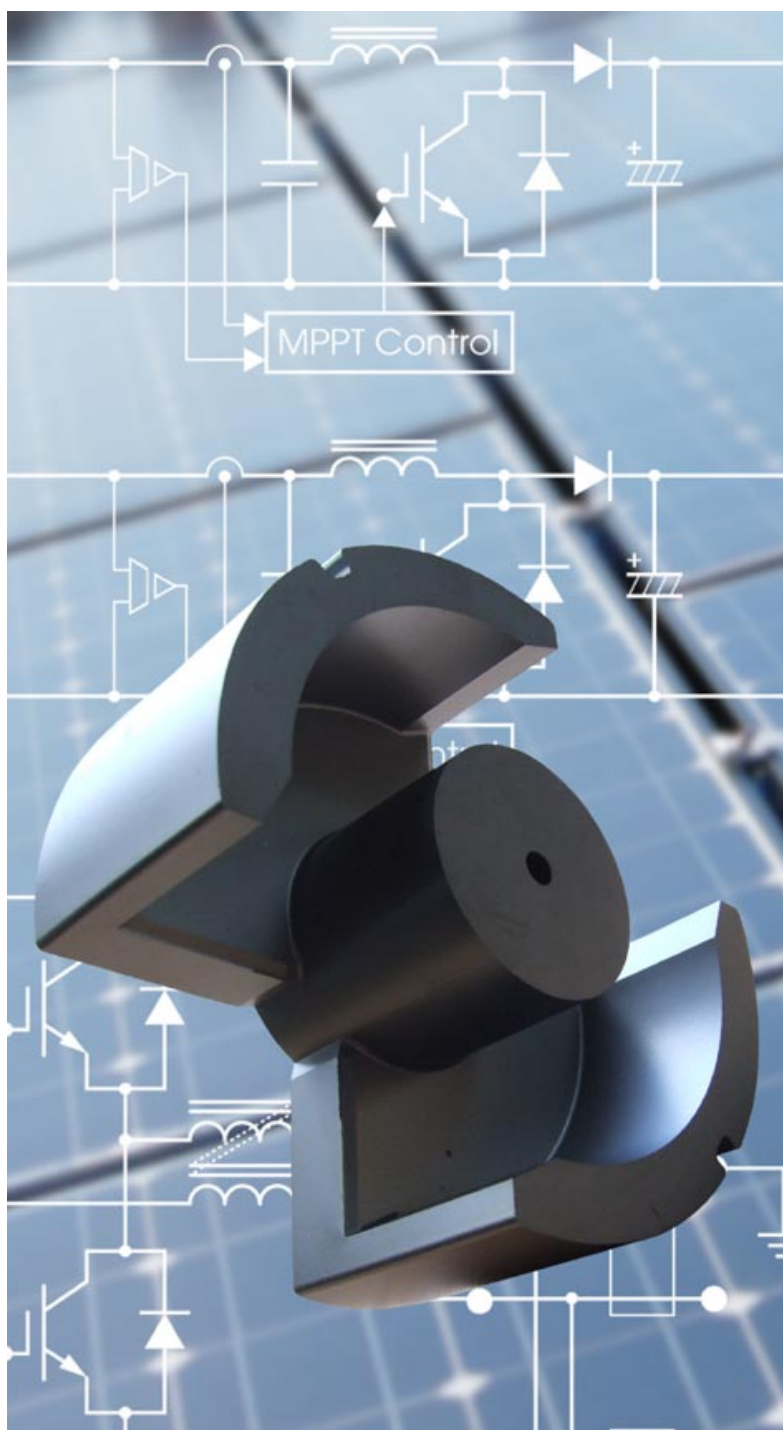


Low Loss And High Saturation Flux Density Ferrite For High-power Transformers And Reactors

PE90

Material

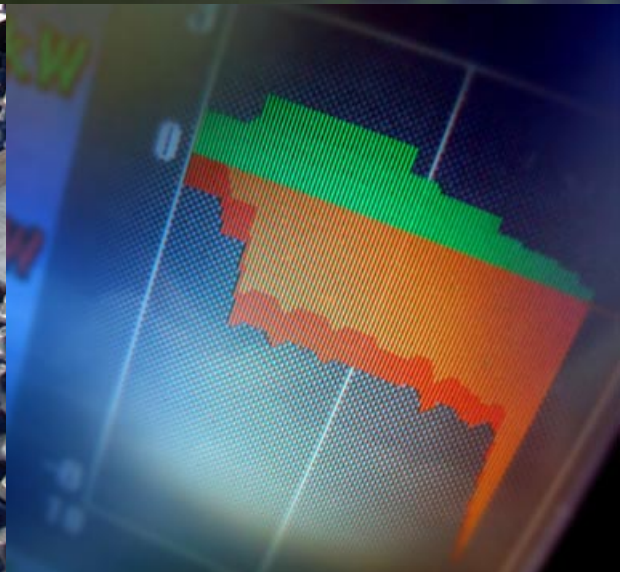




er bereich	Wirkungsgrad _{pmed}	Note	Platz	W...
0 V	96,9 %	sehr gut +	1	97,2 %
57 V	96,9 %	sehr gut +	1	97,0 %
10 V	96,8 %	sehr gut +	3	96,9 %
150 V	95,1 %	sehr gut +	4	95,7 %
600 V	94,6 %	sehr gut	5	94,8 %
500 V	94,5 %	gut	6	94,8 %
- 450 V	94,4 %	gut	7	95,1 %
- 550 V	94,1 %	gut	8	94,7 %
- 706 V	94,0 %	gut	9	94,7 %
0 - 435 V	93,9 %	gut	10	94,7 %
50 - 650 V	93,9 %	gut	10	94,7 %
65 - 515 V	93,8 %	gut	12	93,9 %
350 - 623 V	93,8 %	gut	12	93,9 %
114 V	93,8 %	gut	14	93,9 %
	93,4 %	befriedigend	15	93,9 %
	93,2 %	befriedigend	16	93,9 %
		befriedigend	17	93,9 %



There are losses
you can't ignore
even if they're only 0.1%



Low Loss And High Saturation Flux Density Ferrite For High-power Transformers And Reactors

PE90

Material

It's a cutting-edge power ferrite which enables low reactor loss in the step-up chopper circuits and smoothing circuits (inverter unit) of the power conditioners for photovoltaic power generation systems (hereafter called "PV systems").

The power conversion efficiency of power conditioners for PV systems have already reached as much as 95% in the retail model for stand-alone buildings. But the 4.5kW model, for example, still loses 225W of power through heat. Reducing this loss to a 2-digit number — PE90 is probably the world's first power ferrite to support such wishes and the passionate efforts of manufacturers — with a superb magnetic range.

As a material for large cores designed for high currents, PE90 provides both the industry's highest level saturation magnetic flux density of 430mT and the lowest level core loss of 400kW/m³. This makes PE90, in a similar size, a replacement for soft magnetic metal reactors in 3-5 kW power conditioners which operate at switching frequencies of 15-20kHz.

Core shapes such as UU, PQ, PM, EC, and so on, which seek high-efficient magnetic path designs, are standardized in diverse sizes. Special shapes and prototypes can of course also be provided.

PE90 allows reactor/transformer designs even smaller and lower in loss for applications utilizing PE22, a conventional high Bs material, such as general-purpose inverters, uninterruptible power supplies, hybrid cars, electric cars, railroad vehicles, and so forth.

Product conforming to RoHS Directive.*

* Conformity to RoHS Directive: This means that, in conformity with EU Directive 2002/95/EC, lead, cadmium, mercury, hexavalent chromium, and specific bromine-based flame retardants, PBB and PBDE, have not been used, except for exempted applications.

Efforts toward maximized system electric generation and waste-free use. PE90 offers new possibilities at this ultimate technological level.

Can reactor loss be ignored?

From the beginning of development, new electric power generating systems of 3.5-5.5kW, such as PV systems, mid-sized wind power generation, and fuel battery electric generation for stand alone/complex housing, are the application that we considered appropriate to demonstrate the advantages of PE90, which exceeded the limitations of conventional ferrite specifications.



Power conditioners which are essential for such systems have multiple reactors and transformers that are vital in power conversion processes, but the losses from the reactors and transformers can no longer be ignored.

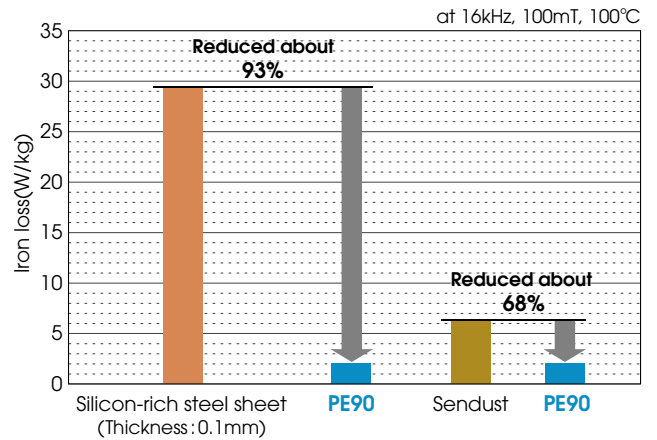
According to the simulation of reactor loss (for smoothing inverters) where 3kW output power, 1mH inductance, 15A electric current effective value, 24A current peak, and 16kHz operating frequency are used, the reactor loss (iron loss + copper loss) of silicon-rich steel sheet and sendust is around 14W, which is about 0.47% of 3kW rated output power.

