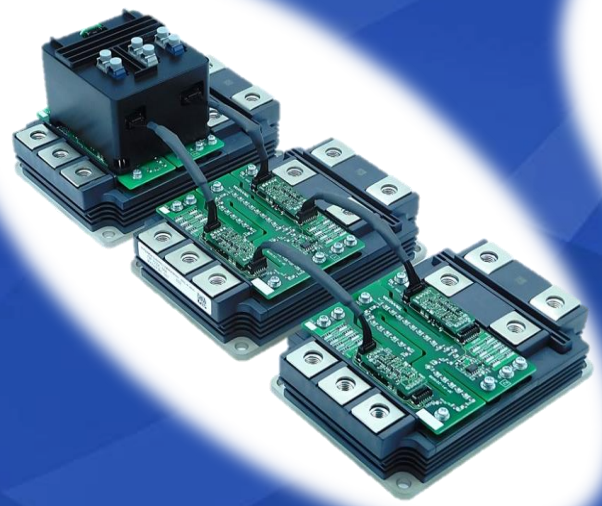
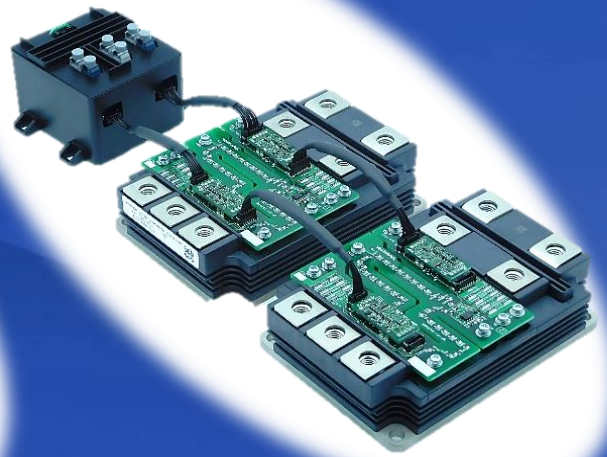
Gate Driver optimized for Mitsubishi Electric 3300V

Full SiC power module FMF750DC-66A /FMF800DC-66BEW





SUSTAINABLE DEVELOPMENT GOALS

TAMURA
Your One and Only Company

TAM-GDM-00030

Issued on 1st Jun '24 Unit division HQ Japan

Rev F

Index

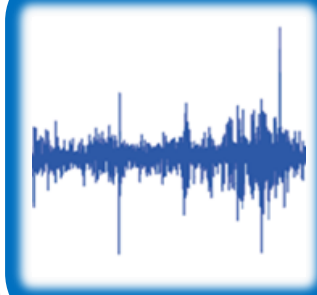
Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

01 Why, we started development gate drivers

Circuit design Technology

Transformer Technology

Potting Technology



EMI/EMC Solution

Market Awareness

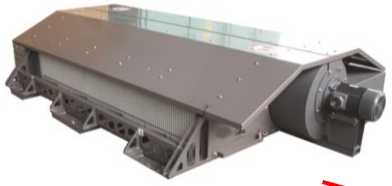
Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

01 When, we started development gate drivers

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

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

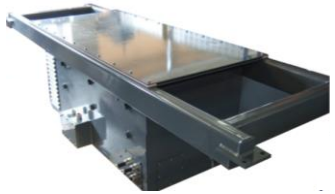
02 Tamura Total solution for Traction Market

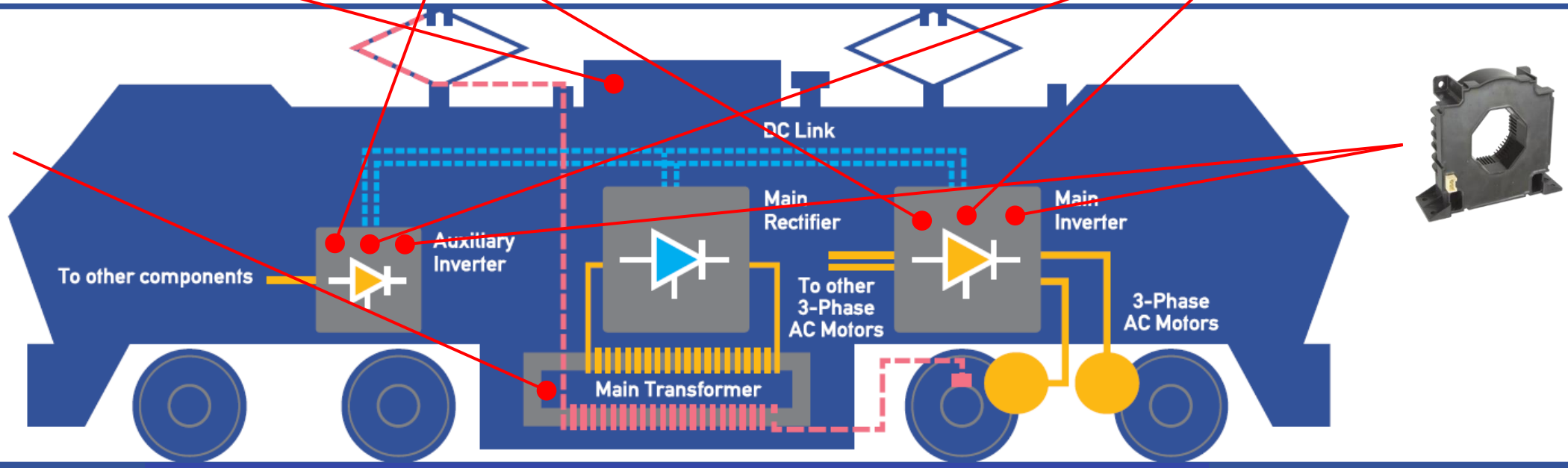


Roof mounted

Collaboration of
Power semiconductors manufacturers

Underframe mounted

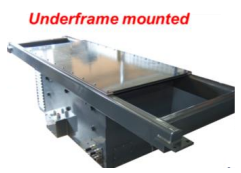




Provide of main components for Traction converter !

