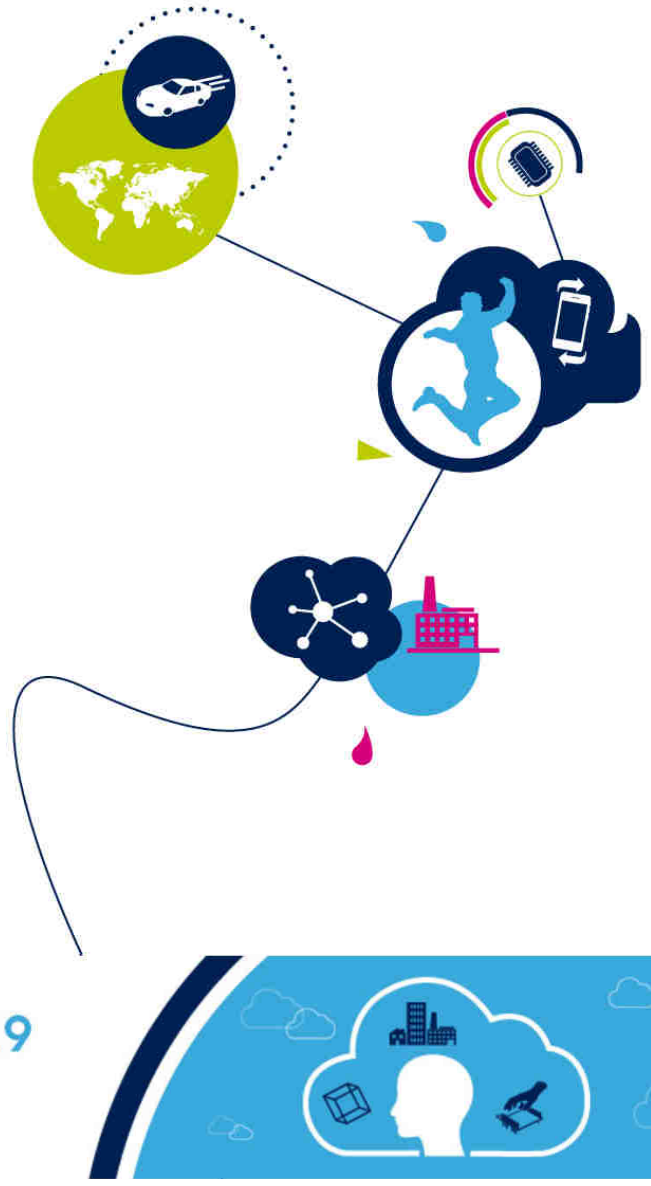
Making Applications Smarter with ST's VIPower™ Intelligent Power Switches and H-Bridge Drivers

Sara Mattioli - ADG Marketing Region Americas



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Technology Tour 2019

Minneapolis, MN | October 24

ST Automotive Advantage

- **Higher reliability** in the final application
  - ISO-TS 16949 International quality management standard
  - Stringent AEC-Q100 electronics stress test qualified
  - Zero ppm target

- **Longevity** (Longer “lifetime” of the devices)
  - Typical 15 year production lifetime

- **High operating temperature range** (-40°C up to 150°C junction temp)

- **Feature rich** solutions
  - Extensive Diagnostics and Protection features
  - Functional Safety design approach according ISO-26262

- **High Value**
  - Leverage ON large automotive volumes to provide high value products at a competitive price

Choose Automotive whenever harsh environmental conditions, stringent reliability and safety requirements and long term supply are key for Customer success

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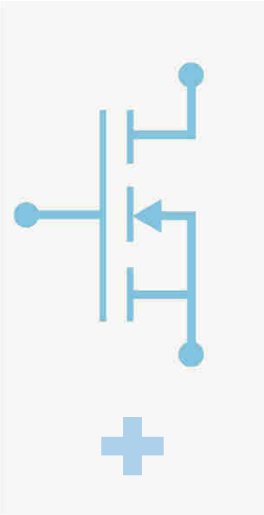
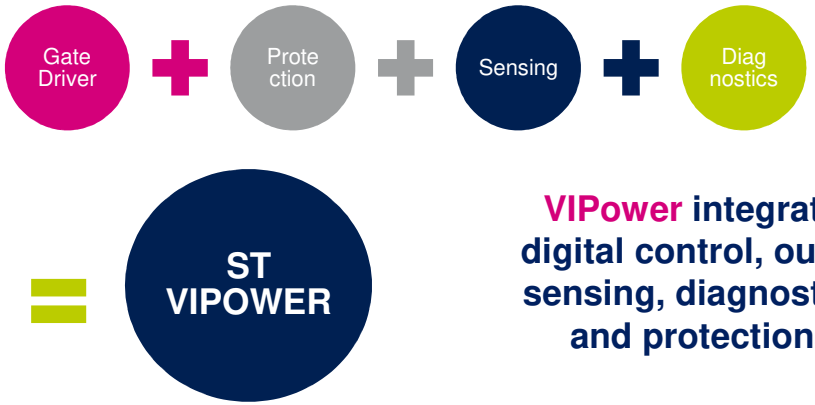
What is ST VIPower™ ?



- A MOSFET used as a power switch requires supplementary circuitry for:
  - **Driving the MOSFET** efficiently to reduce losses and EMI
  - **Protecting the MOSFET** from destruction by excessive current, voltage, or temperature
  - **Feeding back status** information to the logic controller



VIPower integrates digital control, output sensing, diagnostics, and protections

- Discrete design:
  - Considerable design effort
  - High component count
  - Large board space
  - Reduced circuit reliability
  - Increased assembly costs

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VIPower™ Roadmap

Approaching the 5th wave of Innovation

12V NETWORK

1st Generation → Diagnosis & Reliability → Family Expansion → Miniaturization → 48V NETWORK Hybridization

