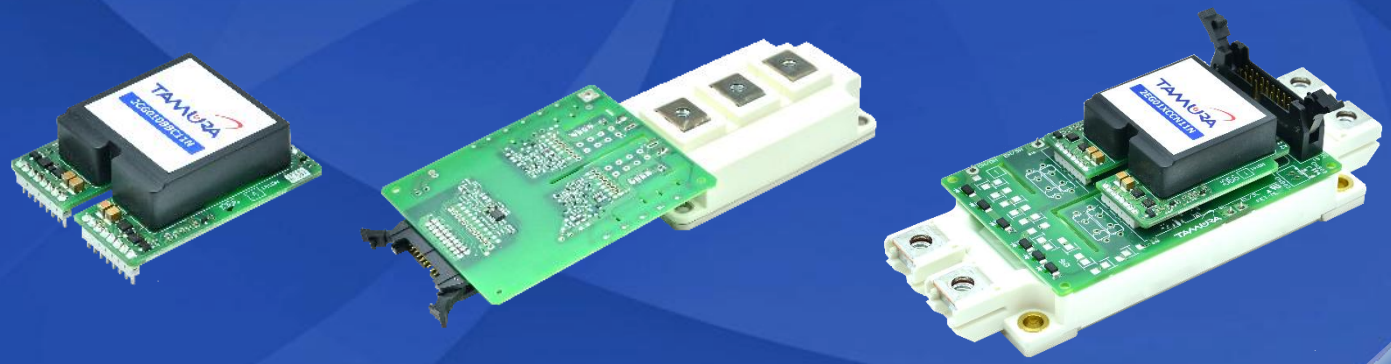
# Gate drivers that bring out the performance of Infineon Technologies AG / SiC Power Modules



SUSTAINABLE DEVELOPMENT GOALS

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TAMURA
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TAM-GDM-00017

Issued on 1st May '25 Unit division HQ Japan

Rev C

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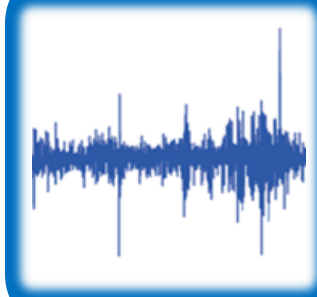
# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-1. Why ??

Circuit design Technology

Transformer Technology


Potting Technology



EMI/EMC Solution

Market Awareness

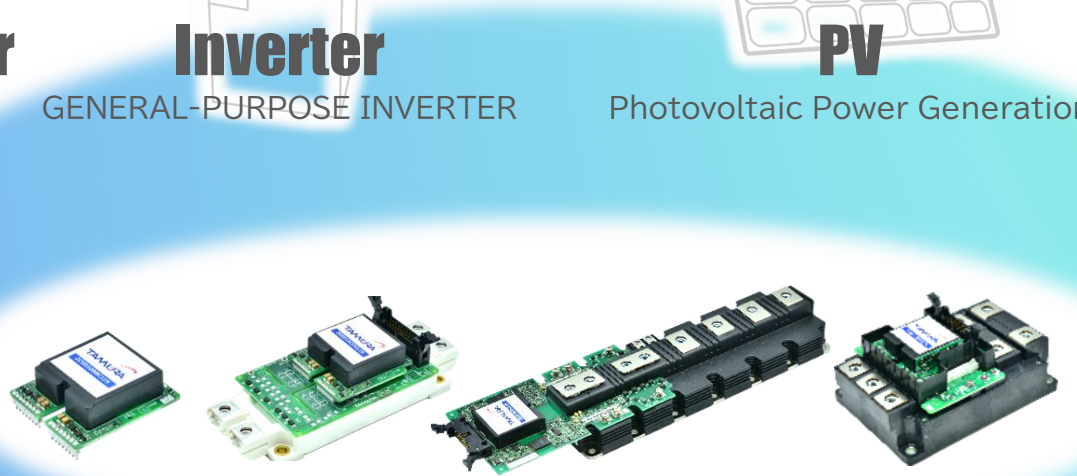
# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-1. When ??

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|
| **IGBT** | | 2DD of DC-DC convertor | 2CG-D for IGBT | 2EG-C<br>Mitsubishi (2in1)<br>FUJI (2in1)<br>Infineon (2in1) | 2PG/2QG<br>FUJI (2in1)<br>Infineon (2in1) | 2LG-C<br>Mitsubishi (2in1) | 2LG-C Parallel | | For Traction Infrastructure<br>Mitsubishi (LV100(HV)) |
| **SiC** | 2DM/2DU for SiC<br>ROHM | 2DD of DC-DC convertor | 2CG-B for SiC | 2CG-B + 2RB<br>Infineon | 2EG-B<br>ROHM | | 2CG-B + 2RB<br>Wolfspeed | | Mitsubishi (LV100(HV)) |

# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-2. Application



**Motor Controller**

**Inverter**
GENERAL-PURPOSE INVERTER

**PV**
Photovoltaic Power Generation

**Wind**
Wind Power Generation

**Robotics**

**Grid/SVG**
Electric grid

**Welding**
Welding Machine

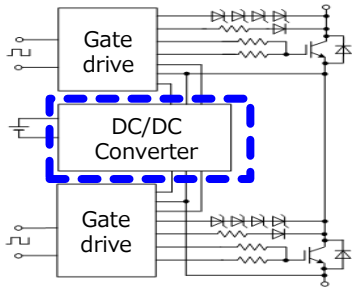
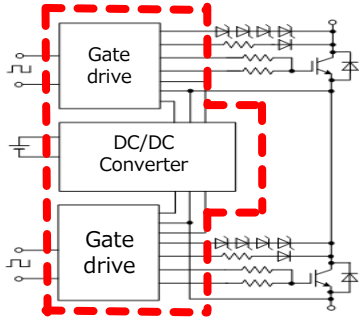
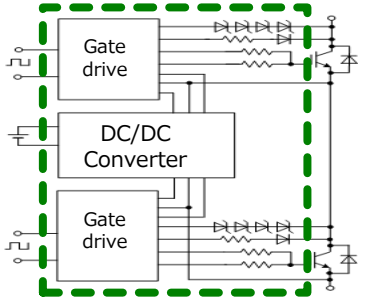
**UPS**
Uninterruptible Power Supply

**EV Charger**
**EV Stand**

**ESS**
Energy Storage System

# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-3. Product Configuration

| | DC/DC Converter | Gate Driver Module | Gate Driver Unit |
|---|---|---|---|
| Function | 2in1 PM designated DC/DC Converter | DC/DC Converter + Gate drive | Gate Driver Module + Gate resistors Protective function |
| Block diagram |  |  |  |
| Appearance |  <br>2DD series |  <br>2CG-B/D series |  |

## 1-4. Features of Gate Driver Modules

### Features of All-SiC Power Module

Feature① Short circuit tolerance is lower than Si

Feature② Low threshold voltage VGS (th) (1V~3V)

Feature③ VGS(+) :On resistance does not decrease at 15V
VGS(−) :Low tolerance (Less than −7V)

Feature④ dV/dt can be set high

Feature⑤ High frequency operation is possible

**Gate Driver Module solves all problems!**

# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-4. Features of Gate Driver Modules

