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Power Quality and Harmonic
:Causes and Effects with Paper Mill Factory

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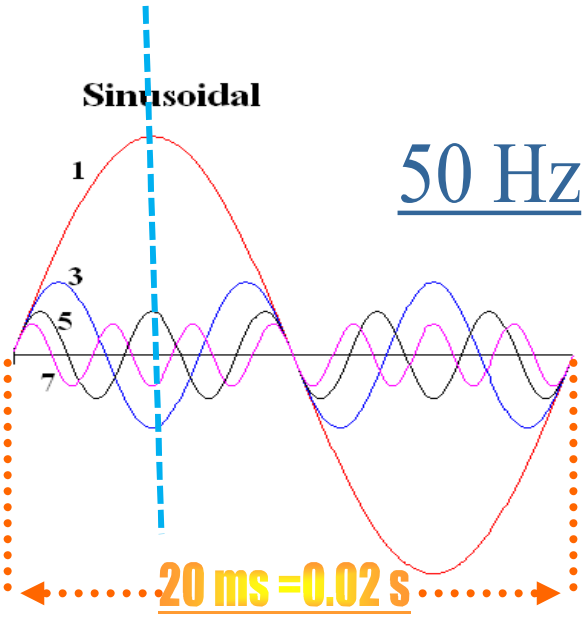
Topics

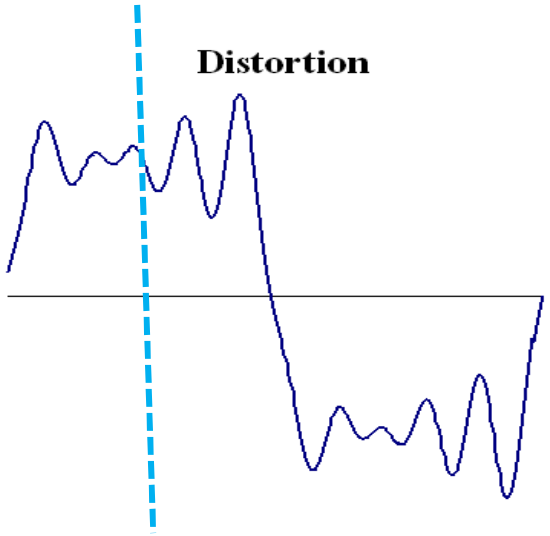
- *Introduction*
- *Power Quality standard*
- *Single line diagram*
- *Results*
  - *Power Quality Assessment*
  - *Relationships in Power Quality Monitoring Systems*
  - *Simulation Model*
- *Conclusion*
- *Q&A*

What is “Harmonics Voltage”?

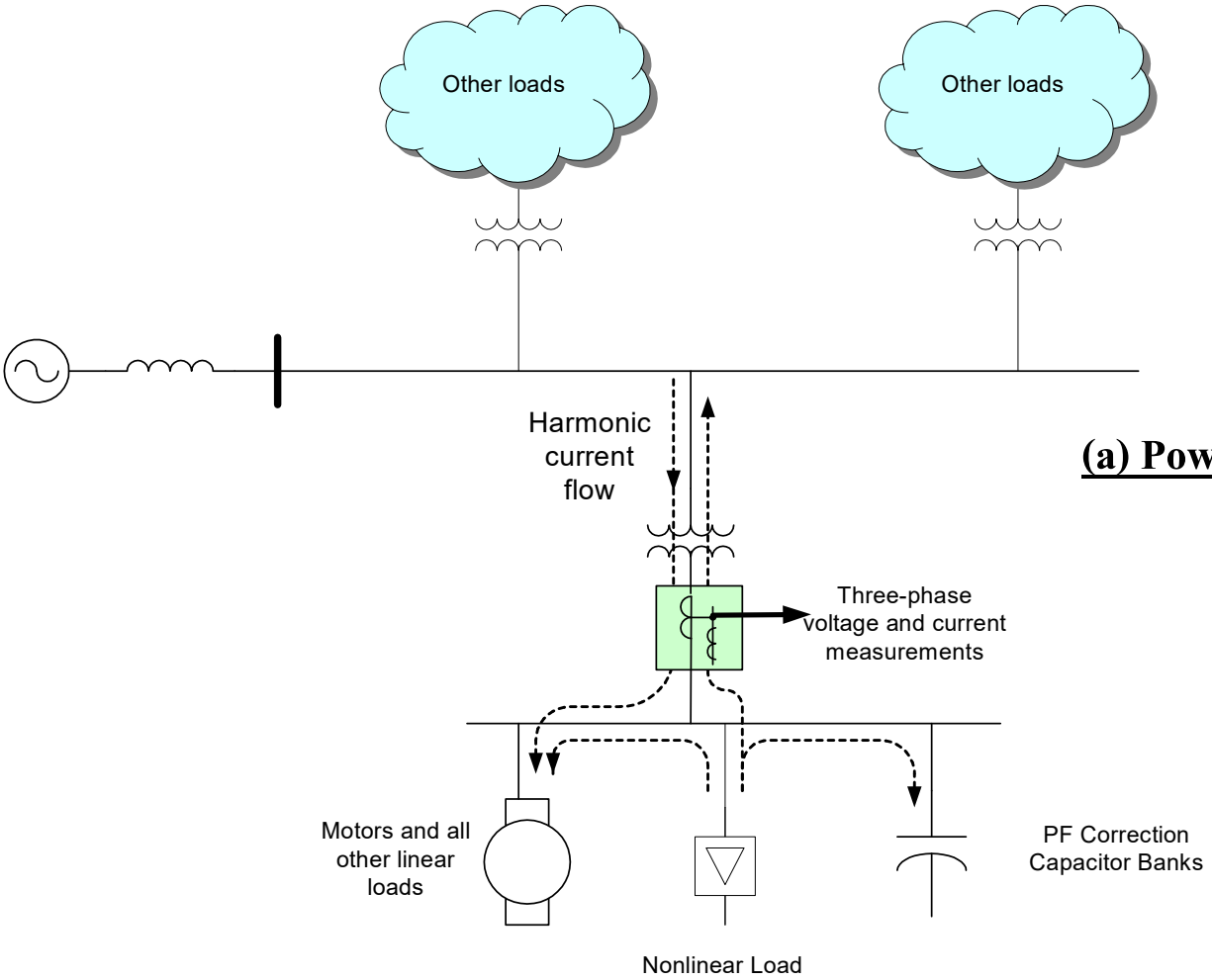
A sinusoidal voltage with a frequency equal to an integer multiple of the fundamental frequency of the supply voltage (EN50160)

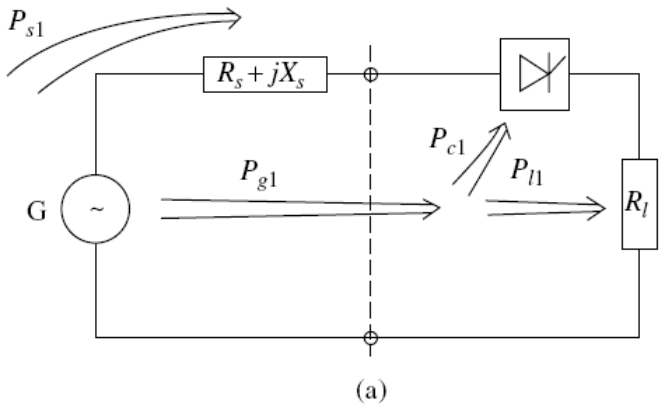
Order 3 : 3 × 50 Hz = 150 Hz



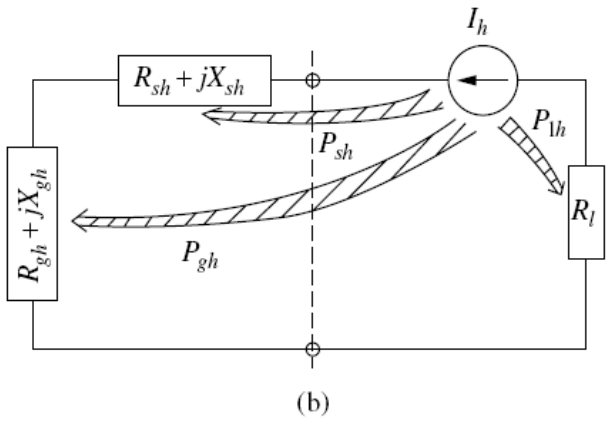


Where is the source of the harmonics?





