PEA SMART ENERGY FOR BETTER LIFE AND SUSTAINABILITY

Power Quality Thailand LTD.

Case Study of Mitigate Power Quality Problems of Industrial Electrical Systems that Affects the Capacitor Bank Using by a Detune Filter.

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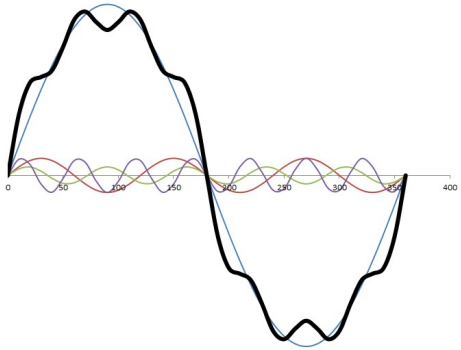
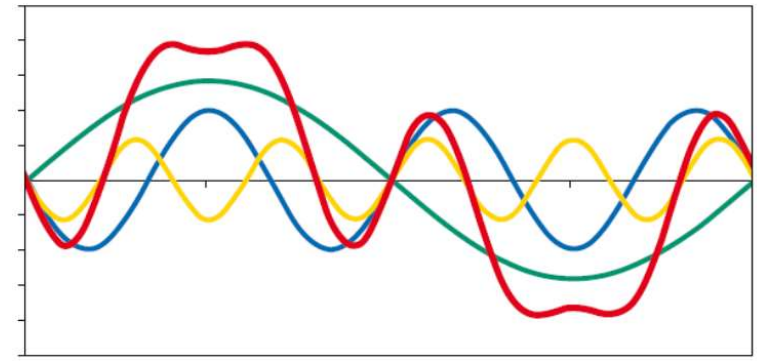


Agenda

- **Introduction**
- **Flow Chart**
- **Result**
- **Conclusion**



Caption:

- nonsinusoidal waveform
- first harmonic (fundamental)
- third harmonic
- fifth harmonic

Introduction

Industrial Electrical Systems

Transformer

VSD

Machine

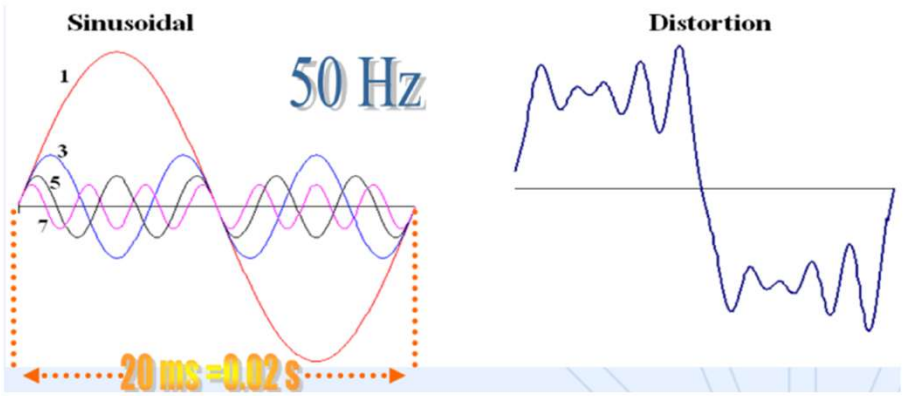
Capacitor Bank

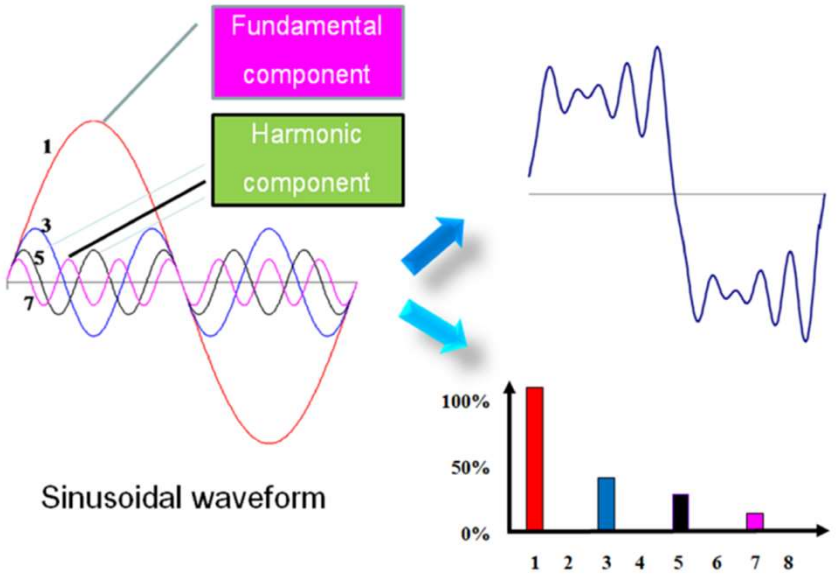
Harmonic

- A sinusoidal voltage with a frequency equal to an integer multiple of the fundamental frequency of the supply voltage

Examaple:

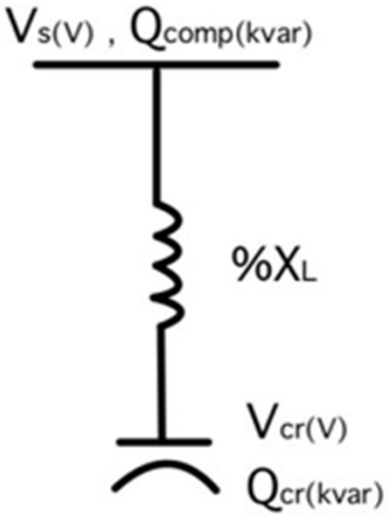
- Order 3 : 3 × 50 Hz = 150 Hz



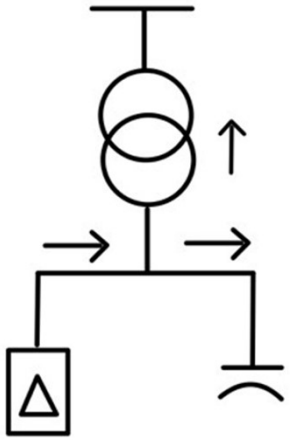


Detuned filter

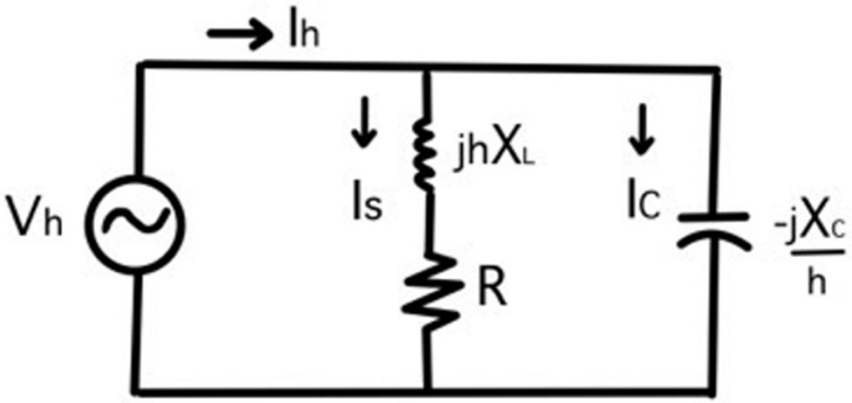
Detuned filter are usually used in series with capacitor banks in order to improve the power factor in your system. The reactors also help to protect your system and capacitor banks from over current during switching on or overloading of capacitor banks due to harmonic resonance.



