SGS-THOMSON MICROELECTRONICS

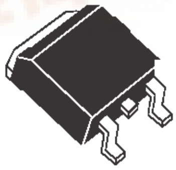
# RBO40-40G/M/T

Application Specific Discretes
A.S.D.™

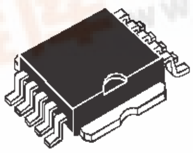
## REVERSED BATTERY AND OVERVOLTAGE PROTECTION CIRCUIT (RBO)

### FEATURES

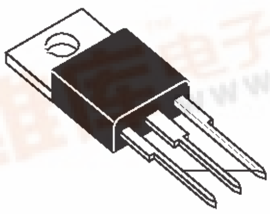
- PROTECTION AGAINST "LOAD DUMP" PULSE
- 40A DIODE TO GUARD AGAINST BATTERY REVERSAL
- MONOLITHIC STRUCTURE FOR GREATER RELIABILITY
- BREAKDOWN VOLTAGE : 24 V min.
- CLAMPING VOLTAGE : ± 40 V max.
- COMPLIANT WITH ISO / DTR 7637



$D^2PAK$
RBO40-40G



PowerSO-10™
RBO40-40M



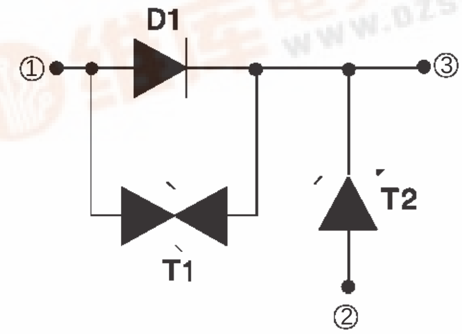
TO220AB
RBO40-40T

### DESCRIPTION

Designed to protect against battery reversal and load dump overvoltages in automotive applications, this monolithic component offers multiple functions in the same package :

D1 : reversed battery protection
T1 : clamping against negative overvoltages
T2 : Transil function against "load dump" effect.

### FUNCTIONAL DIAGRAM



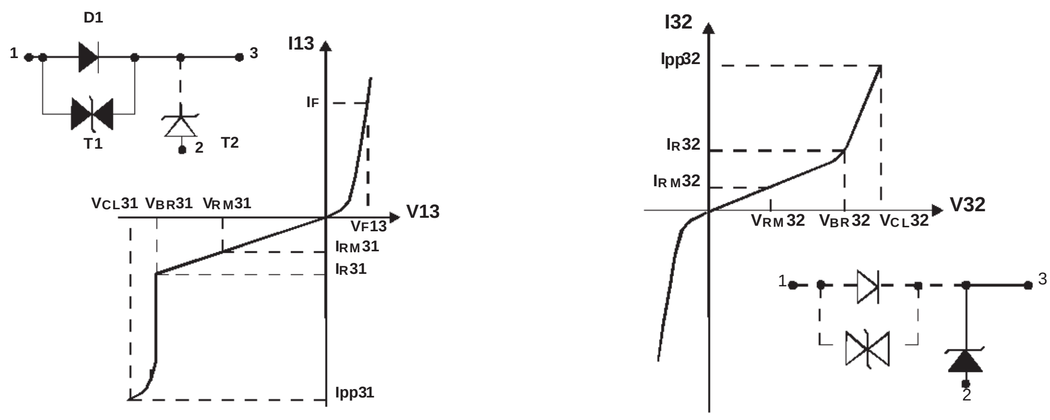
## ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $I_{FSM}$ | Non repetitive surge peak forward current (Diode D1) | tp = 10 ms | 120 | A |
| $I_F$ | DC forward current (Diode D1) | Tc = 75°C | 40 | A |
| $V_{PP}$ | Peak load dump voltage (see note 1and 2) 5 pulses (1 minute between each pulse) | | 80 | V |
| $P_{PP}$ | Peak pulse power between Input and Output (Transil T1) Tj initial = 25°C | 10/1000 µs | 1500 | W |
| $T_{stg}$ Tj | Storage temperature range Maximum junction temperature | | - 40 to + 150 150 | °C |
| $T_L$ | Maximum lead temperature for soldering during 10 s at 4.5mm from case for TO220AB | | 260 | °C |

**Note 1 :** for a surge greater than the maximum value, the device will fail in short-circuit.
**Note 2 :** see Load Dump curves.
TM : PowerSO-10, TRANSIL and ASD are trademarks of SGS-THOMSON Microelectronics.

## THERMAL RESISTANCE

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| Rth (j-c) | Junction to case | RBO40-40M RBO40-40G RBO40-40T | 1.0 1.0 1.0 | °C/W |
| Rth (j-a) | Junction to ambient | RBO40-40T | 60 | °C/W |




**Ex :** VF 13 . between Pin 1 and Pin 3 VBR 32 . between Pin 3 and Pin 2

| Symbol | Parameter |
|---|---|
| $V_{RM31}/V_{RM32}$ | Stand-off voltage Transil T1 / Transil T2. |
| $V_{BR31}/V_{BR32}$ | Breakdown voltage Transil T1 / Transil T2. |
| $I_{R31}/I_{R32}$ | Leakage current Transil T1 / Transil T2. |
| $V_{CL31}/V_{CL32}$ | Clamping voltage Transil T1 / Transil T2. |
| $V_{F13}$ | Forward voltage drop Diode D1. |
| $I_{PP}$ | Peak pulse current. |
| $\alpha T$ | Temperature coefficient of $V_{BR}$. |
| $C_{31}/C_{32}$ | Capacitance Transil T1 / Transil T2. |
| $C_{13}$ | Capacitance of Diode D1 |

**ELECTRICAL CHARACTERISTICS : DIODE D1** (- 40°C < $T_{amb}$ < + 85°C)

| Symbol | Test Conditions | Value | | | Unit |
|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | |
| $V_{F\ 13}$ | $I_F$ = 40 A | | | 1.9 | V |
| $V_{F\ 13}$ | $I_F$ = 20A | | | 1.45 | V |
| $V_{F\ 13}$ | $I_F$ = 1 A | | | 1 | V |
| $V_{F\ 13}$ | $I_F$ = 100 mA | | | 0.95 | V |
| $C_{13}$ | F = 1MHz $V_R$= 0 V | | 3000 | | pF |

