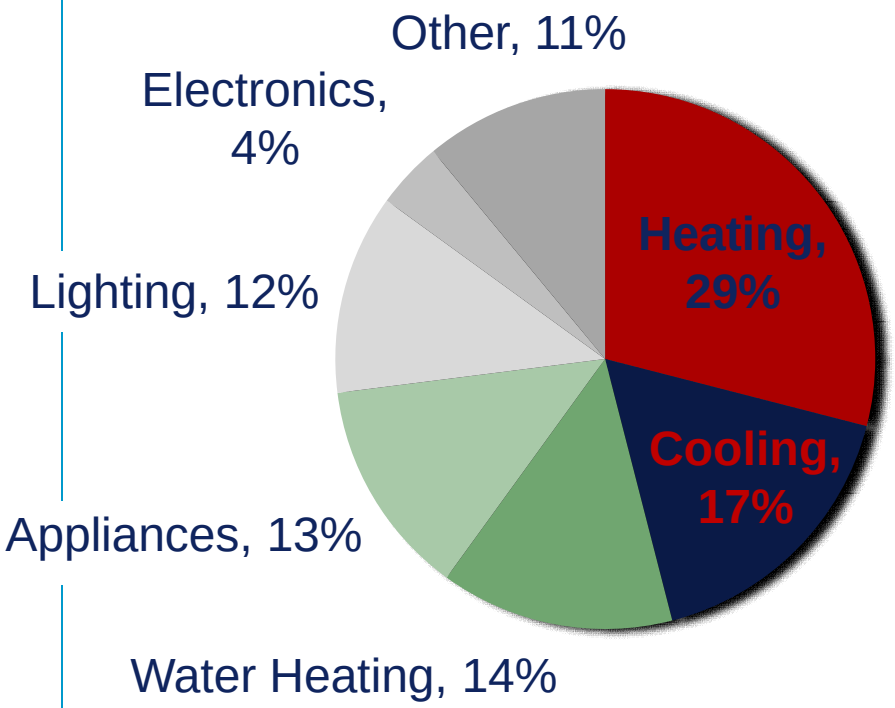
HVAC Sensors, Controls, and Human Feedback Interfaces

April 26, 2010

Dr. Amr Gado

Emerson Climate Technologies

Heating And Cooling Consume Almost Half of Total Residential Energy



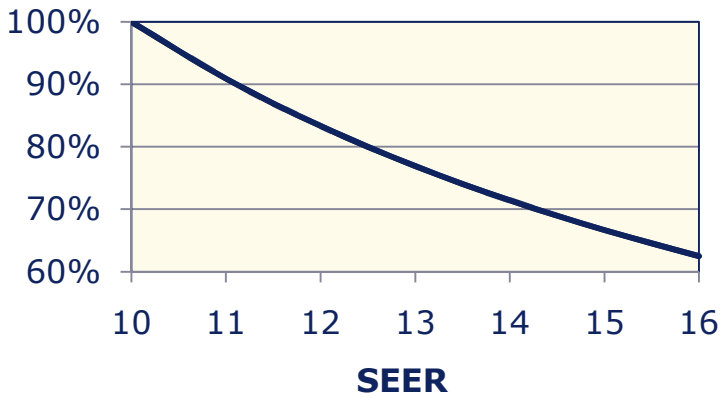
Residential Energy Consumption

Source: EPA

One way to reduce residential HVAC energy consumption is by increasing **System Design Efficiency**

Cooling Energy Cost

Relative to 10 SEER



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Studies Show 50-73% of Residential HVAC Installations Have Problems, Reducing Efficiency by 30-50%

