HOLTEC

Presentation on:

"MASTERING POWER DISTRIBUTION WITH ETAP & ILMS"

: A SMART APPROACH TO MULTI SOURCE, MULTI LOAD SYSTEM

By Rajesh Gupta

ETAP SOFTWARE

HOLTEC

- A Specialized software tool for electrical power system modeling, design and analysis.
- An **Off-Line Simulator**.
- Can be used to **optimize project engineering, plant operation & integration of new sources of power and loads**.
- In Holtec, we have **latest** Version 24.0, suitable for 500 buses.

STUDIES WITH ETAP IN HOLTEC

HOLTEC

- Short Circuit
- Load Flow
- Relay Coordination
- Transient Stability / Motor Acceleration
- Arc Flash
- Harmonics Analysis

Followed by Design & Implementation of

High Speed ILMS

ETAP STUDIES – WHEN?

HOLTEC

- Recommended to conduct during **project stage**.
- If not available/done, advised to do for **Running Plants**.
- **Identify safe operational modes** amongst all available.
- Have plan to add **New Power Source or Major Load.**
- To perform **Protection Coordination** Study.

SHORT CIRCUIT STUDIES

HOLTEC

- An analysis of an electrical system which determines the magnitude of the currents that flow **during an electrical fault**.

- **Comparing calculated values against the equipment ratings** is the first step to ensuring that the power system is safely protected.

SHORT CIRCUIT STUDIES – *Result!*

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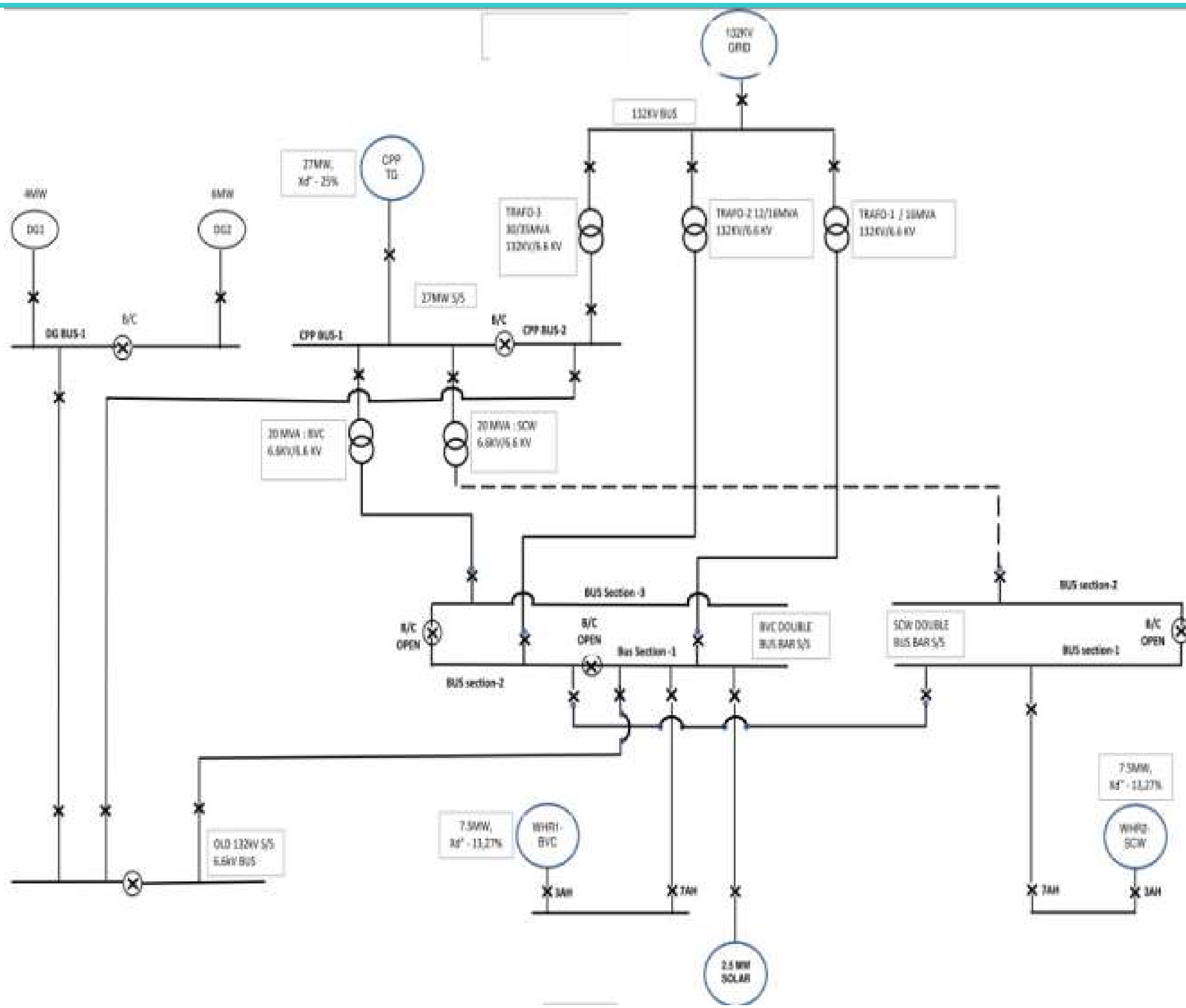
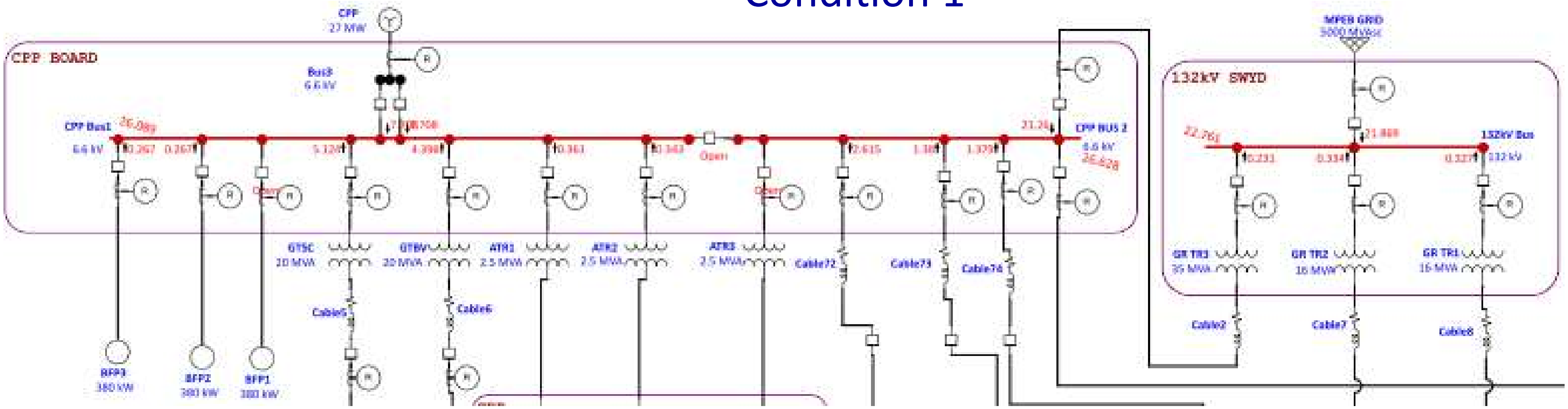
- Check & Ensure "All buses and associated equipment's **short circuit rating** are appropriate in all predefined operational scenarios".
- Identify **Safe Operational Scenarios** amongst all possible.
- Validation of arrangements for adding **New Power Sources or Major Loads (**keeping system SC level within rated limit).

SHORT CIRCUIT EXAMPLE

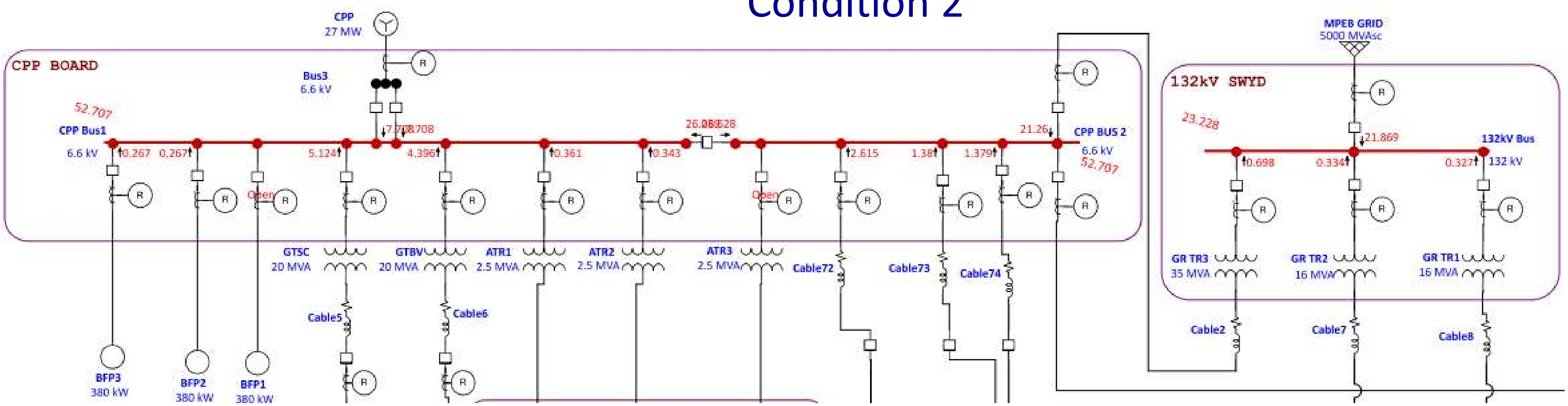


SHORT CIRCUIT EXAMPLE

Condition 1



Condition 2



SHORT CIRCUIT EXAMPLE

HOLTEC

Sl. No	Bus Voltage	Bus Description	Bus Rating in kA	Fault KA as per ETAP Study for Conditions			
				Condition 1	Condition 2	Condition 3	Condition 4
132kV SWITCH YARD							
1	132kV	132kV SWYD	31.5	22.76	23.23	22.23	23.03
CAPTIVE POWER PLANT							
1	6.6kV	CPP bus Section 1 (CPP Side)	40	26.09	52.71	52.71	57.72
2	6.6kV	CPP bus Section 2 (Grid TR3 Side)	40	26.63	52.71	52.71	57.72
3	0.433kV	CPP LV Bus Sec 1 (ATR1 Side)	50	45.66	47.96	47.96	48/16
4	0.433kV	CPP LV Bus Sec 2 (ATR2 Side)	50	45.87	48.07	48.07	48.27
5	0.433kV	CPP LV Bus Sec 3 (ATR3 Side)	50	45.87	48.07	48.07	48.27
XXXX CEMENT PLANT							
1	6.6kV	XXXX DBB (CPP Bus)	40	14.54	17.30	17.30	23.86
2	6.6kV	XXXX DBB (Grid TR1 Bus)	40	25.79	25.80	51.28	19.21
3	6.6kV	XXXX DBB (Grid TR2 Bus)	40	26.26	26.27	51.28	20.39
4	6.6kV	Raw Mill Site Bkr (From CPP Bus 2)	NA	26.63	52.71	52.71	57.72
5	6.6kV	C.M .1 Site Bkr (From CPP Bus 2)	NA	26.63	52.71	52.71	57.72
6	6.6kV	C.M .2 Site Bkr (From CPP Bus 2)	NA	26.63	52.71	52.71	57.72
7	6.6KKV	OLD 132 SS bus 1 (CPP & DG Side)	22	25.00	25.01	47.55	18.83
8	6.6KKV	OLD 132 SS bus 2 (Grid Tr1 Side)	22	25.00	25.01	47.55	18.83
9	6.6KKV	Substation-No-1 Bus	22	22.00	22.01	36.92	17.15
10	6.6KKV	Substation No-2 Bus	40	14.31	16.97	16.97	23.19
11	6.6KKV	Substation No-3 Bus	40	14.04	16.58	16.58	22.39
12	6.6KKV	Substation No-4 Bus	40	24.94	24.95	47.31	18.8
13	6.6KKV	New Kiln Cooler Substation Bus	40	13.96	16.49	16.49	23.19
14	6.6KKV	XXXX WHR PP bus	40	24.29	24.29	42.76	21.99

LOAD FLOW STUDIES

HOLTEC

- An **analysis** of an electrical system **during steady state situation** (normal operating condition) with various operational scenarios.
- Load flow studies are required for deciding / achieving the **economic operation** of the power system, therefore plays a very vital role in power system studies.

