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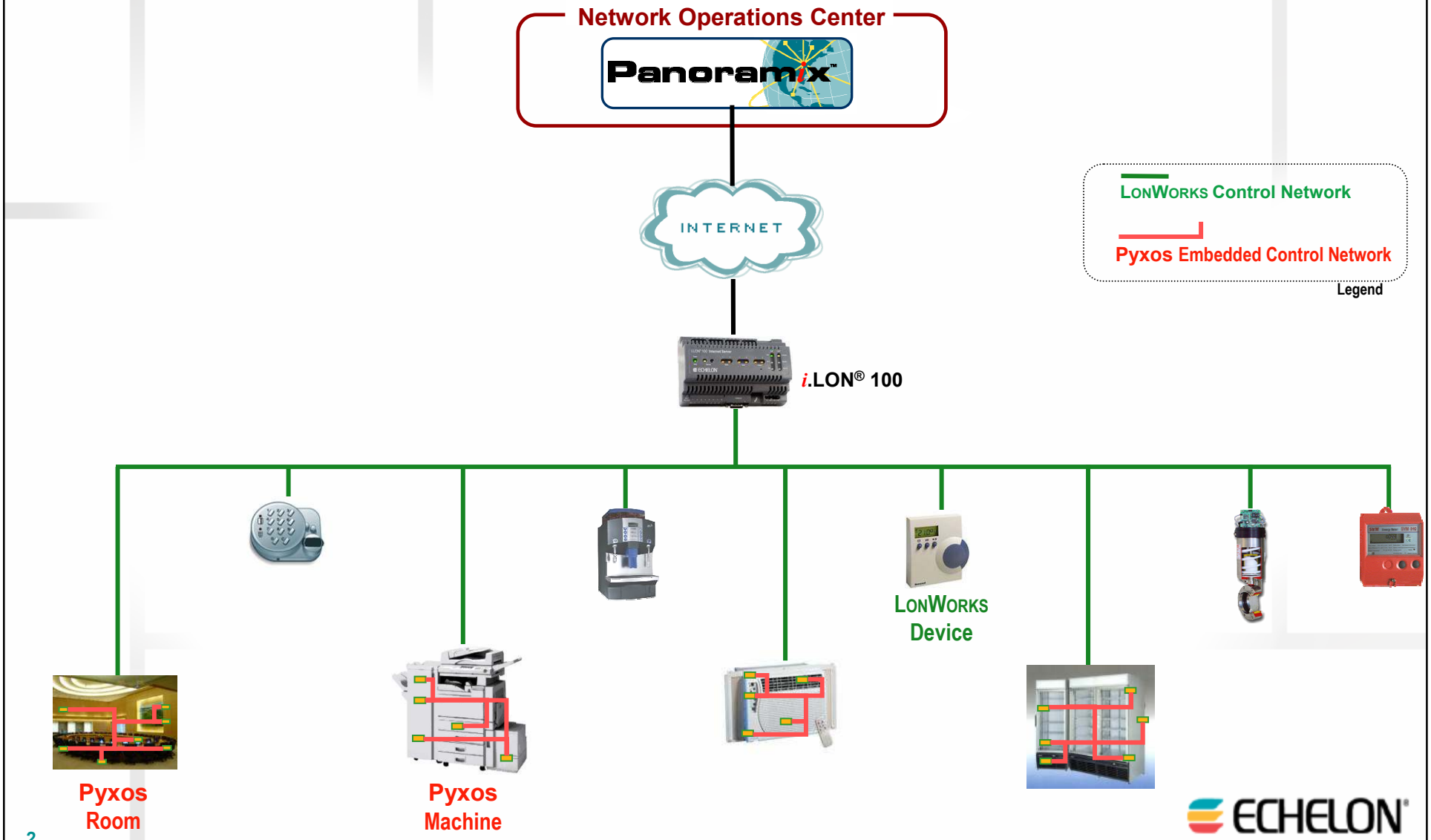
Pyxos™ FT
Technical Overview

Echelon's Control Ecosystem

The Pyxos & LonWorks® Platforms



The Pyxos & LonWorks Platforms
Key Differentiators

- **The LonWorks Platform**
  - Ideal for control networks including building, home, transportation, and industrial systems
  - Scales to millions of devices
  - Integrates the Internet, existing buses, web services
  - Peer-to-peer architecture
  - Control backbone for wired or wireless sensor networks
- **The Pyxos Platform for Embedded Control Networks**
  - Ideal for extending LonWorks networks to smallest sensor or device
  - Very high speed, deterministic performance
  - Master/slave architecture
  - Ideal sensor networking platform for up to 32 devices
    - Use LonWorks control networks as communications backbone
  - Price/performance to embed networks inside machines
    - Replaces complex wiring harnesses & simple bus technologies

Contents

- Introduction to Pyxos FT Networking Technology
- Link Layer Protocol Overview
- Hardware Design Considerations
- System Design and Application Development
- Features Comparison with Other Technologies

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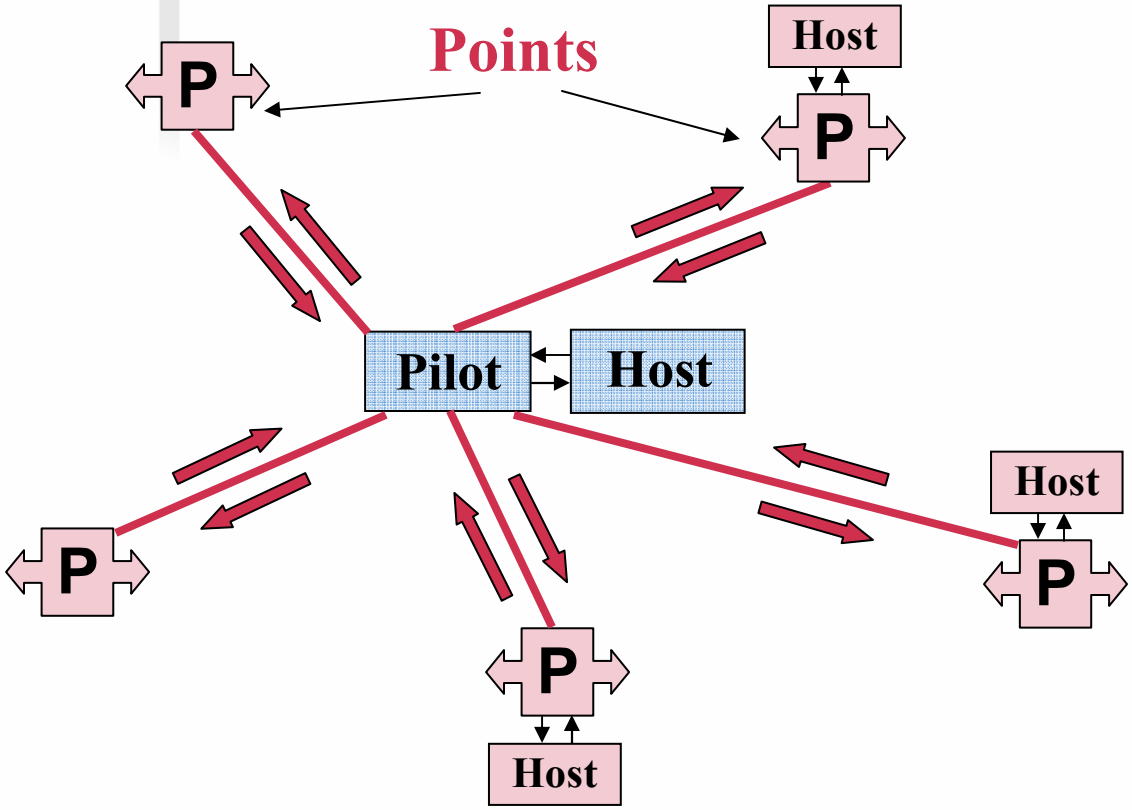
Pyxos FT

Introduction to Pyxos FT Networking Technology

Pyxos Networks - Logical Diagram



- All communication goes through the Pilot

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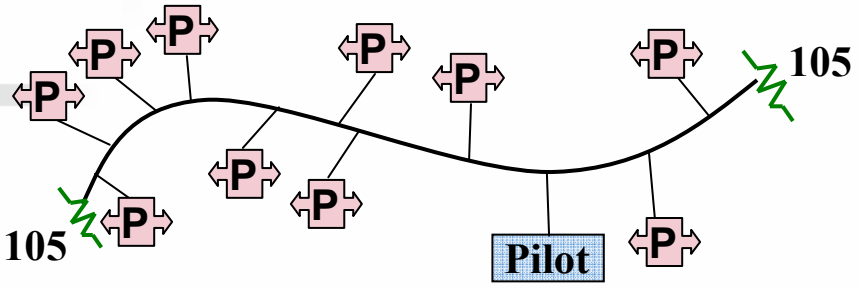
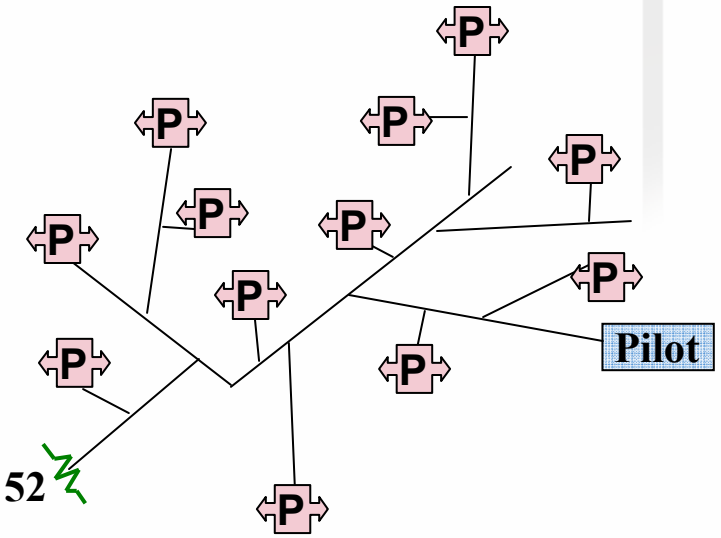
Pyxos Networks – Wiring Topologies

Bus Topology



- 400 meters max
- 0.3 meter stubs
- Terminated at both ends
- Up to 32 Points

Free Topology



- Combination of star, loop, daisy chain or bus
- 100 meters max
- Single termination anywhere
- Up to 32 Points

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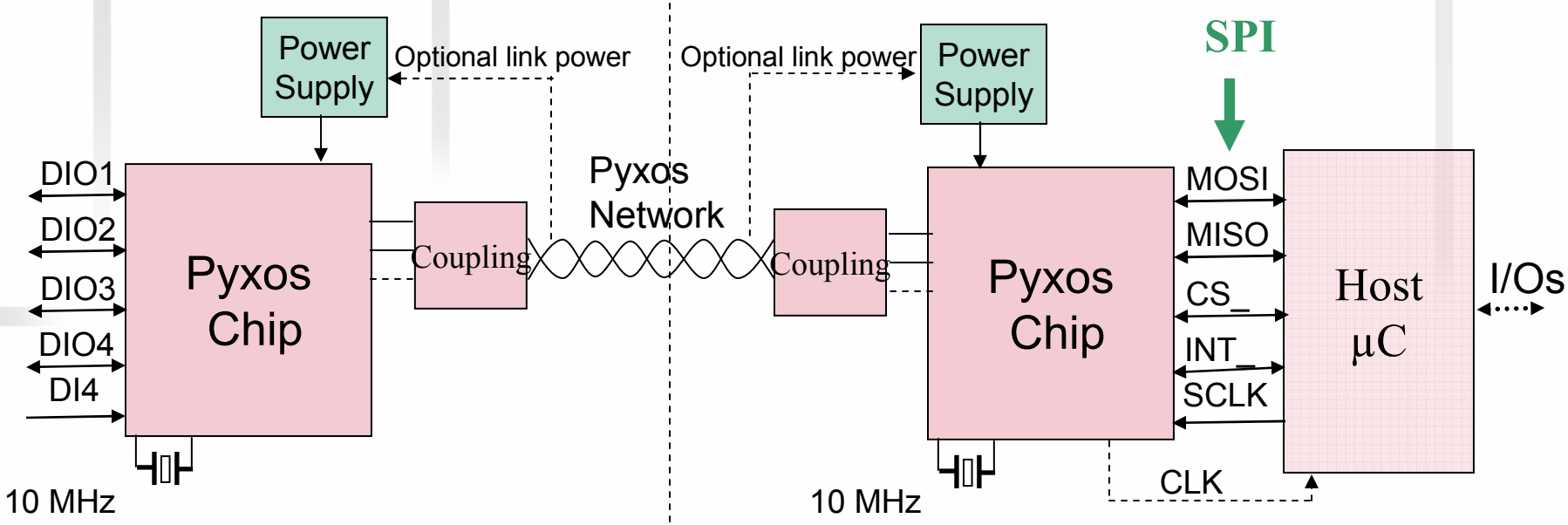
Pyxos Point