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

02 Tamura Total solution for Traction Market

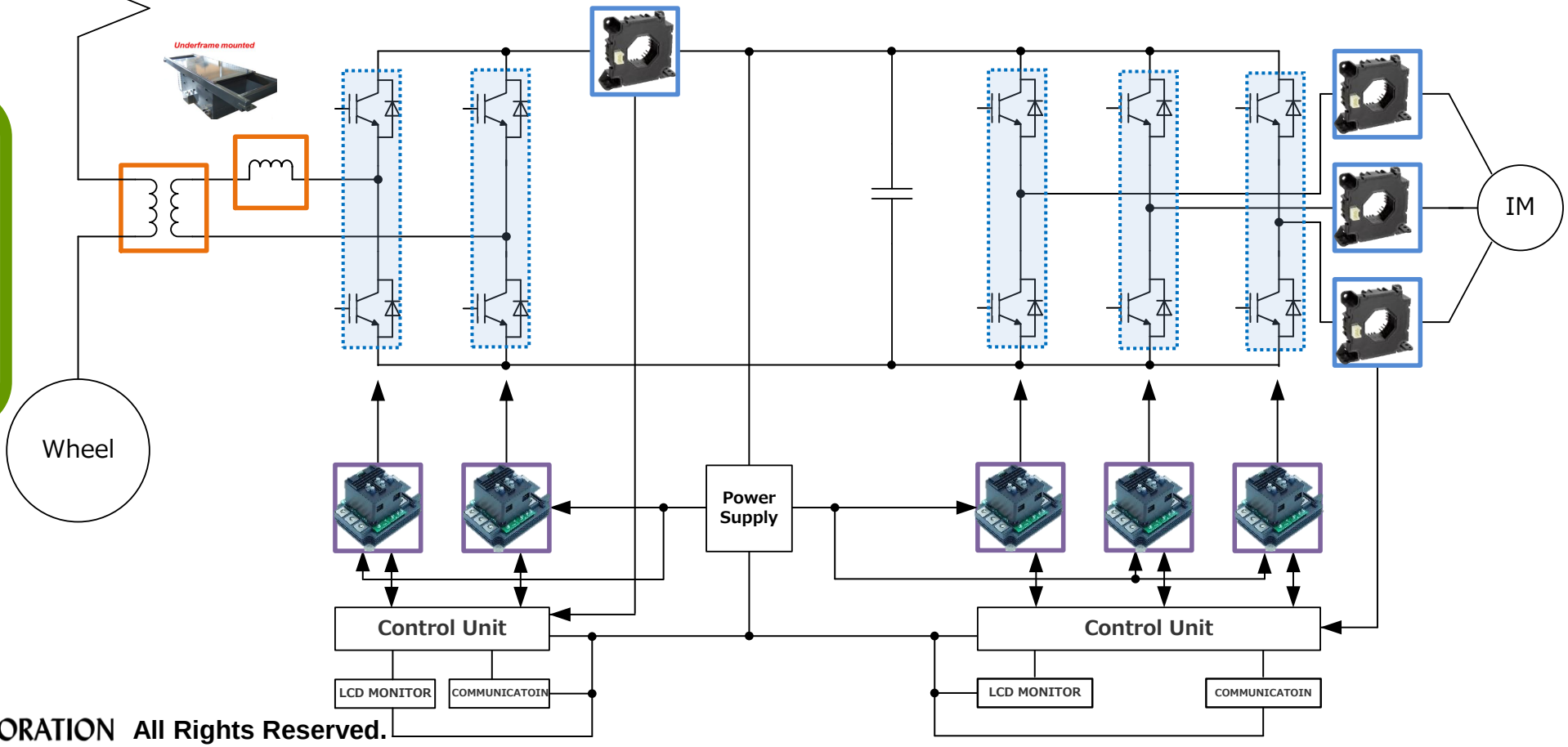


Reactor

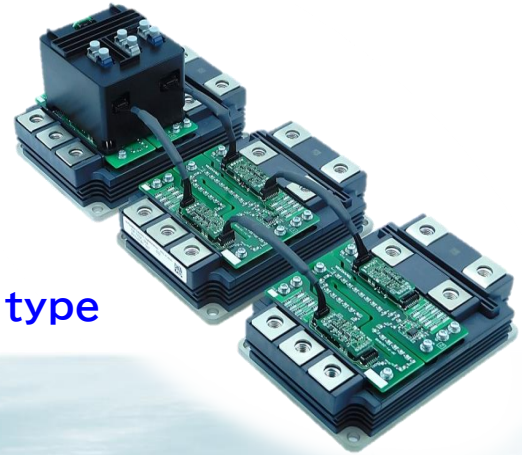
Gate Driver

Current sensor

Traction inverter

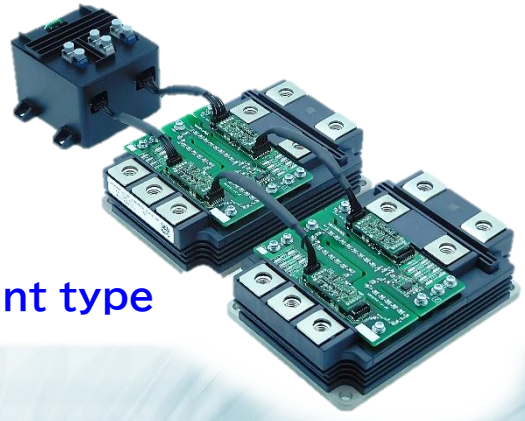


Suitable for Traction Converter

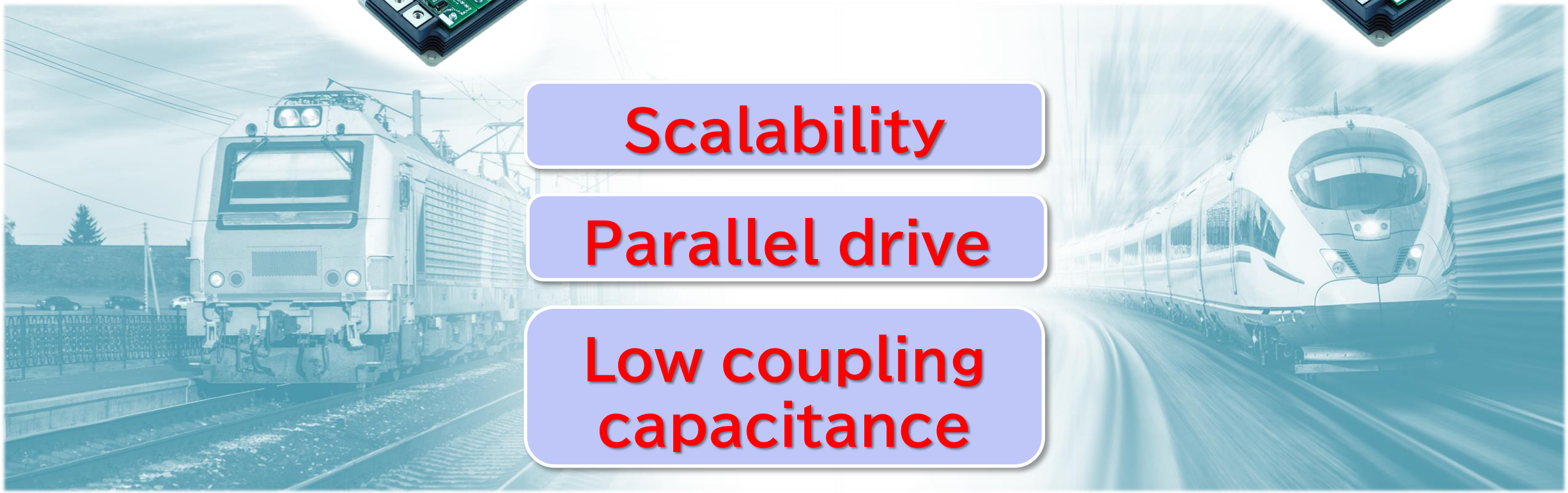


Top mounting type

Check here !



