Application Note

xEVCap
Guidelines for the assembly

February 2026

Summary
This application note provides general guidelines for mounting the xEVCap on busbars. After a brief introduction to the xEVCap, it presents the results of practical trials of the soldering process for these capacitors. The second section includes insights from Rogers Corporation, a leading busbar company. The third section details a selective wave soldering process that can be easily applied for mass production. Also, laboratory trials using a selective laser soldering process; however, this one does not address aspects of industrialization.

1. Introduction

xEVCap is a DC-link capacitor solution for the main powertrain inverter of electric vehicles (xEVs). As of July 2024, it has been offered to the market [1]. The xEVCap innovation stems from four pillars: modularity and scalability, design for application, design for manufacturing, and standardization and catalog products [2]. Samples are available upon request. All related product information can be found in references [1, 3, 7].

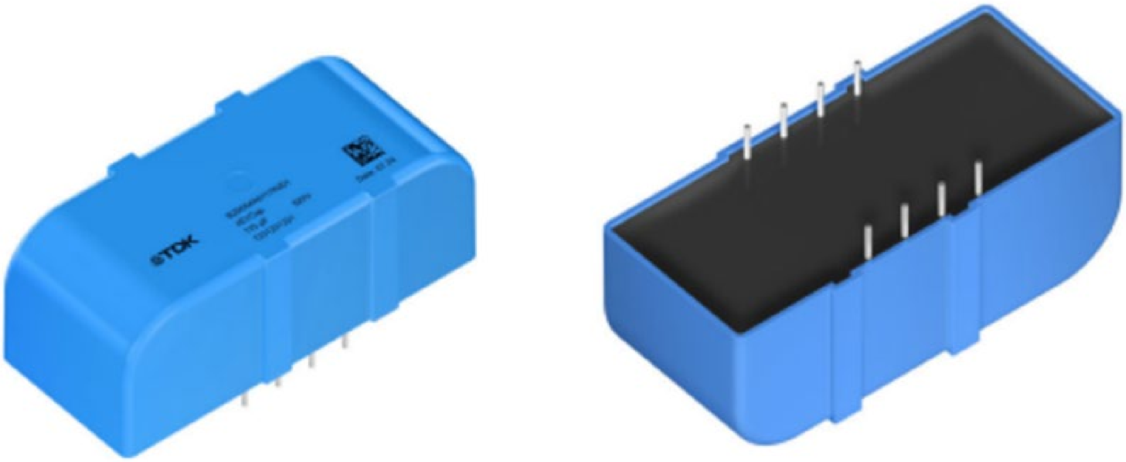


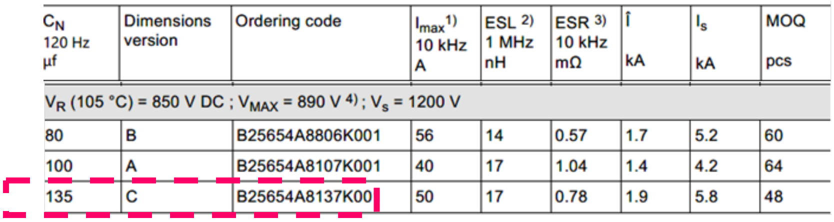
Figure 1: xEVCap lead wire version capacitor unit

A single capacitor unit cannot provide the necessary capacitance, current (I_{RMS}), parasitic self-inductance (ESL), or power for the powertrain inverter within the typical power range (e.g., 150 to 300 kW). The example below, given in [1], illustrates this for an 800 V/250 kW system.

C [µF]	450 (min.)
$I_{c\ RMS}$ (max.) [A]	250 to 300
I_{dc} (max.) [A]	250 to 300
V_R [V]	800 (900 for a limited time)
P [kW]	250
$I_{ph\ RMS}$ (max.) [A]	400 to 500 (max. 650 for 10 s)
ESL [nH]	~7

Table 1: Analysis of system requirements (collaboration with STMicroelectronics)

For the system in Table 1, four 135 µF/850 V capacitor units in parallel were proposed. The part number is highlighted in Table 2.



C_N 120 Hz µf	Dimensions version	Ordering code	I_{max} 1) 10 kHz A	ESL 2) 1 MHz nH	ESR 3) 10 kHz mΩ	Î kA	I_s kA	MOQ pcs
V_R (105 °C) = 850 V DC ; V_{MAX} = 890 V 4) ; V_s = 1200 V								
80	B	B25654A8806K001	56	14	0.57	1.7	5.2	60
100	A	B25654A8107K001	40	17	1.04	1.4	4.2	64
135	C	B25654A8137K00	50	17	0.78	1.9	5.8	48

Table 2: xEVCap capacitors for 850 V in lead wire version [2]

The capacitor units should be connected in parallel using busbars, such as a laminated or stacked busbar. These, in turn, connect to the power semiconductors or power modules. Although a printed circuit board (PCB) connection is another mounting option, it is not commonly used for the main power train inverter because PCBs have a lower current-handling capability. Each capacitor has eight round copper terminals (four for each polarity), each with a diameter of 1.2 mm and plated with pure tin. Proper mounting requires soldering to ensure a reliable finish.

