# Silicon Diffused Power Transistor — BUT11APX

## GENERAL DESCRIPTION

Enhanced performance, new generation, high-voltage, high-speed switching npn transistor in a plastic full-pack envelope intended for use in horizontal deflection circuits of colour television receivers. Features exceptional tolerance to base drive and collector current load variations resulting in a very low worst case dissipation.

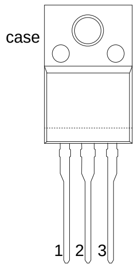
## QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{CESM}$ | Collector-emitter voltage peak value | $V_{BE}$ = 0 V | - | 1000 | V |
| $V_{CBO}$ | Collector-Base voltage (open emitter) | | - | 1000 | V |
| $V_{CEO}$ | Collector-emitter voltage (open base) | | - | 450 | V |
| $I_C$ | Collector current (DC) | | - | 5 | A |
| $I_{CM}$ | Collector current peak value | | - | 10 | A |
| $P_{tot}$ | Total power dissipation | $T_{hs} \leq 25$ ˚C | - | 32 | W |
| $V_{CEsat}$ | Collector-emitter saturation voltage | | - | 1.5 | V |
| $I_{Csat}$ | Collector saturation current | | 3.5 | - | A |
| $t_f$ | Fall time | $I_{Csat}$=2.5A,$I_{B1}$=0.5A,$I_{B2}$=0.8A | 145 | 160 | ns |

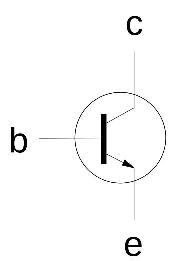
## PINNING - SOT186A

| PIN | DESCRIPTION |
|---|---|
| 1 | base |
| 2 | collector |
| 3 | emitter |
| case | isolated |

## 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 | - | 1000 | V |
| $V_{CEO}$ | Collector to emitter voltage (open base) | | - | 450 | V |
| $V_{CBO}$ | Collector to base voltage (open emitter) | | - | 1000 | V |
| $I_C$ | Collector current (DC) | | - | 5 | A |
| $I_{CM}$ | Collector current peak value | | - | 10 | A |
| $I_B$ | Base current (DC) | | - | 2 | A |
| $I_{BM}$ | Base current peak value | | - | 4 | A |
| $P_{tot}$ | Total power dissipation | $T_{hs} \leq 25$ ˚C | - | 32 | W |
| $T_{stg}$ | Storage temperature | | -65 | 150 | ˚C |
| $T_j$ | Junction temperature | | - | 150 | ˚C |

## THERMAL RESISTANCES

| SYMBOL | PARAMETER | CONDITIONS | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| $R_{th\ j-hs}$ | Junction to heatsink | with heatsink compound | - | 3.95 | K/W |
| $R_{th\ j-a}$ | Junction to ambient | in free air | 55 | - | K/W |

## ISOLATION LIMITING VALUE & CHARACTERISTIC

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

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $V_{isol}$ | R.M.S. isolation voltage from all three terminals to external heatsink | f = 50-60 Hz; sinusoidal waveform; R.H. ≤ 65% ; clean and dustfree | - | | 2500 | V |
| $C_{isol}$ | Capacitance from T2 to external heatsink | f = 1 MHz | - | 10 | - | pF |

