

## Designing a motherboard for a MC3602 B / MC3606 B Motion Controller

### Summary

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FAULHABER offers an evaluation board for the plug-in Motion Controllers MC 3602 B / MC 3606 B. This evaluation board, combined with a set of mating connectors, is all needed to get started with a MC3602 B / MC3606 B.

For the final application a motherboard needs to be designed to exactly fit your construction space. This application note provides the guidelines for the motherboard design, including the hardware filters relevant for achieving EMC conformance.

- The footprints of the two versions are explained on page 2 and 3.  
The MC3602 B version is using one Board to Board connector. To carry the higher continuous current, the MC3606 B needs an extra Board to Board connector. Safe connection to the motherboard can be achieved by using steel spacers and screws.
- It is recommended to use at least a 4-layer PCB, with detailed layer descriptions on page 4.
- Explanations on EGND and shielding highlight their importance for EMC conformance and signal integrity. How EGND and shielding is realized, can be seen on page 4.
- Depending on the power supply, an optional EMC supply filter might have to be considered as described on page 6.
- And finally, the part names of useful PCB connectors are provided.

For further information on the MC3602 B / MC3606 B pin description refer to the technical manual, for functionality description refer to the [drive functions manual](#).

For further guidelines on shielding, cable length and functional earth see [application note 187](#).

### Applies To

Motion Controllers MC3602 B / MC3606 B

## Description

### The Footprint

The **MC3602 B** version uses only one Board to Board connector allowing for a compact design. It has an onboard micro-USB interface (X1) for convenient configuration in the application without using CAN or RS232 interface for this purpose.

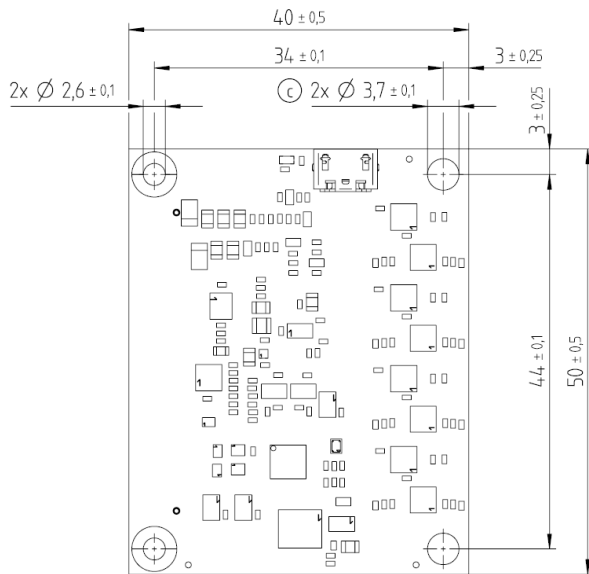


Figure 1: Top view of MC3602 B – in mm

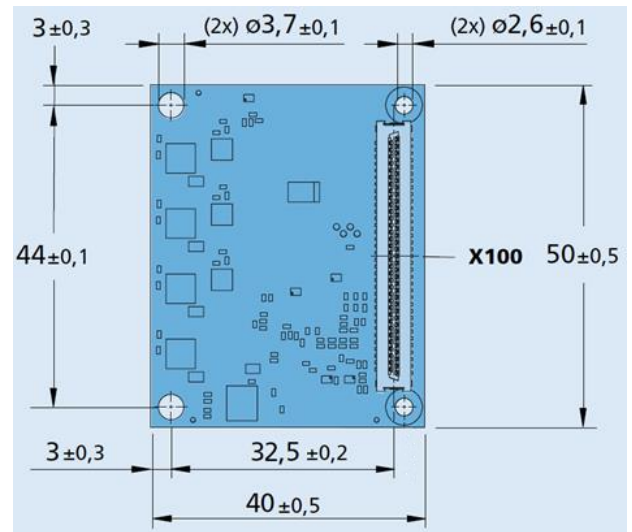


Figure 2: Bottom view of MC3602 B – in mm

To place a MC3602 B on a motherboard the following sockets are needed:

Quantity	Type	Manufacturer	Part name
1	69P Conan Lite receptacle	Amphenol	10162581-3134169LF
2	Steel Spacer M2.5 (4mm board distance)	Würth	9774040151R

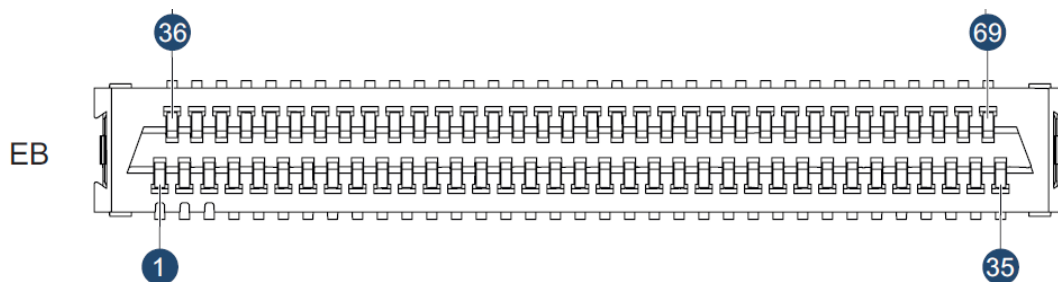


Figure 3: Pin numeration

The **MC3606 B** version is the higher power version. Additional pins are needed for the higher currents supplied by the motion controller.

