DATA SHEET

General
RF Power Modules and Transistors for Mobile Phones

1996 Jun 06

File under Discrete Semiconductors, SC09

Philips Semiconductors

PHILIPS

QUALITY

Total Quality Management

Philips Semiconductors is a Quality Company, renowned for the high quality of our products and service. We keep alive this tradition by constantly aiming towards one ultimate standard, that of zero defects. This aim is guided by our Total Quality Management (TQM) system, the basis of which is described in the following paragraphs.

QUALITY ASSURANCE

Based on ISO 9000 standards, customer standards such as Ford TQE and IBM MDQ. Our factories are certified to ISO 9000 by external inspectorates.

PARTNERSHIPS WITH CUSTOMERS

PPM co-operations, design-in agreements, ship-to-stock, just-in-time and self-qualification programmes, and application support.

PARTNERSHIPS WITH SUPPLIERS

Ship-to-stock, statistical process control and ISO 9000 audits.

QUALITY IMPROVEMENT PROGRAMME

Continuous process and system improvement, design improvement, complete use of statistical process control, realization of our final objective of zero defects, and logistics improvement by ship-to-stock and just-in-time agreements.

Advanced quality planning

During the design and development of new products and processes, quality is built-in by advanced quality planning. Through failure-mode-and-effect analysis the critical parameters are detected and measures taken to ensure good performance on these parameters. The capability of process steps is also planned in this phase.

Product conformance

The assurance of product conformance is an integral part of our quality assurance (QA) practice. This is achieved by:

- Incoming material management through partnerships with suppliers.
- In-line quality assurance to monitor process reproducibility during manufacture and initiate any necessary corrective action. Critical process steps are 100% under statistical process control.
- Acceptance tests on finished products to verify conformance with the device specification. The test results are used for quality feedback and corrective actions. The inspection and test requirements are detailed in the general quality specifications.
- Periodic inspections to monitor and measure the conformance of products.

Product reliability

With the increasing complexity of Original Equipment Manufacturer (OEM) equipment, component reliability must be extremely high. Our research laboratories and development departments study the failure mechanisms of semiconductors. Their studies result in design rules and process optimization for the highest built-in product reliability. Highly accelerated tests are applied to the products reliability evaluation. Rejects from reliability tests and from customer complaints are submitted to failure analysis, to result in corrective action.

Customer responses

Our quality improvement depends on joint action with our customer. We need our customer’s inputs and we invite constructive comments on all aspects of our performance. Please contact our local sales representative.

Recognition

The high quality of our products and services is demonstrated by many Quality Awards granted by major customers and international organizations.

PRO ELECTRON TYPE NUMBERING SYSTEM

Basic type number

This type designation code applies to discrete semiconductor devices (not integrated circuits), multiples of such devices, semiconductor chips and Darlington transistors.

FIRST LETTER

The first letter gives information about the material for the active part of the device.

- A Germanium or other material with a band gap of 0.6 to 1 eV
- B Silicon or other material with a band gap of 1 to 1.3 eV
- C Gallium arsenide (GaAs) or other material with a band gap of 1.3 eV or more

R Compound materials, e.g. cadmium sulphide.

SECOND LETTER

The second letter indicates the function for which the device is primarily designed. The same letter can be used for multi-chip devices with similar elements.

In the following list low power types are defined by $R_{th\ j\text{-}mb}$ > 15 K/W and power types by $R_{th\ j\text{-}mb} \leq$ 15 K/W.

A Diode; signal, low power

B Diode; variable capacitance

C Transistor; low power, audio frequency

D Transistor; power, audio frequency

E Diode; tunnel

F Transistor; low power, high frequency

G Multiple of dissimilar devices/miscellaneous devices; e.g. oscillators. Also with special third letter; see under Section “Serial number”

H Diode; magnetic sensitive

L Transistor; power, high frequency

N Photocoupler

P Radiation detector; e.g. high sensitivity photo-transistor; with special third letter

Q Radiation generator; e.g. LED, laser; with special third letter

R Control or switching device; e.g. thyristor, low power; with special third letter

S Transistor; low power, switching

T Control or switching device; e.g. thyristor, low power; with special third letter

U Transistor; power, switching

W Surface acoustic wave device

X Diode; multiplier, e.g. varactor, step recovery

Y Diode; rectifying, booster

Z Diode; voltage reference or regulator, transient suppressor diode; with special third letter.

SERIAL NUMBER

The number comprises three figures running from 100 to 999 for devices primarily intended for consumer equipment, or one letter (Z, Y, X, etc.) and two figures running from 10 to 99 for devices primarily intended for industrial or professional equipment.(1)

(1) When the supply of these serial numbers is exhausted, the serial number may be expanded to three figures for industrial types and four figures for consumer types.

Version letter

A letter may be added to the basic type number to indicate minor electrical or mechanical variants of the basic type.

RATING SYSTEMS

The rating systems described are those recommended by the IEC in its publication number 134.

Definitions of terms used

ELECTRONIC DEVICE

An electronic tube or valve, transistor or other semiconductor device. This definition excludes inductors, capacitors, resistors and similar components.

CHARACTERISTIC

A characteristic is an inherent and measurable property of a device. Such a property may be electrical, mechanical, thermal, hydraulic, electro-magnetic or nuclear, and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

BOGEY ELECTRONIC DEVICE

An electronic device whose characteristics have the published nominal values for the type. A bogey electronic device for any particular application can be obtained by considering only those characteristics that are directly related to the application.

RATING

A value that establishes either a limiting capability or a limiting condition for an electronic device. It is determined for specified values of environment and operation, and may be stated in any suitable terms. Limiting conditions may be either maxima or minima.

RATING SYSTEM

The set of principles upon which ratings are established and which determine their interpretation. The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

Absolute maximum rating system

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type, as defined by its published data, which should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

The equipment manufacturer should design so that, initially and throughout the life of the device, no absolute maximum value for the intended service is exceeded with any device, under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

Design maximum rating system

Design maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

The equipment manufacturer should design so that, initially and throughout the life of the device, no design maximum value for the intended service is exceeded with a bogey electronic device, under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, variation in characteristics of all other devices in the equipment, equipment control adjustment, load variation, signal variation and environmental conditions.

Design centre rating system

Design centre ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply voltage.

LETTER SYMBOLS

The letter symbols for transistors detailed in this section are based on IEC publication number 148.

Basic letters

In the representation of currents, voltages and powers, lower-case letter symbols are used to indicate all instantaneous values that vary with time. All other values are represented by upper-case letters.

Electrical parameters[1] of external circuits and of circuits in which the device forms only a part are represented by upper-case letters. Lower-case letters are used for the representation of electrical parameters inherent in the device. Inductances and capacitances are always represented by upper-case letters.

The following is a list of basic letter symbols used with semiconductor devices:

B, b	Susceptance (imaginary part of an admittance)
C	Capacitance
G, g	Conductance (real part of an admittance)
H, h	Hybrid parameter
I, i	Current
L	Inductance
P, p	Power
R, r	Resistance (real part of an impedance)
V, v	Voltage
X, x	Reactance (imaginary part of an impedance)
Y, y	Admittance
Z, z	Impedance.

(1) For the purpose of this publication, the term ‘electrical parameters’ applies to four-pole matrix parameters, elements of electrical equivalent circuits, electrical impedances and admittances, inductances and capacitances.

Subscripts

Upper-case subscripts are used for the indication of:

- Continuous (DC) values (without signal), e.g. I_B
- Instantaneous total values, e.g. i_B
- Average total values, e.g. $I_{B(AV)}$
- Peak total values, e.g. I_{BM}
- Root-mean-square total values, e.g. $I_{B(RMS)}$.

