PLUS (Power Line Data BUS) Avionics Data Bus

Power PLUS Data over the same Aircraft Wiring -
Reducing its Weight, Volume and Complexity

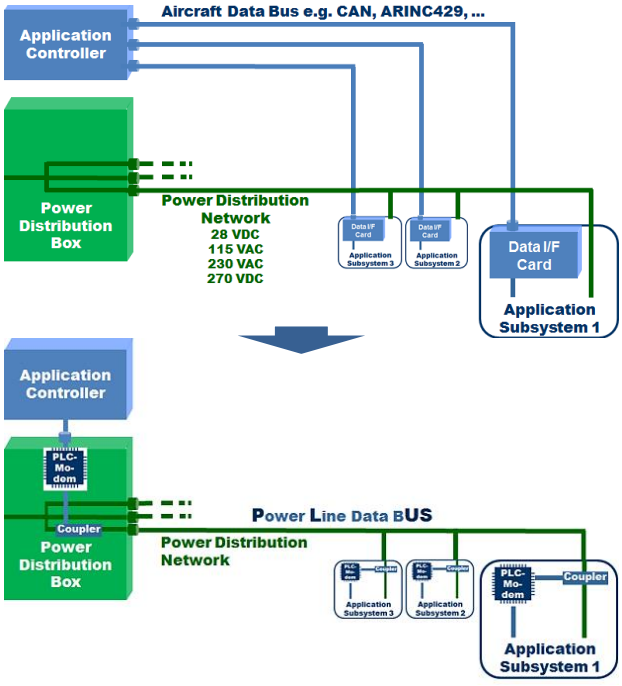
Today's traditional avionics systems consist of separate power and data networks. This leads to a significant amount of wiring within the aircraft. The trend towards the More Electric Aircraft means that the number of electrically controlled systems within the aircraft is increasing. Therefore a means is required in order to reduce the overall amount of wiring in the aircraft.

One potential solution is Power Line Communications (PLC). With the PLC approach data is transmitted over the existing aircraft power distribution network. The data network may then be completely removed. PLC components are integrated into application devices and therefore a single connector is provided for both power and data. PLC has the potential to provide a significant reduction in aircraft wiring, weight and volume. Also the absence of the data network reduces the complexity of the overall wiring and means that less wire routing must be performed. The necessary maintenance will also be reduced.

However, the power distribution network has not been designed for high speed data delivery. The wiring is unshielded, highly asymmetric and often ramified. PLC cannot expect the same communications channel available to a dedicated data network such as Ethernet or CAN. The PLC channel is highly frequency selective due to reflections occurring at impedance discontinuities. As the channel is also dependent upon the topology and load conditions it will vary from location to location even within a single network. The application equipment attached to the power distribution network will also generate significant background and transient noise. These conditions lead to the main challenges for the use of PLC within the aircraft:

- Achieving availability and integrity requirements by providing robust communications.
- Fulfilling Electromagnetic Compatibility (EMC) requirements for both emissions and susceptibility.

While these challenges for PLC are not unique to the avionics environment, the safety critical nature of the application means that the requirements are more strict and that deterministic behavior must be provided under all conditions.



The **PLUS Avionics** data bus is based on the **PLUS** (Power Line Data BUS) protocol and technology platform specifically targeting safety-critical, real-time systems. The **PLUS Avionics** data bus has been designed around:

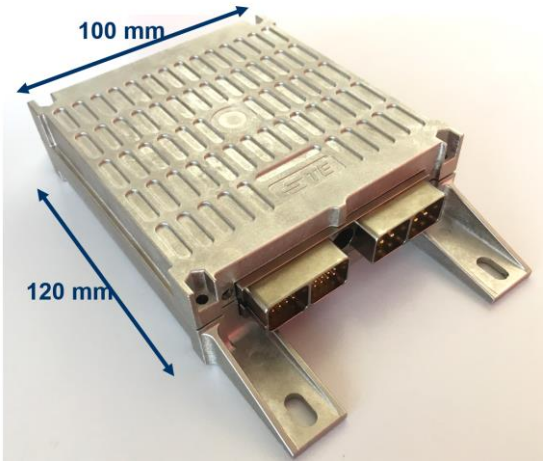
- A proven standard from other industries for the physical layer (IEEE 1901).
- A proven avionics standard for bus arbitration (ARINC 629).
- Custom optimizations and additional protocol layers.

One of the main design goals has been to use the available bandwidth from the broadband transmission in order to optimize the data availability and integrity rather than simply increasing the data rate. Furthermore the protocol has been designed to provide predictable behavior even in the presence of a less-than-predictable channel.