The soldering process subjects capacitors to thermal stress. Therefore, it is crucial to adhere to the cautions specified in the datasheet [1]. Exceeding the recommended temperatures can result in internal damage, including increased equivalent series resistance (ESR) due to problems in the electrode-film contact area, or decreased insulation resistance due to damage to the biaxially oriented polypropylene (BOPP) dielectric. For capacitors mounted on PCBs using the wave soldering method, the maximum body temperature must be kept within the specified limits: During preheating, the temperature (T_p) must be lower than +110 °C; during soldering, the temperature (T_s) must be lower than +120 °C; and the soldering time (T_s) must be lower than 45 seconds.

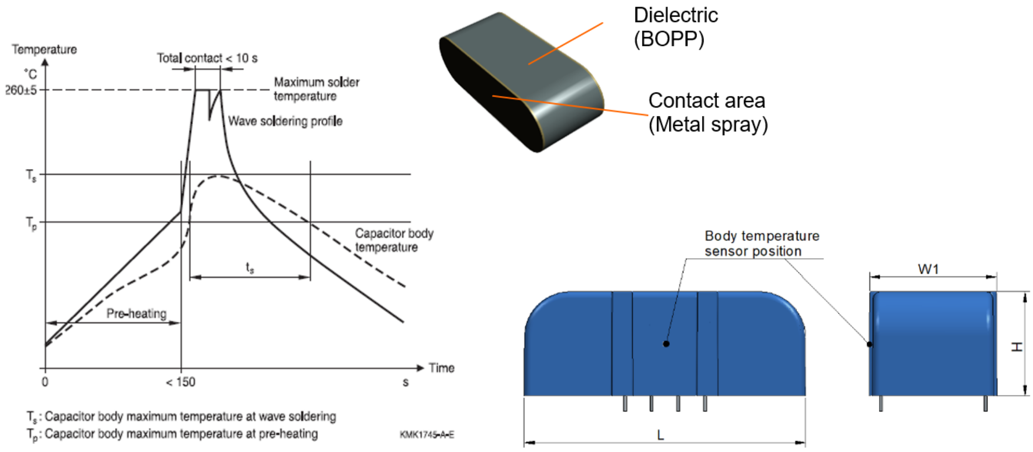


Figure 2: (Upper right) xEVCap internal element.
*(Bottom right and left) Extract from the mounting guidelines of B25654A*001 Datasheet [2]*

Figure 3 shows an example of a real assembly of preliminary prototype versions of the xEVCap [2].

Figure 3: Double Side Cooling Power Module High Power traction inverter 300kW and xEVCap mounted on the laminated busbar (right) (Collaboration with ST Microelectronics)

2. Laminated busbar

With more than 40 years of experience designing and manufacturing ROLINX laminated busbars, Rogers Corporation is an industry leader. A laminated busbar is a multilayer construction of conductors—copper or aluminum—separated by thin dielectric materials and laminated into one structure.

Figure 4: Busbar examples (Rogers Corporation)

A busbar is an electrical circuit made up of multiple layers that distributes current from capacitors (buffers) to power modules (IGBTs, MOSFETs) through specific connections. In this sense, it is like a multilayer PCB; however, the busbar has the advantage of using thicker conductors. This allows it to carry higher currents. Typical currents range from a few dozen amps to several hundred amps, and even kiloamps for the thickest busbar conductors.

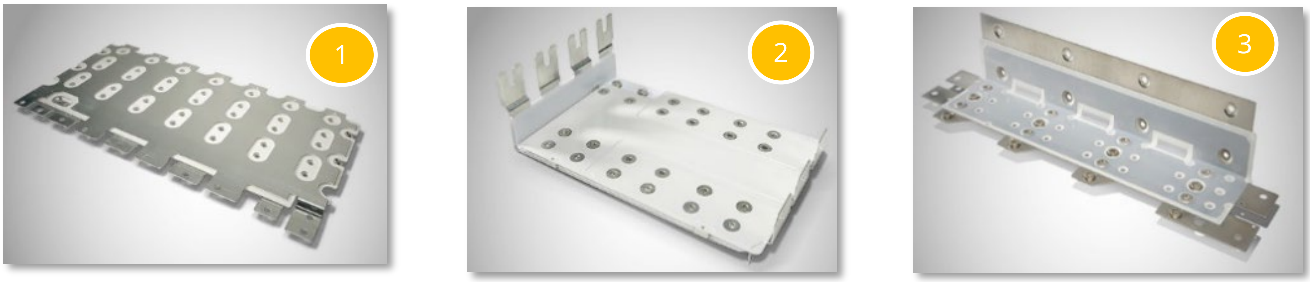


Figure 5: Busbar types by Rogers Corporation:
(1) ROLINX Easy (2) ROLINX Performance (3) ROLINX Thermal

Rogers designs and manufactures three main types of busbars (Fig. 5):

– ROLINX Easy is the most cost-efficient and simplified busbar solution. Designed to replace stacked busbars, it simplifies the supply chain. It does not include outer insulation.

- ROLINX Performance uses state-of-the-art laminated busbar technology for high-power applications with demanding requirements. It provides optimized inductance and controls partial discharge.
- ROLINX Thermal can upgrade existing power systems to a higher power level. It extends operation temperatures to +130 °C, enabling more power to pass through the same amount of copper.