## STATIC CHARACTERISTICS

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

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $I_{CES}$ | 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 | - | - | 2.0 | mA |
| $I_{EBO}$ | Emitter cut-off current | $V_{EB}$ = 9 V; $I_C$ = 0 A | - | - | 10 | mA |
| $V_{CEOsust}$ | Collector-emitter sustaining voltage | $I_B$ = 0 A; $I_C$ = 100 mA; L = 25 mH | 450 | - | - | V |
| $V_{CEsat}$ | Collector-emitter saturation voltages | $I_C$ = 3.0 A; $I_B$ = 0.6 A | - | 0.25 | 1.5 | V |
| $V_{BEsat}$ | Base-emitter saturation voltage | $I_C$ = 2.5 A; $I_B$ = 0.33 A | - | - | 1.3 | V |
| $h_{FE}$ | DC current gain | $I_C$ = 5 mA; $V_{CE}$ = 5 V | 10 | 22 | 35 | |
| $h_{FE}$ | | $I_C$ = 500 mA; $V_{CE}$ = 5 V | 14 | 25 | 35 | |
| $h_{FEsat}$ | | $I_C$ = 2.5 A; $V_{CE}$ = 5 V | 10 | 13.5 | 17 | |
| $h_{FEsat}$ | | $I_C$ = 3.5 A; $V_{CE}$ = 5 V | 8 | 10 | 12 | |

## DYNAMIC CHARACTERISTICS

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

| SYMBOL | PARAMETER | CONDITIONS | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| | Switching times (resistive load) | $I_{Csat}$ = 2.5 A; $I_{B1}$ = $-I_{B2}$ = 0.5 A; $R_L$ = 75 ohms; $V_{BB2}$ = 4 V; | | | |
| $t_{on}$ | Turn-on time | | 0.5 | 0.7 | µs |
| $t_s$ | Turn-off storage time | | 3.3 | 4 | µs |
| $t_f$ | Turn-off fall time | | 0.33 | 0.45 | µs |
| | Switching times (inductive load) | $I_{Csat}$ = 2.5 A; $I_{B1}$ = 0.5 A; $L_B$ = 1 µH; $-V_{BB}$ = 5 V | | | |
| $t_s$ | Turn-off storage time | | 1.4 | 1.6 | µs |
| $t_f$ | Turn-off fall time | | 145 | 160 | ns |
| | Switching times (inductive load) | $I_{Csat}$ = 2.5 A; $I_{B1}$ = 0.5 A; $L_B$ = 1 µH; $-V_{BB}$ = 5 V; $T_j$ = 100 ˚C | | | |
| $t_s$ | Turn-off storage time | | 1.7 | 1.9 | µs |
| $t_f$ | Turn-off fall time | | 160 | 200 | ns |

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

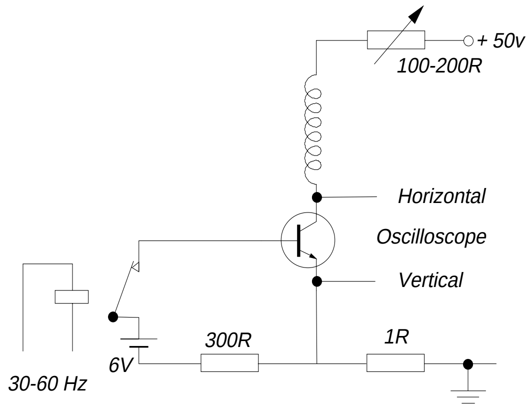



Fig.1. Test circuit for $V_{CEOsust}$.

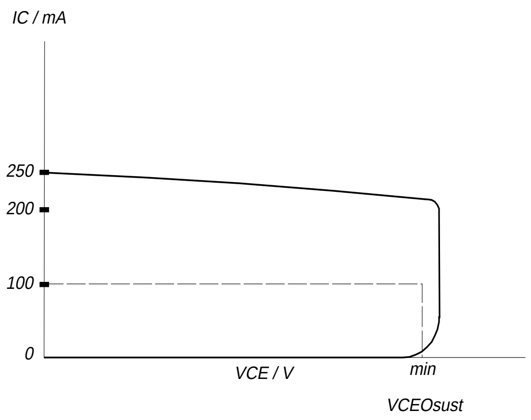



Fig.2. Oscilloscope display for $V_{CEOsust}$.

