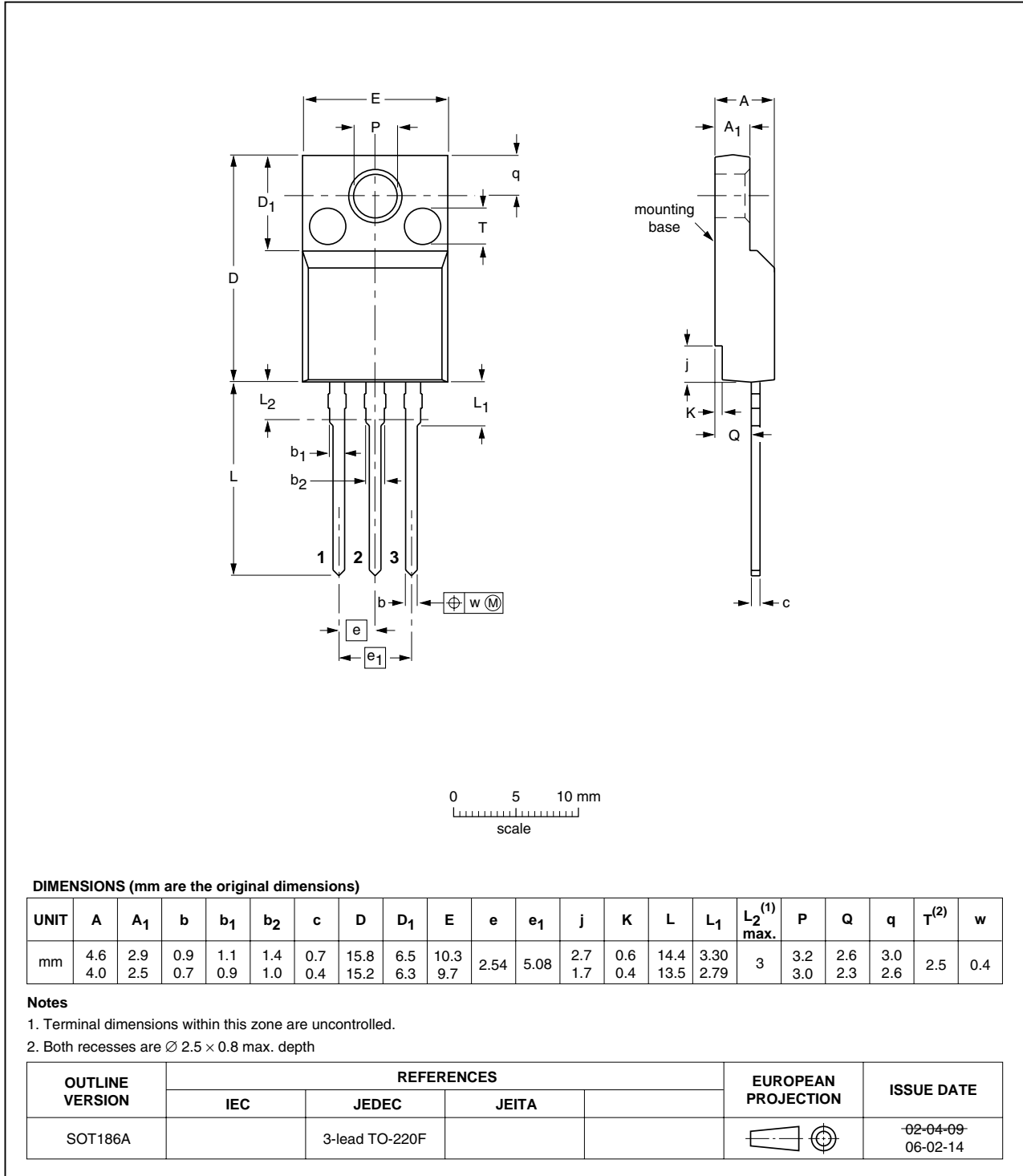


Fig 16. Package outline SOT186A (TO-220F)

## 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

### 10.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	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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