15th Annual PQSynergy™ International Conference and Exhibition 2015

VOLTAGE DIP MITIGATION IN SINGAPORE

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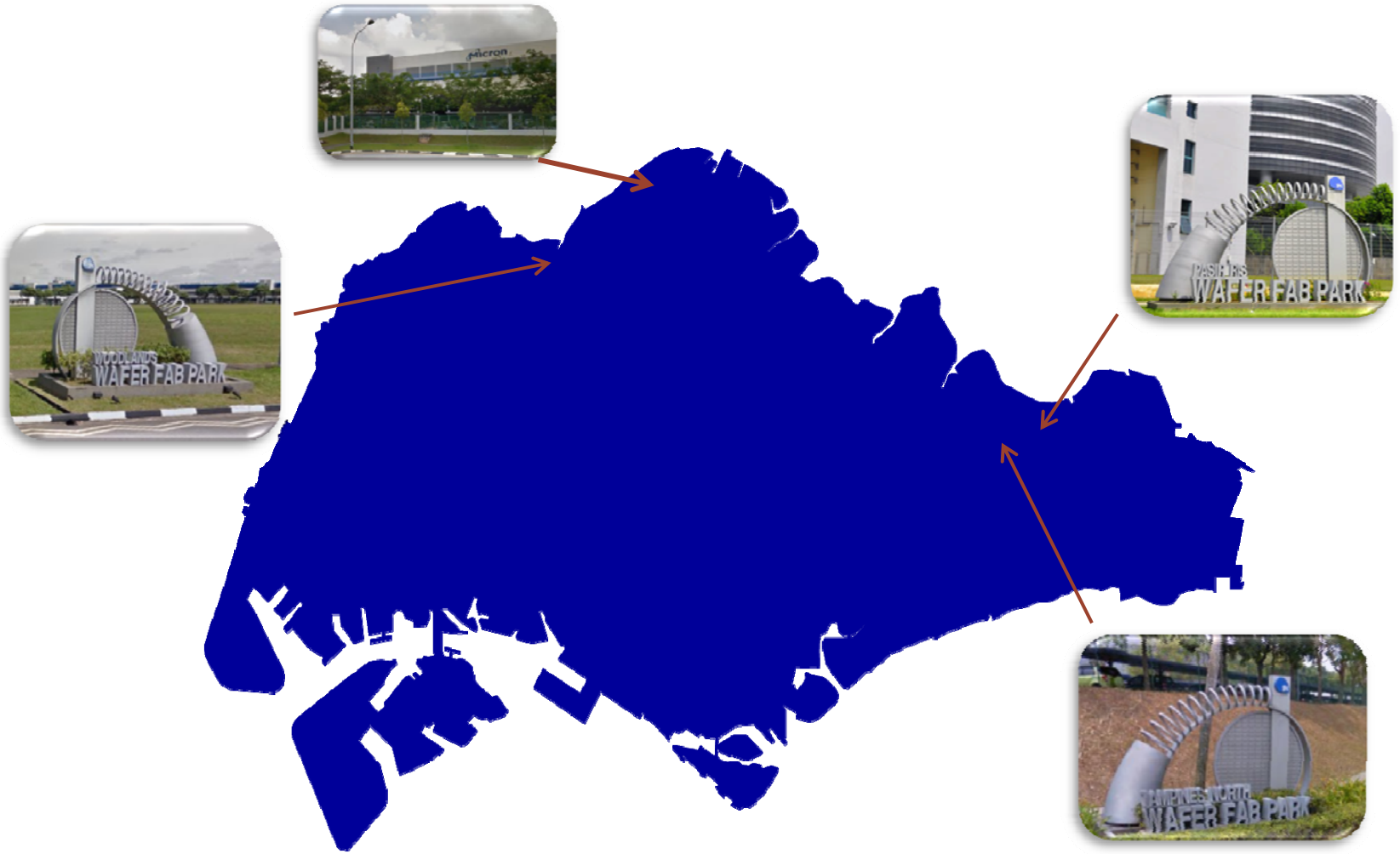
OUTLINE

- Introduction
- Voltage Dip Statistics
- Historical Perspectives
- Lessons Learnt
- Case Study

SINGAPORE – A FINANCIAL HUB

IS ALSO HOME TO SOME WAFER FABS



- 4 main wafer fabrication parks
- 14 silicon wafer fab plants
- ~20 semiconductor assembly & test operations

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VOLTAGE DIP STATISTICS

VOLTAGE DIP INCIDENTS

Number of voltage dip incidents by type of incidents

Incident	2006	2007	2008	2009	2010	2011	2012	2013
Outage of Tenaga Nasional Berhad - SP PowerAssets Inter-Connector	0	1	0	1	0	1	0	0
Generation Companies' Equipment Failure	0	0	0	0	0	0	0	0
SP PowerAssets' Cable/Equipment Failure and Cable Damage	5	2	11	4	2	2	5	13
Consumers' Cable/Equipment Failure	12	5	8	7	2	10	17	9
Total	17	8	19	12	4	13	22	22