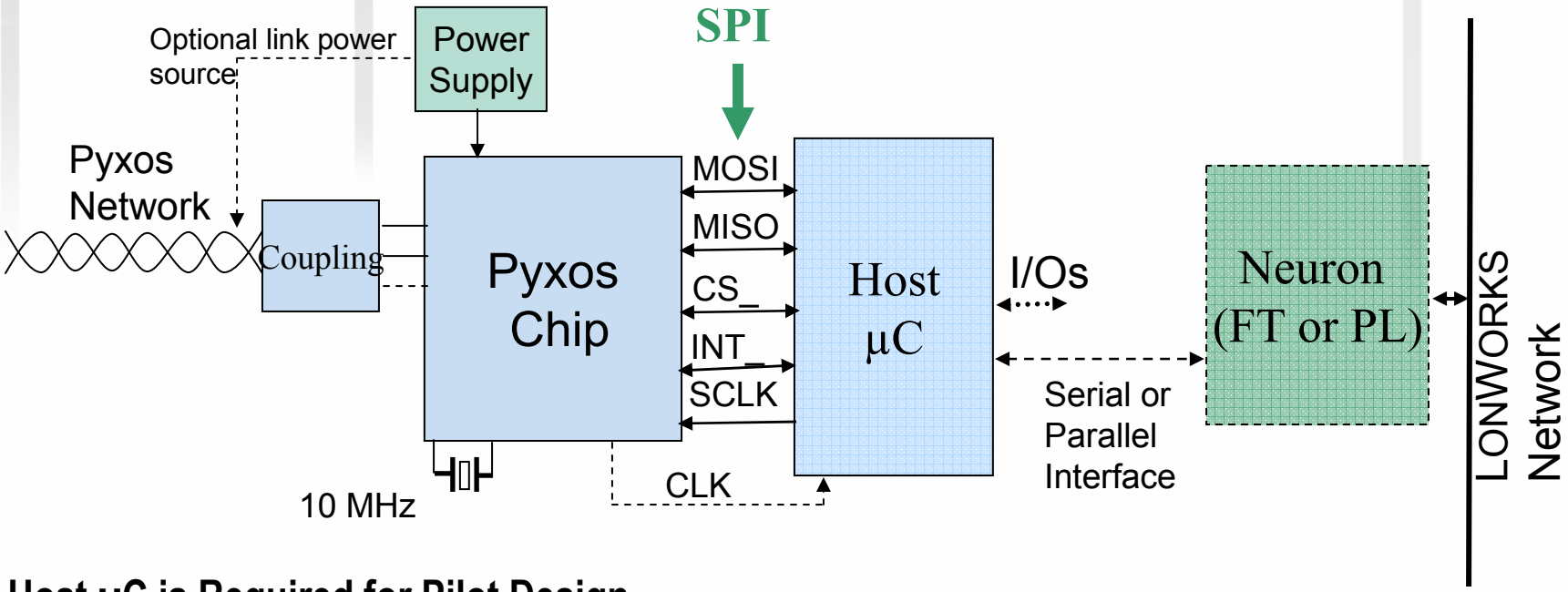
Unhosted Point

- No µC needed
- 4 digital I/Os
- 1 digital Input
- Most cost-effective design for simple nodes

Hosted Point

- Use µC based on application requirement
- SPI connection to host µC
- Use I/O connections on host µC
- 10MHz clock available from Pyxos chip

Pyxos Pilot



- **Host µC is Required for Pilot Design**
  - Host processor is moderate to high end
  - SPI interface between Pyxos Chip and Host µC
  - 10 MHz clock available from Pyxos chip
- **Link Power Source Optional**
  - Either Pilot or any Point on the Pyxos network can be power source
- **Pilot Variations**
  - Stand Alone – Not connected to other networks
  - Networked – Uses LONWORKS networks (or others) to connect to control applications or Internet

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Pyxos Networks – Key Features

Features	Specification	
Function	Free Topology, Link Power, twisted-pair transceiver	
Network Connections	Polarity-insensitive	
Protocol	Deterministic Time Division Multiplexed (TDM) protocol with automatic retries on any CRC error	
MAC ID	Built-in	
Installation	Self-organizing network with automatic, hardwired, and manual service-pin methods	
Maximum Pyxos points per Pyxos Pilot	32	
Transmission Rate	312.5 kilobits per second, fixed polling cycle	
Pyxos Network Variables (PNVs) per hosted Pyxos Point	128 four-byte PNVs per Pyxos Point. Larger size PNVs can be defined within total memory size available	
Data Integrity	Forward Error Correction of up to 2 bit errors per packet; 18 bit packet CRC	
LONWORKS Network Variables per Pyxos Pilot	62 when using ShortStack, 4096 when using MIP	
Response Time	25ms scan time for 32 Pyxos Points. Scan time is dependent on the total number of Pyxos Points, e.g., 1.8ms for 2 Pyxos Points.	
Communication Distance	Single termination (free topology): 100m maximum total wire	Double termination: 400m maximum, 0.3m max stub length
Network Wiring	Unshielded CAT-5 24AWG (0.5mm) and Belden 8471 16AWG (1.3mm) twisted pair wire	

Pyxos Networks – Key Features (contd.)

Features	Specification
Link Power	Supports 24VAC or 24VDC link power with optional external components; Reference designs provided for both switching and linear power supplies Application Output Current: up to 100mA @ 3.3V DC
Coupling Options	Direct connect (for applications within a single enclosure) Non-isolated/Grounded Non-isolated/Floating Transformer-isolated
ESD (IEC 61000-4-2)	Designed to comply with 61000-4-2 Level 4 (contact - 8kV; air - 15kV)
ESD (HBM) (for network pins)	8kV
Common Mode range (0 – 60Hz)	277Vrms with Transformer-isolated coupling +/-40V with Non-isolated/Grounded coupling
Conducted RF immunity (IEC 61000-4-6)	Designed to comply with 61000-4-6 Level 3 (10Vrms)
I/O	4 digital I/Os and 1 digital input without a microcontroller (5V tolerant)
Pyxos Host Microcontroller Interface	SPI (Serial Peripheral Interface)
Pyxos Pilot Power Supply Output (VDD)	3.3V ±10%
Operating Temperature	-40C to +85C
Package	20 Pin QFN 5 x 5 mm package

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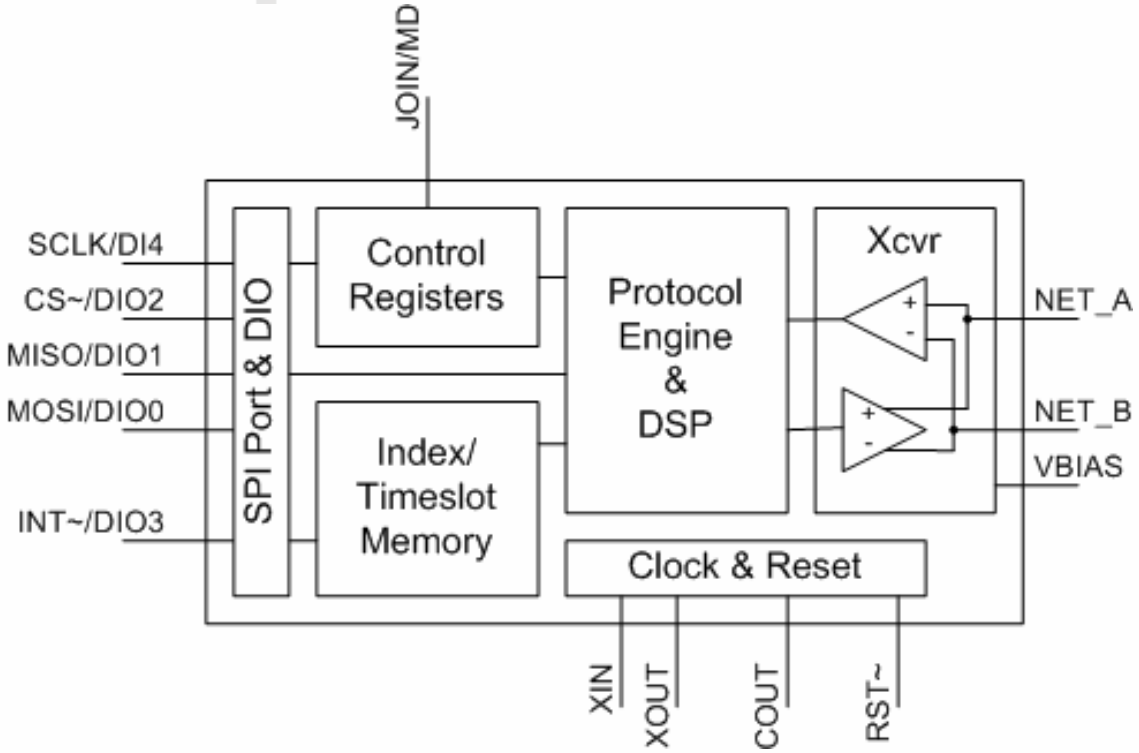
Pyxos Chip Block Diagram



- A Pyxos chip can be configured as a Pilot or a Point
- SPI port pins for a hosted Point and I/O pins for an unhosted Point are shared

