Prince Mohammad University
Department of Electrical Engineering

Smart Power Management System

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Outline

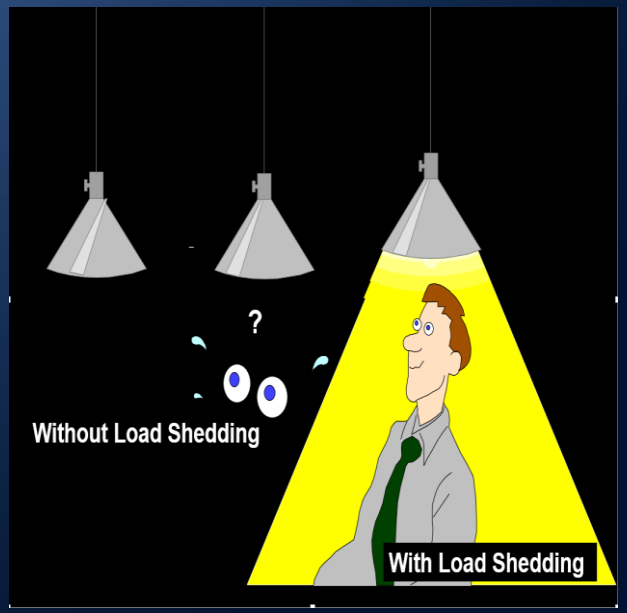
- Project definition & Objectives.
- Project Specifications.
- Project Architecture.
- Background &Previous students projects.
- Design : Subsystems.
- Design : Component Selection
- Testing
- Project Management
- Completed Work
- References

Project Definition

- Designing a simple generation and distribution scheme with automatic load shedding through automation system for avoiding the black out in plant.

Project Objectives

- Avoid black-outs.
- Avoid production Loss.
- Minimize operational costs.
- To avoid accident and have safe operation for operators.

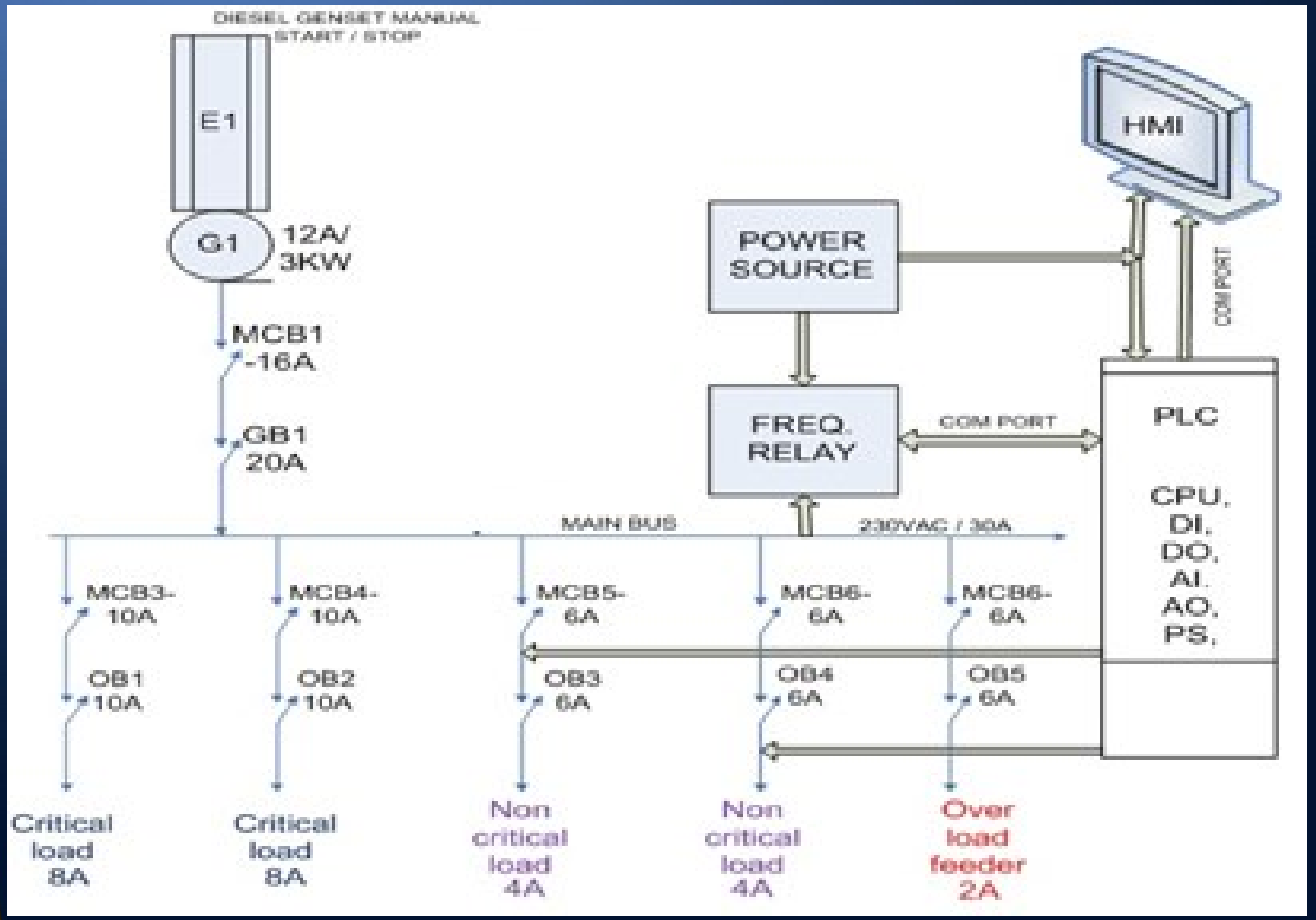


Project Specifications

1. Designing and arrangement of single power source & power monitoring meter for PLC input.
2. All the parameters will be assigned as an analog I/O's & Digital I/O's from external source to a programmable controller and software logics.
3. Interface module for monitoring and communication.
4. Designing of Common distribution panel for power and control wirings.
5. Managing critical and non critical loads for practical simulation of implementing the AUFLS response.

AUFLS – Automatic under frequency load shedding.

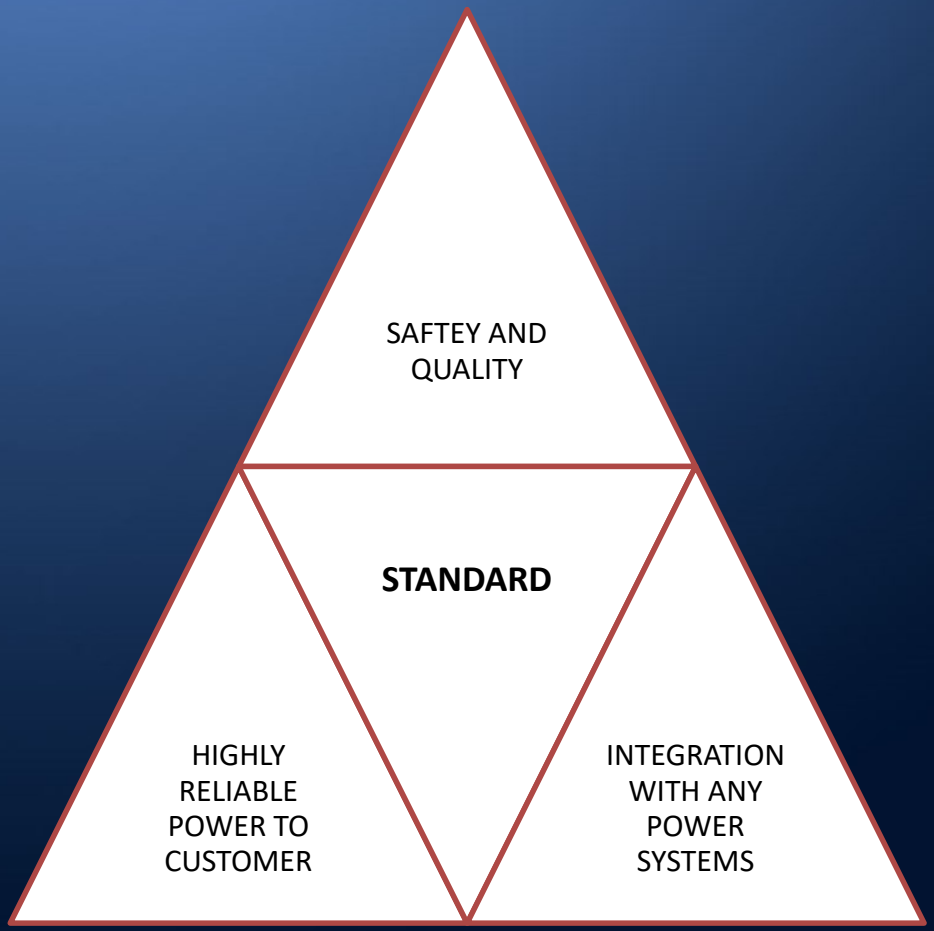
Project Architecture



Background: Problems

- Blackouts on critical loads.
- Money Loss.
- Production interruptions and delays.
- Reliable power to customers.

