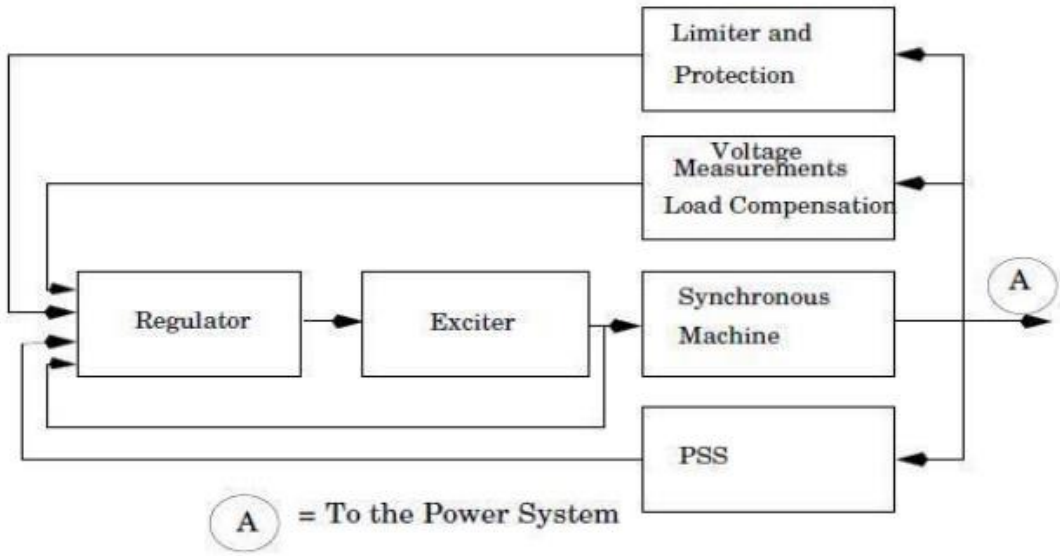
EXCITATION SYSTEMS REQUIREMENTS

- Meet specified response criteria.
- Provide limiting and protective functions are required to prevent damage to itself, the generator, and other equipment.
- Meet specified requirements for operating flexibility
- Meet the desired reliability and availability, by incorporating the necessary level of redundancy and internal fault detection and isolation capability.

1. **ELEMENTS OF EXCITATION SYSTEM**



Schematic picture of a synchronous machine with excitation system with several control, protection, and supervisory functions

Exciter*:*

- provides dc power to the synchronous machine field winding constituting the power stage of the excitation system.

Regulator:

- Process and amplifies input control signals to a level and form appropriate for control of the exciter.
- This includes both regulating and excitation system stabilizing function.

Terminal voltage transducer and load compensator:

- Senses generator terminal voltage, rectifier and filters it to dc quantity, and compares it with a reference which represents the desired terminal voltage.

Power system stabilizer:

- provides an additional input signal to the regulator to damp power system oscillation.

Limiters and protective circuits:

- These include a wide array of control and protective function which ensure that the capability limits of the exciter and synchronous generator are not exceeded.

TYPES OF EXCITATION SYSTEM

Today, a large number of different types of exciter systems are used. Three main types can be distinguished:

DC excitation system,

- where the exciter is a DC generator, often on the same axis as the rotor of the synchronous machine.

AC excitation system,

where the exciter is an AC machine with rectifier.