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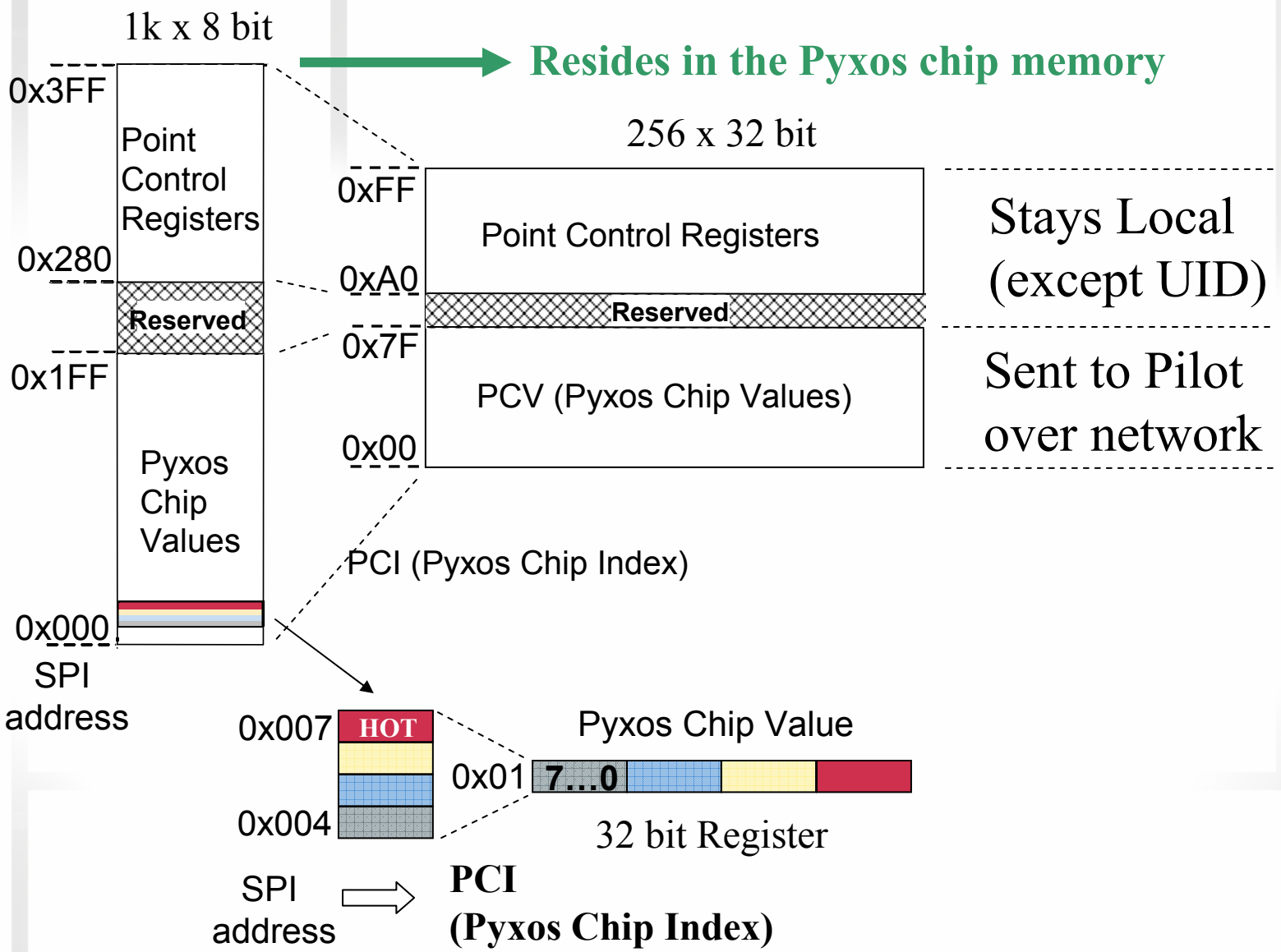
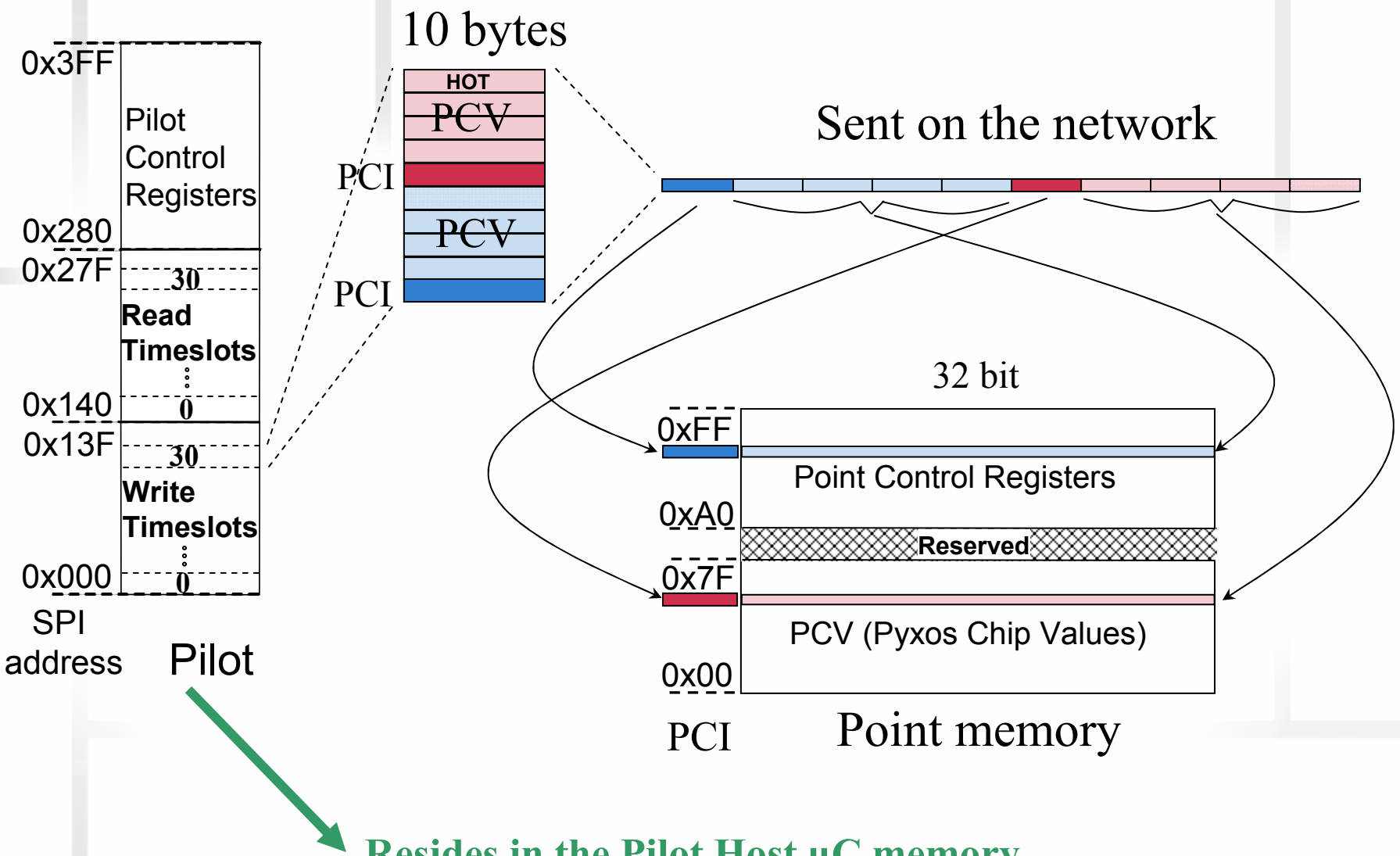
Pyxos FT

Link Layer Protocol Overview

Pyxos Point Memory Map



Pyxos Pilot Memory Map



Resides in the Pilot Host µC memory

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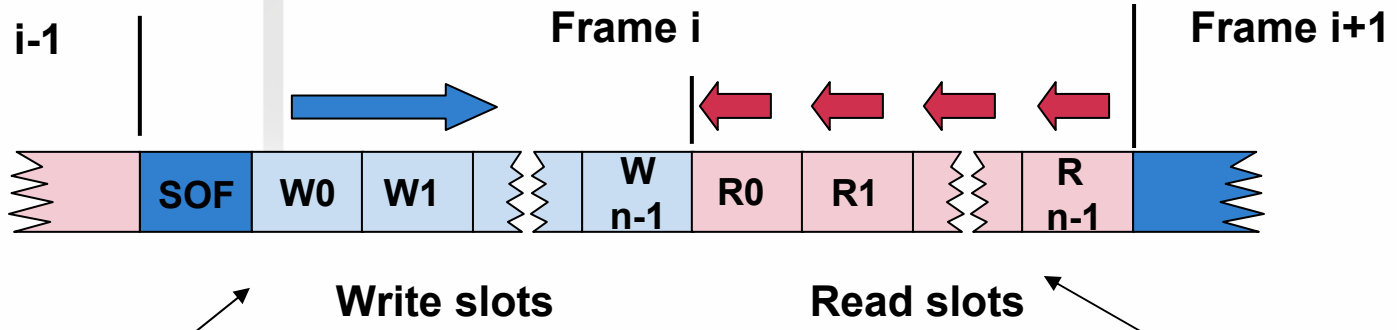
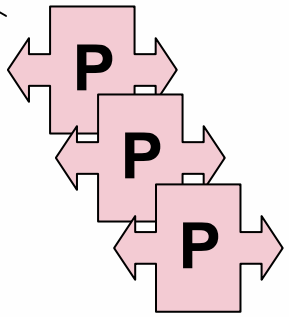
Pyxos Network Frames



Description	time
Start of Frame	278.4 us
Write timeslot	355.2 us
Read timeslot	416 us
Frame time (2 slots)	1.8 ms
Frame time (32 slots)	25 ms



- **Frames are sent continuously in Pilot Auto mode**
  - Frames can be sent manually to save power
- **Each frame has both read and write slots**
- **Frame rate depends on the number of slots**

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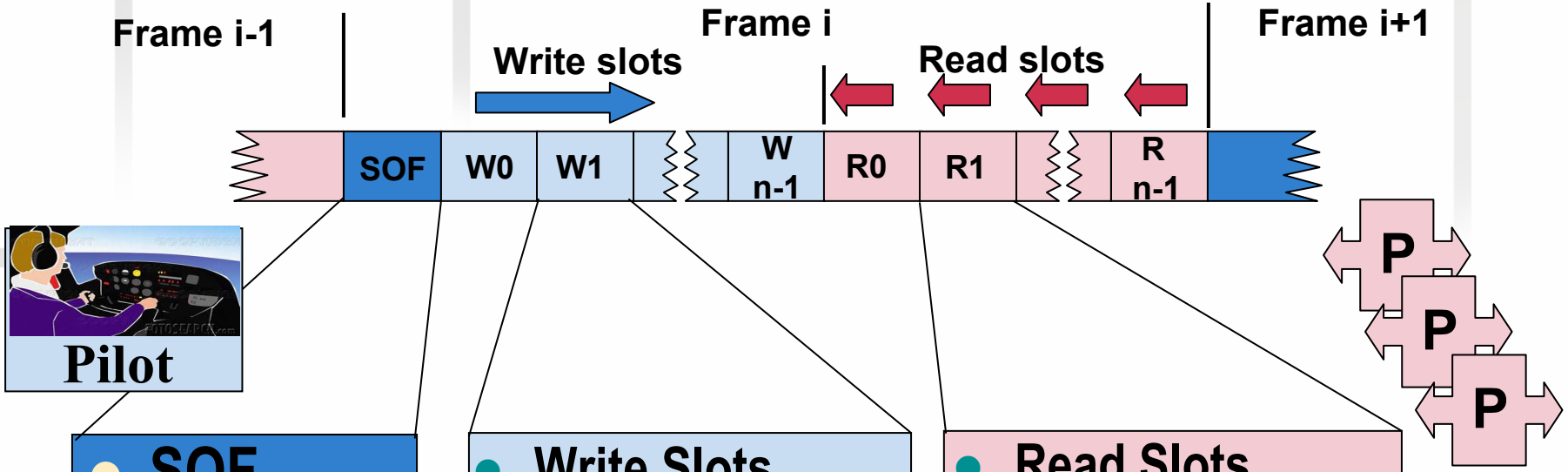
Pyxos Network Frame Contents



- **SOF**
  - Synch
  - # slots
  - CRC18
- **Write Slots**
  - 2*[PCI,PCV]
  - TID flag
  - ACK flag
  - ACKd TID flag
  - CRC18
- **Read Slots**
  - Synch
  - 2*[PCI,PCV]
  - TID flag
  - ACK flag
  - ACKd TID flag
  - CRC18

Note: TID - Transaction IDentification

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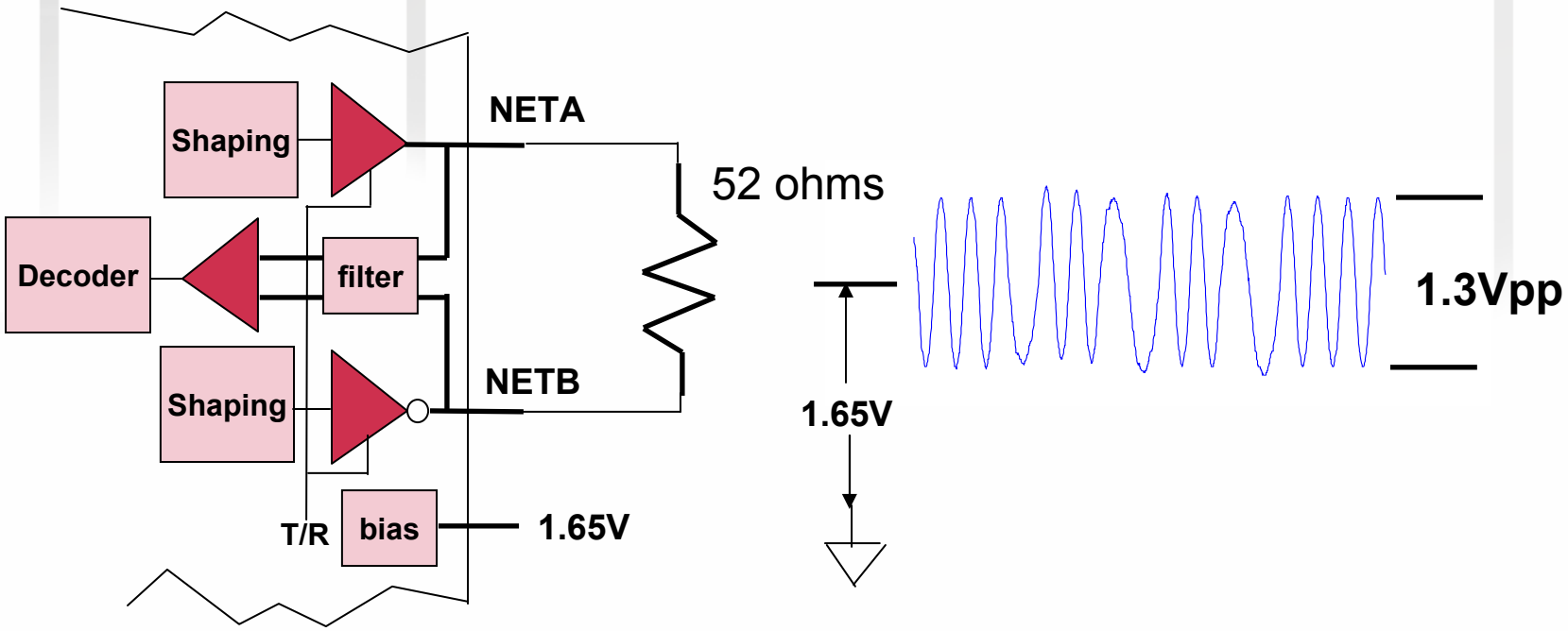
Hardware Design Considerations

