Cairo University
Faculty of Engineering
Mech. Power Department

CAIRO UNIVERSITY
FACULTY OF ENGINEERING

ACC Virtual Labs
Automatic Control Circuits & Virtual Labs for Mechanical Power Systems
معمل التحكم الأوتوماتيكي و المعامل الإفتراضية لأنظمة القوى الميكانيكية

دبلوم تطبيقات التحكم الأوتوماتيكى فى نظم القوى الميكانيكية

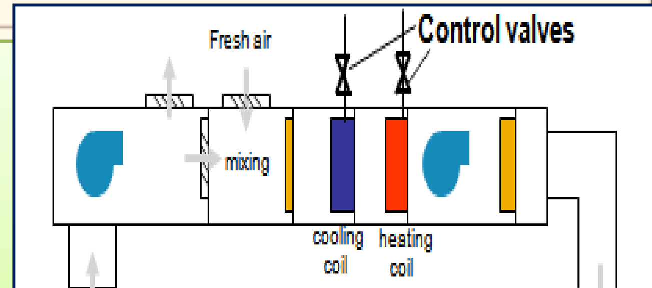
MEP 599 Diploma Design Project for Acadimic Year 2013/2014

Applications of Virtual Labs for Air-Conditioning Plant (HVAC)

by Eng. Maey Essa Mohamed
Dr. Mohsen Sayed Soliman , ACC Manager and Dr. Amro Abdel Raouf, ACC Vice Manager
Mechanical Power Engineering Department

Abstract:

The purpose of this project is to provide students with a fundamental understanding of control sensors and systems and how they are applied to the many parts of practical heating, ventilation, & air-conditioning systems in commercial buildings. These control fundamentals, theory, and data for various types of control systems provide essential background for efficient application of automatic control processes to heating, ventilation and air-conditioning systems. The analysis and calculations are done using an advanced Virtual Lab program. Verification and evaluation of HVAC system performance is done by that program. Also, a calibration is done for that virtual lab by comparing internal calculations done by the program with external engineering calculations using psychometry charts, conservation equations&thermo-fluid relations to get same output results.



Cooling coil is controlled by T_{DP} set-point T_{air} & T_{DP} sensors

if $T_{DP\,measured} > T_{DP\,set\text{-}point}$ → send signal to open more the CC valve

if $T_{DP\,measured} < T_{DP\,set\text{-}point}$ → send signal to close more the CC valve

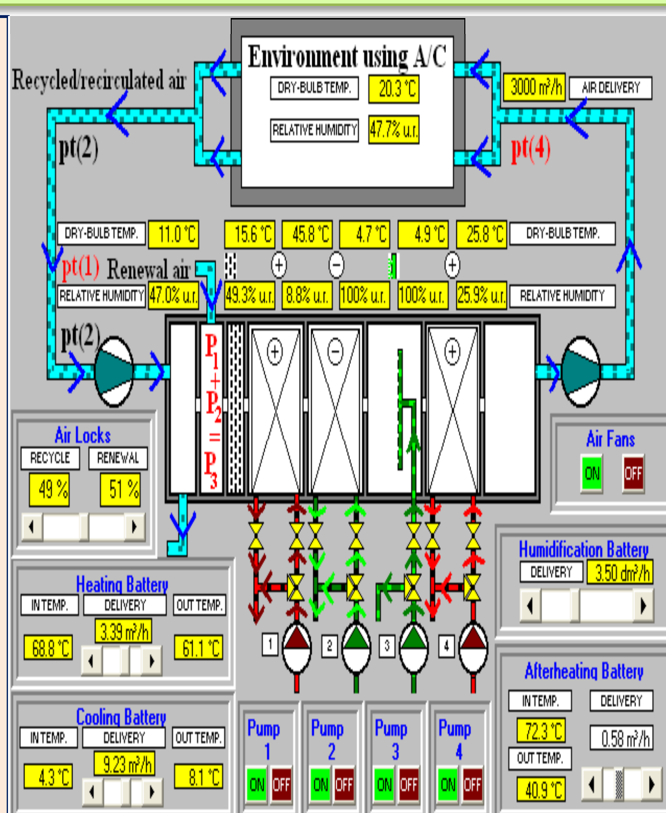
- Heating coil is controlled by T_{air} set-point

