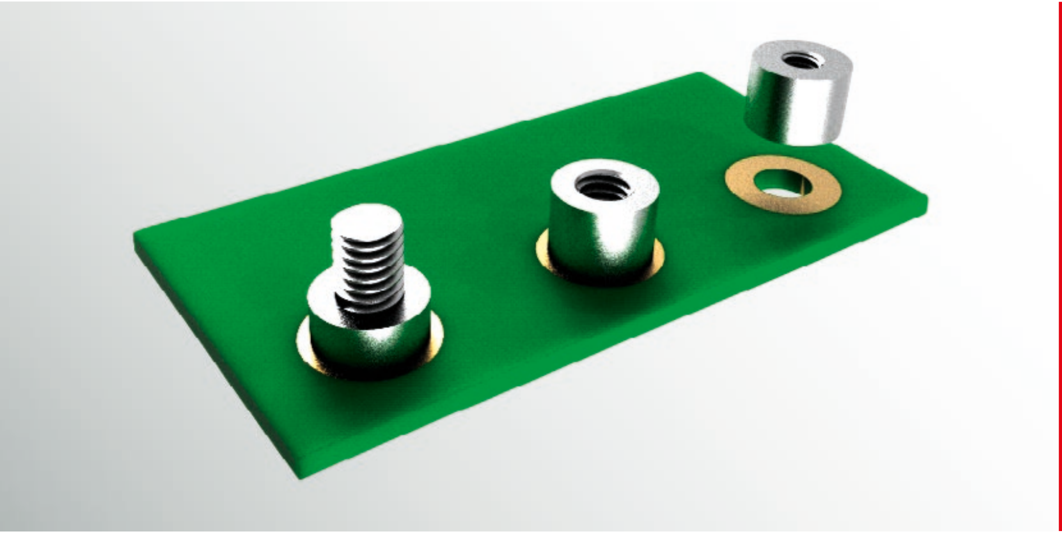
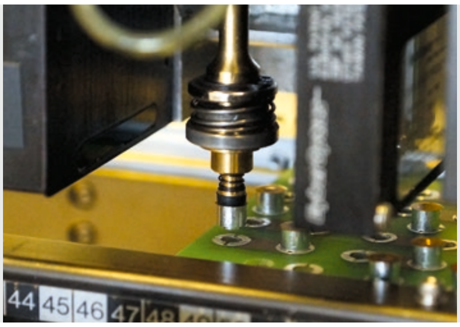
# SMD Power Elements

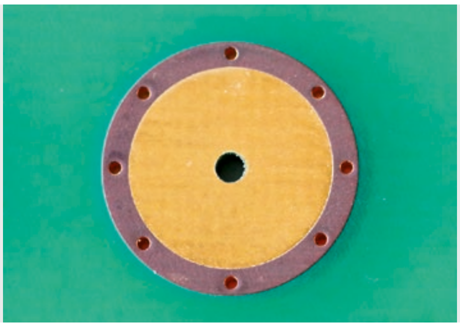
Design Guide

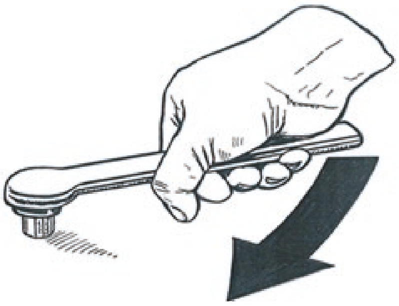


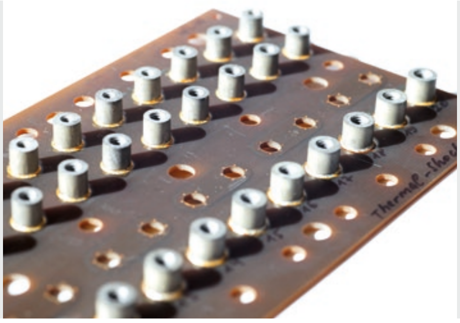
50 A
SMD Technology
Small Size
High Current

