



Network Enabled Battery Health Monitoring System

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NC STATE UNIVERSITY



Presentation Outline



- Project Introduction
- Demo Circuit Design
- ZigBee Network Setup
- Data Packet Re-design
- LabVIEW GUI Design
- Test and Validation
- Summary



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Project Background



Power Plant

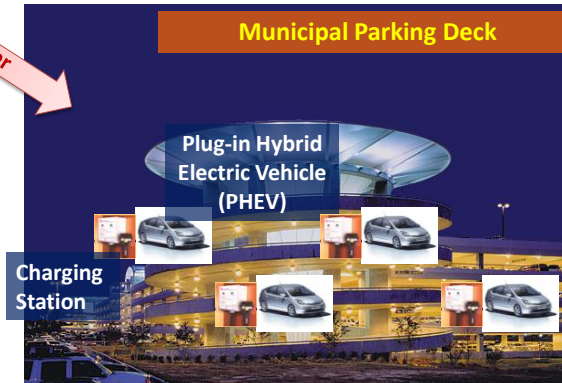


Transmission Line



Power

Municipal Parking Deck



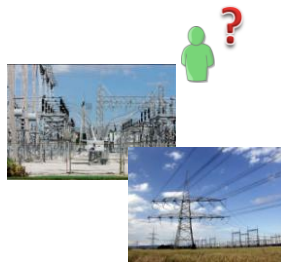
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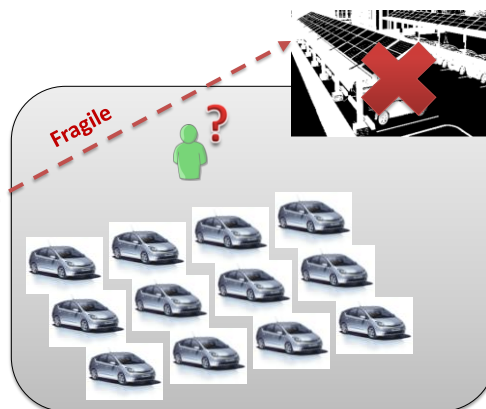
Problem



- Large penetration of PHEV causes problem
- Potential threats & anxiety



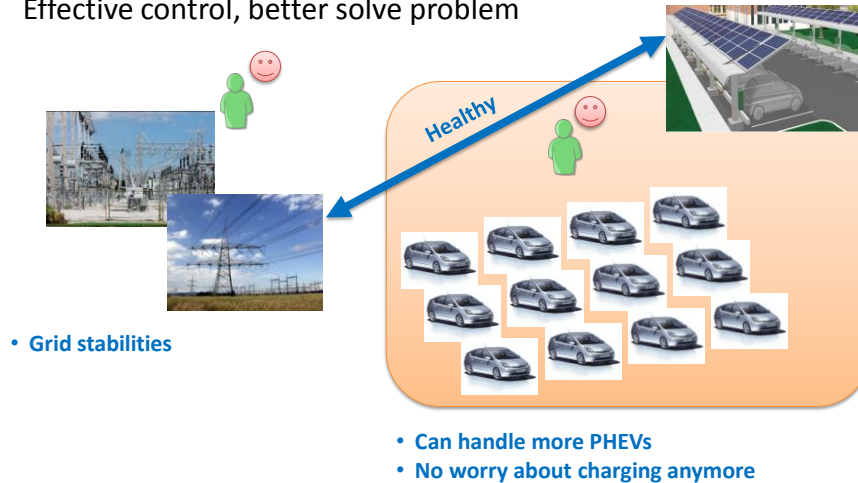
- Grid instabilities and disruptions



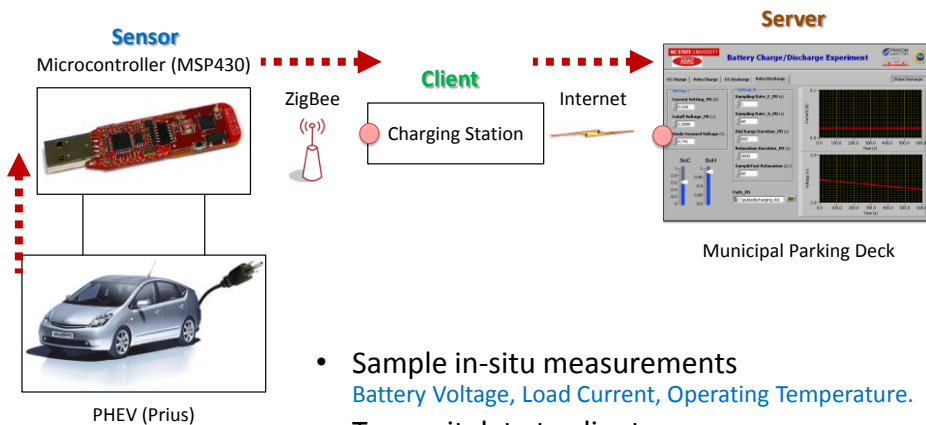
- Number of PHEVs are increasing
- Stable charging station in need

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- Network Enabled Battery Health Monitoring
- Effective control, better solve problem



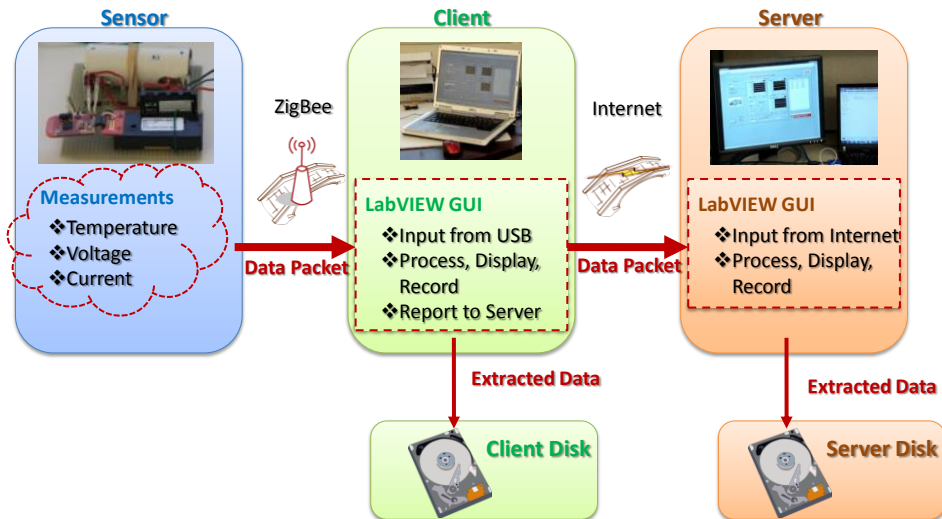
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- Sample in-situ measurements
Battery Voltage, Load Current, Operating Temperature.
- Transmit data to client
- Report to server for further processing
State-of-Charging, State-of-Health, Optimal Power Distribution, etc.