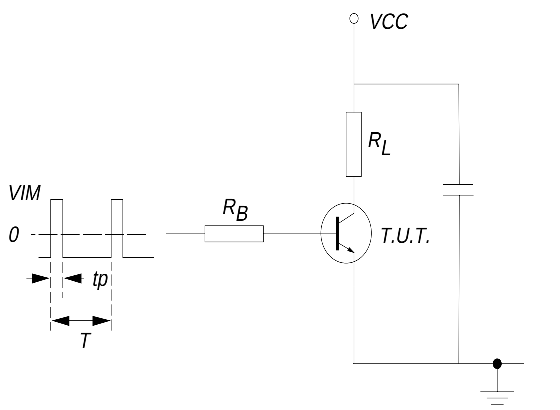



Fig.3. Test circuit resistive load. $V_{IM}$ = -6 to +8 V
$V_{CC}$ = 250 V; $t_p$ = 20 µs; $\delta = t_p / T$ = 0.01.
$R_B$ and $R_L$ calculated from $I_{Con}$ and $I_{Bon}$ requirements.

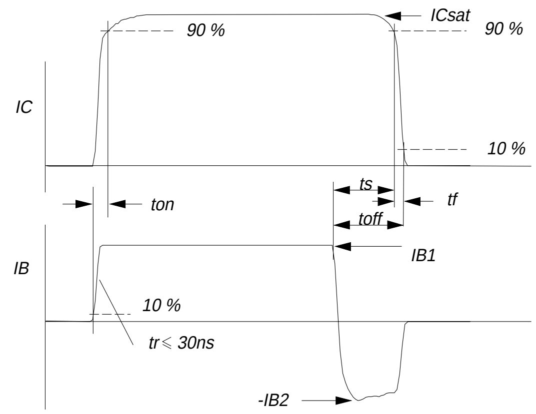



Fig.4. Switching times waveforms with resistive load.

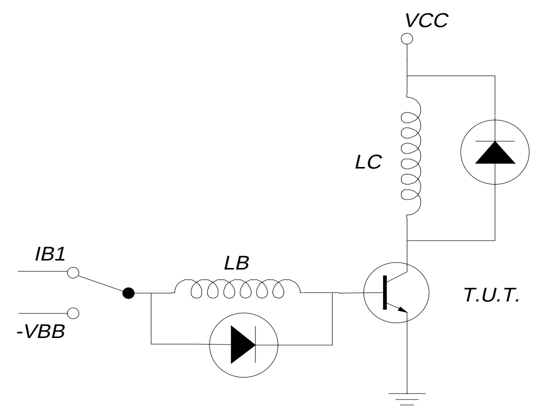



Fig.5. Test circuit inductive load.
$V_{CC}$ = 300 V; -$V_{BE}$ = 5 V; $L_C$ = 200 uH; $L_B$ = 1 uH

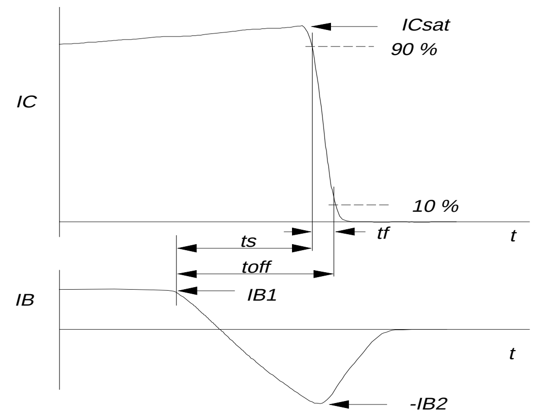



Fig.6. Switching times waveforms with inductive load.

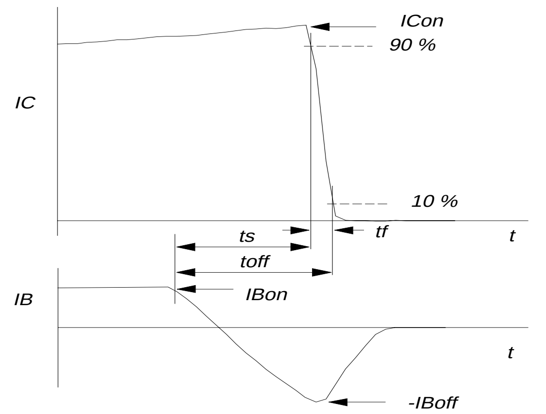



Fig.7. Switching times waveforms with inductive load.