Lower-case subscripts are used for the indication of values applying to the varying component alone:

- Instantaneous values, e.g. i_b
- Root-mean-square values, e.g. $I_{b(rms)}$
- Peak values, e.g. I_{bm}
- Average values, e.g. $I_{b(av)}$.

The following is a list of subscripts used with basic letter symbols for semiconductor devices:

A, a	anode
amb	ambient
(AV), (av)	average value
B, b	base
(BO)	breakover
(BR)	breakdown
case	case
C, c	collector
C	controllable
D, d	drain
E, e	emitter
F, f	fall, forward (or forward transfer)
G, g	gate
H	holding
h	heatsink
I, i	input
j-a	junction to ambient
j-mb	junction to mounting base
K, k	cathode
L	load
M, m	peak value
(min)	minimum
(max)	maximum
mb	mounting base
O, o	As first subscript: reverse (or reverse transfer), rise. As second subscript: repetitive, recovery. As third subscript: with a specified resistance between the terminal not mentioned and the reference terminal
(OV)	Overload
P, p	Pulse
Q, q	Turn-off
R, r	As first subscript: reverse (or reverse transfer), rise. As second subscript: repetitive, recovery. As third subscript: with a specified resistance between the terminal not mentioned and the reference terminal
(RMS), (rms)	Root-mean-square value
S, s	As first subscript: series, source, storage, stray, switching. As second subscript: surge (non-repetitive). As third subscript: short circuit between the terminal not mentioned and the reference terminal
stg	Storage
th	Thermal
TO	Threshold
tot	Total
W	Working
X, x	Specified circuit
Z, z	Reference or regulator (zener)
1	Input (four-pole matrix)
2	Output (four-pole matrix).

Applications and examples

TRANSISTOR CURRENTS

The first subscript indicates the terminal carrying the current (conventional current flow from the external circuit into the terminal is positive).

Examples: I_B, i_B, i_b, i_{bm}.

TRANSISTOR VOLTAGES

A voltage is indicated by the first two subscripts: the first identifies the terminal at which the voltage is measured and the second the reference terminal or the circuit node. The second subscript may be omitted when there is no possibility of confusion.

Examples: V_{BE}, v_{BE}, v_{be}, V_{bem}.

SUPPLY VOLTAGES OR CURRENTS

Supply voltages or supply currents are indicated by repeating the appropriate terminal subscript.

Examples: V_{CC}; I_{EE}.

A reference terminal is indicated by a third subscript.

Example: V_{CCE}.

DEVICES WITH MORE THAN ONE TERMINAL OF THE SAME KIND

If a device has more than one terminal of the same kind, the subscript is formed by the appropriate letter for the terminal, followed by a number. Hyphens may be used to avoid confusion in multiple subscripts.

Examples:

I_{B2}	Continuous (DC) current flowing into the second base terminal
V_{B2-E}	Continuous (DC) voltage between the terminals of second base and emitter.

MULTIPLE DEVICES

For multiple unit devices, the subscripts are modified by a number preceding the letter subscript. Hyphens may be used to avoid confusion in multiple subscripts.

Examples:

I_{2C}	Continuous (DC) current flowing into the collector terminal of the second unit
V_{1C-2C}	Continuous (DC) voltage between the collector terminals of the first and second units.

ELECTRICAL PARAMETERS

The upper-case variant of a subscript is used for the designation of static (DC) values.

Examples:

h_{FE}	Static value of forward current transfer in common-emitter configuration (DC current gain)
R_E	DC value of the external emitter resistance.

The static value is the slope of the line from the origin to the operating point on the appropriate characteristic curve, i.e. the quotient of the appropriate electrical quantities at the operating point.

The lower-case variant of a subscript is used for the designation of small-signal values.

Examples:

h_{fe}	Small-signal value of the short-circuit forward current transfer ratio in common-emitter configuration
$Z_i = R_i + jX_i$	Small-signal value of the input impedance.

If more than one subscript is used, subscripts for which a choice of style is allowed, the subscripts chosen are all upper-case or all lower-case.

Examples: h_{FE}, y_{RE}, h_{fe}.

FOUR-POLE MATRIX PARAMETERS

The first letter subscript (or double numeric subscript) indicates input, output, forward transfer or reverse transfer.

Examples: h_i (or h_{11}), h_o (or h_{22}), h_f (or h_{21}), h_r (or h_{12}).

A further subscript is used for the identification of the circuit configuration. When no confusion is possible, this further subscript may be omitted.

Examples: h_{fe} (or h_{21e}), h_{FE} (or h_{21E}).

DISTINCTION BETWEEN REAL AND IMAGINARY PARTS

If it is necessary to distinguish between real and imaginary parts of electrical parameters, no additional subscripts are used. If basic symbols for the real and imaginary parts exist, these may be used.

Examples: $Z_i = R_i + jX_i$, $y_{fe} = g_{fe} + jb_{fe}$.

If such symbols do not exist or are not suitable, the notation shown in the following examples is used.

Examples:

Re (h_{ib}) etc. for the real part of h_{ib}

Im (h_{ib}) etc. for the imaginary part of h_{ib}.

TAPE AND REEL PACKING

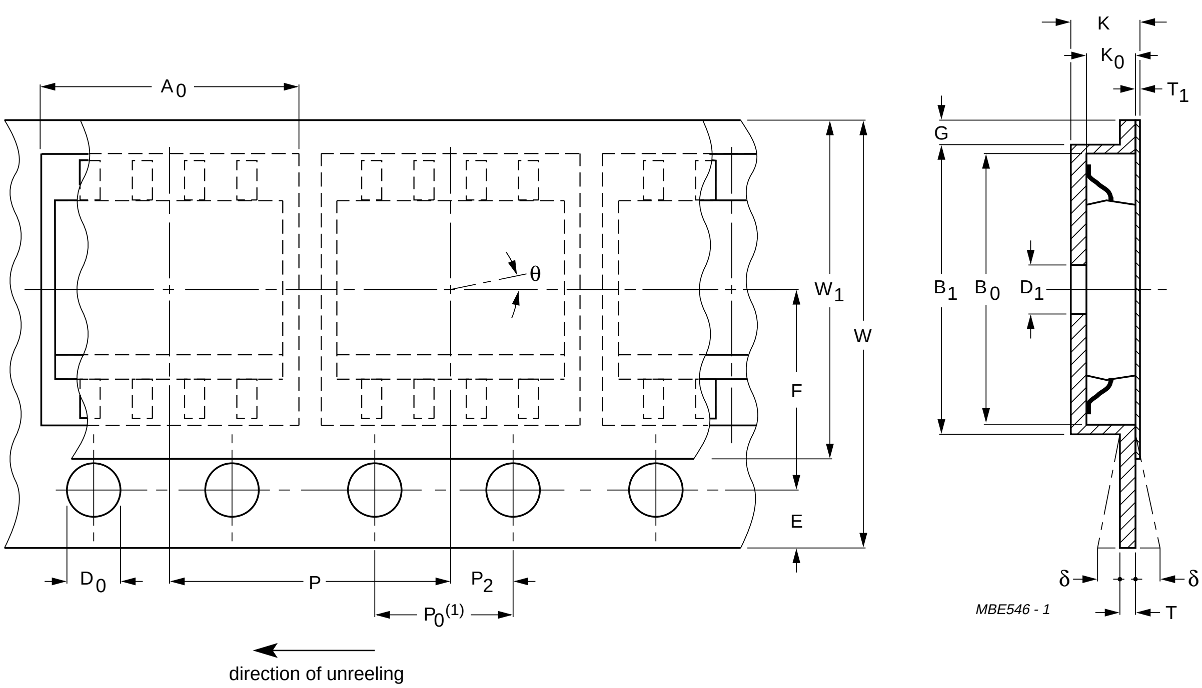
Packing types

Table 1 Packing quantities per reel

PACKAGE	TAPE WIDTH (mm)	REEL SIZE (mm)	QUANTITY PER REEL	12NC (note 1) ends with:
SOT96 (SO8)	12	330	2500	...118
SOT223	12	180	3000	...115
SOT321A	40	330	600	...135
SOT321B	40	330	600	...135

