Static VAR compensator for Windmill.

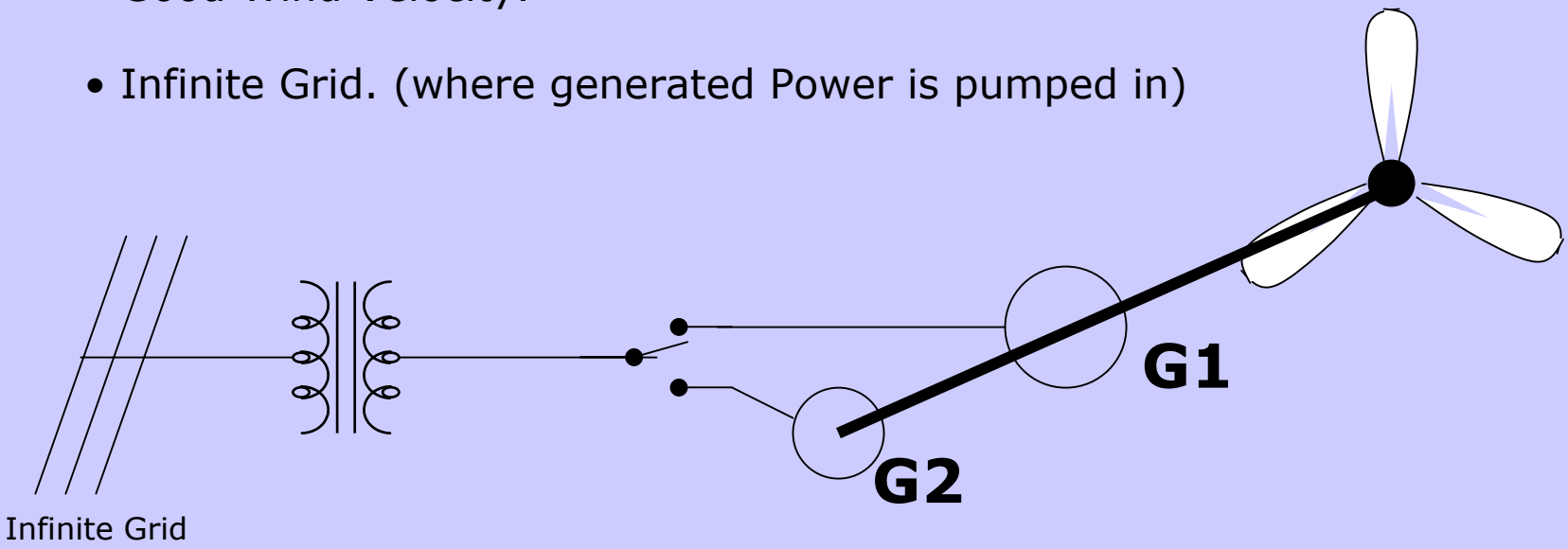
Tushar Mogre

Windmill Power Generation Schemes:

- By use of Induction Generators.
- By use of Line commutated inverters. (Thyristorised)

Basic Generation Requirements:

- Good Wind Velocity.
- Infinite Grid. (where generated Power is pumped in)



