

# BUT12AX

Silicon diffused power transistor

Rev. 01 — 16 June 2004

Product data

## 1. Product profile

### 1.1 Description

High voltage, high speed, NPN power transistor in a plastic package.

### 1.2 Features

- Isolated package
- Fast switching.

### 1.3 Applications

- Inverters
- Switching regulators
- Motor control systems
- DC-to-DC converters.

### 1.4 Quick reference data

- $V_{CESM} \leq 1000 \text{ V}$
- $I_C \leq 8 \text{ A}$
- $P_{tot} \leq 23 \text{ W}$
- $t_f \leq 0.8 \text{ } \mu\text{s}$ .

## 2. Pinning information

Table 1: Pinning - SOT186A (TO-220F), simplified outline and symbol

Pin	Description	Simplified outline	Symbol
1	base (b)		
2	collector (c)		
3	emitter (e)		
mb	mounting base; isolated		

**SOT186A (TO-220F)**



**PHILIPS**

### 3. Ordering information

Table 2: Ordering information

Type number	Package		Version
	Name	Description	
BUT12AX	TO-220F	Plastic single-ended package; isolated heatsink mounted; 1 mounting hole; 3 leads.	SOT186A

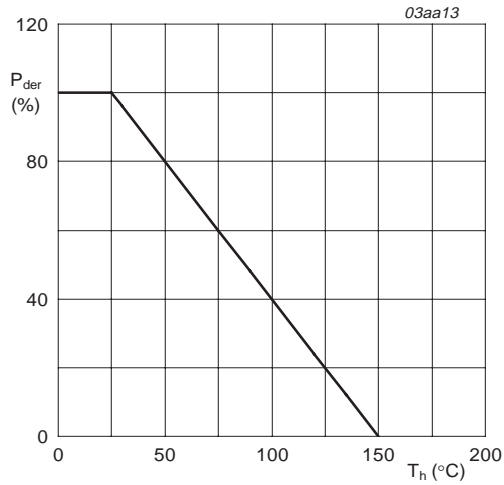
### 4. Limiting values

Table 3: Limiting values

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

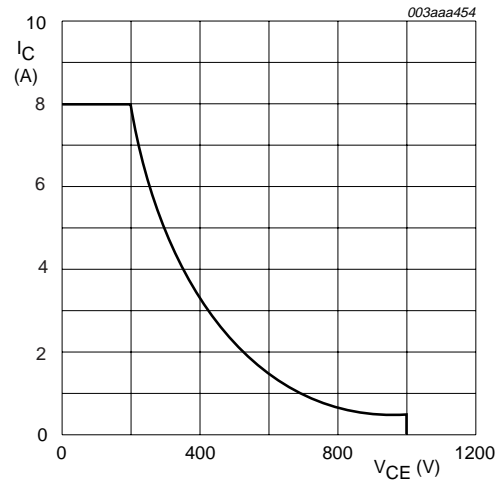
Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CESM}$	peak collector-emitter voltage	$V_{BE} = 0\text{ V}$	-	1000	V
$V_{CEO}$	collector-emitter voltage	base open circuit	-	450	V
$I_C$	collector current	Figure 2 and 3	-	8	A
$I_{Csat}$	collector saturation current		-	5	A
$I_{CM}$	peak collector current	Figure 3	-	20	A
$I_B$	base current (DC)		-	4	A
$I_{BM}$	peak base current		-	6	A
$P_{tot}$	total power dissipation	$T_h = 25\text{ °C}$ ; Figure 1	[1] -	23	W
$T_{stg}$	storage temperature		-65	+150	°C
$T_j$	junction temperature		-	+150	°C

[1] Mounted without heatsink compound.



