



# VCU Kit Solution

## 整车控制器整体解决方案

Patrick Zhang

Marketing Manager  
Powertrain and Safety BU, GC&SA  
STMicroelectronics (Shanghai) Co., Ltd.



- VCU(vehicle control Unit) is key component in electrical vehicle. It controls kinds of EV actuators by analyzing inputs signals such as accelerator signals ,braking signals etc., and implement inverter driving control, power distribution control, braking energy recirculation control and so on.
- ST L9788 is a new generation U-chip device dedicated on VCU and EMS applications. ST offers VCU total solution by using L9788 together with our automotive Power architecture SPC574 series MCU.
- ST solution key features as below:
  - High integrated solution, it can meet whole VCU system requirements with only 2 key devices.
  - Compliant with function safety ISO26262 requirement.
  - Maintain device operation even when input voltage down to 3.1V
  - Integrated new gen CAN FD to support higher baud rate communication in VCU application
  - Adopt MSC(up to 40MHz) interface for driver control and diagnostic information transfer

# Electric Vehicles Classification

## by Electrification Level

**ICE**



Internal Combustion Engine  
Gas

**HEV**



Hybrid-EV  
ICE + Electric  
Gas only

**PHEV**



Plug-in HEV  
ICE + Electric  
Also rechargeable by el source

**ER-EV**



Extended range EV  
ICE + Electric  
ICE not driving wheels

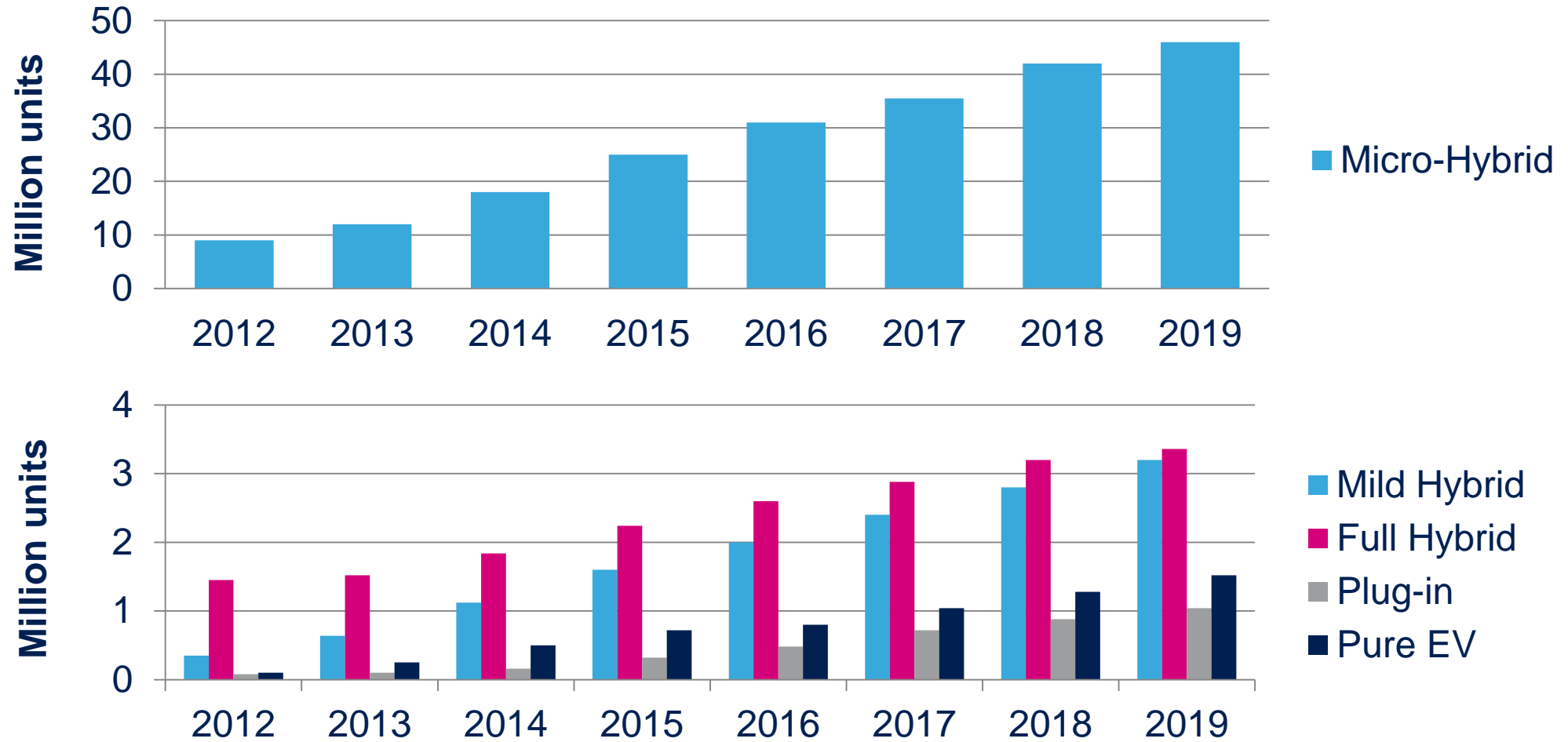
**EV**



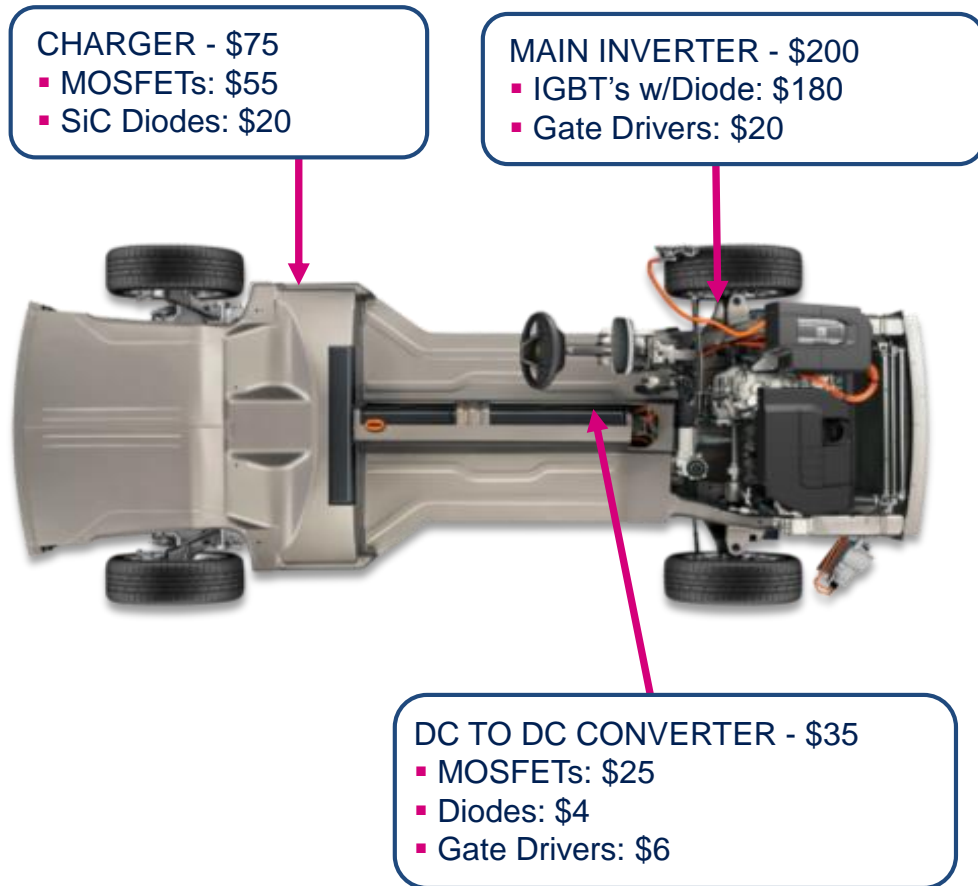
Only Electric  
Fuell Cell (FCEV) or  
battery supplied (BEV)

# HEV/EV Market Forecast

Micro-hybrids will have much higher volumes...