M0-1 — 1st Relay Replacement
1993
320mΩ.mm²
3.0µ lithography

M0-3
2000
160mΩ.mm²
1.2µ lithography

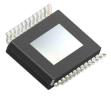
M0-5
2006
85mΩ.mm²
0.6µ lithography

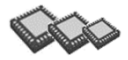
M0-7
2013
40mΩ.mm²
0.35µ lithography

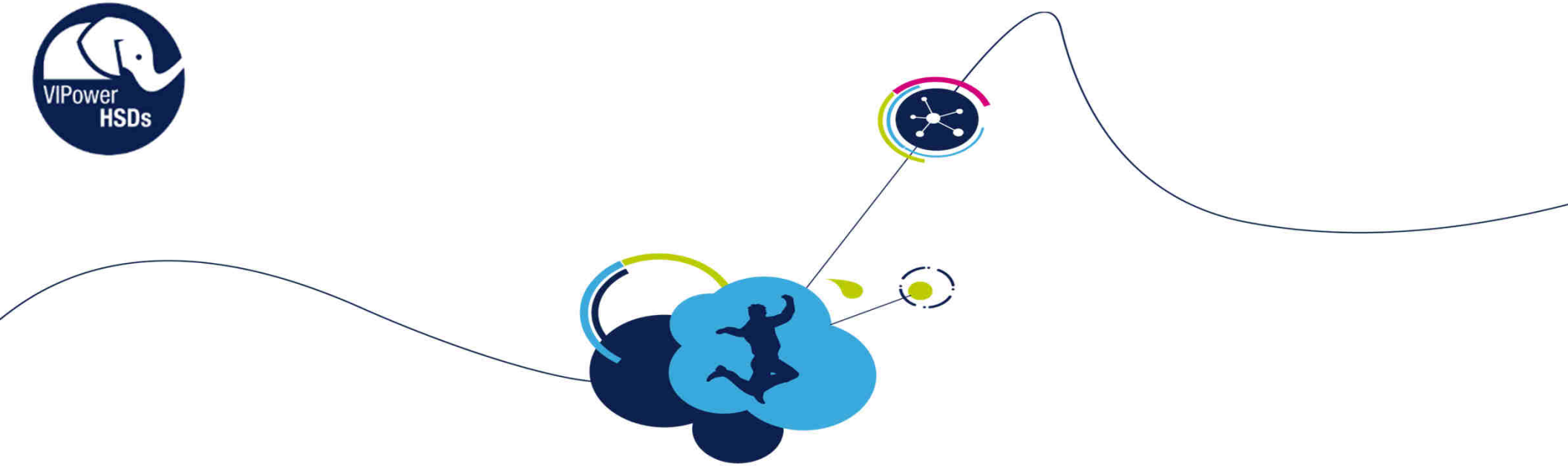
M0-7E
NEW
35mΩ.mm²
0.35µ lithography

M0-9 — Integration
2020
12mΩ.mm²
0.18µ lithography

100V M0-11 — 48V Electrification







High Side Drivers

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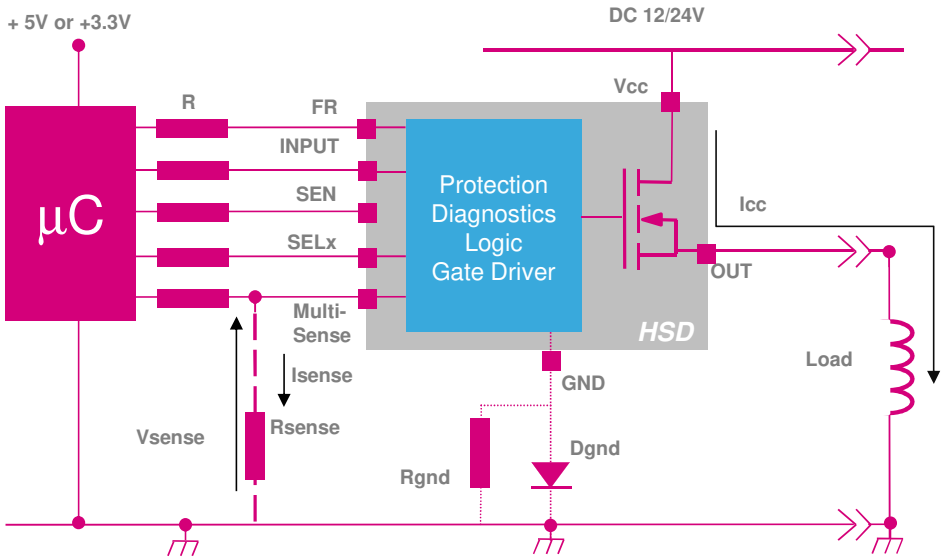
VIPower™ M0-7 HSDs
Intelligent Power Switches



- **An ST High-side Driver switches current into grounded loads (resistive, inductive or capacitive)** and safely protects itself and the system from potentially dangerous fault conditions
- ST Product portfolio includes 1-ch, 2-ch, and 4-ch with analog sense and RDS(ON) values from 1.5mΩ to 140mΩ.

ST Technologies enable a Broad range portfolio:

- **M0-7** (4V-28V)
- **M07-SPI**: M07 with SPI
- **M07-E** (2.85V-28V): M07 w/enhanced features
- **M0-5T** (8V-36V): for 24V systems
- **M09**: next generation for 12V systems
- **M11**: next generation for 48V applications

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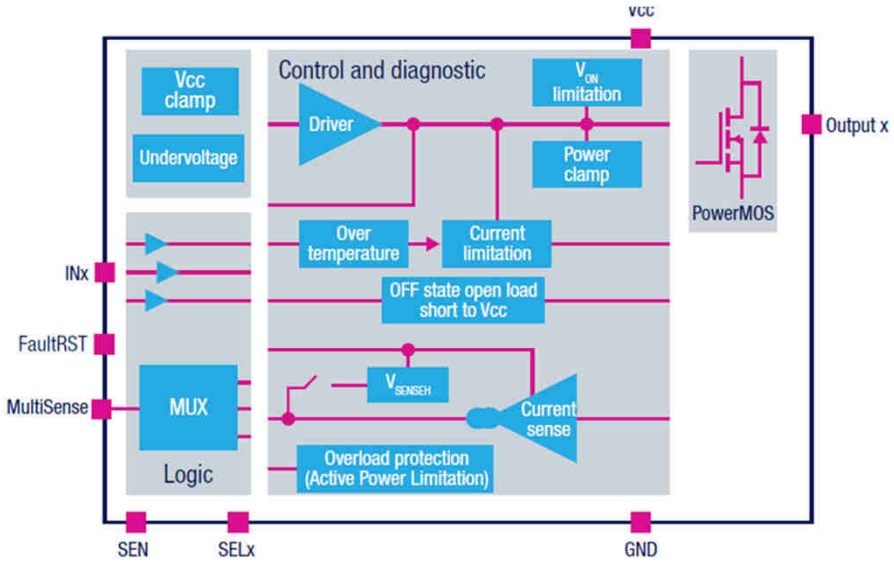
Small, Reliable,
Fully Protected

VIPower™ M0-7 HSDs
Intelligent Power Switches

Key Benefits

- Scalable portfolio, spreading from low-power to high-current switches, offering full SW and HW compatibility
- Benchmark short-circuit robustness (Grade A, up to 1,000,000 cycles)
- PCB shrinkage and weight reduction thanks to the highest package density in the market
- Low-voltage operation down to 2.85V, ensuring functionality during cold cranking
- Ultra low quiescent current, allowing minimal battery consumption in idle mode
- Best in class EMI performances



Key Features

- Fully Protected: Over Voltage, Under Voltage, Over Temperature, Voltage Clamp, Overload & Short Protection
- Configurable auto-restart or latch-off protection against hazardous conditions
- New Multi-Sense diagnostic, providing analog feedback on load current, chip temperature and battery voltage
- Symmetrical turn on/off

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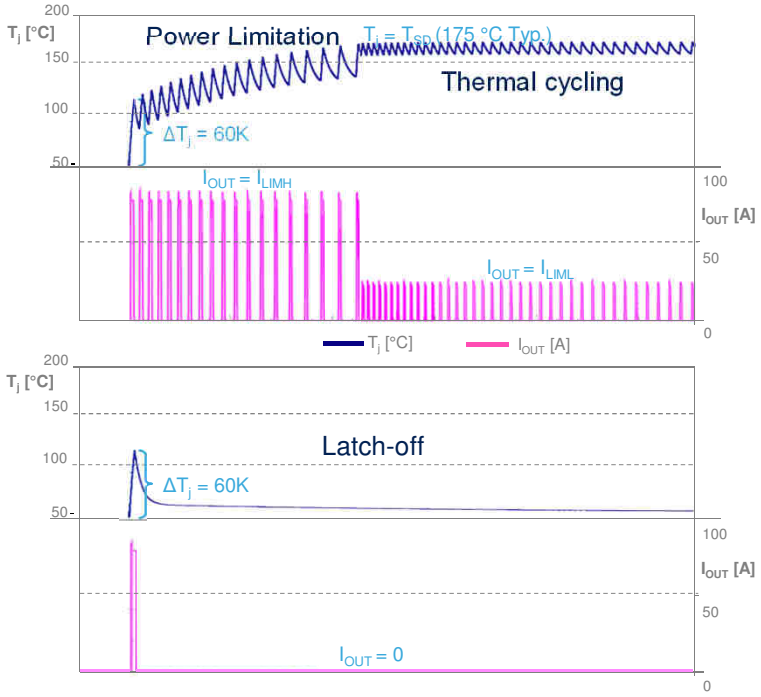
VIPower™ M0-7
Key Features and Benefits

Power limitation (ST exclusive) and configurable latch-off

- ★ • Power limitation (ST patent) contributes in thermo-mechanical **stress reduction during over-load/short-circuit**
  - Average power is limited when a ΔT_j > 60K is detected
  - Configurable **auto restart** or **latch off** makes the device **robust against overload**
- ★ • Latch off capability significantly **extends reliability** by avoiding repetitive demagnetization discharge from inductive loads and/or long term operation in overload conditions



>1,000,000 repetitive short circuit cycles "Grade A" according to AECQ100-012

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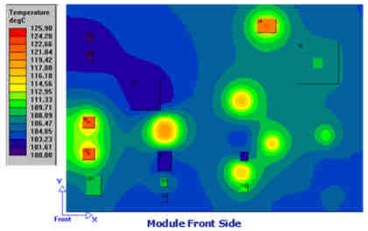
VIPower™ M0-7
Key Features and Benefits

Multi-sense pin (ST exclusive)

Slug Temperature Monitoring



+/- 7°C accuracy

Current sensing – benefits:

- The high-precision analog current sensing allows currents to be monitored for different load types, such as bulbs and LEDs
- Enables **torque control for motor control** applications
- Enables **smart control for circuit protection and load distribution**

Temperature sensing – benefits:

- **Board temperature profiling** reveals critical conditions
- Slug temperature monitor available in ON and OFF states
- **Optimizing PCB thermal design** during development
- **Improving current sense accuracy** by on-board compensation of thermal drifts
- **Power dissipation management** by adapting load driving profile in critical conditions

V_{BAT} sensing – benefits:

- V_{BAT} sensing can be used in conjunction PWM control to keep constant the input power at lamps when V_{BAT} varies
- Having embedded voltage sensing allows
  - **Resource saving at MCU side** (one ADC input can be shared for T and V_{BAT} sensings)
  - External components reduction

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VIPower™ M0-7
Key Features and Benefits

Improved EMI performance

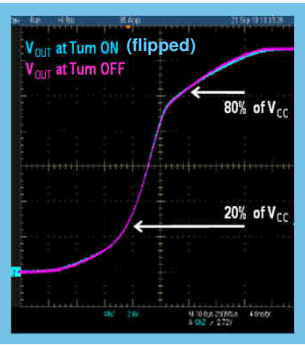
Benefits

- **Symmetrical Turn ON and OFF shapes** (ST Exclusive):
  - Rise and Fall times constant with PWM frequency
  - Faster switching times
- **Optimal edge shaping** and slew-rates:
  - **-10%** switching losses compared to competition, **-30%** compared to M05
  - Improved EMC performance - CISPR 25 class 5 EMI emission level

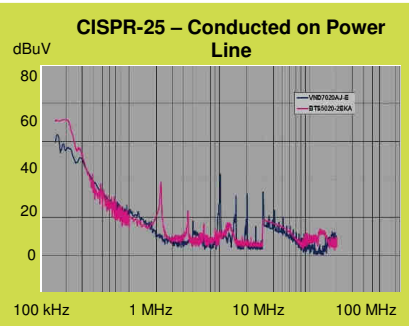
Lower switching losses and better EMI performances (vs competition)

Best in class thermal efficiency and electromagnetic emission performances

Symmetrical turn-on / turn-off



Improved EMI Performance



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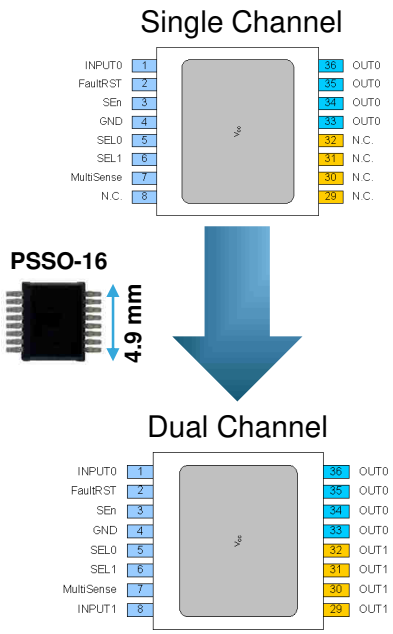
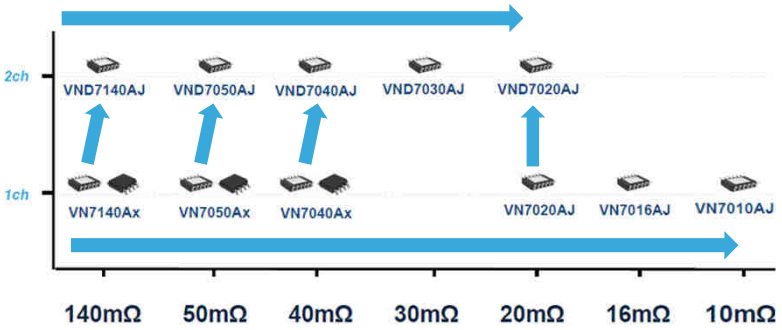
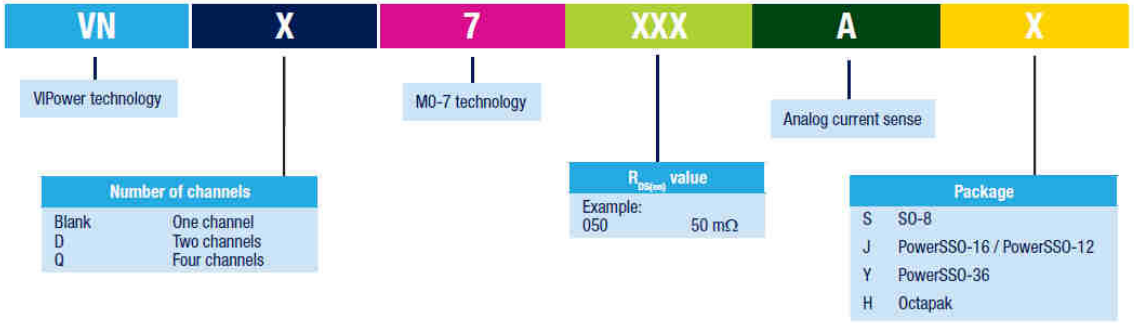
VIPower™ M0-7
Key Features and Benefits

Family Concept





VIPOWER M0-7 HIGH-SIDE DRIVER PART NUMBERING



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VIPower™ M0-7/M0-7E

High Side Drivers Portfolio Overview

VIPower™ M0-7 / M0-7E | VIPower™ Zero

Four output channels

VNQ7E110AJ

VNQ7140AJ | VNQ7050AJ | VNQ7040AY

Two output channels

VND7E070AJ | VND7E040AJ | VND7E025AJ

VND7140AJ (*) | VND7050AJ (*) | VND7040AJ | VND7030AJ | VND7020AJ | VND7012AY | VND7004AY

One output channel

VN7E010AJ | VN7007ALH | VN7004CLH | VN7003ALH (*)

VN7140AJ | VN7050AJ | VN7040AJ | VN7020AJ | VN7016AJ | VN7010AJ | VN7008AJ | VN7007AH | VN7004CH | VN7003AH (*)

VN7140AS (*) | VN7050AS | VN7040AS

ON-state resistance

140mΩ	50mΩ	40mΩ	30mΩ	20mΩ	16mΩ	12mΩ	10mΩ	8mΩ	7mΩ	4mΩ	3mΩ
2.5A	4A	4.5A	5A	6A	7A	9A	9.5A	10A	13A	17A	20A


PSSO-36


PSSO-16


Octapak


SO-8

M0-7E series (PSSO-16)

Max DC Current is based on 85C ambient and 4 layer board

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(*) cold cranking capability on specific part numbers in PSSO-12

M0-7 VIPowerZero HSDs

Evaluation Boards

- **EV-VN7007AH/ALH**
- **EV-VN7004CH/CLH**
- **EV-VND7004AY**
- **EV-VN7003AH/ALH**

Target Applications

- **Heating**
- **Power Distribution Switch**
- **High current relays replacement**
- **Engine Cooling Fan**

RDSon from 1.5mΩ to 7mΩ

Octapak
Footprint 51mm²

PowerSSO-36

VN7003AH (*)
VN7003ALH (*)
VN7004CH
VN7004CLH
VN7007AH
VN7007ALH
VND7004AY
VN7000AY **COMING SOON, Q1 2020** (*)

KEY Value Proposition

- **Family approach: low RDSon subfamily with pin-to-pin compatibility**
- **Octapak & PSSO36 package – improved package thermal dissipation**
- **Low RDSon to address high current applications from 9A to 30A**

(*) LV124 severe cold cranking pulse immunity (operation down to 2.85V)

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M0-7E VIPower™ HSDs

Evaluation Boards

- EV-VN7E010
- EV-VND7E040AJ
- EV-VND7E050AJ
- EV-VNQ7E100AJ

Target Applications

- ADAS battery safety switch
- Applications requiring superior current sense accuracy & cold cranking

Product Portfolio

4ch 100mΩ VNQ7E100AJ			
	2ch 50mΩ VND7E050AJ	*2ch 40mΩ* VND7E040AJ	
			1ch 10mΩ VN7E010AJ

KEY Value Proposition

- **Family approach: Enhanced features with pin-to-pin with M0-7**
- **PowerSSO-16 package – improved package thermal dissipation**
- **Superior Current Sense Precision**
- **LV124 severe cold cranking pulse immunity (operation down to 2.85V)**

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M0-7SPI VIPower™ HSDs

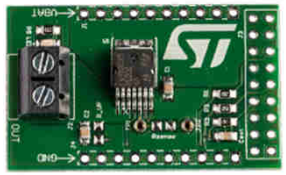
Key Characteristics

- 16 bit ST-SPI Interface
- 3V and 5V Microcontroller compatibility
- Direct Input control
- Bulb/LED mode
- Multiplexed Analog Current Sense
- Advanced Limp Home
- Very low stand-by current
- Start-Stop compatible operation
- PowerSSO-36 expandability