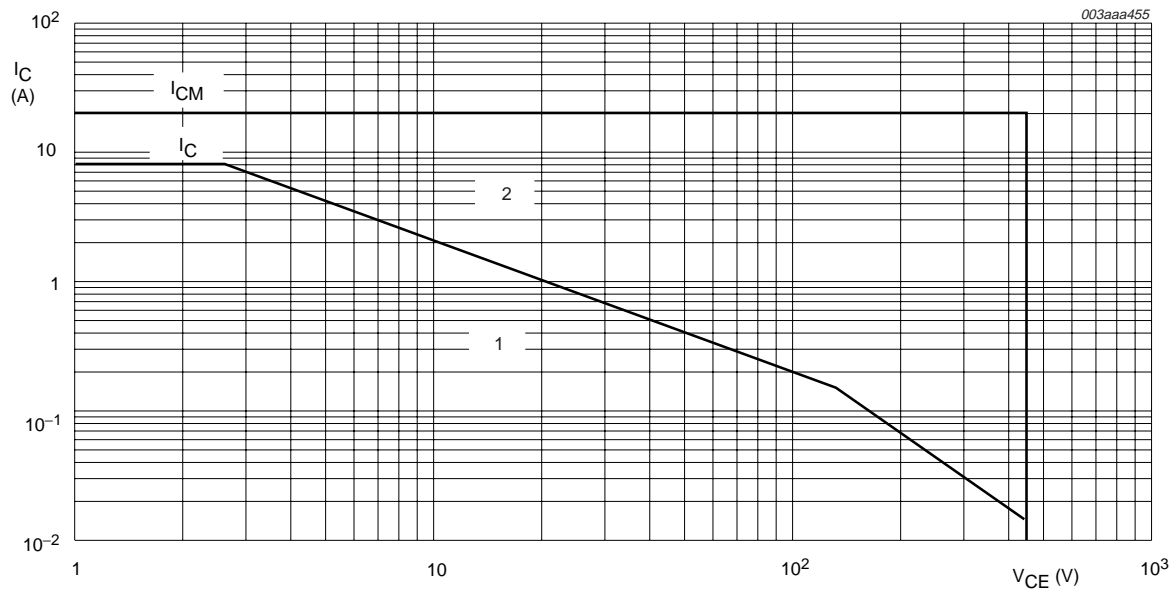
$$P_{der} = \frac{P_{tot}}{P_{tot(25^\circ C)}} \times 100\%$$

**Fig 1. Normalized total power dissipation as a function of heatsink temperature.**



$V_{BE} = -1 \text{ V to } -5 \text{ V}; T_h = 100^\circ \text{C}.$

**Fig 2. Reverse bias safe operating area; continuous collector current as a function of collector-emitter voltage.**



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

- 1 - Region of permissible DC operation.
- 2 - Permissible extension for repetitive operation.

**Fig 3. Forward bias safe operating area; continuous and peak collector currents as a function of collector-emitter voltage.**

## 5. Thermal characteristics

**Table 4: Thermal characteristics**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
$R_{th(j-h)}$	thermal resistance from junction to heatsink	Mounted without heatsink compound	[1]	-	-	5.5	K/W
		Mounted with heatsink compound	[1]	-	-	3.9	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient		-	55	-	K/W	

[1] External heatsink connected to mounting base.