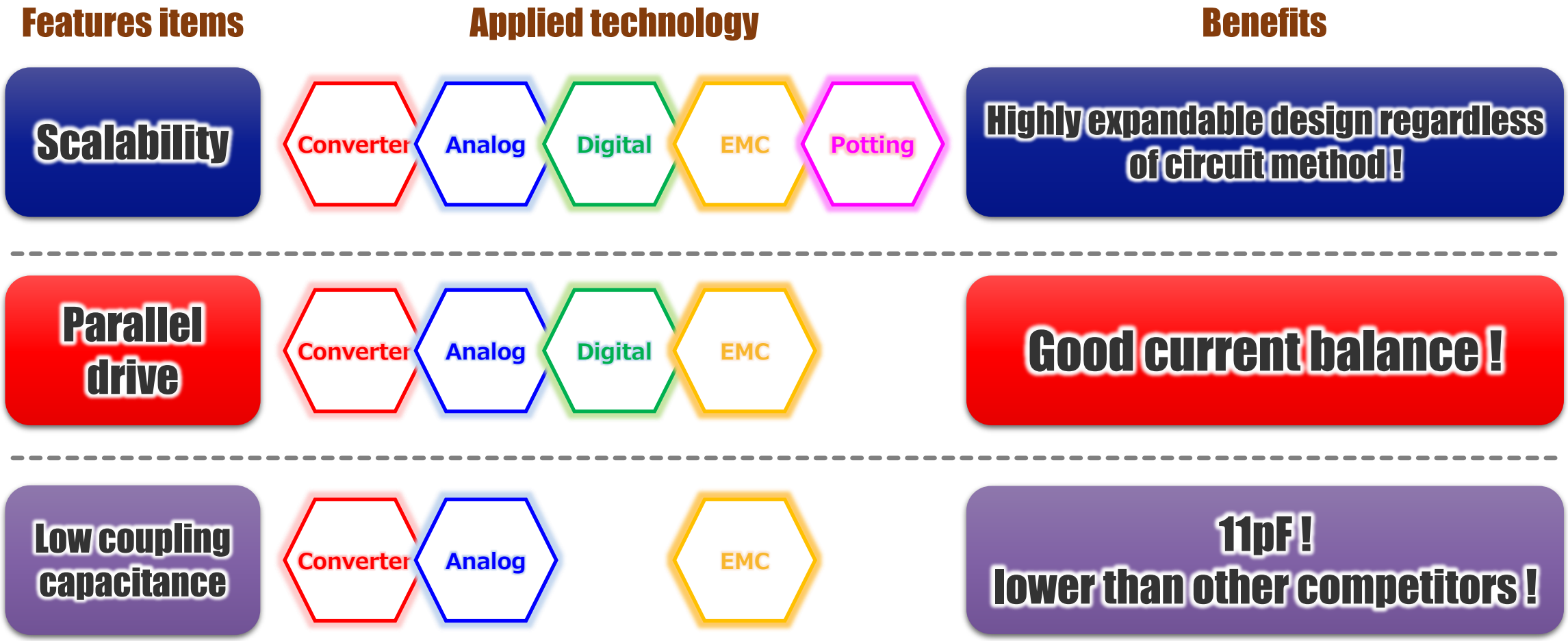
Side placement type



- Scalability
- Parallel drive
- Low coupling capacitance

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

03 Three features of Tamura Gate Driver



Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

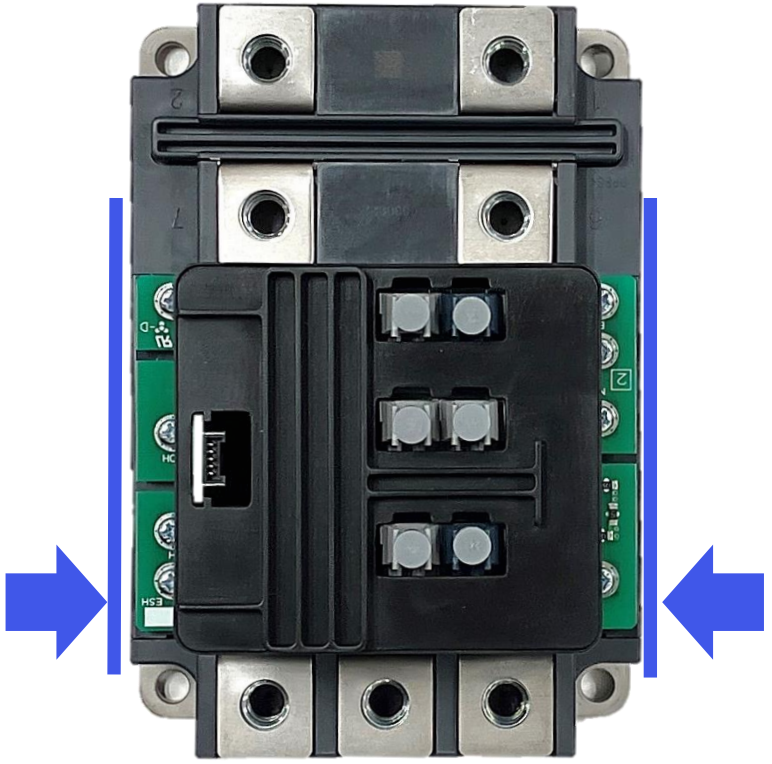
03 Three features of Tamura Gate Driver

Scalability

Compact size!
Less than 50% *
322cc

* Compared to other companies

Can be mounted on Power module!



Same width as power module

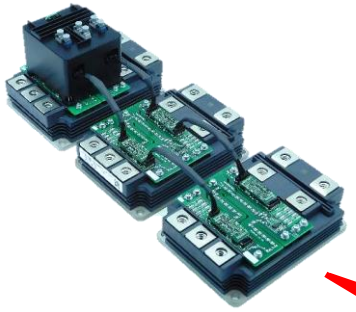
Contribute to compact design of system thanks to “no protrusion”

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

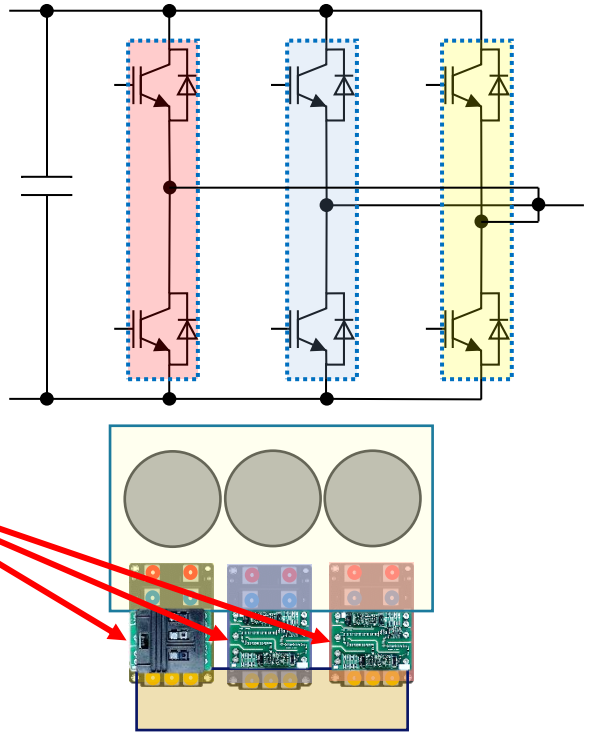
03 Three features of Tamura Gate Driver

Scalability

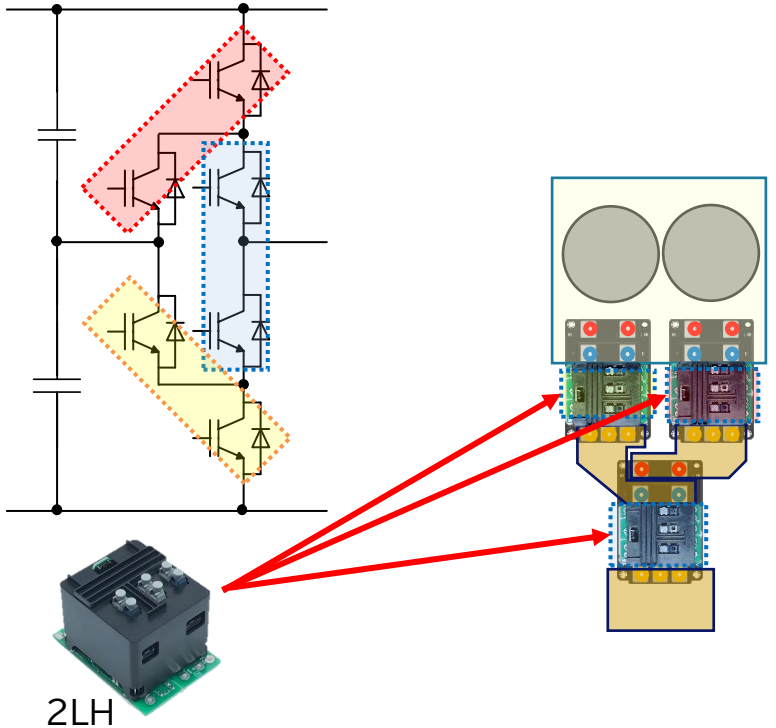
FMF750DC-66A
With 2-level / 3pcs paralleling



2LH + Follower



FMF750DC-66A
With 3-level ANPC (I-Type)



2LH

Highly expandable design regardless of circuit method

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

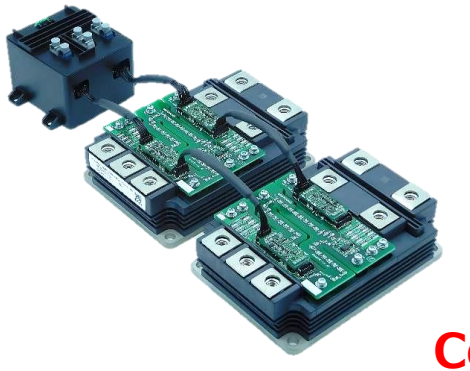
03 Three features of Tamura Gate Driver

Scalability

Compact size!
Less than 50% *

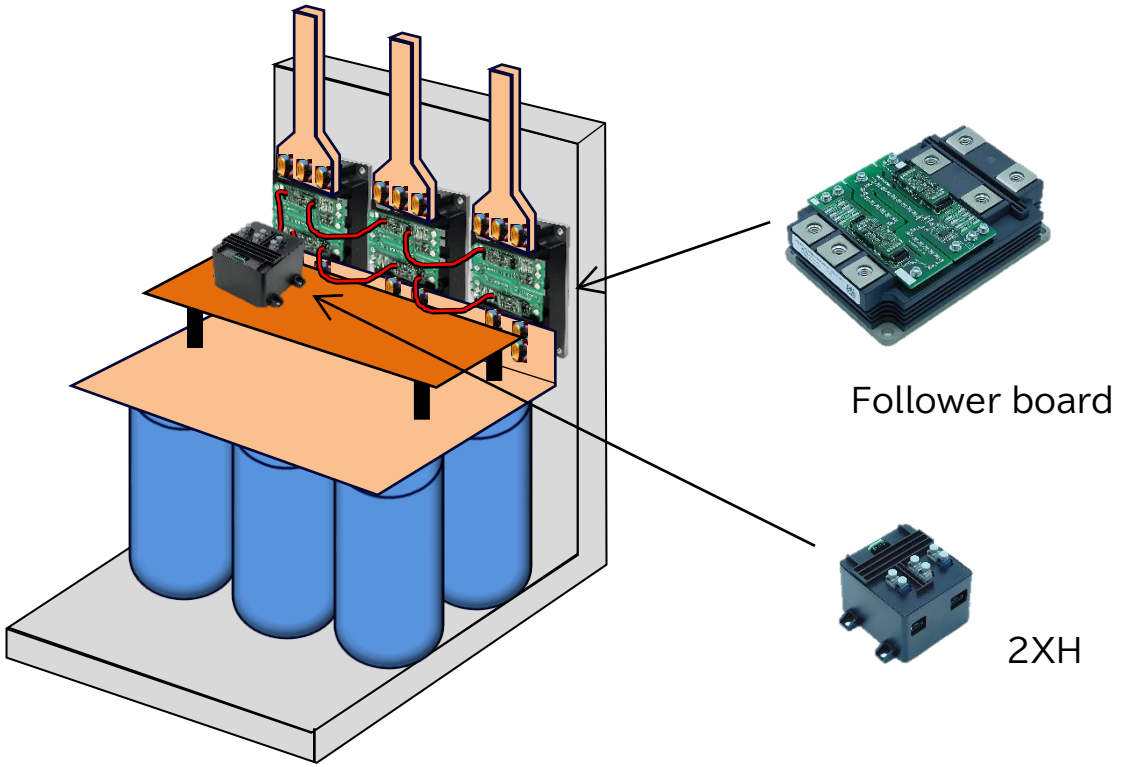
322cc

＊Compared to other companies



Overhead space available !

