



# PHE13005

Silicon diffused power transistor

21 January 2014

Product data sheet

## 1. General description

High voltage, high speed NPN planar-passivated power switching transistor in a SOT78 plastic package intended for use in high frequency electronic lighting ballast applications

## 2. Features and benefits

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

## 3. Applications

- Electronic lighting ballasts

## 4. Quick reference data

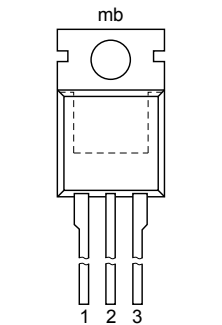
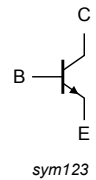
Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$I_C$	collector current	DC; <a href="#">Fig. 4</a> ; <a href="#">Fig. 1</a> ; <a href="#">Fig. 2</a>	-	-	4	A
$P_{tot}$	total power dissipation	$T_{mb} \leq 25\text{ °C}$ ; <a href="#">Fig. 3</a>	-	-	75	W
$V_{CESM}$	collector-emitter peak voltage	$V_{BE} = 0\text{ V}$	-	-	700	V
<b>Static characteristics</b>						
$h_{FE}$	DC current gain	$I_C = 1\text{ A}$ ; $V_{CE} = 5\text{ V}$ ; $T_{mb} = 25\text{ °C}$ ; <a href="#">Fig. 11</a>	12	20	40	
		$I_C = 2\text{ A}$ ; $V_{CE} = 5\text{ V}$ ; $T_{mb} = 25\text{ °C}$ ; <a href="#">Fig. 11</a>	10	17	28	



## 5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	B	base	 <p>TO-220AB (SOT78)</p>	 <p>sym123</p>
2	C	collector		
3	E	emitter		
mb	C	mounting base; connected to collector		

## 6. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
PHE13005	TO-220AB	plastic single-ended package; heatsink mounted; 1 mounting hole; 3-lead TO-220AB	SOT78

## 7. 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; Fig. 4; Fig. 1; Fig. 2	-	4	A
$I_{CM}$	peak collector current		-	8	A
$I_B$	base current	DC	-	2	A
$I_{BM}$	peak base current		-	4	A
$P_{tot}$	total power dissipation	$T_{mb} \leq 25\text{ °C}$ ; Fig. 3	-	75	W
$T_{stg}$	storage temperature		-65	150	°C
$T_j$	junction temperature		-	150	°C
$V_{EBO}$	emitter-base voltage	$I_C = 0\text{ A}$	-	9	V

