ENERTECH

ONE-STOP SERVICE ▪ Harmonic diagnosis & consulting ▪ Harmonics attenuation transformer ▪ Harmonic filter ▪ Earthquake-proof transformer ▪ ESS

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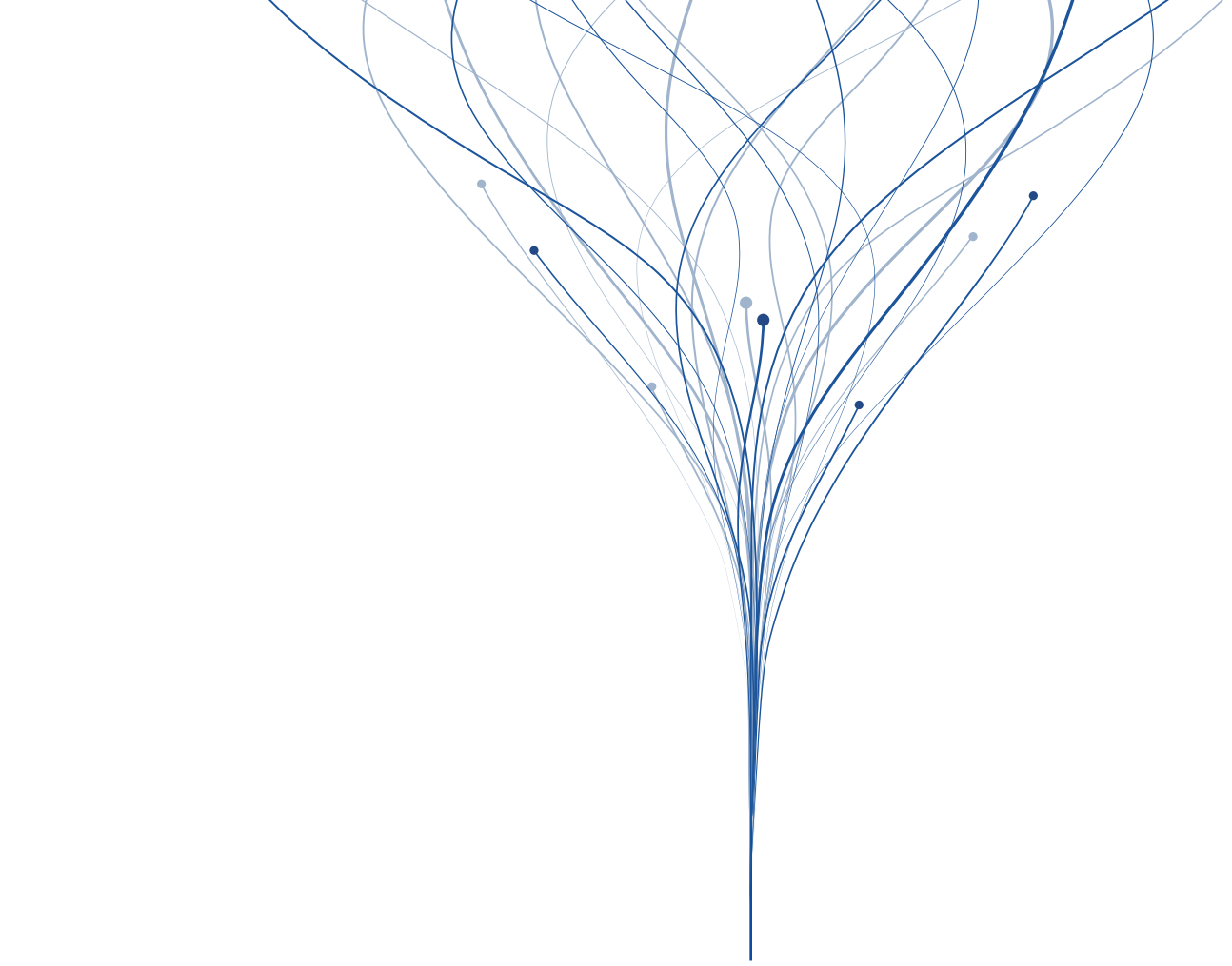
5 power generation companies under KEPCO

Joint R&D New product

한국동서발전㈜ 한국서부발전㈜ KOMIPO 한국중부발전 KOEN 한국남동발전 한국남부발전㈜



ENERTECH

INNOVATIVE ENERGY SOLUTION

CARBON NEUTRALITY & ESG MANAGEMENT PARTNERS

ONE-STOP SERVICE

- Harmonic diagnosis & consulting
- Harmonics attenuation transformer
- Harmonic filter
- ESS
- Earthquake-proof transformer

enertech

Carbon Neutrality & ESG Management Partners

ENERTECH

Based on know-how accumulated for more than 20 years
in the field of **harmonics and power quality,**
Enertech Co., Ltd. provides **one-stop service** from
harmonics diagnosis ▶ solution provision ▶ maintenance and A/S.

ONE-STOP SERVICE

01

DIAGNOSIS & CONSULTING

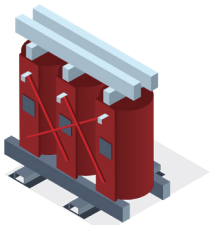
Harmonic diagnosis

Harmonic diagnosis · analysis
Electric power quality & Efficiency improvement
Energy-saving consulting

02

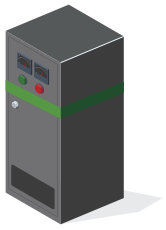
PROVIDING SOLUTIONS

Harmonics attenuation transformer



Hybrid transformer
Earthquake-proof transformer
High efficiency transformer

Harmonic filter



Hybrid harmonic filter
Active filter
Passive filter

03

MAINTENANCE & A/S

ESS

For peak power reduction
For solar power system Connection
For replacement of Emergency generator

CONTENTS

HYBRID
TRANSFORMER

5 power generation companies under KEPCO
Joint R&D New product

HYBRID Cast-resin Transformer

HYBRID Oil-immersed Transformer

It is an all-in-one transformer with the function of killing three birds with one stone having **transformer function & harmonics reduction & unbalance improvement function**, while holding the industry's first green certification, contributing to carbon neutrality.

- **Purpose** Distribution transformer
- **Type** Cast-resin / Oil-immersed
- **Efficiency** Standard consumption efficiency (high efficiency)
- **Insulation** Cast-resin (Type B or F), Oil-immersed (Type A)

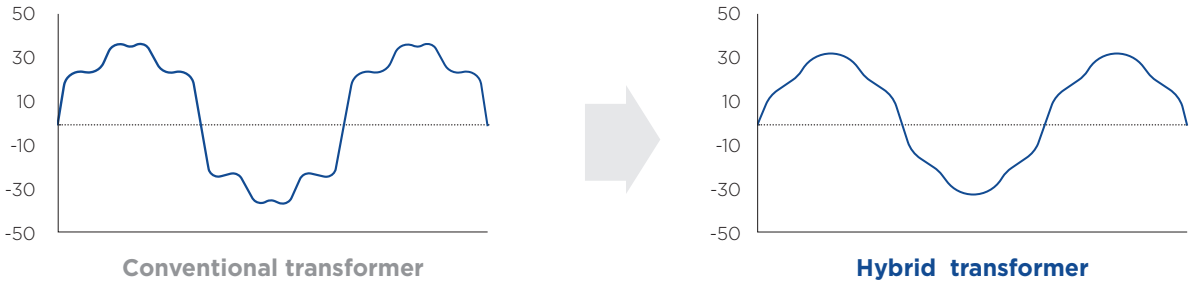
Patent & Certification

- New Excellent Technology (NET), Green Technology
- Korea Government Excellent Product · Performance certification · High efficiency certification
- **Patent registration** in Korea, USA and China
- Selected as a **priority purchase product** for public institutions
- **Developed and commercialized products for the first time** in the industry

Expected Effects

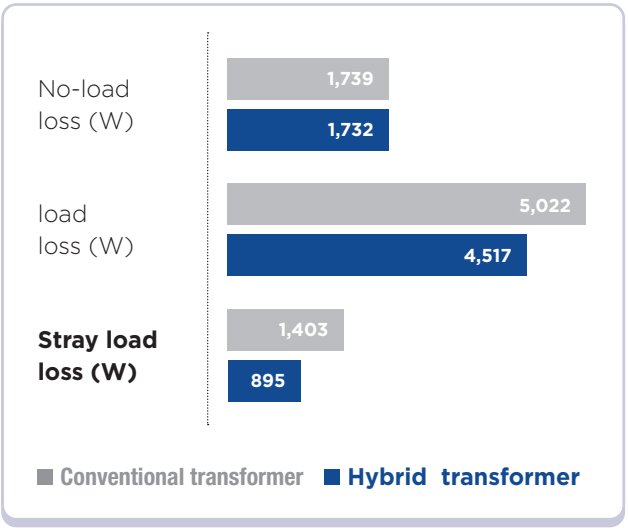
Hybrid transformers reduce harmonic waves, power loss, and winding temperature,
reducing LCC(Life Cycle Cost) costs by 15~20% compared to conventional transformers.

01. **Improved power quality** by reducing harmonics by 36-70%



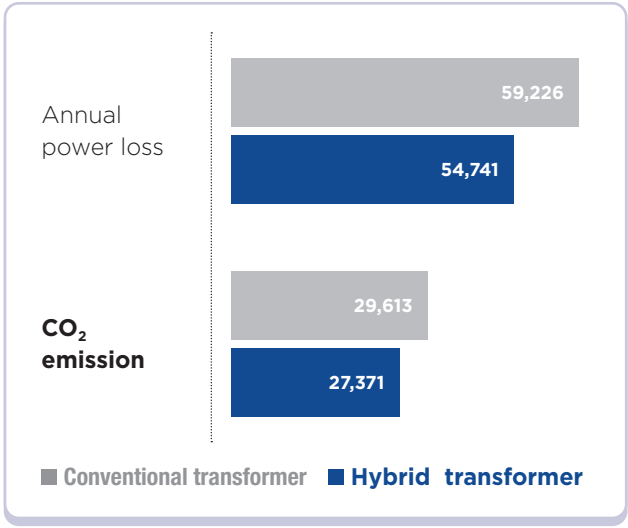
02. The winding temperature is reduced by 8~13%, which **extends the life of the transformer.**

03. **Up to 7.6% reduction in transformer losses** due to reduced stray load loss



※ Total Loss = No Load Loss + Load Loss

04. **Reducing carbon emissions 2,243kg per year** due to reduced power loss

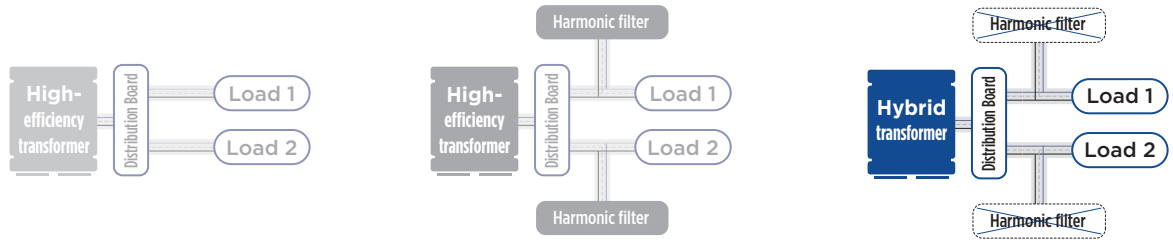


※ The data distributed by the NIFoS November 2013 applies "standard carbon absorption of major forest species"

Competitor Comparison

The hybrid transformer reduces **investment costs by 30~35% and power loss by 5~7%** compared to the installation method of 「Transformer + Harmonic filter」.