Pyxos Chip Transceiver



- Differential transmit output impedance ~ 120 ohms
- Differential receive input impedance ~ 13k ohms

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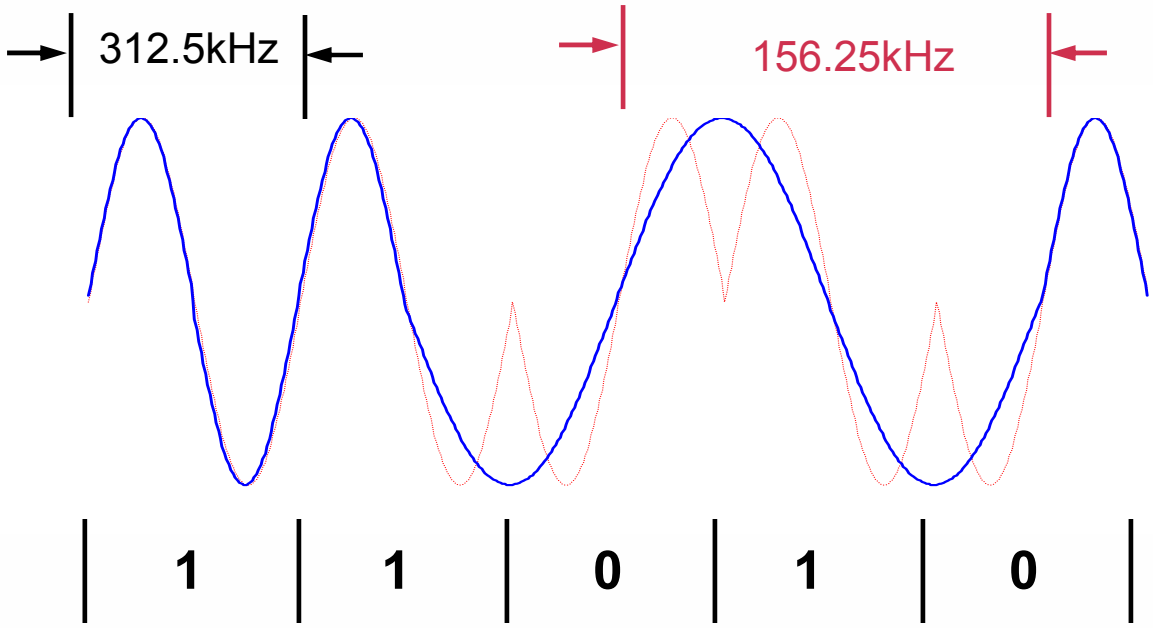
Pyxos Modulation Format

- **Manchester**
  - Biphase PSK with $F_c=F_b$
  - Shaped to minimize reflections
  - Each bit is 1 cycle of 312.5 kHz
  - Preamble coding makes the channel polarity independent



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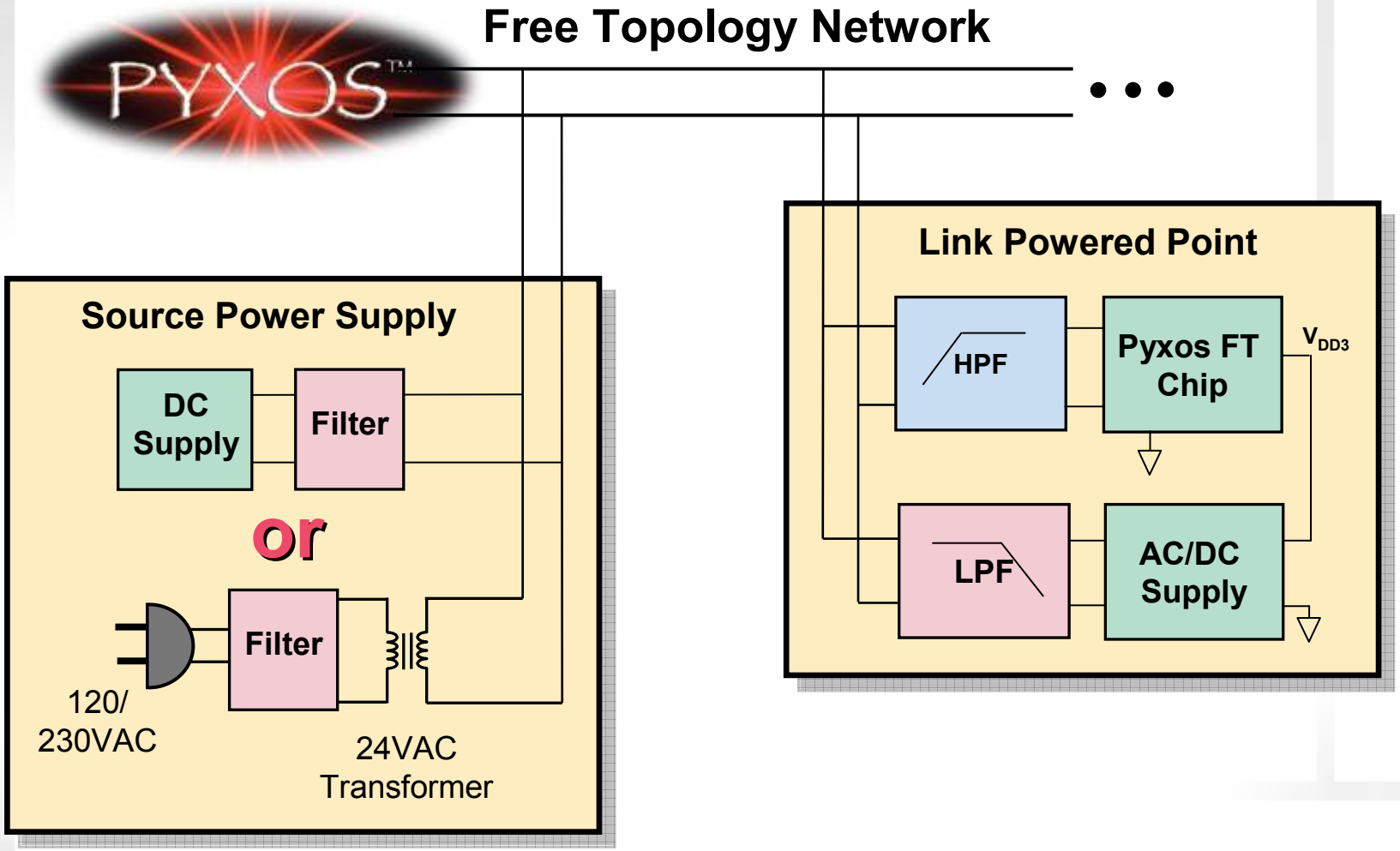
Link Power Concept



Pyxos Link Power – Supports 24VAC or 24VDC for Link Power

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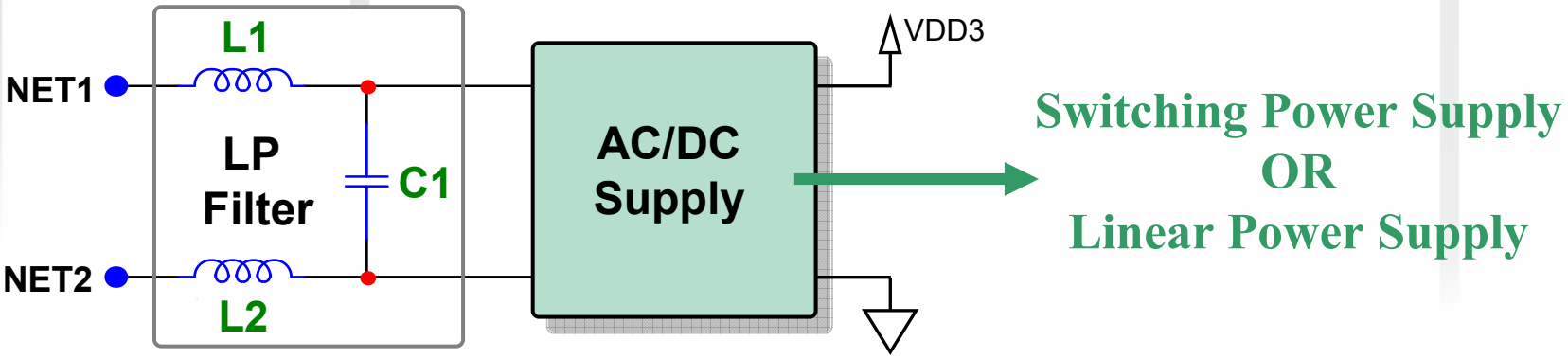
Link Power – Point Power Supply

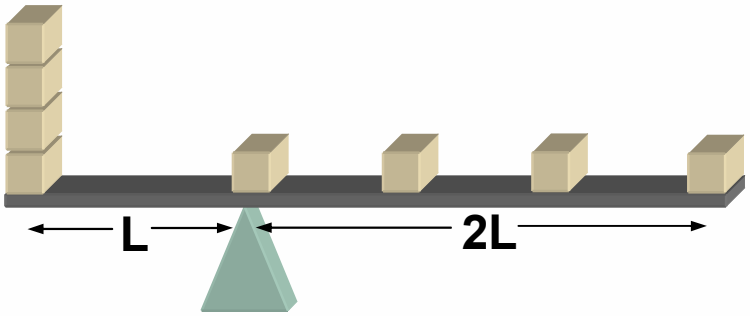


Parameter	Switching Power Supply		Linear Power Supply	Units
Input Voltage Range	8.5V – 40V		8.5V – 40V	V
Output Voltage	3.3V ±10%		3.3V ±10%	V
Approximate Cost	~1.75		~0.75	$@10k
Application Current	100	35	15	mA
Power Unit Loading	1	½	½	PULs

- A Pyxos link powered network can support up to 32 PULs
- Reference designs available for both switching and linear power supplies

Link Power – Power Limited Distance

- **Factors that affect power limited distance**
  - Wire size
  - Bus or Free topology
  - AC or DC power source
  - Number of Power Unit Loads (PULs) on each segment from the power source
  - Distribution of PUL's on each segment
- **Initially assume all PULs at end of segment**
- **Uniform PUL distribution doubles the distance**



- **Think of the distance to the "center of gravity" of the PULs on a segment**

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Link Power – Maximum Distance

- Length to "center of gravity" of each leg from power source

Distance (m)	Belden 8471 Cable				Cat 5 Cable			
	Bus		Free		Bus		Free	
PULs	AC	DC	AC	DC	AC	DC	AC	DC
4	400	400	100	100	115	133	71	100
8	330	400	100	100	54	66	35	61
12	208	263	100	100	34	43	24	41
16	145	195	100	100	24	32	17	30
20	108	155	86	100	17	25	14	24
24	84	126	71	100	13	20	11	20
28	67	108	61	100	11	17	10	17
32	52	92	52	92	8	15	8	15

- Assuming maximum average wire temperature of 55°C
- Above table assumes all PULs at same point; Link Power distance can be increased by distributing the loads

