Residential Control Systems (for High Performance Buildings)

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Learning Objectives

1. Understand basic residential control systems.
2. Communicating versus non-communicating control systems.
3. Understand the limitations in manufacturer's default controls for residential equipment and how they communicate (or don't) with other equipment.
4. Learn about the different communication protocols.
5. Learn how to best integrate control systems in advanced and during equipment selection.

Terminology

1. Smart thermostat: WI-FI enabled thermostats That's it.
2. Digital input – can only tell if something is on/off switch, nothing in-between
3. Bimetallic strip – example of digital, open/closed
4. Analogue inputs – variable signal (voltage, current, or resistance)
5. Deadband – temperature swing where no response will occur. ± 2°F

Condenser

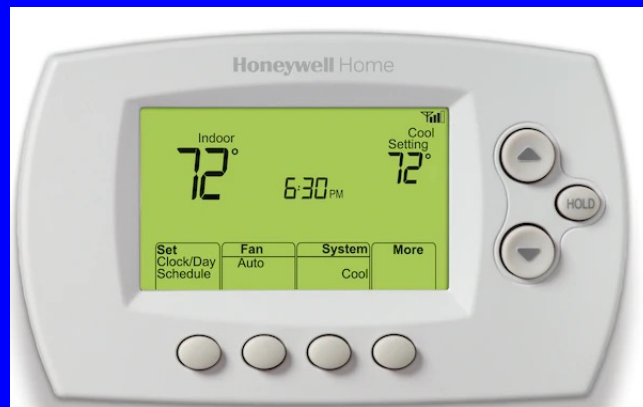
Fossil fuel furnace

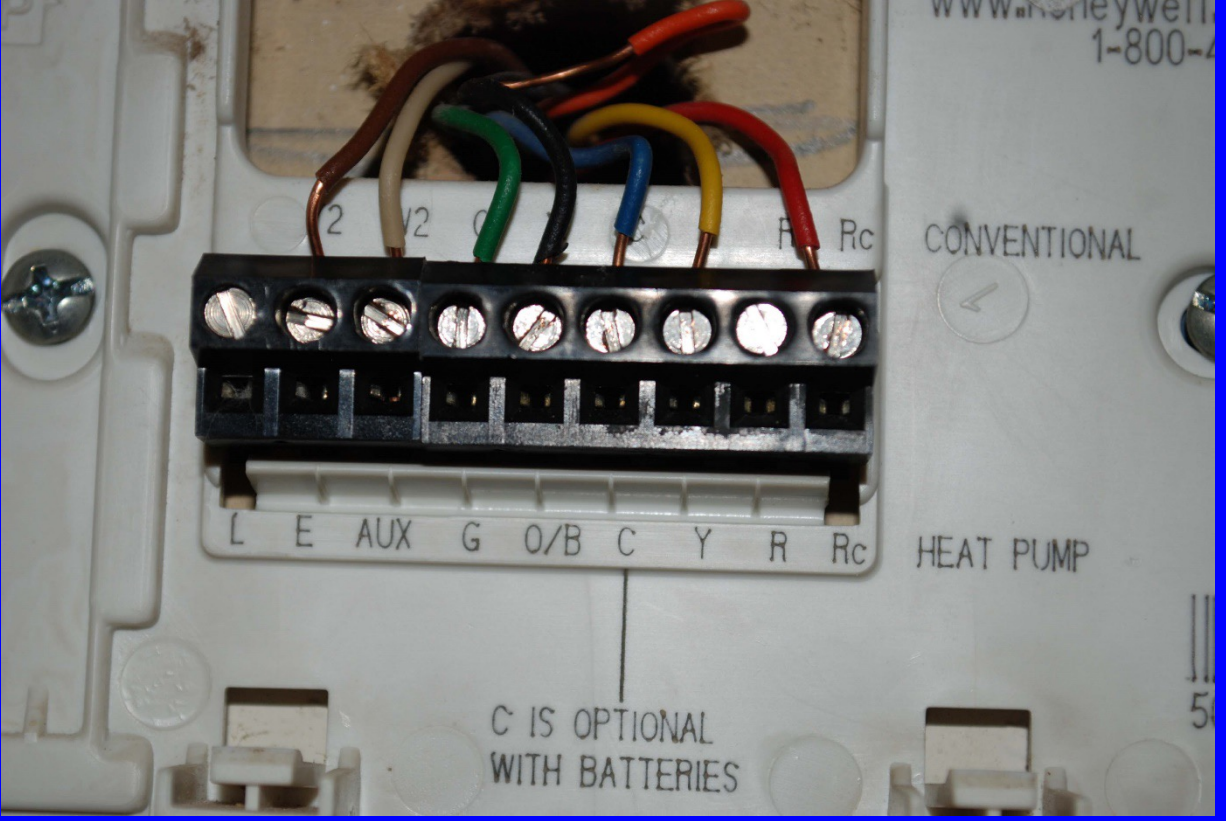
Hot Water Generation

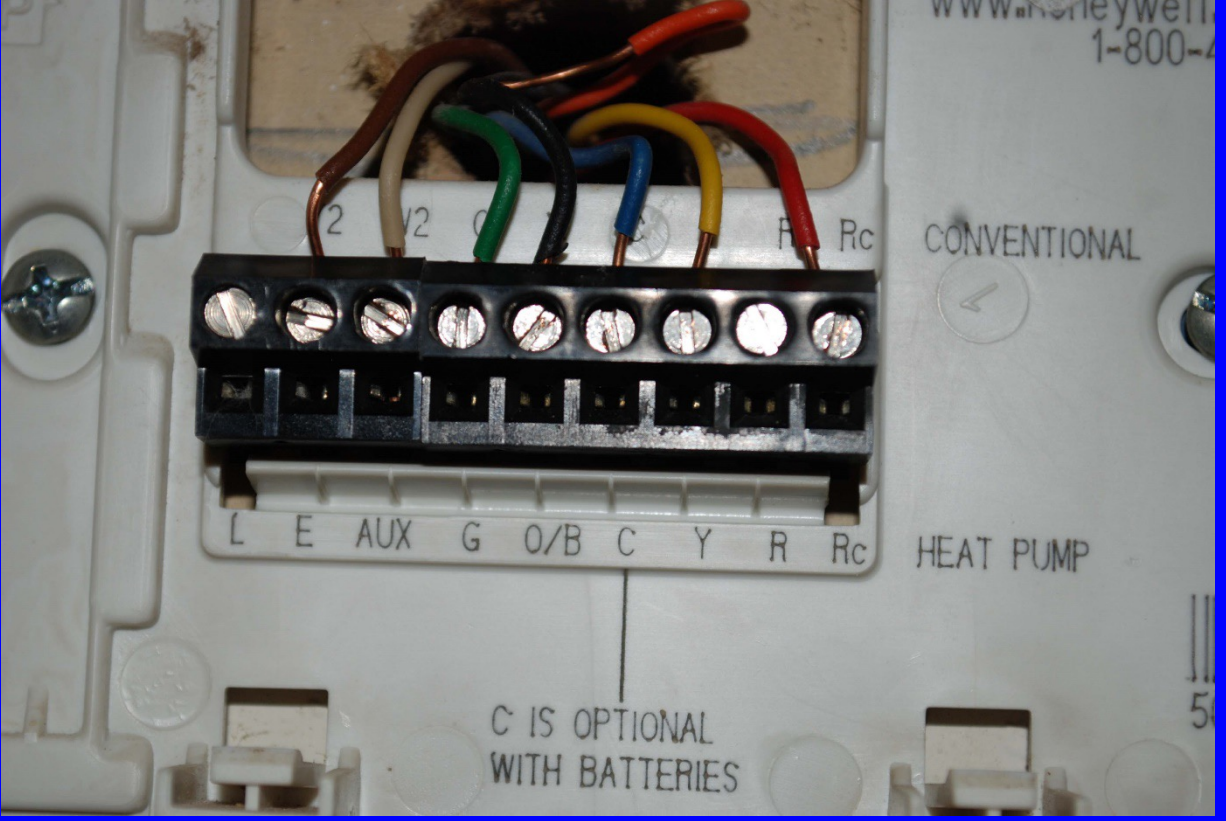
Air Distribution

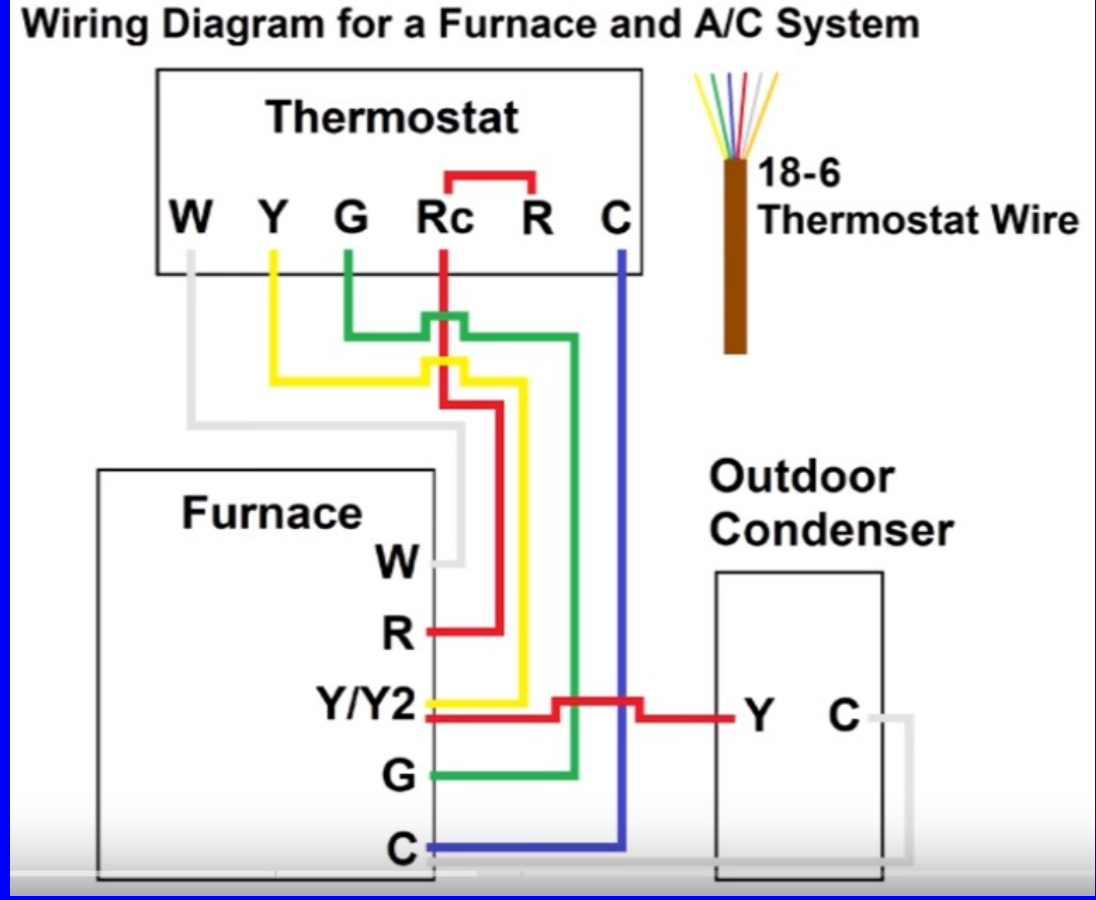
Zone Dampers

Thermostat




2 /2 R Rc
CONVENTIONAL
L E AUX G O/B C Y R Rc
HEAT PUMP
C IS OPTIONAL
WITH BATTERIES





Wire Terminals

- R = Red, Power (24V, Rh=power for heating, Rc = power for cooling, etc.)
- W = White, Heating
- Y1 = Yellow, cooling compressor 1 (yellow)
- Y2 = cooling compressor 2
- G = Green, Fan
- O/B – O, B, or OB is switching the changeover valve in a heat pump system
- O= reverse the valve from heating to cooling
- B = switches valve from cooling to heating

S, S1, S2 = outdoor sensor, additional sensors

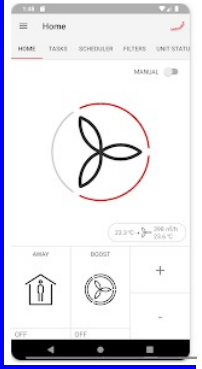
AUX = Auxiliary

E = Emergency

C = Common (Blue or black)

Condenser
(inverter)

Hot Water
Generation



Ventilation

Thermostat

Dehumidification

Air Distribution
(multi-speeds)

