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Discrete Semiconductor for EV Charger

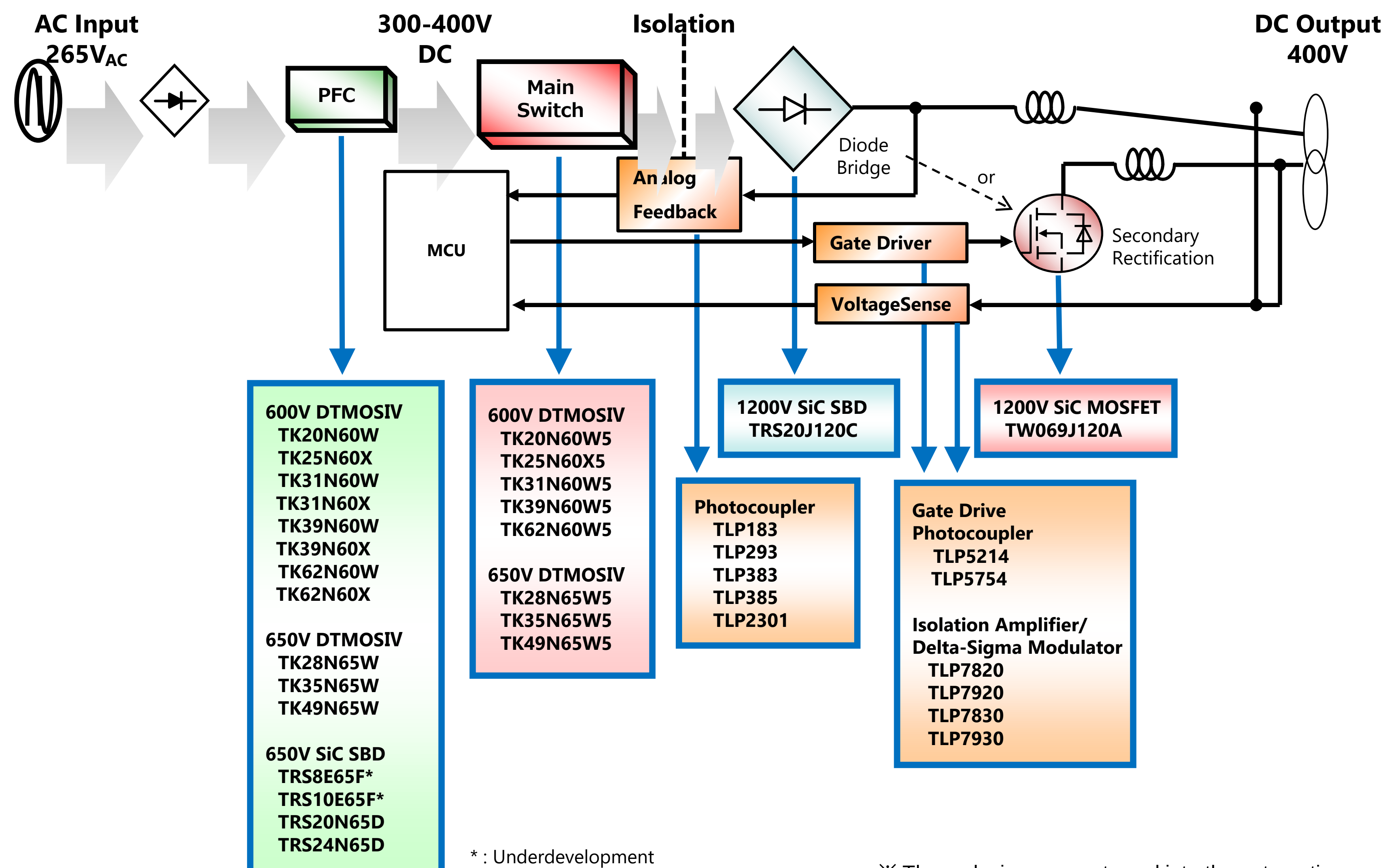
January 2016

Toshiba Discrete Semiconductor Technology Corporation
Global Development Department
Discrete Business Development Division

R630-751-07-15B-032

Toshiba Recommendation for EV Charger

Application Example for EV Charger



* : Underdevelopment

※ These devices are not used into the automotive.

Recommendable Devices for EV Charger

MOSFET

Package name (Toshiba)	Series	Part Number	Absolute Maximum Ratings			Circuit Configuration	$R_{DS(ON)}$ max(Ω)	Q_g typ.	C_{iss} typ.	Remark
			V_{DSS}(V)	V_{GSS}(V)	I_D(A)	Circuit Configuration	V_{GS}=10V	(nC)	(pF)	
 TO-247	Standard	TK20N60W	600	±30	20	N-ch	0.155	48	1680	DTMOSIV
		TK31N60W		±30	30.8	N-ch	0.088	86	3000	DTMOSIV
		TK39N60W		±30	38.8	N-ch	0.065	110	4100	DTMOSIV
		TK62N60W		±30	61.8	N-ch	0.04	180	6500	DTMOSIV
		TK28N65W	650	±30	27.6	N-ch	0.11	75	3000	DTMOSIV
		TK35N65W		±30	35	N-ch	0.08	100	4100	DTMOSIV
		TK49N65W		±30	49.2	N-ch	0.055	160	6500	DTMOSIV
	High-Speed Diode	TK20N60W5	600	±30	20	N-ch	0.175	55	1800	DTMOSIV
		TK31N60W5		±30	30.8	N-ch	0.099	105	3000	DTMOSIV
		TK39N60W5		±30	38.8	N-ch	0.074	135	4100	DTMOSIV
		TK62N60W5		±30	61.8	N-ch	0.045	205	6500	DTMOSIV
		TK25N60X5		±30	25	N-ch	0.14	60	2400	DTMOSIV-H
		TK28N65W5	650	±30	27.6	N-ch	0.13	90	3000	DTMOSIV
		TK35N65W5		±30	35	N-ch	0.095	115	4100	DTMOSIV
		TK49N65W5		±30	49.2	N-ch	0.057	185	6500	DTMOSIV
	High-speed switching	TK25N60X	600	±30	25	N-ch	0.125	40	2400	DTMOSIV-H
		TK31N60X		±30	30.8	N-ch	0.088	65	3000	DTMOSIV-H
		TK39N60X		±30	38.8	N-ch	0.065	85	4100	DTMOSIV-H
		TK62N60X		±30	61.8	N-ch	0.04	135	6500	DTMOSIV-H

SiC MOSFET

Package name (Toshiba)	Series	Part Number	Absolute Maximum Ratings			Circuit Configuration	$R_{DS(ON)}$ max(Ω)	Q_g typ.	C_{iss} typ.	Remark
			V_{DSS}(V)	V_{GSS}(V)	I_D(A)		V_{GS}=20V	(nC)	(pF)	
 TO-3P(N)	Silicon Carbide	TW069J120A	1200	+25 −12	47	N-ch	0.069	75	1700	New Product

Recommendable Devices for EV Charger

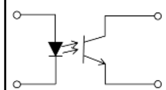
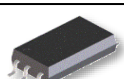
SiC SBD

Package	Part Number	Absolute Maximum Ratings					Circuit Configuration	Electrical Characteristics(Max) (Per Leg)				
		V_{RRM}(V)	$I_{F(DC)}$(A)	I_{FP}(A)	T_j(℃)	T_{stg}(℃)		I_{RRM}(μA)	V_{FM}(V)	@I_{FM}(A)	C_j(pF)(Typ.)	Conditions
 TO-220-2L	TRS8E65F*	650	8	(51)	175	-55～175	Single	(20)	1.7	8	(32)	V_R=650V f=1MHz
	TRS10E65F*		10	(67)				(20)	1.7	10	(39)	
 TO-247	TRS20N65D		20 (Both Legs)	200 (Both Legs)			Center Tap	90	1.7	10	55	V_R=650V f=1MHz
	TRS24N65D		24 (Both Legs)	220 (Both Legs)				90	1.7	12	65	
 TO-3P(N)	TRS20J120C	1200	20	310			Single	90	2	20	105	VR=600V f=1MHz

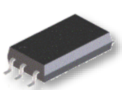
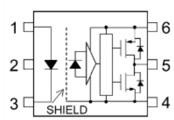
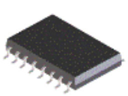
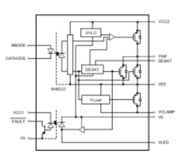
* : Underdevelopment

Recommendable Devices for EV Charger

Photocoupler

Package name (Toshiba)	Function		Part Number	Current Transfer Ratio	Collector -Emitter Voltage	Turn-on/Turn-off Time (IF=16mA,RL=1.9kΩ)	Operating Temperature	Isolation Voltage
				CTR(I_C/I_F) (%)	V_{CEO}(V)	ton/toff(Typ.) (μs)	T_{opr}(℃)	BVs (Vrms)
 SO4	DC input OpenCollector Output	General-purpose	TLP291(SE	50 to 600	80	0.5/40	-55 to 110	3750
		Low Input	TLP293	50 to 600	80	0.4/35	-55 to 125	3750
 4pin SO6		General-purpose	TLP185(SE	50 to 600	80	0.5/40	-55 to 110	3750
		Low Input	TLP183	50 to 600	80	0.4/35	-55 to 125	3750
		20kbps	TLP2301	50 (min.)	40	15/8 ※1	-55 to 125	3750
 4pin SO6L		General-purpose	TLP385	50 to 600	80	0.5/40	-55 to 110	5000
		Low Input	TLP383	50 to 600	80	0.5/40	-55 to 125	5000

Gate Drive Photocoupler

Package name (Toshiba)	Function	Part Number	I_{OP}(Max.) (A)	Threshold LED Input Current	Supply Voltage Operating Range	Propagation Delay Time (Max.)	Operating temperature	Isolation Voltage
				I_{FLH} (Max.) (mA)	V_{CC} (V)	T_{pHL}/T_{pLH} (μs)	T_{opr} (℃)	BVs (Vrms)
 SO6L	Gate Driver RtoR※2 UVLO 	TLP5754	±4.0	4.0	15 to 30	0.15	-40 to 110	5000
 SO16L	Smart Gate Driver Over Current Protection Active Miller Clamp RtoR※2, UVLO 	TLP5214		6.0	15 to 30	0.15	-40 to 110	5000

※1 Propagation Delay Time (Max.) TpLH/TpHL (μs) (IF=1mA,RL=10kΩ)
※2 RtoR : Rail to rail output

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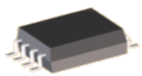
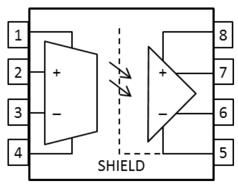
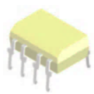
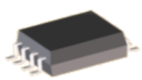
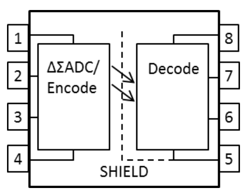
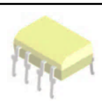
Recommendable Devices for EV Charger

Isolation Amplifier / Delta-sigma Modulator

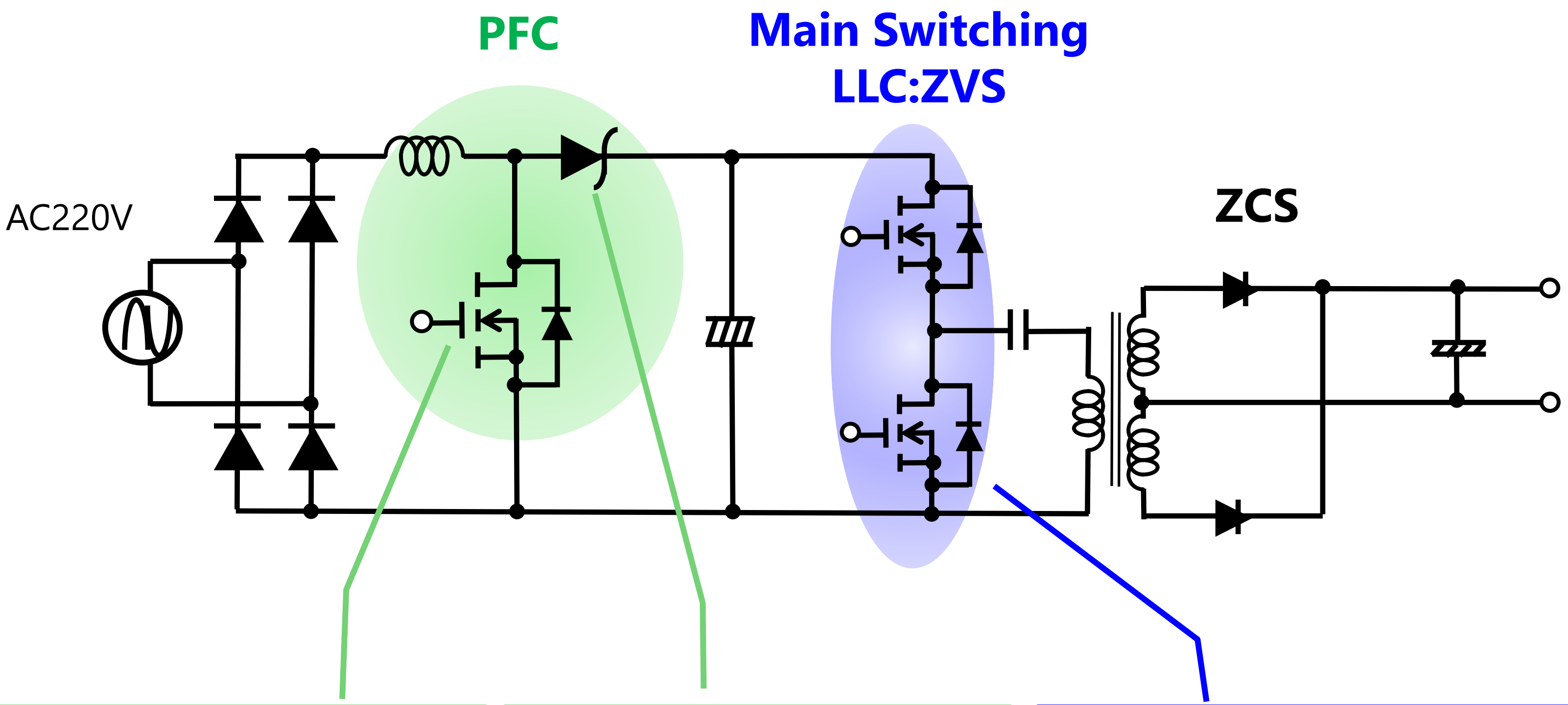
Package name (Toshiba)	Function	Part Number	Gain (Ta=25°C)	Supply Current (Max.)	Supply Voltage	Equivalent input resistance	Operating temperature	Isolation Voltage
				IDD1 (mA)[※3] IDD2 (mA)[※4]	VDD1 (V) VDD2 (V)	RIN (kΩ)	Topr (℃)	BVs (Vrms)
 SO8L	Isolation Amplifier (Analog Output) 	TLP7820	8.2(typ.) RankB: 8.16 to 8.24 RankA: 8.12 to 8.28 None: 7.95 to 8.44 (V/V)	12 10	4.5 to 5.5 3.0 to 5.5	78	-40 to 105	5000
 DIP8		TLP7920		12 10	4.5 to 5.5 3.0 to 5.5	78	-40 to 105	5000
 SO8L	Delta-Sigma Modulator (Digital Output) 	TLP7830	-1 to +1 (%)	12 8	4.5 to 5.5 3.0 to 5.5	78	-40 to 105	5000
 DIP8		TLP7930		12 8	4.5 to 5.5 3.0 to 5.5	78	-40 to 105	5000

※3 IDD1 : Input side supply current
※4 IDD2 : Output side supply current

Circuit Topology
&
Example of Recommended Device

Circuit Topology : 1Φ Input (1)

Single Phase Input : PFC+LLC Solution (1.5kW~ 2.0kW)