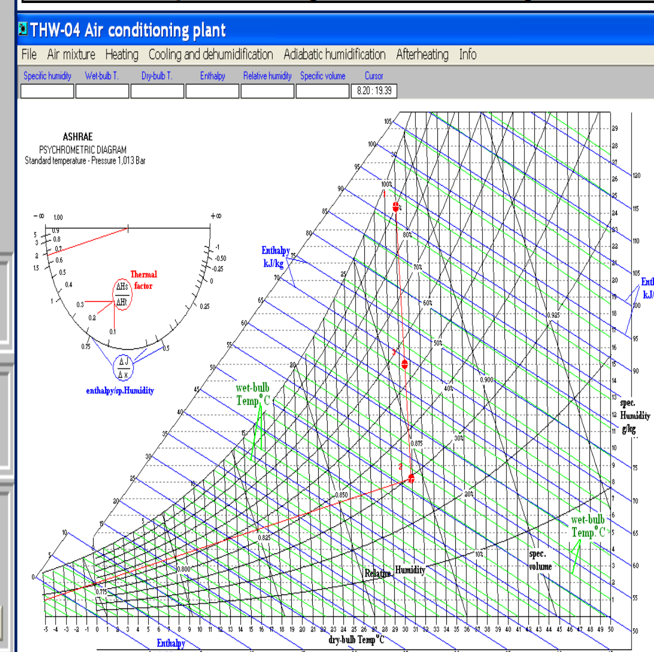
if $T_{air} < T_{air\,set\text{-}point}$ → send the signal to open more the heating coil valve

if $T_{air} > T_{air\,set\text{-}point}$ → send the signal to close more the heating coil valve

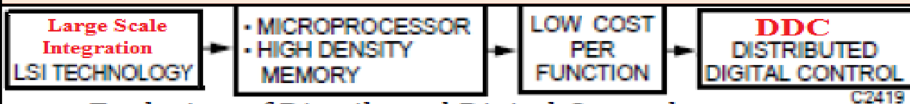
Objectives of project:

- Identifying main concepts of industrial auto. control systems in HVAC applications by modern computer-based programs which simulate those practical control systems.
- Investigation Applications of Automatic Control Virtual Labs to understand their functions, how they work & what are their input & output signals etc .
- Verification of the accuracy &validity of results obtained by HVAC virtual labs through performing engineering &scientific calibrations for those virtual labs. The calibration is done by comparing internal calculations done by those virtual labs with external engineering calculations using the thermo-dynamic, conservation equations, & thermo-fluid relations to get same output results.
- Training students& enggs on Technical Report Writing& Presentation Skills
- Enhancing the skills of Searching for information and adopting self learning capabilities related to Automatic systems and modern computer technologies.