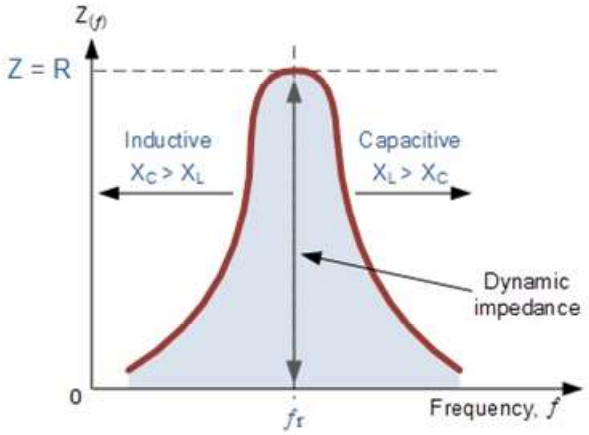
Parallel resonance



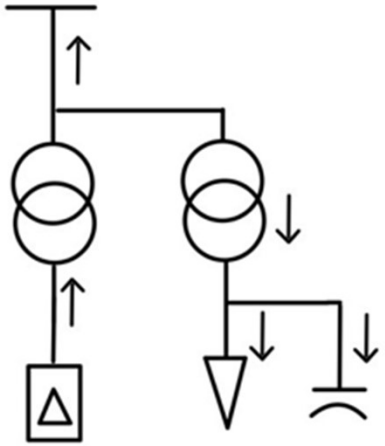
Single line Diagram



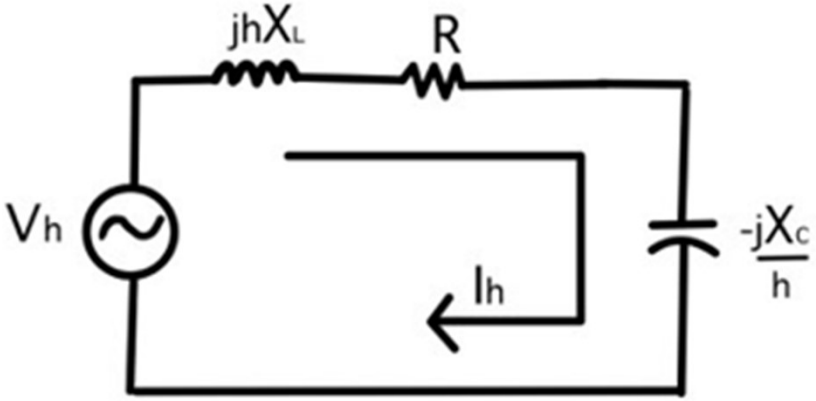
Equivalent Circuit



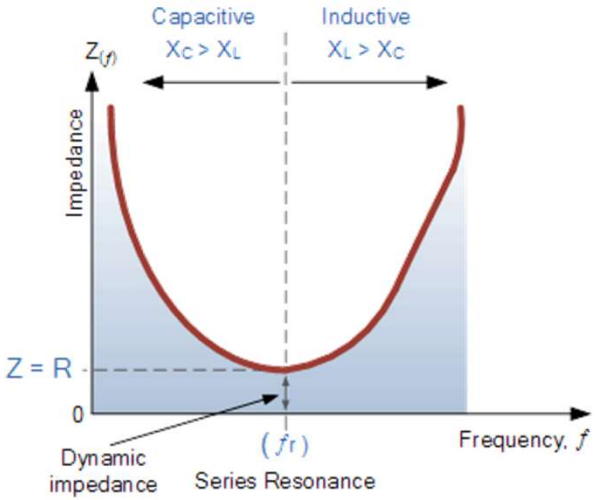
Series resonance



Single line Diagram



Equivalent Circuit



Rating-safety requirements-guide

IEC 60831-1:2002 Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000V Part 1 : General-Performance, testing and rating-safety requirements-guide for installation and operation. It requires that the capacitor be able to operate at 130% of the rated current continuously. This is to be able to support harmonic currents in the electrical system to a certain extent.

PEA Grid code

การไฟฟ้าส่วนภูมิภาค
PROVINCIAL ELECTRICITY AUTHORITY

Provincial Electricity Authority's Regulation

on the Power Network System Interconnection Code

B.E.2559 (2016)

Attachment 1: Specifications of Interconnection Patterns
Attachment 2: Equipment Specifications and Standards
Attachment 3: Voltage Fluctuation Regulation for Business and Industrial Use
Attachment 4: Harmonic Regulation for Business and Industrial Use
Attachment 5: Specifications and Regulations of Control Equipment to be Connected to the SCADA System of a Power Dispatch System Operator
Attachment 6: Converter Test Procedure and Methodology

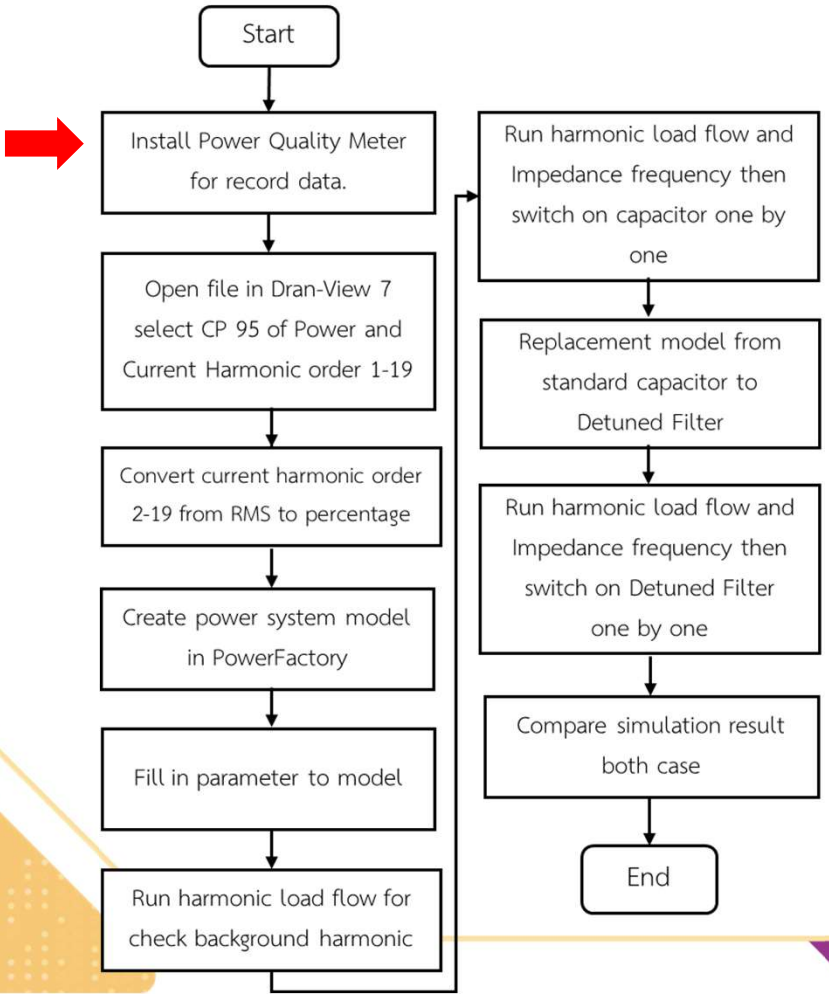
Limit current harmonic for customer at PCC