**ELECTRICAL CHARACTERISTICS : TRANSIL T1** (- 40°C < $T_{amb}$ < + 85°C)

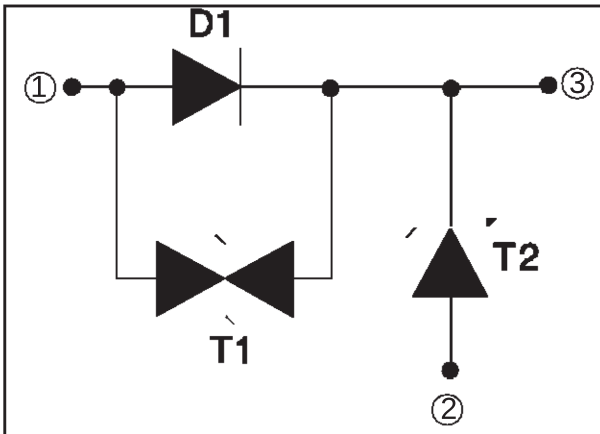
| Symbol | Test Conditions | | Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| $V_{BR\ 31}$ | $I_R$ = 1 mA | | 22 | | 35 | V |
| $V_{BR\ 31}$ | $I_R$ = 1 mA, $T_{amb}$ = 25°C | | 24 | | 32 | V |
| $I_{RM\ 31}$ | $V_{RM}$ = 20 V | | | | 100 | µA |
| $I_{RM\ 31}$ | $V_{RM}$ = 20 V, $T_{amb}$ = 25°C | | | | 10 | µA |
| $V_{CL\ 31}$ | $I_{PP}$ = 37.5A, Tj initial = 25°C | 10/1000µs | | | 40 | V |
| $\alpha$ T | Temperature coefficient of $V_{BR}$ | | | | 9 | $10^{-4}$/°C |
| C 31 | F = 1MHz $V_R$ = 0 V | | | 3000 | | pF |

**ELECTRICAL CHARACTERISTICS : TRANSIL T2** (- 40°C < $T_{amb}$ < + 85°C)

| Symbol | Test Conditions | Value | | | Unit |
|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | |
| $V_{BR\ 32}$ | $I_R$ = 1 mA | 22 | | 35 | V |
| $V_{BR\ 32}$ | $I_R$ = 1 mA, $T_{amb}$ = 25°C | 24 | | 32 | V |
| $I_{RM\ 32}$ | $V_{RM}$ = 20 V | | | 100 | µA |
| $I_{RM\ 32}$ | $V_{RM}$ = 20 V, $T_{amb}$ = 25°C | | | 10 | µA |
| $V_{CL\ 32}$ | $I_{PP}$ = 20 A (note 1) | | | 40 | V |
| $\alpha$ T | Temperature coefficient of $V_{BR}$ | | | 9 | $10^{-4}$/°C |
| $C_{32}$ | F = 1MHz $V_R$ = 0 V | | 8000 | | pF |

**Note 1 :** One pulse, see pulse definition in load dump test generator circuit.

## PRODUCT DESCRIPTION



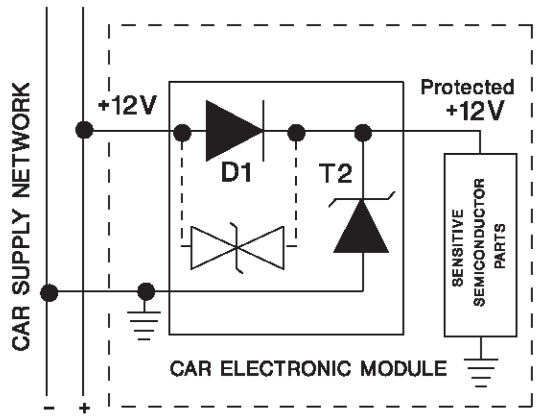

The RBO has 3 functions integrated on the same chip.

D1 : "Diode function" in order to protect against reversed battery operation.

T2 : "Transil function" in order to protect against positive surge generated by electric systems (ignition, relay. ...).

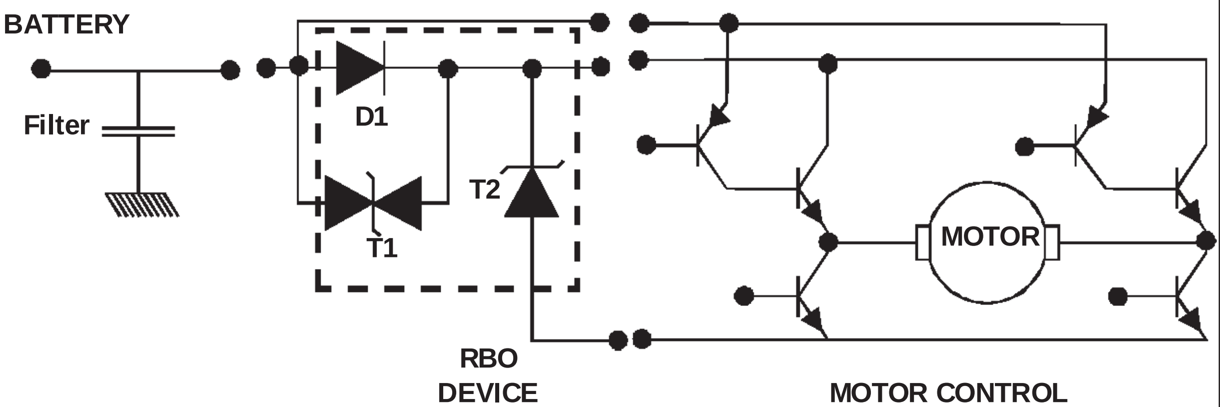
T1 : Protection for motor drive application (See below).

## BASIC APPLICATION




* The monolithic multi-function protection (RBO) has been developed to protect sensitive semiconductors in car electronic modules against both overvoltage and battery reverse.
* In addition, the RBO circuit prevents overvoltages generated by the module from affecting the car supply network.