Design Constrains



Background: Power Management

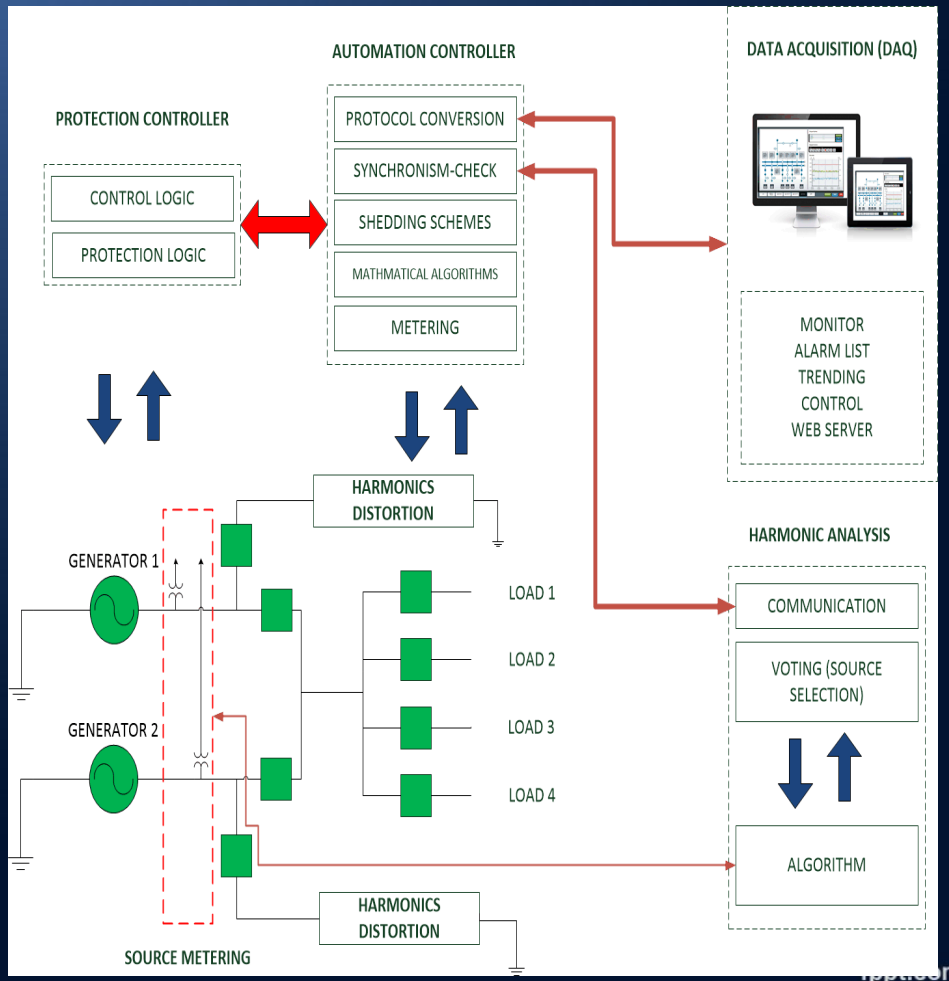
- The power management system will manage the overloads usually happen to the plant to avoid complete blackout.

- The system must design uninterrupted power supply to critical loads and the non critical load to be shut down.

Previous projects

1. Smart Power Management System (SPMS). University of PMU,2016:

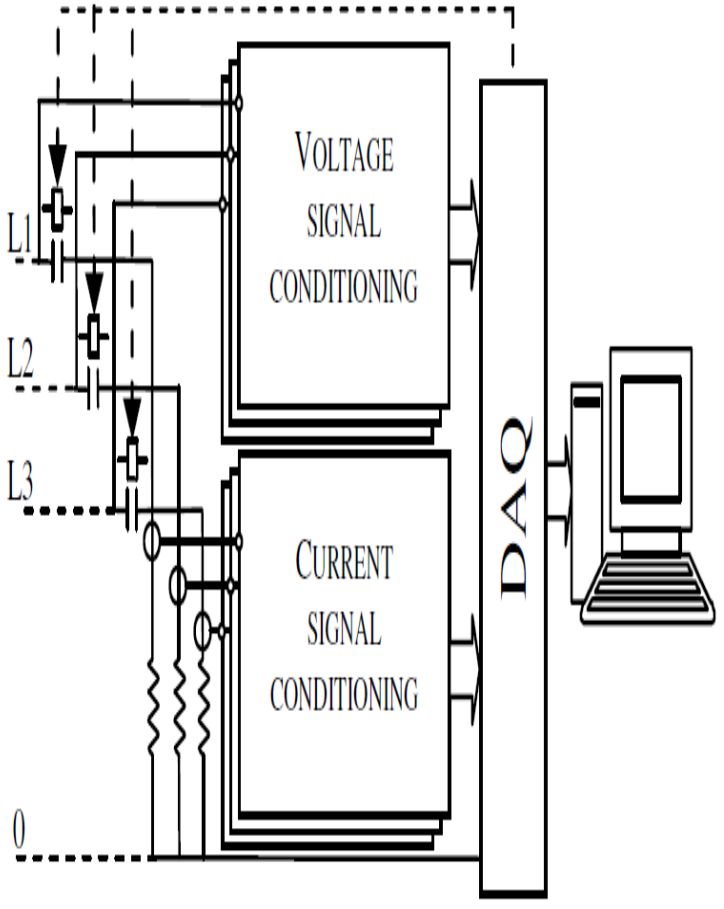
- To design and implement *SCADA* based *power management system* with additional quality based source selection based on harmonics analysis.



Previous projects

2.Power quality monitoring & power measurements, Ss. Cyril and Methodius University,2009

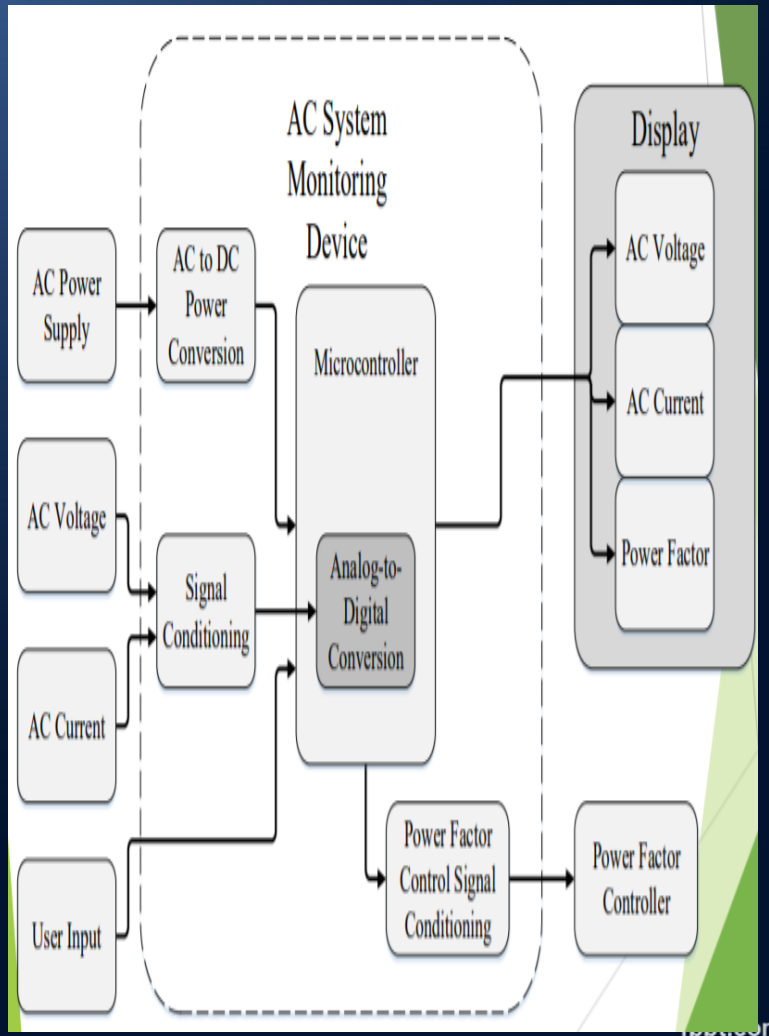
- Quality of electricity supply.
- The detection of the disturbances affecting the line voltages is one of the most qualifying points in the estimation of the “voltage quality” or “supply quality.
- The correct assessment of the quality of the supplied voltage has become one of the key issues in the deregulated electricity market. Ensuring a “high quality” of the supply voltage is the main requirement for ensuring a high “power quality.



Previous projects

3. A.C system monitoring device, BRADLRY university,2016

- Alternating current (AC) monitoring device is a device to monitor voltages, current, power factor, and other AC power characteristics.
- Primarily used in power transmission monitoring and power system protection.
- Key part of the smart grid.
- Reliability.
- Networking Capability.
- Power Factor Control.



Project design & sub system

1.Generation and distribution scheme:

A)Diesel generators
B) Protection MCB's
C) Isolation breakers.
D) Power monitoring device.
E) Common Bus.
F) Frequency monitoring Relays.

