CIP SAFETY ON SERCOS

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Abstract

CIP Safety is currently running on DeviceNet and EtherNet/IP networks, but is soon to be added to SERCOS. This paper describes the anticipated release of the specifications for CIP Safety on SERCOS and outlines how CIP Safety will be used to create safety connections on SERCOS as well as how CIP Safety can be used to create safety connections from DeviceNet or EtherNet/IP to SERCOS.

Keywords

"CIP Safety" SERCOS

Preamble

In November 2006, SERCOS International (SI) and ODVA announced that SI will adopt CIP Safety™ as its functional safety protocol for SERCOS. ODVA has begun work to extend *The CIP Safety Specification* to include safety profiles for SERCOS devices, and SI has started to develop the SERCOS III network adaptation to utilize CIP Safety. This setip is consistent with the desires of industry to have a single, worldwide network protocol for safety applications, and the joint support of CIP Safety by ODVA and SI will facilitate technical and market synergies for users and vendors of functional safety networks.

SERCOS interface is one of the world-leading digital drive interfaces with a history of more than 20 years and worldwide acceptance in all servo-driven motion applications. SERCOS III is based on the established real time mechanisms of the original SERCOS interface, still using the principle of cyclic data transfer with deterministic timing. However, SERCOS III enables the jump to an overall automation field bus not only for motion but also for I/O and safety data. SERCOS III has been defined so that any standard Ethernet frame (e.g., TCP/IP) can be transmitted in a non-real time slot, in parallel to the real time processing.

CIP Safety is a network protocol for functional safety. It has been certified by TÜV Rheinland for use in applications up to Safety Integrity Level 3 (SIL3) in accordance with IEC 61508. The CIP Safety protocol is media independent and its functionality resides in the end nodes, allowing both standard and safety devices to operate on the same network. It provides the user with flexibility in design of safety network architecture to utilize safety programmable controllers or peer to peer communication between sensors and actuators.

CIP Safety on SERCOS means utilizing the CIP Safety protocol to ensure the safety integrity of the transmitted data, the adaptation of the CIP Safety protocol on the SERCOS transport channel and the definition of SERCOS specific safety profiles mapping the SERCOS Parameter structures .

Using CIP Safety as the functional safety protocol on SERCOS III, SI's new generation industrial Ethernet, opens up completely new possibilities and leads to a greater versatility for applications with safety requirements. This provides significant benefits not only to the SERCOS users and vendors but for the worldwide safety community, especially with the direct Slave to Slave communication feature of SERCOS III, safety messages can be exchanged directly between the safety devices even without any safety PLC resulting in fast reaction times. CIP Safety gives the user the requested flexibility regarding automation topologies and the interoperability between different networks. It allows for the exchange of safety protocols between different networks without the requirement for a safe gateway, e.g. from an EtherNet/IP network to SERCOS III and vice versa.

What is CIP Safety on SERCOS?

In order to be able to use the communication systems for functional safety, errors like repeat, loss, insertion, wrong order, corruption, delay, coupling safety data with safety or standard data and time delay in IT structures must be reliably detected. Aiming at the support of CIP Safety as standard for the safety-relevant communication, the network organisations SERCOS International (SI) decided to adopt CIP Safety as the functional safety protocol for SERCOS. This plays to the wish of users and manufacturers not to be obliged to support different safety protocols but to be able to concentrate on one global standard instead. The joint activities are, however, limited to the advancement of the CIP Safety protocol. Both user organisations continue to independently advance their Ethernet based communication solutions.

Subsequently, it is described what the use of CIP Safety with SERCOS (i.e., CIP Safety on SERCOS) means, particularly which adaptations are necessary for this purpose in SERCOS. For the explanation of the actual CIP Safety protocol security mechanisms, it is here referred to the CIP Safety specification – CIP Networks Library, Volume 5, CIP Safety.

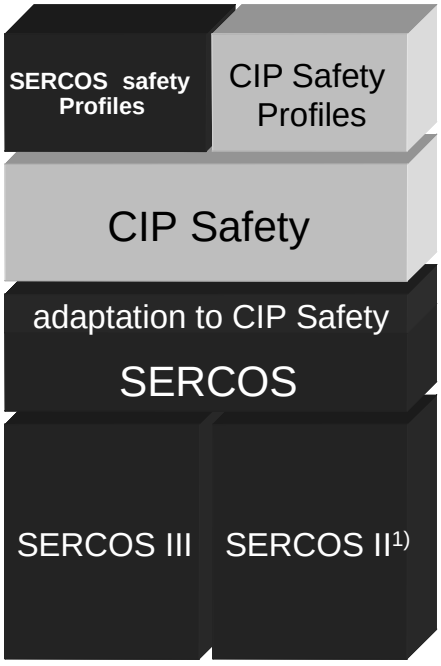


Figure 1 : CIP Safety on SERCOS

As shown in Figure 3, an adaptation layer of SERCOS is necessary for the utilization of CIP Safety, which adapts the CIP Safety data transmission on the SERCOS transport layer.

