

Power MOSFETs Opportunity

Product Marketing & Application
Jerry Chen
Nov 27th 2019

Jerry Chen

Product Line Marketing, base in Taipei, response for product roadmap and product development

Before TSC

Fairchild Semiconductor

- Computing Segment Marketing
- Low Voltage MOSFET Marketing

Vishay Siliconix

- Product Application, Asia Pacific & Japan
- Regional Marketing and Field Application, Taiwan

Agenda

- TSC Power MOSFETs Overview
- TSC MOSFET Marketing and Product Strategy
- Automotive Customer's MOSFET Demand
- Q&A

TSC Power MOSFETs Overview

Product Offering

- Voltage Range:
 - HVM: 500V ~ 1000V
 - LVM: 20V ~ 150V
- Silicon Technology:
 - HVM: Planar & Super Junction
 - LVM: High Density Trench
- Various Package:
 - Through Hole and SMD
- Configuration:
 - Single, Dual, Asymmetric Dual



Features

- 100% UIS Tested
- 100% Rg Tested
- High Eas Capability
- Small FOM (Figure Of Merit)

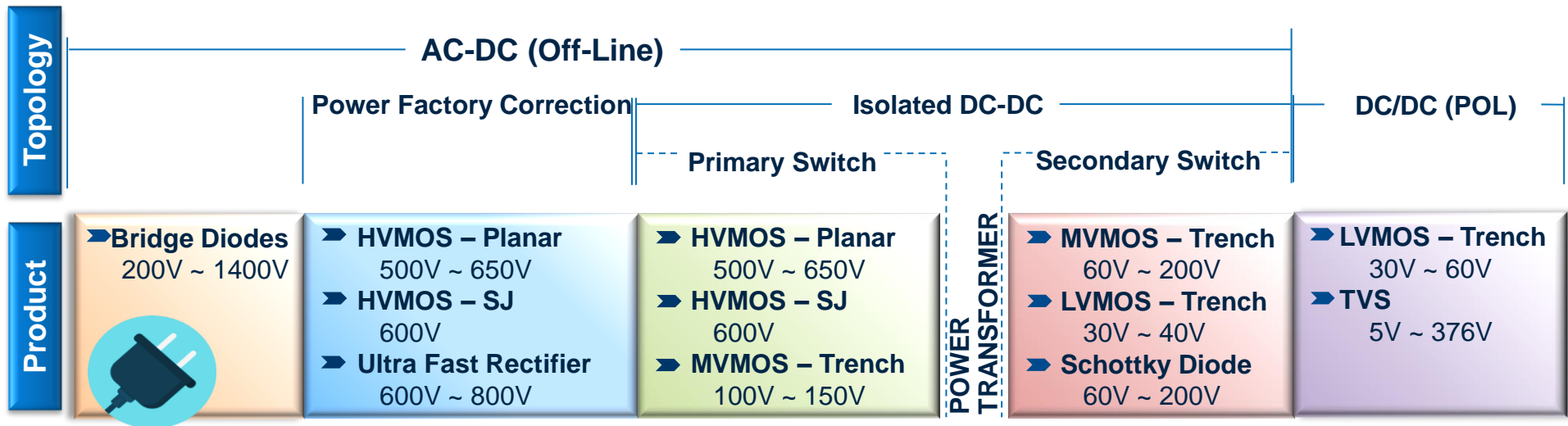


Target Markets

- Industrial
- Automotive
- Server / Telecom
- Consumer
- LED Lighting
- Computing



Broad range product offering for power conversion application



POWER TRANSFORMER



TSC Power MOSFET Development Strategy

Strategy partnership with world class foundry

- Advance technology development
- Reliable capacity and competitive wafer price



Experience design team from tier 1 IDM

- Advance technology development
- Performance competitive with global tier 1 MOSFET suppliers



Dual back-end assembly site development

- Both in-house and OSAT assembly are available
- Satisfy customers crisis management requirement

Application and customers driven

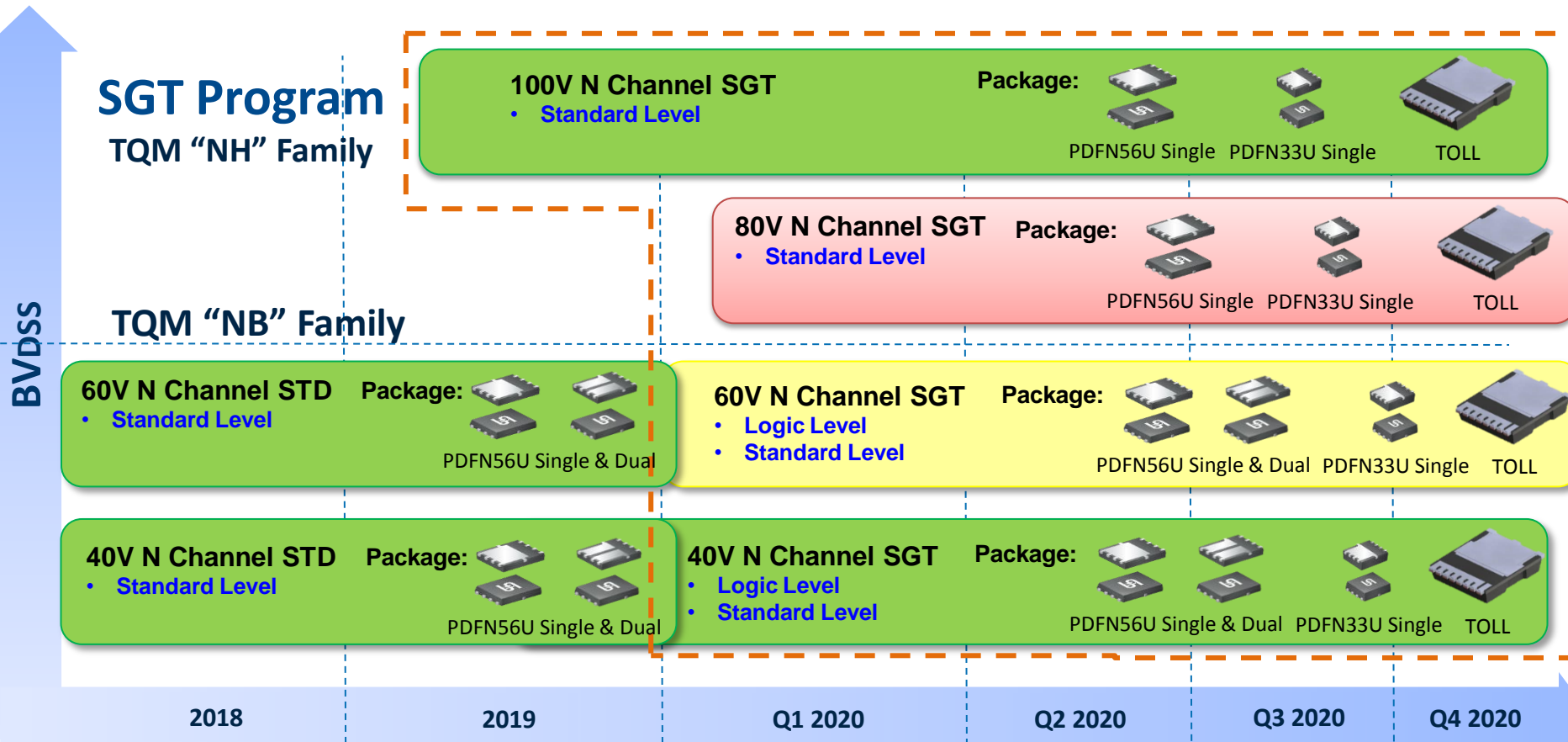
- Deep engage with tier 1 customers to understand products specific demand
- Product roadmap, spec aligned with customers demand