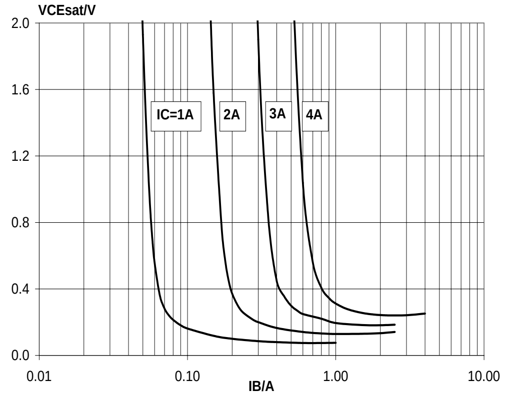



Fig.10. Collector-Emitter saturation voltage.
Solid lines = typ values, $V_{CEsat}$ = f(IB); $T_j$=25˚C.

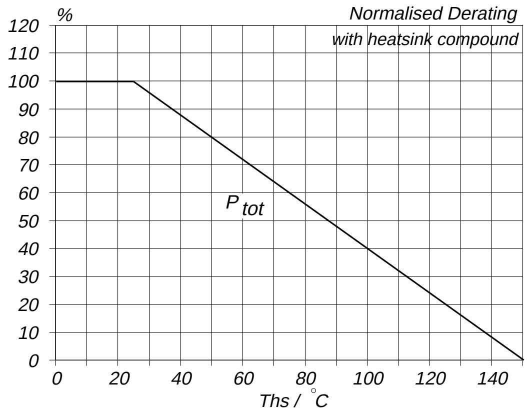



Fig.8. Normalised power dissipation.
PD% = 100·PD/PD $_{25°C}$ = f ($T_{hs}$)

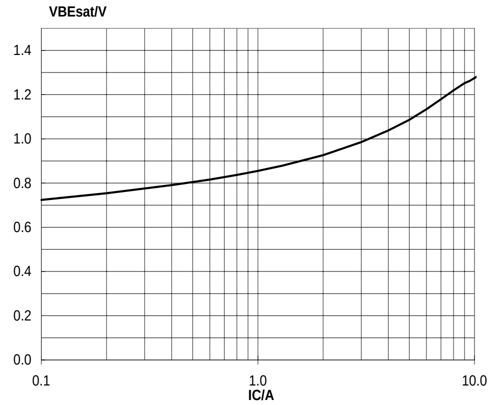



Fig.11. Base-Emitter saturation voltage.
Solid lines = typ values, $V_{BEsat}$ = f(IC); at IC/IB =4.

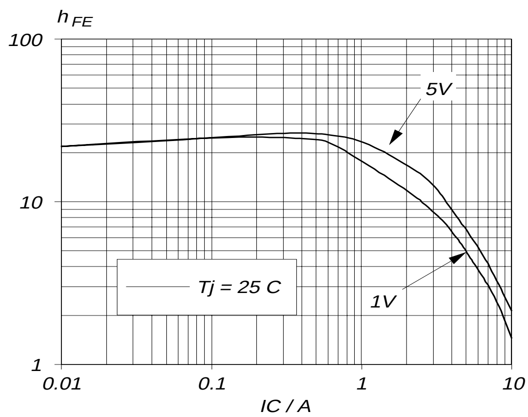



Fig.9. Typical DC current gain. $h_{FE} = f(I_C)$
parameter $V_{CE}$

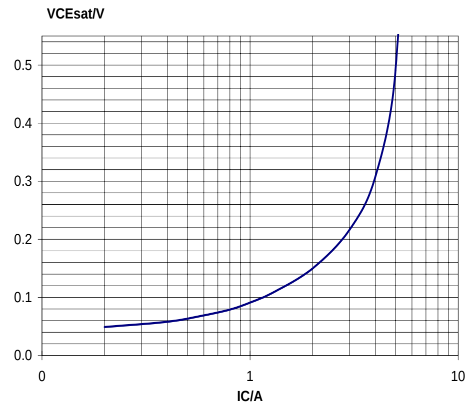



Fig.12. Collector-Emitter saturation voltage.
Solid lines = typ values, $V_{CEsat}$ = f(IC); at IC/IB =4.

