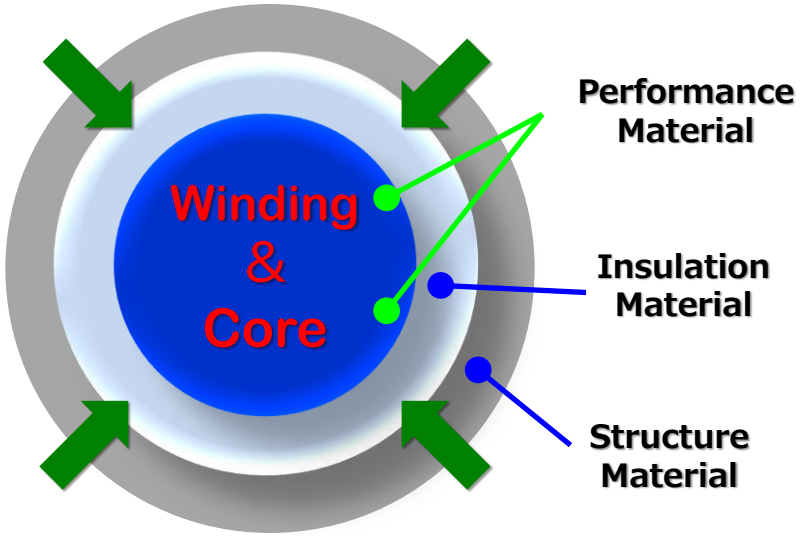
Advanced Power Magnetic Technology for PV·E-mobility·Super charger

Power Magnetic Component Design Disciplines

世界最先端パワー磁気技術

Innovation & Creation



- **High Power High Frequency Design Technology**
- **Auxiliary Material Effective Design Technology**

Materials Technology

- Magnetic Material Innovation
- Winding Wire Material

Keys

+

Magnetic Design Technology

- High Efficiency & Low Loss
- High Extra Values
- Simplification & Low cost
- Design for Automation Production

Routes

+

Manufacture Technology

- High-quality Process
- High-Efficiently manufacture
- Fast cost allocation

Methods

BREAKDOWN
Key Bottlenecks

Technology
Quality
Cost

Create Much More Values (Quality, Cost Performance)

Advanced Magnetic Technologies Introduction

Integrated Magnetics — Integrated Magnetics Achieve High Power Density & Low Loss Design

Hybrid Technology — Hybrid Magnetic Technology

Acoustic Technology — Sound noise reduce Technology

L-I Trimming Technology — L-I Curve Trimming Technology

X-Core Technology — Supper Magnetic Core Material Technology

EMC Technology — Very low EMC Noise Transformer and Reactor Design Technology

Edgewise Technology — Large Aspect Ratio Edgewise Winding Technology for water-cooling & Oil-cooling

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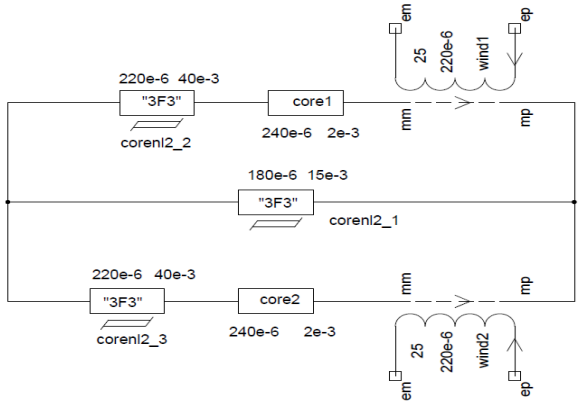
Integrated Magnetics

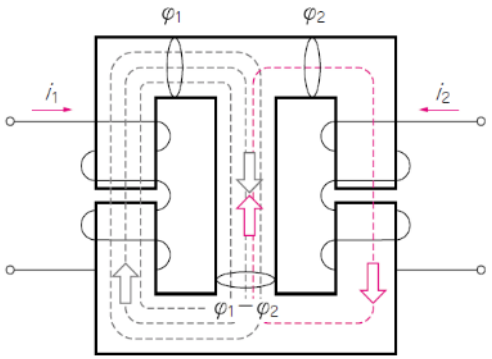
The technology of building an effective magnetic structure to design multiple magnetic functions such inductor, transformer, EMC choke using one set of core as within a single part.

Application design samples:

1. Using two windings to build 2 coupling inductor in one package with a coupling coefficient from 0 to less than 100% for interleave boost or PFC circuit
2. Using 2 windings to build 2 resonant inductors, 1 low magnetization inductor and 1 idea transformer in a set of magnetic core for a 6.6KW CLLC converter
3. Using 2 windings to design a common choke with a large normal inductance for EMC filter, etc.



A Magnetic circuit simple model for integrated reactor

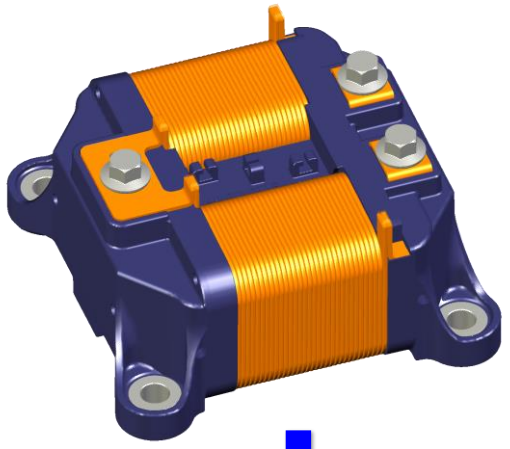


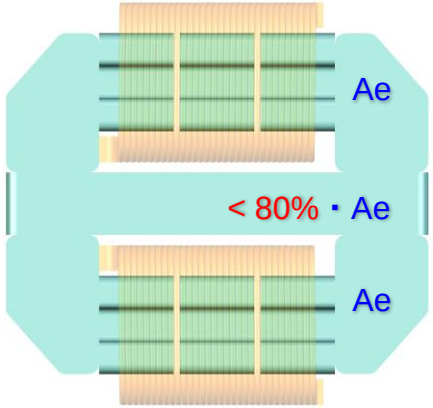
Flux direction

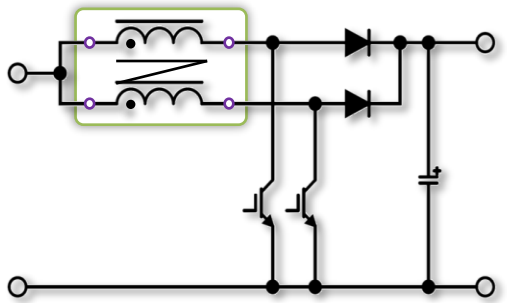
Flux inside core

Flux is cancelled largely within the middle core which improves core loss & cuts core volume

2 in one integrated reactor







Flux-cancel effect enables much smaller core section area at the middle common core under interleave application

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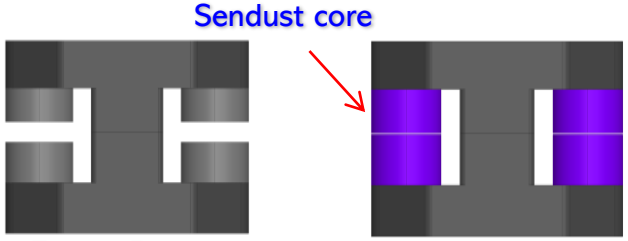
Hybrid Technology

The effective technology by applying different core materials at different part of the magnetic circuit to improve not only such as DC bias characteristic but also achieving less core loss and winding eddy loss for power reactor design

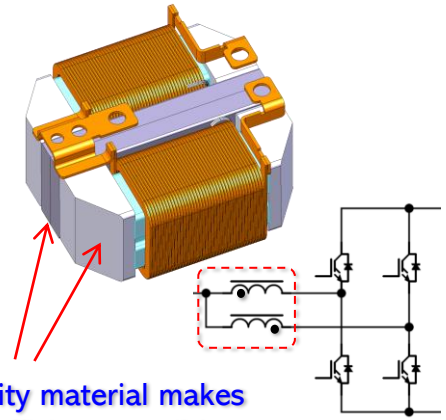


Ferrite Reactor
Ferrite material only

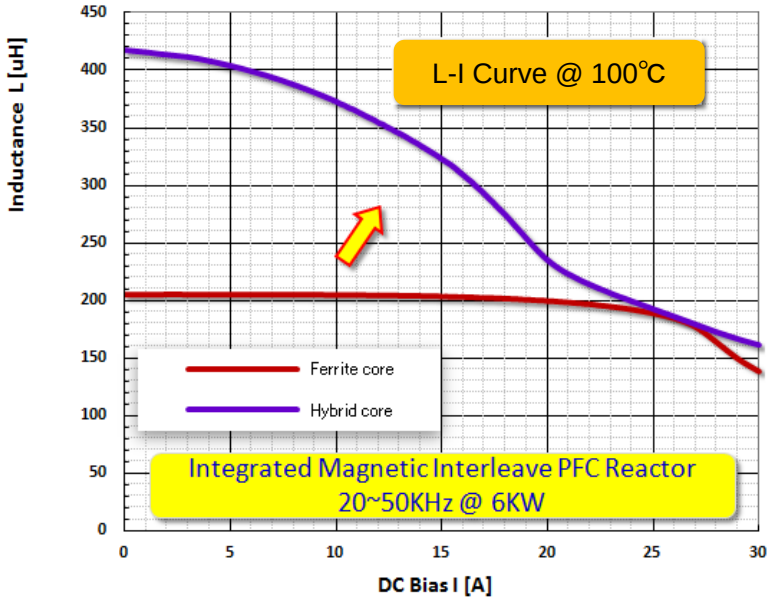
Hybrid Reactor
Ferrite + Sendust hybrid design

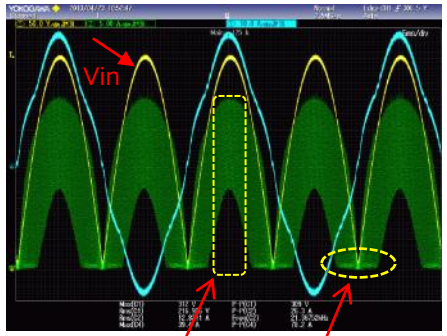
At LLC transformer design (at 150KHz), since if only using ferrite material, there are large length of gaps to get low total permeability, new high frequency low permeability powder core (NPA-19μ, POCO) is a best core material inside winding, the air gap length can be largely reduced, the winding eddy loss gets very smaller.

