



FTF 2016
TECHNOLOGY FORUM

THE WORLD'S BEST POWER MOSFETS FOR MOTOR CONTROL – EVER!

CHRIS BOYCE
HEAD OF MARKETING & BUSINESS DEVELOPMENT,
NXP POWERMOS BUSINESS LINE
FTF-SMI-N1889
MAY 16, 2016




“Dad, what do you do at work?”



<https://www.facebook.com/nrklivsstil/videos/10154044139728619/>

AGENDA

Key “Motor Control” Takeaways

- New, Big, Diverse Opportunities
- Power MOSFETs Make a Difference
- NXP has Optimized Devices 
- Perfect for Solution-selling with Micros

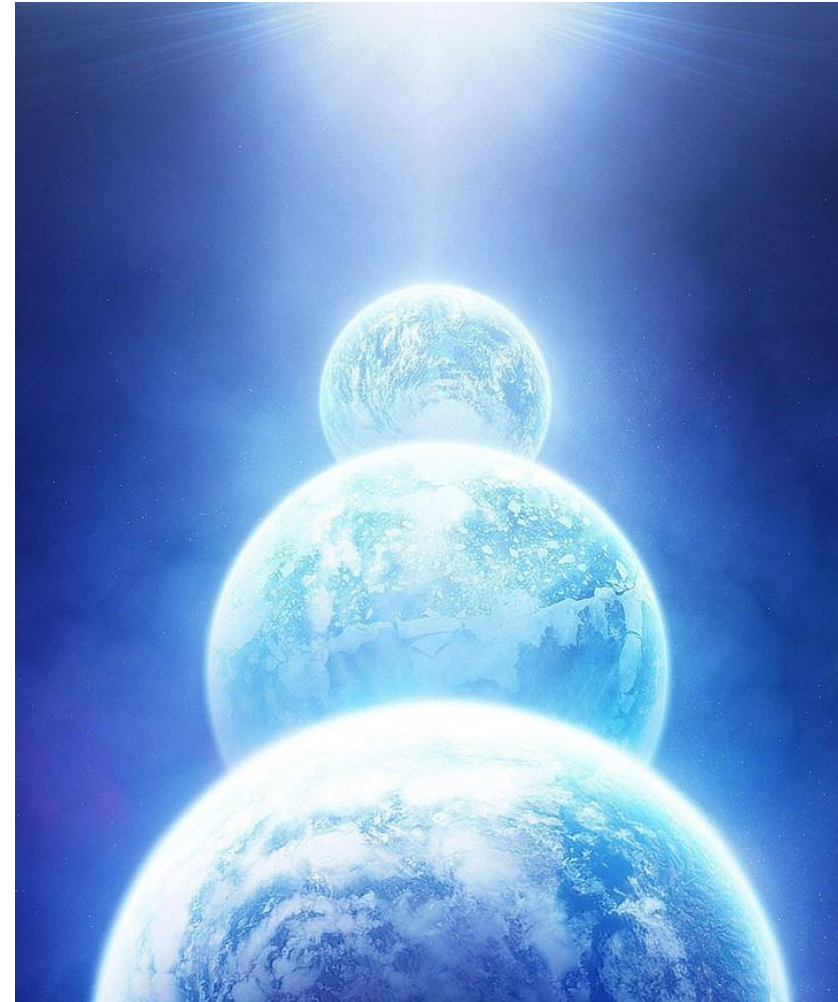


NEW, BIG, DIVERSE OPPORTUNITIES



When Planets Align...

- Sometimes, technologies, cost curves, capabilities and application requirements simply align
 - Increasingly powerful DC motors
 - Higher performance batteries
 - Smart microcontrollers and software
 - Efficient, robust power components



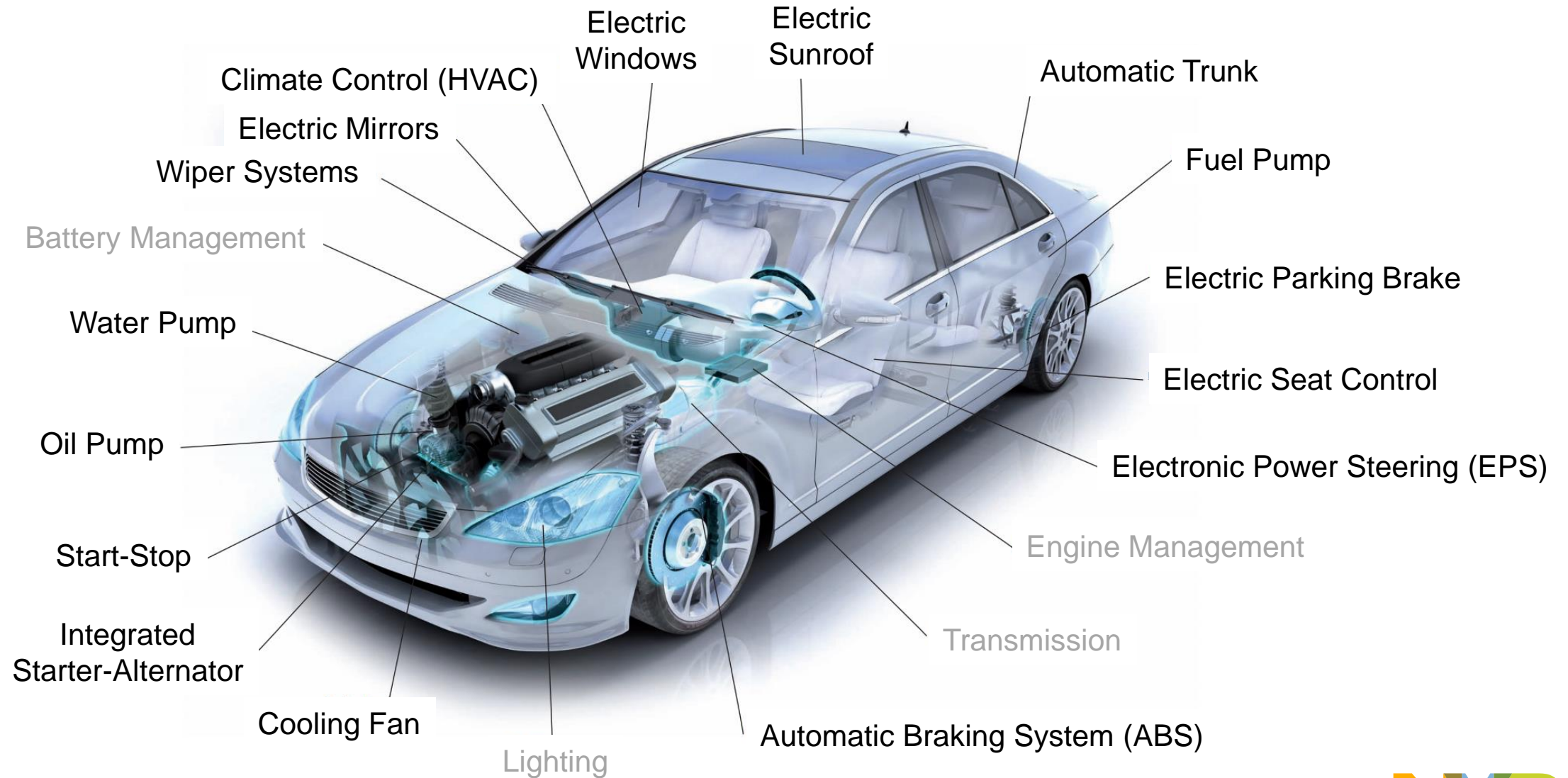
The Power Tool Story



Mobility



Motor Control in Cars



POWER MOSFETS MAKE A DIFFERENCE



Key MOSFET Requirements in Motor Control (1)

1. Breakdown voltage, V_{DS}

- Increasing battery voltages for higher power solutions
- 30V and 40V MOSFETs mainstream today; some 60V devices for new designs
- 100V requirement for fork-lift trucks, light electric vehicles and similar

V_{DS}

2. Max current, I_D rating

- I_D rating most important for management of fault condition, e.g. locked rotor
- MOSFET must survive until OCP activates, typically 1-2ms to several seconds

$I_{D(max)}$

3. Thermal performance

- Low thermal resistance, R_{th} , allows better performance at higher temperatures
- Higher $T_{j(max)}$ enables improved $I_{D(max)}$, $P_{tot(max)}$, repetitive avalanche and SOA
- Low R_{DSon} required to manage temperature rather than for system efficiency

R_{th}

$T_{j(max)}$

R_{DSon}

Key MOSFET Requirements in Motor Control (2)

4. Avalanche Rating

- MOSFETs often taken into avalanche in motor control applications
- High avalanche rating, $E_{DS(AL)S}$, preferred
- Sometimes difficult to compare between manufacturers due to ratings cited at different I_D

$E_{DS(AL)S}$

5. Spike Control

- Often an issue driven by EMI qualification concerns
- Managing reverse recovery can help; Q_r should be as low as possible and recovery waveform should be symmetrical (S-Factor =1)

EMI

Key MOSFET Requirements in Motor Control (3)

6. Gate Drive

- Preference for both **Logic Level** (collapsing battery voltage) and **Standard Level** (immunity to false turn on) depending on application

V_{th}

7. Safe Operating Area (SOA)

- Considered important in fault conditions where collapsing battery voltage means gate is not driven so hard
- MOSFETs sometimes driven straight from micro
- (Also important in battery protection)

SOA

8. Size

- Trend towards greater power density
- Enabled by R_{DSon} and thermal performance

mm²


“NextPower Cordless”

**NXP MOSFETS OPTIMIZED FOR
MOTOR CONTROL**





NextPower Cordless Portfolio


Professional

TO220			$R_{DS(on)}$ ($V_{GS}=10V$)	I_D [max]
40V	SL	PSMN1R5-40PS	1.6m Ω	150A
	LL	PSMN1R9-40PL	1.6m Ω	150A
60V	SL	PSMN2R6-60PS	2.6m Ω	150A
	LL	PSMN2R5-60PL PSMN3R3-60PL	2.6m Ω 3.4m Ω	150A

DIY

TO220			$R_{DS(ON)}$ ($V_{GS}=10V$)	I_D [max]
40V	SL	PSMN2R8-40PS	2.8m Ω	100A
	LL	PSMN2R1-40PL	2.2m Ω	150A
60V	SL	PSMN3R9-60PS	3.9m Ω	130A
	LL	PSMN4R2-60PL	3.9m Ω	130A

LFPAK56			$R_{DS(on)}$ ($V_{GS}=10V$)	I_D [max]
30V	LL	PSMN0R9-30YLD	0.87m Ω	300A
		PSMN1R0-30YLD	1.0m Ω	300A
		PSMN1R2-30YLD	1.2m Ω	100A
		PSMN1R4-30YLD	1.4m Ω	100A
		PSMN2R4-30YLD	2.4m Ω	100A
40V	LL	PSMN1R0-40YLD	1.1m Ω	300A
		PSMN1R4-40YLD	1.4m Ω	240A

