ADDRESSING ISSUES IN RENEWAL INTEGRATION BY USING SPARE GENERATORS AS SYNCHRONOUS CONDENSER

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BACKGROUND

- India is committed to reduce Green House Gas Emission by 30% in 2030 w. r. t. emission of year 2005.
- It is worth to share that a 4000MW Coal based plant consumes 2500 tons per hour of Oxygen to burn Coal and releases 3500 Tons $CO_{2.}$
- On annual basis this size power plant produces 28 million tons of CO2 and eat up 20 million tons of Oxygen
- A target to add 175GW renewable power generation is set to be achieved by 2022.
- Replacement of average 50GW Coal based power generation by renewable generation will reduce 400 million tons of CO2 emission and save 300 million tons of Oxygen in air.

ISSUES IN RENEWABLE INTEGRATION

- Unpredictable wind pattern and sometimes cloud movement affects generation, Real power generation pattern is inconsistent.

- As the point of connection power is feed to grid through inverter. The conversion of DC output from solar panels is feed to IGBT based inverter, which converts the DC into AC and this output is not a pure sine wave.

- Due to no rotating mass like that in conventional thermal or hydro power plant, renewable generation lacks system inertia.

DIFFERENCE WITH CONVENTIONAL GENERATION

- The conventional turbo generators and hydro power plant generators are designed to give Reactive Power Support grid, which is almost 50-60 percent of its rated capacity, which is not available in Renewable power generation.
- In any electrical network electricity do not travel without reactive power support.
- In renewable power plants, the output of wind or solar power is sent to grid through an inverter and transformer.
- In this arrangement, the reactive support is achieved by external FACTs device.

MEETING VARING REAL POWER DEMAND

The real power is the useful portion of electricity, which travel from generator to the load.

The load demand from the unpredictable renewable output is met

- By augmenting variable renewable power generation by battery back up, pump storage hydro power plant or flexible operation of thermal plants.
- The Gas based fast response alternatives can also meet the load while operating in conjunction with short time battery back up.

UNDERSTANDING REACTIVE POWER

- Reactive power is that portion of electricity, which makes the electricity flow from generator to load point.
- Reactive Power is generated by synchronous machines and Capacitors.
- Machines with high Short Circuit Ratio contribute more in Reactive power support.
- Reactive power is consumed by transformers and motors.
- Reactive power is also consumed in transporting electricity.
- Therefore, Reactive Power generated and consumed only by electrical equipment. Its origin and end both are in the electrical system.

REACTIVE COMPENSATION REQUIREMENT FOR RENEWABLES

- Real power cannot travel in absence of reactive power. So it is used to transport electricity from generation to load points.
- Reactive power cannot travel more than 100 km from source point and thus to be generated at its point of consumption.
- Solar and Wind based generation do not generate reactive power similar to conventional plants. It is to be produced by adding FACTS devices at renewable generation point.
- Proposed Synchronous Condenser based solution overall have superior performance w. r. t. static compensators (STATCOM).

Synchronous Condenser

PERFORMANCE COMPARISON OF FACTS DEVICES

Sl. No.	Parameter	STATCOM	Synchronous Condenser
1	Short Circuit Current	Poor	Good
2	Overload	Poor	Good
3	Response time	Excellent	Good
4	Inertia	Negligible	Good
5	Handling Transient – fault condition	Excellent	Good
6	Handling Dynamic cond.	Good	Good
7	Efficiency	99.2%	98.5%
8	Harmonic	Present	Nil

Advantages of Synchronous Condenser

- It can very well meet the system Reactive Power demand expected in future as discussed above.
- Excellent to support inertia requirements during changing grid conditions.
- Available up to very large range (e.g. +720MVAR/-360MVAR).
- Low voltage ride through capability during peak condition.
- Fast dynamic compensation.
- Good overload capability.
- Efficiency more than 98%.
- Maintains power quality acts as sink for harmonics originating from static devices.

PROPOSAL cont.....

- This paper suggest use of several spare or retired Synchronous generator machines to maximise the real renewable output into the grid.

- Whereas the STATCOM can only support reactive power, Synchronous Condenser will also enhance the inertia of grid, which could be useful in saving the grid by short duration active support.

- Synchronous Generators can deliver 10MVAR-7000MVAR, by consuming a meagre 200kW to 4000kW excitation power and friction & windage losses.

Why Synchronous Condenser for Wind/ Solar generation

The wind and solar generation has following limitation as they are connected to Grid by Static Frequency Converter:

- Limited Inertia of machine.
- Limited Short Circuit Current.
- Limited Voltage Support.
- Limited Overload capacity.

The Synchronous Condenser performance is much superior meeting above requirements.