If we simulate the iron loss particular to a reactor of silicon-rich steel sheet and sendust at an operating frequency of 16kHz, you can see that it reaches a level about three to ten times higher than that of ferrite reactors. Of course the differences of the iron losses and core losses shown below aren't directly reflected to reactor loss because copper loss from windings is also added to reactor loss. But as shown in the core loss comparison, the "20kHz" of the operating frequency range of 15-20kHz, which is set for power conditioners, is almost the usable limit value of the reactors of silicon-rich steel sheet and sendust.

But as if to confirm the simulation result — the loss is only 0.47% of rated output power (3kW) per reactor, and less than 1% even for two — the power conver-

Comparative example of reactor iron losses

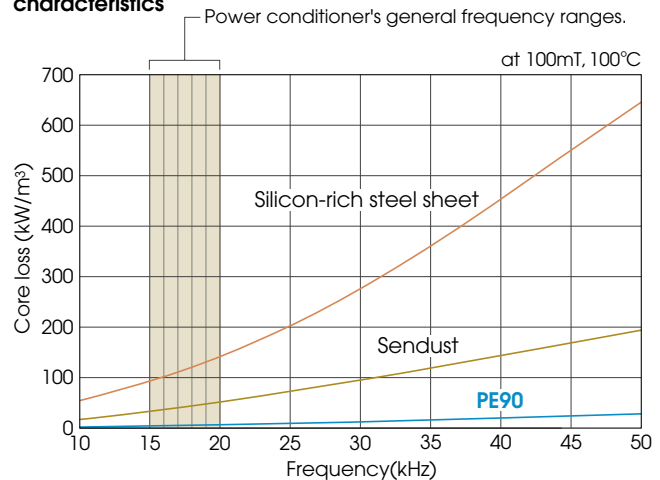
Simulation values based on reactor design conditions of similar characteristics.



Even if the resistivity value is raised by increasing the amount of silicon, and the occurring eddy current range is reduced by pressing and multi-layering strip sheet metal, the iron loss level of reactors using silicon sheet metal is greater than that of ferrite cores with a resistivity value a hundred times higher. The core loss shows a sharp rise as frequency increases.

But the core loss of a silicon sheet metal reactor, which has an iron loss about fourteen times higher than that of ferrite, stays at a practical level of 17 or 18kHz power conditioner operating frequency. Thanks also to the large saturation magnetic flux density, it has been the top core material for reactors for large current applications.

Comparative example of core loss vs. frequency characteristics



sion efficiency of the power conditioner has already reached 94-95% in slim/small standard retail wall-hanging models. Through improvement of soft switching circuits which realizes zero-current switching, and using a new inverter system which allows great reduction of loss, 4kW retail models for general household use with over 97% of power conversion efficiency have already been released.

Low Loss And High Saturation Flux Density Ferrites For High-power Transformers And Reactors

PE90 Material



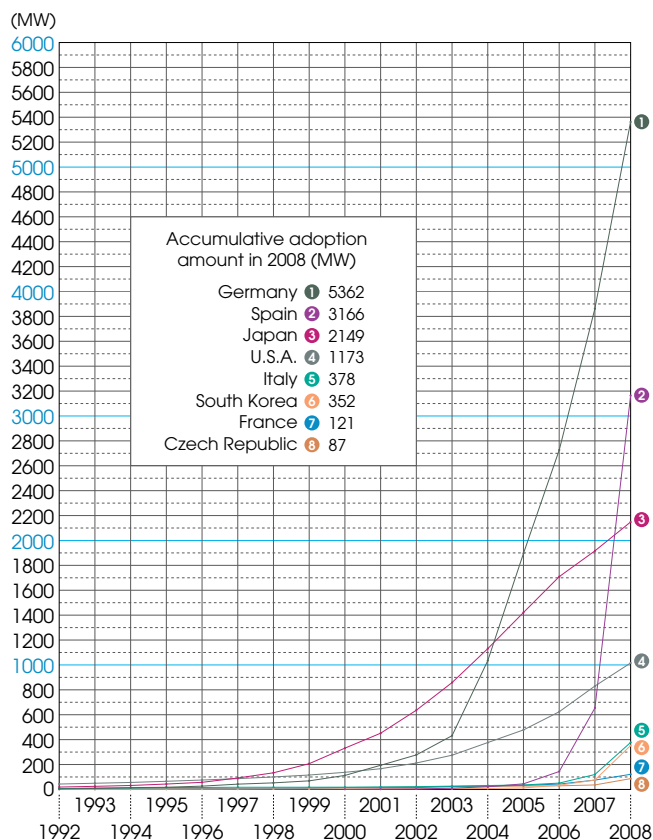
Seeing these figures may make you think that reactor loss is nothing to worry about. And that has been correct until now.

But how will it be from now on?

The day has arrived where you can't afford to ignore the heat of reactors anymore.

Major nations focus their effort on PV systems in the new energy market. The European PV systems market, in particular, has been making an annual development of 50%, and so surfacing as the largest market in the world. There are many cases of national-scale efforts such as building massive photovoltaic power generation facilities of several tens of megawatts. But it is obvious that Germany's feed-in tariffs and the following similar promotional efforts in Spain and Italy have initiated the significant expansion of the European market.

Accumulated amount of PV system adoption in each nation



Source of the accumulated data in each nation / 1992-2007: Report IEA-PVPS T1-17 "TRENDS IN PHOTOVOLTAIC APPLICATIONS 1992 and 2007"

Accumulated data in 2008: Each nation's adoption amount in 2008 (Reference: Tech-on! Nikkei Electronics / March 26, 2009) was added to its accumulative data in 2007.

The success and worldwide propagation of surplus electric power purchasing systems in Europe have been accelerating the need for early collection of system

installation costs. It is expected that the industry's activities, in which the power conditioner's power conversion efficiency is measured and evaluated to make a ranking for publication, and each nation's effort to include the power conditioner's efficiency as one of the Eco mark system conditions rapidly expand.

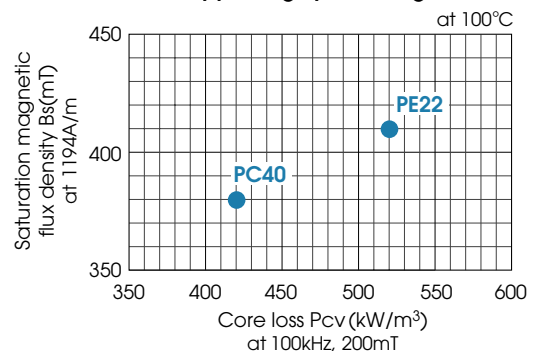
Power conversion efficiency is shown on the Internet, in newspapers, magazines, catalogues, and so on, along with other information, such as prices, product lives, and repair and maintenance costs. A difference of a mere 0.5% can make a difference in the advantages of the power conditioner and systems, and favorability of manufacturers. This trend is becoming common for the nations of the new energy market.

Borderline efficiency where forced air cooling is unnecessary

At the final stage of high-efficiency power conversion circuit design, where achievement of more than 98% efficiency is vital in competition, whether the reactor supports "-0.5%" can change a manufacturer's advantage in the market. In thermal design, at the decision level whether air-cooling fan is not required in a power conditioner, PE90 is probably the world's first power ferrite which can make a difference and lead all its competitors in such efforts.

Being ahead of the rest of the world, PC40 materials were developed that achieved the industry's lowest level of coreless properties in the large ferrite core category for large power applications, as was the PE22 material which achieved industry's highest saturation magnetic flux. These materials have been responding to the need for large cores in industrial fields, in particular for reactors and transformers, and for heating and magnetic induction application, and such.

Materials which support high power large cores



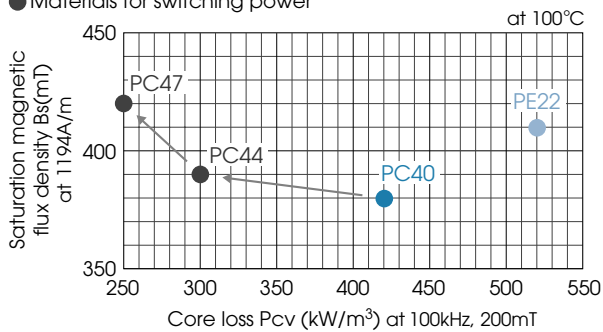
In improving the advantages of these two materials, we attempted to cultivate the magnetic characteristic area which have been "unexploited by any materials before" with further increases of saturation magnetic flux while the core loss level is greatly reduced. The first result from the attempt is the efforts to support the

Development concept / Features and advantages

latest needs of switching power — the development efforts evolving from the PC40 material to the PC47 material, as shown below.

