TENAGA NASIONAL

Better. Brighter.

Power Quality: Issues and Mitigation

TNB ENERGY SERVICES SDN BHD (424407-M)

COMPANY BACKGROUND

A wholly-owned subsidiary of TNB

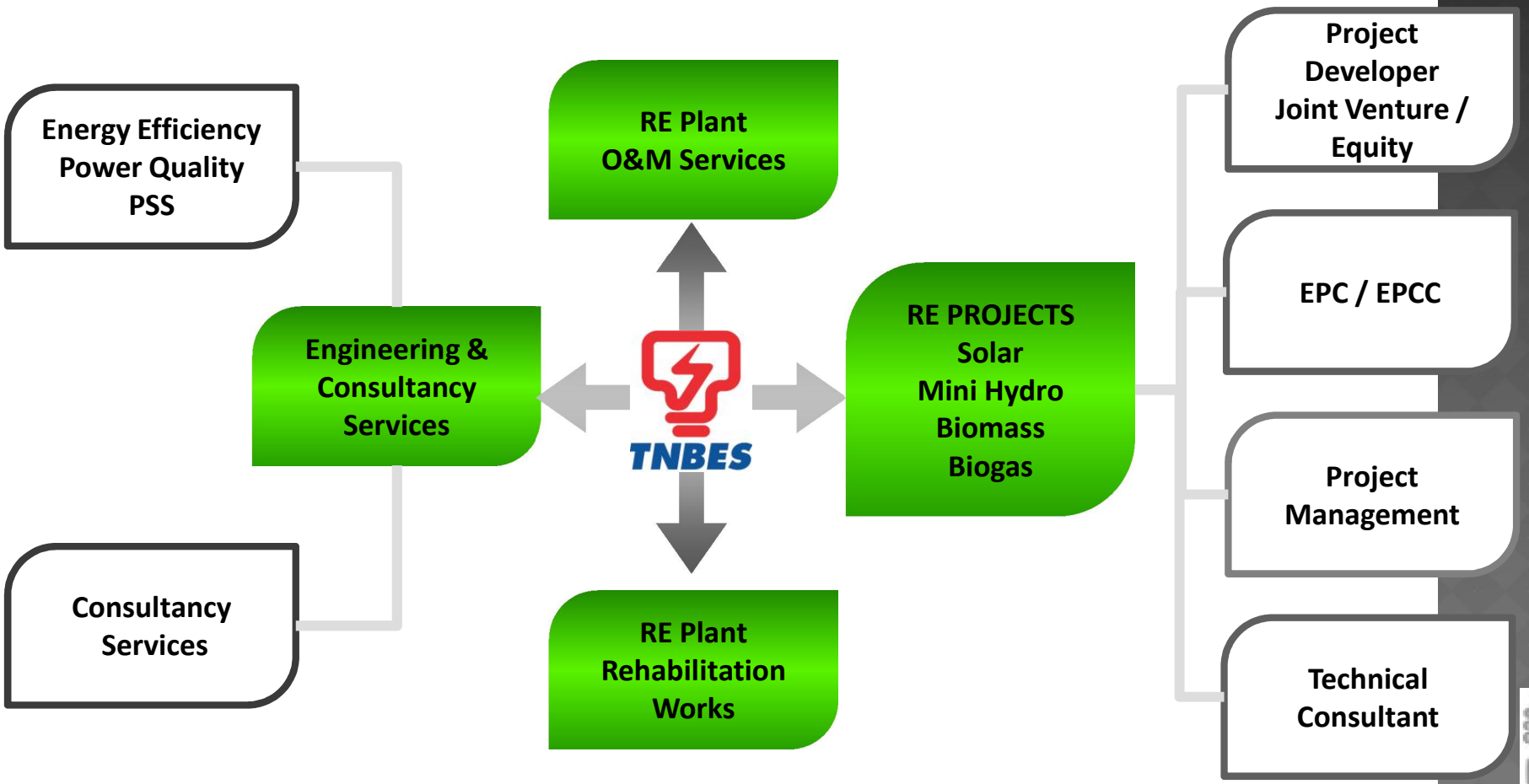
Established in 1997, no. of staff 150
(50 Engineers)

Implementer of TNB's Green Energy initiatives & SOLUTION PROVIDER for customers in Green Energy projects and services

Pioneer in Solar Hybrid projects and industry leader in EE services

Scope of Services

With experience and proven track record, TNBES has positioned itself as a solution provider in Green Energy and the leading Energy Services Company (ESCo) of choice



CONTENT

1. **Introduction – Overview**
2. **Problem Statement**
3. **PQ Mitigation Services**
4. **Conclusion**

TNB PQ Projects – Two Major Initiatives

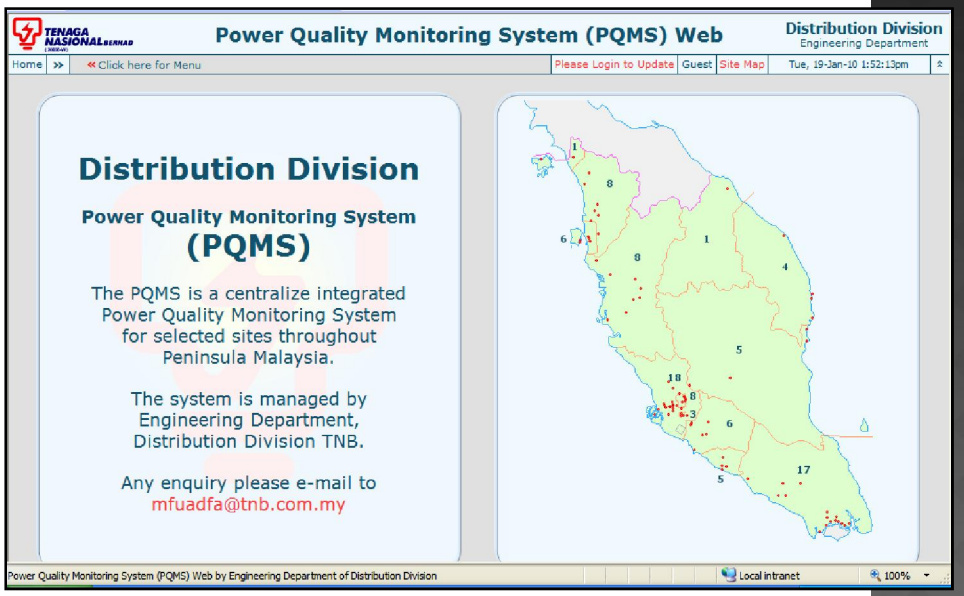
1. **Power Quality Monitoring System (PQMS)**
   - Started in year 2005
   - Monitor more than 150 substations (2015)
   - Total Investment – more than RM10 million

2. **Free PQ Services to Customers**
   - Started in year 2007
   - Served more than 140 customers (2015)
   - Total Investment – more than RM5 million

Power Quality Monitoring System (PQMS)

Developed by TNB for Power Quality Management

It is a centralize integrated Power Quality Reporting, for data captured from monitoring devices installed throughout Peninsula Malaysia as shown on the map



It comprises of a database server connected to backbone whose main function is to gather, store, process and analyze the collected power quality data and to generate useful information for use by management, operating staff and the customers.

Total of 150 monitoring devices has been installed, 59 in Phase I, 16 in Phase II, and 15 in Phase III and 60 in Phase IV

Power Quality Mitigation Services

SINGAPORE EXPERIENCE

"Singapore prided itself on providing good infrastructure, but while its power quality is already among the best in the world, it is not good enough for the many high-tech industries which invest here."

Prime Minister *Goh Chok Tong* was speaking at the ground breaking ceremony of Chartered Semiconductor Manufacturing's S$3.6 Billion wafer fabrication plant in Woodlands.

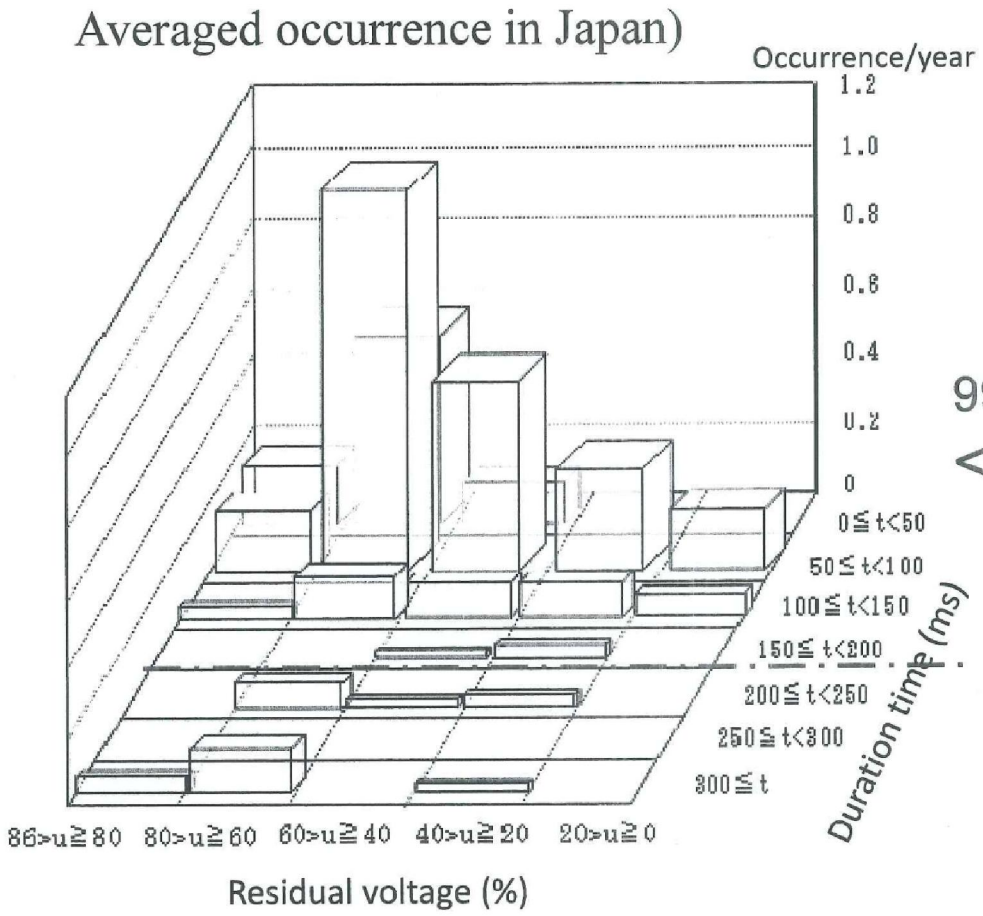
22kV System Compares Well Against Systems in USA and Europe

	SARFI-70	SARFI-80	SARFI-90
Singapore	4.1	5.0	8.5
EPRI DPQ Project (USA)	17.7	27.3	49.7
UNIPEDE DISDIP Mixed Systems (Europe)	44.0	NA	103.1
UNIPEDE DISDIP Cable Systems (Europe)	11.0	NA	34.6

Notes:
EPRI DPQ: Distribution Power Quality Project carried out by Electric Power Research Institute on 24 utilities in the USA.
UNIPEDE DISDIP: Distribution Survey carried out in nine European countries by the Union of International Producers and Distributors of Electrical Energy, Europe

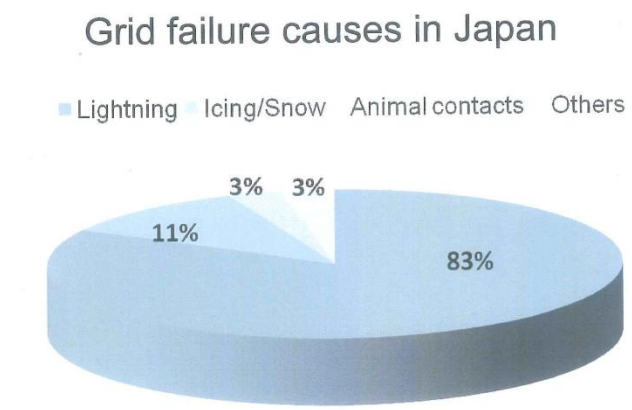
Source:
http://www.singaporepower.com.sg

JAPAN EXPERIENCE



Source:
Shizuki Electric Co. Inc

99% or more
< 200msec



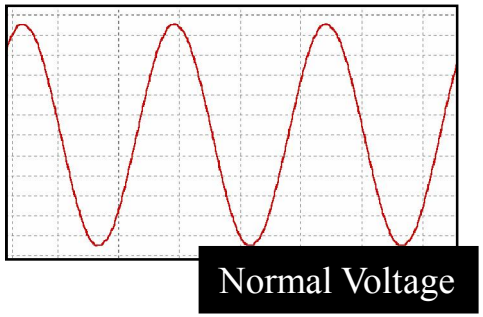
Lightning is the major cause of Voltage sags

OVERVIEW

- **Definition of Power Quality**

  'Any power problem manifested in voltage, current or frequency deviations that results in failure or misoperation of customer equipment'

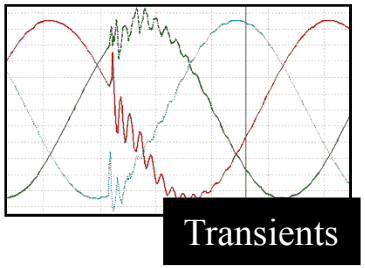
- **For continuous operation, equipment needs continuous rms voltage waveforms and frequencies**

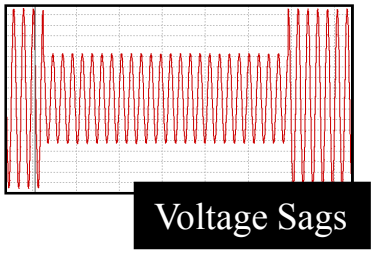


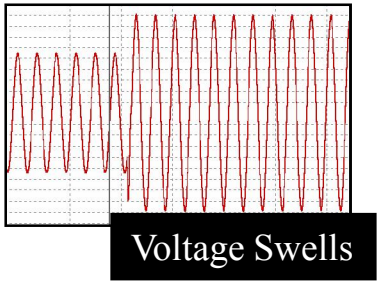
- **The truth about electrical system: They are not 100% 'clean/sinewave' at certain time only due to external disturbances**

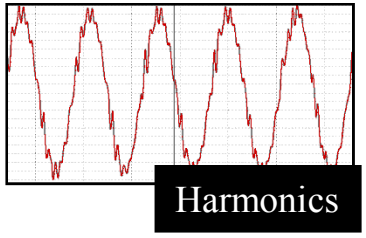
OVERVIEW

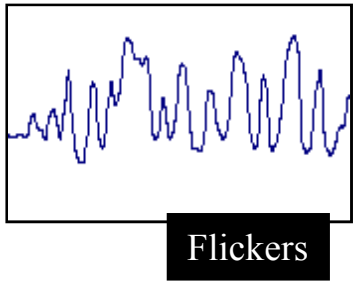
- **Classification of Events**
  - **Temporary Conditions**
    - Transients (<0.5 cycle)
    - Sags and Swells (0.5 cycle - 1 minute)
    - Long Term Voltage Variation (> 1 minute)
    - Flicker
  - **Steady-State Conditions**
    - Harmonics