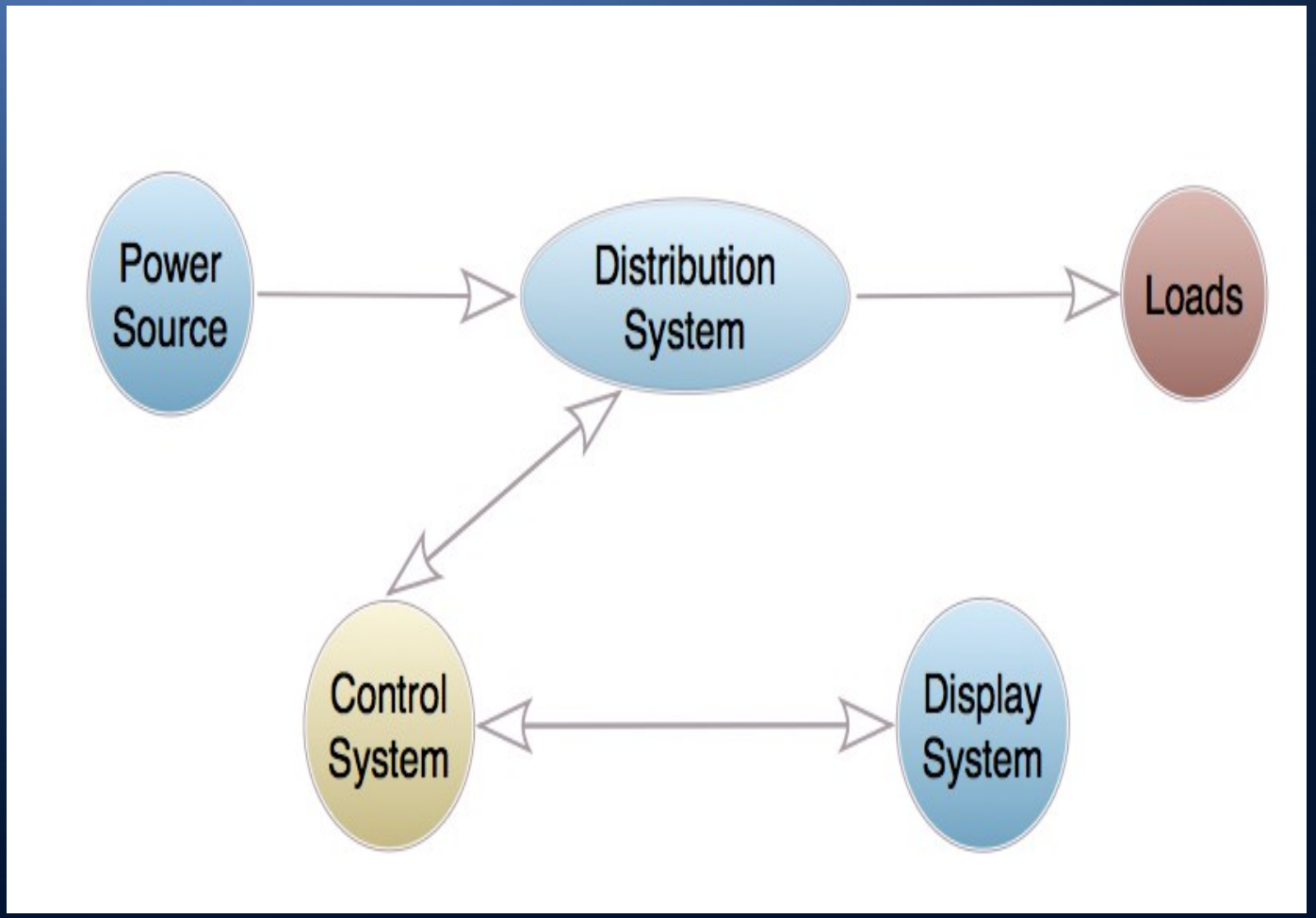
2. Programming logic controllers:

A)I/O's hardware and software designing.
B) Assigning the logics.
C) Communication Between Frequency relay and system.

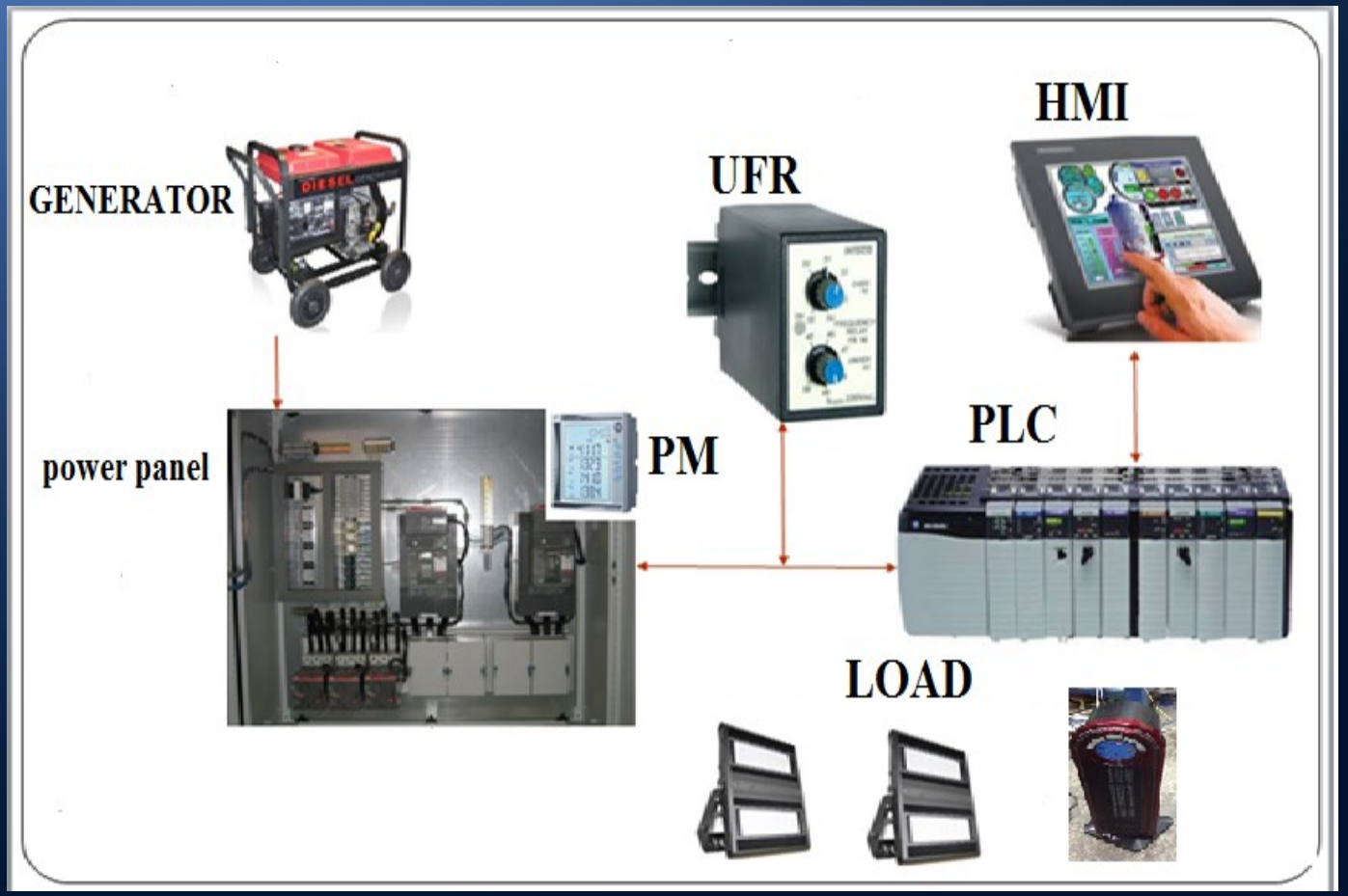
3. HMI (Human machine interface system):

A) Designing of animated scheme.
B) Communication between PLC & HMI.

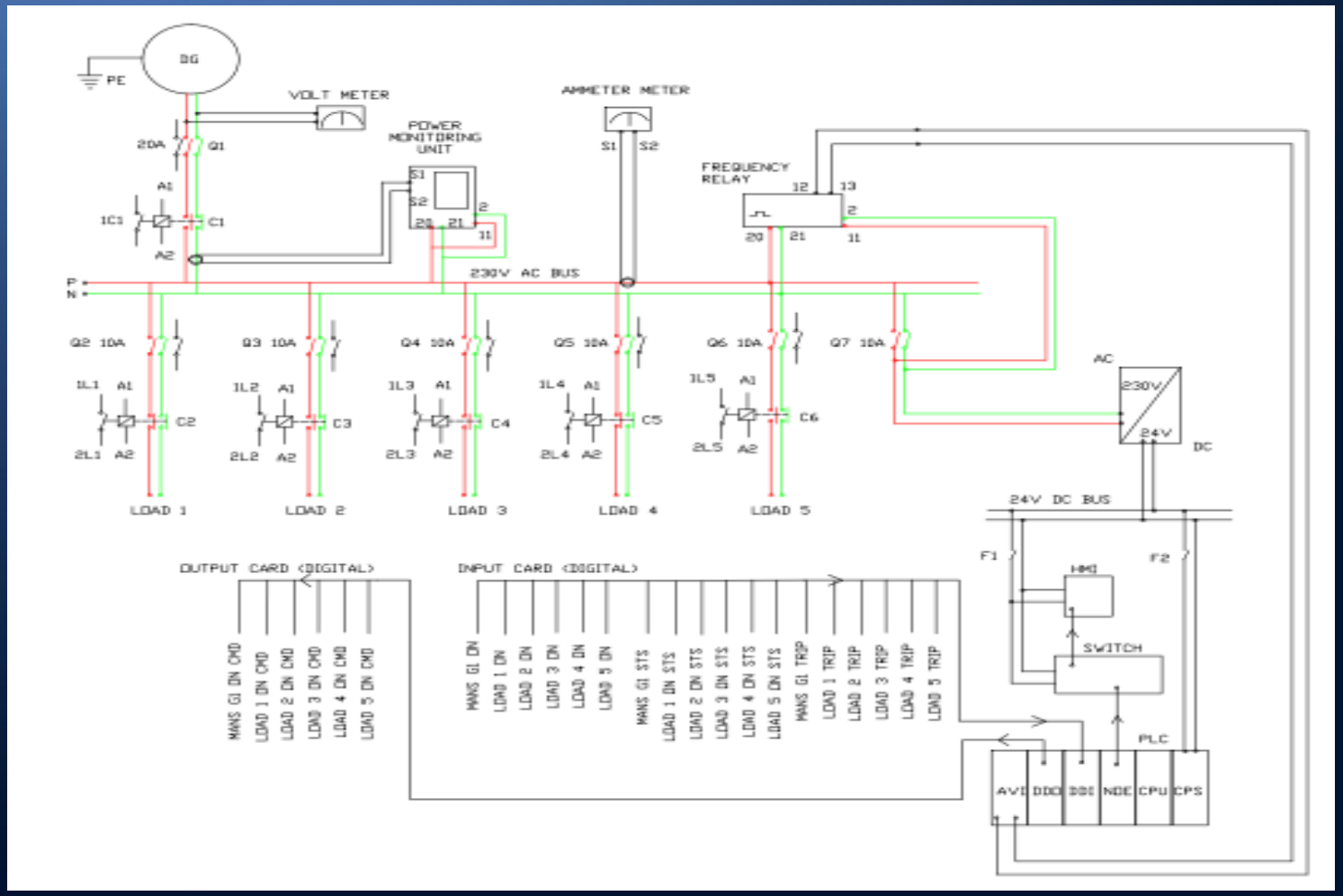
Sub systems



SCHEME LAYOUT



Design Power & Control Circuit Diagram



PLC Module

Mitsubshi PLC

- Memory for storage (ROM): 32 MB
- Memory for operation (RAM): 128 MB
- Internal 5V DC: 1.2 A
  Internal 24 V DC: 0.3 A

