On Board Charger Fighting Guide

2021.08.30
System Solutions Engineering Headquarters
FAE1 Dept.
High Power FAE Division
Electric Powertrain Group

Key points in promotion of power device for OBC

- I introduced SiC, but customer does not evaluate it because the cost is higher than Si device.
- The customer evaluates SiC, but it is only for high end model.
- There is no products to introduce for mid and low end models….

Is there a such situation in your daily promotion activities?

For the diversifying OBC requirements,

ROHM solves the issue with SiC + Hybrid IGBT + IGBT solution!

Requirement	Used devices in market	ROHM omnidirectional strategy
Focus on efficiency	SiC MOS	SiC MOS (SCT series)
Focus on balance	SJ MOS	Hybrid IGBT(RGWxxC series)
Focus on cost	IGBT/SJ MOS	IGBT (RGW series)

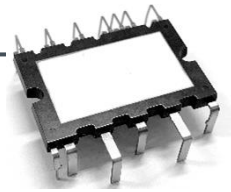
Hybrid IGBT (IGBT + SiC SBD) could cover SJ MOS market.

We can promote them in all direction from High end to low end models.

Competitor is still in development, let’s occupy the market now!

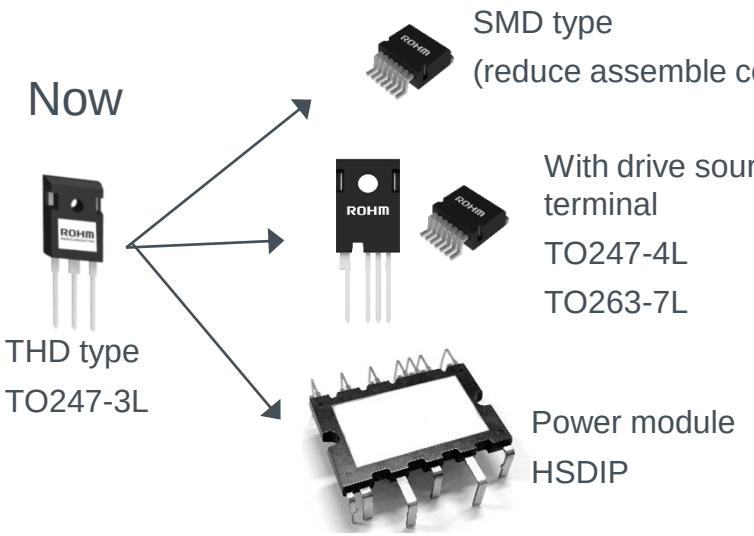
Key points in promotion of SiC Power Module

- It is difficult to meet customer demand for miniaturization only by promoting discrete products.
- We were asked by management or R&D engineers regarding ROHM's roadmap for OBC.



Why don't you make a proposal to meet customer needs for miniaturization?

ROHM can promote not only discrete products also SiC Power Module for diversified OBC requirements and future demand.



Significant space reduction from TO247
(e.g.14pcs→3pcs)

ROHM package strategy

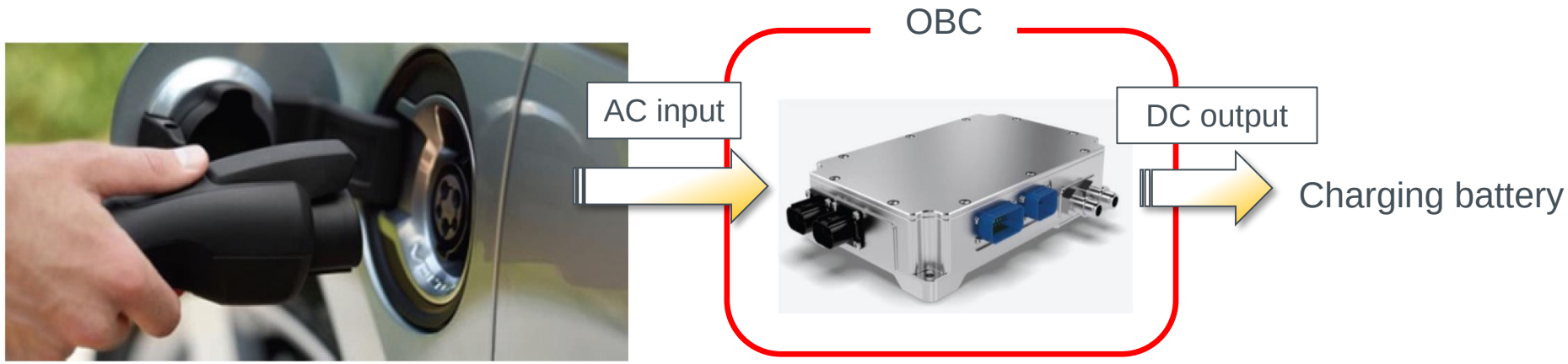
Responds to customer requirement in all directions with Power module in addition to THD,SMD packages.

Probably there are still many customers who do not know that ROHM is developing power modules.

Let's promote the new SiC module!

What is On Board Charger (OBC) ?

- Battery charging circuit for EV or PHEV
- Used in all of EV and PHEV
- AC input（100～240V) ⇒ DC output（200～450V)* depending on battery voltage
- Output power : generally from 3.3kW to 22kW
  （Higher output power enables to charge battery rapidly.)



Current status / Entire OBC market trend

Increasing number of customers who is considering IGBT and Hybrid IGBT solution.
SMD package trend is expanding in Europe and US.
Partially top side cooling package is beginning to consider.

Currently SiC SBD has been used in interleaved PFC.
For new models SIC MOSFETs are evaluated.

Hybrid and IGBT are considered instead of SJ-MOS.
Uni-directional is still mainly, but bi-directional OBC are also used.

In order to reduce mounting cost, SMD package has adopted from an early stage, and TO-263 is being mainstream.
Top side cooling PKG starts to be considered.

Mainly used SiC MOSFET solution.
Mainly used TO-247,
however module solution is considered in future.

C company aggressively adopts SiC.
and top side cooling package.

Other companies SiC-MOS of TO247.

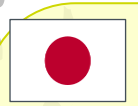
There is a customer that is considering top side cooling package.

Most of the latest model is bi-directional type.

SiC is adopted for high end model
and IGBT is adopted in low end model.

Main PKG is still TO-247.

There is a one customer that is considering top side cooing package



Interleaved type is mainly used because of uni-direction.
There is a trend to replace SJ-MOS with Hybrid IGBT or IGBTs to reduce costs.
TO-247 is mainly used now.

In 2021 Jul.

Market trend

- Topology

  In order to charge on board battery AC inputs from single phase power supply or three phase power supply. There are several type of topologies depending on difference of output power, focusing efficiency or cost.

  In general output power line up are 3.3kW, 6.6kW, 11kW, and 22kW.

  Its trend is higher power (decreasing Charging time) following battery capacity increasing.

  There are several topology for PFC circuit as interleaved, bridge-less totem pole, Vienna etc..

- Bi-directional type（Charge-Discharge）

  AC outlets in EV can be used for leisure and emergency thorough

  It is called Bi-directional type OBC(Charge-Discharge). It spread trend at the center of China.

Market trend

- 800V Battery

General battery voltage is around 400V, on the other hand higher 800V enables to decrease charging time and weight saving of harness used around.
This trend is spread from the high end models in EU and China.
800V battery usually needs 1200V absolute max voltage device, and SiC is the best choice as the characteristics of high voltage and low loss.

- Package trend

There are many entry manufacturers and is very strict price competition in this market.
Price is really key point especially for low power OBC, so general-purpose package such as TO-247 are used.

Recently number of models considering modules and SMD package are gradually increased. ROHM is developing SMD type SiC MOSFET with TO-263-7L.
We have additionally started to developing SiC power modules with 4in1 and 6in1 configuration.
Also in Europe an expensive high heat dissipation metal board (IMS) is required when using SMD PKG products because standard FR-4 board does not have enough heat dissipation capability. Therefore top side cooling package is being considered in order to reduce mounting cost.

ROHM's position

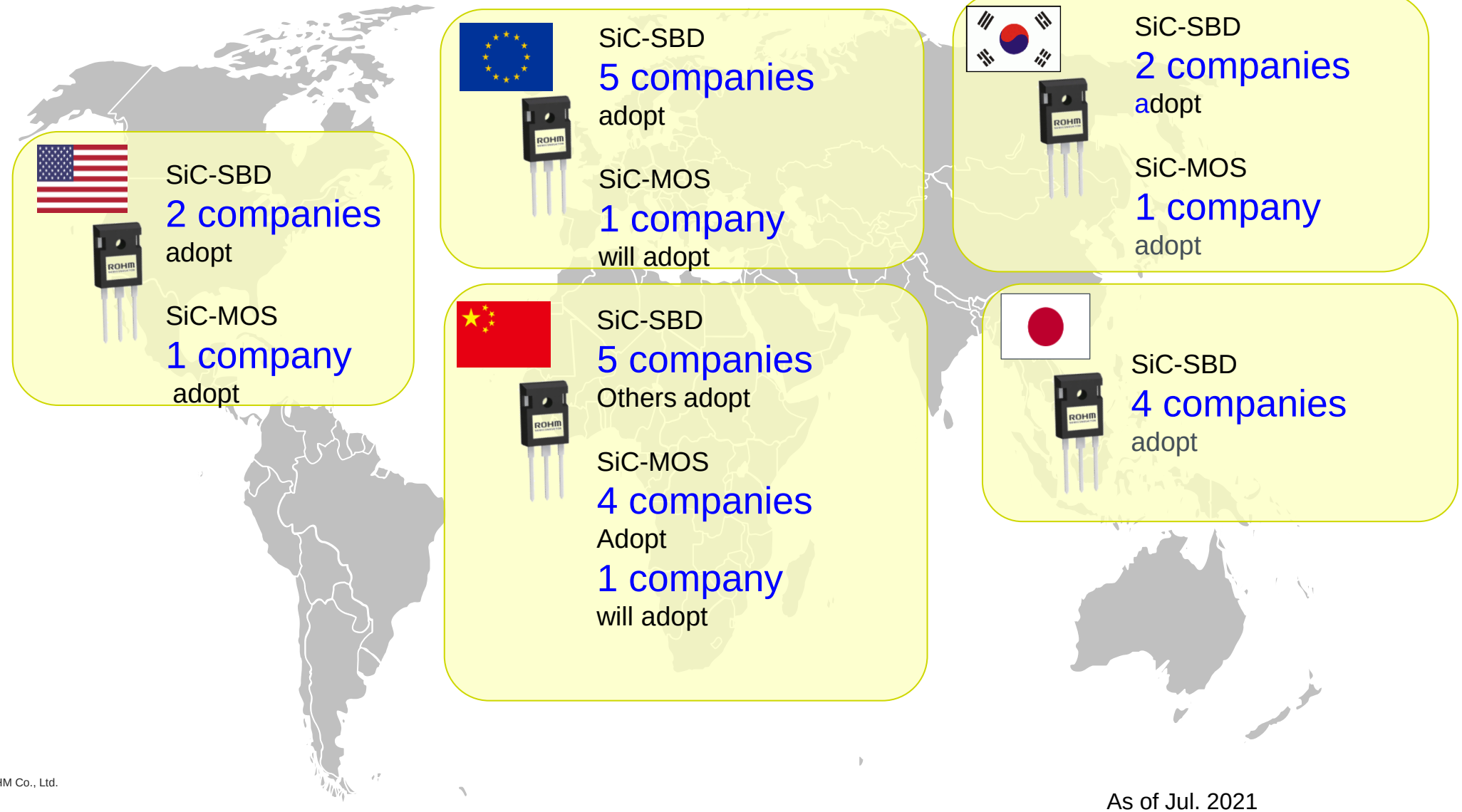
- SiC

  - Rohm released the first Automotive grade SiC-SBD before competitors. So ROHM SiC SBD has been adopted in automotive OBC since 2012. Many customers adopted Rohm one because of its lower VF than competitors.

  - Regarding SiC MOS, ROHM released trench gate structure MOSFET as Gen 3 in 2015. Also automotive grade(AEC-Q101) released in the last year. It has been used in OBC and DCDC converter. ROHM has high market share because of fully integrated production system from SiC substrate to assembly.
  After releasing Rohm generation 3, actual some competitors investigated ROHM and released good characteristics SiC MOS.
  Although specific driver condition for SiC and countermeasure of gate surge protection are sometimes needed, we provide some application notes for them. Please refer to them from web page.

Actual sales in OBC market

More than 20 companies adopt ROHM's SiC devices.



SiC-SBD
2 companies
adopt

SiC-MOS
1 company
adopt

SiC-SBD
5 companies
adopt

SiC-MOS
1 company
will adopt

SiC-SBD
2 companies
adopt

SiC-MOS
1 company
adopt

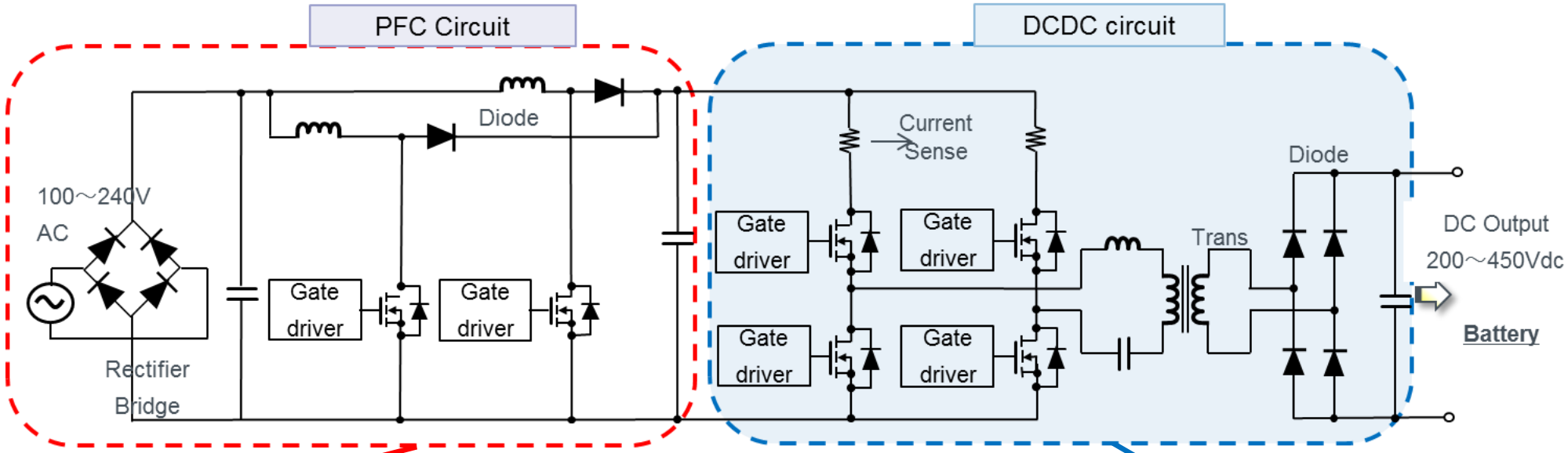
SiC-SBD
5 companies
Others adopt

SiC-MOS
4 companies
Adopt
1 company
will adopt

SiC-SBD
4 companies
adopt

As of Jul. 2021

OBC Basic Structure



PFC*

*Power Factor Correction:
（Suppress Harmonic noise）

【Role】

・Suppress Harmonic noise to follow Regulations

・AC→DC （Rectifier/Boost）

【Circuit type】

・Interleaved PFC

・Totem pole PFC, etc.

DC-DC converter

【Role】

・Convert PFC DC voltage to predetermined charge voltage

・DC→DC （Isolation/Boost）

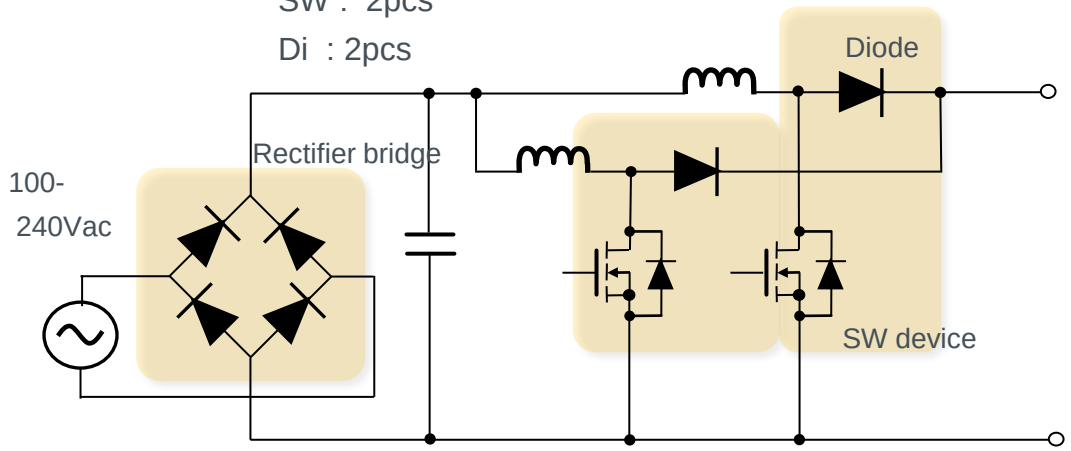
【Circuit type】

・LLC Resonant
(Half-Bridge、Full-Bridge etc.)