At some interleave boost reactor designs,

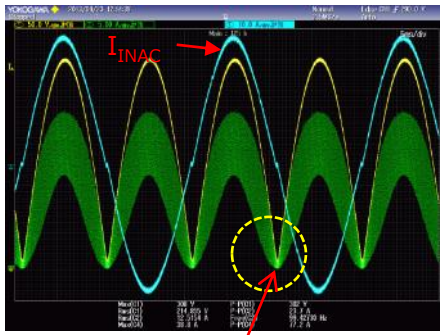


Different permeability material makes right coupling coefficient possible





- CCM current area
- DCM current area



Hybrid Design extends CCM operating range improved the total harmonic distortion(THD), also largely reduced eddy loss of windings

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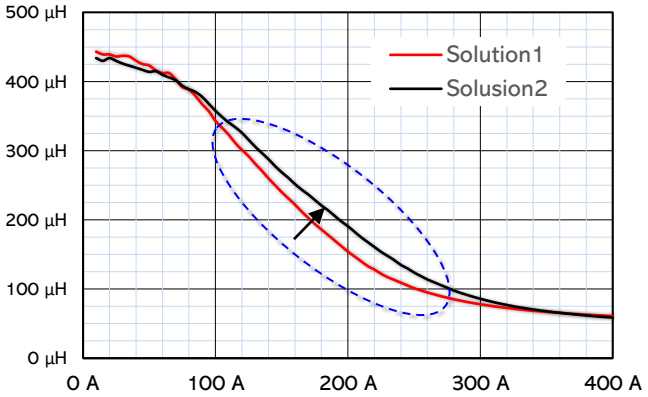
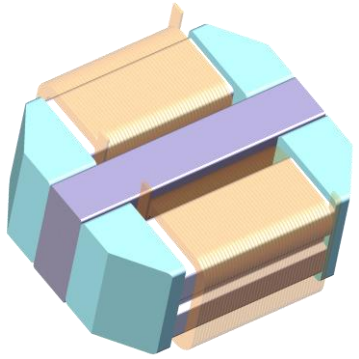
L-I Trimming Technology

L-I Trimming Technology is a creative magnetic design technique by applying different permeability core material, special core shape, different section area at different part of magnetic circuit to adjust part of L-I curve to meet the unique requirement of component inductance characteristic from power topology.

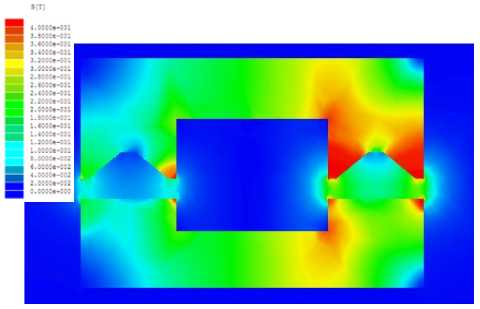


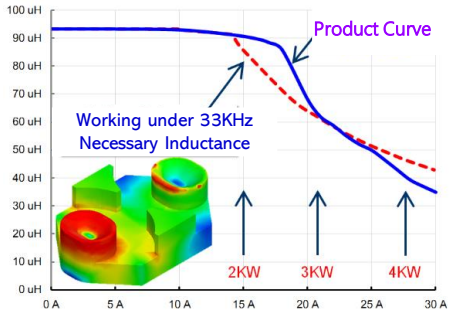


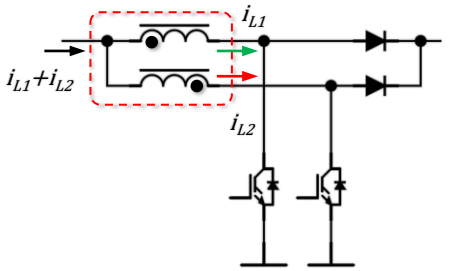
L-I Trimming Application
Design by different permeability, section area, core shape changes I-L curve

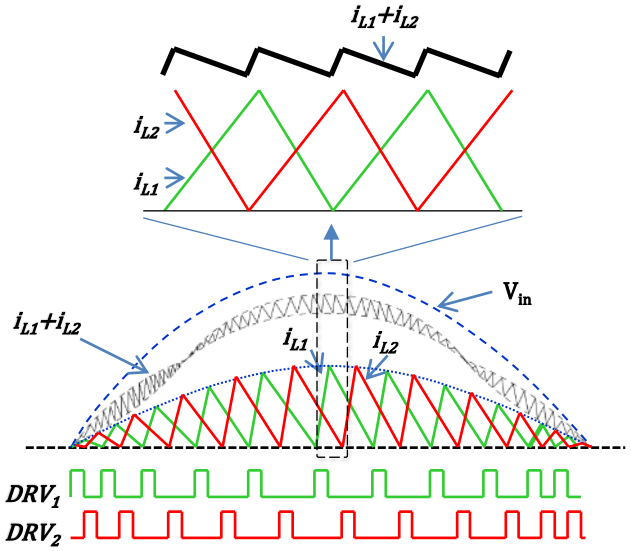
Here are two typical innovational cases

1. by applying such technique, a very low cost & high-efficient 3KW IGBT CRM PFC is designed to replace MOSFETs and fast recovery diodes (Patented by Tamura*)
2. 38KW@10KHz continue power of interleave boost reactor for PHEV application with good cost performance









Representative example showing variable air gap design & its L-I curve characteristic

World first 3KW IGBT CRM Interleave PFC Application

★ This 3KW IGBT CRM PFC solution & patent copyright is applied by Tamura Corporation

High efficiency · Low cost · Best EMC
Interleave CRM PFC Solution for high power application

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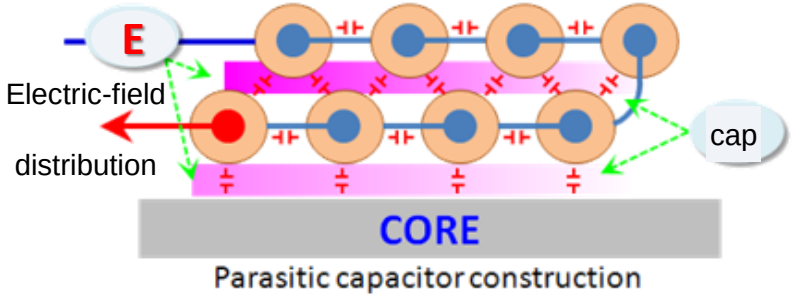
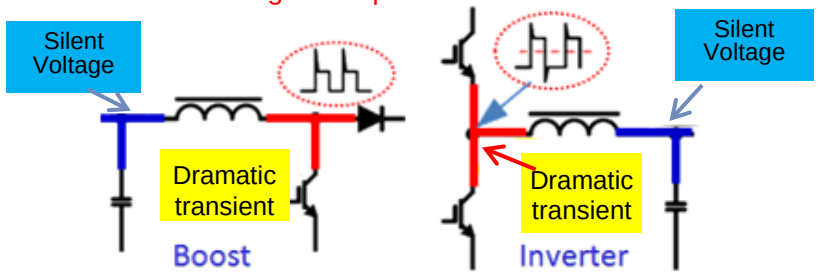
EMC Technology

EMC technology in power magnetic component design is to reduce winding parasitic capacitance & the energy stored in such parasitic capacitors by optimizing winding structure, thus, there is no significant high frequency resonant current spike which results extra EMC noise.



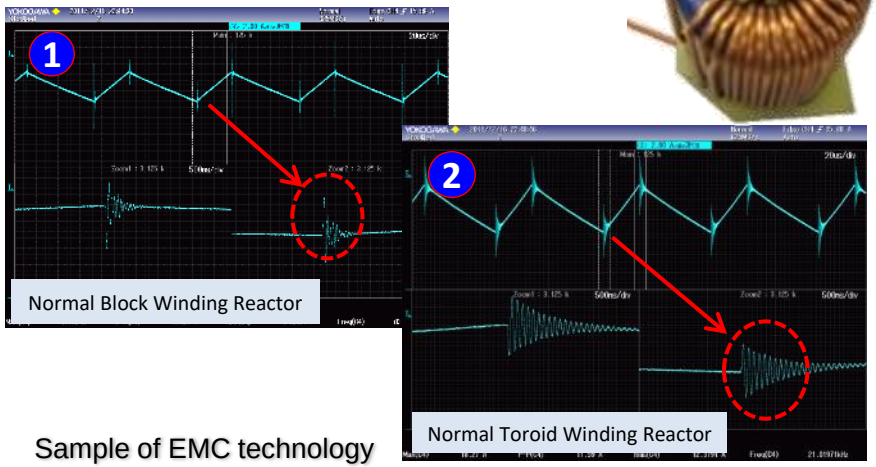
$L_{leakage} + C_{parasitic} + R_{DC}$



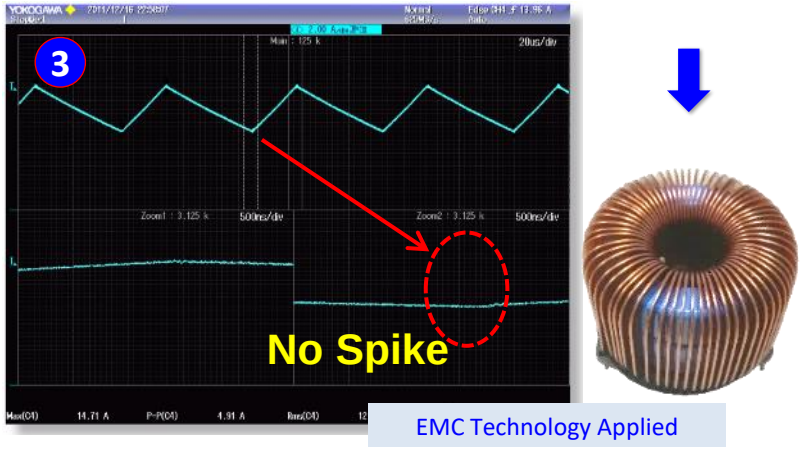
$C_{parasitic}$ is charged & discharged dramatically by very high dV/dt

EMI Noise Source Mechanism

High frequency LCR networks resonance makes the reactor to be an active EMI noise source!



Sample of EMC technology



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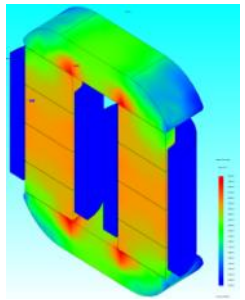
Acoustic Technology

Power reactor ACL sound noise mainly comes from large amount of invisible tiny air gaps that exist among magnetic core, between cores, windings, and joints of different parts.

