21st Annual PQSynergy™ International Conference and Exhibition 2023

Cass study : Power Quality problems in Container Terminal

Prawat Deekla, Power Quality Products, Hitachi Energy (Thailand) Limited

2022-09-18

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1. Introduction
2. Abstract
3. Principles
4. Case study
5. Q & A

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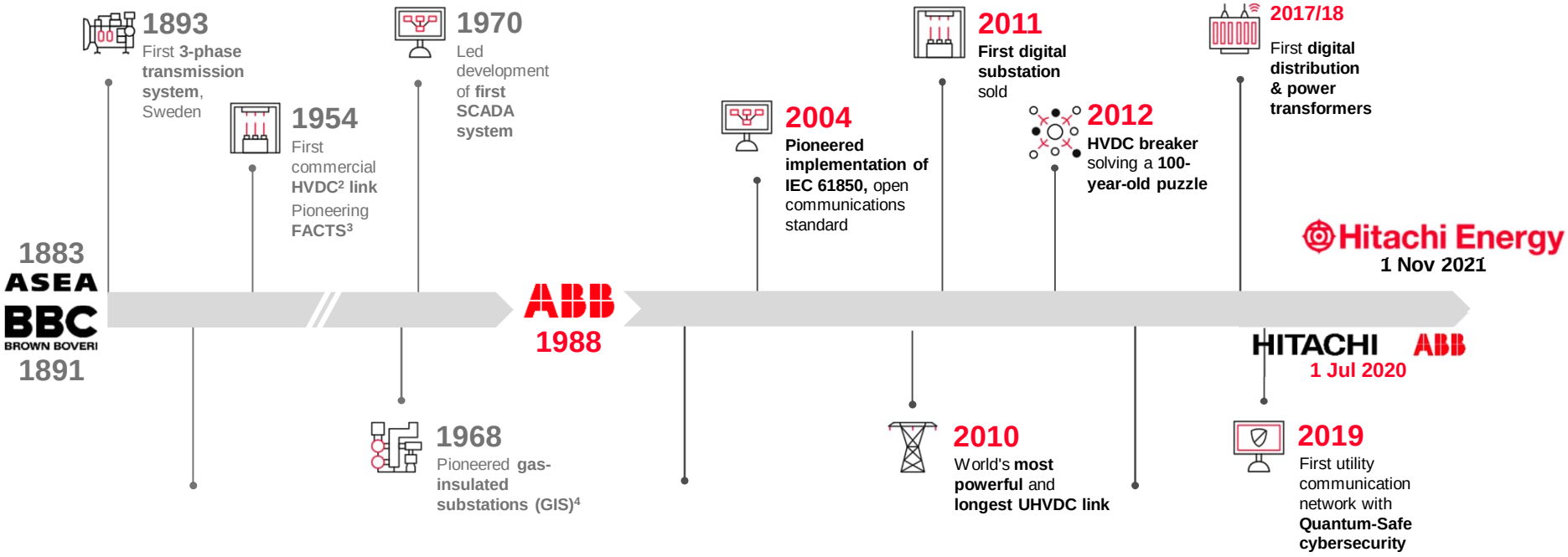
Our heritage: Hitachi Energy



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Case study

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Case 1: Fast Reactive Compensation at MV level with dynamic response compensator at Container Terminal

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Case 1: Power Quality problems in Container Terminal

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Abstract

Sea transport has been the largest carrier of freight throughout recorded history. Today, it remains just as important as 90% of international trade is being handled by merchant shipping. Quick cargo handling at ports is critical to reduce the cost of docking and technology is a major factor in achieving this.

Poor power quality can damage the port's electrical system. It is also prone to spreading through the supply grid and can cause disturbances such as voltage fluctuations in the electrical networks of other users on the same grid. In some cases, penalties are incurred.

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Case 1: Power Quality problems in Container Terminal

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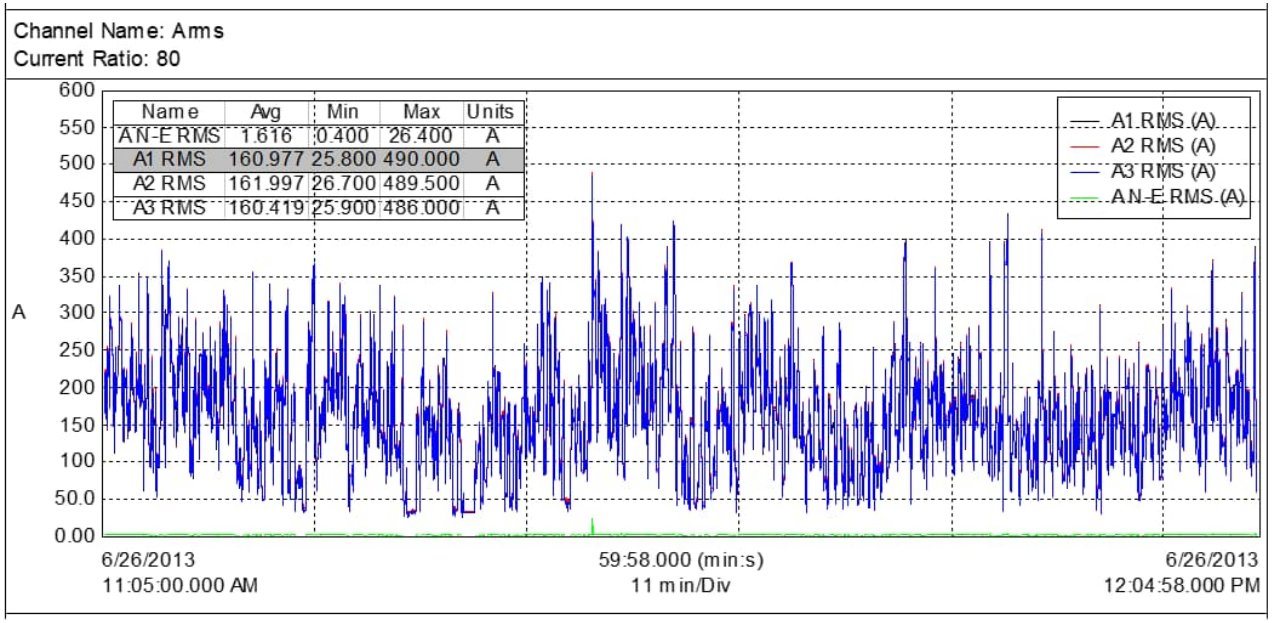
Traditionally, low cos φ problems are solved using fixed or contactor switched capacitor banks. However, loads whose reactive power demand is high and/or has a rapidly changing pattern, cannot be adequately compensated by these solutions.



