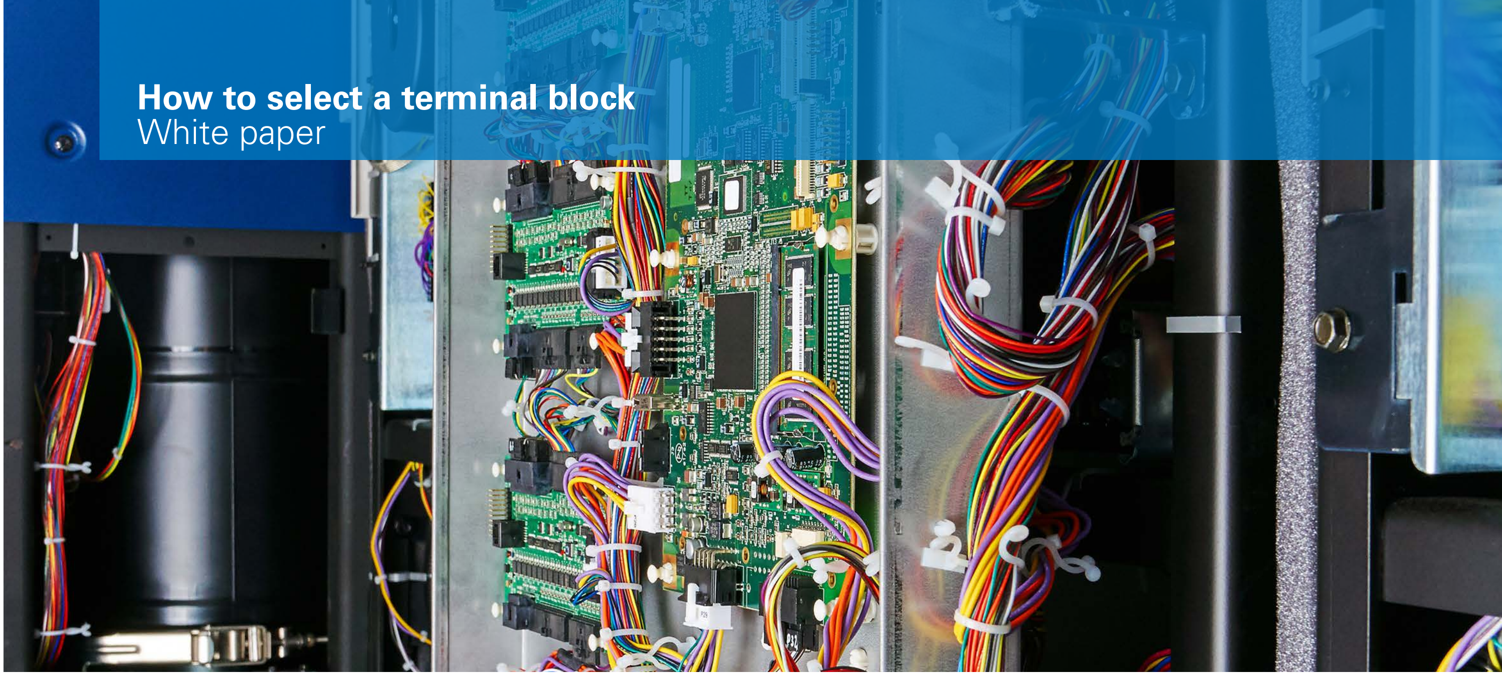
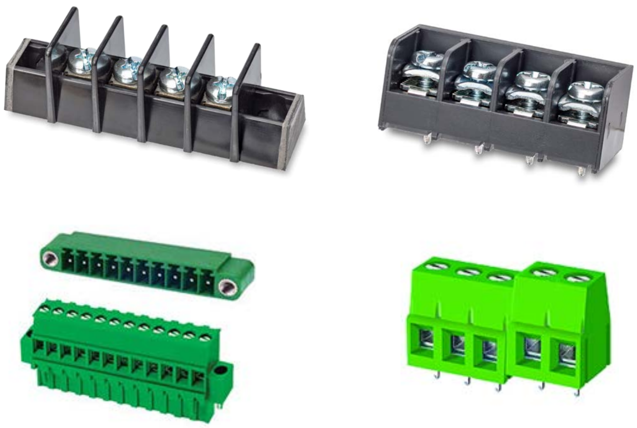


How to select a terminal block



Executive summary

Terminal blocks are common connectors that are intended to safely and effectively bridge the gap between two different circuits. Since they typically have power delivered from a larger source that is carried by wire conductors, terminal blocks are commonly found on industrial and power management electronic devices, such as variable frequency drives, motor protection relays, power and energy meters, power supplies and converters, HVAC and traffic controls, programmable logic controllers and many others. Power is most commonly delivered by wire, so it is always an option to land these wires directly to the assembly without costly adapters that only conform to certain products. Electricians and other installers can quickly work with this simple form of equipment installation and electrical integration.