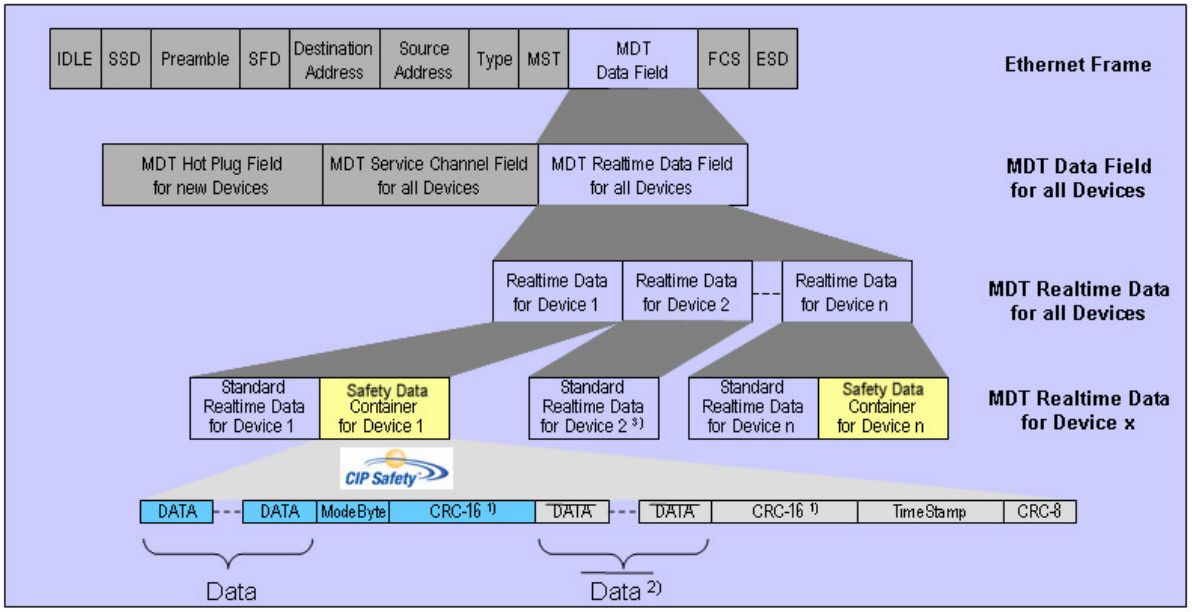
Adaptation to CIP Safety means:

- CIP Safety mechanism and data formats will be adopted unmodified
- Minimum implementation of standard CIP (Connection Manager, Message Router, Identity)

Apart from that, a SERCOS safety profile will be defined allowing for the description of the safety profile (parameters and behavior) with SERCOS parameters.

Transport channel

Figure 4 shows the telegram set-up of a "MDT Data Field"(**M**aster **D**ata **T**elegramm) within the scope of an Ethernet frame, which contains a configurable data container for real-time data for each device. The real-time data of a device is again divided into standard and safety data. The safety data is CIP Safety telegrams either in the short format (2 bytes) or in the long format (up to 250 bytes). The picture shows a simplified 1:1 illustration that also applies to the AT telegram (**A**cknowledge **T**elegram from Device). On closer examination, it becomes apparent that due to the temporal differences between SERCOS cycle (t_{SERCOS}) and safety cycle (t_{safety}), there is potential for optimization with regard to the bandwidth to be provided. Particularly in the processing of the safety signals in a safety control, a safety cycle is many times a SERCOS cycle, which is specified by the demands on the motion control.



In case of the short protocol (max. 2 Byte data): Instead of CRC-16 1) only a CRC-8 is used and the inverted data 2) do not apply
3) Device 2 does not contain any safety data.

Figure 2 : Transport channel

Figure 5 shows a logical CIP Safety data connection. Data from a safety application is transmitted to the safety validator client. The latter processes the safety protocol accordingly., Data is transmitted via a data connection, to the safety validator server in the consumer that again provides the data to the safety application.
As the message must contain a time stamp, there must from time to time be a time synchronization between consumer and producer. While the data connection runs in one direction from the producer to the consumer, the time synchronization is initiated by the producer and answered by the consumer.

