Exciter and Governors

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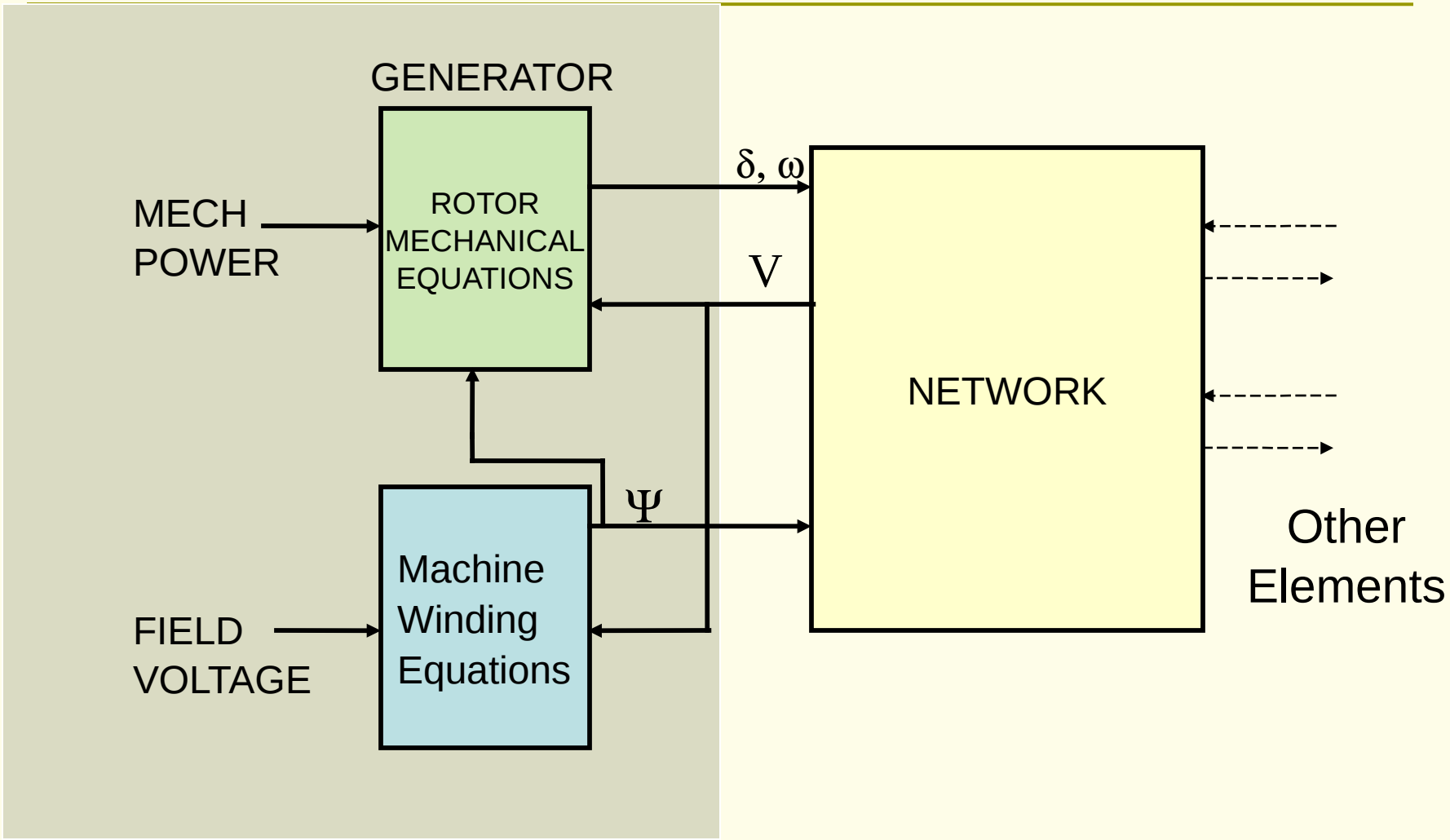
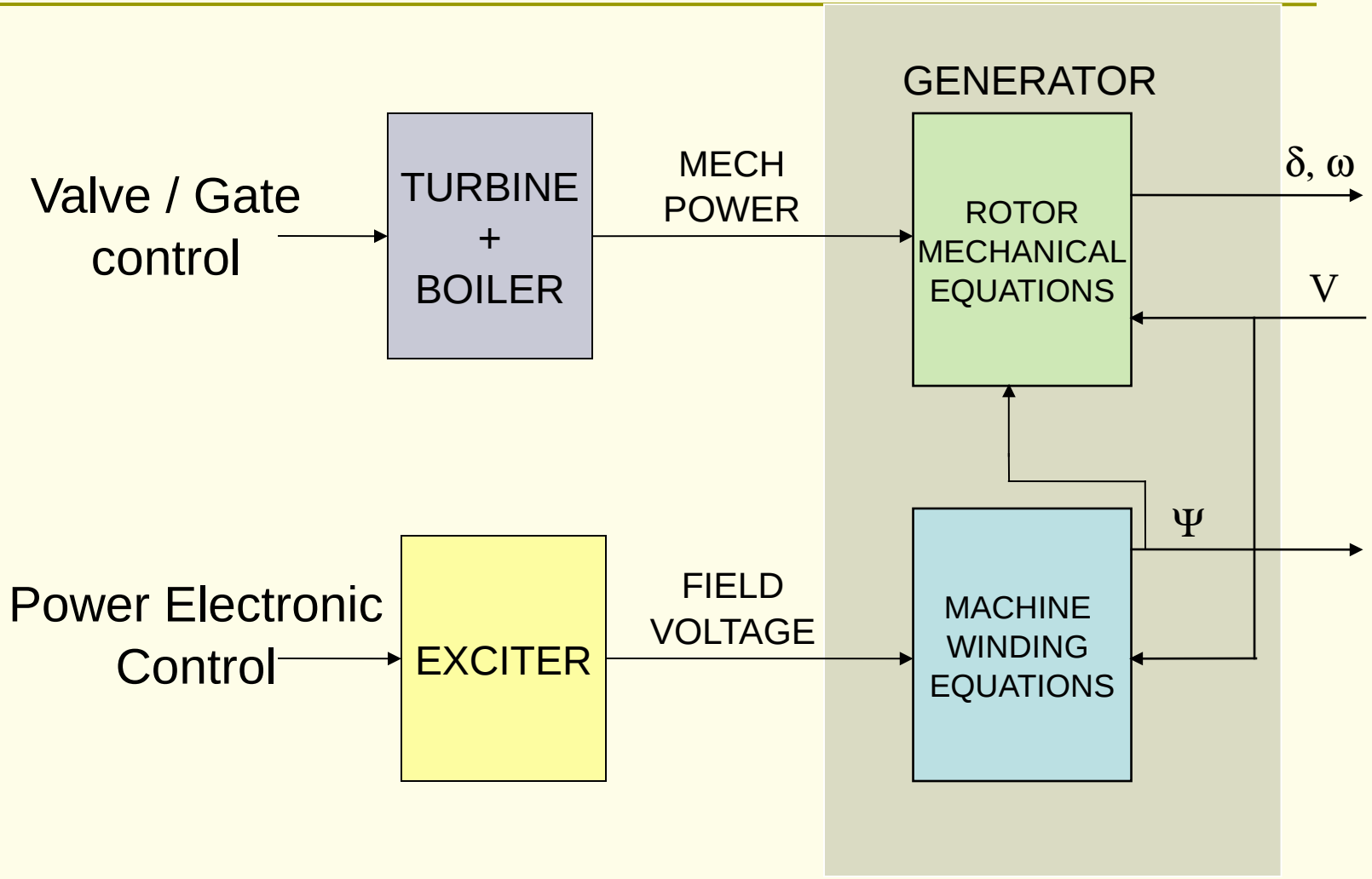
Excitation Systems