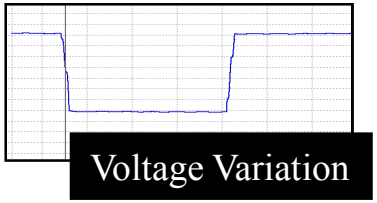

Transients


Voltage Sags


Voltage Swells


Harmonics

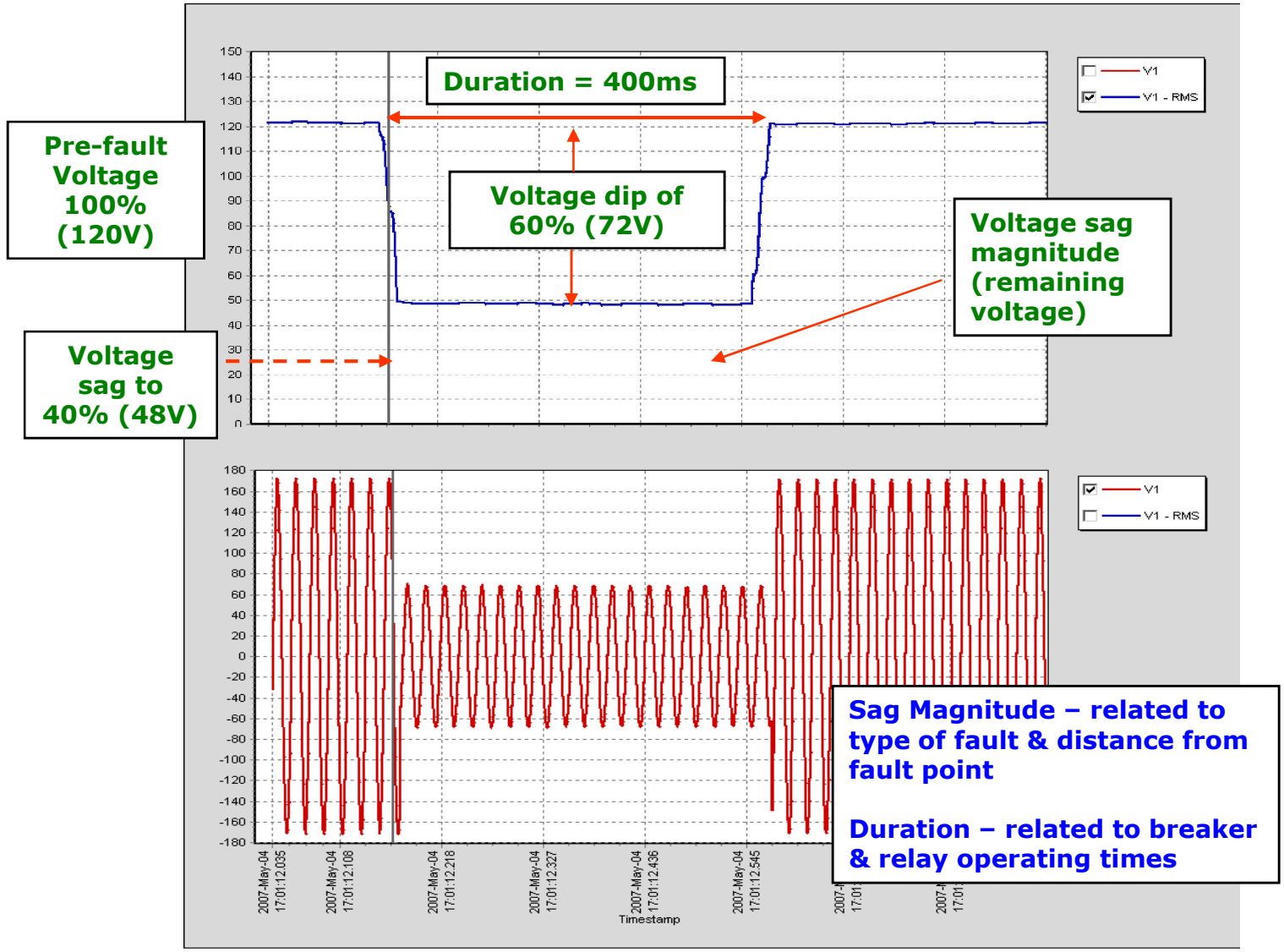

Flickers


Voltage Variation

- **Most PQ problems faced by customers is Voltage Sag**

OVERVIEW

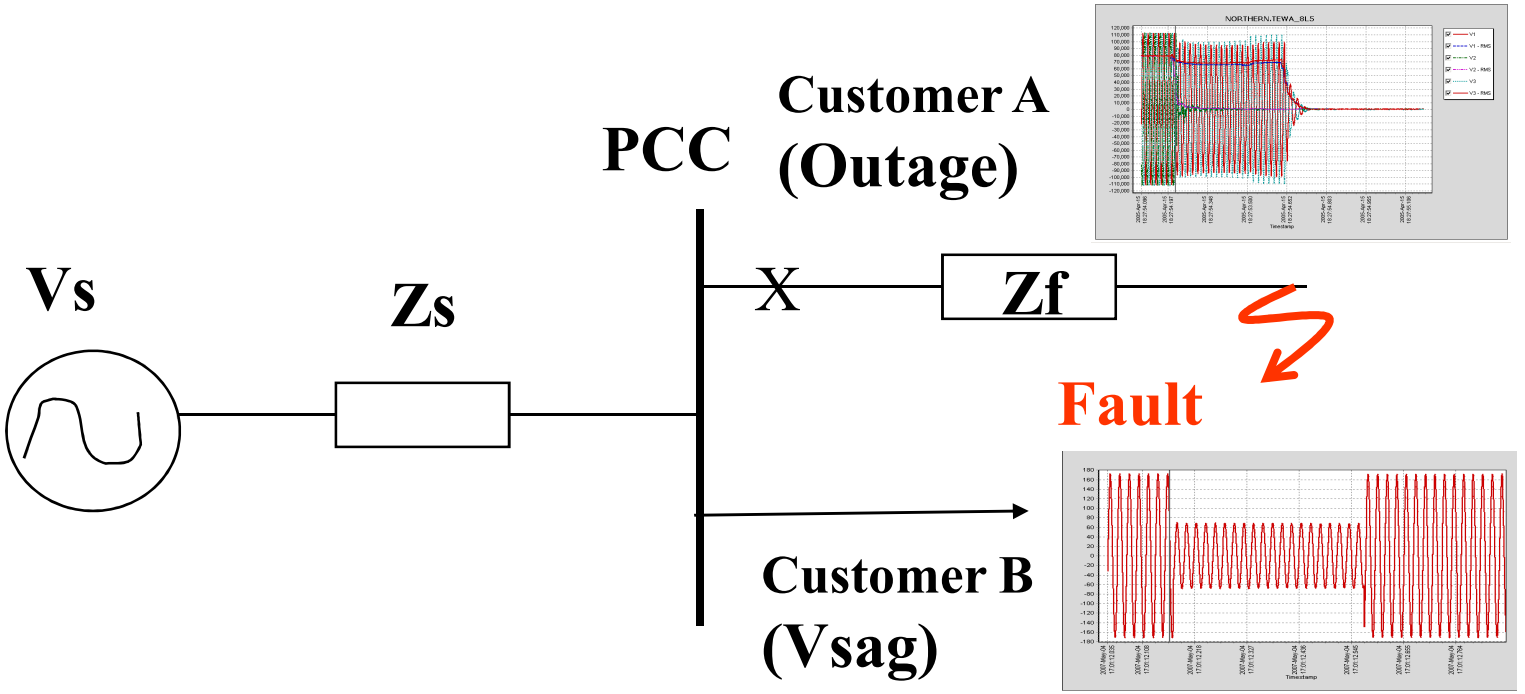
Voltage Sag - Magnitude & Duration



Sag Magnitude – related to type of fault & distance from fault point

Duration – related to breaker & relay operating times

OVERVIEW



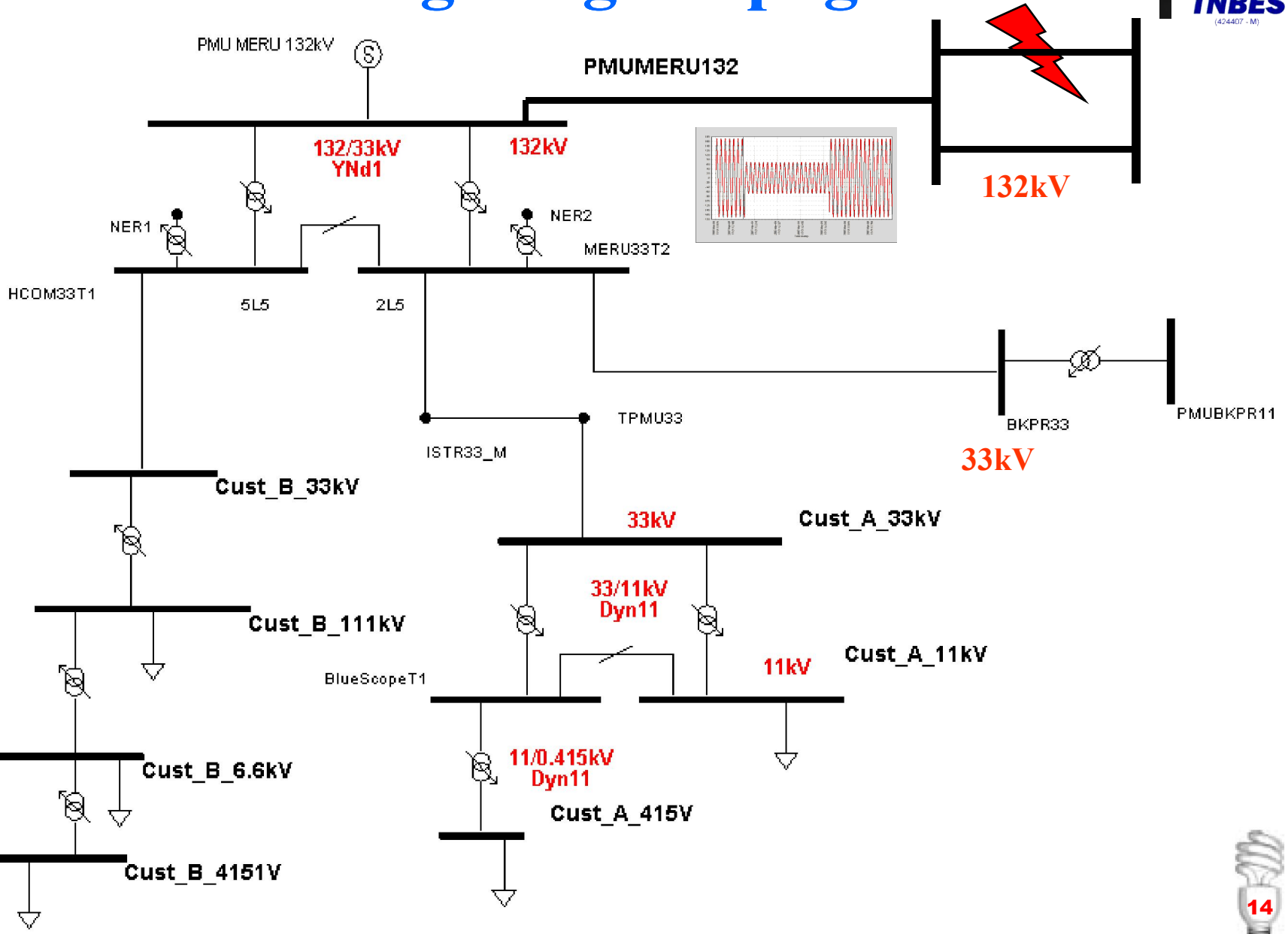
Power Quality on Voltage Sag

- Voltage sag occurs naturally as a result of lightning strikes, flashovers, power system faults, 3rd party interference (crane, digging, theft), etc
- They cannot totally eliminated because many voltage sags are caused by natural phenomenon

Impact of voltage sag

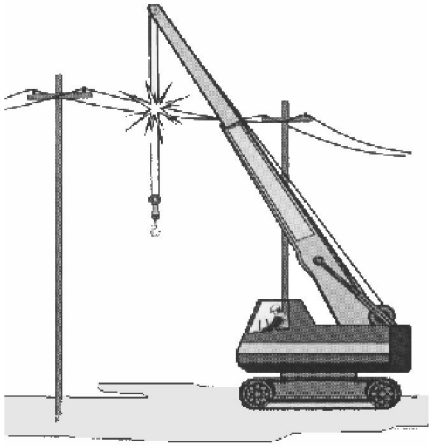
- Equipment malfunctioned
- Manufacturing process stopped
- Lost productivity, idle people and equipment
- Others

Voltage Sag Propagation

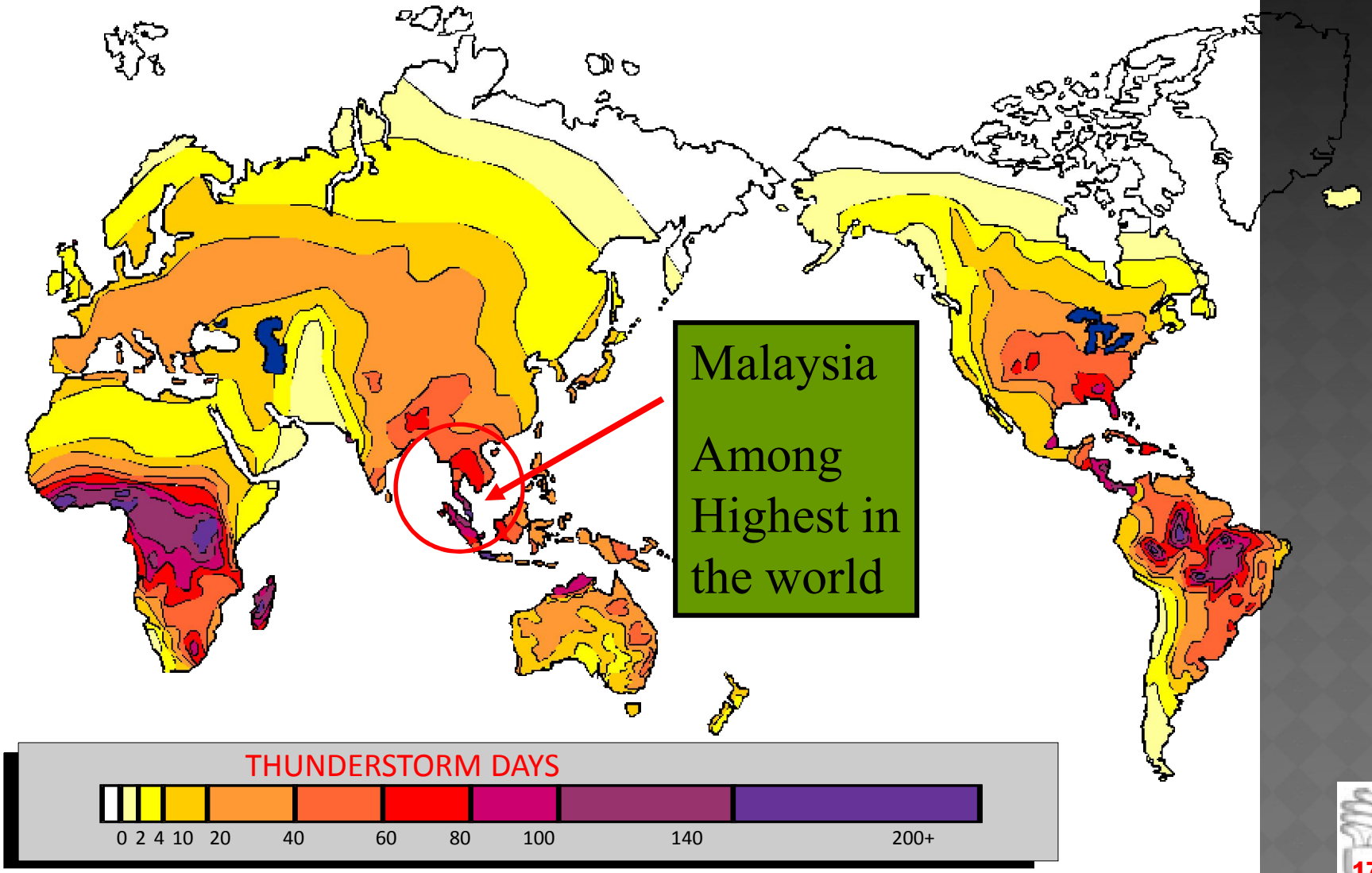


Causes of Voltage Sag (1)

Causes of Voltage Sag (2)



LIGHTNING DAYS



OVERVIEW

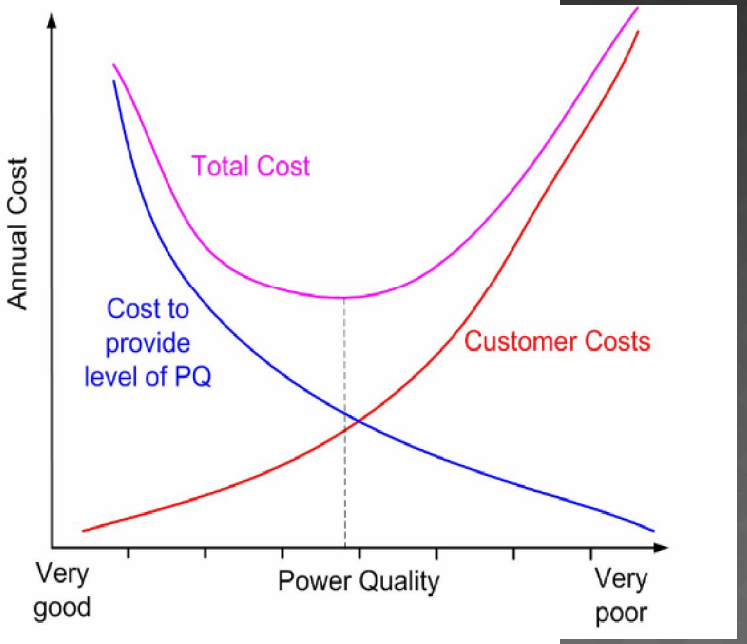
Concept of PQ: Compatibility/EMC problem between the source and the load, not perfection of source

i.e. Power delivered by grid compatible with equipment connected, and vice versa.

Why? The causes

Voltage sag cannot be eliminated (inherent)

- There are always two solutions to compatibility:
  - Either improve the power, or make the load tougher



Action (shared responsibility): To mitigate the problem

- ***Utility***
- ***Customers***
- ***Equipment manufacturer***
- ***Regulator***

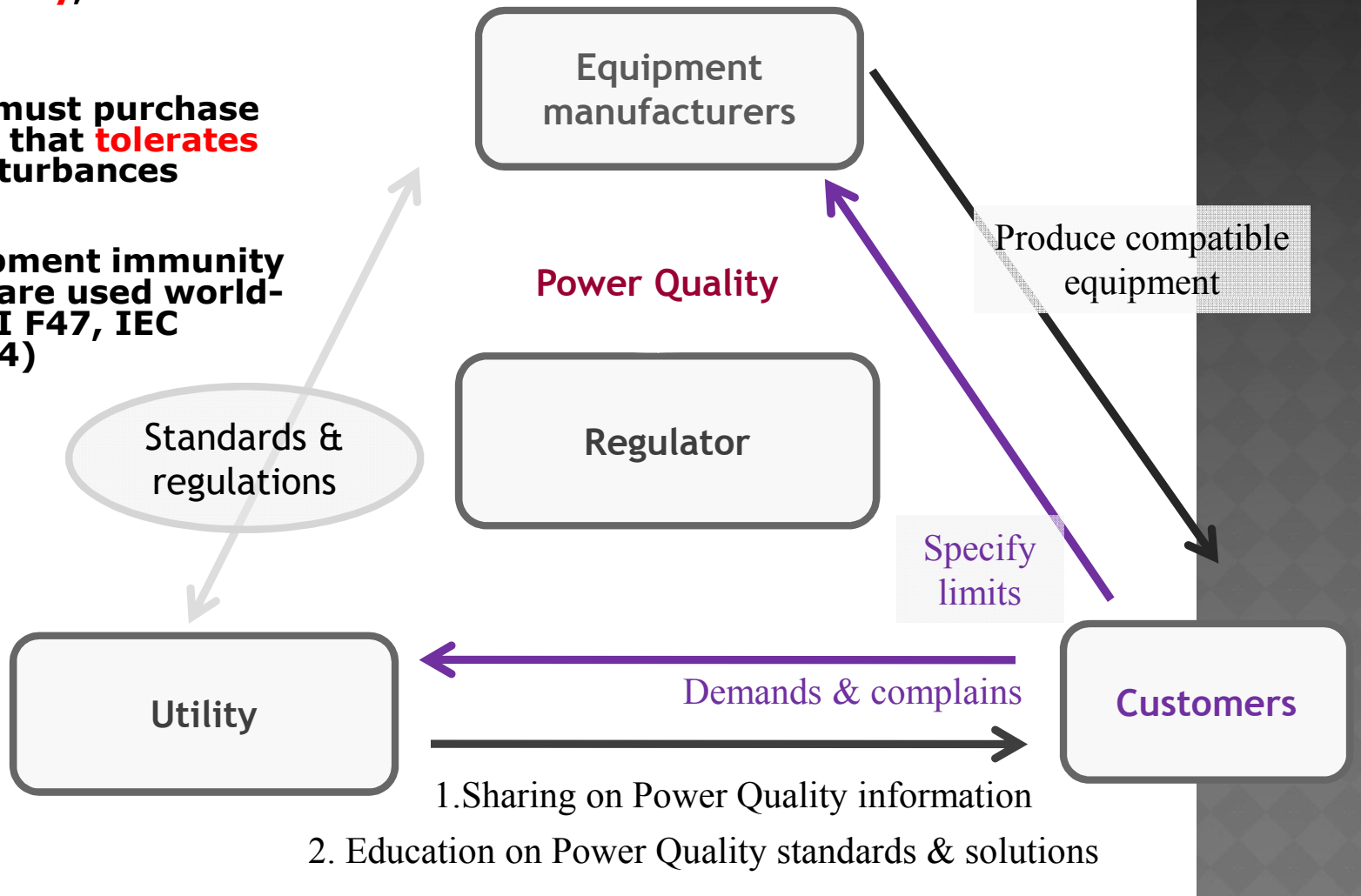
} Have role to play

- ***Standards/Guidelines, Immunity Level, SARFIx***

Power Quality is a shared responsibility…

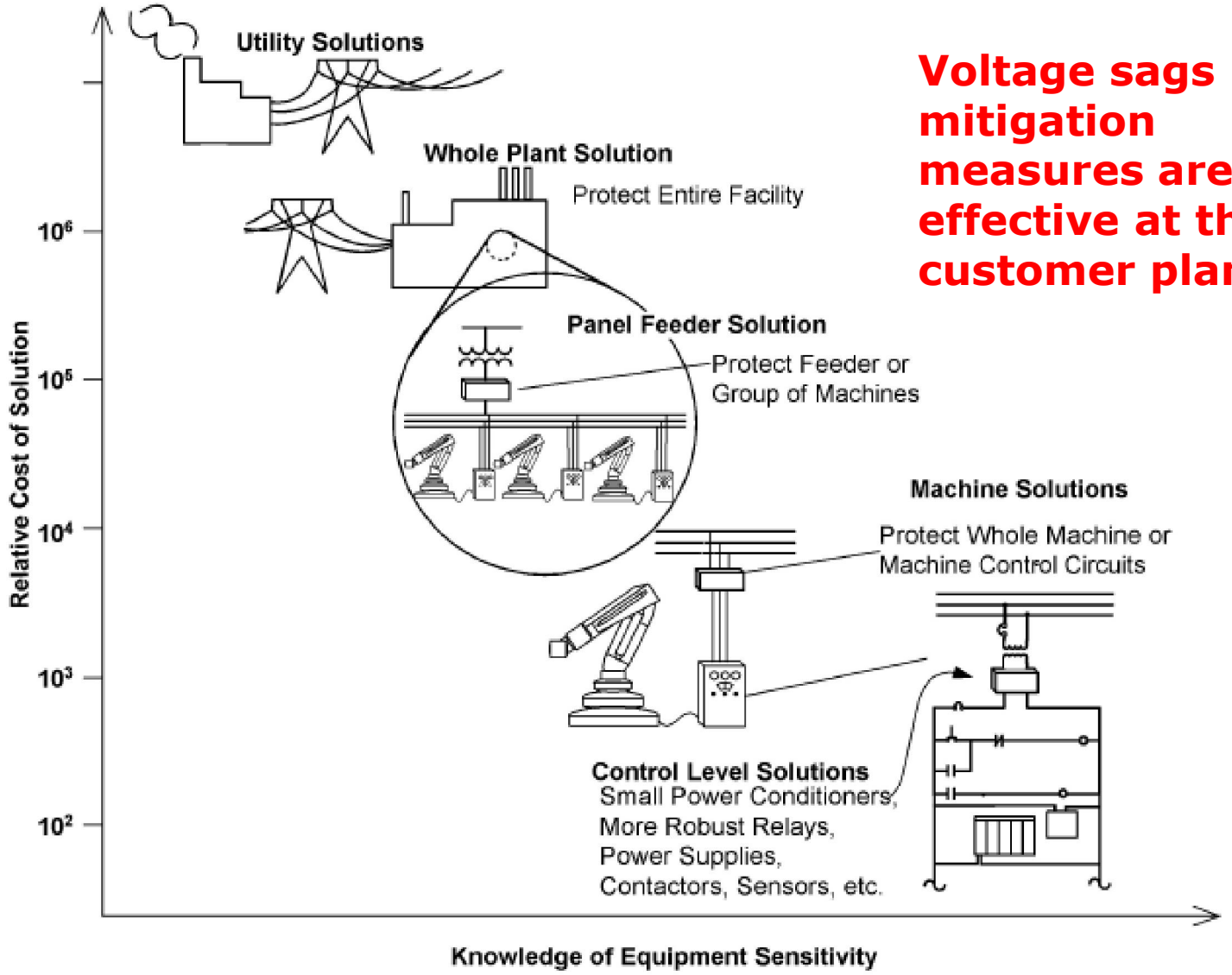
SOLVING POWER QUALITY ISSUES IS EVERY PROFESSIONAL'S RESPONSIBILITY

- **Utility must deliver some level of quality, but not perfection**
- **Customer must purchase equipment that tolerates normal disturbances**
- **More equipment immunity standards are used world-wide (SEMI F47, IEC 61000-4-34)**



WHERE TO SOLVE THE PROBLEM

Cost



Voltage sags mitigation measures are more effective at the customer plant end

PROBLEM STATEMENT

The cost of PQ disturbance:

1.Product-related losses, such as loss of product/materials, lost production capacity, disposal charges, and increased inventory requirements.