# Contents

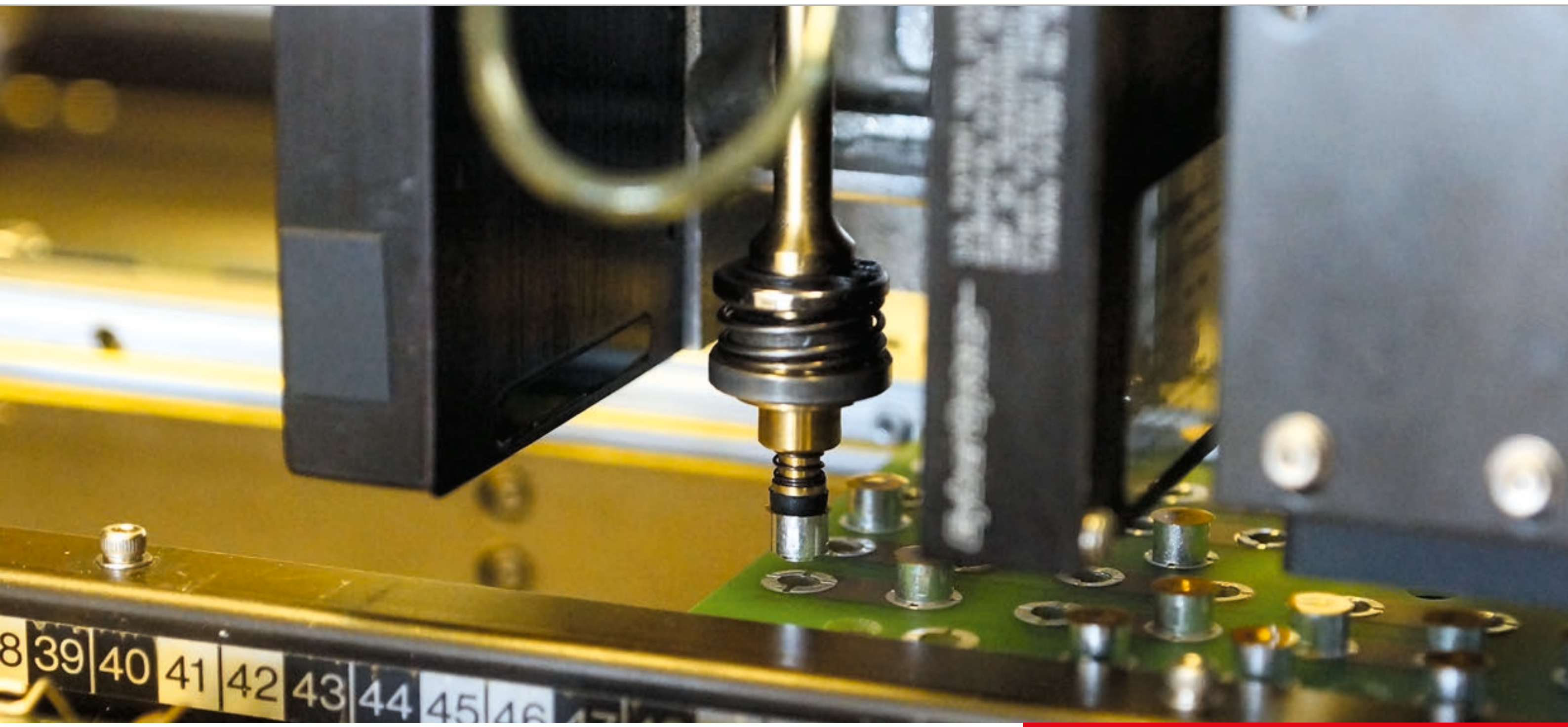








# SMD Power Elements

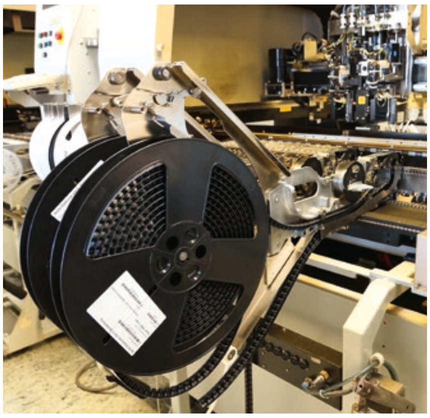


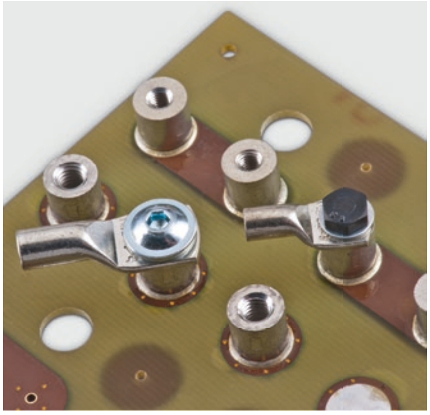
## Low contact resistances provide for low temperatures on the circuit board

- Today, modern electronic boards are mainly assembled with automatic placement machines and are subsequently soldered in the reflow process. This permits a high component density in the smallest of spaces. Here the high level of heat generation is an issue faced often by developers.

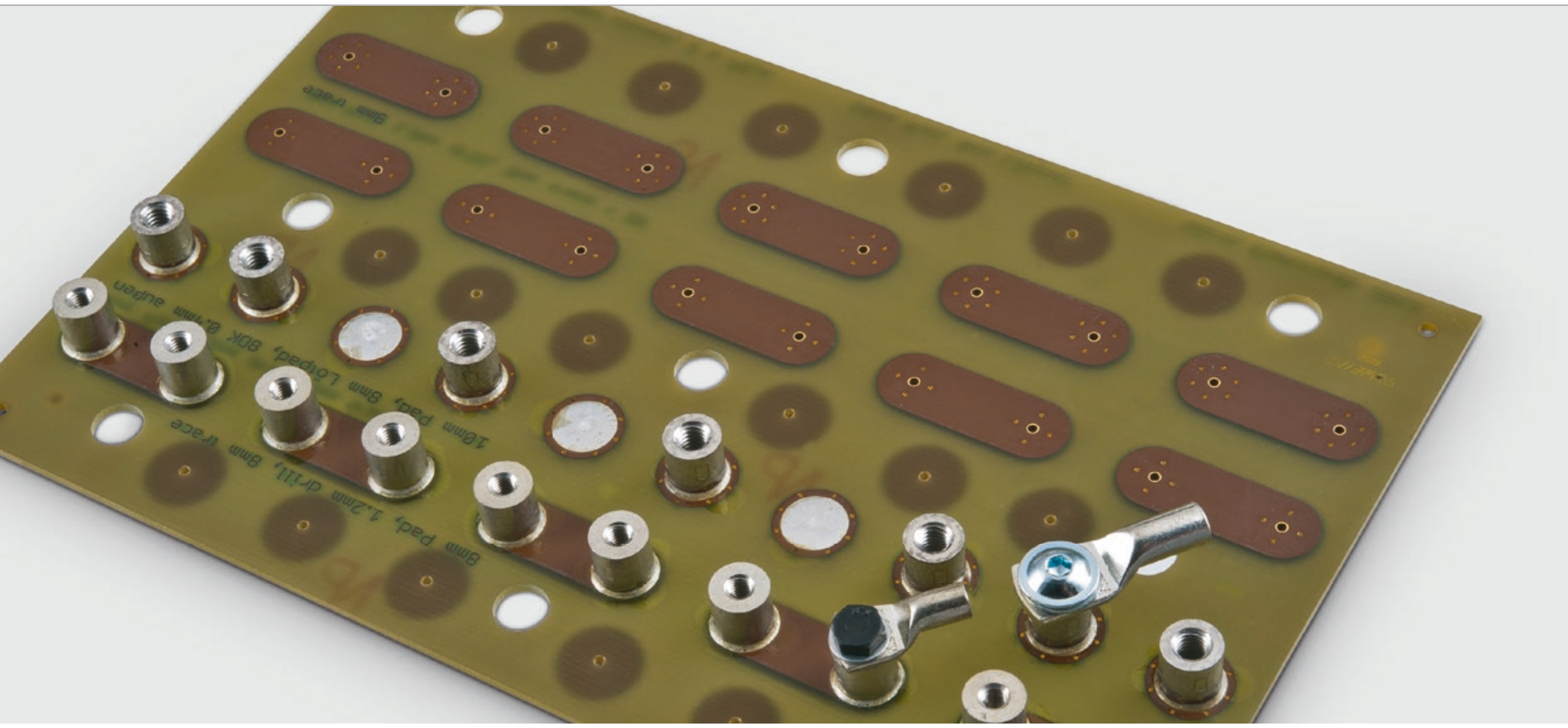
- SMD power elements are the result of the consistent advancement of our products for the benefit of our customers. SMD power elements combine the advantages of SMD assembly in conjunction with high-current technology. Within seconds, the components can be assembled off the reel onto the circuit board with all other SMD components and subsequently soldered in the reflow process.