Eaton offers feed-through terminal blocks and/or barrier strips that expect wire to have the conductive path managed through the housing in the rear of the block. There are varying voltage ratings and current ratings within the portfolio. This document will review wire feed through terminal blocks, different components, common terms, synonyms and items to consider when selecting a terminal block to integrate into your device or system.

Powering Business Worldwide

Product Types

The Eaton Electronics division portfolio breaks down into three main categories: Single Row Terminal Blocks, IEC Style Printed Circuit Board (PCB) Terminal Blocks and Edge Connectors.

Single Row Terminal Block - Commonly referred to as barrier strips and often found in North America, these terminal blocks have a screw down terminal with a standard product accepting a wire directly underneath the screw. Typically, they have more bottom side terminal options available in the same footprint and can accept different wire accessories on the top side of terminal.

IEC PCB Terminal Block - Often referred to as Euro Style; this terminal block is common everywhere but orginated in IEC assemblies. Bare wire enters the block to cage clamp or spring loaded by mechanical force. There are many different footprints available for the same pitch and generally all have printed circuit board solder pins.

Edge Connectors - The housing on edge connectors accepts a printed circuit board edge to match with copper traces on the board, as well as screws to fasten the block to an enclosure. They can be solderless and have a mechanical connection.

Terminal Block Components

All of the terminal blocks within Eaton's portfolio have a couple of common components that are found across the different styles. These components, while varying in shape and size, perform the same basic function. The different forms allow the overall product to have a different fit, form and function. Following are the types and definitions of these components:

Terminal – Circuit path where wire engages and carries current through the housing. Typically made of a copper alloy.

Housing – Material that insulates conductive path from exterior and adjacent circuits. Generally made of plastic.

Fastener – Mechanism that applies force or ensures the wire is connected to terminal. Made of various metal alloys.

Common Terminal Block Specifications

The features of the terminal, housing and fastener are also a factor in determining the electrical and mechanical specifications of the product. These specifications are common across the Eaton product line and help define the fit, form and function of the terminal block as well.

Poles: The number of individual circuits, or adjacent terminals, contained within the terminal block.

Pitch: The distance from one pole to the next. It's measured from one feature to the same feature on the adjacent pole with the distance typically being the same for all poles. This is also called center-to-center distance.

Voltage Rating: The maximum system voltage that the terminal block is designed to be installed within. Generally, this electrical specification is a function of the pitch and the dielectric strength of the housing. More detailed information on this can be found in the appendix concerning terminal block standards.

Current Rating: This is the maximum nominal current rating per pole that the terminal block is intended to be used. Generally, this electrical specification is a function of the cross-sectional area, conductivity of the terminal, and the resulting heat rise at rated current (per UL1059) or power dissipated at rated current (per IEC 60947-7).

Wire Range: The minimum and maximum wire sizes the terminal block is rated to accept.

Torque Rating: The maximum torque the hardware is designed to withstand while fastening a wire, within the wire range specification, to the terminal and not deform.

Things to Consider

Now that the specifications are defined and the different options can be evaluated/compared, there are several things to consider when selecting the right terminal block for the application. Like most electronic circuits, the first items to evaluate are the circuit parameters of the application, including the nominal current, the system voltage, and the number of circuits needed. The current and voltage rating of the terminal block needs to be above the nominal current rating and system voltage.

Additional care should be taken when there are temporary voltage surges or inrush currents that can occur. The more frequent that these temporary overvoltages and overcurrents occur, the more that the terminal block should be oversized to meet the application needs. The number of circuits will directly correlate to the number of poles needed on the terminal block.

The next item, and very important for terminal blocks, is the terminal configuration. The equipment designer must evaluate how the circuit path will be completed on the "through" side of the connection. IEC-style terminal blocks are typically all short PCB solder connections for wave soldering. Barrier Strips also have short PCB solder connections, but also can have male quick connects, longer solder pins, hand wired for hand soldering, screw threads, solder turrets and more. The options for barrier strips will vary depending on what is logical based on the pitch. Edge connectors are often mechanically attached and provide a solderless connection with the terminals providing spring forces on PCB traces.

