BIRZEIT UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY

PROTECTION AND AUTOMATION IN ELECTRICAL POWER SYSTEMS

POWER SYSTEM CONTROL

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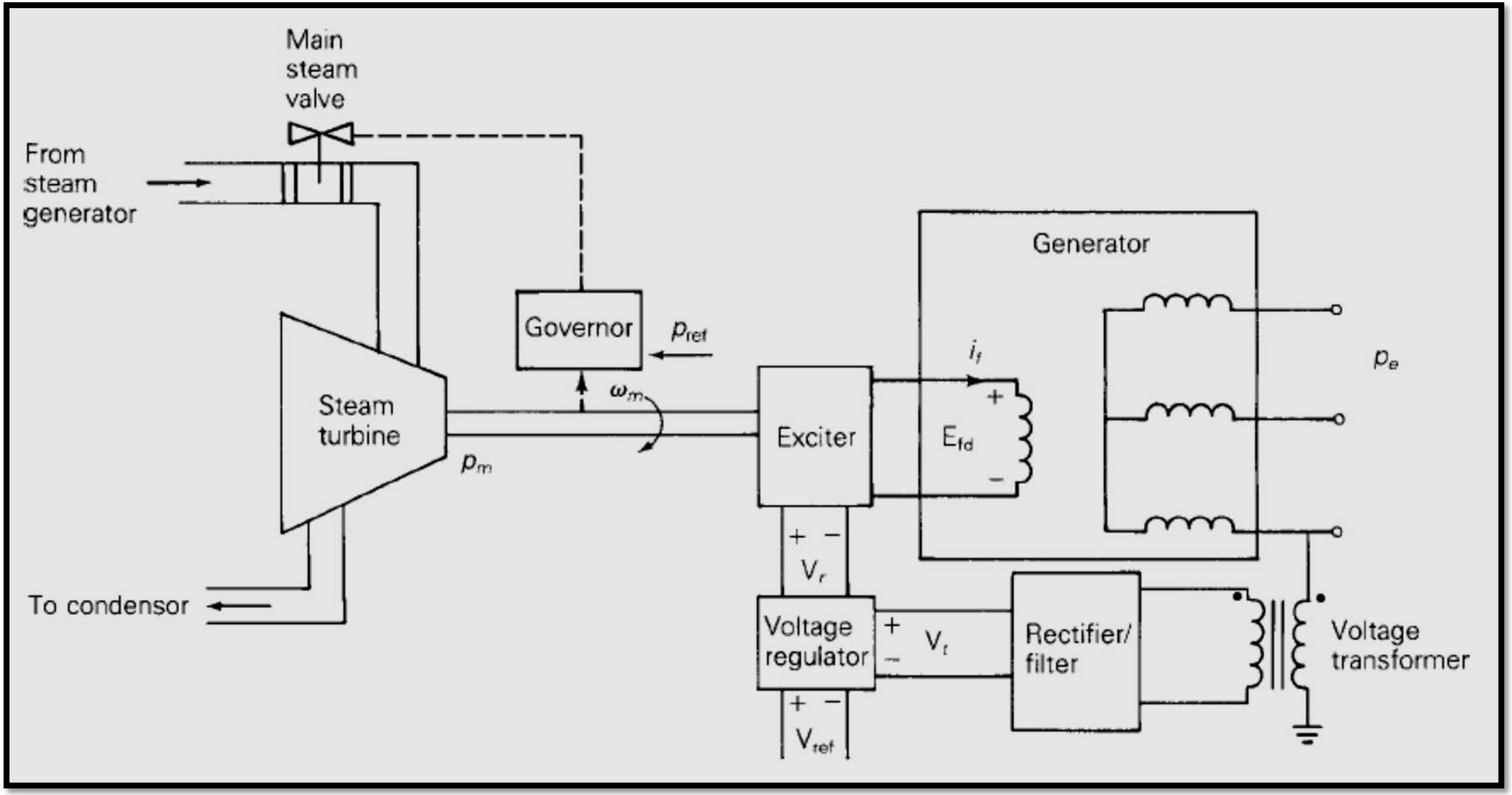
Voltage regulator and turbine-governor controls for a steam-turbine generator

The next figure shows two basic controls of a steam turbine-generator: the voltage regulator and turbine-governor. The voltage regulator adjusts the power output of the generator exciter in order to control the magnitude of generator terminal voltage V_t. When a reference voltage V_{ref} is raised (or lowered), the output voltage V_r of the regulator increases (or decreases) the exciter voltage E_{fd} applied to the generator field winding, which in turn acts to increase (or decrease) V_t. Also a voltage transformer and rectifier monitor V_t, which is used as a feedback signal in the voltage regulator. If V_t decreases, the voltage regulator increases V_r to increase E_{fd}, which in turn acts to increase V_t.