Progress of low core loss material PC40 improvement

- Materials which support high power large cores
- Materials for switching power

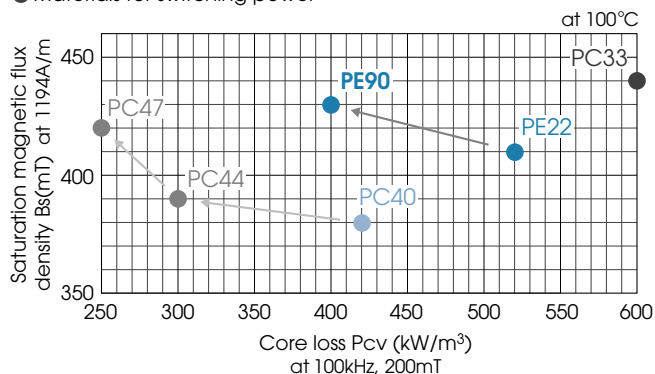


Currently, the core loss of these materials is close to 250kW/m³, about 40% lower, and the saturation magnetic flux density reached is 420mT, which exceeds that of the high Bs material PE22.

PE90 is one of the latest results of our efforts since the development of PE22, which was developed as a high Bs material for high power. In addition to PC47, this material allowed a new specification area which exceeds the existing limitations of the ferrite physical control theory. It was the birth of a new reactor which can greatly reduce reactor loss (iron loss + copper loss) while circuit conditions are satisfied in a size similar to that of conventional silicon steel sheet and sendust reactors.

Progress of low core loss material PC40 improvement

- Materials which support high power large cores
- Materials for switching power



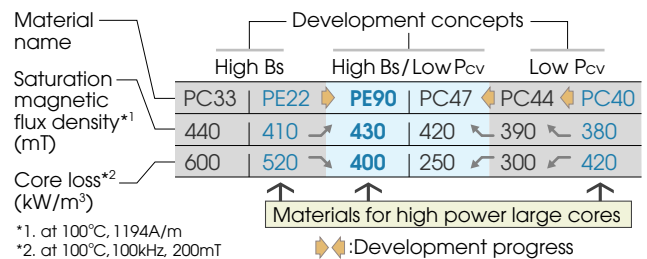
Conditions required for low-loss reactors which can support development efforts.

First, it has to have a saturation magnetic flux density which can support the peak current of 3.3-5.5kW power conditioners for household PV systems, which many nations do their best to popularize. Next, high

efficiency with much lower losses than those of reactors and transformers built from conventional core materials such as silicon steel sheet and sendust, must be achieved as practical characteristics in actual operation with windings. If these two conditions can be satisfied, low-loss reactors and transformers which can reinforce the efforts of power conditioner developers who compete for a 1% efficiency margin in the world market can be realized.

Our image of such useful components has resulted in unprecedented specifications.

We achieved a high Bs value of 430mT, which is close to that of the PC33 material, which has the industry's highest level of saturation magnetic flux density in the high power large core ferrite category, and a value of 400kW/m³, which is lower than that of the low-loss material, PC40. The 23% core loss reduction, in particular, is a significant improvement, allowing unprecedented freedom in designing reactors.



Prototype reactors put an end to previous beliefs.

Ferrites are easily molded and have a high degree of freedom in designing shapes, and an advantage in finding ideal magnetic path without wasting or overdoing anything based on intended uses, and also boast outstanding low loss quality. But because ferrite's saturation magnetic flux density is less than half that of soft magnetic metal materials, and power conditioner's circuits have operating frequencies of 15-20kHz, core cubic capacity and winding volume tend to be large and superior low-loss advantages are not utilized. But the completion of PE90 put an end to all of these tales.

DC superposition characteristics are a vital source of information for decision making in designing reactors and transformers. On the next page, the evolution of characteristics from PE22 to PE90 are shown.

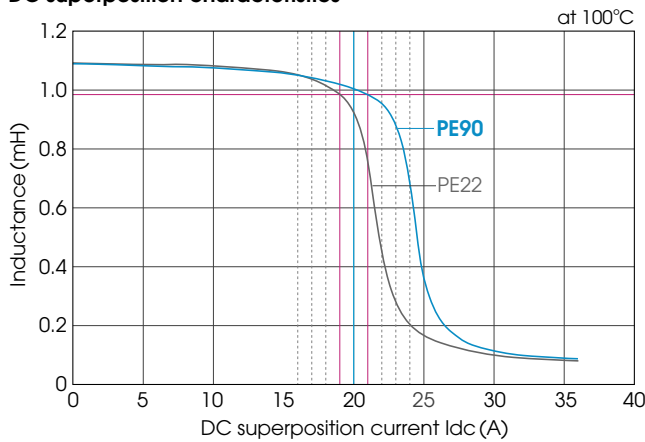
It's a real example of a prototype reactor where the reactor's dimensions are W109 × T55 × H115mm and PE22 and PE90 have a similar level of inductance value (1.1mH) and adjusted air gap values, and DC superposition current peak value, which is determined by magnetic saturation (where the inductance value decreased by 10% from the level where Idc=0A), was adjusted to around 20A.

Low Loss And High Saturation Flux Density Ferrites For High-power Transformers And Reactors

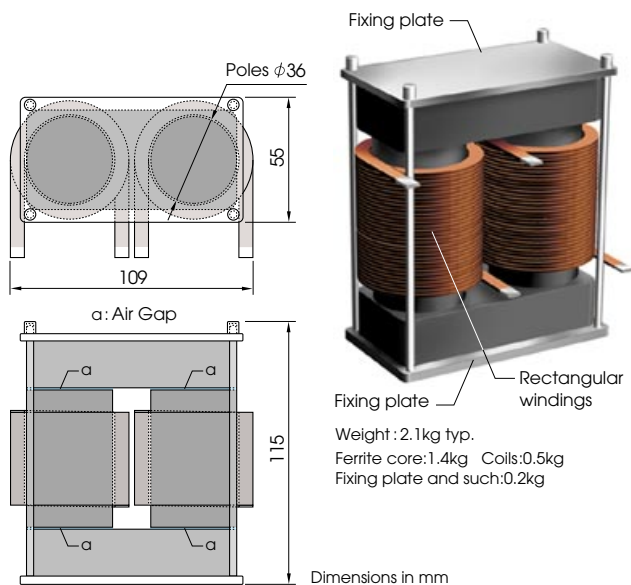
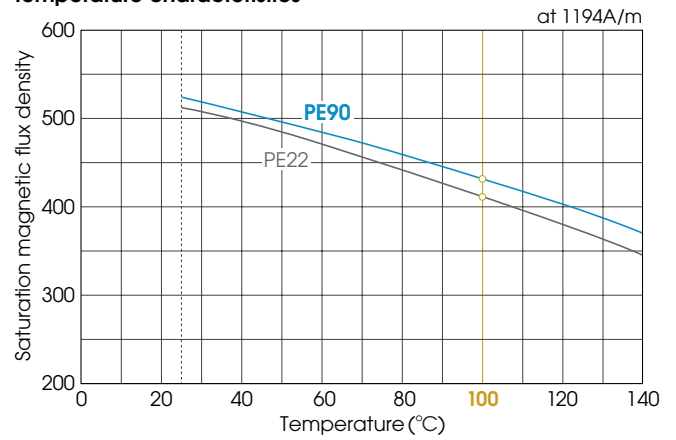
PE90 Material



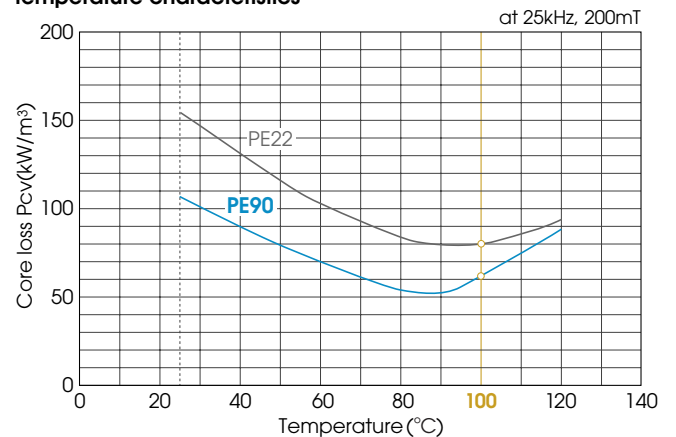
Example of inductance change vs. DC superposition characteristics



Comparative example of saturation magnetic flux density vs. temperature characteristics



Comparative example of core loss vs. temperature characteristics



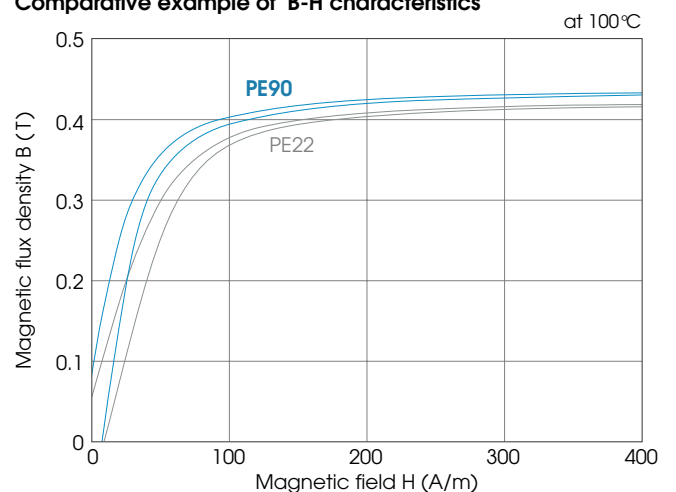
The conventional high saturation magnetic flux density material PE22 reached magnetic saturation at 19A. The newly developed PE90 can function as a reactor up to 21A, a level about 10% higher than that of PE22. What made this increase possible? Let's take a closer look.

