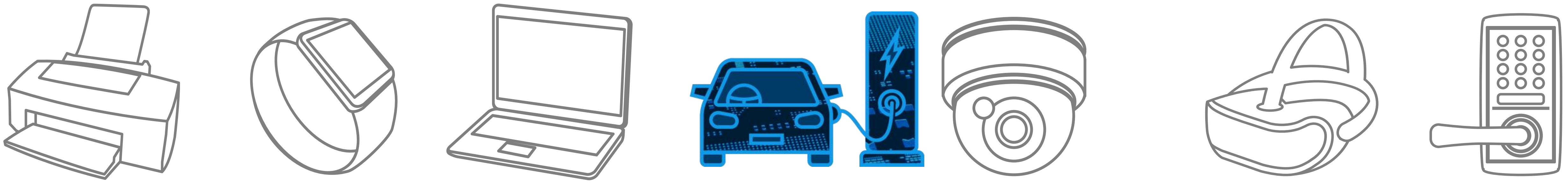
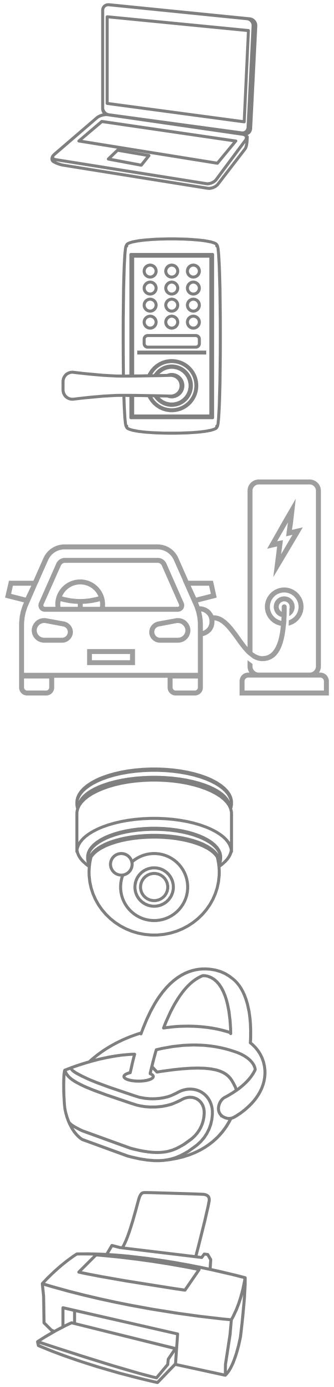
TOSHIBA

Automotive Off-Board EV Charging (Level 3)

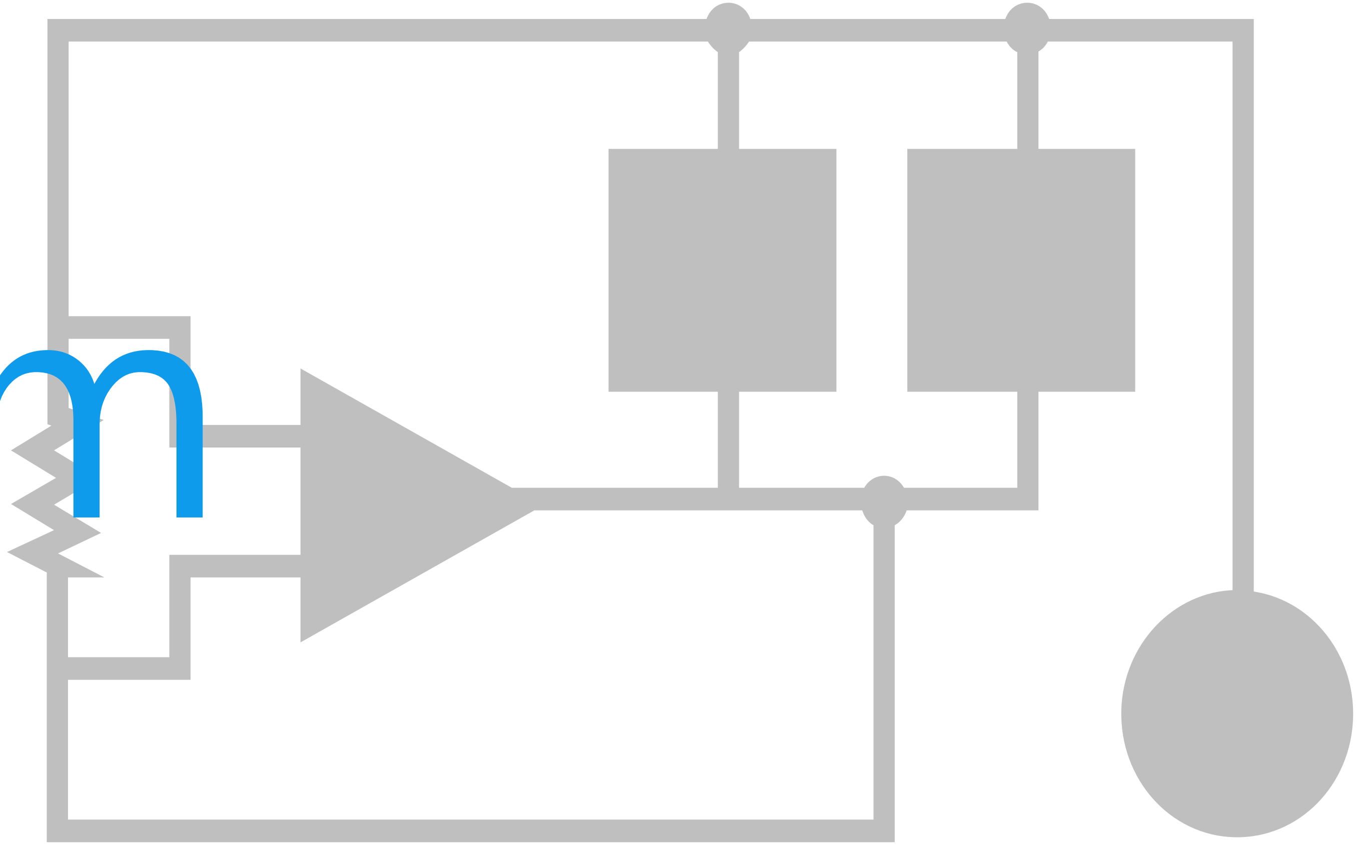
Solution Proposal by Toshiba





Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.

Block Diagram



The EV Charging Ecosystem Overview

AC charging

- Currently up-to 22kW
- 120 Volt, 240 Volt
- Level 1 & 2

OBC/BMS

DC charging

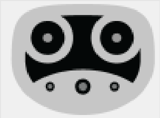
- Fast charging 50-300kW
- Up to 480 Volt
- Level 3

SAE J1772 connector

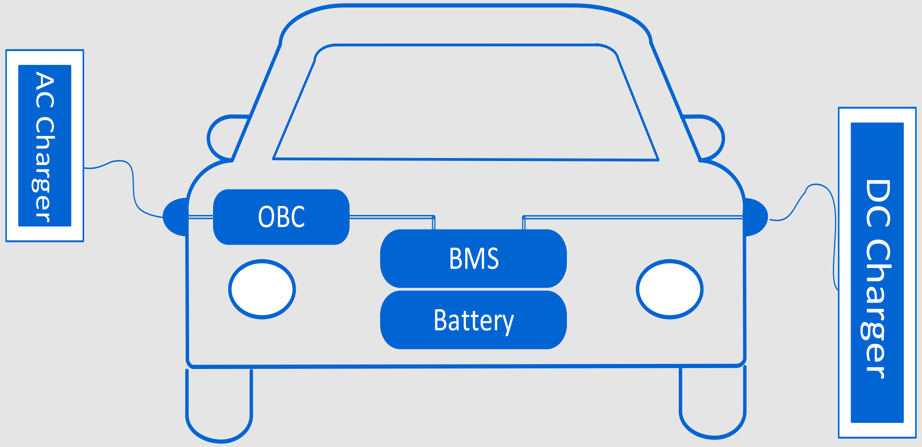
AC version

Migrating?

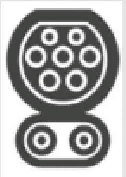
NACS J3400 connector



AC, DC and AC+DC versions

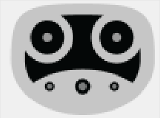


CCS connector



3 phase AC + DC

NACS J3400 connector



AC, DC and AC+DC versions

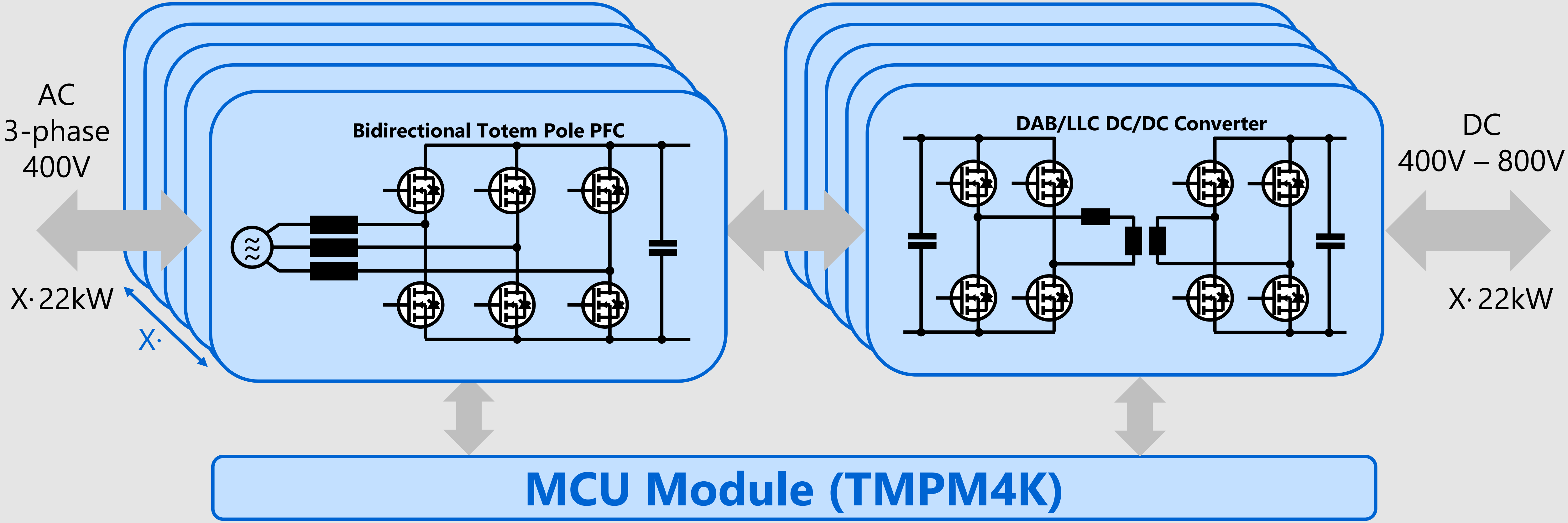
Residential Charging Stations

Public Fast Charging Stations

OBC: On Board Charger
BMS: Battery Management System

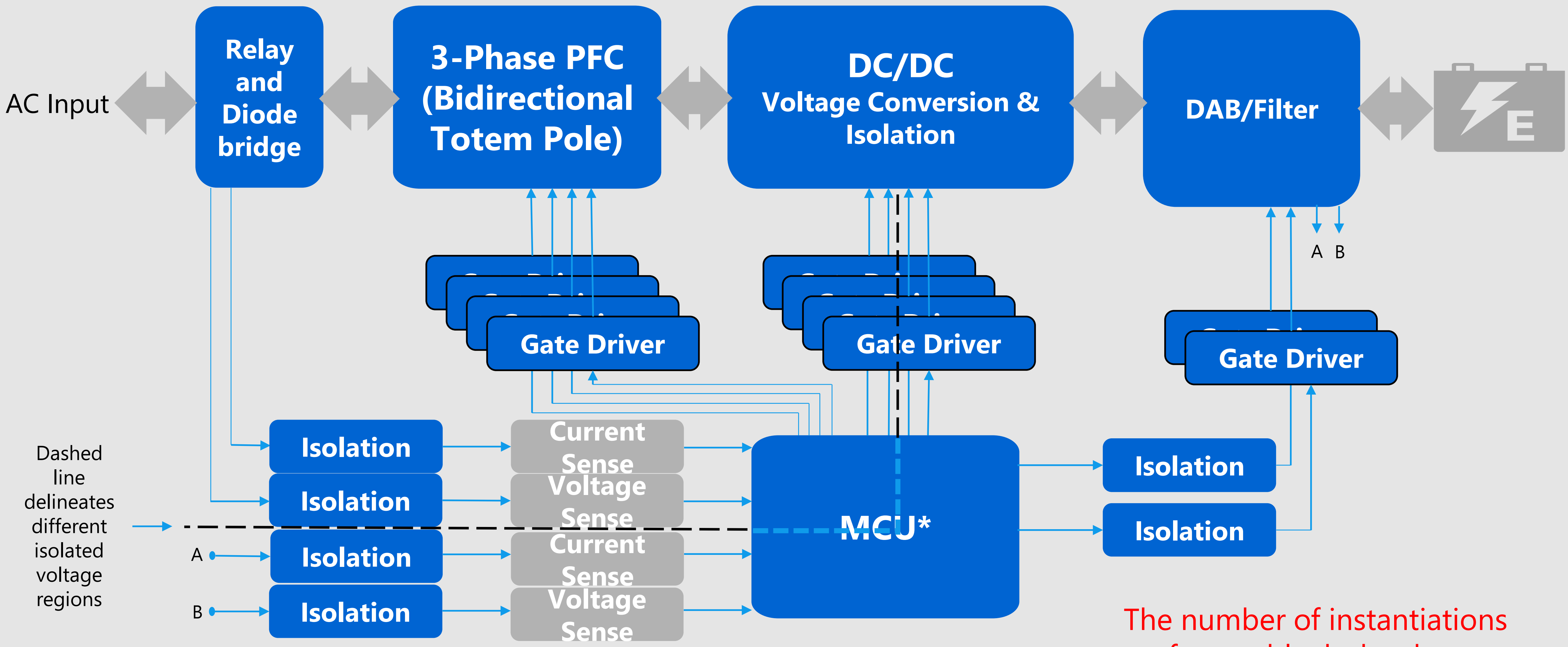
This presentation will focus on Level 3 fast charging stations

Stackable Level 3 EV Charging System



- **+** Only one EV-charging system needs to be developed
- **-** Synchronization between EV-charging systems required

DC Fast Charging Platform Single Stack Block Diagram



The number of instantiations of some blocks has been reduced for clarity

* MCU Block is ideally split into two MCUs to help maintain voltage domain isolation between PFC and DAB

Device solutions to address customer needs

As described above, in the design of Off-board Chargers, **“Improvement of reliability”**, **“Reduction of power consumption”** and **“Miniaturization“** are important factors. Toshiba’s proposals are based on these three solution perspectives.