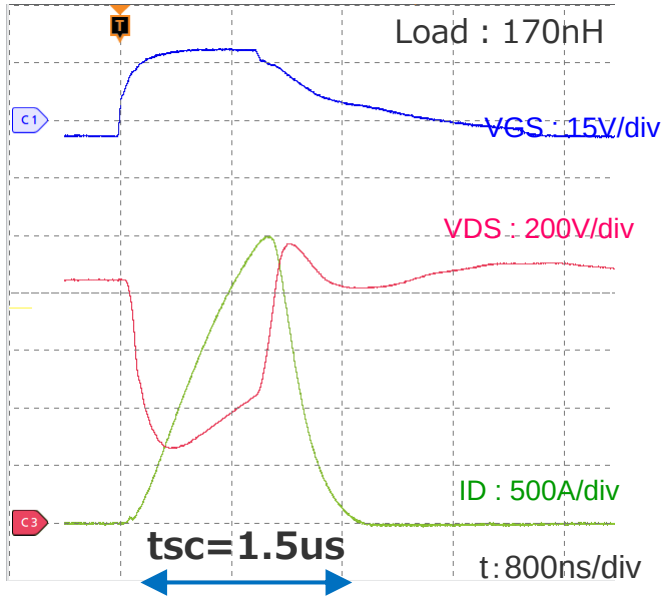
Feature ① Short circuit tolerance is lower than Si

Small chip area

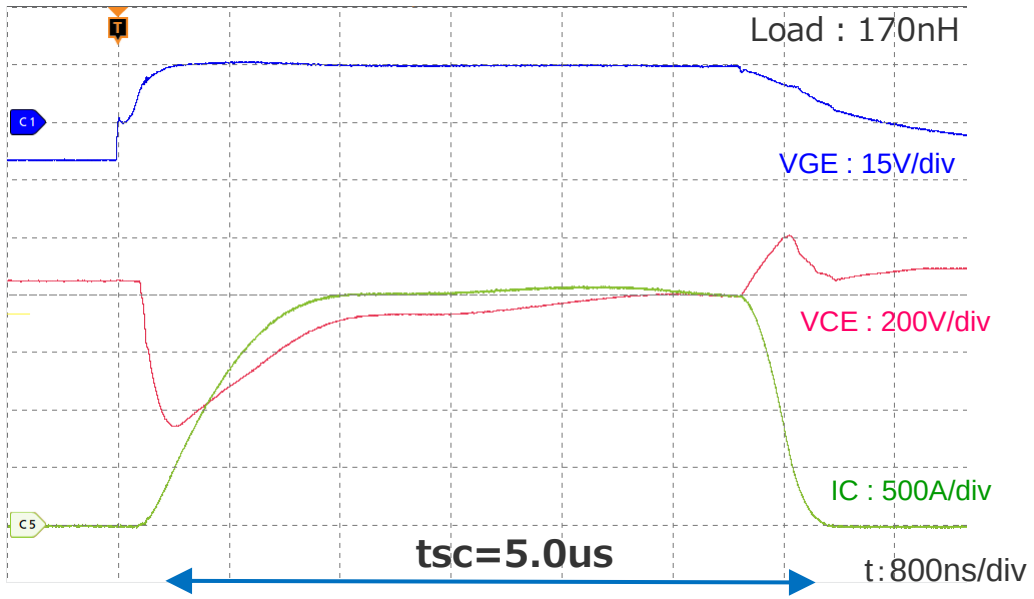
- Wide band gap
- High breakdown voltage
- High temperature operation

**Support with a gate driver** ・・・ Short-circuit mask time (tsc) adjustment function

SiC power module （1200V 300A）
Waveform with shorted load




IGBT power module (1200V 300A)
Waveform with shorted load




**Adjustable with external capacitor capacity**

Optimal value of SiC : 1.0~3.0us

Optimal value of IGBT : 3.0~7.0us

# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

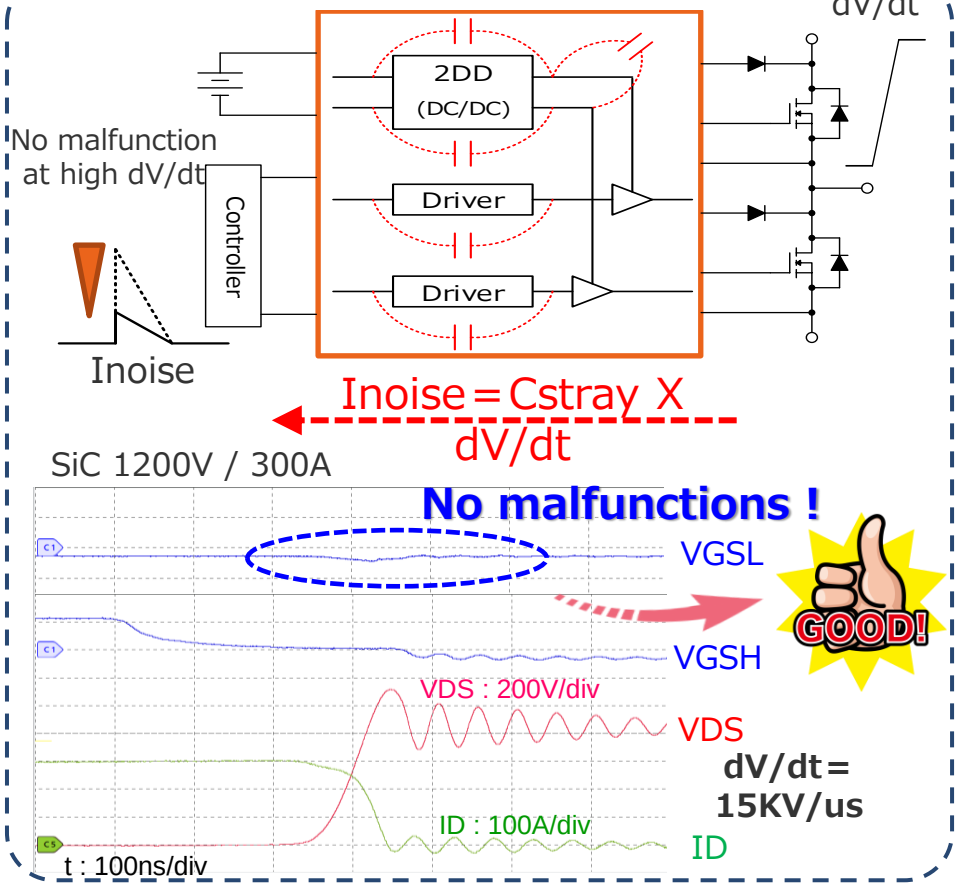
## 1-4. Features of Gate Driver Modules

Feature② Low threshold voltage $V_{GS}$ (th) (1V~3V)

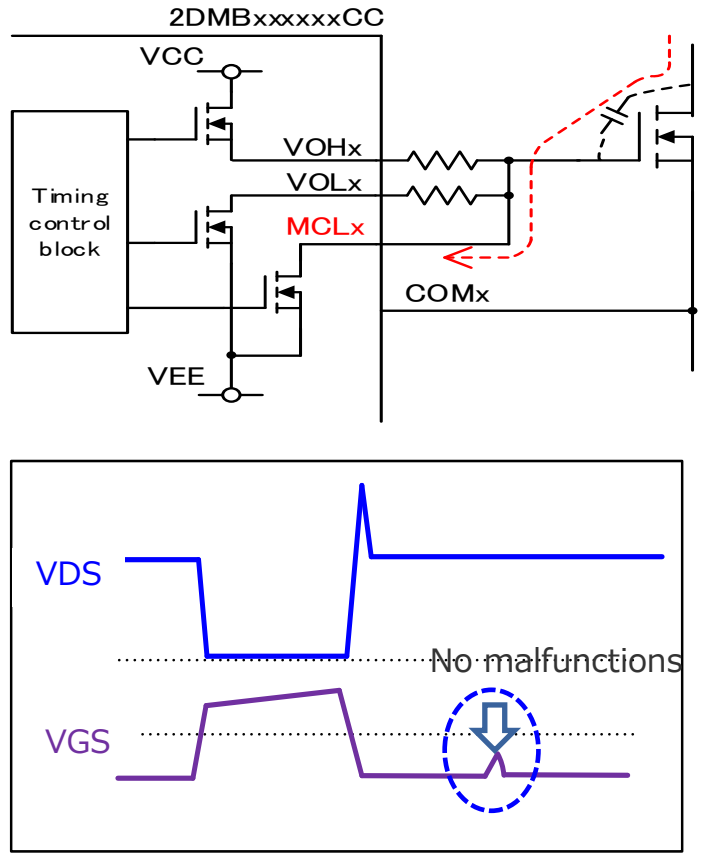
--- IGBT is 6V~7V --- Beware of malfunctions from IGBT