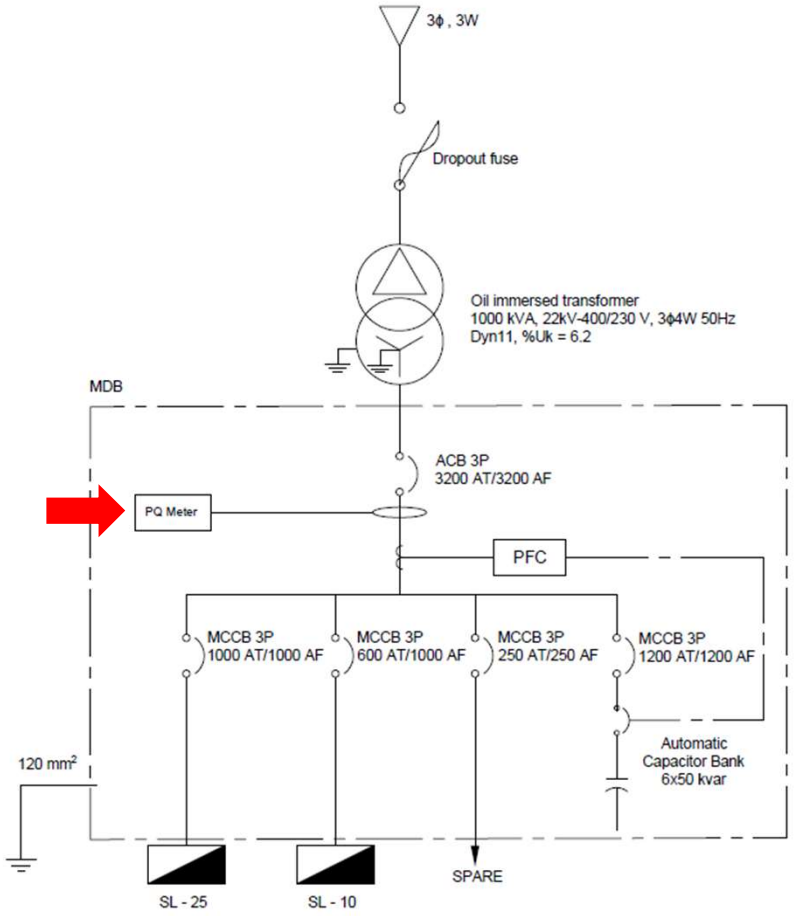
Voltage Level at PCC (kV)	Current Harmonics limit and Sequence (A rms)																	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0.4	48	34	22	56	11	40	9	8	7	19	6	16	5	5	5	6	4	6
11 and 12	13	8	6	10	4	8	3	3	3	7	2	6	2	2	2	2	1	1
22, 24 and 33	11	7	5	9	4	6	3	2	2	6	2	5	2	1	1	2	1	1
69	8.8	5.9	4.3	7.3	3.3	4.9	2.3	1.6	1.6	4.9	1.6	4.3	1.6	1	1	1.6	1	1
115 and above	5	4	3	4	2	3	1	1	1	3	1	3	1	1	1	1	1	1

Limit voltage harmonic for customer at PCC

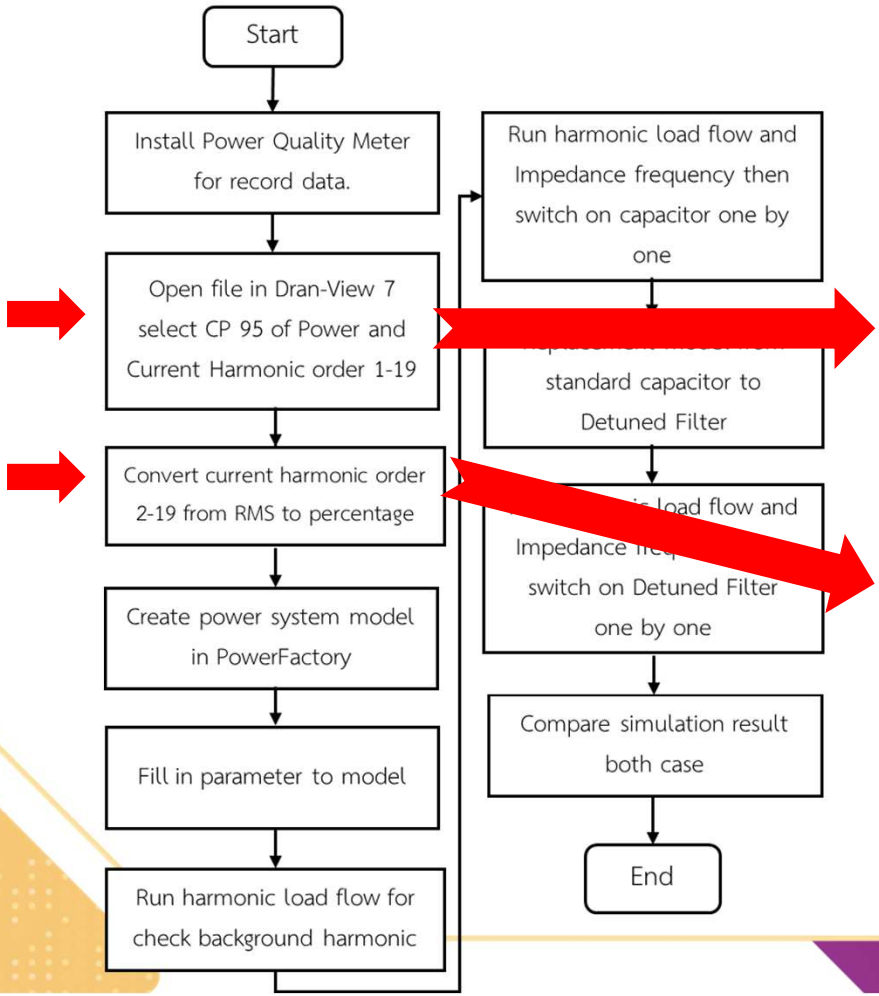
Voltage Level at PCC (kV)	voltage harmonic distortion limits (%)	voltage harmonic distortion limits each level	
		odd	even
0.400	5	4	2
11, 12, 22 and 24	4	3	1.75
33	3	2	1
69	2.45	1.63	0.82
115 and above	1.5	1	0.5

Flow Chart


Start
Install Power Quality Meter for record data.
Open file in Dran-View 7 select CP 95 of Power and Current Harmonic order 1-19
Convert current harmonic order 2-19 from RMS to percentage
Create power system model in PowerFactory
Fill in parameter to model
Run harmonic load flow for check background harmonic
Run harmonic load flow and Impedance frequency then switch on capacitor one by one
Replacement model from standard capacitor to Detuned Filter
Run harmonic load flow and Impedance frequency then switch on Detuned Filter one by one
Compare simulation result both case
End


3ϕ , 3W
Dropout fuse
Oil immersed transformer
1000 kVA, 22kV-400/230 V, 3ϕ4W 50Hz
Dyn11, %Uk = 6.2
MDB
ACB 3P
3200 AT/3200 AF
PQ Meter
PFC
MCCB 3P
1000 AT/1000 AF
MCCB 3P
600 AT/1000 AF
MCCB 3P
250 AT/250 AF
MCCB 3P
1200 AT/1200 AF
Automatic
Capacitor Bank
6x50 kvar
120 mm²
SL - 25
SL - 10
SPARE

