FOR ENERGY EFFICIENT INNOVATIONS

THINK ON.

www.onsemi.cn

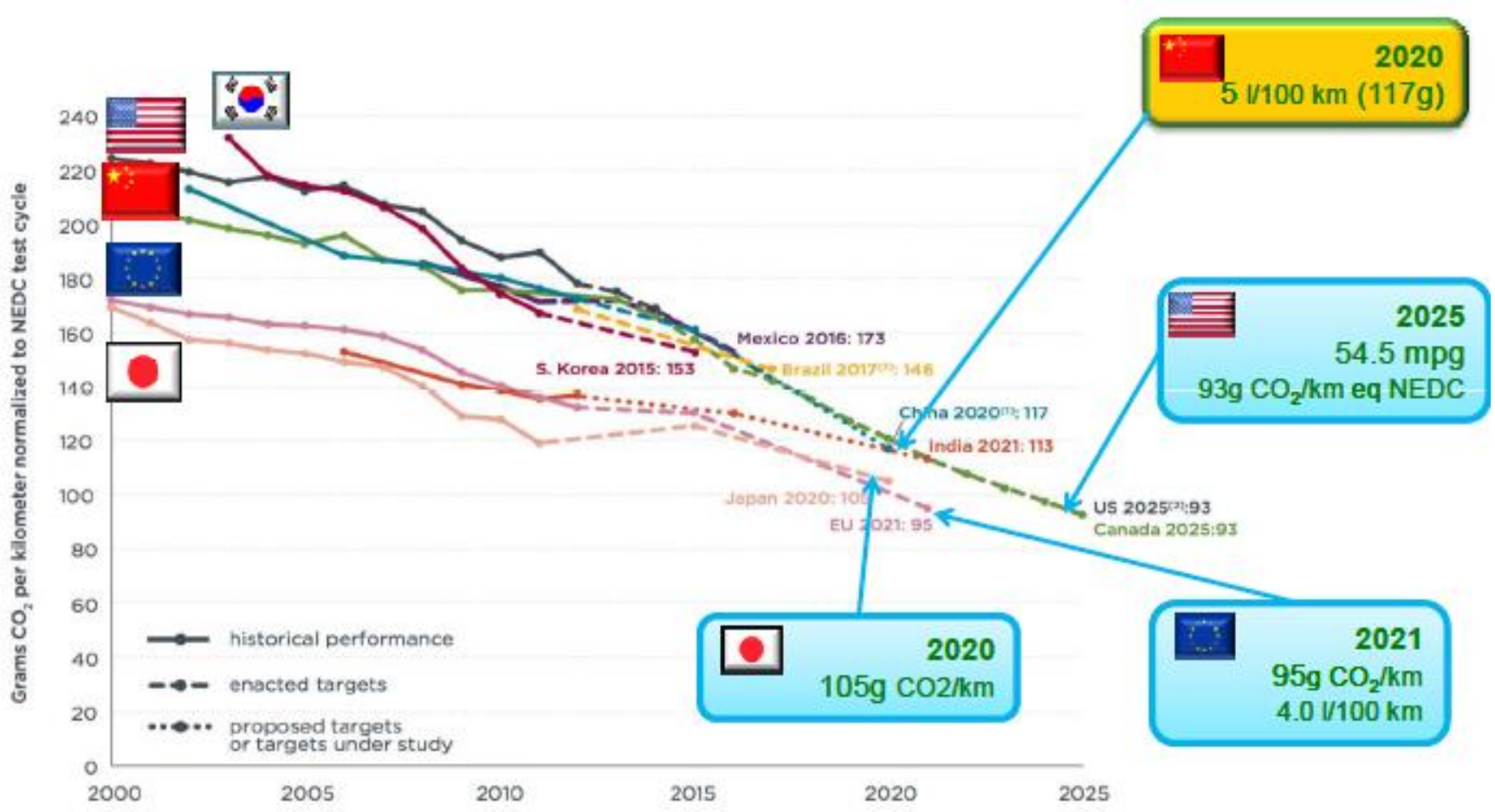
48V应用方案：中压功率MOSFET分立器件和模块

Jackie.Zhao@onsemi.com

17317602839

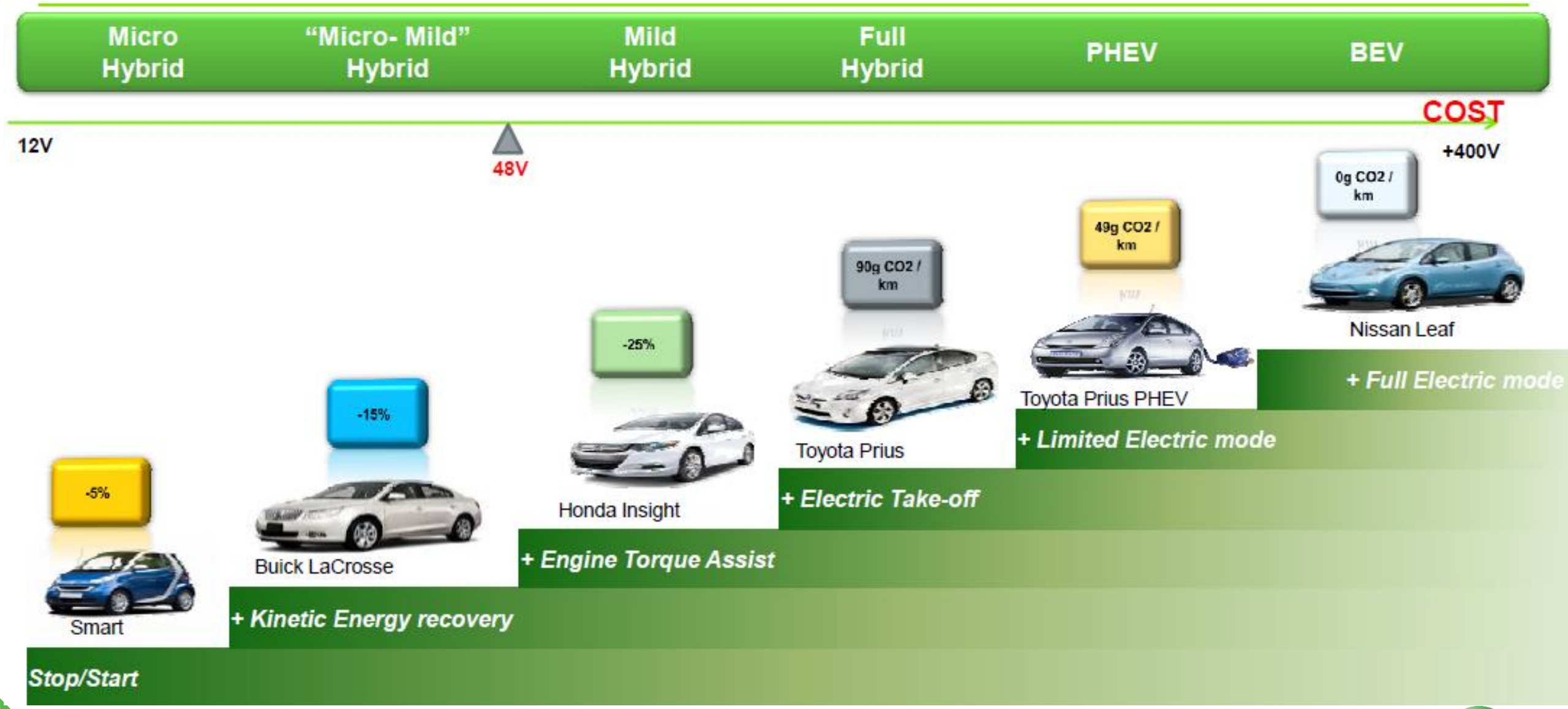
Auto PSG Marketing

DRIVER FOR HYBRIDIZATION : LEGISLATION

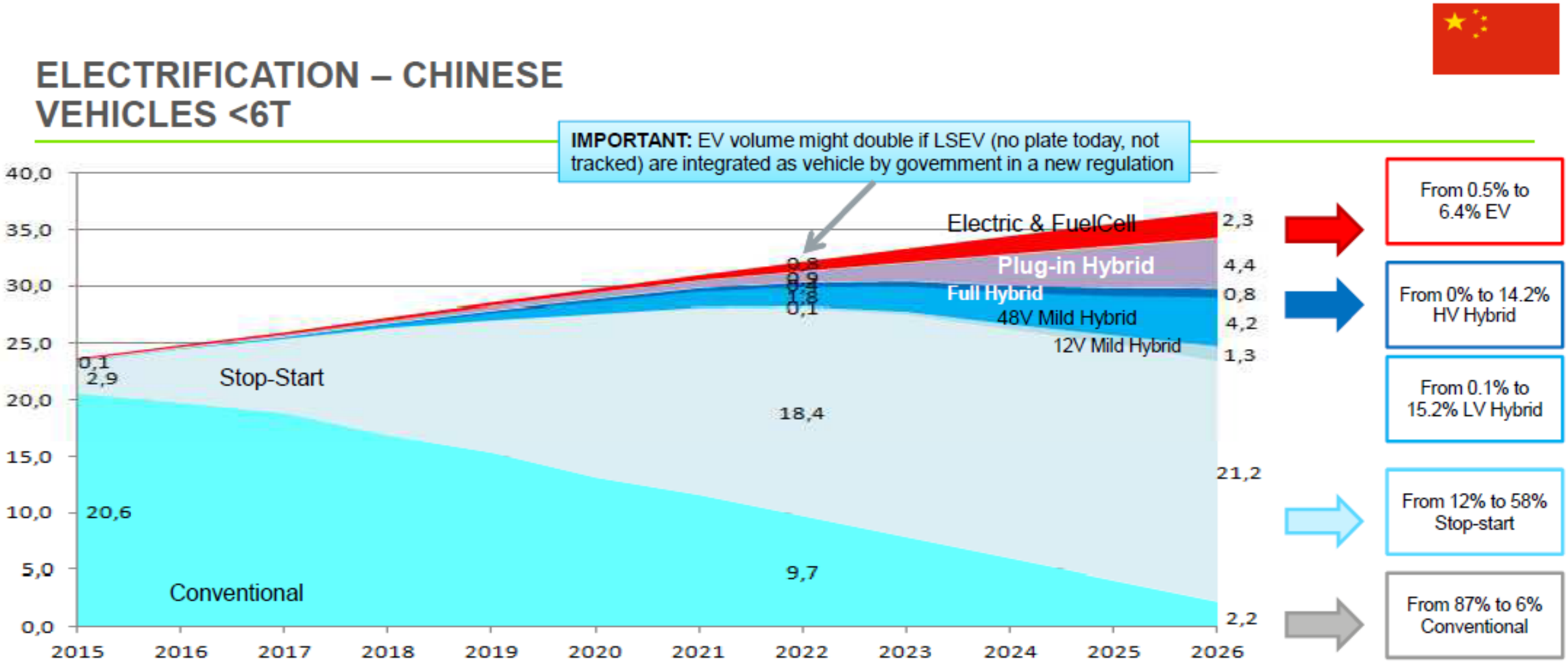


Worldwide regulations are converging.
Solutions for CO2 reductions will be global.

Cost Vs Benefit



ELECTRIFICATION – CHINESE(VEHICLES <6T)



Evolution of Automotive Power Supply

HEV/EV

60V Safety

48 V

Implications for Automotive Semiconductors

12 & 24V

Jump Start
Load dump (clamped)
ISO Pulses

6 V

1950's

20XX

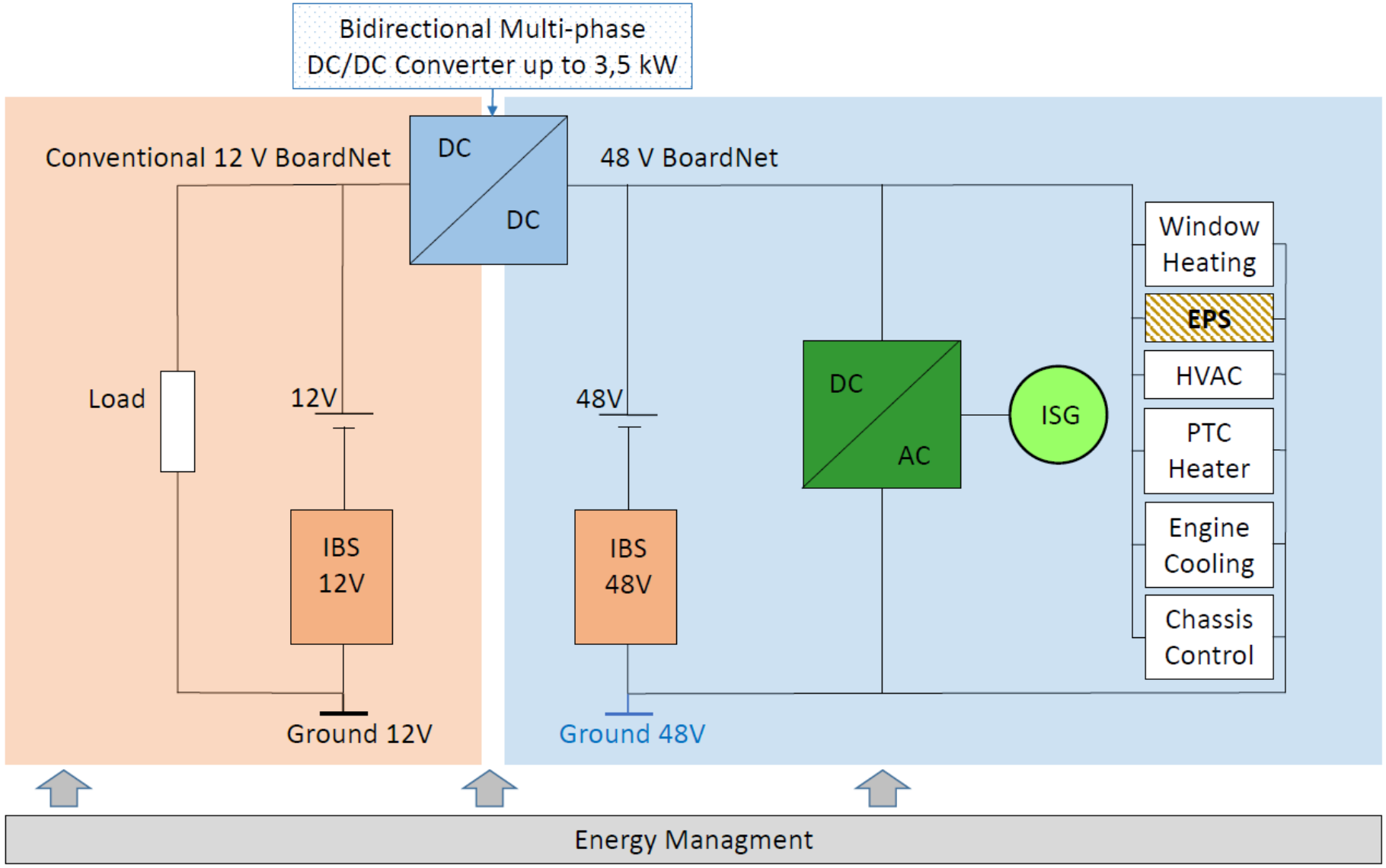
Goals

- Insure interoperability & cost reduction
- Push adoption of non-insulated 48V technologies in China and US

