

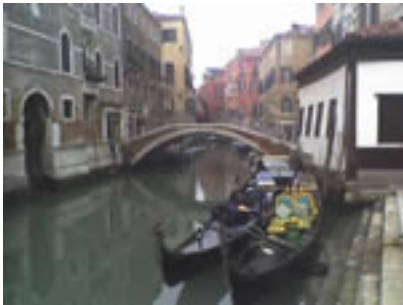


UIE working group Power Quality

Voltage Dip Immunity of Equipment and Installations

TUTORIAL

Improving Process Immunity (Part 7)



The First International Conference on Smart Grids, Green
Communications and IT Energy-aware Technologies

ENERGY 2011

May 22-27, 2011 - Venice/Mestre, Italy



Flow chart of Immunity Objectives



PROCESS TO IMPROVE PROCESS IMMUNITY AGAINST VOLTAGE DIPS

SUPPLY PERFORMANCE - Get information about what voltages dips should be expected or are typical at PCC

Contact electrical utility and ask for assessment of the PCC in terms of how many voltage dips can be expected or are typical. Alternatively the customer can measure by himself at the PCC.

RESPONSIBILITY: Customer & electrical network operator
 DELIVERABLE: **Assessment of number, magnitude and length of voltage dips over one year**

PROCESS PERFORMANCE REQUIREMENT

Assessment of the number of process trips a customer can tolerate in a typical year of production.

RESPONSIBILITY: Customer
 SUPPORT: Third party consultants might help if no internal resource available
 DELIVERABLE: **Number of process trips a customer is willing to accept**

PIT (PROCESS IMMUNITY TIME) - Process assessment to find the critical equipment

Here it is important to focus on the PROCESS itself and not on individual equipment as the process is the important part.

RESPONSIBILITY: Customer
 SUPPORT: Third party consultants might help if no internal resource available
 DELIVERABLE: **List of critical path equipment AND the required performance criteria**

PROCESS IMMUNITY REQUIREMENT

With the inputs from the supply performance and the process performance requirement the required voltage dip immunity curve for the process can be established.

RESPONSIBILITY: Customer
 DELIVERABLE: **Required voltage dip immunity curve for the process**

EQUIPMENT PERFORMANCE REQUIREMENT

With the PIT, the required performance criteria (full operation, recovery, assist) and the required immunity curve for the process the assessment for each individual equipment from the critical path can be done. Remark: various combinations of voltage tolerance and performance criterion may work (e.g. equipment full operating during dip or restart if PIT is high).

RESPONSIBILITY: Customer
 SUPPORT: Third party consultants might help if no internal resource available
 DELIVERABLE: **Required voltage dip immunity curve for the equipment**

EQUIPMENT / MITIGATION SELECTION

Get information from equipment manufacturer on ride through capabilities of their equipment (and costs)
 Get information about voltage dip mitigation devices (and their costs)

- 1 – Equipment commercially available? YES → buy if cheaper than mitigation AND cheaper than financial loss due to expected process trips
- 2 – Specify equipment with better ride through capabilities in bidding for new equipment → use catalogue of PQ Labels (includes voltage dip ride through requirement, performance criteria, and required tests to be performed) → buy if cheaper than mitigation AND cheaper than financial loss due to expected process trips
- 3 → buy voltage dip mitigation device if cheaper than financial loss due to expected process trips

Other possibility would also be to work with the electrical utility in order to improve the supply performance (e.g. due to power quality contracts) or to change the process performance requirement or the process itself (e.g. use other technology, or other location with better supply if possible)



Step 1 – Supply Performance

"Information on voltage dips expected or typical at PCC"

