# NASPI Work Group Virtual Meeting

# Analysis of Low Voltage ride through capability of Photovoltaic solar generation using synchrophasors

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**Rahul Shukla**
Chief Manager, POSOCO
India

# Dimensions of Indian Power System

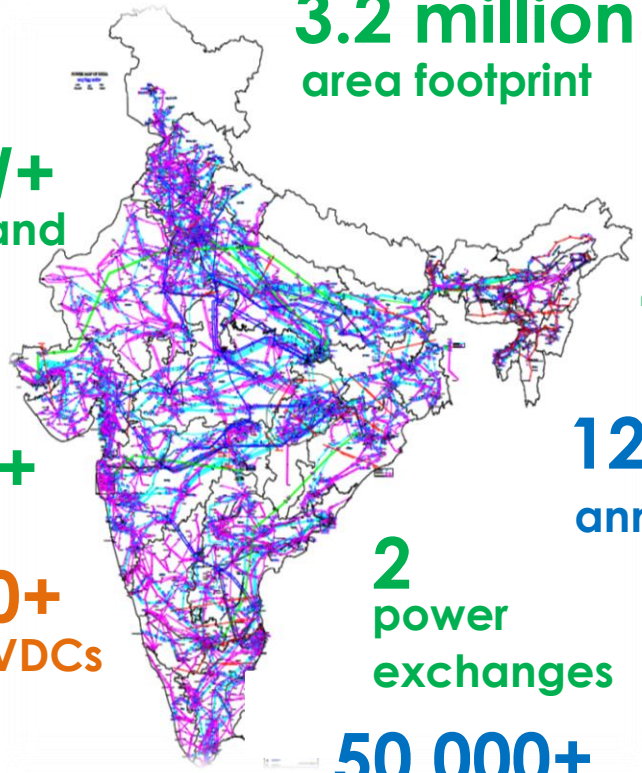
**395 GW+**
generation capacity

**3.2 million km²**
area footprint

**1.3 Billion+**
people served

**200 GW+**
peak demand

**> 4.5 TWh**
daily energy met



**4 GW+**
international exchanges

**425,000 ckm+**
EHV transmission

**120 TWh+**
annual market trades

**~106 GW**
renewables

**10+**
HVDCs

**2**
power exchanges

**6000+**
market participants

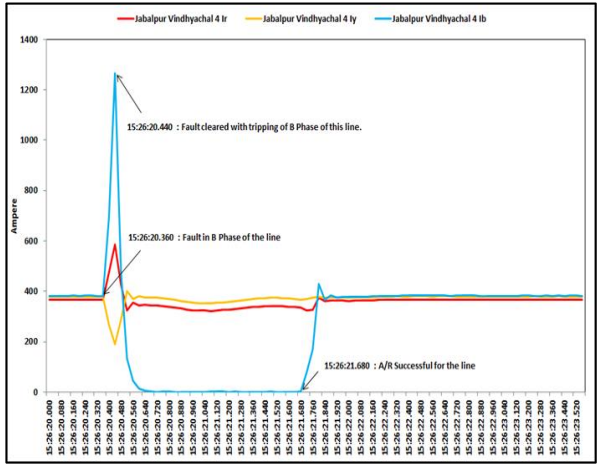
**~ 100 GW**
inter-regional capacity

**50,000+**
market transactions

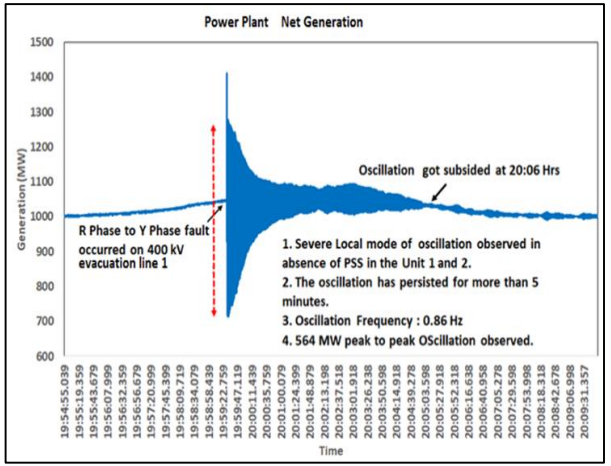
# NASPI Synchrophasors: Real Time Applications