Modicon Quantum 140 Series
Make : Schneider

- 24 V DC
- Ambient air temperature for operation 0...60 °C
- Ambient air temperature for storage -40...85 °C

Diagram of PLC

PS : PLC Power Supply
CPU: Central Processing Unit
NOE: Ethernet Communication Card
DI : Digital Input
DO :Digital Output
AI : Analog Input
HMI : Human Machine Interface

HMI

Information to PLC
Analog Input Bus
Frequency

230V
/24V
DC

Commands from
PLC
Breakers close/open

CPU | PS | NOE | DI | DO | AI

INFORMAYION TO
PLC
status for
breakers\contactors

DIGITAL OUT PUT

Complementary	
Group of channels	4 groups of 8
Discrete output logic	Negative logic (sink)
Addressing requirement	2 output words
Discrete output voltage	24 V DC
Output voltage limits	19.2...30 V
Absolute maximum output	56 V for 1.3 s decaying pulse
Voltage drop	0.4 V 0.5 A
Maximum load current	4 A per group 16 A per module
Surge current	<= 5 A for 0.0005 s
Response time	<= 1 ms at state 1 to state 0 <= 1 ms at state 0 to state 1
Leakage current	0.4 mA 30 V
Load inductance	Inductance(H) = 0.5/((current(A))² x (switching frequency(Hz))) 50 Hz
Fault indication	Blown fuse Loss of field power
Associated fuse rating	5 A per group 3 A each point
Isolation between channels and bus	1780 Vrms DC for 1 minute
Isolation between group	500 Vrms DC for 1 minute
Protection type	Internal output protection by 5 A fuse per group
Power dissipation	1.75 W + (0.4 V x total module load current)
Marking	CE
Local signalling	32 LEDs green input status 1 LED red external fault detected (F) 1 LED green bus communication is present (Active)
Bus current requirement	330 mA
Module format	Standard
Product weight	0.45 kg

CPU

Main	
Range of product	Modicon Quantum automation platform
Product or component type	Processor
Software name	ProWORX 32 Concept
Processor name	80486
Mathematical coprocessor	With

Complementary	
Clock frequency	66 MHz
Memory description	Internal RAM 896 kB
Exact time for 1 Kinstruction	0.1...0.5 ms LL984
Watchdog timer	250 ms
Clock drift	+/-8 s/day at 32...140 °F (0...60 °C)
I/O words	30 I/32 O distributed 64 I/64 O max local 64 I/64 O remote
I/O words/network	500 I/500 O distributed
Drops/Network	63 distributed
Number of drops	31 remote
Number of network	2 remote 3 distributed
Battery type	Lithium 7 µA 210 µA
Battery capacity	1.2 Ah
Battery life	10 yr
Number of port	1 Modbus Plus 2 Modbus RS232
Communication module processor capacity	6 NOM, NOE, CR, NMS

Power Supply

Main	
Range of product	Modicon Quantum automation platform
Product or component type	Power supply module
Power supply type	Redundant

Complementary	
Input voltage	125 V DC 100...150 V
Input current	500 mA 125 V
Inrush current	28 A 125 V
Input power interruption	<= 1 ms
Associated fuse rating	2 A slow-blow
Output voltage	5.1 V DC
Power supply output current	8 A redundant
Output overvoltage protection	Internal
Output overload protection	Internal
Power dissipation	6 + (1.5 x Iout) where Iout is in A
Local signalling	1 LED green power (PWR OK)
Marking	CE
Module format	Standard
Product weight	0.65 kg

Environment	
Standards	CSA C22.2 No 142 UL 508
Product certifications	CUL FM Class 1 Division 2
Resistance to electrostatic discharge	4 kV contact conforming to IEC 801-2 8 kV on air conforming to IEC 801-2
Resistance to electromagnetic fields	10 V/m 80...2000 MHz conforming to IEC 801-3

Analog input module

Main	
Range of product	Modicon Quantum automation platform
Product or component type	Analogue input module
Type of filter	Single pole low pass - 3 dB at 847 Hz +/- 20 %

Complementary	
Analogue input number	8
Input type	Differential
Addressing requirement	9 input words
Analogue input type	Bipolar current 20 mA Bipolar voltage +/- 10 V Bipolar voltage +/- 5 V Unipolar current 0...20 mA Unipolar voltage 0...10 V Unipolar voltage 0...5 V
Analogue input resolution	16 bits +/- 10 V 16 bits +/- 5 V 16 bits 0...10 V 16 bits 0...20 mA 16 bits 0...5 V 16 bits 20 mA
Linear measuring range	(Input range) x 1.024 mA (Input range) x 1.024 V
Absolute maximum input	25 mA 50 V DC
Input impedance	> 20 Ohm voltage 250 MOhm +/- 0.03 %
Absolute accuracy error	+/- 0.03 % +/- 0.05 % of full scale maximum
Linearity error	+/- 0.008 %
Accuracy drift according to temperature	+/- 0.0015 % of full scale/°C <= 0.004 % of full scale /°C
Common mode rejection	> - 80 dB 60 Hz

Ethernet network TCP/IP module

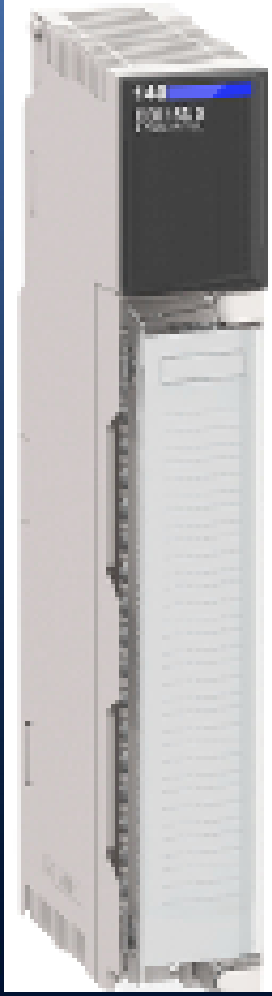
Main

Range of product	Modicon Quantum automation platform
Product or component type	Ethernet network TCP/IP module
Concept	Transparent Ready
Web server	Class B30
Web services	Data Editor (via PC terminal) Diagnostics via predefined web pages Rack viewer
Communication service	Bandwidth management FDR server Global Data I/O scanning Modbus TCP messaging SNMP network management
Communication port protocol	Ethernet Modbus TCP/IP
Physical interface	MT/RJ 100BASE-FX fiber optic RJ45 10BASE-T/100BASE-TX twisted pair
Transmission rate	10/100 Mbit/s

Complementary

Redundancy	Yes hot standby redundant architecture
Supply	Via the power supply of the rack
Marking	CE
Local signalling	1 LED 10 Mbps or 100 Mbps data rate (10 MB/100 MB) 1 LED collision detection (Coll) 1 LED download mode (Kernel) 1 LED Ethernet module fault (Fault) 1 LED Ethernet network status (RUN) 1 LED full-duplex mode (Fduplex) 1 LED module ready (Ready) 1 LED network active (Link) 1 LED rack operational (Active) 1 LED transmission/reception activity (TxAct/RxAct)