PFC Circuit（Rectifier/Boost）

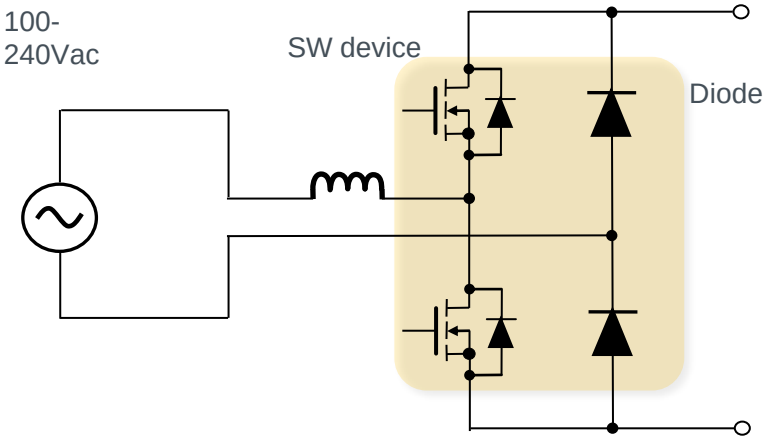
Interleaved PFC

Rectifier bridge: 1pcs
SW： 2pcs
Di ：2pcs

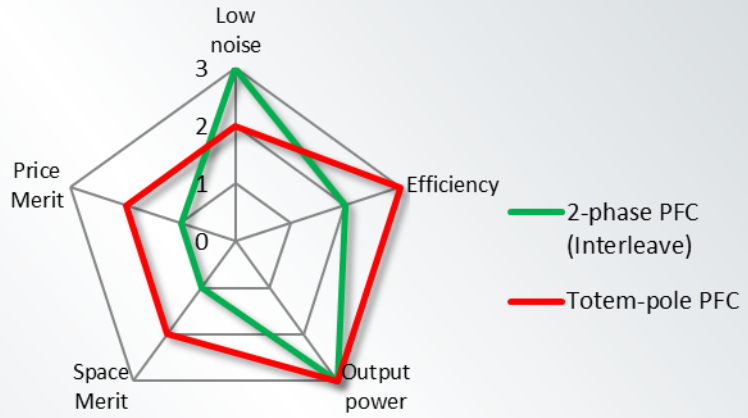


Totem pole PFC

Rectifier bridge: none
SW: 2pcs
Di : 2pcs



【Feature of each circuit type】



■ **Interleaved PFC**

Merit: Low noise
Big Power output available
Demerit: Inefficient by rectifier bridge(big loss)
Many components, Bigger space, Higher cost

■ **Totem pole PFC**

Merit: Big Power output available
High efficiency because no rectifier bridge
(Low Loss)
A few components, small space, low cost
Demerit: Bigger Ripple than 2-phase Interleaved PFC

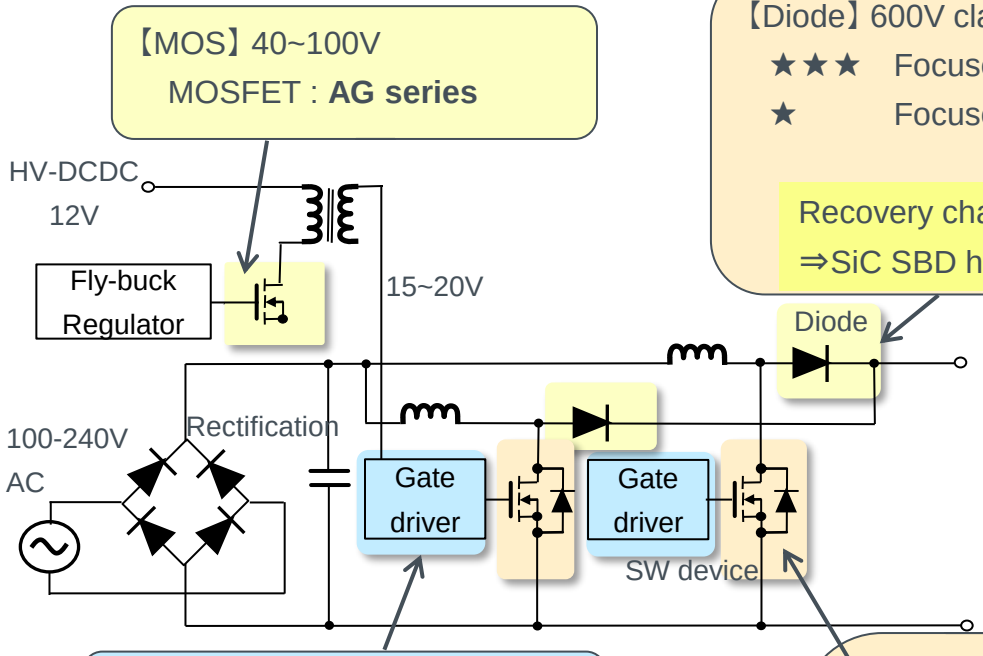
Uni-directional OBC (Interleaved PFC)

SiC device enables high efficiency and miniaturization

【MOS】40~100V
MOSFET : **AG series**

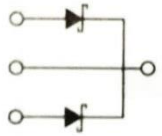
【Diode】600V class~
★★★ Focused efficiency / SiC SBD : **SCS2XXA series**
★ Focused cost / FRD : **RFUH series**
RFS series (Developing)
Recovery characteristic influence SW device loss and efficiency.
⇒SiC SBD has small recovery current achieves higher efficiency.

★★★：Best
★★：standard
★：Possible to use



【Knowledge】

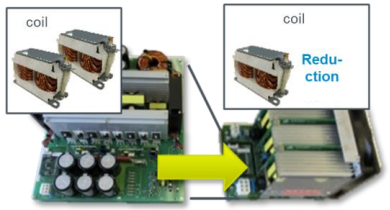
Diode：Marge space by 2 elements
in 1 package type
e.g.:SCS220AE2HR, etc.



【Gate driver】3,750V
: **BM61S/MxxRFV series**

【Knowledge】

Higher switching frequency make Coil inductor value smaller, and downsize the PCB



【SW device】650V class~
★★★ Focused efficiency / SiC MOS：**SCT3XXXAL series**
★★★ Focused efficiency / SJ-MOS : **ROHM does not have**
★★ Focused cost / IGBT : **RGWxxxx65DHR series**

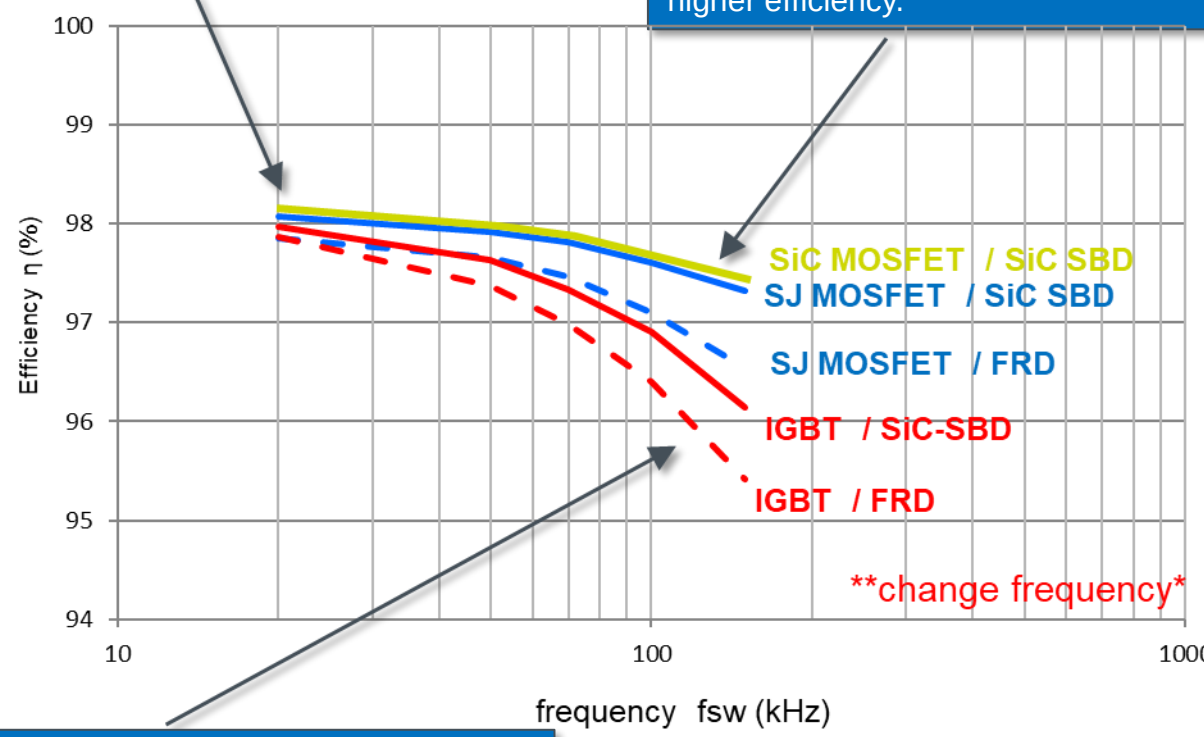
In interleaved PFC, SJ MOSFETs and IGBTs are generally used because the recovery current of SW devices is not generated.
Multiple Si devices are sometimes used in parallel depending on output power.
Advantage of SiC MOS is that it can handle large current with small chip size.
SiC MOS could contribute to downsizing by reducing the number of components.

Interleaved PFC efficiency simulation-1

IGBT -> Cost saving, SiC MOS -> Higher efficiency and downsizing

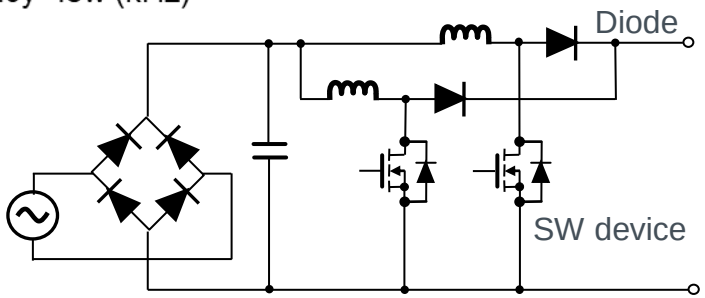
At low frequency range, difference of each device is small

At high frequency range, SiC and SJ MOSFET that have good switching characteristics achieves higher efficiency.



In general, operation at higher frequency makes lower efficiency due to increasing SW loss.

However it enables to reduce coil size.



<Device Spec.>

【SW device】

■ SCT3060AL
SiC MOSFET
650V/39A/TO-247N

■ A company
SJ MOSFET
（High speed recovery type）
650V/30A

■ RGW60TS65D
IGBT
650V/30A/TO-247N

【Diode】

■ SCS220AGHR
SiC SBD
650V/20A/TO-220AC

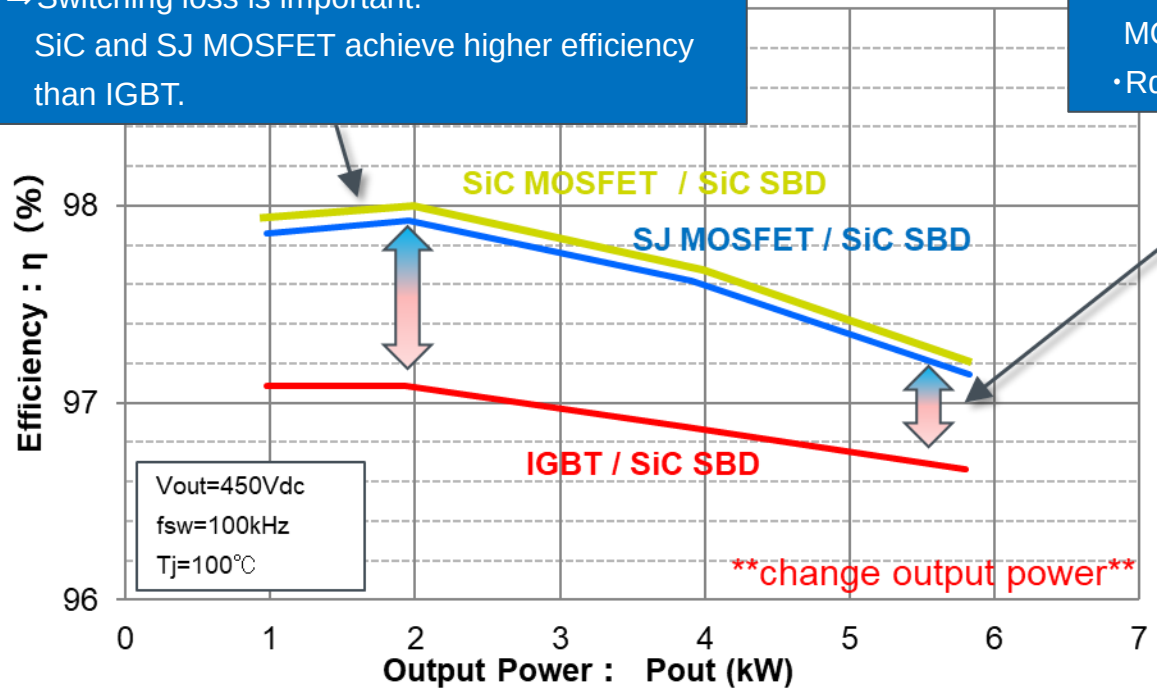
■ RFUH20TF6S
FRD
600V/20A/TO-220NFN

Interleaved PFC efficiency simulation-2

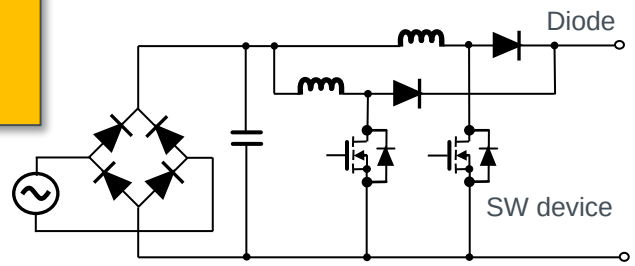
SiC MOS achieves higher efficiency in all output power range.

■ Low Power Range
⇒Switching loss is important.
SiC and SJ MOSFET achieve higher efficiency than IGBT.

■ High Power Range
・Rds-on has a significant influence, SiC and SJ MOSFET could achieve higher efficiency.
・Rds-on of IGBT is too high at high frequency.



Using for Low power OBC IGBT that is lower cost is sometimes adopted.



<Device Spec.>

【SW device】

■ SCT3060AL
SiC MOSFET
650V/39A/TO-247N

■ A company
SJ MOSFET
(High speed recovery type)
650V/30A

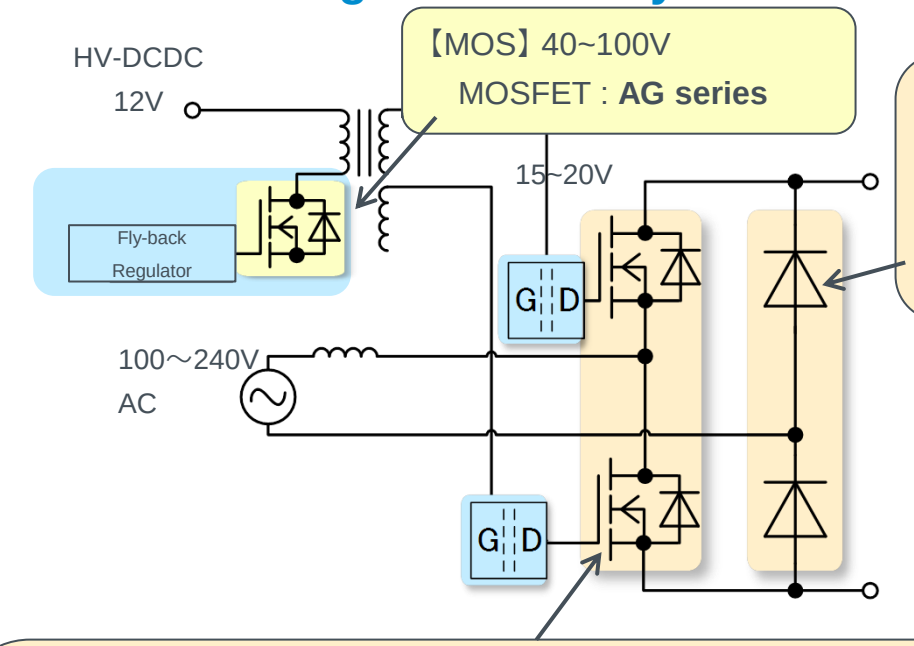
■ RGW60TS65D
IGBT
650V/30A/TO-247N

【Diode】

■ SCS220AGHR
SiC SBD
650V/20A/TO-220AC

Uni-directional OBC (Totem pole PFC)

SiC MOSFET is the best for totem pole PFC.
Hybrid IGBT achieves higher efficiency than SJ-MOS!



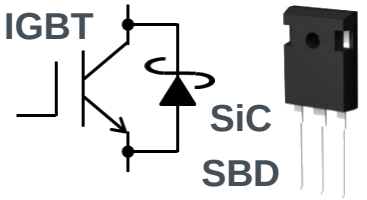
【MOS】40~100V
MOSFET : **AG series**

【Diode】600V class~
Si FRD : **RFN series**
RFL series(developing)
RFN(RFL) series is suitable for improving rectification diode efficiency.