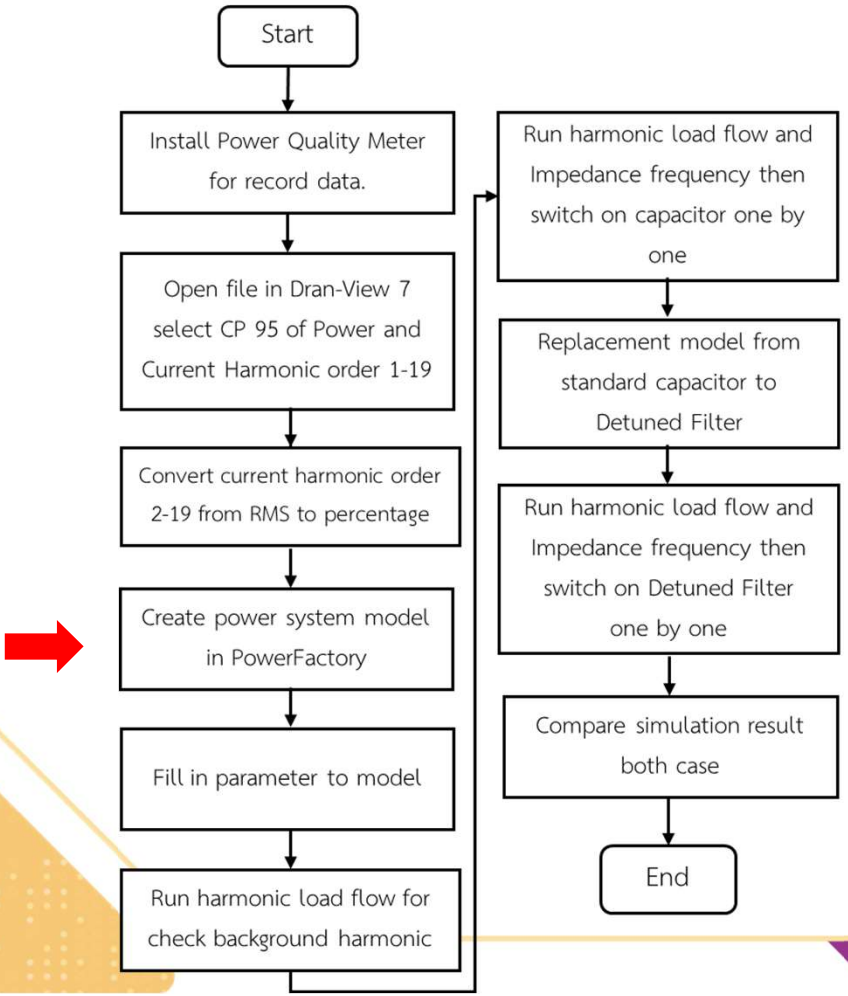
Flow Chart



	95%
TOTP(kW)	599.3
TOTQFnd(kVAR)	372.1

	95%
AI HG01	1003
BI HG01	1135
CI HG01	994.5
AI HG02	1.801
BI HG02	2.288
CI HG02	2.272
AI HG03	13.13
BI HG03	11.55

$$\text{AI HG02 (\%)} = \frac{AI\ HG02\ (A)}{AI\ HG01\ (A)} = \frac{1.801}{1003} * 100 = 0.18$$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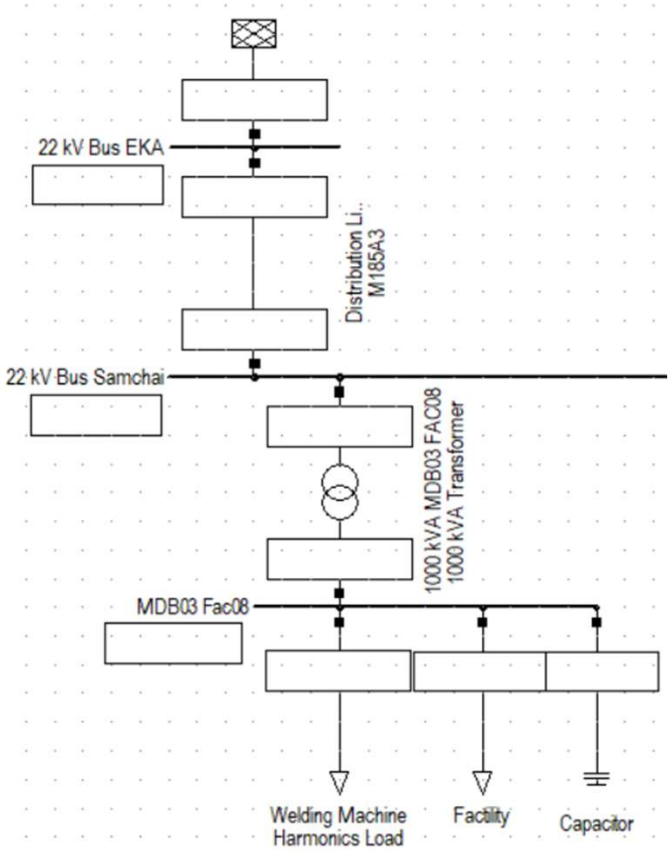
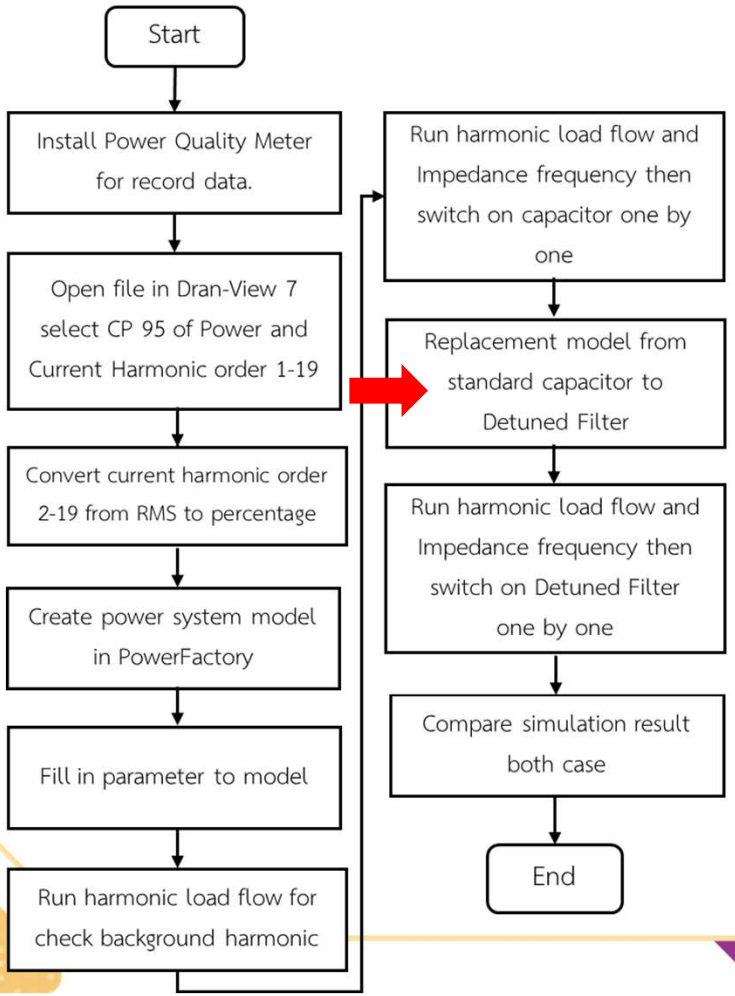
Run harmonic load flow and Impedance frequency then switch on capacitor one by one
Replacement model from standard capacitor to Detuned Filter
Run harmonic load flow and Impedance frequency then switch on Detuned Filter one by one
Compare simulation result both case
End


22 kV Bus EKA
Distribution Li..
M185A3
22 kV Bus Samchai
1000 kVA MDB03 FAC08
1000 kVA Transformer
MDB03 Fac08
Welding Machine
Harmonics Load
Factlity
Capacitor