# ...But Large Power Silicon Content is in Full-Hybrid 5



Device Type	Value Per Vehicle (\$)
Large Scale Trench IGBT with diodes (dices)	\$180
High Voltage MOSFETs	\$60
Low Voltage MOSFETs	\$20
SiC Diodes	\$20
Ultrafast diode	4\$
Gate Drivers	\$26

**Total silicon value:  
\$310**

Average values  
ST estimate

# 2015 HEV Semi Content



## Standard

- 339 USD/car



## Mild-hybrid

- 517 USD/car
- 5-15kw
- Fuel saving 15%



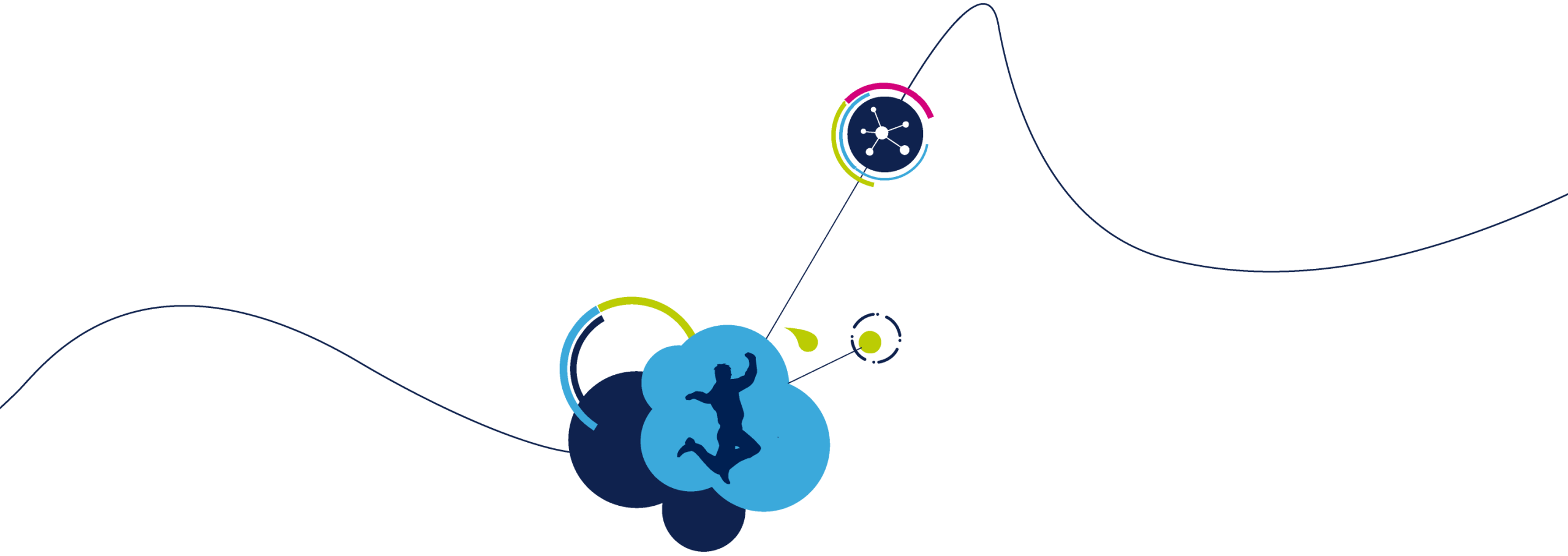
## Full-Hybrid

- 645 USD/car
- 20-80kw
- Fuel saving 25 to 65%



## Pure EV

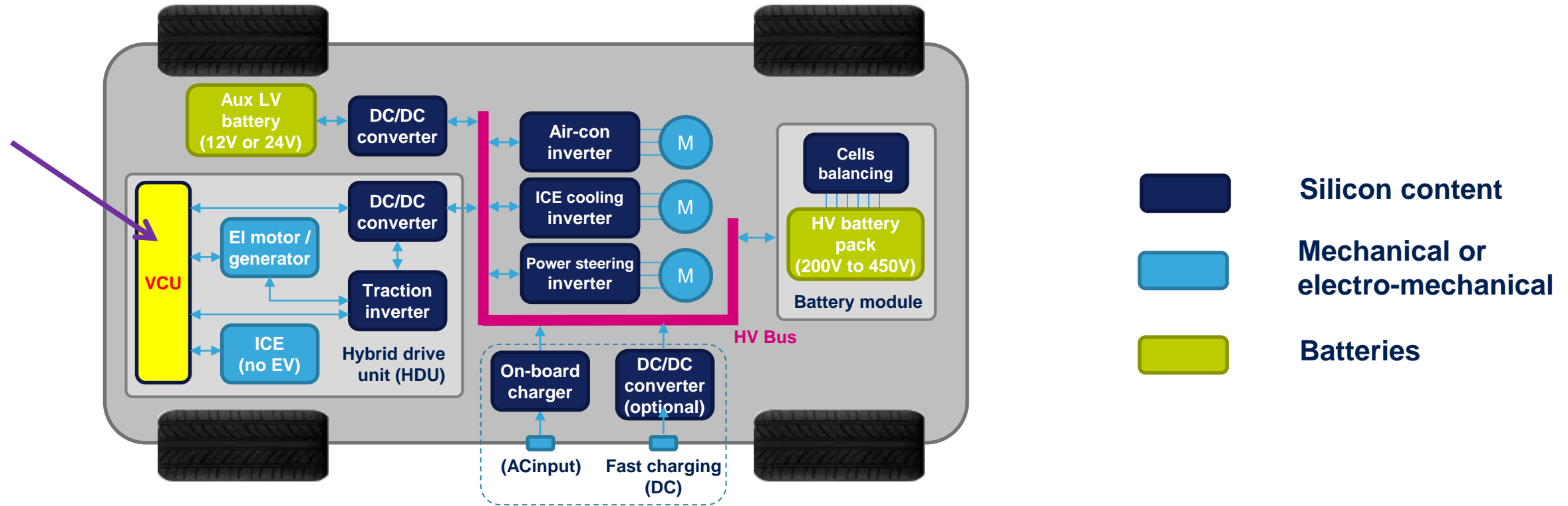
