Wind Turbine Control

A. Introduction

   3. Different Control Purposes

- Supervisory Control

→ MONITOR THE TURBINE & SEQUENCES OF ACTIONS THAT TURBINE TAKES
- START-UP & SHUT-DOWN

- Dynamic Control

→ ADDRESSING DYNAMIC VARIATIONS OF THE MACHINE OR ENVIRONMENT

- CHANGES IN WIND SPEED

Wind Turbine Control

A. Introduction

    5. Control Regions

REGION I — TURBINE NOT PRODUCING POWER — HANDLES THE PORTION OF START-UP WHERE IS NOT PRODUCING POWER

REGION II — POWER PRODUCTION IS A FRACTION OF RATED POWER — MAXIMIZE POWER PRODUCTION WHILE ALLOWING FOR INCREASES IN POWER PRODUCTION

REGION III — TURBINE OPERATES AT RATED POWER

MAINTAIN POWER
CONTROL LOADS, PRODUCE TORQUE NEZOSARY, BUT NO MORE

GE 1.5 SLE

REGION I

REGION III

REGION II

Power (kW)

Wind Speed (m/s)
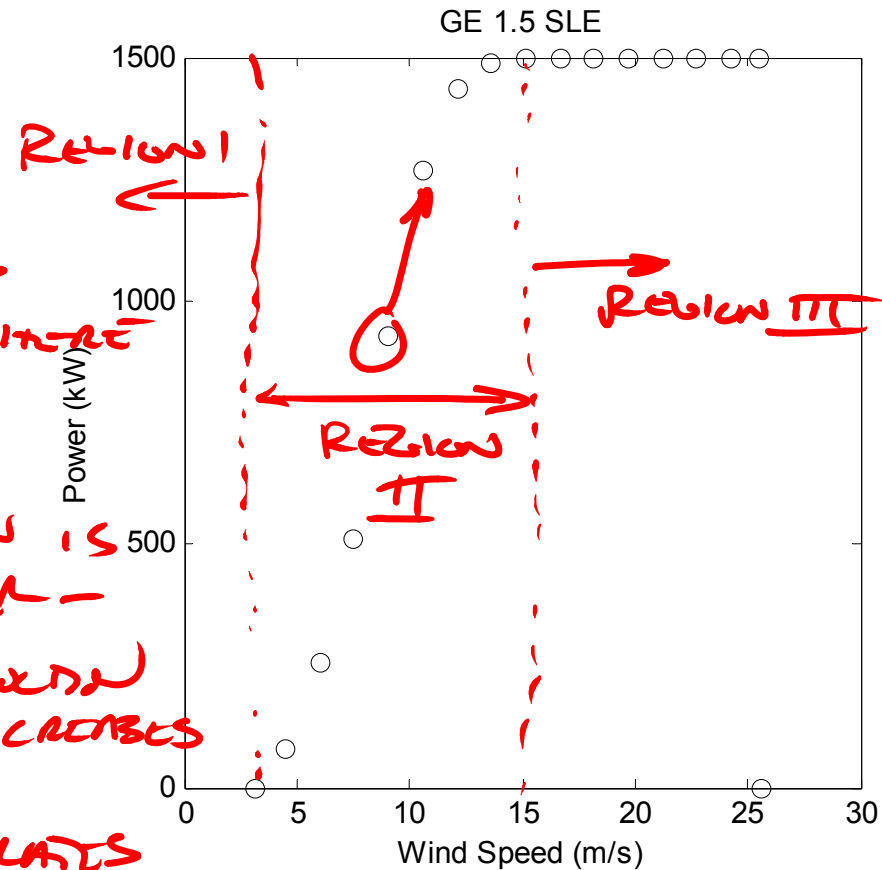
Wind Turbine Control

B. Control Basics

1. The System

THIS IS WHAT WE ARE TRYING TO Control

IT MAY BE COMPRISED OF MANY SUBSYSTEMS

SYSTEM OF SYSTEMS

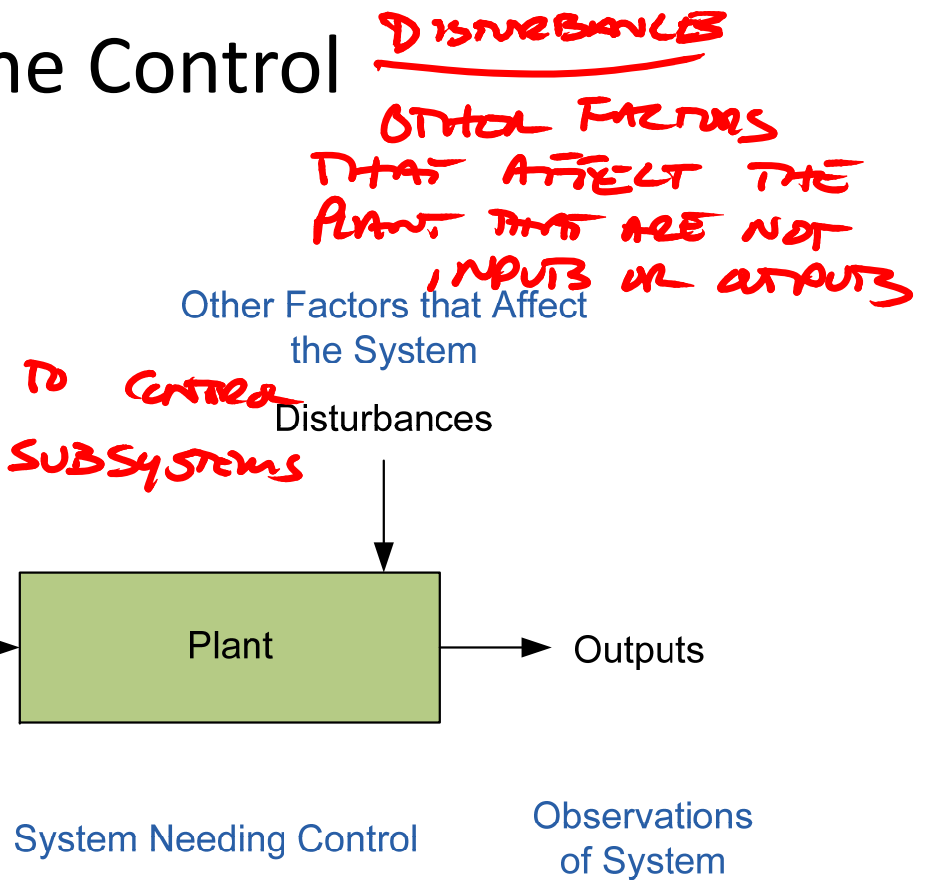SYSTEM = PLANT IN Control WORLD

INPUTS (ACTUATORS)

COMPONENTS THAT PRODUCE CHANGES IN THE SYSTEM THROUGH SOME ACTION

PART OF THE PLANT { • MOTOR IS COMMANDED TO MOVE SOMETHING
• COMPONENTS TURNED ON OR OFF TO CHANGE SYSTEM }

INPUTS ARE GENERALLY SIGNALS, ALTHOUGH MECHANICAL DEVICES MAY BE CONSIDERED INPUTS

DISTURBANCES

OTHER FACTORS THAT AFFECT THE PLANT THAT ARE NOT INPUTS OR OUTPUTS

Other Factors that Affect the System

Disturbances

Inputs → Plant → Outputs

Produce Changes in System

System Needing Control

Observations of System

OUTPUTS (SENSORS)