Start
Install Power Quality Meter for record data.
Open file in Dran-View 7 select CP 95 of Power and Current Harmonic order 1-19
Convert current harmonic order 2-19 from RMS to percentage
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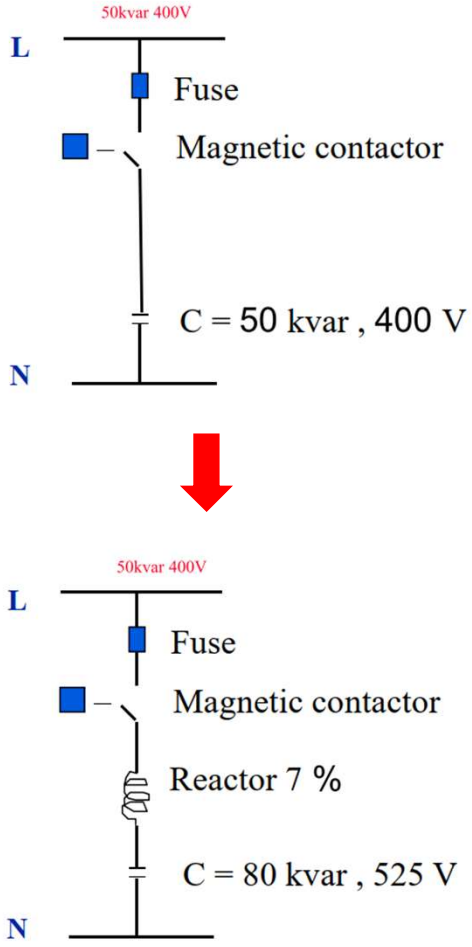
Run harmonic load flow and Impedance frequency then switch on capacitor one by one
Replacement model from standard capacitor to Detuned Filter
Run harmonic load flow and Impedance frequency then switch on Detuned Filter one by one
Compare simulation result both case
End


50kvar 400V
L
Fuse
Magnetic contactor
C = 50 kvar , 400 V
N
50kvar 400V
L
Fuse
Magnetic contactor
Reactor 7 %
C = 80 kvar , 525 V
N

Result

1. Background System

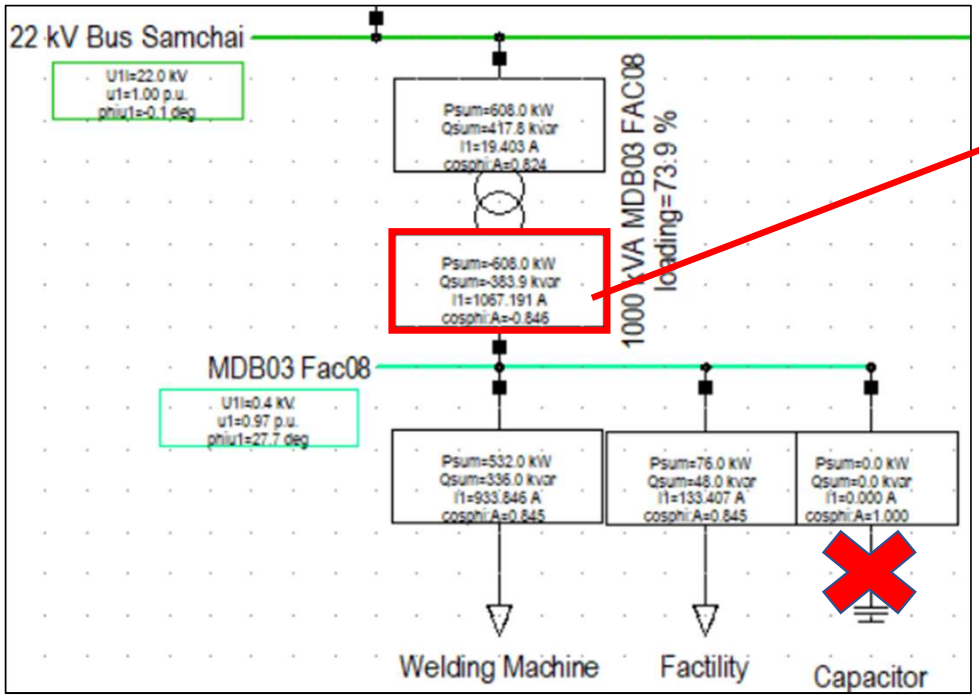
2. Standard Capacitor Bank

3.Detune Filter

1. Background System

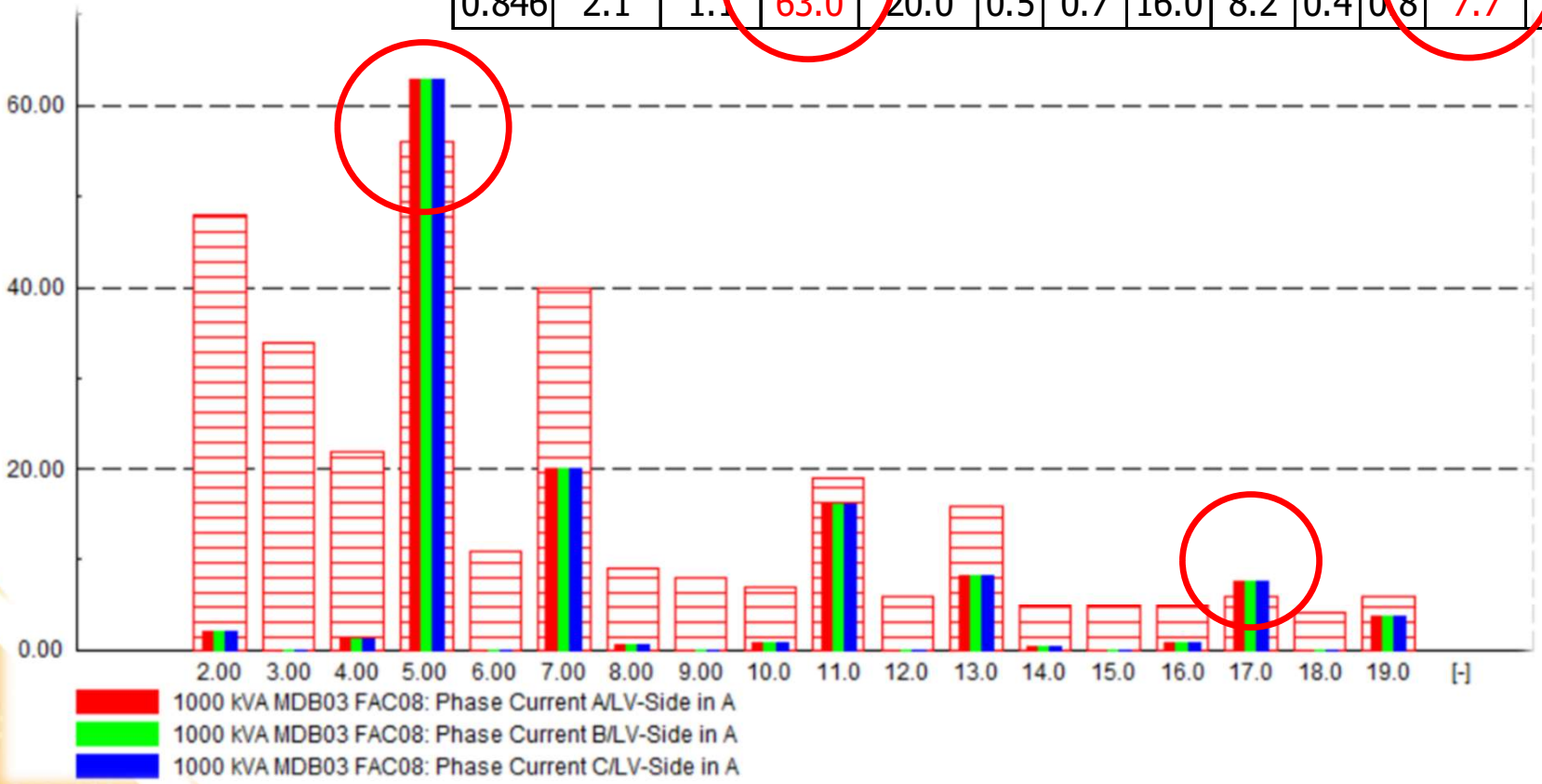
2. Standard Capacitor Bank

3.Detune Filter



Psum=-0.608 MW
Qsum=-0.384 Mvar
I1=1.071 kA
cosphisum=-0.846

PF.	Current harmonic (A)												THDv (%)
	2	4	5	7	8	10	11	13	14	16	17	19	
0.846	2.1	1.1	63.0	20.0	0.5	0.7	16.0	8.2	0.4	0.8	7.7	3.7	2.09