StanleyBlack&Decker

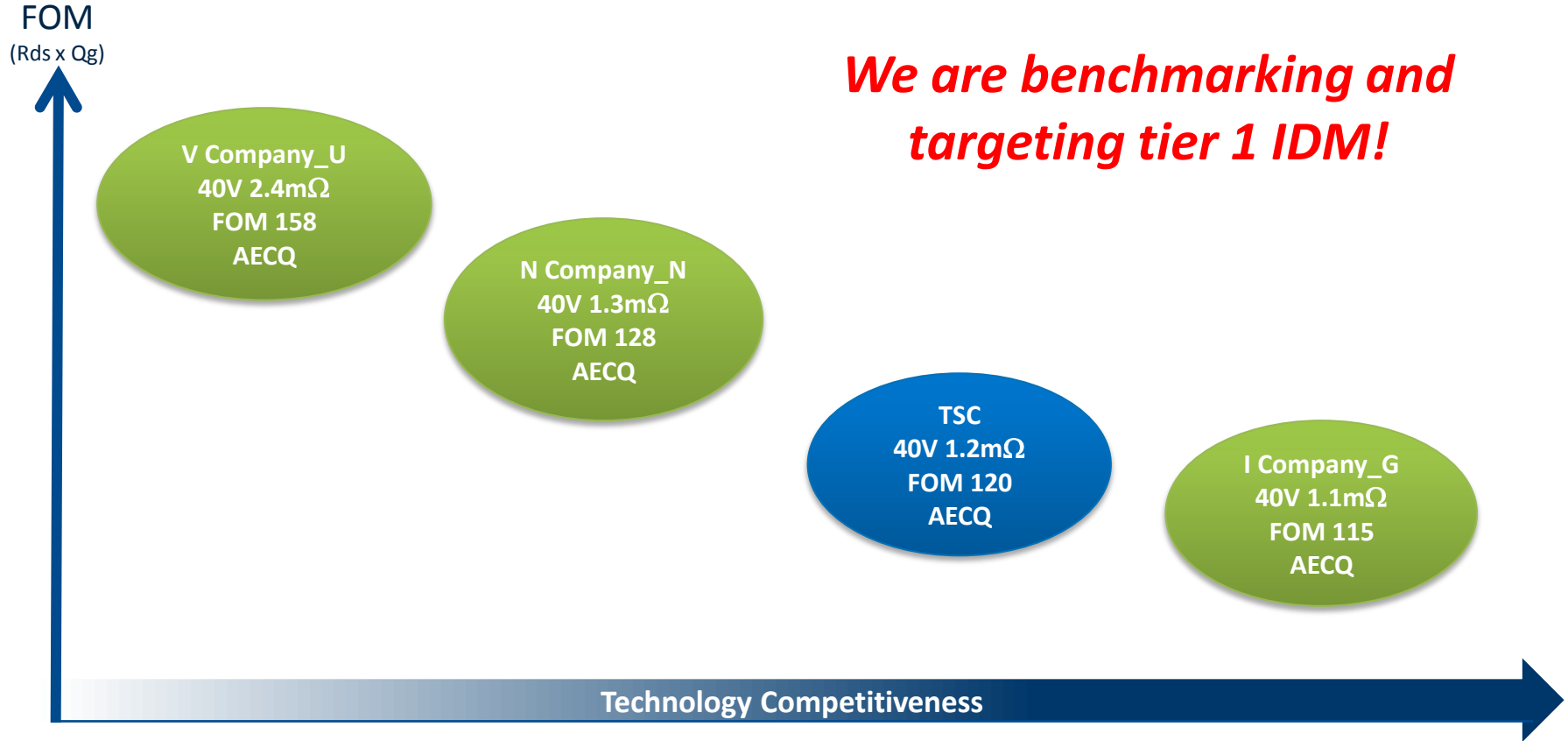


Automotive N Channel MOSFET Product Development



Feasibility Plan In Dev

MOSFET Technology Competitiveness



Global Sales Channels and Customers AVL Position



- + Headquarter
- Sales office
- Front-End
- Back-End

- Founded in Taiwan
- 15 Branch Offices Worldwide
- 4 Production Sites in Asia

Global Sales Channels and Customers AVL Position

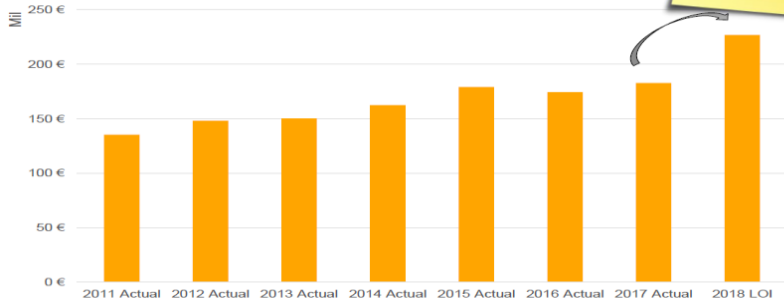


We focus on automotive and industrial customers!

- Founded in Taiwan
- 15 Branch Offices Worldwide
- 4 Production Sites in Asia

One of Automotive Customer's MOSFET Demand

PVO development in Mio EUR @ BUD xrate
 MOSFETs (packaged + bare die) growth by 24%



≥40V Cluster is biggest @Conti
 2018 Volumes amount to ~50%
 B&S is main MOSFET consumer @Continental

©

Year	Quantities B1	Quantities A	Quantities C	Quantities F
FY2020	138.000.000	15.000.000	5.000.000	15.000.000
FY2021	218.000.000	25.000.000	6.000.000	30.000.000
FY2022	289.000.000	30.000.000	9.000.000	43.000.000
FY2023	330.000.000	33.000.000	7.650.000	45.000.000
FY2024	315.000.000	31.000.000	6.250.000	36.000.000
FY2025	252.000.000	28.000.000	4.850.000	30.000.000
FY2026	201.600.000	24.000.000	4.300.000	22.800.000

Packages

5x6 single	x			
5x6 dual	x		x	x
3x3 single	x	x	x	x

Body Platform MOSFET specification overview

specification	class	symbol / unit	Typ A	Typ B1	Typ C	Typ F
Technology			n-Channel , logic level			
Drain source voltage	V_ds_max	[V]	40			
Gate source voltage	V_gs_max	[V]	+/- 20			
Gate source threshold voltage	V_gs_thres	[V]	1,0 ... 2,5V			
Gate source ZTC voltage	V_gs_ztc	[V]	≤4,5			
Gate capacity	C_iss	[nF]	≤5,0	2,5	≤1,0	≤1,0
Gate input charge	Q_g_tot	@Vgs=5V [nC]				
		@Vgs=10V [nC]	n/a	≤50	≤20	≤20
max. switching frequency	[kHz]	[kHz]	≤1	20	20	≤20
		R_dson_max @25°C [mW]	≤5	≤8	≤12	≤20
max. On state resistance	R_dson_max	@150°C [mW]				
		@25°C [mW]	≤3,5	≤6,5	≤10	≤16
Continous drain current	I_d	@25°C [A]	80	40	20	15
		@100°C [C]	60	30	15	10
Pulsed drain current	I_d_max @ Tps300µs	@25°C [A]	320	160	80	80
		@150°C [A]				
Short circuit current	I_sc @ Tps5µs	@25°C [A]		320	160	160
		@150°C [mJ]				
single pulse avalanche clamp energy	E_aval	@25°C [mJ]				
		@150°C [mJ]				
body diode reverse current	I_rev	@25°C [A]				
diode reverse recovery time	t_rr	[nsec]	≤50			

TSC MOSFETs qualification in progress!

TSC Confidential and Proprietary



TSC MOSFET Marketing and Product Strategy

Focus Application

- Automotive
- Industrial Motor Control
- Telecom and Connectivity Power



Product Development

- Strategy partnership with world class foundry
- Both In-house and OSAT assembly
- Experience design team from tier 1 IDM

Promotion

- Global sales branch office
- Global distribution channel
- Leverage rectifier tier 1 customers AVL position
- Product is qualifying in "C", "B", "H" automotive customers



Competitiveness

- Competitive technology
- Fast reaction for market demand
- Good service

Thank you

Taiwan Semiconductor Co., Ltd.

Headquarters

Address: 11F. No. 25 Sec. 3, Beishin Rd, Shindian District, New Taipei City, Taiwan R.O.C.

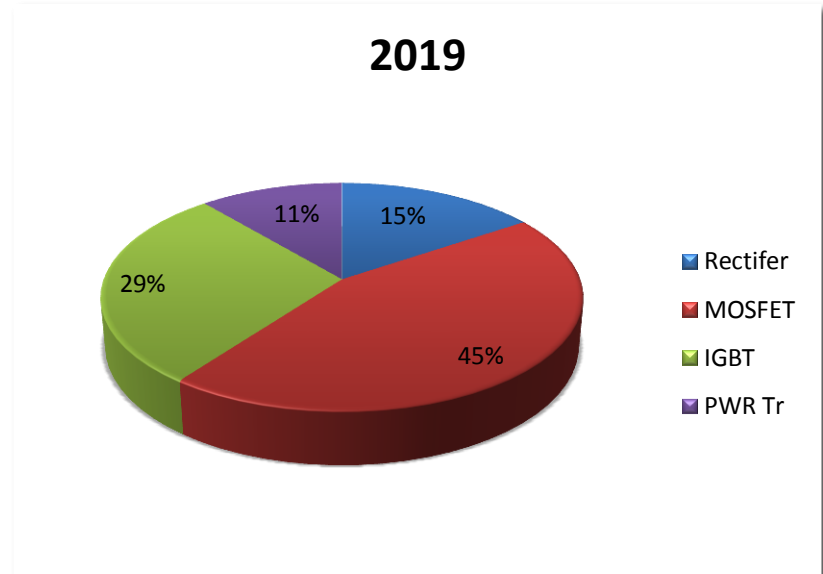
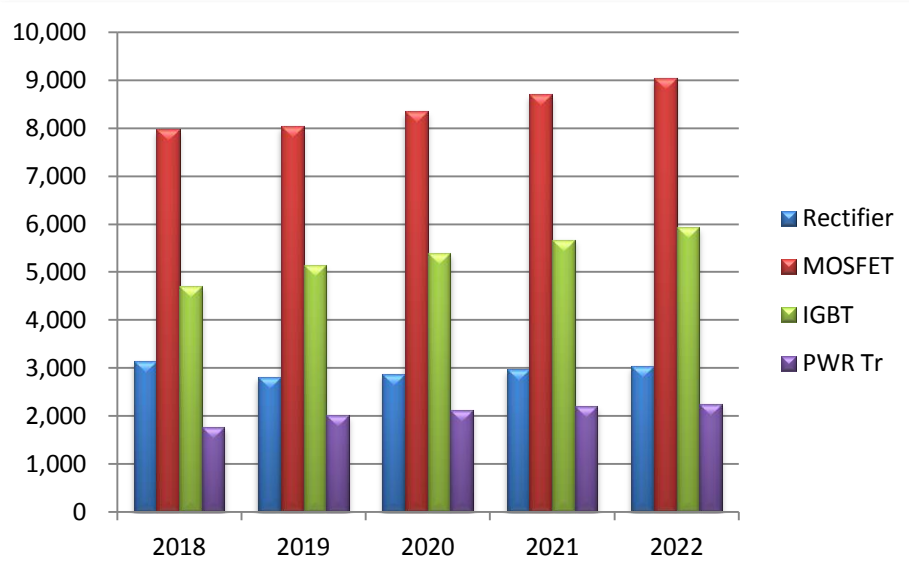
Telephone: +886-2-8913-1788