## Monitoring and Alarm

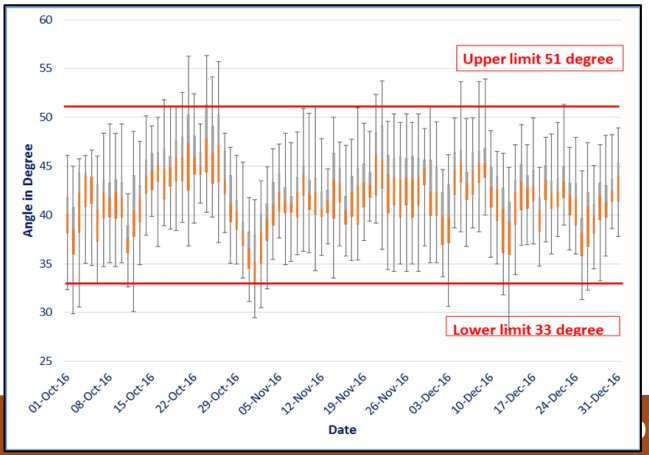

## Event Detection



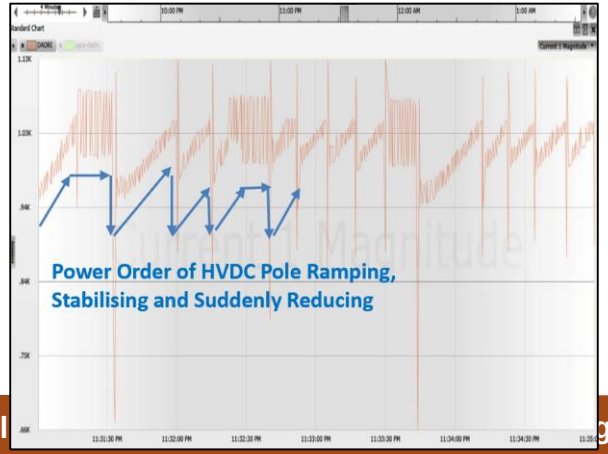

## Low Frequency Oscillation




## Wide Area Angular Separation




## Monitoring of Controlling Devices

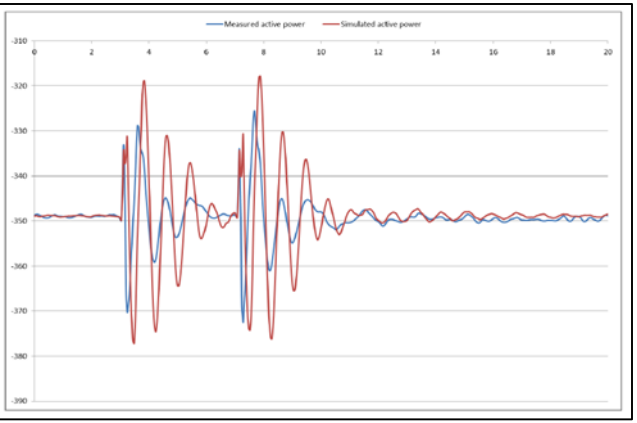



## Synchronisation and Islanding

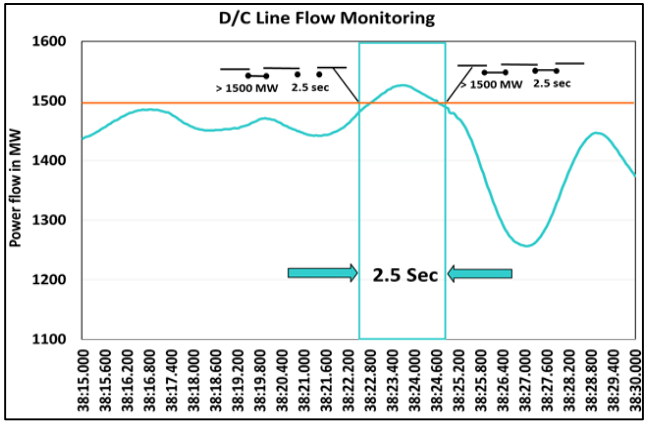

Frequency of the two system when in synchronization and when separated from each other.