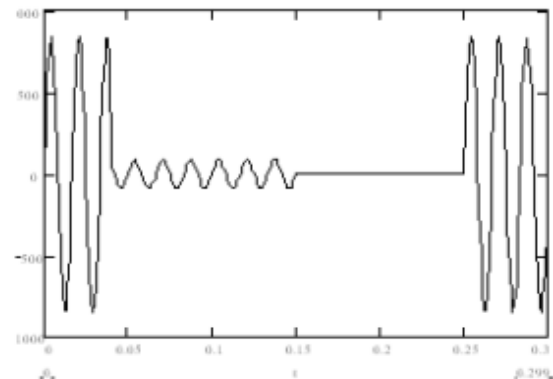
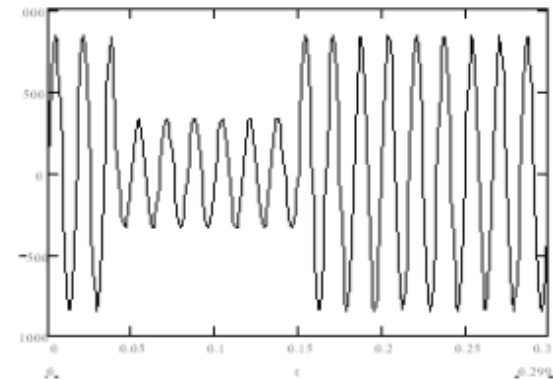
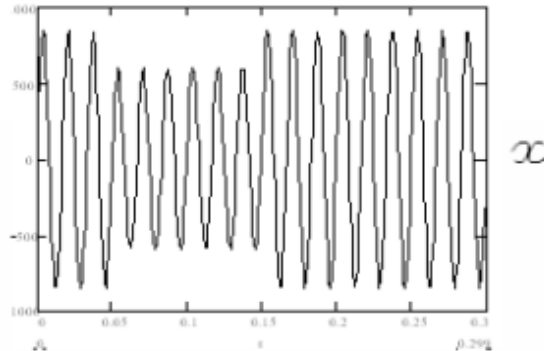
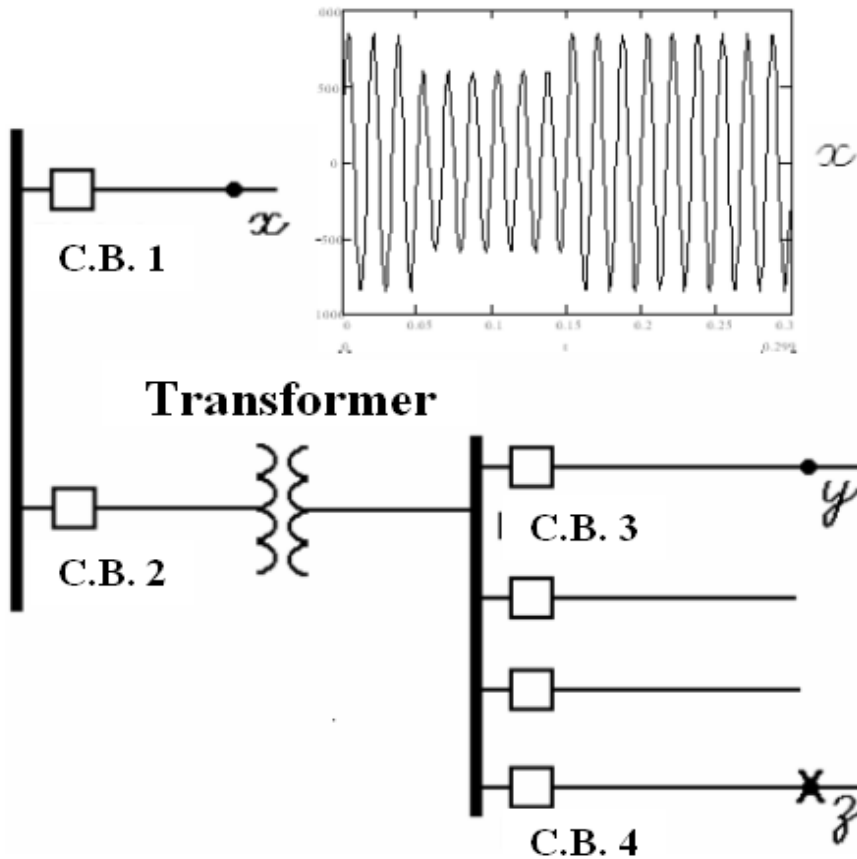
Power supply performance characteristics :

- **Voltage Level**
- **Network configuration**
- **Transformers configurations**
- **Overhead Vs underground networks**
- **Length of adjacent network**
- **Vegetation**
- **Weather (lightning, wind, snow, ice, ...)**
- **Pollution (salt, fire,...)**
- **Other loads**



