

412TW-PA-18249



**POWER-LINE COMMUNICATION:
NON-INTRUSIVE INSTRUMENTATION
NETWORKING**

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14. ABSTRACT We are in the process of designing a data over power-lines solution with the hopes of providing Ethernet connectivity over existing aircraft power lines or any spare wires already installed. Our plan is to build a matched pair of boxes that will act as bridges to connect two spatially separate Ethernet nets to each other over production aircraft wiring. These bridges will give us an easy way to connect remote smart transducers, DAUs or recorders located in hard to reach places, like wings or engines, with minimal to no wire runs. Tying into production power, and using the PLC connection for programming, control and data transfers as well as downstream system power on/off control will shorten the modification installation time, which will reduce aircraft down time and modification cost.					
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Power-Line Communication

Non-Intrusive Instrumentation Networking

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Powerline Communication Problem



Pilot Control Panel

Primary SI Data Recorder



Remote DAUs or Transducers



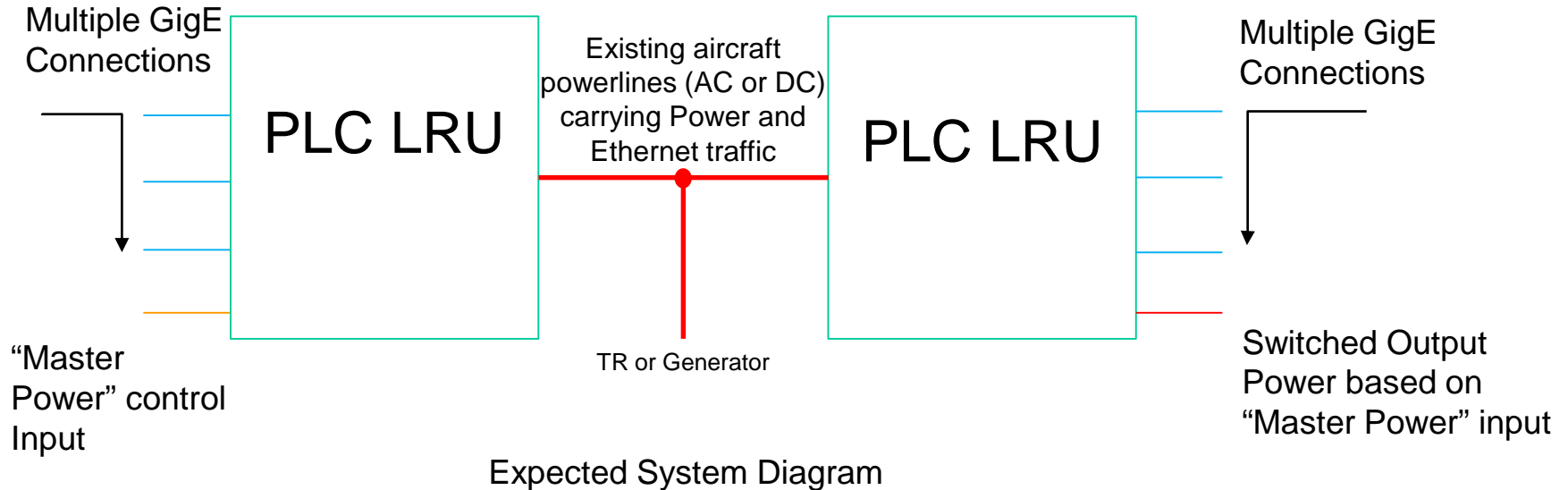
Powerline Communication Problem



Space is limited!