LFPAK56			$R_{DS(on)}$ ($V_{GS}=10V$)	I_D [max]
30V	LL	PSMN3R0-30YLD	3.1m Ω	100A
		PSMN4R0-30YLD	4.1m Ω	95A
		PSMN6R0-30YLD	6.0m Ω	66A
		PSMN7R5-30YLD	7.5m Ω	51A
		PSMN1R6-40YLC PSMN1R8-40YLC	1.5m Ω 1.8m Ω	100A

NextPowerS3 types in **bold** text

150A Maximum Current in TO220

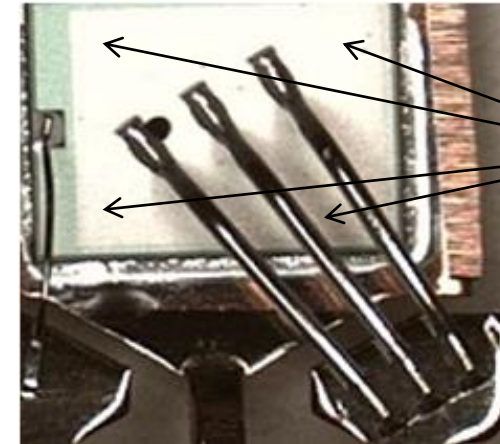
VDS	$I_{D(max)}$	R_{th}	$T_{j(max)}$	R_{DSon}
$E_{DS(AL)S}$	EMI	V_{th}	SOA	mm ²

- **Increased bond-wire diameters**

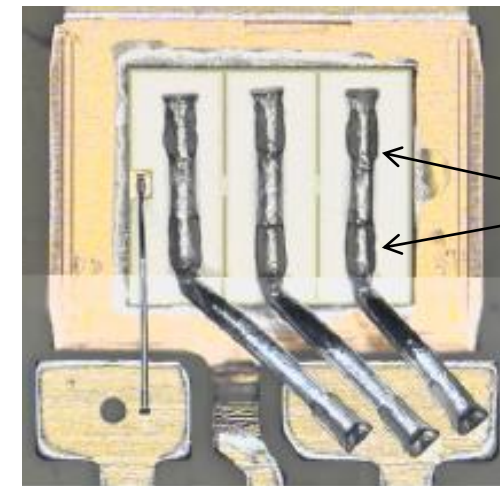
- 3 x 350 μ m >>> 3 x 500 μ m wires
- Approximately 2X increase in cross section area

- **Parallel “stitch” bonding**

- Increased contact area from wire to die surface
- Improved current spreading over die surface



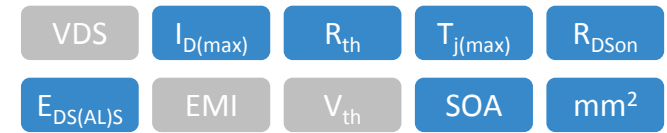
Competitor Device



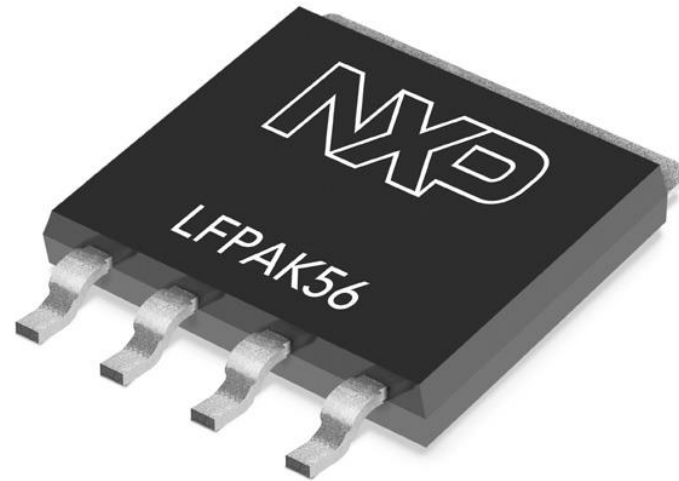
NextPower Cordless Device



LFPAK – The Toughest Power Package



Power-SO8
Compatible
(5mm x 6mm)



“No glue, no wires, 175 °C”

QFN/DFN3333
Compatible
(3.3mm x 3.3mm)

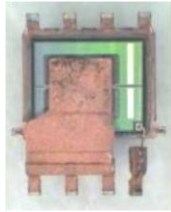


“Tougher just got smaller”

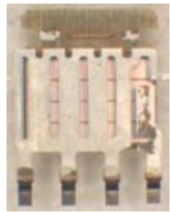
LFPAK – Copper Clip Advantage



Al wire bonding



Cu Clip + wire gate



Cu Clip + Au bump



Ribbon Bond

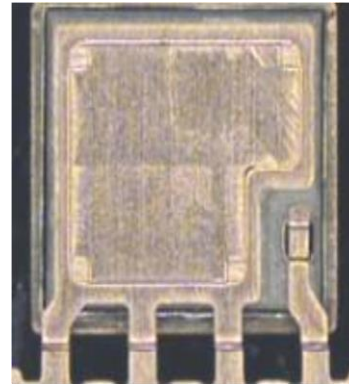


Cu wire bonding



Cu Clip + wire gate

Not all power packages are created EQUAL



Integrated Cu clip
NXP (LFPAK)

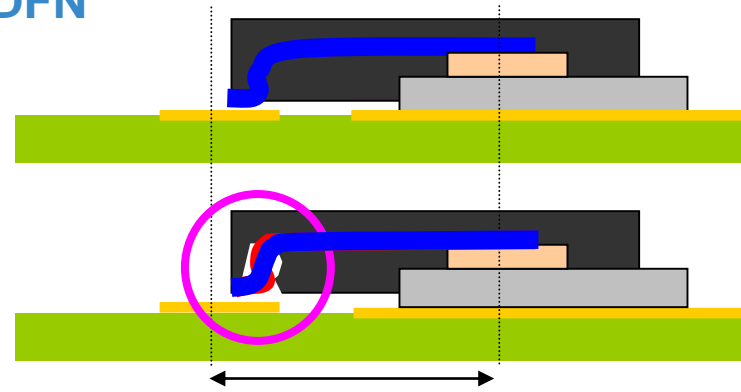
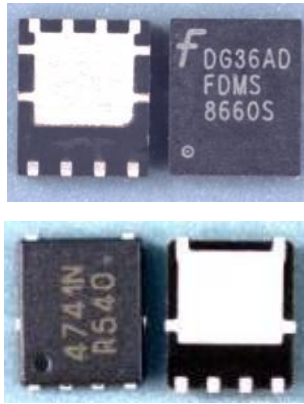
Integrated Cu Clip gives:

- $T_{j(max)} = 175^{\circ}C$
- Low $R_{package}$
- Low $R_{ds(on)}$
- Low $R_{th(j-pcb)}$
- Low inductance
- Effective heat removal – reduced heat spots
- Single source-attach process
- High reliability
- Automotive AEC-Q101 qualified

LFPAK – Mechanical & Thermal Toughness

VDS	$I_{D(max)}$	R_{th}	$T_{j(max)}$	R_{DSon}
$E_{DS(AL)S}$	EMI	V_{th}	SOA	mm ²

Traditional QFN / DFN



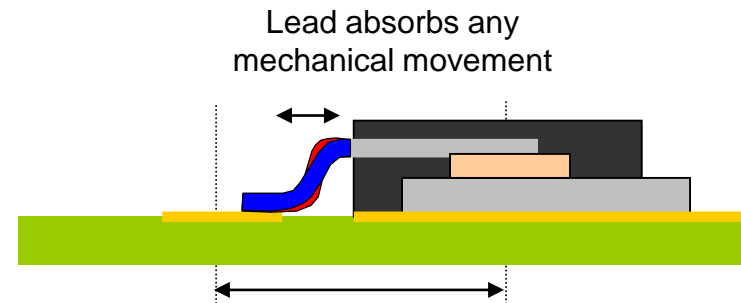
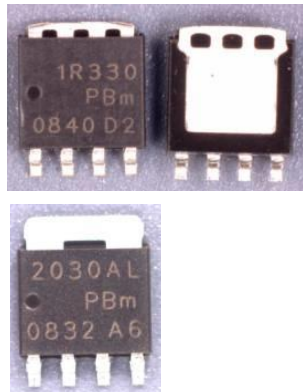
Movement due to thermal and/or mechanical stress in PCB

Fully encapsulated pins do not allow for movement.

Cracks in mould compound can lead to moisture ingress, ionic contamination and early failure.

Risk of solder joint failure under source and gate pins.