In addition to these types, there are specific solutions for the EV market. One of these solutions has been specially developed to integrate film capacitors, such as TDK's xEVCap: **ROLINX CapLink**. This line of busbars has a distinctive design that enables capacitors to be soldered into ROLINX laminated busbars. The combined assembly is lightweight and has high power density and extremely low inductance. These characteristics make it ideal for SiC power semiconductors.

Voltage rating [V]	400 to 1200
Peak voltage [V]	1600
I_{DC} or I_{AC} (cont.) [A]	60 to 500
Stray inductance [nH]	<10 (depending on terminal design)
No. of capacitors	2 to 10+
Operating temperature (max-) [°C]	+105 (typ. Continuous)
Relative humidity [%]	95 (at +55 °C)
Conductor material	Copper, Aluminum
Plating	Sn, Ni
Insulation CTI [V]	≤ 600

Table 1: ROLINX CapLink typical values

Since the busbars are fully custom-made, the electrical ratings can be extended to fit as many capacitors as the application requires. For reference, a 17 x 17 cm CapLink can accommodate three xEVCaps with footprint C and perform more than 400 A (RMS) at 850 V.

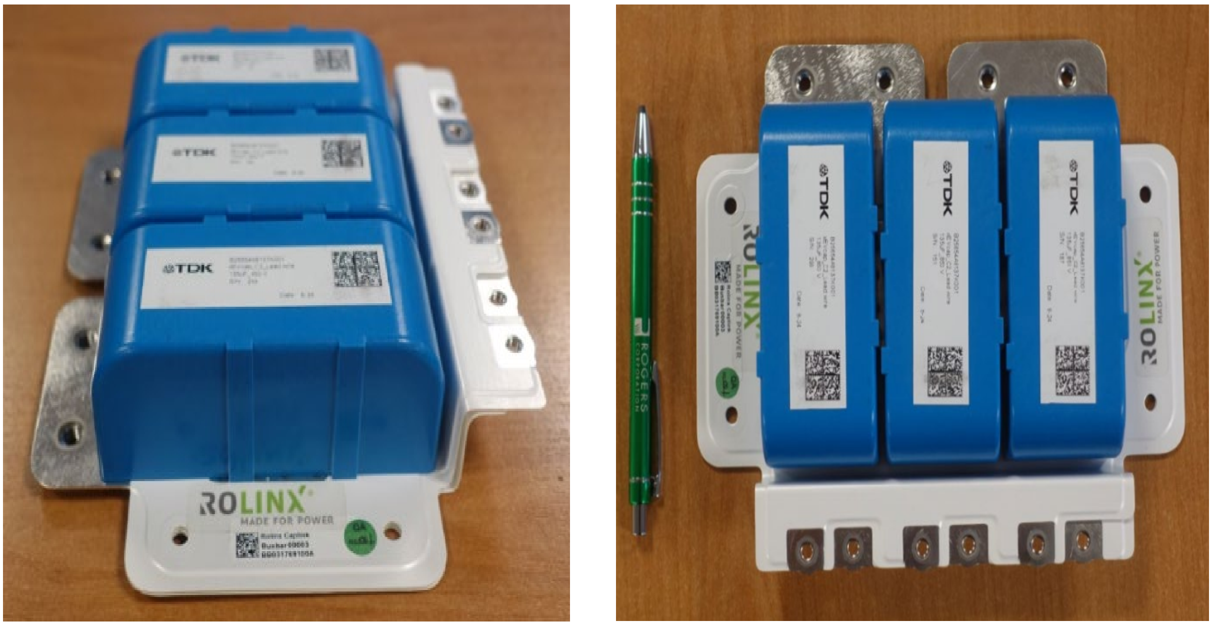


Figure 3: Design example of three xEVCap (B25654A8137K001, 135µF) with ROLINX CapLink (Collaboration between TDK and Rogers Corporation)

For more information, please contact Rogers Support [4] and check the ROLINX design guidelines on the Rogers Design Support Hub [5].

3. Guidelines about soldering processes to busbars

Rogers chose one of two approaches to integrate capacitors into their laminated busbar: a special busbar design that concentrates heat at the soldering point and allows for a standard soldering process, such as robot soldering, selective wave soldering, or wave soldering. Robot and selective wave soldering can be performed as described below. However, wave soldering requires a protective mask to prevent damage to the busbar insulation and limit temperature increase during the process.

Rogers has experience with all of the above processes, but the process used for xEVCap is a manual soldering process involving an iron and solder wire. Due to the special design of the ROLINX CapLink around the soldering point, the busbar-to-capacitor soldering process is the same as standard pin soldering.

1. Place the capacitor(s) in position, with the pins protruding through the soldering holes.
2. Simultaneously touch the tip of the heated iron to the busbar conductor and the capacitor pin. Hold this position for three to four seconds to heat the conductor and pin until the solder melts and forms a soldering cone around the pin.
3. Remove the soldering iron and allow the solder to cool down naturally.

During the test process, temperature was measured in the busbar and on the capacitors.

As Figure 7 shows, the temperature rises to a maximum of +40 °C on the busbar surface and to less than +30 °C on the capacitors, which is very low compared to the limits shown in Figure 2. Due to its high thermal conductivity, the busbar can quickly dissipate heat, while the CapLink soldering design concentrates enough heat to melt solder and ensure a flawless joint.