## 6. Characteristics

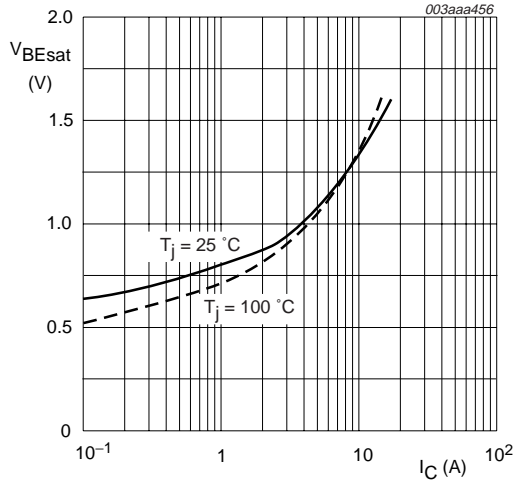
**Table 5: Characteristics**

$T_j = 25\text{ }^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
<b>Static characteristics</b>							
$V_{CE0sus}$	collector-emitter sustaining voltage	$I_C = 100\text{ mA}$ ; $I_{Boff} = 0\text{ A}$ ; $L = 25\text{ mH}$ ; Figure 9 and 10	400	-	-	V	
$V_{CEsat}$	collector-emitter saturation voltage	$I_C = 5\text{ A}$ ; $I_B = 1\text{ A}$ ; Figure 5	-	-	1.5	V	
$V_{BEsat}$	base-emitter saturation voltage	$I_C = 5\text{ A}$ ; $I_B = 1\text{ A}$ ; Figure 4	-	-	1.5	V	
$I_{CES}$	collector-emitter cut-off current	$V_{CE} = V_{CESM}$ ; $V_{BE} = 0\text{ V}$					
		$T_j = 25\text{ }^\circ\text{C}$	[1]	-	-	1	mA
		$T_j = 125\text{ }^\circ\text{C}$	[1]	-	-	3	mA
$h_{FE}$	DC current gain	$V_{CE} = 5\text{ V}$ ; Figure 8					
		$I_C = 10\text{ mA}$	10	18	35		
		$I_C = 1\text{ A}$	10	20	35		
<b>Dynamic characteristics</b>							
$t_{on}$	turn-on time	$I_{Con} = 5\text{ A}$ ; $I_{Bon} = I_{Boff} = 1\text{ A}$ ; resistive load; Figure 11 and 12	-	-	1	$\mu\text{s}$	
$t_s$	carrier storage time	$I_{Con} = 5\text{ A}$ ; $I_{Bon} = I_{Boff} = 1\text{ A}$ ; resistive load; Figure 11 and 12	[2]	-	-	4	$\mu\text{s}$
		$I_{Con} = 5\text{ A}$ ; $I_{Bon} = 1\text{ A}$ ; $V_{CL} = 250\text{ V}$ ; $T_{mb} = 100\text{ }^\circ\text{C}$ ; inductive load; Figure 13 and 14	-	1.9	2.5	$\mu\text{s}$	
$t_f$	fall time	$I_{Con} = 5\text{ A}$ ; $I_{Bon} = I_{Boff} = 1\text{ A}$ ; resistive load; Figure 11 and 12	-	-	0.8	$\mu\text{s}$	
		$I_{Con} = 5\text{ A}$ ; $I_{Bon} = 1\text{ A}$ ; $V_{CL} = 300\text{ V}$ ; $T_{mb} = 100\text{ }^\circ\text{C}$ ; inductive load; Figure 13 and 14	-	200	300	ns	

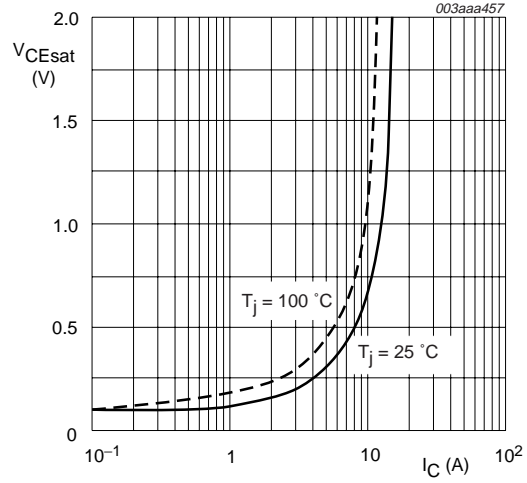
[1] Measured with a half-sinewave voltage.

