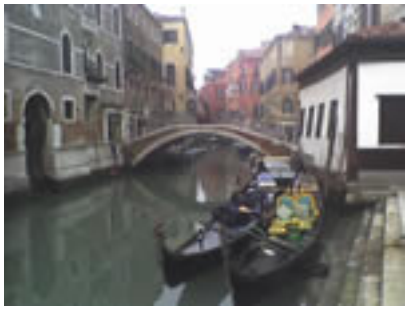
UIE working group
Power Quality

Voltage Dip Immunity of Equipment and Installations

TUTORIAL

Improving Process Immunity

(Part 7)

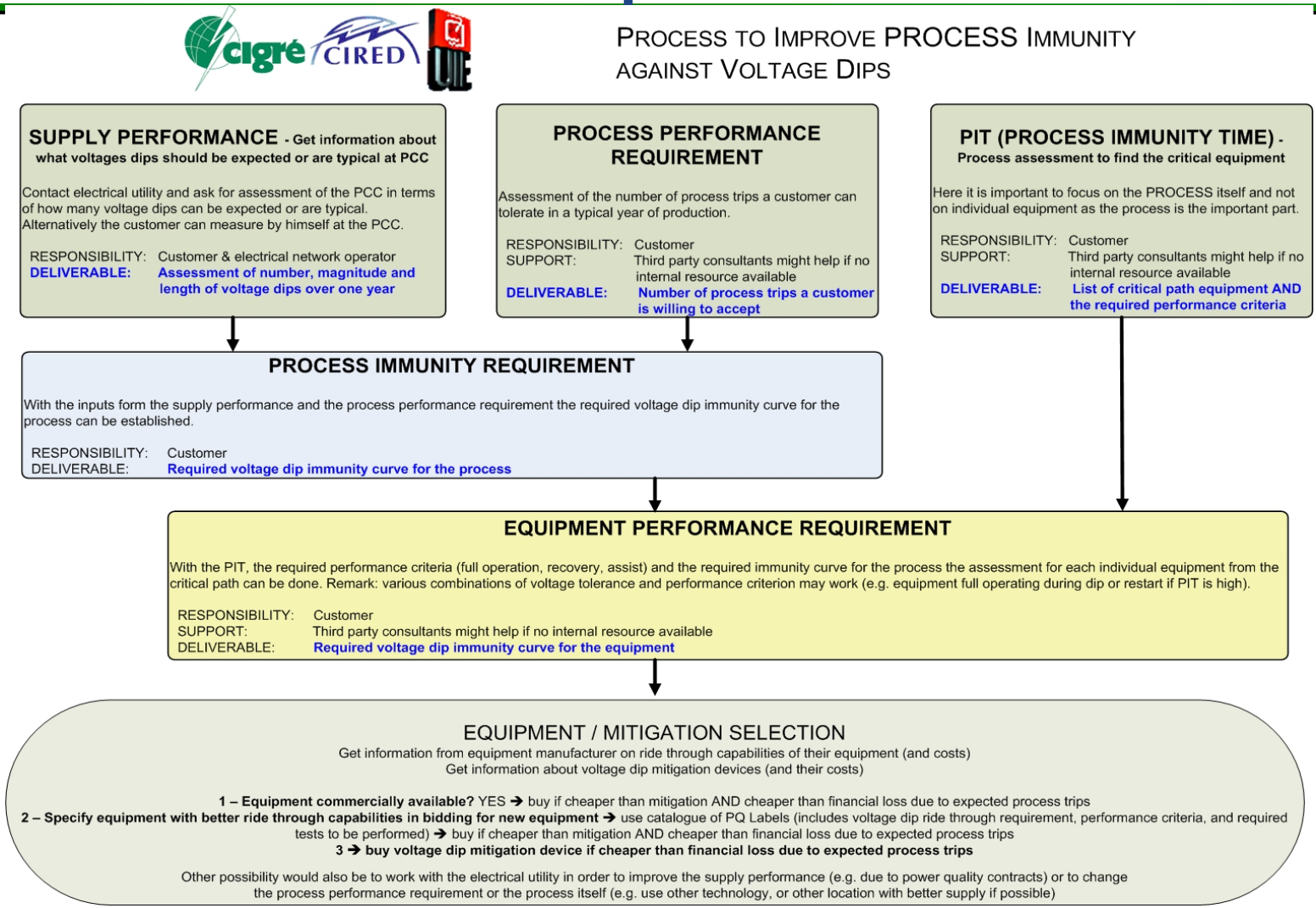


The First International Conference on Smart Grids, Green Communications and IT Energy-aware Technologies