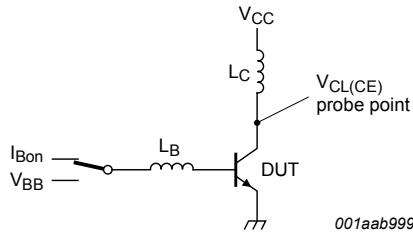


Fig. 1. Test circuit for reverse bias safe operating area

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

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

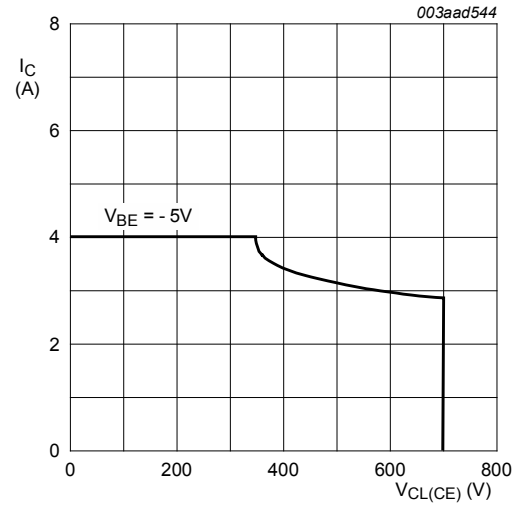


Fig. 2. Reverse bias safe operating area

$$T_j \leq T_{j(max)} \text{ } ^\circ\text{C}$$

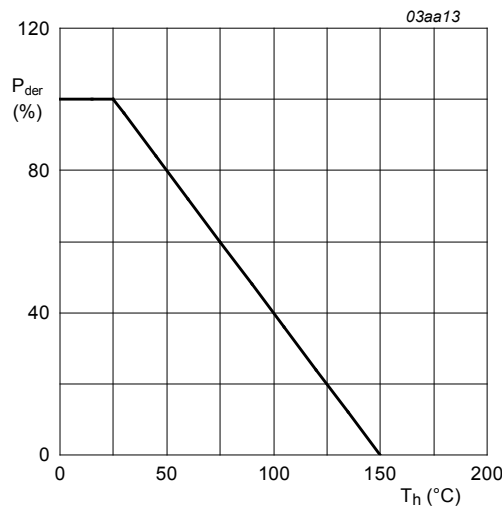


Fig. 3. Normalized total power dissipation as a function of heatsink temperature

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

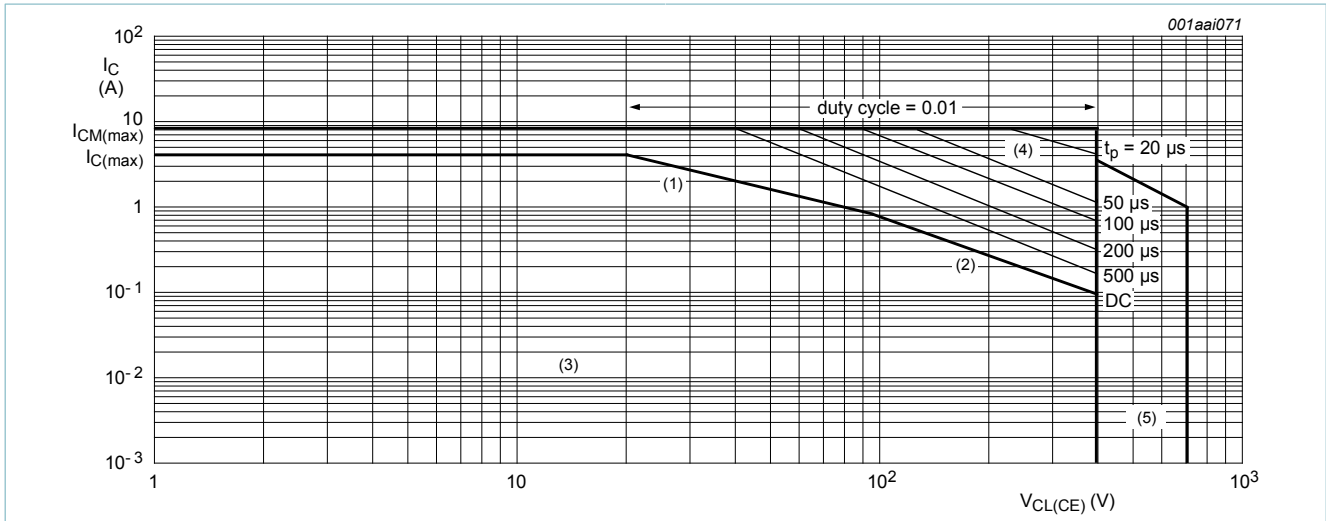


Fig. 4. Forward bias safe operating area

maximum lines(2)Second breakdown limits(3)Region of permissible DC operation(4)Extension of operating region for repetitive pulse operation

### 8. Thermal characteristics

Table 5. Thermal characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$R_{th(j-mb)}$	thermal resistance from junction to mounting base	Fig. 5	-	-	1.67	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	-	60	-	K/W