LOAD FLOW STUDIES – Result!

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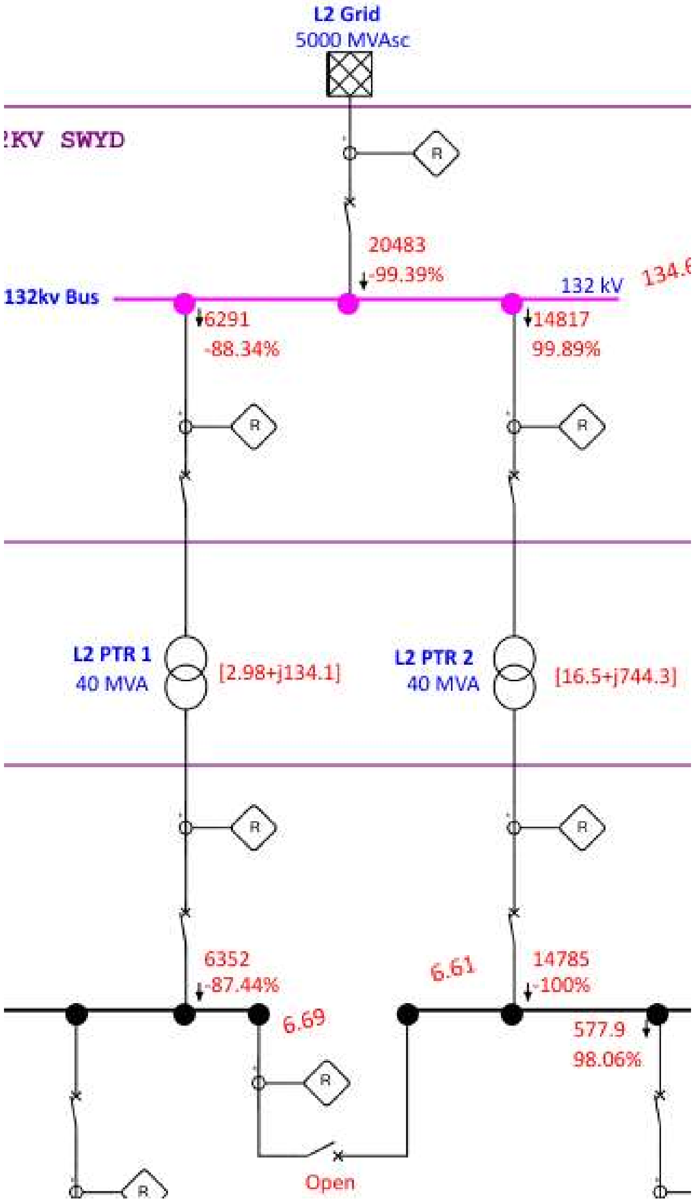
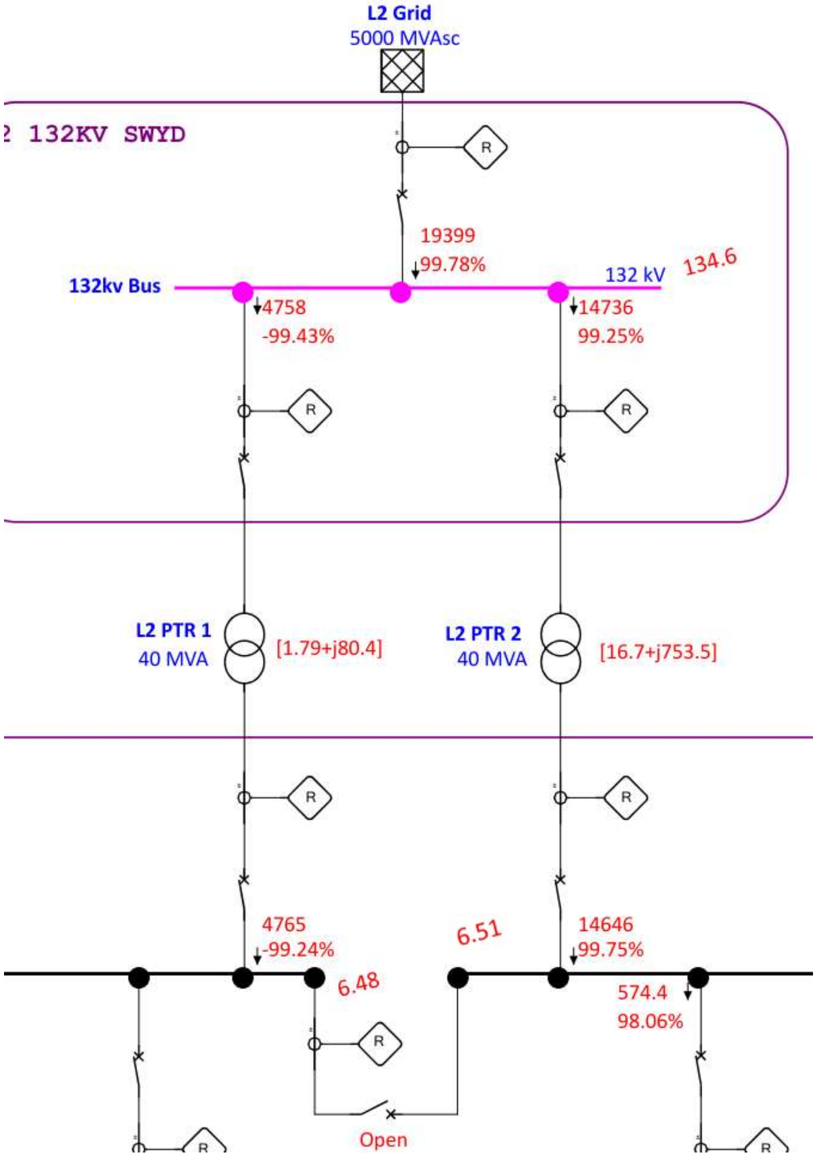
- Check & Ensure "adequacy of **continuous rating of various equipment's and branches** (cables) in all predefined operation scenarios".
- Observe the power flow pattern (both active and reactive power).
- Check & **optimise voltage profile** at different buses of the system.
- Determine and **optimise the power factor** of generator, Grid and at various busses.
- To determine & **minimize Distribution losses** & **Optimise equipment efficiency**.

LOAD FLOW STUDIES EXAMPLE



Existing



Optimized

LOAD FLOW STUDIES EXAMPLE

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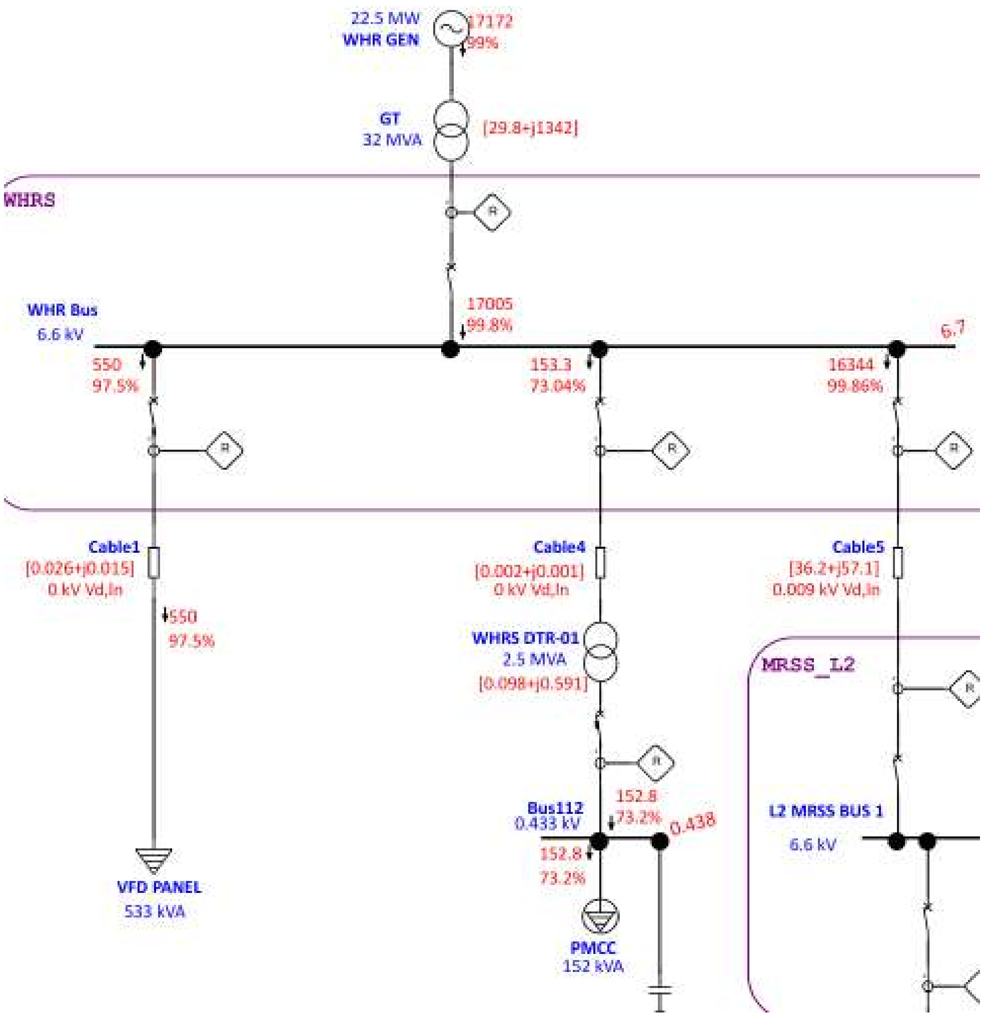
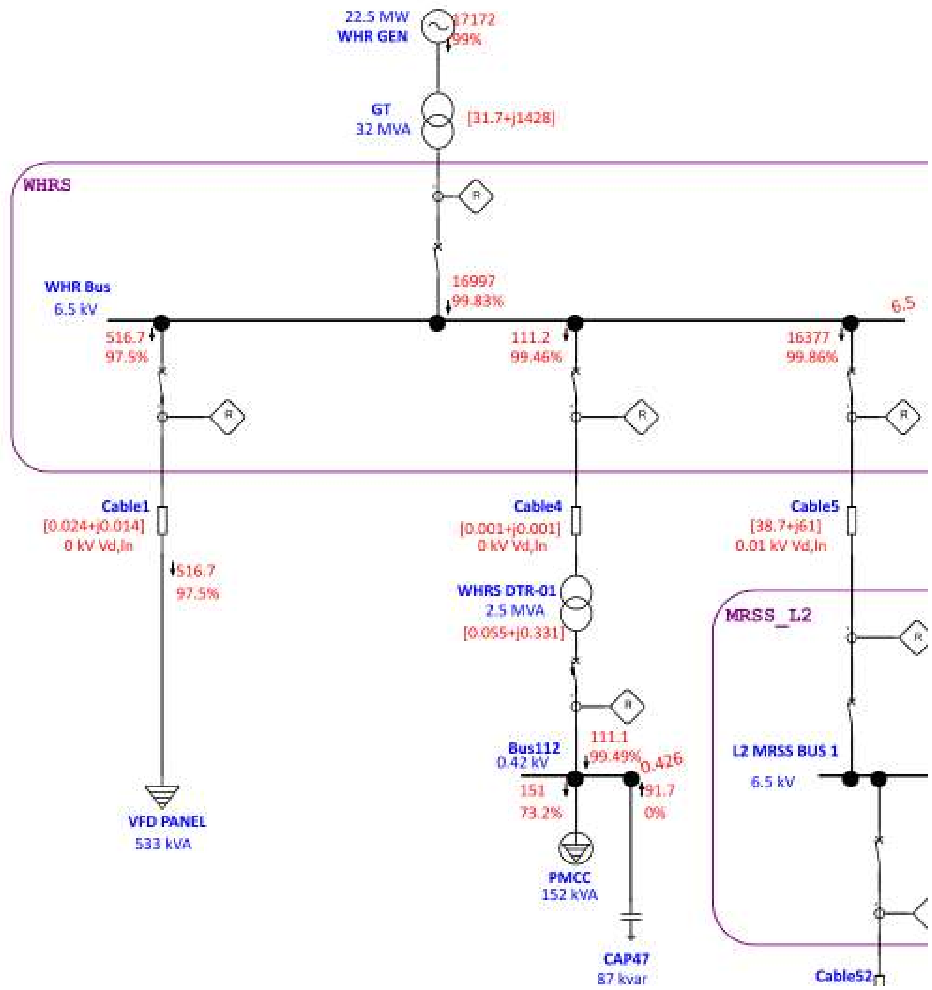