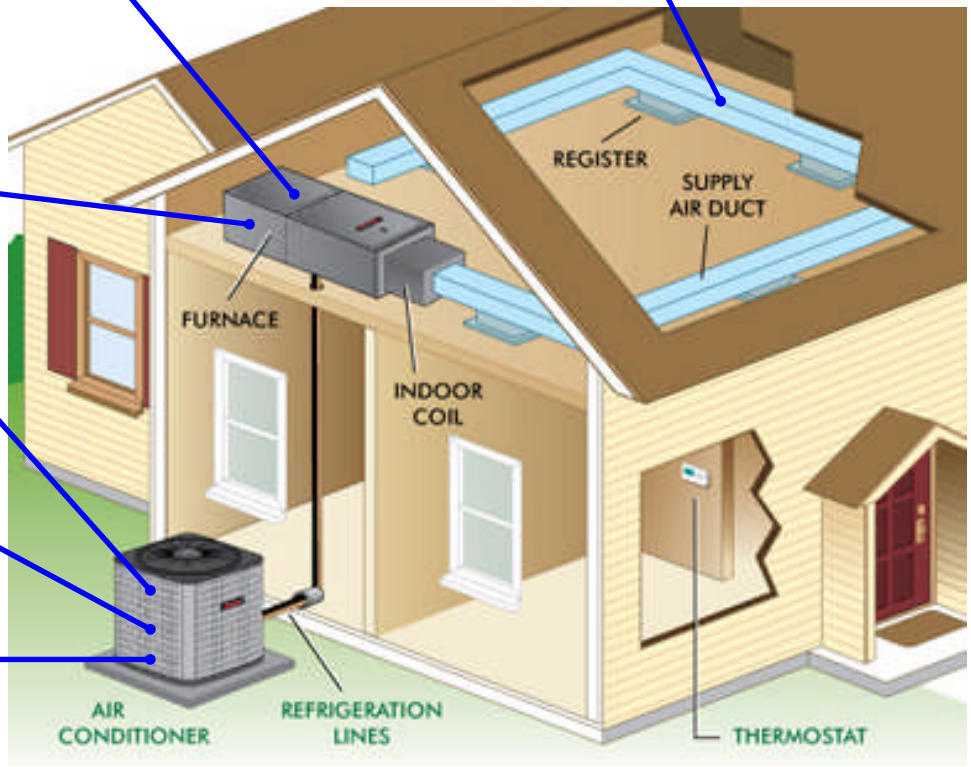
Inadequate Airflow	Systems Affected	Reduced Efficiency
	44-72%	8%