ENERGY 2011

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

Flow chart of Immunity Objectives



Step 1 – Supply Performance

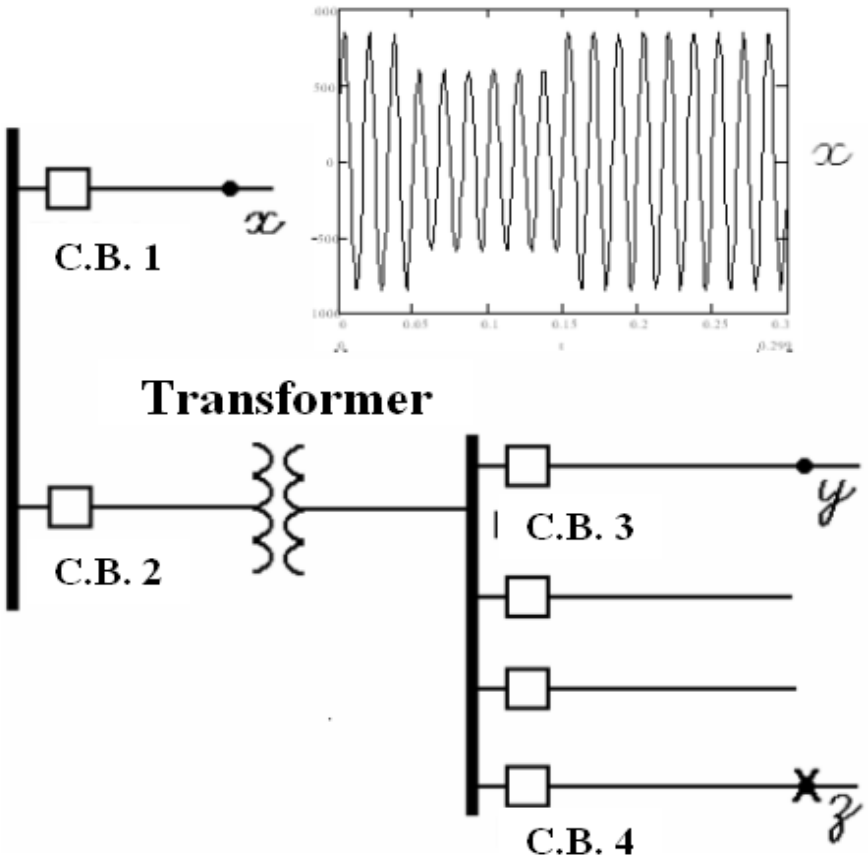
"Information on voltage dips expected or typical at PCC"

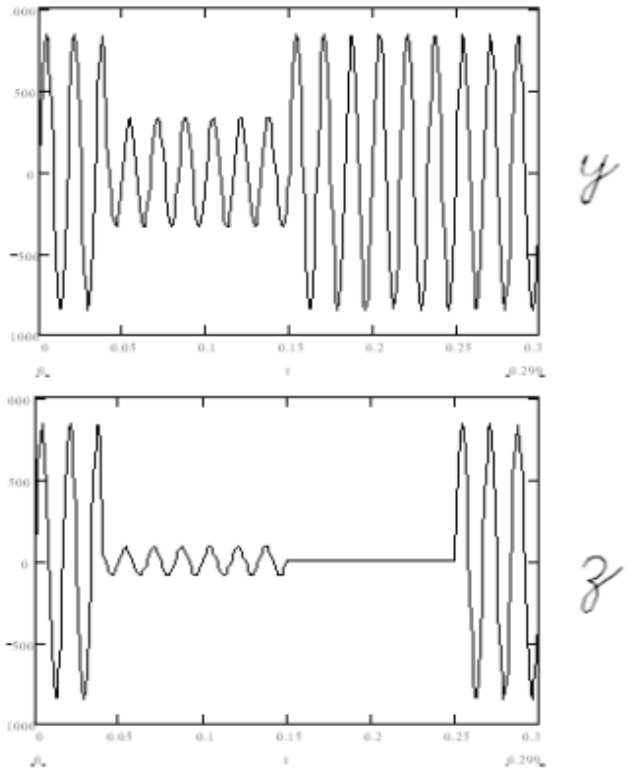
Power supply performance characteristics :