- The large-area connection to the pad results in a low contact resistance and low self-heating. Currents of up to 50 A are possible depending on the layout. At the same time, the components offer high holding forces and torques.





# Component Assembly



- The assembly process can be performed both manually and fully automated. Placement by hand is possible for small or sample series. In case of components having through-hole threads, attention must be paid that no solder paste gets into the thread.

- In fully automated assembly, the components are packaged on the reel and, like the other SMD components, are ready for automatic processing. The component is picked up from the belt with a vacuum pipette and is placed on the circuit board. The picking from the belt is defined by the picking area, the weight of the component and the negative pressure generated by the vacuum pipette.

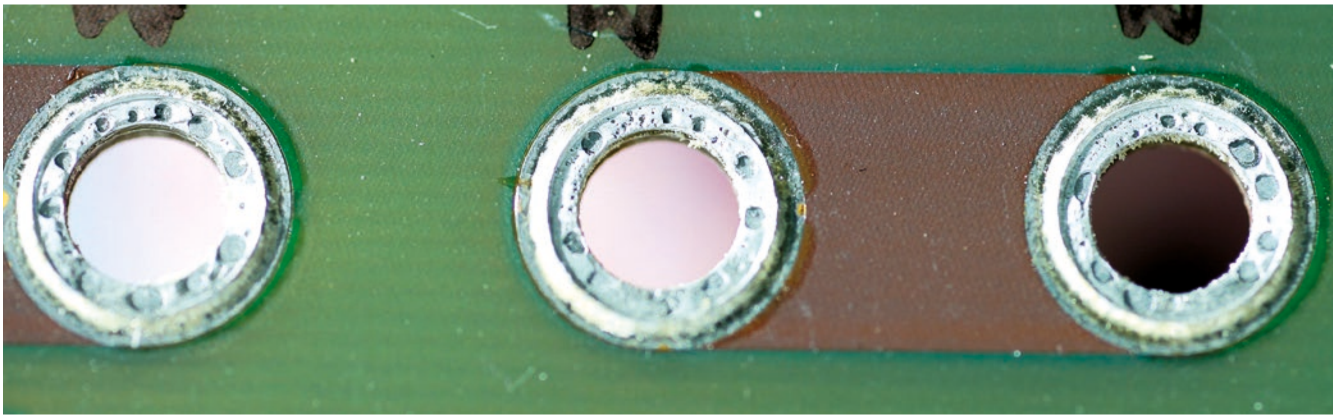
- In order to ensure trouble-free processing with all automatic placement machines, the components are equipped with a capton foil or pick and place cap. The pick and place cap is made of LCP material and was specifically developed for the soldering process. After soldering, the cap or the capton foil is disposed of. The capton foil is especially designed with a tab to facilitate removal. SMD power elements with M4 outer thread have no pick and place cap, as the picking area is large enough in this case.

# Tin is not necessarely tin!

A special solder surface has been developed for the hot-air reflow technique. Different tin coatings were investigated in many series of experiments to attain optimal wetting and the best holding forces. In the electroplating facility there are many ways of influencing the coating process with pre-treatments and post-treatments, as well as the addition of organic additives, such as oxidation stabilizers, grain refiners and brighteners. So that is why not all tin-plating is alike. As presented in the right picture, an incorrect coating can lead to discolorations, tin spalling and a poor soldering result.