Duct Leakage	Systems Affected	Reduced Efficiency
	Almost all	17%

Mismatched Systems	Systems Affected	Reduced Efficiency
	TBD	TBD

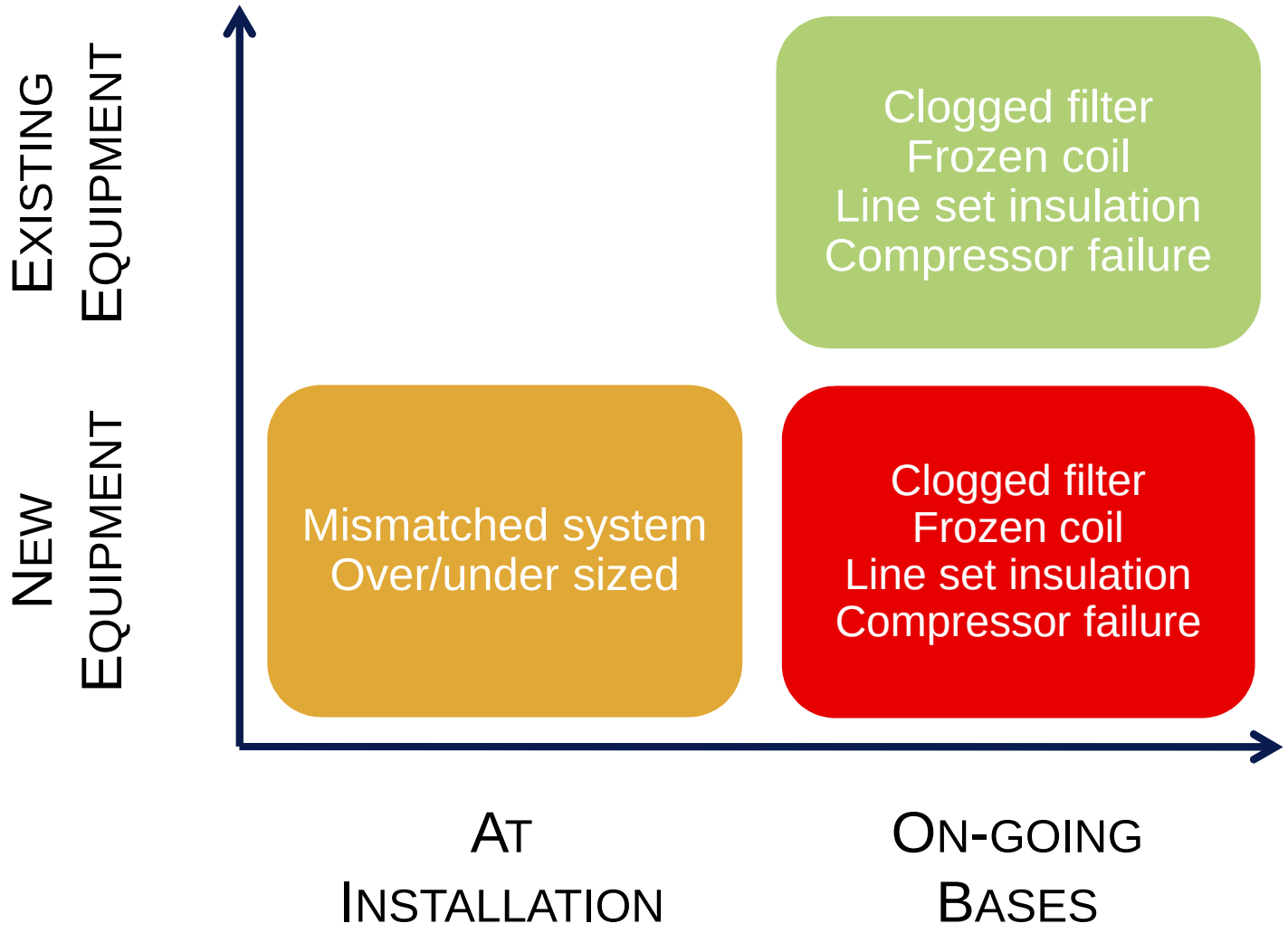
Improper Refrigerant Charge	Systems Affected	Reduced Efficiency
	60-70%	10-20%

Over / Undersized System	Systems Affected	Reduced Efficiency
	50%	2-10%



Source: Open literature

The Value Proposition Is Multidimensional



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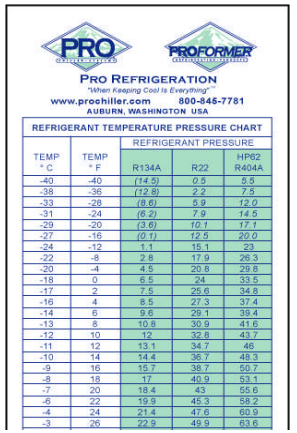
P&T Sensing for Charge Indication

To charge the system, the technician is supposed to …

1. Measure liquid line pressure



PRO REFRIGERATION

"When Keeping Cool Is Everything"

www.prochiller.com 800-845-7781

AUBURN, WASHINGTON USA

REFRIGERANT TEMPERATURE PRESSURE CHART

TEMP °C	TEMP °F	REFRIGERANT PRESSURE R134A	R22	HP62 R404A
-40	-40	(14.5)	0.5	5.5
-38	-36	(12.8)	2.2	7.5
-33	-28	(8.6)	5.9	12.0
-31	-24	(6.2)	7.9	14.5
-29	-20	(3.6)	10.1	17.1
-27	-16	(0.1)	12.5	20.0
-24	-12	1.1	15.1	23
-22	-8	2.8	17.9	26.3
-20	-4	4.5	20.8	29.8
-18	0	6.5	24	33.5
-17	2	7.5	25.6	34.8
-16	4	8.5	27.3	37.4
-14	6	9.6	29.1	39.4
-13	8	10.8	30.9	41.6
-12	10	12	32.8	43.7
-11	12	13.1	34.7	46
-10	14	14.4	36.7	48.3
-9	16	15.7	38.7	50.7
-8	18	17	40.9	53.1
-7	20	18.4	43	55.6
-6	22	19.9	45.3	58.2
-4	24	21.4	47.6	60.9
-3	26	22.9	49.9	63.6

2. Read corresponding saturation temperature from table

3. Measure liquid line temperature

Degree of Subcooling = Saturation Temp. – Liquid Line Temp.