Example) Power electronic building block (PEBB)

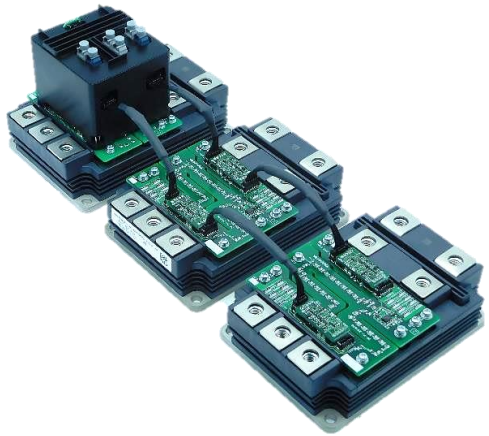


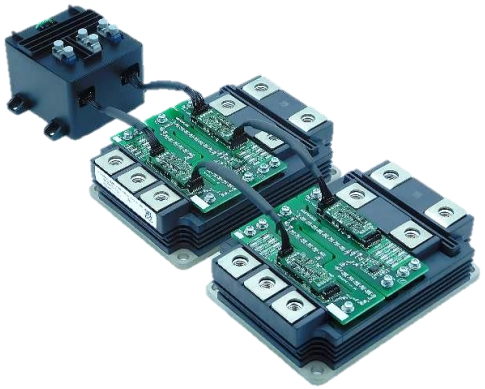
Contribute to compact design of system thanks to “no protrusion”

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

03 Three features of Tamura Gate Driver

Parallel drive





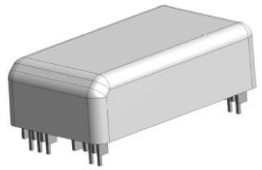
Coming soon !

Event	2024	2025
ES2 for FMF800DC-66BEW	Design review Evaluation (Short circuit)	Evaluation (3parallel, ~Oct/'24) ★ MP Start

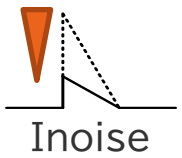
03 Three features of Tamura Gate Driver

Low coupling capacitance

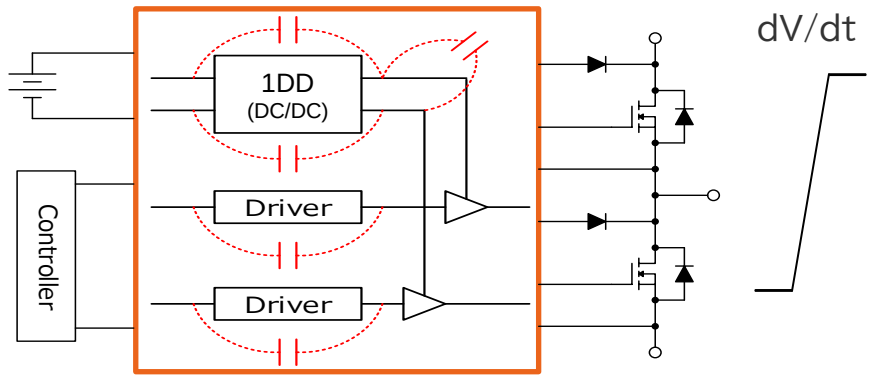
No malfunctions even during high-speed switching.
⇒ Reduction of parasitic capacitance !



No malfunction at high dV/dt

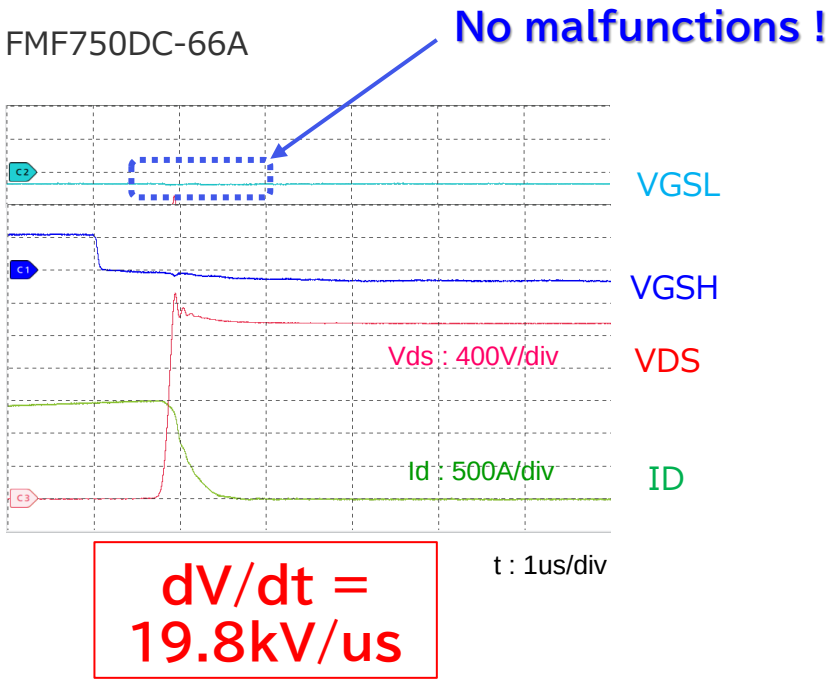


Conceptual diagram



Inoise = Cstray X dV/dt

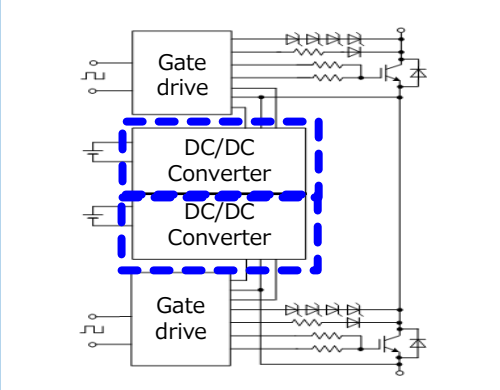
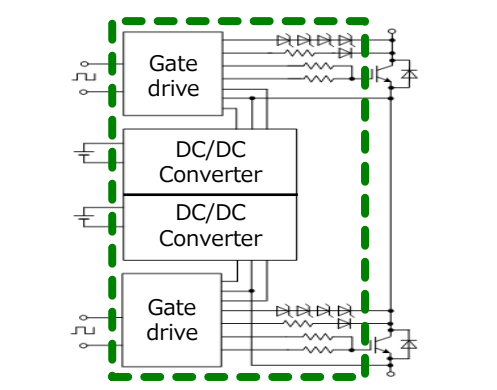
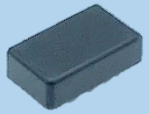
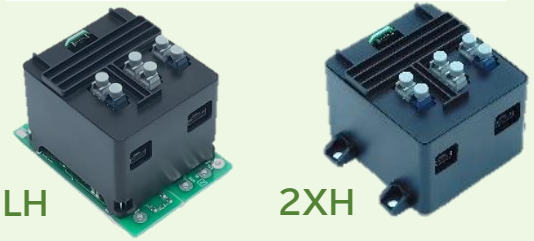
FMF750DC-66A