## MOTOR DRIVER APPLICATION

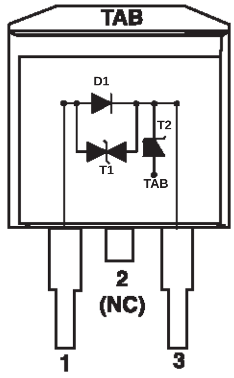



In this application, one half of the motor drive circuit is supplied through the "RBO" and is thus protected as per its basic function application.
The second part is connected directly to the "car supply network" and is protected as follows :
- For positive surges : T2 (clamping phase) and D1 in forward-biased.
- For negative surges : T1 (clamping phase) and T2 in forward-biased.

**PINOUT configuration in D²PAK :**

- Input (1) : Pin 1
- Output (3) : Pin 3
- Gnd (2) : Connected to base Tab

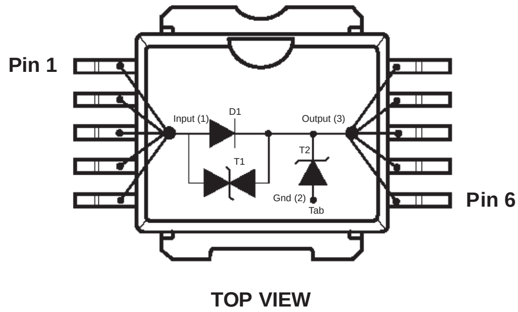
Marking : Logo, date code, RBO40-40G




**PINOUT configuration in PowerSO-10 :**

- Input (1) : Pin 1 to 5
- Output (3) : Pin 6 to 10
- Gnd (2) : Connected to base Tab

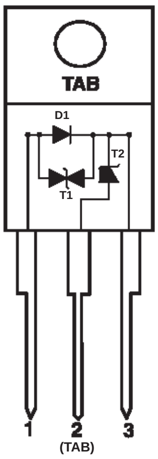
Marking : Logo, date code, RBO40-40M




**PINOUT configuration in TO220AB :**

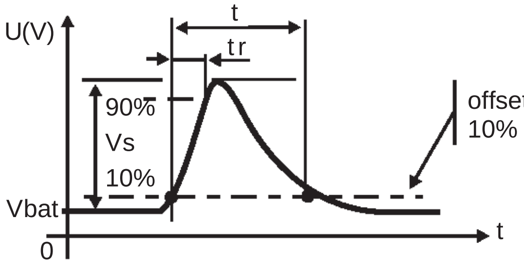
- Input (1) : Pin 1
- Output (3) : Pin 3
- GND (2) : Connected to base Tab

Marking : Logo, date code, RBO40-40T

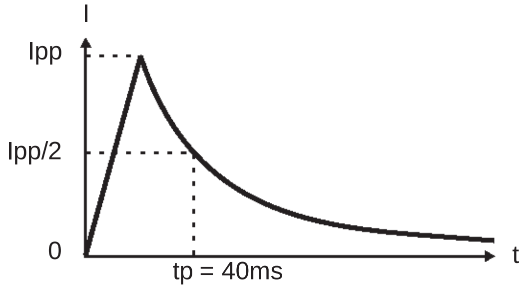


## LOAD DUMP TEST GENERATOR CIRCUIT (SCHAFFNER NSG 506 C). Issued from ISO / DTR 7637.

**Open circuit (voltage curve)**
**(pulse test n°5)**




**Corresponding current wave with D.U.T.**




| Impulse | N°5 |
|---|---|
| Vs (V) | 66.5 |
| Vbat (V) | 13.5 |
| Ri (Ω) | 2 |
| t (ms) | 200 (*) |
| tr (ms) | <10 |
| Number | 5 |

60s between each pulse
(*) Generator setting

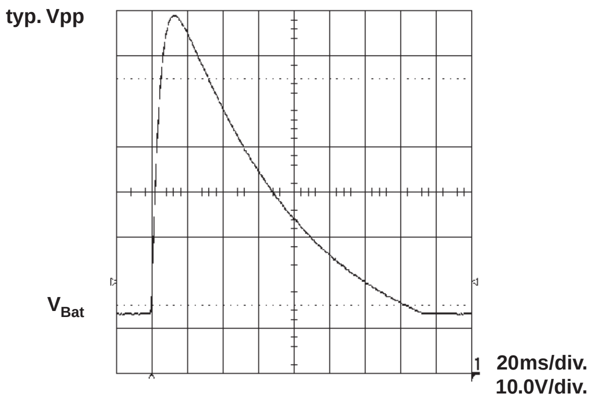
## CALIBRATION METHOD FOR SCHAFFNER NSG 506 C

1) With open circuit (generator is in open circuit):
- calibrate Vs

2) With short circuit (generator is in short circuit):
- calibrate Ri (Ri = 2Ω)

3) With D.U.T.
- calibrate tp (tp = 40ms @ Ipp/2)

**Typical Voltage curve (open circuit)**




**Typical Voltage and Current curve with D.U.T.**

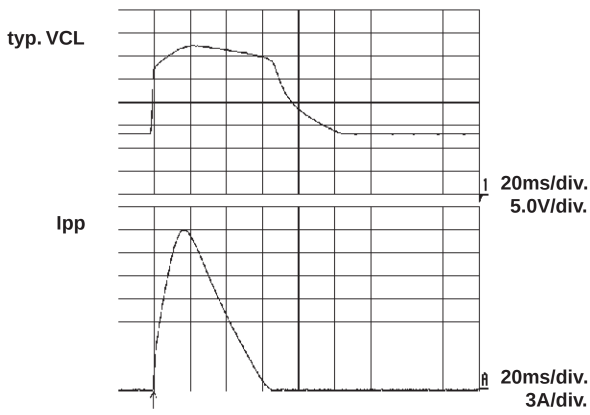


**Fig. 1 :** Peak pulse power versus exponential pulse duration (Tj initial = 85°C).

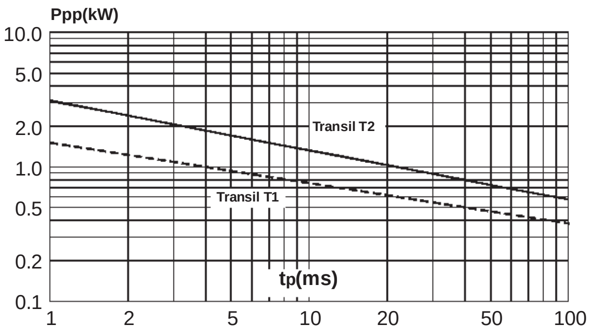



**Fig. 2-1 :** Clamping voltage versus peak pulse current (Tj initial = 85°C).

Exponential waveform tp = 40 ms and tp = 1 ms (TRANSIL T2).