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Network Enabled Battery Health Monitoring System

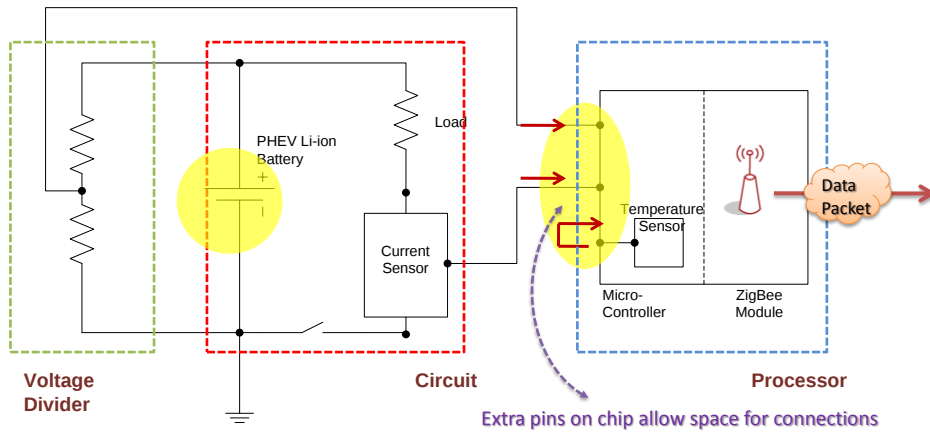


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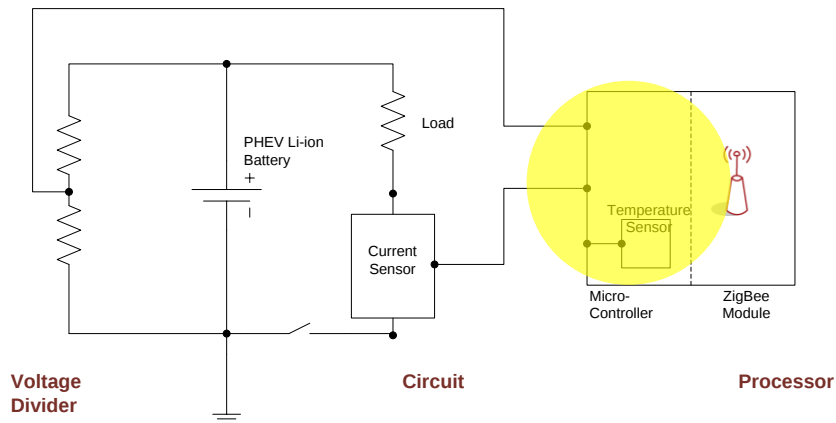
- Project Introduction
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- Discharge PHEV Li-ion battery
- Use voltage divider

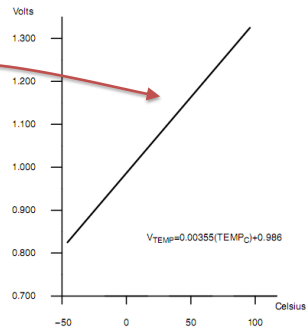
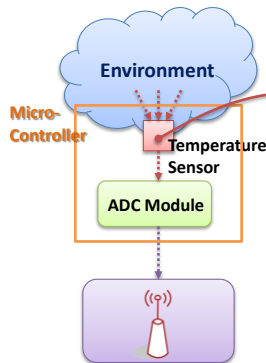


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- **Integrated Temperature Sensor**
- Integrated ADC Module
- NT-5 – Magneto-Resistive Current Sensor

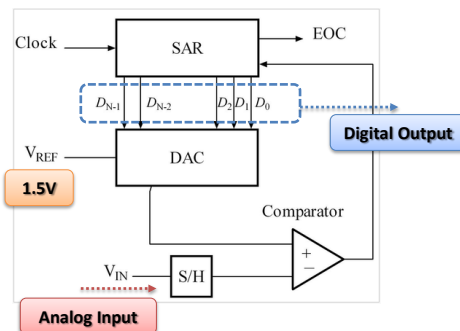


Typical Temperature Sensor Transfer Function

- **Easy to use**
- **Offset error can be large**
Need to be calibrated

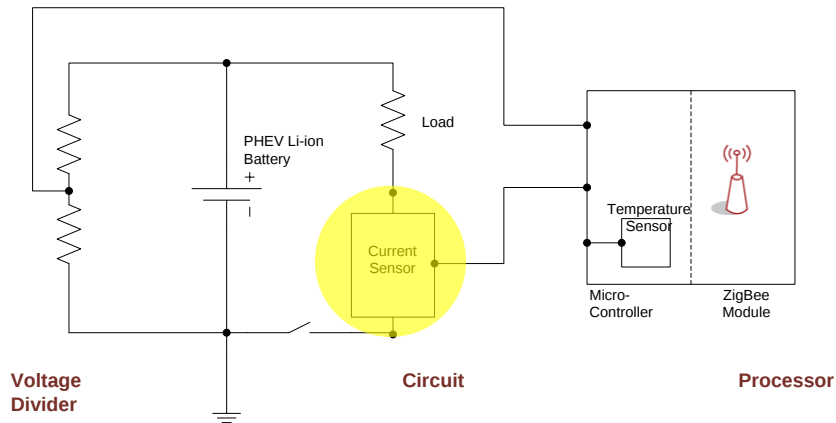
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- Integrated Temperature Sensor
- **Integrated ADC Module**
- NT-5 – Magneto-Resistive Current Sensor