Region 17

SARFI	Yr10	Yr11
90	3.6	5
80	1.3	1.3
70	1.3	0.6

Region 16

SARFI	Yr10	Yr11
90	1	0
80	1	0
70	1	0

Region 15

SARFI	Yr10	Yr11
90	1.1	1.1
80	0.9	0.2
70	0	0.2

Region 14

SARFI	Yr10	Yr11
90	3.7	1
80	1	1
70	0.3	1

Region 13

SARFI	Yr10	Yr11
90	1.7	1.9
80	0.1	1
70	0.1	1

Region 1

SARFI	Yr10	Yr11
90	1.4	1
80	0.3	0.1
70	0.1	0.1

Region 2

SARFI	Yr10	Yr11
90	1.2	0.2
80	0	0
70	0	0

Region 3

SARFI	Yr10	Yr11
90	3.4	3.1
80	0.4	0.4
70	0.3	0.3

Region 4

SARFI	Yr10	Yr11
90	5.8	1.6
80	2	0.5
70	1.6	0.4

22kV SARFI MAP

SYSTEM AVERAGE

SARFI	Yr10	Yr11
90	2.1	1.5
80	0.5	0.4
70	0.3	0.4

Region 12

SARFI	Yr10	Yr11
90	3.3	2
80	0.4	1
70	0.4	1

Region 11

SARFI	Yr10	Yr11
90	1.4	0.5
80	0.3	0.1
70	0.1	0.1

Region 10

SARFI	Yr10	Yr11
90	1.8	1
80	0.1	1
70	0	1

Region 5

SARFI	Yr10	Yr11
90	0.4	1.1
80	0	0.3
70	0	0

Region 6

SARFI	Yr10	Yr11
90	0.3	0
80	0	0
70	0	0

Region 7

SARFI	Yr10	Yr11
90	1.6	1.5
80	0.2	0.3
70	0	0.2

Region 8

SARFI	Yr10	Yr11
90	1	1
80	0	0.1
70	0	0.1

Region 9

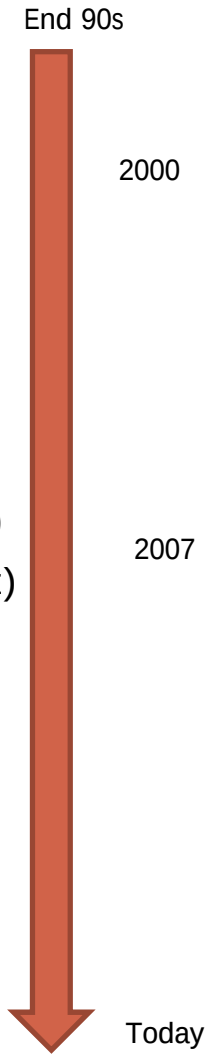
SARFI	Yr10	Yr11
90	2	1.9
80	0.3	0.1
70	0.1	0.1

HISTORICAL PERSPECTIVES

- 3 MV PQDs purchased by PG for trial.
- 2 MV PQDs decommissioned.
- Singapore network split into 2 x 230kV blocks.
  Regulatory control on Licensed Engineers – dip related
- PG set up S$150 mil PQS fund (50% co-share).
  SP Systems introduced low voltage dip compensators (Dynacom).
- PG installed Power Quality Monitoring System (80 stations). 22kV to 400kV.
- Last MV PQD removed. Customer moved out.
- Singapore network further split into 4 x 230kV blocks (North/South/East/West)
- Economic Development Board PQS grant (50% co-share, up to S$5 mil per plant)
- PG PQMS expanded ~ 160 stations

- Code of Practice for Earthworks in the vicinity of electricity cables

- PG PQMS Phase I renewal programme



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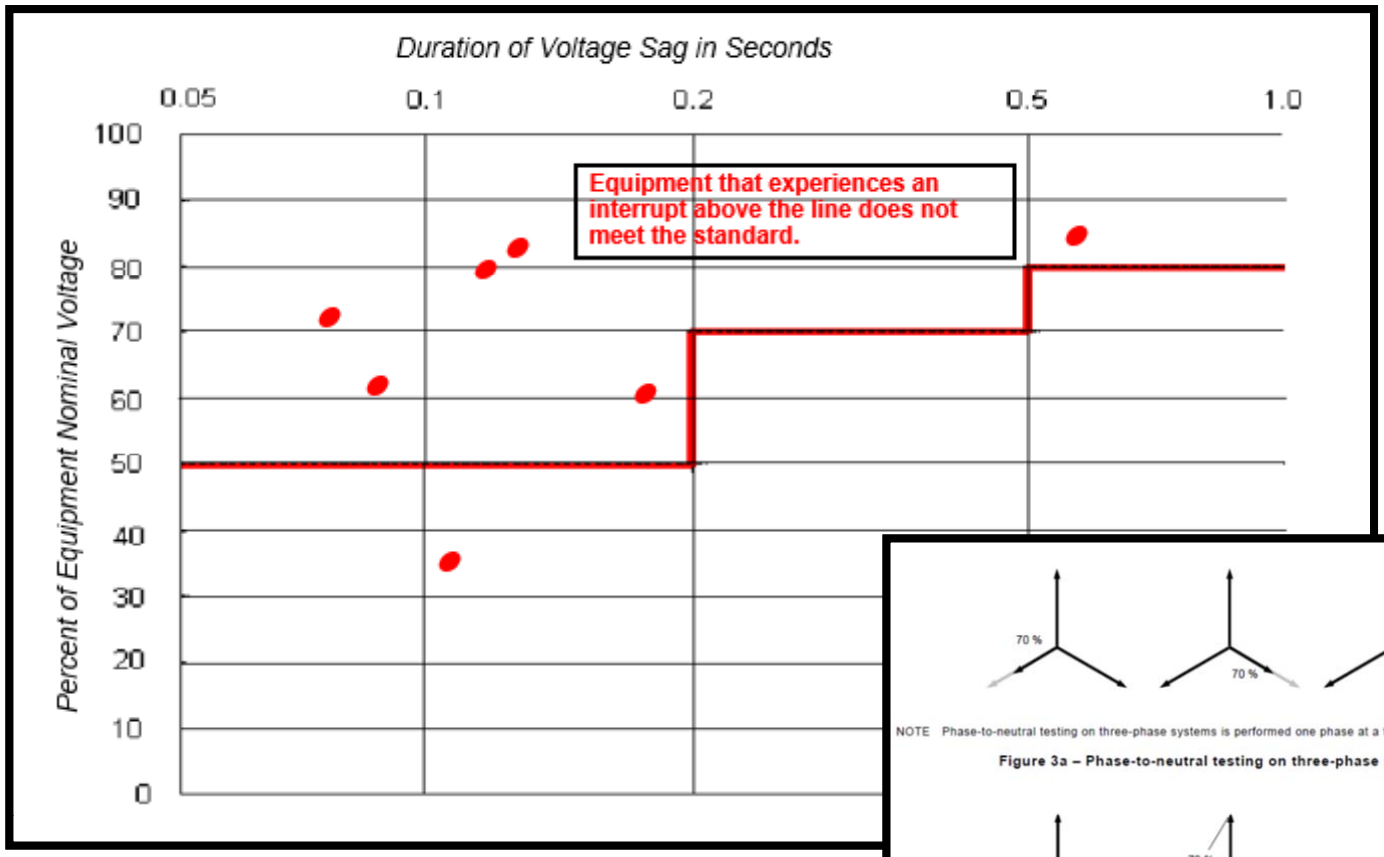
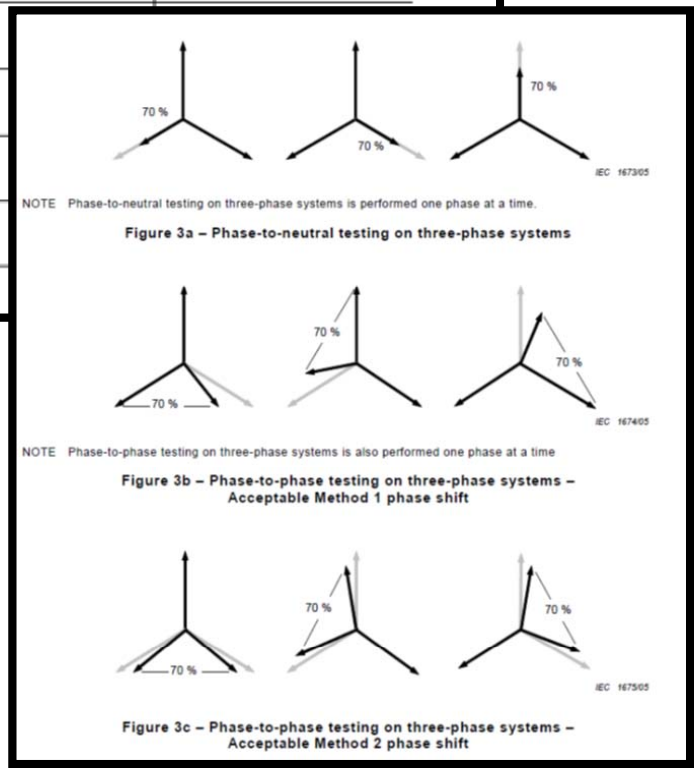
LESSONS LEARNT