Zone Dampers


COOLING
75

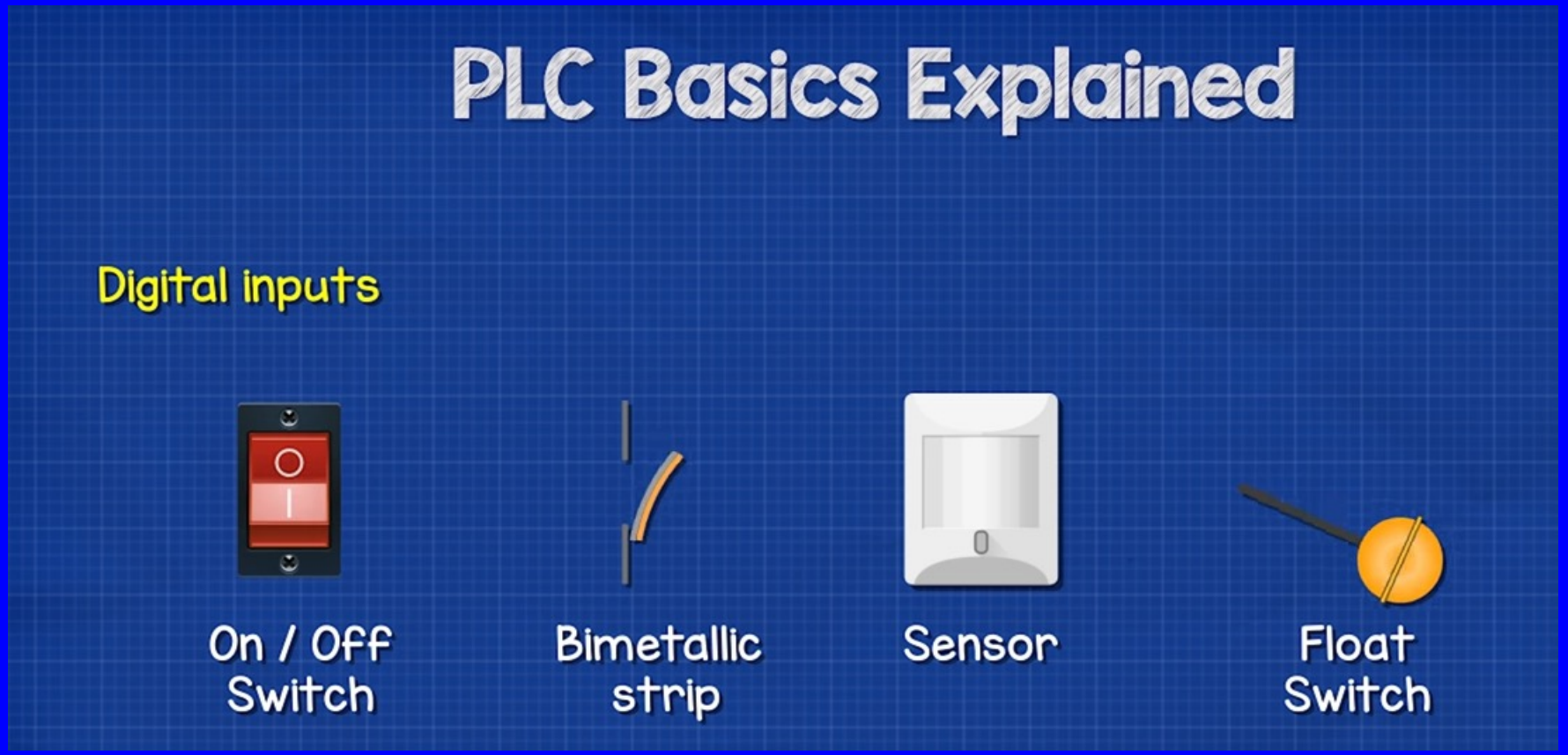

Y1
G
R
W1
C
O
B


53%
26
26
22


Rc
G
Y1
Y2
O/B
PEK
Rh
C
W1
W2
ACC-
ACC+

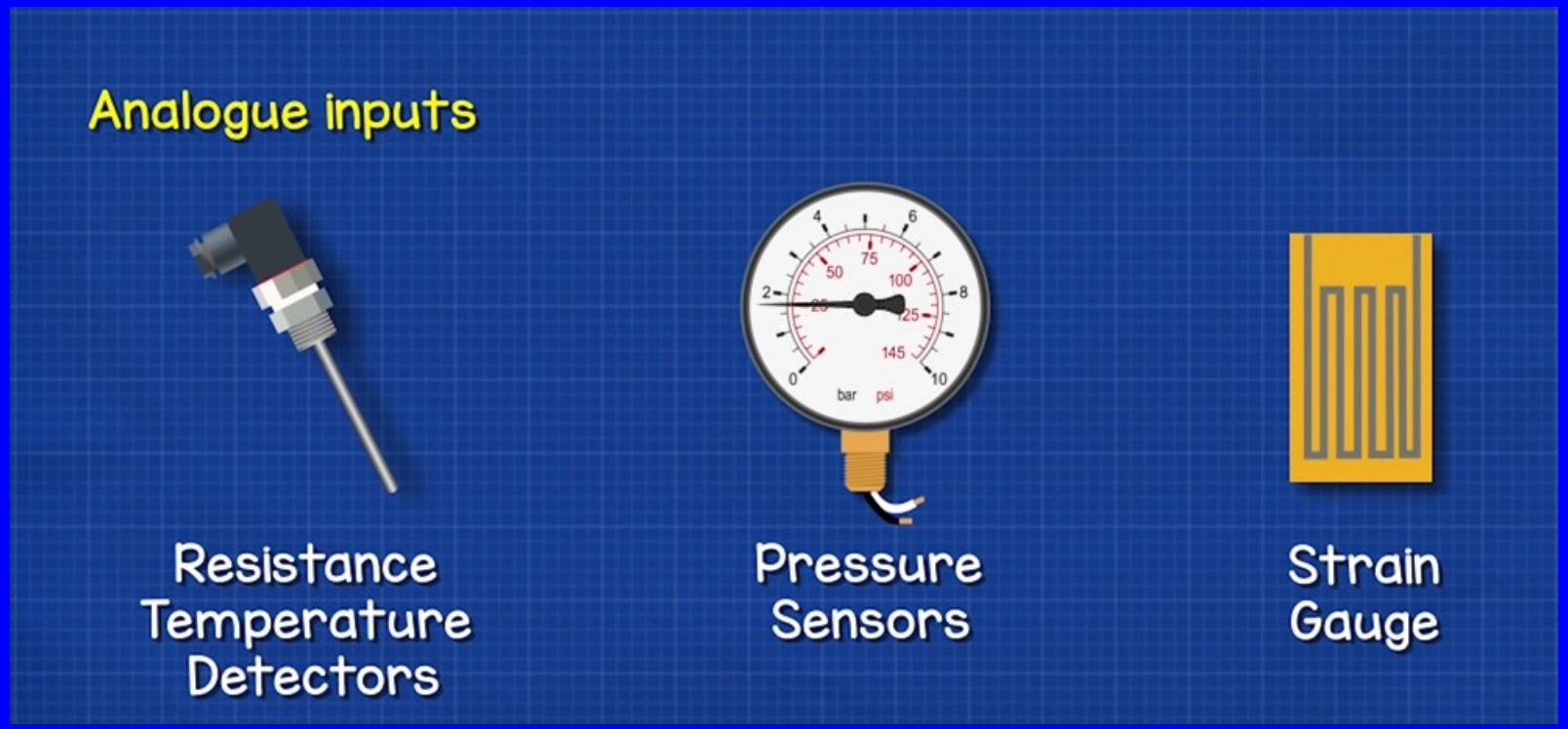
Terminology

1. Programmable Logic Controller (PLC) – small computer, following a set of rules (code)



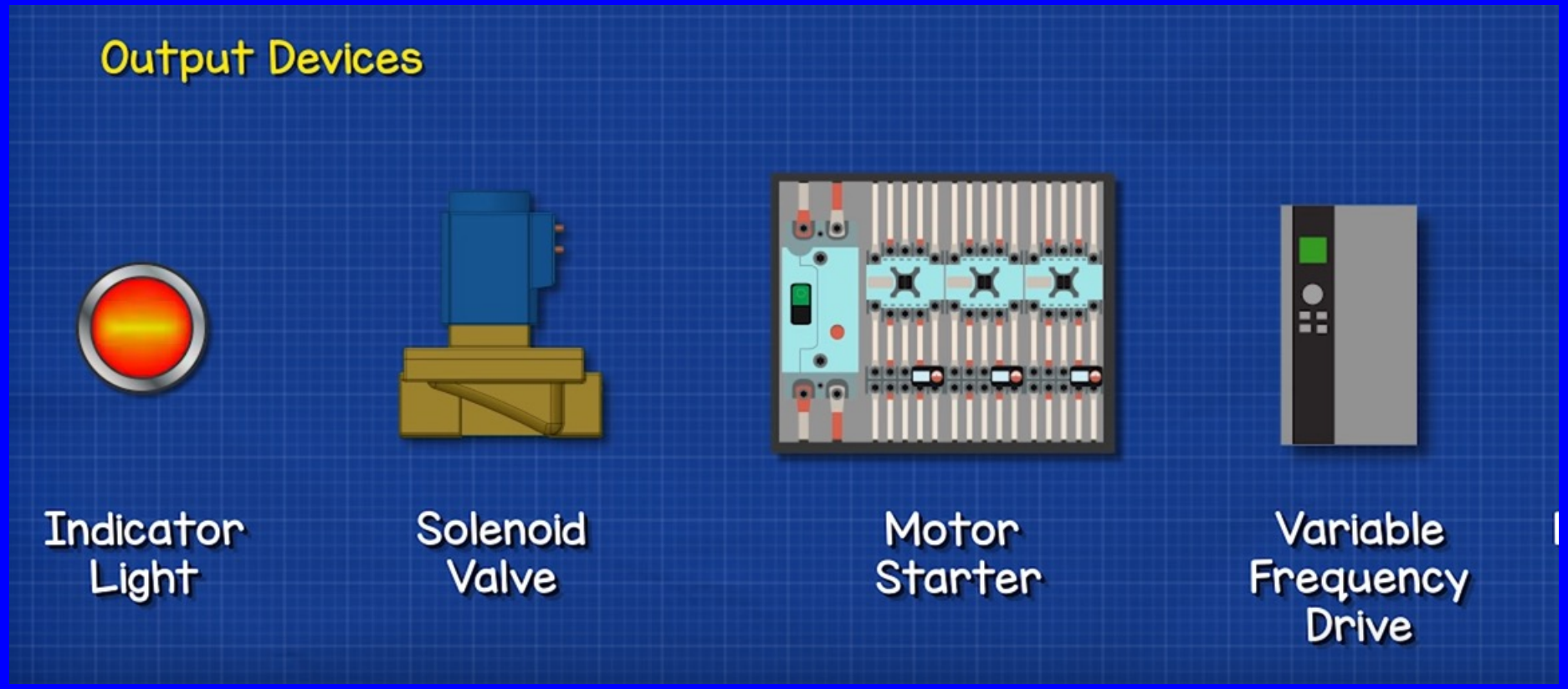
Reference: TheEngineeringMindset.com

Analog inputs



