FREE TOPOLOGY NETWORK FOR WIRED COMMUNICATIONS WITH SMART TRANSCEIVERS
Agenda

- Overview
- Physical Media Comparison – FT vs RS-485
- LonWorks 2.0 Platform
  - Series 5000 products overview
  - Key new features of FT 5000 / Neuron 5000
  - Benefits to customers
  - New memory architecture
    - Using external serial memories
    - Allowed memory configurations
    - Programming external memories
  - FT-X3 communication transformer
- Summary
Overview
Power of LONWORKS 2.0 Platform
Deliver More Capable and Valuable Control Networks

- Building Intelligence goes Deeper into Devices
  - Demand response better ‘tuned’ to occupants

- Process Automation Gets More Integrated
  - More devices added to the manufacturing network
  - Simple network architectures

- Next Generation of Smart Products Get Smarter
  - Increased functionality at lower cost
  - Expansion of energy aware products

- New Emerging Markets
  - Intelligent quick-service restaurants
  - Automated small building systems
Echelon Pioneering Energy Control

1988
Echelon founded by AC Markkula to create energy control solutions

1990
Launched the LonWorks control networking platform

1998
IPO on NASDAQ

1999
LonWorks becomes US national control standard

2000
Honeywell makes global commitment to LonWorks

2000
Won Enel contract for enabling technology for 30M+ smart meters

2004
US Army Corps of Engineers standardizes on LonWorks smart buildings

2005
Won first major NES production customer: Vattenfall Sweden

2006
LonWorks becomes China national control standard

2009
LonWorks becomes global ISO standard for building controls

2009
Won Duke Energy contract

2010
LonWorks becomes global ISO standard for ECoS for smart grid

2011
First major streetlighting win in China

2011
100M Controlling over 100M smart devices

1988
Echelon founded by AC Markkula to create energy control solutions
Energy Control Products for Embedded Control Market

System Management & Operating System Software
Integration Tools, Development Tools and more

Connectivity & Control Devices
Smart Servers and Routers

Embedded Components
Microprocessors, Smart Transceivers, Control Modules
Intelligent Control Network Solutions – Range of Applications

LonWorks offers Solutions for a Range of Applications

- **Simple Embedded Control Networks**
  - Implement Embedded Control between devices configured in a small network

- **Medium Level Embedded Control Network**
  - Establish control between several devices located at multiple sites
  - Eliminates need for a central controller for a cost effective solution

- **Large Multi-location, highly complex embedded control Network linking several devices and networks**
  - Size of a LonWorks network is not limited by the number of nodes or I/O points
  - Theoretical limit is 32,385 nodes on a single domain, with a virtually unlimited number of domains
Physical Media Comparison – FT vs RS-485
TP/FT-10 Free Topology Channel (ANSI/CEA 709.3) was designed to overcome the many limitations RS-485

- Lower cost and easier installation
- Better electrical isolation
- More robust performance
- Greater flexibility

Features compared
- Wiring and Installation Costs
- Shielded vs. Unshielded Cable
- Mis-Wiring Effects
- Transceiver Faults
- Loop Wiring and Cable Faults
Wiring and Installation Costs

- RS-485 must be installed in a bus topology, with zero length stubs and attention to polarity
  - It is not intuitive for an installer to use bus topology wiring – star wiring is much easier to install and troubleshoot
    - New wiring and devices must be added with care
- TP/FT-10 channel may be installed in any topology, and offers polarity insensitivity
  - Star, loop, bus or mixed topology may be used – installer can select the most convenient and inexpensive wire routing
    - Installers used to a particular style of wiring require no retraining
    - New wiring and devices can be added by simply tapping into the existing wiring
RS-485 uses an unbalanced differential pair – requires shielded cable
  - Every device on the network must be connected to ground through a return signal to minimize noise on the data lines
  - Data conductors consist of a twisted pair plus a shield
TP/FT-10 transceivers use transformer-isolated differential Manchester signaling
  - Provides noise immunity without signal ground
  - No shielded cable required
Mis-Wiring Effects

- RS-485 is polarity sensitive
  - Reversing polarity causes communication errors
  - Manufacturers apply different labeling conventions: A, B, +, and – designations are not consistently applied
    - Networks using RS-485 drivers from different suppliers may experience mis-wiring issues
    - Connection problems require checking an idle network with a voltmeter