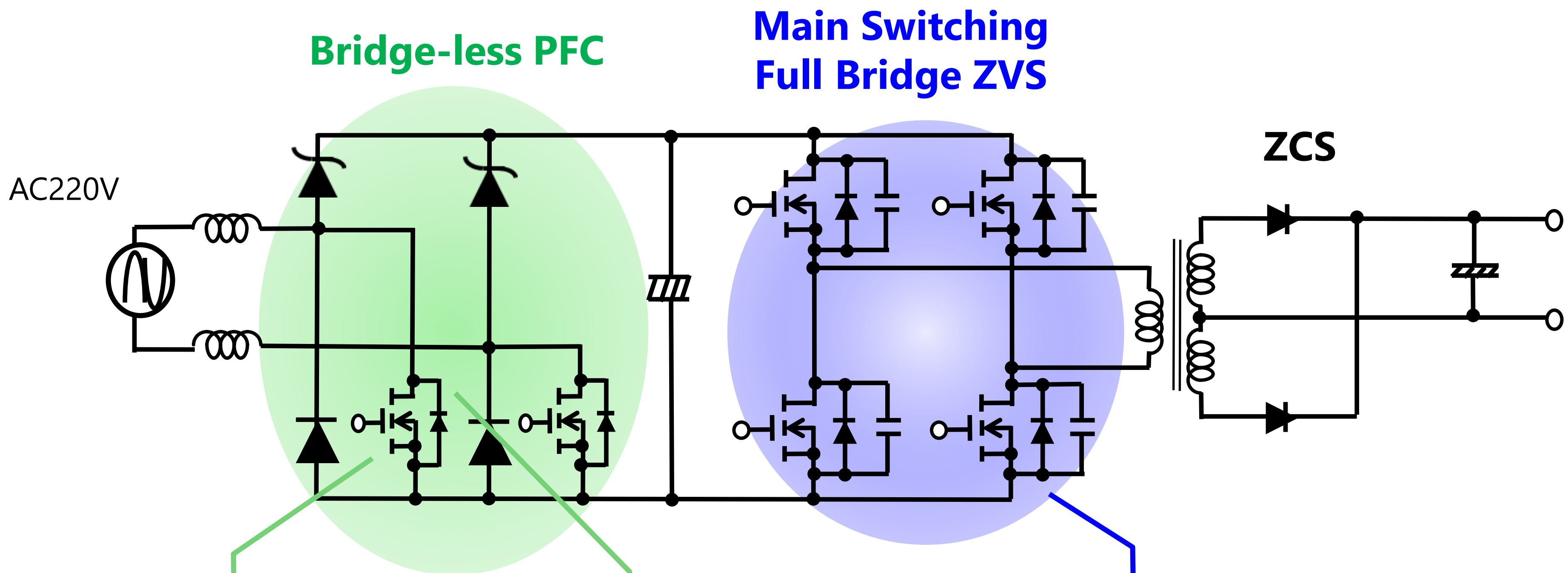
DTMOSIV(1pc) for PFC
- TK39A60W
- TK31N60W

SiC SBD (1pc) for PFC
- TRS8E65F (Feb./16 ES)
- TRS10E65F (Mar./16 ES)

DTMOSIV(2pcs) for Main Sw'g
- TK20N60W5
- TK25N60X5

Circuit Topology : 1Φ Input (2)

Single Phase Input : Bridge-less PFC+FB Solution (3.3kW)



DTMOSIV(2pcs) for PFC
TK31N60W
TK39N60W

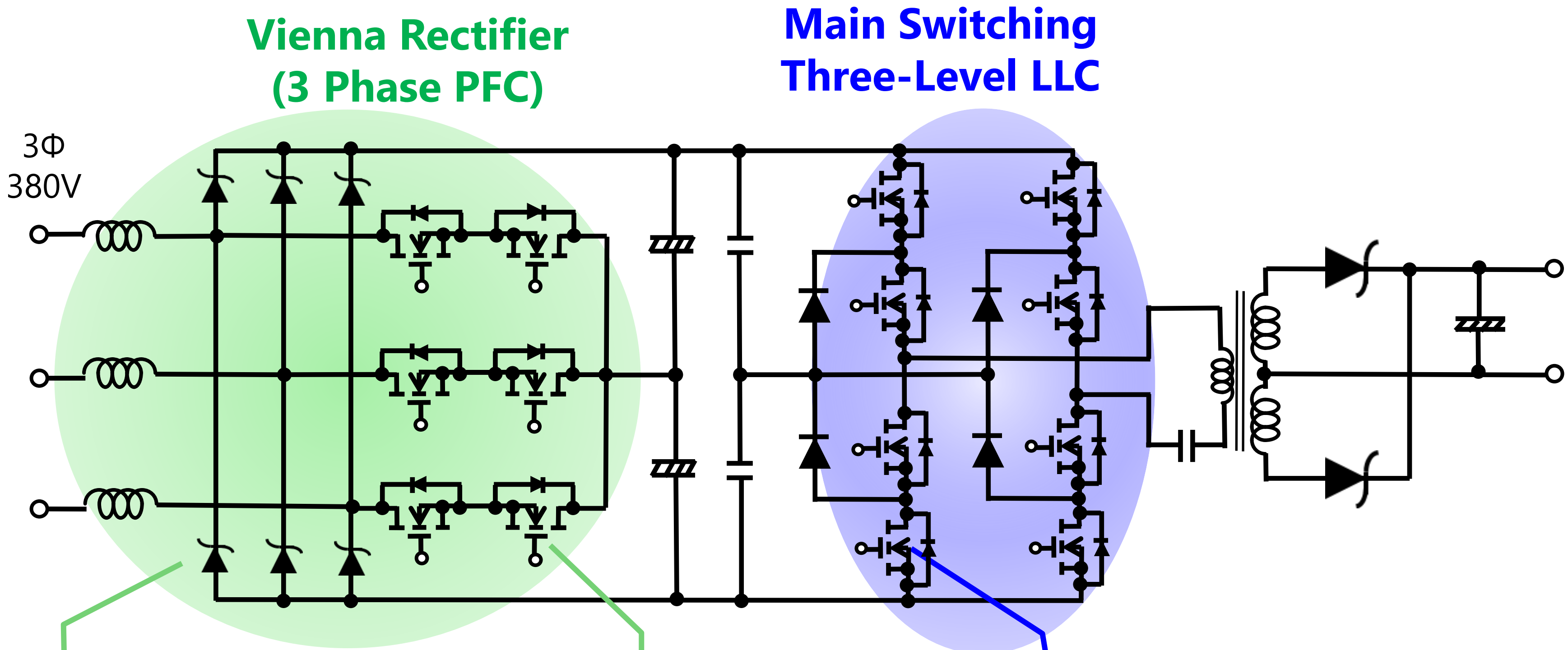
SiC SBD(2pcs) for PFC
TRS10E65F (Feb./16 ES)

Note : there is
possibility to use 2phase inter-leaved

DTMOSIV(4pcs) for Main Sw'g
TK31N60W5
TK39N60W5

Circuit Topology : 3Φ Input (1)

Three Phase Input : Vienna PFC+3Level LLC （6.6 ~15kW)



SiC SBD (6pcs) for Rectification
TRS20J120C

DTMOSIV(6pcs) for PFC
TK62N60W / TK62Z60X
TK100L60W
TK49N65W

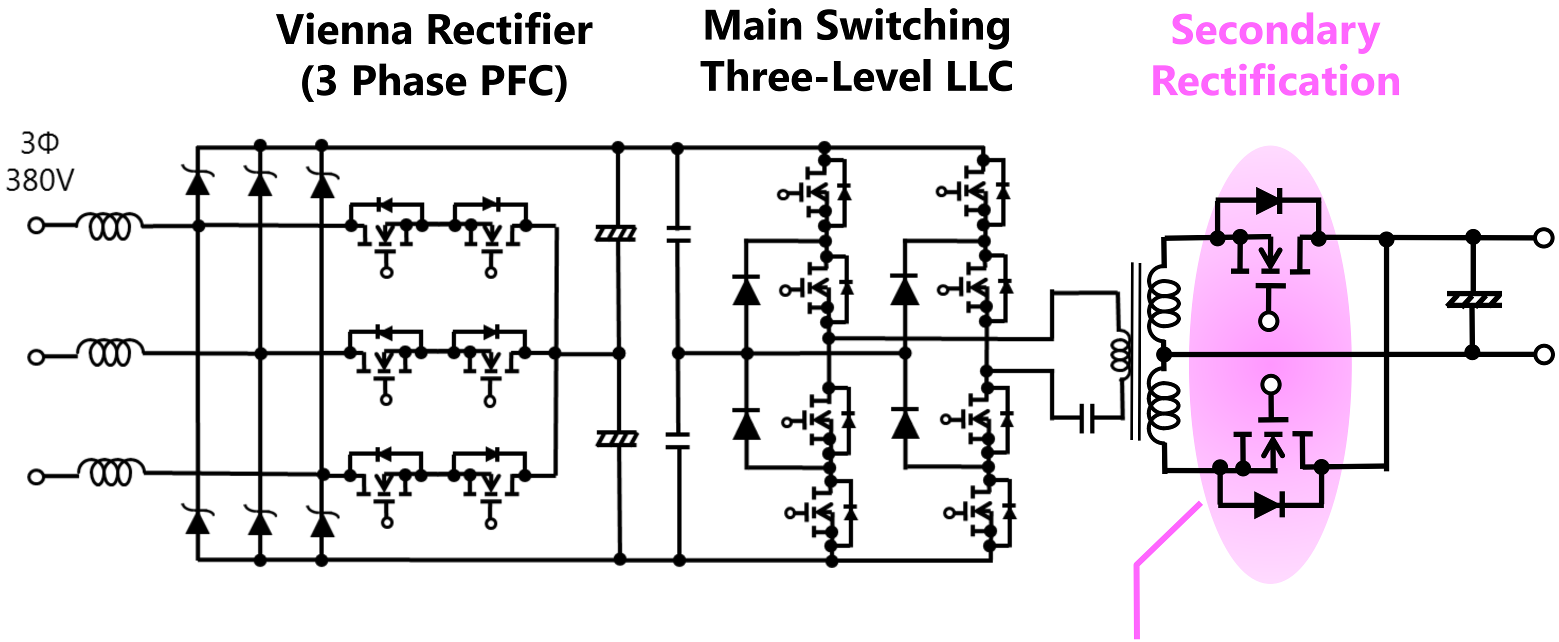
DTMOSIV(8pcs) for Main Sw'g
TK39N60W5 / TK49N65W5
TK62N60W5

Remarks : MOSFETs will used with 2 parallel operation for exceeding 10kW power.
In future, it will be possible to change 1200V SiC MOSFET instead of the above 600V SJMOS.

Circuit Topology : 3Φ Input (1)

Three Phase Input : Vienna PFC+3Level LLC (< 15kW)

Applied Synchronous Rectification by SiC MOSFET

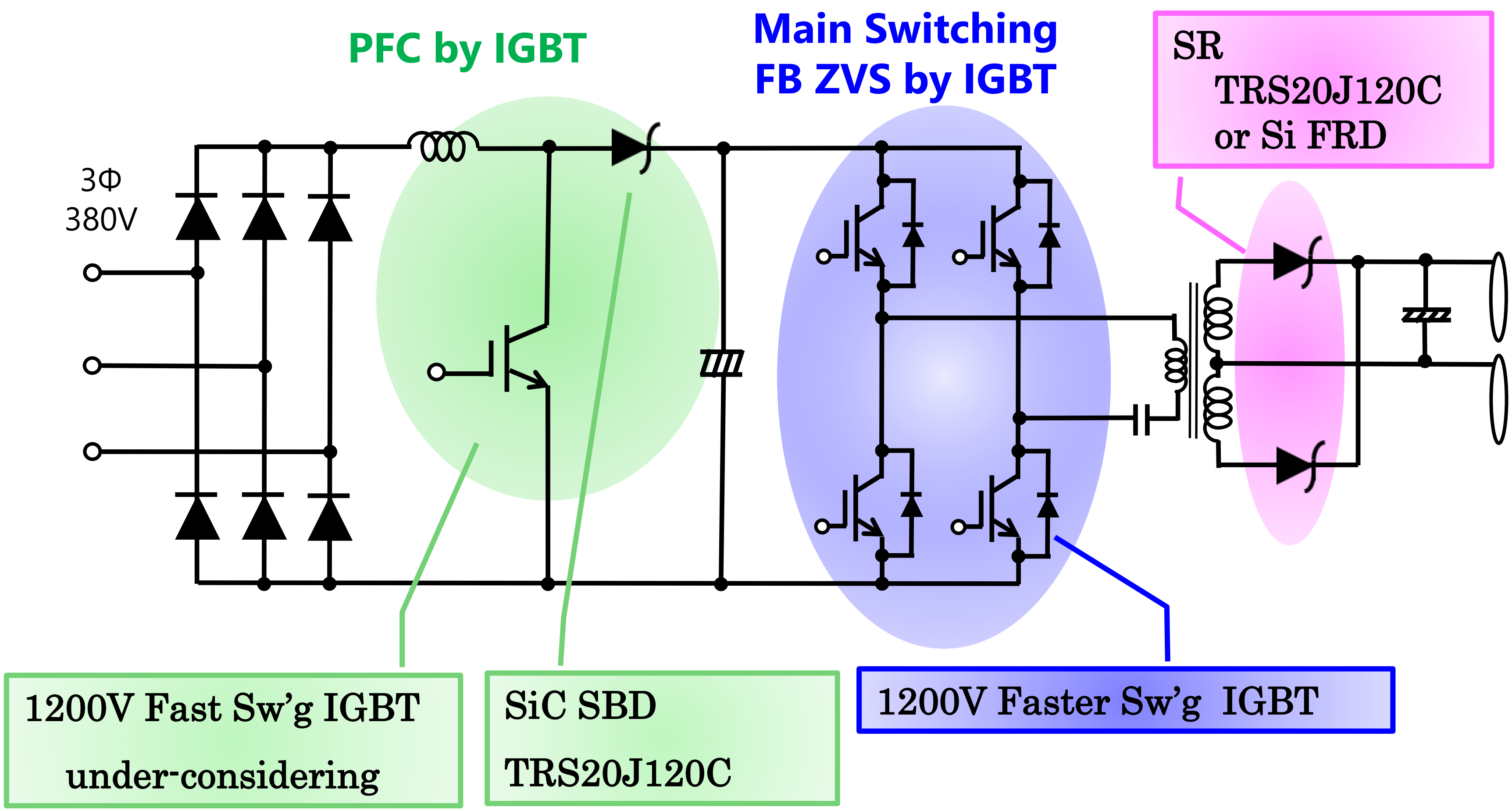


Synchronous Rectification

TW069J120A
(1200V/69mΩ/SiC MOSFET

Circuit Topology : 3Φ Input (2)

