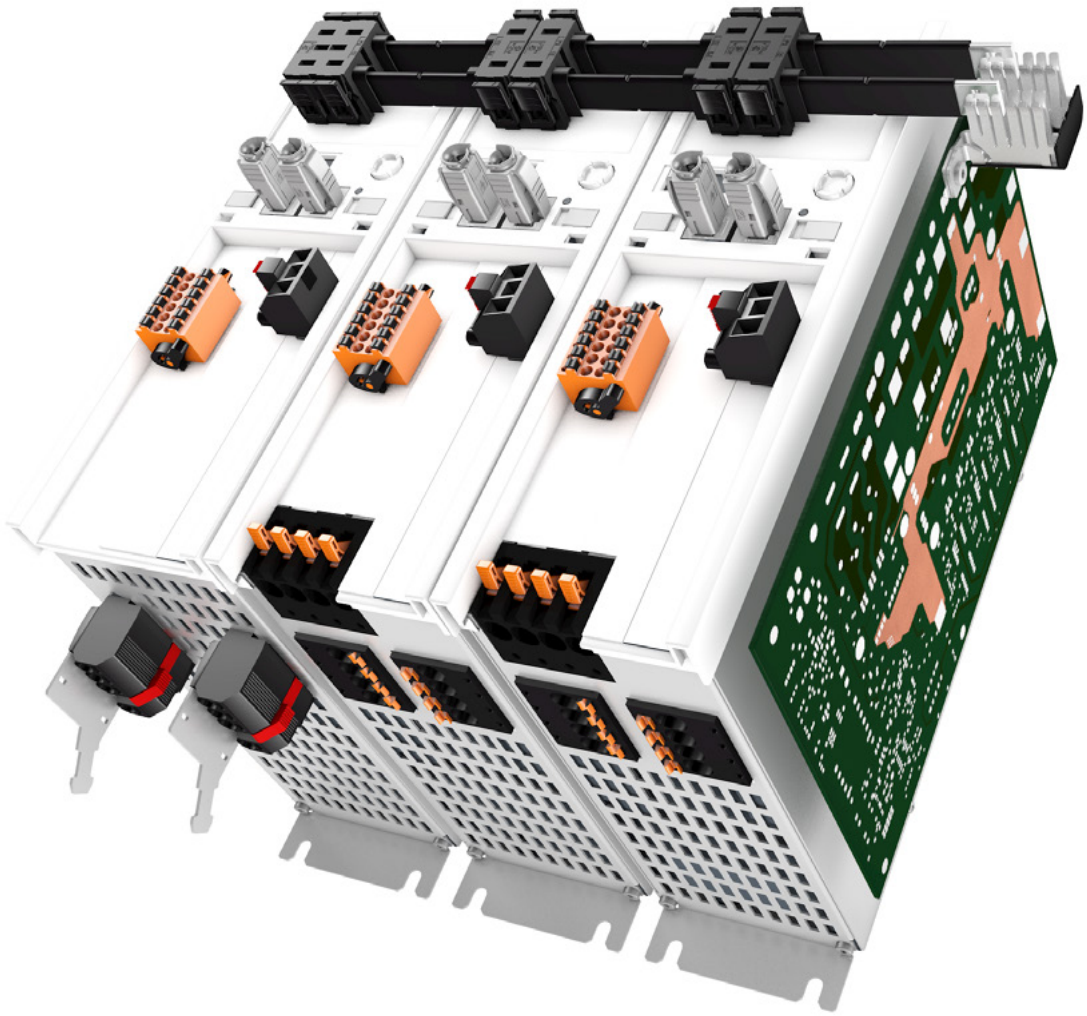
Weidmüller

Simple device integration of DC link power supply and 24 V supply for servo multi-axis amplifiers

Whitepaper



Contents

1. Introduction

Industrial robots, machine tools, printing facilities and many other machines used in the manufacturing industry would be unthinkable without servo drives. When it comes to rotational speed, torque changes, overload and holding torque they are far superior to other types of drive. Servo drives combine position, speed and torque control with the highest demands for dynamics and precision.