Note

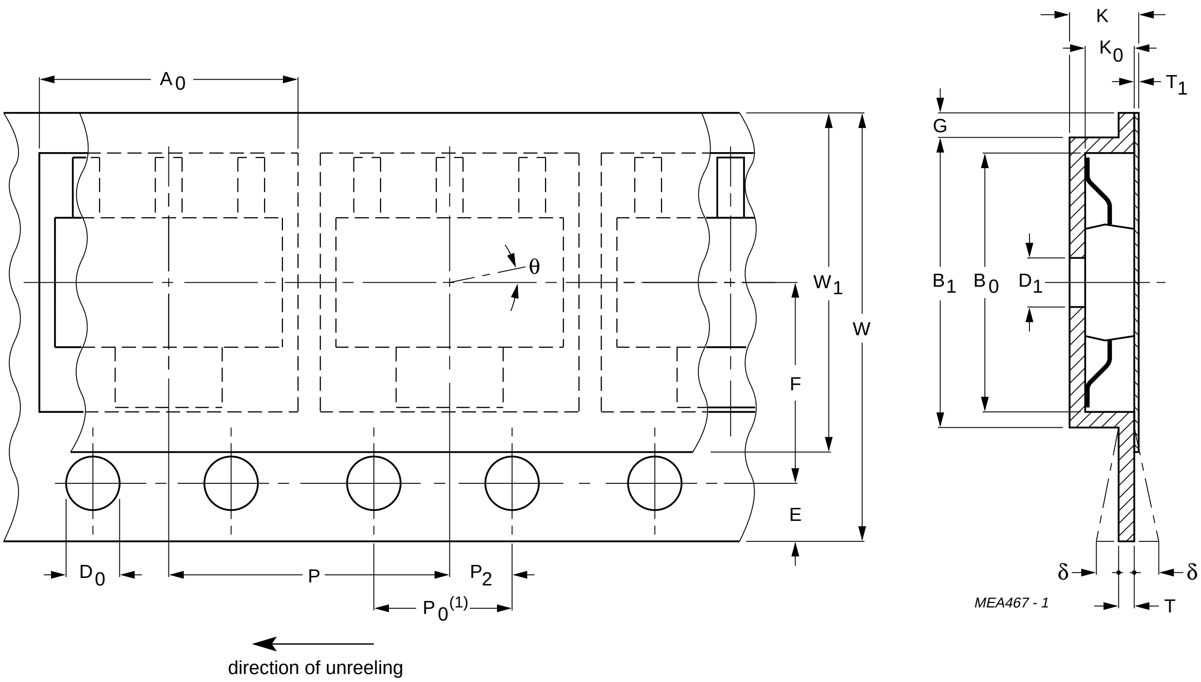
1. 12NC is the Philips twelve-digit ordering code.



For dimensions see Table 2.

(1) Tolerance over any 10 pitches: ±0.2 mm.

Fig.1 Specification for 12 mm tape (SOT96).



For dimensions see Table 2.

(1) Tolerance over any 10 pitches: ±0.2 mm.

Fig.2 Specification for 12 mm tape (SOT223).

Table 2 Tape dimensions (in mm)

DIMENSION (Figs 1 and 2)	**12 mm CARRIER TAPE**	**TOLERANCE**
Overall dimensions		
W	12.0	±0.2
K	<2.4	–
G	>0.75	–
Sprocket holes; note 1		
D_0	1.5	+0.1/–0
E	1.75	±0.1
P_0	4.0	±0.1
Relative placement compartment		
P_2	2.0	±0.1
F	5.5	±0.05
Compartment		
A_0	Compartment dimensions depend on package size. Maximum clearance between device and compartment is 0.3 mm; the minimum clearance ensures that the device is not totally restrained within the compartment.	
B_0		
B_1		
K_0		
D_1	>1.5	–
P	8.0	±0.1
θ	<15°	–
Cover tape; note 2		
W_1	<9.5	–
T_1	<0.1	–
Carrier tape		
W	12.0	±0.2
T	<0.2	–
δ	<0.3	–

Notes

1. Tolerance over any 10 pitches ±0.2 mm.
2. The cover tape shall not overlap the tape or sprocket holes.

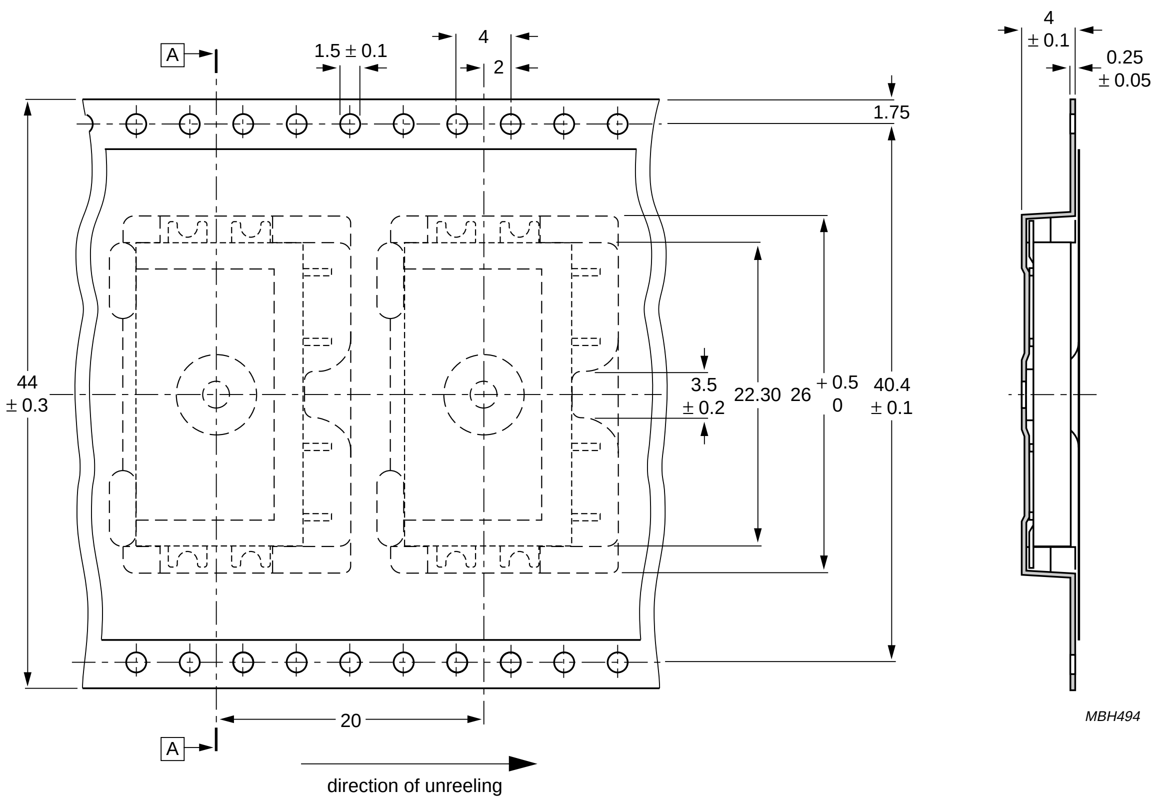


Fig.3 Specification for 40 mm tape (SOT321A).

