

Vehicle to Grid Communication Standards Development Support

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Project ID #
VSS055

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

- Start – Oct. 2010 (Project Start)
- Finish – Sept. 2014
- 50% Complete

Budget

- Total project funding
 - DOE share - 125k
 - Contractor share - None
- Funding Received in 2011
 - DOE share – 375k
- Funding for FY12
 - DOE share -125k

Barriers

- Lack of codes and standards for communication between PHEV and grid
- Communication technology options are not yet agreed upon for automotive application

Collaborators

- Society of Automobile Engineers
- EPRI, ANL
- Maxim, TI, Ariane Controls

Objectives

MYPP Relevance:

Address codes and standards needed to enable wide-spread adoption of electric-drive transportation technologies.

- ▶ Provide technical support for the development of SAE standards for vehicle to grid communications (J2847/2, /3, /5)
- ▶ Perform laboratory testing of communication technologies in support of the SAE Standard J2931/1
- ▶ Validate end-to-end communication using SEP 2.0 requirements in SAE Standard J2847/1 to support vehicle charging based on utility programs

Technical Approach

Objective: *Provide technical support for the development of SAE standards for vehicle to grid communications (J2847/2, /3, /5)*

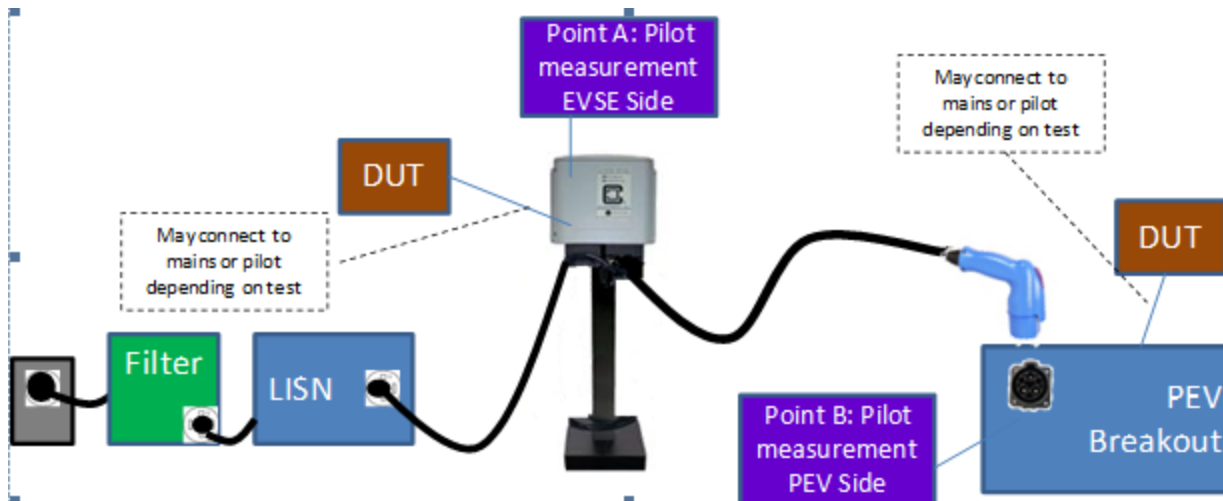
- ▶ SAE Standard J2847/2: DC-Charging Communication
- ▶ SAE Standard J2836/3: Reverse Energy Power Flow Communication
- ▶ SAE Standard J2836/5: Customer Communication
 - Participate in working group meetings and contribute to document development
 - Review and recommend changes to harmonize documents with related US and European standards

Technical Approach

Objective: *Perform laboratory testing of communication technologies in support of the SAE Standard J2931/1*

- ▶ Coordinate with EPRI and ANL to test PLC technologies for J2931/1 requirements
 - Test three PLC technologies: TI (Concerto) and MAXIM (Tahoe 2) – G3, and Ariane Controls – FSK according to the EPRI/SAE test plan
 - Test communication performance over control pilot or mains or both depending on the technology
- ▶ Provide additional application layer testing input using the laboratory test bench developed in FY'10-11 used to test low-frequency, narrow-band technologies