E-mail: marketing@mail.ts.com.tw

Website: www.taiwansemi.com

Q&A

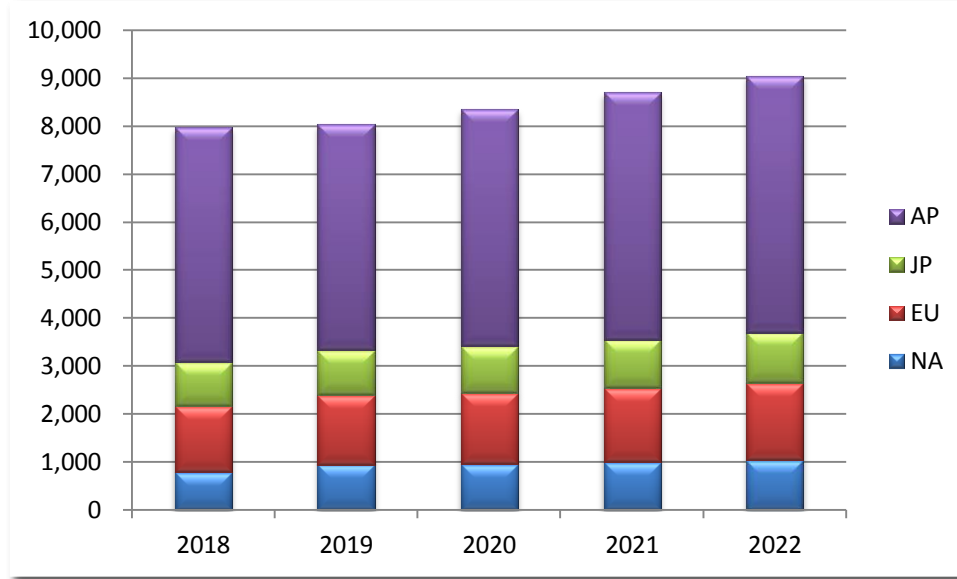
Power Discrete Semiconductor Market Overview



Region	2018	2019	2020	2021	2022
Rectifier	3,147	2,801	2,869	2,968	3,039
MOSFET	7,974	8,030	8,349	8,695	9,044
IGBT	4,705	5,140	5,389	5,674	5,932
PWR Tr	1,766	2,011	2,117	2,195	2,249
Total	17,592	17,982	18,724	19,531	20,263

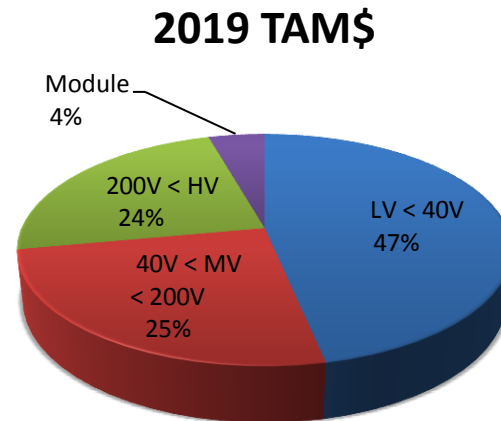
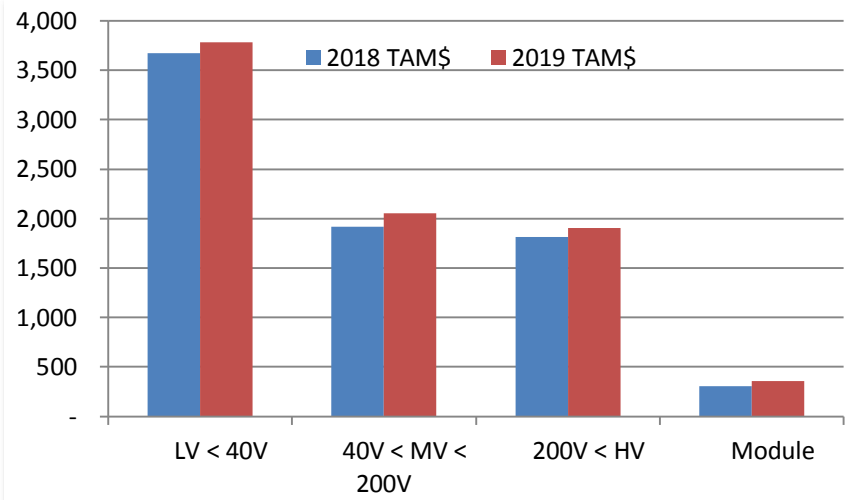
- Power MOSFET has 45% among of Power Discrete market
- Power MOSFET and IGBT still have sustainable growth

Power MOSFET Revenue Projection



Region	2018	2019	2020	2021	2022
NA	788	942	964	1,001	1,043
EU	1,376	1,454	1,480	1,539	1,601
JP	921	934	970	1,011	1,053
AP	4,889	4,700	4,935	5,144	5,347
WW	7,974	8,030	8,349	8,695	9,044
YoY	18%	1%	4%	4%	4%

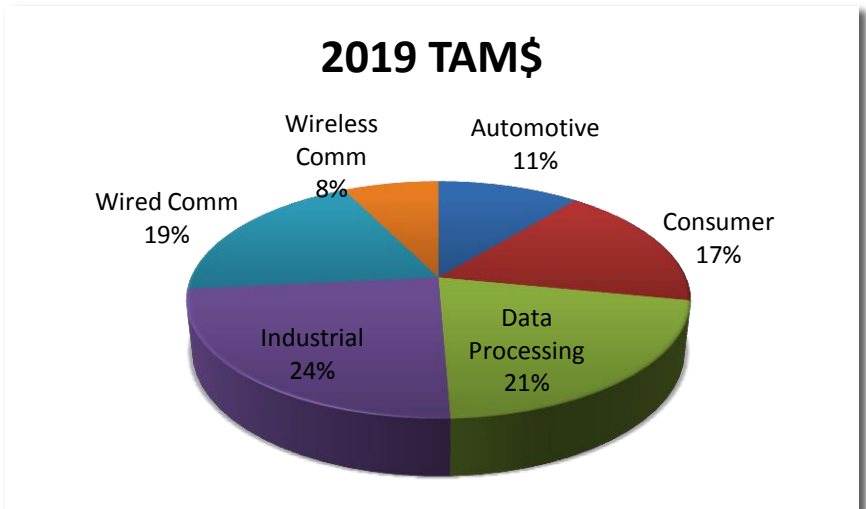
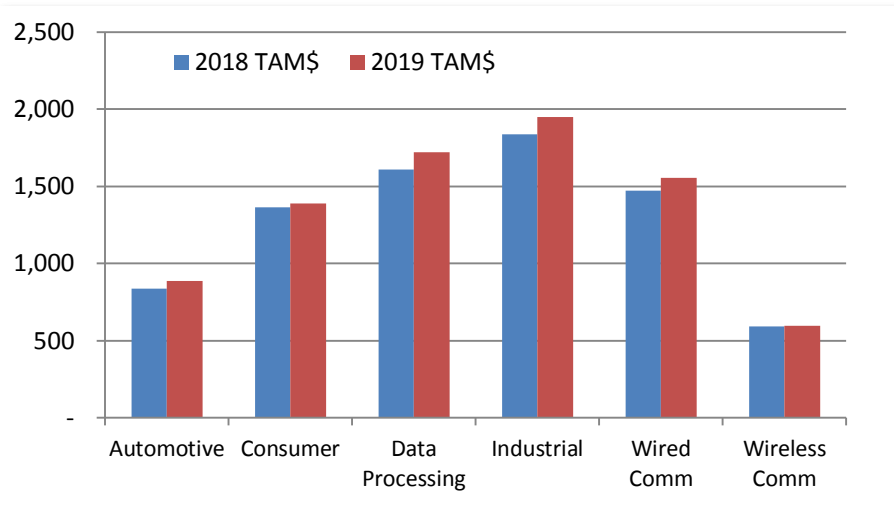
Power MOSFETs TAM (by voltage / category)



Voltage / Category	2018 TAM\$	2019 TAM\$	Growth% 18~19
LV < 40V	3,672	3,782	3.0%
40V < MV < 200V	1,919	2,053	7.0%
200V < HV	1,815	1,906	5.0%
Module	305	356	16.7%
Total MOSFET	7,711	8,097	5.0%

- 30V and 20V MOSFETs majority are for PC and consumer, price is big issue even TAM is big
- 40~200V MV MOSFETs key market are automotive, industry and telecom, stable growth and fair price
- Module (DrMOS) is growing fast on server and PC market

Power MOSFETs TAM (by market segment)



Market Segment	2018 TAM\$	2019 TAM\$	Growth% 18~19
Automotive	836	886	6.0%
Consumer	1,364	1,390	1.9%
Data Processing	1,609	1,722	7.0%
Industrial	1,839	1,949	6.0%
Wired Comm	1,473	1,554	5.5%
Wireless Comm	591	597	1.0%
Total MOSFET	7,711	8,097	5.0%

- Driving Factors:**
- Automotive: ADAS, mechanical to electrical
 - Data Processing: server, cloud computing
 - Industrial: automation, mechanical to electrical
 - Wire Comm: IoT, 5G

Source: IHS+WSTS

Power MOSFET Voltage by End Application

Product Category End Application	Low Voltage			Mid Voltage						High Voltage			
	=< 20V	30V	30V (DrMOS)	40V	60V	80V	100V	150V	200V	500V	650V	800V	1000V
Smart Phone	⊙												
Tablet	⊙												
Notebook PC	○	⊙	⊙										
Server		⊙	⊙										
MB/Graphic Card		⊙	⊙										
Power Tool			○	⊙	⊙	○	○						
PoE (PSE and PD)			○				⊙	⊙					
Telecom BMP				○	○	○	⊙	○	○				
Power Supply					○	○	○			○	⊙	○	
Charging Station										○	⊙		
LED Lighting										○	⊙	○	
Smart Meter			○								○		⊙
Industry Automation				⊙	⊙	○	○				○		⊙
Automotive (ICE)			○	⊙	○	○	○	○					