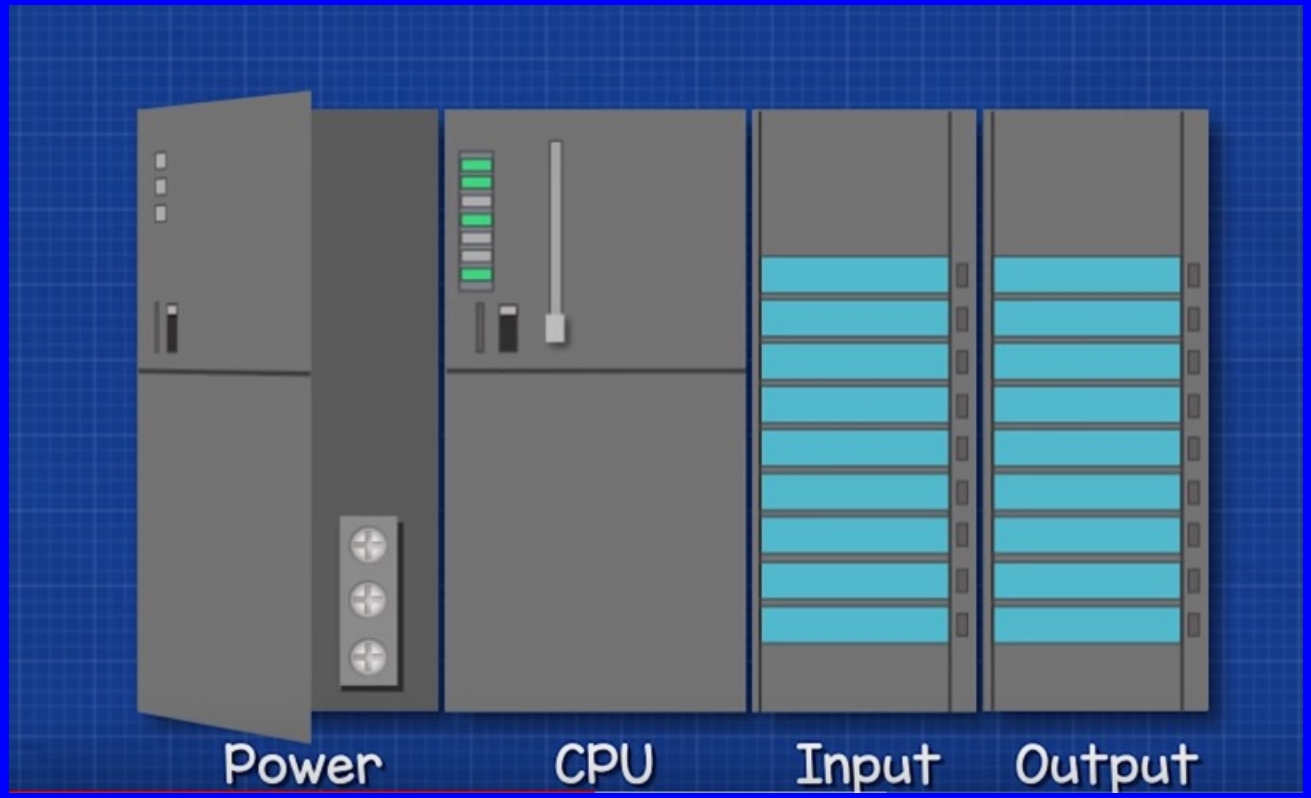
Reference: TheEngineeringMindset.com

Terminology



Reference: TheEngineeringMindset.com

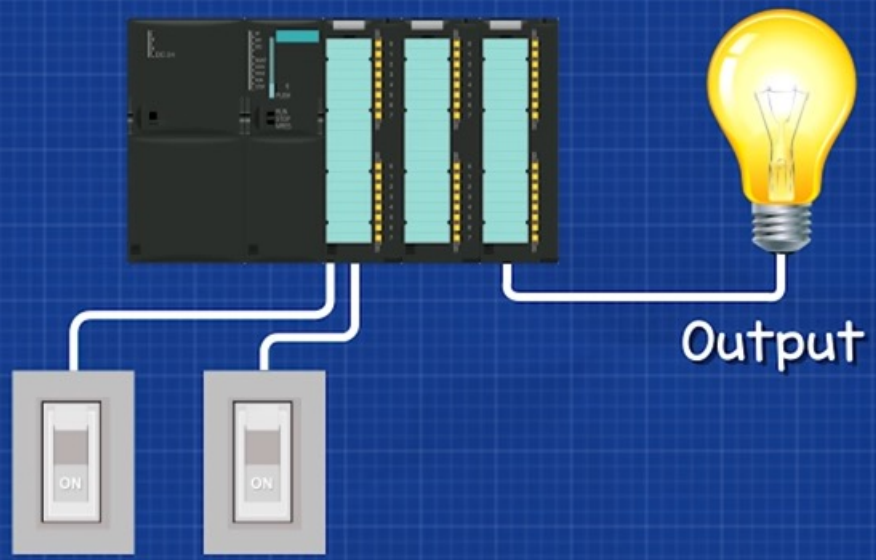
PLC



Reference: TheEngineeringMindset.com

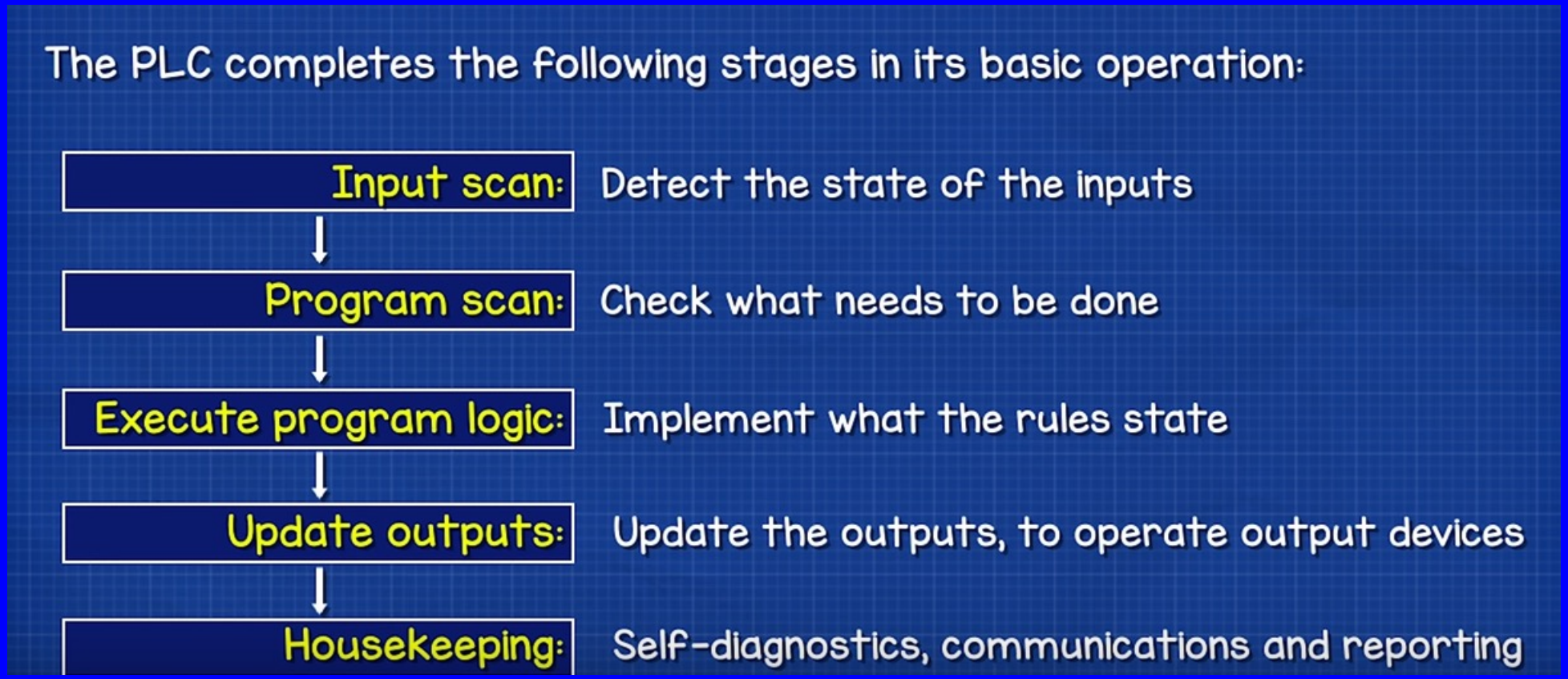
PLC Basics Explained

The basic operation of a PLC
is to perform
a pre-programmed output,
depending on the input signal,
by following a set of rules