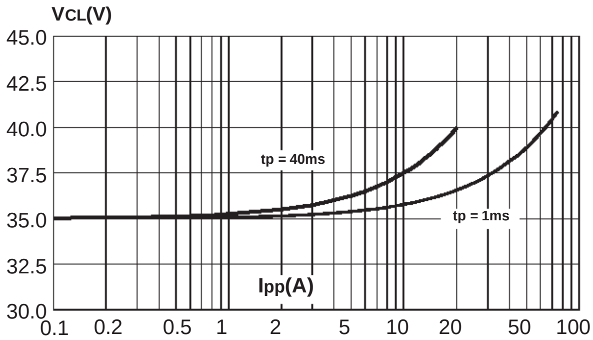



**Fig. 2-2 :** Clamping voltage versus peak pulse current (Tj initial = 85°C).

Exponential waveform tp = 1 ms and tp = 20 µs (TRANSIL T1).

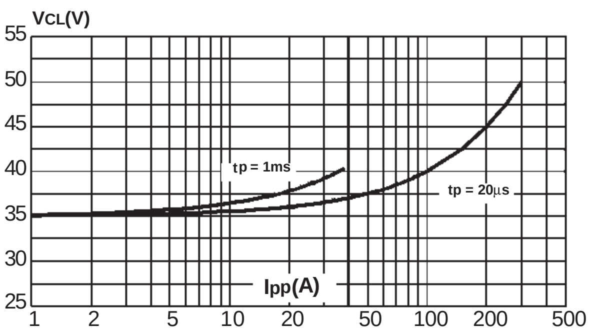



**Fig. 3 :** Relative variation of peak pulse power versus junction temperature.

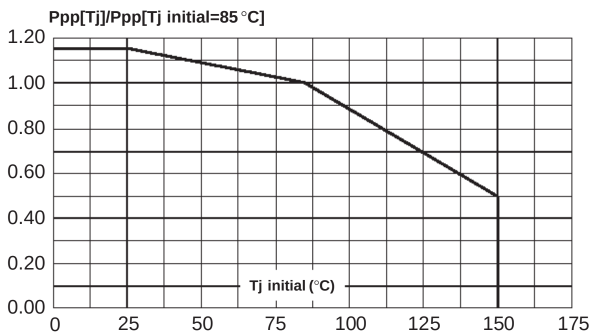


**Fig. 4 :** Relative variation of thermal impedance junction to case versus pulse duration.

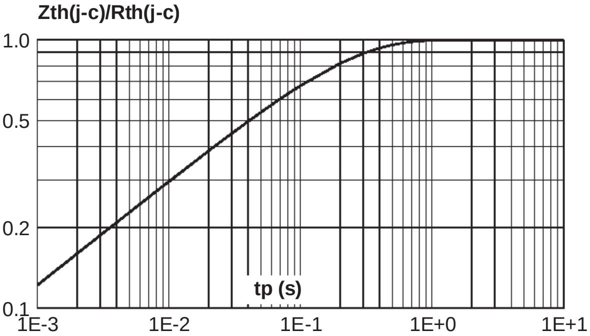



**Fig. 5-1 :** Peak forward voltage drop versus peak forward current (typical values) - (TRANSIL T2).

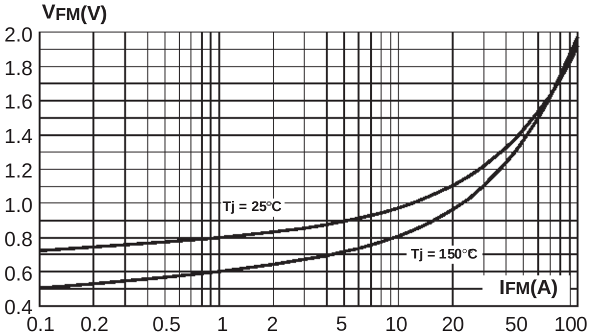



**Fig. 5-2 :** Peak forward voltage drop versus peak forward current (typical values) - (DIODE D1).

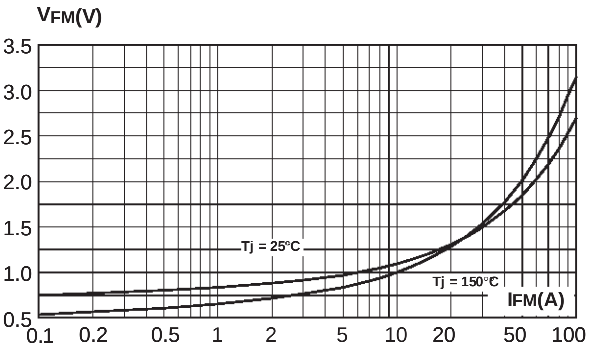
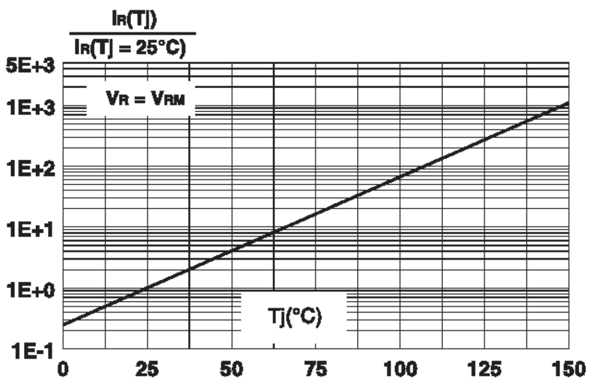