POE
High Power

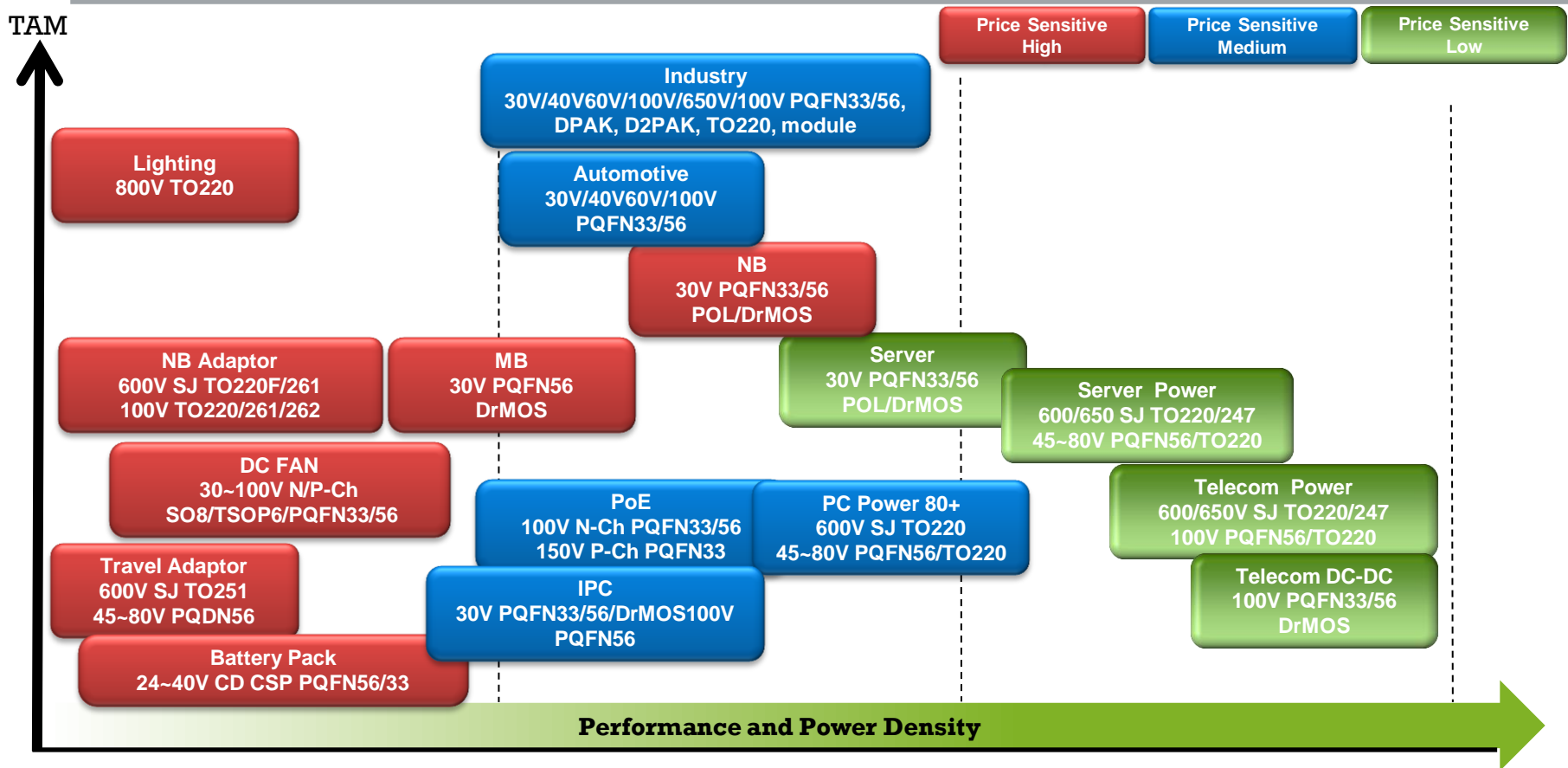


○ minor ⊙ major



TS TAIWAN SEMICONDUCTOR

Power MOSFET TAM and Price Sensitive by Application



Market Segment Deep Dive

- **Power Supply (Telecom Power)**
- Power of Ethernet
- Industrial Motor Control
- Automotive



Power Supply MOSFET Requirements

Power rating [W]

10W

100W

1KW

5KW



Telecom Power

- 600V/650V SJ MOSFET for PFC
- 600V/650V SJ MOS FRFET for LLC
- 80~200V MV MOSFET

Server Power

- 600V/650V SJ MOSFET for PFC
- 600V/650V SJ MOSFET for LLC
- 45~80V MV MOSFET
- PQFN Package for space saving



PC Power

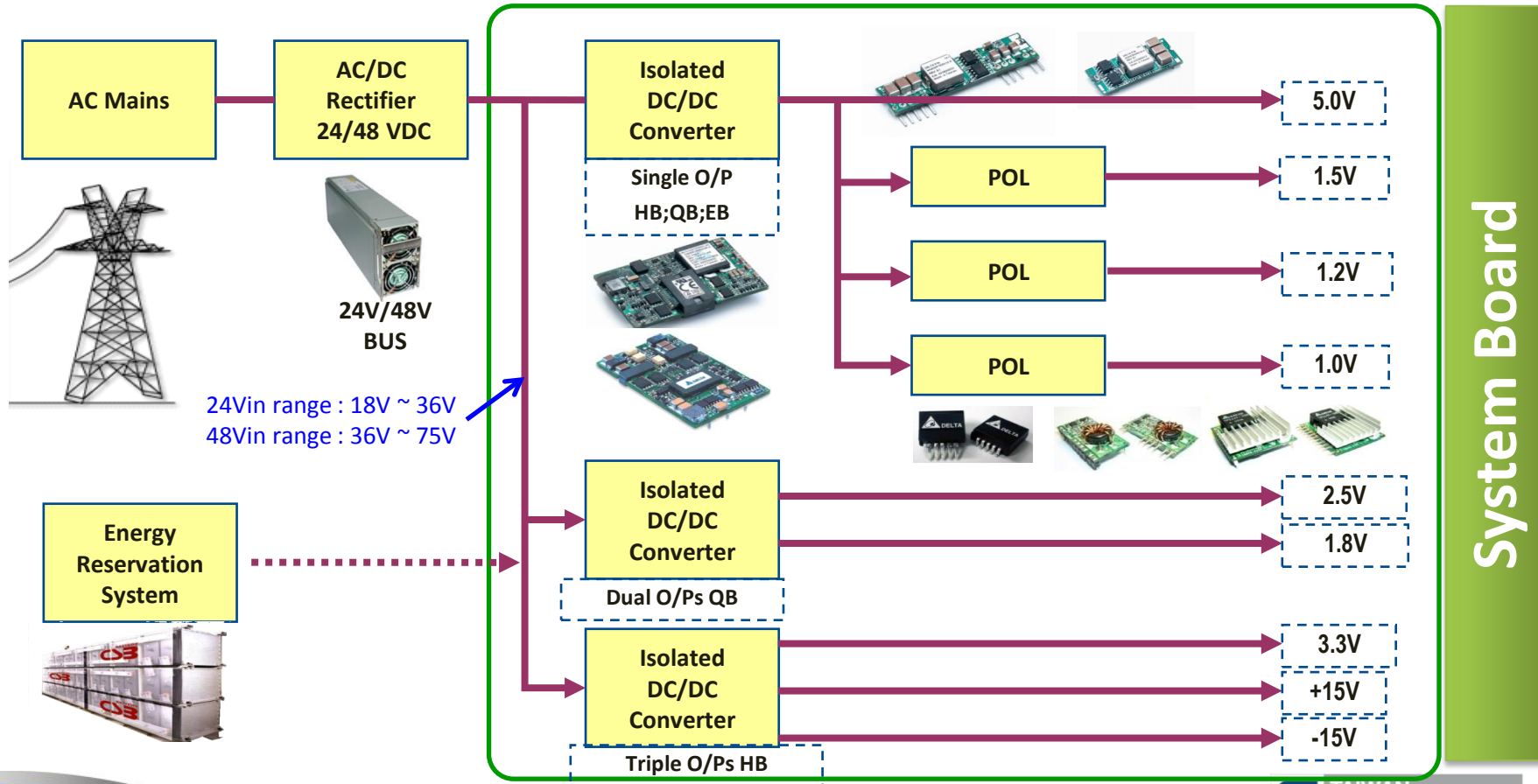
- 600V, 800V SJ & 60V MV MOS
- More focus on 80plus product