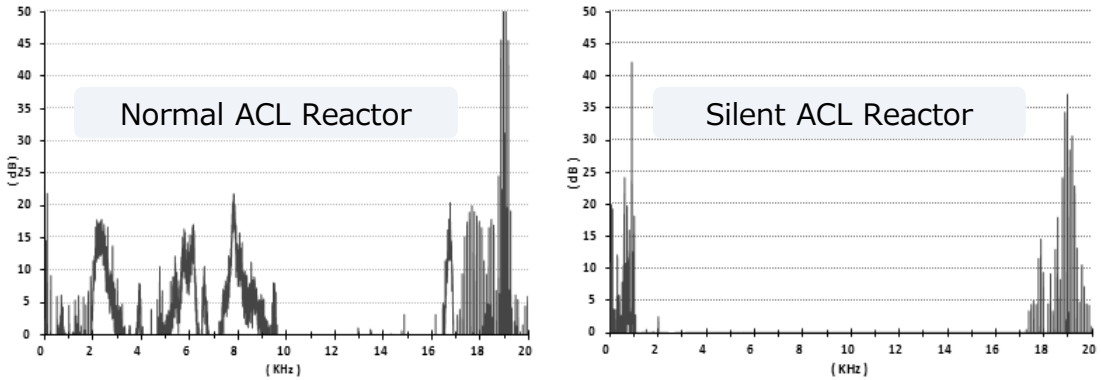
Effective acoustic technology is greatly reducing these noise mechanism than ACL reactor is under very strong electromagnetic vibration & core magnetic hysteresis vibration operating condition.

Mechanism on Audio Noise

- Magnetic distortion
- Magnetic stress vibration
- Mechanic vibration & resonance
- Narrow air gap structure
- Harmonic distortion current



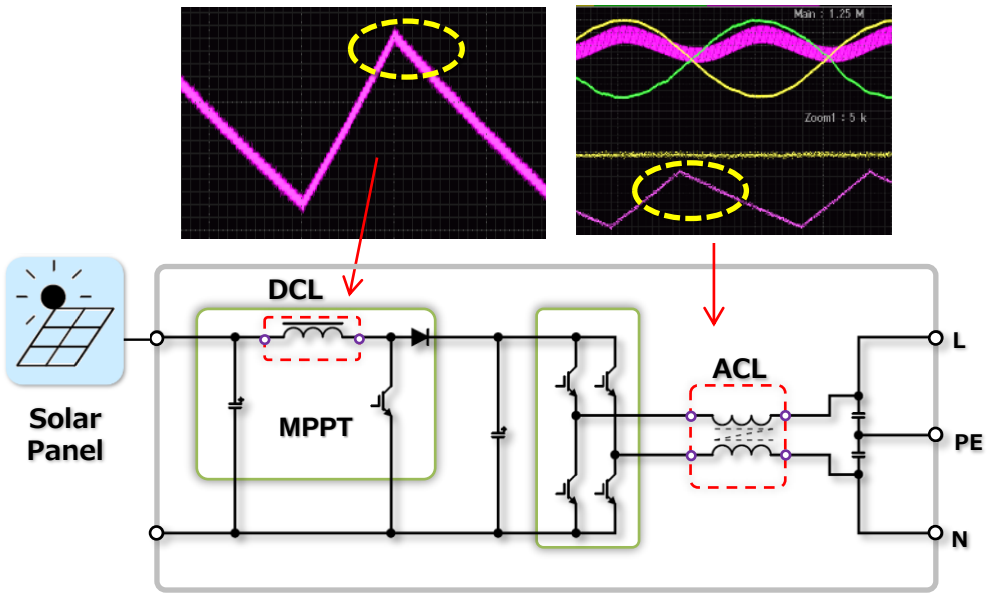
A low sound noise ACL magnetic structure with many pieces of block cores



Audio noise spectrum comparison for 6KW photovoltaic inverter ACL reactor

(Effect testing after applying audio noise control technology)

Low Audio Noise & No Current Spike



6.0KW low sound noise (PSU <29dB) at PV application

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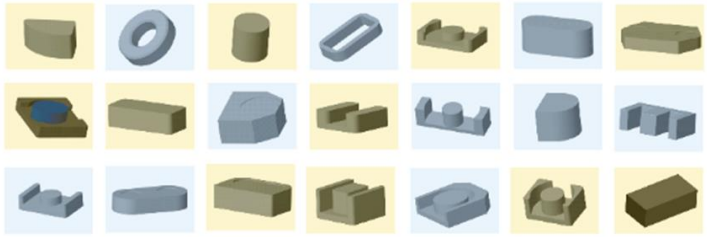
Make electricity purer・smoother

X Powder Technology

poco

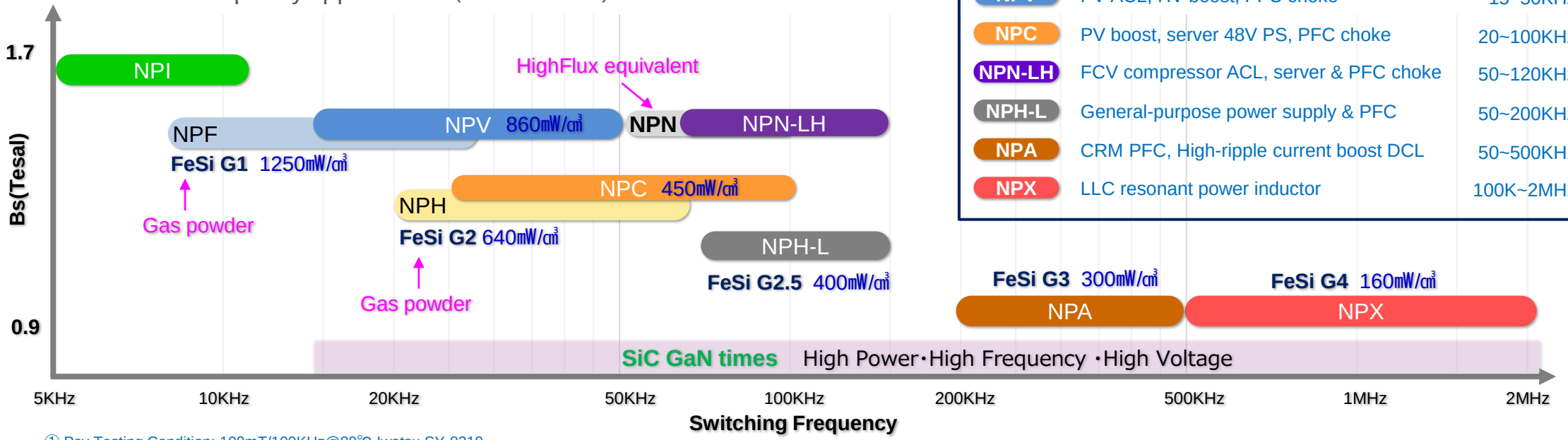
The world's most innovative developer of soft magnetic powder core materials



Advanced magnetic material for inductor

New materials of SiC/GaN times

- Core-shaped innovation meets flexible inductor design
- Wide size dimension range
- Wide frequency applications（5KHz~2MHz）



Typical applications

NPI	HV boost, 800V super-charge boost	5~15KHz
NPV	PV ACL, HV boost, PFC choke	15~50KHz
NPC	PV boost, server 48V PS, PFC choke	20~100KHz
NPN-LH	FCV compressor ACL, server & PFC choke	50~120KHz
NPH-L	General-purpose power supply & PFC	50~200KHz
NPA	CRM PFC, High-ripple current boost DCL	50~500KHz
NPX	LLC resonant power inductor	100K~2MHz

① Pcv Testing Condition: 100mT/100KHz@80℃ Iwatsu SY-8219

MTC Japan technical support center of POCO magnetic application

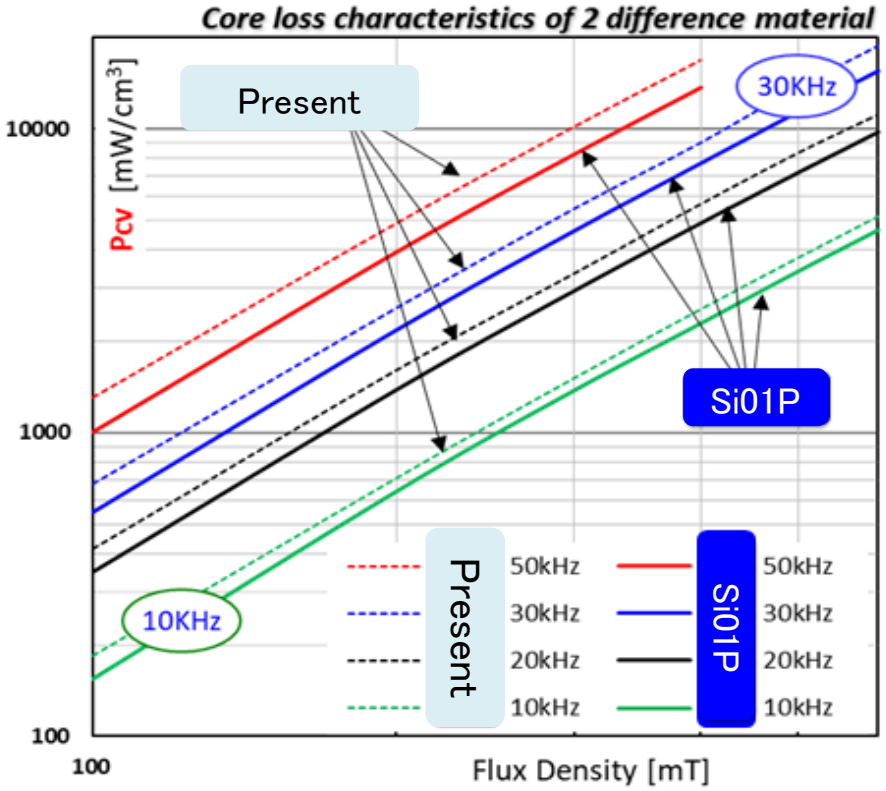
Advanced Power Magnetic Technology for PV·E-mobility·Super charger