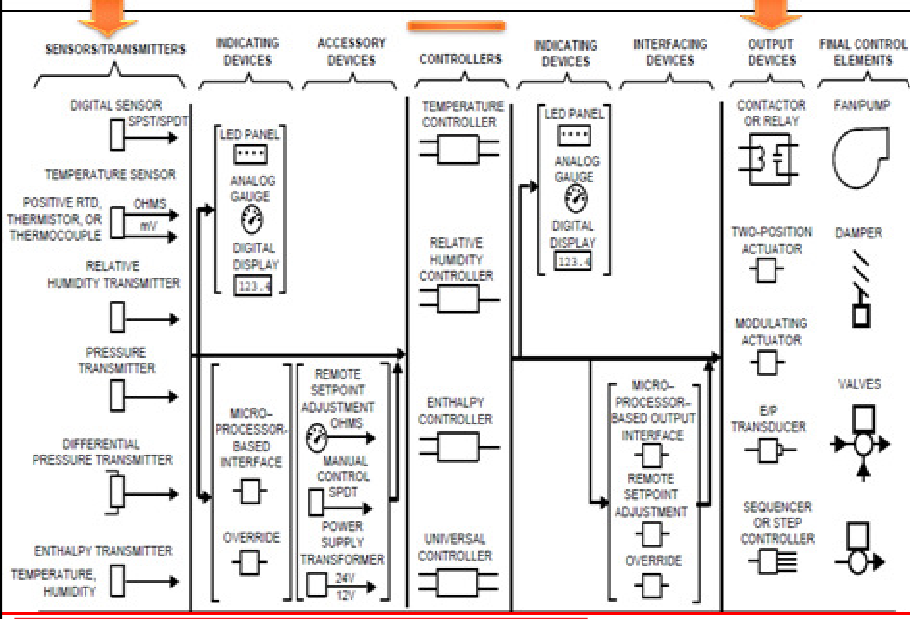


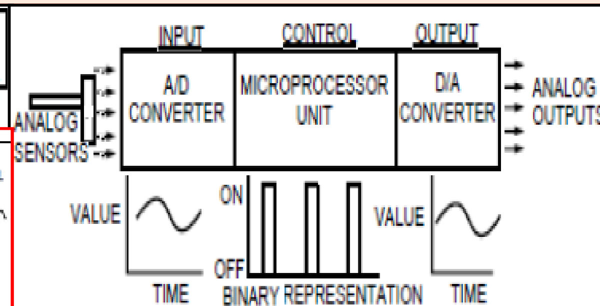


DDC is often used to control HVAC (heating, ventilation & air conditioning) devices as valves via microprocessors using software to perform control logic. Such systems receive analog/digital inputs from sensors& devices installed in HVAC system and, according to control logic, provide analog/digital outputs to control HVAC devices. These systems may be mated with a software package that graphically allows operators to monitor, control, alarm & diagnose building equipment remotely. (like our project).

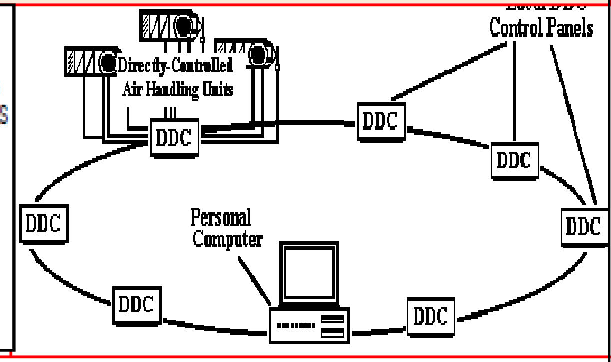


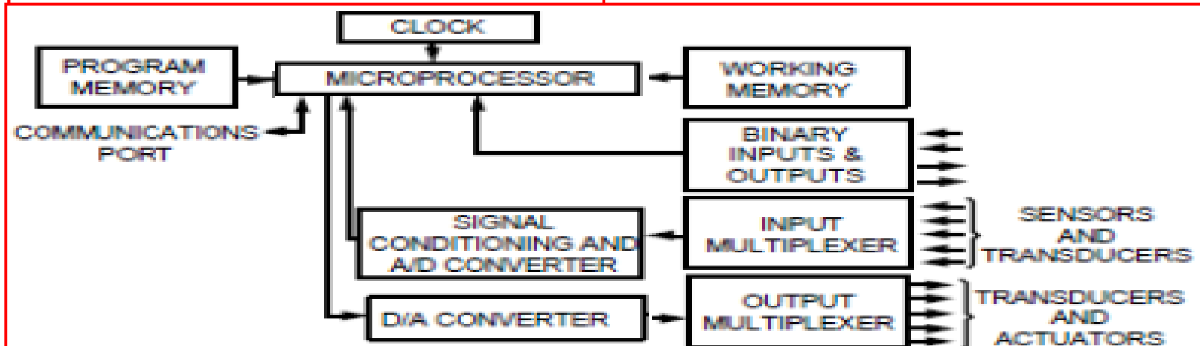
Evolution of Distributed Digital Control.





Analog Functions of a Digital Controller.





Microprocessor Controller Configuration

Function of HVAC controls

A Heating, Ventilating, and Air-Conditioning (HVAC) Control system operates the mechanical equipment (boilers, chillers, pumps, fans, etc.) to maintain the proper environment in a cost-effective manner. A proper environment is described with four variables: temperature, humidity, pressure and ventilation.

Temperature: The comfort zone for temperature is between 68°F (20°C) and 75°F (25°C). Temperatures less than 68°F (20°C) may cause some people to feel too cool. Temperatures greater than 78°F (25°C) may cause some people to feel too warm. Of course, these values vary between people, regions and countries.