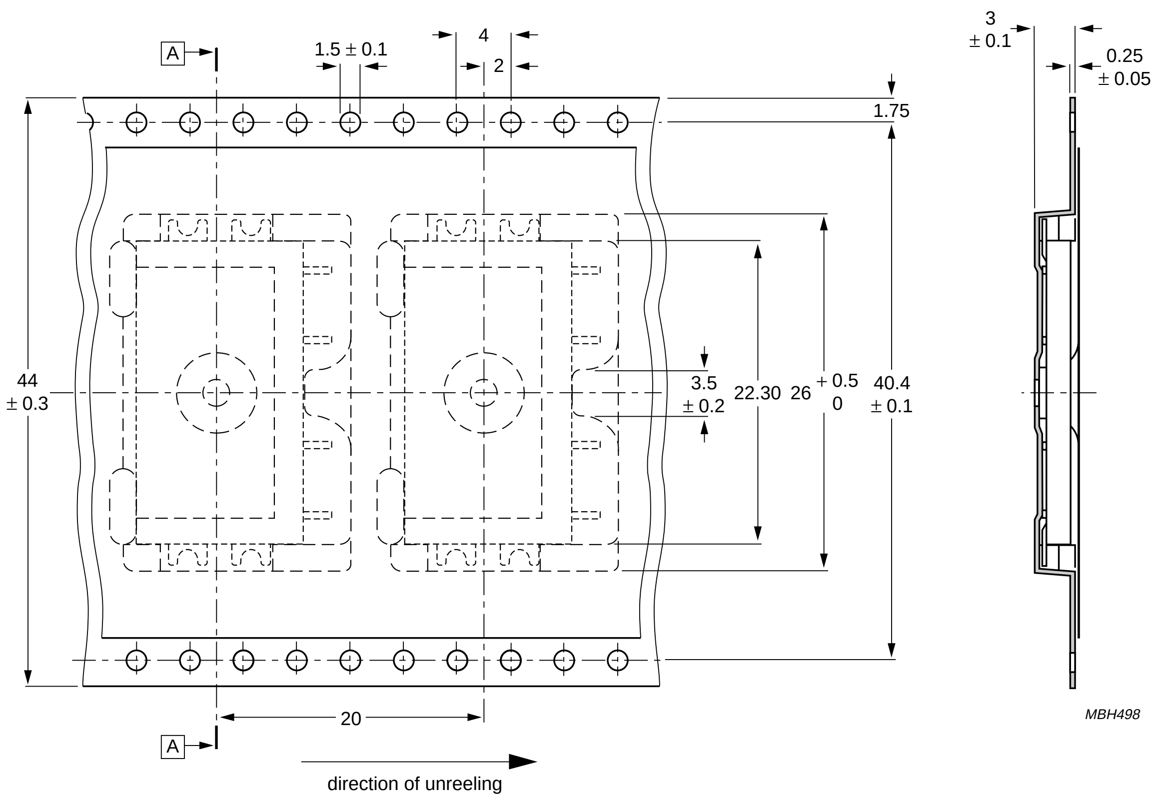
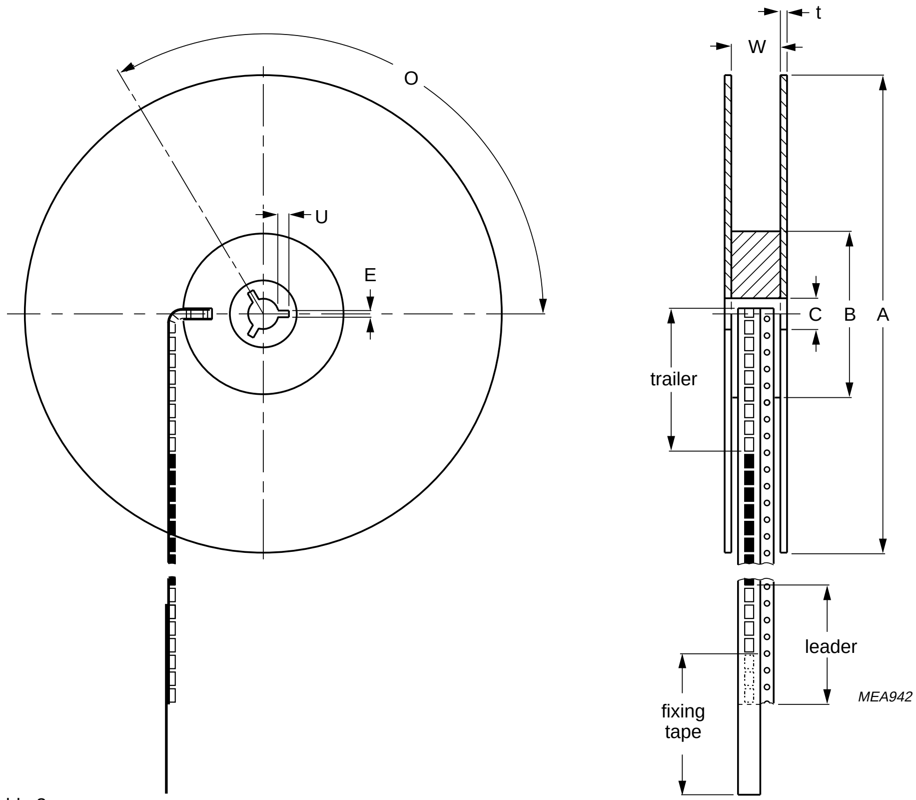


Fig.4 Specification for 40 mm tape (SOT321B).



For dimensions see Table 3.

Fig.5 Reel specification.

Table 3 Reel dimensions (in mm)

DIMENSION (see Fig.5)	12 mm CARRIER TAPE	TOLERANCE	40 mm CARRIER TAPE	TOLERANCE
Flange				
A	180(1) or 330	±0.5	330	–
t	1.5	+0.5/–0.1	3	–
W	12.4	18.0+0.2	44.4	+2/–0
Hub				
B	62	±1.5	101	±1.5
C	12.75	+0.15/–0.2	13	±1.5
Key slot				
E	2	±0.2	1.5	–
U	4	±0.5	3.6	–
O	120°	–	120°	–

Note

1. Large reel diameter depends on individual package (286 or 350).

MOUNTING AND SOLDERING

Introduction

This chapter gives an overview of the mounting and soldering methods which can be applied to the SMD transistors, SMD modules, and the Flange mounted modules, all of which are present in this handbook.

Surface mounting techniques

For SMD transistors reflow soldering is recommended. For the SMD modules only reflow soldering is allowed. Surface mounting techniques are complex and this chapter provides only a simplified overview of the subject.

Reflow soldering

SOLDER PASTE

Most reflow soldering techniques utilize a paste that is a mixture of flux and solder. The solder paste is applied to the substrate before the components are placed. It is of sufficient viscosity to hold the components in place and, therefore, an application of adhesive is not required. Drying of the solder paste by preheating increases the viscosity and prevents any tendency for the components to become displaced during the soldering process. Preheating also minimizes thermal shock and drives off flux solvents.