Figure 4: Detail of the manual soldering process and finished soldering points with temperature monitoring: ***Channel 1:*** *Busbar surface, next to capacitor 1.* ***Channel 2****: Capacitor 1.* ***Channel 3****: Busbar surface, next to capacitor 2.* ***Channel 4:*** *Capacitor 2.* ***Channel 5:*** *Busbar surface, next to capacitor 3.* ***Channel 6:*** *Capacitor 3 . (Rogers Corporation)*

3.1 Trials with selective wave soldering

Tests were conducted on a selective soldering machine from Kurtz Ersa using an SAC305 solder alloy with a crucible temperature of +290 °C. The ROLINX module with assembled capacitors can pass directly through the machine, eliminating the need for mounting on a pallet or carrier. However, the position of the machine's stoppers may need adjusting because the device is not square.

For this experiment, a universal pallet is used to support the device and hold the data logger because temperature profiles must be monitored. This adds complexity to the process because calculating the exact XYZ position of the pins to be soldered is difficult. However, this complexity would not be an issue in a mass production process.

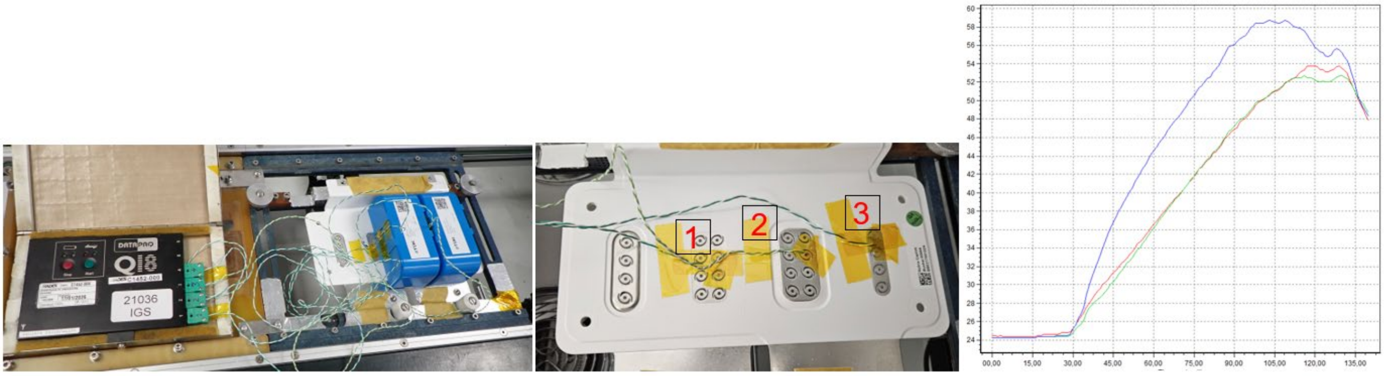


Figure 5: Detail of selective wave soldering trial with datalogger and probe position.
Temperature monitoring during preheating at Trial 3

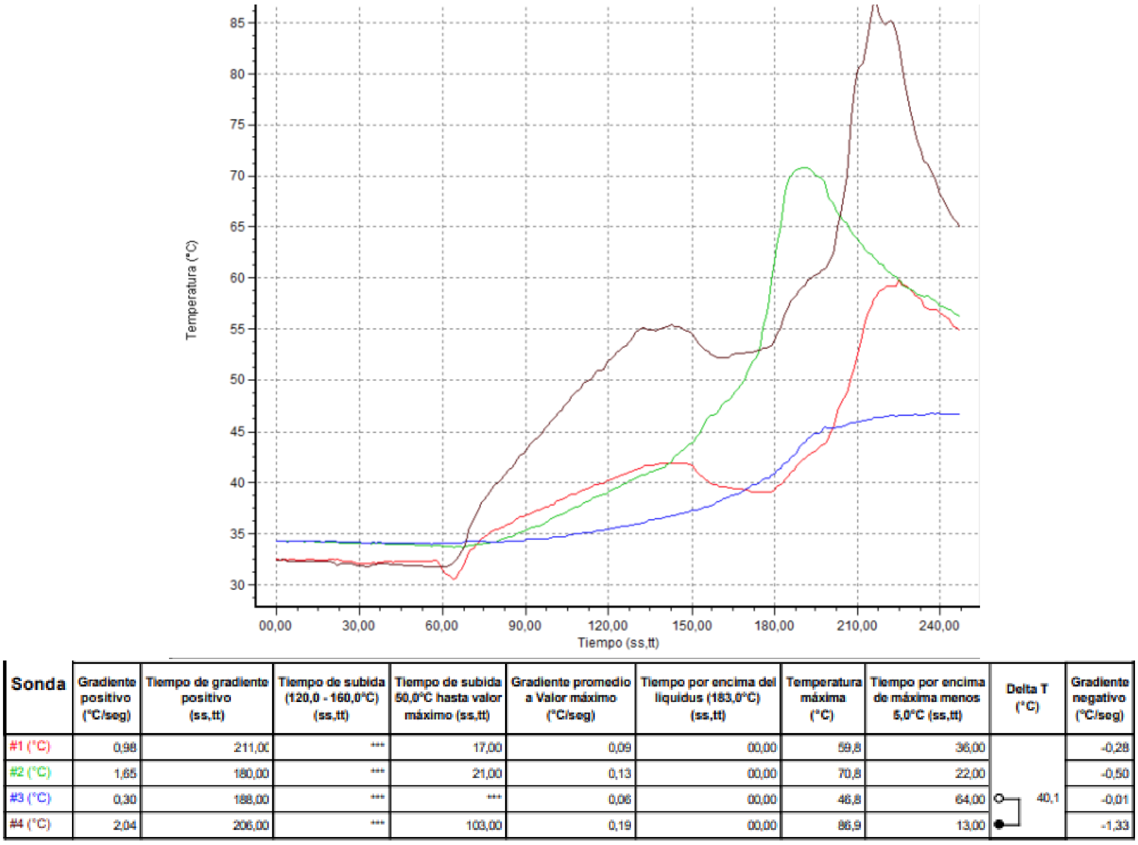
A) Preheating: The idea is to use only the bottom preheater and target a peak temperature of +90 to +100 °C. After a couple of trials, the temperature dropped below +60 °C, which was sufficient for good soldering, as will be demonstrated later.