Standardization challenges :

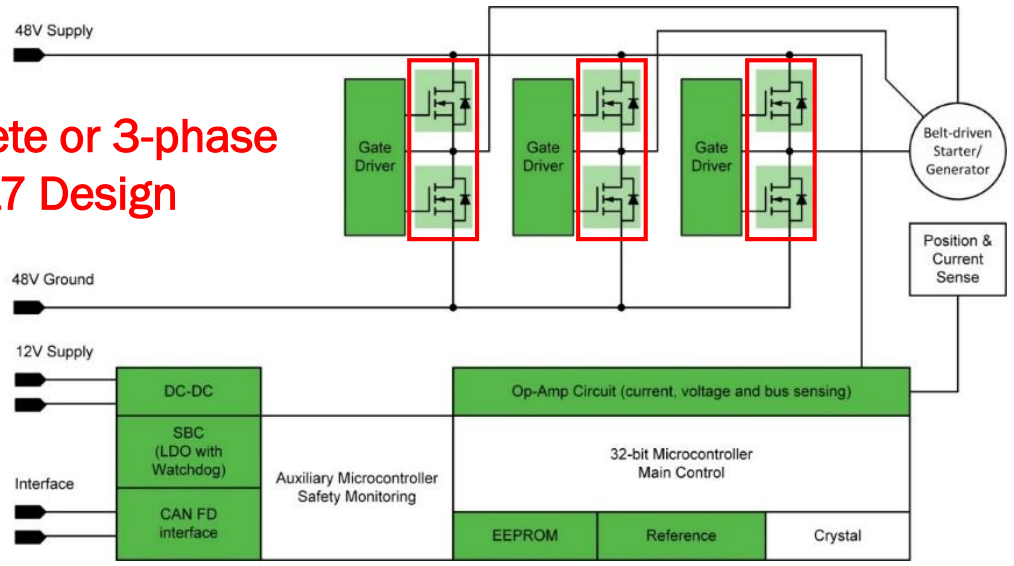
- Description of system behavior
- Strike a good compromise between a "traction network" and an "accessory network"
- Arcing and fusing
- cost down

Topology 48V/12V

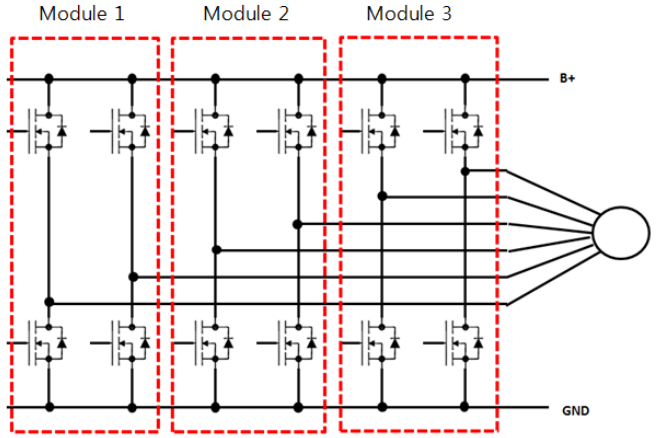


48V Applications - BSG Block Diagrams

Discrete or 3-phase APM17 Design



6-phase or APM15 Design



Key products

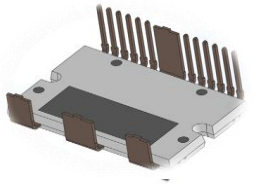
- 80V to 100V discrete MOSFET's
- APM17/15 half-bridge modules
- Half-bridge gate driver
- Current sense amplifiers
- Op-amps

Key development direction

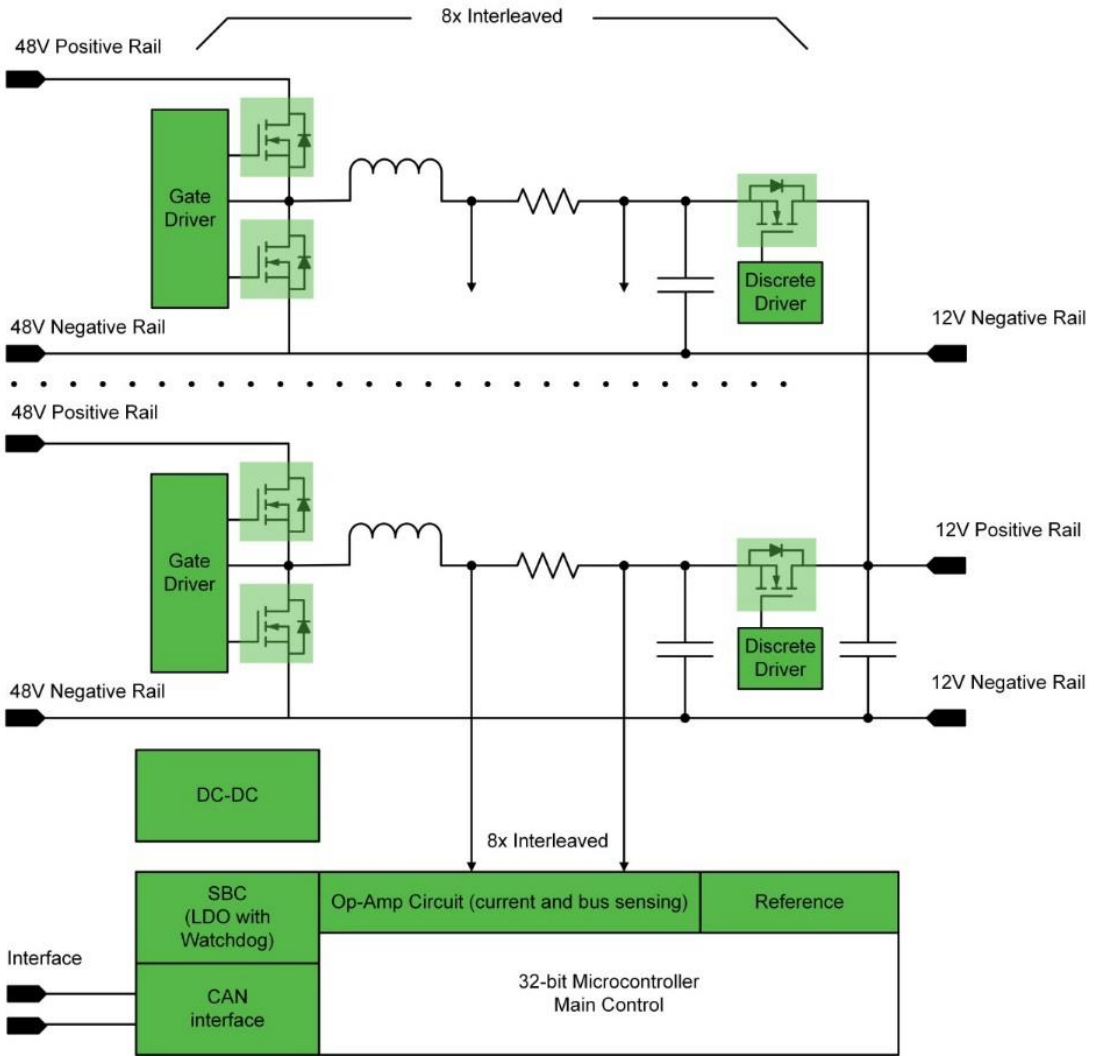
- Reduce overall system size and cost
- Half-bridge automotive power modules available in multiple configurations

APM17

APM15



48V-12V DC-DC Converter Block Diagram



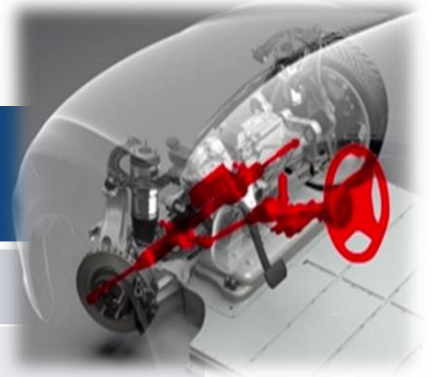
Key products

- 80V/100V MOSFET's for buck-boost switching
- 30V/40V MOSFETs for OR-ing and safe turn-off
- Half-bridge MOSFET drivers
- Current sense op-amps

Key development direction

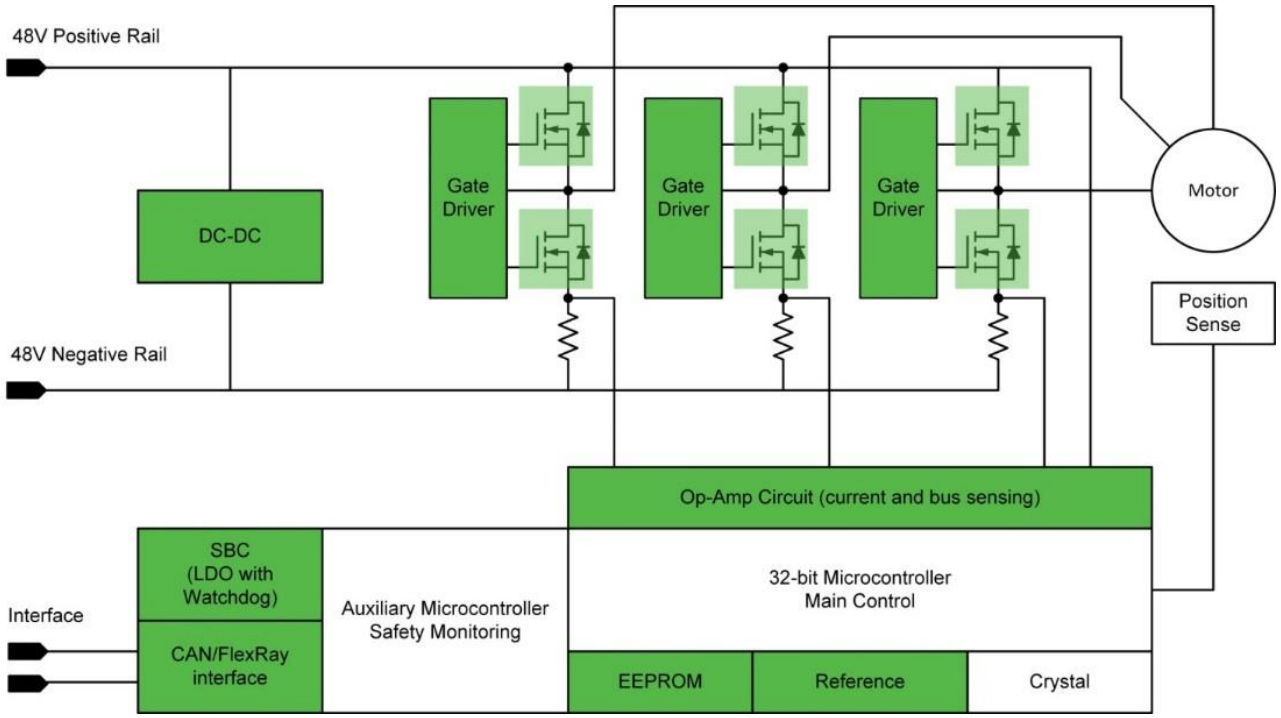
- Reduce overall system size and cost
- Use wide band-gap products and/or faster switching to achieve this
- Higher levels of integration

EPS and Other 48V Auxiliary Loads



Load	Block diagram	Power	Introduction timeframe
E-Turbo (Supercharger)	E-Turbo	5 – 8kW	2016-2020
Roll stabilization	48V motor 1kW – 3kW	4kW (4x 1kW)	2016-2020
Power Steering	48V motor 1kW – 3kW	3kW	2021-2025
Engine cooling fan	48V motor 300W - 1kW	800W	2021-2025
Engine water pump	48V motor 300W - 1kW	800W	2021-2025
Windscreen deicing	48V motor 300W - 1kW	1kW	2021-2025
Climate compressor	48V motor 1kW – 3kW	3kW	2026-2030
Solar roof	48V motor 1kW – 3kW	3kW	2026-2030

48V Auxiliary Motor Drive Block Diagram



Key products

- 80V/100V MOSFETs
- MOSFET module
- Gate drivers
- Current sense amps
- LDO
- DC-DC
- SBC
- CAN interface