ARE OBSERVATIONS OF THE SYSTEM THAT TELL US SOMETHING ABOUT ITS STATE
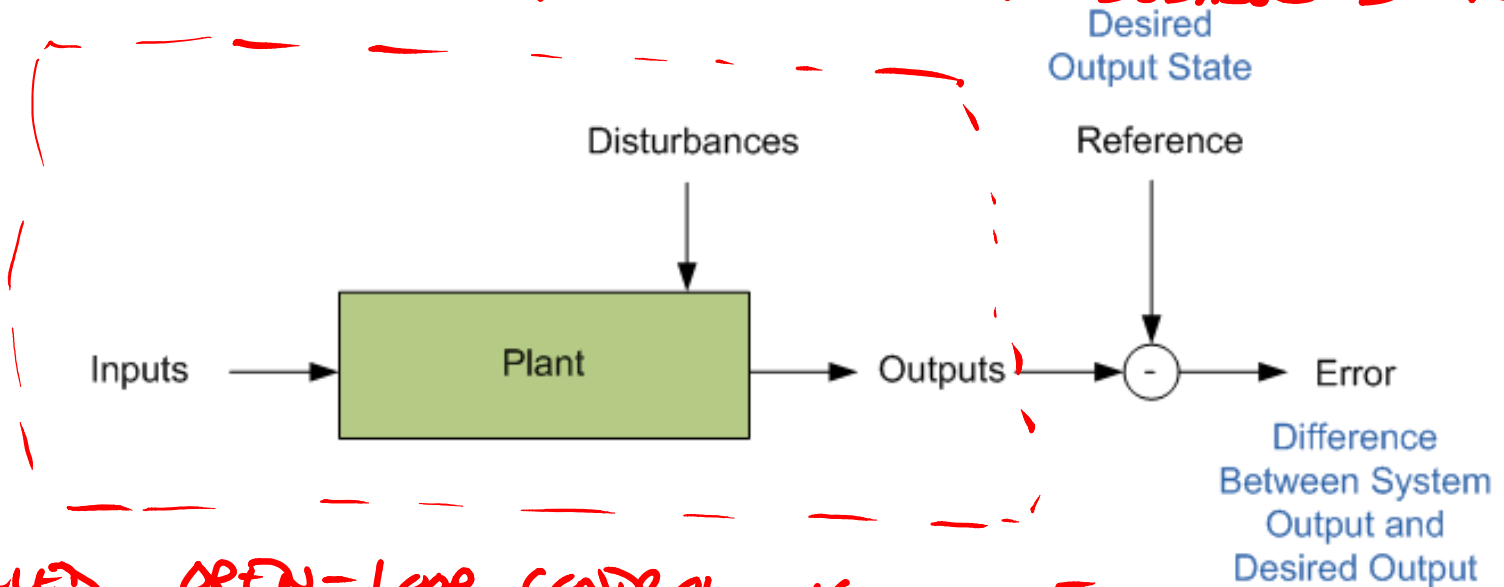
MOST OFTEN A SENSOR THAT PROVIDES INFORMATION ABOUT THE STATE

Wind Turbine Control

B. Control Basics

   2. What is Control?

FIRST STEP IN "CLOSED-LOOP" CONTROL IS TO EVALUATE HOW A CERTAIN INPUT AFFECTS THE OUTPUT WITH REFERENCE TO A DESIRED STATE

Desired Output State

Disturbances

Reference

Inputs → | Plant | → Outputs → (−) → Error

Difference Between System Output and Desired Output

SO CALLED OPEN-LOOP CONTROL IS WHERE THE INPUTS ARE CHANGED TO CAUSE A CHANGE IN OUTPUT. THERE IS NO COMMUNICATION OF HOW OUTPUT CHANGED COMMUNICATED BACK