Step 1 – Supply Performance

HOW LONG ? \Rightarrow Network protection

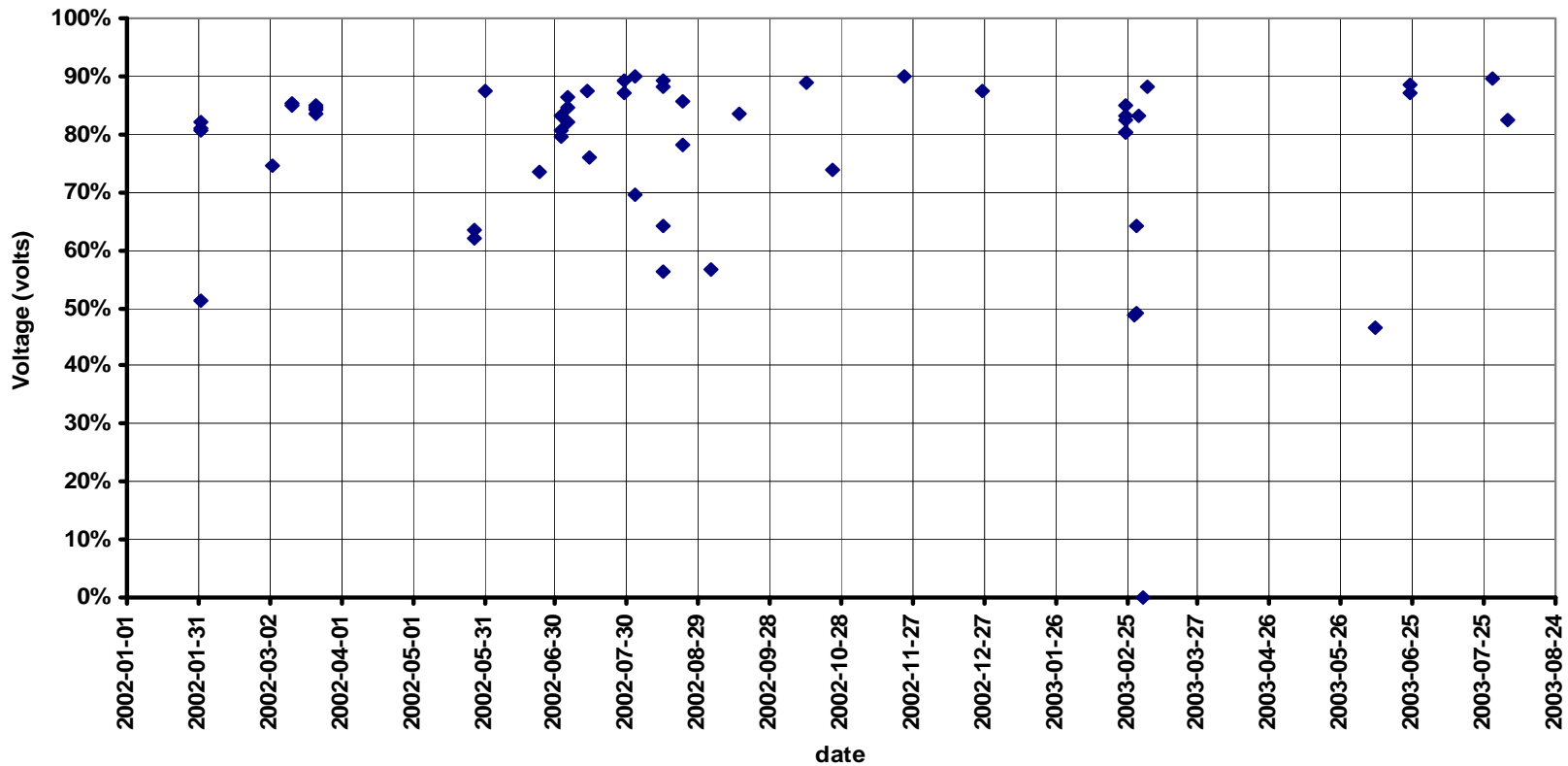


WHERE ? \Rightarrow Voltage drop



Step 1 – Supply Performance

Example - Voltage dips at a facility
Voltage dip in time





Step 1 – Supply Performance

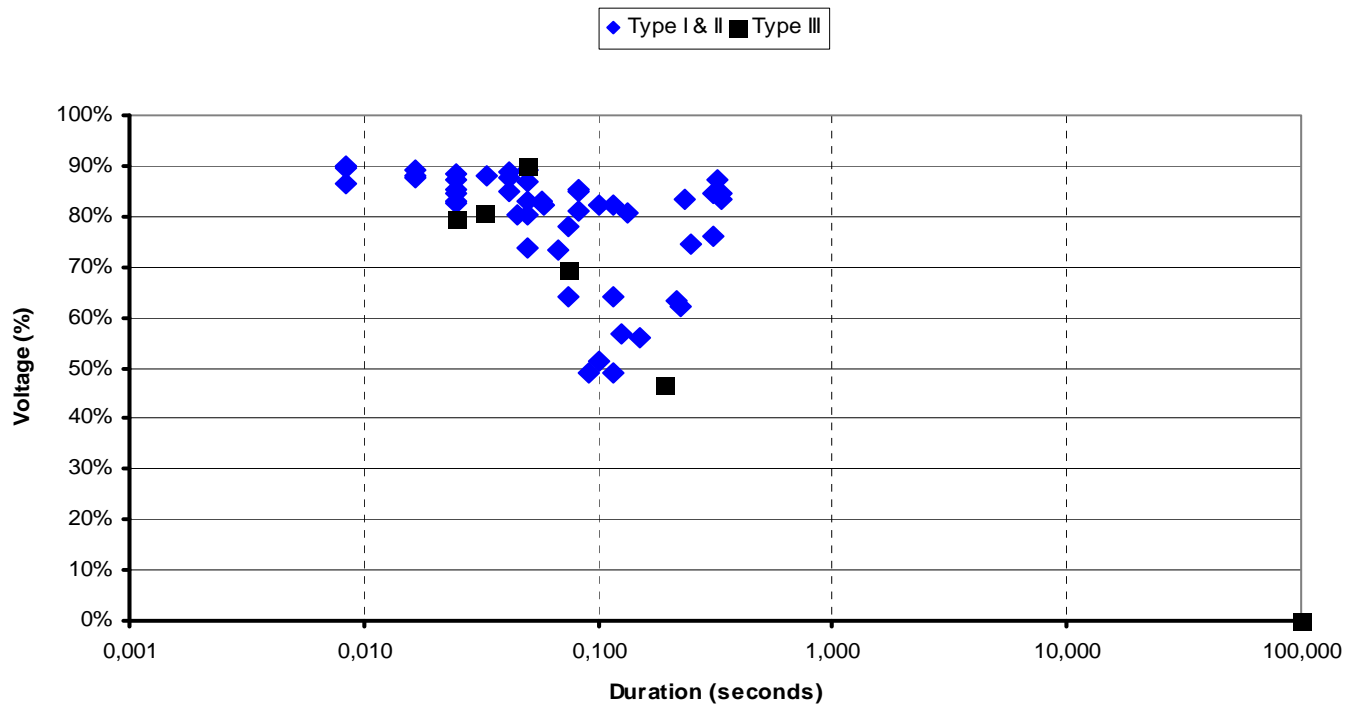
#	Date	Time	Type	Duration (seconds)	Min. Remaining voltage (%)	Depht ØA	Depht ØB	Depht ØC
13	2002-05-27	18:06:00	I	0,217	63%	108,7 %	63 %	111,5 %
14	2002-05-31	12:14:52	II	0,320	87,3%	89%	87,3%	101,7%
15	2002-06-23	18:27:07	II	0,067	73,5%	73,5%	76,7%	98,5%
16	2002-07-02	17:01:18	I	0,025	83%	97,4%	83%	92,2%
17	2002-07-02	18:17:33	III	0,033	80,5%	80,7%	80,5%	85,5%
19	2002-07-05	11:16:51	I	0,008	86,5%	94,2%	97,7%	86,5%
20	2002-07-05	11:55:16	I	0,025	84,5%	92,3%	97,1%	84,5%
21	2002-07-05	16:30:40	II	0,100	82,1%	82,1%	96,1%	89,6%
28	2002-08-14	16:31:26	II	0,150	56,1%	56,1%	58,2%	85,6%
51	2003-06-09	9:51:01	III	0,192	46,6%	48,1%	48,4%	46,6%