2.Labor-related losses, such as idled employees, overtime, cleanup, and repair.

3.Ancillary costs, such as damaged equipment, lost opportunity cost, and penalties due to shipping delays.

Estimated Losses of Voltage Dip Events

Source: PQ Baseline Study in Peninsular Malaysia by Energy Commission

Year	International Standards	Total Cost (RM)
2011	SEMI F47	520,157,000
	IEC 61000-4-34	473,341,000
2012	SEMI F47	933,545,144
	IEC 61000-4-34	910,445,144

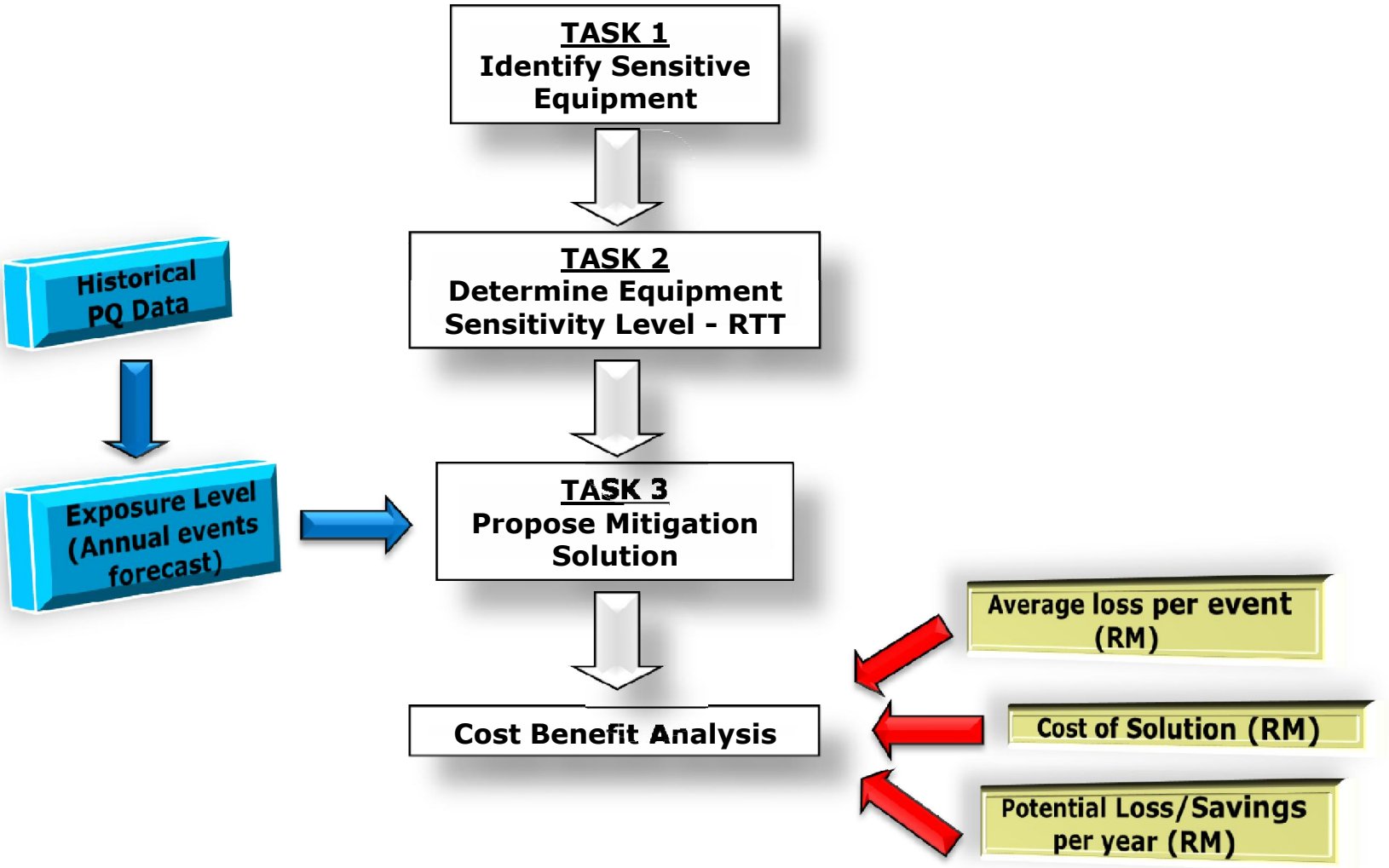
Power Quality Mitigation Services

OBJECTIVE

1. To investigate PQ problems faced by the customer
2. To identify the most probable 'weak point' or sensitive equipment/processes within the customer facilities
3. To establish the sensitivity level of equipment towards voltage sags at the customer facilities
4. To establish exposure level towards voltage sags
5. To recommend optimum/cost effective solutions and cost benefit analysis

SERVICES METHODOLOGY

Flow-chart of the PQ Consultancy Services



TESTING EQUIPMENT - SAG GENERATOR

- Single Phase

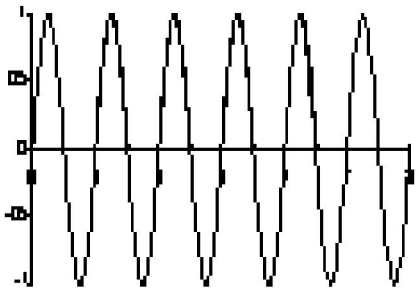
  CHROMA Programmable AC Source (3kVA)

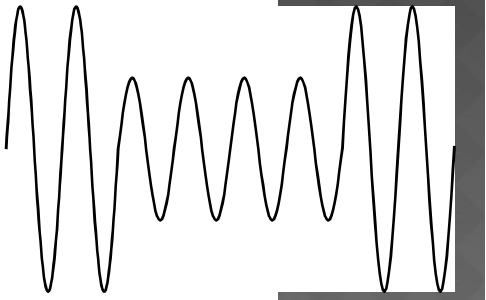
- 3-phase

  PSL Industrial Power Corruptor (200A)

Ride-Through Test (RTT)

Equipment Performance (Ride-through Capability) Evaluation



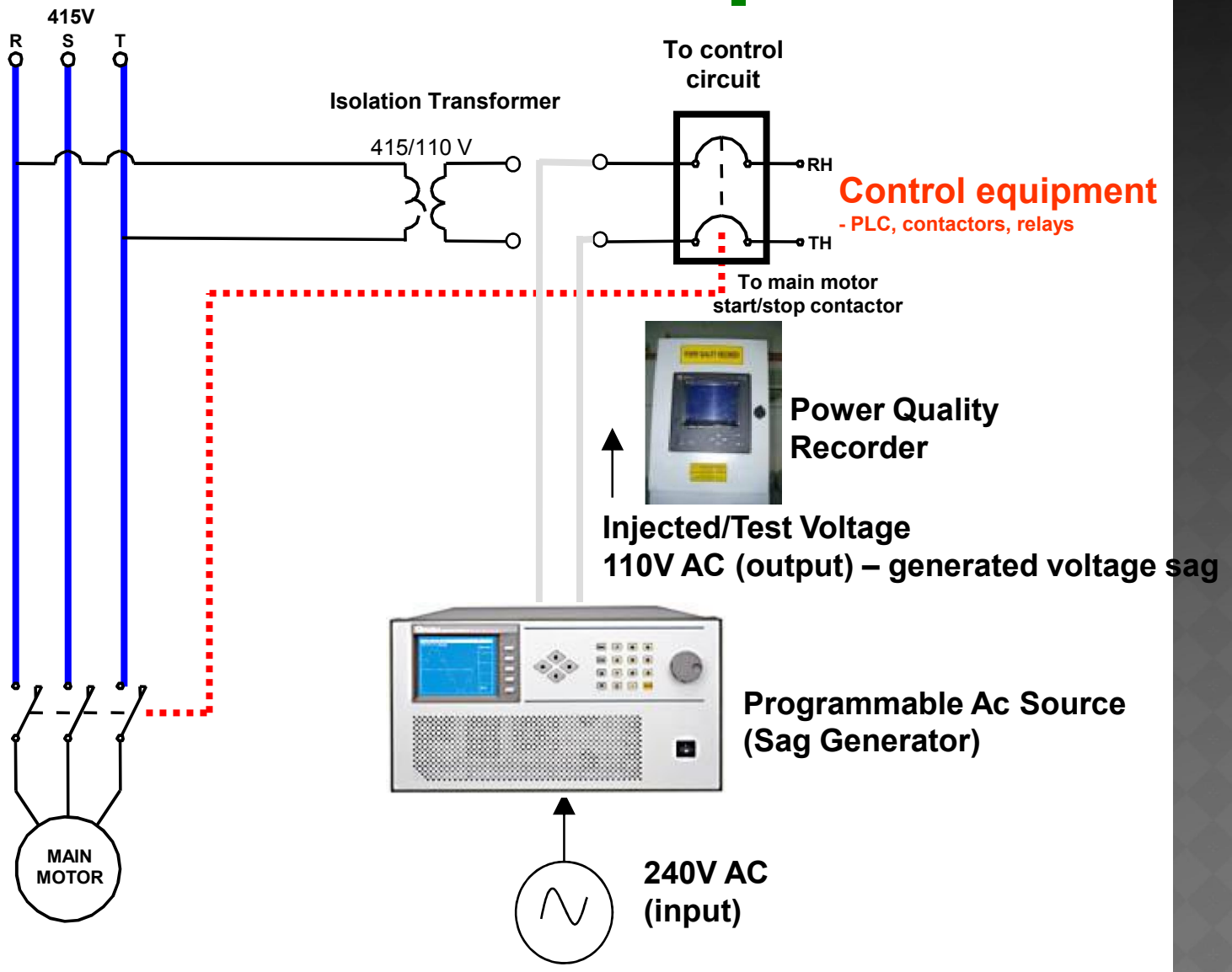


Normal Supplied Voltage

Generated Voltage Sag (defined magnitude & duration)

Programmable AC Source (Sag Generator)

RTT Setup

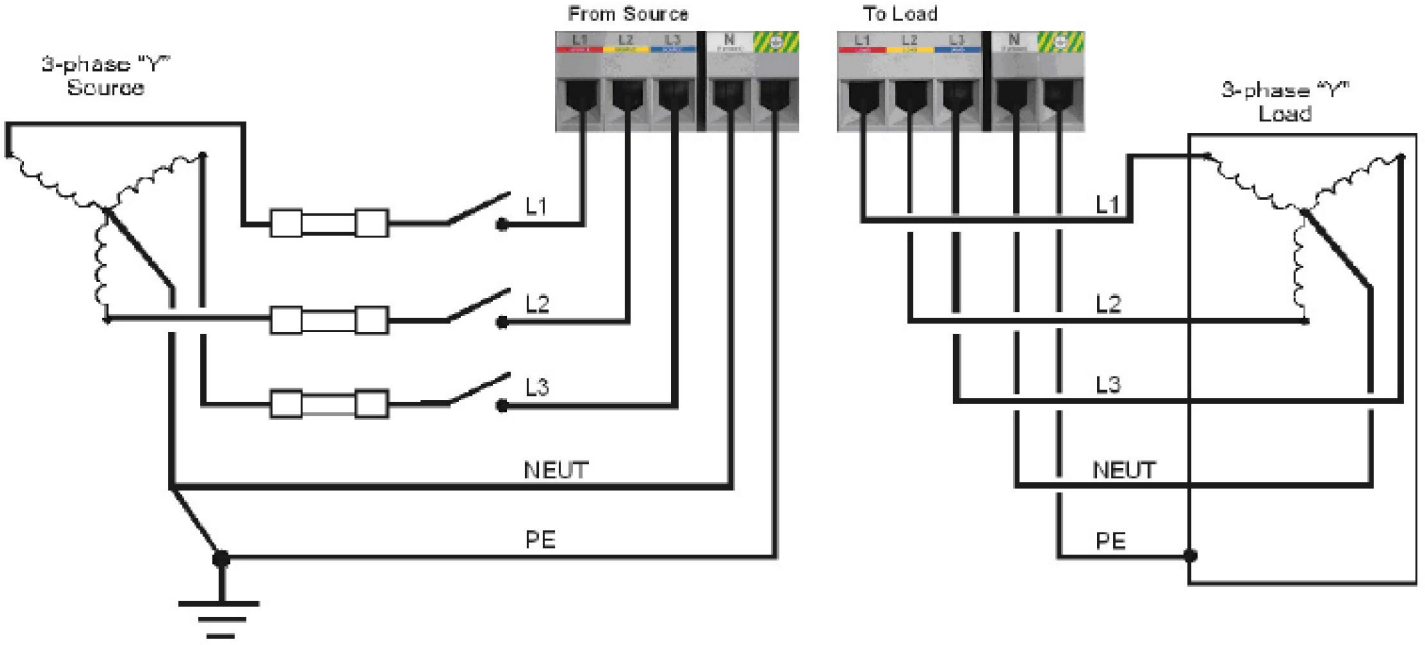


Primary Equipment – motors, pumps, chiller

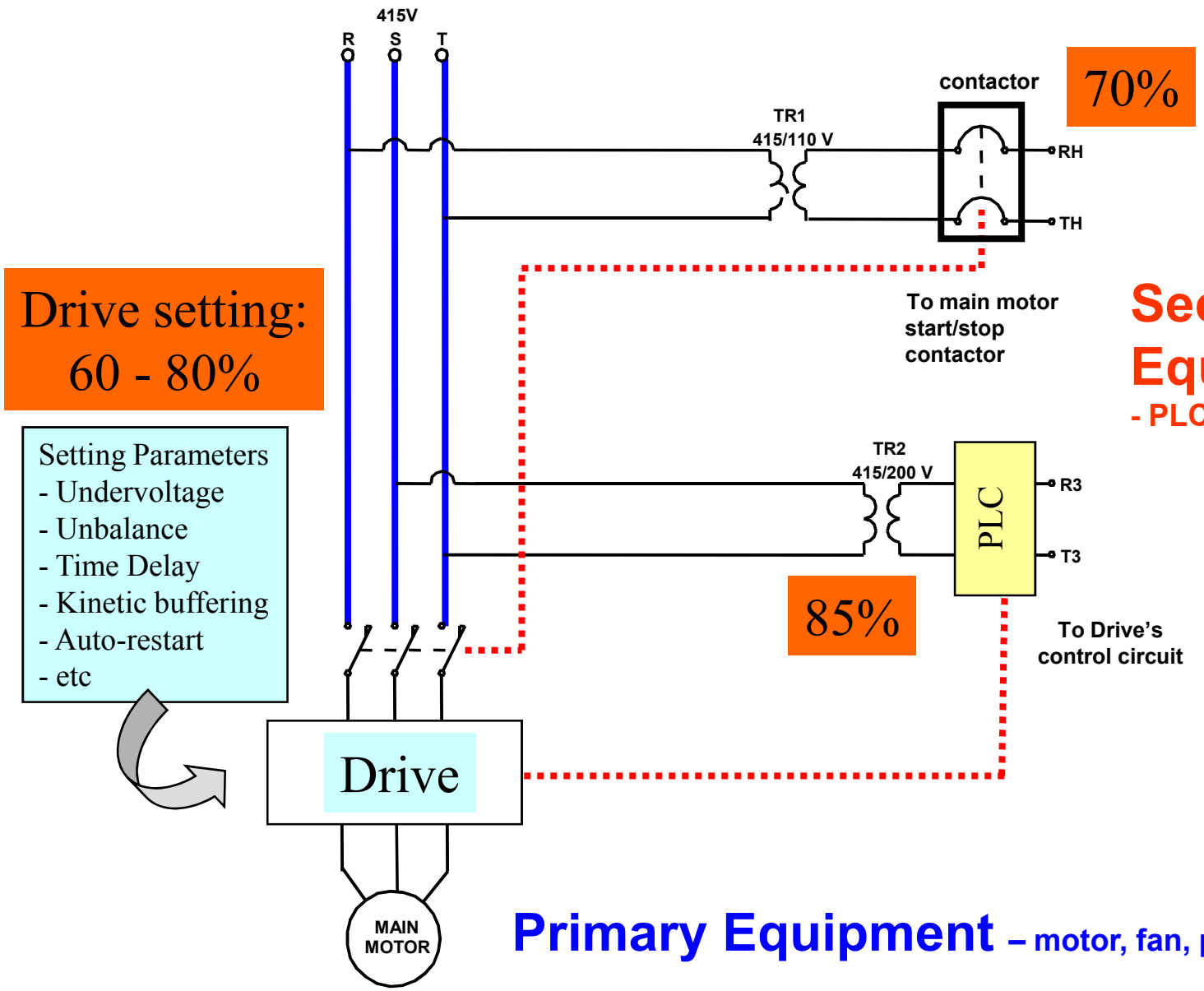
RTT Setup

(3-phase sag generator)

Max = 200A



Example of RTT Results - Equipment Sensitivity Levels



Secondary Equipment
- PLC, contactors, relays

Primary Equipment – motor, fan, pump, chiller

Guidelines on Ride-through Capability

- **CBEMA**
  (Computer Business Equipment Manufacturers Association)

- **ITIC**
  (Information Technology Industry Council)

- **SEMI F47**
  (SEMI – Semiconductor Equipment & Materials International)

- **Malaysian Standard**
  MS IEC 61000-4-34 (Class 3)