Key development direction

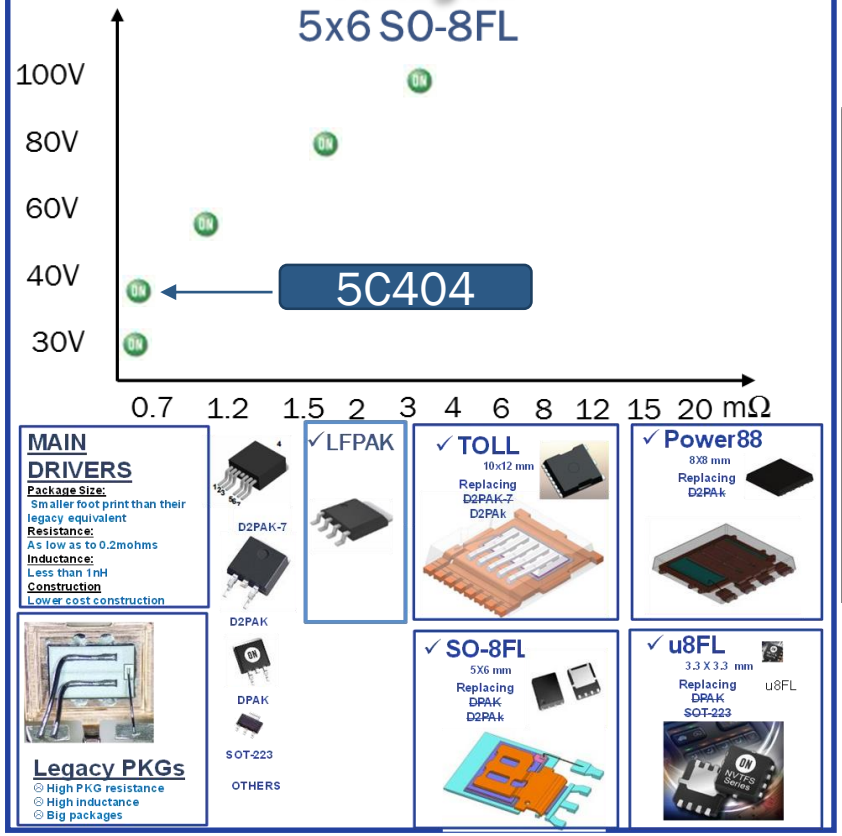
- Reduce overall system size and cost
  - Simplify thermal design

Automotive MOSFET Discrete

Leadership Automotive MOSFETs and Market Position

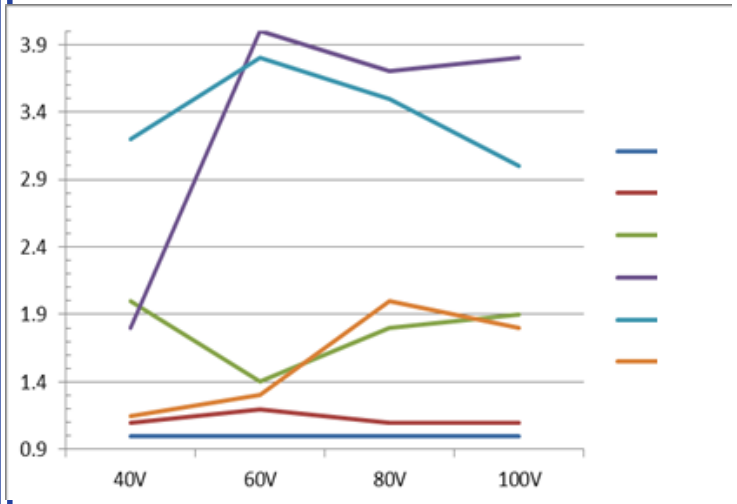
Best Silicon Performance

Lowest MOSFET RDS(on) across a wide range of voltages.



Best Performing Silicon Technology

Absolute lowest specific resistance for every breakdown voltage



*Normalized RDS-ON Vs, Competition Estimates

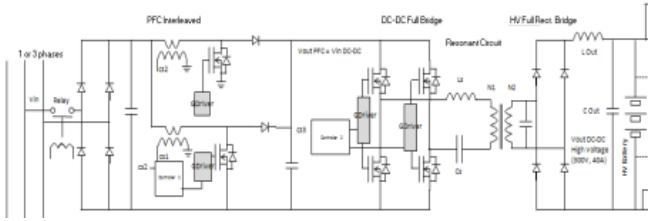
Broadest Pkg. Offering

	ON								
D2PAK-7	P	X	X	X	X		X		
D2PAK	X	X	X	X	X	X	X	X	X
DPAK	X	X	X	X	X	X	X	X	X
SOT-223	X	X	X					X	
TO-LL	X	X							
Pwr88	D	X*							
5x6	X	X	X			X	X	X	X
3x3	X	X	X		X	X	X	X	
2x2	D			X		X			
LFPAK88	D				X				
LFPAK56	X			X	X				
LFPAK33	D			X					
8x8 DC	X	X*							
5x6DC	X	X*	X						

Key Focus Areas for Automotive MOSFETs

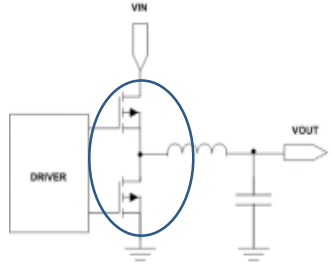
HEV/EV

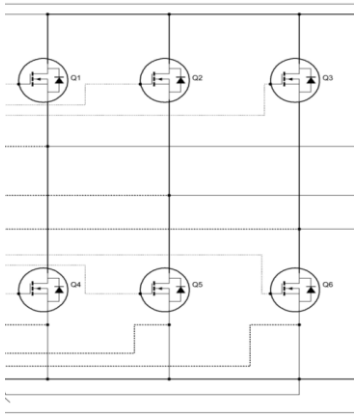
- On board charger
- HV DC-DC
- Traction Inverter



48V Systems

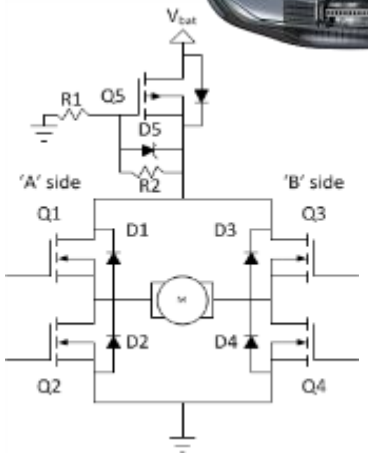
- DC/DC conversion
- Starter Generator
- Motor Control





ADAS / Relay Replacement.

- Motor Control
- DC/DC Conversion



Car Electrification / Traditional Applications

- Pumps
- Electric Power Steering
- Electric Fan.
- DC/DC Conversion.
- Traditional Engine Control Units
- Transmission Control Units

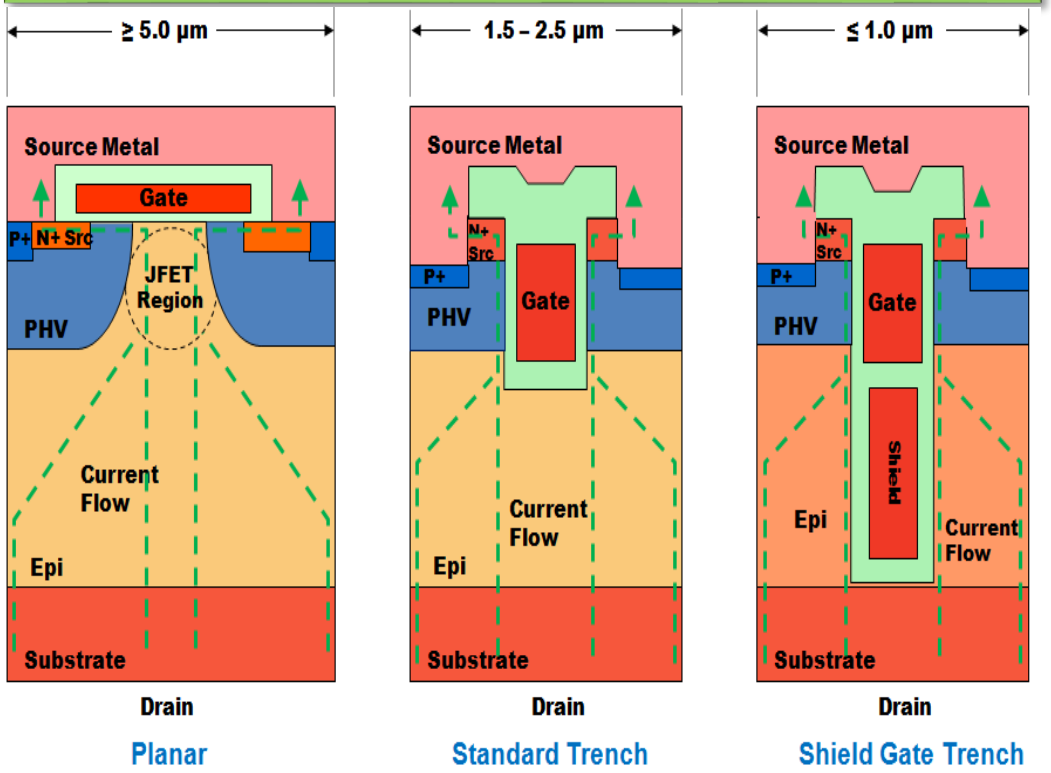
Automotive MOSFET BU Internal Manufacturing Footprint

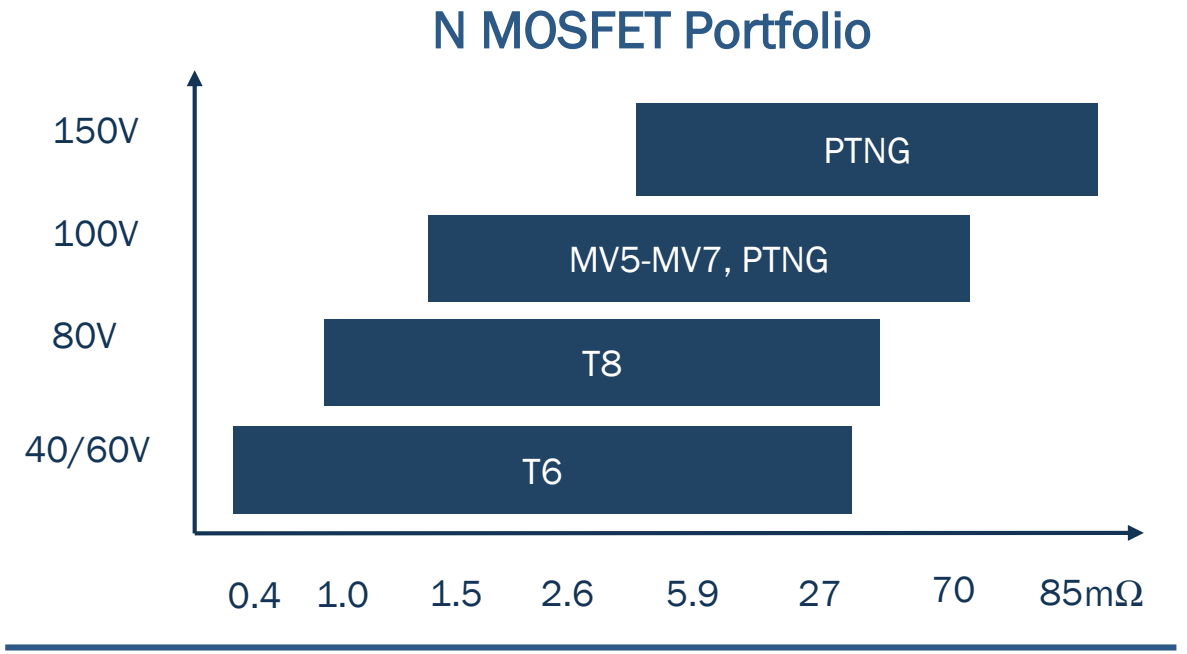
High Performance Silicon LMV Technology

What Customers are looking for?