	Preheater: Time [s]/Power (%) (+ Tolerance (Time/Power))	**Preheating cycle time [s]**	**Peak temperature [°C]**
Trial 1	65/50 (+ 10/20)	75	+47
Trial 2	65/75 (+ 10/40)	75	+53
Trial 3	65/75 (+ 10/40)	75	+59

B) Soldering tests: They are performed with a contact time of approximately 3.5 s per point (shorter time should be feasible but will require more trials). After confirming that the soldering quality is correct, temperature probes have been placed on the outside of the capacitor to measure the temperature reached during soldering (Fig. 9). Probes 1 and 2 were placed on the side of the capacitor, aligned with one of the leads. Probe 1 was located 3 mm from the bottom edge, probe 2 at 5 mm. Probe 3 was positioned to align with the lead at mid-height. Probe 4 was attached to the chassis because soldering the adjacent leads would reach a higher temperature this time.

Figure 6: Probe position for soldering trials.

As can be seen from the temperature curves in Figure 10, Probe 2 reaches a slightly higher temperature (approximately +72 °C) because it is positioned lower down, closer to the soldering area. Probe 1 reaches approximately +59 °C, and probe 3 barely reaches +47 °C. All temperatures are far below the specified soldering temperature of +120 °C to avoid damaging the capacitors.



Sonda	Gradiente positivo (°C/seg)	Tiempo de gradiente positivo (ss,tt)	Tiempo de subida (120,0 - 160,0°C) (ss,tt)	Tiempo de subida 50,0°C hasta valor máximo (ss,tt)	Gradiente promedio a Valor máximo (°C/seg)	Tiempo por encima del liquidus (183,0°C) (ss,tt)	Temperatura máxima (°C)	Tiempo por encima de máxima menos 5,0°C (ss,tt)	Delta T (°C)	Gradiente negativo (°C/seg)
#1 (°C)	0,98	211,0	***	17,00	0,09	00,00	59,8	36,00		-0,28
#2 (°C)	1,65	180,00	***	21,00	0,13	00,00	70,8	22,00		-0,50
#3 (°C)	0,30	188,00	***	***	0,06	00,00	46,8	64,00	○ 40,1	-0,01
#4 (°C)	2,04	206,00	***	103,00	0,19	00,00	86,9	13,00	●	-1,33

Figure 7: Temperature monitoring during soldering

C) Soldering quality: Visually, it is apparent that the soldering is correct with proper wetting. The small flux residues observed can be removed by brushing. This has not been done to document their presence (Fig. 11, left). These residues can be minimized to be almost imperceptible by reducing the amount of flux used. (More tests are needed to determine the optimal amount.) The X-ray images (Fig. 11, right) demonstrate that the solder properly rose and formed a meniscus (cone) at the top.

Figure 11: Soldering Quality

D) Conclusion: With proper wetting, selective wave soldering is feasible. Process time is the total soldering time for each lead (24 leads x 3.5 seconds + 0.7 seconds) plus the time for movement between leads. However, these times can be significantly reduced, as it may not be necessary to solder for such a long duration. (This requires conducting more trials.) Also, for high volumes, it is recommended to use a multiwave solder module to solder all leads simultaneously.

3.2 About mounting xEVCap in Printed Circuit Boards

The xEVCap series features a flat base to maximize volumetric efficiency and vibration resistance, thus minimizing parasitic inductance. However, mounting a flat component flush against a flat substrate may create a near-hermetic seal.