- 670 USD
- 15 – 150kw



# Architecture and Topologies

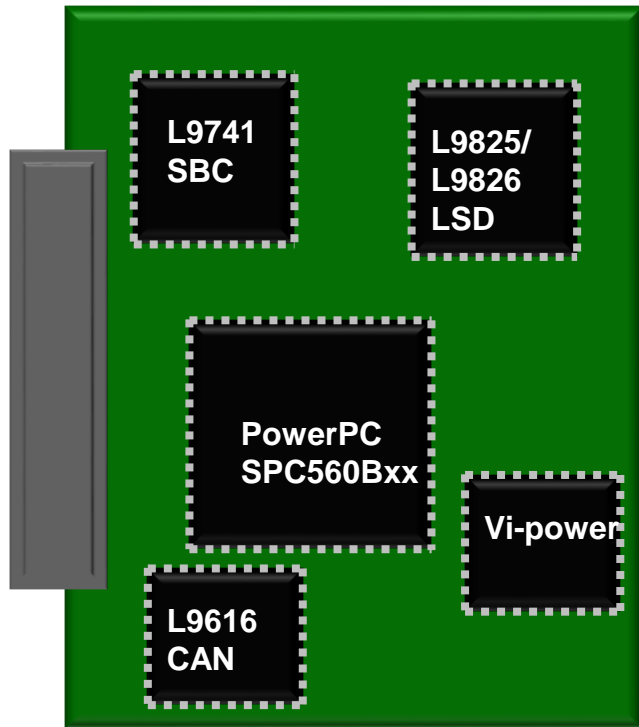
# e-Vehicles Block Diagram

HEV/EV

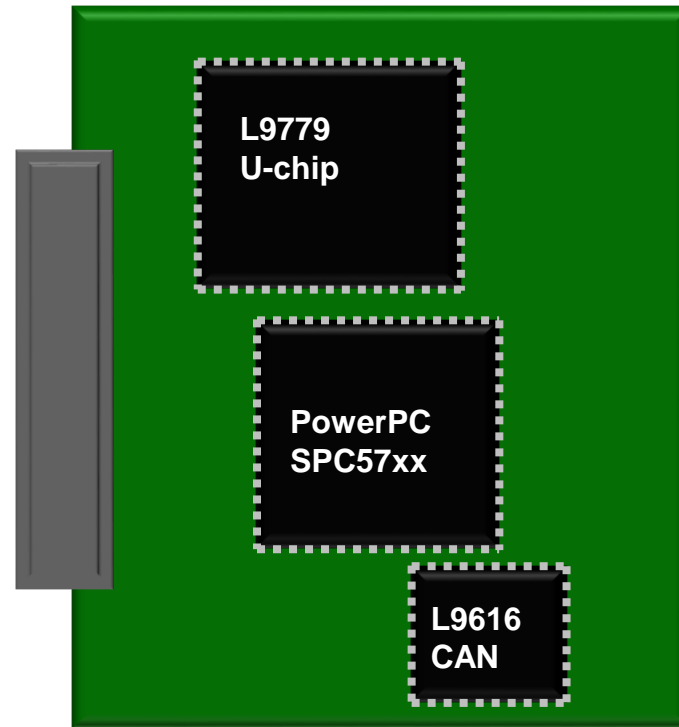




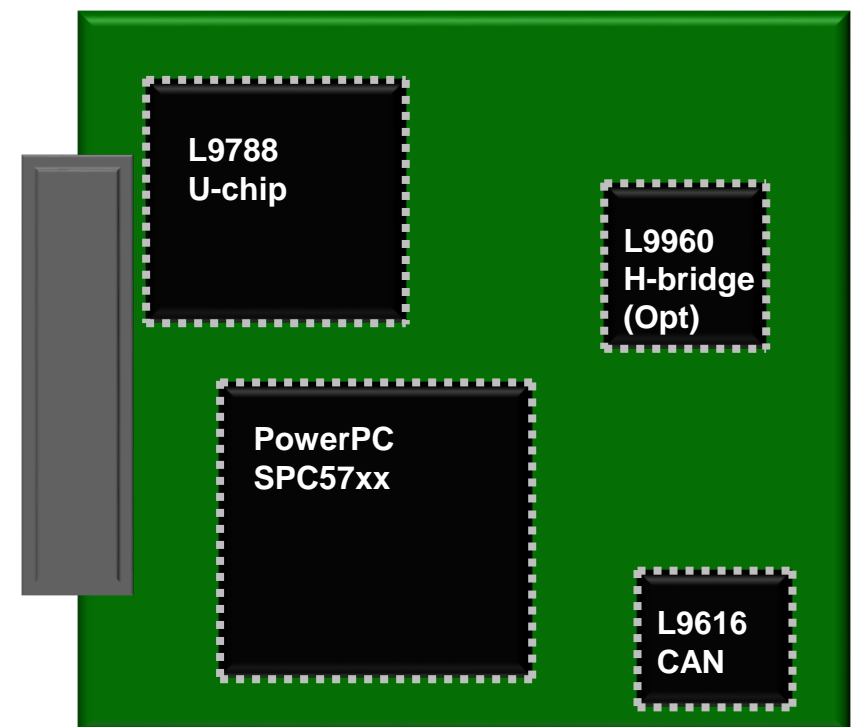
# ST VCU Kit Solution



**Low End**  
(discrete solution)



**Mid End**  
(integrated solution)

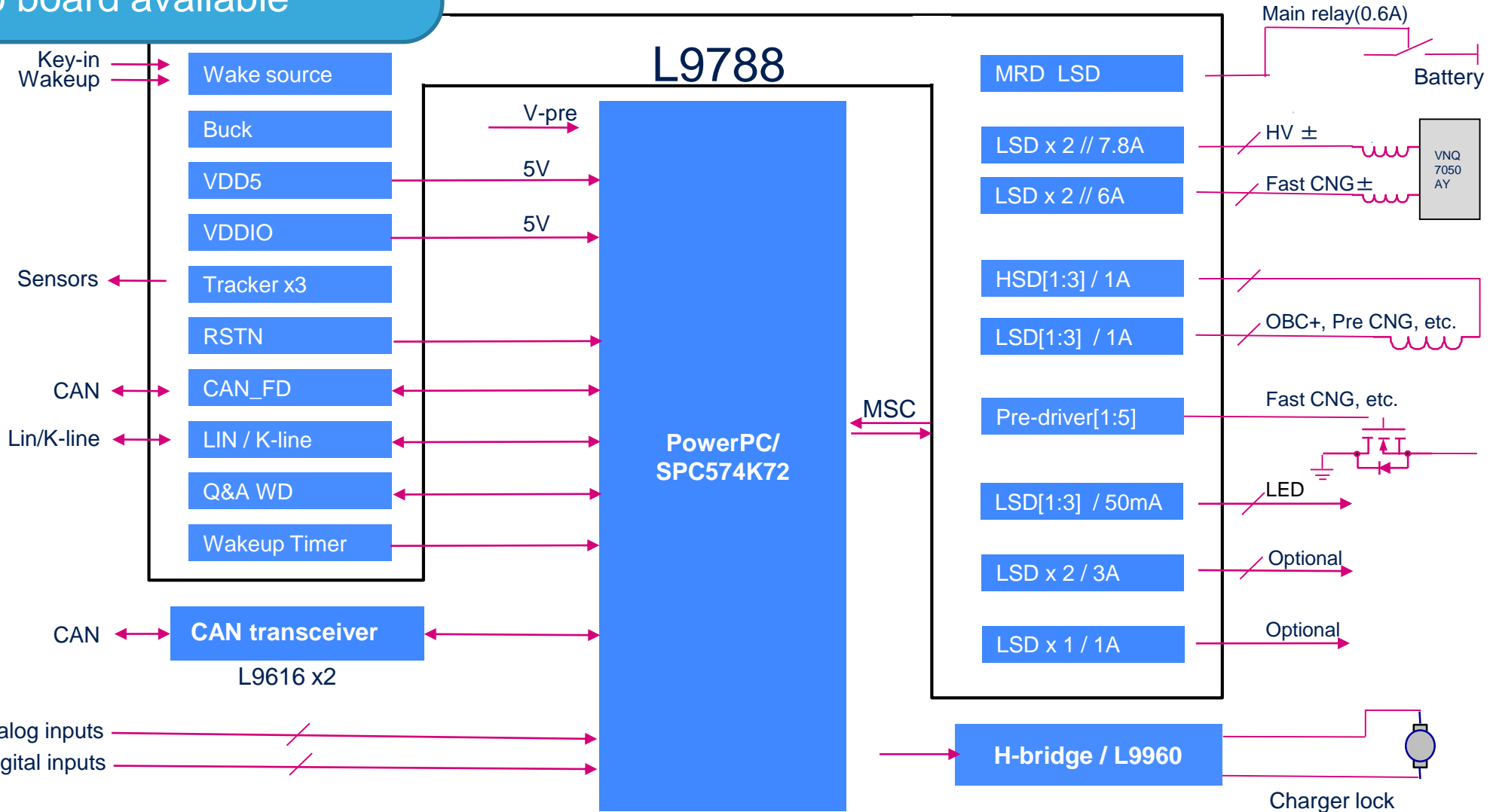


**High End**  
(integrated solution)  
w/ function safety

# ST VCU Kit Solution

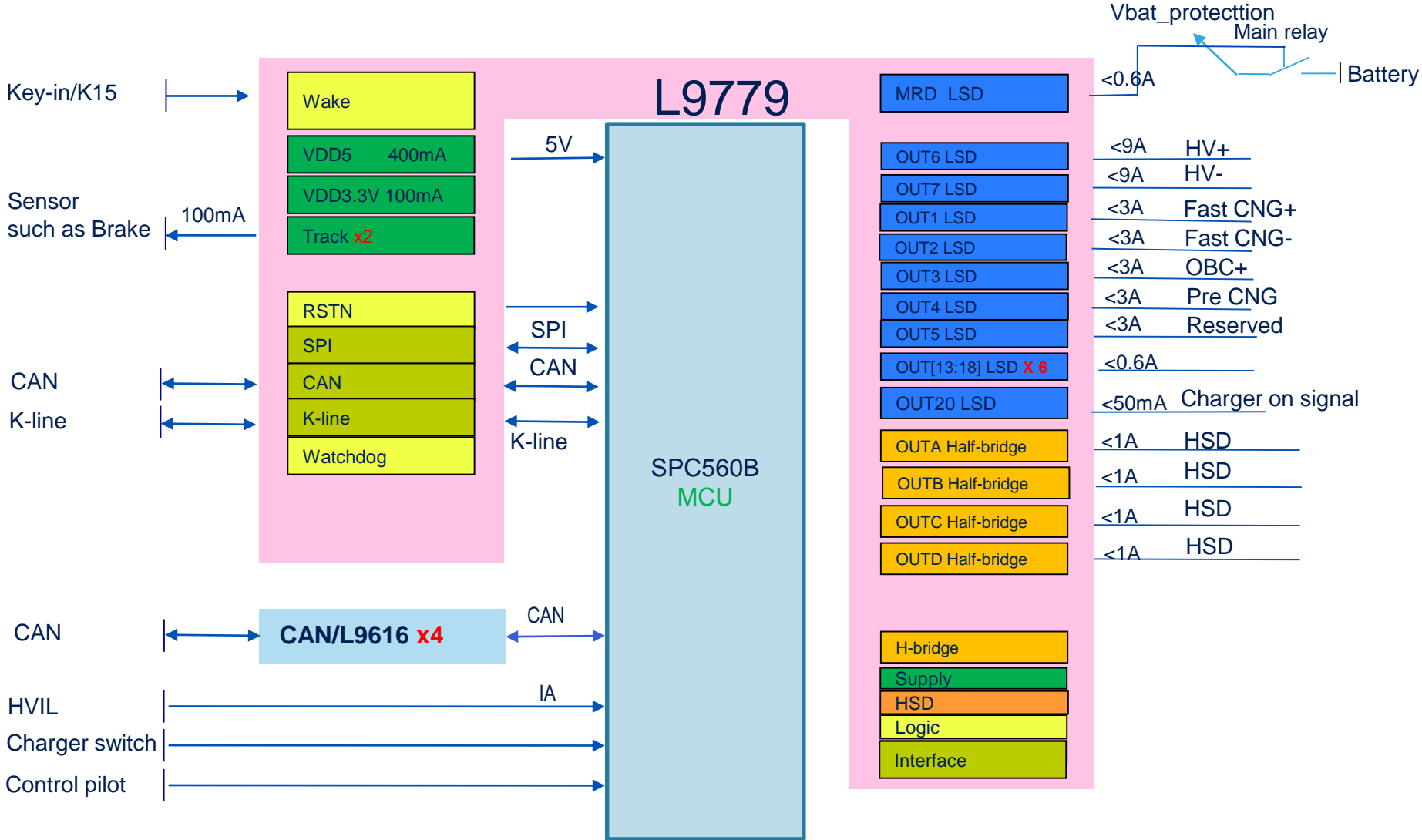
## High End

- High integrated solution
- Function safety compliance
- CAN FD available
- Demo board available



