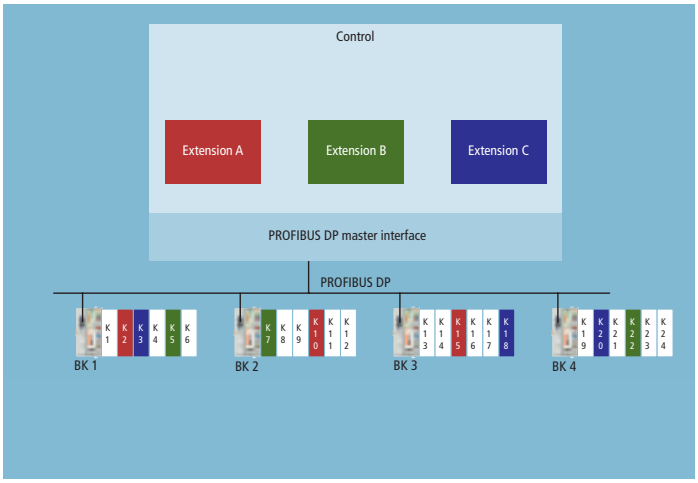
Programming tips for configuring a production machine

Multi-configuration mode for Profibus DP Bus Coupler

Production machines usually consist of a standard machine part and optional expansions. This applies to both software and hardware. Particularly for these applications, the modular automation kit from Beckhoff offers significant advantages.

Users are already familiar with the option to reuse software modules and the flexible exchange of the fieldbus system through a simple Bus Coupler exchange without changes in Bus Terminals configurations. The multi-configuration mode for the Profibus DP Bus Coupler offers further optimization options, as shown in the following example. A machine with the machine extensions A, B and C, whose process signals communicate with the Beckhoff Bus Couplers BK3110, BK3120 or BK3520 via Profibus DP, could be structured as follows:



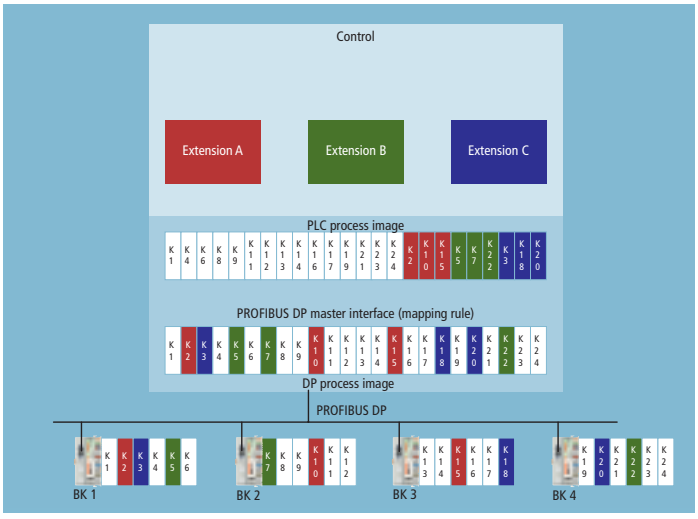
Controller (e.g. TwinCAT, S7-400, etc.), Profibus DP master interface (e. g. FC3101, CX1500-M310, etc.) for sending or receiving the process signals via the Profibus DP and Beckhoff Bus Coupler with Bus Terminals as interface to the machine process. The areas shown in white relate to machine parts that are available as standard. The machine extensions A, B and C are shown in red, green and blue. It can be seen that each extension is associated both with software modules within the control program and process signals that are connected to the controller via Bus Terminals.

It makes sense to design the control programs such that all options are included but only the required software modules are activated. Then the machine manufacturer does not have to maintain eight different control programs for all possible machine options. Writing a control program for all machine configurations requires the same I/O always appear at the same addresses in the control process image. This means that I/O can be added or taken from the machine without changing the control process image. It takes a good understanding of the various process images in a control system to really understand how adding and changing process signals affect the control process image. This is explained in further detail in the following paragraphs. In the case of Profibus, the programs control process image is linked to the Profibus DP master interface process image which is linked to the Profibus DP slave process image. A Profibus DP master interface must be reconfigured when I/O is added or removed from a DP slave. This ensures the master interface process image matches what is actually connected. With the Beckhoff Bus Couplers, reconfiguration is not necessary when additional I/O is added.