**Support with a gate driver** ･･･Reduction of parasitic capacitance and Miller clamp circuit

### Reduction of parasitic capacitance




### Miller clamp circuit



# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-4. Features of Gate Driver Modules

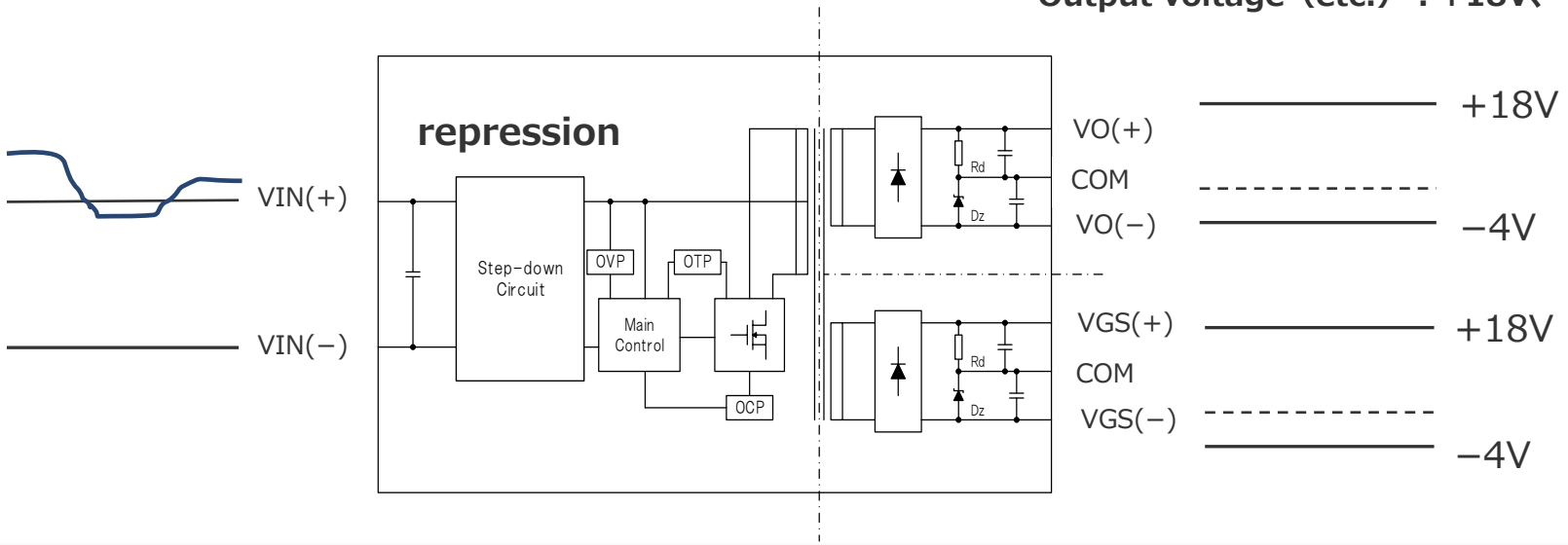
Feature③ $V_{GS}(+)$ :On resistance does not decrease at 15V
$V_{GS}(-)$ :Low tolerance（Less than −7V）

--- IGBT's Gate driver cannot be used

**Support with a gate driver ･･･Constant voltage control of $V_{GS}$**

**Input voltage : 13V~28V**

**Output voltage（etc.）: +18V、−4V**




Controls the gate voltage to be constant even for input fluctuations
The gate voltage is constant even for output fluctuations
(SW frequency, QG of power module)