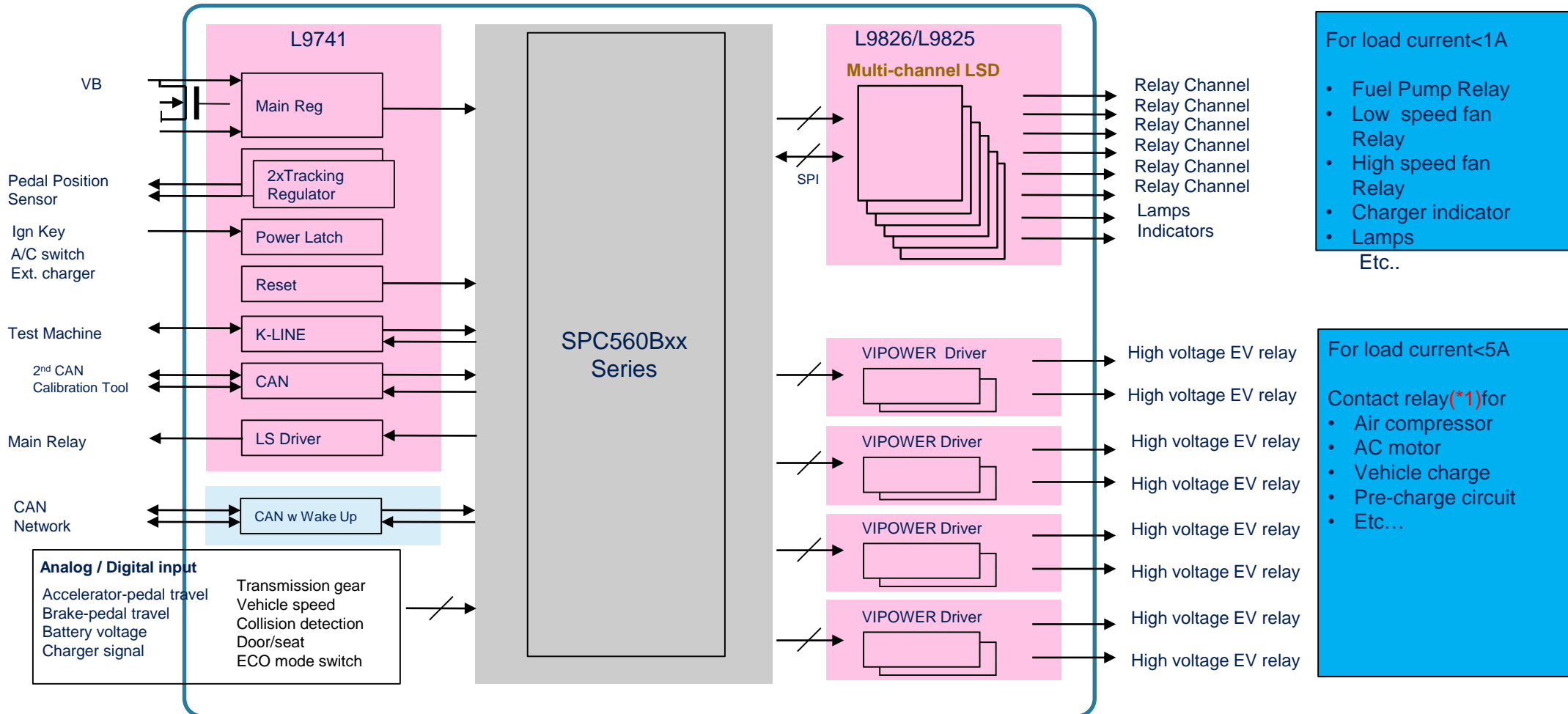
# ST VCU Kit Solution

## Mid End



# ST VCU Kit Solution

## Low End

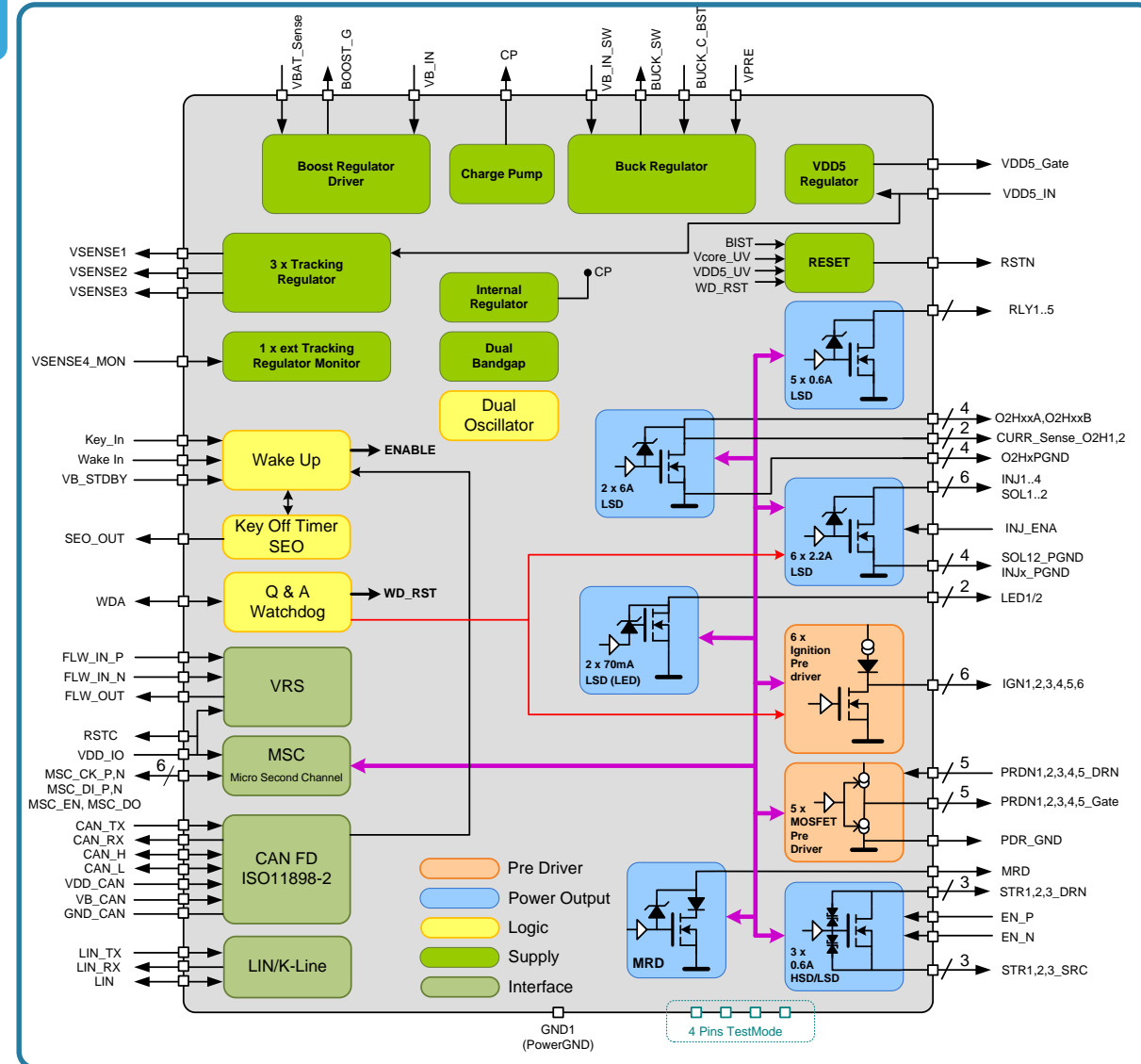


Note(1\*): for high voltage EV relay/高压接触器, normally Inrush current(peak):<5A, hold current<1A; Details current requirement depends on Type/Spec of EV Contact Relay(Contactor)

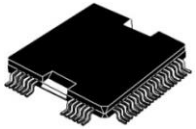
# New Gen U-chip L9788

## Technical information

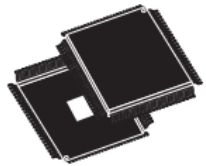
- 1 pre boost regulator and 1 pre buck regulator
- 1 linear 5V regulator with 1A output current
- 3 independent self-protection 5V tracking regulator with 150mA output.
- 1 input voltage pin for monitor external tracking.
- Coordinated soft start-up of all regulators.
- 4 channel LS injector LS drivers
- 2channel LS drivers for O2H load with current sense
- 2 channel LS camshaft or solenoid drivers
- 5 channel LS relay drivers
- 2 channel LS LED drivers
- 3 channel LS/HS drivers with low battery function for smart start
- 1 channel LS main relay driver (MRD) with internal diode for reverse battery protection
- 5 channel pre-drivers for external FET drivers – Predriver 1&3 configurable for O2H load with external Rshunton the source of Ext Nch Mos
- 6 channel pre-drivers for internal or external igniter drivers
- 1 K-Line ISO9141/LIN 2.1 compliant
- Integrated charge-pump
- VRS-interface
- Watchdog
- Pin Wake-up Temperature sensor and monitoring
- Stop-counter with Wake-up
- Dual bandgap reference & oscillator
- Micro-second-channel MSC for differential single ended mode
- SEO function
- CAN-FD with wake up by CAN function
- ISO26262 compliant



# U-chip L9788 vs L9779



**L9779**  
**HiQuad 64**



**L9788**  
**TQFP100-EP**

Power Supply	<ul style="list-style-type: none"> <li>5V regulator with external NMOS (700mA)</li> <li>3.3V+/-2% main linear regulator, 100mA</li> <li>2 x 5V tracking regulators, 100mA</li> </ul>			<ul style="list-style-type: none"> <li>Boost regulator to maintain device operation when cranking voltage drop to 3.1v (VBAT pin)</li> <li>6v Buck regulator VPRE output(1.6A) with integrated internal power MOSFET</li> <li>5V regulator with external NMOS (1000mA)</li> <li>3 x 5V tracking regulators, 150mA</li> <li>1x tracking regulator monitor</li> </ul>		
	Wake-up			KEY_IN / WAKE_IN / CAN / Wake Up Timer		
LS Driver	<ul style="list-style-type: none"> <li>1 Main Relay 1.5Ω max., 300mA, Vb min 4.3V</li> <li>1 Start Relay 1.5 Ω max., 600mA, 48V clamp</li> <li>5 Relay 1.5 Ω max., 600mA, 48V clamp</li> <li>4 Injector 0.72 Ω max., 2.2A, 58V clamp</li> <li>2 O2 Heater 0.47 Ω max., 5A, 45V clamp</li> <li>1 High Current 0.72 Ω max., 3A, 58V clamp</li> </ul>			<ul style="list-style-type: none"> <li>1 Main Relay 1.5 Ω max., 1A, 50v clamp</li> <li>5 Relay 1.5 Ω max., 1A, 50V clamp</li> <li>4 Injector LSD 0.6 Ω max., 3A, 55V clamp</li> <li>2 O2 Heater 0.216 Ω max., 7.8A, 50V clamp with current sense option</li> <li>2 High Current 0.47 Ω max., 3A, 55V clamp</li> </ul>		