Improvement of reliability

Robustness

Reduction of power consumption

High efficiency
·
Low loss

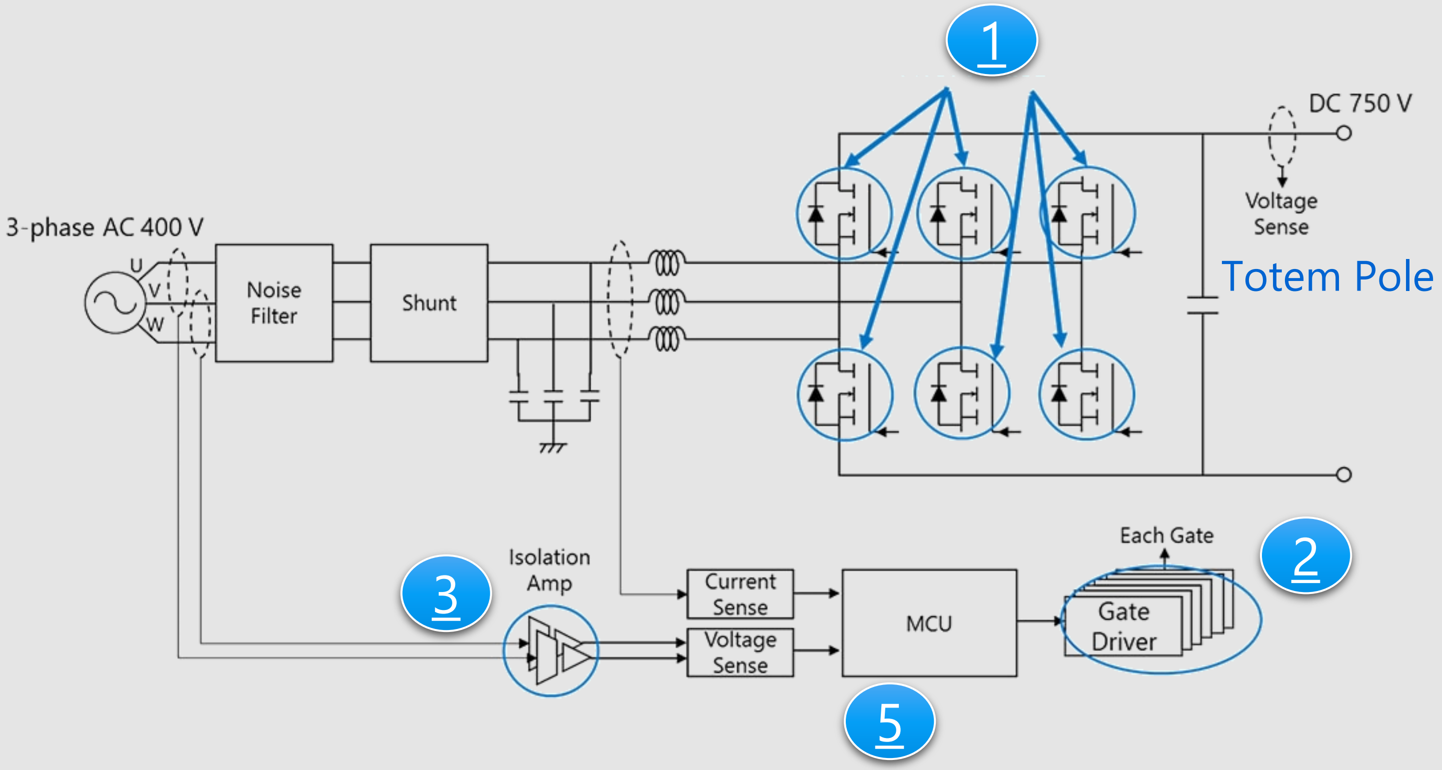
Miniaturization

Small size package

Device solutions to address customer needs

	Robustness	High efficiency · Low loss	Small size package
1 SiC Series 1200V MOSFET	●	●	
2 Gate Driver	●		●
3 Isolation Amplifier	●	●	●
4 Superjunction Series 650V MOSFET	●	●	●
5 MCU	●	●	●
6 H-Bridge Driver	●	●	●
7 Brushed MCD	●	●	●

AC Input and PFC Stage



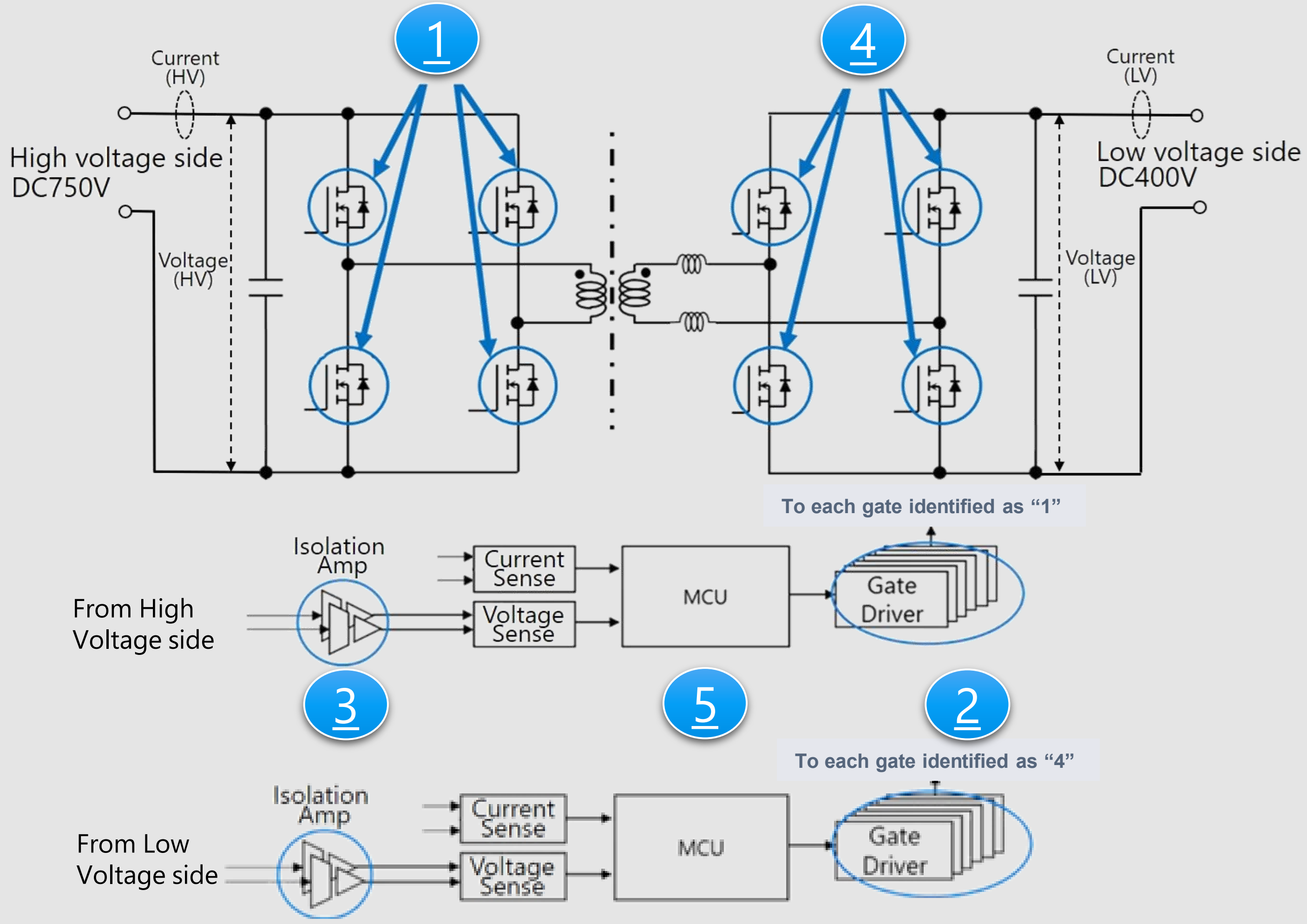
Criteria for device selection

- It is necessary to select the product with the suitable voltage and current ratings for each application.
- It is necessary to select a gate driver according to the characteristics of the switching device to be driven.
- The use of latest process technology such as SiC allows for fast switching of high voltage signals

Proposals from Toshiba

- **SiC 1200V MOSFETs** 1
- **Gate driver to drive SiC MOSFETs** 2
- **Isolation Amplifiers** 3
- **MCU** 5

DC/DC Voltage Conversion, Isolation and DAB Output Filter



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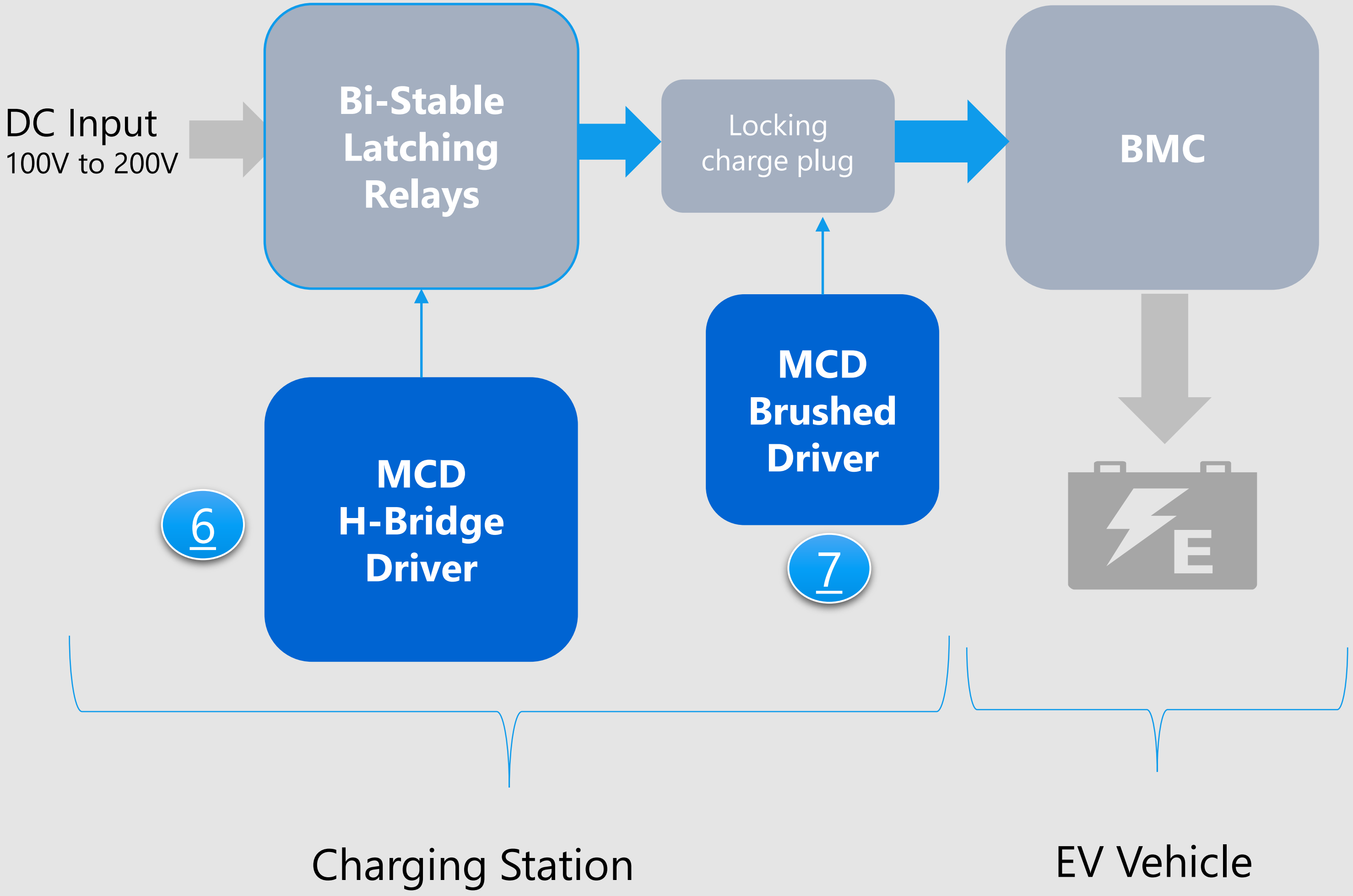
Proposals from Toshiba

- **SiC 1200V MOSFET** 1
- **Gate driver** 2
- **Isolation Amplifier** 3
- **SuperJunction 650V MOSFET** 4
- **MCU** 5

Additional Controls for Safety and Reliability for Charging Systems



Criteria for device selection

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- The use of latest process technology such as SiC allows for fast switching of high voltage signals

Proposals from Toshiba

- **MCD H-Bridge Driver to control Bi-stable latching relays** 6
- **MCD Brushed driver to operate locking plug** 7

Recommended Devices

SiC Series 1200 V MOSFET

TW015N120C / TW030N120C / TW045N120C / TW015Z120C / TW030Z120C / TW045Z120C

Robustness

High efficiency · Low loss

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

Value provided

Efficient high-power switching with good heat conductivity.

1 Built-in SBD

Low V_F with built-in SBD

- Toshiba V_F=1.35V typ.
- Competitor V_F = 3.2~4.6V typ.

-> Good reliability due to lower ON resistance!

2 Low R_{on} * Q_{gd}

Low R_{on} * Q_{gd} values allows for efficient and fast switching

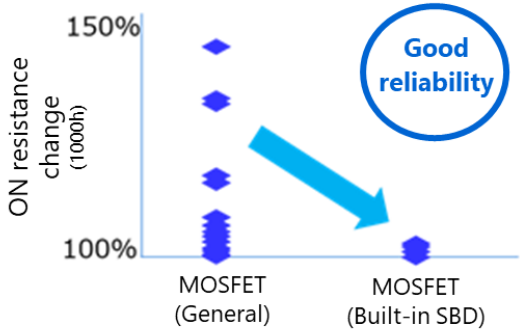
The lowest value compared to competitors and Toshiba's 2nd generation.

3 Wider V_{GSS} Rating

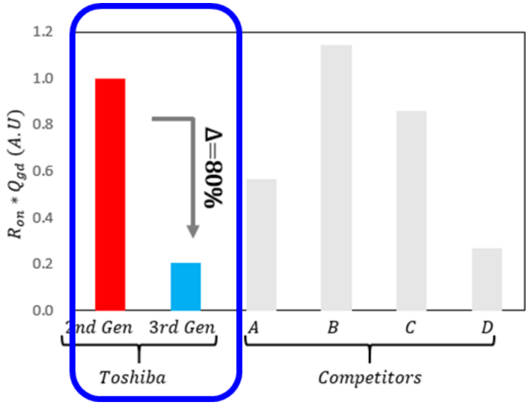
Wider VGSS ratings compared with the competition's SIC MOSFETs

VGSS: -10V ~ 25V (Recommend: 18V)

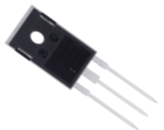
Built-in SBD gives low ON resistance!



The lowest R_{on} *Q_{gd} anywhere!



Line up

Part number	TW015N120C	TW030N120C	TW045N120C	TW015Z120C	TW030Z120C	TW045Z120C
Package	TO-247 			TO-247-4L 		
Abs Max I_D (A)	100	60	45	100	60	45
$R_{ds(on)}$ Typ **(Ω)**	15	30	45	15	30	45
Q_{gd} (nC)	158	82	57	158	82	57
C_{ISS} (VDS=300V) (pF)	6000	2925	1969	6000	2925	1969

① Line up of SiC MOSFET (1200V)

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

Generation	Package	Part Number	Absolute Maximum Ratings					Electrical Characteristics		
			V_{DSS} (V)	V_{GSS} (V)※1	I_D (A) ※2	T_j (℃)	T_{stg} (℃)	$R_{DS(ON)}$ typ. (mΩ)※3	Q_g typ. (nC)	C_{iss} typ. (pF)※4
3rd Generation	TO-247	TW015N120C	1200	-10～25	100	175	-55～175	15	158	6000
		TW030N120C			60			30	82	2925
		TW045N120C			40			45	57	1969
		TW060N120C			36			60	46	1530
		TW140N120C			20			140	24	691
	TO-247-4L	TW015Z120C			100			15	158	6000
		TW030Z120C			60			30	82	2925
		TW045Z120C			40			45	57	1969
		TW060Z120C			36			60	46	1530
		TW140Z120C			20			140	24	691

Note : The information in this table is subject to change without notice.

