Using LabVIEW for Automotive Communications and Diagnostics

Tristan Jones
Technical Marketing Engineer
Agenda

• Introduction to embedded networks
  ▪ CAN, LIN, Flexray
  ▪ National Instruments Hardware
• On-Board Diagnostics
• Conclusion
What are Embedded Networks?

Without Embedded Networks

With Embedded Networks

Embedded Network Bus
Scope of Automotive Embedded Networks

- **CAN**
  - High Speed
  - Fault Tolerant
- **LIN**
- **FlexRay**
Controller Area Network (CAN)

- Peer-to-Peer
- High Speed: 1 Mbps
- Fault Tolerant: 125 kb/s
- Medium Cost
- Differential Signaling

Currently Most Popular
NI-CAN Driver Software

• Supports all NI PCI, PXI, and PCMCIA CAN Interfaces
• Supports LabVIEW, LabVIEW Real-Time LabWindows/CVI, Microsoft Visual Basic, Microsoft Visual C++, and Borland C/C++ programming environments
• Exposes 100% of the CAN interfaces functionality
  – Develop your own custom applications
  – 2 Built-in APIs
    • Frame API
    • Channel API
CAN Software

• CANopen LabVIEW Library
• Automotive Diagnostic Command Set
  ▪ KWP2000, Diagnostics On CAN, ISO 15765-2,
• ECU Measurement and Calibration Toolkit
  ▪ CCP and XCP
Measurement and Automation Explorer (MAX)

- Hardware and software configuration utility
- Import CAN database files (.dbc or .ncd)
- Create and edit CAN channels
- Test panel for CAN Channels
- CAN bus monitor utility
- Update National Instruments software
Quick Demo – Channel API
Local Interconnect Network (LIN)

- Master-Slave
- 20 Kbps
- Cheap!
- Single Wire
- Similar to RS-485
- New and Lightweight
GOOD: Low-cost USB-CAN/LIN (New!)
USB CAN and LIN

- Low-Cost solution starting at £215
- Offered in HS, LS, and LIN versions
- HW sync options available from £315
- Frame API only
USB CAN and LIN Targeted Applications

• Automotive
  - In-Vehicle Data Logging (Via MAX)
  - Bus monitoring
  - Automotive Diagnostics
    - OBD-II
    - Reading Trouble Codes
    - Initiating Tests

• Benchtop
Synchronisation (USB-847xS models)

- 3-pin COMBICON connector
- Shared timestamp clock, and start trigger
- Slave: Auto detection of 20 Mhz, 10 Mhz, or 1 Mhz external clocks
- Master: Generates 1MHz clock
Better: Series 2 CAN
National Instruments Series 2 CAN Hardware

• High speed CAN
  ▪ Max. Baud rate 1Mb/s

• Low speed/Fault-tolerant CAN
  ▪ Max. Baud rate of 125kb/s

• Single Wire CAN

• Software Selectable CAN
  ▪ High, Low, or Single Wire
BEST: CompactRIO CAN module
CAN on CompactRIO

• 2 Port High-Speed & Low-speed CAN Modules
• Transmit / Receive 100% bus load at 1 Mbps
• ISO 11898-compliant for standard (11-bit) and extended (29-bit) arbitration IDs
• Hardware Synchronisation with any CompactRIO I/O Module
FlexRay
Increased Communication Across Subsystems

- Engine Control
- Transmission Control
- Telematics
- Thermal Management
- Start/Stop
- 42 V Starter-Generator
- Minimal hybrid
- Brake-by-Wire (EHB)
- Steer-by-Wire
- Adaptive Cruise Control (ACC)
- Surround Sensing
- Vehicle Guidance

Powertrain Management

Chassis Management
FlexRay History: 1990’s

• CAN too limited for X-by-wire
  ▪ Bandwidth: bits per second
  ▪ Determinism: frame at precise time
  ▪ Redundancy: tolerate failures in cable or ECU

• Assumption: Standard protocol

• Various contenders
  ▪ TTCAN, TTP, Byteflight, …
  ▪ Byteflight used as basis of FlexRay 1.0 standard
Will FlexRay Replace CAN?

