



# Application and Processing Instructions

**PowerElements**

**ERNI Electronics GmbH**

Seestrasse 9 | 73099 Adelberg / Germany | +49 7166 50-0 | [www.erni.com](http://www.erni.com)



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## 1 Fundamentals

These Application und Processing Instructions serve as a supplement to the ERNI Electronics GmbH & Co.KG. **PowerElements** catalog.

ERNI PowerElements are used in all kinds of applications that serve to supply 'power,' meaning high currents, to printed circuit boards. In addition to these products, ERNI offers suitable insulators to prevent short circuits and contact with the connections on the cable side, such as cable lugs.

## 2 Product Features

ERNI PowerElements are available in various designs.

### **PowerElements with a massive press-fit zone**

- M3, M4, M5, M6, M8, M10, M12
- One-part and two-part
- Male thread, female thread, right angle
- Full pin population, circular pin population, two rows pin population

### **PowerElements for SMD soldering technology**

- M3, M4, M5, M6, M8, M10
- Male thread, female thread, female through-hole thread
- With or without centering pins

### Twist and contact protection for PowerElements with male thread

- Specially designed for placement on the PowerElement pins
- To avoid short circuits to adjacent components
- To enable smaller distances between adjacent PowerElements

## 3 Current Carrying Capacity

### 3.1 GENERAL

The current-carrying capacity of our PowerElements is, generally speaking, not critical.

A single PowerElement can transmit several hundred amperes. However, the actual current-carrying capacity when using FR4-based PCBs with a typical maximum temperature of 135° C essentially depends on the customer application. Higher temperatures are generally possible when using thermally more stable base materials.

The PowerElement can only ensure the current-carrying capacity if it is not additionally heated up by the peripherals. This means that the surrounding circuit or assembly needs to act as a heat sink and shall be able to dissipate heat generated by the current flow.

The setup can be checked by testing the application directly or in advance by means of a suitable simulation. ERNI can carry out the simulation of current-carrying capacity, provided that we are made familiar with the circuit and environmental conditions details.

It only makes sense for ERNI to generate 'derating curves' (according to IEC 60512-5-2) if the application can be precisely replicated. Otherwise, the simulation results may deviate from the actual conditions and scales.



### 3.2 POWERELEMENTS WITH A MASSIVE PRESS-FIT ZONE

The entry for current-carrying capacity in the ERNI PowerElements Catalog reads: approx. 10 A per pin – depending on the design. As a result, a PowerElement with 25 pins can transfer electrical current of approximately 250 A.

Our investigations revealed current-carrying capacities of several hundred amperes at 20°C (for more details, see the derating curves in the appendix on pages 15 ff.). For these investigations, we constructed multi-layer test printed circuit boards with thick copper layers.

It needs to be taken into account that the current-carrying capacity can usually be restricted through the connected cable or by the application selected by the customer. A decisive factor in determining the current-carrying capacity is the low electrical contact resistance between the copper sleeve of a printed circuit board and the press-fit pin of the PowerElement.

### 3.3 POWERELEMENTS FOR SMD SOLDERING TECHNOLOGY

A current-carrying capacity of up to 200 A is specified in the ERNI PowerElement Catalog. Our investigations revealed that a corresponding arrangement of the multi-layered printed circuit board featuring thick copper enabled several hundred amperes to be reached at 20°C. It must be taken into account that the current carrying capacity is usually limited by the connected cable or by the application selected by the customer, as is known from massive conformal press-fit zones.

## 4 Processing Instructions

### 4.1 PRINTED CIRCUIT BOARD

ERNI PowerElements are designed for very high current-carrying capacities. This means it is crucial that the PowerElements are only applied in combination with printed circuit boards that feature wide conductor tracks or wide-spread copper arrangements. No narrow conductor tracks may run through the area of the via sleeves. It is recommended to use multi-layer printed circuit boards with thick copper layers. In order to achieve the highest current carrying capabilities. Moreover, care should be taken to ensure that the via sleeves in the printed circuit board have a copper thickness of 25  $\mu\text{m}$  to 60  $\mu\text{m}$ . The copper thickness should usually be 35  $\mu\text{m}$ . This ensures that the printed circuit board structure is sufficiently stable for mounting PowerElements.