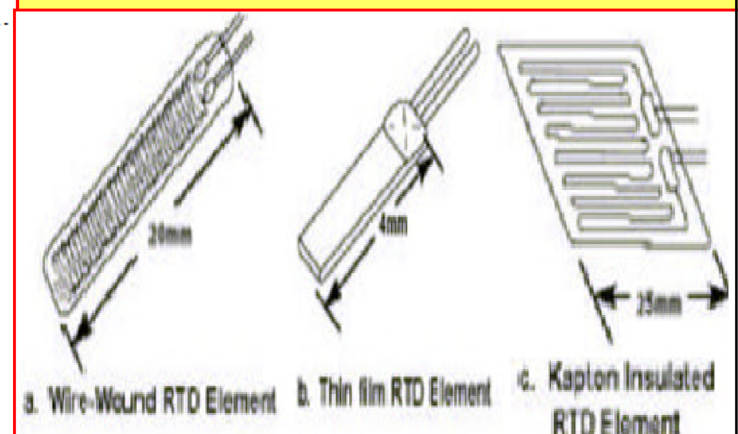
Humidity: The comfort zone for humidity is between 20% relative humidity (RH) and 60% RH. Humidity less than 20% RH causes the room to be too dry, which has an adverse effect on health, computers, printers, and many other areas. Humidity greater than 60% RH causes the room to be muggy and increases the likelihood of mildew problems.

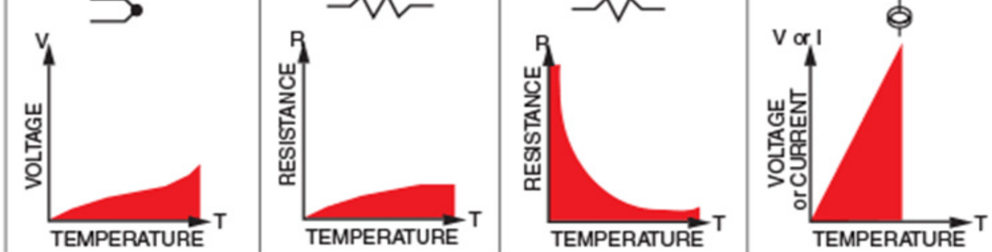
Pressure: The rooms and buildings typically have a slightly positive pressure to reduce outside air infiltration. This helps in keeping the building clean.

Ventilation: Rooms typically have several complete air changes per hour. *Indoor Air Quality* (IAQ) is an important issue. The distribution pattern of the air entering room must keep people comfortable without feeling any drafts, and this is important as well.

Temperature sensors

- **Resistance Temperature Detector (RTD)**
- **The RTD is a temperature sensing device whose resistance changes with temperature.**
- **RTDs can take many different shapes.**

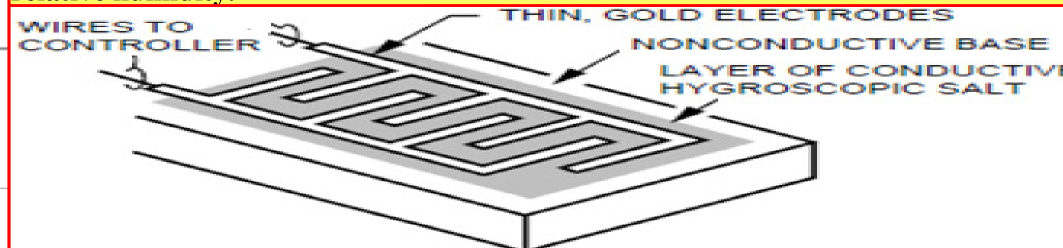


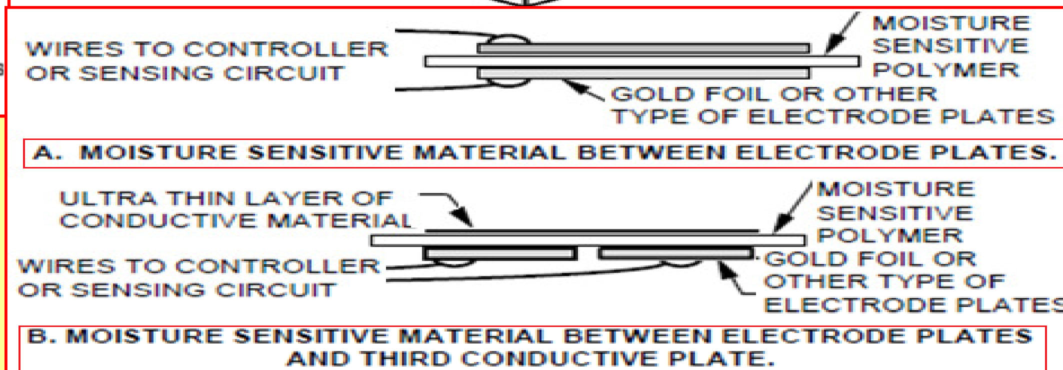


	Thermocouple	RTD	Thermistor	I. C. Sensor
Advantages	Self-powered Simple Rugged Inexpensive Wide variety Wide temperature range	Most stable Most accurate More linear than thermocouple	High output Fast Two-wire ohms measurement	Most linear Highest output Inexpensive
Disadvantages	Non-linear Low voltage Reference required Least stable Least sensitive	Expensive Current source required Small Δ R Low absolute resistance Self-heating	Non-linear Limited temperature range Fragile Current source required Self-heating	T<200°C Power supply required Slow Self-heating Limited configurations