Product	High Power	Medium Power
VNQ7003SY	2x 7 mOhm	2x 25 mOhm
VNQ7004SY	2x 9 mOhm	2x 35 mOhm

VIPower M0-7SPI reduces your overall system cost by:

- Optimizing your PCB area with more channels into the same package
- Simplifying the interconnections to the Micro with the SPI interface
- Improving your diagnostic capability



Evaluation Board

- **EV-VNQ7003SY**

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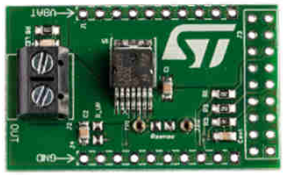
VIPower™ M0-5T HSDs for 24V Systems

Key Features

- **Supply voltage operating range: 8V – 36V**
- **Jump start voltage capability: 48V**
- ***Clamping voltage: >58V***
- Fault Reset / Standby pin
- Proportional load current sense
- Off state open load detection
- Output short to VCC detection
- Overload and short to ground latch off
- Thermal shutdown latch-off

Typical applications

- **Lighting**
- **Heating**
- **Relay Control**
- **DC Motor Control systems**



Evaluation Boards

- **EV-VND5T035AK**
- **EV-VND5T100AJ**

P/N	N of Channel	Ron	IlimH(typ)	Notes
VN5T006ASP-E	1	6mΩ	115A	
VN5T016AH-E	1	16mΩ	60A	
VND5T016ASP-E	2	40mΩ	70A	
VND5T050AK-E	2	50mΩ	34A	
VND5T035K/S-E	2	35mΩ	42A	
VND5T035LK/S-E	2	35mΩ	42A	Current sense optimized for LED driving
VND5T100AJ/S-E	2	100mΩ	22A	
VND5T100LAJ/S-E	2	100mΩ	22A	Current sense optimized for LED driving

Key Benefits

- **High durability in overload due to enhanced protection concept**
- **Complete set of protections and diagnostic**
- **Energy compatibility according to truck cables (*40uH stray inductance and Ilimmax*)**

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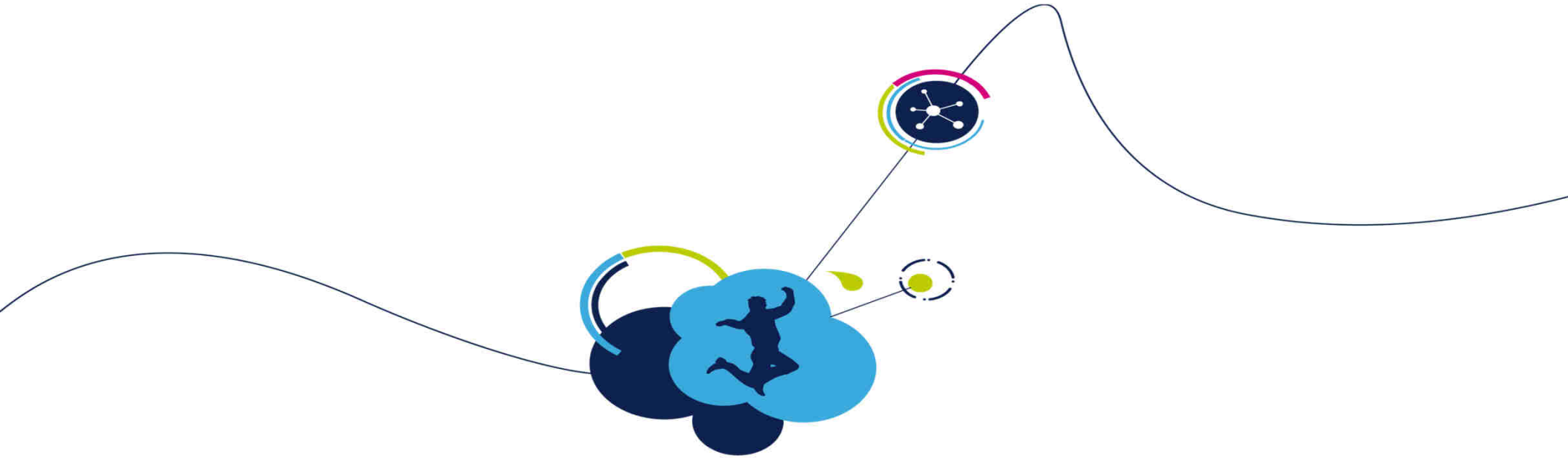

Low Side Drivers

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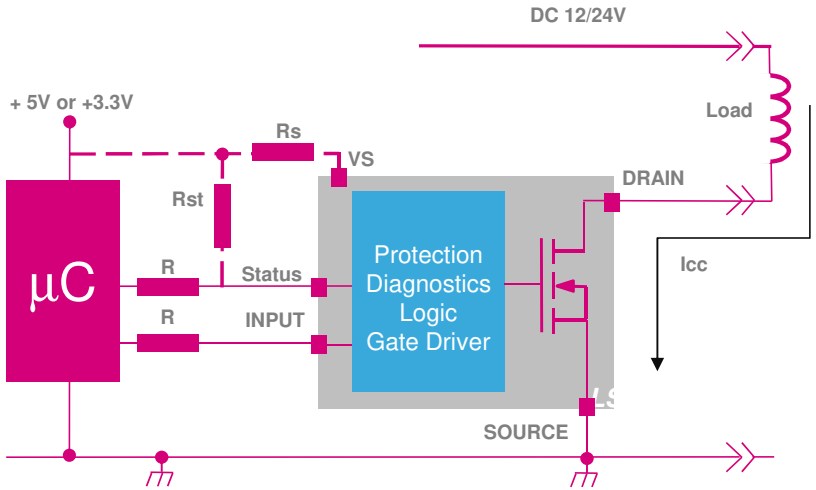
VIPower™ OmniFET Low Side Drivers



- **A ST Low-side Driver switches current into Battery connected loads (resistive, inductive or capacitive)** and safely protects itself and the system from potentially dangerous fault conditions
- Product portfolio includes 1-ch, 2-ch, with diagnostic feedback and RDS(ON) values from 30mΩ to 300mΩ.

ST Technologies enable a Broad range portfolio:

- M02 with clamp 70V: OmniFET
- M03 with clamp 45V: OmniFETII
- M05 Technology with clamp 41V: OmniFETIII
- Highest switching frequency w/M02 OmniFET
- Enhanced diagnostics w/M05 OmniFETIII

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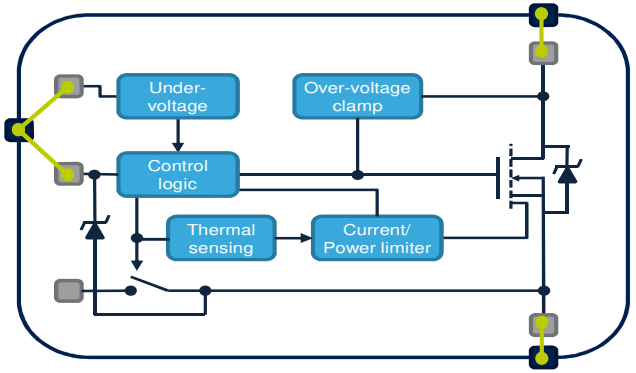
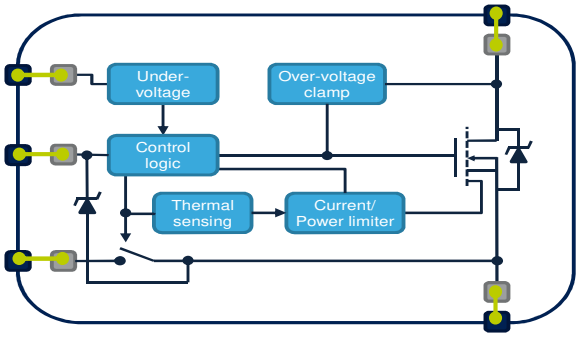
VIPower™ M0-5 OMNIFETIII LSDs

Simple 3 Leads Option



- **Pin2Pin compatibility with discrete** PowerMOSFET and OMNIFET II
- 3V CMOS compatible input
- Very low supply current from the battery (drain) pin
- Fast switching times
- Current and power limitation
- Over temperature protection (no feedback)
- **41V clamp voltage**
- ESD protection