**TP/FT-10 transceivers are polarity-insensitive**

Transceiver Faults

- RS-485 drivers can experience a high-impedance, tri-state condition when no devices are transmitting and add devices are listening
  - Leaves floating wires feeding all receivers
  - Requires designers to install pull-down, pull-up resistors to simulate an idle condition
  - Improper biasing will affect network communications

**TP/FT-10 transceivers are not susceptible to this condition**

- Transceiver failure does not affect network performance
- RS-485 cannot work in a ring or survive cable faults
- TP/FTT-10 channel can be wired in a ring as a means of surviving a cable open

RS-485 Bus Topology

FTT-10A Ring Topology

No operation (termination lost); possible marginal operation between some nodes

Works perfectly!
## Feature Comparison - Summary

<table>
<thead>
<tr>
<th></th>
<th>TP/FT-10</th>
<th>RS-485</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiring and Installation Costs</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Shielded vs. Unshielded Cable</td>
<td>Unshielded</td>
<td>Shielded</td>
</tr>
<tr>
<td>Mis-Wiring Effects</td>
<td>Minimal</td>
<td>Severe</td>
</tr>
<tr>
<td>Transceiver Faults</td>
<td>Minimal</td>
<td>Severe</td>
</tr>
<tr>
<td>Loop Wiring and Cable Faults</td>
<td>Survives</td>
<td>Fails</td>
</tr>
</tbody>
</table>
LonWorks 2.0 Platform
The LONWORKS 2.0 Platform Empowers Next Generation Control Infrastructures

- ~ 50% node cost reduction related to control networking for devices using FT Smart Transceivers
- Next generation technology in control networking
  - Up to 16x effective clock speed increase over previous designs
  - Lower Overall Power
  - More Network Variables and Alias
- Eliminates LonMaker® and LNS® credits
  - Simpler and friendly installation
  - Fully backward-compatible
- Increased memory; uses cost-effective and easily sourced external memory
  - Low power design and reduced board space
  - Increased Processor Performance
Protocol Processor Use Models in Embedded Control

**Neuron Chip**
- Neuron core
  - Application processor
  - 2 protocol processors
  - Interrupt processor (5000 only)
  - I/O hardware
- Neuron firmware
  - Implements protocol
- Transceiver interface

**Smart Transceiver**
- Neuron core
  - Application processor
  - 2 protocol processors
  - Interrupt processor (FT 5000 only)
  - I/O hardware
- Neuron firmware
  - Implements protocol
- Built-in transceiver
- System-on-a-chip

**Host-based Processor**
- Any processor
- Optionally use a Neuron Chip or Smart Transceiver for the protocol
- Or, port the protocol to your processor
Processor Use Models in Embedded Control – contd.

- Neuron core
  - Application processor
  - 2 protocol processors
  - Interrupt processor (5000 only)
  - I/O hardware
- Neuron firmware
  - Implements protocol
  - Transceiver interface

- Application processor
- 2 protocol processors
- Interrupt processor (5000 only)
- I/O hardware
- Neuron firmware
  - Implements protocol
  - Built-in transceiver
  - System-on-a-chip

- Any processor
  - Optionally use a Neuron Chip or Smart Transceiver for the protocol.
  - Or, port the protocol to your processor.

- 32-bit RISC processor core from Altera (Host Processor)
- Neuron used as a Communication Processor
- Use Neuron Chip or Smart Transceiver for the protocol
- Used to implement highly complex Embedded Intelligent Control Networks
Neuron as a Complete Device or Communications Co-processor

Neuron Chip/Smart Transceiver As a Complete Device
(Simple to Medium Complexity Intelligent Networks)

Neuron Chip/Smart Transceiver As a Communication Co-processor For a Host CPU
(Medium to Large Complexity Intelligent Networks)
Series 5000 Products Offering

- FT 31x0: 5V chip, 62 NVs
- FT 5000: 3.3V chip, 4-32x faster
- Neuron 5000: 3.3V chip, 4-32x faster

Higher Performance Neuron Core

- Features & Performance

- 254 Network Variables
- 62 Network Variables

Introducing the Smaller & Faster Echelon 5000 Series

- Product Introduction

2002 - 2010
FT 5000 Smart Transceiver – Cost Effective Solution

Node Cost includes:
- Smart Transceiver (Neuron core + Transceiver)
- Transformer
- Memory