(a) Power flow at the fundamental frequency



(b) Harmonic power flow

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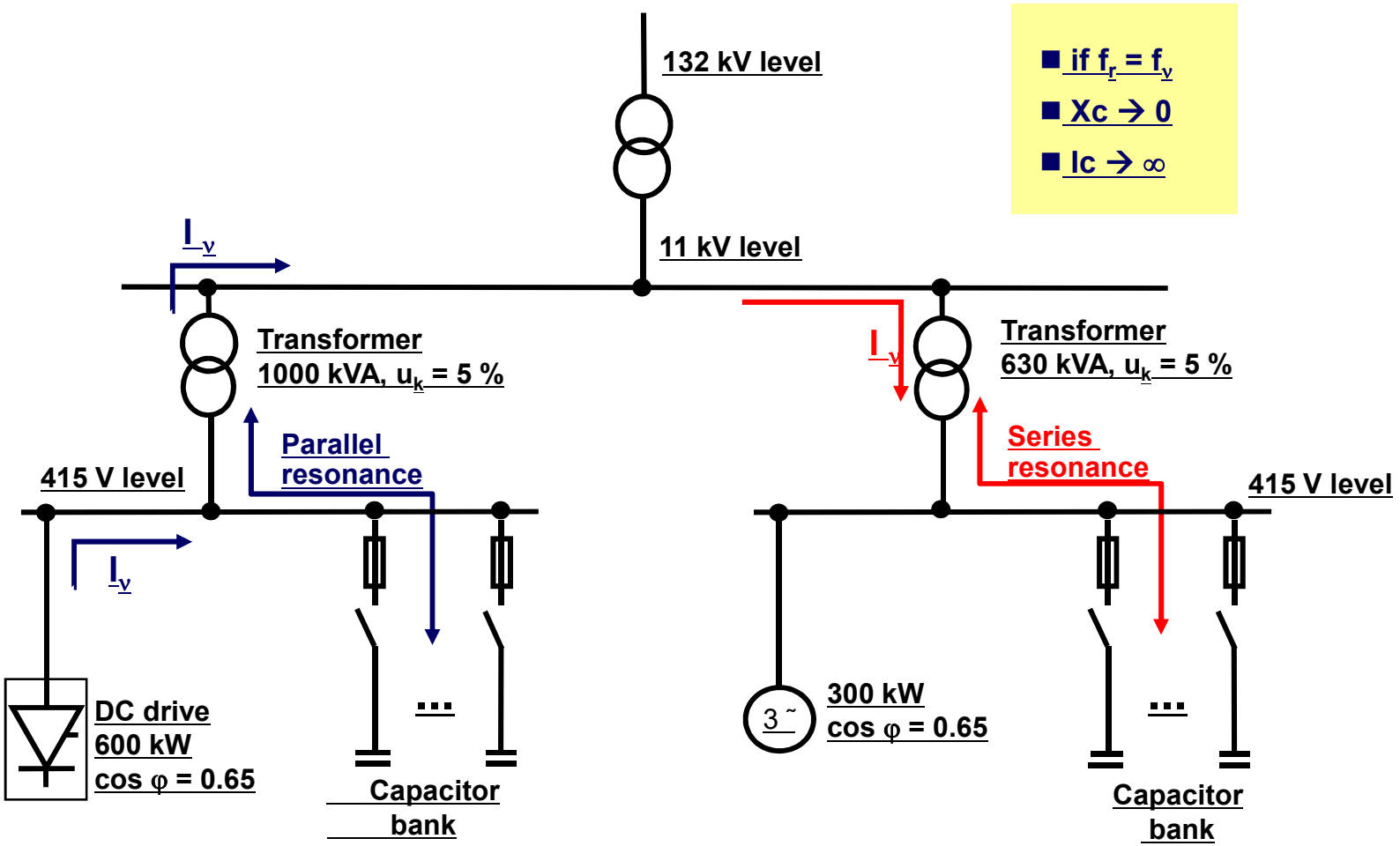
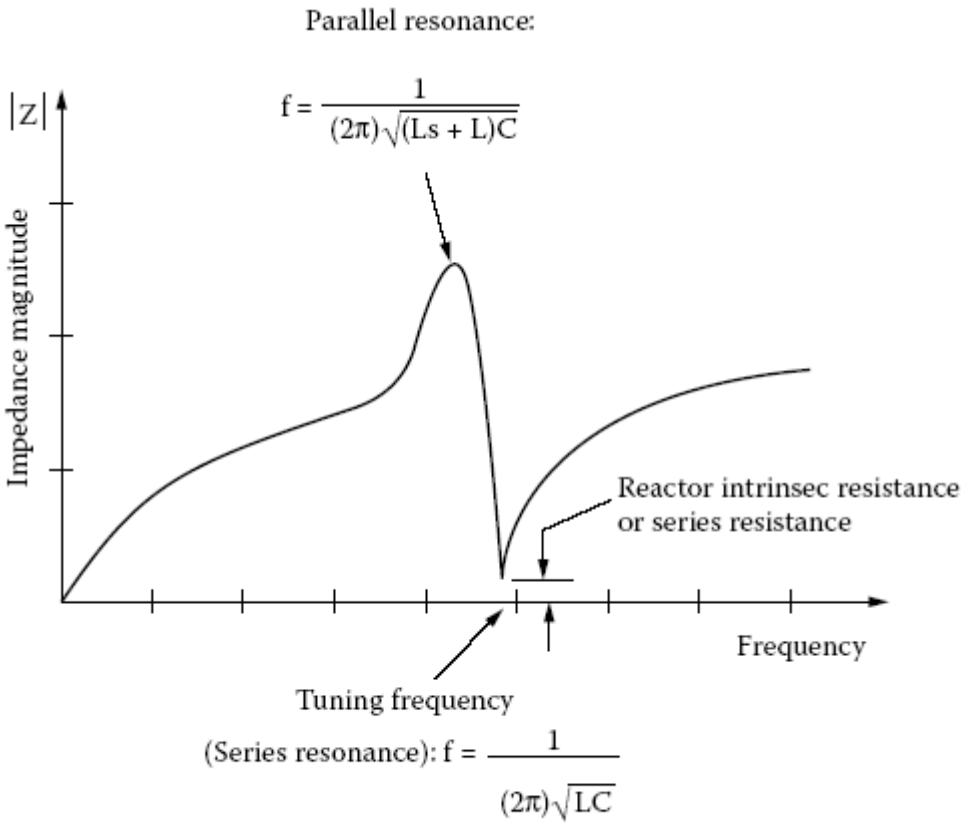
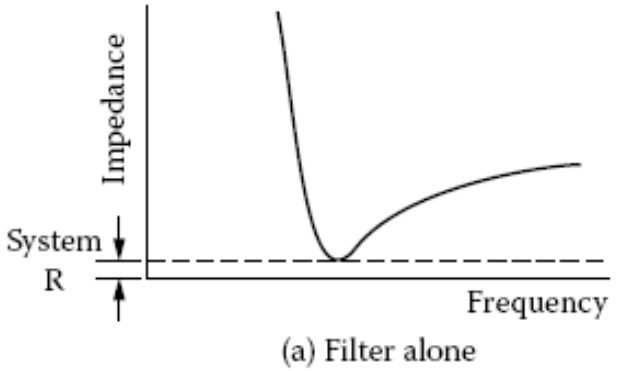
Parallel vs Series resonance



Parallel vs Series resonance





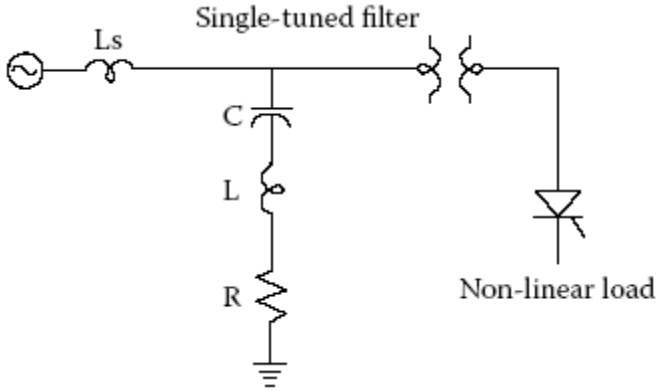


FIGURE 6.3 Resonant points on a single-tuned series RLC filter.

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Power Quality standard

Point of Common Coupling : PCC (kV)	Total Harmonic Distortion Voltage THDv (%)	Individual Harmonic Distortion Voltage(%)	
		Odd	Even
0.4	5	4	2
11,12,22 and 24	4	3	1.75
33	3	2	1
69	2.45	1.63	0.82
115 and above	1.5	1	0.5

Harmonic : referring to PRC-PQG-01/1998

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Power Quality standard

Point of Common Coupling : PCC (kV)	Pst	Plt
Below 115 kV	**1.0**	**0.8**
More than 115 kV	0.8	0.6

Pst ; Short-Term Severity Values (10 minutes)
Plt : Long-Term Severity Values (2 hours)

