Performance Evaluation and Review of System Protection Scheme Design with the help of Synchrophasor Measurements

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NASPI Work Group meeting and first International Synchrophasor Symposium

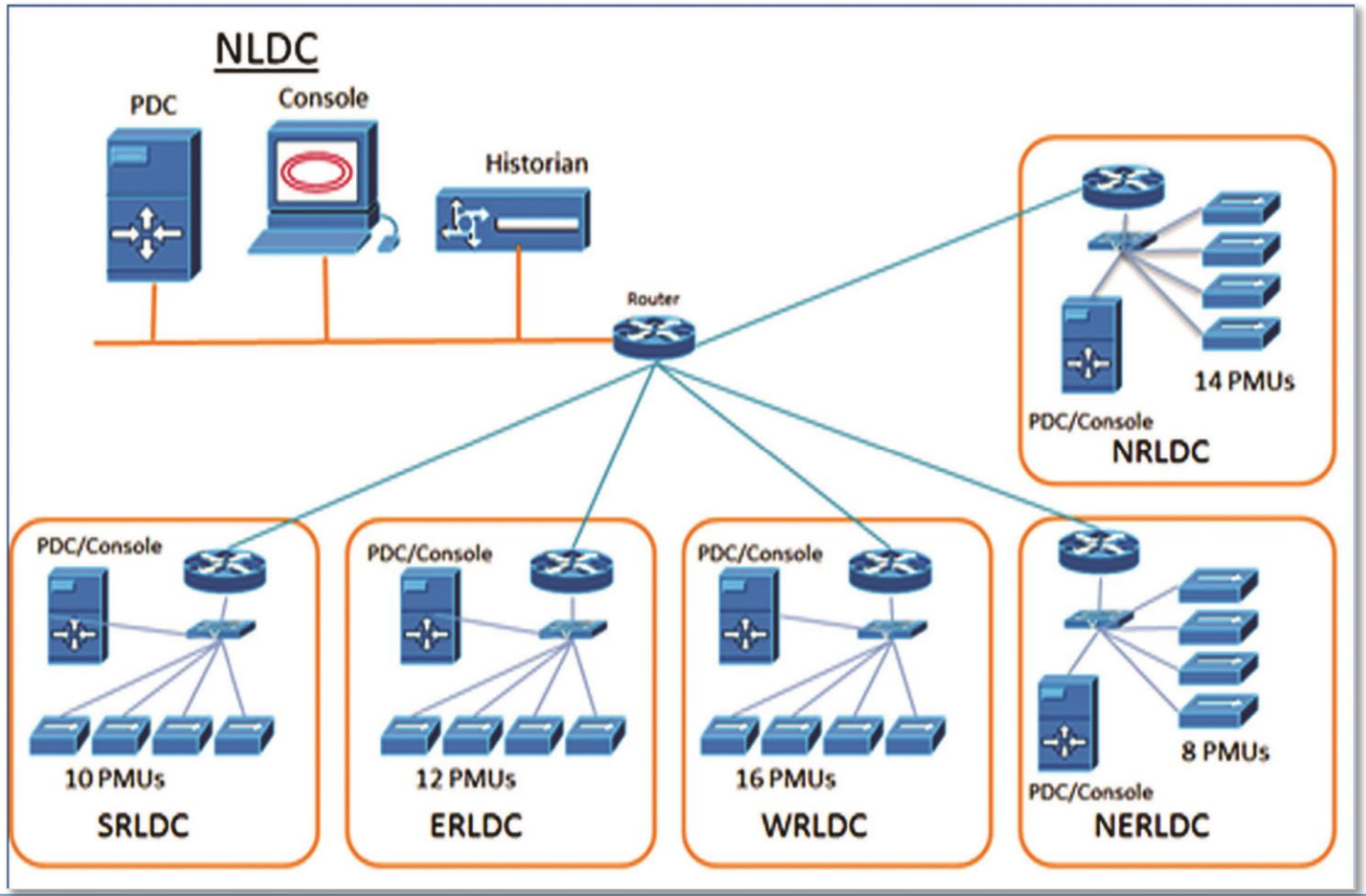
Outline

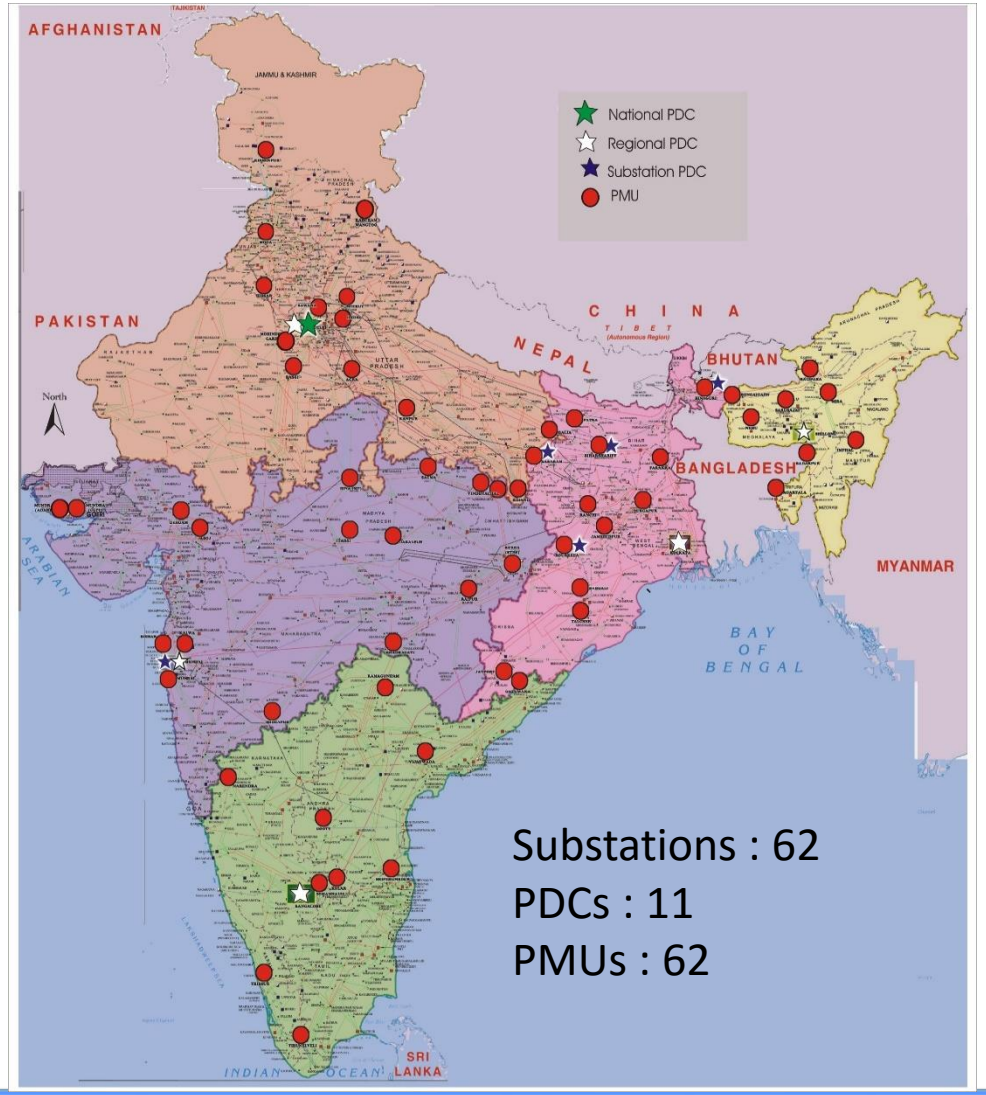
- **WAMS in India – Progress Update**
- **System Protection Schemes in India**
- **Case Studies- Performance Evaluation and Review of SPS**
- **Summary**