The printed circuit boards should preferably be made of FR4 base materials. Other base materials and/or other fillers should undergo sufficient testing prior to their application. The printed circuit board should be at least 2 mm thick.

### 4.2 MOUNTING OF MASSIVE POWERELEMENTS

For the press-fit process a suitable press and suitable tools (upper and lower supporting tools) are required. The upper tools must be designed in such a way that the flat surfaces serve as supports; male threads are not suitable as supports and should be recessed with suitable drill holes. Flat punches are suitable for mounting PowerElements with a flat surface on the top, such as PowerElements with a female thread. The press-fit base (PFB) should consist of a stable support plate that features drill holes that are as narrow as possible at the positions that correspond to the press-fit pins. The drill holes need to be adapted to the respective press-fit pins and should have a diameter that is 0.1mm greater than the pin diagonal. (Example: press-fit pin edge length: 1.13 x 1.13 mm, press-fit pin diagonal: 1.6mm, drill hole in the PFB: 1.7 mm.)

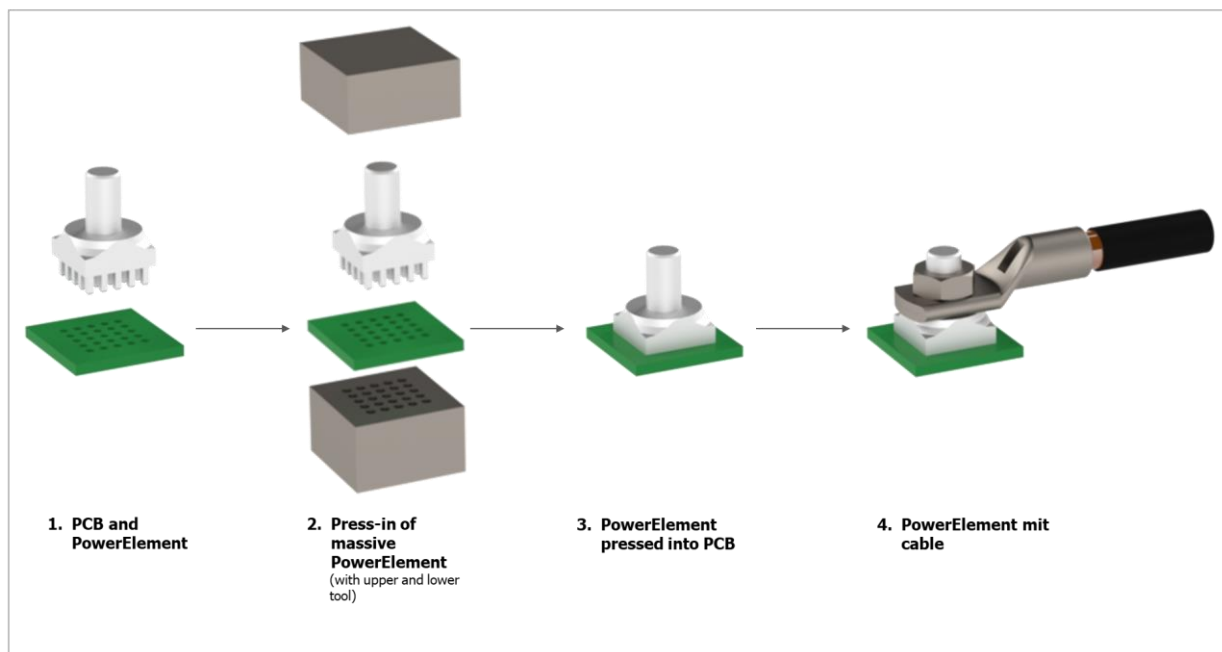


Fig. 1: Press-in of massive PowerElements

Using a correct press-fit base (PFB) greatly restricts the 'jet effect' (see explanation further below), since this partially supports printed circuit board sleeves during mounting. The PowerElement press-fit pins penetrate the printed circuit board's copper sleeves during assembly at the four edges of the square cross section and can also partially penetrate the printed circuit board. This means that the maximum conductor pattern deformation of 50 µm stipulated by IEC 60352-5 Section 5.2.2.5 cannot be ensured in every case for PowerElements (IPC-A-610 Class 3 not possible). For reliable electrical connection, at least 75 percent of the edges should contact the copper sleeve.

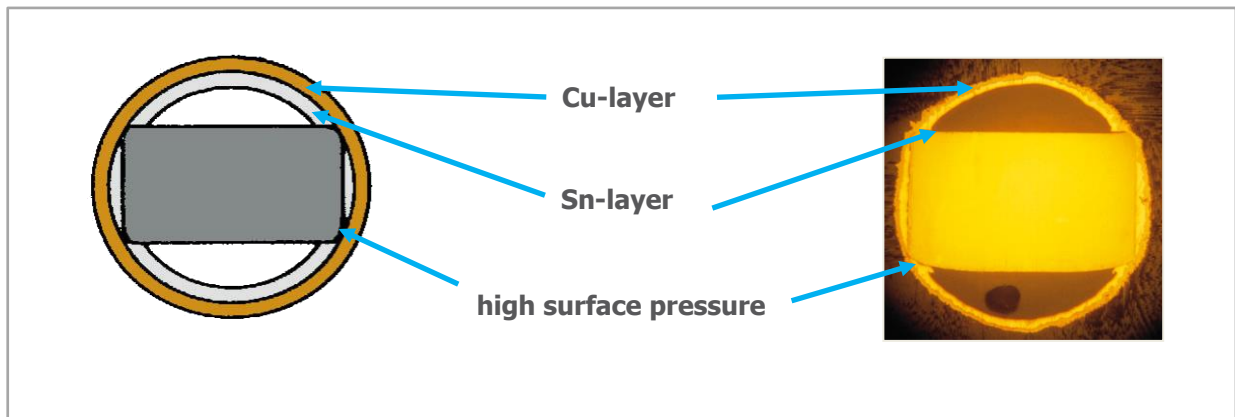


Fig. 2: Contacting PowerElement in PCB hole

During the press-fit process one-part PowerElements should be positioned at a distance of 0.1 (-0.1) mm from the printed circuit board surface.