Adaptor & Charger

- 600~800V SJ MOSFET
- 100~120V MV MOSFET



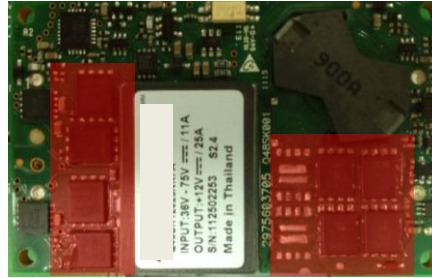
Telecom Power Architecture



System Board

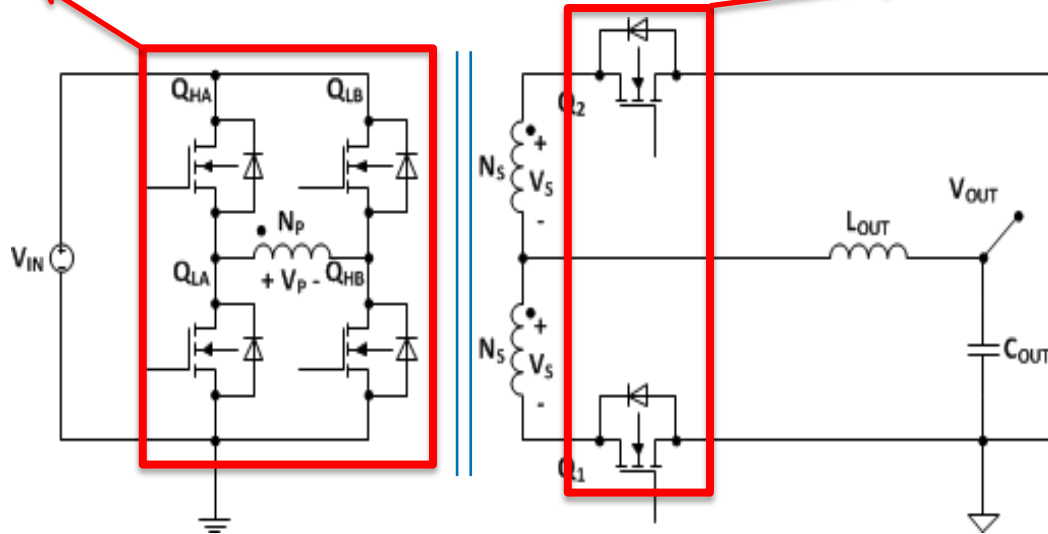
Isolated DC-DC Design Example

Primary-side
Full-Bridge MOSFET
 Q_{HA} , Q_{LA} , Q_{HB} , Q_{LB} :
100V MOSFET
Critical Parameters:
 Q_g , Q_{gd}



Secondary-side
Centre-tapped rectifier
MOSFETs Q_1 , Q_2 :
30V ~ 100V MOSFET
Critical Parameters:
 R_{ds} , Q_{rr} , T_{rr}

$V_{in} = 36V \sim 75V$



6~10 pcs MOSFETs (\$3~5) per board

Proprietary

Market Segment Deep Dive

- Power Supply (Telecom Power)
- **Power of Ethernet**
- Industrial Motor Control
- Automotive



Power Of Ethernet

POE
High Power

UPS



PSE



PoE

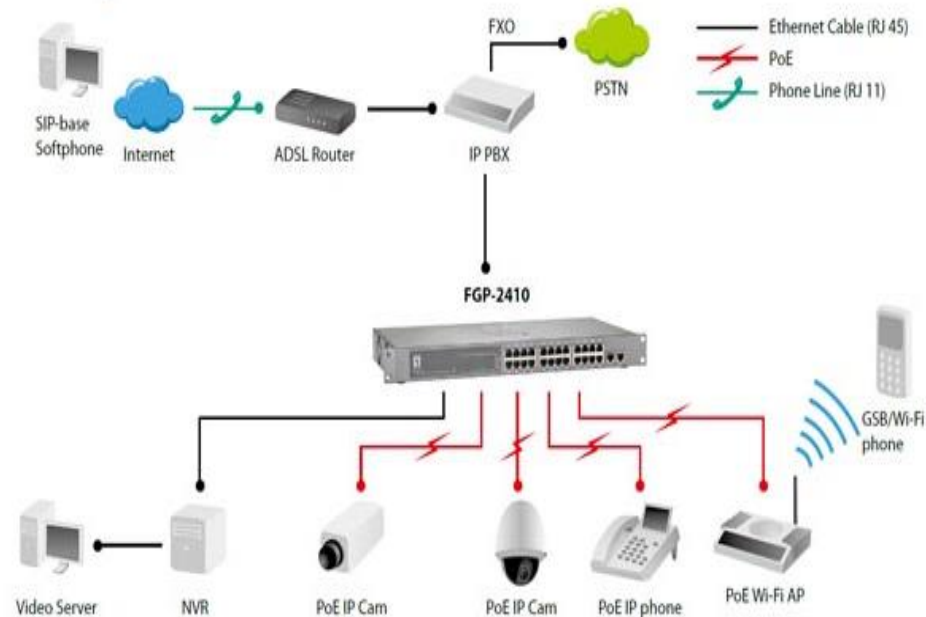
PSU




PD



Product Diagram



802.3af and 802.3at Power Classification

Standard PoE parameters and comparison		
Property	802.3af (Type 1)	802.3at (Type 2) 
Power available at PD	12.95 W	25.50 W
Maximum power delivered by PSE	15.40 W	30.0 W
Voltage range (at PSE)	44.0 – 57.0 V	50.0 – 57.0 V
Voltage range (at PD)	37.0 – 57.0 V	42.5 – 57.0 V
Maximum current	350 mA	600 mA per mode
Maximum cable resistance	20 Ω (Category 3)	12.5 Ω (Category 5)
Supported modes	Mode A (endspan), Mode B (midspan)	Mode A (endspan), Mode B (midspan)

PD Power Requirements



13 to 20 W	802.11n	40 to 50W	PTZ IP Cameras / With heaters
	Biometric Access Control		Thin Clients
20 to 30W	Thin Clients	50 to 80W	Point of Sales
	RFID Readers		Information Kiosks
	Video IP Phones		Laptops
	PTZ IP Cameras	Thin Clients	
	Alarm Systems	Point of Sales	
30 to 40W	Thin Clients	80W to 120W	Information Kiosks
	Industrial Sensors		PTZ IP Cameras / With heaters
	Access Controls		Desktops
	Video IP Phones		Laptops
	PTZ IP Cameras		High Power Wireless
	Workgroup switches		Thin Clients
Point of Sales	Point of Sales		
Information Kiosks	Information Kiosks		