Resistance Relative Humidity Sensor

- **An older method that used resistance to determine relative humidity depended on a layer of hygroscopic salt, such as lithium chloride or carbon powder, deposited between two electrodes .**
- **materials absorb and release moisture as a function of the relative humidity, causing a change in resistance of the sensor. An electronic controller connected to this sensor detects the changes in resistance which it can use to provide control of relative humidity.**



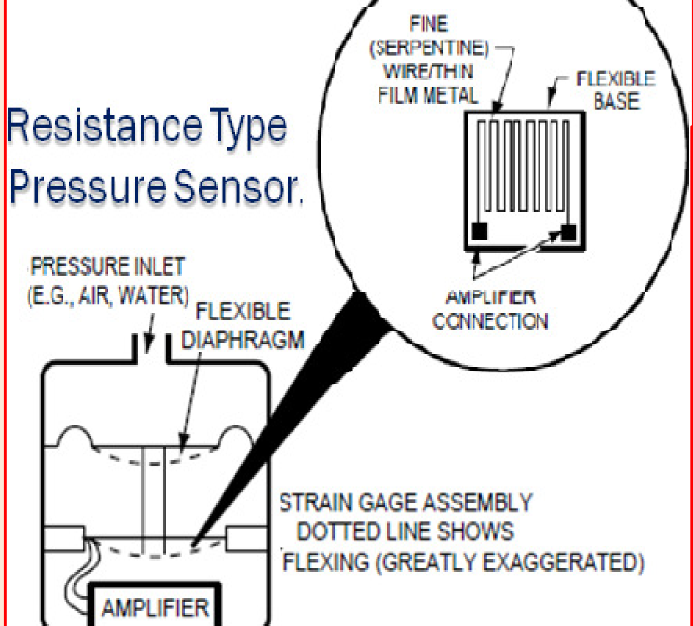


Capacitance Relative Humidity Sensor

- **A method that uses changes in capacitance to determine relative humidity measures capacitance between two conductive plates separated by a moisture sensitive material as polymer plastic**
- **As the material absorbs water, the capacitance between the plates decreases and the change can be detected by an electronic circuit.**

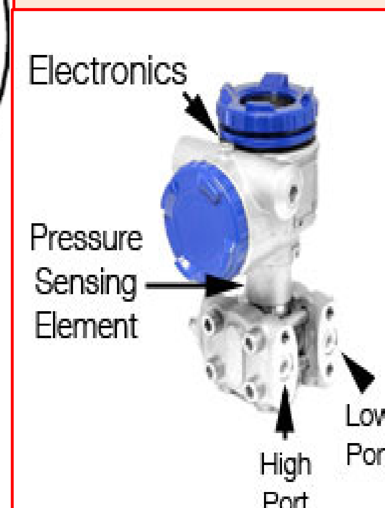
Pressure Transmitter: Working principle

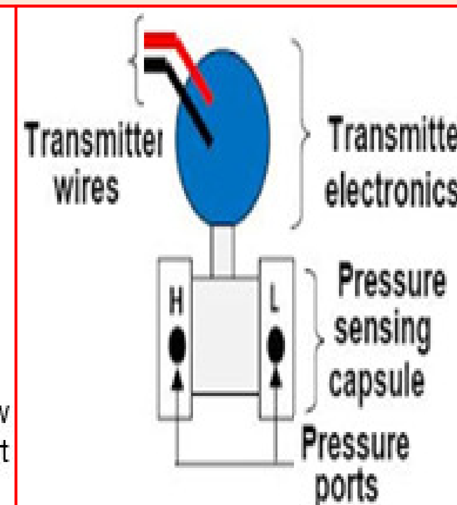
Electronic pressure sensor converts pressure changes into a signal such as voltage, current, or resistance that can be used by an electronic controller. A method measures pressure by detecting changes in resistance uses a small flexible diaphragm and a strain gage assembly . Strain gage assembly is stretched or compressed as the diaphragm flexes with pressure variations. The stretching or compressing of the strain gage changes the length of its fine wire/thin film metal, which changes the total resistance.