SEMI F47

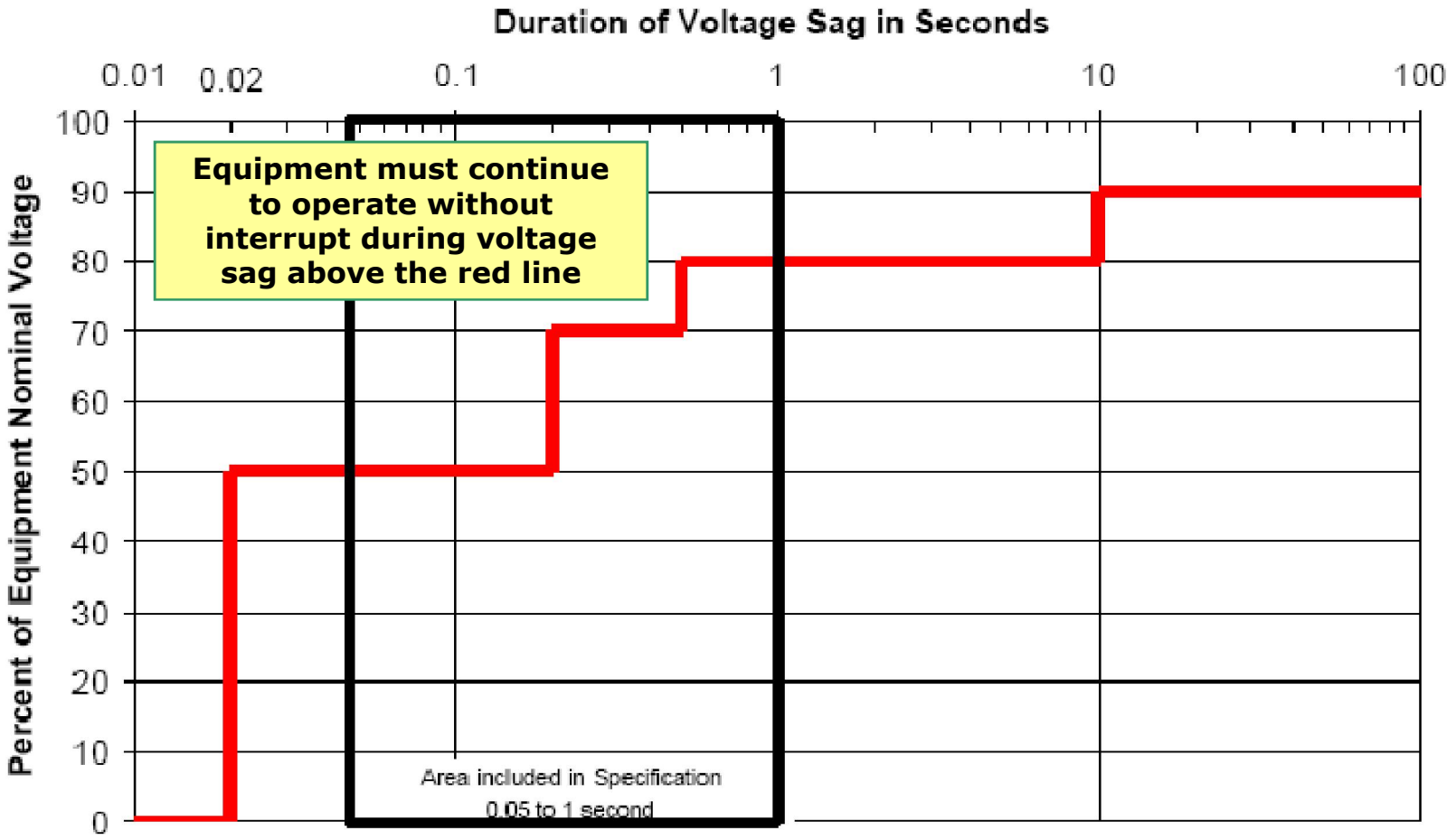
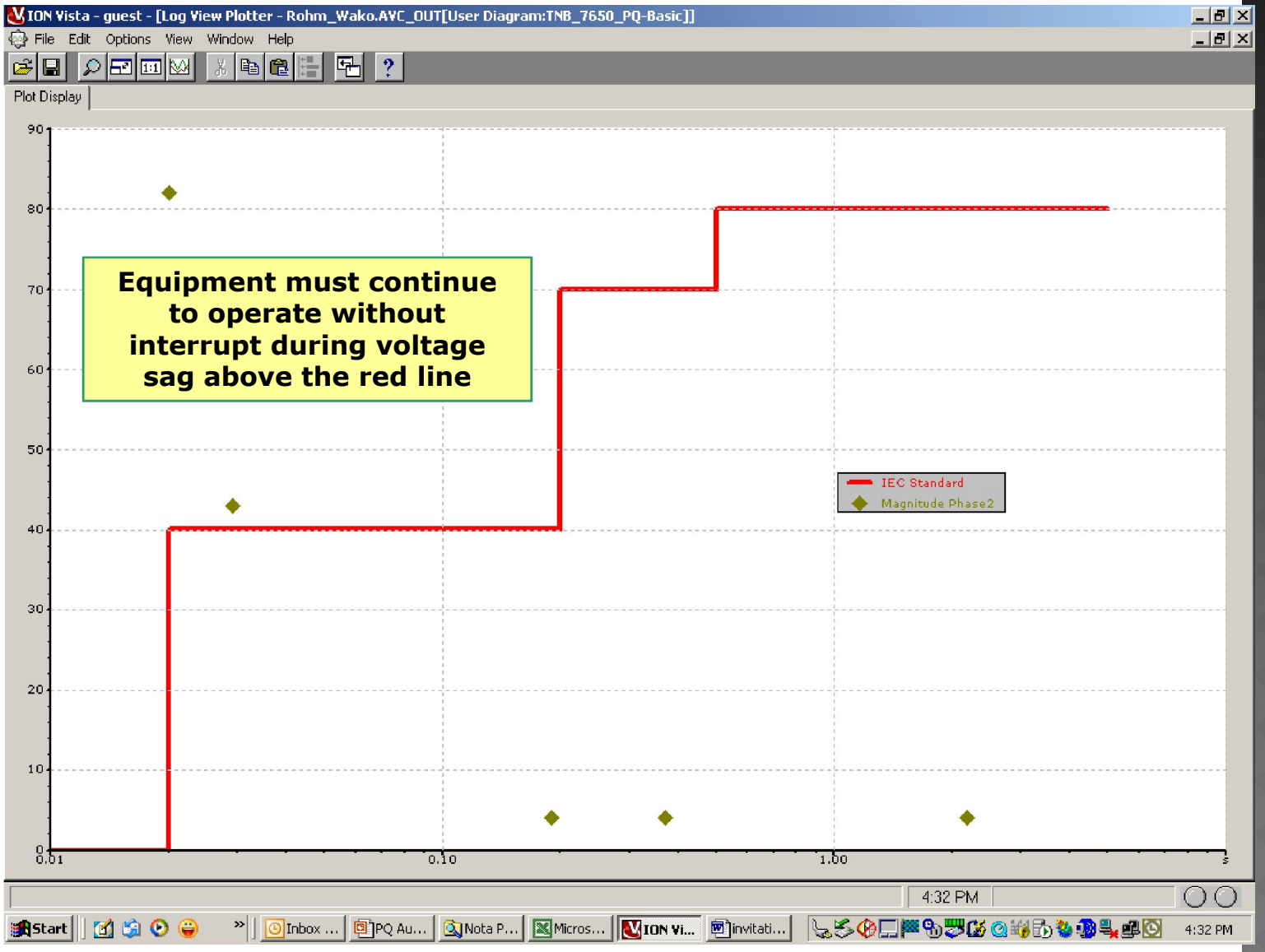
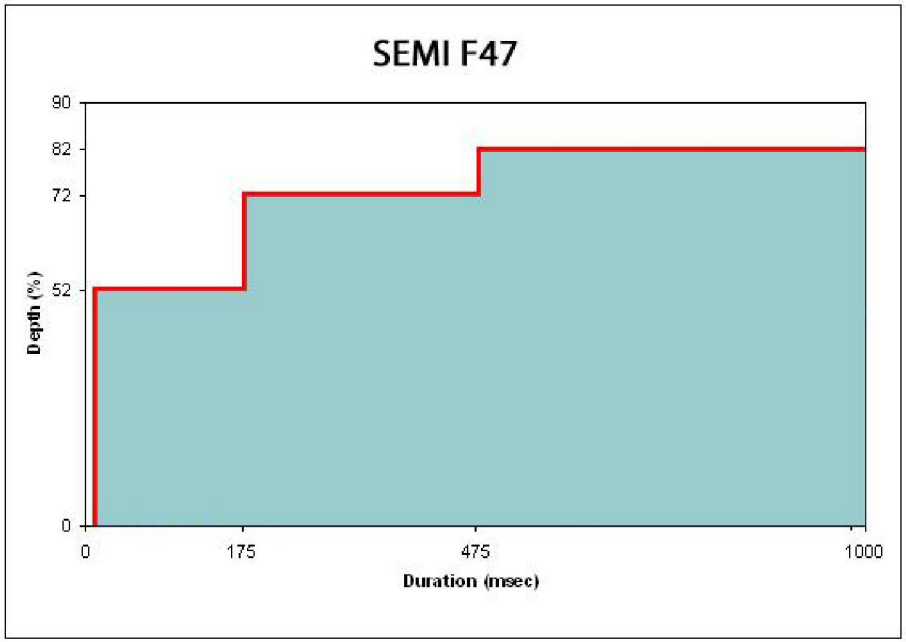


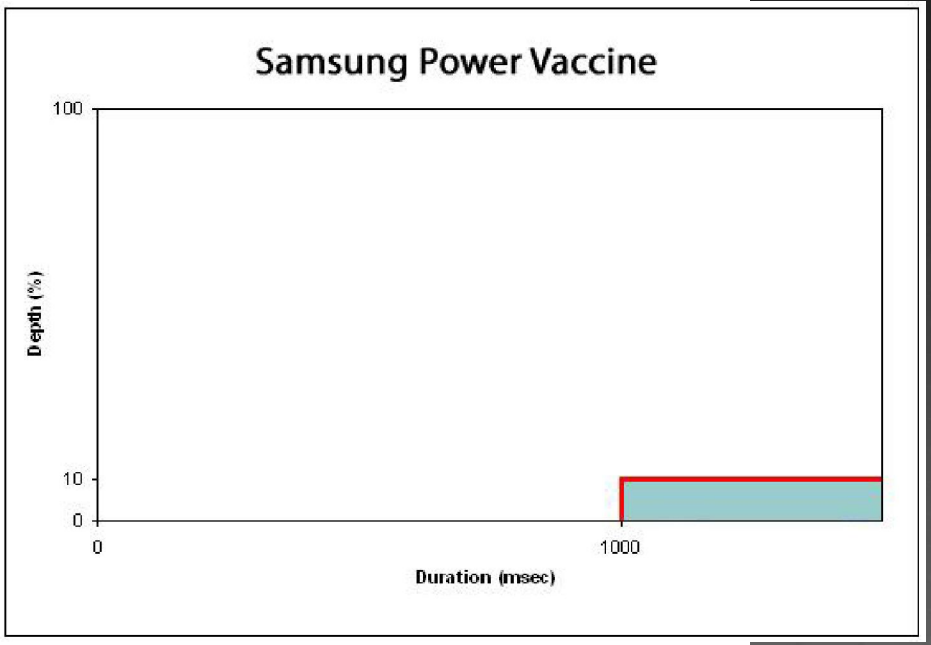
Figure R1-1
Recommended Semiconductor Equipment Voltage Sag Ride-Through Capability Curve from 0 to 100 Seconds

Voltage Sag Immunity Std in Malaysia
MS IEC 61000-4-34, Class 3



Samsung Power Vaccine



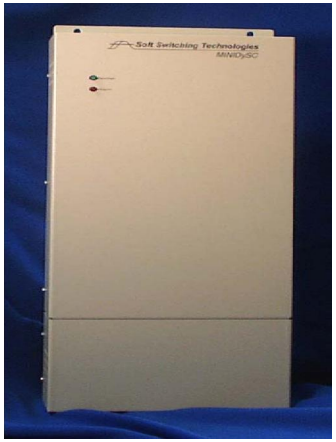


Samsung Semiconductor has developed a "Power Vaccine" specification for semiconductor manufacturing equipment, which is far more stringent than the usual power quality immunity specification for this type of equipment, SEMI F47

The Samsung "Power Vaccine" specification requires semiconductor manufacturing equipment to tolerate a complete loss of power for 1 second.

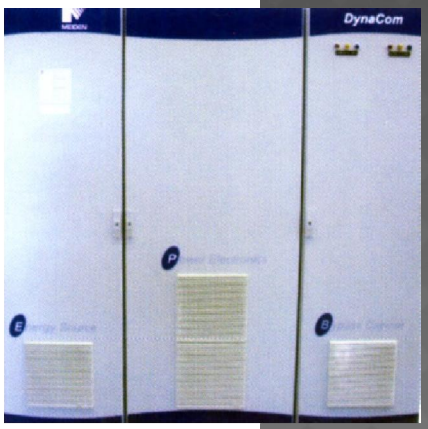
Single-phase PQ Mitigation Equipment

PQ Mitigation Equipment	Type of Energy Storage	Output Voltage Waveform	Ride-through Capability
1a. MiniDySC (Dynamic Sag Corrector)	Ultra-capacitor	Sinusoidal	0% voltage for 50ms
1b. MiniDySC (Dynamic Sag Corrector) - Extended	Ultra-capacitor	Sinusoidal	0% voltage for 200ms
2. Dip-Free	Ultra-capacitor	Square	0% voltage for 1 sec
3. Dip-Proofing Inverter (DPI)	Ultra-capacitor	Square	0% for for 3 secs
4. Voltage Dip Compensator (VDC)	Transformer	Sinusoidal	36% voltage for 2.1s
5. On-Line UPS	Battery	Sinusoidal	0% for >1mins



Three-phase PQ Mitigation Equipment

PQ Mitigation Equipment	Type of Energy Storage	Rating / Capacitty	Ride-through Capability
1. ABB AVC (Active Voltage Conditioner)	Transformer	1. AVC1 : 20 - 60 kVA 2. AVC2 : 165 - 2000 kVA 3. AVC RTS	1. 30% for 10s (1-phase) 2. 30% for 200ms (3-phase) 3. 0% for 30secs
2. Pro-DySC	Ultra-capacitor	10 - 3000 kVA	0% voltage for 50ms 0% voltage for 200ms (extended)
3. Meiden Dynamic Voltage Compensator	1. Ultra-capacitor 2. Battery	1. Ultra-Cap: 350A - 700A 2. Battery : 350A - 1400A	40% voltage for 1 sec



PRO DySC

ABB

VECTEK Electronics Ltd

MEIDEN POWER SOLUTIONS

SEMI F47 Compliant Components

D Line Contactors

D Line contactors are Semi F47 compliant and are perfect for EMO contactor contactor applications. D-line contactors are available in 115A and 150A versions. The addition of overloads for motor starting applications create Semi F47 compliant starters. D Line contactors are designed to accept ring terminals for wire termination. All carry UL, IEC, CE mark.
Click here for 9 to 32 Amps.
Click here for 40 to 150 Amps

F-Line Contactors

F line contactors are Semi F47 compliant and are perfect for EMO contactor applications. F-line contactors range from 185A -780A. The addition of overloads for motor starting applications create Semi F47 compliant starters. F-Line contactors are designed to accept ring terminals for wire termination. All carry UL, IEC, CE mark.
Click here for more information.

CA2K and SK Relays

The smallest industrial control relay in the industry. The basic relay is a 2 pole configuration-adding contact blocks converts it into a 4 pole device. Semi F47 compliant with 24Vac and 120Vac coils, and carry UL, IEC, CE mark. A DC version is also available. Click here for more information.

Phaseo DC Power Supplies

Phaseo DC power supplies are new from Square D. Their narrow design saves panel space and all models din rail mount. Available in 2A (48W), 3A (72W), 5A (120W), and 10A (240W) with 12, 24, or 48Vdc output and offer manual or automatic/manual selectable reset capability. The automatic/manual selectable reset models include harmonic filtering circuitry to satisfy EN 6100-3-2. All models are Semi F47 compliant and carry UL, IEC, and CE mark.
Click here for more information.

CASE STUDY #1 (DETAILED)

ABC BERHAD

TYRE MANUFACTURING COMPANY

ABC Berhad has been selected based on several complaints on voltage sag experienced by the customer

Located at Taiping, Perak

ABC Berhad, in a relatively short span of a decade, has emerged as a global tyre manufacturer with exports more than 60 countries

CUSTOMER DETAILS

No.	Item	Details
a.	Customer Name	ABC Bhd
b.	Product	Tyre
c.	TNB Branch/Region/State	Taiping / Perak
d.	Voltage Level	11kV
e.	Source of Supply	PMU Kamunting 132/11kV
f.	Tariff	E2 Industrial
g.	Maximum Demand (MW)	X.X MW
h.	Monthly bill	RM XXX,000
i.	Estimated losses due to PQ events (RM)	Min: XX,000 Max: XXX,000

PQ DISTURBANCE

- **Based on discussion held and walkthrough audit:**

Date	Description	Time	Tripped equipment
21-Feb-08	Voltage Dip	6.15 pm	All Boiler house equipment were trip except 1&2
		7.40 pm	
11-Feb-08	Voltage Dip	11.45 am	Auxiliary pump 1&2
			Process water pump 2
			Low pressure air compressor
			High pressure air compressor 3
			Cooling tower pump 1&2
			Cooling tower fan 1, 2 & 3.

EQUIPMENT AFFECTED

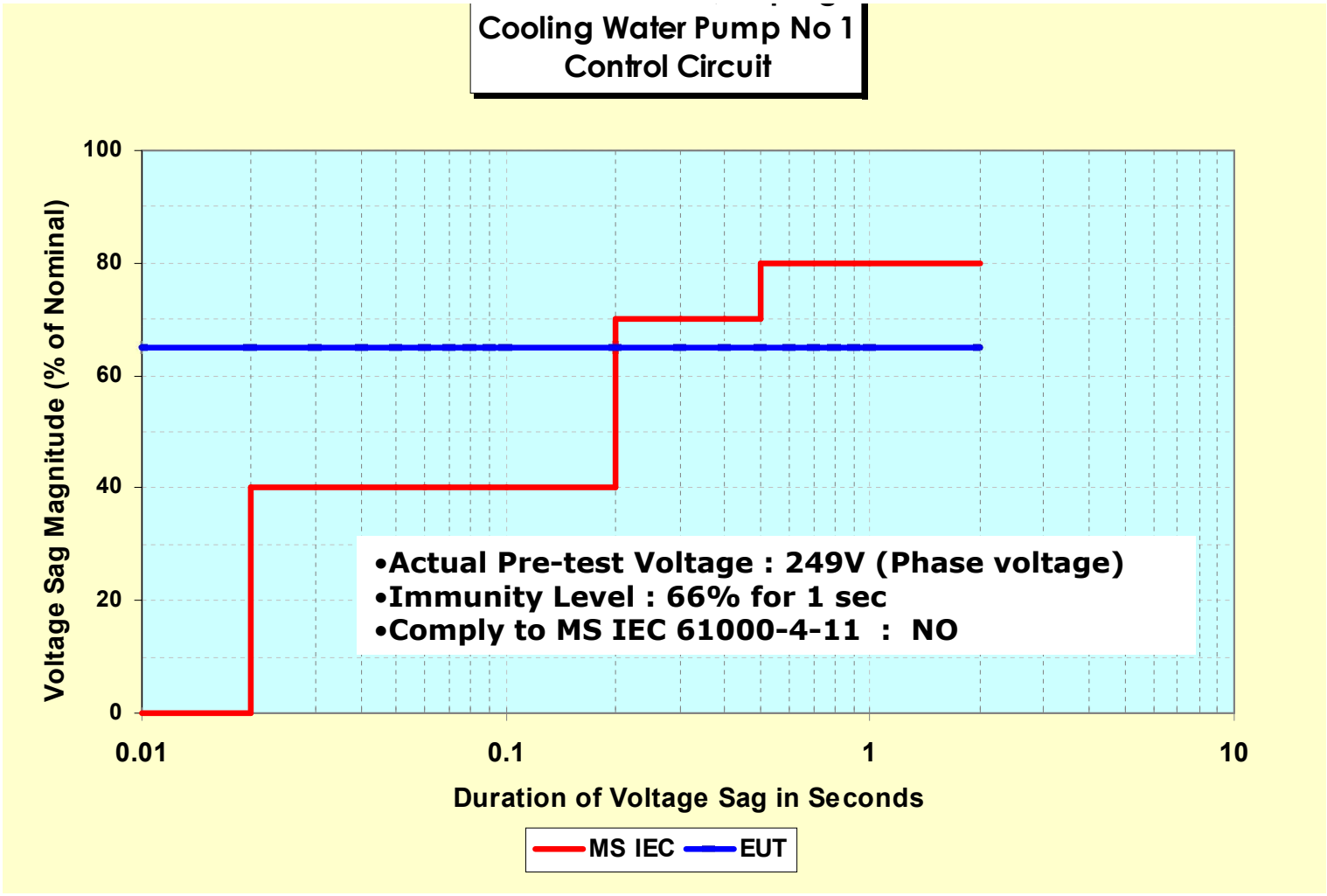
No.	Equipments	Additional Information	No of Unit	Level of Sensitivity
a.	Cooling Water Supply Pump	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	3 units	Critical
b.	Water Supply Pump	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Critical
c.	Low Pressure Compressor	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	5 units	Sensitive
d.	Cooling Water Return Pump	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Sensitive
e.	High Pressure Compressor	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Sensitive
f.	CT Pump	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Sensitive
g.	Boiler	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Sensitive

EQUIPMENT AFFECTED

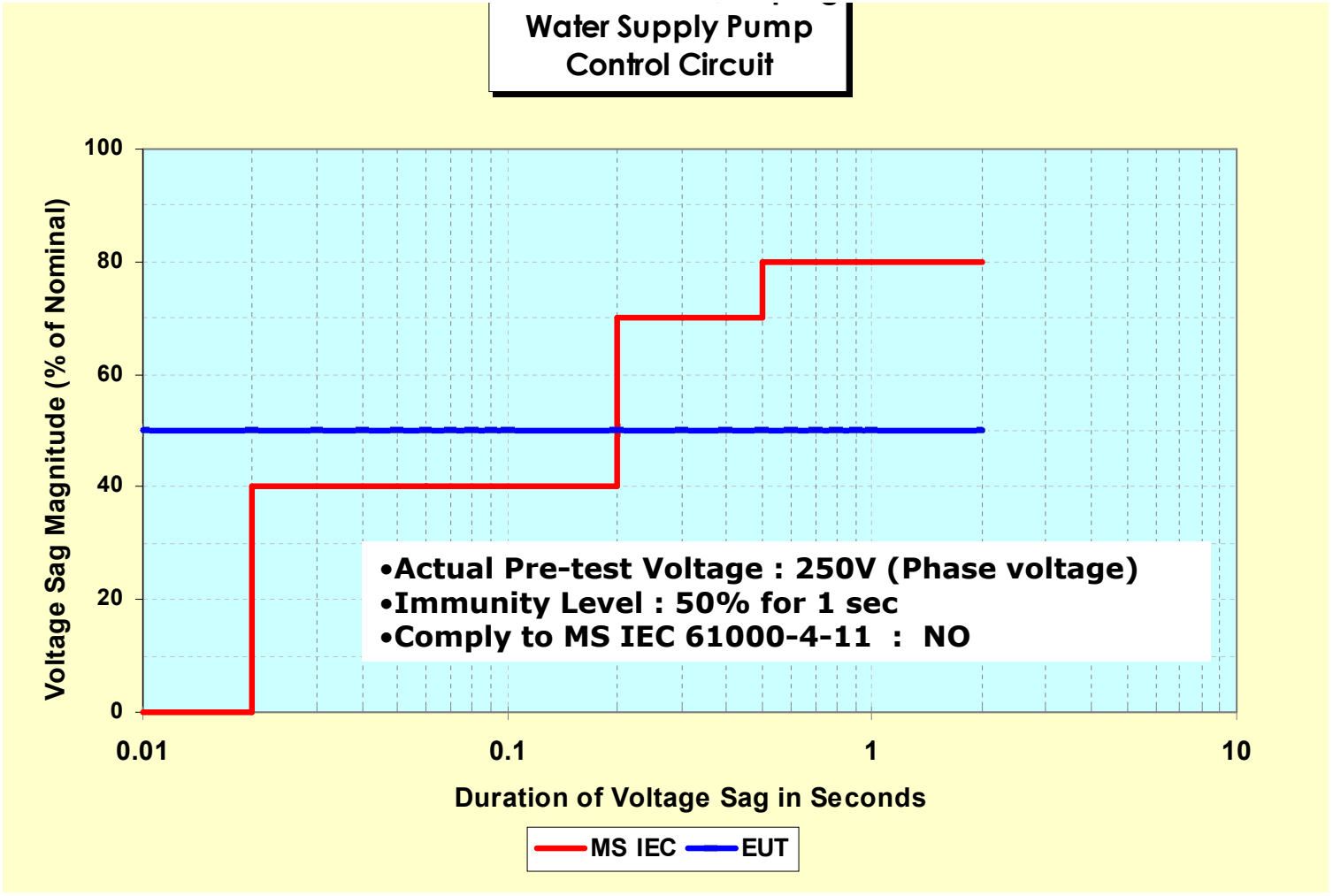
No.	Equipments	Additional Information	No of Unit	Level of Sensitivity
a.	Cooling Water Supply Pump	Main circuit, 415V, 3 phase Control circuit with magnetic contactor, 240V, 1 phase	3 units	Critical
b.	Water Supply Pump	Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Critical
c.	Low Pressure Compressor	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	5 units	Sensitive
d.	Cooling Water Return Pump	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Sensitive
e.	High Pressure Compressor	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	units	Sensitive
f.	CT Pump	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Sensitive
g.	Boiler	- Main circuit, 415V, 3 phase - Control circuit with magnetic contactor, 240V, 1 phase	2 units	Sensitive