Voltage regulator and turbine-governor controls for a steam-turbine generator



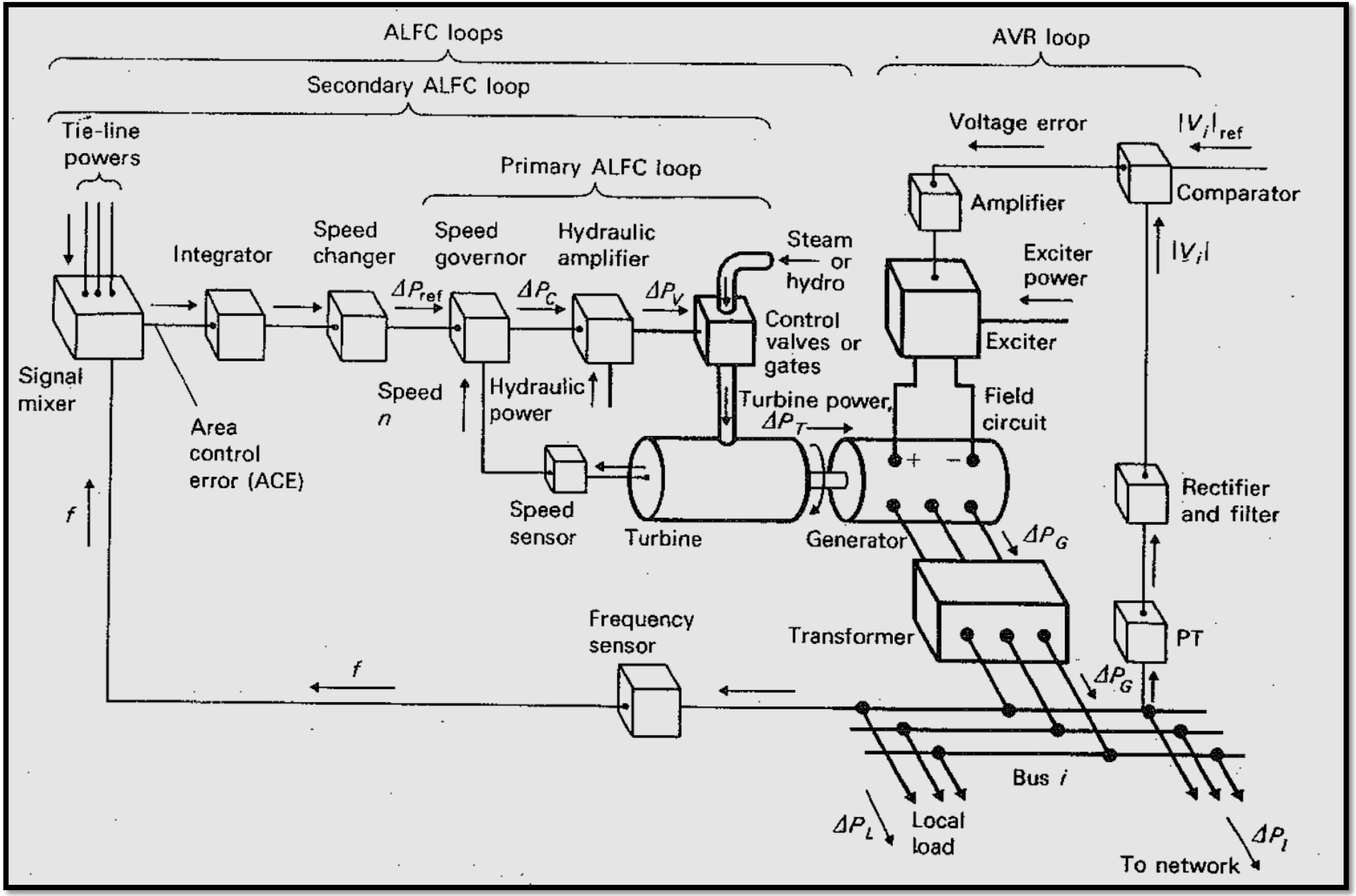
Voltage regulator and turbine-governor controls for a steam-turbine generator

The turbine-governor shown in the previous figure adjusts the steam valve position to control the mechanical power output pm of the turbine. When a reference power level P_{ref} is raised (or lowered), the governor moves the steam valve in the open (or close) direction to increase (or decrease) p_m. The governor also monitors rotor speed ω_m, which is used as a feedback signal to control the balance between pm and the electrical power output p_e of the generator. Neglecting losses, if p_m is greater than p_e, ω_m increases, the governor moves the steam valve in the close direction to reduce pm. Similarly, if p_m is less than p_e, ω_m decreases, the governor moves the valve in the open direction.

Voltage regulator and turbine-governor controls for a steam-turbine generator

- **In addition to voltage regulators at generator buses, equipment is used to control voltage magnitudes at other selected buses. Tap-changing transformers, switched capacitor banks, and static var systems can be automatically regulated for rapid voltage control.**

- **Central controls also play an important role in modern power systems. Today's systems are composed of interconnected areas, where each area has its own control center. There are many advantages to interconnections. For example, interconnected areas can share their reserve power to handle anticipated load peaks and unanticipated generator outages. Interconnected areas can also tolerate larger load changes with smaller frequency deviations than an isolated area.**



ALFC loops
AVR loop
Secondary ALFC loop
Tie-line powers
Primary ALFC loop
Voltage error
$|V_i|_{ref}$
Comparator
Amplifier
Signal mixer
Integrator
Speed changer
Speed governor
Hydraulic amplifier
Steam or hydro
Exciter power
Exciter
$|V_i|$
ΔP_{ref}
ΔP_C
ΔP_V
Control valves or gates
Area control error (ACE)
Speed n
Hydraulic power
Turbine power, ΔP_T
Field circuit
Speed sensor
Turbine
Generator
Rectifier and filter
ΔP_G
f
Transformer
PT
Frequency sensor
Bus i
ΔP_L
Local load
ΔP_i
To network