Mahendragarh discovers Automatic Power Factor Correction system.

Static Synchronous Compensator, a power electronic device, anchors the key innovation to trim auxiliary power cost.

±500 kV Mundra-Mahendragarh HVDC transmission system is a bipolar link that evacuates up to 2500 MW of power from the Adani Power - Mundra Super Thermal Power Station at Gujarat to the Mahendragarh of Haryana state.

However, auxiliary power cost is a major expense at Mahendragarh Substation. In a bid to cut down this cost a 1 MW Solar power plant was installed here in July 2017.

Auxiliary load in the Mahendragarh station is mainly inductive. Two most critical systems, Transformer Cooling System and Valve Cooling System make use of Induction motors.

Due to this inductive auxiliary equipment, Mahendragarh station was drawing more reactive power from the grid leading to the poor power factor.

Therefore, ATIL commissioned a study to understand the load conditions of auxiliary system.

Power quality measurement was performed at different locations to understand the present load conditions of auxiliary system (both 33 kV and 415 V). The measurement was conducted using HIOKI 3197 Power Quality Analyser.

Decoding Auxiliary Power structure at Mahendragarh Converter Station-

1. Auxiliary power is supplied through two nos. 33 kV incomer feeders and each is connected to distinct substation of state utility (at a time one feeder is used).
2. Tariff metering is done at sending end (State Electricity Board) of utility and tariff is based on apparent power demand (kVA).
3. Two nos. dedicated 33 kV/415 V, 2000 kVA Transformers feed each Pole-1 & Pole-2 of HVDC converter station. The required auxiliary systems of Pole-1 and Pole-2 of HVDC Bi-Pole link is catered through the dedicated 415 V AC Distribution Boards (i.e., ACDB-1 [POLE-1] & ACDB-2 [POLE-2]).

Problem Statement:

- Low (lagging) power factor due to inductive auxiliary load.
- Variation in power factor due to site specific conditions.
- Variation in Auxiliary load with respect to operational requirements

Opportunity -

- Correction of power factor provided an opportunity for sizeable savings in Auxiliary power cost.

Pole1: 415 V ACDB-1			
Sl. No	Description	Value	Units
1	Supply Transformer kVA Rating	2000	kVA
2	Bus Nominal Voltage	415	V
3	Measurement Location	415V Incomer Feeder	
4	Date of Measurement	6th June 2018	
5	Duration of Measurement	30 minutes	
6	CT Ratio	3200/1A (Measuring CT)	
Consolidated Measurement Recorded Data (06/06/2018)			
7	Maximum Apparent Power	503	kVA
8	Maximum Real Power	395	kW
9	Maximum Reactive Power	311	kVAR
10	Minimum Apparent Power	92	kVA
11	Minimum Real Power	72	kW
12	Minimum Reactive Power	57	kVAR
13	Average Apparent Power	419	kVA
14	Average Real Power	327	kW
15	Average Reactive Power	262	kVAR

Consolidated Measurement Data for Pole 1 ACDB-1 Incomer

Pole2: 415 V ACDB-2			
Sl. No	Description	Value	Units
1	Supply Transformer kVA Rating	2000	kVA
2	Bus Nominal Voltage	415	V
3	Measurement Location	415V Incomer Feeder	
4	Date of Measurement	6th June 2018	
5	Duration of Measurement	30 minutes	
6	CT Ratio	3200/1A (Measuring CT)	
Consolidated Measurement Record Data (06/06/2018)			
7	Maximum Apparent Power	725	kVA
8	Maximum Real Power	568	kW
9	Maximum Reactive Power	450	kVAR
10	Minimum Apparent Power	525	kVA
11	Minimum Real Power	407	kW
12	Minimum Reactive Power	330	kVAR
13	Average Apparent Power	610	kVA
14	Average Real Power	478	kW
15	Average Reactive Power	378	kVAR

Consolidated Measurement Data for Pole 2 ACDB-2 Incomer

33kV Main Incomer			
Sl. No	Description	Value	Units
1	Supply	State Utility (Dhanonda)	--
2	Bus Nominal Voltage	33	kV
3	Measurement Location	33kV Incomer feeder-2 (Dhanonda)	
4	Date of Measurement	6th June 2018	
5	Duration of Measurement	30 minutes	
6	CT Ratio	1200/1A (Protection CT)	
Consolidated Measurement Record Data (06/06/2018)			
7	Maximum Apparent Power	1285	kVA
8	Maximum Real Power	983	kW
9	Maximum Reactive Power	828	kVAR
10	Minimum Apparent Power	810	kVA
11	Minimum Real Power	632	kW
12	Minimum Reactive Power	505	kVAR
13	Average Apparent Power	818	kVA
14	Average Real Power	621	kW
15	Average Reactive Power	529	kVAR

Measurement data for 33kV Incomer Feeder-2

Key findings of the data analysis:

- Minimum power factor observed on 33 kV switchgear incomer was **0.76**.
- The Total Voltage Harmonic Distortion's (V_{THD}) at 33 kV switchgear was well within the acceptable IEEE519 limits.
- Variation of load profile during the measurement was -15% with respect to maximum loading.

After analysis it was decided to provide a compensation of 1000 kVAR to improve the power factor.

A reactive power compensation STATCOM system at 33 kV level by GEPC was selected for power factor correction. The power factor compensator converter system consists of STATCOM (LV Voltage source converters), Transformer and control system. The STATCOM system can provide variable compensation between ± 1000 kVAR at 33 kV based on PWM technique.

APFC Panel and Transformer

About STATCOM:

STATCOM or Static Synchronous Compensator is a power electronic device using force commutated devices like IGBT, GTO etc. to control the reactive power flow through a power network and thereby increasing the stability of power network.

It is a member of the Flexible AC Transmission System (FACTS) family of devices.

STATCOM is a shunt device which is connected in shunt with the line.

The terms Synchronous in STATCOM means that it can either absorb or generate reactive power in synchronization with the demand to stabilize the voltage of the power network.

Conclusion:

The initiative helped in increasing the power factor of auxiliary supply system from 0.76 to unity. It cut down the auxiliary power consumption and led to considerable savings in auxiliary power expenses.

Savings Statistics:

INCOMER FEEDER-2		
P	-0.65	MW
Q	-0.46	MVAR
F	49.94	HZ
PF	-0.77	-
IR	13.60	A
IY	13.60	A
IB	12.59	A
VRY	34.28	KV
VYB	34.00	KV
VBR	34.08	KV

Power consumption before installation of APFC

INCOMER FEEDER-2		
P	-0.65	MW
Q	-0.01	MVAR
F	49.91	HZ
PF	-0.99	-
IR	11.08	A
IY	10.58	A
IB	10.08	A
VRY	34.32	KV
VYB	34.04	KV
VBR	34.08	KV

Power consumption after installation of APFC

Benefits:

Power factor of Auxiliary supply system increased from 0.76 to unity. It has decreased the Auxiliary power consumption and has led to considerable savings in auxiliary power expense.