- **Successive Approximation ADC**
Accuracy
High speed
Relatively low cost

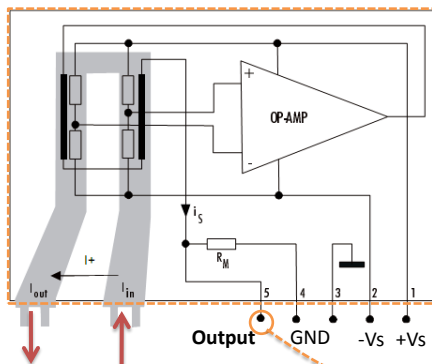
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Current Sensor

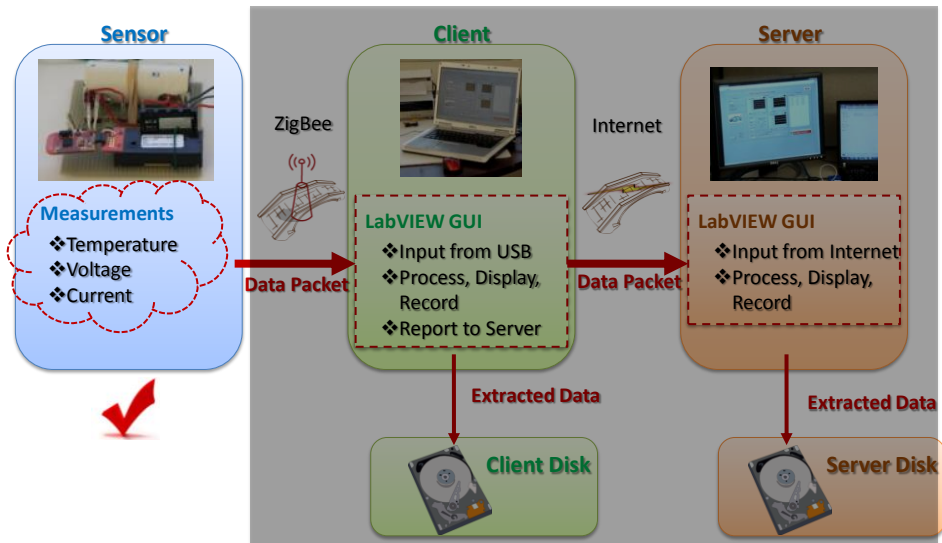
- Integrated Temperature Sensor
- Integrated ADC Module
- **NT-5 – Magneto-Resistive Current Sensor**



- **The MR Effect**
Electrical resistance changes when external magnetic field applied
- **Voltage proportional to current**
- **Wide measurement range**
- **High accuracy**

Micro-Controller

Network Enabled Battery Health Monitoring System



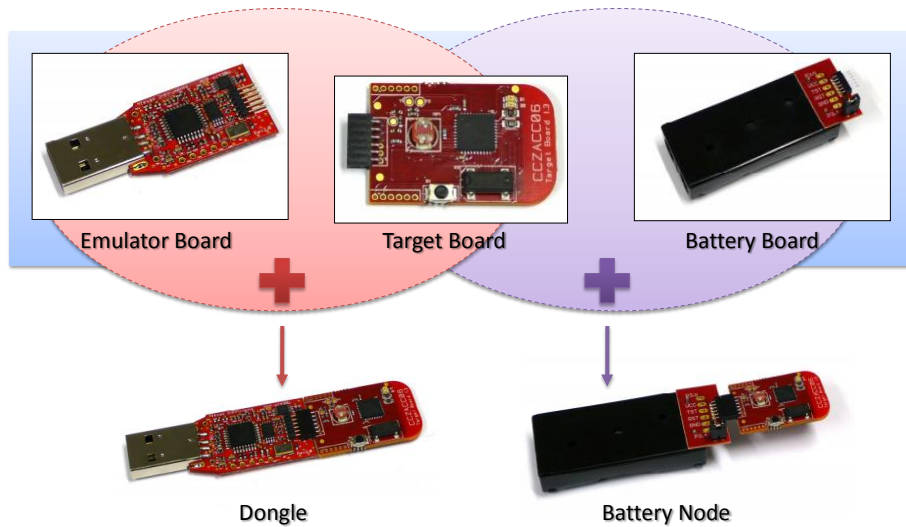
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eZ430-RF2480 Demo Kit



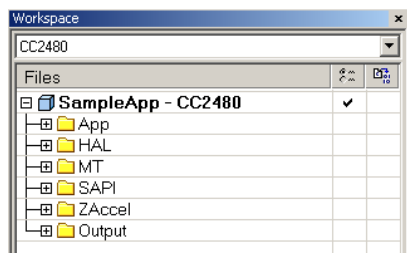
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ZigBee Accelerator Sample Application (ZASA)



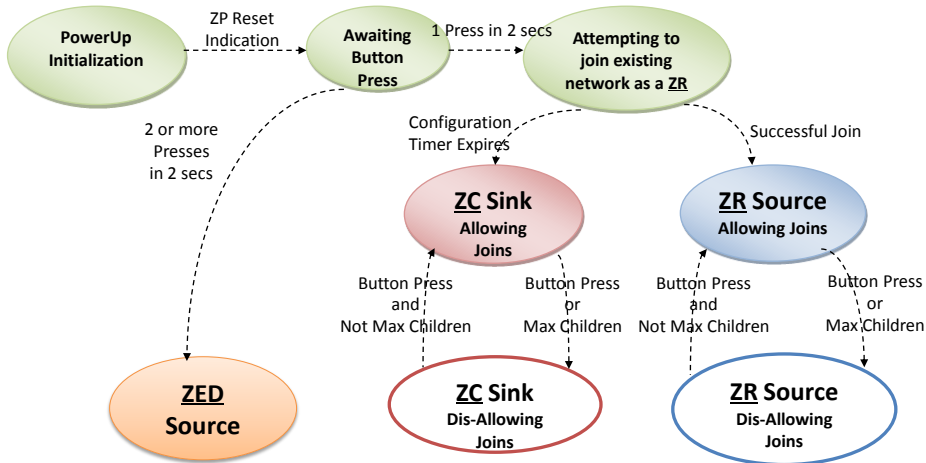
- Runs on MSP430, Interfaces to CC2480 device via SPI
- Makes use of CC2480 device easier
- Possible to integrate functions



- Application
- Hardware Abstraction Layer
- Monitor-Test
- Simple Application Programming Interface
- ZigBee Accelerator
- Output