Events log example



Step 1 – Supply Performance

Example - Voltage dips at a facility
Voltage dip on the worst phase cases



Voltage dips measured at a facility over a 1,5 year period



Step 2 – Process Performance Requirement

"Assessment of the number of process trips a customer can tolerate in a year"

#	Date	Time	Type	Duration (seconds)	Min. Remaining voltage (%)	Lost of load (minutes)	Cost (rubber & plastics) minimum = 3\$/kW [*] Based = 5 MW	Cost (semiconductor) minimum = 20\$/kW[*] Based = 25 MW
13	2002-05-27	18:06:00	I	0,217	63%	0	-	-
14	2002-05-31	12:14:52	II	0,320	87,3%	30	7 500 \$	37 500 \$
15	2002-06-23	18:27:07	II	0,067	73,5%	30	7 500 \$	37 500 \$
16	2002-07-02	17:01:18	I	0,025	83%	0	-	-
17	2002-07-02	18:17:33	III	0,033	80,5%	20	5 000 \$	25 000 \$
19	2002-07-05	11:16:51	I	0,008	86,5%	0	-	-
20	2002-07-05	11:55:16	I	0,025	84,5%	0	-	-
21	2002-07-05	16:30:40	II	0,100	82,1%	0	-	-
28	2002-08-14	16:31:26	II	0,150	56,1%	80	20 000\$	100 000\$
51	2003-06-09	9:51:01	III	0,192	46,6%	120	30 000\$	150 000\$