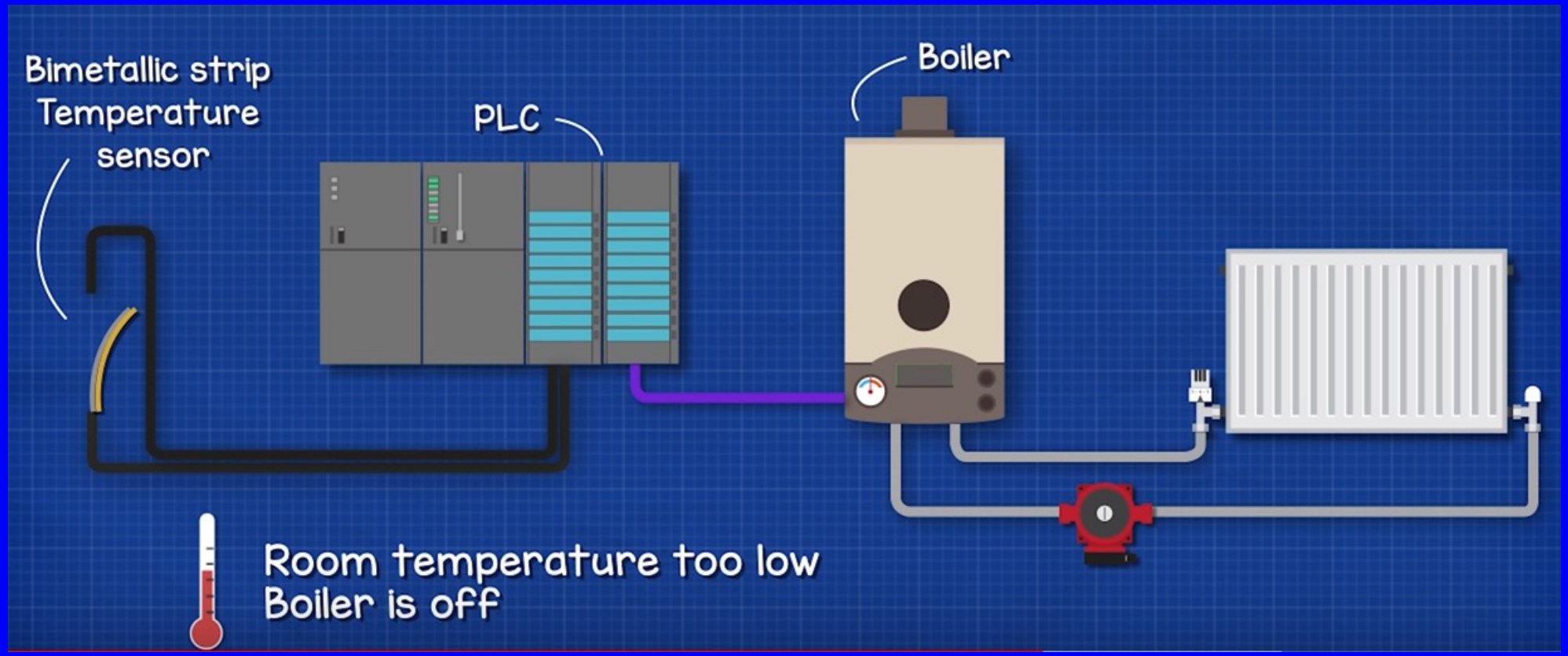
Switch 1	Closed
Switch 2	Closed
Lamp	On

Reference: TheEngineeringMindset.com



1. Analog signal (100 milliseconds) more time to process than digital (2 milliseconds)

Reference: TheEngineeringMindset.com



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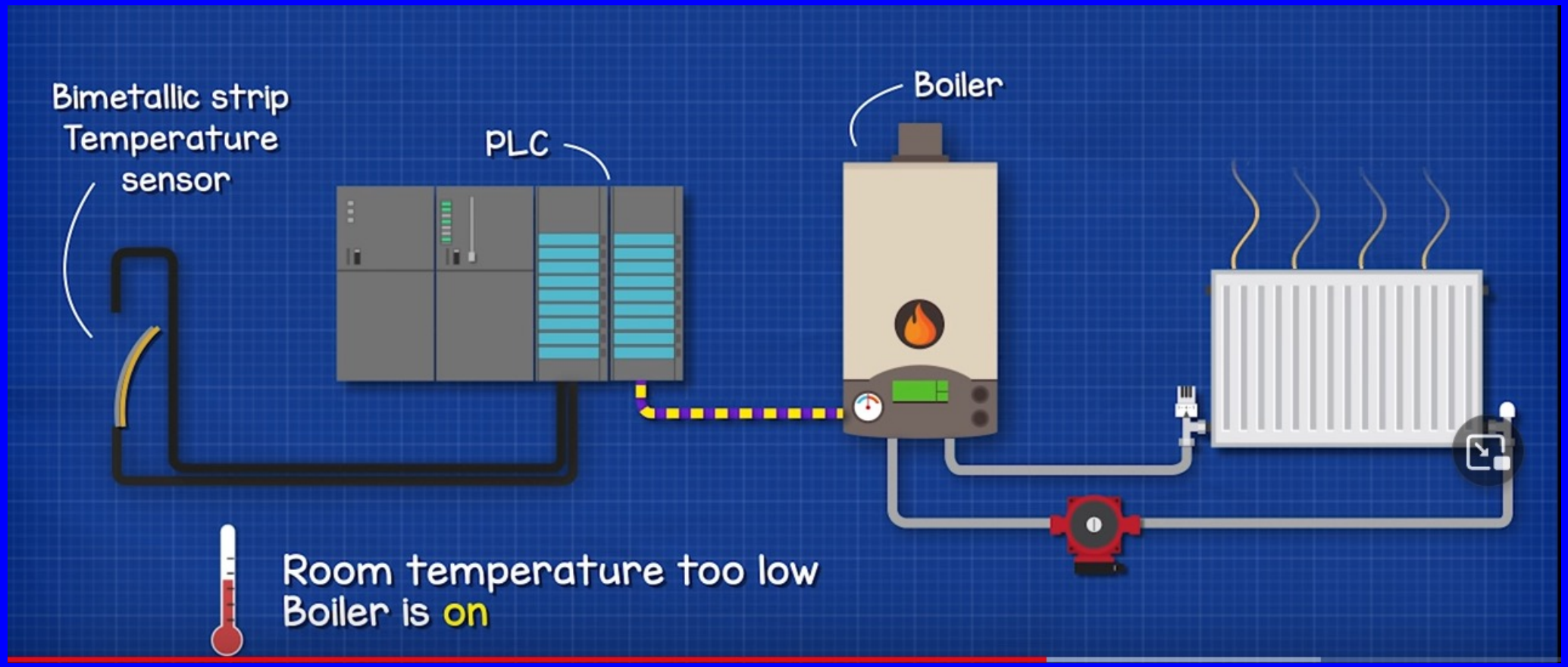
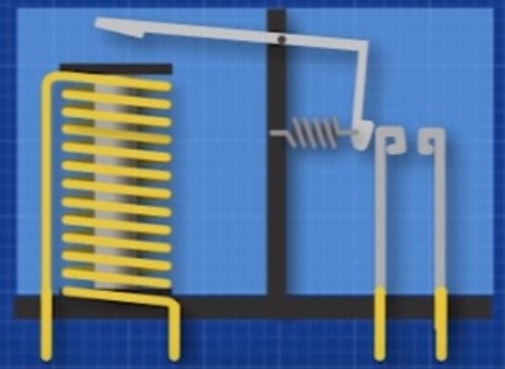