**Improved SiC reliability**
**Low loss operation**

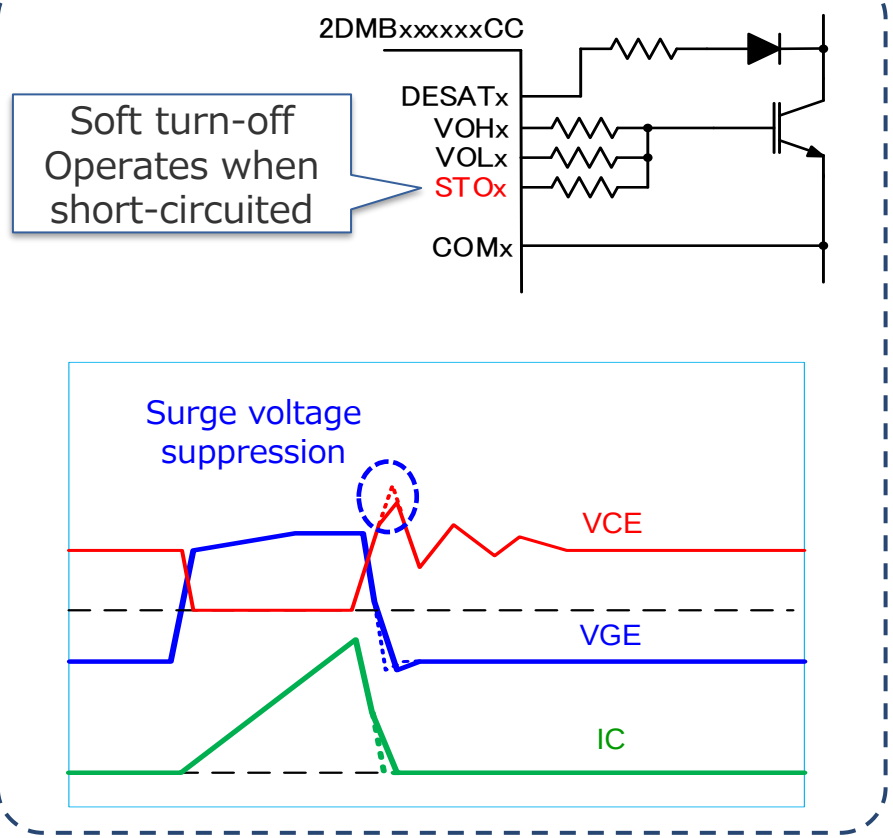
## 1-4. Features of Gate Driver Modules

Feature④ dV/dt can be set high

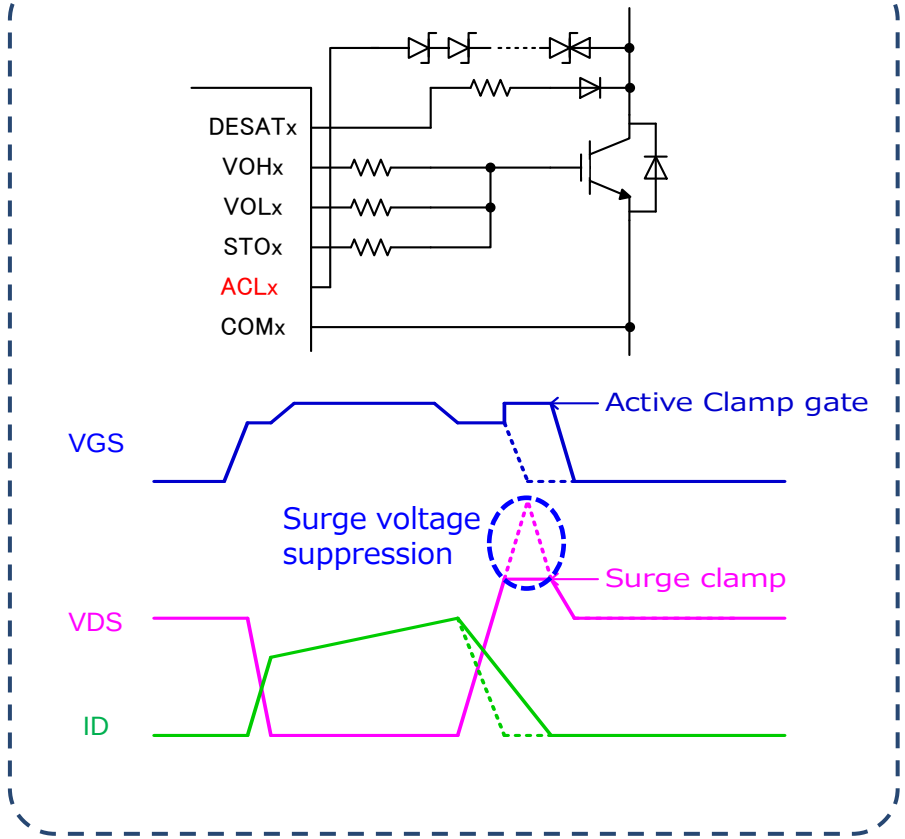
Turn-on: Recovery current is small
Turn-off: No tail current

**Support with a gate driver** ・・・Ability to suppress surge voltage with high dV/dt (Soft turn-off, Active clamp)

### Soft turn-off




### Active clamp (Option)



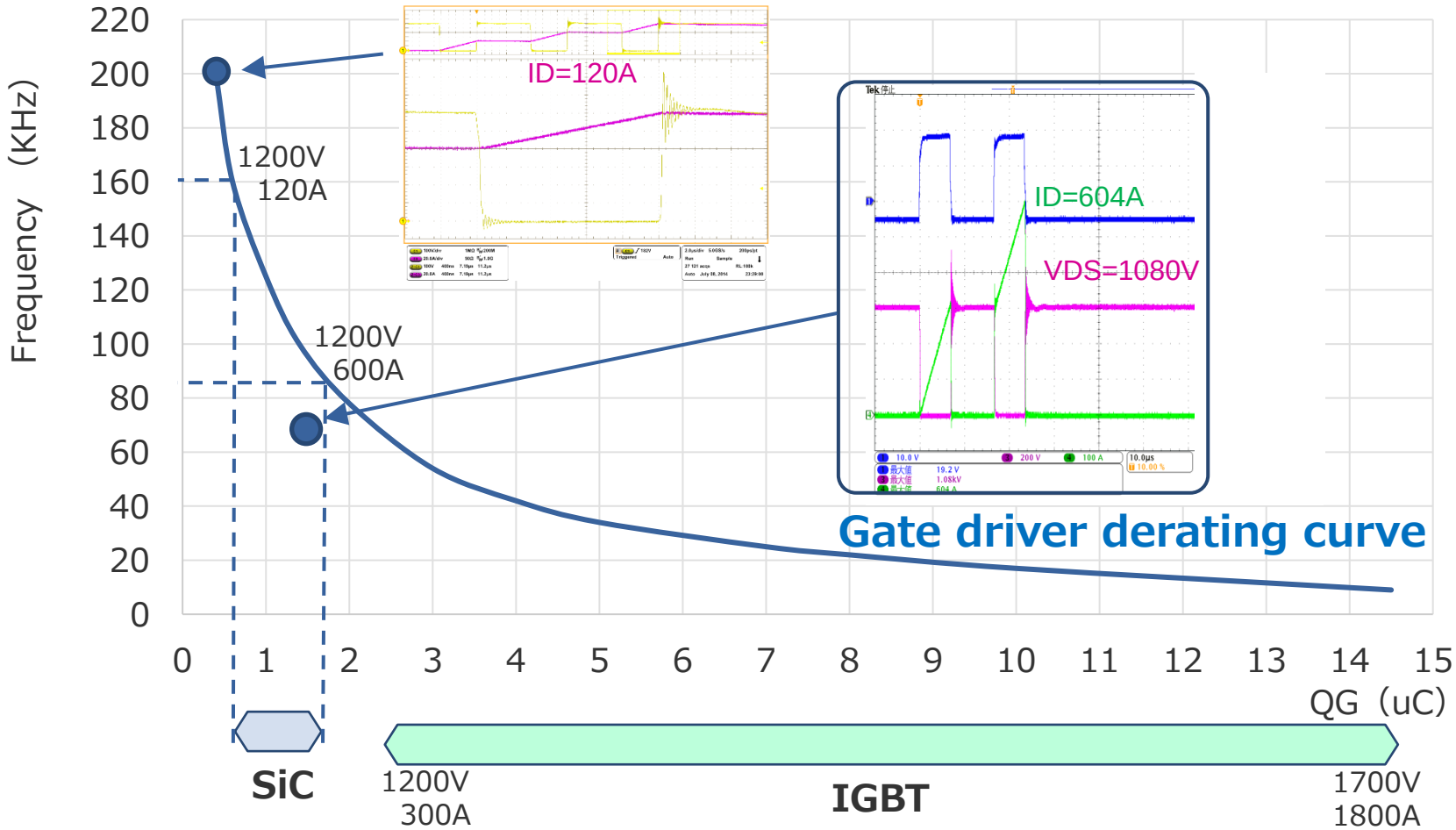
# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-4. Features of Gate Driver Modules

Feature⑤ High frequency operation is possible

Drive power needs to be increased

**Support with a gate driver** ・・・Output capacity considering SiC power module



# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

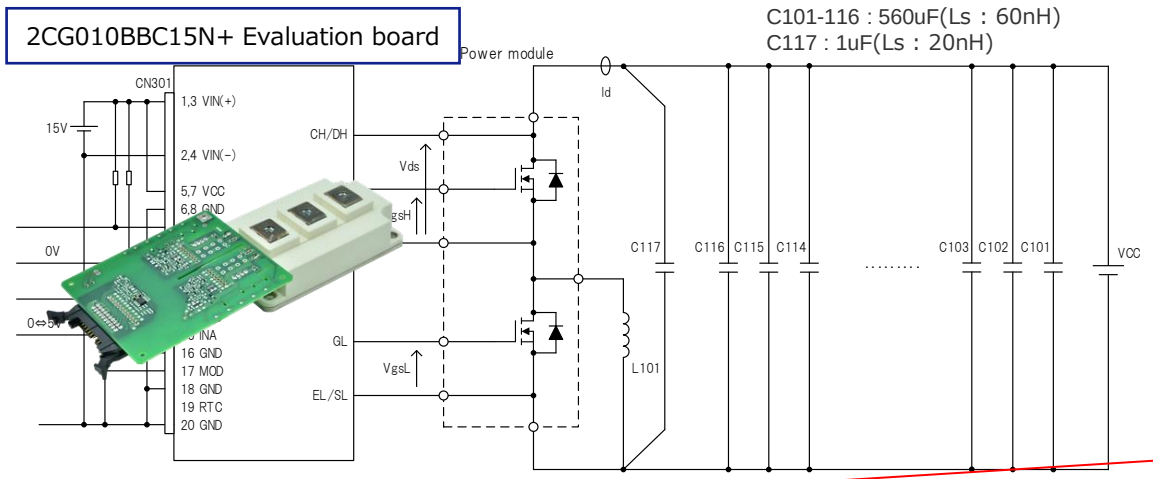
## 1-5. Gate drive waveform of SiC power module (2 Pulse test)