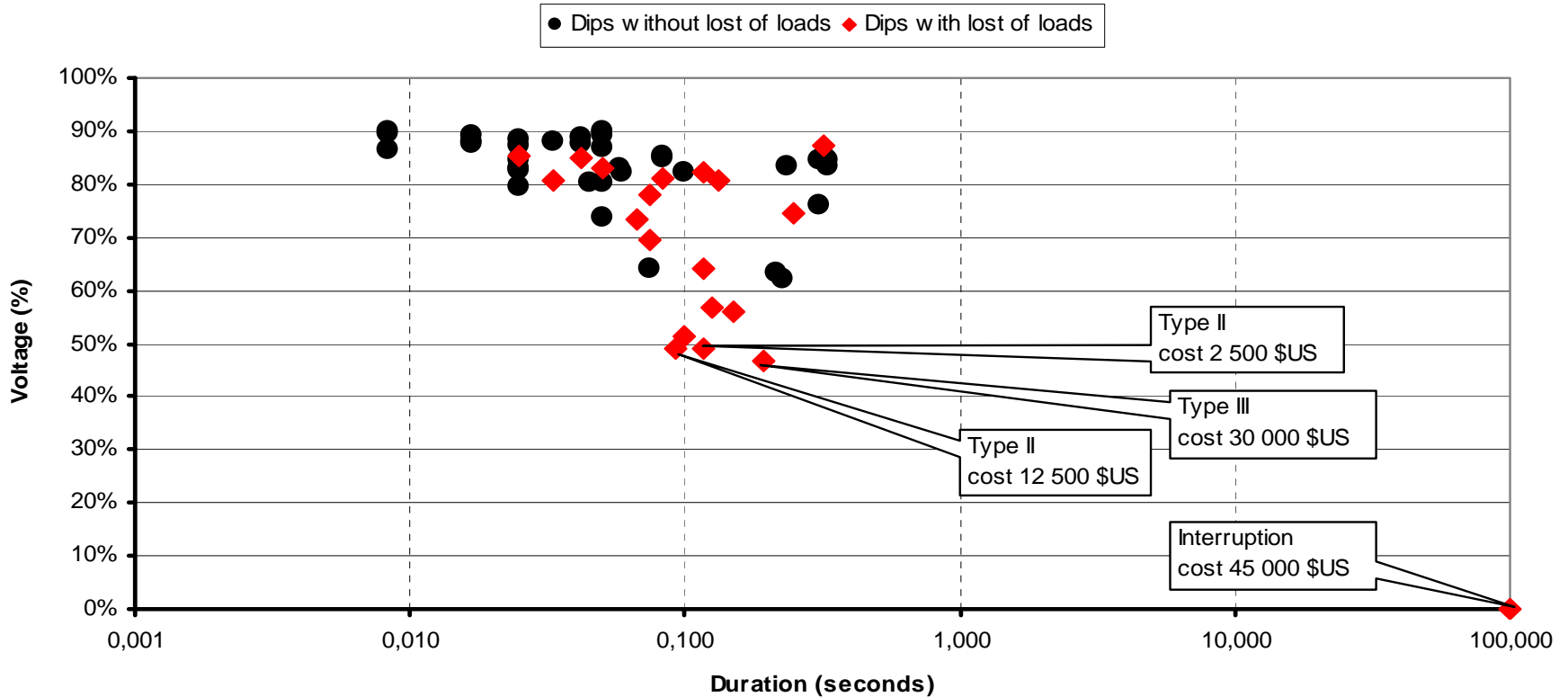
Impact on process

*ref.: http://www.energypulse.net/centers/article/article_display.cfm?a_id=1890



Step 2 – Process Performance Requirement

Voltage dips impact on the process (from the worst phase cases)



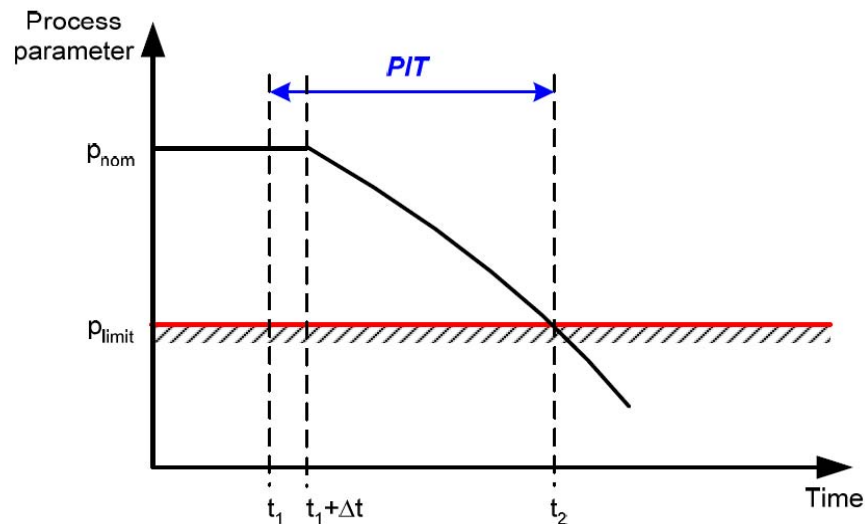


Step 3 – PIT (Process Immunity Time)

"Process assessment to find the critical equipments"

PIT definition :

"Time interval between the start of the voltage interruption and the moment the process parameter goes out of the allowed tolerance limit"





Step 3 – PIT (Process Immunity Time)

LEVEL 1	LEVEL 2	LEVEL 3	Process parameter	PIT	Priority	Action
Reactor						
	Cooling					
		DOL IM 1 (water)	Reactor cooling water temp	5s	4	Restart 1
		Oil pump	Oil pressure	1,5s	2	Crucial
		DOL IM 2 – fan	Cooling of the water circuit	3min	7	Restart 3
	Reaction					
		DOL IM 3 (feed)	Flow rate	30s	6	Restart 2
		ASD 1 (mixer)	Reaction time	6s	5	Restart
		ASD 2 (air)	% O ₂	2s	3	Mitigate
	Control					
		Temperature sensor	Reactor temperature	1 h	8	
		Oxygen measurement	% O ₂	1s	1	Mitigate
		PLC with UPS		1 h	8	