MOST CONTROL TYPES DO NOT CONSIDER THIS "REAL" CONTROL

HOWEVER, IT PROVIDES USEFUL INFORMATION — HOW DOES THE SYSTEM CHANGE AS INPUTS CHANGE
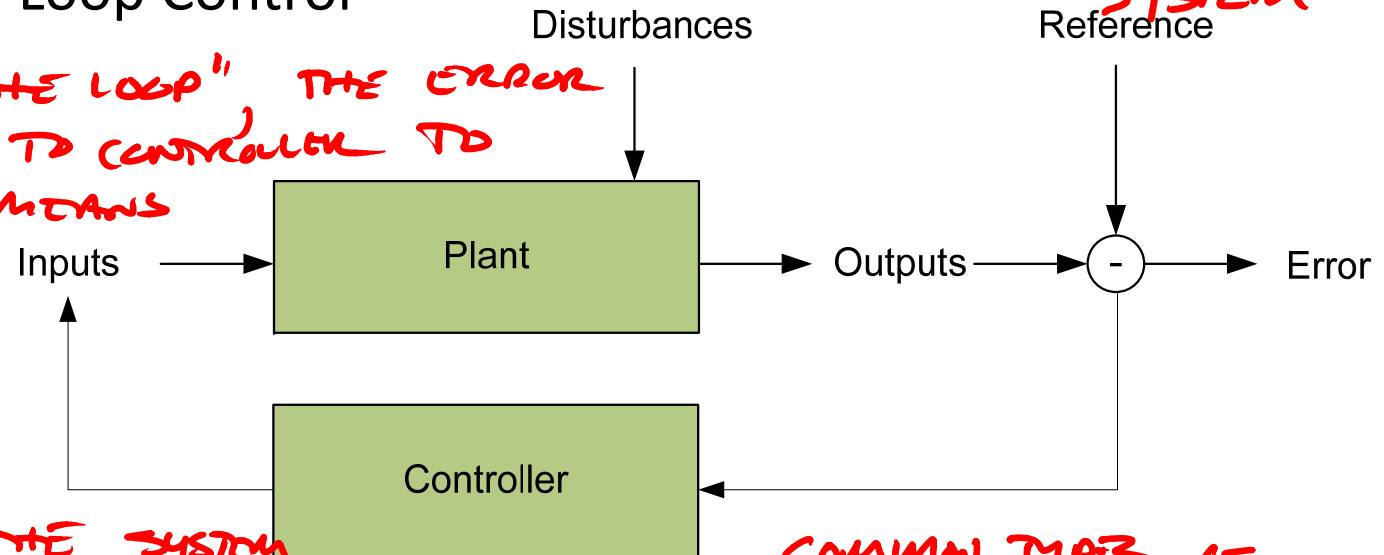
Wind Turbine Control

SIMPLEST TYPE
OF SYSTEM

1 INPUT, 1 OUTPUT
SYSTEM

B. Control Basics

3. Closed-Loop Control

TO "CLOSE THE LOOP" THE ERROR
IS FED BACL TO CONTROLLER TO
PROVIDE A MEANS
OF ACHIEVING
THE DESIRED
STATE

Disturbances

Reference

Inputs → [Plant] → Outputs → (-) → Error

[Controller]

Changes input to
System to Reduce Error

THE PART OF THE SYSTEM
THAT MAKE THE DECISIONS
OF HOW TO CHANGE INPUTS
BASED ON CURRENT OUTPUTS (ERROR)

⇓
CONTROLLER

(CHANGES INPUTS
BASED ON SENSITIVITY
AS WELL AS HISTORY)