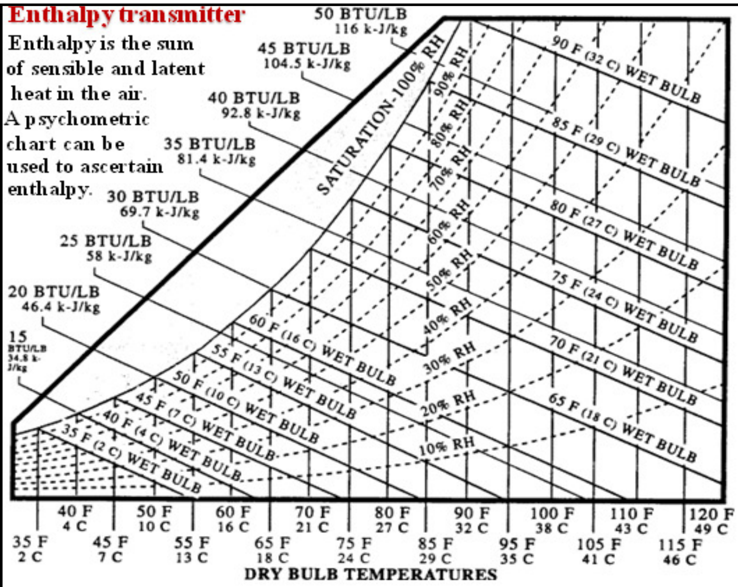


Differential Pressure Transmitter

This equipment will sense the difference in pressure between two ports and produce an output signal with reference to a calibrated pressure range



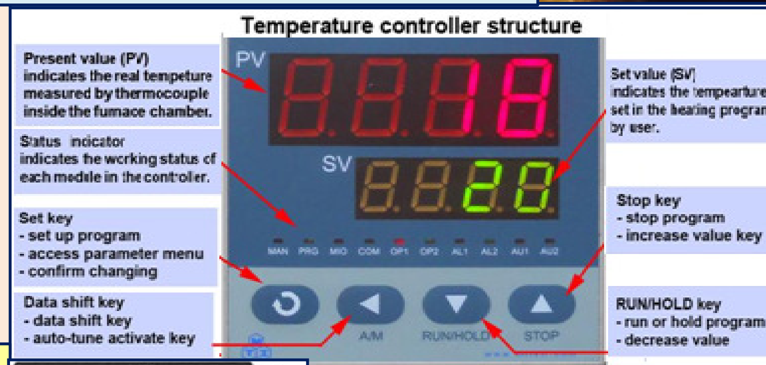


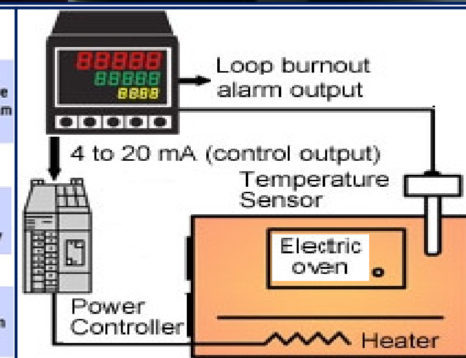


Ex- Carrier:33CSENTHSW Enthalpy Switch/Receiver,33CSENTSENEnthalpy Sensor
The accessory enthalpy switch/receiver measures both temperature and humidity and converts the data into a relay output dependent on the sensor mode. Mode 1 is designed to energize the relay at a fixed set point of a certain value of BTU/lb. Mode 2 is used in conjunction with the enthalpy sensor to measure both indoor and outdoor enthalpy and to determine which is greater. The enthalpy switch output can be normally open or normally closed.

CONTROLLER: The electronic controller receives a sensor signal, amplifies and/or conditions it, compares it with the set-point, and derives a correction if necessary. The output signal typically positions an output device (actuator).

Temperature Controllers
Temperature controllers typically require a specific type or category of input sensors.
Some have input circuits to accept RTD sensors such as BALCO or platinum elements, while others contain input circuits for thermistor sensors.
These controllers have set-point and throttling range scales labeled in degrees F or C.