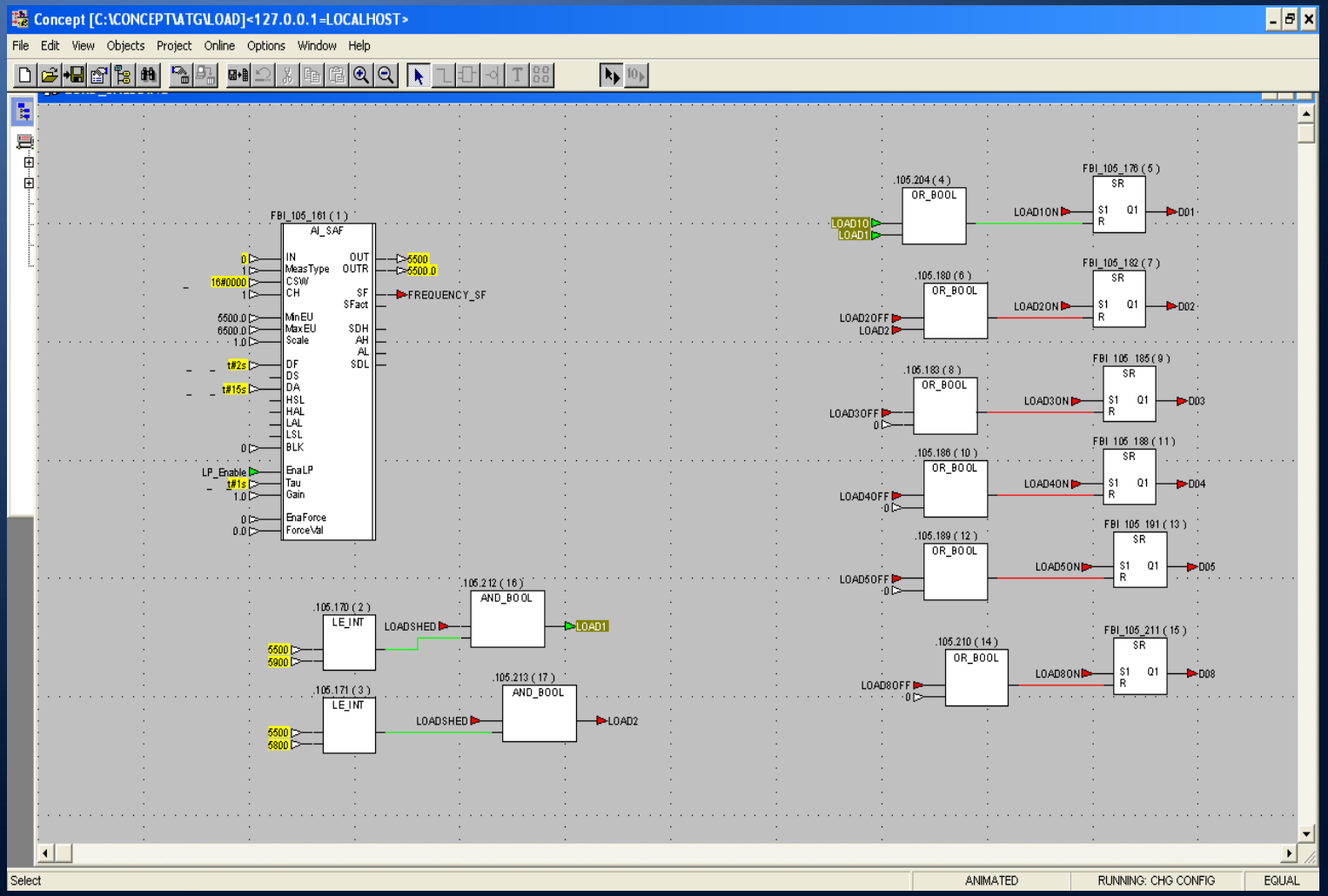
Discrete input module



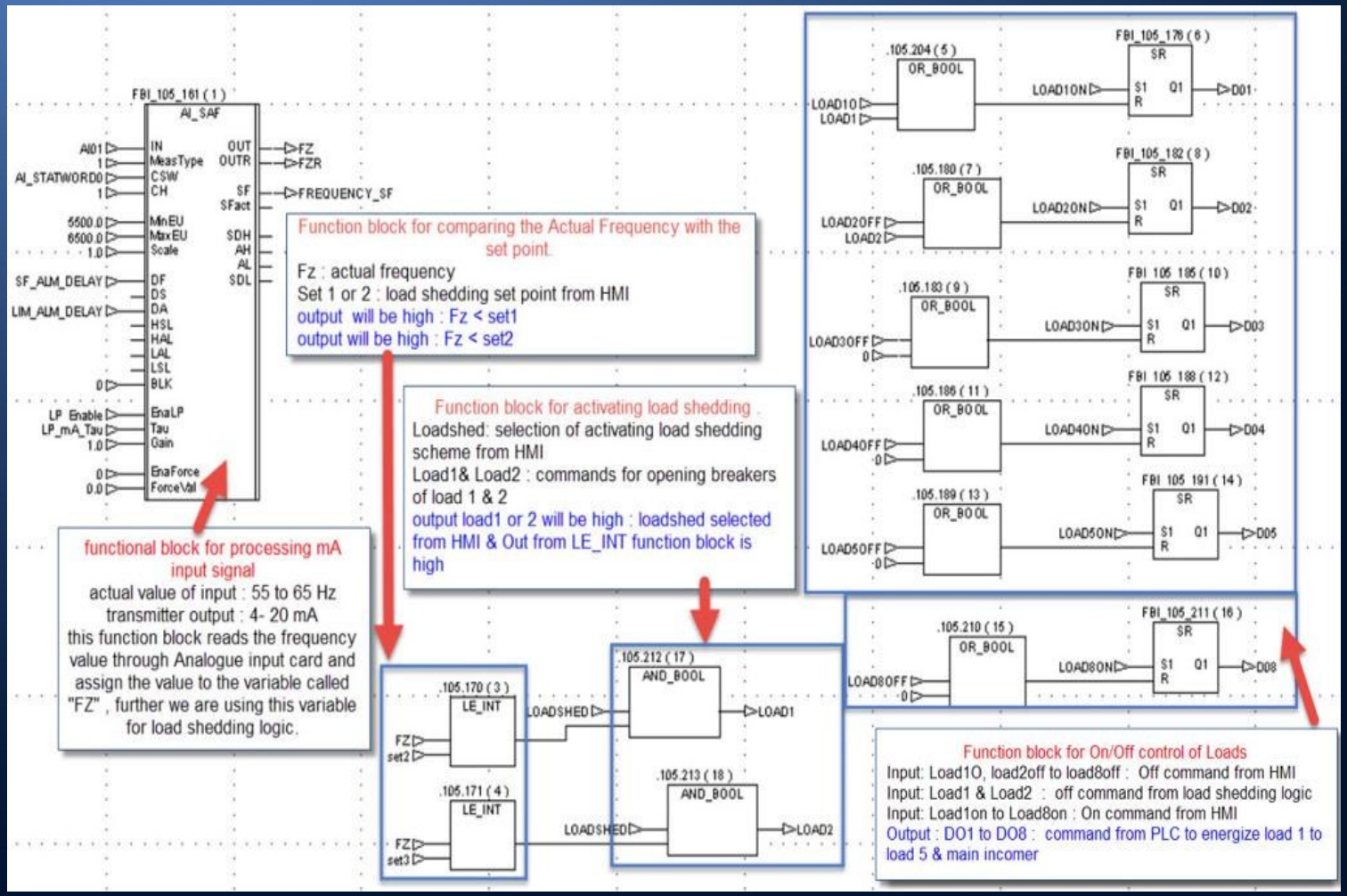
Main	
Range of product	Modicon Quantum automation platform
Product or component type	Low voltage dc discrete input modules
Discrete input number	32

Complementary	
Group of channels	4
Logic input	Positive (sink)
Discrete input voltage	24 V DC
Input voltage limits	19.2...30 V
Voltage state 1 guaranteed	15...30 V DC
Voltage state 0 guaranteed	-3...5 V DC
Current state 1 guaranteed	>= 2 mA at Us = 5.5 V and Uin = 0 V
Current state 0 guaranteed	<= 0.5 mA
Addressing requirement	2 input words
Input impedance	2500 Ohm
Leakage current	200 mA at Us = 5.5 V and Uin = 4 V
Absolute maximum input	30 V continuous 56 V during 1.3 ms decaying pulse
Response time	<= 1 ms from state 0 to state 1 <= 1 ms from state 1 to state 0
Protection type	Input protection by resistor limited
Power dissipation	1.7 W + (0.36 x number of points on)
Isolation between group and bus	1780 Vrms for 1 minute
Isolation between group	500 Vrms for 1 minute
Local signalling	1 LED green bus communication is present (Active) 1 LED red external fault detected (F) 32 LEDs green input status

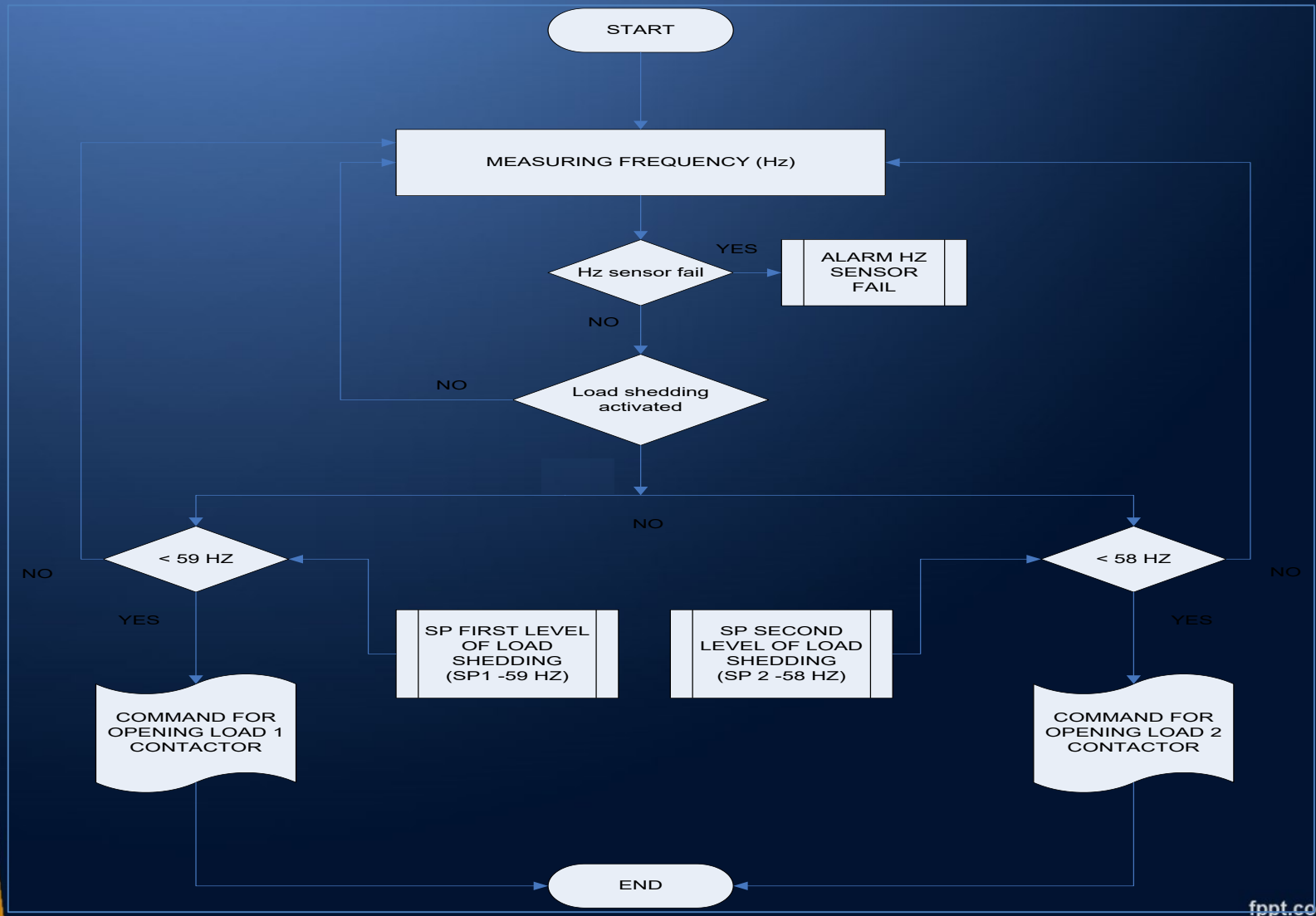
PLC – FUNCTIONAL LOGICS



PLC – FUNCTIONAL LOGICS WITH EXPLANATION



flow chart



Human machine Interface (HMI)