Existing



Optimized

LOAD FLOW STUDIES EXAMPLE

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Project:	**ETAP**	Page: 12
Location:	20.0.2C	Date: 31-05-2022
Contract:		SN: HOLTECCON2
Engineer:	Study Case: LF Con 1	Revision: Base
Filename:		Config.: Normal

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag
	kw	kvar	kw	kvar	kW	kvar	From	To	
TR10	582.8	362.3	-579.7	-344.0	3.0	18.3	99.7	97.9	1.76
TR2	-652.2	-334.2	655.8	355.6	3.6	21.4	99.2	98.5	0.74
TR3	-182.4	-219.0	183.0	222.2	0.5	3.1	100.1	98.5	1.56
TR4	-634.9	-393.5	638.6	415.6	3.7	22.1	99.0	98.5	0.54
TR5	-258.5	-228.0	259.3	232.7	0.8	4.7	99.8	98.3	1.46
TR6	244.1	348.1	-243.0	-341.3	1.1	6.8	98.3	99.4	1.06
TR7	280.8	290.6	-279.9	-285.6	0.8	5.0	98.5	99.9	1.49
TR8	-549.8	-398.0	552.0	411.6	2.3	13.6	99.5	98.4	1.08
TR9	566.1	348.5	-563.7	-334.5	2.3	14.0	99.7	98.3	1.38
					466.4	3444.3			

LOAD FLOW STUDIES EXAMPLE

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3.4.2 Recommendation for optimisation of MV & LV Buses Voltage & PF

It is recommended to maintain optimum voltage and PF on each MV & LV Bus Section. Maintaining Voltage and PF on each LV & MV Bus Section will help a lot to maintain Grid PF unity irrespective of the operating condition. Hence recommendation proposed shall be same for all operating condition. Following are recommendations to optimise Voltage and PF on all MV & LV Buses:

- **Maintain both the lines 6.6kV Voltage in Auto.** This shall be achieved with the help of Auto operation of Power Transformer Tap Changer. To achieve it, the AVR and Tap changer control section need to be checked and set right if found any defect. Also setting in AVR shall be done considering **target bus Voltage 6.5kV** with bandwidth such that OLTC shall not have very frequent operation. For this the services of AVR service engineer will be required.
- Line 1 power transformers are not designed as per the requirement of existing Grid voltage variation. Modification cost shall be almost same as cost of new transformer hence **Replace Line 1 both Power Transformers** with same rating new transformers however tap changer shall be designed for +10% to -15% Voltage variation. This will not only help in maintaining optimum bus voltage at 6.6kV buses but also be **very much helpful for stoppages of plant due to over voltage condition.**
- **Maintain Optimum LV Bus Voltage (420V).** This shall be achieved by maintaining all distribution taps as suggested in Table – 3.4.2-1 & Table -3.4.3-2.

S. No.	Distribution Transformer	Tap Position during measurement	Proposed Tap Position	Action Proposed
LINE-1				
MRSS				
1	T-11	1	2	Change
2	T-21	1	2	Change
3	T-2A1	1	2	Change
4	T-2A2	1	2	Change
5	T-2B1	1	2	Change
6	T-2B2	1	2	Change

LOAD FLOW STUDIES EXAMPLE

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SAVING POTENTIAL (BY IMPLEMENTING SUGGESTION OF LOAD FLOW STUDY)								
S. No	**Observation**	**Recommendations**	**Expected Benefits**	**Saving in KW**	**Saving/Yr (Rs in Lacs)**	**Expected Investment (Rs in Lac)**	**Pay Back in Years**	**Implement. Period**
1	Existing Operating condition is having high distribution losses	It is strongly recommended to operate as detailed in condition 6	Saving in distribution losses	60.8	33.71	-		Immediate
2	In both lines, voltage control on 6.6kV buses are kept in manual and normally maintained 6.6kV and above by operator only if bus voltage raised abnormally.	It is strongly recommended to maintain both the lines 6.6kV buses voltage in Auto with target Voltage 6.5kV. To achieve this, it is proposed that Grid Power Transformers AVR shall be kept in Auto mode.	1. Equipment Safety since over voltage can be harmful to equipment. 2. Voltage base Losses in the MV equipment can be save.	26.6	14.75	3.0	0.19	Immediate

POWER SYSTEM PROTECTION

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Objective

- Identify system faults and automatically initiate action to isolate the faulty equipment or section of electrical network whilst ensuring minimum disruption to healthy part of the system.

- Prevent or minimize equipment damage by reducing the arc flash energy with quick identification of fault and rapid disconnection of faulty equipment or section of electrical installation.

STAGES OF FAULT CLEARANCE

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Occurrence of fault.

- Occurrence of fault

Measurement by instrument transformer.

- Measurement by instrument transformer

Analysis by protective relay for initiating selective tripping.

- Analysis by protective relay for initiating selective tripping

Switchgear to clear the fault.

- Switchgear to clear the fault

RELAY CHARACTERISTICS

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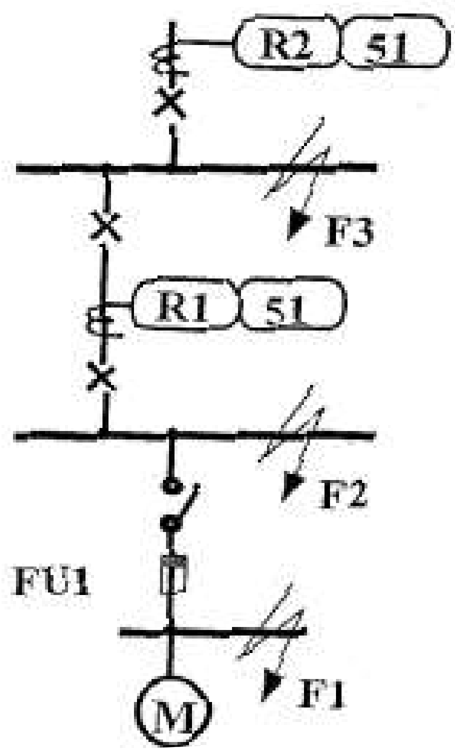
- **SPEED** (Fast to make decision)
  - Minimizes damage from current
  - Maximizes power transfer and system stability
- **SECURITY** (Malfunctioning)
  - Relay should not cause CB to open during normal conditions
- **DEPENDABILITY** (Reliability)
  - Relay should cause CB to open during abnormal operation
- **SENSITIVITY** (Pickup value)
  - Ability to detect all abnormal and fault conditions
- **SELECTIVITY**
  - Ability to discriminate between faults internal and external to its intended zone of protection

PRIMARY & BACKUP PROTECTION

- Devices closest to the fault offers primary protection.
- Device next in line offers backup protection.
- If the primary protective device fail to clear the fault, backup protection should operate to clear the fault.



Function of Fuse FU1

- Primary for F1 Fault

Function of R1 Relay

- Primary for F2 Fault
- 1st backup for F1 Fault

Function of R2 Relay

- Primary for F3 Fault
- 1st backup for F2 Fault
- 2nd backup for F1 Fault

WHY RELAY COORDINATION

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- The objective of relay coordination study is to determine the characteristics, ratings, and settings of protective devices.
- Achieve good and reliable selectivity of the protection to limit the supply interruption to the smallest area possible.
- To give a clear indication of the faulted part of the network. This makes it possible to direct the corrective action to the faulty part of the network and the supply to be restored as rapidly as possible.

WHEN RELAY COORDINATION

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- **During Project** planning stages of a new system.

- In the **case where an existing system is modified** and **new loads and/or sources are installed**, or when existing major equipment is replaced with higher rated equipment.