- Mitigation at equipment level most economical (equipment cost), but
- Requires an in-depth study (not that simple)
- Needs involvement and participation of equipment engineers, not just the facilities' engineers
- SEMI-F47 -> quite poorly understood





NOTE Phase-to-neutral testing on three-phase systems is performed one phase at a time.

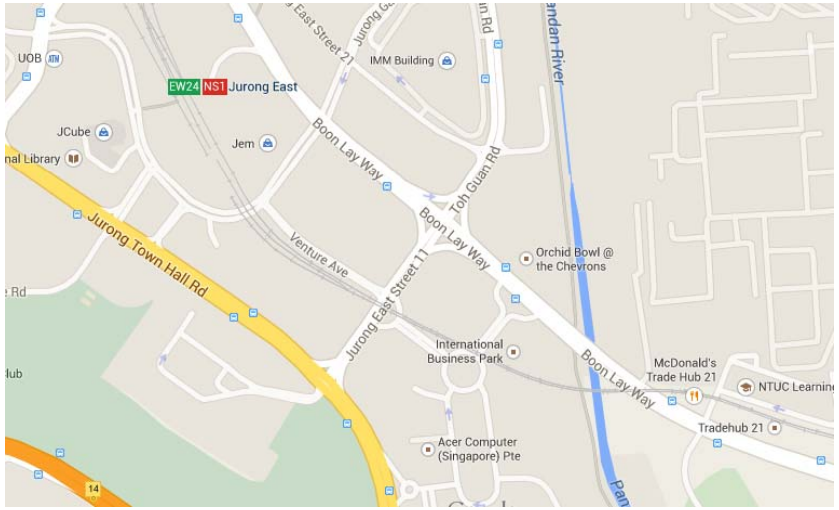
Figure 3a – Phase-to-neutral testing on three-phase systems

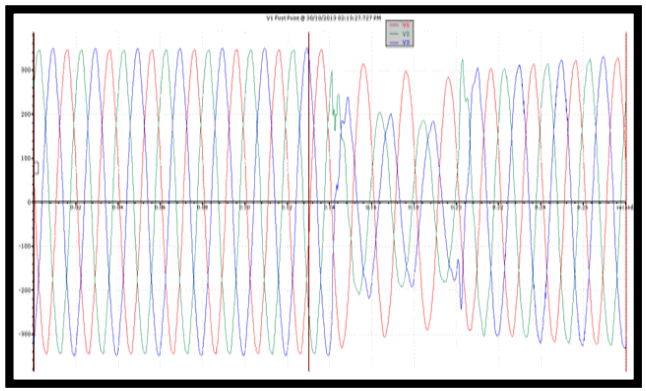
NOTE Phase-to-phase testing on three-phase systems is also performed one phase at a time

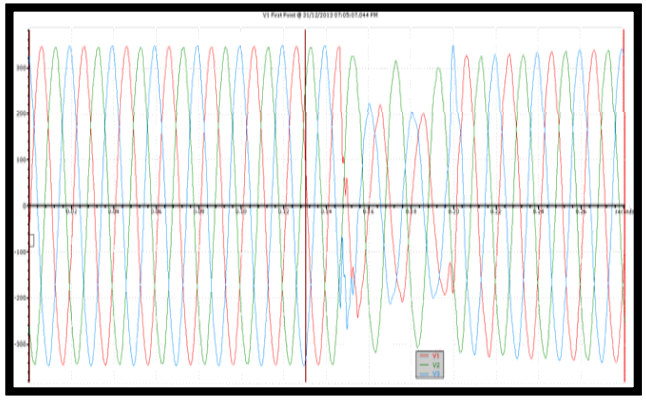
Figure 3b – Phase-to-phase testing on three-phase systems – Acceptable Method 1 phase shift

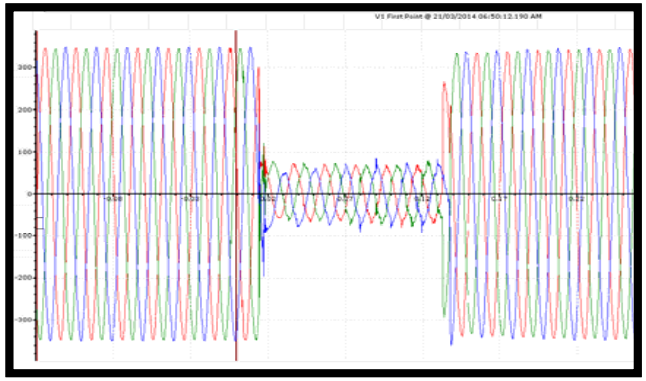
Figure 3c – Phase-to-phase testing on three-phase systems – Acceptable Method 2 phase shift