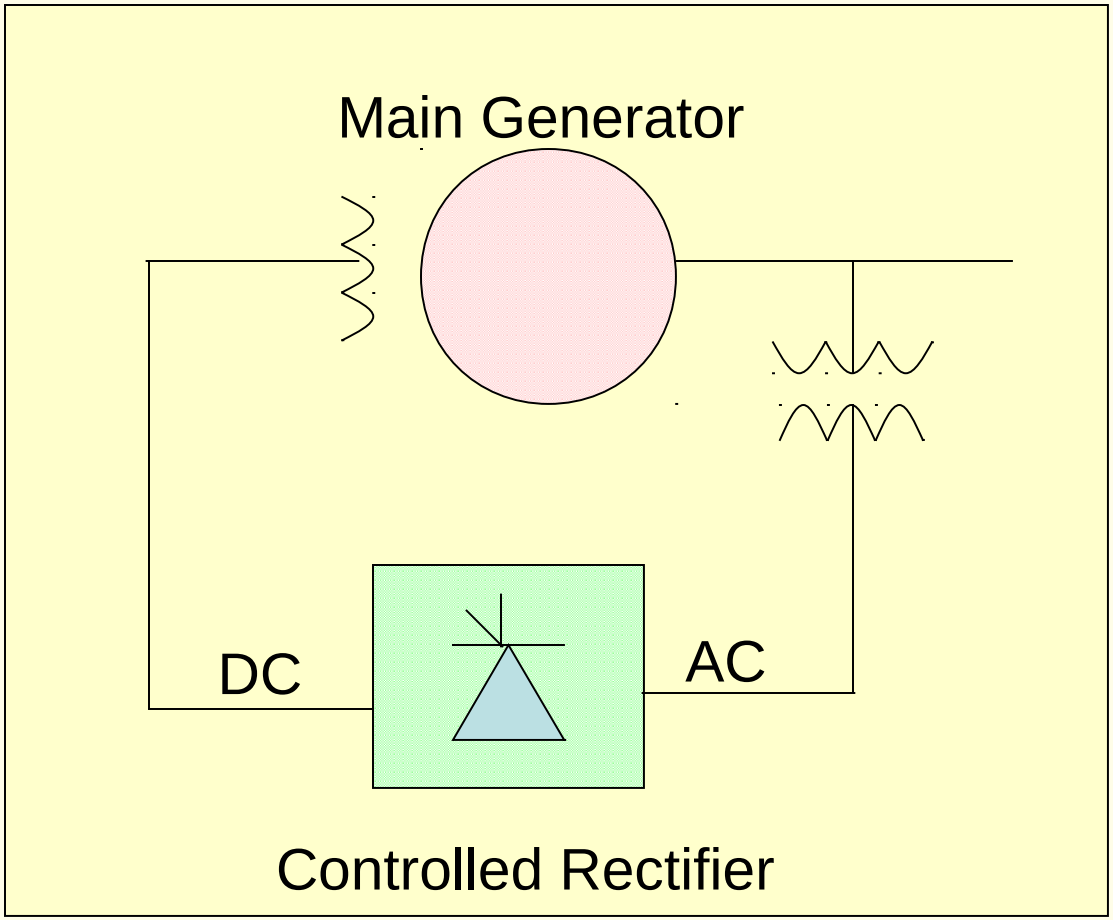
System Block Diagram

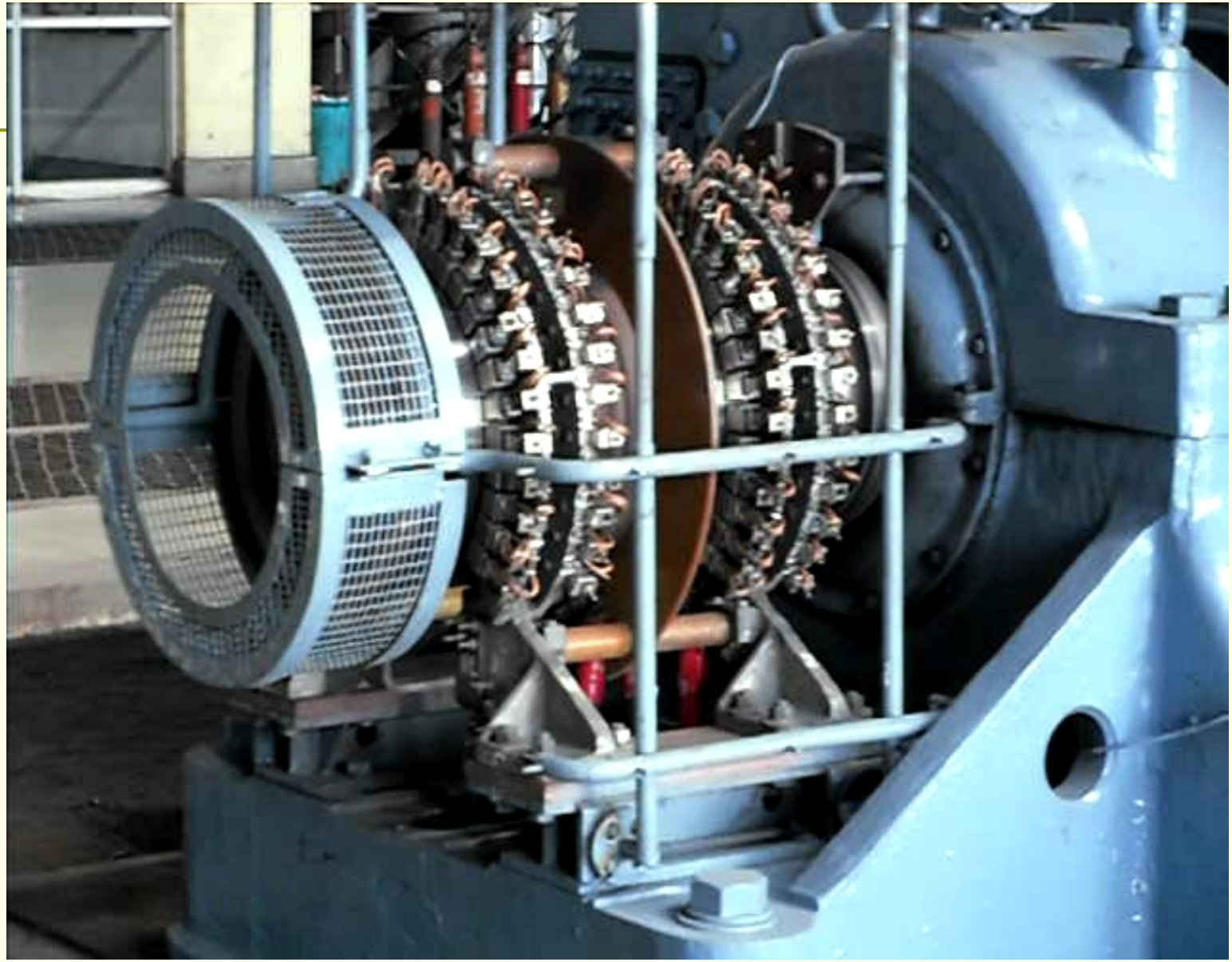


Additional Subsystems

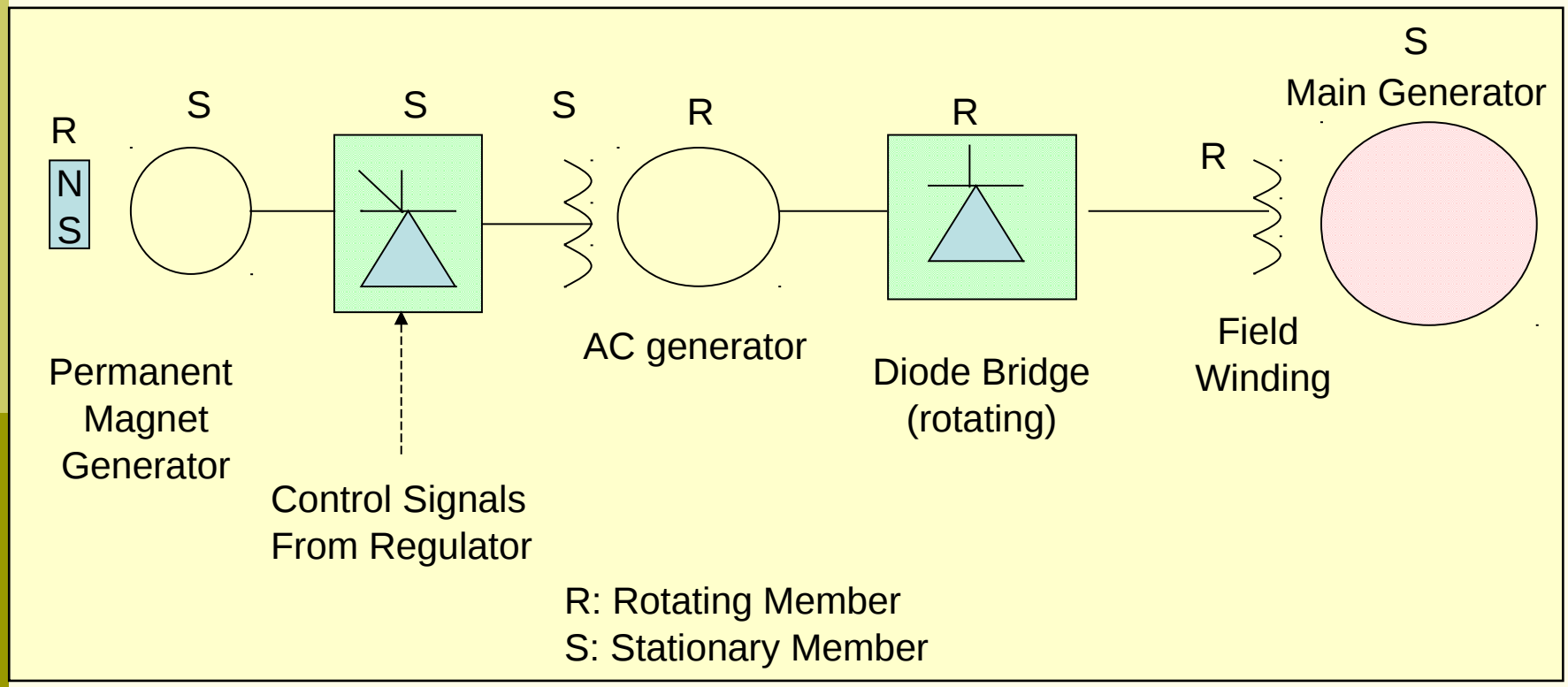


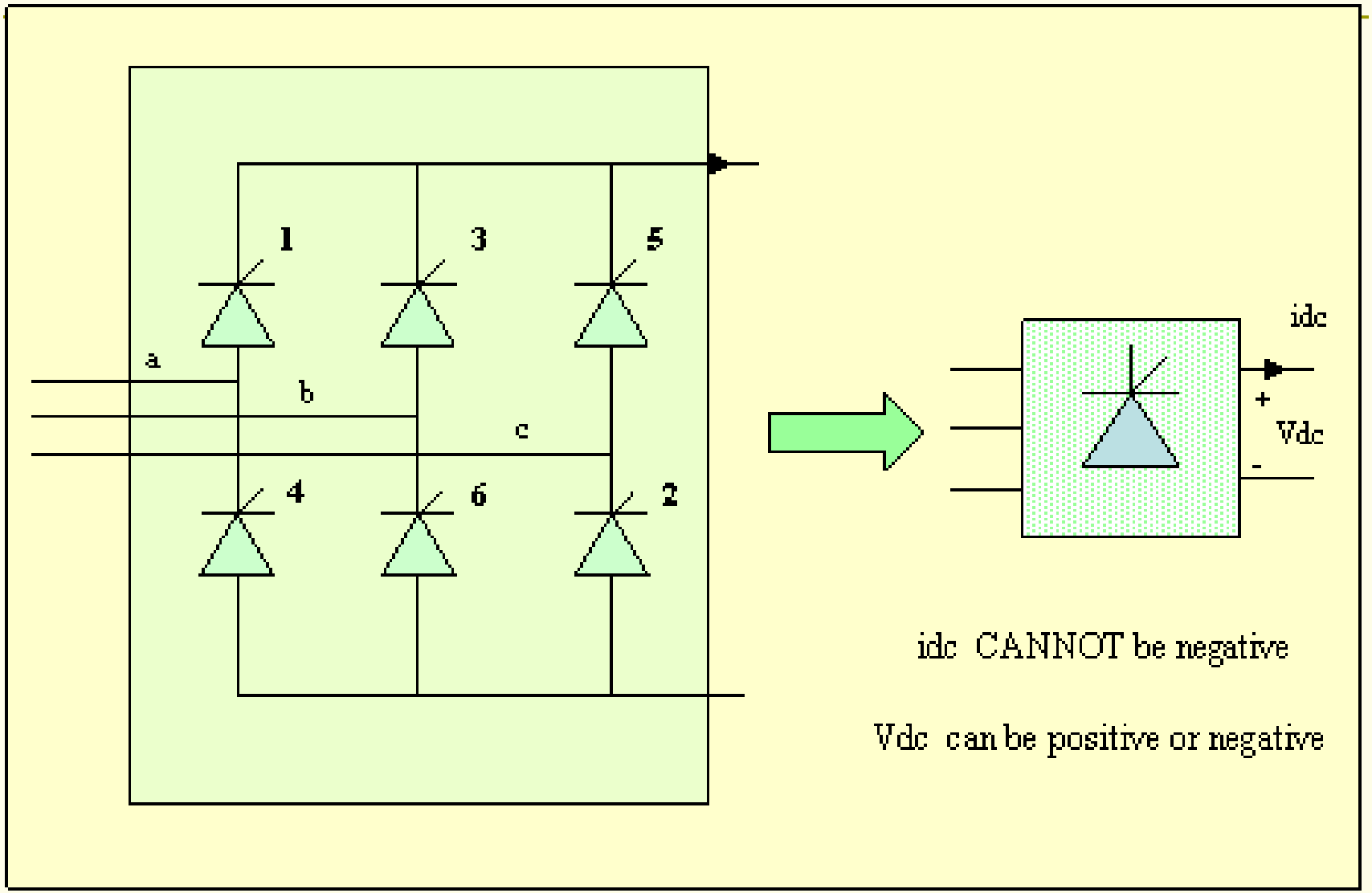
Static Excitation



