# Silicon Diffused Power Transistor PHE13009

## GENERAL DESCRIPTION

The PHE13009 is a silicon npn power switching transistor in the TO220AB envelope intended for use in high frequency electronic lighting ballast applications, converters, inverters, switching regulators, motor control systems, etc.

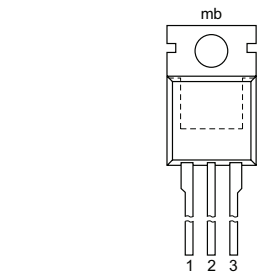
## QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{CESM}$ | Collector-emitter voltage peak value | $V_{BE}$ = 0 V | - | 700 | V |
| $V_{CBO}$ | Collector-Base voltage (open emitter) | | - | 700 | V |
| $V_{CEO}$ | Collector-emitter voltage (open base) | | - | 400 | V |
| $I_C$ | Collector current (DC) | | - | 12 | A |
| $I_{CM}$ | Collector current peak value | | - | 24 | A |
| $P_{tot}$ | Total power dissipation | $T_{mb} \leq 25$ ˚C | - | 80 | W |
| $V_{CEsat}$ | Collector-emitter saturation voltage | $I_C$ = 5.0 A;$I_B$ = 1.0 A | 0.32 | 1.0 | V |
| $h_{FEsat}$ | | $I_C$ = 5.0 A; $V_{CE}$ = 5 V | - | 40 | |
| $t_f$ | Fall time | $I_C$ = 5.0 A; $I_{B1}$ = 1.0 A | 0.1 | 0.5 | µs |

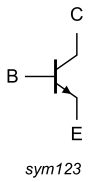
## PINNING - TO220AB

| PIN | DESCRIPTION |
|---|---|
| 1 | base |
| 2 | collector |
| 3 | emitter |
| tab | collector |

## PIN CONFIGURATION




## SYMBOL




## LIMITING VALUES

Limiting values in accordance with the Absolute Maximum Rating System (IEC 134)

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{CESM}$ | Collector to emitter voltage | $V_{BE}$ = 0 V | - | 700 | V |
| $V_{CEO}$ | Collector to emitter voltage (open base) | | - | 400 | V |
| $V_{CBO}$ | Collector to base voltage (open emitter) | | - | 700 | V |
| $I_C$ | Collector current (DC) | | - | 12 | A |
| $I_{CM}$ | Collector current peak value | | - | 24 | A |
| $I_B$ | Base current (DC) | | - | 6 | A |
| $I_{BM}$ | Base current peak value | | - | 12 | A |
| $P_{tot}$ | Total power dissipation | $T_{mb} \leq 25$ ˚C | - | 80 | W |
| $T_{stg}$ | Storage temperature | | -65 | 150 | ˚C |
| $T_j$ | Junction temperature | | - | 150 | ˚C |

## THERMAL RESISTANCES

| SYMBOL | PARAMETER | CONDITIONS | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| $R_{th\ j\text{-}mb}$ | Junction to mounting base | | - | 1.56 | K/W |
| $R_{th\ j\text{-}a}$ | Junction to ambient | in free air | 60 | - | K/W |

## STATIC CHARACTERISTICS

$T_{mb}$ = 25 ˚C unless otherwise specified

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $I_{CES}$,$I_{CBO}$ | Collector cut-off current [1] | $V_{BE}$ = 0 V; $V_{CE}$ = $V_{CESMmax}$ | - | - | 1.0 | mA |
| $I_{CES}$ | | $V_{BE}$ = 0 V; $V_{CE}$ = $V_{CESMmax}$; $T_j$ = 125 ˚C | - | - | 5.0 | mA |
| $I_{CEO}$ | Collector cut-off current | $V_{CEO}$ = $V_{CEOMmax}$ (400V) | - | - | 0.1 | mA |
| $I_{EBO}$ | Emitter cut-off current | $V_{EB}$ = 9 V; $I_C$ = 0 A | - | - | 1 | mA |
| $V_{CEOsust}$ | Collector-emitter sustaining voltage | $I_B$ = 0 A; $I_C$ = 10 mA; L = 25 mH | 400 | - | - | V |
| $V_{CEsat}$ | Collector-emitter saturation voltage | $I_C$ = 5.0 A;$I_B$ = 1.0 A | - | 0.32 | 1.0 | V |
| | | $I_C$ = 8.0 A;$I_B$ = 1.6 A | - | - | 2.0 | V |
| $V_{BEsat}$ | Base-emitter saturation voltage | $I_C$ = 5.0 A;$I_B$ = 1.0 A | - | 1.0 | 1.3 | V |
| | | $I_C$ = 8.0 A;$I_B$ = 1.6 A | - | 1.1 | 1.6 | V |
| $h_{FE}$ | DC current gain | $I_C$ = 5.0 A; $V_{CE}$ = 5 V | 8 | - | 40 | |
| $h_{FEsat}$ | | $I_C$ = 8.0 A; $V_{CE}$ = 5 V | 6 | - | 30 | |