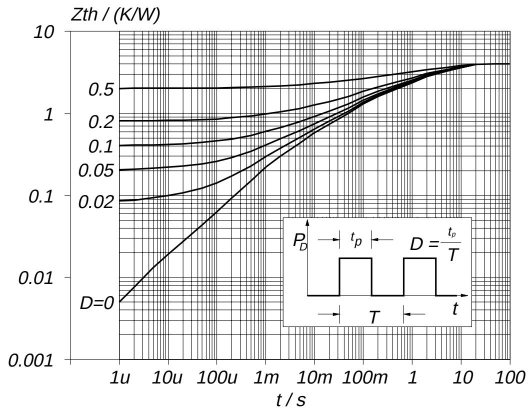



*Fig.13. Transient thermal impedance.*
*$Z_{th\ j\text{-}hs} = f(t)$; parameter $D = t_p/T$*

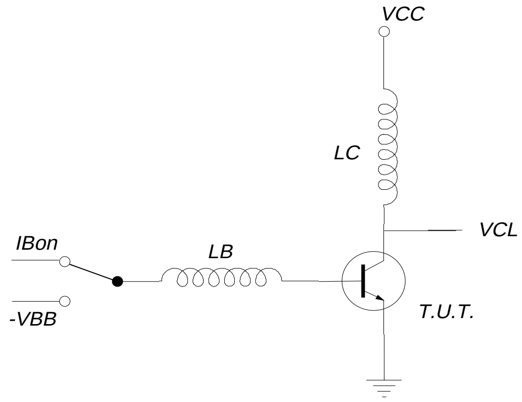



*Fig.15. Test circuit RBSOA. $V_{cl} \leq 1000V$; $V_{cc} = 150V$; $V_{BB} = -5V$; $L_B = 1\mu H$; $L_c = 200\mu H$*