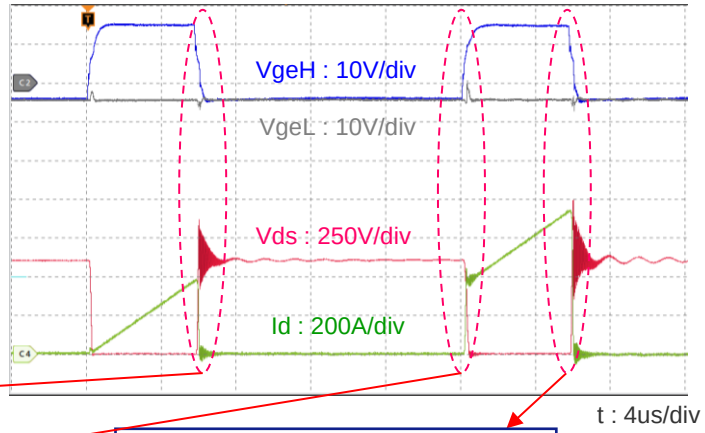
**SiC MOSFET : FF3MR12KM1**

DC Link : 600V,　Ron : 4.3Ω, Roff : 3.6Ω,　Upper arm,　Tj=25℃

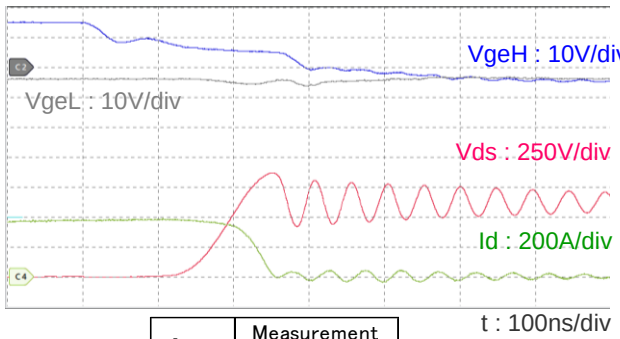
2CG010BBC15N+ Evaluation board

Highly stable gate drive with proprietary drive circuit and miller clamp circuit (patent pending)



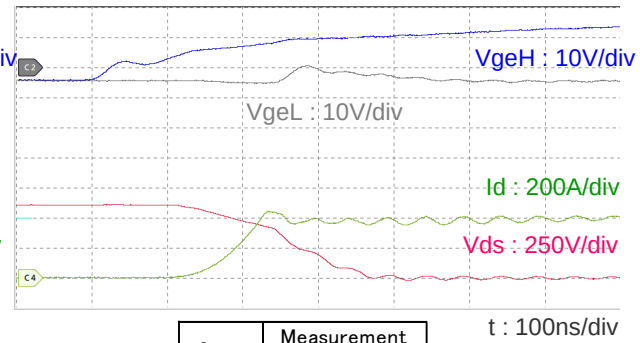




### Turn OFF / Ic =375A



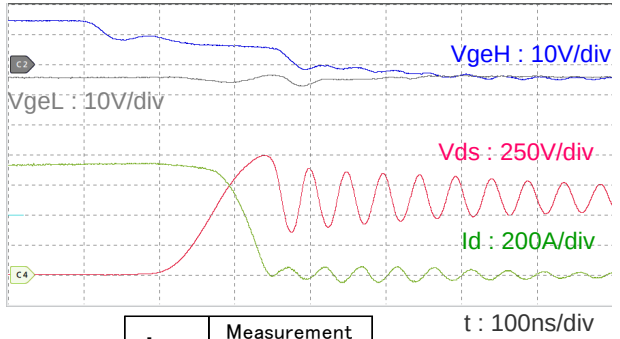

| Item | Measurement value | |
|---|---|---|
| Vdsp | 866 | V |
| dV/dt | 8.8 | kV/us |
| di/dt | 6.2 | kA/us |
| Eoff | 13 | mJ |

### Turn ON / Ic =375A




| Item | Measurement value | |
|---|---|---|
| dV/dt | 4.6 | kV/us |
| di/dt | 5.0 | kA/us |
| Eon | 19 | mJ |

### Turn OFF / Ic =750A




| Item | Measurement value | |
|---|---|---|
| Vdsp | 992 | V |
| dV/dt | 9.2 | kV/us |
| di/dt | 10.3 | kA/us |
| Eoff | 33 | mJ |

# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-5. 2 Pulse test (Enlarged waveform)