※1 : V_{GSS} pulse
※2 : T_a=25 ℃
※3 : V_{GS}=18 V, T_a=25 ℃
※4 : V_{DS}=800 V, f = 100kHz
※5 : V_{GS}=20 V, T_a=25 ℃

1 Line up of SiC MOSFET (650V)

※1 : V_{GSS} pulse
※2 : T_a=25 ℃
※3 : V_{GS}=18 V, T_a=25 ℃
※4 : V_{DS}=400 V, f = 100kHz

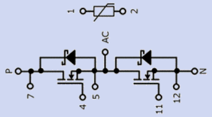
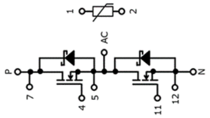
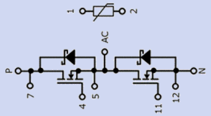
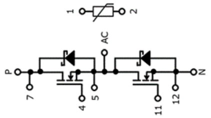
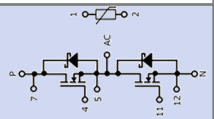
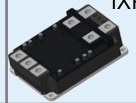
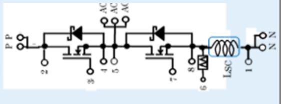
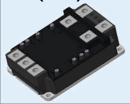
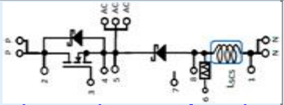
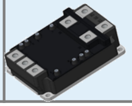
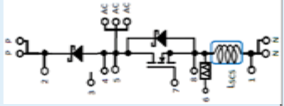
Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

Generation	Package	Part Number	Absolute Maximum Ratings					Electrical Characteristics			ES	CS	MP
			V_{DSS} (V)	V_{GSS} (V) ※1	I_D (A) ※2	T_j (℃)	T_{stg} (℃)	$R_{DS(ON)}$ typ. (mΩ)※3	Q_g typ. (nC)	C_{iss} typ. (pF)※4			
3rd Generation	TO-247	TW015N65C	650	-10～25	100	175	-55～175	15	128	4850	OK	OK	OK
		TW027N65C			58			27	65	2288	OK	OK	OK
		TW048N65C			40			48	41	1362	OK	OK	OK
		TW083N65C			30			83	28	873	OK	OK	OK
		TW107N65C			20			107	21	600	OK	OK	OK
	TO-247-4L	TW015Z65C			100			15	128	4850	OK	OK	OK
		TW027Z65C			58			15	128	4850	OK	OK	OK
		TW048Z65C			40			27	65	2288	OK	OK	OK
		TW083Z65C			30			48	41	1362	OK	OK	OK
		TW107Z65C			20			83	28	873	OK	OK	OK
	New TOLL	TW015U65C			100			15	128	4850	2Q 2024	3Q 2024	4Q 2024
		TW027U65C			58			27	65	2288	2Q 2024	3Q 2024	4Q 2024
		TW048U65C			40			48	41	1362	2Q 2024	3Q 2024	4Q 2024
		TW083U65C			30			83	28	873	2Q 2024	3Q 2024	4Q 2024
	New DFN8×8	TW(030)V65C			(58)			(30)	(65)	(2288)	2Q 2024	3Q 2024	4Q 2024
		TW(050)V65C			(40)			(50)	(41)	(1362)	2Q 2024	3Q 2024	4Q 2024
		TW(090)V65C			(30)			(90)	(28)	(873)	2Q 2024	3Q 2024	4Q 2024
		TW(120)V65C			(20)			(120)	(21)	(600)	2Q 2024	3Q 2024	4Q 2024

Note: The information in this table is subject to change without notice.

1 SiC MOSFET Module Development Roadmap

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

	Rated Voltage /Current	Product Name	Package / Circuit	CY2023	CY2024	CY2025	CY2026
SiC-MOS FET Module	1.2kV 600A	Mass Production MG600Q2YMS3	Tch(Max)=150℃  2-153A1A 	MP			
	1.2kV 400A	Under development MG400Q2YMS3	Tch(Max)=150℃  		ES (3/'24) MP(9/'24)		
	1.7kV 400A	Mass Production MG400V2YMS3	Tch(Max)=150℃  	MP			
	1.7kV 250A	Under development MG250V2YMS3	Tch(Max)=150℃  	ES	MP(3/'24)		
	2.2kV 250A	Mass Production MG250YD2YMS3	Tch(Max)=150℃  	ES MP(8/'23)			
	3.3kV 800A	Mass Production MG800FXF2YMS3	Tch(Max)=175℃  iXPLV Ag Sintering technology  humidity resistance improved version	ES MP(10/'23)			
	3.3kV 800A	Mass Production MG800FXF1ZMS3	Tch(Max)=175℃   humidity resistance improved version	ES MP(12/'23)			
	3.3kV 800A	Mass Production MG800FXF1JMS3	Tch(Max)=175℃   humidity resistance improved version	ES MP(12/'23)			

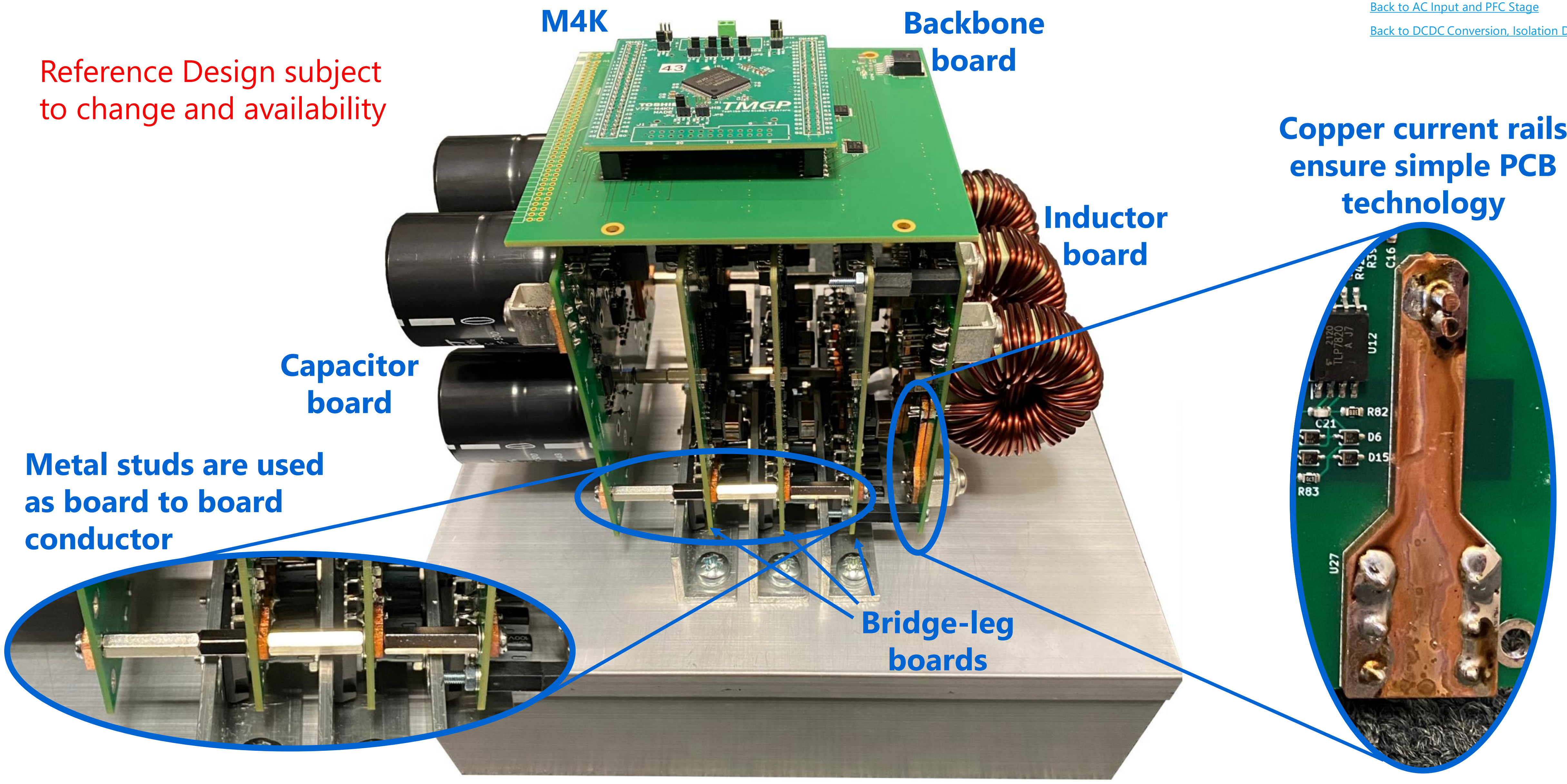
ES Engineering sample, MP: Mass Production

Production lead time : 7 month

1 The SiC-Cube – 3-Phase PFC (Toshiba Reference Design)

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

Reference Design subject to change and availability



Smart Gate Driver

2

TLP5214/TLP5214A/TLP5814H

Robustness

Small size package

[Back to AC Input and PFC Stage](#)
[Back to DCDC Conversion, Isolation DAB](#)

Value provided

Highly integrated 4.0A output current SiC gate drive photocoupler in an efficient SO16L package

1 Protects against overcurrent of power devices

Gate driving with isolation with two LEDs

Feedback function for fault mode

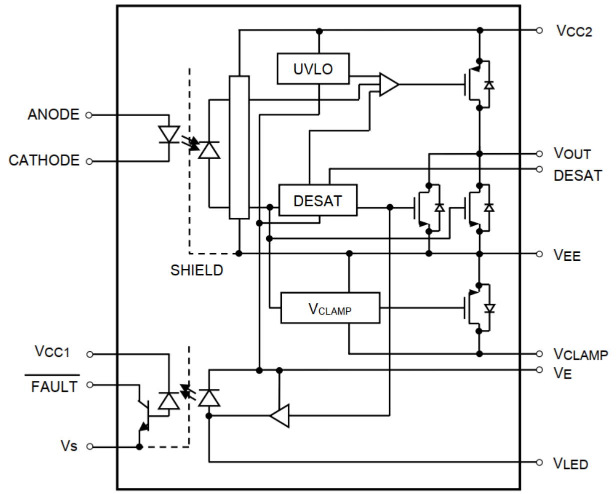
Built-in protective functions

2 2 Protective Functions

- Soft shut down in time to prevent the driven transistor from any short circuit breakdown
- Active mirror clamp to help flow damaging current away from driven device

3 Small Size Package

In an efficient SO16L package



Line up

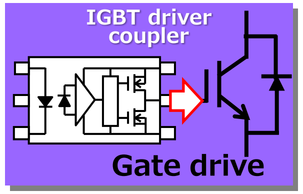
Part number	TLP5214	TLP5214A	TLP5814H*
Total Supply Voltage (V)	15 to 30		15 to 23
Peak Output Current (A)	-4.0 / +4.0		-4.8 / +6.8
Supply Current (mA)	3.8		6.8
Threshold input current MAX (mA)	6		3.0
Switching time tpLH/tpHL MAX (ns)	150		150
DESAT leading edge blanking time Typ. (µs)	0.2	1.1	NONE
VtClamp threshold voltage for Mirror Clamp (V)	3.0	2.5	2.5
Package	SO 16L		SO 8L

* Under Development

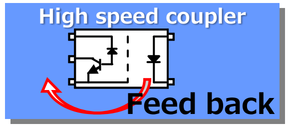
② Smart Gate Driver TLP5212, TLP5214/A Summary

[Back to AC Input and PFC Stage](#)
[Back to DCDC Conversion, Isolation DAB](#)

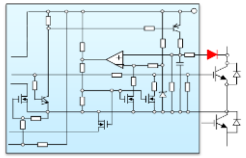
① gate driving with isolation



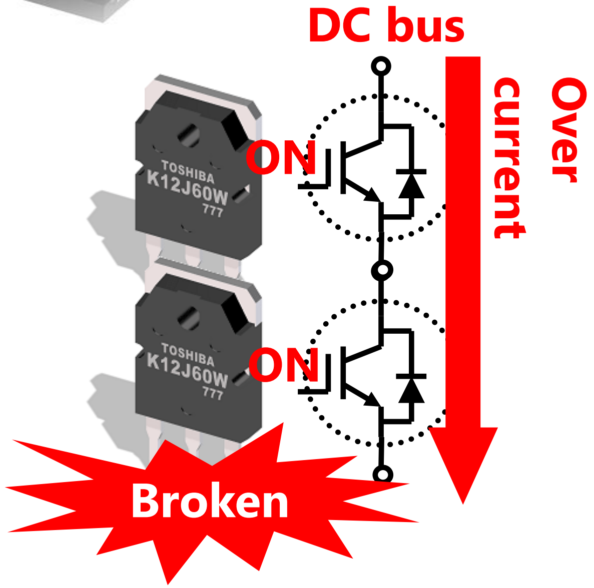
② Feed back function for fault mode



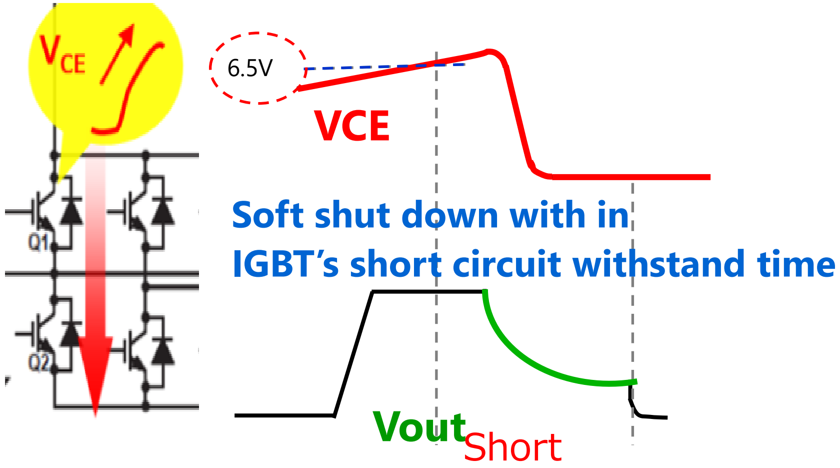
② Protective functions



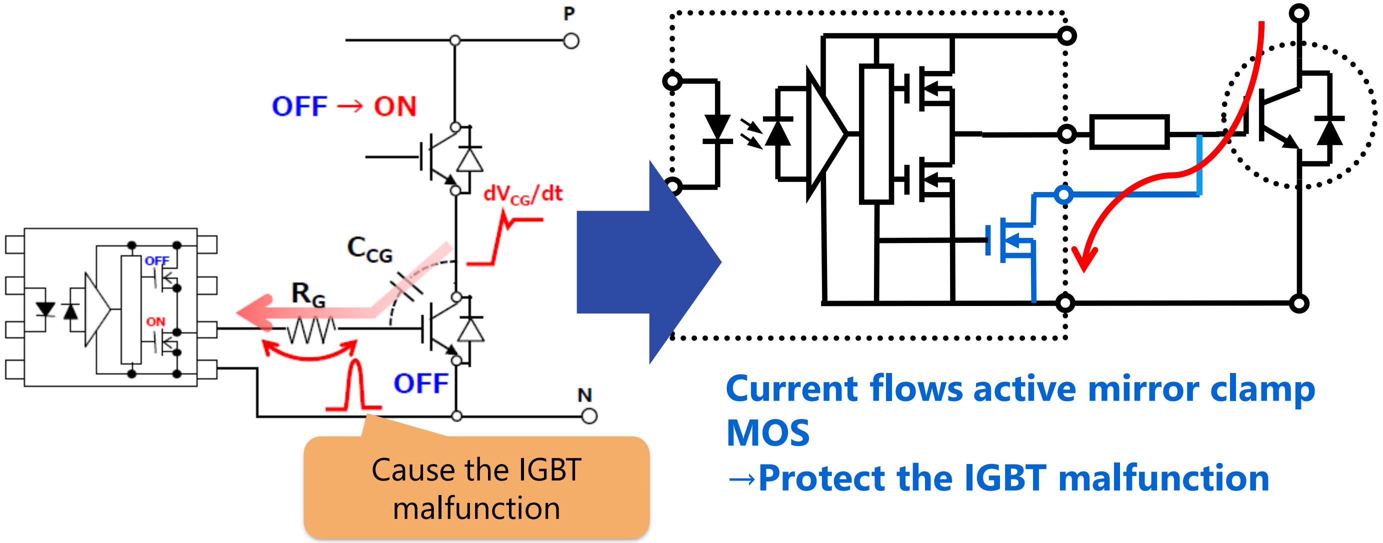
SGD protects against overcurrent of power devices.