The main components of a servo axis are the servo motor and the servo inverter (Figure 1). Depending on the application, the servo motor is equipped with a transmission and brake system together with sensors for angle and speed feedback. The servo inverter (often called servo amplifier, servo controller or servo drive) is positioned between the controller and servo motor. Its function is to convert control commands into a powerful enough signal to drive the motor. The inverter comprises the power and control electronics for control, setpoint generation and monitoring. The power unit is usually designed as a DC voltage link amplifier. The DC link is usually generated directly from the 3-phase mains supply via a diode bridge, i.e. without a transformer (Figure 2).

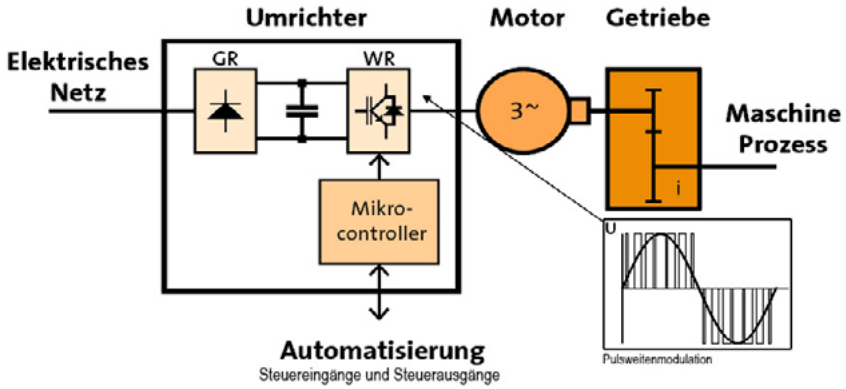


Figure 1: Functional description of the servo drive

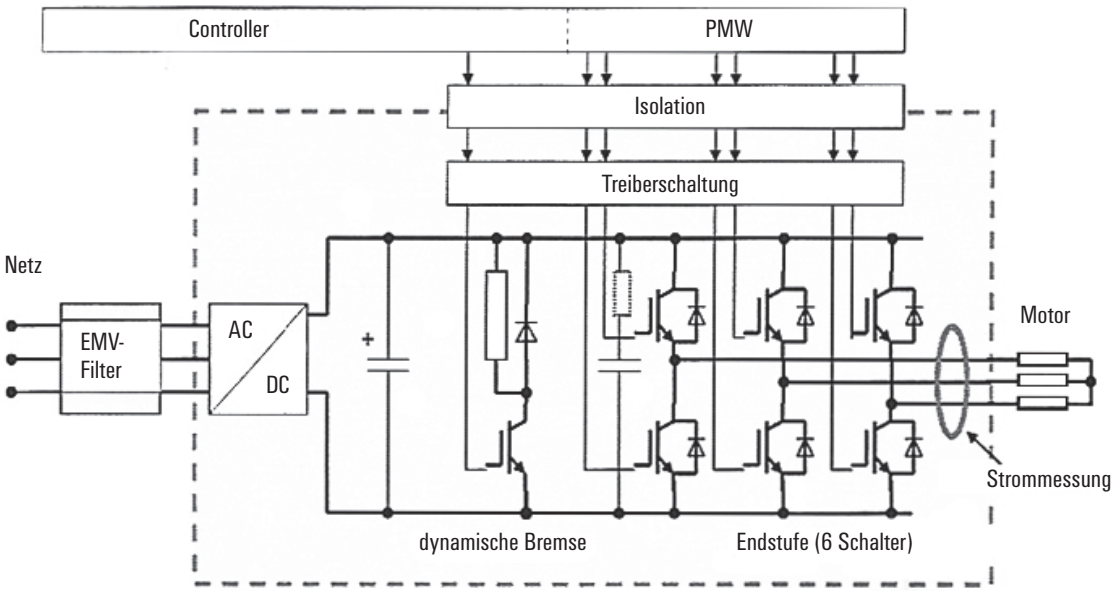


Figure 2: Block diagram of the power electronics of the servo amplifier

High performance in the smallest of spaces: single and multi-axis amplifiers

With motors, space is obviously at a premium. This applies in particular to robot arms, for which size and weight both play a big part, as the drives for grabbers sometimes "run along" the entire structure. However, space for inverters is also becoming increasingly important as the devices are required to take over more and more functions. Whereas the first servo drives were merely auxiliary or actuator drives, the latest models feature complex functions that were previously implemented with mechanical solutions. Examples include angle synchronisation, electronic cams, touch probe processing or torque control Digitalisation and advances in control technology have enabled these types of complex motion sequences to be transferred to the servo drive, so that the dividing line for control functions continues to be pushed back, and in some cases eliminated completely.

