INTRO TO CONTROL SYSTEMS

MISSIONS:

- DEFINE CONTROLS AND CONTROL SYSTEMS
- GIVE EXAMPLES AND DISCUSSING CONTROL SYSTEMS
- DEFINE COMMON TERMS FROM THE PROCESS CONTROL INDUSTRY
- EXAMINE VARIOUS CONTROL SYSTEM TRAINERS

DEFINING CONTROLS

INPUT DEVICES

SENSORS

OUTPUTS

DEFINING CONTROL SYSTEMS

- INPUT DEVICES
- PROCESSOR (PLC, PID…)
- OUTPUT(S)

EXAMPLE CONTROL SYSTEM 1

- MOTOR CONTROL
  - SERVO, STEPPER, DC OR AC MOTOR
  - ENCODER / POSITION FEEDBACK
  - OUTPUT CONTROLLED TO ACHIEVE POSITION, VELOCITY, AND ACCELERATION TARGETS

EXAMPLE CONTROL SYSTEM 2

- HVAC SYSTEM
  - HEATERS AND A/C, HUMIDITY CONTROL, AIR DUCTING CONTROLS
  - TEMPERATURE, HUMIDITY AND AIRFLOW / QUALITY SENSORS
  - OUTPUTS CONTROLLED TO MEET ENVIRONMENTAL TARGETS EFFICIENTLY

EXAMPLE CONTROL SYSTEM 3

- HYDRAULIC POSITIONING
  - ANALOG CONTROL VALVES
  - MAGNETIC SENSORS TO DETERMINE CYLINDER POSITION
  - VALVE POSITIONS CAREFULLY CONTROLLED TO REGULATE POSITION AND SPEED

EXAMPLE CONTROL SYSTEM 4

- LIQUID CAPACITY MONITORING
- ANALOG VALVES TO CONTROL FILLING / EMPTYING RATES, TEMP SENSORS
- LEVEL AND TEMPERATURE SENSORS
- VALVE POSITIONS REGULATE FILL LEVEL, MIXING RATIOS (RECIPES) AND TEMPS

TERMS IN PROCESS CONTROL

CONTEXT IS KEY – SOME DEFINITIONS CHANGE BASED ON INDUSTRY AND APPLICATION.

INTERVIEW TECHS IN VARIOUS INDUSTRIES TO GAIN A BETTER UNDERSTANDING OF THE APPLICATIONS OF THESE CONCEPTS.

INPUT

ANY DEVICE CAPABLE OF TAKING A SIGNAL FROM ONE SOURCE AND SENDING IT TO A RECEIVING DEVICE.

SENSORS – ENVIRONMENT INTO ‘SIGNAL’

HMI – DIGITAL TAGS INTO ‘SIGNAL’

NETWORKS, LIKE ETHERNET – ‘SIGNALS’ CAN COME FROM NEARLY **ANY** DEVICE

ALSO CAN REFER TO THE TERMINAL WHICH RECEIVES THE ‘SIGNAL’

OUTPUT

ANY DEVICE WHICH RECEIVES A SIGNAL AND DOES SOMETHING WITH THE SIGNAL

LOAD DEVICES – RELAYS, STARTERS, VISUAL AND AUDIBLE INDICATORS

HMI – GRAPHICS CAN BE PROGRAMMED TO SHOW STATUSES AND INFORMATION

OTHER PROCESSORS – ROBOT, MICROCONTROLLER…

ALSO CAN REFER TO THE SIGNAL WHICH IS BEING SENT OUT OF ANY DEVICE.

DISCRETE

ANY SIGNAL WHICH IS LIMITED TO MERELY ON OR OFF.

INPUTS – EXAMPLE: LIGHT SWITCH, PUSHBUTTON, LIMIT SWITCH, SOME SENSORS

OUTPUTS – EXAMPLE: RELAY, LIGHT, SOLENOID

CAN BE DC OR AC!

ANALOG

SIGNALS WHICH CAN TRANSITION FROM OFF TO ON

REQUIRED WHENEVER INFORMATION MUST BE MORE PRECISE THAN ON/OFF

EXAMPLES: DISTANCE, TEMPERATURE OR ORIENTATION INPUTS, VALVES AND HEATER OUTPUTS

DIGITAL

THE FORMAT OF DATA TRANSFER WHICH USES BITS (ON/OFF) TO SEND DATA

ANALOG SIGNALS CAN BE SENT AS DIGITAL STRINGS

DISCRETE SIGNALS CAN BE SENT AS DIGITAL BITS

AC AND DC STATUSES CAN BE SENT AS DIGITAL INFORMATION

ACTUATOR

TECHNICAL TERMS FOR SOMETHING THAT MOVES

OFTEN HYDRAULIC OR PNEUMATIC CYLINDER

LINEAR MOTORS

SOMETIMES TURNING DEVICES ARE CALLED ‘ROTARY ACTUATORS’