$$\sqrt[3]{\frac{1}{n}\sum_{j=1}^{j=n}(Pst_j)^3}$$

Voltage fluctuation : referring to PRC-PQG-02/1998

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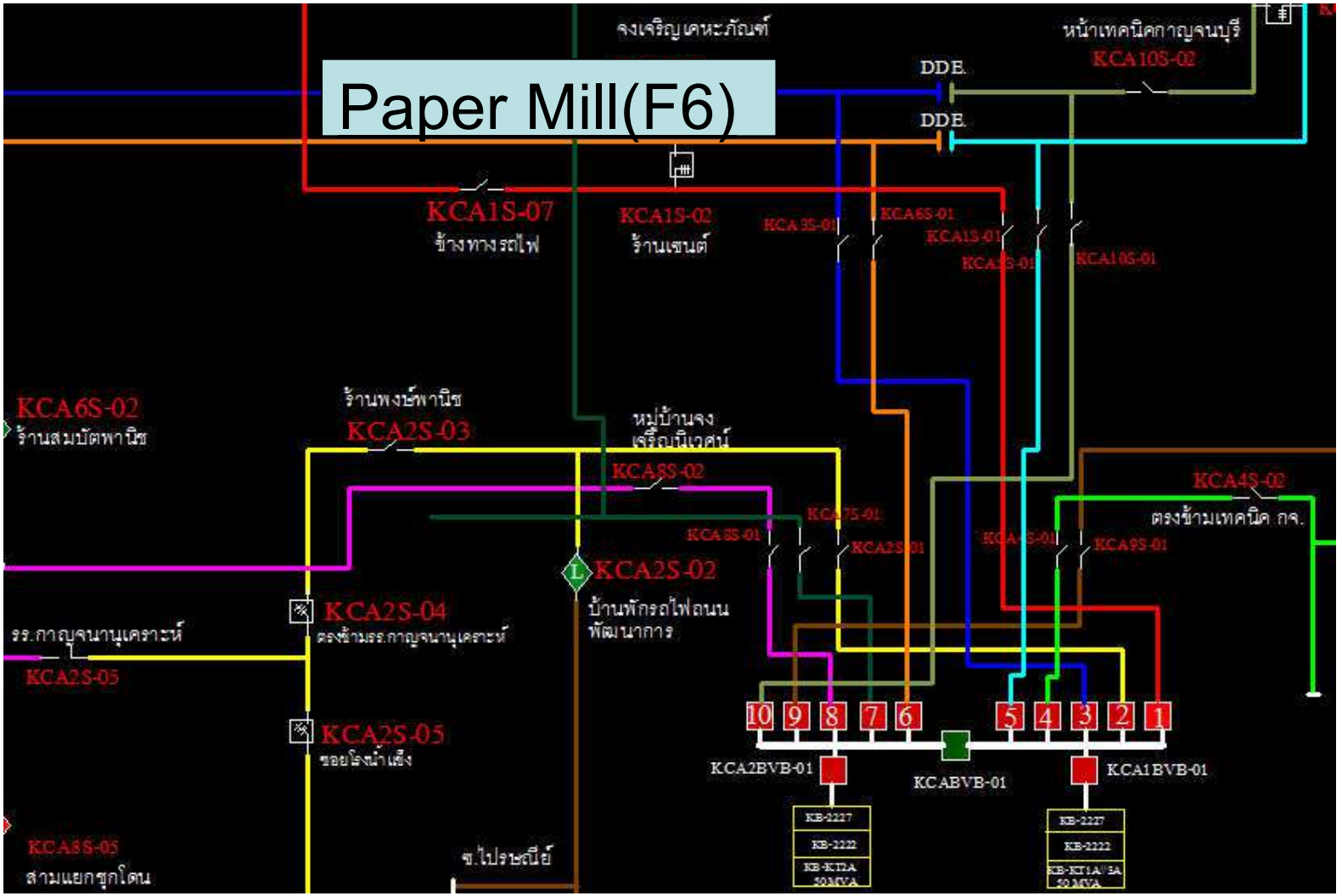
Paper Mill Factory



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Paper Mill Factory

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Paper Mill Factory : Survey

Paper Mill Machine
- DC Motor 200 hp
- DC Inverter 6 pulse

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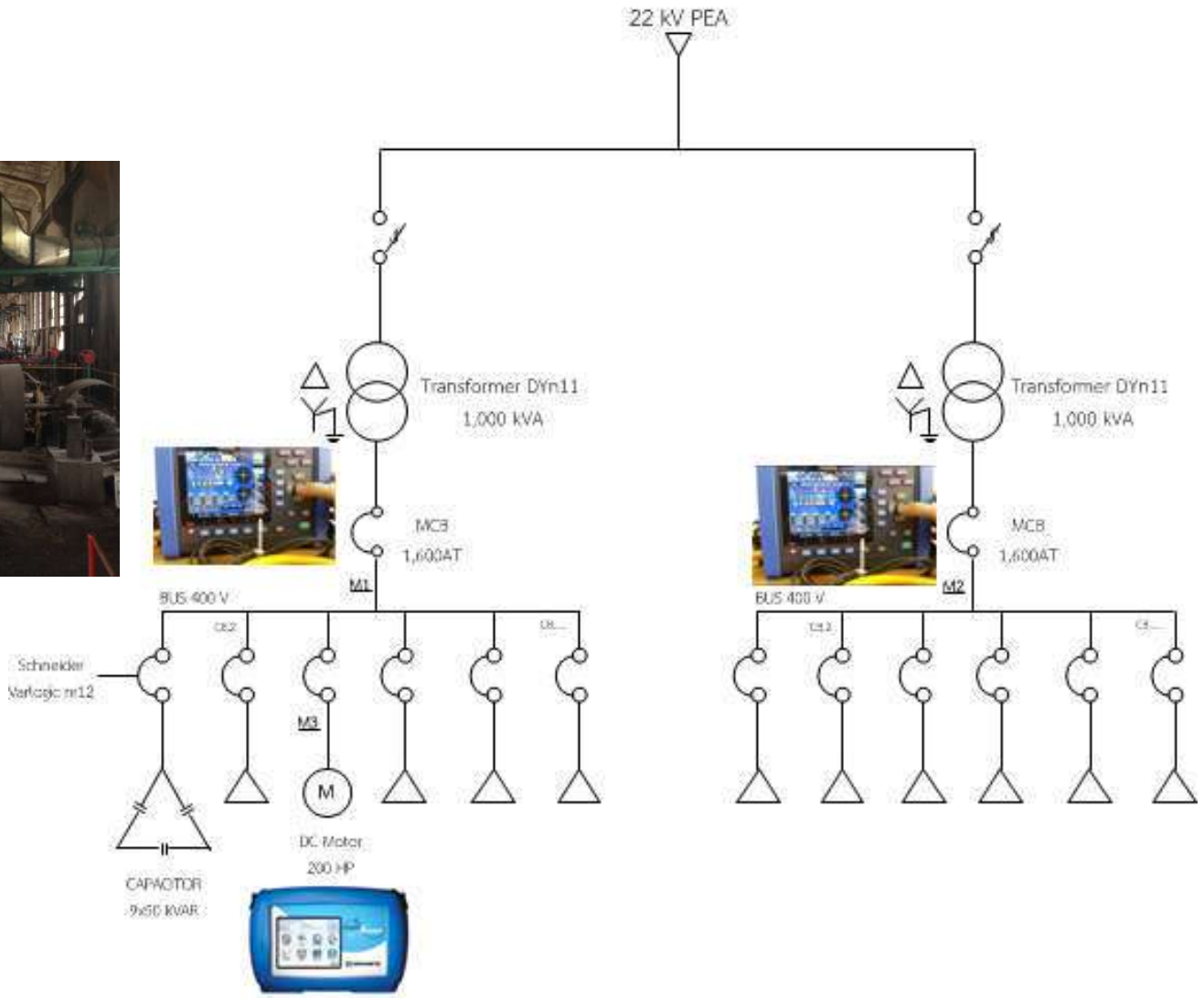
Single line Diagram



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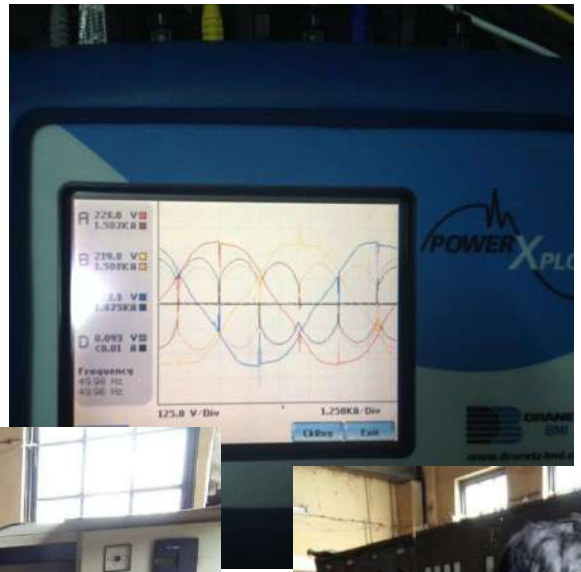
Power Quality monitoring



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Results

Table 1 Power Quality Assessment at M1

NO.	Parameter	Limit		CP95	Note
		Min.	Max.		
1	Voltage				
	- Phase A	207 V	253 V	233.67 V	Comply
	- Phase B			235.26 V	Comply
	- Phase C			232.24 V	Comply
2	*Frequency	49.5 Hz	50.5 Hz	*50.05 Hz	Comply
3	Total Harmonics Distortion: %THDv				
	- Phase A	-	> 5 %	4.70%	Comply
	- Phase B			4.26%	Comply
	- Phase C			3.60%	Comply
4	Harmonics Current Order 2-19	-	Table 2	Table 2	Not Comply
5	Voltage Unbalance : Vub		> 2 %	0.78	Comply
6	Voltage Fluctuation : Pst				
	- Phase A	-	>1.00	0.59	Comply
	- Phase B			0.43	Comply
	- Phase C			0.50	Comply
7	**Power Factor	0.85 lag	0.85 lead	0.99 lag	Comply