**Fig. 6 :** Relative variation of leakage current versus junction temperature.



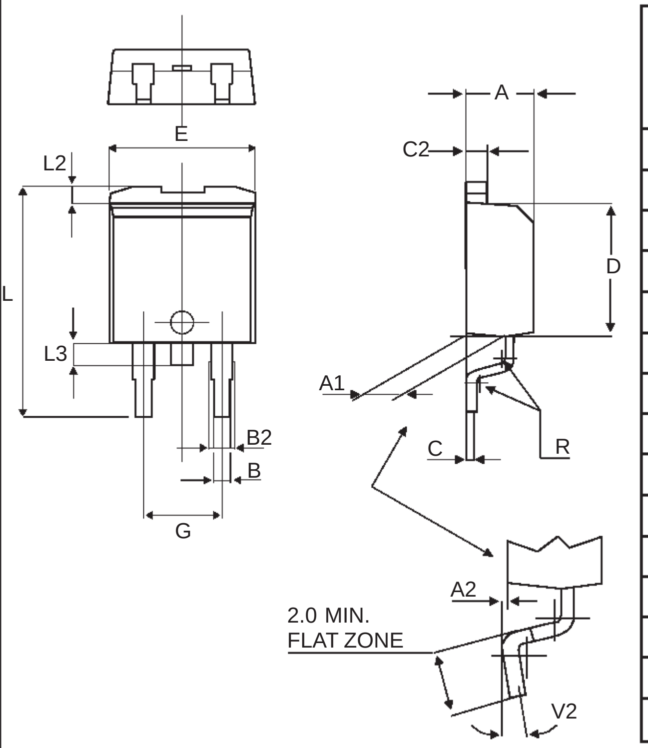

## ORDERING INFORMATION

**RBO 40 - 40 M**

- RBO: Reversed Battery & Overvoltage protection
- 40: $I_{F(AV)}$ = 40 A
- 40: $V_{CL}$ = 40V
- M: Package :
  M = PowerSO-10
  G = $D^2PAK$
  T = TO220AB

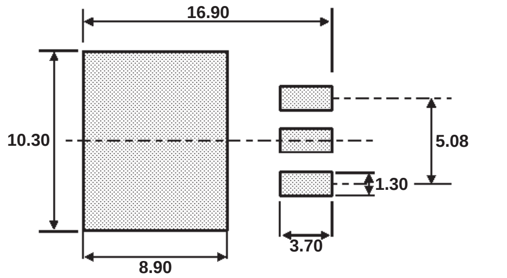
## PACKAGE MECHANICAL DATA

D²PAK Plastic




| REF. | DIMENSIONS | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 4.30 | | 4.60 | 0.169 | | 0.181 |
| A1 | 2.49 | | 2.69 | 0.098 | | 0.106 |
| A2 | 0.03 | | 0.23 | 0.001 | | 0.009 |
| B | 0.70 | | 0.93 | 0.027 | | 0.037 |
| B2 | | 1.40 | | | 0.055 | |
| C | 0.45 | | 0.60 | 0.017 | | 0.024 |
| C2 | 1.21 | | 1.36 | 0.047 | | 0.054 |
| D | 8.95 | | 9.35 | 0.352 | | 0.368 |
| E | 10.00 | | 10.28 | 0.393 | | 0.405 |
| G | 4.88 | | 5.28 | 0.192 | | 0.208 |
| L | 15.00 | | 15.85 | 0.590 | | 0.624 |
| L2 | 1.27 | | 1.40 | 0.050 | | 0.055 |
| L3 | 1.40 | | 1.75 | 0.055 | | 0.069 |
| R | | 0.40 | | | 0.016 | |
| V2 | 0° | | 8° | 0° | | 8° |