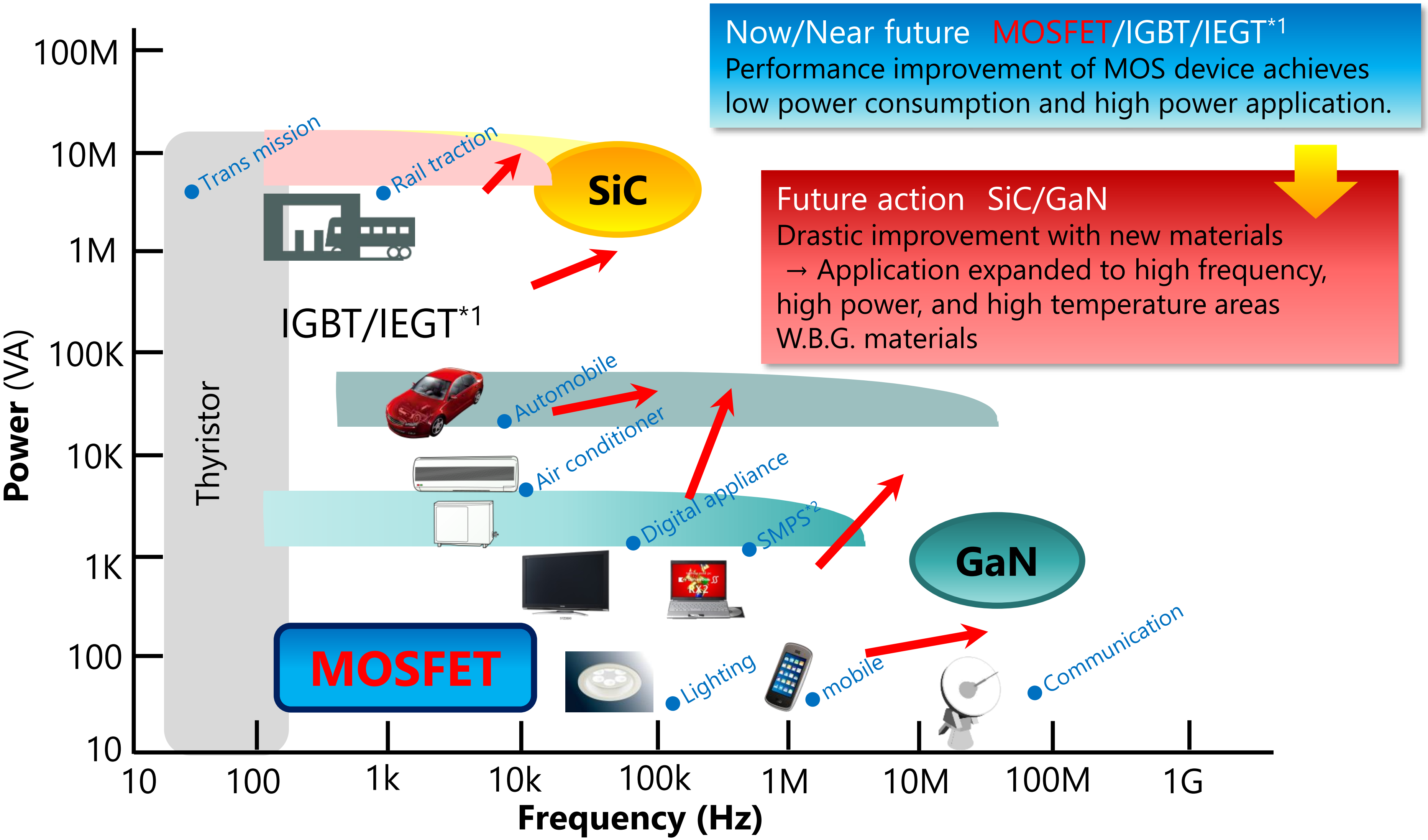
Three Phase Input : IGBT Solution (_< 30kW)



Feature of Toshiba Power Devices & Photocoupler

Power MOSFETs

Power Device Market Trend (Power Density)



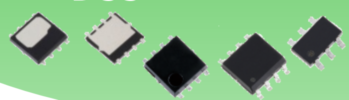
*1 : IEGT : Injection Enhanced Gate Bipolar Transistor
*2 : SMPS : Switched-mode power supply

Toshiba's MOSFETs Meet a Wide Range of Application Needs.

Small Low-On-Resistance MOSFETsMOSFET
V_{DSS}=12～60V

The combination of excellent trench process and packaging technologies provide low on-resistance. This helps to improve the performance of your applications.

Low Voltage MOSFETs
V_{DSS}=12V～250V



Latest Trench MOS
U-MOSVIII-H / U-MOSIX-H Series

High-efficiency MOSFET series for AC-DC and DC-DC power supplies,fabricated using the latest Gen-8 / 9 trench-gate process

Mid-High Voltage MOSFETs
V_{DSS}=200V～900V

Super-Junction DTMOSIV Series
New π-MOSⅧ Series

The super-junction DTMOS Series achieves low on-resistance and low gate charge (Qg) due to the use of the latest super-junction structure.
The latest addition to the π-MOS portfolio, the π-MOSVII Series offers reduced capacitances due to optimized chip design and is available with a greatly wider range of electrical characteristics.

Automotive MOSFETs

Automotive-grade MOSFETs feature low on-resistance, low capacitance, high current and high quality, and help improve the performance and reduce the power consumption of automotive applications.

Toshiba's POWER MOSFETs

Low Voltage MOSFETs

the latest Gen-8 trench-gate process
U-MOSⅧ-H Series V_{DSS} =20 V to 250 V

Development of the **U-MOSIX-H** series is started by the latest generation

I develop a new package and extend development for industry, Automotive

LV-MOS

High Voltage MOSFETs

DTMOSⅣ Standard High-Speed Switching with a high-speed diode Series V_{DSS}=600V、650V
Start the development of the 800V product

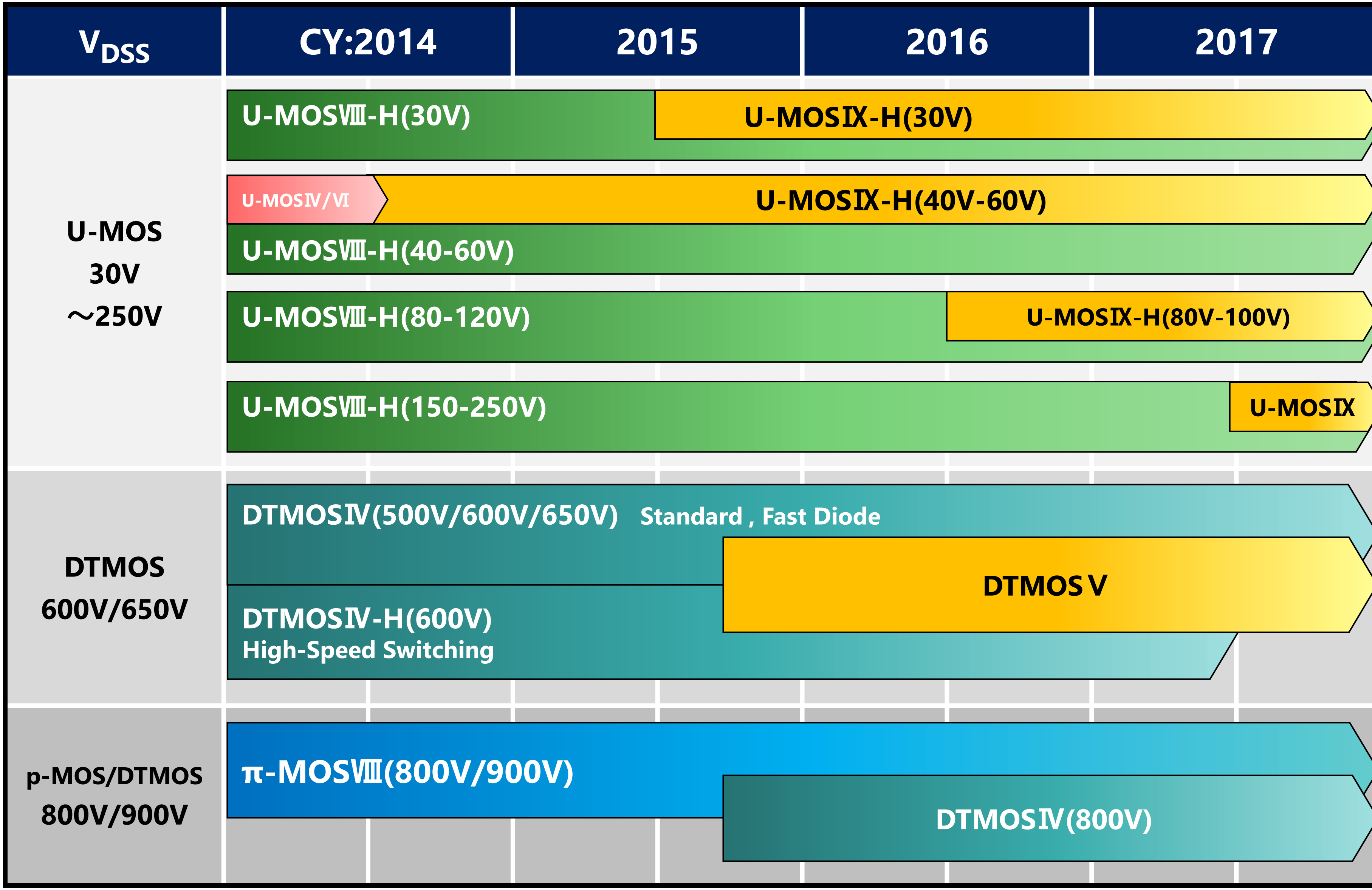
π-MOSⅧ High Voltage (V_{DSS}=800~900V)

New Package for DTMOSⅣ-H
TO-247 4pin package for High Power SPS

HV-MOS

These devices help to save energy and improve power efficiency.

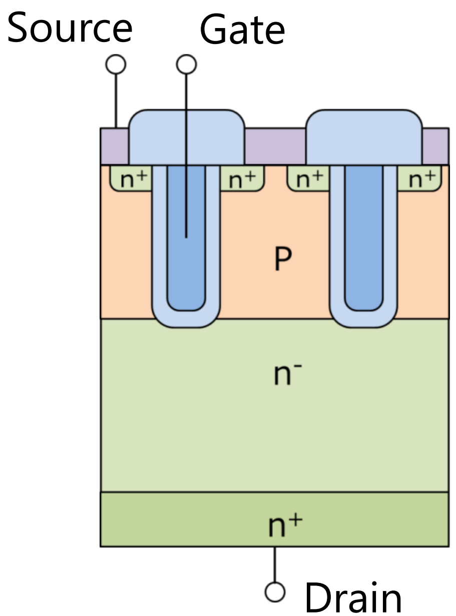
Power MOSFET Design Road Map



Structures of Toshiba MOSFETs

U-MOS

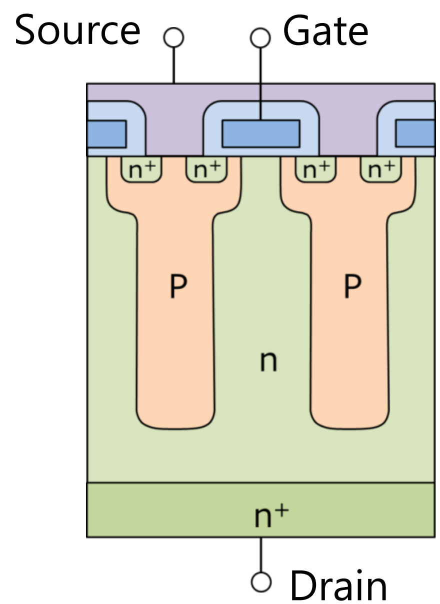
Trench Structure



Higher channel density is achieved by connecting channels vertically to form a U-groove at the gate region, a structure that yields a lower on-resistance than other MOSFET structures. The trench structure is primarily used for relatively low-VDSS MOSFETs.

DTMOS

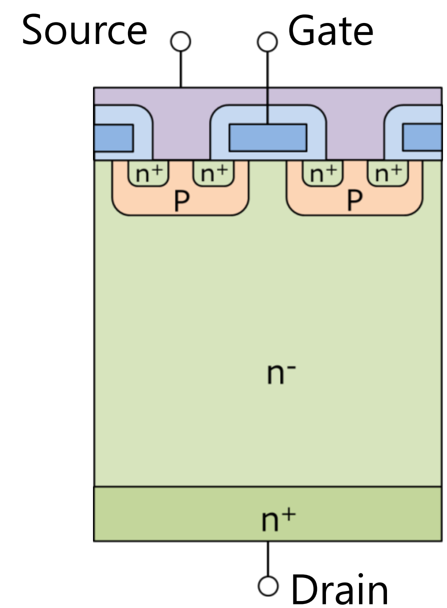
Super-Junction Structure



The super-junction structure, which has P-type pillar layers as shown at left, realizes high withstand voltage and on-resistance lower than the conventional theoretical limit of silicon.

π-MOS

Double-Diffusion Structure



Toshiba Power MOSFETs use a double-diffusion MOS (D-MOS) structure, which provides high withstand voltage, to form channels. This structure is especially well suited to high withstand voltage and high-current devices.
A high level of integration yields a high-performance Power MOSFET with low on-resistance and low power loss.

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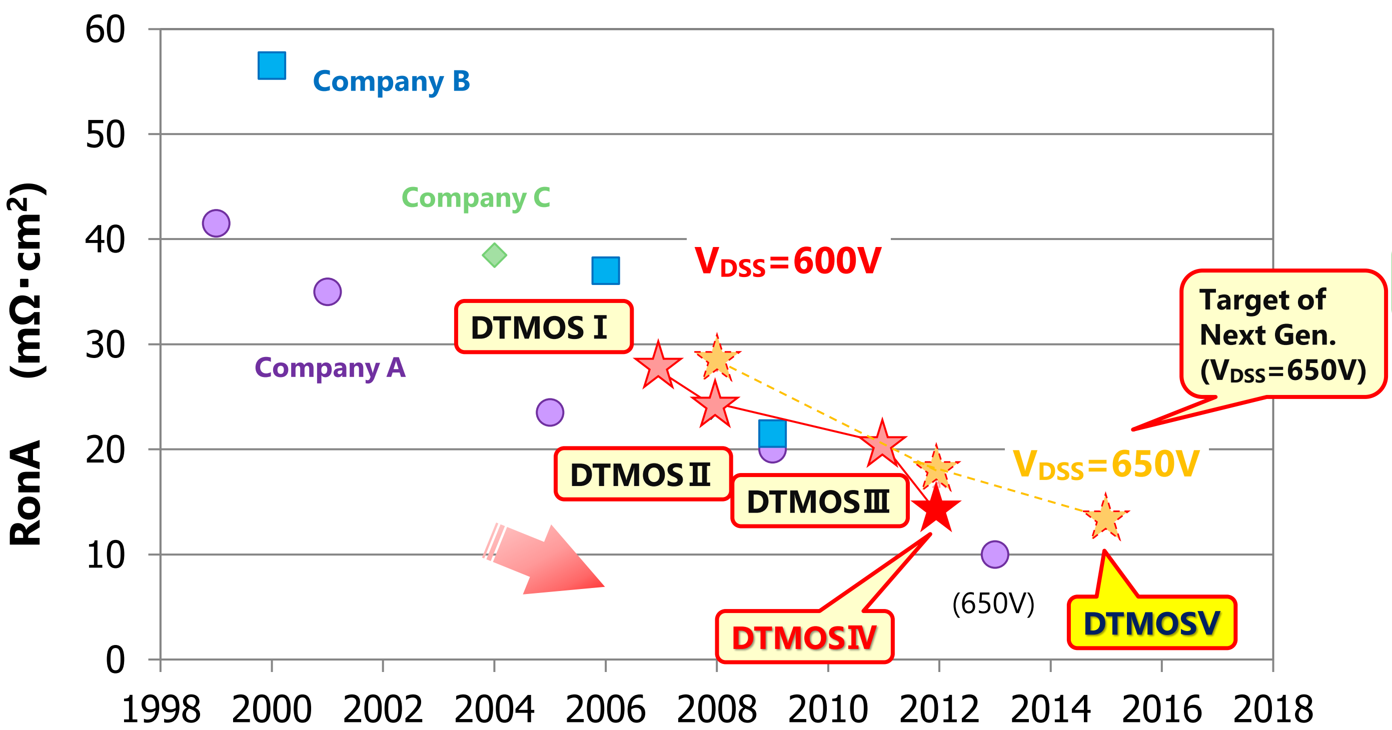
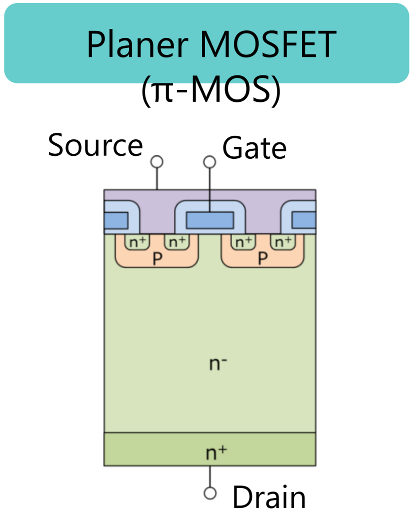
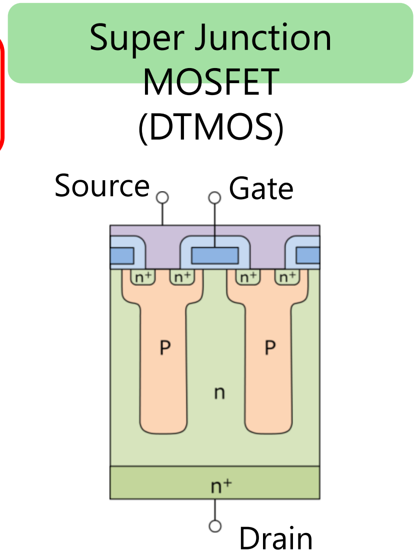
DTMOS
(Toshiba SJMOS)

TOSHIBA SJMOS's (DTMOS) Trend

DTMOS supporting higher efficiency & compact design for high power converter, by Lowest RonA and combination with variable packages.