- **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

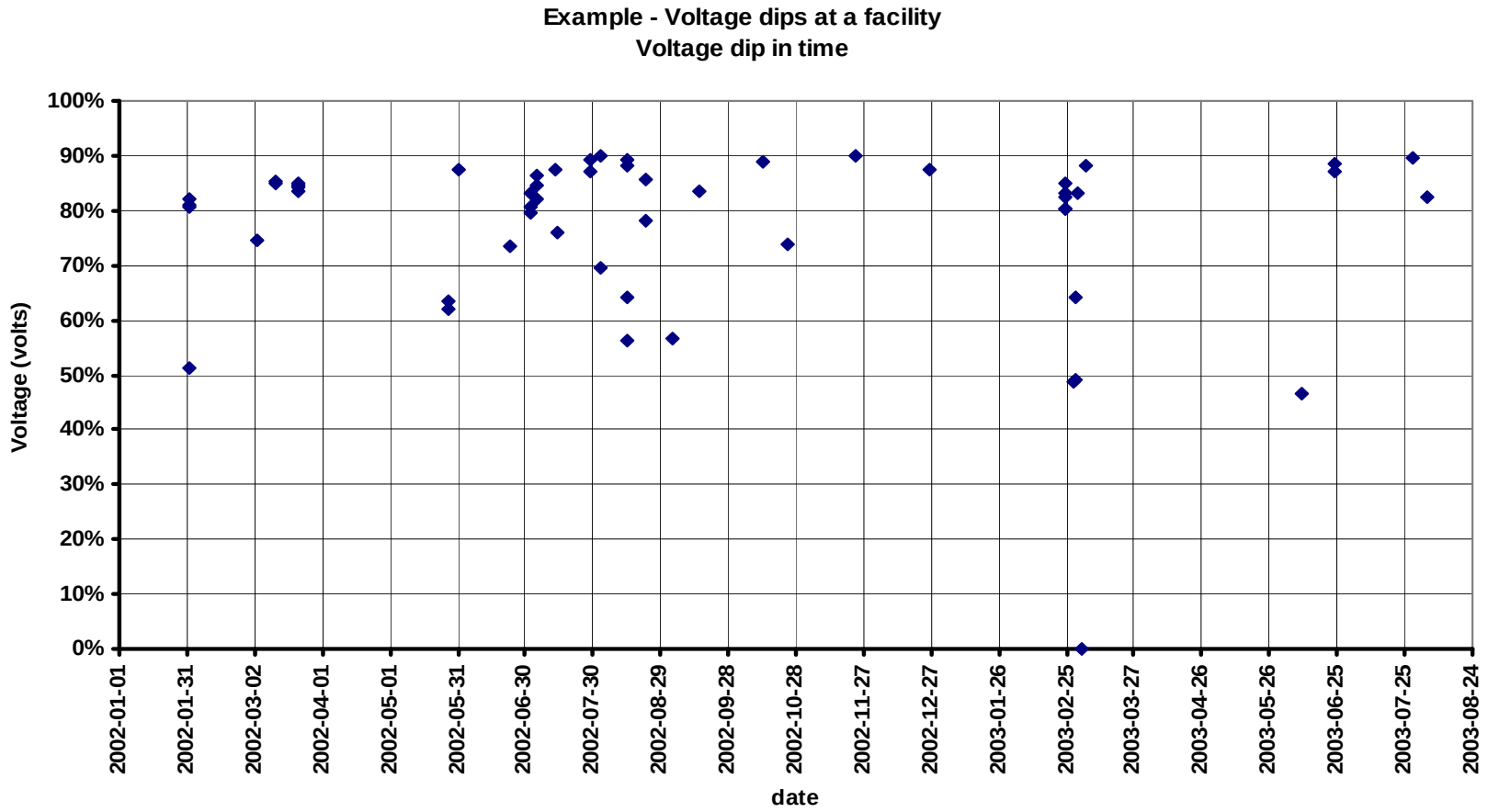
HOW LONG ? ⇒ Network protection





WHERE ? ⇒ Voltage drop

Step 1 – Supply Performance

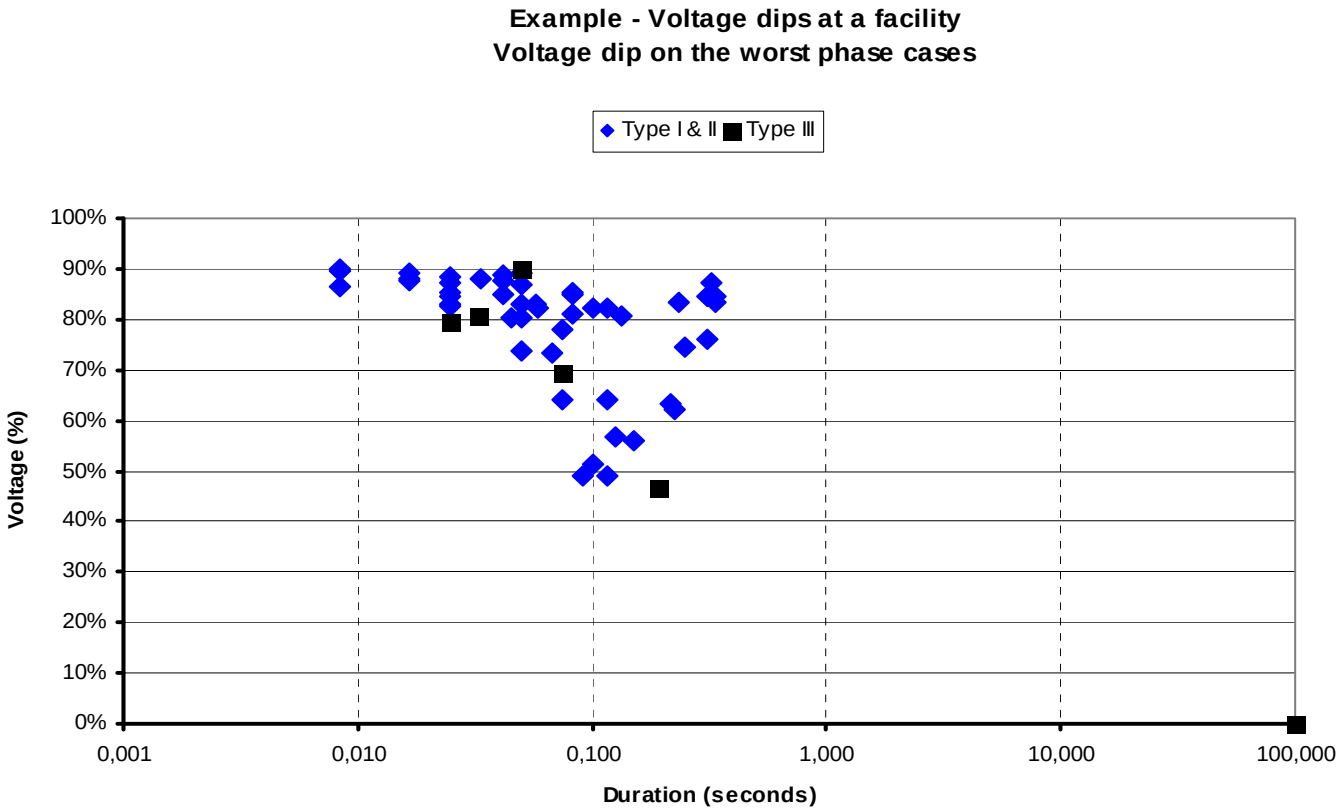