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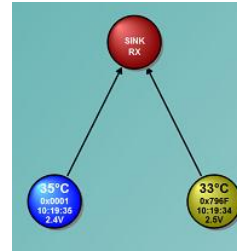
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- Plug Dongle to USB port, and configure it as a Coordinator
- Configure Battery Node as Router or End Device
- Different topologies in different situation



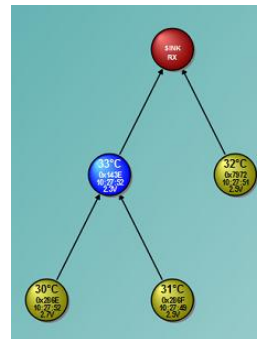
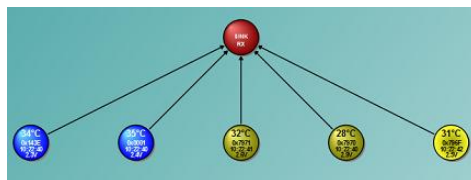
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- Insert Dongle to PC, and configure it as a Coordinator
- **Configure Battery Node as Router or End Device**
- Different topologies in different situation



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- Insert Dongle to PC, and configure it as a Coordinator
- Configure Battery Node as Router or End Device
- Different topologies in different situation



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Data Packet Redesign

- Data packet is in 16-byte: {control field, data field}
- Analysis and extraction

Control Field

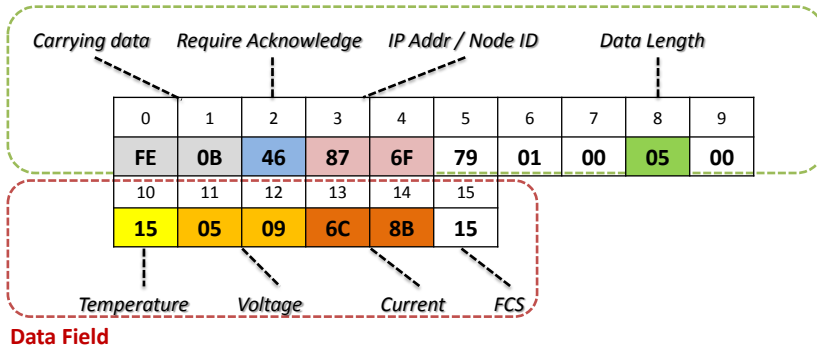
0	1	2	3	4	5	6	7	8	9
FE	0B	46	87	6F	79	01	00	05	00
10	11	12	13	14	15				
15	05	09	6C	8B	15				

Data Field

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- Different parts of data packet
- Data precision consideration: 5 effective digits

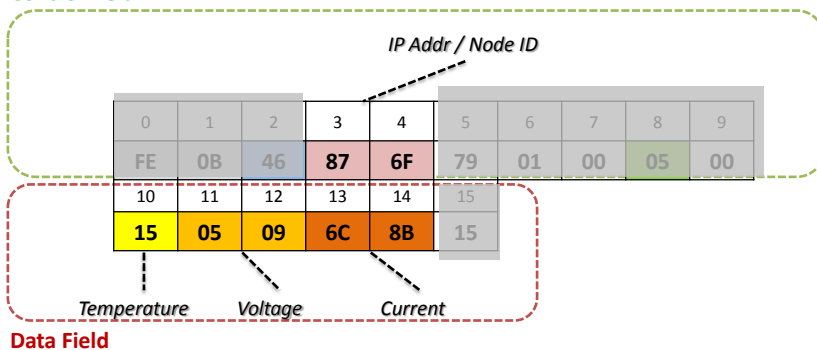
Control Field



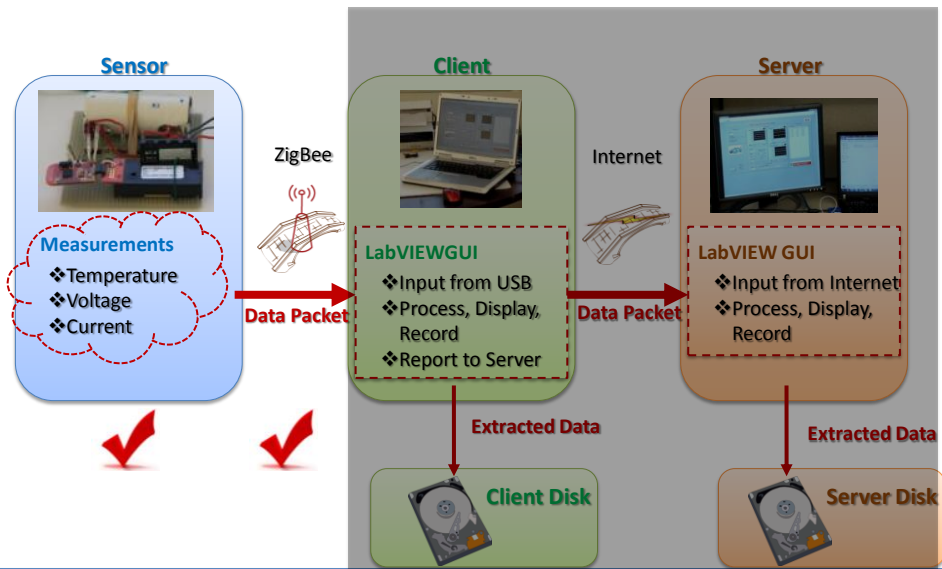
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- Useful information (unshaded)

Control Field



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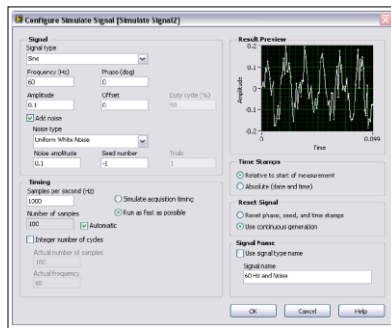
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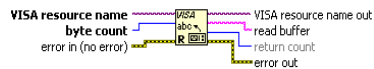
-
- Project Introduction
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- Features of LabVIEW
 - Convenient to make graphic display and operation interface
 - ✓ Matlab
 - Virtual Instrument between software and hardware