Variation of DTMOSIV series

Example : TK31N60 □

W5

DTMOSIV HSD
High-Speed Body type

For customers who are looking for solutions to reduce the recovery loss of body diode of MOSFET

- ✓ Half-Bridge or Full-Bridge circuit in AC-DC power supply
- ✓ Motor drive application

W

DTMOSIV
Standard type

X

DTMOSIV SE-H
Low Qgd & Fast Switching Speed type

For customers who re looking for solutions to achieve high-efficiency

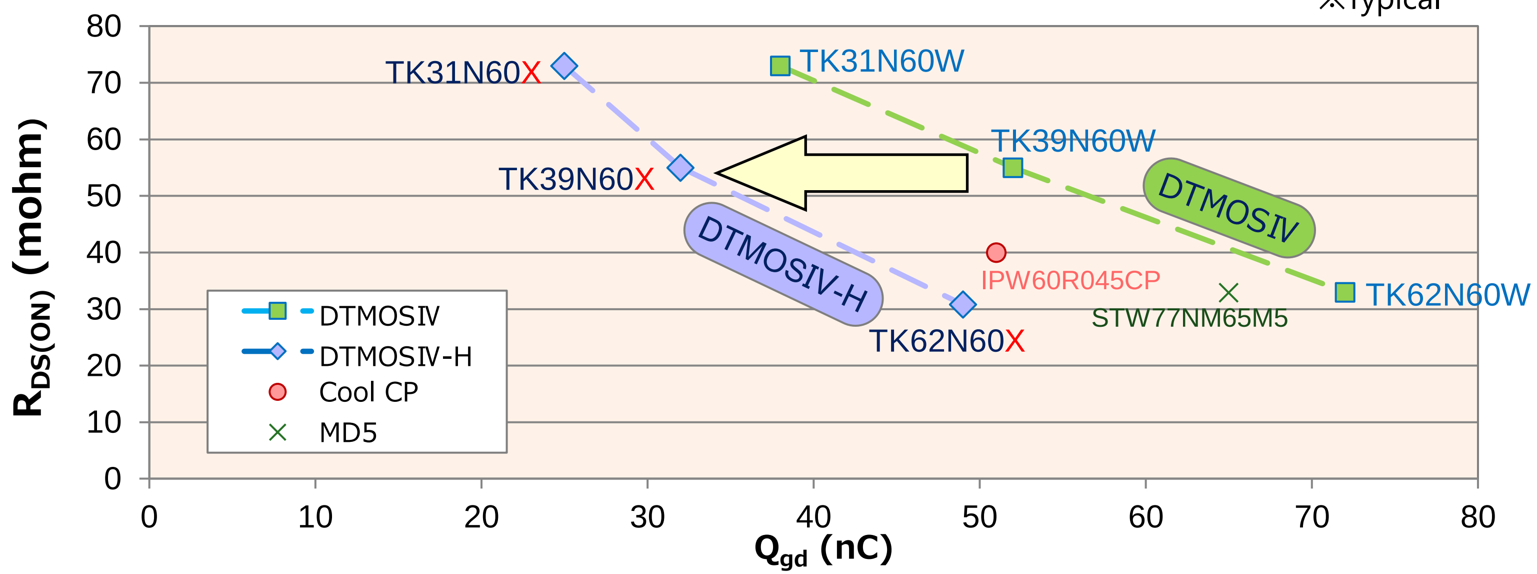
- ✓ PFC circuit in High efficiency power supply for server, Telecom or PCS for PV inverter

IN TOSHIBA, WE ARE EXPANDING OUR LINEUP IN ORDER TO COVER WHAT VARIOUS APPLICATIONS NEED

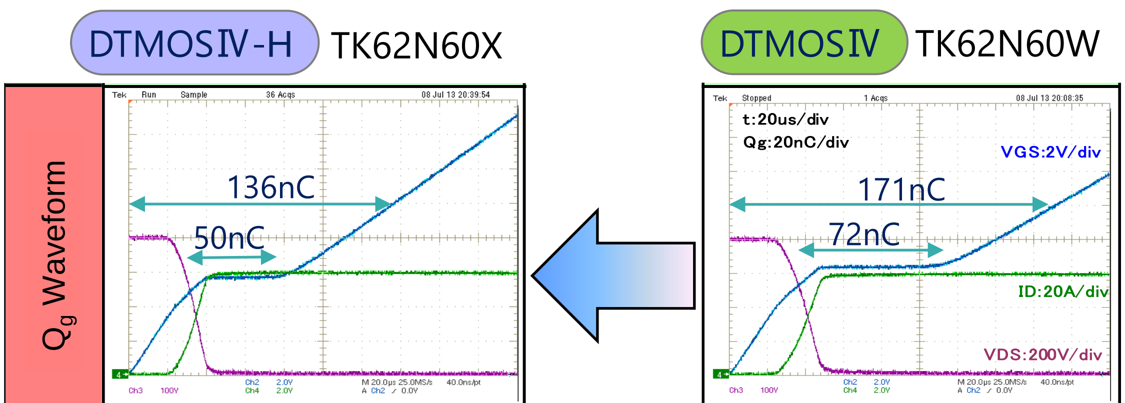
DTMOSⅣ(V_{DS}=600V) High speed version "X"

$R_{DS(ON)}$ – Q_{gd} trade-off improvement

$R_{DS(ON)}$ – Q_{gd} Trade off Characteristic



This series is based on DTMOSⅣ technology, but with lower gate capacitance by change in gate design (Q_{gd} decrease by around 30%) . →Faster switching leads to higher efficiency



	TK62N60X	TK62N60W
Qg	136nC	171nC
Qgd	49.8nC	72.2nC
Qgs1	33.3nC	38.0nC

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DTMOSⅣ-H (V_{DSS}=600V) High-Speed Switching series

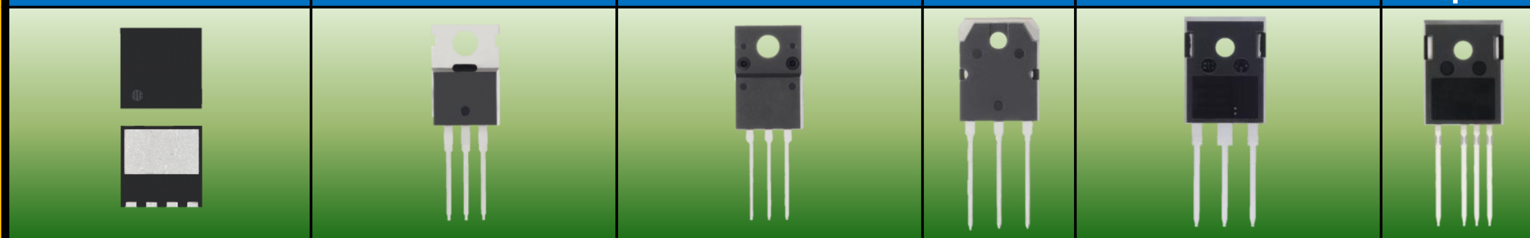
Classification expressed by last letter of part name

"W" … Standard type

"X" … High-speed switching type

New

I_D (A)	$R_{DS(ON)}$ MAX (Ω)	Q_g (nC)		8×8mm DFN		TO-220		TO-220SIS		TO-3P(N)	TO-247		TO-247 4pin
		W	X	W	X	W	X	W	X	W	W	X	X
15.8	0.19	38	-	TK16V60W		TK16E60W		TK16A60W		TK16J60W	TK16N60W		
20	0.155/ 0.17	48	-	TK20V60W (0.17Ω)		TK20E60W		TK20A60W		TK20J60W	TK20N60W		
25	0.125/ 0.135	-	40		**TK25V60X (0.135Ω)**		**TK25E60X**		**TK25A60X**			**TK25N60X**	**TK25Z60X Under development**
30.8	0.088/ 0.098	86	65	TK31V60W (0.098Ω)	**TK31V60X (0.098Ω)**	TK31E60W	**TK31E60X**	TK31A60W		TK31J60W	TK31N60W	**TK31N60X**	**TK31Z60X Under development**
38.8	0.065	110	85					TK39A60W		TK39J60W	TK39N60W	**TK39N60X**	**TK39Z60X Under development**
61.8	0.040	180	135							TK62J60W	TK62N60W	**TK62N60X**	**TK62Z60X Under development**



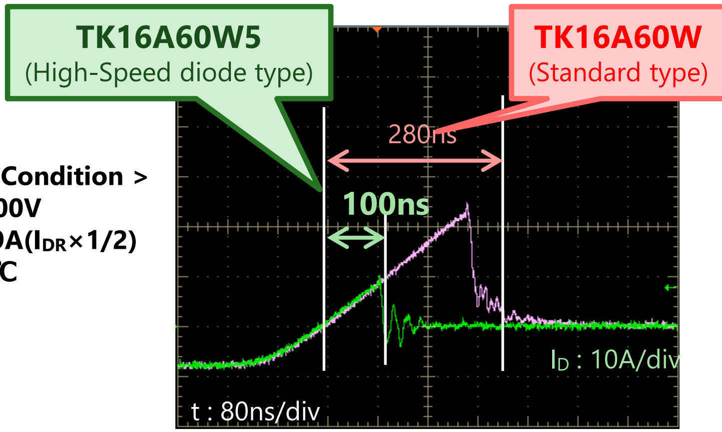
Under Investigation → Making ES → ES available → Under MP

Note: Specification and schedule of products under development are subject to change.

DTMOSⅣ High-Speed (Fast Recovery) Diode Ver. "W5"

Fast body diode version based on DTMOSⅣ, which make more efficient

High-Speed body diode



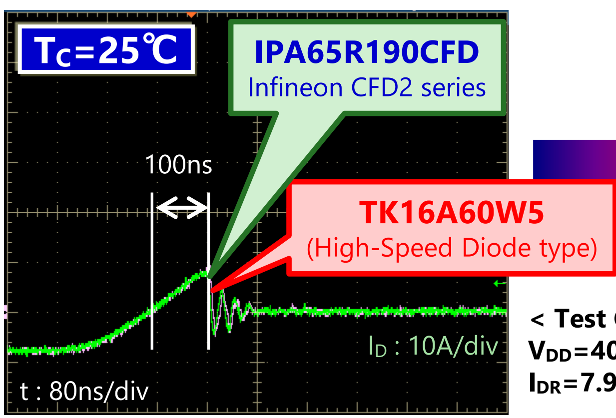
< Test Condition >
V_{DD}=400V
I_{DR}=7.9A(I_{DR}×1/2)
T_C=25℃

Comparison for Specification

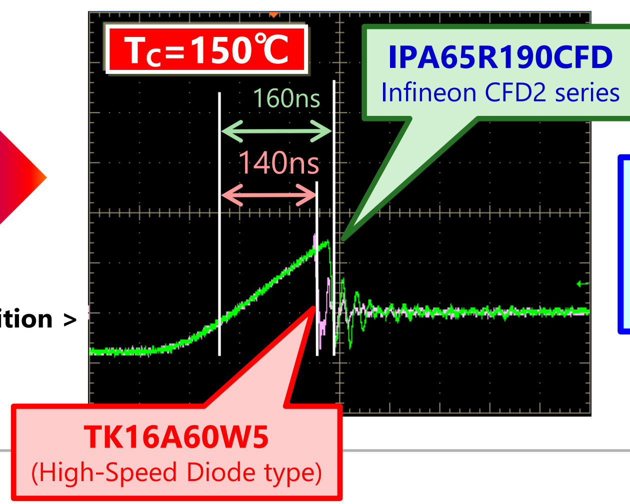
Type	Standard	High Speed Diode
Part No.	TK16A60W	TK16A60W5
Rating	600V / 15.8A	600V / 15.8A
On Resistance ($R_{DS(ON)}$)	0.19Ω MAX	0.23Ω MAX
Reverse Recovery time (t_{rr})	280ns	100ns

High-Speed body diode can reduce "Recovery Loss" due to 70% faster reverse recovery time

Better temperature coefficience

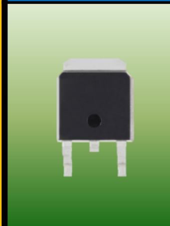
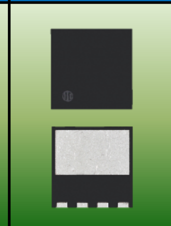
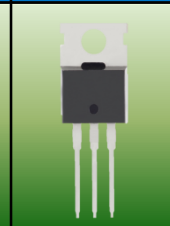
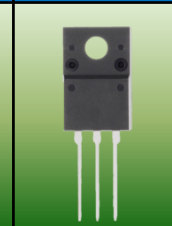
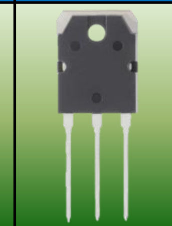
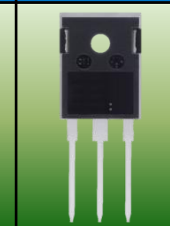


< Test Condition >
V_{DD}=400V
I_{DR}=7.9A



More lower switching loss at high temperature can be achieved by better temperature dependency of DTMOSⅣ.

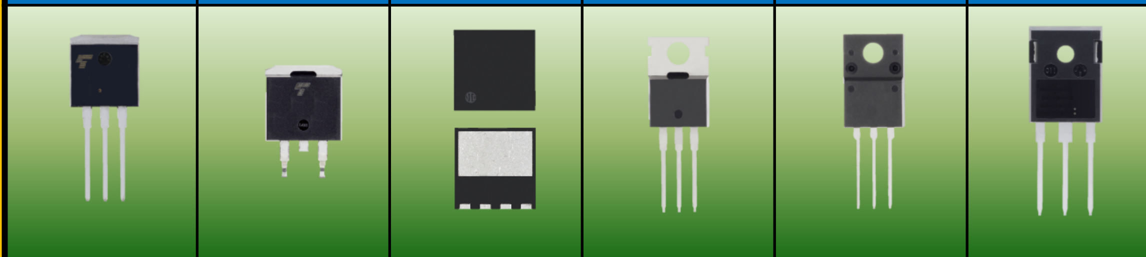
DTMOSIV (V_{DSS}=600V, w/Fast Diode) series Product Lineup

I_D (A)	$R_{DS(ON)}$ MAX (Ω)	DPAK (TO-252)	D2PAK (TO-263)	8×8mm DFN	TO-220	TO-220SIS	TO-3P(N)	TO-247	Q_g (nC) Typ.	C_{iss} (V_{DS}=300V) (pF) Typ.	t_{rr} (ns) Typ.
											