# Synchro phasors: Off-line Applications

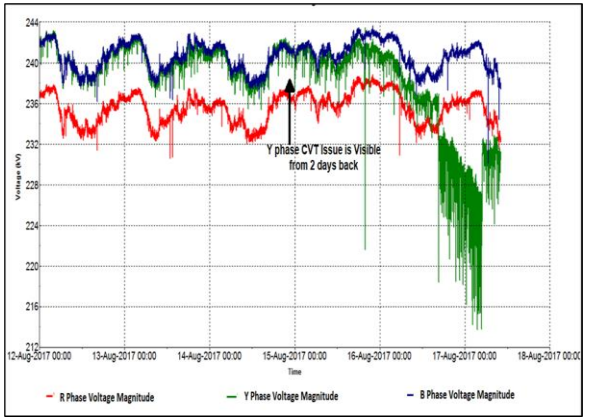
## Model Validation



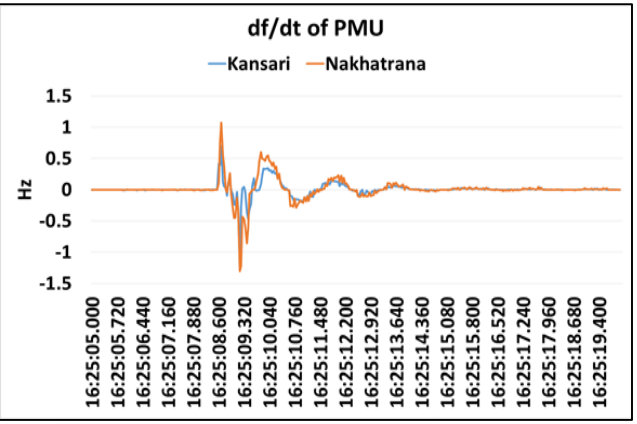

## SPS Improvement



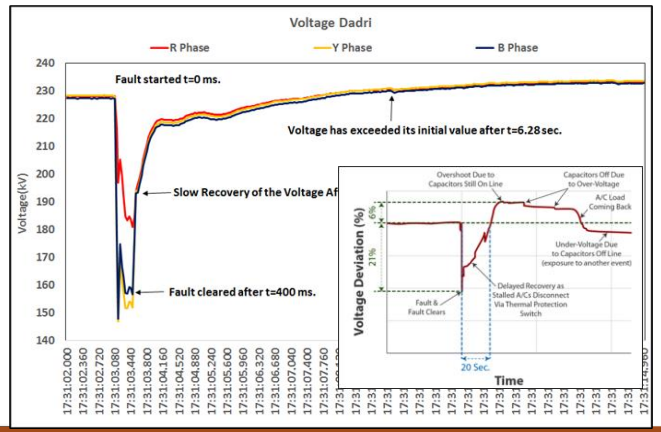

## Asset Management



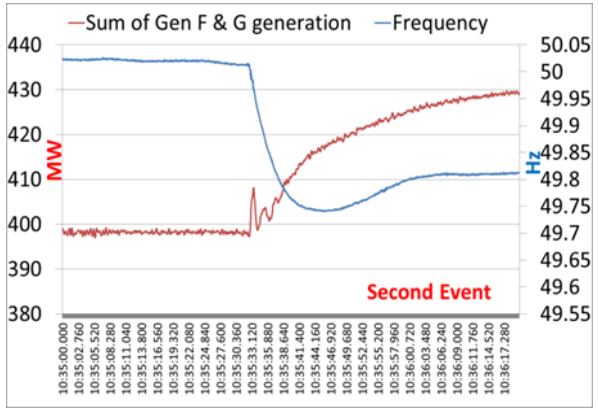

## Protection Operation




## Delayed Voltage Recovery




## Governor Response of Generator



# Regulatory Requirements for RE Plants

Frequency Response by RE based plants

Active Power – Set Point Control

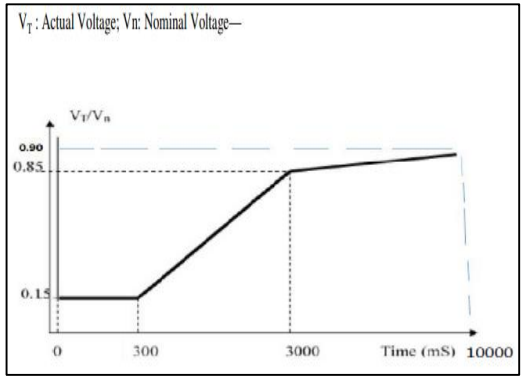
Voltage Ride Through Applicability

Low Voltage - (LVRT)
High Voltage (HVRT)

Provision to vary Active and Reactive Power*

Short Circuit Ratio – five or above

Rate of Change of Power < ±10% per minute




| Over voltage (pu) | Minimum time to remain connected (Seconds) |
|---|---|
| 1.30 < V | 0 Sec (Instantaneous trip) |
| 1.30 ≥ V > 1.20 | 0.2 Sec |
| 1.20 ≥ V >1.10 | 2 Sec |
| V ≤ 1.10 | Continuous |

* Based on the signal from the State Load Dispatch Centre or Regional Load Dispatch Center