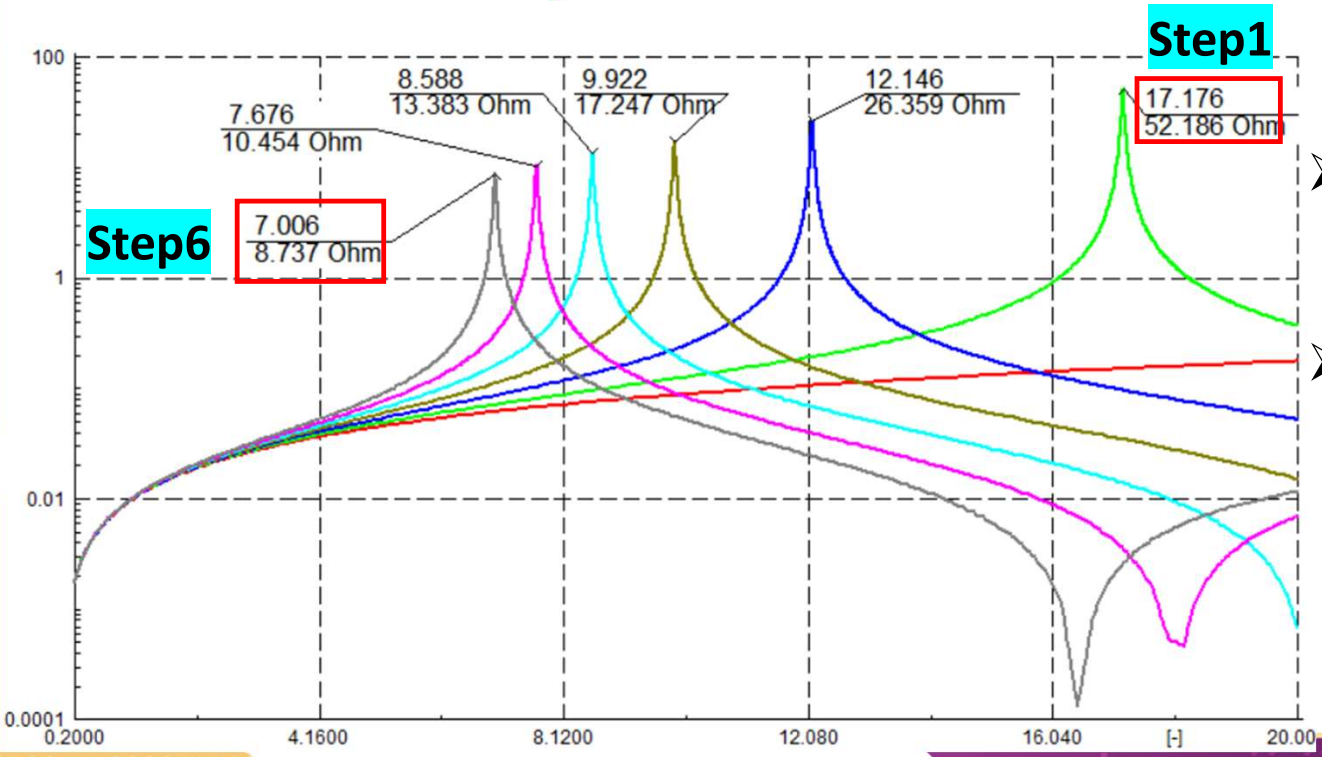
1. Background System

2. Standard Capacitor Bank

3.Detune Filter

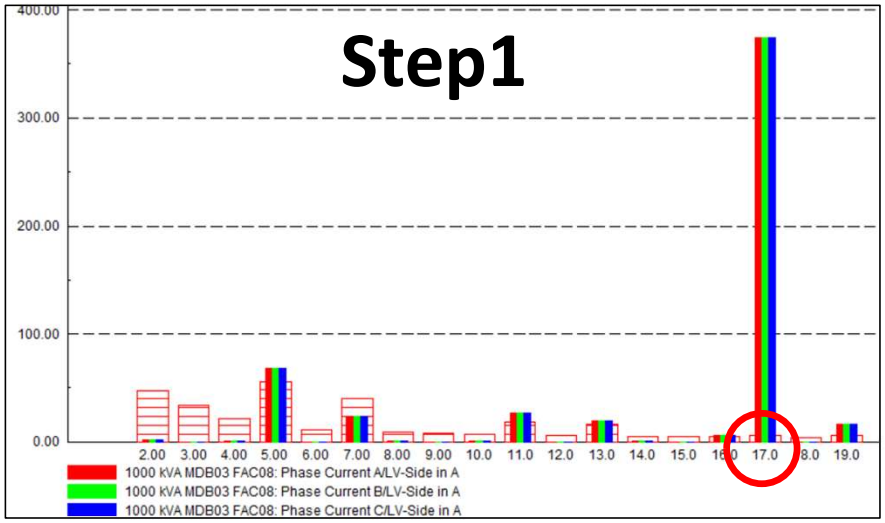
original harmonics

PF.	Current harmonic (A)												THDv (%)
	2	4	5	7	8	10	11	13	14	16	17	19	
0.846	2.1	1.1	63.0	20.0	0.5	0.7	16.0	8.2	0.4	0.8	7.7	3.7	2.09

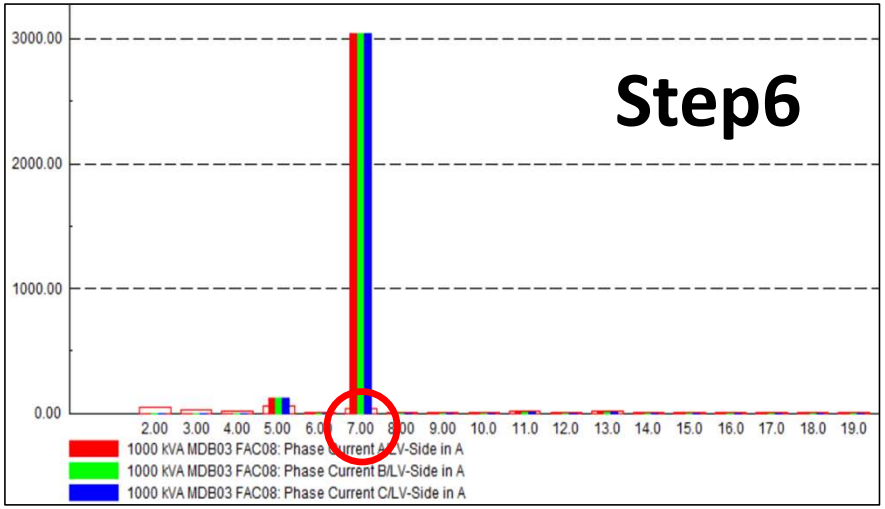


- Step1 A parallel resonance occurs at 17.176 which is close to the original harmonics at 17.
- Step6 A parallel resonance occurs at 7.006 which is close to the original harmonics at 5.