- Low Resistance
- Low Qg
- Low and Soft Reverse recovery

Technology	Breakdown Voltage
T6	30V, 40V, 60V
T8	80V
MV5-MV7	80V (MV7), 100V (MV5), 150V (MV5)
PTNG	100, 150V





ON Semiconductor Leading Performance MOSFET Package Technologies

MAIN DRIVERS

Package Size:
Smaller foot print than their legacy equivalent

Resistance:
As low as to 0.2mohms

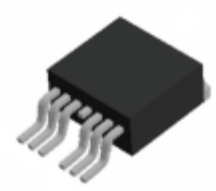
Inductance:
Less than 1nH

Construction
Lower cost construction

Legacy PKGs

☹ High PKG resistance
☹ High inductance
☹ Big packages

Legacy



D2PAK-7

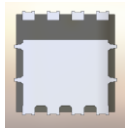
D2PAK

DPAK

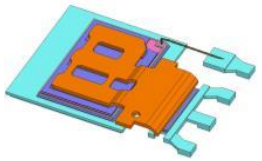
SOT-223

Flat lead

A — TO Leadless- 10x12mm



A — POWER88 8x8mm



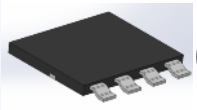
A — POWER56 SO8FL 5x6mm

A — POWER33 u8FL 3x3mm

D — POWER22 2x2mm

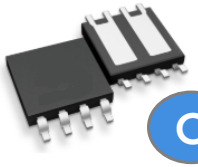
Roadmap

LFPAK (Gull-wing)



C — LFPAK88 8x8mm

A — LFPAK56 5x6mm

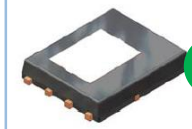


C — LFPAK56 5x6 Dual

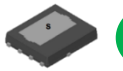
D — LFPAK33 3x3mm

Roadmap

Dual Cool



A — DC88 8x8mm



A — DC56 5x6mm

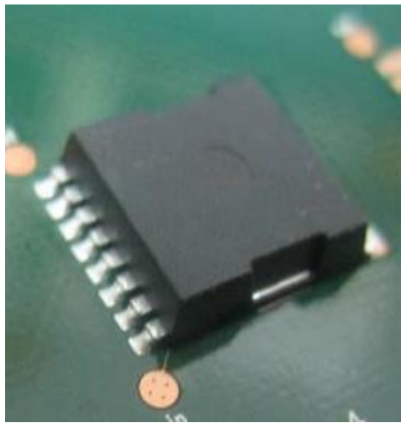
Roadmap

Public Information

A	D	C
Available	Development	Concept

LMV MOSFET Portfolio TOLL

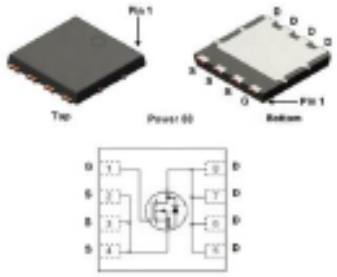
Part Number	Package	Configuration	Polarity	BV_{DSS} (V)	Gate Level	$R_{DS(on)}$ max @ 10V (mΩ)	Q_G @10V typ (nC)	Samples	RTM	Tech'
NVBLS0D5N04C	TOLL	Single	N	40	SL	0.5	TBD	Now	Now	T6
NVBLS0D5N04M8	TOLL	Single	N	40	SL	0.57	220	Now	Now	MV8
FDBL9401L-F085	TOLL	Single	N	40	LL	0.6	280	Now	Now	MV8
FDBL9401-F085T6	TOLL	Single	N	40	SL	0.72	148	Now	Now	T6
NVBLS0D7N04M8	TOLL	Single	N	40	SL	0.75	144	Now	Now	MV8
FDBL9403L-F085	TOLL	Single	N	40	LL	0.85	186	Now	Now	MV8
FDBL9403-F085T6	TOLL	Single	N	40	SL	0.95	108	Now	Now	T6
FDBL9406L-F085	TOLL	Single	N	40	LL	1.1	121	Now	Now	MV8
FDBL9406-F085T6	TOLL	Single	N	40	SL	1.2	90	Now	Now	T6
NVBLS0D7N06C	TOLL	Single	N	60	SL	0.75	170	Now	Now	T6
NVBLS001N06C	TOLL	Single	N	60	SL	0.9	143	Now	Now	T6
FDBL86561-F085	TOLL	Single	N	60	SL	1.1	170	Now	Now	MV7
FDBL86563-F085	TOLL	Single	N	60	SL	1.5	130	Now	Now	MV7
FDBL86566-F085	TOLL	Single	N	60	SL	2.4	80	Now	Now	MV7
NVBLS1D1N08H	TOLL	Single	N	80	SL	1.05	10	Now	Now	T8
FDBL86361-F085	TOLL	Single	N	80	SL	1.4	172	Now	Now	MV7
NVBLS1D7N08H	TOLL	Single	N	80	SL	1.7	110	Now	Q4'20	T8
FDBL86363-F085	TOLL	Single	N	80	SL	2	130	Now	Now	MV7
FDBL86366-F085	TOLL	Single	N	80	SL	3	86	Now	Now	MV7
NVBLS1D5N10MC	TOLL	Single	N	100	SL	1.55	125	Q4'20	Q3'21	PTNG
NVBLS1D7N10MC	TOLL	Single	N	100	SL	1.7	tbc	Q4'20	Q3'21	PTNG
FDBL86062-F085	TOLL	Single	N	100	SL	2	95	Now	Now	PTNG
FDBL86063-F085	TOLL	Single	N	100	SL	2.6	76	Now	Now	PTNG
FDBL86066-F085	TOLL	Single	N	100	SL	4.1	46	Now	Now	PTNG
NVBLS4D0N15MC	TOLL	Single	N	150	SL	4	tbc	Now	Now	PTNG
FDBL86210-F085	TOLL	Single	N	150	SL	6.3	70	Now	Now	MV5



TOLL = 10X12 mm
TO LEADLESS

LMV MOSFET Portfolio Power88 (P88)

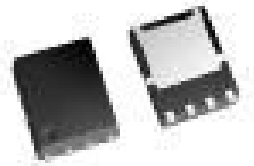
Part Number	Package	Configuration	Polarity	BV_{DSS} (V)	Gate Level	$R_{DS(on)}$ max @ 10V (mΩ)	Q_G @10V typ (nC)	Samples	RTM	Tech'
NVMTS0D4N04CL	Pwr88	Single	N	40	LL	0.4	341	Now	Now	T6
NVMTS0D6N04CL	Pwr88	Single	N	40	LL	0.42	tbc	Now	Now	T6
NVMTS0D4N04C	Pwr88	Single	N	40	SL	0.45	250	Now	Now	T6
NVMTS0D6N04C	Pwr88	Single	N	40	SL	0.48	185	Now	Now	T6
NVMTS0D7N04CL	Pwr88	Single	N	40	LL	0.63	205	Now	Now	T6
NVMTS0D7N04C	Pwr88	Single	N	40	SL	0.67	141	Now	Now	T6
NVMTS1D0N04CL	Pwr88	Single	N	40	LL	1	tbc	Now	Q4'20	T6
NVMTS1D1N04C	Pwr88	Single	N	40	SL	1.1	tbc	Now	Q4'20	T6
NVMTS1D3P04M8L	Pwr88	Single	P	40	LL	1.3	338	Ask BU	Ask BU	MV8P
NVMTS1D8P04M8L	Pwr88	Single	P	40	LL	1.8	96	Ask BU	Ask BU	MV8
NVMTS003P04M8L	Pwr88	Single	P	40	LL	3	149	Ask BU	Ask BU	MV8P
NVMTS0D7N06CL	Pwr88	Single	N	60	LL	0.68	225	Now	Now	T6
NVMTS0D7N06C	Pwr88	Single	N	60	SL	0.72	152	Now	Now	T6
NVMTS001N06CL	Pwr88	Single	N	60	LL	0.81	165	Now	Now	T6
NVMTS001N06C	Pwr88	Single	N	60	SL	0.91	113	Now	Now	T6
NVMTS1D2N08H	PWR88	Single	N	80	SL	1.1	148	Now	Now	T8
NVMTSC1D3N08M7	PWR88DC	Single	N	80	SL	1.25	170	Now	Now	MV7
NVMTS1D5N08H	PWR88	Single	N	80	SL	1.4	120	Now	Now	T8
NVMTS2D0N08H	PWR88	Single	N	80	SL	2	tbc	Ask BU	Ask BU	T8
NVMTS002N08M7	PWR88	Single	N	80	SL	2	tbc	Ask BU	Ask BU	MV7
NVMTS2D5N08H	PWR88	Single	N	80	SL	2.5	tbc	Ask BU	Ask BU	T8
NVMTS2D5N08M7	PWR88	Single	N	80	SL	2.5	tbc	Ask BU	Ask BU	MV7
NVMTS4D0N08H	PWR88	Single	N	80	SL	4	tbc	Ask BU	Ask BU	T8
NVMTS004N08M7	PWR88	Single	N	80	SL	4	tbc	Ask BU	Ask BU	MV7
NVMTS1D6N10MC	PWR88	Single	N	100	SL	1.6	107	Now	Q2'21	PTNG
NVMTSC1D6N10MC	PWR88DC	Single	N	100	SL	1.6	107	Now	Q2'21	PTNG
NVMTS002N10MC	PWR88	Single	N	100	SL	2	87	Now	Q2'21	PTNG
NVMTS2D5N10MC	PWR88	Single	N	100	SL	2.5	69	Now	Q2'21	PTNG
NVMTS003N10MC	PWR88	Single	N	100	SL	3	57	Now	Q2'21	PTNG
NVMTS4D3N15MC	PWR88	Single	N	150	SL	4.3	tbc	Now	Q4'20	PTNG
NVMTSC4D3N15MC	PWR88DC	Single	N	150	SL	4.3	tbc	Now	Q4'20	PTNG
NVMTS6D0N15MC	PWR88	Single	N	150	SL	6	tbc	Now	Q4'20	PTNG



Power88 = 8x8 mm

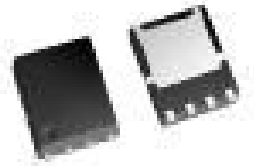
LMV MOSFET Portfolio PWR56/S08FL – 30V&40V single NMOS

Part Number	Package	Configuration	Polarity	BV_{DSS} (V)	Gate Level	$R_{DS(on)}$ max @ 10V (mΩ)	Q_G @10V typ (nC)	Samples	RTM	Tech'
NVMFS4C01N	S08FL	Single	N	30	LL	0.67	139	Now	Now	T6
NVMFS4C302N	S08FL	Single	N	30	LL	1.15	11.6	Now	Now	T6
NVMFS4C03N	S08FL	Single	N	30	LL	1.7	45.2	Now	Now	T6
NVMFS4C05N	S08FL	Single	N	30	LL	2.8	30	Now	Now	T6
NVMFS4C306N	S08FL	Single	N	30	LL	3.4	11.6	Now	Q3'20	T6
NVMFS4C308N	S08FL	Single	N	30	LL	4.8	8.4	Now	Q3'20	T6
NVMFS4C310N	S08FL	Single	N	30	LL	6	9.7	Now	Now	T6
NVMFS5C404NL	S08FL	Single	N	40	LL	0.67	181	Now	Now	T6
NVMFS5C404N	S08FL	Single	N	40	SL	0.7	128	Now	Now	T6
NVMFS5C406NL	S08FL	Single	N	40	LL	0.7	tbc	Now	Now	T6
NVMFS5C406N	S08FL	Single	N	40	SL	0.8	110	Now	Now	T6
NVMFS5C410NL	S08FL	Single	N	40	LL	0.82	143	Now	Now	T6
NVMFS5C410N	S08FL	Single	N	40	SL	0.92	86	Now	Now	T6
NVMFS5C420NL	S08FL	Single	N	40	LL	1	tbc	Now	Q3'20	T6
NVMFS5C420N	S08FL	Single	N	40	SL	1.1	tbc	Now	Q3'20	T6
NVMFS5C426NL	S08FL	Single	N	40	LL	1.2	65	Now	Now	T6
NVMFS5C426N	S08FL	Single	N	40	SL	1.3	65	Now	Now	T6
NVMFS5C430NL	S08FL	Single	N	40	LL	1.4	70	Now	Now	T6
NVMFS5C430N	S08FL	Single	N	40	SL	1.7	47	Now	Now	T6
NVMFS5C423NL	S08FL	Single	N	40	LL	2	50	Now	Now	T6
NVMFS5C442N	S08FL	Single	N	40	SL	2.3	32	Now	Now	T6
NVMFS5C442NL	S08FL	Single	N	40	LL	2.5	50	Now	Now	T6
NVMFS5C450NL	S08FL	Single	N	40	LL	2.8	35	Now	Now	T6
NVMFS5C450N	S08FL	Single	N	40	SL	3.3	23	Now	Now	T6
NVMFS5C456NL	S08FL	Single	N	40	LL	3.7	18	Now	Now	T6
NVMFS5C456N	S08FL	Single	N	40	SL	4.5	18	Now	Now	T6
NVMFS5C460NL	S08FL	Single	N	40	LL	4.5	23	Now	Now	T6
NVMFS5C460N	S08FL	Single	N	40	SL	5.3	13	Now	Now	T6
NVMFS5C466NL	S08FL	Single	N	40	LL	7.3	16	Now	Now	T6
NVMFS5C466N	S08FL	Single	N	40	SL	8.1	10	Now	Now	T6
NVMFS5C468NL	S08FL	Single	N	40	LL	10.3	7.3	Now	Now	T6
NVMFS5C468N	S08FL	Single	N	40	SL	12	5	Now	Now	T6



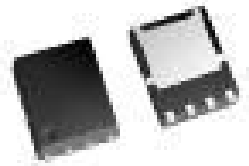
LMV MOSFET Portfolio PWR56/S08FL – 80V

Part Number	Package	Configuration	Polarity	BV_{DSS} (V)	Gate Level	$R_{DS(on)}$ max @ 10V (mΩ)	Q_G @10V typ (nC)	Samples	RTM	Tech'
NVMFS6H800NL	SO-8FL	Single	N	80	LL	1.9	85	Now	Now	T8
NVMFS6H800N	SO-8FL	Single	N	80	SL	2.1	85	Now	Now	T8
NVMFS6H801NL	SO-8FL	Single	N	80	LL	2.7	tbc	Now	Now	T8
NVMFS6H801N	SO-8FL	Single	N	80	SL	2.8	64	Now	Now	T8
NVMFS6H818NL	SO-8FL	Single	N	80	LL	3.5	46	Now	Now	T8
NVMFS6H818N	SO-8FL	Single	N	80	SL	3.7	46	Now	Now	T8
NVMFS6H824NL	SO-8FL	Single	N	80	LL	4	tbc	Now	Now	T8
FDWS86368-F085	PWR56	Single	N	80	SL	4.5	57	Now	Now	MV7
NVMFS6H824N	SO-8FL	Single	N	80	SL	4.5	38	Now	Now	T8
NVMFS6D1N08H	SO-8FL	Single	N	80	SL	5.5	28	Now	Now	T8
NVMFS6H836NL	SO-8FL	Single	N	80	LL	6.2	24	Now	Now	T8
NVMFS6H836N	SO-8FL	Single	N	80	SL	6.7	24	Now	Now	T8
NVMFD6H840NL	SO-8FL	Dual	N + N	80	LL	6.9	tbc	Now	Now	T8
FDWS86369-F085	PWR56	Single	N	80	SL	7.5	35	Now	Now	MV7
NVMFS6H848NL	SO-8FL	Single	N	80	LL	8.8	tbc	Now	Now	T8
NVMFS6H848N	SO-8FL	Single	N	80	SL	9.4	16	Now	Now	T8
NVMFS6H852NL	SO-8FL	Single	N	80	LL	13.1	tbc	Now	Now	T8
FDWS86380-F085	PWR56	Single	N	80	SL	13.4	35	Now	Now	MV7
NVMFD6H846NL	SO-8FL	Dual	N + N	80	LL	14	16	Now	Now	T8
NVMFS6H852N	SO-8FL	Single	N	80	SL	14.2	11	Now	Now	T8
NVMFS6H858NL	SO-8FL	Single	N	80	LL	19.5	tbc	Now	Now	T8
NVMFS6H858N	SO-8FL	Single	N	80	SL	20.7	7	Now	Now	T8
FDMS86381-F085	PWR56	Single	N	80	SL	22	14	Now	Now	MV7
NVMFD6H852NL	SO-8FL	Dual	N + N	80	LL	25.5	tbc	Now	Now	T8
NVMFS6H864NL	SO-8FL	Single	N	80	LL	29	6	Now	Now	T8
NVMFS6H864N	SO-8FL	Single	N	80	SL	32	5	Now	Now	T8