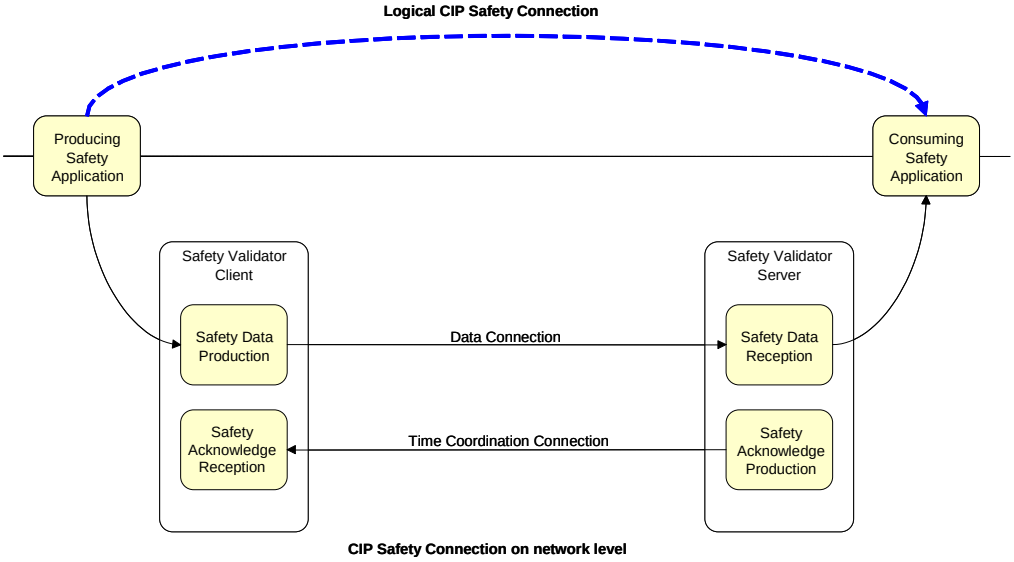


Figure 3: CIP Safety connections

CIP connections are established via an unconnected explicit message containing a Safety Open service request. Upon success, data is cyclically transmitted between the two participants via the established I/O connection.

As SERCOS does not support such connection establishments during the run-time but all data connections in SERCOS telegrams must be configured, a cyclic container must either be provided in the SERCOS telegram for this purpose or the container that has already been used for the I/O connection must be used in a multiplex operation, i.e., firstly for the connection establishment and subsequently for the transmission.

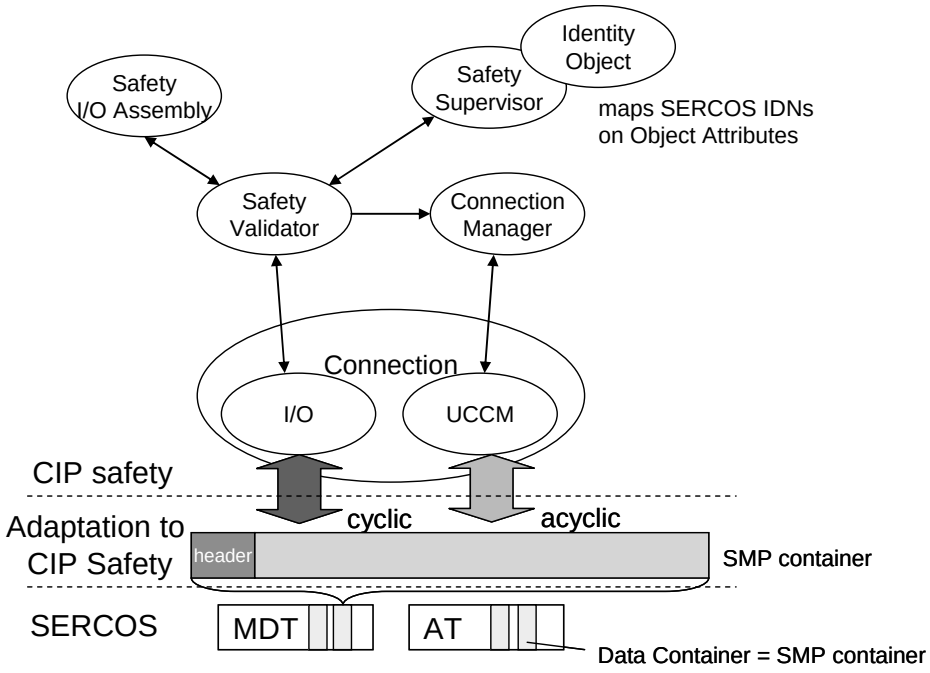


Figure 4 : CIP Safety Adaptation

Figure 6 shows the CIP objects and their mapping on the SERCOS telegram. By means of the SERCOS Messaging Protocol (SMP) it is possible to transmit services and data in the same cyclically configured safety data container, irrespective whether in the MDT or in the AT.

