

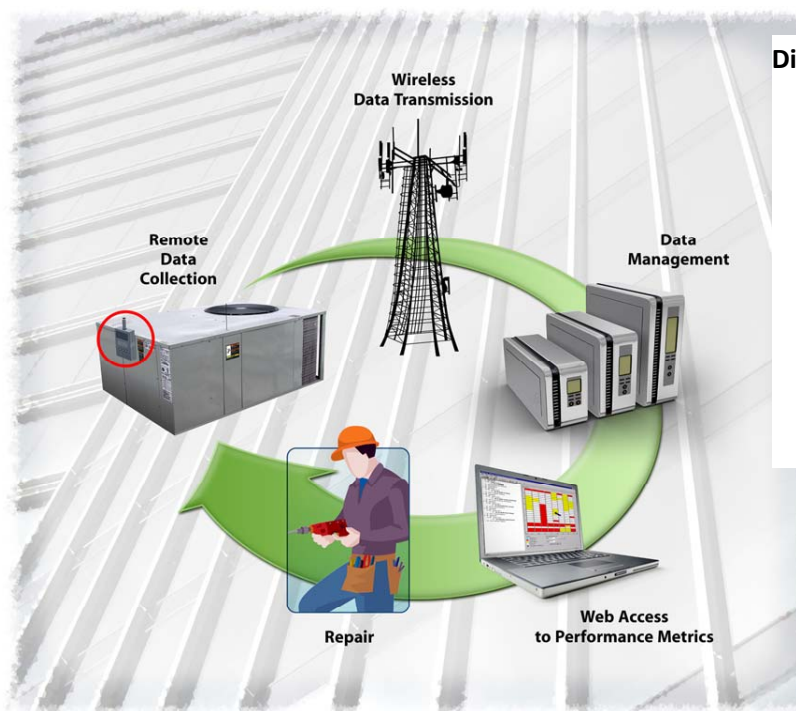
Smart Monitoring and Diagnostic System for Packaged Air Conditioners and Heat Pumps

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Smart Monitoring and Diagnostic System (SMDS)



Diagnostics Provided

- Packaged HVAC Unit Air-Side Fault Detection and Diagnostics
- Packaged HVAC Unit Efficiency Monitor and Diagnostics
- Optional: Packaged Unit Refrigerant-Side Fault Detection and Diagnostics

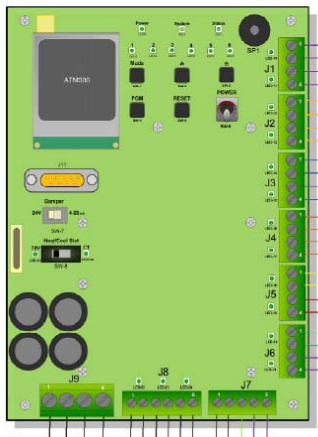


SMDS Hardware



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SMDS Circuit Board and Sensors