01. Installation Drawing



High-efficiency transformer | Transformer + Harmonic filter | **Hybrid transformer**

02. Investment Cost (Unit: million)

Transformer: Mold TR 1,500kVA standard/Consumer Price Information and Pricing (Company L, E)
Harmonic filter: Active filter (Company S) 200A*2EA/THD 25% design standard

03. Maintenance Cost (Unit: million)

Total Cost: Actual Consumption + THD Loss | Load: (60% × 14h) + (30% × 10h)
THD: 25.5% | Cost: 115₩ | LCC(Life Cycle Cost): 20year

04. Annual Savings (Unit: million)

Maintenance cost savings compared to high-efficiency TR

05. Payback Period (Unit: million)

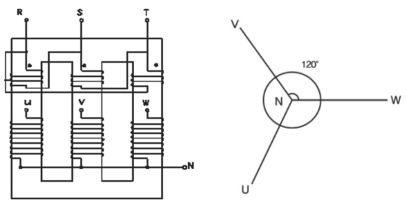
Investment cost increase ÷ Annual savings

※ The investment cost and payback period may differ depending on the capacity and specifications of the transformer.

Core Technology Comparison

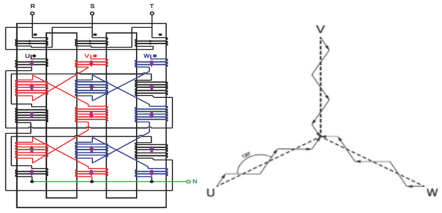
The hybrid transformer **reduces harmonics and minimizes power loss** through the patented Zig-Zag Winding.

01. **Harmonic wave attenuation** by applying Zig-Zag Winding patented technology



Conventional transformer
Normal Winding

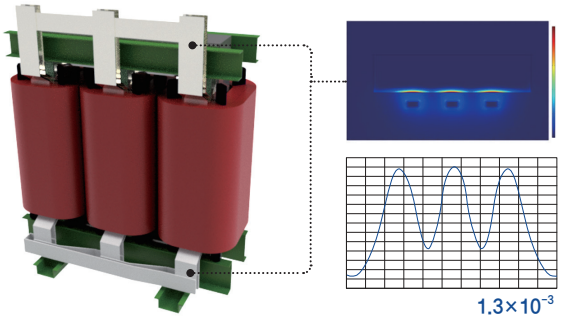
Maintaining 120° phase difference with forward turns ratio structure in each phase ▸ Harmonic attenuation ×



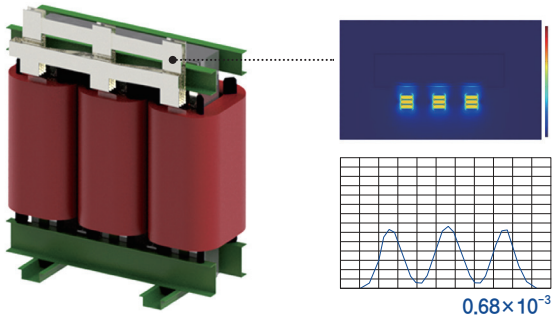
Hybrid transformer
Zig-Zag Winding

30° phase control with forward and reverse Zig-Zag winding structure in each phase ▸ Harmonic attenuation ○

02. **Reduced stray load loss** by optimizing the lead wire design

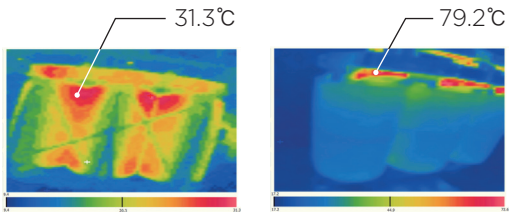


Conventional transformer

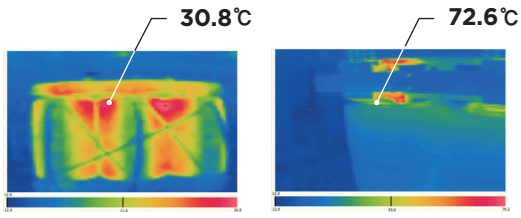


Hybrid transformer

03. **Reduced hot-spot temperature** by enhancing the tie-plate structure



Conventional transformer



Hybrid transformer

Thermal imaging camera measurement ▸▸▸ 8.3% reduction in hot-spot temperature
*KERI temperature rise test ▸▸▸ 13.3% reduction in LV winding temperature

* KERI : The Korea Electrotechnology Research Institute

Necessity

The proliferation of non-linear electrical loads like LEDs, inverters, UPS, and electric vehicle chargers has increased harmonic waves and electrical damage risks. **A harmonic filters or Hybrid transformers are essential** for safeguarding against these issues and optimizing efficiency.

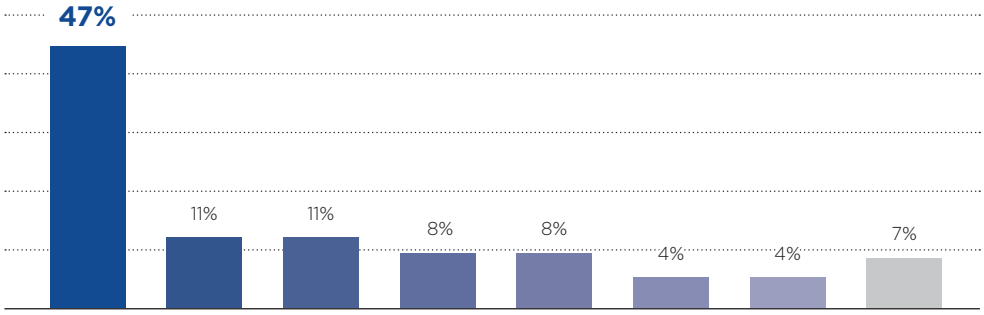
Harmonic source

※ Source : KEPCO「Distribution System Harmonic Management Standards」

Device	Types of circuits
DC subway substation, electrochemical, etc.	3 phase bridge
Alternating-current electric railway vehicle	Single phase bridge
General-purpose inverters, elevators, refrigeration and air conditioners, etc.	3 phase/Single phase bridge
UPS, Power supply for communication, distributed device for grid connection	3 phase/Single phase bridge (PWM control)
Reactive power compensator (SVC), lighting device, heater	rnating current power controller
Electric motors (for rolling, cement, AC railway vehicles)	Cyclone converter
For steelmaking	Alternating current arc furnace
etc. (LED, induction, Electric vehicle charging device)	-

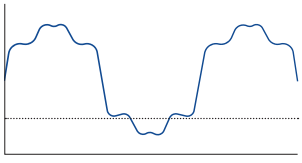
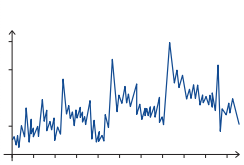
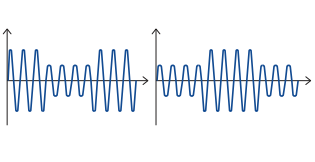
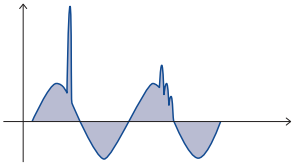
Power quality disruption factors

Harmonics are the main cause of deteriorating power quality and cause electrical accidents such as equipment failure, malfunction, and shortened lifespan. Therefore, measures to reduce harmonics are important to improve power quality.



※ Source : Japanese Electrical Society Technical Report No. 581

Harmonics
Black out
Flicker
Sag
Transient
Voltage fluctuations
Unbalance
etc.

Type	Harmonics	Flicker	Sag & Swell	Transient / Over Voltage
Waveform				
Occurrence Time	Sustainability	> 0.2s (0.5 Cycles)	8ms - 3s (0.5 - 180 Cycles)	> 3s (> 180 Cycles)
Cause	Nonlinear load	Welding, Arc furnace	Inrush current, Short circuit, Lightning strike, Switching, Large load	Lightning strike, Short circuit, Motor, Condenser, Arc furnace, Compressor
Effect	Increase in losses, Decrease in efficiency, Overheating, Noise, Malfunction	Flickering lights, Eyestrain, Trigger	Relay burned out, Device shutdown, Motor RPM	Circuit breaker trip, Malfunction, Burnout of controller

Harmful Effects of Harmonics

Harmonics cause **various forms of damage** such as increased loss, heat, noise, and malfunction in the power system and various electrical facilities.

Effects on Transformers

01. Increased Eddy current loss ▸▸▸ Increased iron loss

Iron loss increase rate

$E_1 = (W_i / W_{i1}) \times 100\ [\%]$

$W_i = (K_1 \times E_a^m) + \{K_2 \times (K_f \times E_a)^2\}$

W_i : Iron loss
W_{i1} : Core loss during excitation of the fundamental wave voltage
Ea : Average value of excitation voltage including harmonics
m : Essence of Steinmetz (Around 1.6 to 2.5)
k_f : Excitation voltage waveform factor including harmonics
kf >1, In case of fundamental wave only kf = 1
K_1, K_2 : Integer

※ Hysteresis loss and eddy current loss increase due to harmonic current

02. Skin effect ▸▸▸ Copper loss increase

Copper loss increase rate

$E_C = (W_C / W_{C1}) \times 100\ [\%]$

$W_{C1} = I_1^2 \times R \times (1 + \beta)$

$W_C = W_{C1} + I_1^2 R \times \sum_2^n \alpha^2_n (1 + \beta \times n^m)$

W_{C1} : Copper loss at fundamental wave current I_1
R : Series resistance of the windings
β : Stray loss coefficient for fundamental wave
W_c : Copper loss at the time of harmonic inflow
n : Harmonic order
α_n : I_n / I_1 = nth order wave content rate
m : coefficient (m = around 1.6 ~ 2.0)

※ Skin Effect-Induced Copper Loss Increase

03. Capacity reduction ▸▸▸ 64% Output reduction

Three - phase load

$$THDF = \sqrt{\frac{P_{LL\text{-}R}(pu)}{P_{LL}(pu)}} \times 100\ [\%]$$

$P_{LL\text{-}R}(pu) = 1 + P_{EC\text{-}R}(pu)$
$P_{LL}(pu) = 1 + (K\text{-factor} \times P_{EC\text{-}R}(pu))$
$P_{EC\text{-}R}$: Eddy current

■ In case of K-factor 13
(Mold TR-Eddy Current Loss = 14%)

$$THDF = \sqrt{\frac{1 + 0.14}{1 + 13 \times 0.14}} \times 100 = 64\ [\%]$$

04. Winding temperature ▸▸▸ Increase 39%

Transformer winding temperature rise

$\Delta\Theta_o = \Delta\Theta_1 \times (I_e / I_1)^{1.6}$

Ex.) In case of fundamental wave current 650A, ITHD 48%
Since the equivalent current (IRMS) including harmonic current is 800A, the transformer temperature rise in this case is as follow

$\Delta\Theta_o = \Delta\Theta_1 \times (800/650)^{1.6} = \Delta\Theta_1 \times 1.394$

I_1 : fundamental current
I_e : Equivalent current including harmonic current
$\Delta\Theta_1$: Winding temperature rise due to fundamental current
$\Delta\Theta_o$: Temperature rise of oil-immersed transformer

※ The winding temperature increased by about 39% compared to the temperature rise due to the fundamental wave current

Impact on power system and electrical facilities

※ Source : Power Quality Technology Co., Ltd.