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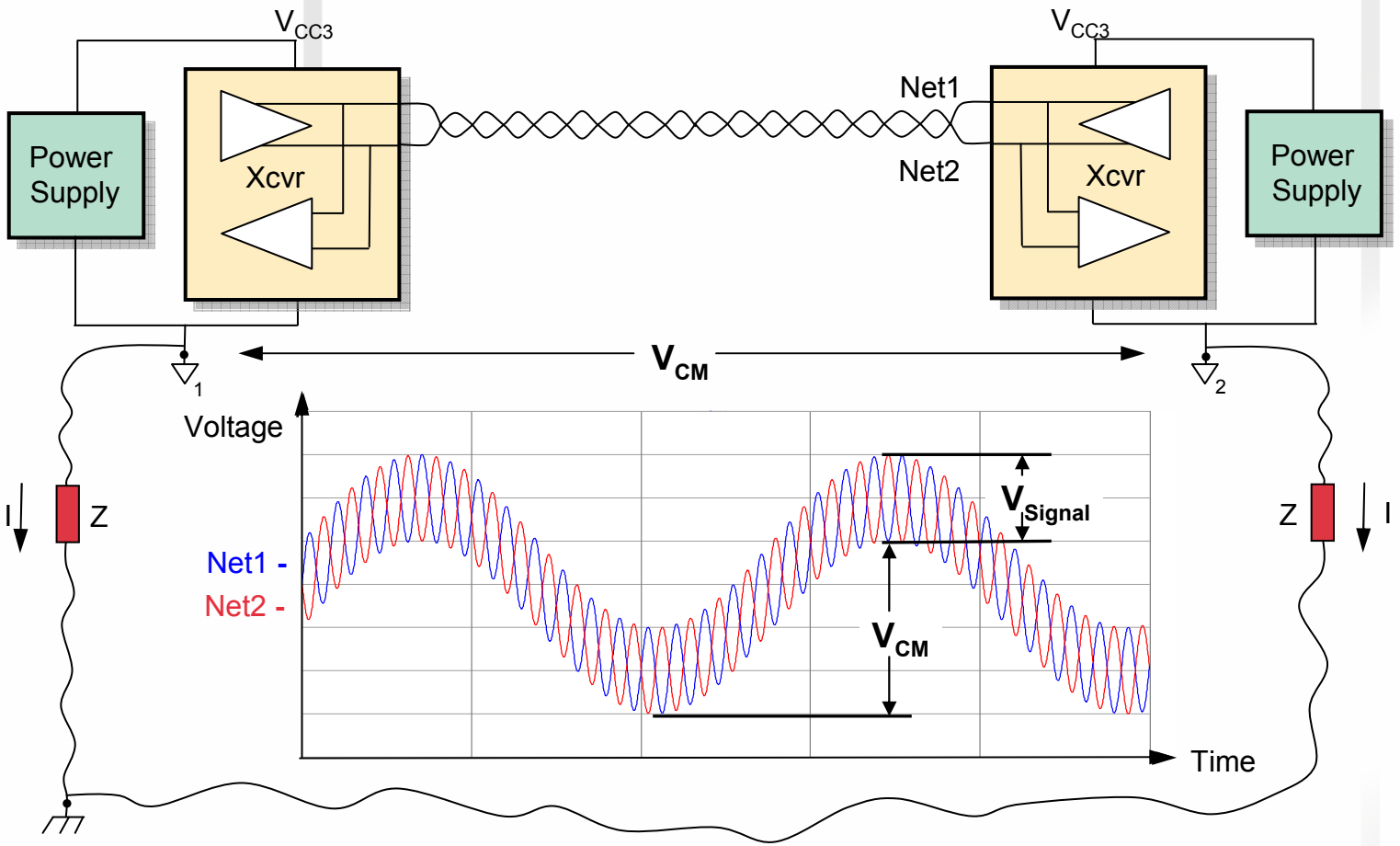
What is Common Mode Noise?



- **"In practical systems, ground potentials vary widely from node to node, often exceeding the [RS485, +12 -7V] specified range" -** Linear Tech Design Note 228
- **"Many applications see common-mode voltages beyond this range, such as +/-24V "**
  - National Semiconductor Application Note 979

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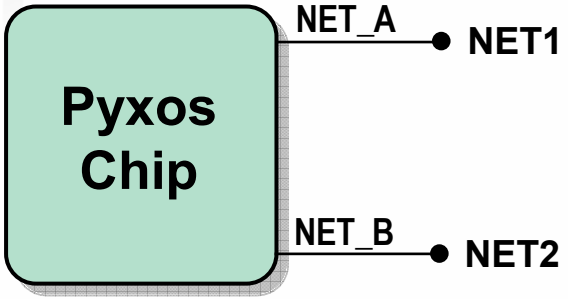
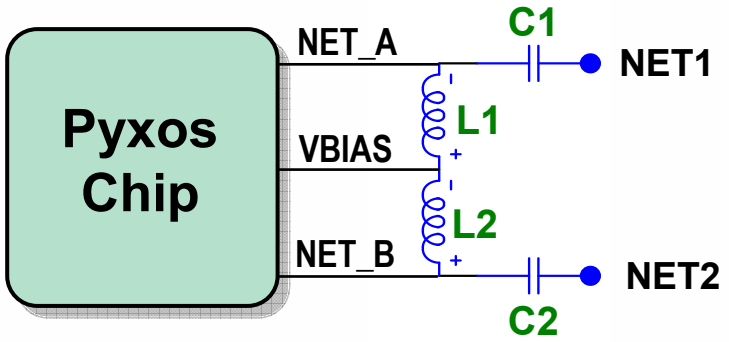
Multiple Network Coupling Options

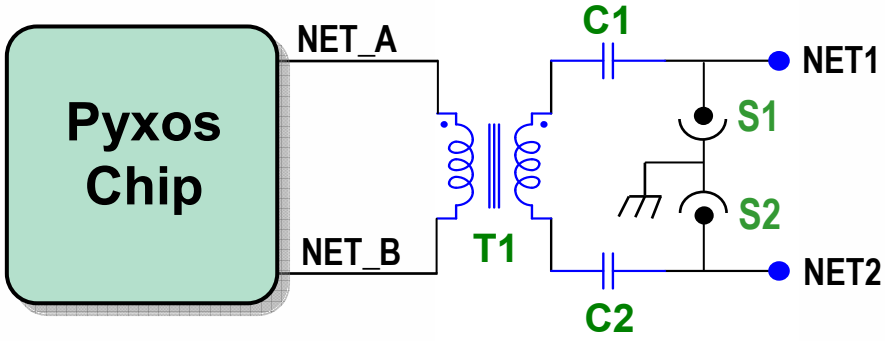
- Pyxos FT technology covers a wide range of common mode requirements with multiple coupling options



Direct Connect



Non-Isolated and Floating



Transformer-Isolated

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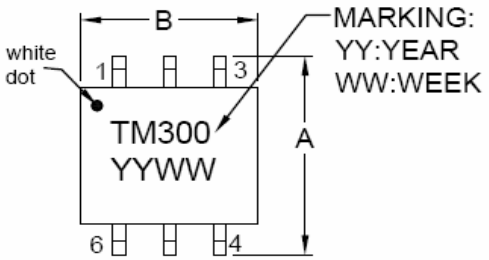
Coupling Transformer Information

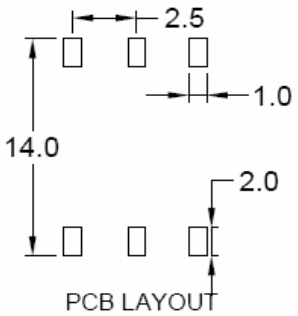
- **Transformers available directly from** Transtek Magnetics

Magnetics products for a changing world.™

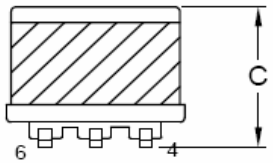
1. DIMENSIONS(UNIT: mm)



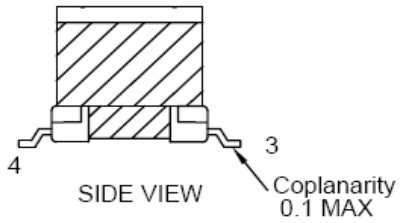
TOP VIEW



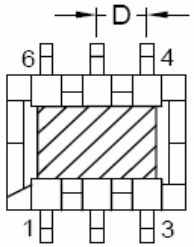
PCB LAYOUT



FRONT VIEW

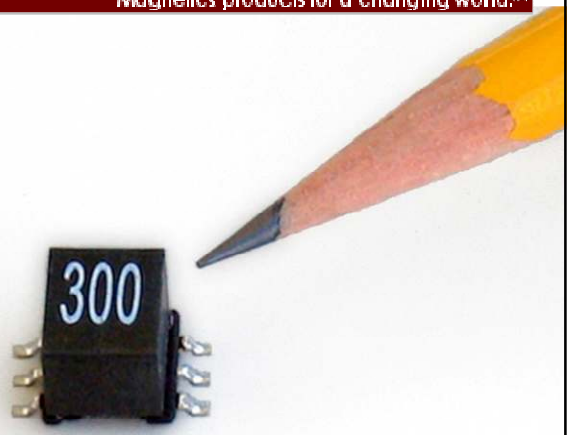


SIDE VIEW



BOTTOM VIEW

A= 14.0 MAX
B= 11.0 MAX
C= 10.0 MAX
D= 2.50 ± 0.3



TMS80040CS

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Coupling Option Summary

Coupling Type	Application	Node Power	Node Grounding	CMR DC-60Hz	CMR >100kHz	~Coupling Cost $@10k
Direct	Same Box	Common	Common	0-VCC3	0-VCC3	0.00
Non-Isolated	Network	Link or Local	Local	+/-40V	1VRMS	0.15
Floating	Network	Link or Local	Floating	Isolation Limit	10VRMS	0.15
Transformer Isolated	Network	Link or Local	Local	277VAC	10VRMS	0.35

Superior to RS485 in most application environments

Superior to RS485

Dramatically superior to RS485

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Pyxos IC Immunity and ESD Test Results

Test	Transformer-Isolated	Non-Isolated		Direct Connect	
		Device GND is Earth Grounded	Device GND Floating	System GND is Earth Grounded	System GND Floating
EN 61000-4-2 ESD	TBD	TBD	TBD	TBD	TBD
EN 61000-4-3 Radiated RF	10V/m (Level 3)	10V/m (Level 3)	10V/m (Level 3)	10V/m (Level 3)	10V/m (Level 3)
EN 61000-4-4 Network Burst	2kV (Level 4)	2kV (Level 4)	2kV (Level 4)	2kV (Level 4)	2kV (Level 4)
EN 61000-4-5 Network Surge	2kV (Level 3)	2kV (Level 3)	2kV (Level 3)	N/A	N/A
EN 61000-4-6 Conducted RF	10Vrms (Level 3)	1Vrms (Level 1)	3Vrms (Level 2)	1Vrms (Level 1)	3Vrms (Level 2)
CISPR 22 Radiated EMI	Level A	Level A	Level A	Level A	Level A

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Immunity & EMI Test Summary

- Transformer-Isolated devices are the most robust
- Lower-cost Non-Isolated devices are robust enough for many applications, and have better 60Hz common-mode noise rejection than most RS-485 transceivers
- The immunity of Non-Isolated devices is improved by floating the device's logic ground with respect to Earth ground

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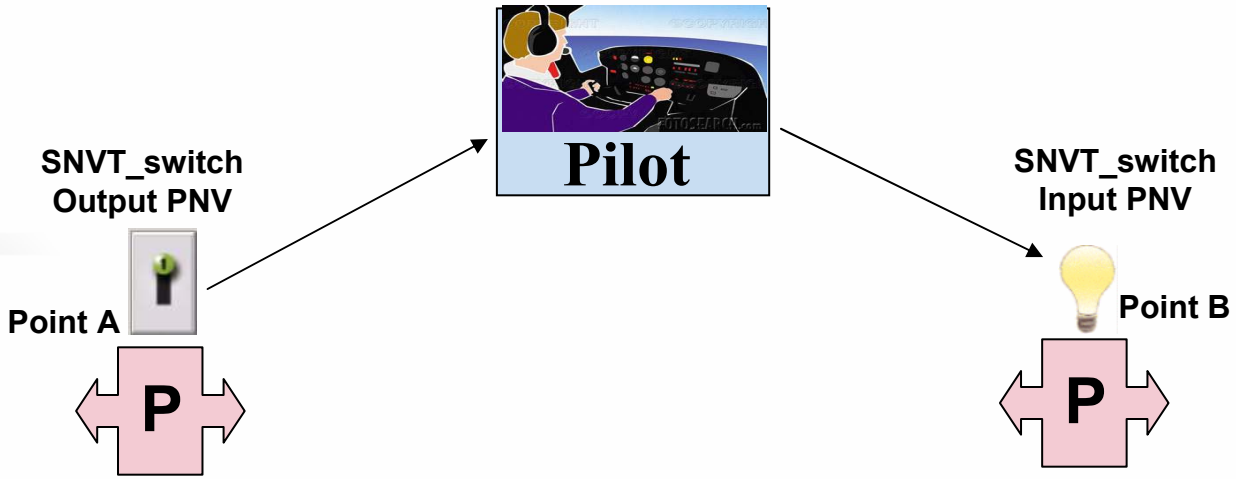
Pyxos FT

System Design & Application Development

Pyxos Network Variables (PNVs)

- **Network data is passed using Pyxos Network Variables**
- **Each Pyxos Network Variable has**
  - Direction
  - Size
  - Format
- **PNVs defined by the Point**
  - The collection of PNVs defines a Point's interface
  - Point sends output variables to Pilot
  - Pilot updates input variable on Points
- **Each Point can have up to 128 PNVs of four bytes each or longer PNVs with proportionate reduction in # of PNVs**



Pyxos Network Variables (contd.)