Step 1 – Supply Performance

#	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



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

Step 2 – Process Peformance Requirement

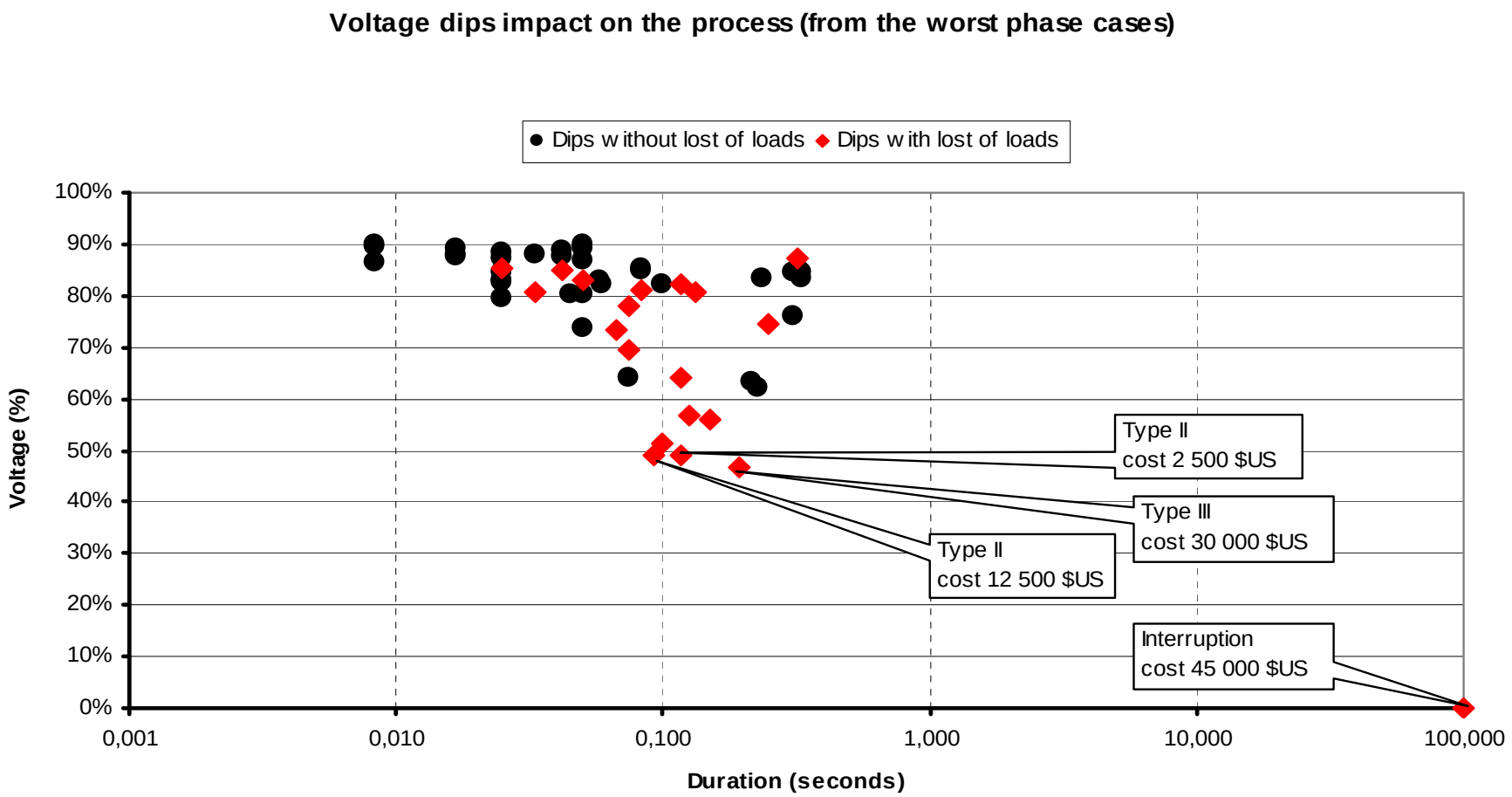