Some technicians don't know, some don't care

The result is a miss-charged system

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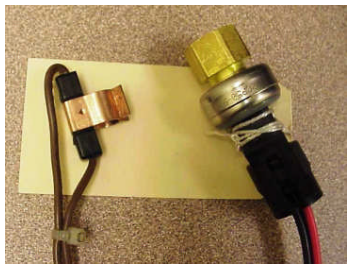
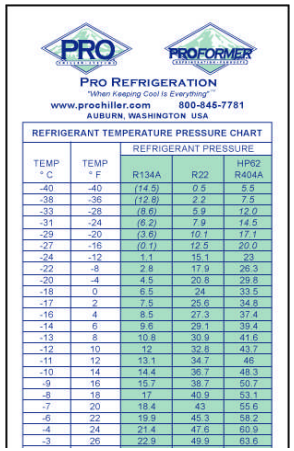
Emerson's Charge Indication Solution Automates Decision Taking

What Technicians Use Now

Charging Manifold & Temp. Sensor

Could Become





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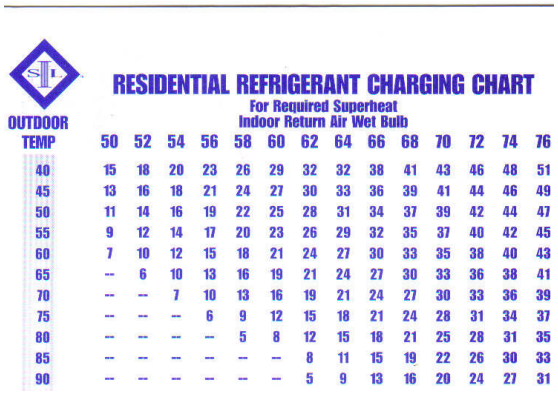


RESIDENTIAL REFRIGERANT CHARGING CHART
For Required Superheat
Indoor Return Air Wet Bulb

OUTDOOR TEMP	50	52	54	56	58	60	62	64	66	68	70	72	74	76
40	15	18	20	23	26	29	32	32	38	41	43	46	48	51
45	13	16	18	21	24	27	30	33	36	39	41	44	46	49
50	11	14	16	19	22	25	28	31	34	37	39	42	44	47
55	9	12	14	17	20	23	26	29	32	35	37	40	42	45
60	7	10	12	15	18	21	24	27	30	33	35	38	40	43
65	--	6	10	13	16	19	21	24	27	30	33	36	38	41
70	--	--	7	10	13	16	19	21	24	27	30	33	36	39
75	--	--	--	6	9	12	15	18	21	24	28	31	34	37
80	--	--	--	--	5	8	12	15	18	21	25	28	31	35
85	--	--	--	--	--	--	8	11	15	19	22	26	30	33
90	--	--	--	--	--	--	5	9	13	16	20	24	27	31

Refrigerant Table and OEM Target Subcooling Table

Charge Indication Is Valuable To The Homeowner And Technician

- Shows if the system is properly charged with refrigerant
- Helps technicians during installation of the outdoor unit and during maintenance
- Ongoing indicator for homeowners
- Allows the technician to show homeowner he did a good job
- Requires adding pressure transducer to the system

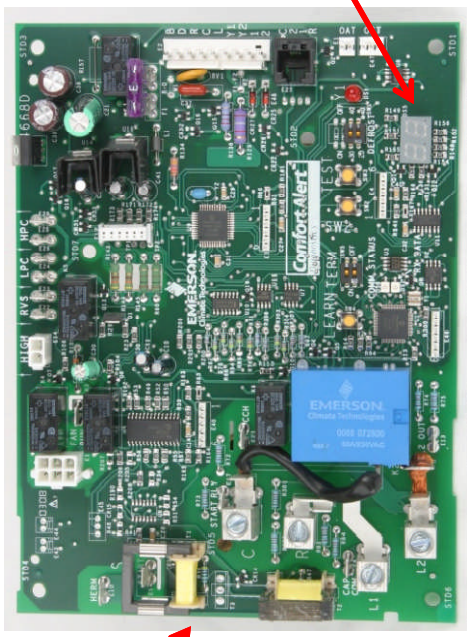
Electronics Make For Better Use Of Sensors