Immediately · Short term		Mid · Long-term
· Resonance caused by voltage and current, power factor reduction	· Malfunction of precision control device	· Reduce motor and transformer life
· Decrease in power generation	· Increased facility noise and vibration	· Acceleration of deterioration of dielectric materials and insulation materials
· Neutral over current	· Current and voltage distortion	· Rising economic costs
· Overcurrent of cables, transformers, generators, power capacitors	· Induced disturbance of telephone and communication lines	
· Unpredictable shutdown of the protection system	· Overdesign (wires, transformers, power capacitors)	

Transformer	Wires and conductors	Rotating machine	Capacitor for power	Overcurrent	Circuit breaker · Other
· Power quality technology	· Overheating	· Overheating	· Overheating	· Abrupt stop	· Ampacity reduction
· Overheating, increased noise	· Corona outbreak	· Decrease in efficiency	· Over-resonance	· Inaccurate measurement	· Noise, Vibration
· Capacity reduction	· Neutral over current	· Shortened device lifespan	· Overcurrent	· Non-integer harmonic generation	· Acceleration of life deterioration
· Insulation breakdown	· Capacity reduction	· Tog uneven	· Overvoltage insulation explosion	· Malfunction	· Drop in power factor
	· Insulation breakdown	· Vibrational torque		· Frequent part failure	· Decreased fuse capacity
	· Skin Effect				· Signal, communication failure

Harmonics Standards

To prevent against electrical damage caused by harmonics, 「Harmonics standards」 are being enforced globally.

Korean Standards

MOLIT – Incoming transfer facility design criteria

▪ Revision of building electrical equipment design standards

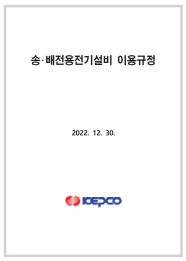
· Legislation: Article 44 of the Construction Technology Promotion Act and Article 65 of the Enforcement Decree of the same Act
· Criteria : Building electrical equipment design standards (KDS 31 60 10 : 2019)
· Review : Public announcement
· Notification: **October 11, 2019 (molit Notice No. 2019-549)**

Field	Incoming transfer facility
Before mendment	Transformers are selected in consideration of the place of use, economic feasibility, and electrical characteristics, but when installed inside a building, a transformer with more than standard consumption efficiency should be used.
After mendment	When selecting a transformer, the place of use, load characteristics, efficiency, safety, etc. must be considered, and a standard efficiency transformer is used. However, **in the case of facilities with a high harmonic generation load ratio, a transformer with harmonic attenuation function or a transformer with equivalent or better** performance can be used to improve power quality and reduce power loss.

KEPCO – Regulations on the use of electric facilities for transmission and distribution

▪ KEPCO harmonic regulation

· Regulation : Regulations on the use of electric facilities for transmission and distribution (July 01, 2019) and enforcement rules (December 16, 2019)
· Content : **Harmonics (THD) acceptance criteria and protection device installation**
· Subject : Users of electric furnaces and electric railways (mandatory application)



International Standards

IEC 61000 Harmonic Standard

Table. Allowable current ampacity by equipment

Harmonics (n)	Equipment Classification			
	Balanced 3-phase equipment, Tools, sound equipment, Household appliances (A)	Portable device, Arc welding machine (A)	Lighting equipment (A)	PC, Monitor, TV, , Refrigerator, Freezer (Under 600W) (A)
Odd Harmonics				
3	2.30	3.45	30 X Power factor	2.30
5	1.14	1.71	10	1.14
7	0.77	1.155	7	0.77
9	0.40	0.60	5	0.40
11	0.33	0.495	3	0.33
13	0.21	0.315	3	0.21
15 ≤ n ≤ 39	0.15 × 15/n	0.225 × 15/n	3	0.15 × 1 5/n
Even Harmonics				
2	1.08	1.62	2	-
4	0.43	0.645	-	-
6	0.30	0.45	-	-
8≤ n ≤40	0.23 × 8/n	0.345 × 8/n	-	-

IEEE Std. 519 Standard for Harmonic

Table 1—Voltage distortion limits

Bus voltage V at PCC	Individual harmonic (%)	Total harmonic distortion THD (%)
$V \le 1.0$ kV	5.0	**8.0**
1 kV < $V \le 69$ kV	3.0	**5.0**
69 kV < $V \le 161$ kV	1.5	**2.5**
161 kV < V	1.0	**1.5**[a]

a High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal whose effects will have attenuated at points in the network where future users may be connected.

Table 2—Current distortion limits for systems rated 120 V through 69 kV

Maximum harmonic current distortion in percent of I_L						
	Individual harmonic order (odd harmonics)[a,b]					
I_{sc}/I_L	$3 \le h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h \le 50$	TDD
< 20[c]	4.0	2.0	1.5	0.6	0.3	**5.0**
20 < 50	7.0	3.5	2.5	1.0	0.5	**8.0**
50 < 100	10.0	4.5	4.0	1.5	0.7	**12.0**
100 < 1000	12.0	5.5	5.0	2.0	1.0	**15.0**
> 1000	15.0	7.0	6.0	2.5	1.4	**20.0**

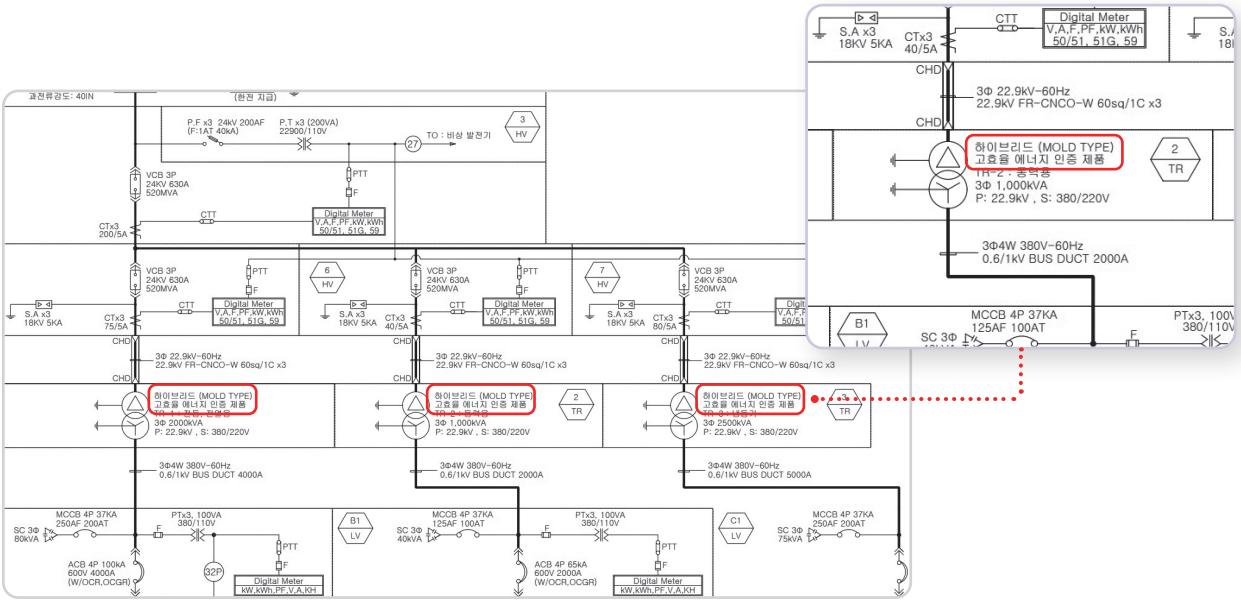
a Even harmonics are limited to 25% of the odd harmonic limits above.
b Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.
c All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L

where
I_{sc} = maximum short-circuit current at PCC
I_L = maximiun demand load current (fundamental frequency component) at the PCC under normal load operating conditions

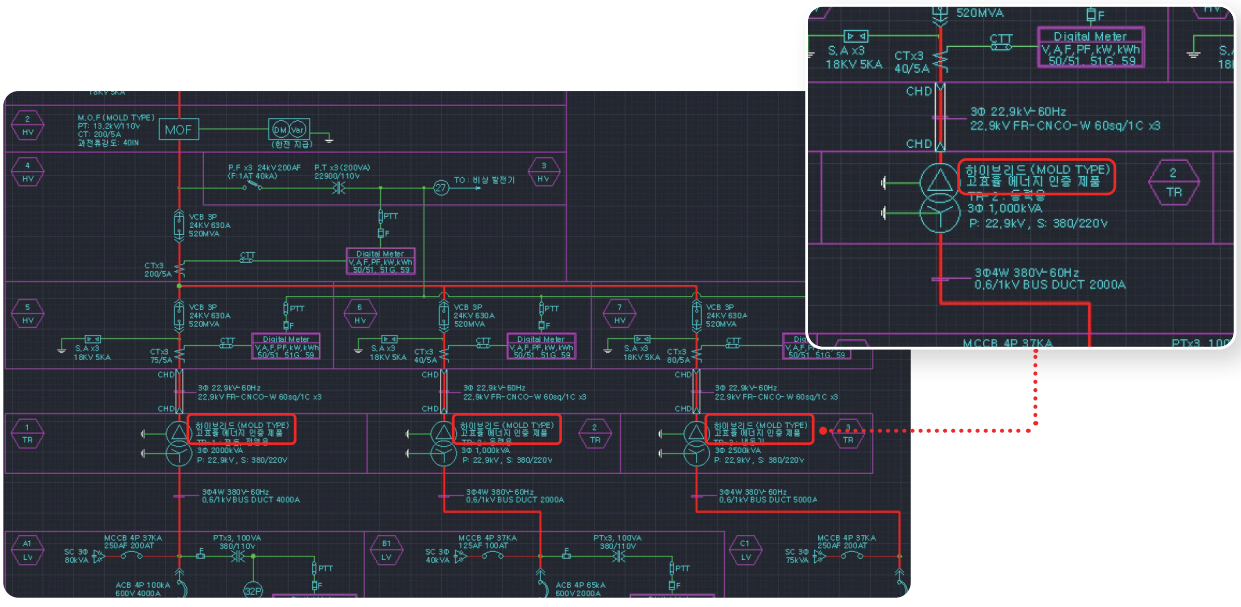
Design / Specification Application Examples

· The design application and specifications are simple, minimizing the engineer's working time.
· We offer technical seminars and design resources to approximately 30 metropolitan-area design firms.

Application case 01



Application case 02



Installation Cases

Korea Airports Corporation (Gimpo Airport)

Harmonic Reduction **45.8%**, Unbalance Improv. **98.3%**, PF Improv. **4.2%**

Before	After	Note
High-efficiency transformer + Active Filter (1,700 kVA)	**Hybrid Transformer** (1,700 kVA)	Measures to reduce harmonics, the existing active filter was replaced with a hybrid transformer.