The advantage of this solution is that two machine configurations only differ in terms of the hardware used (machine components and Bus Terminals), but not in terms of the software. A machine extension only requires the additional Bus Terminals to be plugged in and wired and the associated extension to be activated (e. g. via the MMI interface of the machine); no software changes are required.

Process image interfaces

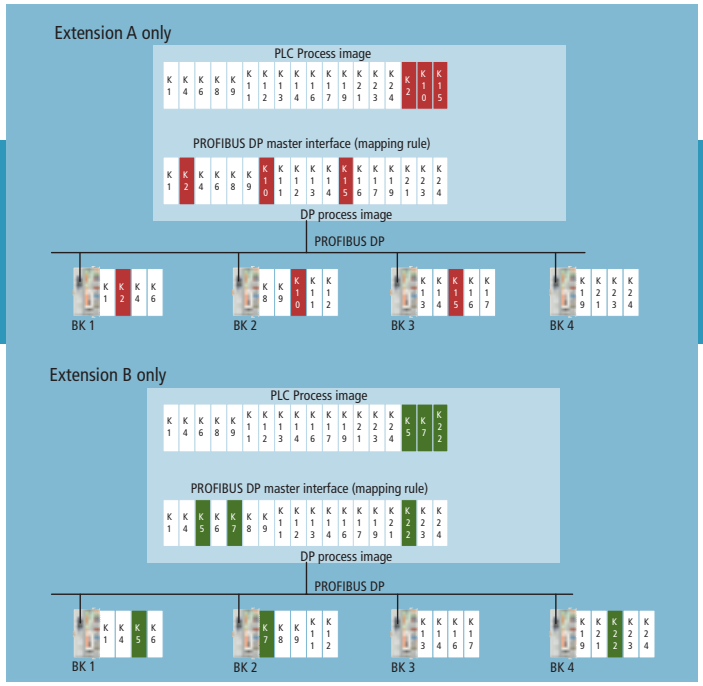
The interfaces between controller, Profibus DP master interface, Bus Coupler and Bus Terminals form process images, in which the process signals are stored according to certain algorithms:

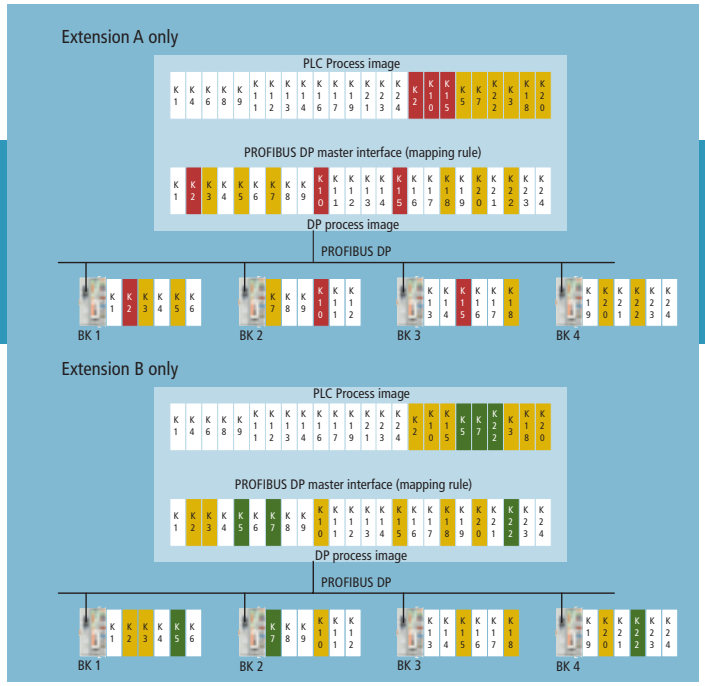


The process signals of a DP slave (Bus Coupler BK3110, BK3120 or BK3520) are always transferred in a data exchange telegram, in which the outputs are sent by the DP master and the inputs are received in the associated telegram response. In the Profibus DP master interface, the process images exchanged with the Bus Couplers are mapped to the process images of the control according to a mapping rule.