Emerson's '*Unitary Control*' and '*Comfort Alert*' provide diagnostics and protection for outdoor units

First Use of **Compressor-As-A-Sensor**

- Control
  - Compressor – single or two stage
  - Defrost – time temp or demand
- Diagnostics
  - Low / hi side pressure
  - Open start / run
  - Welded contactor
  - Locked rotor
  - Internal protector trip
  - Short cycle

Local Display (status/faults)



Current Transformers (Compressor start & run)

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What Could Be Done With 2 Current Transformers And A Control Board

Fault	Action	Feedback		
		Tstat Display	Tstat Menu	Contractor
Short cycling	--	--	Fault code & message	Fault recall
Pressure switch trip	Compr. & fan off	--		
Low Voltage	Low stage	--		
Compressor protector trip	--	"Call For Service"		
Locked rotor	Lockout			
Open start/run	Lockout			
…				
…				

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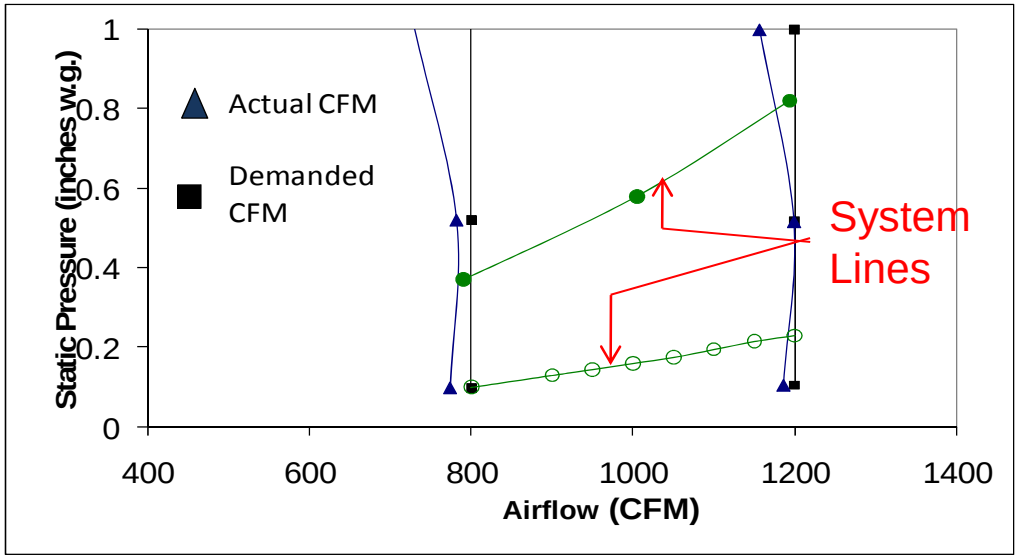
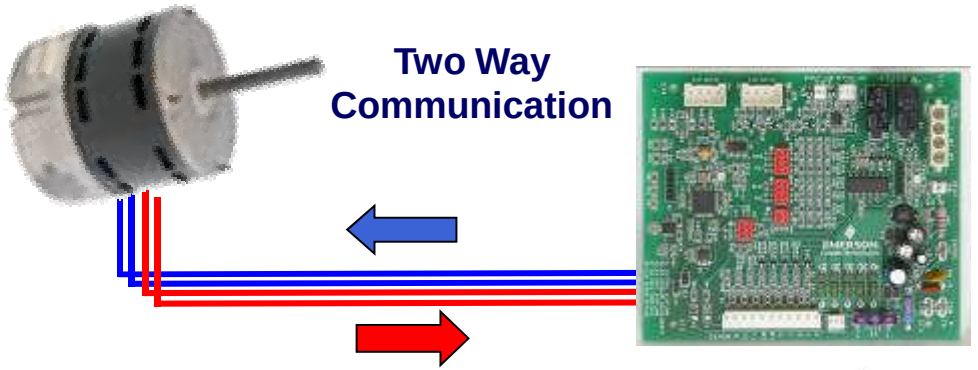
Motor-As-A-Sensor: Provides System Data & Value Through Motor Sensing Technologies