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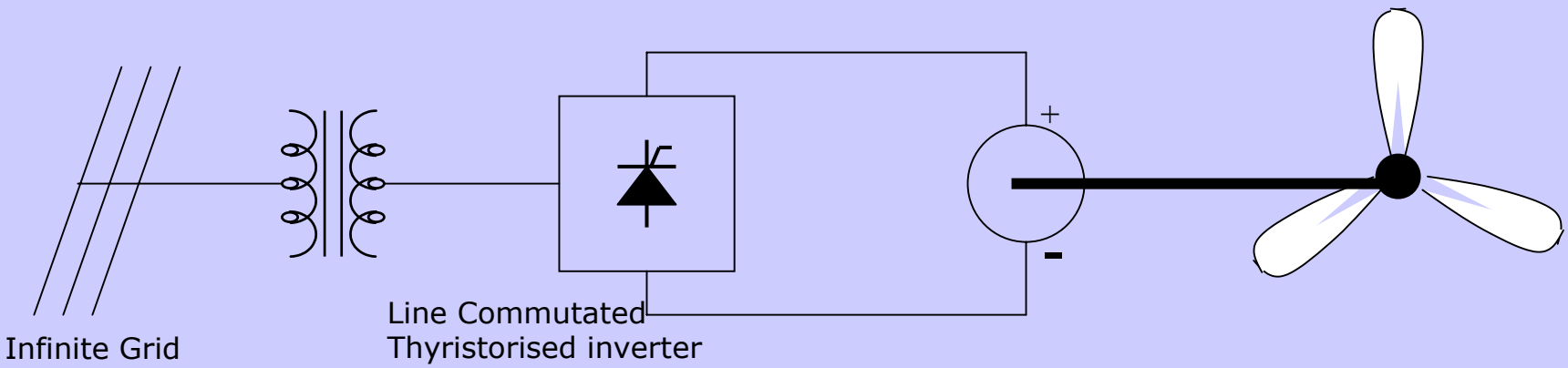
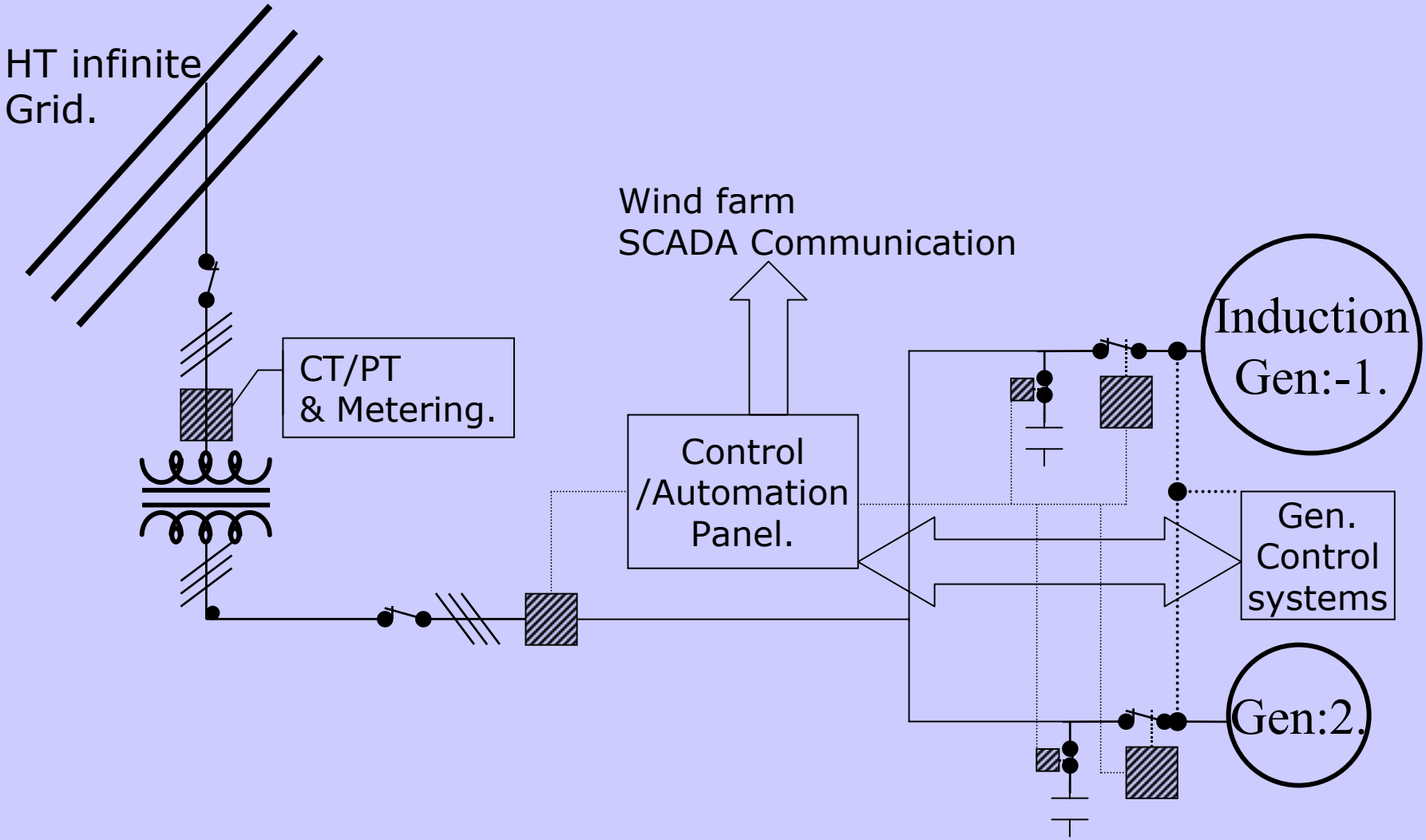


Basic Scheme of a windmill. (With Induction Generators)