As shown in the comparative chart at the top right, the saturation magnetic flux density at 100°C is 410mT for PE22, and 430mT for PE90: The difference is only 4.8%. Despite this, PE90's DC superposition characteristics increased remarkably—the reason for this can be seen on comparing the core losses and magnetization curves of both.

PE90's core loss at 100°C is lower than that of PE22 by 23%, which makes the rise of magnetic flux density steep, and the minor loop's linearity was maintained right up and just before it was saturated.

In other words, PE90 has acquired superb DC superpo-

Comparative example of B-H characteristics



sition characteristics which can easily realize low-loss reactors of the sizes similar to conventional reactors with soft magnetic metal by plunging into a low core loss material world where no other high saturation magnetic flux density materials can enter.

Development concept / Features and advantages

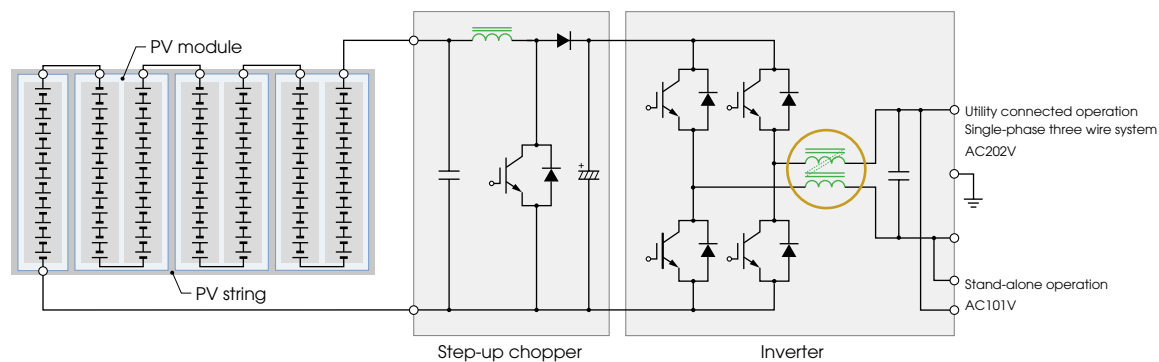
This reactor can reduce the waste of inverters' smoothing circuit by about 30%.

Next, the total iron and copper losses, that is, the "actual performance" of the reactors which are integrated to the power conditioners, were compared. It's a simulation of the reactors used for a smoothing circuit of the inverters for 3 kW-level household PV system power conditioners.

Results of inverter smoothing reactor's simulation (referential value)

Actual preset temperature at the time of loss calculation: 100°C

Circuit configuration of the power conditioners (3kw)



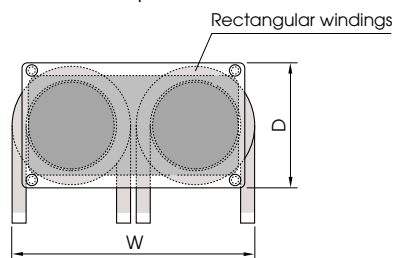
Design conditions of the reactors

Output power	3kW
Inductance	1mH
Effective current	15A
Ripple current	2.8A _{0-p}
Peak current	24A
Ripple frequency	16kHz

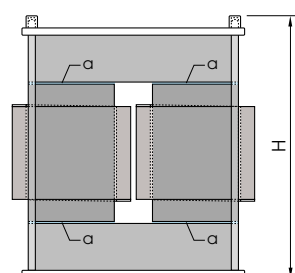
Loss comparison with silicon steel sheet

Core material	Silicon-rich steel sheet	PE90
Core shapes* ¹ (mm)	W105×H110×D60	W105×H110×D60
Reactor loss (W)	14.4	9.7
loss amount ratio* ² (%)	100	67.4
loss reduction amount (W)	-	4.7
Increase of generated electricity* ³ (kWh/year)	-	4.94
Increase of CO ₂ reduction (kg/year)	-	2.25

Reactor shapes



a: Air Gap (Optimized for each material)



Loss comparison with sendust

Core material	Sendustt	PE90
Core shapes* ¹ (mm)	W100×H110×D60	W105×H110×D60
Reactor loss (W)	13.8	9.7
loss amount ratio* ² (%)	100	70.3
loss reduction amount (W)	-	4.1
Increase of generated electricity* ³ (kWh/year)	-	4.31
Increase of CO ₂ reduction (kg/year)	-	1.95

*1. Cross sections of the core and rectangular windings: Set the same for both materials. Windings of metal cores: number of winding turns where iron loss and copper loss are almost the same were set.

*2. Proportion where the loss of the compared reactor is 100.

*3. The rated generation capacity multiplication ratio: 1051.2 (24h × 365 days × 0.12), which seeks the actual value of annual power generation of solar cells, was used as the loss reduction amount specified above.

*4. Based on the CO₂ emission intensity: 0.453kg-CO₂/kWh (Federation of Electric Power Companies/analysis and evaluation of CO₂ emission/2007).

Winding count / Loss / Loss ratio

Core material	Silicon-rich steel sheet	Sendustt	PE90
Reactor loss (W)	14.4	13.8	9.7
Winding count	72	66	74
Iron loss (W)	7.49	7.45	0.55
Iron loss ratio (%)	52.0	54.0	5.7
Copper loss (W)	6.92	6.35	9.15
Copper loss ratio (%)	48.0	46.0	94.3

Low Loss And High Saturation Flux Density Ferrites For High-power Transformers And Reactors

PE90 Material



As the results show, if the PE90 material core is used, a reduction of about 33% of a similar sized silicon steel sheet reactor loss, and a reduction of about 30% for a similar sized sendust reactor loss, can be attained.

Of course, this is only a referential value, but one can see a possibility which may be accelerated by PE90.

Potential for 30-50kHz power conditioners

Most of the power conditioners which achieved 95% efficiency have trench IGBTs (Insulated Gate Bipolar Transistor), which provide high-speed operation and low loss properties. But this IGBT with a high-speed soft recovery diode can support switching up to around 30kHz. The IGBT for high power applications has recently been made significantly lower in losses and faster in speed, giving birth to 30-50kHz drive elements which keep high-speed switching requirements of power conditioners in mind.

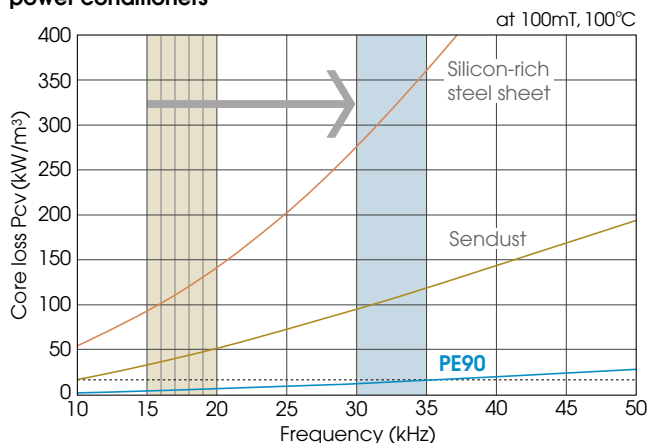
Highly motivated efforts for zero-current switching circuit design technology are being made. With the current efficiency level of the cutting-edge models, it seems that the level of switching loss has been reduced to an insignificant level.

Under these circumstances, if all of the installed conventional reactors, including those for step-up choppers were to be replaced by those with PE90, there would be no good reason to keep the power conditioner's operating frequency between 15 and 20kHz because of the PE90's core loss frequency characteristics.

around 15-20kHz. This will increase copper loss, but the required magnetic flux density will decrease at the same time because the frequency is higher, and, as a result, the core can be reduced in size. It is therefore possible that the core loss increase, the loss per unit volume, will be reduced.

The certainty of this possibility can be proven only after many simulations with diverse circuit configuration conditions are made. But if expected results are obtained, the new reactor will be able to realize further efficient power conditioners with a reactor one-size smaller than the existing one.