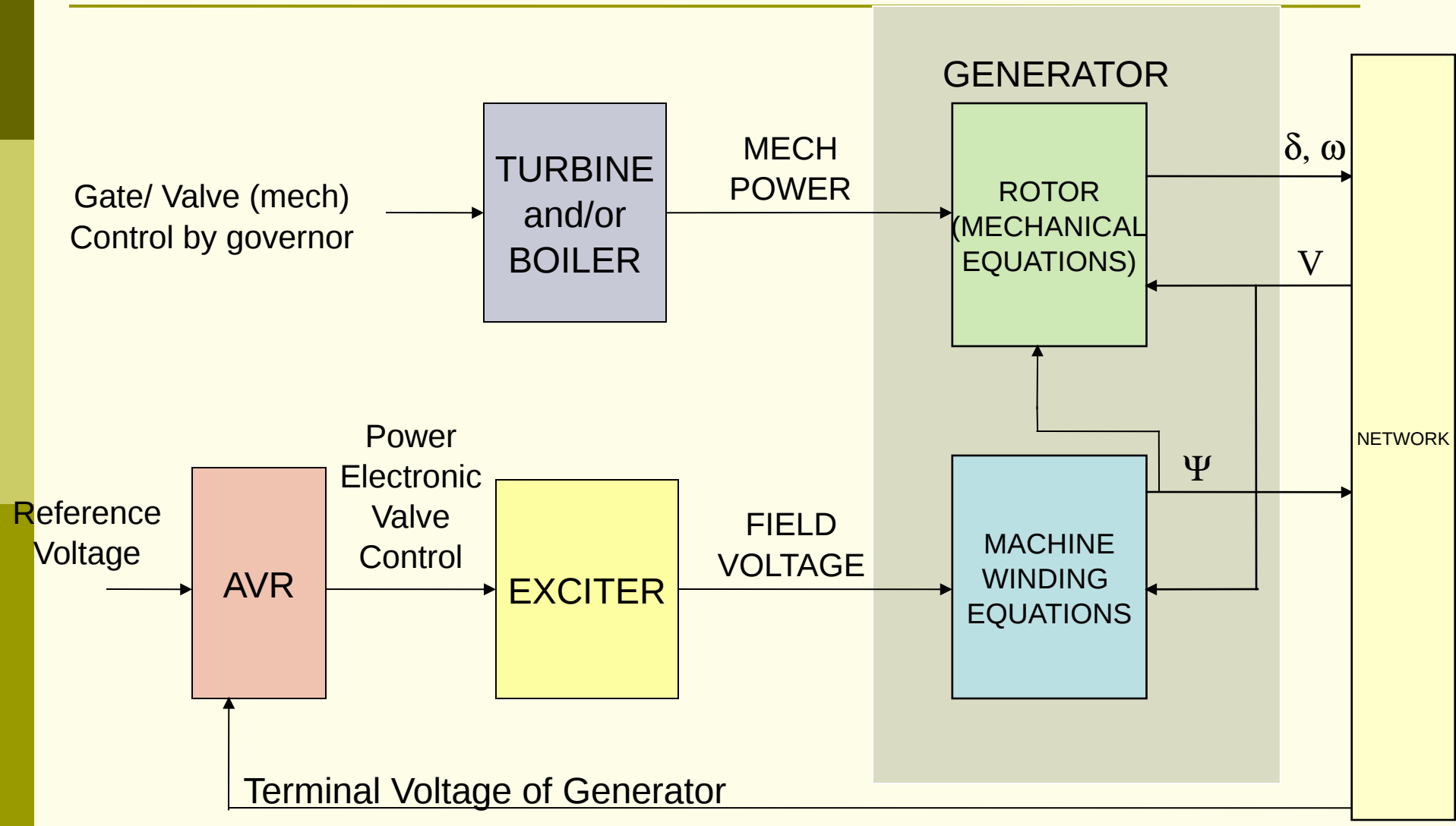


Brushless Excitation

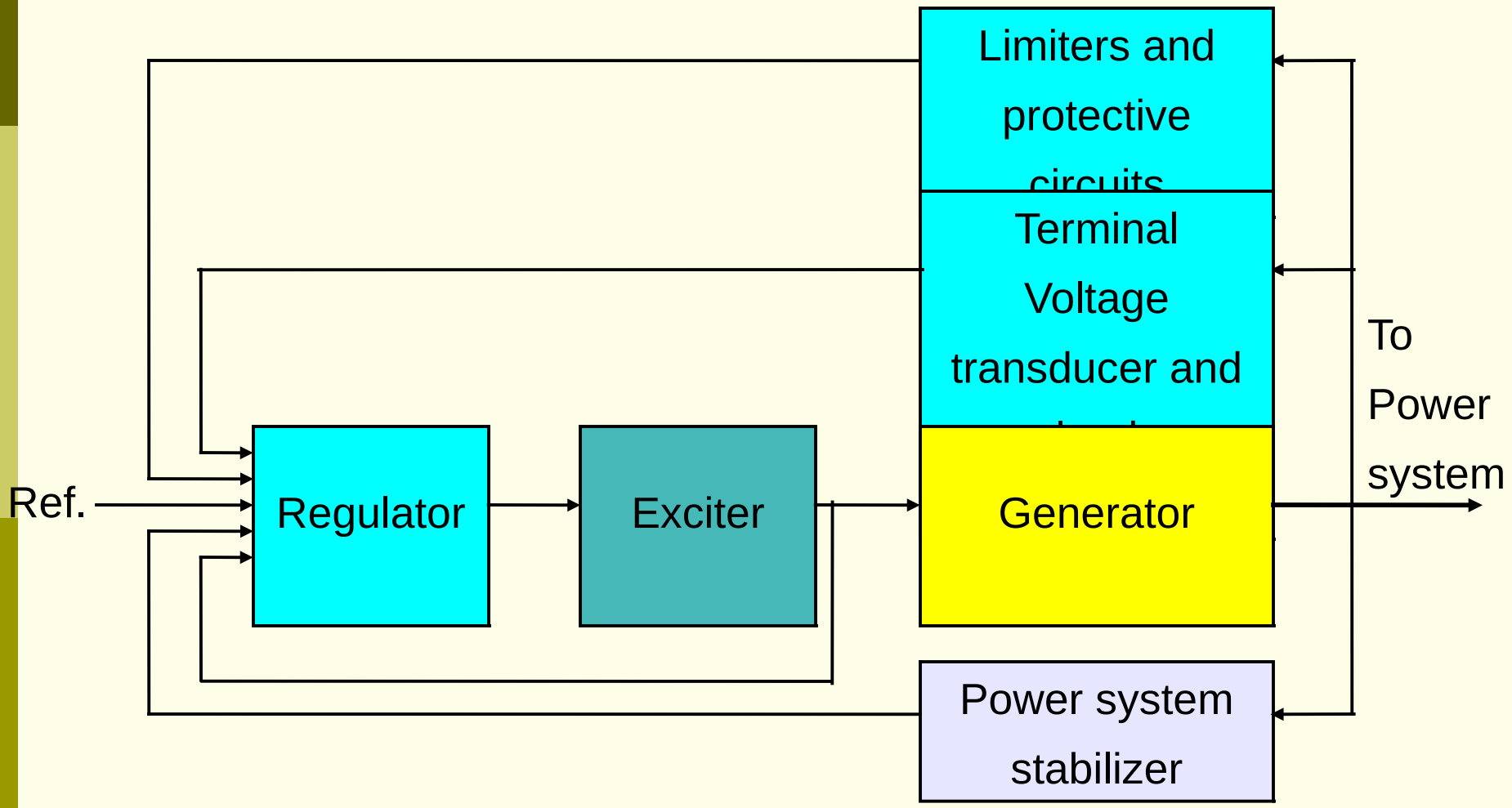



1
3
5
a
b
c
4
6
2
idc
+
Vdc
-
idc CANNOT be negative
Vdc can be positive or negative

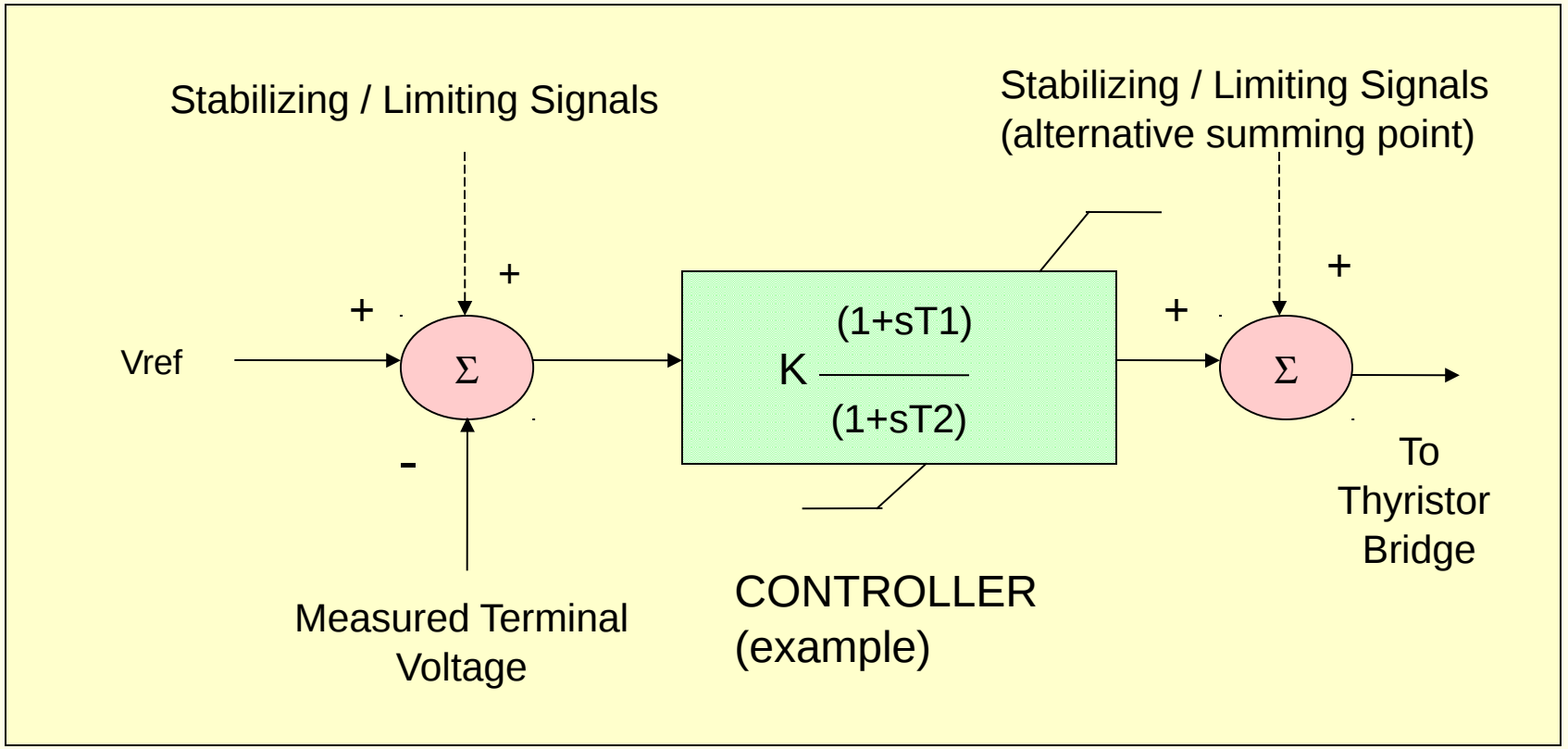
AVR


GENERATOR
Gate/ Valve (mech)
Control by governor
TURBINE
and/or
BOILER
MECH
POWER
ROTOR
(MECHANICAL
EQUATIONS)
δ, ω
V
NETWORK
Ψ
Power
Electronic
Valve
Control
Reference
Voltage
AVR
EXCITER
FIELD
VOLTAGE
MACHINE
WINDING
EQUATIONS
Terminal Voltage of Generator