[2] turn-off storage time



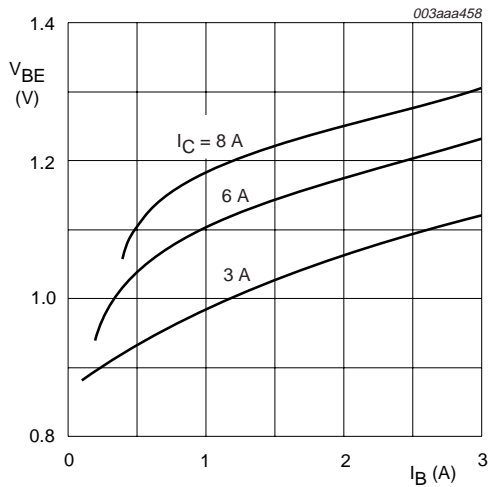
$T_j = 25^\circ\text{C}$  and  $100^\circ\text{C}$

**Fig 4. Base-emitter saturation voltage as a function of collector current; typical values.**



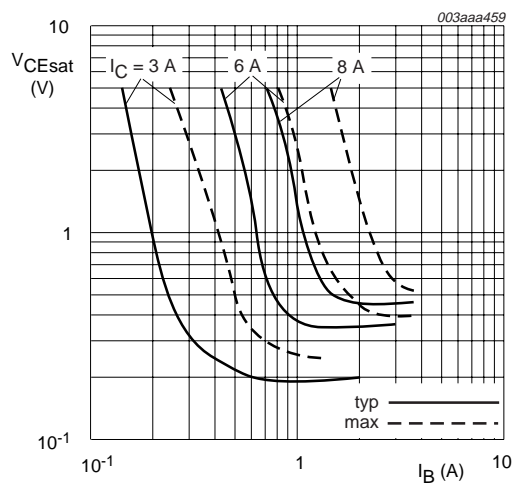
$T_j = 25^\circ\text{C}$  and  $100^\circ\text{C}$

**Fig 5. Collector-emitter saturation voltage as a function of collector current; typical values.**

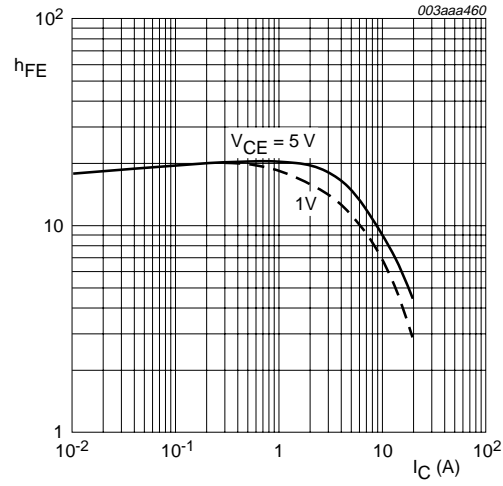


$T_j = 25^\circ\text{C}$

**Fig 6. Base-emitter voltage as a function of base current; typical values.**

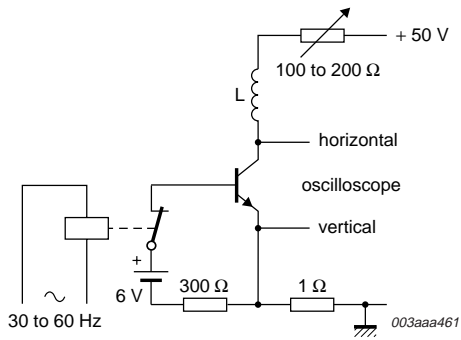


**Fig 7. Collector-emitter saturation voltage as a function base current; typical and maximum values.**

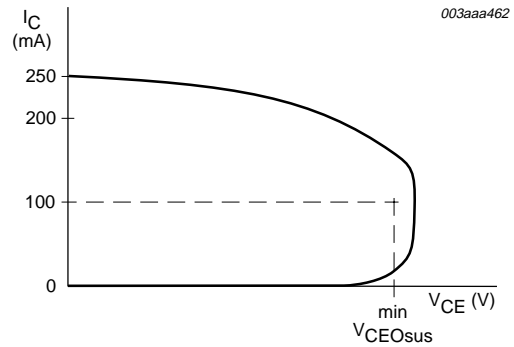


$V_{CE} = 5\text{ V and } 1\text{ V}$

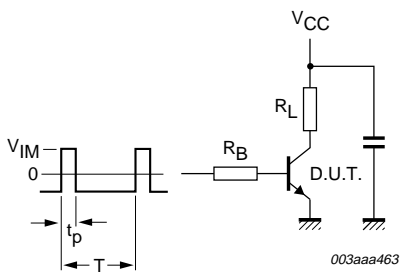
**Fig 8. DC current gain as a function of collector current; typical values.**