Potential for high-speed operation next-generation power conditioners



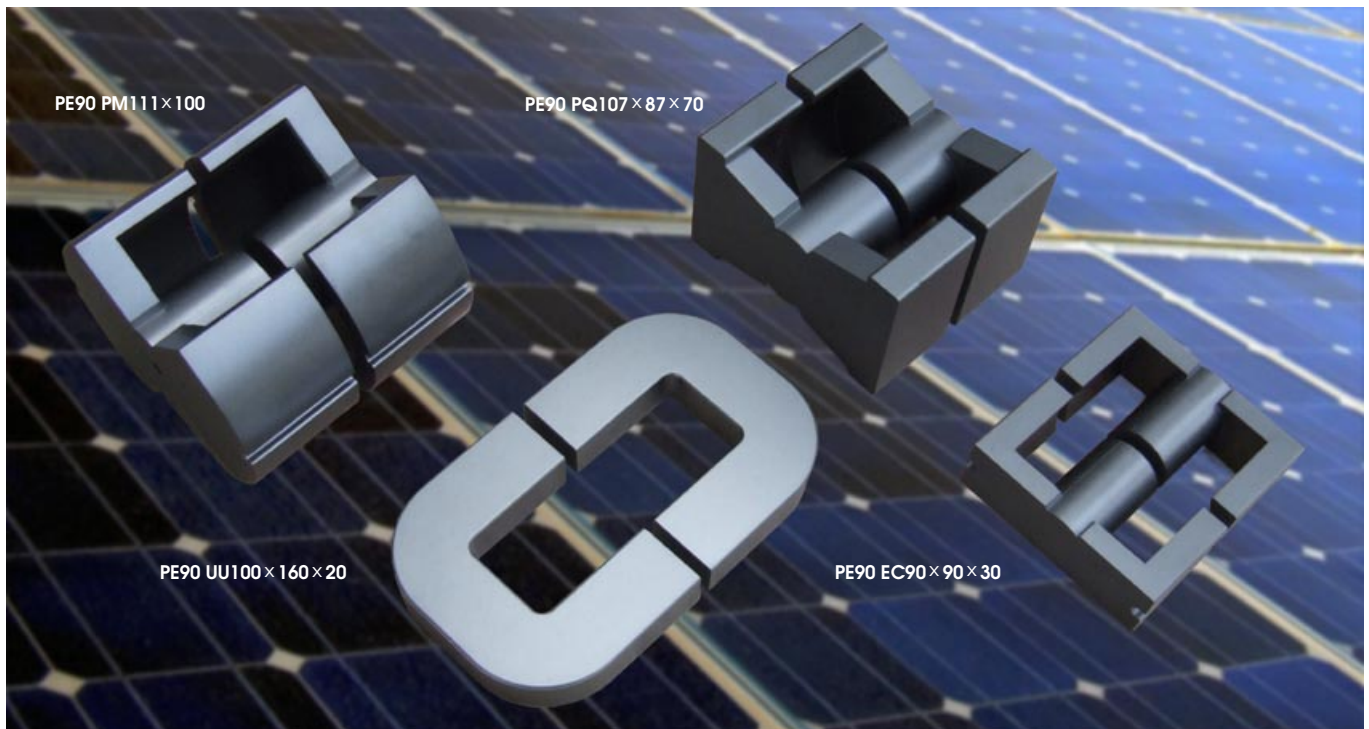
With PE90, operating frequency can be set at 30-35 kHz, for example, which is double the current value, although the frequency range will become the one where the use of silicon steel sheets and sendust is difficult.

Even in such a frequency range, the core loss of PE90 remains much lower than that of the sendust material

Material characteristics / Frequency characteristics / Thermal characteristics

The magnetic characteristics which can be provided to large ferrite cores for high current greatly depend on the technological level and knowhow of sintering process control. To realize the world's finest magnetic characteristics, which could be done using usual small cores, a precise and uniformed atmosphere control is required throughout all sintering processes. We have established

originally designed atmosphere furnaces and sintering process control technologies, making mass production of large cores, which significantly exceed conventional characteristic limitations, possible. The world's smallest low loss materials and world's top level high-saturation magnetic flux density materials were realized even in the realm of high power large ferrite cores.



The core shapes and sizes such as those of the PM, PQ, UU, EC series, which are ideal for circuit design specifications are included in the product lineup. We can also provide non-standard shapes. Please feel free to contact us.

Typical applications

Reactors and transformers for power conditioners used for PV systems, middle-scale wind force generation systems, fuel-cell-power generation systems, and those hybrid power generation system.

Reactors and transformers for large current purposes such as general-purpose invertors, rail-road vehicles, hybrid cars, electric cars, uninterruptible power supplies, medical equipments, and so forth.

Comparison of material characteristics

Material name		PE22	PE90
Initial permeability*1	(at 23 °C)	1800±25%	2200±25%
Core loss*2 P _{cv}	(kW/m ³)		
	(at 90 °C)	79	60
	(at 100 °C)	80	68
Saturation magnetic flux density*3 B _s	(mT)		
	(at 23 °C)	510	530
	(at 100 °C)	410	430
Residual magnetic flux density*3 B _r	(mT)	(at 23 °C) 140	170
Intrinsic coercive force*3 H _c	(A/m)	(at 23 °C) 16	13
Curie temperature T _c	(°C)	200 min.	250 min.
Specific electric resistance	(Ω·m)	3.0	6.0
Apparent density d _{app}	(kg/m ³)	4.8 × 10 ³	4.9 × 10 ³
Thermal expansion coefficient	(1/K)	12 × 10 ⁻⁶	12 × 10 ⁻⁶
Thermal conductivityK	(W/mK)	5	5
Specific heat C _p	(J/kg·K)	600	600
Flexural strengthδ _{b3}	(N/m ²)	9 × 10 ⁷	9 × 10 ⁷
Young modulus E	(N/m ²)	1.2 × 10 ¹¹	1.2 × 10 ¹¹
Magnetostriction constantλ _s		-0.6 × 10 ⁻⁶	-0.6 × 10 ⁻⁶

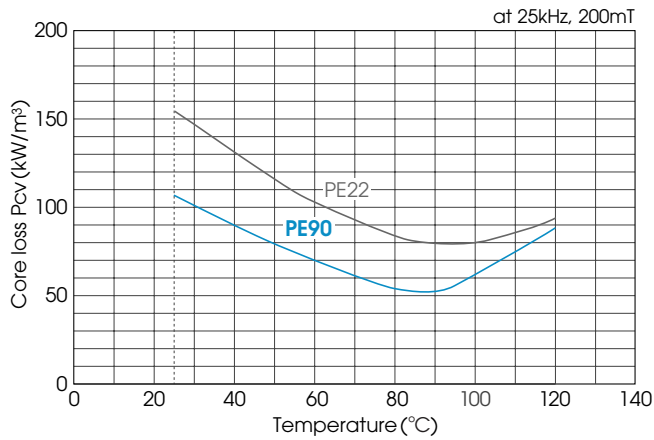
*1. at 1kHz, 0.4A/m *2. at 25kHz, 200mT *3. at 1194A/m

Low Loss And High Saturation Flux Density Ferrites For High-power Transformers And Reactors

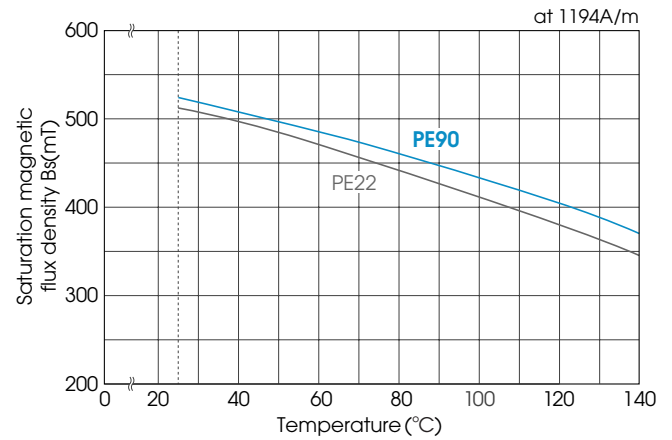
PE90
Material



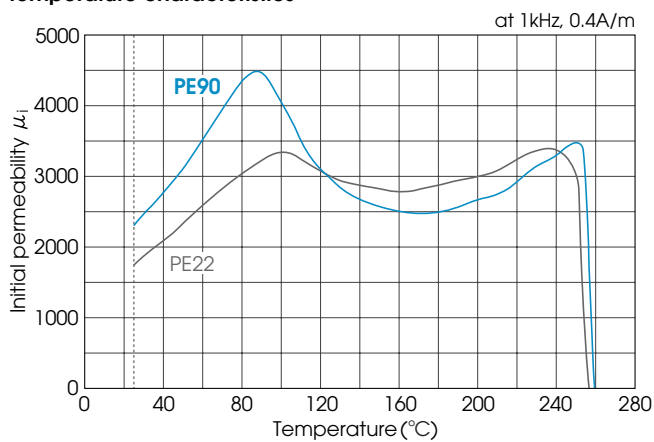
Comparative example of core loss vs. temperature characteristics



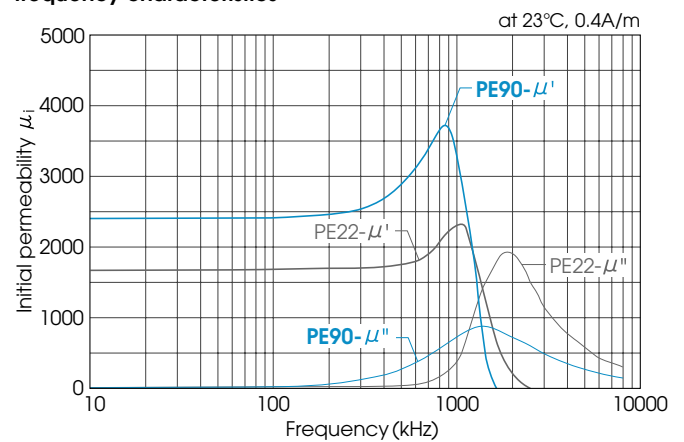
Comparative example of saturation magnetic flux density vs. temperature characteristics



Comparative example of initial permeability vs. temperature characteristics



Comparative example of initial permeability vs. frequency characteristics



Information related to power conditioners

Basic circuits and reactor loss occurrence mechanism

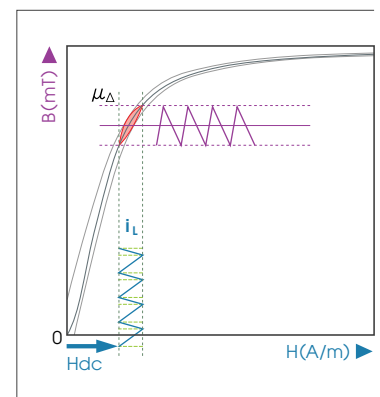
Due to the reactor current occurred by the ON-OFF switching of IGBT and the discharging/charging of capacitors in the parallel arrangement, the direct voltage which is output from solar cells is raised to 320V*, and the utility-connected inverters in the next step reverses the power flow to AC 202V of the commercial power source.