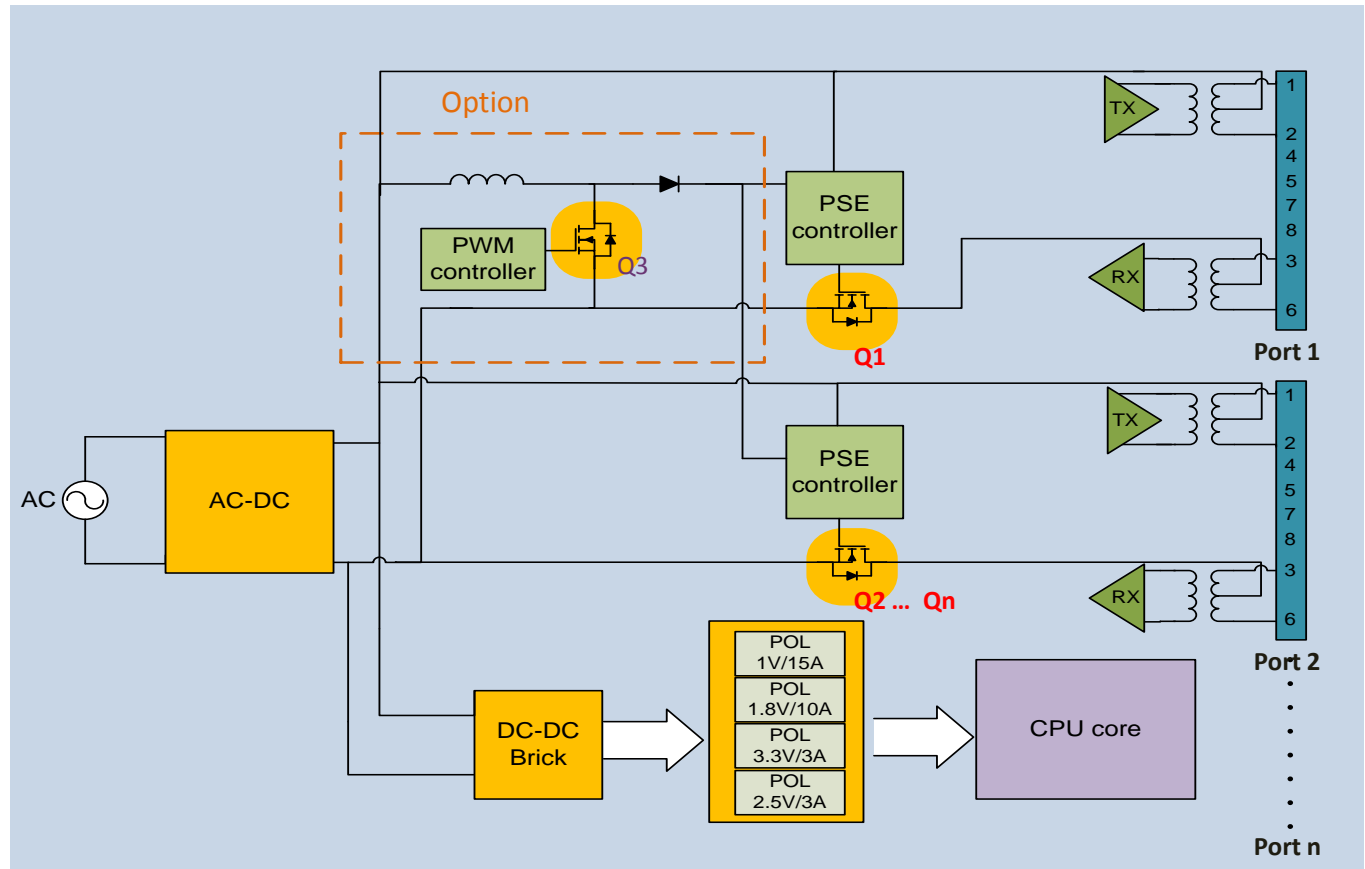


PSE – Power Source Equipment Power Diagram

Boost Converter Switch
100V PQFN3x3

PSE Control Switch
100V SOT223, PQFN3x3

POLs
Buck converters



PD – Power Device Power Diagram

Power Device Bridge

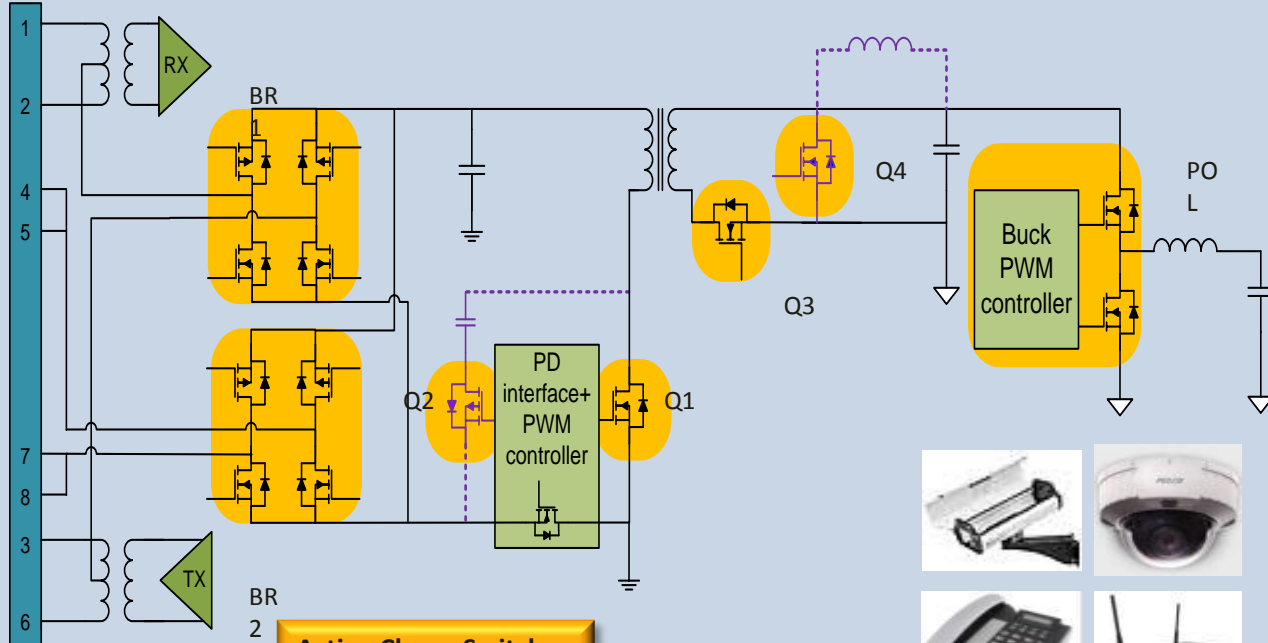
Schottky Bridge
MOS-Bridge

Power Device DC-DC

Primary Switch 150V
PQFN56, SO8, SSOT3

Power Device DC-DC

2nd SR FETs 30V
PQFN56, SO8, PQFN33



Active Clamp Switch

150V PQFN33 P-CH



PD Potential BOM Cost

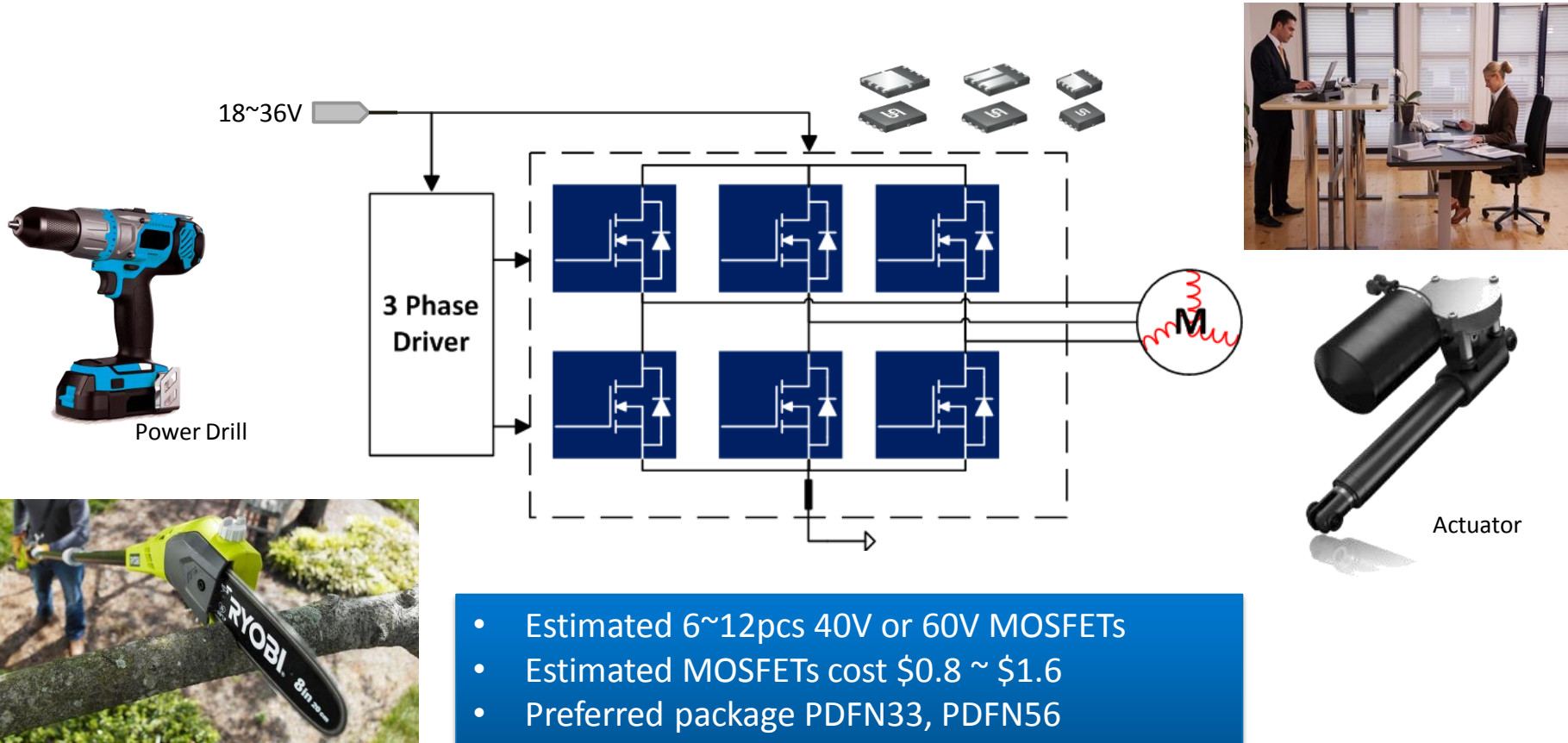
PoE Std.	Power	DC-DC Topology	Bridge BR1 and BR2	Primary SW Q1	Clamp FET Q2	2 nd SR Q3 and Q4	BOM Cost
IEEE802.3af	~ 7W	Fly-Back	Schottky-Bridge *2 100V	150V N-Ch S08/PDFN33 Rds 130mohm	Not Applicable	30V N-Ch SOT-23/TDFN22 Rds 250mohm	\$0.352
IEEE802.3af	15W	Fly-Back	Schottky-Bridge *2 100V	150V N-Ch S08/PDFN33 Rds 65mohm	Not Applicable	30V N-Ch SOT-23/TDFN22 Rds 250mohm	\$0.480
IEEE802.3at	25W	Fly-Back	MOS-Bridge 100V	150V N-Ch S08/PDFN33 Rds 65mohm	Not Applicable	30V N-Ch PDFN33 Rds 8.5mohm	\$1.074
PoE++	60W	Active clamp forward	MOS-Bridge 100V	150V N-Ch PDFN56 Rds 50mohm	150V P-Ch S08/PDFN33 Rds 1000mohm	30V N-Ch PDFN56 Rds 3.6mohm	\$1.330
PoE++	90W	Active clamp forward	MOS-Bridge 100V	150V N-Ch PDFN56 Rds 50mohm	150V P-Ch S08/PDFN33 Rds 300mohm	30V N-Ch PDFN56 Rds 2.0mohm	\$1.426

Market Segment Deep Dive

- Power Supply (Telecom Power)
- Power of Ethernet
- **Industrial Motor Control**
- Automotive



MOSFET Motor Control End Application

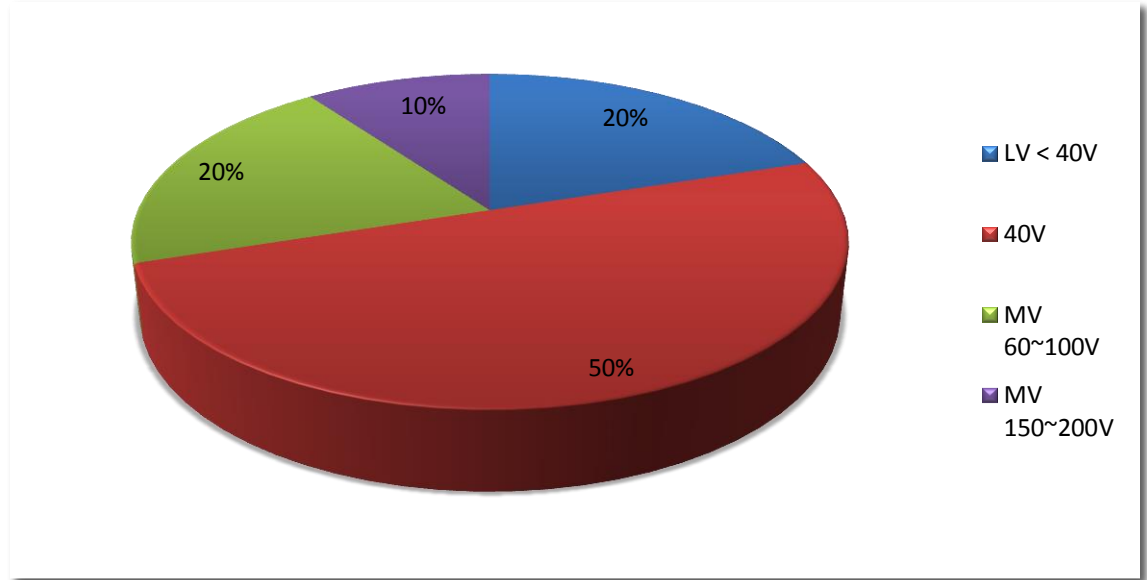
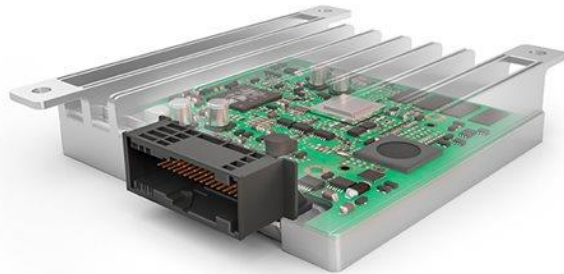