- **Uses rich set of standard data types defined by LonMark® and Echelon**
  - Builds on wealth of extensive work
    - Standard Network Variable Types (SNVTs)
    - Standard Enumerations and Language Strings
  - Standard definitions represent the wide variety of data types used in control systems
- **Manufacturers can provide standard descriptions of their devices defining their interfaces for use by other manufacturers' devices**
  - Expands the applicability of products to a bigger ecosystem

Point Registration Overview

- **Registration is the process of assigning every point a slot and informing the pilot what points are present**
- **Every Point must be assigned a unique slot**
  - Slot numbered 0 – 31
- **Registration uses a combination of:**
  - Pyxos chip built-in protocol
  - API firmware available from Echelon
  - Host Application Code
- **Uses factory assigned UID**
  - 48 bit unique ID
- **Uses User assigned PID**
  - A 64 bit program ID identifies what kind of node it is
    - Unhosted nodes all have zeros for the program ID

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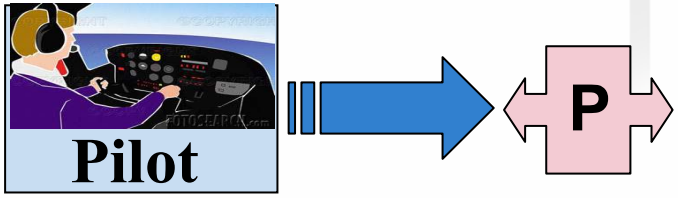
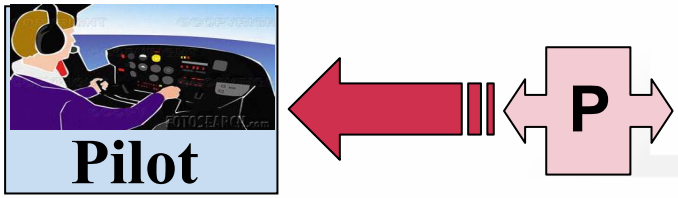
Point Registration Schemes

- **Auto**
  - Pilot assigns unique slot to point
  - Hosted points
  - No user intervention

- **Manual**
  - Pilot assigns slot to point
  - Must be used for unhosted points
  - Multiple points can have same PID
  - User intervenes
    - to help identify points



- **Hardwired**
  - Point assigns itself a unique slot
    - Hosted points have preassigned slots
  - Pilot must know about it
  - No user intervention



Auto and Hardwired registration create truly self-organizing network

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Pyxos System Design

- **Pilot**
  - Designed for a particular type application
  - Knows the types of Points in the system
    - How to register them
    - How they interact
- **Points**
  - Send data to Pilot and receive data from Pilot
  - No system knowledge
  - May be used in many types of applications

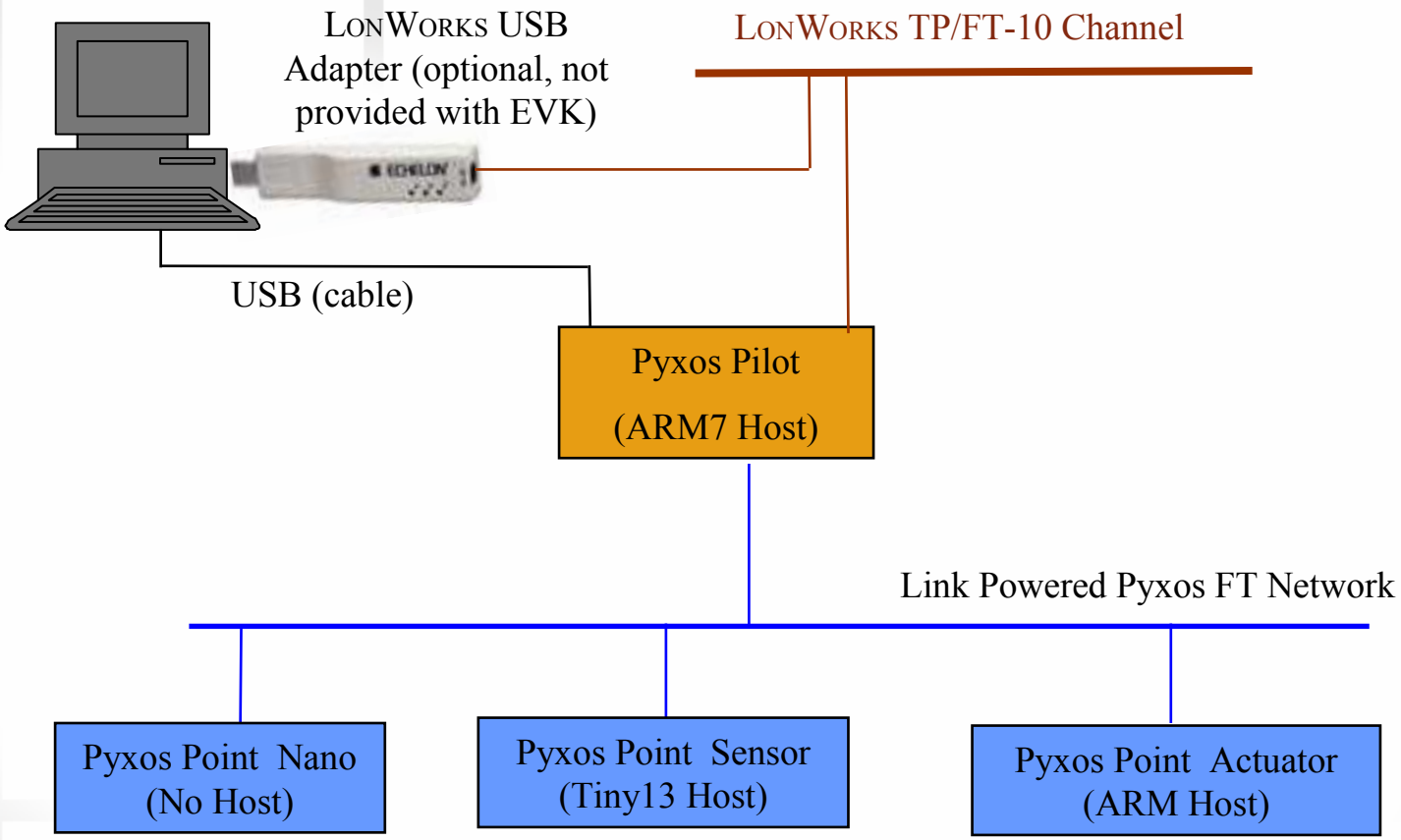
Pyxos System Design Tradeoffs

- **Closed/Open**
  - Closed systems may be simpler to design
  - Open systems benefit from volume of third party components
- **Static/Dynamic**
  - Dynamic systems allow for use in more applications
    - Varying number of Points of each type
    - Richer set of operations
    - User intensive setup/registration
  - Static systems allow for easier setup
    - No user interaction required
    - Difficult to expand

Product Offering

- **Pyxos FT Network Chip**
- **Pyxos EVK Evaluation Kit**
  - Reference designs and Functioning Evaluation boards
    - Pyxos Points (Nano, Sensor, Actuator), Pyxos Pilot Nodes and Link Power Supply
  - Pyxos Pilot & Pyxos Point API software
    - Pyxos Point API for a host processor
    - Pyxos Pilot API for a host processor
  - Development tools
    - Example Application code
    - Pyxos Application Configuration Utility

Pyxos EVK Overview



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Pyxos EVK Highlights

- **Create & demonstrate**
  - Simple standalone Pyxos networks
  - Easy integration to LONWORKS networks
- **Demonstration of specific capabilities**
  - Deterministic response time for each Pyxos Point
  - Automatic binding of Pyxos network variables
  - Monitoring and control of Pyxos Points
  - Easy LONWORKS integration
  - Ease of installation methodology (Hardwired, automatic & plug-press-and-play)
- **Secure network access**
  - Detection of new, removed, or failed Pyxos Points

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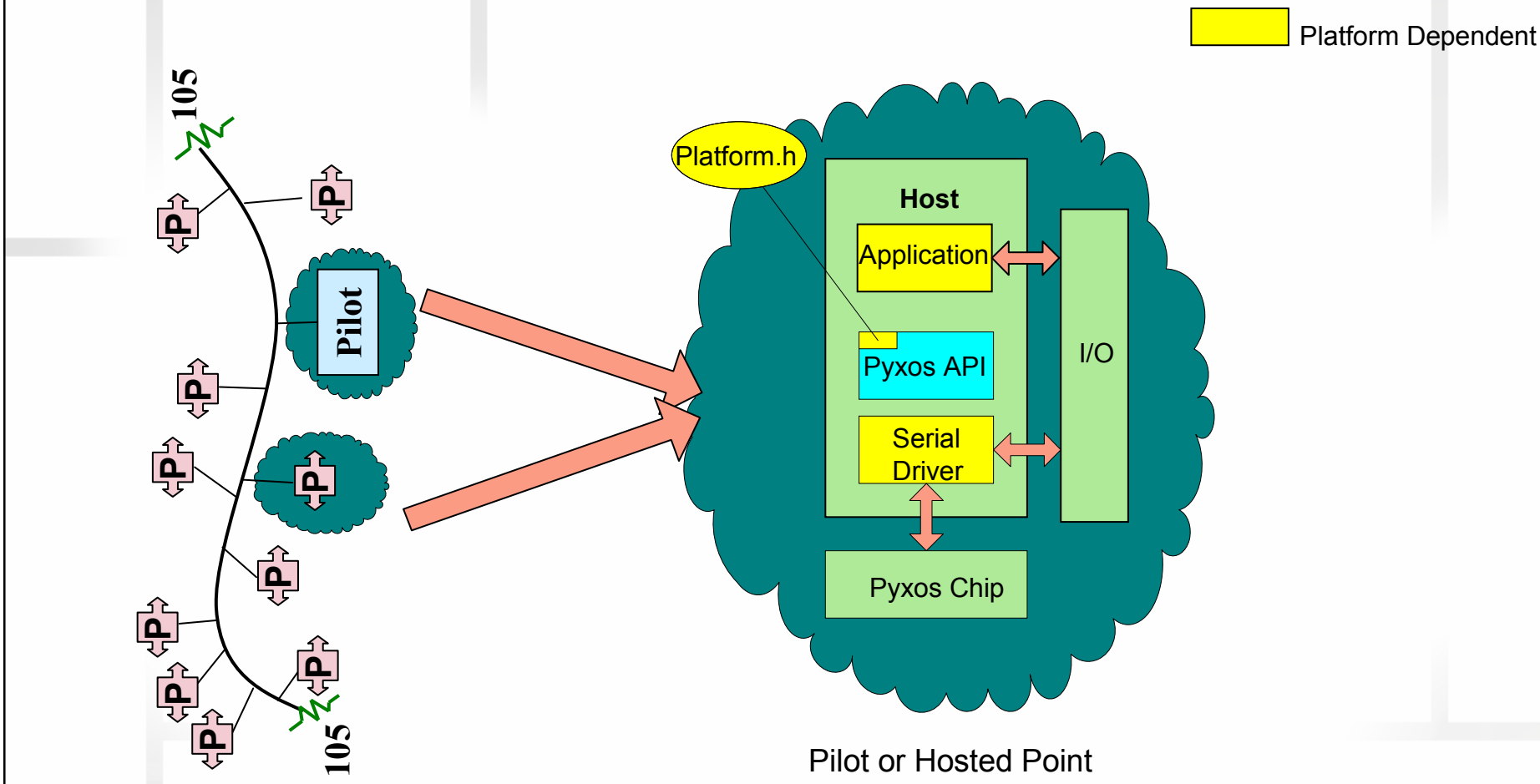
Application Development



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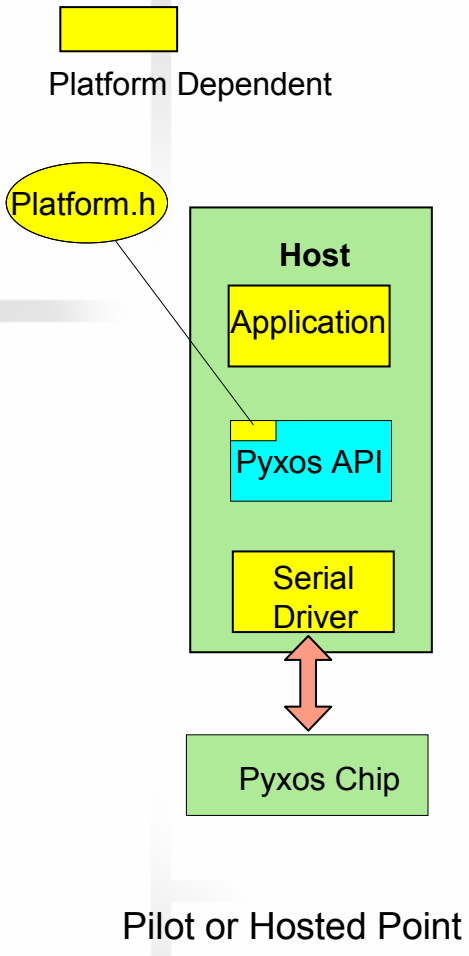
Application Development (contd.)



