Update your PLCs quickly, easily, and without errors

PLC migration: The connection of state-of-the-art PLCs to existing wiring

Whitepaper

Simplification and acceleration of necessary PLC migration processes

Efficient solutions for controller wiring

A large number of programmable logic controllers will soon reach the end of their service life. Many plants must therefore be equipped with a new PLC. However, the rewiring between controllers, sensors, and actuators required in this context can make replacement a lengthy and costly challenge. To save costs and increase plant availability, it makes sense to retain the existing wiring.

Various solutions are available for connecting controllers to an existing wiring system as an alternative to the conventional point-to-point wiring. These solutions enable a much simpler, faster, and faultless replacement. On the following pages, these solutions are presented and described in detail with their advantages and savings potential.

Content

PLC Migration
The most important theses at a glance

Programmable Logic Controllers (PLC) can operate reliably over a very long period of time. For this reason, control systems in industrial applications are usually not replaced. In some cases, however, a migration from „old“ to „new“ is sensible and necessary. If, for example, a plant is extended by new plant components or machines, this often requires a change to a state-of-the-art control system. This migration from an existing to a new PLC is usually extremely complex.

The distinction between „migration“ and „retrofit“

The terms migration and retrofit are often used synonymously. However, this is not correct, since they are two clearly distinguishable processes.

- Retrofit means the technical upgrade of an outdated PLC. This can be done in various ways. For example, an outdated power supply unit can be replaced by a new one in order to increase the efficiency. It is also possible in this context to install shielded cables or a more powerful CPU (Elaborate, no reference to what CPU is, like PLC in above paragraph) unit with a higher clock frequency.
- Migration means the complete replacement of a PLC with a new control system. For cost and time reasons, the aim is to keep the existing sensor/actuator wiring unchanged.

How to simplify the PLC migration?

Three theses with possible solutions

Thesis 1: Migration solutions simplify PLC exchange

Well thought-out migration solutions save time and reduce the workload considerably. A distinction is made between bridge and card solutions. If pre-assembled cables are also used, the migration can be carried out even more efficiently.

Thesis 2: PLC transfer elements and pre-assembled cables save time

PLC transfer elements increase the flexibility of the system, are versatile, and facilitate any further PLC migration. Pre-assembled cables save time during installation and troubleshooting, which increases system availability. With these measures in PLC migration, 95 % of the changeover time can be saved even in small systems.

Thesis 3: Plant control systems become more flexible with PLC transfer elements

The high flexibility of PLC transfer elements enables them to be used worldwide in machine and plant control systems for a wide range of applications. International companies are thus able to design systems which are hardware independent of the respective controller. Within a short time, the sensor/actuator level can be connected to I/O modules of PLC systems from different manufacturers via suitable pre-assembled cables.

On the following pages we will pursue the question of whether and to what extent these theses can be proven.

Note: This white paper only covers hardware migration. The migration of the software will not be discussed here, as it is the responsibility of the system integrators.

Challenges

Reasons for the necessity of a PLC migration

The decision to replace a control system is usually not taken lightly, as it involves high costs. For the following reasons, however, it makes sense to plan and carry out PLC migration processes.

1. End of life

Electronic components usually have a limited life span. Reasons for this are ageing hardware, changed standards, or product innovations. For two frequently used control systems, migration is becoming gradually unavoidable:

- SIMATIC S5 (Siemens; market launch 1979)
- PLC-5 (Allen Bradley; market launch 1980)

Both systems have been used for over 35 years. Although they still perform their work reliably in many places, their probability of failure increases with age. Expensive repair and replacement measures become unavoidable. Technical support by the manufacturers has usually already been discontinued. This makes it more difficult to obtain spare parts in case of repairs. Many plant operators are therefore forced to consider PLC migration.

2. Inadequate hardware

Many plants have to be expanded during their operating period. This often pushes the hardware of the PLC used to its limits. For example, modern communication interfaces are missing, the process cycle is too long, or the CPU does not support the additionally required I/O modules. Even in such cases, replacing the PLC cannot be avoided.

3. Insufficient flexibility

Machines and plants are exported all over the world today. For this purpose, they often must be adapted to different regional requirements and regulations. For example, a company producing in Europe may have to plan and equip its plants with control systems from different manufacturers in order to serve the international markets. It is of course advantageous if only the PLC has to be replaced.