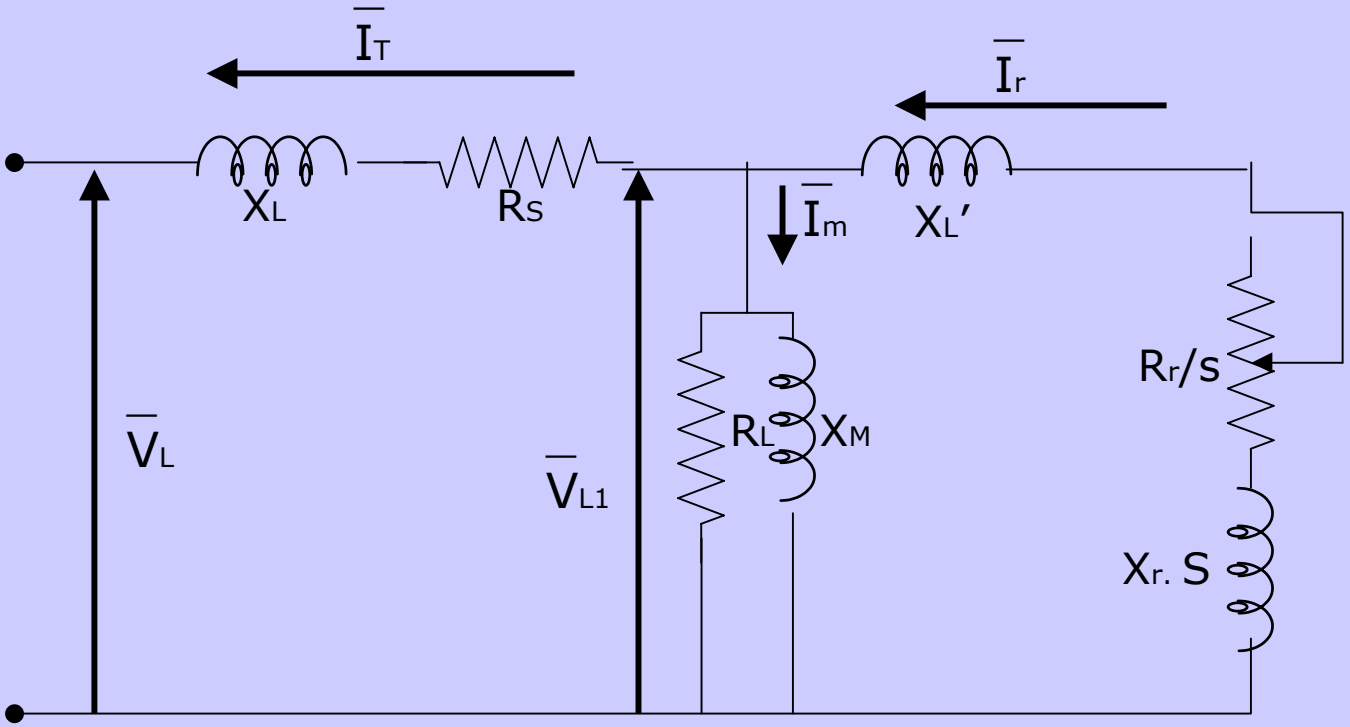
Here the generators that are used are Induction Machines.

When Induction Machines are made to run more than the synchronous speeds, they start acting like generators, this is the principle used for generating.

But while Generating too, the Magnetizing reactance of these machines still takes the inductive current from the grid.

Also the variable slip can generate additional inductive variable component that is reflected on the grid.

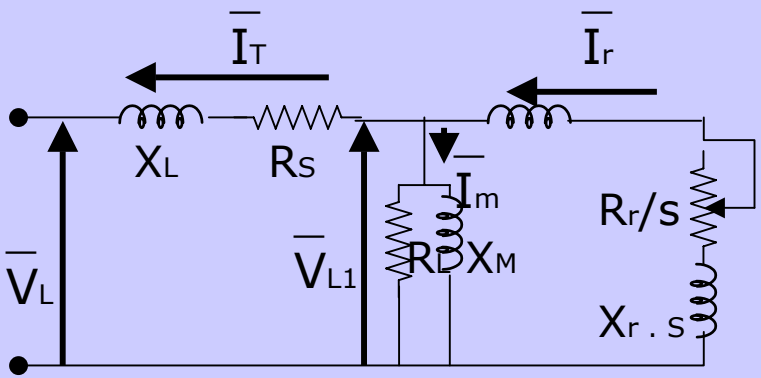
Induction Machine Equivalent Circuit.