Results

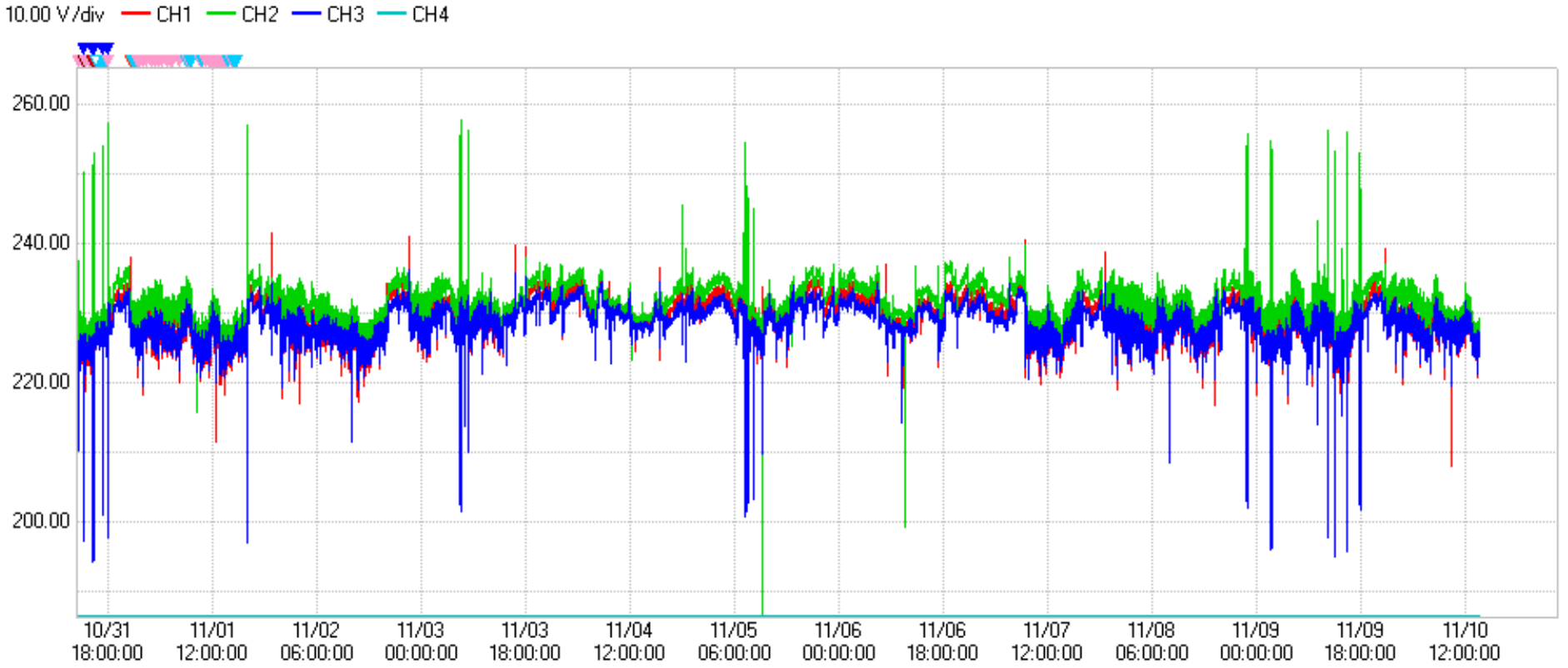
Table 2 Harmonics Current at M1

Order	2	3	4	5	6	7	8	9	10
Limit @ 400 V	48	34	22	56	11	40	9	8	7
Monitoring	4.15	4.19	2.5	75.52	6.57	54.23	23.21	34.98	11.85
Note	Comply	Comply	Comply	X	Comply	X	X	X	X

Order	11	12	13	14	15	16	17	18	19
Limit @ 400 V	19	6	13	5	5	5	6	4	6
Monitoring	100.86	4.96	39.46	3.12	4.49	5.25	23.92	2.98	11.74
Note	X	Comply	X	Comply	Comply	X	X	Comply	X

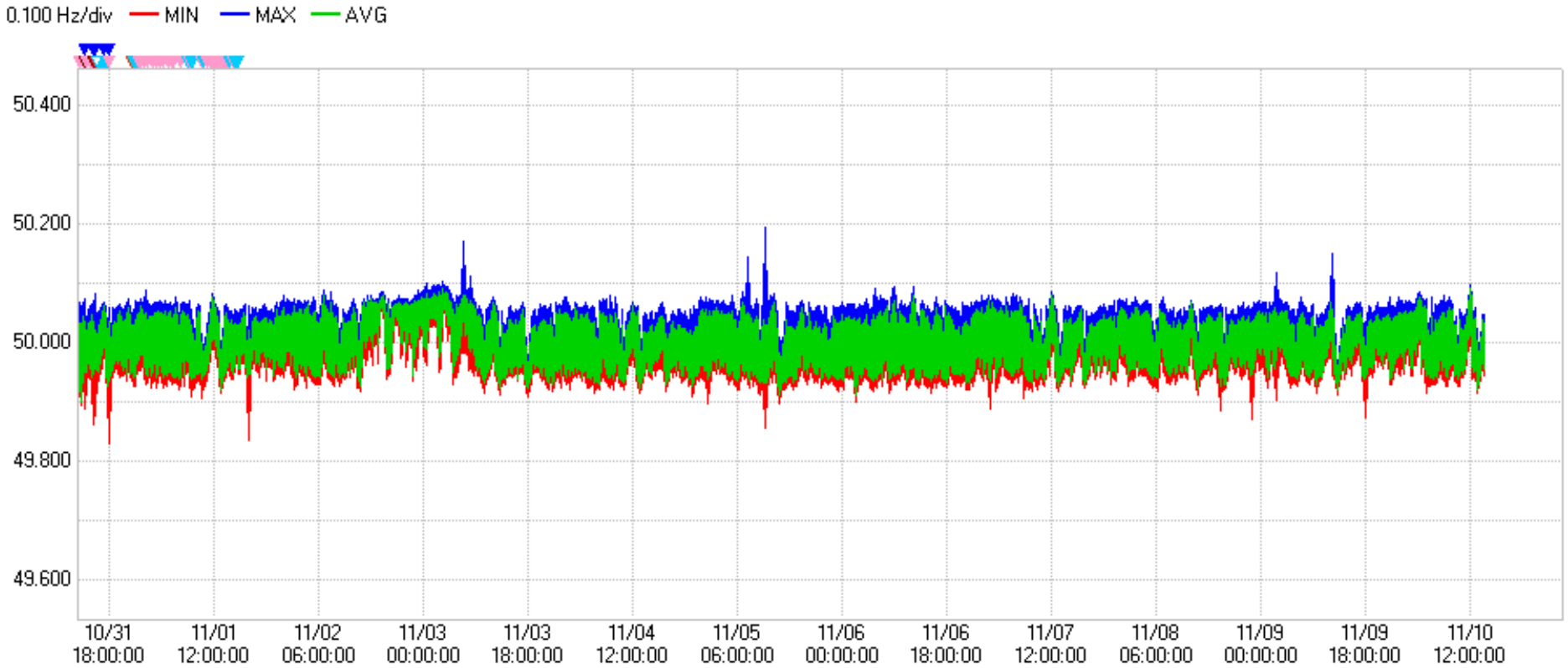
Relationships in Power Quality Monitoring Systems