Protective function-1 Soft shout down



Protective function-2 Active mirror clamp



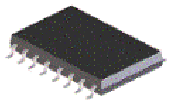
Current flows active mirror clamp MOS
→Protect the IGBT malfunction

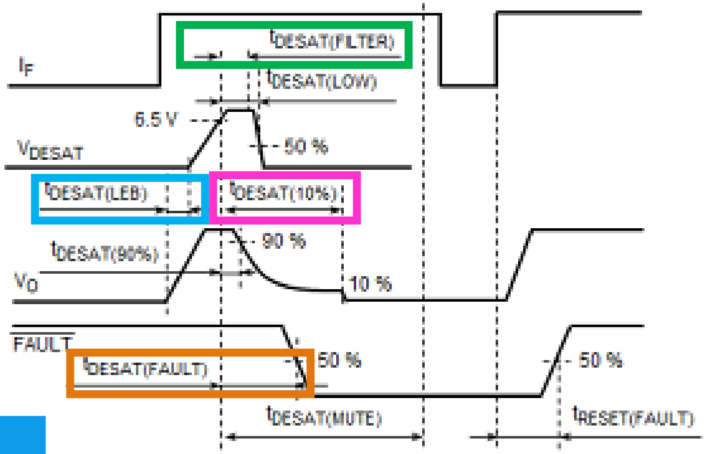
Smart Gate Driver TLP5214A vs. TLP5214

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

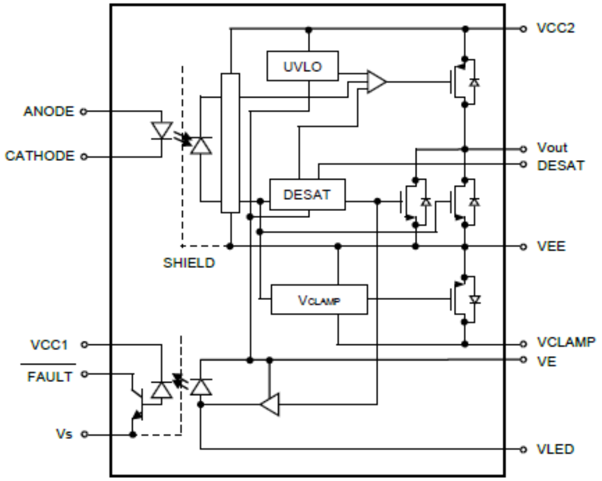
■ Differences between TLP5214A and TLP5214

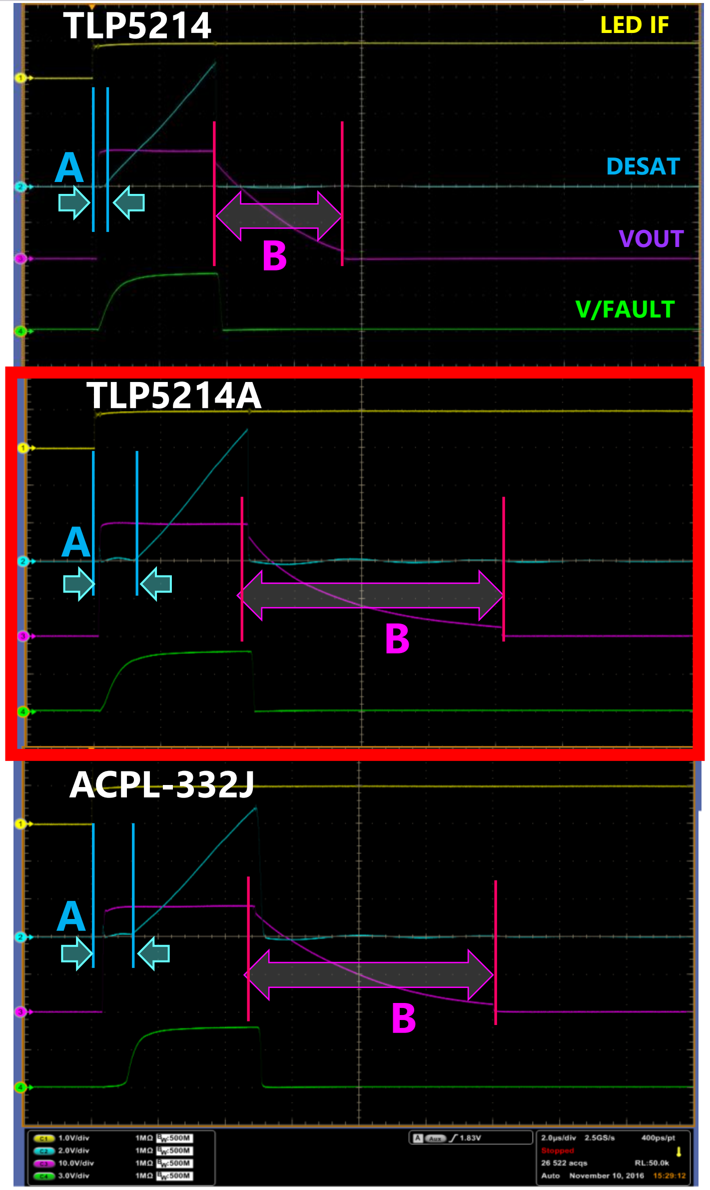
Longer **DESAT mask $t_{DESAT(LEB)}$(~0.2 → ~1.1$_{\mu s\ typ.}$)**
Longer **soft shutdown time (~3.5 → ~7$_{\mu s\ typ.}$)**
Added "**DESAT filter time**" for high noise immunity **(90$_{ns\ typ.}$)**
tDESAT(FAULT)(0.5us → 0.55us typ.)





	TLP5214	TLP5214A
tDESAT(LEB)	0.2µs（typ.）	1.1µs（typ.）
tDESAT(10%)	3.5µs（typ.）	7.0µs（typ.）
DESAT filter time	-	90ns（typ.）
tDESAT(FAULT)	0.5µs（max.）	0.55µ（max.）





Operation behavior [during protection mode]

2 Gate Driver Coupler with Active Miller Clump function

TLP5814H Under Development

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

Built in MOSFET for miller clump prevent self turn on of power devices easily.

Feature

- Active Miller Clamp function
- High peak output current
- High CMTI

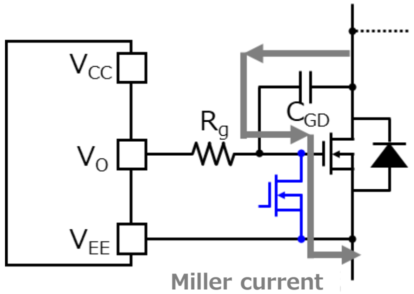
Part name	TLP5814H
Peak output current (Max.)	+6.8 / -4.8 A
Peak clamp sink current (Max.)	6.8 A
CMTI (Min.)	±70 kV/µs
Operating temp. (max)	125 ℃
Supply voltage	15 to 23 V

SO8L
Creepage : 8 mm
DTI : 0.4 mm
Bvs : 5000 Vrms

To avoid self turn-on.

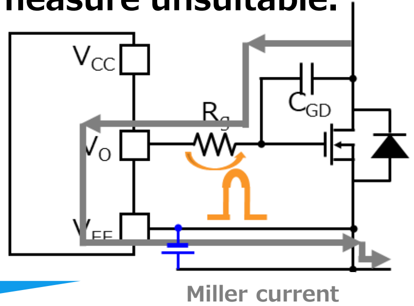
Adding a shunt circuit

It is necessary to add a bypass element and its control circuit.

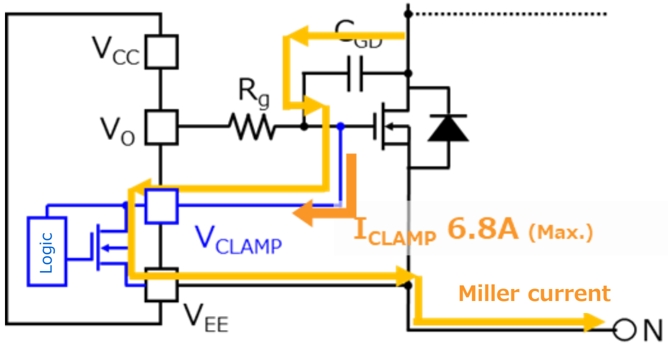


Using a negative gate power supply

SiC-MOSFETs have a low gate negative bias tolerance, making this countermeasure unsuitable.



Self turn on prevention with TLP5814H



SiC MOSFET

Provides robust self-turn-on prevention for SiC-MOSFETs

IGBT

Reduced negative bias power supply circuit

Development schedule and specifications are subject to change

2 Smart gate driver comparison table

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

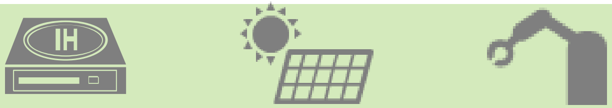
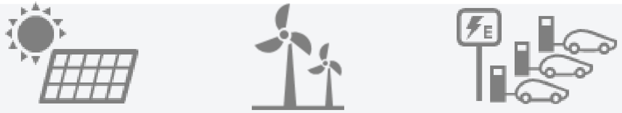
*** Under development**

Item	Symbol	TLP5214	TLP5214A	TLP5814H*
Total supply voltage	VCC2-VEE	15 ～ 30 V		13 ～ 23 V
Negative supply voltage	VE-VEE	-15 V ～ 0 V		-
Positive supply voltage	VCC2-VE	15V ～ 30 - (VE - VEE)		-
Positive supply voltage	VCC1	3.3 ～ 5.5 V		13 ～ 23 V
Threshold input current	IFHL	6 mA		3 mA
Peak output current	IOPH/IOPL	-4.0 / +4.0 A (max.)		-4.8 / +6.8 A
Propagation delay time	tpLH、tpHL	50 ～ 150 ns		150 ns max
Propagation delay skew	tpsk	-80 ～ +80 ns (max.)		-75 ～ +75 ns
DESAT threshold voltage	VDESAT	6 ～ 7.5 V	5.9 ～ 7.5 V	None
Blanking cap. charge current (typ.)	ICHG	-0.24 mA		
DESAT leading edge blanking time (typ.)	tDESAT(LEB)	0.2 µs	1.1 µs	
Soft shut down time (typ.)	tDESAT(10%)	3.5 µs	7.0 µs	
Clamp pin threshold voltage (typ.)	VtClanp	3.0 V	2.5 V	2.5 V
Clamp low level sinking current (typ.)	ICL	1.8 A	1.8 A	3.8 A
UVLO P threshold (typ.)	UVLO+	11.6 V	11.6 V	12.5 V
UVLO N threshold (typ.)	UVLO-	10.3 V	10.3 V	11.0 V
Common Mode Transient Immunity (min.)	CMTI	± 35 kV/µs	± 35 kV/µs	± 70 kV/µs
Fault reset method		LED trigger		LED trigger

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

2 Toshiba Gate Driver Couplers

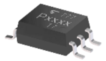
For more efficient and reliable Systems

Target Devices	MOSFET / IGBT	SiC MOSFET
Application		
Temp.	Ta : 110 ⇒ 125 ℃	Ta : 125 ℃
Frequency	Under 100 kHz	50 to **400 kHz**
CMTI	Under 50 kV/µs	50 to **100 kV/µs**
Gate Current	Around ±5 A	Around ±5 A
Gate Voltage	±10 V / +18 V, -10 V	+18 V, -5 V

Parameter

Existing Product Examples

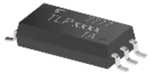
TLP152 / TLP151A



Gate Driver for power **MOSFETs** and **IGBTs**

Main Specification:
100/110℃, 20kV/µs, ±2.5A, 10 to 30V

TLP5705H



Gate Driver for **IGBTs** and **SiC MOSFETs**

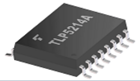
Main Specification:
125℃, 50kV/µs, ±5A, 15 to 30V

TLP5774H / TLP5754H

Gate Driver for power **MOSFETs, IGBTs** and **SiC MOSFETs**

Main Specification:
125℃, 35kV/µs, ±4A, 15/10 to 30V

TLP5212 / TLP5222



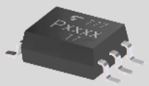
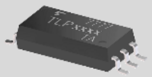
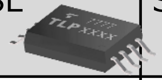
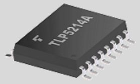
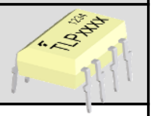
Smart Gate Driver for **IGBT s** and **SiC MOSFETs**

Main Specification:
110℃, 25kV/µs, ±2.5A, 15 to 30V

② IGBT/MOSFET Gate Driver Coupler Lineup

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

Blue letter : Recommended package **Red letter ： New Products**

Creepage & clearance		5mm	8mm	8mm	8mm	7 or 8mm
Isolation voltage		3750 Vrms	5000 Vrms	5000 Vrms	5000 Vrms	3750 Vrms
Peak output current	Propagation Delay time(max)	SO6 	SO6L 	SO8L 	SO16L 	DIP8 
6.0 A	500 ns					TLP358H*H
5.0 A	500 ns		**TLP5705H***H			
4.0 A	150 ns		**TLP5754***R **TLP5754H***R*H **TLP5774***R*10 **TLP5774H***R*H*10		**TLP5214***R*OC*AMC **TLP5214A***R*OC*AMC	
2.5 A	150 ns		**TLP5752***R **TLP5752H***R*H **TLP5772***R*10 **TLP5772H***R*H*10			
	200 ns	**TLP152***10	**TLP5702** **TLP5702H***H	**TLP5832**	**TLP5212***OC*AMC **TLP5222***OC*AMC *AR	TLP352*H
	300 ns				**TLP5231***R*OC	
	500 ns					TLP250H*H TLP350H*H
1.0 A	150 ns		**TLP5751***R **TLP5751H***R*H **TLP5771***R*10 **TLP5771H***R*H*10			
0.6 A	200 ns	**TLP155E***10				
	500 ns	**TLP151A***10	**TLP5701***10			TLP351A*10
	700 ns	**TLP151***10				TLP351H*10 *H