374.2 A

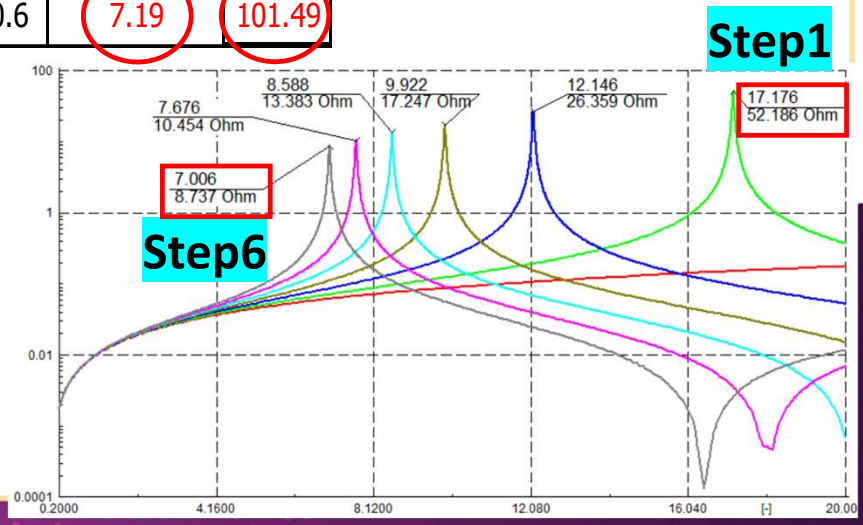


3,035.9 A



Capacitor Bank															
Step No.	PF.	Current harmonic (A)												Ic(rms)/I(cr)	THDv (%)
		2	4	5	7	8	10	11	13	14	16	17	19		
1	0.875	2.1	1.1	68.6	23.9	0.7	1.1	27.1	19.1	1.1	6.0	374.2	16.6	5.38	31.14
2	0.904	2.2	1.2	75.3	29.7	0.9	2.2	88.6	55.9	1.1	1.1	8.0	2.6	1.23	6.30
3	0.931	2.2	1.3	83.6	39.5	1.5	41.9	69.0	11.3	0.4	0.5	3.9	1.4	1.11	4.91
4	0.955	2.2	1.4	94.0	58.8	3.9	2.0	24.7	6.3	0.2	0.3	2.6	0.9	1.03	3.32
5	0.975	2.2	1.5	107.5	116.0	6.1	1.0	15.0	4.3	0.2	0.2	1.9	0.7	1.05	4.76
6	0.990	2.3	1.6	125.7	3035.9	1.7	0.7	10.8	3.3	0.1	0.2	1.5	0.6	7.19	101.49

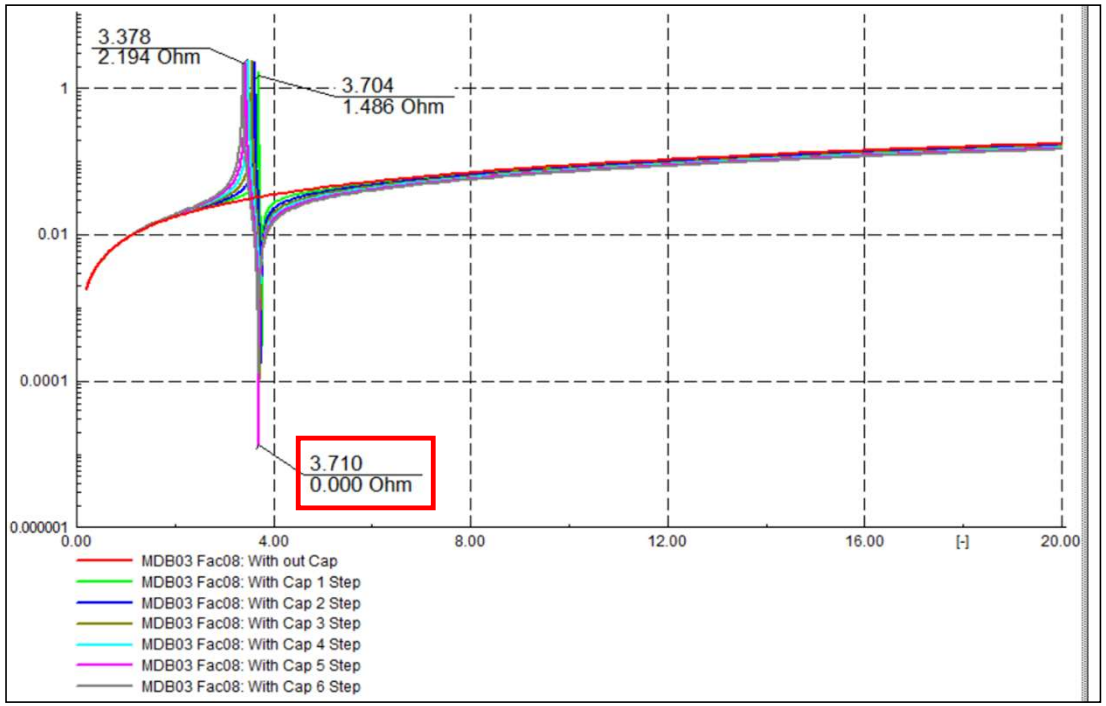
In addition, the 5th and 11th harmonics, which are negative sequences, It will cause the motor to rotate in the opposite direction or against the normal direction of rotation, causing the motor to become hot because power must be used to resist this force.