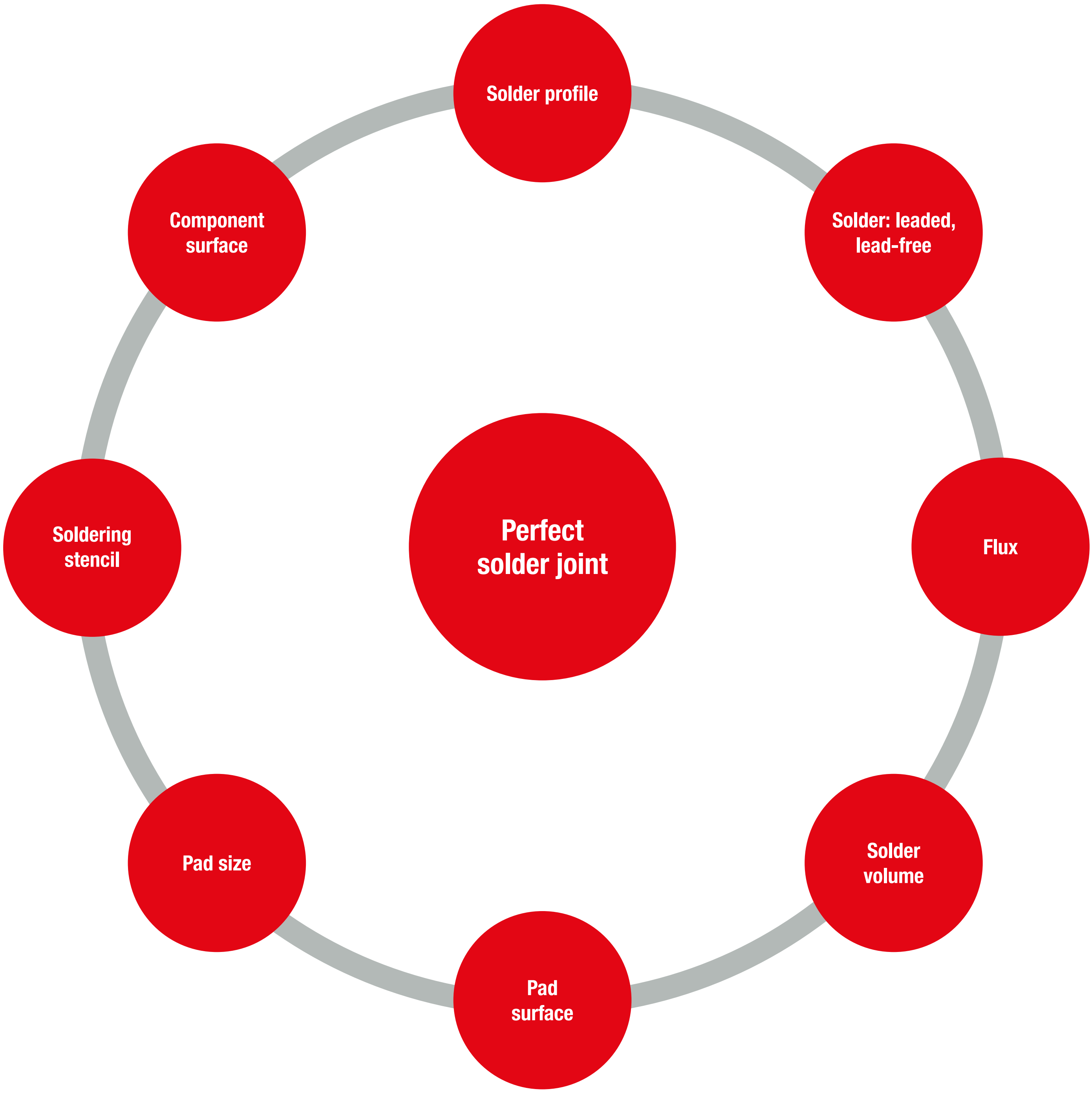
- Similarly, a barrier layer and a coating thickness adapted to the component volume is crucial for the perfect soldering result. Applying tin on the surface too thickly can lead to accumulations, the “orange peel” effect and melting of the surface in the soldering process. Subsequent connection with the cable lug can result in significantly higher resistance at the point of contact.

- In contrast, too little tin applied causes poorer wetting and can have a negative impact on the air voids (see picture below) in the solder joint. On account of the large contact surface, air voids cannot be excluded, but because the holding forces are mainly defined by the meniscus formation, they are not so critical in practice.



# Perfect Solder Joint

The soldering result is influenced by many factors. Many variables should be considered throughout the treatment process in order to obtain an optimal solder joint. Effective wetting and a well formed meniscus are essential for the holding forces and low contact resistances on the circuit board.



# Pad Geometry

The solder result and the resulting holding forces depend on optimal pad geometry. On the basis of the IPC TM 650 test method, the pad size was specially matched to the component in terms of the adhesive strength of copper layers on FR4, such that no further layout design measures are generally necessary. (Fig. 1)

If higher strength is required, there are some simple ways of improving the stability of the pad. The simplest way is to create the copper area larger than the solder pad. The larger contact area to the FR4 material achieves greater stability. (Fig. 2)

In addition, the copper surface can be configured with vias. A via has the effect of a „rivet“ and enhances the connection to the base material of the circuit board. (Fig. 3)

An equally popular method of strengthening SMD pads is to place the via directly in the pad. It should be kept in mind that the fluid solder can flow downwards through the vias and there may not be sufficient solder available for the solder joint. (Fig. 4)