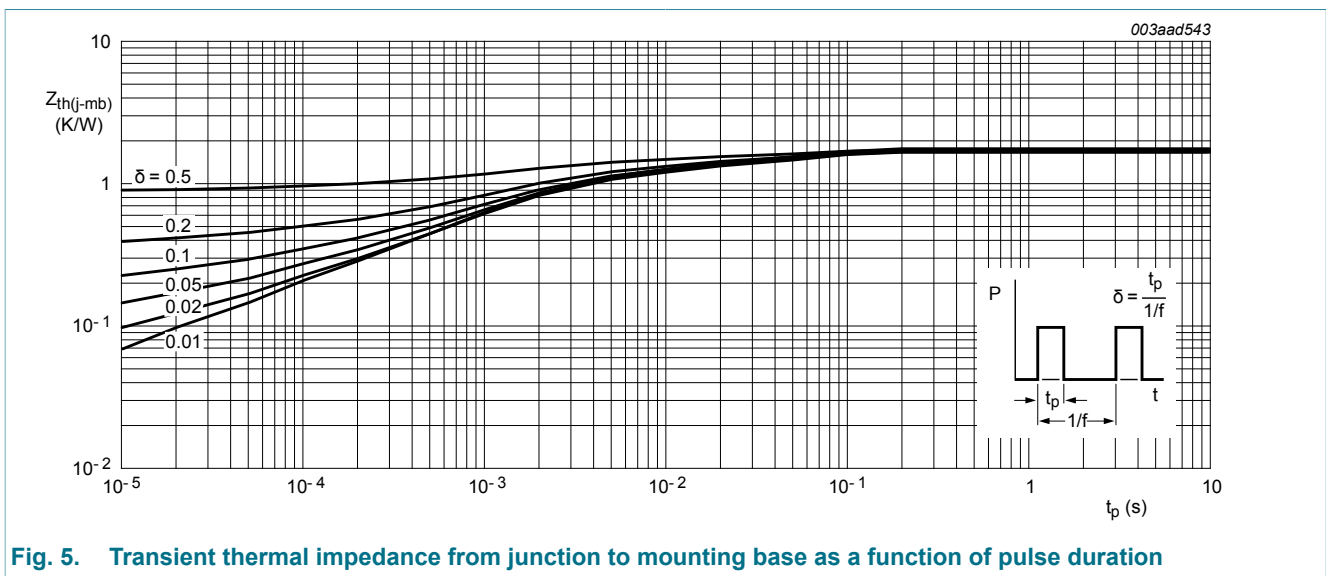


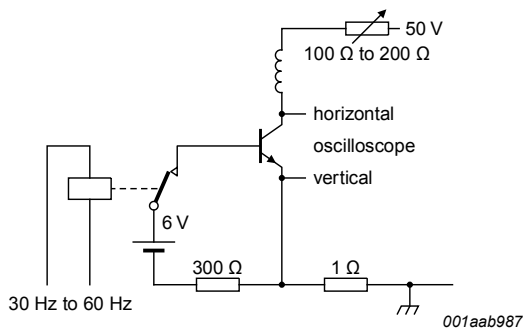
Fig. 5. Transient thermal impedance from junction to mounting base as a function of pulse duration