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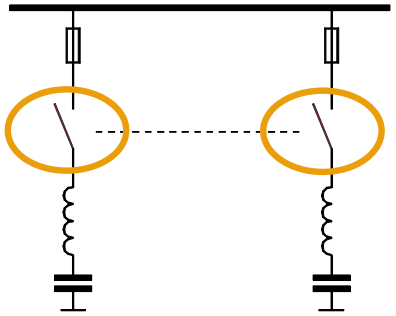
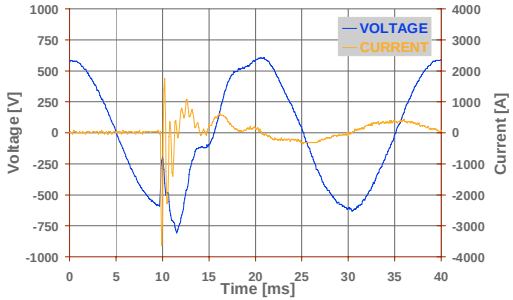
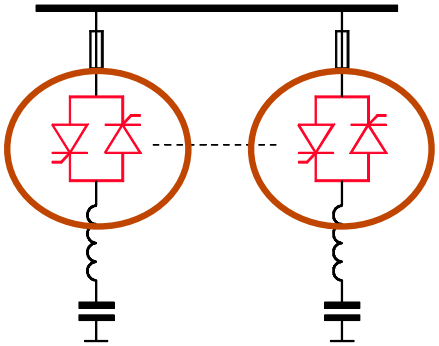
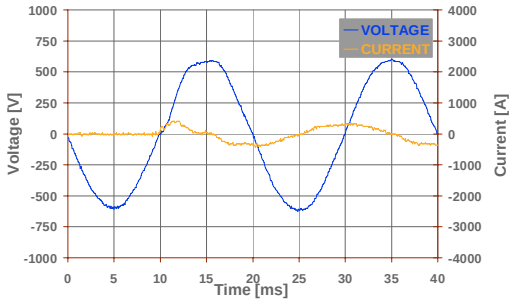
Conventional banks





Transient free switching





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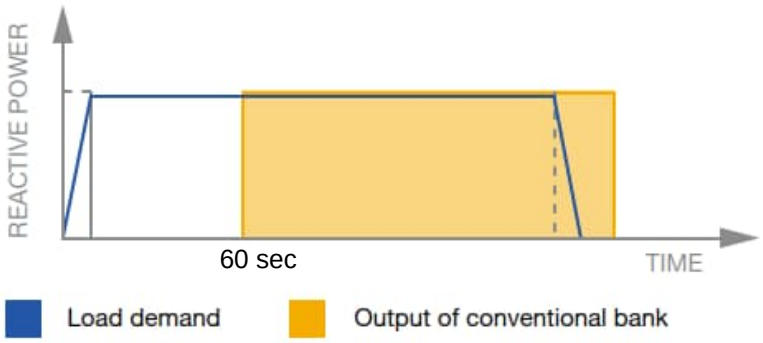
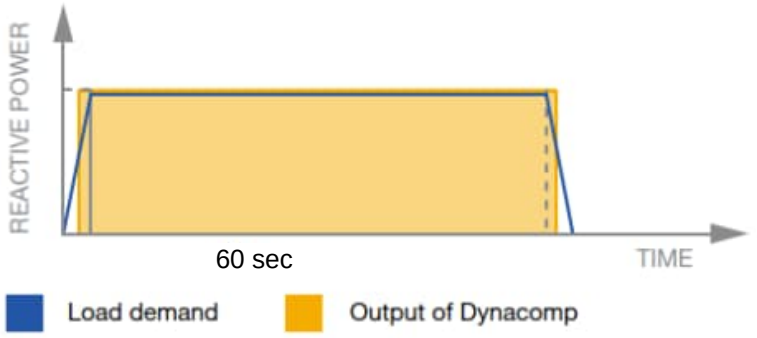


Conventional banks



Transient free switching

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Comparation

Conventional banks	Transient free switching
Need time to discharge the capacitors	Ultra rapid response time
High inrush current	No disturbances at switching in of the capacitors
Limited life of the contactors	
Create disturbances	
Put stress on the elements	

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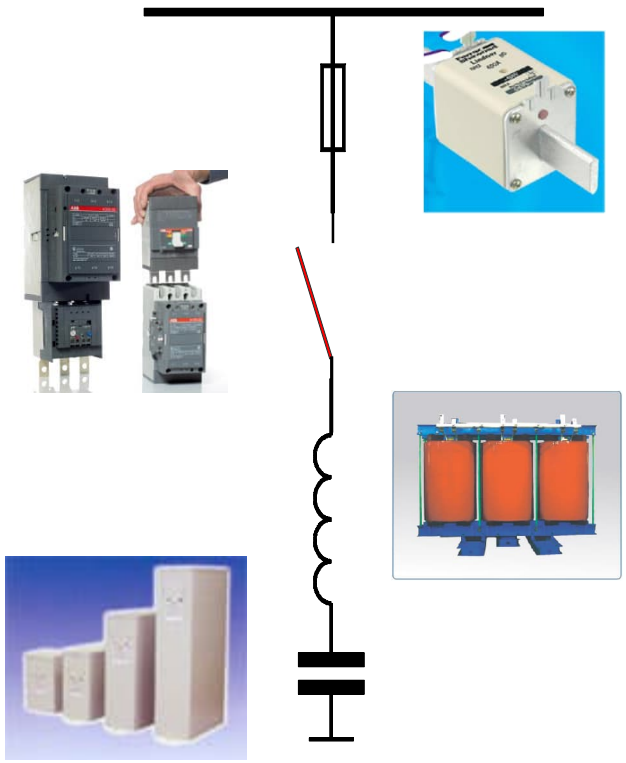
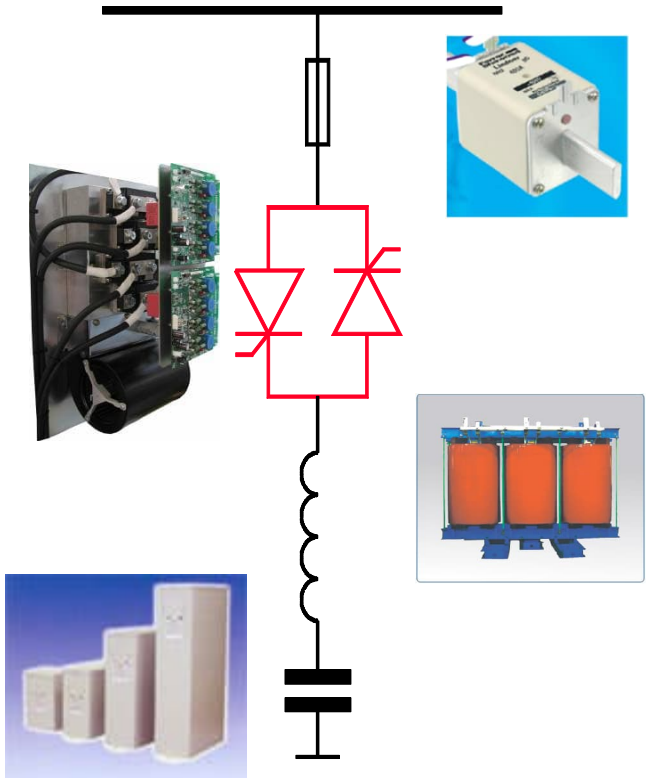
Conventional banks



Transient free switching



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Project background

- The terminal has seven quay cranes that operate simultaneously and move each container in less than two minutes.
- Container Terminal is situated at the Port
- Crane is main load with DC drive
- Load varies fast (a fast-varying active power & reactive power)

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Problems

The Power Quality Challenge

- The cranes at the port use DC drives to enhance the efficiency of their motors, however they draw high reactive power. This results in low power factor and poor power quality.
- Consequences of poor power quality:
  - Potential damage to the port's electrical system
  - Disturbances such as voltage fluctuations in the electrical networks of other users on the same grid
  - Penalties from the utility of up to $50,000 per month

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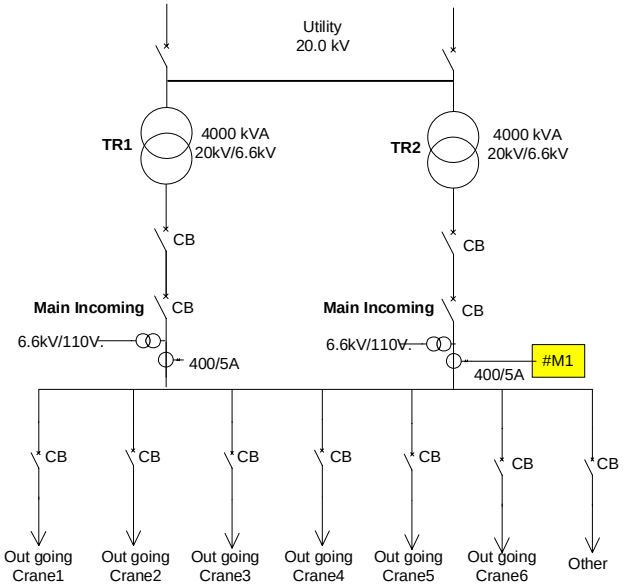
Single line diagram



- The data measurement was measured when without existing capacitor bank in system.
- The data measurement was measured when the system ran normal load.