Screen printing

This is the best high-volume production method of solder paste application. An emulsion-coated, fine mesh screen with apertures etched in the emulsion to coincide with the surfaces to be soldered is placed over the substrate. A squeegee is passed across the screen to force solder paste through the apertures and on to the substrate. The layer thickness of screened solder paste is usually between 150 and 200 μm.

Stencilling

In this method a stencil with etched holes to pass the paste is used. The thickness of the stencil determines the amount of amount of solder paste that is deposited on the substrate. This method is also suited to high-volume work.

Dispensing

A computer-controlled pressure syringe dispenses small doses of paste to where it is required. This method is mainly suitable for small production runs and laboratory use.

Pin transfer

A pin picks up a droplet of solder paste from a reservoir and transfers it to the surface of the substrate or component. A multi-pin arrangement with pins positioned to match the substrate is possible and this speeds up the process time.

REFLOW TECHNIQUES

Thermal conduction

The prepared substrates are carried on a conveyor belt, first through a preheating stage and then through a soldering stage. Heat is transferred to the substrate by conduction through the belt. Figure 6 shows a theoretical time/temperature relationship for thermal conduction reflow soldering. This method is particularly suited to thick film substrates and is often combined with infrared heating.

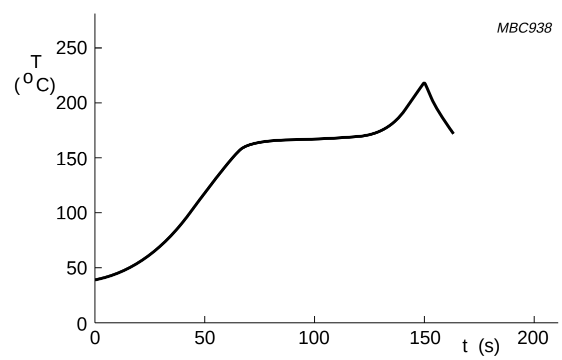


Fig.6 Theoretical time / temperature curve for a typical thermal conductive reflow cycle.

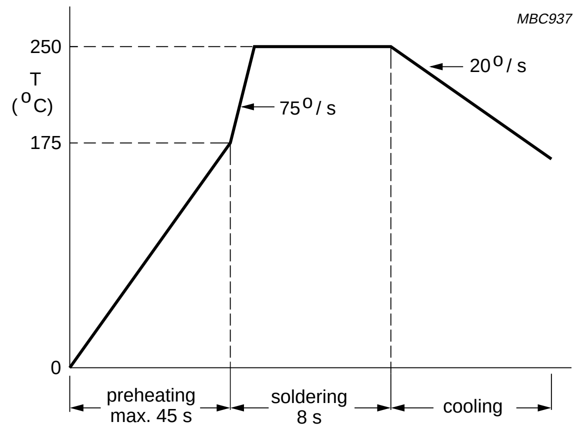


Fig.7 Typical temperature profile of an infrared oven operating at a belt speed of 0.41 mm / min.

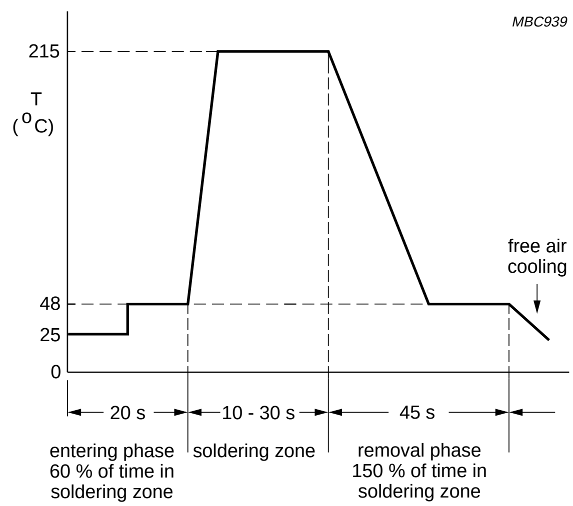


Fig.8 Theoretical time / temperature curve relationship for dual vapour reflow soldering.

Infrared

An infrared oven has several heating elements giving a broad spectrum of infrared radiation, normally above and below a closed loop belt system. There are separate zones for preheating, soldering and cooling. Dwell time in the soldering zone is kept as short as possible to prevent damage to components and substrate. A typical heating profile is shown in Fig.7. This reflow method is often applied in double-sided prints.

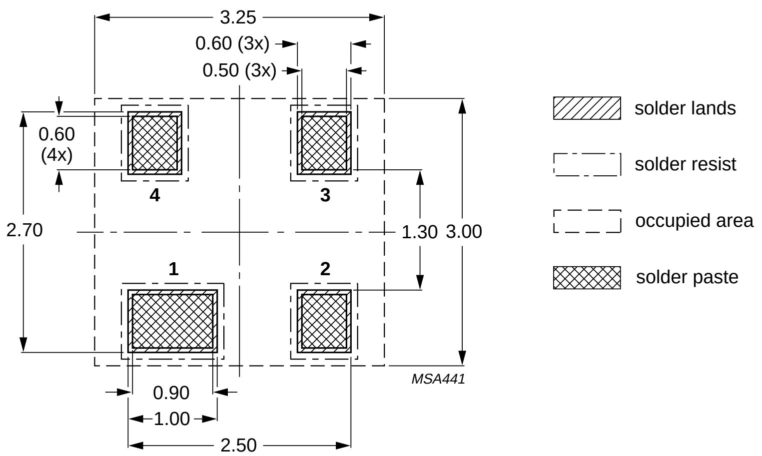
Vapour phase

A substrate is immersed in the vapours of a suitable boiling liquid. The vapours transfer latent heat of condensation to the substrate and solder reflow takes place. Temperature is controlled precisely by the boiling point of the liquid at a given pressure. Some systems employ two vapour zones, one above the other. An elevator tray, suspended from a hoist mechanism passes the substrate vertically through the first vapour zone into the secondary soldering zone and then hoists it out of the vapour to be cooled.
A theoretical time/temperature relationship for this method is shown in Fig.8.

SMD transistors

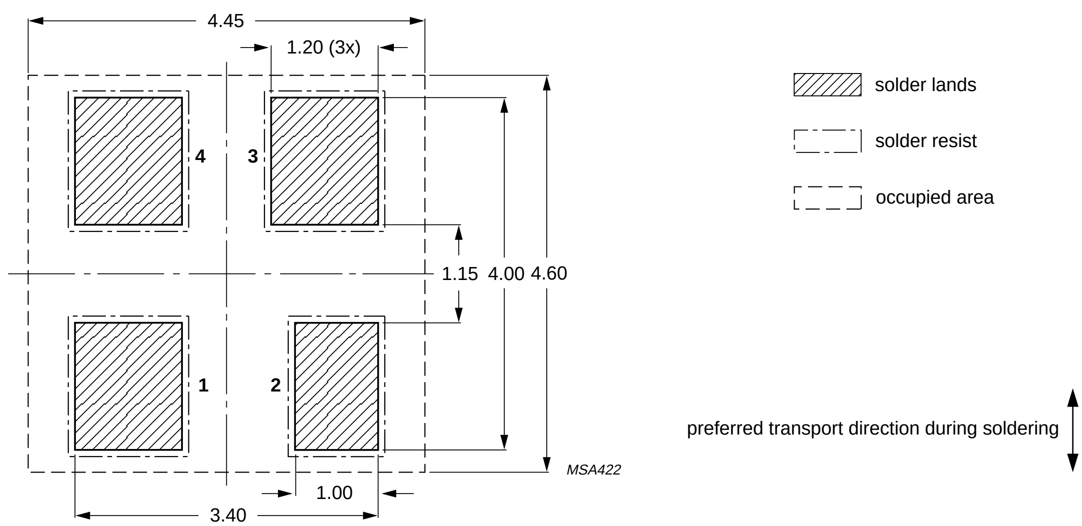
Soldering footprints for SMD transistors included in this handbook are as follows:

SOT143/SOT143R FOOTPRINTS



Dimensions in mm.
Placement accuracy: ±0.25 mm.