Market Segment Deep Dive

- Power Supply (Telecom Power)
- Power of Ethernet
- Industrial Motor Control
- **Automotive**



2019 MOSFETs TAM – Automotive (ICE)



Market Segment	2019 TAM \$	LV < 40V	40V	MV 60~100V	MV 150~200V
Automotive (ICE)	845	169	423	169	85

- Average \$40 ~ \$50 per car
- Application ECU

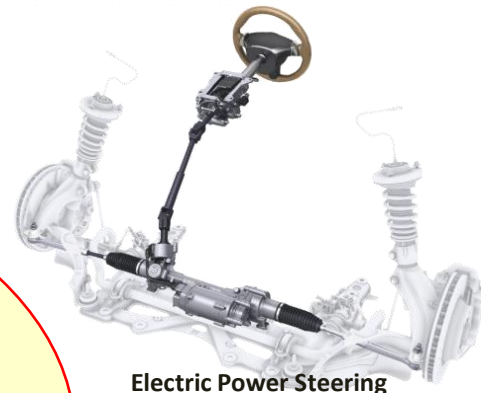
Source: ROT

MOSFET for Motor Drive Application in Automotive

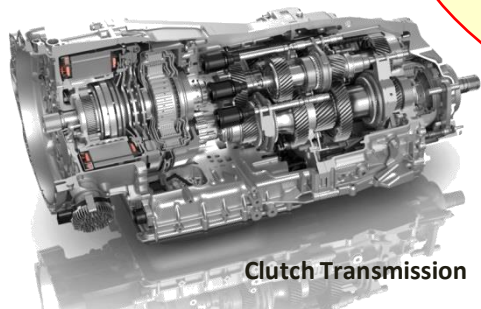
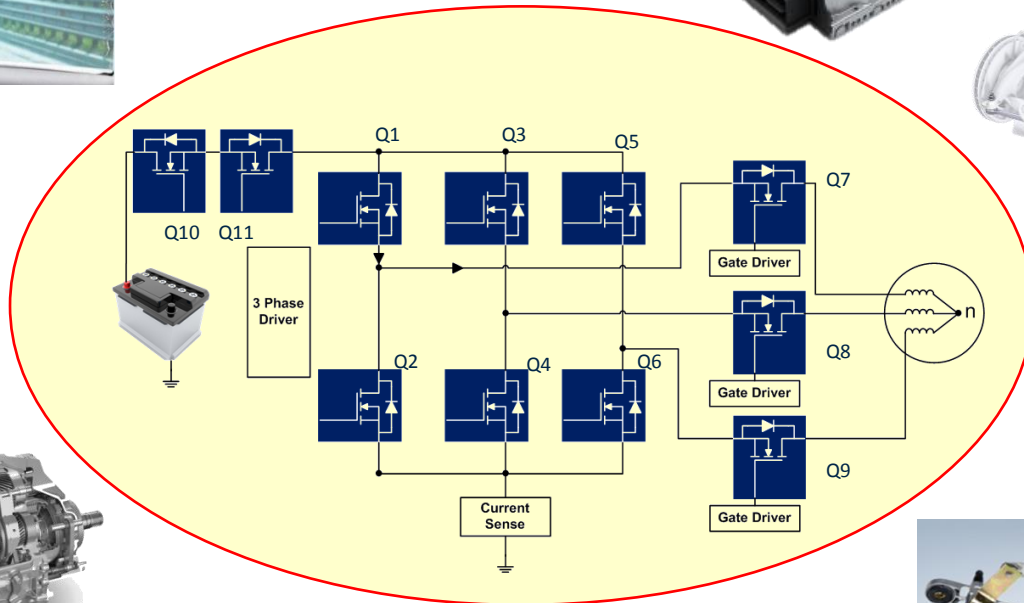


Windscreen Wiper

ECU



Electric Power Steering



Clutch Transmission



Power Window Lift

Requirement:

- VDS 40V and 60V
- Low RDS(on)
- Preferred package PDFN56 and PDFN33

Legislation As Main Drive for 48V Mild Hybrid System

CO₂ Fleet Emission Targets 2020



Incentives and Low/Zero Emission Zones

London



Low Emission Zones

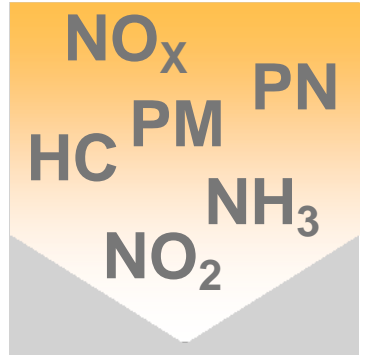
Beijing



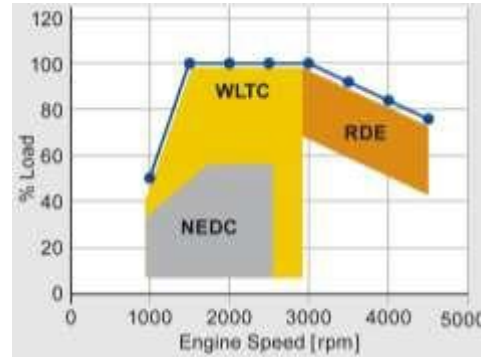
No external vehicle during rush-hours







Pollutant Emission Reduction



Global Test Procedures

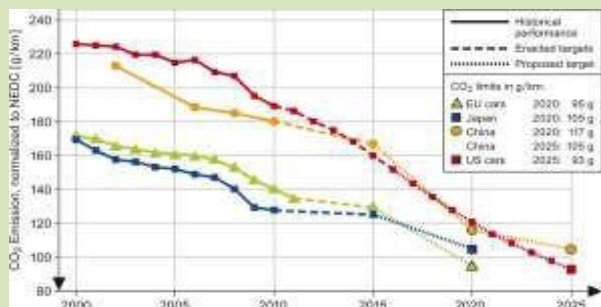


	NEDC 2017: WLTC 2017: RDE
	FTP 2020: RDE
	NEDC 2017: WLTC (exp.)
	JC08

NEDC: New European Drive Cycle
WLTC: World Light duty Test Cycle RDE:
Real Drive Emissions

Strong Growth in 48 Volt and High Volt Hybridization

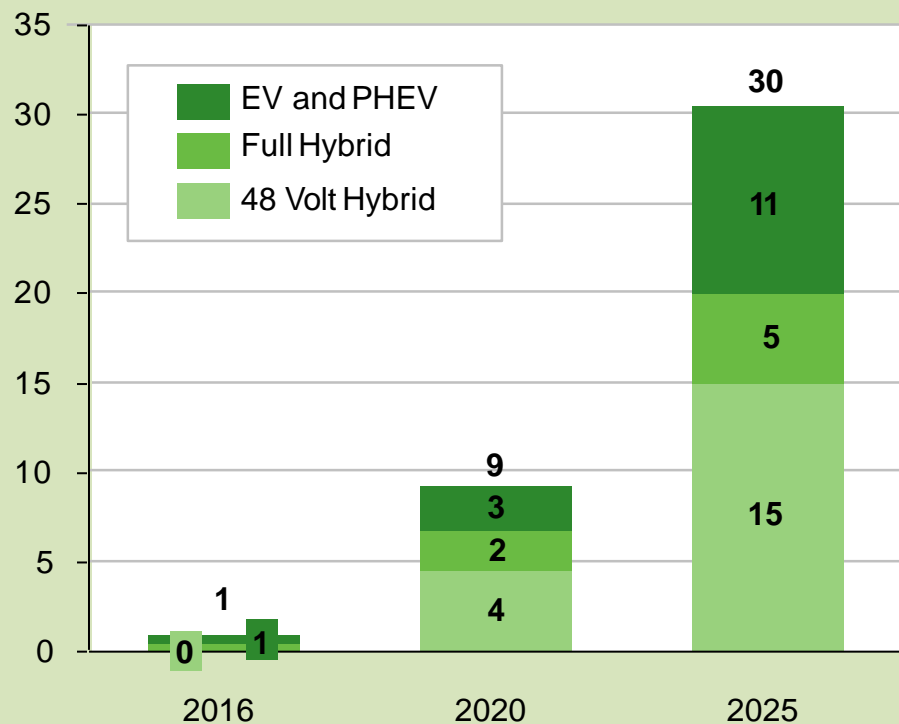
CO₂ Legislation



Incentives and Regulations

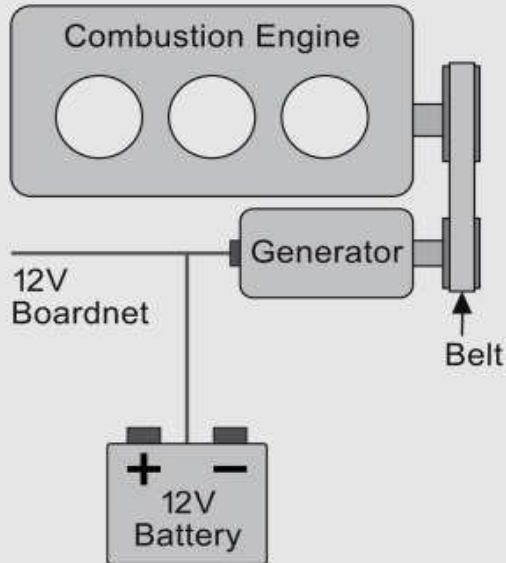


Electrification (Million Vehicles)