*R＝Full swing output (rail to rail)
H =Operation temperature: 125 ℃ (max)
10 =Operation voltage: 10 V (min)

∗ L =Low LED current: IFLH=2mA (max)
∗ AR = Auto Reset from the protection mode
∗ OC = AMC Over voltage detection (VDESAT)

∗ AMC = Active Miller clamp

3 Isolation Amplifier

TLP7820/TLP7830

Robustness | High efficiency · Low loss | Small size package

Back to AC Input and PFC Stage

Back to DCDC Conversion, Isolation DAB

Value provided

. Efficient and robust isolation amplifiers for voltage or current sensing applications

1 Adapted for voltage or current sensing operations

TLP7820 for current sensing

TLP7830 for voltage sensing

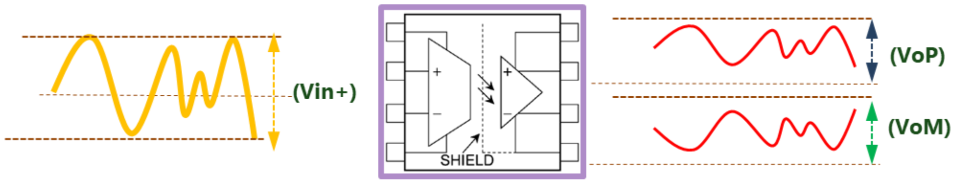
2 Robust strong device

High temperature stability (120ppm/K)
EMI Robustness
Minimal gain variation exhibited
Meets maximum operating insulation voltage of 1414V.
(DIN EN/EN/IEC 60747-5-5 Option (D4))

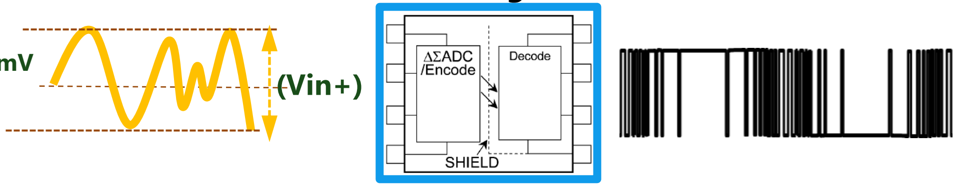
3 Low height package

SO 8L package has creepage of 8mm.
Pin to pin compatible to popular isolation amplifiers such as ACPL-C79x, and exhibits lower input power consumption

TLP7820 analog out



TLP7830 digital out

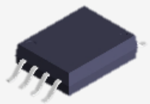
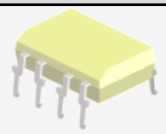


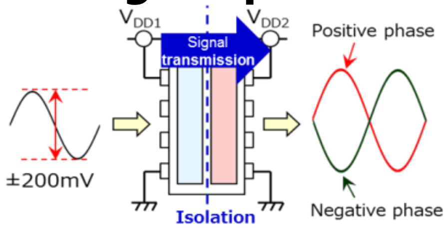
Line up

Part number	TLP7820	TLP7830
Package	SO 8L	
Isolation Voltage (Vrms)	5000	
Max Allowable Operating Insulation Voltage (V_{IORM})	1414 (EN 60747-5-5)	
Output Voltage (differential analog output) (V)	0 ~ 2.5V	-
Gain (Ambient temp 25°C)	8.2x	-
Output type / Clock type	-	1 bit digital / CLK output
Input side supply voltage V_{DD1} (V)	4.5~5.5	
Output side supply Voltage V_{DD2} (V)	3.0~5.5	
Input voltage range (mV)	+/- 300	+/- 320
Input voltage range - linear area (mV)	+/- 200	+/- 200
Operating Temperature (°C)	-40 ~ 105	

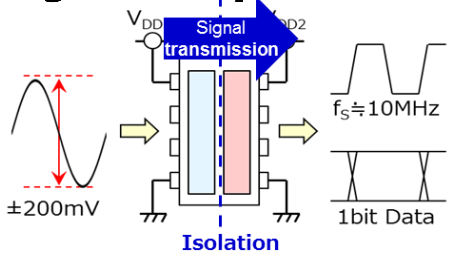
3 Isolation Amplifier Line-up

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

Creepage / Clearance	8 mm	7 or 8 mm
Isolation Voltage	5000Vrms	5000Vrms
Output type	 SO8L	 DIP8
Analog output	TLP7820	TLP7920
Digital output	TLP7830	TLP7930



Rank	Gain Rank Marking	Gain (Min)	Gain (Typ.)	Gain (Max)	Unit
None (±3 %)	Blank, A, B	7.95	8.2	8.44	V/V
Rank A (±1 %)	A, B	8.12	8.2	8.28	
Rank B (±0.5 %)	B	8.16	8.2	8.24	



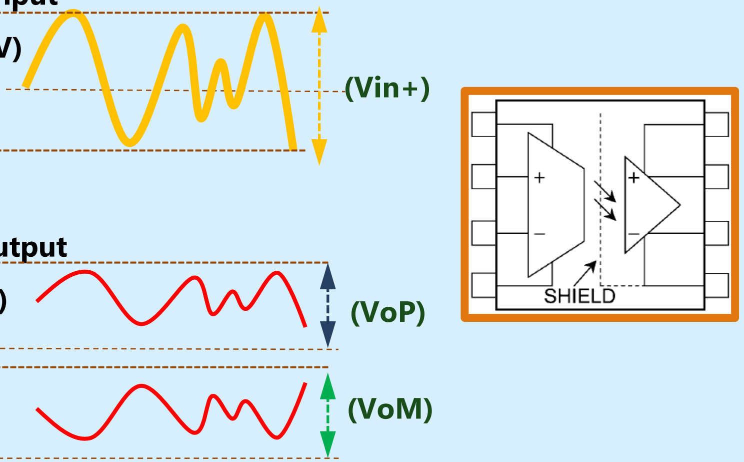
Analog output

Analog signal input

(max±300mV)

Analog signal output

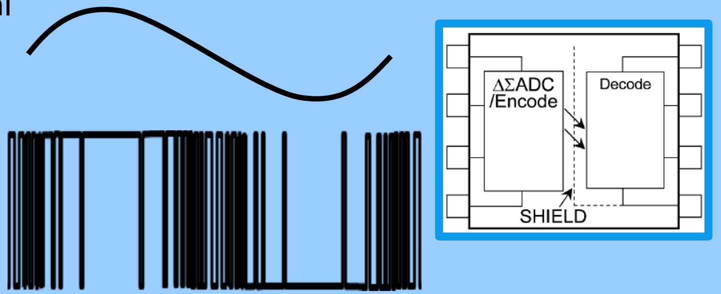
(max ±2.5V)