The SERCOS Messaging Protocol (SMP) allows a (fragmented) cyclic and (fragmented) acyclic transmission of data within a SERCOS data container which gets cyclically transmitted on the real-time channel. The SMP header controls the fragmentation or priority of the messages. (Lower priority data packets can be interrupted by higher priority packets)

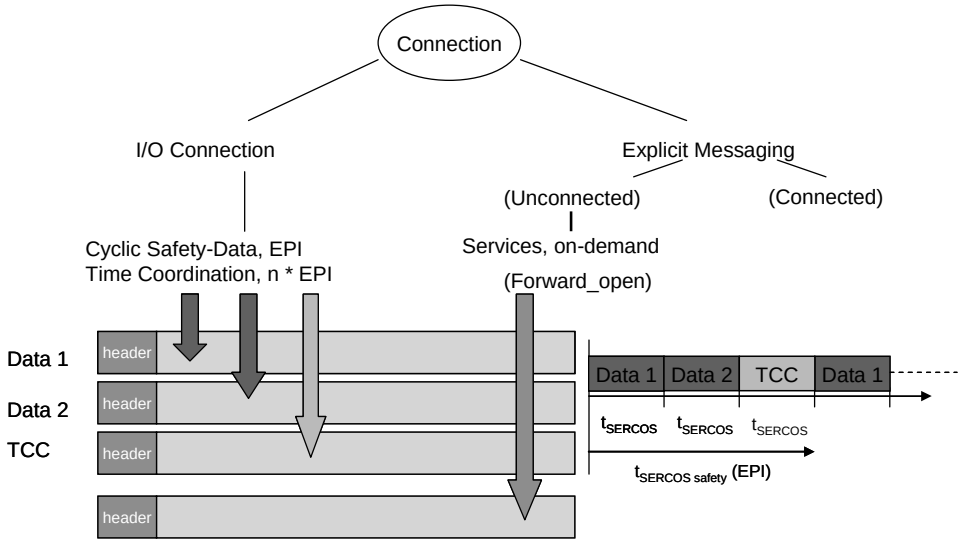


Figure 5 : SERCOS Messaging Protocol

At first, the data connection is established via a “Safety_open“, embedded in one or several SMP protocols. If this connection is available, the CIP Safety protocols will be transmitted cyclically. In this respect, a CIP Safety protocol can be distributed to several SERCOS cycles. From time to time, time coordination takes place. In a bidirectional connection, in which consumers are also producers and vice versa, the response “Time Coordination Connection (TCC)“ may then also be transmitted in the SMP container instead of cyclic data. Prerequisite is t_{Safety} = EPI >= $x*t_{SERCOS} + y*t_{SERCOS}$, where x is the number of SERCOS cycles for the transmission of the CIP Safety protocol and y is the number of SERCOS cycles for the transmission of the Time Coordination.

A bidirectional connection is to be explained by the example shown in Figure 8. If any safety control transmits data to a corresponding safety I/O, the data to the outputs are contained in the MDT assigned safety container. The response of the time coordination is returned to the master in the AT of the I/O device. I.e., in this example, an I/O connection is mapped in the MDT and a time coordination connection in the AT. Thus, each connection between master and slave requires one SMP container in the MDT and one in the AT. However, as the I/O device also transmits data to the control, you can for this purpose use the same container in the AT. The response to the time coordination can then be transmitted via the same data container in which the I/O device receives the data from the control.