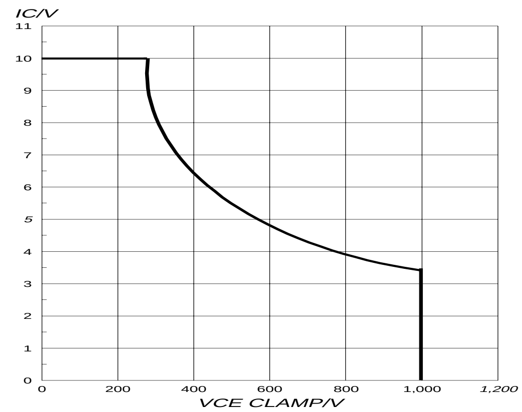



*Fig.14. Reverse bias safe operating area. $T_j \leq T_{j\ max}$*

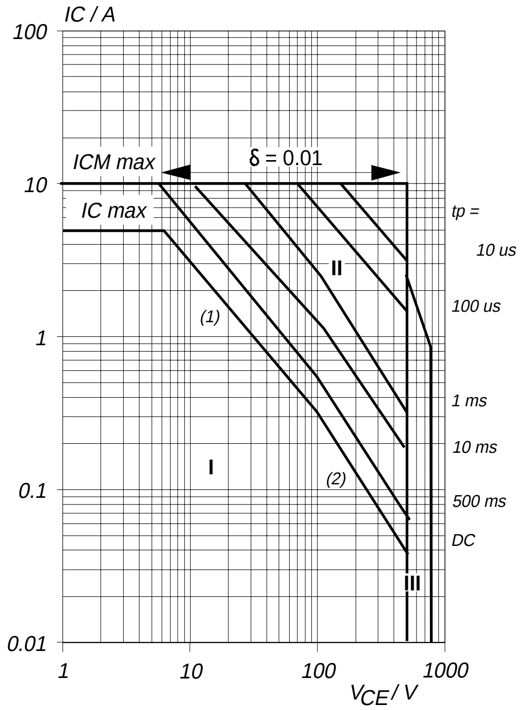



*Fig.16. Forward bias safe operating area. $T_{hs} \leq 25$ ˚C*

| | |
|---|---|
| (1) | $P_{tot}$ max and $P_{tot}$ peak max lines. |
| (2) | Second breakdown limits. |
| I | Region of permissible DC operation. |
| II | Extension for repetitive pulse operation. |
| III | Extension during turn-on in single transistor converters provided that $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0.6\ \mu s$. |
| NB: | Mounted with heatsink compound and 30 ± 5 newton force on the centre of the envelope. |

## MECHANICAL DATA

*Dimensions in mm*

*Net Mass: 2 g*

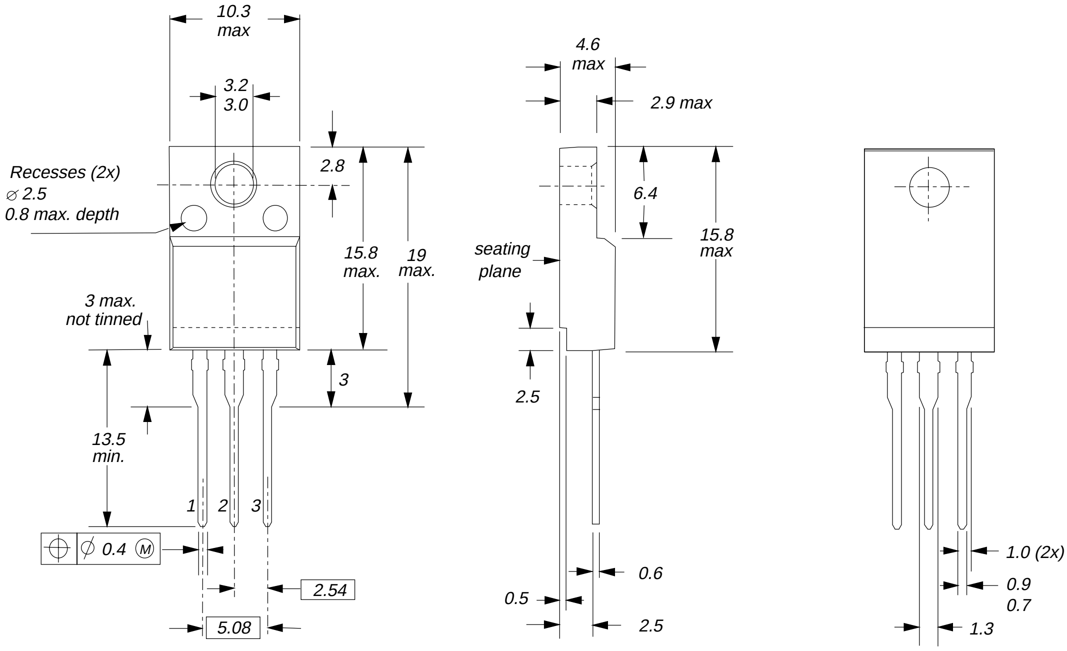



*Fig.17. SOT186A; The seating plane is electrically isolated from all terminals.*

**Notes**

1. Refer to mounting instructions for F-pack envelopes.
2. Epoxy meets UL94 V0 at 1/8".

## DEFINITIONS

| Data sheet status | |
|---|---|
| Objective specification | This data sheet contains target or goal specifications for product development. |
| Preliminary specification | This data sheet contains preliminary data; supplementary data may be published later. |
| Product specification | This data sheet contains final product specifications. |
| **Limiting values** | |
| Limiting values are given in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of this specification is not implied. Exposure to limiting values for extended periods may affect device reliability. | |
| **Application information** | |
| Where application information is given, it is advisory and does not form part of the specification. | |
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