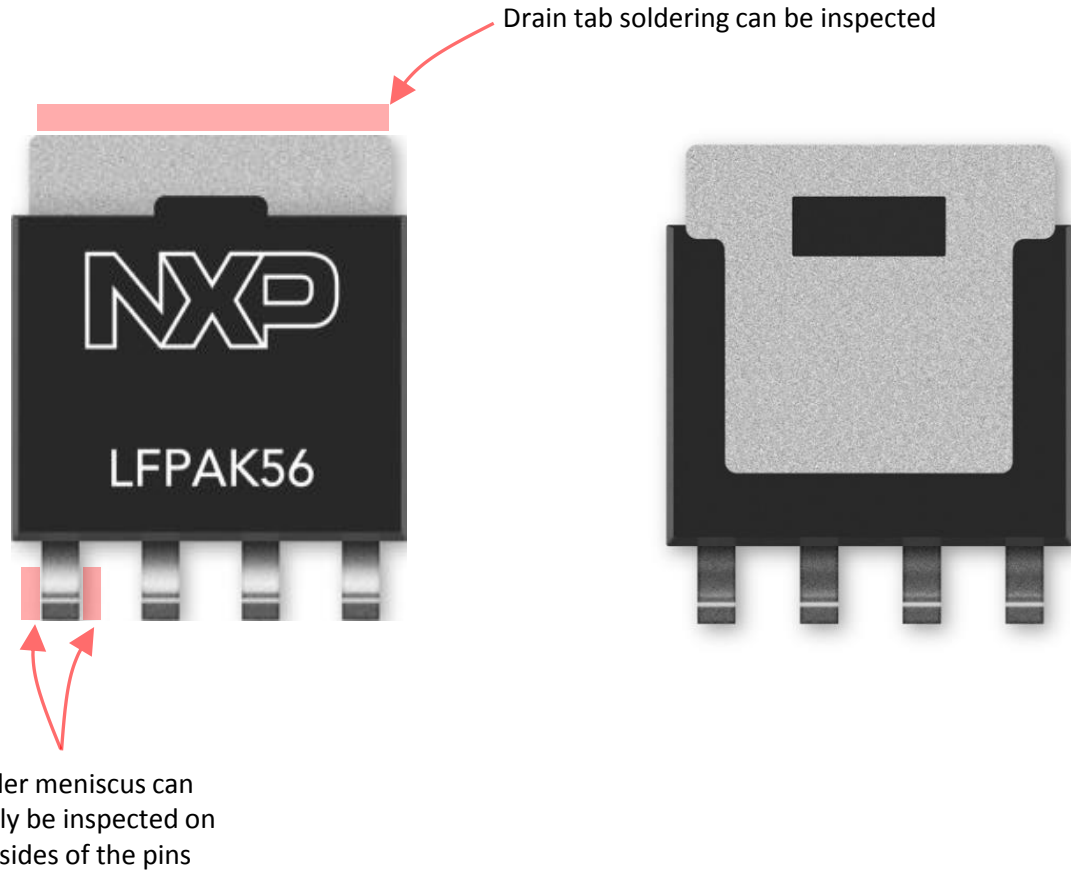
LFPAK56 & LFPAK33



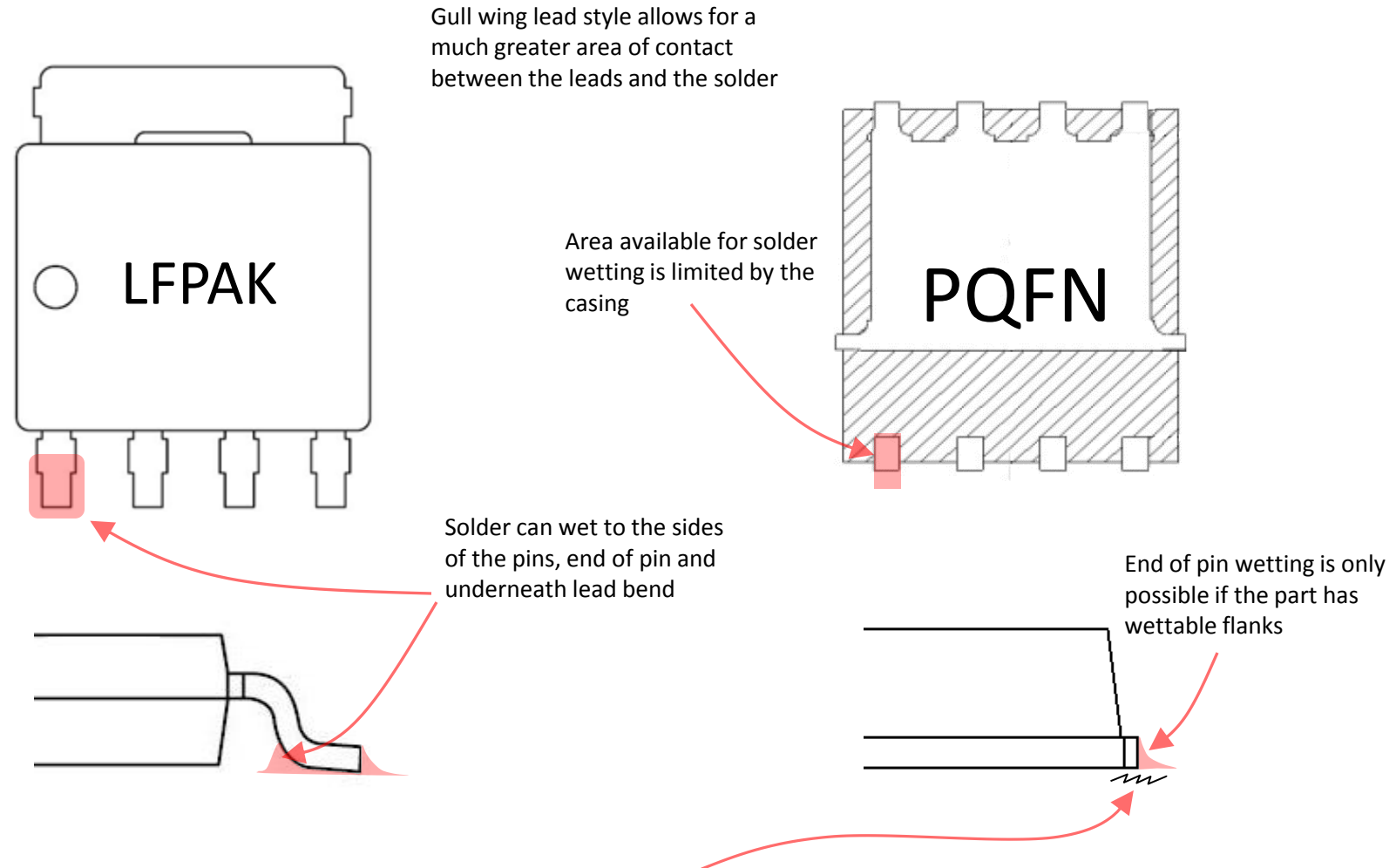
Movement due to thermal and/or mechanical stress in PCB

LFPAK pins absorb stresses associated with thermal expansions and mechanical strains from PCB bending and flexing

LFPAK – AOI Solder Inspection



LFPAK – Solder Wetting



RESULT: QFN style much more susceptible to **cracked solder joints** as a result of thermal cycling / mechanical stress

LFPAK – 100% Footprint Compatible

- Competitor devices confirmed to fit on NXP’s “universal footprints” (5x6 and 3x3)
- LFPAK confirmed to fit on all competitor recommended footprints

Soldering Quality

- ▶ The following shows the x-ray inspection images of the eight manufacturer’s devices with the standard stencil openings used, and utilising the “STD” drain copper pad footprint.
- ▶ The dark gray color indicates the solder coverage underneath the component body.
- ▶ There was no significant change in solder coverage whichever stencil design was used.
- ▶ In all cases there was the presence of some acceptable voiding under the drain tab, but the source and gate leads appeared void free.

	NXP LFPAK33	NXP DFN3333-S	Vishay POWERPAK8 1212-S	Infinion PG-TD 80N-S	Falrohlid MLP 3.3 x 3.3	ON SEMI WDFN8 3.3x3.3	STM POWERFlat 3.3x3.3	IR PQFN 3x3
STD								

Placement Acceptability

- ▶ IPC Class : 3 Placement criteria was used. This gives a margin of 25% error for placement misalignment when the devices are positioned on the board footprint and then soldered into position through reflow.
- ▶ No issue with placement either before or after reflow with NXP’s universal footprint was experienced.
- ▶ Examples of the post reflow images for the eight package types:

NXP - LFPAK33	NXP - DFN3333-S	Vishay - POWERPAK8 1212-S	Infinion PG-TD 80N-S
Falrohlid - MLP 3.3 x 3.3	ON SEMI - WDFN8 3.3x3.3	STM - POWERFlat 3.3x3.3	IR - PQFN 3x3

- Verified by independent consultancy (reports available)

LFPAK – Maximum Current

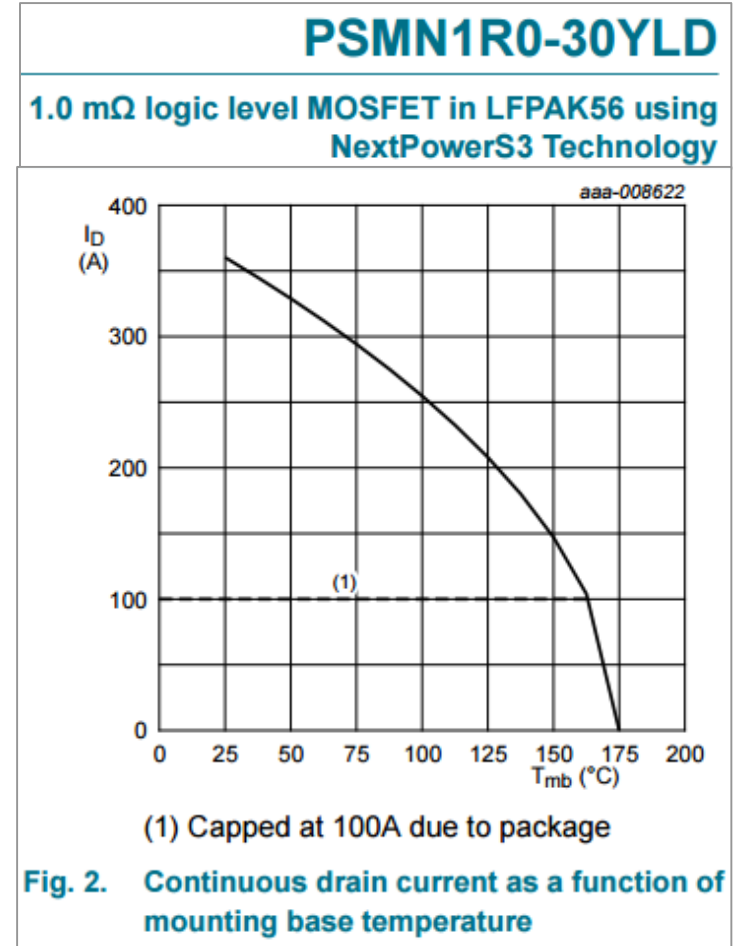
- 100A limit set at LFPAK launch in 2007 when best $R_{DS(on)}$ was $\sim 3m\Omega$ (25V). This value has endured.
- Incorrectly labelled “package limit”, in reality it was a production test limit
- $R_{DS(on)}$ of new PSMN0R7-25YLD is $0.7m\Omega$
- Planning to increase LFPAK max current datasheet rating to $>100A$