5	0.95 / 0.99	TK5P60W5 (0.99Ω) Under development				TK5A60W5 Under development			11.5	370	65
7	0.65 / 0.67	TK7P60W5 (0.67Ω)				TK7A60W5			16	490	75
8	0.54 / 0.56	TK8P60W5 (0.56Ω)				TK8A60W5			22	590	80
9.7	0.45					TK10A60W5			23	720	85
15.8	0.23 / 0.24		TK16G60W5	TK16V60W5 (0.24Ω) Under development	TK16E60W5	TK16A60W5	TK16J60W5	TK16N60W5	43	1350	100
20	0.175 / 0.19			TK20V60W5 (0.19Ω)	TK20E60W5	TK20A60W5	TK20J60W5	TK20N60W5	55	1800	110
25	0.14 / 0.15	High-Speed Switching "X" w/HSD		TK25V60X5 (0.15Ω) Under development	TK25E60X5	TK25A60X5		TK25N60X5	60	2400	120
30.8	0.099 / 0.109			TK31V60W5 (0.109Ω)			TK31J60W5	TK31N60W5	105	3000	135
38.8	0.074						TK39J60W5	TK39N60W5	135	4100	150
61.8	0.045						TK62J60W5	TK62N60W5	205	7100	170

Under Investigation → Making ES → ES available → Under MP

Note: Specification and schedule of products under development are subject to change.

DTMOSIV (V_{DSS}=650V, w/Fast Diode) series Product Lineup

I_D (A)	$R_{DS(ON)}$ MAX (Ω)	I2PAK (TO-262)	D2PAK (TO-263)	DFN8x8	TO-220	TO-220SIS	TO-247	Q_g (nC) Typ.	C_{iss} (V_{DS}=300V) (pF) Typ.	t_{rr} (ns) Typ.
										
13.7	0.30	TK14C65W5	TK14G65W5		TK14E65W5	TK14A65W5	TK14N65W5	40	1300	100
17.3	0.23					TK17A65W5		50	1800	110
(22)	(0.19 /0.20)			TK(22)V65X5 Under development		TK(22)A65X5 Under development		TBD	TBD	TBD
27.6	0.13 /(0.14)			TK28V65W5 Under development			TK28N65W5	90	3000	115
35	0.095					TK35A65W5	TK35N65W5	115	4100	130
49.2	0.057						TK49N65W5	185	6500	145

Under Investigation → Making ES → ES available → Under MP

Note: Specification and schedule of products under development are subject to change.

Advantage of New Package for Hi-power SPS：TO-247 4L

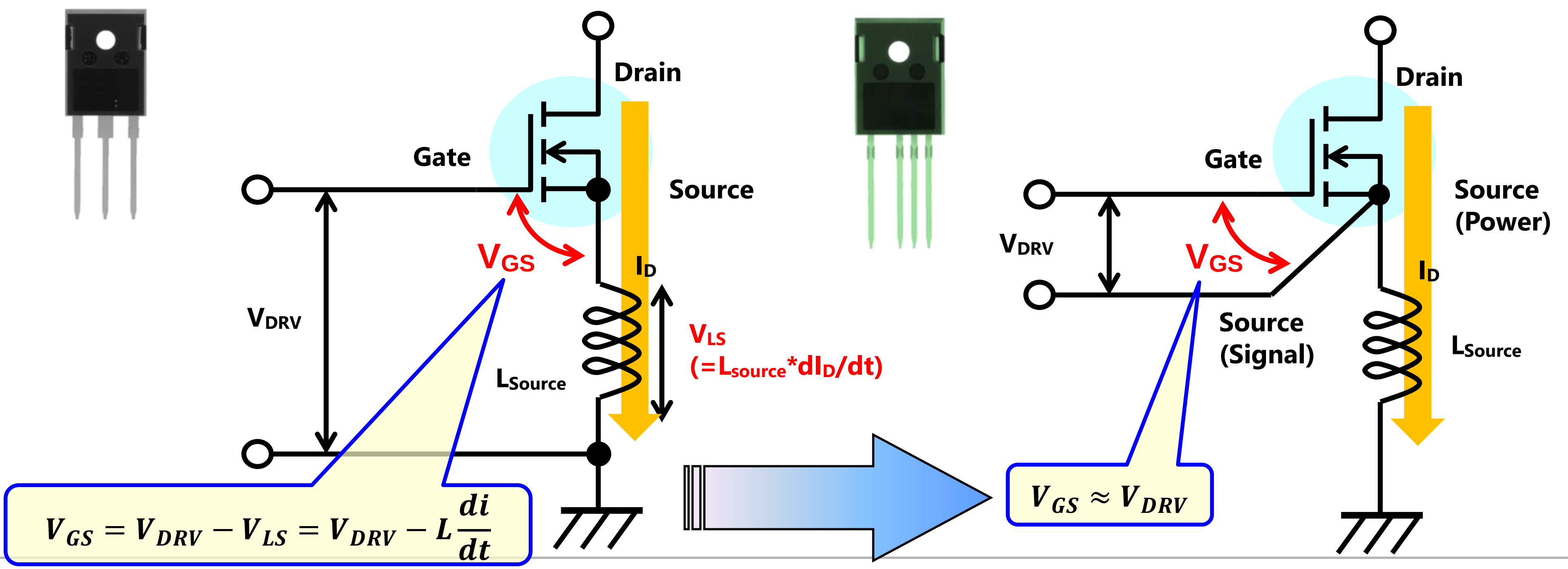
While packages such as TO-247 are usually used for high-speed switching and high current applications, big package size causes longer internal wiring causing larger internal inductance. TO-247-4L is developed to eliminate the effect of the internal source inductance when driving FET by separating signal source pin.

For 3pin package (TO-247)

Both the source wire inductance (L_{source}) and drain current slope (dI_D/dt) induced reverse voltage affects gate-source voltage (V_{GS}) when driving the FET.

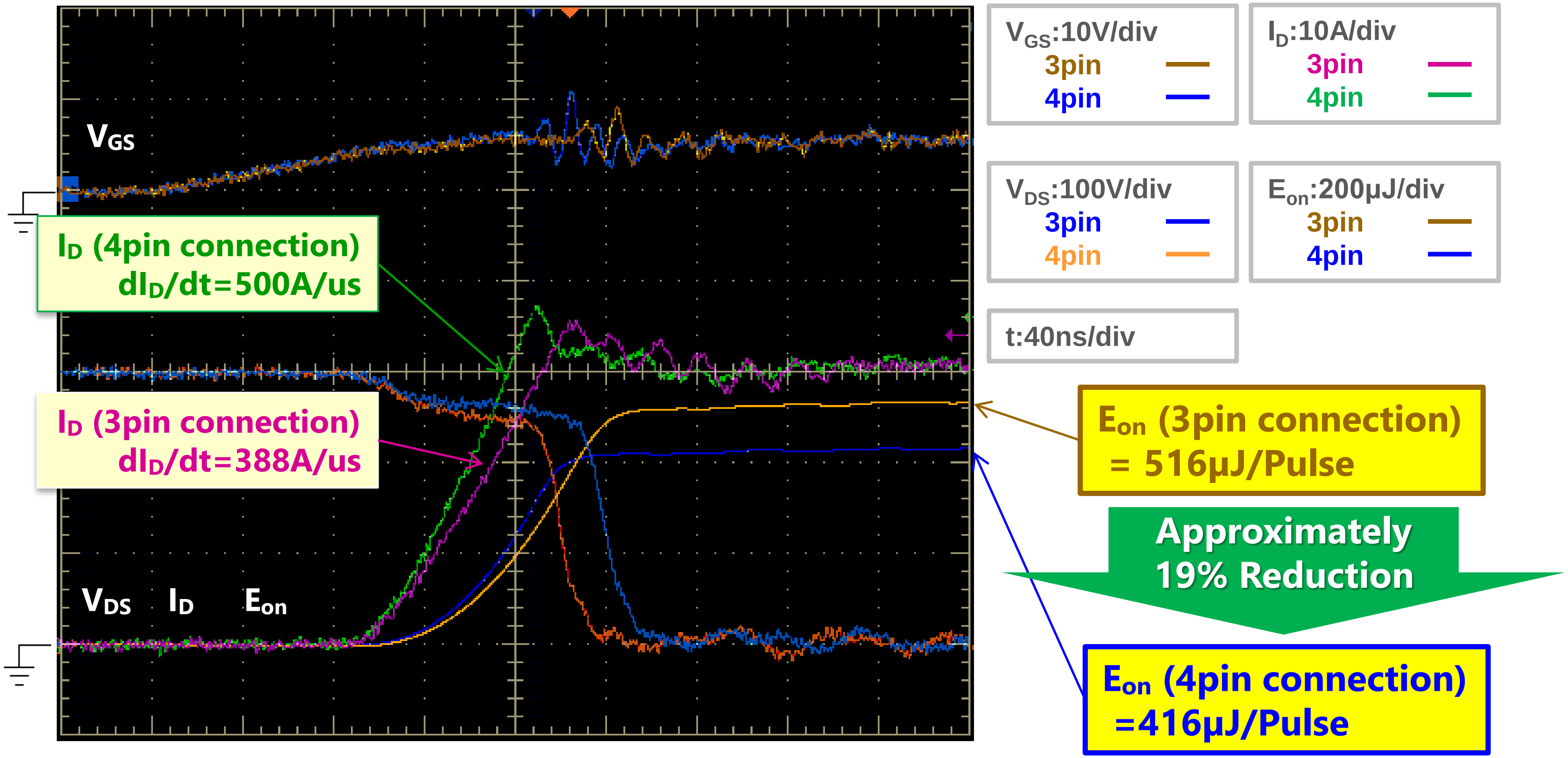
For 4pin package (TO-247-4L)

Effect of source wire inductance (L_{source}) and drain current slope (dI_D/dt) induced reverse voltage is eliminated by separating signal source wire, which optimizes high-switching capability.



Turn-On Loss Reduction by TO-247 4L

Part No. : TK62Z60X (600V, 0.040ΩMAX.)
Test Condition : V_{DD}=300V, V_{GG}=+10V/0V, I_D=30.9A, R_G=27Ω, L=0.5mH, Ta=25℃

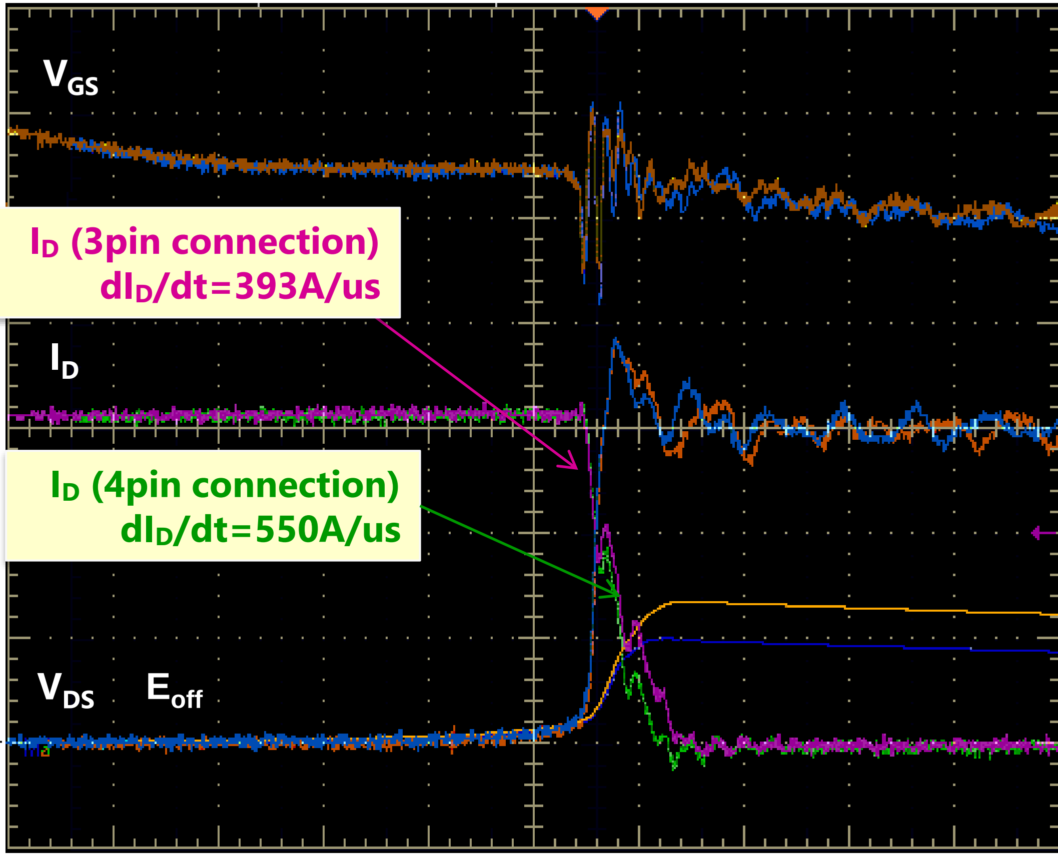


E_{on} reduction available by using "Signal source" terminal.

Turn-Off Loss Reduction by TO-247 4L

Part No. : TK62Z60X (600V, 0.040ΩMAX.)

Test Condition : V_{DD}=300V, V_{GG}=+10V/0V, I_D=30.9A, R_G=27Ω, L=0.5mH, Ta=25℃



V_{GS}:10V/div
3pin
4pin

I_D:10A/div
3pin
4pin

V_{DS}:100V/div
3pin
4pin

E_{off}:200μJ/div
3pin
4pin

t:40ns/div

E_{off} (3pin connection) = 268μJ/Pulse

Approximately 25% Reduction

E_{off} (4pin connection) =200μJ/Pulse

E_{off} reduction available by Signal source terminal.

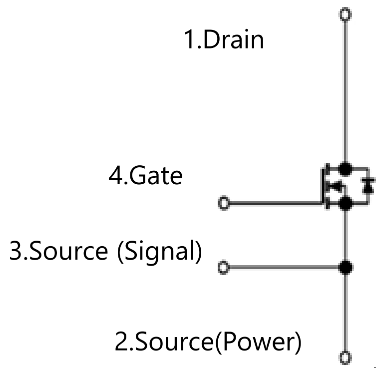
Lineup **of New Package for Hi-power SPS**：TO-247 4L

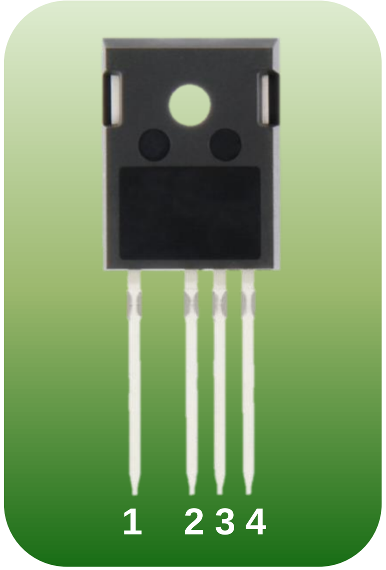
Concept & Feature

- ✓ **Expanding a lineup with DTMOSⅣ-H (Fast Switching type) series.**
- ✓ **By excluding a Source Inductance from driving circuit.**
  ➔ To improve switching behavior and efficiency by reducing switching losses

Package Image & Pin configuration

1. Drain
2. Source (Power)
3. Source (Signal)
4. Gate





Line up Idea & Target Schedule

Chip Design	Part No.	V_{DSS} & $R_{DS(ON)}$ max	Schedule (CY)				
			2015/1Q	2015/2Q	2015/3Q	2015/4Q	2016/1Q
DTMOSⅣ-H	TK25Z60X	600V 125mΩ	ES			MP	
	TK31Z60X	600V 88mΩ	ES			MP	
	TK39Z60X	600V 65mΩ		ES		MP	
	TK62Z60X	600V 40mΩ	ES			MP	

Note: Specifications of products under development may change without prior notice.