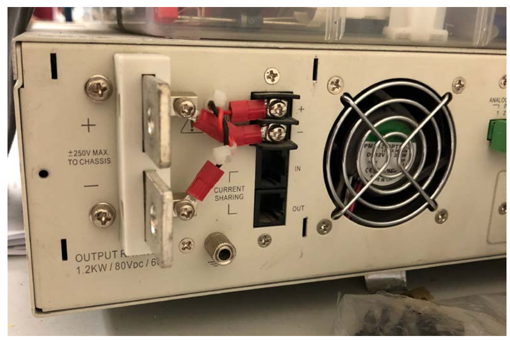


Figure 1. Ring terminals on barrier strip example

Occasionally, the overall footprint and wire entry is thought of as a function of the pitch or the overall width, but all three dimensions must be considered. The most common barrier strips offer many terminations in the same plastic base, but can allow for ring or fork terminals, female quick connects, and solder terminals in place of the standard bare wire terminals. See Figure 1 for an example of ring terminals accepted on barrier strips. Due to the different type of construction, IEC-styles offer many different wire entry orientations in the same pitch, resulting in different physical footprints, including space saving tiered options. There are also different options for fastening, including a cage clamp, spring clamp and screwless clamp. Edge connectors are unique in their footprint and wire entry, and can provide the best combination, depending on the assembly. All of these footprint and wire entry considerations have the goal of making the task of integrating into a piece of equipment or assembly easier. They should also allow for the end user to easily connect wires and manage where they fit around the assembly.

Lastly, after managing the above issues, there is always the opportunity to provide additional functionality. These additional features can ensure proper assembly for the OEM and proper installation for the end user with pole numbering or custom markings. Optional hardware can provide better corrosion resistance for some non-current carrying components for better aesthetics. Terminal block covers can provide better shock protection for the general public, but also better environmental protection in normal industrial environments.

Examples:

Figure 2 is a compact/micro 3-phase variable frequency drive (VFD) with the top cover removed for illustration purposes. There are seven different wire to board terminal blocks shown – three barrier strips and four IEC-style – but all of them are mounted on the printed circuit board. The design engineer chose the barrier strips as they are the terminals that will be receiving highest power, in this case up to 25 A at 480 Vac.

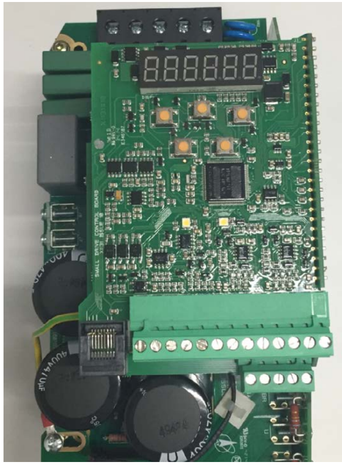


Figure 2.

There are IEC-style terminal blocks that are rated to accept this current and voltage, however, in some cases with VFDs, electricians prefer to use ring terminals, making barrier strips the preferred terminal block in this application. The designer chose the IEC-style terminal blocks for the logic control terminals to have a high circuit density (small pitch) as those circuits are naturally low current and low voltage. These particular terminal blocks are also depluggable, so the plug can be removed from the header to allow for easier installation of the smaller I/O wires.

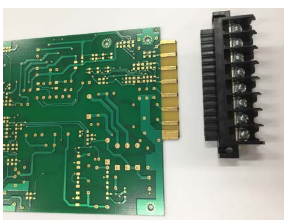


Figure 3.

Figure 3 shows how an edge connector would connect to a printed circuit board, with the appropriate pitch and copper traces.

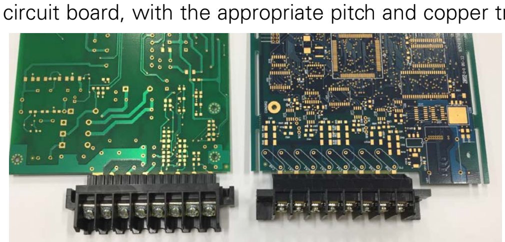


Figure 4.

Figure 4 demonstrates different edge connector footprints and how these solutions can also provide support to the PCB when mounted with an appropriate enclosure.