- **Source code (ANSI C) provided for**
  - Pyxos EVK application
    - Pilot – Room controller
    - Point – Sensor and actuator
  - Pyxos API
    - Only Platform.h needs to be updated for platform dependent data type definitions
  - SPI serial driver
- **Platform used**
    - Pilot (and Actuator Hosted Point) – Atmel ARM7
    - Sensor Point – Atmel AVR Tiny 13
- **New application development**
  - Update source code for new platform (all highlighted yellow)
  - Update application code for new application
  - Compile the code for new platform

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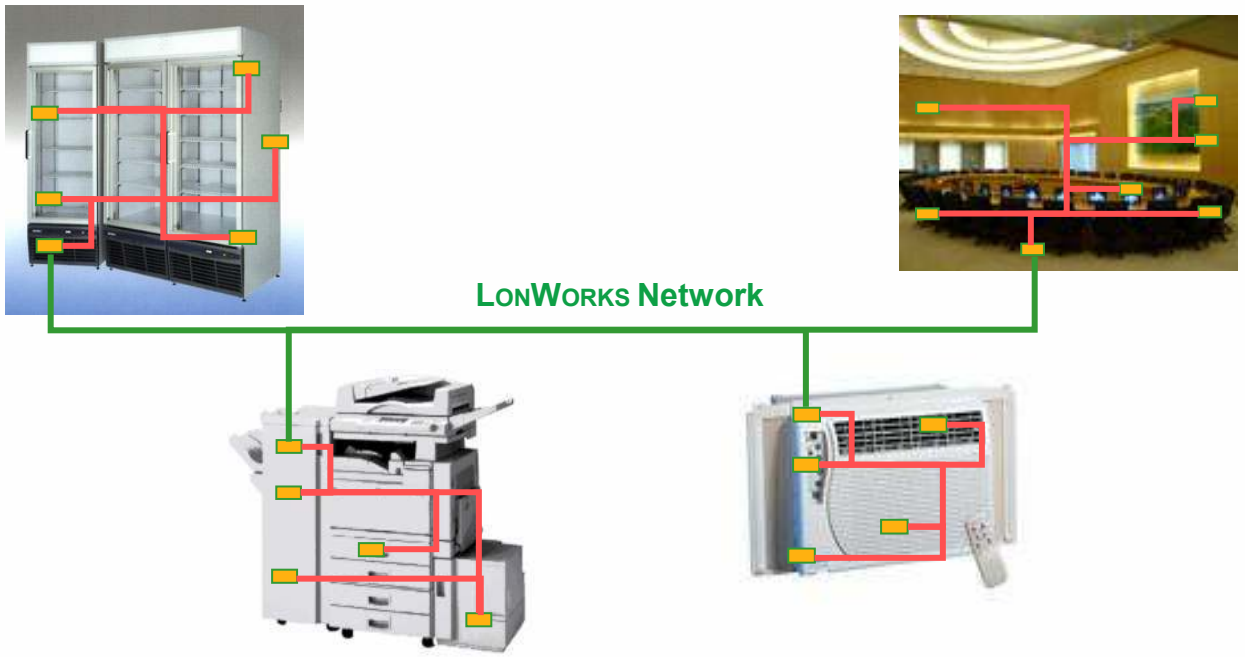
Extending Beyond Pyxos Networks

- **Multiple machines with Pyxos embedded networks are aggregated using a LonWorks control network**



- **Seamless integration with LonWorks**
  - Both Pyxos and LonWorks use same standard data type definitions

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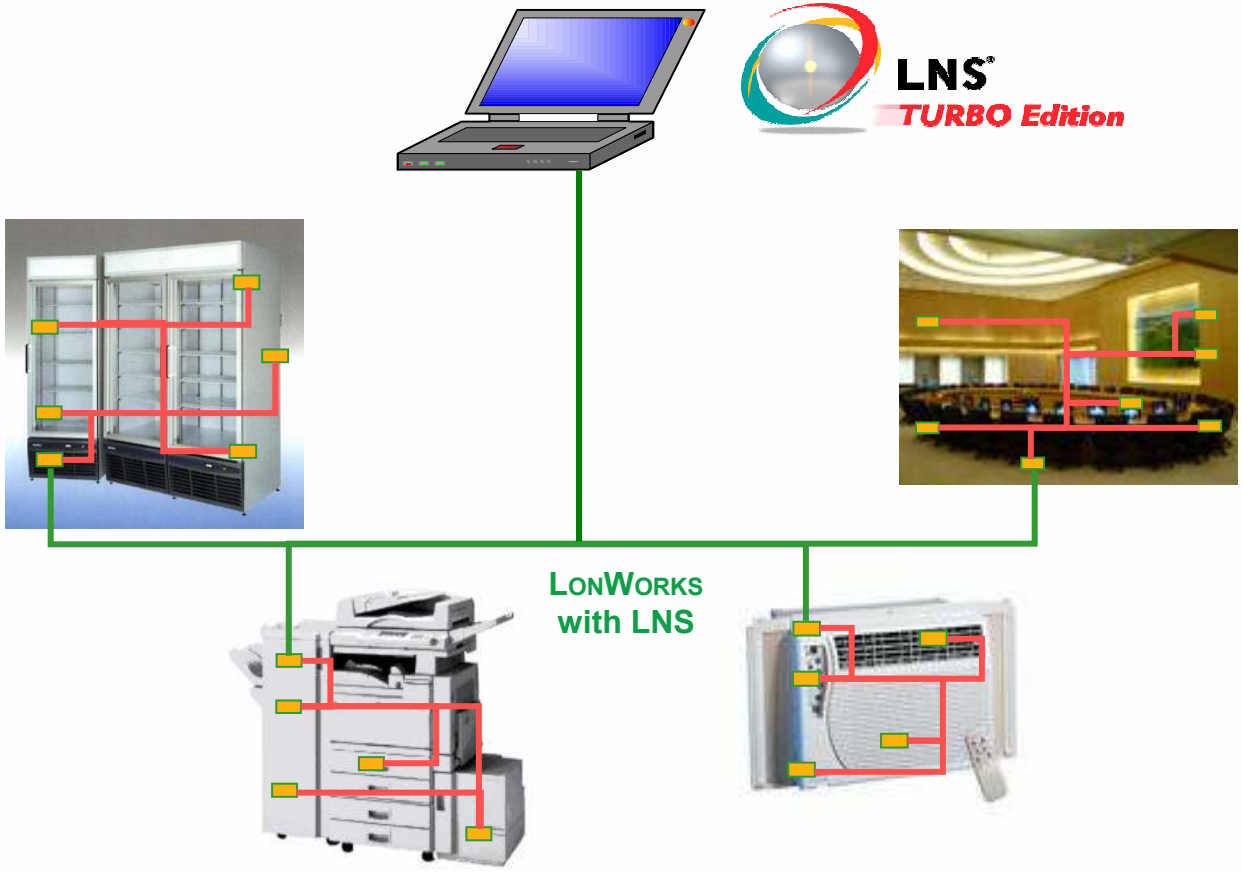
Leverage the LONWORKS Platform to Add Sophisticated Features

- Sophisticated systems can be engineered using an LNS® based tool such as the LonMaker® Integration Tool



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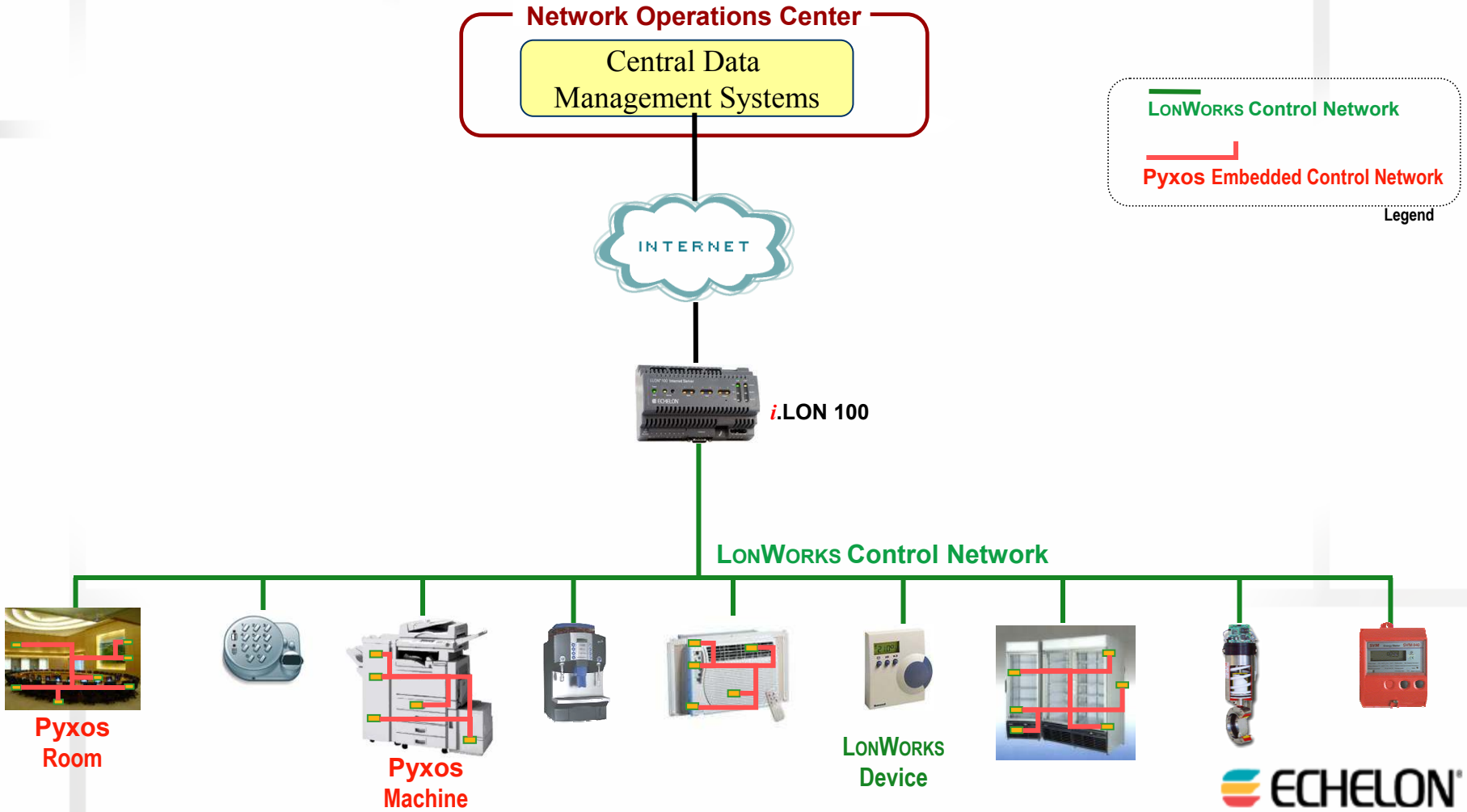
Pyxos & LonWorks
A Complete Control Ecosystem

- **Interface with the Internet and beyond using the Pyxos and LonWorks platforms**



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Pyxos FT

Features Comparison with Other Technologies

Key Benefits

- **Pyxos chip includes protocol**
  - Most competing technologies leave the burden of protocol development to developer (RS-485, CAN, Zigbee)
- **Robust communication built into**
  - Physical layer
    - High common mode noise rejection and interference immunity
    - High ESD and electrical disturbances immunity
  - Higher layers
    - Forward Error Correction of up to 2 bits;18 bit CRC error detection
    - Fully acknowledged transactions with automatic retries
- **Self-organizing**
  - Automatic and hardwired registration modes represent truly self-organizing network
- **Cost-effective**
  - Unhosted Points provide digital I/Os without the use of a host microcontroller
  - Hosted Points and Pilot provide complete flexibility to chose any microcontroller based on application requirement