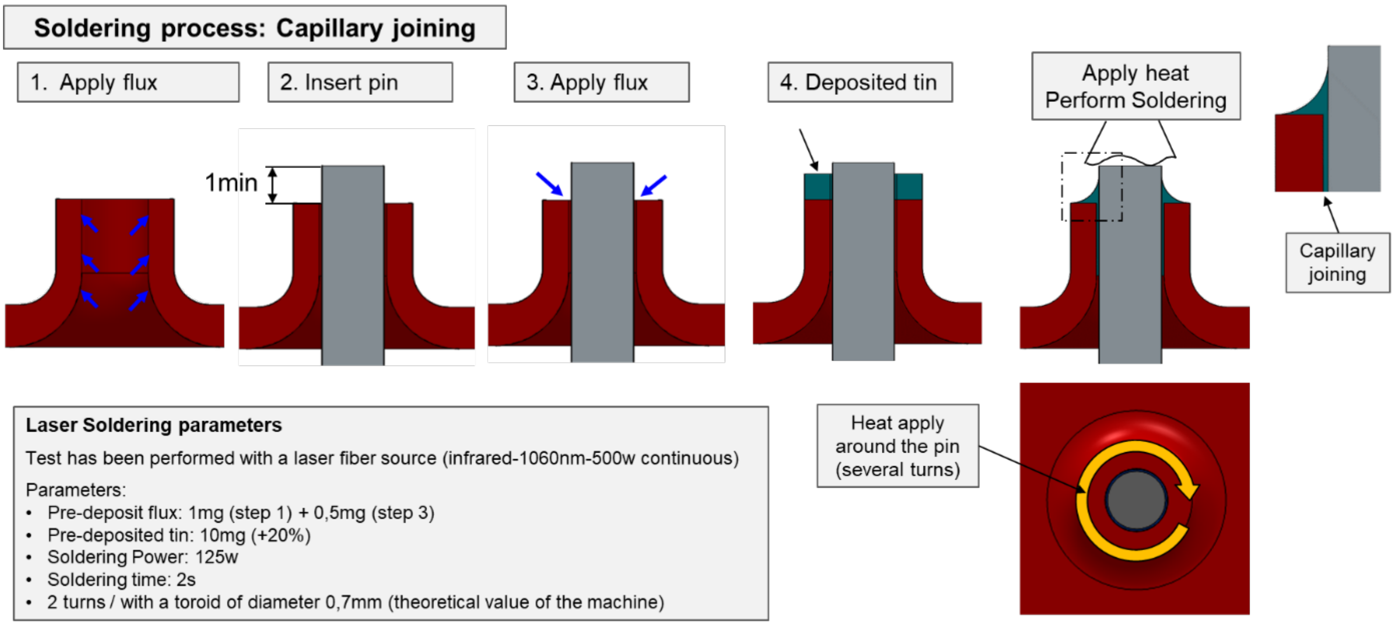
During the soldering process (wave, selective, or manual), this creates a risk of overpressure due to:
- Air expansion: Air trapped under the component expands rapidly when heated.
- Flux outgassing: Soldering flux generates vapor upon activation.

Without an evacuation path, this pressure can cause the component to lift/float, or cause solder defects (blowholes) as gas forces its way through the liquid solder

To address both the gas pressure issue and thermal management, designing "soldering islands" (thermal relief patterns) around the contact pins can be a good option. This design isolates the pin's solder pad from the surrounding copper plane using narrow connection bridges ("spokes"). The soldering island design inherently solves the overpressure issue without the need for additional drilled holes in the PCB. For specific PCB layouts where soldering islands are not possible due to, for example, extreme current density requirements, a dedicated vent hole can be used instead, centrally beneath the capacitor body.

3.3 Trials with laser soldering process and TDK stacked busbar design

To prevent damage to insulators while ensuring efficiency, cleanliness, and a high-quality soldering finish, selective soldering methods are recommended. In this experiment, a custom-designed busbar connection for lead wires by TDK was utilized instead of the Rogers CapLink busbar. The proposed five-step laser soldering process (Fig. 12) minimizes heat input and solder material while achieving an optimal solder joint through capillary action.



Laser Soldering parameters

Test has been performed with a laser fiber source (infrared-1060nm-500w continuous)

Parameters:
- Pre-deposit flux: 1mg (step 1) + 0,5mg (step 3)
- Pre-deposited tin: 10mg (+20%)
- Soldering Power: 125w
- Soldering time: 2s
- 2 turns / with a toroid of diameter 0,7mm (theoretical value of the machine)

Figure 12: Illustration of the experiment in 5 steps performed for the soldering of xEVCap lead wire terminals

The laser soldering equipment was adapted for these trials with additional fixtures and custom programming. After two passes of the laser beam around the wire, the temperature of the capacitor body (CH2; see Fig. 14) did not increase significantly. Only the soldering area (CH1) was heated.