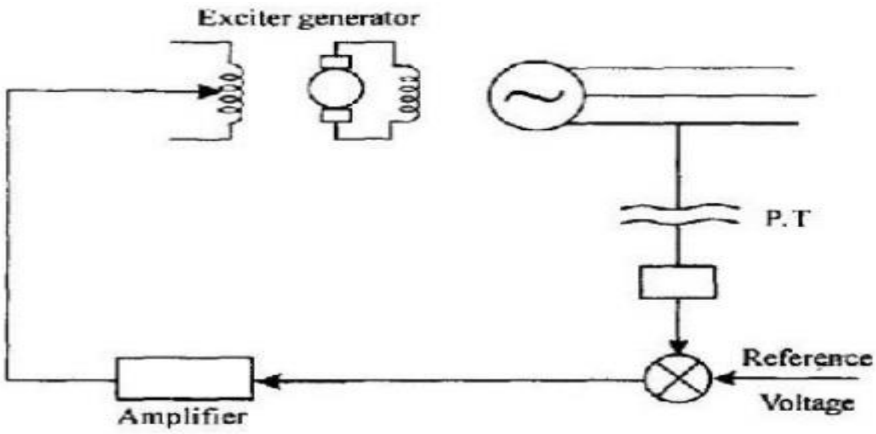
Static excitation system

- where the exciting current is fed from a controlled rectifier that gets its power either directly from the generator terminals or from the power plant"s auxiliary power system, normally containing batteries.
- In the latter case, the synchronous machine can be started against an unenergised net, "black start". The batteries are usually charged from the net.

Block Schematic of Excitation Control:

➢ A typical excitation control system is shown in Fig.

➢ The terminal voltage of the alternator is sampled, rectified and com pared with a reference voltage; the difference is amplified and fed back to the exciter field winding to change the excitation current.