RIDE THROUGH TEST

IMMUNITY LEVEL



IMMUNITY LEVEL



EXPOSURE LEVEL

- **ABC Berhad is exposed to voltage sag from transmission (132kV and above) and distribution (11kV) system that can be due to any fault in TNB systems as well as fault in customer's plant/substation**
- **The effect of the voltage sag on equipments in ABC Berhad depends on the severity of the voltage sag and the immunity level against voltage sag of the equipments itself**
- **Voltage sag data was extracted from PQ recorder installed at PMU KAMUNTING (incorporated in TNB Power Quality Monitoring System) to match ABC Berhad disturbance record**
- **Based on SARFI Index, the exposure level for ABC Berhad can be determined.**

SARFI INDEX

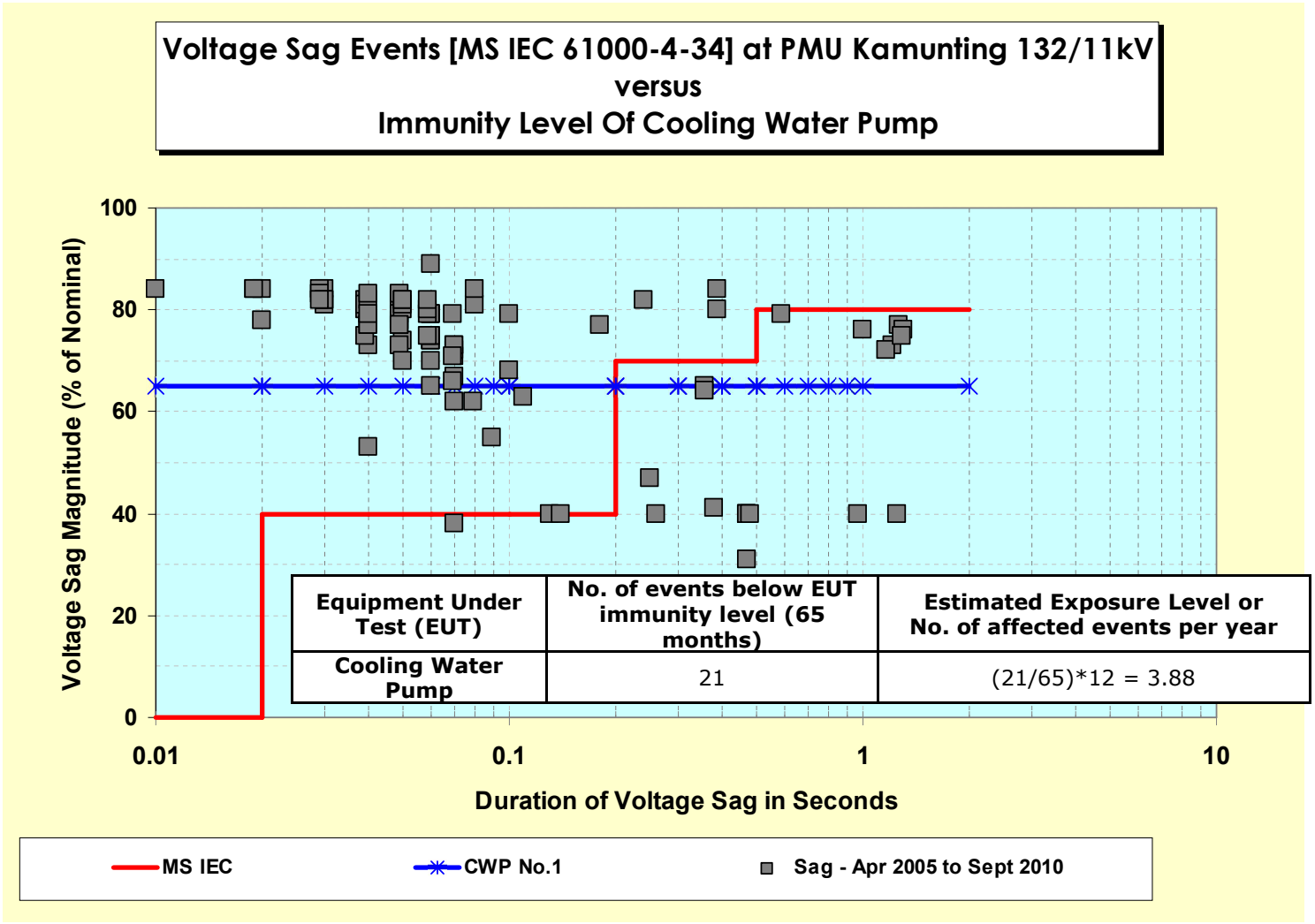
SARFI Index for PMU Kamunting 132kV/11kV

SARFI	Sep-10	2009	2008	2007	2006	Apr-05	Average per year
90	10	15	23	13	18	18	17.91
80	6	11	17	12	12	7	12.00
70	1	4	8	6	4	1	4.43
60	1	3	6	4	1	0	2.77
50	1	3	4	4	1	0	2.40
40	0	1	0	1	0	0	0.37
30	0	0	0	0	0	0	0.00
20	0	0	0	0	0	0	0.00
10	0	0	0	0	0	0	0.00
0	0	0	0	0	0	0	0.00

Note:

SARFI (System Average RMS Variation Frequency Index) is an index counting the number of voltage sag event below certain levels. For example, SARFI-70 is a number of voltage sag events for voltage sag below 70%.

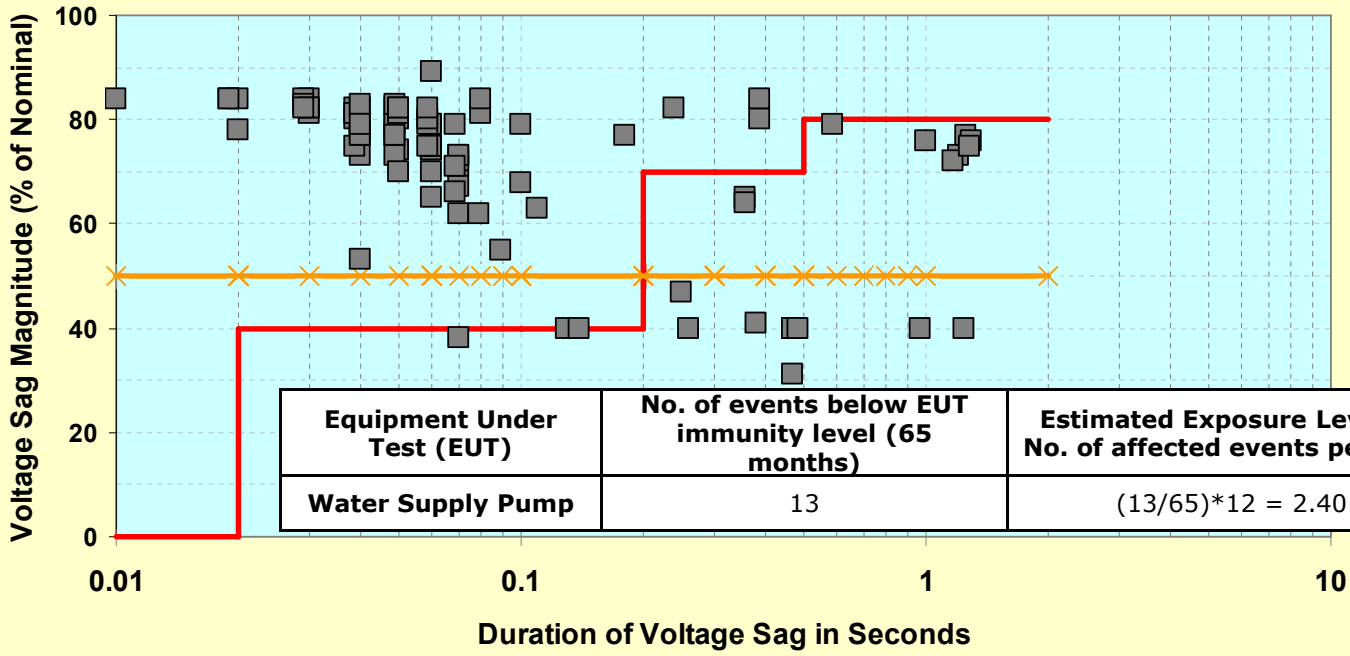
EXPOSURE LEVEL



Equipment Under Test (EUT)	No. of events below EUT immunity level (65 months)	Estimated Exposure Level or No. of affected events per year
Cooling Water Pump	21	(21/65)*12 = 3.88

EXPOSURE LEVEL

Voltage Sag Events [MS IEC 61000-4-34] at PMU Kamunting 132/11kV versus Immunity Level Of Water Supply Pump

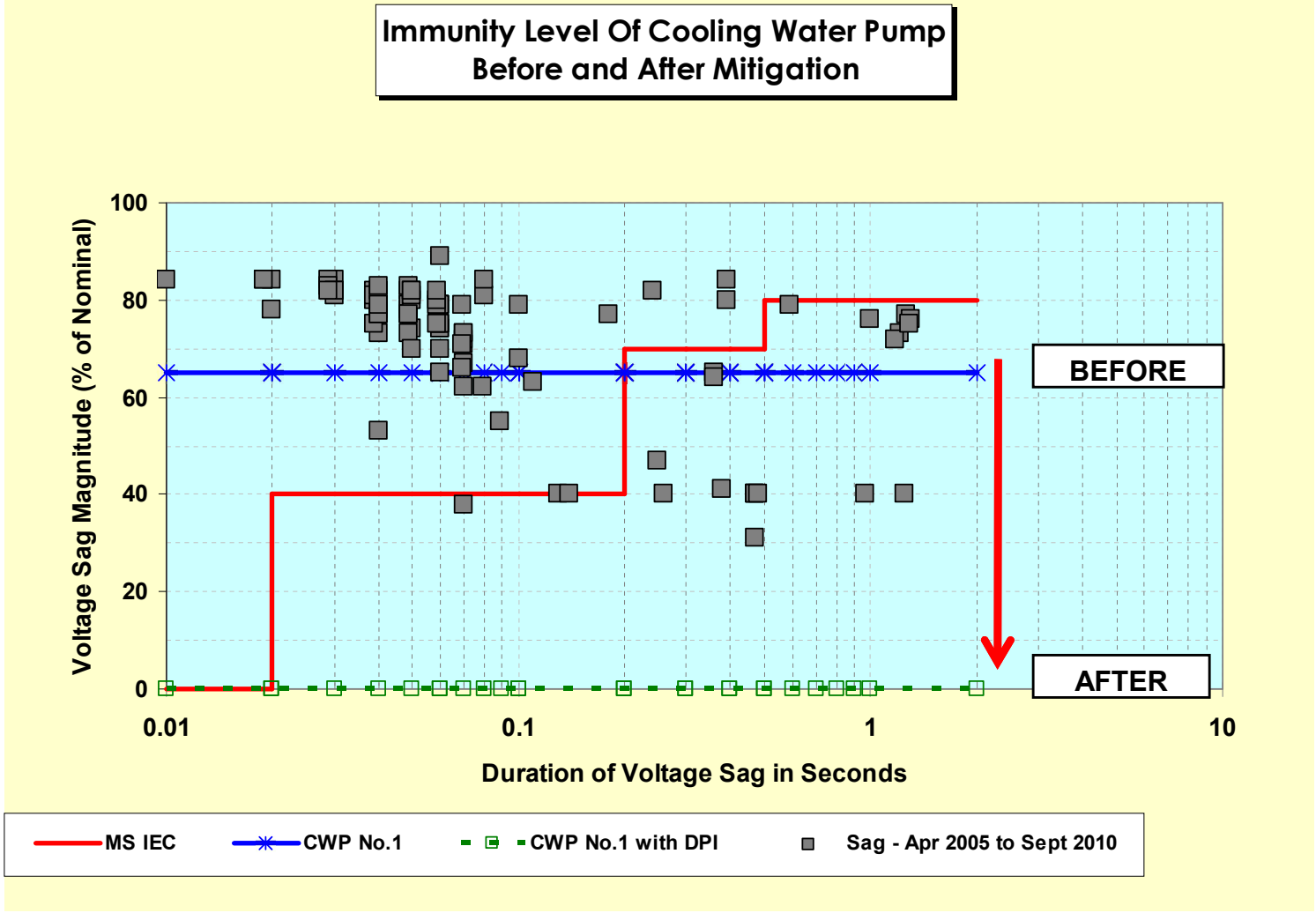


Equipment Under Test (EUT)	No. of events below EUT immunity level (65 months)	Estimated Exposure Level or No. of affected events per year
Water Supply Pump	13	(13/65)*12 = 2.40

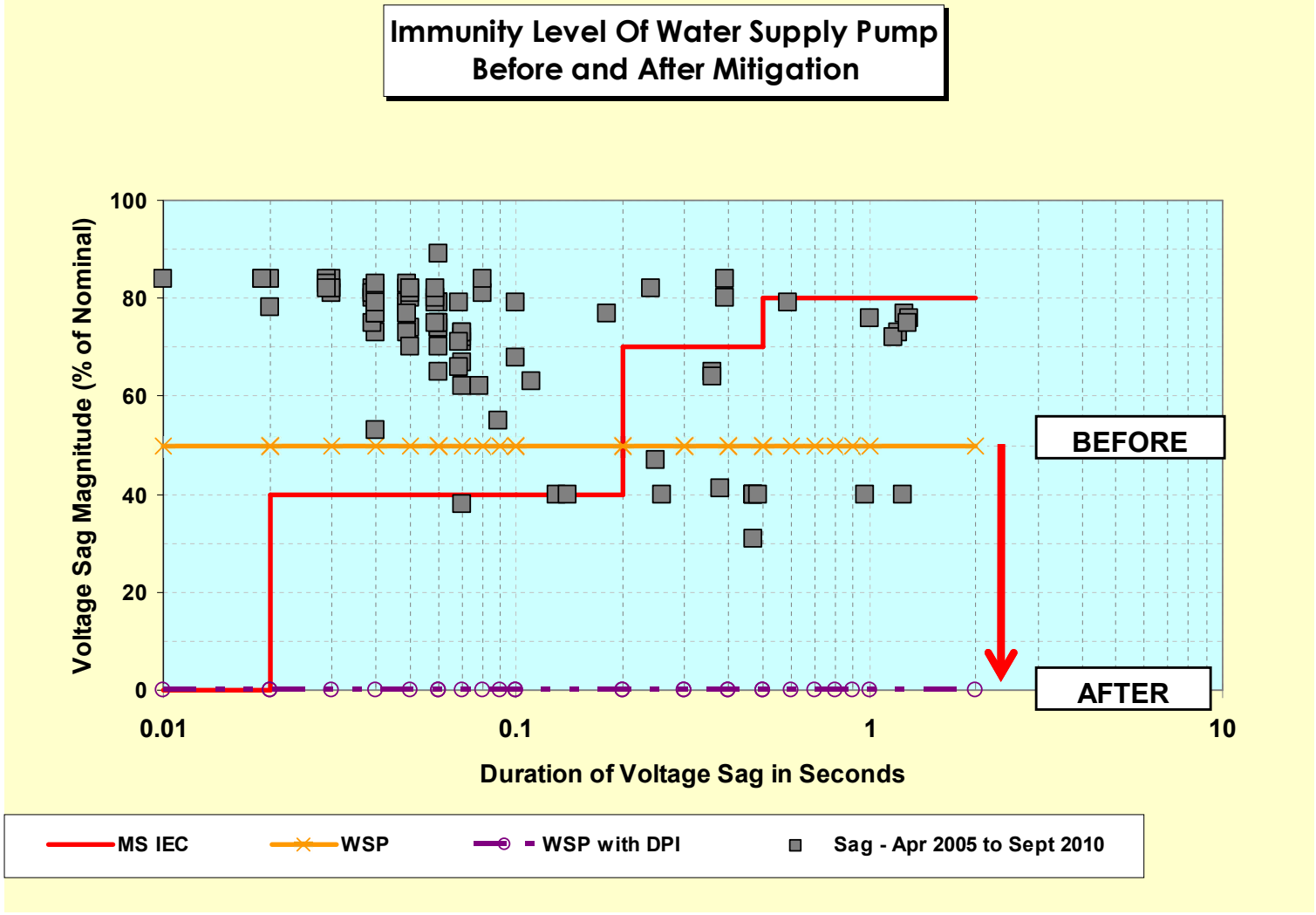
PROPOSAL TO MITIGATE VOLTAGE SAG

- Mitigation solution is proposed to improve the immunity level of the machine by installing single-phase mitigation equipment
- This is proving by installation of PQ Mitigation Equipment (PQME), Dip Proofing Inverter at the circuit during Ride-Through Test (RTT)
- DPI can support the voltage missing up to 0% for 1 second
- DPI is the most popular solution for mitigating voltage sag because the range of its price is inexpensive and free maintenance compare to Uninterruptable Power Supply (UPS).

PROPOSAL TO MITIGATE VOLTAGE SAG



PROPOSAL TO MITIGATE VOLTAGE SAG



ECONOMIC ANALYSIS

- **Cost Benefit Analysis for Cooler Water Pump**

No.	Descriptions	Without PQ Mitigation Equipment (A)	With PQ Mitigation Equipment (B)
1	Number of Events/Year	≈ 4	≈ 1
2	Estimated Production Loss per year		
a	Maximum mentioned: RM10,000/event/machine	RM40,000	RM10,000
b	Minimum mentioned: RM1,000/event/machine	RM4,000	RM1,000
3	Savings : [(A) - (B)]		
a	Maximum assumed:	RM30,000	
b	Minimum assumed:	RM3,000	
4	Cost of Solution	RM15,000/machine	
5	Payback Period (year) : [(4) / (3)]		
a	Maximum assumed:	0.5 year (6 months)	
b	Minimum assumed:	5.0 years (60 months)	

ECONOMIC ANALYSIS

- **Cost Benefit Analysis for Water Supply Pump**

No.	Descriptions	Without PQ Mitigation Equipment (A)	With PQ Mitigation Equipment (B)
1	Number of Events/Year	≈ 2	≈ 1
2	Estimated Production Loss per year		
a	Maximum mentioned: RM10,000/event/machine	RM20,000	RM10,000
b	Minimum mentioned: RM1,000/event/machine	RM2,000	RM1,000
3	Savings : [(A) - (B)]		
a	Maximum assumed:	RM18,000	
b	Minimum assumed:	RM9,000	
4	Cost of Solution	RM15,000/machine	
5	Payback Period (year) : [(4) / (3)]		
a	Maximum assumed:	0.8 year (10 months)	
b	Minimum assumed:	1.7 years (20 months)	

RECOMMENDATION

- It is recommended that **ABC Berhad** Berhad to consider installing appropriate mitigation equipment permanently as follows:
  - Cooling Water Pump – DPI of 1.3kVA
  - Water Supply Pump – DPI of 1.3kVA

- The installation of the DPI for Cooling Water Pump and Water Supply Pump will improve the immunity level of the equipments against voltage sag and hence will save **ABC Berhad** from production loss

- Based on the cost-benefit analysis, the solution is feasible with relatively short payback period.