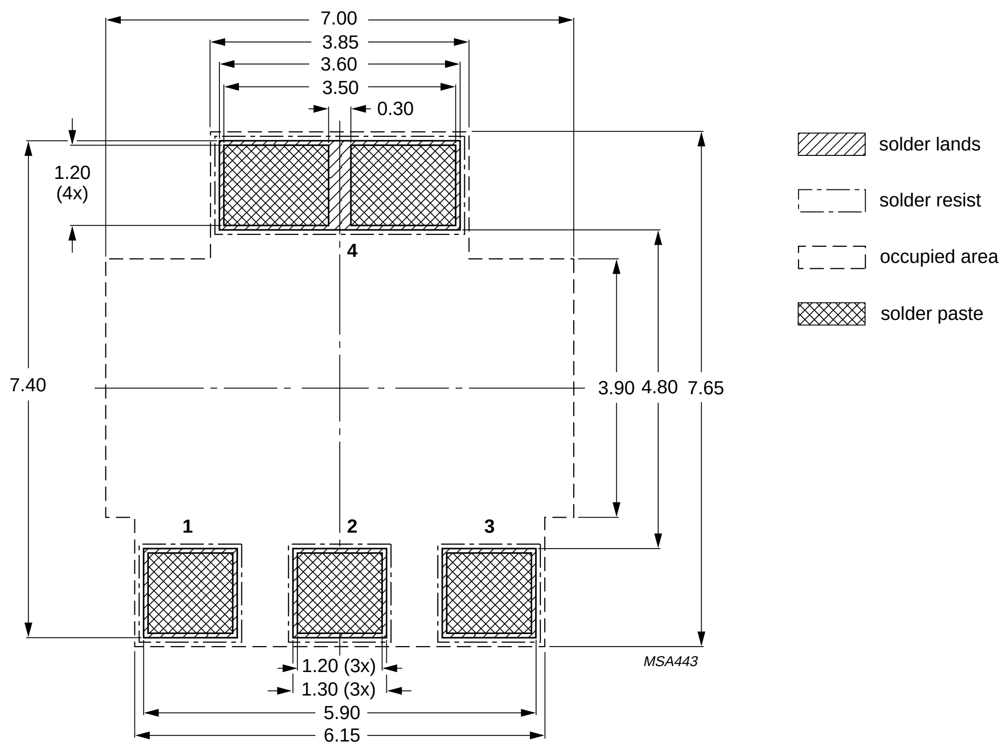
Fig.9 Reflow soldering footprint for SOT143; typical dimensions.



Dimensions in mm.
Placement accuracy: ±0.25 mm.

Fig.10 Wave soldering footprint for SOT143; typical dimensions.

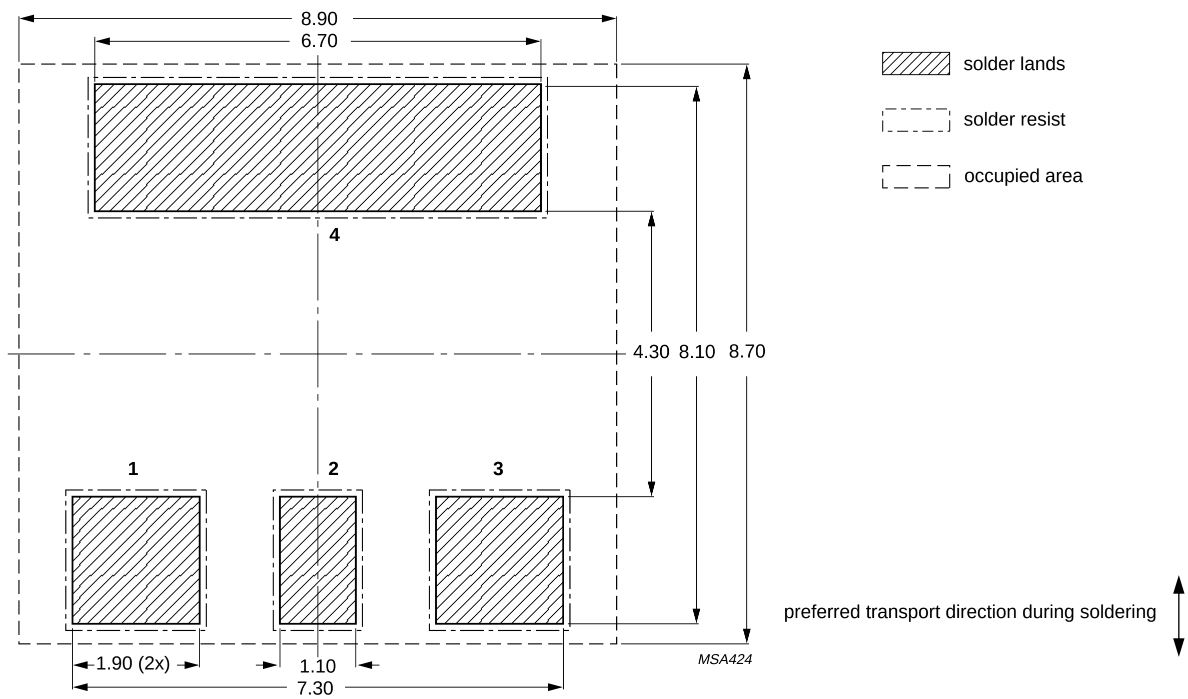
SOT223 FOOTPRINTS



Dimensions in mm.

Placement accuracy: ±0.25 mm.

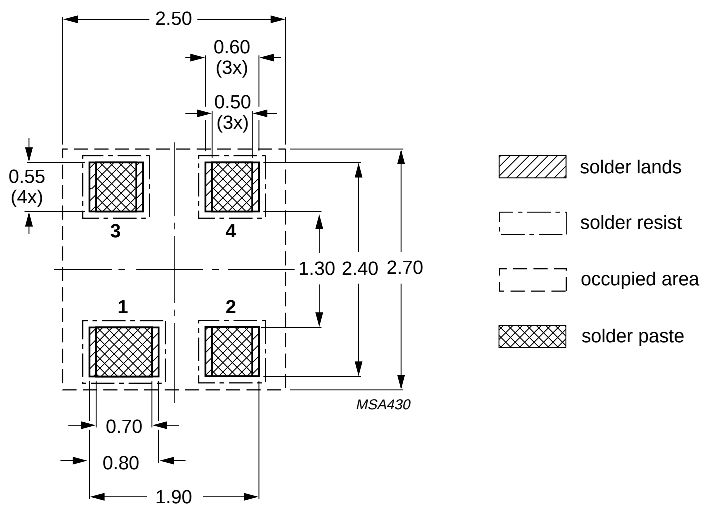
Fig.11 Reflow soldering footprint for SOT223; typical dimensions.



Dimensions in mm.
Placement accuracy: ±0.25 mm.