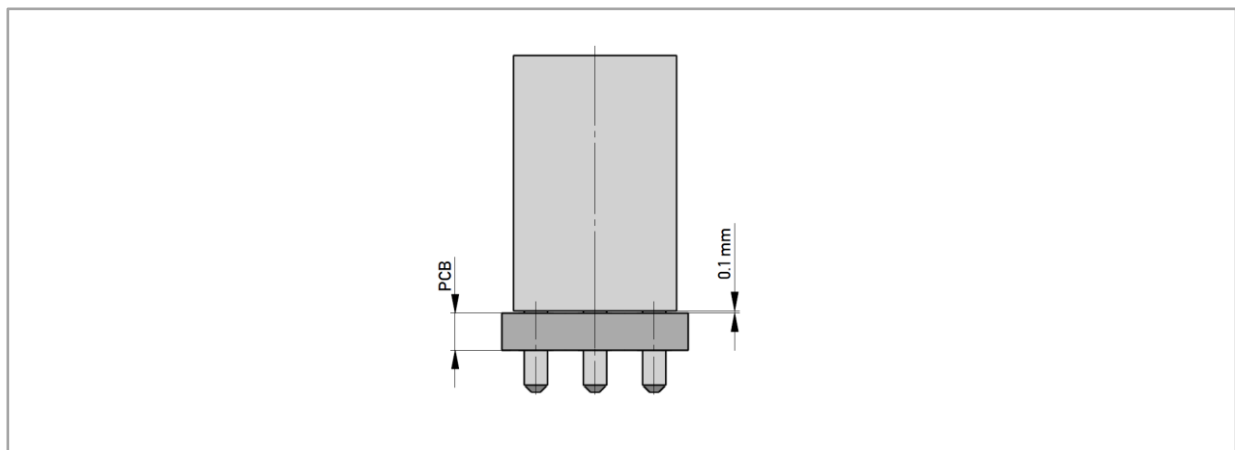


Fig. 3: Press-in conditions: distance between PowerElement and PCB surface

The high force during the press-fit process in conjunction with the massive press-fit pins can generate a so-called 'jet effect'. This means that the copper on the via sleeve is displaced and its functional connection faces are slightly lifted from the printed circuit board (lifted pads). The conductor connections must not be separated from the through-hole plating sleeve.

During the press-fit process for the massive pins, the via sleeve as well as parts of the FR4 base material are slightly deformed. Delamination may occur in the base material.



However, this does not detrimentally affect quality or reliability, since all of the PowerElement pins have the same electrical potential.

The pins can scrape off material when pressed in and thus generate chips and flakes. If this chip formation in the application is to be classified as critical for neighbor electronics, appropriate measures should be taken to remove or fix the chips or abrasion. To achieve technical cleanliness, subsequent cleaning or varnishing is recommended.

Various qualification tests were carried out to confirm the quality and reliability of the press-fit connections of PowerElements.

### **4.3 MOUNTING OF TWO-PART POWERELEMENTS**

Two-part PowerElements are pressed into the printed circuit board from both sides. The support surfaces on either side protect the printed circuit board against mechanical strains during assembly in the installation space. Moreover, a far lower height is required when using two-part PowerElements.

Two-part PowerElements must be pressed "on block" using a force limit switch; that means the pins on the upper component must touch the top of the bottom component.