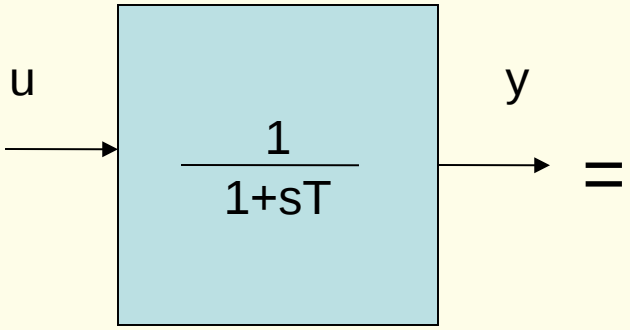
Functional block diagram (Kundur)



AVR Block Diagram - Example



Understanding Transfer Functions



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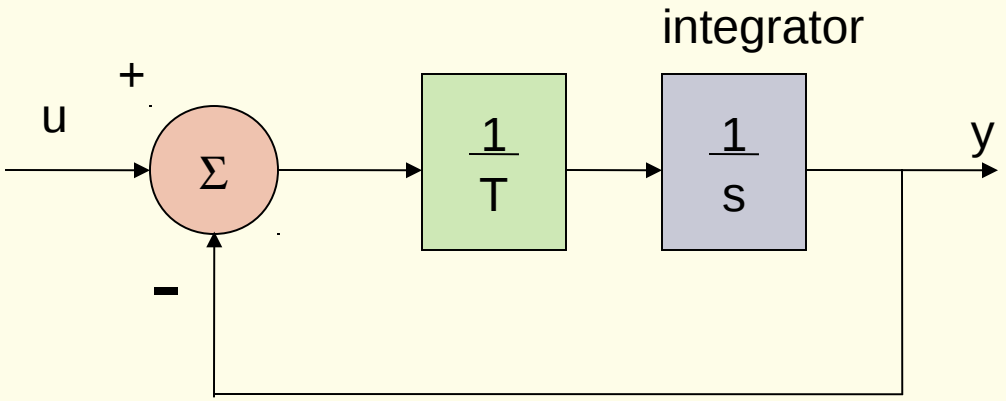
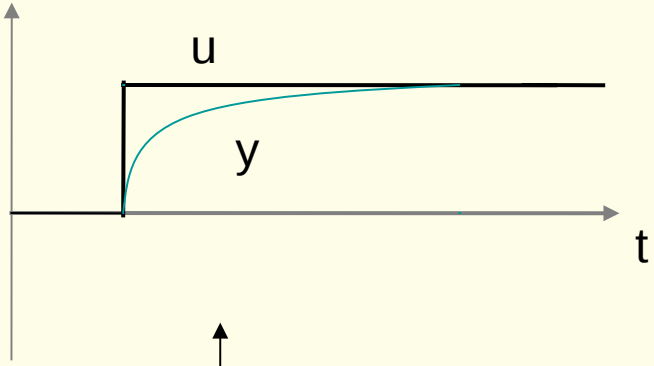
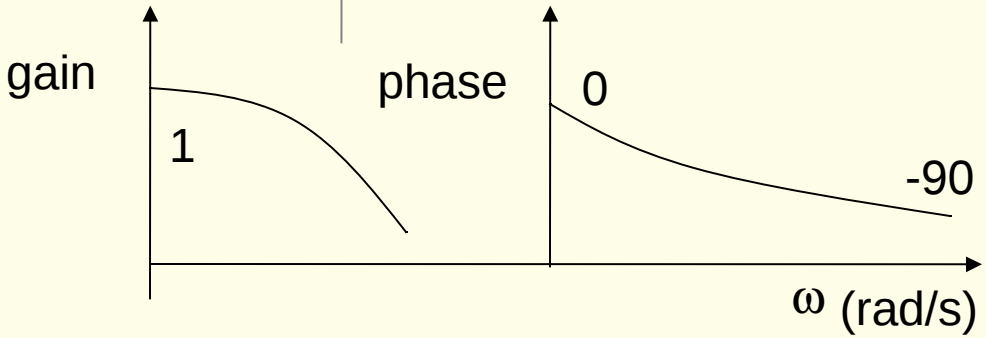