SiC SBD

Design Road Map for SiC Product

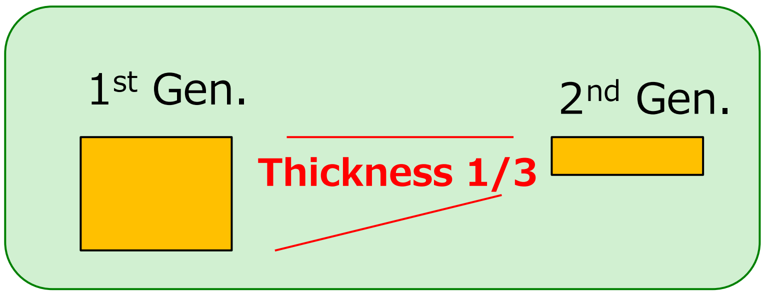
	14(FY)				15(FY)				16(FY)	
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q
SiC SBD 650V	**1st Generation** ・PKG Line Up ・Current Rating I_F=6A,8A,10A,12A,16A,20A,24A  TO-220-2L  TO-247  TO-220F-2L									
							2nd Generation ・Concept Downsizing of Die ⇒Cost Performance UP I_{FSM} Up⇒Destruction Ability Up			
SiC SBD 1.2kV		**1st Generation** ・PKG Line Up ・Current Rating I_F=20A  TO-3P(N)								
SiC MOSFET 1.2kV							**1st Generation** ・Target Spec V_{DD}=1200V /$R_{DS(ON)}$=69mΩmax TO-3P(N)			

Development Concept of 2nd Gen. 650V SiC SBD (1)

Improved Forward Performance by thinner Wafer process

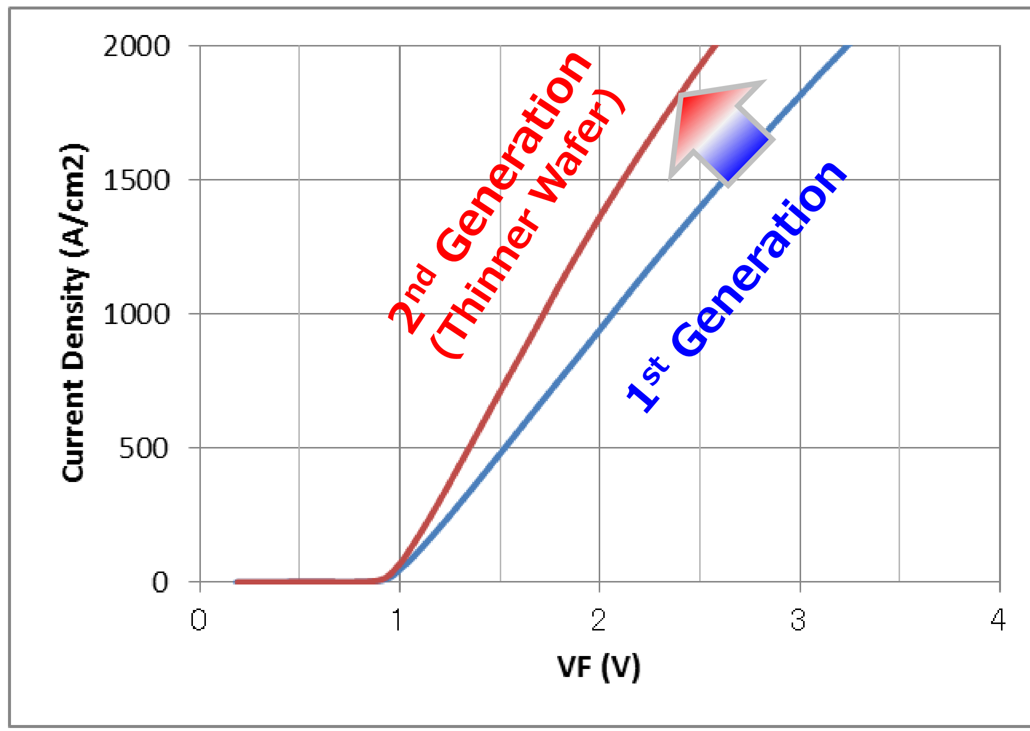
Ron = 1.2mΩ ⇒ 0.8mΩ・cm^2

Thinner Wafer Technology in 2nd Generation



"Forward on resistance" per unit area **is Reduced to 2/3 level compared with 1st Generation's**

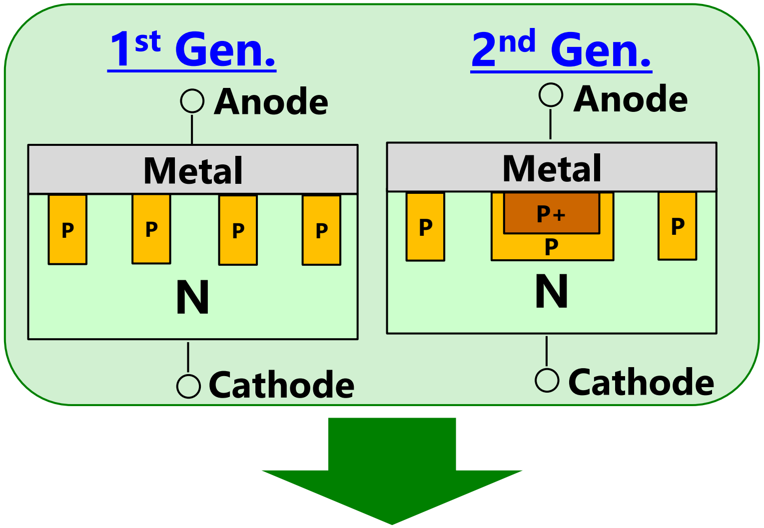
Current Density – Forward Drop (@Rated Current Region)



Development Concept of 2nd Gen. 650V SiC SBD

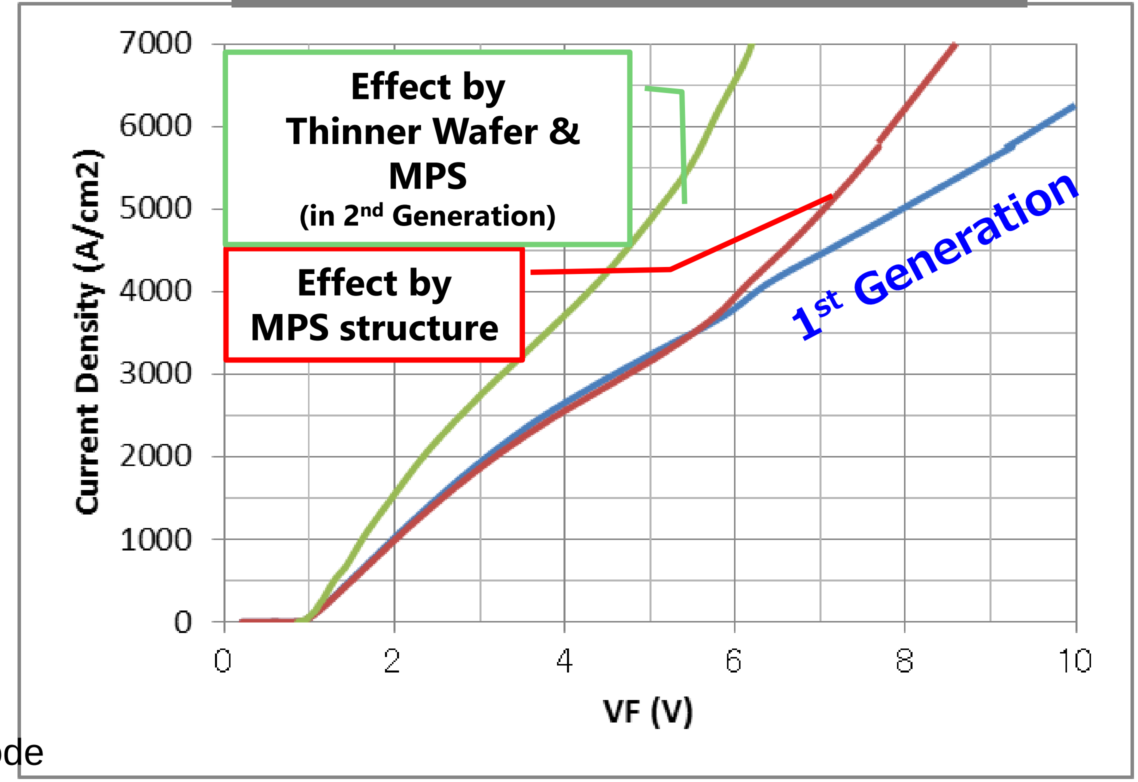
Much improved Forward Drop Characteristic by MPS structure, and Surge Current Capability also improved

MPS Techology in 2nd Generation



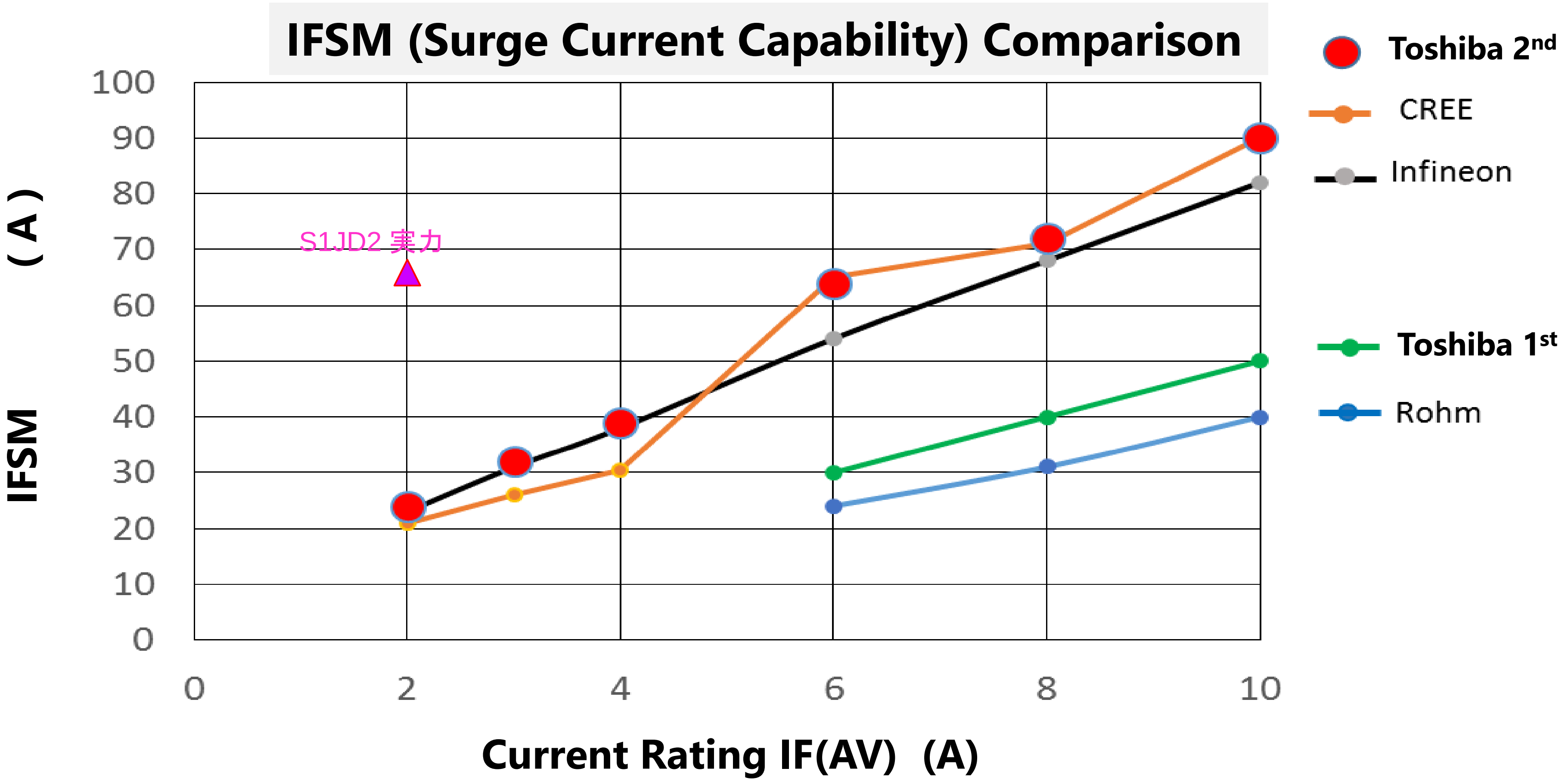
Improved I_{FSM} Capability

Current Density – Forward Drop (@Hi-current Region)

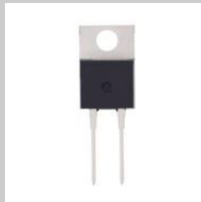
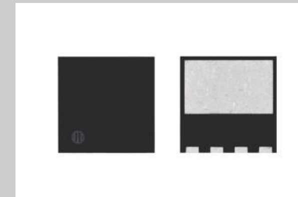


Note MPS : **M**erged **P**in **S**chottky barrier diode

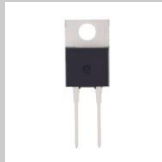
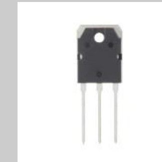
2nd Gen. SiC SBD IFSM Capability



2nd Gen. 650V SiC SBD Line up Plan

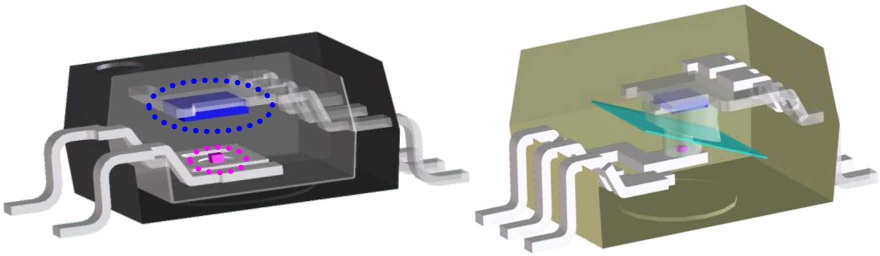
V_{RRM} (V)	Current rating (A)	TO-220-2L (2Leads)	TO-220F-2L (2Leads)	DPAK	8×8DFN
					
650	2	TRS2E65F ES: May/'16 MP: Sep./'16		TRS2P65F	
	3	TRS3E65F ES: May/'16 MP: Sep./'16		TRS3P65F	
	4	TRS4E65F ES: Mar./'16 MP:July/'16	TRS4A65F ES: Mar./'16 MP: Aug./'16	TRS4P65F	TRS4V65F
	6	TRS6E65F ES: Feb./'16 MP: June/'16	TRS6A65F ES: Mar./'16 MP: July/'16	TRS6P65F	TRS6V65F
	8	TRS8E65F ES: Mar./'16 MP: July/'16	TRS8A65F ES: Apr./'16 MP: Aug./'16	TRS8P65F	TRS8V65F
	10	TRS10E65F ES: Feb./'16 MP: June/'16	TRS10A65F ES: Mar./'16 MP: July/'16	TRS10P65F	TRS10V65F

1st Gen 650V /1200VSiC SBD Line up

V_{RRM} (V)	Current rating (A)	TO-220 -2L (2Leads)	TO-220F-2L (2Leads)	TO-247 (Center Tap)	TO-3PN
					
650	6	TRS6E65C MP:OK	TRS6A65C MP:OK		
	8	TRS8E65C MP:OK	TRS8A65C MP:OK		
	10	TRS10E65C MP:OK	TRS10A65C MP:OK		
	12	TRS12E65C MP:OK	TRS12A65C MP:OK	TRS12N65D MP:OK	
	16		TRS16A65C MP:OK	TRS16N65D MP:OK	
	20			TRS20N65D MP:OK	
	24			TRS24N65D MP:OK	
1200	20				TRS20J120C MP:OK