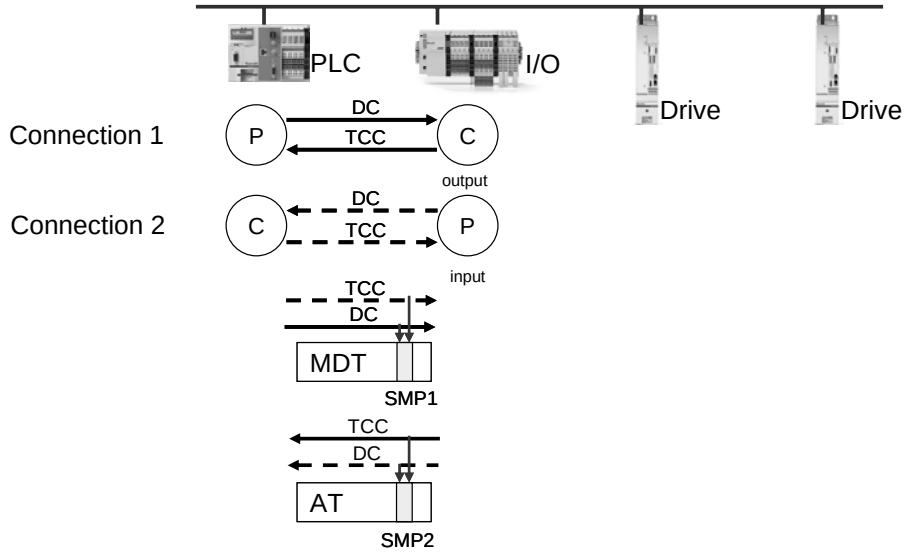


Figure 6 : Example of a bidirectional connection

In unidirectional producer-consumer connection with unidiretional payload data, the data and the response to the time coordination are contained in different containers in the MDT and AT. Here, only the following applies: t_{Safety} = EPI >= $x*t_{SERCOS}$.

According to the time requirement, you can configure the data width of the Safety data container and/or the SMP container. 10 bytes allow, for example, for the transmission of a short protocol in one SERCOS cycle or for the transmission of 4 bytes user information in two SERCOS cycles.

In case of a direct cross-communication, any data is mapped in the AT. Then, each device will put its data as multicast message into the corresponding SMP container (see Figure 9).

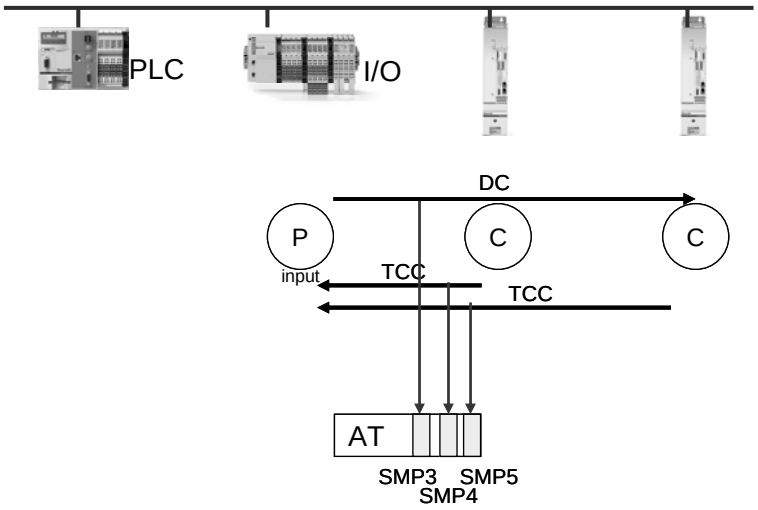


Figure 7 : Example of a multicast connection

Thus, a diversified network can be set-up using CIP Safety on SERCOS. Apart from unicast connections, multicast connections are possible, as well. Apart from classical master-slave-connections, peer to peer-connections are possible, as well. As CIP Safety is routing enabled, safety data can also be exchanged across the boarders of a SERCOS network between SERCOS masters and also between SERCOS slaves.

CIP Safety on SERCOS – Ready for a global safety world!

As the data exchanged between two safety participants is encapsulated, i.e., both connection end points guarantee safety integrity, the subordinate transport layer becomes the “Black channel“. Thus, routing of CIP Safety messages between different networks is possible, as well. As shown in Figure 10, safety messages can be exchanged between a DeviceNet network and a SERCOS network. No safety-relevant requirements are made to the gateway. The gateway is only responsible for copying the encapsulated CIP Safety message from the DeviceNet protocol into the SERCOS protocol and vice versa.