Mitsubshi HMI

- Memory for operation (RAM):

  128 MB (GT2705 has 80 MB)

- Display 5.7", 8.4", 10.4", 12.1",

  and 15" size, 65536 colors TFT

  LCD display

Schneider HMI

Model ; XBTGT 6330

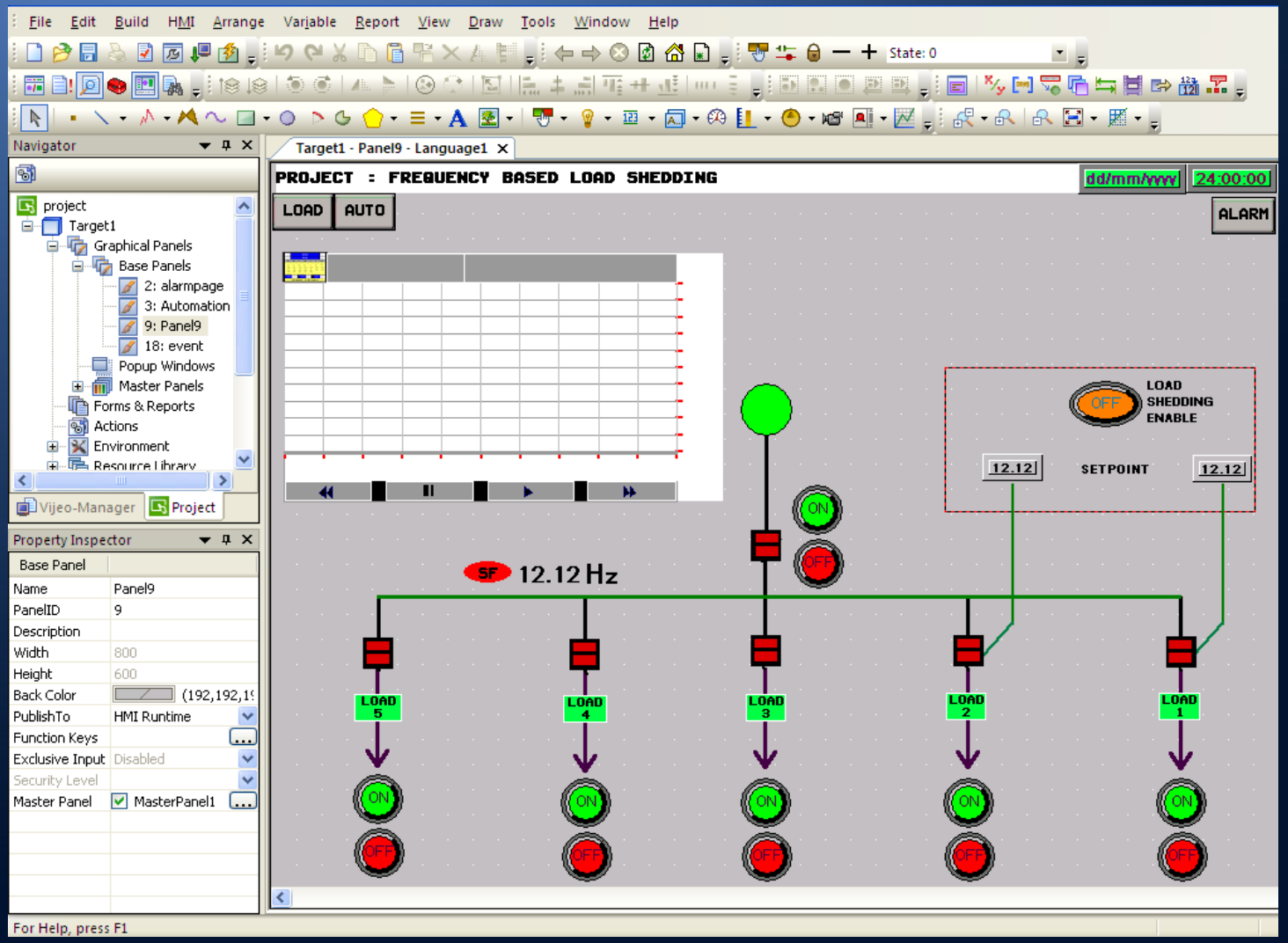
- display size 12.1 inch
- memory description: 512 kB SRAM back up of data with lithium battery back-up
- Brightness: 8 levels via touch panel

HMI

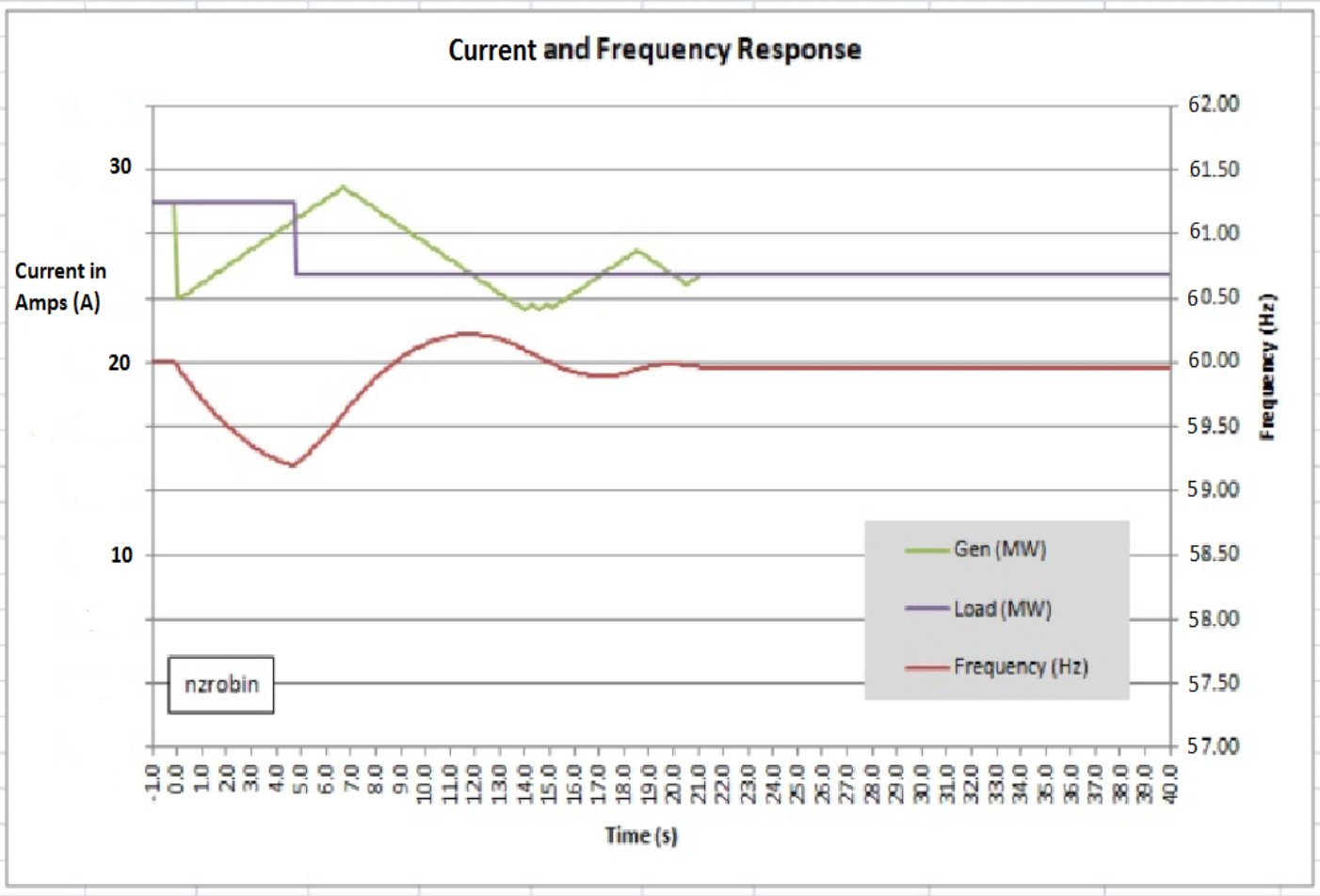
Main	
Range of product	Magelis XBTGT
Product or component type	Advanced touchscreen panel
Display type	Backlit colour TFT LCD
Display colour	65536 colours
Display resolution	800 x 600 pixels SVGA
Display size	12.1 inch
Software type	Configuration software
Software designation	Vijeo Designer
Operating system	Magelis
Processor name	CPU RISC
Processor frequency	266 MHz
Memory description	512 kB SRAM back up of data with lithium battery back-up
Resistance to electrostatic discharge	6 kV conforming to IEC 61000-4-2 level 3
Cut-out dimensions	301.5 (+ 1/- 0) x 227.5 (+ 1/- 0) mm

Complementary	
Touch sensitive zone	1024 x 1024
Touch panel	Analogue
Backlight lifespan	50000 hours
Brightness	8 levels via touch panel
Character font	Korean Japanese (ANK, Kanji) Chinese (simplified Chinese) Taiwanese (traditional Chinese) ASCII (European characters)
[Us] rated supply voltage	24 V DC
Supply	External source
Supply voltage limits	19.2...28.8 V