HEV. PHEV. EVQC. FCV specialized magnetic core material

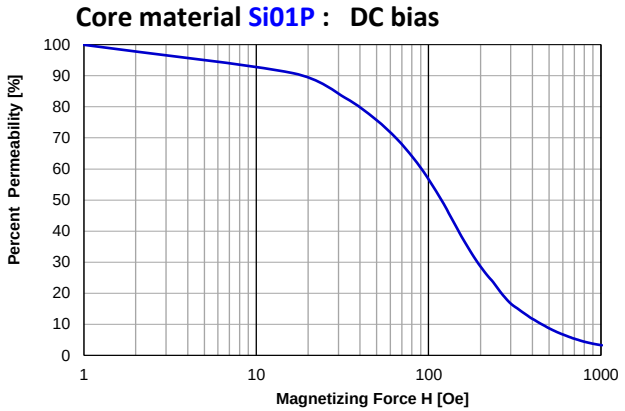
Features

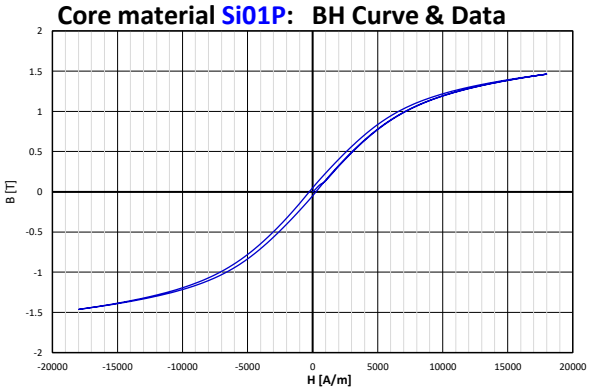
- Strong DC bias characteristic
- Low core loss
- High density core technology
- Low sound noise core technology

Si01P 8~12KHz IGBT 30~250KW
Si02P 30~50KHz SiC 30~250KW
Si03P 50~100KHz SiC 30~250KW



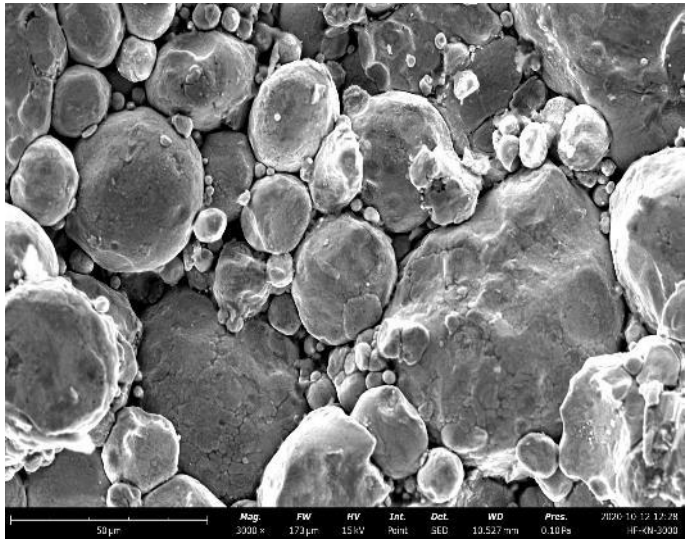
(Eaglerise joint development project)





Material composition （Si01P）

	Element Number	Element Symbol	Element Name	Atomic Conc.	Weight Conc.
	6	C	Carbon	22.25	7.04
	8	O	Oxygen	15.51	6.53
	13	AL	Aluminum	2.12	1.51
	14	Si	Silicon	4.76	3.52
	26	Fe	Iron	55.36	81.41



Powder core inner dimension - SED
（secondary electron detector）

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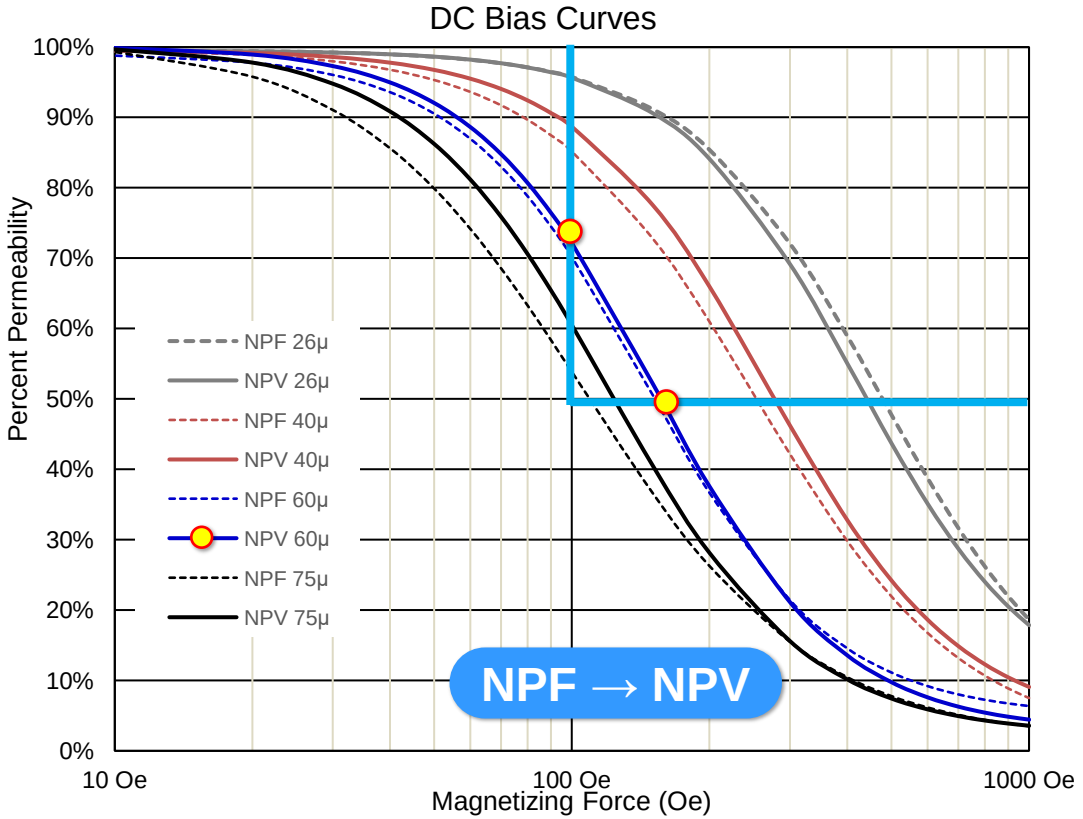
New generation FeSi magnetic powder material