WAMS in India 2015

Integration of PMUs

Regional Level → **National Level**

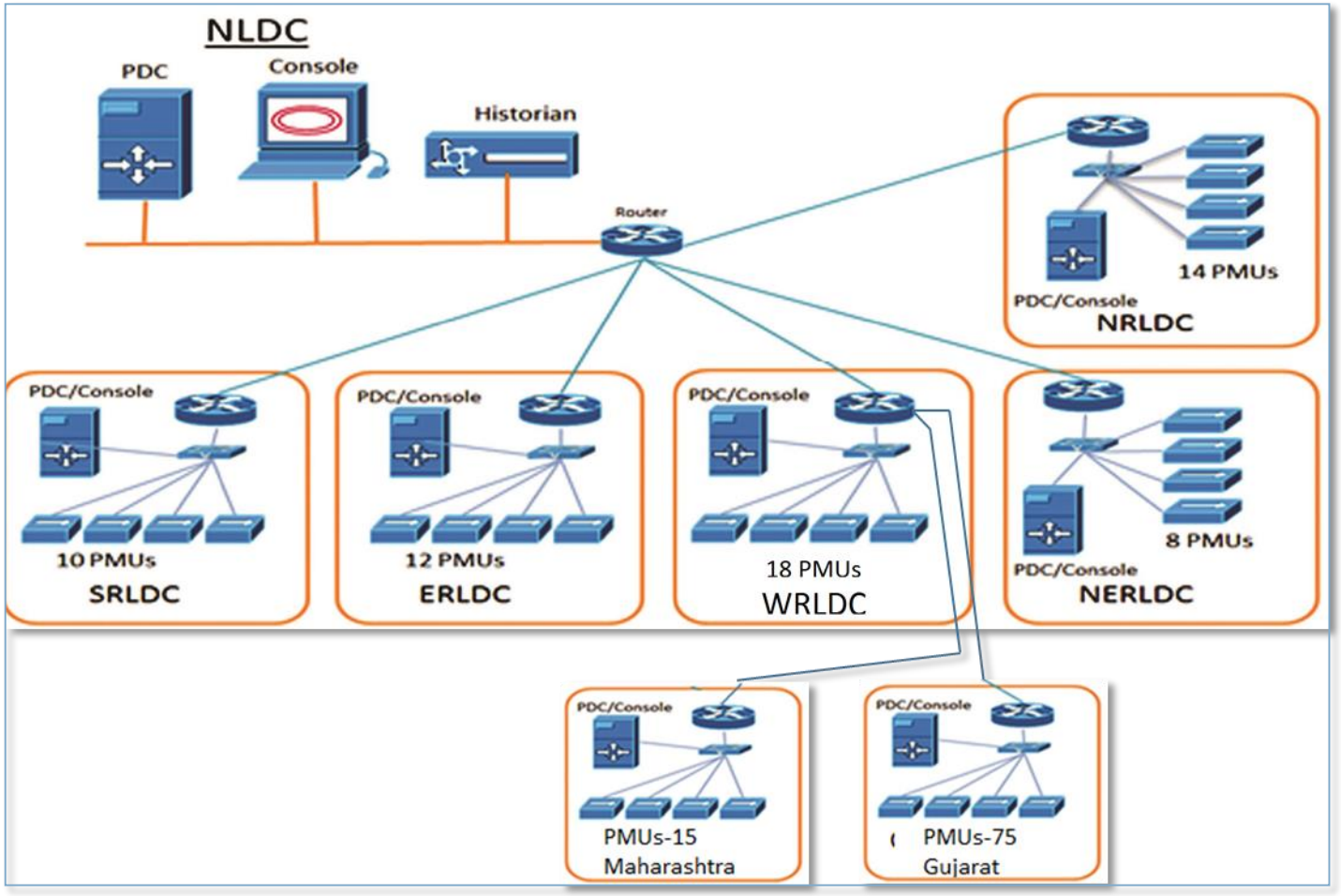


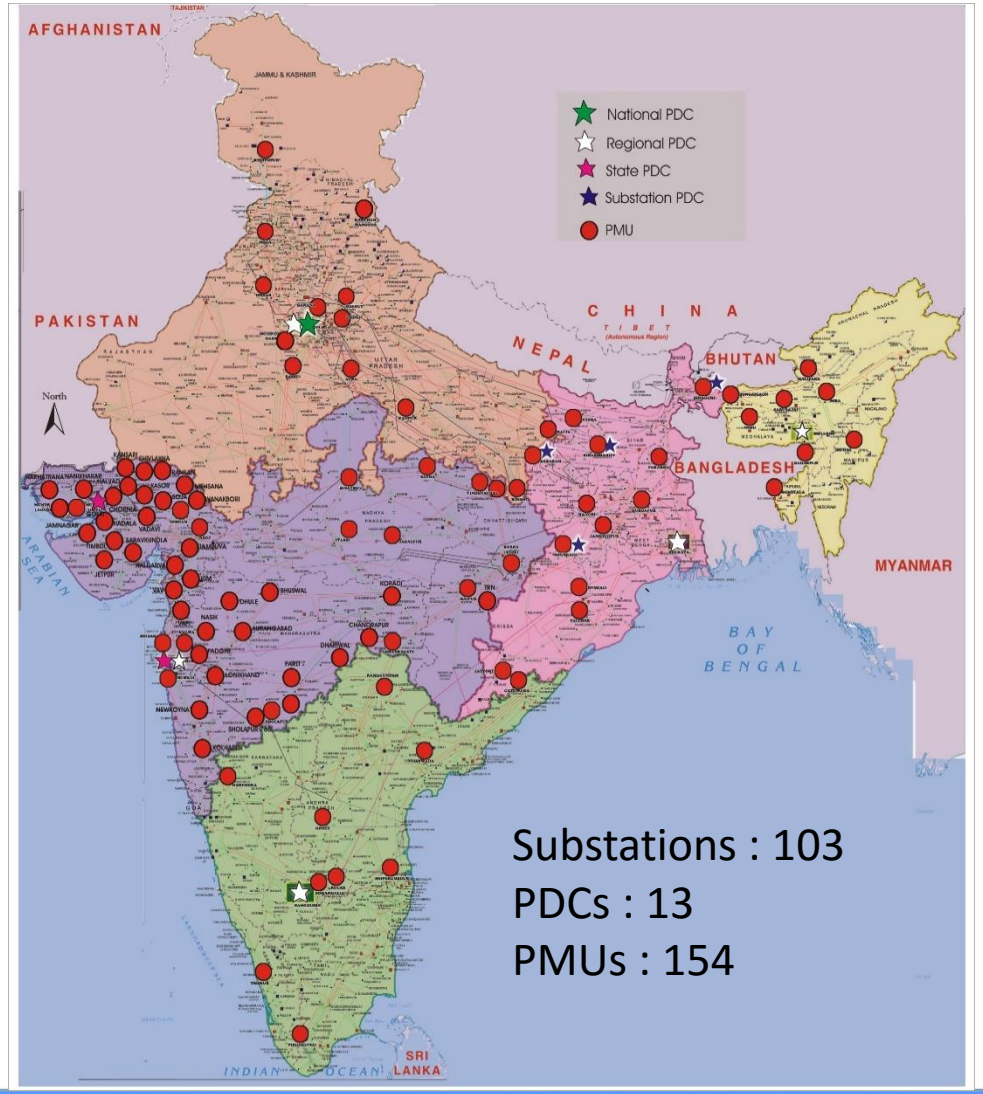


WAMS in India 2016

Integration of PMUs

State Level → Regional Level → National Level





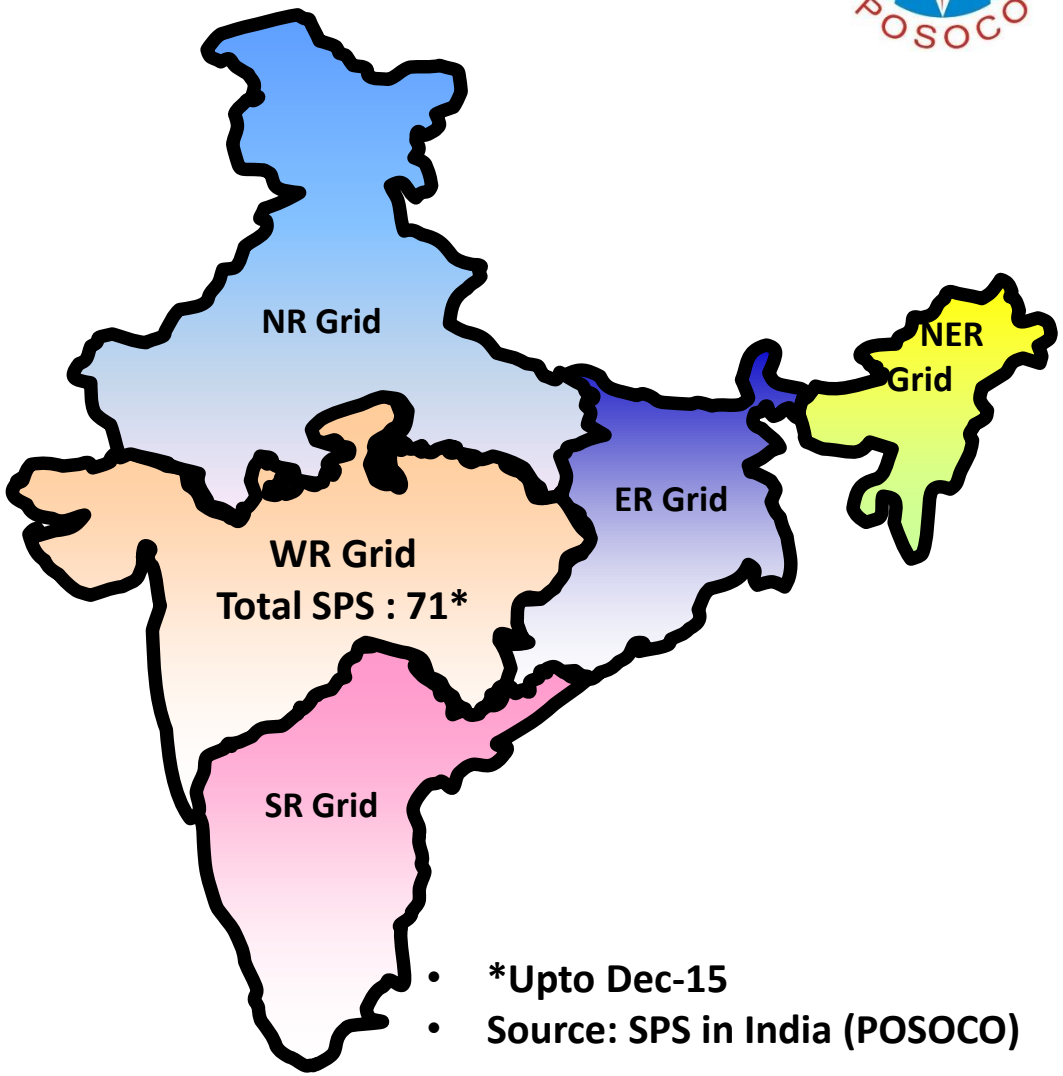
System Protection Schemes (SPS) in India