Synchronous Condenser – a novel solution

- To achieve 175GW renewable generation, the power will be injected to the grid at several hundred points.
- Variability of generation as well as load will severely affect the transmission and distribution network.
- Each of the renewable generation point of connection distribution network with several loads feed through Variable Frequency Drives and LED lighting, will be introducing harmonics into the network.
- Multipoint reactive power injection using Synchronous Condenser could be the best possible alternative for overall quality improvement of generation, transmission and distribution network.

MVAR Support by 660MW/800MW Machine

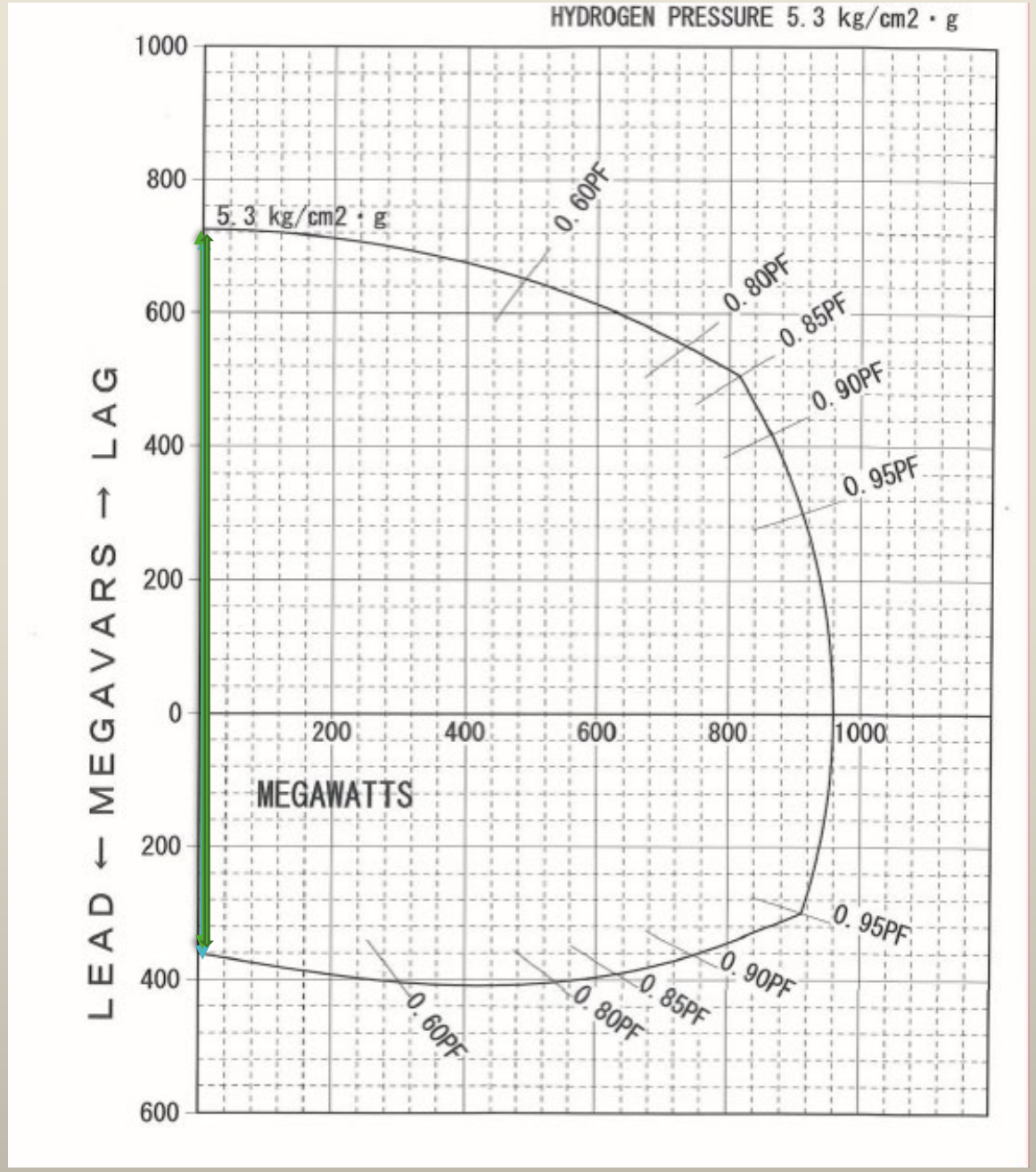
- The 960MVA (800MW) machine can deliver/ absorb MVAR in range of