Space requirements for so-called multi-axis amplifiers are particularly important in complex machines and systems that use large numbers of drives. An axis system always consists of one power module and several axis modules.

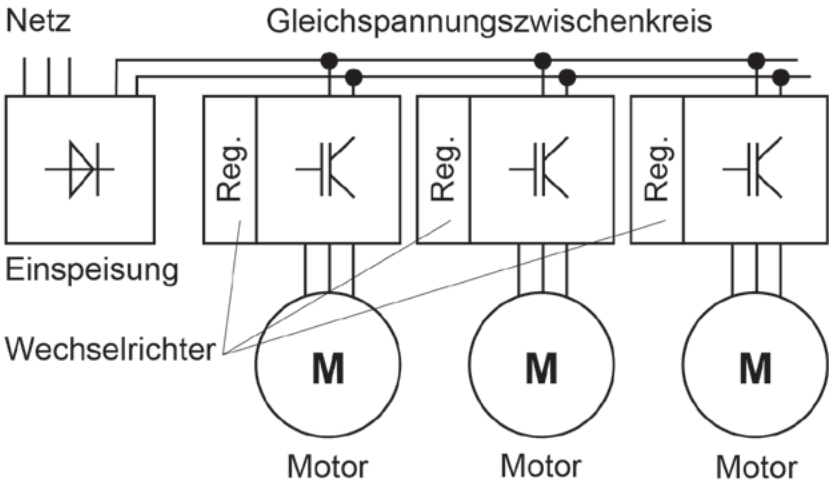


Figure 3: Axis system server controller

The power supply module feeds the DC link and often the 24 V supply of the controller, which is usually electronically isolated. In addition to saving space, the advantage of a multi-axis amplifier is that power can be exchanged between the axes through a shared DC link, a shared DC bus. This allows the braking energy of individual axes to be buffered and re-used for accelerating other axes. This minimises energy dissipation when braking and the associated unnecessary conversion to waste heat; additional cooling measures are also eliminated. If necessary, the excess braking energy can also be feed back to the grid using an energy recovery module.

This is just one of the many benefits of servo multi-axis amplifiers. Nevertheless, the complex energy flows present special challenges for design engineers. The installation and electrical connectivity of the 24 V supply cannot simply be designed "top down". It has to meet all the relevant standards, even in extreme operating conditions. Correctly designed electrical connectivity for an axis system with regard to the DC link and the 24 V supply are critical for market success and customer acceptance of a servo multi-axis amplifier. This white paper is designed to help with this part of the process.

2. Requirements for the DC link in device integration

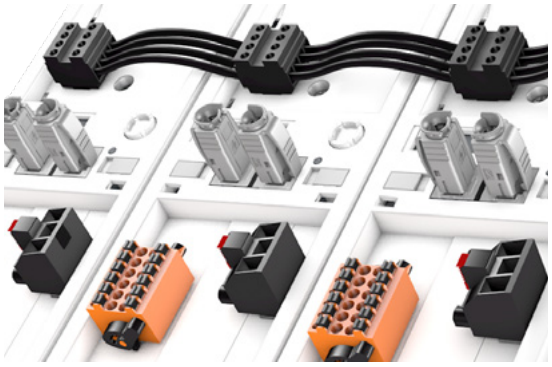
As already stated, the design and development for the installation and connectivity of a DC link is particularly challenging for servo multi-axis amplifiers. With a modular system like this, the design of the power supply (module), for instance, must take into account the number of connected loads (axes with different power requirements). A power feed needs to be selected that will provide sufficient power from the mains supply to the DC link for all operating conditions of the drive system. If the power feed is under-designed, the power in the DC link will cut out under certain loads and the entire drive system will fail.