Full Spec Version (5 pins)



- Supplied by an external supply
- 3V CMOS compatible digital input
- Very low supply current from the battery (drain) pin
- Fast switching times
- Current and **power limitation**
- Over-temperature protection
- **Status pin**
- OFF-state: open load/short to ground
- ON-state: over temperature
- **41V clamp voltage**
- ESD protection

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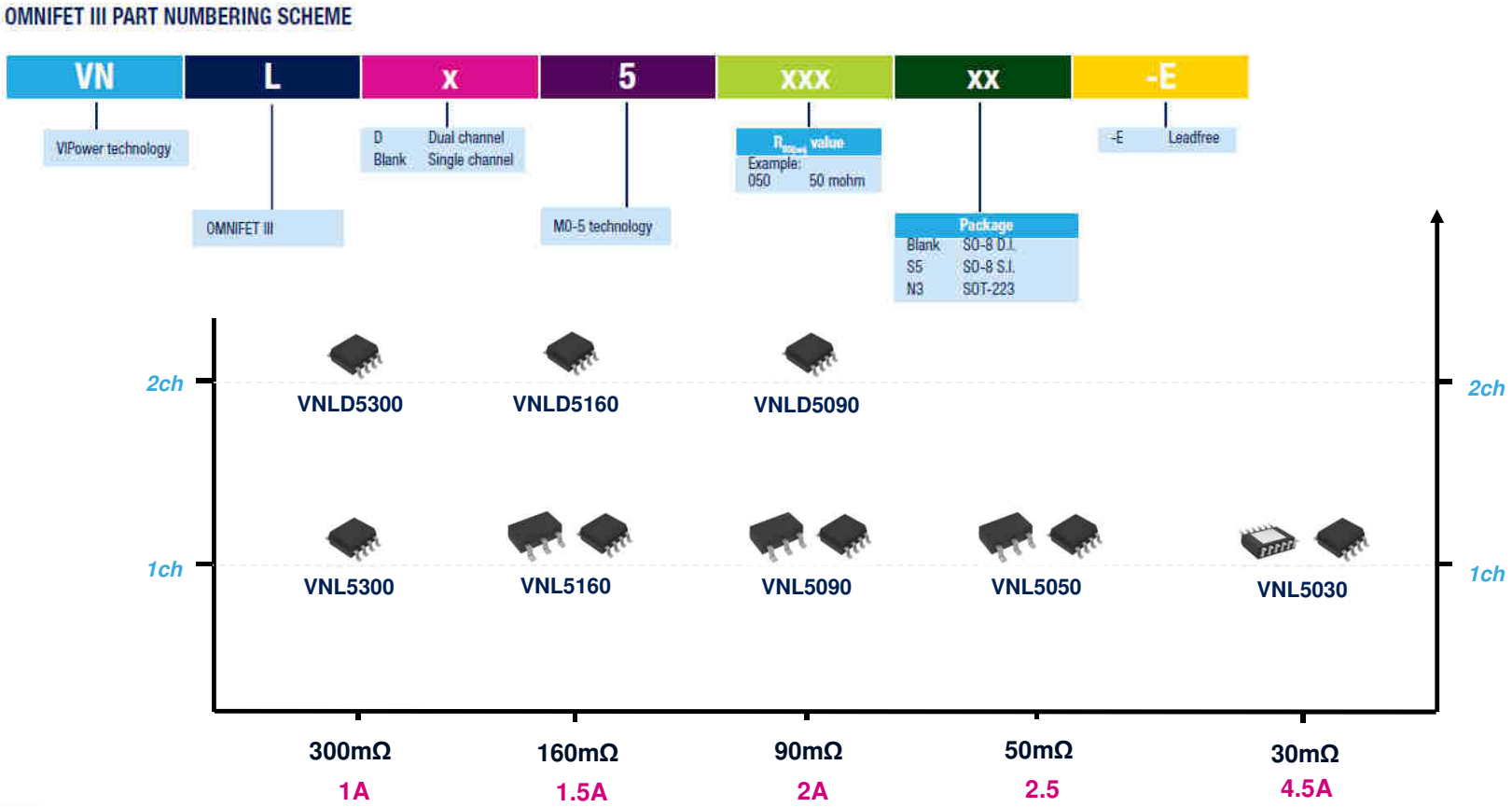
VIPower™ OMNIFET III: Product Portfolio



Max DC Current is based on 85C ambient and 4 layer board

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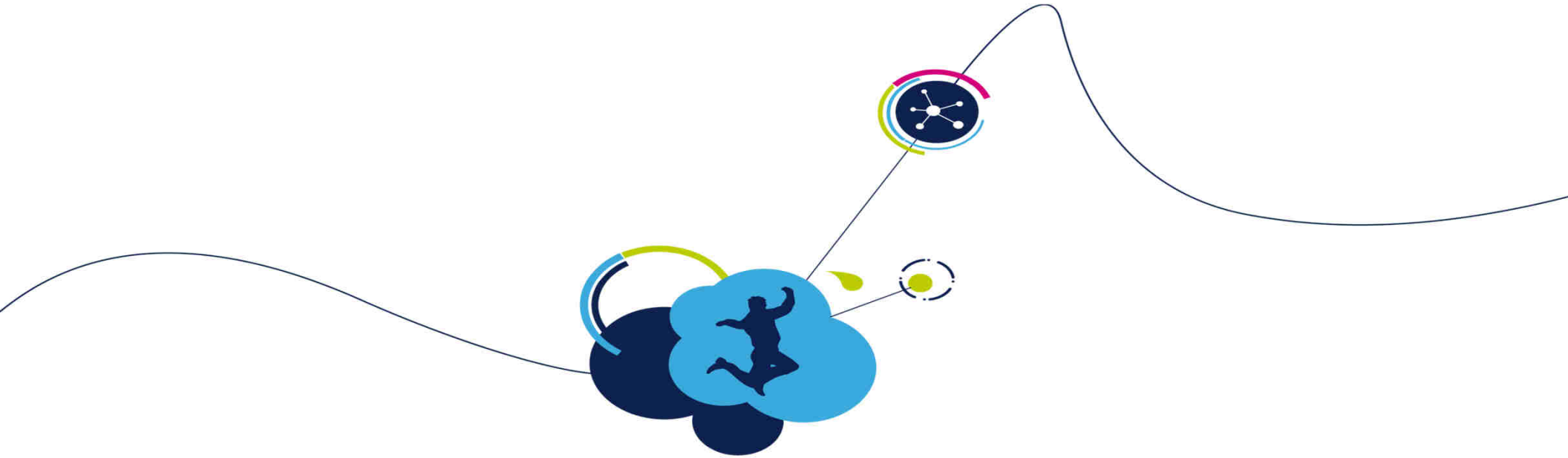

Roadmap

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VIPower™ M0-9 HSDs

Product families

VIPower HSDs-SPI

VIPower Zero

VIPower HSDs

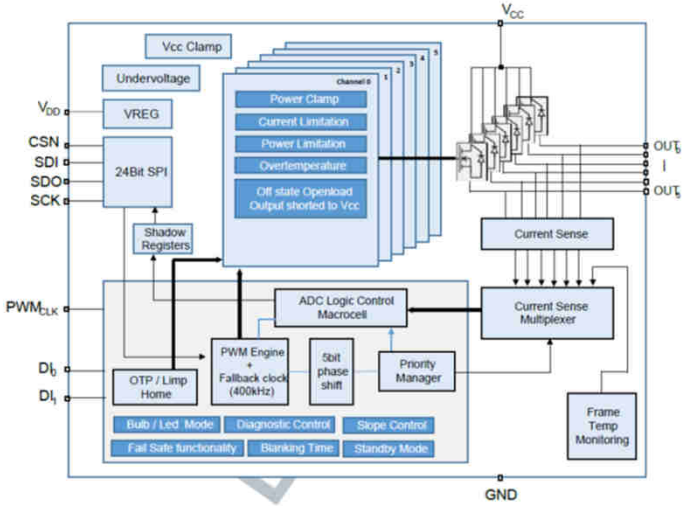
Coming soon

VIPower H-Bridges

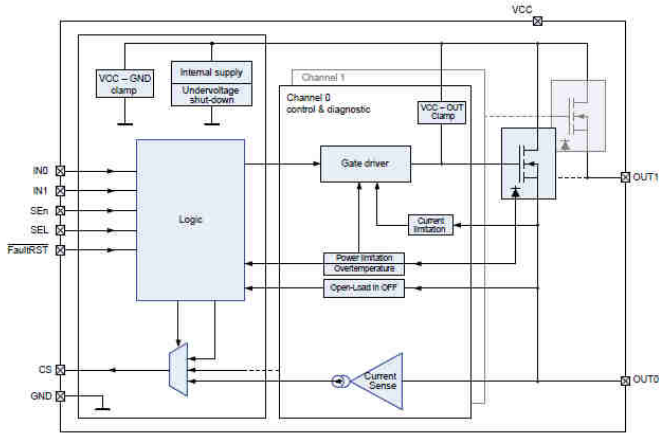
18 Products
In development

First Product Release:
Q2-2020

Full Family Release:
Q2-2021



6 Products with SPI Interface



12 Products with Parallel Inputs

M0-9 VIPower™ SPI High Side Drivers

Key Features

- Digital Current Sense
- Integrated PWM generation and sampling synchronization unit
- Up to six channels in a QFN 6x6
- Pin-to-Pin Compatible

