PQ Audit - The right choice to ensure power system performance

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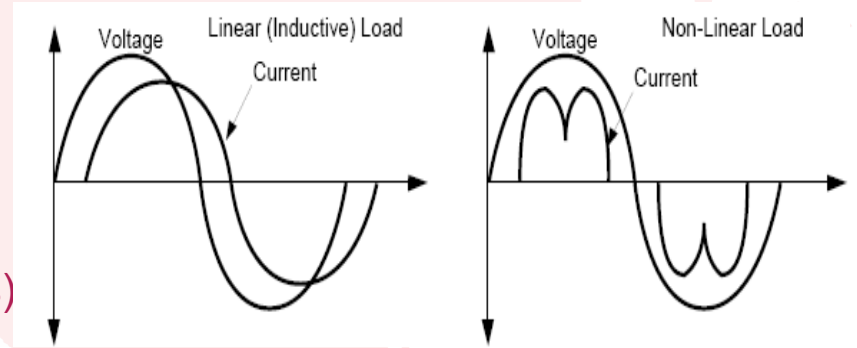
Outline

- Power Quality
- Present Challenges
- Harmonics & Its Impact on DISCOM
- Future Challenges – Roof-Top Solar
- PQ Audit – TPDDL case study
- Way Ahead

What is PQ

- IEEE Defination : POWER QUALITY is the ability of a system or an equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment
- Broader Parameters are :
  - Voltage (RMS, min / max)
  - Current (RMS, min / max)
  - Frequency
  - Flicker
  - Harmonics
  - Short interruption (sags, swells)
  - Transients



Power Quality

- Today's industrial development are related with generalized use of computers, adjustable speed drives and other microelectronic loads which are a major source of harmonics.
- Massive penetration of such loads in the grid will cause additional power losses and malfunction of grid component
- Bad Power quality may result into equipment failures, process interruptions, increase in energy bill, etc. and if not improved may result into huge economical losses

The Economic losses are inversely proportional to PQ

India suffers a staggering loss of INR 100,000 Crore due to nationwide power disturbances (including power outages).

Indian industries are spending INR 30,000 Crore annually to operate inefficient power back-ups using Gensets and Inverters.

Present Challenges (1/2)

Electronic Devices	New Generation Load Equipment	Utility Customers
• Use of Semiconductors • Non-linear relationship between voltage & current	• Microprocessors • Power Electronic Devices • Relay Operations • CNC Machines	• Process controls • SMPS of Desktops / Laptops • Electronics of all sorts • Interconnected Network Issues

Present Challenges (2/2)

Power System Efficiency	Switched shunt capacitors	Power System response to faults
• Adjustable Speed Generator / Motor Drive • Shunt Capacitors	• Utility power-factor correction • Customer power-factor correction	• Reclosing circuit breakers during faults • System disturbances of all sorts

Impact on DISCOM

- Overheating and premature failure of transformers
  - Increased iron and copper losses or eddy currents due to stray flux losses
- Overheating / damage of Neutral Ground Conductors
  - In 3-phase 4-wire system, Single-phase harmonic will add rather than cancel on the neutral conductor
- Malfunction / Mal-Operation of Sensitive Tele-control and Protection Relays
- Power factor correction capacitor failure
  - Reactance of a capacitor bank decreases as the frequency increases
  - Capacitor bank acts as a sink for higher harmonic currents
  - The System-Series and parallel Resonance can cause dielectric failure or rupture the power factor correction capacitor failure due to Over-Voltages & Over-Currents
  - Voltage Regulation

Future Challenges due to Rooftop Solar

Voltage & Current distortion may increase with increase in no. of Solar Power Inverters

Further complication of distribution feeder protection and control mechanism due to heavy inrush current

Inability of the Grid connected PV system inverter to control the reactive current drawn from Non linear loads

Power Conversion losses : From DC to AC supply

TPDDL Case Study : Methodology Followed

Collection of THD values from Relays and identification of feeders with high THD values	• Data Collected from IED's • Total Harmonic Distortion (THD) obtained from relays and energy meters installed on C&R panels
Sampling of Harmonic contents of select feeders	• Feeders having THD values > permissible limits for instantaneous values were selected (IEEE/CEA Guidelines) • Spectrum of voltage and current waveform obtained
Power quality analysis	• Analysis of Voltage & Current spectrum for select period

TPDDL Case Study : Standard Followed

- IEEE 519-1992 Standard : Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

CURRENT HARMONICS LIMITS

Ratio I_{scc} / I_{load}	Odd numbers (<11), in (%)	Odd numbers (>35), in (%)	THD (%)
< 20	4.0	0.3	5.0
20 - 50	7.0	0.5	8.0
50 - 100	10.0	0.7	12.0
>1000	15.0	1.4	20.0

VOLTAGE HARMONICS LIMITS

Bus Voltage	Voltage Harmonic limit as (%) of Fundamental	THD (%)
<= 69 KV	3.0	5.0
69 to 161 KV	1.5	2.5
>= 161 KV	1.0	1.5

TPDDL Case Study: Conclusion

- Single Phase Vs Three phase load
- HVDS Network
- Transmission Utility – Voltage Sags
- DISCOM Equipment Vs Consumer Equipment
- Unbalancing
- Transient – Switching Operations

Way Forward & Summary

- Power Quality Monitoring has become an essential component of Power System
- Availability of PQ meters at affordable prices in Indian Markets
- Customers incentivization policies to be formulated to maintain proper PQ (like Installation of Constant Voltage Transformer's & Distribution Static compensators, APFCs etc.)
- All stake holders of renewable energy (Governments, Utilities, Equipment manufacturers, Customers) must give their inputs for framing long term policies, in a time bound manner
- Development of enhanced interface devices with better filtering options

Thank You