dV/dt = 19.8kV/us

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

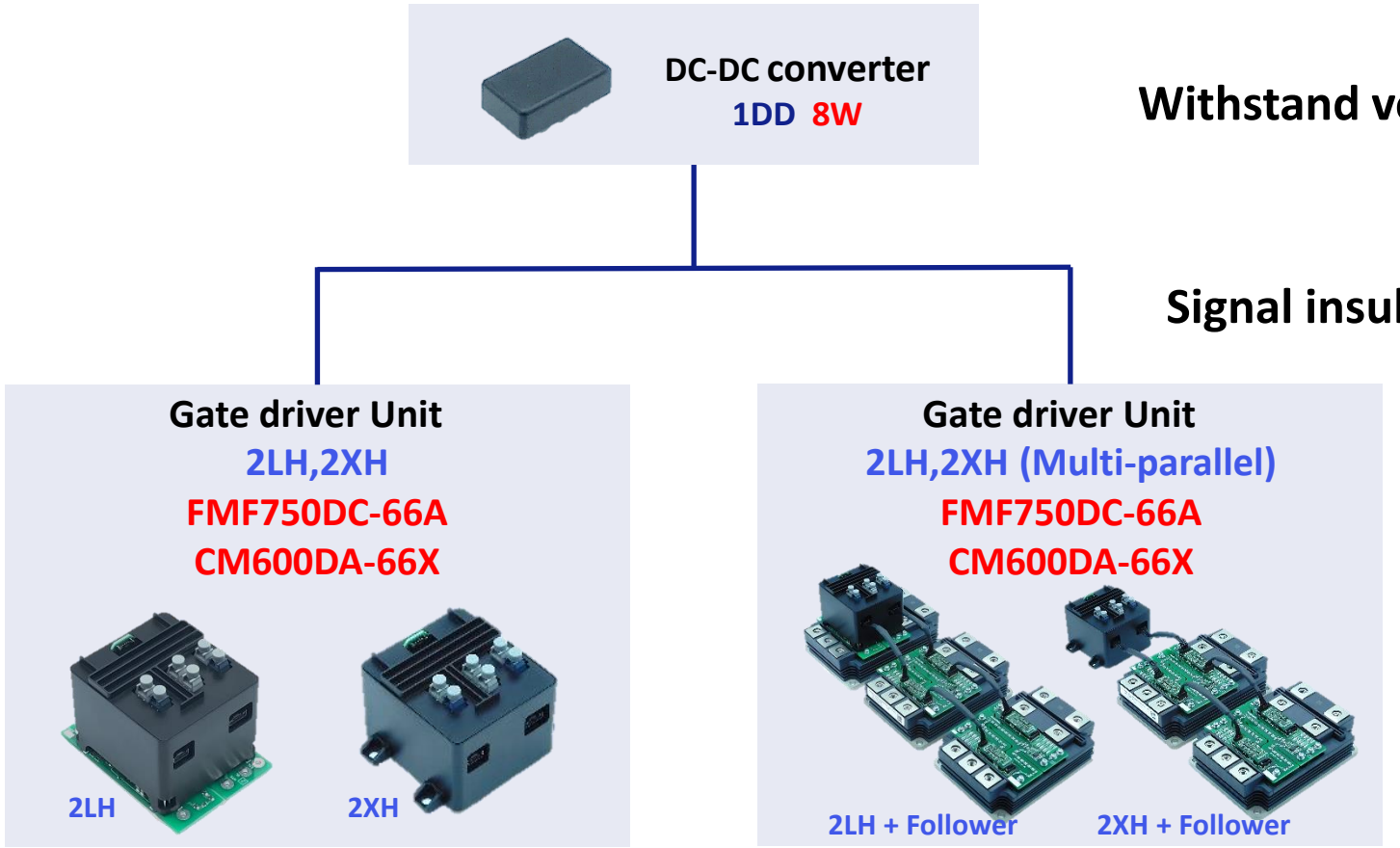
04 Introduction of Tamura Gate driver 2LH / 2XH series

Product	**DC/DC Converter**	**Gate Driver Unit**
Function	**PM designated DC/DC Converter**	**DC/DC Converter** + **Gate drive Circuit** + **Gate resistors Protective function**
Block diagram		
Appearance	 1DD	 2LH 2XH

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

04 Introduction of Tamura Gate driver 2LH / 2XH series

Products tree



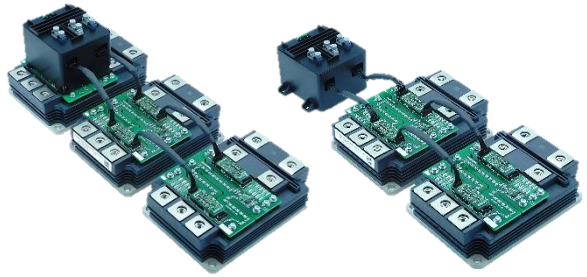
Withstand voltage : **10.8kV**

Signal insulation : **Optical**

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

04 Introduction of Tamura Gate driver 2LH / 2XH series

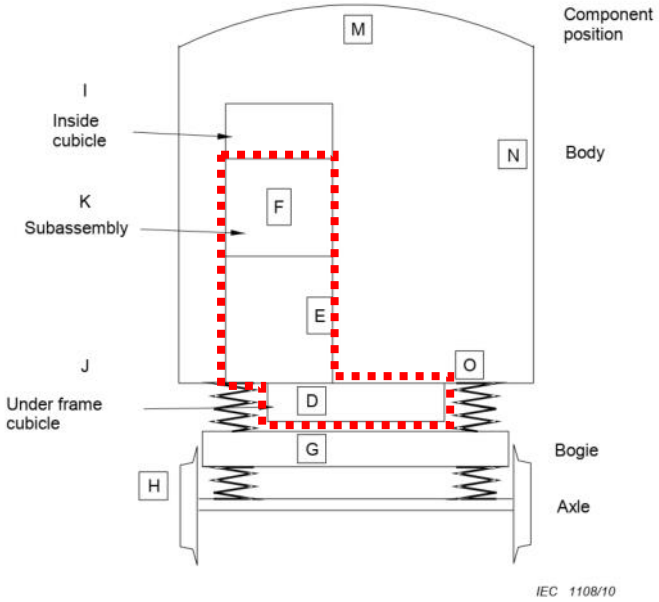
Specification



Item	Specification	Actual
Isolation voltage (Pri-Sec)	10.8kV	>18kV
Isolation voltage (Sec-Sec)	6.7kV	Checking limit value
Partial discharge extinction voltage	4.95kVpeak(min)	Checking limit value
Clearance/Creepage(Pri-Sec)	23.8mm/50.4mm	←
Clearance/Creepage(Pri-Sec)	8mm/22mm	←
Coupling capacitance	11pF	←
Signal interface	Fiber-optic	←
Size	70.2X76.3X60.2=322cc	←

04 Introduction of Tamura Gate driver 2LH / 2XH series

Specification (Vibration tests)

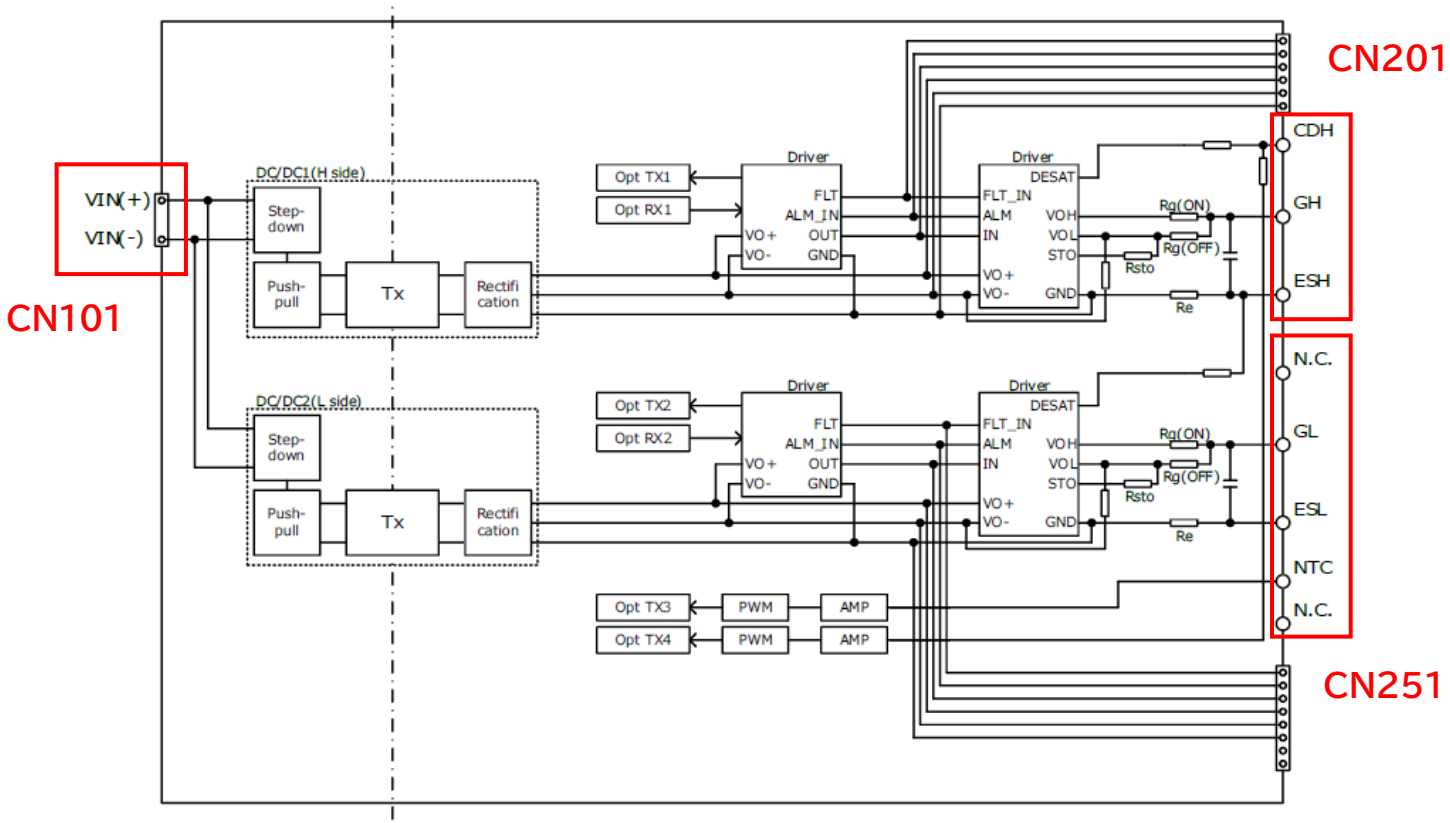


Category	Location	Description of equipment location
1 Class A	M N O I and J	Components which are mounted directly on to or under the car body
1 Class B	D	Components mounted into an underframe cubicle which is in turn fixed to the car body
1 Class B	K and E	Components mounted into a large internal cubicle which is in turn fixed to the car body
1 Class B	F	Components mounted into subassemblies which are in turn mounted into a cubicle which is in turn fixed to the car body
2	G	Cubicles, subassemblies, equipment and components which are mounted on the bogie of a railway vehicle
3	H	Subassemblies, equipment and components or assemblies which are mounted on to the axle assembly of a railway vehicle