Digital output

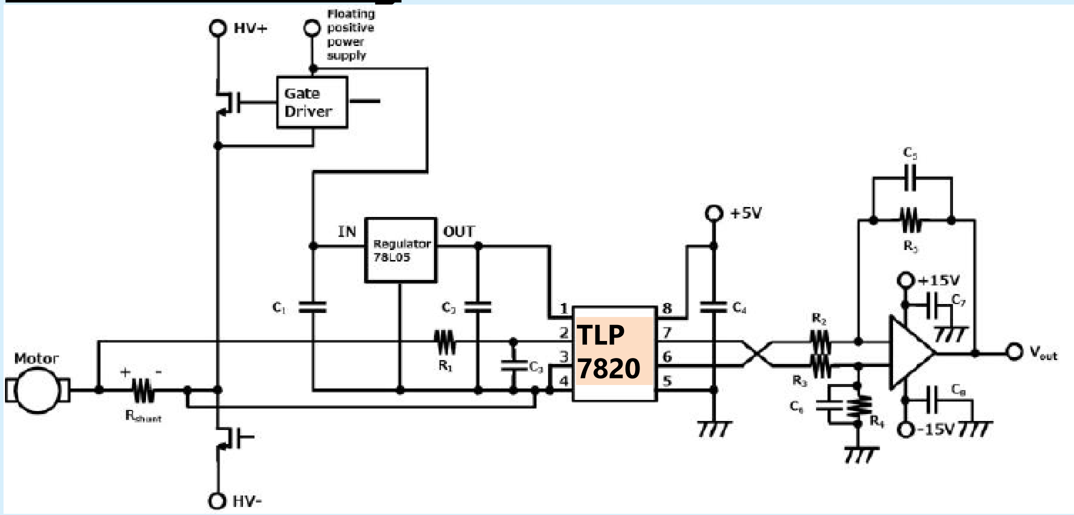
Analog input signal

Bit stream data

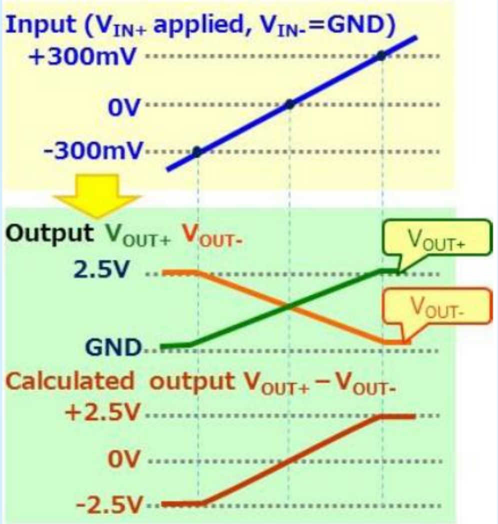


3 Isolation Amplifier Reference Circuits

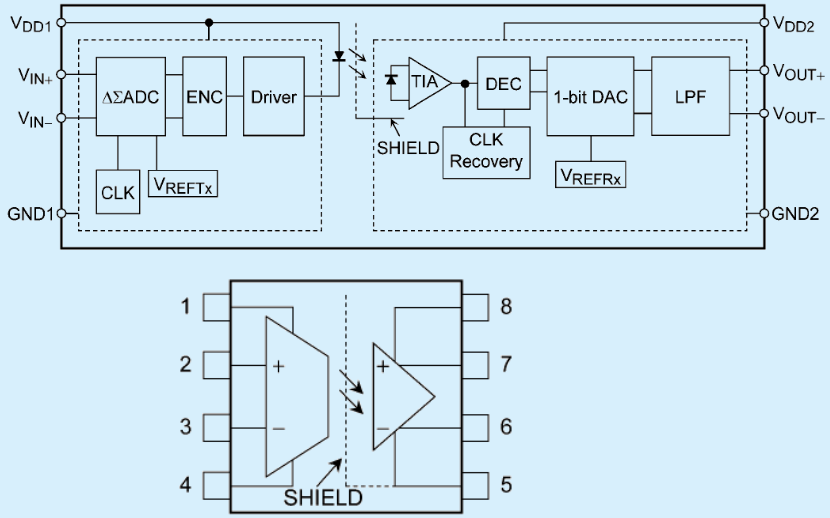
■Current sensing



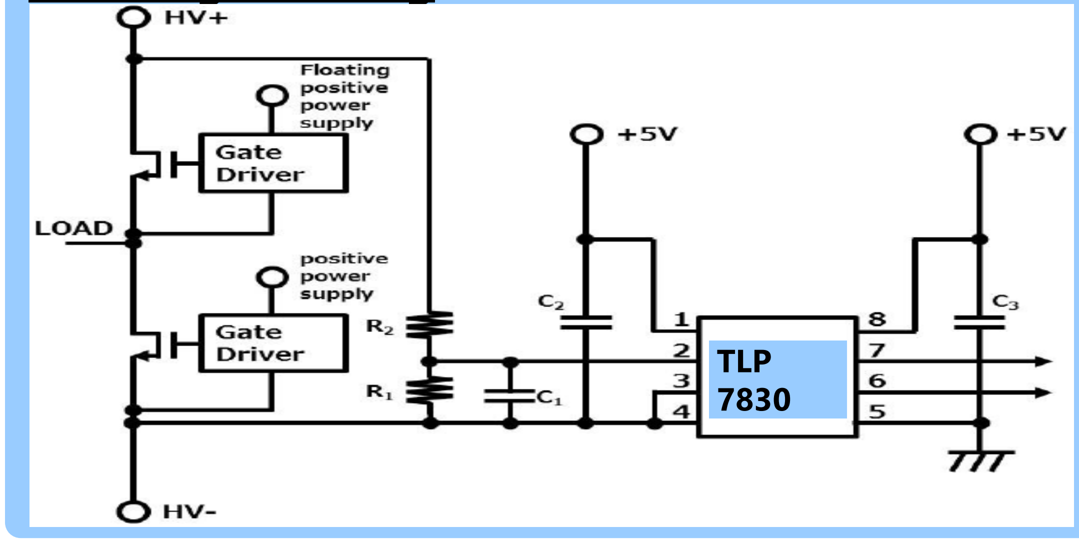
■Analog output



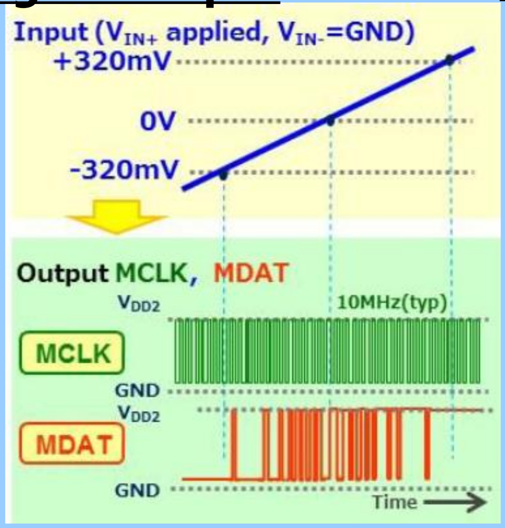
■ Internal circuit



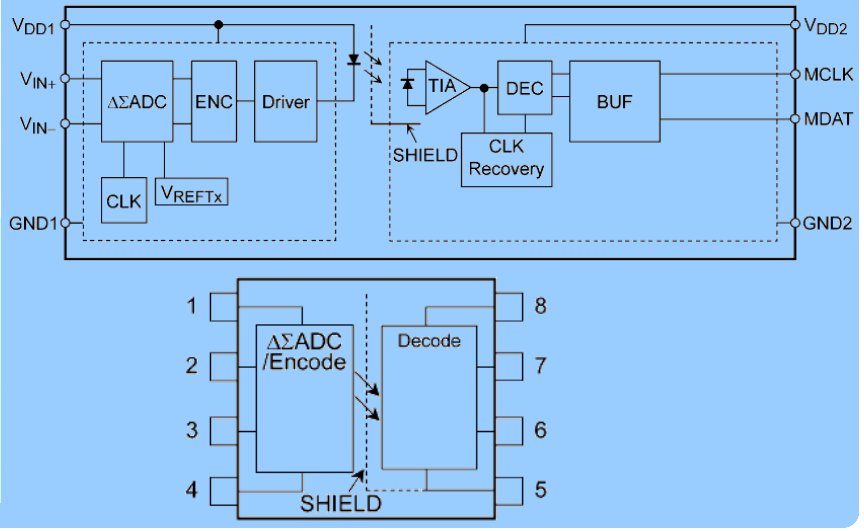
■ Voltage sensing



■ Digital output



■ Internal circuit



3 TLP7820/7920 vs. Competitor's item

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

in front of "[]": (typ.), inside of []: specification value.	TLP7820	TLP7920	ACPL-C79x	ACPL-790x	HCPL-7840	AMC1200
Package / Isolation Voltage (AC1min)	SO8L / 5kVrms	DIP8 / 5kVrms	SSO-8 / 5kVrms	DIP8 / 5kVrms	DIP8 / 3.75kVrms	SOP8 / 2.8kVrms
Maximum Allowable Operating Insulation Voltage V_{IORM} D4 Option	1414 Vpeak	TLP7920 890Vpeak TLP7920F 1140Vpeak	1230 Vpeak	891 Vpeak	891 Vpeak	1200 Vpeak
Output voltage (differential analog output)	Single Phase, 0 ~ 2.5 V		Single phase, 0 ~ 2.5 V		Single phase, 1.29 ~ 3.8V	Single phase, 1.29～3.8V
Operating Temperature T_A	-40 ~ 105 ℃		-40 ~ 105 ℃		-40 ~ 100 ℃	-40 ~ 105 ℃
Input (Primary) side supply voltage V_{DD1}	4.5 ~ 5.5 V		4.5 ~ 5.5 V		4.5 ~ 5.5 V	4.5 ~ 5.5 V
Output (Secondary) side supply voltage V_{DD2}	3.0 ~ 5.5 V		3.0 ~ 5.5 V		4.5 ~ 5.5 V	2.7 ~ 5.5 V
Input Voltage Range(Liner area / Full-scale)	±200 mV / ±300 mV		±200 mV / ±300 mV		±200 mV / ±300 mV	±250 mV / ±320 mV
Gain (T_A=25℃)	8.2 times		8.2 times		8 times	8 times
Gain error (T_A=25℃)	±0.5 / ±1 / ±3 %		±0.5 / ±1 / ±3 %		±5 %	± 0.5 %
Magnitude of Gain Change vs. Temperature	0.00012 V/V/℃		-0.00041 V/V/℃		0.00025 V/V/℃	±0.00045V/V/℃ (±56 ppm/℃)
Nonlinearity over ±200 mV Input Voltage $INL_{200@Ta25℃}$	0.02 [max.0.13] %		0.05 [max.0.13] %		0.0037 [max.0.35] %	0.075 %
Nonlinearity over ±100 mV Input Voltage INL_{100}	0.01 [max.0.06] %		0.02 [max.0.06] %		0.0027 [max.0.2] %	N/A
Input Offset Voltage	+0.9 [-0.6~2.4] mV		+0.6 [-1~2] mV		+0.3 [±3] mV	+0.2 [±1.5] mV
Magnitude of Input Offset Change vs. Temperature	2 [max.6] µV/℃		3 [max.10] µV/℃		3 [max.10] µV/℃	±1.5 [max.±10] µV/℃
Small-Signal Bandwidth (-3 dB)	[min.140] 200 kHz		[min.140] 200 kHz		[min.50] 100 kHz	[min.60] 100 kHz
Equivalent Input Impedance	78 kΩ		22 kΩ		500 kΩ	28 kΩ
Input Side Supply Current I_{DD1}	**8.6 [max.12] mA**		mA	13[max.8.5] mA	10.86 [max.15.5] mA	5.4 [max.8] mA
Output Side Supply Current I_{DD2}	**6.2 [max.10] mA**		[max.12] mA		11.56 [max.15.5] mA	4.4 [max.7] mA

Similar Gain and Offset voltage

Lower Power consumption

3 TLP7830/7930 vs. Competitor's item

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

in front of "[]": (typ.), in side of []: specification value	HCPL-7860	TLP7830	TLP7930	ACPL-C797	ACPL-7970	ACPL-796J
Package/Isolation Voltage(AC1min)	DIP8/3.75 kVrms	SO8L / 5 kVrms	DIP8/ 5 kVrms	SSO-8 / 5 kVrms	DIP8 / 5 kVrms	SO-16 / 5 kVrms
Maximum Allowable Operating Insulation Voltage V_{IORM}) D4 Option	891 Vpeak	1414 Vpeak	TLP7920 890 Vpeak TLP7920F 1140 Vpeak	1414 Vpeak	891 Vpeak	1230 Vpeak
Output type / CLK type	1bit digital / CLK output	1 bit digital / CLK Output		1 bit digital / CLK Output		1 bit digital / CLK input
Operating Temperature T_{opr}	-40～85 ℃	-40～105 ℃		-40～105 ℃		-40～105 ℃
Input side supply voltage V_{DD1}	4.5～5.5 V	4.5～5.5 V		4.5～5.5 V		4.5～5.5 V
Output side supply voltage V_{DD2}	4.5～5.5 V	3.0～5.5 V		3.0～5.5 V		3.0～5.5 V
Input voltage range	±320 mV	±320 mV		±320 mV		±320 mV
Input voltage range(liner area)	±200 mV	±200 mV		±200 mV		±200 mV
Gain error(Ta=25℃)	±1 %	±1 %		±1 %		±1 %
Gain error(Ta=T_{opr})	±2 %	±2 %		±2 %		±2 %
VREF Drift vs. Temperature@VDD1=5V	60 ppm/℃	60 ppm/℃		60ppm/℃		60 ppm/℃
Differential Nonlinearity DNL	±1 LSB	±0.9 LSB		±0.9 LSB		±0.9 LSB
Integral Nonlinearity $INL_{200@Ta85℃}$	3[±30] LSB	4(±15) LSB		3[±15] LSB		3[±15] LSB
SNDR	66 dB	(min. 65)75 dB		[min.65]75 dB		[min.65]75 dB
Offset Error	0[±3] mV	+0.6(-1~2) mV	+0.9 (-0.3~2.7) mV	+0.3[-1~2] mV	+0.4[±2] mV	+3[-1~4.5] mV
Offset Drift vs. Temperature	2 [max.10] uV/℃	1.2 (max.3) uV/℃	1.2 (max.3) uV/℃	1 [max.3.5] uV/℃	2 [max.6] uV/℃	－[max.3.5] uV/℃
Average Input Resistance	450 kΩ	78kΩ		24kΩ		33kΩ
Input side supply current I_{DD1}	10[max.15] mA	**8.5(max.12) mA**		9[max.14]mA		14[max.19] mA
Output side supply current I_{DD2}@5V	10[max.15] mA	**4.9(max.8) mA**		5.2[max.8]mA		6[max.8] mA

Similar SNDR and Offset voltage

Lower Power consumption

4 DTMOS-VI 650V SuperJunction MOSFET

TK190U65Z / TK155U65Z / TK110U65Z / TK090U65Z / TK065U65Z

Robustness | High efficiency · Low loss | Small size package

Back to DCDC Conversion, Isolation DAB

Value provided

Low on-resistance contributes to reduce system power consumption and more efficient switching

1 Low $R_{DS(ON)}$ * A

$R_{DS(ON)}$ per unit area is reduced for better efficiency and power savings

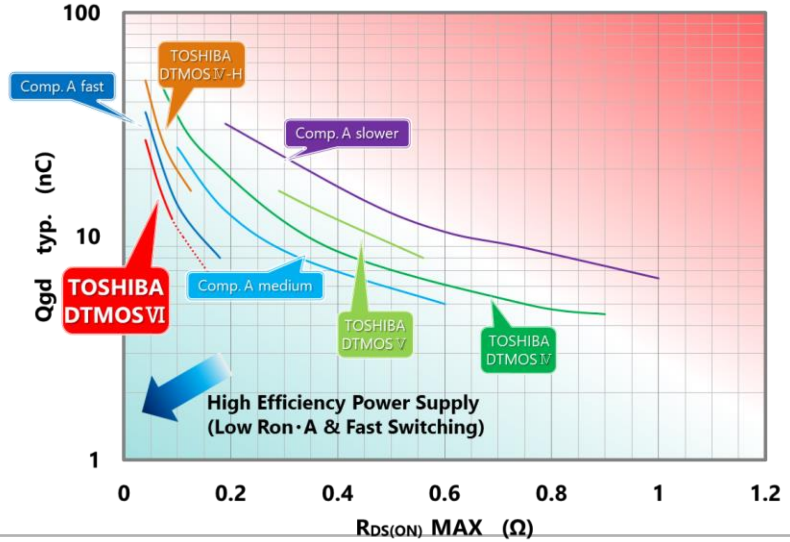
2 Low Switching Losses

Low **Q_{gd}** allows for faster switching

Large contribution in light – heavy load

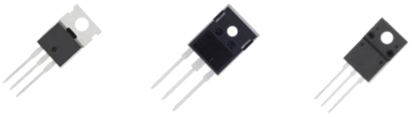
3 Efficient Packages

Powerfully efficient TOLL packages are available.
Also available in DFN, TO-220 and TO-247 type packages.



3 packages with Kelvin sourcing:

Standard 3-pin packages:

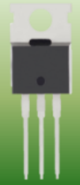
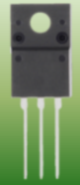
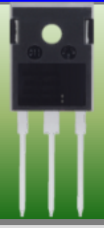
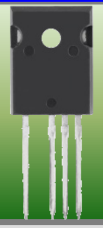
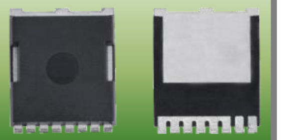


Line up

Part number	TK190U65Z	TK155U65Z	TK110U65Z	TK090U65Z	TK065U65Z
Package	TOLL 				
Package body size	10 x 11.7 x 2.3 mm				
$R_{ds(on)}$ Max **(Ω)**	0.19/0.21	0.155/0.17	0.11/0.125	0.090/0.099	0.65
Q_{gd} (nC)	25	29	40	47	62
C_{ISS} (VDS=300V) (pF)	1370	1636	2250	2780	3650

4 DTMOSⅥ (V_{DSS}=650V) series Lineup & Schedule Idea

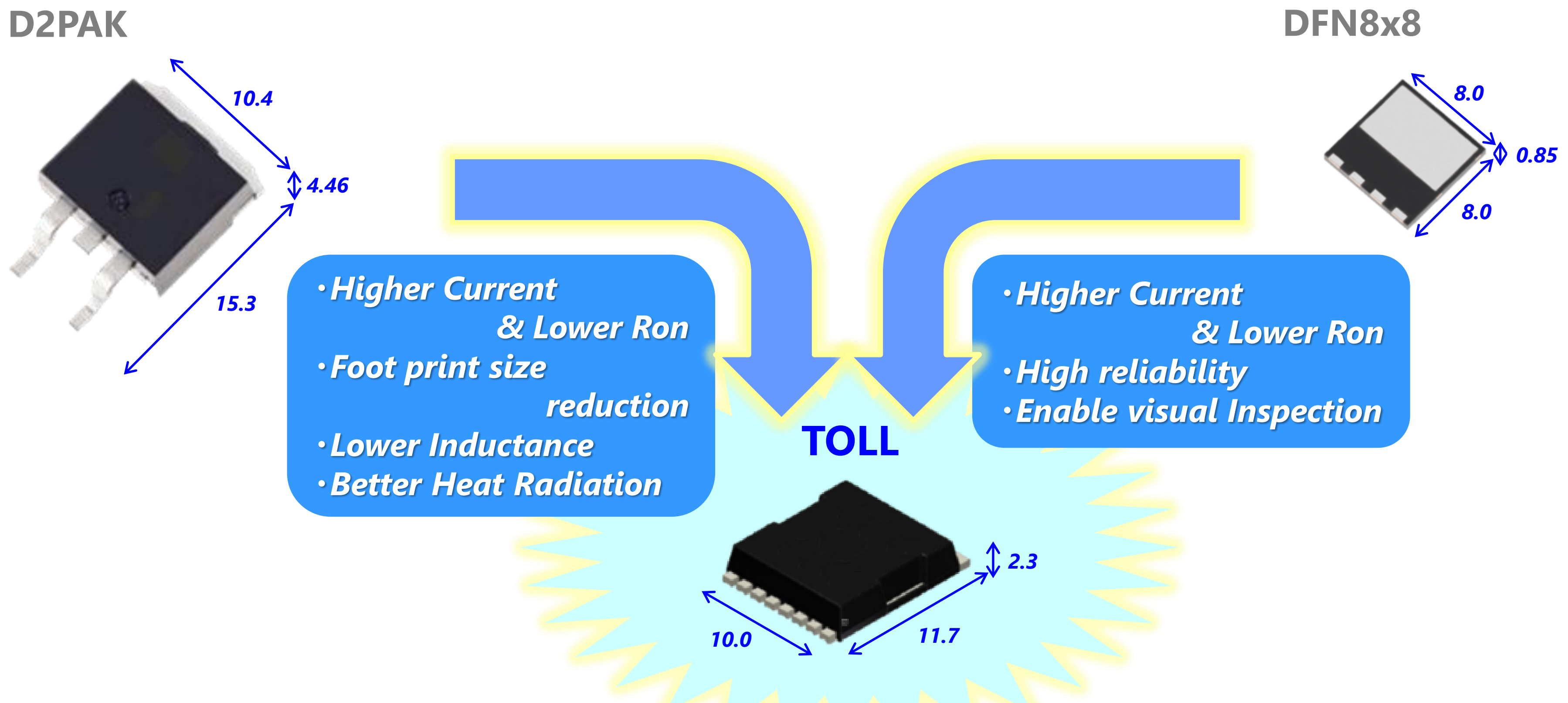
Back to DCDC Conversion, Isolation DAB

$R_{DS(ON)}$ Max (Ω)	DFN8x8	TO-220	TO-220SIS	TO-247	TO-247-4L	TOLL	Q_g Typ. (nC)	C_{iss} (V_{DS}=300V) Typ. (pF)
								
0.19 / 0.21	TK210V65Z MP : OK	TK190E65Z MP : OK	TK190A65Z MP : OK			TK190U65Z MP : OK	25	1370
0.155 / 0.17	TK170V65Z MP : OK	TK155E65Z MP : OK	TK155A65Z MP : OK			TK155U65Z MP : OK	29	1635
0.11 / 0.125	TK125V65Z MP : OK	TK110E65Z MP : OK	TK110A65Z MP : OK	TK110N65Z MP : OK	TK110Z65Z MP : OK	TK110U65Z MP : OK	40	2250
0.090 / 0.099	TK099V65Z MP : OK	TK090E65Z MP : OK	TK090A65Z MP : OK	TK090N65Z MP : OK	TK090Z65Z MP : OK	TK090U65Z MP : OK	47	2780
0.065				TK065N65Z MP : OK	TK065Z65Z MP : OK	TK065U65Z MP : OK	62	3650
0.040				TK040N65Z MP : OK	TK040Z65Z MP : OK		105	6250

4 New SMD Package “TOLL” for DTMOS

Back to DCDC Conversion, Isolation DAB

TOLL package will provide “High Efficiency” by Kelvin connection and “High Power Density” by compact package size



◆**Target Application**

: Server & Telecom Power, Industrial Power, PV inverter, etc.