Supply Voltage Variations



Relationships in Power Quality Monitoring Systems

Supply Voltage Frequency



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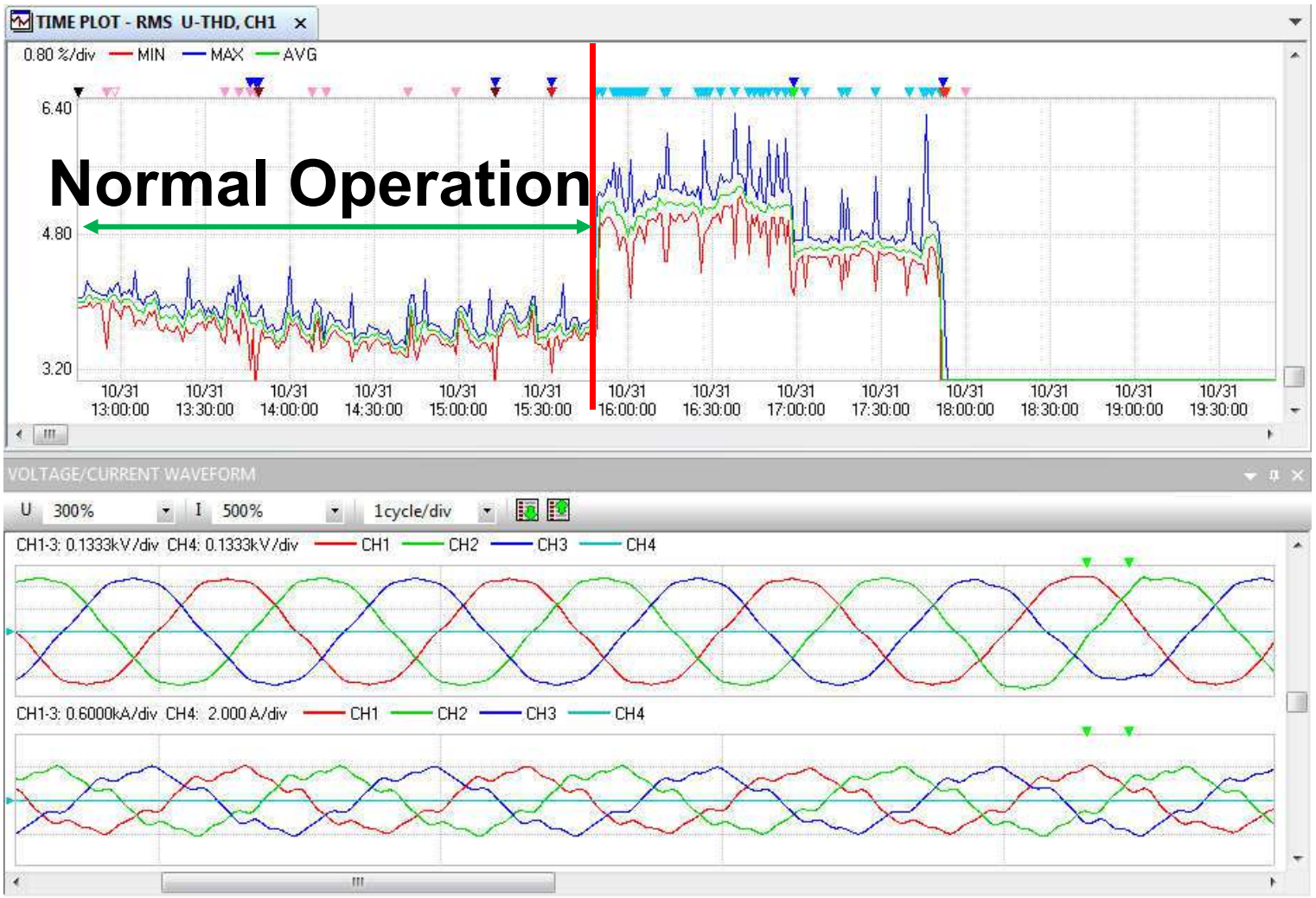
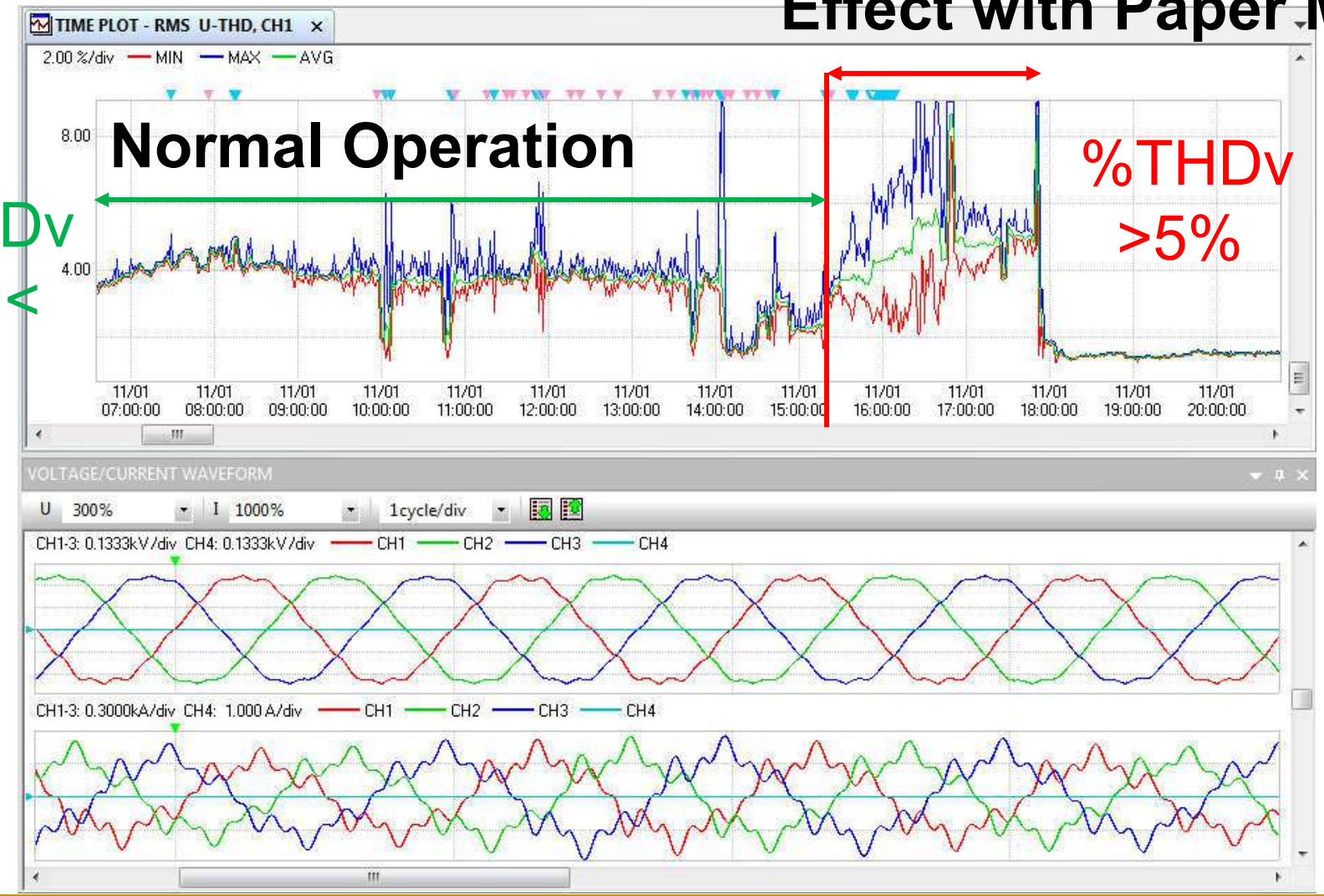
Relationships in Power Quality Monitoring Systems

%THDv
4% <



Relationships in Power Quality Monitoring Systems

Effect with Paper Mill



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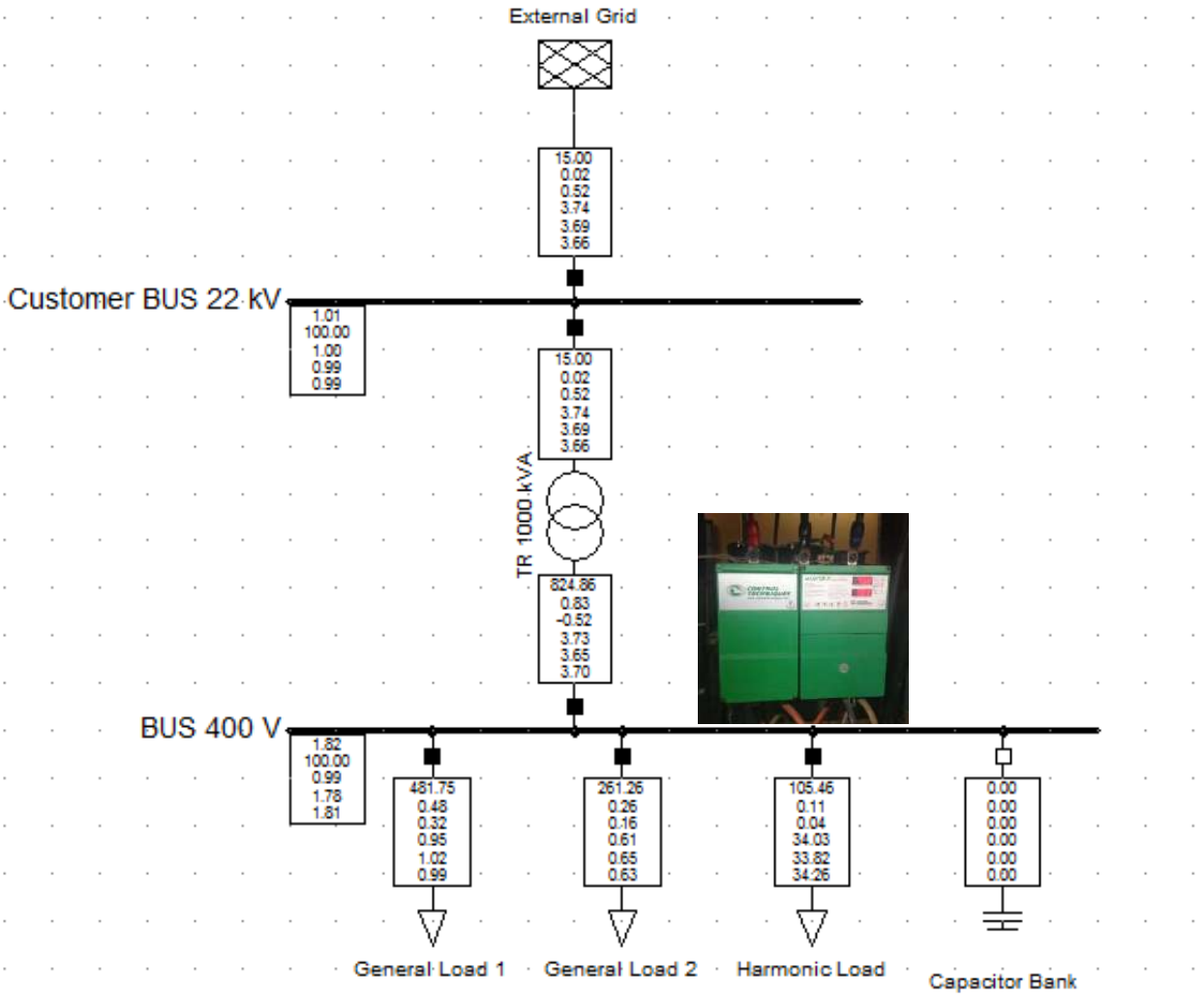
Simulation Model