~50% Reduction in Node Cost with FT 5000

FT 5000 Node Cost
Key Features – 5000 Series

- 3.3V Supply
- Four 8-bit processors on board
- New memory architecture
  - Less expensive
  - Easily sourced from multiple vendors
  - Enables faster chip operation
  - 64KB on-chip RAM
- 12 I/O pins supporting 35 programmable I/O models
  - 5 V and 3.3 V I/O operation
- Performance enhancement
  - 80MHz maximum internal clock frequency (can be scaled down for power savings)
  - 254 NVs without the use of ShortStack® Micro Server
  - On Chip Hardware multiplier and divider
  - User interrupts supported
  - Hardware UART
- Significant reduction in node cost
  - Up to a 50% node cost
- No Credits
- Small 7mm x 7mm QFN package
- FT 5000 – Smart Transceiver: Neuron 5000 + Free Topology Transceiver
- Neuron 5000 – Neuron Processor Core
Key Features – 5000 Series (cont’d)

- Backward compatibility with
  - Communication Channel (FT 5000 Smart Transceiver only)
  - Instruction Set
  - I/O support
- Complies with worldwide communications standards
  - ISO/IEC 14908-1
  - ANSI/CEA 709.1
- Increased performance of Serial I/O models
  - Hardware support for SPI and SCI/UART serial interfaces
  - 16-entry FIFO at input and output
- FT 5000 combines the functionality of FT 3120® and FT 3150® Smart Transceivers
  - No non-volatile memory (NVM) on-chip for 5000 series
  - External Serial NVM for non-volatile data (application code/data, configuration data)
    - Increased flexibility in choosing serial NVM based on application size
    - Easy upgrade in application memory size without new board layout
  - Smaller Footprint for FT 5000 and Serial memory will result in smaller board layout
5000 Series Customer Benefits

- **Cost Reduction**
  - 3.3V chip
    - Less interface circuitry and/or on-board power supplies
  - Significant Node cost reduction
    - Includes FT 5000 chip, memory and transformer price

- **Smaller Footprint Designs**
  - Small QFN package
  - Uses small external memories: 8-pin SOIC package

- **Higher Performance and New functionality**
  - Using a variety of higher performance features
    - HW Multipliers and Dividers
    - Interrupts
  - Increases memory space for application and data
# Series 5000 vs. Series 3100 Comparison

<table>
<thead>
<tr>
<th>Specification</th>
<th>Series 3100</th>
<th>Series 5000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3120 Core</td>
<td>3150 Core</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>5.0V</td>
<td>3.3V</td>
</tr>
<tr>
<td>External Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface</td>
<td>None</td>
<td>Parallel</td>
</tr>
<tr>
<td>Pricing (64KB NVM)</td>
<td>N/A</td>
<td>$1 - $2</td>
</tr>
<tr>
<td>Packages</td>
<td>N/A</td>
<td>32 PLCC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32 TSOP</td>
</tr>
<tr>
<td>Internal memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAM</td>
<td>2KB</td>
<td>64KB</td>
</tr>
<tr>
<td>ROM</td>
<td>12KB</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>4KB</td>
<td>16KB</td>
</tr>
<tr>
<td>NVM</td>
<td>4KB</td>
<td>0.5KB</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal clock speed (max)</td>
<td>20MHz</td>
<td>10MHz</td>
</tr>
<tr>
<td></td>
<td>80MHz</td>
<td></td>
</tr>
<tr>
<td>Interrupts</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Hardware Multiplier</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Packages</td>
<td>32 SOIC</td>
<td>64 TQFP</td>
</tr>
<tr>
<td></td>
<td>44 TQFP</td>
<td>48 QFN</td>
</tr>
<tr>
<td>Network Variables</td>
<td>62</td>
<td>254</td>
</tr>
</tbody>
</table>
Series 5000 vs. Series 3100 Comparison

- Series 5000 IO pin changes:
  - 3.3V output, 5V tolerant inputs, all are 8mA source / sink
  - No pullups on IOs (only on SERVICE~ and RESET~)

- Series 5000 transceiver changes:
  - No internal differential transceiver (for DC or TP/XF channels)

- Series 5000 timing changes:
  - WDT reset period is now fixed across clock rates (840ms)
  - BIST flash on SERVICE~ pin is 76Hz, not 2kHz

- Other Series 5000 differences:
  - Sleep mode not supported (wasn’t supported on FT 31x0 either)
  - Xtal oscillator output doesn’t support driving buffer (may change)
FT 5000 Current Consumption Comparison

Series 5000 chips have good current consumption in addition to faster processing power.

