

PLUS (Power Line Data BUS) based Avionics Data Bus

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



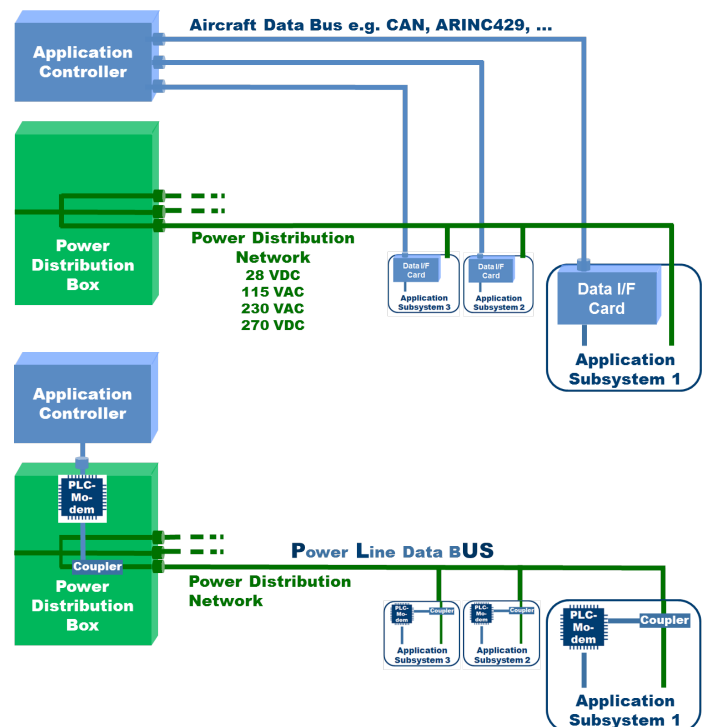
Today's traditional avionics systems consist of separate power and data networks. This leads to a significant amount of wiring within the aircraft. The trend towards the More Electric Aircraft means that the number of electrically controlled systems within the aircraft is increasing. Therefore a means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

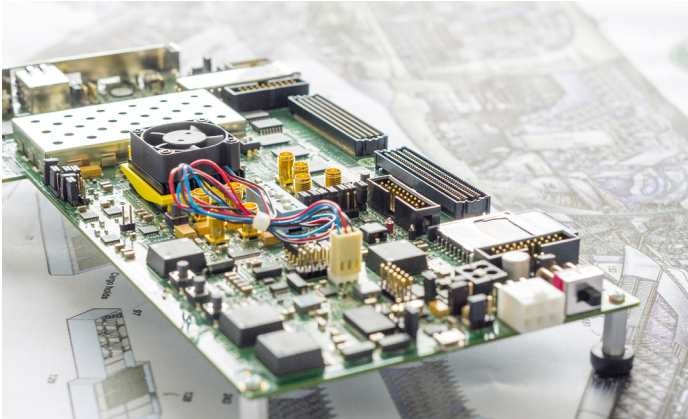
- A proven standard from other industries for the physical layer (IEEE 1901).
- A proven avionics standard for bus arbitration (ARINC 629).
- Custom optimizations and additional protocol layers.

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



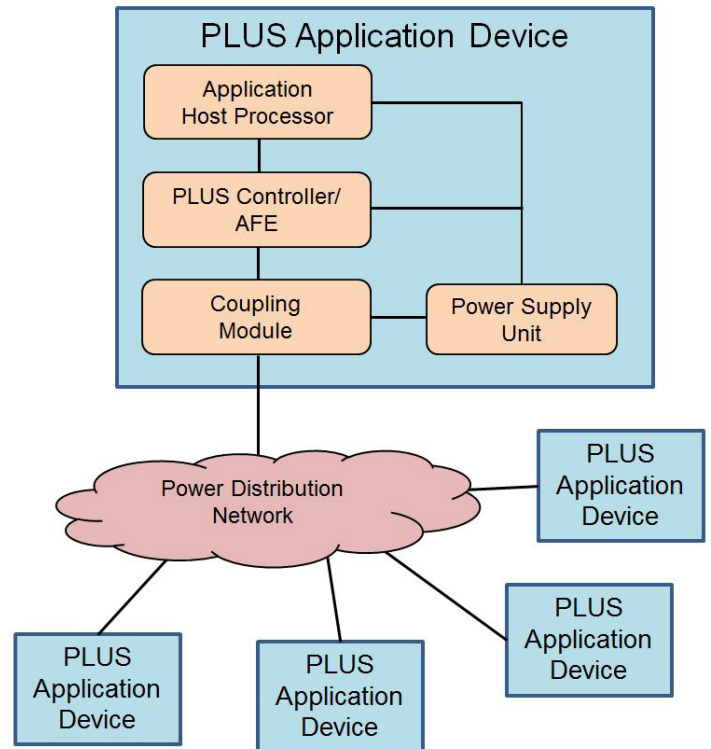
PLUS Architecture

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 (CM):** The 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-frequency power signal. It may be considered as the one component 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 Specification

Parameter	Abbr.
Physical Layer Signal	Orthogonal Frequency Division Multiplexing (OFDM)
Signal spectrum	Configurable: 2-50MHz
Max. number of data sub-carriers	1'968
Sub-carrier spacing	24.414 kHz
Modulation	BPSK, QPSK, 8-QAM, 16-QAM
Physical data rates	20 Mbps - 144 Mbps
Forward Error Correction	Convolutional Turbo Coding
Error Detection	Multi-level Cyclic Redundancy Check (CRC)
Bus arbitration	ARINC-629 Basic Protocol
Network Architecture	Peer-to-peer without central clock master
Supported gateway functionality	CAN bus, Ethernet / IP
Supported power distribution networks	28VDC, 115VAC (variable and fixed), 230VAC (variable and fixed) [single phase and 3-phase]

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