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Soldering wires to sensor contact pads

Procedure to solder wires to sensor contact pads cleanly and with minimal thermal impact – application to MilliNewton-B force sensor as an example.

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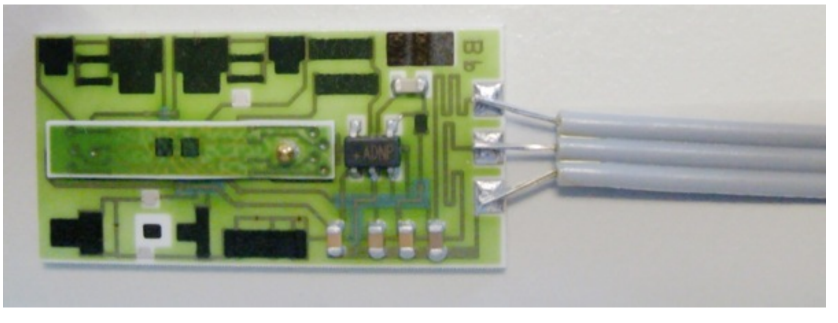

Summary

The tedious and expensive process of attaching SIL contacts to the sensor edges may be advantageously replaced by soldering wires and cables directly to the sensor contact pads. However, this process is a bit more critical, as applying excessive heat can damage contact pad metallisations and alter the sensor characteristics.
This document details how to safely solder wires onto the pre-tinned contact pads of MilliNewton-B sensors (figure 1), which have been designed to be relatively tolerant to this process step. This procedure is also applicable to similar products.

1. Introduction

In order to allow easy plugging, unplugging, and otherwise uncritical interconnection, sensors are usually fitted with SIL (single-in-line) contacts or come pre-cabled (figure 1).

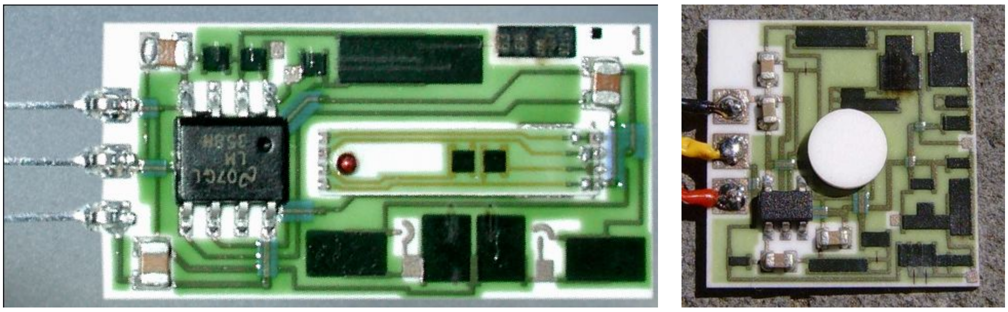

Figure 1. MilliNewton with SIL contacts (left); CentoNewton with cables (right).

These features allow easy further connection for the user, with no risk of damaging the sensors. However, it entails very cumbersome and expensive back-end processes, which can be avoided by directly soldering cables onto the sensor output pads.
However, directly applying heat from a soldering iron to the pads may, when carried out carelessly, damage the sensor. This damage has two most common causes:

1) The thick-film metallisation of the contact pad is leached out by the molten solder.
2) The sensor is damaged by the thermal stresses occurring during the soldering operation. This need not be breakage of the ceramic; a more subtle form of damage is drift of the trimmed resistors, where the thermal stresses propagate microcracks originating from the laser trim cuts.

Compatibility with direct wire soldering thus entails measures both in device design and fabrication, as well as a proper procedure for the soldering itself. The MilliNewton-B force sensor, for instance, includes several features to allow this process.

- Thick pad metallisation layer, to offer good resistance vs. leaching
- Low trimmed resistor count & low trim amplitudes
- Placement of critical components, especially trimmed resistors, away from the heat-affected zone
- Pre-tinned pads (i.e. pads covered with solder), for rapid and easy soldering without contamination
- No sensitive, high-impedance circuit traces near the solder pads that could be easily affected contamination such as coming from solder flux residues

The following sections describe the soldering procedure in detail, as well as the results of qualification tests.

2. Soldering procedure

2.1. Starting material – sensor + wires

For directly soldering wires to the sensors, applying additional solder by a soldering iron is not recommended, as this causes additional stress on the sensor and can leave unwanted contamination. One should best use the soldering iron to apply only heat, which is possible with pre-tinned pads and wires.

Figure 2 shows the sensor, a MilliNewton-B with pre-tinned pads, available in the "P" variant (as opposed to "L" with SIL contacts). Pre-tinned wires are widely available, or can be easily tinned by an appropriate bath (figure 3). In the latter case, one may want to clean the solder flux residue, although this is not always necessary with "no-clean" fluxes.

Of course, both single wires and ribbon cables may be used. Ribbon cables (as in figure 3) should be used when possible, as they usually are more convenient to handle and place.