**Listing of all process components such as :
Motor, drive, controls, PLC, sensors, lights, ...**



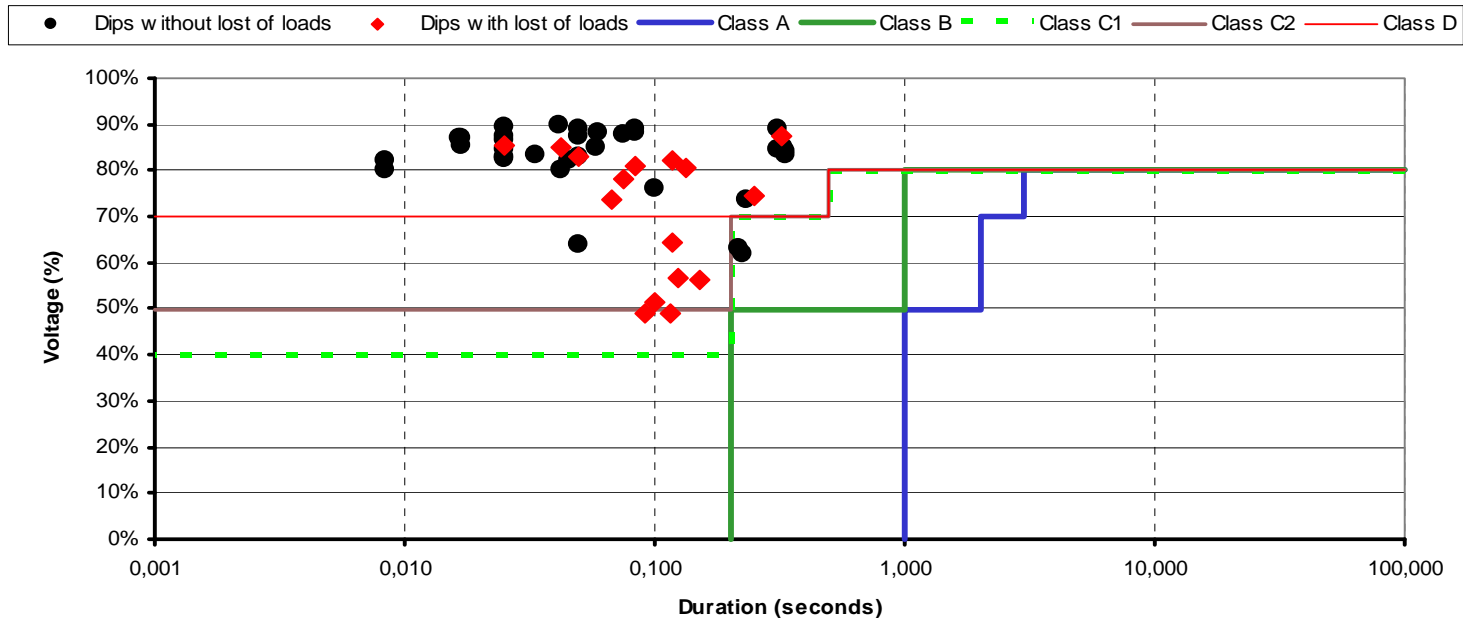
Step 4 – Process Immunity Requirement

"Determination of the appropriate immunity curve"

Type I & II Voltage dips

Voltage dips on the worst phase cases

Note: Only Type I & II curves are shown for simplification

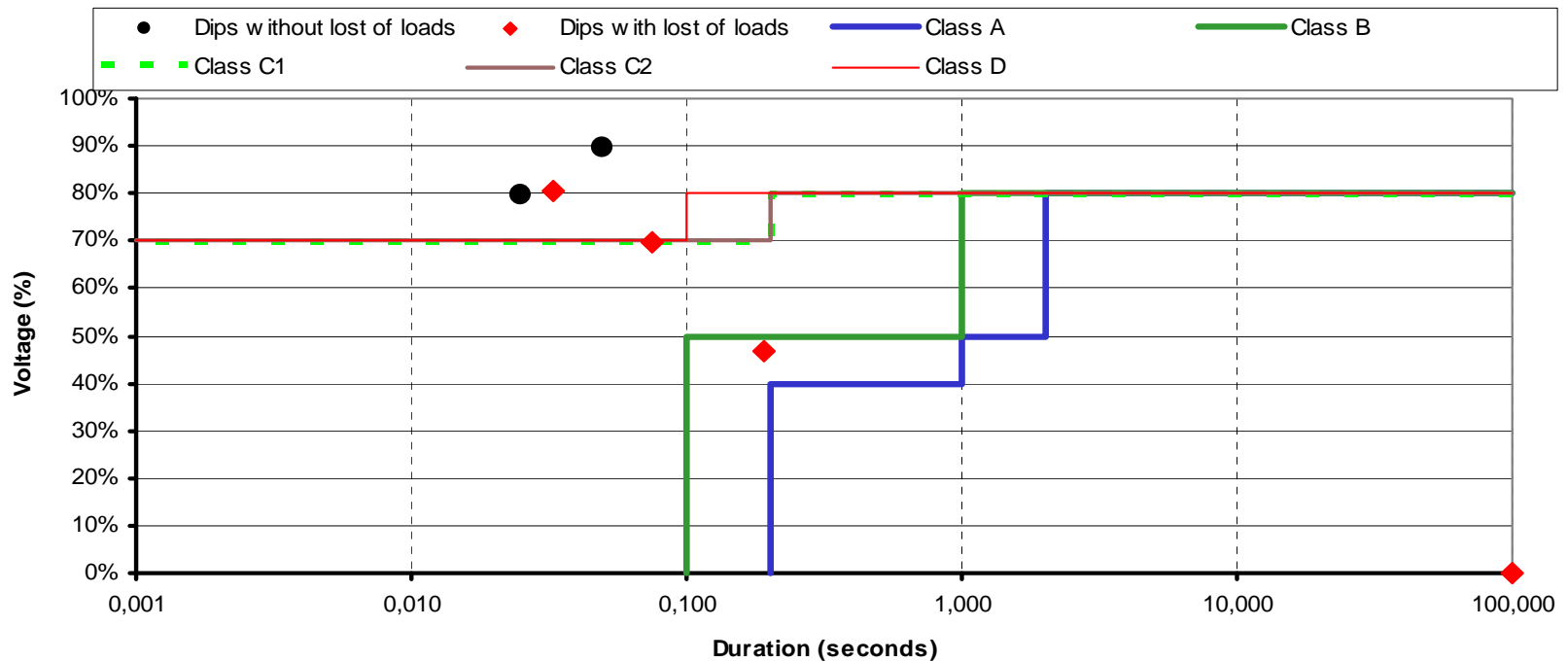




Step 4 – Process Immunity Requirement

Type III Voltage dips

Voltage dips on the worst phase cases
Note: Only Type III curves are shown for simplification