"Assessment of the number of process trips a customer can tolerate in a year"

#	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 Peformance Requirement

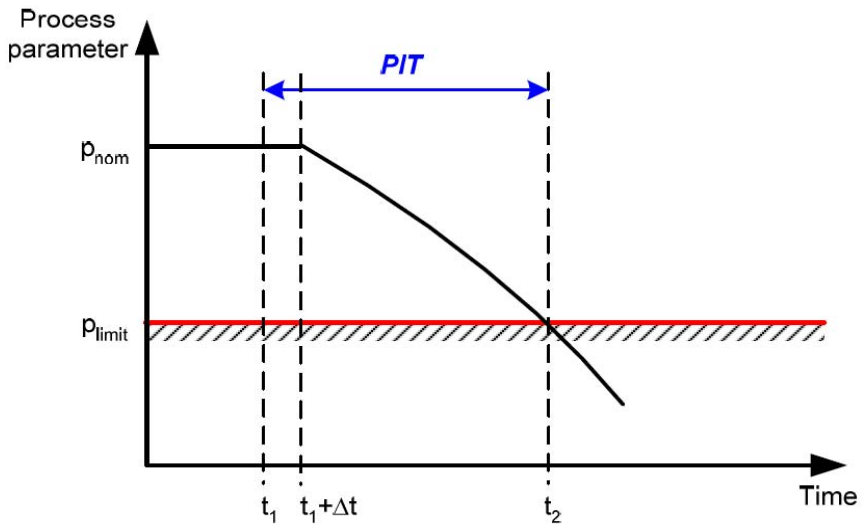


Step 3 – PIT (Process Immunity Time)