LMV MOSFET Portfolio PWR56/S08FL – 100V

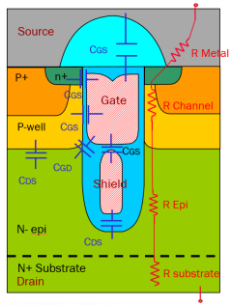
Part Number	Package	Configuration	Polarity	BV_{DSS} (V)	Gate Level	$R_{DS(on)}$ max @ 10V (mΩ)	Q_G @10V typ (nC)	Samples	RTM	Tech'
NVMFS002N10MCL	SO-8FL	Single	N	100	LL	2.7	tbc	Q4'20	Q3'21	PTNG
NVMFS003N10MC	SO-8FL	Single	N	100	SL	2.9	tbc	Q4'20	Q3'21	PTNG
NVMFS3D6N10MCL	SO-8FL	Single	N	100	LL	3.6	70	Now	Now	PTNG
NVMFS004N10MC	SO-8FL	Single	N	100	SL	4	tbc	Q4'20	Q3'21	PTNG
FDWS86068-F085	PWR56	Single	N	100	SL	6.4	31	Now	Now	PTNG
NVMFD010N10MCL	SO-8FL	Dual	N + N	100	LL	10	tbc	Q4'20	Q3'21	PTNG
NVMFS015N10MCL	SO-8FL	Single	N	100	LL	12.2	20	Now	Now	PTNG
NVMFS016N10MCL	SO-8FL	Single	N	100	LL	15	tbc	Q4'20	Q3'21	PTNG
NVMFD020N10MCL	SO-8FL	Dual	N + N	100	LL	20	tbc	Q1'21	Q3'21	PTNG
NVMFS021N10MCL	SO-8FL	Single	N	100	LL	21	tbc	Q4'20	Q3'21	PTNG
NVMFD027N10MCL	SO-8FL	Dual	N + N	100	LL	27	tbc	Q4'20	Q3'21	PTNG
NVMFS027N10MCL	SO-8FL	Single	N	100	LL	27	tbc	Q4'20	Q3'21	PTNG
NVMFS040N10MCL	SO-8FL	Single	N	100	LL	40	tbc	Q4'20	Q3'21	PTNG
NVMFD040N10MCL	SO-8FL	Dual	N + N	100	LL	42	tbc	Q4'20	Q3'21	PTNG



Automotive MOSFET Module

ON SEMI Automotive Power Module Solutions

World Wide Top #2 Power Semicon Supplier



World Wide leadership in Automotive Transfer Molded DBC

MOSFET
IGBT
SiC
GaN

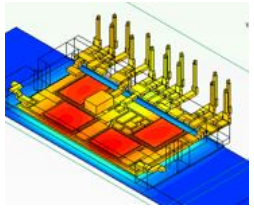
Package Tech.

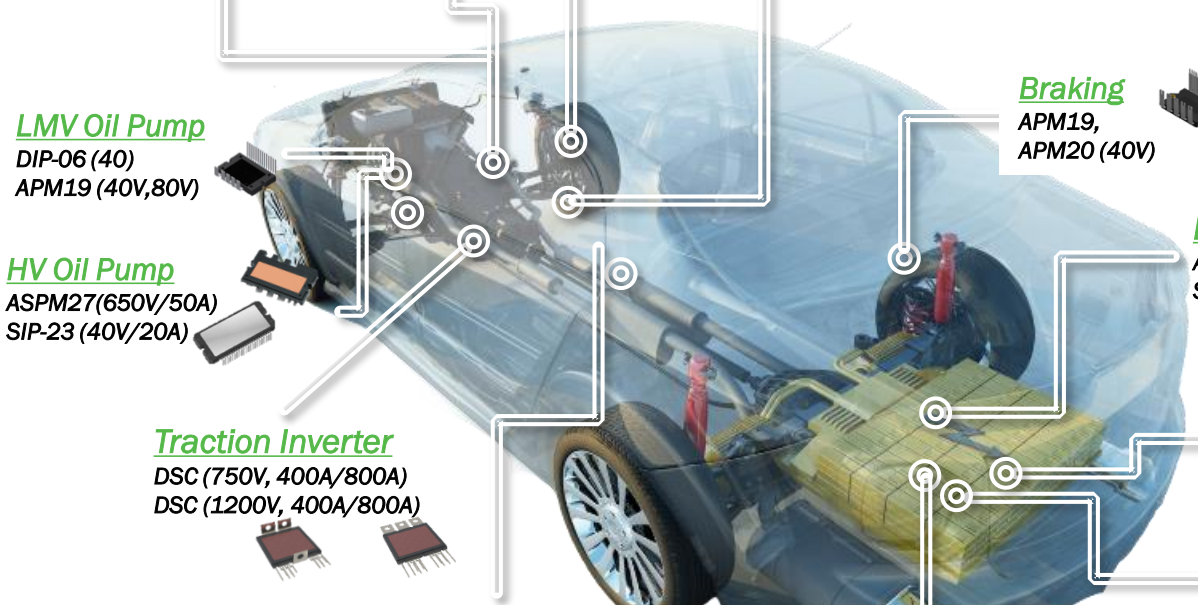
ON's APM

Long history of proven high reliability

Proven Quality

Custom Solution





48V Supercharger, E-Comp
APM21(80V, 100V)

EPS (12V,48V)
APM7, 11 (40V)
APM20 (40V)
APM22 (40V)
APM19 (40,80V)

HV Supercharger
ASPM27(650V/50A):

48V BSG/ISG
APM16M (80V,100V)
APM21 (80V,100V)

Braking
APM19,
APM20 (40V)

LMV Oil Pump
DIP-06 (40)
APM19 (40V,80V)

Battery Cooling Fan
APM27(650V/50A)
SIP-23 (40V/20A)

HV Oil Pump
ASPM27(650V/50A)
SIP-23 (40V/20A)

OBC
APM16 (650V)

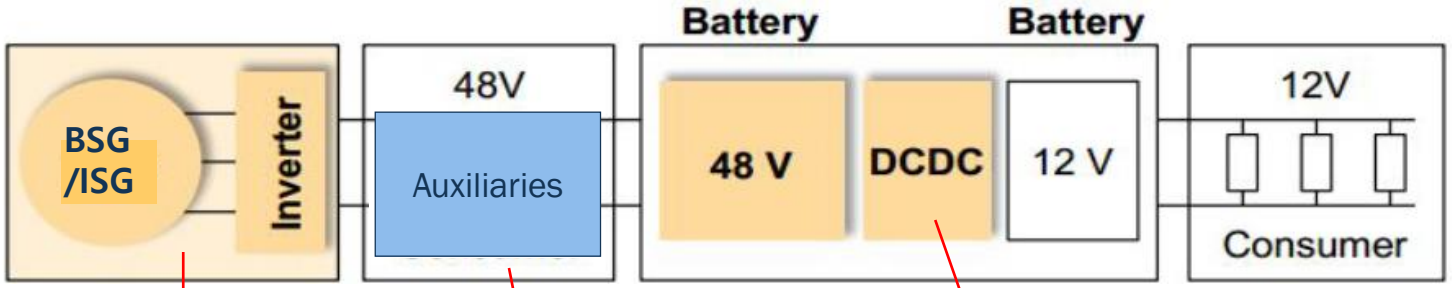
Traction Inverter
DSC (750V, 400A/800A)
DSC (1200V, 400A/800A)

HV DC-DC
APM16 (65

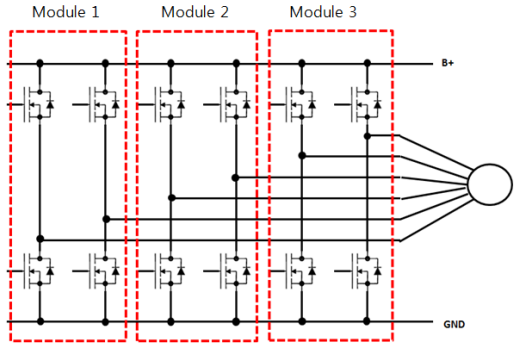
HV E-Compressor
ASPM27 (650V)
ASPM27 (600V)
ASPM34 (1200V)
ASPM16 (750V)

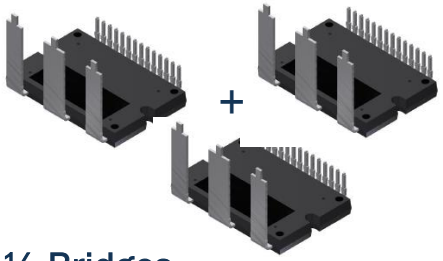
48V DC/DC Battery Switch
APM19 (80V)
APM16M (80V)

APM Solutions for 48V Mild Hybrid



3phase Motors (15-30 kW)





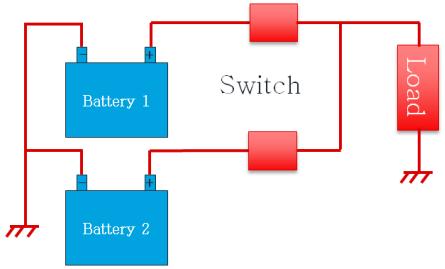
½ Bridges

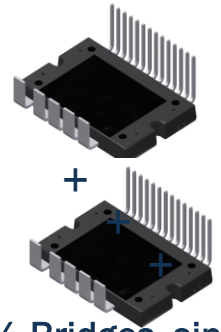
3phase Motors (1-3kW)
- E –Compressor
- E-Supercharger

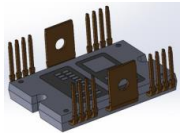
3phase Bridges

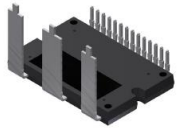
DC/DC converters
Main Battery switch/ Load Switch replacing mechanical relay

APM X 2 for 48V DC-DC converter
: For 6 phase system





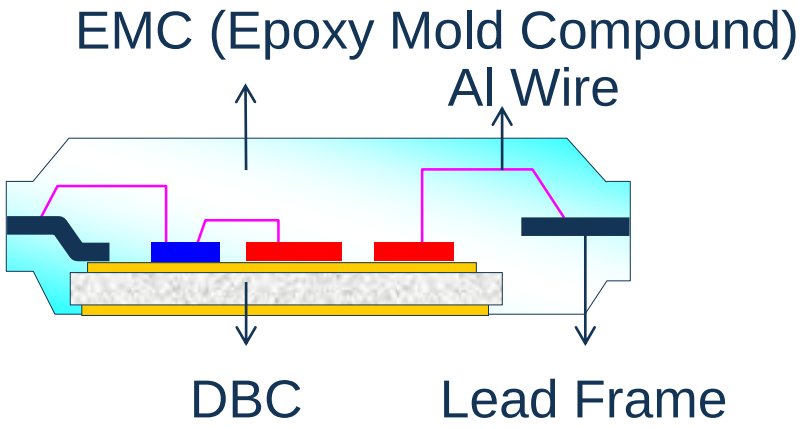


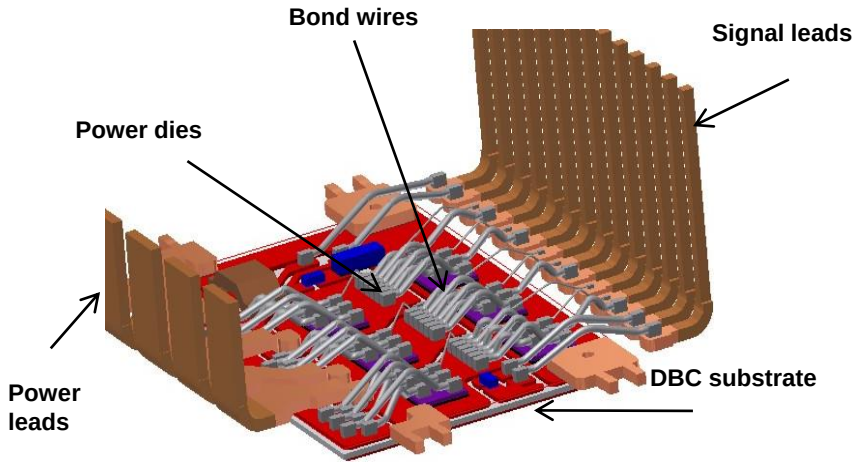


½ Bridges, single switches, back-to-back switches

APM Structure (DBC based)