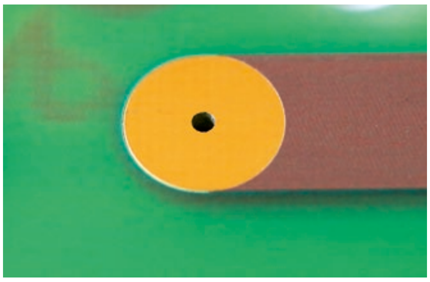


Fig. 1

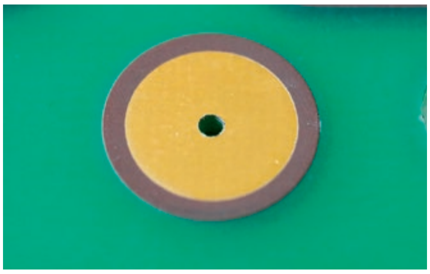


Fig. 2

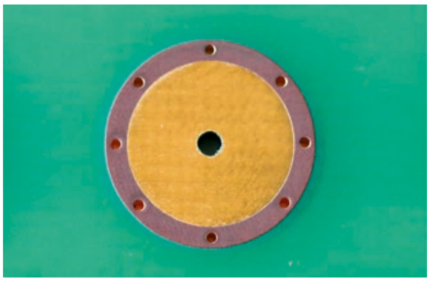


Fig. 3

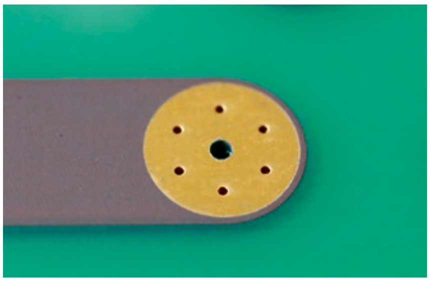


Fig. 4

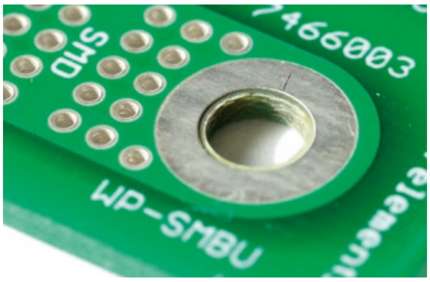
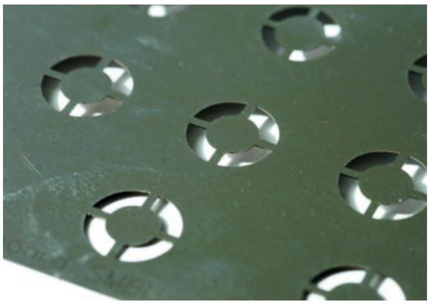
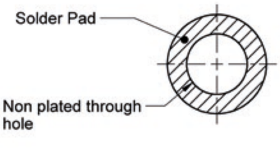


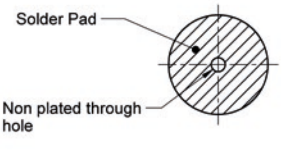
Fig. 5

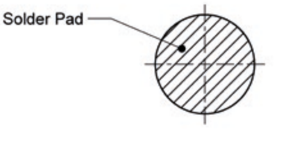
## Stencil

- The solder stencil should be designed as recommended on the datasheet. The drill holes in the circuit board must be covered by the stencil, such that no solder flows into the holes.
- The drill hole in the circuit board for the alignment pin and the screw must not be through-contacted! (Fig. 5)







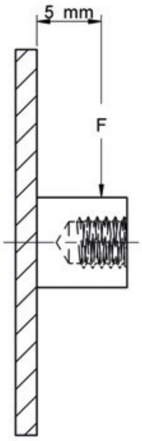


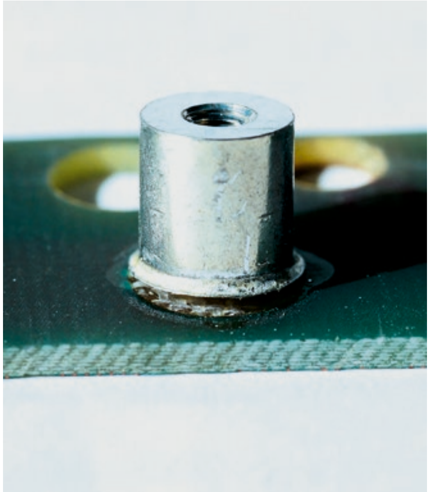
Stencil suggestion:

# Tearing Force

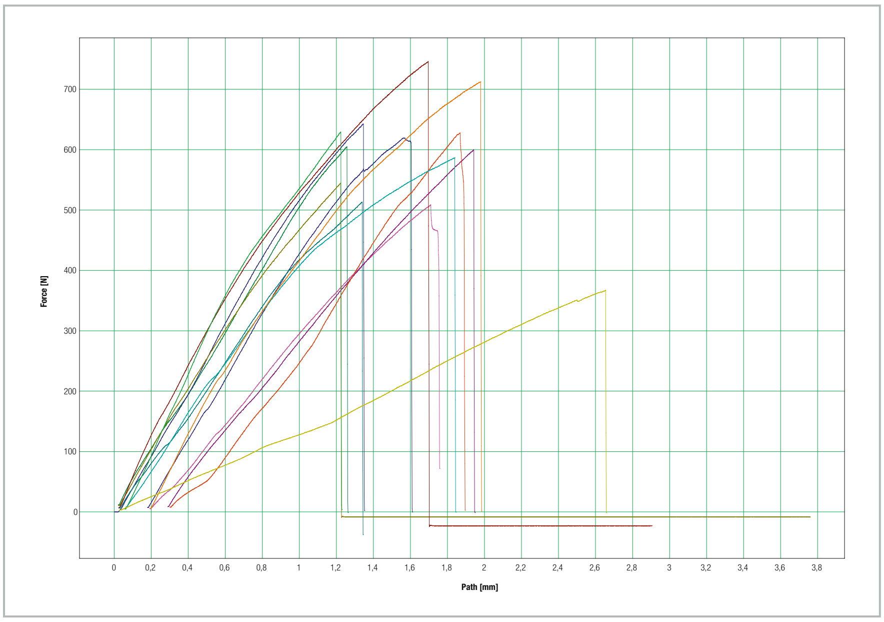
Measurement of the tearing force should simulate a load similar in strength to that of a strong pull on the cable if the cable lug is screwed to the component. The tearing forces on the component from the circuit board were measured in numerous experiments by applying and measuring a force at a 5 mm distance. The force was increased linearly up until tearing.