"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	

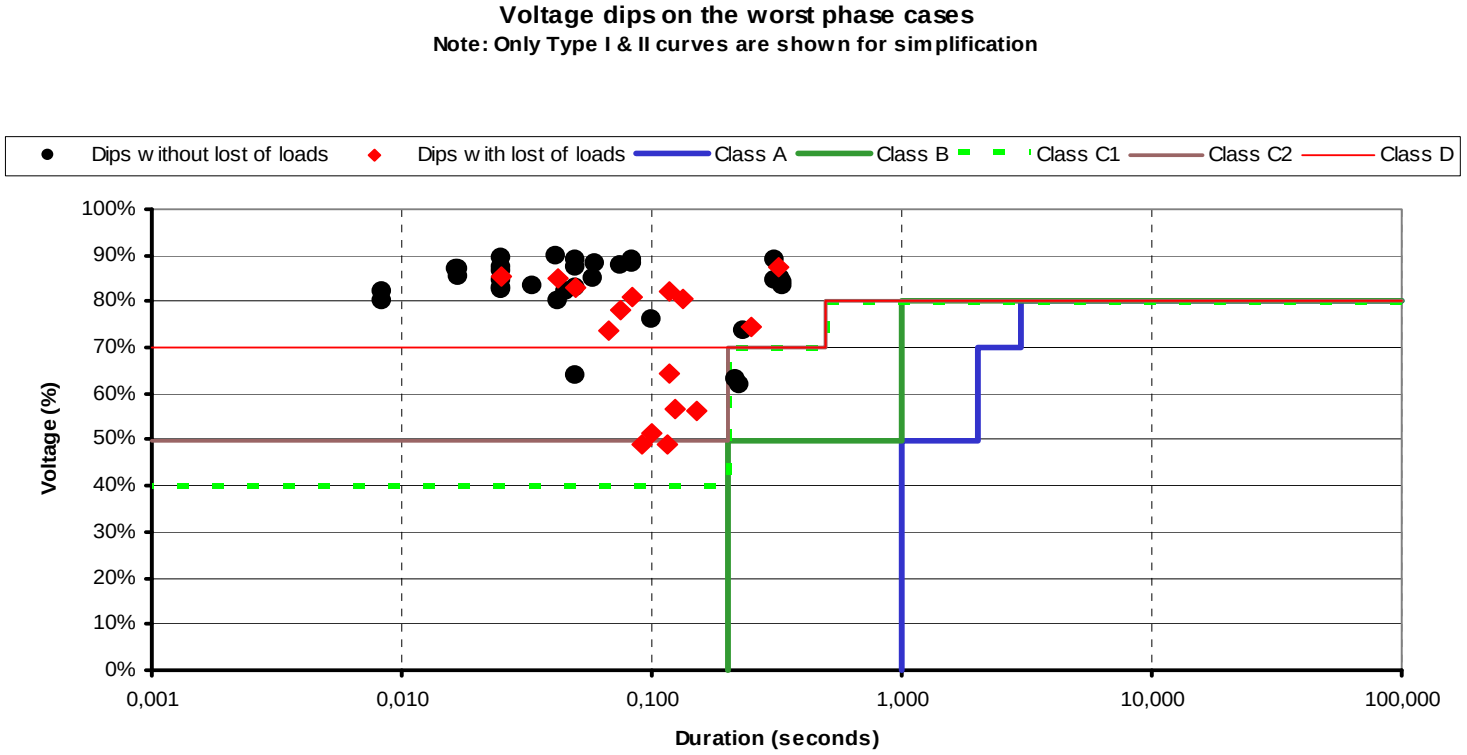
Listing of all process components such as :