【SW device】650V class~
Focused efficiency / SiC MOSFET： **SCT3xxxA series**
Focused balance (cost / efficiency) / Hybrid IGBT : **RGWxxx65C series (developing)**
Focused cost / IGBT : **RGWxxxx65D/E series**

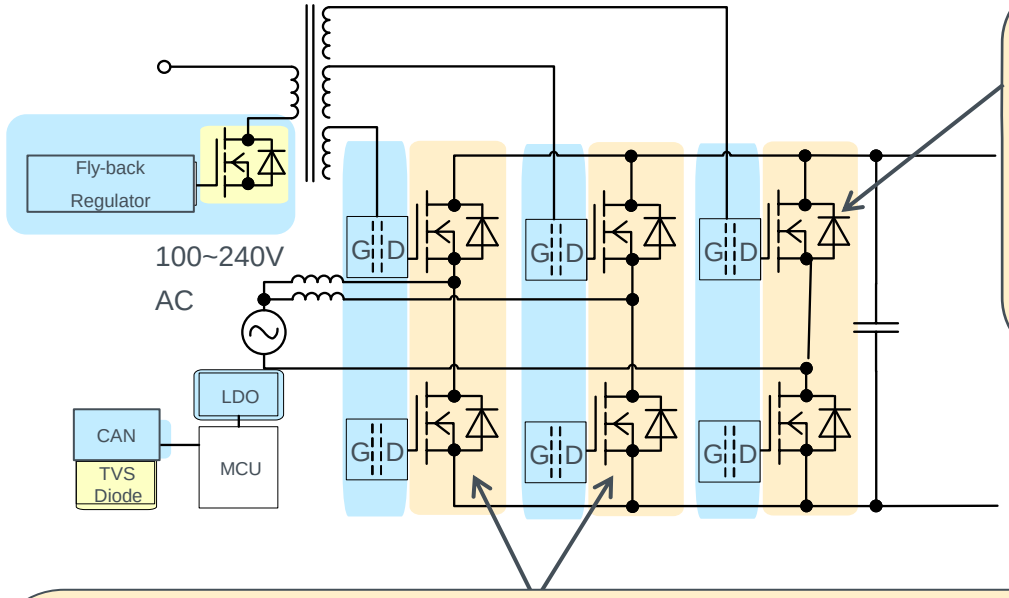
Important characteristics at switching side are
・Recovery characteristic at switching device
・Low conduction loss (Low Rds-on)
Therefore the best device is SiC-MOS and the next is Hybrid-IGBT.

Hybrid IGBT



Power device for Interleaved Totem-pole PFC（Bi-direction OBC）

Fast recovery characteristic of SiC is ideal for all PFC and LLC circuit.



【Rectifier device】650V～

Low cost / IGBT : **RGWxxxx65E series**

Switching characteristics are not required.

In many cases, IGBTs are the best choice because of focusing on cost.

Full-Rate E series is recommended because of better thermal design.

【SW device】650V class~

★★★ Focused efficiency / SiC MOSFET： **SCT3xxxA series**

★★ Focused balance (cost / efficiency) / Hybrid IGBT : **RGWxxx65C series (developing)**

★ Focused cost / IGBT : **RGWxxxx65D/E series**

Important characteristics at switching side are

・Recovery characteristic at switching device

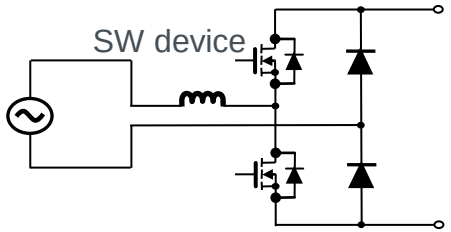
・Low conduction loss (Low Rds-on)

Therefore the best device is SiC-MOS and the next is Hybrid-IGBT.

Recommended SW device for totem-pole PFC

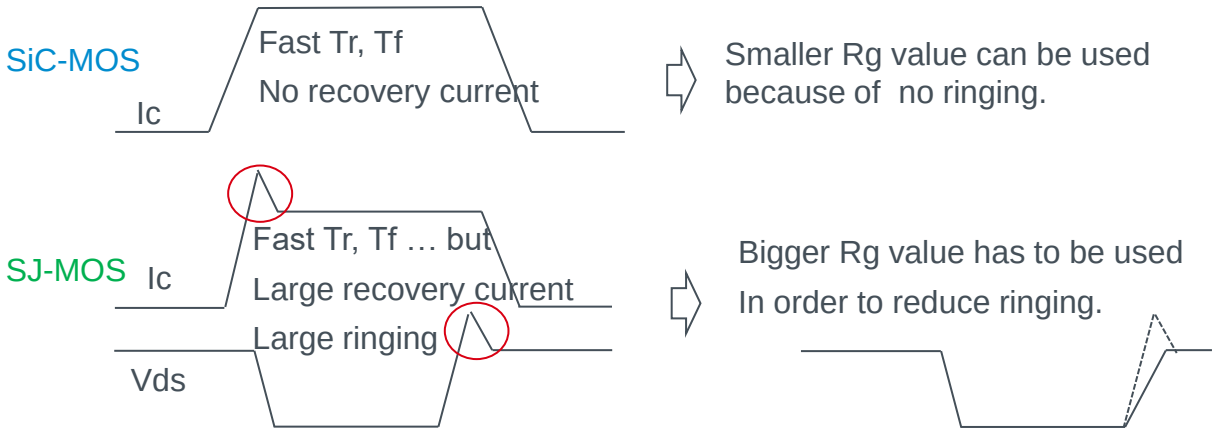
What is the best choice in totem pole PFC?
The order is SiC MOSFET> Hybrid> SJ-MOS> IGBT.

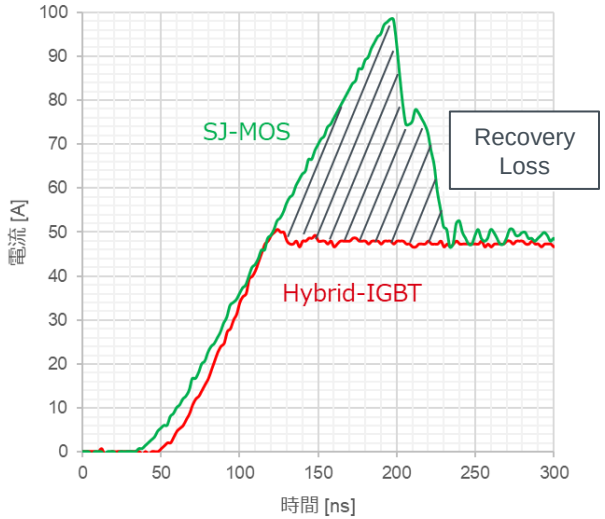
Totem-pole PFC



	SiC-MOS	Hybrid	SJ-MOS	Fast SW IGBT
Tr/Tf	Best	Better	Best	Better
Recovery current	Best	Best	Not so good	Not so Good
Ringing	Best	Best	Not so good	Best
Tail current	Best	Better	Best	Better

SW device characteristics in totem-pole circuit

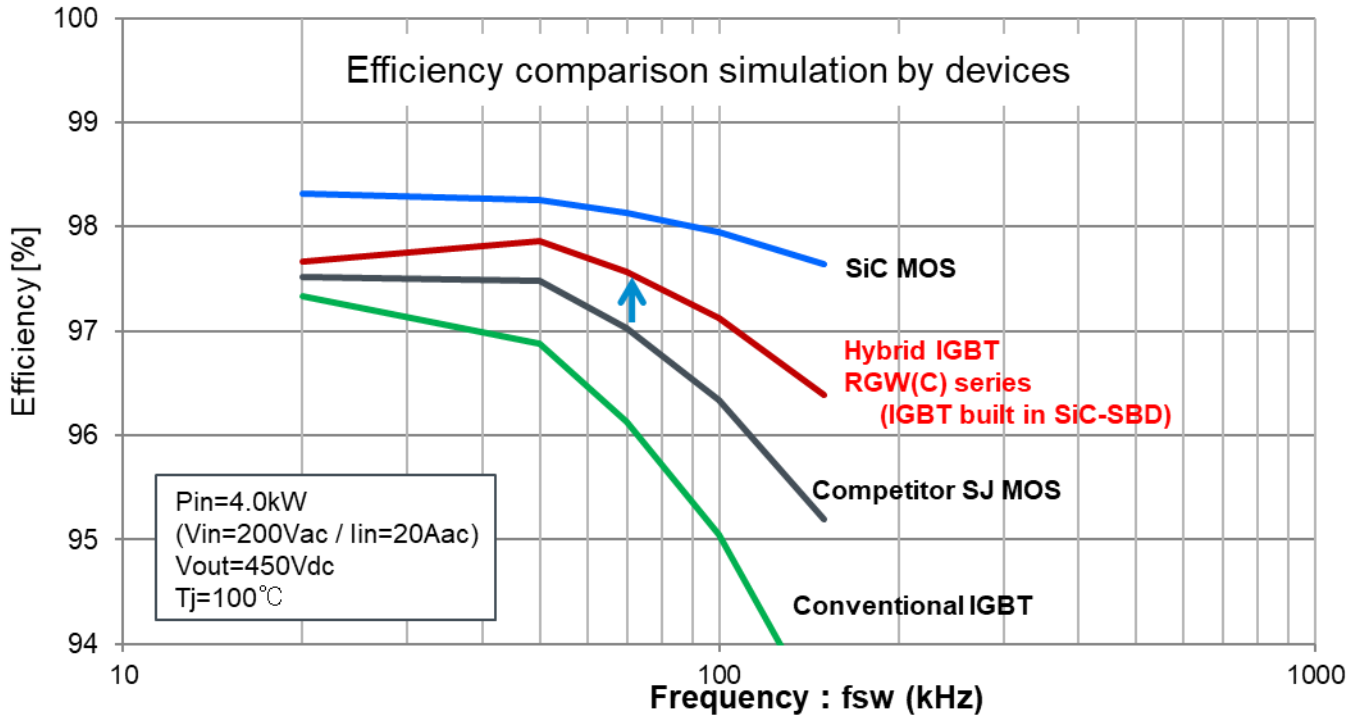




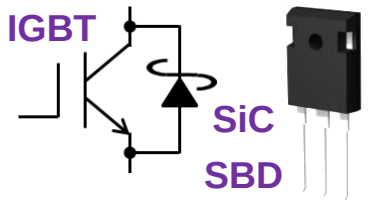
SiC-SBD has no recovery current. It makes almost no recovery loss.

Totem pole PFC efficiency simulation-3

Hybrid IGBT has higher efficiency than SJ-MOS.



Hybrid IGBT includes an IGBT chip and SiC-SBD chip in one package.



Hybrid IGBT/RGW(C) series comparison with SJ MOS

Efficiency: approx.0.5% improvement @70kHz

→ Approx.20W loss reduction@4.0kW

Downsizing of heat sink

Ensure thermal design margin

<Device Spec.>

【SW device】

■ SCT3060AL
SiC-MOSFET
650V/39A/TO-247N

■ RGW00TS65C
Hybrid-IGBT
650V/50A

■ A company
SJ-MOSFET
(High speed recovery type)
650V/50A

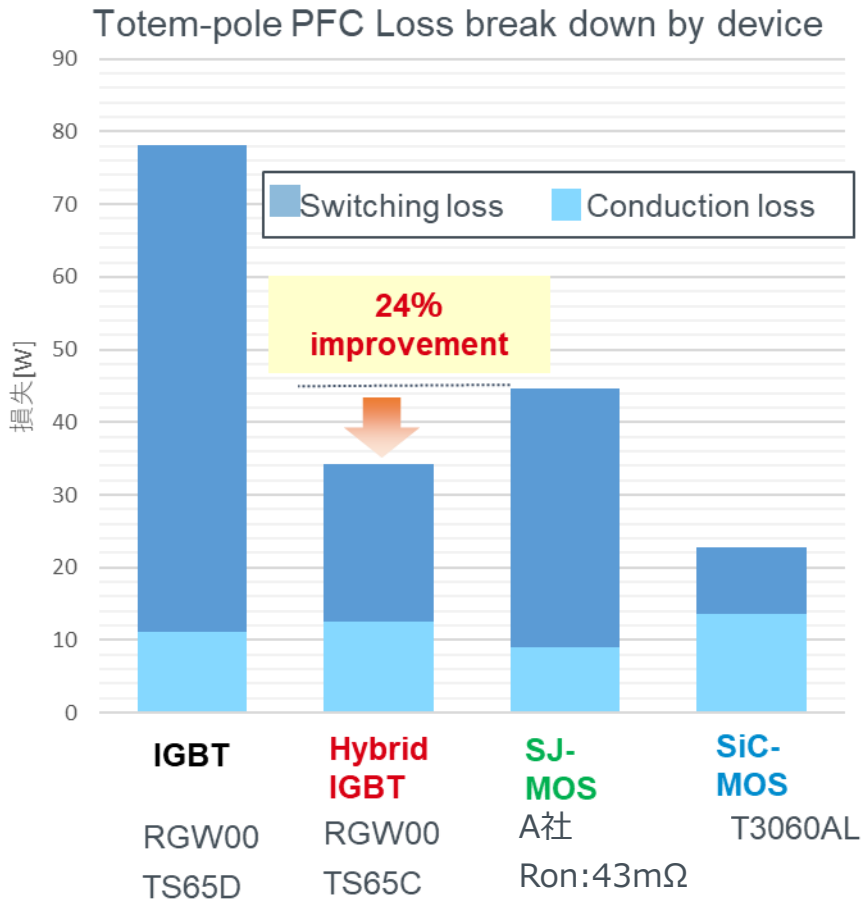
■ RGW60TS65D
IGBT
650V/30A/TO-247N

【Diode】

■ RFN20TF6S
FRD
600V/20A/TO-220NFN

Totem-pole PFC : Hybrid IGBT vs SJ-MOS

Hybrid IGBT has no recovery current. Switching loss is less than SJ MOSFETs.



ROHM does not have automotive grade SJ MOS, however Hybrid IGBT can replace from SJ MOS. Efficiency can be improved with the same price level.

【Supplementary comment in the left figure】

Why SiC-MOS conduction loss is bigger?

Comparison devices are

SiC-MOS : 650V 60mΩ(typ.)

SJ MOS : 650V 43mΩ(typ.)

Total energy loss even 60mΩ is enough small to fight with SJ-MOS.

「Knowledge」

Conduction loss is the sum of on-resistance loss at switching element and Vf loss of non-switching side diode element.

Since there is a difference in Vf between silicon FRD included in IGBT and SiC SBD included in Hybrid IGBT, conduction loss of Hybrid IGBT is slightly larger.

RGW00TS65C : conduction loss12.6W (Vf=1.21V)

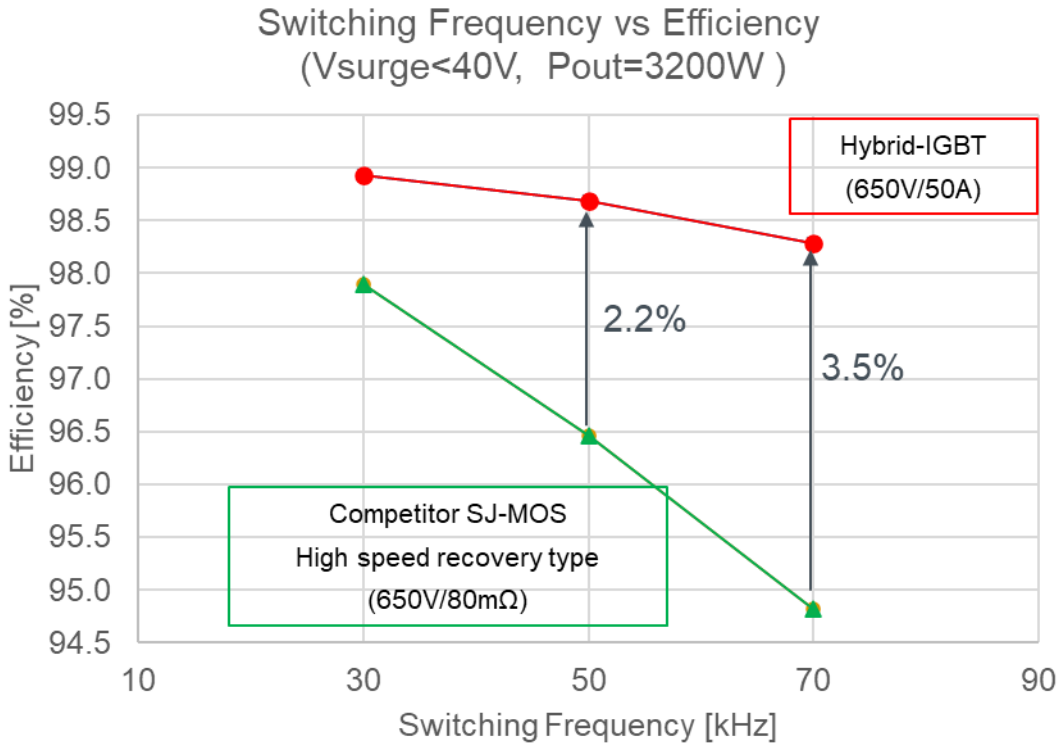
RGW00TS65D : conduction loss11.2W (Vf=1.18V)

（Tj=100℃）

Totem pole PFC : Hybrid IGBT vs SJ-MOS

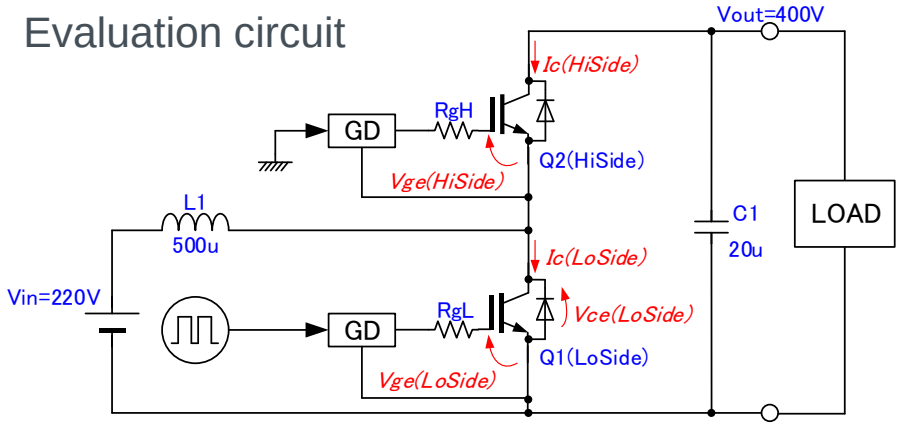
Hybrid IGBT is more efficient than SJ MOSFETs and is ideal for totem pole PFC.