The torque formula **M=F*l** allows the tearing force to be determined for every other length.





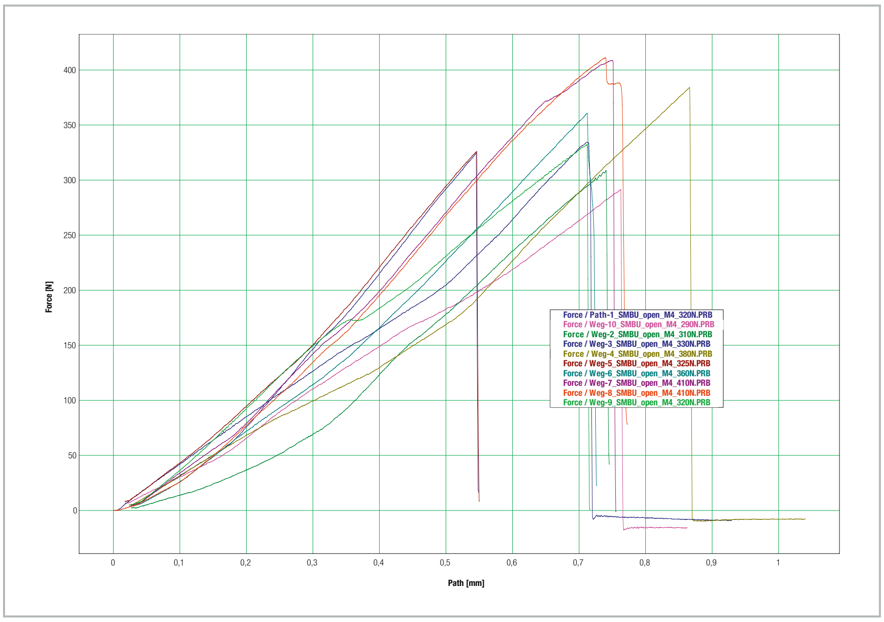
In the lower graph, the tearing forces for the components are presented with a threaded blind hole. The maximum tearing force was 745 N, i.e. a weight of over 70 kg has to hang on the cable such that the component is torn off the circuit board. Assuming a typical holding force of 60 N/mm² for a good hexagonal crimp on the tubular cable lug, for a 2.5 mm² cable the cable would already slip out of the cable lug at 150 N. This value is even lower for simple crimping of cable lugs. On average most values were above 500 N.



# Tearing Force

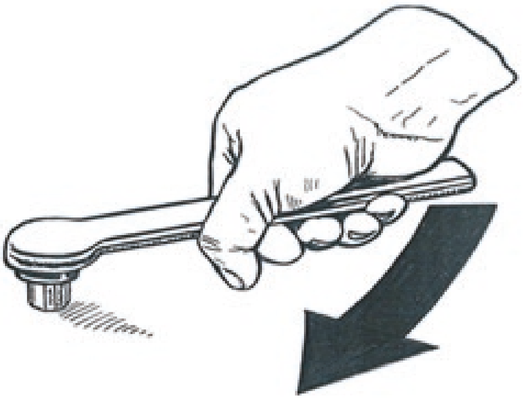
Due to the drill hole in the circuit board, the tearing forces for components with through-threads are lower as a result of the lower contact area on the pad.

The tearing forces are presented in the lower graph. The max. tearing force was 410 N. On average, the values were above 300 N.



# Permitted torque

SMD power elements offer a large-area connection and transmission of high currents in circuit boards. The maximum permitted torque has to be observed in order to prevent mechanical destruction of the elements!



**Mechanical properties for brass (reference values):**

- Material: CuZn39Pb3
- Shear strength: 350 N/mm²
- Tensile strength: 480 N/mm²
- Elastic limit: 340 N/mm²
- Elongation: 20 %
- Elastic modulus: 96 kN/mm²
- Torsional modulus: 32 kN/mm² (shear modulus

**Table for SMD power elements**

| Thread size (metric) | M3 through-thread | M4 through-thread | M3 closed thread | M4 closed thread |
|---|---|---|---|---|
| **Max. tightening torque [Nm] *** | 0.5 | 1.2 | 0.5 | 1.2 |
| **Min. breaking torque [Nm] **** | 3.0 | 2.9 | 3.8 | 3.8 |
| **Max. breaking torque [Nm] **** | 4.1 | 3.9 | 4.6 | 4.6 |
| **Mean breaking torque (30 pcs.) [Nm]** | 3.6 | 3.5 | 4.3 | 4.3 |

* Along the lines of DIN267 Part 25; values for brass material (Ms 63).

** Measured values (torque): Destruction of the components or the solder joint is to be assumed at these mechanical loads. The components must never be loaded above these values.

The breaking torque is strongly dependent on the quality of the solder joint and the screw used. As apparent from the table, the breaking torque exceeds the prescribed tightening torque many times over. SMD power elements may only be loaded with the values from the ‚max. tightening torque‘ line in the table!

# SMD Power Elements

## Characteristics

- Material: Brass
- Surface: Tin-plated
- Heat Resistant: up to +155 °C
- Tightening torque: M3 (0.5 Nm), M4 (1.2 Nm)
- Packaging: bulk, reel
- Current Rating: max. 50 A (20°C)*

(*Operating current depends on pcb, cross section of the cable and cable lug.)