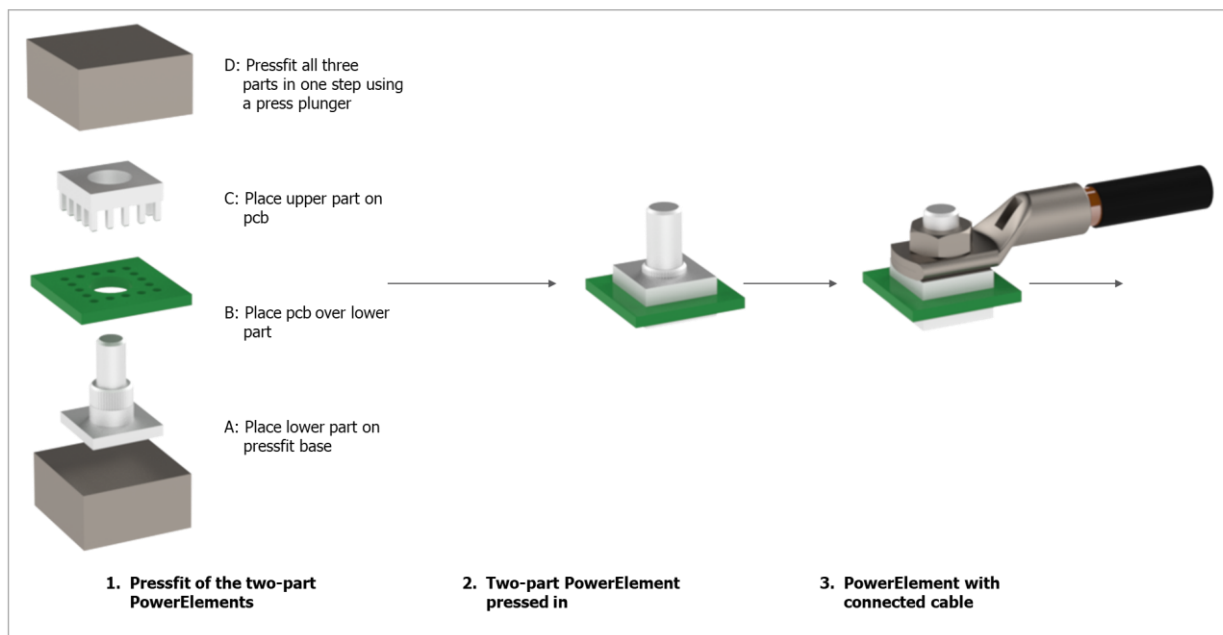


Fig. 4: Press-in of two-part PowerElements

## 4.4 SOLDERING OF SMD POWERELEMENTS

Soldering ovens with inert gas (nitrogen) are strongly recommended for soldering SMD PowerElements. This minimizes oxidation during the soldering process, which improves wetting and thereby helps to ensure more homogenous solder joints.

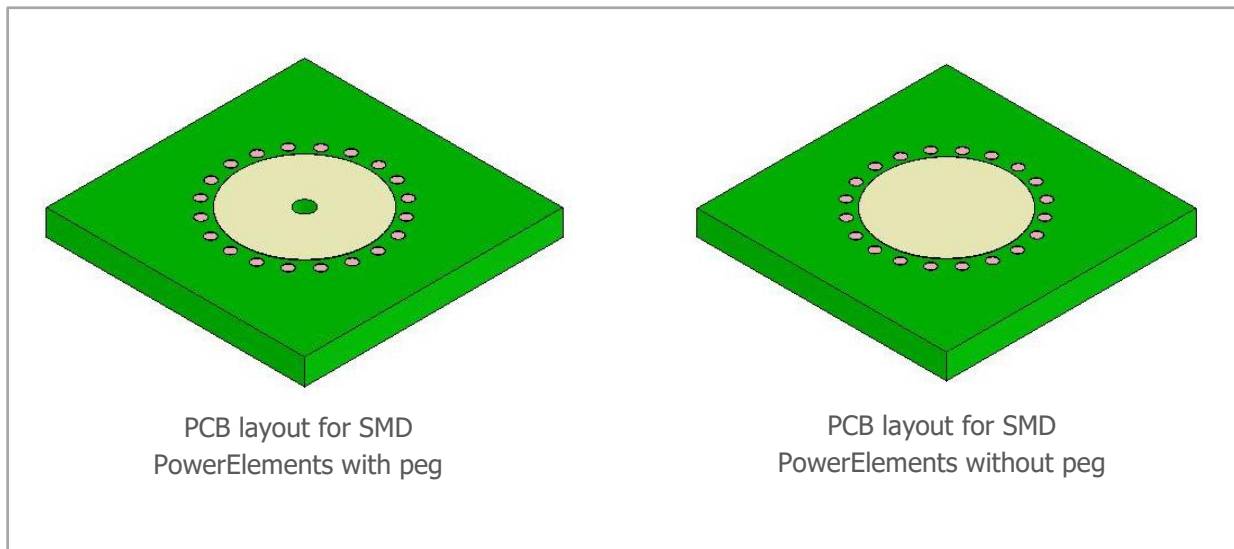
The soldering parameters and the solder paste should be selected so that as few as possible voids occur within the solder joints. This is necessary to achieve sufficient shear strength and low electrical and thermal resistance.

The soldering profile should correspond to the standard requirements stipulated in IPC/JEDEC-STD-020.

- The pad diameter (soldering surface) should typically be 0.5mm larger than the diameter of the PowerElement.
- Vias around the pad ensure greater current-carrying capacity
- Recommended solder paste thickness: 150  $\mu\text{m}$

- The solder paste should only be applied to approximately 50 percent of the soldering surface.  
Otherwise the electrical and thermal resistance between PowerElement and pad might be too high for the application.