Efficiency comparison in actual board by device



Turn-off surge of SJ MOS is larger due to fast switching. Therefore the efficiency is compared by different gate resistance value considering surge voltage.

➢ Evaluation circuit



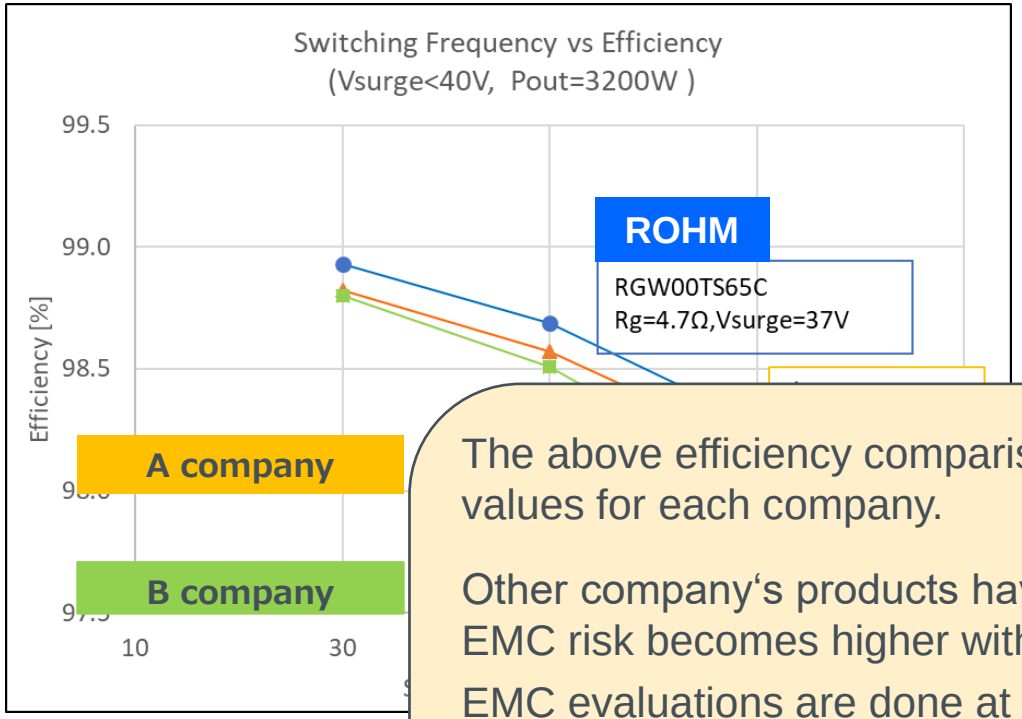
＊Totem pole PFC works same as Boost circuit with Hi side Vg=0V

➢ Evaluation Board

Totem pole PFC : Hybrid IGBT vs Competitors (efficiency)

ROHM Hybrid-IGBT achieves higher efficiency than other company‘s products. (surge voltage <40V)

➢ Comparison with competitors(Actual evaluation board)



・RGW00TS65C, which has a small Vcesat, offers better efficiency than that of other companies' Hybrid-IGBTs when operated at a surge voltage of 40V or less in consideration of the EMC measures of the set.

	ROHM	A company	B company
Efficiency	98.7%	98.6%	98.5%

➢ Evaluation condition

Vin=220Vdc, Vout=400Vdc
Iout=8Amax（Pout=3.2kW
fsw=30k, 50k, 70kHz
Rg：Controlled at Vsurge

The above efficiency comparison data is evaluated using different gate resistance values for each company.

Other company‘s products have larger surge voltage as shown on the next page, and EMC risk becomes higher with same gate resistance value.

EMC evaluations are done at the end of development, so problems might be occurred later on.

Therefore, from customer's point of view it is fair comparison to select suitable gate resistance value. In this evaluation the surge voltage was adjusted less 40V less.

As of result, by using ROHM products it is possible to achieve higher efficiency application design than other companies.

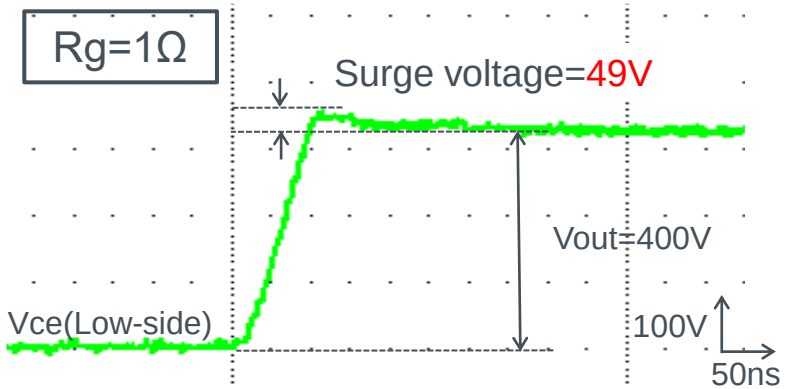
Totem pole PFC : Hybrid IGBT vs Competitors (Turn off surge)

ROHM IGBT makes easy design for EMC countermeasure.

■ Switching waveform comparison

➢ ROHM : RGW00TS65C

Small surge voltage (Small EMC risk)

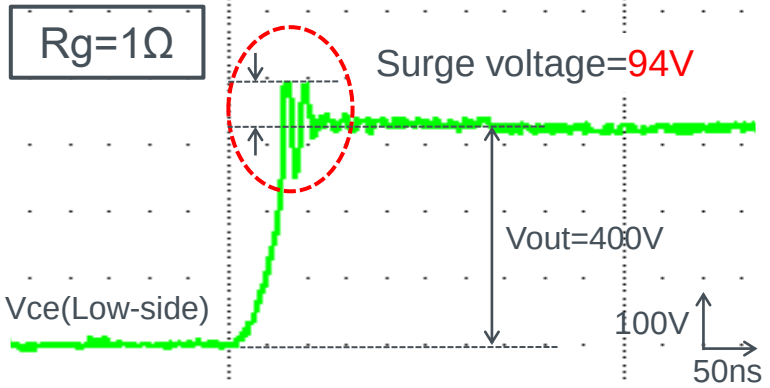


Since each device has different characteristics, it is necessary to evaluate with optimum gate resistance value.

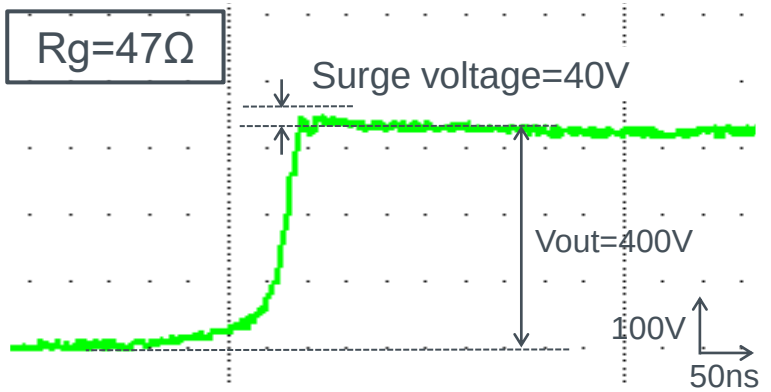
For ROHM products, the recommended gate resistance value is below 10Ω because surge voltage at turn off is small.

➢ Competitor product (A company)

Large surge voltage (Large EMC risk)



How to depress surge voltage less than 40V?



As a result, it is necessary to increase the gate resistance value.

Then efficiency was decreased. (Refer to previous page)

Hybrid-IGBT vs Competitors (Rg value setting)

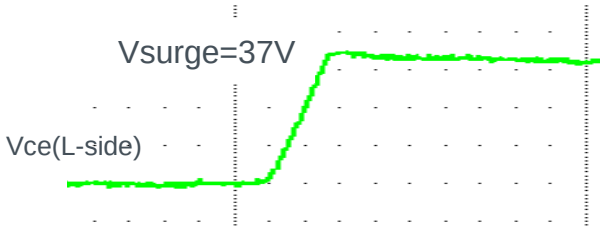
Competitor's hybrid-IGBTs make large surge voltage when low Rg value is used, EMC issue might be occurred.

Rg value setting which Vsurge does not exceed 40V. (= The Rg values are used in the page 20.)

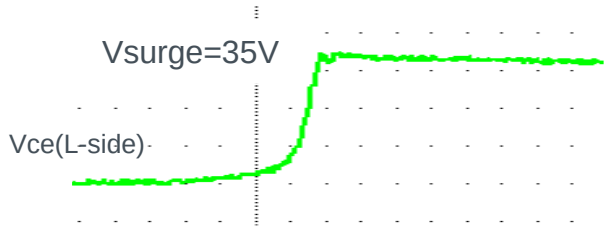
ROHM / RGW00TS65C	A company	B company
Rg=4.7Ω	Rg=47Ω	Rg=56Ω
dV/dt(On)=18.7V/ns	dV/dt(On)=15.0V/ns	dV/dt(On)=9.6V/ns
dV/dt(Off)=6.1V/ns	dV/dt(Off)=10.8V/ns	dV/dt(Off)=6.0V/ns

If Rg value is smaller than the above value, dV / dt will be faster, but it is not recommended because there is a concern that noise countermeasures will be necessary during EMC evaluation with vehicle.

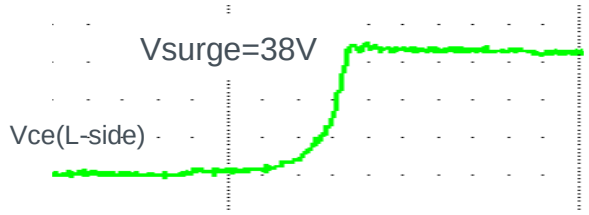
RGW00TS65C
(fsw=30kHz、Iout=8A、Rg=4.7Ω)



A company
(fsw=30kHz、Iout=8A、Rg=47Ω)



B company
(fsw=30kHz、Iout=8A、Rg=56Ω)



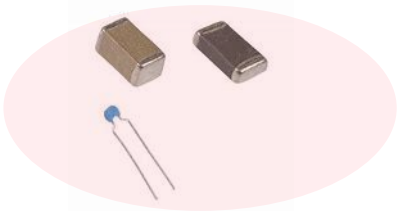
【Knowledge】

＊Vehicle EMC evaluation：

CISPR-25 and ISO-11452 are standards that ROHM should take EMC measures as a device manufacturer.

Similarly, our customer (Tier 1) must pass such standards CISPR-12 and ISO-11451 as a EMC test with vehicle.

CISPR-12 is a standard for noise (emission) emitted by sets such as OBC.



Noise reduction filters and capacitors are being used for EMC countermeasures.

Hybrid IGBT spec comparison

ROHM's hybrid IGBT is characterized by low conduction loss thanks to low Vcesat, and low Vf makes lower conduction loss during commutation mode.

RGW series has a slightly slower SW speed than competitor's one, but Vcesat is superior to others.
In addition, the integrated SiC SBD has a lower VF and is better to other companies.

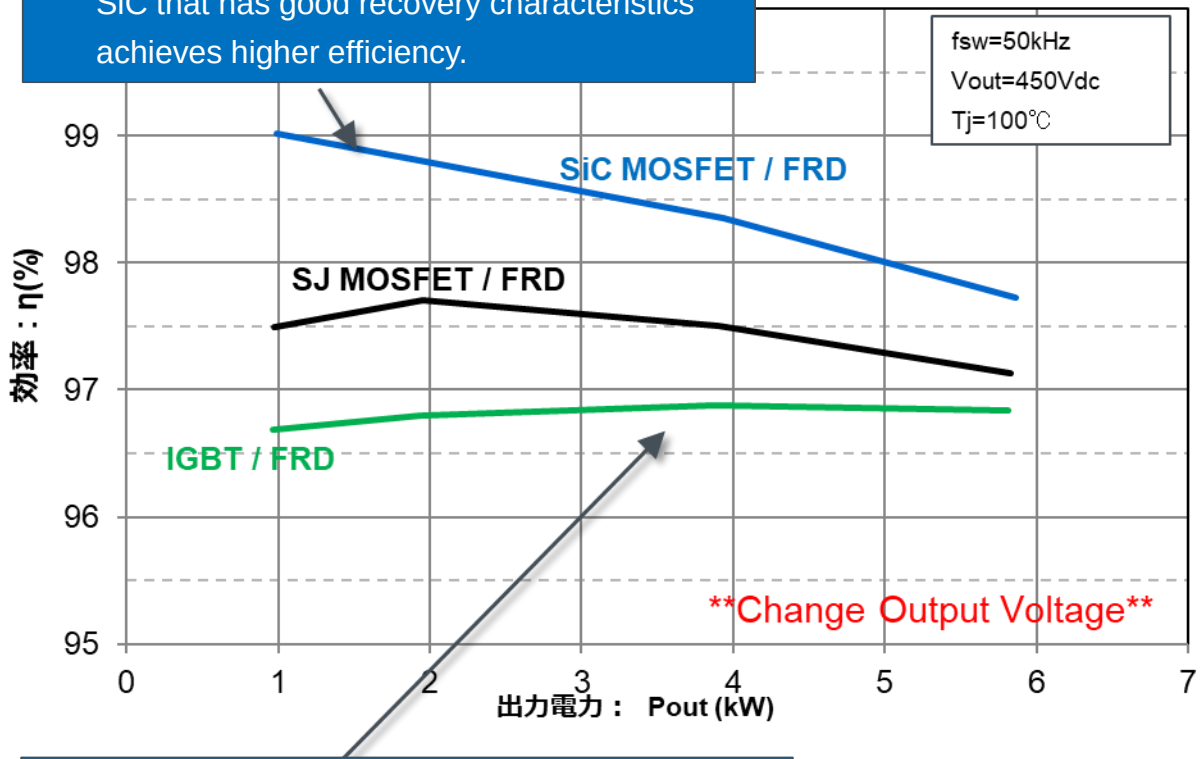
	Rohm	A company	B company	unit
	RGW00TS65C	(2017-07-18) Developing	Aug.2019 Mass production	
Vce	650	650	650	V
Ic	50	50	50	A
(IGBT)				
Vcesat(25℃)	-/1.5/1.9	-/1.66/2.1	-/1.6/2.1	V
Vcesat(175℃)	-/1.85/-	-/2.03/-	-/1.9/-	V
Ciss	4200	2800	3098	pF
Coss	104	65	265	pF
Crss	79	11	9	pF
(SBD)				
Vf	-/1.35/1.55 (25℃)	-/1.5/1. 7 (25℃)	-/1.45/1.75 (25℃)	V
	-/1.63/- (175℃)	-/1.8/2.1 (150℃)	-/1.83/- (175℃)	V
Trr	33 (25℃)	TBD	–	ns
	37 (175℃)	TBD	–	ns
Total Capacitance	730 (VR=1V)	TBD	103 (VR=400V)	pF
	74 (VR=600V)	TBD	99 (VR=600V)	pF

SBD VF：200mV difference at high temperature

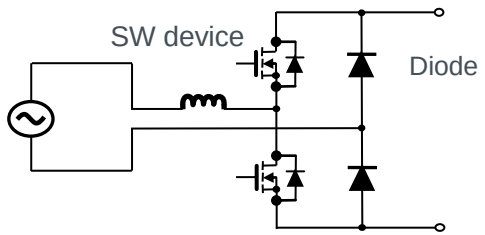
Simulation data (Totem pole PFC)

SiC MOS is the best choice for totem pole circuit.

Low Power Range
Switching Loss has a significant influence, so SiC that has good recovery characteristics achieves higher efficiency.



High Power Range
Rds-on is important characteristic, and SiC advantage becomes smaller.
Ron of IGBT is small, so efficiency does not reduce.