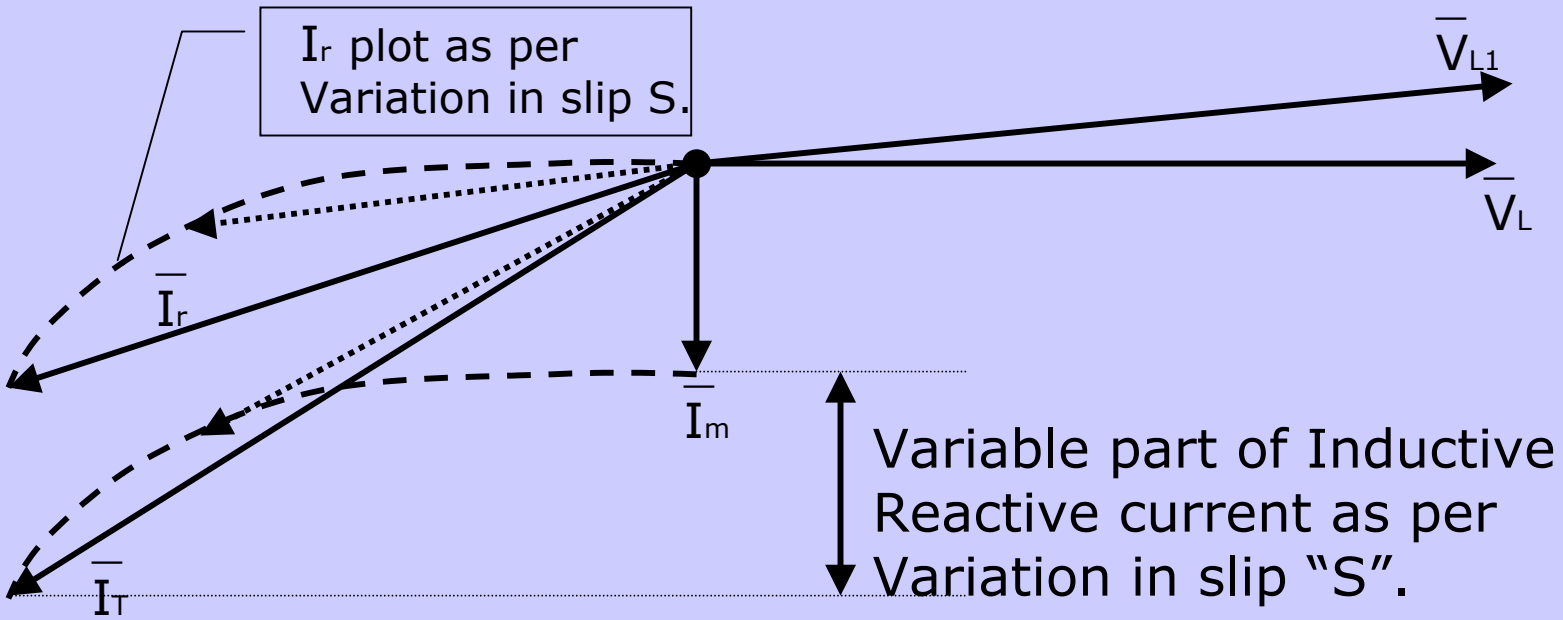


This is per phase equivalent circuit. From this schematic Its clear that:

$$\bar{I}_T = \bar{I}_r - \bar{I}_m .$$

Phasor Diagram Representation.