## DYNAMIC CHARACTERISTICS

$T_{mb}$ = 25 ˚C unless otherwise specified

| SYMBOL | PARAMETER | CONDITIONS | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| | Switching times (resistive load) | $I_{Con}$ = 5 A; $I_{Bon}$ = -$I_{Boff}$ = 1 A; $R_L$ = 75 ohms; $V_{BB2}$ = 4 V; | | | |
| $t_s$ | Turn-off storage time | | 2.2 | 3.3 | µs |
| $t_f$ | Turn-off fall time | | 0.26 | 0.7 | µs |
| | Switching times (inductive load) | $I_{Con}$ = 5 A; $I_{Bon}$ = 1 A; $L_B$ = 1 µH; -$V_{BB}$ = 5 V | | | |
| $t_s$ | Turn-off storage time | | 1.35 | 2.3 | µs |
| $t_f$ | Turn-off fall time | | 0.1 | 0.5 | µs |
| | Switching times (inductive load) | $I_{Con}$ = 5A; $I_{Bon}$ = 1 A; $L_B$ = 1 µH; -$V_{BB}$ = 5 V; $T_j$ = 100 ˚C | | | |
| $t_s$ | Turn-off storage time | | - | 3.2 | µs |
| $t_f$ | Turn-off fall time | | - | 0.9 | µs |

**1** Measured with half sine-wave voltage (curve tracer).

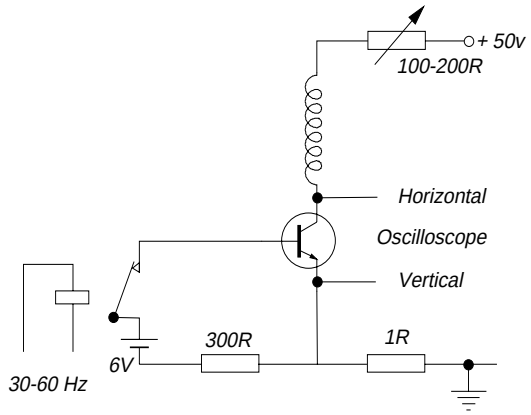



*Fig.1. Test circuit for $V_{CEOsust}$.*

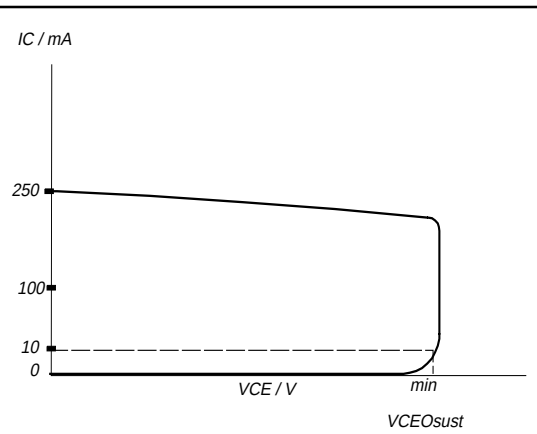



*Fig.2. Oscilloscope display for $V_{CEOsust}$.*

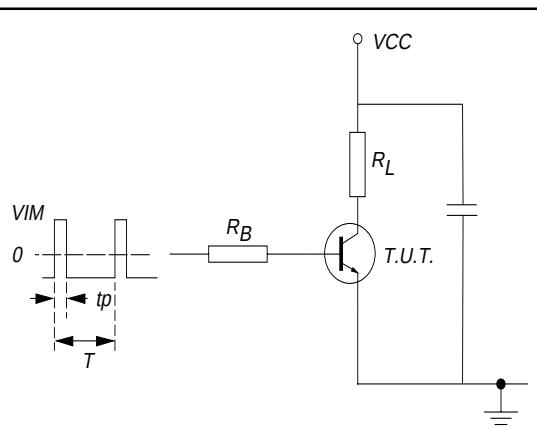



*Fig.3. Test circuit resistive load. $V_{IM}$ = -6 to +8 V*
*$V_{CC}$ = 250 V; $t_p$ = 20 μs; δ = $t_p$ / T = 0.01.*
*$R_B$ and $R_L$ calculated from $I_{Con}$ and $I_{Bon}$ requirements.*