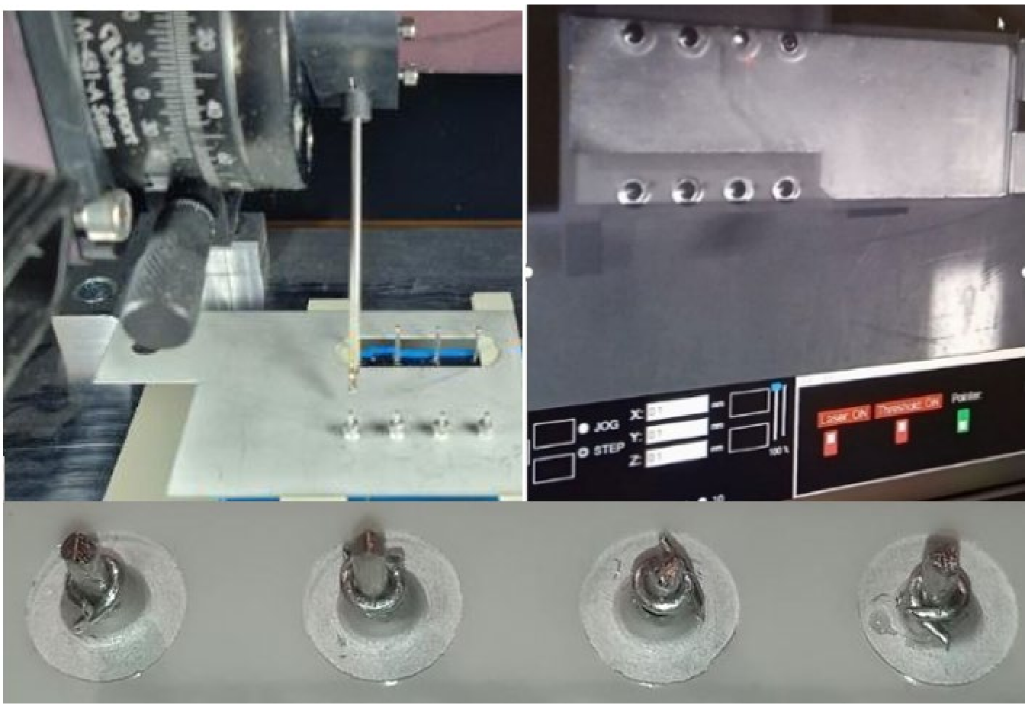


Figure 8: Equipment used for laser soldering (upper left). During soldering (upper right). Prototypes of soldering tin preforms deposited around the lead wire (Step 4), just before soldering (bottom).

Temperature was monitored in different areas (see Fig. 14). Results showed that it was far below their maximum temperature ratings (Fig. 15).

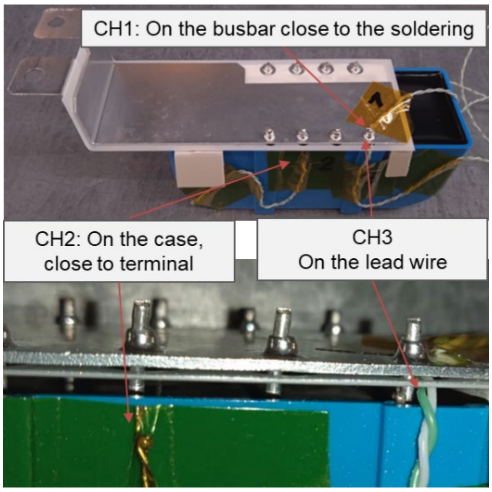


Figure 14: Locations of the temperature sensors

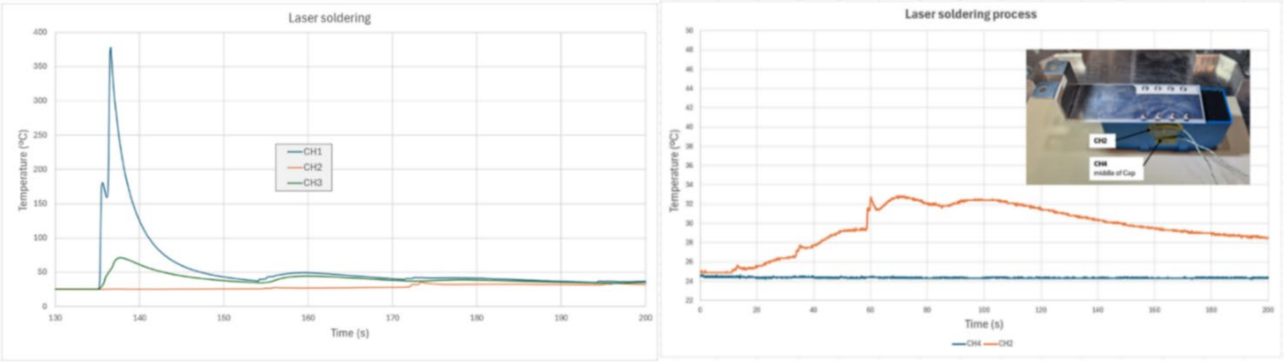


Figure 9: Temperature profiles in different areas. No stress for the capacitor. (CH4 (blue)=centre of capacitor side).

The methodology involved trial and error until the soldering quality was stable. Preliminary trials revealed issues such as gaps in the solder area, burnt tips, and burnt insulators (Fig. 16). These issues were often due to manual tin-flux deposition control or excessive time and power. The primary challenge was that the laser equipment was not designed for capillary soldering. During these trials, the laser spot diameter had to be manually adjusted and was sometimes too wide.

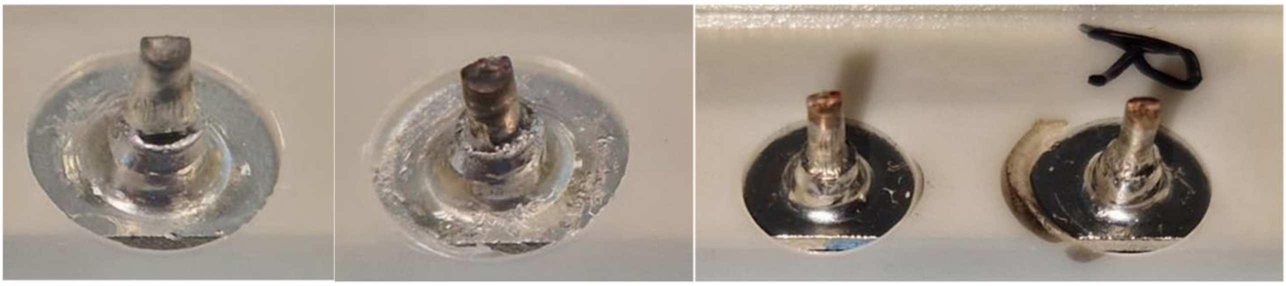


Figure 10: Solder gap (left), burnt tip (center), damaged insulation sheet (right).