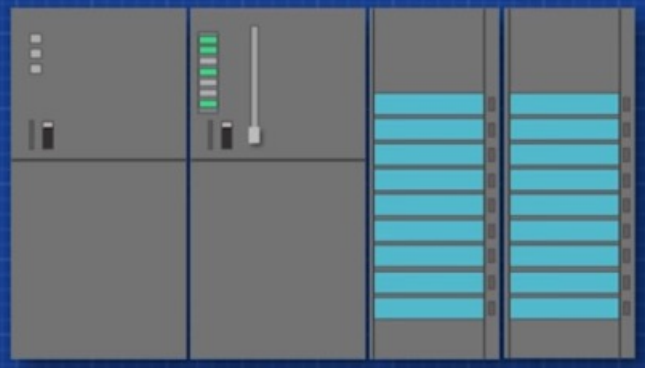
Reference: TheEngineeringMindset.com

This is very simple
a relay could be used instead



However, a PLC is better
because it has a time function

It can check date and time
before turning on



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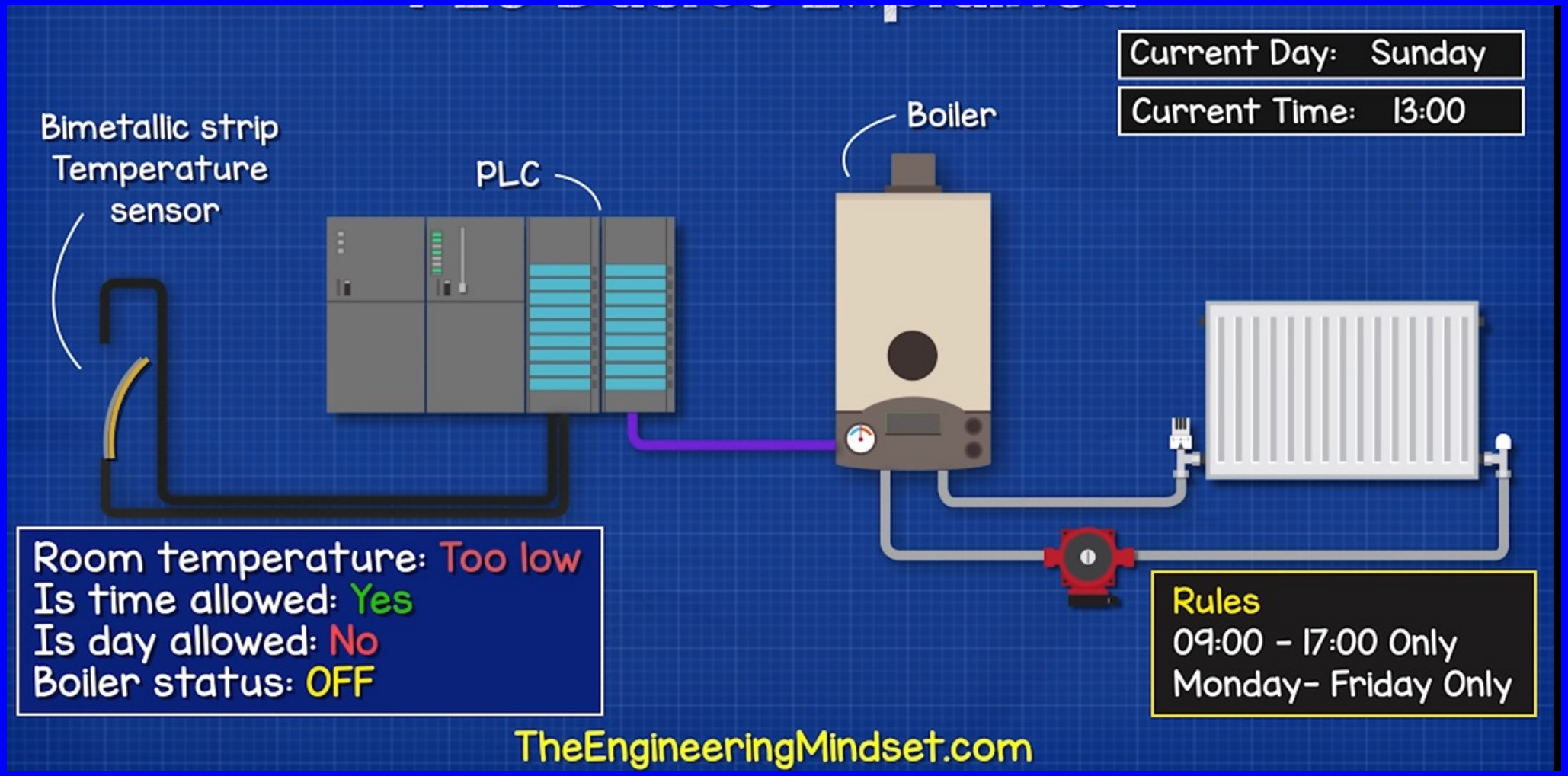

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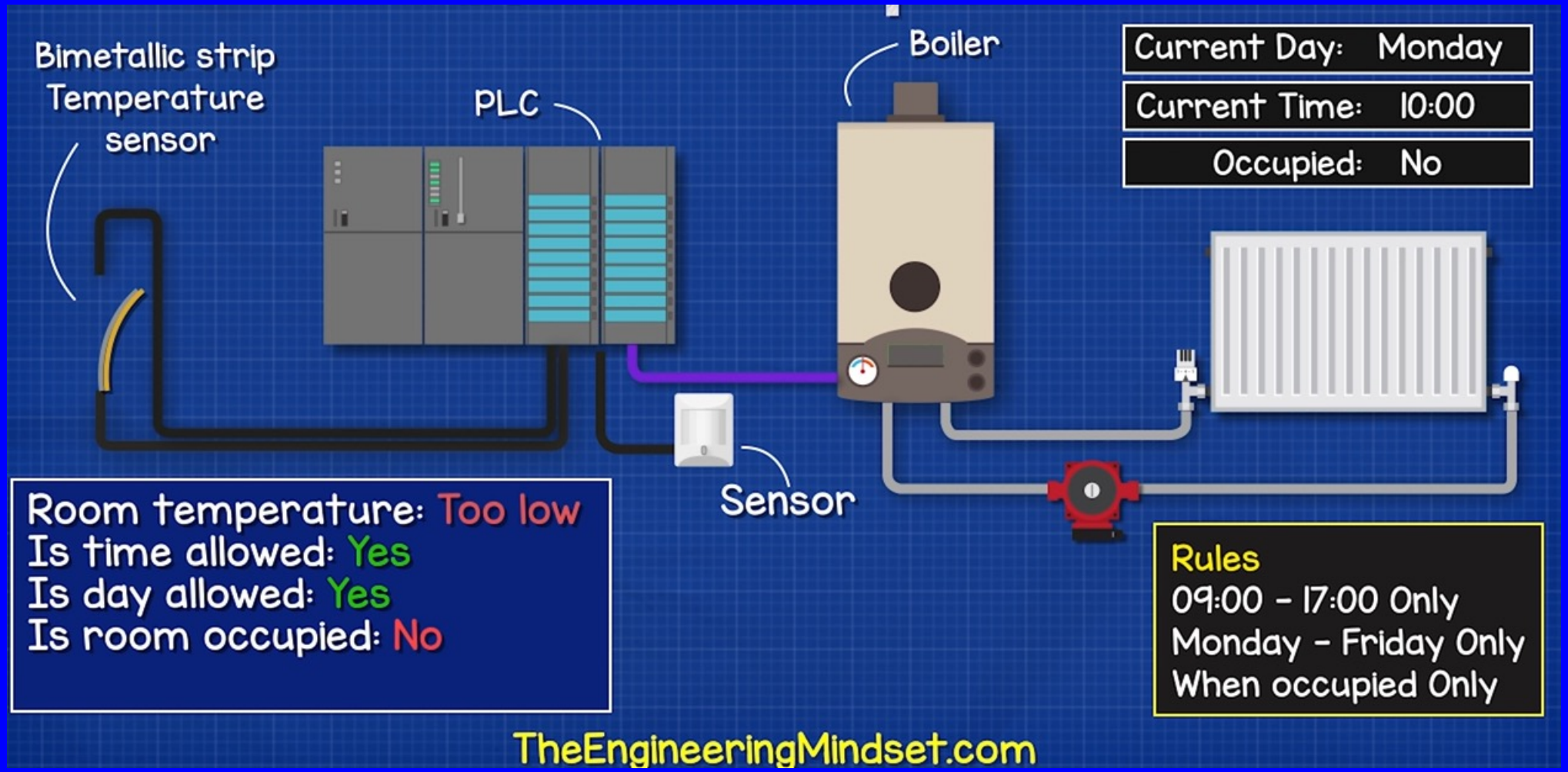