Step 5 – Equipment Performance Requirement

"Determination of the appropriate immunity curve and performance criteria for each individual equipment"

LEVEL 1	LEVEL 2	LEVEL 3	Process parameter	PIT	Priority	Action
		DOL IM 1 (water)	Reactor cooling water temp	5s	4	Restart 1

Voltage dip immunity label		Equipment performance criteria		
		Full operation	Self-recovery	Assisted-recovery
Immunity class	A			
	B			
	C1			
	C2			
	D		X	



Step 5 – Equipment Performance Requirement

"Determination of the appropriate immunity curve and performance criteria for each individual equipment"

LEVEL 1	LEVEL 2	LEVEL 3	Process parameter	PIT	Priority	Action
		Oil pump	Oil pressure	1,5s	2	Crucial

Voltage dip immunity label		Equipment performance criteria		
		Full operation	Self-recovery	Assisted-recovery
Immunity class	A			
	B			
	C1			
	C2	X		
	D			



Step 5 – Equipment Performance Requirement

Economic for Rubber & Plastics industry

	<i>Cost (rubber & plastics) minimum = 3\$/kW [°]</i>					
	<i>Based = 5 MW</i>	<i>If Class D used</i>	<i>If Class C2 used</i>	<i>If Class C1 used</i>	<i>If Class B used</i>	<i>If Class A used</i>
Total lost	212 500 \$	135 000 \$	90 000 \$	75 000 \$	75 000 \$	45 000 \$
saving	0 \$	77 500 \$	122 500 \$	137 500 \$	137 500 \$	167 500 \$
	0,0%	36,5%	57,6%	64,7%	64,7%	78,8%

Conclusion :

If no class \Rightarrow no change, no investment, 212 k\$ of lost in 1,5 year

If Class D \Rightarrow ~1/3 of saving on 212 k\$

If Class C2 \Rightarrow ~2/3 of saving on 212 k\$

Choice now depend on ROI (cost of equipment ?)



Step 6 – Equipment Selection

As proposed by CIGRE-CIRED-UIE Joint Working Group C4.1.10
Equipment Immunity Specification
Voltage dip immunity Class D

Class D curve for type I + II

Class D curve for type III

Voltage dip immunity label		Pass / Fail criteria		
		Full operation	Self-recovery	Assisted-recovery
Immunity class	D	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Testing Procedure Requirements

<p>Testing for Type I and II voltage dip required :</p> <ul style="list-style-type: none"> ▪ 80% for 3 seconds ▪ 70% for 500 milliseconds <p>(Testing methods shall be according to IEC-61000-4-11 & IEC-61000-4-34)</p>	<p>Testing for Type III voltage dip required :</p> <ul style="list-style-type: none"> ▪ 80% for 3 seconds ▪ 70% for 200 milliseconds
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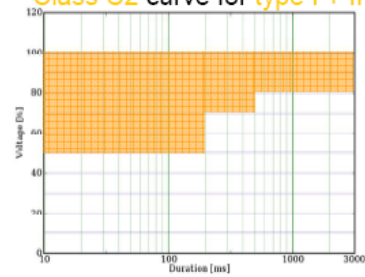
Step 6 – Equipment Selection

As proposed by CIGRE-CIRED-UIE Joint Working Group C4.1.10

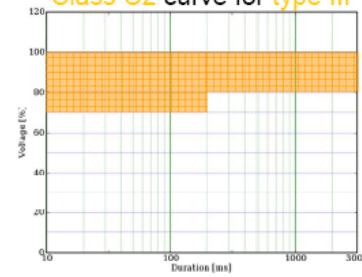
Equipment Immunity Specification

Voltage dip immunity Class C2

Class C2 curve for type I + II



Class C2 curve for type III



Voltage dip immunity label		Pass / Fail criteria		
		Full operation	Self-recovery	Assisted-recovery
Immunity class	C2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Testing Procedure Requirements

Testing for Type I and II voltage dip required :

- 80% for 3 seconds
- 70% for 500 milliseconds
- 50% for 200 milliseconds

(Testing methods shall be according to IEC-61000-4-11 & IEC-61000-4-34)

Testing for Type III voltage dip required :