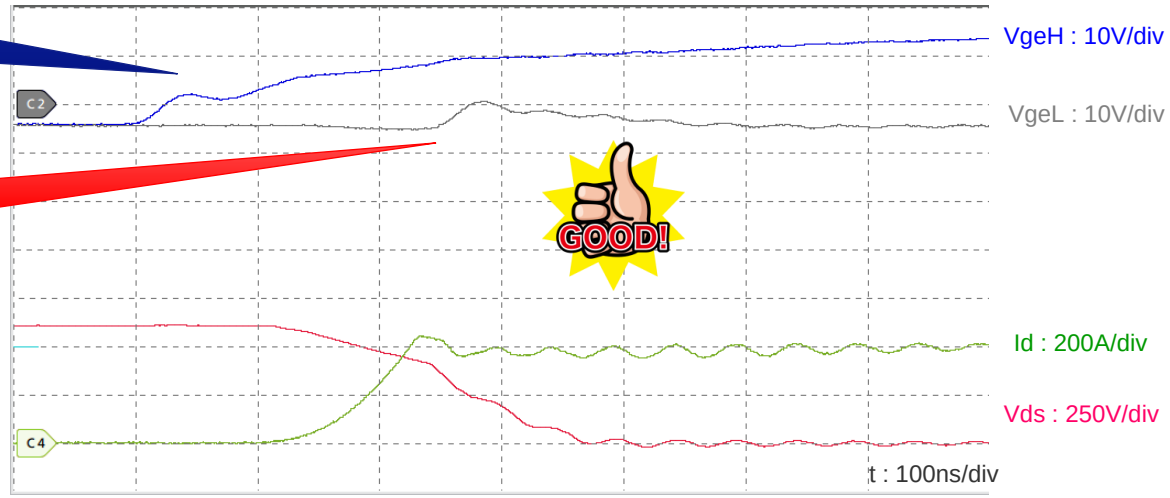
**SiC MOSFET : FF3MR12KM1**

SW side gate (turn ON)
No ringing and no overshoot

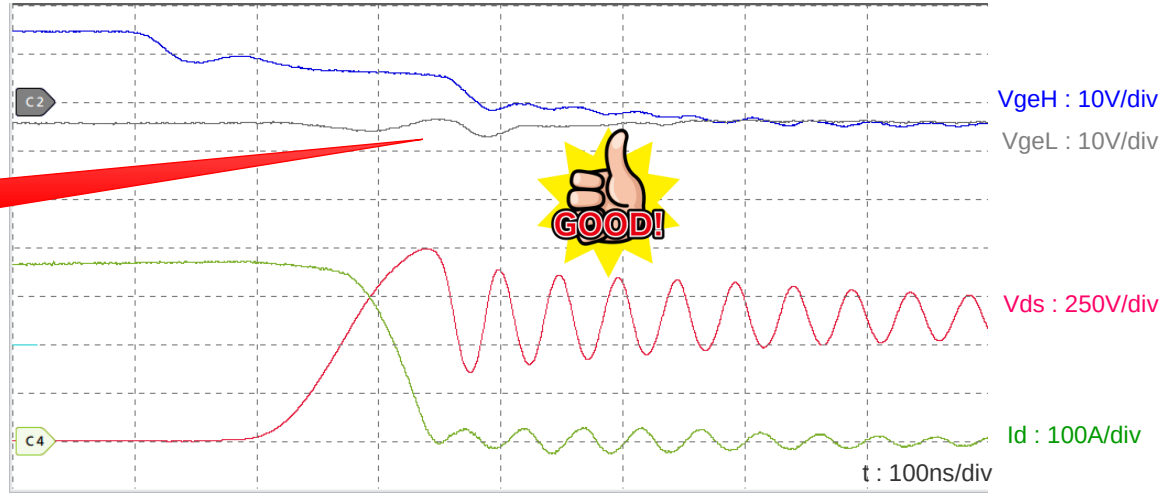
OFF side gate
Stable L state without malfunction

OFF side gate
Stable L state without malfunction

Turn ON / Ic =375A




Turn OFF / Ic =750A



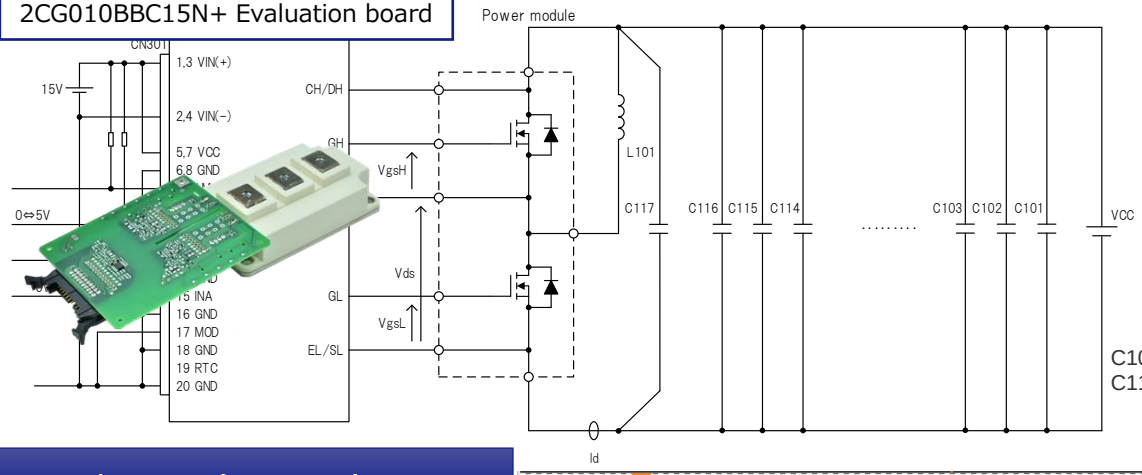
# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-5. Gate drive waveform of SiC power module (Short circuit test)

**SiC MOSFET : FF3MR12KM1**

DC Link : 600V, Ron : 4.3Ω, Roff : 3.6Ω, Lower arm, Tj=25℃

2CG010BBC15N+ Evaluation board




C101-116 : 560uF(Ls : 60nH)
C117 : 1uF(Ls : 20nH)

This driver suppresses the Vds peak voltage in the short circuit by our original circuit technology, and can control the mask time to prevent false short circuit detection. (Patent pending)

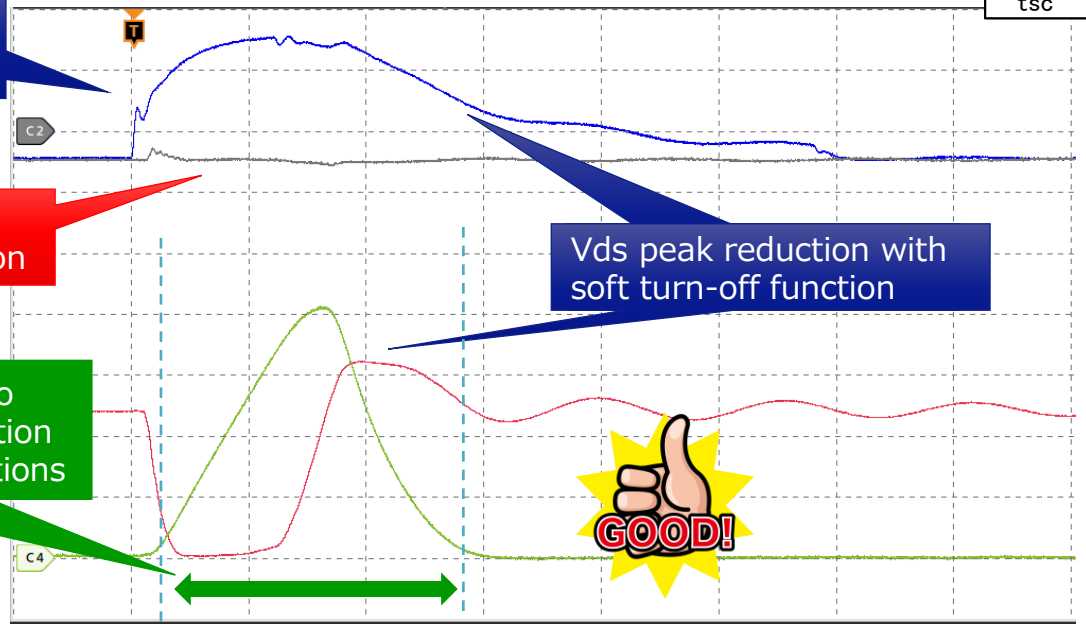
| Item | Measurement value | |
|---|---|---|
| Vdsp | 806 | V |
| Idp | 4124 | A |
| tsc | 2.28 | us |

SW side gate (turn ON)
No ringing and no overshoot

OFF side gate
Stable L state without malfunction

Vds peak reduction with soft turn-off function

Constant control of mask time to prevent false short circuit detection regardless of short circuit conditions




VgeL : 10V/div
VgeH : 10V/div
Vds : 250V/div
Id : 1kA/div
t : 1us/div

# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-6. Comparison and expansion

### Advantage of Tamura Gate driver modules (2CG-B / 2CG-D)

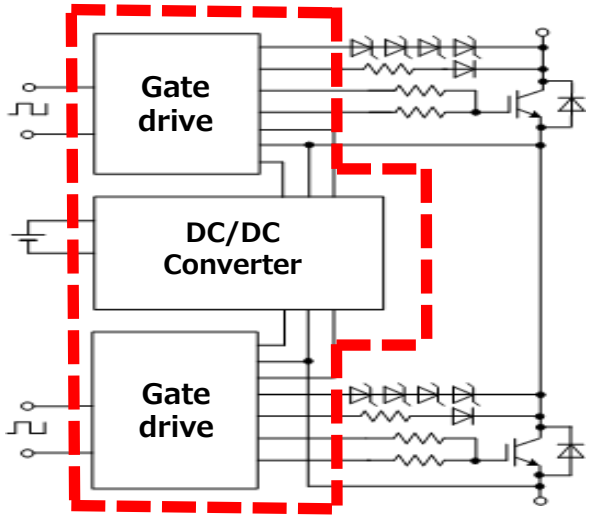
| Item | TAMURA | Company A (4W) | Advantages |
|---|---|---|---|
| Power module | **SiC-MOSFET** /IGBT | IGBT | O |
| Input Voltage | **13.5-26.4V** | 14.5-15.5V | O |
| Output Voltage | +15V/-10V **+15V/-15V** **+18V/-4V** **+18V/-2V** **+15V/-4V** | +15V/-10V | O |
| Peak output current | **±43A** | ±35A | O |
| Frequency | **150kHz (Max)** | 100kHz (Max) | O |
| Isolation capacitance | **12pF(TYP)** | 22pF | O |
| CMTI | **70kV/us** | 50kV/us | O |
| Protection | **Soft turn off** Active Clamp **Miller Clamp** | Active Clamp | O |