## 9. Characteristics

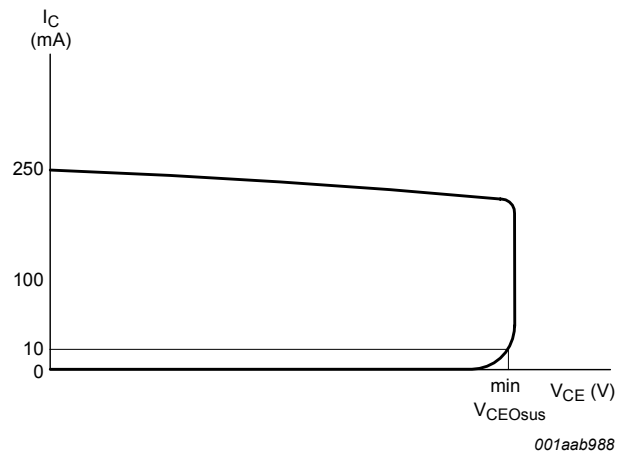
Table 6. Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Dynamic characteristics</b>						
$t_s$	storage time	$I_C = 2\text{ A}$ ; $I_{B(on)} = 0.4\text{ A}$ ; $I_{B(off)} = -0.4\text{ A}$ ; $R_L = 75\ \Omega$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; resistive load; <a href="#">Fig. 12</a> ; <a href="#">Fig. 13</a>	-	2.7	4	$\mu\text{s}$
		$I_C = 2\text{ A}$ ; $I_{B(on)} = 0.4\text{ A}$ ; $V_{BB} = -5\text{ V}$ ; $L_B = 1\ \mu\text{H}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; inductive load; <a href="#">Fig. 14</a> ; <a href="#">Fig. 15</a>	-	1.2	2	$\mu\text{s}$
		$I_C = 2\text{ A}$ ; $I_{B(on)} = 0.4\text{ A}$ ; $V_{BB} = -5\text{ V}$ ; $L_B = 1\ \mu\text{H}$ ; $T_{mb} = 100\text{ }^\circ\text{C}$ ; inductive load; <a href="#">Fig. 14</a> ; <a href="#">Fig. 15</a>	-	1.4	4	$\mu\text{s}$
$t_f$	fall time	$I_C = 2\text{ A}$ ; $I_{B(on)} = 0.4\text{ A}$ ; $I_{B(off)} = -0.4\text{ A}$ ; $R_L = 75\ \Omega$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; resistive load; <a href="#">Fig. 12</a> ; <a href="#">Fig. 13</a>	-	0.3	0.9	$\mu\text{s}$
		$I_C = 2\text{ A}$ ; $I_{B(on)} = 0.4\text{ A}$ ; $V_{BB} = -5\text{ V}$ ; $L_B = 1\ \mu\text{H}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; inductive load; <a href="#">Fig. 14</a> ; <a href="#">Fig. 15</a>	-	0.1	0.5	$\mu\text{s}$
		$I_C = 2\text{ A}$ ; $I_{B(on)} = 0.4\text{ A}$ ; $V_{BB} = -5\text{ V}$ ; $L_B = 1\ \mu\text{H}$ ; $T_{mb} = 100\text{ }^\circ\text{C}$ ; inductive load; <a href="#">Fig. 14</a> ; <a href="#">Fig. 15</a>	-	0.16	0.9	$\mu\text{s}$
<b>Static characteristics</b>						
$I_{CES}$	collector-emitter cut-off current	$V_{BE} = -1.5\text{ V}$ ; $V_{CE} = 700\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$	-	-	1	mA
		$V_{BE} = -1.5\text{ V}$ ; $V_{CE} = 700\text{ V}$ ; $T_j = 100\text{ }^\circ\text{C}$	-	-	5	mA
$I_{CBO}$	collector-base cut-off current	$V_{CB} = 700\text{ V}$ ; $I_E = 0\text{ A}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$	-	-	1	mA
$I_{CEO}$	collector-emitter cut-off current	$V_{CE} = 400\text{ V}$ ; $I_B = 0\text{ A}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$	-	-	0.1	mA
$I_{EBO}$	emitter-base cut-off current	$V_{EB} = 9\text{ V}$ ; $I_C = 0\text{ A}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$	-	-	1	mA
$V_{CEO(sus)}$	collector-emitter sustaining voltage	$I_B = 0\text{ A}$ ; $I_C = 10\text{ mA}$ ; $L_C = 25\text{ mH}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 6</a> ; <a href="#">Fig. 7</a>	400	-	-	V
$V_{CE(sat)}$	collector-emitter saturation voltage	$I_C = 1\text{ A}$ ; $I_B = 0.2\text{ A}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 8</a> ; <a href="#">Fig. 9</a>	-	0.1	0.5	V
		$I_C = 2\text{ A}$ ; $I_B = 0.5\text{ A}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 8</a> ; <a href="#">Fig. 9</a>	-	0.2	0.6	V
		$I_C = 4\text{ A}$ ; $I_B = 1\text{ A}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 8</a> ; <a href="#">Fig. 9</a>	-	0.3	1	V
$V_{BE(sat)}$	base-emitter saturation voltage	$I_C = 1\text{ A}$ ; $I_B = 0.2\text{ A}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 10</a>	-	0.85	1.2	V

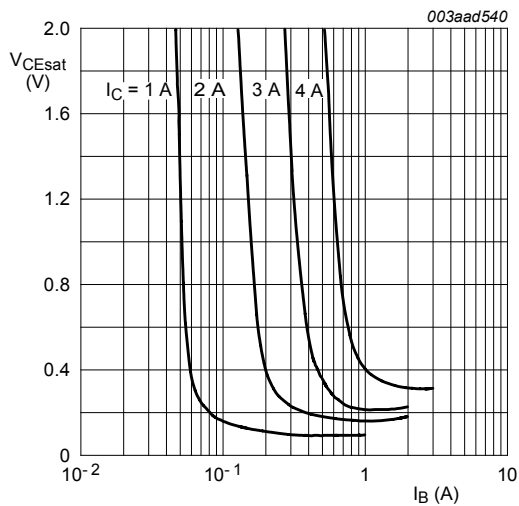
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		$I_C = 2\text{ A}$ ; $I_B = 0.5\text{ A}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 10</a>	-	0.92	1.6	V
$h_{FE}$	DC current gain	$I_C = 1\text{ A}$ ; $V_{CE} = 5\text{ V}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 11</a>	12	20	40	
		$I_C = 2\text{ A}$ ; $V_{CE} = 5\text{ V}$ ; $T_{mb} = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 11</a>	10	17	28	