- 80% for 3 seconds
- 70% for 200 milliseconds



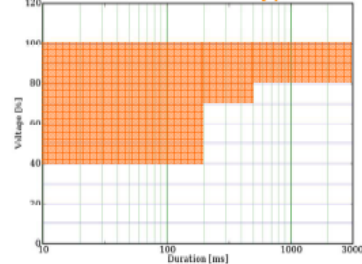
Step 6 – Equipment Selection

As proposed by CIGRE-CIRED-UIE Joint Working Group C4.1.10

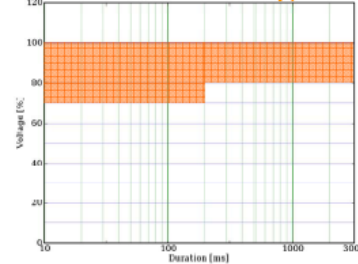
Equipment Immunity Specification

Voltage dip immunity Class C1

Class C1 curve for type I + II



Class C1 curve for type III



Voltage dip immunity label

Pass / Fail criteria

Full operation

Self-recovery

Assisted-recovery

Immunity class

C1



Testing Procedure Requirements

Testing for Type I and II voltage dip required :

- 80% for 3 seconds
- 70% for 500 milliseconds
- 40% for 200 milliseconds

(Testing methods shall be according to IEC-61000-4-11 & IEC-61000-4-34)

Testing for Type III voltage dip required :

- 80% for 3 seconds
- 70% for 200 milliseconds

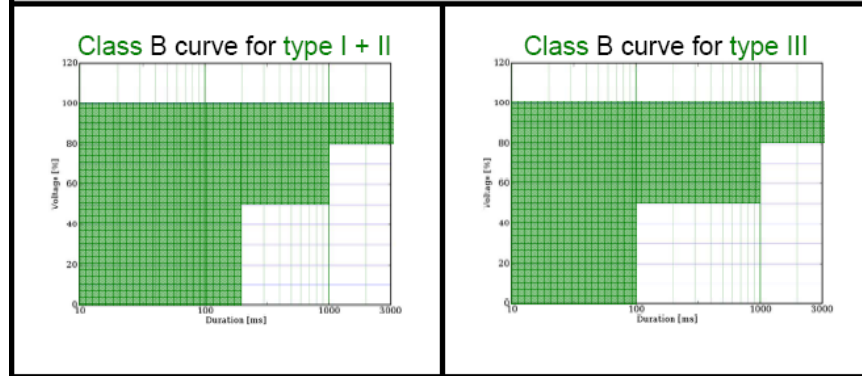


Step 6 – Equipment Selection

As proposed by CIGRE-CIRED-UIE Joint Working Group C4.1.10

Equipment Immunity Specification

Voltage dip immunity Class B



Voltage dip immunity label		Pass / Fail criteria		
		Full operation	Self-recovery	Assisted-recovery
Immunity class	B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Testing Procedure Requirements

Testing for Type I and II voltage dip required :

- 80% for 3 seconds
- 50% for 1 second
- 0% for 200 milliseconds

(Testing methods shall be according to IEC-61000-4-11 & IEC-61000-4-34)

Testing of Type III Voltage dip required

- 80% for 3 seconds
- 50% for 1 second
- 0% for 100 milliseconds



Step 6 – Equipment Selection

As proposed by CIGRE-CIRED-UIE Joint Working Group C4.1.10
Equipment Immunity Specification
 Voltage dip immunity Class A

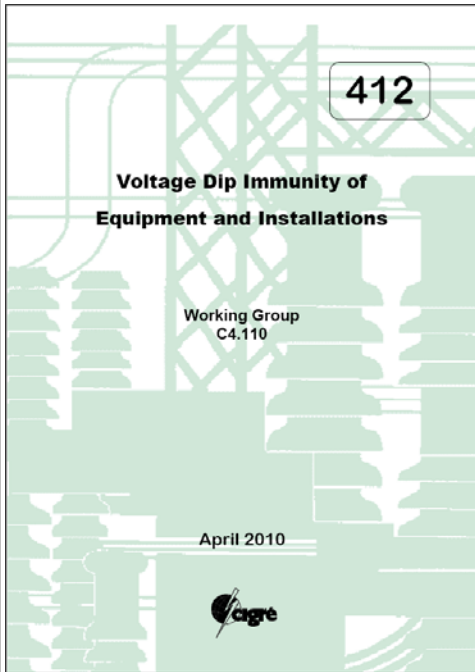
Class A curve for type I + II

Class A curve for type III

Voltage dip immunity label		Pass / Fail criteria		
		Full operation	Self-recovery	Assisted-recovery
Immunity class	A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Testing Procedure Requirements

<p>Testing for Type I and II voltage dip required :</p> <ul style="list-style-type: none"> ▪ 70% for 3 seconds ▪ 50% for 2 seconds ▪ 0% for 1 second <p>(Testing methods shall be according to IEC-61000-4-11 & IEC-61000-4-34)</p>	<p>Testing for Type III voltage dip required :</p> <ul style="list-style-type: none"> ▪ 80% for 3 seconds ▪ 50% for 2 seconds ▪ 40% for 1 second ▪ 0% for 200 milliseconds
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The report can be obtained in electronic format for free from:

www.uie.org;

a hardcopy can be purchased from

www.e-cigre.org

CIGRE/CIRED/UIE Joint Working Group C4.110

**Voltage Dip Immunity of
Equipment and Installations**

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