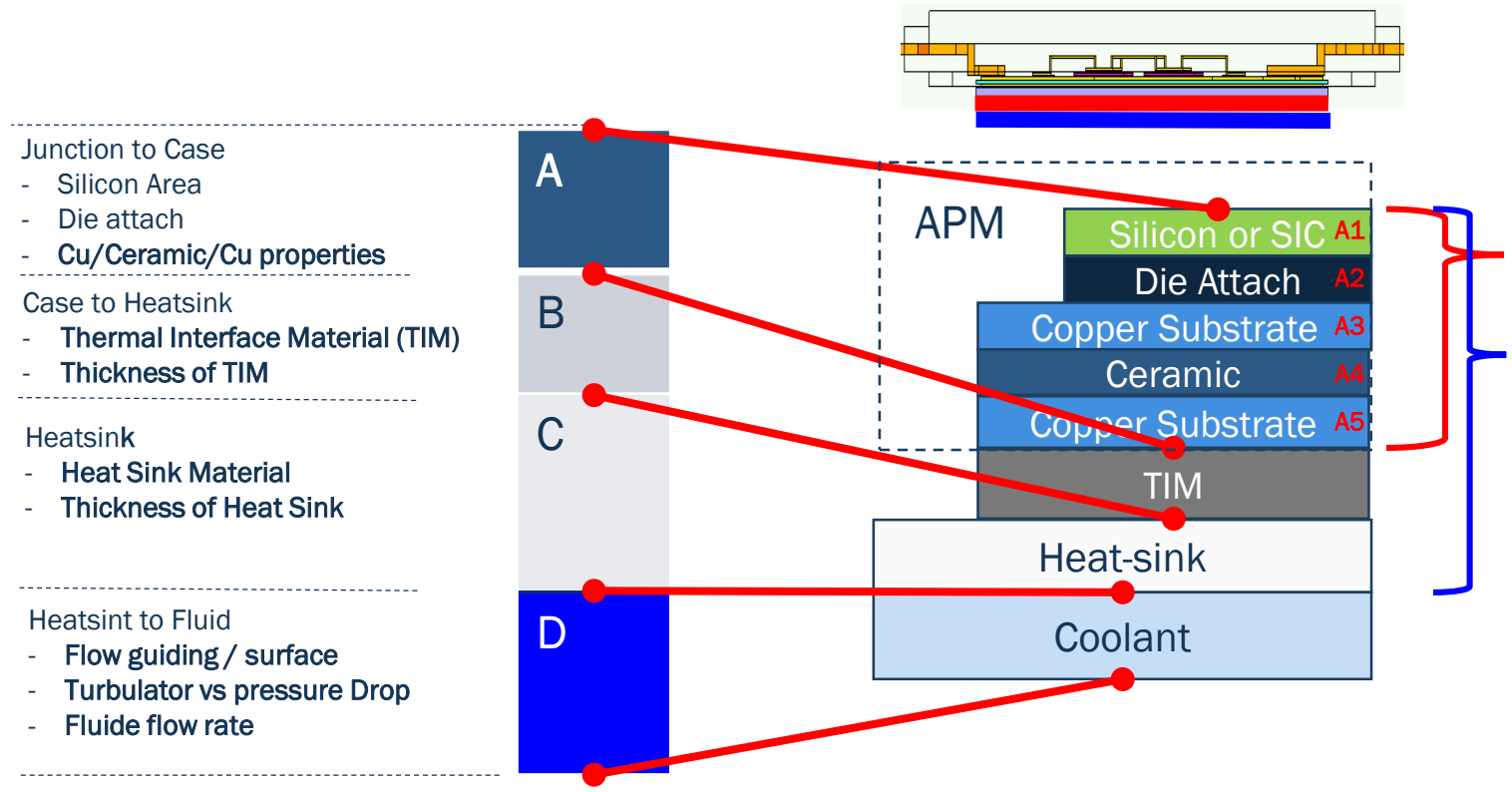
- **Transfer Molded Package**
- **Components: EMC, DBC, Lead Frame, Al Wire/DLA (Direct Leadframe Attach.)**





Benefit: Thermal

ON APM design enabling better thermal performance of total Rth junction to Heat sink



	APM – ON	Discrete
Rthjc – junction to case = A (A1~A5)	>	
Rthjs – junction to heat sink = A+B+C	<	

Rthjs Simulation result (Per 44mm^2 die)

	Low Rth Substrate		AL2O3 Substrate	
	Rth, ˚C/W	%	Rth, ˚C/W	%
A1	0.0202	4.6%	0.0232	3.3%
A2	0.0185	4.2%	0.0185	2.6%
A3	0.0202	4.6%	0.0190	2.7%
A4 – Ceramic	0.0621	14.1%	0.3465	48.7%
A5	0.0113	2.6%	0.0105	1.5%
B TIM	0.0619	14.0%	0.0581	8.2%
C Heat Sink	0.2468	56.0%	0.2363	33.2%
TOTAL	0.4410	---	0.7120	---

A : Options of vertical structure selection and Internal Design defines Rth Per Power rating of application

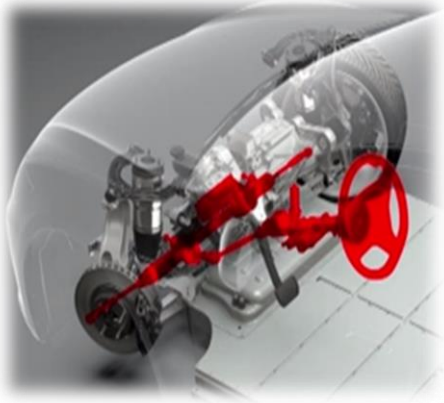
B : By the usage of APM, enable thin layer of B for minimum Rth of of **A+B**

C/D : Customer's design per system requirements

Benefit: Proven Reliability

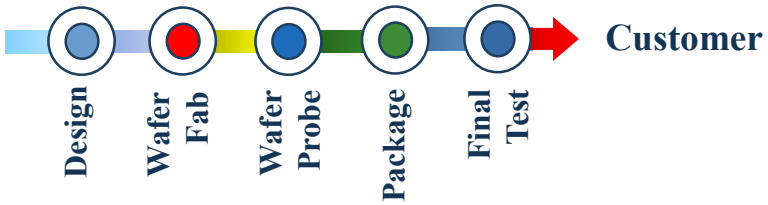
Field proven experience

11 years life in the field



APM released in 2008 for Electrical Power Steering and has been leader in MOSFET Module for LV Auto

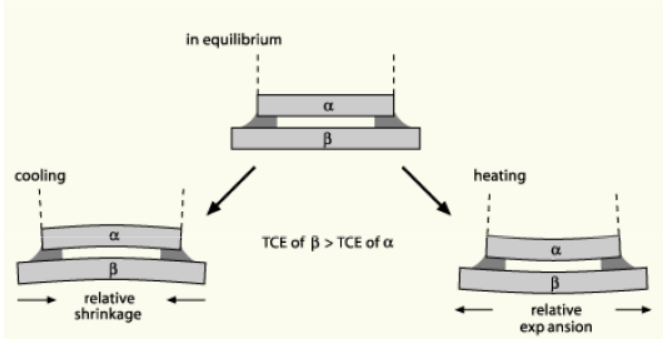
Fab+ Assmebly Total Solution

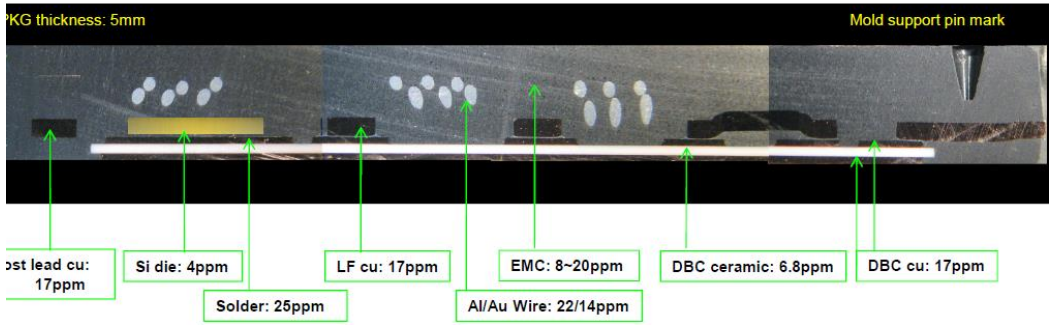


Minimized CTE mismatch in Transfer

Mold DBC technology enables long term thermal cycling

*** CTE(Coefficient of thermal Expansion) mismatch?**



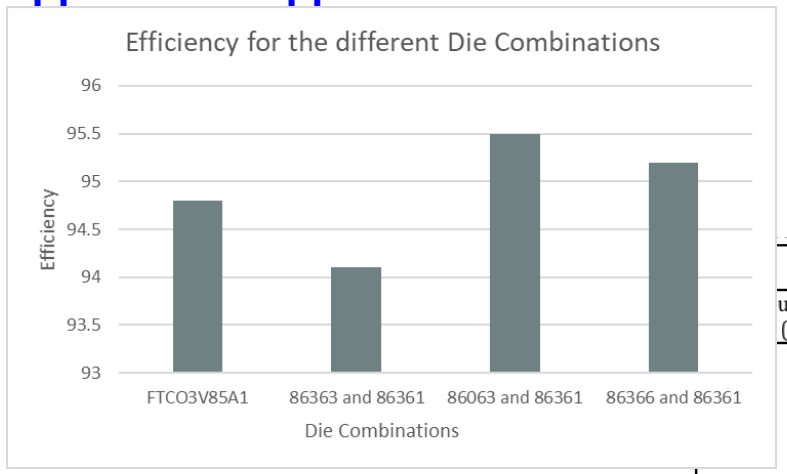


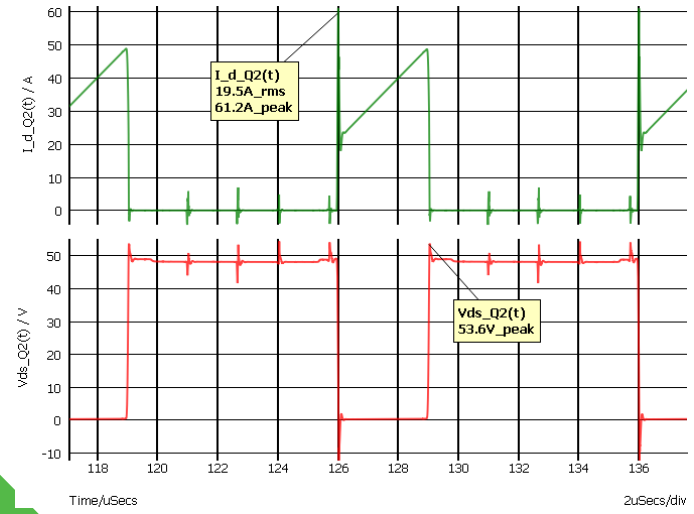
< Structure of power module >

unit: ppm/° C

Benefit: Electrical Performance

Deveopment for best fit for customer requirement in Electrical performance, supported by customized application support.

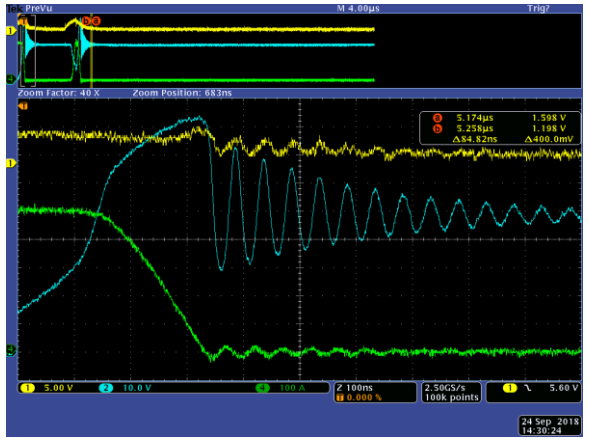




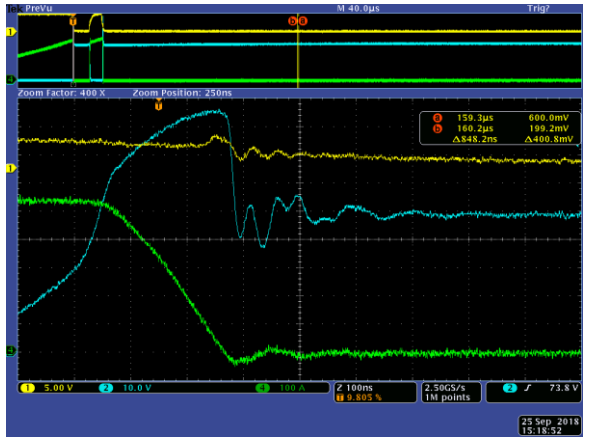
Device			Current [Arms/unit]	P_{sw} [W/unit]	P_{con} [W/unit]	P_{total}/unit [W/unit]	P_{total} [W]
ut Load Inductor (6 x 3.6µH)			36.5Arms	3W			18W
MOSFET	Phase leg 1-High	No	High side 20.5A_rms	11.2	1	12.2	24.4
		RC		11.3	0.9	12.2	24.4
	Phase leg 1-Low	No		5.8	1	6.8	13.6
		RC		5.3	1.4	6.7	13.4
	Phase leg 2-High	No		10	0.8	10.9	21.8
		RC		10.1	0.8	10.9	21.8
	Phase leg 2-Low	No	Low side 30.4A_rms	5.8	0.9	6.7	13.4
		RC		5.1	1.2	6.3	12.6
	Phase leg 3-High	No		10.9	1	11.9	23.8
		RC		10.9	0.9	11.8	23.6
	Phase leg 3-Low	No		5.7	1.1	6.8	13.6
		RC		5.4	1.5	6.9	13.8
RC Snubber			1.1W_on +1.3W_off = 2.4W				14.4
Control and misc.			4				8
Total Converter Loss and Efficiency 86366 +86361	No Snubber		Total Converter Power Dissipation = 136.6W and Converter Efficiency, $E = \frac{2902W}{(2902W+136.6W)} \times 100\% \cong 95.5\%$				
	RC Snubber		Total Converter Power Dissipation = 151W and Converter Efficiency, $E = \frac{2960W}{(2960W+151W)} \times 100\% \cong 95.2\%$				