JURONG GATEWAY









October 2013 to March 2014

- 30-10-2013 dip by 48%
- 31-12-2013 dip by 43%
- 21-03-2014 dip by 80%

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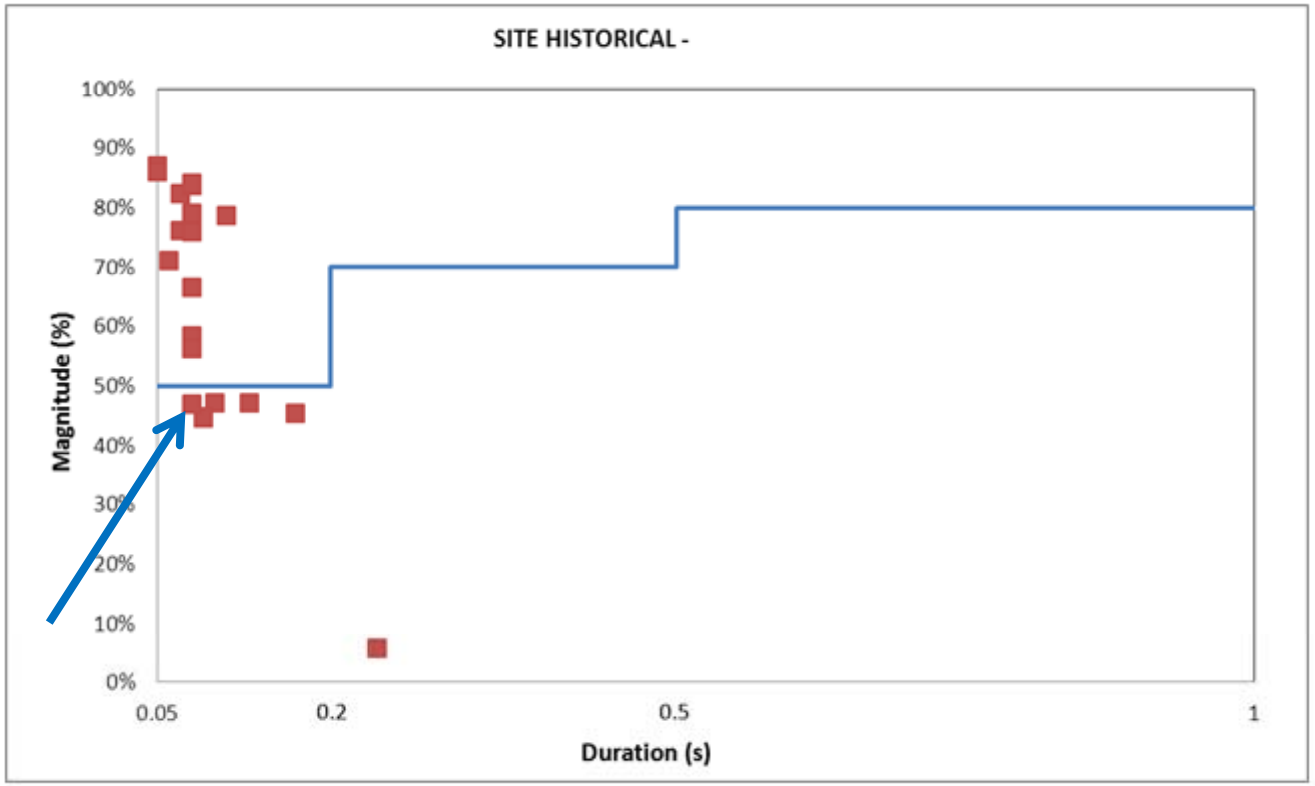
CASE STUDY

- Some escalators in a public place found stopped
- A case of inconvenience and possibly safety
- Coincided with a transmission-level fault (single-phase)
- Which caused an island-wide voltage dip with ¼ of the island felt the greatest impact

CASE STUDY (CONT'D)

- Inquiry
- Why some escalators were not affected?
- What is the ride-thru of these escalators?
- And what are the possible preventive measures? Any commercially available solutions?

SITE HISTORICAL FIGURES (22KV)



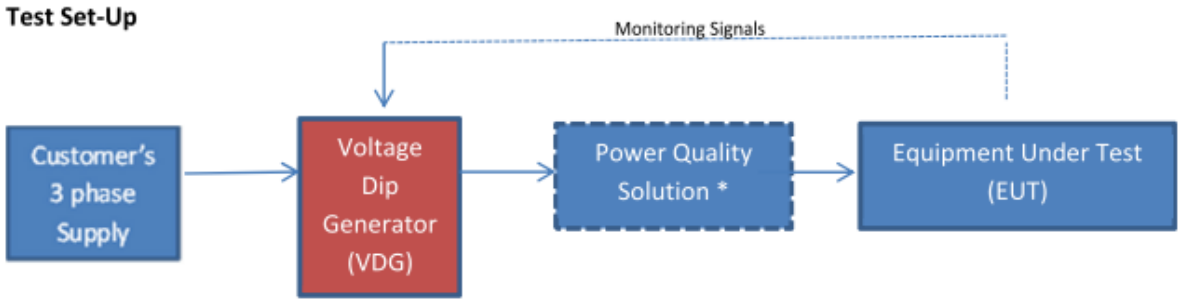
SITE STUDY

- Supply to escalator's control were taking in from two phases
- Control circuits: relays and contactors
- Phase monitoring relay (Unb:15%, 5 sec)
- Dip values recorded at 22kV, needs to estimate the corresponding LV dip values seen by escalator

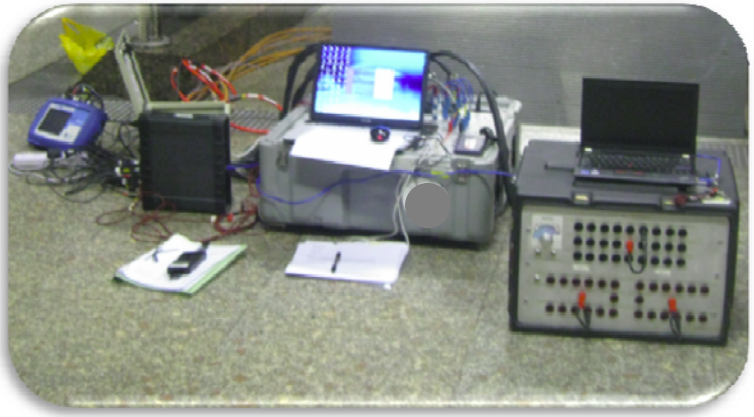
Location	Retained Voltage (%)& Duration (ms)		
	V_{12}, Duration	V_{23}, Duration	V_{31}, Duration
Measured 66kV	50.5% , 80ms	47.0%, 80ms	87.6%, 30ms
Measured 22kV	50.9%, 80ms	48.2%, 80ms	86.5%, 50ms
Estimated LV	**25.8%, 90ms**	**75.8%, 70ms**	**78.0%, 70ms**

