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I/O Mirror (Binary Signal Transmission) based on a proprietary protocol

(bi-directional transmission of all signals via an Ethernet network between client and server by means of a proprietary protocol).

A) Consideration of Bandwidth in LAN

The communication is based on UDP/IP messages of a proprietary protocol which are exchanged continuously between the two devices. The length of the messages, consisting of data, UDP header, IP header, Ethernet-Frame-Overhead is fixed at 60 Bytes in both directions. The exchange of messages on these point to point connections is done in a ping-pong manner, i.e. the reception of a message by one device results in the direct transmissions of a message to the other device whereupon this device will again answer as soon as possible and so on and so forth.

In a LAN, on which two participating SICAM I/O-Unit devices communicate with each other via an Ethernet switch or across several Ethernet switches and the channel delay is small (in the micro second range), less than 1000 packets per second are exchanged and the corresponding bit rate of the communication is less than 500 kBit/s. For secure operation the continuous rate may not drop below 0,5MBit/s. With a bandwidth of at least 0.5MBit/s there are no time delays in the I/O mirror (binary signal transmission) application.

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B) Consideration of Bandwidth outside a LAN such as in a private WAN

In a private WAN it is recommended to reserve a bit rate of 500 kBit/s for the transmission of binary signals. In addition the WAN overhead must be considered.

When communicating via WAN the channel delay times will generally be higher than it is the case with LAN, and may be in the range of several milliseconds up to even seconds depending on the number of communication nodes in the path, the distance and type of communication. As a result of the ping-pong procedure described above the number of exchanged packets per second and therefore the bit rate decreases as the total communication delay (send and receive path) increases. The packet rate stated above may be assumed to be the maximum rate; the actual rate obtained in practice will be lower as a result of the channel delay time. When determining the required bandwidth in the WAN it may be necessary to consider a longer message length that will be the result of adding e.g. labels in an MPLS network.

I/O Mirror (Binary signal transmission) based on IEC 61850 GOOSE

(uni-directional or bi-directional transfer of all signals via Ethernet)

A) Consideration of Bandwidth in LAN:

The communication is based on IEC 61850 GOOSE (Generic Object Oriented Substation Event). These are uni-directional (not acknowledged), Ethernet (not IP) based messages, that are sent continuously on a periodic basis from one device to one or several (multicast) other devices. The message length (including Ethernet frame overhead) with GOOSE communication and SICAM I/O-Units is fixed at 185 Bytes.

As long as the state of the binary input remains unchanged, the GOOSE messages are sent repeatedly with a relatively long interval (settable, default value is 3 s). This results in a low bit rate of below 1 kBit/s. In the event of a state change the GOOSE messages are initially sent with very short intervals (minimum period: 1 ms) and subsequently the interval is increased successively until the steady state interval is reached. This method results is short peaks, of 1.5 Mbit/s, in the communication bit rate.

B) Consideration of Bandwidth, outside LAN as well as private WAN

IEC 61850 GOOSE as Ethernet, but not as IP based communication, in many cases demands special techniques for the transport over WAN such as Layer 2 Tunneling Protocol (L2TP) or Virtual Private Wire Service (VPWS) via MPLS.

Requirements for switches in Utilities with IEC 61850 GOOSE:

IEEE 802.1q - VLANs for GOOSE segmenting (VLAN 0 must be supported)

IEEE 802.1p – Prioritization of GOOSE telegrams

When determining the required bandwidth in WAN the packet overhead introduced by these techniques must be taken into account. In the case of VLAN there is e.g. an additional 4 Bytes for the VLAN tag to be considered. The mentioned peak bit rate for the GOOSE communication should be considered for the reserved bandwidth. GOOSE-Packets should be forwarded with high priority in the WAN. Packet delay and lost packets should be minimized by means of suitable measures.

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