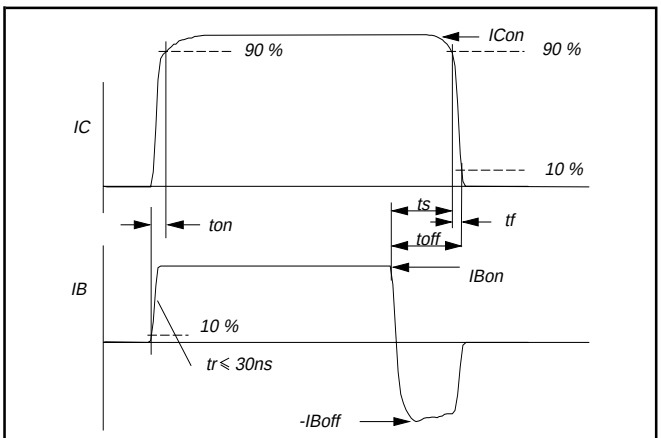



*Fig.4. Switching times waveforms with resistive load.*

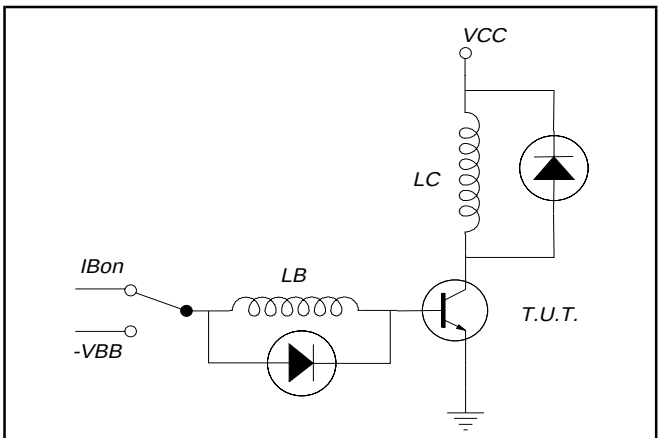



*Fig.5. Test circuit inductive load.*
*$V_{CC}$ = 300 V; -$V_{BE}$ = 5 V; $L_C$ = 200 uH; $L_B$ = 1 uH*