- Airflow Verification
  - Can provide verification that airflow is within QI standard - between 85 to 115%
- Clogged Filter & Frozen Coil
  - Can determine when system performance is down due to cogged filter or frozen coil



Provide Real Time Performance Monitoring, Operational Status & Diagnostics



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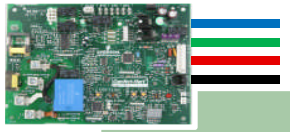
Prognostic Capabilities of Smart HVAC Systems

TRADITIONAL AC UNIT

- No diagnostic information

AC W/ COMFORT ALERT

- Compressor & Motor-As-A-Sensor
- 9 Fault Codes
- Proactive Protection
- Fault tolerant mode



SMART AC

- Communicating system
- Easier to install
- 40+ status & diagnostic codes
- More proactive protection & limp-along
- Homeowner alerts

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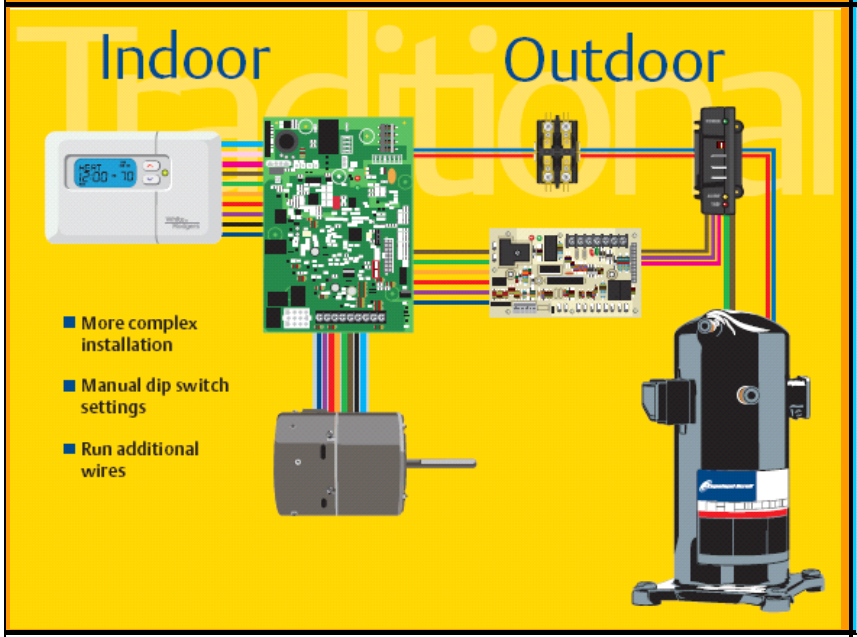
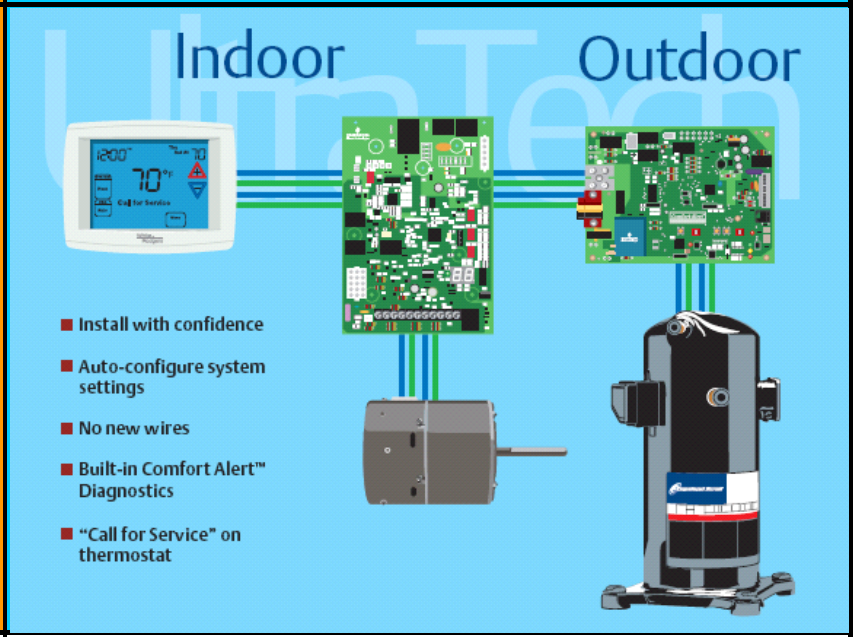
Smart HVAC Systems – Automation Provides Efficient Solutions