- No: Ongoing Cost/Benefit tradeoffs

![Diagram showing FlexRay, CAN, LIN, and MOST with bandwidth requirements.](image-url)
BMW Ships First Car with FlexRay

• 2007 BMW X5
• AdaptiveDrive: Controls roll and dampening
• Uses single FlexRay channel
NI FlexRay Solutions

• Currently NI does not make FlexRay Interfaces
• Recommended boards:
  ▪ TZM FlexRay PXI Interface
  ▪ Used by MicroNova in BMW Engine Simulator
On Board Diagnostics (OBD)

USB CAN Interfaces

Automotive Diagnostic Command Set
NO + C<sub>x</sub>H<sub>y</sub> → Smog
Closed-Loop Emissions System
Problem: How do regulators test and enforce functioning emissions systems?
Solution: On Board Diagnostics Standards

• Emissions
  ▪ Move the testing from garage to the car

• Test tools
  ▪ Reduce variety of tools & costs for repair centers

• Fringe benefits for Engineers
  ▪ Universal access to engine parameters and trouble codes
History of On-board Diagnostics

- 1970 – Clean Air Act
- 1982 – GM OBD-I Systems
- 1988 – CARB OBD-1 Requirement
- 1996 – Federal OBD-II Requirement
- 2001 – EU adopts EOBD
- 2008 – CAN-based OBD-II
Diagnostics are good for Manufacturers…

- Longevity / accelerated testing
- Assist all testing procedures
- Diagnostic Trouble Codes
- Custom control of on-board devices
- Download ECU updates
Diagnostics are good for the Aftermarket...

- Diagnostic Trouble Codes
- Logging vehicle data during tests
- Standard interface for all new automotives
- Wide Variety of data
- “Black box”

Not good for:
- Deterministic data
- High sampling rates (over 5-10 Hz)
- Model-specific data (without documentation)
OBD-II Architecture

- Connector
- Embedded Network
- Diagnostic Services
- Trouble Codes / Parameter IDs
- External Tester Behavior

OBD-II Standards

$01 $02 $03 $04 $05 $06 $07 $08 $09

P0010 P1522 P1011 P0171 P0525 P0028
Diagnostic Services

- Embedded Network Buses are simple:
  - 8-Byte Frames
  - No built-in large message handling
- What if we want to:
  - Not interrupt critical communications
  - Send messages, strings, or codes larger than 8 bytes?
  - Send new Firmware to the ECU?
  - Establish a session with the ECU?
Automotive Diagnostic Command Set

- Set of functions for automotive protocols
- Implement automotive diagnostic protocols in LabVIEW and CVI/C
  - KWP2000 and Diagnostics On CAN
- Works with all NI CAN interfaces
- Develop and deploy custom diagnostic applications
Automotive Diagnostic Command Set

- http://ni.com/can/
- Supports standard KWP2000 and ISO-15765 services
- Includes ECU Simulator example
Test Services

• SAE J1979 (ISO 15031-5): Defines test modes and parameters

• Services of interest:
  - $01 – Get Real-Time Diagnostic Data
  - $02 – Get Freeze Frame data
  - $03 – Get Trouble Codes
  - $04 – Clear Trouble Codes
  - $06 – Specific system monitoring Results
  - $09 – Current Vehicle Information
Applications

• Real-time display of parameters not on dashboard
• Logging vehicle data
• Correlating vehicle data measurements to other measurements (Sound, Vibration, Acceleration, voltage, etc)
• Custom garage test-tools
NI Tools for Automotive Diagnostics

- NI Automotive Diagnostic Command Set
- NI USB-8473(s) CAN interface
- DB9 to J1962 adapter cable

Primary Engine ECU

ni.com
NI Automotive Diagnostic Command Set

NI USB-8473(s) CAN interface

DB9 to J1962 adapter cable
• Full compiled, graphical programming environment
• Target desktop, mobile, industrial, and embedded
• Thousands of out-of-the-box mathematics and signal processing
• Seamless connectivity with millions of I/O devices
Summary

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