  +720 to -360 MVAR

- The 776MVA (660MW) machine can deliver/ absorb MVAR in range of

  +600 to – 300 MVAR

THE MACHINE CAN DELIVER DOUBLE MVAR AS COMPARE TO WHAT IT ABSORBS

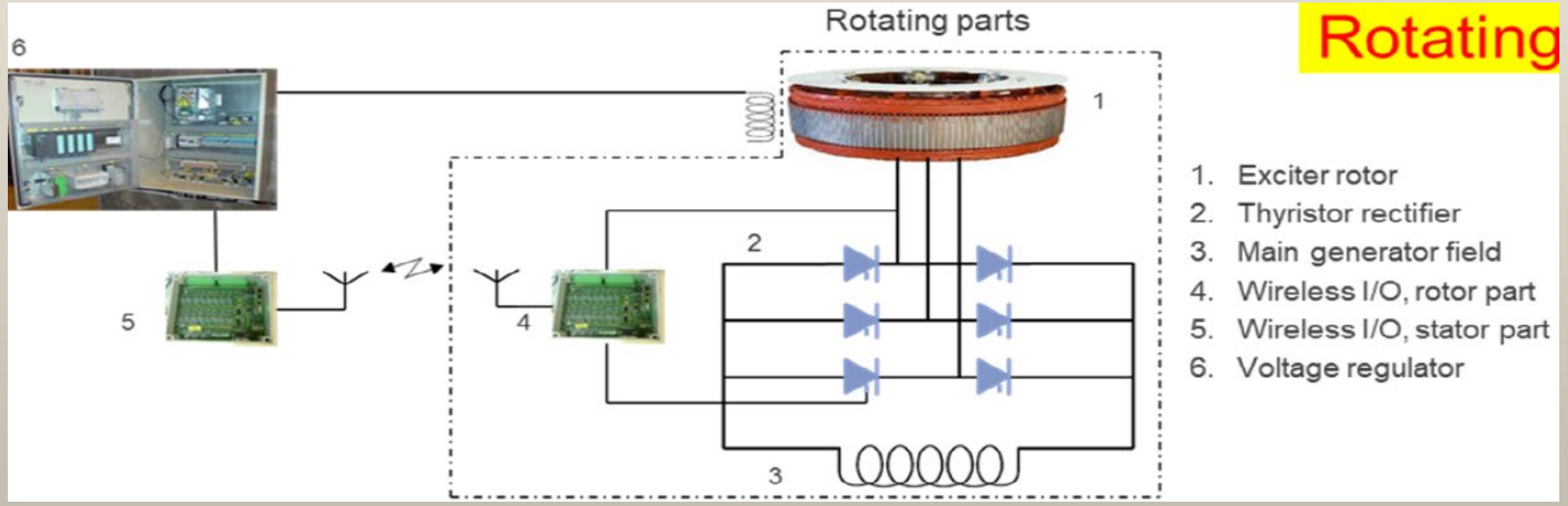

HYDROGEN PRESSURE 5.3 kg/cm2 · g
1000
800
600
400
200
0
200
400
600
800
1000
5.3 kg/cm2 · g
0.60PF
0.80PF
0.85PF
0.90PF
0.95PF
LEAD ← MEGAVARS → LAG
MEGAWATTS
200
400
600
0.95PF
0.90PF
0.85PF
0.80PF
0.60PF