Category	Location	Vibration waveform	Amplitude frequency	Maximum acceleration (Reference)	Test time	Standard
1-ClassB	D,K,E,F	Random	12.6mm 2~150Hz	16.89m/s^2	XYZ Each 5h	IEC61373

04 Introduction of Tamura Gate driver 2LH / 2XH series

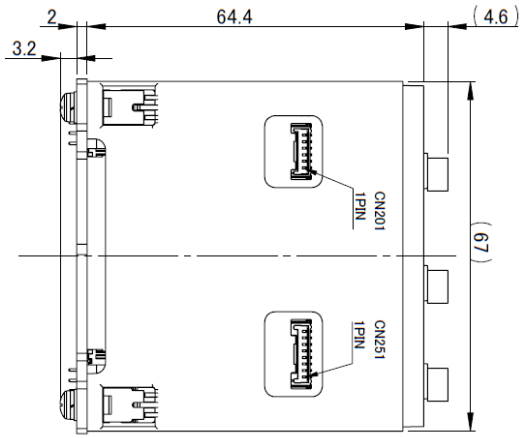
Block diagram

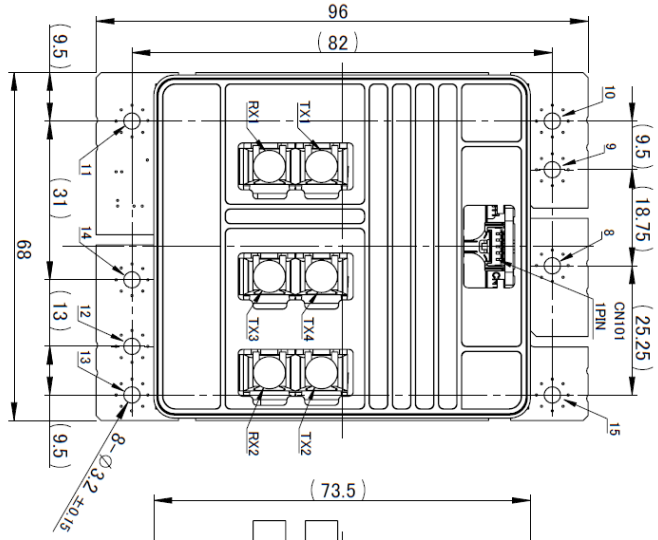


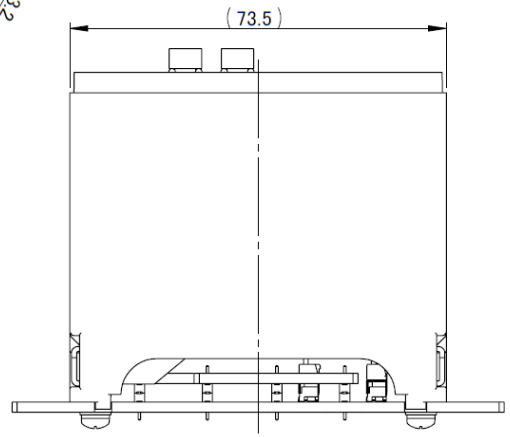
Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

04 Introduction of Tamura Gate driver 2LH / 2XH series

Out line & Pin function





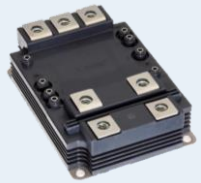
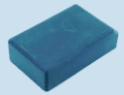
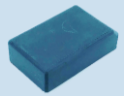


Pin No.	Channel	Function
CN101	Common	DC/DC input
RX1	Upper arm	Input signal (Receiver)
TX1	Upper arm	Alarm signal (Transmitter)
RX2	Lower arm	Input signal (Receiver)
TX2	Lower arm	Alarm signal (Transmitter)
TX3	Lower arm	PWM output of measured NTC temperature (Transmitter)
TX4	Lower arm	PWM output of measured DC link voltage (Transmitter)
CN201	Upper arm	For parallel connection
CN251	Lower arm	For parallel connection

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Products line-up

Underdevelopment

Package	I_C /I_D	Part No	Gate Driver Unit				DC-DC converter	
			2LH / 2XH				1DD	
	Vce = 1700V							
	1200	CM1200DA-34X	 2LH	 2XH	 Follower	+15/-10V type		+15/-10V type
	Vds or Vce = 3300V							
	375	FMF375DC-66A	 2LH	 2XH	 Follower	+17V/-5V type		+17V/-5V type
	750	FMF750DC-66A						
		FMF750DC-66A-1						
	800	FMF800DC-66BEW				+17V/-7V type		+17V/-7V type
	600	CM600DA-66X				+15/-10V type		+15/-10V type

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Matching data (2-pulse / Short circuit)

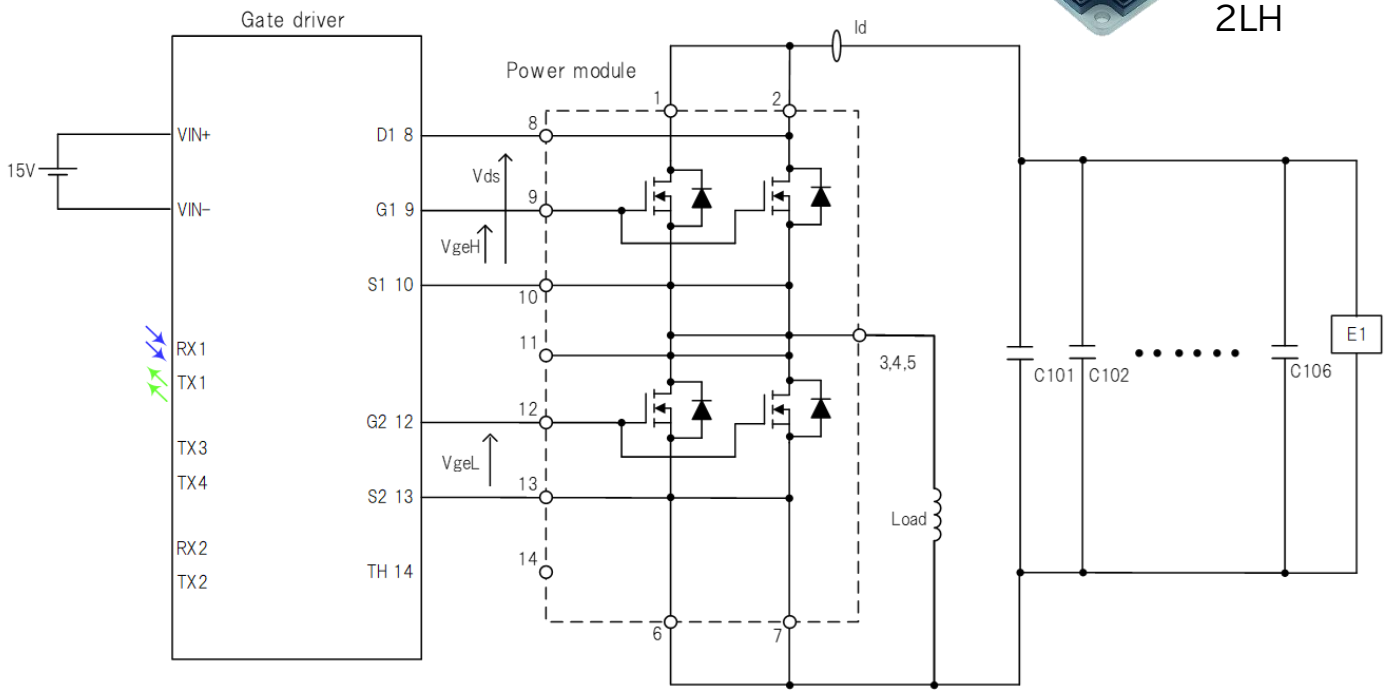
(Data is from Mitsubishi Electric FMF750DC-66A)

2LH

Test condition

Item	Description
Device	FMF750DC-66A
Gate driver	2LH series (TBD)
Gate voltage	+17V/-5V
Gate resistor	Ron:2.0Ω, Roff:0.9Ω
DC-link voltage (VCC)	1800V, 2200V
Main circuit current	750A, 1500A
Switching condition	Period:100us on duty:20-30%
Load inductance	55uH
Junction temperature	150℃

Test Circuit for Upper arm



C101-106 : 490uF
Ls :About 40nH

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Matching data (2-pulse / Short circuit)

(Data is from Mitsubishi Electric FMF750DC-66A)