VISA Open

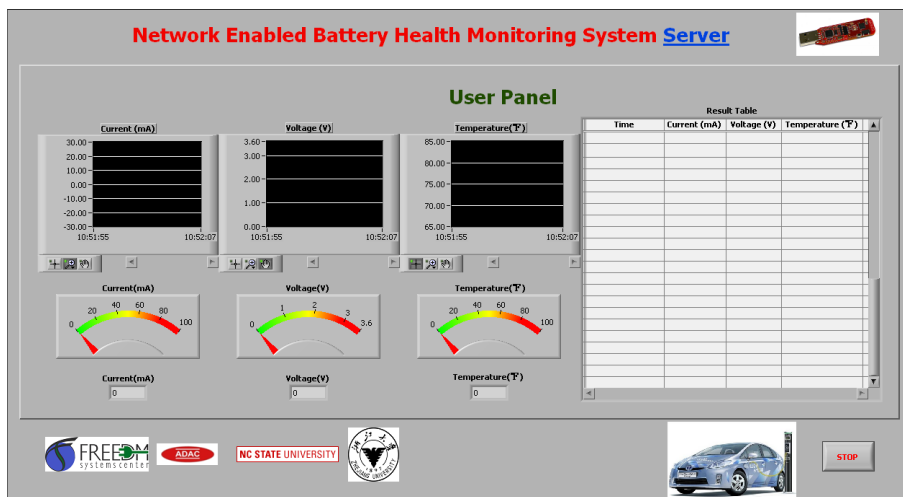


VISA Read



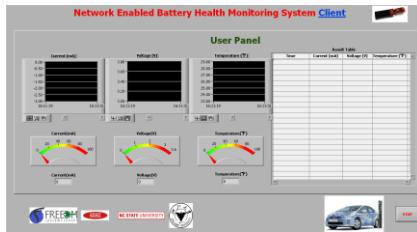
VISA Write

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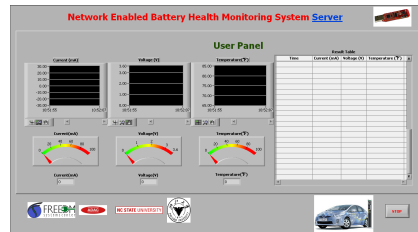


- Direct, Vivid and Multi-Angle expression

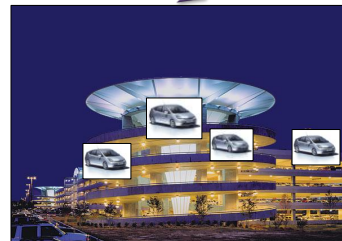
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Client



Server



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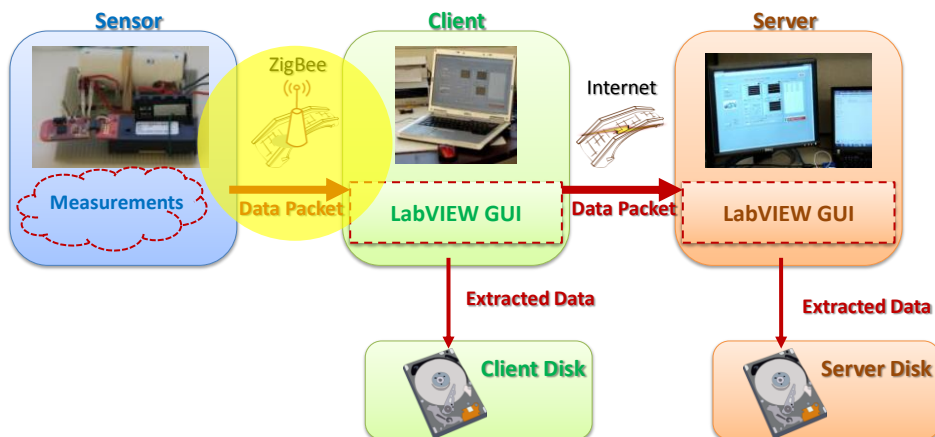
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Data Transmission

- ZigBee/USB - VISA
- TCP/IP



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- eZ430 Demo Kit



Dongle



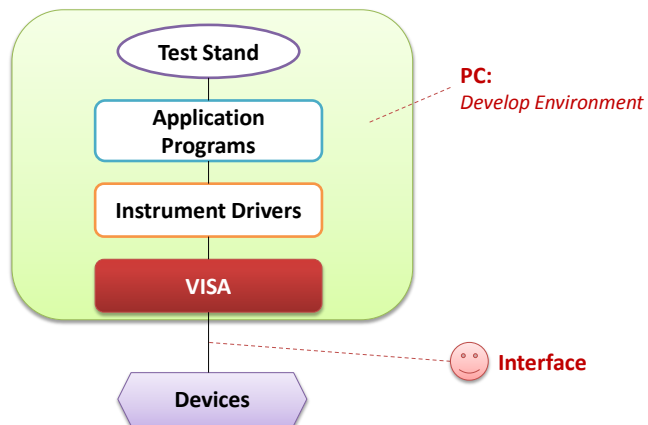
Battery Node



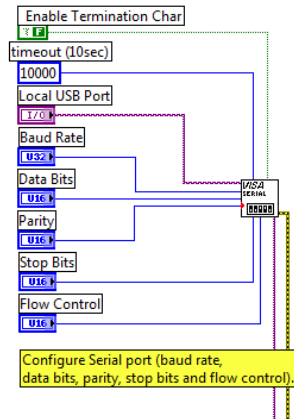
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ZigBee - VISA

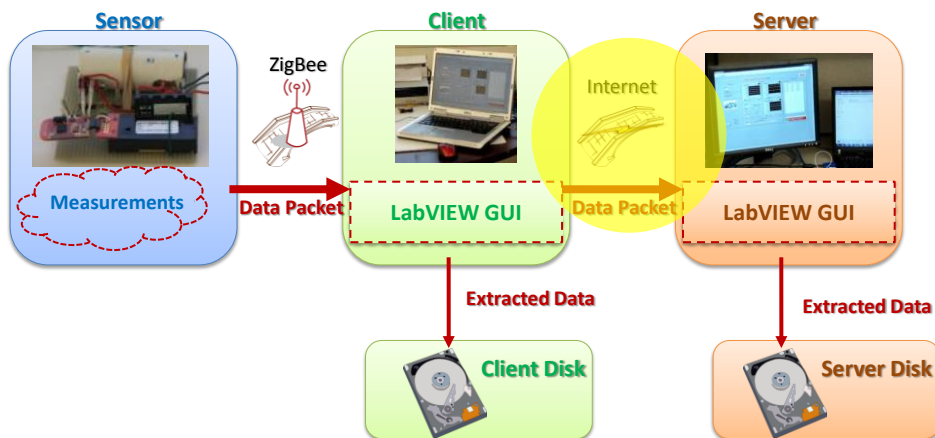
- VISA: The Virtual Instrument Software Architecture
- Read and Write