Thermistors

- outdoor air
- return air



Thermistors & humidity sensors

- mixed air
- supply air



Current switch

- supply fan status

Direct connections

- heating/cooling status
- damper signal

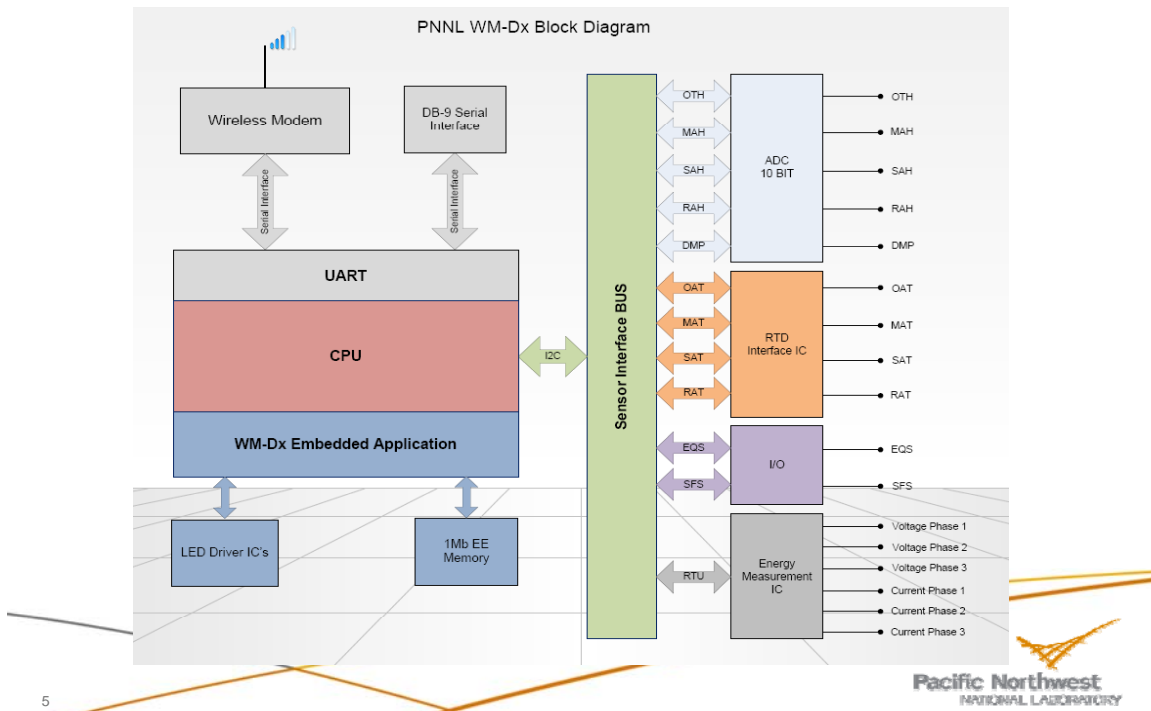
Voltage taps and ground

- Direct connections



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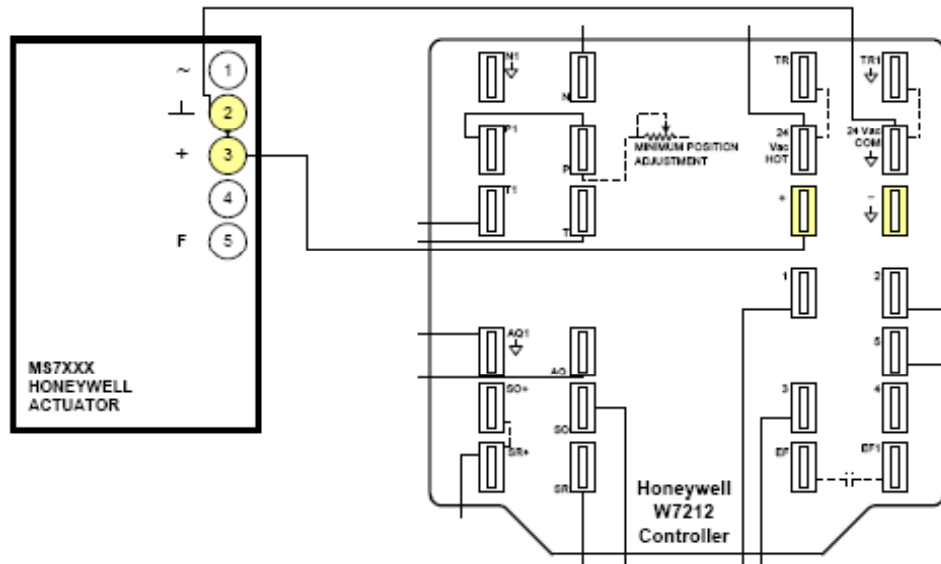
SMDS Major Components



Temperature and Humidity Sensors Installation



Damper Position Signal Example



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Diagnostic Algorithms

- ▶ Outdoor-Air Ventilation and Economizer Operation
 - Algorithms from Outdoor-Air Economizer Diagnostician (OAE) module of the Whole-Building Diagnostician (WBE)
 - Tested on many units with results published
 - <http://www.buildingsystemsprogram.pnl.gov/fdd/wbd/index.stm> for details and list of publications
- ▶ Efficiency Monitor/Diagnostician
 - Based on RTU power use and change in enthalpy of air across the cooling coil.
 - Rated air flow rate is used to calculate COP—looking for changes in cooling efficiency rather than accurate absolute value
- ▶ Refrigerant-side Diagnostics
 - Based on troubleshooting rules from Carrier Corporation. 1992. *General Training Air Conditioning II – Module Troubleshooting*.

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Air-Side User Interface

Overview EffDx AirDx

Time Period: Yesterday

Site	Name	Status
WmDx	WmDx 2002477	

Overview EffDx AirDx

Time Period: Today

Site	Name	OK #	Configuration Issue	Ventilation Issue	Energy Issue	Control, Sensor or Other Problem
WmDx	WmDx 2002477	3	0	0	16	0

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Air-Side User Interface – Graphic Hourly Results