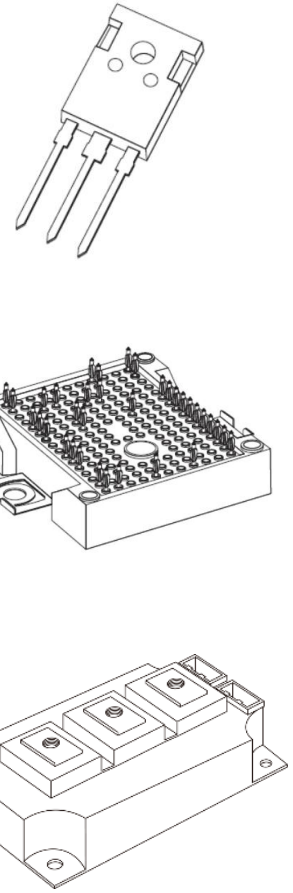
# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-6. Comparison and expansion

### Deployment example of Tamura Gate driver modules (2CG-B / 2CG-D)


Gate Driver Module

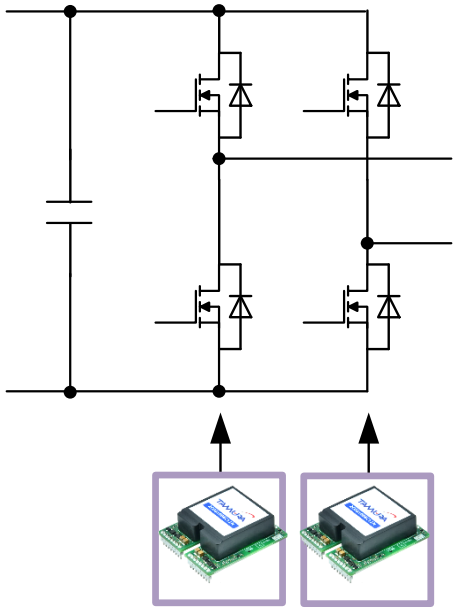


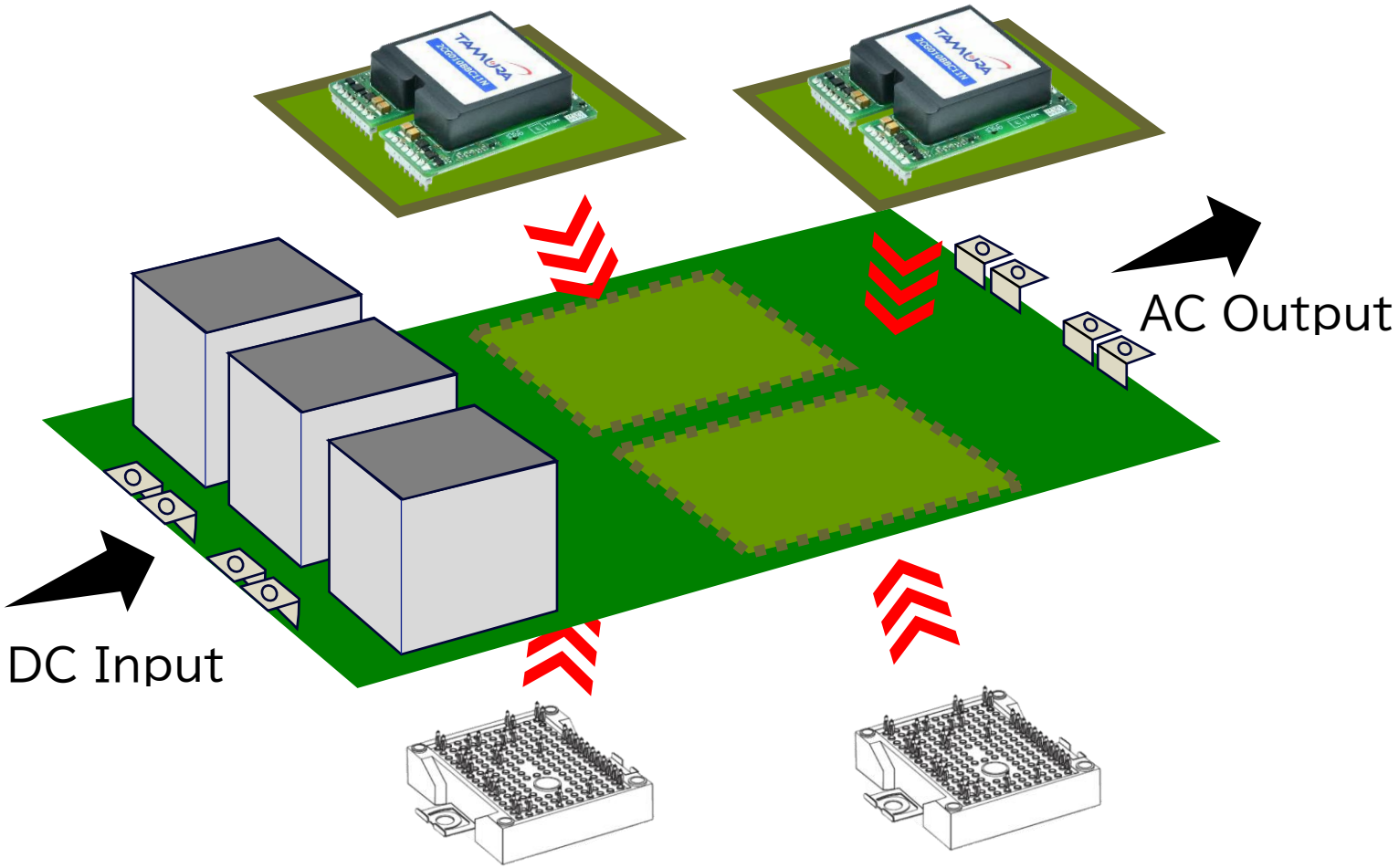
# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-6. Comparison and expansion

### Deployment example of Tamura Gate driver modules (2CG-B / 2CG-D)



EV Charger
(DC-AC section)



# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-7. Product Line-up

### Gate Driver Module 2CG-B / 2CB-D series

| | | MODEL | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2CG010BBC11N | 2CG010BBC12N | 2CG010BBC13N | 2CG010BBC14N | 2CG010BBC15N | 2CG010DBC11N |
| Output | Output voltage(+) | +15V | +15V | +18V | +18V | +15V | +15V |
| | Output voltage(-) | -10V | -15V | -4V | -2V | -4V | -10V |
| | Output power/1ch | 4.0W | 3.3W | 3.5W | 3.2W | 3.0W | 4.0W |
| | Number of output | 2 | | | | | |
| | Peak output current | ±43A | | | | | |
| Input | Input voltage | DC13~28V | | | | | |
| | Logic input voltage | DC3.3V, 5V | | | | | |
| Insulation | Withstand voltage | Primary to secondary AC5KV / Secondary to secondary AC4KV | | | | | |
| | Partial discharge extinction voltage | 2400V peak or more | | | | | |
| Function | Mode select | Direct mode / Half bridge mode | | | | | |
| | DESAT protection | Yes | | | | | |
| | Soft turn off | Yes | | | | | |
| | Active clamp | No | | | | | Yes |
| | Miller clamp | Yes | | | | | No |