<table>
<thead>
<tr>
<th>Current Consumption</th>
<th>FT 5000 Typical</th>
<th>FT 5000 Maximum</th>
<th>FT 3120 Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx mode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 MHz</td>
<td>9 mA</td>
<td>15 mA</td>
<td>35 mA</td>
</tr>
<tr>
<td>10 MHz</td>
<td>9 mA</td>
<td>15 mA</td>
<td>42 mA</td>
</tr>
<tr>
<td>20 MHz</td>
<td>15 mA</td>
<td>23 mA</td>
<td>60 mA</td>
</tr>
<tr>
<td>40 MHz</td>
<td>23 mA</td>
<td>33 mA</td>
<td></td>
</tr>
<tr>
<td>80 MHz</td>
<td>38 mA</td>
<td>52 mA</td>
<td></td>
</tr>
<tr>
<td>Tx mode</td>
<td>$I_{DD3-RX} + 15$ mA</td>
<td>$I_{DD3-RX} + 18$ mA</td>
<td>$I_{DD3-RX} + 15$ mA</td>
</tr>
</tbody>
</table>

Note: FT 31x0 chips’ internal clock is ½ of the external clock rate.
LonWorks Node with FT 5000 Smart Transceiver
5000 Series - New Memory Architecture Support

- Neuron 3120 Core
  - Internal NVM (4KB only)
- Neuron 3150 Core
  - External Parallel Flash/EEPROM
  - Performance limited by external memory access time
  - Limited availability of 3.3V parallel memories
- Neuron 5000+ Core
  - External Serial Flash/EEPROM
  - External memory image copied into internal RAM to execute the application
  - Performance NOT limited by external memory access time
16KB ROM
- Holds default V19 firmware system image

64KB RAM
- Shadows entire memory space for fast CPU operation
- 44KB user accessible

No on-chip non-volatile memory
- Except to store Neuron IDs
Serial Interfaces supported
- I²C (Inter-Integrated Circuit)
- SPI (Serial Peripheral Interface)

Types of serial memories supported
- EEPROM (can use either I²C or SPI interface)
- Flash (only use SPI interface)

Required (to store configuration data)
- At least 2KB off-chip EEPROM

Optional (to store application code)
- Larger capacity EEPROM OR additional flash memory
  - Only first 2KB of EEPROM or Flash is used

FT 5000
Smart Transceiver IC

Serial EEPROM
(2KB or larger)

Serial SPI
Flash (optional)

I²C or SPI

SPI

I/O
## 5000 Series – Supported Memory Configurations

<table>
<thead>
<tr>
<th>EEPROM</th>
<th>Flash</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I²C</td>
<td>SPI</td>
<td>A single I²C EEPROM memory device, from 2 KB to 64 KB in size</td>
</tr>
<tr>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
<td>One I²C EEPROM (at least 2 KB in size, up to 64 KB in size, but the system uses only the first 2 KB of the EEPROM memory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One SPI flash memory device</td>
</tr>
<tr>
<td>✓</td>
<td></td>
<td>A single SPI EEPROM memory device, from 2 KB to 64 KB in size</td>
</tr>
<tr>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
<td>One SPI EEPROM (at least 2 KB in size, up to 64 KB in size, but the system uses only the first 2 KB of the EEPROM memory)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One SPI flash memory device</td>
</tr>
</tbody>
</table>
# 5000 Series – External Serial Memory Interface Support