Custom options

Eaton does support custom options as the above requirements may require configurations that are not shown on the datasheet or catalog. Custom product could have special markings for ease of assembly or for the end user. The configuration of barrier strips allows for different fasteners to be installed on adjacent poles. When this is requested, a standard product will not suffice. A custom part number can be created to support this custom pole configuration.

Figure 5.

Figure 6.

Figure 5 demonstrates a customization of a barrier strip. This barrier strip has different 3/16" wide male quick connect extending from the fastening side of the terminal block. This allows a female quick connect to snap onto the male blade for fast assembly. This is just one form of customization that can be provided with terminal blocks. The barrier strips in Figure 6 show custom marking capabilities for different applications. These additional markings, performed at the factory, helps end users connect to the right wires to each block, reducing wiring errors in product integration.

Please contact Eaton for custom product availability and configuration

Testing

After these items are considered and a candidate is selected, Eaton recommends that the terminal block is tested in the application under the same environmental conditions that the complete assembly would experience. This could be the ambient conditions, highest nominal current, temporary overvoltages or inrush currents, potential tension on wires, smallest wires the terminal block would see, having no airflow, and variability in solder joints. The goal would be to evaluate possible sources of heat and how to manage them. Eaton can support providing samples for testing purposes as recommended above.

Apendix

Eaton Compliance References

Eaton's electronic terminal blocks comply fully with UL 1059 and CSA 22.2 No. 158 terminal block standards and have UL 94 V-0 self-extinguishing flammability classification. The blocks are recognized under UL file number E62622. Ratings higher than those listed are possible and can vary, depending on the application and must be evaluated on a case by case, individual basis by the manufacturer.

UL 1059 & CSA 22.2 No. 158 Voltage Rating

Voltage ratings of terminal blocks are based on the minimum spacing between electrically conductive parts and a minimum withstand voltage. The spacing is measured under two conditions: 1) through air, defined as the shortest distance an arc must travel through an air path from one electrically conductive part to a grounded surface; and 2) over surface, defined as the shortest distance an arc must travel as it tracks along the surface of an insulating material from one electrically conductive part to another at opposite polarity or from an electrically conductive part to a grounded surface. The withstand voltage, termed dielectric withstand, is dependent on the voltage rating. The value is 1000 V plus twice the rated voltage for one minute; this is tested under both conditions listed above. Table A provides the UL 1059 and CSA 22.2 NO 158 spacing requirements, in inches. Table B describes what voltage rating each Eaton family of terminal block is rated to, per the minimum spacing requirements and application environments described within UL 1059.

IEC Compliance

Eaton's electronic terminal blocks comply with the requirements in IEC Publication 60947-7-1, Terminal Blocks for Copper Conductors. These blocks are concurrently recognized and certified under the UL Classification Program. Details of the IEC rating system is provided on the following page. Ratings, except where indicated, are concurrent with UL 1059.

CE

In 1998, Eaton received CE certification on all products. For terminal blocks, CE is a self-certification mark applied to products that have met safety and performance requirements set forth by the European Union (EU). This mark is required for free movement of product in the European market.

Table A. UL 1059 spacing requirements

Application	Voltage rating	Spacing through Air	Spacing over surface
Class A Service equipment, including dead-front switchboards, panelboards, service entrance devices, etc	51 - 150 151 - 300 301 - 600	0.50 0.75 1.00	0.75 1.25 2.00
Class B Commercial appliances, including business equipment, electronic data processing equipment, etc.	51 - 150 151 - 300 301 - 600	0.06 0.09 0.38	0.06 0.09 0.50
Class C General industrial, including machine tool controls, which can further be defined as equipment governed by UL 508	51 - 150 151 - 300 301 - 600	0.13 0.25 0.38	0.25 0.38 0.50
Class D Industrial Devices having limited ratings	51 - 150 301 - 600	0.06 0.19	0.13 0.38

Table B. Overall UL 1059 voltage ratings

Eaton Family	CLASS A			CLASS B			CLASS C			CLASS D	
	51-150 V	151-300 V	301-600 V	51-150 V	151-300 V	301-600 V	51-150 V	151-300 V	301-600 V	51-150 V	151-300 V
A0/CB0					X		X			X	
A1/CB1					X		X			X	
A2/CB2					X			X			
LP2					X		X				
A3/CB3						X			X		
LP3					X		X				
A4/B4	X					X			X		
A38						X			X		
B38					X			X			

IEC 60947-7-1

Similar to UL1059 Classes, IEC 60947-7-1 refers to IEC60947-1 which outlines the general rules for low-voltage switchgear and control gear as well as defines creepage and clearance limits based on pollution degrees. The pollution degree refers to the environmental conditions for which the equipment is intended.