PNNL Testing - Scope



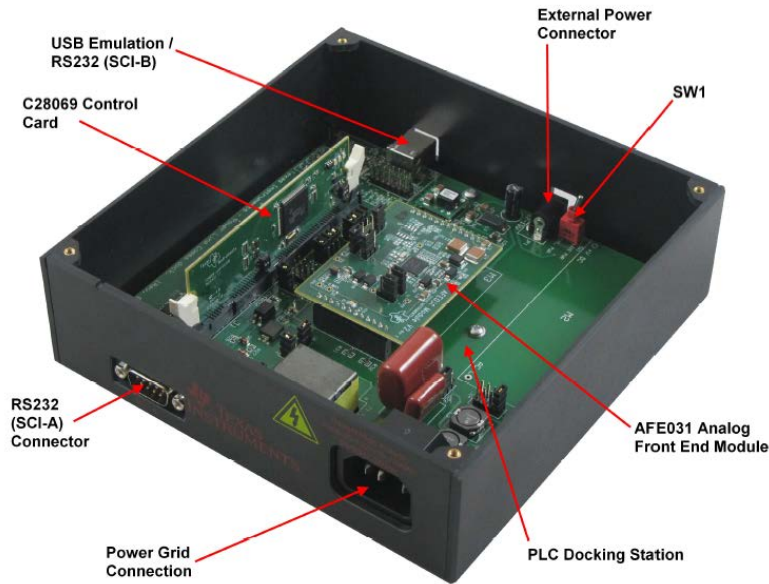
Test Equipment

LISN: Com-Power LI-215A
Oscilloscope: Tektronix Model TDS5104B
Spectrum Analyzer: Agilent Model N9320B
Charging Station: Coulomb CT2100
Charger: Hymotion / A123 L5

(Ref: SAE J2931 PLC Communication Test Plan – S316a, Jan 2012 Hybrid Committee working document)

- **Pilot Signal Impairment** - interference legacy devices assured.
- **Throughput** - MAC/PHY throughput and Application Data (payload) rates.
- **Latency** - round trip message times.
- **Crosstalk** – susceptibility and immunity between cordsets.
- **Interference** - susceptibility from household products.
- **Coexistence** - physical network interference testing.
- **Distance:** cordset length communication performance

Texas Instruments - Concerto



Description

The TI Concerto board is intended for communication on the Control Pilot line of the standardized SAE J1772™ connector.

The TI Concerto board is capable of using IPv6, CAN, or RS232 for communications.

Implementation:

CAN is used as the communications interface with the PEV to the Concerto board.

RS-232 is used to configure the board.

IPv6 is used for communications between the Concerto board and the IPv6 network.

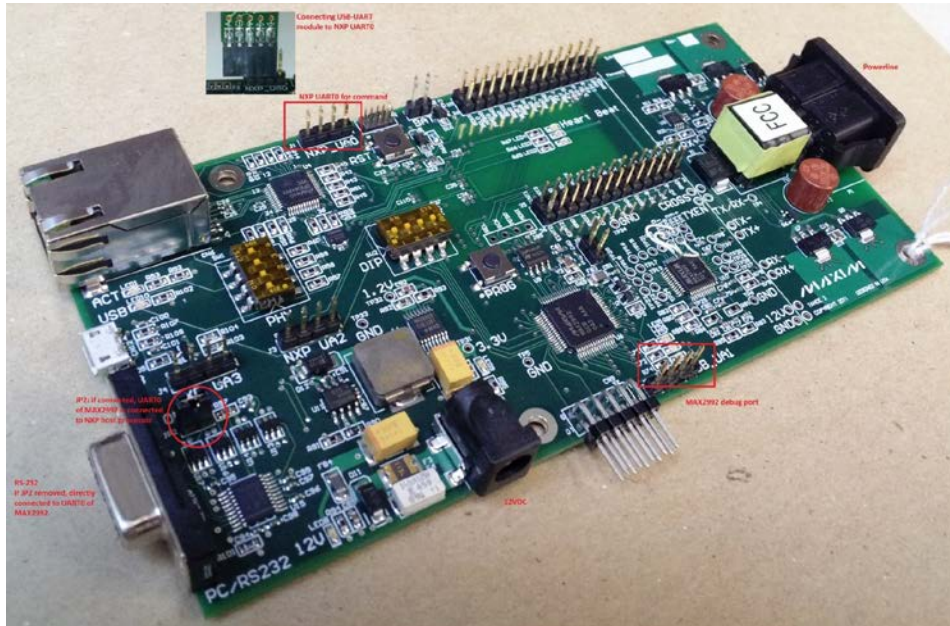
Capability:

IPv6, USB, CAN and ZigBee hardware interface available for future firmware development.

Maturity:

Supplied firmware adequate to demonstrate capability using RS232 interface.

MAXIM – Tahoe 2



Description

The MAXIM Tahoe 2 board is intended for communication on the Control Pilot line of the standardized SAE J1772™ connector.

The MAXIM Tahoe 2 board is capable of using IPv6, CAN or RS232 for communications.

Implementation:

RS-232 is used to configure or test the board. IPv6 is used for communications between the Tahoe 2 board and the IPv6 network.

CAN hardware interface available through daughter board.

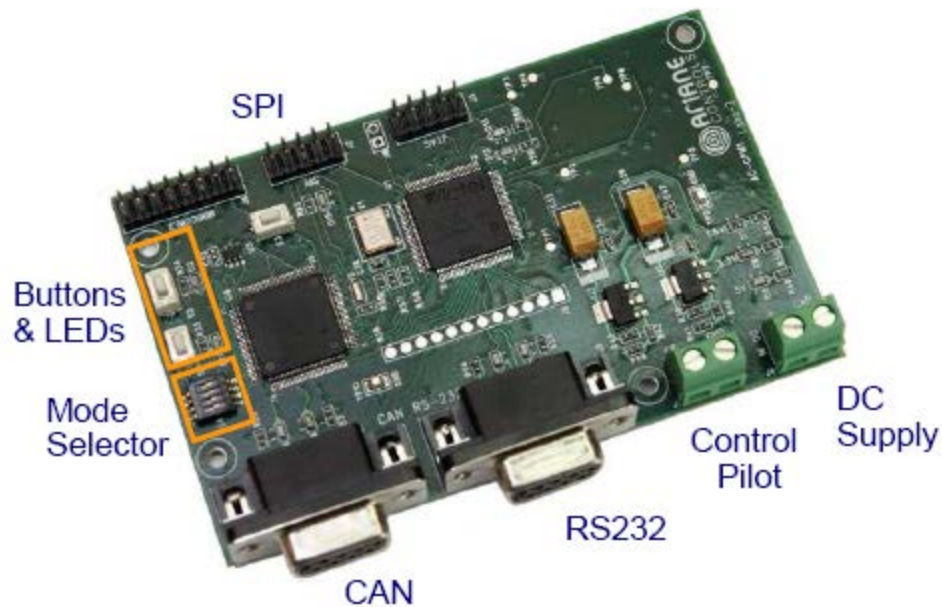
Capability:

CAN hardware interface available for future firmware development.

Maturity:

Supplied firmware adequate to demonstrate capability using either RS232 or IPv6 interface.

Ariane Controls - AC-CPM1



Description

The Ariane Control's AC-CPM1 board is intended for communication on the Control Pilot line of the standardized SAE J1772™ connector. The Analog Front End is optimized for communication on Control Pilot with data rates of 100kbps. The on-board application code is implemented on Renesas 78K0R MCU

The Ariane Control's AC-CPM1 board is capable of using SPI, CAN, or RS232 for communications.