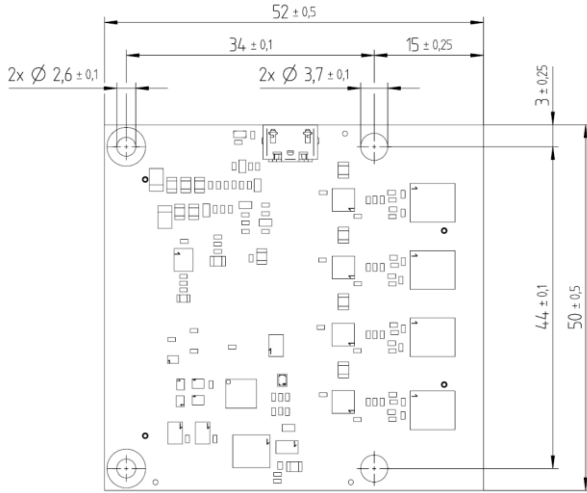


Figure 4: Top view of MC3606 B – in mm

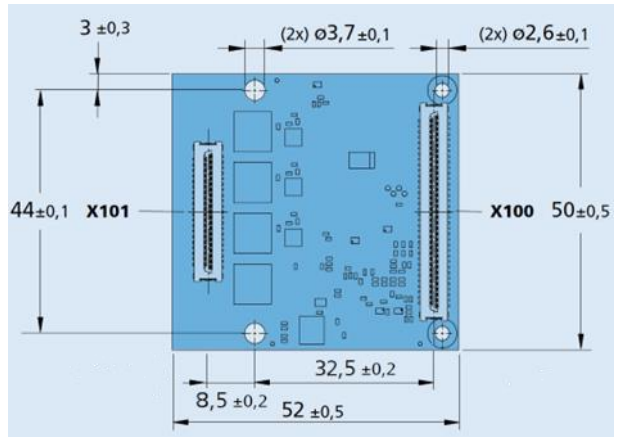


Figure 5: Bottom view of MC3606 B – in mm

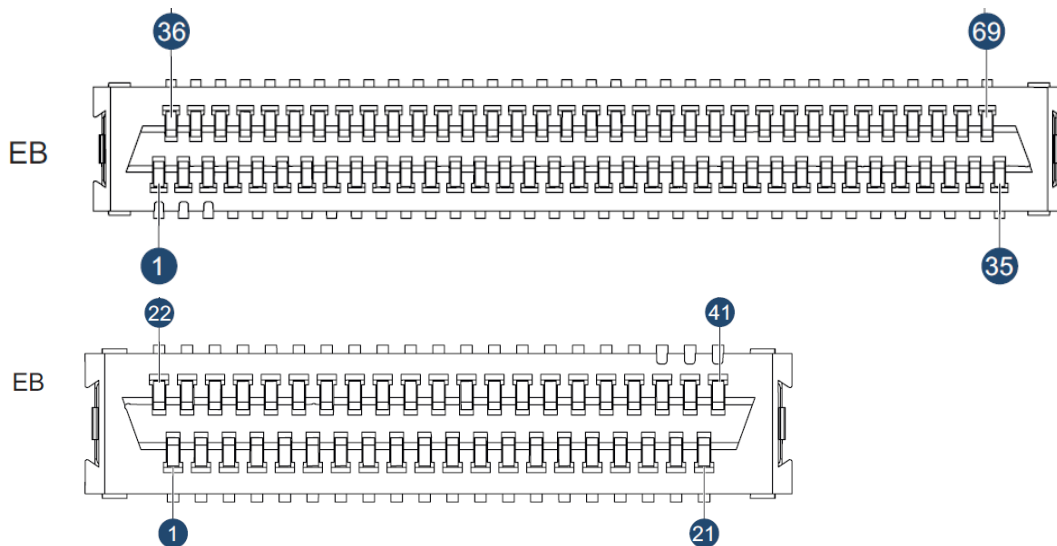


Figure 7: Pin numeration

To place a MC3606 B on a motherboard the following sockets are needed:

Quantity	Type	Manufacturer	Part name
1	69P Conan Lite receptacle	Amphenol	10162581-3134169LF
1	41P Conan Lite receptacle	Amphenol	10162581-3134141LF
2	Steel Spacer M2.5 (4mm board distance)	Würth	9774040151R

## Layer stackup

It is highly recommended to use at least a 4-layer PCB for the motherboard design.

- Reserve one layer for the power supply voltage and one layer for its return path (GND). Use the two middle layers for this purpose.
- The top and the bottom layers are to be used as EGND layers, sharing its layers with motor phases and signal traces.

## Recommended layer stackup

Layer structure	Signals
Top Layer	EGND + motor phases and signal traces
Layer 2	GND (supply return path), only
Layer 3	U <sub>mot</sub> (motor supply) + U <sub>p</sub> (electronics supply), only
Bottom Layer	EGND + signal traces

## EGND and shielding



EGND equals functional earth of the PCB.

A functional earth concept for the complete system combined with shielding of the motor phases is essential for passing EMC conformance tests. Depending on the cable length the encoder and sensor lines have to be shielded as well to achieve signal integrity.

Here are the guidelines to setup a robust system:

- Establish a metal base plate (functional earth).
- Insert PCB mounting holes for the steel spacers in the motherboard design.
- Place gold-plated pads around the mounting holes as shown in figure 9, on the top and the bottom layer.
- Make sure these pads are connected to the EGND layers.
- The EGND signal has to be connected to the supply via at least 2 x Y-Capacitors as shown below.