2 pulse test of upper arm

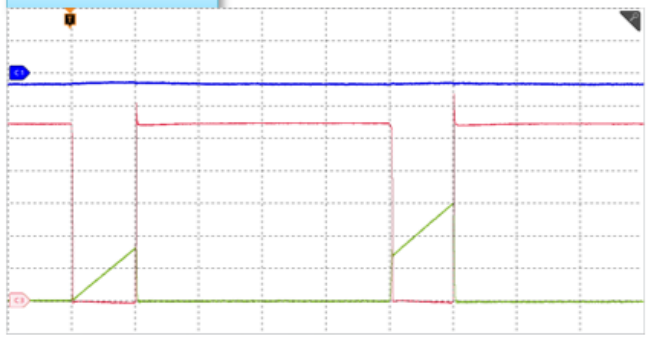
VCC=2200V, Ron:2.0Ω, Roff:0.9Ω, Tj=150℃

VgsL:15V/div, VgsH:15V/div, Vds:400V/div, Id:500A/div, t:20us/div

【2 pulse test】

Vds,Id,VgsH

Vds,Id,VgsL



SOA

2LH

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Matching data (2-pulse / Short circuit)

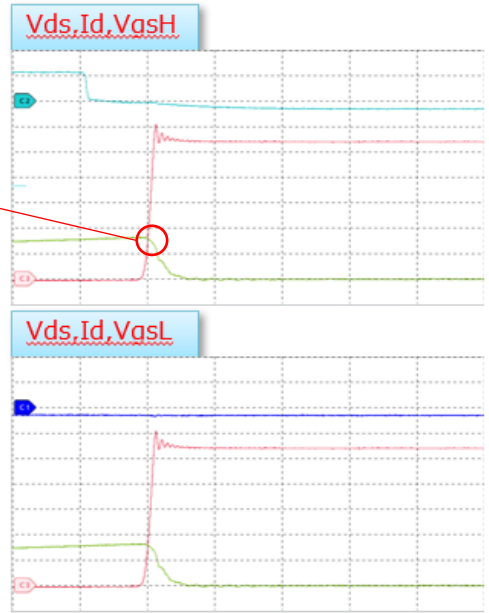
(Data is from Mitsubishi Electric FMF750DC-66A)

2 pulse test of upper arm (expansion)

VCC=2200V, Ron:2.0Ω, Roff:0.9Ω, Tj=150℃

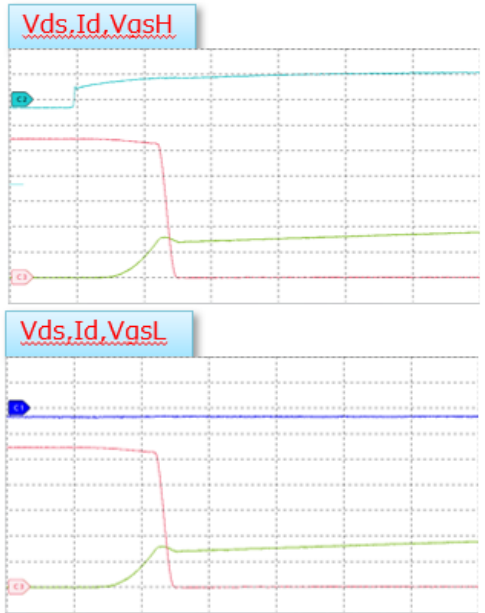
VgsL:15V/div, VgsH:15V/div, Vds:400V/div, Id:500A/div, t:1us/div

Turn OFF / Id =750A



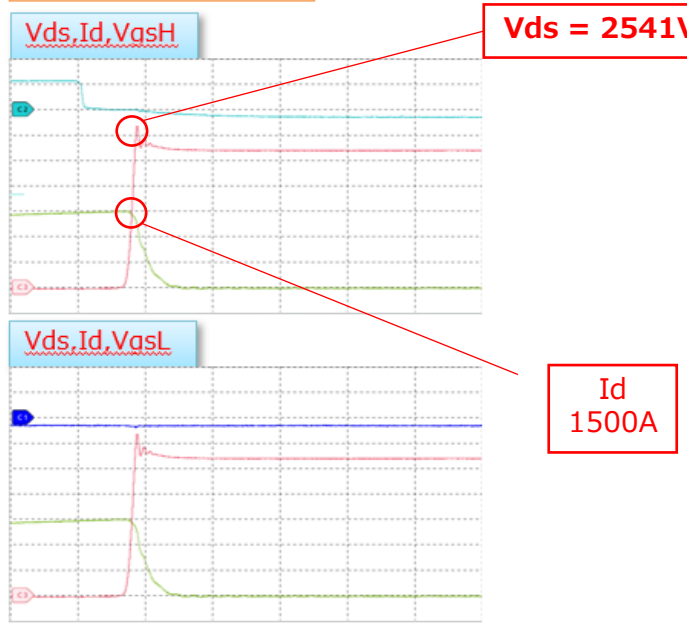
Item	Measurement Value	unit
Vdsp	2428	V
dV/dt	17.3	kV/us
dI/dt	4.7	kA/us
Eoff	358	mJ

Turn ON / Id =750A



Item	Measurement Value	unit
dV/dt	11.1	kV/us
dI/dt	1.8	kA/us
Eon	629	mJ

Turn OFF / Id =1500A



Item	Measurement Value	unit
Vdsp	2541	V
dV/dt	19.8	kV/us
dI/dt	5.4	kA/us
Eoff	795	mJ

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Matching data (2-pulse / Short circuit)

(Data is from Mitsubishi Electric FMF750DC-66A)

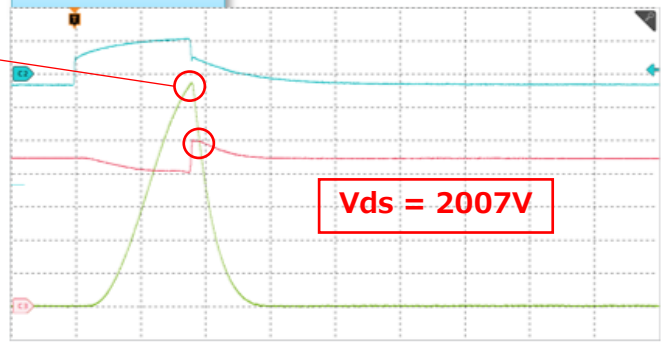
Short circuit test of upper arm

VCC=1800V, Ron:2.0Ω, Roff:0.9Ω, Tj=150℃

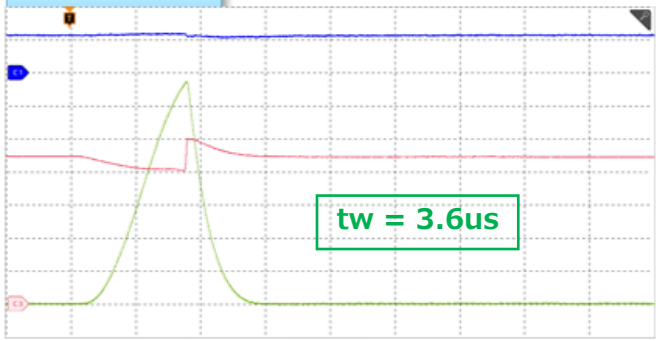
VgsL:15V/div, VgsH:15V/div, Vds:400V/div, Id:1kA/div, t:2us/div

Id
6743A

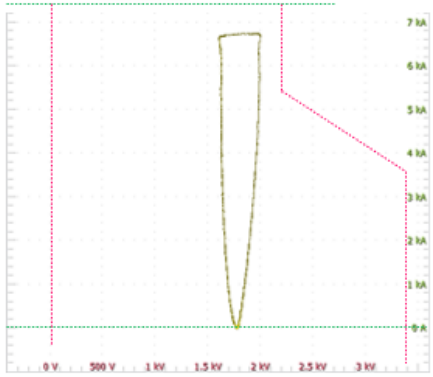
Vds,Id,VgsH



Vds,Id,VgsL



SOA



Item	Measurement Value	unit
Vdsp	2007	V
Idp	6743	A
tsc	3.6	us

※tsc : 10% to 90% of Vgs

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Matching data (2-pulse / Short circuit)