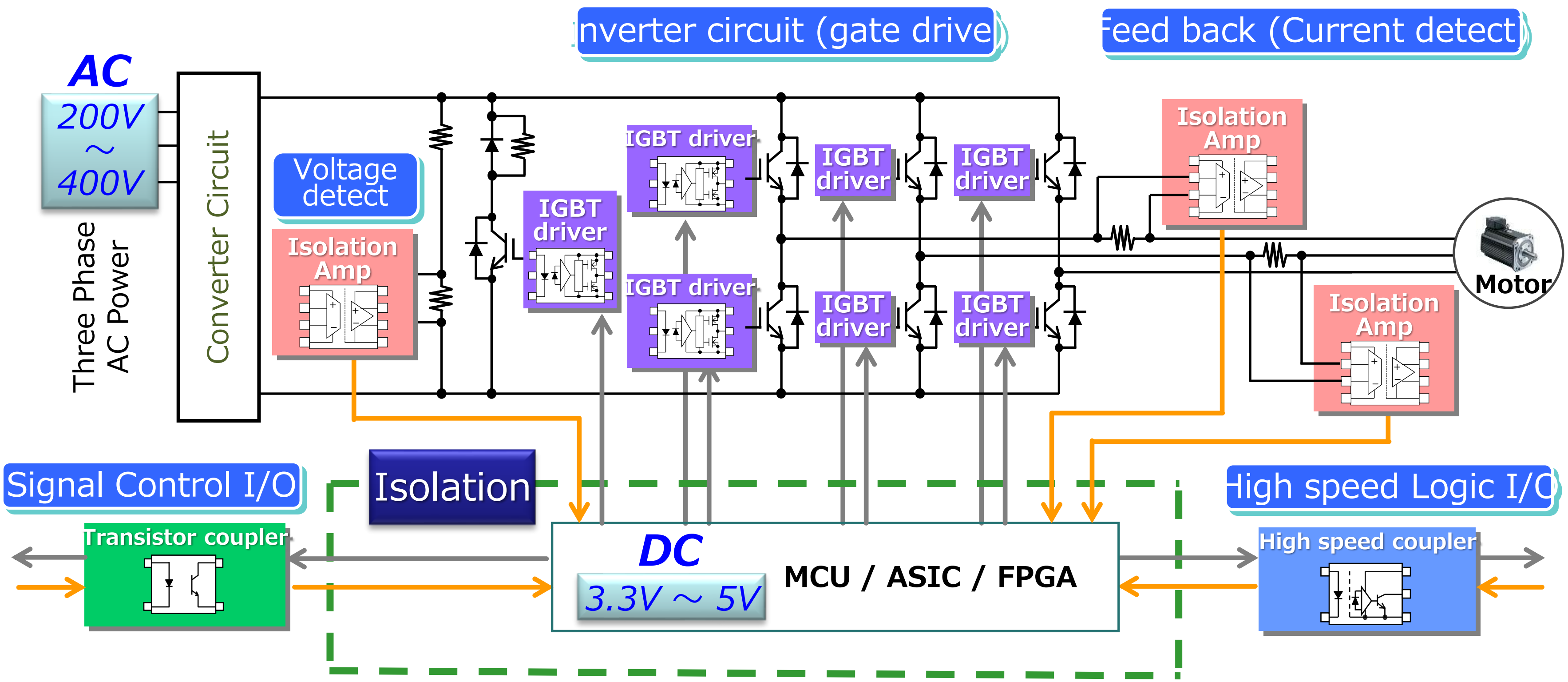
IC coupler

- **IGBT/MOSFET Driver Couplers**
- IPM Driver Couplers
- High Speed Couplers
- Isolation amplifier



TOSHIBA Photocouplers for Inverter system

Block diagram



NEW
Signal control I/O TLP383 TLP293

0.5mA Low input Tr coupler
TLP383 ／ TLP293
LED input current

NEW
IGBT Gate driver TLP5214 TLP5754

Smart gate driver : TLP5214
 Over current protection
Rail to Rail : TLP5754

NEW
Current·Voltage Detection TLP7820

Isolation amp : TLP7820
 Analog output
 Gain error ±0.5～3%(25℃)

NEW
High speed Logic I/O TLP2761

Low I_{FHL} 10Mbps : TLP2761
 Trigger current 1.3mA
20M Logic IC : TLP2768A

Line-up of IGBT Driver coupler

OCP : Over current protection
AMC: Active miller clamp

Creepage & clearance		5mm	4mm	7 or 8mm	7 or 8mm	8mm	8mm
Isolation voltage		3750 Vrms	3750 Vrms	5000 Vrms	3750 Vrms	5000 Vrms	5000 Vrms
Output peak current	Data rate	SO6 (Thailand)	SO8	SDIP6	DIP8	SO6L (Thailand)	SO16L
6.0 A	500 ns				TLP358H		
4.0 A	150 ns					TLP5754 (Rail to rail)	TLP5214 (OVC/AMC Rail to rail)
2.5 A	500 ns			TLP700H	10 TLP250H TLP350H		
	~200 ns	10 TLP152		TLP700A	TLP352	TLP5702	
	~150 ns (Low skew)					TLP5752 (Rail to rail)	
1.0A	~150 ns (Low skew)					TLP5751 (Rail to rail)	
0.6A	700 ns			10 10 TLP701H	10 TLP351H 10	10	
	500 ns	10 TLP151A	10 TLP2451A	TLP701A	TLP351A	TLP5701	
	~200 ns (Low skew)	10 TLP155E		10 TLP705A			

Orange colored area
T_{opr}=125˚C
High temp. series

Yellow colored area
T_{opr}=110 ˚C
High temp. series

10 :Vcc=10 to 30V

Blue Letter : Recommended Product

*The products without the mark of 10 are Vcc=15 to 30V.

*The product without the temperature notation is T_{opr}=100˚C (Max).

Low Input IGBT/MOSFET Gate Driver Coupler

TLP5771 / TLP5772 / TLP5774

Low Input Rail-to-rail output SO6L package version appeared!

Feature

★Input threshold current : 2.0mA (Max)
★Rail to Rail Output :
Output Voltage≒Power Supply Voltage(Vcc)
★Thin package : 2.3mm (Max)
★Isolation voltage : 5kVrms (Min)
★Supply voltage : 10V ~ 30V
★Toshiba's SO6L recommended land pattern can accept Avago's Stretched-SO6.

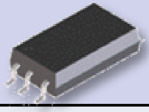
Application

★PV inverter
★Inverter
★AC servo
★Compact motor driver
★Industrial sewing machine

★Mass production starts in Thailand from January 2016!

Thailand Produced

Fundamental terms

Product name	TLP575x	TLP577x
Package	SO6L 	
Creepage / Clearance	8mm(min)	
Output peak current	±1.0／±2.5／±4.0A	
Operation temperature	-40℃ ～ 110℃	
Supply voltage	15V ～ 30V	10V ～ 30V
Supply current	3mA (Max)	3mA (Max)
Propagation delay time	150ns (Max)	150ns (Max)
Input threshold current	4mA (Max)	2mA (Max)

TLP5771 (Iout ±1A)
TLP5772 (Iout ±2.5A)
TLP5774 (Iout ±4A)

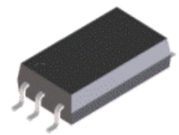
◆TLP577× series is ideal for better noise environment because they are possible to drive directly from the MCU at low input current, also ideal for MOSFET drive because of wider supply voltage range.
◆TLP575× series is ideal for industrial application to drive large IGBT because of Supply voltage range from 15V.

TOSHIBA
Leading Innovation >>>

Low power loss (Rail to rail) IGBT/MOSFET driver coupler

TLP5751 / 5752 / 5754

1.0A output | 2.5A output | 4.0A output

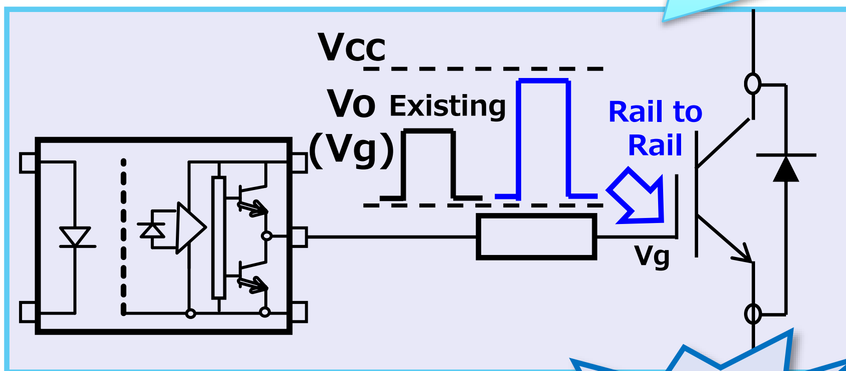


Generating a full swing voltage output signal . Contribute to low power consumption.

Feature

- Rail to rail output
- High speed 150ns(Max)
- Low skew ±80ns
- Supply current 3mA(Max)
- Threshold current 4mA(Max)
- Operating temp. T_{opr}:-40~110˚C
- Direct replacement of ACPL-P340 series

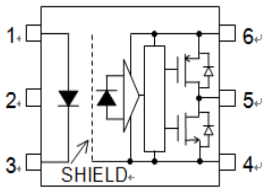
＊What's Rail to rail ?



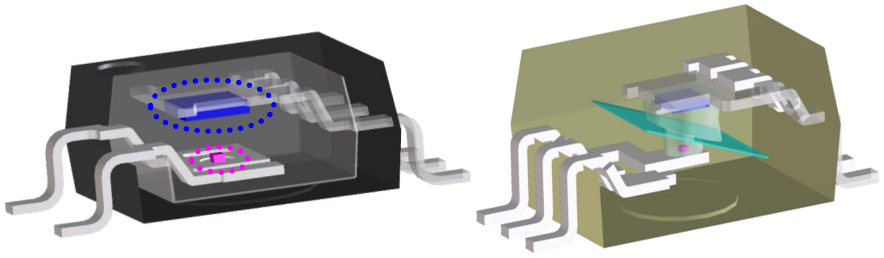
Conduction loss 10% down

	Company A ACPL-P340	TOSHIBA TLP5751 NEW	Existing TLP701A
Package height	3.6mm	**2.3mm**	4.25 mm
V_{OH}	V_{CC}-0.3V	**V_{CC}-0.3V**	V_{CC}-4V
V_{OL}	0.2V	**0.2V**	1.0V
Peak current	1.0A	**1.0A**	0.6A
T_{opr}	-40 to 105˚C	**-40 to 110˚C**	-40 to 100˚C
t_{pHL}/t_{pLH}	200 ns	**150 ns**	500ns
t_{psk}	±100ns	**±80ns**	N/A
V_{CC}	15 ~ 30V	**15 ~ 30V**	10~30V
BV_s	5000 V_{rms}	**5000 V_{rms}**	5000 V_{rms}

Internal circuit



Isolation Amplifier

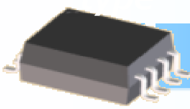


Isolation amplifier Development schedule

Nov.	Dec.	Jan.	Feb.	Mar.

Analog output

Safety standard approval

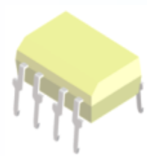


Thin PKG

SO8L ･･･ACPL-C79x compatible (Company "A")

NEW — TLP7820 MP:OK

Height : 2.3mm



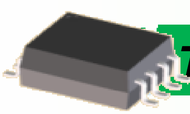
Standard PKG

DIP8 ･･･ACPL-790x compatible (A Company "A")

NEW — TLP7920 MP

Digital output type

Safety standard approval

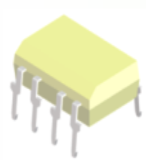


Thin PKG

SO8L ･･･ACPL--C797 compatible (Company "A")

TLP7830 ES → NEW — TLP7830 MP

Height : 2.3mm

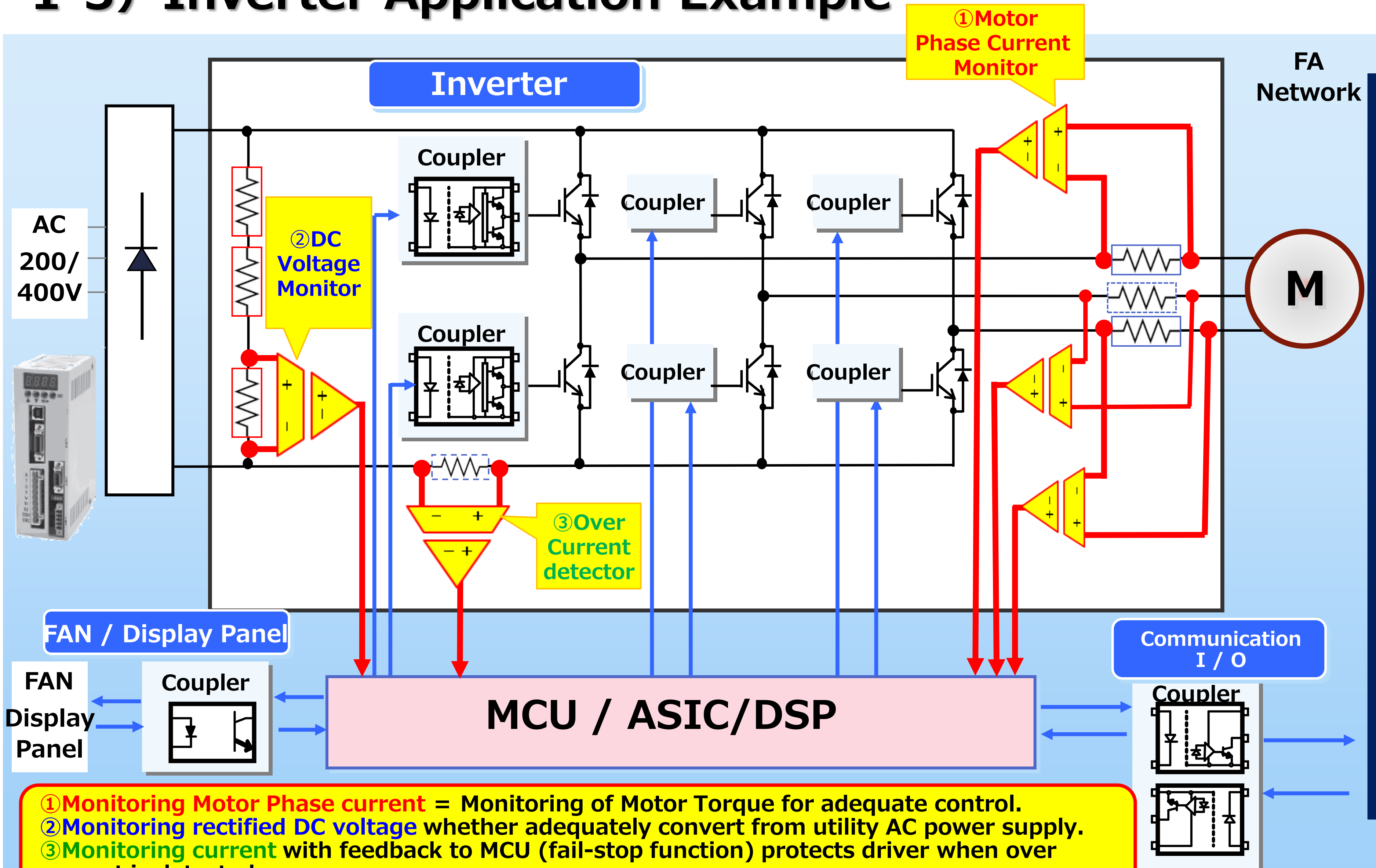


Standard PKG

DIP8 ･･･ACPL-7970 compatible (Company "A")

TLP7930 ES → NEW — TLP7930 MP

1-3) Inverter Application Example



①Monitoring Motor Phase current = Monitoring of Motor Torque for adequate control.
②Monitoring rectified DC voltage whether adequately convert from utility AC power supply.
③Monitoring current with feedback to MCU (fail-stop function) protects driver when over current is detected.

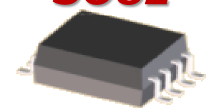
Isolation AMP Analog output type

TLP7820 / TLP7920

TLP7820 and TLP7920 are first analog output type isolation amplifier in Toshiba.
These are compatible with company "A", ACPL-C79x and ACPL-790x.
This contributes to low capacity power supply cause of
lower power consumption designing than company "A" .
TLP7820 is housed in Toshiba new thin package SO8L(height:2.3mm).
It can reduce a mounting space more than A company item.