Key Benefits

- Output current monitoring precision 5% at nominal current
- No micro A/D needed
- Lower external components count
- Less micro resources needed
- Reduced micro workload
- Fully portable Software

Product	Rdson (typ.)	Package	ES	FS	PQC
VN9D30Q100F	2x35mΩ + 4x100mΩ	QFN	Available (PPSO-16)	Q2/2020	Q3/2020
VN9D5D20F	2x5mΩ + 2x20mΩ	QFN	Available	Q2/2020	Q4/2020
VN9E30F	6x30mΩ	QFN	Q3/2019	Q3/2020	Q4/2020
VN9D7D20F	2x7mΩ + 2x20mΩ	QFN	Q4/2020	Q1/2021	Q2/2021
VN9Q25D70F	4x25mΩ + 2x70mΩ	QFN	Q3/2020	Q1/2021	Q2/2021
VN9T25T70F	3x25mΩ + 3x70mΩ	QFN	Q1/2021	Q2/2021	Q3/2021

TV

Date: September 2019
Timeline Information can be subject to variations without advance notification

M0-9 VIPower™ Parallel Product portfolio

Lower R_{dson} in Small Package

- M0-9 Standard further extends the largest family of HSDs in the market
- Single, Dual and Quad channels
- Full pin-to-pin and SW compatible with M0-7
- The best current sense accuracy ever reached in a High Side Driver
- All comes in PowerSSO-16
- Self turn on in Reverse Battery

Product	Rdson (typ.)	Package	ES	FS	PQC
VND9800AJ	2x10mΩ	PSSO-16	Available	Q1/2020	Q2/2020
VN9004AJ	1x4mΩ	PSSO-16	Available	Q3/2020	Q2/2021
VNQ9025AJ	4x21mΩ	PSSO-16	Available	Q3/2020	Q2/2021
VND9012AJ	2x12mΩ	PSSO-16	Q2/2020	Q4/2020	Q1/2021
VN9012AJ	1x12mΩ	PSSO-16	Q3/2020	Q4/2020	Q1/2021
VND9016AJ	2x16mΩ	PSSO-16	Q4/2020	Q1/2021	Q2/2021
VN9006AJ	1x6mΩ	PSSO-16	Q2/2020	Q4/2020	Q1/2021
VN9016AJ	1x16mΩ	PSSO-16	Q3/2020	Q4/2020	Q1/2021
VND9025AJ	2x25mΩ	PSSO-16	Available	Q3/2020	Q4/2020
VNQ9080AJ	4x80mΩ	PSSO-16	Available	Q3/2020	Q4/2020
VN9008AJ	1x8mΩ	PSSO-16	Q3/2020	Q4/2020	Q1/2021
VND9008AJ	2x8mΩ	PSSO-16	Q3/2020	Q1/2021	Q2/2021

TV

Date: September 2019
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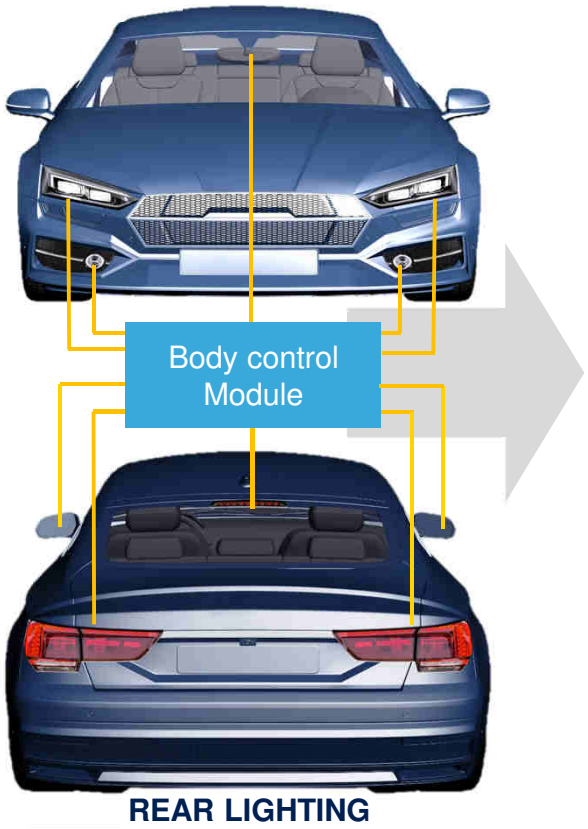
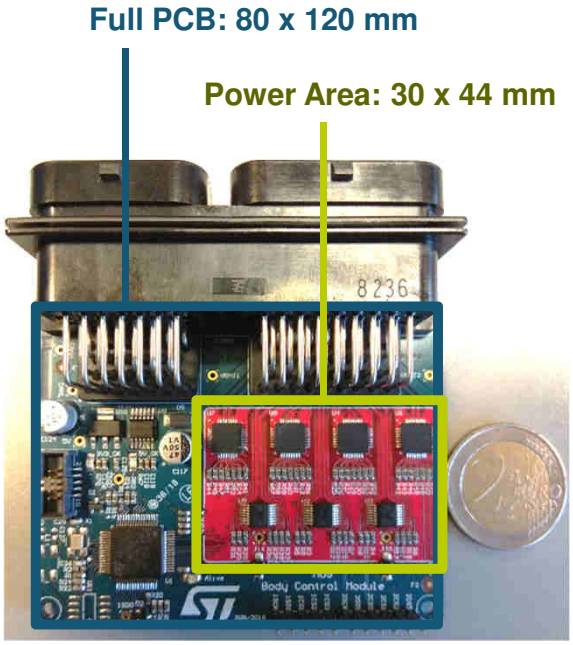
New VIPower Generation: M0-9SPI

32 Channels BCM Demonstrator





Module Driving
32 Channels

VIPower M0-9 SPI Competitive advantages
-55% PCB Power-Area vs Parallel Smart Power
-30% external components
Up to **25%** Microcontroller Workload reduction
-66% Microcontroller I/O and ADC

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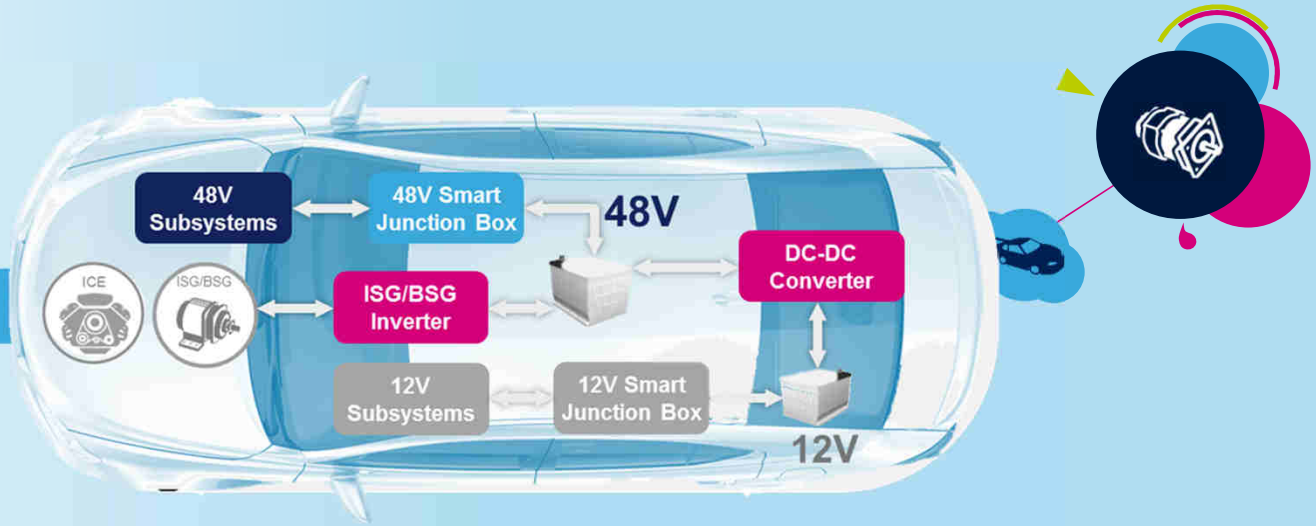
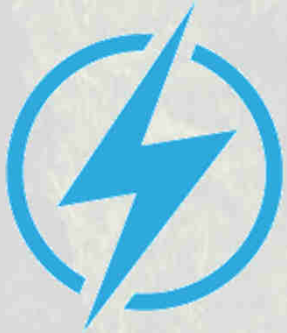
VIPower for 48V