CONCLUSION

ABC Berhad

The objectives of the study were achieved, where:

1. **To investigate PQ problems faced by the customer**
    1. **Based on complaint by the customer, they suffered from Voltage Sag events**

2. **To identify the most probable 'weak point' or sensitive equipment/processes within the customer facilities**
    1. **Cooling Water Pump**
    2. **Water Supply**

3. **To establish the sensitivity level of equipment towards voltage sags at the customer facilities**
    1. **Cooling Water Pump – 66% for 1 second**
    2. **Water Supply Pump – 50% for 1 second**

4. **To establish exposure level towards voltage sags**
    1. **Cooling Water Pump – 3.88 events per year**
    2. **Water Supply Pump – 2.40 events per year**

5. **To recommend optimum/cost effective solutions and cost benefit analysis**
    1. **Cooling Water Pump – Dip Proofing Inverter of 1.3kVA**
    2. **Water Supply Pump – Dip Proofing Inverter of 1.3kVA**

CASE STUDY #2

ABC Sdn Bhd

Semiconductor Manufacturing Company

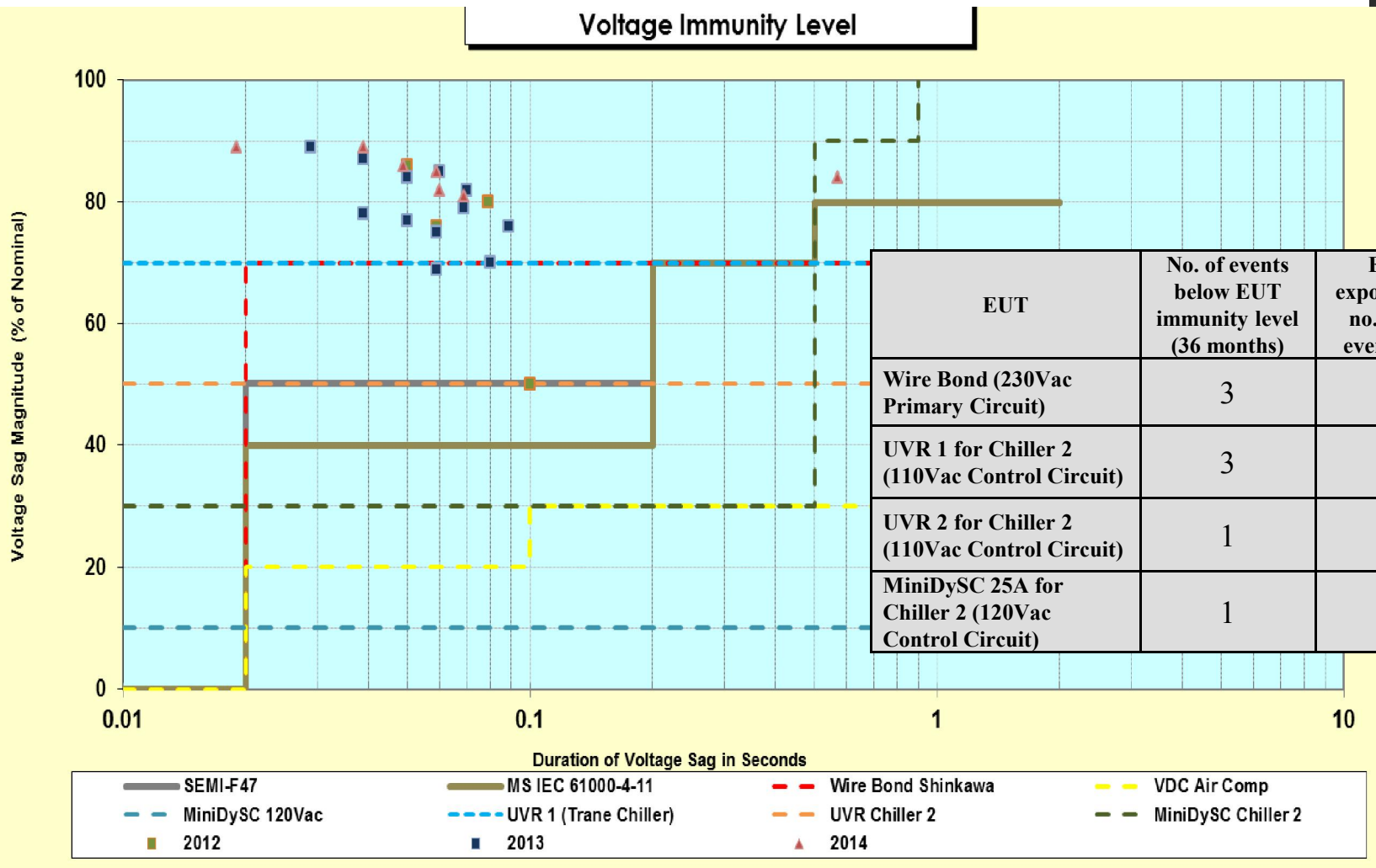
Batu Berendam, Melaka

ABC Sdn Bhd has been selected based on a complaint on voltage sag experienced by the customer

IMMUNITY LEVEL - TEST RESULTS

No	Equipment Under Test	Immunity Level (Ride Through Capability)	MS IEC 61000 / SEMI F47
1.	**Wire Bond 230Vac Primary Circuit**	Voltage sag at VL – N a) 0% voltage sag up to 20ms b) 70% voltage sag up to 1s	**NOT COMPLY (SEMI F47)**
2.	**VDC for Air Compressor 240Vac Secondary Circuit**	Voltage sag at VL – N a) 0% voltage sag up to 20ms b) 20% voltage sag up to 100ms c) 30% voltage sag up to 1s	COMPLY **(MS IEC)**
3.	**MiniDySC 6A for Air Compressor 120Vac Control Circuit**	Voltage sag at VL – N a) 10% voltage sag up to 1000ms	COMPLY **(MS IEC)**
4.	**UVR 1 for Chiller 2 110V Control Circuit**	Voltage sag at VL – N a) 70% voltage sag up to 1000ms	**NOT COMPLY (MS IEC)**
5.	**UVR 2 for Chiller 2 110V Control Circuit**	Voltage sag at VL – N a) 50% voltage sag up to 1000ms	**NOT COMPLY (MS IEC)**
6.	**MiniDySC 25A for Chiller 2 120Vac Control Circuit**	Voltage sag at VL – N a) 30% voltage sag up to 500ms b) 90% voltage sag up to 900ms	**NOT COMPLY (MS IEC)**

EXPOSURE LEVEL

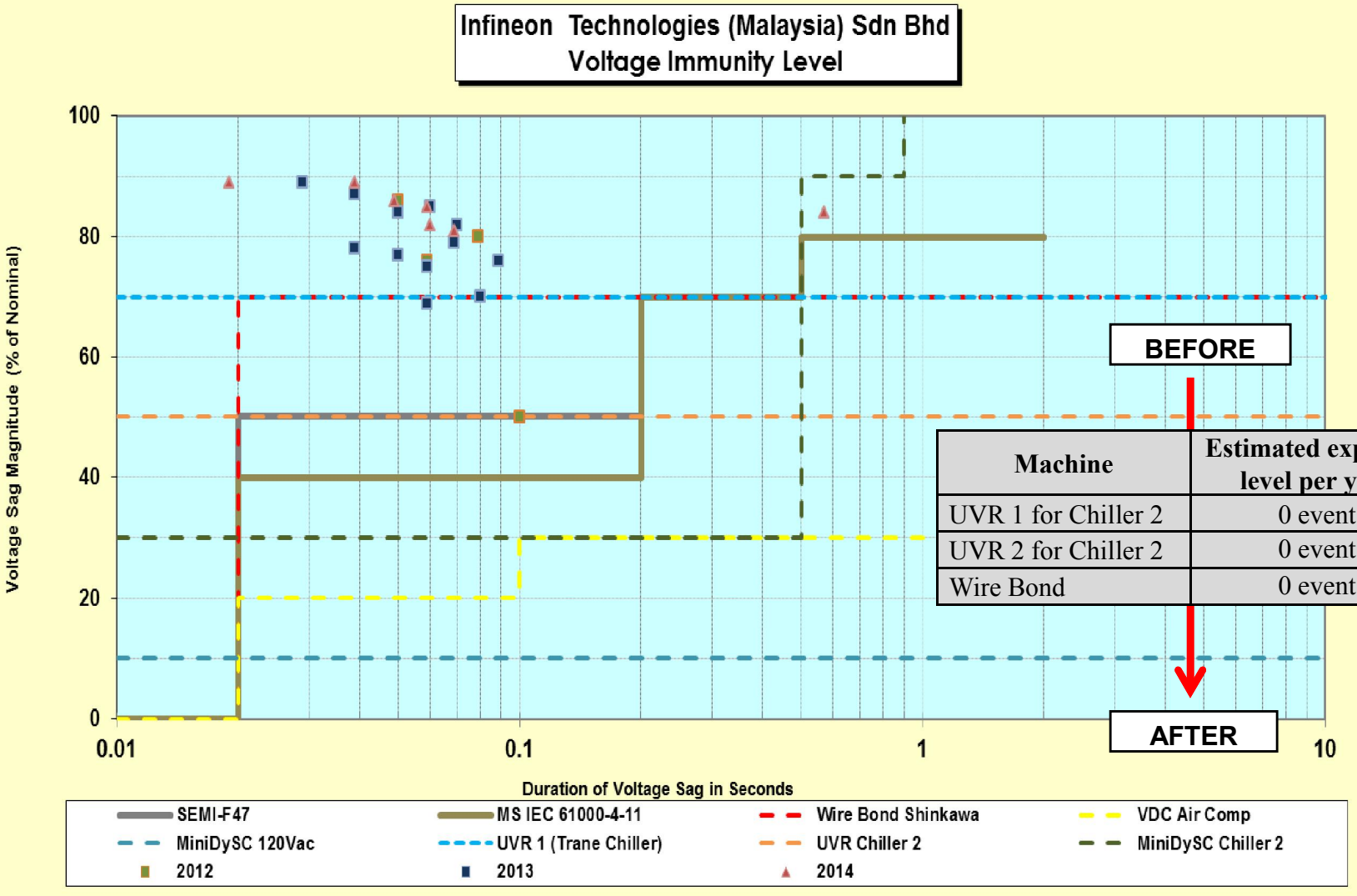


EUT	No. of events below EUT immunity level (36 months)	Estimated exposure level or no. of affected events per year
Wire Bond (230Vac Primary Circuit)	3	1.00
UVR 1 for Chiller 2 (110Vac Control Circuit)	3	1.00
UVR 2 for Chiller 2 (110Vac Control Circuit)	1	0.33
MiniDySC 25A for Chiller 2 (120Vac Control Circuit)	1	0.33

PROPOSAL TO MITIGATE VOLTAGE SAG

Type of Voltage Sag Mitigation	Machines & Proposed Mitigation Measures	Remarks	Estimated Cost (RM)
PARTIAL PROTECTION	**Machines:** **UVR 1 & 2 For Chiller 2** (110Vac, 1-ph) **Mitigation Measures:** To disable the under voltage relay **OR** to change the relay	This will provide protection and improve the overall immunity level of the control circuit toward voltage sag to comply with MS IEC 61000 Guidelines.	**Minimum Cost**
FULL PROTECTION	**Machines:** **Wire Bond** (230Vac, 16A; 4kVA, 1-ph) **Mitigation Measures:** To install PQME to the primary circuit (three – phase)	**UPS (1-phase, 4kVA):** 0% sag up to 10 minutes	**RM4,000** **RM1,000/kVA** (Excluding Installation)

PROPOSAL TO MITIGATE VOLTAGE SAG



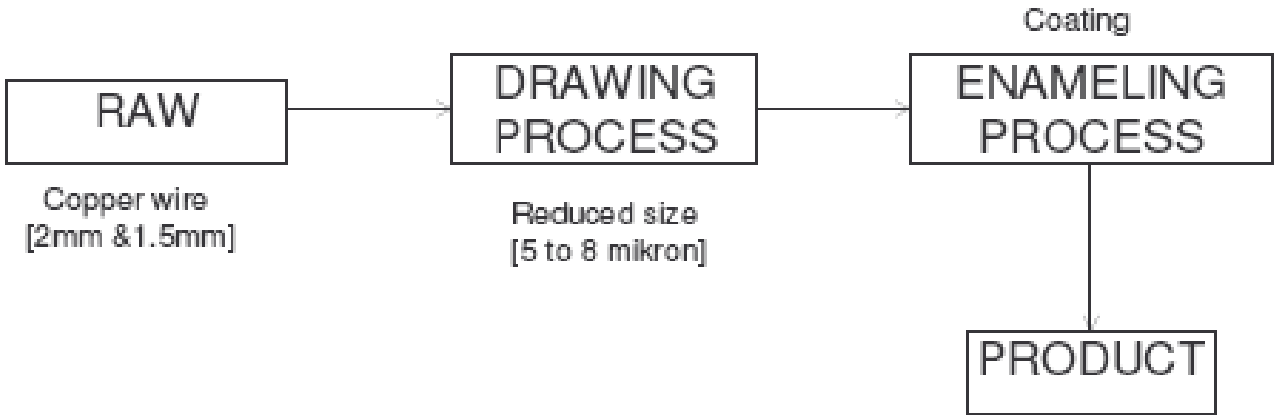
Machine	Estimated exposure level per year
UVR 1 for Chiller 2	0 event
UVR 2 for Chiller 2	0 event
Wire Bond	0 event

CASE STUDY #3

XYZ Sdn Bhd

World's Largest Fine and Ultra Fine Copper Wire Manufacturing Company

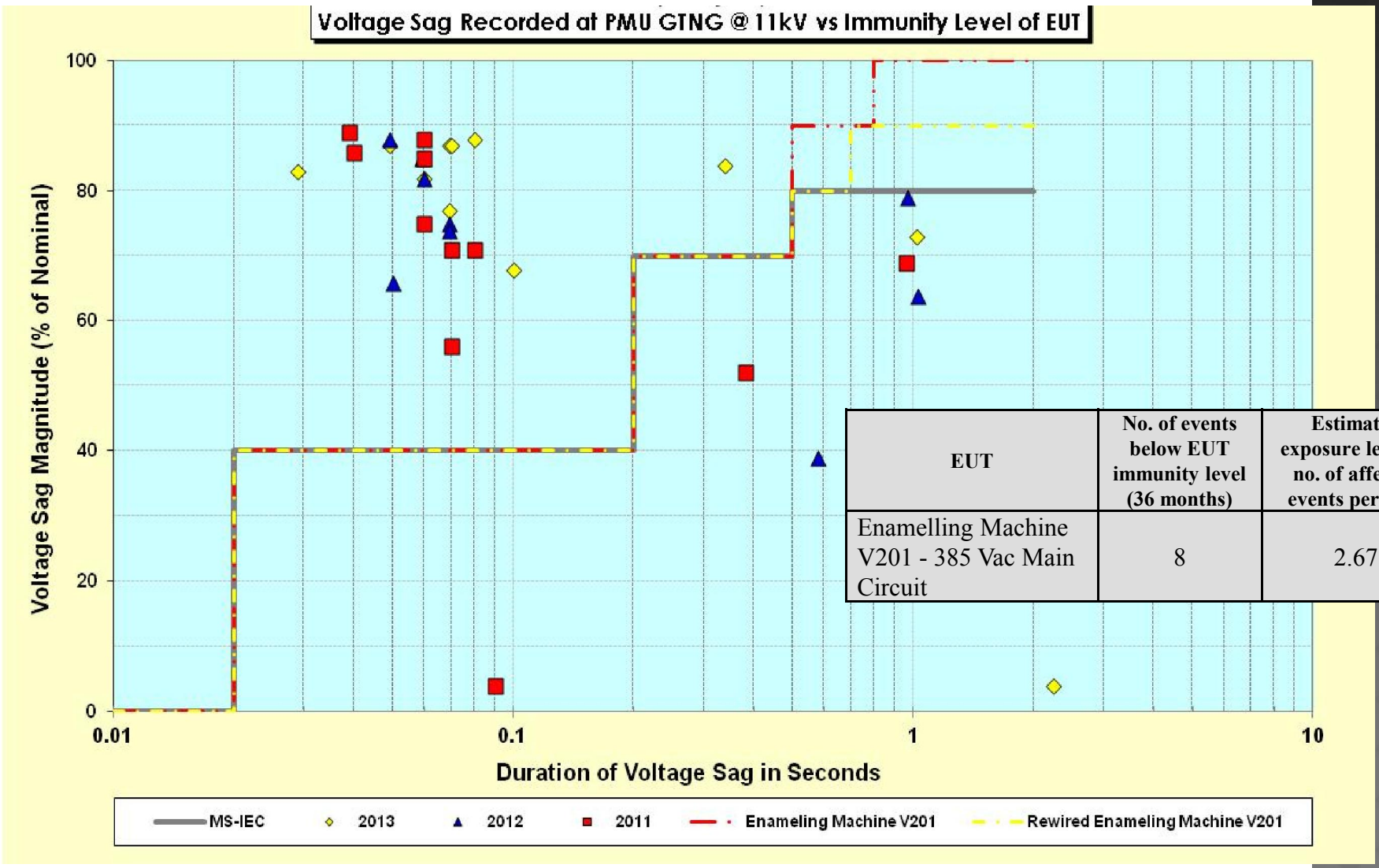
Bentong, Pahang



IMMUNITY LEVEL – TEST RESULTS

No	EUT	Immunity level (Ride Through)	MS-IEC
1.	Enamelling Machine V201 - 385 Vac Main Circuit	Voltage Sag at phase voltage L-L a) 0% voltage sag up to 20ms b) 40% voltage sag up to 200ms c) 70% voltage sag up to 500ms d) 90% voltage sag up to 1000ms	Not Comply

EXPOSURE LEVEL

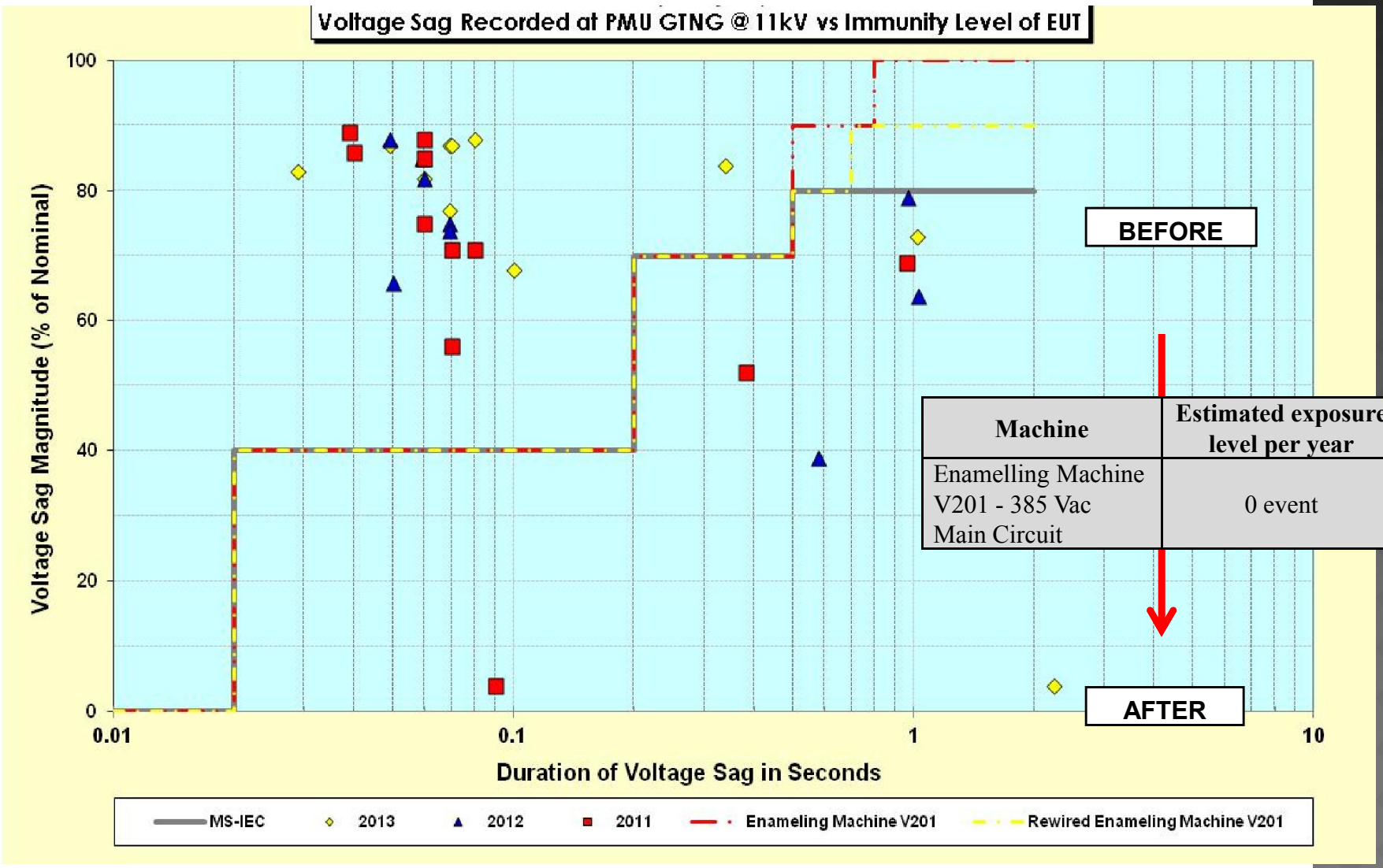


EUT	No. of events below EUT immunity level (36 months)	Estimated exposure level or no. of affected events per year
Enamelling Machine V201 - 385 Vac Main Circuit	8	2.67

