Simplifying Multiprotocol Industrial Ethernet Communication

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December 2016
Agenda

• Introduction to Industry 4.0

• Need & Challenges with Deterministic Industrial Ethernet

• Changes in Industrial Drives & focus on Industrial Ethernet

• Programmable Real-Time Unit and Industrial Communication Subsystem (PRU-ICSS)

• Sitara™ application processors with PRU-ICSS support
What is Industry 4.0?

• 1\textsuperscript{st} Industrial Revolution:
  – Use of Steam & Water

• 2\textsuperscript{nd} Industrial Revolution:
  – Mass Production & use of electrical energy

• 3\textsuperscript{rd} Industrial Revolution:
  – Introduction of Computerization, IT & Digital communications

• Industry 4.0
  – Next set of technological evolution and trends for automation, data exchange and control in industrial and manufacturing technologies
Industry 4.0:

For the factory,
Industry 4.0 describes the organization of production processes based on technology and devices autonomously communicating with each other along the value chain: a model of the ‘smart’ factory of the future where computer-driven systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions based on self-organization mechanisms.

Source: Industrie 4.0, Study for ITRE Committee
The “Internet of Things” has many Protocols

- SmartFactory
  - Industrial Ethernet (Profinet, EIP, EtherCAT, ..) IO-Link
  - NFC/RFID, Wifi

- SmartBuilding
  - Industrial Ethernet, LON, KNX, BACnet, DALI, Zigbee, Wifi

- SmartGrid
  - GPS, BT, Wifi, Ethernet, NFC

- SmartHome
  - BT, Wifi, Ethernet, PLC, Modbus, KNX

- SmartLife
  - GPS, BT, Wifi, Ethernet, NFC

- SmartVehicle
  - Lin, MOST, FlexRay, TTE
  - AVB gen 1, 2, TSN
  - BT, Wifi, NFC, ..
Manufacturing with Industry 4.0: Cyber Physical Production System

Key attributes:
- Heterogeneous Network
- Real-time communication
- Secure access and coms
- Decentralized manufacturing
- Intelligence in Field Level
- Cognitive and self-healing system
- Energy Efficient
Communication between product, machine, operator and cloud requires different feature profiles.

All three communication technologies are required in Industry 4.0.
Industrial Communication in Factory Automation

- Industrial Automation System = HMI + PLC + Sensors + Motor Control
- Connectivity is the heart of automation for greater productivity
- Efficient & scalable system solutions (hardware & software) are critical for equipment needed for smart factories
Main Industrial Ethernet standards

Top 5 Ethernet based standards

• Profinet RT/IRT
  – Factory automation including drives, some stack overhead

• EtherCAT:
  – Large IO systems and drives, gaining momentum in Asia

• Ethernet/IP
  – IEEE compliance, CIPSync for drives, strong in Process Automation

• POWERLINK
  – Open technology, popular with inverters, lacks hard real-time, strong in China

• Sercos III
  – Optimized technology for drives, only one stack partner besides own stack
Requirements of Industrial Ethernet

- Slave devices must support 2x industrial Ethernet ports
  - Enables Ethernet line and ring topology
  - Removes need of Ethernet hubs and switches
- Frame processing
  - On-the-fly
  - Cut-through
- Master devices can have one or two Ethernet ports
  - Ring topology
  - Redundancy
- Standard Ethernet Media Access Control (MAC) does not support the requirements for industrial Ethernet
- Most industrial Ethernet standards require specific MAC implementation
- Current Industrial Ethernet standards build-in a certain degree of determinism by managing worst case latency jitter and cycle time.
Industrial Drive Types?

Types of Industrial drives

Motor Integrated Drive
- Usually includes Drive and Stepper Motor

Servo Drive System
- Controls, powers Servo Motor and monitors feedback

Modular Drive System
- Coordinated Drives in applications with multiple axes

Integrated Servo Drive
- Servo Motor with integrated position encoder
Motion Control – Architecture (today)

Functional Safety Domain
- Safe communication
- Safe control
- Safe position

- PLC / Motion

- Industrial Ethernet (Profinet IRT, Ethernet/IP, EtherCAT, Powerlink, Sercos 3, …)
- Digital Encoder (EndAT 2.2, Hiperface DSL BiSS, SSI, …)

- Motion Controller

- 24V IO
- Position Feedback
- Single axis Drive
- Multi axis Drive

- Motor integrated Drive
- Motor integrated Drive
- Motor integrated Drive

- Master
- Slave

- Time Synchronization Domain

- Redundancy Domain
Integration of Communication Functions in Drives
TI solves the complex slave communications problem by integrating multi-protocol support in SoCs

**Typical Solution – Today**

- MCU for application
- External ASIC/FPGA for single protocol industrial Ethernet communications