	Stepper or HSD/LSD		<ul style="list-style-type: none"> <li>2 Low Cur. 50mA</li> <li>1 Low Cur. 50mA</li> </ul>		<ul style="list-style-type: none"> <li>2 Low Cur. 70mA with LED load driving function</li> </ul>	
Pre-driver	<ul style="list-style-type: none"> <li>HSD 1.5 Ω max., LSD 1 Ω max, 600mA</li> <li>4 HSD &amp; 4LSD</li> </ul>		<ul style="list-style-type: none"> <li>4 LSD</li> </ul>		<ul style="list-style-type: none"> <li>3x configurable HSD / LSD, 1.5 Ω max, 1A</li> <li>Delay off function for 1x RLY and 2x STR drivers</li> </ul>	
	<ul style="list-style-type: none"> <li>4 IGBT</li> <li>2 Ext. MOS</li> </ul>		<ul style="list-style-type: none"> <li>4 IGBT</li> <li>3 Ext. MOS</li> </ul>		<ul style="list-style-type: none"> <li>4 IGBT</li> <li>6x IGBT</li> <li>5x Ext. MOS (2 channel for O2H load with external Rshun)</li> </ul>	
Sensor I/F	<ul style="list-style-type: none"> <li>Self configuring variable reluctance sensor If.</li> <li>ISO9141 transceiver (K-Line)</li> </ul>					
Communication	<ul style="list-style-type: none"> <li>Micro-second ch.</li> <li>CAN ISO11898-2</li> </ul>		<ul style="list-style-type: none"> <li>SPI + 12 // In</li> <li>CAN ISO11898-2</li> </ul>			
	<ul style="list-style-type: none"> <li>Self configuring variable reluctance sensor If.</li> <li>LIN 2.1 transceiver with K-LINE compatible</li> </ul>					
Diagnosis & Protection	<ul style="list-style-type: none"> <li>Thermal &amp; short shutdown for drivers</li> <li>Short to Vbat and Ground, Open Load (Drivers)</li> <li>UV &amp; OV on VDD5 and UV on Vbat</li> <li>Switch Engine Off (SEO) for INJx / LSD13,14</li> <li>MSC communication activity monitoring (MSC interface device only)</li> </ul>			<ul style="list-style-type: none"> <li>Micro-second channel</li> <li>CAN FD transceiver and meet ISO11898-5</li> </ul>		
	<ul style="list-style-type: none"> <li>Thermal &amp; short protection for regulator &amp; drivers</li> <li>Short to Vbat and Ground, Open Load (Drivers)</li> <li>UV &amp; OV on VDD5, Vbat, VPRE, VDDIO, VTRK</li> <li>Dedicated SEO signal output, more flexible</li> <li>EN_P/EN_N pin dedicated switch off path</li> <li>MSC communication activity monitoring</li> </ul>					
Supervision	<ul style="list-style-type: none"> <li>Watchdog</li> <li>RST</li> </ul>		<ul style="list-style-type: none"> <li>No WD,</li> </ul>		<ul style="list-style-type: none"> <li>Watchdog</li> <li>2x RST output (RSTN / RSTC)</li> <li>ISO26262 compliant</li> </ul>	
	<ul style="list-style-type: none"> <li>Watchdog</li> <li>2x RST output (RSTN / RSTC)</li> <li>ISO26262 compliant</li> </ul>					