Harmonics (unit: %)

Before	After
15.3	8.3

Unbalance (unit: %)

Before	After
11.8	0.2

PF (unit: %)

Before	After
0.95	0.99

Ulsan Airport

Aviation lights : Harmonic Reduction **68.6%**, Unbalance Improv. **24.5%**, PF Improv. **2.4%**
General power : Harmonic Reduction **50.0%**, Unbalance Improv. **67.7%**, PF Improv. **2.9%**

Before	After	Note
High-efficiency transformer (Aviation lights & General power)	**Hybrid Transforme** (Aviation lights & General power)	Replaced to reduce harmonics in aviation lighting and general power facilities

ITHD (unit: %)

	Before	After
Aviation lights	35.3	11.1
General power	20.2	10.1

Unbalance (unit: %)

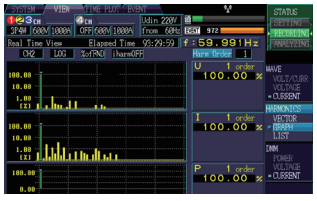
	Before	After
Aviation lights	5.3	4.0
General power	35.6	11.5

PF (unit: %)

	Before	After
Aviation lights	90.1	92.3
General power	95.5	98.3

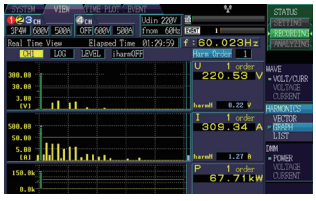
Before/After - Aviation lights

Before Installation
High efficiency mold 150 kVA

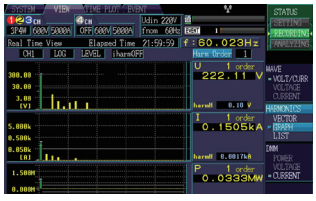


After Installation
Hybrid Oil type 2000 kVA

Before/After - General power



Before Installation
High efficiency mold 600 kVA



After Installation
Hybrid Oil type 750 kVA

Korea Expressway Corporation (Tunnel LED)

Harmonic Reduction **49.1%**, Unbalance Improv. **1.0%**

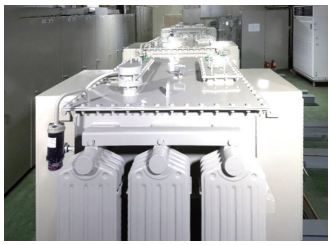
Before	After	Note
High-efficiency transformer (200 kVA)	**Hybrid Transformer** (200 kVA)	Measures to reduce harmonics in tunnel LED loads

Category	High-efficiency transformer (Before)			Hybrid Transformer (After)			Reduction rate (%)		
	LED Dimming			LED Dimming			LED Dimming		
	15%	50%	100%	15%	50%	100%	15%	50%	100%
Voltage(V)	376	375	375	**377**	**377**	**377**	△0.3	△0.5	△0.5
Current(A)	62	105	166	**51**	**89**	**156**	▼17.7	▼15.2	▼6.0
Real Power(kW)	34	65	106	**30**	**56**	**101**	▼11.8	▼13.8	▼4.7
Apparent Power(kVA)	40	68	108	**33**	**58**	**102**	▼17.5	▼14.7	▼5.6
PF	0.85	0.95	0.98	**0.90**	**0.97**	**0.99**	**△5.9**	**△2.1**	**△1.0**
V_THD(%)	1.8	1.5	1.5	**1.5**	**1.6**	**1.4**	**▼16.7**	**△6.7**	**▼6.7**
I_THD(%)	17.1	8.3	5.7	**13.9**	**7**	**3.1**	**▼18.7**	**▼15.7**	**▼45.6**
I_TDD(%)	6.5	4.8	5.3	**4**	**3.5**	**2.7**	**▼38.5**	**▼27.1**	**▼49.1**

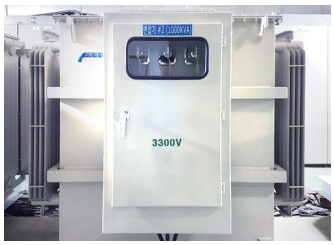
※ Real-time power analysis according to LED dimming ratio (15, 50, 100%)

OO Factory (Inverter Load)

1,500 kVA : Harmonic Reduction **47.1%**, Unbalance Improv. **39.4%**, PF Improv. **3.2%**
1,000 kVA : Harmonic Reduction **58.7%**, Unbalance Improv. **51.7%**, PF Improv. **10.8%**



Hybrid Oil type 1,000 kVA



Hybrid Oil type 1,000 kVA

Hybrid Oil type 1,000 kVA

Hybrid Oil type 1,500 kVA

Category	1,500 kVA			1,000 kVA		
	Before	After	Rate of Change(%)	Before	After	Rate of Change(%)
V_THD(%)	1.4	**1.1**	**▼ 21.4**	1.3	**1.1**	**▼ 15.4**
I_THD(%)	5.1	**2.7**	**▼ 47.1**	13.8	**5.7**	**▼ 58.7**
V_Unb(%)	0.7	**0.3**	**▼ 57.1**	0.7	**0.2**	**▼ 71.4**
I_Unb(%)	10.4	**6.3**	**▼ 39.4**	6	**2.9**	**▼ 51.7**
PF(%)	86.4	**89.2**	**△ 3.2**	73.3	**81.2**	**△ 10.8**

Performance

Government Agency / Public Institution


Government Complex Sejong


Institute of Justice


Judicial Research and Training Institute


Suwon District Court


Suwon High Prosecutor's Office


Sejong Government Complex Multipurpose Facility


Comprehensive Medical Complex


Korean National Police University


Pangyo Techno Valley Global R&D Center


Jincheon National Training Center


Korea Water Resources Corporation


Korea Rural Community Corporation


Korea Gas Corporation


Korea National Oil Corporation


Korea Expressway Corporation


Agency for Defense Development


National Health Insurance Service


Korea Coal Corporation


KRC Gyeonggi Regional Office


Seoul Main Customs Office


Suwon District Court Integrated Building


Suwon Convention Center


Gyeonggi-do Provincial Government


Jecheon Art Center


Pangyo Creative Economy Valley


Gyeongsangbuk-do Provincial Government


Korea Electric Power Corporation


Sejong Center for the Performing Arts


NTS Jungbu District Office


NTS Seodaemun District Office

Major Company

POSCO

Samsung SDS

Doosan Enerbility

Ssangyong C&E

Ssangyong C&B

Haitai

Nongshim

SHINHAN BANK

Jeonju Paper

KT&G Sintanjin Factory

We have successfully delivered our products to **more than 700 critical facilities, including airports, government agencies, large corporations**, and power plants etc.

Airport / Power Plant / LH Corporation

Airport International Terminal
Gimpo

Airport Cargo Terminal
Gimpo

Airport
Ulsan

Airport
Gimhae

Airport
Cheongju

Thermal Power Plant
Dangjin

Thermal Power Plant
Honam

Thermal Power Plant
Donghae

Combined Power Plant
Ulsan

Thermal Power Plant
Samcheonpo

LH Headquarters
Jinju

LH Innovation City
Chungbuk

LH New Town
Uijeongbu

LH New Town
Namyangju

LH New Town
Gwanggyo

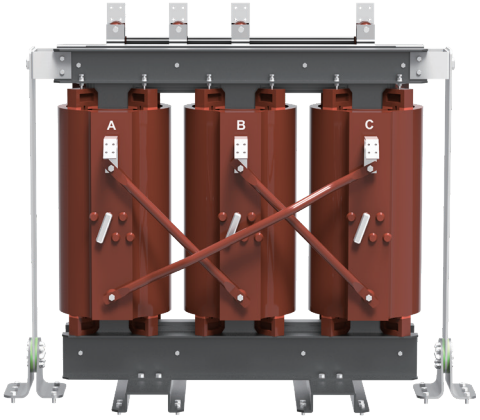
EARTHQUAKE-PROOF TRANSFORMER

Industry-leading

0.8g class seismic transformer

특허청

SEISMIC Cast-resin Transformer

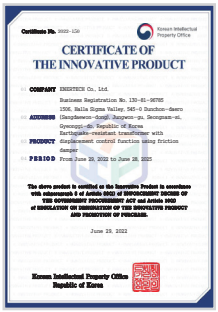


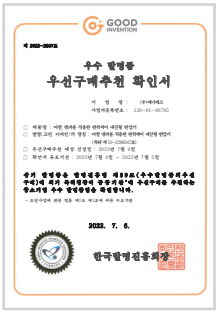
SEISMIC Oil-immersed Transformer

As a transformer with **the industry's best seismic performance that can withstand an earthquake** of magnitude 8.6, it is a product whose technological excellence has been verified, such as **Korea Government Excellent Product, innovative products, and performance certifications**

- **Purpose** Distribution transformer
- **Type** Cast-resin / Oil-immersed
- **Efficiency** Standard consumption efficiency (high efficiency)
- **Insulation** Cast-resin (Type B or F), Oil-immersed (Type A)

Patent & Certification





- **Designated as an Korean Innovative Product by the Public Procurement Service** for the first time in the industry
- **Korea Government Excellent Product**
- Ministry of Land, Infrastructure and Transport 「**Securing seismic performance technology**」 R&D performance
- **Excellent Performance Certification**
- **Patent registration in Korea, USA and China**

Technology & Expected Effects

01. More than 0.8g of seismic performance by applying rotary friction damper (patent 10 - 2286047)

By applying friction damper technology, it has the industry-leading level of seismic resistance of over 0.8g, and has improved seismic performance by **60%** compared to existing transformers.

02. Seismic displacement-controlled within 50mm by applying a support frame

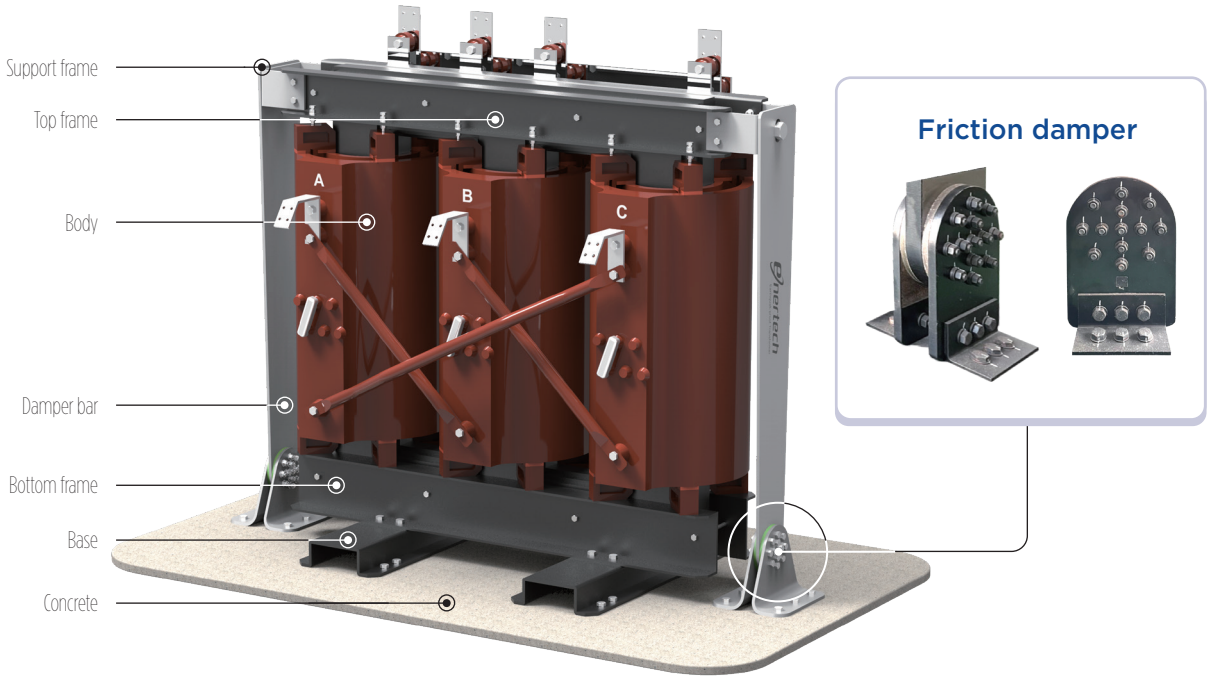
The support frame technology reduces seismic displacement in the Y-direction by up to **90%** compared to conventional transformers.

03. 20% reduction in LCC cost by minimizing installation time & space

Economical with a **20%** reduction in Life Cycle Cost (LCC) achieved through decreased manufacturing costs, installation time, and space compared to competitors' products.