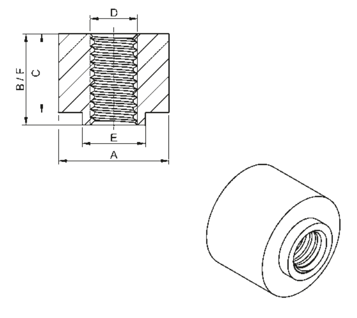
## Features

- Simpler and faster automated assembly
- Time & cost efficient
- Low resistance and self-heating
- High current carrying capacity
- Small footprint
- High mechanical forces and torques

COMPLIANT RoHS&REACh WÜRTH ELEKTRONIK

| Order Code Bulk | Order Code Reel | Diameter Ø A (mm) | Total height B (mm) | Body length C (mm) | Thread size D (mm) | Socket/Pin diameter E (mm) | Thread length F (mm) | Format Type | Type |
|---|---|---|---|---|---|---|---|---|---|
| **746 600 3** | **746 600 3 R** | 7 | 6 | 5 | M3 | 4 | 6 | A | Bush |
| **746 600 4** | **746 600 4 R** | 7 | 6 | 5 | M4 | 5 | 6 | A | Bush |
| **746 610 3** | **746 610 3 R** | 7 | 7.8 | 7 | M3 | 1 | 4 | B | Bush |
| **746 610 4** | **746 610 4 R** | 7 | 7.8 | 7 | M4 | 1 | 4 | B | Bush |
| **746 620 3** | **746 620 3 R** | 7 | 7 | 7 | M3 |  | 4 | C | Bush |
| **746 620 4** | **746 620 4 R** | 7 | 7 | 7 | M4 |  | 4 | C | Bush |
| **746 611 3** | **746 644 3 R** | 7 | 8.8 | 8 | M3 | 1 | 5 | D | Shank |
| **746 611 4** | **746 644 4 R** | 7 | 8.8 | 8 | M4 | 1 | 5 | D | Shank |
| **746 621 3** | **746 621 3 R** | 7 | 8 | 8 | M3 |  | 5 | E | Shank |
| **746 621 4** | **746 621 4 R** | 7 | 8 | 8 | M4 |  | 5 | E | Shank |

## Type A



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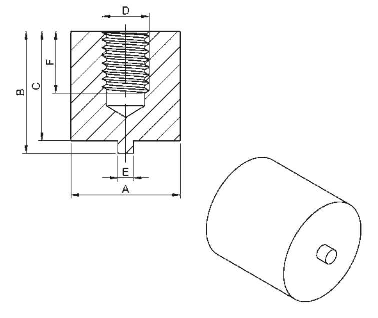
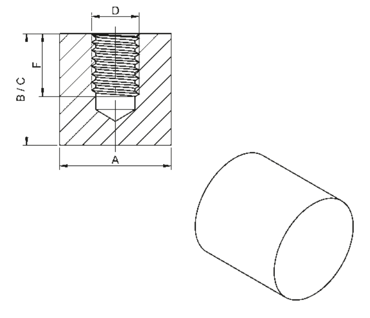
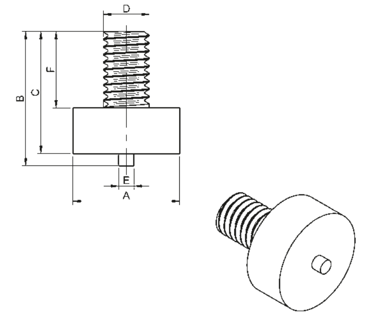


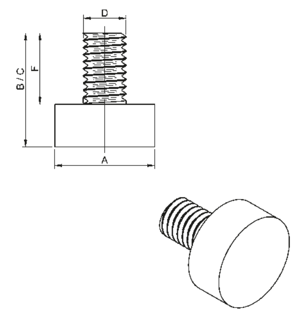
## Type C



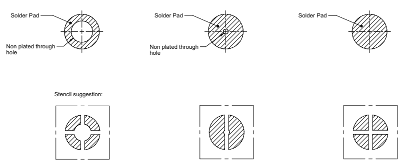
## Type D



## Type E



## Solder Pad

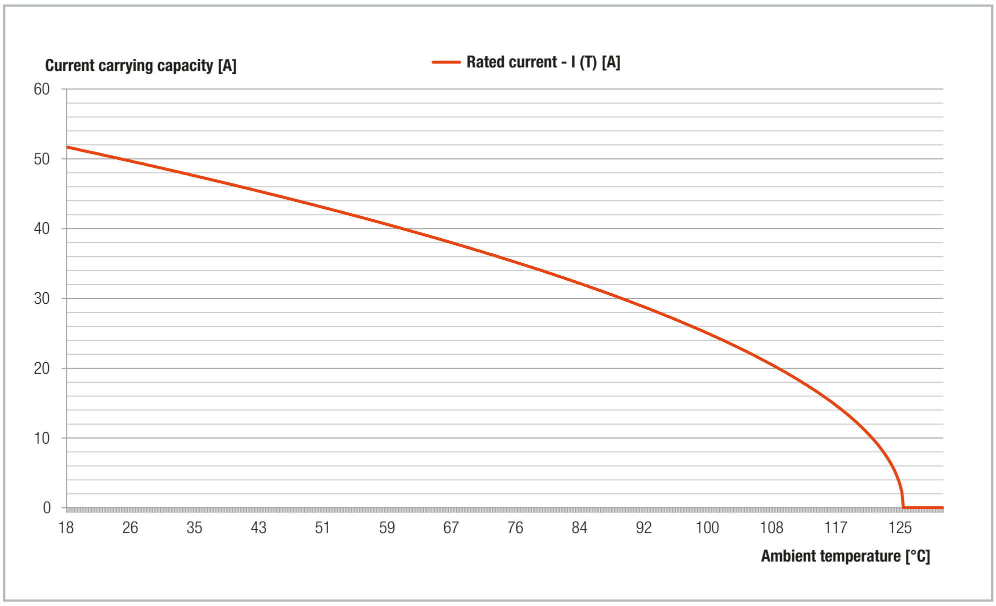


# Current Carrying Capacity

Low contact resistances are achieved as a result of the large-area connection to the pad. This ensures a low level of heat generation and favors overall temperature performance on the board.