- Existing power equipment:
  - Distribution Transformer 4,000 kVA, 20 kV/6.6 kV
  - The system does have existing plain shunt capacitor bank
- Background
  - Port Crane, large DC motor
- Issues
  - Low Power Factor, High %THDv & %THDi

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Summary table of field measurement at 6.6kV

The Data of Power, Power Factor, Voltage, Current,THD and individual harmonics

Parameter	Data at # M1 (6.6 kV)		
	When system have crane 4 units		
	L1	L2	L3
V_{L-L} (V)	6,385	6,391	6,386
I (Amp.)	369.07	368.34	367.74
P (kW)	3,105.6		
S (kVA)	3,910.6		
Q (kvar)	2,638.2		
PF	0.762 lagging		
DPF	0.780 lagging		
% THDv	3.69%	3.62%	3.46%
% THDI	21.90%	21.19%	22.21%

Harmonic Order	Existing harmonic pollution		Recommendation G5/4 at 6.6 kV	
	V (%)	I (A)	V (%)	I (A)
2	0.1	5.8	1.5	28.9
3	0.1	3.3	3.0	48.1
5	3.3	75.1	3.0	28.9
7	0.2	14.4	3.0	41.2
9	0.1	2.4	1.2	9.6
11	0.8	15.0	2.0	39.4
13	0.5	5.5	2.0	28.7
15	0.1	1.6	0.3	1.4
17	0.4	3.0	1.6	13.6
19	0.3	2.2	1.2	9.1
21	0.2	1.2	0.2	0.7
%THD	3.69%	21.90%	4.0%	-

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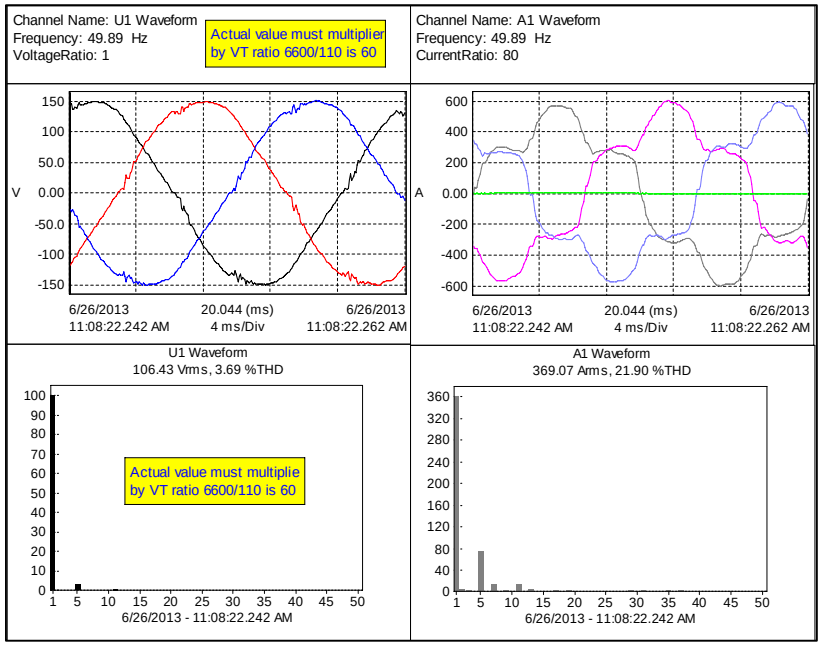
Monitoring results at 6.6kV

- Harmonics Voltage and Current waveform at Main Incoming 6.6kV (#M1) when ran crane 4 units.



U1 Waveform

	(%)		(%)		(%)
H01	100.0	H18	0.0	H35	0.4
H02	0.1	H19	0.3	H36	0.1
H03	0.1	H20	0.1	H37	0.4
H04	0.1	H21	0.2	H38	0.1
H05	3.3	H22	0.1	H39	0.1
H06	0.1	H23	0.2	H40	0.1
H07	0.2	H24	0.1	H41	0.4
H08	0.0	H25	0.2	H42	0.1
H09	0.1	H26	0.1	H43	0.4
H10	0.1	H27	0.1	H44	0.1
H11	0.8	H28	0.1	H45	0.0
H12	0.1	H29	0.4	H46	0.1
H13	0.5	H30	0.1	H47	0.4
H14	0.1	H31	0.3	H48	0.1
H15	0.1	H32	0.1	H49	0.4
H16	0.1	H33	0.0	H50	0.1
H17	0.4	H34	0.2		

A1 Waveform

	RMS		RMS		RMS
H01	360.4	H18	0.9	H35	2.2
H02	5.8	H19	2.2	H36	0.7
H03	3.3	H20	1.1	H37	2.4
H04	1.1	H21	1.2	H38	0.1
H05	75.1	H22	0.8	H39	0.3
H06	2.0	H23	1.3	H40	0.1
H07	14.4	H24	0.8	H41	1.8
H08	0.9	H25	1.2	H42	0.7
H09	2.4	H26	0.8	H43	1.7
H10	1.6	H27	0.8	H44	0.4
H11	15.0	H28	0.8	H45	0.1
H12	1.9	H29	2.5	H46	0.3
H13	5.5	H30	0.9	H47	1.2
H14	1.0	H31	2.4	H48	0.4
H15	1.6	H32	0.7	H49	1.3
H16	0.8	H33	0.2	H50	0.3
H17	3.0	H34	0.8		

6/26/2013 - 11:08:22.242 AM
Value
144.1 — U1 Waveform
-117.0 — U2 Waveform
-27.14 — U3 Waveform
Actual value must multiplier by VT ratio 6600/110 is 60

6/26/2013 - 11:08:22.242 AM
Value
4.143 — A1 Waveform
-343.8 — A2 Waveform
341.3 — A3 Waveform

Name	Date	Time	Duration	Avg	Units
U1 Waveform	6/26/2013	11:08:22.242 AM	20.044	106.429	V
U2 Waveform	6/26/2013	11:08:22.242 AM	20.044	106.517	V
U3 Waveform	6/26/2013	11:08:22.242 AM	20.044	106.443	V

Name	Date	Time	Duration	Avg	Units
A N-E Waveform	6/26/2013	11:08:22.242 AM	20.044	2.994	A
A1 Waveform	6/26/2013	11:08:22.242 AM	20.044	369.074	A
A2 Waveform	6/26/2013	11:08:22.242 AM	20.044	368.337	A
A3 Waveform	6/26/2013	11:08:22.242 AM	20.044	367.735	A