Rotary friction damper and rotational moment (Mp) optimization design

· Structural design optimized for transformer structure and load (0.5 ~ 20 tons)
· Design drawing considering the dynamic characteristics (natural period, response acceleration, response displacement) and behavior characteristics of the transformer
· Optimizing two types of friction dampers for commercialization, considering construction convenience, space/time minimization, and economic feasibility.



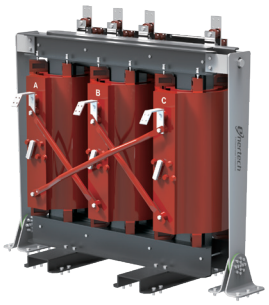
Competitor Comparison

· Compared to competitors recognized as 'Korea Government Excellent Products' as of May 2023, our seismic transformers demonstrate excellence in the following areas:

01. Product Image

Company A

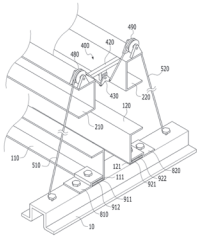
Company B



Our Company

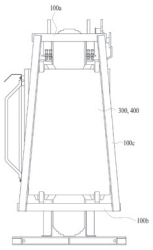
02. Core Technology & Features

Company A rolling wire



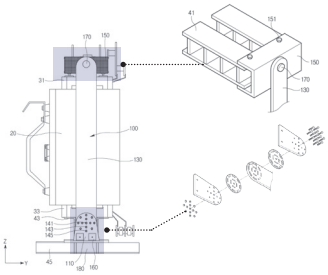
Structural modifications raise manufacturing costs and decreasing durability.

Company B steel support



Excellent durability, but increased installation space and time.

Our Company friction damper



Excellent durability, workability, and reduced installation area.

03. Seismic Performance

Company A	Company B	Our Company
0.5g	0.55g	0.88g

※ Based on the standards of each company's certified test report and 'Korea Government Excellent Product' specifications.

04. Seismic Displacement

Company A	Company B	Our Company
-	-	19mm

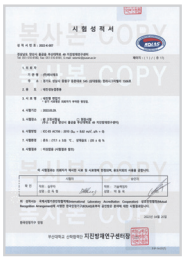
※ In the case of A and B companies, seismic displacement test was not conducted.

KOLAS Certified Test Report

01.

02.

03.



- **Test standard :** **ICC ES AC 156 standard**
- **Test samples :** 3 types of seismic restraint transformers (750 kVA, 1,500kVA, 3,000 kVA)
- **Testing agency :** SGS Korea, Earthquake Disaster Prevention Research Center

01. 750 kVA certified test report (SGS Korea)
02. 1,500 kVA certified test report (Earthquake Disaster Prevention Research Center)
02. 3,000 kVA certified test report (Earthquake Disaster Prevention Research Center)

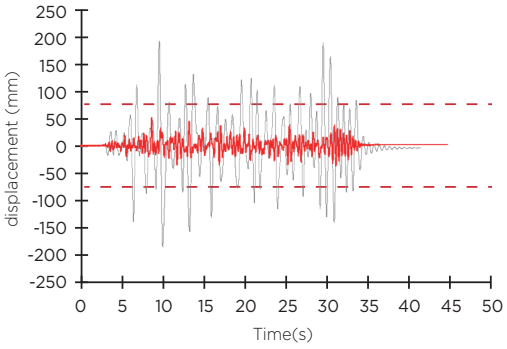
Evaluation items	Unit	750 kVA	1,500 kVA	3,000 kVA	Criteria	Test result
Seismic performance	g	**0.80**	**0.80**	**0.88**	0.55 or more	pass
Maximum displacement	mm	**32.7**	**25.0**	**19.0**	75 or below	pass
Amplification coefficient	a_p	**Satisfaction**	**Satisfaction**	**Satisfaction**	$1.0 \le a_p \le 2.5$	pass

■ Response Displacement

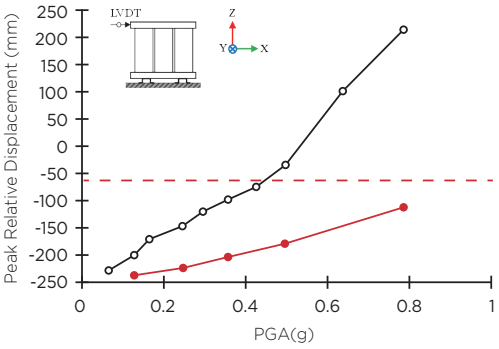
90% reduction

Existing transformer — Seismic transformer

* PGA : Peak Ground Acceleration



<Displacement-Time graph 0.8g or over level>

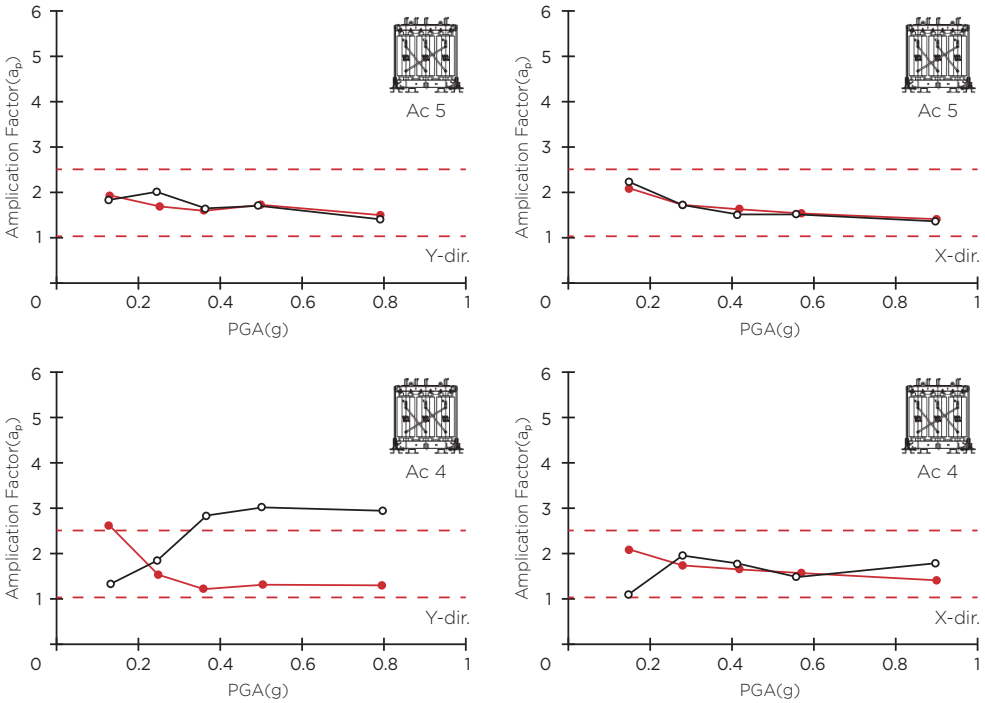


<PRD compared to PGA>

■ Amplification Factors

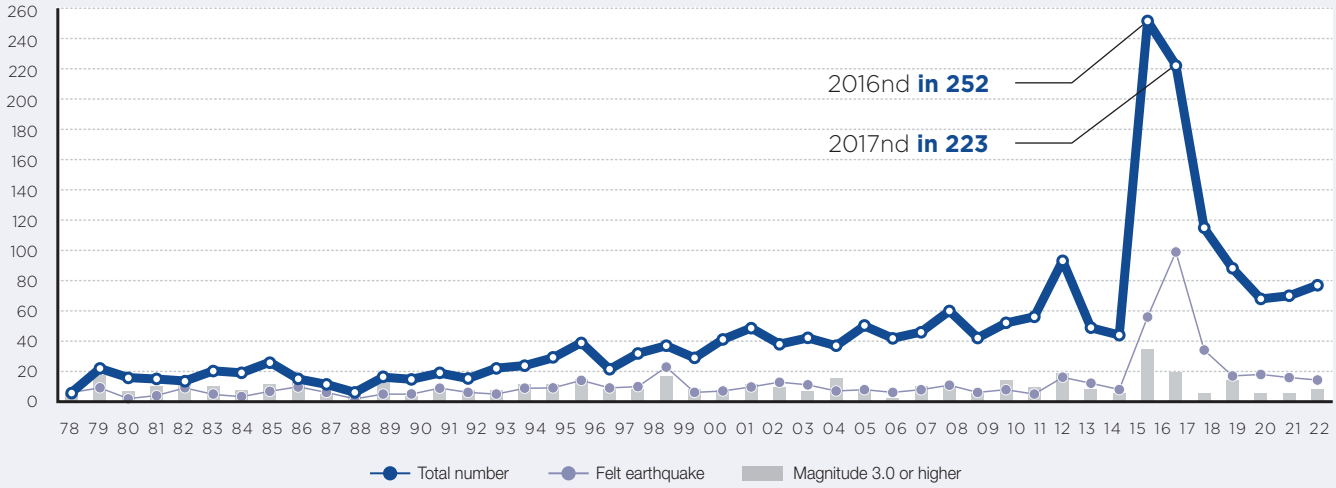
Meet the safety standards set forth in the criteria FEMA E-74 and ACSE 7-16

Existing transformer — Seismic transformer



Necessity & Thesis Presentation

Earthquake frequency and strong earthquake trend in Korea



A transformer is a critical power supply; earthquake-induced damage can result in significant secondary issues, such as power outages and fires. Hence, it's considered an **essential component of building electrical installations requiring seismic design.**

Thesis Presentation & Technology Seminar

Academic & thesis presentations

Academic presentations (6)	SCI journals (3)
2019 Spring Architectural Institute of Korea	Dinh, N. H., Lee, S. J., Kim, J. Y., & Choi, K.-K. (2020). Study on seismic performance of a mold transformer through shaking table tests. Applied Sciences, 10(1), 361.
2019 Spring Korean Concrete Institute	
2021 Fall Earthquake Engineering Society of Korea	Dinh, N. H., Kim, J. Y., Lee, S. J., & Choi, K.-K. (2019). Seismic vulnerability assessment of hybrid mold transformer based on dynamic analyses. Applied Sciences, 9(15), 3180.
2022 Spring Korea institute for Structural Maintenance and Inspection	
2022 Fall Korean Institute of Electrical Engineers (KIEE)	Lee, S. J., Park, W. I., Lee, J. E., Dinh, N. H., &Choi, K.-K. (2022, September). Hysteresis response of rotary friction dampers developed for seismic operational performance of non-structural components vulnerable to overturning. In Structures (Vol. 43, pp. 1447-1462). Elsevier.
Korea Society of Seismic Isolation and Vibration Control	

Seismic Site Classification by Seismic Magnitude Scales

· The frequency and intensity of major earthquakes are rising worldwide.

· Existing products have been verified up to 0.55g, but this is based on the minimum design acceleration of the ground floor.

· Per the Earthquake Engineering Society's research and design guidelines, **high-rise buildings often experience seismic forces exceeding 0.66g due to amplification.** Therefore, transformers installed on middle and upper floors must meet a seismic performance requirement of over 0.8g.