VIPower™ for Mild-Hybrid
Application Solutions

Complete Solution for 48V Boardnet Actuation and Power Distribution



Smart Integrated Brushless / DC Motor Drivers

VNHB11xx *series*

- Low Ohmic Integrated half-bridge
- 100V Thermally Protected MOSFETs
- Non dissipative high precision current sensing
- Reduce PCB footprint and number of components

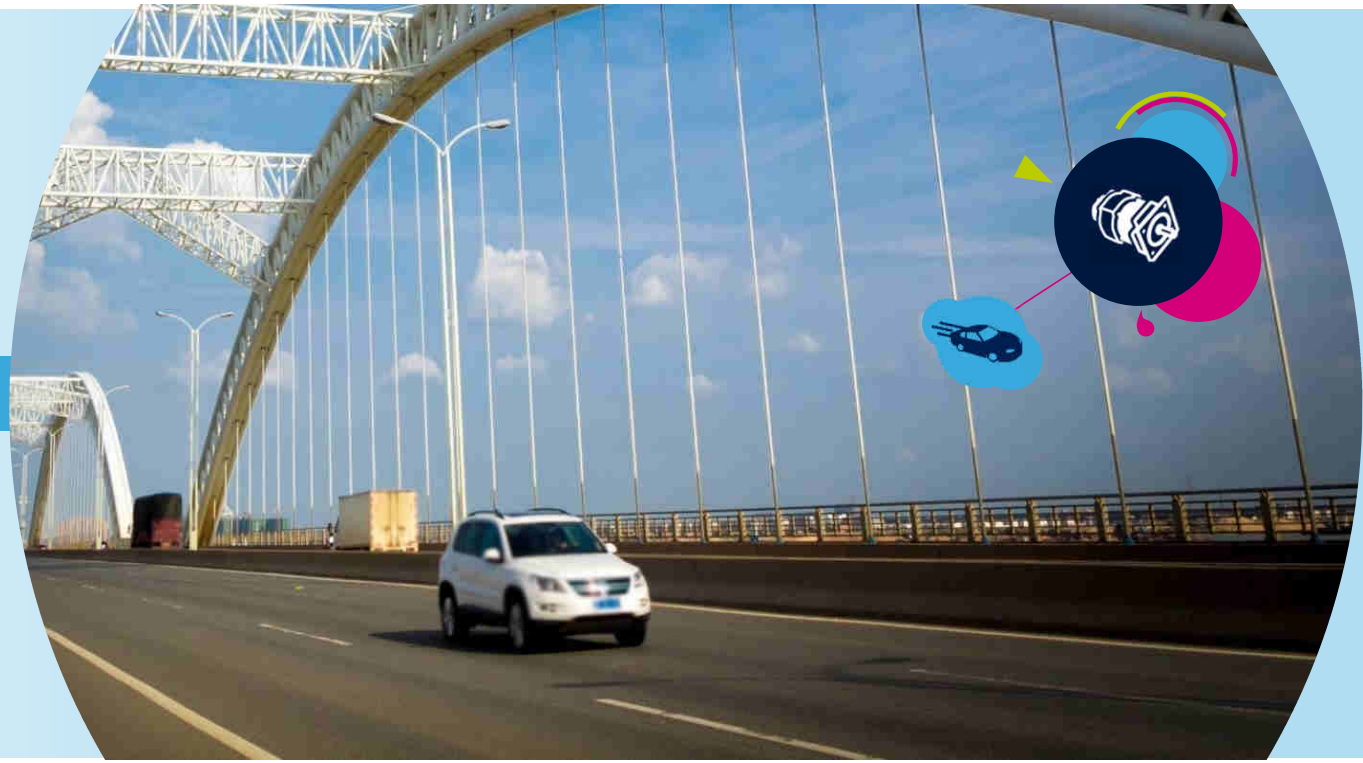
SOP 2021

Smart Integrated High Side Power Switches

VNx148xx *series*

- Low Ohmic High Side Power Switches
- Single and dual channel in a package
- Non dissipative Current Sense
- Advanced Protections and diagnostics

Motor Control ICs



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VNH Family
Integrated H-Bridge Drivers

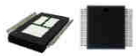
DC motor drivers with integrated non-dissipative current-sense

VNH9013Y
VNHD7008AY
VNHD7012AY*
VNH7040AY
VNH7070AY
VNH7070BAS
VNH7100BAS
VNH5019A
VNH5050A
VNH5180A
VNH5200AS

VNH9 –Power Only
VNH7 series
VNH5 series

10mΩ 20mΩ 40mΩ 70mΩ 100mΩ 200mΩ R_{ON} per leg

12A 10A 5A 3.5A 3A 2A Nominal Current


PowerSSO-36


SO-16N
Plastic

Fully embedded motor driver
Dual HS with external LS actuation and protection
Quad MOS with thermal sensor and no current sense

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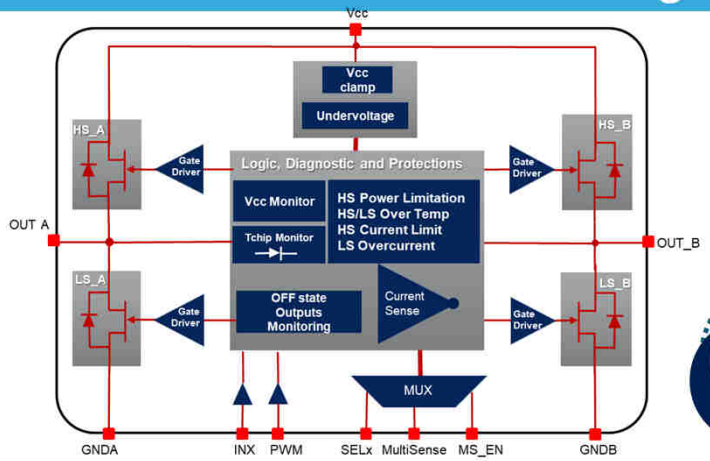
VNH Integrated H-Bridges

New Mid-High ohmic VIPower™ M0-7 H-Bridges



Part number	Ron per leg	I_{LIM}	Package	Target Application
VNH7070BAS	70mΩ	15A	SO-16N	Power lock - Mirror Adjust
VNH7100BAS	100mΩ	12A	SO-16N	Power Lock
VNH7070AY	70mΩ	20A	PowerSSO-36	Safe lock
VNH7040AY	40mΩ	35A	PowerSSO-36	Dual Washer Pump

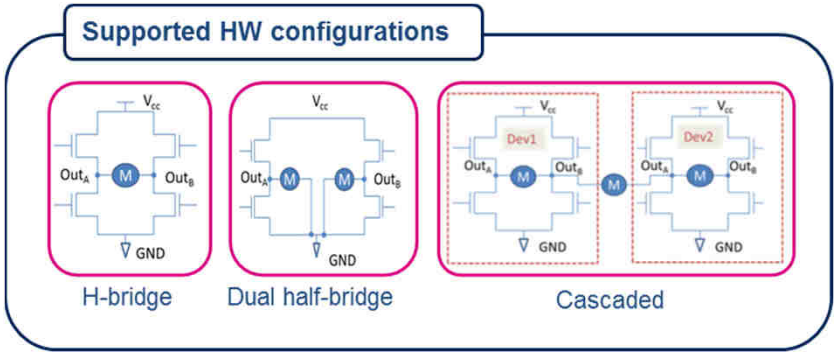
Supported by Twister

Key Features

- Multisense pin for diagnostic
- Non-dissipative current sense
- Very Low Stand-by current (1µA typ)
- PWM operations up to 20 kHz
- 3V CMOS compatible inputs