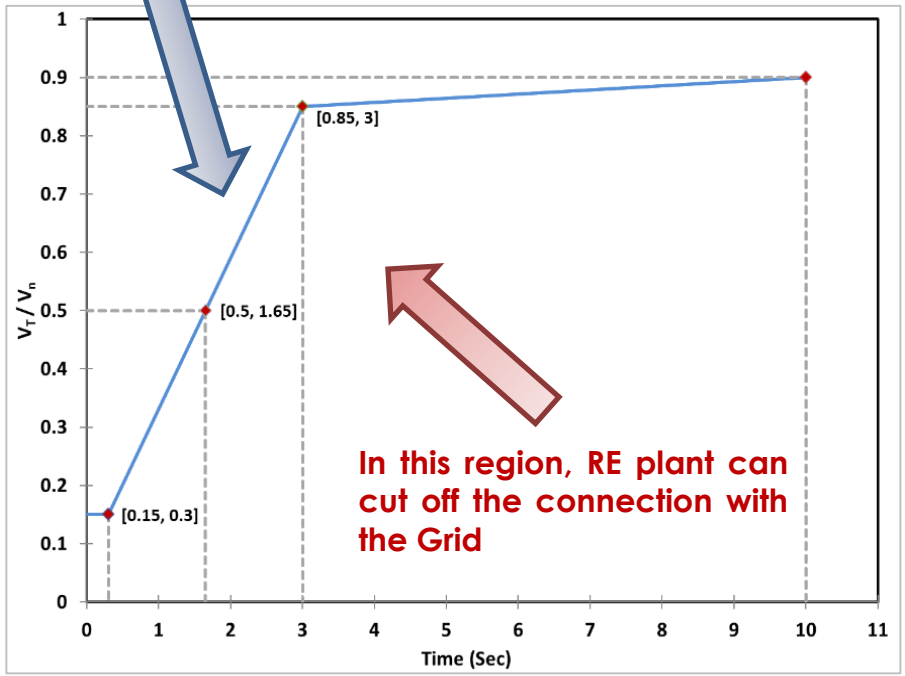
**Illustration:** Voltage Ride Through,

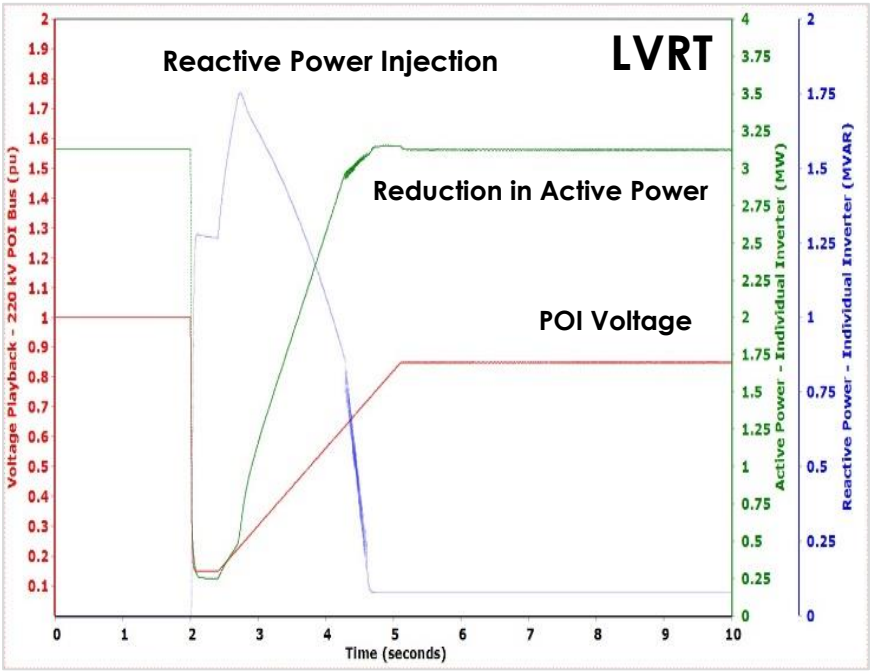
# Low Voltage Ride Through

## Technique to ensure uninterrupted connectivity of RE plant in case of grid fault

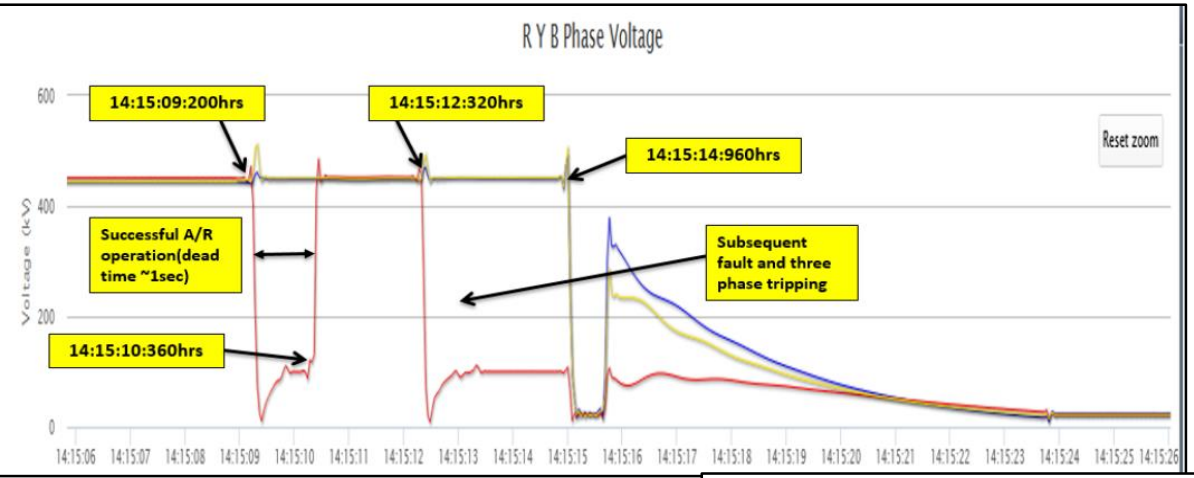
Back

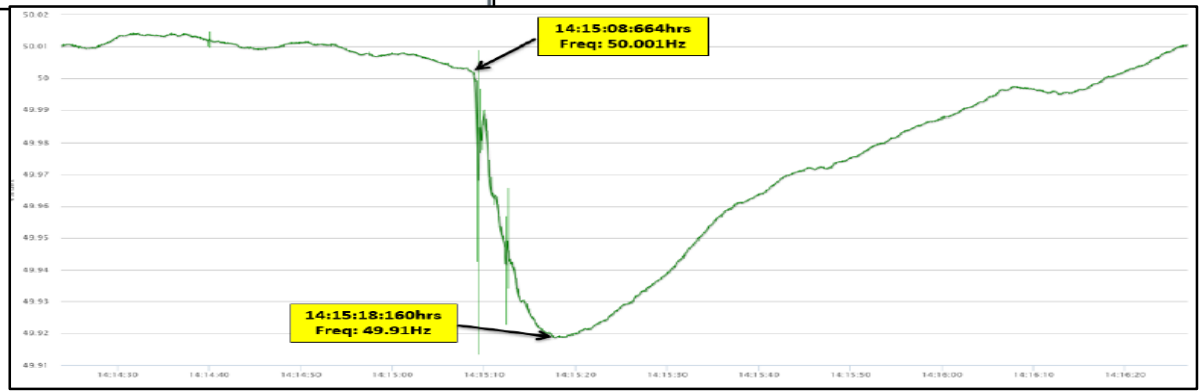
In this region, RE plant mandated to stay connected to the Grid