The micro-environment of the creepage distance or clearance, and not the environment of the equipment, determines the effect on insulation. The micro-environment might be better or worse than the environment of the equipment. It includes all factors influencing the insulation, such as climatic and electromagnetic conditions, generation of pollution, etc. Therefore, for equipment intended for use within an enclosure or provided with an integral enclosure, the pollution degree of the environment in the enclosure is applicable.

For purposes of evaluating clearances and creepage distances, the four degrees of pollution of the micro-environment are established:

- Pollution degree 1: No pollution or only dry, non-conductive pollution occurs.
- Pollution degree 2: Normally, only non-conductive pollution occurs. Occasionally, a temporary conductivity caused by condensation may be expected.
- Pollution degree 3: Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation.
- Pollution degree 4: The pollution generates persistent conductivity caused, for instance, by conductive dust or by rain or snow.

Pollution degree 3 is the standard pollution degree for industrial applications, unless otherwise stated by the relevant product standard. However, other pollution degrees may be considered to apply depending on the particular application or micro-environment.

Impulse withstand voltage – highest peak value of an impulse voltage, of prescribed form and polarity, which does not cause breakdown under specified test conditions.

Comparative tracking index (CTI) – numerical value of the maximum voltage in volts at which a material withstands 50 drops of a test solution without tracking (clause 2.3 of IEC 60112)

- Material Group I 600 <= CTI
- Material Group II 400 <= CTI < 600
- Material Group IIIa 175 <= CTI < 400
- Material Group IIIb 100 <= CTI < 100

Homogeneous Field: electric field which has an essentially constant voltage gradient between electrodes, such as that between two spheres where the radius of each sphere is greater than the distance between them.

Inhomogeneous Field: electric field which does not have an essentially constant voltage gradient between electrodes.

Table D - Minimum clearances in air

Rated impulse withstand voltage U_{imp} kV	Minimum clearances (mm)							
	Case A Inhomogeneous field conditions				Case B Homogeneous field conditions			
	Polution degree				Polution degree			
	1	2	3	4	1	2	3	4
0.33	0.01				0.01			
0.5	0.04	0.2	0.8		0.04	0.2		
0.8	0.10			1.6	0.1		0.8	1.6
1.5	0.5	0.5			0.3	0.3		
2.5	1.5	1.5	1.5		0.6	0.6		
4.0	3.0	3.0	3.0	3.0	1.2	1.2	1.2	
6.0	5.5	5.5	5.5	5.5	2.0	2.0	2.0	2.0
8.0	8.0	8.0	8.0	8.0	3.0	3.0	3.0	3.0
12.0	14.0	14.0	14.0	14.0	4.5	4.5	4.5	4.5

NOTE: The values of minimum clearances in air are based on 1.2/50 us impulse voltage, for barometric pressure of 80 kPa, equivilant to normal atmospheric pressure at 2,000 m above sea ,level.