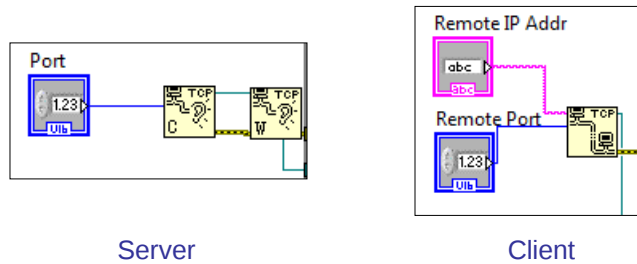
- Many Parameters to be Configured
- Data Packet: Hexadecimal String



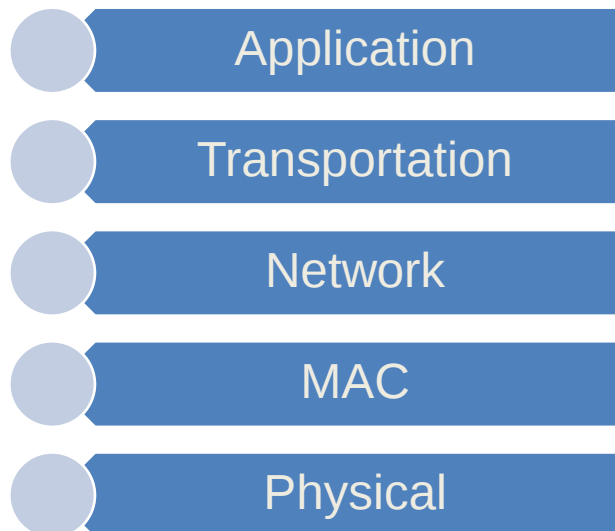
- ZigBee - VISA
- TCP/IP



- Server – Client model
 - Passive - Active
 - Connection Oriented
 - Reliable Data Transmission

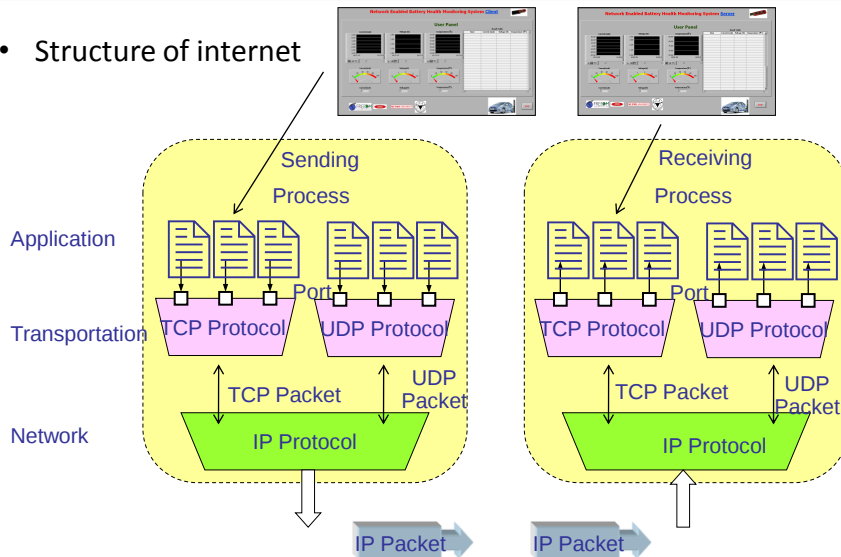


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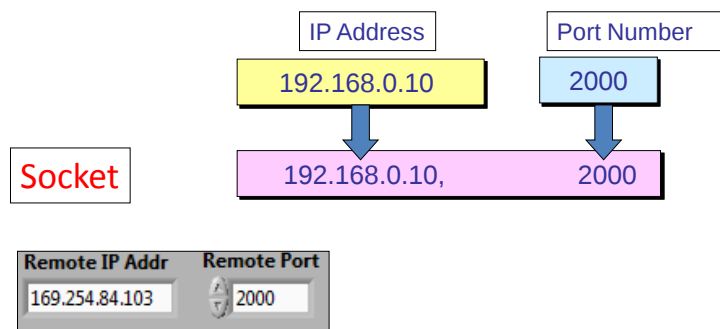
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- Structure of internet

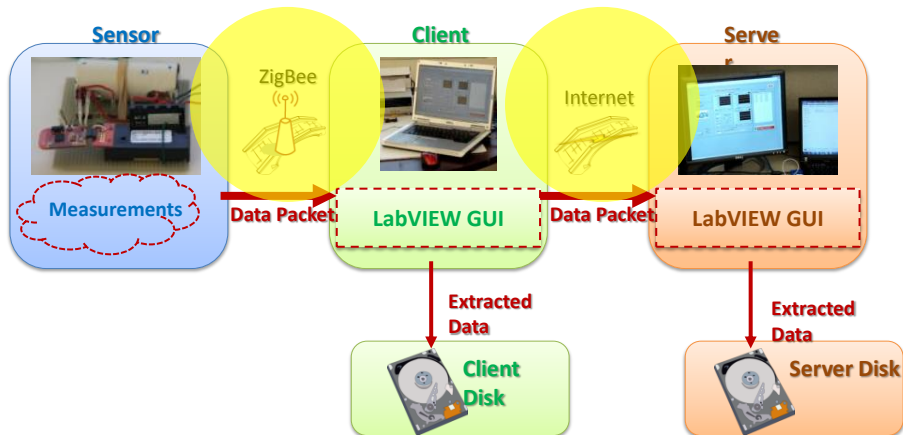


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- Unique identification of process in computer