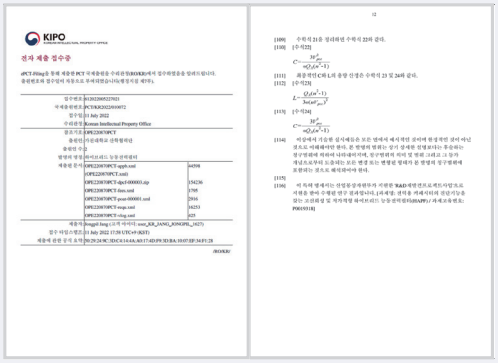
※ Source: Seismic Design Practical Guidelines for Transmission and Substation Equipment / Korea Electric Power Corporation (KEPCO), 2004

JMA (Japan Meteorological Agency)		MM (USA)	Earthquake zone (building standards)		Ground acceleration (g)	ICC ES AC 156 (m/s^2)	Richter seismometer (scale M)	note
situation	designation		KR	USA				
Record only on seismometer	0 (insensitive)	I					1	
					0.0008 0.001	0.00784 0.0098	2	
Only felt by standing or sensitive people	I (weak)	II						
		III	0	0	0.0025	0.0245	3	
Windows and lights shake	II (minor)	IV						
					0.008 0.01	0.0784 0.098	4	
The house shakes and the water in the bowl spills	III (mild)	V			0.025	0.245		
The house shakes violently and the water in the bowl spills	IV (medium)	VI	1	1	0.03	0.294		
					0.05	0.49		◂ Yeongwol Earthquake M:45 ('96.12)
The wall cracked and the tombstone is toppled over	V (strong)	VII	2	2A	0.08	0.784	5	◂ Hongseong Earthquake M:5 ('78.10) ◂ Songnisan Mountain M:5.2 ('78.9) ◂ Uljin Earthquake M:5.2 ('04.5)
					0.1	0.98		
		VIII		2B	**0.12**	**1.176**		◁ **Domestic hydro and thermal power 0.12g**
					0.14	1.372	6	
About 30% of houses were damaged, the ground cracked and landslides occurred.	VI (violent)	IX		3	**0.2**	**1.96**		◁ **Domestic nuclear power plant 0.2g**
					0.25	2.45		
							7	◂ San Francisco M:7.0 ('89.10)
			doesn't exist					◂ Gobae Earthquake M:7.2 ('95.1)
		X			0.40	3.92		◂ Taiwan Earthquake M:7.6 ('99.9)
30% or more of houses were damaged, the ground cracked and landslides occurred.	VII (very violent)							◂ India Earthquake M:7.7 ('01.1)
								◂ Türkiye Earthquake M:7.8 ('99.8)
		XI		4			8	◂ Indonesia Earthquake M:7.9 ('00.6)
		XII			0.80	7.84		◂ Kanto Earthquake M:8.3 ('23)
							9	◂ Indonesia Earthquake M:8.9 ('04.12)

HARMONIC FILTER

Ministry of Trade, Industry and Energy (MOTIE)
「**2021 R&D Rediscovery Project**」 performance

Korean Patent Certificate



PCT application

It is a new product **significantly improves economic feasibility and efficiency** compared to competitors. It **reduces maintenance costs and predicts lifespan** through a DC-Link capacitor fault diagnosis algorithm.

- **Type** HAPF-S, HAPF-M
- **Capacity** 50A ~ 400A
- **Efficiency** 95.0% more

Expected Effects

Efficiency	Response Time	Unbalance Compensation	Reactive power compensation
≥ 95%	≤ 5ms	≥ 96%	≥ 99.0%

Main Features

As a real-time device for detecting and mitigating harmonic currents generated by nonlinear loads, it saves energy and prevents electrical accidents through expected effects such as **reducing harmonics, improving unbalance, and reducing reactive power**.

01. Superior performance and efficiency

- Total Harmonic Distortion (THD) and order-specific harmonic compensation (selectable from 2nd to 50th odd orders)
- Displacement Power Factor (DPF) correction and Power Factor (PF) correction
- Real-time mitigation of harmonic currents through IGBT

02. Safety improvement with built-in Protection Circuit

- Short circuit, over voltage, overcurrent, phase sequence failure and current reverse sequence protection
- Application of DC Link capacitor fault diagnosis algorithm
- No resonance with the system
- Auto stop and reset button

03. Modular design considering expandability

- Modular structure with improved system reliability through slim design
- Implement space optimization with rack-mounted type and wall-mounted type
- System configuration optimized for 3-phase power

04. Intelligent FFT

- Unique intelligent FFT algorithm
- System impedance automatic calculation ▶ resonance prevented
- Maintaining high system reliability

05. Graphical user interface

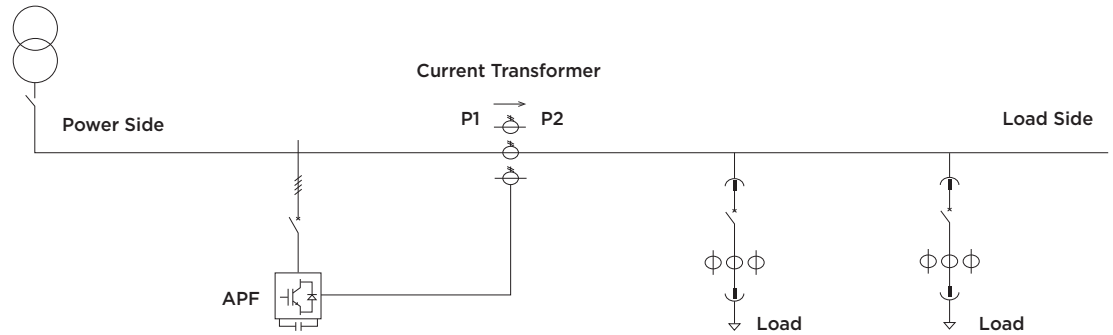
- 7 inch central HMI
- Displays voltage, current, frequency, before and after THDi, apparent/active/reactive power, etc.
- User-centered interface configuration

Technical Specifications

Module Rating	50 A	100 A
Cooling method	air cooling	
Environmental	-20 ~ 55°C	
Scalability	Up to 4 units can be connected in parallel	
CT	50:5 ~ 10000:5	
Power consumption	≤ 2.5% of rated capacity	
Efficiency	95% or above	
Air volume	≥ 200 m^3/h	≥ 500 m^3/h
Grid frequency	60 Hz ± 5%	
Grid voltage	400 V ± 15%	
Connection method	3 phase + N + PE	
Display	7 inch touch screen HMI	
Communication protocol	RS485, Modbus communication	
Protection level	IP 20	
Dimension (W×D×H)	560 × 550×190 mm	500×559×210 mm
Weight	30kg	50kg

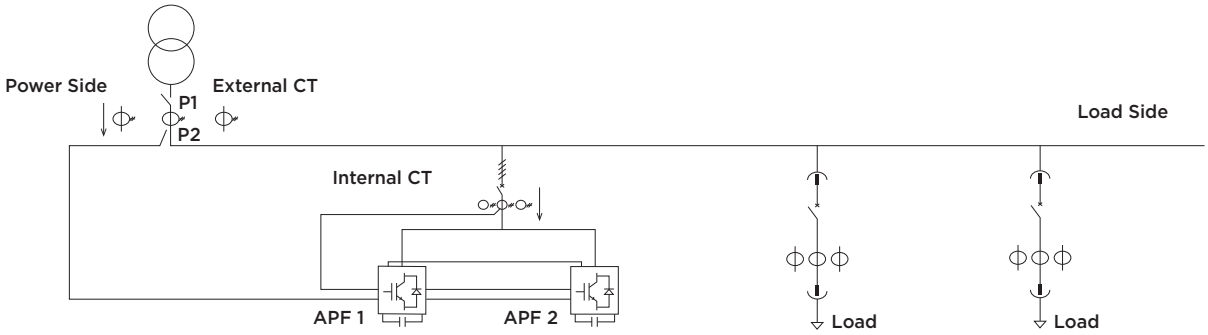
How To Install

CT is installed at load side when a single unit is in operation



※ APF = Active Power Filter

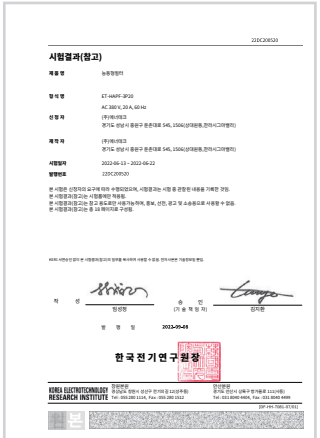
CT is installed at power side when devices are running in parallel

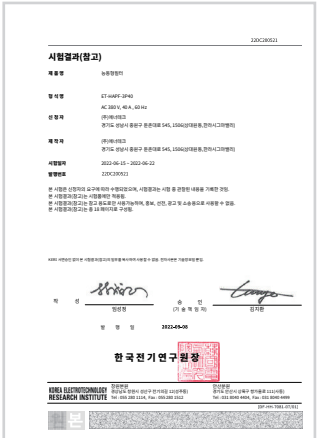


※ APF = Active Power Filter

Certified Test Report

Harmonic filter performance test and electromagnetic wave test (Korea Electrotechnology Research Institute)

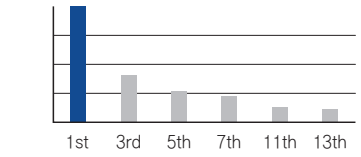


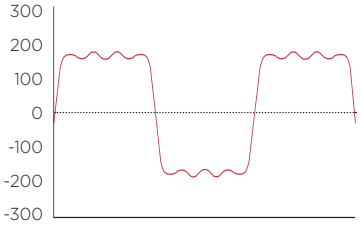


Operating Principle

01. Harmonic generation

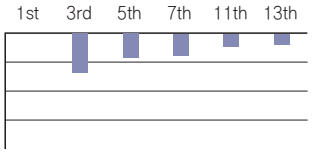
- Generation of current/voltage distortion waves
- Power quality deterioration and increase in losses
- Overheating, breakdown, reduced efficiency, shortened lifespan

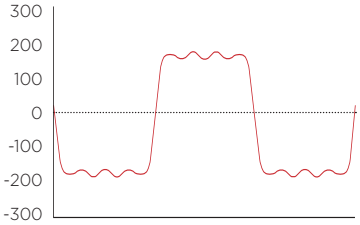




02. Harmonic filter installation

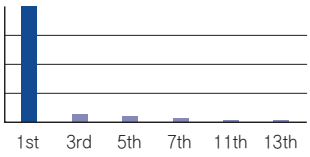
- Real-time detection of harmonic generation
- Generate out-of-phase harmonics
- Harmonic mitigation and power quality improvement

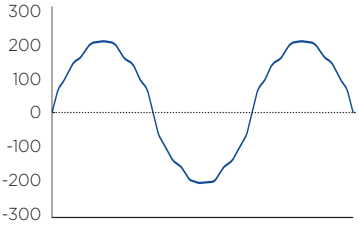




03. Installation effect

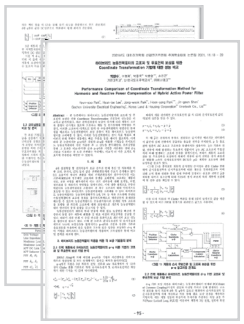
- Harmonic mitigation, power factor correction
- Maximize efficiency, accident prevention, improve lifespan
- Reduce power loss, save energy



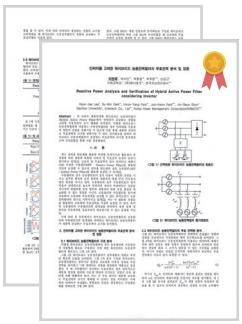


Thesis Presentation

01.



02.



Academic presentation (2 cases)

01. Selection of phase synchronization technique to improve phase tracking performance (2021.11, Fall Conference of the Korean Institute of Electrical Engineers (KIEE))

02. Performance Comparison of Coordinate Transformation Techniques for Power Quality Improvement of Hybrid Active Power Filters (2022.07, Summer Conference of the Korean Institute of Electrical Engineers (KIEE))
Best Paper Award (2022.10.25)

01.