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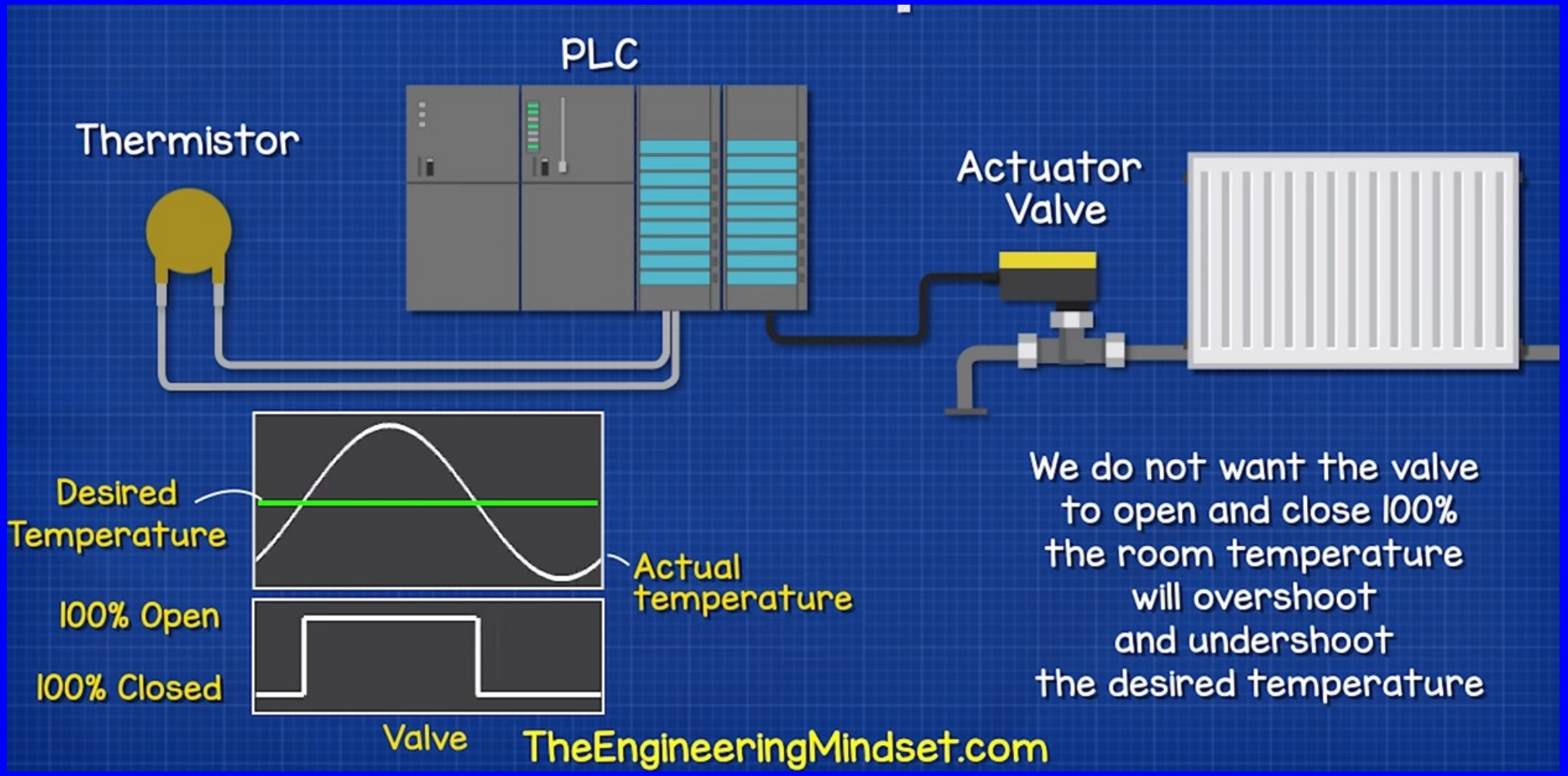


Today's thermostats are basically PLC

Reference: TheEngineeringMindset.com

PLC Advantages

- The control software is stored locally, so in the event of a building energy management system failure, the PLC can carry on.

- The connections between the PLC inputs and outputs are made by the software and not lots of separate physical wires

- PLC's are smaller than hard wired relay banks, but can still use relays where needed

- PLC's are easy to reprogram

- Fault finding is easier and faster with PLC's

- You can load the same programme onto multiple PLC units to save time

- You can expand the inputs and outputs with more cards.

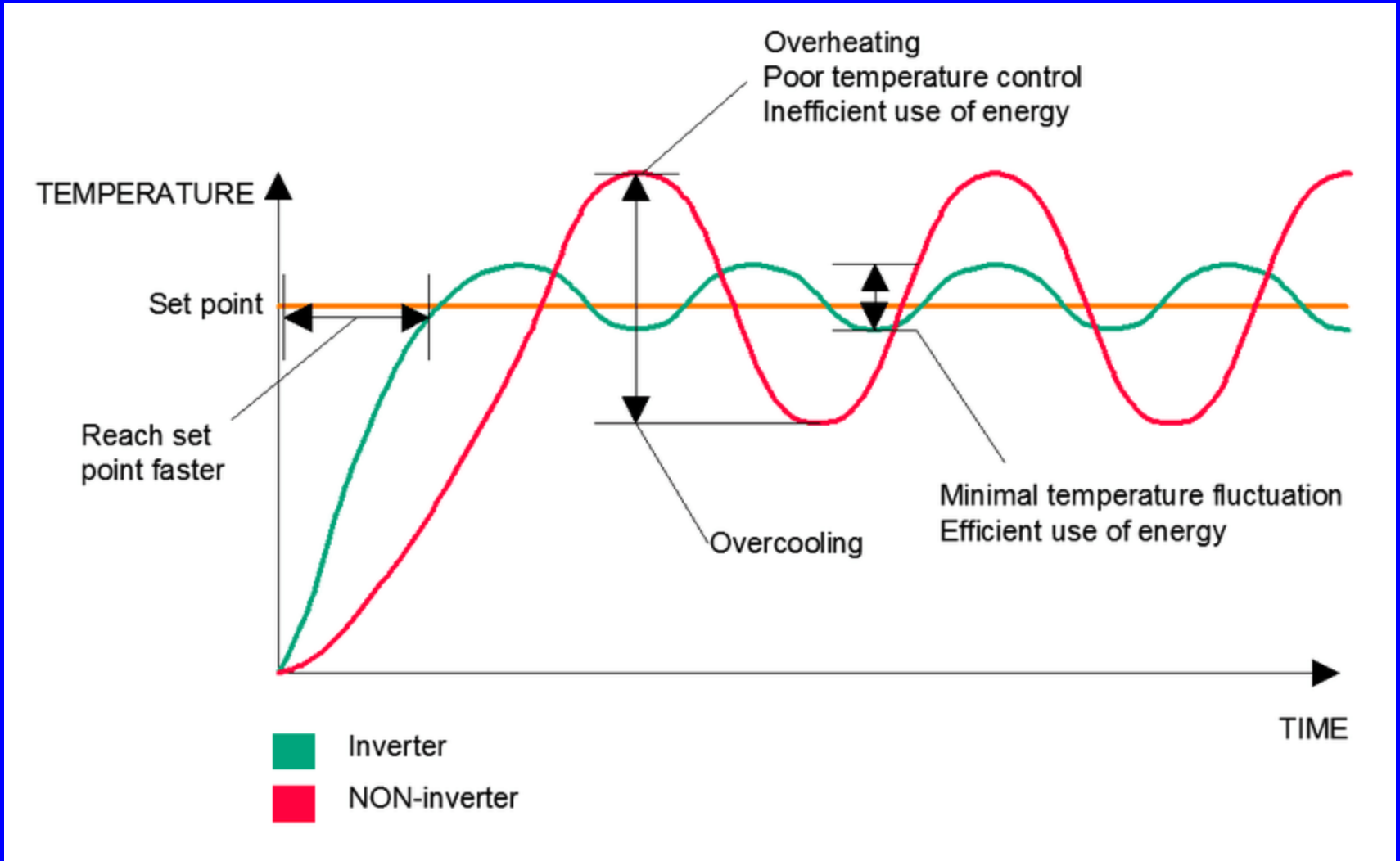
TheEngineeringMindset.com

PLC Disadvantages

PLC Disadvantages

1. Still overshoot (discomfort)
2. Still on/off
3. Still trial & error.
4. Following static set of rules.
5. Still reactive not proactive.
6. Still hard to account for additional equipment.
7. Still deal with operational issues like turn down ratio.

Today's Heat Pumps



Péan, Thibault & Gennari, Luca. (2014). Conditioning of a Plus-energy House using Solar Systems for both Production of Heating and Nighttime Radiative Cooling. 10.13140/RG.2.2.21894.37444.

Today's Heat Pumps are communicating HVAC Systems

1. [Most] all variable-capacity HVAC systems require 4 wires – 2 power wires for heating and cooling and two wires for communication between components

2. When communicating equipment is installed, the thermostat searches for the components in similar fashion to how your smartphone searches for a Bluetooth speaker you want it to pair with

3. Once the thermostat and components are paired, the components communicate to the thermostat what their capabilities are in terms of heating and cooling capacity and, for blower motors, how much air they can move through the system, which allows the thermostat to set up optimal performance

Today's Heat Pumps are communicating HVAC Systems

4. Each component has an electronic address, so the thermostat knows where the data is coming from and can send data back to that component to control its operation.

5. A computerized serial network allows each component to send ongoing performance data that refines performance.

6. Indoor and outdoor sensors allow the thermostat control to determine and communicate exactly how much heating or cooling, dehumidification or humidification and air flow are required to keep the home optimally comfortable