5 MCU

M4K Series ARM Cortex-M4

Robustness | High efficiency · Low loss | Small size package

Back to AC Input and PFC Stage

Back to DCDC Conversion, Isolation DAB

Value provided

System cost down, high efficiency system, development efficiency improvement

1 Built-in Arm® Cortex®-M4 CPU core

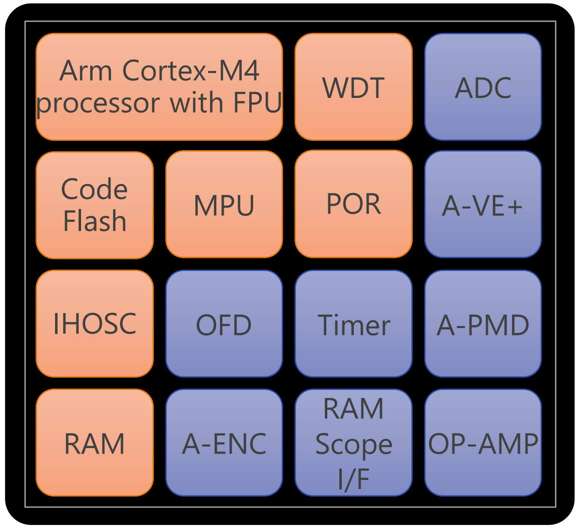
Built-in Cortex-M4 core with Thumb instruction set improves energy efficiency. Various development tool and their partners allow users many options.

2 Suitable for sensing analog signal

Built-in multi-channel ADC and CPU system executes sensing data processing efficiently at low cost

3 Small self-contained MCU system with memory

Cortex-M4 and Toshiba process technology bring to the small package an entire system with code and data flash for reduced footprint and reduced power consumption.

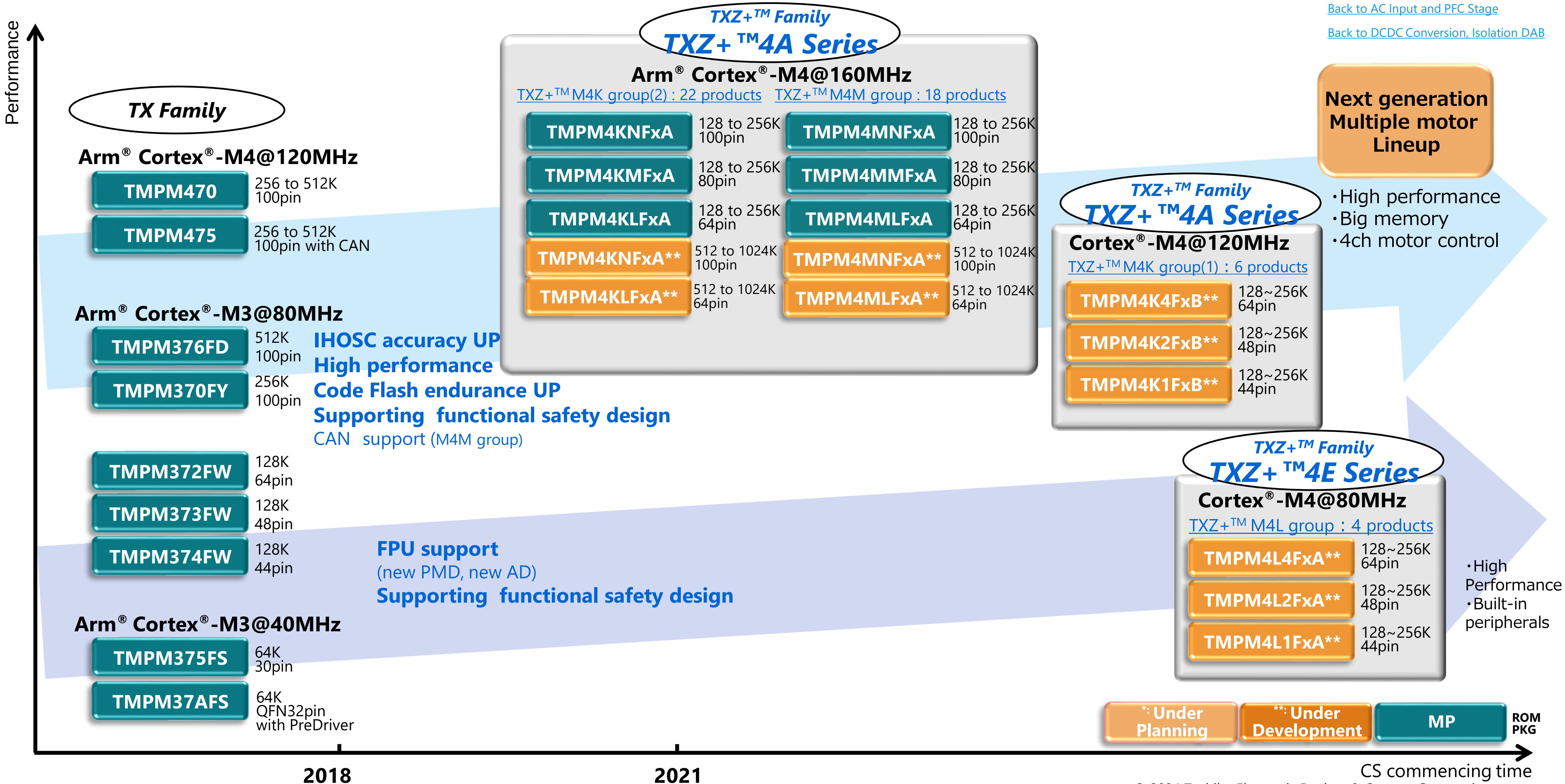


Sample Line Up

Part number	TMPM4KNWAFG	TMPM4KNWADFG
Package	LQFP 100	QFP 100
Maximum operation frequency	160 MHz	160 MHz
Code Flash	128 KB	128 KB
Data Flash	32 KB	32 KB
RAM	24 KB	24 KB
Timer	Up to 12ch	Up to 12ch
UART / SIO	4 / 2	4 / 2
I2C	2	2
ADC	32ch (12bit)	32ch (12bit)
I/O (Mux'd - MAX)	87	87

5 MCU Roadmap

Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB



Back to AC Input and PFC Stage
Back to DCDC Conversion, Isolation DAB

5 TXZ+™ Family/ M4K Group Overview

Arm® Cortex®-M4 core max. frequency 160MHz
Sophisticated control with high-precision analog circuits

- **Cortex-M4 core, Memory, System Control**

- Supply voltage: 4.5 to 5.5V
- Max frequency: 160MHz
- Operation temperature: -40 to 105℃
- Memory
  - Code Flash: 1024KB to 128KB (W/E 100K times)
  - Data Flash: 32KB (W/E 100k times)
  - RAM: 64KB to 24KB
- Low power: Clock gear(1/1 to 1/16 dived)
  Stand-by mode(IDLE/STOP1)
- Built-in OSC(IHOSC): 10MHz
- External interrupt(INT): 22ch
- DMAC: 1unit
- Power on reset(POR)/ Low voltage detection(LVD)
- Frequency detection(OFD): 1ch
- Debug circuit: JTAG/SW,TRACE(4bit), NBDIF (80,64pins: SW only)
- CRC calculation circuit(CRC): 1ch

- **Memory, Package**

Part Number	Code Flash	Data Flash	RAM	Package
TMPM4KNFxAFG	Y: 256KB W: 128KB	32KB	24KB	P-LQFP100-1414-0.50
TMPM4KNFxADFG				P-QFP100-1420-0.65
TMPM4KMFxAFG				P-LQFP80-1212-0.50
TMPM4KLFxAUG				P-LQFP64-1010-0.50
TMPM4KLFxAFG				P-LQFP64-1414-0.80

Part Number	Code Flash	Data Flash	RAM	Package
TMPM4KNFxAFG**	10: 1024KB D: 512KB	32KB	64KB	P-LQFP100-1414-0.50
TMPM4KNFxADFG**				P-QFP100-1420-0.65
TMPM4KLFxAUG**				P-LQFP64-1010-0.50
TMPM4KLFxAFG**				P-LQFP64-1414-0.80

Note1) "x" of Part number means sign of code flash size.
Note2) **: Under development

- **Peripherals (Timer)**

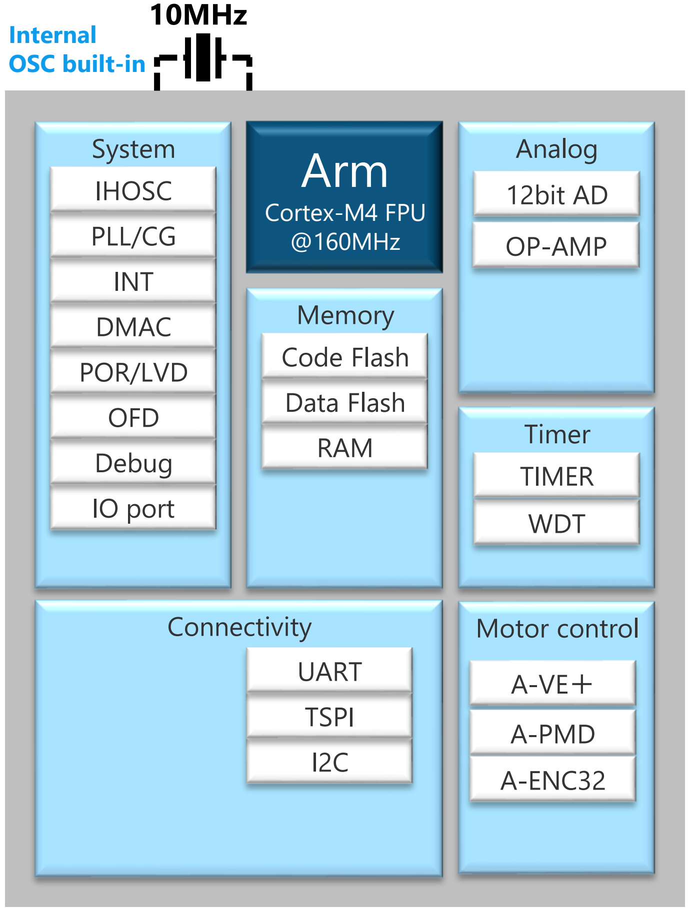
- 32(16)-bit timer: 6(12)ch
- Independent Watchdog timer(WDT): 1ch

- **Peripherals (Analog)**

- 12-bit AD converter: 32ch (3unit/min. 1µs)
- OP-AMP: 3ch

- **Peripherals (Connectivity & Motor Control)**

- CAN: -
- UART: 4ch
- TSPI(SPI/SIO): 2ch
- I2C: 2ch
- Advanced Vector Engine plus(A-VE+): 1ch
- Advanced programmable motor driver(A-PMD): 3ch
- Advanced encoder input(A-ENC32): 3ch



Note3) Specification given in this page is the maximum specification of M4K group(2).
Please refer to a function table for details.

Robustness | High efficiency · Low loss | Small size package

Back to Additional Controls for Safety and Reliability

Value provided

H-Driver to control bi-stable dual latched relays for home chargers

1 Efficient design to handle dual latched relays

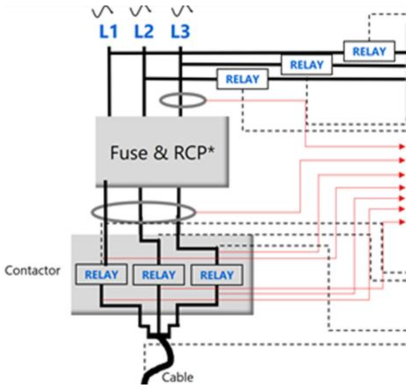
This 2 channel MCD is designed to drive two H bridges via PWM controlled constant current.

2 Low R_{DSON}

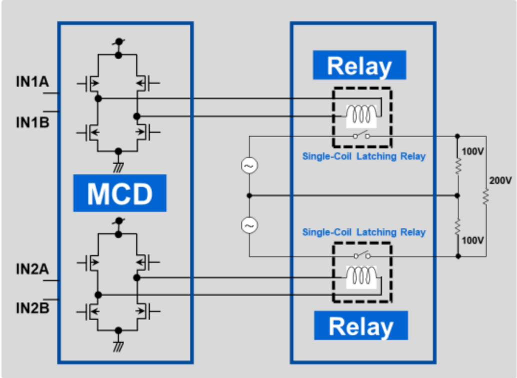
Good efficiency from the low on-resistance to help run cool and save power

3 Small package

Available in a small 16 lead QFN 3.0x3.0mm package can help save board space



Application Outline



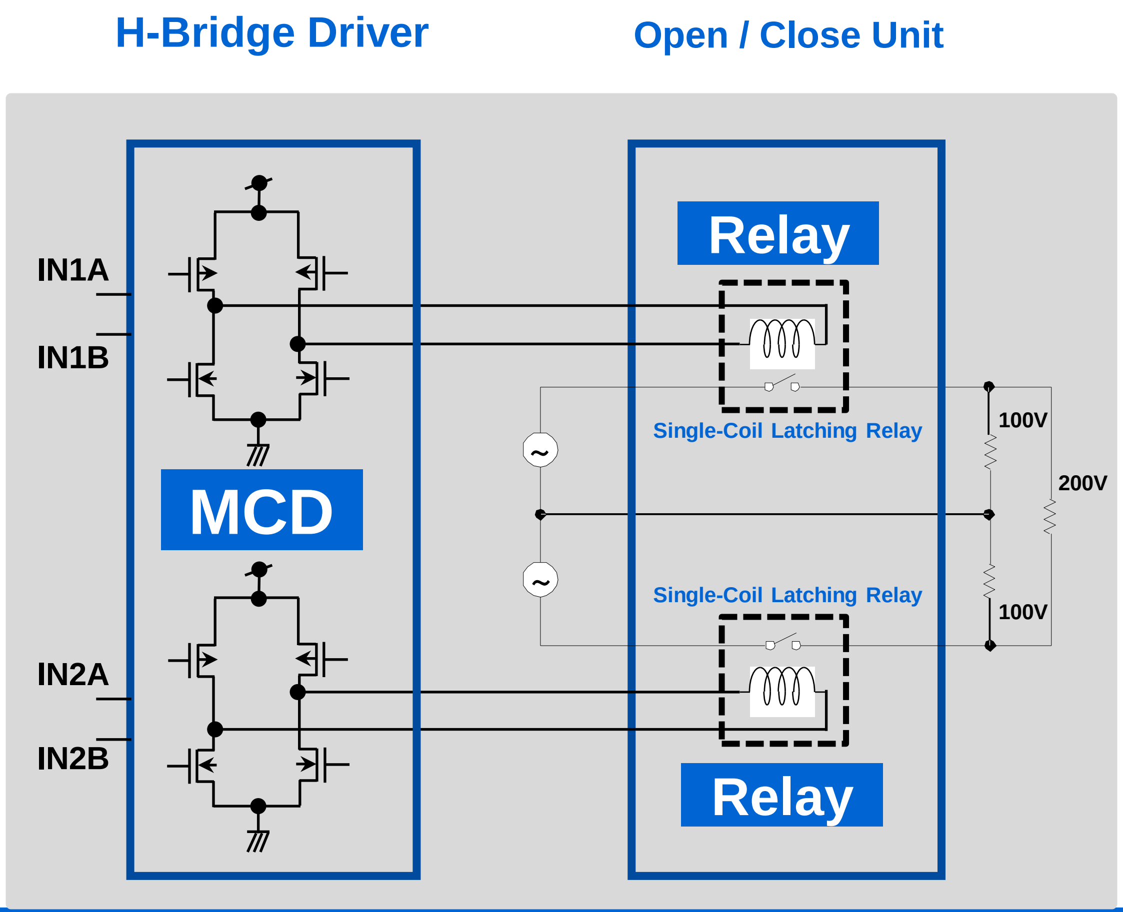
TC78H660 Use Case

Sample Line Up

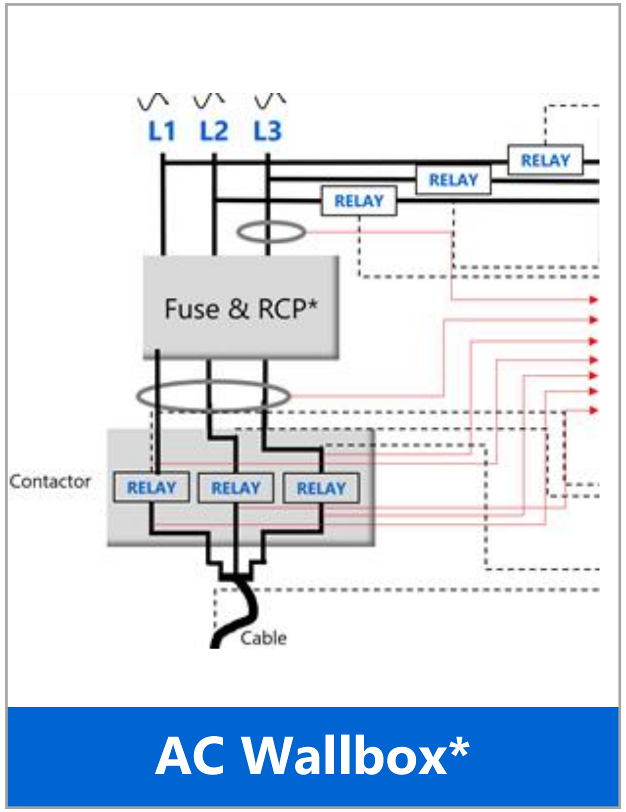
Part number	TC78H660FTG	TC78H660FNG
Package	QFN16 3x3mm	SSOP 16 5.0x6.4mm
Operating Voltage (V)	2.5V to 16.0	
Output Current (A)	2.0	
R_{DSON} (Ω)	0.48	
Built-in V_{CC} Regulator?	Yes	
Error Detect Functions	Thermal Shutdown, Over Current Under Voltage Lockout	