02.

03.

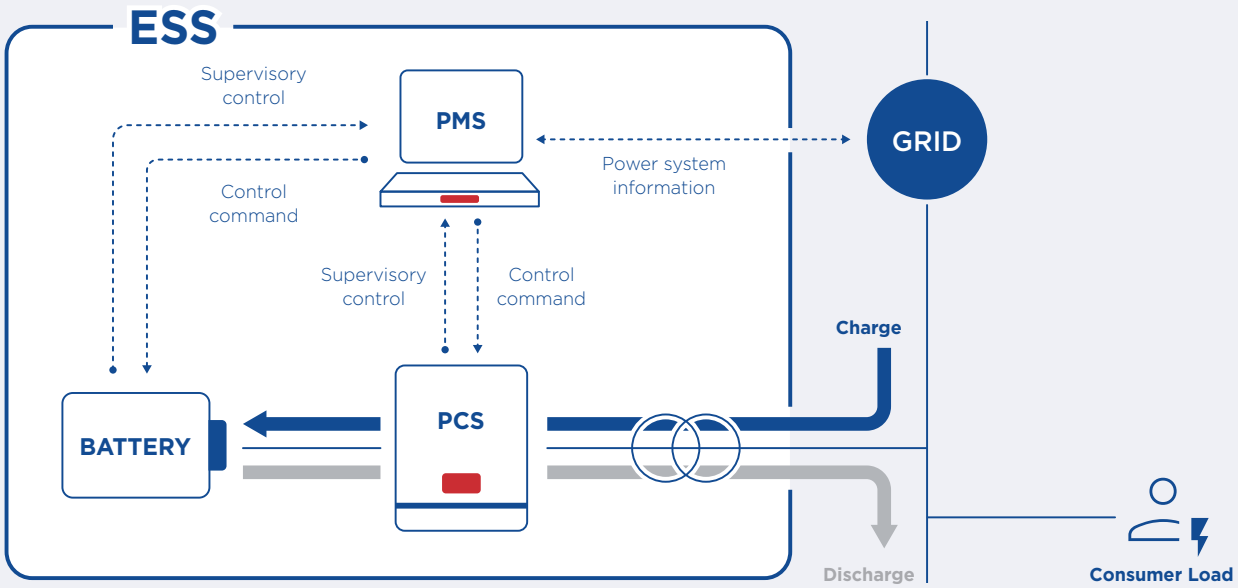
Paper published (3 cases)

01. Selection of Phase Synchronization Techniques to Improve Grid-Linked Phase Tracking Performance of Hybrid Active Power Filters (2021.09, Journal of the Korean Institute of Electrical Engineers (KIEE))

02. Performance Comparison of Coordinate Transformation Techniques for Power Quality Improvement of Hybrid Active Power Filters (2022.03, Journal of the Korean Institute of Electrical Engineers (KIEE))

03. Improved parameter design method of hybrid active power filter (HAPF) for power factor and harmonic compensation (2022.03, Journal of the Korean Institute of Electrical Engineers (KIEE))

ENERGY STORAGE SYSTEM



Is serves as an efficient energy storage device, effectively reducing peak power demands and lowering electrical costs. It efficiently stores surplus energy and releases it as needed, optimizing power usage efficiency

· Installation Objective : Peak power reduction, renewable energy connection, frequency adjustment, replacement of emergency power generation

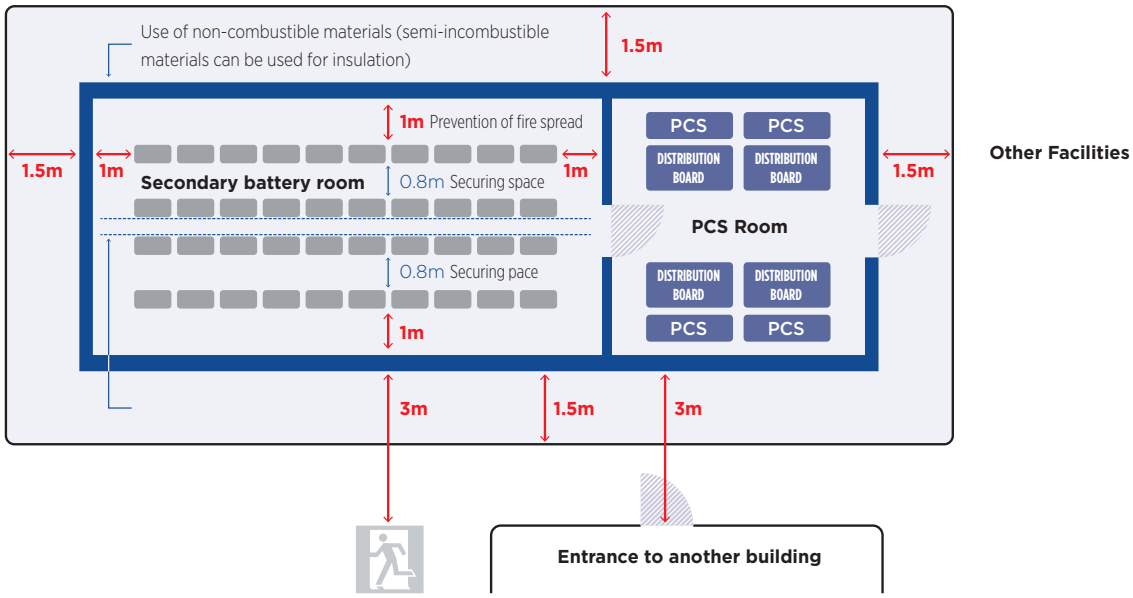
Installation Regulations

Content	Scope of Application
Mandatory Installation	「Regulations on Rationalization of Public Institutions' Energy Use」 Article 11, Paragraph ⑤
Scope of Application	「Regulations on Promotion of High Efficiency Energy Appliances」
Electrical Facility Regulations	① Article 67 of the Electricity Business Act and Article 43 of the Enforcement Decree of the same Act ② Korea Electrical Equipment Regulations in accordance with Article 4 of Electrical Equipment Technical Standards (Ministry of Commerce, Industry and Energy Notice No. 2023-364)
Fire Protection Regulations	「Fire Safety Performance Criteria for Electricity Storage Facilities (NFPC 607)」
Inspection and checkup before use	KESC 「Announcement on Electrical Equipment Inspection and Inspection Methods and Procedures」

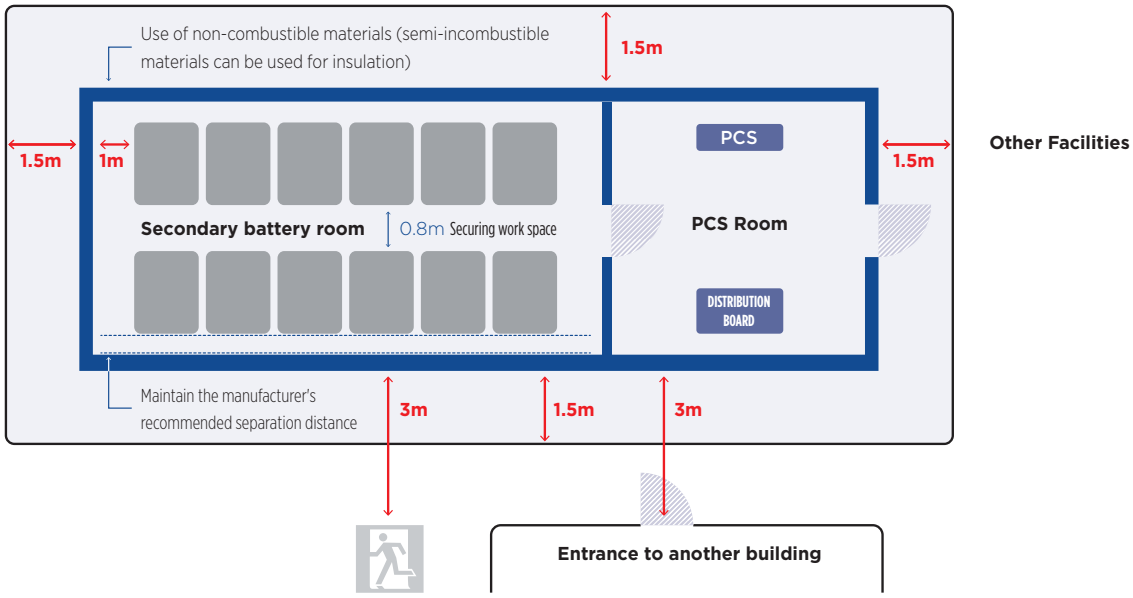
Installation Requirements

Installed in a dedicated building (outdoor)

01. Separation distance when installed in a dedicated building (outdoor)



02. Separation distance when installed in a dedicated building (outdoor) container

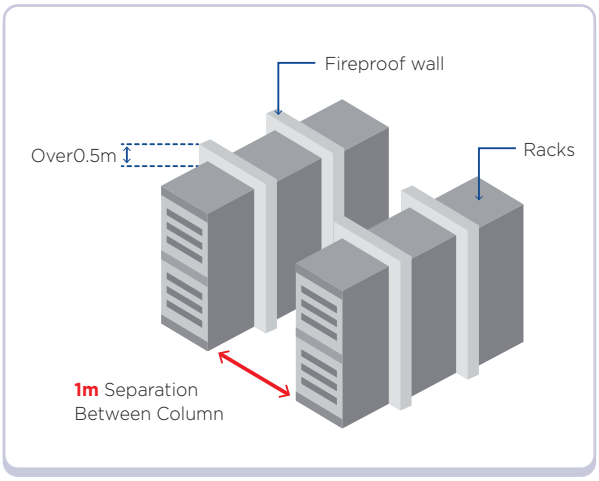


※ Container size: area 29.725 m2 or less (KS T ISO 668 applied)