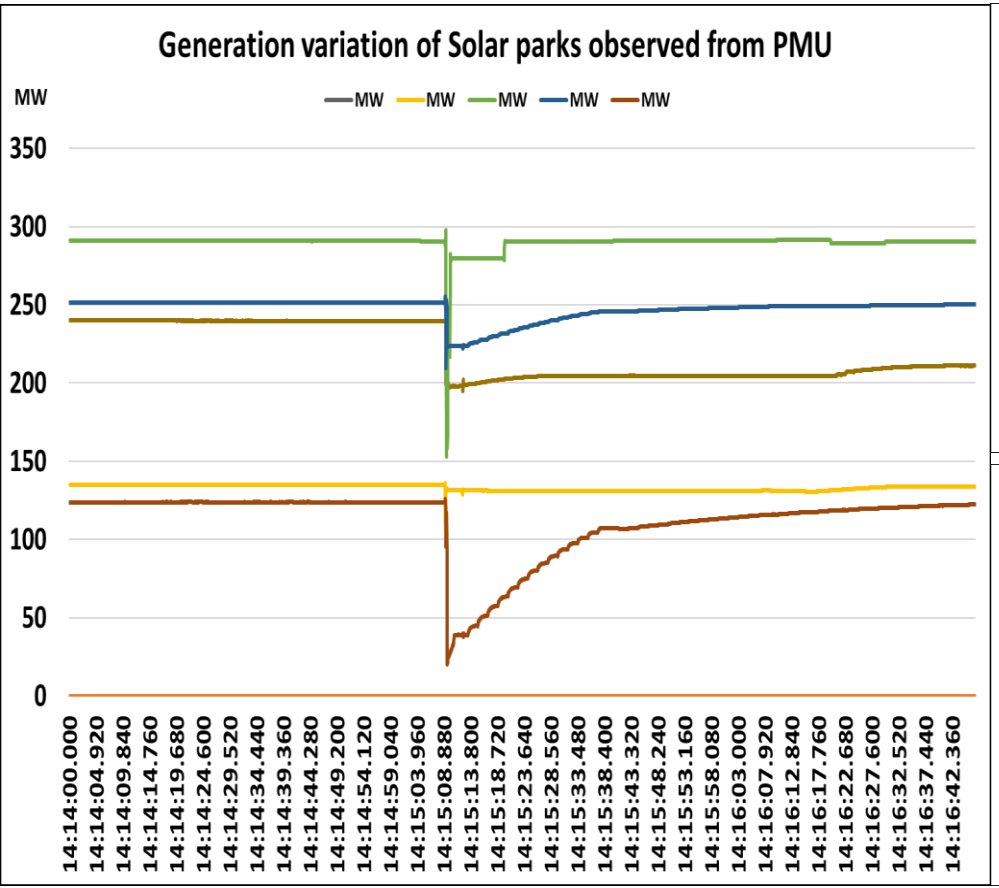



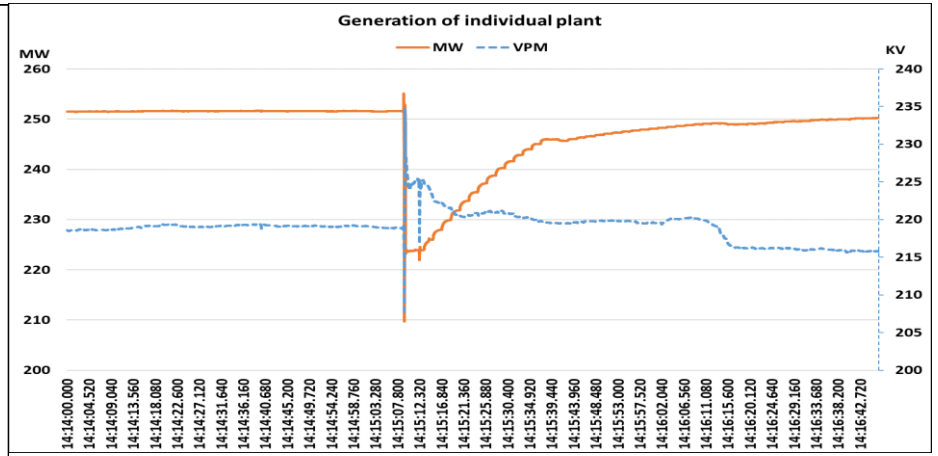
# Fault in EHV system near large solar parks and corresponding loss of generation