- **Total Number of SPS in India : 129***
- **Wide Impact SPS in WR Grid**

Control Actions	Total	Percentage
Load Rejection	20	59%
Generation Rejection	7	21%
Generation and Load Rejection	6	18%
HVDC Control	1	3%

- **Local Impact SPS in WR Grid**

Control Actions	Total	Percentage
Load Rejection	34	92%
Generation Rejection	3	8%

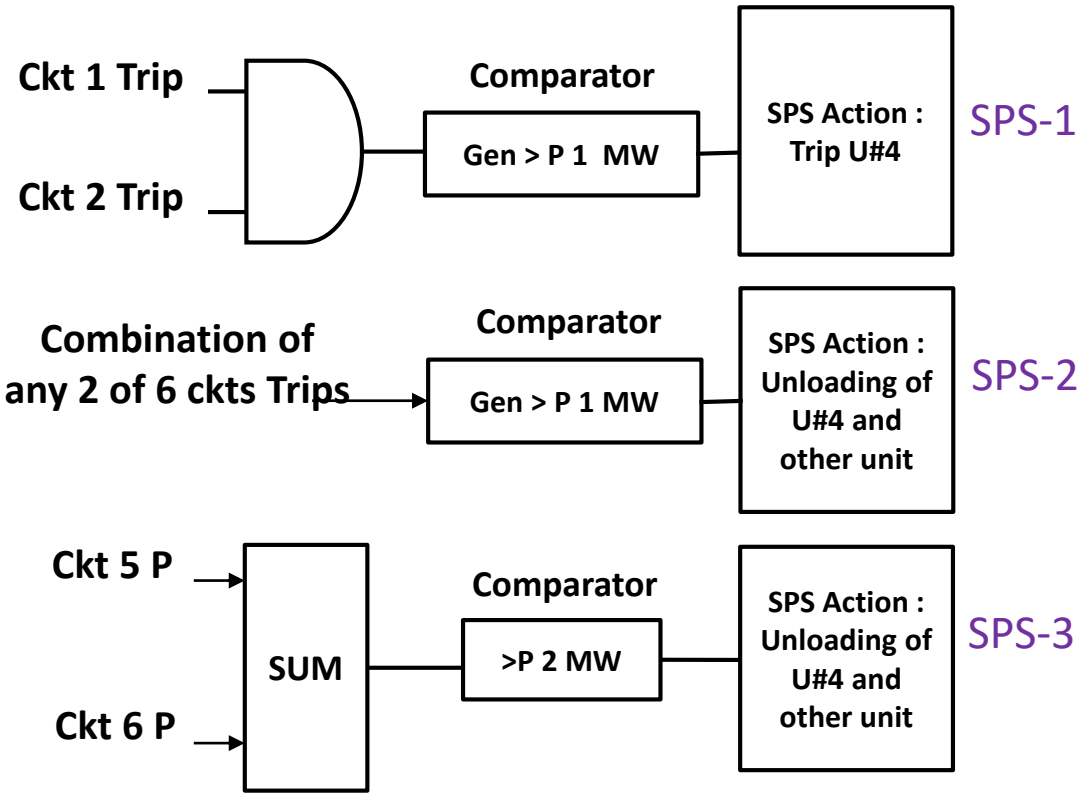


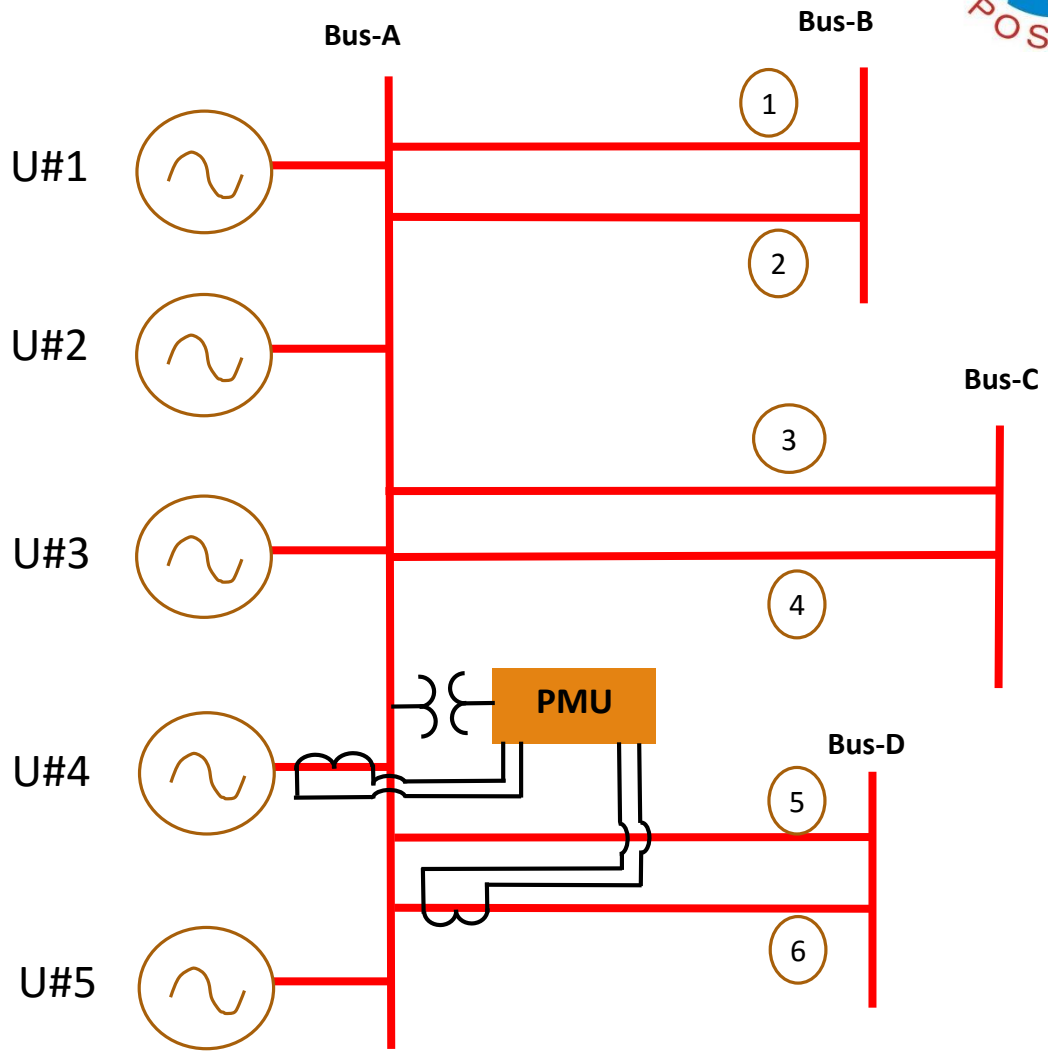
- *Upto Dec-15
- Source: SPS in India (POSOCO)

Performance Evaluation and Review of SPS
Case Study-I

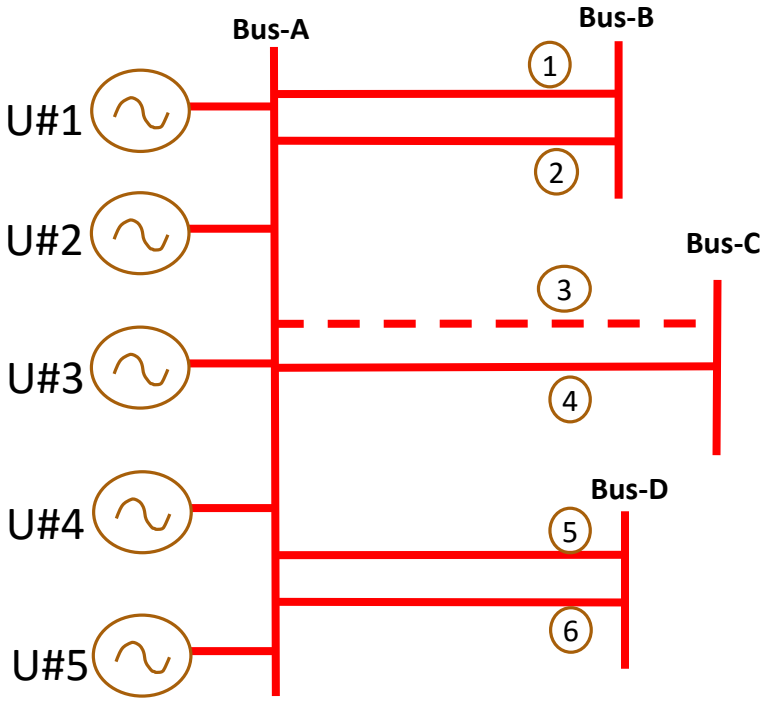
Assessing Speed of the SPS

- **Two Analog, Six Digital Inputs**



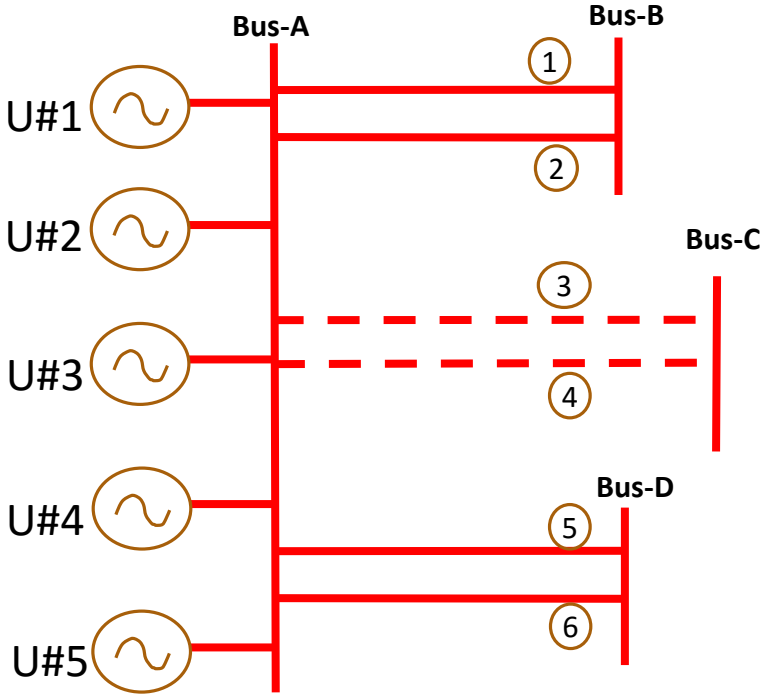


Assessing Speed of the SPS contd.