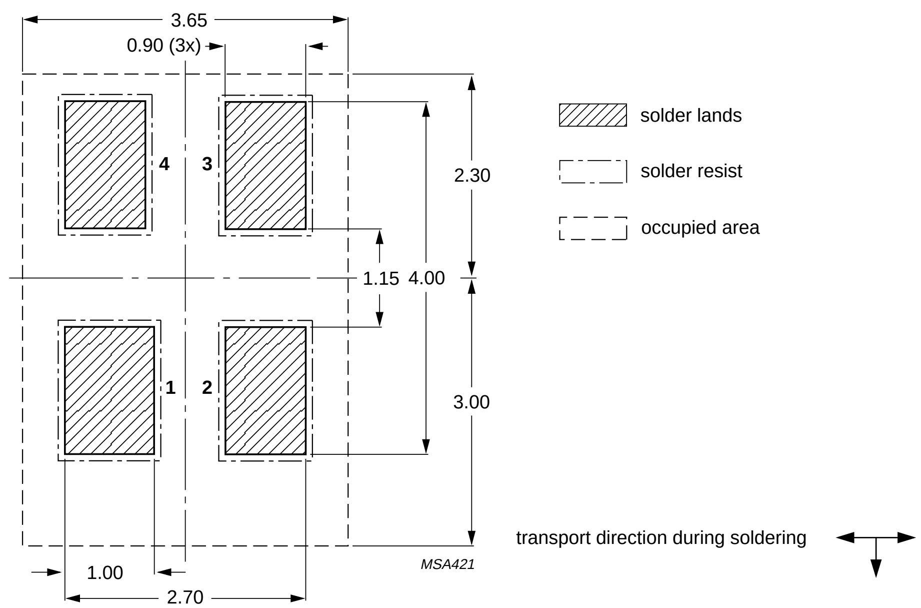
Fig.12 Wave soldering footprint for SOT223; typical dimensions.

SOT343 FOOTPRINTS



Dimensions in mm.
Placement accuracy: ±0.25 mm.

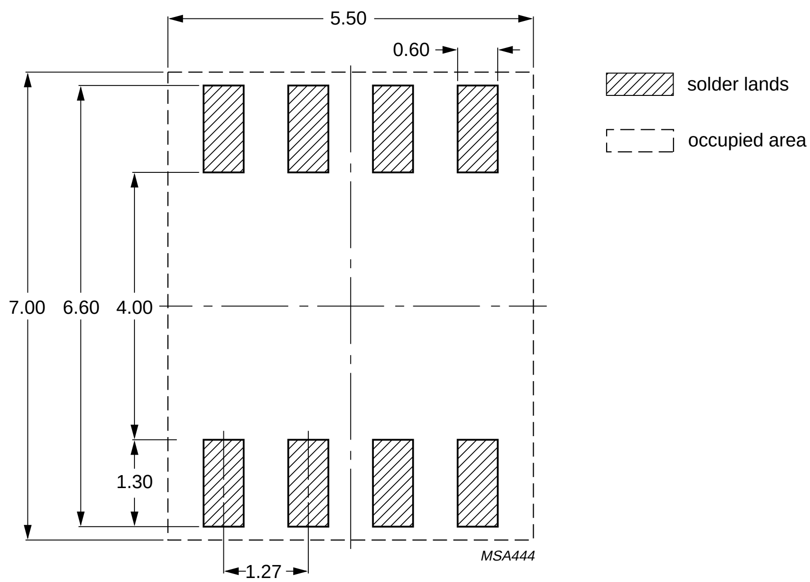
Fig.13 Reflow soldering footprint for SOT343; typical dimensions.



Dimensions in mm.
Placement accuracy: ±0.25 mm.

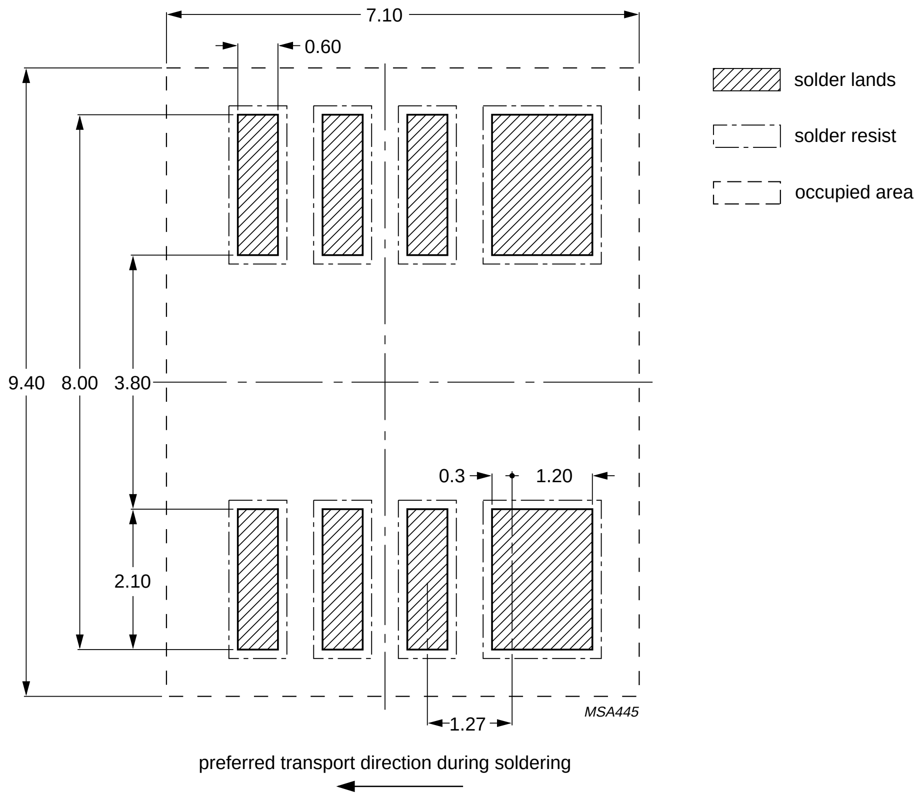
Fig.14 Wave soldering footprint for SOT343; typical dimensions.

SOT96 (SO8) FOOTPRINTS



Dimensions in mm.
Placement accuracy: ±0.25 mm.

Fig.15 Reflow soldering footprint for SOT96 (SO8); typical dimensions.



Dimensions in mm.
Placement accuracy: ±0.25 mm.

Fig.16 Wave soldering footprint for SOT96 (SO8); typical dimensions.

SOLDERING OF SMD MODULES

SMD modules can be soldered by using the reflow technique. Wave soldering is not allowed for SMD modules. Conditions for reflow soldering are as follows:

The indicated temperatures are those at the solder interfaces.

Advised solder types are types with a liquidus below or equal to 210 °C.

Solder dots or solder prints must be large enough to wet the contact areas.

Footprints for soldering should cover the module contact area +0.1 mm on all sides.

Soldering can be carried out using a conveyor oven, a hot air oven, an infrared oven or a combination of these ovens.

Hand soldering must be avoided because the soldering iron tip can exceed the maximum permitted temperature of 250 °C and damage the module.

The maximum soldering times at different temperatures are indicated as follows:

At 100 °C, t = 350 s

At 125 °C, t = 300 s

At 150 °C, t = 200 s

At 175 °C, t = 100 s

At 200 °C, t = 50 s

At 250 °C (maximum temperature), t = 5 s.