Implementation:

CAN is used as the communications interface with the PEV to the AC-CPM1.

RS-232 is used to configure the board.

SPI is used for communications between the AC-CPM1 board and an external microcontroller.

Capability:

IPv6 Capability will be externally provided.

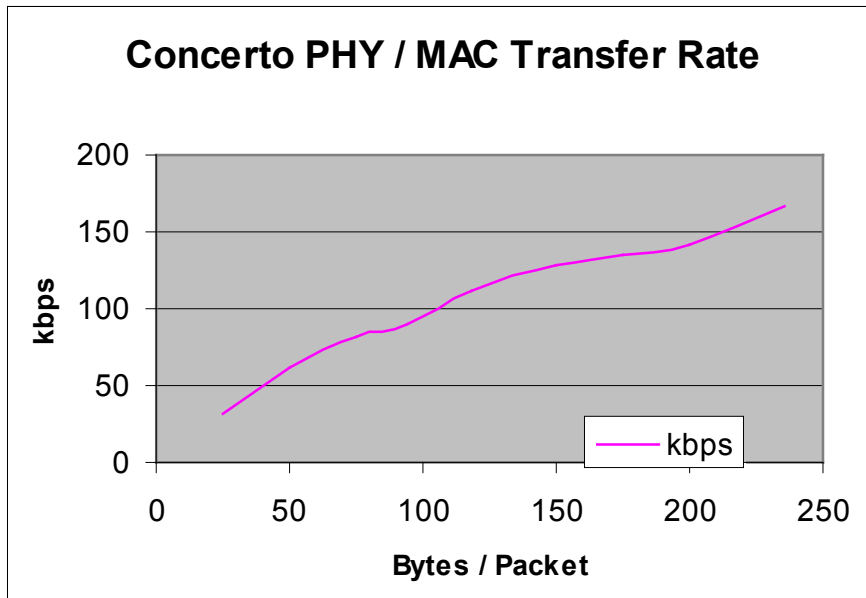
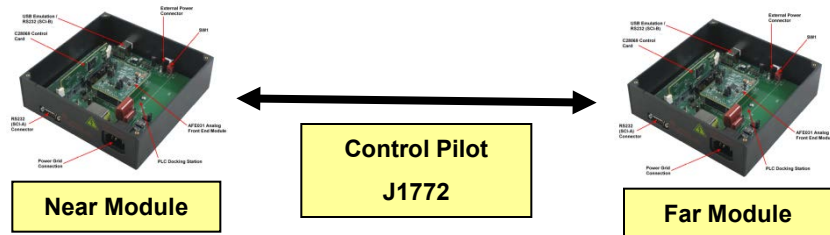
Maturity:

Supplied firmware adequate to demonstrate capability using either RS232 or CAN interface.



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Texas Instruments – Concerto Throughput Configuration



Test Description

- MAC/PHY data rate is # bytes/transfer time.
- Packet size 25 to 236 bytes.
- Transfer Time = 6.4 – 11.36 milliseconds