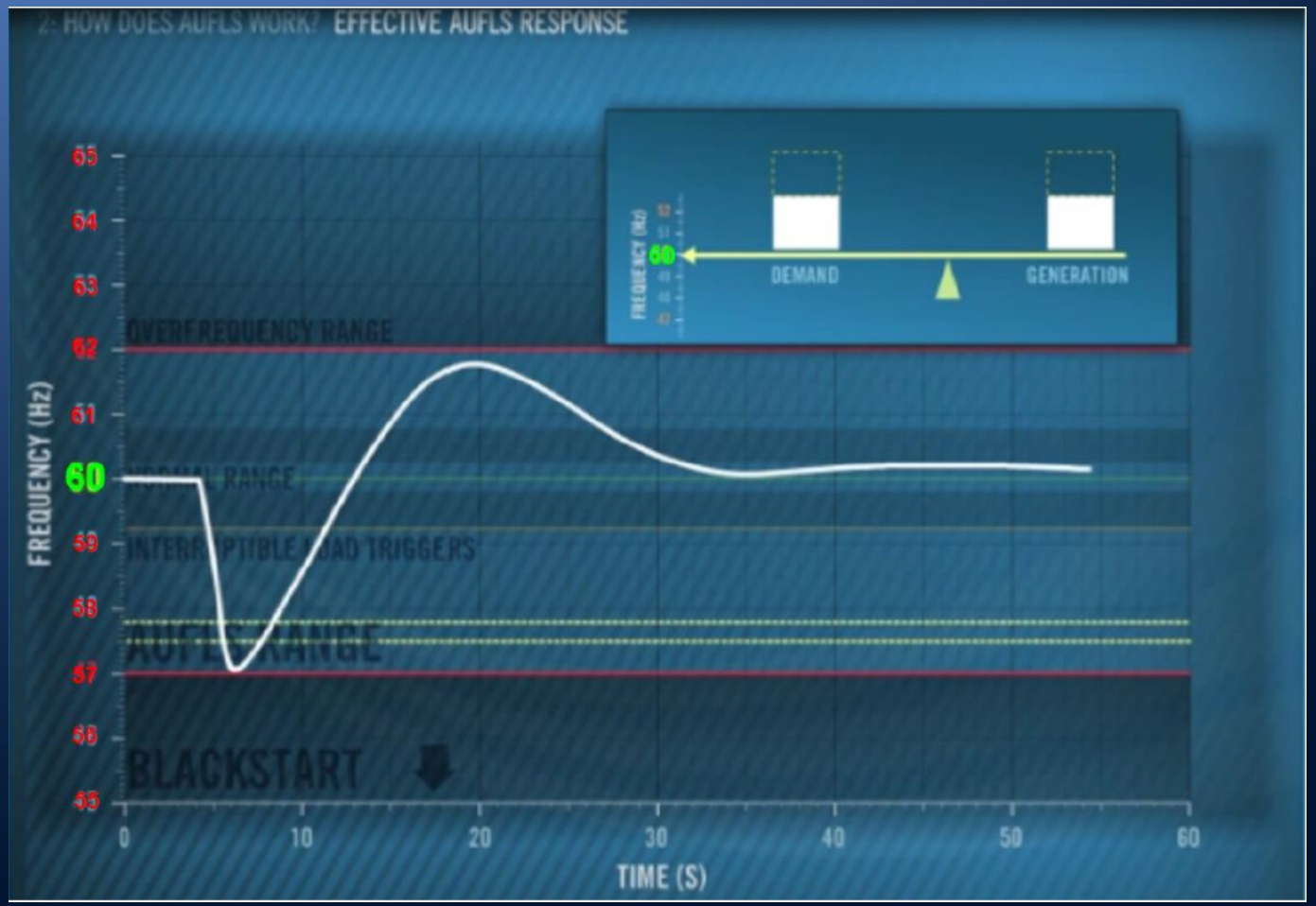
PLC – HMI DESIGN DRAWING



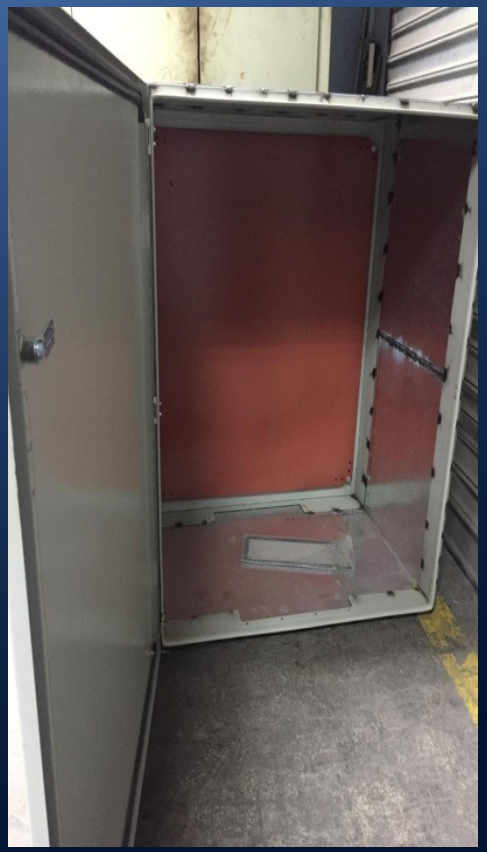
Current and Frequency Response

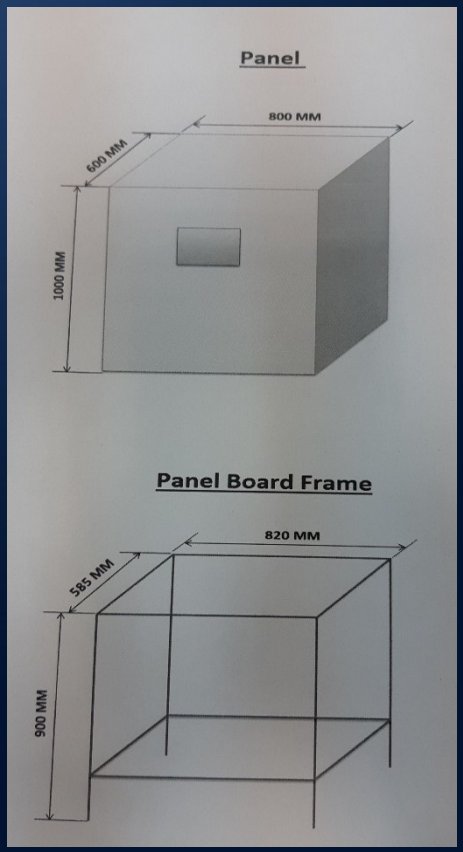


AUFLS Curve

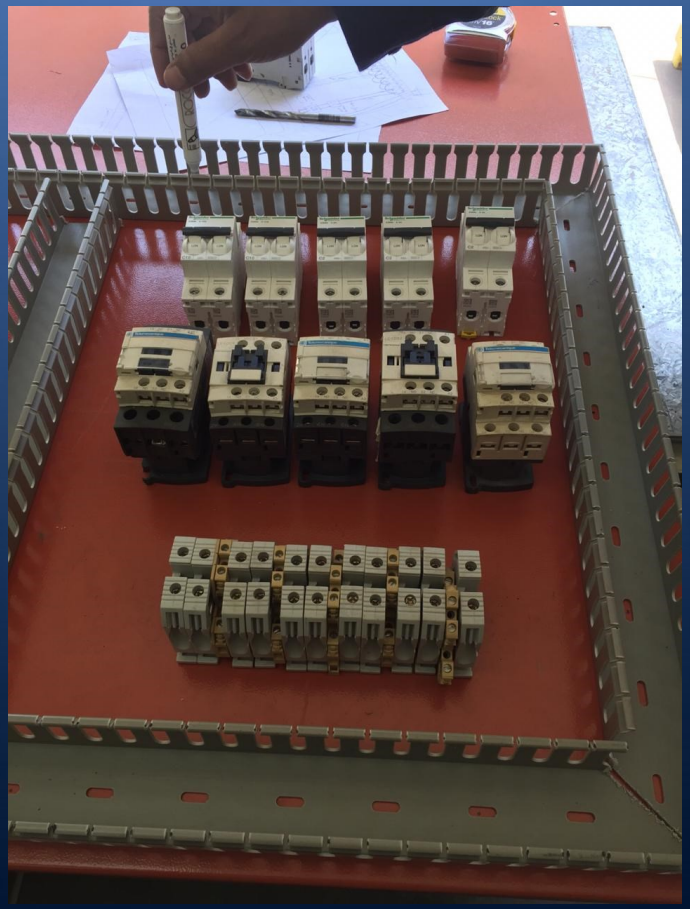


Design Component Selection

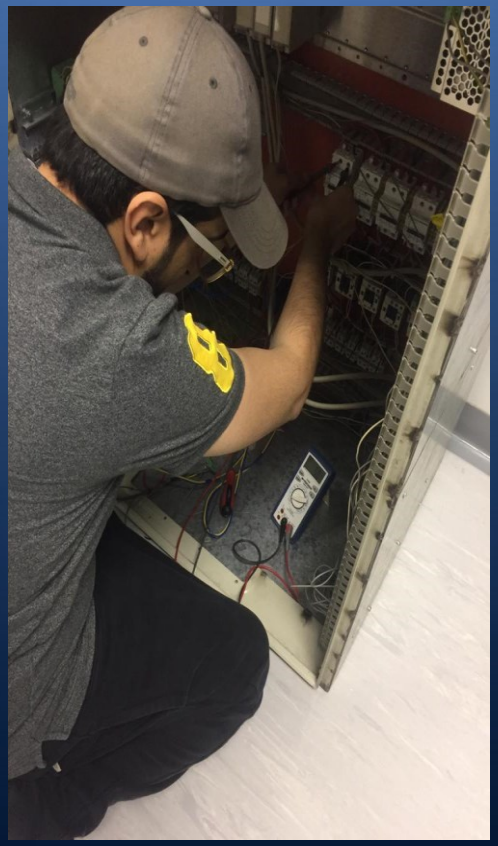


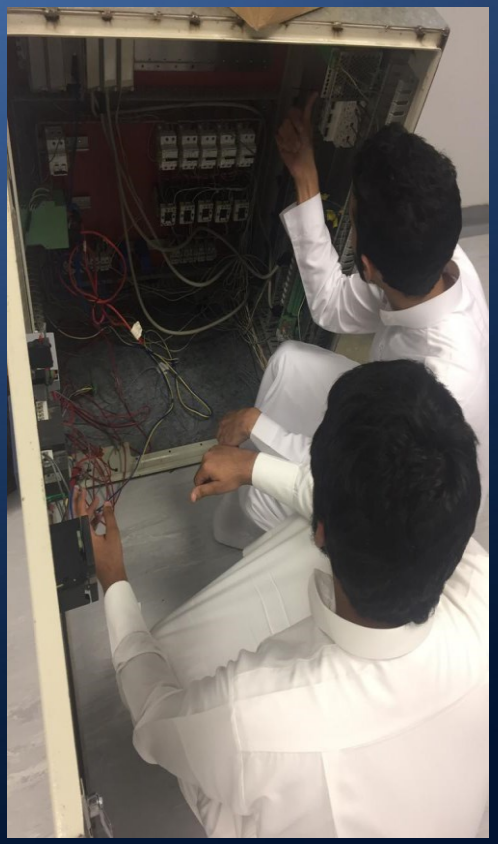


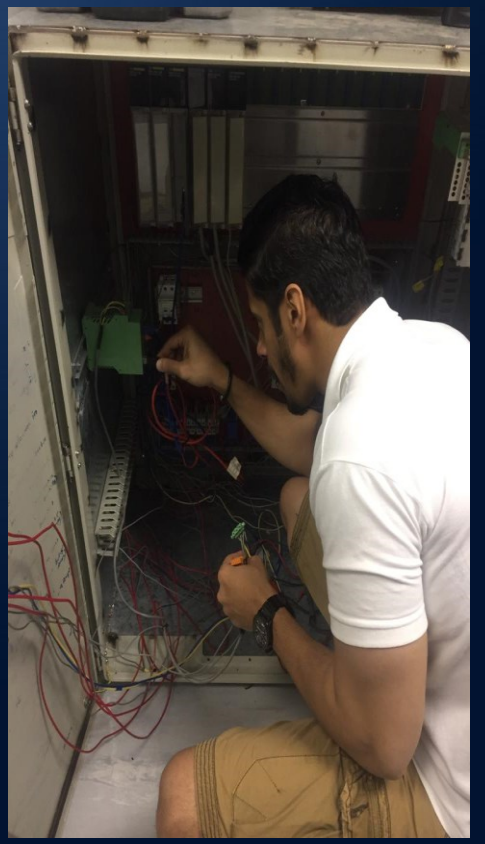
Design Component Selection



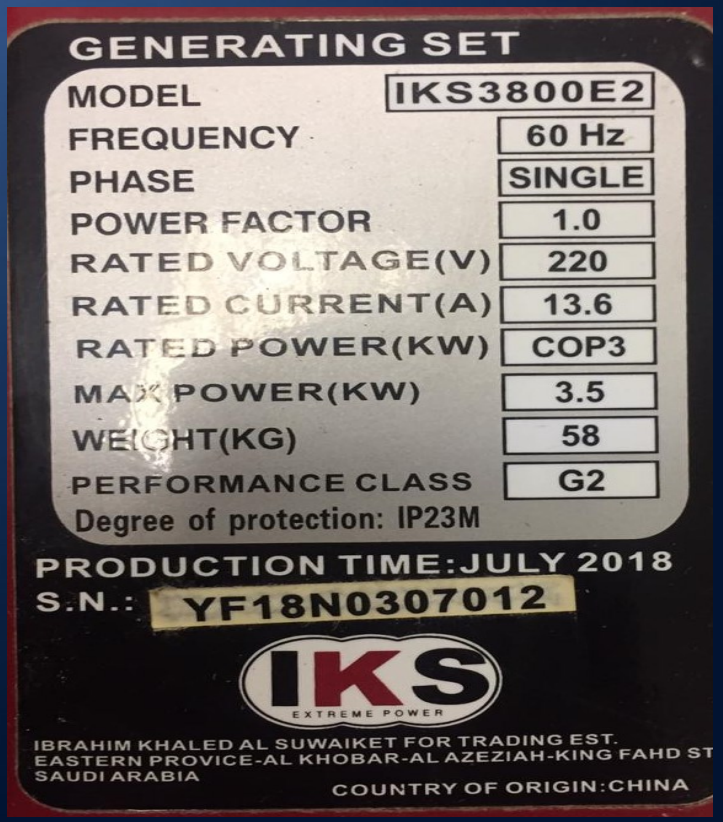
Testing







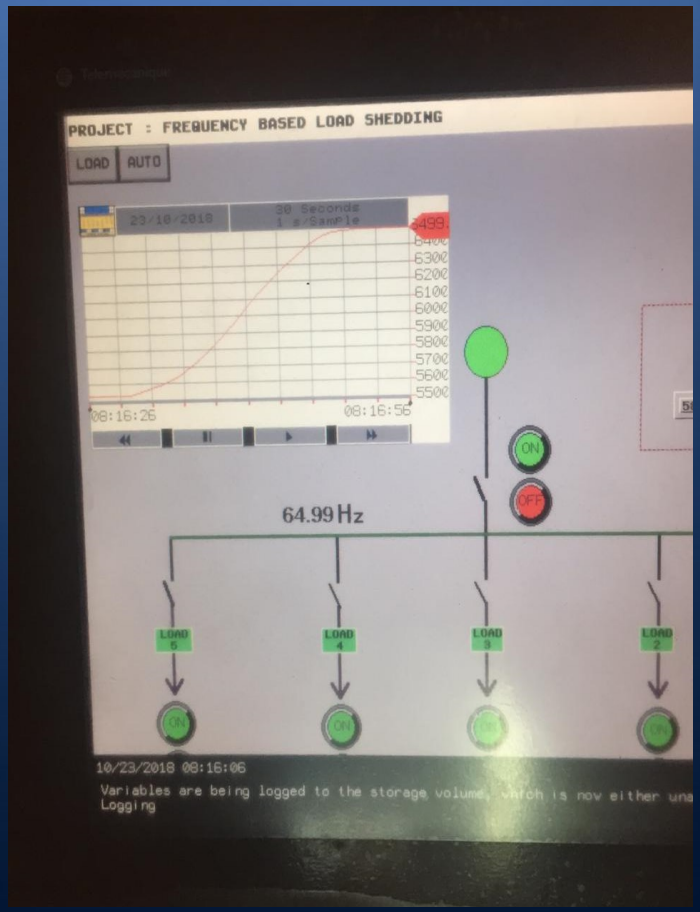
Testing Subsystem1: Power Source



Testing Subsystem 2: Distribution System

Testing Subsystem 3: Control System

Testing Subsystem 4: Display System



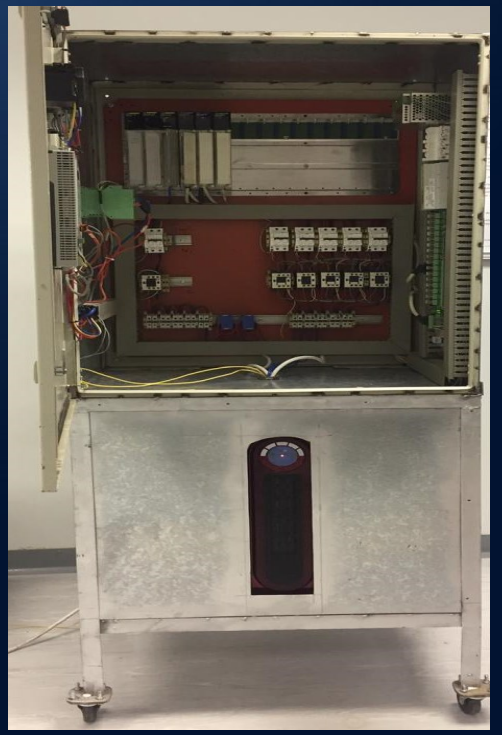
Testing Subsystem 5:Loads

Project Management Plan

SN	Tasks & Responsibilities		Begin**	End**	% Completion
1	Implement Design for SS2 (Distribution System)	MS MH	Sep 10	Sep14	100%
2	Selection of Source (Generator) for SS1	AR AS	Sep15	Sep17	100%
3	Design control component subsystem SS3(PLC)	MS MH	Sep20	Sep23	100%
4	Implement Design for(PLC & HZ Relay) per logic SS3	MS AS	Sep 23	Nov 15	100%
6	Implement Design for (HMI configuration)SS3	MH AR	Sep 23	Nov14	100%
