ADENEAS Newsletter #4

Power Line Communications Network Configuration

Hello! I am Stephen Dominiak, the Head of Technology at plc-tec AG in Switzerland. Within the ADENEAS project, I am the Work Package 3 (WP3) lead. WP3 focuses on topics related to Powerline Communications (PLC). In this fourth newsletter, I will discuss the PLC network configuration concept and tool developed within the ADENEAS project.

ADENEAS develops technology enablers to pave the way for a safe, light, self-configuring, autonomous, and modular power and data distribution network that is scalable to all aircraft sizes. A hybrid network combining wired, wireless, and PLC is being investigated for the data distribution network. Within WP3, the following PLC-related topics are addressed:

1. Electromagnetic Compatibility (EMC)
2. PLC Network Configuration Concept and Tool
3. PLC Interface Standardization
4. PLC Testing on Novel Power Distribution Conductor Concepts

The ADENEAS project targets the deployment of a Power Line Communications (PLC) data bus for a wide range of aircraft systems. A critical factor in achieving that goal is providing a PLC network that can be easily configured to support different systems. This newsletter will focus on the PLC network configuration concept and tool used to achieve that goal.

Power Line Communications (PLC) is a wired communication technology that uses the aircraft Power Distribution Network (PDN) for data transmission by superimposing a modulated high-frequency carrier signal over the standard power signal. The PLC signal is modulated completely independent of the underlying power signal, i.e., it will function over any DC, AC, or even non-energized systems. PLC combines the advantages of wireline communications with an existing (non-dedicated) wiring network. The specific advantage of PLC comes because it has been designed explicitly for communications over wiring channels that have not been designed for high-speed data communications. Because of its robustness, the PLC technology may be employed to reliably communicate over shielded or unshielded wired networks normally used for low-frequency applications such as power lines, telephone lines (twisted pair copper), or low data rate signaling/control lines.

plc-tec AG has developed a PLC technology to support the requirements of safety-critical, real-time applications in avionics and other niche market areas. The technology is known as the Power Line data bUS (PLUS). The main design goals for PLUS are to maximize reliability, reduce latency and provide deterministic behavior. These goals differ from commercial PLC technology, which includes much dynamic behavior to support plug-and-play and high bandwidth applications. PLUS is the only PLC technology that has been developed specifically for use in Mission-and Time-critical (MTC) systems, such as an avionics data bus for safety-critical avionics systems.

All communications systems must make optimum use of the available channel resources. Resources may be shared in the dimensions of frequency, time, or space (see Figure 1). To maximize the benefits a PLC solution provides, it would be necessary to operate several PLC systems concurrently in a single aircraft. However, extending the use of PLC to several systems within the aircraft is not so straightforward. This is because the power line wiring within the aircraft is generally unshielded, and wiring from several systems is co-located within large wiring harnesses within the aircraft. The crosstalk of the high-frequency PLC signal between the co-located wires between different systems within these harnesses is relatively high. In other words, a dependency is introduced between different systems because PLC transmissions from one system may be received by PLC nodes from a different system. There exists a need to operate several co-located PLC networks (one PLC network per system) independently. If spatial separation cannot be provided, the PLUS PLC technology provides both frequency and time division methods. Following an innovative frequency division multiplexing scheme, multiple co-located PLUS networks can be configured to operate on different orthogonal frequency channels, as shown in Figure 2. This scheme allows multiple PLC systems to operate independently of one other, which is critical for error containment and optimized use of the available resources. Each PLUS modem within a single network will then share the communications resources according to a time division scheme.