8. Limiting values

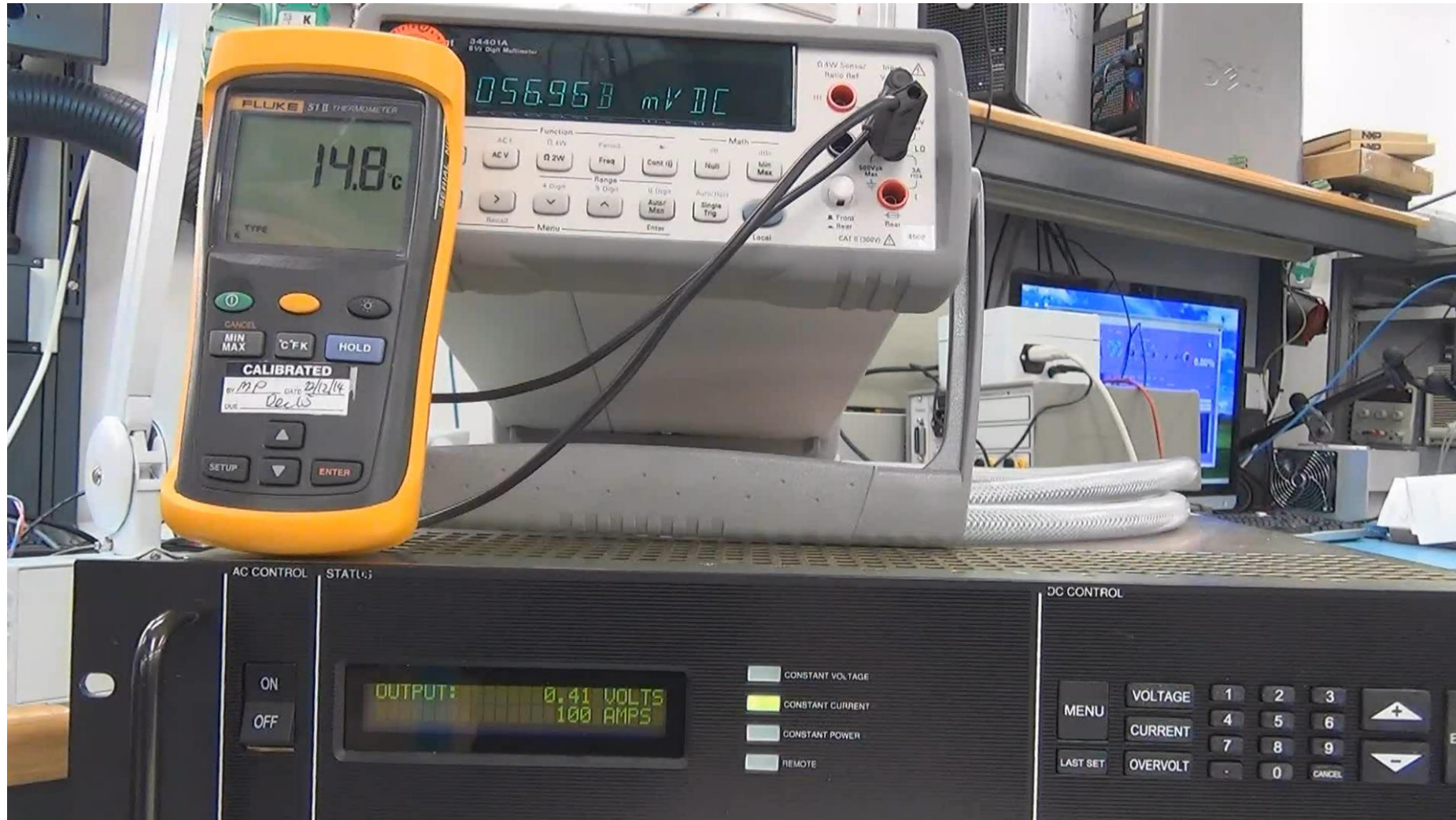
Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V _{DS}	drain-source voltage	25 °C ≤ T _j ≤ 175 °C	-	30	V
V _{DGR}	drain-gate voltage	25 °C ≤ T _j ≤ 175 °C; R _{GS} = 20 kΩ	-	30	V
V _{GS}	gate-source voltage		-20	20	V
P _{tot}	total power dissipation	T _{mb} = 25 °C; Fig. 1	-	238	W
I _D	drain current	V _{GS} = 10 V; T _{mb} = 25 °C; Fig. 2	[1]	100	A
		V _{GS} = 10 V; T _{mb} = 100 °C; Fig. 2	[1]	100	A



LFPAK Maximum Current



PSMN1R0-30YLD – Current Rating



PSMN1R0-30YLD

N-channel 30 V, 1.0 mΩ, 300 A logic level MOSFET in LPAK56 using NextPowerS3 Technology

27 October 2015

Product data sheet

4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DS}	drain-source voltage	$25\text{ °C} \leq T_j \leq 175\text{ °C}$	-	-	30	V
I_D	drain current	$T_{mb} = 25\text{ °C}$; $V_{GS} = 10\text{ V}$; Fig. 2	[1]	-	300	A

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

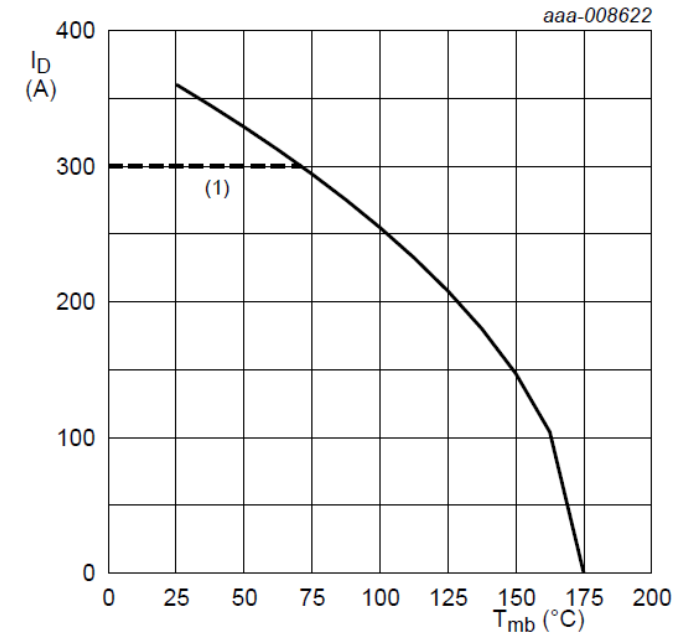
I_D	drain current	$V_{GS} = 10\text{ V}$; $T_{mb} = 25\text{ °C}$; Fig. 2	[1]	-	300	A
		$V_{GS} = 10\text{ V}$; $T_{mb} = 100\text{ °C}$; Fig. 2	-	-	255	A

Avalanche ruggedness

I_{AS}	non-repetitive avalanche current	$V_{sup} \leq 30\text{ V}$; $V_{GS} = 10\text{ V}$; $T_{j(\text{init})} = 25\text{ °C}$; $R_{GS} = 50\ \Omega$	[2]	-	190	A
----------	----------------------------------	---	-----	---	-----	---

[1] 300A Continuous current has been successfully demonstrated during application tests. Practically the current will be limited by PCB, Thermal design and operating temperature.

[2] Protected by 100% test



(1) 300A continuous current has been successfully demonstrated during application tests. Practically the current will be limited by PCB, Thermal design and operating temperature

Fig. 2. Continuous drain current as a function of mounting base temperature

$$V_{GS} \geq 10V$$

LFPAK – Maximum Current



200A

LFPACK – Maximum Current

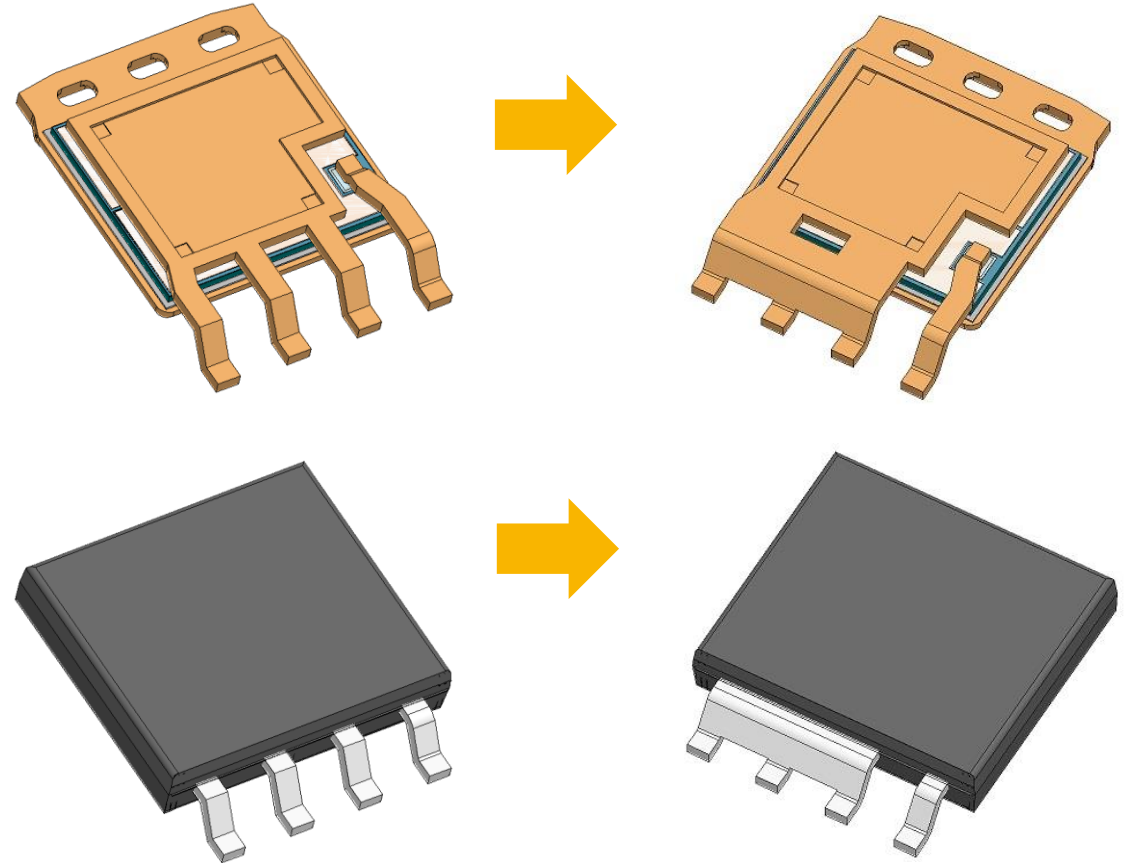
Heatsink @ 25 °C	NXP	NXP	ON Semi	AOS	IR	Infineon
	PSMN0R9-30YLD	PSMN1R0-30YLD	NTMFS4931N	AON6500	IRFH8303PbF	BSC011N03LS
Tj [max] (°C)	150	175	150	150	150	150
Tmb (°C)	25	25	25	25	25	25
Delta T (°C)	125	150	125	125	125	125
Rdson [max] VGS=10V 25°C (mΩ)	0.87	1.02	1.1	0.95	1.1	1.1
Rdson Tjmax Correction Factor	1.64	1.8	1.55	1.5	1.7	1.4
Rdson [max] VGS=10V Tjmax (mΩ)	1.43	1.84	1.71	1.43	1.87	1.54
Rth (j-mb) [max] (K/W)	0.43	0.63	1.2	1.5	0.8	1.3
Calculated Id [max] 25°C (A)	451	360	247	242	289	250
Datasheet Id [max] 25°C (A)	300	300	246	200	100	100
	(package limited)	(package limited)		(package limited)	(source bonding limited)	(package limited)
Avalanche Current, I _{AS} [max] 25°C (A)	190 (100% tested)	190 (100% tested)	Not quoted	Not quoted	Not quoted	50
Safe Operating Current, VDS=20V, 10ms (A)	9	6	9 (theoretical, no Spirito)	4 (theoretical, no Spirito)	1	0.35

- NXP max current raised to 300A
- Avalanche current raised to 190A, 100% production tested
- NXP best in class on all parameters