t=0

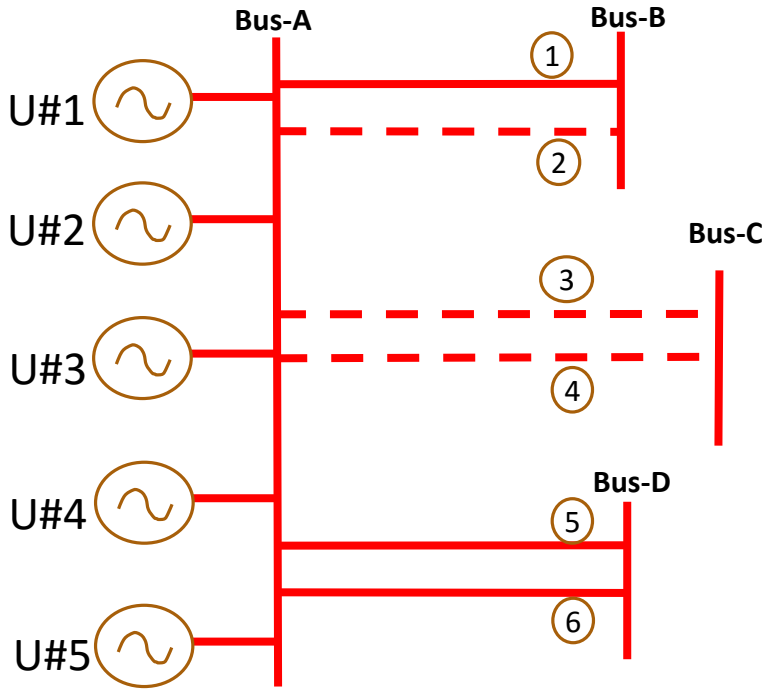
Occurrence of an Event



t_1=11 min 13 sec 3 msec

SPS-2 criteria satisfied

Envisaged Action : Units unloading

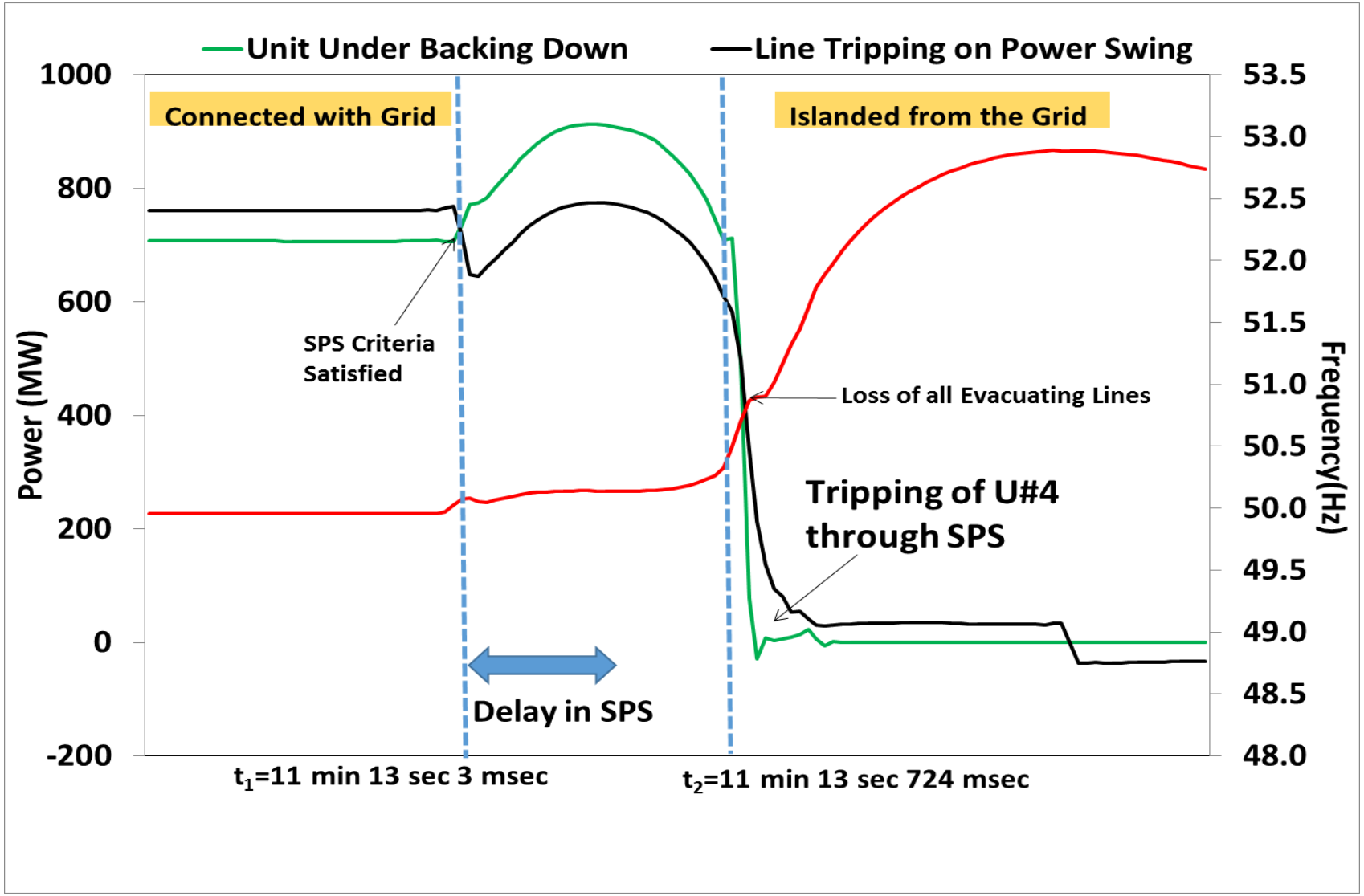


t_2=11 min 13 sec 724 msec

SPS-3 criteria satisfied

Envisaged Action : Units unloading

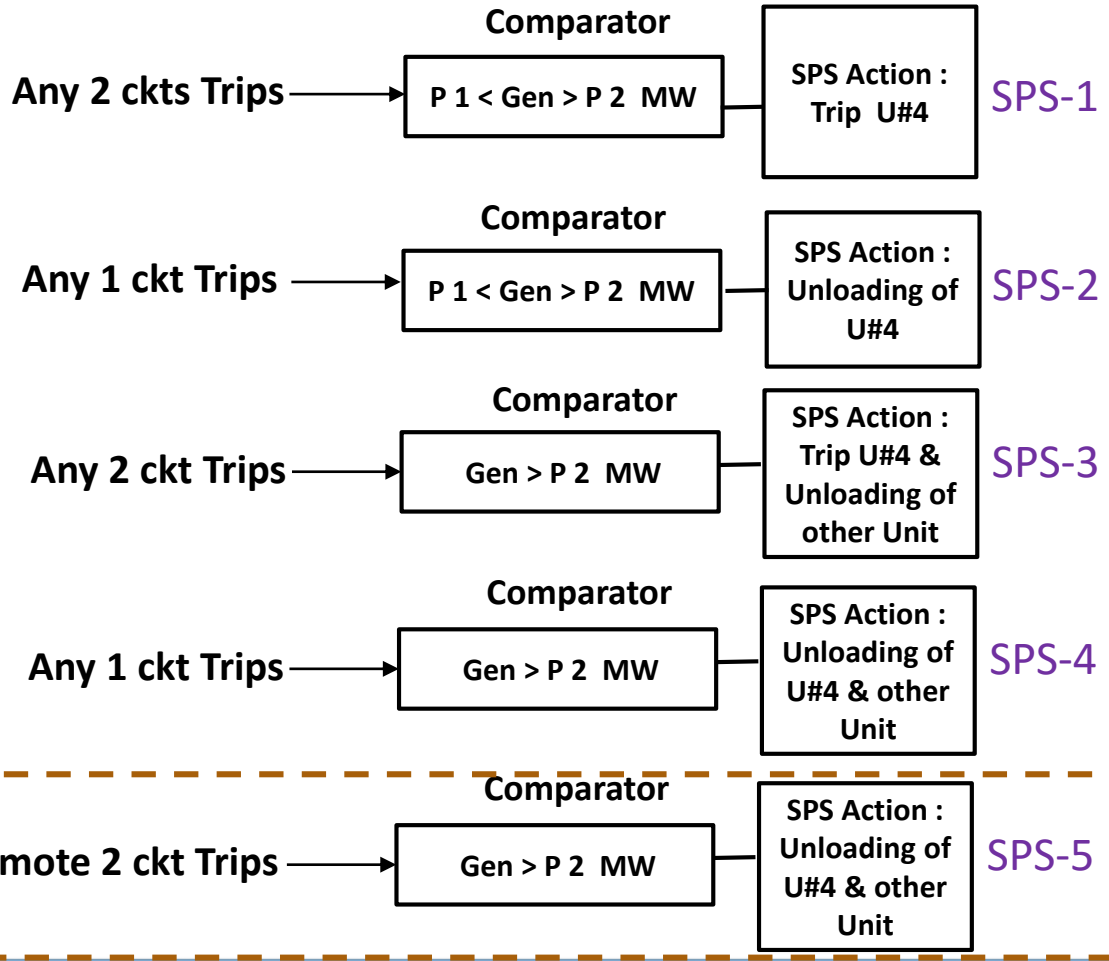
Assessing Speed of the SPS contd.