For example, reducing the power or diameter of the laser beam and increasing the number of turns slightly will promote a more uniform and gradual temperature distribution. This approach enhances capillary action and prevents burning of unwanted areas, such as the tip and insulator. However, cutting the wire over the neck could lead to tip burning due to chips. Further investigation and control of these aspects are required to integrate this mounting process into mass production.

After several trials, the results were finally positive. Good soldering quality and a technically feasible process were achieved. This results in a smooth soldering appearance, good wetting, and no cold solder. The tin material filled the gap between the pin and the hole completely. There was no damage to the plastic insulation or the pin from the laser due to excessive heating, and there were no signs of burns.

Figure 17: xEVCap with own TDK busbar design. After laboratory trials of the soldering process. Details of terminals and finishes.

4. Future Work

A series of tests will be conducted to evaluate and prove the reliability of the capacitor-to-busbar joint technology. Mass production requires process optimization, control, and reduction of cycle time. In laser soldering, for example, the tin wire could incorporate flux, so automating preform insertion or auto-feeding the tin wire is essential. We tested this laser soldering method with SMD film capacitors, which otherwise require larger, more expensive dielectrics and enclosures to be compatible with standard SMT reflow processes. Other factors that need to be investigated to support the incorporation of these new selective soldering processes for mounting electronic components include power consumption, factory area, cleanliness, quality, process control, and yield.

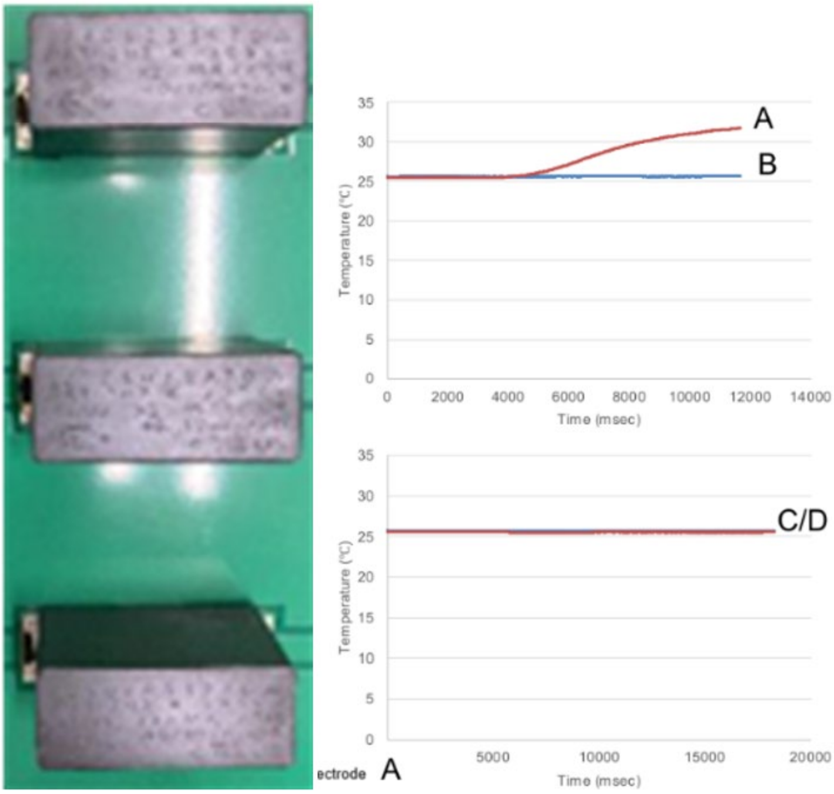


Figure 18: Detail of temperature profile for laser soldering to an SMD film capacitor (X2- 2.2µF-305Vac). Laser soldering process applied to SMD film capacitors by Hamamatsu Photonics [6]

References

[1] xEVCap B25654A*001, Datasheet, July 2024

[2] D. Olalla, G. Kulkarni, F. Rodriguez, "A Modular DC-Link Capacitor Solution for the Main Powertrain Inverter of xEVs," *PCIM Europe 2024; International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management*, Nürnberg, Germany, 2024, pp. 1809-1815, doi: 10.30420/566262249.

[3] Search and Simulation Tool CLARA (Characteristics, Comparison, Simulation, Spice, and mechanical 3D models)

[4] Rogers Corporation Support

[5] Rogers Design Support Hub

[6] T-SMILS Laser heating system L15570 series | Hamamatsu Photonics [hamamatsu.com], Dec 2021

[7] D. Olalla, T. Wagner, F. Rodriguez, A. Espinar “A Practical Use of xEVCap: The Modular and Standard DC-Link Capacitor Solution for the Main EV Powertrain Inverter”, APEC March 2025, PCIM May 2025

About TDK Corporation

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