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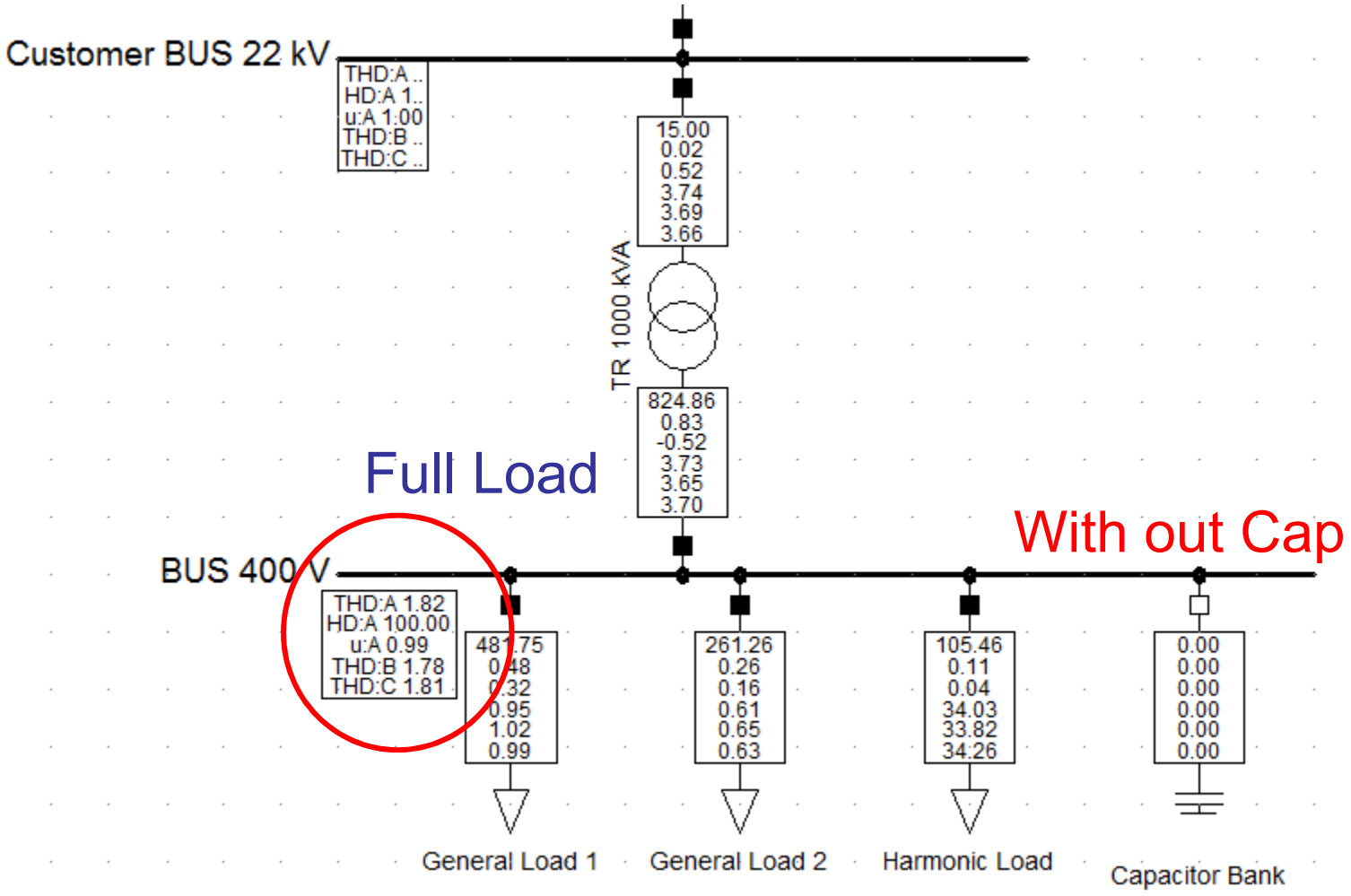

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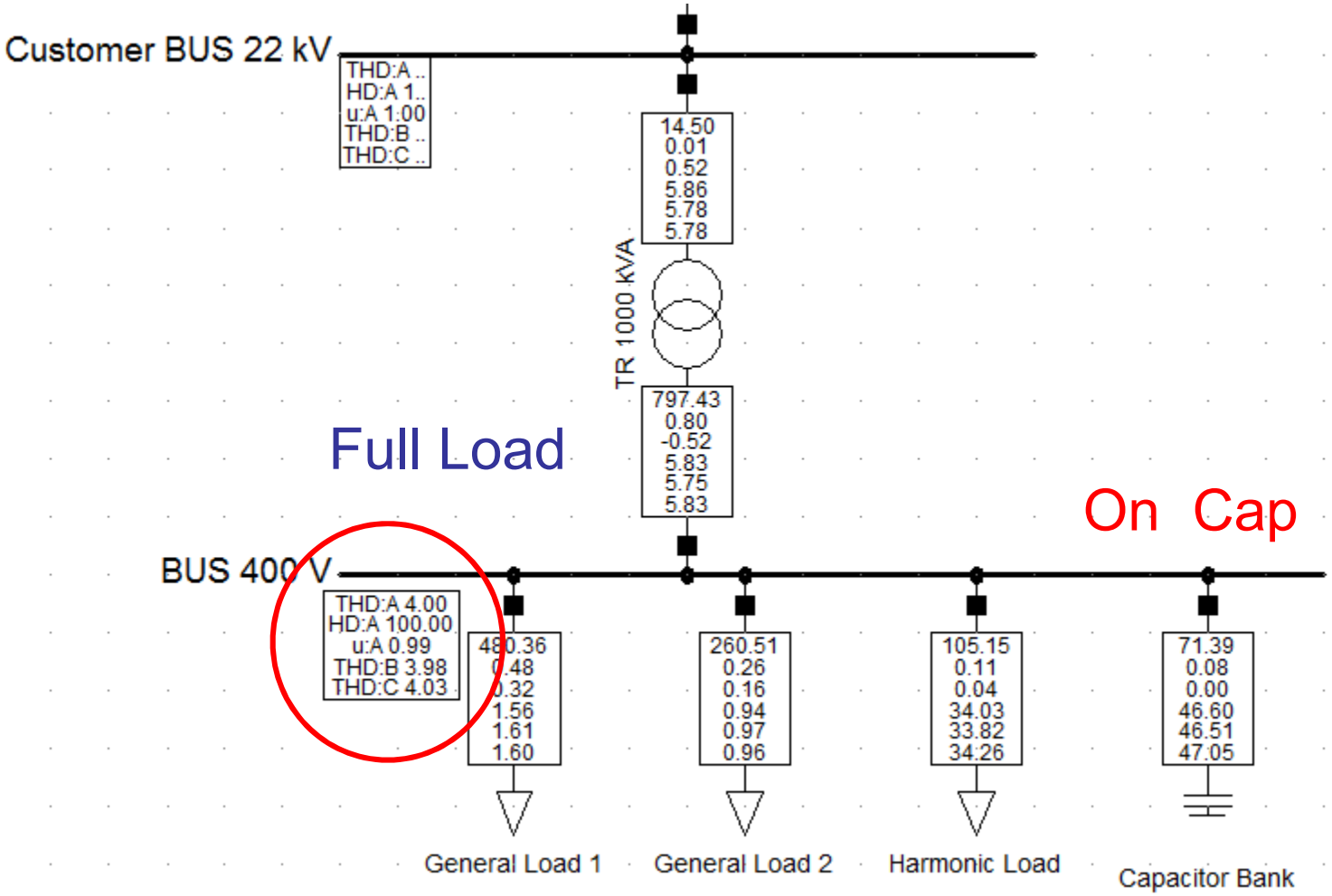

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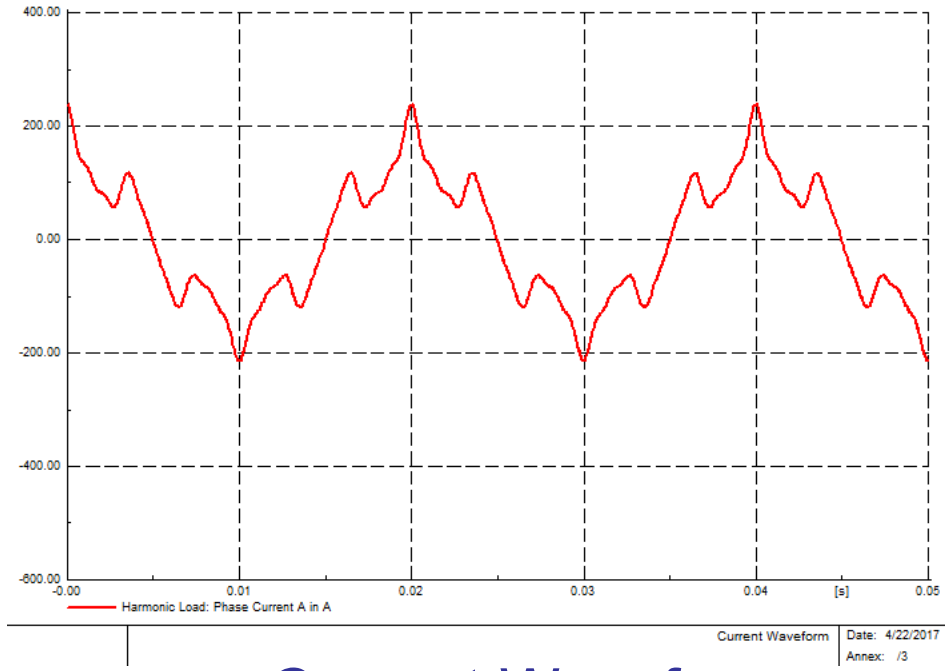
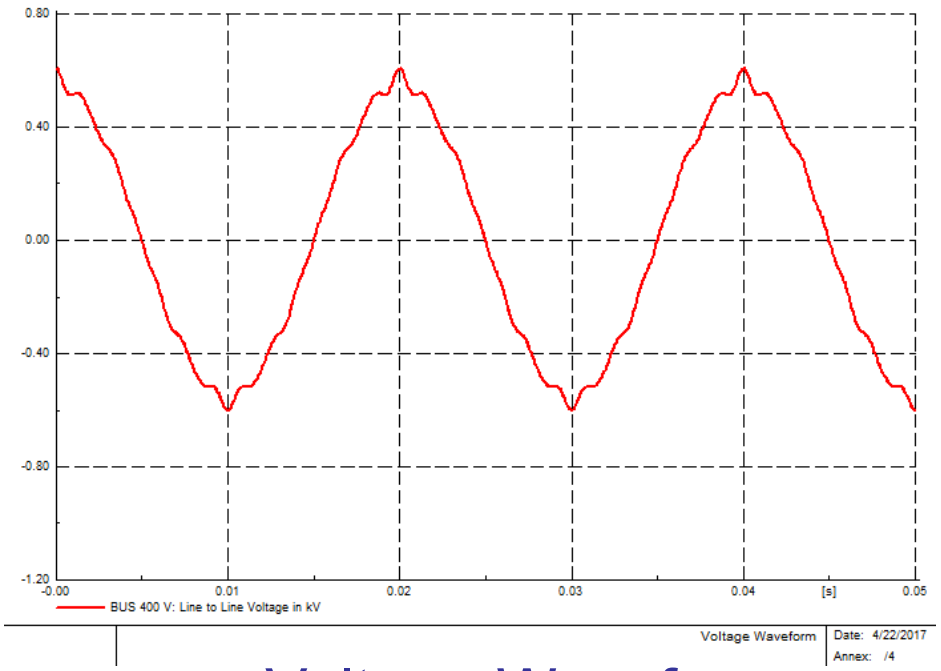