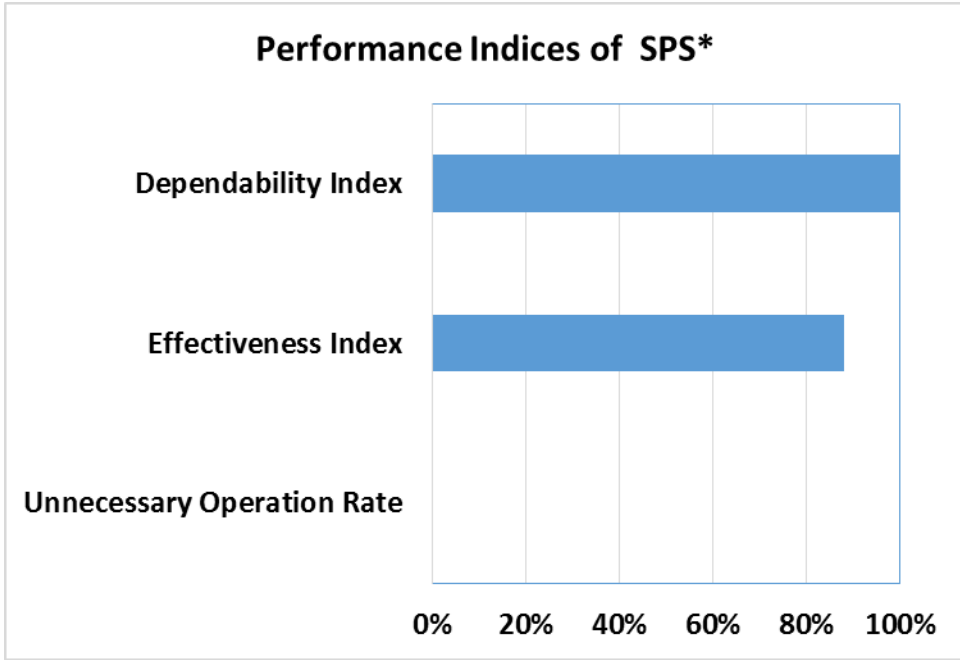
- Delay observed in Unit Unloading
- Observation through PMU

Revised SPS Design & Performance

- **SPS Logic Modified**
- **Delay in unit unloading is rectified**



- **Performance of Modified SPS**
  - **Successful Operations : 7**
  - **Unsuccessful Operations : 0**
  - **Unnecessary Operations : 0**
  - **Number of Failures : 1**

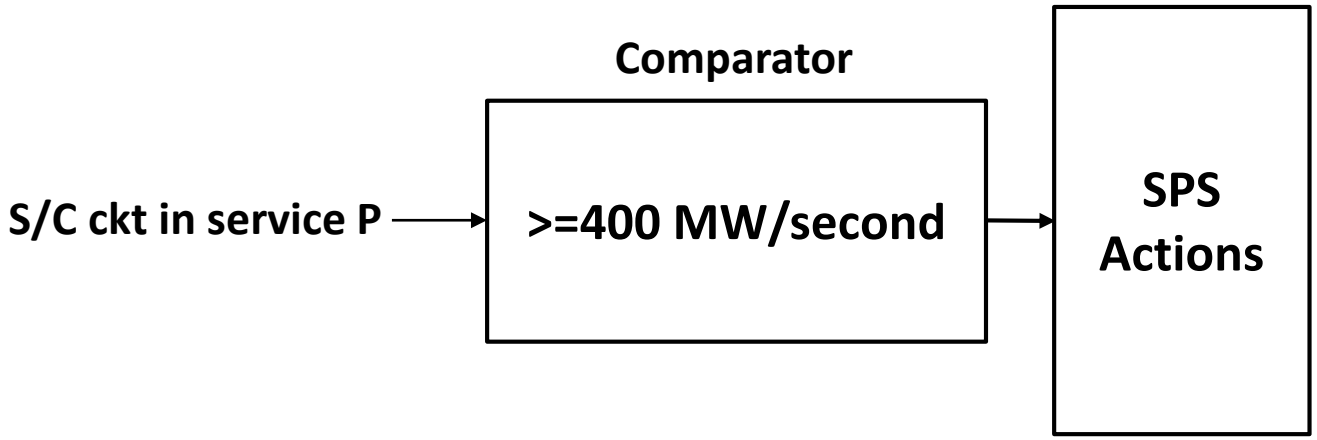


* Upto Dec-15

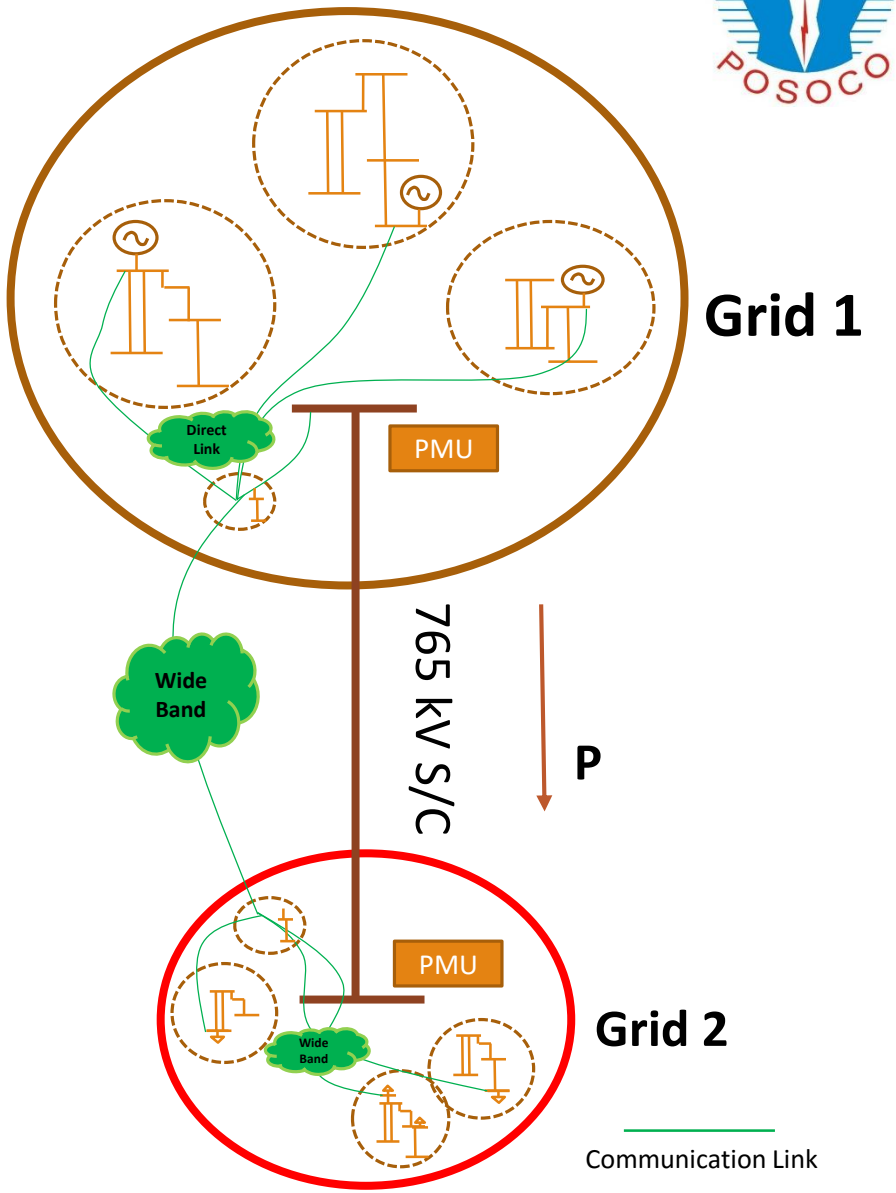
Performance Evaluation and Review of SPS
Case Study-II