Motor, drive, controls, PLC, sensors, lights, …

Step 4 – Process Immunity Requirement

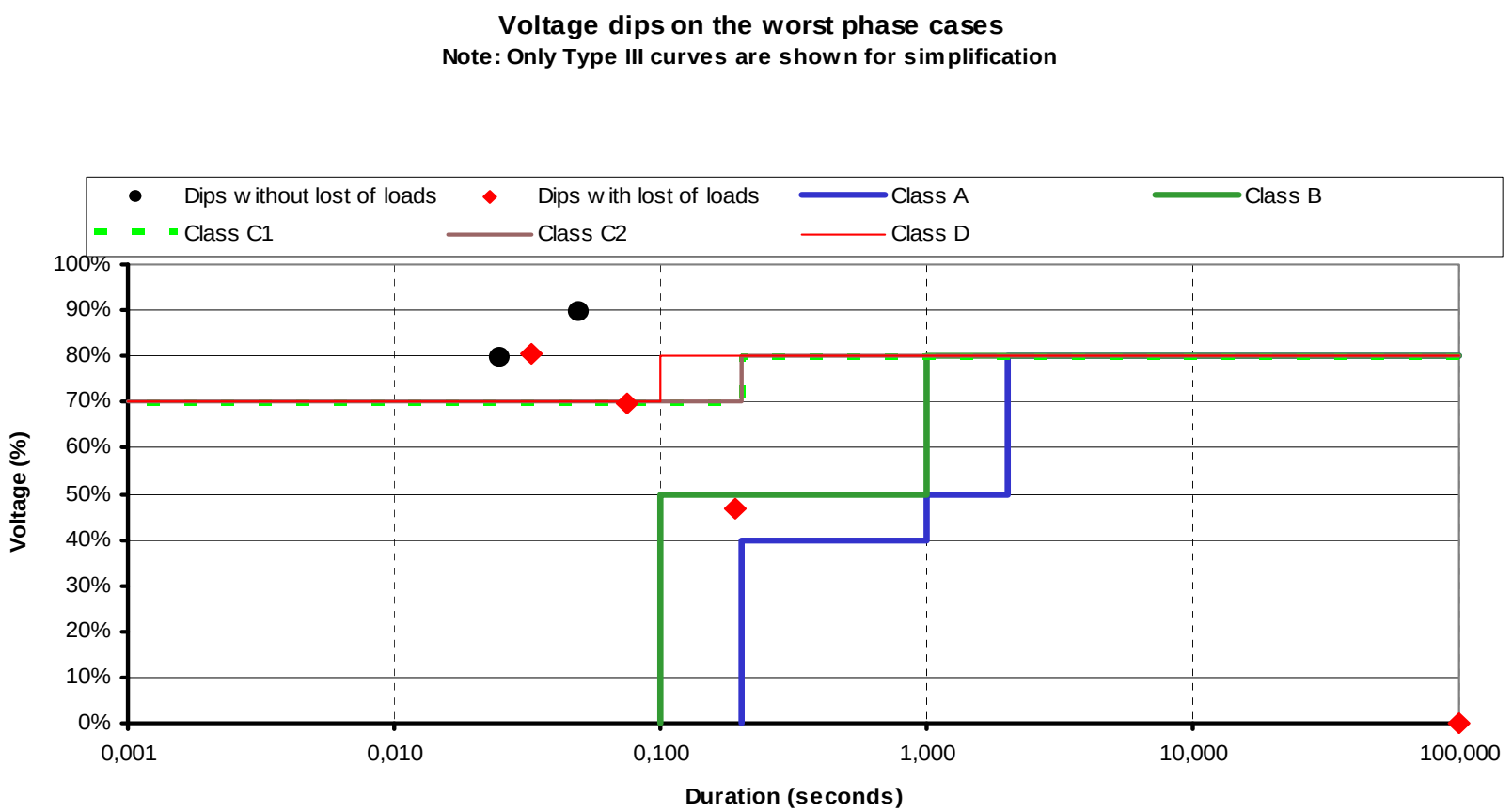
"Determination of the appropriate immunity curve"

Type I & II Voltage dips



Step 4 – Process Immunity Requirement

Type III Voltage dips



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

	Cost (rubber & plastics) minimum = 3$/kW [*] Based = 5 MW	If Class D used	If Class C2 used	If Class C1 used	If Class B used	If Class A used
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 ⇒ no change, no investment, 212 k$ of lost in 1,5 year

If Class D ⇒ ~1/3 of saving on 212 k$

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

Choice now depend on ROI (cost of equipment ?)

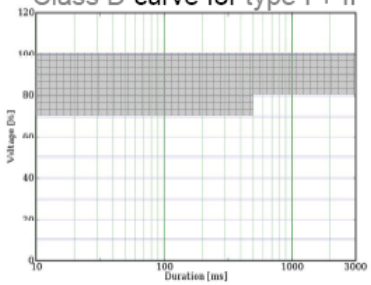
Step 6 – Equipment Selection

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

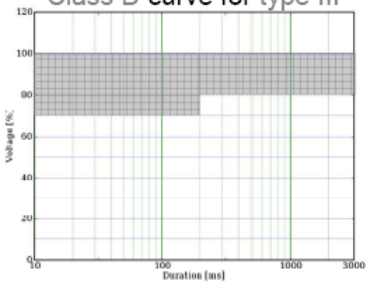
Equipment Immunity Specification

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	☐	☐	☐

Testing Procedure Requirements

Testing for Type I and II voltage dip required :

- 80% for 3 seconds
- 70% for 500 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

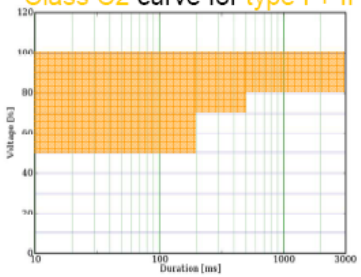
Step 6 – Equipment Selection

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

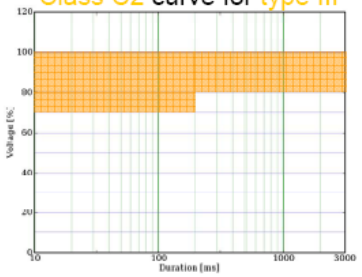
Equipment Immunity Specification

Voltage dip immunity Class 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	☐	☐	☐