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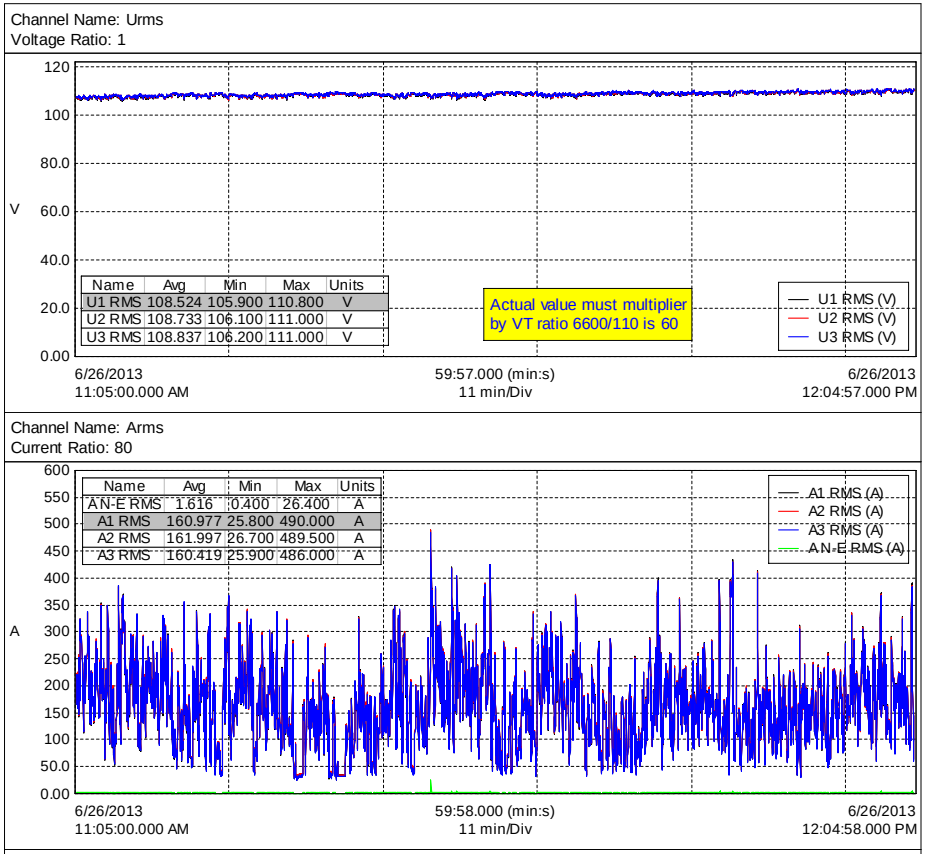
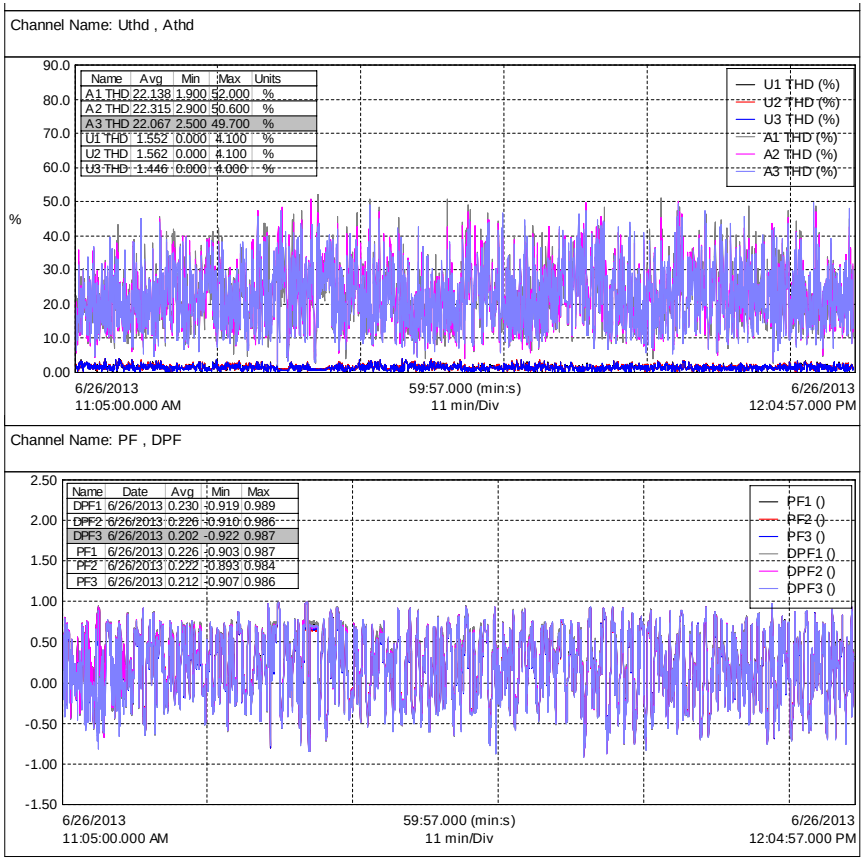
Monitoring results at 6.6kV





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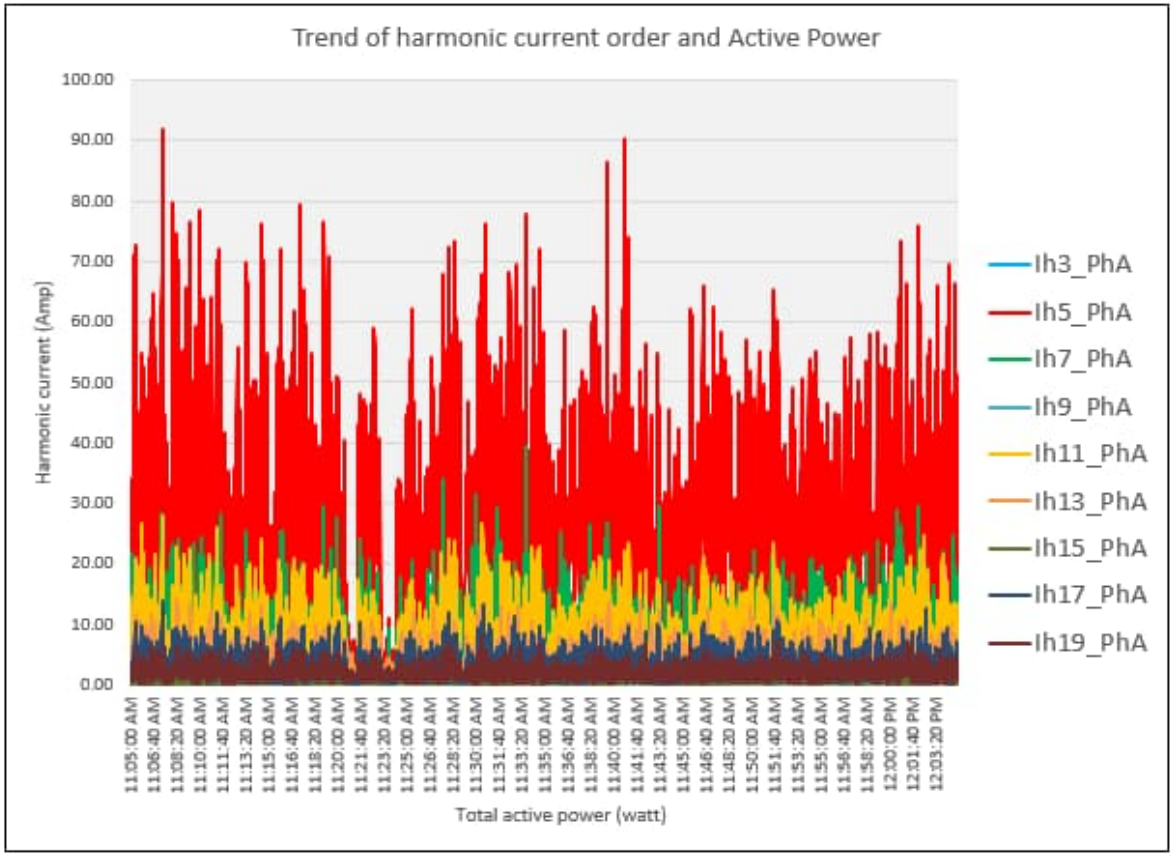
Monitoring results at 6.6kV