COORDINATION CURVE

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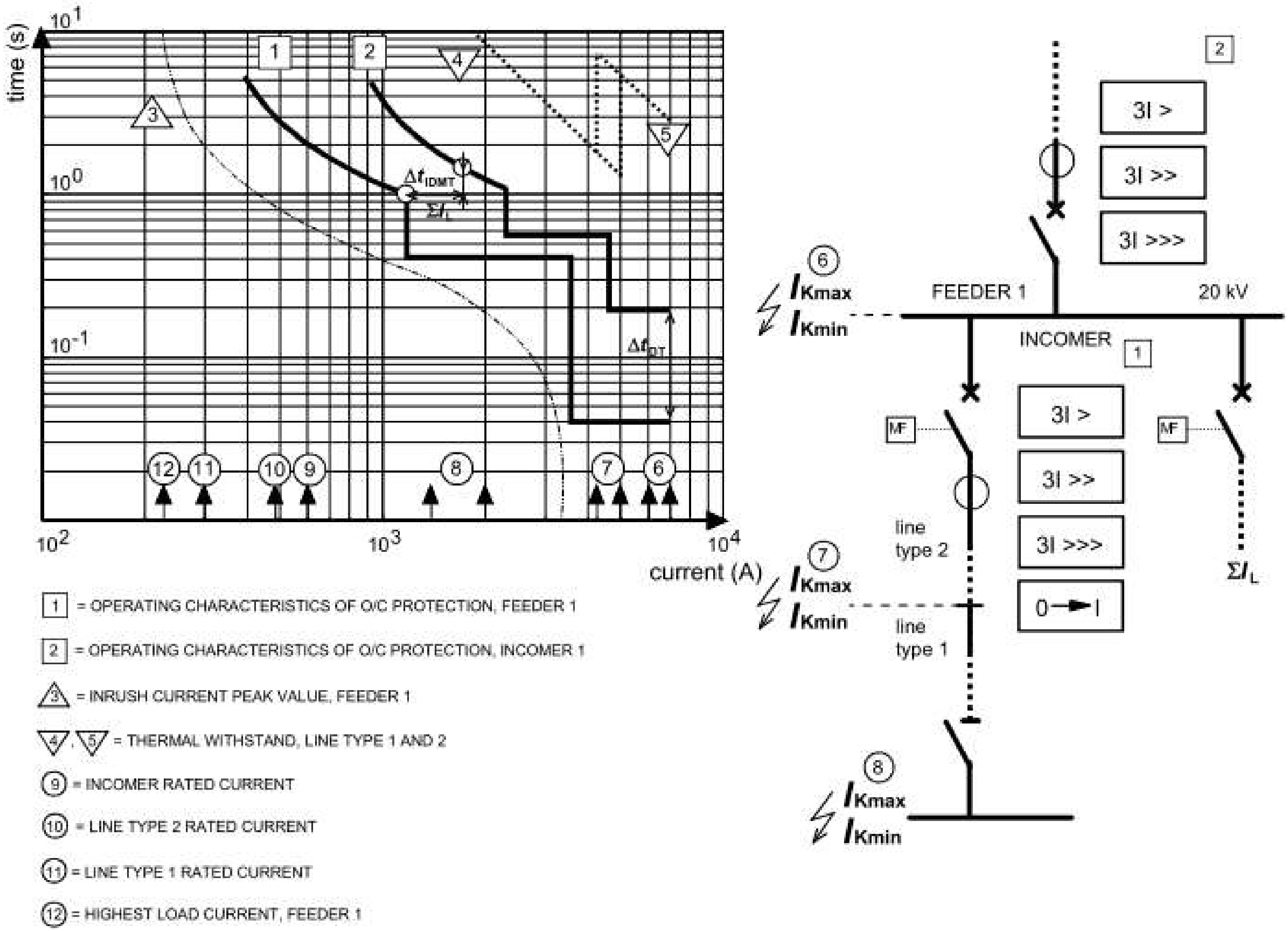
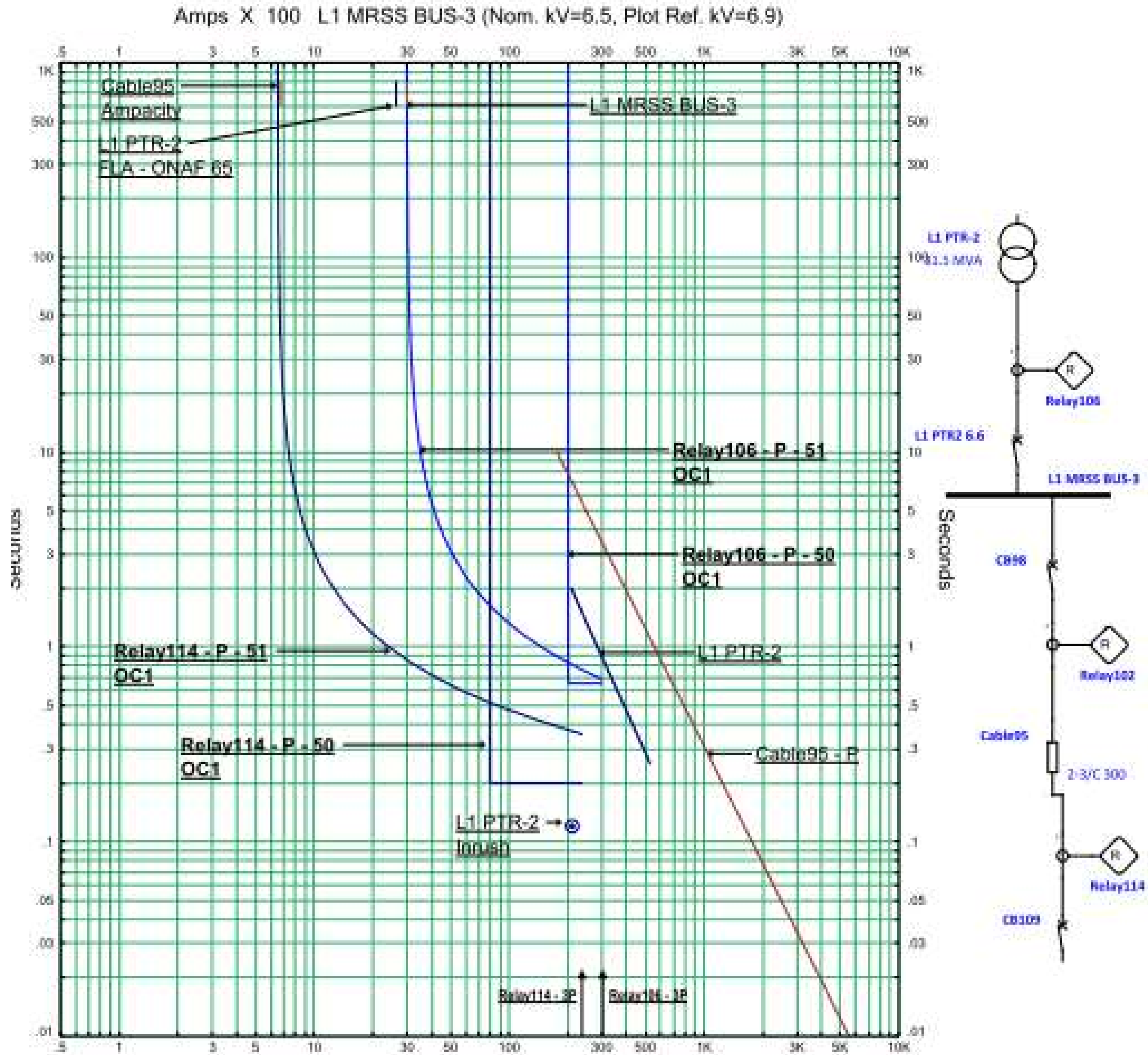


RELAY COORDINATION EXAMPLE - CURVE



RELAY COORDINATION EXAMPLE - SETTING

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Project:	YANBU CEMENT PLANT	ETAP		Page:	1
Location:	SAUDI ARABIA	16.0.0C		Date:	12-10-2016
Contract:				Revision:	Base
Engineer:					
Filename:	YANBU Relay Co-ordination	Protective Device Settings			

OCR: Relay1

MFR: Siemens   Tag #:

Model: 7UM62

	CT	Base kV	If (kA)
Phase:	600/5		
GND:	600/5		
Sen. GND:	600/5		

OC Level: OC1

		Range	Setting
Phase TOC	IEC - Very Inverse		
	Pickup (Tap)	0.5 - 20 Sec - 5A	5.950
	Time Dial		0.600
Ground INST	Pickup	0.002 - 1 Sec - 1A	0.146
	Time Delay	0 - 60 Sec	1.000

RELAY COORDINATION SUGGESTION

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0.3.3 ON RELAY COORDINATION

Relay coordination has been performed on ETAP software considering all possible operating conditions. Following are the observations and recommendations:

- In both lines, we are proposing **replacement of relays due to Upgrade / as per protection requirement**. Details for the relays to be replaced are available in Table 4.4.1 & Table 4.4.2.
- **It is recommended to implement relay settings as proposed "Setting 4.6.1 & Setting 4.6.2".** Please note we are suggesting settings for proposed relays to be replaced. Until relay replacement old relays to be set with same setting as for as possible.
- During Visit Both Tie feeders between WHR MV Bus and MRSS Bus 1 were found "ON". **It is strongly recommended to keep only one Tie feeder "ON".** Keeping Both Tie "ON" creates relay coordination issue.
- NGR for WHR Generator Transformer and Power Transformer 1 found "ON" while WHR was in parallel operation with Power TR1 although there is a provision of Motorized Isolator in WHR NGR. **It is strongly recommended to ensure that WHR GT NGR Isolator shall be "OFF" while WHR is running in parallel with Any of the power Transformers. For the same, a suitable logic shall be developed in WHR DCS.** Please note if both shall be ON shall create uncoordinated tripping during Earth Fault in system.
- NGR for WHR Generator Transformer is designed to limit earth fault current to 100A whereas for power transformers NGR's are designed for 600A. To avoid uncoordinated tripping due to E/F during the Island operation of **WHR (if any proposed) its NGR shall be changed to limit E/F current to 600A**.
- Line 1 MRSS Bus 2 has 02 Tie feeders for DG Bus. As per operational requirement and to avoid relay coordination complexity, **it is recommended to always Switch ON only one Tie feeder for DG Bus 1 (Refer Relay coordination SLD)**. If required, a second Tie feeder shall be used as spare feeder.
- Line 2 MRSS Bus has 02 Tie feeders for DG Bus. As per operational requirement and to avoid relay coordination complexity, **it is recommended to always Switch ON only one Tie feeder for DG Bus 1 (Refer Relay coordination SLD)**. If required, a second Tie feeder shall be used as spare feeder.

POWER SYSTEM STABILITY

HOLTEC

- Property of power system containing 02 or more machines.
- Ability to return to normal or stable operation after having been subjected to some form of disturbance.
- 03 Types of Stabilities
  - ✓ **Steady State** – Response to gradually increasing load. Define upper limit of loading without loss of synchronism when loading is increased gradually.
  - ✓ **Dynamic** - Response to small disturbance occur in system producing oscillation. Dynamically stable is these oscillations do not acquire more than certain amplitude and die quickly.
  - ✓ **Transient** - Response to large disturbance which may cause large changes in rotor speed, power angle and power transfer. It is a fast phenomenon usually evident within few seconds.

TRANSIENT STABILITY STUDY

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- **The Study** of the dynamics of Power System under large disturbance : (*Three phase faults at generator terminals or at Grid side, losses of generation or loss of load etc*) .
- This study results indicates first angular swing and subsequent **angular swings** of generator rotor with **critical fault clearing time** by which fault or faulty part of the system should be isolated to remain / maintain the synchronism of balance system.
- During such disturbance, all parallel connected sources / generators will have tendency to feed fault. With clearance of fault on a disturbance, these disturbed parameters of each generator will try to regain its original values / position through in shortest possible time.