Electrical connectivity also needs to be designed for correspondingly high total currents in the DC link. This applies in particular to axis systems with many servo axes, as very high currents of typically more than 100 A can quickly be produced in the DC link. Daisy-chain cabling, i.e. connection from device to device, in such an axis system becomes increasingly difficult for wires and cables with large cross-sections. The cables are stiff and create lateral forces on the connectors similar to a spring under tension. Such cables are difficult to use and can sometimes get jammed. Large wire cross-sections also require a correspondingly greater bending radius. If sockets are close together, the cable runs will be unnecessarily long and looped in some way. This takes up both space and material. The installation costs for the DC link of such axis systems are very high if conventional solutions are used. Plug-in connectors are recommended more for individual units that are only combined in small numbers. Applications that only have a few axes can therefore take advantage of a shared DC link, and the servo amplifier can be used as a single unit. As a guide, wiring with connectors or connection terminals has in practice shown to work for combinations of two to four servo amplifiers. Because of the limited number of cables and reduced current carrying capacity the wiring costs continue to be acceptable for the user.

If more than four servo amplifiers are grouped together, it makes more sense to use busbars for the DC link and the 24 V control power supply than classic wiring. The table below compares the advantages and disadvantages of the two systems. Busbar systems are generally able to transfer comparatively high total currents and require little space. However, even this variant requires many specifications to be observed with regard to design and approval.

Comparison: use of a wiring solution with plug-in connectors or a BUS system:

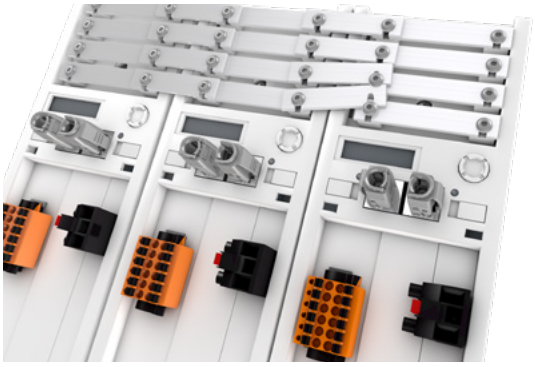
Conventional installations of a DC link using cables and connection terminals or plug-in connectors



Advantages:
- Connection terminals or plug-in connectors from different manufacturers are readily available.
- Standard approvals for IEC and UL available.

Disadvantages:
- Wiring is costly
- Large installation spaces are required due, in particular, to the bending radius of the cables
- Limited selection of cables and therefore limited current carrying capacity (up to 16 mm² still possible)

Manufacturer-specific busbar solutions



Advantages:
- Exact adaptation to the device design
- Compact design is possible
- High current carrying capacity with correctly designed busbars and contacts

Disadvantages:
- Costly development
- High level of investment
- High approval costs
- It is difficult to remove a single module from a row of other modules

Plug-in connectors are recommended more for individual units that are only combined in small numbers. Applications with only a few axes can therefore take advantage of a shared DC link, and a single servo amplifier can also be used as a standalone device. Because of the limited range of wires and the corresponding limited current carrying capacity, and because the wiring costs continue to be acceptable for the user, a combination of two to four servo amplifiers using plug-in connectors or connection terminals has shown to work in practice.

Busbar solutions, on the other hand, have shown to be the optimal solution for the DC link and the 24 V control power supply for axis systems with many servo axes. Due to the high total currents in the BUS connections, an economical and space-saving solution can be implemented using copper busbars. Nevertheless, this solution poses an number of challenges in terms of the design and approval of such busbar systems.

Requirements for a standard-compliant design of busbar solutions for the DC link

All products must be certified in accordance with the local applicable standards for the market in a given country. IEC standards apply in Europe and other areas of the world, UL standards apply in USA and in Canada those of the Canadian Standards Association (CSA). There are a number of differences between the standards, which makes global product approval more difficult. The requirements for UL are generally stricter than those for the IEC..

For servo amplifiers installed in a control cabinet, in addition to the installation standards, IEC 61800 "Adjustable Speed Electrical Power Drive Systems" and in North America UL 61800-5-2 (Standard for Power Conversion Equipment) are particularly relevant.

When designing busbar solutions for the DC link, UL 61800-5-2 imposes particularly high requirements. The UL describes the minimum requirements that need to be met by electrically operated devices and power conversion devices such as frequency converters and servo amplifiers to eliminate the risk of fire from such devices. Devices in accordance with UL 61800-5-2 are, in turn, installed in industrial control cabinets and must comply with UL 61800-5-2 (Industrial Control Equipment) or CSA C22.2 installation standards. Determining the correct clearance and creepage distances and designing for field or factory wiring are some of the main reasons why device manufacturers find it challenging to produce a busbar solution for the DC link.