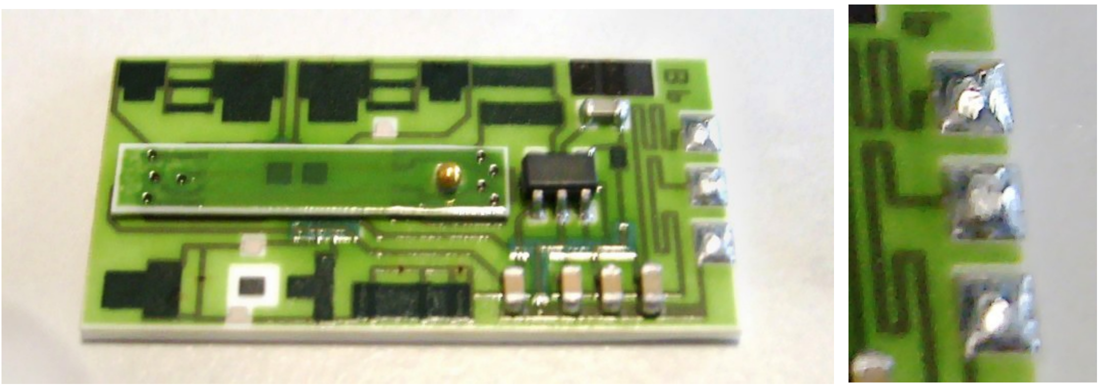

Figure 2. MilliNewton-B sensor with pre-tinned pads ("P" variant; inset: enlarged view of the pads).

Figure 3. Tinning wire ends by dipping into molten solder (left), and resulting wires (right).

2.2. Soldering

The recommended soldering procedure is as follows:

- **Soldering iron**. The temperature of the soldering iron must be determined experimentally as the lowest practical temperature, i.e. where the solder will melt within ≤ 5 s. For Sn62 = 62Sn + 36Pb + 2Ag solder, without pre-heating of the sensor, ca. 350°C is a good starting point.
- **Placement**. Place the tinned cable so that the ends rest on the (equally tinned) sensor pads, where they are to be soldered. In practice, this is best done by using an appropriate mounting jig, consisting of mechanical guides, to easily ensure proper placement of the wires / ribbon cable and the sensor.
- **Soldering**. With the iron, **rapidly** melt the solder on each contact (figure 4); **the time the solder is in the molten state must not exceed 5 s**. This is possible with pre-tinned contact pads & wires, as a good bond is established as soon as both solders (on the pad and on the wire) have melted and fused together; no time is wasted for wetting of the surfaces by the solder (reducing high-temperature exposure), and no solder flux is needed (reducing contamination). The result is shown in figure 5.

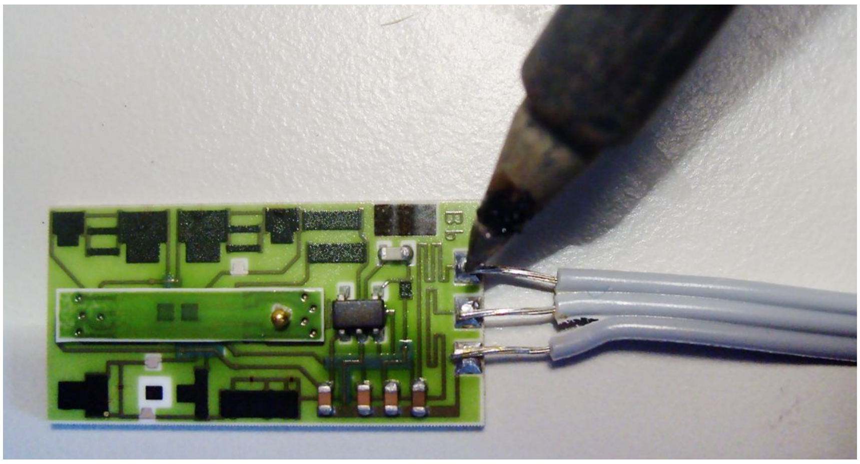

Figure 4. Soldering the wires to the pads without additional material, by melting the solder on the pads and on the wires.

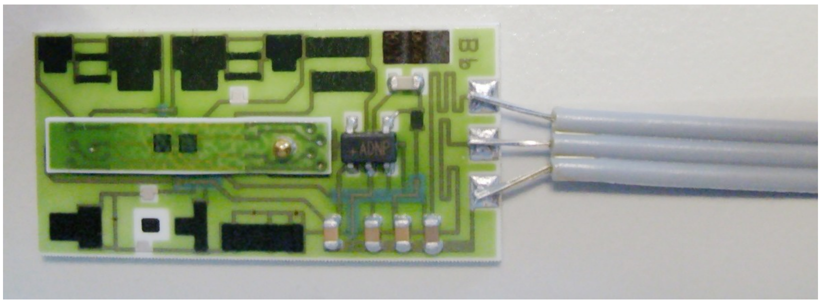

Figure 5. A sensor soldered to a ribbon cable with this procedure.

3. Qualification of the procedure

Tests

To qualify this procedure, >10 sensors were soldered to cables using this procedure, or subjected to simulated soldering tests by melting the solder pads. Some notes on the tests are given below.

- The solder used for tinning the pads and the wires was Sn62 (Sn62 = 62Sn + 36Pb + 2Ag), which corresponds to the solder used in the current sensor version (MilliNewton-Bb). This solder has a melting point of ca. 180°C.
- The sensors were not pre-heated, i.e. were at room temperature.
- Melting of the solder on the three pads was carried out sequentially, with a soldering iron set at 350°C.
- The solder was kept in the molten state ca. 5 s.
- The sensor offset was measured (powering the sensors with 5 V DC) before and after the melting test, as this is the most sensitive indicator of sensor integrity.

Results

Immediately after the test, a strong positive offset shift (ca. 50 mV) appears. This shift, however, is only transient, due to temperature gradients in the sensor base, and disappears as these gradients decay (in less than 1 min).

For > 10 sensors, no significant offset shift was detected: all offset values were within 3 mV (i.e. 0.1% full scale) of their initial value.