A soldering curve is shown in Fig.17:

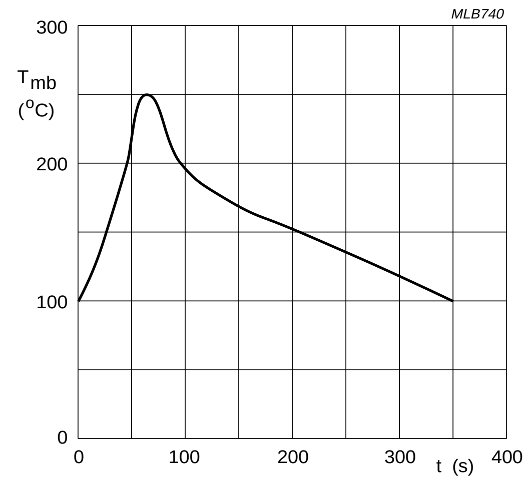


Fig.17 Maximum allowable temperature profile.

Cleaning

The following may be used for cleaning:

- Alcohol
- Bio-Act (Terpene Hydrocarbon)
- Triclean B/S
- Acetone.

Ultrasonic cleaning should not be used since this can cause serious damage to the product.

MOUNTING OF FLANGE MOUNTED MODULES

General

The modules are manufactured using a ceramic substrate soldered to a copper or iron flange or mounting base; this causes a small thermal mismatch between these two components. A further thermal mismatch will exist between the mounting base and the heatsink to which it is mounted. Because of these mismatches, precautions must be taken to avoid unnecessary mechanical stresses being applied to the ceramic substrate and other components within the module resulting from variations in temperature during operating cycles.

Design of heatsink

To ensure that the maximum specified mounting base temperature will not be exceeded under maximum fault conditions, the module should always be mounted on a heatsink of suitable thermal resistance.

The mounting area of the heatsink should be flat and free from burrs and loose particles. Particular attention should be paid to the mounting hole areas. The maximum amount of bowing along the plane of the module should not exceed 0.1 mm. Where anodizing is used, the area under the module should be milled clean as the presence of anodizing under the module can result in high resistance earth paths, leading to oscillation and early failure, in addition to poor thermal contact.

The heatsink should be rigid and not prone to bowing under thermal cycling conditions. The thickness of a solid heatsink should not be less than 5 mm, to ensure a rigid assembly. On finned heatsinks, the module should be mounted along a plane parallel to the fins.

Mounting of module

To ensure a good thermal contact and to prevent mechanical stresses when bolted down, the flatness of the mounting base is designed to be typically better than 100 µm.

The module should be mounted to the heatsink using 3 mm bolts with flat washers. The bolts should first be tightened to “finger tight” and then further tightened in alternating steps to a maximum torque of 0.4 to 0.6 Nm.

A thin, even layer of thermal compound should be used between the mounting base and the heatsink to achieve the best possible contact thermal resistance. Excessive use of thermal compound will result in an increase in thermal resistance and possible bowing of the mounting base; too little will also result in poor thermal resistance.

Once mounted on the heatsink, the module leads can be soldered to the printed-circuit board. A soldering iron may be used up to a temperature of 250 °C for a maximum of 10 seconds at a distance of 2 mm from the plastic cap. ESD precautions must be taken to protect the device from electro-static damage.

Electrical connections

The main earth return path of all modules is via the mounting base; it is therefore important that the heatsink is well earthed and that return paths are kept as short as possible. Failure to ensure this may result in loss of output power or oscillation, which in turn will have a detrimental effect on the module life.

The RF output connection should be to correctly-designed 50 Ω terminations. Failure to do this will result in a mismatch being presented to the module, with a resulting reduction in module life.

CAUTION

Under no circumstances must the maximum specified operating or storage temperatures be exceeded, even for short periods.

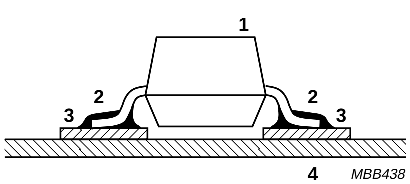
THERMAL CONSIDERATIONS

Thermal resistance

Circuit performance and long-term reliability are affected by the temperature of the transistor die. Normally, both are improved by keeping the die temperature (junction temperature) low.

Electrical power dissipated in any semiconductor device is a source of heat. This increases the temperature of the die about some reference point, normally an ambient temperature of 25 ºC in still air. The size of the increase in temperature depends on the amount of power dissipated in the circuit and the net thermal resistance between the heat source and the reference point.

Devices lose most of their heat by conduction when mounted on a a printed board, a substrate or heatsink. Referring to Fig.18 (for surface mounted devices mounted on a substrate), heat conducts from its source (the junction) via the package leads and soldered connections to the substrate. Some heat radiates from the package into the surrounding air where it is dispersed by convection or by forced cooling air. Heat that radiates from the substrate is dispersed in the same way.



Heat radiates from the package ‘1’ to ambient.
Heat conducts via leads ‘2’, solder joints ‘3’ to the substrate ‘4’.

Fig.18 Heat losses.

The elements of thermal resistance shown in Fig.19 are defined as follows:

- $R_{th\ j\text{-}mb}$ thermal resistance from junction to mounting base
- $R_{th\ j\text{-}c}$ thermal resistance from junction to case
- $R_{th\ j\text{-}s}$ thermal resistance from junction to soldering point
- $R_{th\ s\text{-}a}$ thermal resistance from soldering point to ambient
- $R_{th\ c\text{-}a}$ thermal resistance from case to ambient ($R_{th\ s\text{-}a}$ and $R_{th\ c\text{-}a}$ are the same for most packages)
- $R_{th\ j\text{-}a}$ thermal resistance from junction to ambient.

The temperature at the junction depends on the ability of the package and its mounting to transfer heat from the junction region to the ambient environment. The basic relationship between junction temperature and power dissipation is:

$$T_{j\ max} = T_{amb} + P_{tot\ max}(R_{th\ j\text{-}s} + R_{th\ s\text{-}a})$$
$$= T_{amb} + P_{tot\ max}(R_{th\ j\text{-}a})$$

where:

- $T_{j\ max}$ is the maximum junction temperature
- T_{amb} is the ambient temperature
- $P_{tot\ max}$ is the maximum power handling capability of the device, including the effects of external loads when applicable.

In the expression for $T_{j\ max}$, only T_{amb} and $R_{th\ s\text{-}a}$ can be varied by the user. The package mounting technique and the flow of cooling air are factors that affect $R_{th\ s\text{-}a}$.
The device power dissipation can be controlled to a limited extent but under recommended usage, the supply voltage and circuit loading dictate a fixed power maximum.
The $R_{th\ j\text{-}s}$ value is essentially independent of external mounting method and cooling air; but is sensitive to the materials used in the package construction, the die bonding method and the die area, all of which are fixed.

Values of $T_{j\ max}$ and $R_{th\ j\text{-}s}$, or $R_{th\ j\text{-}c}$ or $R_{th\ j\text{-}a}$ are given in the device data sheets. For applications where the temperature of the case is stabilized by a large or temperature-controlled heatsink, the junction temperature can be calculated from

$T_j = T_{case} + P_{tot} \times R_{th\ j\text{-}c}$ or, using the soldering point definition, from $T_j = T_{solder} + P_{tot} \times R_{th\ j\text{-}s}$.

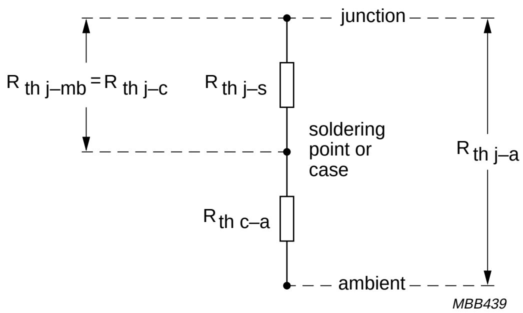


Fig.19 Representation of thermal resistance paths of a device mounted on a substrate or printed board.