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

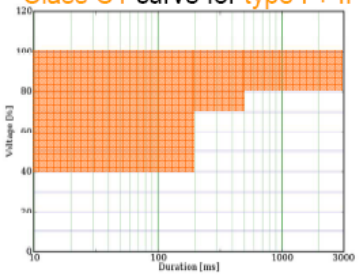
Step 6 – Equipment Selection

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

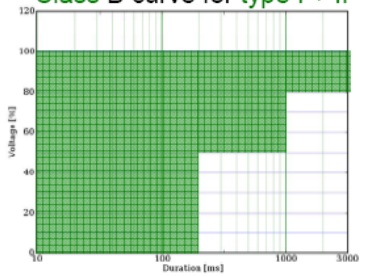
Step 6 – Equipment Selection

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

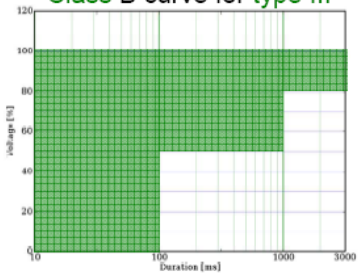
Equipment Immunity Specification

Voltage dip immunity Class B

Class B curve for type I + II



Class B curve for type III



Voltage dip immunity label		Pass / Fail criteria		
		Full operation	Self-recovery	Assisted-recovery
Immunity class	B	☐	☐	☐

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

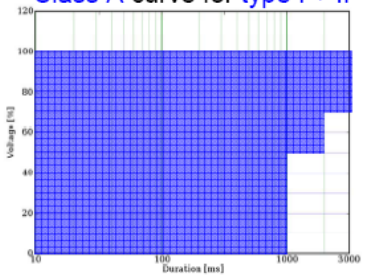
Step 6 – Equipment Selection

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

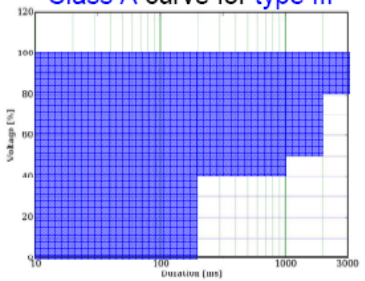
Equipment Immunity Specification

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	☐	☐	☐

Testing Procedure Requirements

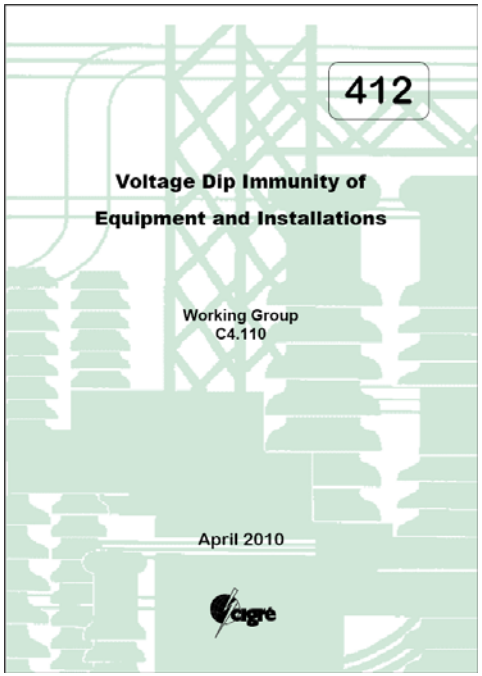
Testing for Type I and II voltage dip required :

- 70% for 3 seconds
- 50% for 2 seconds
- 0% for 1 second

(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
- 50% for 2 seconds
- 40% for 1 second
- 0% for 200 milliseconds



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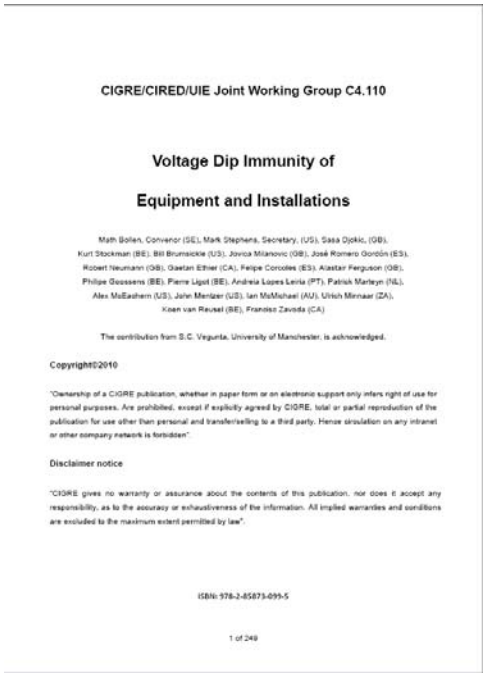
CIGRE/CIRED/UIE Joint Working Group C4.110

Voltage Dip Immunity of

Equipment and Installations

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