Summary Results Charting Config Notifications

EffDx AirDx

0	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
1	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
2	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
3	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
4	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
5	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
6	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
7	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
8	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
9	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
10	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
11	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
12	System OK	System OK	System OK	System OK	System OK
13	System OK	System OK	System OK	System OK	System OK
14	System OK	System OK	System OK	System OK	System OK
15	System OK	System OK	System OK	System OK	System OK
16	System OK	System OK	System OK	System OK	System OK
17	System OK	System OK	System OK	System OK	System OK
18	System OK	System OK	System OK	System OK	System OK
19	System OK	System OK	System OK	System OK	System OK
20	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
21	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
22	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue
23	Energy Issue	Control, Sensor or Other Problem	Energy Issue	Control, Sensor or Other Problem	Energy Issue

Diag Code: 455
 Local Time: 2008-09-15T07:01:00
 Message: "The economizer should be operating, but instead is off. Outdoor-air ventilation is adequate to meet occupant needs, mechanical cooling is on, and the outdoor-air is cooler than the return-air. As a result, cooling energy is being wasted because cool outdoor-air is not being used for "free" cooling."

Legend

- System OK
- Diag Config Issue
- Ventilation Issue
- Energy Issue
- Control, Sensor or Other

Select Date Ranges

Interval: 7

Start Date - End Date: 9/9/2008 - 9/16/2008

Prev Next

Efficiency Monitoring/Diagnostics User Interface

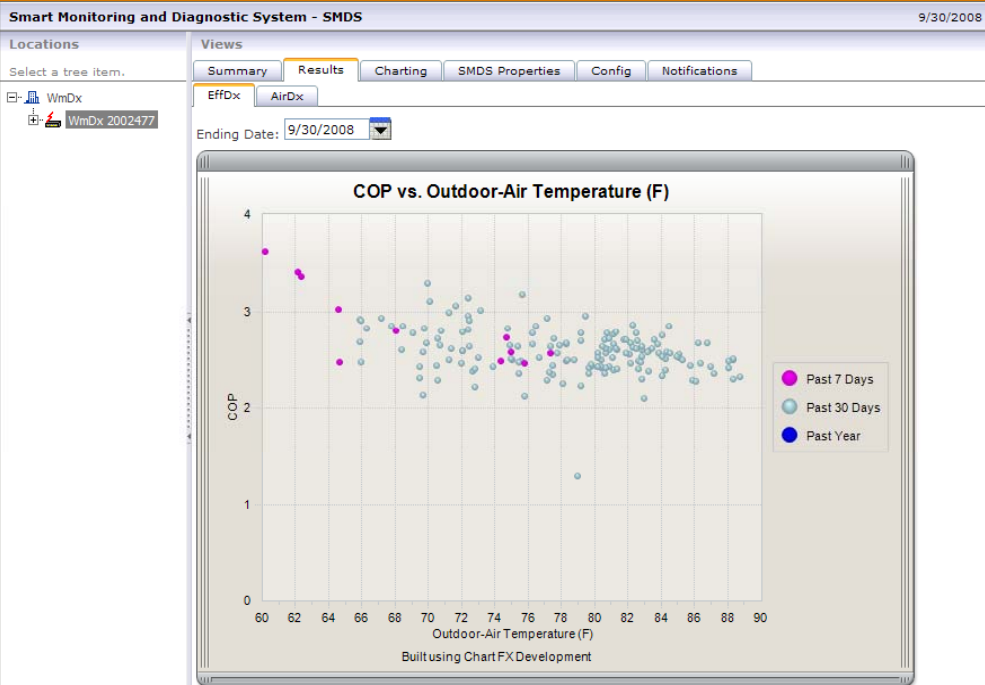
Overview **EffDx** AirDx

Time Period: Today

Site	Name	Eff #	Eff Min	Eff Max	Eff Avg	Sensor Faults
WmDx	WmDx 2002477	10	2.40	2.90	2.66	0



Efficiency Monitoring/Diagnostics User Interface



Potential Benefits

- ▶ Enable RTU maintenance based on actual operating condition of units (condition-based maintenance) rather than periodic preventive maintenance only or neglect.
- ▶ Enable rapid response to urgent service needs.
- ▶ Target technician time on units that need it most during a service call.
- ▶ Inform owners and service providers on degradation in unit efficiency to inform service decisions.
- ▶ Energy and cost savings to owners.
- ▶ More satisfied building occupants.
- ▶ Higher-level service offering for HVAC contractors.

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Status

- ▶ Field testing on approximately 100 rooftop air conditioners and heat pumps in Washington State.
- ▶ Six HVAC contractors participating—east and west sides of Cascades.
- ▶ Collecting data for:
 - Time required for installation
 - Diagnostic performance
 - User perceptions
 - Service actions taken
 - Energy impacts
 - Impressions of users
- ▶ Installations in Fall 2008 and Spring 2009.
- ▶ Project completion in December 2009.
- ▶ Exploring development of lower-cost SMDS.

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Thank you!