Protections

- UV, OV, Thermal shutdown[1]
- Protection vs. loss of GND and VCC
- Outputs protected for short vs. GND and Vcc
- Cross-conduction protection
- Current & Power limitation
- Integrated Thermal Protection



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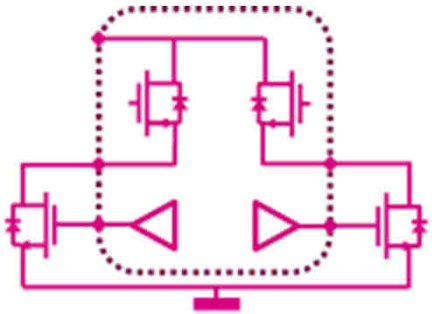
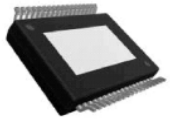
[1]UV: Under-voltage OV: Over-voltage

VNHD Integrated H-Bridges

New Low Ohmic M0-7 H-Bridges – The VIPower solution for up to 200W DC motors





PSSO36

Supported by Twister

Part number	Ron per channel	I_{LIM}	Package	Target Application
VNHD7008AY	8mΩ	51A	PowerSSO-36	Sun Roof, Windows lift, power Seat, Power Trunk Lift Gate
VNHD7012AY	12mΩ	38A	PowerSSO-36	Sun Roof, Windows lift, power Seat, Power Trunk Lift Gate

Tailored and compact full bridges in combination with latest dual-channel STripFET™ F7 technology PowerMOS:

- **STL64DN4F7AG 8mΩmax**
- **STL76DN4LF7AG 6mΩmax**

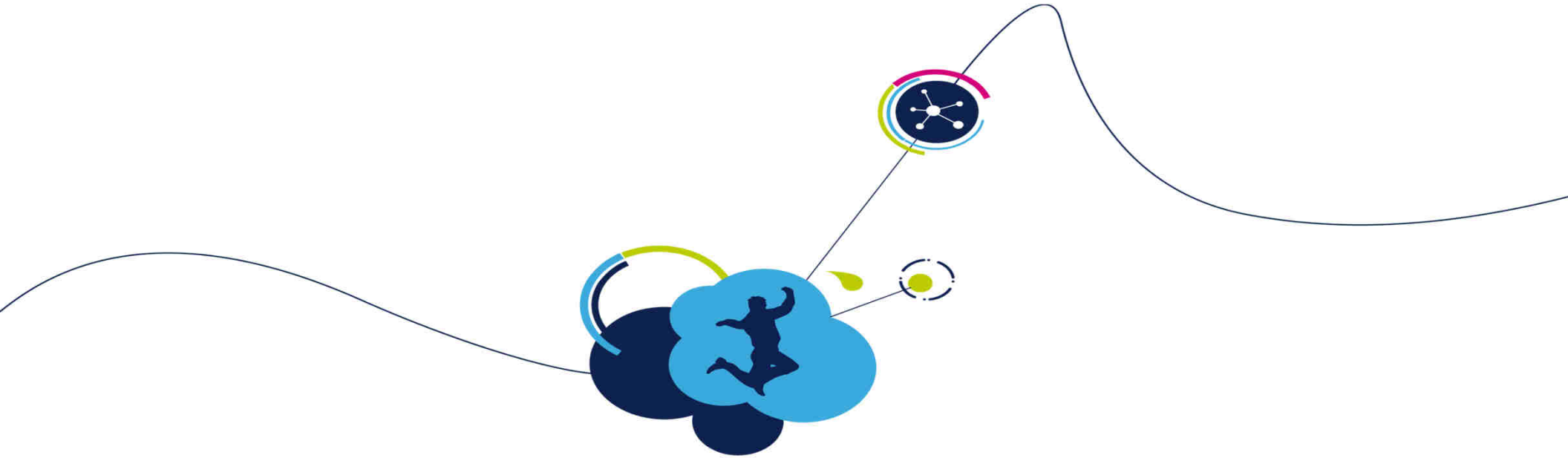
Key Features

- **Multisense pin for diagnostic**
- **Non-dissipative current sense**
- **Very Low Stand-by current (1µA typ)**
- **PWM operations up to 20 kHz**
- **3V CMOS compatible inputs**

Protections

- **UV, OV, Thermal shutdown[1]**
- **Protection vs. loss of GND and VCC**
- **Outputs protected for short vs. GND/Vcc**
- **Current & Power limitation**
- **Cross-conduction protection**
- **Integrated Thermal Protection**
- **Drain and Source voltage monitoring of external power MOSFETs**

[1]UV: Under-voltage OV: Over-voltage



Supporting Tools

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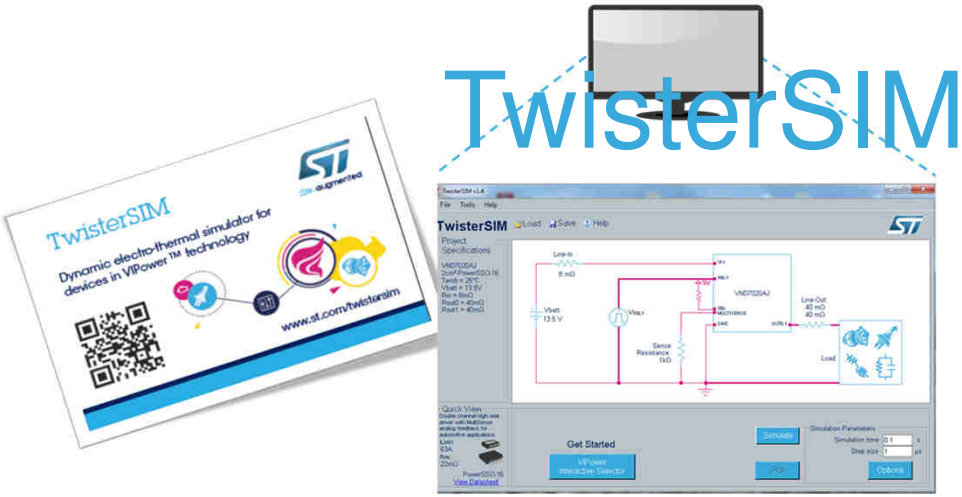
VIPower™ FINDER and TwisterSIM

Easy Product Selection

VIPower-FINDER available for Android™ and iOS™

Easy device selection by Parametric or Smart search function

Available for Android and iOS



TwisterSIM

Free download: ***www.st.com/twistersim***
Support: ***twistersim@st.com***
Forum: ***www.st.com/twistersim-forum***

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Collaterals

Brochure and Flyers

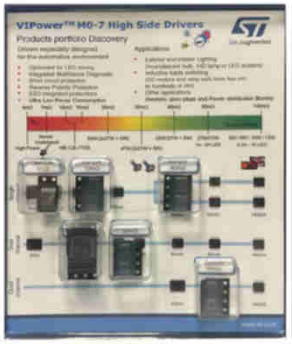
H-Bridges Hardware Design Guide

HSD Hardware Design Guide

Evaluation Boards

Discovery Kits

Samples Kit



SAMPLEKITM0-7

SAMPLEKITVNH7

SAMPLEKITM0-7E

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To summarize … Why ST VIPower™ ?

Key Features

- **Best-in-class VIPower™ Technology enabling high power density integration**
- **Best in Class Protection and Diagnostics (Power limitation with Programmable Latch-off and Multisense* ST IPs)**
- **Best in Class Performance: EMI/EMC (CISPR25), lower switching Losses (-10%) and ultra-low standby current**
- **Family approach: broad RDSon range , Single/Dual/Quad channels, P2P compatibility**
- **TwisterSim: Unique, free and easy to use Product Selector and Electro-Thermal Simulator**

Key Benefits

- **Smallest packages on the market**
- **Enhanced Reliability**
- **Efficiency and Performance**
- **Flexibility and Scalability**
- **Supporting Tools**

... Plus 25 years experience and a strong roadmap ahead !

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* Current, Voltage and Temperature in all M07 devices (Current sense in M05)

thank you!

If any questions pls. contact me at
sara.mattioli@st.com

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