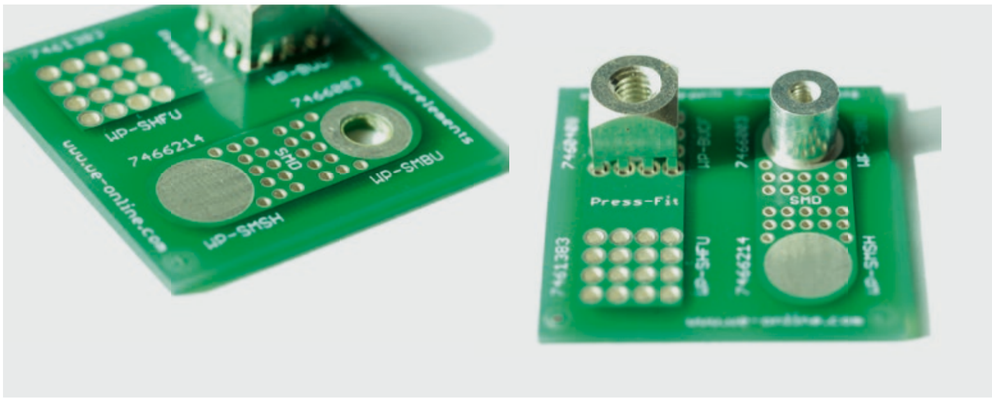
Currents up to 100 A are achieved with multilayer circuit boards and large cable cross-sections. In many cases, the cable cross-section is the limiting factor. According to VDE0100, a 4 mm² can only be used up to a maximum of 42 A continuous current at 20 °C. So the cable limits the current before the power element.

The derating curve shown below was measured with 6 mm² and a 2 x 70 µm circuit board.



As shown in the pictures, the current transmission into the lower layers must be through the additional vias. A 0.3-0.4 mm diameter and min. 25 µm copper-plating per via are recommended. The distribution of current in the lower layers is problematic for currents above 70 A, as the current carrying capacity of the vias is limited and a large amount of space is required on the board.

It is therefore recommended to switch to press-fit technology for even higher currents. This technology still offers unrivaled low resistances and even better temperature characteristics.



# Our Requirements for SMD Power Elements

✓ **Five Time Reflow Test**
J-STD-020D

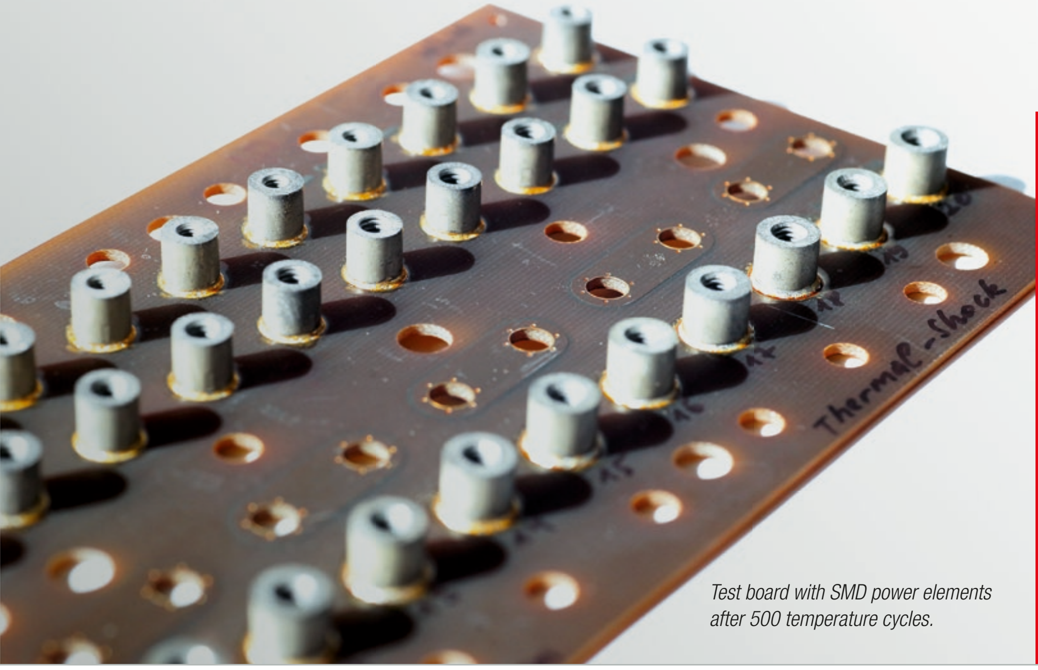
✓ **Solderability**
JESD22-B102

✓ **Thermal Shock**
MIL-STD-202, Method 107
- Temperature -55 °C to 155 °C
- Dwell time 30 minutes
- Cycles: 500
- Transfer time max. 20 s

✓ **Vibration Test**
MIL-STD-202, Method 204
- 10g for 20 minutes
- 12 cycles each of 3 orientations
- 15-2000 Hz

✓ **Moisture Resistance**
MIL-STD-202, Method 106
- Temperature: 65 °C
- Humidity: 95 %
- Duration: 500 h

✓ **RoHS & REACh Compliant**
Würth Elektronik power elements are manufactured from the material CuZn39Pb3 and therefore compliant to the RoHS requirements with regard to copper alloys.



*Test board with SMD power elements after 500 temperature cycles.*

**SMD power elements display very high reliability**

**The requirements of the relevant standards are exceeded by far**

# more than you expect