TLP7820

SO8L

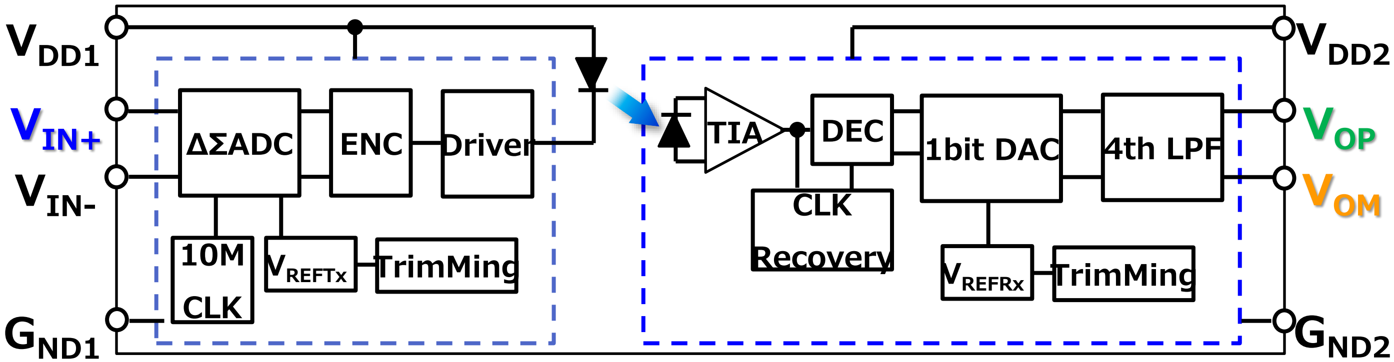


In MP

TLP7920

DIP8

'16/Jan

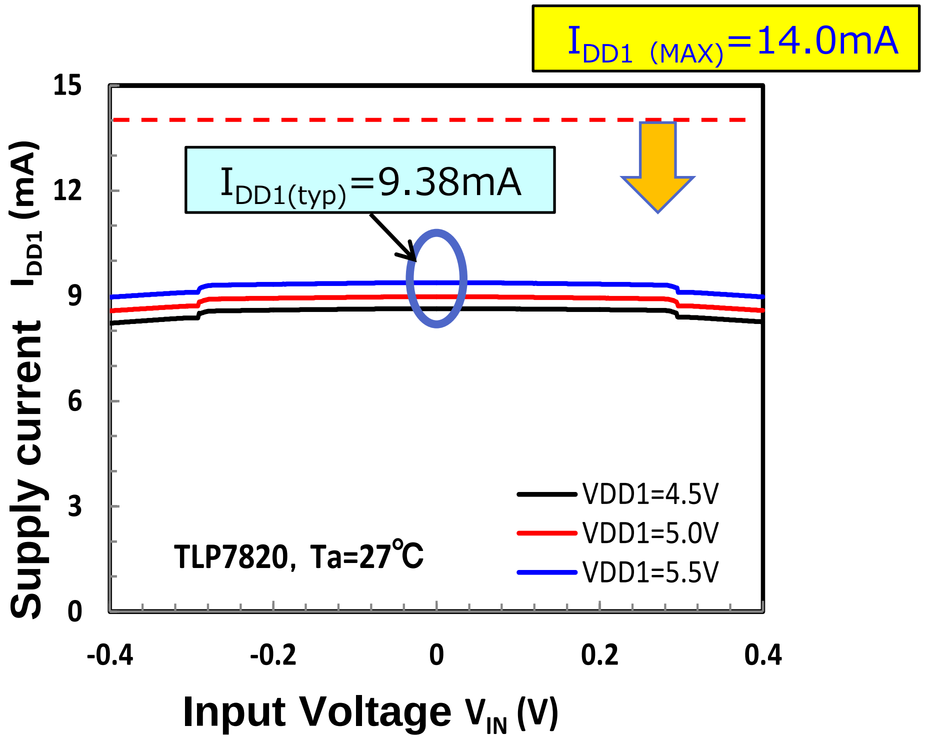


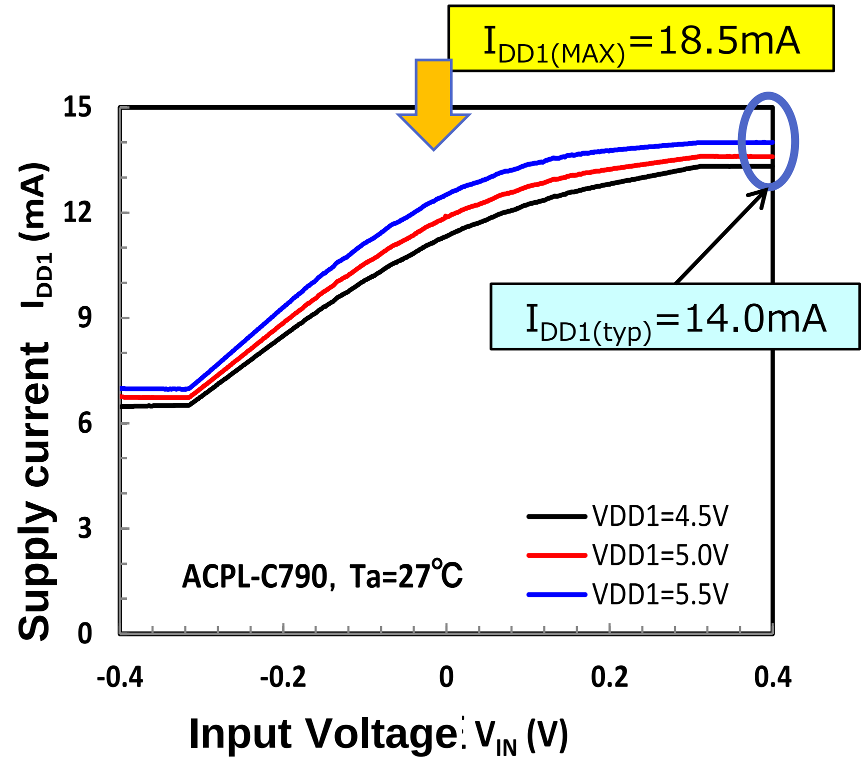
	Company "A"	TOSHIBA	TOSHIBA	Company "A"
	ACPL-C79x	TLP7820	TLP7920	ACPL-790x
Height	3.6 mm	*40%less!* 2.3 mm	4.0 mm	
Output type	Single phase =0～2.5V			
Operation temperature : T_{opr}	-40 to 105˚C			
Input Voltage Range	±200mV/±300mV			
Gain error(25℃)	±0.5/±1/±3%	±0.5/±1/±3		±0.5/±1/±3%
V_{DD1} Supply current : I_{DD1}	13(Max18.5)mA	*25%less!* 9.5(Max14)mA *less!*		13(Max18.5)mA
Isolation voltage : BV_s	5000 V_{rms}			

Feature Input side low supply current

Isolation AMP

Reference



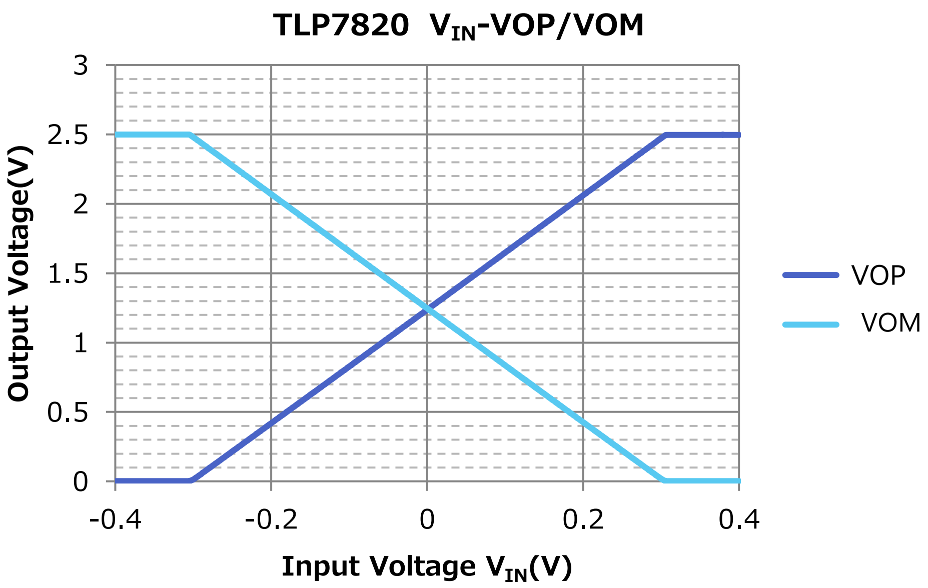


Input side supply current of Analog output type is **30%** lower than company A.

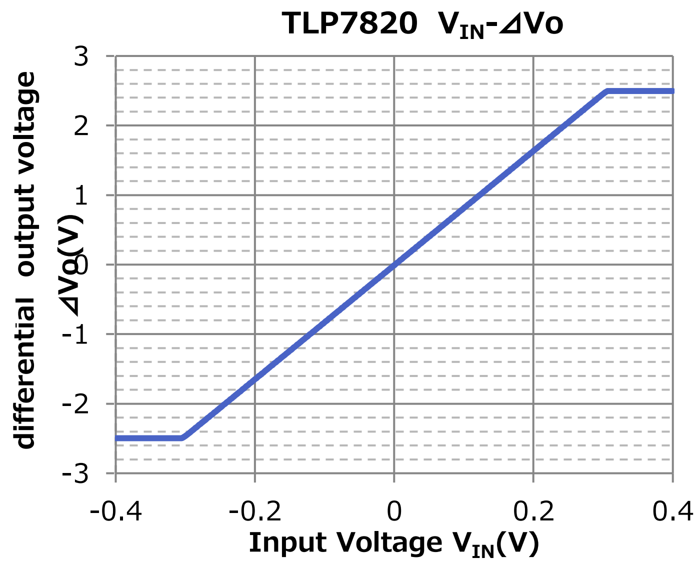
（Reference）TLP7820 Evaluation result

Reference

○Vin-VOP/VOM



○VIN-⊿Vo



Test condition：VDD1=5.0V,VDD2=5.5V,Ta=27℃

Test result：INL_{200} = 0.0189%

INL_{100} = 0.0098%

input full scale range = ±304mV

Gain = 8.2 time

$CMRR_{IN}$ = 86.16dB

※This result is made by ES sample.

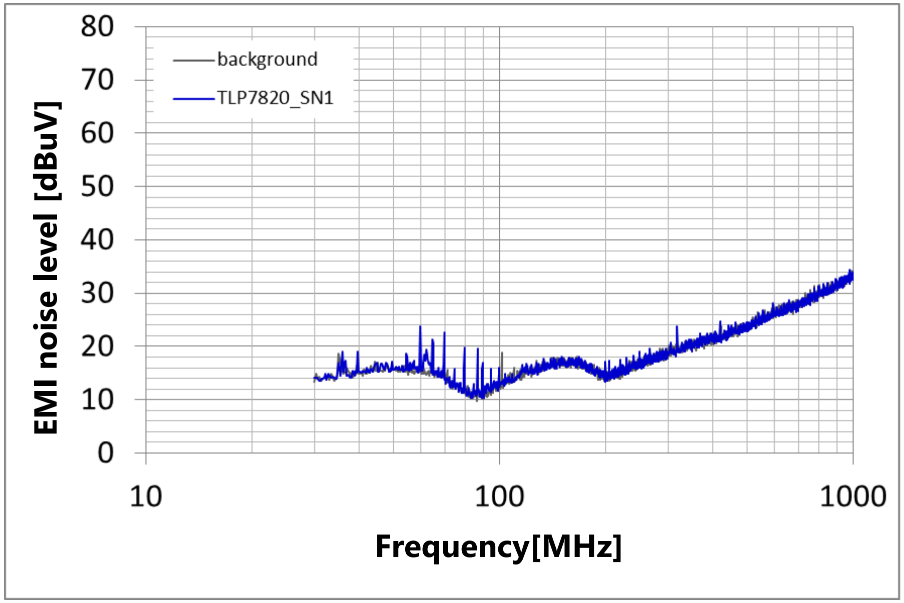
Reference

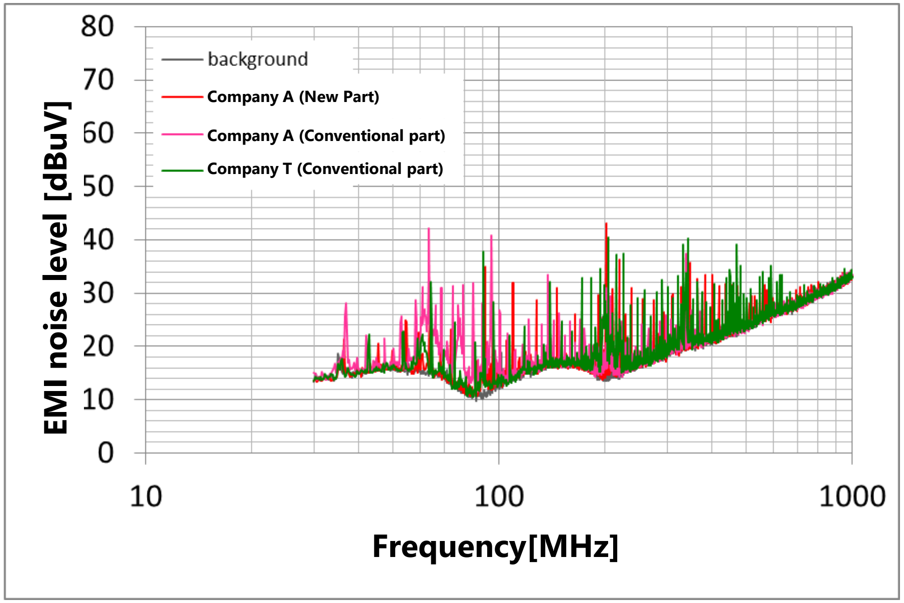
EMI ~ TLP7820 vs Competitor ~

■ TLP7820(Analog output)

■ Competitor

・ACPL-C79B(Avago)
・HCPL-7840(Avago)
・AMC1200 (TI)





<<Test condition>>
- VDD1=VDD2=5V, Ta=25℃
- Input differential voltage Vin+ - Vin-=0mV (offset voltage condition)
- Output: open
- Sample size: TLP7820…2pcs, other item…1pc

TLP7820 has a better EMI performance against competitors.

2-1) Isolation Amp. Developing Item, comparison Chart (Analog output)

() : Target Spec in front of "[]": (typ.), inside of []: specification value.	TLP7820	TLP7920	ACPL-C79x	ACPL-790x	HCPL-7840	AMC1200
Package / Isolation Voltage (AC1min)	SO8L/5 kVrms	DIP8/5 kVrms	SSO-8/5kVrms	DIP8/5 kVrms	DIP8/3.75 kVrms	SOP8/2.8 kVrms
(Maximum Allowable Operating Insulation Voltage V_{IORM}) D4 Option	(1230 Vpeak)	TLP7920(890Vpeak) TLP7920F(1230Vpeak)	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 [Max0.13] %		0.05 [Max0.13] %		0.0037 [Max0.35] %	0.075 %
Nonlinearity over ±100 mV Input Voltage INL_{100}	0.01 [Max0.06] %		0.02 [Max0.06] %		0.0027 [Max0.2] %	N/A
Input Offset Voltage	+0.9 [-0.6~2.4] mV	+0.73 [-0.7~2.1]mV	+0.6 [-1~2] mV		+0.3 [±3] mV	+0.2 [±1.5] mV
Magnitude of Input Offset Change vs. Temperature	2 [Max6] μV/℃		3 [Max10] μV/℃		3 [Max10] μV/℃	±1.5 [Max±10] μV/℃
Small-Signal Bandwidth (-3 dB)	[Min140] 200 kHz		[Min140] 200 kHz		[Min50] 100 kHz	[Min60] 100 kHz
Equivalent Input Impedance	78 kΩ		22 kΩ		500 kΩ	28 kΩ
Input Side Supply Current I_{DD1}	**8.6 [Max12] mA**		13[Max18.5] mA	13[Max18.5] mA	10.86 [Max15.5] mA	5.4 [Max8] mA
Output Side Supply CurrentI_{DD2}	[illegible]		7 [Max12] mA		11.56 [Max15.5]	4.4 [Max7] mA

Same about Gain and Offset voltage

Lower Power consumption

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