$$\frac{1}{s}\,\frac{u-y}{T} = y$$

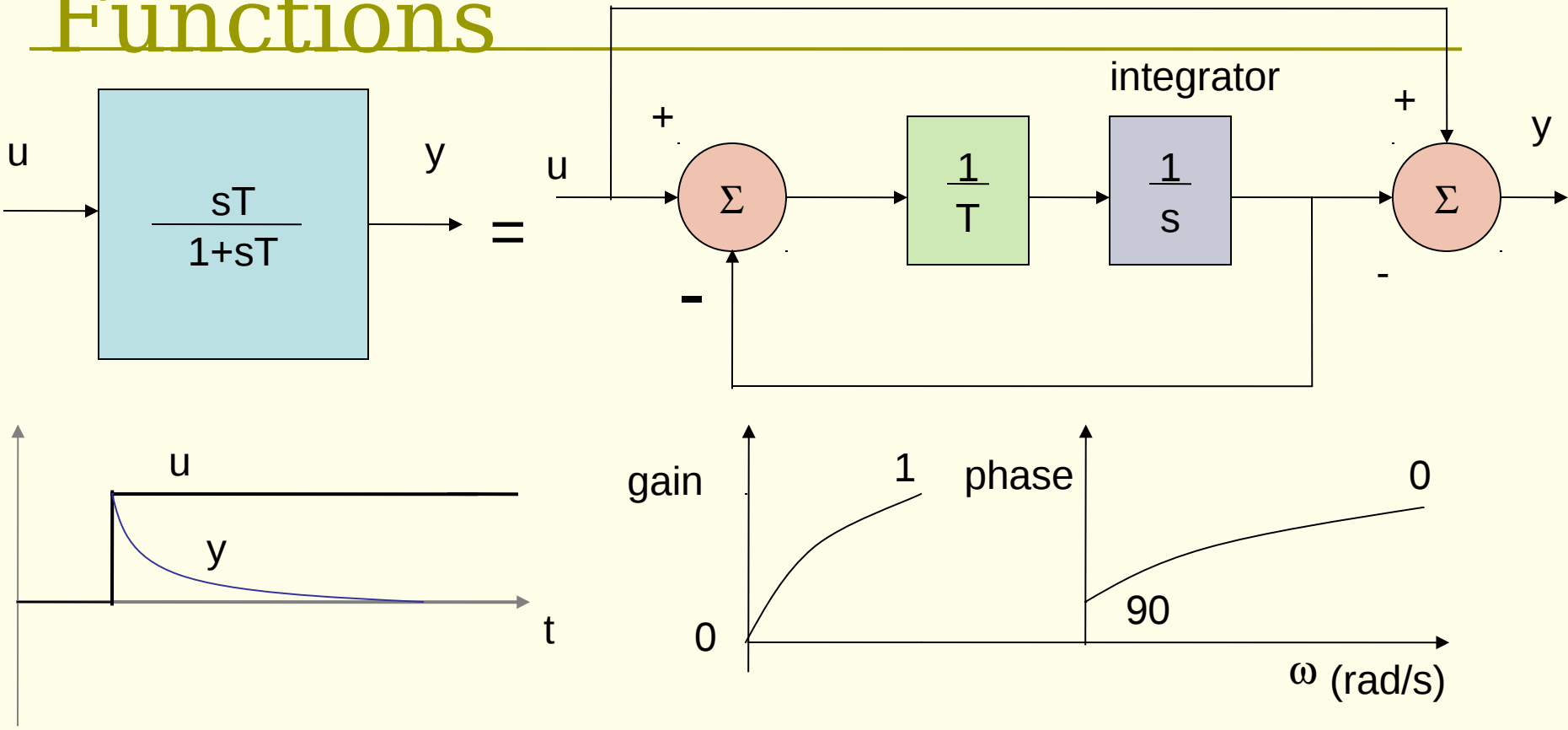
STEP RESPONSE



SINUSOIDAL STEADY STATE RESPONSE FOR VARIOUS FREQUENCIES



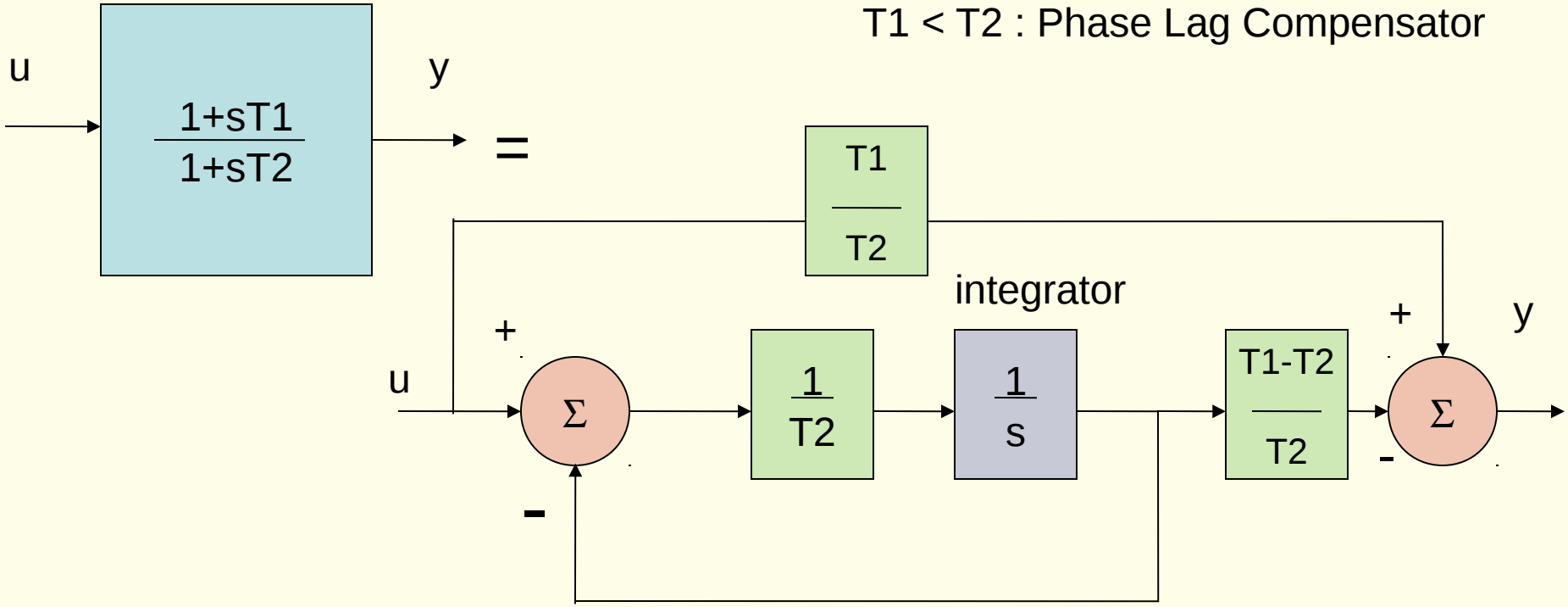
Understanding Transfer Functions



- Integration/Summing/Gains done by **OP-AMPS** in **Analog AVR**
- Integration/Summing/Gains done by **numerical algorithms** in **Digital AVR (DVR)**

Understanding Transfer Functions

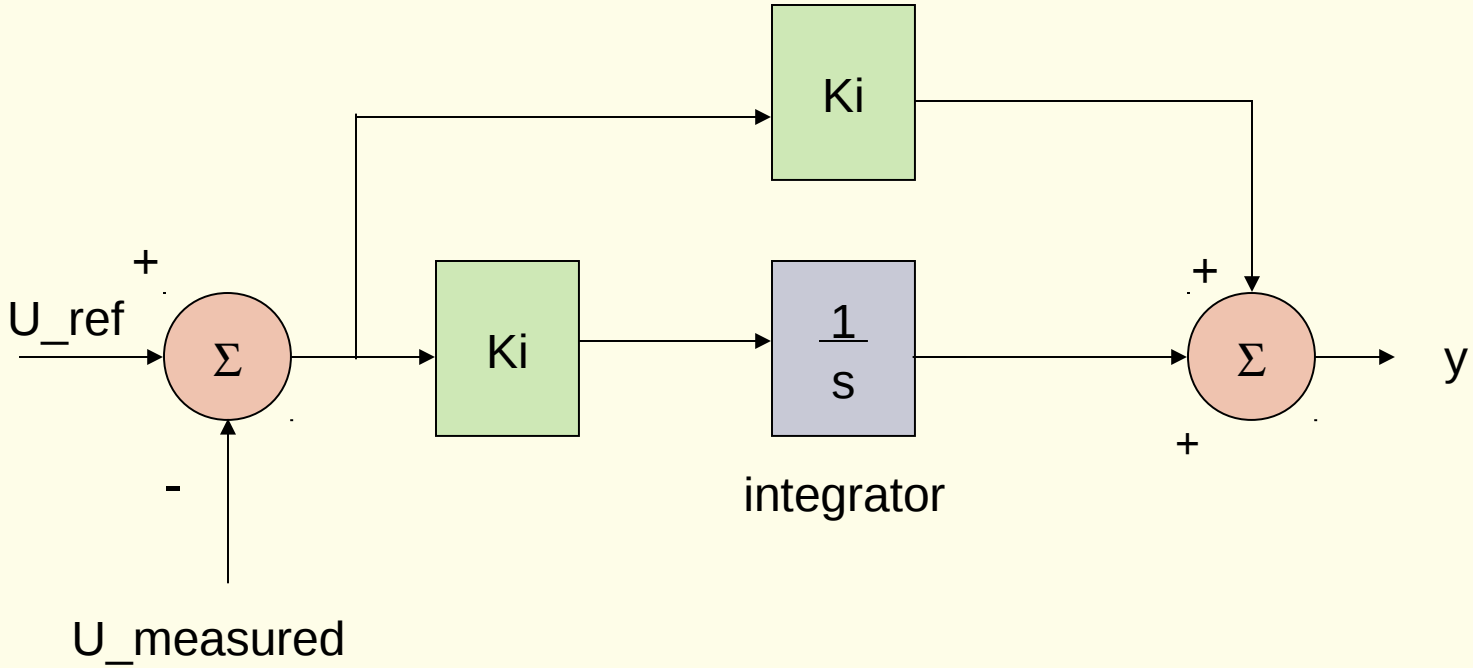
T1 > T2 : Phase Lead Compensator
T1 < T2 : Phase Lag Compensator



- Integration/Summing/Gains done by **OP-AMPS** in **Analog AVR**
- Integration/Summing/Gains done by **numerical algorithms** in **Digital AVR (DVR)**