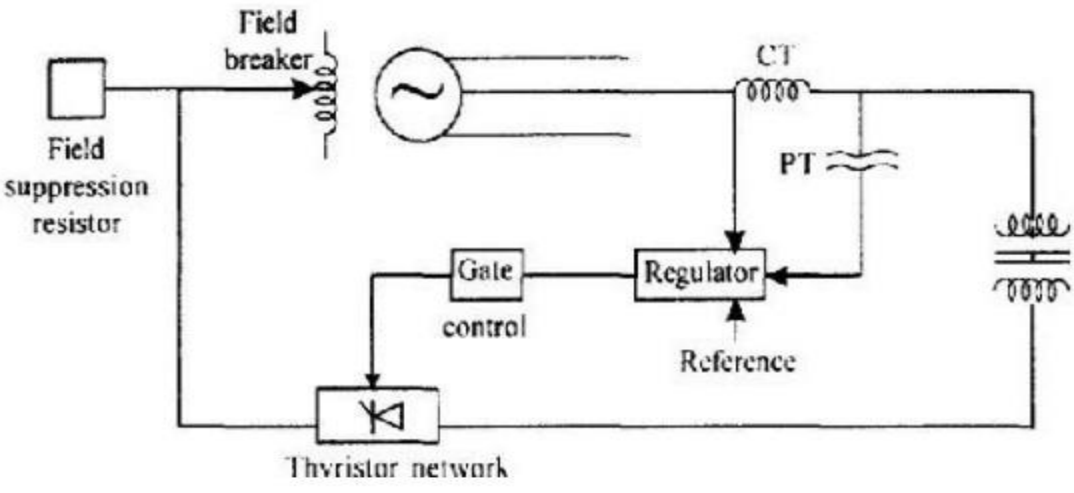


Block Diagram of excitation system

1. STATIC EXCITATION SYSTEM

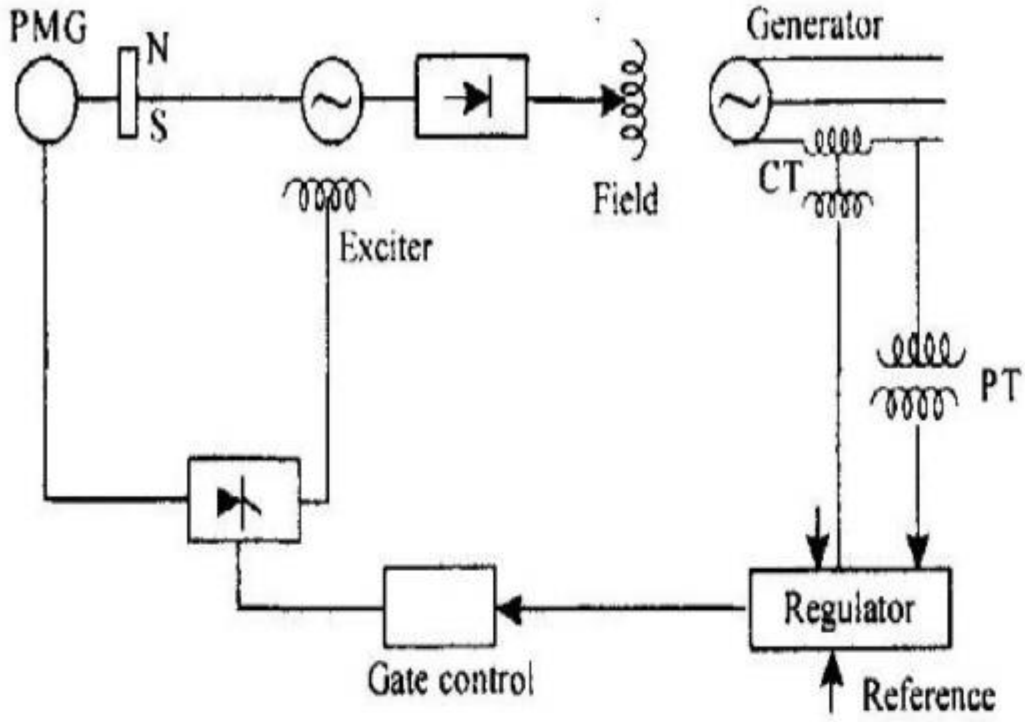
- In the static excitation system, the generator field is fed from a thyristor network shown in Fig.
- It is just sufficient to adjust the thyristor firing angle to vary the excitation level.
- A major advantage of such a system is that, when required the field voltage can be varied through a full range of positive to negative values very rapidly with the ultimate benefit of generator Voltage regulation during transient disturbances.

- The thyristor network consists of either 3-phase fully controlled or semi controlled bridge rectifiers.
- Field suppression resistor dissipates Energy in the field circuit while the field breaker ensures field isolation during generator faults.