Because the rules for UL certification are stricter than those for certification based on IEC standards, products should be developed to meet UL standards from the outset. By the same token, products which already have UL registration take priority. Underwriters Laboratories (UL) has a service on their official website (http://ul.com/) where users can find out about the status (listed or unlisted) of a component free of charge. The manufacturer name and certificate number (cURus) are required. At Weidmüller, this information can be found in the online catalogue under "Rated data acc. to UL".

3. Practical example of available and approved busbar solutions for the DC link

With multi-axis amplifiers used for controlling large numbers of drives, the correct solution is to have busbar systems for the DC link and the 24 V control voltage. The lower installation costs for the user and a compact design make more sense both economically and technically than conventional wiring. If the busbar system is properly designed, it provides an ideal combination of easy handling, optimal space utilisation and reliability. This section describes the practical implementation of an approved busbar solution that is available on the market and which device manufacturers can easily integrate in their equipment for multi-axis servo amplifiers. The particular problems described in the previous section can thus be avoided.

The modular busbar solution from Weidmüller is ideal for the DC link and the 24 V control voltage supply from IP20 multi-axis servo amplifiers. The system consists of a connection block (BUS connector - PB Con) with spring contacts for mounting the busbars and a screw connection to the respective PCB of a device in the axis system. The connection block is thus used for both the mechanical and the electrical connection of the busbar. The busbars are available in two versions. To supply power to the axis system the spring contact runs the full length of the connection block. This enables a power supply of up to 160 A to be fed to the busbar system. The drive modules are connected together using busbar connectors in 50 mm, 100 m or modular lengths, depending on the width of the device. Isolation end caps provide touch-safe connections

Another advantage of the system is that it is suitable for both top and front mounting of devices. The spring contact system has tolerance compensation for module offsets of up to +-2 mm, which gives the device designer a degree of freedom to fasten the DC link connections to the front of the panel or from above. This means that the system can be perfectly adapted to the installation conditions of the respective group of devices.