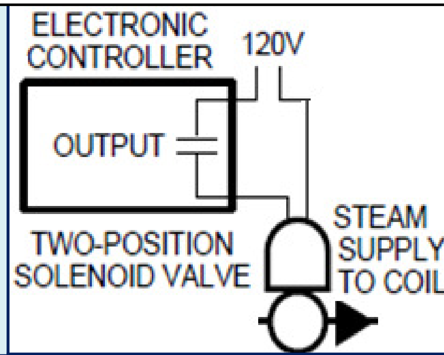
Relative Humidity Controllers: Input circuits for relative humidity controllers typically receive the sensed relative humidity signal already converted to a 0 to 10V dc voltage or 4 to 20 mA current signals. Set-point & scales for these controllers are in percent relative humidity.

Enthalpy Controllers: Enthalpy controllers are specialized devices that use specific sensors for inputs. In some cases, the sensor may combine temperature and humidity measurements and convert them to a single voltage to represent enthalpy of the sensed air.

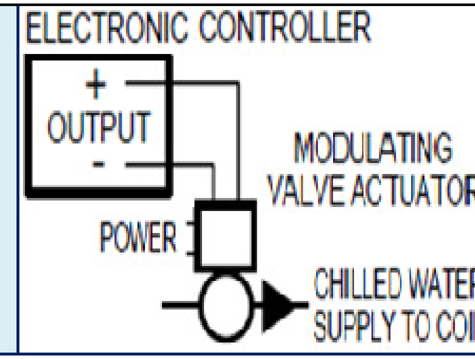
Universal Controllers:: Input circuits of universal controller can accept one or more of standard transmitter/transducer signals. The most common input ranges are 0 to 10V dc & 4 to 20 mA. Other input variations in this category include 2 to 10V dc& a 0 to 20 mA signal. Because these inputs can represent a variety of sensed variables such as a current of 0 to 15 amperes or pressure of 0 to 21000 kPa, the settings and scales are often expressed in percent of full scale only.

OUTPUT DEVICES: Actuator, relay, and transducer are output devices which use the controller output signal (voltage, current, or relay contact) to perform a physical function on the final control element such as starting a fan or modulating a valve. Actuators can be divided into devices that provide two-position action and those that provide modulating action.

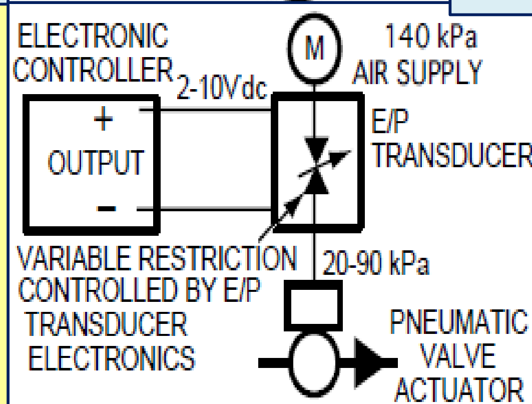
TWO-POSITION: 2-position devices as relays, motor starters & solenoid valves have only 2 discrete states. The devices interface between controller and the final control element.
For example, when a solenoid valve is energized, it allows steam to enter a coil which heats a room .



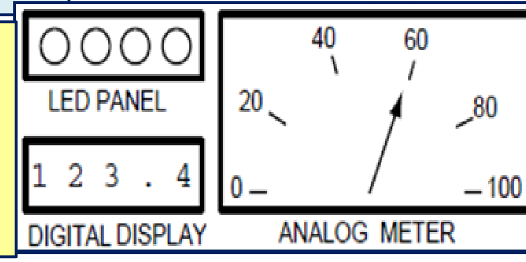
MODULATING: These actuators use a varying control signal to adjust the final control element. For example, a modulating valve controls the amount of chilled water entering a coil so that cool supply air is just sufficient to match the load at a desired set-point .



TRANSDUCER: In some applications ,a transducer converts a controller output to a signal usable by actuator. For example Electronic-to-Pneumatic (E/P) transducer: elect to-pneumatic converts modulating 2 -10Vdc signal output from controller to pneumatic proportional modulating 20-90 kPa signal for a pneumatic actuator.



INDICATING DEVICE:
Electronic control system can be enhanced by visual displays that show system status and operation.



INTERFACE WITH OTHER SYSTEMS: It is often necessary to interface an electronic control device to a system such as a microprocessor-based building management system.