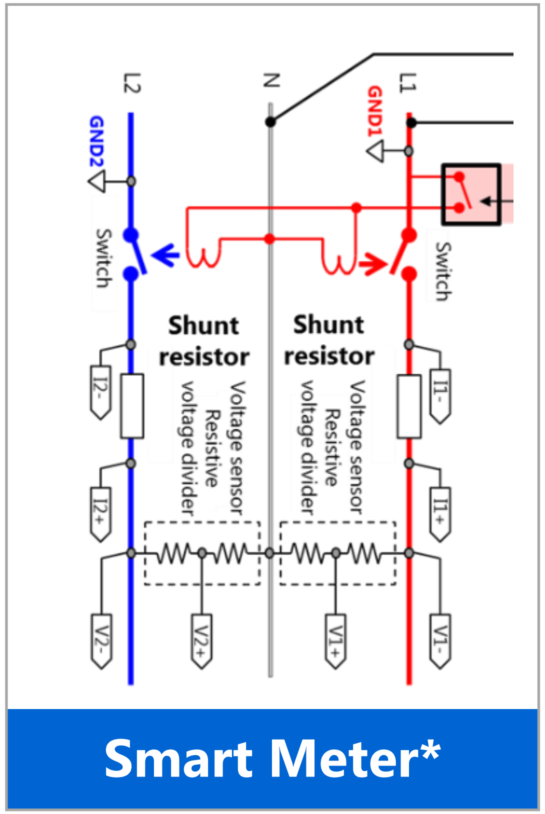
6 "Special" use case: MCD as H-Bridge Driver for latching relays

Back to Additional Controls for Safety and Reliability



Applications using latching relays





1x TC78H660* for driving 2x bi-stable latching relays

*Using Toshiba MCD for latching relays for above application examples is under customer's own responsibility, no guarantee by Toshiba

TC78H660FTG/FNG 18V/2.0A 2ch Brushed DC Motor Driver

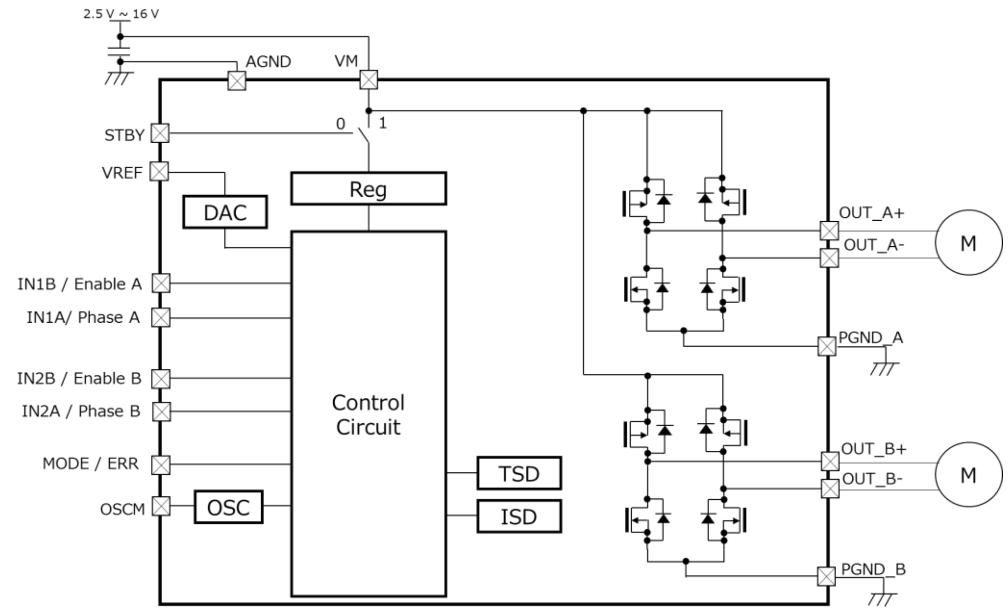
Back to Additional Controls for Safety and Reliability

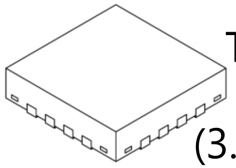
Dual channel integrated H-Bridge / Small Package

Features

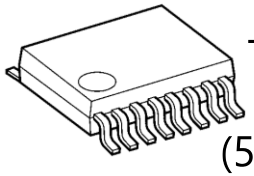
- **Operation supply voltage range**
  VM = 2.5V to 16V
- **Multi I/F**
  "Phase & Enable" and "IN" input mode
- **Low Voltage Interface**
  Operates input signals with 1.8V
- **Low Rds(on)**
  $R_{DS(on)(H+L)}$ = 0.48Ω(Typ.)
- **Energy saving**
  Ultra-low stand-by current 0.1μA (max)
- **Current detection**
  No need of external current detection resistor (ACDS)
- **Single power supply**
  BOM reduction with integrated regulator

Block Diagram





TC78H660**FTG**
QFN16
(3.0mm × 3.0mm)



TC78H660**FNG**
SSOP16
(5.0mm × 6.4mm)

MCD Driver for Locking Charge Plug

TB67H450AFNG / TB67H451AFNG

Robustness | High efficiency · Low loss | Small size package

Back to Additional Controls for Safety and Reliability

Value provided

For added safety, an MCD can manage and drive the locking mechanism on the charging plug

1 Wide voltage range operation

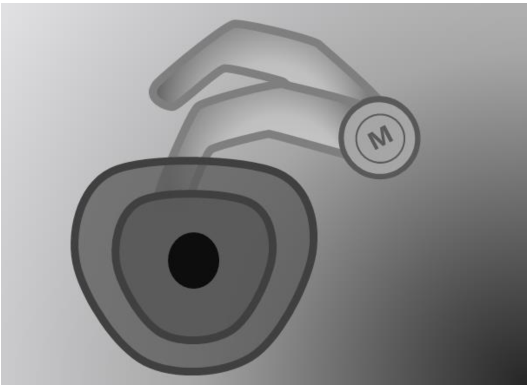
This brush motor controller part can fully operate from 4.5V (ideal for batteries) to 44.0V.

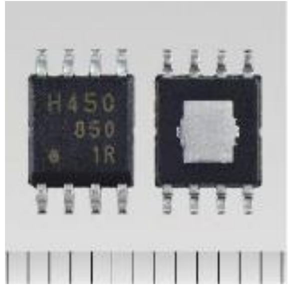
2 Low R_{SDON}

Low R_{SDON} allows for low standby current, better power savings when not in use.

3 Small package

Small 8pin HSOP package provides flexible use in tight spaces.



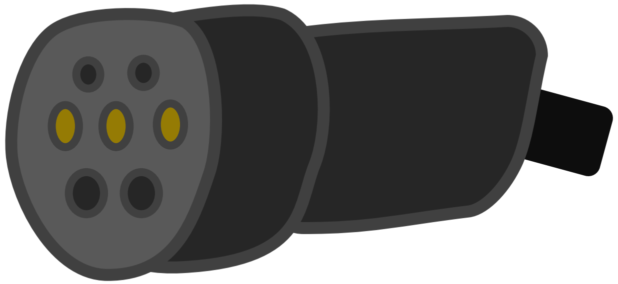


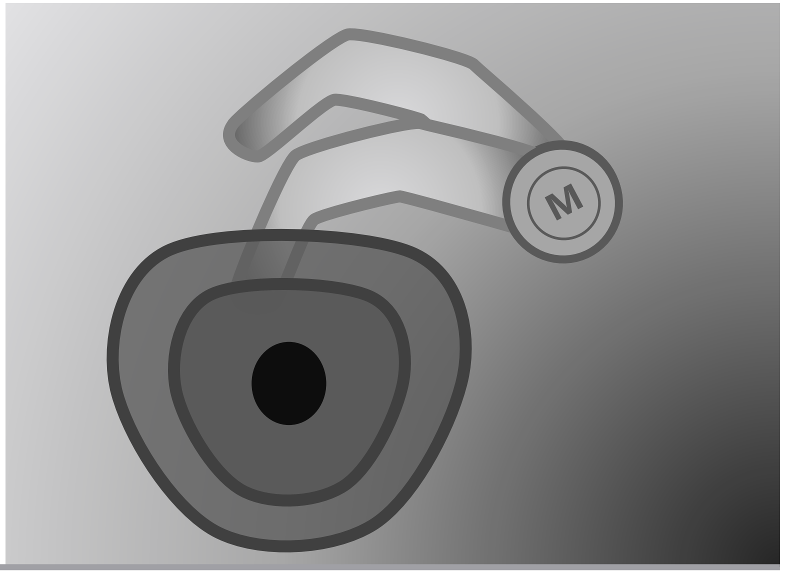
Line up

<table>
<tr><td colspan="2">Part number</td><td>TB67H450AFNG</td><td>TB67H451AFNG</td></tr>
<tr><td colspan="2">Package</td><td colspan="2">HSOP 8 pin 4.9 x 6.0mm</td></tr>
<tr><td colspan="2">Operating Voltage (V)</td><td colspan="2">4.5 to 44.0</td></tr>
<tr><td colspan="2">Output Voltage/Current (V/A)</td><td colspan="2">50 / 3.5</td></tr>
<tr><td colspan="2">R_{DSON} (Ω)</td><td colspan="2">0.60</td></tr>
<tr><td colspan="2">Standby Current (μA)</td><td colspan="2">Yes</td></tr>
<tr><td rowspan="3">Return after error detection</td><td>Under Voltage Lock Out</td><td colspan="2">Return by Power On</td></tr>
<tr><td>Under Current (ISD)</td><td>Latch Operation</td><td rowspan="2">Auto Resume</td></tr>
<tr><td>Thermal Shutdown (TSD)</td><td>Auto Resume</td></tr>
</table>

Use case: MCD for charging cable lock/unlock mechanism

Back to Additional Controls for Safety and Reliability

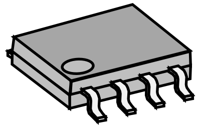




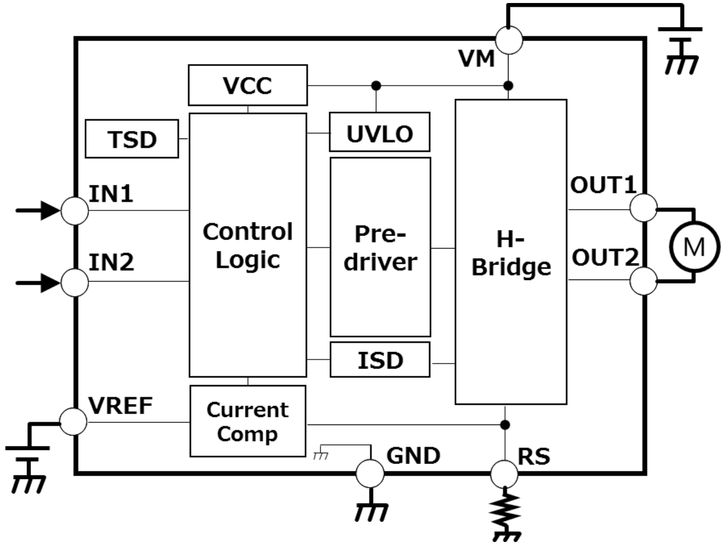
electromechanical
cable lock mechanism

DC Motor for the mechanical lock using TB67H451A as motor driver

- 50V, 3.5A Brushed DC Motor Driver
- Small 8-pin package
- Drop-in replacement to TI equivalent



P-HSOP8
(4.9×6.0mm)



Back to Additional Controls for Safety and Reliability

7

TB67H450AFNG / TB67H451AFNG 50V/3.5A, 1ch Brushed DC Motor Driver

Small Package / Compatibility / Low Standby Current

Features

- **8pin Package**
  Industry standard package and pinout
- **Energy saving**
  Standby current 1μA max
  Automatic standby mode
- **Low Rds(on)**
  $R_{DS(on)(H+L)}$ = 0.6Ω(Typ.)
- **Wide operating voltage**
  VM=4.5V to 44V
- **Constant current function**
  Adjustable with VREF voltage and sense resistor
- **Various Abnormal-state detection**
  Under Voltage Lockout (UVLO)
  Over Current (ISD)
  Thermal Shutdown (TSD)

Compatibility

<table>
<tr><th colspan="2">Specification Item</th><th>Allegro
A4950</th><th>TI
DRV8870</th><th>Toshiba
TB67H450A</th><th>Toshiba
TB67H451A</th></tr>
<tr><td colspan="2">Output voltage/current</td><td>40V/3.5A</td><td>50V/3.6A</td><td colspan="2">50V/3.5A</td></tr>
<tr><td colspan="2">Operating voltage</td><td>8~40V</td><td>6.5~45V</td><td colspan="2">4.5~44V</td></tr>
<tr><td colspan="2">Standby current</td><td colspan="2">10μA max.</td><td colspan="2">1μA max.</td></tr>
<tr><td colspan="2">Output on-resistance</td><td colspan="4">0.6Ω</td></tr>
<tr><td rowspan="3">Return After Error Detection</td><td>Under Voltage Lockout</td><td colspan="4">Return by power on</td></tr>
<tr><td>Over Current (ISD)</td><td>Latch Operation</td><td rowspan="2">Auto Resume</td><td>Latch Operation</td><td rowspan="2">Auto Resume</td></tr>
<tr><td>Thermal Shutdown (TSD)</td><td>Auto Resume</td><td>Auto Resume</td></tr>
</table>

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