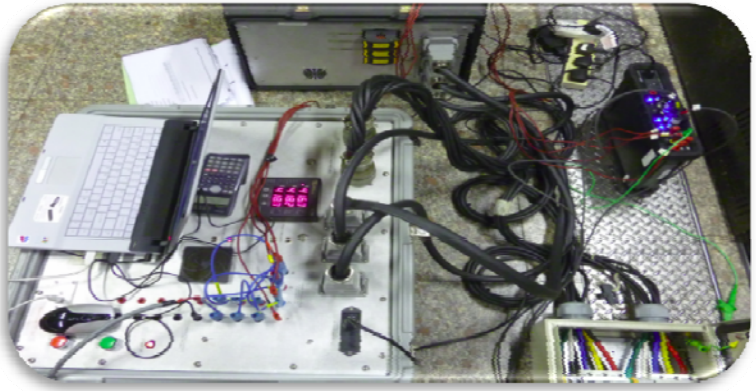
VOLTAGE DIP TEST

- One on ‘affected’ escalator
- One on ‘unaffected’ escalator
- Likely difference was due to different phases supplying the control circuit
- Possible conflict with local code of practice for escalator, if a Power Quality solution is installed

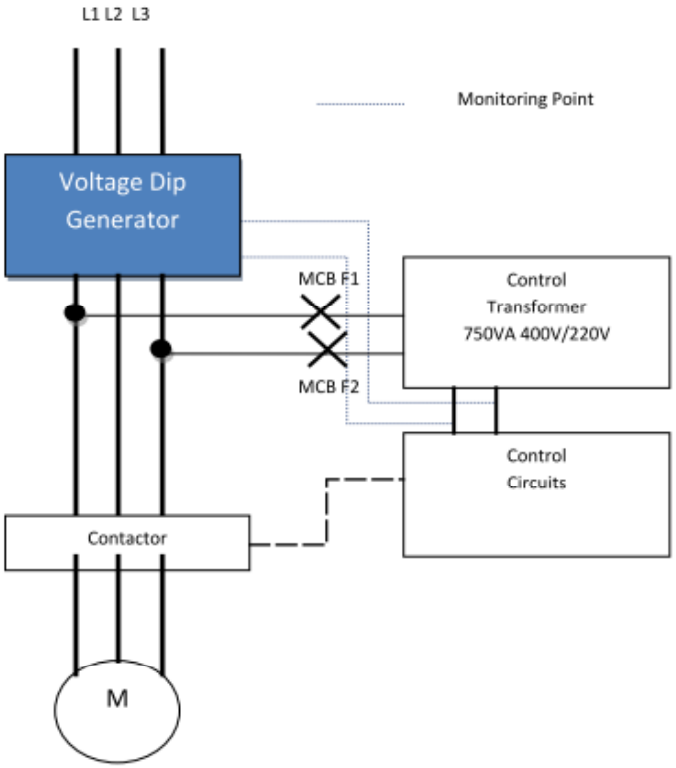


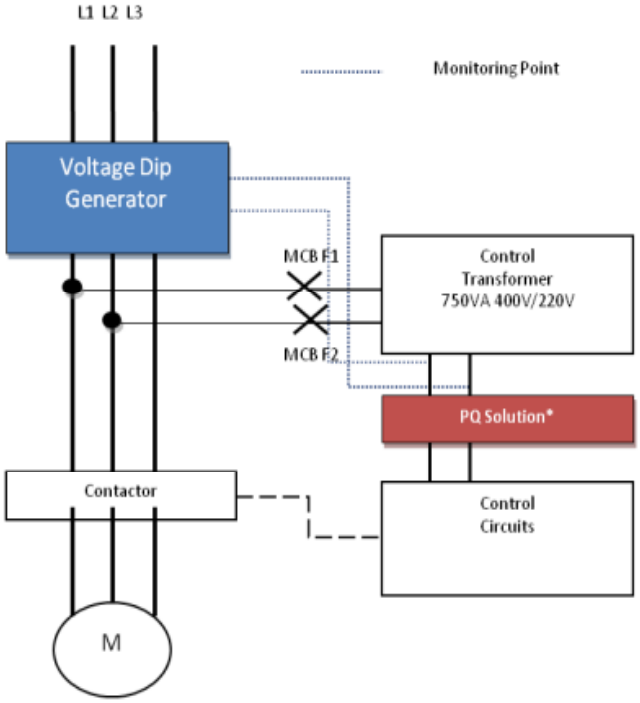
TEST SET UP



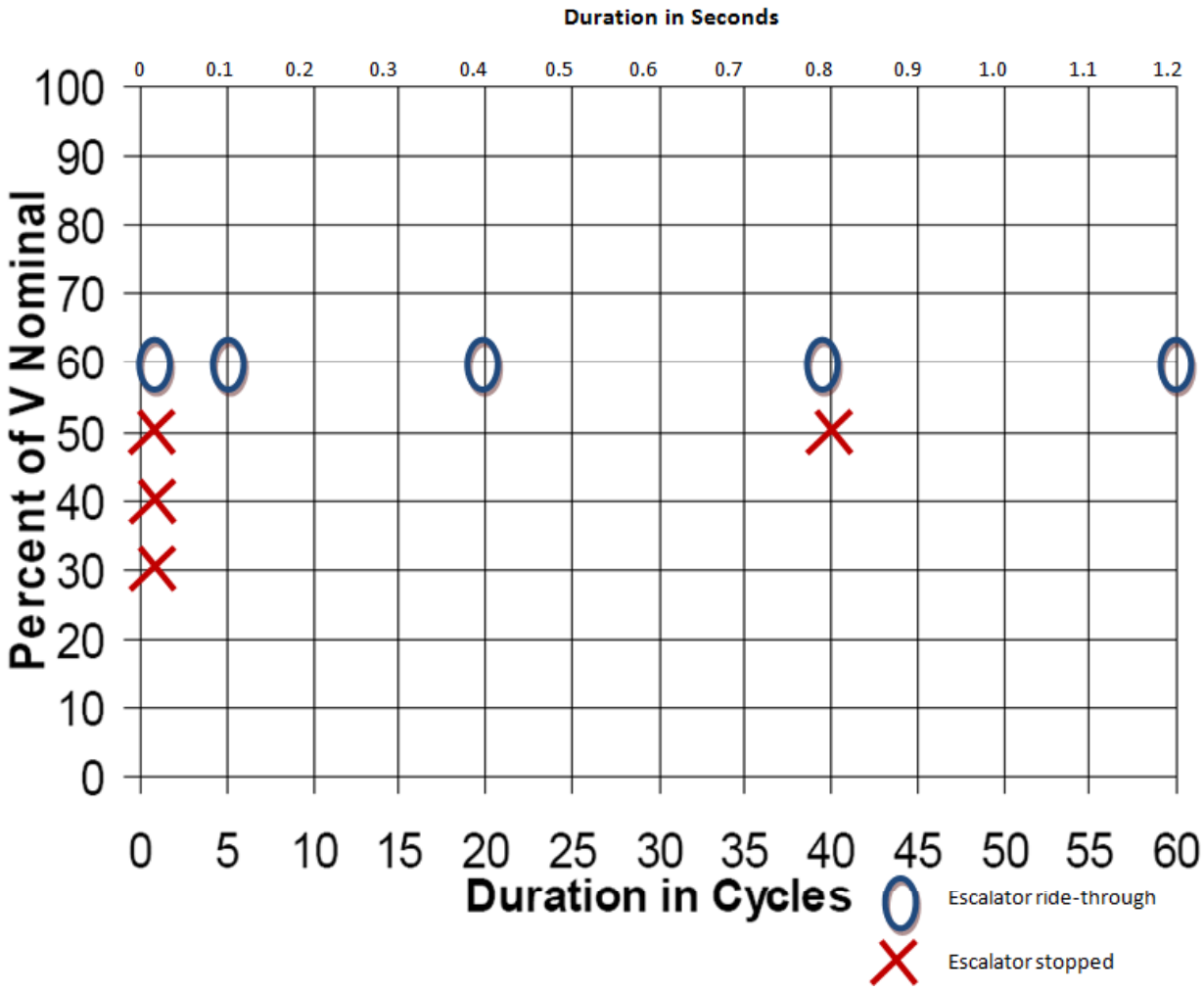


TEST SET UP



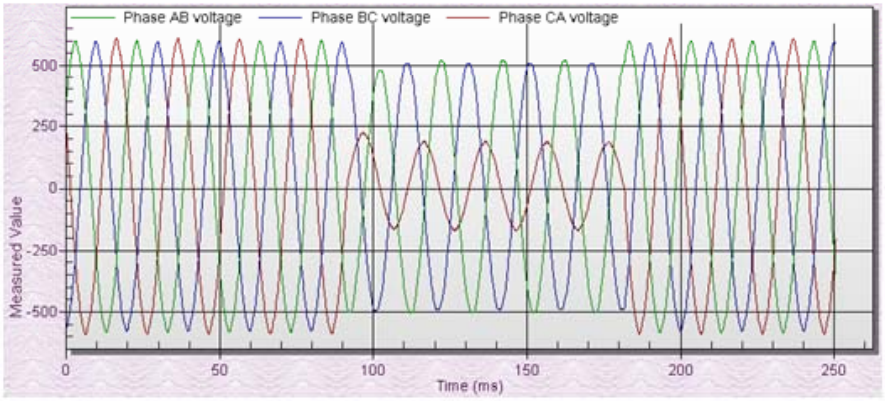


DIP TEST RESULTS - SELECTED

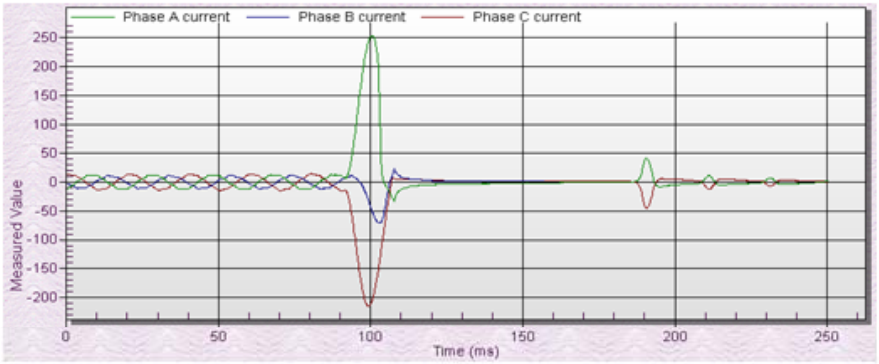


ON ‘UNAFFECTED’ ESCALATOR

Event	Vab	Vbc	Vca	Duration (ms)	Duration (cycles)	Comment
D2-1c	88	88	**30**	0.09	4.5	Escalator Stopped



Voltage Waveforms



Current Waveforms

Circuit size: 100A
Running amps: 9 ~ 11A

- Unaffected escalator’s control circuit was taking from Phase L31
- Estimated to have dip by 22%, 70ms
- Retained voltage of 78%

CONCLUSION

- Both escalators exhibited same ride-thru characteristics
- Voltage dip of more than 40% (retained voltage of less than 60%) that affects supply to the control transformer → 

- 'Unaffected' escalator was taking supply from Phase L31
- PQ solution was effective. But need further advise by escalator specialists to ensure safety features relating to its braking system will not be compromised

HK CP FOR LIFTS & ESCALATORS

8.4.1 General Provisions

8.4.1.1 Escalators shall have a braking system by means of which they can be brought to rest with a largely uniform deceleration and maintained stationary (operational braking); see also Clauses 10.2.1.6 and 10.2.4. There shall be no intentional delay in the application of the braking system, except under Clause 8.4.1.2(c).