Calculation example 1:

Effort and costs of a PLC migration with classic single wiring

In general, short downtimes and maximum system availability must be guaranteed when replacing the PLC. However, the duration of a complete PLC exchange is immensely high with conventional individual wiring, which leads to long downtimes and causes the total costs to rise exponentially. The following example shows how much time is normally required for a complete PLC replacement.

The aim is to migrate an AB PLC-5 to a newer generation PLC. The PLC-5 is equipped with six digital I/O modules. Each module has 32 connection points for the signals. That means: a total of 192 lines have to be connected. During the migration, each line must be individually released from the terminal point, adjusted in length, stripped, crimped with ferrule, and connected to the new I/O modules. An experienced specialist needs about 2 minutes per line for these steps. This results in a total assembly time of approx. 6.5 hours. Additional time must be planned for error analysis and the function check.

For larger systems, a loss of production of several days must be expected in the course of the conversion. Considering the financial aspect, a skilled worker costs an average of 50.00 € per hour. This means that for this small plant, 320.00 € of pure personnel costs are already incurred. Further costs for the acquisition of new hardware, the breakdown of the plant, or the time for troubleshooting are added. In this way, the total costs of a replacement may increase quickly.

Solution approaches

Possibilities for an efficient PLC migration

In order to minimise the high expenditure of time and money for a PLC replacement, possibilities should be found to use the existing sensor/actuator wiring of a plant. In this way, installation and testing times can be saved and plant availability increased. Various solutions can be used for this purpose, which are described below. Please note that the migration issue is handled differently on the European and North American markets.

1. Bridge Solution – Using a new mounting rack

Fig. 4.1: Migration rack for a bridge solution (example)

The use of mounting racks for PLC migration is widespread in Europe. They require no additional space in the control cabinet and are therefore very efficient. Before installing a mounting rack, the existing PLC must be completely disassembled. Only the front connectors of the input and output modules are removed, the wiring remains unchanged. In the next step a suitable mounting rack is placed in place of the PLC*.

After this is done, the front adapters (FADs) are mounted to the migration rack. Depending on the type of the I/O card, suitable FADs must be used. The front connector of the I/O card to be migrated can be adapted directly. The signals are routed via the printed circuit board to industrial standard connectors. The FAD can be mounted on a mounting rail in the control cabinet or in a rack.

In the next step, the mounting rack is extended by a TS35 standard mounting rail or a manufacturer-specific mounting rail. Finally, the front adapters are connected to the new I/O cards of the PLC. Pre-assembled cables are used for this. They are equipped with the manufacturer-specific connector of the PLC as well as with a universal connector for contacting the front adapters. Pre-assembled cables are tested and available in different lengths.

Fig. 4.2: Front adapter/FAD (example)

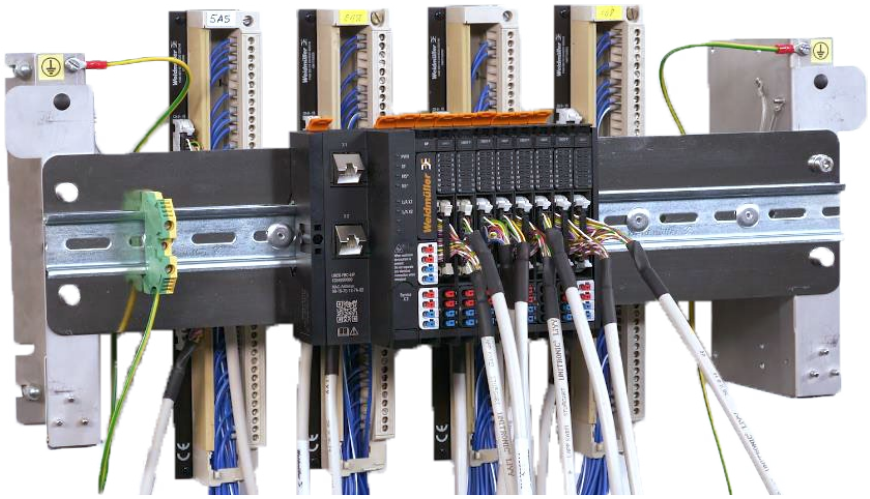


Fig. 4.3: Bridge solution Siemens S5-115 to Weidmüller u-remote. The value „plant availability" considers the downtimes of a plant. Production time and downtime are put into relation. This is described in formula 4.1. For economic reasons, maximum plant availability is aimed for. During migration or replacement, however, a plant failure is to be expected, which reduces plant availability.