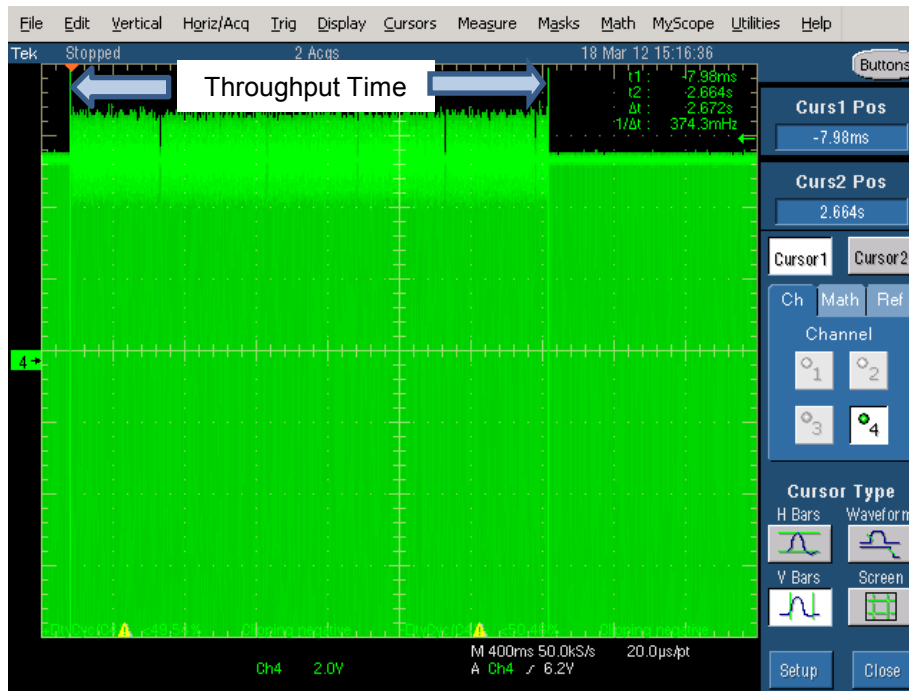
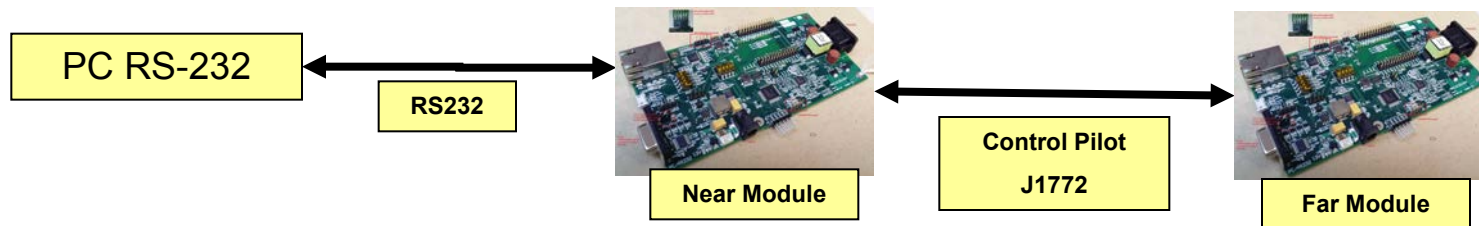
Results

Amplitude – 1.24 V pp

Throughput – 105 Kbps (MAC Layer) –
Average Transfer Rate - transfer rate is dependent on
packet size.

- Note –data collected with Control Pilot toggling at 1 kHz.

MAXIM – Max2992 Throughput Configuration



Test Description

- MAC/PHY data rate is # bytes/transfer time.
- Packet size 31485 bytes.
- Transfer Time = 2.672 seconds