SOLENOID

A COIL WITH A PLUNGER

INDUCTIVE LOAD

MAINLY FOR HYDRAULIC AND PNEUMATIC CONTROL

USUALLY, THE PLUNGER IS THE ‘SPOOL’ CONTROLLING THE FLUID FLOW

TRANSDUCER

ELEMENT THAT CONVERTS PHYSICAL QUANTITY TO ELECTRIC SIGNAL

WHEN PAIRED WITH AMPLIFIER/COMPARATOR IT BECOMES A SENSOR

SOMETIMES THE TWO TERMS ARE USED INTERCHANGEABLY

FEEDBACK

ANY SIGNAL THAT REPORTS A ‘PARAMETER’ WHICH IS THE QUANTITY YOU WANT TO CONTROL

COMMONLY USED IN PID SYSTEMS

ROTATIONAL OR LINEAR POSITION, TEMPERATURE, HUMIDITY, LEVEL, ETC

-- ALSO, THIS INCLUDES FLIGHT INFO FOR UAVS

OPEN LOOP

CONTROL SIGNALS SENT OUT INTO A ‘BLACK BOX’ – NO FEEDBACK

CORRECTIONS ARE IMPOSSIBLE

IDEAL FOR SYSTEMS WHICH ARE ULTRA CONSISTENT, OR HAVE A WIDE DEGREE OF TOLERANCE, OR ARE VERY LOW RISK OF INJURY/DAMAGE

CLOSED LOOP

CURRENT SYSTEM POSITION (OR OTHER KEY VARIABLE) IS KNOWN CONSTANTLY

CURRENT VALUE IS COMPARED WITH TARGET VALUE AND USED TO CALCULATE AND OUTPUT

THE SYSTEM CAN BE MADE RELIABLE, ACCURATE, AND FAST!

PID

PROPORTIONAL, INTEGRAL, DERIVATIVE CONTROLLER

CALCULATES THE POWER THAT SHOULD BE SENT TO THE OUTPUT

THE PID CONTROLLER IS USUALLY A BOX THAT MIGHT LOOK LIKE A PLC, BUT FUNDAMENTALLY IS MUCH DIFFERENT

PID CONT

SOMETIMES, ONLY P OR PI IS USED

IN SOME OTHER CASES, A SECOND DERIVATIVE TERM IS USED (PIDD)

PROCESS VARIABLE

IN A PID SYSTEM, YOU NEED PRECISION IN SOME ASPECT

THE PROCESS VARIABLE IS THE KEY INFORMATION TO BE TRACKED

IN MOTION: POSITION, VELOCITY AND ACCELERATION

OTHER SYSTEMS: TEMPERATURE, LIQUID LEVEL

SET POINT

TARGET FOR YOUR PROCESS VARIABLE (SEE BEFORE)

MIGHT BE A SINGLE POINT – “WE NEED TO GET TO 100 DEGREES”

OFTEN IS AN ENTIRE MOTION PROFILE – “WE NEED TO GET TO THIS POSITION AT THIS VELOCITY, THEN MOVE TO A NEW POSITION AT A NEW VELOCITY…”

GAIN

FOR EACH CALCULATION OF P, I AND D, AMOUNT OF INFLUENCE FROM EACH

COMES FROM AMPLIFIER CIRCUITS WITHIN THE CONTROLLER

GAIN IS THE AMPLIFICATION OF AN ACTUAL SIGNAL AMPLIFIER

TUNE

THE PROCESS OF MANUALLY OR AUTOMATICALLY ADJUSTING GAIN LEVELS FOR THE OPTIMUM PROCESS SETTINGS

MODERN CONTROLLERS – TUNED AUTOMATICALLY

OLDER OR SIMPLER SYSTEMS, MANUALLY ADJUST POTENTIOMETERS IN THE AMPLIFIER CIRCUITS

MOTOR CONTROL VS MOTION CONTROL

MOTOR CONTROL INVOLVES THE CIRCUITS NECESSARY TO DRIVE A MOTOR – STARTERS, RELAYS, SERVO AND STEPPER DRIVES.

MOTION CONTROL IS A PID SYSTEM WHICH INCORPORATES FEEDBACK, PID CONTROL, THE MOTOR CONTROL AND THE MOTOR ITSELF

MOTION CONTROL CAN ALSO REFER TO HYDRAULIC MOTION – NO MOTORS!

CONTROL SYSTEM TRAINERS

SIMPLEST:	OPEN LOOP ‘MOTOR CONTROL’ TRAINERS
MORE COMPLEX:	PROCESS CONTROL, LIKE HVAC OR MOTION CONTROL
STILL MORE COMPLEX:	PLC TRAINERS
MOST COMPLEX:	“INDUSTRY 4.0” WITH NETWORKING AND AUTOMATION