*A link voltage which is just above the theoretical minimum voltage (DC 320V for AC 200V of the actual value of AC output 200V) necessary to operate inverters without distortion is set for the DC link voltage, which is impressed to the inverters, because the THD (Total harmonic distortion) of the AC voltage from the inverter has to be reduced to less than acceptable values.

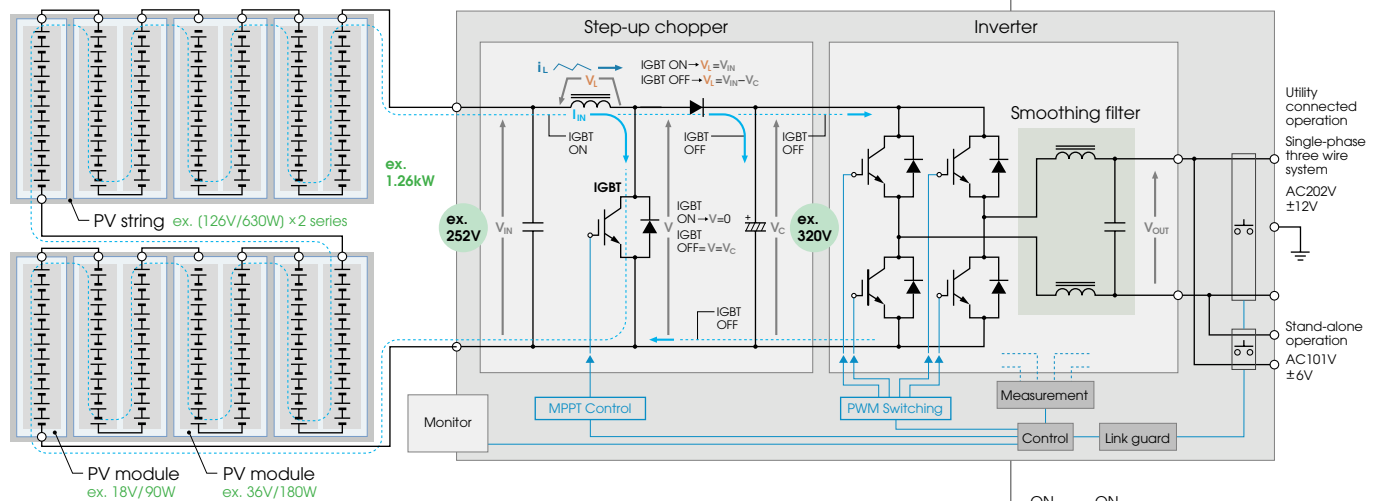
With the fuel-cell power system of 40-80V input to the power conditioners, DC-DC converters, which include inverters and high-frequency transformers, are usually used for boosting because the system has a high electric current value and high booster ratio. In this case,

to connect the system to a DC 202V system, a link voltage of 320V or higher must be provided to the inverter.

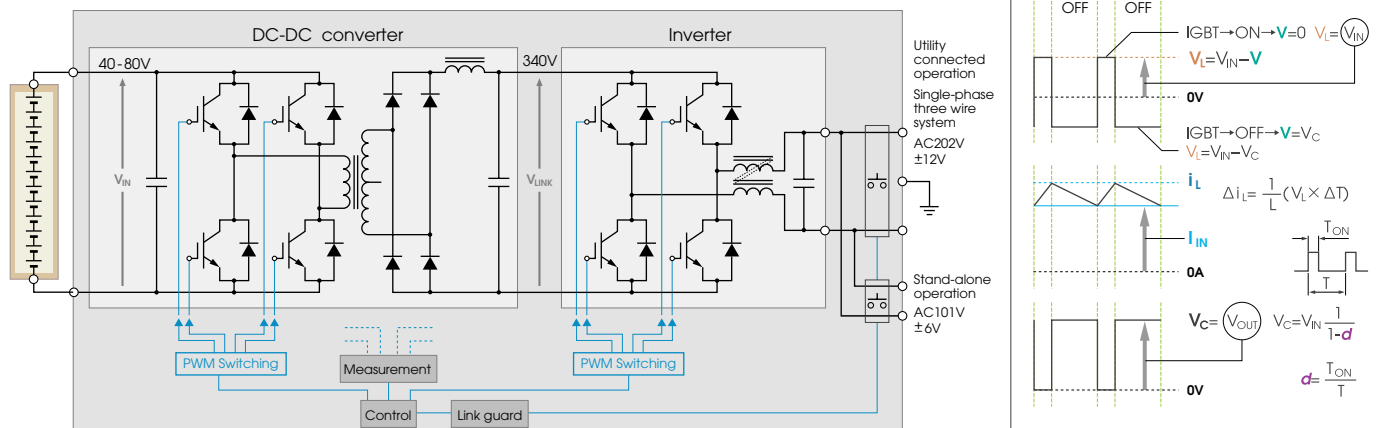
The electric current running in the reactor (or the primary winding of a high-frequency transformer) by IGBT switching causes an eddy current loss which increases proportionally to the area of the minor loop in the reactor's magnetization curves (B-H loop); in other words, the square of the hysteresis loss and switching frequencies. The reactor which connects condensers and filtering circuits at the output terminal of the inverter circuit in the later step also causes similar magnetization losses when it functions as a smoothing circuit which absorbs unnecessary high-frequency elements super positioned in the AC waveforms.



Basic circuit configuration example of PV system power conditioners



Basic circuit configuration example of a fuel-cell power generation system



Low Loss And High Saturation Flux Density Ferrites For High-power Transformers And Reactors

PE90
Material



Efforts toward circuit designs with 99% efficiency

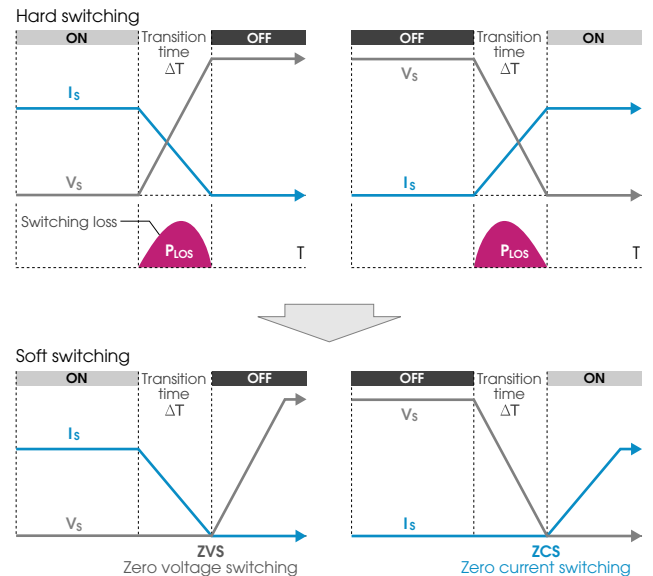
The power conditioners convert the DC power, which was boosted by chopper circuits and DC-DC converters, to the AC power at the system power frequency. Diverse efforts have been made to improve power conversion efficiency.

For instance, trench IGBTs, which have the smallest losses at the moment, are often used in the inverter section, where a link DC voltage of around 320 is linked to the system at an AC voltage of 202.

For the soft-switching method (ZCS: Zero-current switching), to avoid switching loss in the step-up chopper circuit (or DC-DC step-up converters composed of inverters and high-frequency transformers) at the input stage, diverse methods have been invented, including those using commutation circuits (phase control), as well as sundry circuit structures using resonance phenomena. Some reports indicate that 97-98% of power conversion efficiency has been achieved on a step-up circuit unit level.