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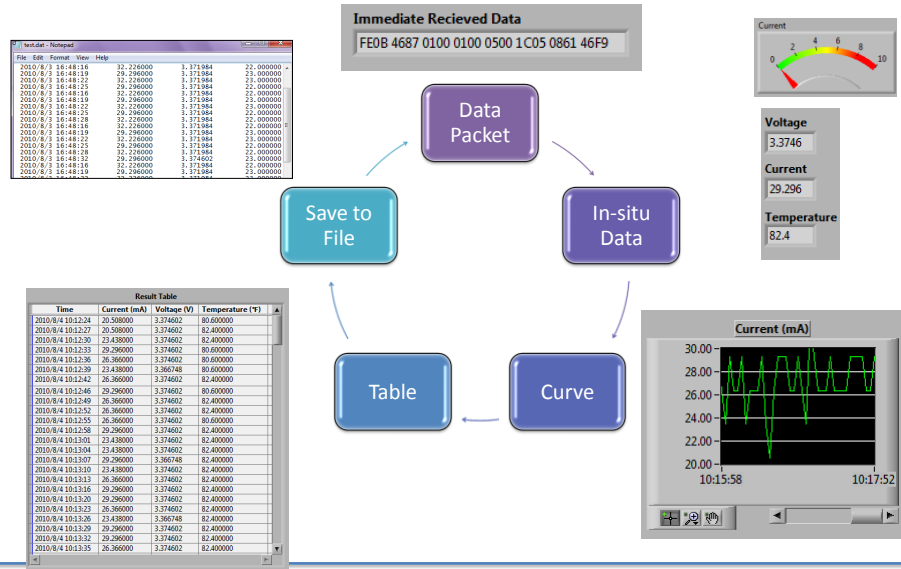
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Data Display



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Data Display



- Numerically

Immediate Recieved Data

FE0B 4687 0100 0100 0500 1C05 0861 46F9

Voltage

3.3746

Current

29.296

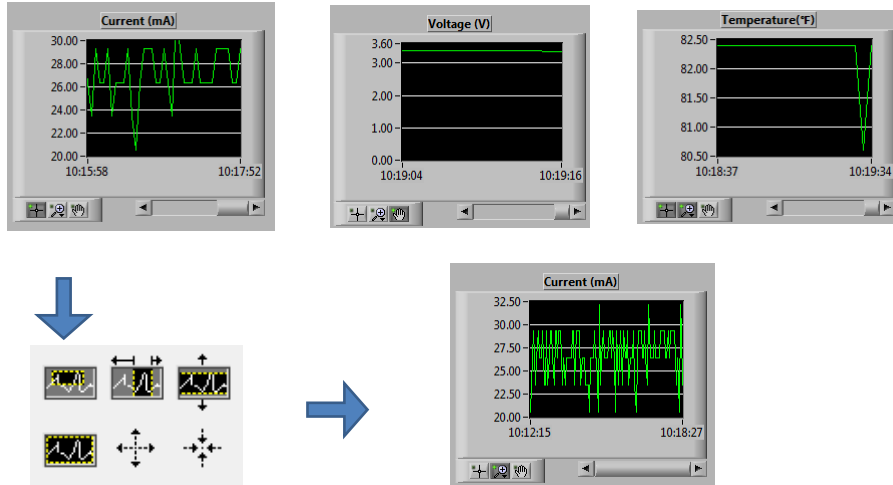
Temperature

82.4

Result Table			
Time	Current (mA)	Voltage (V)	Temperature (°F)
2010/8/4 10:12:24	20.508000	3.374602	80.600000
2010/8/4 10:12:27	20.508000	3.374602	82.400000
2010/8/4 10:12:30	23.438000	3.374602	82.400000
2010/8/4 10:12:33	29.296000	3.374602	80.600000
2010/8/4 10:12:36	26.366000	3.374602	80.600000
2010/8/4 10:12:39	23.438000	3.374602	82.400000
2010/8/4 10:12:42	26.366000	3.374602	82.400000
2010/8/4 10:12:45	29.296000	3.374602	80.600000
2010/8/4 10:12:48	26.366000	3.374602	82.400000
2010/8/4 10:12:51	23.438000	3.374602	82.400000
2010/8/4 10:12:54	20.508000	3.374602	82.400000
2010/8/4 10:12:57	23.438000	3.374602	82.400000
2010/8/4 10:13:00	23.438000	3.374602	82.400000
2010/8/4 10:13:03	29.296000	3.374602	82.400000
2010/8/4 10:13:06	26.366000	3.374602	82.400000
2010/8/4 10:13:09	23.438000	3.374602	82.400000
2010/8/4 10:13:12	20.508000	3.374602	82.400000
2010/8/4 10:13:15	23.438000	3.374602	82.400000
2010/8/4 10:13:18	26.366000	3.374602	82.400000
2010/8/4 10:13:21	29.296000	3.374602	82.400000
2010/8/4 10:13:24	26.366000	3.374602	82.400000
2010/8/4 10:13:27	23.438000	3.374602	82.400000
2010/8/4 10:13:30	20.508000	3.374602	82.400000
2010/8/4 10:13:33	23.438000	3.374602	82.400000
2010/8/4 10:13:36	26.366000	3.374602	82.400000
2010/8/4 10:13:39	29.296000	3.374602	82.400000
2010/8/4 10:13:42	26.366000	3.374602	82.400000
2010/8/4 10:13:45	23.438000	3.374602	82.400000
2010/8/4 10:13:48	20.508000	3.374602	82.400000
2010/8/4 10:13:51	23.438000	3.374602	82.400000
2010/8/4 10:13:54	26.366000	3.374602	82.400000
2010/8/4 10:13:57	29.296000	3.374602	82.400000
2010/8/4 10:14:00	26.366000	3.374602	82.400000

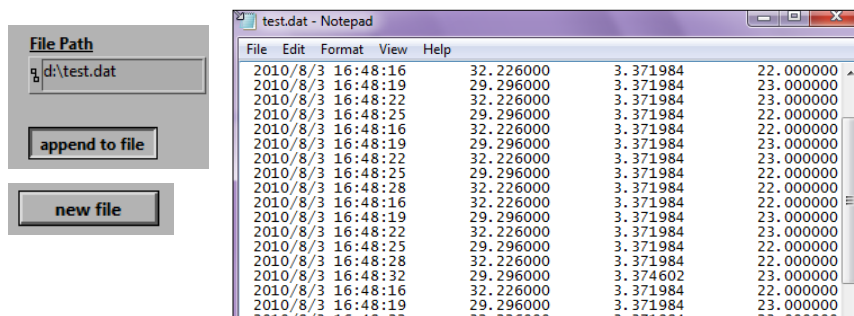
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- Graphically