TRANSIENT STABILITY STUDY- With ETAP

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- The Study performed with various operating and fault conditions.
- Establish Critical fault clear time by Simulation of Fault & its time duration (Fault clearing time) on ETAP & run program.
- Result of study creates various curves like Power Angle, Generator Electrical & Mechanical power, speed, etc.
- First swing of relative movement between rotors (power angle) of all generating sources, in each of the study case, is monitored. It shall be below 100Degree and subsequent swings should be decreased to ensure that the disturbance is damped.
- Set protection relay to clear fault well below critical fault clearing time.

TRANSIENT STABILITY CURVE

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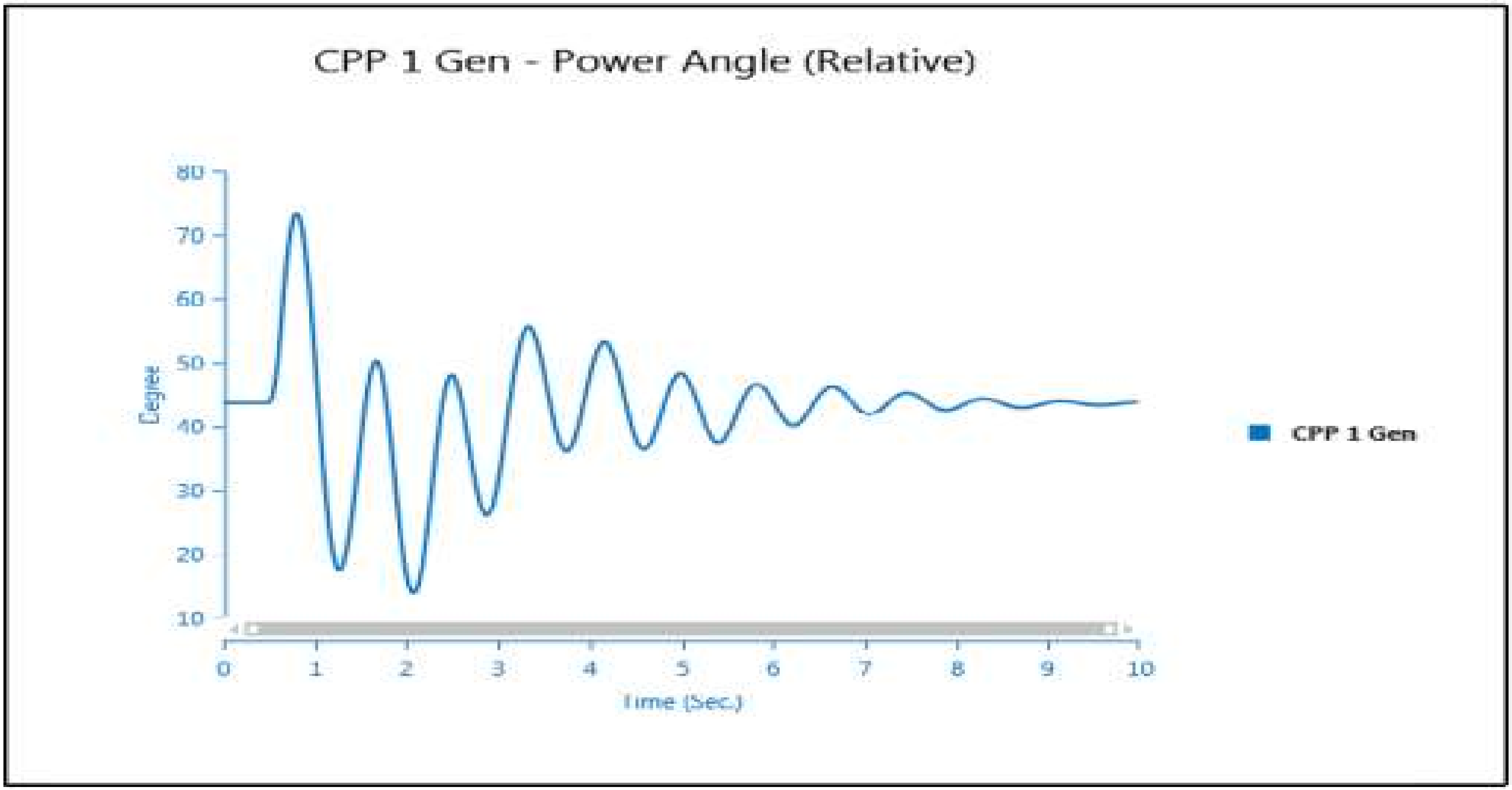
ETAP
19.0.1C

Project:
Location:
Contract:
Engineer:

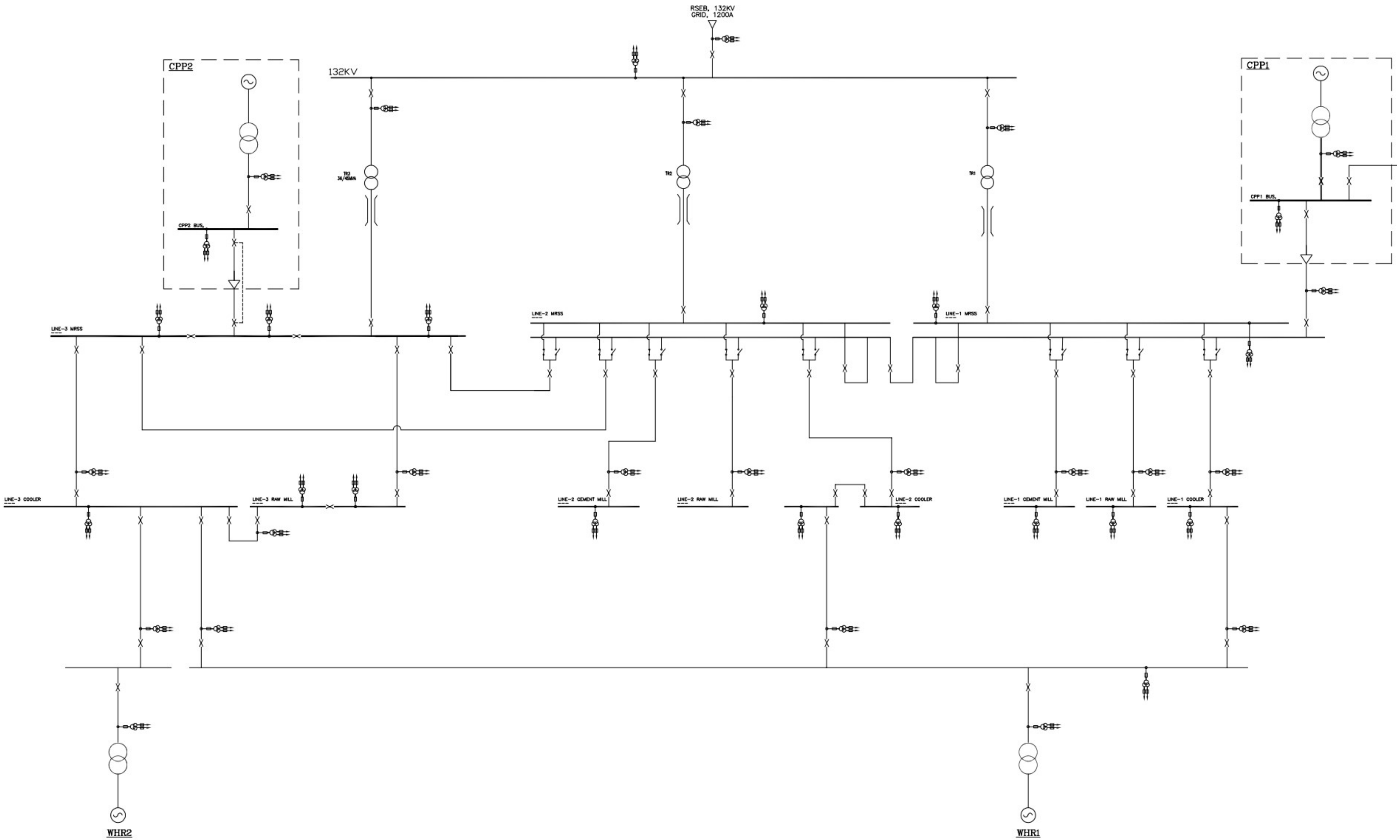
Study Case: Mode1 Case1

Date: 11-01-2020
SN: HOLTECCON2
Revision: Base
Config: Normal



TRANSIENT STABILITY EXAMPLE

HOLTEC



TRANSIENT STABILITY EXAMPLE

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MODE 1: Grid + 1X38MW TG + 1X31.5MW TG + 1X18MW WHR + 1X12MW WHR TG

CASE 1

PLOT FOR THREE PLASE SHORT CIRCUIT AT Grid BUS

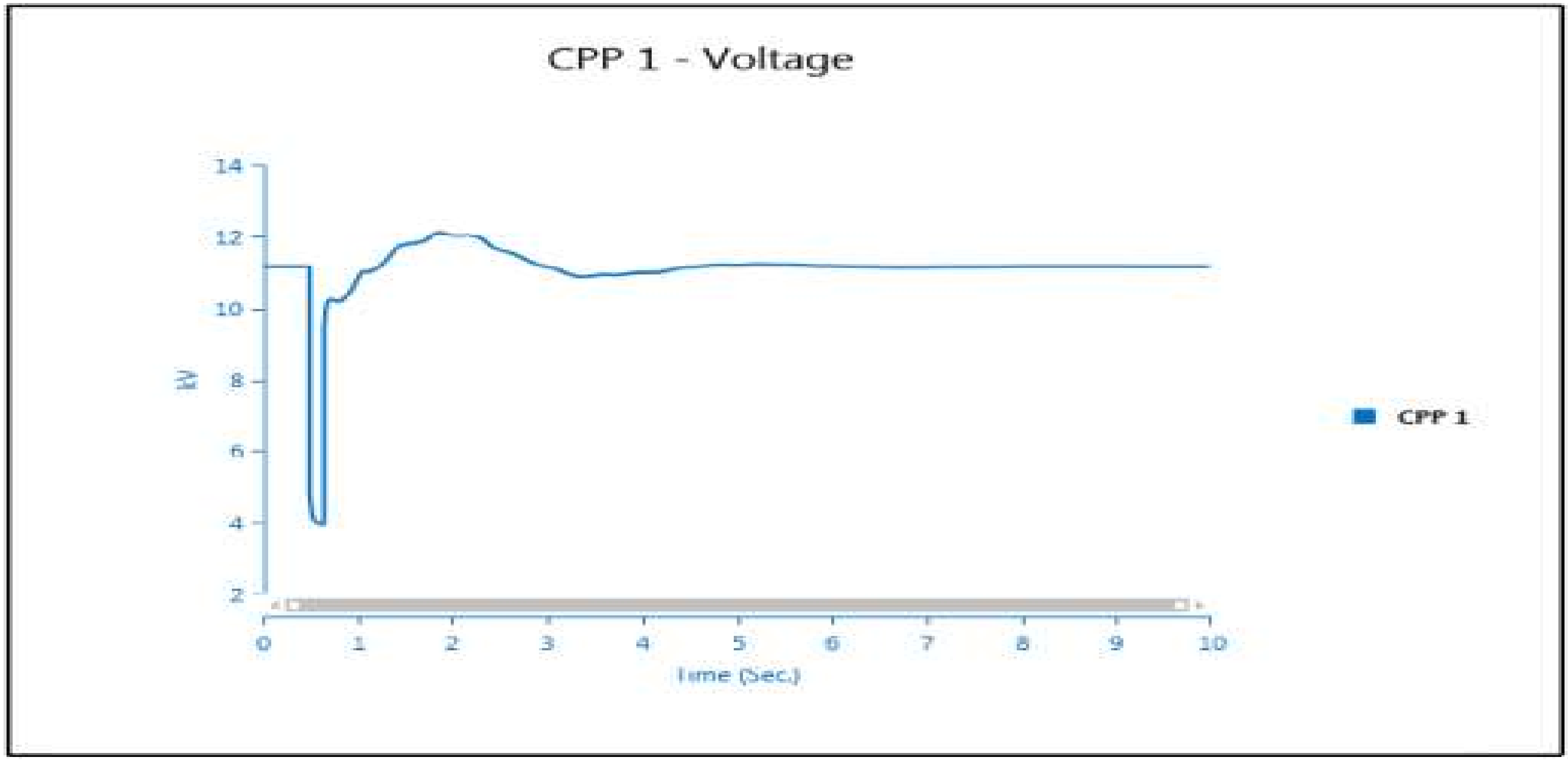
FAULT SIMILATED AT	0.500 SEC
FAULT CLEARED AT	0.650 SEC
CRITICAL FAULT CLEARING TIME	0.150 msec