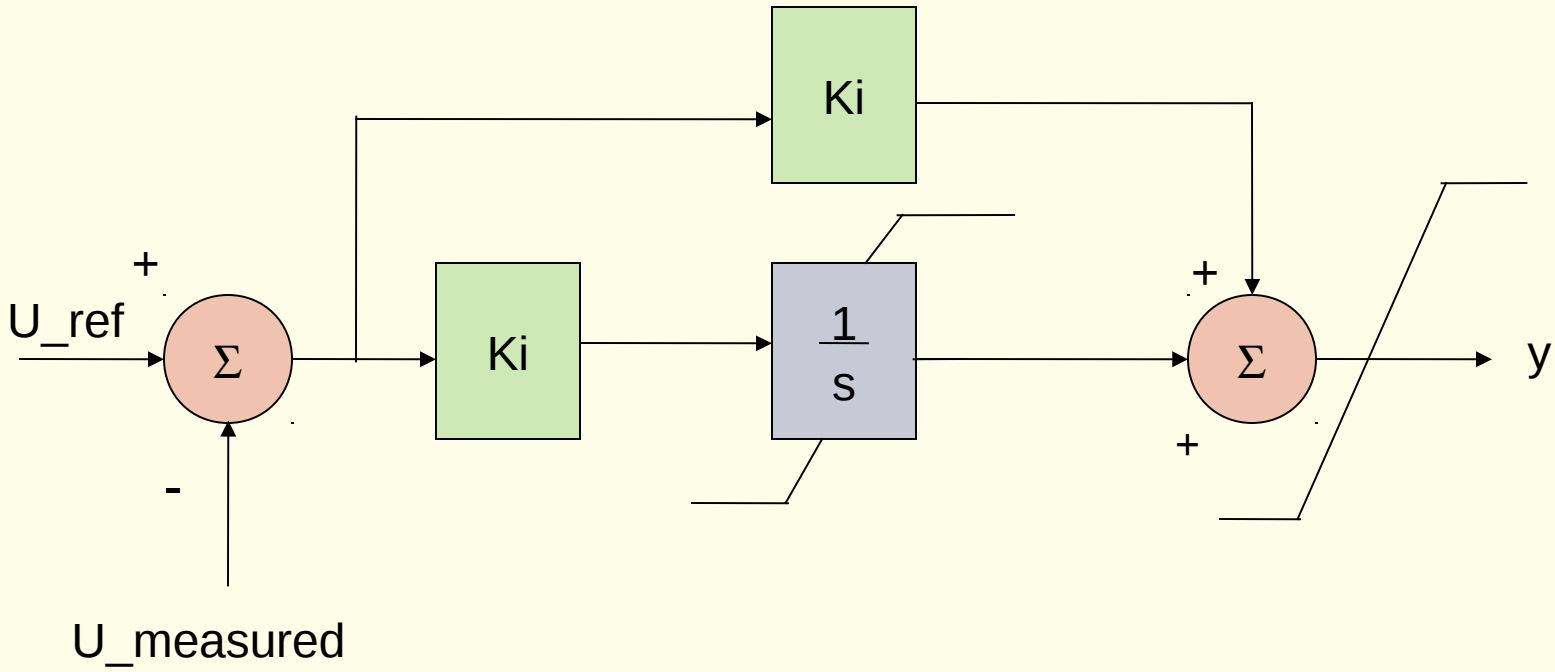
Understanding Transfer Functions

P-I Regulator



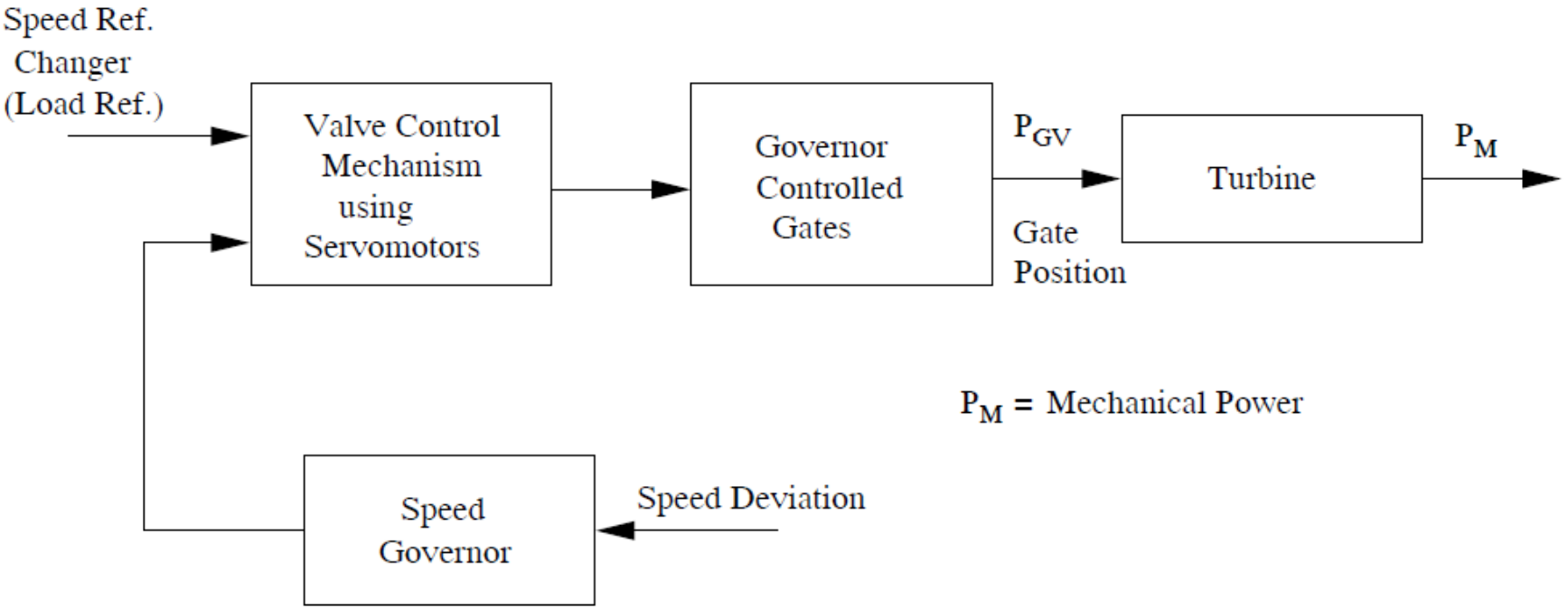
Steady State Error ?