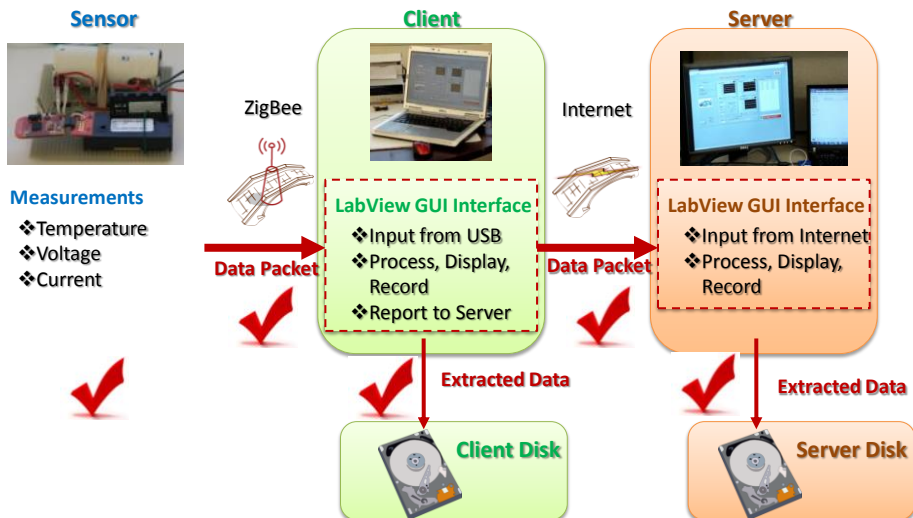


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- Save data in document



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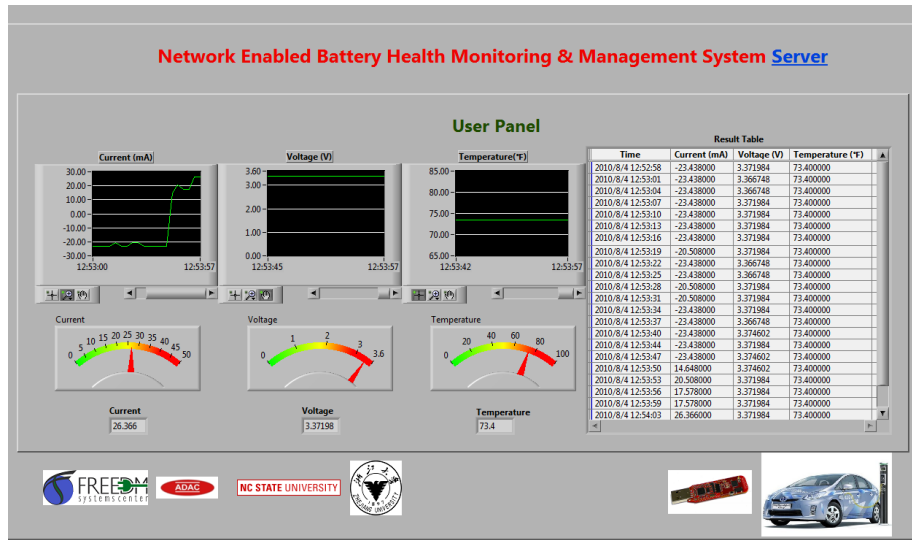


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Test and Validation



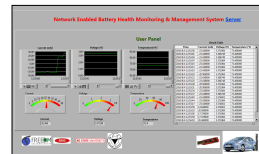
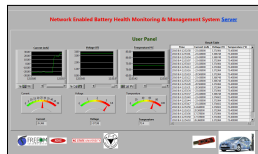
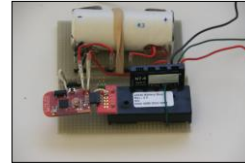
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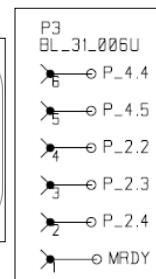
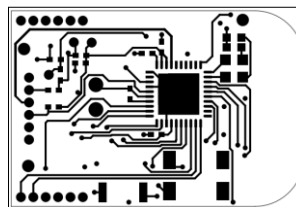
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- Hardware: eZ430 Demo Kit & NT-5
- Data Transmission: ZigBee & internet
- Data Display: LabVIEW GUI



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- Portability
 - Small and light
- Convenient for user
- Easy Expandability
 - 5 available GPIO Pins
 - Two independent cells
 - At most four cells in series
 - Multiplexer



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Demo Video



- View a 3-minute demo video
- http://www.adac.ncsu.edu/Project_folder/Project_home_page.htm#Future

2010 Summer Intern Projects *New!*

(1) Network Enabled Battery Health Monitoring and Management System

Fan Yang and Zhengyang Liu, junior students from Zhejiang University, Hangzhou, China

This project aims at building online instruments that can transmit sampled voltage, load current and temperature of a PHEV Li-ion battery to laptop via ZigBee wireless network, and to Municipal Parking Lot Charging Station via Internet.

Please click [here](#) for a detailed project description, or click [here](#) for a demo vedio.

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Q&A



Thank you for your listening!

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- Intersection and non-linearity of current sensor
 - Magneto-Resistive Current Sensor
- Data Rate VS. Sample Rate
- TCP/IP

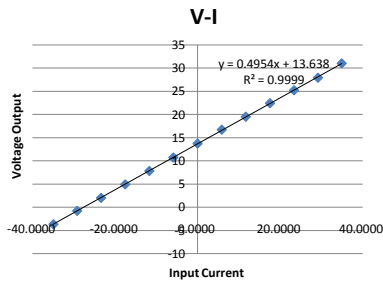
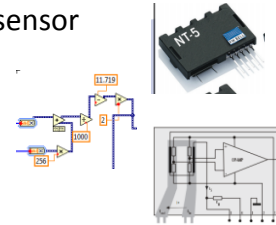


Table1. Measurements of output voltage towards input current

Voltage Output/mV	31	27.9	25.2	22.4	19.5	16.7	13.7
Current Input/mA	34.96	29.20	23.40	17.56	11.70	5.87	0.00
Voltage Output/mV	10.7	7.8	4.9	2	-0.8	-3.7	
Current Input/mA	-5.87	-11.70	-17.56	-23.40	-29.20	-34.96	