Static Excitation System

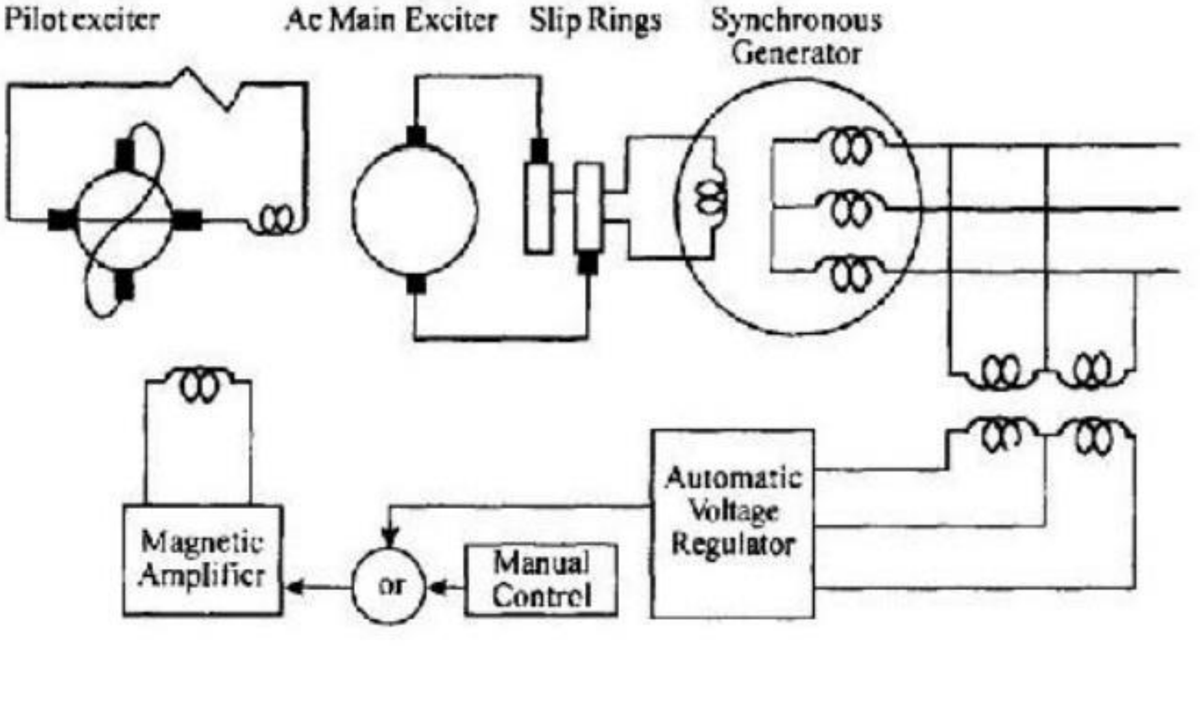
- **2. BRUSHLESS EXCITATION SCHEME**



Brushless Excitation Scheme

➢ In the brushless excitation system of an alternator with rotating armature and stationary field is employed as the main exciter.
➢ Direct voltage for the generator excitation is obtained by rectification through a rotating, semiconductor diode network which is mounted on the generator shaft itself.
➢ Thus, the excited armature, the diode network and the generator field are rigidly connected in series.
➢ The advantage of this method of excitation is that the moving contacts such as slip rings and brushes are completely eliminated thus offering smooth and maintenance-free operation.
➢ A permanent-magnet generator serves as the power source for the exciter field.
➢ The output of the permanent magnet generator is rectified with thyristor network and is applied to the exciter field.
➢ The voltage regulator measures the output or terminal voltage, compares it with a set reference and utilizes the error signal, if any, to control the gate pulses of the thyristor network.

3. AC EXCITATION SYSTEM



Ac Excitation System

Exciter and Voltage Regulator:

The function of an exciter is to increase the excitation current for voltage drop and decrease the same for voltage rise. The voltage change is defined

$$\Delta V \underline{\Delta} (V_1 - V_{ref})$$

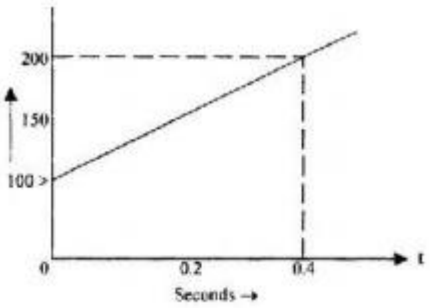
Where V_1 is the terminal voltage and
V_{ref} is the reference voltage.

Exciter ceiling voltage:

- It is defined as the maximum voltage that may be attained by an exciter with specified conditions of load.

Exciter response:

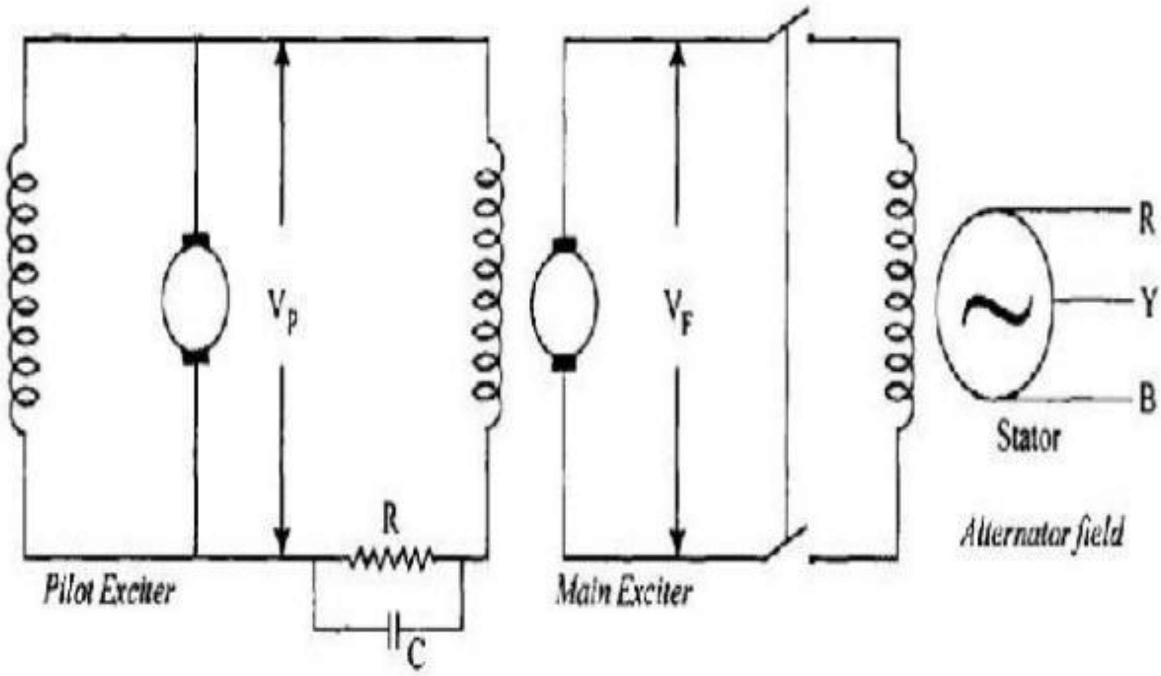
- It is the rate of increase or decrease of the exciter voltage. When a change in this voltage is demanded. As an example consider the response curve shown in Figure.



Exciter Response

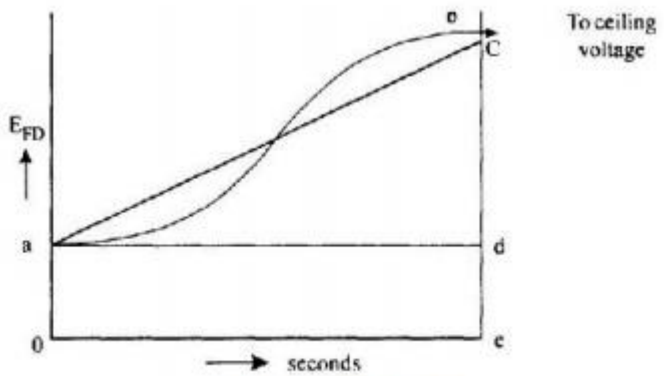
Exciter builds up*:*

- The exciter build up depends upon the field resistance and the charging of its value by cutting or adding.
- The greatest possible control effort is the complete shorting of the field rheostat when maximum current value is reached in the field circuit.
- This can be done by closing the contactor.



AC excitation operations

When the exciter is operated at rated speed at no load, the record of voltage as function of time with a step change that drives the exciter to its ceiling voltage is called the exciter build up curve. Such a response curve is show in Figure.4.14