7	Test and refine design for(Develop the logic concept for (PLC) SS3	MS MH	Oct1	Nov15	100%
8	Integrate subsystems SS1&SS2 & SS3& SS4	AS AR	Oct1	Nov5	100%
9	Measurement System configuration	All	Oct1	Nov5	100%
10	Complete wiring for testing power circuit	All	Oct1	Nov17	100%
11	Integrate all subsystems	All	Nov 1	Nov18	100%
12	Test and make final changes	All	Nov1	Nov20	100%
13	write progress reports (weekly)	All	Nov7	Nov8	100%
14	Prepare midterm presentations	All	Nov7	Nov11	100%
17	Prepare Demo. (prototype)	All	Nov20	Nov29	100%
18	Prepare Final presentation	All	Nov 20	Dec 5	100%
19	Prepare final report	All	Nov 20	Dec 5	100%

Completed Work

- Integrate all subsystem.
- Test subsystem 1,2,3,4&5.
- Power and Control Circuit.



Project Management: Challenges

- Cost.
- Power Source Efficiency.
- PLC Programing.

Project Prototype

References

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- ENEAS power management. (n.d.). *Load Shedding for Industry Grids*. Retrieved February 16, 2018, from https://w3.siemens.com.br/home/br/automacao-energia/aplicacoes/Documents/Descarte de cargas ingeligente (Load Shedding).pdf.
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Thank you