**FOOT-PRINT** D²PAK



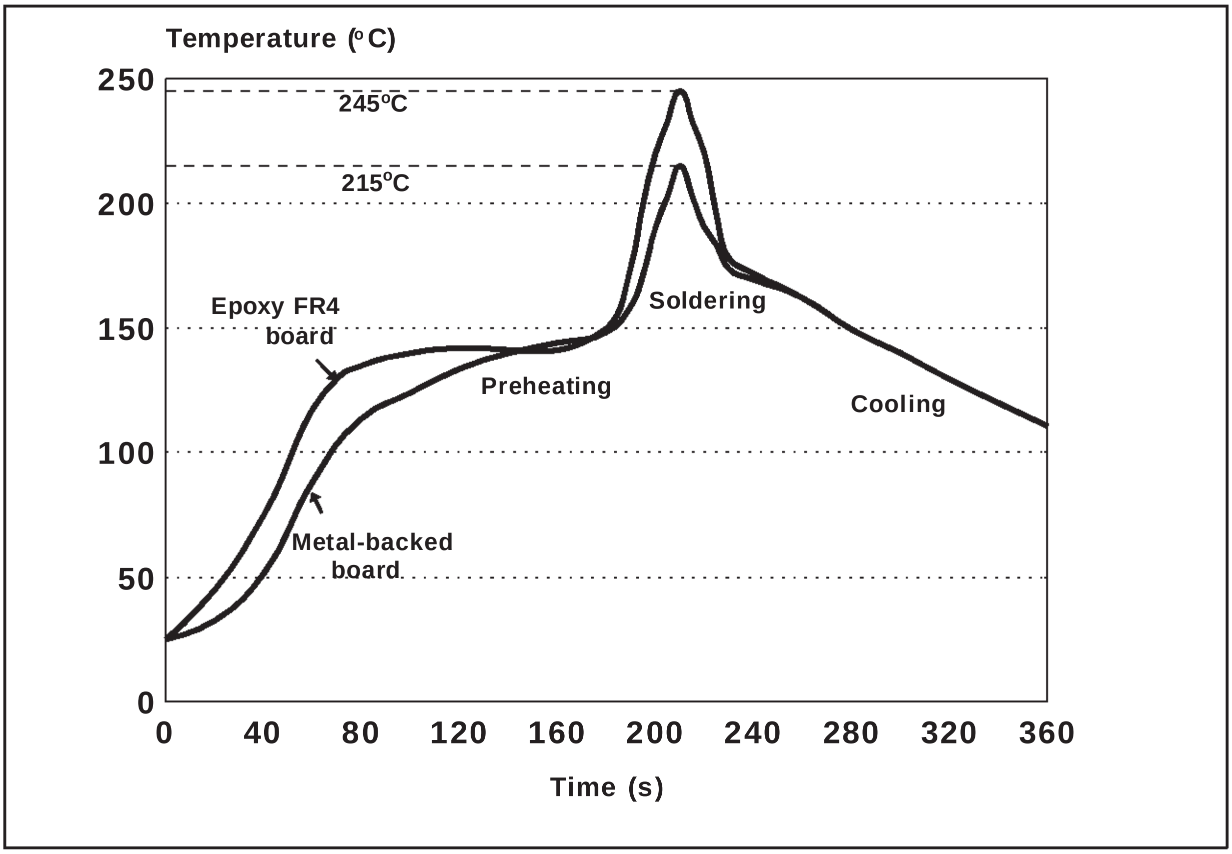
## SOLDERING RECOMMENDATION

The soldering process causes considerable thermal stress to a semiconductor component. This has to be minimized to assure a reliable and extended lifetime of the device. The PowerSO-10 package can be exposed to a maximum temperature of 260°C for 10 seconds. However a proper soldering of the package could be done at 215°C for 3 seconds. Any solder temperature profile should be within these limits. As reflow techniques are most common in surface mounting, typical heating profiles are given in Figure 1,either for mounting on FR4 or on metal-backed boards. For each particular board, the appropriate heat profile has to be adjusted experimentally. The present proposal is just a starting point. In any case, the following precautions have to be considered :

- always preheat the device
- peak temperature should be at least 30 °C higher than the melting point of the solder alloy chosen
- thermal capacity of the base substrate

Voids pose a difficult reliability problem for large surface mount devices. Such voids under the package result in poor thermal contact and the high thermal resistance leads to component failures. The PowerSO-10 is designed from scratch to be solely a surface mount package, hence symmetry in the x- and y-axis gives the package excellent weight balance. Moreover, the PowerSO-10 offers the unique possibility to control easily the flatness and quality of the soldering process. Both the top and the bottom soldered edges of the package are accessible for visual inspection (soldering meniscus).
Coplanarity between the substrate and the package can be easily verified. The quality of the solder joints is very important for two reasons : (I) poor quality solder joints result directly in poor reliability and (II) solder thickness affects the thermal resistance significantly. Thus a tight control of this parameter results in thermally efficient and reliable solder joints.

**Fig. 1 :** Typical reflow soldering heat profile



## SUBSTRATES AND MOUNTING INFORMATION

The use of epoxy FR4 boards is quite common for surface mounting techniques, however, their poor thermal conduction compromises the otherwise outstanding thermal performance of the PowerSO-10. Some methods to overcome this limitation are discussed below.

One possibility to improve the thermal conduction is the use of large heat spreader areas at the copper layer of the PC board. This leads to a reduction of thermal resistance to 35 °C for 6 $cm^2$ of the board heatsink (see fig. 2).

Use of copper-filled through holes on conventional FR4 techniques will increase the metallization and decrease thermal resistance accordingly. Using a configurationwith 16 holes under the spreader of the package with a pitch of 1.8 mm and a diameter of 0.7 mm, the thermal resistance (junction - heatsink) can be reduced to 12°C/W (see fig. 3). Beside the thermal advantage, this solution allows multi-layer boards to be used. However, a drawback of this traditional material prevents its use in very high power, high current circuits. For instance, it is not advisable to surface mount devices with currents greater than 10 A on FR4 boards. A Power Mosfet or Schottky diode in a surface mount power package can handle up to around 50 A if better substrates are used.

**Fig. 2 :** Mounting on epoxy FR4 head dissipation by extending the area of the copper layer

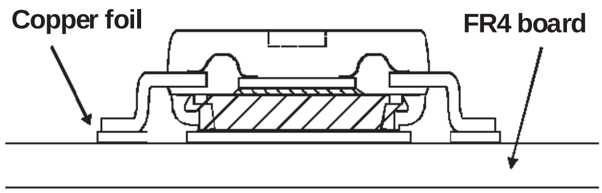
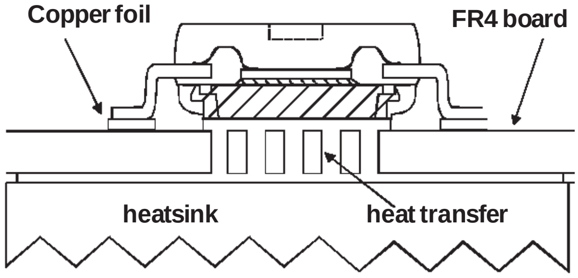



**Fig. 3 :** Mounting on epoxy FR4 by using copper-filled through holes for heat transfer



A new technology available today is IMS - an Insulated Metallic Substrate. This offers greatly enhanced thermal characteristics for surface mount components. IMS is a substrate consisting of three different layers, (I) the base material which is available as an aluminium or a copper plate, (II) a thermal conductive dielectrical layer and (III) a copper foil, which can be etched as a circuit layer. Using this material a thermal resistance of 8°C/W with 40 $cm^2$ of board floating in air is achievable (see fig. 4). If even higher power is to be dissipated an external heatsink could be applied which leads to an $R_{th}$(j-a) of 3.5°C/W (see Fig. 5), assuming that $R_{th}$ (heatsink-air) is equal to $R_{th}$ (junction-heatsink). This is commonly applied in practice, leading to reasonable heatsink dimensions. Often power devices are defined by considering the maximum junction temperature of the device. In practice , however, this is far from being exploited. A summary of various power management capabilities is made in table 1 based on a reasonable delta T of 70°C junction to air.