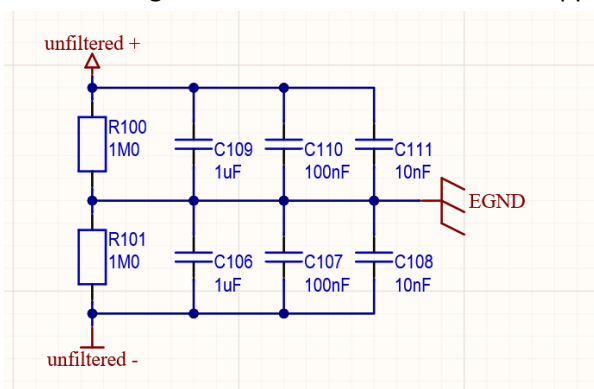


Figure 9: Defining EGND

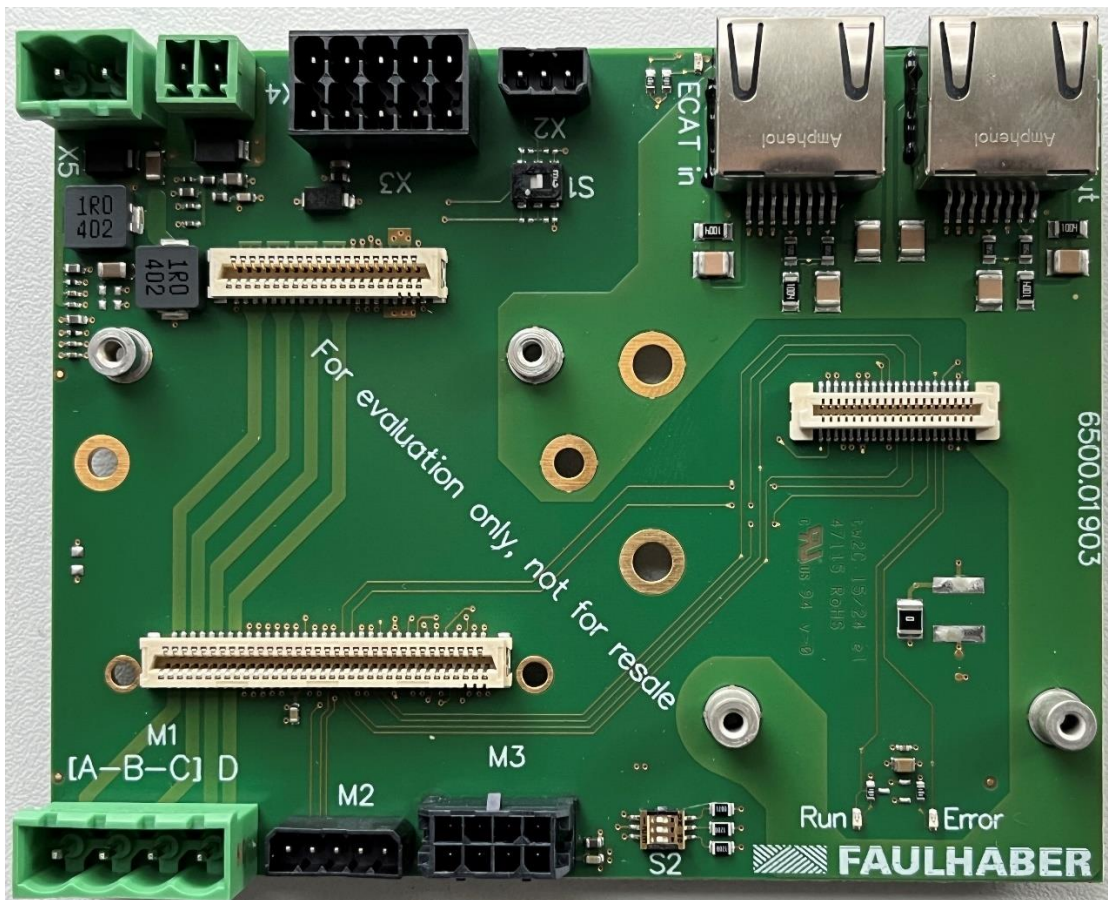


Figure 10: Evalboard 6500.01903 with mounting holes and EGND pads

- Connect EGND of the PCB with the metal base plate using screws, washers and spacers made of metal.
- For shielding ideally place a shield clamp next to the motor connector on the PCB and attach it to an additional gold-plated EGND pad via a screw.

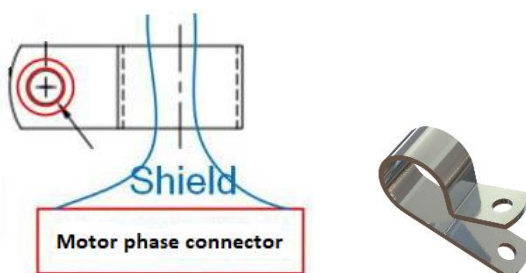


Figure 11: Shielding of motor phases, using a shield clamp connected to the PCB

- Instead of directly connecting the shield clamp to the PCB, it can be placed on the metal base plate next to the motherboard, too.