on PV·V2H·Quick Charger·PHEV/EV high power reactor

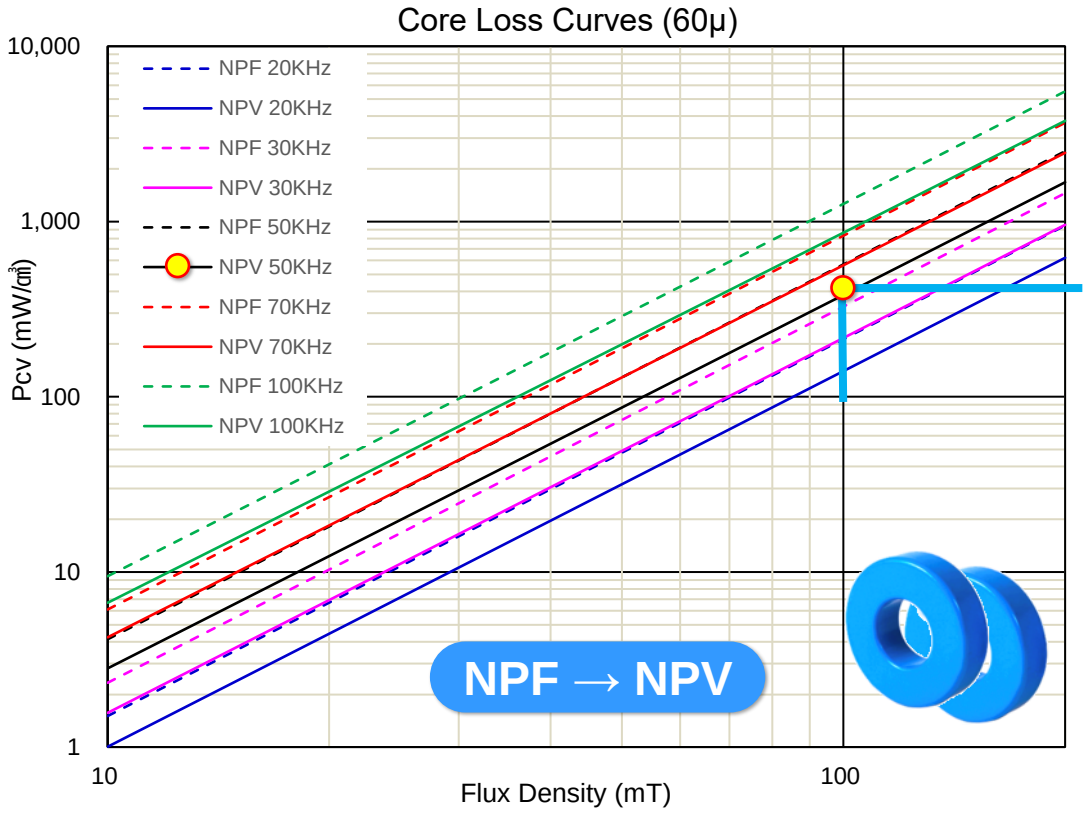
NPV High Power・FeSi New Material

NPV FeSi Series（15～50kHz）



Strong DC Bias & much loss cut

NPF FeSi G1 upgrade **NPV**



MTC Japan technical support center of POCO magnetic application

Advanced Power Magnetic Technology for PV·E-mobility·Super charger

New generation FeSi magnetic powder material

on PV·V2H·Quick Charger·PHEV/EV high power reactor

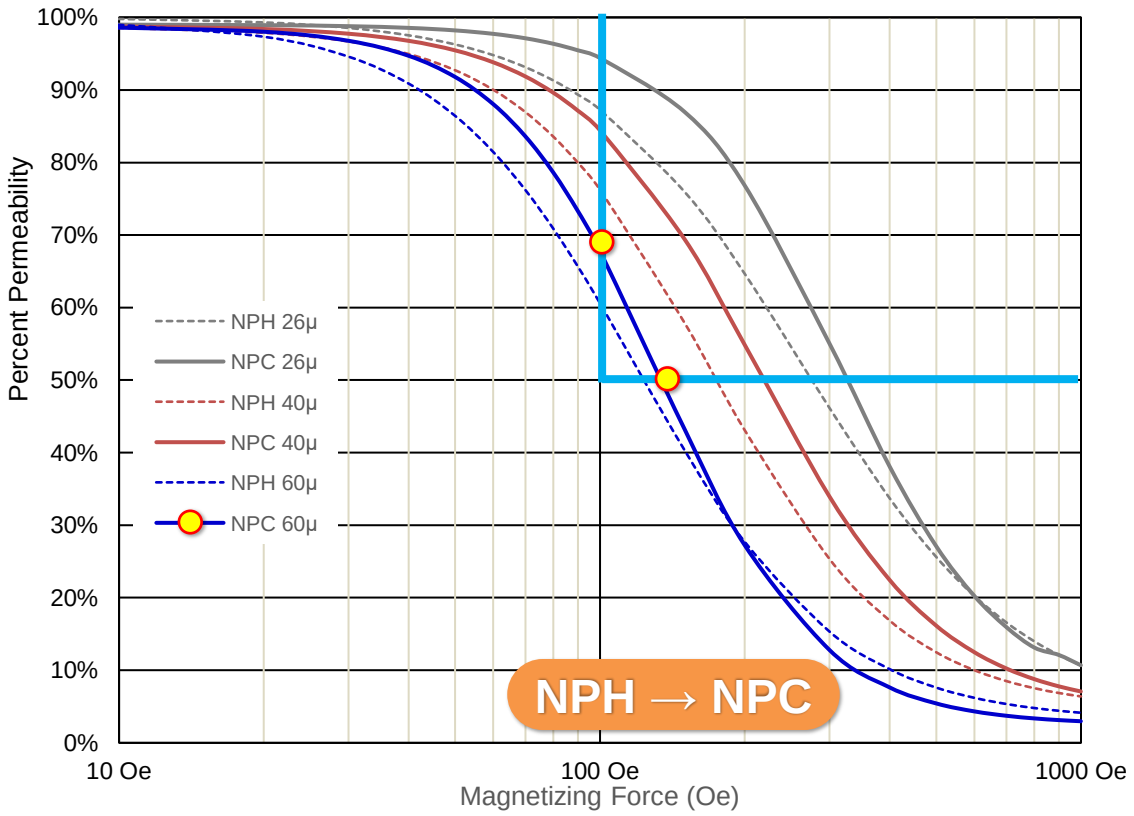
NPC High Power・FeSi New Material

NPC FeSiシリーズ（20～100kHz）

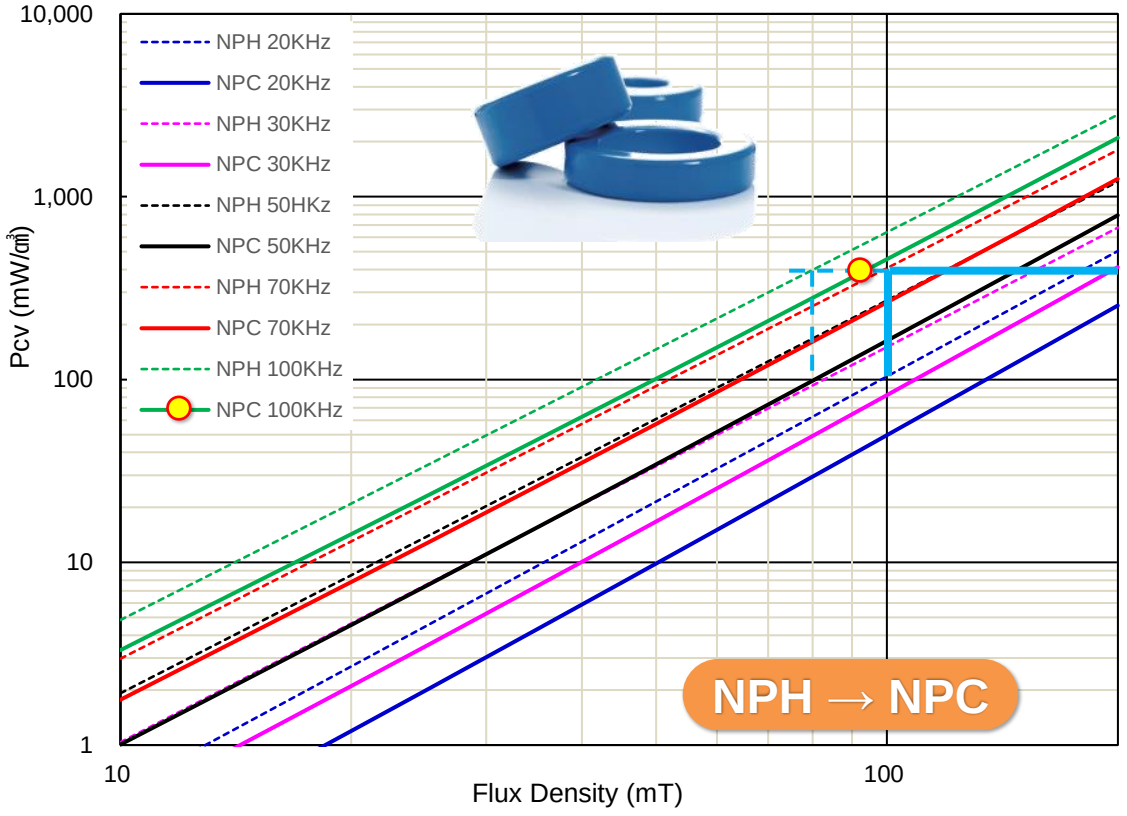
Strong DC Bias & much loss cut

NPH FeSi G2 upgrade **NPC**

DC Bias Curves



Core Loss Curves (60μ)



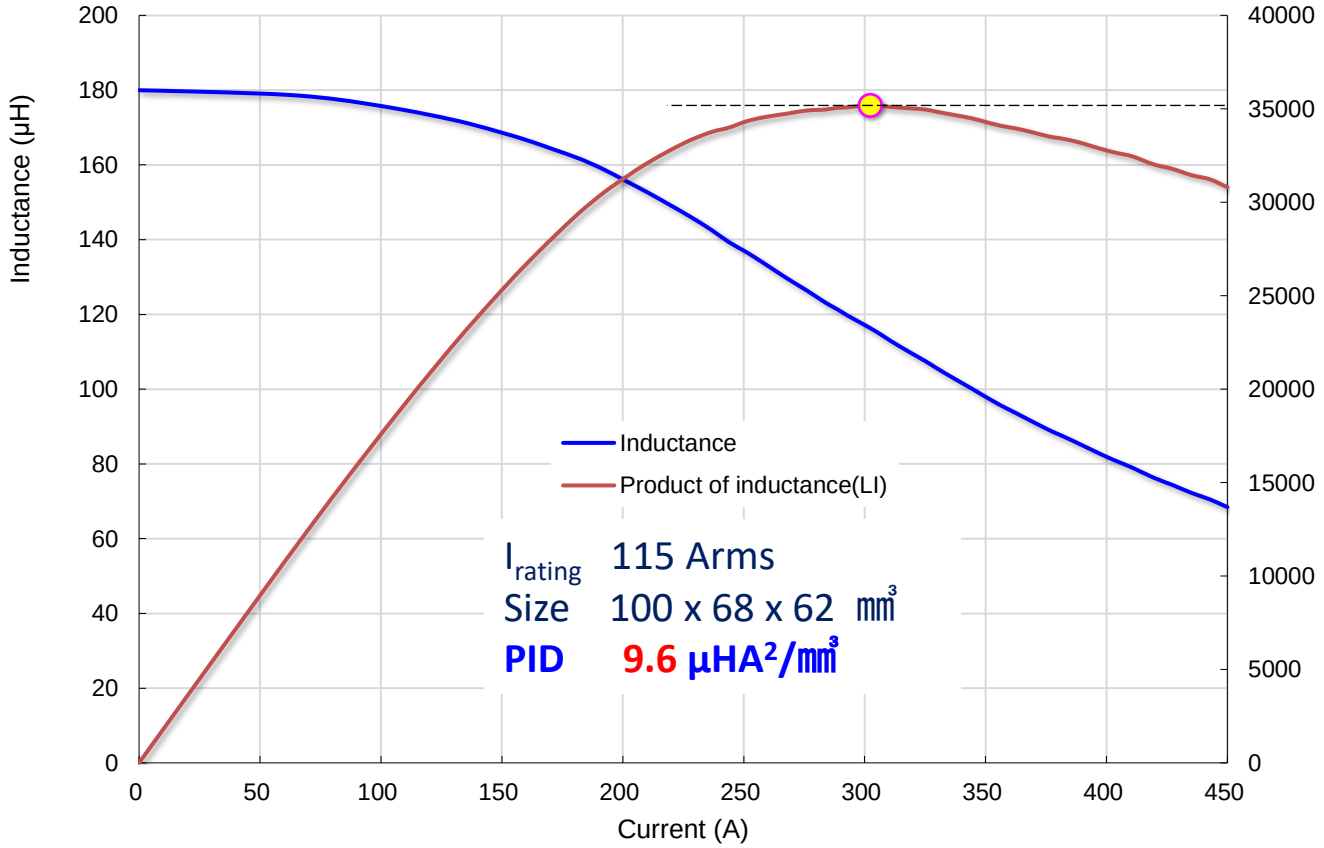
MTC Japan technical support center of POCO magnetic application

PID Evaluation

Power Inductance Density(PID) Index

An effective method to measure the energy-stored transmission capability

example to calculate PID Index



Inductor stored energy	$E = \frac{1}{2} L \times I^2$
Inductance current curve	**L-I (DC Bias)**
Inductance current Product	$P = L \times I$
Inductor safety operating current	I_{rms}
Inductor volume & size	$V_e = L \times W \times H$

Power Inductance Density(PID) Index (designed)

$$PID = \frac{P_{max} \times I_{rms}}{V_e} \quad (\mu HA^2/mm^3)$$

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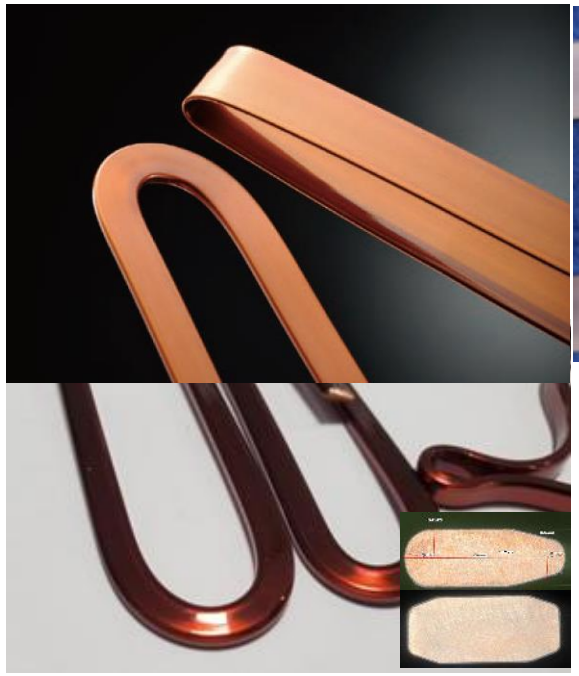
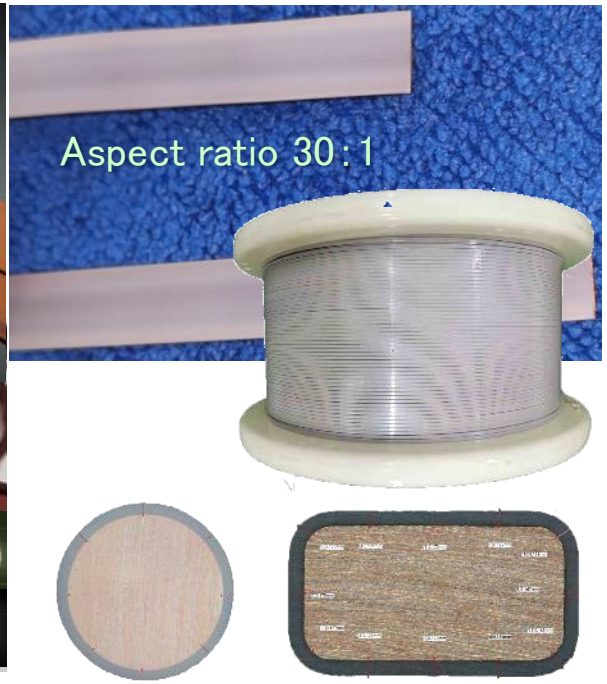
■ Advanced magnet wire technology