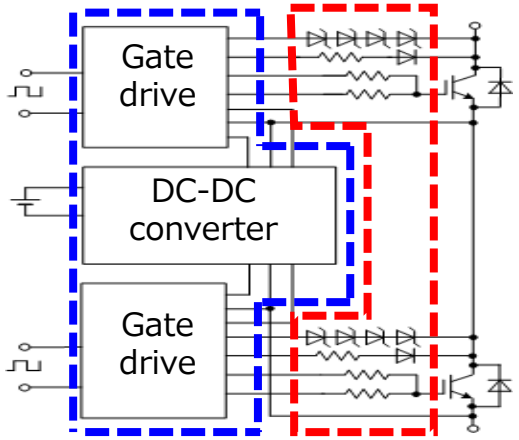
# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

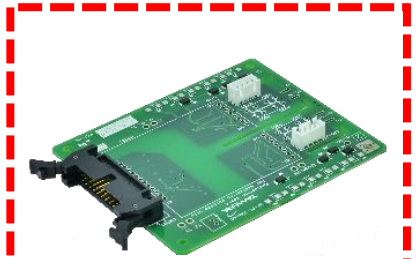
## 1-7. Product Line-up for EconoDUAL™ and 62mm type

| Package | $I_{DN}$ | Part No | TAMURA Driver | | | |
|---|---|---|---|---|---|---|
| | | | Evaluation board | 2CG-B | 2DD | |
|  | $V_{DS}$ = 1200V | | | | | |
| | 180 | FF6MR12KM1H |  | 2RB020BB | 2CG010BBC13N (+18/-4V)  | 2DD180407C (+18V/-4V)  |
| | | FF6MR12KM1HP | | | | |
| | 280 | FF3MR12KM1H | | | | |
| | | FF3MR12KM1HP | | | | |
| | 420 | FF2MR12KM1H | | | | |
| | | FF2MR12KM1HP | | | | |
| | 560 | FF1MR12KM1H | | | | |
| | | FF1MR12KM1HP | | | | |
| | $V_{DS}$ = 2000V | | | | | |
| | 200 | FF5MR20KM1H |  | 2RB020BB | 2CG010BBC13N (+18/-4V)  | 2DD180407C (+18V/-4V)  |
| | | FF5MR20KM1HP | | | | |
| | 300 | FF4MR20KM1H | | | | |
| | | FF4MR20KM1HP | | | | |
| | 400 | FF3MR20KM1H | | | | |
| | | FF3MR20KM1HP | | | | |

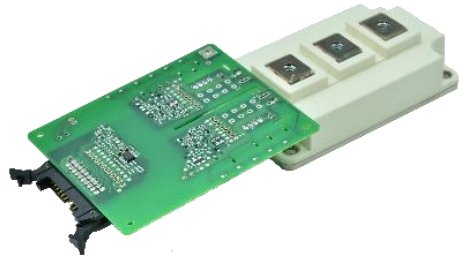
$I_{DN}$ :Implemented drain current


Gate Driver Module
(2CG-B series)



Evaluation board
(2RB series)



*Can be connected directly !*



EconoDUAL™ is registered trademark of Infineon Technologies AG, Germany.

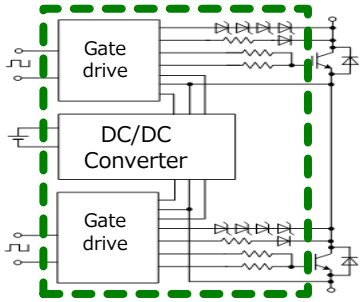
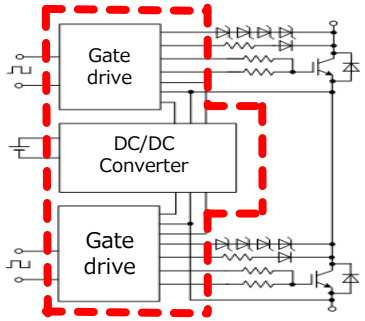
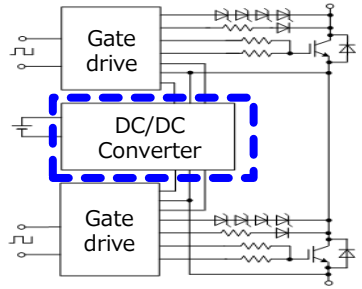
# Gate drivers that bring out the performance of Infineon Technologies AG SiC Power Modules

## 1-7. Product Line-up for EconoDUAL™ and 62mm type

| Package | $I_{DN}$ | Part No | Gate Driver Unit | Gate Driver Module | DC-DC |
|---|---|---|---|---|---|
| | | | 2EG-B  | 2CG-B  | 2DD  |
|  | $V_{DS}$ = 1200V | | | | |
| | 500 | FF1MR12MM1H_B11* | 2EG01XBxN13N | 2CG010BBC13N | 2DD180407C |

*The gate driver is not press-fit compatible, so please solder it.

x: Signal input voltage selectable “ C ” => 3.3~15V “ D ” => 15V

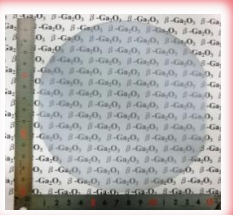
| | Gate Driver Unit | Gate Driver Module | DC/DC Converter |
|---|---|---|---|
| Product | Gate Driver Unit | Gate Driver Module | DC/DC Converter |
| Function | Gate Driver Module + Gate resistors Protective function | DC/DC Converter + Gate drive | 2in1 PM designated DC/DC Converter |
| Block diagram |   |   |   |

# Index

# Introduction of One Tamura (General application)

## Device technology

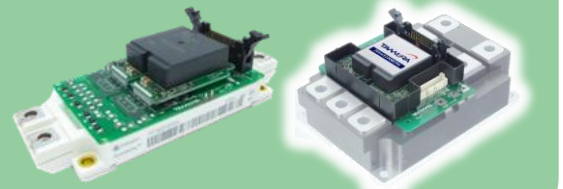
$Ga_2O_3$



Novel Crystal Technology, Inc.

## Gate driver

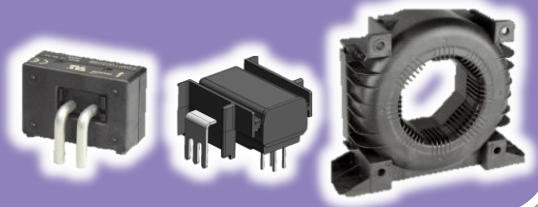
### Circuit technology



Gate Driver Unit

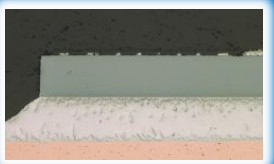
## Module technology

### Current sensor



# Power electronics technology and main products

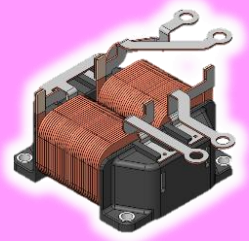
## Soldering technology



Electric Chemicals
Soldering material
Die attach material
TIM material

## Reflow soldering system

## Automotive reactor



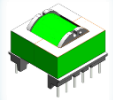
Reactor for PF
（2 in 1）

## Passive components

Reactor Trans Coil

Large reactor/
transformer

Toroidal coil



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Tamura's mascot "Quenu"