**TI’s ARM + PRU-ICSS solution offers 5 Benefits**

- Significant system BOM savings by eliminating the external ASIC for each protocol.
- Supports multiple protocols using the same hardware (PRU is completely programmable)
- Lower Power
- Easily adapt to changing standards and add additional standards through life of the product
- Scalable solution for HMI, PLC and motion control devices
PRU-ICSS: Programmable Real-Time Industrial Communications

TI Sitara Processors simplify development for Industrial applications through the PRU-ICSS:

- Deterministic RISC cores with dedicated I/O and memory used for industrial Ethernet and Fieldbus protocols
- Hard real-time performance, fully deterministic
- C Programmability

Benefits of TI’s PRU-ICSS solution:
- System BOM savings from eliminating ASICs or FPGAs used for industrial Ethernet. Saves power, size, cost
- Software-based solution: Supports multiple real-time protocols with the same hardware, adapts to changing standards
- Scalable solution for master and slave industrial Ethernet, motor control, redundancy, and more.

Protocols Supported (not full list):
- EtherCAT
- PROFINET
- PROFINET
- SERCOS
- BISS INTERFACE
- EnDat 2.2
- HIPERFACE" DSL
Certified Industrial Communication Protocols

Faster time to market

- Certified Industrial Communication protocols
- Integrated Scalable
AMIC110

**Benefits**
- PRU-ICSS provides a programmable solution to multiprotocol fieldbus support
- Protocols supported include: EtherCAT, PROFINET, EtherNET/IP, PROFIBUS, HSR, PRP, and more

**Industrial Fieldbus Communications for:**
- Factory Automation & Controls
- Motor Drives
- Grid Infrastructure

**Software and development tools**
- Free TI-RTOS support packages direct from TI

**Power Estimates**
- Total Power: 600mW-1000mW
- Standby Power: ~25mW
- Deep Sleep Power: As low as 3mW

**Schedule and packaging**
- Status: Available today
- Documentation on ti.com
- Packaging: 15x15, 0.8mm

<table>
<thead>
<tr>
<th>System Services</th>
<th>Connectivity and IOs</th>
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<tr>
<td>EDMA</td>
<td>USB2 OTG +PHY x2</td>
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<td>JTAG/ETB</td>
<td>CAN x2</td>
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<tr>
<td>Timers x8</td>
<td>PWM x3</td>
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<tr>
<td>WDT</td>
<td>McASP x2</td>
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<tr>
<td>RTC</td>
<td>GPMC / NAND/NOR (16bit ECC)</td>
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<tr>
<td>12-bit ADC(1)</td>
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<td>ARM® Cortex A8</td>
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<tr>
<td>300 MHz</td>
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<td>32K/32K L1</td>
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<tr>
<td>256K L2 w/ECC</td>
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<td>64K RAM</td>
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<tr>
<td>64KB L3 Shared RAM</td>
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<td>LPDDR1/DDR2/DDR3/DDR3L</td>
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**Industrial Communication Subsystem**
EtherCAT®, PROFINET®, EtherNET/IP™, PROFIBUS, HSR/PRP, and more
AMIC110 + C2000 Connected Industrial Drive

- AMIC110 limited quantity devices available Now!
- For more information and product collateral please visit: www.ti.com/product/amic110
AMIC110 – Multiprotocol Made Easy

Multiprotocol support, low-cost, simple to use

Multi-protocol

PRU-ICSS
- Dedicated HW for Protocol Support
- AMIC110 provides:
  - EtherCAT, Ethernet/IP, Profinet, Profibus, and more
- Certified protocol implementations

Low - Cost

AMI110
- Cost-efficient, multi-protocol solution
- EtherCAT low-cost reference design available in 1Q17
- Multi-protocol support enabled

Simple-to-use

FIRMWARE PROVIDED
- No Software programming required for EtherCAT
  - Firmware provided
  - Common EtherCAT ASIC register compatible
- AMIC110 development board - Coming Soon

Replaces ASICs for Communications

Supports low-cost configurations

No Software Development Required
# Resources to learn more about Sitara Industrial Communications Solutions

## Industrial Communications TI Designs for AMIC110 and other AM335x Sitara Platforms

<table>
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<th>Protocol</th>
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<td>EtherCAT for Connected Industrial Drives</td>
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<tr>
<td>PROFINET</td>
<td>PROFINET Slave Communication on Sitara Development Platform</td>
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<tr>
<td>Ethernet/IP</td>
<td>Ethernet/IP Communication on Sitara Development Platform</td>
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<tr>
<td>Sercos</td>
<td>Sercos III Communication on Sitara Development Platform</td>
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<tr>
<td>Ethernet Powerlink</td>
<td>Ethernet Powerlink on Sitara Development Platform</td>
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<tr>
<td>PROFIBUS</td>
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## Other Resources

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<td>PRU-ICSS</td>
<td>Learn more about Programmable Real-time Unit and Industrial Communication SubSystem</td>
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<tr>
<td>Development Tool</td>
<td>AM3359 processor industrial communications engine development platform</td>
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Questions?