Current Waveform



Voltage Waveform

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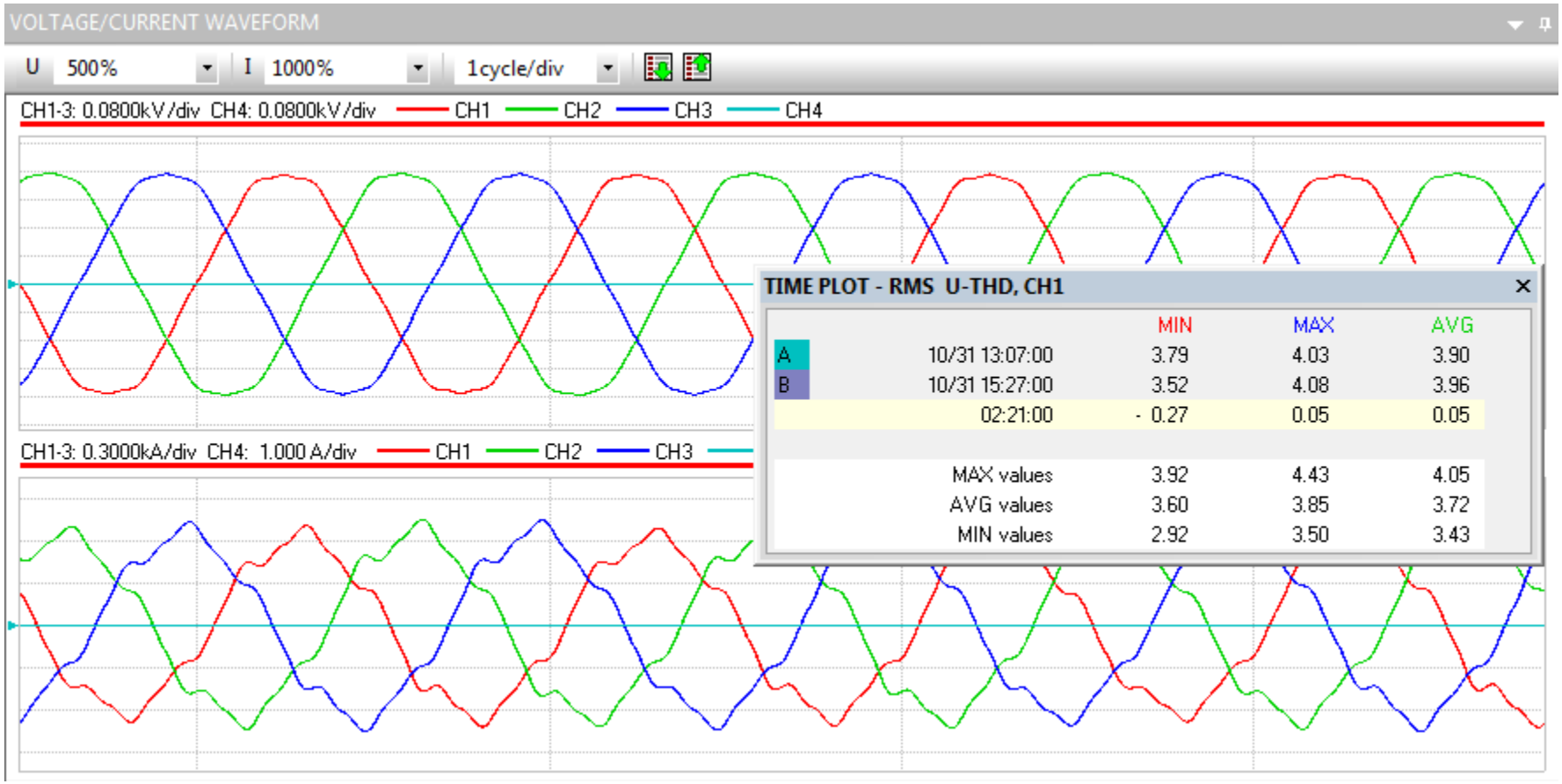
Simulation Model



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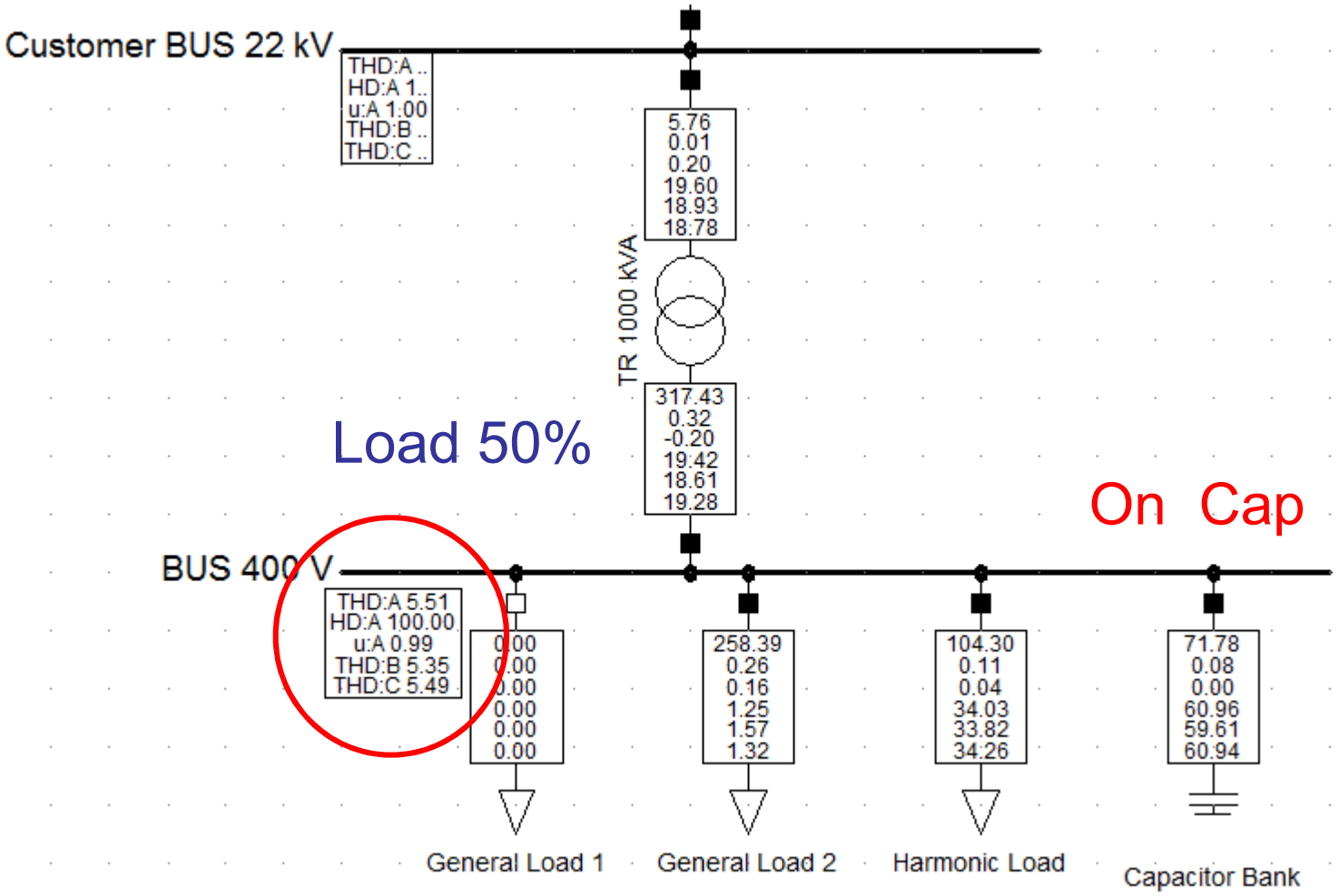