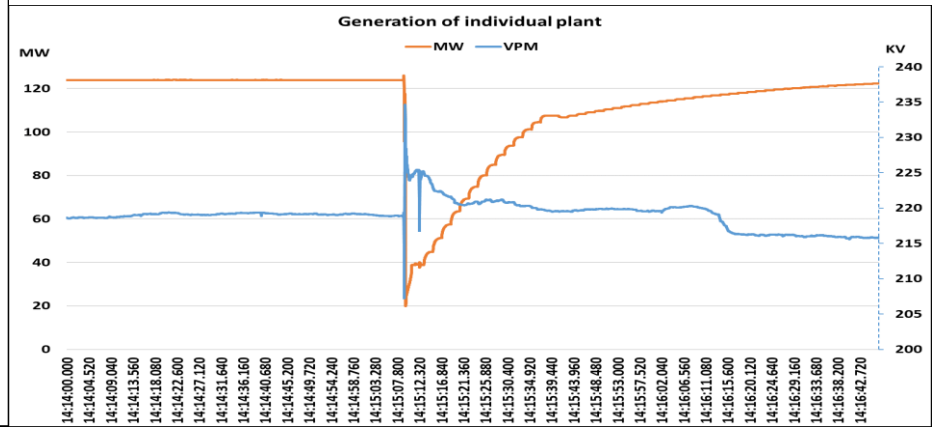


# Variation of generation in Solar parks connected to same station as observed from PMU



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