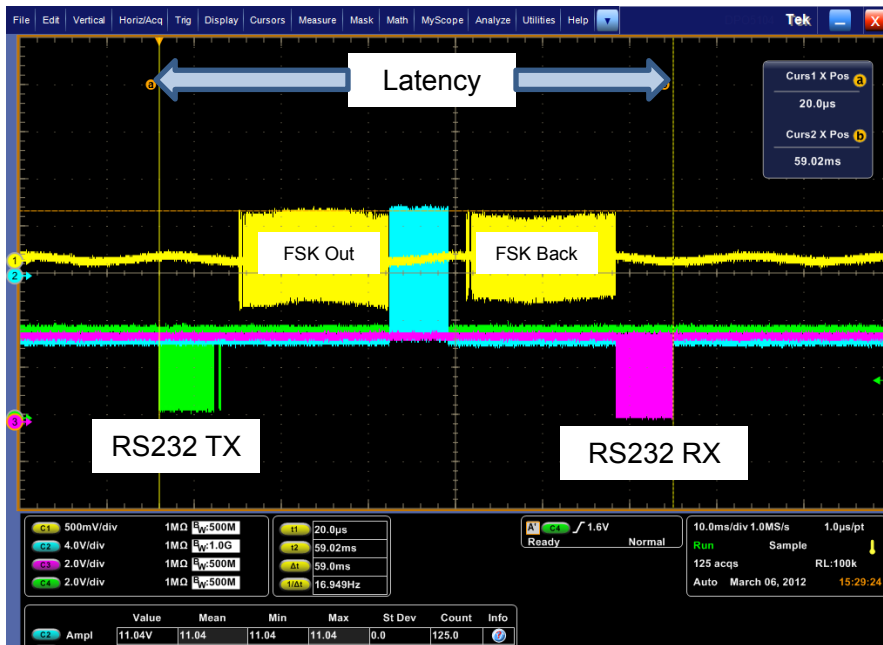
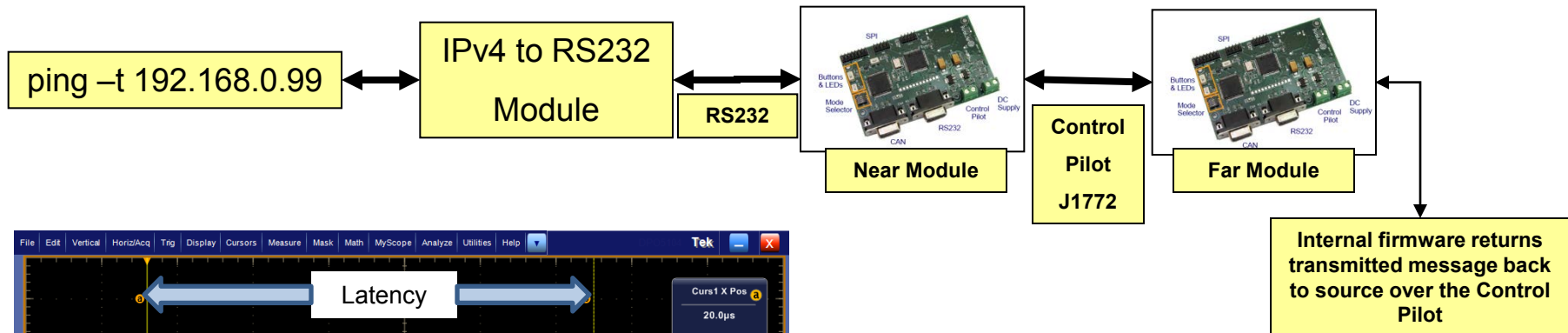
Results

Amplitude – 1.32 V pp

Throughput – 89 Kbps (MAC Layer) – a newer code set may meet 100K bps rate

- Note – this data was collected with Control Pilot toggling at 1 kHz.

Ariane Controls – AC-APM1 Ping Test Configuration



- Note – this test data was collected to verify testing method. Control Pilot is NOT toggling at 1kHz.

Test Description

- The ping command indicates 32 byte packet size. The actual IPv4 RS232 packet size is 74 bytes.
- The IPv4 to RS232 module converts the ping command to RS232 to the near module. The ACK back to the PC is delayed until the “far” module returns the transmitted packet.

Results

Amplitude – 0.74 V pp

Latency – 47.3 ms. (IPv4 ping)

Throughput – 39 K (MAC Layer)



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FY'12 Standards Support – Progress

- ▶ **SAE Standard J2847/2: DC-Charging Communication**
 - Updated isolation monitoring requirements, state diagrams and sequence diagrams
 - Harmonized DIN 70121 XML names and types with J2847/2 signals
 - Reviewed and recommended changes to the overall document

- ▶ **SAE Standard J2836/3: Reverse Energy Power Flow Communication**
 - Contributed to use case development for ancillary services and smart charging
 - Recommended removal of V2L, V2H and V2V (out of scope of V2G communication)
 - Introduced transactive controls concept to determine grid power requirements and optimize energy flow from distributed energy resources

