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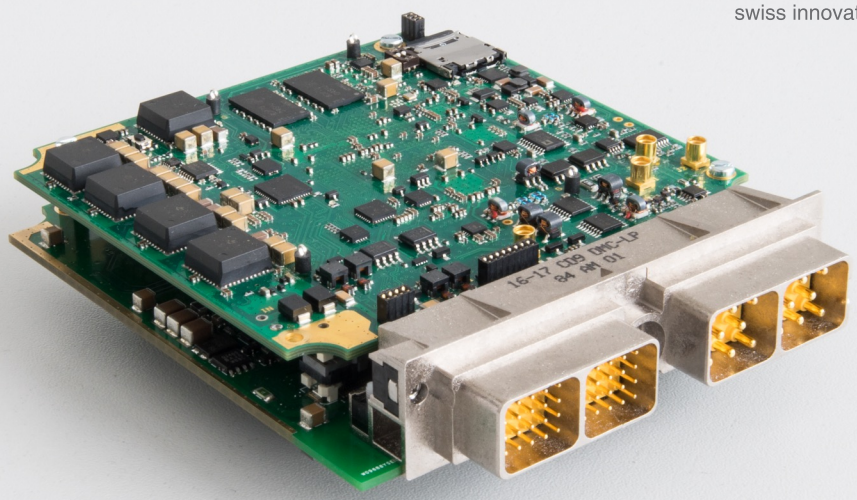

Power Line data bUS PLUS

Cost effective data communications using existing cabling

Power Line data bUS PLUS

Lucerne University of Applied Sciences and Arts (HSLU) and the HSLU spinoff plc-tec AG have developed a Power Line Communications (PLC) technology, PLUS specifically for Mission and Time Critical (MTC) applications in aircraft, rail, smart grid, etc. PLUS provides a reliable, real-time PLC network with deterministic behavior.

PLUS Approach

The PLUS protocol works on top of any power distribution network without requiring any modifications to the existing wiring. The data network can be completely removed. The signal is modulated independently of the underlying power signal. plc-tec has control of all aspects of the PLUS technology enabling design assurance compliance and customizations.

PLUS Protocol Variants

PLUS-Avionics: The PLUS protocol originally targeted MTC avionics applications. The PLUS-Avionics data bus has been designed around a proven standard for the physical layer (IEEE 1901) and a proven avionics standard for bus arbitration (ARINC-629).

PLUS-PTB: The PLC Train Backbone (PTB) provides a data communication backbone for freight trains based on reliable, real-time PLC enabling transmission of critical data over the freight train bus bar. PTB uses the same physical layer as PLUS-Avionics but provides an alternative bus arbitration enabling a reliable end-to-end link across the whole train.

PLUS-Smart Grid: PLUS-Smart Grid targets critical applications for grid monitoring and control at the medium voltage level. It extends the PLUS-Avionics protocol additionally providing a highly accurate time synchronization protocol (PLUS-TimeSync).

PLUS Protocol Specification

PLUS Physical Layer	IEEE 1901 Multi-channel Orthogonal Frequency Division Multiplexing (OFDM) with variable channel bandwidth support				
Carrier Modulation	QPSK, 16-QAM, 64-QAM				
Frequency Range	2 - 42 MHz				
Channel Modes	Mode 0	Mode 1	Mode 2	Mode 3	Mode 4
Bandwidth	40 MHz	30 MHz	20 MHz	10 MHz	5 MHz
Carrier Spacing	24.414 kHz	16.276 kHz	12.207 kHz	6.104 kHz	3.052 kHz
Symbol Duration	40.96 μs	61.44 μs	81.92 μs	163.84 μs	327.68 μs
Physical Data Rates	16 Mbps – 116 Mbps	10 Mbps – 77 Mbps	8 Mbps – 58 Mbps	4 Mbps – 29 Mbps	2 Mbps – 14 Mbps
FEC	Convolutional Turbo Coding with code rates 1/2 and 16/18				
Error Detection	Multi-level Cyclic Redundancy Check (CRC)				
Protocol Variants	PLUS-Avionics		PLUS-Smart Grid		PLUS-PTB
Bus Arbitration	ARINC-629 Basic Protocol with bus quiet time optimization				Master/slave token protocol
Network Architecture	Peer-to-peer without central clock master				Master/slave with deterministic multi-hop (relay nodes)
Network Setup/ Management	No network management traffic Zero network setup time		Time synchronization with PLUS-TimeSync (accuracy <2μs)		Train Topology Detection using PLUS signal with PLUS-TTD
Data interfaces	- PLUS provides gateway data interfaces to CAN and Ethernet/IP networks - Multiplexing of multiple networks is supported				

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