The PowerSO-10 concept also represents an attractive alternative to C.O.B. techniques. PowerSO-10 offers devices fully tested at low and high temperature. Mounting is simple - only conventional SMT is required - enabling the users to get rid of bond wire problems and the problem to control the high temperature soft soldering as well. An optimized thermal management is guaranteed through PowerSO-10 as the power chips must in any case be mounted on heat spreaders before being mounted onto the substrate.

**Fig. 4 :** Mounting on metal backed board

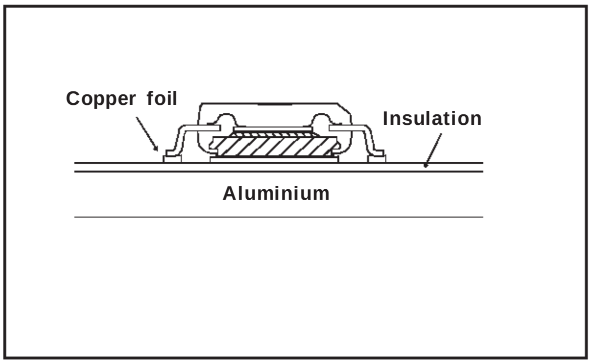



**Fig. 5 :** Mounting on metal backed board with an external heatsink applied

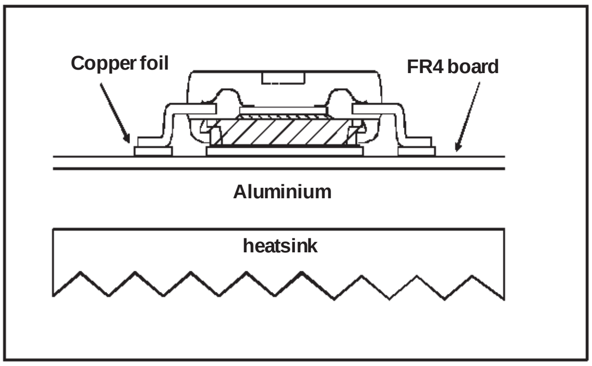
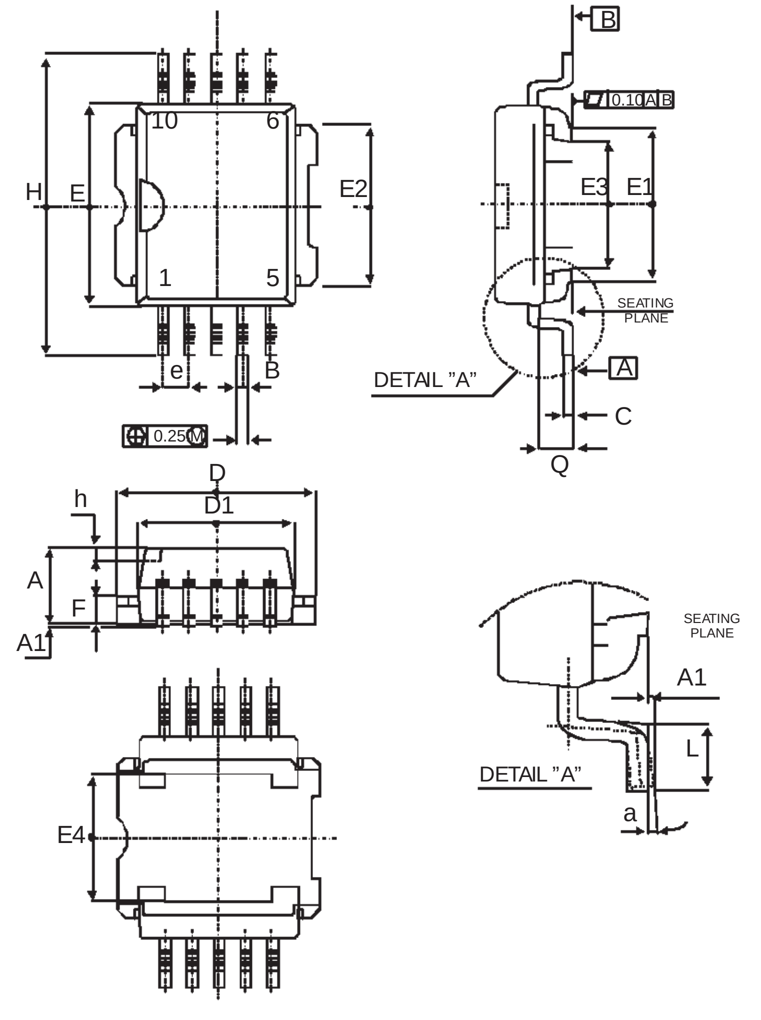



TABLE 1

| PowerSo-10 package mounted on | $R_{th}$ (j-a) | P Diss |
|---|---|---|
| 1.FR4 using the recommended pad-layout | 50 °C/W | 1.5 W |
| 2.FR4 with heatsink on board (6$cm^2$) | 35 °C/W | 2.0 W |
| 3.FR4 with copper-filled through holes and external heatsink applied | 12 °C/W | 5.8 W |
| 4. IMS floating in air (40 $cm^2$) | 8 °C/W | 8.8 W |
| 5. IMS with external heatsink applied | 3.5 °C/W | 20 W |

## PACKAGE MECHANICAL DATA

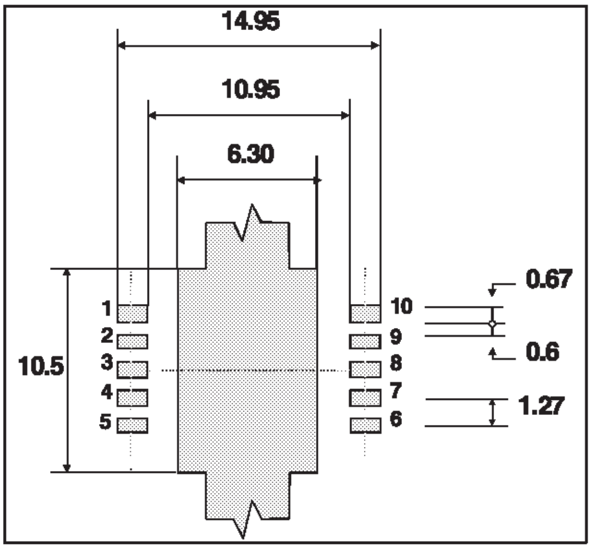



| REF. | DIMENSIONS | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 3.35 | | 3.65 | 0.131 | | 0.143 |
| A1 | 0.00 | | 0.10 | 0.00 | | 0.0039 |
| B | 0.40 | | 0.60 | 0.0157 | | 0.0236 |
| C | 0.35 | | 0.55 | 0.0137 | | 0.0217 |
| D | 9.40 | | 9.60 | 0.370 | | 0.378 |
| D1 | 7.40 | | 7.60 | 0.291 | | 0.299 |
| E | 9.30 | | 9.50 | 0.366 | | 0.374 |
| E1 | 7.20 | | 7.40 | 0.283 | | 0.291 |
| E2 | 7.20 | | 7.60 | 0.283 | | 0.299 |