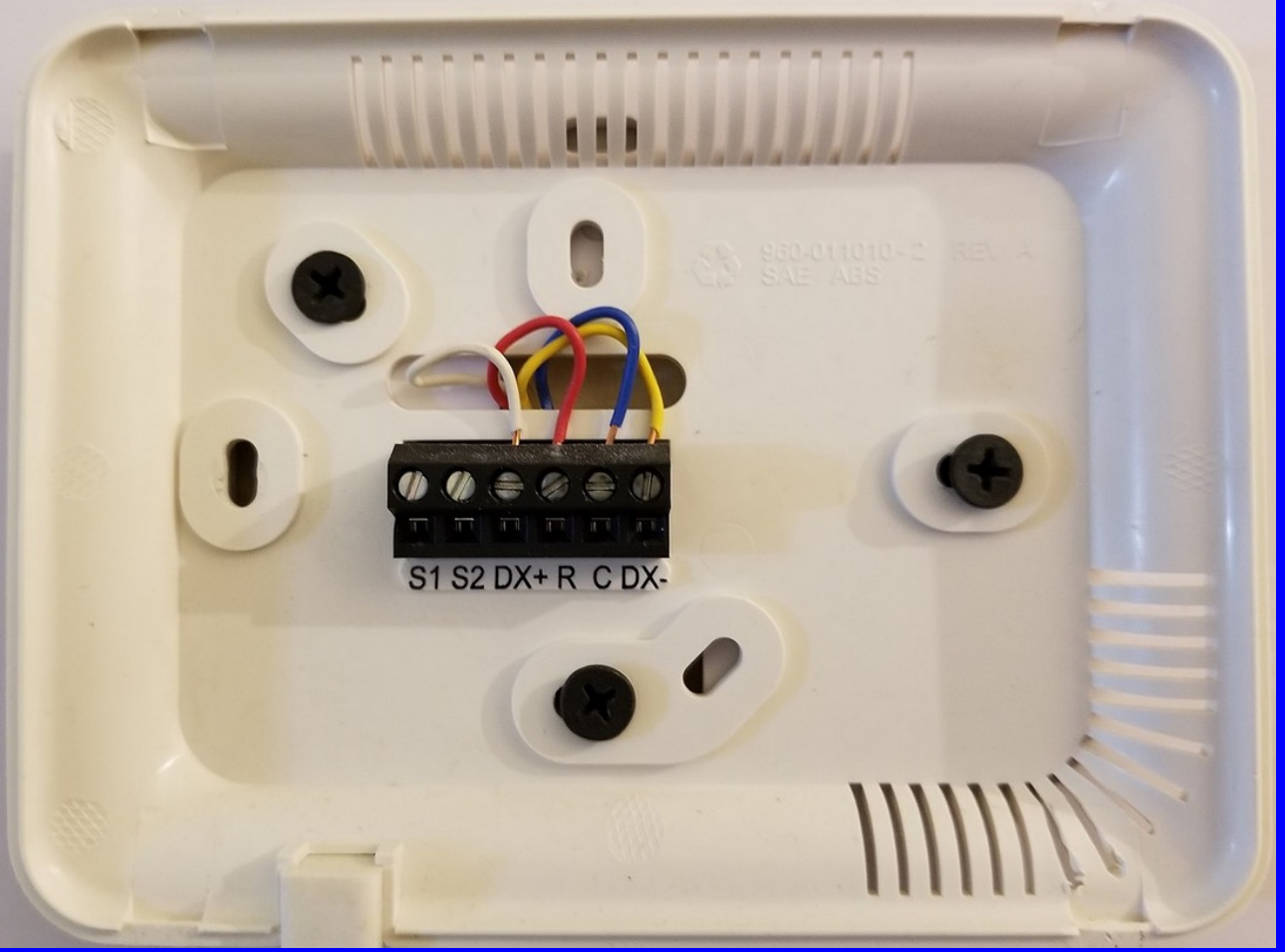
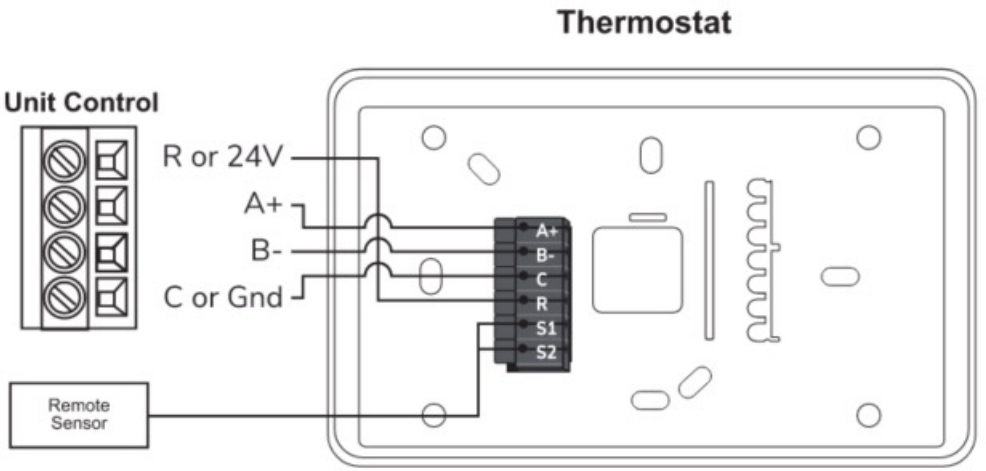


Diagram 1: Thermostat Connections



Thermostat Connections

A+	Communications (Positive)
B–	Communications (Negative)
C	24V Common for Control Circuit
R	24V Supply for Control Circuit
S_1	Remote Sensor
S_2	Remote Sensor

https://en.wikipedia.org/wiki/Nest_Thermostat


COOLING
75


Y1
G
R
W1
C
O
B


53%
26
26
22


Rc
G
Y1
Y2
O/B
PEK
Rh
C
W1
W2
ACC-
ACC+

Example Communicating controls

What do the major brands call their communicating systems?

- Carrier: Infinity (or Greenspeed)
- Bryant: Evolution
- Amana, Goodman and Daikin: ComfortNet
- Trane and American Standard (Mitsubushi): ComfortLink II
- Rheem and Ruud: Comfort Control System
- Lennox: iComfort
- Maytag, Tappan, Westinghouse and others: iQ Drive
- Heil, Comfortmaker, Keep Rite and others: Observer
- Armstrong Air: Comfort Sync
- York: Affinity
- Luxaire: Acclimate
- Coleman: Echelon
- Climate Master: iGate
- Water Furance: CM-U series

Communicating Controls Advantages

1. The highest efficiency ratings and lowest operating costs of any type system

2. Modulating heating, cooling and blower speed to precisely balance temperatures

3. Lower noise levels due to system components running at less than maximum capacity

4. The best dehumidification when air conditioning

5. Optimized comfort control in standard and zoned systems

6. Data exchanged between components allows the system to diagnose issues and alert technicians for tuning the system for best performance, providing maintenance and making repairs

7. Notifications alert homeowners to the need for minor maintenance such as changing an air filter or cleaning a condenser

Communicating Controls Disadvantages

Communicating Controls Disadvantages

1. Communicating equipment is **significantly more expensive** than non-communicating equipment.

2. Some communicating systems from all brands tend to stop communicating, and getting them to communicate again can be difficult.

3. Repairs to communicating equipment are much costlier

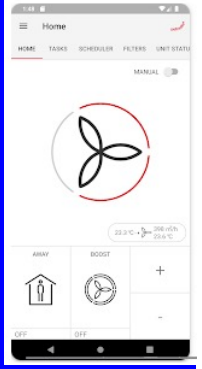
4. Communicating thermostats are proprietary to the manufacturer... and most of the time offer features not available with after-market thermostats.

5. Many technicians do not have experience installing and setting up communicating HVAC technology

Condenser
(inverter)

Hot Water
Generation

Thermostat
???



Ventilation

Dehumidification

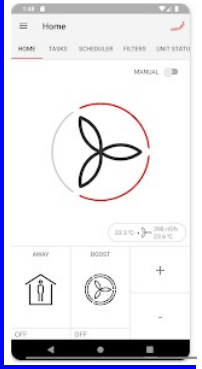
Air Distribution
(multi-speeds)

Zone Dampers

Condenser
(inverter)