PROPOSAL TO MITIGATE VOLTAGE SAG

Type of Voltage Sag Mitigation	Machines & Proposed Mitigation Measures	Remarks	Estimated Cost (RM)
FULL PROTECTION	**Machines:** Enamelling Machine V201 (385 Vac Main Circuit – 3phase) **Mitigation Measures:** To install PQME to main circuit of equipment	This will provide protection and improve the overall immunity level of the machines toward voltage sag to comply with MS MS-IEC Guidelines (i.e. 40% for 200ms)	**3-phase UPS** RM1,700 per kVA (excluding installation)

PROPOSAL TO MITIGATE VOLTAGE SAG



Machine	Estimated exposure level per year
Enamelling Machine V201 - 385 Vac Main Circuit	0 event

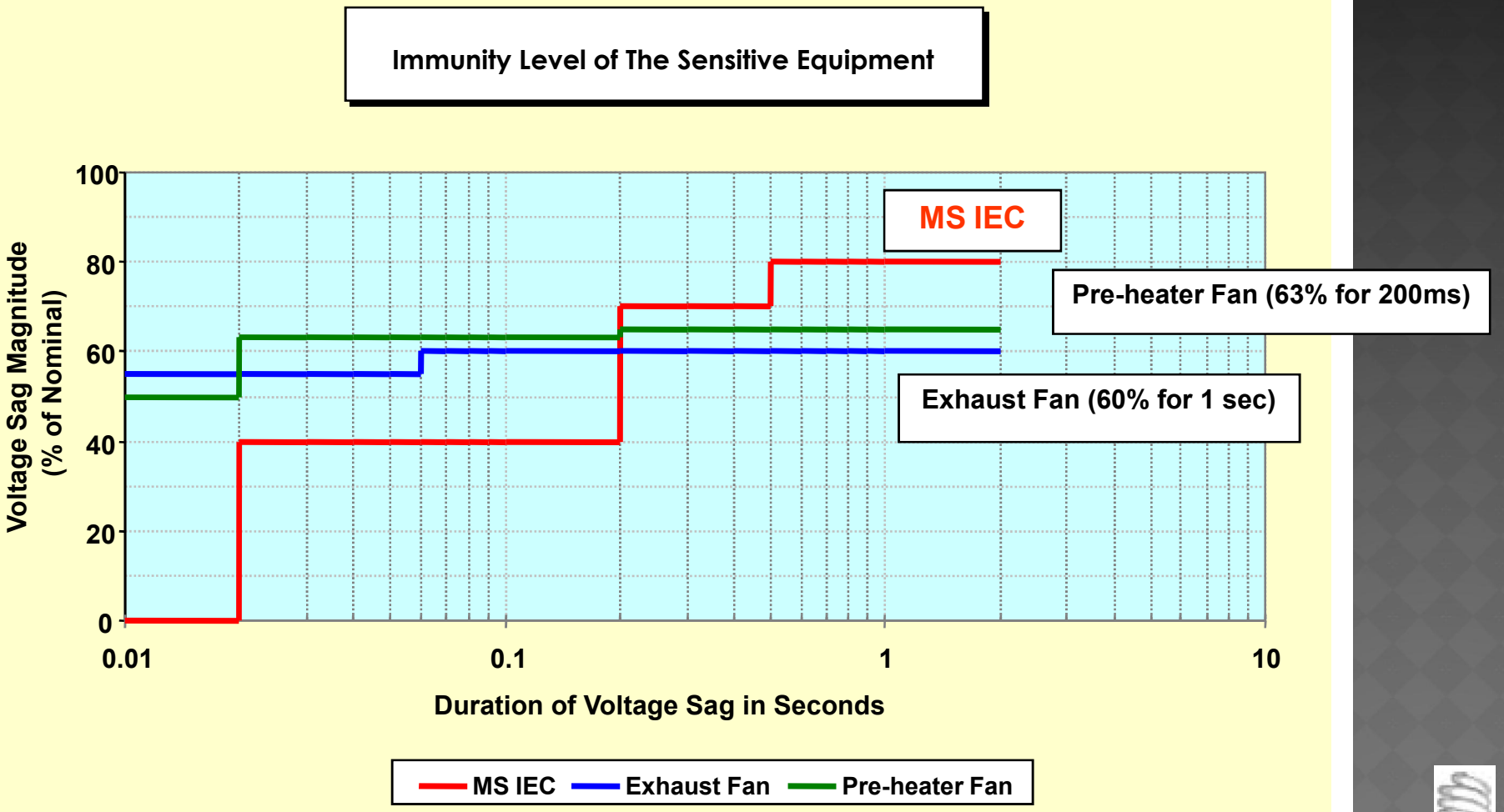
CASE STUDY #4

Cement Plant

Rawang, Selangor

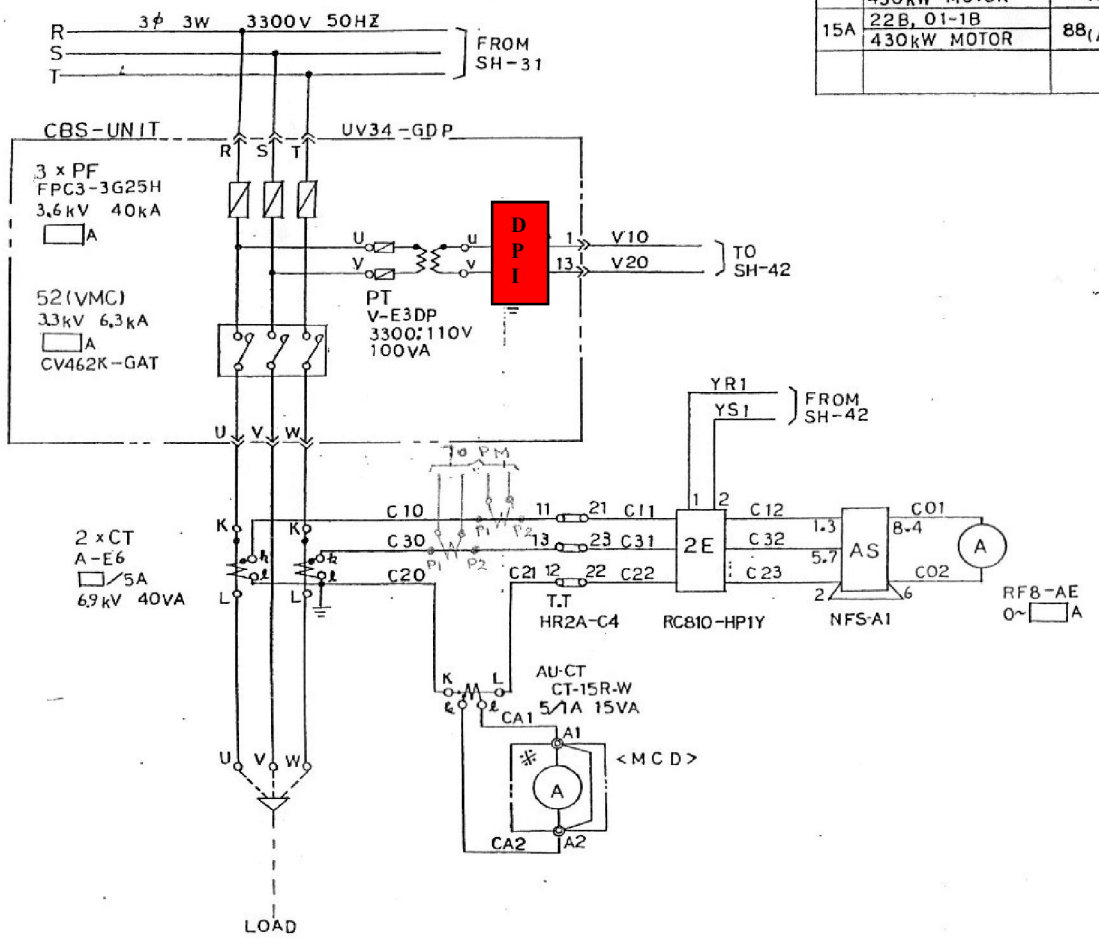
- **Sensitive & critical equipment**
  - Kiln Pre-heater fan – 11kV, 2300kW motor (2 units)
  - Kiln EP exhaust fan – 3.3kV, 430kW (2 units)
- **Number of Disturbance to the plant due to voltage sag events**
  - 2004 : 5, 2005 : 7, 2006 : 4, 2007 : 1
- **Estimated Losses due to voltage sag event**
  - between RM28k and RM193k

CEMENT PLANT IMMUNITY LEVEL



Exhaust Fan Control Circuit

UNIT NO.	CIRCUIT NAME / LOAD	RATING	PF (A)	52 (A)	CT & AM-METER (A)	CT 2NDARY	2ER TURN	2ER OC(%)	2ER OP(%)	REMARK
14B	22B, 01-1A 430kW MOTOR	88 (A)	M200	300	150/5 150(450)	2.9(A)	2	84	99	
15A	22B, 01-1B 430kW MOTOR	88 (A)	M200	300	150/5 150(450)	2.9 (A)	2	84	99	



◎TERMINALS FOR EXTERNAL CABLE
※DEVICE OF EXTERNAL
MCD : CENTRAL CONTROL DESK

<14B><15A>

検図 CHECKED BY M. Yamaguchi Dec. 12 '78	設計 DESIGNED BY M. Morisada Nov. 24 '78	THREE LINE DIAGRA	
保管 REGISTERED		GKK3 -949999	

東京芝浦電気株式会社
TOSHIBA CORPORATION
TOKYO JAPAN

Jan. 31 '79 CHG. In M.Y
Jan. 31 '79 CHG. M.Y

INSTALLATION OF PQ MITIGATION EQUIPMENT

- 4 units of single-phase PQME (DPI and VDC)
- Details of DPI/VDC : 110V, 1 kVA
- Protection for control circuits
- Commissioning date : 17 Apr 2008

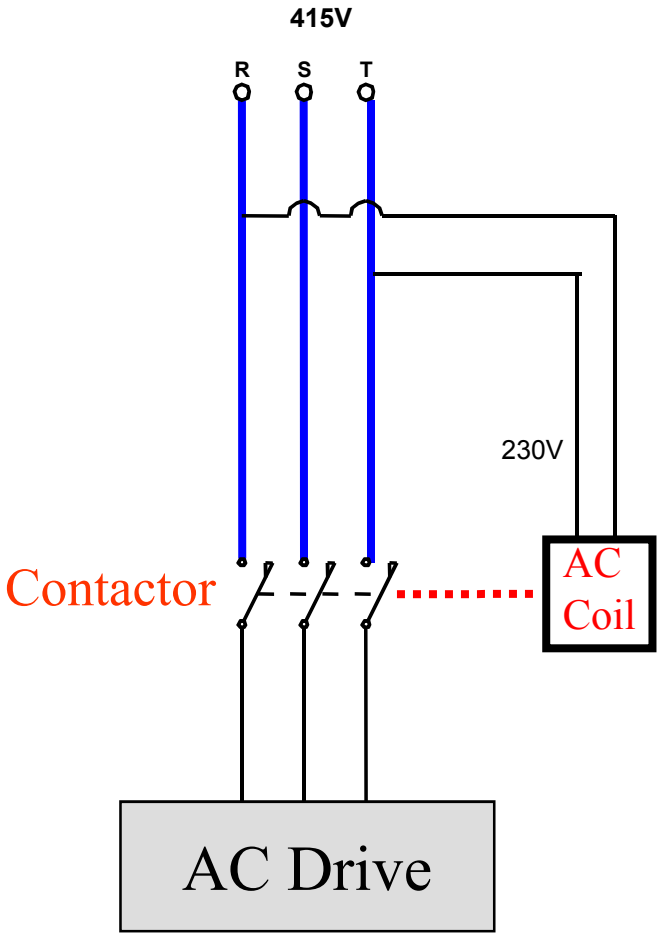
CASE STUDY #5

Chemical Plant

Gebeng, Kuantan, Pahang

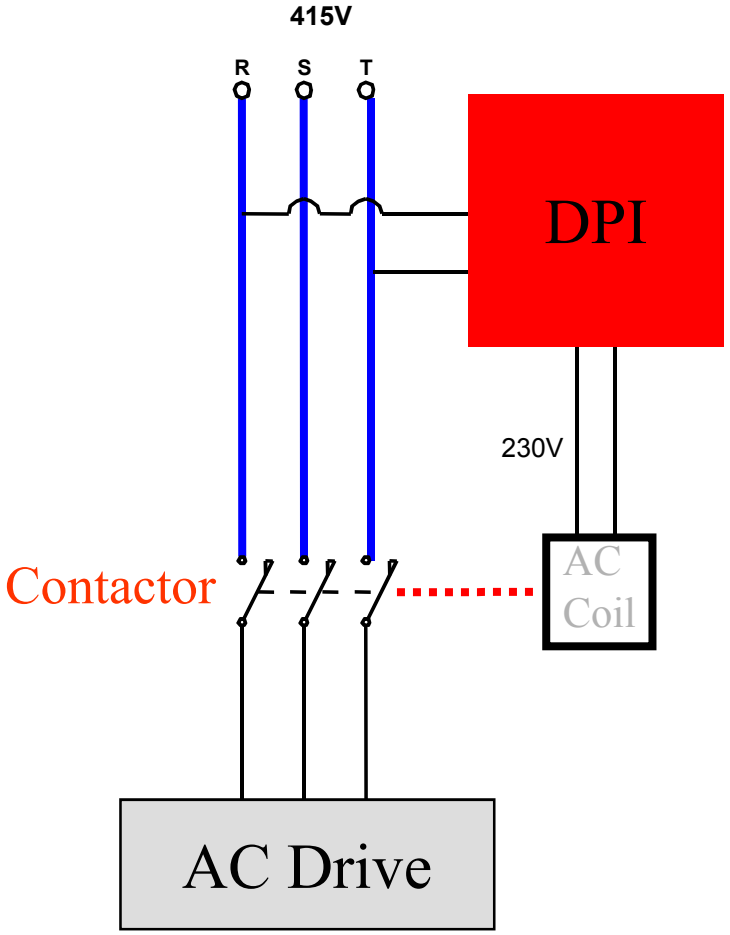
- **Sensitive & critical equipment**
  - AC Adjustable Speed Drive for Quencher Pump - 0.415kV 224kW Motor (2 units)
- **Number of Disturbance to the plant due to voltage sag events**
  - 2006 : 7, 2007 : 9
- **Findings**
  - RTT conducted on the control circuit of ABB drive ACS 600
  - Existing immunity level at 65% for 0.2 sec, 70% for 1 sec for drive incoming contactor
  - Trial run on the contactor coil circuit using DPI
  - Latest event on 23 Oct 2007 (sag to 25% for 310ms) showed that the DPI supported the contactor coil during the voltage sag

Drive's Incoming Contactor



Voltage sag from single-phase fault will cause the contactor to open. Once the contactor opens, the drive will experience a total loss of supply

Drive's Incoming Contactor



Exposure Level : Before Mitigation = 10 events/year
After Mitigation (partial) = 0 events/year

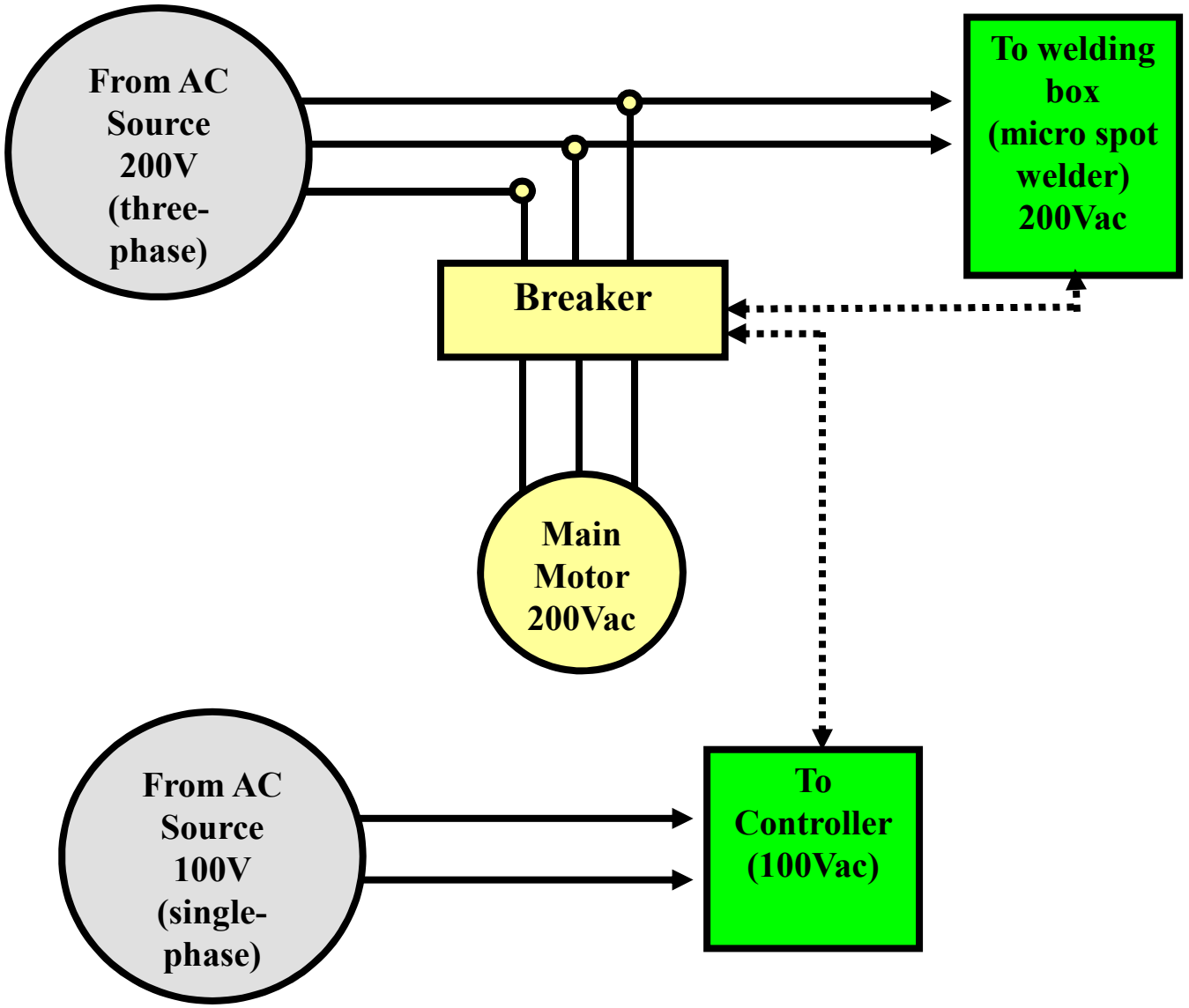
CASE STUDY #6

Electronics Plant

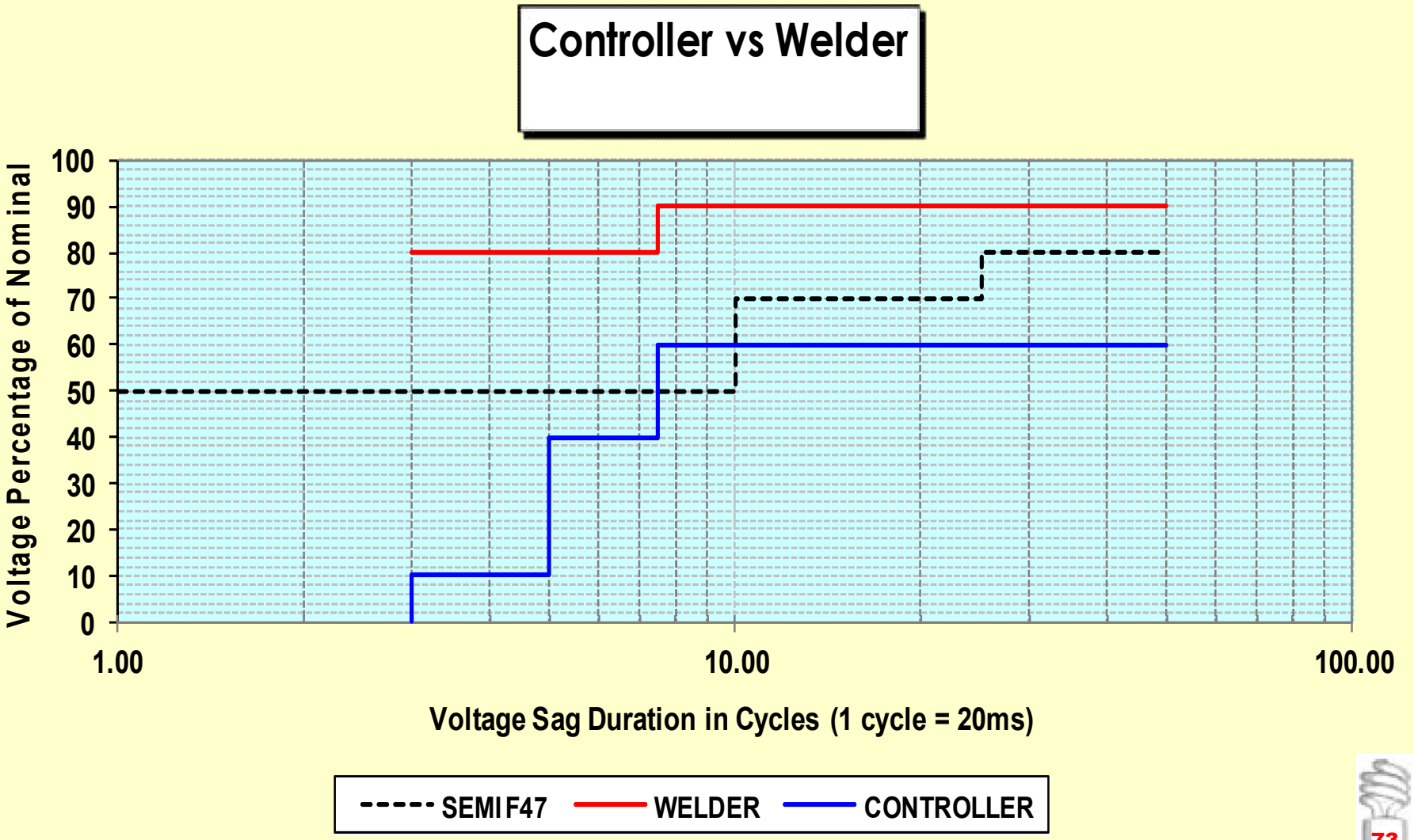
Kota Bharu, Kelantan

- **List of sensitive & critical equipment**
  - Diode production machine
- **Findings**
  - Diode production machine – consists of a welder and a controller
  - Existing immunity level : Welder at 85%, controller at 60%