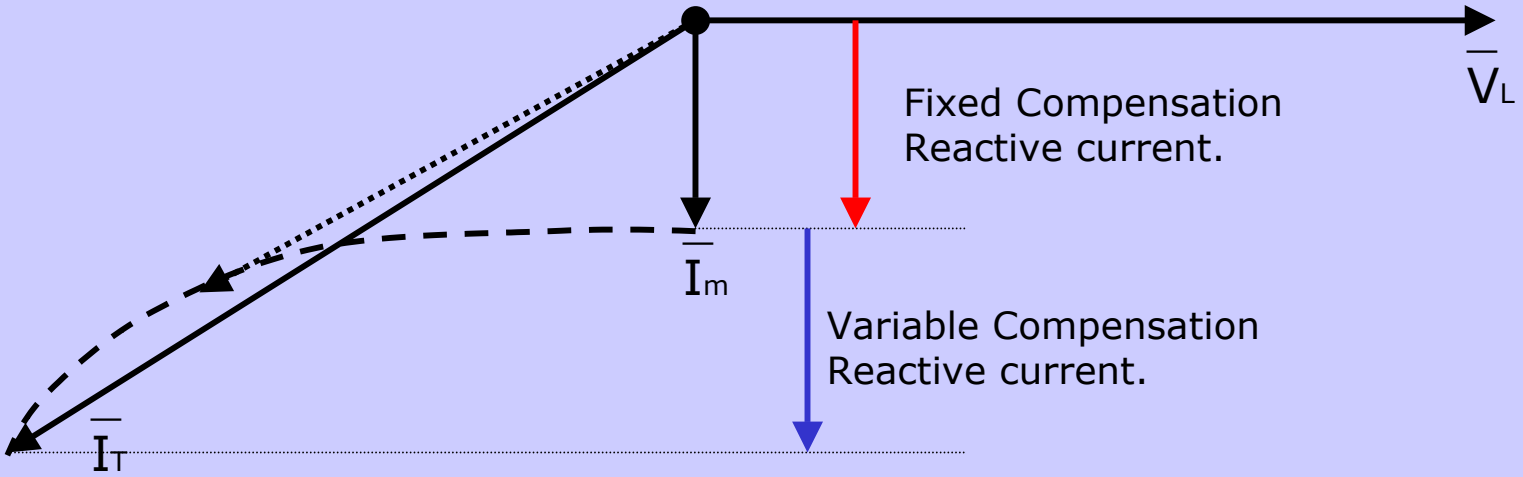


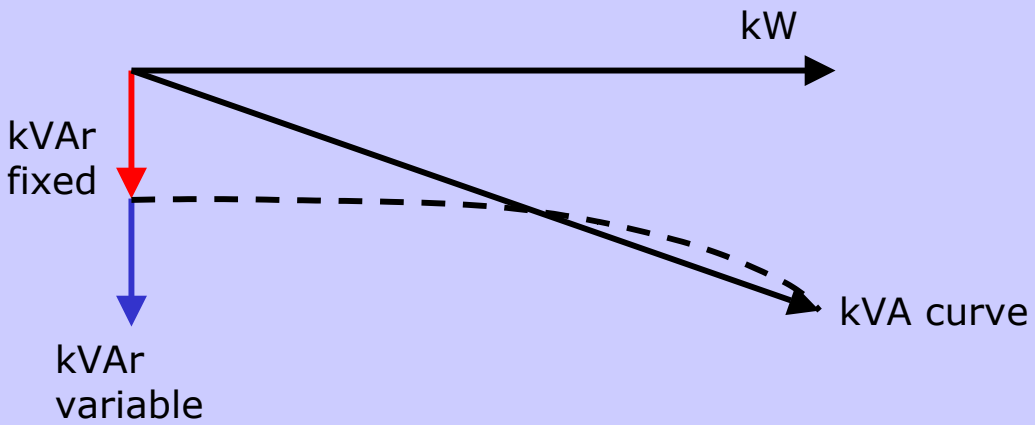
This Phasor presentation shows that

Variation in the slip “S” while generation introduces variable reactive component in the total current pushed on to the grid.

It can also be noted that this variable component varies quite rapidly with the variation in slip when Induction Generator is loaded almost near full load.

Now in case of windmill application, the slip varies as per wind velocity which is normally a continuously variable parameter.



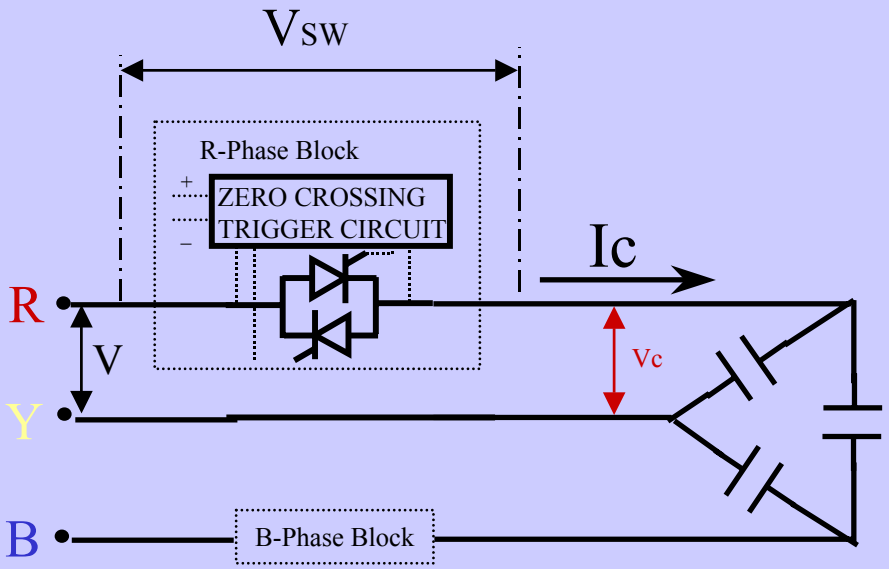


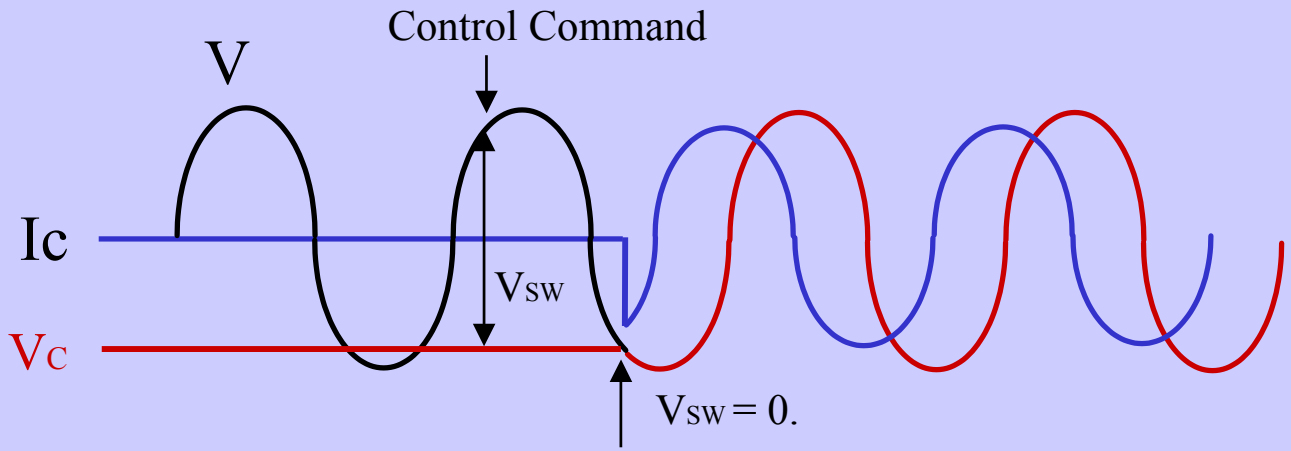
This shows that to keep the reactive component to minimum level while windmill is generating, Variable capacitor needs to be introduced in the mains network.