8.4.1.2 The braking system shall operate automatically:

(a) in the event of loss of the voltage supply;

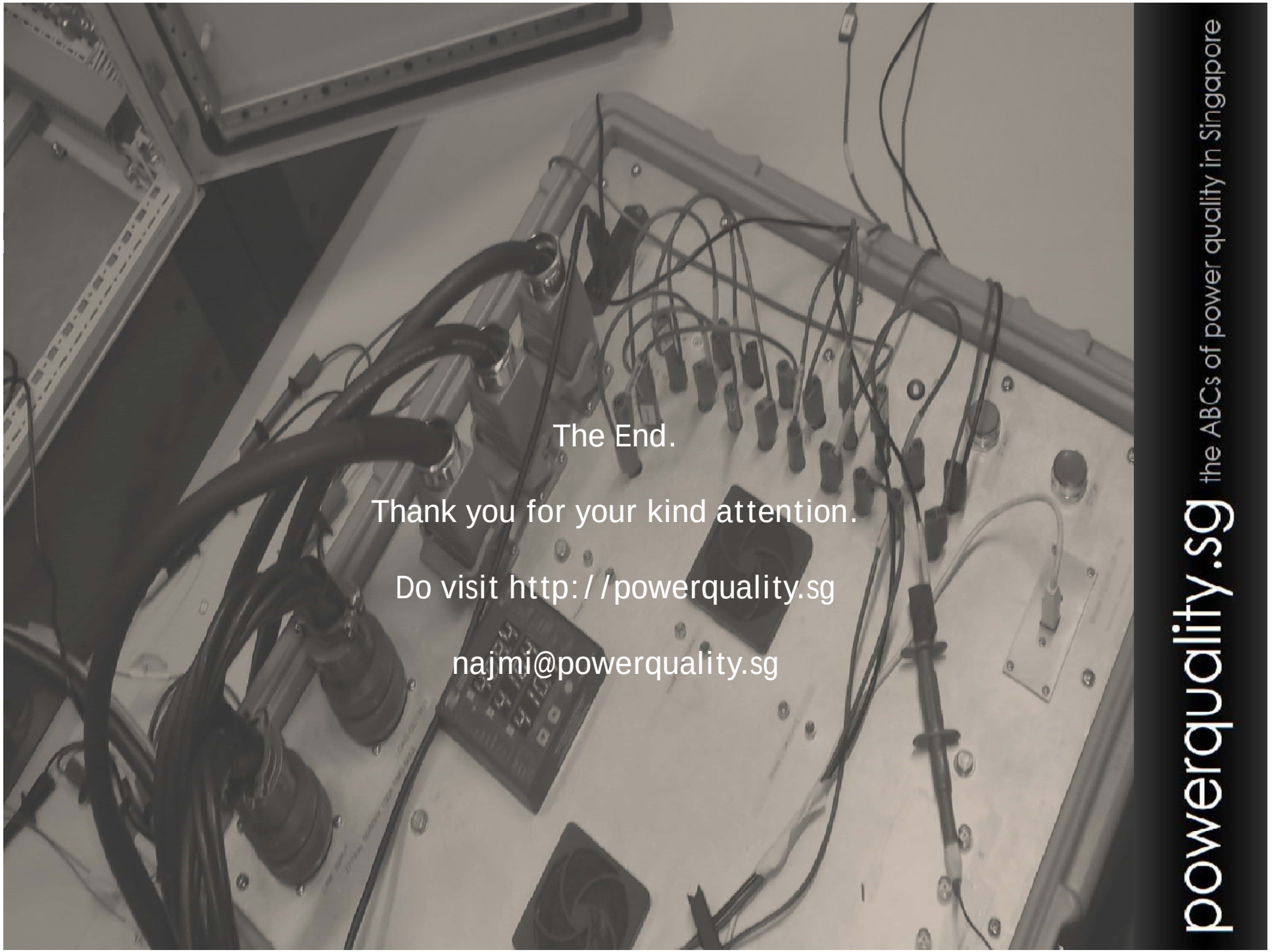
(b) in the event of loss of the voltage supply to the control circuits; or

✳ (c) for an escalator installation equipped with protection devices to enable it to sustain operation (ride through) during power supply voltage dips,

(i) at the lapse of 0.2 s of a continuous supply voltage dip of more than 10% of the supply voltage; or

(ii) at a voltage dip exceeding 60% of the supply voltage, or

(iii) at the failure of the protection device.


The End.
Thank you for your kind attention.
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PG PURCHASED 3 MV PQD FOR TRIAL

- 3 different manufacturers
- To assess application feasibility
- Lessons learnt include
  - reliability and manufacturing quality of components such as repeated failures of IGBTS
  - need to understand dynamic load characteristics
  - foot-print considerations
- *"Power Quality Initiatives in Singapore" – presented at CIRED 2001*

REGULATORY CONTROL

To: All Licensed Electrical Engineers

Dear Sirs

MEASURES TO CONTROL VOLTAGE DIPS CAUSED BY FAILURE OF CONSUMERS' HIGH VOLTAGE ELECTRICAL EQUIPMENT

Consumers and their licensed electrical engineers are to ensure that their high voltage equipment are maintained properly to prevent failure of the equipment which can cause voltage dip. The Authority will implement new measures to control voltage dips due to failure of consumers' high voltage equipment with effect from 1 Nov 2000.

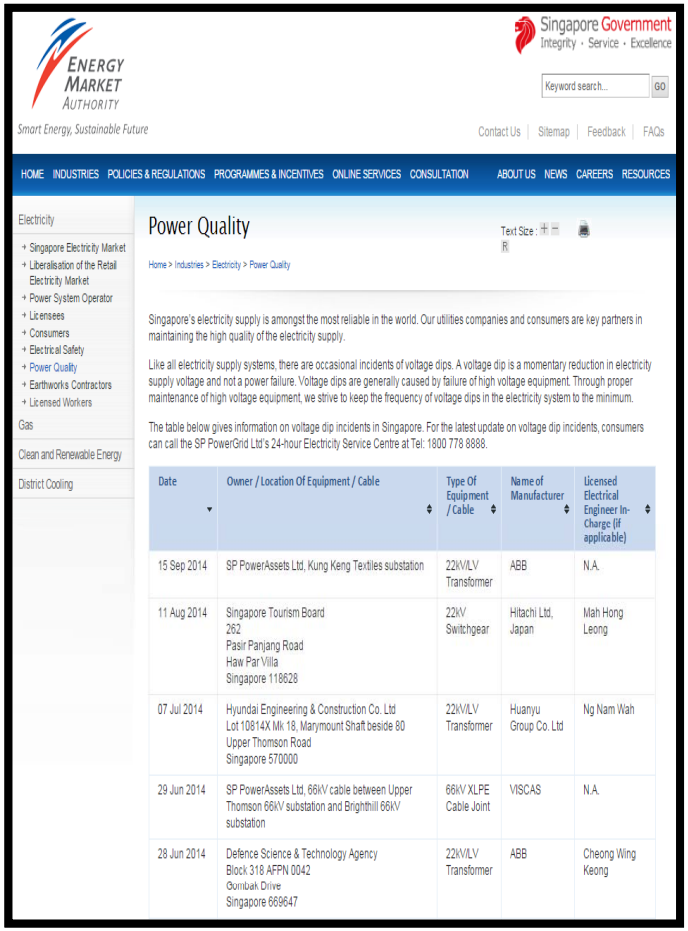
2 With the new measures, a licensed electrical engineer (LEE) will have his case reviewed by an inquiry committee on the third occurrence of voltage dip caused by failure of high voltage equipment in any of the electrical installations under his charge within 24 months. The LEE would have his licence suspended if the inquiry committee finds that he failed to exercise due diligence in his work.