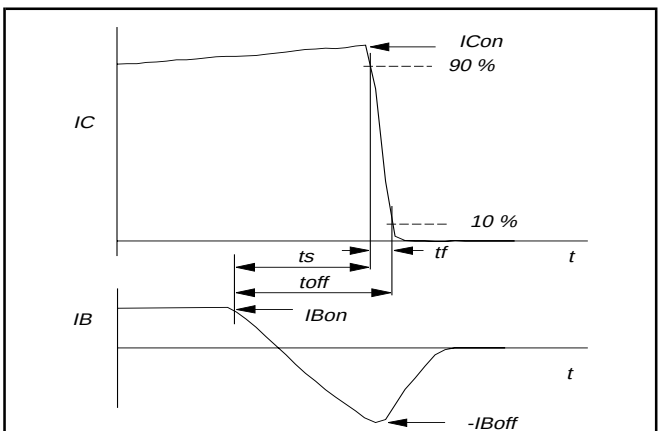



*Fig.6. Switching times waveforms with inductive load.*

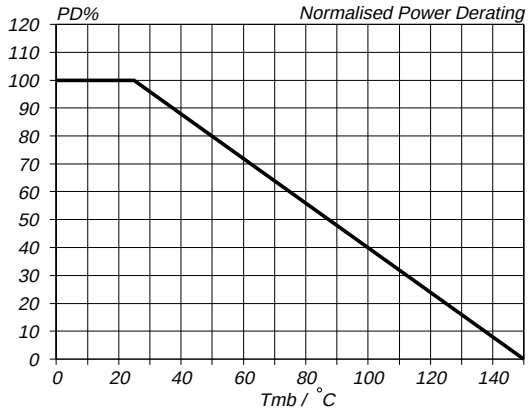



*Fig.7. Normalised power dissipation. PD% = 100·PD/PD $_{25°C}$ = f ($T_{mb}$)*

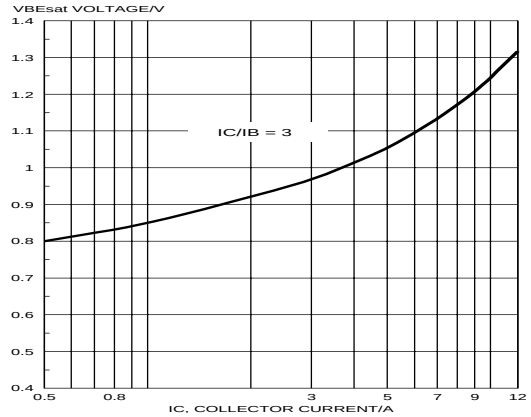



*Fig.10. Base-Emitter saturation voltage. Solid lines = typ values, $V_{BEsat}$ = f(IC); at IC/IB =5.*

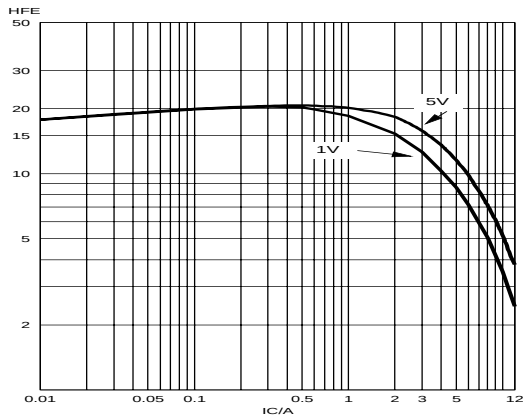



*Fig.8. Typical DC current gain. $h_{FE}$ = f($I_C$) parameter $V_{CE}$*

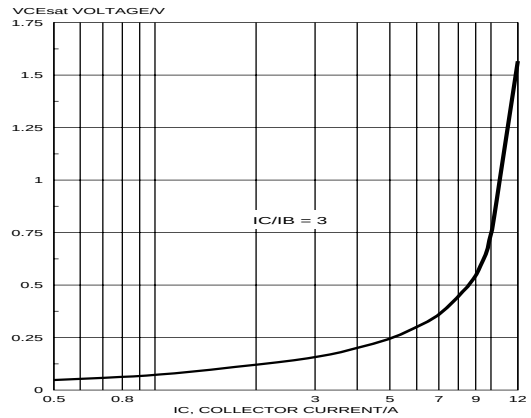



*Fig.11. Collector-Emitter saturation voltage. Solid lines = typ values, $V_{CEsat}$ = f(IC); at IC/IB =5.*

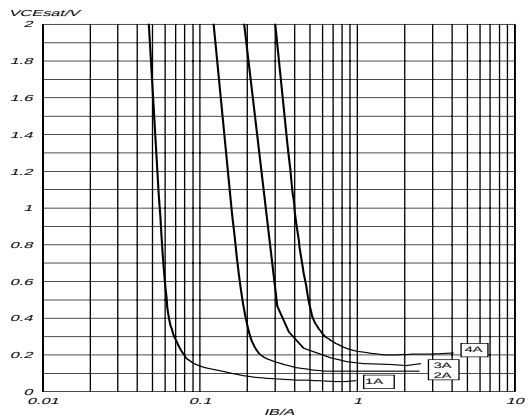



*Fig.9. Collector-Emitter saturation voltage. Solid lines = typ values, $V_{CEsat}$ = f(IB); $T_j$=25˚C.*

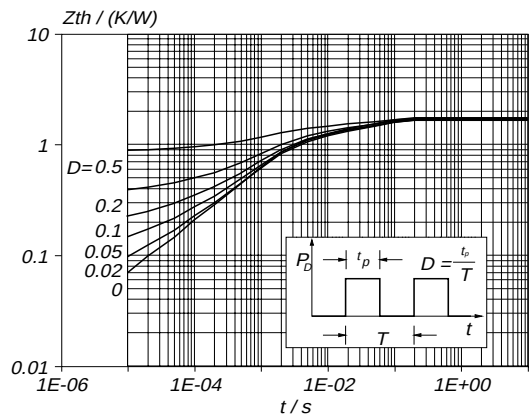



*Fig.12. Transient thermal impedance. $Z_{th\ j\text{-}mb}$ = f(t); parameter D = $t_p$/T*