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

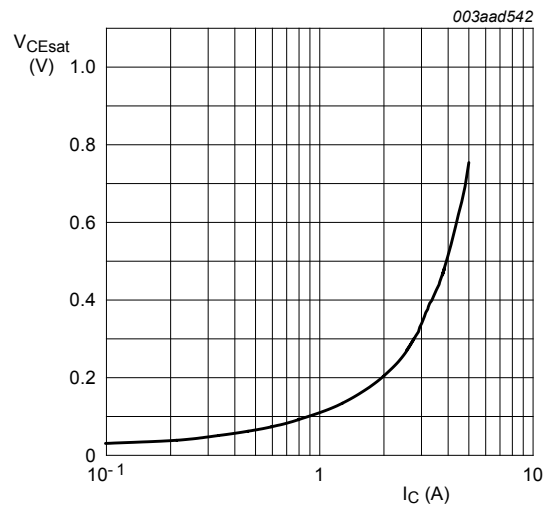


**Fig. 7. Oscilloscope display for collector-emitter sustaining voltage test waveform**



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

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



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

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

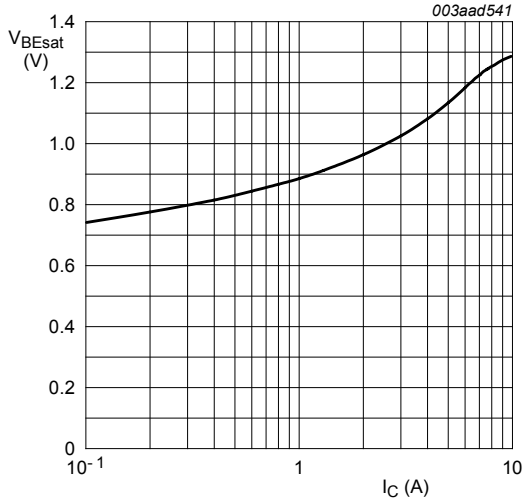


Fig. 10. Base-emitter saturation voltage; typical values

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

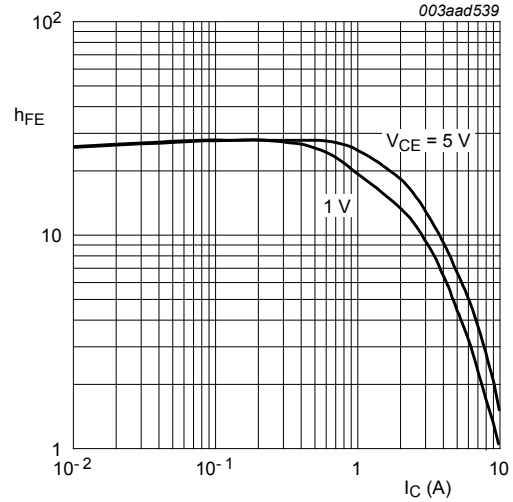


Fig. 11. DC current gain as a function of collector current; typical values

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

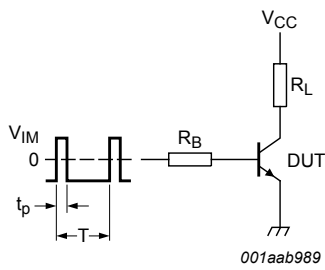


Fig. 12. Test circuit for resistive load switching

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

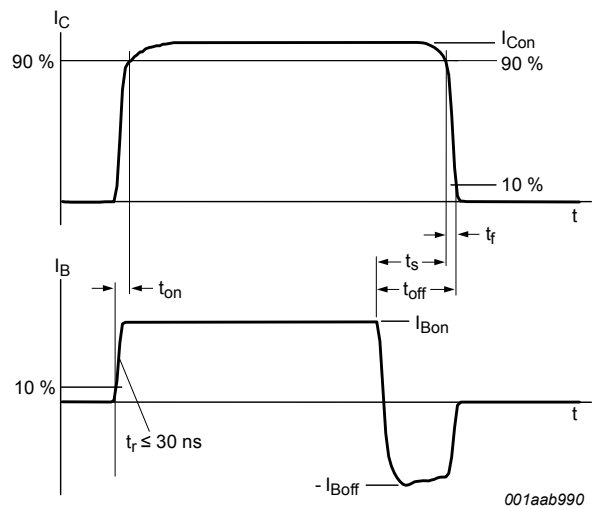
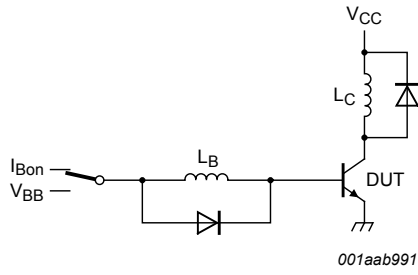
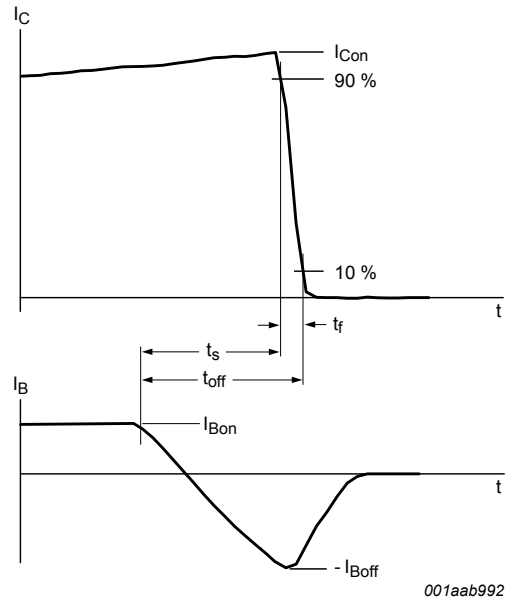


Fig. 13. Switching times waveforms for resistive load