3 The new measures will also require the consumer to carry out an independent maintenance audit and implement priority recommendations after the third failure of his high voltage equipment in the same electrical installation within 24 months. His licence for the electrical installation may be suspended and his electricity supply cut off for a period deemed necessary for the independent maintenance audit to be carried out and for priority recommendations to be implemented.

4 The Authority will also post records of all high voltage equipment failures which caused voltage dips on its web page. The information posted will include the name of consumer, the type of equipment, the equipment manufacturer, the LEE in charge of the installation and the date of equipment failure.

5 We would advise you to work closely with your clients to ensure proper maintenance of their high voltage equipment.

6 If you need clarification, please email to EMA_RD_ELISE@ema.gov.sg.



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SP SYSTEMS DYNACOM

New voltage dip compensators from Singapore Power division

02/10/2002

2 October 2002 - SP Systems Pte Ltd (SP Systems), a wholly owned subsidiary of Singapore Power Limited has launched a new range of voltage dip compensators - the single-phase DynaCom.

DynaCom protects power quality sensitive equipment against voltage sags, which are inherent in any power system. Damage to or failures of power cables, switchgears or transformers normally cause the voltage sags. The DynaCom overcomes voltage sags by injecting a compensating voltage into the power supply, effectively "filling-in" the voltage sags. It is able to respond and compensate within 2 milliseconds for a voltage that dips to as low as 40 per cent nominal voltage for up to 1 second.

Designed for single-phase applications, the new DynaCom uses ultra-capacitors as energy storage device. The innovative use of ultra-capacitors makes SP Systems one of the industry's first to apply this technology in power quality devices. In addition, ultra-capacitors are maintenance-free and are more durable than conventional energy storage devices such as batteries.

The compact and easy-to-install single-phase DynaCom frees-up space at the customers' premises. It also enables easy retrofitting of existing manufacturing equipment, which are sensitive to voltage sags. These environmentally-friendly single-phase DynaCom units come with ratings of 12.5A, 25A and 50A, 50 Hz or 60 Hz.

Anticipating the single-phase DynaCom to be well-received, Mr Jeremy Seah, General Manager of SP Systems said, "The current market could augur well for the new range of DynaCom. While many companies, such as the wafer fabrication and semi-conductor plants, may have tightened their finances, the demand for higher quality electricity persists as an uncorrected voltage sag in the power system could cost them more if no precautionary measures are taken."

"With the proliferation of micro-processor based applications that are sensitive to the quality of power, increasing importance is placed on power quality by end-users. To cater to the different needs of our customers, SP Systems also develops, manufactures and offers three-phase DynaCom in addition to the single-phase DynaCom." Mr Seah added.

GOVERNMENT GRANT

POWERCONNECT Home

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- Going The Extra Mile During An Outage
- Essential Services Power Quality Meeting
- Combined Cables & Pipes Earthworks Monitoring
- Network Performance

Printer friendly version

EDB Power Quality Scheme Grant Closes In May

The closing date to apply for the Power Quality Scheme (PQS) grant from the Economic Development Board is end May 2009.

PQS is the Board's one-off initiative launched in June 2007 to help manufacturing companies implement power quality solutions to enhance their protection against voltage dips.

EDB will co-share 50 per cent of the cost of purchasing and installing the voltage dip mitigation devices, up to S$5 million per plant.

The grant's application window runs from June 2007 to May 2009 and companies have up to two years as the qualifying period for implementation.

For more information on the PQS grant, please contact Cyrus Siu, EDB's Senior Officer for Resource Development, at email: cyrus_siu@edb.gov.sg or tel: 6832 6063.

NEW CODE OF PRACTICE

SINGAPORE STANDARD

SS 576 : 2012

(ICS 29.060; 93.020)

CODE OF PRACTICE FOR

Earthworks in the vicinity of electricity cables

There has been a steady increase in the number of Notice for Commencement of Earthworks (NCE) forms submitted to SP Power Grid Ltd. The corresponding increase in earthworks activities has subjected the electricity cables to a higher probability of being damaged. Damage to electricity cables can cause either power failures or voltage dips. Such damages will have an adverse impact on the reliability and quality of electricity supply to consumers.

To reduce the probability of damage to electricity cables, a new Singapore Standard (SS) Code of Practice (CP) for Earthworks in the Vicinity of Electricity Cables has been developed to raise the awareness, the level of vigilance and the level of competence among the stakeholders so as to prevent damage to underground electricity cables.

This standard applies to all forms of earthworks carried out in the vicinity of underground electricity cables. It provides practical preventive measures in different situations involving earthworks aimed at avoiding damage to cables.

Damage to property of electricity licensee Electricity Act

85.—(1) Any person who wilfully removes, destroys or damages any electrical plant or electricity cable in the transmission network belonging to or under the management or control of an electricity licensee or hinders or prevents the electrical plant or electricity cable from being used or operated in the manner in which it is intended to be used or operated shall be guilty of an offence and shall be liable on conviction to a fine not exceeding $10,000 or to imprisonment for a term not exceeding 3 years or to both.

(2) Notwithstanding subsection (1), any person who, in the course of carrying out any earthworks, damages or suffers to be damaged any high voltage electricity cable in the transmission network belonging to or under the management or control of an electricity licensee shall be guilty of an offence and shall be liable on conviction to a fine not exceeding $1 million or to imprisonment for a term not exceeding 5 years or to both.