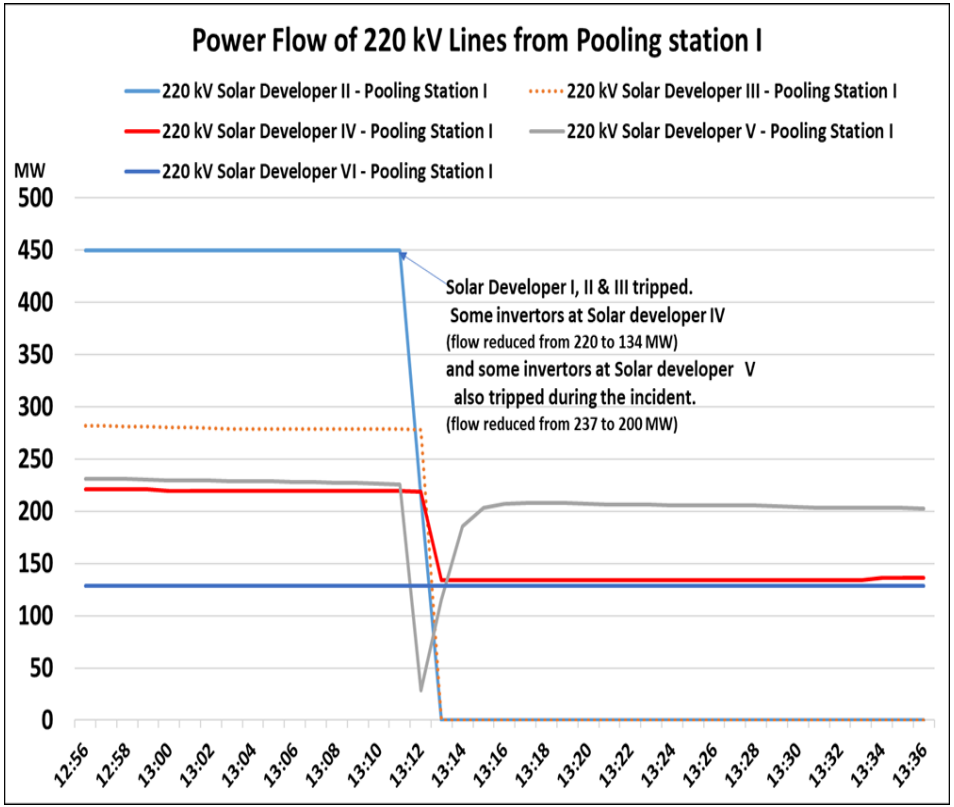
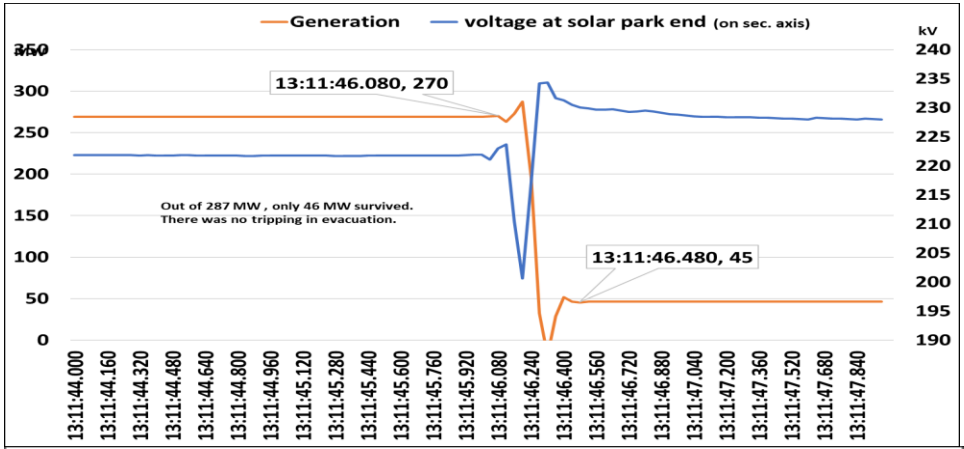
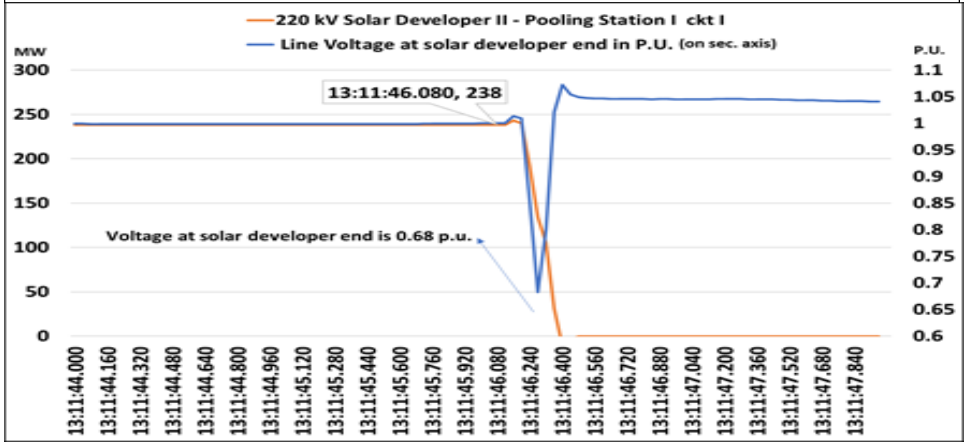
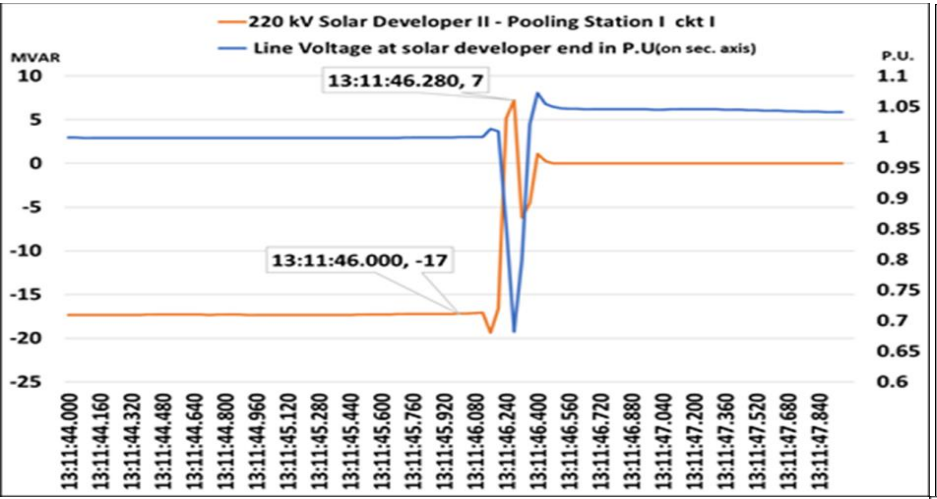
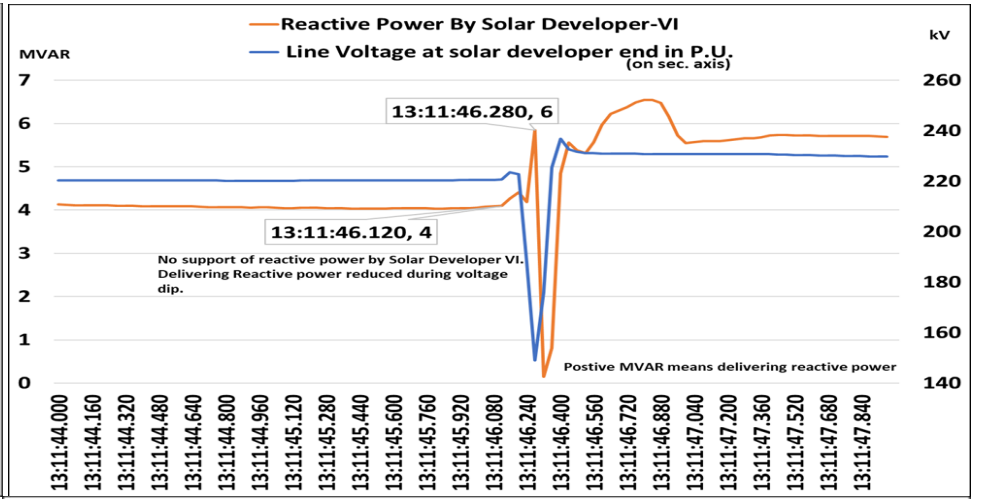