**L9779WD**

**L9779**

**L9779WDSPI**

**L9788**

# L9741- 12V System-basis-Chip

## Power stage

- 5V (VDD) regulator  $\pm 2\%$  400mA
- 2ch 5V tracking regulator with VDD 100mA

## Communication & Interface

- 1ch CAN transceiver w/o wake up(1MHz)
- 2ch K-line interface
- 1ch VRS interface
- 1ch Full Differential To Single-Ended Op-Amp with 4 programmable Gains

## Output

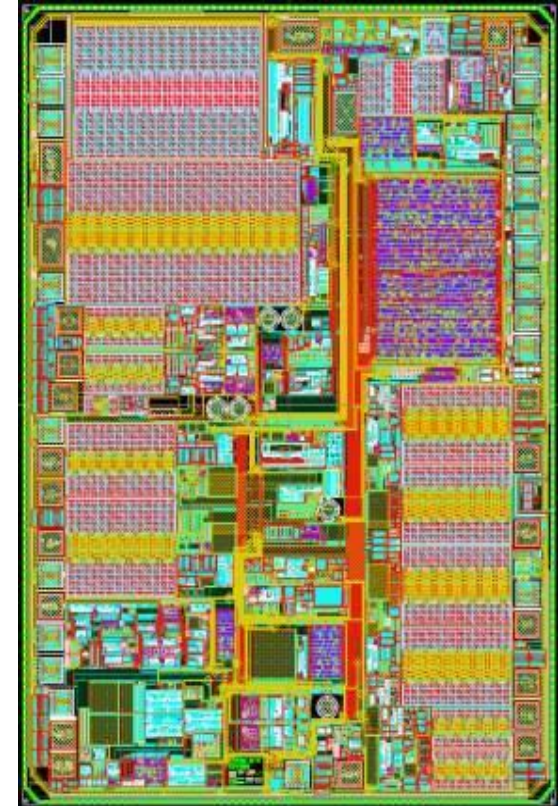
- 1ch Protected HS output 50mA
- 1ch LS output 0.9A/ clamp 35V

## Diagnosis & Protection

- OC, OV, OT
- Dual Multifunction Rest

## Package

- Power SO36



PowerSO36

Block

# L9826/L9825 – 12V Multi-low Side Driver

## L9826/L9825

### Power stage

- 8 low side

### Load current Per channel

- L9826-1.5Ω@25°C, 3ΩMax
- L9825-0.75 Ω@25°C, 1.5 ΩMax

### Power Control

- 8-bit SPI
- 2 pin for OUT1&2

### Clamping

- 50V clamping

### Diagnosis & Protection

- ON - SCB
- OFF - SCG / OL

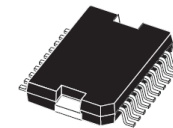
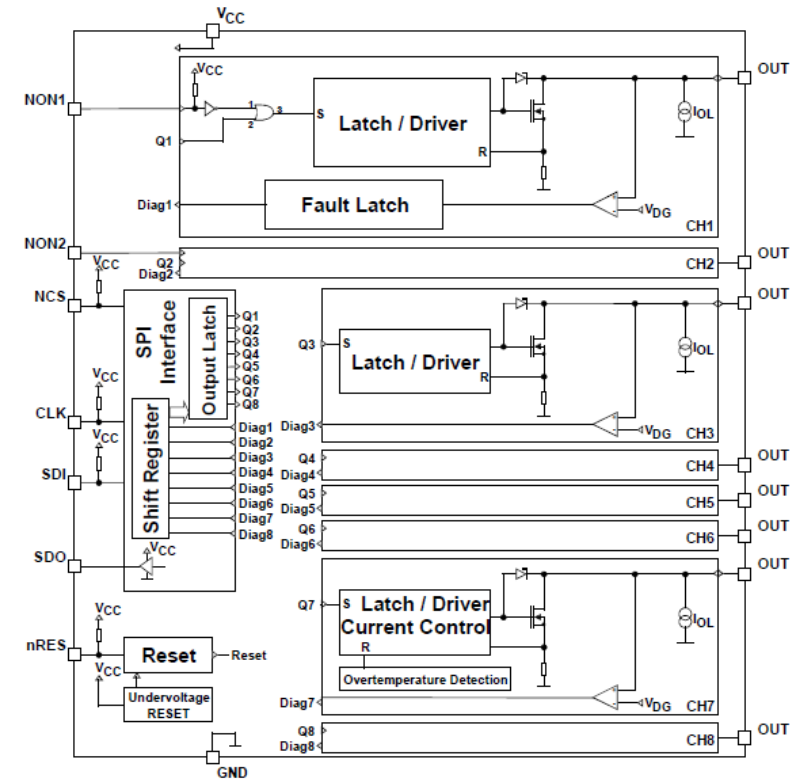
### Package

- L9826-SO20
- L9825-PowerSO20

### Additional Features

- OUT1&2 for inrush current

**Recommended**



L9826 SO20 L9825 PowerSO20

Highly Flexible



# 12V Multi-HS/LS Driver

	L9651	L9826/5	L9848	L9733	L9753	L9301
Power stage	<ul style="list-style-type: none"> <li>4 low side</li> </ul>	<ul style="list-style-type: none"> <li>8 low side</li> </ul>	<ul style="list-style-type: none"> <li>2 Low side + 6 configurable high / low side</li> </ul>	<ul style="list-style-type: none"> <li>8 configurable high / low side</li> </ul>	<ul style="list-style-type: none"> <li>2 Low side + 6 configurable high / low side</li> </ul>	<ul style="list-style-type: none"> <li>8 Low side + 4 configurable high / low side</li> </ul>
Load current Per channel	<ul style="list-style-type: none"> <li>&lt;2.2A</li> </ul>	<ul style="list-style-type: none"> <li>L9826 &lt;0.5A</li> <li>L9825 &lt; 1A</li> </ul>	<ul style="list-style-type: none"> <li>&lt;0.8A</li> </ul>	<ul style="list-style-type: none"> <li>&lt; 1A</li> </ul>	<ul style="list-style-type: none"> <li>&lt; 0.8A / 0.4A selectable</li> </ul>	<ul style="list-style-type: none"> <li>&lt;1/3A-0.6Ω ch</li> <li>&lt;2/6A-0.3Ω ch</li> </ul>
Power Control	<ul style="list-style-type: none"> <li>4 pin for OUT1,2,3&amp; 4</li> </ul>	<ul style="list-style-type: none"> <li>8-bit SPI</li> <li>2 pin for OUT1&amp;2</li> </ul>	<ul style="list-style-type: none"> <li>8-bit SPI</li> <li>2 pin for OUT5&amp;6</li> </ul>	<ul style="list-style-type: none"> <li>16-bit SPI</li> <li>3 pin for OUT6,7&amp;8</li> </ul>	<ul style="list-style-type: none"> <li>16-bit SPI</li> <li>4 pin for OUT3,4,5&amp;6</li> </ul>	<ul style="list-style-type: none"> <li>8 IN pin for output 1~8 &amp; DRN/SRC 1~4</li> </ul>
Clamping	<ul style="list-style-type: none"> <li>70V clamping</li> </ul>	<ul style="list-style-type: none"> <li>50V clamping</li> </ul>	<ul style="list-style-type: none"> <li>35V for low side, -30V for high side</li> </ul>	<ul style="list-style-type: none"> <li>40V for low side, -14V for high side</li> </ul>	<ul style="list-style-type: none"> <li>55V for low side, -32V for high side</li> </ul>	<ul style="list-style-type: none"> <li>37V for low side</li> </ul>
Diagnosis & Protection	<ul style="list-style-type: none"> <li>ON- SCB, OT</li> <li>OFF- SCG, OL</li> </ul>	<ul style="list-style-type: none"> <li>ON - SCB</li> <li>OFF - SCG / OL</li> </ul>	<ul style="list-style-type: none"> <li>1 fault bit for open, short &amp; thermal down</li> </ul>	<ul style="list-style-type: none"> <li>Open load</li> <li>SCB high side</li> <li>SCG low side</li> <li>Over current</li> </ul>	<ul style="list-style-type: none"> <li>Open load</li> <li>SCB high side</li> <li>SCG low side</li> <li>Over current</li> </ul>	<ul style="list-style-type: none"> <li>Open load</li> <li>SCB high side</li> <li>SCG low side</li> <li>Over current</li> <li>Thermal protection</li> </ul>
Package	<ul style="list-style-type: none"> <li>PowerSO20</li> </ul>	<ul style="list-style-type: none"> <li>L9826-SO20</li> <li>L9825-PowerSO20</li> </ul>	<ul style="list-style-type: none"> <li>SO28</li> </ul>	<ul style="list-style-type: none"> <li>PowerSSO28</li> </ul>	<ul style="list-style-type: none"> <li>PowerSSO28</li> </ul>	<ul style="list-style-type: none"> <li>PowerSSO36</li> </ul>
Additional Features	<ul style="list-style-type: none"> <li>Fast inductive load switch off</li> </ul>	<ul style="list-style-type: none"> <li>OUT1&amp;2 for inrush current</li> </ul>	<ul style="list-style-type: none"> <li>Reverse battery protection</li> </ul>	<ul style="list-style-type: none"> <li>Latch / no latch mode</li> <li>Additional VDDIO supply</li> </ul>	<ul style="list-style-type: none"> <li>VDDIO supply</li> <li>LED mode</li> <li>Reverse battery</li> </ul>	<ul style="list-style-type: none"> <li>Several configuration for high/low side</li> <li>High Tj &amp; Tsd</li> </ul>

High Performance

Highly Flexible

Highly Flexible

Highly Flexible

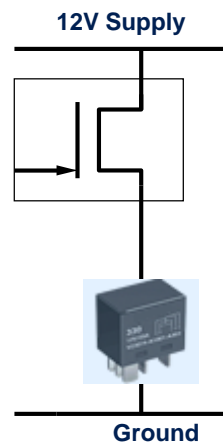
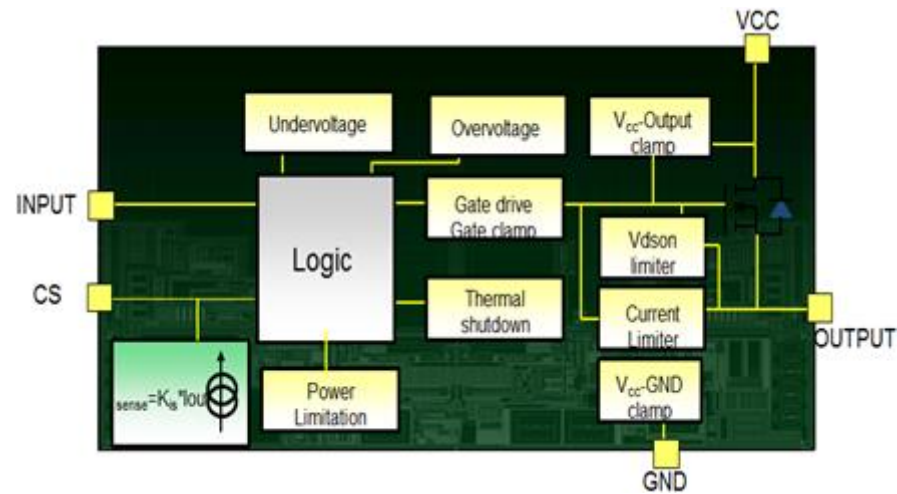
Highly Flexible

Highly Flexible & Performance



# 12V Standard HSD—VIPower M0-7 Family

18



- **Family Approach for 20+ P/N with same feature set concept**
  - Different Ron
  - Single, Dual, Quad channel
  - Pin to pin approach (compatibility for single, dual channel with Ron from 8 to 140mohm)
- **Protection Feature**
  - Different Current Limitation
  - Self limiting of fast thermal transient
  - Thermal shutdown (auto-restart / latch off)
  - Over voltage clamp
  - Under-voltage shutdown
  - Reverse battery protection (Hybrid device)
  - Loss of ground and loss of Vcc protection
  - Electrostatic discharge protection
- **Diagnostic**
  - Proportional load current sense
  - Multisense pin to provide chip slug temperature & Vbat
  - Current sense disable
  - Thermal shutdown indication
- **Small foot print (20mm<sup>2</sup> for most of devices)**
- **Ultra Low Quiescent Current (0.5mA max/chip)**

# 12V Standard HSD—VIPower M0-7 Family Portfolio

$R_{DS(ON)}$	1 OUTPUT CHANNEL	2 OUTPUT CHANNELS	4 OUTPUT CHANNELS	5 OUTPUT CHANNELS	
7 m $\Omega$	VN7007A(L)H				Parallel interface STANDARD
8.5 m $\Omega$	VN7008AJ				
10 m $\Omega$	VN7010AJ				
12 m $\Omega$		VND7012AY			
16 m $\Omega$	VN7016AJ				
20 m $\Omega$	VN7020AJ	VND7020AJ			
30 m $\Omega$		VND7030AJ			
40 m $\Omega$	VN7040AJ/AS	VND7040AJ	VNQ7040AY		
50 m $\Omega$	VN7050AJ/AS	VND7050AJ	VNQ7050AJ		
140 m $\Omega$	VN7140AJ/AS	VND7140AJ	VNQ7140AJ		

## LEGEND:

Part Numbering: VNx7yyyAz

*x*: None, D, Q or P according to # of ch.

*yyy*:  $R_{ds(ON)}$  in m $\Omega$  at 25°C (No asym.)

*z*: according to package as below

**H**: OCTAPAK

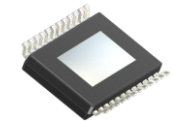
**S**: SO-8

**J**: PowerSSO-16

**Y**: PowerSSO-36

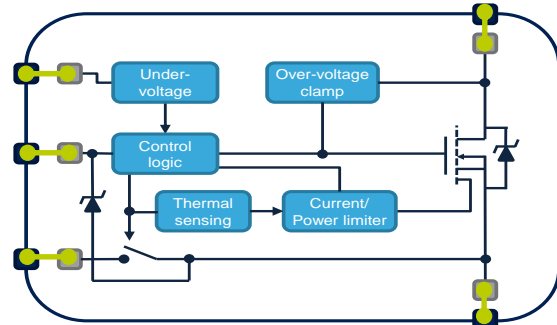
In development

Commercial maturity



# 12V Standard LSD—OmnifetIII Family

SO-8



- **Family Approach for 10+ P/N with same feature set concept**

- Different Ron
- Single, Dual channel
- SOT223 and SO-8 as main package

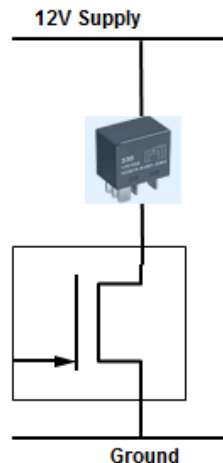
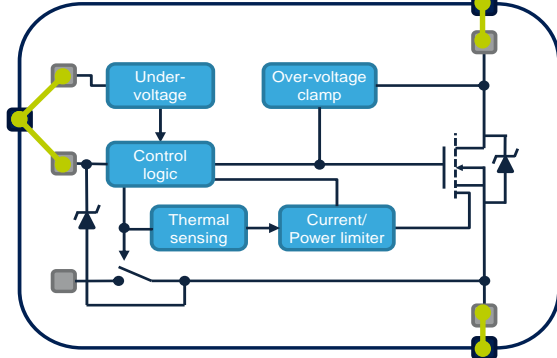
- **Protection Feature**

- Different Current Limitation
- Self limiting of fast thermal transient
- Thermal shutdown (auto-restart)
- Over voltage clamp
- Electrostatic discharge protection

- **Diagnostic**

- Status output (for SO-8 package devices)

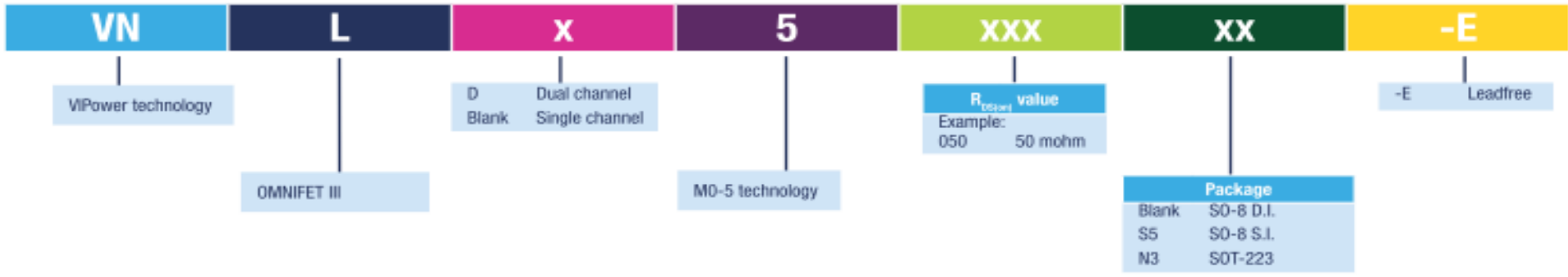
SOT223



# 12V Standard LSD—OmnifetIII Family Portfolio



### OMNIFET III PART NUMBERING SCHEME



# 24V Standard HSD—VIPower M0-5T Family



Stray inductance is typically higher in 24V systems than in regular automotive environment. M05T products have been tailored for matching this special requirements

## Key characteristics

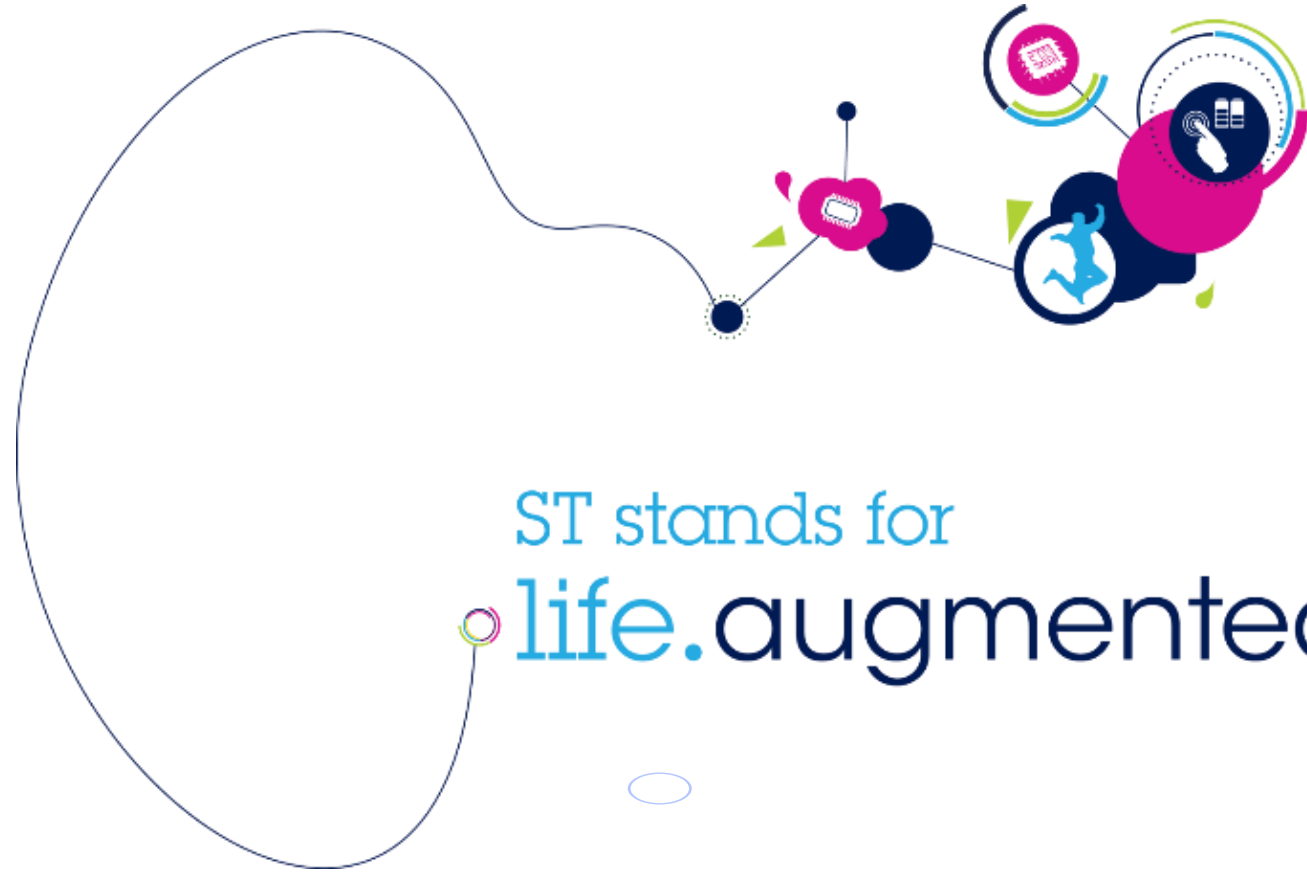
- Supply voltage operating range: 8V – 36V
- Jump start voltage capability: 48V
- Clamping voltage: >58V
- Energy Capability >40 $\mu$ H, 312m $\Omega$  @ 32V, ILIMHmax
- Stand By Current 5 $\mu$ A

## Protection features

- Self limiting of fast thermal transient
- Thermal shutdown
- Load current limitation
- **Programmable output Latch-off**
- Under-voltage shut-down
- Over-voltage clamp
- Protection against loss of ground and loss of Vcc
- Electrostatic discharge protection
- Reverse battery protection

## Diagnostic functions

- Fault Reset / Stand-by pin
- Proportional load current sense
- Open load detection (on/off state)
- Overload and short to ground latch off
- Thermal shut-down latch-off



ST stands for  
**life.augmented**