PLUS Avionics Key Features – Robustness, determinism, low latency

- Robust transmission with physical data rates up to several 10's of Mbps
- Bus arbitration based on a deterministic protocol
- Peer-to-peer architecture with no single point-of-failure
- Stateless connections minimize setup and recovery times
- Multiplexing of multiple data services onto a single bus
- Optimized delivery of small frame sizes with low-latency
- Advanced error detection schemes increase data integrity
- Signal transmission techniques designed to minimize emissions and improve susceptibility according to the RTCA DO-160 requirements
- Configurable operational frequencies

Power Line Data BUS PLUS
Protocol & Technology Platform



PLUS Modem Prototype Platform

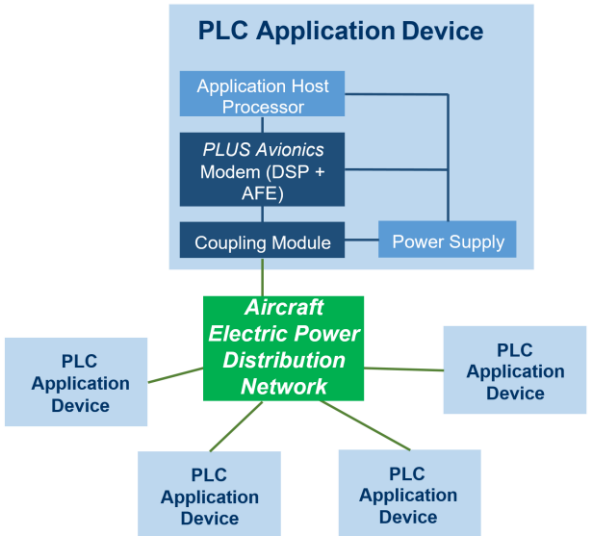
The **PLUS** protocol targets ***safety-critical and real-time*** applications requiring dependable and robust data communications, e.g. avionics, electrical grid monitoring & automation and vehicular communications.

The **PLUS** protocol works on top of any power distribution network ***without requiring any modifications to the existing wiring***. The signal is modulated independently of the underlying power signal.

In order to provide maximum weight savings the necessary components enabling the **PLUS** solution may be integrated directly into the application devices. These additional components include:

- **PLUS** Controller: System-on-Chip (SoC) providing the digital signal processing and protocol functionality for **PLUS**.
- Analog Front End (AFE): Provides transceiver functionality including digital/analog signal conversion and variable signal amplification.
- Coupling Module: Consists of passive analog components which couple the high frequency PLC signal onto the power line. It also filters and protects the AFE from the low-fre-quency power signal. It may be considered as the one com-ponent that is dependent upon the characteristics of the power distribution network. However, generic couplers may be designed which support a variety of different power networks.

The **PLUS** Controller may be interfaced to the application host processor using a suitable high-speed data interface. Gateway functionality may also be provided to an existing data bus such as a CAN bus or Ethernet/IP network. This allows two or more secondary networks to be bridged across a **PLUS** network. Deterministic multiplexing of multiple data interfaces is also supported by **PLUS**.



PLUS Avionics Architecture

PLUS Specification

Physical Layer Signal	Multi-channel Orthogonal Frequency Division Multiplexing (OFDM) with 2048-point FFT				
Modulation	BPSK, QPSK, 8-QAM, 16-QAM				
Frequency Range	2-42 MHz				
Channel Modes	Mode A	Mode B	Mode C	Mode D	Mode E
Channel Bandwidth	40 MHz	30 MHz	20 MHz	10 MHz	5 MHz
Sub-carrier Spacing	24.414 kHz	16.276 kHz	12.207 kHz	6.104 kHz	3.052 kHz
OFDM Symbol Duration	40.96 µs	61.44 µs	81.92 µs	163.84 µs	327.68 µs
Physical Data Rates	20 Mbps – 142 Mbps	14 Mbps – 104 Mbps	10 Mbps – 71 Mbps	5 Mbps – 35 Mbps	2.5 Mbps – 17 Mbps
Forward Error Correction	Convolutional Turbo Coding with code rates 1/2, 16/21 and 16/18				
Error Detection	Multi-level Cyclic Redundancy Check (CRC) CRC-40, CRC-32, CRC-8				
Bus arbitration	ARINC-629 Basic Protocol with bus quiet time optimization				
Network Architecture	Peer-to-peer without central clock master				
Network Setup/Management	- Zero network setup time - No network management traffic				
Data services	- Gateway functionality for CAN bus, Ethernet / IP - Multiplexing of multiple data services supported				
Supported power distribution networks	28VDC, 115VAC, 230VAC, 270VDC				

CC Intelligent Sensors and Networks
Prof. Dr. U. Dersch
ulrich.dersch@hslu.ch
+41 41 349 3525
Technikumstrasse 21, CH-6048 Horw
www.hslu.ch/isn

Lucerne University of Applied Sciences and Arts
HOCHSCHULE LUZERN
Technik & Architektur