For the further system setup, please refer to [application note 187](#) for more details on shielding, applicable cable length, and the concept of functional earth. The application note 187 uses examples of larger machinery for demonstration, but all the principles also apply to the smallest embedded devices.

## EMC Filter Design – recommended motor phase filter

The FAULHABER controller MC3602 B and MC3606 B have 4 motor phase filters onboard which significantly reduce radiated EMI, which is essential for passing related EMC conformance tests. In addition, the filters increase robustness of the system, in terms of the signal integrity of the motor feedback sensor.



Under normal circumstances no further motor filters are needed on the motherboard to pass EMC conformance tests. For special requirements please contact our Motion Control Support.

## EMC Filter Design – optional supply filter

The above mentioned motor phase filters are damping radiated EMI. When considering EMC, conducted EMI is a relevant aspect, too. Largely depending on the used power supply an optional additional supply filter might have to be considered to dampen conducted EMI.

When using a low-cost power supply, it is more likely that a supply filter is going to be necessary to pass any related EMC conformance tests. More expensive power supplies on the other hand usually already have filter components included which make additional filtering obsolete.



So, what to look for when selecting a power supply and aiming to avoid the use of an additional supply filter? Usually a good hint is the power supply's datasheet information about passing EMC tests related to conducted emission, without any restrictions.

The following section describes the optional supply filter, the component selection and highlights what to pay attention to when designing the layout.

The supply filter:

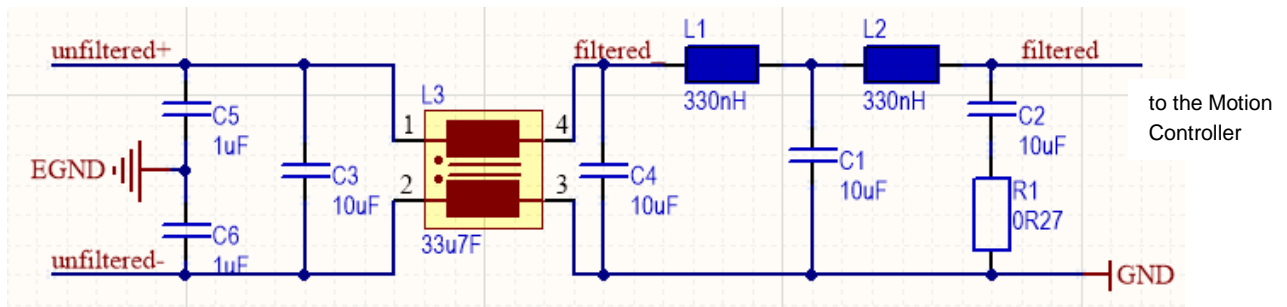


Figure 12 : Common mode filter

Differential mode filter

As shown in figure 15 the supply filter consists of two parts, a common mode filter and a differential mode filter. The input of the common mode part is connected to the DC supply voltage (unfiltered+, unfiltered-). The output of the differential mode filter part supplies the Motion Controller and is connected to the pins Umot + Up (motor and electronics supply) and GND.

The selection of the supply filter components:

Common mode choke	Quantity	Type	Manufacturer	Part name
L3	1	33 uH	TDK	ACM1211-102-2PL-TL01

Inductors	Quantity	Type	Manufacturer	Part name
L1, L2	2	0.33 uH	Sumida	0420CDMCCDS-R33MC
Capacitor	Quantity	Type	Manufacturer	Part name
C1, C2, C3, C4	4	10 uF, 50V, X7R, 1206, multilayer ceramic capacitor	Such as: TAYO YUDEN KEMET TDK	UMK316BBJ106ML-T C1210C106K5RACTU C3216X7R1H106K160AC