Traditional High End System	Smart HVAC System
	
New wires, dipswitch settings	*No new wires, autoconfiguration*
Complex	**Easy to Install**

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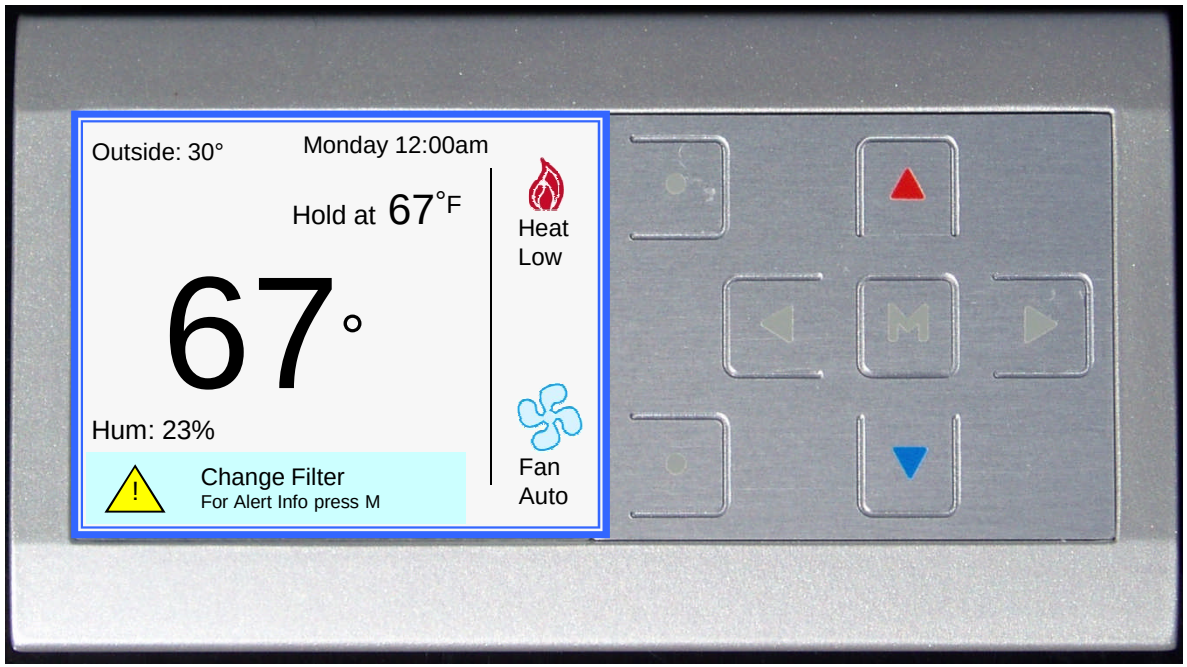
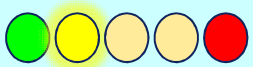
Smart HVAC Systems – User Friendly Access to Performance Information

- Recognize components on the network, no DIP switch settings
- Remote access is possible
- Sensor & diagnostic information distributed through the system
- Simple display for homeowner and detailed display for the contractor