$$\textit{Plant availability} = \frac{\textit{Total time - Downtime}}{\textit{Total time}} \times 100\ \% \qquad (4.1)$$

** All components of the migration rack must be connected to the protective equipotential bonding according to the currently valid regulations!*

2. Card Solution - use of the existing mounting rack

An alternative to the bridge solution, in which the entire PLC is replaced, is the so-called card solution. Here the chassis of the PLC to be migrated is retained. The Card-Solution also puts the availability of the system in the foreground. This method is very common in North America.

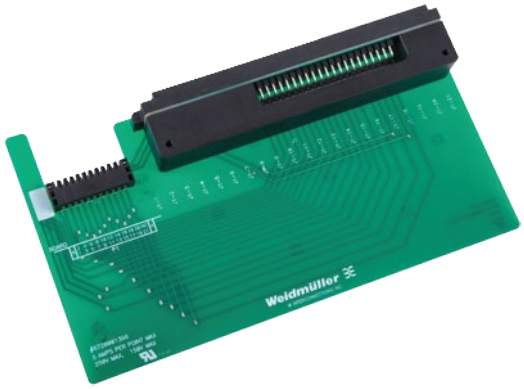


Fig. 4.4.: Example adapter card

When rebuilding, the front connectors of the I/O cards are removed first. The wiring of the front connectors remains unchanged. In the next step, the I/O cards of the PLC are removed from the chassis and replaced by suitable card adaptors. The adapter cards have a connector for the I/O cards to be migrated, which is provided as a universal contact option. After the adapter cards have been mounted in the chassis, the previously dismounted front connectors including the sensor-actuator wiring are plugged in. The PLC to be migrated to is mounted in the control cabinet in close proximity. Finally, the adapter cards are connected to the PLC using pre-assembled cables (see above).

$$\textit{Plant availability} = \frac{\textit{Total time - Downtime}}{\textit{Total time}} \times 100\ \% \qquad (4.2)$$

3. Weidmüller system cabling solutions with PLC transfer elements

To simplify any future migration process, PLC transfer elements are the right choice. They serve as the interface between the control-side system line and the field-side connections of the sensor-actuator level. On PLC transfer elements, all electrical connections are routed via a single printed circuit board. This is equipped with a standard industrial connector, which bundles a direct connection of all pre-assembled cables and PCB terminals for the connection of the field components. This means that PLC migration can be carried out within a few minutes by simply plugging in a new connector.

Wire to Wire

- I/O connected wire by wire to PLC

System Wiring

- I/O connected to an interface
- Interface connected by one or two Pre-assembled cable (PAC) to PLC

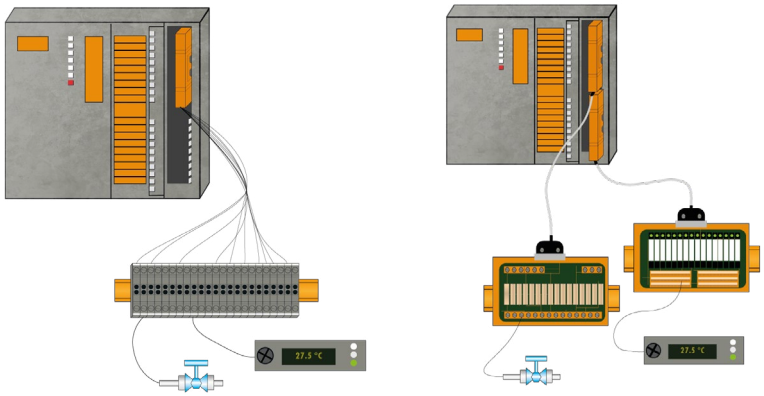


Fig. 4.5.: System wiring based on PLC transfer elements and pre-assembled cables ensures a considerable acceleration of the migration process. This is particularly evident when compared to conventional point-to-point wiring.