Technology Comparisons

Feature	Pyxos	CAN	AS-I	LIN
Self-organizing network * (Left as an exercise for the developer)	☑	☒*	☒	☒
Deterministic operation * (Unbounded latency for messages with the same arbitration preamble)	☑	☒*	☑	☑
High-speed signaling * (19.2kbps maximum)	☑	☑	☑	☒*
≤25ms response time	☑	☑	☑	☒
Direct digital I/O without a microcontroller * (Requires either an integrated or external microcontroller)	☑	☒*	☑	☒*
Designed for multiple media * (Other media require gateways or additional modem IC)	☑	☒*	☒	☒*
Free topology wiring up to 100 meters, bus topology 400 meters	☑	☒	☒	☒
High common mode immunity * (Requires external isolation components at added cost)	☑	☒*	☑	☒
Power and data combined on polarity-insensitive wire pair * (Wiring is polarity-sensitive and relies on cable profile and connectors to avoid miswiring)	☑	☒	☒*	☒
18-bit packet cyclic redundancy check (CRC) * (One byte checksum) ***(Parity)	☑	☑	☒*	☒*
Automatic retry on CRC error * (Messages may be lost without detection)	☑	☑	☑	☒*
Open API for Pilot / controller interoperability * (Varies by supplier - different implementations are not interoperable)	☑	☒*	☑	☒
Seamless interface to LONWORKS networks	☑	☒	☒	☒
Internet options including tunneling and SOAP/XML messaging	☑	☒	☒	☒

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Technology Comparisons (cont'd)

Feature	Pyxos	DALI
Self-organizing network * (Requires a network manager and network database to configure the network and make changes)	☑	☒*
Deterministic operation * (Unbounded latency for messages with the same arbitration preamble)	☑	☑
High-speed signaling * (1.2kbps maximum)	☑	☒*
≤25ms response time	☑	☒
Direct digital I/O without a microcontroller * (All DALI nodes require a microcontroller)	☑	☒*
Designed for multiple media	☑	☒
Bus topology 400 meters * (300 meter maximum total wire)	☑	☒*
High common mode immunity * (Subject to significant noise issues especially at longer distances)	☑	☒*
Power and data combined on polarity-insensitive wire pair	☑	☑
18-bit packet cyclic redundancy check (CRC)	☑	☒
Low cost nodes	☑	☑
Seamless interface to LONWORKS networks * (DALI networks are not extendable – they require a gateway into BAS systems or once the maximum number of nodes has been reached)	☑	☒*
Internet options including tunneling and SOAP/XML messaging * (There is no DALI infrastructure for interfacing with the Internet or Web services based applications)	☑	☒*

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Technology Comparisons (cont'd)

Feature	Pyxos	Zigbee	Z-Wave
Low-cost node	☑	☑	☑
Self-organizing network	☑	☒	☒
Robust communication in the face of noise and impairments	☑	☒	☒
Designed for multiple media	☑	☒	☒
Interoperable hybrid wired and wireless networks	☑	☒	☒
Open standard protocol between devices	☒	☒	☒
Open standard protocol between Pilot / controllers	☑	☑	☒
Open Pilot / controller API	☑	☒	☒
Standardized object models	☑	☒	☒
Ecosystem for small and large system architectures	☑	☒	☒
Seamless interface to LONWORKS networks	☑	☒	☒
Internet options including SOAP/XML	☑	☑	☒

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Technology Comparisons (cont'd)

Feature	Pyxos	RS-485
Self-organizing network	☑	Protocol not included; depends on which protocol used
Deterministic operation	☑	
≤25ms response time	☑	
High-speed signaling	☑ 312.5kbps	Variable
Direct digital I/O without a microcontroller	☑	☒
Bus topology distance	☑ 400m	Variable Distance
Free topology	☑ 100m	☒
High common mode immunity * (three out of four coupling options provide same or better common mode noise rejection)	☑*	Variable dependent on how expensive RS-485 used
Power and data combined on polarity-insensitive wire pair	☑	☒
18-bit packet cyclic redundancy check (CRC)	☑	☒
Error Correction for up to 2-bit errors per packet	☑	☒
Low cost nodes	☑	Variable
Simple interface to LONWORKS networks	☑	☒

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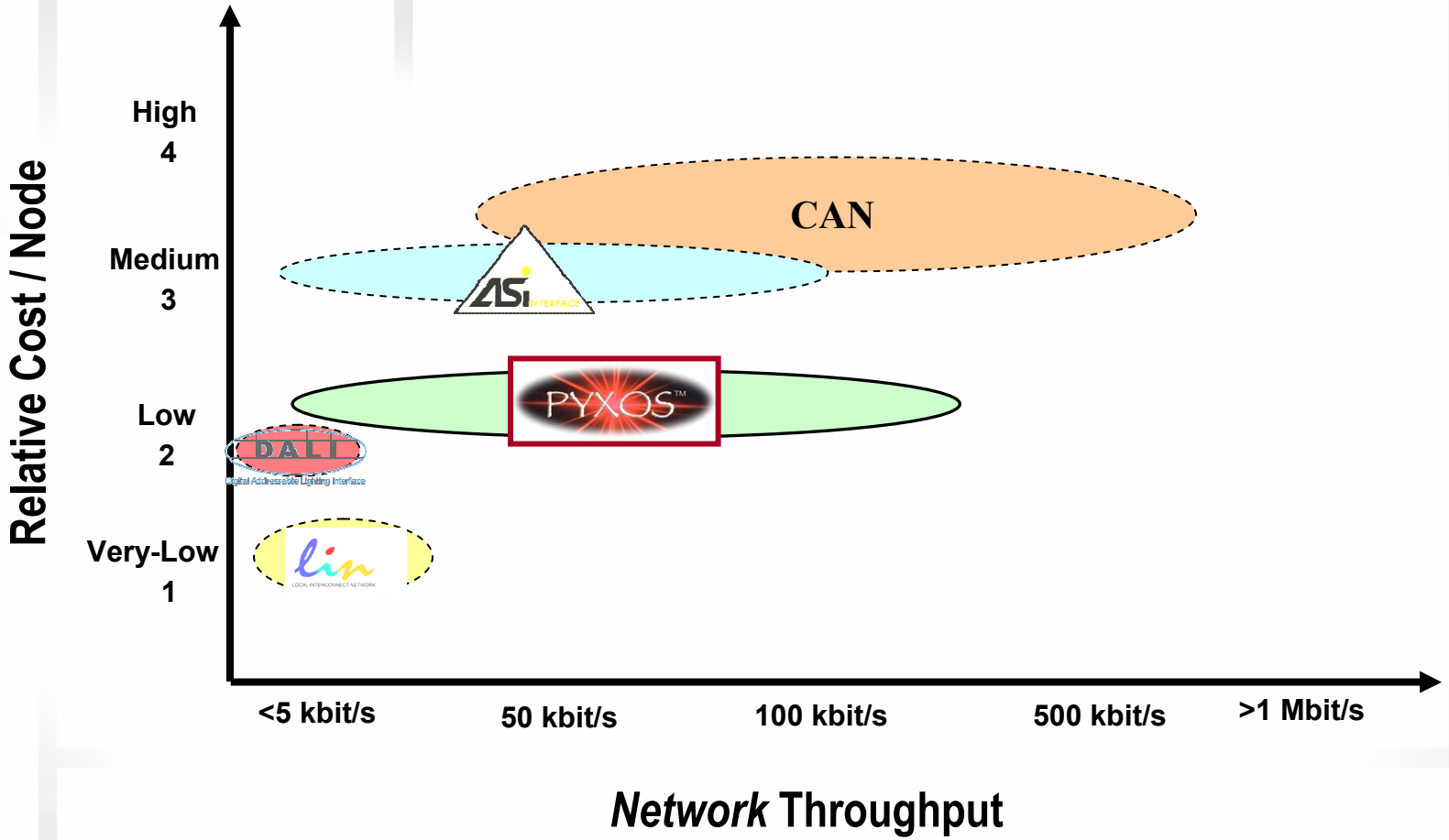
Technology Comparisons

Pyxos Networks Price/Performance Advantage



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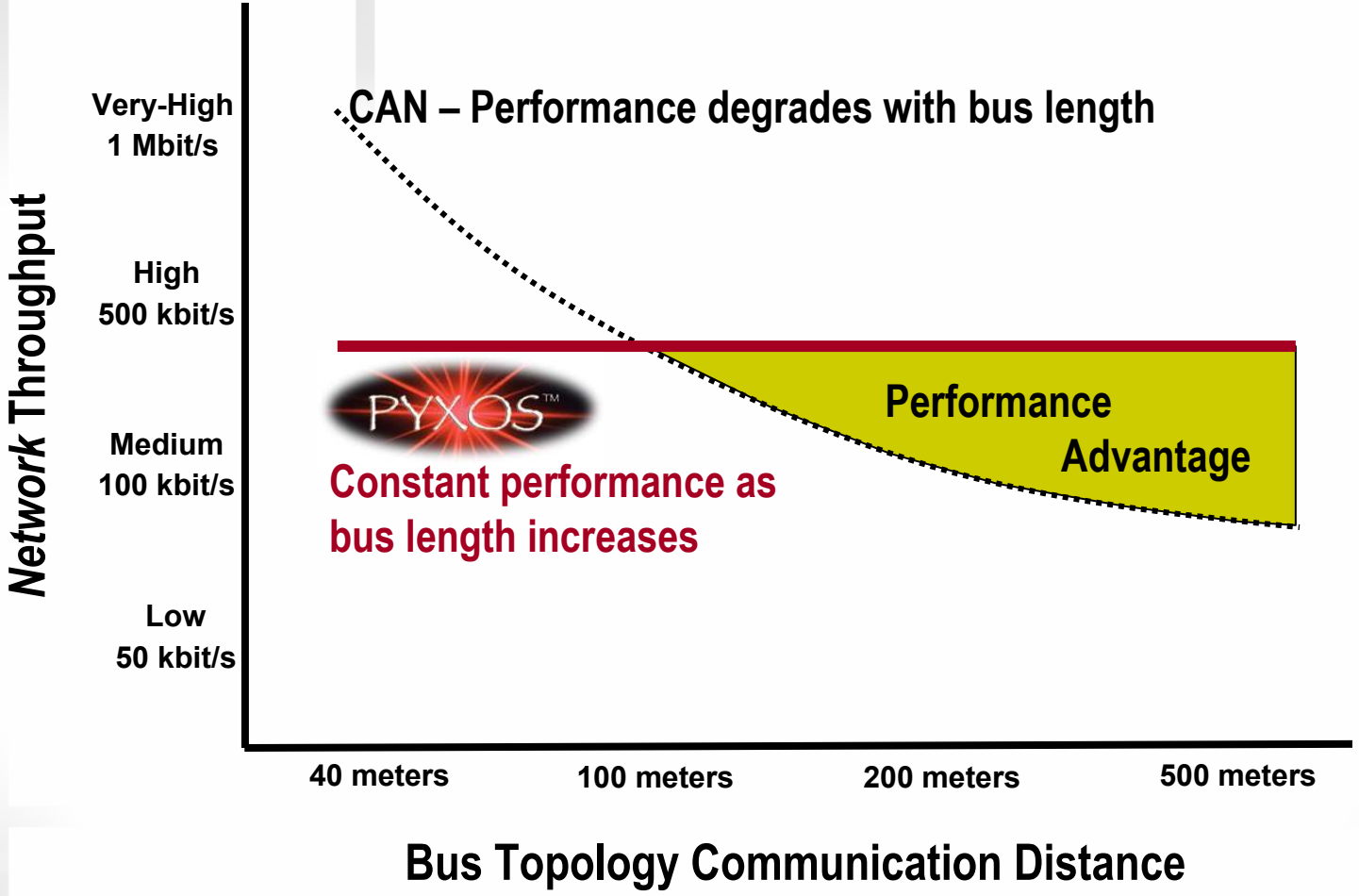
Technology Comparison

Pyxos vs. Controller Area Network (CAN)



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Summary

- **Pyxos networks uniquely meet the needs of sensor and I/O networks**
  - Extending control applications
  - Embedded control inside machines
- **Pyxos networks are**
  - Deterministic (less than 25ms response time)
  - High Speed (312.5kbps)
  - Highly robust
    - Forward error correction and 18 bit CRC error detection
    - Exceptionally high common mode and magnetic noise immunity
  - Self-organizing
- **Pyxos network communication chip**
  - Includes protocol
  - Is very inexpensive