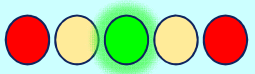
Air Filter Monitor

Good Change



Charge Monitor

High Low



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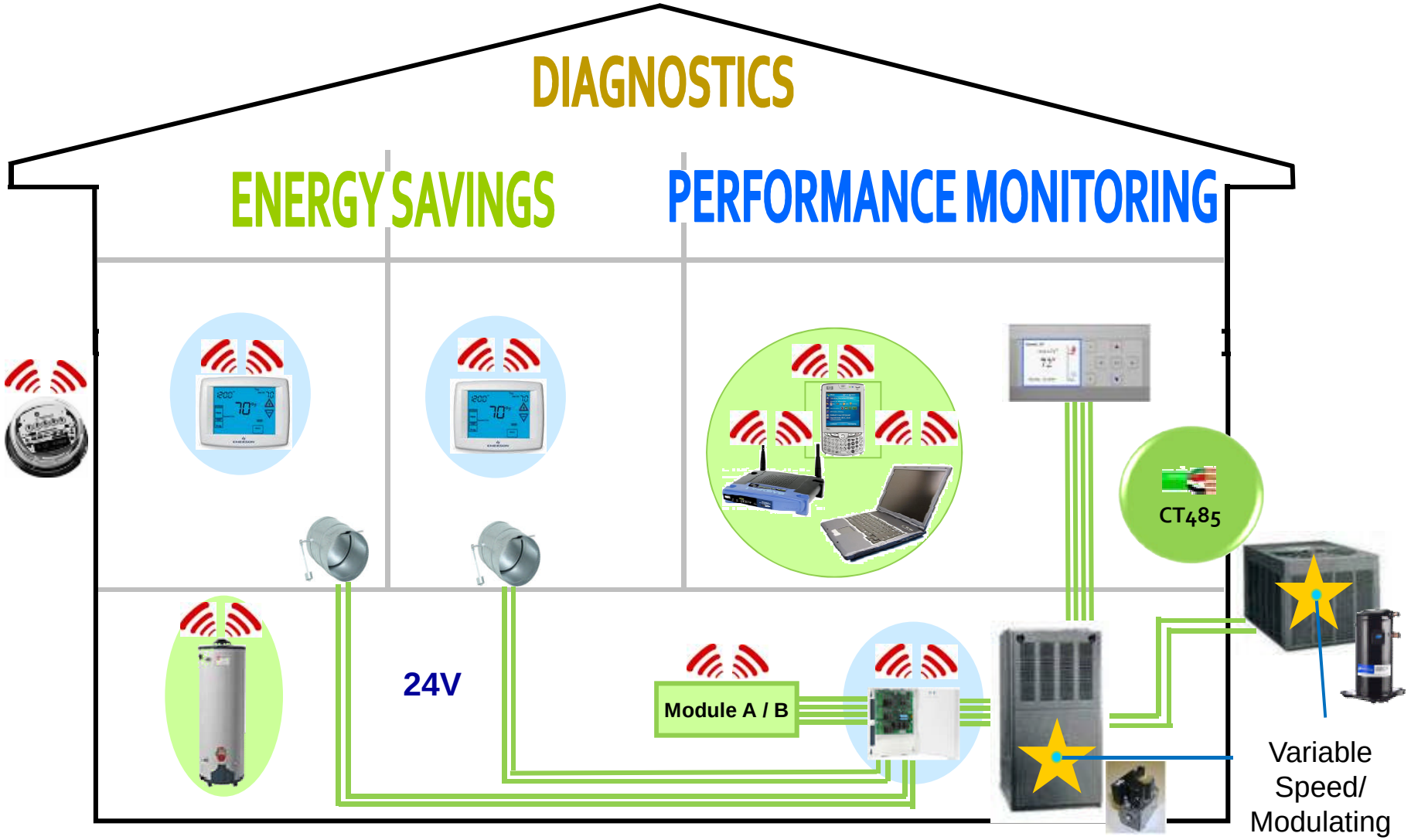
Smart HVAC Systems are the Enabling Foundation to Integrated Solutions



Conclusions

- A lot of value can be delivered from common sensors if electronics are used to diagnose and protect the system
- Component manufacturers can leverage their components as sensors
- Communications (between components and to the outside of the system) allow for better use of system information and better performing systems
- The way the information is utilized can affect market acceptance to the solution