This too, should be done by continuously monitoring the instantaneous loading parameters on the Generator and then instantaneously adjusting the parameters values.

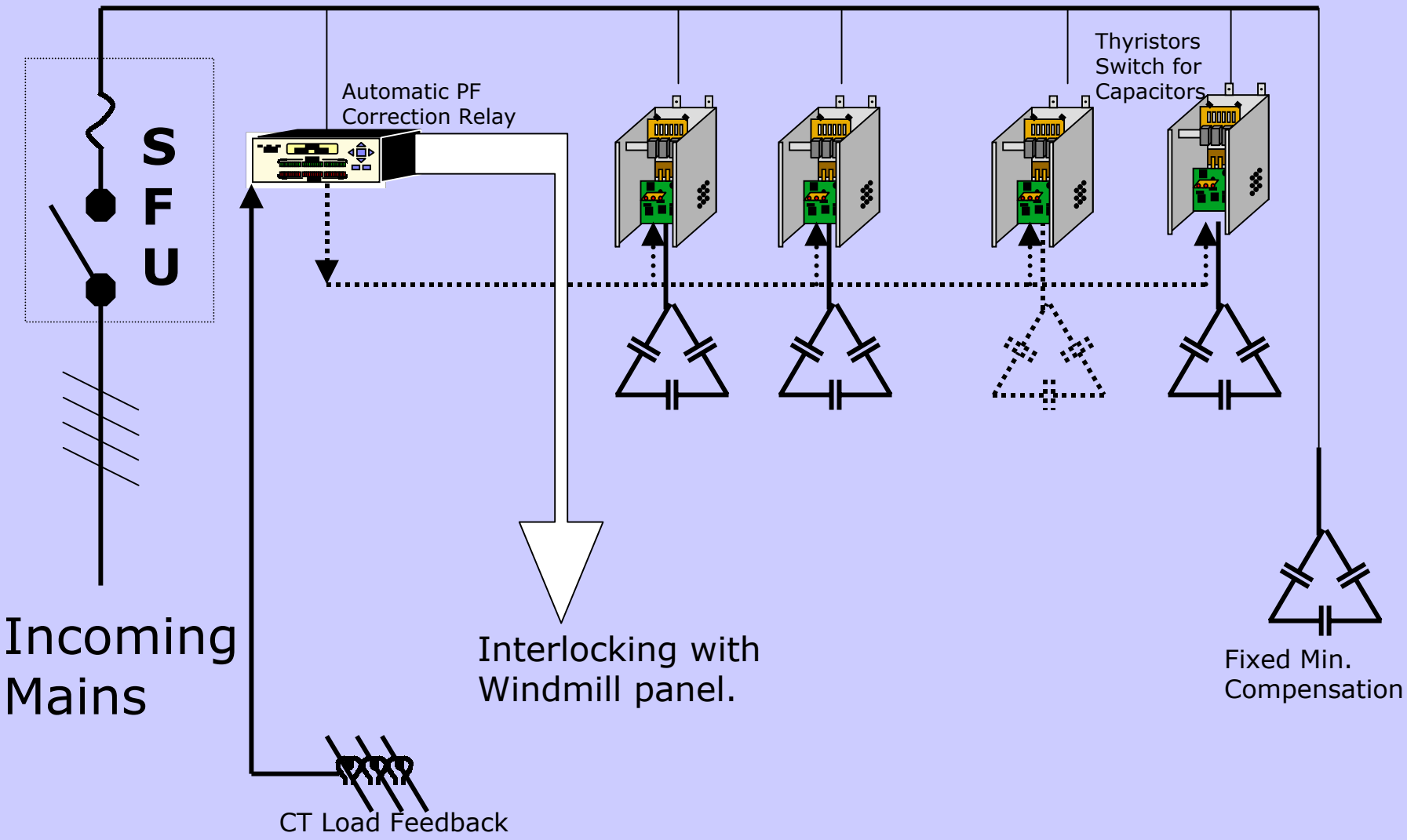
This is possible by high speed thyristorised capacitor switching system.
Or
By use of PWM inverter, the method recently developed, popularly known as “Stat-Con”.

High Speed thyristorised Switching system.