**Fig. 14. Test circuit for inductive load switching**

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



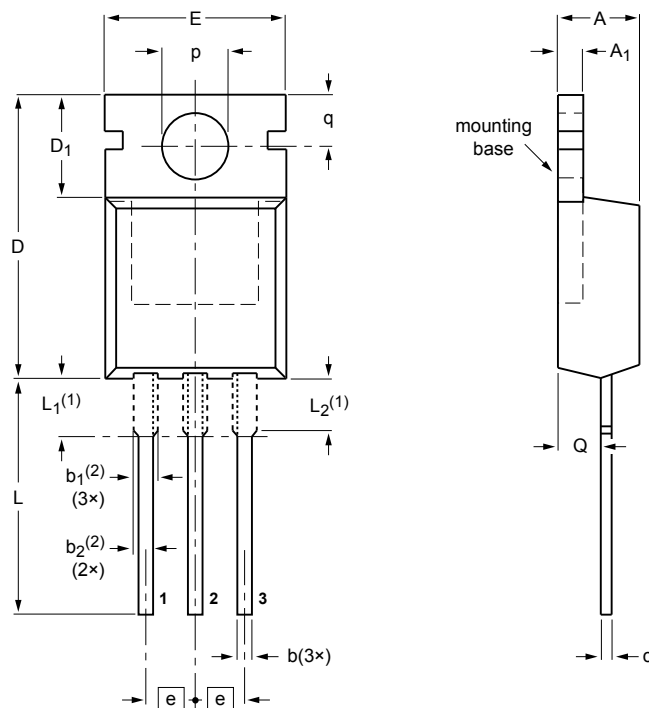
**Fig. 15. Switching times waveforms for inductive load**



### 10. Package outline

Plastic single-ended package; heatsink mounted; 1 mounting hole; 3-lead TO-220AB

SOT78



**DIMENSIONS** (mm are the original dimensions)

UNIT	A	A <sub>1</sub>	b	b <sub>1</sub> (2)	b <sub>2</sub> (2)	c	D	D <sub>1</sub>	E	e	L	L <sub>1</sub> (1)	L <sub>2</sub> (1) max.	p	q	Q
mm	4.7 4.1	1.40 1.25	0.9 0.6	1.6 1.0	1.3 1.0	0.7 0.4	16.0 15.2	6.6 5.9	10.3 9.7	2.54	15.0 12.8	3.30 2.79	3.0	3.8 3.5	3.0 2.7	2.6 2.2

**Notes**

- Lead shoulder designs may vary.
- Dimension includes excess dambar.

OUTLINE VERSION	REFERENCES			EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA		
SOT78		3-lead TO-220AB	SC-46		08-04-23 08-06-13

Fig. 16. Package outline TO-220AB (SOT78)

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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.
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