Assessing Dependability of the SPS

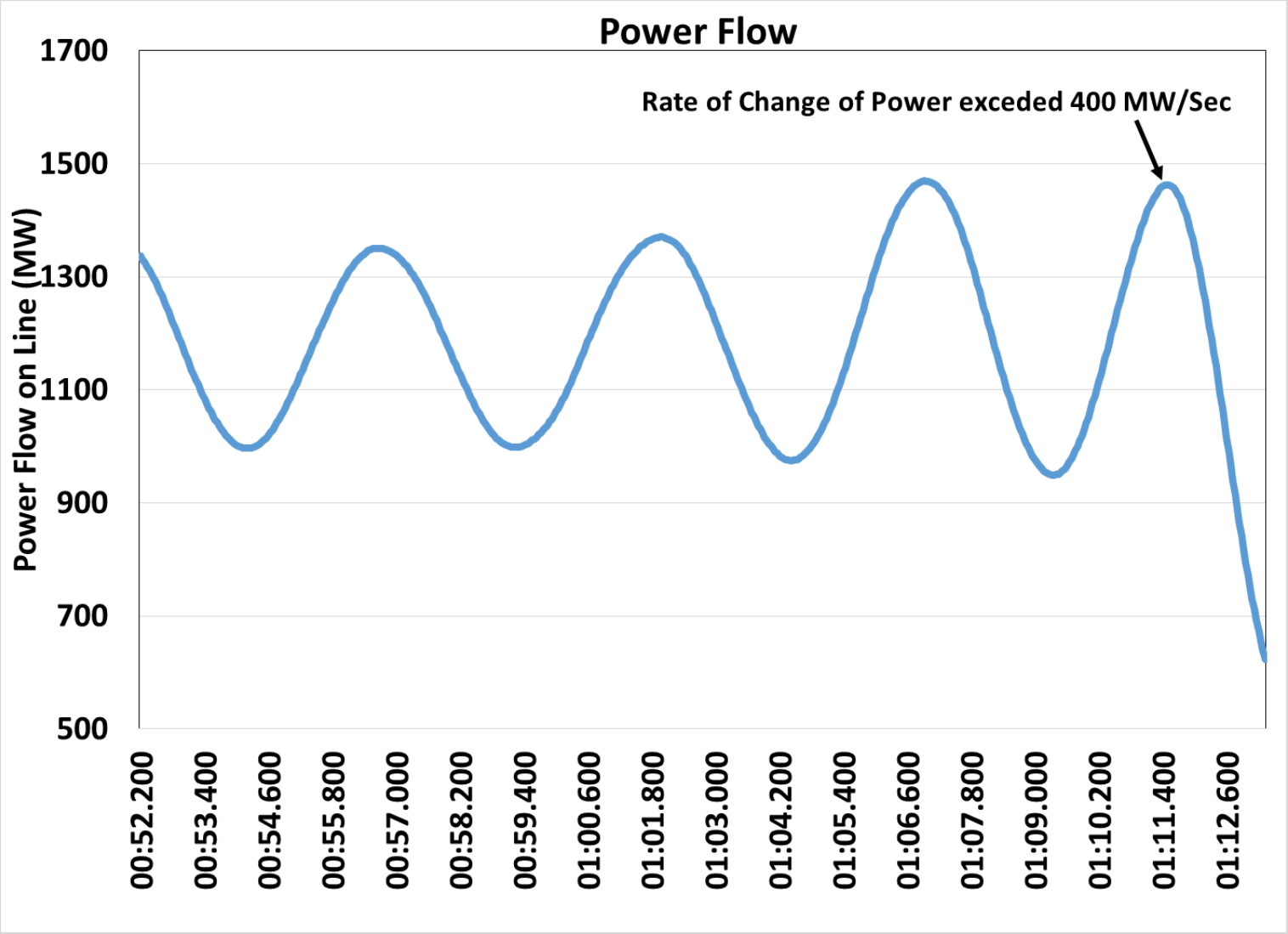
- **One Analog, Two Digital Inputs**



- **SPS Actions**
  - **Generation Rejection in Grid 1**
  - **Load Rejection in Grid 2**



Assessing Dependability of the SPS contd.



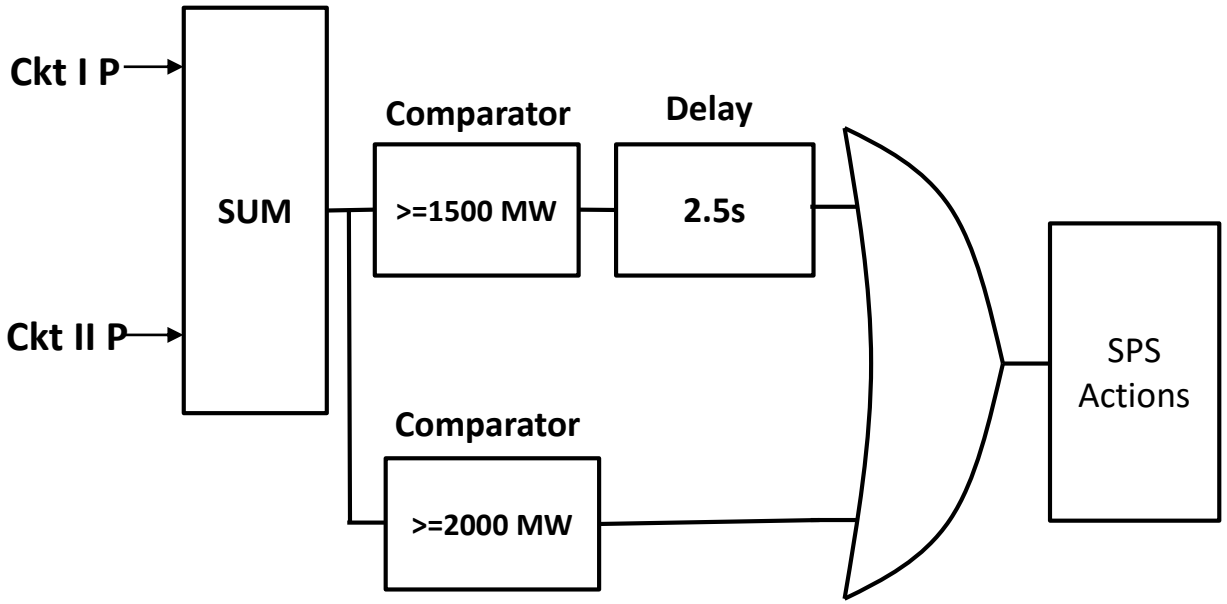
- **Number of Operations : 24***
  - **Successful Operations : 23**
  - **Unsuccessful Operations : 0**
  - **Unnecessary Operations : 1**
  - **Failures : 0**
- **SPS is disabled**
  - **SPS triggered irrespective of power flow direction**

*Up to Dec-15

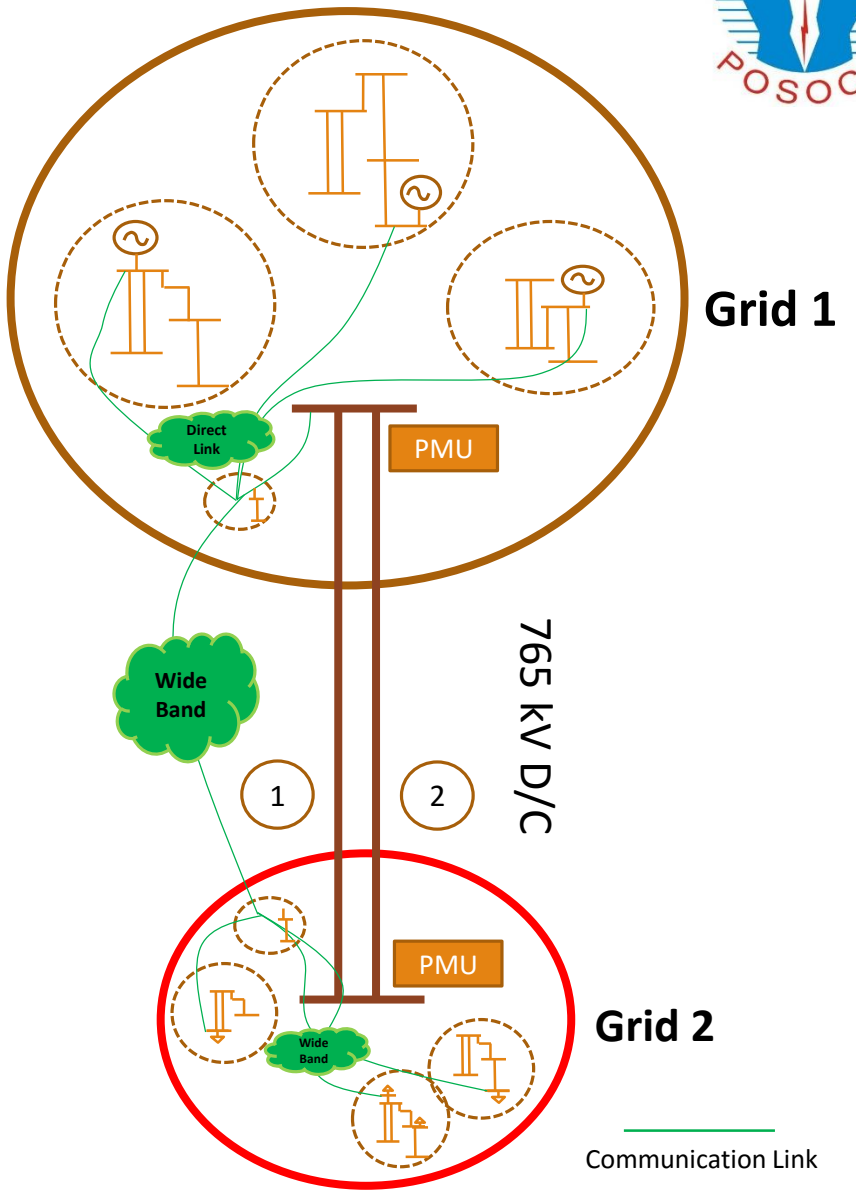
Performance Evaluation and Review of SPS
Case Study-III