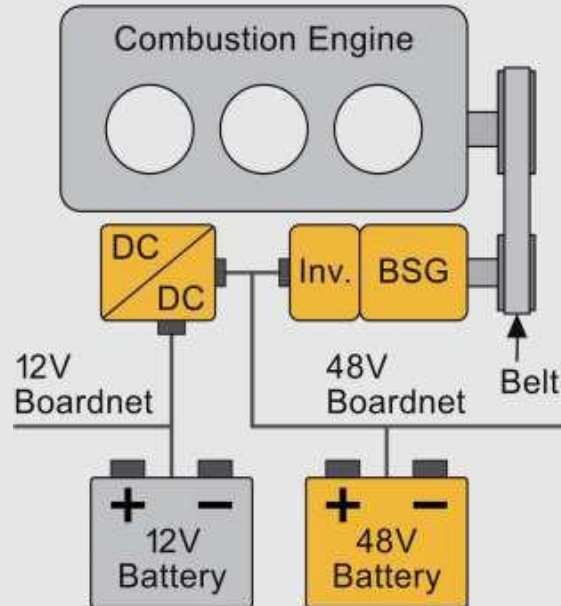


Configuration with Belt Starter Generator

Conventional System



48 Volt System



- Simple system integration, replaces the generator
- No high voltage protection necessary
- Belt starter generator with 15 kW peak performance:
 - Fast engine start
 - Recuperation and boost
 - 13% CO₂ saving in NEDC

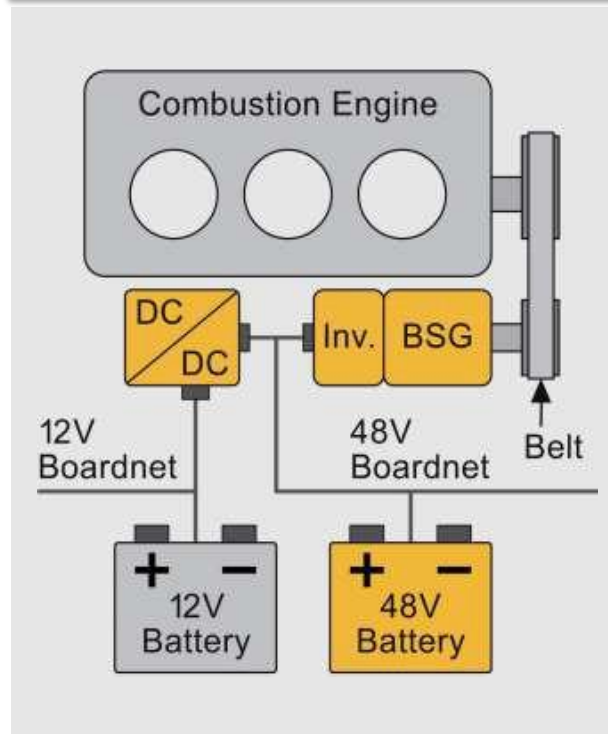
MOSFET Opportunity in 48V Mild Hybrid

3 kW DC/DC Converter



- Estimated 28 ~38pcs 80V or 100V MOSFETs
- Estimated MOSFETs cost \$25 ~ \$35
- Preferred package TOLL

48 Volt System



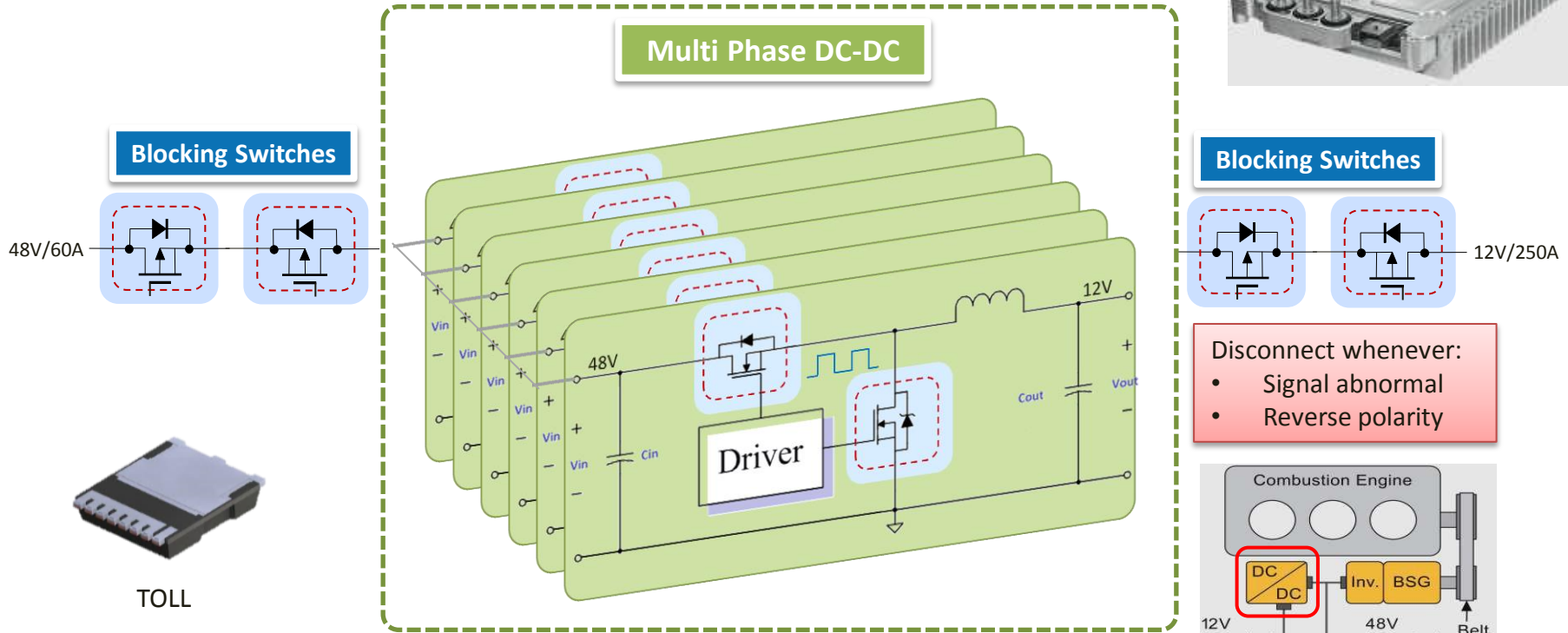
15 kW Belt Starter Generator



0.5 kWh Li-Ion Battery

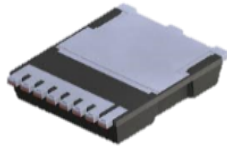


3kW DC-DC with Blocking Switches

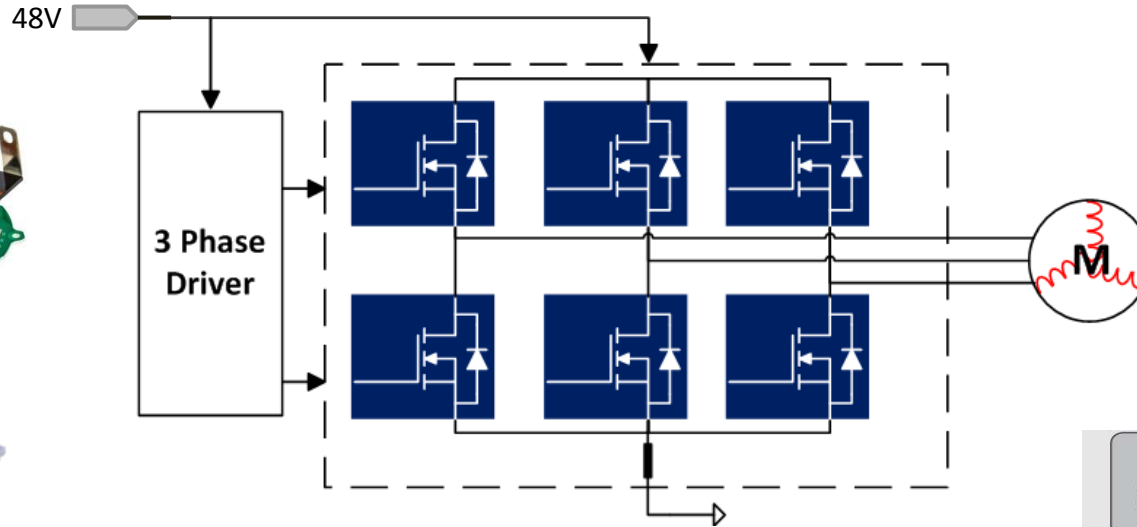


- Estimated 16~20pcs 80V or 100V MOSFETs
- Estimated MOSFETs cost \$15 ~ \$18
- Preferred package TOLL

48V BSG Inverter



TOLL



- Estimated 12~18pcs 80V or 100V MOSFETs
- Estimated MOSFETs cost \$11 ~ \$16
- Preferred package TOLL