LFPAK Roadmap – Merged Leads

VDS	$I_{D(max)}$	R_{th}	$T_{j(max)}$	R_{DSon}
$E_{DS(AL)S}$	EMI	V_{th}	SOA	mm ²

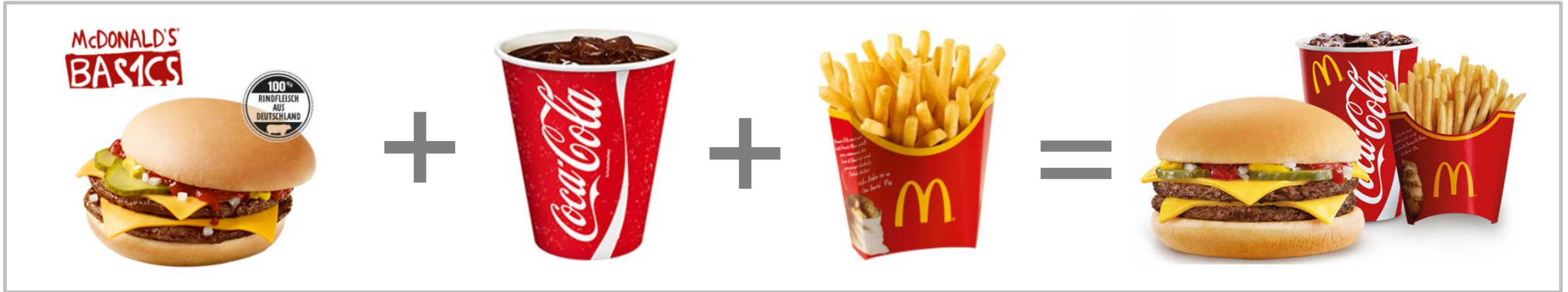
- **Lower package resistance**
 - 0.07m Ω (-30%)
- **Higher current**
- **Improved thermal performance**
- **Power-SO8 compatible**
 - No change to PCB footprint



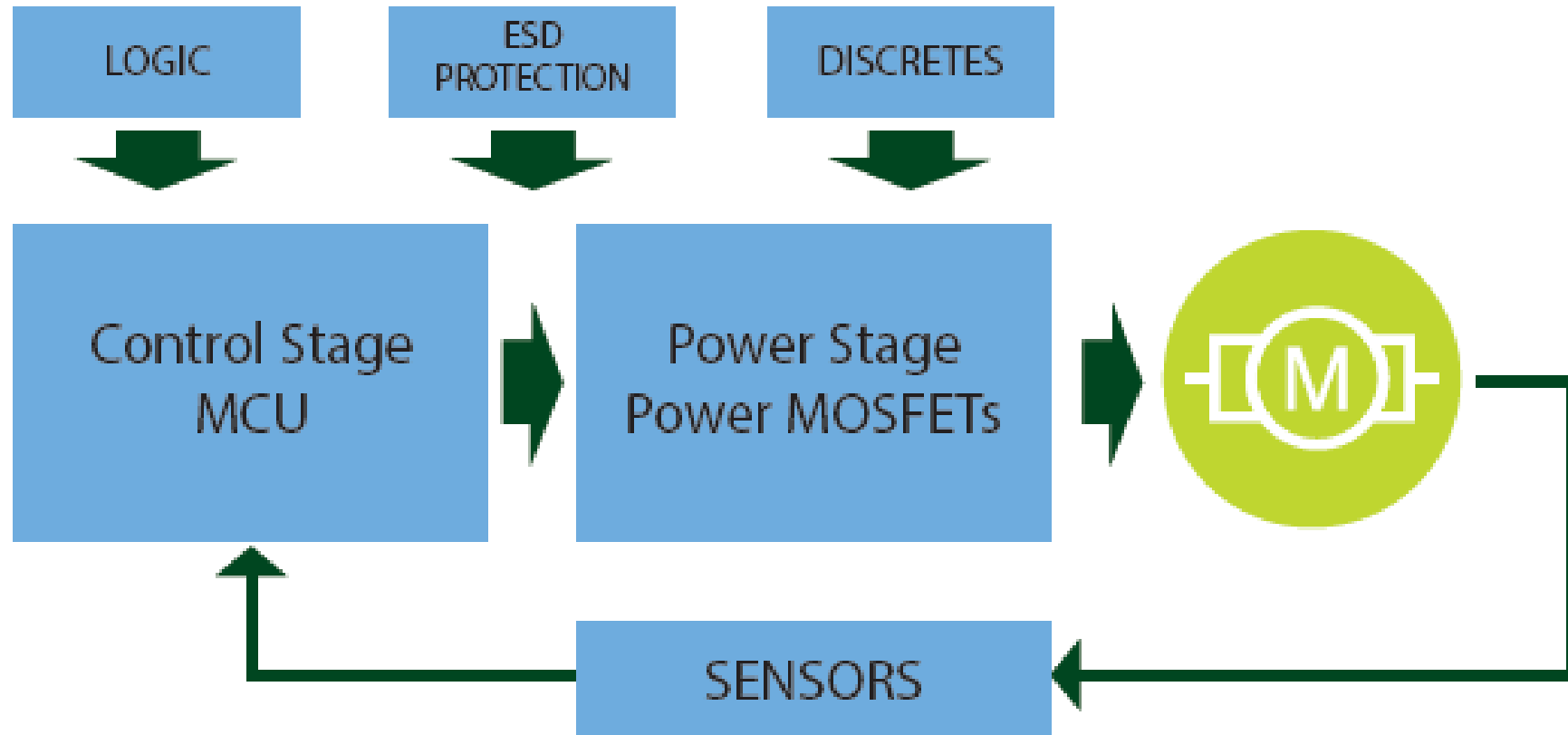
SOLUTION-SELLING WITH MICROS



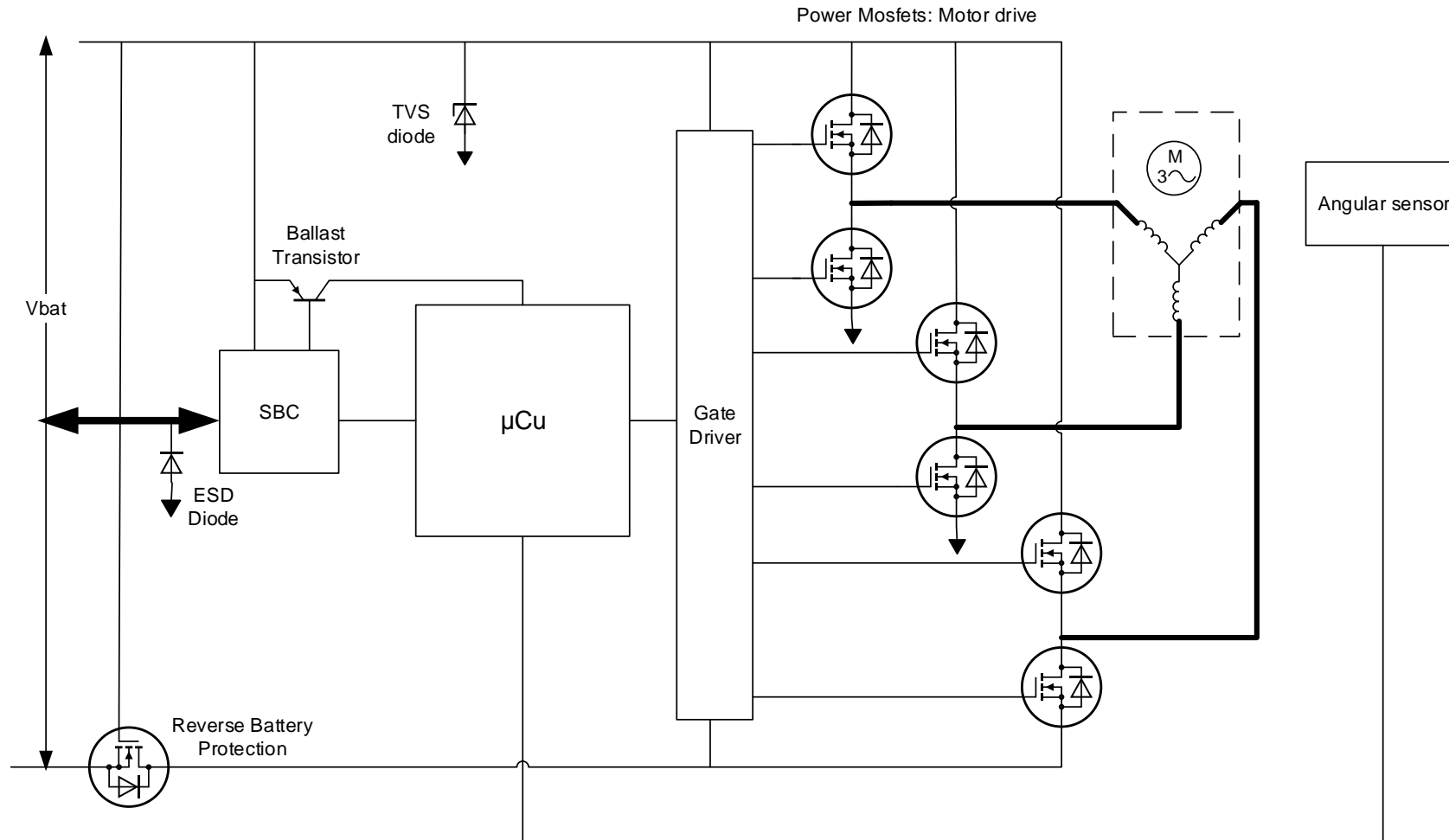
Solution-Selling



Motor Control



System Overview for BLDC Motor Control



Unmanned Aerial Vehicle UAV



Unmanned Aerial Vehicle (UAV)

Reference-Design and NXP Cup
Initial Proposal

Gregory Camuzat / Mohit Kedia / Iain Galloway

March 25st. 2016



Type	Qty	Preferred Solution	Specs
Microcontroller	1	NXP MKV11Z128VFM7	32-bit ARM M0+ 75MHz 128KB Flash 16KB RAM KMS, CAN, 32-QFN 5x5mm
Gate driver	1	Fairchild FAN7888MX	3 half-bridge gate-drive IC 20-SOIC 7.5*12.8mm
MOSFET	6	NXP PSMN1R4-30YLD	V_{DS} 30V, I_D 100A, I_{DM} 1019A, $R_{\theta_{DS(on)}}$ 1.42m Ω , 56-LFPAK 4*5mm
OpAmp	4	Fairchild FAN4852IMU8X	9MHz low-power dual CMOS Amplifier 8-MSOP 3*3mm
CAN Transc.	1	NXP TJA1051TK/3, 118	High-speed CAN transceiver (2Mbit/s) with 8kV ESD protection 8-HVSON 3x3mm