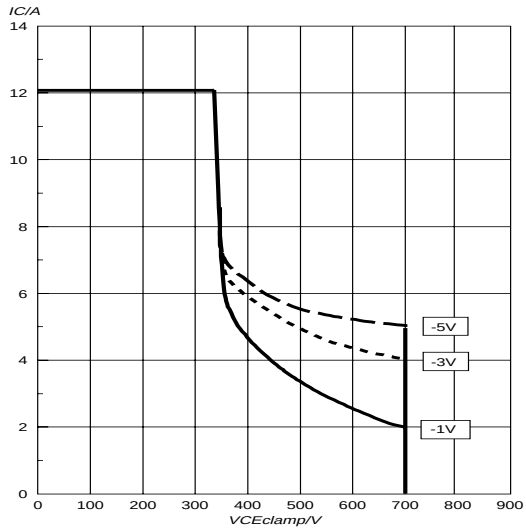



*Fig.13. Reverse bias safe operating area ($T_j < T_{jmax}$) for $-V_{be}$ = 5V,3V and 1V.*

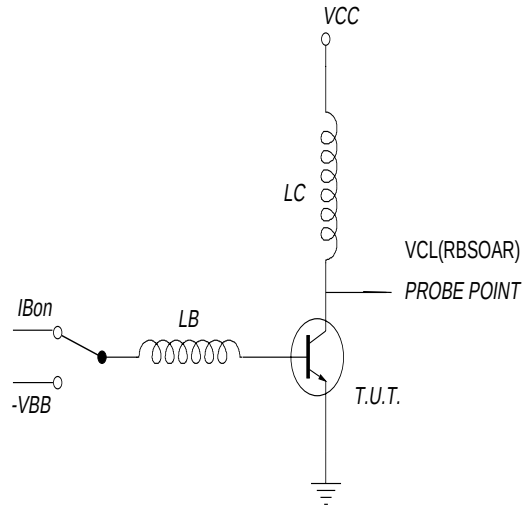
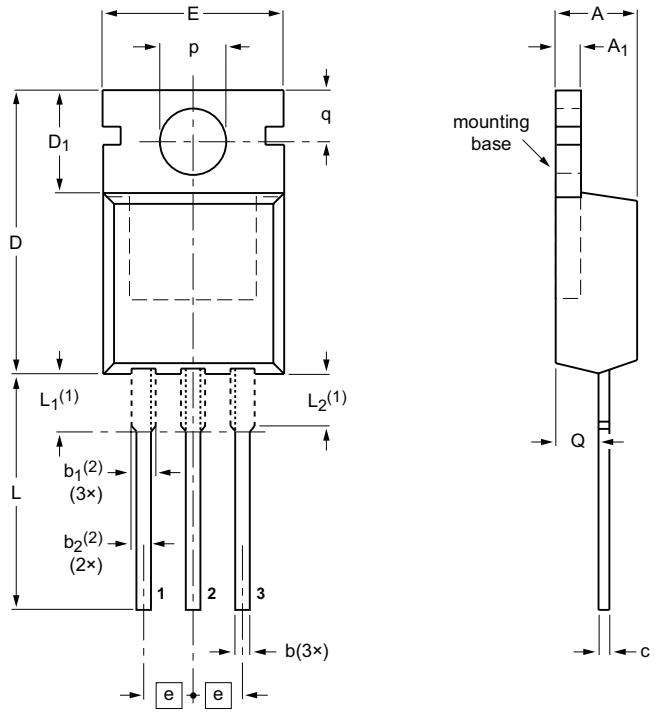


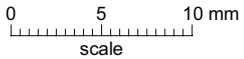

*Fig.14. Test circuit for reverse bias safe operating area.*

*$V_{clamp}$ < 700V; $V_{cc}$ = 150V; $-V_{be}$ = 5V,3V & 1V; $L_B$ = 1μH; $L_C$ = 200μH*

## MECHANICAL DATA

**Plastic single-ended package; heatsink mounted; 1 mounting hole; 3-lead TO-220AB** **SOT78**




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

| UNIT | A | $A_1$ | b | $b_1$(2) | $b_2$(2) | c | D | $D_1$ | E | e | L | $L_1$(1) | $L_2$(1) max. | p | q | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 4.7<br>4.1 | 1.40<br>1.25 | 0.9<br>0.6 | 1.6<br>1.0 | 1.3<br>1.0 | 0.7<br>0.4 | 16.0<br>15.2 | 6.6<br>5.9 | 10.3<br>9.7 | 2.54 | 15.0<br>12.8 | 3.30<br>2.79 | 3.0 | 3.8<br>3.5 | 3.0<br>2.7 | 2.6<br>2.2 |

**Notes**
1. Lead shoulder designs may vary.
2. Dimension includes excess dambar.

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

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