Capacitor	Quantity	Type	Manufacturer	Part name
C5, C6	3	1 uF, 50V, X7R, 1206, multilayer ceramic capacitor	Such as: TAYO YUDEN KEMET TDK WE	UMK107AB7105MA-T C1206C105J5REC7800 C3216X7R1H105K160AB 885012208093

Resistor	Quantity	Type	Manufacturer	Part name
R1	1	0.027 Ohm, 0603 or 0805	any	



The layout of the supply filter:

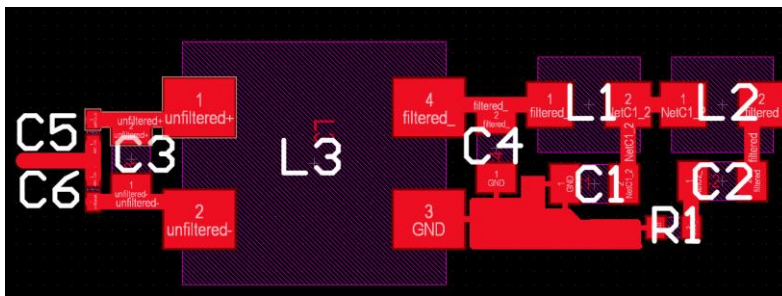
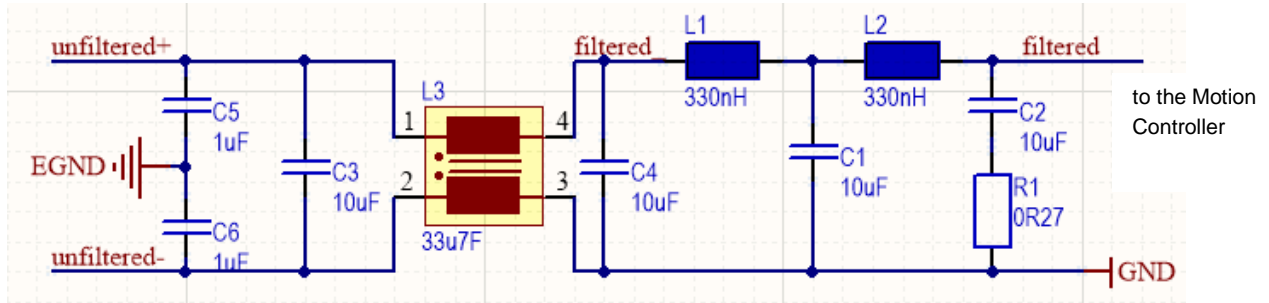


Figure 13: Layout and schematic of the supply filter

Here are the guidelines for the filter design. Please follow them strictly for the filter to be effective.

- Place the filter as close as possible to the Motion Controller.
- Arrange the components in a compact way, to avoid parasitic effects.
- Route tracks on one layer only.
- Make sure to connect the Y-capacitors C5 and C6 to EGND (not GND), which is essential for the effectiveness of the filter.

If size is relevant an even more compact design could look like this:

- Place the common mode choke L3 on the top side of the PCB
- Place the rest of the filter on the bottom side, directly opposite to the choke.

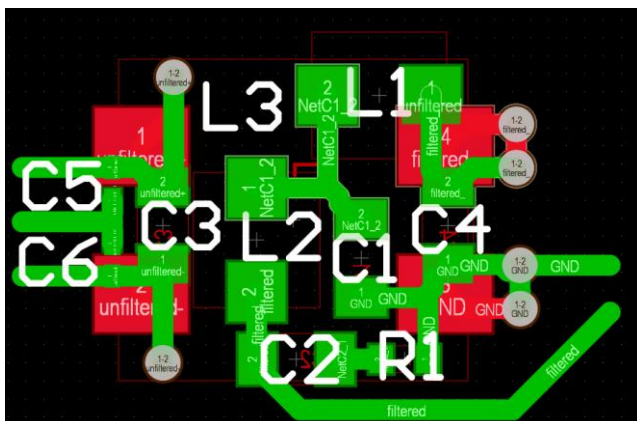


Figure 14: Layout of size-optimized supply filter



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