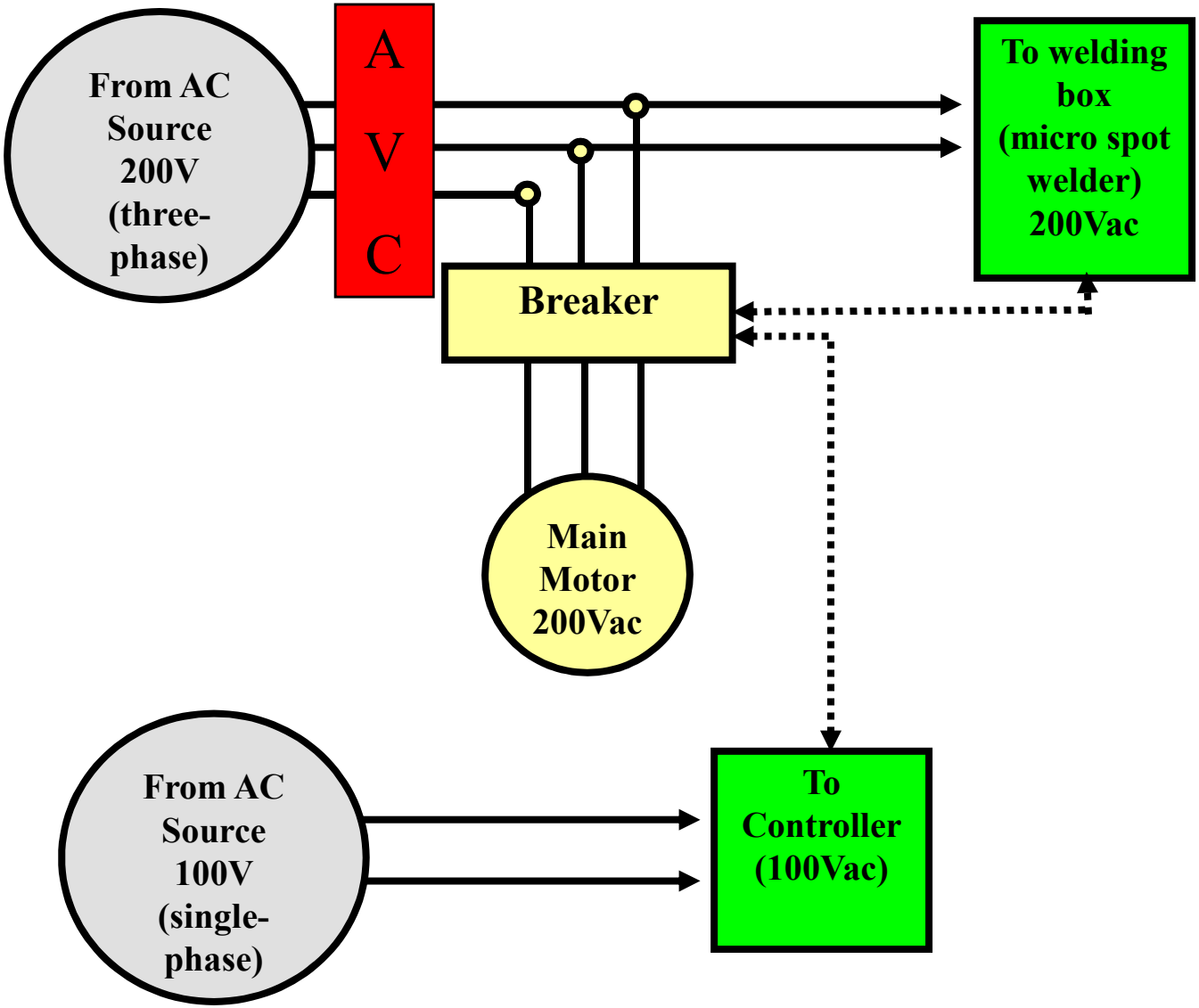
ELECTRONICS PLANT



RTT RESULTS


Controller vs Welder
Voltage Percentage of Nominal
100
90
80
70
60
50
40
30
20
10
0
1.00
10.00
100.00
Voltage Sag Duration in Cycles (1 cycle = 20ms)
SEMI F47
WELDER
CONTROLLER

SOLUTION – VECTEK ACTIVE VOLTAGE CONDITIONER (AVC) AT WELDER (200V)

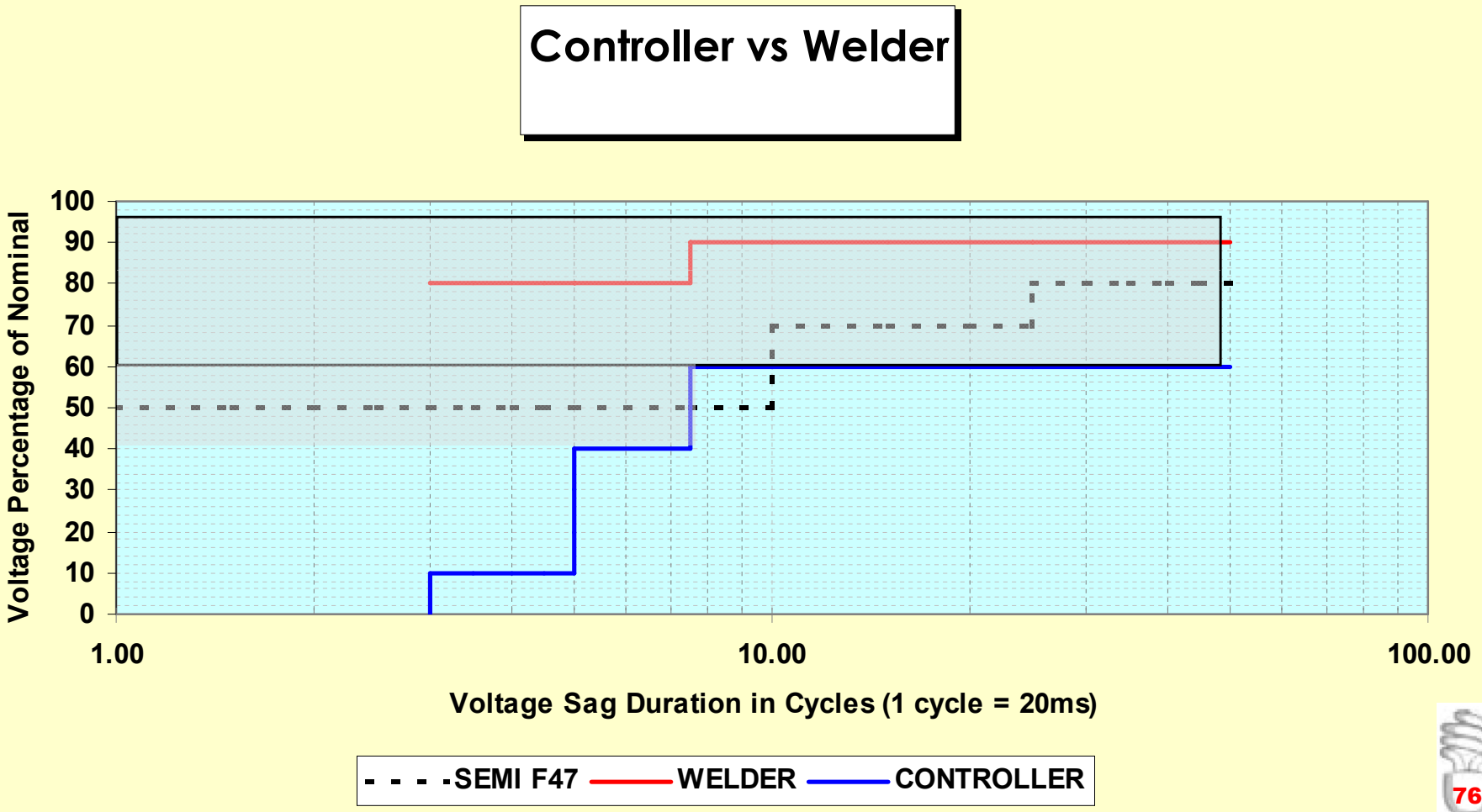


INSTALLATION OF AVC

- AVC was installed at the 200V system of the DWA Machine (welder circuit)
- AVC Details: 50kVA, 200V, 3-phase
- Commissioning Date: 30 Aug 2007

DWA IMMUNITY LEVEL WITH AVC @ WELDER

AVC able to support voltage sag to 40% and above on 200V system (Welder circuit)



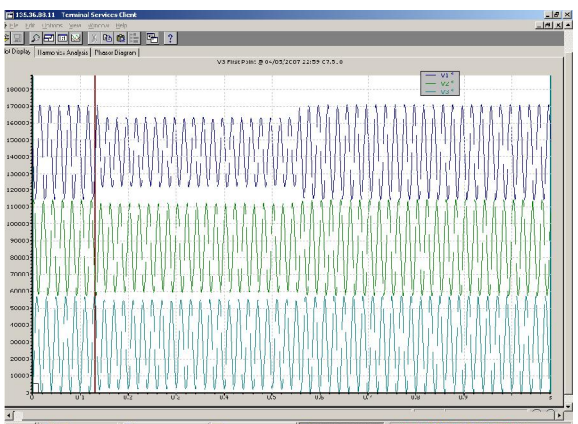
AVC PERFORMANCE

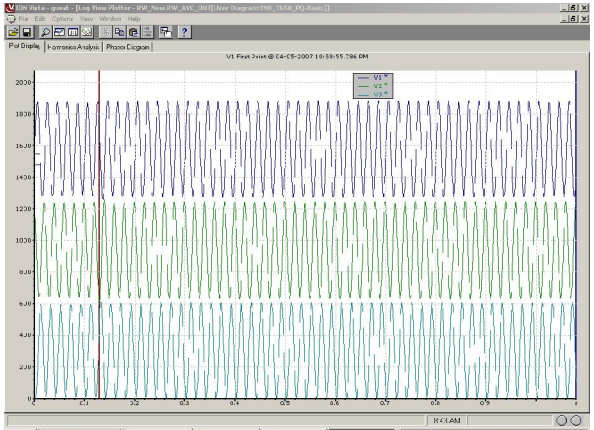
	PMU Panchor 33kV				AVC Input - 210V				AVC Output - 210V			
timestamp	Duration (sec)	Phase 1	Phase 2	Phase 3	Duration (sec)	Phase 1	Phase 2	Phase 3	Duration (sec)	Phase 1	Phase 2	Phase 3
07/05/2007@12:25:28	0.409	72	72	73	0.421	69	70	70	0.01	90	89	90
04/05/2007@22:59:08	0.421	76	96	103	0.420	92	93	77	0.009	105	102	111
04/05/2007@21:52:25	0.439	74	95	96	0.429	92	93	77	0.009	96	97	88

PMU Panchor /

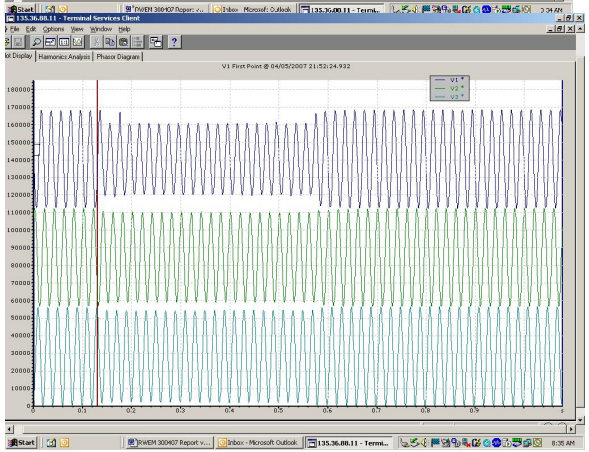
AVC

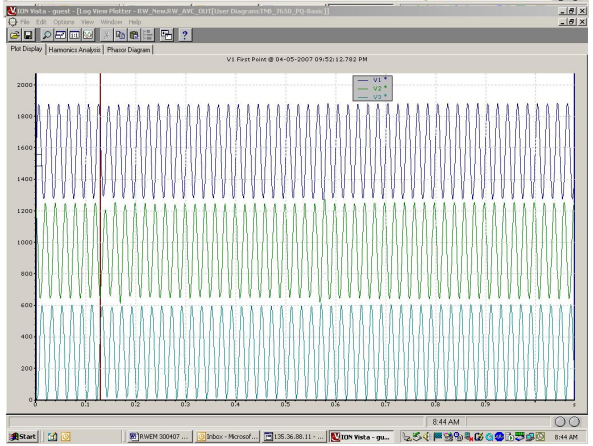
4 May 2007 @ 22.59





4 May 2007 @ 21.52





CASE STUDY #7

Electronics Plant

Seremban, Negeri Sembilan

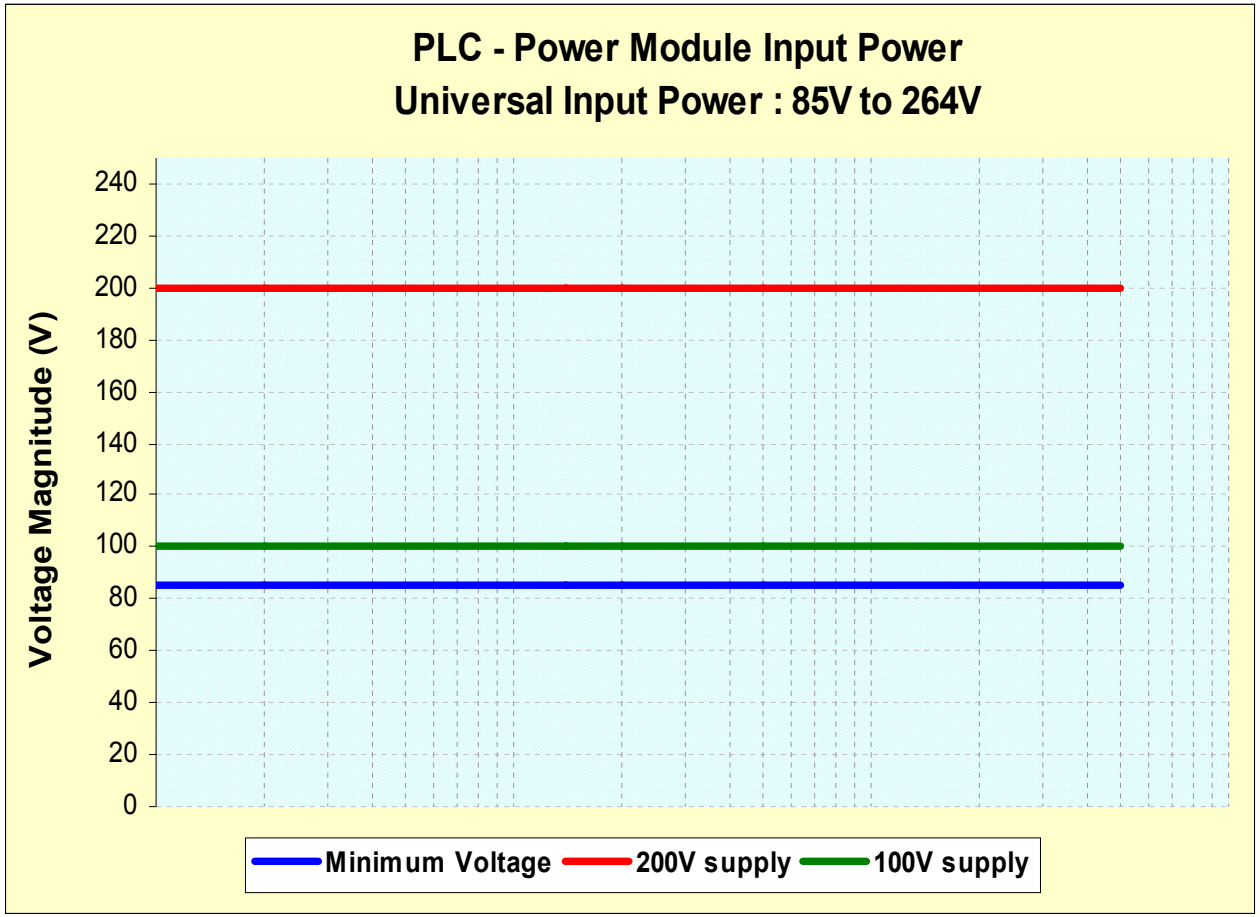
- **Findings**
  - Facilities (chiller & compressor) already protected by a single-phase mitigation equipment
  - Production area protected by UPS
  - Some UPS in bypass mode – suspect batteries failure

  - Critical equipment
    - PLC – has two types of power module input power
      - Two separate terminals : 100V – 120V or 200V – 240V (+10% to –15%)
      - One universal terminal : 85V to 264V

  - PLC with universal terminal has better immunity level if correct supply voltage is selected
    - Universal terminal : 85V to 264V
      - Using 100V supply : Immunity level = 85% (85V)
      - Using 200V supply : Immunity level = 42.5% (85V)

Electronics Plant, Seremban

- PLC with universal terminal has better immunity level if correct supply voltage is selected



Universal Input Power : 85V to 264V

Minimum Voltage : 85V

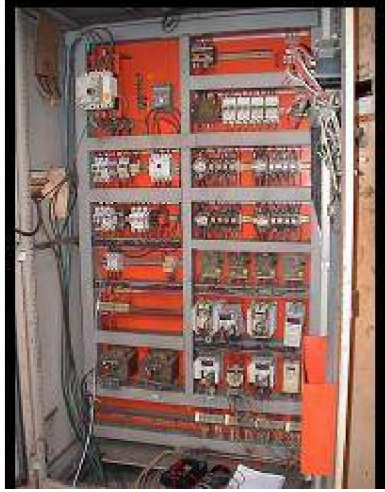
Immunity Level (remaining voltage)

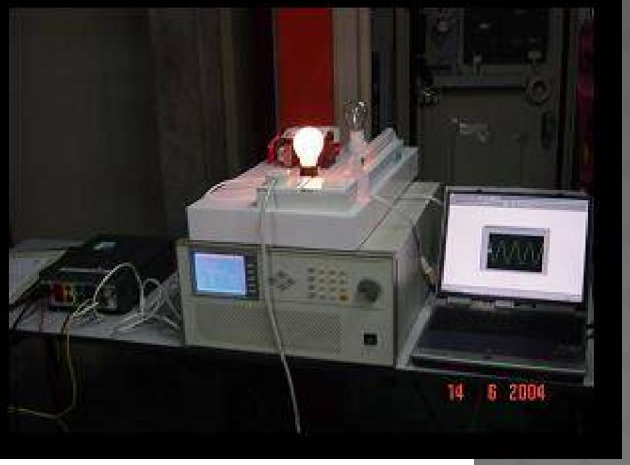
Using 100V supply : 85V/100V = 85%

Using 200V supply : 85V/200V = 42.5%

Using 230V supply : 85V/230V = 37%

PQ AUDIT & TESTING





PQ AUDIT & TESTING

PQ AUDIT & TESTING


TENAGA NASIONAL
Better. Brighter.
THANK YOU
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Tel: +603 7662 5111 Fax: +603 7662 5112/5113
Solution Provider for:
• Power Quality
• Energy Efficiency
• Renewable Energy
• Power System Study
TNBES
(424407-M)
Making It Happen, Getting It Done