<Device Spec.>

【SW device】
■ SCT3060AL
SiC MOSFET
650V/39A/TO-247N

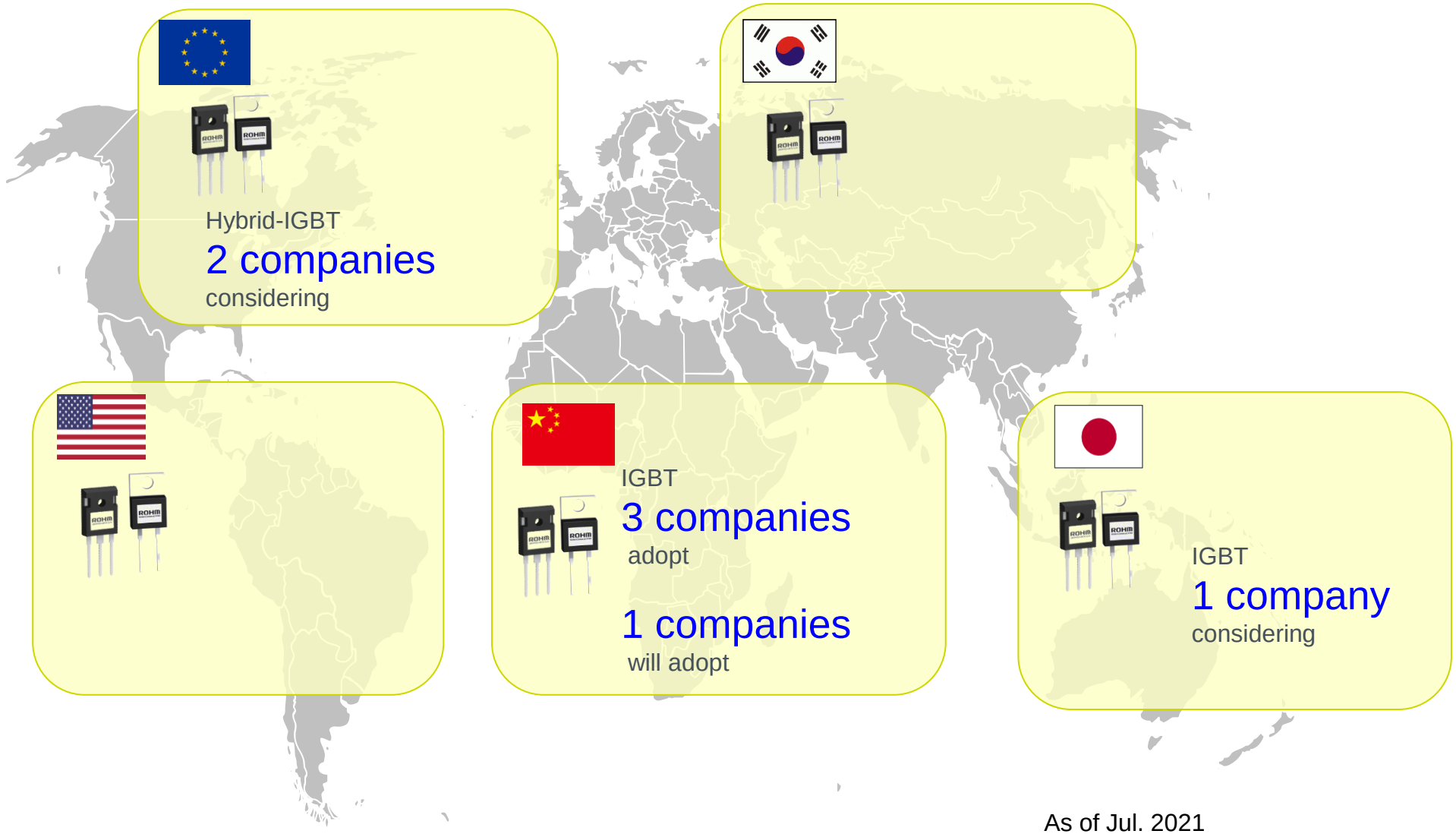
■ A company
SJ-MOSFET
（High speed recovery type）
650V/50A

■ RGW60TS65D
IGBT
650V/30A/TO-247N

【Diode】
■ RFN20TF6S
FRD
600V/20A/TO-220NFN

IGBT promotion status in OBC market

With the variations of needs, the adoption and evaluation of IGBTs and Hybrid-IGBTs are increasing.

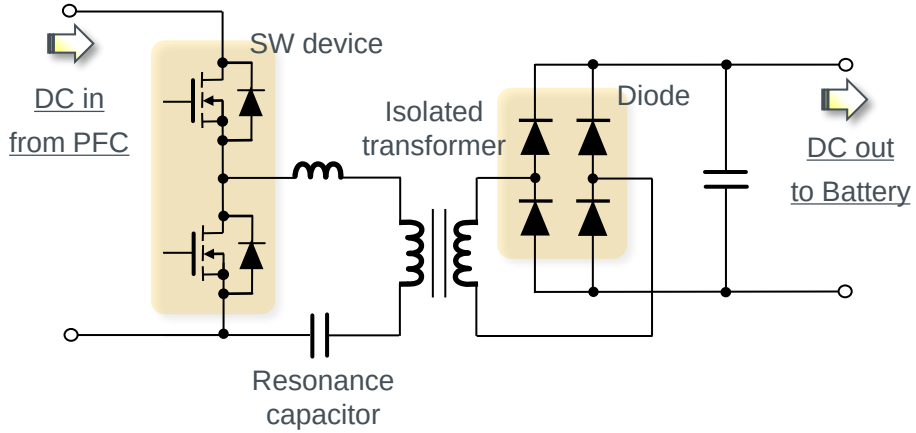


As of Jul. 2021

DC-DC Converter (Buck/Isolate)

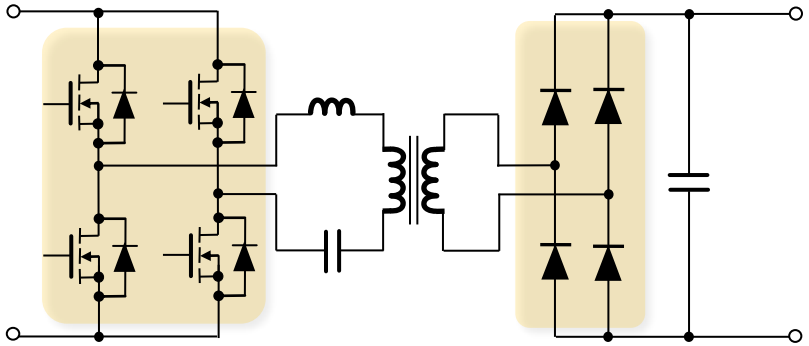
LLC Resonant (Half-bridge)

- Primary SW device : 2pcs
- Secondary Diode : 4pcs

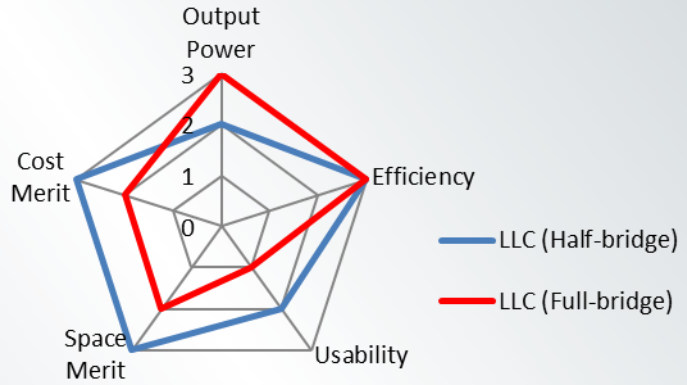


LLC Resonant (Full-bridge)

- Primary SW device : 4pcs
- Secondary Diode : 4pcs



【Feature of Each circuit type】



LLC (Half-bridge)

Merit: Possible to isolate Primary and Secondary
High efficiency
A few around Components, small space, low cost

Demerit: Output power is smaller than Full-bridge.

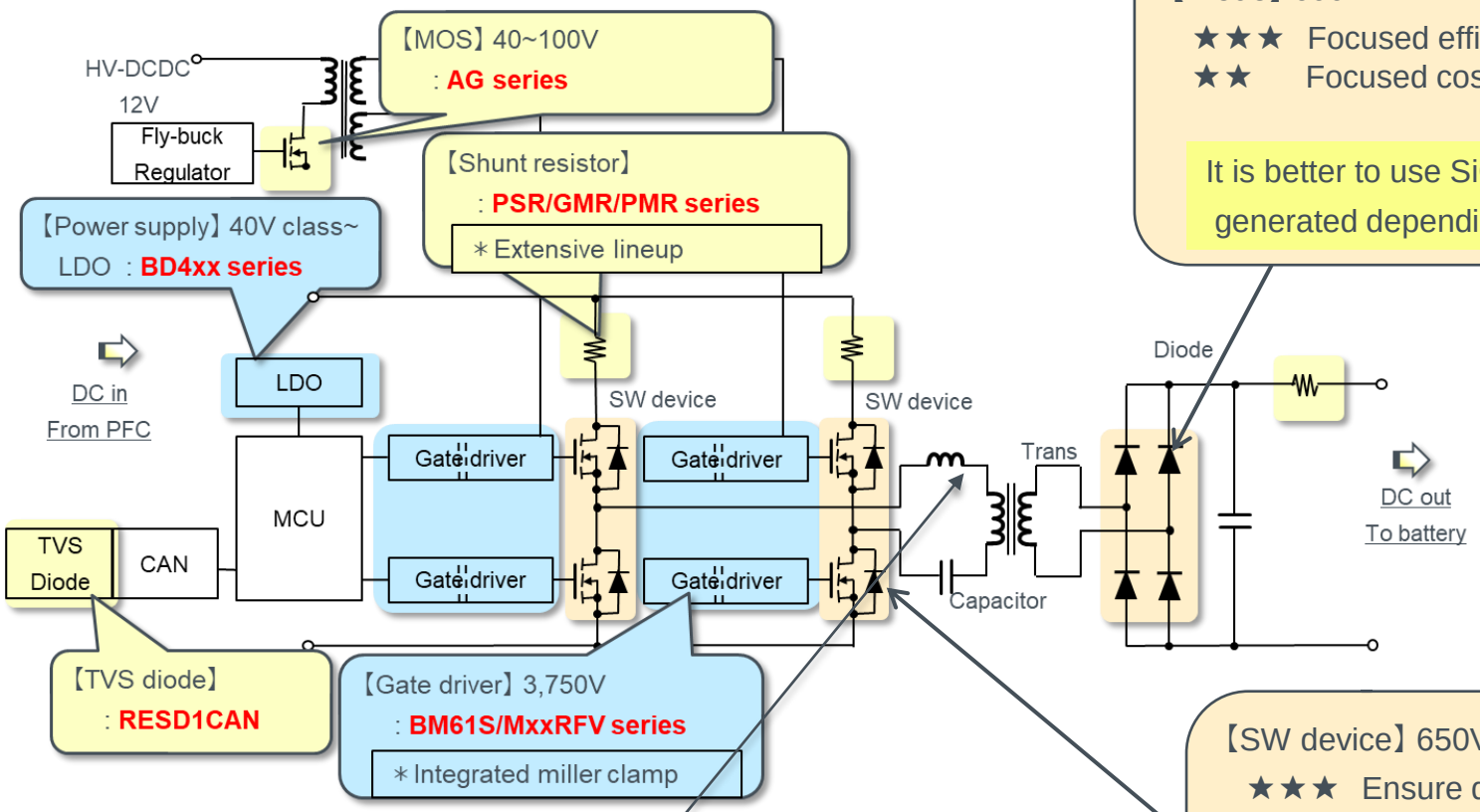
LLC (Full-bridge)

Merit : Possible to isolate Primary and Secondary
High efficiency
Output power is higher than Half-bridge.

Demerit: Many around components,
Bigger space, Higher cost
More Complex control than Half-bridge.

LLC Resonant Circuit

Solution proposal for each circuit demands.



【Diode】600V～

★★★ Focused efficiency / SiC SBD: **SCS2xxA series**
★★ Focused cost / FRD :**RFUH series**
RFS series(developing)

It is better to use SiC SBD because recovery current is generated depending on the conditions.

★★★：Best
★★：standard
★：Possible to use

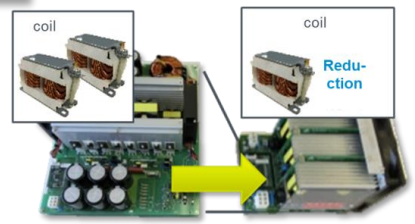
【SW device】650V～

★★★ Ensure design margin / SiC MOSFET: **SCT3xxxA series**
★★ Focused cost / SJ MOSFET: ROHM does not have

Since the operation of SW device is ZVS, there is no big difference in efficiency whether using SiC MOSFET or SJ MOSFET, but under the condition that large load fluctuation occurs, SiC MOSFET which has higher endurance is recommended.

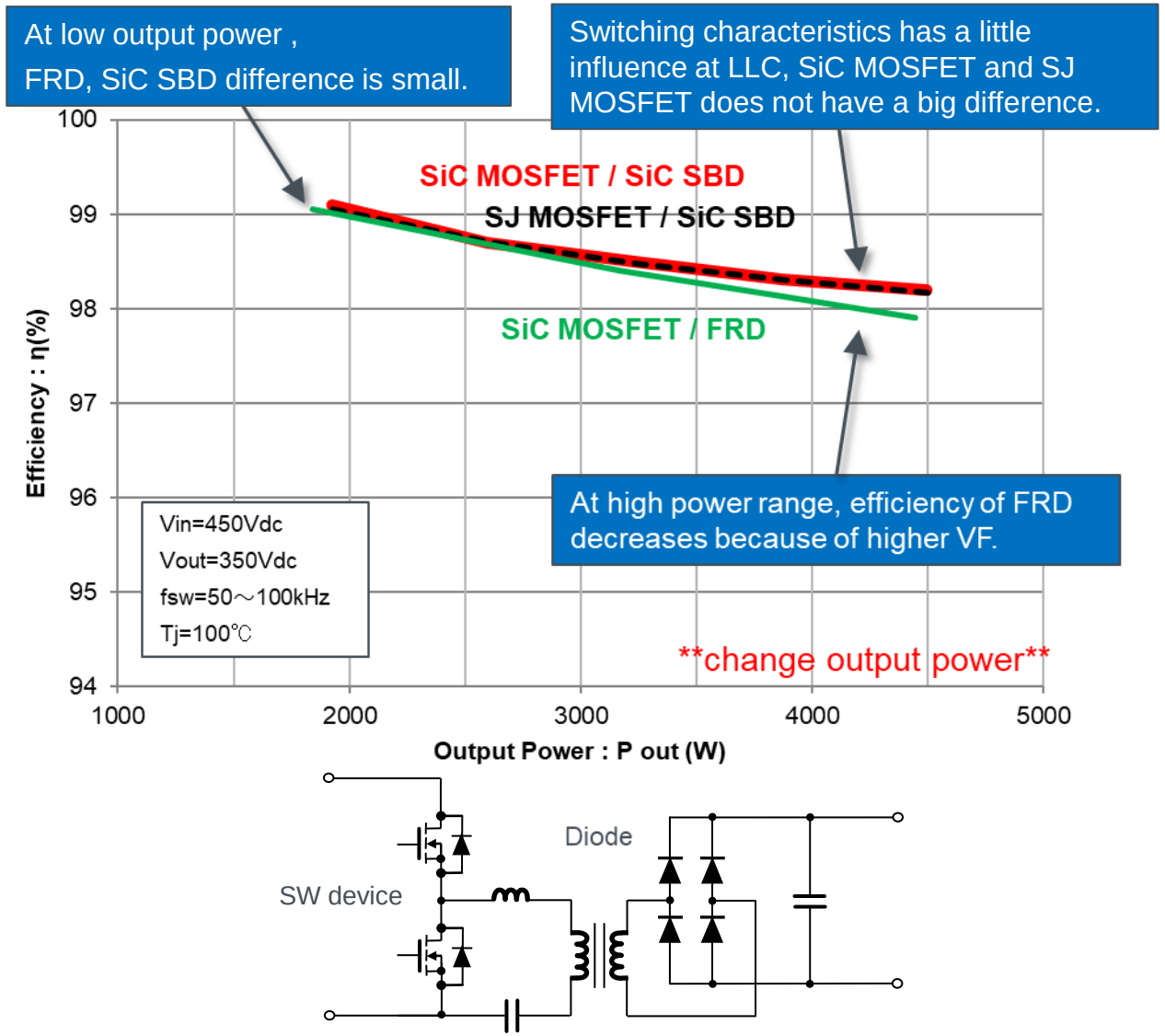
【Knowledge】

Higher switching frequency enables to reduce inductance value, then PCB design can be minimized.



Simulation data (LLC Resonant)

Efficiency by SiC and SJ MOS is almost same, but SiC is recommended because of higher robustness against load transient.