PLC transfer elements can be used universally and independently of the respective control system. On the control side, the modules are equipped with the following standard connectors:

- IDC (IEC60603-13) DIN41651 male connector, 20-pin, for digital signals up to 60 V DC or 75 V AC@1 A
- RSV plug connector 24/36-pole for digital signals > 60 V DC / 75 V AC)
- D-Sub IEC 807-2/DIN 41652 / 15- or 25-pole male connector for analogue signals/shielded cable

Using pre-assembled cables, the digital and analogue I/O modules of the respective PLC can be easily and quickly adapted to the PLC transfer elements.

The field-side connection of sensors and actuators is ensured on the interface modules via PCB terminals with screw connection, tension spring or PUSH IN connection. Common plus or minus potentials can be optionally bridged via the printed circuit board for all input and output terminals. In addition, an external supply voltage can be fed in via separate connections. In the control cabinet, PLC transfer elements are usually mounted on standard mounting rails.

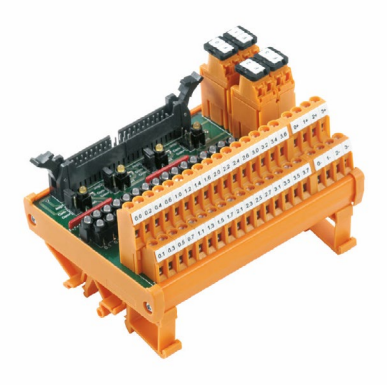


Fig. 4.6.: Example of a PLC transfer element

PLC transfer elements are used as connection interface for input and output signals of the PLC. They offer the possibility of directly connecting sensors or actuators in single-, two- or three-wire technology. In addition, active multi-relay couplers for electrical isolation, power amplification, or voltage level adjustment of I/O signals are available in different versions. The optional equipment of the PLC transfer elements with components such as LED displays, diodes, fuses, isolating switches, and test sockets increase the functional range in the respective applications.

Calculation example 2:

Effort of a PLC migration using migration solutions

This example refers to the complete replacement of a PLC, as already described for calculation example 1 (p. 7). For better comparability, we will use the same initial condition here. This means: A PLC-5 with six digital I/O modules is to be replaced by a current PLC. The same modules with 32 signal connections each are available. The following table compares the possible methods and work steps with the times for the respective execution.

Work steps	Single wiring	Bridge-Solution	Migration Card Solution
Cutting the cables to length	35 min	not applicable	not applicable
Stripping and crimping	28 min	not applicable	not applicable
Removing the previous front connectors	not applicable	40 s	40 s
Connection to the new PLC	20 min	30 s	30 s
Snap on the front adapters, mount the existing front connectors	not applicable	20 s	not applicable
Replacing the previous I/O modules with adapter cards	not applicable	not applicable	30 s
Attaching the pre-assembled cables	not applicable	30 s	30 s
Time without one-off work	1h 23 min	2 m	2 m 10 s
Mounting the new PLC	15 min	4 min	15 min
Construction of the migration rack and assembly	not applicable	10 min	not applicable
Total	1 h 38 min	16 min	17 min 10 s
Troubleshooting	up to several hours	not applicable	not applicable

Tab. 4.1.: Summary of the different possibilities for a migration per module (32 bit)

The example shows: Compared to conventional point-to-point wiring, bridge and migration card solutions are considerably more economical. For example, a specialist needs only 20 minutes to perform a complete PLC migration. With an average hourly wage of 50 €, the personnel costs are only 16.65 €. If pre-assembled cables are used, which are tested for insulation and continuity, time-consuming troubleshooting can also be dispensed with. Although the material costs are somewhat higher than for point-to-point wiring, because the migration accessories must be purchased in addition to a new PLC. However, these additional costs are negligible in view of the high savings achieved through short downtimes and increased system availability.

Highest efficiency from a single source

Complete migration solutions from Weidmüller

Weidmüller supplies all components required for a successful PLC migration. These include mounting racks, front adapters, pre-assembled cables and PLC modules. These are described in detail on the following pages:

1. Mounting racks

We offer you tested and easy to install racks for older control systems of the following manufacturers:

- Siemens S5 115 H, S5 135 H
- Schneider Electric TSX 7 H
- Allen Bradley PLC-5

Mounting racks from Weidmüller offer a number of advantages that significantly accelerate the migration process and therefore increase system availability. Each rack is designed according to defined requirements. A key feature is to place the racks exactly at the position of the previous control unit in order to use the existing drill holes.