**Fig 9. Test circuit for collector-emitter sustaining voltage.**

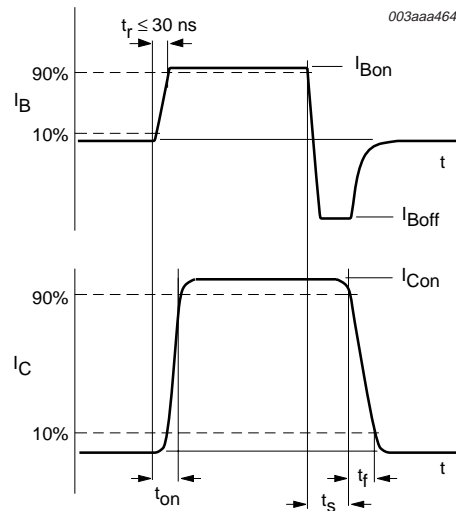


**Fig 10. Oscilloscope display for collector-emitter sustaining voltage.**

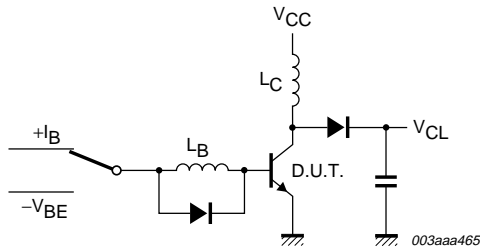


$V_{CC} = 250 \text{ V}$ ;  $t_p = 20 \mu\text{s}$ ;  $V_{IM} = -6 \text{ V to } 8 \text{ V}$ ;  $t_p/T = 0.01$ .  
The values of  $R_B$  and  $R_L$  are selected in accordance with  $I_{Con}$  and  $I_{Bon}$  requirements.

**Fig 11. Test circuit for resistive load switching times**

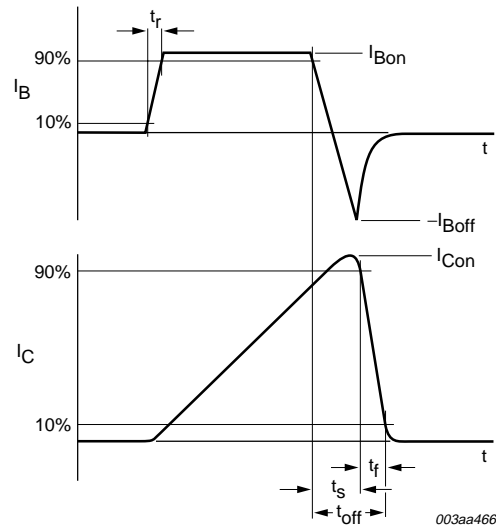


**Fig 12. Switching time waveforms with resistive load.**



$V_{CL} \leq 1000 \text{ V}$ ;  $V_{CC} = 30 \text{ V}$ ;  $V_{BE} = -1 \text{ V to } -5 \text{ V}$ ;  
 $L_B = 1 \mu\text{H}$ ;  $L_C = 200 \mu\text{H}$

**Fig 13. Test circuit for inductive load switching and reverse bias safe operating area.**



**Fig 14. Switching time waveforms with inductive load.**

## 7. Isolation characteristics

**Table 6: Isolation characteristics**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{isol(RMS)M}$	Peak RMS isolation voltage from all three terminals to external heatsink.	$f = 50 \text{ to } 60 \text{ Hz}$ ; sinusoidal waveform; $RH \leq 65\%$ ; clean and dust-free.	-	-	2500	V
$C_{c-h}$	Capacitance from collector to external heatsink.		-	12	-	pF