Assessing Dependability of the SPS

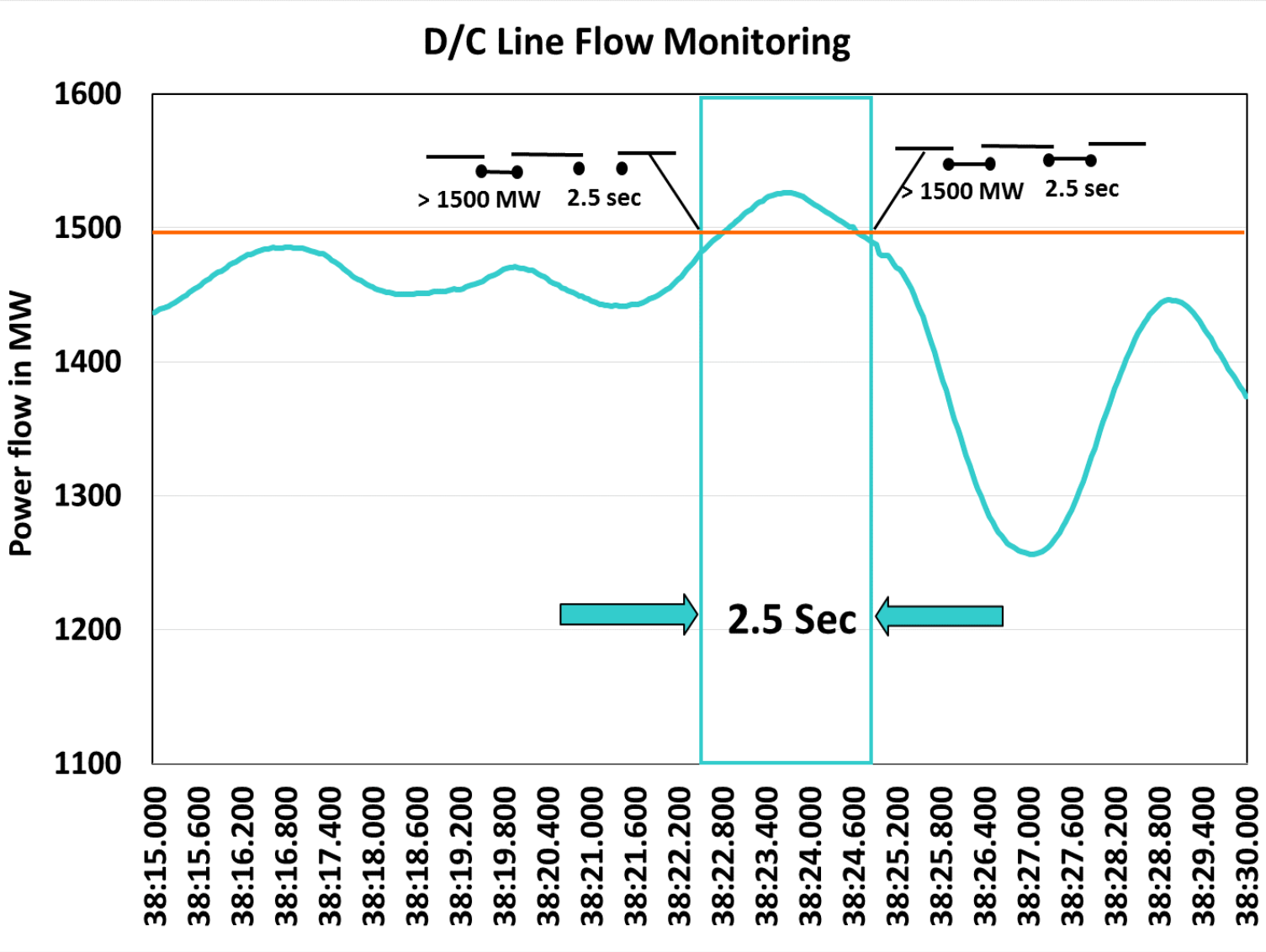
- **Two Analog Inputs**



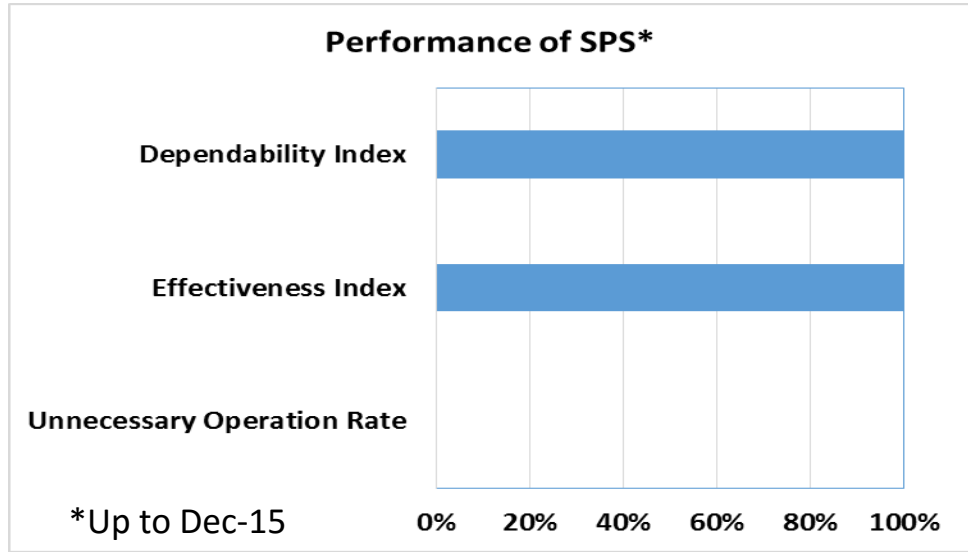
- **SPS Actions**
  - **Generation Rejection in Grid 1**
  - **Load Rejection in Grid 2**



Assessing Dependability of the SPS contd.



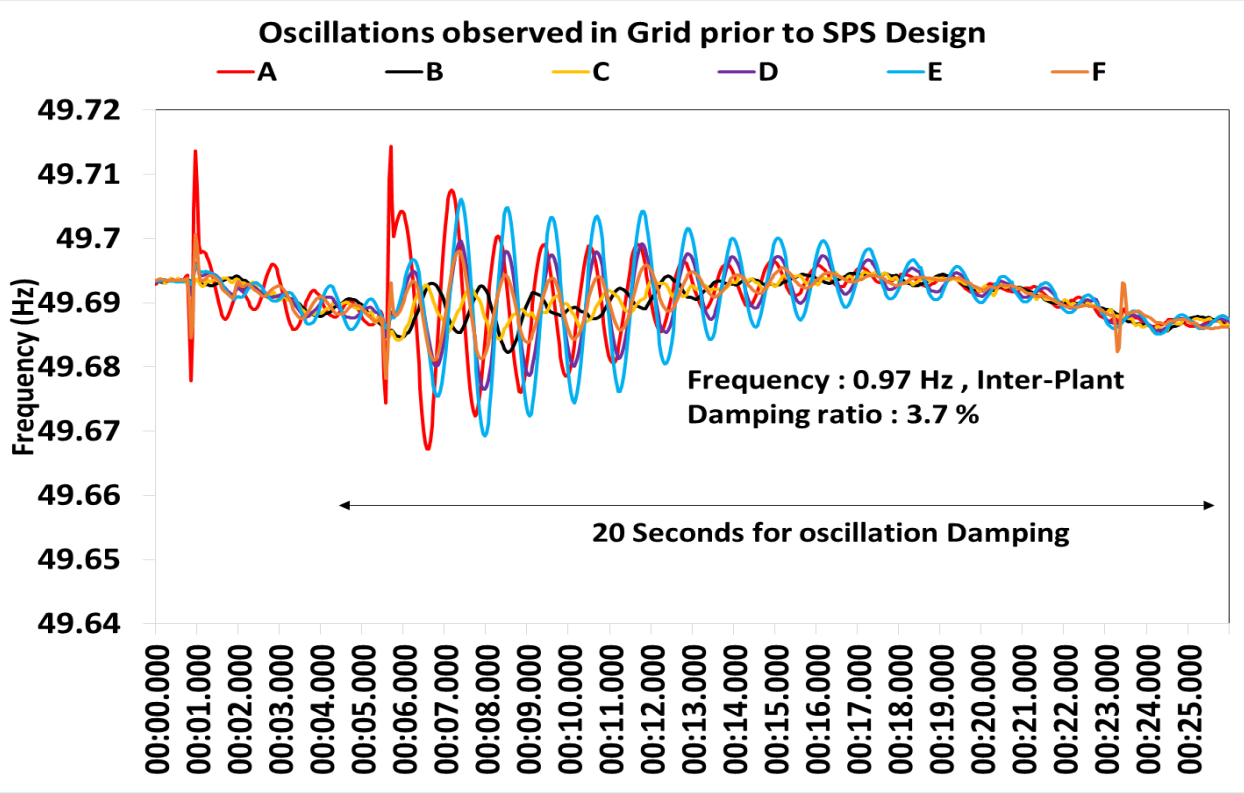
- **Number of operations : 15**
  - **Successful Operations : 15**
  - **Unsuccessful Operations : 0**
  - **Unnecessary Operations : 0**
  - **Failures : 0**
- **Introducing time delay reduced frequent operation of SPS**