Motor Control

Motor Types

3-Phase Brushless DC (BLDC) Motor

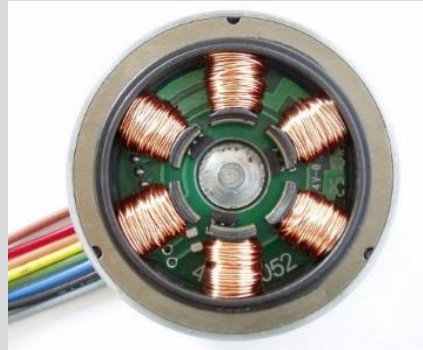
Control is done with 6 or 9 MOSFETs

Benefits

- High Controllability
- Low Losses
- Better Lifetime
- Less Noise

Control

- 6-9 MOSFETs



Brushed DC Motor

Control is done with 1, 2 or 4 MOSFETs

Benefits

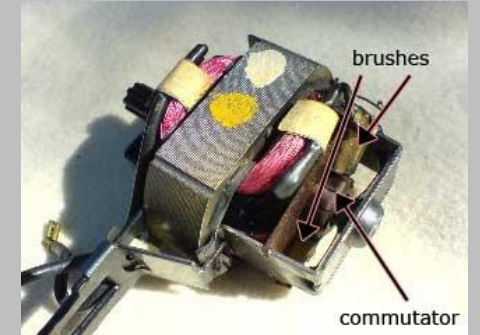
- Low cost

Opportunities

- Relays Replacement

Control

- 1-4 MOSFETs

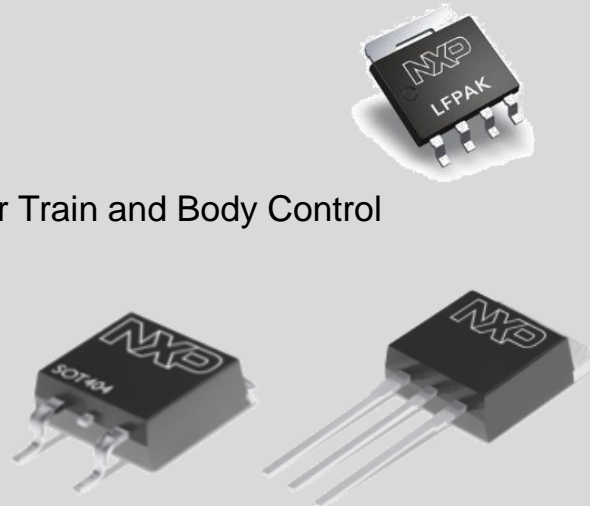


Power Needs

High Power Solution: BLDC

Application Focus: Power Train and Body Control

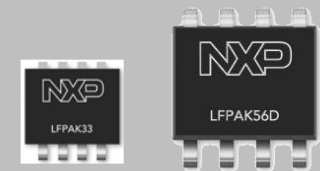
- EPS
- Braking
- HVAC
- Cooling fan
- Water pump
- Transmission



Low Power Solution: BLDC & Brushed DC Motor

Application focus: Body Control

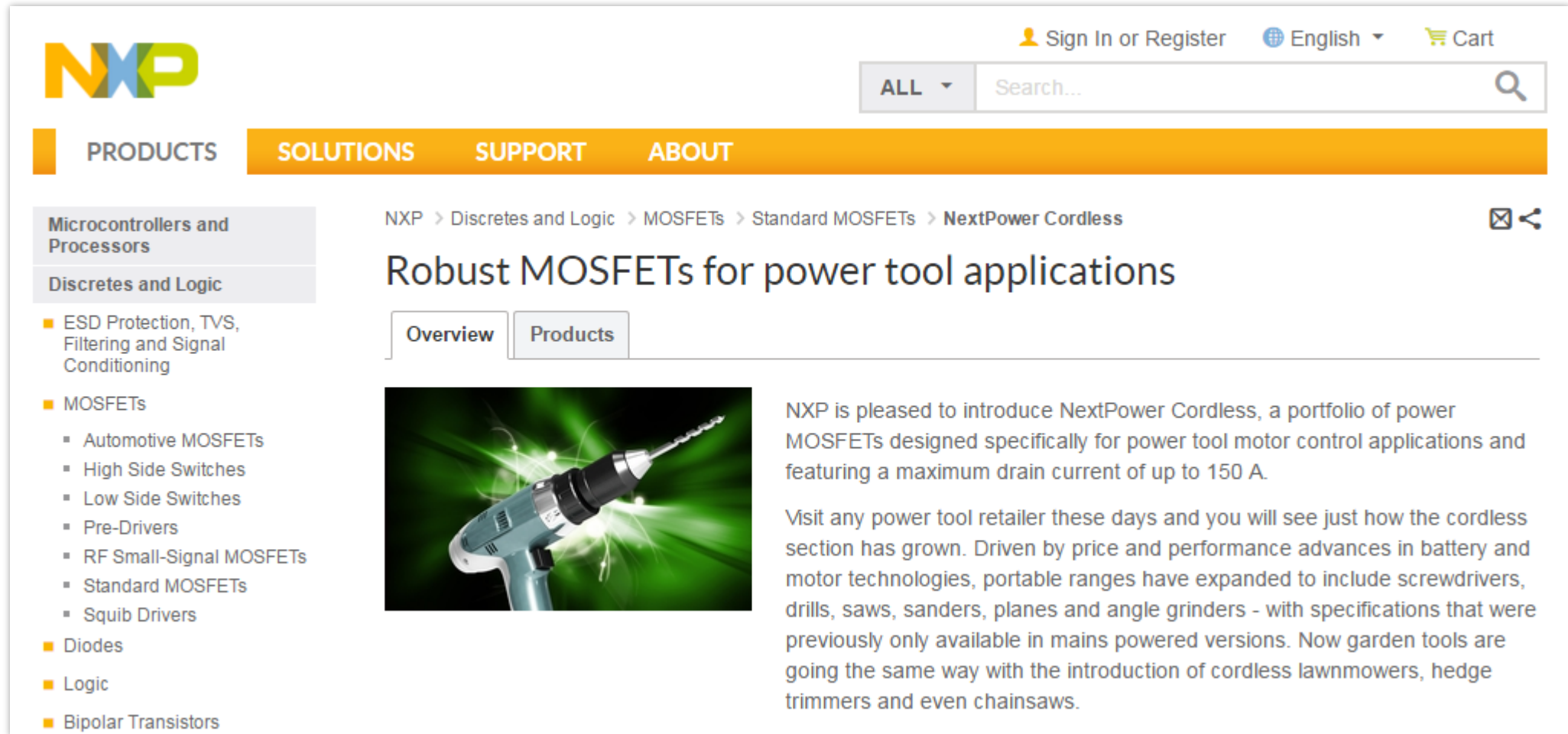
- Mirror control (Brushed)
- Windows lifter (BLDC)
- Seat control (Brushed)
- Sun roof control (BLDC)
- Valve shutters (Brushed)



TOOLS & INFO



NextPower Cordless on the Web



The screenshot displays the NXP website's product page for 'NextPower Cordless'. The page features a navigation bar with 'PRODUCTS', 'SOLUTIONS', 'SUPPORT', and 'ABOUT'. A search bar is located in the top right corner. The main content area is titled 'Robust MOSFETs for power tool applications' and includes a breadcrumb trail: 'NXP > Discretes and Logic > MOSFETs > Standard MOSFETs > NextPower Cordless'. Below the title are two tabs: 'Overview' and 'Products'. A central image shows a cordless drill with green energy effects. To the right of the image, the text states: 'NXP is pleased to introduce NextPower Cordless, a portfolio of power MOSFETs designed specifically for power tool motor control applications and featuring a maximum drain current of up to 150 A. Visit any power tool retailer these days and you will see just how the cordless section has grown. Driven by price and performance advances in battery and motor technologies, portable ranges have expanded to include screwdrivers, drills, saws, sanders, planes and angle grinders - with specifications that were previously only available in mains powered versions. Now garden tools are going the same way with the introduction of cordless lawnmowers, hedge trimmers and even chainsaws.'

NXP

Sign In or Register English Cart

ALL Search...

PRODUCTS SOLUTIONS SUPPORT ABOUT

Microcontrollers and Processors


Discretes and Logic

- ESD Protection, TVS, Filtering and Signal Conditioning
- MOSFETs
 - Automotive MOSFETs
 - High Side Switches
 - Low Side Switches
 - Pre-Drivers
 - RF Small-Signal MOSFETs
 - Standard MOSFETs
 - Squib Drivers
- Diodes
- Logic
- Bipolar Transistors

NXP > Discretes and Logic > MOSFETs > Standard MOSFETs > NextPower Cordless

Robust MOSFETs for power tool applications

Overview Products



NXP is pleased to introduce NextPower Cordless, a portfolio of power MOSFETs designed specifically for power tool motor control applications and featuring a maximum drain current of up to 150 A.

Visit any power tool retailer these days and you will see just how the cordless section has grown. Driven by price and performance advances in battery and motor technologies, portable ranges have expanded to include screwdrivers, drills, saws, sanders, planes and angle grinders - with specifications that were previously only available in mains powered versions. Now garden tools are going the same way with the introduction of cordless lawnmowers, hedge trimmers and even chainsaws.

nxp.com/nextpower-cordless

NXP PowerMOS on the Web

Microcontrollers and Processors
Discretes and Logic
ESD Protection, TVS, Filtering and Signal Conditioning
MOSFETs
Automotive MOSFETs
High Side Switches
Low Side Switches
Pre-Drivers
RF Small-Signal MOSFETs
Standard MOSFETs
Squib Drivers
Diodes
Logic
Bipolar Transistors
Identification and Security
Interface and Connectivity
Media and Audio Processing
Power Management
RF
Sensors
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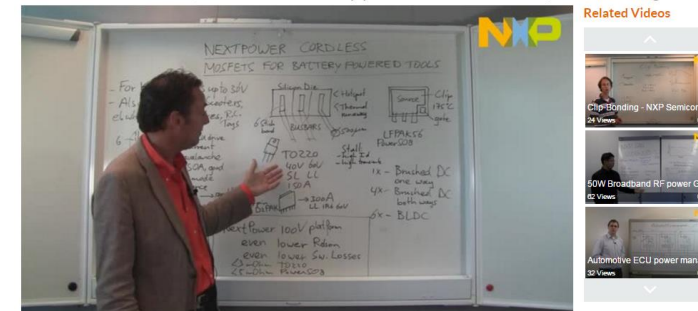
Products/Parts
84 of 415
Show/Hide Parameters (7 Hidden)
Reset Filters
Compare Selected

Download XLS Download PDF Email Link

Products/Parts	Order	Package version	Package name	Product status	Channel type	Number of transistors
<input type="checkbox"/> BUK7Y07-30B	Buy Options	SOT669	LFFPAK56; Power-SO8	Production	N	1
<input type="checkbox"/> BUK7Y08-40B	Buy Options	SOT669	LFFPAK56; Power-SO8	Production	N	1
<input type="checkbox"/> BUK7Y10-30B	Buy Options	SOT669	LFFPAK56; Power-SO8	Production	N	1
<input type="checkbox"/> BUK7Y102-100B	Buy Options	SOT669	LFFPAK56; Power-SO8	Production	N	1
<input type="checkbox"/> BUK7Y113-100E	Buy Options	SOT669	LFFPAK56; Power-SO8	Production	N	1
<input type="checkbox"/> BUK7Y12-100E	Buy Options	SOT669	LFFPAK56; Power-SO8	Production	N	1
<input type="checkbox"/> BUK7Y12-40E	Buy Options	SOT669	LFFPAK56; Power-SO8	Production	N	1