Integrating the snubber inside provide Enhanced EMI performance

No Snubber



With Snubber Inside Module



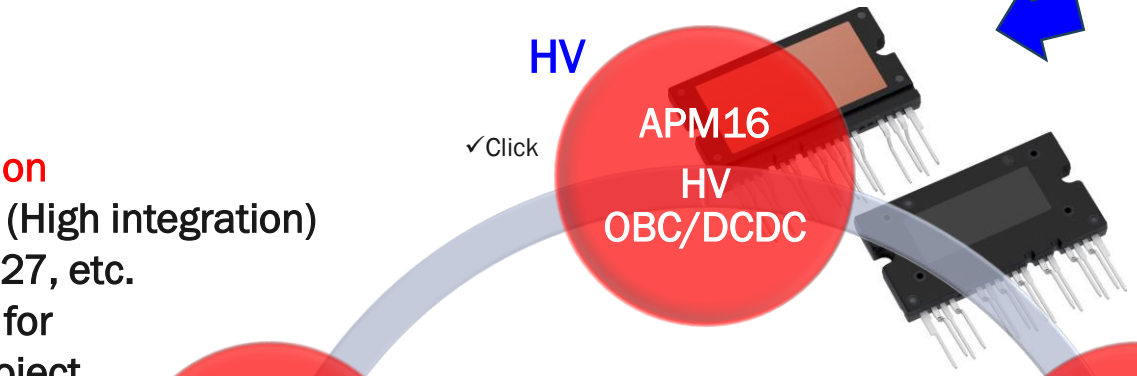
KEY products of Today

- Customization Solution
  - HV : Layout Custom (High integration)
    In APM28/APM27, etc.
  - L,MV : PKG Custom for
    High volume Project

HV

APM16
HV
OBC/DCDC

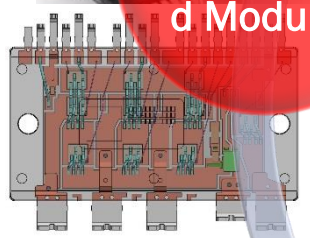
Why?
- Compact Solution
- Higher Efficiency
- Thermal Performance
- Proven tech for Auto Reliability
- HV Isolation
- Lower Cost than Case module



✓Click

LV, MV, HV

Other
Customize
d Modules



✓Click

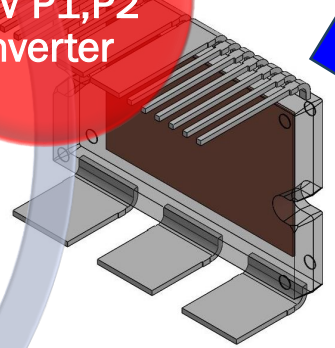
LV, MV, HV
Bare Die
Biz

Promote Module and
Bare Die Together

✓Click

MV

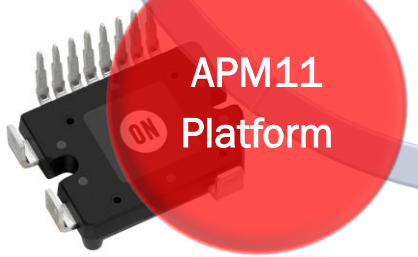
APM17M
48V P1,P2
Inverter



Why?
- Cost effective High Power Density
- Best Performance (Thermal, Inductance, EMI)
- Proven tech for Auto Reliability

✓Click

APM11
Platform

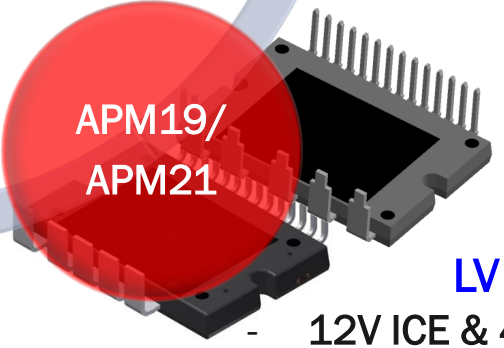


- Power Half Bridge
- Battery Switch

LV MV

✓Click

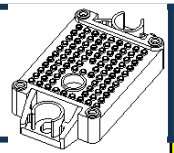
APM19/
APM21



LV MV
- 12V ICE & 48V~ Inverter / DC DC

APM Competitive landscape

Vs. Gel-filled Case Module

Feature	Case Module Gel-filled 	ON's APM
Rth Junction to Heat Sink	Higher	Lower (by better flatness)
Package Warp Control	Worse (using Cu base)	Better
Reliability	Lower	Higher
Weight/Size	Higher	Lower

Vs. Discrete Solution

Feature	Discrete Solution	ON's APM
Rth Junction to Heat Sink	Higher	Lower
Current Carrying Capacity/ Total Resistance	Limited	Better
EMI	Poor	Enhanced
System Weight/Size	Higher	Lower

Vs. Gel-filled Case Module – System

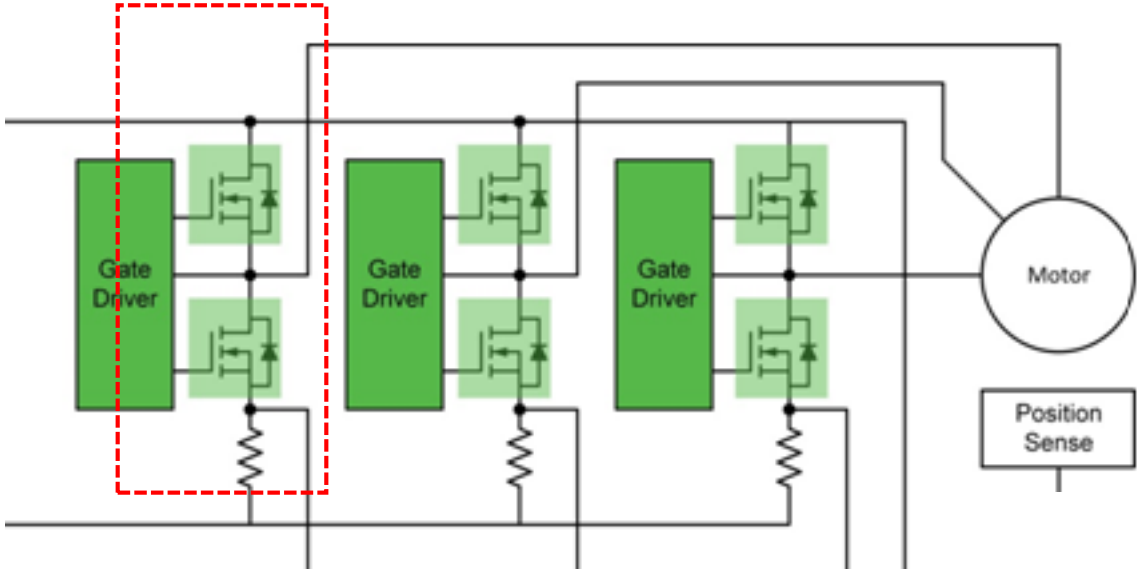
Feature	System level Case Module Gel-filled 	ON's APM
Rth Junction to Heat Sink	**Higher**	**Lower**
Reliability	**Lower**	**Higher** Thermal Stress Vibration Mechanical Shock, etc.
Testing	**Limited** for testing Individual Power Components	**Full** Test Coverage
Qualification	**Limited** to full validate or high cost	**Full** Rel. atudy with enough rel. Characterizations

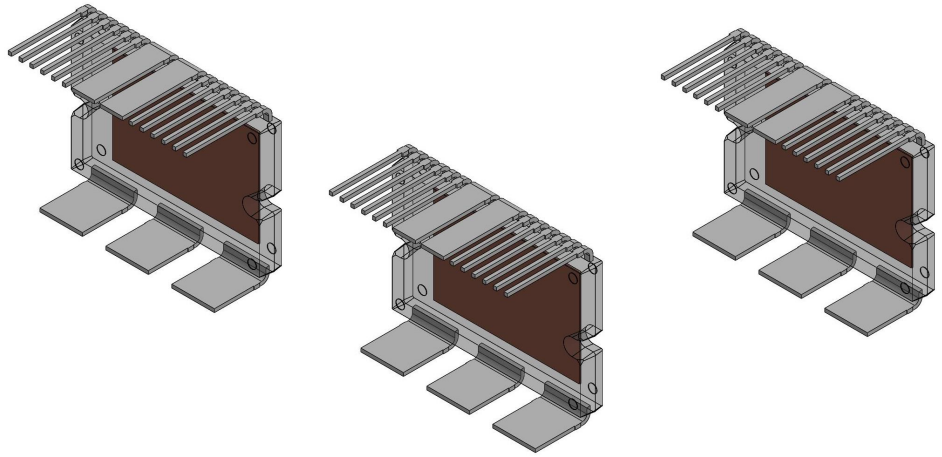
Vs. Competitors in the Market

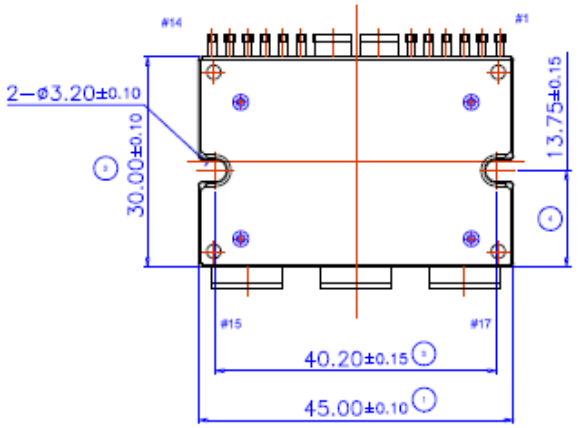
.Silicon Performance
.Proven Quality in the Field Application
.Rich Portfolio of MOSFET & Module platform
(World wide #1 Module suppler (volume))
.Application Support (Solution Provider)

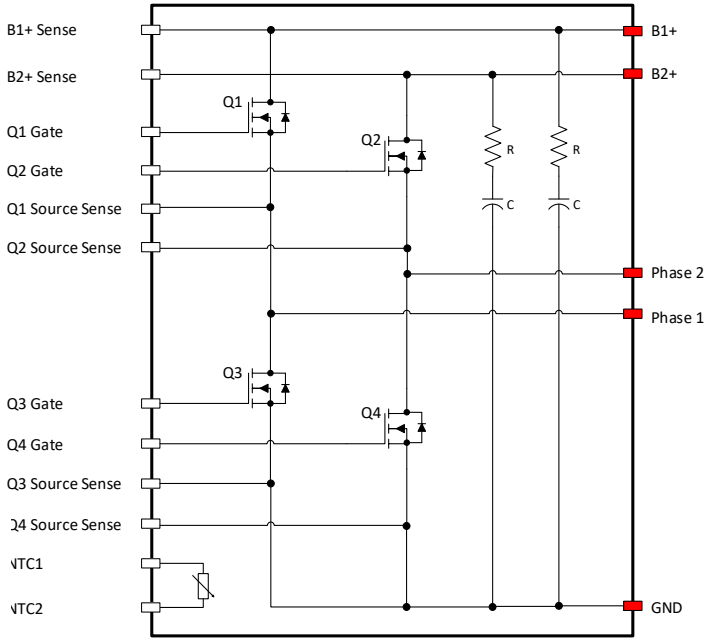
APM17M for 3 phase and 6 phase Inverter

- APM17M Platform







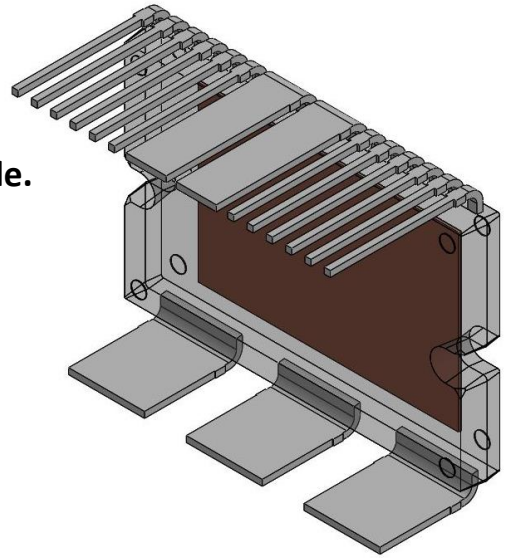


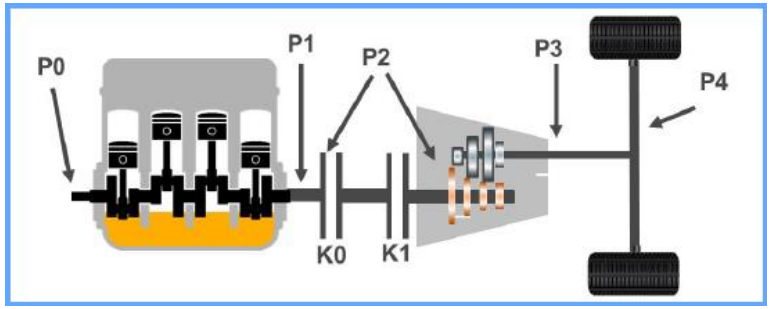
Lead forming option can be customized

APM17Mxx for 48V Mild Hybrid Main inverter – In Development

Description

- High Power 48V Main Inverter solutions
- Flexible application both 3 phase and 6 phase motor system by 3 APMs
- Low junction-sink thermal resistance
- Highly integrated compact design
- Low electrical resistance
- Low stray Inductance
- Better EMI with snubber inside module.
- Electrical isolation over 3KV
- Easy and reliable installation
- High current handling
- Improved overall system reliability
- Temperature sensing
- Pb Free
- Automotive qualified – AQG324