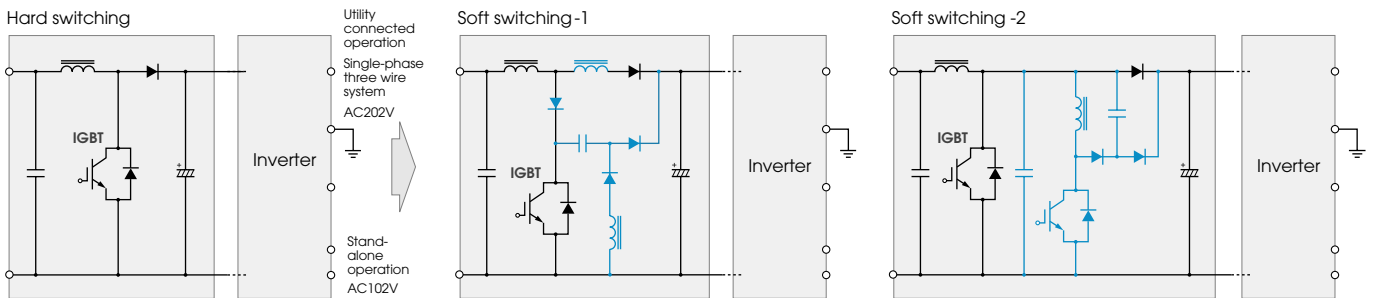
Conceptual model of voltage/current waveform control by soft switching

V_s : Voltage at both ends of IGBT I_s : Current of IGBT

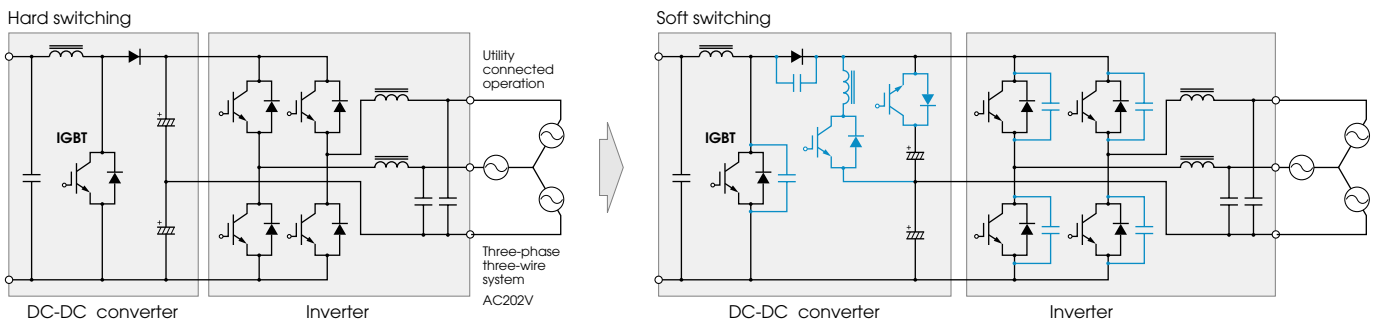


Example of a soft switching circuit

DC-DC converter(step-up chopper)



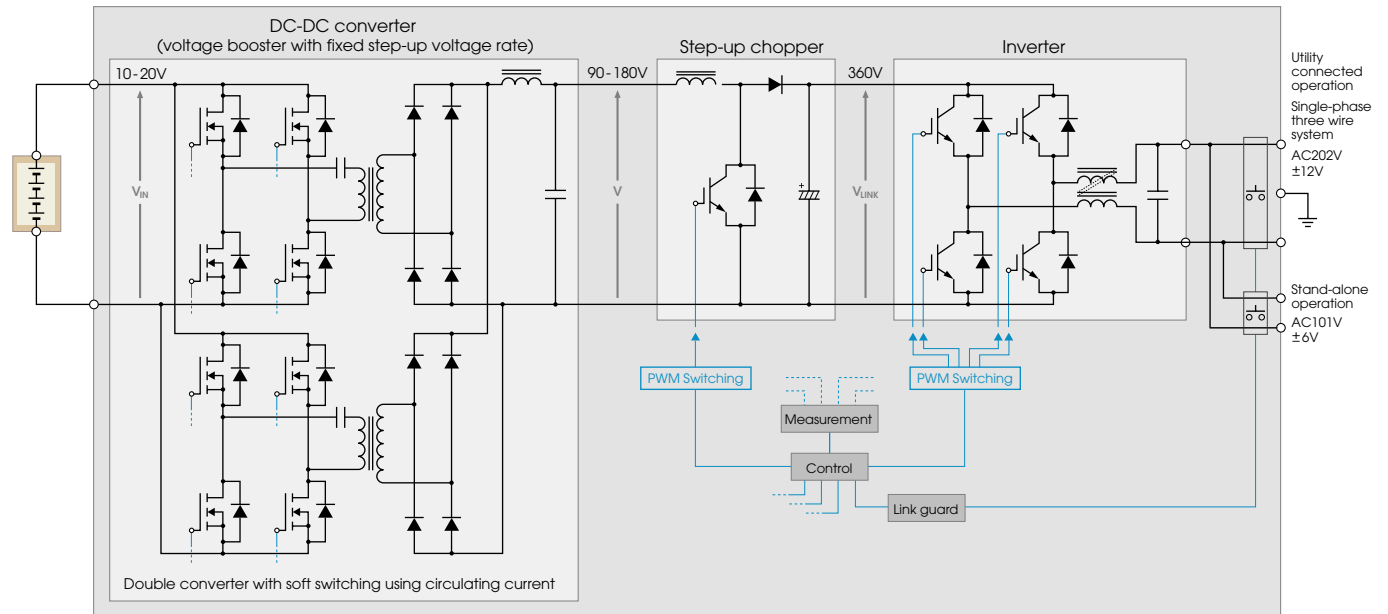
Industrial use 3-phase 200V utility-connected power conditioner



Information related to power conditioners

Example of high-efficient circuit design using soft switching

Example of a fuel-cell power system power conditioner circuit (low voltage/high-current input)



Low Loss And High Saturation Flux Density Ferrites For High-power Transformers And Reactors

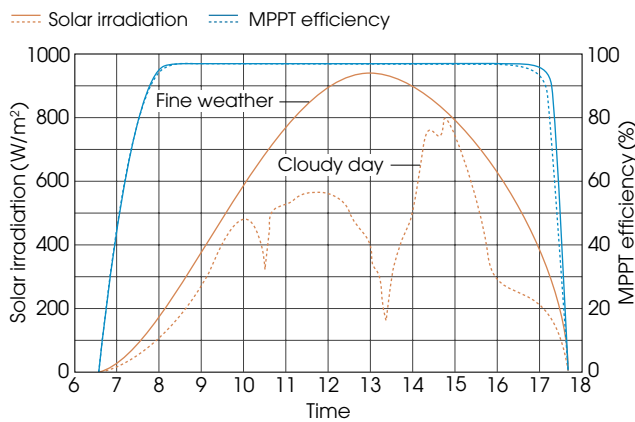
PE90
Material



Near 99.9% of MPPT efficiency is sought through parallel multiplication of the step-up chopper.

For PV system power conditioners, the efficiency of MPPT (Maximum-Power-Point Tracking), which always maintains the power from solar cells according to the changes in the solar irradiation and temperature, at the maximum level is one more element which "makes a huge difference" in the annual amount of power generation.

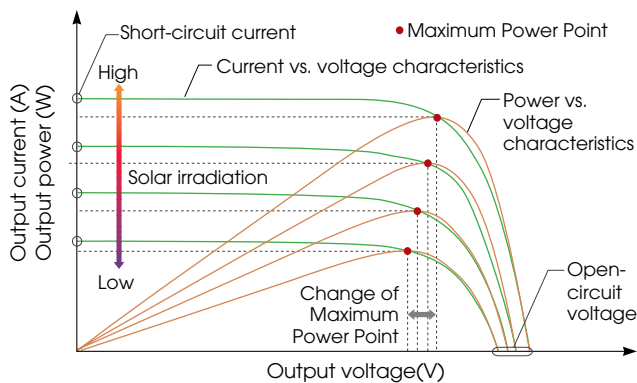
Conceptual model of MPPT efficiency



The MPPT efficiency of power conditioners depends on how quickly and accurately solar cells output tracks the maximum power point of solar cells, which shifts based on the changes in the solar irradiation and ambient temperature.

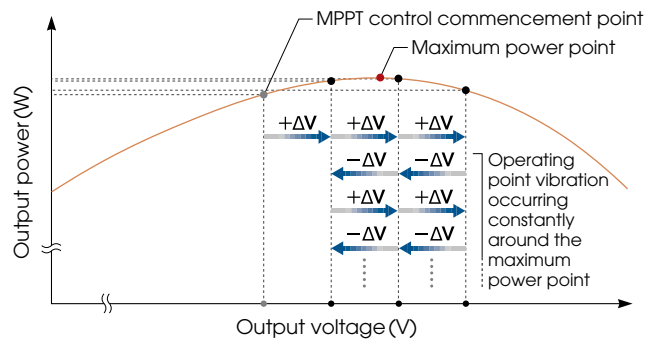
Output characteristics of solar cells

Changes in maximum power point of solar cells depending on the changes in the solar irradiation



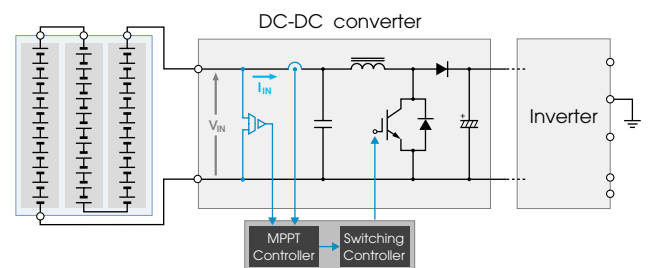
There are already new models which achieve the MPPT efficiency of more than 99.5% in the general-use 4-5kW class through new search methods to cancel the loss from the conventional "hill-climbing search", which tracks maximum power point, and strict high-efficiency design where each PV string of different sunshine condition is controlled by MPPT step-up choppers in the parallel arrangement.