Special shape magnet wires



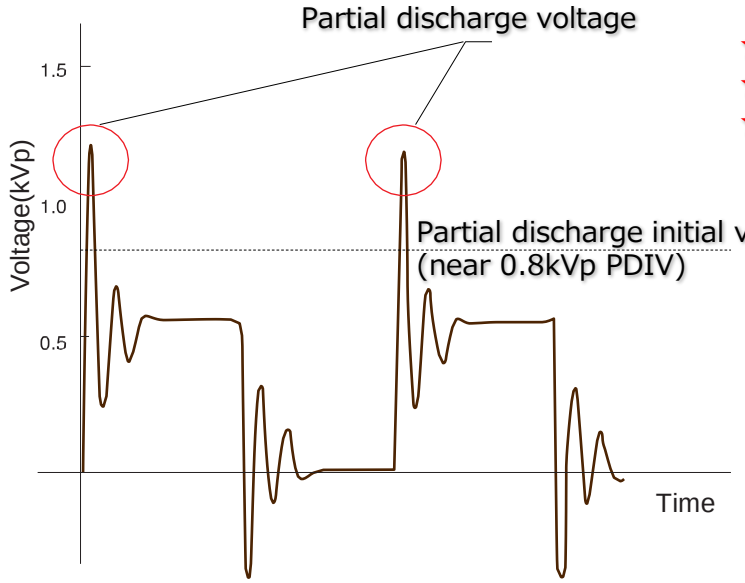
★ PEEK extrusion flat wire for edgewise winding



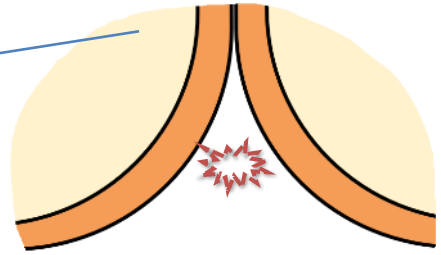
Aspect ratio 1~30: 1
Enameled Edgewise Wire
Special section shape Edgewise

Round & Aspect ratio 1~30: 1
PEEK Extrusion Magnet Wire
Round wire
Edgewise wire
Reinforced insulation Edgewise wire

Collaboration with victrex



★ Coating flexibility
★ Anti-PDIV ability
★ ATF oil Compatibility



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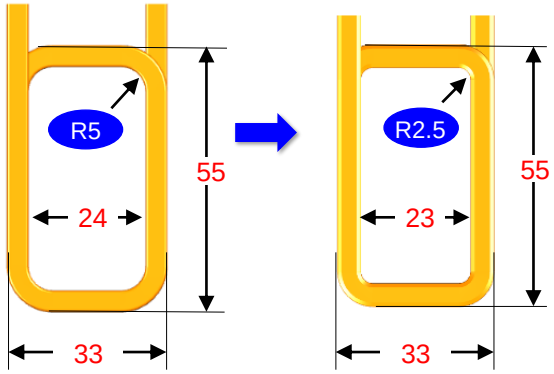
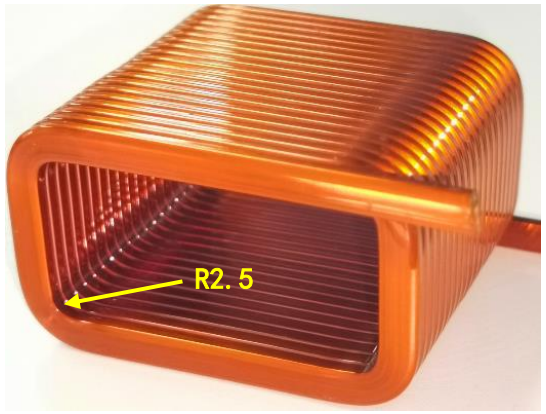
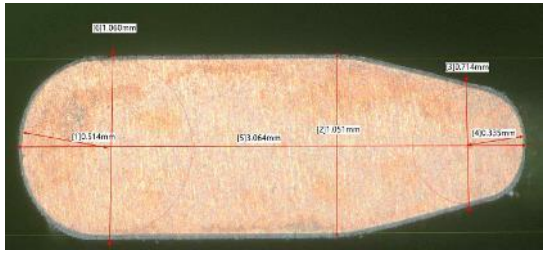
Advanced edgewise winding technology

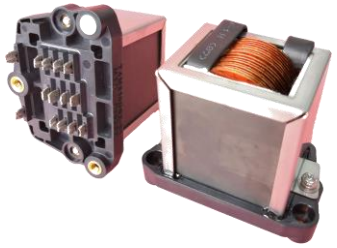
Smaller angle bending technology on 90° right angle edgewise winding enables compact size design & reduces parts loss, etc.





Different special wire shape design for water-cooling & oil-cooling improves heat dissipation effect & reduces winding volume

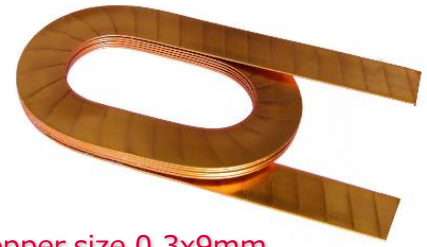




★ Word first technology

Aspect ratio 30:1 reinforced insulation edgewise winding technology for high-power high-frequency transformer

Aspect ratio 30: 1 wire & winding



Copper size 0.3x9mm

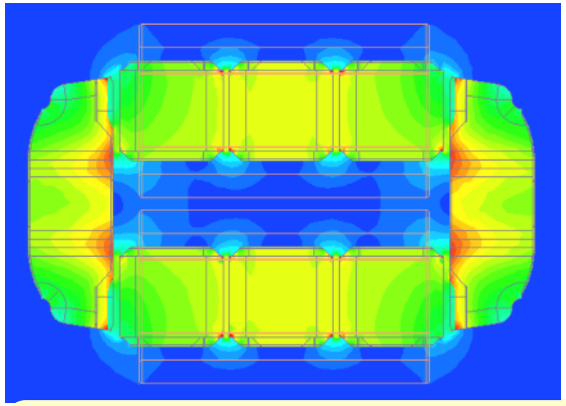
Polyimide film sintering wire & winding

Advanced Power Magnetic Technology for PV·E-mobility·Super charger

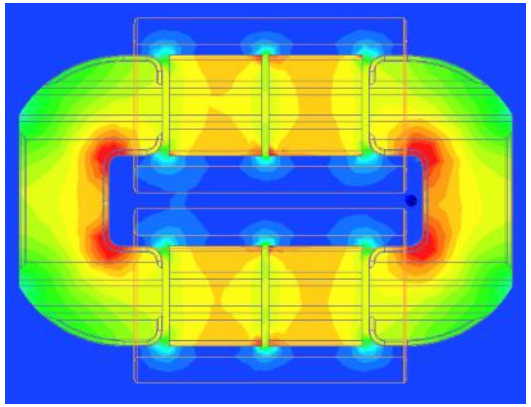
■ Ultra-low AC loss hybrid magnetics

★ Optimized magnetic circuit design greatly reduces AC loss

High winding crossing flux leaking structure

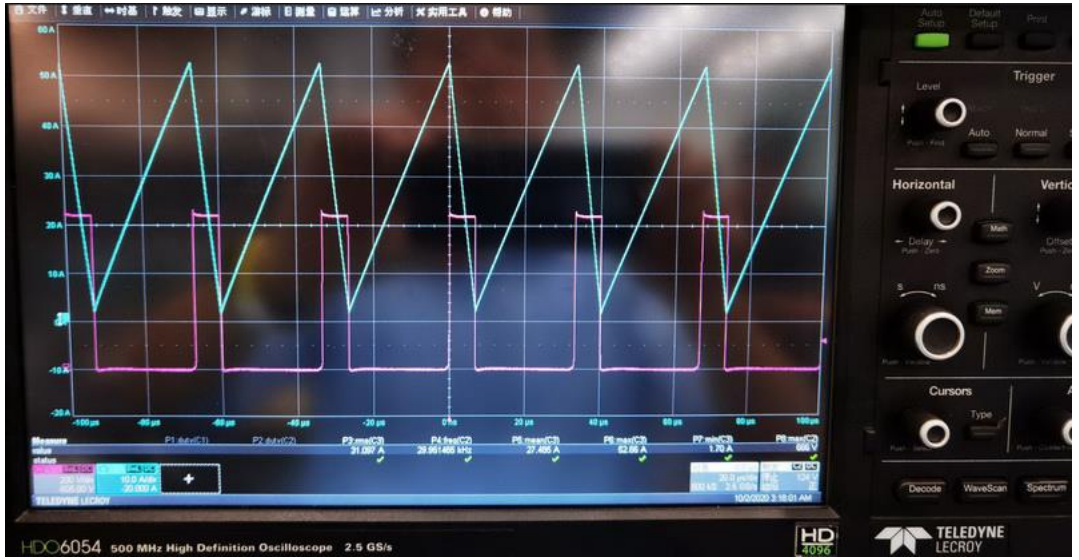


Low winding crossing flux leaking structure
(even under much higher magnetic strength)



$$P_{core} = P_{Hysteresis} + P_{EddyCurrent} + P_{Residual}$$

$$P_{coil} = P_{SkinEffect} + P_{ProximityEffect} + P_{WindingEddy} + P_{DC} + P_{CirculatingCurrent}$$