A greater number of vias positively influences the current-carrying capacity. Hence, we recommend to provide a sufficient amount of vias already during the design phase.



*Fig. 5: PCB layout for SMD PowerElements*

### 4.5 INSTALLATION OF CABLES AND OTHER COMPONENTS

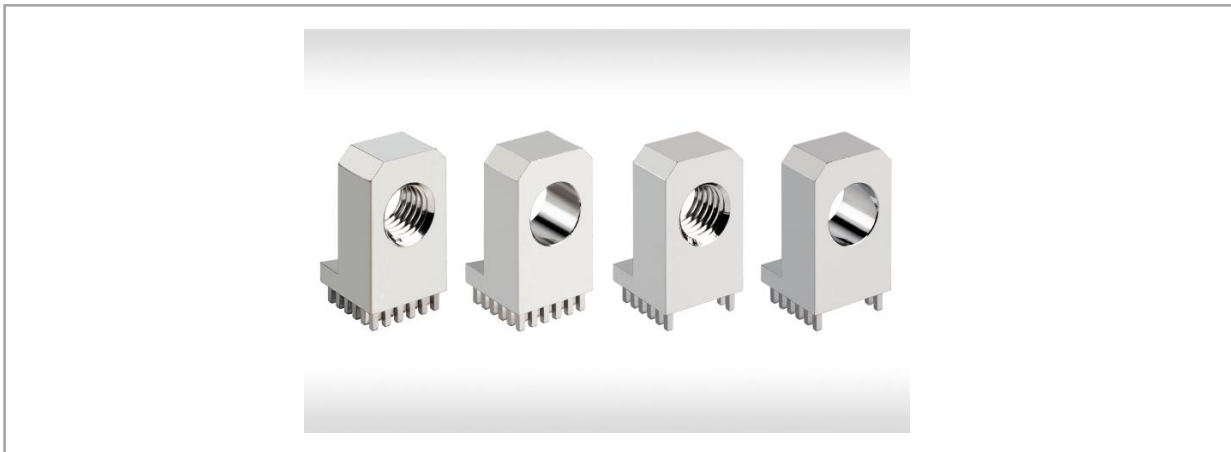
For screw connections between cable lugs, components, or other coupling elements with the PowerElements, the following considerations need to be considered:

- The component that needs to be screwed must have plane-parallel surfaces
- The PowerElements and the components that need to be screwed must be free from oils, fats, or other lubricants.
- Maximum tightening torques for PowerElements:

Thread	Tightening Torque
M3	0,5 Nm
M4	1,2 Nm
M5	2,2 Nm
M6	3,9 Nm
M8	9,0 Nm
M10	17,0 Nm
M12	35,0 Nm

Fig. 6: Tolerance ranges for tightening torques: +0 / -20 %

- During fastening, only torques are to be applied to the screwing elements; additional bending forces, e.g. due to unilaterally acting spring washers, are to be avoided. To decouple bending forces on screwing tools, flexible shafts or universal joints inserted between hand lever and screw drive, for example, are suitable.
- Only shear forces may act on the press-fit pins during screwing; forces along the press-fit direction of the pins must be avoided. In the case of PowerElements with thread or through-hole at right angles to the press-fit direction (for examples, see the following figure), the PowerElements must be held in place, e.g. by holding them with an open-ended wrench.



*Fig. 7: PowerElements with thread or through-hole at right angles to the press-in direction*

### **4.6 INTRODUCTION OF FORCES**

The permanent introduction of static or dynamic forces into the PowerElements must be avoided as far as possible. Particularly in the case of tall designs, this could otherwise result in considerable forces and torques being introduced into the printed circuit board.

### **4.7 REPAIR OF POWERELEMENTS**

Replacing PowerElements for the purpose of repair is not intended.

## 5 Appendix

Typical derating curves for PowerElements used in press-fit technology and SMD:

