



Diodes Automotive-Compliant Products

2Q22

This presentation contains Diodes proprietary and confidential information



Diodes Automotive-Compliant/Grade Products

- **Diodes Incorporated Automotive-Compliant products targeted at the Automotive market space are all:**

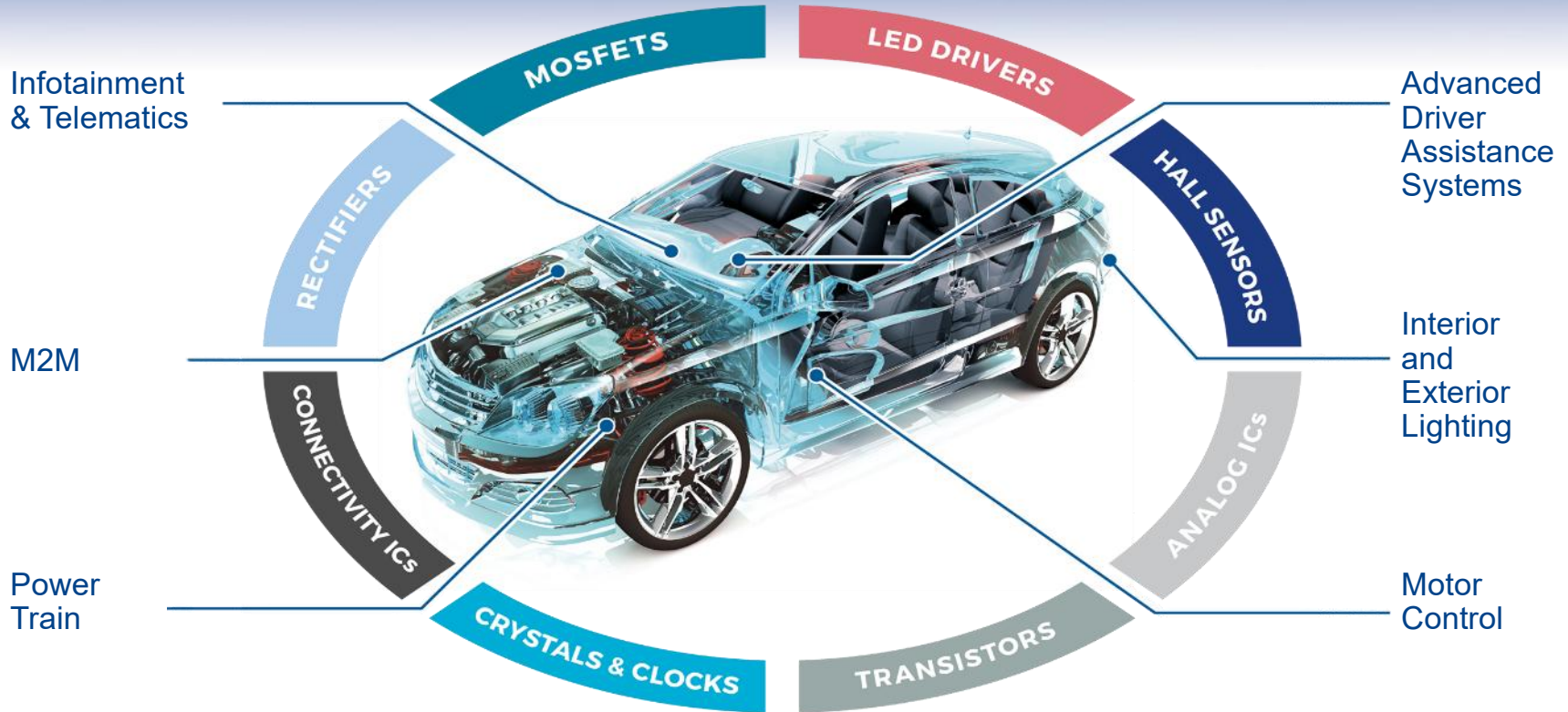
1. Qualified to AEC-Q100, AEC-Q101, AEC-Q104, and AEC-Q200 respectively
2. Manufactured in facilities certified to the rigorous IATF 16949 standard,
3. Capable of customer audit to VDA6.3.
4. Supported by PPAP (Production Part Approval Process) documentation
5. Specific change controlled



- **Diodes Incorporated Automotive-Compliant products are identifiable by a 'Q' suffix**

- Standard Products are made and supplied to within Diodes standard quality control envelope. Standard Discretes might or might not have AEC-Q101 qualification and are aimed at Commercial and Industrial applications.

Portfolio of 2000+ Automotive 'Q' products



Automotive Applications Driving Growth

Focus Applications:

Connected Driving - merging of:

- **ADAS** (Advanced Driver Assistance Systems)
- **Telematics**
- **Infotainment Systems**

Connectivity & Timing
Power Management

Comfort, Style and Safety

- **Lighting**
 - Migration to LED and intelligent illumination
- **BLDC motor control**
 - Migration from Brushed to Brushless DC Motors

LED Drivers,
MOSFETs & Rectifiers

MOSFETs, Gate Drivers,
Rectifiers & Sensing

Electrification/Powertrain

- **Conventional Powertrain → Hybrid → Electrification**
 - Expansion to 48V battery
- **Battery management**

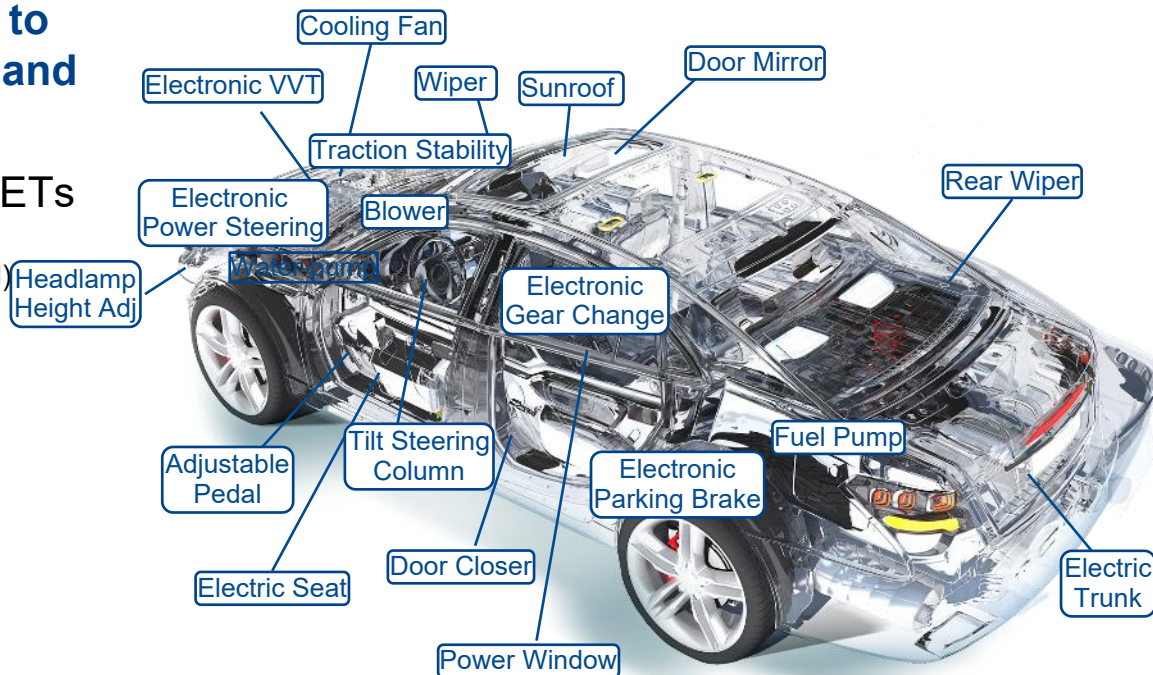
MOSFETs, Rectifiers

Automotive Brushless DC (BLDC) Motors

Migrating from Brushed to BLDC Motors (≤ 30 /car)

Automotive market moving to BLDC motors for reliability and efficiency

- High power-density MOSFETs
- 175°C (DMTH) Low $R_{DS(ON)}$ MOSFETs
- Schottky Diodes
- Super-Barrier Rectifiers
- Hall Latches and Sensors
- Self-Protected (IntelliFET) MOSFETs
- Gate Drivers
- Crystals

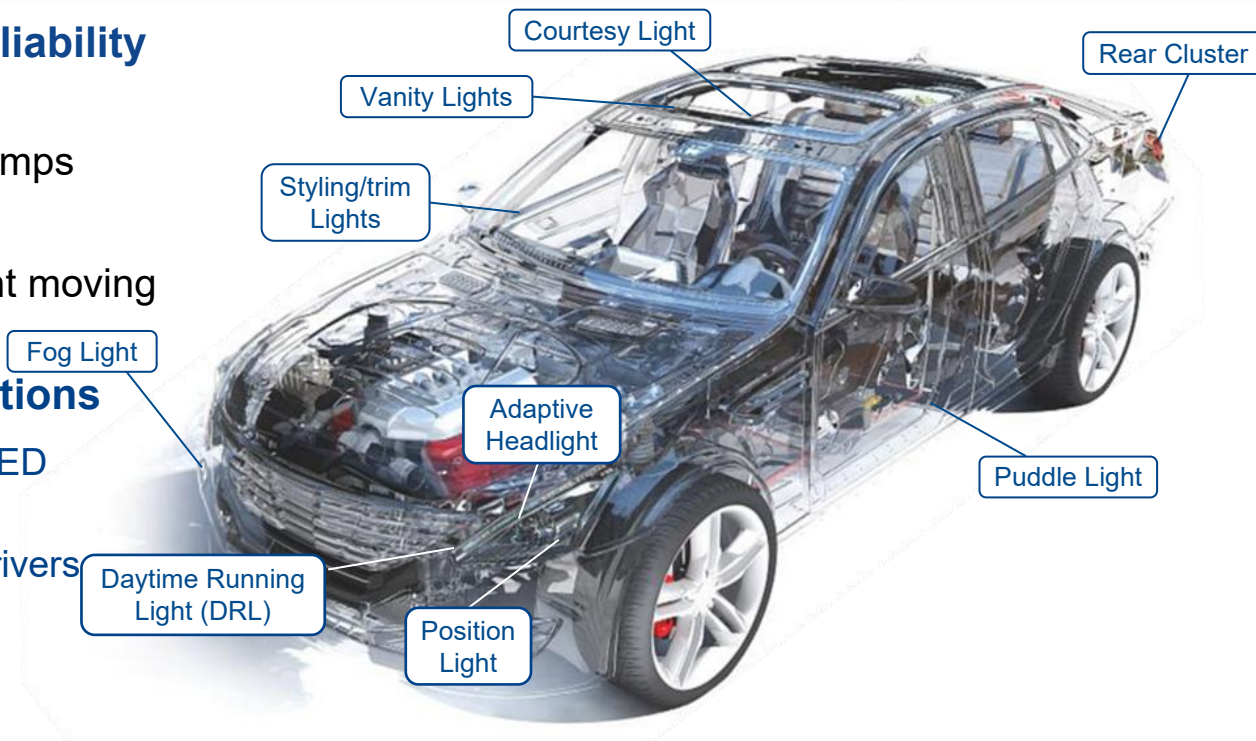


Automotive Lighting – Moving to LED

Penetration of LED lamps is growing across all car-classes

Efficiency and safety/reliability are key drivers

- Daytime Running Lamps
- Rear Lamps
- Automotive Headlight moving to LED
- **Simple versatile solutions**
 - Buck-boost and Boost LED Drivers
 - Linear and Buck LED Drivers
 - MOSFETs, BJTs and Rectifiers
 - Crystals



Connected Driving

Merging of Telematics, Infotainment and ADAS

Drives higher speed data rates and increased number of channels

- **PCIe Packet Switch**

Adds more real-time ports to SoC

- **ReDrivers**

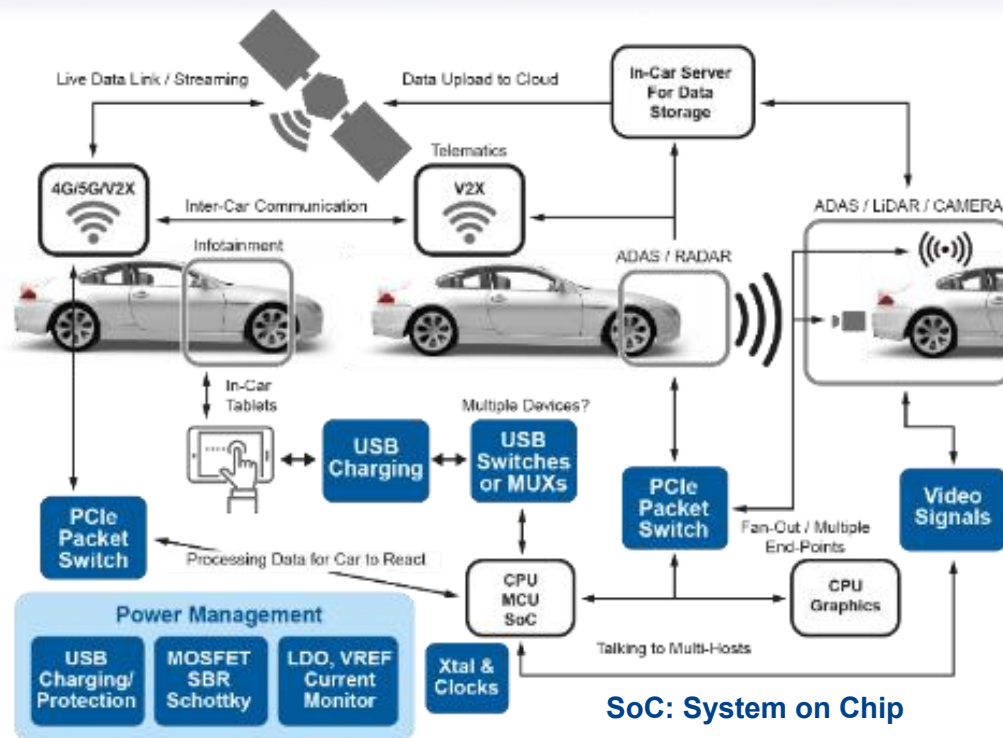
Provides Reliable High-speed data interface for USB and other standards

- **Reliable Clock signals solutions**

Crystals/XO & Clock IC

- **Power Management solutions**

USB-Charging Solutions
DC-DC converters, LDOs
MOSFETs
BJTs
Rectifiers
TVS



Powertrain and Battery Management

Internal Combustion Engine (ICE) and Gearbox continue to dominate

Growth of Hybrid and E-vehicles driving 48V systems and Li-batteries

- Needs more complex battery management
- Forecast growth of EV and Hybrid from 8.5 Million units (2017, 9%) to 14.3 Million units by 2021 (13.5%)

Drives the need for

- DIODES™ high power-density MOSFET
- 175°C Low $R_{DS(ON)}$ MOSFETs (DMTH)
- High temperature Rugged MOSFETs (DMNH)
- Schottky and Super-Barrier Rectifiers
- Self-protected (IntelliFET) MOSFETs
- Crystals



DIODES is trademark of Diodes Incorporated.

Broad Automotive 'Q' Portfolio

Discrete Products	Analog & Power Management	Connectivity and Timing
<u>Bipolar Transistors</u>	Voltage and Current Regulation - LED Drivers - Linear Voltage Regulators & LDOs - DC-DC Converters - USB Charging - Load/USB Switches	Timing Products - Crystals and XO - Clocks
<u>MOSFETs</u> - High Temp, Lateral, and Trench - IntelliFET™		
<u>Diodes and Rectifiers</u> - Schottky Diodes - Zener Diodes - Super Barrier Rectifiers (SBR)®	Gate & Relay Drivers	Connectivity ICs - Packet Switches - Signal Switches - USB2 protected signal switches - Signal Integrity/ReDrivers - USB Charging - I/O Expanders
<u>Protection</u> TVS	Sensing - Current Monitors - Hall Sensors	
Application Specific Discrete Reverse Battery Protection	Standard Automotive Linear ICs - Shunt Regulators - Shunt References - Op Amps and Comparators - Audio Amplifiers	Logic - Single Gate Logic - Voltage translators

First Automotive-compliant parts to market

In development

New Family

IntelliFET and SBR are the registered trademark of Diodes Incorporated.



Automotive compliant (Q) - AEC-Qualified, in IATF 16949 manufacturing sites supporting PPAP

DIODES Automotive Analog & Power Management IC

	Product Type		Status				
Automotive Power Management IC	<u>LED Drivers</u>	DC-DC	ZXLD13xxQ/AL886xQ			& portfolio expansion	
		Linear	AL58xxQ BCR4xxQ				
	Motor Control		ZXBM5409Q		ZXBM5xxxQ Brushed		
	<u>DC-DC Converters</u>		AP64xxxQ	AP6110xQ	AP63xxxQ	AP64060Q	AP66xxxQ
	<u>USB</u>	<u>Power Switches</u>	Type-A charger	AP2265xQ		Type-C Charger	
		Charger		PI5USB2546Q/AQ			
	<u>LDOs</u>		'1117 type & AP7315Q/43Q		AP7347Q	40V CMOS LDOs	
	Gate Driver IC		DGD05473Q		Portfolio expansion		
Automotive Analog IC	<u>Hall Sensors</u>		AH3x6xQ (Latch, Unipolar, Omnipolar)		2-wire ISO 26262 rdy	Dual-latch ISO 26262 rdy	3-D sensor
	<u>Current Monitors</u>		ZXCT1xxxQ			ZXCT199Q/21xQ	
	Shunt Regulators		TL/TLV431 type				
	Shunt References		LM404x type				
	Op Amps & Comparators		LM290xQ		AS2333Q	AS2376Q	
	Audio Amps		PAM8904Q		Under review		
					Production	Development	Roadmap

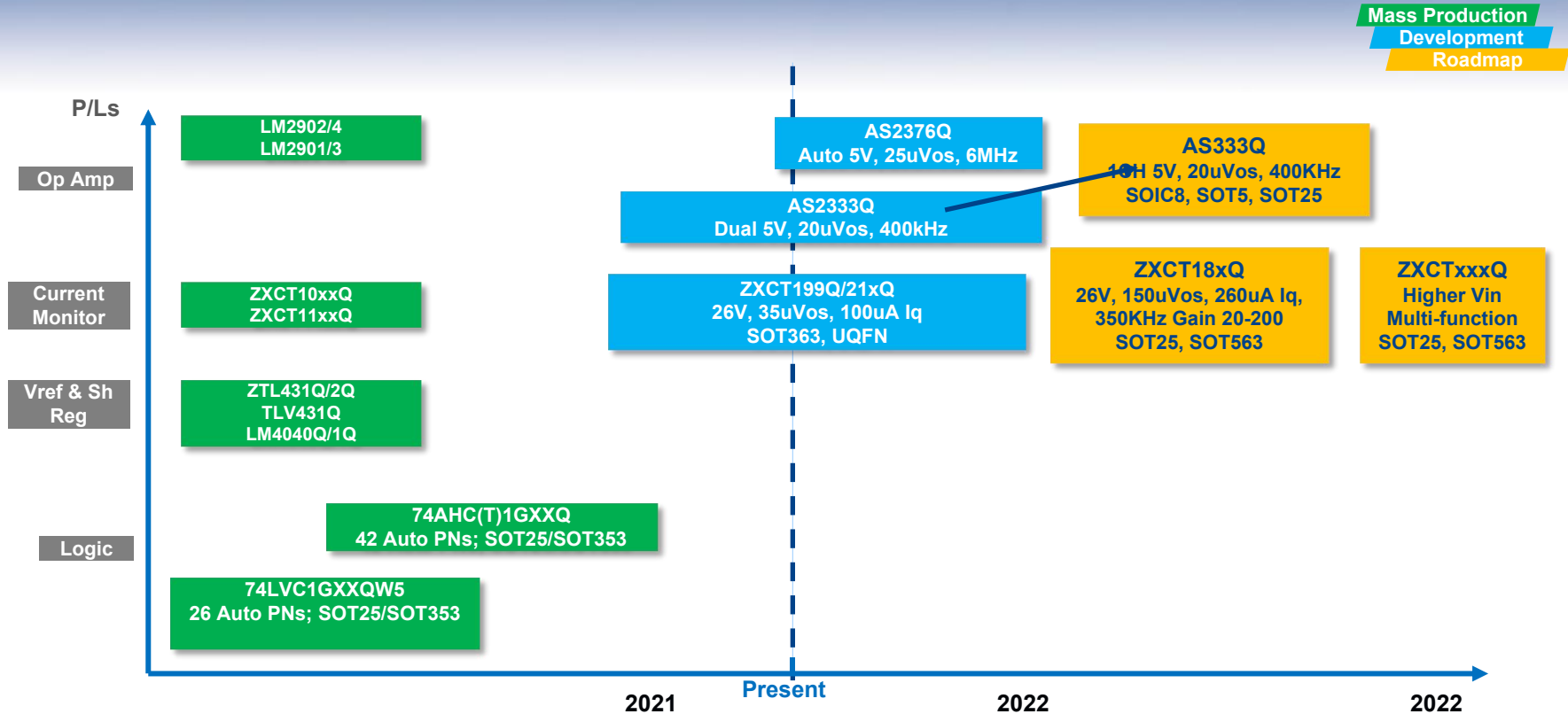
Automotive-Compliant High-Side Current Monitors

Simple high-side current sensing for over-current detection in motors

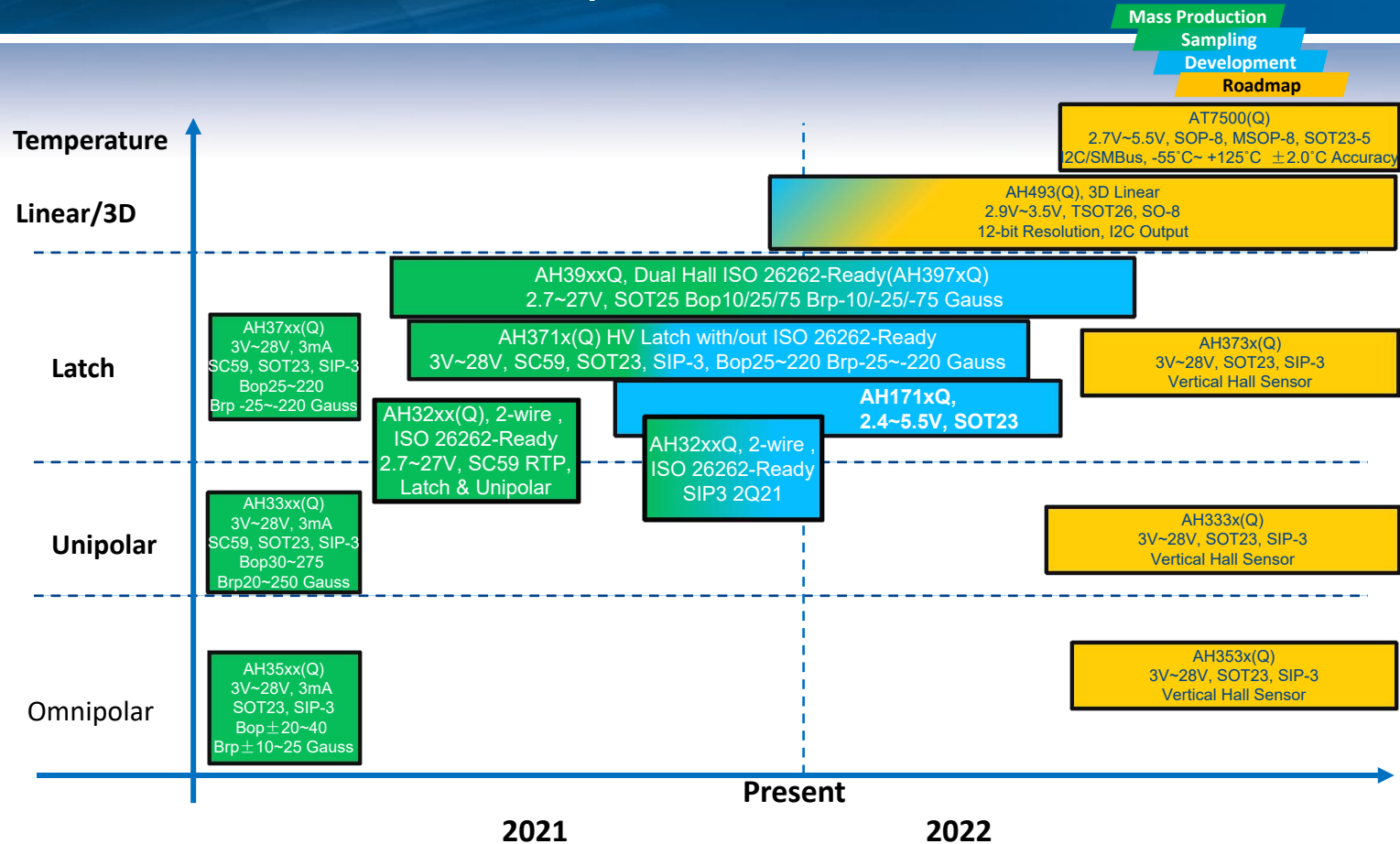
- avoids disturbing the ground reference point

Part	Description	V _{IN} (V)	V _{CC} (V)	Accuracy @ 100mV	Quiescent Current	Gain $\left(\frac{V_{OUT}}{V_{SENSE}}\right)$	Bandwidth (MHz)	Package
Current-Output								
ZXCT1008/9Q	Cost effective current monitor	2.5 to 20	None	±2.5%	4µA	10mA/V	2	SOT23
ZXCT1082Q	60V Improved accuracy	2.7 to 60	2.5 ~ 60	2%	25µA	Prog	0.5	SOT25
ZXCT1083Q	Improved accuracy	2.7 to 40	2.5 ~ 40	2%	25µA	Prog	0.5	SOT25
ZXCT1107/9Q	V _{IN} > ZXCT1008/9.	2.5 to 36	None	±3.4%	3µA	4mA/V	0.3	SOT23
ZXCT1110Q	Smaller offset than ZXCT1107/9	2.5 to 36	None	±1.8%	3µA	4mA/V	0.3	SOT25
Voltage Output								
ZXCT1080Q	60V common-mode range	3 to 60	4.5 ~ 12	±3%	30µA	10	0.5	SOT25
ZXCT1081Q	40V common-mode range	3 to 40	4.5 ~ 12	±3%	30µA	10	0.5	
ZXCT1084Q	60V common-mode	enhanced performance	2.7 to 60	2%	25µA	25	0.5	SOT25
ZXCT1085Q	40V common-mode		2.7 to 40			25	0.5	
ZXCT1086Q	60V common-mode		2.7 to 60			50	0.2	
ZXCT1087Q	40V common-mode		2.7 to 40			50	0.2	
ZXCT199Q	High precision RRI bidirectional	-0.1 to 26	2.7 to 26	80µV	65µA	50, 100, 200	0.07 ~0.014	SOT363

Standard Linear & Logic Roadmap



Sensor Products Roadmap



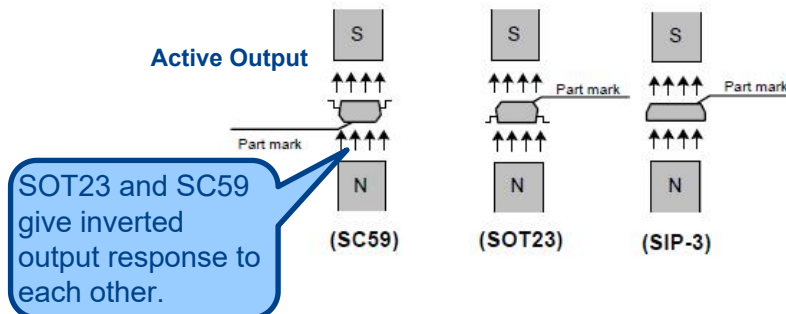
Automotive High Voltage Hall Effect Latch Family

- **Wide operating range**
 - 3V to 28V over -40°C to 150°C
- **Low 3mA Supply Current**
- **Single channel 30mA Open-drain output**
- **Chopper Stabilized with temperature compensation**
 - ensures higher reliability and improves stability
- **Wide Protection features:**
 - High ESD Withstand (highest in industry): HBM: 8kV, CDM: 2kV, MM: 800V
 - Low Leakage reverse blocking diodes
 - Zener clamps on supply and output pins
 - Output (tight tolerance) Over-current Limit
 - 32V Load Dump capability

Wide Selection of Package Options

- SOT23, SC59, SIP-3
- SC59 gives opposite magnetic polarity sense AH3763Q, AH3764Q, AH3765Q

Part	Sensitivity	Operating Point Bop (Gauss)			Release Point Brp (Gauss)			Package
		Min	Typ	Max	Min	Typ	Max	
AH3763Q	H	15	30	45	-45	-30	-15	SOT23, SC59, SIP-3
AH3764Q		20	40	60	-60	-40	-20	
AH3765Q	M	50	70	90	-90	-70	-50	SOT23, SIP-3
AH3766Q		80	110	140	-140	-110	-80	
AH3767Q	L	110	140	170	-170	-140	-110	
AH3768Q		140	175	200	-200	-175	-140	
AH3769Q		170	220	250	-250	-220	-170	



AH371xQ: High Voltage Latch Hall Effect Switches

AH3712(Q) Sample Now
AH371xQ Production Q3'22

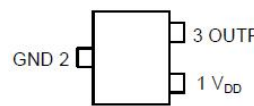
The Diodes Advantage

The AH371x are reliable high-voltage, high performance Hall effect latch for automotive applications.

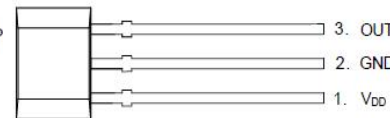
- Wide Operating Voltage of 3 to 27V
- Resistant to physical stress
- Ultra low switch-point drift over full temperature range
- Fast power-on time and response time 13μs and 5μs
- High ESD Capability 8kV HBM, 1kV CDM
- SC59, SOT23, SIP-3 and SWP-DFN2020(AH3712Q only)

Applications

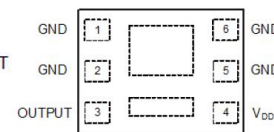
- Brushless DC motor, power tool, e-bike, angular position sensing



SC59 and SOT23



SIP-3



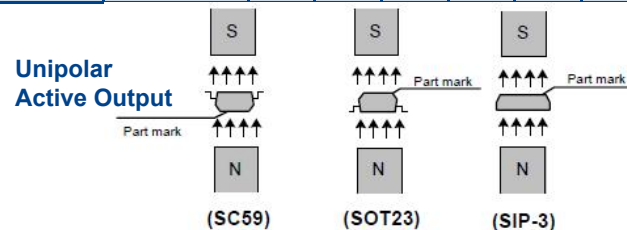
U-DFN2020-6/SWP
(AH3712Q Only)

Part Number	Output Type	Operating Voltage Range (V)	IDD (mA) Typical	Bop (Bops +ve/ Bopn -ve) (Min) gauss	Bop (Bops +ve/ Bopn -ve) (Typ) gauss	Bop (Bops +ve/ Bopn -ve) (Max) gauss	Brp (Brps +ve/Brpn -ve) (Min) gauss	Brp (Brps +ve/Brpn -ve) (Typ) gauss	Brp (Brps +ve/Brpn -ve) (Max) gauss	Typical Hysteresis Bhys gauss	Features	Packages
AH3712(Q)	Open Drain	3 to 27	2.5	10	25	40	-40	-25	-10	50	Reverse blocking, Over current protection, Over voltage clamp	SC59, SOT23, SIP3, U-DFN2020-6/SWP
AH3713(Q)				15	30	45	-45	-30	-15	60		
AH3714(Q)				20	40	60	-60	-40	-20	80		
AH3715(Q)				50	70	90	-90	-70	-50	140		
AH3716(Q)				80	110	140	-140	-110	-80	220		
AH3717(Q)				110	140	170	-170	-140	-110	280		

Automotive Unipolar & Omnipolar Hall Sensor Family

- **Wide operating range**
 - 3V to 28V over -40°C to **150°C**
 - Grade 0 AEC-Q100 qualified (PPAPable)
- **Low 3mA Supply Current**
- **Single channel 30mA Open drain output**
- **Chopper Stabilized with temperature compensation**
 - ensures higher reliability and improves stability
- **Wide Protection features:**
 - High ESD Withstand:
 - HBM: 8kV, CDM: 2kV, MM: 800V
 - Low Leakage reverse blocking diodes
 - Zener clamps on supply and output pins
 - Output Over-current (tight tolerance) Limit
 - 32V Load Dump capability

Part	Type	Operating Point Bop (Gauss)			Release Point Brp (Gauss)			Package		
		Min	Typ	Max	Min	Typ	Max	SOT23	SIP-3	SC59
AH3362Q	Unipolar	15	30	45	5	20	35	Y	Y	Y
AH3363Q	Unipolar	40	55	70	20	35	50	Y	Y	Y
AH3364Q	Unipolar	60	80	100	40	60	80	Y	Y	-
AH3365Q	Unipolar	80	100	120	60	80	100	Y	Y	-
AH3366Q	Unipolar	65	100	135	50	85	120	Y	Y	Y
AH3367Q	Unipolar	95	115	140	70	90	120	Y	Y	Y
AH3368Q	Unipolar	130	155	180	105	130	160	Y	Y	-
AH3369Q	Unipolar	150	175	200	125	150	180	Y	Y	-
AH3390Q	Unipolar	180	220	240	155	195	220	Y	Y	Y
AH3391Q	Unipolar	235	275	295	210	250	275	Y	Y	-
AH3562Q	Omnipolar	±10	±20	±30	±5	±10	±20	Y	Y	-
AH3563Q	Omnipolar	±15	±30	±45	±10	±20	±35	Y	Y	-
AH3564Q	Omnipolar	±20	±40	±60	±10	±25	±45	Y	Y	-

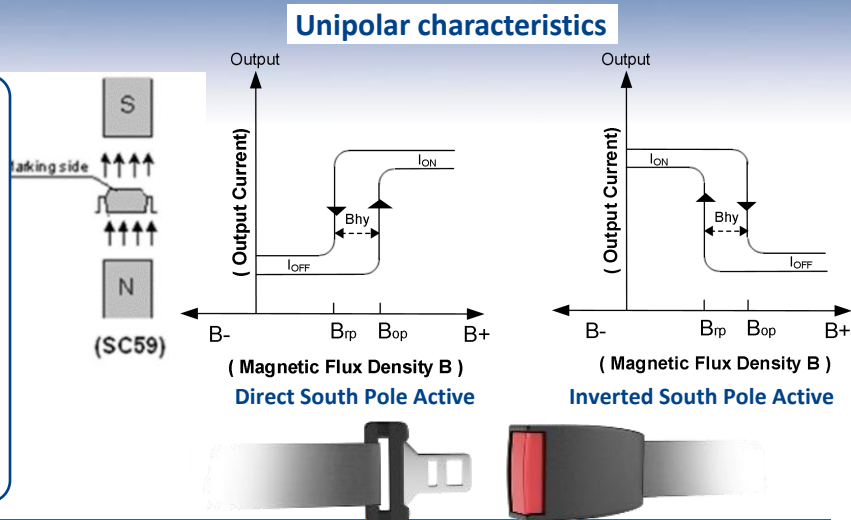


AH32xxQ: Automotive Two-wire Hall-Effect Unipolar/Latch

The Diodes Advantage

Advanced design for position and proximity sensing in automotive applications

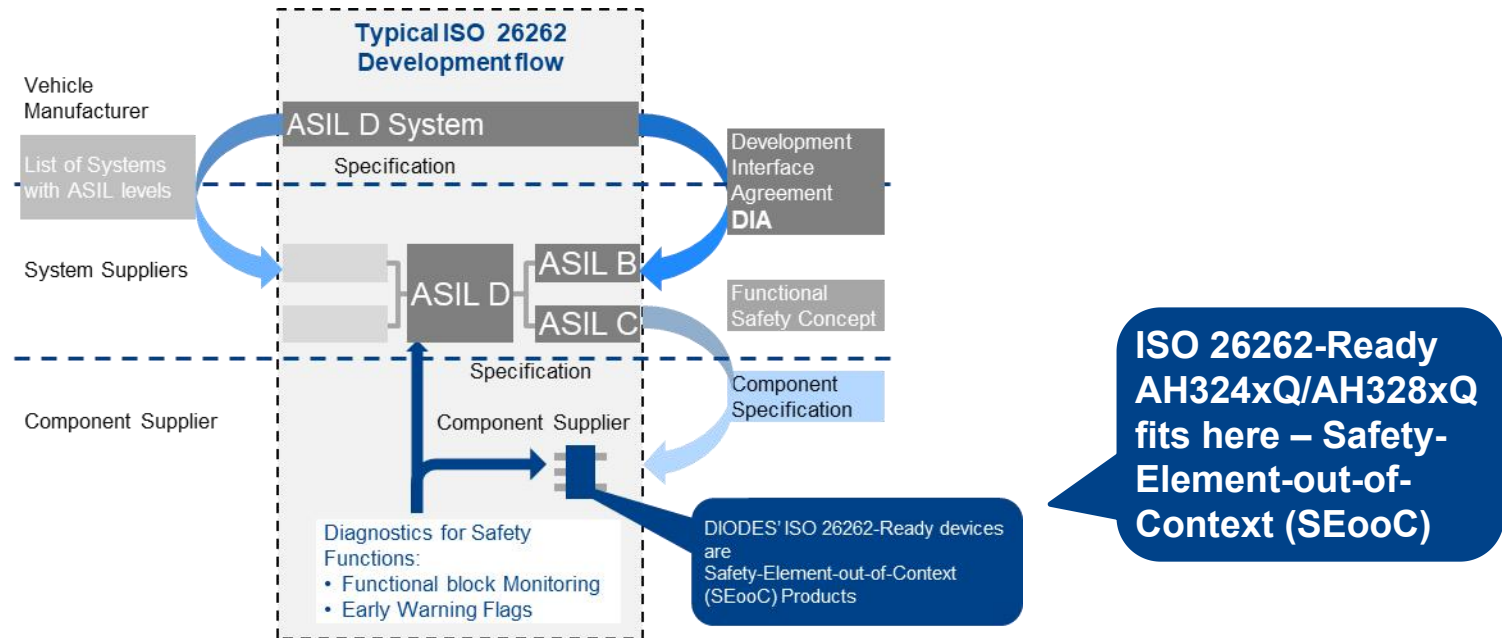
- **Automotive compliant** with AEC-Q100 qualification manufactured in IATF 16949 certified sites supporting PPAP documents
- **Integrated diagnostics (AH324xQ/328xQ) to support ISO26262 ASIL Compliant systems**
- **High sensitivity (AH3270Q/71Q & AH3280Q/81Q)**
- **Wide operating voltage range**
- **Chopper stabilized** for accuracy & stable B_{OP}/B_{RP}
- **High 8kV ESD withstand** for robustness & reliability



Part Name		Active Pole	Type	Operating Voltage (V)	Supply Current		Operating Point Bop (Gauss)			Release Point Brp (Gauss)			Ambient Temp (°C)	Packages
No ISO 26262	ISO 26262 Ready				South (mA)	Other (mA)	Min	Typ	Max	Min	Typ	Max		
AH3270Q	AH3280Q	Direct South	Latch	2.7 to 27	14.5	3.3	3	18	33	-33	-18	-3	-40 to +150	SC59, SIP3
AH3271Q	AH3281Q	Direct South	Latch	2.7 to 27	14.5	6	3	18	33	-33	-18	-3		
AH3272Q	AH3282Q	Direct South	Latch	2.7 to 27	14.5	3.3	10	30	50	-50	-30	-10		
AH3231Q	AH3241Q	Inverted South	Unipolar	2.7 to 27	6	14.5	55	90	125	35	70	105		
AH3232Q	AH3242Q	Direct South	Unipolar	2.7 to 27	14.5	6	30	60	90	10	40	70		
AH3233Q	AH3243Q	Direct South	Unipolar	2.7 to 27	14.5	6	20	45	70	3	28	53		

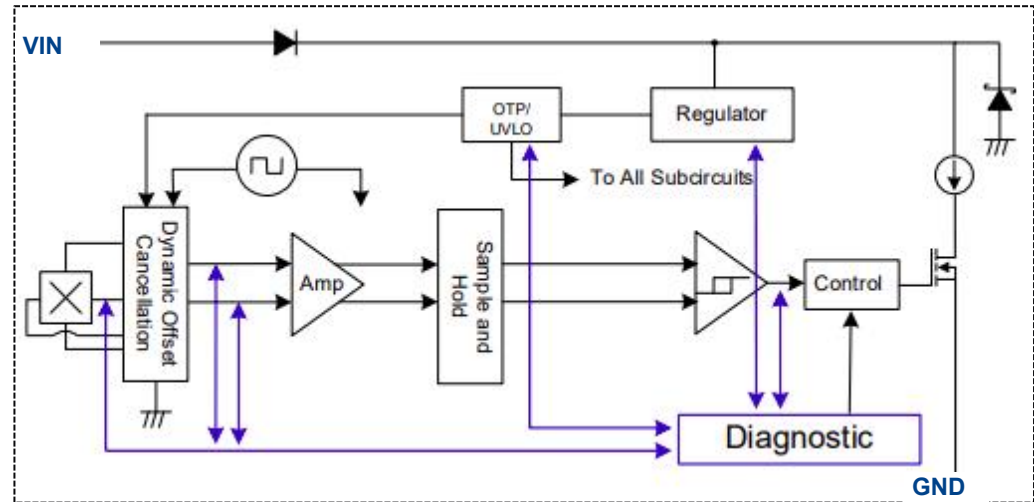
AH324xQ/AH328xQ & Functional Safety

- AH324xQ/AH328xQ have been designed from their outset for functional safety applications → As a Safety-Element-out-of-Context (SEooC) product
- AH324xQ / AH328xQ **do not have** functional safety certificate
→ functional safety certificate/ASIL is for the system not our component



AH324xQ/AH328xQ ISO 26262 Functionality

- **AH324xQ/AH328xQ have integrated self-diagnostic function**
 - Designed for systems requiring functional safety.
 - Self-diagnostic operates automatically in background without need of external activation
 - Once an error is detected, device enters “Safe Mode”
 - output (supply) current drops to 1mA → warning signal to system
 - **The following are monitored as part of the “Self-diagnostics”:**
 - Vdd under-voltage detection
 - Over-temperature detection
 - Self-test of major functional blocks
- 
- ```
graph LR; VIN --> D1[Diode]; D1 --> OTP[OTP]; D1 --> Regulator[Regulator]; Regulator --> Output[Output]; Output --> Load[Load]; Load --> GND;
```

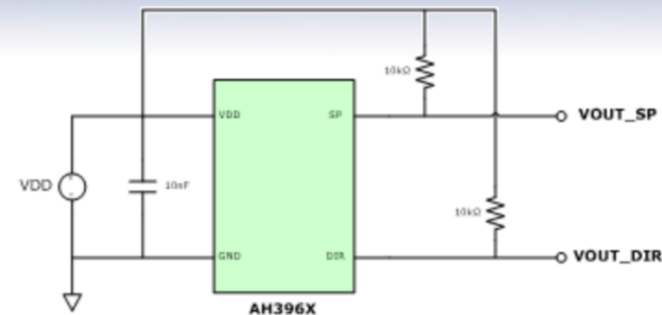


# AH39xxQ: Automotive Dual-Latch (with Speed & Direction Detection)

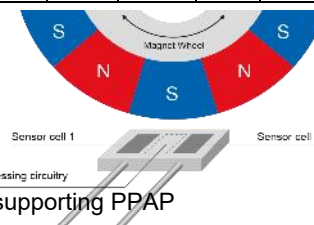
Sample 2Q22  
Production 3Q22

## The Diodes Advantage

- **Automotive compliant** with AEC-Q100 qualification manufactured in IATF 16949 certified sites supporting PPAP documents
- **Integrated diagnostics (AH397xQ) to support ISO26262/ASIL Compliant systems**
- **Wide operating voltage range 2.7V ~ 27V**
- **Chopper stabilized - superior temperature stability with tight matching between channels**
- **-18V Reverse battery protection**
- **Small TSOT25 package**



| Part Name      |                   | V <sub>IN</sub> | I <sub>DD</sub> | BOP   |     |     | BRP   |     |     | Hysteresis |     |     | Magnetic |     |        |     | Output |      |     |     | Type  | Active Pole |
|----------------|-------------------|-----------------|-----------------|-------|-----|-----|-------|-----|-----|------------|-----|-----|----------|-----|--------|-----|--------|------|-----|-----|-------|-------------|
|                |                   |                 |                 |       |     |     |       |     |     |            |     |     | Matching |     | Offset |     |        |      |     |     |       |             |
| No<br>ISO26262 | ISO26262<br>Ready | V               | mA              | Gauss |     |     | Gauss |     |     | Gauss      |     |     | Gauss    |     |        |     | OUT1   | OUT2 | SPD | DIR |       |             |
|                |                   |                 |                 | Min   | Typ | Max | Min   | Typ | Max | Min        | Typ | Max | Min      | Max | Min    | Max |        |      |     |     |       |             |
| AH3965Q        | AH3975Q           | 2.7 to 27       | 50              | 2     | 10  | 30  | -30   | -10 | -2  | 5          | 20  | 35  | -25      | 25  | -15    | 15  |        |      | Y   | Y   | Latch | South       |
| AH3966Q        | AH3976Q           |                 |                 | 10    | 25  | 40  | -40   | -25 | -10 | 40         | 50  | 60  | -15      | 15  | -15    | 15  |        |      | Y   | Y   |       |             |
| AH3967Q        | AH3977Q           |                 |                 | 50    | 75  | 100 | -100  | -75 | -50 | 120        | 150 | 180 | -30      | 30  | -20    | 20  |        |      | Y   | Y   |       |             |
| AH3968Q        | AH3978Q           |                 |                 | 50    | 75  | 100 | -100  | -75 | -50 | 120        | 150 | 180 | -30      | 30  | -20    | 20  | Y      | Y    |     |     |       |             |



# Power Management Strategy and Key Messages

## ...a Growing Portfolio for Reliable and Cost-effective Automotive Power Tree Solutions

### ➤ LED Drivers – Expanding

- Simple Hysteretic Buck & Buck-boost
- High power density Linear → Multi-channel with SPI/I2C/UART/LIN – In development

### ➤ DC-DC Buck Converters – Expanding

- Offer full range Vin max from 5.5V to 40V, expanding up to 60V (2Q22)
- 40V Automotive compliant DC-DC products released spanning 1A to 5A in SO-EP
- 32V in SOT26 and in DFN2030 from 2A to 3.5A as well as 1A & 3A, 5.5V DC-DC

### ➤ LDO and Linear Regulators – Expanding

- Focused on Connected Driving low noise application with high PSRR products
- Expanding portfolio → up to 1A and up to 60V LDOs in development

### ➤ Load Switches and Application Specific Solutions – in development

- Adjustable overcurrent protected USB/Load switch Released
- USB-C charger port solution with DFP controller & Power SW in AEC-Q100 qual
- Ideal Diode Controller for Reverse Battery Protection in AEC-Q100 qual

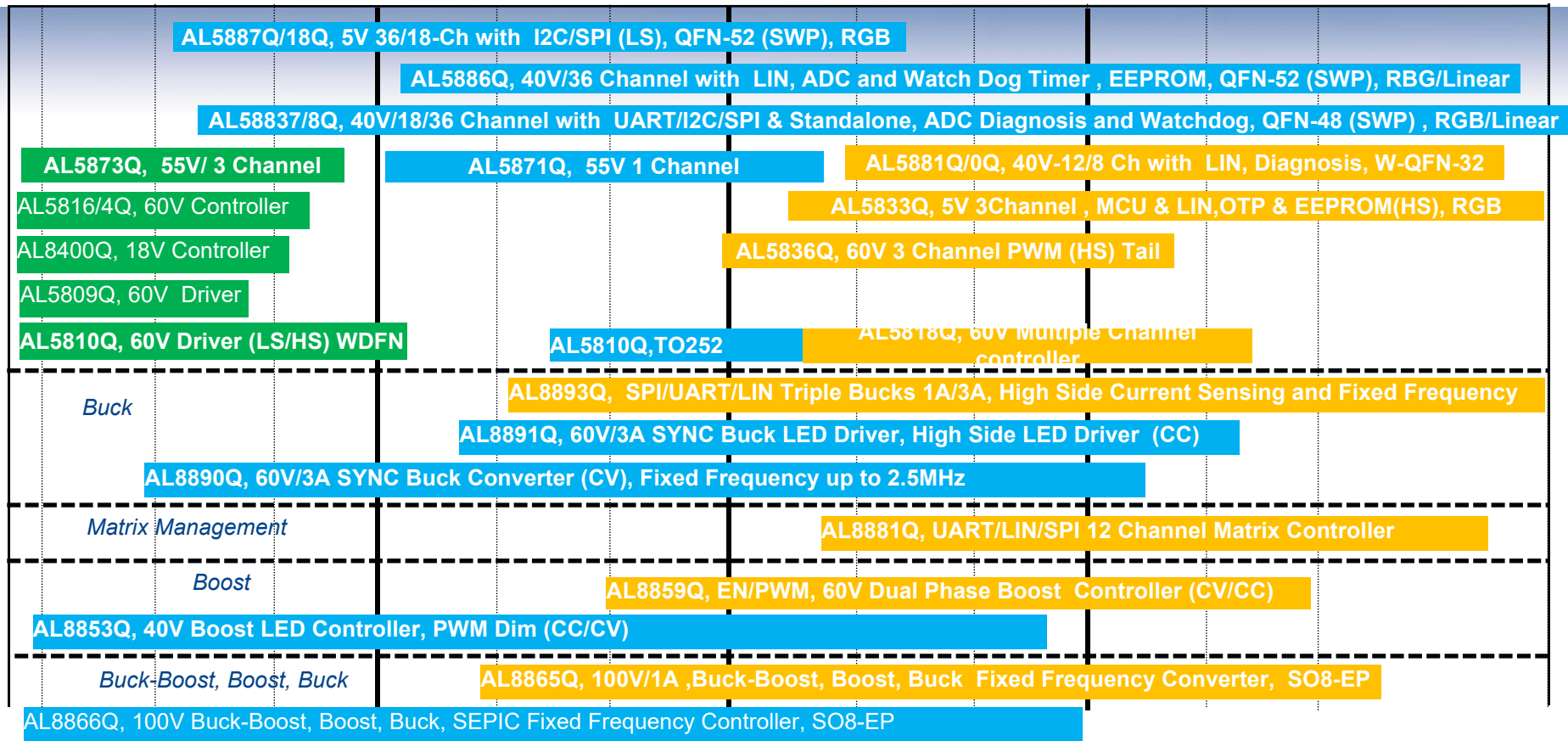


# Automotive LED Driver Roadmap

Production

Engineering

Roadmap



In Production

1H'2022

2H'2022

2023



Automotive compliant (Q) - AEC-Qualified, in IATF 16949 manufacturing sites supporting PPAP

Diodes Incorporated-Customer Confidential

APL

# Front Lighting Topology and Applications

Production

Development

Roadmap

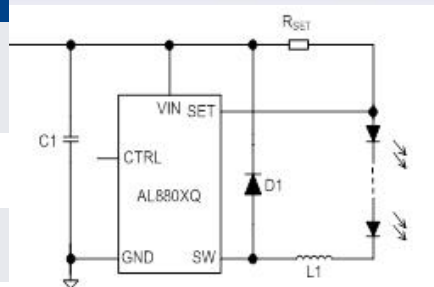
| Applications                           | Topology            | DIODES LED Drivers                               | Advantage                                                                         |
|----------------------------------------|---------------------|--------------------------------------------------|-----------------------------------------------------------------------------------|
| Headlamps<br>(Hi/Low Beam)             | Buck-Boost          | ZXLD1371Q,<br>AL8871Q AL8866Q                    | Single sense resistor drive for wide dynamic drive of LEDs                        |
|                                        | Buck<br>(voltage)   | AL8890Q                                          | Simple drive of high current automotive lighting power rails with fault detection |
| Daytime Running Lamps (DRL)            | Buck-Boost          | ZXLD1371Q<br>AL8871Q AL8866Q                     | Single sense-resistor control for wide dynamic drive of LEDs                      |
| Fog Lamps                              | Buck                | AL8860Q/61Q                                      | Simplest solution for driving on-same-board LEDs                                  |
|                                        |                     | AL8843Q/62Q AL8863Q                              |                                                                                   |
| Integrated Forward Matrix Lamp Modules | Boost and 2-ch Buck | AL8859Q Boost AL8853Q                            | High efficiency with advanced digital coms and Diagnostics                        |
|                                        |                     | AL8890Q – 1-ch Buck<br>AL8892Q – 2-ch Buck w/SPI |                                                                                   |
| Signal/Position                        | Linear              | AL8400Q, AL5814Q/16Q,                            | Simple low overheads linear LED drive                                             |
|                                        |                     | AL5809Q/10Q AL5818Q                              |                                                                                   |

# 40V/55V Automotive Buck LED Drivers, AL88xxQ

The AL88xxQ provides a simple, low EMI solution for Automotive LED lamps

## The DIODES Advantage

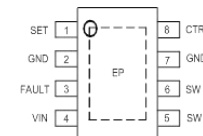
- **40V/55V  $V_{IN}$  up to 3A LED drive**  
Drives 1W and 3W LED from 12V and 24V batteries
- **Small footprint solution**  
→ requires 4 components
- **Controlled edge speeds**  
Improves EMI; Easier PCB layout
- **±5% initial average LED current accuracy**



Status: MP



MSOP-8EP



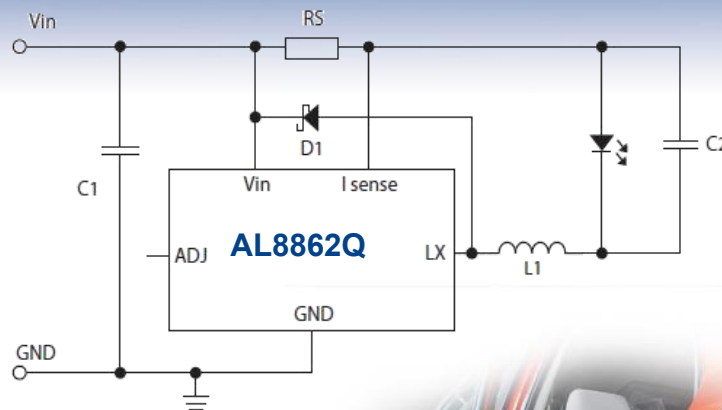
SO-8EP

| Part    | Min $V_{IN}$ | Max $V_{IN}$ | LED Current | Accuracy | Max $f_{sw}$ | Efficiency | Hysteresis | Dimming |        | Protection Features    |                      |           |                        | Sense Voltage | Ambient Temperature Range | Package  |
|---------|--------------|--------------|-------------|----------|--------------|------------|------------|---------|--------|------------------------|----------------------|-----------|------------------------|---------------|---------------------------|----------|
|         |              |              |             |          |              |            |            | PWM     | Analog | Inductor Current Limit | Sense Resistor Short | Over-Temp | Fault Status Indicator |               |                           |          |
|         | V            | V            | A           | %        | kHz          | %          | %          |         |        | A                      |                      |           |                        | mV            | °C                        |          |
| AL8860Q | 4.5          | 40           | 1.5         | ±5       | 1000         | 97         | 20         | Y       | Y      | N                      | N                    | Y         | N                      | 100           | -40~+125                  | MSOP-8EP |
| AL8861Q |              |              |             |          |              | 97         | 13         | Y       | Y      | 2                      | Y                    | Y         | N                      | 100           | -40~+125                  |          |
| AL8843Q | 4.5          | 40           | 3           | ±5       | 1000         | 97         | 13         | Y       | Y      | N                      | N                    | Y         | N                      | 100           | -40~+125                  | SO-8EP   |
| AL8862Q | 5            | 55           | 1           | ±4       | 1000         | 97         | 13         | Y       | Y      | N                      | Y                    | Y         | Y                      | 100           | -40~+125                  |          |

# Interior/Exterior Lamps – DC-DC LED Drivers

## Diodes Advantage

- 5~60V input range Buck LED Drivers supports normal 9~16V typical battery range and load dumps
- 1A switch → Drives 0.5, 1 and 3W LEDs
- Qualified to AEC-Q100 grade 1
- +125°C ambient temperature range
- High accuracy
  - ZXLD1366: 2.5%
  - AL8862Q: 5%



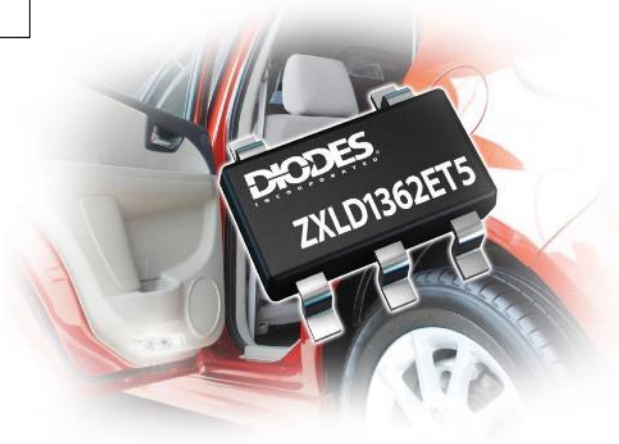
### Key Products

ZXLD1366Q

AL8861Q

AL8862Q

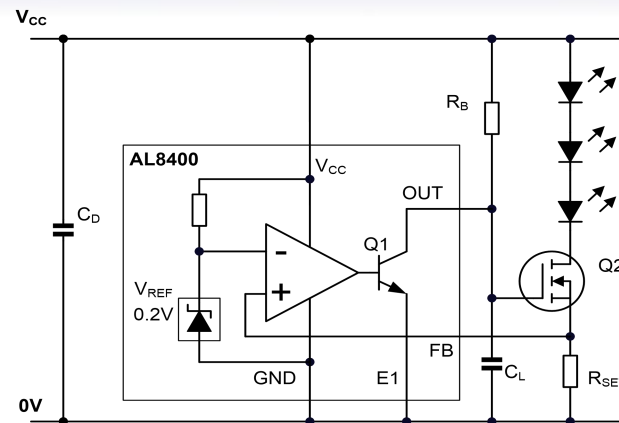
PDS3S140Q D1



# Interior Lamps – Linear LED Drivers

## Diodes Advantage

- 5~60V input range Linear LED Drivers supports normal 9~16V typical battery range and load dumps
- Small footprint solution drivers  
SOT26 (BCR4xxQ) and PowerDi123 (AL5809Q)
- Low headroom (<1V) controllers  
Reduces headroom and optimises BJT footprint/Pdis
- Qualified to AEC-Q100 grade 1
- +125°C ambient temperature range
- High accuracy
  - AL8400Q: 3%
  - AL5814Q: 4%



### Key Products

BCR42xQ

AL8400Q

AL5809Q

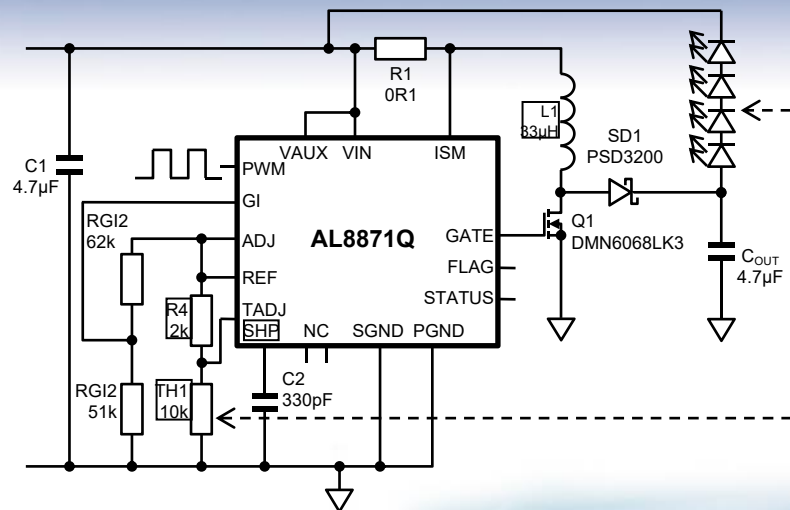
AL5814Q



# Daytime Running Lamps

## Diodes Advantage

- 5~60V input range DC-DC LED Driver
  - Operates over whole battery (6~16V) voltage range
- Buck-boost mode works over  $V_{BATT}$  range including Load Dump
- 2% accuracy → better matching between DRL pair
- Qualified to AEC-Q100 grade 1
  - Ambient temperature up to +125°C
- LED thermal protection loop



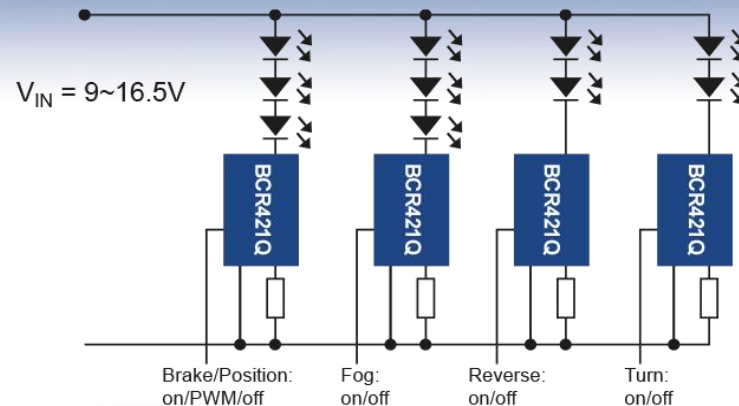
| Key Products |        |
|--------------|--------|
| ZXLD1371Q    |        |
| ZXLD1370Q    |        |
| DMN6040SEQ   | MOSFET |
| PDS3S140Q    | D1     |
| PDS3200Q     |        |



# Rear Lamp Clusters

## Diodes Advantage

- Operate over whole battery (9~16.5V or 5~16.5V) voltage range
- Qualified to AEC-Q100 grade 1
  - Wide temperature range  $>+85^{\circ}\text{C}$
- Low EMI
- Simple cost-effective solution for driving 20~150mA LEDs
- AL5873Q 3-Ch LED driver with High & Low brightness Enable
  - Simple solution for using same LED for tail and brake lamps
- BCR421Q PWM dimmable
  - Simple adjustment of brightness



### Key Products

AL5873Q

AL5809Q

BCR421Q

AL5814Q

# Power Rail Management Strategy and Key Messages

## ...a Broad Portfolio for Reliable and Cost-effective Automotive Power Tree Solutions

### ➤ DC-DC Buck Converters – Expanding

- Offer full range Vin max from 5.5V to 40V, expanding up to 60V
- **40V** Automotive compliant DC-DC products released spanning 1A to 5A in SO-EP
- 32V in SOT26 and in DFN2030 from 2A to 3.5A as well as 1A & 3A, 5.5V DC-DC

### ➤ LDO and Linear Regulators –

- Focused on ADAS low noise application with high PSRR products
- Expanding portfolio → up to 1A and up to 60V LDOs in development

### ➤ Load Switches and Application Specific Solutions – in development

- Adjustable overcurrent protected USB/Load switch Released
- USB-C charger port solution with DFP controller & Power SW in AEC-Q100 qual
- Ideal Diode Controller for Reverse Battery Protection in AEC-Q100 qual

# Automotive Power Management – Voltage Rails

|                  | Past                                                         | 2022                                                     | 2023                                |
|------------------|--------------------------------------------------------------|----------------------------------------------------------|-------------------------------------|
| DC-DC Converters | 60V DC-DC AP66200Q/300Q 2A/3A with PG                        |                                                          | AP66060Q/030Q with PG               |
|                  | 40V DC-DC Converters AP64xxxQ:<br>1A, 2A, 3.5A, 5A in SO-8EP | AP64060Q<br>TSOT26 0.6A                                  | AP6420xQ/30xQ<br>DFN 2A/3A          |
|                  | 32V DC-DC Converters with PG<br>AP63356Q/7Q: 3.5A DFN2030    | 32V AP63x00Q/1Q<br>2A & 3A TSOT26                        | AP6470xQ<br>7A                      |
|                  | 5V DC-DC Converters<br>AP61100Q/2Q: 1A<br>SOT563             | AP61302Q/00Q<br>with/out PG 3A SOT563                    |                                     |
| Load Switches    | AP22653Q: 2.5A ADJ Iout                                      | AP22655Q: 3.0A ADJ Iout                                  | AP2291xQ: Load Switch               |
| LDOs             | 20V, 1A NPN LDO<br>ZLDO1117Q:<br>SOT223 & TO252:             | AP7583AQ/Q: 42V with/out PG,<br>300mA TO252/DFN/MSOP-8EP | AP7387Q: 60V 150mA<br>DFN2020/SOT89 |
|                  | 6V SOT25 CMOS LDOs<br>AP7315Q/43Q/47Q 150/300/500mA          |                                                          | AP7875Q: 40V 150mA<br>SO-8EP/SOT89  |
| ASSP             |                                                              | AP74700Q: Ideal Diode Controller                         | AP74701Q: Ideal Diode Controller    |
|                  |                                                              | AP25810LQ: USB-C DFP Solution                            |                                     |

Production

Sampling

Development

Roadmap



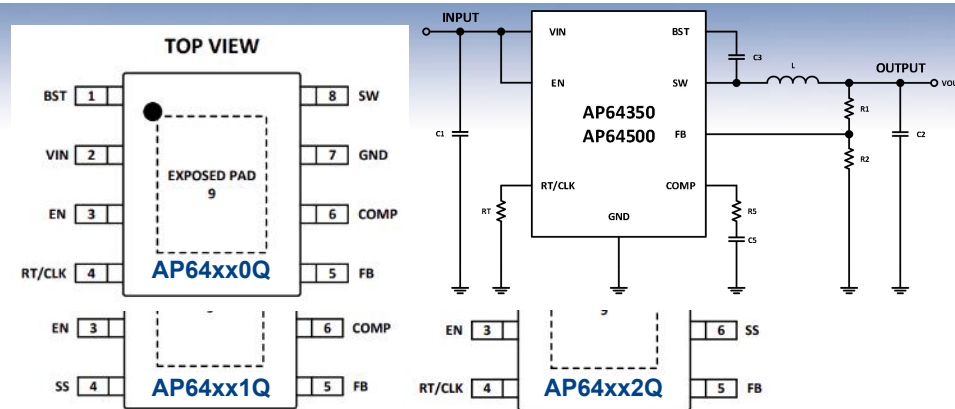
Automotive compliant (Q) - AEC-Qualified, in IATF 16949 manufacturing sites supporting PPAP

Diodes Incorporated-Customer Confidential

# AP6410xQ/20xQ/35xQ/50xQ – 40V Sync Buck Converters

## The DIODES ADVANTAGE

- $V_{IN}$  3.8V to 40V**  
 Works across the full battery rails – including load dump
  - Synchronous DC-DC Converters**  
 Removes the need for external diode – saves PCB space BOM cost and improves efficiency
  - Programmable  $f_{SW}$  (AP64x0Q/x2Q) with ext. clock synchronization**  
 Low frequency (100kHz) – high-efficiency solution  
 High frequency (2.2MHz) – small-form factor solution
  - 1 $\mu$ A Shutdown Current and Low Quiescent Current ( $I_Q$ )**  
 Helps systems meet standby current requirements
  - Adjustable Soft-Start Time (AP64xx1Q/AP64xx2Q)**  
 Reduces inrush current
  - Designed for Best-in-Class EMI Performance**  
 Ringing resistant switching node at 4ns rise time  
 Spread spectrum switching frequency (FSS)
- All AP64xx0/1/2 variants with 1A, 2A, 3.5A and 5A output currents are in same SO-8 pinout

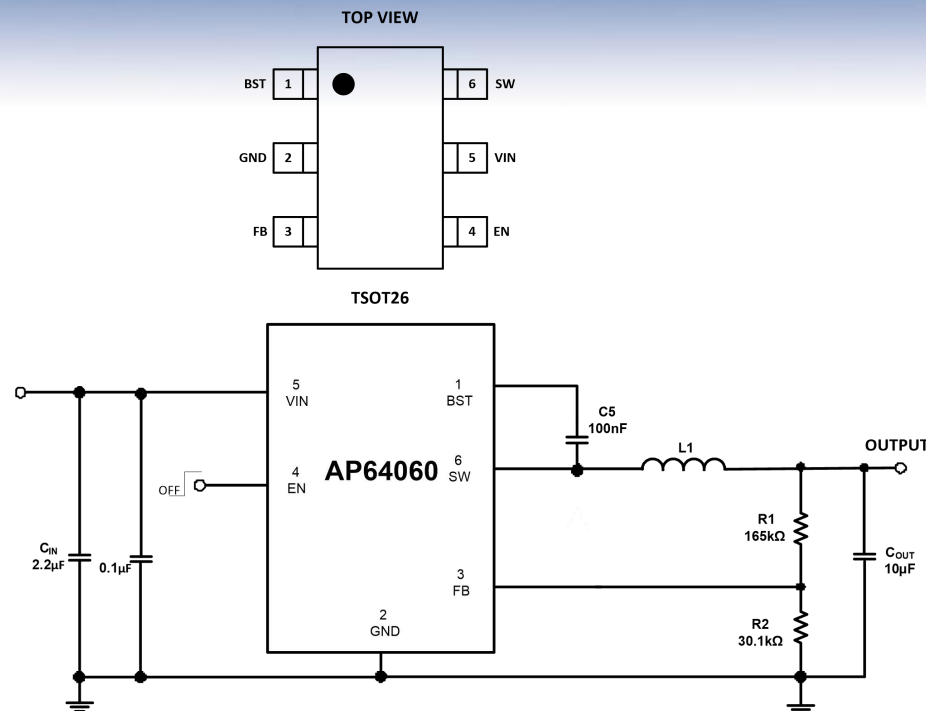


| Part Number | $I_{OUT}$ (A) | $f_{SW}$ (kHz) | Key Features (Pin #) |           |           |         |
|-------------|---------------|----------------|----------------------|-----------|-----------|---------|
|             |               |                | Adj. $f_{SW}$        | Ext. Sync | Ext. Comp | Adj. SS |
| AP64100Q    | 1.0           | 100 - 2200     | Y (4)                | Y (4)     | Y (6)     | -       |
| AP64102Q    |               | 100 - 2200     | Y (4)                | Y (4)     | -         | Y (6)   |
| AP64200Q    | 2.0           | 100 - 2200     | Y (4)                | Y (4)     | Y (6)     | -       |
| AP64202Q    |               | 100 - 2200     | Y (4)                | Y (4)     | -         | Y (6)   |
| AP64350Q    | 3.5           | 100 - 2200     | Y (4)                | Y (4)     | Y (6)     | -       |
| AP64351Q    |               | 570            | -                    | -         | Y (6)     | Y (4)   |
| AP64352Q    |               | 100 - 2200     | Y (4)                | Y (4)     | -         | Y (6)   |
| AP64500Q    | 5.0           | 100 - 2200     | Y (4)                | Y (4)     | Y (6)     | -       |
| AP64501Q    |               | 570            | -                    | -         | Y (6)     | Y (4)   |
| AP64502Q    |               | 100 - 2200     | Y (4)                | Y (4)     | -         | Y (6)   |



## The DIODES ADVANTAGE

- **V<sub>IN</sub> 4.5V to 40V**
  - ✓ Works across the full supply rails of 12-V Automotive applications
- **Low Quiescent Current (I<sub>Q</sub>) and Shutdown Current**
  - ✓ 90μA I<sub>Q</sub>
  - ✓ 1μA shutdown current
- **2MHz Switching Frequency**
- **Less than 0.1% Output Ripple at 12V**
- **Designed for Low-Cost External Components Solution**
- **Designed for Best-in-Class EMI Performance**
  - ✓ Ringing resistant switching node at 4ns rise time
  - ✓ Frequency spread spectrum



| Device   | Max I <sub>OUT</sub> | R <sub>DS(ON)-HS</sub> | R <sub>DS(ON)-LS</sub> | I <sub>Q</sub> | Max Operating T <sub>J</sub> | T <sub>A</sub> Range | Package |
|----------|----------------------|------------------------|------------------------|----------------|------------------------------|----------------------|---------|
| AP64060Q | 0.6A                 | 600mΩ                  | 300mΩ                  | 90μA           | 150°C                        | -40 to 125°C         | TSOT26  |

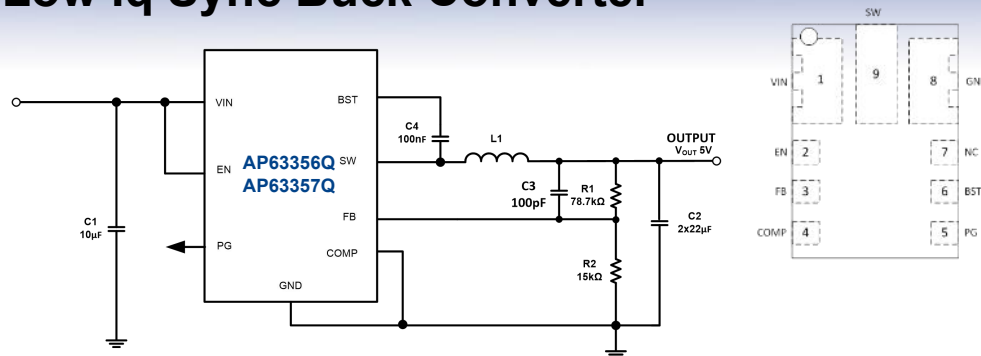
# Automotive Compliant DC-DC AP6335xQ

## 3.8 – 32Vin, 3.5A, Best-in-class EMI, Low Iq Sync Buck Converter

### The DIODES ADVANTAGE

- **V<sub>IN</sub> 3.8V to 32V. Withstand 40V 400ms Input Surge**  
Works across the full Automotive voltage range
- **22μA low quiescent current & 1μA I<sub>SD</sub>**  
Maximizes light load efficiency
- **Designed for Low EMI**  
SW ringing resistant @ 4ns rise time  
Frequency Spread Spectrum, FSS
- **450kHz switching frequency (AP63356Q/7Q)**  
Excludes MW frequency band
- **PFM and PWM Options**  
PWM only (AP63356Q) has fixed frequency  
PFM mode (AP63357Q) → Light-Load High efficiency
- **AP63356Q/7Q have PG & same pinout in QFN2030-13**

AP63200Q (2A) & AP63300Q (3A) without Power  
Good same pinout in TSOT26  
→ undergoing AEC-Q100 qualification



### Design for EMI Performance

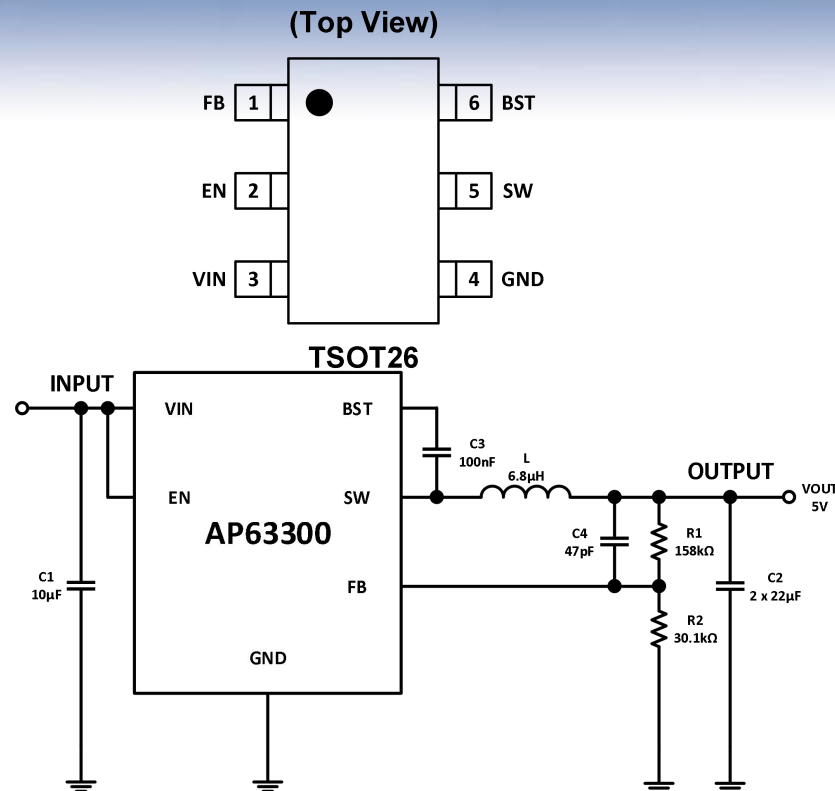
- SW ringing resistant /CCM @ 4ns rise time



| Part Number | Input Voltage |                      | Output Current | f <sub>sw</sub> | HTL | FB  | I <sub>Q</sub> | Packages       |
|-------------|---------------|----------------------|----------------|-----------------|-----|-----|----------------|----------------|
|             | Min V         | Max V                |                |                 |     |     |                |                |
| AP63356Q    | 3.8           | 32<br>(40 transient) | 3.5            | 450             | N   | 0.6 | 0.022          | QFN2030<br>-13 |
| AP63357Q    |               |                      |                |                 | Y   |     | 0.0258         |                |

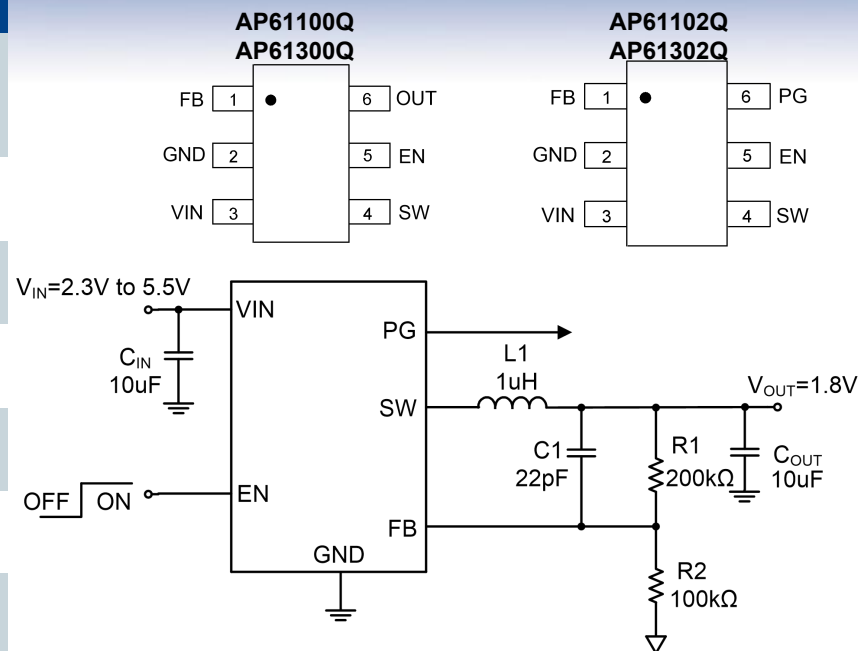
## The DIODES ADVANTAGE

- **$V_{IN}$  3.8V to 32V. Withstand 40V 400ms Input Surge**  
Works across the full voltage range of Automotive Applications
- **Wide Output Voltage range: 0.8V to near 100% of  $V_{IN}$  (LDO Mode)**  
Duty cycle extends to 100% for few switching period which acts like an LDO
- **Designed for Low EMI**  
SW ringing resistant @4ns rise time  
Frequency Spread Spectrum, FSS (AP63200Q/3Q/5Q, AP63300Q)
- **Ease of Layout Design**  
Minimum number of external components  
Pinout supports single layer PCB
- **PFM and PWM Options**  
PWM only (AP63x01Q) has fixed frequency  
PFM mode (AP63x00Q/3Q/5Q) delivers Light-Load High efficiency
- **2A and 3A Pin-to-Pin Compatible**



## The DIODES ADVANTAGE

- 2.3V to 5.5V operating voltage range**  
Covers both 5V and 3.3V rail conversion to core in infotainment, ADAS and Telematics applications
- Low (15 $\mu$ A) Quiescent Current ( $I_Q$ )**  
Maximizes light load efficiency
- PWM Programmable Mode Control thro' Enable**  
Enable-pin controls PWM/PFM modes
- PG with Internal 5M $\Omega$  Pull-up (AP61102Q/302Q)**  
Reduce BOM counts
- 1k $\Omega$  Soft Output Discharge**  
Ensures no residue charge on output
- High Operating Frequency of 2.2MHz**  
Reduced external LC size & outside MW band
- SOT563 Pinout Compatibility between 1A and 3A**  
Simple PCB layout with design flexibility



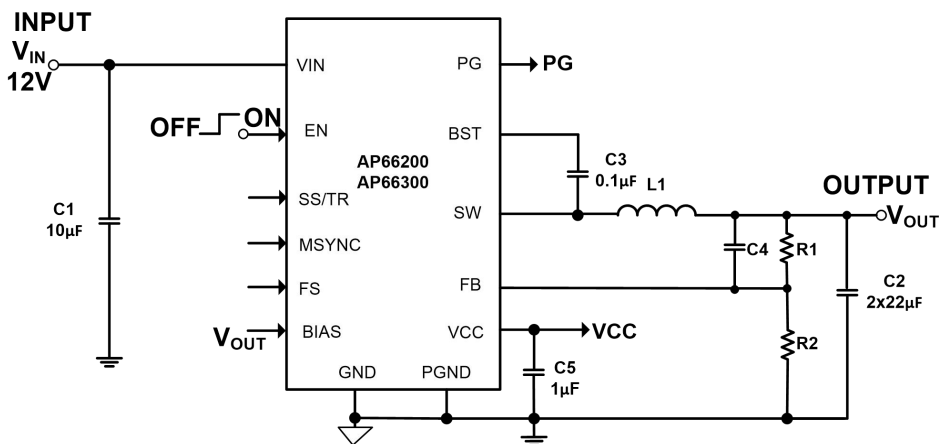
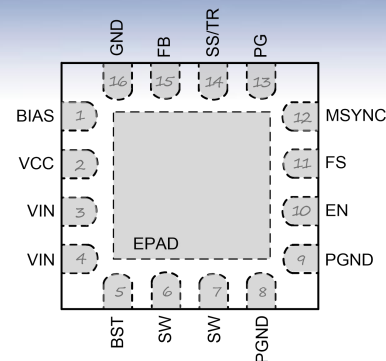
| Part Number     | Input Voltage |     | Output Current | $f_{SW}$ | Efficiency | $R_{DS(ON)}$ |          | FB Voltage | Pin 6 Function | $I_Q$   | $I_{SD}$ | Package |
|-----------------|---------------|-----|----------------|----------|------------|--------------|----------|------------|----------------|---------|----------|---------|
|                 | Min           | Max |                |          |            | HS           | LS       |            |                |         |          |         |
|                 | V             | V   |                |          |            | M $\Omega$   | $\Omega$ |            |                | $\mu$ A | $\mu$ A  |         |
| AP61100Q / 102Q | 2.3           | 5.5 | 1              | 2200     | 95         | 110          | 80       | 0.6        | OUT / PG       | 15      | 0.1      | SOT563  |
| AP61300Q / 302Q | 2.3           | 5.5 | 1              | 2200     | 95         | 70           | 50       | 0.6        | OUT / PG       | 19      | 0.1      | SOT563  |

# AP66200/AP66300 – 2A/3A 60V Buck Converters

ES Now  
Production 2Q22

## The DIODES ADVANTAGE

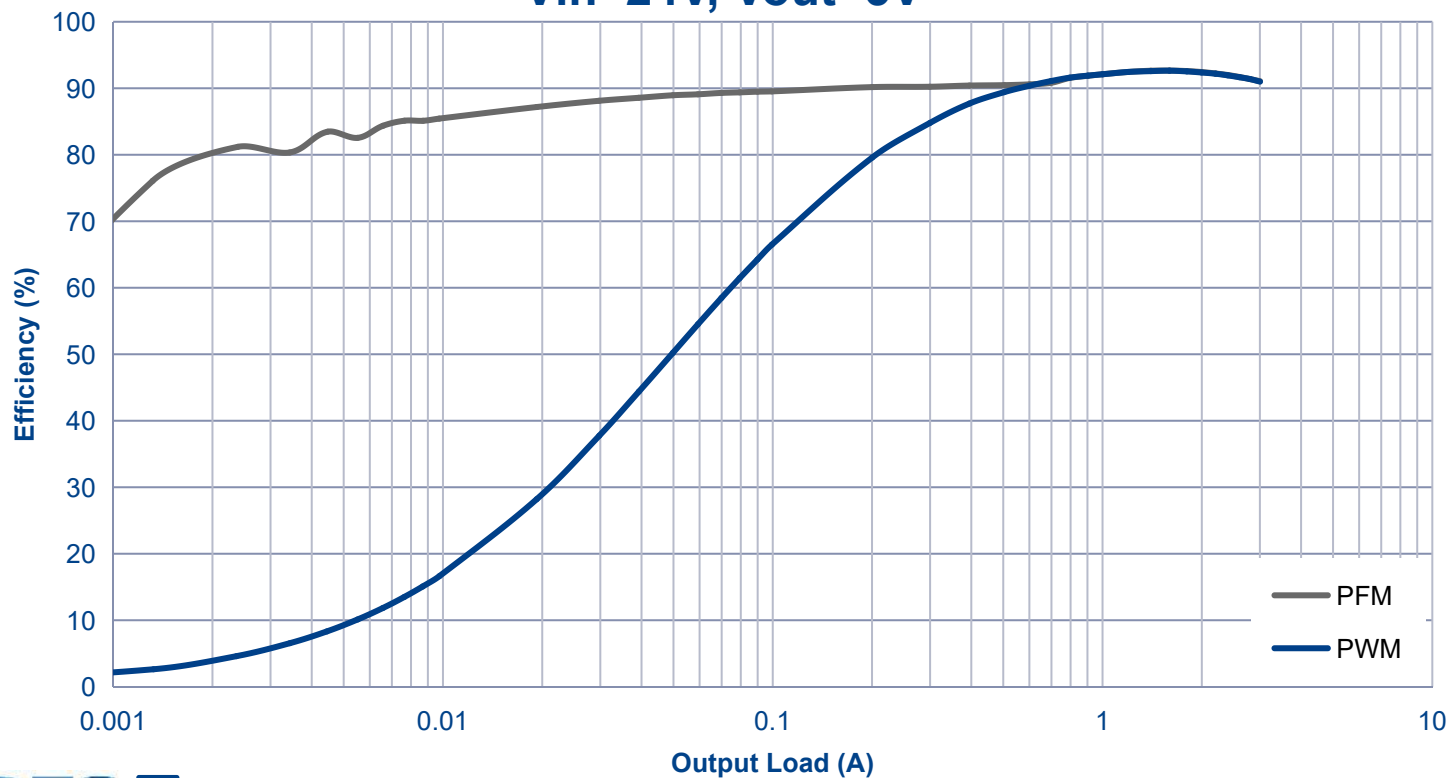
- **$V_{IN}$  3.8V to 60V**
  - ✓ Works across the full supply rails of commercial, industrial, and automotive applications
  - ✓ AEC-Q100 Qualified Grade 1 Option
- **Programmable  $F_{SW}$  with clock synchronization**
  - ✓ Low frequency from 300kHz – high-efficiency solution
  - ✓ High frequency to 2.5MHz – small-form factor solution
- **Wide Output Voltage Range: 0.8V to near 100% of  $V_{IN}$  (LDO Mode)**
  - ✓ Duty cycle can extend to 100% for several switching cycles, acts like an LDO
- **Low Quiescent Current ( $I_Q$ ) and Shutdown Current**
  - ✓ 22 $\mu$ A  $I_Q$
  - ✓ 1 $\mu$ A shutdown current
- **Programmable Soft-Start Time and Tracking**
  - ✓ Reduces inrush current
  - ✓ Select various power sequencing
- **Designed for High Efficiency Performance**
  - ✓ Enhanced efficiency w/ bias: up to 94%



# Efficiency

SWITCHES: PFM Mode, FS to VCC, Bias to VOUT, EN to VIN, External SS

**AP66300Q**  
**Vin=24V, Vout=5V**

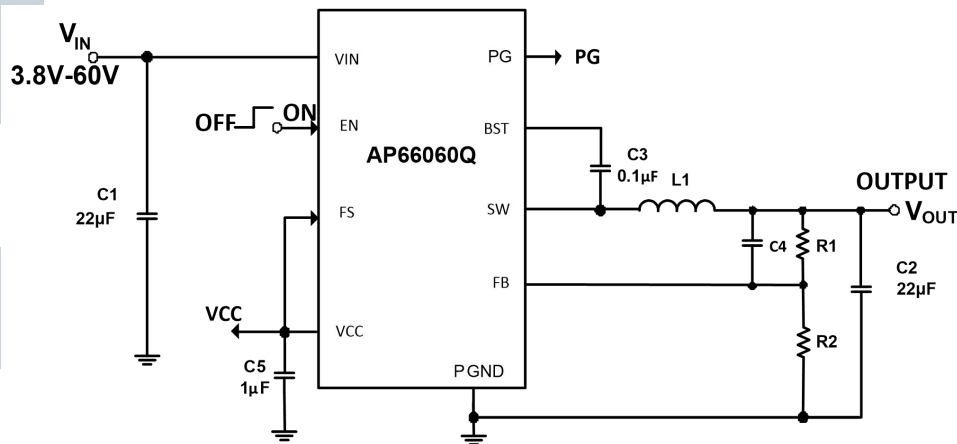
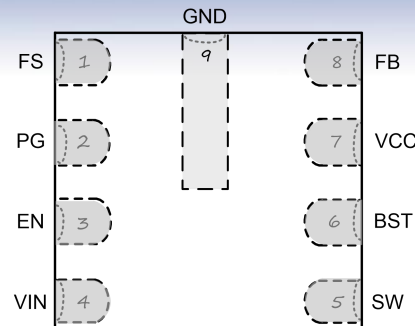




# AP66030Q & AP66060Q – 300mA/600mA 60V Buck Converters

## The DIODES™ ADVANTAGE

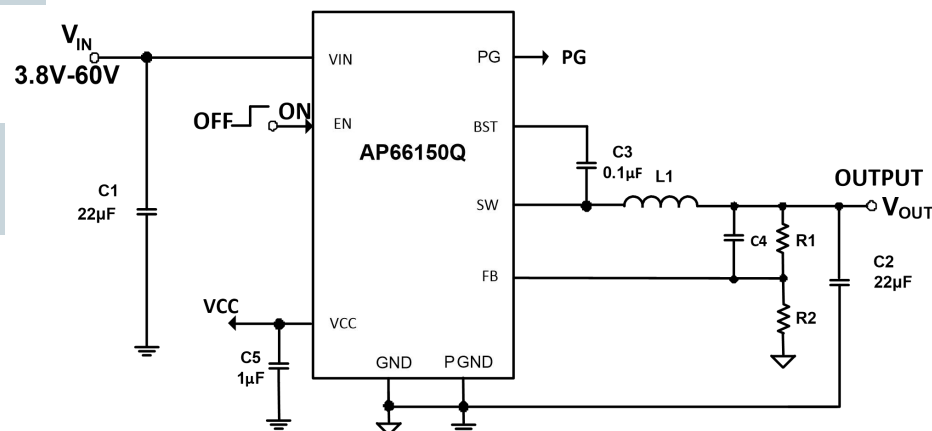
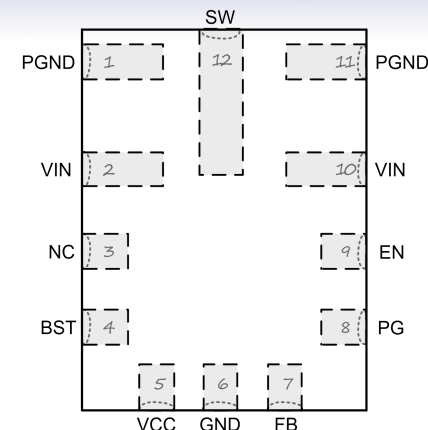
- **V<sub>IN</sub> 3.8V to 60V**
  - ✓ Works across the full supply rails of commercial, industrial, and automotive applications
  - ✓ AEC-Q100 Qualified Grade 1 Option
- **Programmable F<sub>sw</sub>**
  - ✓ Low frequency from 200kHz – high-efficiency solution
  - ✓ High frequency to 2.5MHz – small-form factor solution
  - ✓ Default to 1MHz or 2.2MHz
- **Wide Output Voltage Range: 0.8V to near 100% of V<sub>IN</sub> (LDO Mode)**
  - ✓ Duty cycle can extend to 100% for several switching cycles, acts like an LDO
- **Low Quiescent Current (I<sub>Q</sub>) and Shutdown Current**
  - ✓ 20μA I<sub>Q</sub>
  - ✓ 1μA shutdown current
- **MODE Options**
  - ✓ PFM/PWM – High light load efficiency
  - ✓ PWM only – Low output ripple
- **PG with internal pull-up**



# AP66100Q/1Q/150Q/1Q – 1A/1.5A 60V Buck Converters

## The DIODES™ ADVANTAGE

- **V<sub>IN</sub> 3.8V to 60V**
  - ✓ Works across the full supply rails of commercial, industrial, and automotive applications
  - ✓ AEC-Q100 Qualified Grade 1 Option
- **Various F<sub>SW</sub> Options**
  - ✓ Low frequency 400kHz – high-efficiency solution
  - ✓ Mid frequency 1MHz – balanced between efficiency and form
  - ✓ High frequency 2.1MHz – small-form factor solution
- **Wide Output Voltage Range: 0.8V to near 100% of V<sub>IN</sub> (LDO Mode)**
  - ✓ Duty cycle can extend to 100% for several switching cycles, acts like an LDO
- **Low Quiescent Current (I<sub>Q</sub>) and Shutdown Current**
  - ✓ 20μA I<sub>Q</sub>
  - ✓ 1μA shutdown current
- **MODE Options**
  - ✓ PFM/PWM – High light load efficiency
  - ✓ PWM only – Low output ripple
- **PG with internal pull-up**



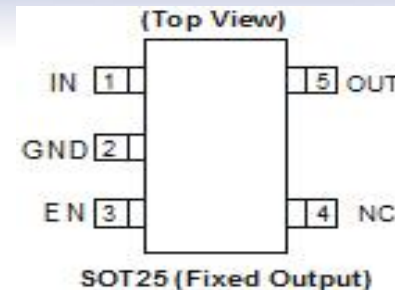
# Automotive “Q” Linear Regulators and LDOs

| Part Number | Type   | I <sub>out</sub><br>A | V <sub>in</sub> |                        | Output Voltage<br>V        | V <sub>Dropout</sub><br>Max<br>V | I <sub>q</sub><br>μA | Enable | Power<br>Good | Packages                          |
|-------------|--------|-----------------------|-----------------|------------------------|----------------------------|----------------------------------|----------------------|--------|---------------|-----------------------------------|
|             |        |                       | Max             | Min                    |                            |                                  |                      |        |               |                                   |
|             |        |                       | V               | V                      |                            |                                  |                      |        |               |                                   |
| AP7315Q     | LDO    | 0.15                  | 5.25            | 1.7                    | Fixed 1.1 ~ 3.3            | 0.29                             | 35                   | Yes    | No            | SOT25                             |
| AP7343Q     | LDO    | 0.3                   | 5.25            | 1.7                    | Fixed 0.9 ~ 3.3            | 0.31                             | 35                   | Yes    | No            | SOT25                             |
| AP7347DQ    | LDO    | 0.5                   | 5.5             | 1.7                    | Fixed 1.0 ~ 5.0            | 0.32                             | 60                   | Yes    | No            | SOT25,<br>W-DFN2020-6 (SWP)       |
| AP7375Q     | LDO    | 0.3                   | 45              | 3                      | 1.8, 3.0, 3.3, 5.0         | 0.65                             | 2.1                  | Yes    | No            | SOT89, TO252-4, SO-8EP            |
| AP7387Q     | LDO    | 0.15                  | 60              | 5                      | 3,3.3,3.6,5                | 1.1                              | 2                    | No     | No            | SOT23, SOT25, SOT89               |
| AP7583AQ    | LDO    | 0.3                   | 42              | V <sub>OUT</sub> + 1   | 3.3, 5.0, ADJ (1.2)        | 0.5                              | 10                   | Yes    | Yes           | MSOP-8, TO252,<br>W-DFN2020 (SWP) |
| AP7583Q     | LDO    |                       |                 |                        |                            |                                  | 2.5                  | Yes    | No            |                                   |
| ZLDO1117Q   | LDO    | 1                     | 20              | V <sub>OUT</sub> + 1.5 | Fixed 1.2 ~ 5 + ADJ (1.25) | 1.35                             | 4000                 | No     | No            | SOT223, TO252                     |
| ZMR250Q     | Linear | 0.05                  | 22.5            | 4.5                    | 2.5                        | 1.4                              | 40                   | No     | No            | SOT23                             |
| ZMR330Q     | Linear | 0.05                  | 24              | 5.3                    | 3.3                        | 1.44                             | 170                  | No     | No            | SOT23                             |
| ZMR500Q     | Linear | 0.05                  | 25              | 7                      | 5                          | 1.2                              | 70                   | No     | No            | SOT23                             |
| ZXTR2005ZQ  | Linear | 0.03                  | 100             | 10                     | 5                          | 1.5                              | 270                  | No     | No            | SOT89                             |
| ZXTR2105FFQ | Linear | 0.015                 | 7               | 60                     | 5                          | -                                | 450                  | No     | No            | SOT23F                            |
| ZXTR2105FQ  | Linear | 0.03                  | 7               | 60                     | 5                          | -                                | 450                  | No     | No            | SOT23                             |
| ZXTR2108FQ  | Linear | 0.015                 | 10              | 60                     | 8                          | -                                | 500                  | No     | No            | SOT23                             |
| ZXTR2112FQ  | Linear | 0.015                 | 15              | 60                     | 12                         | -                                | 500                  | No     | No            | SOT23                             |

# Automotive-Compliant 5.5V LDOs

## High PSRR, Low Noise 500/300/150mA LDOs with/out Discharge

- **Automotive compliant (Q)** - AEC-Qualified, in IATF 16949 manufacturing sites supporting PPAP
- **Wide Input Range, 1.7V to 5.25V**  
Covers 5V, 3.3V rails including button cells
- **High PSRR (75dB @1kHz) & Low Noise (60uVrms @ 10Hz to 100kHz)**  
Suitable for noise sensitive applications, such as audio, video and RF.
- **Low Quiescent Current at 35uA**  
Supports standby requirements within automotive environment; enable pin reduces current to <1μA.
- **Large number of fixed Output Voltages:**  
AP7343Q (0.9 to 3.6V), AP7315Q (1.1 to 3.3V)
- **Available in industry standard footprint SOT25 package**



| Part Number | Input Voltage |      | Output Current | Max Dropout Voltage | I <sub>Q</sub> | Fixed Output Voltages | Temperature Range |          | Package                |
|-------------|---------------|------|----------------|---------------------|----------------|-----------------------|-------------------|----------|------------------------|
|             | Min           | Max  |                |                     |                |                       | Ambient           | Junction |                        |
|             | V             | V    |                |                     | μA             | V                     | °C                | °C       |                        |
| AP7315Q     | 1.7           | 5.25 | 150            | 0.5                 | 35             | 1.1 to 3.3            | -40~125           | -40~125  | SOT25                  |
| AP7343Q     |               |      | 300            | 0.51                | 35             | 0.9 to 3.3            |                   |          |                        |
| AP7347DQ    |               |      | 500            | 0.32                | 60             | 1.0 to 4.3            |                   |          | SOT25, DFN2020-6 (SWP) |

# AP7583Q/AQ – Wide Vin 300mA LDO

Production  
2/3Q22

| P/N      | Max Vin (V) | Vout (V) | Iout (mA) | VDROP @ Full Load (mV) | I <sub>Q</sub> (uA) | PSRR @1kHz (dB) | Enable | Power Good | AEC-Q100 | Package                       |
|----------|-------------|----------|-----------|------------------------|---------------------|-----------------|--------|------------|----------|-------------------------------|
| AP7583Q  | 42          | 1.8~5    | 300       | 650                    | 2.7                 | 70              | Yes    | No         | Yes      | MSOP8, W-DFN2020 (SWP), TO252 |
| AP7583AQ |             |          |           |                        |                     |                 | Yes    | Yes        | Yes      |                               |

## DIODES™ Advantage

### Automotive-compliant

AEC-Q100 Grade 1 in IATF 16949 facilities supporting PPAP

### Power Good feature (AP7583AQ)

### High 75dB PSRR & Low Noise

Targeted for noise sensitive apps EG Infotainment & RF rails

### High input voltage up to 42V (absolute 45V)

Withstands 40V load-dump conditions

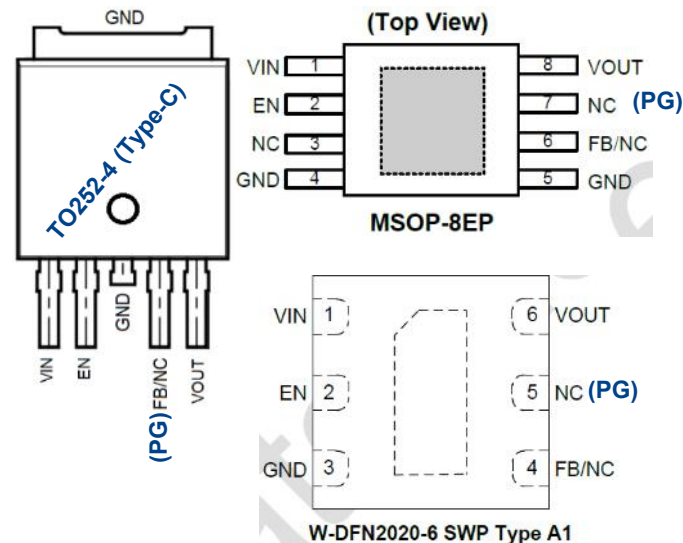
### Low 2.7uA I<sub>Q</sub>

Supports “permanently connected to battery” applications

### Industry standard pin out in

MSOP-8EP, W-DFN2020-6 (with side wall plating) and TO252-4 package

## AP7583Q (AQ) packages & Pinout

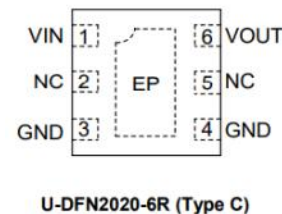
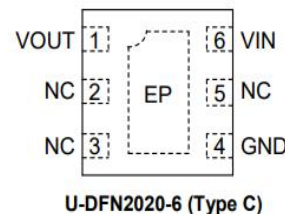
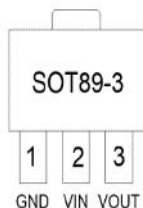
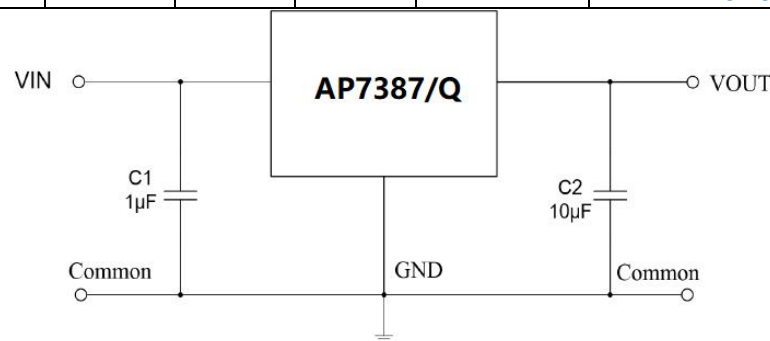


# AP7387Q – Wide Vin 60V 150mA LDO

| P/N     | Max Vin (V) | Vout (V)        | Iout (mA) | VDROP (mV) @ Full Load | Iq (uA) | PSRR @1kHz (dB) | Enable | Power Good | AEC-Q100 Grade | Package            |
|---------|-------------|-----------------|-----------|------------------------|---------|-----------------|--------|------------|----------------|--------------------|
| AP7387Q | 60          | 3.0/3.3/3.6/5.0 | 150       | 700 @100mA             | 2       | 70              | No     | No         | 1              | SOT89, W-DFN2020-6 |

## Key Features

- High PSRR 70dB@1kHz,
- Low Iq 2uA
- High input voltage up to 60V (absolute 80V)
- AEC-Q100 grade 1 qualified (AP7387Q)





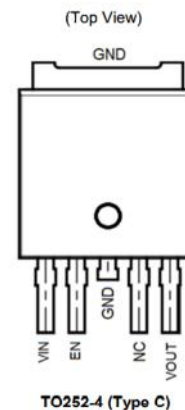
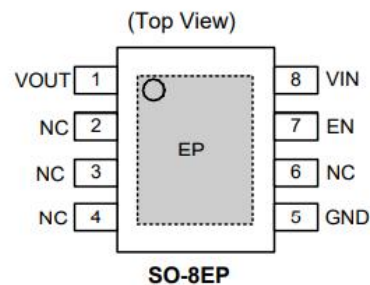
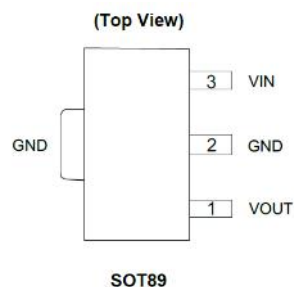
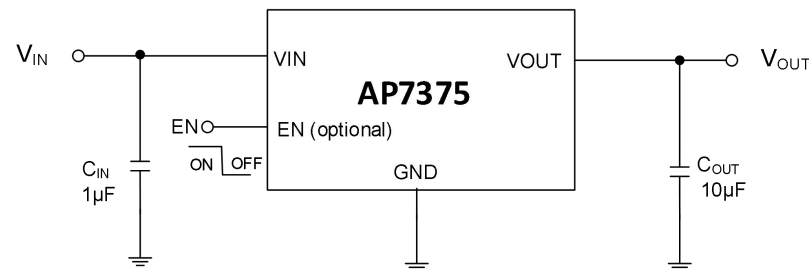
# AP7375Q – Wide Vin 45V 300mA LDO

Q part  
SO-8EP Sample 22Q1  
SO-8EP Production 22Q2

| P/N     | Max Vin (V) | Vout (V)           | Iout (mA) | VDROP (mV) @ Load | Iq (uA) | PSRR @1kHz (dB) | Enable | Power Good | AEC-Q100 Grade | Package                |
|---------|-------------|--------------------|-----------|-------------------|---------|-----------------|--------|------------|----------------|------------------------|
| AP7375Q | 45          | 1.8, 3.0, 3.3, 5.0 | 300       | 350 @100mA        | 2.1     | 85              | No/Yes | No         | 1              | SOT89, TO252-4, SO-8EP |

## Key Features

- High PSRR 85dB@1kHz,
- Low Iq 2.1uA
- High input voltage up to 45V (absolute 55V)
- Enable function SO-8EP and TO252



# Vision of USB Ports inside Vehicle

## Demand for USB charging within cars is growing and evolving:

- |              |                   |                              |                          |
|--------------|-------------------|------------------------------|--------------------------|
| 1. Phones    | 5V/9V/12V/15V/20V | → at increasing power levels | → Type-C with/out USB-PD |
| 2. PADs      | 12V/15V           | → at increasing power levels | → Type-C USB-PD          |
| 3. Notebooks | 15V/20V           |                              | → Type-C USB PD          |

## Charging Style move to

- USB Type-C with PD (vs. Type-A only or Type-C only)
- Combination of Type-C and Type-A Ports to support various Popular Fast Charging (PD3.0/QC4+/5)
- Load Sharing among Type-C/Type-A ports for greater flexibility
- Charging profile de-rating due to temperature and battery status → QC5



Rear Seat USB



Front Armrest USB



Head Unit USB



Below Head Unit USB

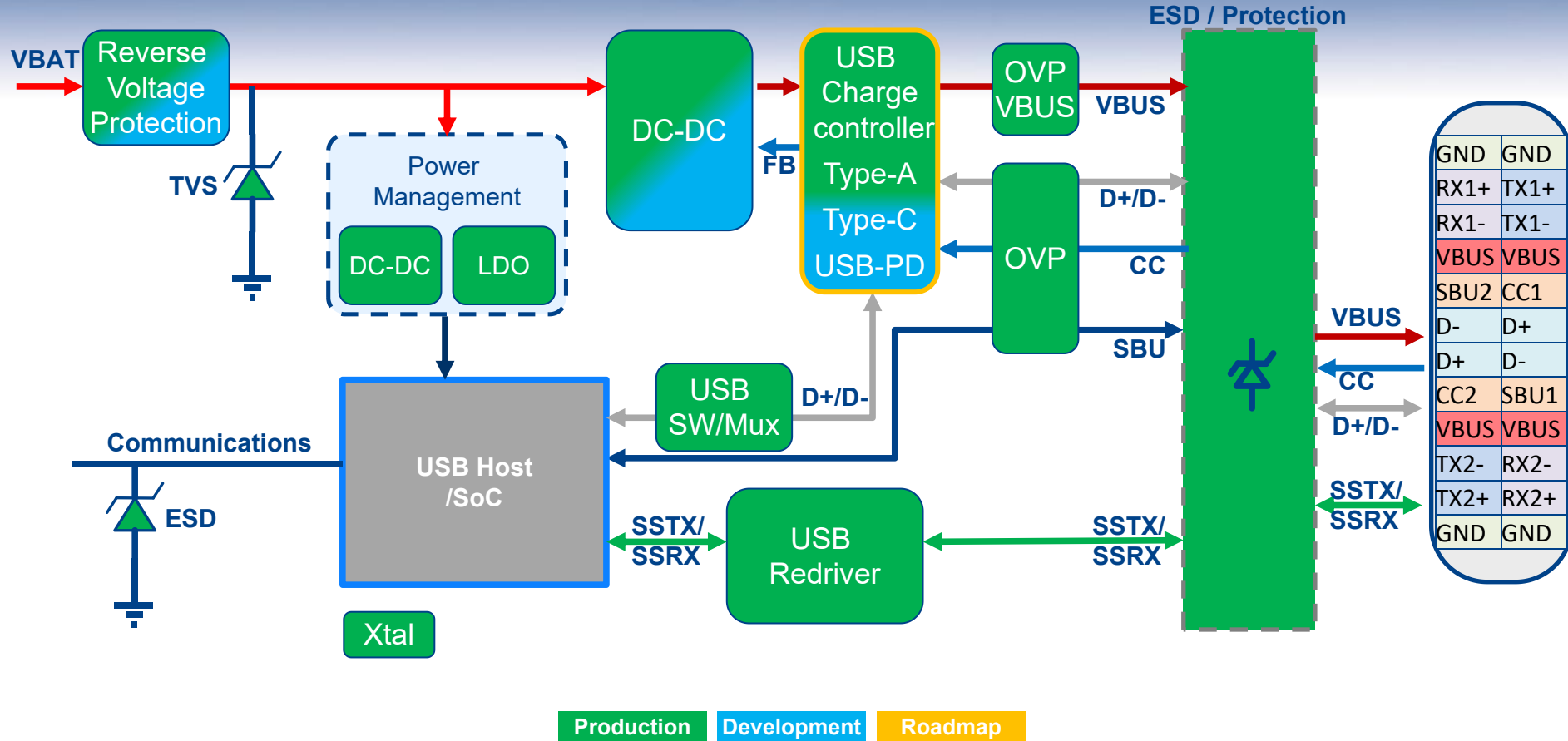


Glove Compartment USB

|      |      |
|------|------|
| GND  | GND  |
| RX1+ | TX1+ |
| RX1- | TX1- |
| Vbus | Vbus |
| SBU2 | CC1  |
| D-   | D+   |
| D+   | D-   |
| CC2  | SBU1 |
| Vbus | Vbus |
| TX2- | RX2- |
| TX2+ | RX2+ |
| GND  | GND  |

| Function / Feature              | Function   | USB - C | USB-PD<br>(> 5V) | USB - A      |
|---------------------------------|------------|---------|------------------|--------------|
| Power supply Buck               | Power      | √       |                  | √            |
| Power supply Buck-boost         | Power      |         | √                |              |
| Power switch                    | Power      | √       | √                | √            |
| Power switch                    | Protection | √       | √                | √            |
| CC nego, CC Detect/Pol, VCONN   | Nego       | √       | √                |              |
| CC-PD nego                      | Nego       |         | √                |              |
| CC protection                   | Protection | √       |                  |              |
| SBU protection                  | Protection | √       |                  |              |
| RX/TX SS protection             | Protection | √       |                  | (USB 3 only) |
| RX/TX SS Redriver               | Signal     | √       |                  | (USB 3 only) |
| Alternate mode DP Redriver/ Mux | Signal     | √       |                  |              |
|                                 |            |         |                  |              |
| D+/D- BC1.2/apple/samsung Nego  | Nego       | √       |                  | √            |
| D+/D- Protection                | Protection | √       |                  | √            |
| D+/D- Data / Mux                | Signal     | √       |                  | √            |

# Diodes' Automotive USB Solutions



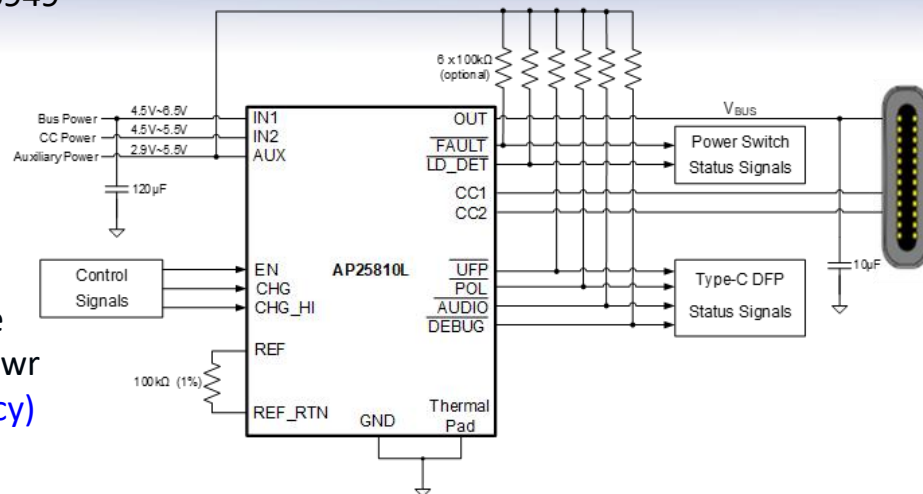
# Automotive USB-Charging Product Roadmap

|                              | Current                                                                                                                                                                                                                                                       | 2021             | 2022                                                              |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------|
| Type-C & PD3.0 PPS (Premium) | USB-PD 2-chip solution (12V/24V Battery Systems) <ul style="list-style-type: none"> <li>➤ 1-Ch Buck-Boost Controller with PPS Support, I2C interface APY36576Q &amp;</li> <li>➤ 2-Ch USB-PD/QC protocol decoder with I2C interface AP43776Q ES Now</li> </ul> | RTM 3Q22<br>2Q22 | USB-PD Single-channel Buck-Boost + PD 3.0 PPS Decoder AP43076Q    |
| Type-C (Low Cost)            | AP25810Q<br>3A Power Switch with DFP/CC Controller 2Q22                                                                                                                                                                                                       |                  | AP258xxQ: AP25810LQ w/ HV capability, cable drop comp & BC1.2 DCP |
| Type-A (Legacy)              | PI5USB2546AQ<br>73-mΩ Power Switch<br>BC1.2 USB detection<br>Supports 5V @ 2.4A                                                                                                                                                                               |                  |                                                                   |
|                              | Production                                                                                                                                                                                                                                                    | Development      | Roadmap                                                           |

# AP25810LQ - USB-C DFP/CC Controller with Power Switch

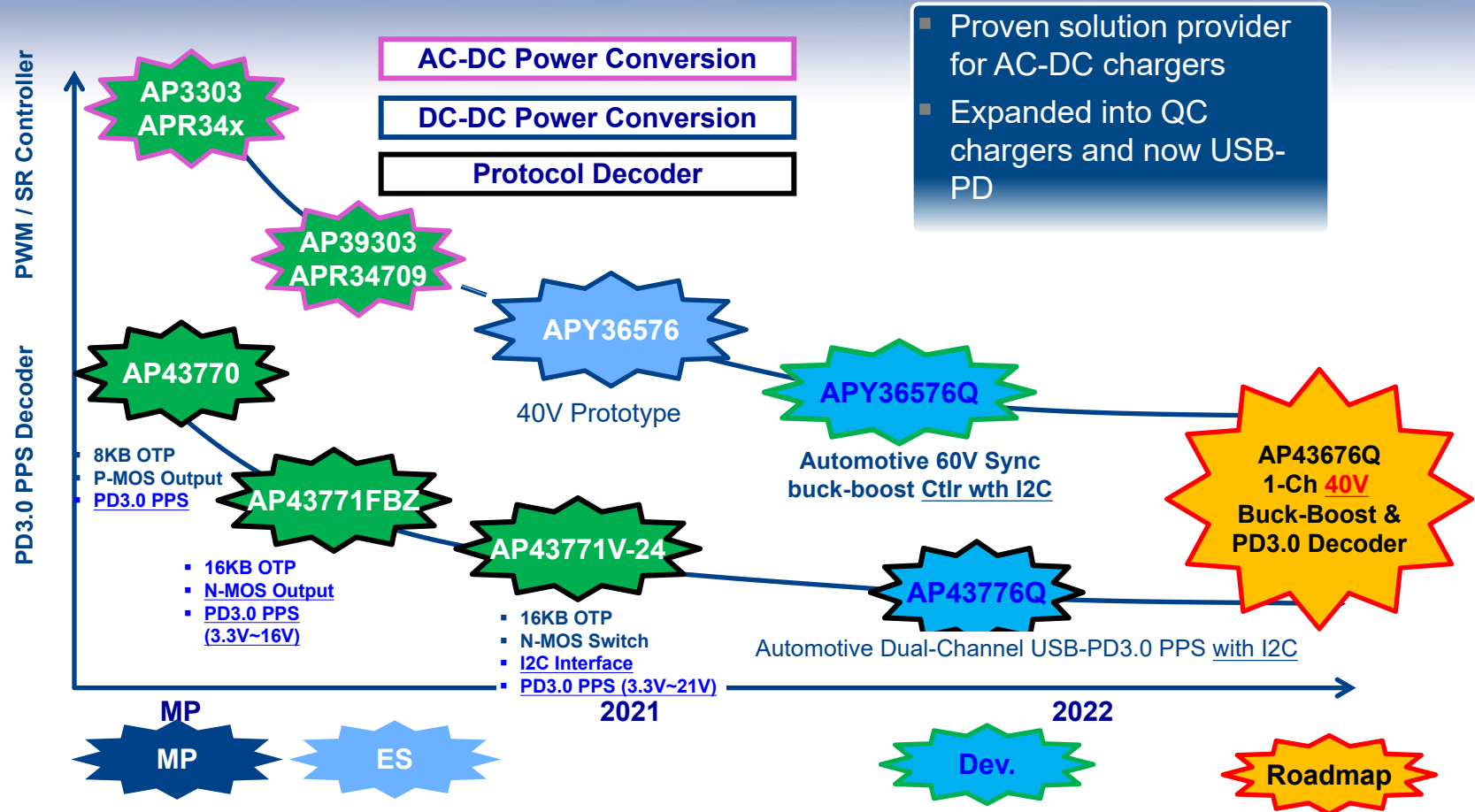
Production in 2Q 2022

- **Automotive compliant** (Q) - AEC-Qualified, in IATF16949 manufacturing sites supporting PPAP
- Power supply: 4.5V to 6.5V
- Integrated 35 mΩ (typ) High-side MOSFET
- **USB Type-C Rev 1.2 Downstream Facing Port (DFP) controller (without USB-PD)**
  - Connector Attach/Detach detection
  - **STD/1.5A/3A** capability advertisement on CC line
  - Dedicated Supply for Charging, Vconn & Device Pwr
- **Selectable 3.4A/1.67A current limit ( $\pm 7.5\%$  accuracy)**
- Load detection to enable port power management
- CC1/CC2/Vout withstand up to 6.5V
- ESD protection:
  - HBM >3.5kV, CDM >2kV
  - IEC61000-4-2 Air Discharge >15kV
  - IEC61000-4-2 Contact Discharge >8kV
- Package: QFN3040-20

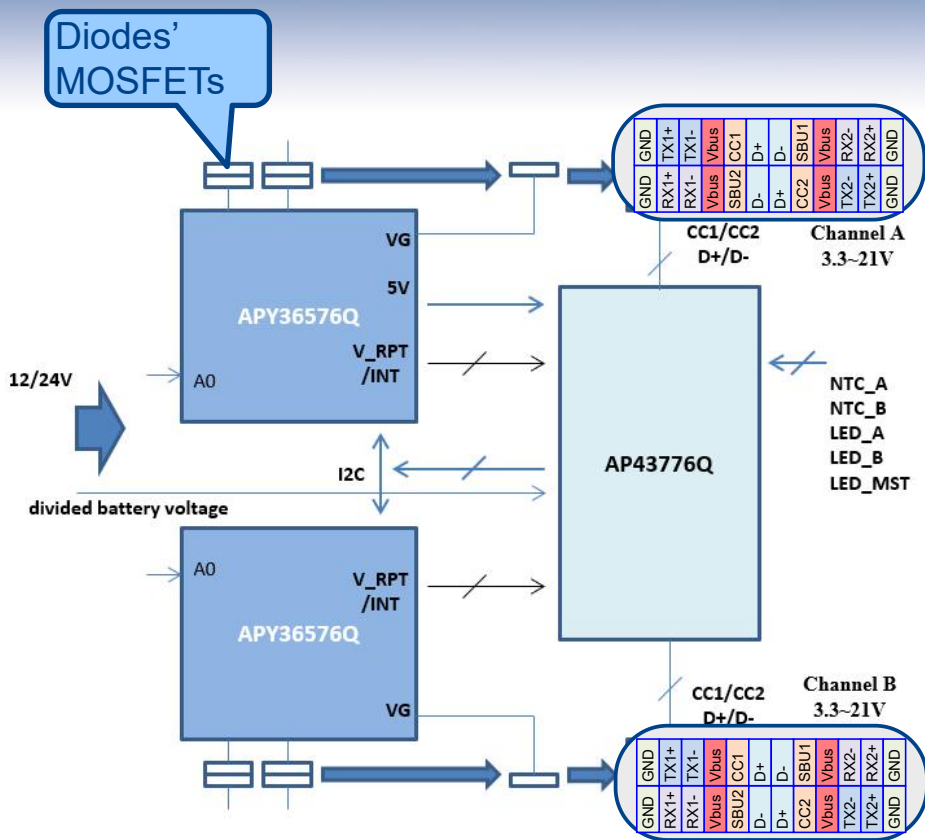




# Diodes' USB-PD evolution



# Dual-Port 2C Car Charger Module



## 2C System Configuration

- **APY36576Q 1-Ch 60V Buck-Boost Controller**
  - 60V HV BCD to support 12V/24V Battery Systems
- **AP43776Q 2-Ch PD3.0 PPS Decoder**
  - 2-Ch Quick Charging with power sharing
- **Protocol Supported**
  - PD3.0 PPS/QC4+/QC5
  - QC3.0
- **Communication Link**
  - Intra-Module: I2C between APY36576Q & AP43776Q
  - Inter-Module: UART/GPIO from module to module
- **Smart Load Sharing Scheme**
  - Only one Type-C Plugged in – 65W
  - Two Type-C Port plugged in - 45W + 18W Split
  - Or, any Pre-set Manufacturing Power Sharing Scheme
- **Charging Profile De-rating**
  - Temperature
  - Battery Status
  - Fault Status (FAULT Pin/GPIP, I2C Registers)
- **Charging LED Indication Lights**

# Type-C Automotive Connectivity Products

| Part Number  | Major Features Summary          | Max<br>T <sub>A</sub><br>°C | I/O<br>Tolerant | OVP | USB<br>2.0 | USB<br>3.1<br>Gen2 | DP<br>1.4 | Package      |
|--------------|---------------------------------|-----------------------------|-----------------|-----|------------|--------------------|-----------|--------------|
| PI3USB221EQ  | USB2 Mux                        | 125                         | 5.5V            | *   | *          |                    |           | U-QFN1520-10 |
| PI3USB4000DQ | USB2 Mux with High-V protect    | 125                         | 24V             | *   | *          |                    |           | U-QFN1520-10 |
| PI3USB4002Q  | USB2 Switch with High V protect | 125                         | 24V             | *   | *          |                    |           | U-QFN1520-10 |
| PI3DPX1207Q  | USB3.1G2 alt DP1.4 redriver     | 85                          | 6V              |     |            | *                  | *         | U-QFN9035-42 |

|      |      |
|------|------|
| GND  | GND  |
| RX1+ | TX1+ |
| RX1- | TX1- |
| VBUS | VBUS |
| SBU2 | CC1  |
| D-   | D+   |
| D+   | D-   |
| CC2  | SBU1 |
| VBUS | VBUS |
| TX2- | RX2- |
| TX2+ | RX2+ |
| GND  | GND  |

# USB-C Pins and Voltage ratings

53

|      |      |
|------|------|
| GND  | GND  |
| RX1+ | TX1+ |
| RX1- | TX1- |
| VBUS | VBUS |
| SBU2 | CC1  |
| D-   | D+   |
| D+   | D-   |
| CC2  | SBU1 |
| VBUS | VBUS |
| TX2- | RX2- |
| TX2+ | RX2+ |
| GND  | GND  |

|              | Function                 | Power Switch | Vbus     |      |      |     | D+/D-    |      |      |      | CC/SBU   |      |      |     | TX±/RX±  |      |      |     |
|--------------|--------------------------|--------------|----------|------|------|-----|----------|------|------|------|----------|------|------|-----|----------|------|------|-----|
|              |                          |              | Short to |      |      | ESD | Short to |      |      | ESD  | Short to |      |      | ESD | Short to |      |      | ESD |
|              |                          |              | GND      | Vbat | Vbus |     | GND      | Vbat | Vbus |      | GND      | Vbat | Vbus |     | GND      | Vbat | Vbus |     |
| DPS1133FIAQ  | Vbus Power switch        | Yes          | OCF      | 24V  | 24V  |     | -        | -    | -    | -    | -        | -    | -    | -   | -        | -    | -    | -   |
| AP25810LQ    | USB-C UFP ctrl           | Yes          | OCF      | No   | 5V   | 2kV | -        | -    | -    | -    | Yes      | No   | 5V   | 2kV | -        | -    | -    | -   |
| AP258xxQ     | USB-C UFP ctrl enhanced  | Yes          | OCF      | Yes  | 24V  | 2kV | Yes      | -    | Yes  | -    | Yes      | No   | 5V   | 2kV | -        | -    | -    | -   |
| PI5USB2546AQ | USB 2 CDP/DCP            | Yes          | OCF      | No   | 5V   | 2kV |          |      |      |      | -        | -    | -    | -   | -        | -    | -    | -   |
| AP43776Q     | USB PD ctrl              | Ext          | I_lim    | -    | -    | -   | Yes      | No   | 5V   | 2kV  | Yes      | 24V  | 24V  | 2kV | -        | -    | -    | -   |
| AP43076Q     | USB PD ctrl + buck/boost | Ext          | I_lim    | -    | -    | -   | Yes      | No   | 5V   | 2kV  | Yes      | 24V  | 24V  | 2kV | -        | -    | -    | -   |
| DPO2039Q     | CC/SBU OVP               | No           | -        | -    | -    | -   | Yes      | 24V  | 24V  | 8kV  | Yes      | 24V  | 24V  | 8kV | -        | -    | -    | -   |
| PI3USB4000DQ | USB2 Mux                 | No           | -        | -    | -    | -   | Yes      | 24V  | 24V  | 10kV | -        | -    | -    | -   | -        | -    | -    | -   |
| PI3USB4002AQ | USB2 Sw                  | No           | -        | -    | -    | -   | Yes      | 24V  | 24V  | 10kV | -        | -    | -    | -   | -        | -    | -    | -   |

These signals are ac-coupled and so any DC short will create a short-term transient

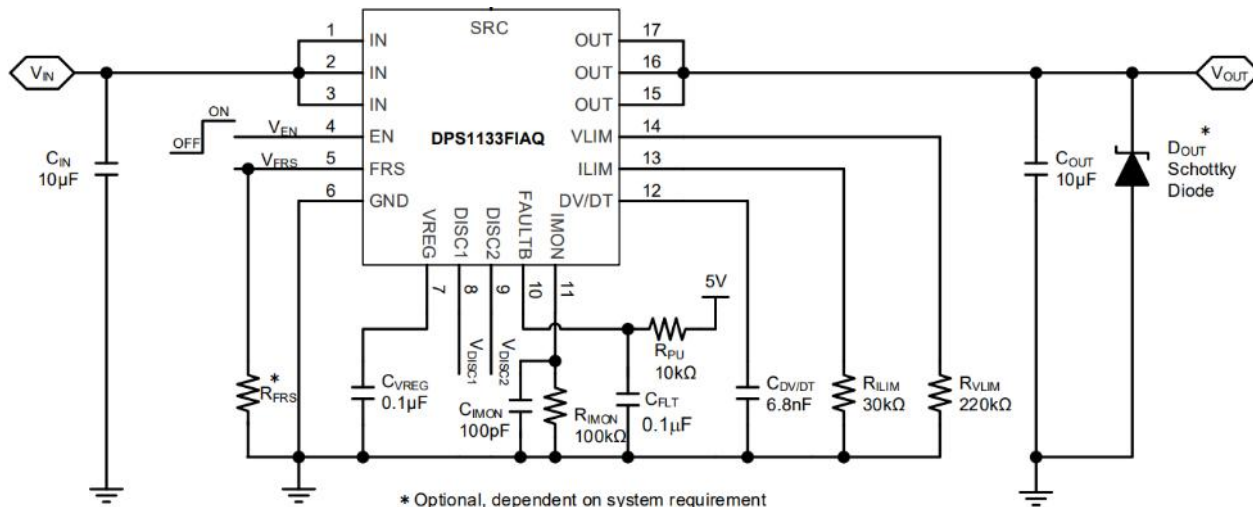
Production

Development

Roadmap

# DPS1133FIAQ – Protected VBUS Power Switch

- **24V/3A 1-CH POWER SWITCH WITH FAST ROLE SWAP**
  - 30mΩ  $R_{DS(ON)}$  of Embedded MOSFET
- **Integrated Adjustable Current & Voltage Limits**
- **Individual/simultaneous Discharge of Input and Output Ports**
- **Comprehensive Built-in Fault Detection and Recovery Mechanisms**
  - Input UVLO,
  - Reverse Voltage & Current Blocking
  - Thermal Shutdown
  - Overcurrent and Short-Circuit Protection
- **Adjustable soft-start (DV/DT Control)**
- **FAULTB Flag**
  - 7ms Blanking Time
- **IMON reports output current**

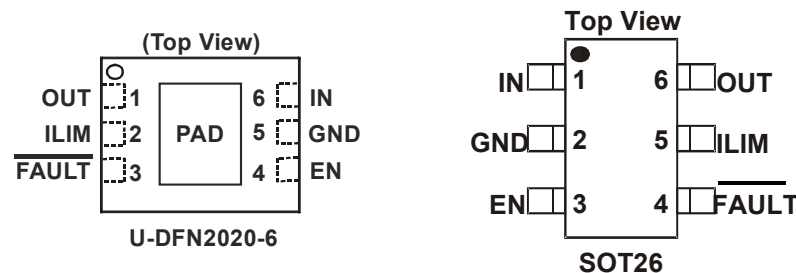


# AP22653Q 5V 2.1A USB Power Distribution Switch

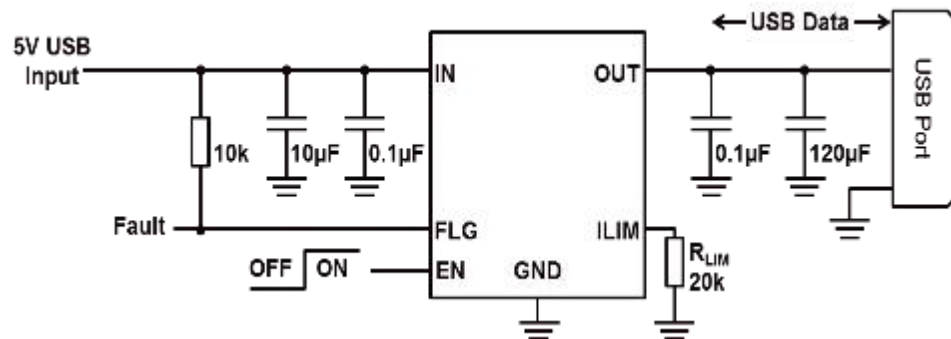
Provides fast and accurate adjustable overcurrent protection for improved robustness of 5V to 2.5V rails

## DIODES Advantage

- **Accurate ( $\pm 10\%$ ) & adjustable current limit from 150mA to 2.5A**  
Single device used across platforms, with just a resistor change
- **Low  $R_{DS(ON)}$  of 55m $\Omega$**   
Reduced voltage drop and power loss
- **Fault Report (FLG) with Blanking time**  
improves system robustness
- **Reverse current blocking/limiting, UVLO, overcurrent, overtemperature, and short-circuit protection with auto-recovery**  
Improves robustness of USB ports
- **AEC-Q100 grade 3 in qualification**  
Supports ambient temperature up to 85°C



## Typical Application Circuit

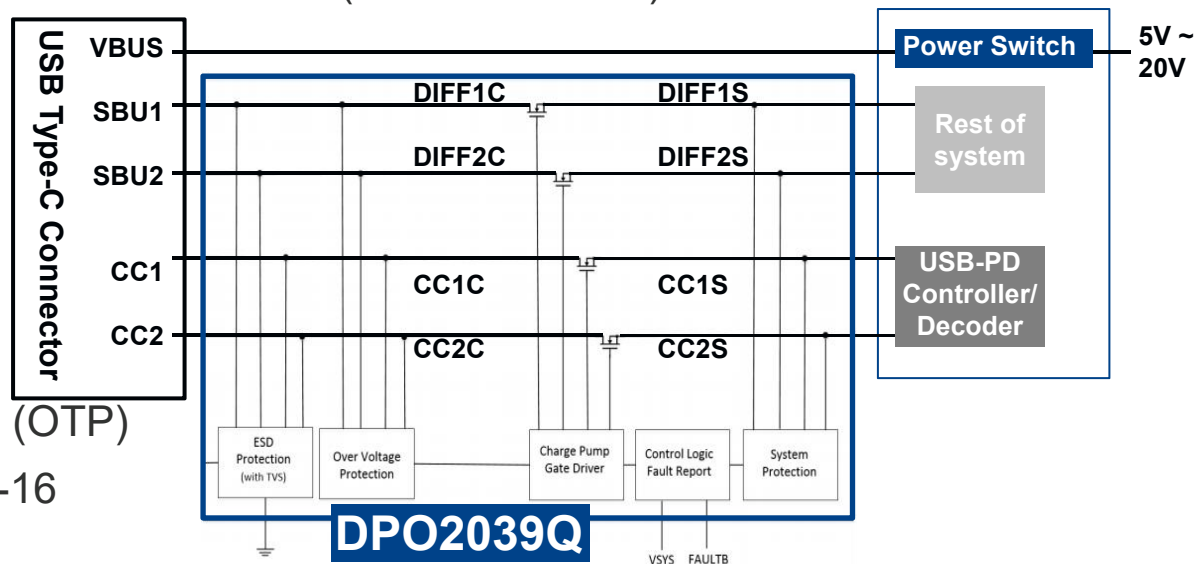




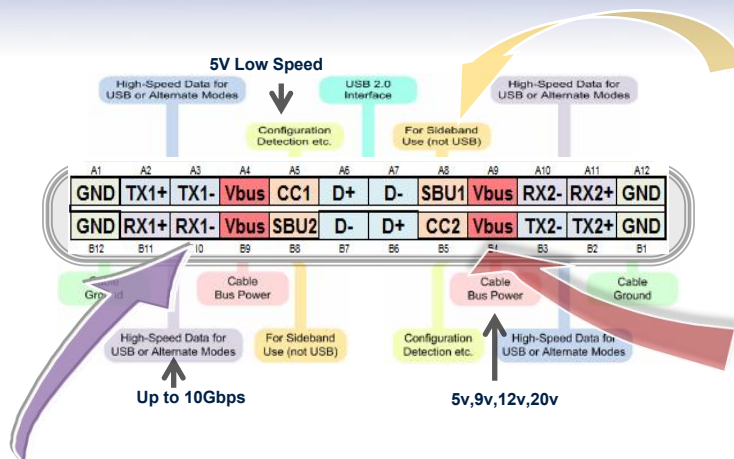
# DPO2039Q – USB-C data/control signal OVP

## ■ DPO2039Q provides 4-channel (2-pairs) overvoltage and ESD Protection

- Protects CC and D+/D- or SBU signals
- Inline OVP Protection against short-to-VBUS (connector short)
  - 300mΩ FETs on CC pins
  - 5Ω FET on DIFF pins
  - Fast <2.5ms disconnect response to OVP
- High ESD clamping
  - ±8kV contact ESD,
  - ±15kV air ESD
- Overtemperature Protected (OTP)
- Small footprint U-DFN3030-16



# USB-C® ESD Protection Solution for Automotive



## USB3.x Protection for 5/10Gbps on [ RX+/- & TX+/- , D+/D- ] Low capacitance and hence low loss. Small package

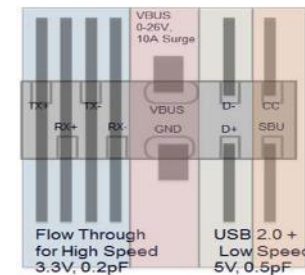
| Product No.    | # CH. | Direction | App.   | Cj (pF) | IEC-61000-4-2 |            | Vclamp @16A TLP=100ns | Vc@Ipp (8/20us) | Package |
|----------------|-------|-----------|--------|---------|---------------|------------|-----------------------|-----------------|---------|
|                |       |           |        |         | Air (kV)      | Cont. (kV) |                       |                 |         |
| DESD3V3Z1BCSFQ | 1     | Bi        | USB3.x | 0.17    | ±8            | ±8         | 11.5V                 | 4.5 V@3.5A      | DSN0603 |
| D5V0X1BA2LPQ   | 1     | Bi        | USB3.x | 0.3     | ±30           | ±25        | -                     | 17V@4A          | DFN1006 |
| DT1240-04LPQ   | 4     | Uni       | USB2.0 | 0.55    | ±16           | ±14        | 10.5V                 | 9.4V@5.5A       | DFN2510 |
| D12V0X1B2LPQ   | 1     | Bi        | USB2.0 | 0.5     | ±4            | ±20        | -                     | 25V@4A          | DFN1006 |
| D24V0F2U3WQ    | 2     | Uni       | USB2.0 | 0.8     | ±5            | ±10        | -                     | 50V@2.5A        | SOT323  |

## TVS Protection on [ CCx & SBUx ] High Surge V >150V, High ESD>30kV

| Product No.   | App. | # of Chan | Direction | Vc @ Ipp max (8/20us) | Package |
|---------------|------|-----------|-----------|-----------------------|---------|
| D5V0H1U2LPQ   | CCx  | 1         | Uni       | 12.5V@30A             | DFN1006 |
| D6V3H1U2LPQ   | CCx  | 1         | Uni       | 12.5V @30A            | DFN1006 |
| D12V0HA1U2LPQ | CCx  | 1         | Uni       | 20V@25A               | DFN1006 |
| D3V3H1B2LPQ   | SBUx | 1         | Bi        | 9V@40A                | DFN1006 |
| D5V0H1B2LPQ   | SBUx | 1         | Bi        | 12.5V @30A            | DFN1006 |

## Power Protection on [ V<sub>BUS</sub> : 5V, 9v, 12V, 20v ]High Vc and Ipp

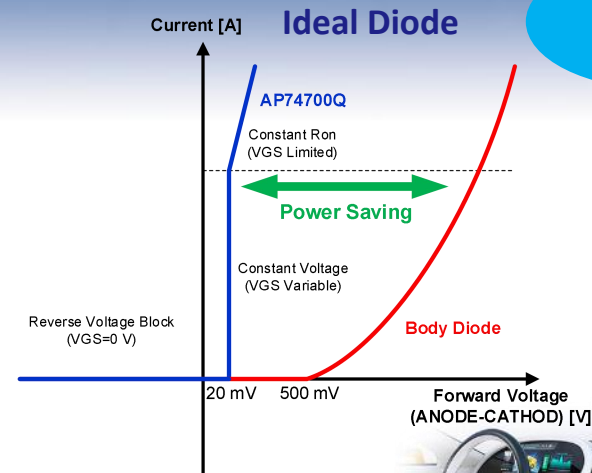
| Product No.      | # CH | Direction | Vc @Ipp Max (8/20us) | Ppk (8/20us) | Package |
|------------------|------|-----------|----------------------|--------------|---------|
| D5V0S1U2LP1610Q  | 1    | Uni       | 11.5V @120A          | 1300W        | DFN1610 |
| D12V0S1U2LP1610Q | 1    | Uni       | 20V@65A              | 1300W        | DFN1610 |
| D20V0S1U2LP1610Q | 1    | Uni       | 36V @ 37A            | 1300W        | DFN1610 |
| D24V0S1U2LP1610Q | 1    | Uni       | 42V @ 31A            | 1300W        | DFN1610 |



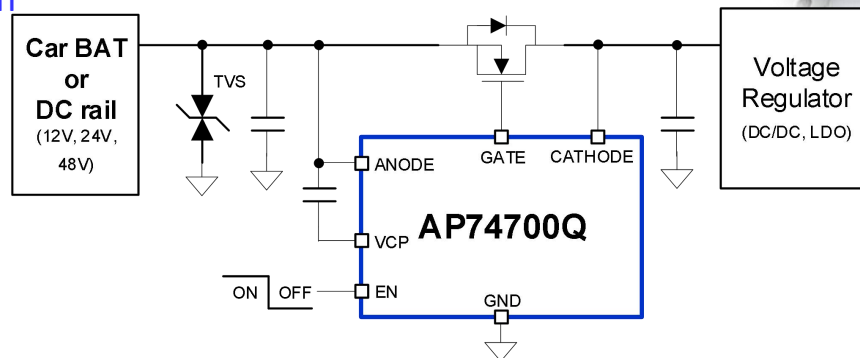
# AP74700Q - Reverse-Voltage Protection Ideal-Diode Controller

ES 3Q21  
RTP 2Q22

- **-65 V reverse-voltage rating**
- Input voltage range: +3.2 V to **+65 V** (3.9 V start-up)
- Charge pump for external N-ch MOSFET
- **20 mV ANODE to CAHODE forward voltage drop regulation**
- 80 $\mu$ A operating current (EN=HIGH)
- 1 $\mu$ A shutdown current (EN=LOW)
- Fast reverse current block response of < 0.75  $\mu$ s.
- **Compliance to automotive transient requirements with TVS**
  - ISO 7637-2 transient pulses
  - ISO 16750-2 load dump suppression
- ESD protection:
  - Human Body Model : 2 kV
  - Charged Device Model : 1 kV
- SOT26
- **p2p with LM74700-Q1**



**Typical Application Circuit**



# Automotive Connectivity, Logic, and Timing

... an expanding portfolio with and without protocol specific functionality  
for high-speed signals and clocks

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Timing       | <ul style="list-style-type: none"><li>▪ <b>High reliability Crystals and Crystal Oscillators (XO)</b> up to 125°C<br/>Stable clock source over wide temp range</li><li>▪ <b>High-speed Clocks</b> with Spread Spectrum and low jitter<br/>Reduced EMI and better accuracy<br/>Multi-channel fanout</li></ul>                                                                                                                                                                                                                                                                                                                      |
| Connectivity | <ul style="list-style-type: none"><li>▪ <b>PCIe 2 Packet Switches</b>: → Designed in Qualcomm reference designs<br/>Increases number of ports of SoC, Core chip for higher performance</li><li>▪ <b>PCIe 3 Packet Switches</b> → 4Q2022</li><li>▪ <b>ReDrivers</b> with configurable options<br/>Extends USB 3.x cable drive lengths → open the eye for optimized performance &amp; signal quality</li><li>▪ <b>USB Switches and Muxes</b> → USB 2 and USB 3 for USB-C signalling</li><li>▪ <b>IO Expanders</b> → Expands IO port of SoC/μP with <b>built-in</b> signal level-shifting</li><li>▪ <b>Analog Switches</b></li></ul> |
| Logic        | <ul style="list-style-type: none"><li>▪ <b>Single Gate Logic</b> → Small footprint leaded solution for buffering, inverting, &amp; routing</li><li>▪ <b>Voltage Translators</b> → translating I/O signals to/from SoC</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                   |

# DIODES' Automotive Serial Connectivity, Logic & Timing

| Product Type                 |                          |       | Status                                        |            |               |
|------------------------------|--------------------------|-------|-----------------------------------------------|------------|---------------|
| PCIe Packet Switches         |                          |       | PI7C9X2Gx04xxQ (PCIe Gen2)                    |            | PCIe 3.0      |
| Signal Integrity (ReDrivers) |                          |       | USB3.x, USB-C + Alt-DP                        |            | PCIe 3.4, 4.0 |
| USB data switches/Muxes      |                          |       | USB2.x with HV withstand                      |            |               |
| Timing                       | Crystals (Xtals)         |       | FYQ, FLQ, FHQ, FWQ, XRQ                       |            |               |
|                              | Crystal Oscillators (XO) |       | HXQ, FNQ, FDQ, FKQ, KDQ, KKQ, KXQ             |            |               |
|                              | Clock IC                 | PCIe  | PCIe 2.0, 3.0, 4.0 clock generator and Buffer |            |               |
|                              |                          | Other | CMOS fanout Buffer, RTC                       |            |               |
| Logic – standard gates       |                          |       | 74LVC1GxxQ                                    | 74AHC1GxxQ | 74xxx2GxxQ    |
| Logic – Level shifting       |                          |       | PI4ULSxxxQ                                    | PI4ULSxxxQ |               |

Production

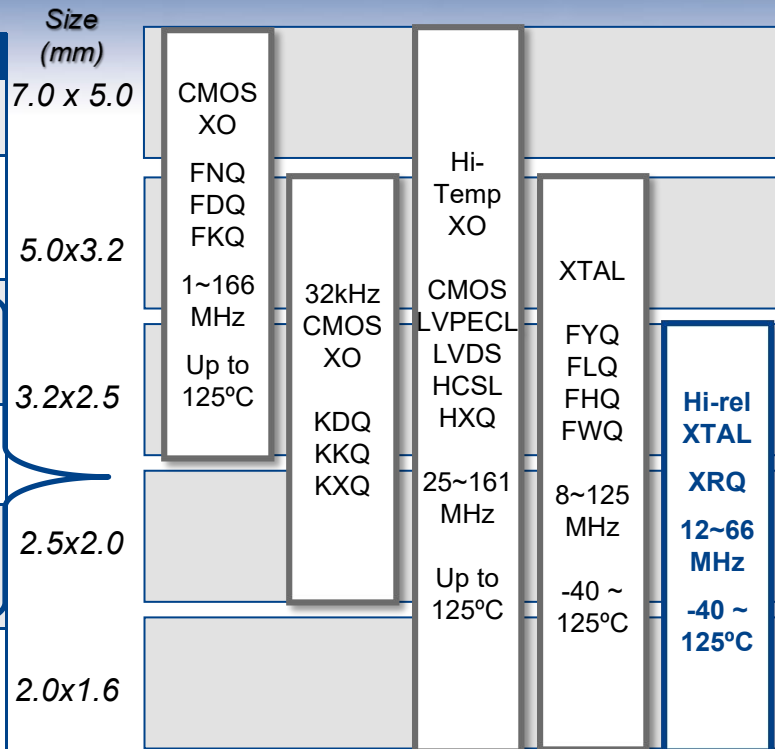
Development

Roadmap

# Automotive Compliant Timing Product Portfolio

## DIODES™ Advantage

- **Automotive compliant (Q)** - AEC-qualified, manufactured in IATF 16949 certified sites supporting PPAP documents
- **Total Timing Solutions – FCP + IC**  
Supports Infotainment, clusters, telematics, ADAS, Connected box, TPMS, etc. applications
- **AEC-Q200 grades 3, 2, & 1 qualified Xtal and XO**  
Automotive quality and reliability  
Long term commitment and support
- **Broad Portfolio for Crystals and Oscillators**  
Options for various sizes, stabilities, and frequencies
- **Xtals designed in Broadcom BroadR-Reach reference design**  
Core chip proven solutions
- **Automotive-compliant Clock Generator/Buffers (inc up to PCIe 4.0) and RTC**  
high-speed interface & data rate → PCIe 1.0/ 2.0/3.0/4.0  
Cost saving with multiple outputs





# Why Diodes' Automotive Crystals?

| Customer Requirements/ Concerns  |                             | Standards                                            | Diodes Commercial                                                                  | Diodes Automotive                                                                    | Benefit                                                                                               |
|----------------------------------|-----------------------------|------------------------------------------------------|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Portfolio                        | Example: 3.2.x2.5mm         |                                                      | 8 to 80MHz                                                                         | 8 to 80MHz                                                                           | Large frequency range including low frequencies typically used for Automotive CAN bus and MCUs        |
| Performance                      | ESR (3.2x2.5mm)             | 50Ω                                                  | 40Ω                                                                                | 40Ω                                                                                  | Ensures oscillation startup                                                                           |
| End System Manufacturing         | Supports Ultrasonic Welding | NA                                                   |   |   | Improves DPPM by at least 10x                                                                         |
| Endurance in Dynamic Environment | Vibration                   | AEC-Q200<br>5g                                       | 4x more (20g)                                                                      | 4x more (20g)                                                                        | Tested beyond typical standards for additional robustness and durability. Ensuring better reliability |
|                                  | Mechanical Shock            | AEC- Q200/<br>JESD22-B104<br>100g                    | 15x more (1500g)                                                                   | 80x more (8000g)                                                                     |                                                                                                       |
|                                  | Drop test                   | JIS-C0044<br>75cm height                             | >1.5x (120cm)                                                                      |                                                                                      |                                                                                                       |
|                                  | Centrifugal                 | SAE-J2657<br>1500g                                   | NA                                                                                 | 1500g                                                                                |                                                                                                       |
| Climate Endurance                | High Moisture               | High temp & High humidity, 1000 hours<br>+85°C/85%RH |   |   |                                                                                                       |
|                                  | Thermal Shock               | -55°C to +125°C.                                     |  |  |                                                                                                       |

# Why Diodes' Automotive Oscillators?

| Customer Requirements/ Concerns  |                                                                                 | Standards                                         | Diodes Commercial                                                                 | Diodes Automotive                                                                   | Benefit                                                                                               |
|----------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Portfolio                        | Various sizes, the most complete output levels, wide range of Vdd (1.8 to 3.3V) | CMOS, LVPECL, LVDS, HCSL                          | CMOS, LVPECL, LVDS, HCSL                                                          | CMOS, LVPECL, LVDS, HCSL                                                            | Complete portfolio to support current and future timing needs in Automotive applications              |
| Performance                      | Phase Jitter (ps)                                                               | Ex. PCIe 4.0 – 0.5ps                              | 0.5ps                                                                             | 0.2ps                                                                               | Provides very big margin for performance                                                              |
| Endurance in Dynamic Environment | Vibration                                                                       | AEC-Q200 5g                                       | 4x more (20g)                                                                     | 4x more (20g)                                                                       | Tested beyond typical standards for additional robustness and durability. Ensuring better reliability |
|                                  | Mechanical Shock                                                                | AEC- Q200/ JESD22-B104 100g                       | 15x more (1500g)                                                                  | 80x more (8000g)                                                                    |                                                                                                       |
| Climate Endurance                | High Moisture                                                                   | High temp & High humidity, 1000 hours +85°C/85%RH |  |  |                                                                                                       |
|                                  | Thermal Shock                                                                   | -55°C to +125°C.                                  |  |  |                                                                                                       |

# Timing Automotive Clock IC – PCIe and Buffers

| Family                                  | Part Number   | Description                          |                     | Package  | Temp. (°C) | Qual Status |
|-----------------------------------------|---------------|--------------------------------------|---------------------|----------|------------|-------------|
| PCIe Clock Generators and Clock Buffers | PI6C557-05Q   | 4-output PCIe Gen1/2 clock Gen       |                     | TSSOP-20 | -40 ~ 85   | AEC-Q100 G3 |
|                                         | PI6C557-03AQ  | 2-output PCIe Gen1/2 clock Gen       |                     | TSSOP-16 | -40 ~ 85   | AEC-Q100 G3 |
|                                         | PI6C557-01BQ  | 1-output PCIe Gen1/2 clock Gen       |                     | TQFN-16  | -40 ~ 85   | AEC-Q100 G3 |
|                                         | PI6LC48H02Q   | 2-output PCIe Gen1/2/3 clock Gen     |                     | TSSOP-16 | -40 ~ 85   | AEC-Q100 G3 |
|                                         | PI6CG182Q     | 2-output 1.8V PCIe Gen4 clock Gen    |                     | TQFN-24  | -40 ~ 105  | AEC-Q100 G2 |
|                                         | PI6CG184Q     | 4-output 1.8V PCIe Gen4 clock Gen    |                     | TQFN-32  | -40 ~ 105  | AEC-Q100 G2 |
|                                         | PI6CG188Q     | 8-output 1.8V PCIe Gen4 clock Gen    |                     | TQFN-48  | -40 ~ 105  | AEC-Q100 G2 |
|                                         | PI6CB184Q     | 4-output 1.8V PCIe Gen4 clock Buffer |                     | TQFN-32  | -40 ~ 105  | AEC-Q100 G2 |
| Clock Buffers                           | PI6C49CB01Q2  | 1 output Differential to LVCMOS      | No OE pin           | SO-8     | -40 ~ 105  | AEC-Q100 G2 |
|                                         | PI6C49CB01Q3  |                                      |                     |          | -40 ~ 85   | AEC-Q100 G3 |
|                                         | PI6C49CB02Q2  | 2-output LVCMOS, 2.5/3.3V            | No OE pin           |          | -40 ~ 105  | AEC-Q100 G2 |
|                                         | PI6C49CB02Q3  |                                      |                     |          | -40 ~ 85   | AEC-Q100 G3 |
|                                         | PI6C49CB04AQ2 | 4-output LVCMOS, 1.5~3.3V            | OE pin, no pull-up  |          | -40 ~ 105  | AEC-Q100 G2 |
|                                         | PI6C49CB04AQ3 |                                      |                     |          | -40 ~ 85   | AEC-Q100 G3 |
|                                         | PI6C49CB04BQ2 | 4-output LVCMOS, 1.5~3.3V            | No OE pin           |          | -40 ~ 105  | AEC-Q100 G2 |
|                                         | PI6C49CB04BQ3 |                                      |                     |          | -40 ~ 85   | AEC-Q100 G3 |
|                                         | PI6C49CB04CQ2 | 4-output LVCMOS, 1.5~3.3V            | OE pin with pull-up |          | -40 ~ 105  | AEC-Q100 G2 |
|                                         | PI6C49CB04CQ3 |                                      |                     |          | -40 ~ 85   | AEC-Q100 G3 |

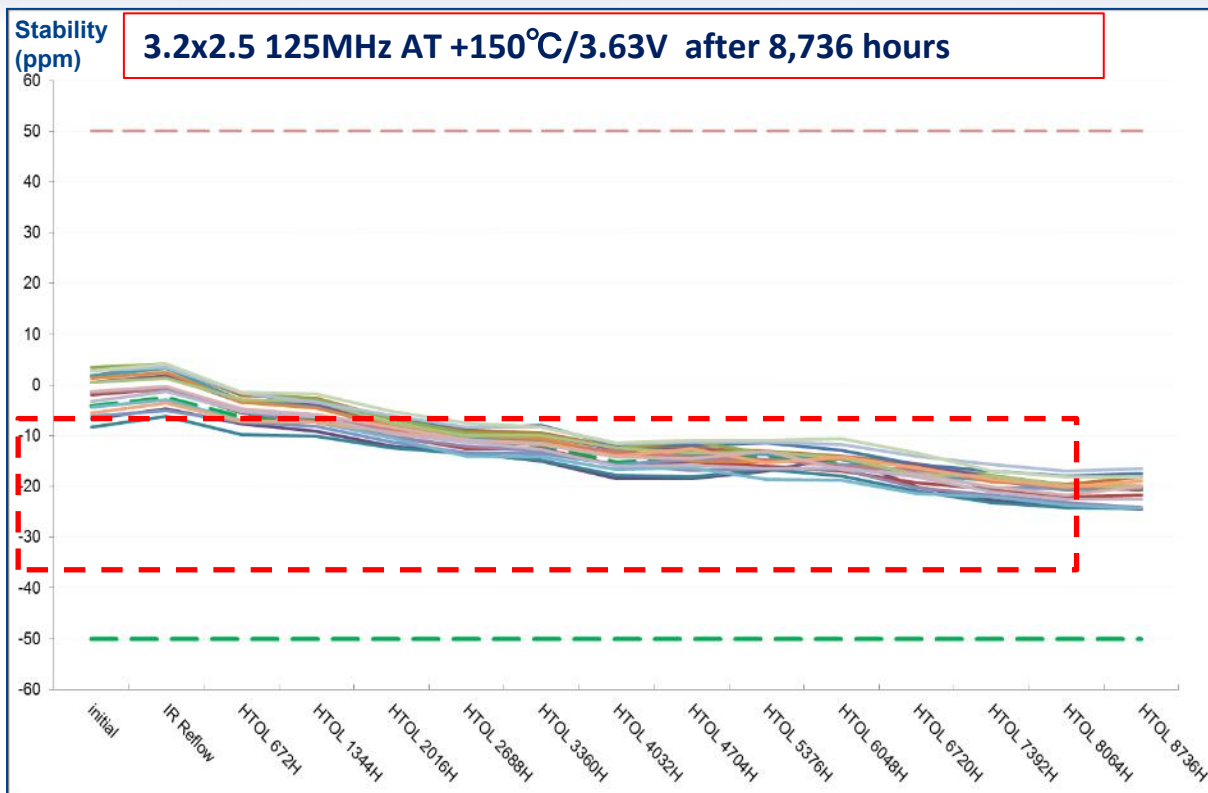
# Why use Diodes Automotive PCIe Clock Generators?

| Features                   | Benefits                                                                                                                                                                                                                                   |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low Power                  | <ul style="list-style-type: none"><li>PI6CG18xQ family utilizes low power HCSL, providing &gt;70% power savings</li></ul>                                                                                                                  |
| Minimize BOM               | <ul style="list-style-type: none"><li>PI6CG18xQ family has integrated resistors, saving 4 resistors/ output, upto 32 resistors</li></ul>                                                                                                   |
| Designed for AVI           | <ul style="list-style-type: none"><li>PI6CG18xQ family uses wettable/ side walled QFN for optimized Automated Visual Inspection</li></ul>                                                                                                  |
| AEC-Q100 Qualified         | <ul style="list-style-type: none"><li>Clock IC qualified and shipping in automotive applications since 2014</li></ul>                                                                                                                      |
| Spread Spectrum support    | <ul style="list-style-type: none"><li>Diodes' PCIe Clock Generators have spread spectrum support to lower EMI (important in automotive applications)</li></ul>                                                                             |
| Proven technology          | <ul style="list-style-type: none"><li>Millions of units shipped in Automotive applications</li></ul>                                                                                                                                       |
| Long term support          | <ul style="list-style-type: none"><li>Diodes' has extensive portfolio and roadmap to support PCIe timing, PCIe 1.0, 2.0, 3.0 and 4.0</li><li>Already shipping in Automotive today, so long term support guaranteed</li></ul>               |
| Full PCIe timing portfolio | <ul style="list-style-type: none"><li>Full portfolio with oscillators, clock generators and buffers depending on design requirements</li><li>Already have next generation low power PCIe Clocks with 70% lower power consumption</li></ul> |
| Total Solution             | <ul style="list-style-type: none"><li>Diodes has all crystal and clock IC to provide timing solution</li></ul>                                                                                                                             |

# Automotive-Compliant Xtal & XO: Outstanding Reliability

■ Excellent long-term stability

■ >53 year MTBF



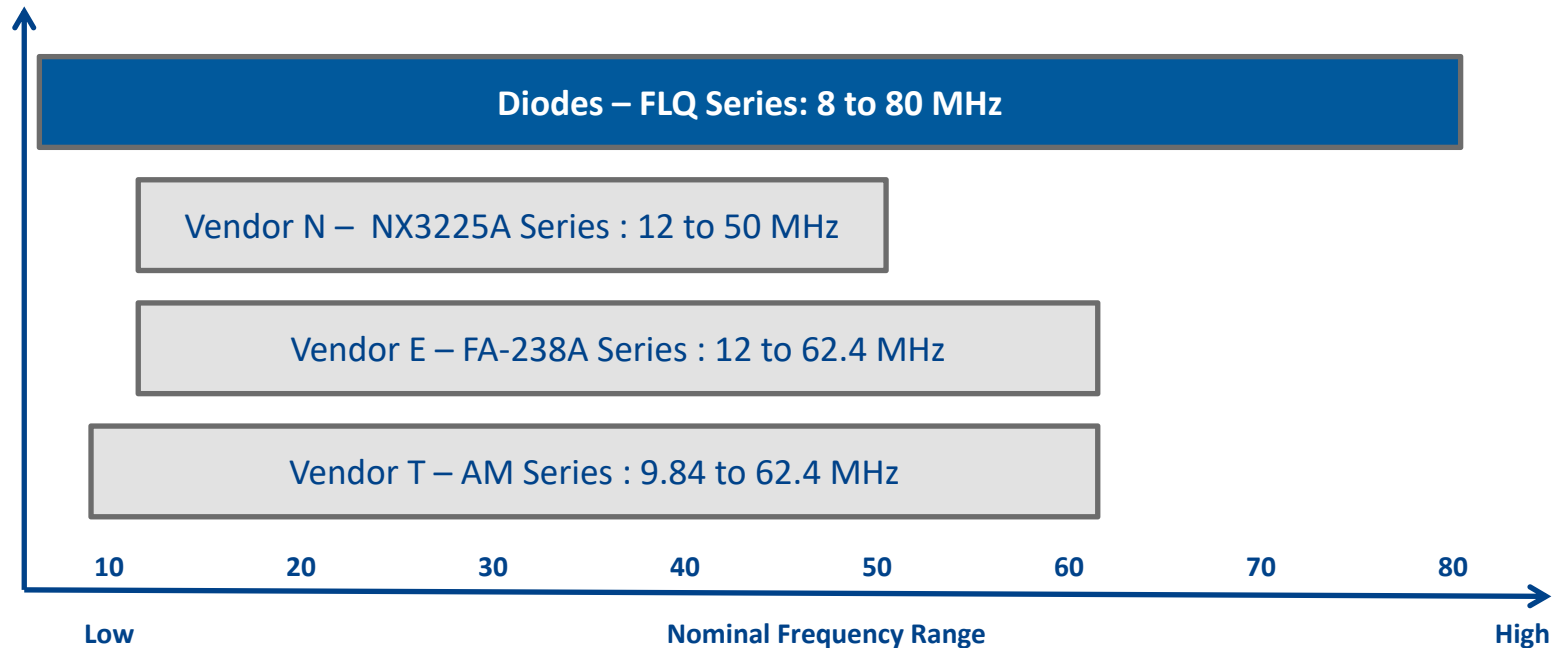
## High Temp Operating Life (HTOL)

|                     |                              |
|---------------------|------------------------------|
| Type                | 3.2x2.5mm<br>125MHz 3.3V±10% |
| Condition           | +150°C @ 3.63V               |
| HTOL (Hour)         | 8736                         |
| Life Time<br>@ 85°C | 53.31 Year                   |

# Automotive-Compliant Xtal & XO: Widest frequency range

## ■ 3.2x2.5 Seam Sealing Crystal Comparison

- Smallest size for 8MHz - saving board space,
- Using main stream package – best cost structure, availability and longevity

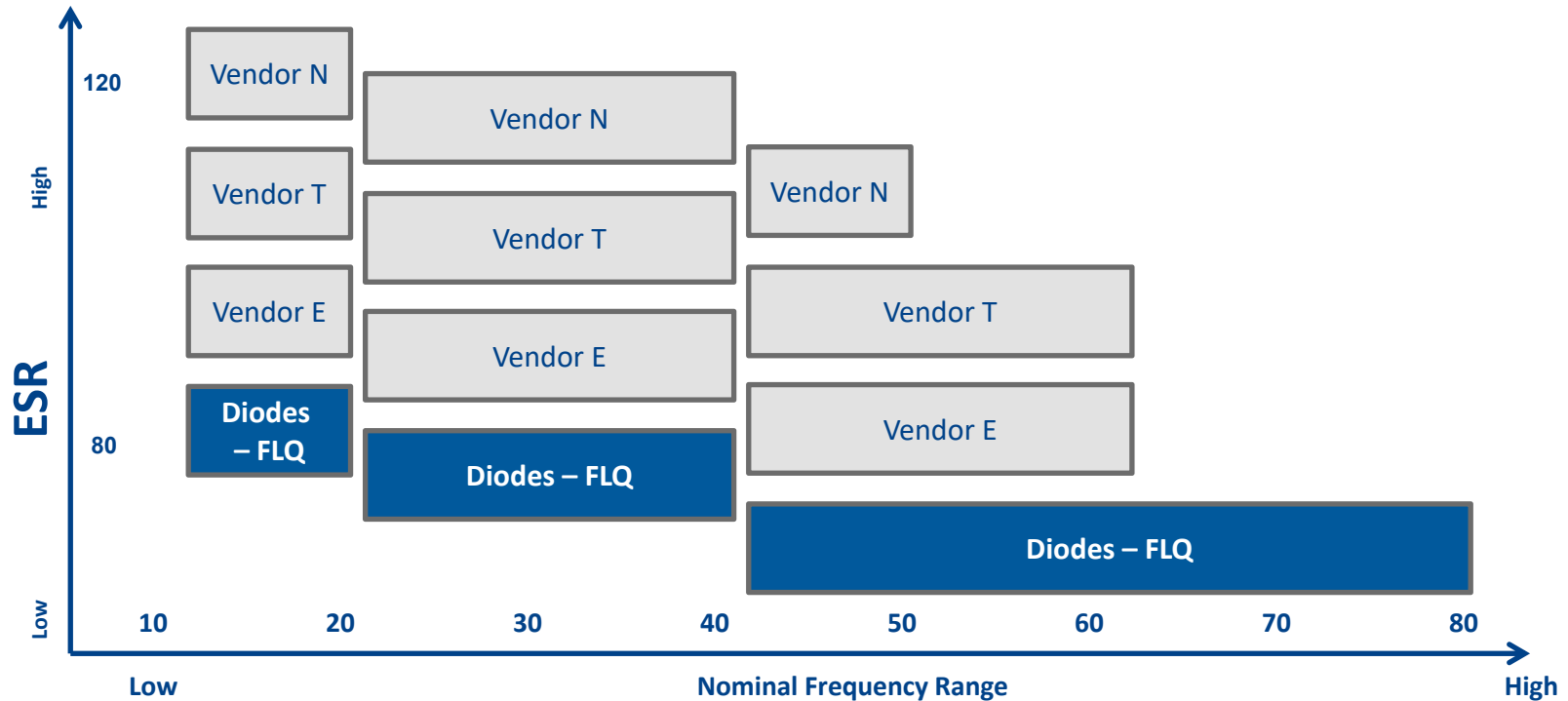




# Automotive-Compliant Xtal & XO: Lowest ESR

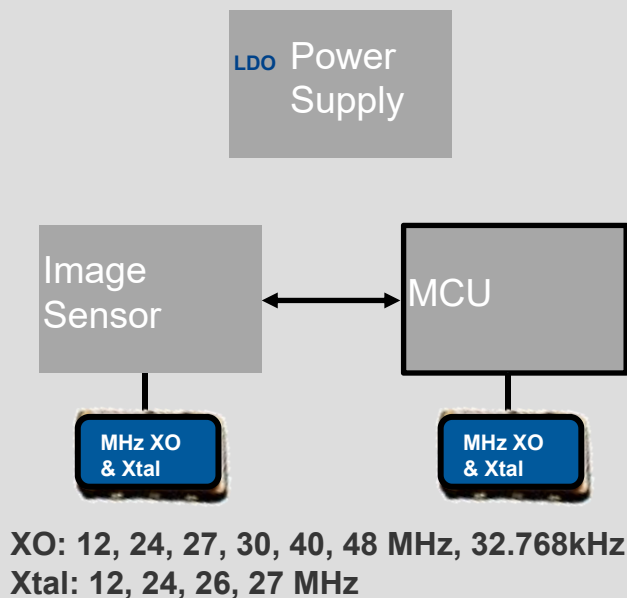
## ■ 3.2x2.5 Seam Sealing Crystal Comparison

- Lowest Equivalent Series Resistance (ESR) ensures reliable oscillation

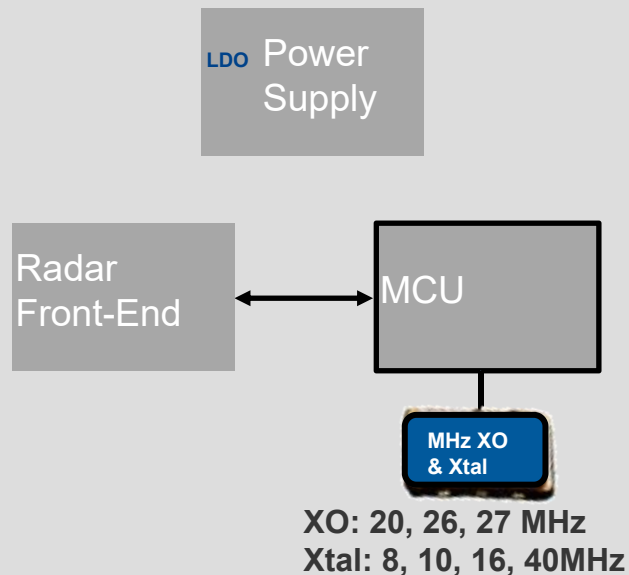


# ADAS – Timing Solutions

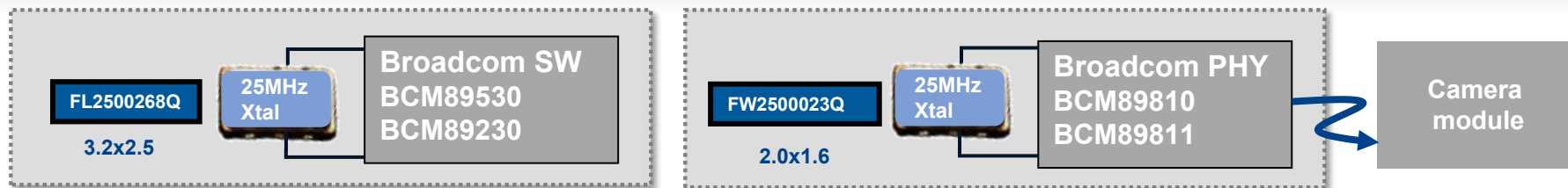
## Rear / Surround / Front View Camera



## Radar System



# 25MHz Crystal for BroadR-Reach®



- **FL2500268Q & FW2500023Q (Camera Module) on the Reference Design**
  - 3225 & 2016 size, 15ppm cal. Tolerance /50ppm stability
- **AEC-Q200 Qualified Device**
  - No additional qualification needed
- **Speed up design, guaranteed by chipset vendor**

# Diodes' Automotive Compliant Serial Connectivity

- Automotive-compliant (Q) - AEC-Q100 qualified, manufactured in IATF 16949 certified sites supporting PPAP documents

| P/N                        | Description                                                |                  |                                              | AEC-Q100 Grade |
|----------------------------|------------------------------------------------------------|------------------|----------------------------------------------|----------------|
| Signal Integrity/Redrivers |                                                            |                  |                                              |                |
| PI3EQX7741AIQ              | 3.3V, USB3.x 5.0Gbps ReDriver with Equalization & Emphasis | 1-port (Rx & Dx) | Extends the drive length of USB3             | 3              |
| PI3EQX501BQ                |                                                            | 1-channel        |                                              | 3              |
| PI3DPX1207Q                | 10Gbps USB-C DP-Alt Linear Redriver with AUX               |                  | DP1.4 over USB-C                             | 2              |
| PCIe Packet Switches       |                                                            |                  |                                              |                |
| PI7C9X2G304ELQ             | 3-Port, 4-Lane SlimPacket PCIe 2 Packet Switch             |                  | Expands the effective number of SoC/μP Ports | 3              |
| PI7C9X2G304EVQ             | 3-Port, 4-Lane SlimPacket PCIe 2 Packet Switch             |                  |                                              | 2              |
| PI7C9X2G304SLQ             | 3-Port, 4-Lane SlimPacket PCIe 2 Packet Switch             |                  |                                              | 3              |
| PI7C9X2G404ELQ             | 4-Port, 4-Lane SlimPacket PCIe 2 Packet Switch             |                  |                                              | 3              |
| PI7C9X2G404EVQ             | 4-Port, 4-Lane SlimPacket PCIe 2 Packet Switch             |                  |                                              | 2              |
| PI7C9X2G404SLQ             | 4-Port, 4-Lane SlimPacket PCIe 2 Packet Switch             |                  |                                              | 3              |
| IO Expanders               |                                                            |                  |                                              |                |
| PI4IOE5V6416Q              | Low-voltage I2C-bus I/O                                    | 16-bit           | μP I/O expansion with Level shifting         | 2              |
| PI4IOE5V6534Q              | Expander with Level shifting                               | 34-bit           |                                              | 2              |

# Automotive Compliant Packet Switch Product Portfolio

PCIe provides the highest-speed (minimal latency) data path between SoC/ $\mu$ P and memory, RAM and peripherals in Automotive Connected Apps

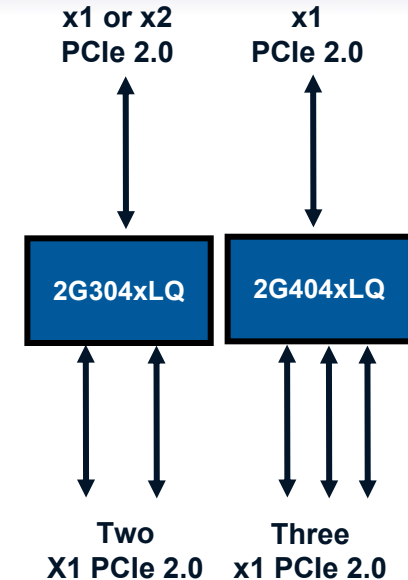
## DIODES Advantage

- **Broad PCIe 2 Packet Switch Portfolio**
  - Expands SOC's PCIe fanout
  - Integrated clock buffer simplifies implementation
  - Supports Infotainment, clusters, telematics, ADAS applications
- **Designed in Qualcomm Telematics Reference Design**  
Core chip verified solution to meet the application needs
- **Only AEC-Q100 Qualified Packet Switch**  
Automotive quality and reliability  
Long term commitment and support
- **Low Power Consumption to Meet Automotive Requirement**  
Leaves power margin for other functions in systems



# PI7C9X2G304Q/404Q Key Features

- **Compliant to PCI Express specification rev 2.1**
  - Support Access Control Service (ACS) for peer-to-peer traffic
  - Support Address Translation (AT) packet for SR-IOV
  - Supports Latency Tolerance Reporting (LTR) & Optimized Buffer Flush Fill (OBFF) to improve Platform Power Management
- **Expands the effective PCIe ports of the SoC/system processor**
- **Integrated PCIe clock buffer for each downstream port**
- **Programmable PHY drive and EQ**
- **I2C bus support**
- **Advanced Power Management**



- 2G304/ 404SLQ: 128 LQFP 14x14mm
- 2G304/ 404ELQ: 136 aQFN 10x10mm



# PI7C9X2G304Q/404Q Comparison

| PI7C9X                        |                | PI7C9X2G304Q                                                    | PI7C9X2G404Q            | Other suppliers                  |
|-------------------------------|----------------|-----------------------------------------------------------------|-------------------------|----------------------------------|
| # Port/ Lane                  |                | 3 Port/ 4Lane                                                   | 4Port/ 4Lane            | 3 or 4Port/ 4Lane                |
| Configuration                 |                | 1x1 (x2) Up<br>2 x1 Down                                        | 1x1 Up<br>3 x1 Down     | 1x1 (x2) Up,<br>2 (3) x1 Down    |
| Integrated Clock Buffer       |                | YES                                                             | YES                     | Yes/No*                          |
| AECQ-100 Grade                | <b>ELQ/SLQ</b> | <b>3</b>                                                        | <b>3</b>                | N/A                              |
|                               | <b>EVQ</b>     | <b>2</b>                                                        | <b>2</b>                |                                  |
| Power consumed<br>(5Gbps typ) | <b>ELQ/SLQ</b> | 0.7 W <sup>^</sup>                                              | 0.7 W <sup>^</sup>      | 0.8~1.63W                        |
|                               | <b>EVQ</b>     | <b>0.3W<sup>^</sup></b>                                         | <b>0.3W<sup>^</sup></b> |                                  |
| Latency (typ.)                |                | <b>150ns</b>                                                    | <b>150ns</b>            | 180~250ns                        |
| Advanced Power Saving         |                | YES                                                             | YES                     | N/A                              |
| Ambient<br>Temperature        | <b>ELQ/SLQ</b> | <b>-40~ +85°C</b>                                               | <b>-40~ +85°C</b>       | -40 ~ 85/ 0~ +70°C               |
|                               | <b>EVQ</b>     | <b>-40~ +125°C</b>                                              | <b>-40~ +125°C</b>      |                                  |
| Signal Integrity              |                | Programmable                                                    | Programmable            | N/A                              |
| ACS/ AT Support               |                | YES                                                             | YES                     | N/A                              |
| LTR/ OBFF Support             |                | YES                                                             | YES                     | N/A                              |
| PCIe Spec.                    |                | <b>PCIe 2.1</b>                                                 | <b>PCIe 2.1</b>         | PCIe 2.0~2.1                     |
| Package                       |                | <b>EVQ/ELQ:</b> aQFN 136 10x10mm<br><b>SLQ:</b> LQFP128 14x14mm |                         | BGA 15/19x15/19mm<br>QFN 10x10mm |
| Automotive Production         |                | Yes                                                             | Yes                     | N/A                              |

<sup>^</sup>: Pd includes clk buffer

\*Some have it

# Automotive-compliant ReDriver Products

| Description                     | Part Number   | Package | Temp.     | Qual Status |
|---------------------------------|---------------|---------|-----------|-------------|
| USB3.0 single channel re-driver | PI3EQX501BQ   | 8-TQFN  | -40 ~ 85C | AEC-Q100 G3 |
| USB3.0 two channel re-driver    | PI3EQX7741AIQ | 20-TQFN | -40 ~ 85C | AEC-Q100 G3 |

- **Reduces RJ, ISI Jitters, BER & Enhance Eye Mask across long Cable or Trace**
- **USB3.0 Cable Length extended: 6~7m (32 AWG), 8~10m (28 AWG)**
- **Optimizing USB3.1/3.0 Signal Quality**
  - Programmable Output Swing
  - Emphasis/De-Emphasis and EQ at the Tx and Rx Channels
- **Reducing PCB Material cost with single USB3.1/3.0 ReDriver solution**
- **PI3EQX7741AIQ provides:**
  - 1-port USB 3.0 operation
  - Pin adjustable receiver EQ: 3 to 9dB
  - Automatic receiver detect configuration
- **PI3EQX501BQ provides:**
  - 1- USB 3.0 differential channel (TX or Rx)
  - Pin adjustable Rx EQ: 3, 6 or 9dB
  - Pin adjustable o/p emphasis: 0, -3.5, -6dB

# PI3DPX1207Q – 10Gbps USB-C DP-Alt 4:4 Linear ReDriver

## Description

Automotive-compliant Type-C DP-Alt Linear ReDriver

Supporting DisplayPort 1.4 (8Gbps) signals over USB Type-C (10Gbps) as well as USB 3.2

Its 4:4 channel configuration supports 4 operating modes through device settings:

- 1. 4-channel DP1.4
- 2. 4-port 10G USB3.2 Gen2 (SuperSpeed USB 10Gbps)
- 3. 1-port USB3.2 Gen2 + 2-channel DP1.4
- 4. 2-port 10G USB3.2 Gen 2x2 (SuperSpeed USB 20Gbps)

It's on Qualcomm's SA8155 - Snapdragon™ Automotive Development Platform (ADP)

How does this part fit into the current portfolio?

1st automotive-compliant USB-C DP-Alt ReDriver

## Target Applications

|              |                            |  |  |
|--------------|----------------------------|--|--|
| Infotainment | Instrument Cluster Display |  |  |
|--------------|----------------------------|--|--|

# Automotive Logic and Voltage Translation

Automotive-compliant Logic and Voltage Translation products are AEC-Q100 qualified, manufactured in IATF 16949 certified sites supporting PPAP documentation.

Automotive single-gate logic products help eliminate PCB routing compromises within Infotainment, telematics, and ADAS systems.

Automotive voltage translation family consists of 2-, 4-, & 8-bit products that bidirectionally convert the smaller voltage levels of the core chip to the higher voltage levels of the peripheral devices.

## Automotive Single-gate logic

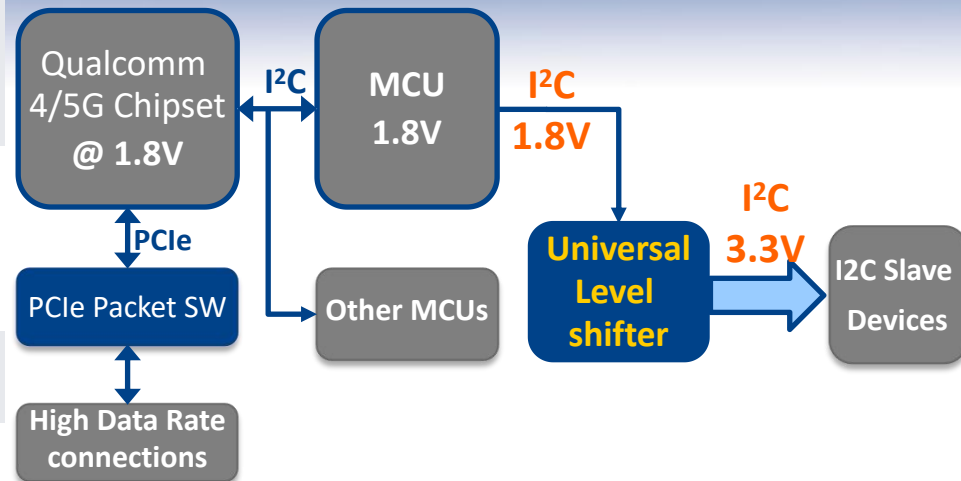
Three distinct families with differing operating voltages, switching speeds and drive capability, are available covering the 12 most popular functions in SOT25 and SOT353 packages for ease of placement

## Automotive Voltage Translation

Simple Auto-direction solutions for I/O signals translation to/from logic levels of peripheral/slave devices and the lower I/O voltages of high-end  $\mu$ C/ $\mu$ P/SoC.

# Automotive Compliant Voltage Translation Portfolio

- 2-, 4-, & 8-bit Universal Level Shifter (ULS) family  
Converts voltages between core chip and peripheral devices
- High-end  $\mu$ C/ $\mu$ P/SoC have lower core and I/O voltages  
Need I/O signals translating to/from logic levels of peripheral/slave devices
- Applies to GPIO, I2C & SPI  
Covering wide range of voltages and speeds
- Applications within ADAS, Infotainment and Telematics  
Covering HUD, AVN, cameras, LIDAR  
→ All apps that have high-end processing



| Part Number   | Translation |            | Automatic Direction Sensing | Level Shift   | Max Signal Rate | Prop Delay ns | Bits Needed | Temperature Range °C | Packages     |
|---------------|-------------|------------|-----------------------------|---------------|-----------------|---------------|-------------|----------------------|--------------|
|               | From V      | To V       |                             |               |                 |               |             |                      |              |
| PI4ULS5V108Q  | 0.95 ~ 3.3  | 1.8 ~ 5    | Yes                         | Bidirectional | 100MHz          | 2.2           | 8           | -40 to 125           | TSSOP-20     |
| PI4ULS5V202Q  | 1.2 ~ 5.5   | 1.2 ~ 5.5  | Yes                         | Bidirectional | 20Mb/s          | 20            | 2           | -40 to 125           | MSOP-8       |
| PI4ULS3V304AQ | 0.9 ~ 2.0   | 1.65 ~ 3.6 | Yes                         | Bidirectional | 140MHz          | 3.0           | 4           | -40 to 125           | U-QFN1720-12 |

# Automotive-Compliant Logic – LVC1G & AHC/T1G

| Type   | Description                        | LVC         | AHC         | AHCT        | All         | Packages     |
|--------|------------------------------------|-------------|-------------|-------------|-------------|--------------|
|        |                                    | Min VCC (V) | Min VCC (V) | Min VCC (V) | Max VCC (V) |              |
| 1G00Q  | 2-Input <b>NAND</b> Gate           | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G02Q  | 2-Input <b>NOR</b> Gate            | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G04Q  | <b>INVERTER</b>                    | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G06Q  | <b>INVERTER</b> Open-drain         | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G07Q  | <b>BUFFER</b> Open-drain           | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G08Q  | 2-Input <b>AND</b> Gate            | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G09Q  | 2-Input <b>AND</b> Gate Open-drain |             | 2           |             | 5.5         | SOT353/SOT25 |
| 1G125Q | 3-state <b>BUFFER</b> OE LOW       | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G126Q | 3-state <b>BUFFER</b> OE HIGH      | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G14Q  | Schmitt Trigger <b>INVERTER</b>    | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G17Q  | Schmitt Trigger <b>BUFFER</b>      | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G32Q  | 2-Input <b>OR</b> Gate             | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |
| 1G34Q  | <b>BUFFER</b>                      | 1.65        |             |             | 5.5         | SOT353/SOT25 |
| 1G86Q  | 2-Input <b>XOR</b> Gate            | 1.65        | 2           | 4.5         | 5.5         | SOT353/SOT25 |

| Production                                                                                                                                                                              | 2022                                                                                                                                            |                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| <p>AEC-Q200 Crystals &amp; XO:<br/>Grade 1,2 &amp; 3</p> <p>PI6C557-xxQ<br/>Clk Generators</p> <p>RTC</p> <p>PI6CG/CB18xxxQ<br/>PCIe CG/Buffer</p> <p>PI6C49X020xQ<br/>Buffer, 105C</p> | <p>UCQ PCIe 5.0 XO 125°C<br/>AEC-Q104 Grade 1</p> <p>AEC-Q200 150C Crystals</p> <p>PCIe 4.0 1.8V 125°C CG</p> <p>PCIe 3.0/4.0 3.3V 125°C CG</p> | Precision Timing            |
| <p>PI3EQX7741Q/501BQ<br/>- USB3.0 Redrivers</p> <p>PI3DPX1207Q 10G USB-C DP ALT<br/>Redriver</p>                                                                                        | <p>PI3UPI1608Q, 8 channel PCIe 4.0 Redriver</p> <p>PI3DBS16222Q2</p>                                                                            | Redrivers/<br>Active Mux    |
| <p>PI7C9X2Gx04SLQ/ELQ/EVQ<br/>PCIe2 Packet Switches</p>                                                                                                                                 | <p>PI7C9X3G606/ 808/816/ 1632GPQ<br/>PCIe3 Packet Switches, AEC-Q100 Grade3</p>                                                                 | PCIe Packet Switches        |
| <p>PI5USB2546Q USB Charging<br/>Controller w/Power SW</p> <p>PI5USB2546AQ –<br/>2.4A Apple</p>                                                                                          |                                                                                                                                                 | USB Charging                |
| <p>PI3USB4000DQ 2:1 Mux 28V I/O tol</p> <p>PI3USB221EQ1 2:1 Mux 5V I/O tol</p>                                                                                                          | <p>PI3USB212/7Q USB2 repeater</p>                                                                                                               | USB/Type C<br>Signal Switch |
| <p>PI4IOE5V6416Q</p> <p>PI4IOE5V6534Q</p>                                                                                                                                               | <p>PI4IOE5V6416RQ</p>                                                                                                                           | I2C IOE/Mux                 |
| <p>74LVC1GxxQ</p> <p>AHC/T1GQ</p>                                                                                                                                                       | <p>Other families</p>                                                                                                                           | GP. Logic                   |
| <p>PI4ULS5V202Q/5V108Q</p> <p>PI4ULS3V304AQ</p>                                                                                                                                         |                                                                                                                                                 | ULS                         |
|                                                                                                                                                                                         | <p>PI3A27518Q Analog SW</p> <p>PI3CH480Q Bus SW</p>                                                                                             | Analog/Bus/<br>Audio Switch |

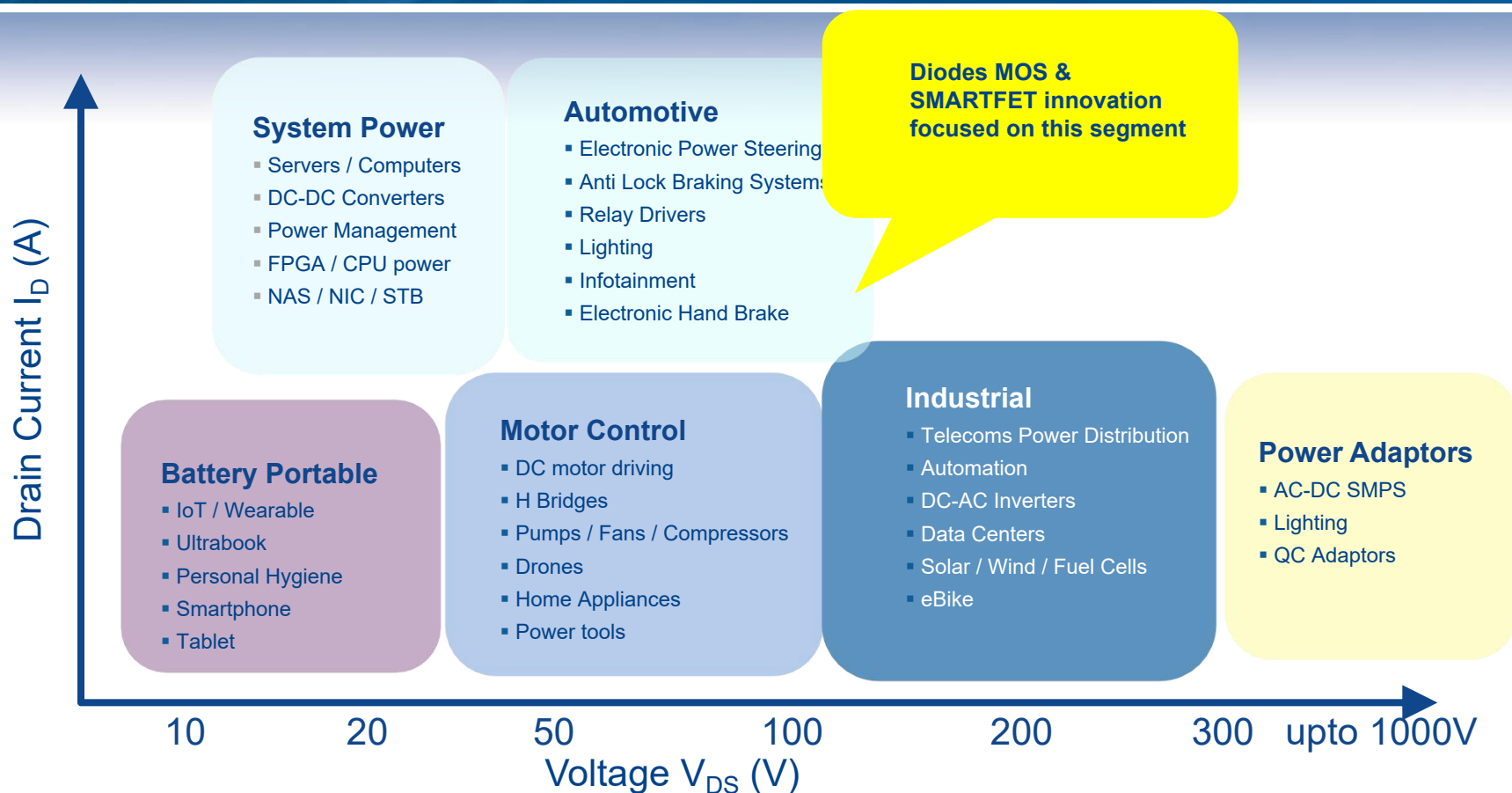
Production

Development

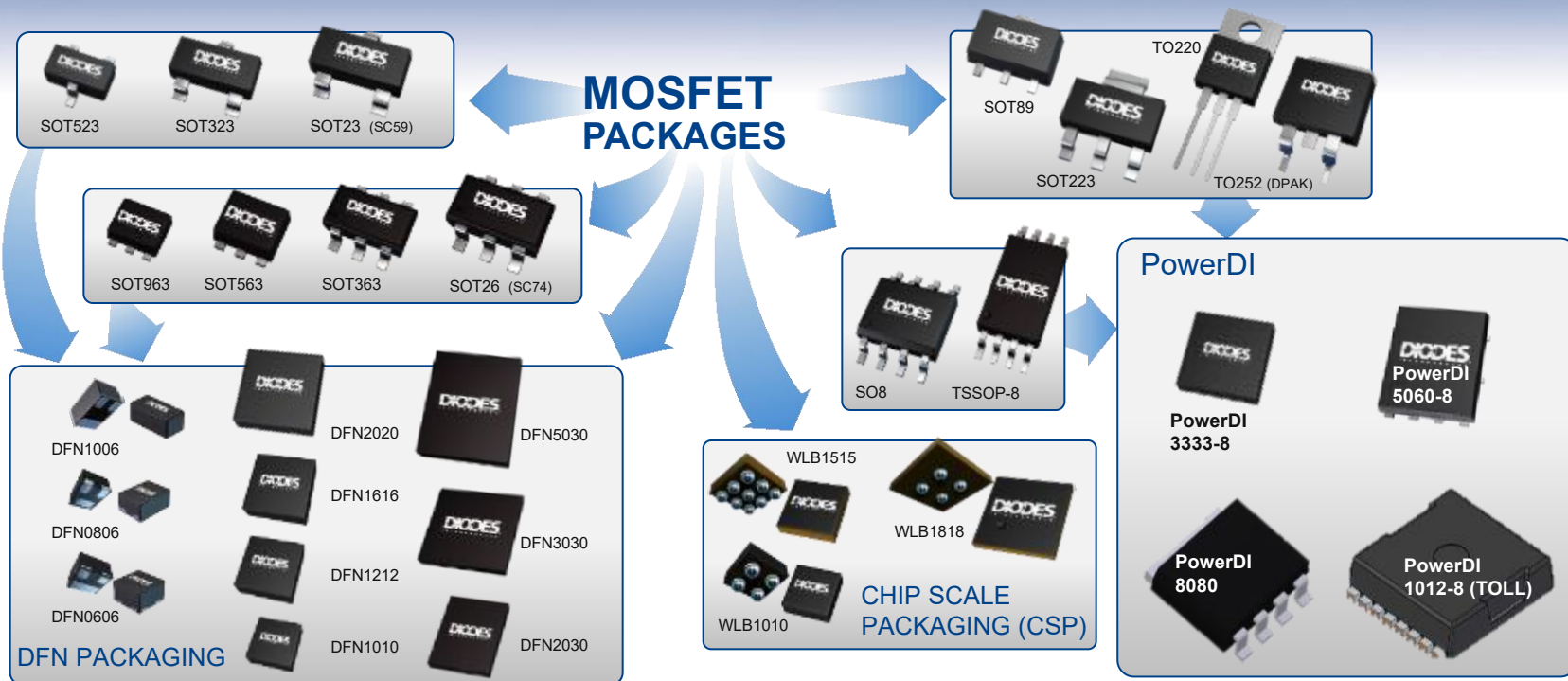
Roadmap



# MOSFET and Power Product Market Coverage



# Diodes Inc. MOSFET Portfolio



- **800+ MOSFETs** from Small-Signal to Power MOSFETs
- BVDSS from **8 to 700V**
- N channel, P channel, Duals, Quads

- In-house assembly provides an extensive packaging capability
- More mass production packages are available.

## Focus: Miniaturization and Power Efficiency



~ 2019

2020 ~ 2022

# Automotive MOSFET Automotive Portfolio

## Innovation focused on 175C MOS

Page 84

|                                   | High-Temperature (175C) MOSFET              | Standard (150C) MOSFET                            |
|-----------------------------------|---------------------------------------------|---------------------------------------------------|
| Number of Active Products         | 100                                         | 280                                               |
| Number of Products in Development | 15                                          | 5                                                 |
| Polarity                          | N, N+N, P,                                  | N, N+N, P, P+P, N+P                               |
| Voltage Range (V)                 | 30V to 100V                                 | 12V to 200V                                       |
| Lowest Rdson                      | 1m $\Omega$ lowest Rds(on)                  | 1m $\Omega$ lowest Rds(on)                        |
| Packages                          | PD5060, PD3333, DPak, DFN2020, TOLL, PD8080 | PD5060, PD3333, DPak, DFN2020, SOT, SOT23, TSOT26 |

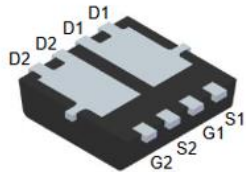
### Focus Packages



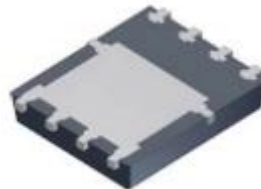
DFN2020



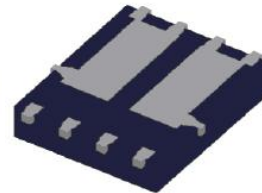
PowerDI3333



Dual PowerDI3333



PowerDI5060



Dual PowerDI5060

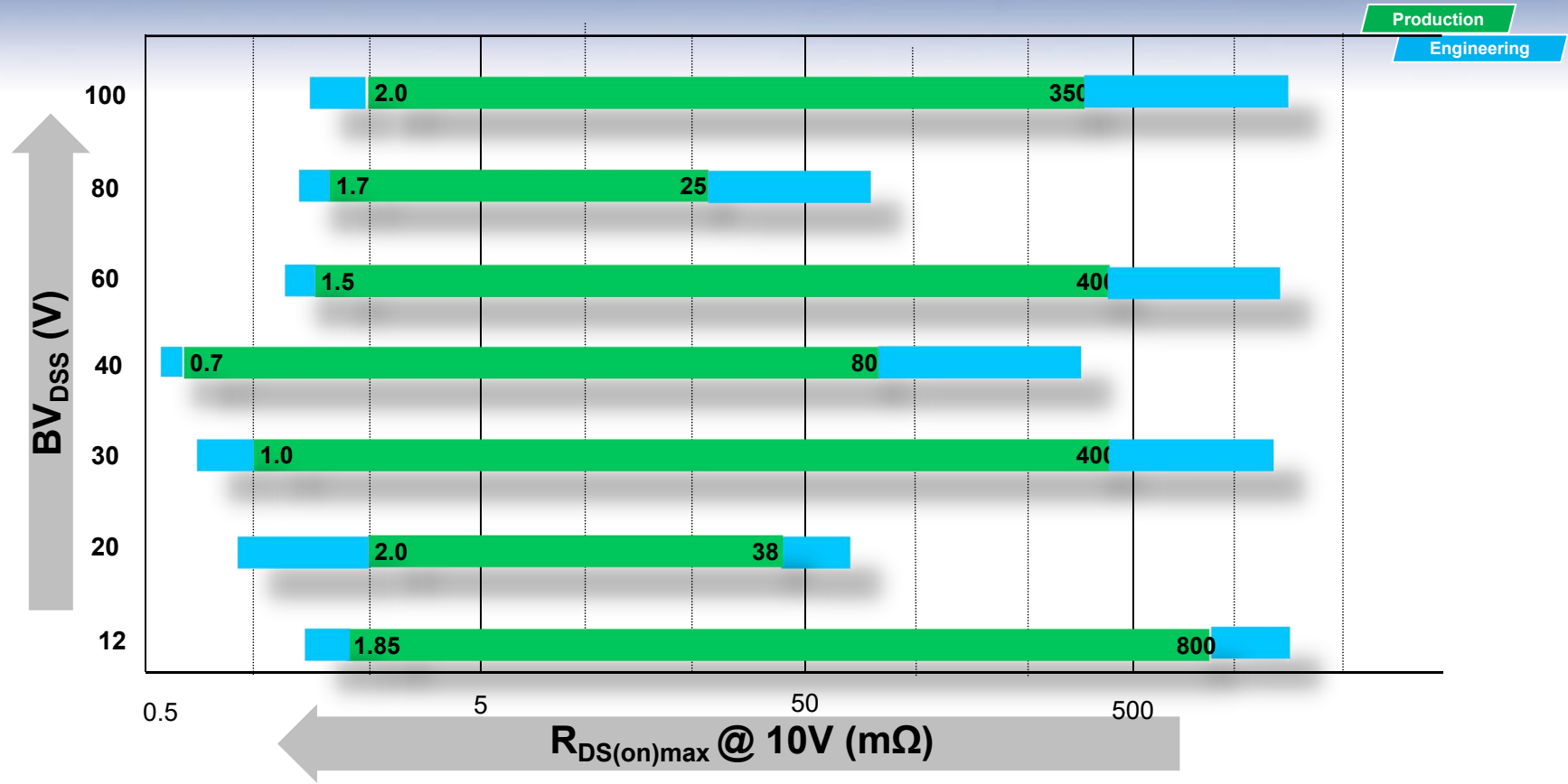
### Occasional New Products in "Older" Packages

SO-8

TO252 (DPak)

TO263 (D2PAK)

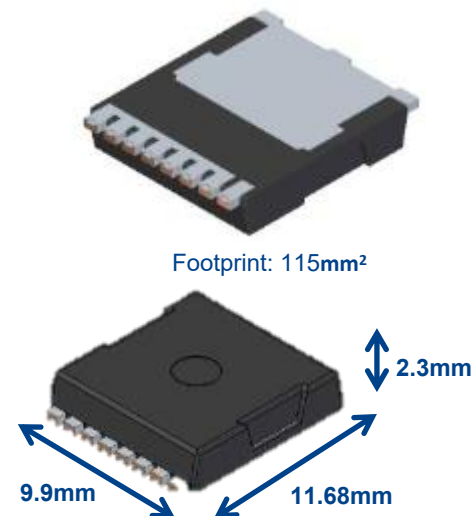
# MOSFET Product Portfolio (12 – 150V)



# Diodes TOLL (PD1012S) Product Portfolio

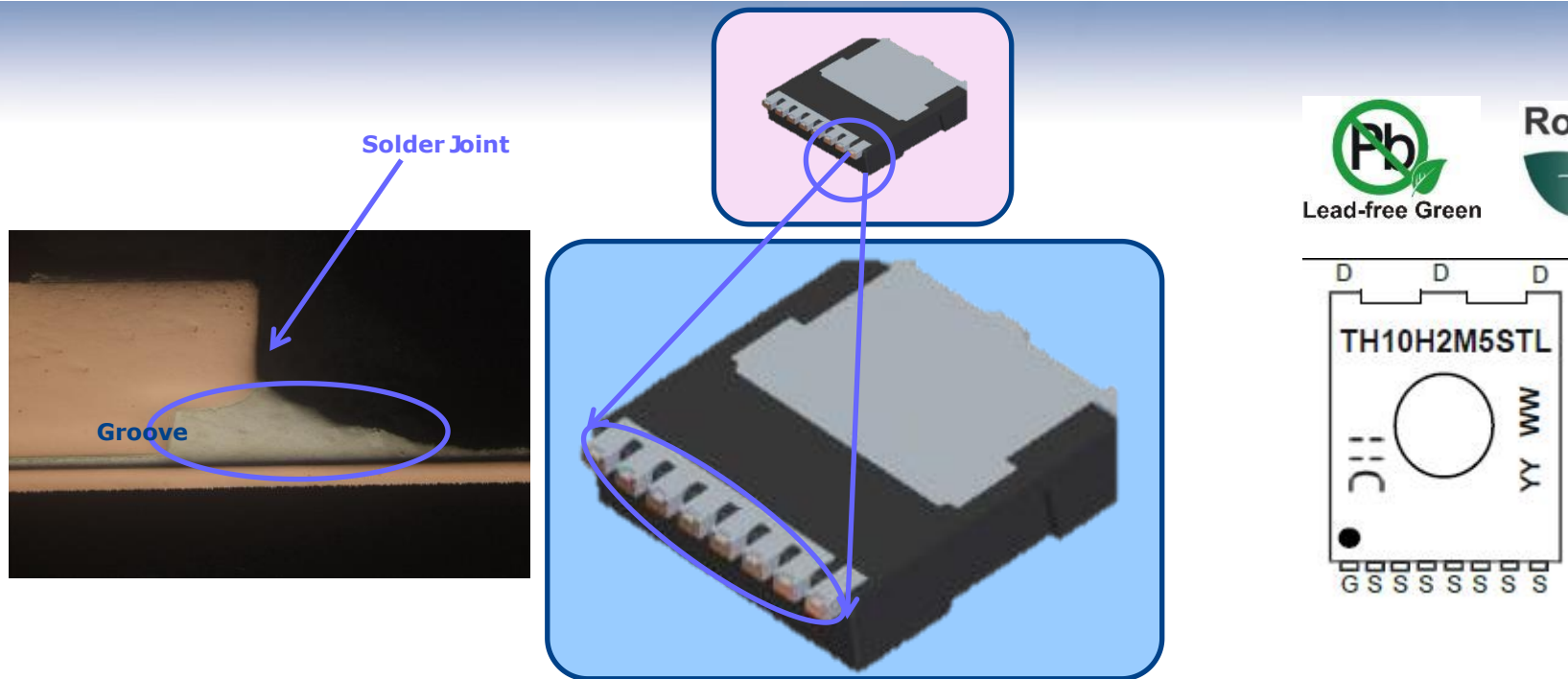
| Parts                  | Package      | Polarity | V <sub>DS</sub> (V) | V <sub>gss</sub> (V) | ID (A) | Vgsth (V) | Max R <sub>DS(on)</sub> @10V (mΩ) | Qg typ @Vgs=10V (nC) | Ciss (pf) @25V <sub>DSS</sub> | E <sub>AS</sub> (mJ) | I <sub>AS</sub> (A) | Max Tj | Availability |
|------------------------|--------------|----------|---------------------|----------------------|--------|-----------|-----------------------------------|----------------------|-------------------------------|----------------------|---------------------|--------|--------------|
| <b>DMTH4001STLWQ</b>   | PowerDI1012S | N        | 40                  | 20                   | 300    | 2 – 4     | 1.0                               | 150                  | 13185                         | 760                  | 76                  | 175    | Released     |
| <b>DMTH8001STLWQ</b>   | PowerDI1012S | N        | 80                  | 20                   | 231    | 2 – 4     | 1.7                               | 138                  | 8894                          | 1104                 | 47                  | 175    | Released     |
| <b>DMTH8003STLWQ</b>   | PowerDI1012S | N        | 80                  | 20                   | 239    | 2 – 4     | 2.5                               | 136.5                | 8614                          | 800                  | 73                  | 175    | Q2'22        |
| <b>DMTH10H1M7STLWQ</b> | PowerDI1012S | N        | 100                 | 20                   | 267    | 2 - 4     | 2                                 | 147                  | 9871                          | 800                  | 73                  | 175    | Released     |
| <b>DMTH10H2M5STLWQ</b> | PowerDI1012S | N        | 100                 | 20                   | 248    | 2 – 4     | 2.5                               | 124                  | 8450                          | 701                  | 68                  | 175    | Released     |

- Footprint only 115mm<sup>2</sup> vs 150mm<sup>2</sup> for D2PAK, 60% smaller than D2Pak
- Package height of only 2.3mm PKG height vs 4.5mm for
- low R<sub>thjc</sub> for better thermal performance
- Low parasitic inductances for improved EMI
- Up to 300A current capability enables higher power density designs
- Enables a visual inspection due to Tin plated grooved leads
- Footprint compatible with Infineon/On Semi/AOS/
- Applications: 48V power system/high power Motors/Battery switch





# Diodes TOLL support Visual Inspection - AOI



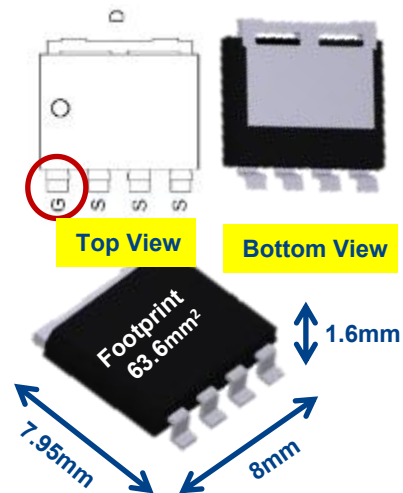
- Trapezoid Groove on the tips of gate and source contacts
- Wettable Flank for Improved Optical Inspection
- Terminals: Finish – Matte Tin Annealed over Copper Lead frame.  
Solderable per MIL-STD-202, Method 208



# PowerDI8080 – DMTH4M70SPGWQ

| Brand    | Parts                            | Package         | Polarity | V <sub>DS</sub><br>(V) | V <sub>gss</sub><br>(V) | ID (A)<br>Tc@<br>25C | Vgsth<br>(V) | Max<br>R <sub>DS(on)</sub><br>@10V<br>(mΩ) | Qg<br>@Vgs<br>=10V<br>(nC) | Ciss. @<br>50V <sub>DSS</sub><br>(pF) | Tj<br>(Max) | Status   |
|----------|----------------------------------|-----------------|----------|------------------------|-------------------------|----------------------|--------------|--------------------------------------------|----------------------------|---------------------------------------|-------------|----------|
| DIODES   | DMTH4M70SPGW*<br>DMTH4M70SPGWQ** | PowerDI8080-4   | N        | 40                     | 20                      | 460                  | 2 – 4        | 0.7                                        | 117.1                      | 10053                                 | 175         | Released |
| Onsemi   | ZVMTS0D7N04C                     | DFNW8           | N        | 40                     | 20                      | 430                  | 2 – 4        | 0.67                                       | 140                        | 9281                                  | 175         | Released |
| Nexperia | BUK7S0R7-40H                     | LFPAK88         | N        | 40                     | 20                      | 425                  | 2.4 – 3.6    | 0.7                                        | 144                        | 11228                                 | 175         | Released |
| Vishay   | SQJQ144AE                        | PowerPAK 8 x 8L | N        | 40                     | 20                      | 575                  |              | 0.9                                        | 116                        | 7220                                  | 175         | Released |

- Footprint only 63.6mm<sup>2</sup> vs 150mm<sup>2</sup> for D2PAK, only 1.6mm PKG height vs 4.5mm for D2PAK, **85% space reduction** than D2PAK
- Clip design for low parasitic inductances and low R<sub>thjc</sub> for better thermal performance
- Design for PCB constrained high current automotive applications
- Gull Wing leads for High reliability
- Better FOM factor
- Pin function compatible with Nexperia/ Onsemi (**Pin 1: Gate, Pin 2~4: Source, Top: Drain**)
- Applications: 12V High Power system/LED lighting/OBC/Driving Solenoids ..etc.



# 175C rated 30V/40V Automotive Compliant N channel MOSFET <4mohm

| Product       | Polarity | V <sub>DS</sub> (V) | V <sub>GS</sub> (V) | I <sub>D</sub> (A) | V <sub>GSTH</sub> (V) | R <sub>DSON</sub> @ V <sub>GS</sub> =10V | R <sub>DSON</sub> @ V <sub>GS</sub> =4.5V | Qg (nC) @ V <sub>GS</sub> =10V | Ciss (Pf) @ 1/2 VDS | E <sub>AS</sub> (mJ) | I <sub>AS</sub> (A) | Tj (°C) | Package       | Availability |
|---------------|----------|---------------------|---------------------|--------------------|-----------------------|------------------------------------------|-------------------------------------------|--------------------------------|---------------------|----------------------|---------------------|---------|---------------|--------------|
| DMTH31M7LPSQ  | N        | 30                  | 20                  | 100                | 1 to 3                | 1.7                                      | 2.4                                       | 5741                           | 90                  | 215                  | 65                  | 175     | PowerDI5060   | Released     |
| DMTH32M5LPSQ  | N        | 30                  | 20                  | 170                | 1 to 3                | 2.2                                      | 3.2                                       | 68                             | 3944                | 140                  | 50                  | 175     | PowerDI5060   | Released     |
| DMTH3004LPSQ  | N        | 30                  | 20                  | 145                | 1 to 3                | 3.8                                      | 6                                         | 44                             | 2370                | 110                  | 11                  | 175     | PowerDI5060   | Released     |
| DMTH3004LK3Q  | N        | 30                  | 20                  | 75                 | 1 to 3                | 4                                        | 7                                         | 44                             | 2370                | 110                  | 11                  | 175     | TO252 (DPAK)  | Released     |
| DMTH3004LFGQ  | N        | 30                  | 20                  | 91                 | 1 to 3                | 5.5                                      | 8.5                                       | 44                             | 2370                | 110                  | 11                  | 175     | PowerDI3333   | Released     |
| DMTH4M70SPGWQ | N        | 40                  | 20                  | tbc                | 2 to 4                | 0.7                                      | -                                         | tbc                            | tbc                 | tbc                  | tbc                 | 175     | PowerDI8080   | Q4 2021      |
| DMTH4M90SPSQ  | N        | 40                  | 20                  | 100                | 2 to 4                | 0.9                                      | -                                         | 144                            | 10737               | 434                  | 93                  | 175     | PowerDI5060   | Q2 2022      |
| DMTH4001SPSQ  | N        | 40                  | 20                  | 100                | 2 to 4                | 1                                        | -                                         | 143                            | 10737               | 440                  | 94                  | 175     | PowerDI5060   | NRND         |
| DMTH4M95SPSQ  | N        | 40                  | 20                  | 100                | 2 to 4                | 1                                        | -                                         | tbc                            | tbc                 | tbc                  | tbc                 | 175     | PowerDI5060   | Q2 22        |
| DMTH41M8LPSQ  | N        | 40                  | 20                  | 204                | 2 to 4                | 1.8                                      | -                                         | 79                             | 6968                | 265                  | 73                  | 175     | PowerDI5060   | Released     |
| DMTH42M3LPSQ  | N        | 40                  | 20                  | TBD                | 1 to 3                | 2.3                                      | 4.2                                       | tbc                            | tbc                 | tbc                  | Tbc                 | 175     | PowerDI5060   | Q2 2022      |
| DMTH4004SPSQ  | N        | 40                  | 20                  | 100                | 2 to 4                | 2.7                                      | -                                         | 60                             | 3714                | 200                  | 45                  | 175     | PowerDI5060   | Released     |
| DMTH4004LPSQ  | N        | 40                  | 20                  | 100                | 1 to 3                | 2.5                                      | 5                                         | 69                             | 5220                | 283                  | 53                  | 175     | PowerDI5060   | Released     |
| DMTH4004LK3Q  | N        | 40                  | 20                  | 100                | 1 to 3                | 3                                        | 5                                         | 83                             | 4450                | 90                   | 30                  | 175     | TO252 (DPAK)  | Released     |
| DMTH4004SCTBQ | N        | 40                  | 20                  | 100                | 2 to 4                | 3                                        | -                                         | 69                             | 4305                | 200                  | 45                  | 175     | TO263 (D2PAK) | Released     |
| DMTH43M8LFGQ  | N        | 40                  | 20                  | 100                | 1 to 2.5              | 3                                        | 5                                         | 40                             | 2798                | 165                  | 13                  | 175     | PowerDI3333   | Released     |
| DMTH43M8LPSQ  | N        | 40                  | 20                  | 100                | 1 to 2.5              | 3.3                                      | 5                                         | 38.5                           | 2693                | 87                   | 13                  | 175     | PowerDI5060   | Released     |
| DMTH43M8LK3Q  | N        | 40                  | 20                  | 119                | 1 to 2.4              | 3.6                                      | 5.2                                       | 38                             | 2693                | 87                   | 13                  | 175     | TO252 (DPAK)  | Released     |
| DMTH43M8LPDQ  | N+N      | 40                  | 20                  | 100                | 1 to 2.5              | 3.6                                      | 5.2                                       | 38.5                           | 2693                | 87                   | 13                  | 175     | PowerDI5060   | Q4 2021      |
| DMTH4005SPSQ  | N        | 40                  | 20                  | 90                 | 2 to 4                | 3.7                                      | -                                         | 49                             | 3062                | 53                   | 32                  | 175     | PowerDI5060   | Released     |

# Typical application - Brushless DC (BLDC) Motor Control

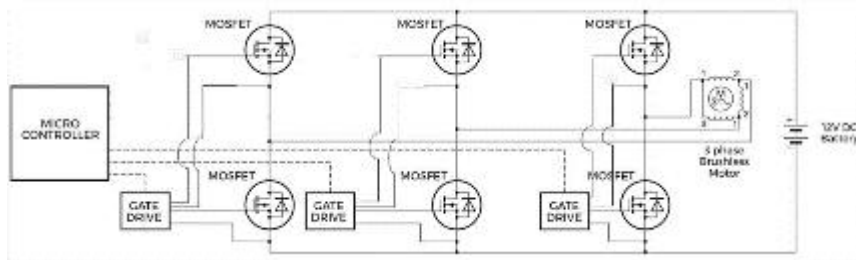
## MOSFET REQUIREMENTS FOR BLDC

- **Low RDS(ON)** – Reduced conduction losses
- **Low QGD** – Reduced switching losses
- **100% Avalanche Rated** – Ensures robust design able to withstand the reverse avalanche energy generated by the BLDC.
- **Rated to 175° C** – For use in high ambient temperature environments.
- **Low Thermal Resistance Package** – Maintain low operating temperature

## Highlighted Product

|               |                       |
|---------------|-----------------------|
| DMTH40001SPSQ | High Power BLDC       |
| DMTH43M8LPSQ  | Low Power BLDC (300W) |

- Brushless DC (BLDC) Motor control provides improved performance, longer lifetime, reduced noise and greater ease of use when compared to equivalent mechanical solutions.
- Consequently, three phase BLDC systems are widely used in Automotive applications such as fuel pumps, water pumps, Anti-Lock Braking Systems (ABS) and provide additional torque for Power steering systems.
- In BLDC motor systems, MOSFETs are typically configured in a three phase bridge arrangement to drive the DC motor and must be capable of handling start-up and stalled motor currents of up to six times the continuous current rating of the motor.



# New Product Highlight 2 : DMTH4008LFDFWQ - Released

## The Diodes Advantage

- **40V 11mOhm N MOS in DFN2020**
- **Low  $R_{DS(on)}$**   
Minimising on state losses ensures power dissipation is reduced
- **Rated to 175C**  
AEC-Q101 Qualified at 175°C → ideal for high temperature ambient use
- **Low profile, small footprint package**  
Occupies 10% PCB footprint of larger packages, such as SOT223 package, enabling designers to shrink designs whilst maintaining performance.
- **Higher power density**  
These DFN leadless package is thermally efficient with a thermal resistance of only 14.8 °C/W enabling a greater power density to be achieved.
- **Automotive Compliant**  
AEC-Q101 Qualified, manufactured in IATF 16949 certified sites and PPAP capable

Note: More on our website, search for “FDE” or “FDF”.



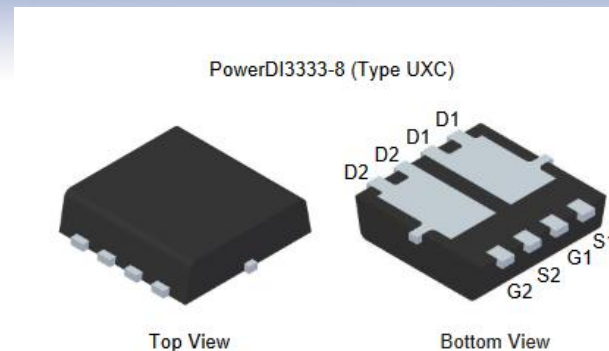
## Applications:

- DMT series for DC-DC conversion
- Load Switch

# Industry first Dual PowerDI3333-8

## The Diodes Advantage

- **Low Figure of Merit ( $R_{DS(on)} \times Q_g$ )**  
Minimizing on-state losses ensures power dissipation is reduced
- **PD3333**  
Occupies just 46% PCB footprint of SOT223 package, enabling designers to shrink designs whilst maintaining performance.
- **Higher power density**  
DFN leadless package is thermally efficient with a thermal resistance of only 8.4 °C/W → greater power density.
- **Automotive Compliant**  
AEC-Q101 Qualified, manufactured in IATF 16949 certified sites and PPAP capable



## Applications:

- DC-DC conversion
- Load Switch

| Product        | Polarity | $V_{DS}$<br>(V) | $V_{GS}$<br>(V) | $I_D$<br>(A) | $V_{GSTH}$<br>(V) | $R_{(DS(on))}$<br>@10V <sub>G</sub><br>s | $R_{(DS(on))}$<br>@4.5V <sub>G</sub><br>s | $Q_g$<br>(nC)<br>@10V <sub>G</sub><br>s | Ciss (Pf)<br>typ<br>@ 1/2<br>VDS | $E_{AS}$<br>(mJ) | $I_{AS}$<br>(A) | Tj<br>(°C) | Package           |
|----------------|----------|-----------------|-----------------|--------------|-------------------|------------------------------------------|-------------------------------------------|-----------------------------------------|----------------------------------|------------------|-----------------|------------|-------------------|
| DMT47M2SLDVQ   | N+N      | 40              | 20              | 30           | 1.2 to 2.3        | 11                                       | 15                                        | 14                                      | 891                              | 24               | 22              | 150        | PowerDI3333       |
| DMTH4014LDVWQ  | N+N      | 40              | 20              | 39           | 1 to 3            | 15                                       | 25                                        | 11.2                                    | 750                              | 19.6             | 19.8            | 175        | PowerDI3333 (SWP) |
| DMTH6015LDVWQ* | N+N      | 60              | 20              | 19.7         | 1.3 to 2.5        | 20.5                                     | 27                                        | 14.3                                    | 825                              | 20.8             | 20.4            | 175        | PowerDI3333       |

# 175C rated 30V/40V Automotive Compliant N channel MOSFET >4mohm

| Product       | Polarity | V <sub>DS</sub><br>(V) | V <sub>GS</sub><br>(V) | I <sub>D</sub><br>(A) | V <sub>GSTH</sub><br>(V) | R <sub>(DS(on))</sub><br>@10V<br>V <sub>GS</sub> | R <sub>(DS(on))</sub><br>@4.5V<br>V <sub>GS</sub> | Qg (nC)<br>@<br>V <sub>GS</sub> =10V | Ciss (Pf)<br>typ<br>@ 1/2 VDS | E <sub>AS</sub><br>(mJ) | I <sub>AS</sub><br>(A) | Tj<br>(°C) | Package           | Availability |
|---------------|----------|------------------------|------------------------|-----------------------|--------------------------|--------------------------------------------------|---------------------------------------------------|--------------------------------------|-------------------------------|-------------------------|------------------------|------------|-------------------|--------------|
| DMTH4005SK3Q  | N        | 40                     | 20                     | 90                    | 2 to 4                   | 4.5                                              | -                                                 | 49                                   | 3062                          | 53                      | 32                     | 175        | TO252 (DPak)      | Released     |
| DMTH45M5LFVWQ | N        | 40                     | 20                     | TBC                   | 1 to 2                   | 5.5                                              | 7.9                                               | TBC                                  | TBC                           | TBC                     | TBC                    | 175        | PowerDI3333(SWP)  | Q2 2022      |
| DMTH45M5LPSWQ | N        | 40                     | 20                     | TBC                   | 1 to 2                   | 5.5                                              | 7.9                                               | TBC                                  | TBC                           | TBC                     | TBC                    | 175        | PowerDI5060(SWP)  | Q2 2022      |
| DMTH45M5LPDWQ | N+N      | 40                     | 20                     | TBC                   | 1 to 2                   | 5.5                                              | 7.9                                               | TBC                                  | TBC                           | TBC                     | TBC                    | 175        | PowerDI5060(SWP)  | Q2 2022      |
| DMTH45M5SPSWQ | N        | 40                     | 20                     | TBC                   | 2 to 4                   | 5.5                                              | TBC                                               | TBC                                  | TBC                           | TBC                     | TBC                    | 175        | PowerDI5060(SWP)  | Q2 2022      |
| DMTH45M5SPDWQ | N+N      | 40                     | 20                     | TBC                   | 2 to 3.5                 | 5.5                                              | TBC                                               | TBC                                  | TBC                           | TBC                     | TBC                    | 175        | PowerDI5060(SWP)  | Q2 2022      |
| DMTH4007LPSQ  | N        | 40                     | 20                     | 100                   | 1 to 3                   | 6.5                                              | 9.8                                               | 29                                   | 2492                          | 20                      | 20                     | 175        | PowerDI5060       | Released     |
| DMTH4007LK3Q  | N        | 40                     | 20                     | 70                    | 1 to 3                   | 7.3                                              | 9.8                                               | 29                                   | 1895                          | 20                      | 20                     | 175        | TO252 (DPAK)      | Released     |
| DMTH47M2LPSWQ | N        | 40                     | 20                     | TBC                   | 1.2 to 2.3               | 7.3                                              | 12                                                | 14                                   | 891                           | 24                      | 22                     | 175        | PowerDI5060 (SWP) | Released     |
| DMTH48M3SFVWQ | N        | 40                     | 20                     | TBC                   | 2 to 4                   | 8.3                                              | -                                                 | 12                                   | 897                           | 35                      | 27                     | 175        | PowerDI3333 (SWP) | Released     |
| DMTH4007LK3Q  | N        | 40                     | 20                     | 70                    | 1 to 3                   | 7.3                                              | 9.8                                               | 29                                   | 1895                          | 20                      | 20                     | 175        | TO252 (DPAK)      | Released     |
| DMTH4007SPDQ  | N        | 40                     | 20                     | 18                    | 2 to 4                   | 8.6                                              | -                                                 | 42                                   | 2026                          | 89                      | 24                     | 175        | PowerDI5060       | Released     |
| DMTH4007SPSQ  | N        | 40                     | 20                     | 50                    | 1 to 3                   | 7.6                                              | -                                                 | 42                                   | 2082                          | 60                      | 20                     | 175        | PowerDI5060       | Released     |
| DMTH47M2LFVWQ | N        | 40                     | 20                     | 50                    | 1 to 3                   | 8.9                                              | 13.5                                              | 12.3                                 | 881                           | 26.6                    | 23.1                   | 175        | PowerDI5060       | Q2 2022      |
| DMT47M2SLDVQ  | N+N      | 40                     | 20                     | 30                    | 1.2 to 2.3               | 11                                               | 15                                                | 14                                   | 891                           | 24                      | 22                     | 150        | PowerDI3333       | Released     |
| DMTH4008LDFWQ | N        | 40                     | 20                     | 12                    | 1 to 3                   | 11.5                                             | 18                                                | 14                                   | 1030                          | 32                      | 14                     | 175        | DFN2020-6 (SWP)   | Released     |
| DMTH4008LPDWQ | N+N      | 40                     | 20                     | 55                    | 1 to 3                   | 12.3                                             | 20                                                | 17.6                                 | 1000                          | 27                      | 23                     | 175        | PowerDI5060 (SWP) | Released     |
| DMTH4008LPSQ  | N        | 40                     | 20                     | 65                    | 1 to 3                   | 8.8                                              | 13                                                | 15                                   | 1088                          | 26                      | 26                     | 175        | PowerDI5060       | Released     |
| DMTH4011SPDQ  | N+N      | 40                     | 20                     | 55                    | 1 to 3                   | 12                                               | 18.5                                              | 15                                   | 767                           | 238                     | 30                     | 175        | PowerDI5060       | Released     |
| DMTH4014LFVWQ | N        | 40                     | 20                     | 55                    | 1 to 3                   | 14                                               | 19                                                | 15                                   | 767                           | 21                      | 12                     | 175        | PowerDI3333       | Released     |
| DMTH4014LDVWQ | N+N      | 40                     | 20                     | 39                    | 1 to 3                   | 15                                               | 25                                                | 11.2                                 | 750                           | 19.6                    | 19.8                   | 175        | PowerDI3333 (SWP) | Released     |
| DMTH4014LPSWQ | N        | 40                     | 20                     | 43.5                  | 1 to 3                   | 14.5                                             | 25                                                | 11.2                                 | 750                           | 19.6                    | 19.8                   | 175        | PowerDI5060 (SWP) | Released     |
| DMTH4014SPSWQ | N        | 40                     | 20                     | 43.5                  | 2 to 4                   | 14.8                                             | -                                                 | 10.6                                 | 805                           | 19.4                    | 19.7                   | 175        | PowerDI5060 (SWP) | Released     |
| DMTH4014LPDQ  | N+N      | 40                     | 20                     | 44                    | 1 to 3                   | 15                                               | 25                                                | 10                                   | 733                           | 21                      | 12                     | 175        | PowerDI5060       | Released     |



# MOSFETs for DC to DC Conversion

## MOSFET REQUIREMENTS FOR DCDC CONVERSION

- **High Side MOSFET (Q1)**
  - Low gate charge ( $Q_{GD}$ )
  - Low gate resistance ( $R_g$ )
  - Low input capacitance ( $C_{iss}$ )
- **Low Side MOSFET (Q2)**
  - Low  $R_{DS(ON)}$  – minimise conduction losses
  - **100% Avalanche Rated** – Ensures robust design able to withstand the reverse avalanche energy generated by the BLDC.

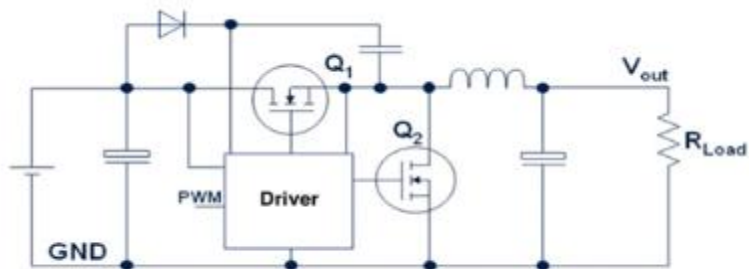


Figure 1: The architecture of a typical synchronous DC/DC converter.

## Highlighted Product

|                |           |
|----------------|-----------|
| DMTH4008LFDFWQ | High Side |
| DMTH43M8LFGQ   | Low Side  |

- As well as the nominal maximum power that the DC/DC converter can deliver, the two MOSFETs need to handle voltage spikes caused by parasitic inductances and a current level equal to the maximum output current, plus 50 percent of the ripple current. The losses from the high side (Q1 and low side (Q2) are important. Not only will static losses from the on-resistance through the transistor cause lower efficiency, but so will losses incurred during switching.
- **Q1 – High Side MOSFET**  
In high frequency synchronous conversion topologies the high side MOSFET can often be switched at frequencies twice that of the low side MOSFET. Therefore, the Gate charge, gate resistance and input capacitance are key parameters.
- **Q2 – Low side MOSFET**  
The low side MOSFET is usually conduction losses ( $R_{dson}$ ) dominated with additional conduction losses for dead time.



# 175C rated 60V Automotive Compliant N channel MOSFET <10mOhm

| Product       | V <sub>DS</sub> | V <sub>GS</sub> | I <sub>D</sub> | V <sub>GSTH</sub> | R <sub>(DS(on))</sub><br>@V <sub>GS</sub> = |      | Q <sub>g</sub><br>@V <sub>GS</sub> = | Typ Ciss<br>@ ½ V <sub>DS</sub> | E <sub>AS</sub> | I <sub>AS</sub> | T <sub>j</sub> | Package           | Status   |
|---------------|-----------------|-----------------|----------------|-------------------|---------------------------------------------|------|--------------------------------------|---------------------------------|-----------------|-----------------|----------------|-------------------|----------|
|               | V               | V               | A              | V                 | 10V                                         | 4.5V | @10V                                 | pF                              | mJ              | A               | °C             |                   |          |
|               |                 |                 |                |                   | mΩ                                          | mΩ   | nC                                   |                                 |                 |                 |                |                   |          |
| DMTH61M5SPSWQ | 60              | 20              | 225            | 2 to 4            | 1.5                                         | -    | 131                                  | 8306                            | 641             | 36              | 175            | PowerDI5060 (SWP) | Released |
| DMTH61M8LPSWQ | 60              | 20              | 225            | 1 to 3            | 1.6                                         | 2.8  | 115                                  | 8320                            | 605             | 35              | 175            | PowerDI5060 (SWP) | Released |
| DMTH61M8SPSQ  | 60              | 20              | 100            | 2 to 4            | 1.6                                         | -    | 131                                  | 8306                            | 641             | 36              | 175            | PowerDI5060       | Released |
| DMTH6002LPSWQ | 60              | 20              | 100            | 1 to 3            | 2                                           | 3.3  | 131                                  | 8299                            | 661             | 21              | 175            | PowerDI5060       | Released |
| DMTH6004LPSQ  | 60              | 20              | 100            | 1 to 3            | 3.1                                         | 4.5  | 78                                   | 5339                            | 160             | 40              | 175            | PowerDI5060       | Released |
| DMTH6004SPSQ  | 60              | 20              | 100            | 2 to 4            | 3.1                                         | -    | 95                                   | 4556                            | 200             | 45              | 175            | PowerDI5060       | Released |
| DMTH6004SCTBQ | 60              | 20              | 100            | 2 to 4            | 3.4                                         | -    | 95                                   | 4556                            | 200             | 45              | 175            | TO263 (D2PAK)     | Released |
| DMTH6004SK3Q  | 60              | 20              | 100            | 2 to 4            | 3.8                                         | -    | 95                                   | 4556                            | 200             | 45              | 175            | TO252 (DPAK)      | Released |
| DMTH6005LFGQ  | 60              | 20              | 100            | 1 to 2.5          | 4.1                                         | 7    | 49                                   | 3150                            | 171             | 18              | 175            | PowerDI3333       | Q2 2022  |
| DMTH6005LK3Q  | 60              | 20              | 90             | 1 to 3            | 5.6                                         | 10   | 47                                   | 2962                            | 83              | 41              | 175            | TO252 (DPAK)      | Released |
| DMTH6005LPSQ  | 60              | 20              | 100            | 1 to 3            | 5.5                                         | 10   | 47                                   | 2962                            | 98              | 15              | 175            | PowerDI5060       | Released |
| DMTH6006LPSWQ | 60              | 20              | 100            | 1 to 2.5          | 6.5                                         | 10   | 35                                   | 2162                            | 41              | 28              | 175            | PowerDI5060 (SWP) | Released |
| DMTH6010SK3Q  | 60              | 20              | 70             | 2 to 4            | 8                                           | -    | 30                                   | 2841                            | 20              | 27              | 175            | TO252 (DPAK)      | Released |
| DMTH6010LK3Q  | 60              | 20              | 70             | 1 to 3            | 8                                           | 12   | 41                                   | 2090                            | 20              | 20              | 175            | TO252 (DPAK)      | Released |
| DMTH6010LPSQ  | 60              | 20              | 80             | 1 to 3            | 8                                           | 12   | 41                                   | 2090                            | 20              | 20              | 175            | PowerDI5060       | Released |
| DMTH6010LPSWQ | 60              | 20              | 80             | 1 to 3            | 8                                           | 12   | 41                                   | 2090                            | 20              | 20              | 175            | PowerDI5060 (SWP) | Released |
| DMTH69M8LFVWQ | 60              | 16              | 45             | 1 to 3            | 9.5                                         | 13.3 | 33                                   | 1925                            | 45              | 30              | 175            | PowerDI3333 (SWP) | Released |

# 175C rated 60V Automotive Compliant N channel MOSFET >10mOhm

| Product        | Polarity | V <sub>DS</sub> (V) | V <sub>GS</sub> (V) | I <sub>D</sub> (A) | V <sub>GSTH</sub> (V) | R <sub>DS(on)</sub> @10V V <sub>GS</sub> | R <sub>DS(on)</sub> @4.5V V <sub>GS</sub> | Qg (nC) @ V <sub>GS</sub> =10V | Ciss (Pf) typ @ 1/2 VDS | E <sub>AS</sub> (mJ) | I <sub>AS</sub> (A) | Tj (°C) | Package           |
|----------------|----------|---------------------|---------------------|--------------------|-----------------------|------------------------------------------|-------------------------------------------|--------------------------------|-------------------------|----------------------|---------------------|---------|-------------------|
| DMTH6009LK3Q   | N        | 60                  | 20                  | 59                 | 0.7 to 2              | 10                                       | 13.8                                      | 33                             | 1925                    | 20                   | 20                  | 175     | TO252 (DPAK)      |
| DMTH6009LPSQ   | N        | 60                  | 20                  | 89                 | 0.7 to 2              | 10                                       | 12                                        | 33                             | 1925                    | 20                   | 20                  | 175     | PowerDI5060       |
| DMTH6010LPDQ   | N+N      | 60                  | 20                  | 47                 | 1 to 3                | 11                                       | 16                                        | 40                             | 2615                    | 20                   | 20                  | 175     | PowerDI5060       |
| DMTH6012LPSWQ  | N        | 60                  | 20                  | 51                 | 1 to 2.5              | 14                                       | 21                                        | 14                             | 785                     | 8                    | 13                  | 175     | PowerDI5060 (SWP) |
| DMTH6016LPSQ   | N        | 60                  | 20                  | 37                 | 1 to 3                | 16                                       | 24                                        | 17                             | 864                     | 12                   | 15                  | 175     | PowerDI5060       |
| DMTH6016LK3Q   | N        | 60                  | 20                  | 46                 | 1 to 3                | 17                                       | 24                                        | 17                             | 864                     | 12                   | 15                  | 175     | TO252 (DPAK)      |
| DMTH6016LFDFWQ | N        | 60                  | 20                  | 9                  | 1 to 3                | 18                                       | 27,5                                      | 15                             | 925                     | 12                   | 15                  | 175     | DFN2020-6 (SWP)   |
| DMTH6016LFVWQ  | N        | 60                  | 20                  | 41                 | 1 to 2.5              | 16                                       | 27                                        | 15                             | 939                     | 16                   | 15                  | 175     | PowerDI3333 (SWP) |
| DMTH6016LSDQ   | N+N      | 60                  | 20                  | 8                  | 1 to 2.5              | 19.5                                     | 28                                        | 17                             | 864                     | 12                   | 15                  | 175     | SO-8              |
| DMTH6016LPDQ   | N+N      | 60                  | 20                  | 8                  | 1 to 2.5              | 19                                       | 28                                        | 17                             | 864                     | 12                   | 15                  | 175     | PowerDI5060       |
| DMTH6015LDVWQ* | N+N      | 60                  | 20                  | 19.7               | 1.3 to 2.5            | 20.5                                     | 27                                        | 14.3                           | 825                     | 20.8                 | 20.4                | 175     | PowerDI3333       |
| DMTH6015LPDWQ* | N+N      | 60                  | 20                  | 36.3               | 1.3 to 2.5            | 20                                       | 27                                        | 14.3                           | 825                     | 20.8                 | 20.4                | 175     | PowerDI5060       |

\* = ESD gate protection diodes

| Parts         | Package     | Polarity | V <sub>DS</sub><br>(V) | V <sub>gss</sub><br>(V) | ID<br>(A) | Vgsth<br>(V) | R <sub>DS(on)</sub> MAX<br>(mΩ) |       | Qg typ<br>@Vgs=10V<br>(nc) | Typ.Ciss<br>@25V <sub>DSS</sub><br>(pf) | E <sub>AS</sub><br>(mJ) | I <sub>AS</sub><br>(A) | Tj max<br>(°C) | Availability |
|---------------|-------------|----------|------------------------|-------------------------|-----------|--------------|---------------------------------|-------|----------------------------|-----------------------------------------|-------------------------|------------------------|----------------|--------------|
|               |             |          |                        |                         |           |              | @10V                            | @4.5V |                            |                                         |                         |                        |                |              |
| DMNH6035SPDWQ | PowerDI5060 | N+N      | 60                     | 20                      | 33        | 1 to 3       | 35                              | 44    |                            | 879                                     | 230                     | 21                     | 175            | Released     |
| DMNH6065SPDWQ | PowerDI5060 | N+N      | 60                     | 20                      | 27        | 1 to 3       | 65                              | 79    | 9.5                        | 466                                     | 89                      | 13                     | 175            | Released     |
| DMNH6065SSDQ  | SO8         | N+N      | 60                     | 20                      | TBC       | 1 to 3       | 65                              | 79    | 9.5                        | 466                                     | 89                      | 13                     | 175            | Released     |

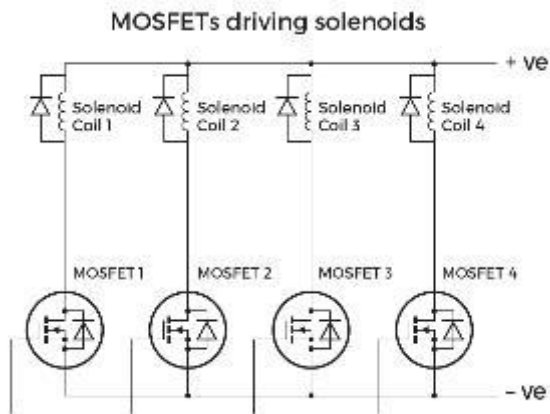
## Features

- Planar MOSFETs have a superior SOA and UIS capability than Trench MOSFETs
- This capability is required in specific Automotive applications – injector coils.
- Optimised for avalanche
- Rated to 175C
- Automotive compliant
  - AEC Qualified, in IATF 16949 manufacturing sites supporting PPAP

# MOSFETs for Driving Solenoids

## MOSFET REQUIREMENTS FOR DRIVING SOLENOIDS

- **Low RDS(ON)** – Reduced conduction losses
- **100% Avalanche Rated** – Ensures robust design able to withstand the reverse avalanche energy generated by the solenoid coil.
- **Rated to 175° C** – For use in high ambient temperature environments.
- **Low Thermal Resistance Package** – Maintain low operating temperature



## Highlighted Product

DMNH6035SPDWQ

Driving two Solenoids

DMNH6065SPDWQ

Driving two solenoids

- Solenoids are simple electromechanical devices that consist of an electromagnet and a ferromagnetic piston that is 'pushed' or 'pulled' as current flows through the inductive component.
- A MOSFET is typically used to drive a solenoid as it can provide the voltage across the solenoid winding for it to energize and also provides, via the body diode, an alternate path for when the solenoid is de-energized. When the solenoid de-energizes the current will flow via the recirculating diode but will also present reverse avalanche energy to the MOSFET

# 175C rated 80V/100V Automotive Compliant N channel MOSFET

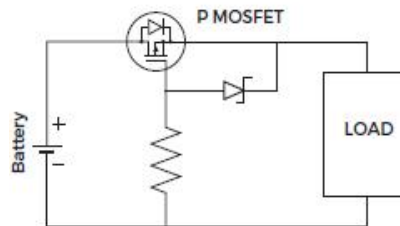
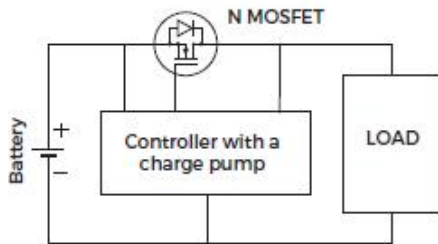
| Product         | Polarity | V <sub>DS</sub><br>(V) | V <sub>GS</sub><br>(V) | I <sub>D</sub><br>(A) | V <sub>GSTH</sub><br>(V) | R <sub>(DS(on))</sub><br>@V <sub>GS</sub> =10V<br>(mΩ) | R <sub>(DS(on))</sub><br>@V <sub>GS</sub> =5V<br>(mΩ) | Qg<br>@ V <sub>GS</sub> =10V<br>(nC) | Ciss<br>@ 1/2 V <sub>DS</sub><br>(Pf) | E <sub>AS</sub><br>(mJ) | I <sub>AS</sub><br>(A) | Tj<br>(°C) | Package           | Availability |
|-----------------|----------|------------------------|------------------------|-----------------------|--------------------------|--------------------------------------------------------|-------------------------------------------------------|--------------------------------------|---------------------------------------|-------------------------|------------------------|------------|-------------------|--------------|
| DMTH84M1SPSQ    | N        | 80                     | 20                     | 100                   | 2 to 4                   | 4                                                      | 5.7@6V                                                | 63                                   | 4209                                  | 264                     | 23                     | 175        | PowerDI5060       | Released     |
| DMTH8008SPSQ    | N        | 80                     | 20                     | 92                    | 2 to 4                   | 7.8                                                    | -                                                     | 34                                   | 1950                                  | 80                      | 40                     | 175        | PowerDI3333       | Released     |
| DMTH8008LPSQ    | N        | 80                     | 20                     | 91                    | 1 to 3                   | 7.8                                                    | 11                                                    | 41                                   | 2345                                  | 26                      | 23                     | 175        | PowerDI3333       | Released     |
| DMTH8008LFGQ    | N        | 80                     | 20                     | 70                    | 2 to 4                   | 6.9                                                    | 10.4                                                  | 38                                   | 2254                                  | 162                     | 18                     | 175        | PowerDI3333       | Released     |
| DMTH8012LK3Q    | N        | 80                     | 20                     | 50                    | 1 to 3                   | 16                                                     | 21                                                    | 46                                   | 2051                                  | 147                     | 80                     | 175        | TO252 (DPAK)      | Released     |
| DMTH8012LPSQ    | N        | 80                     | 20                     | 72                    | 1 to 3                   | 17                                                     | 21                                                    | 46                                   | 2051                                  | 10                      | 12                     | 175        | PowerDI5060       | Released     |
| DMTH8028LPSWQ   | N        | 80                     | 20                     | 32                    | 1 to 3                   | 25                                                     | 38                                                    | 10                                   | 641                                   | 23                      | 13                     | 175        | PowerDI5060 (SWP) | Released     |
| DMTH8028LFVWQ   | N        | 80                     | 20                     |                       | 1 to 3                   |                                                        |                                                       |                                      |                                       |                         |                        | 175        |                   | Released     |
| DMTH8030LPDWQ   | N        | 80                     | 20                     | 28.5                  | 1 to 3                   | 26                                                     | 45                                                    | 10.5                                 | 631                                   | 23                      | 12.5                   | 175        | PowerDI5060 (SWP) | Released     |
| DMTH10H4M5SPSQ  | N        | 100                    | 20                     | 100                   | 2 to 4                   | 4.3                                                    | 6.2                                                   | 80                                   | 4843                                  | 240                     | 40                     | 175        | PowerDI5060       | Released     |
| DMTH10H009SPSQ  | N        | 100                    | 20                     | 100                   | 2 to 4                   | 8.9                                                    | -                                                     | 30                                   | 2085                                  | 181                     | 11                     | 175        | PowerDI5060       | Released     |
| DMTH10H010SPSQ  | N        | 100                    | 20                     | 98                    | 2 to 4                   | 8.5                                                    | -                                                     | 54                                   | 2592                                  | 150                     | 10                     | 175        | PowerDI5060       | Released     |
| DMTH10H015SPSQ  | N        | 100                    | 20                     | 98                    | 2 to 4                   | 15                                                     | 19.5@6V                                               | 54                                   | 2343                                  | 13                      | 16                     | 175        | PowerDI5060       | Released     |
| DMTH10H015SK3Q  | N        | 100                    | 20                     | 53                    | 2 to 4                   | 14                                                     | 20@6V                                                 | 33                                   | 2343                                  | 85                      | 8                      | 175        | TO252 (DPAK)      | Released     |
| DMTH10H015LPSQ  | N        | 100                    | 20                     | 44                    | 1 to 3                   | 16                                                     | 18@6V                                                 | 33                                   | 1871                                  | 85                      | 16                     | 175        | PowerDI5060       | Released     |
| DMTH10H017LPDQ  | N+N      | 100                    | 20                     | 60                    | 2 to 4                   | 17                                                     | 28                                                    | 14                                   | 1968                                  | 150                     | 10                     | 175        | PowerDI5060       | Released     |
| DMTH10H025LPSQ  | N        | 100                    | 20                     | 45                    | 1 to 3                   | 23                                                     | 30@6V                                                 | 21                                   | 1477                                  | 96                      | 8                      | 175        | PowerDI5060       | Released     |
| DMTH10H025LK3Q  | N        | 100                    | 20                     | 45                    | 1.3 to 2.5               | 22                                                     | 30@6V                                                 | 21                                   | 1477                                  | 13                      | 16                     | 175        | TO252 (DPAK)      | Released     |
| DMTH10H032LPSWQ | N        | 100                    | 20                     | 37                    | 1.3 to 2.5               | 32                                                     | 50                                                    | 11.9                                 | 683                                   | 25                      | 13                     | 175        | PowerDI5060 (SWP) | Released     |
| DMTH10H032LPDWQ | N+N      | 100                    | 20                     | 34                    | 1.3 to 2.5               | 32                                                     | 50                                                    | 11.9                                 | 683                                   | 25                      | 13                     | 175        | PowerDI5060 (SWP) | Released     |
| DMTH10H032LFVWQ | N        | 100                    | 20                     | Tbc                   | 1.3 to 2.5               | 32                                                     | 50                                                    | 11.9                                 | 683                                   | 25                      | 13                     | 175        | TO252 (DPAK)      | Released     |
| DMTH10H072LDFWQ | N        | 100                    | 20                     | 11                    | 1.3 to 2.5               | 68                                                     | 116                                                   | tbc                                  | tbc                                   | tbc                     | tbc                    | 175        | DFN2020 (SWP)     | Q4 2022      |

# MOSFETs for Reverse Battery Protection

## MOSFET REQUIREMENTS FOR REVERSE BATTERY

- **Low RDS(ON)** – Reduced conduction losses
- **100% Avalanche Rated** – able to withstand ISO7637 pulses
- **Rated to 175° C** – For use in high ambient temperature environments.

Reverse Polarity using  
N Channel MOSFET



Reverse Polarity using  
P Channel MOSFET

## Highlighted Product

|               |                                         |
|---------------|-----------------------------------------|
| DMTH6004SCTBQ | Reverse Polarity using N Channel MOSFET |
| DMPH4015SK3Q  | Reverse Polarity using P Channel MOSFET |

To change a vehicles battery during maintenance or at the end of battery life. There is therefore a risk that the battery could

be reconnected in 'reverse' causing a damaging 'short circuit' to be applied across the Electronic Control Units (ECU's) in the vehicle. For this reason all automotive ECU's include a reverse polarity protection scheme.

The simplest solution is a diode in series with the power rail but the power losses are relatively high. A more efficient solution is to use either N or P channel MOSFET. Reverse polarity solutions that use P channel MOSFETs generate lower power losses than those using a diode and can be implemented with a minimal number of passive components. By comparison, reverse polarity protection circuits that use N-channel MOSFETs deliver the lowest power losses but require a charge pump to provide the gate drive voltage, adding complexity, cost and component count.

# 175C rated 40V/60V Automotive compliant P channel MOSFET

| Parts         | Package     | V <sub>DS</sub><br>(V) | V <sub>gss</sub><br>(V) | ID<br>(A) | Vgsth<br>(V) | R <sub>DS(on) MAX</sub><br>(mΩ) |       | Qg typ<br>@Vgs=10V<br>(nC) | Ciss<br>@25V <sub>DSS</sub><br>(pF) | E <sub>AS</sub><br>(mJ) | I <sub>AS</sub><br>(A) | Tj<br>max<br>(°C) | Status   |
|---------------|-------------|------------------------|-------------------------|-----------|--------------|---------------------------------|-------|----------------------------|-------------------------------------|-------------------------|------------------------|-------------------|----------|
|               |             |                        |                         |           |              | @10V                            | @4.5V |                            |                                     |                         |                        |                   |          |
| DMPH33M8SPSWQ | PowerDI5060 | -30                    | 20                      | TBC       | -1 - -3      | 3.8                             | 8     | 127                        | 3772                                | TBC                     | TBC                    | 175               | Q2 2022  |
| DMPH3010LPSQ  | PowerDI5060 | -30                    | 20                      | -60       | -1 - -3      | 7.5                             | 10    | 66                         | 6807                                | 113                     | -47                    | 175               | Released |
| DMPH4015SK3Q  | T0252-3L    | -40                    | 20                      | -50       | -1~-2.5      | 10                              | 14    | 42.7                       | 4234                                | 260                     | -22                    | 175               | Released |
| DMPH4015SPSQ  | PowerDI5060 | -40                    | 20                      | -11.4     | -1~-2.5      | 10                              | 14    | 42.7                       | 4234                                | 260                     | -22                    | 175               | Released |
| DMPH4015SSSQ  | SO8         | -40                    | 20                      | -50       | -1~-2.5      | 11                              | 15    | 42.7                       | 4234                                | 260                     | -22                    | 175               | Released |
| DMPH4013SK3Q  | T0252-3L    | -40                    | 20                      | -55       | -1~-3        | 15                              | 23    | 67                         | 4004                                | 176                     | -16                    | 175               | Released |
| DMPH4013SPSQ  | PowerDI5060 | -40                    | 20                      | -75       | -1~-3        | 15                              | 23    | 67                         | 4004                                | 176                     | -16                    | 175               | Released |
| DMPH4025SFVWQ | PowerDi3333 | -40                    | 20                      | -20       | -0.8 1.8     | 25                              | 45    | 33.7                       | 1293                                | 31                      | -25                    | 175               | Released |
| DMPH4023SK3Q  | T0252-3L    | -40                    | 20                      | -50       | -1~-3        | 26                              | -     | 18.7                       | 1091                                | 85                      | -40                    | 175               | Released |
| DMPH4025SFVWQ | PowerDi3333 | -40                    | 20                      | -20       | -0.8 1.8     | 25                              | 45    | 33.7                       | 1293                                | 31                      | -25                    | 175               | Released |
| DMPH4029LFGQ  | PowerDI333  | -40                    | 20                      | -22       | -1~-3        | 29                              | 45    | 17                         | 1626                                | 32                      | -25                    | 175               | Released |
| DMPH6023SK3Q  | T0-252-3L   | -60                    | 20                      | -35       | -1~-3        | 33                              | 40    | 53                         | 2569                                | 60                      | -35                    | 175               | Released |
| DMPH6050SSDQ  | SO8         | -60                    | 20                      | 5.2       | -1~-3        | 50                              | 70    | 11.9                       | 1293                                | 30.8                    | 24.8                   | 175               | Released |
| DMPH6050SK3Q  | TO252-3L    | -60                    | 20                      | -23.5     | -1~3         | 50                              | 70    | 25                         | 1377                                | 31                      | -25                    | 175               | Released |
| DMPH6050SPDQ  | PowerDI5060 | -60                    | 20                      | 5.2       | -1~-3        | 50                              | 70    | 11.9                       | 1293                                | 30.8                    | 24.8                   | 175               | Released |
| DMPH6050SSDQ  | SO8         | -60                    | 20                      | 5.2       | -1~-3        | 50                              | 70    | 11.9                       | 1293                                | 30.8                    | 24.8                   | 175               | Released |
| DMPH6250SQ    | SOT23       | -60                    | 20                      | 5.3       | -1~-3        | 155                             | 240   | 4                          | 512                                 | -                       | -                      | 175               | Released |

## Features

- Optimised for avalanche
- Product highlighted in yellow is planar structure (rest are trench)



Automotive compliant (Q) - AEC-Qualified, in IATF 16949 manufacturing sites supporting PPAP



# IntelliFET Automotive 'Q' Portfolio

## Product Features and Benefits

- **Automotive compliant** – AEC-Q100 Qualified, in IATF 16949 manufacturing sites supporting PPAP
- **Low-Side Portfolio**
- **High Side Portfolio**



# Low Side SmartFET – Relay Driver

- **Integrated Solution**

- Replaces 3 to 4 discrete components
- Small form factor package reduces PCB area

- **Integrated Active Clamp**

Eliminates the need for external freewheeling diodes

- **Automotive compliant** – AEC Qualified, in IATF 16949 manufacturing sites supporting PPAP

- **Robust Design**

Interface between sensitive logic and DC relay coils  
Capable of supplying 150mA to 12V, 24V and 48V coils

- **Second Source to NUD3160DM**



| Part        | V <sub>DS</sub><br>(V) | V <sub>GS</sub><br>(±V) | I <sub>DS</sub> @ T <sub>A</sub> =<br>+25° C<br>(A) | P <sub>D</sub><br>@ T <sub>A</sub> = +25° C<br>(W) | R <sub>DS(ON)</sub> Max<br>(mΩ)<br>@ V <sub>GS</sub> = |      | C <sub>ISS</sub> Typ<br>(pF) | Q <sub>G</sub> Typ<br>@ V <sub>GS</sub> = 5V<br>(nC) | ESD<br>(HBM) | E <sub>Z</sub><br>(mJ) | Package |
|-------------|------------------------|-------------------------|-----------------------------------------------------|----------------------------------------------------|--------------------------------------------------------|------|------------------------------|------------------------------------------------------|--------------|------------------------|---------|
|             |                        |                         |                                                     |                                                    | 10V                                                    | 5V   |                              |                                                      |              |                        |         |
| DMN61D8LVTQ | 60                     | 12                      | 0.47                                                | 0.61                                               | -                                                      | 1800 | 12.9                         | 0.74                                                 | 4kV          | 200                    | SOT26   |
| DMN61D8LQ   | 60                     | 12                      | 0.47                                                | 0.6                                                | -                                                      | 1800 | 12.9                         | 0.74                                                 | 4kV          | 200                    | SOT23   |

# Self-Protected MOSFET Automotive 'Q' Portfolio

| Part         | Config. | TAB    | BV <sub>DSS</sub> | I <sub>D</sub> (A)  | PD  | R <sub>DS(on)</sub> Max (mΩ) @ V <sub>IN</sub> |       | V <sub>DS</sub> (S/C) | E <sub>AS</sub>      | Package Outlines | Status         |
|--------------|---------|--------|-------------------|---------------------|-----|------------------------------------------------|-------|-----------------------|----------------------|------------------|----------------|
|              |         |        | (V)               | V <sub>IN</sub> =5V | (W) | 3V                                             | 5V    | 10V                   | V <sub>IN</sub> = 5V |                  |                |
| BSP75GQ      | Single  | Drain  | 60                | 1.4                 | 2.5 | -                                              | 0.675 | 0.55                  | 36                   | 550              | Released       |
| BSP75NQ      |         | Source | 60                | 1.2                 | 1.5 | -                                              | 0.675 | 0.55                  | 36                   | 550              | Released       |
| ZXMS6001N3Q  |         | Source | 60                | 1.1                 | 1.5 | 2                                              | 0.675 | -                     | 36                   | 550              | Released       |
| ZXMS6002GQ   |         | Drain  | 60                | 1.4                 | 2.5 | -                                              | 0.675 | 0.55                  | 36                   | 550              | Released       |
| ZXMS6003GQ   |         | Drain  | 60                | 1.4                 | 2.5 | -                                              | 0.675 | 0.55                  | 36                   | 550              | Released       |
| ZXMS6004DGQ  |         | Drain  | 60                | 1.3                 | 3   | 0.6                                            | 0.5   | -                     | 36                   | 490              | Released       |
| ZXMS6004FFQ  |         | -      | 60                | 1.3                 | 1.5 | 0.6                                            | 0.5   | -                     | 36                   | 90               | Released       |
| ZXMS6004N8Q  |         | -      | 60                | 1.3                 | 1.6 | 0.5                                            | 0.3   | -                     | 36                   | 120              | Released       |
| ZXMS6004SGQ  |         | Source | 60                | 1.3                 | 1.6 | 0.6                                            | 0.5   | -                     | 36                   | 480              | Released       |
| ZXMS6004SGQ  |         | Source | 60                | 1.3                 | 1.6 | 0.6                                            | 0.5   | -                     | 36                   | 480              | Released       |
| ZXMS6005DGQ  |         | Drain  | 60                | 2                   | 1.6 | 0.25                                           | 0.2   | -                     | 24                   | 490              | Released       |
| ZXMS6005N8Q  |         | -      | 60                | 2                   | 1.6 | 0.25                                           | 0.2   | -                     | 24                   | 120              | Released       |
| ZXMS6005SGQ  |         | Source | 60                | 2                   | 1.6 | 0.25                                           | 0.2   | -                     | 24                   | 490              | Released       |
| ZXMS6006DGQ  |         | Drain  | 60                | 2.8                 | 3   | 0.1                                            | 0.125 | -                     | 16                   | 490              | Released       |
| ZXMS6006SGQ  |         | Source | 60                | 2.8                 | 3   | 0.1                                            | 0.125 | -                     | 16                   | 490              | Released       |
| ZXMS6008FFQ  |         | -      | 60                | 1.1                 | 1.5 | 0.8                                            | 0.7   | -                     | 36                   | 90               | SOT23F Q2 2022 |
| ZXMS6004DN8Q | Dual    | -      | 60                | 1.3                 | 1.6 | 0.5                                            | 0.3   | -                     | 36                   | 120              | Released       |
| ZXMS6004DT8Q |         | -      | 60                | 1.2                 | 2.3 | 0.6                                            | 0.5   | -                     | 36                   | 210              | Released       |
| ZXMS6005DN8Q |         | -      | 60                | 1.8                 | 1.2 | 0.25                                           | 0.2   | -                     | 16                   | 120              | Released       |
| ZXMS6005DT8Q |         | -      | 60                | 1.8                 | 1.6 | 0.25                                           | 0.2   | -                     | 24                   | 210              | Released       |
| ZXMS6006DT8Q |         | -      | 60                | -                   | 2.1 | 0.1                                            | 0.125 | -                     | 16                   | 210              | Released       |

# High Side IntelliFET Product Portfolio

## HS IntelliFET

| Product             | Channel | V <sub>S</sub><br>(V) | Max<br>V <sub>SLD</sub><br>(V) | I <sub>L nom,</sub><br>typ<br>(A) | V <sub>S</sub> (S/C) | P <sub>TOT</sub><br>max<br>(W) | R <sub>DS(on)</sub><br>(typ)<br>@25C<br>(mΩ) | R <sub>DS(on)</sub><br>(MAX)<br>@150C<br>(mΩ) | E <sub>AS</sub><br>(mJ) | Package | Target<br>RTP |
|---------------------|---------|-----------------------|--------------------------------|-----------------------------------|----------------------|--------------------------------|----------------------------------------------|-----------------------------------------------|-------------------------|---------|---------------|
| <b>ZXMS81045SPQ</b> | Single  | 5 - 28                | 41                             | 4.0                               | 24                   | 1.6                            | 45                                           | 90                                            | 40                      | SO-8    | Active        |
| <b>ZXMS81090SPQ</b> | Single  | 5 - 28                | 41                             | 3.0                               | 24                   | 1.5                            | 90                                           | 180                                           | 50                      | SO-8    | Q2 2022       |
| <b>ZXMS81120SPQ</b> | Single  | 5-28                  | 41                             | 2.0                               | 24                   | 1.4                            | 180                                          | 360                                           | 70                      | SO-8    | Q2 2022       |
| <b>ZXMS82045SPQ</b> | Dual    | 5 - 28                | 41                             | 4.5                               | 24                   | 2.0                            | 45                                           | 90                                            | 42                      | SO-14   | Q3 2022       |
| <b>ZXMS82090SPQ</b> | Dual    | 5 – 28                | 41                             | 3.5                               | 24                   | 1.9                            | 90                                           | 190                                           | 35                      | SO-14   | Q3 2022       |
| <b>ZXMS82180SPQ</b> | Dual    | 5 – 28                | 41                             | 2.5                               | 24                   | 1.8                            | 120                                          | 240                                           | 28                      | SO-14   | Q3 2022       |



SO-8



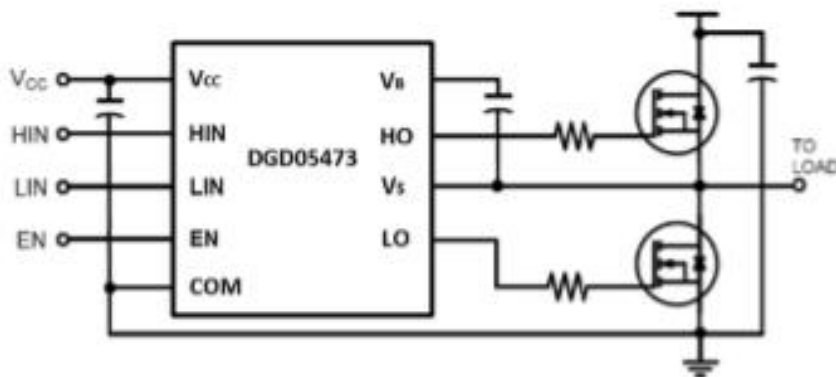
SO-14

# Automotive-compliant Gate Drivers

## High Side (HS) / Low-Side (LS) and Half-Bridge Gate Drivers

| Part Number | Gate Driver Type | Integrated Bootstrap Diode | Offset Voltage Max (V) | Vcc Supply Voltage (V) | Inputs       | Output Current lo+ typ (mA) | Output Current lo- typ (mA) | Internal Deadtime typ (ns) | t <sub>on</sub> / t <sub>off</sub> typ (ns) | t <sub>r</sub> / t <sub>f</sub> typ (ns) | Package    |
|-------------|------------------|----------------------------|------------------------|------------------------|--------------|-----------------------------|-----------------------------|----------------------------|---------------------------------------------|------------------------------------------|------------|
| DGD05473Q   | HS / LS          | Yes                        | 50                     | 4.5 – 14               | HIN, LIN, EN | 1500                        | 2500                        | N/A <sup>a</sup>           | 20 / 23                                     | 16 / 12                                  | DFN3030-10 |

<sup>a</sup> = N/A Not Applicable as these are High-side / Low-side



Typical Configuration

# Super Barrier Rectifier (SBR) Automotive 'Q' Portfolio

- **Low Forward Voltage ( $V_F$ )**

The lower forward voltage of the Super Barrier Rectifier ensures power dissipation is minimized

- **Low Reverse Leakage ( $I_R$ )**

Reduced High Temperature reverse leakage provides increased reliability against thermal runaway at high temperature

- **Avalanche rated**

100% Avalanche tested ensuring more rugged and reliable end applications

Reverse avalanche capability that is up to 10x > Schottky diode

|                       | Forward Voltage, $V_F$ | Leakage current, $I_R$ | Junction Temp, $T_J$        | Reverse Recovery $t_{rr}$ | Reverse Avalanche |
|-----------------------|------------------------|------------------------|-----------------------------|---------------------------|-------------------|
| Ultra-Fast Rectifiers | ✗ High $V_F$           | ✓ Low $I_R$            | ✓ $T_J < 175^\circ\text{C}$ | ✓ Fast                    | ✗ low             |
| Standard Rectifiers   | ✗ High $V_F$           | ✓ Low $I_R$            | ✓ $T_J < 175^\circ\text{C}$ | ✗ Slow                    | ✗ low             |
| Schottky              | ✓ Low $V_F$            | ✗ High $I_R$           | ✓ $T_J < 150^\circ\text{C}$ | ✓ Fast                    | ✗ low             |
| <b>SBR</b>            | ✓ Low $V_F$            | ✓ Low $I_R$            | ✓ $T_J < 200^\circ\text{C}$ | ✓ Fast                    | ✓ VHigh           |
| <b>TrenchSBR</b>      | ✓ Ultra Low $V_F$      | ✓ Ultra Low $I_R$      | ✓ $T_J < 200^\circ\text{C}$ | ✓ Fast                    | ✓ High            |

# 20V to 45V SBR Automotive Compliant 'Q' Portfolio

| Part Number                  | Configuration | VRRM (V) | IO (A) | IFSM (A) | VF (V) | IR (μA) | CT typ (pF) | EAS (mJ) | TJ (°C) | Packages        |
|------------------------------|---------------|----------|--------|----------|--------|---------|-------------|----------|---------|-----------------|
| <a href="#">SBR8U20SP5Q</a>  | Single        | 20       | 8      | 180      | 0.51   | 300     | 360         | 146      | 150     | PowerDI5        |
| <a href="#">SBRT05U20LPQ</a> | Single        | 20       | 0.5    | 10       | 0.39   | 50      | -           | -        | 150     | X1-DFN1006-2    |
| <a href="#">SBRT05U20S3Q</a> | Single        | 20       | 0.5    | 10       | 0.4    | 70      | -           | -        | 150     | SOD323          |
| <a href="#">SBR15U30SP5Q</a> | Single        | 30       | 15     | 280      | 0.49   | 300     | -           | 1074     | 150     | PowerDI5        |
| <a href="#">SBR140S1FQ</a>   | Single        | 40       | 1      | 30       | 0.51   | 100     | 110         | -        | 150     | SOD123F         |
| <a href="#">SBR1A40S3Q</a>   | Single        | 40       | 1      | 20       | 0.55   | 500     | -           | -        | 150     | SOD323          |
| <a href="#">SBR2A40P1Q</a>   | Single        | 40       | 2      | 50       | 0.5    | 100     | -           | -        | 150     | PowerDI123      |
| <a href="#">SBR3A40SAQ</a>   | Single        | 40       | 3      | 45       | 0.5    | 400     | -           | -        | 150     | SMA             |
| <a href="#">SBR3U40P1Q</a>   | Single        | 40       | 3      | 75       | 0.47   | 400     | -           | -        | 150     | PowerDI123      |
| <a href="#">SBR3U40S1FQ</a>  | Single        | 40       | 3      | 50       | 0.49   | 180     | -           | -        | 150     | SOD123F         |
| <a href="#">SBRT3U40P1Q</a>  | Single        | 40       | 3      | 75       | 0.49   | 180     | 40          | -        | 150     | PowerDI123      |
| <a href="#">SBR5A45SAFQ</a>  | Single        | 45       | 5      | 100      | 0.56   | 200     | 80          | -        | 150     | SMAF            |
| <a href="#">SBR1045CTLQ</a>  | Dual          | 45       | 10     | 90       | 0.55   | 300     | 150         | 200      | 150     | TO252 (DPAK)    |
| <a href="#">SBR1045D1Q</a>   | Single        | 45       | 10     | 90       | 0.58   | 300     | 400         | 200      | 150     | TO252 (DPAK)    |
| <a href="#">SBR1045SP5Q</a>  | Single        | 45       | 10     | 180      | 0.55   | 450     | 500         | -        | 150     | PowerDI5        |
| <a href="#">SBR10A45SP5Q</a> | Single        | 45       | 10     | 180      | 0.53   | 400     | 45          | -        | 150     | PowerDI5        |
| <a href="#">SBR10U45D1Q</a>  | Single        | 45       | 10     | 125      | 0.57   | 300     | -           | 620      | 150     | TO252 (DPAK)    |
| <a href="#">SBR10U45SP5Q</a> | Single        | 45       | 10     | 275      | 0.47   | 300     | 600         | 530      | 150     | PowerDI5        |
| <a href="#">SBR20M45D1Q</a>  | Single        | 45       | 20     | 140      | 0.61   | 100     | -           | -        | 150     | TO252 (DPAK)    |
| <a href="#">SBR3045CTBQ</a>  | Dual          | 45       | 30     | 180      | 0.7    | 500     | -           | 180      | 150     | TO263AB (D2PAK) |
| <a href="#">SBR30A45CTBQ</a> | Dual          | 45       | 30     | 175      | 0.55   | 500     | 500         | 135      | 150     | TO263AB (D2PAK) |



# 60V to 100V SBR Automotive Compliant 'Q' Portfolio

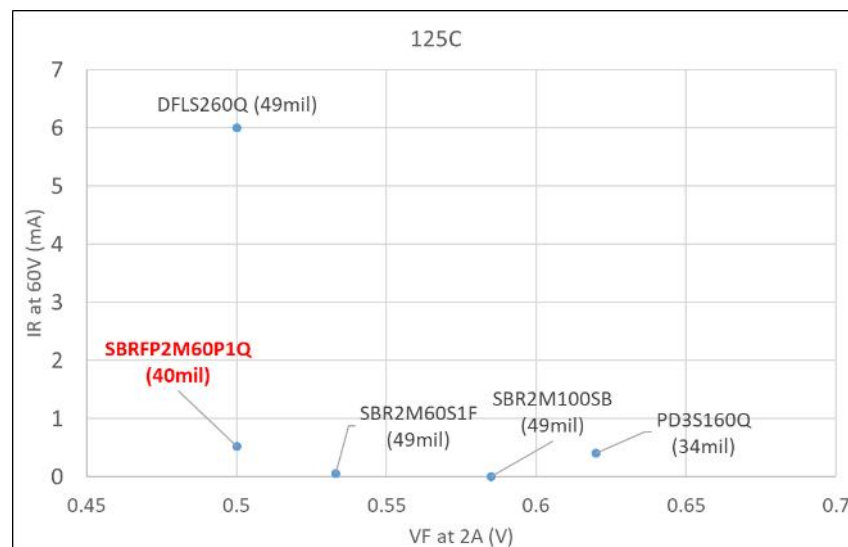
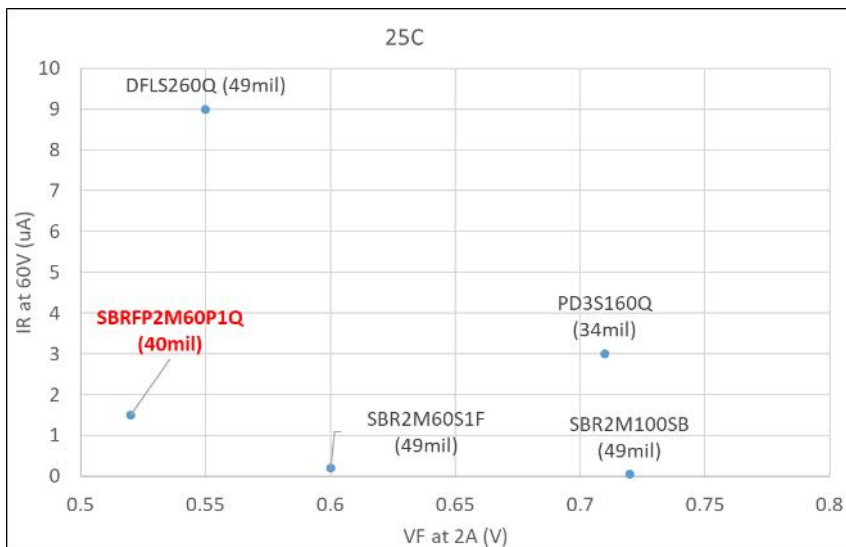
| Part Number                   | Configuration | VRRM (V) | IO (A) | IFSM (A) | VF (V) | IR (μA) | CT typ (pF) | EAS (mJ) | TJ (°C) | Packages               |
|-------------------------------|---------------|----------|--------|----------|--------|---------|-------------|----------|---------|------------------------|
| <a href="#">SBR0560S1Q</a>    | Single        | 60       | 0.5    | 15       | 0.5    | 100     | -           | -        | 150     | SOD123                 |
| <a href="#">SBR20A60CTBQ</a>  | Dual          | 60       | 20     | 180      | 0.79   | 500     | -           | 500      | 150     | TO263AB (D2PAK)        |
| <a href="#">SBR2M60S1FQ</a>   | Single        | 60       | 2      | 30       | 0.7    | 0.8     | -           | -        | 150     | SOD123F                |
| <a href="#">SBR2U60S1FQ</a>   | Single        | 60       | 2      | 35       | 0.51   | 150     | 75          | -        | 150     | SOD123F                |
| <a href="#">SBR30A60CTBQ</a>  | Dual          | 60       | 30     | 180      | 0.63   | 330     | 450         | 600      | 150     | TO263AB (D2PAK)        |
| <a href="#">SBR3U60P1Q</a>    | Single        | 60       | 3      | 80       | 0.62   | 100     | -           | -        | 150     | PowerDI123             |
| <a href="#">SBR3U60P5Q</a>    | Single        | 60       | 3      | 80       | 60     | 0.06    | 110         | -        | 150     | PowerDI5               |
| <a href="#">SBR3U60SLDQ</a>   | Dual          | 60       | 3      | 60       | 0.6    | 100     | 110         |          | 150     | PowerDI5060-8 (Type D) |
| <a href="#">SBR660CTLQ</a>    | Dual          | 60       | 6      | 80       | 0.57   | 300     | 130         | 190      | 150     | TO252 (DPAK)           |
| <a href="#">SBR8U60P5Q</a>    | Single        | 60       | 8      | 280      | 0.53   | 330     | 400         | 800      | 150     | PowerDI5               |
| <a href="#">SBRT10U60D1Q</a>  | Single        | 60       | 10     | 140      | 0.52   | 400     | -           | -        | 150     | TO252 (DPAK)           |
| <a href="#">SBRT3U60P1Q</a>   | Single        | 60       | 3      | 70       | 0.56   | 150     | -           | -        | 150     | PowerDI123             |
| <a href="#">SBR02U100LPQ</a>  | Single        | 100      | 0.25   | 5        | 0.8    | 1       | -           | -        | 150     | X1-DFN1006-2           |
| <a href="#">SBR10M100P5Q</a>  | Single        | 100      | 10     | 220      | 0.88   | 2       | 245         | -        | 150     | PowerDI5               |
| <a href="#">SBR12U100P5Q</a>  | Single        | 100      | 12     | 250      | 0.78   | 250     | 300         | 592      | 150     | PowerDI5               |
| <a href="#">SBR15U100CTLQ</a> | Dual          | 100      | 15     | 100      | 0.8    | 100     | 150         | 192      | 150     | TO252 (DPAK)           |
| <a href="#">SBR6100CTLQ</a>   | Dual          | 100      | 6      | 78       | 0.74   | 100     | 80          | 120      | 150     | TO252 (DPAK)           |
| <a href="#">SBR8M100P5Q</a>   | Single        | 100      | 8      | 130      | 0.88   | 2       | -           | -        | 150     | PowerDI5               |
| <a href="#">SBR1U150SAQ</a>   | Single        | 150      | 1      | 42       | 0.7    | 100     | -           | -        | 150     | SMA                    |
| <a href="#">SBR20M150D1Q</a>  | Single        | 150      | 20     | 160      | 0.9    | 50      | 670         | -        | 150     | TO252 (DPAK)           |
| <a href="#">SBR10U200P5Q</a>  | Single        | 200      | 10     | 180      | 0.88   | 100     | 200         | -        | 150     | PowerDI5               |
| <a href="#">SBR1U200P1Q</a>   | Single        | 200      | 1      | 40       | 0.82   | 50      | -           | -        | 150     | PowerDI123             |
| <a href="#">SBR40U200CTBQ</a> | Dual          | 200      | 40     | 280      | 0.93   | 0.2     | 500         | -        | 150     | TO263AB (D2PAK)        |

# Diodes SBRFP – Industry leading performance

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- **M-Series (Low Reverse Leakage Current)**  
Motor Control, LED Lighting,
- **Ultra-low forward voltage,**  
minimizes conduction losses thereby increasing power efficiency
- **High temp stability of leakage current**  
increases reliability
- **Small die size increase power density**  
improved performance over larger packaged parts

| Product      | Package | VRRM (V) | VF max (V) | IR max (μA) | RTM     |
|--------------|---------|----------|------------|-------------|---------|
| SBRFP2M60P1Q | PDI123  | 60       | 0.58       | 12          | 2Q 2022 |



# Schottky Automotive Q Portfolio

The PowerDI123 and PowerDI5 packages feature proprietary clip die attach that improves  $I_{FSM}$  and reliability. Plus, both PowerDI5 and PowerDI123 feature off board profiles of just 1.1mm and 1mm respectively, providing designers with a high-density, low-profile Schottky portfolio.

## Product Features and Benefits

- **Automotive compliant** – AEC Qualified, in IATF 16949 manufacturing sites supporting PPAP
- **Low Profile Package**
  - PowerDI123 off board profile of 1mm, 62% thinner than SMA
  - PowerDI5 off board profile of 1.1mm, 50% thinner than DPAK
- **Small Form Factor Package**
  - PowerDI5 PCB footprint is 26mm<sup>2</sup>, 55% smaller than DPAK
  - PD123 PCB footprint is 7.5mm<sup>2</sup>, 60% smaller than SMA



Package Cross Sections

Diodes Incorporated's patent-pending flat lead frame heat-sink solder pad results in higher power dissipation and surge capabilities in a compact, low-profile package.

PowerDI is a registered trademarks of Diodes Incorporated.



**Automotive compliant (Q)** - AEC-Qualified, in IATF 16949 manufacturing sites supporting PPAP

# Automotive Schottky 'Q' Portfolio

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| Part Number  | Configuration | VRRM (V) | IO (A) | IFSM (A) | VF (V) | IR (μA) | CT (pF) typ | Packages    | Availability |
|--------------|---------------|----------|--------|----------|--------|---------|-------------|-------------|--------------|
| PD3S120LQ    | Single        | 20       | 1      | 33       | 0.42   | 160     | 200         | PowerDI323  | Released     |
| PD3S130HQ    | Single        | 30       | 1      | 22       | 0.45   | 100     | 200         | PowerDI323  | Released     |
| PD3S130LQ    | Single        | 30       | 1      | 22       | 0.42   | 1500    | 150         | PowerDI323  | Released     |
| PD3S140Q     | Single        | 40       | 1      | 22       | 0.55   | 50      | 130         | PowerDI323  | Released     |
| PD3S160Q     | Single        | 60       | 1      | 22       | 0.64   | 50      | 130         | PowerDI323  | Released     |
| PD3S220LQ    | Single        | 20       | 2      | 33       | 0.49   | 160     | 200         | PowerDI323  | Released     |
| PD3S230HQ    | Single        | 30       | 2      | 30       | 0.6    | 100     | 200         | PowerDI323  | Released     |
| PD3S230LQ    | Single        | 30       | 2      | 30       | 0.45   | 1500    | 150         | PowerDI323  | Released     |
| PDS1040Q     | Single        | 40       | 10     | 275      | 0.51   | 300     | N/A         | PowerDI5    | Released     |
| PDS3100Q     | Single        | 100      | 3      | 90       | 0.76   | 100     | 260         | PowerDI5    | Released     |
| PDS3200Q     | Single        | 200      | 3      | 180      | 0.78   | 10      | 520         | PowerDI5    | Released     |
| PDS340Q      | Single        | 40       | 3      | 90       | 0.49   | 500     | 490         | PowerDI5    | Released     |
| PDS360Q      | Single        | 60       | 3      | 100      | 0.62   | 100     | 380         | PowerDI5    | Released     |
| PDS4150Q     | Single        | 150      | 4      | 180      | 0.76   | 10      | 530         | PowerDI5    | Released     |
| PDS4200HQ    | Single        | 200      | 4      | 100      | 0.84   | 1       | N/A         | PowerDI5    | Released     |
| PDS5100HQ-13 | Single        | N/A      | 5      | N/A      | 0.71   | 3.5     | N/A         | PowerDI5    | Released     |
| PDS5100Q     | Single        | 100      | 5      | 120      | 0.79   | 200     | 310         | PowerDI5    | Released     |
| PDS540Q      | Single        | 40       | 4      | 150      | 0.52   | 250     | 700         | PowerDI5    | Released     |
| PDS560Q      | Single        | 60       | 4      | 150      | 0.6    | 150     | 500         | PowerDI5    | Released     |
| PDS760Q      | Single        | 60       | 7      | 275      | 0.62   | 200     | 1050        | PowerDI5    | Released     |
| SDM160S1FQ   | Single        | 60       | 1      | 50       | 0.53   | 0.06    | 48          | SOD123F     | Released     |
| SDM1M40LP8Q  | Single        | 40       | 1      | 8        | 0.66   | 20      | 25          | U-DFN1608-2 | Released     |
| SDM2100S1FQ  | Single        | 100      | 2      | 50       | 0.83   | 0.15    | 42          | SOD123F     | Released     |
| ZHCS1000QTA  | Single        | 40       | 1      | 5.2      | 0.6    | 100     | 17          | SOT23       | Released     |
| ZHCS350Q     | Single        | 40       | 350    | 0.91     | 0.81   | 12      | 3.3         | SOD523      | Released     |
| ZHCS500QTA   | Single        | 40       | 0.5    | 3        | 0.55   | 40      | 20          | SOT23       | Released     |
| ZHCS506Q     | Single        | 60       | 0.5    | 2.5      | 0.63   | 50      | N/A         | SOT23       | Released     |
| ZHCS750QTA   | Single        | 40       | 0.75   | 5.2      | 0.49   | 100     | 25          | SOT23       | Released     |
| ZLLS2000Q    | Single        | 40       | 2      | 12       | 0.54   | 40      | 65          | SOT24       | Released     |
| ZLLS400Q     | Single        | 40       | 0.52   | 2.5      | 0.5    | 10      | 15          | SOD323      | Released     |

# Automotive TVS 'Q' Portfolio

## Product Features and Benefits

- **ESD protection Portfolio**
- **Powerline protection (ISO7637 pt 1, 2, 3 Compliant)**
- **Automotive compliant** – AEC Qualified, in IATF 16949 manufacturing sites supporting PPAP
- **IEC Compliant**  
IEC61000-4-2 and 6100-4-5 compliant against electrostatic discharge.
- **Small Form Factor Package**



# Diodes Automotive “Q” Product Portfolio

## ✓ CAN-LIN-FLEX

DESDxLIN2WSQ Series  
DESDxCAN2SOQ Series  
DESDxFlex2SOQ Series  
DUPx105SOQ Series

## ✓ General IO

ESD Protect : DxV0L1B2xQ  
Surge Protect : D5V0A5V3Q  
Multi- Protect : D5V0L4B5Q

## Power Line & Load Dump

SOD123F : DTVSxV0S1UR (400w)  
SMAJx(C)Q (400w)  
SMBJx(C)Q (600w)  
SMCJx(C)Q (1.5Kw/3Kw)  
DO218 : SM5x/8xQ (4.6Kw/6.6Kw)



## ✓ Infotainment

RF : DESD18VF1xQ  
USB2.0 : D5V0F2U3xQ  
LVDS : DT1042-04xQ  
USB3.0 : DT1240-04xQ  
RJ45 : DT2042-04xQ  
Audio : D5V0L1B2xQ



# Power line Protection TVS – 200W to 400W in D0219AA and SOD123FL

## DIODES™ Advantage

### 200W and 400W uni/bi-directional TVS in SOD123FL and DO219AA

- IEC6100-4-2, 61000-4-4 and IEC 61000-4-5 compliant
- unidirectional
- excellent clamping capability
- **Automotive compliant (Q)** - AEC-101 Qualified, in IATF 16949 manufacturing sites supporting PPAP



| Product              | Config | V <sub>rw</sub> (V) | Min V <sub>br</sub> (V) | I <sub>R</sub> (mA) | I <sub>pp</sub> (A) | V <sub>clamp</sub> @ I <sub>pp</sub> (V) | P <sub>pk</sub> (W) | Package | Released |
|----------------------|--------|---------------------|-------------------------|---------------------|---------------------|------------------------------------------|---------------------|---------|----------|
| DFLT5V0 – DFLT40AQ   | Uni    | 5 – 40              | 6.4~49.1                | <0.4                | 24.5 – 3.5          | 9.2 – 64.5                               | 225                 | SOD123F | Released |
| DTVS3V3-DTVS33SP4URQ | Uni    | 3.3 - 36            | 5.2 - 40                | <1                  | 43.8 – 6.9          | 8 – 58.1                                 | 400                 | SOD123F | Q1 22    |
| SMFL5.0 – SMFL200CAQ | Bi     | 6.4 – 224           | 6.4~248                 | <1                  | 43.5 – 1.2          | 9.2 – 324                                | 400                 | DO219AA | Released |



# Power line Protection TVS – 400W to 3000W SMA, SMB and SMC

## DIODES™ Advantage

### 400W - 3000W uni/BIdirectional TVS in SMA, SMB, SMC

- Industry standard SMA, SMB, SMC packages
- ISO7637-2 ISO10605
- Unidirectional, bidirectional
- excellent clamping capability
- **Automotive compliant (Q)** - AEC-101 Qualified, in IATF 16949 manufacturing sites supporting PPAP



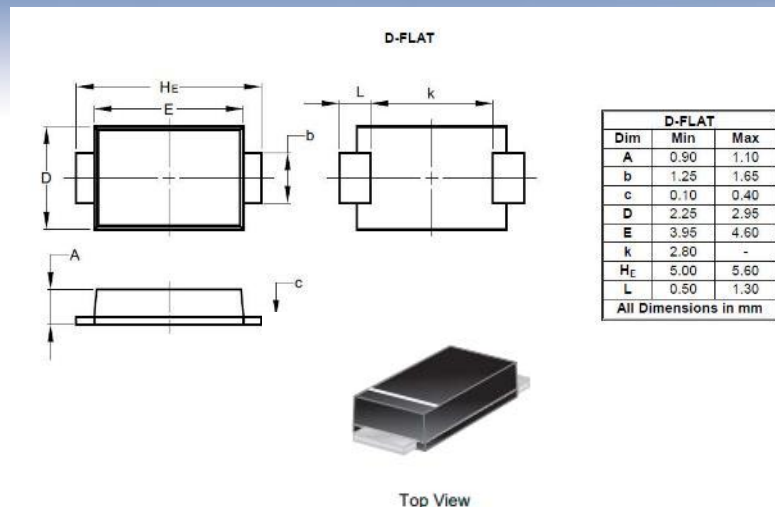
| Product                   | Dir    | V <sub>rw</sub> (V) | V <sub>br</sub> (V) | I <sub>R</sub> (mA) | I <sub>pp</sub> (A) | V <sub>clamp</sub> @ I <sub>pp</sub> (V) | P <sub>pk</sub> (W) | Package | Released |
|---------------------------|--------|---------------------|---------------------|---------------------|---------------------|------------------------------------------|---------------------|---------|----------|
| SMAJ5.0 – SMAJ200(C)AQ    | Uni/bi | 5 - 200             | 6.4– 248            | <0.1                | 43.5 – 1.2          | 0.2 – 324                                | 400                 | SMA     | Released |
| SMA6J5.0 – SMAJ188(C)AQ   | Uni/bi | 5 - 188             | 6.4 – 248           | <0.1                | 65.2 – 1.8          | 9.2 – 328.6                              | 600                 | SMA     | Released |
| SMBJ5.0 – SMBJ170(C)AQ    | Uni/Bi | 5 – 170             | 15.6 – 44.2         | <0.1                | 65.2– 1.9           | 9.2 – 324                                | 600                 | SMB     | Released |
| SMCJ5V0 – SMCJ36(C)AQ     | Uni/Bi | 14 – 36             | 15.6– 44.2          | <0.1                | 64.7 – 25.8         | 23.2 – 58.1                              | 1500                | SMC     | Released |
| 3.0SMCJ14 -3.0SMCJ30(C)AQ | Uni/bi | 14- 30              | 15.6 – 36.8         | <0.1                | 129.3 – 62          | 23.2 – 48.8                              | 3000                | SMC     | Released |

# Power line Protection TVS – 400W and 600W in DFLAT package

## DIODES™ Advantage

### 400W and 600W unidirectional TVS in DFlat package

- Low profile package – 60% thinner than SMA
- Footprint compatible with SMA and SMB
- Unidirectional
- IEC6100-4-2, 61000-4-4 and IEC 61000-4-5 compliant
- **Automotive compliant (Q)** - AEC-101 Qualified, in IATF 16949 manufacturing sites supporting PPAP



| Product                  | Dir | V <sub>rw</sub> (V) | V <sub>br</sub> (V) | I <sub>R</sub> (mA) | I <sub>pp</sub> (A) | V <sub>clamp</sub> @ I <sub>pp</sub> (V) | P <sub>pk</sub> (W) | Package | Released |
|--------------------------|-----|---------------------|---------------------|---------------------|---------------------|------------------------------------------|---------------------|---------|----------|
| P4SMAJ5.0 – P6SMAJ85ADFQ | Uni | 5 – 85              | 6.4– 104            | <0.1                | 43.5 – 2.9          | 9.2 – 137                                | 400                 | DFlat   | Released |
| P6SMAJ5.0 – P6SMAJ85ADFQ | Uni | 5 – 85              | 6.4– 108            | <0.1                | 65.2 – 4.4          | 9.2 – 137                                | 600                 | DFlat   | Released |

# Load Dump Protection TVS – 3.6kW and 4.6kW

## DIODES™ Advantage

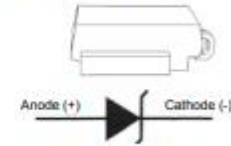
### 3.6kW and 4.6kW unidirectional TVS in DO218

- 3.6kW and 4.6kW peak pulse power dissipation
- ISO16750 pulse A and B compliant
- ISO7637-2 pulse 1,2a 3a and 5 compliant
- **Automotive compliant (Q)** - AEC-Q101 qualified, in IATF 16949 manufacturing sites supporting PPAP



Top View

Polarity: Heatsink is anode



Pin Information

| Product           | Dir | V <sub>rw</sub> (V) | V <sub>br</sub> min (V) | I <sub>R</sub> (uA) | I <sub>pp</sub> (A) | V <sub>clamp</sub> @ I <sub>pp</sub> (V) | P <sub>pk</sub> (W) | Package | Status   |
|-------------------|-----|---------------------|-------------------------|---------------------|---------------------|------------------------------------------|---------------------|---------|----------|
| DM5W10 – DM5W36AQ | Uni | 10 - 36             | 11.1 – 44.2             | <20                 | 211 – 61            | 17 – 58                                  | 3600                | DO218   | Released |
| DM6W10 – DM6W36AQ | Uni | 10 - 43             | 11.1 – 44.4             | <20                 | 271 – 79            | 17 – 58                                  | 4600                | DO218   | Released |

# Load Dump Protection TVS – 6.6kW

## DIODES™ Advantage

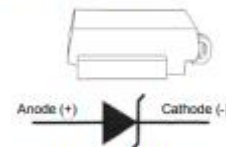
### 6.6kW unidirectional TVS in DO218

- 6.6kW peak pulse power dissipation
- ISO7637-2 pulse 5 compliant
- ISO7637-2 pulse 5 compliant
- **Automotive compliant (Q)** - AEC-Qualified, in IATF 16949 manufacturing sites supporting PPAP



Top View

Polarity: Heatsink is anode



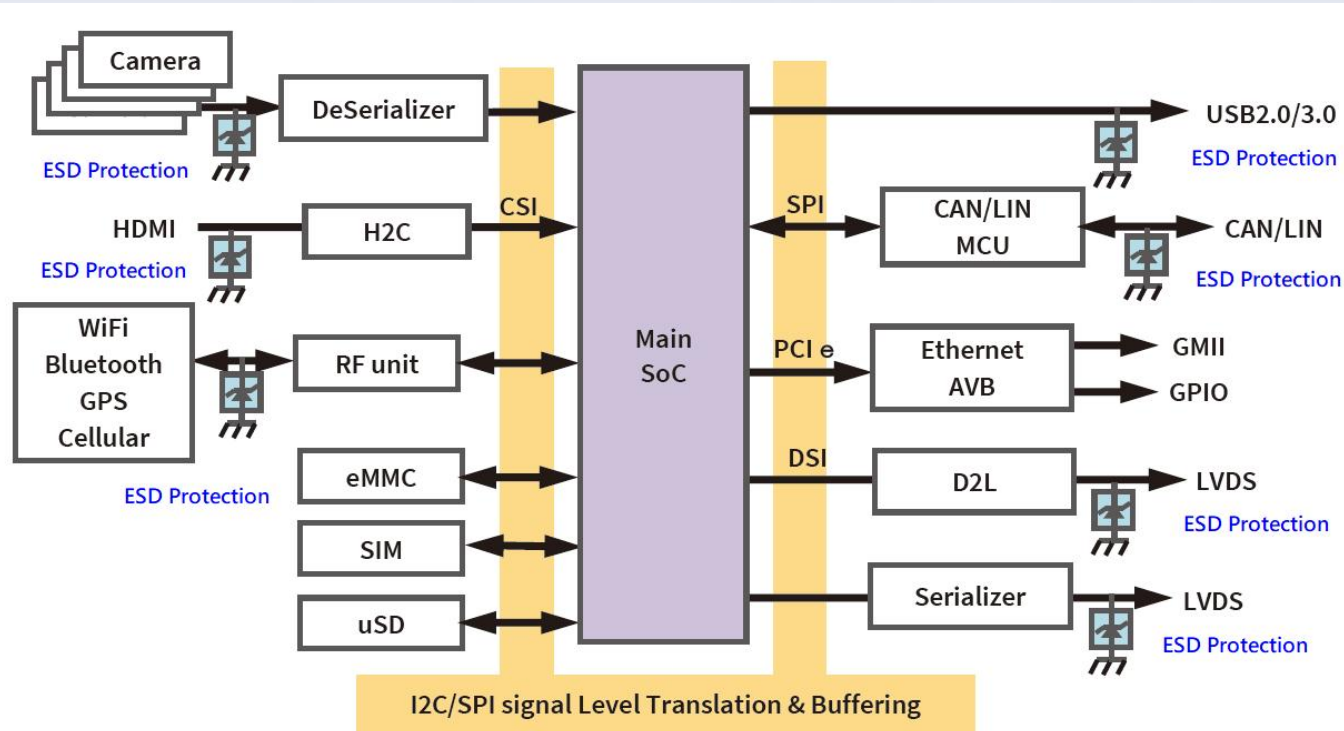
Pin Information

| Product           | Dir | V <sub>rw</sub><br>(V) | V <sub>br</sub> min<br>(V) | I <sub>R</sub> (uA) | I <sub>pp</sub><br>(A) | V <sub>clamp</sub><br>@ I <sub>pp</sub><br>(V) | P <sub>pk</sub><br>(W) | Package | Release to<br>Market |
|-------------------|-----|------------------------|----------------------------|---------------------|------------------------|------------------------------------------------|------------------------|---------|----------------------|
| DM8W10 – DM8W43AQ | Uni | 10 - 43                | 11.1 – 58.4                | <10                 | 65 – 1.4               | 351 – 86                                       | 6600                   | DO218   | SEE NOTE             |

Note : PCN will be issued in Q3 to re introduce this portfolio in Q4 21

# In Vehicle infotainment (IVI)

System Block



# Bipolar Transistor Automotive 'Q' Portfolio

## Industry-leading Bipolar solutions...

### DIODES™ Advantage

- **Automotive compliant**

AEC Qualified, in IATF 16949 manufacturing sites supporting PPAP

- **Broad Portfolio**

NPN, PNP, Darlingtons, pre biased transistors, Gate Drivers, Linear LED drivers.

- **Low  $V_{CE(SAT)}$**

Leading edge silicon technology gives best in class saturation voltage performance to footprint.

- **High Gain**

High minimum gain helps to reduce the base current requirements and aids faster switching

# Bipolar Transistor Automotive Portfolio – High Runners

| Part Number |            | V <sub>CEO</sub> | I <sub>C</sub> | I <sub>CM</sub> | P <sub>D</sub> | h <sub>FE</sub> |                 |     |                 | V <sub>CE</sub> (sat) |                                  |      |                                  | Package  |
|-------------|------------|------------------|----------------|-----------------|----------------|-----------------|-----------------|-----|-----------------|-----------------------|----------------------------------|------|----------------------------------|----------|
| NPN         | PNP *      |                  |                |                 |                | Min             | @I <sub>C</sub> | Min | @I <sub>C</sub> | Max                   | @ I <sub>C</sub> /I <sub>B</sub> | Max  | @ I <sub>C</sub> /I <sub>B</sub> |          |
|             |            | (V)              | (A)            | (A)             | (W)            |                 | (A)             |     | (A)             | (mV)                  | (A/mA)                           | (mV) | (A/mA)                           |          |
|             | FMMT717Q   | 12               | 2.5            | 10              | 0.625          | 300             | 0.1             | 180 | 2.5             | 17                    | 0.1/10                           | 170  | 1.5/50                           | SOT23    |
| FMMT618Q    | FMMT718Q   | 20               | 2.5            | 6               | 0.625          | 300             | 0.2             | 200 | 2               | 15                    | 0.1/10                           | 200  | 2.5/ 50                          | SOT23    |
|             | FZT789AQ   | 25               | 3              | 6               | 2              | 250             | 1               | 200 | 2               | 250                   | 1/10                             | 450  | 2/20                             | SOT223   |
| FMMT491AQ   | FMMT591AQ  | 40               | 1              | 2               | 0.5            | 300             | 0.5             | 200 | 1               | 300                   | 0.5/50                           | 500  | 1/100                            | SOT23    |
| DXT690BP5Q  |            | 45               | 3              | 6               | 3.2            | 400             | 1               | 150 | 2               | 360                   | 1/5                              | 320  | 2/40                             | PowerDI5 |
| ZXT690BKQ   |            | 45               | 3              | 6               | 3.9            | 400             | 1               | 60  | 3               | 360                   | 1/5                              | 320  | 2/40                             | TO252-3L |
| FMMT619Q    |            | 50               | 2              | 6               | 0.625          | 300             | 0.2             | 100 | 2               | 200                   | 1/10                             | 220  | 2/50                             | SOT23    |
| FMMT491Q    | FMMT591Q   | 60               | 1              | 2               | 0.5            | 100             | 0.5             | 80  | 1               | 150                   | 0.5/50                           | 250  | 1/100                            | SOT23    |
| DXT651Q     | DXT751Q    | 60               | 3              | 6               | 2              | 100             | 0.5             | 40  | 2               | 300                   | 1/100                            | 600  | 3/300                            | SOT89    |
| FZT651Q     | FZT751Q    | 60               | 3              | 6               | 2              | 100             | 0.5             | 40  | 2               | 300                   | 1/100                            | 600  | 3/300                            | SOT223   |
| ZXTN2010ZQ  | ZXTP2012ZQ | 60               | 4.3            | 15              | 2.1            | 100             | 2               | 45  | 5               | 65                    | 1/100                            | 110  | 2/200                            | SOT89    |
| ZXTN2010GQ  | ZXTP2012GQ | 60               | 5.5            | 15              | 3              | 100             | 2               | 10  | 10              | 70                    | 1/100                            | 250  | 5/500                            | SOT223   |
|             | ZXT951KQ   | 60               | 5              | 15              | 3              | 100             | 2               | 10  | 10              | 50                    | 0.1/10                           | 460  | 5/500                            | TO252-3L |
| BCX5616Q    | BCX5316Q   | 80               | 1              | 1.5             | 1              | 100             | 0.15            | 25  | 0.5             | 500                   | 0.5/50                           | -    | -                                | SOT89    |
| BCP5616Q    | BCP5316Q   | 80               | 1              | 2               | 2              | 100             | 0.15            | 25  | 0.5             | 500                   | 0.5/50                           | -    | -                                | SOT223   |
| FMMT634Q    |            | 100              | 0.9            | 5               | 0.625          | 15,000          | 1               | -   | -               | 960                   | 1/5                              | -    | -                                | SOT23    |
| FZT653Q     | FZT753Q    | 100              | 2              | 6               | 2              | 100             | 0.5             | 25  | 2               | 300                   | 1/100                            | 500  | 2/200                            | SOT223   |
| MJD31CUQ    | MJD32CUQ   | 100              | 3              | 5               | 15             | 25              | 1               | 10  | 3               | 1200                  | 3/375                            | -    | -                                | TO252-3L |
|             | FZT953Q    | 100              | 5              | 10              | 3              | 100             | 1               | 30  | 4               | 50                    | 0.1/10                           | 420  | 4/400                            | SOT223   |
| ZXTN4004KQ  |            | 150              | 1              | 3               | 3.8            | 60              | 0.085           | 100 | 0.15            | 250                   | 0.1/5                            | -    | -                                | TO252-3L |
| FMMT459Q    |            | 450              | 0.15           | 0.5             | 0.625          | 50              | 0.03            | -   | -               | 75                    | 0.02/2                           | 90   | 0.05/6                           | SOT23    |
|             | FMMT560Q   | 500              | 0.15           | 0.5             | 0.625          | 100             | 0.001           | 80  | 0.05            | 200                   | 0.02/2                           | 500  | 0.05/10                          | SOT23    |



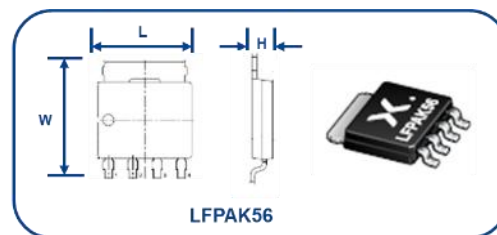
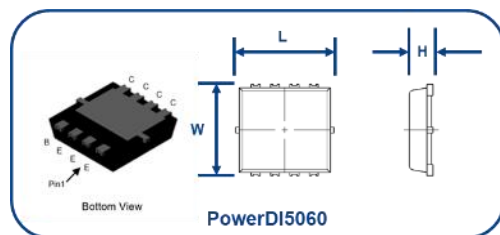
# Bipolar Transistors - package portfolio

123

| Gull Wing                                                                                                                                                                                                                              |                                | Flat lead                                                                                                                                                                                                                                                                                                                                                               |                                    | DFN (leadless)                                                                                                                                                                                                                                                                                                                                                                                  |                                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| Diodes Package                                                                                                                                                                                                                         | Similar to                     | Diodes Package                                                                                                                                                                                                                                                                                                                                                          | Similar to                         | Diodes Package                                                                                                                                                                                                                                                                                                                                                                                  | Similar to                      |
| TO252                                                                                                                                                                                                                                  | DPAK                           | PowerDI5060                                                                                                                                                                                                                                                                                                                                                             | LFPAK56/SOT669<br>LFPAK56D/SOT1205 | DFN3020-8                                                                                                                                                                                                                                                                                                                                                                                       |                                 |
| SOT223<br>SM8                                                                                                                                                                                                                          | SC73                           | PowerDI3333                                                                                                                                                                                                                                                                                                                                                             |                                    | DFN2020-3<br>DFN2020-3 (SWP)                                                                                                                                                                                                                                                                                                                                                                    | SOT1061/WDFN3<br>SOT1061D/WDFN3 |
| SOT23<br>SOT26                                                                                                                                                                                                                         | SC59/SST3<br>TO236/TSOP6/SST6  | PowerDI5                                                                                                                                                                                                                                                                                                                                                                |                                    | DFN2020-6<br>DFN2020-6 (SWP)                                                                                                                                                                                                                                                                                                                                                                    | SOT1118/XDFN3<br>SOT1118D/DFN3  |
| SOT323<br>SOT363                                                                                                                                                                                                                       | SC70/UMT3<br>TSSOP6/SC-88/UMT6 | SOT89                                                                                                                                                                                                                                                                                                                                                                   | MPT3                               | DFN1006-3                                                                                                                                                                                                                                                                                                                                                                                       | SOT883<br>SOT883B               |
| SOT523                                                                                                                                                                                                                                 |                                | SOT23F                                                                                                                                                                                                                                                                                                                                                                  |                                    | DFN0808-3                                                                                                                                                                                                                                                                                                                                                                                       |                                 |
|                                                                                                                                                                                                                                        |                                | SOT563                                                                                                                                                                                                                                                                                                                                                                  | SOT669                             | DFN1006-3                                                                                                                                                                                                                                                                                                                                                                                       |                                 |
|                                                                                                                                                                                                                                        |                                | SOT963                                                                                                                                                                                                                                                                                                                                                                  |                                    |                                                                                                                                                                                                                                                                                                                                                                                                 |                                 |
| <ul style="list-style-type: none"> <li>Compatible with automated optical solder inspection</li> <li>Can run PCB tracks beneath package body</li> <li>Poor silicon to footprint ratio.</li> <li>Restricted component density</li> </ul> |                                | <ul style="list-style-type: none"> <li>Pin extended beyond package for compatibility with automated optical solder inspection</li> <li>Exposed pad under die for improved thermal performance</li> <li>Cannot run PCB tracks beneath package body</li> <li>Low package height</li> <li>Very good silicon to footprint ratio.</li> <li>High component density</li> </ul> |                                    | <ul style="list-style-type: none"> <li>Standard DFN requires x-ray solder inspection</li> <li>Side-Wall Plated (SWP) flanks enable optical inspection</li> <li>Exposed pad under die for improved thermal performance</li> <li>Cannot run PCB tracks beneath package body</li> <li>Low package height</li> <li>Very good silicon to footprint ratio.</li> <li>High component density</li> </ul> |                                 |

Focus for Innovation

| Part Number  | $V_{CEO}$ | $I_C$ | $I_{CM}$ | $P_D$ | $h_{FE}$ |              |     |              | $V_{CE(sat)}$ |                     |           |                     | $f_T$ |
|--------------|-----------|-------|----------|-------|----------|--------------|-----|--------------|---------------|---------------------|-----------|---------------------|-------|
|              | V         | A     | A        | W     | Min      | @ $I_C$<br>A | Min | @ $I_C$<br>A | Max<br>mV     | @ $I_C/I_B$<br>A/mA | Max<br>mV | @ $I_C/I_B$<br>A/mA | MHz   |
| <b>NPN</b>   |           |       |          |       |          |              |     |              |               |                     |           |                     |       |
| DXTN3C60PSQ  | 60        | 3     | 8        | 3     | 200      | 1            | 100 | 2            | 120           | 1/50                | 270       | 3/300               | 140   |
| DXTN3C100PSQ | 100       | 3     | 8        | 3     | 150      | 0.5          | 20  | 2            | 150           | 1/50                | 330       | 3/300               | 140   |
| <b>PNP</b>   |           |       |          |       |          |              |     |              |               |                     |           |                     |       |
| DXTP3C60PSQ  | -60       | -3    | -8       | 3     | 150      | -1           | 100 | -2           | -225          | 1/50                | -360      | 3/300               | 135   |
| DXTP3C100PSQ | -100      | -3    | -8       | 3     | 160      | -1           | 45  | -2           | -110          | -500/-50            | -360      | 2/200               | 125   |



|             | Length (L) | Width (W) | Area                | Height (H) |
|-------------|------------|-----------|---------------------|------------|
| PowerDI5060 | 5.15mm     | 6.15mm    | 31.7mm <sup>2</sup> | 1mm        |
| DPAK        | 6mm        | 6.6mm     | 39.6mm <sup>2</sup> | 2.3mm      |
| LFAK56      | 5mm        | 6.2mm     | 31mm <sup>2</sup>   | 1.2mm      |

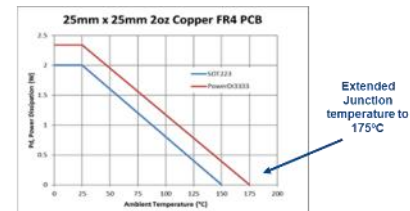
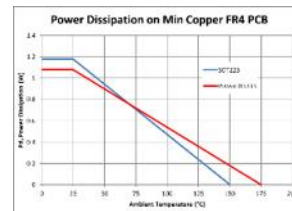
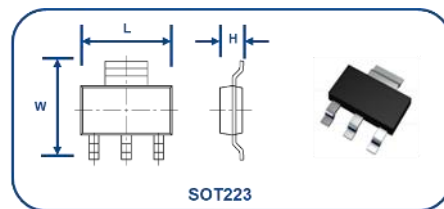
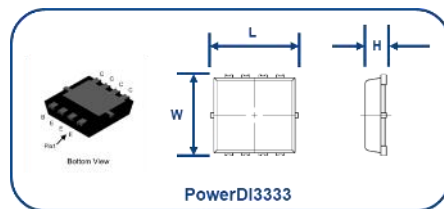
## Applications

Various Power Management functions:

- **Linear regulation**
- **LDO regulation**
- **Load switches**
- **Backlighting Applications**

# PowerDI3333 – Smaller, thermally efficient alternate to SOT223

| Part Number   | Polarity | V <sub>CEO</sub> | I <sub>C</sub> | I <sub>CM</sub> | P <sub>D</sub> | h <sub>FE</sub> |                       |     |                       | V <sub>CE (sat)</sub> |                                          |            |                                          | Status   |
|---------------|----------|------------------|----------------|-----------------|----------------|-----------------|-----------------------|-----|-----------------------|-----------------------|------------------------------------------|------------|------------------------------------------|----------|
|               |          | V                | A              | A               | W              | Min             | @ I <sub>C</sub><br>A | Min | @ I <sub>C</sub><br>A | Max.<br>mV            | @ I <sub>C</sub> /I <sub>B</sub><br>A/mA | Max.<br>mV | @ I <sub>C</sub> /I <sub>B</sub><br>A/mA |          |
| DXTN22040CFGQ | NPN      | 40               | 2              | 3               | 2.3            | 200             | 0.5                   | 80  | 2                     | 220                   | 1/100                                    | 600        | 3/300                                    | Released |
| DXTN22040DFGQ | NPN      | 40               | 2              | 3               | 2.3            | 300             | 0.5                   | 200 | 1                     | 300                   | -0.5/2                                   | 600        | 3/300                                    | Released |
| DXTP07025BGQ  | PNP      | -25              | -3             | -8              | 2.3            | 100             | -1                    | 75  | -2                    | -200                  | -1/-100                                  | -400       | -3/-300                                  | Released |
| DXTP22040CFGQ | PNP      | -40              | -2             | -3              | 2.3            | 200             | -0.5                  | 80  | -2                    | -130                  | -0.5/-50                                 | -350       | -2/-200                                  | Released |
| DXTP22040DFGQ | PNP      | -40              | -2             | -3              | 2.3            | 300             | -0.5                  | 80  | -2                    | -170                  | -0.5/-50                                 | -400       | -2/-200                                  | Released |
| DXTP07040CFGQ | PNP      | -40              | -3             | -6              | 2.3            | 250             | -0.5                  | 150 | -2                    | -250                  | -0.5/-5                                  | 500        | -2/-50                                   | Released |
| DXTP07060BFGQ | PNP      | -60              | -3             | -6              | 2.3            | 100             | -0.5                  | 40  | -2                    | -250                  | -1/-100                                  | -500       | -3/-300                                  | Released |
| DXTP06080BFGQ | PNP      | -80              | -1             | -2              | 2.3            | 50              | -0.05                 | 100 | -0.15                 | -280                  | -500/-50                                 | n/s        | -800/-70                                 | Released |
| DXTP07100BFGQ | PNP      | -100             | -2             | -6              | 2.3            | 100             | -0.5                  | 55  | -1                    | -250                  | -1/-100                                  | -500       | -2/-200                                  | Released |



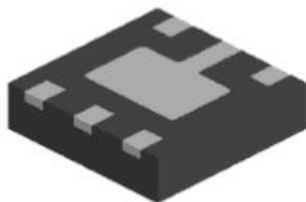
|              | Length (L) | Width (W) | Area                 | Height (H) |
|--------------|------------|-----------|----------------------|------------|
| PowerDI3333  | 3.4mm      | 3.4mm     | 11.56mm <sup>2</sup> | 0.85mm     |
| SOT223       | 6.55mm     | 7.1mm     | 46.5mm <sup>2</sup>  | 1.8mm      |
| Ratio PD:SOT | 51.9%      | 47.9%     | 24.9%                | 47.2%      |

|             | Minimum Cu       |                | 25 x 25mm 2oz CU, FR4 PCB |                | R <sub>θJL</sub> |
|-------------|------------------|----------------|---------------------------|----------------|------------------|
|             | R <sub>θJA</sub> | P <sub>D</sub> | R <sub>θJA</sub>          | P <sub>D</sub> |                  |
| PowerDI3333 | 140°C/W          | 1.07W          | 65°C/W                    | 2.3W           | 8.5°C/W          |
| SOT223      | 106°C/W          | 1.18W          | 62.5°C/W                  | 2.0W           | 12°C/W           |

| Part Number      | Polarity    | V <sub>CEO</sub><br>(V) | I <sub>C</sub><br>(A) | I <sub>CM</sub><br>(A) | P <sub>D</sub><br>(W) | h <sub>FE</sub><br>(Min) | h <sub>FE</sub><br>(@ I <sub>C</sub> )<br>(A) | h <sub>FE</sub><br>(Min 2) | h <sub>FE</sub><br>(@ IC2)<br>(A) | V <sub>CE(SAT)</sub><br>Max<br>(mV) | V <sub>CE</sub> (SAT)<br>(@ I <sub>C</sub> /I <sub>B</sub> )<br>(A/m A) | V <sub>CE</sub> (SAT)<br>(Max.2)<br>(mV) | V <sub>CE(SAT)</sub><br>(@ I <sub>C</sub> /I <sub>B2</sub> )<br>(A/mA) | f <sub>T</sub> |
|------------------|-------------|-------------------------|-----------------------|------------------------|-----------------------|--------------------------|-----------------------------------------------|----------------------------|-----------------------------------|-------------------------------------|-------------------------------------------------------------------------|------------------------------------------|------------------------------------------------------------------------|----------------|
| BC56-16PAWQ      | NPN         | 80                      | 1                     | 2                      | 0.52                  | 100                      | 0.15                                          | 25                         | 0.5                               | 500                                 | 0.5/50                                                                  | N/A                                      | N/A                                                                    | 150            |
| DXTN10060DFJBQ   | NPN         | 60                      | 4                     | 6                      | 1.8                   | 250                      | 0.01                                          | 250                        | 1                                 | 20                                  | 0.1/10                                                                  | 200                                      | 2/50                                                                   | 125            |
| DXTN10060DFJBWQ* | NPN         | 60                      | 4                     | 6                      | 1.8                   | 250                      | 0.01                                          | 250                        | 1                                 | 20                                  | 0.1/10                                                                  | 200                                      | 2/50                                                                   | 125            |
| ZXTP56020FDBQ*   | PNP+<br>PNP | 20                      | 2                     | 3                      | 2.47                  | 250                      | 0.1                                           | 210                        | 0.5                               | 110                                 | 0.05/50                                                                 | 220                                      | 1/50                                                                   | N/S            |
| ZXTP56060FDBQ*   | PNP+<br>PNP | 60                      | 2                     | 3                      | 2.47                  | 170                      | 0.1                                           | 140                        | 0.5                               | 120                                 | 0.5/50                                                                  | 250                                      | 1/50                                                                   | N/S            |

\* Side Wall Plated

U-DFN2020-6



## Applications

Various Power Management functions:

- **Linear regulation**
- **LDO regulation**
- **Load switches**
- **Backlighting Applications**

# Diodes' Automotive Summary

- Broad Portfolio of Automotive Compliant products
  - AEC-Q100/101/104/200 qualified in **IATF 16949** facilities
- Class-leading performance products for key market growth applications
  - Connected driving
    - ADAS (Advanced Driver Assistance Systems)
    - Telematics
    - Infotainment Systems
  - Comfort, style and safety
    - Lighting
    - BLDC motor control
  - Electrification/Powertrain



# Diodes' Automotive Summary

**Thank You**