<Device Spec.>

【SW device】

■SCT3060AL
SiC MOSFET
650V/39A/TO-247N

■SJ MOSFET（reference）
650V/76A

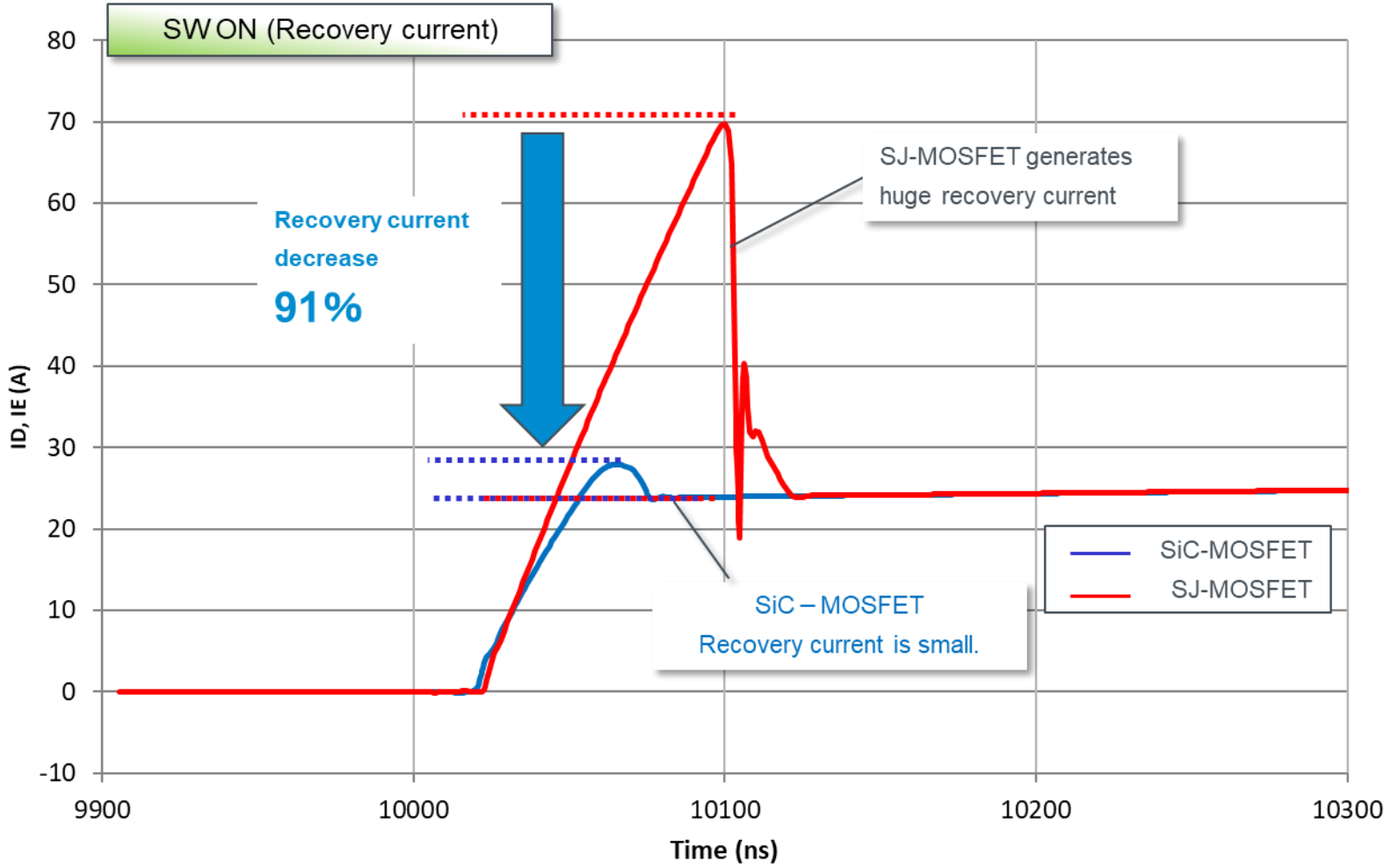
【Diode】

■SCS220AGHR
SiC-SBD
650V/20A/TO-220AC

■RFN20TF6S
FRD
600V/20A/TO-220NFN

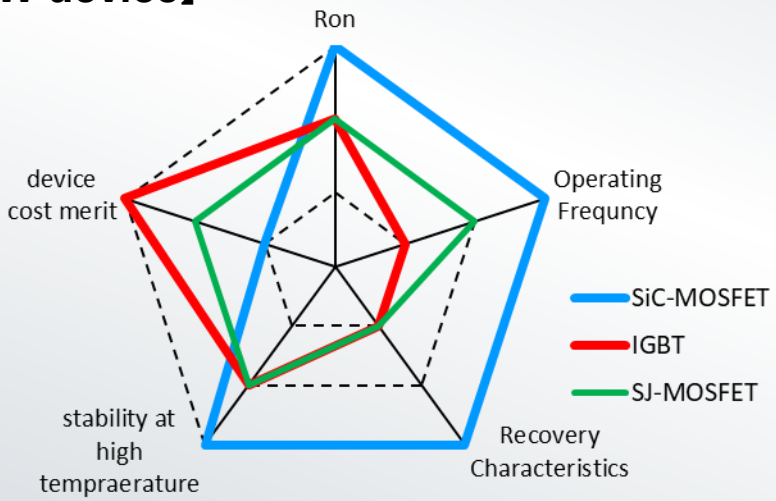
Simulation data (LLC Resonant)

Rapid load transient causes off-resonant, and switching can't work in ZVS, efficiency is influenced by recovery loss.
SiC solution enables to achieve stable operation due to small recovery loss.



Feature of each Power Device

【SW device】



SiC MOSFET

Advantage : Characteristic is the best.
Miniaturize entire application size and reduce total system cost.
Disadvantage : Device cost is still high.

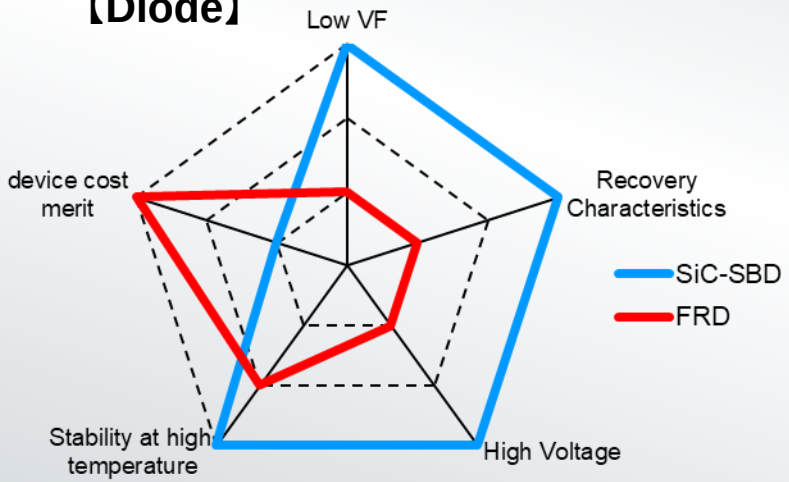
IGBT

Advantage : Device cost is cheaper than others.
Rds-on at high current is lower than SiC and SJ.
Disadvantage : Not suitable for high frequency operation.

SJ(Super Junction) MOSFET

Advantage : Easy to use because of good balance.
Disadvantage : Characteristics are inferior to SiC.

【Diode】



SiC SBD

Advantage : Recovery characteristic is better.
Stable characteristics even high temperature.
Disadvantage : Device cost is still high.

FRD

Advantage : Device cost is cheaper.
Disadvantage : Characteristics are inferior to SiC SBD.

【Knowledge】 SiC advantage

Conventional devices as SJ MOS and IGBT usually generate surge current called ‘Recovery current’.

In case recovery current is large, SW loss becomes large.

Thereby operating frequency is limited.

However SiC device has very small recovery current and achieves high frequency operation.

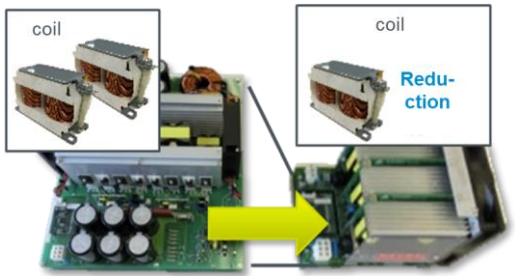
Most of the people may think SiC SW speed is fast, however it is not so big difference with other devices. Advantage of SiC is fast recovery characteristic.

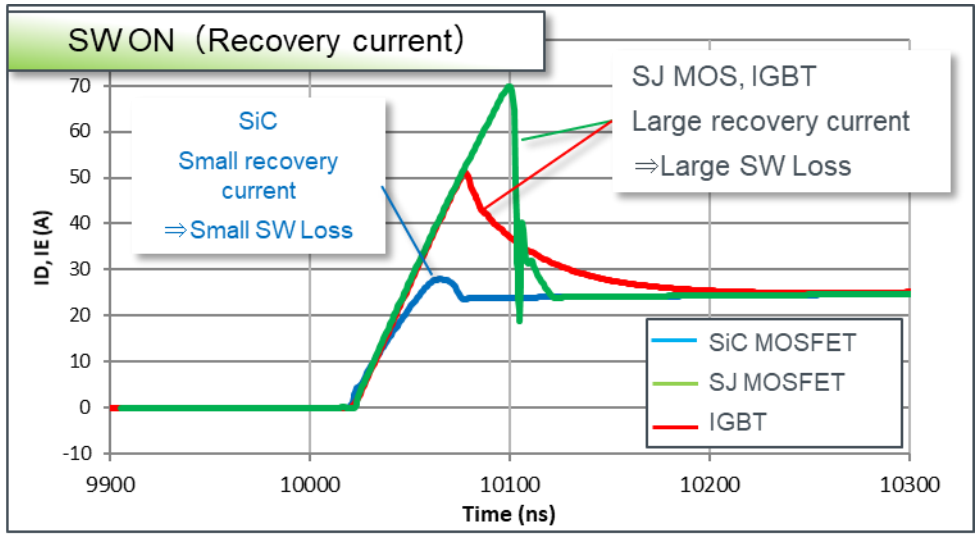
Under high frequency SW loss of IGBT is bigger than others since IGBT has tail current. It is difficult to increase high frequency.

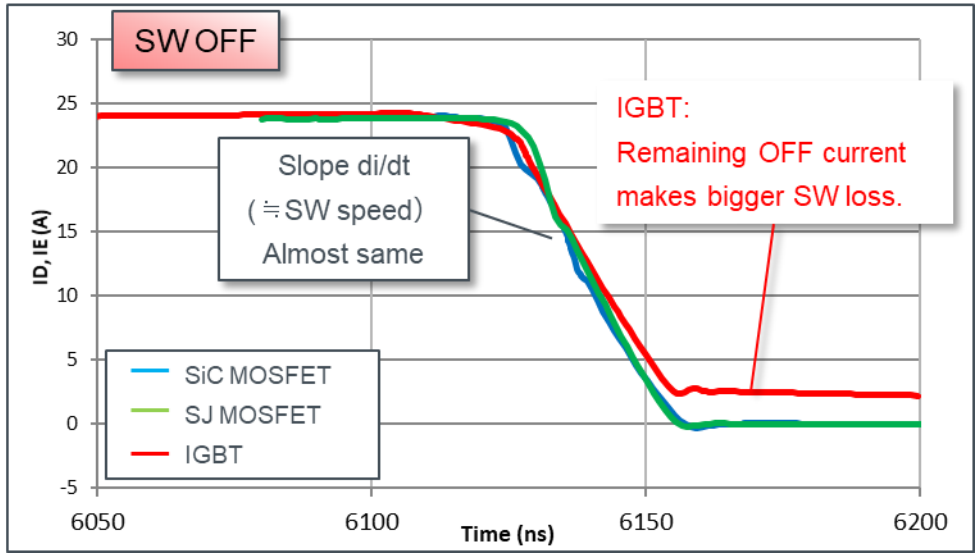
Therefore operating frequency of SiC is the fastest.

・SiC MOSFET ＞ SJ MOSFET ＞ IGBT

As you know, SiC device cost is still higher than Si device, however coil and inductor size can be reduced by increasing frequency. Then total system cost is also minimized even if SiC is adopted.





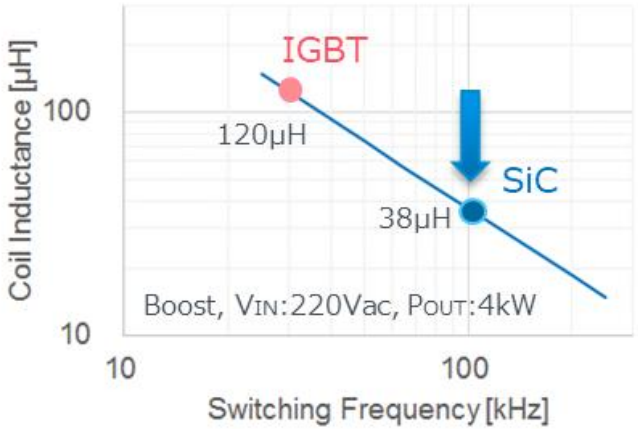


【Knowledge】 SiC Merit

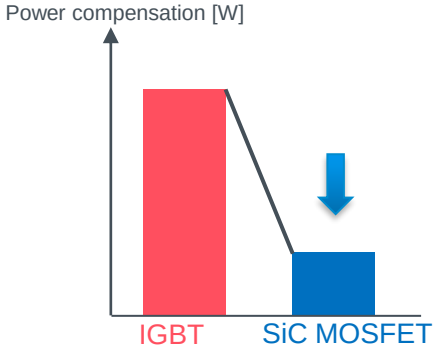
Miniaturization PCB・Lower cost

■ Higher frequency make coil inductor value smaller.

Ideal Inductor value by switching frequency



■ Power compensation saving enables Heat sink miniaturization



Comparison of power compensation

Image of PCB miniaturization

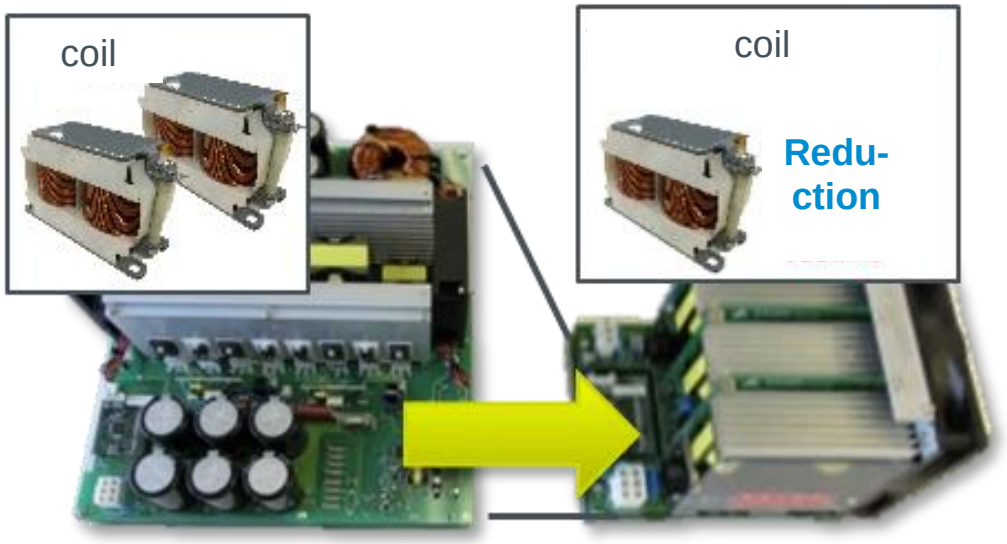


Image of Heat sink miniaturization

Gate Driver

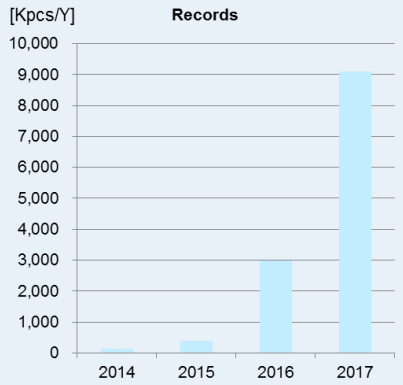
ROHM actual sales (LSI)

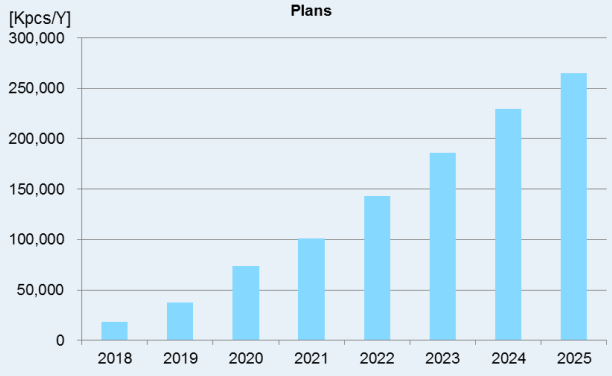
ROHM LSIs obtains huge share in Automotive market, too.

Op-Amp / Comparator
Shipment Qty (Mpcs/Y)

PR Point：Actual Sales by high reliability of isolation elements.

Usually, Gate driver used simple-type for OBC, complex-type for traction inverter.
Both built in on-chip transformer elements are used same technology and microfabrication.





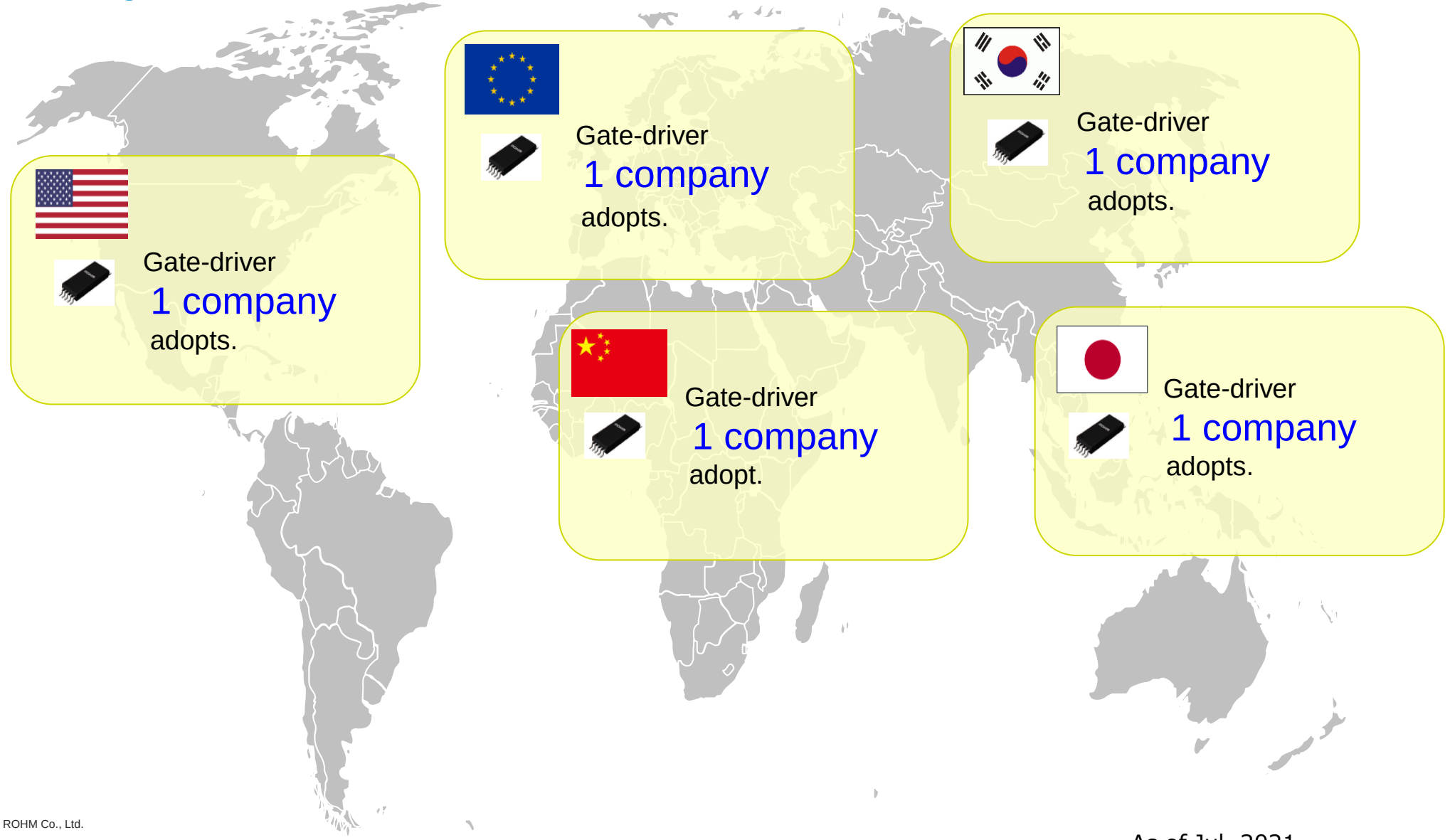
	'17/3	'21/3	'25/3
SiC Capacity	1	x6	x16
Gate-driver Capacity	1	x5	x15

Gate Drivers are
Y2014 adoption from Japan,
Then spread of Korea, EU and US.
Y2019 250 million/year
Rohm invest huge amounts to supply both of power device and gate driver stably.
（shown left bottom figure)

（reference）Actual records for traction inverter in 2019：
As for the power train results, it is proved the reliability
US：1 company、
EU：2 companies
Korea：1 company、
China：5 companies
Japan：6 companies
*refer to next page (OBC)

Gate driver actual sales in OBC market

ROHM gate driver is chosen in the world wide customers.