COMMON TYPES OF
CONTROL

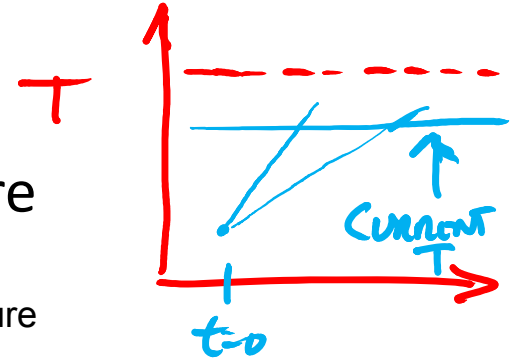• PROPORTIONAL / INTEGRAL /
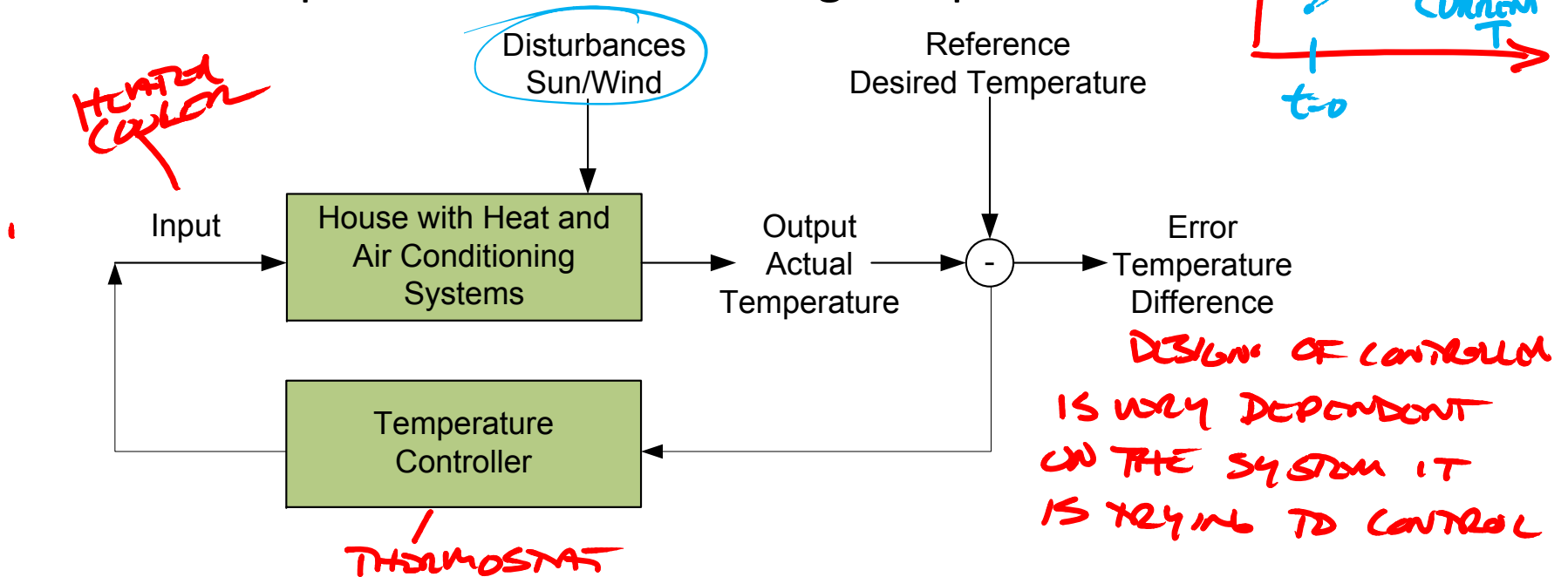DIFFERENTIAL   (PID)

DISTURBANCE ACCOMODATING
CONTROL

LINEAR VS. NON-LINEAR
CONTROL

Wind Turbine Control

B. Control Basics

    4.   Example – Control of Building Temperature

HEATER
COOLER

Disturbances
Sun/Wind

Reference
Desired Temperature

Input

| House with Heat and
Air Conditioning
Systems |

Output
Actual
Temperature

-

Error
Temperature
Difference

| Temperature
Controller |

THERMOSTAT

*DESIGNS OF CONTROLLER
IS VERY DEPENDENT
ON THE SYSTEM IT
IS TRYING TO CONTROL*

INPUT – SIGNAL TO HEATING/COOLING TO TURN ON/OFF

OUTPUT – SIGNAL FROM TEMPERATURE SENSOR

*CONTROLLER – DECIDES WHETHER TO KEEP HEATING COOLING
ON/OFF BASED ON CURRENT TEMPERATURE
& ITS HISTORY*