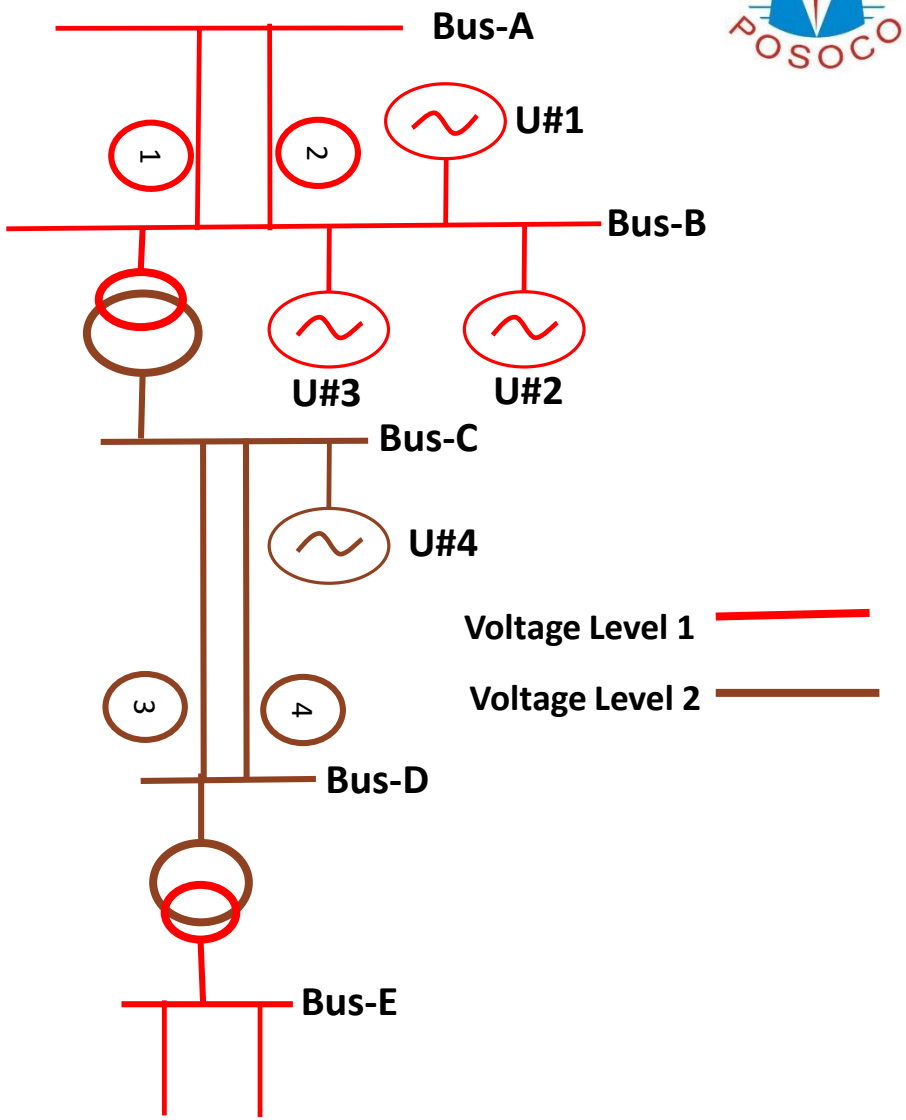


SPS Design
Case Study-IV

SPS Design

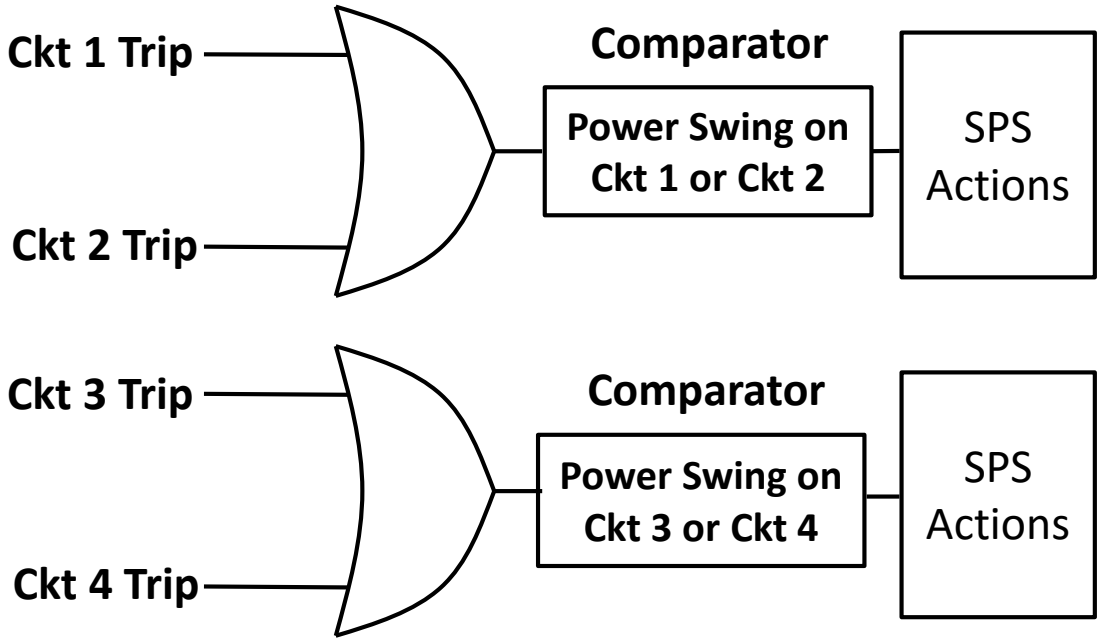
- Tripping of any one of four Ckts, oscillations are observed in Grid
- Tripping of other Ckt on Power Swing

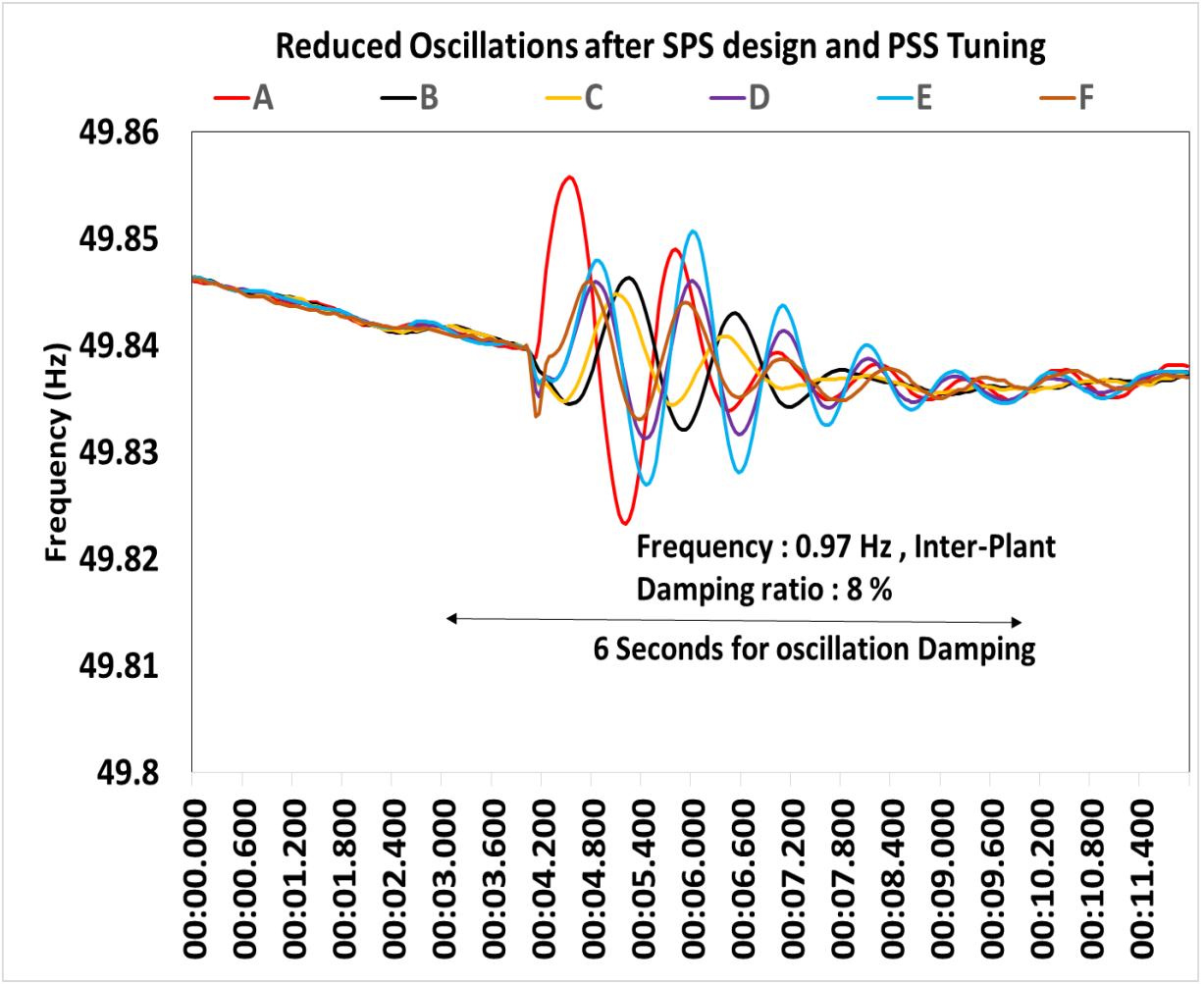




SPS Design Contd.

- **Four Analog, Four Digital Inputs**





- **SPS Actions**
  - **Trip any one Unit**
  - **Blocking tripping of other line on Power Swing**

Summary

- Synchrophasor measurements aided in assessing performance of SPS
- Synchrophasor measurements helped System Operator in reviewing SPS
- Synchrophasor measurements assisted in taking corrective actions to prevent undesirable or delayed SPS actions
- Using Synchrophasor measurements characteristics of SPS
  - Dependability
  - Speed
  - Sensitivity

  are Evaluated

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[2] Industry Experience with Special Protection Schemes , IEEE Transactions on Power Systems, Vol. 11, No. 3, August 1996

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