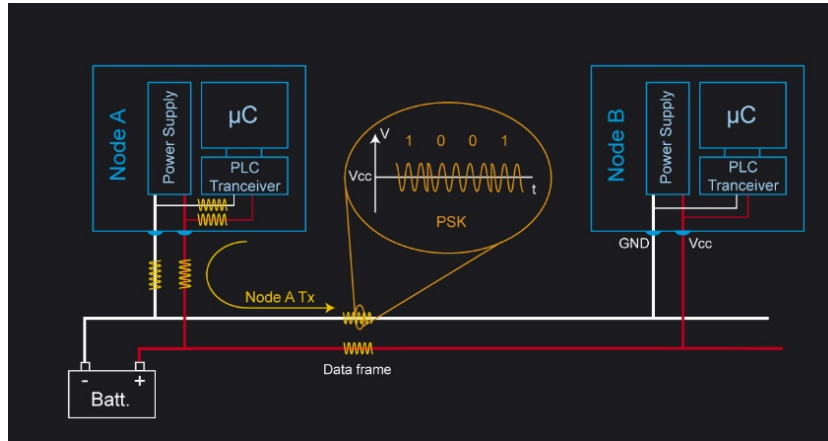
Powerline Communication Goals



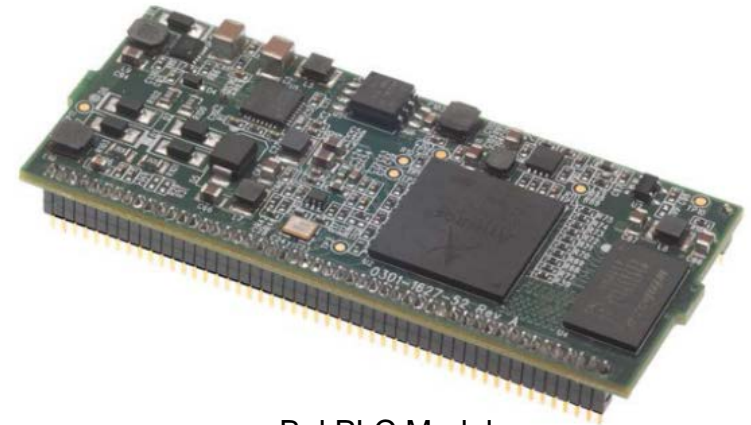
- **Design and build an evaluation PCB**
 - Multiport GigE Ethernet switches
 - Remote controlled Master Power relay



Powerline Communication Concept



PLC provides a communication channel over the existing wires previously used only for power



Bel PLC Module

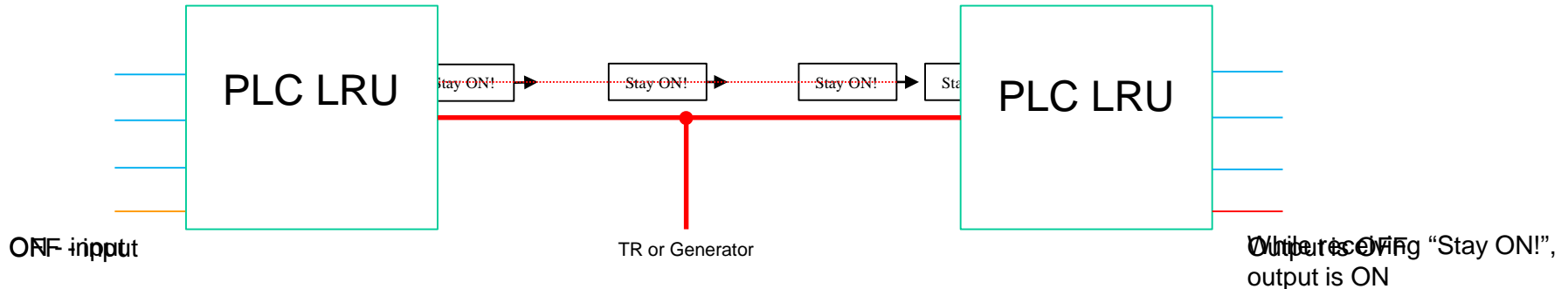
■ Powerline Communication (PLC) evaluation

➤ Bel Power Solutions 0804-5000A50 PLC modem

- IEEE1901 HomePlug AV standard with advertised data rates up to 500Mbps
- Works over DC, AC or dead wires
- GigE PHY connection
- 128-bit AES link encryption



Powerline Communication Concept



■ Master Power System

- When power is switched ON, periodic UDP broadcast messages "Stay ON!"
 - PLC module and downstream systems are powered from the communication channel power.
- When power is switched OFF, UDP broadcast message "TURN OFF!"
 - When the "Stay ON!" commands stop for X seconds, power is removed.
 - In OFF state, the PLC module remains in standby waiting for "Stay ON!" commands.



Powerline Communication Initial Lab Test Data



Test Configuration	Square wave, 30Vp-p @ 1MHz	DC Powered	DC Loaded
6ft Twisted Pair (Ideal baseline)	2-3MB/s, 0.1% error pkts	9-10MB/s, 8.3% error pkts,	8-9MB/s, 8.3% error pkts,
Poor Quality (2 different wire routes, 70ft)	0MB/s, (No data connection)	7.8-8.2MB/s, 9.5% error pkts	7.4-8.6MB/s, 9.2% error pkts
100ft Twisted Pair	512-750KB/s, 0% error rate	9.3-10.6MB/s, 8.5% error pkts	9-10MB/s, 8.6% error pkts

➤ Test method

- Connected two Bel PLC modules with various configurations
- Linked two PCs with MS Windows file sharing
- Copied large (1.6GB) file over the link while monitoring those transfers with WireShark
- Transfer rate was obtained from Windows transfer dialog, and the error rate from WireShark filtering.
 - Error packets include duplicate, retransmission and out-of-order packets

➤ Test conditions

- Square Wave – Two wires with a 30Vp-p square wave
- DC Powered – Two wires with 28VDC added (minimal current flow)
- DC Loaded – Two wires with 28VDC at one end, 5Ω load at the other

➤ All configurations and conditions yielded a 2-3mS ping time



Powerline Communication What's Next



➤ **More Testing**

- Investigate the errored packets and whether they would have resulted in data loss had we been using UDP.
- Test communications over AC power wires (115VAC @ 400Hz, aircraft power)
- Test link reliability and re-acquisition times
- Interference to existing systems CREATED by adding PLC

➤ **Determine Use Case**

- Determine if the capabilities these modules provide are worth proceeding to on-aircraft testing
- Backbone connection, connection to remote nodes, or connection to smart sensor(s).