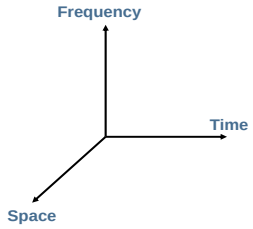

Figure 1: Communication System Resource Sharing Dimensions

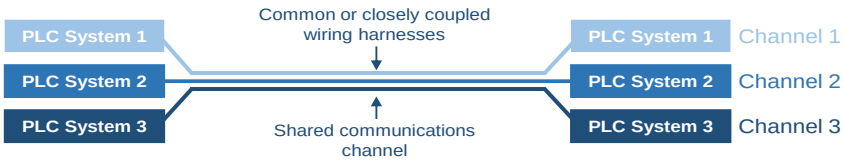

Figure 2: PLUS Frequency Division Multiplexing

A network configuration protocol has been developed in ADENEAS to enable the frequency and time division multiplexing configuration of the PLUS network for different aircraft architectures and systems. The Management Data Service (MDS) for the Power Line data bUS (PLUS) is a data service allowing the remote management of firmware, parameter configuration, and status reading over the PLC network. The MDS network architecture is shown in Figure 3. MDS assumes that an external device (PLUS Management Device – PMD) is used to manage the PLUS network. The PMD is attached to a configuration master through an Ethernet interface. The modem acting as configuration master will forward MDS messages between the PMD and the other configuration slaves (other modems) in the network. A PLUS modem must be enabled to act as the configuration master through the correct combination of data-loading pins. This will place the modem into management mode and allow it to forward MDS messages to the other configuration slaves over the PLC network.

The MDS protocol works as a simple request/response protocol. Requests are generated by the PMD, sent over the Ethernet network to the configuration master, and forwarded to the configuration slaves over the PLC network. The configuration slaves will then respond with responses sent over the PLC network forwarded by the configuration master over the Ethernet network to the PMD. MDS frames will use the Ethernet frame format with a unique payload definition for MDS. Guaranteed transport must be provided for all MDS messages. As the MDS works on top of two data link layer technologies (Ethernet and PLC) which do not offer guaranteed transport mechanisms (e.g., no TCP), guaranteed transport is provided by the PMD in the form of ARQ (repeating requests until a response is received).

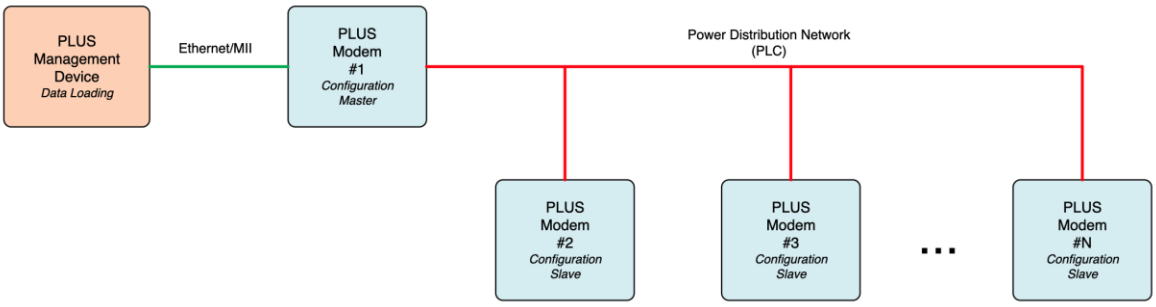

Figure 3: MDS Network Architecture

The PLUS network configuration protocol, MDS, has been realized on a set of PLUS modem prototypes within the ADENEAS project. A PLUS Management Device (PMD) prototype was also developed on a Moxa UC-8112-LX embedded computing platform. The complete concept will be demonstrated within a flying- and ground-based demonstrator within WP7, similar to the architecture shown in Figure 4.

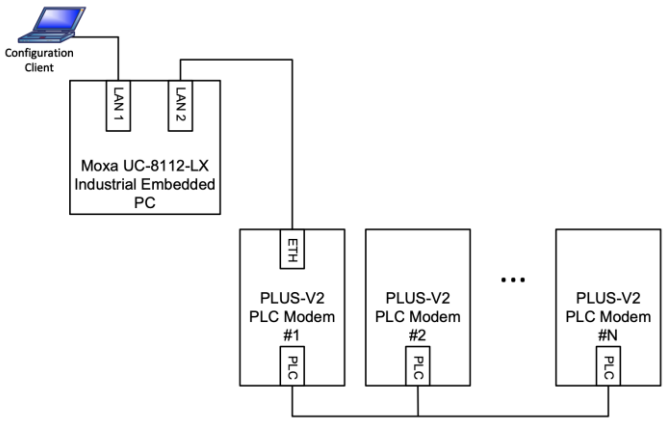

Figure 4: PLUS Network Configuration Demonstrator Architecture