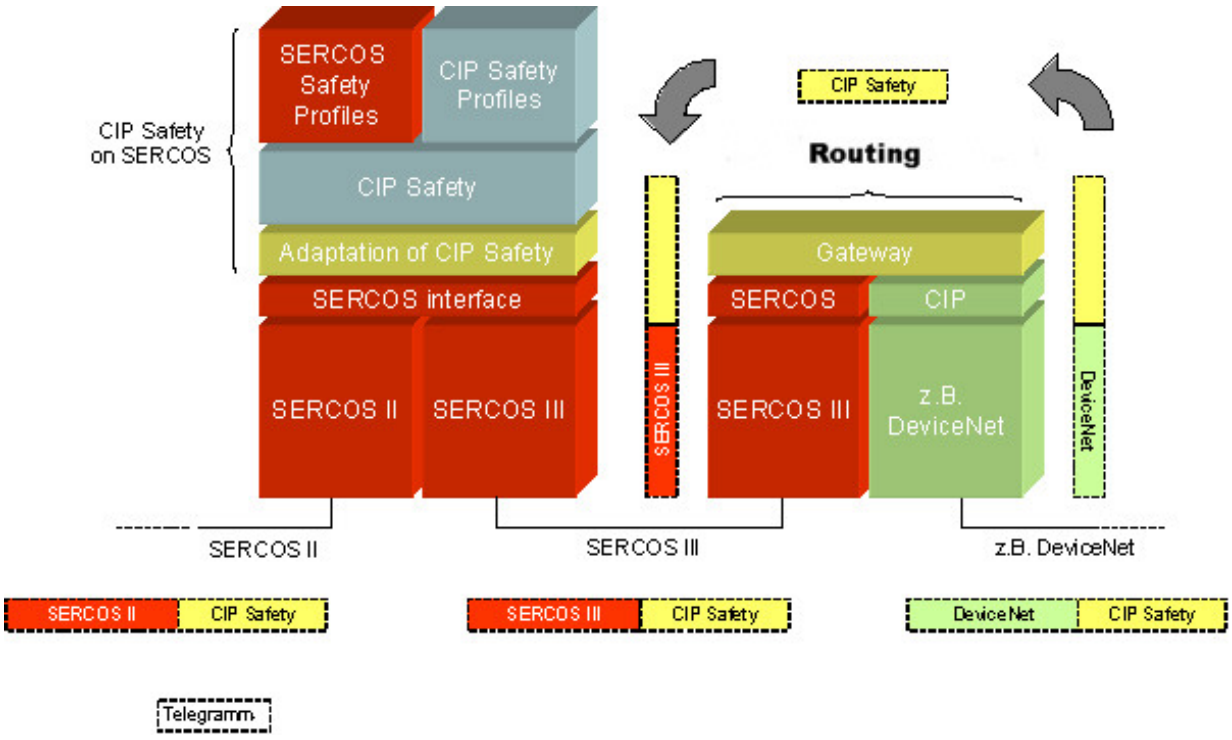


Figure 8 : Routing between different CIP Safety Networks

It is of course also possible to combine other networks using CIP Safety as protocol security mechanisms., A safety controller is, for example, able to access safety drives on a SERCOS network via an EtherNet/IP network and an EtherNet/IP to SERCOS Gateway.

The decisive advantage for component orientated manufacturers is that only one safety stack must be implemented that simultaneously supports several communication networks.

Summary

CIP Safety stands for:

- High investment security by using a certified and already implemented safety protocol by different communication networks
- Reduced development costs for component oriented vendors, since multiple communication networks use the same safety stack
- World-wide market acceptance by a broad interest group

SERCOS III stands for:

- Standardized Ethernet-based real-time communication network for Motion, Logic and I/O with the connectivity to the standard IP world
- Short cycle times (31.25µs) with determinism and a minimum of jitter for high demanding motion control applications
- Suitable for centralized or distributed control architectures (direct cross-communication)
- Increased reliability through diagnosis, hot plugging and hardware redundancy

Therefore CIP Safety on SERCOS combines best in class motion, fast I/O communication, non-RT Communication on an Ethernet-based automation network with a common world wide accepted and well introduced safety protocol.

To use CIP Safety on a SERCOS network, an adaptation layer within SERCOS is necessary. The SERCOS Messaging Protocol (SMP) allows for the mapping of the CIP communication data and services to cyclically defined data containers in the SERCOS telegram. In this respect, the fragmentation mechanism allows for the necessary bandwidth, i.e. to optimize the data width depending on the time requirements.

Safety protocols can be exchanged in a simple way between networks on CIP Safety basis. No safety-relevant requirements are made to the gateways.

The CIP Safety Specification is already available. A future release of The CIP Safety Specification will contain the extensions to the SERCOS III technology. In turn, SERCOS International is working on the integration of CIP Safety onto the SERCOS specifications.

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