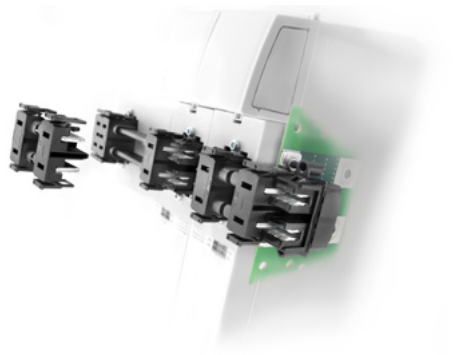


Figure 4: Installation principle for modular busbar solution for axis system

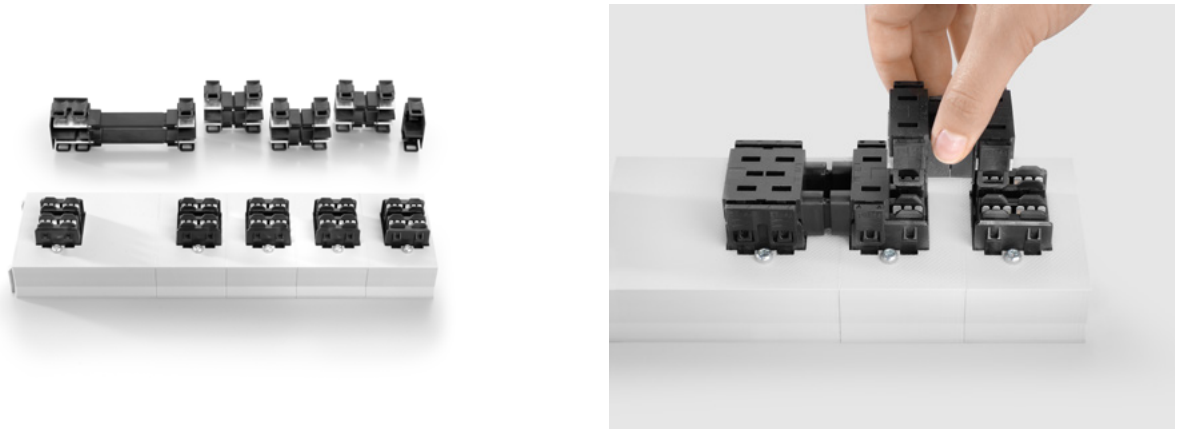


Figure 5: Overview of components in Weidmüller's modular busbar solution

A major advantage of the modular system is that it is suitable for both top and front mounting of devices The spring contact system has tolerance compensation for module offsets of up to +-2 mm, which gives the device designer a degree of freedom to fasten the DC link connections to the front of the panel or from above. This means that the system can be perfectly adapted to the installation conditions of the respective group of devices.

Figure 6: Tolerance compensation is provided by the multi-leg contact spring for device offsetting during installation.

Advantages of the system:

For the user:
- Quick and easy installation of servo multi-axis amplifiers without the need for tools
- Rapid replacement of individual drive modules in an axis system
- Safe latching of the busbar connectors
- Touch-safe design
- The busbar system's tolerance compensation enables the axis group to be easily fastened to the control cabinet mounting plate.

For device developers:
- Simple device integration
- Uncomplicated UL device approval through the use of registered UL components
- Short project lead time, no in-house development costs or own investments
- Ideal dimensioning and technical data for typical servo multi-axis amplifiers
- Different module widths for power supplies and drive modules are possible
- Future-proof design

4. Power bus solutions from Weidmüller

Overview of components:

	Components	Technical Data
	PB-CON 160 S/02/90RFSF AG BK BX 2594720000 Connection block for 2 busbars (e.g. DC+ DC-)	Screw fastening or solder connection to the PCB 2 poles IEC 61984: III/2 1000V – 160A
	PB-FEED 160 50/02RF AG BK BX 2594950000 Busbar connectors for power supply – device module width 50 mm	2 poles IEC 61984: III/2 1000V – 160A UL508: 600V/160A IP 20 when plugged in
	PB-FEED 160 100/02RF AG BK BX 2595180000 Busbar connectors for power supply – device module width 100 mm	2 poles IEC 61984: III/2 1000V – 160A UL508: 600V/160A IP 20 when plugged in
	PB-LINK 160 50/02RF AG BK BX 2595540000 Busbar connector for axis modules - module width 50 mm	2 poles IEC 61984: III/2 1000V – 160A UL508: 600V/160A IP 20 when plugged in
	PB-LINK 160 100/02RF AG BK BX 2594960000 Busbar connector for axis modules - module width 100 mm	2 poles IEC 61984: III/2 1000V – 160A UL508: 600V/160A IP 20 when plugged in
Busbar connector PB-LINK, PB-FED, customised lengths on request		
	PB-ENDCAP 160 02RF BK BX 2594970000 Isolation cap	IP 20 when plugged in

Learn more about our connection solutions for your power electronics devices at:
www.power-electronics-connectors.com

Information and best practices for implementing your projects

As an expert in device connectivity, we are happy to share our expertise. Take a look at our other white papers to find out more about topics such as the following:

PUSH IN wire connection
- Device design according to UL 600
- Connection system and printed circuit board design in motor controls

- Integration of device connectivity into the SMT process

www.weidmueller.com/whitepaper

Further information on the OMNIMATE® product range, the associated design-in services and an application-oriented product-selection tool can all be found at: www.weidmueller.de/OMNIMATE
www.weidmueller.com/omnimate

Rene Arntzen

Author of the whitepaper

After obtaining a degree in Industrial Engineering, René Arntzen (born 1985) began his career as a Product Manager at the Weidmüller Group. Since 2011, he has been responsible for the power connectors product family for device manufacturers. Before studying for his degree, he completed an apprenticeship as an electrical engineer and worked in electrical maintenance during his university studies. During this time, he was able to gain a great deal of practical experience in and expand his knowledge of electrical connectivity.

Contact: PCB.components@weidmueller.com

Weidmüller Interface GmbH & Co. KG
Klingenbergstraße 16
D-32758 Detmold, Germany
T +49 5231 14-0
F +49 5231 14-292083
info@weidmueller.com
www.weidmueller.com

Personal support can
be found on our website:
www.weidmueller.com/contact