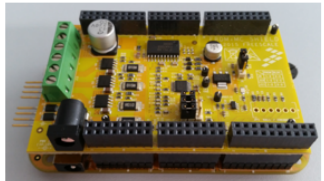
- Full parametric search
- Datasheets
- Application notes
- Device models
- Footprint & package data
- Samples
- Quick Learning videos

NextPower Cordless, mosfets for battery powered tools - NXP Quick Learning 28



Reference Design

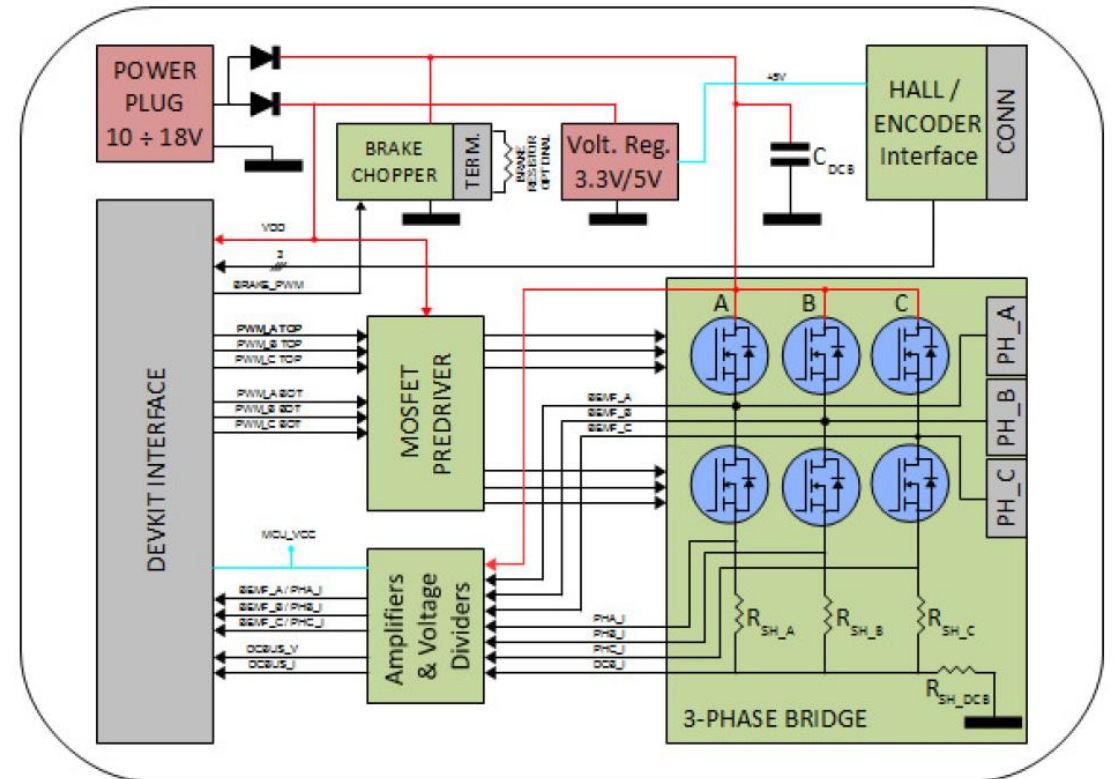
FRDM-MC_SHIELD for Automotive FRDM boards		STATUS : HW design done		
NXP PARTS				
REFERENCE	PCS	PART NUMBER	PACKAGE	
D1, D3	2	PMEG3020EH	SOD123LF	
D4, D5, D6	2	BAS316	SOD323	
Q2, Q3, Q4	3	BUK7K52-60EX	LFPAK	
Q6	1	PMV130ENEAR	SOT23	



*Freedom Power Management Board
Supporting 10-15 different μC*

The first full for reference design solution using it will be FRDM-KEAZ128 + DEVKIT-MCSHIELD that has motor control software

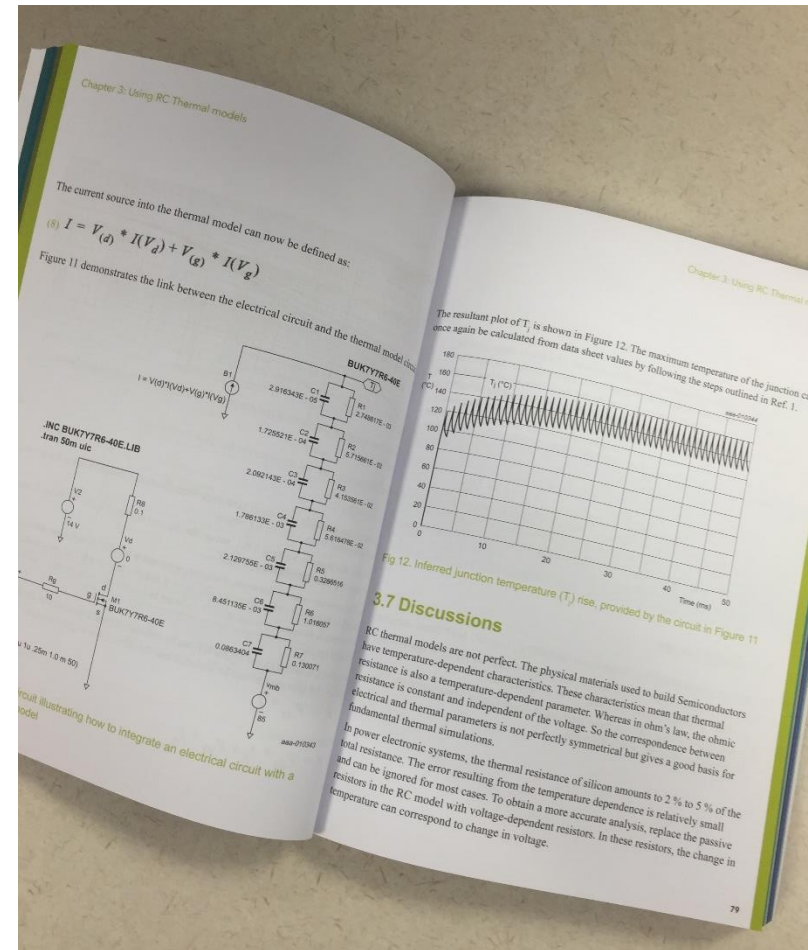
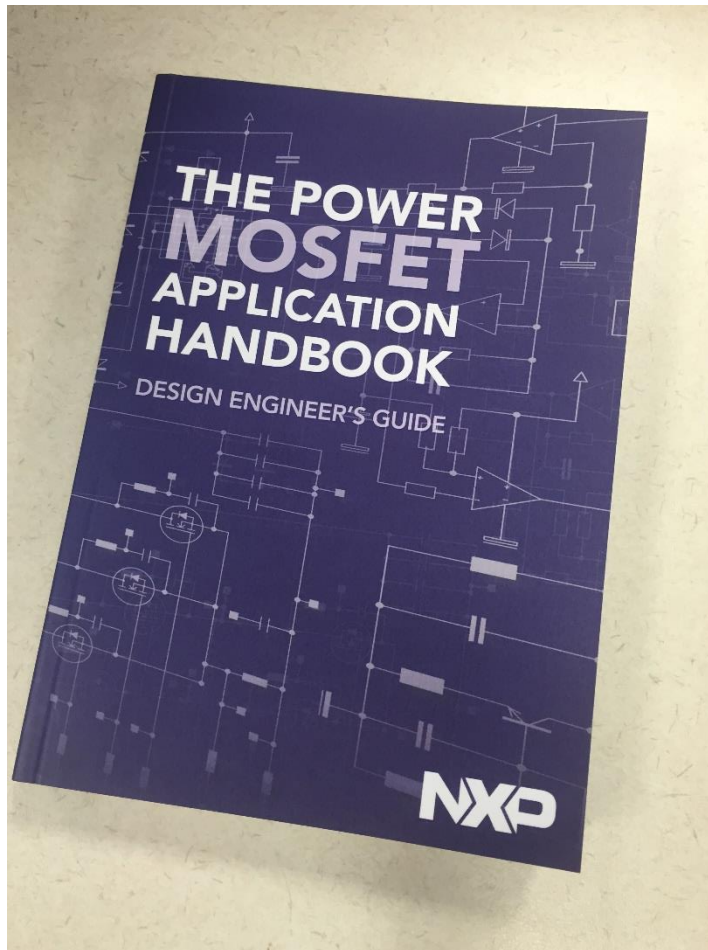
DEVKIT-MCSHIELD for BLDC/PMSM




Brochures, Application Information and Sales Tools



Application Handbook



KEY “MOTOR CONTROL” TAKEAWAYS

- New, Big, Diverse Opportunities
- Power MOSFETs Make a Difference
- NXP has Optimized Devices 
- Perfect for Solution-selling with Micros

A Glimpse of the Future?



<https://www.youtube.com/watch?v=AUq3mBuENiw>



SECURE CONNECTIONS
FOR A SMARTER WORLD

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BACK UP SLIDES

STRUCTURED FOR SUCCESS

Security & Connectivity

Best-in-class security, contactless performance and the most complete solutions to produce unmatched mobile and IoT solutions

Automotive

Sensor and processing technology driving all aspects of the secure connected cars of today and the autonomous cars of tomorrow