| REF. | DIMENSIONS | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| E3 | 6.10 | | 6.35 | 0.240 | | 0.250 |
| E4 | 5.90 | | 6.10 | 0.232 | | 0.240 |
| e | | 1.27 | | | 0.05 | |
| F | 1.25 | | 1.35 | 0.0492 | | 0.0531 |
| H | 13.80 | | 14.40 | 0.543 | | 0.567 |
| h | | 0.50 | | | 0.019 | |
| L | 1.20 | | 1.80 | 0.0472 | | 0.0708 |
| Q | | 1.70 | | | 0.067 | |
| a | 0° | | 8° | 0° | | 8° |

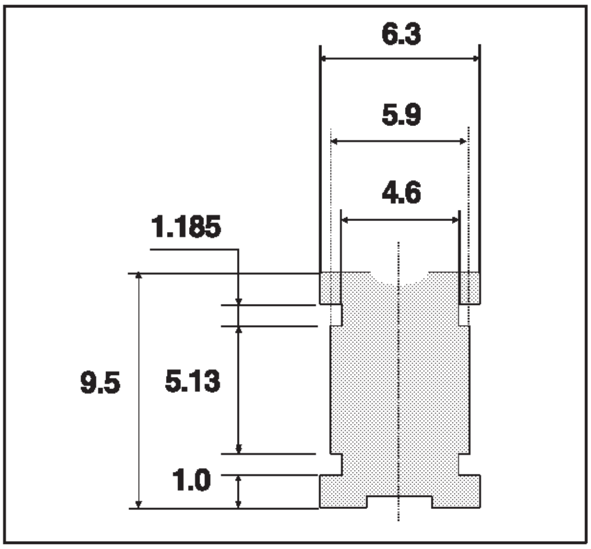
## FOOT PRINT

## MOUNTING PAD LAYOUT RECOMMENDED



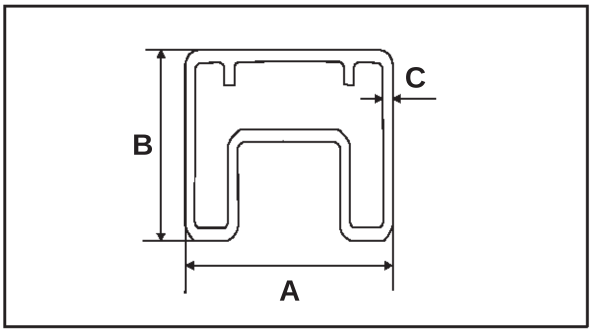

Dimensions in millimeters

## HEADER SHAPE




Dimensions in millimeters

## SHIPPING TUBE

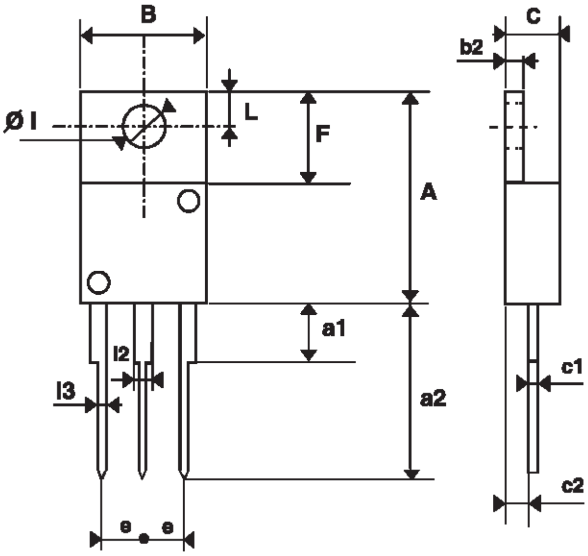



| | DIMENSIONS (mm) |
|---|---|
| | TYP |
| A<br>B<br>C<br>Length tube | 18<br>12<br>0,8<br>532 |
| Quantity per tube | 50 |

Surface mount film taping : contact sales office

## PACKAGE MECHANICAL DATA

TO220AB Plastic




| REF. | DIMENSIONS | | | |
|---|---|---|---|---|
| | Millimeters | | Inches | |
| | Min. | Max. | Min. | Max. |
| A | 14.23 | 15.87 | 0.560 | 0.625 |
| a1 | | 4.50 | | 0.177 |
| a2 | 12.70 | 14.70 | 0.500 | 0.579 |
| B | 10.20 | 10.45 | 0.402 | 0.411 |
| b1 | 0.64 | 0.96 | 0.025 | 0.038 |
| b2 | 1.15 | 1.39 | 0.045 | 0.055 |
| C | 4.48 | 4.82 | 0.176 | 0.190 |
| c1 | 0.35 | 0.65 | 0.020 | 0.026 |
| c2 | 2.10 | 2.70 | 0.083 | 0.106 |
| e | 2.29 | 2.79 | 0.090 | 0.110 |
| F | 5.85 | 6.85 | 0.230 | 0.270 |
| I | 3.55 | 4.00 | 0.140 | 0.157 |
| L | 2.54 | 3.00 | 0.100 | 0.118 |
| l2 | 1.45 | 1.75 | 0.057 | 0.069 |
| l3 | 0.80 | 1.20 | 0.031 | 0.047 |