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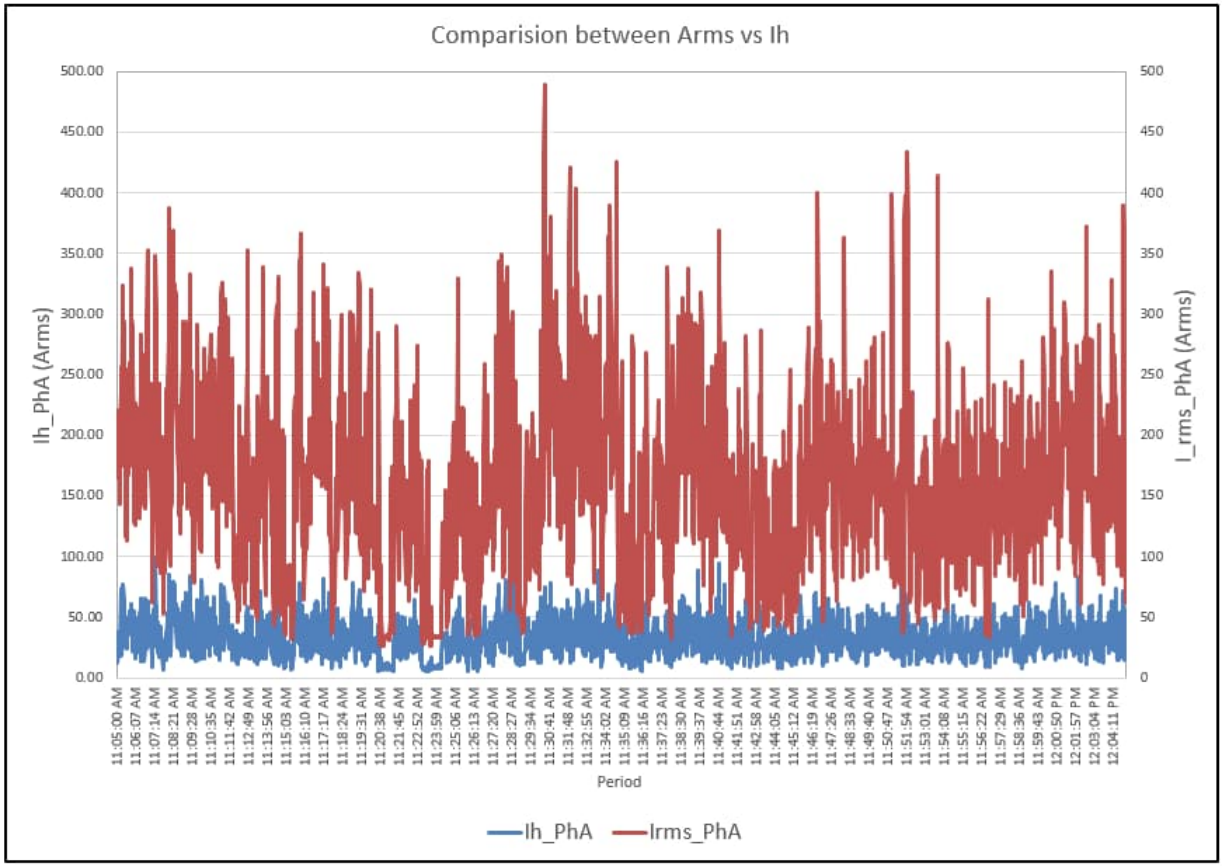
Monitoring results at 6.6kV



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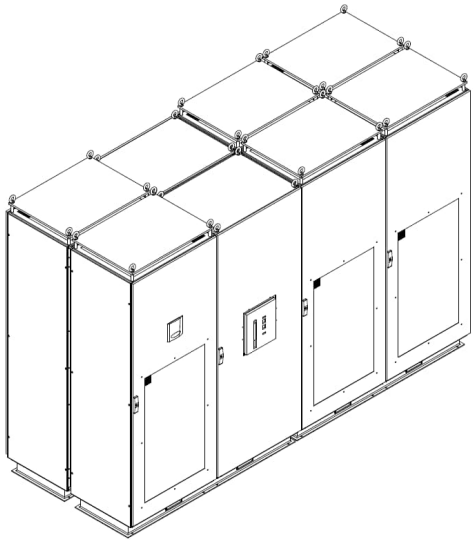
Hitachi Energy Proposed

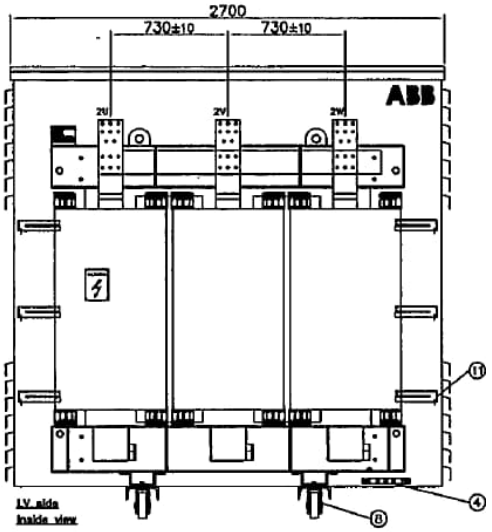
Item1 - LV Dynacomp 7% Detuned Shunt Capacitor Bank

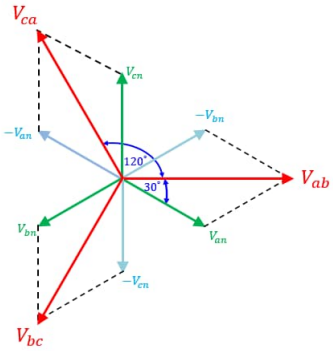
- 2400 kvar [(2x100kvar) + (3x200kvar) + (4x400kvar)], 690V, 50Hz, 3Ph3