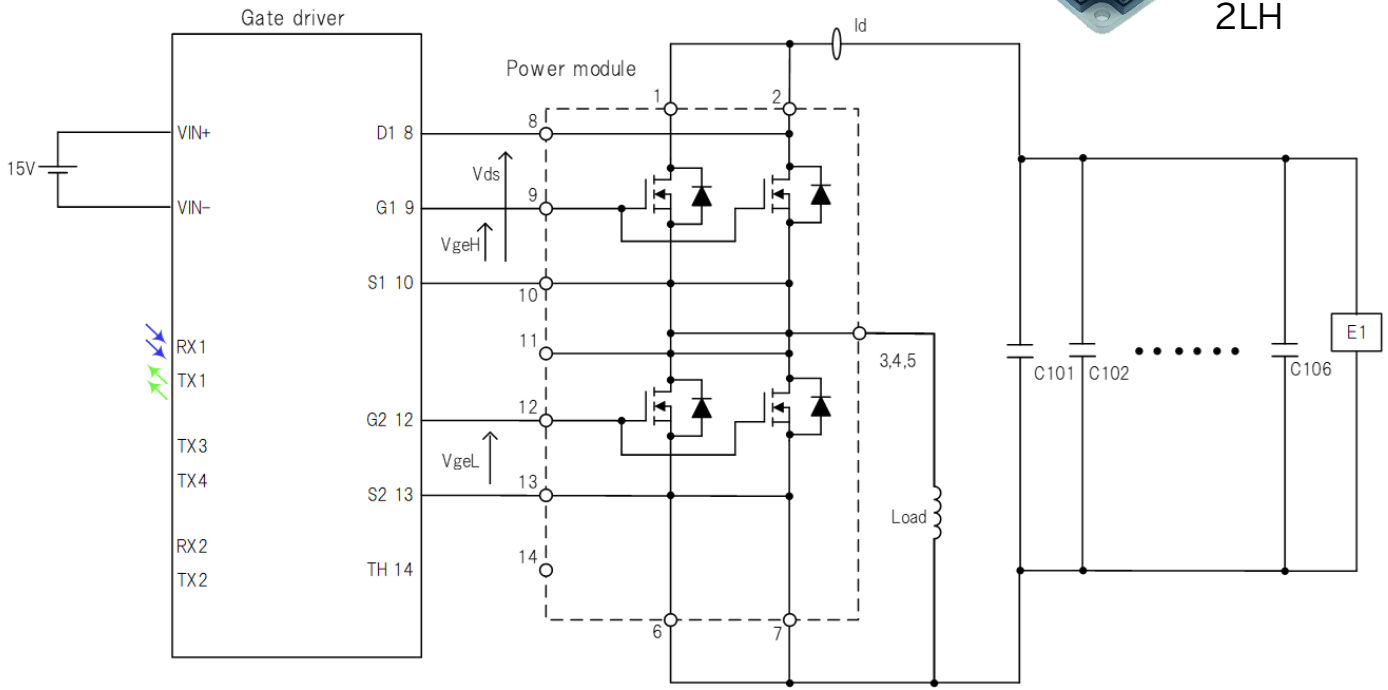
(Data is from Mitsubishi Electric FMF800DC-66BEW)

2LH

Test condition

Item	Description
Device	FMF800DC-66BEW
Gate driver	2LH series (TBD)
Gate voltage	+17V/-7V
Gate resistor	Ron:1.5Ω, Roff:1.5Ω
DC-link voltage (VCC)	2200V
Main circuit current	800A, 1600A
Switching condition	Period:100us on duty:20-30%
Load inductance	55uH
Junction temperature	150℃

Test Circuit for Upper arm



C101-106 : 490uF
Ls :About 40nH

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Matching data (2-pulse / Short circuit)

(Data is from Mitsubishi Electric FMF800DC-66BEW)

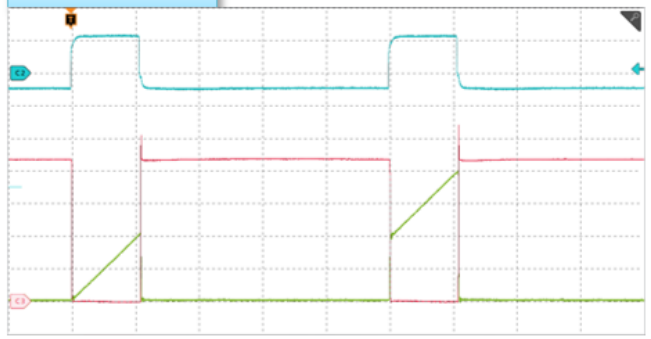
2 pulse test of upper arm

VCC=2200V, Ron:1.5Ω, Roff:1.5Ω, Tj=150℃

VgsL:15V/div, VgsH:15V/div, Vds:500V/div, Id:400A/div, t:20us/div

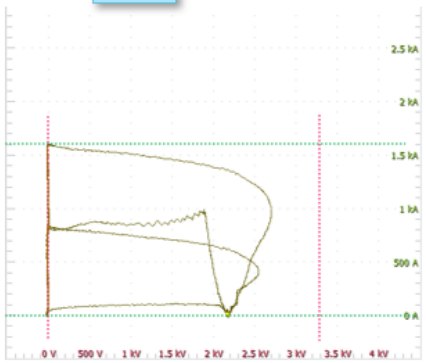
【2 pulse test】

Vds,Id,VgsH



Vds,Id,VgsL

SOA



2LH

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Matching data (2-pulse / Short circuit)

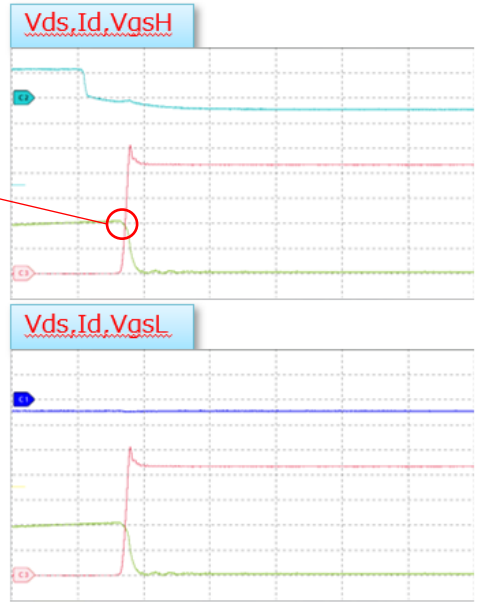
(Data is from Mitsubishi Electric FMF800DC-66BEW)

2 pulse test of upper arm (expansion)

VCC=2200V, Ron:1.5Ω, Roff:1.5Ω, Tj=150℃

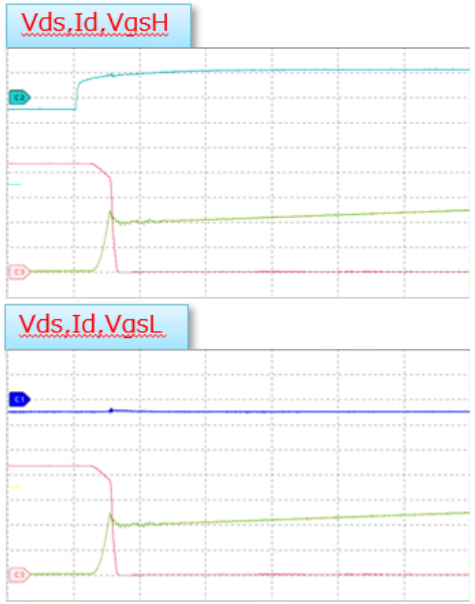
VgsL:15V/div, VgsH:15V/div, Vds:500V/div, Id:400A/div, t:1us/div

Turn OFF / Id =800A



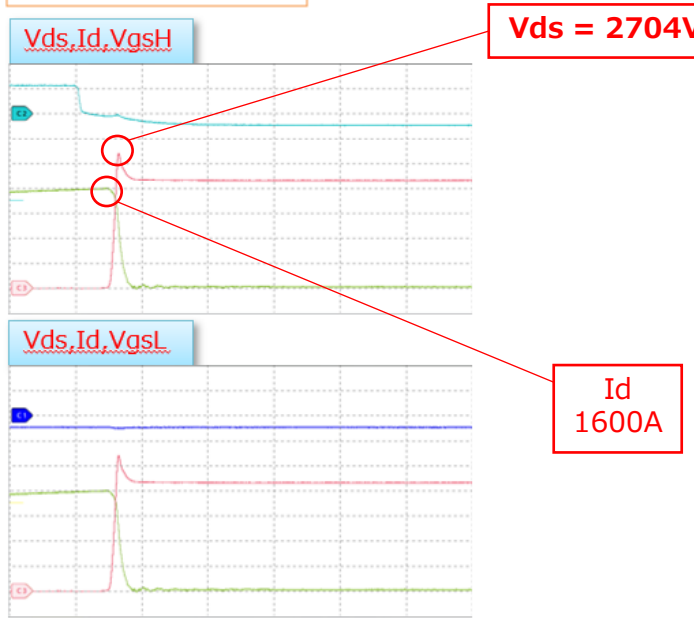
Item	Measurement Value	unit
Vdsp	2545	V
dV/dt	23.5	kV/us
dI/dt	7.6	kA/us
Eoff	153	mJ

Turn ON / Id =800A



Item	Measurement Value	unit
dV/dt	27.1	kV/us
dI/dt	5.8	kA/us
Eon	259	mJ

Turn OFF / Id =1600A



Item	Measurement Value	unit
Vdsp	2704	V
dV/dt	25.6	kV/us
dI/dt	12.5	kA/us
Eoff	380	mJ

Gate Driver optimized for Mitsubishi Electric 3300V Full SiC power module

06 Matching data (2-pulse / Short circuit)

(Data is from Mitsubishi Electric FMF800DC-66BEW)

2LH

Short circuit test of upper arm

Currently being measured.
Please wait until the end of Oct.

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Tamura's mascot "Quenu"


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