TRANSIENT STABILITY CURVE

HOLTEC

ETAP
19.0.1C

Project:		Date:	11-01-2020
Location:		SN:	HOLTECCON2
Contract:		Revision:	Base
Engineer:	Study Case: Mode1 Case1	Config:	Normal

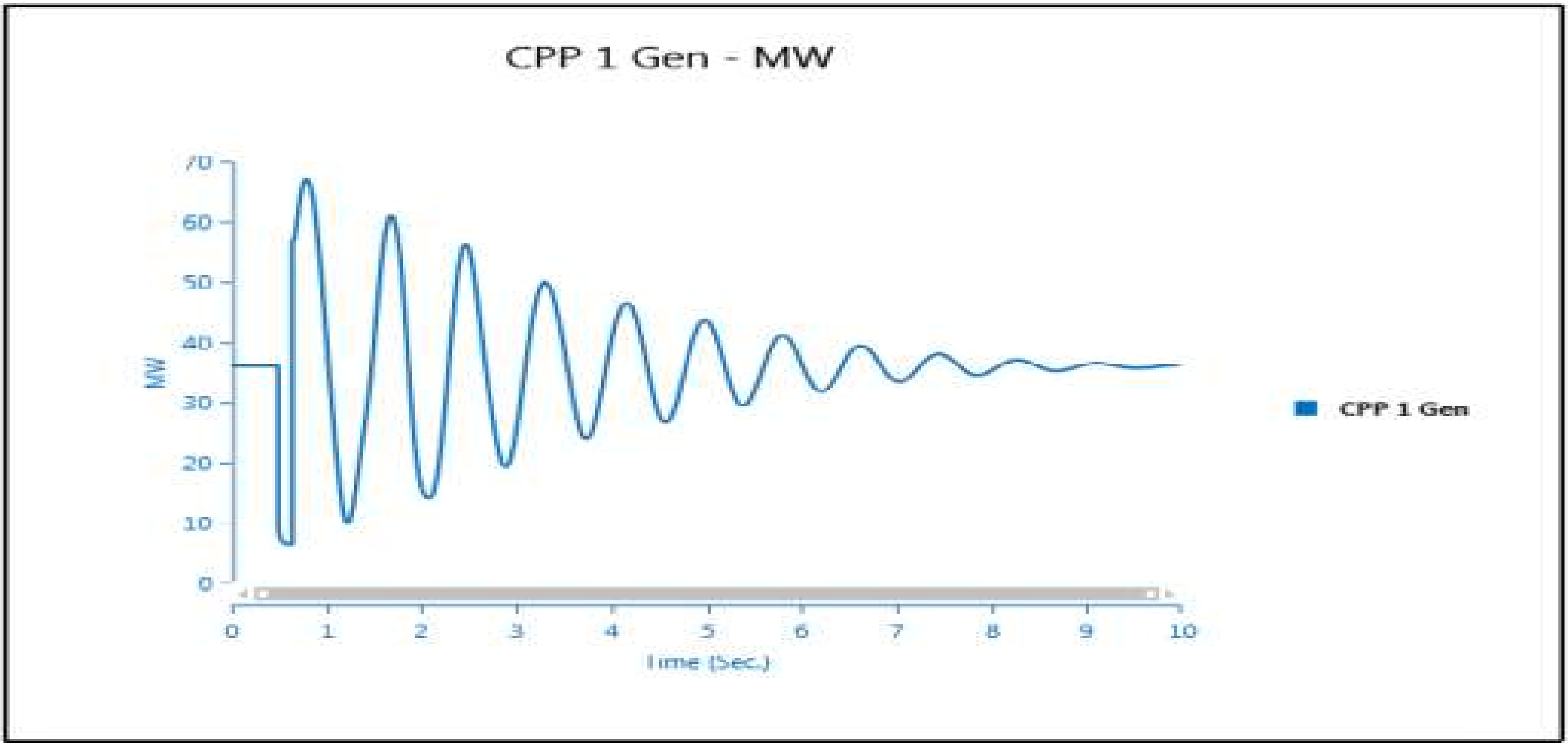


TRANSIENT STABILITY CURVE

HOLTEC

ETAP
19.0.1C

Project:		Date:	11-01-2020
Location:		SN:	HOLTECCON2
Contract:		Revision:	Base
Engineer:	Study Case: Mode1 Case1	Config:	Normal



POWER DISTRIBUTION importance in Cement Plants?

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Cement plants are power intensive and approx. 30% of production cost is power cost.

↓

Availability, power cost, reliability & minimum plant stoppages plays major role in Cement manufacturing cost.

↓

To become competitive, power consumption & cost need to be optimized.

Why has cement plant POWER DISTRIBUTION become so COMPLEX?

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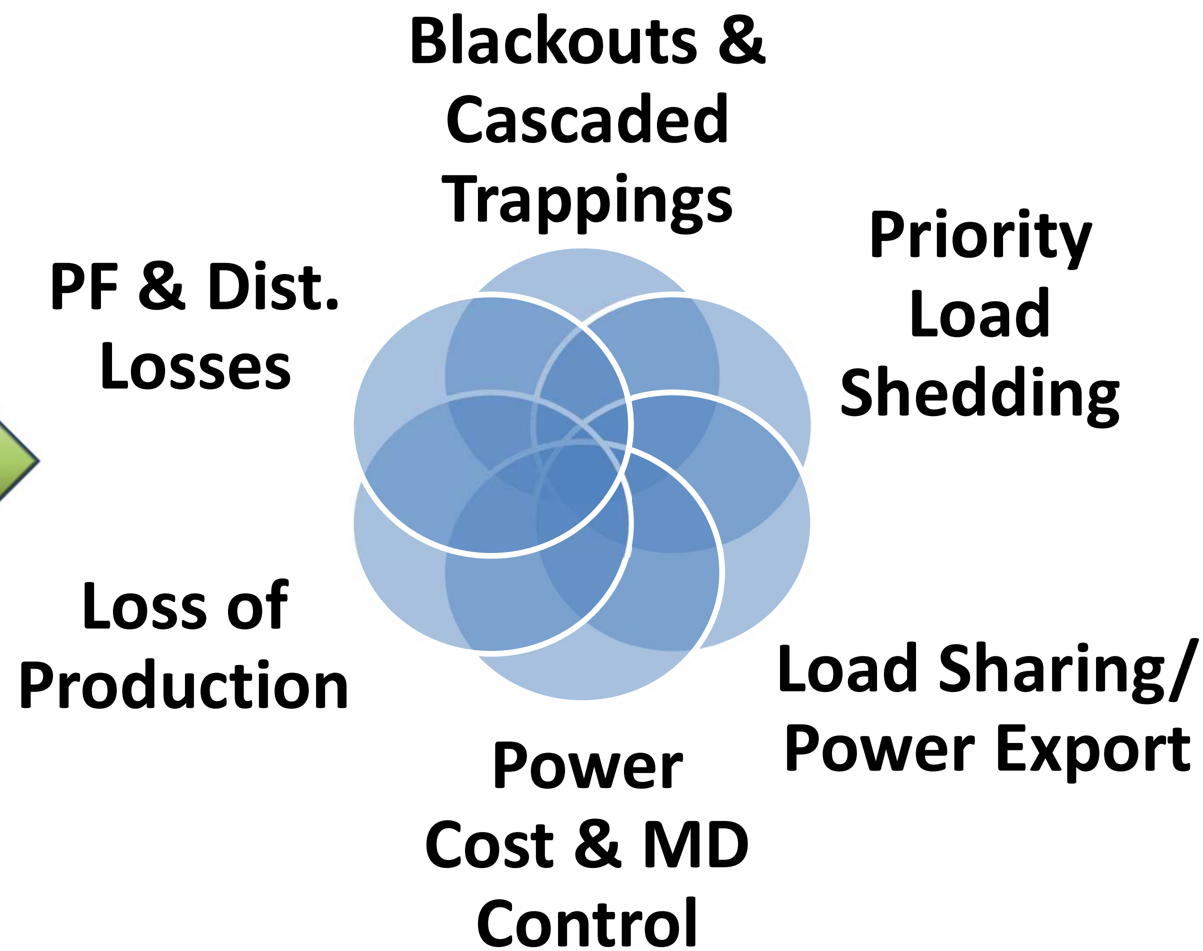
Measures taken to address various power issues

To reduce power costs	Opted various power sources viz GRID, CPP, WHR, Solar, Wind
To reduce power consumption	System modifications
To remunerate rapid growth	Multiple lines at same location

The decision for these improvements were taken at a later stage resulting in *Cement Plant Power Distribution complexity.*

Challenges with COMPLEX POWER DISTRIBUTION!