Item2 - Distribution transformer, dry type

- 3200kVA, 20kV/690V, 50Hz, 3Ph







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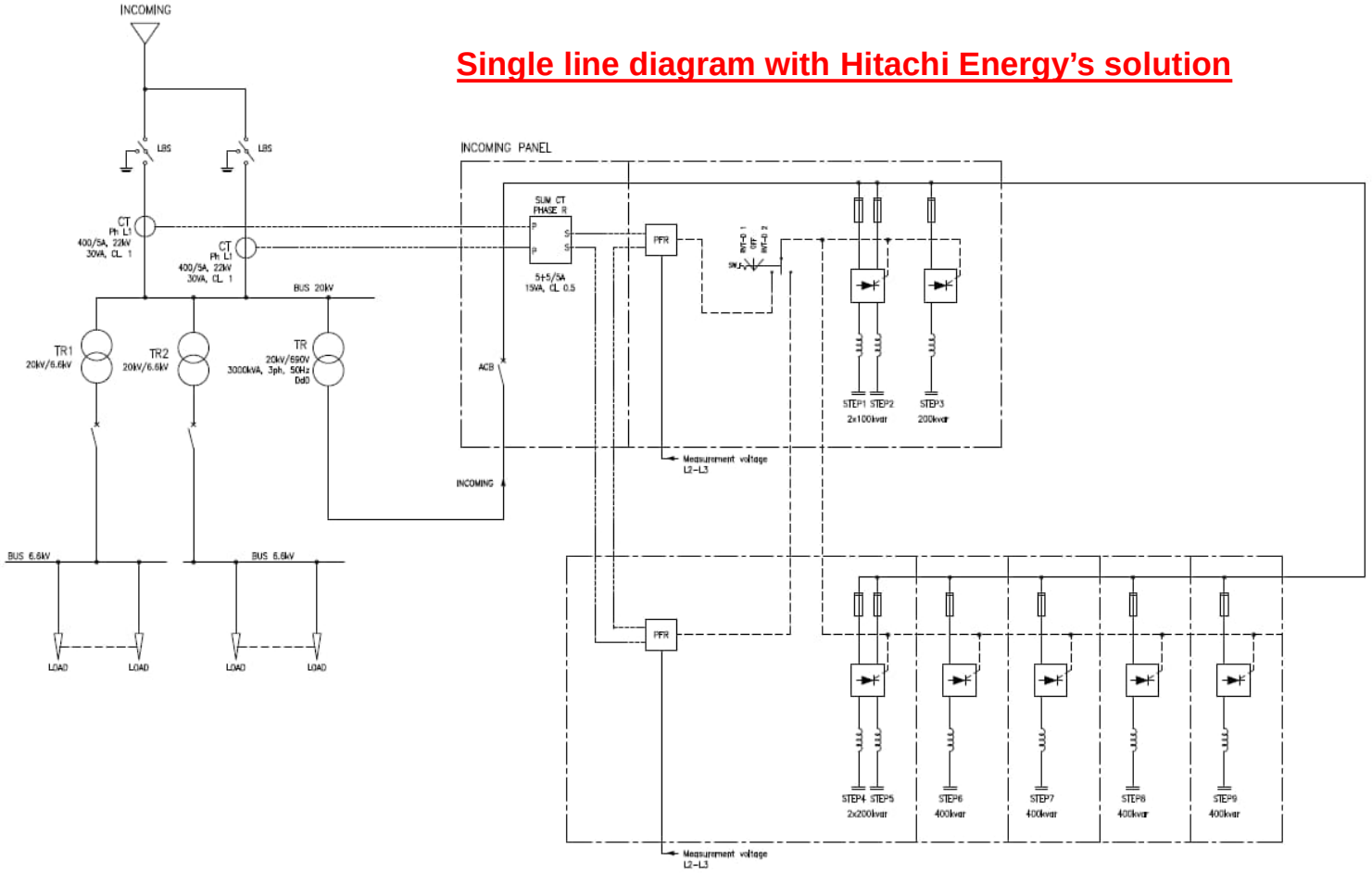
Single line diagram with Hitachi Energy's solution



Internal

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Photo of installation

Measurement at 20kV

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The Data of Power, Power Factor, Voltage, Current, and THD

Parameter	Data at # M1 (20 kV)					
	Without Dynacomp			With Dynacomp		
	L1	L2	L3	L1	L2	L3
V_{L-L} (V)	19,900	19,980	19,940	20,220 ↑	20,340 ↑	20,260 ↑
I (Amp.)	112	109	111	82 ↓	82 ↓	82 ↓
P (kW)	2,799			2,774		
S (kVA)	3,808			2,864 ↓		
Q (kvar)	2,572			708 ↓		
PF	0.732 Lagging			0.969 Lagging ↑		
DPF	0.733 Lagging			0.976 Lagging ↑		
% THDv	1.40%	1.50%	1.30%	0.90% ↓	1.10% ↓	0.90% ↓

Result without Dynacomp and with Dynacomp

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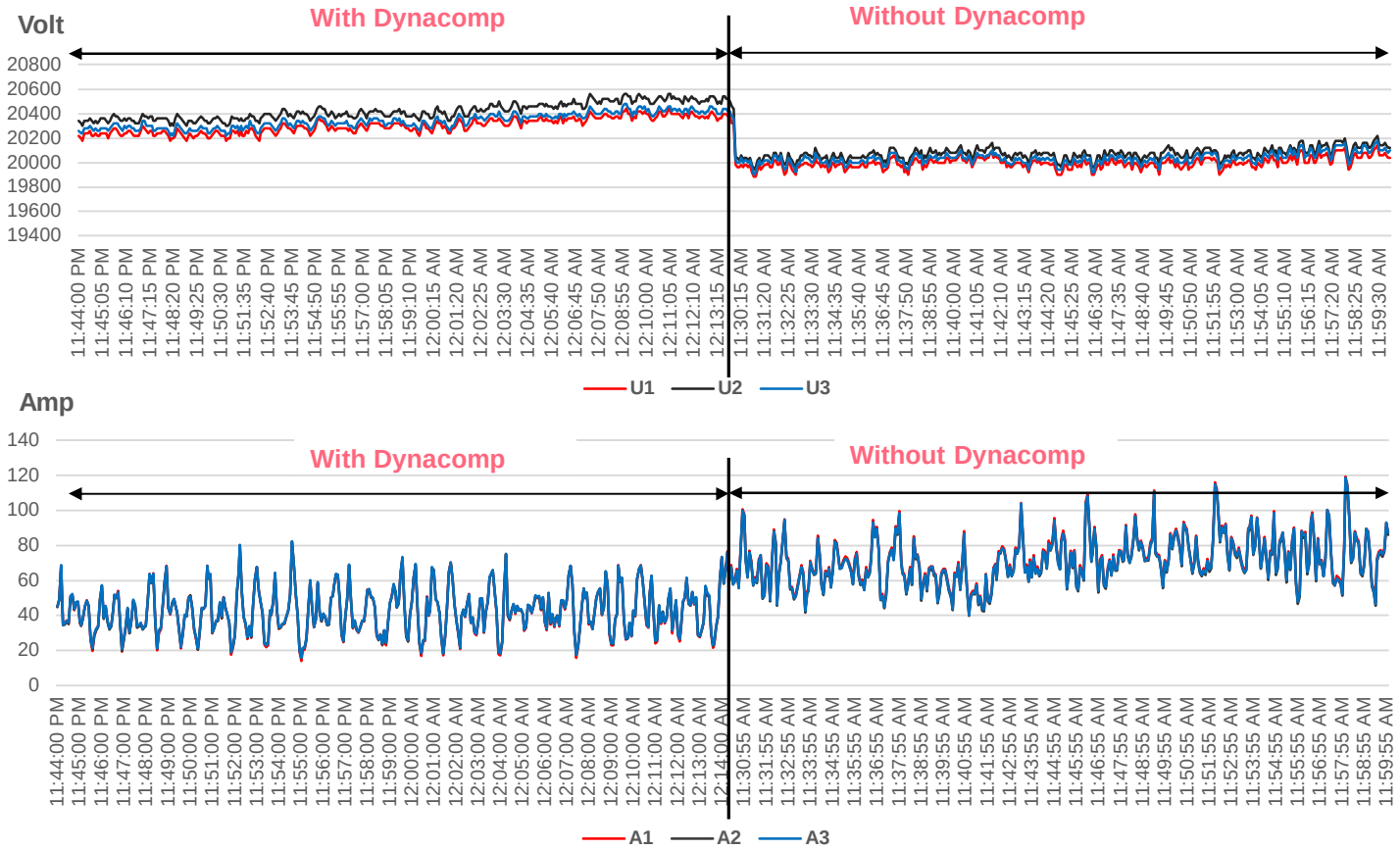
Result Before and After