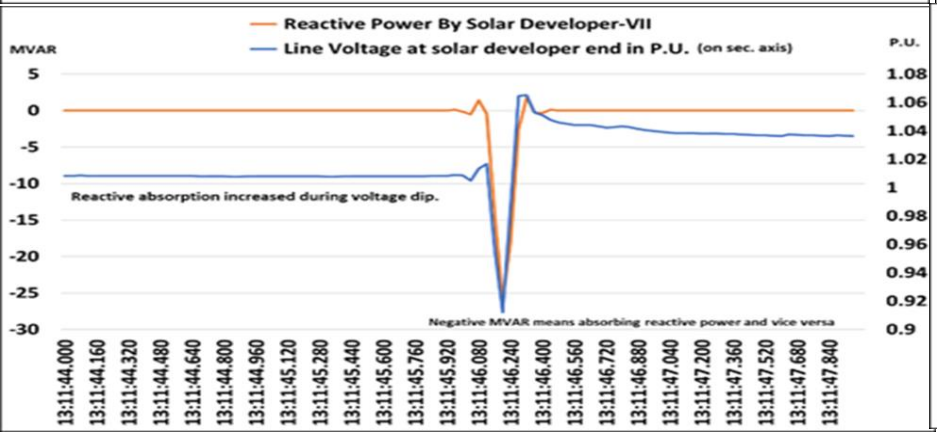



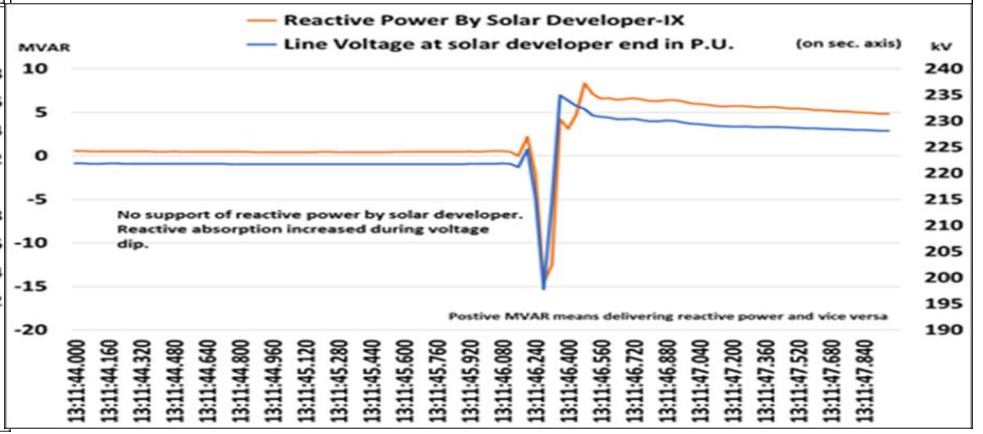



# Reactive Power exchange by solar park during fault

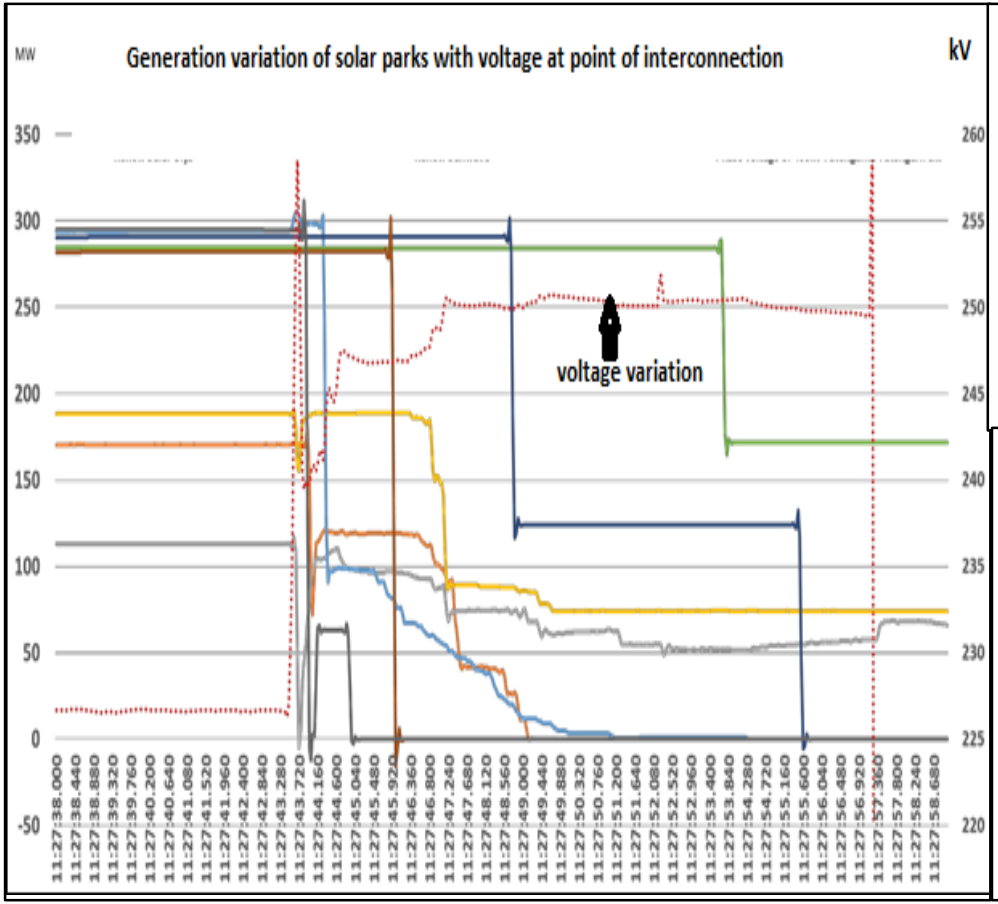


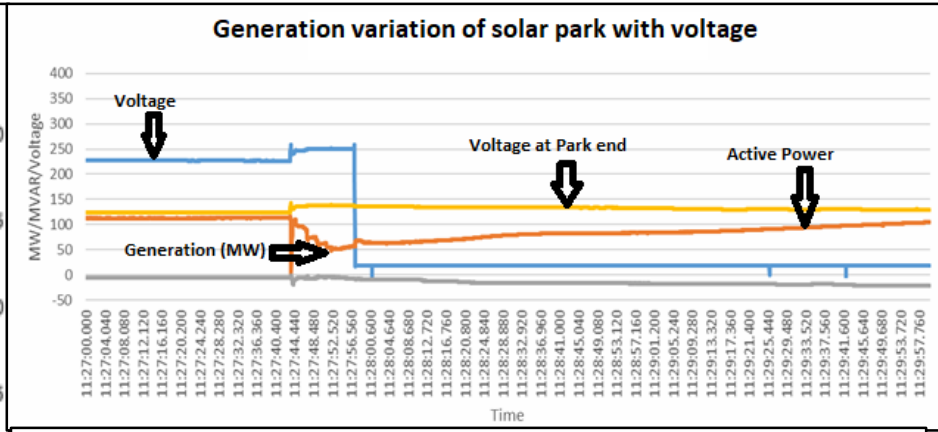



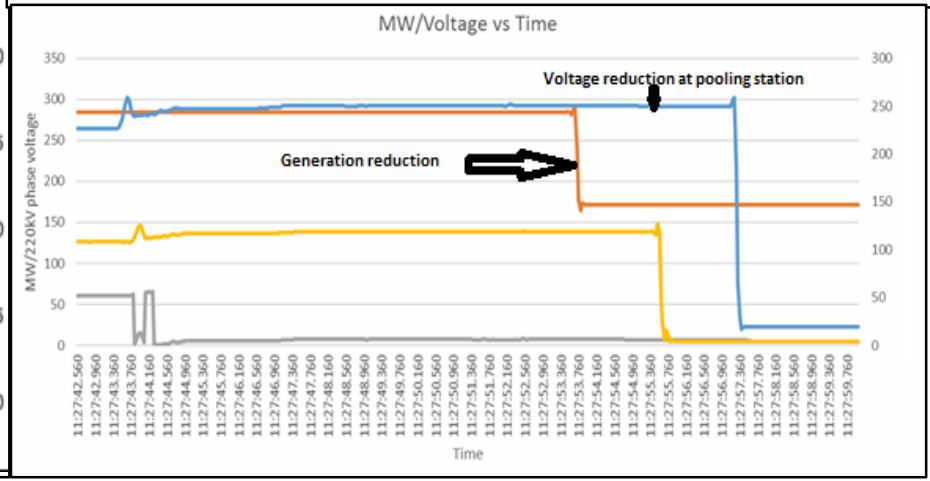



# Performance during high voltage conditions



# Conclusion

- Availability of PMU provides high resolution data of solar park parameters
- Inverter performance can be assessed during fault in network
- Variation in MW/MVAR with voltage helps in identifying issues in controllers
- Line fault protection can also be monitored using PMU and protection upto Point of Interconnection can be coordinated
- Low Voltage Ride Through(LVRT) requirements as per grid code can be validated easily

# Thank you !!

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