Process images of the machine configurations

As shown in the two examples in the figure below, the mapping rule in the Profibus DP master interface changes, depending on which machine extensions are used:



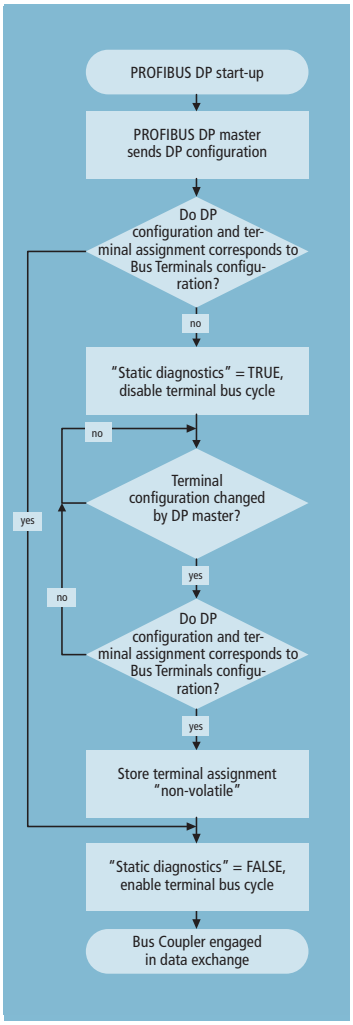


In order to solve the problem of the modified mapping rule, with the Bus Couplers BK3110, BK3120 and BK3520 the mapping can already be carried out in the Bus Coupler (multi-configuration mode).

Setting the Bus Terminal extension in the Bus Coupler

In multi-configuration mode, the Bus Coupler should be configured for the maximum number of Bus Terminals possible. This max Profibus DP setting ensures that the same process image is transferred between the Profibus DP master and the Bus Coupler at all times, irrespective of the machine or I/O configuration. The max Profibus DP configuration is sent by the Profibus DP master to the Bus Coupler during start-up of the Profibus DP bus. The Bus Coupler compares the max configuration received with its own Bus Terminal configuration which may not match because the Bus Coupler does not have the maximum number of I/O signals connected. Recall that the Bus coupler was configured for maximum number of I/O, this means that in the standard configuration mode the Bus Coupler configuration will represent the true number of connected I/O only if the coupler has a full rack of I/O connected. In all other cases the Bus Coupler configuration will think it has a full rack of I/O when there is really less I/O connected unless the Bus Coupler is operated in multi-configuration mode.

The mapping rule ensures that all I/O signals are mapped from the Bus Coupler DP slave to the Master interface even if the Bus Coupler is setup for maximum I/O but in reality there are less I/O connected. The process signals of the Bus Terminals are mapped to the DP process image according to a fixed algorithm (first complex, then digital terminals, in the respective plugged order). The information actually available in the Bus Terminal designed via Profibus DP configuration is transferred via the acyclic DP-V1 Write or, for Profibus DP master interfaces that do not support Profibus DP-V1, via the 2-byte PLC interface. The acyclic DP-V1 Write is usually available via function blocks (TwinCAT: ADS Write) from the control program; the 2-byte PLC interface of the Bus Coupler is mapped directly into the process image of the controller. If a machine is extended, the control program can activate or deactivate the associated Bus Terminals (see examples above, inactive terminals are shown in yellow). Alternatively, the Bus Terminals can be set via the UserPrmData during DP start-up, but this usually requires the DP configuration in the master to be adapted.



State transitions in the Bus Coupler

If the Profibus DP configuration received does match the Bus Terminal configuration in multi-configuration mode, the Bus Coupler sets the "static diagnostics" bit in the Profibus DP diagnostic data and delays the execution of a terminal bus cycle (I/O RUN LED remains off). As soon as the terminal assignment (activated/not activated) has been described by the Profibus DP master, the Bus Coupler carries out another check of the Profibus DP configuration and automatically enters cyclic data exchange: the "static diagnostics" bit in the Profibus DP diagnostic data is deleted, and the terminal bus cycle is carried out cyclically (I/O RUN LED comes on). Furthermore, the terminal assignment is stored in the non-volatile memory of the Bus Coupler, so that during a restart of the Profibus DP, the Profibus DP master does not have to write the terminal configuration again.