160KW Reactor loss analyzer -BBC160K-500A

■ Automotive features on Power Magnetic Component

Automotive Power Inductor

- High performance
- High reliability

高ﾊﾟﾜｰ
ｲﾝﾀﾞｸﾀﾝｽ密度
High inductance density

究極の放熱性
Fast heat dissipation ability

長期耐久性
Long proved life-time

Wide operating temperature range
広い温度特性

High level mechanical vibration & shock
高い機械強度

Good cost performance
ﾍﾞｽﾄ･ﾊﾟﾌｫｰﾏﾝｽ

Application features

Water Cooling

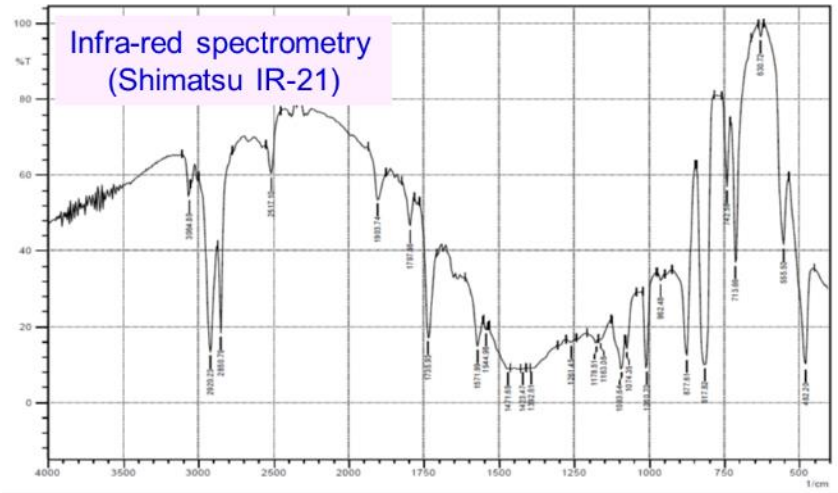
Oil Cooling

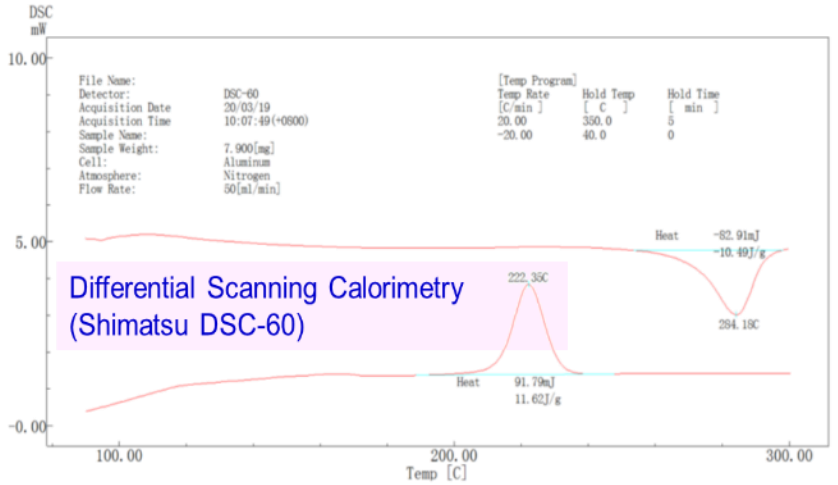
Injection molding technology for automotive application

Anti-heat shock & ATF compatibility PPS material

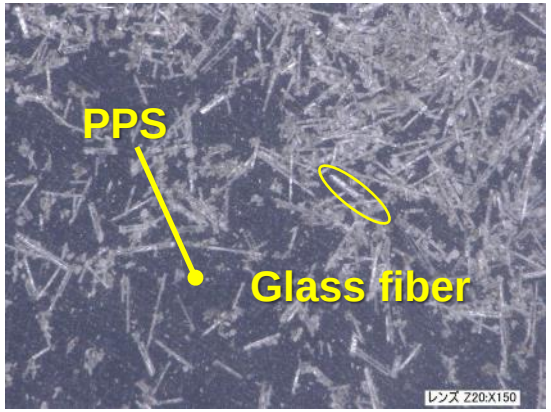
Collaboration with TORAY Innovation by Chemistry

> PPS-(GF+MD)55 <





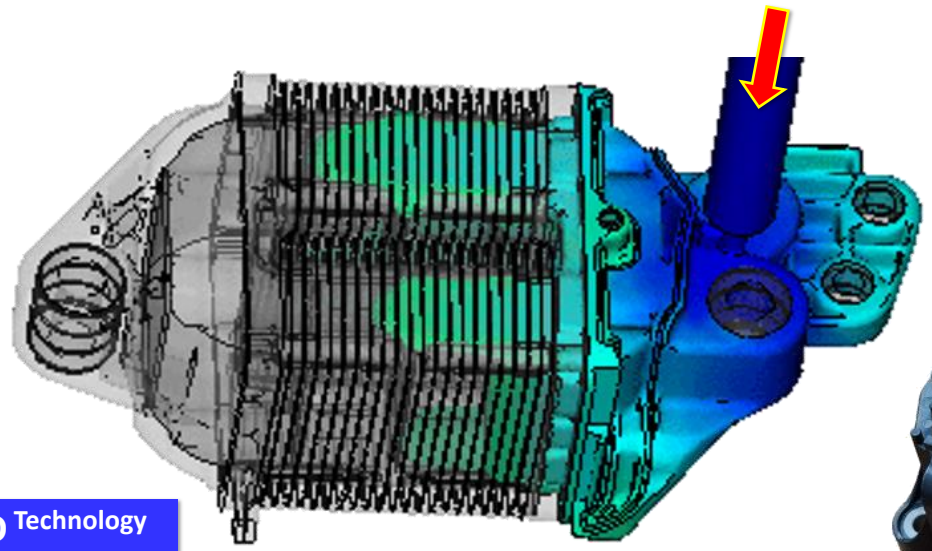
Item	FT-IR	Ash content	DSC		Microscope View
	Hot pressing	600℃、3Hrs	Tm(℃)	Tc(℃)	
HF45-1	PPS	56%	284.2	222.4	GF+MD



Surface & inside between core and winding

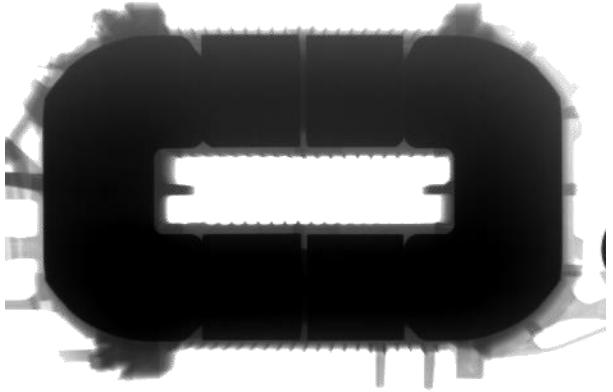
NO any heat-shock cracks found proved Under
1000 heat-shock cycles at -40℃~180℃ range

PPS Injection molding technology



UiD Technology

Product Photo



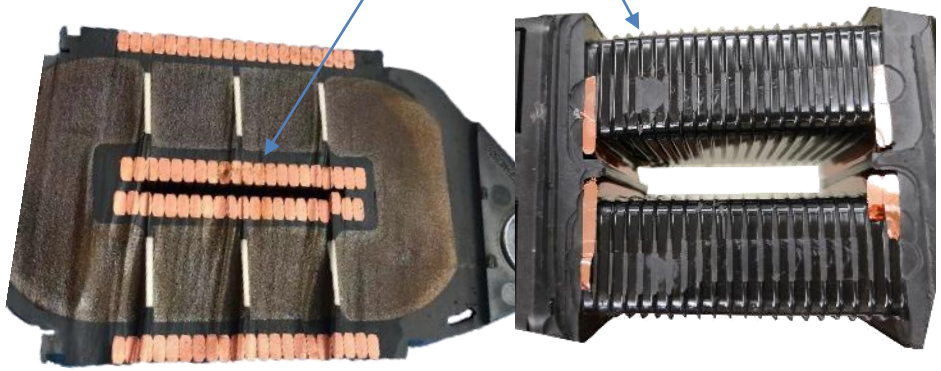
X-layer photo

- Injection molding power inductor structure provides a best way to meet requirements at hard vibration & mechanical shock specs for automotive application.
- Good heat dissipation function
- Good electrical insulation structure

Keeping windings outside of molding benefits heat dissipation for water cooling & oil cooling

(Water cooling reactor)

No any clack full filled PPS within gap from core to winding



Inside molding structure photo

Advanced Power Magnetic Technology for PV･E-mobility･Super charger

Bus bar welding technology

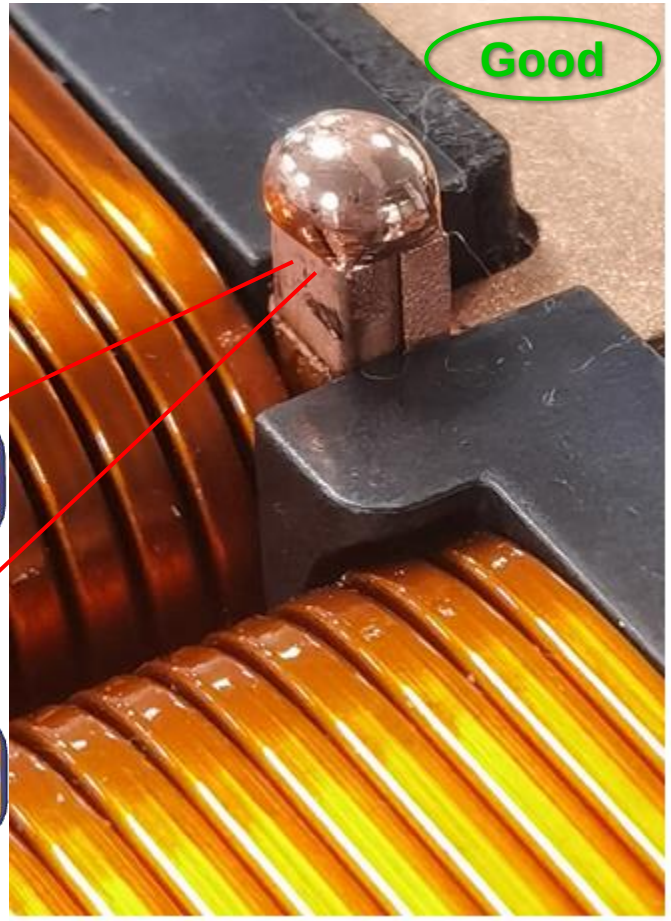
UiD Technology

- ★ High cleanliness
- ★ No joint oxidation
- ★ No coating carbonization
- ★ No joint welding clack
- ★ No welting void