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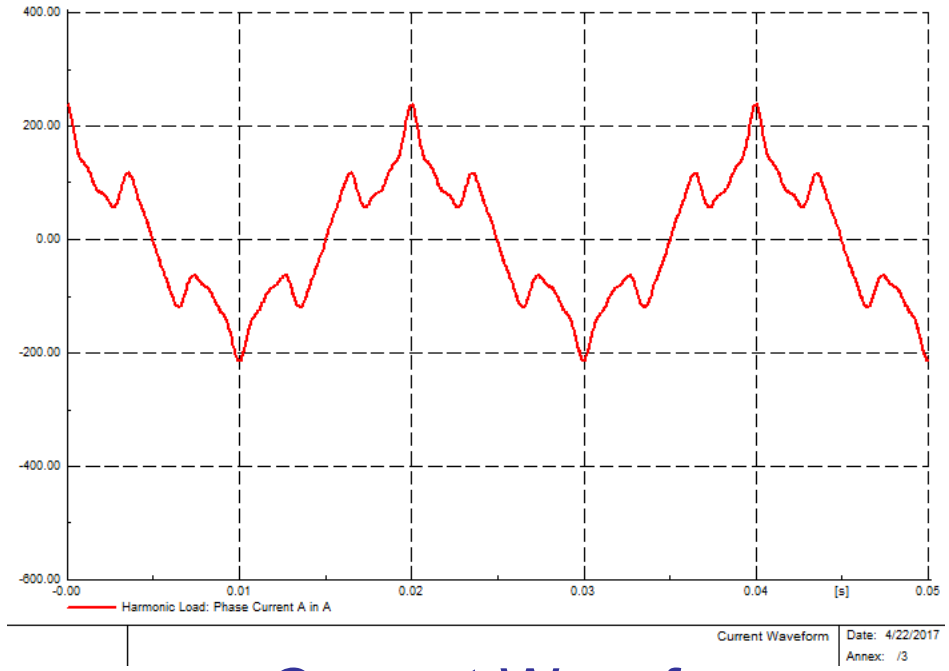
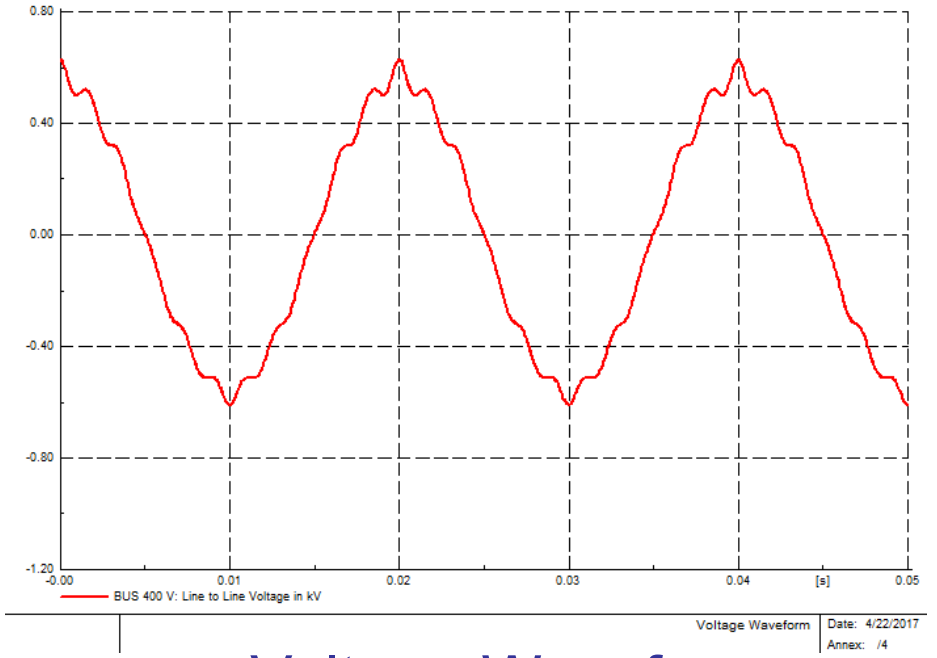
Simulation Model



Current Waveform



Voltage Waveform

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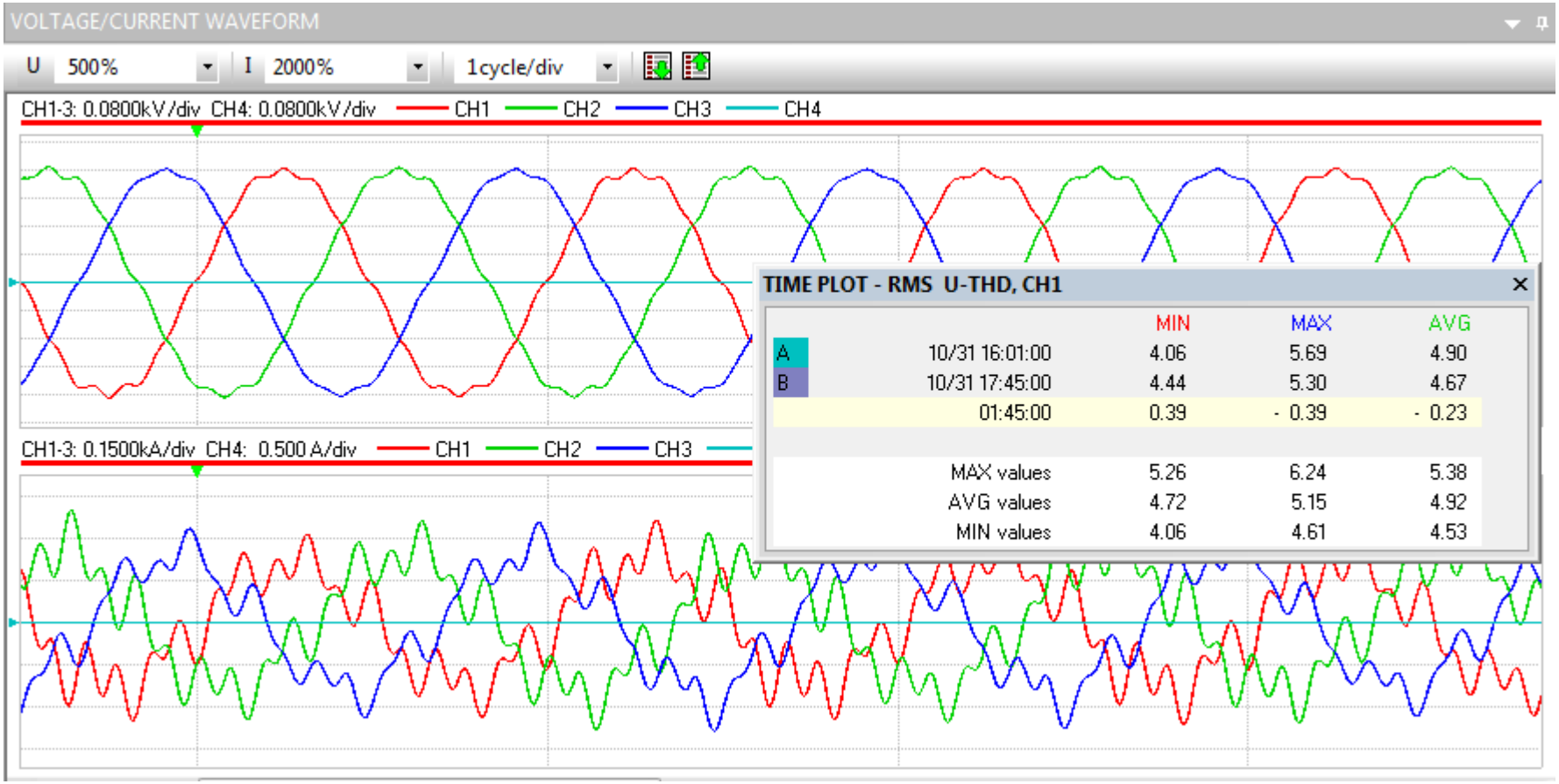
Simulation Model



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The popular solutions

- **Structural modification** - change size or location of capacitor, transformer connection in 12-Pulse converter
- **Third Harmonic Filter in neutral wire (Blocking Filter) in electrical system** – not allowed in some countries
- **Detuned filter** – most popular
- **Tuned filter** – classical but lots of limitations
- **Active filter** – most effective but still high investment

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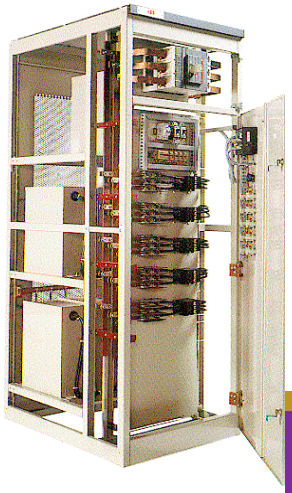
How to choose ? in LV

Low harmonics	Medium harmonics	High harmonics
Don't worry	Parallel resonance	Need filtering
Install plain capacitors	Install detuned filter	Install Tune/active filter



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Conclusion

Power Quality issues in MDB01 caused by Parallel Resonance by transformer and capacitor bank to become Parallel Resonance from harmonic source.

Due to power quality monitoring, it should install Active Filter to reduce harmonic and most effective but still high investment.

Q&A