



FTF 2016
TECHNOLOGY FORUM

POWER MOSFETS IN AUTOMOTIVE APPLICATIONS

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NXP POWERMOS BUSINESS LINE
FTF-AUT-N1888
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AGENDA

- PowerMOS Background and Introduction
- Portfolio Overview
- Package Focus – LFPAK
- Strategic Roadmap and Silicon Overview
- System Solutions
- Tools and Information



POWERMOS INTRODUCTION



Structured For Success



NXP Standard Products

Your 1st Choice for Diodes, Transistors, ESD and EMI Filtering, ssMOS, PowerMOS, ESwitches and Logic

Global Trends



Energy efficiency



Connected and smart device



Reliability in product and service

Reflected in >10,000 Types

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

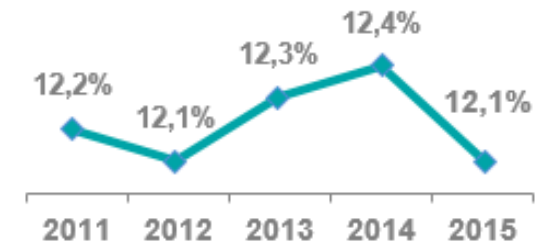
Enabled by

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

Results

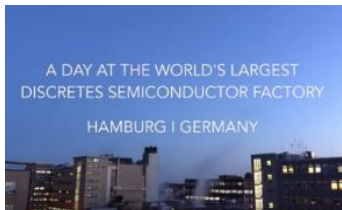
- #1 GA Discretes (incl. ESD protection)
- #2 PowerMOS Automotive
- #3 Logic

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



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

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



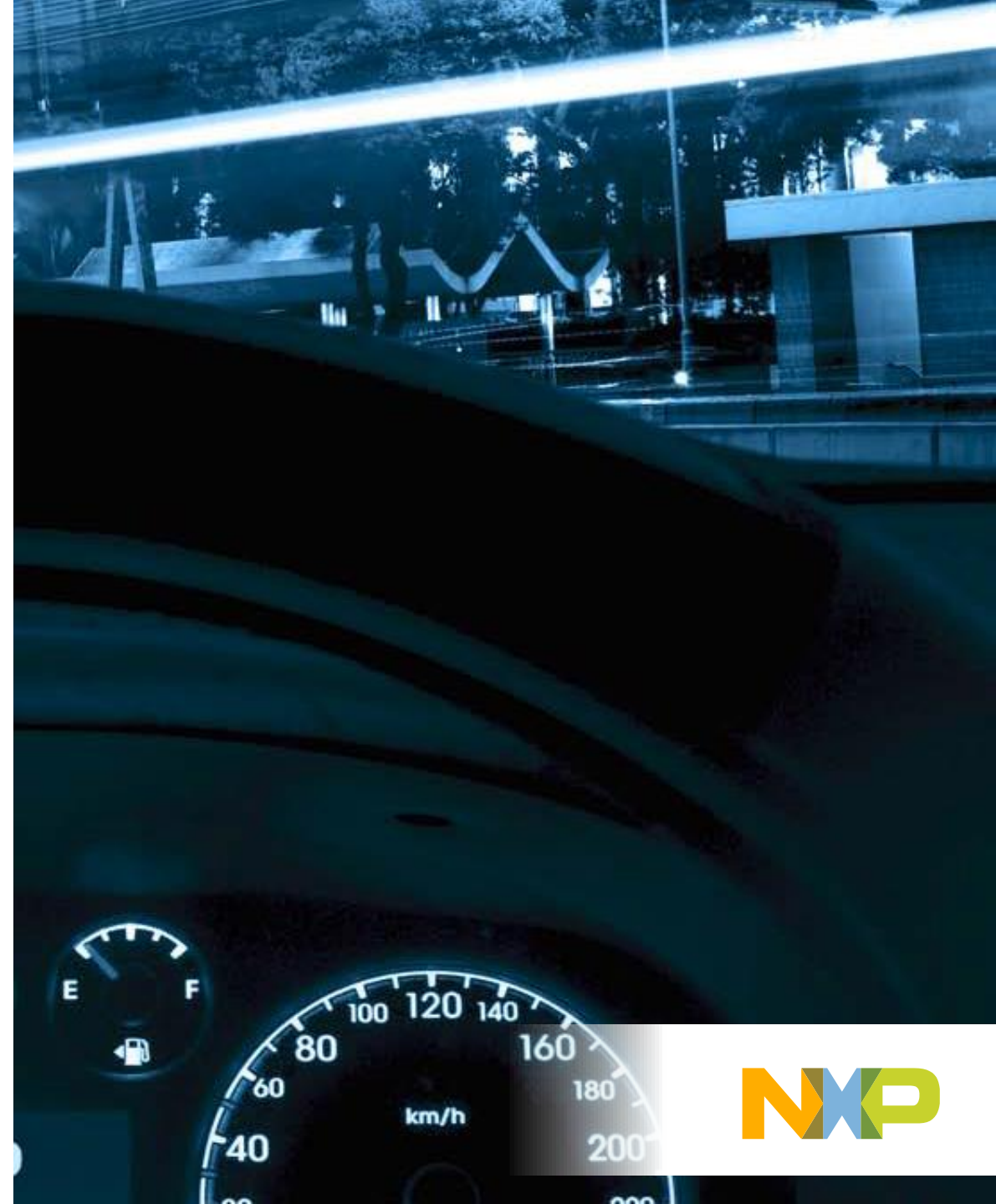
Click on the image to open the Discretes Selection Guide 2016