Limiters

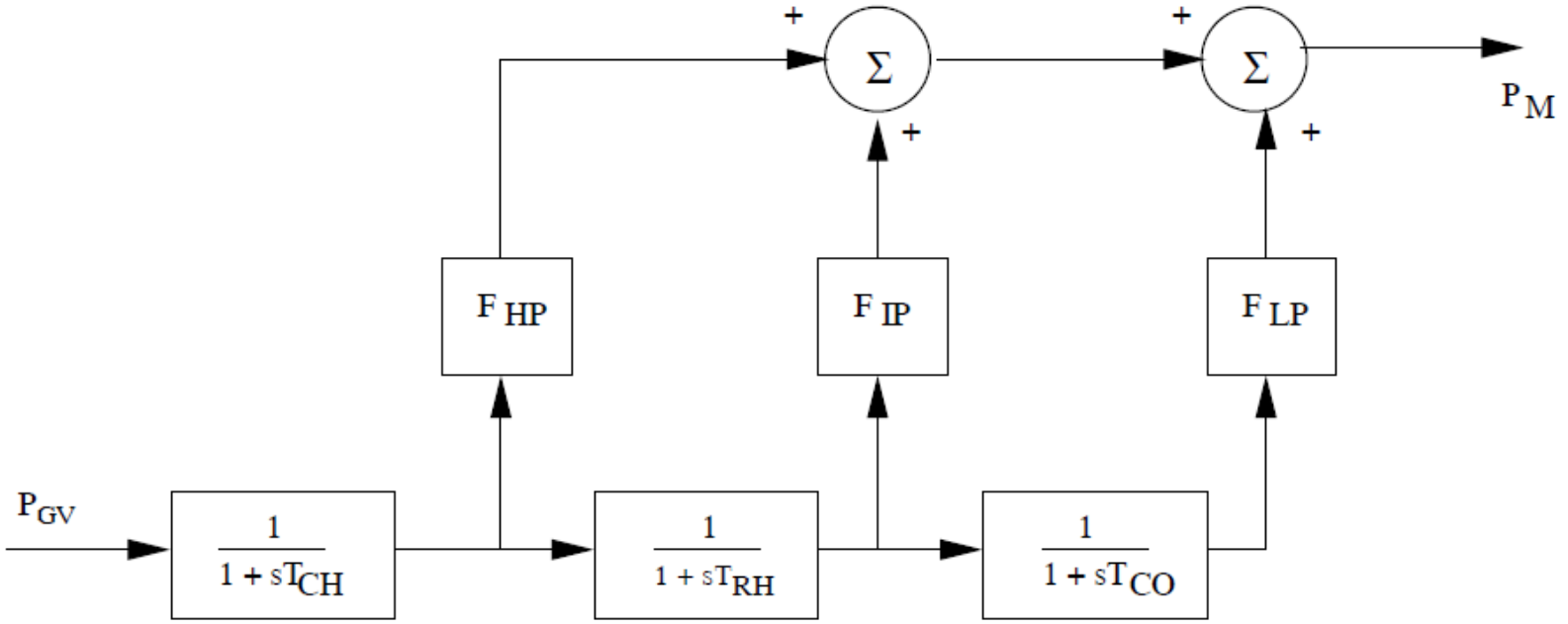


Hard and Soft limiters

Mechanical System

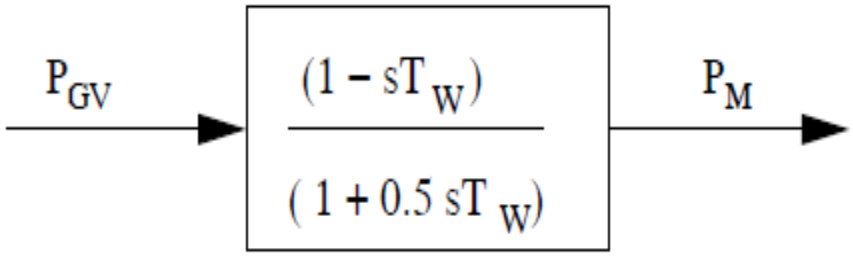


Tandem Compound Single Reheat (Steam Turbine)



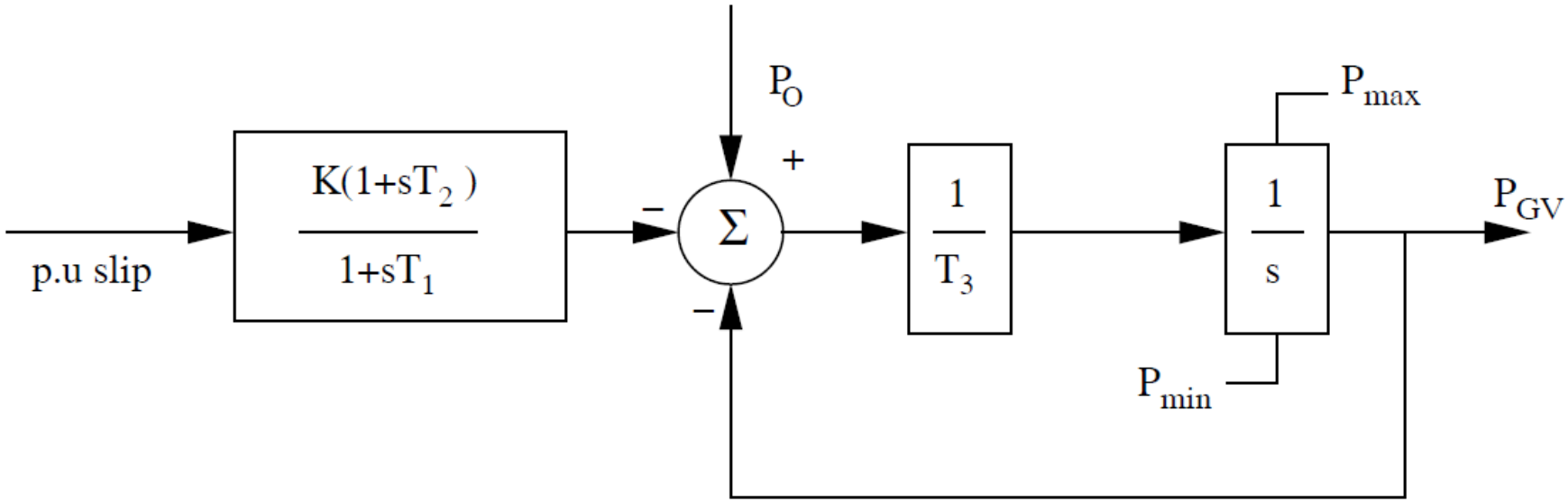
$T_{CH} = 0.1\text{-}0.4$ s	$T_{RH} = 4\text{-}11$ s	$T_{CO} = 0.3\text{-}0.5$ s
$F_{HP} = 0.3$	$F_{IP} = 0.3$	$F_{LP} = 0.4$

Hydraulic Turbine Model



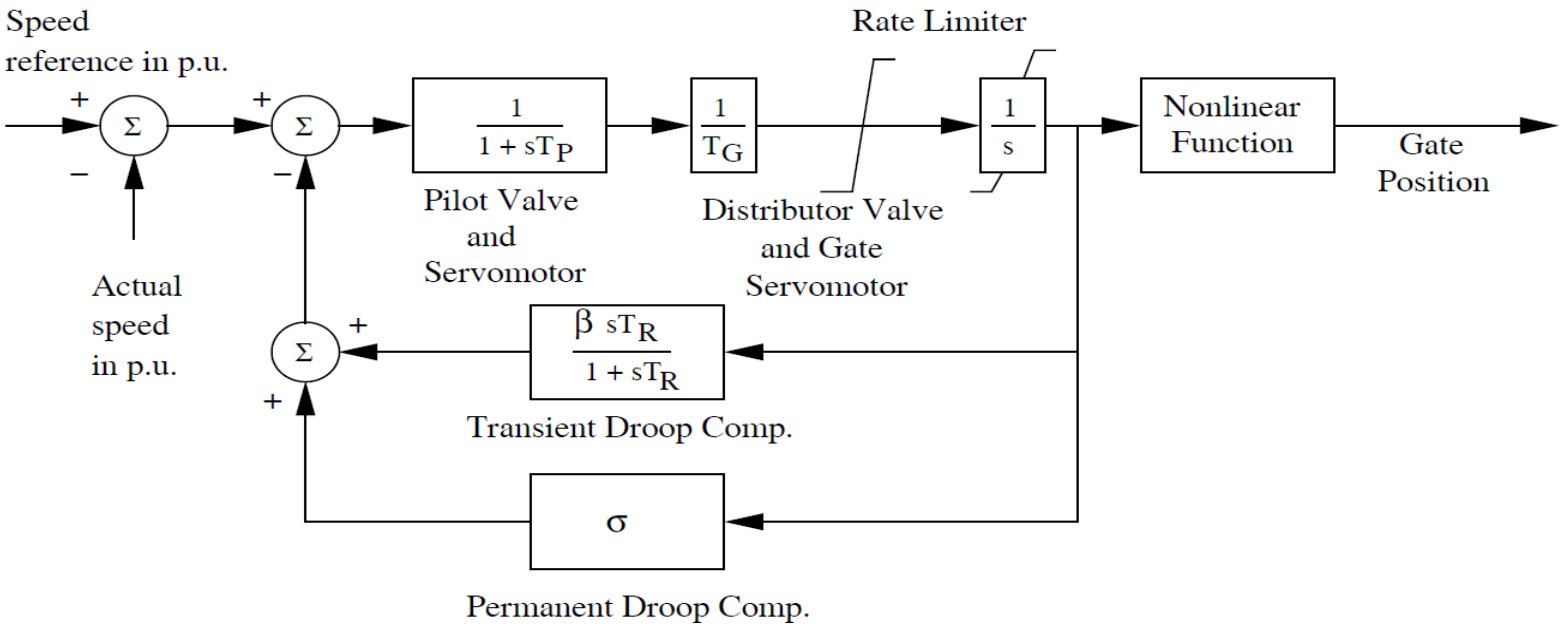
0.5 to 5 s

Governor Model (General Purpose) for Steam Turbines



$T_1 = 0.2$ s	$T_2 = 0$	$T_3 = 0.1$ s
$P_{max} = 1.1\ P_o$	$P_{min} = 0.1\ P_o$	

Governor (Hydraulic Turbine)



In the above figure, T_R and β are calculated as

$$T_R = 5T_W, \qquad \beta = \frac{1.25T_W}{H}$$

where

T_W = water time constant.

H = inertia constant of a machine.

$T_W = 1.0$ s	$T_G = 0.2$ s	$T_2 = 0$
$\sigma = 0.05$		

Typical values of parameters for speed-governor of hydro turbines.