Table C - Minimum creepage distances

Rated insulation voltage of equipment or working voltage ac rms. or dc[4] V	Minimum clearances (mm)														
	Polution degree			Polution degree				Polution degree				Polution degree			
	1 [5]	2 [5]	1	2				3				4			
	Material group			Material group				Material group				Material group			
	[1]	[2]	[1]	I	II	IIIa	IIIb	I	II	IIIa	IIIb	I	II	IIIa	IIIb
10	0.025	0.04	0.08	0.4	2.4	1.0		1.0	1.0	1.6		1.6	1.6	0.025	0.025
12.5	0.025	0.04	0.09	0.42	0.42	1.05		1.05	1.05	1.6		1.6	1.6	0.025	0.025
16	0.025	0.04	0.1	0.45	0.45	1.1		1.1	1.1	1.6		1.6	1.6	0.025	0.025
20	0.025	0.04	0.11	0.48	0.48	1.2		1.2	1.2	1.6		1.6	1.6	0.025	0.025
25	0.025	0.04	0.125	0.5	0.5	1.25		1.25	1.25	1.7		1.7	1.7	0.025	0.025
32	0.025	0.04	0.14	0.53	0.53	1.3		1.3	1.3	1.8		1.8	1.8	0.025	0.025
40	0.025	0.04	0.16	0.56	1.1	1.4		1.6	1.8	1.9		2.4	3.0	0.025	0.025
50	0.025	0.04	0.18	0.6	1.2	1.5		1.7	1.9	2.0		2.5	3.2	0.025	0.025
63	0.04	0.063	0.2	0.63	1.25	1.6		1.8	2.0	2.1		2.6	3.4	0.04	0.04
80	0.063	0.1	0.22	0.67	1.3	1.7		1.9	2.1	2.2		2.8	3.6	0.025	0.025
100	0.1	0.16	0.25	0.71	1.4	1.8		2.0	2.2	2.4		3.0	3.8	0.025	0.025
125	0.16	0.25	0.28	0.75	1.5	1.9		2.1	2.4	2.5		3.2	4.0	0.025	0.025
160	0.25	0.4	0.32	0.8	1.6	2.0		2.2	2.5	3.2		4.0	5.0	0.025	0.025
200	0.4	0.63	0.42	1.0	2.0	15		2.8	3.2	4.0		5.0	6.3	0.025	0.025
250	0.56	1.0	0.56	1.25	2.5	3.2		3.6	4.0	5.0		6.3	8.0	0.025	0.025
320	0.75	1.6	0.75	1.6	3.2	4.0		4.5	5.0	6.3		8.0	10.0	0.025	0.025
400	1.0	2.0	1.0	2.0	4.0	5.0		5.6	6.3	8.0		10.0	12.5	0.025	0.025
500	1.3	2.5	1.3	2.5	5.0	6.3		7.1	8.0	10.0		12.5	16.0	0.025	0.025
630	1.8	3.2	1.8	3.2	6.3	8.0		9.0	10.0	12.5		16.0	20.0	0.025	0.025

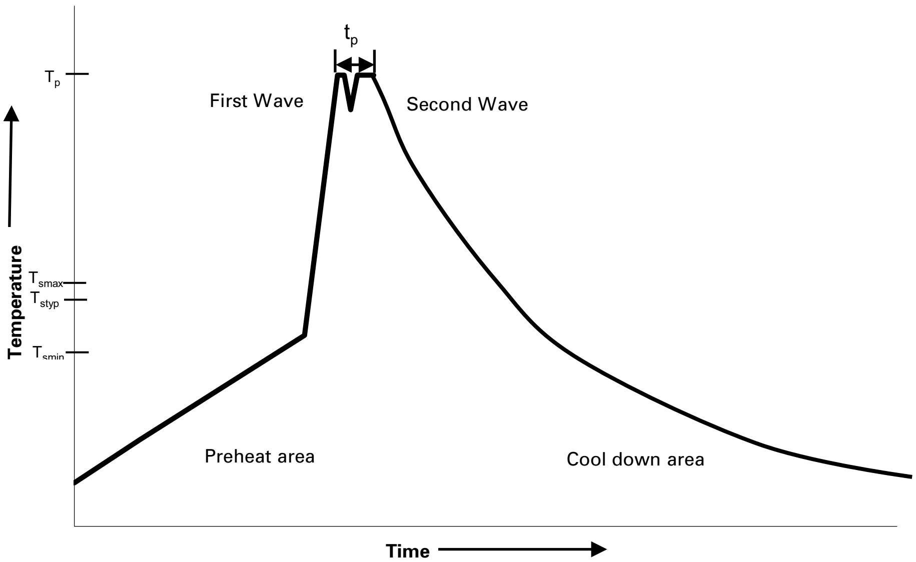
Soldering

For PCB applications Eaton reccomends referencing EN 61760-1:2006

For non- PCB applicaitons manual solder can be done by soldering iron at +350 °C for 4-5 seconds.

Wave solder profile

Reflow soldering not recommended



Reference EN 61760-1:2006

Profile Feature		Standard SnPb Solder	Lead (Pb) Free Solder
Preheat	• Temperature min. (T_{smin})	100°C	100°C
	• Temperature typ. (T_{styp})	120°C	120°C
	• Temperature max. (T_{smax})	130°C	130°C
	• Time (T_{smin} to T_{smax}) (t_s)	70 seconds	70 seconds
Δ preheat to max Temperature		150°C max.	150°C max.
Peak temperature (Tp)*		235°C – 260°C	250°C – 260°C
Time at peak temperature (t_p)		10 seconds max 5 seconds max each wave	10 seconds max 5 seconds max each wave
Ramp-down rate		~ 2 K/s min ~3.5 K/s typ ~5 K/s max	~ 2 K/s min ~3.5 K/s typ ~5 K/s max
Time 25°C to 25°C		4 minutes	4 minutes

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