- P0 / P1 - 6kw, 12kw
- P2, P3, P4 - ~ 24kw

	P2 ~			P0 / P1		P2 ~
	Low Rth Substrate			AL2O3 Substrate		
BV	100V	80V		100V	80V	
Rdson Max	1.0mΩ @25C°	0.82mΩ @25C°	*0.63mΩ @25C° (TBD)*	1.0mΩ @25C°	0.82mΩ @25C°	*0.63mΩ @25C° (TBD)*
Rthjc Max	0.22C/W (TBD)	0.22C/W (TBD)	0.18C/W (TBD)	0.52C/W (TBD)	0.52C/W (TBD)	*0.43C/W (TBD)*
OPN	NXV10H350XT1	NXV08H350XT1	NXV08H400XT1	NXV10H250DT1	NXV08H250DT1	NXV08H300DT1

Dual ½ Bridge

½ Bridge

ICE,48V MHEV – Standard APM19 Platform

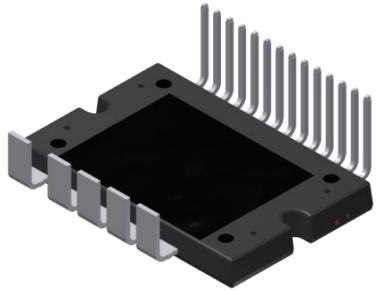
Description

- Low junction-sink thermal resistance
- Highly integrated compact design
- Low electrical resistance
- Better EMI and electrical isolation
- Easy and reliable installation
- High current handling
- Improved overall system reliability
- Precise shunt current sensing
- Temperature sensing
- Automotive qualified

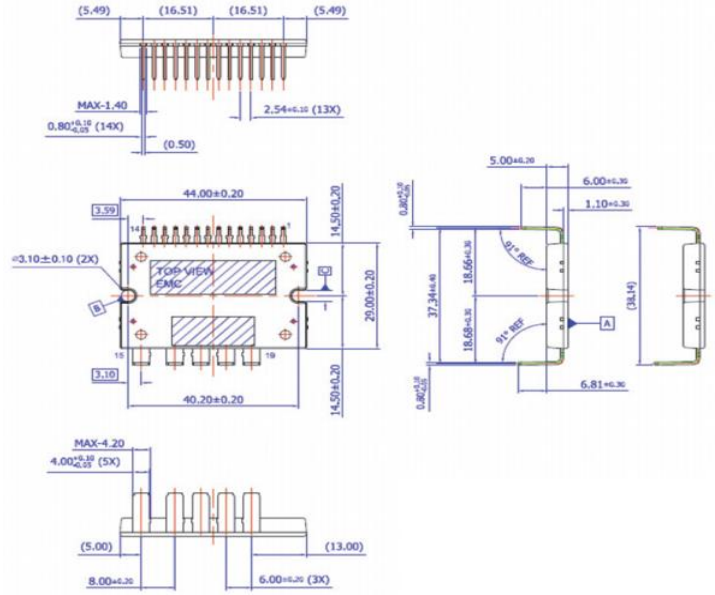
Application

	Transmission Oil Pump	Electrical Power Steering	Intelligent Brake	DC DC converter
12V ICE	40V	40V	40V	
24V Bus/Truck	80V	80V		
48V MHEV	80V	80V	80V	80V

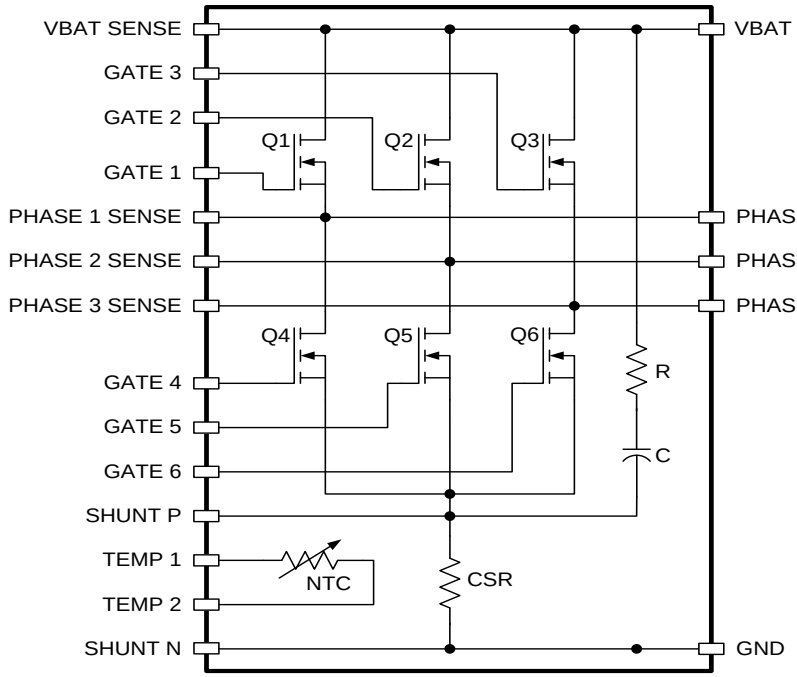
Package : 44 mm × 29 mm × 5.0 mm



Package Details

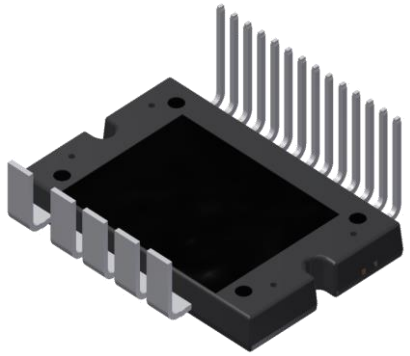


Schematic



ICE,48V MHEV - APM19 Platform Proliferation Plan

Option1	AL203 Substrate	
Option2	40V	80V
Option3	Die Options	



DBC Options	Standard Substrate				
BV Options	40V		80V		80V Die Combination
Die Options	1.45mΩ 0.8(K/W)	1.2mΩ 1(K/W)	3.1mΩ 1(K/W)	2.1mΩ 0.8(K/W)	3.1 / 2.1mΩ 1.0 / 0.8(K/W)
OPN	FTCO3V455A1	NXV04V120DB1	NXV08V080DB1	NXV08V110DB1	FTCO3V85A1
Release Plan	**In Production**	**2019 Newly Released**	**2019 Newly Released**	**2019 Newly Released**	**In Production**
Samples Availability	Available	Available	Available	Available	Available

* Common : All APM19 have 1 NTC, 1 Shunt & R-C Snubber btw B+ & GND

ICE,48V MHEV – Standard APM21 Platform – In development

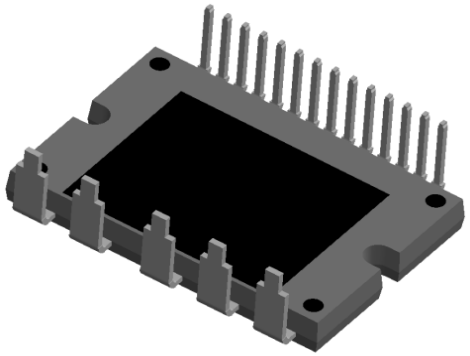
Description

- 2 shunts for current sensing for EPS application
- High Power 48V Motor Inverter solutions
- Low junction-sink thermal resistance
- Highly integrated compact design
- Low electrical resistance
- Better EMI and electrical isolation
- Easy and reliable installation
- High current handling
- Improved overall system reliability
- Temperature sensing
- Automotive qualified

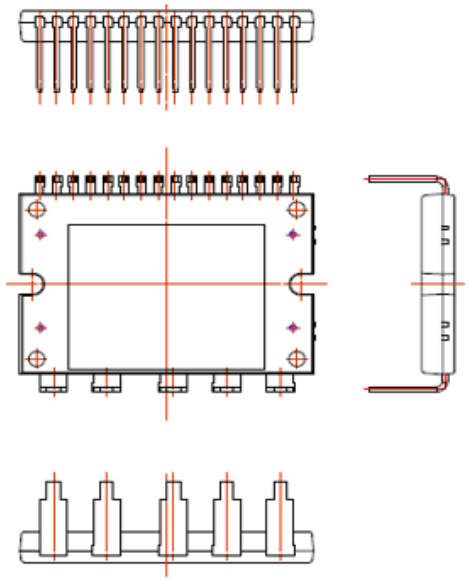
Application

	~ 1kw EPS (2 Shunts EPS)	5~7kw 48V E-Comp/E-Boost	5~7kw 48V E-Super Charger	12kw 48V BSG 6 Phase (APM * 2)
12V ICE	40V	40V	40V	
48V MHEV	80V	80V / 100V	80V / 100V	80V / 100V

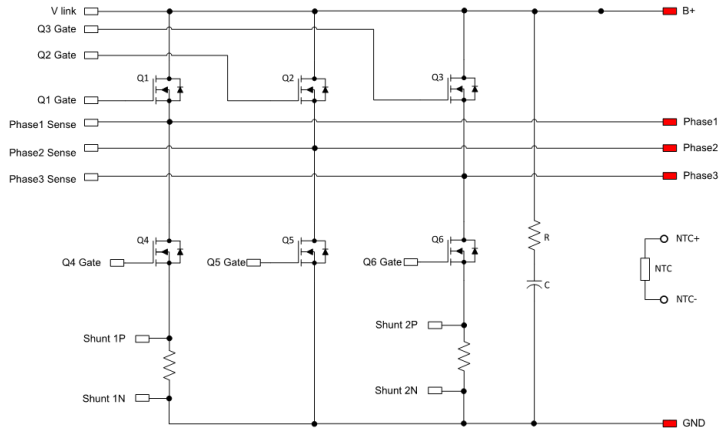
Package : 44 mm × 29 mm × 5.0 mm



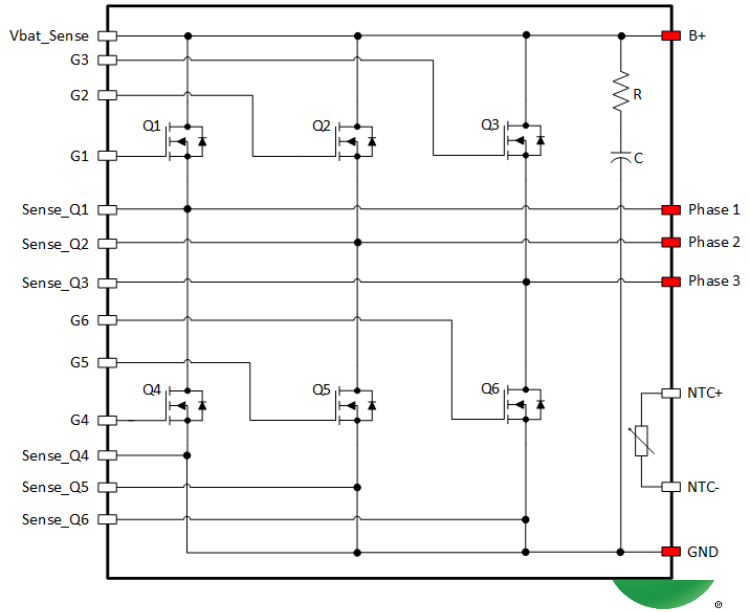
Package Details



Schematic – 2 Shunts EPS

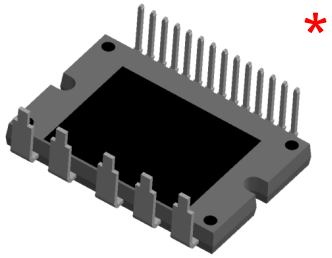


Schematic 2 – 48V High Power



ICE,48V MHEV - APM21 Platform Proliferation Plan

Option1	AL203 Substrate	Low Rth Substrate
Option2	80V	100V
Option3	Die Options	
Option4	Shunt or No shunt	
Option5	Lead Options (Std or Customized)	



* Release Plan can be adjusted per customer's request

DBC Options	Standard Substrate					Low Thermal resistance Substrate		
BV Options	40V	80V		100V	100V / 80V	80V	100V	150V
Eq. Discrete / Rdson max. / Rthjc typ.	FDBL9406 1.2mΩ 1(K/W)	FDBL86366 3.0mΩ 1(K/W)	FDBL86360 1.3mΩ 0.6(K/W)	FDBL86062 2.0mΩ 0.7(K/W)	FDBL86063/86361 2.6 / 1.4mΩ 0.8 / 0.7(K/W)	FDBL86360 1.3mΩ 0.22(K/W)	FDBL86062 2.0mΩ 0.32(K/W)	4.0mΩ 0.22(K/W)
Shunt Options	2 Shunts (BVN-0.5mohm)	2 Shunts (BVN-0.5mohm)	1 Shunt (BVN-0.5mohm)	1 Shunt (BVN-0.5mohm)	No Shunt	No Shunt	No Shunt	1 Shunt (BVN-0.5mohm)
OPN	NXV04V130DB1	NXV08V081DB1	NXV08V170DB1	NXV10V125DB1	NXV09D100DT1	NXV08V230S(X)T1	NXV10V160S(X)T1	NXV15V100S(X)B1

* Customer sample available in 1~3 Months after order

Automotive Power Module for 48V Mild Hybrid Takeaways

- ON SEMI Auto Power Module Solutions
- Product Definition of APM FOR 48V
- BENEFITs of APM for 48V
- APM Platforms for 48V

- ☑ Semiconductor innovations are key enablers of 48V Mild Hybrid vehicle electrification
  - ☑ High performance silicon, extended reliability, module packaging technology, scalable supply chain are key semiconductor aspects of next gen powertrain
- ☑ 48V Architecture is gaining strong momentum, need high power solution where APM is the suitable solution
  - ☑ Benefits of thermal + electrical => Higher Power density + Reliability => Reduced Total Cost
- ☑ Collaborative Co-development for market needs for 48V – APM Application supports solution customization

Thank You