As of Jul. 2021

Miller Clamping function

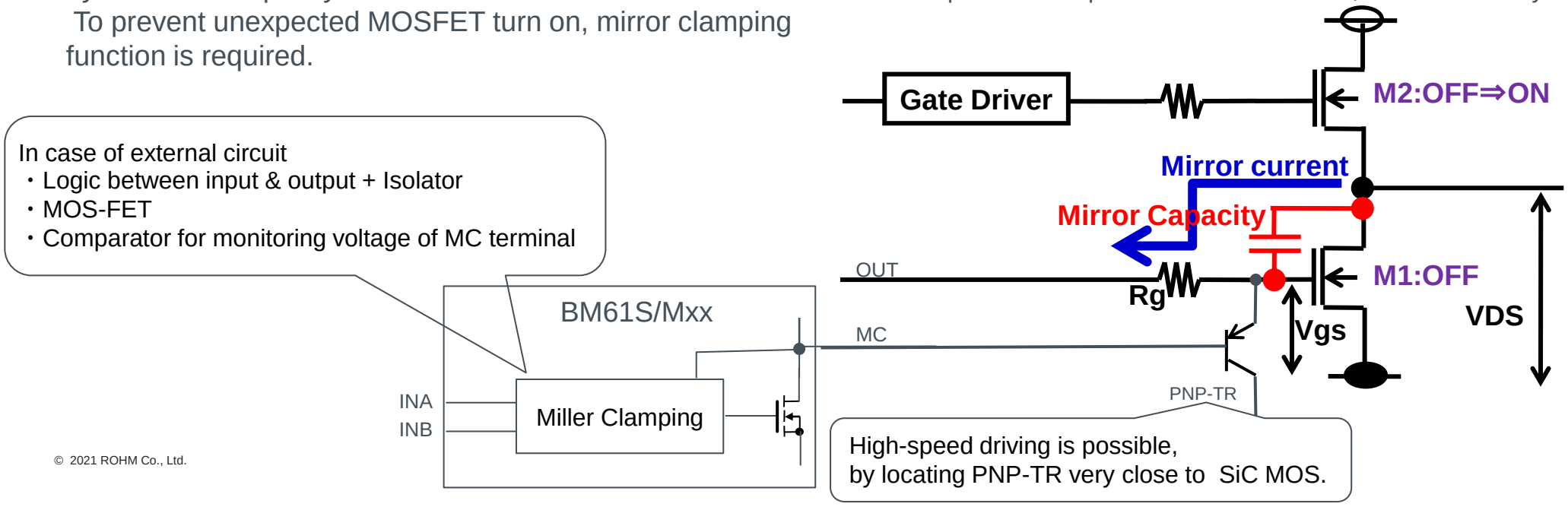
Merit : BM61S/Mxx series are built in miller clamping function. Suitable for SiC driving

DCDC trend : Downsizing of the transformer by high frequency drive.
＝Downsizing of OBC + Cost Down
→ Shift to SiC-MOS from SJ-MOS or IGBT

Mirror clamping function is required for gate drivers to drive SiC.

Reason：
External Rg is bigger than IGBT or SJ-MOS.
Then it likely causes gate voltage(Vgs) to rise up Vgs(Error On) by the mirror capacity.
To prevent unexpected MOSFET turn on, mirror clamping function is required.

Miler clamping：
When M1 becomes ON→OFF,
-Mirror current generate from mirror capacity
-Mirror current flow into gate capacity
-M1 turns error ON by rise of gate voltage
To prevent unexpected MOSFET turn on, mirror current by adding external PNP-TR



Noise Robustness:
by using magnetic coupling for isolation.

Foot pattern space:
comparing with 1ch-LSI x 2 vs. 2ch-LSI x 1

Q/A-1: Magnetic Isolation Robustness against Noise

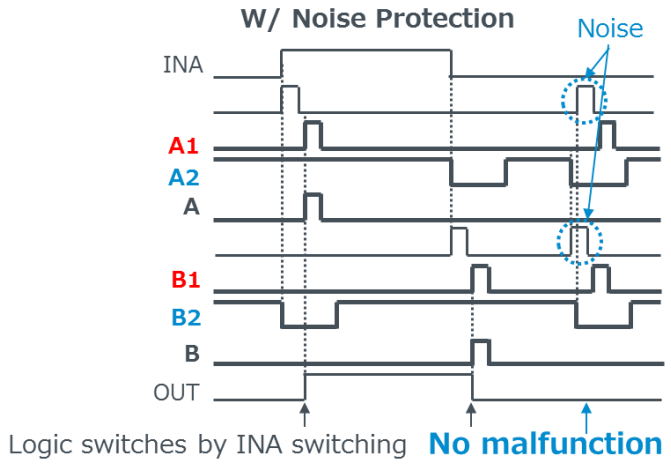
Already improved by market record

There are three type isolation shown right figure. Some customer sometimes says that Magnetic type Rohm is using is week against noise.(See Fig-1)

But actually Rohm isolation technology has already been adopted by many OEMs in W/W, and the market records shows that it is enough reliability about the robustness against noise.

The one of the reason is that filter circuit is inside the IC as shown Fig-2.

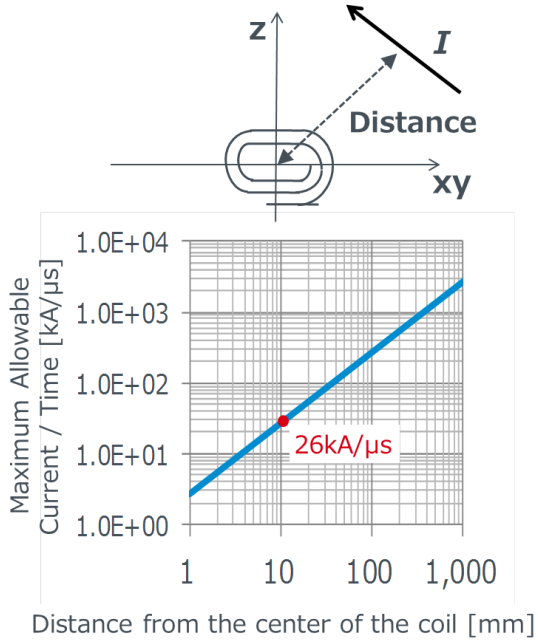
The normal input signals are certainly anti-phase timing into INA/INB, but noise signals are same timing into them. So the filter merge the same timing input signal as noise signal.



【Fig-2】

	Delay Speed	Power consumption	Lifetime	Feature (Ext. noise)	Feature (analog signal)	High reliability
Optical Coupling	Slow	Big	Aging Speed is fast	Not influenced by Magnetic noise	Possible to transmit	
Capacitive Coupling	Fast	Not Increasing by Data speed	Lifetime is long	Not influenced by Magnetic noise	Not transmit. Available by ADC circuit inside	Separated 2chip serial connection cause less possibility of short destruction if one is short.
Magnetic Coupling	Fast	Increasing by Data speed	Lifetime is long	influenced by Magnetic noise. No problem by Filter circuit inside	Not transmit. Available by ADC circuit inside	

【Fig-1】



【Fig-3】

Fig-3 shows the distance between Isolation chip and the magnetic transition by huge current transition.

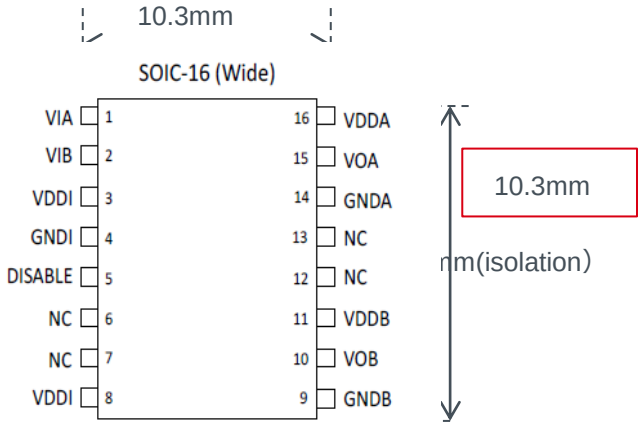
This shows that 26kA/µs abnormal rapid current transition placed 10mm distance from IC is limit .

Simply speaking, problem does not occur under the condition that there is a huge current cables 10mm close to the IC. So there is no problem in normal Traction Inverter.

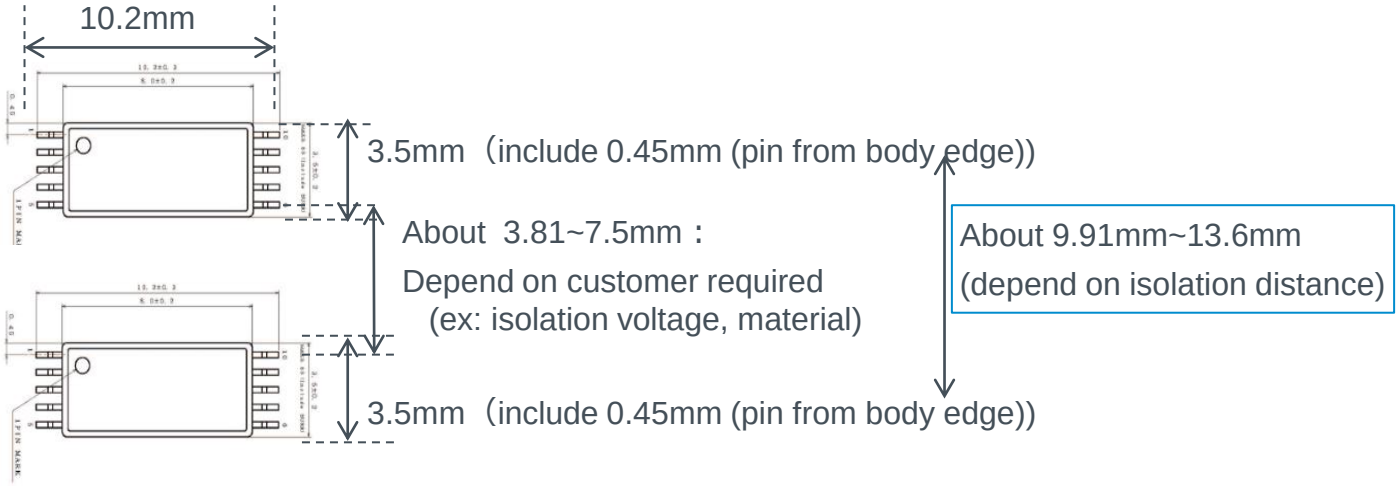
Q/A-2:Foot pattern space: comparing with 1ch-LSIx2 vs. 2ch-LSIx1

1ch (2pcs) vs 2ch (1pcs) Difference of space are very few.

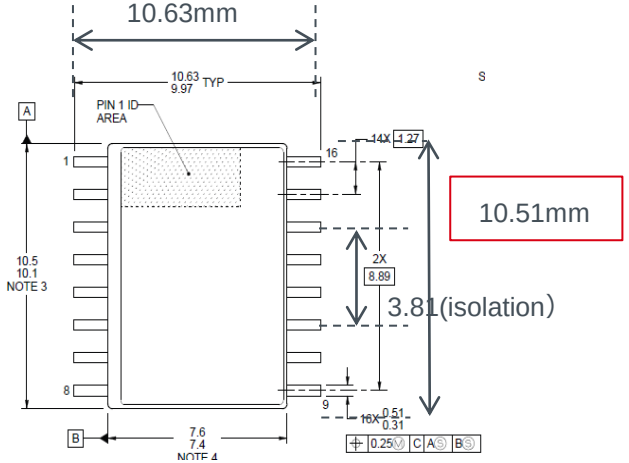
Competitor



BM61S4xRFV



Competitor



New approach for OBC

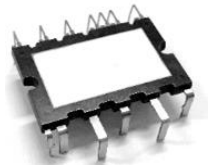
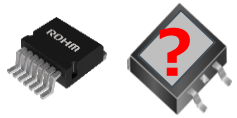
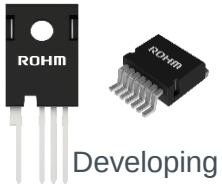
Developing

■ SiC Power Module

Currently the module is developing. The specs are not fixed yet.
・Design sample target schedule : 2022 Q1

・Research sample is available for high priority project and strategic customer. However sample quantity is limited.
If you need samples, please contact with SSE. (Kondo)

SiC power module corresponds to OBC trends for miniaturization and high frequency.

	OBC market trend	
	Miniaturization	High frequency
SiC Power Module	**Integration ＋ Driver source**  Developing	
Discrete	**SMD / Topside cooling**  Developing Planning	**Driver source**  Developing

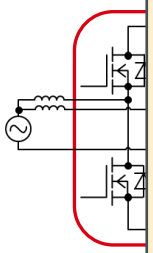
Advantages

- Easy isolation design
- Unnecessary isolation sheet
- Miniaturization and Integration
- High frequency operation by driver source terminals

Space saving

TO-247:14pcs → HSDIP:3pcs

e.g. Bi



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Latest customer situation for module in Jul 2021.

・Adopted competitor module：EU 1company
・Considering module for next model：China 1 company
・Considering ROHM HSDIP：EU, Japan, Taiwan 3 companies.

・Module and SMD package are considered as downsizing trend.
・Most of the customer does not know that ROHM develops module.
Please introduce the module for R&D and management.

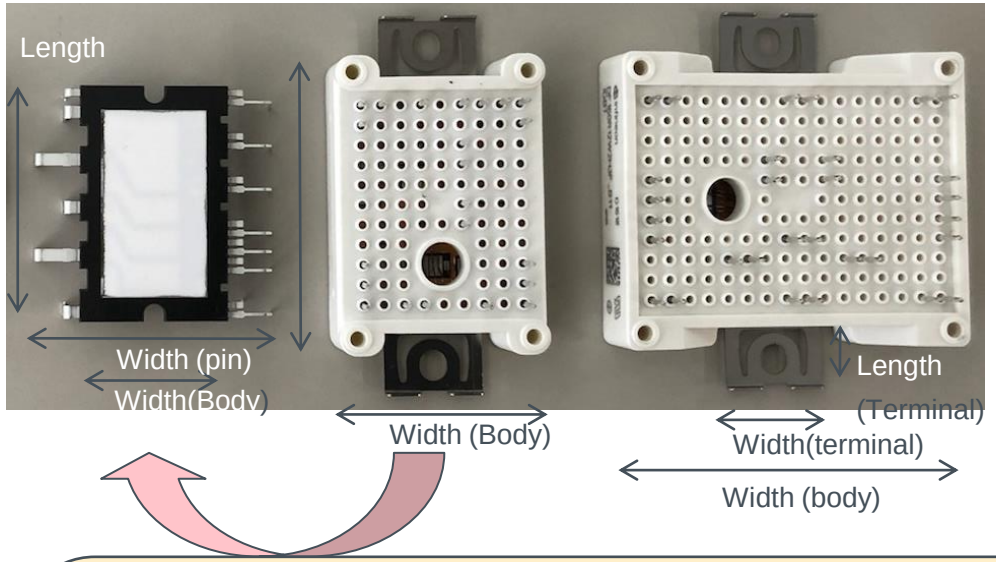
* Schedule and target specification are subject to change without notice.

Package comparison

Developing

24% mounting area reduction against general modules.

ROHM HSDIP　　General power modules

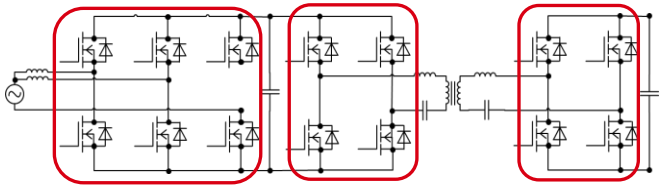


e.g. Bi-directional OBC

Mounting area: 24% space reduction

Volume: 75% reduction

Low height: 12mm→5.5mm



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Some customers have adopted the above.

ROHM HSDIP module has advantages such as smaller package and lower height. Module cost is also better, because of difference of module structure.

Customer may point out module cost is higher than discrete solution(TO-247).

In such case total mounting cost should be calculated, not comparing only components cost. For instance isolation sheets are unnecessary because HSDIP module integrates ceramic substrate.

Additionally number of screws and mounting cost will be less.