ILMS – A TOOL TO ADDRESS



INTEGRATED LOAD MANAGEMENT SYSTEM

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A Dedicated PLC Based Control System intended to achieve:

- **High-Speed** Clearing of Grid Faults / Other critical faults
- Priority based **Fast (<100ms)** Load Shedding by continuous power monitoring of all sources & loads
- Backup df/dt & Manual Load Shedding Function
- Balanced & Unbalanced Load Sharing between Generators
- Active & Reactive Power management for all source / load busses
- Grid PF control & Grid Power Export Control
- Fast Bus Transfer - Transferring Buses from one source to another

ILMS EXAMPLE - SLD

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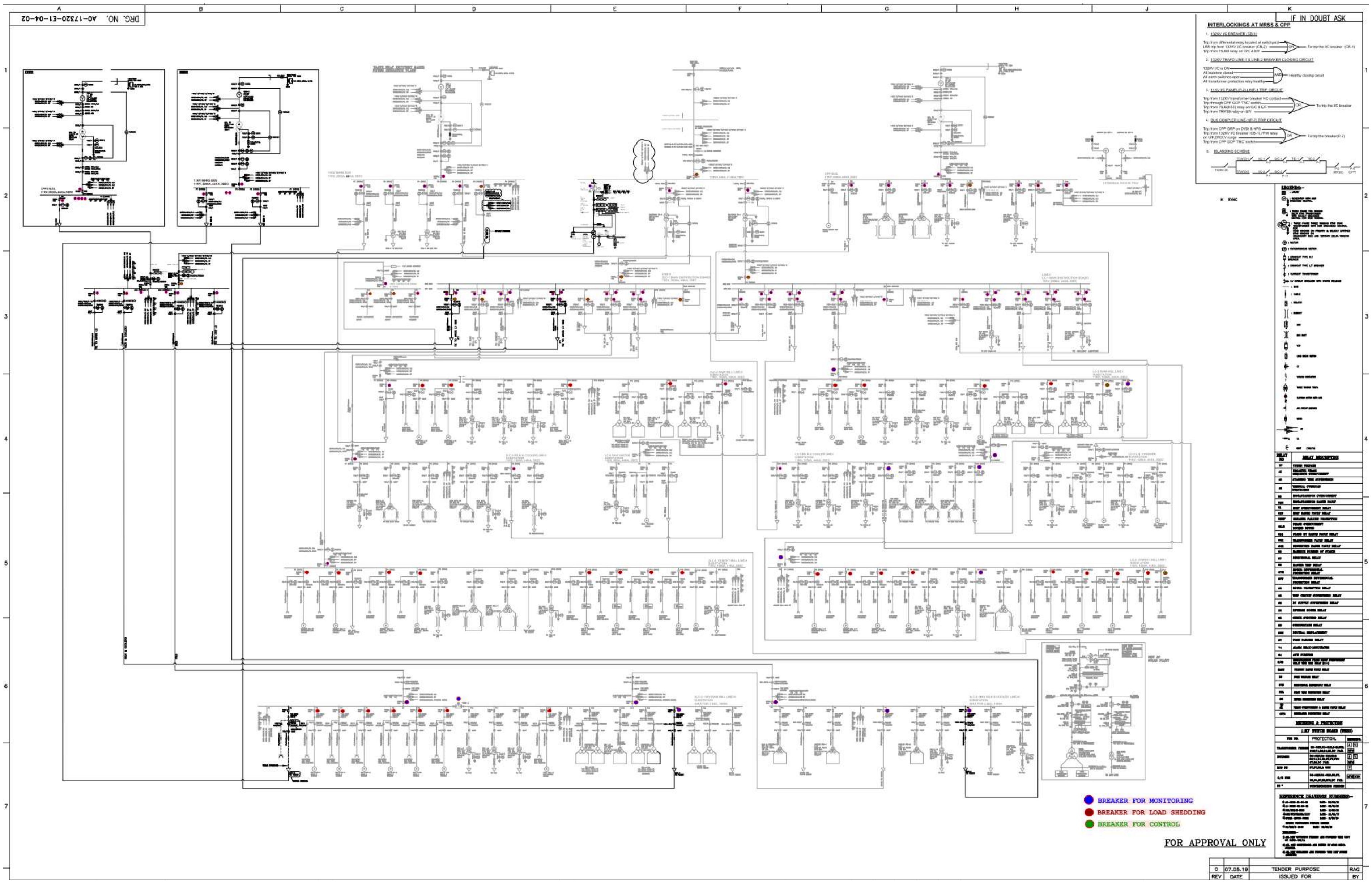
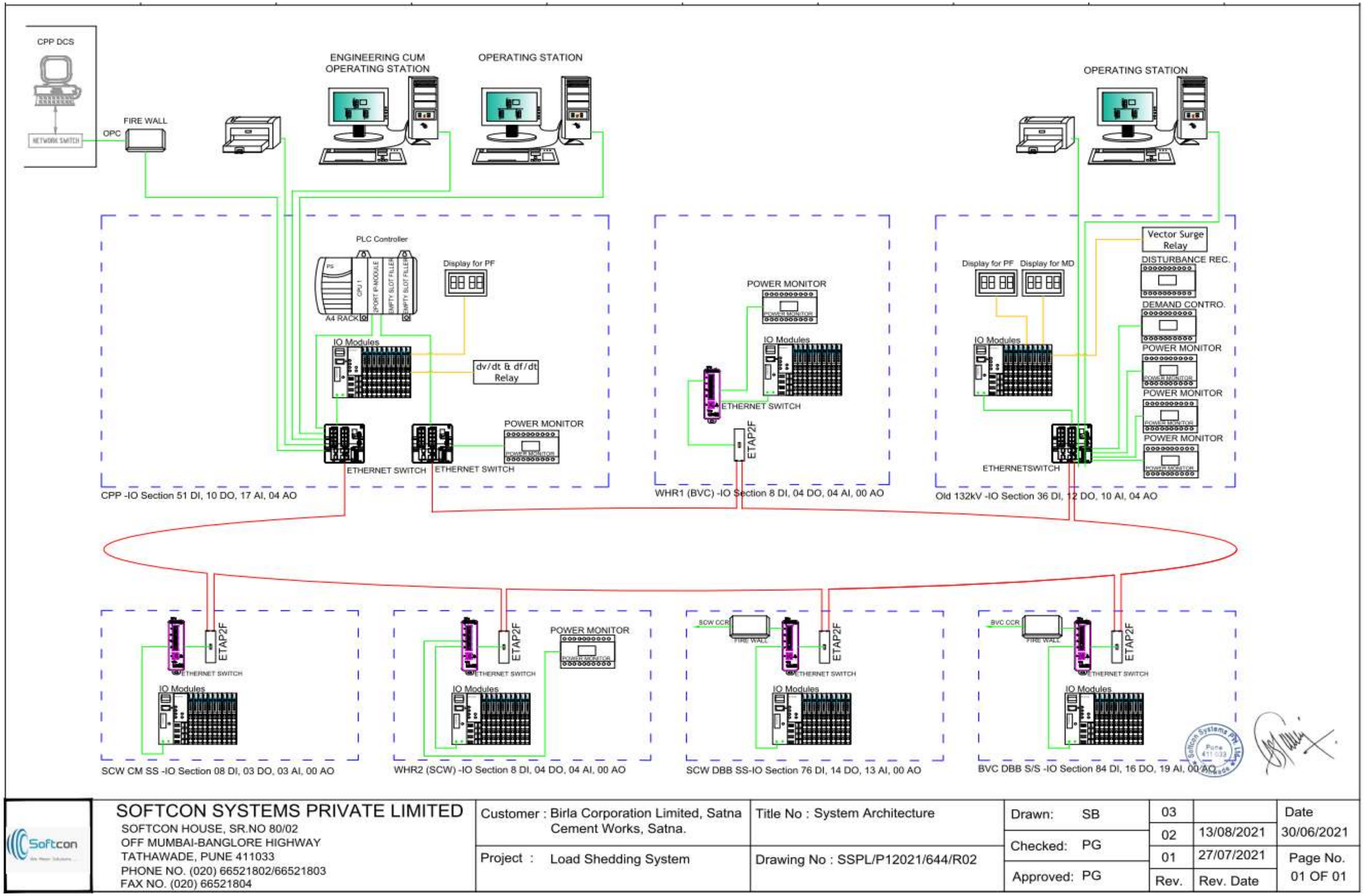


ILMS EXAMPLE - ARCHITECTURE



ILMS EXAMPLE – IO Counts

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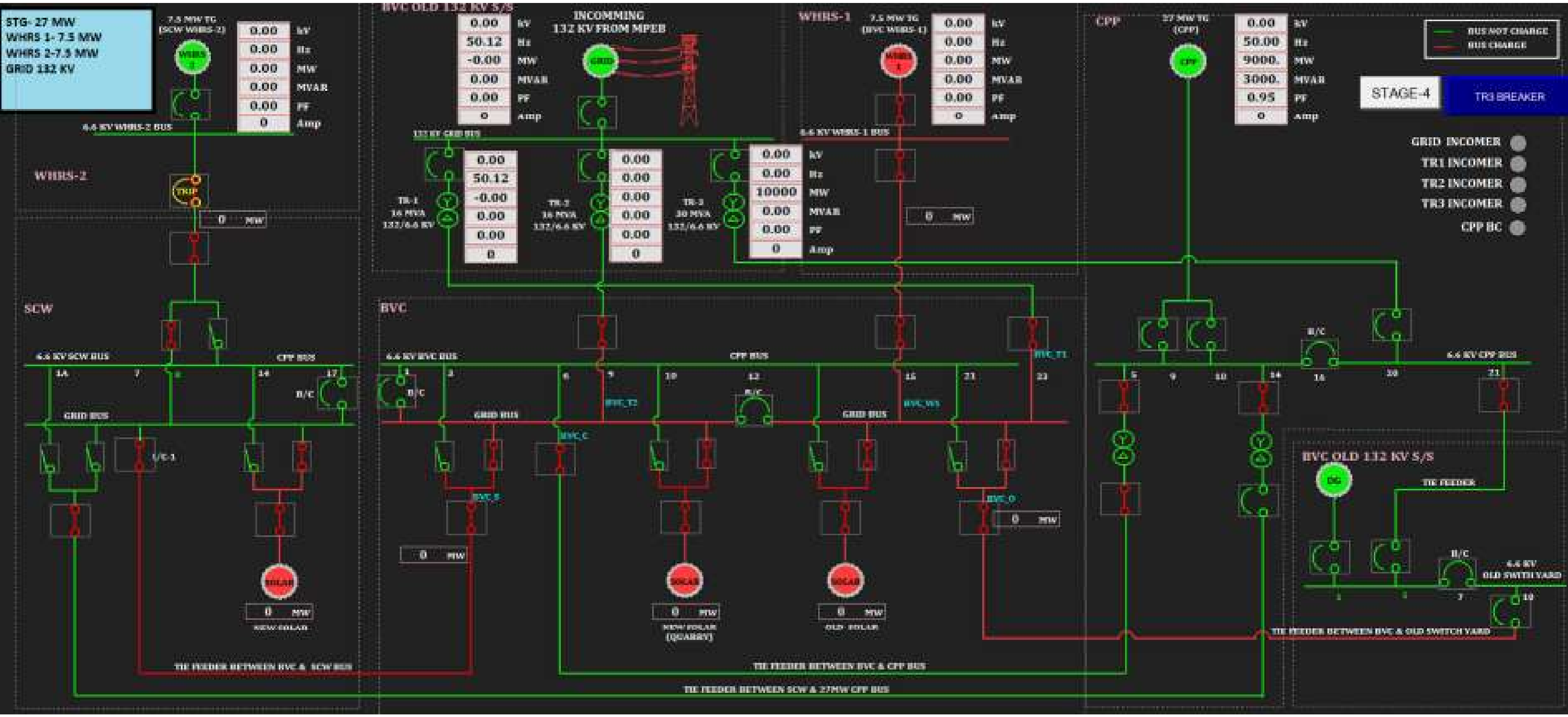
S.No.	EQUIPMENT	No. of Fdrs	Type of Signal			Remarks
			DI	DO	AI	
1	CPP 1	9	27	1	9	
2	CPP 2	6	18	0	6	
3	WHRS PP 1	6	18	1	6	
4	WHRS PP 2	5	15	0	5	
5	MRSS L3 Bus	8	24	1	8	
6	MRSS L2 Bus	9	39	5	9	
7	MRSS L2 (Cap)	4	12	2	4	
8	MRSS L1 Bus	11	47	1	11	
9	MRSS 132 Bus	4	12	1	4	
10	L3 Coal Mill S/S	1	3	1	1	01 breakers for Coal Mill for load shedding
11	L3 Raw Mill S/S	11	33	7	11	07 breakers (For Raw Mill & Coal Mill) for load shedding
12	L3 Kiln & Cooler S/S	3	9		3	
13	L2 Raw Mill S/S	7	21	4	7	04 breakers (For Raw Mill & Coal Mill) for load shedding
14	L2 Kiln & Cooler S/S	2	6		2	
15	L2 Cement Mill S/S	9	27	8	9	08 breakers (For 02 Cement Mills) for load shedding
16	L1 Raw Mill S/S	7	21	5	7	04 breakers (For Raw Mill & Coal Mill) for load shedding
17	L1 Kiln & Cooler S/S	4	12	0	4	
18	L1 Cement Mill S/S	11	33	9	9	08 breakers (For 02 Cement Mills) for load shedding
	Total	**117**	**377**	**46**	**115**	