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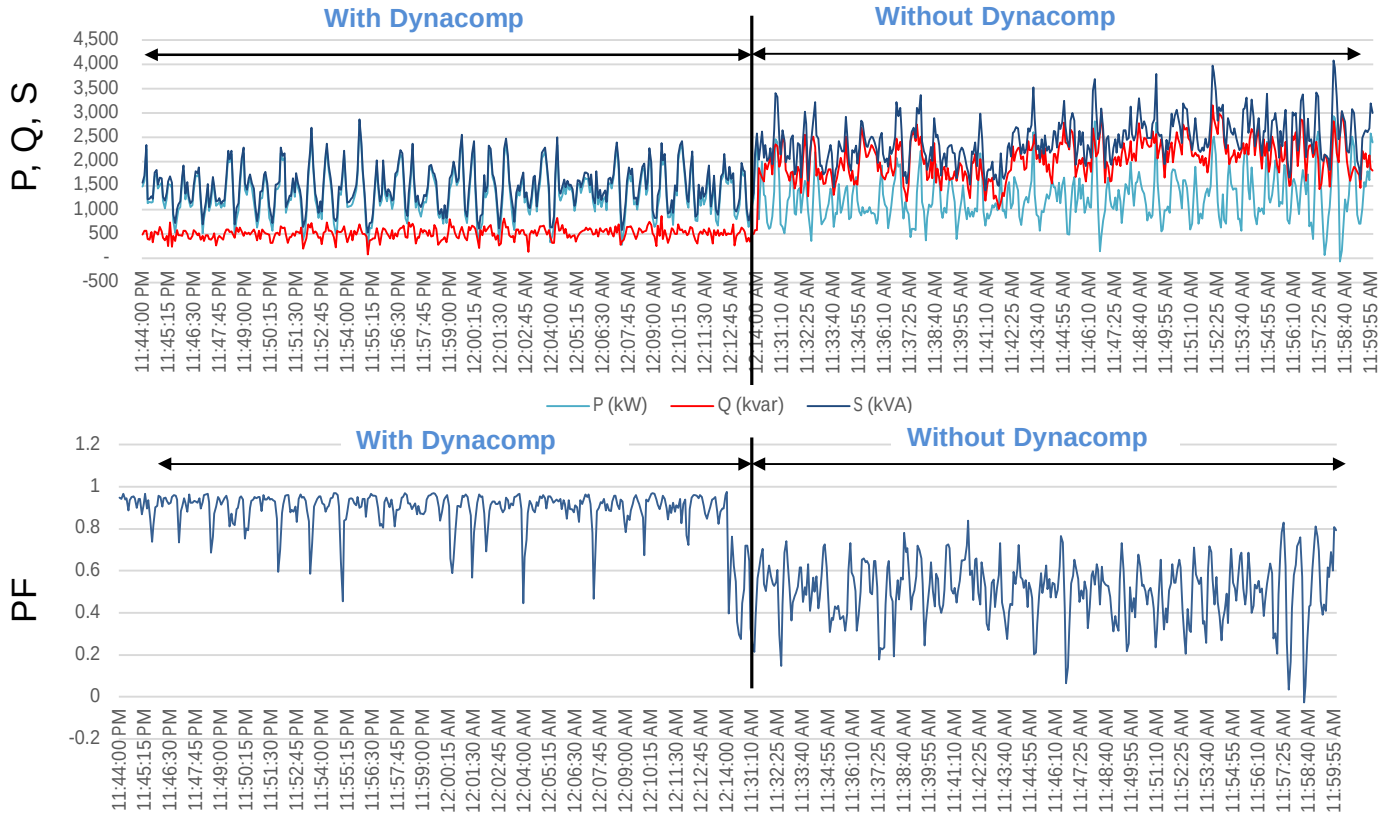
Result Before and After



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Hitachi Energy Dynacomp

- The Dynacomp is a low-voltage thyristor-switched capacitor bank which can be used for ultra-rapid, reactive power compensation and improving power quality.

- **Other Applications of Dynacomp include:**
  - Spot welding machines
  - Rolling mills and big presses with fast switching loads
  - Cranes
  - Lifts
  - Rubber mixer
  - Sawmills and tunnel drills which have very high switching rates

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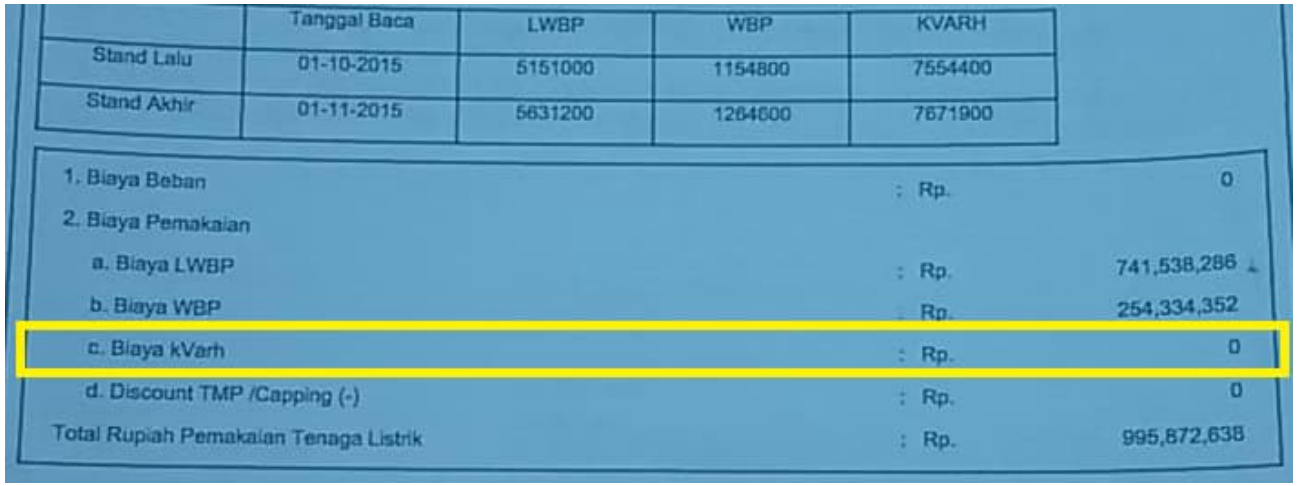
Customer benefits

- Improve power factor
- Improve Power Factor without transients
- Increases available drive power
- Increases network capability
- Can also filter harmonics



	Tanggal Baca	LWBP	WBP	KVARH
Stand Lalu	01-10-2015	5151000	1154800	7554400
Stand Akhir	01-11-2015	5631200	1264600	7671900

1. Biaya Beban	: Rp.		0
2. Biaya Pemakaian			
a. Biaya LWBP	: Rp.		741,538,286
b. Biaya WBP	: Rp.		254,334,352
c. Biaya kVarh	: Rp.		0
d. Discount TMP /Capping (-)	: Rp.		0
Total Rupiah Pemakaian Tenaga Listrik	: Rp.		995,872,638

Zero penalty after 1 month installation

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Hitachi Energy (Thailand): Thailand Business Unit