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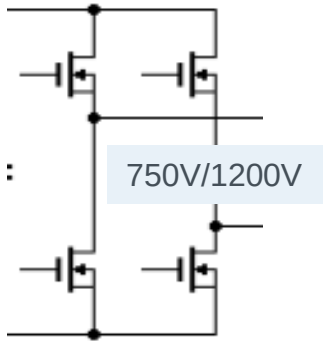
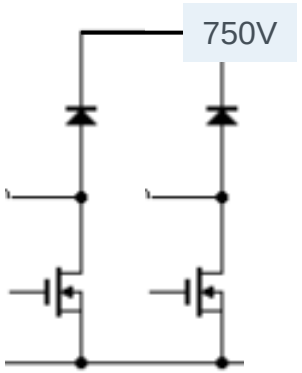
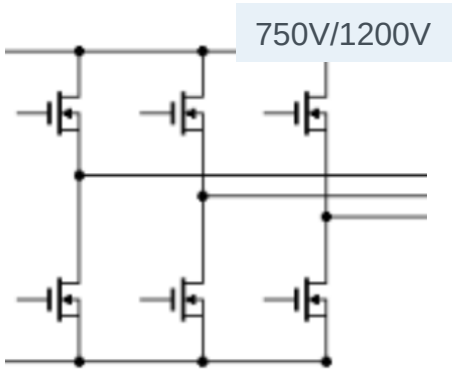
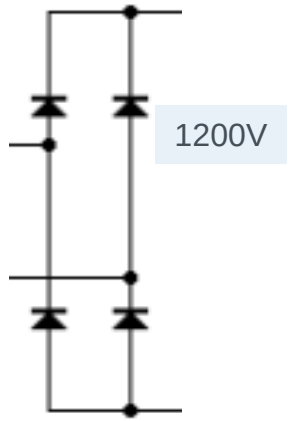
SiC Power Module Target topologies

Developing

1) H bridge	2) boost	3) 3phase B6	4)Diode bridge
	 *MOS: SJ or SiC	 *Without external SBD	
Circuit block			
Phase Shift, LLC DAB Single phase inverter Bi-directional chopper	Boost PFC(interleave)	3 phase inverter 3 phase rectifier	Secondary side rectification
Target applications			
Data center OBC, 12V DCDC PV, Energy storage Wireless charger SMPS	Data center OBC PV inverter SMPS	Motor drive (elevator, servo, HVAC) PV inverter, UPS SMPS	OBC Wireless charger SMPS

Firstly development starts from H bridge and three phase type.
Other topologies are also considerable.

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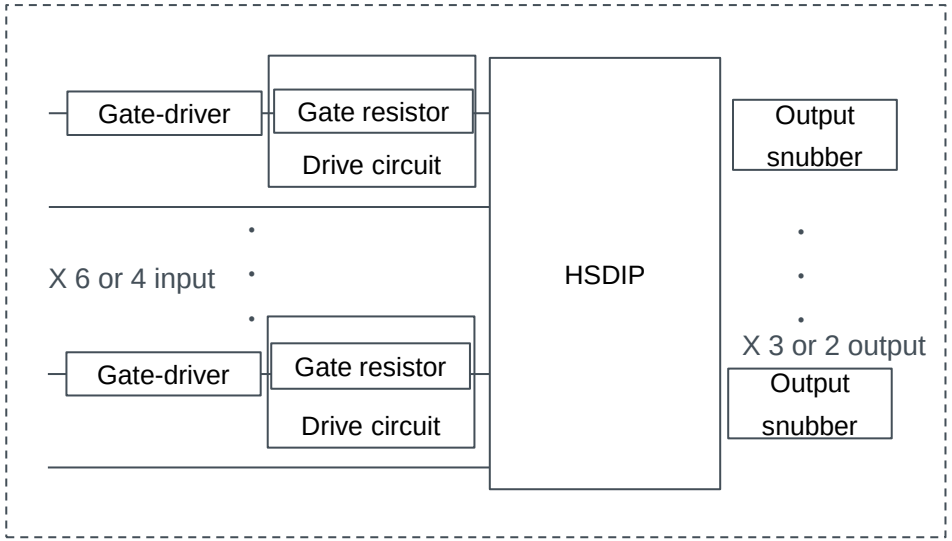
SiC Power Module evaluation board

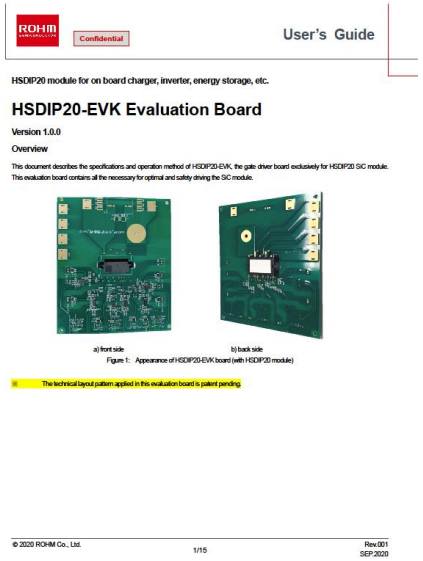
Developing

Please utilize the evaluation boards.

Evaluation board outline



User's Guide


ROHM Confidential User's Guide

HSDIP20 module for on board charger, inverter, energy storage, etc.

HSDIP20-EVK Evaluation Board

Version 1.0.0

Overview

This document describes the specifications and operation method of HSDIP20-EVK, the gate driver board exclusively for HSDIP20 SiC module.
This evaluation board contains all the necessary for optimal and safety driving the SiC module.

a) front side b) back side

Figure 1: Appearance of HSDIP20-EVK board (with HSDIP20 module)

※ The technical layout pattern applied in this evaluation board is patent pending.

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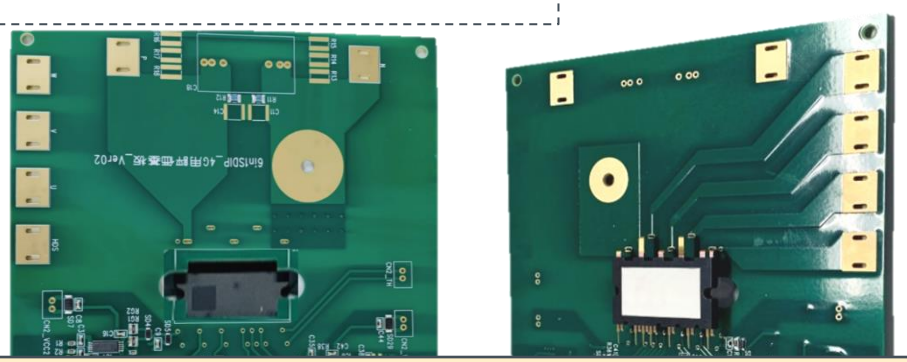


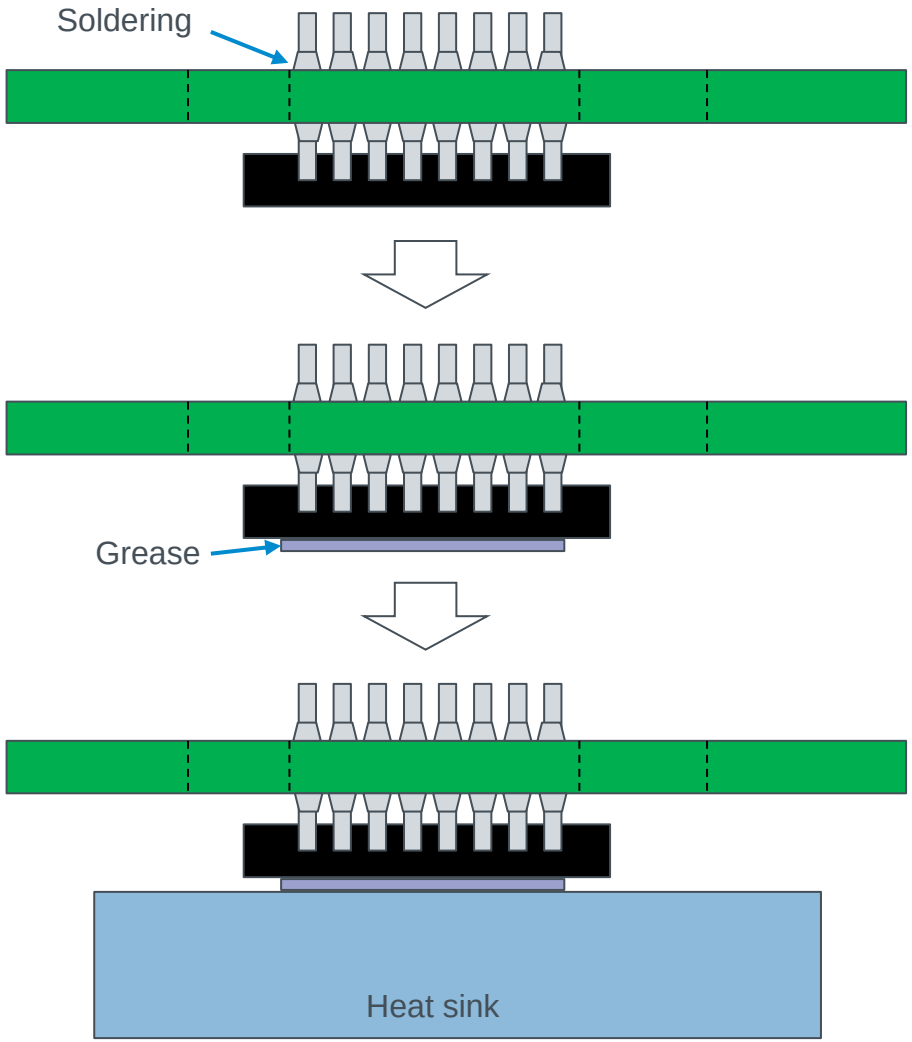
Please explain to the customer the difference in mounting method from the discrete product and the image of the cooling method.

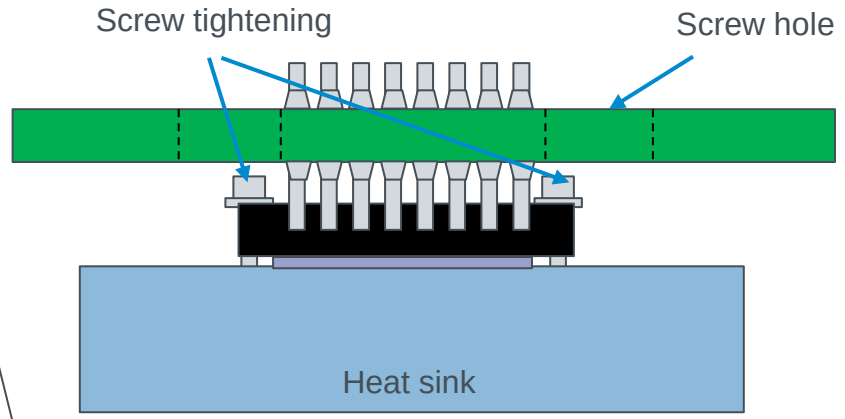
Please give us your feedback on mounting costs, increase / decrease in cooling FIN costs, etc..

* Schedule and target specification are subject to change without notice.

SiC Power Module implementation procedure1

Developing

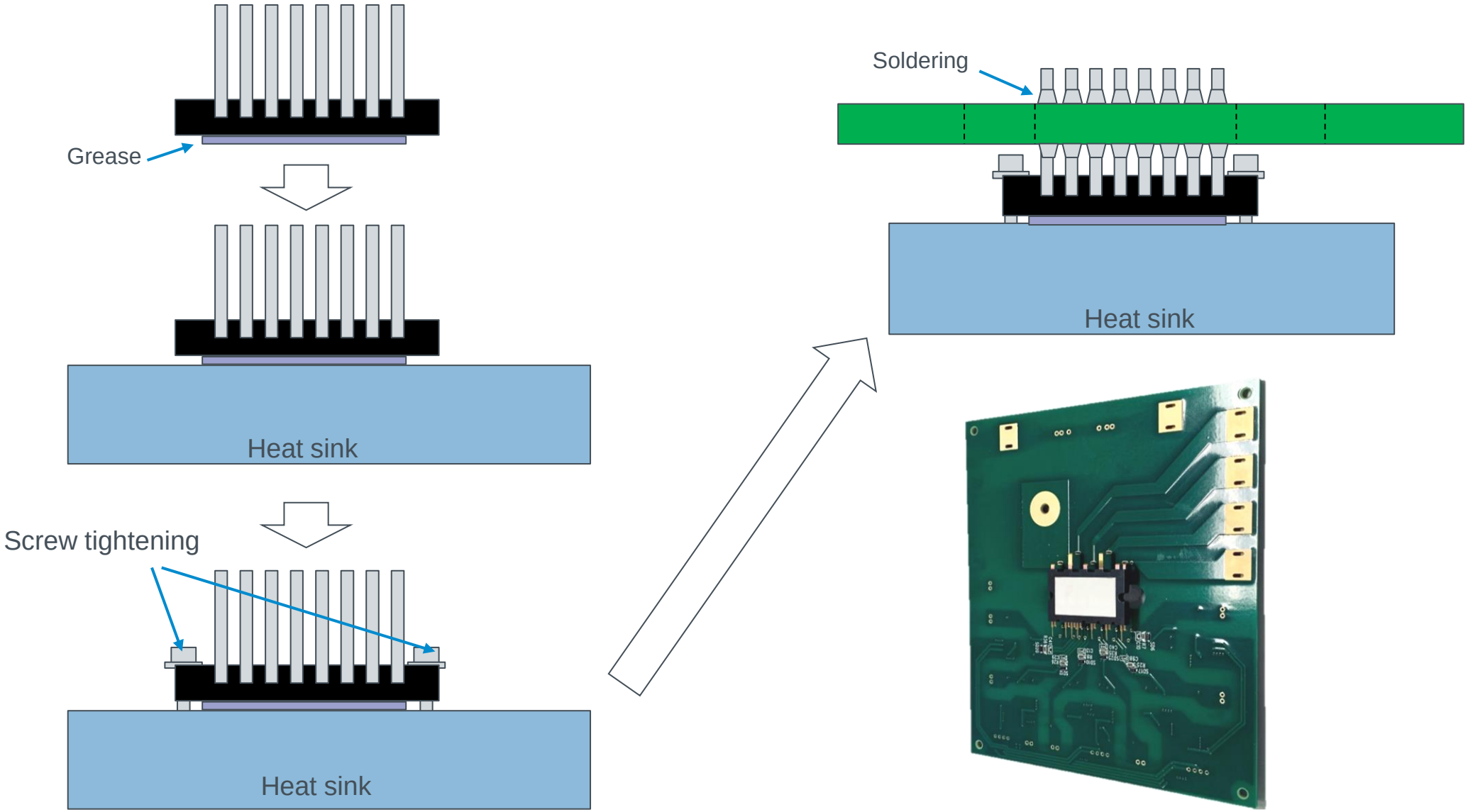




* Schedule and target specification are subject to change without notice.

SiC Power Module implementation procedure2

Developing



* Schedule and target specification are subject to change without notice.

Insulation Distance

Developing

In order to secure insulation distance it needs to keep a distance from heatsink to root of terminal. In some case heat sink should be designed convex structure not flat structure.

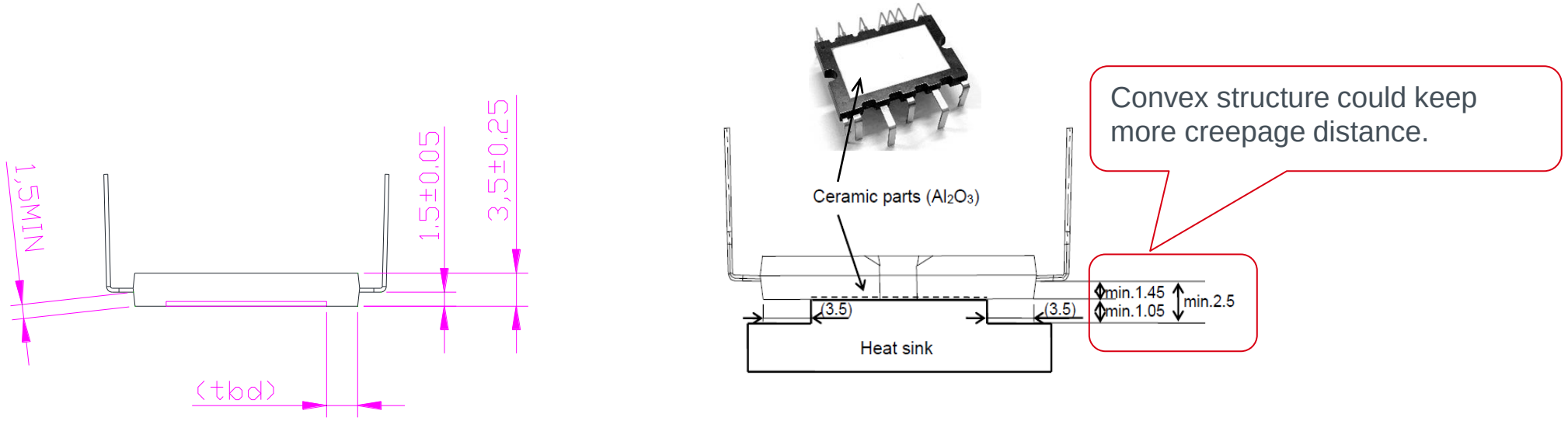


Figure 2.1.2 In the case of using the convex heat sink (Unit: mm)

Creepage Distance	Terminal to heat sink	*	mm
	Terminal to terminal	(typ. 6.7)	mm
Clearance Distance	Terminal to heat sink	min 1.45	mm
	Terminal to terminal	(typ. 5.6mm)	mm

* : depends on heatsink