Installation Requirements

Indoor installation in buildings other than dedicated buildings

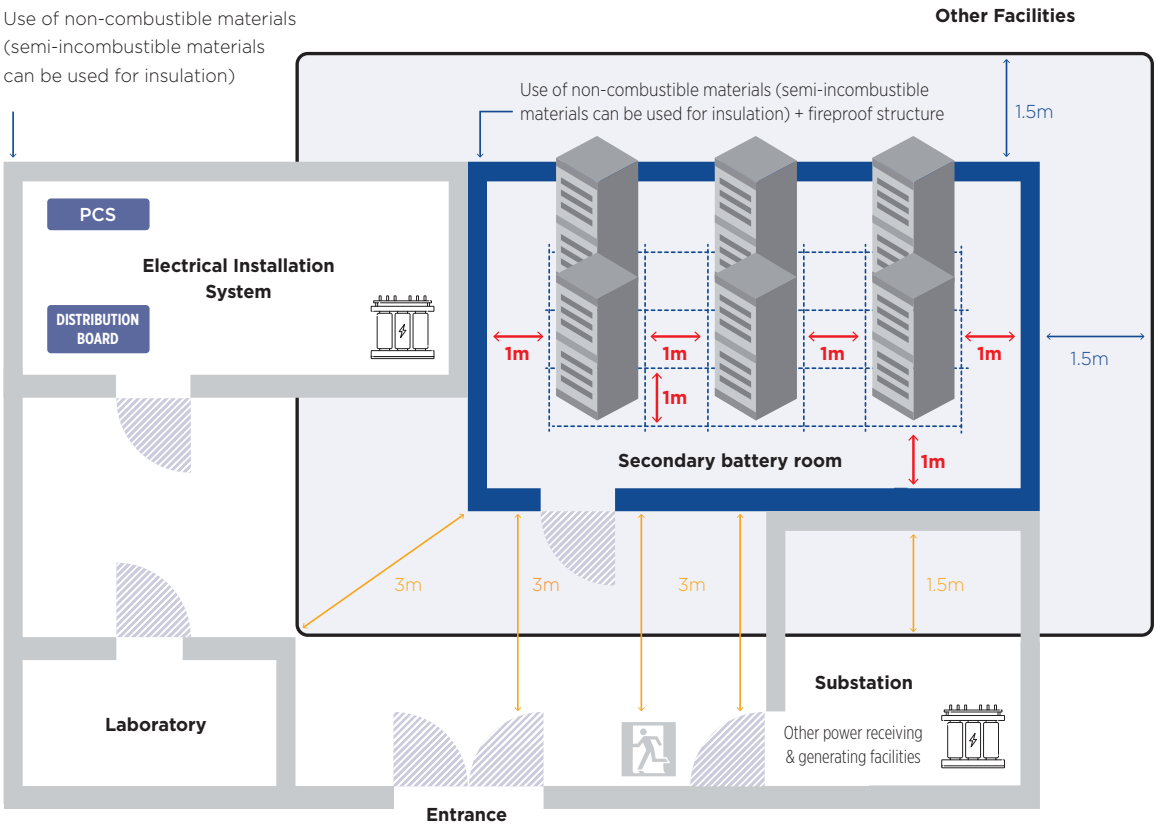
01. Separation distance between columns



- Installed as a fireproof structure in accordance with the「Rules on Standards for Evacuation and Fireproof Structures of Buildings」
- The capacity of each rack is less than 50 kWh, and the total capacity of secondary batteries in the building is less than 600 kWh.
- Space between secondary battery racks and between racks and walls at least 1m apart from each other.
- The secondary battery room should be installed at least 1.5 m away from other facilities in the building (power supply facilities, combustible materials, etc.) and at least 3 m away from similar places such as entrances to rooms or evacuation stairs.

※ Source: KESC announcement
(detailed inspection and inspection standards for electrical equipment)

02. Separation distance when installed indoors



Specifications by Capacity

PCS Capacity (kW)	Battery Capacity (kWh)		Scalability (4Hours)	Note
	Indoor Type	Outdoor Type		
50	100	100	200 kWh	Korea Government Excellent Product (~2025.06)
75	150	150	300 kWh	
101	200	200	400 kWh	
125	250	250	500 kWh	
150	300	300	600 kWh	
200	400	400	800 kWh	
250	500	500	1000 kWh	
300	560	600	1200 kWh	
400	560	800	1600 kWh	
500	1000	1000	2000 kWh	

※ Non-standard sizes are manufactured according to customer orders.

Installation Example

Outdoor Type

01. KIASC
PCS 75 kW, Battery 160 kWh

02. Seoul Southern District Prosecutors' Office
PCS 150 kW, Battery 320 kWh

03. Gyeonggi Provincial Institute of Health and Environment
PCS 100 kW, Battery 200 kWh

01.

02.

03.

Indoor Type

01. National Agricultural Museum Agricultural History and Culture Exhibition Hall Proposal
PCS 150 kW, Battery 320 kWh

02. Ulsan City Art Museum
PCS 100 kW, Battery 200 kWh

01.

02.

HARMONICS
ANALYSIS & COUNTERMEASURES

In order to prevent damage to electrical equipment due to harmonics, reduce loss, and improve efficiency, we present optimized solutions through precise diagnosis and analysis of equipment to help customers reduce maintenance costs and efficiently manage assets.

Necessity

Harmonics are the main culprit of deteriorating electrical quality and cause damage in various forms, such as increased power loss, reduced efficiency, shortened lifespan, and malfunctions.

Power Loss ↑ Facility Efficiency
Maintenance Costs ↑ Facility Lifespan ↓

Impact on power system and electrical facilities

Transformer	Wires and conductors	Rotating machine	Capacitor for power	Overcurrent	Circuit breaker · Other
· Power quality technology · Overheating increased noise · Capacity reduction · Insulation breakdown	· Overheating · Corona outbreak · Neutral over current · Capacity reduction · Insulation breakdown · Skin Effect	· Overheating · Decrease in efficiency · Shortened device lifespan · Tog uneven · Vibrational torque	· Overheating · Over-resonance · Overcurrent · Overvoltage insulation explosion	· Abrupt stop · Inaccurate measurement · Non-integer harmonic generation · Malfunction · Frequent part failure	· Ampacity reduction · Noise, Vibration · Acceleration of life deterioration · Drop in power factor · Decreased fuse capacity · Signal, communication failure

Diagnosis & Consulting

※ Measurable according to international standards

Category	Basic Type	Precision Type
Duration	5-7 Days	25-30 Days
Diagnostic Items	1. Harmonic precision diagnosis 2. Insulation deterioration and temperature distribution 3. Power quality analyze	1. Harmonic precision diagnosis 2. Insulation deterioration and temperature distribution 3. Power quality analyze
Utilized Equipment	Harmonic Analysis Equipment, Infrared Thermal Imaging Diagnostic Equipment	Harmonic Analysis Equipment, Infrared Thermal Imaging Diagnostic Equipment, Power quality analyzer, insulation resistance meter, hook meter, noise meter
Diagnostic Cost	Different depending on location, number of people, equipment, and schedule	Different depending on location, number of people, equipment, and schedule

Expertise & Differentiation

Expert Personnel

Composition of professional manpower such as doctor of engineering, master's degree, electrical engineer

Advanced Equipment

Equipped with 6 advanced analysis equipment, Improvement of Data Reliability

Analytical Techniques

High-quality analysis report using harmonics-specific analysis tools

Experience · Know-How

More than 20 years of various analysis experience and know-how in the field

Procedure

01. Diagnosis Request
- Request for harmonic analysis
- Consultation and review
- Schedule coordination

02. Site Visit
- Securing electrical facility data and drawings
- On-site equipment check
- Consultation on diagnosis scope, place, schedule, etc.
- Diagnosis cost and contract procedure information

03.Contract Signing
- Submit an Estimate
- Drafting and signing a contract

01 → 02 → 03

04. Harmonic Analysis
- Installation of Harmonic Analysis Equipment
- Real-time collection of harmonics and power data
- Load factor, uptime, yield, and temperature measurement

05. Analysis Report
- Data collection and analysis
- Detailed harmonic analysis
- Application of analysis algorithm
- Report writing and submission

06. Post-Maintenance
- Quarterly monitoring
- Ongoing maintenance

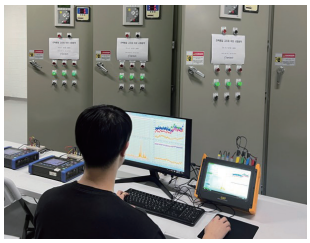
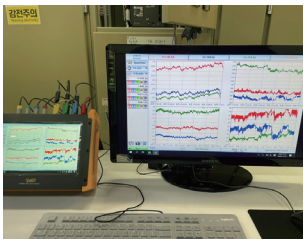
04 → 05 → 06

Diagnosis Case

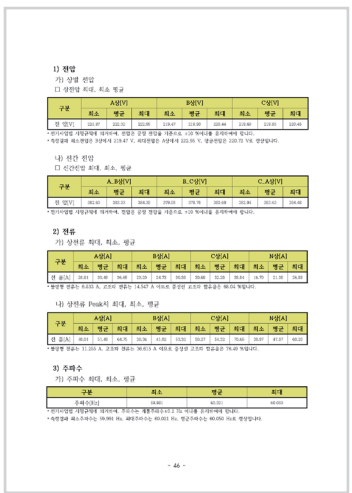
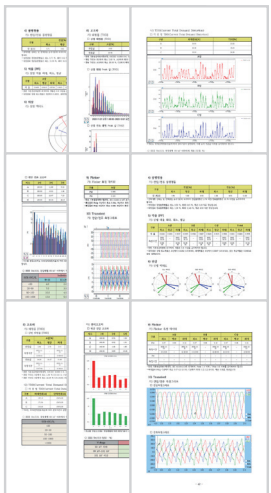
OO COURT

- **Objective :** Devise harmonic reduction and energy saving measures
- **Results :** THD 37.47% reduction and power loss 4.77% reduction

Diagnosis Site

Diagnosis Report

Patent Certificate

We have secured original technology with **24 patent registrations** (22 domestic, 2 overseas) and **6 trademark registrations (2 domestic, 4 overseas) for major products.**

01. 02. 03.

04. 05. 06. 07. 08. 09. 10. 11.

12. 13. 14. 15. 16. 17. 18. 19.

01. Harmonic reduction device
02. Hybrid type harmonic reduction device
03. Harmonic attenuation transformer
04. Reception and distribution panel equipped with hybrid transformer and black box
05. Transformability and harmonics and current unbalance
06. Power quality improvement device and power supply system
07. Low loss hybrid transformer and its manufacturing method
08. IoT-based transformer monitoring system and method
09. Seismic transformer
10. Battery rack-based power management device and energy storage system including the same, charging and discharging the battery racks based on their respective states
11. A power management device capable of compensating for unbalance between battery racks and an energy storage system including the same
12. Transformer tie plate for reducing stray load loss and manufacturing method thereof
13. Hybrid seismic isolator and seismic transformer
14. Rail type hybrid seismic isolator
15. Displacement control seismic transformer with friction damper applied
16. Power converter for fuel cell and its control method
17. Low loss hybrid transformer and its manufacturing method
18. U.S. Patent
19. Chinese Patent

⋮

Technology Certificate

Its excellence is recognized through various technology certifications such as **Korea Government Excellent Product, ISO, CE etc.**

01. 02. 03.

04. 05. 06. 07. 08. 09. 10. 11. 12. 13.

01. Korea Government Excellent Product
02. Korean Innovative Product
03. LH New Technology(Product) Confirmation
04. Green technology certification
05. New Excellent Technology (NET)
06. Excellent Performance Certification
07. Excellent invention priority purchase recommendation confirmation
08. Excellent invention priority purchase recommendation confirmation
09. ISO 9001
10. ISO 14001
11. CE certification
12. Certificate of registration of selected products developed by 5 power generation companies under KEPCO
13. Certificate of Materials/Machinery for management of Efficiency

⋮

Overseas Delivery Performance

Natura
Brazil

Nestle
Brazil

Pepsi
Brazil

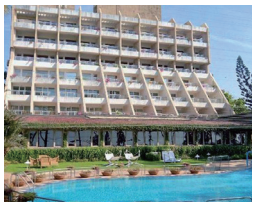
JOY CITY
China

FOUR POINT HOTEL
India

JW MARRIOTT HOTEL
India

RENAISSANCE HOTEL
India

SUNSTAR OVERSEAS
India



THE RESORT HOTEL
India

Taiace engneering sdn bhd
Malaysia

University of Kawajulu-Natal
South Africa

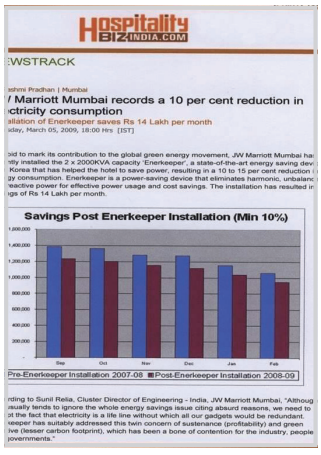
GRAND HYATT HOTEL
UAE

Enertech Global
United states

GOSHI-THANG LONG
Vietnam

SONHA
Vietnam

Press Release



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