Response Curve

$$\text{Response ratio} = \frac{Cd}{0a(0.5)}\ \text{p.u. V / sec}$$

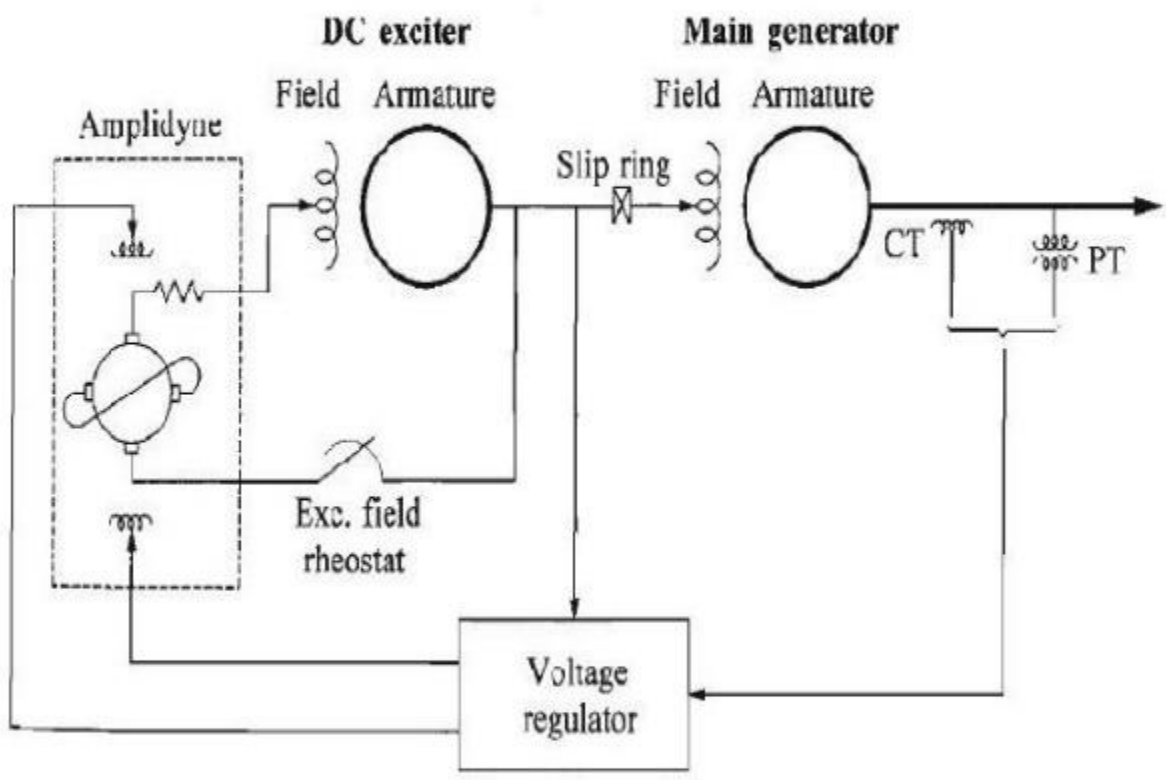
Response ratio	**Conventional Exciter**	**SCR exciter**
0.5	1.25-1.35	1.2
1.0	1.4-1.5	1.2-1.25
1.5	1.55-1.65	1.3-1.4
2.0	1.7-1.8	1.45-1.55
4.0		2.0-2.1

- In general the present day practice is to use 125V excitation up to IOMVA units and 250V systems up to 100MVA units.
- Units generating power beyond IOOMVA have excitation system voltages variedly. Some use 350V and 375V system while some go up to 500V excitation system.

4. DC EXCITATION SYSTEM

- The excitation system of this category utilize dc generator as source of excitation power and provide current to the rotor of the synchronous machine through slip ring.
- The exciter may be driven by a motor or the shaft of the generator. It may be either self excited or separately excited.
- When separately excited, the exciter field is supplied by a pivot exciter comprising a·permanent magnet generator.

➢ Below figure a simplified schematic representation of a typical dc excitation system. It consists of a dc commutator exciter which supplies direct current to the main generator field through slip ring.



DC Excitation System

- ➢ Dc machine having two sets of brush 90 electrical degree apart, one set on its direct
- (d) axis and the other set on its quadrature (q) axis.
- ➢ The control field winding is located on the d axis.
- ➢ A compensating winding in series with the d axis armature current, thereby cancelling negative feedback of the armature reaction.
- ➢ The brushes on the q axis are shorted, and very little control field power is required to produce a large current in the q axis armature.
- ➢ The q axis current is supplied mechanically by the motor.