Grid Automation

- Supporting **50% of the top 250** global electric utilities with leading portfolio
  - Asset and Work Management,
  - Automation and Communication((SCADA, RTU, RE_650,670, REB500, FOX Tele-protection, ETL Power Line Carriers, Wireless TropOS)
  - e-mesh & PowerStore for microgrids & energy storage solution

Grid Integration

- **~15,000 systems** operating around the world
- **Leader in FACTS*, Power Quality & HVDC systems with 130+ GW** installed
  - AIS/GIS/Hybrid/Mobile/Container Substations, SVC, STATCOM, Semiconductors(IGBCs, IGCTs, Thyristors, Diodes), Data Center, Shore to Ship, Railway and e-bus, BESS, Services, Consulting

High Voltage Products

- **Up to 1200 kilovolts AC and 1100 kilovolts DC, leading portfolio**
- **1 in every 4 high-voltage switchgear installed in the world**
  - **HV AIS/GIS/Hybrid Equipment & Services, CT, VT, CVT, CB, GCM, DS-ES, SA**
  - **LV/MV Capacitors, PQpluS™ battery energy storage system**

Transformers

- **Complete range** of power, oil & dry distribution, traction transformers, components, services
- Up to 1200 kV AC and 1100 kV DC, leading portfolio
- **~60 factories** around the world and ~30 service centers

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Hitachi Energy (Thailand): Thailand Business Unit

High Voltage Products

Hitachi Energy is a leader in high-voltage technology, offering a wide range of high-voltage products up to 1,200-kilovolt (kV). We help to enhance the safety, reliability and efficiency of power networks while minimizing environmental impact. Our technology leadership continues to facilitate innovations in areas such as ultra-high-voltage power transmission, enabling smart grids and enhancing eco-efficiency.

Category	Offering	Description
High Voltage products 	Air insulated switchgear	Dead Tank and Live Tank Circuit Breakers (single and 3 phase operations), HV Disconnect Switches, PASS Hybrid Breakers
	Gas insulated switchgear	SF6 and EcoGas solutions, Indoor and Outdoor, packaged solutions (IGA)
	Generator circuit breakers	80-1800 MW solutions with interrupting capacity up to 825 kAIC
	Arresters	Distribution, substation and transmission solutions
	Capacitors & filters	LV-HV solutions, capacitors cans, distribution and shunt banks, metal enclosed capacitor banks, active and passive filter solutions Air cooled reactors and battery energy storage solutions
	HV instrument transformers	Station Service Voltage Transformers (SSVTs), Current Transformers (CT), Voltage Transformers (VTs), Combined Current Voltage Transformers (CCVTs), Inductive Voltage Transformers (IVTs) and Combos

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Power Quality Products

Voltage level	Segment	Products and solutions			
130 - 800 kV	Generation and transmission	 Capacitor units	 Capacitor banks	 Passive filters	 HV surge arresters
40 - 130 kV	Energy intensive industry	 Capacitor units	 Capacitor banks	 Passive Filters	 HV surge arresters
1- 40 kV	Industry and large commercial	 Capacitor units	 Modular capacitor banks	 Pole mounted capacitor banks	 MV surge arresters
0.4- 1 kV	Small industrial, commercial and residential	 Capacitors	 Automatic capacitor banks	 Stepless reactive power compensators	 Active harmonic filters

Profile

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Hitachi Energy Bangpoo Factory, Samutprakarn, Thailand

Started 1990

- ISO9001 & ISO14001 & ISO 45001 certified

Activities

Manufacture LV Capacitor elements

- Assembly LV Capacitor units
- Assembly LV & HV Capacitor banks
- Solution providers of PQ, LV/MV/HV Capacitors/Filter
- Engineering & Services
- Marketing & Sales

Customers

- Thailand: LV/MV/HV Capacitors and PQ solutions to industries and utilities
- Export: CLMD to ID, PH, MY, SG, VN, AU, MM, LA, KH, KR and IPE to CN, IN, BE, TR, GR, TW, BR, CA, MXp
- Export: LV PQ solutions to ID, PH, MY, VN, KR, LA, MM, KH and MV Capacitors for flexible sourcing KR, MY, ID, PH, VN

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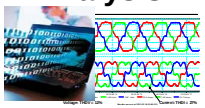
Power Quality Center (Thailand)

01 Measurement

02 Analysis



03 Design

04 Product / Solution

05 Training

06 Services

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Introduction

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LV / MV Capacitor bank

- Key Applications
  - Mining
  - Heavy industry
  - Pulp & Paper
  - Cement
  - Plastics
  - Petro-Chemical
  - Oil & Gas
  - Renewable energy resource

MV reactive power compensation solutions

33 kV Detuned
For Industry

22 kV Detuned
For Wind Farm

22/33 kV C-Bank, PEA
For utility grids

11 kV Detuned
For Petro-Chemical plant

12/24 kV C-Bank, MEA
For utility grids

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HV Open-rack capacitor bank

The grid needed to be strengthened to meet the need for improved transmission capacity

115 kV C-Bank, PEA

For utility grids

230 kV C-Bank, EGAT

For utility grids

115 kV C-Bank, EDC

For utility grids

115 kV C-Bank, EGAT

For utility grids

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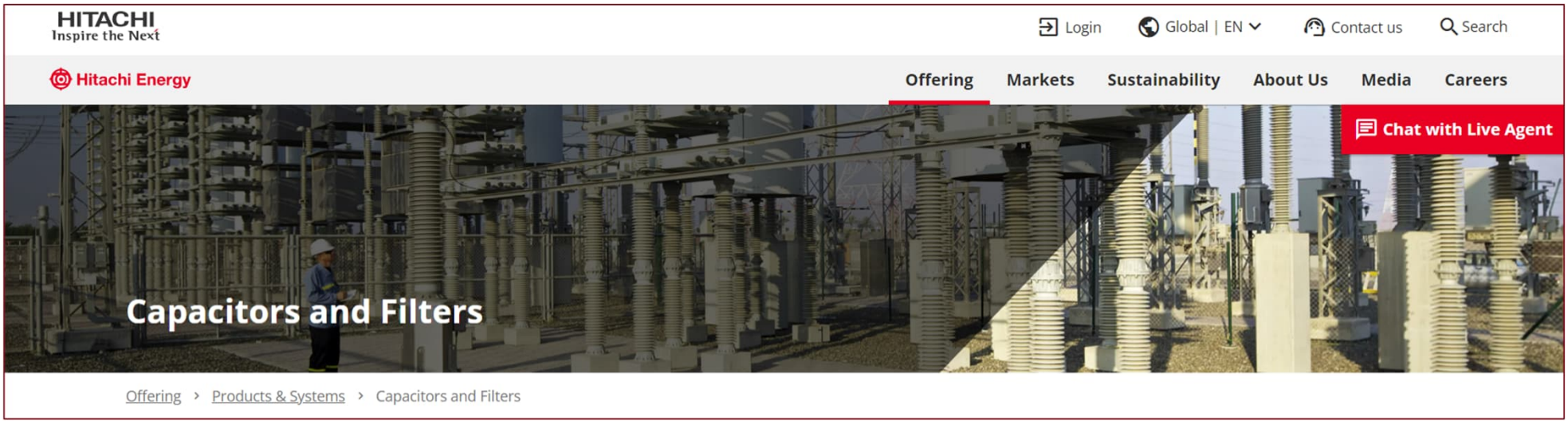
Read more …



https://www.hitachienergy.com/offering/product-and-system/capacitors-and-filters

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Q & A

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