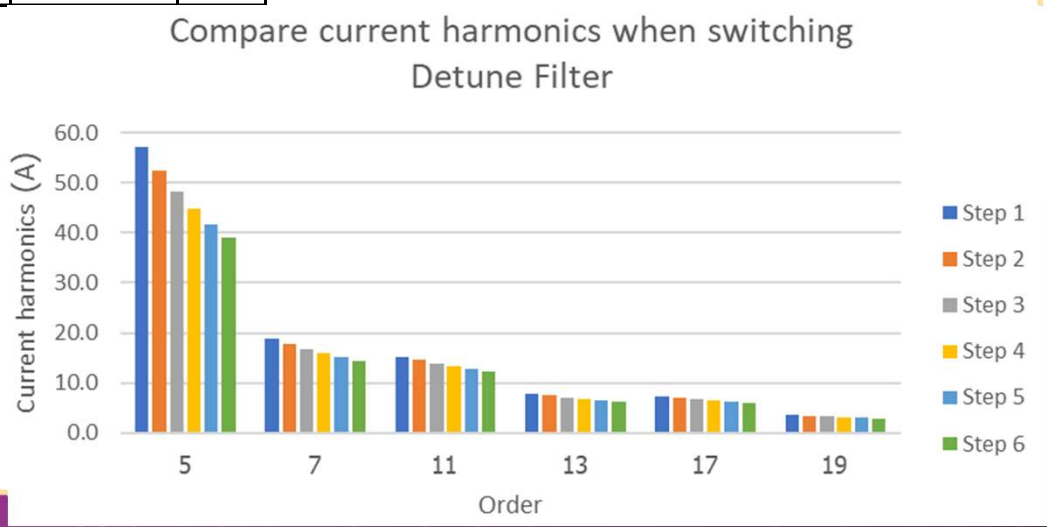
1. Background System

2. Standard Capacitor Bank

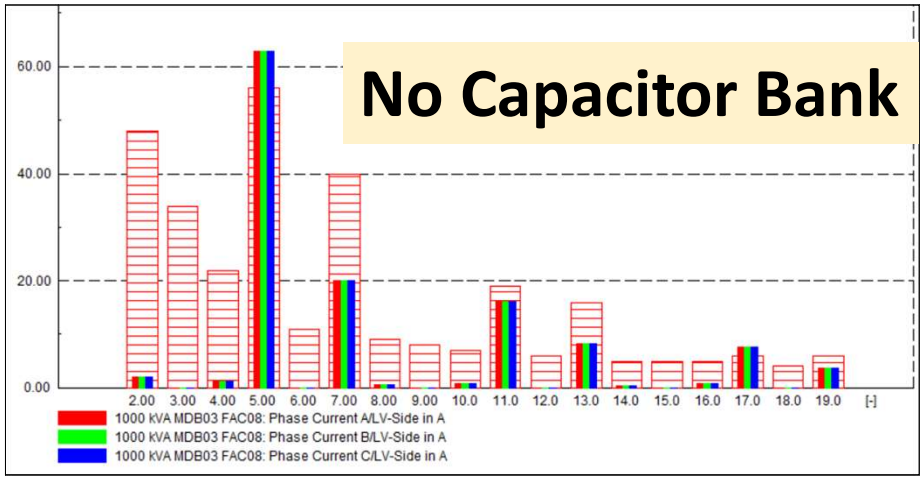
3.Detune Filter

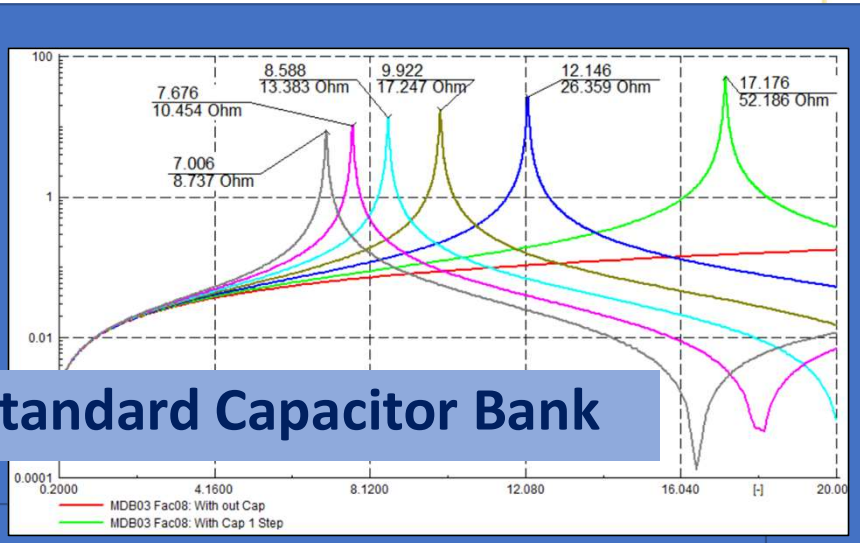


Detune Filter															
Step No.	PF.	Current harmonic (A)												Ic(rms)/I(cr)	THDv (%)
		2	4	5	7	8	10	11	13	14	16	17	19		
1	0.873	2.1	0.8	57.2	18.8	0.5	0.7	15.3	7.8	0.4	0.8	7.4	3.6	1.00	1.94
2	0.900	2.2	0.6	52.4	17.8	0.5	0.7	14.6	7.5	0.3	0.7	7.0	3.4	1.00	1.80
3	0.925	2.2	0.5	48.3	16.8	0.4	0.6	13.9	7.1	0.3	0.7	6.7	3.3	1.00	1.69
4	0.948	2.2	0.4	44.7	16.0	0.4	0.6	13.3	6.8	0.3	0.7	6.5	3.1	1.00	1.58
5	0.968	2.3	0.4	41.7	15.2	0.4	0.6	12.8	6.6	0.3	0.6	6.2	3.0	0.98	1.49
6	0.984	2.3	0.3	39.0	14.5	0.4	0.6	12.3	6.3	0.3	0.6	6.0	2.9	1.00	1.41



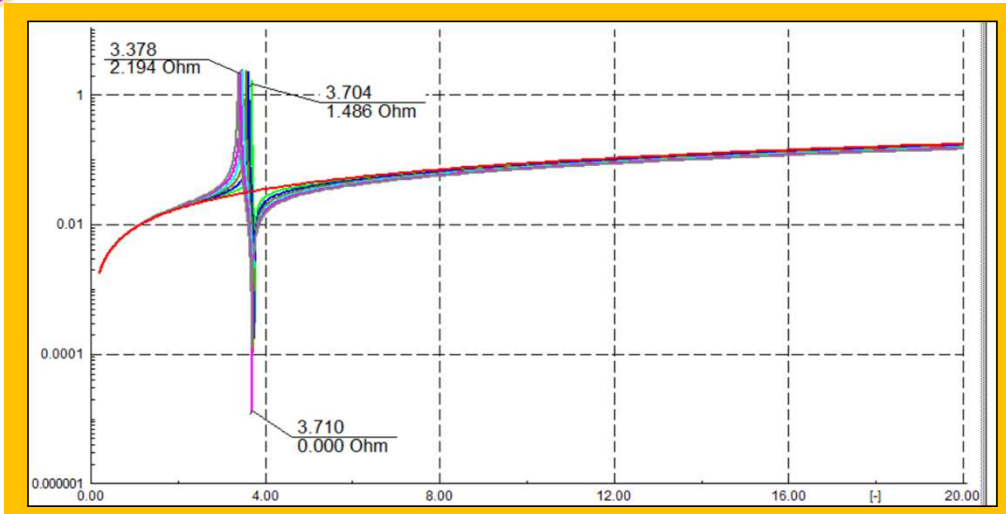
Conclusion





Capacitor Bank

Step No.	PF.	Current harmonic (A)												Ic(rms)/I(cr)	THDv (%)
		2	4	5	7	8	10	11	13	14	16	17	19		
1	0.875	2.1	1.1	68.6	23.9	0.7	1.1	27.1	19.1	1.1	6.0	374.2	16.6	5.38	31.14
2	0.904	2.2	1.2	75.3	29.7	0.9	2.2	88.6	55.9	1.1	1.1	8.0	2.6	1.23	6.30
3	0.931	2.2	1.3	83.6	39.5	1.5	41.9	69.0	11.3	0.4	0.5	3.9	1.4	1.11	4.91
4	0.955	2.2	1.4	94.0	58.8	3.9	2.0	24.7	6.3	0.2	0.3	2.6	0.9	1.03	3.32
5	0.975	2.2	1.5	107.5	116.0	6.1	1.0	15.0	4.3	0.2	0.2	1.9	0.7	1.05	4.76
6	0.990	2.3	1.6	125.7	3035.9	1.7	0.7	10.8	3.3	0.1	0.2	1.5	0.6	7.19	101.49



Detune Filter

Detune Filter															
Step No.	PF.	ค่ากระแสฮาร์มอนิกส์แต่ละอันดับ (A)												Ic(rms)/I(cr)	THDv (%)
		2	4	5	7	8	10	11	13	14	16	17	19		
1	0.873	2.1	0.8	57.2	18.8	0.5	0.7	15.3	7.8	0.4	0.8	7.4	3.6	1.00	1.94
2	0.900	2.2	0.6	52.4	17.8	0.5	0.7	14.6	7.5	0.3	0.7	7.0	3.4	1.00	1.80
3	0.925	2.2	0.5	48.3	16.8	0.4	0.6	13.9	7.1	0.3	0.7	6.7	3.3	1.00	1.69
4	0.948	2.2	0.4	44.7	16.0	0.4	0.6	13.3	6.8	0.3	0.7	6.5	3.1	1.00	1.58
5	0.968	2.3	0.4	41.7	15.2	0.4	0.6	12.8	6.6	0.3	0.6	6.2	3.0	0.98	1.49
6	0.984	2.3	0.3	39.0	14.5	0.4	0.6	12.3	6.3	0.3	0.6	6.0	2.9	1.00	1.41

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Thank You!

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