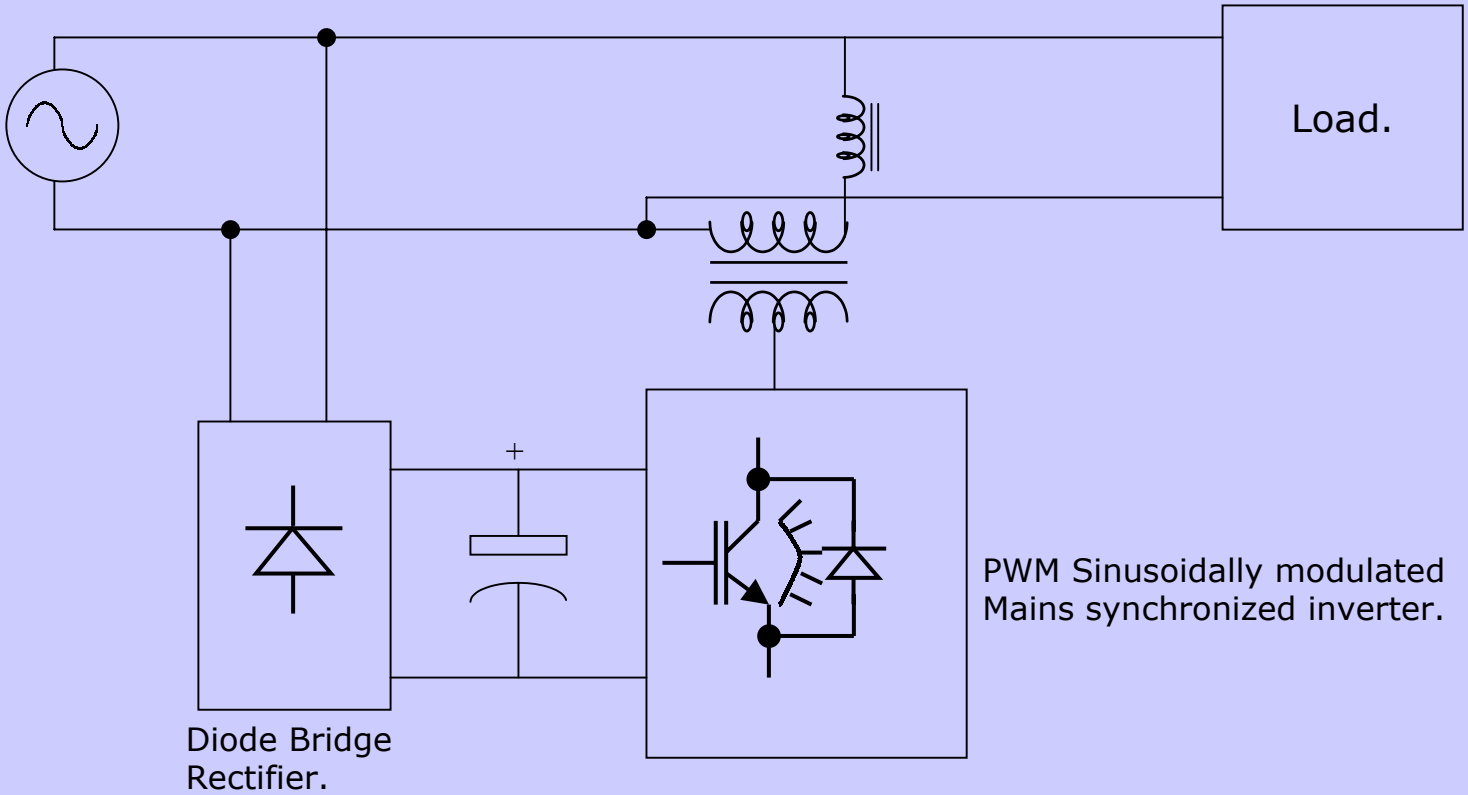


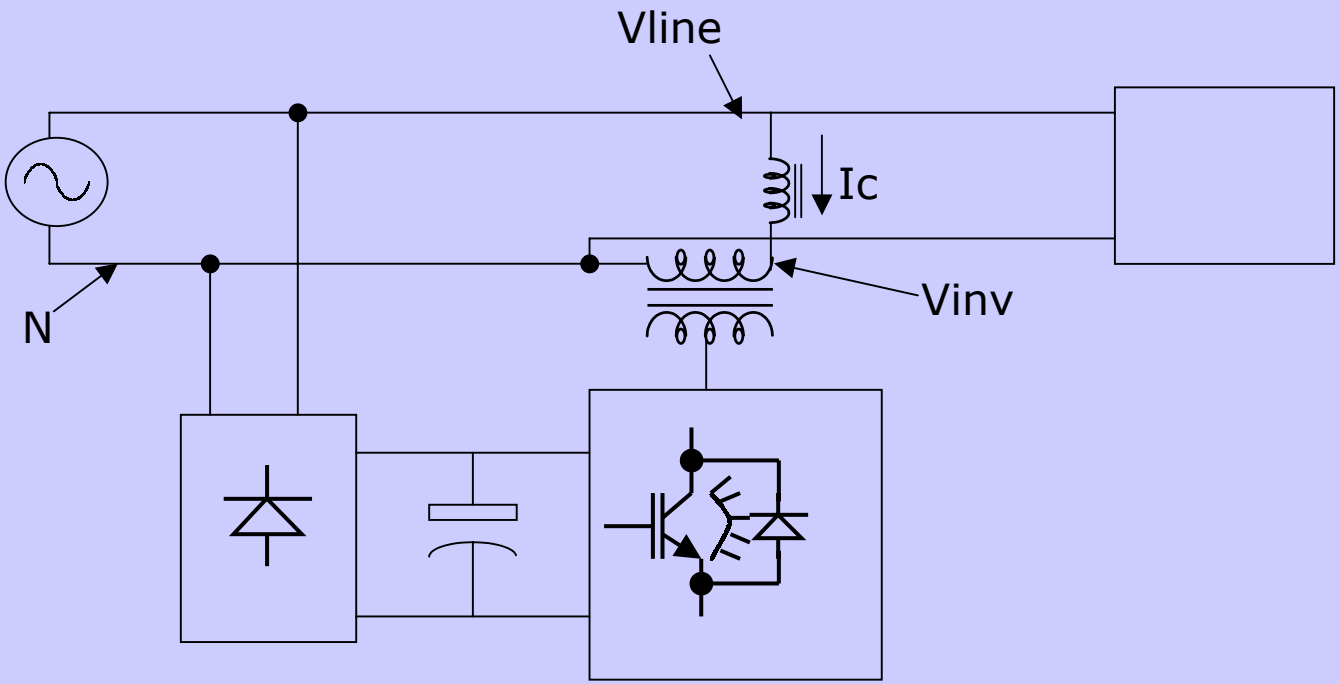


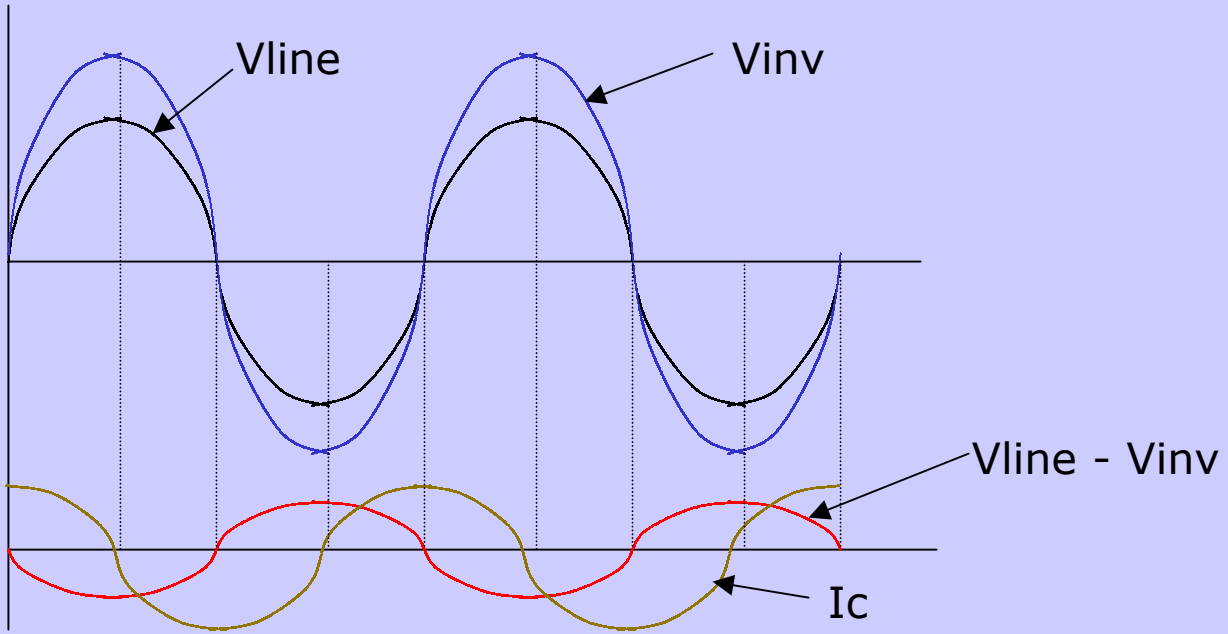
Thyristorised APFC panel Schematic.



PWM Inverter compensation.
Stat-Con.







Specifications Mandatory for APFC panel with Windmill Application.

- Response time better than or equal to 60mS. for full compensation (making PF ≈ 1.00). The time includes the APFC relay response time + switching devices time delay.
- APFC relay should be able to monitor the energy related parameters in all the four quadrants.
- There should be provision for at least three auxiliary inputs and three auxiliary outputs on the relay for the purpose of interlocking with the Windmill automation panel.
- Panel should be sufficiently protected against grid reflected harmonic currents. This can be done by use of detuned capacitors.
- For the transformer inductive no-load currents, sufficient minimum compensation thro' fixed capacitors should be provided.
- The capacitors in the Windmill panel should be modified to suit the minimum Generator inductive compensation.

The Proposed APFC scheme should:

•Maintain the PF = 1.000 ($\pm$ 0.001) at full loading of the generator.

• Should be able to adjust the capacitors with better than 2.5% resolution in KVAr of Generator rated KVA.

• During low wind period, when smaller Generator is ON, the APFC relay should use another set of load current sensing CTs to achieve the desired resolution and accuracy. Or alternately should use wide range CTs along with better accuracy measurement APFC relay.

• The scheme can be either thyristor switched banks or Statcon, both schemes if designed properly can give the desired results.

• Statcon scheme is not much preferred in this application is because of higher costs as compared to that of thyristorised system.

Thank You.