Fig. 5.1: Mounting rack PLC-5

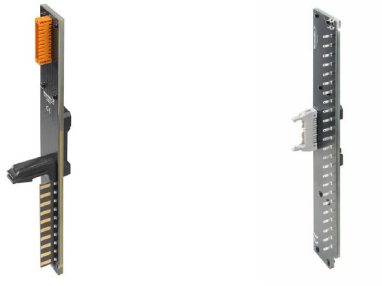
Appropriate screw terminals are provided and marked for earthing the metallic components. Only the wiring must be done individually. The mounting rail is fixed to the top of the racks by means of suitable threaded holes. It must be individually adapted to the new control system. All racks can be opened by means of an integrated hinge, which allows direct access to the front connectors of the previous PLC.

2. Front adapters (FAD)

The number of manufacturer-specific I/O modules of a PLC is reflected in the assignment of suitable front adapters. The following table shows an example of the possibilities.

Tab. 5.1.: Comparison of the front adapters

	S5-115	S5-135	TSX-47	PLC-5
Number of modules	3	3	5	5
Contacts	16-32	16-32	16-24	10-10
Connectors	Post connector IEC60603-13/DIN41651 Pin header 5,08mm			Pin header 5,08mm
Supply voltage	Post connector 30V AC/60V DC Pin header 5,08mm			250V AC
Maximum current	Post connector 1A Pin header 6A			2A
Approval	CE	CE	CE	CE



(a) FAD for PLC-5 (b) FAD for S5

Abb. 5.2.: Front adapters (examples)

3. Pre-assembled cables

Pre-assembled cables are an essential component of any migration solution which can be implemented quickly, easily, and without errors. Our pre-assembled cables are available in variable lengths and in both standard (LIYY) and shielded (LIYCY) versions. They are equipped with a manufacturer-specific PLC adapter on one side and an IDC (IEC 60603-13), RSV or Sub-D connector on the other. The following manufacturers and control systems are supported:

Siemens:	S7 300, S7 400, S7 1200, S7 1500
Schneider Electric:	Micro Premium, Twido, Quantum 340
Rockwell Automation:	SLC500, CompactLogix, ControlLogix
GEFANUC:	90-30, RX3I
Alstom:	C80-35
Omron:	CQM1, CJ1W
Moeller:	XIOC
ABB:	S800
Emerson:	Delta-V
Mitsubishi:	MELSEC Q

(a) Pre-assembled cables for Siemens S7-1500

(b) Pre-assembled cables for Schneider Premium

Fig. 5.3: Examples of pre-assembled cables

To ensure one hundred percent quality, all cables are automatically subjected to a continuity and insulation test.

4. Programmable logic controllers (PLC)

In order to carry out the migration completely, a new PLC is required which completely takes over the tasks of the previous controller. Weidmüller also offers suitable products for this purpose. The u-control series controllers can be universally combined with the u-remote IP20/IP67 I/O fieldbus components. The advantages of the system:

- Compact design
- High flexibility
- User-friendly programming
- Innovative connection technology
- Digital I/O components for direct PLC transfer element connection
- Extensive marking possibilities

Another possibility is to operate the u-remote fieldbus system in combination with control systems from different manufacturers. For this purpose, we offer fieldbus couplers for all common bus protocols.

Fig. 5.4.: u-control

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Kevin Schäfer, B.Sc. (born in 1995) began working with PLC migration and PLC interface units while studying mechatronics. In the international training center, power management and electromagnetic compatibility (EMC) are also among his main topics. Prior to his studies he completed a vocational training as a mechatronics engineer at Weidmüller. Thereby he gained practical experience in an industrial environment.

Rosa Alsina, electronic engineer (born 1972). She began her career at Weidmüller Spain in 1995 as an electronic developer for PLC interfaces and pre-assembled cables. After some time as a local portfolio manager, she took over the role as the global product manager for PLC interfaces and migration solutions in 2018. Her team is focused on providing migration solutions with the target to reduce downtime of customer installations when updating their PLC systems.

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