**8. Package outline**

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

SOT186A

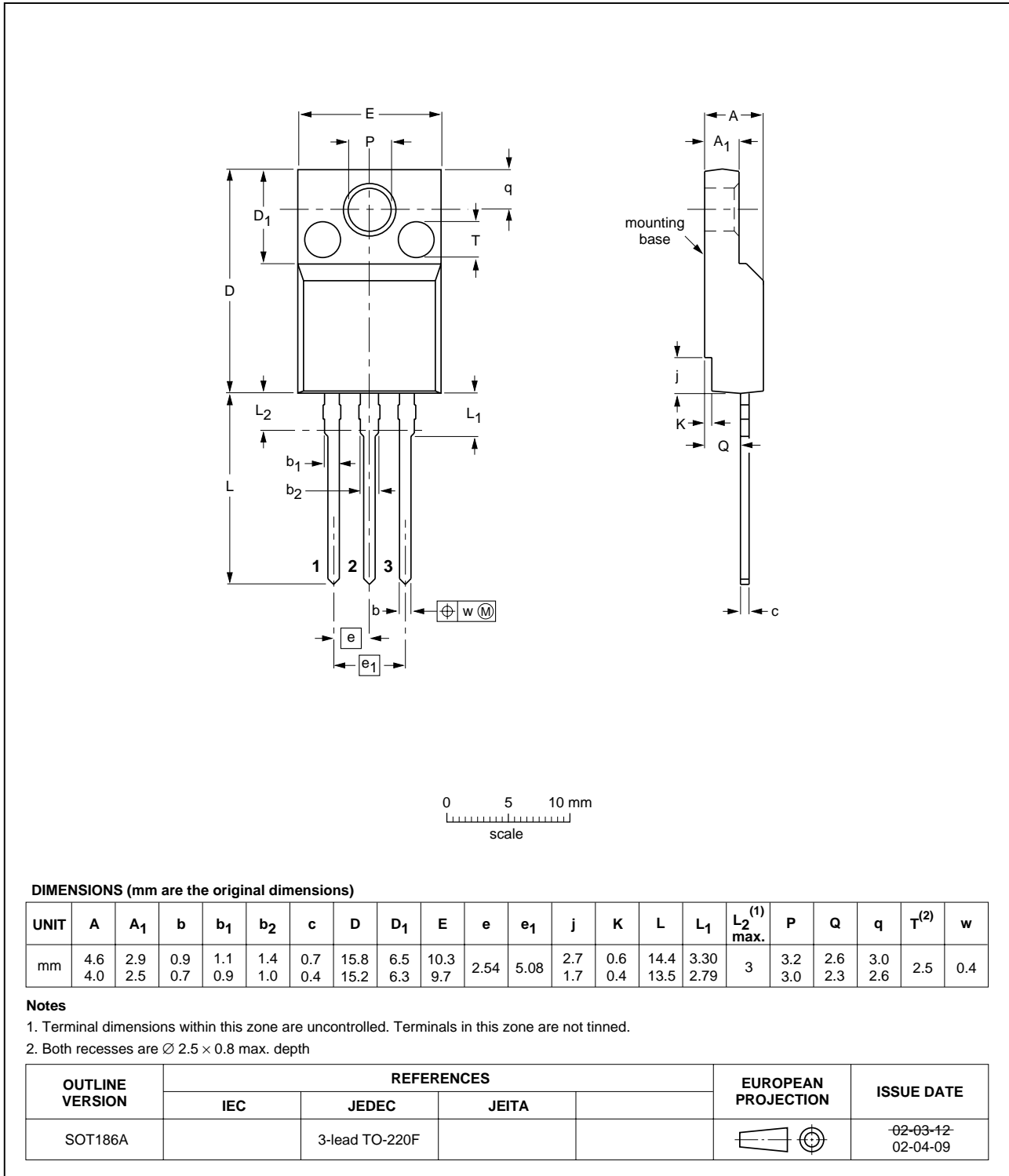


Fig 15. SOT186A (TO-220F).