ILMS EXAMPLE – Screen



ILMS EXAMPLE – Screen

HOLTEC

FEEDER STS	FIXED KW	FEEDER EN\DS	RUNNING KW	MANUAL TRIP	PRIORITY	ERR	FEEDER READY FOR TRIP WHILE ANY SOURCE TRIP WITH RELEVANCY. DW 1	DW 2	DW 3	DW 4	DR 1	DR 2	DR 3	DR 4	DR 5	GRD NVT	GRD EPZ	GRD ASH	CMD STS
ON STS	1000	DIS	1501		19														
ON STS	1000	DIS	1099		3														
ON STS	1000	DIS	2617		18														
ON STS	1000	EN	1852	MAN TRIP	2														
ON STS	1000	EN	1914	MAN TRIP	4														
ON STS	1000	EN	1707	MAN TRIP	5														
ON STS	1000	DIS	1556		16														
ON STS	1000	DIS	1415		14														
ON STS	1000	EN	1124	MAN TRIP	17														
ON STS	1000	EN	2655	MAN TRIP	15														
OFF STS	1000	DIS	0		20														
ON STS	1000	EN	664	MAN TRIP	1														
ON STS	1000	EN	1323	MAN TRIP	6														
ON STS	1000	EN	0	MAN TRIP	11														
ON STS	1000	EN	2079	MAN TRIP	12														
ON STS	1000	EN	2037	MAN TRIP	7														
ON STS	1000	EN	2954	MAN TRIP	10														
ON STS	1000	EN	788	MAN TRIP	13														
ON STS	1000	EN	1810	MAN TRIP	9														
ON STS	1000	EN	2386	MAN TRIP	8														

ILMS EXAMPLE – Screen

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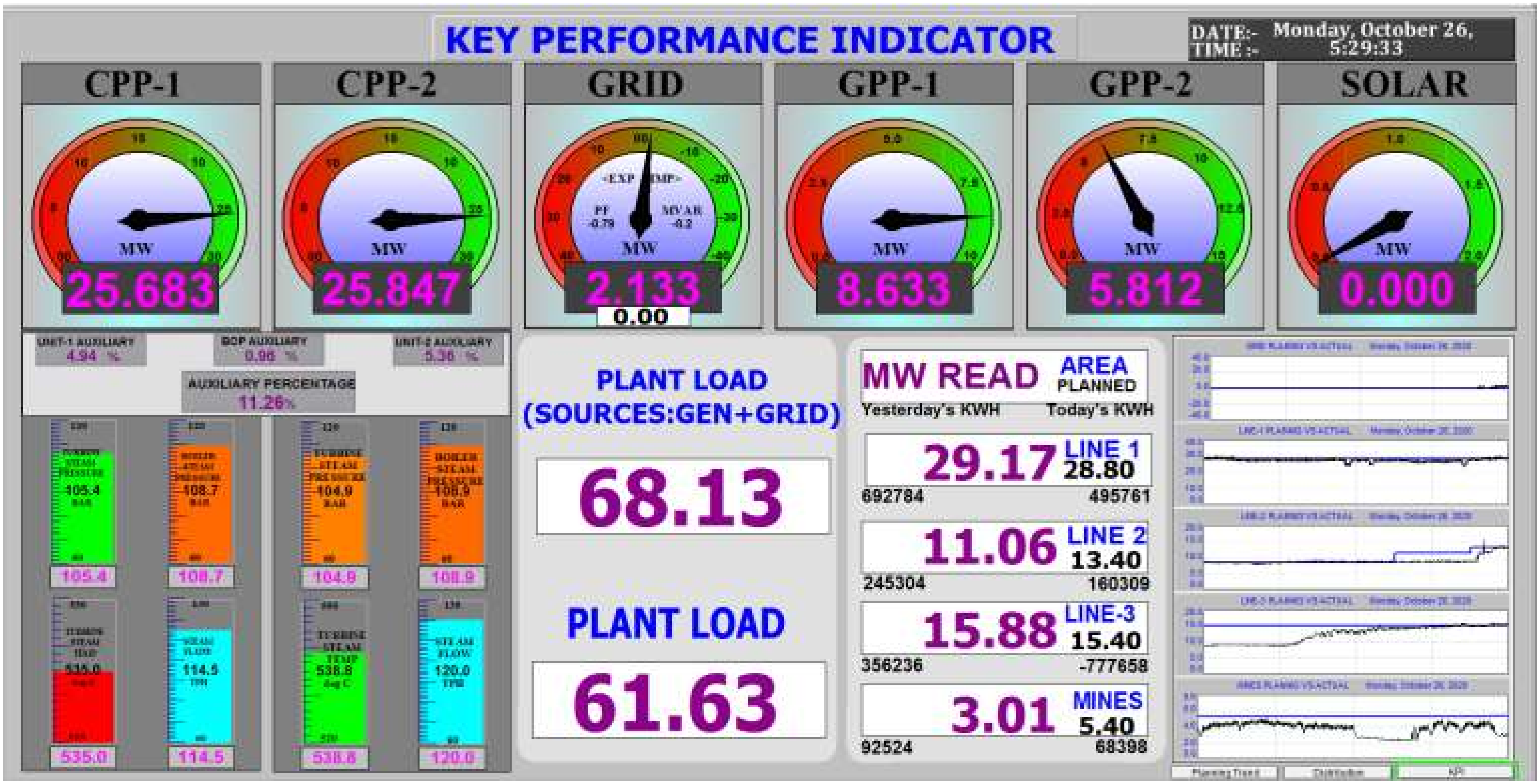
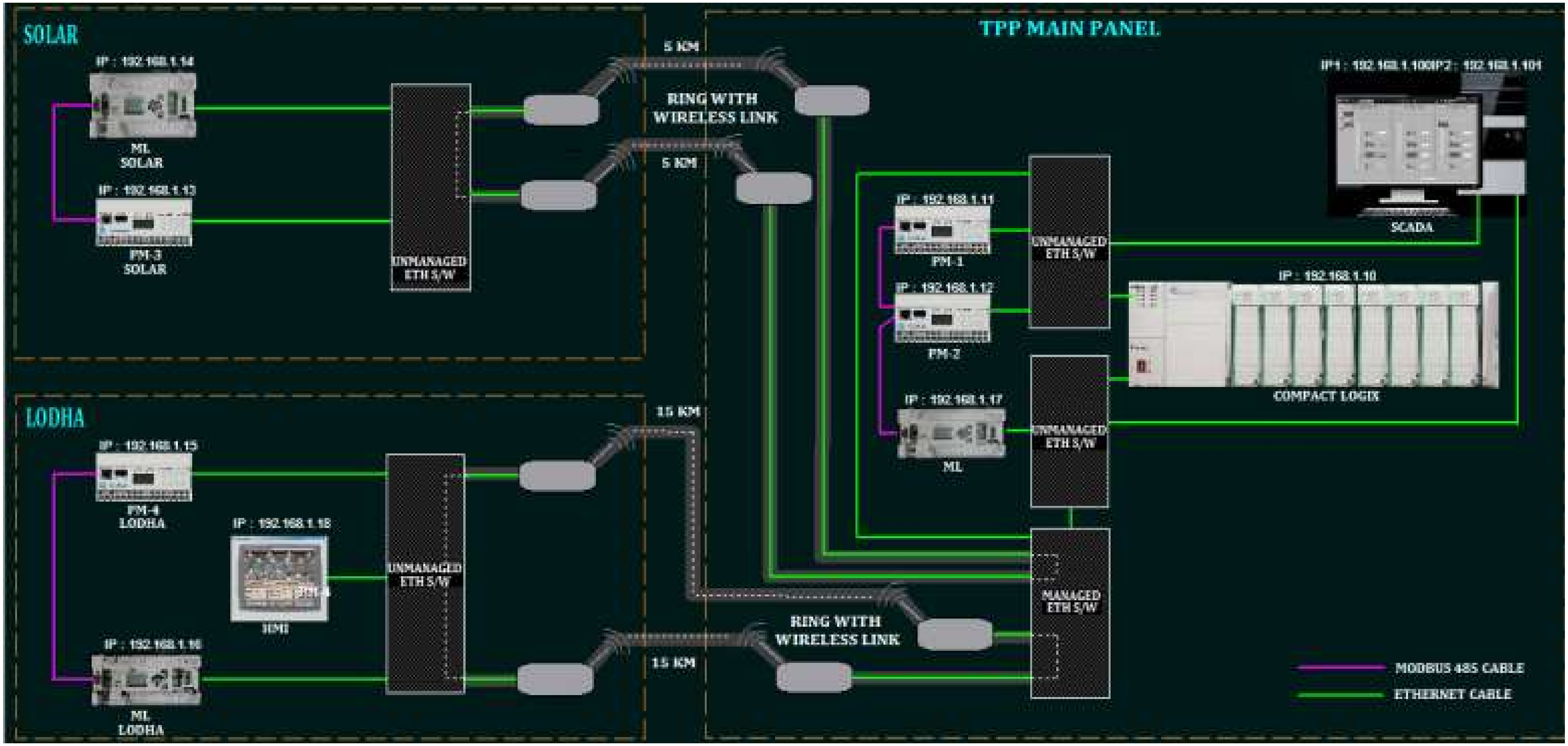


ILMS EXAMPLE – Screen



POWER DISTRIBUTION

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Power distribution is unique for each plant, hence are the problems and its remedial measure

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CONCLUSION

- **With addition of multiple sources, transient stability study is strongly recommended for reliable operation.**
- **With multiple sources and / or multiple lines, an effective ILMS needs to be designed which shall be inline with optimum operating requirement of operating lines and power sources**

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AT LAST

Effectiveness of counteractive measures can only be effective when comprehensive study of power distribution system shall be done by ***an agency, not only having proficiency in electrical system but also having expertise in cement plant system design and operation***.

As Holtec, we would be glad to extend any help, to study and give solutions to the industries

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THANK YOU

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