Hot Water
Generation

Solution 1:
Do Nothing



Ventilation

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Thermostat

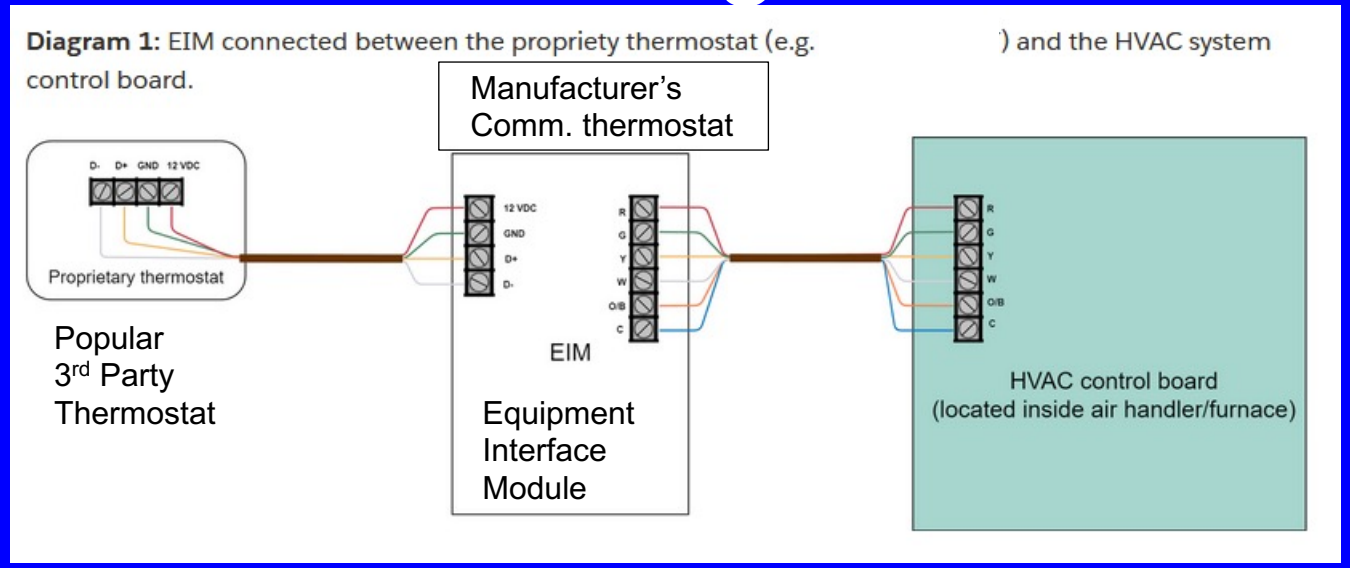
Ventilation

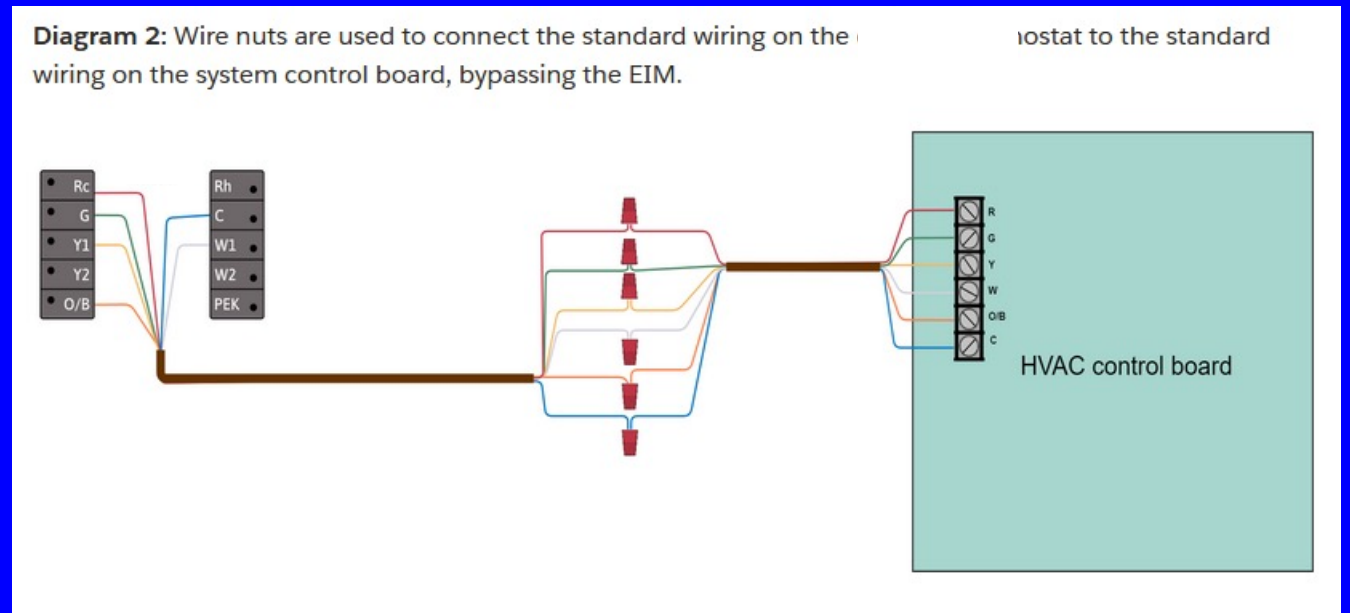
Dehumidification

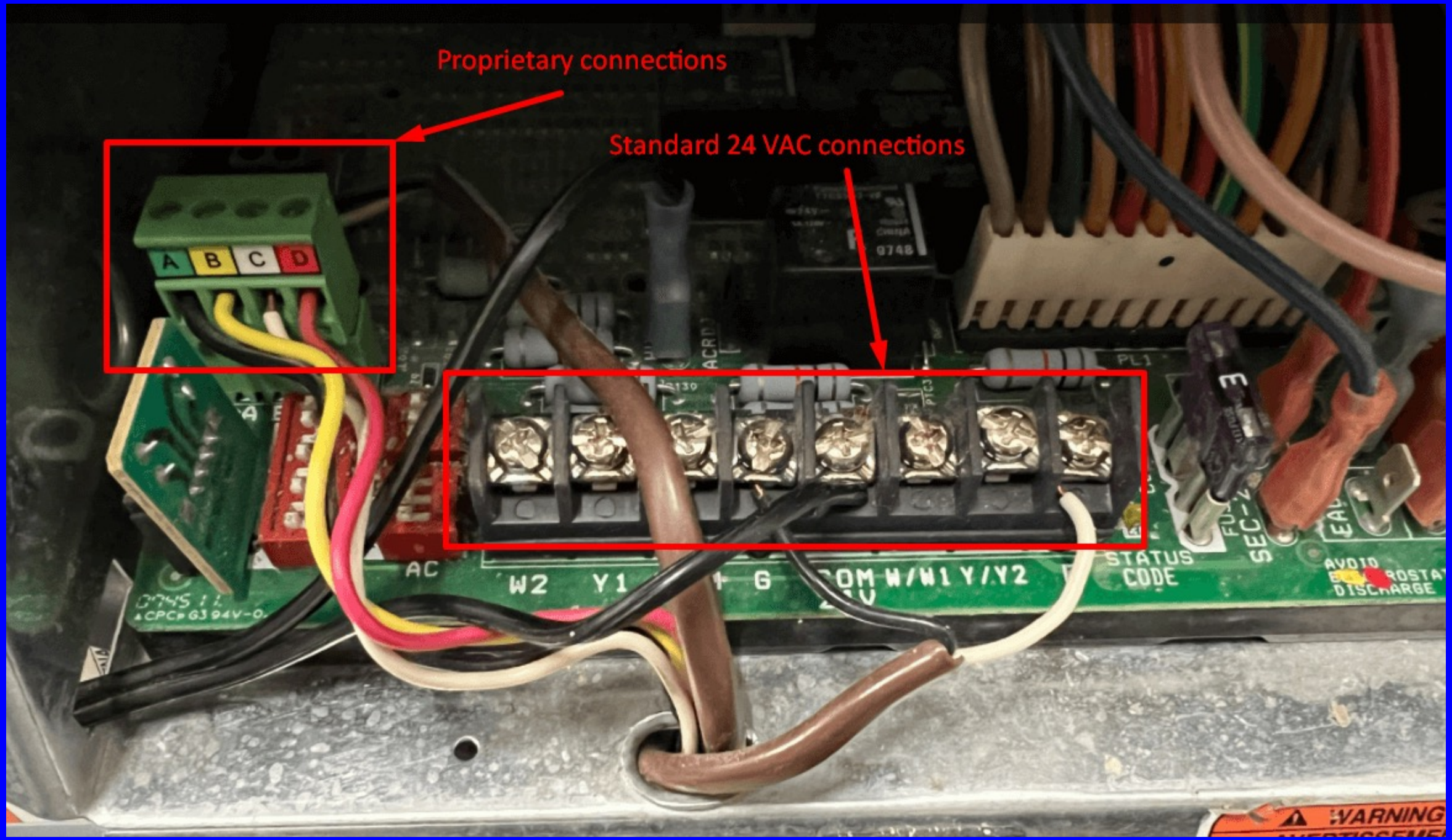
Air Distribution
(multi-speeds)

2. One Vendor

Solution 3: Mount 3rd Party "Upstream" of Communicating Controls






Proprietary connections
Standard 24 VAC connections
A B C D
W2 Y1 G
STATUS CODE
WARNING

Solution 4: Climate Talk

ClimateTalk is a partnership between manufacturers such as Emerson and Johnson Controls (York, Luxaire, Coleman brands). One of its goals is to produce an open communicating protocol that will be standardized across all brands. That will mean, should it succeed, that communicating equipment not made by the same manufacturer will work together.

Solution 5: Existing commercial communicating protocols

COMMUNICATION PROTOCOLS

- The “Set of rules” computers use to communicate with each other.
- Standards:
  - BACnet (MS/TP, IP, Wireless)
  - LonTalk
  - Modbus (RTU, TCP)

ASHRAE BACnet®

LONMARK®

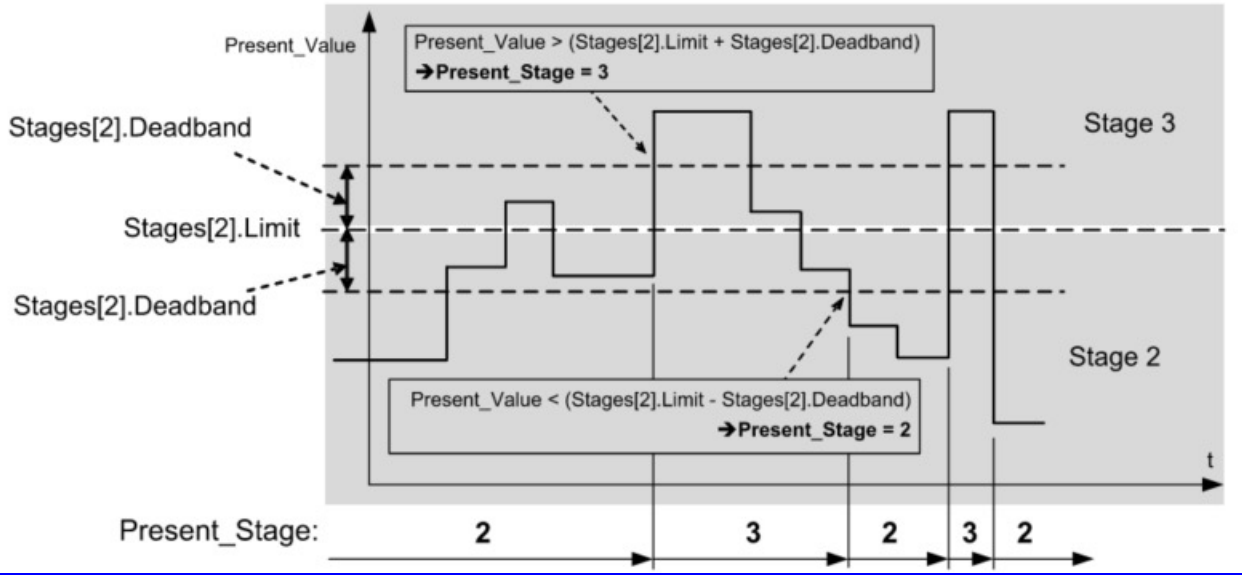
KnX

ADDENDA

ANSI/ASHRAE Addendum bd to
ANSI/ASHRAE Standard 135-2016

BACnet™

A Data Communication Protocol for Building Automation and Control Networks



Summary

1. More equipment and more complex equipment in residential sector will require more complex residential control systems.

2. The continued use of proprietary communication protocols by manufacturer will led to excess complexity or equipment, confused and frustrate occupants, and greater discomfort.

3. Proprietary communication protocols will need to be more user friendly & of greater value to the occupant.

Summary of Solutions

1. Do nothing – what we have works 90% of the time, but does have limitations.

2. Use equipment from all the same family of manufacturers.

3. Insert user friendly interface thermostats “upstream” of communicating control or EIM, if an option.

4. Climate Talk – or similar industry standard or solution

5. Use commercial communicating protocol (BACnet, ModBus, KnX, etc.) Equipment selection will be limited.

Residential Control Systems (for High Performance Buildings)

Thank You

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