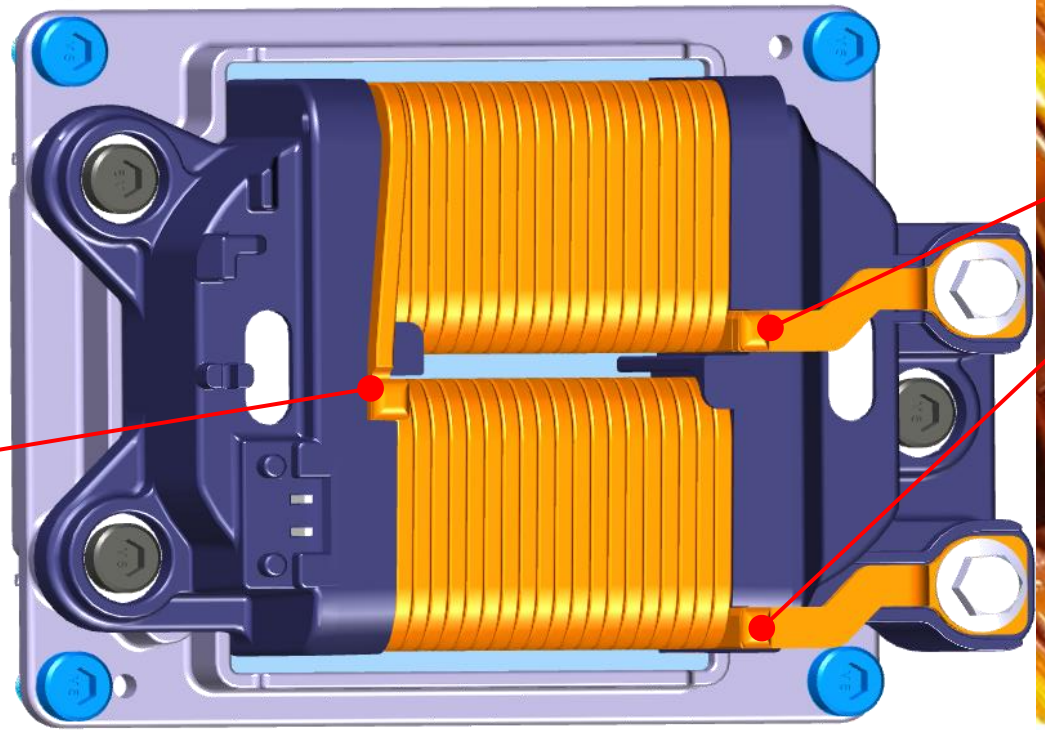
Laser beam welding

- Joint oxidation
- Coating carbonization
- Beam energy degradation

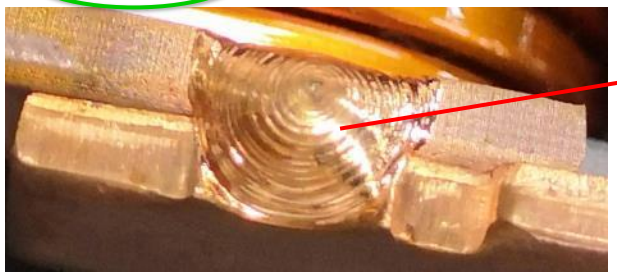
TIG welding technology



High reliability busbar joint



Good

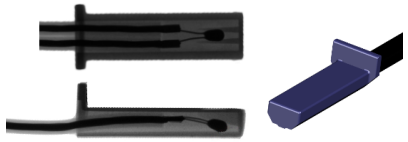


Advanced Power Magnetic Technology for PV·E-mobility·Super charger

Accurate & fast transient response NTC

Features

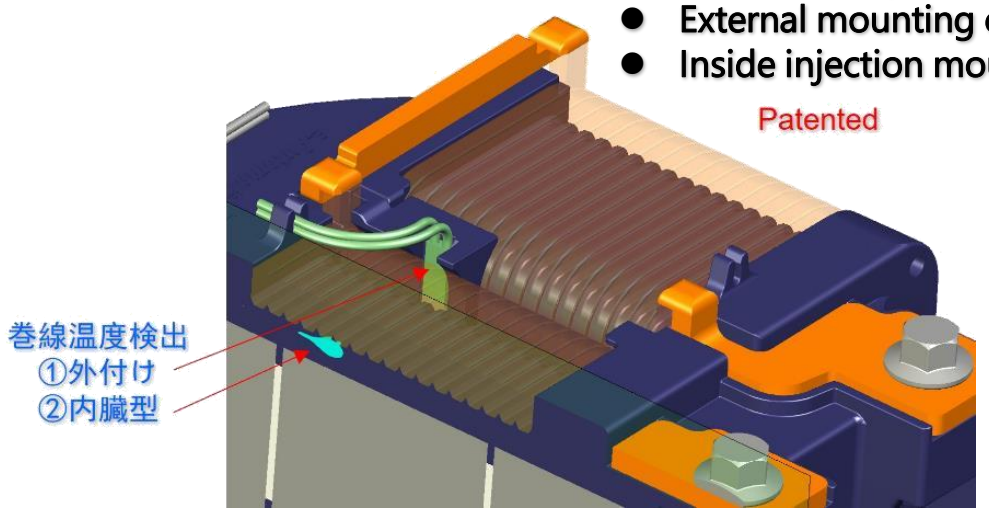
- High reliability NTC chip technology
- High Performance sensor package design providing sensing precision & response
- Very low discreteness
- Low cost



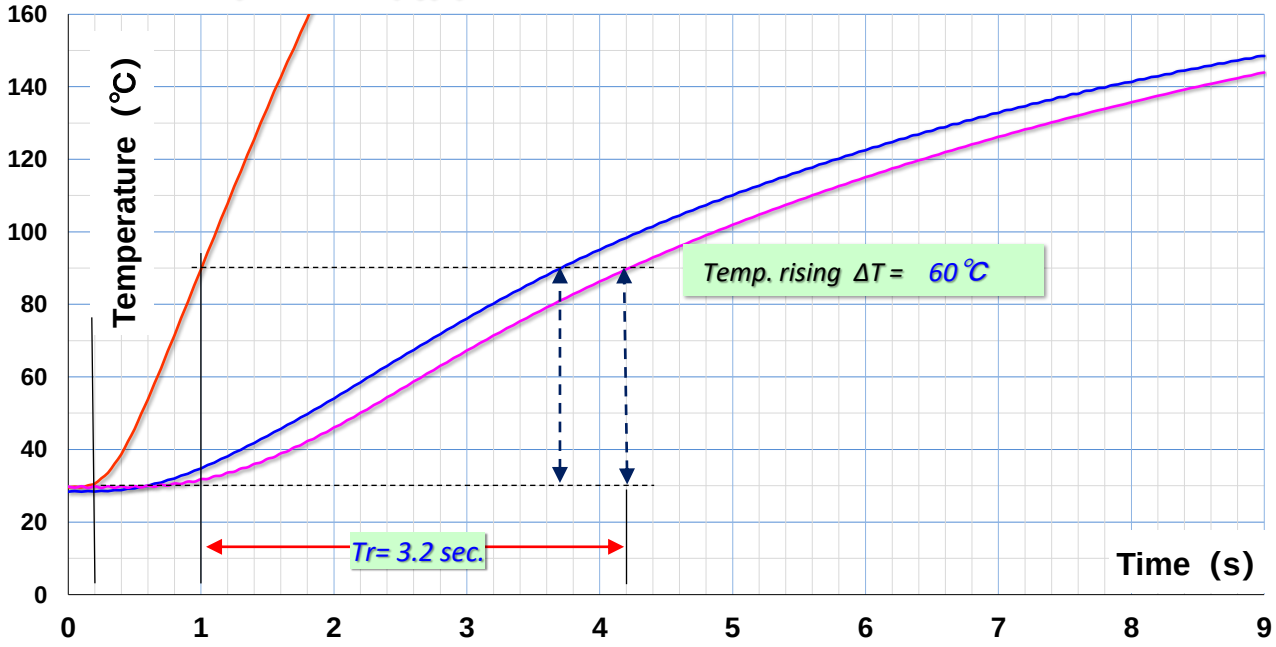
Advanced temperature sensing technology

- External mounting construction
- Inside injection mounting construction

Patented



NTC response time (Typ.)



Ultra-speed heater enables NTC temperature response test.

Automotive production management system through materials, parts, equipment & manufacturing

Automotive Power magnetic component features

Function specification performance

Reliability

Automotive management system

Specification design

High effic. / Small size / T. range / Weight saving / Low noise / Cost perform. / EMC

Reliability design

高温 高湿 / 振動 衝撃 / 耐油性 / 耐応力 / 極寒 極熱 / 熱衝撃 / 耐酸化

Quality risk analysis

Defect / Discreteness / Robust

Quantify Monitor Control

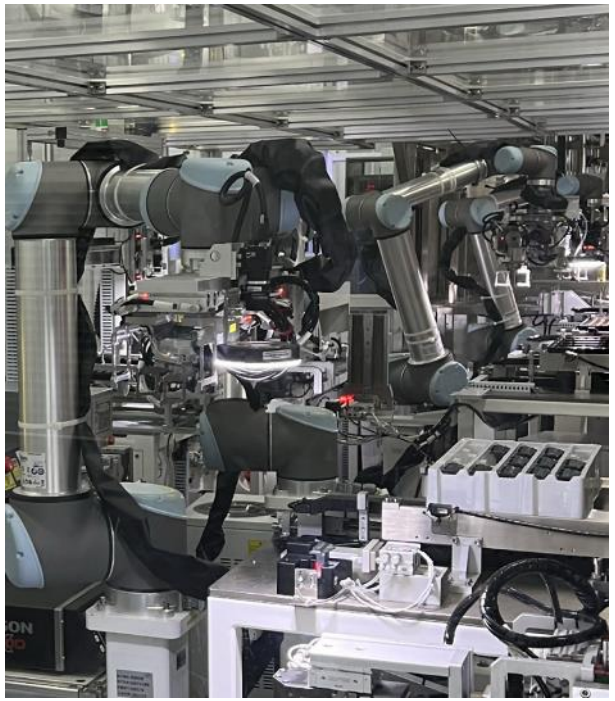
Tracing system

Design Validation

Reliability test

Production Validation

- Automatic production Line



ES	EV	DV	PV	MP
Prototype 試作品作成	Engineering Validation 技術検証	Design Validation 設計検証	Production Validation 生産検証	Mass Validation 初期流動管理

Contact us

SUSTAINABLE DEVELOPMENT GOALS

私たちは持続可能な開発目標（SDGs）を支援しています

POCO 日本アプリケーション技術窓口
POCO Application Tech. Support

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