- 6 Pins dedicated for external serial memory interfaces

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>Used For</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS0~</td>
<td>SPI</td>
<td>SPI slave select 0 (active low)</td>
</tr>
<tr>
<td>SDA_CS1~</td>
<td>SPI, I²C</td>
<td>I²C: serial data (SDA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SPI: slave select 1 (CS1~, active low)</td>
</tr>
<tr>
<td>SCL</td>
<td>I²C</td>
<td>I²C: serial clock (SCL)</td>
</tr>
<tr>
<td>MISO</td>
<td>SPI</td>
<td>SPI master input, slave output</td>
</tr>
<tr>
<td>SCK</td>
<td>SPI</td>
<td>SPI serial clock</td>
</tr>
<tr>
<td>MOSI</td>
<td>SPI</td>
<td>SPI master output, slave input</td>
</tr>
</tbody>
</table>
5000 Series – Using the I2C interface

- Neuron 5000/ FT 5000 chip as the I2C master
- Uses 2 out of 6 pins dedicated for external memory connections
- EEPROM can be 2KB to 64KB in size
  - Only 42KB can be used by application
- Neuron 5000 / FT 5000 Chip as the SPI Master (not multi-master)
- Can either use EEPROM only or both EEPROM and flash memory
- Only 2KB of EEPROM used in case flash is also present
5000 Series - Using Both SPI and I2C interfaces

- Neuron 5000 / FT 5000 chip as the I\(^2\)C/SPI master
- Uses all 6 pins dedicated for external memory connections
- Only 2KB of EEPROM used (even if larger EEPROM is present)
- Pin SDA_CS1~ shared between SPI and I\(^2\)C
  - Only SPI or I\(^2\)C transfer can be active at any time
Comparing Memory Technology – EEPROM vs Flash

- **EEPROM**
  - Has smaller sector size
  - Used commonly for data logging and configuration data

- **Flash Memory**
  - Larger sector sizes
  - Have to write entire sector even if writing one byte in the sector
    - May result in lower total write cycles over lifetime compared to EEPROM
  - Used commonly for application code
  - Minimum size available 64KB
  - Less expensive than similar sized serial EEPROM
Factors Influencing Choice of Memory

- Use of single external memory versus two memories
  - At least 2KB EEPROM is required
  - Example: if 40 KB application space is needed
    - Option 1: Use a 64KB EEPROM
    - Option 2: Use a 2KB EEPROM and a 64KB flash

- Cost comparison between a large EEPROM device and a combination of a small EEPROM and large flash devices
  - Using example above (note pricing may vary):
    - Option 1 cost: $0.75 (64KB EEPROM)
    - Option 2 cost: $0.10 (2KB EEPROM) + $0.36 (64KB Flash) = $0.46

- Use of non-volatile variables by the application
  - Is the memory needed for application code (flash memory preferred) or for data-logging (EEPROM preferred)?
Programming External Memories

- Multiple ways to program external memories
  - Pre-programming before soldering on the board
    - Uses any programmer that programs serial EEPROM/Flash
  - In-circuit programming on the boards
    - Use either pins, headers or test points on the boards to program the serial memory chip
  - Over the network
    - Programmed through FT 5000 Smart Transceivers
Details of FT-X3 Communications Transformer

- Surface mount
  - Not pin compatible with FT-X1 / X2
- Same magnetic noise immunity as FT-X1 or FT-X2 communication transformer
- Backward compatible with FT31x0 transceivers
Development Tools support for Series 5000 products
- Mini FX Evaluation Kit
- NodeBuilder® FX Development Tool

NodeBuilder FX and Mini FX use same hardware

Software only option for customers moving from Evaluation Kit to Development Tools

Support (Buy separate)
- Node Builder FX Hardware + Software
- Node Builder FX Software Only

Multiple transition options for customers
5000 Series Ordering Information

- Product has been in production since May 2010
- Neuron 5000 Processor – Model Number 14305R-2000
- FT 5000 Smart Transceiver – Model Number 14235R-2000
- FT-X3 Communications Transformer – Model Number 14255R-400
- Mini FX Evaluation Kit – Model Number 10000R-40-24
- FT 5000 EVB Evaluation Board – Model Number 28022R
- NodeBuilder FX Development Tool – Model Number 10020R-40-24
Echelon’s technology is the most widely used for smart embedded control worldwide.

Echelon has been a pioneer and leader in the intelligent embedded control networking market.
  - Echelon is committed to this market and is looking to grow this market with leading edge solutions.

Echelon continues to bring products to market that offer customers key benefits.
  - 5000 Series offers customers the benefits of lower cost and higher performance.