- ▶ **SAE Standard J2836/5: Customer Communication**
 - Contributed to use case development for vehicle charging scenarios using utility programs
 - Developed and presented home area network (HAN) interaction scenarios for vehicle charging
 - Defined interface requirements for telematics and mobile devices for customer communications

- ▶ **ANSI EV Standards Panel: Roadmap**
 - Participated in working group meetings and contributed to the telematics interface requirements

FY'12 Testing Status - Summary

Test Description	TI Concerto	Maxim Tahoe 2	Ariane AC-CPM1
<u>Pilot Signal Amplitude</u>	1.32Vpp	1.24Vpp	0.74Vpp
Duty Cycle Impairment - 25μs	3.4μs	0.3μs	3.0μs
<u>Throughput (MAC / PHY) – 100kbps</u>	105 kbps	109 kbps	39 kbps
Throughput (jPerf)	TBD	TBD	TBD
Latency – 25ms	TBD	TBD	47.3ms ⁽²⁾
Crosstalk	TBD	TBD	TBD
Interference	TBD	TBD	TBD
Coexistence	TBD	TBD	TBD
Distance	TBD	TBD	TBD

FY'12 – Accomplishments

► Outreach/Publication:

- Rick Pratt presented a technical seminar at UCLA EV Forum related to electric vehicle communication and grid-friendly charging
- PNNL Report No. PNNL-20844 – Vehicle to Grid Communication Standards Development, Testing and Validation, September 2011
- Presented several testing progress presentations to the SAE committee

► Technology development

- Transactive control communication architecture and strategy developed for EV smart charging (used PNNL internal funding, enables EV participation in Northwest Smart Grid demo project)
- Laboratory test bed and field testing of PLC on mains completed for testing J2847/1 messages

On-going Activities for FY'12

► March – Sept. 2012

- Continue PLC testing support for J2931/1
- Review and contribute to J2936/3, and J2936/5 documents development
- Develop power line communication module prototypes for control pilot communication (based on SAE needs and EPRI requirements documents)
- Implement SEP 2.0 application layer in the prototypes and develop field test plan for end-to-end communication using smart meters
- Identify EVSE and vehicle OEM partners for field testing and demonstration of charge management to validate J2847/1



Collaborators

- ▶ **SAE** – North American Standards development organization developing the electrical connection and communication standards for vehicle-grid communication (J1772, J2836, J2847, J2931)
- ▶ **EPRI** – Research and development organization representing the electric utility industry and involved in use case development and communication testing coordination with ANL and SAE.
- ▶ Industry participants:
 - **TI / Concerto** – Power line communication technology manufacturer
 - **MAXIM / Tahoe** – Power line communication technology manufacturer
 - **Ariane Controls** – Power line communication technology manufacturer

Assumptions and Outcomes

▶ Assumptions

- ▶ PLC technology manufacturers provide evaluation boards and hardware needed for testing
- ▶ SEP 2.0 application layer standard approved for implementation and testing

▶ Outcome

- ▶ PNNL will work with EVSE manufacturers and vehicle manufacturers to incorporate the PLC technology to implement end-to-end communication
- ▶ PNNL will begin field testing in the Lab homes to evaluate the deployment of PLC technologies and validate the J2847/1 requirements for charge management



Project Summary

- ▶ Harmonization activities for J2947/2 nearing completion
- ▶ Substantial completion of PLC technology testing and provided performance data needed to accelerate the technology selection in support of the J2931/1 standard
- ▶ PNNL fulfills a critical role in rapid development and adoption of vehicle to grid communication standards by :
 - Providing technical assistance for standards harmonization, use case development and document reviews to accelerate the development process
 - Assisting PLC technology manufacturer with feedback to resolve issues in developing communication modules
 - Assembling a field test setup using PNNL Lab homes and charging stations to evaluate field performance of end-to-end communication between the vehicle and grid

Questions ?

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