Turbo-Generators need lesser modification

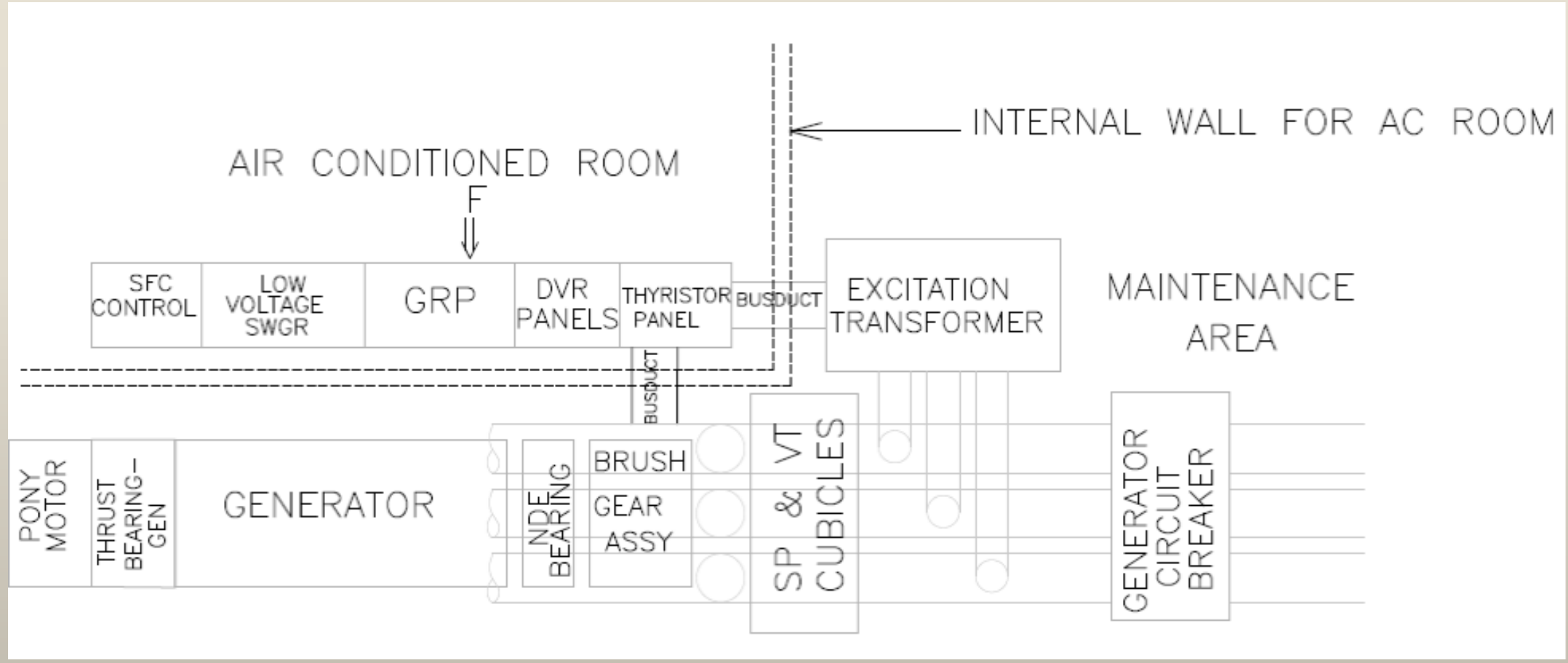
- 500MW/200MW Spare Generator (available due to plant closure) needs to be accessed for healthiness of insulation system by conducting Residual Life Assessment (RLA) study prior to use as Synchronous Condenser.
- The main generator bearing has to be changed to thrust bearing.
- The excitation system is to be static type to meet fast ramp rate requirements. Solutions are available to make Brushless exciter a fast response type.
- The drive motor coupled to synchronous condenser will be fed from VFD.

Fast Response Brushless Exciter - FRBE

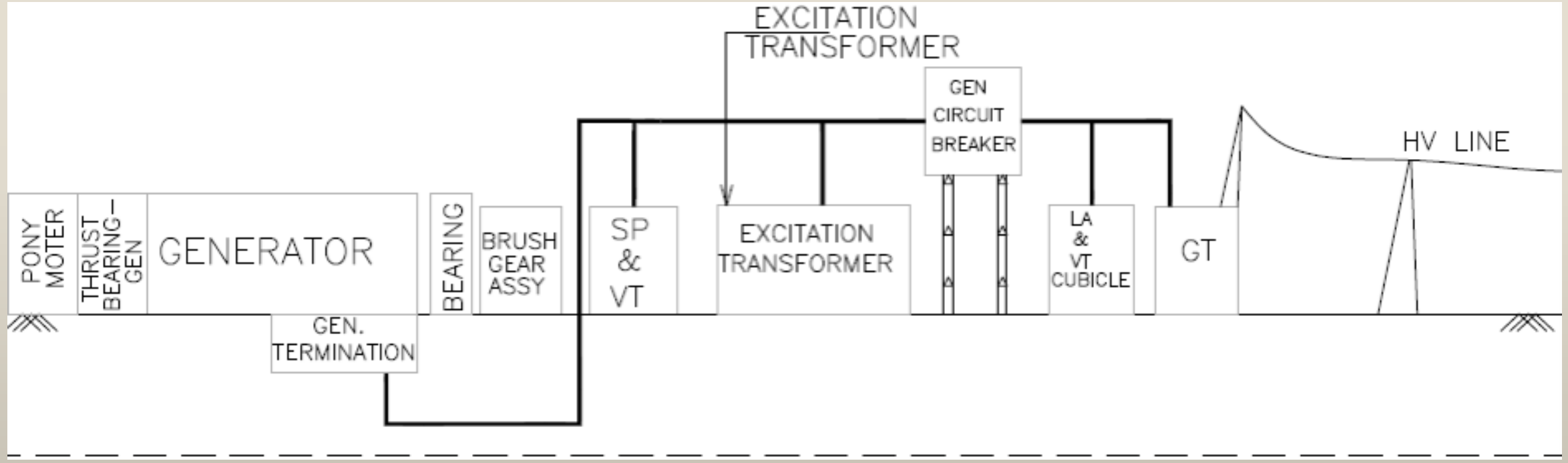
- The solution for modifying existing brushless exciters have been develop to cater new grid code requirement of fast response of machines. They replace rotating diode wheel by thyristor.



Synchronous Condenser Building – Equipment Layout



Synchronous Condenser Building Equipments



THANKS