Operating point vibration in the conventional "hill-climbing search" method which causes losses

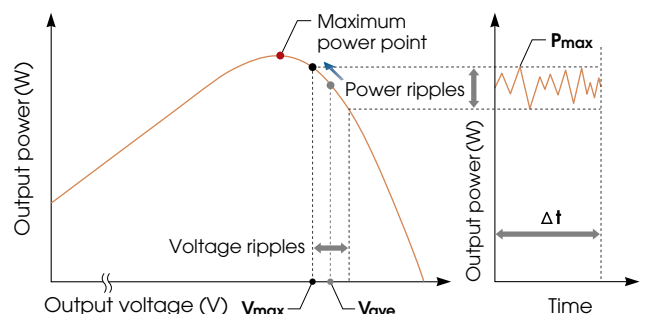
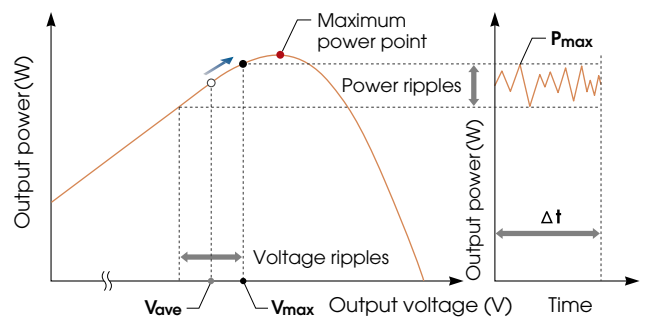


Example of efforts to reduce loss via MPPT control

Low-loss MPPT controlling method using output voltage ripples of solar cells at the time of switching

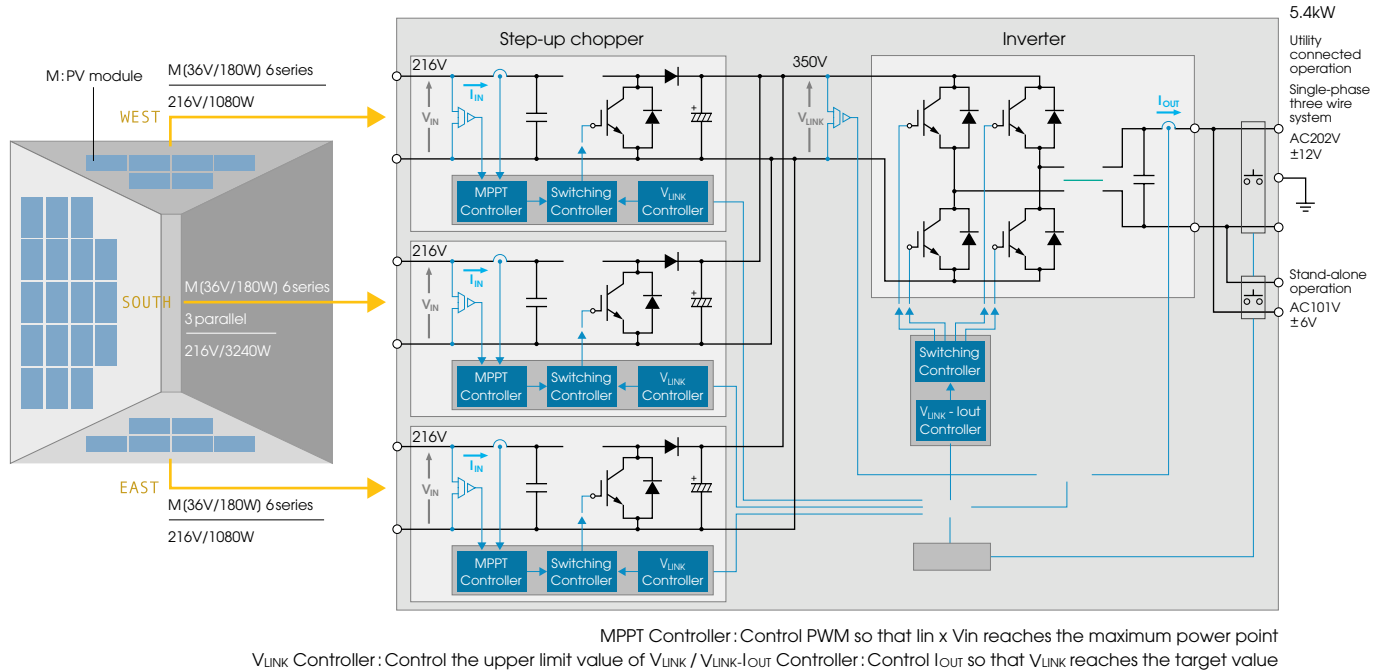


The peak value of power ripples with switching always appears on the side closer to the maximum power point. The feedback control system is configured to control the duty ratio of IGBT so that the average voltage value, "Vave", based on ΔT, tracks Vmax, the value based on the power ripple peak.

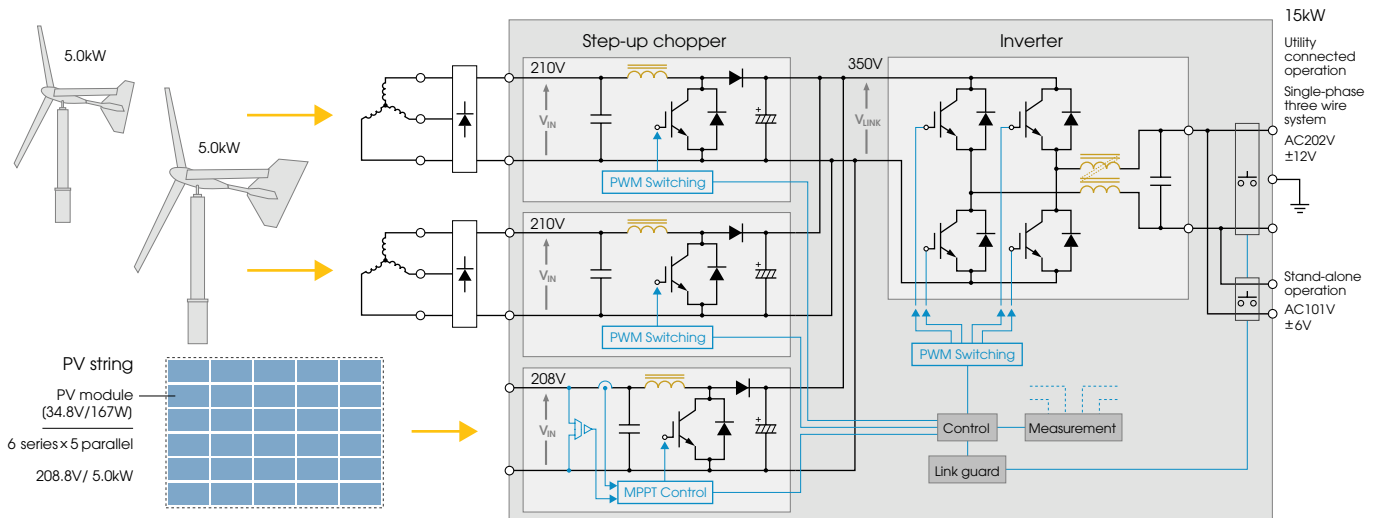


Example of application

Example of a high-efficiency power conditioner circuit which controls MPPT for each PV string (5.4kW scale)



Hybrid system through the combination of two 5kW wind-power generators and one PV string(5kW)

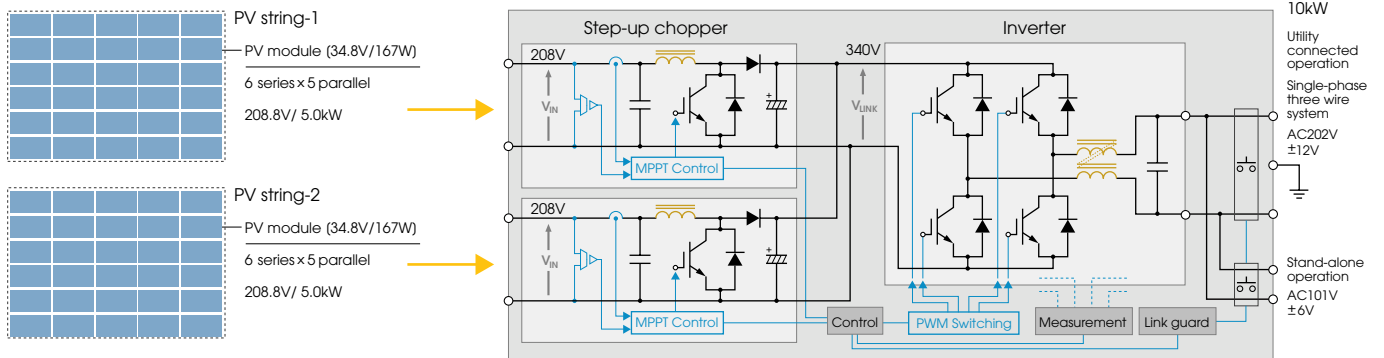


Low Loss And High Saturation Flux Density Ferrites For High-power Transformers And Reactors

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Example of a power conditioner for 10kW PV systems



Example of a mid-sized 100kW PV system configuration