Digital Networking

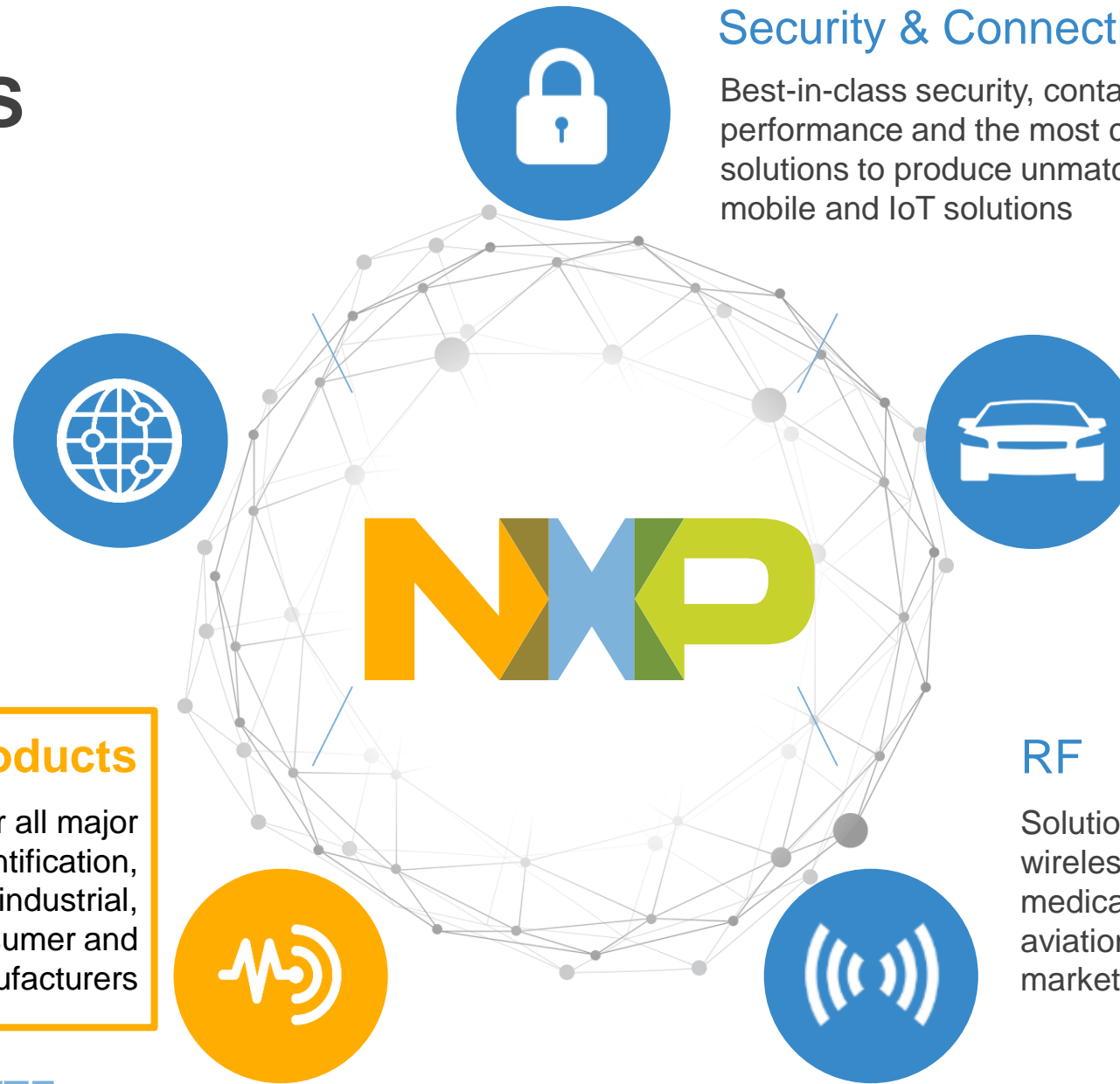
High-performance multicore solutions that transport, analyze and secure data from the edge of the network to the cloud

Standard Products

Leading supplier for all major automotive, identification, wireless infrastructure, industrial, mobile, lighting, consumer and computing manufacturers

RF

Solutions spanning the smartphone, wireless infrastructure, broadcast, medical, mobile radio, military, aviation, cooking and industrial markets



NXP Standard Products

Your 1st Choice for Diodes, Transistors, ESD & EMI Filtering, ssMOS, Power MOS, ESwitches and Logic

Global Trends



Energy efficiency



Connected & smart device



Reliability in product & service

Reflected In
>10,000 Types

- Small-signal Diodes & Transistors
- Medium Power Diodes & Transistors
- Protection & Signal Conditioning
- Small-Signal MOSFETs
- Power MOSFETs
- eSwitches
- Logic Devices

Enabled By

- Cost efficient supply chain
- High quality with <0.1 PPM failure rate
- Extended AECQ-100/101 portfolio
- Best in Class packages

Results

#1

GA Discretes (incl. ESD protection)

#2

PowerMOS Automotive

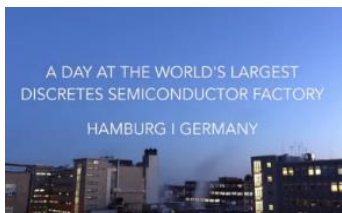
#3

Logic

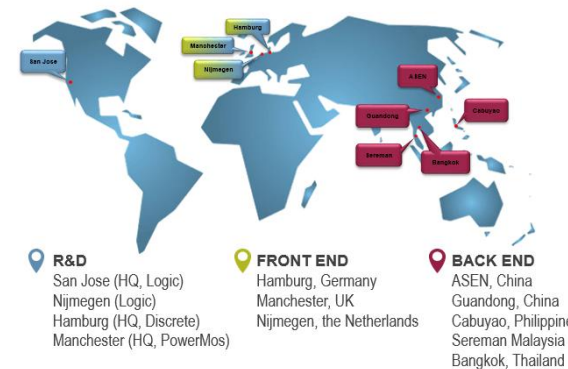
STANDARD PRODUCTS IS YOUR 1st CHOICE SUPPLIER WITH 12.1% MARKET SHARE



Click on the image to watch the video about our Fab in Hamburg



Click on the image to open the Discretes Selection Guide 2016

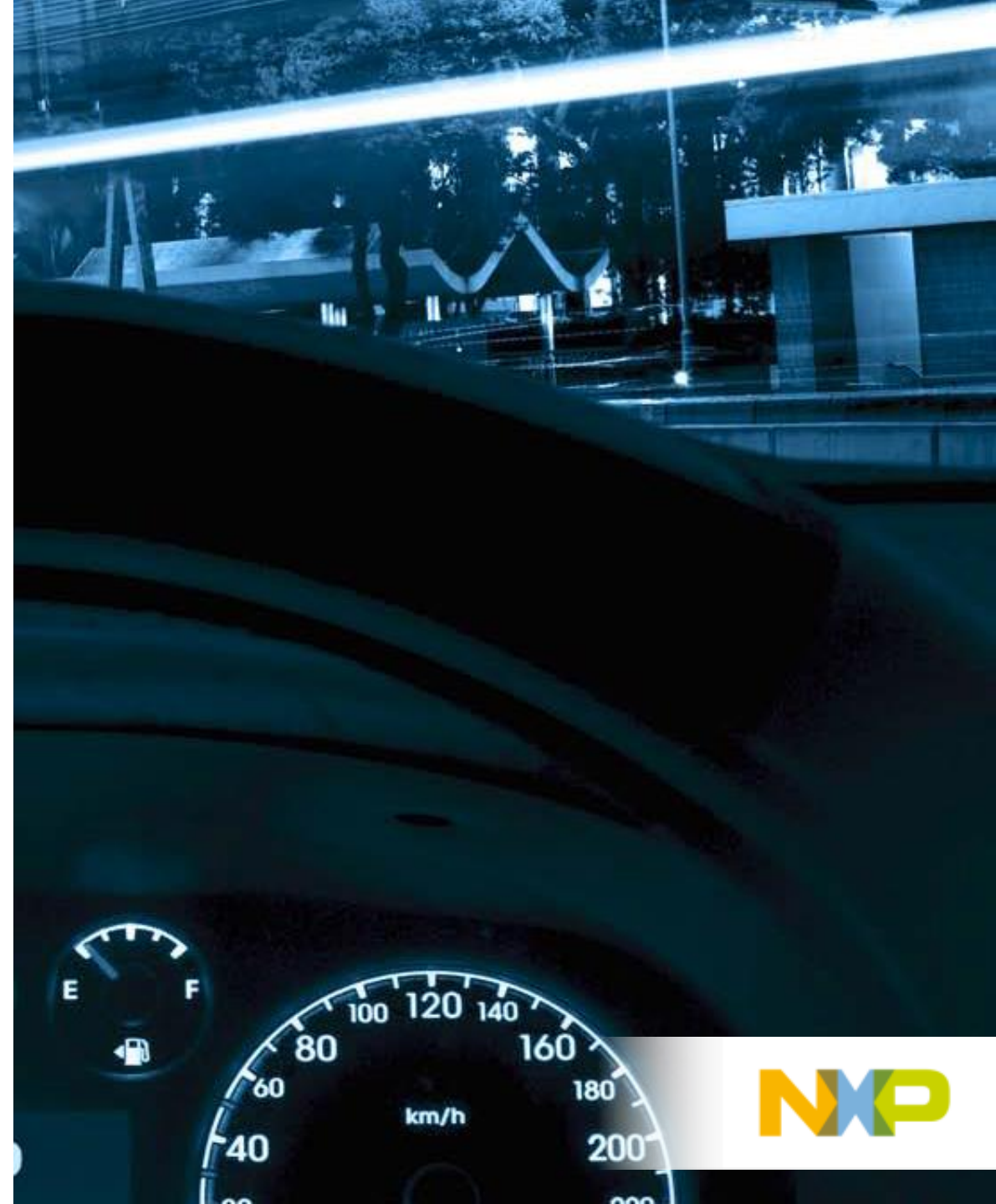


...AND UP TO 70 BLN PCS SHIPPED ANUALLY!













NXP In Automotive Power

- #2 in automotive power MOSFET market
- Largest portfolio of AEC-Q101 qualified devices
- Leadership in engine, transmission, steering & braking applications






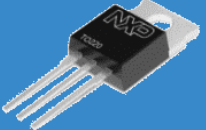
PowerMOS Focus Markets

AUTO	ICT INFRASTRUCTURE	POWER SUPPLIES & UPS	MOTOR CONTROL	MOBILE & COMPUTING
 <p>POWERTRAIN, CHASSIS & SAFETY, BODY & SECURITY</p> <p>AEC-Q101 approved</p>	 <p>BASESTATIONS, ROUTERS, SERVERS, STORAGE</p> <p>High performance DC:DC, Power ORing, Hot-swap, Soft-start, Power-over-Ethernet</p>	 <p>SERVER POWER, FAST CHARGE ADAPTORS, UPSs</p> <p>AC:DC, Synchronous Rectification, DC:AC Inverters, Power ORing,</p>	 <p>VACUUM CLEANERS, POWER TOOLS, DRONES, MODULES</p> <p>Motor Control, Hot-swap, Battery Protection</p>	 <p>SMARTPHONES, NOTEBOOKS, PCS, TABLETS, GRAPHIC CARDS</p> <p>High volume DC:DC, Charging Control, Load Switches, Battery Protection</p>
				
<p style="text-align: center;">Quality & Reliability</p> <p style="text-align: center;">Price / Performance</p>				

Standard MOS Summary Portfolio

$R_{DS(ON)}$ [max] at $V_{GS} = 10V$

Released products as of Jan-15

Package / BV_{DSS}	 LFPAK33	 LFPAK56	 D2PAK	 TO-220 Family
25V	2.8 – 8.65	0.7 – 6.5	–	–
30V	2.4 – 18.1	0.87 – 13.6	1 – 22.6	1.3 – 22
40V	–	1.1 – 14	1.3 – 7.6	1.6 – 7.6
55V..60V	11.3	4 – 24.7	2 – 75	2.2 – 75
75V..80V	–	8.5 – 45	3 – 46	3.3 – 17
100V	36.6 – 71	12 – 72.4	3.9 – 90	4.3 – 90