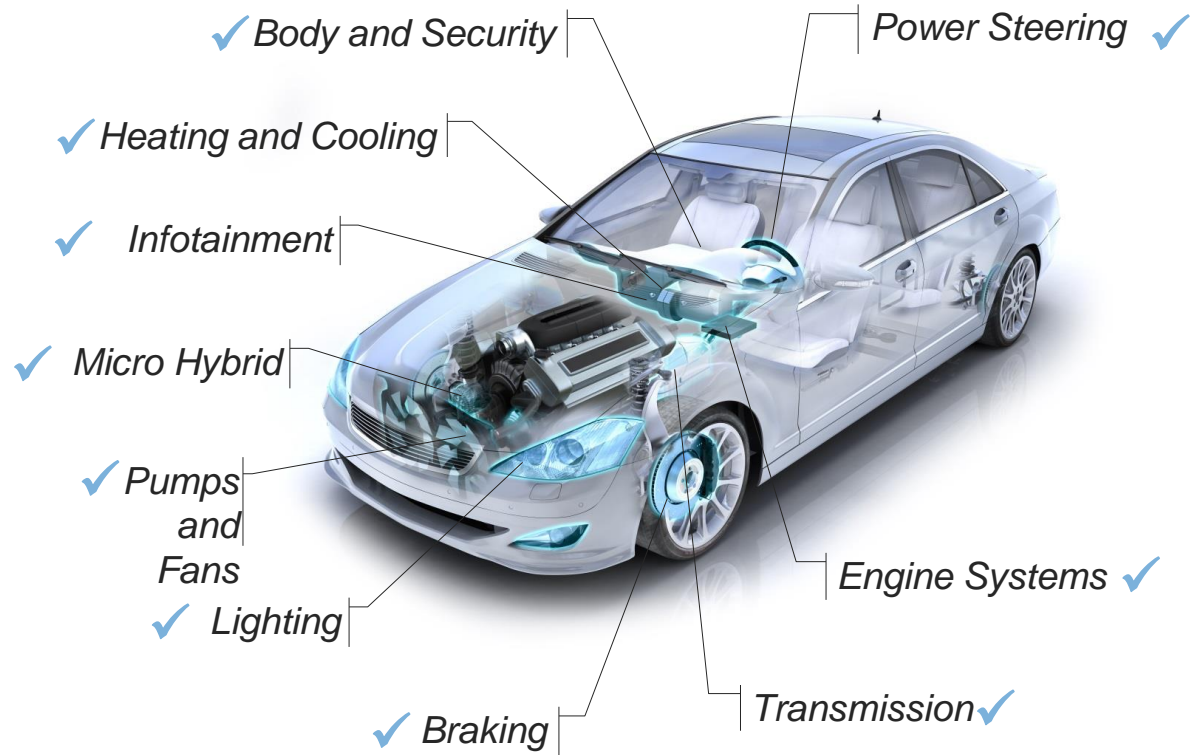
Standard Products @ a Glance

NXP in Automotive Power

- Leading player in the \$750M automotive power MOSFET market
- Employing ~2000 people in 5 countries
- Shipping ~750M pcs of automotive grade product annually
- Significant market share and growth forecast
- Leadership in engine, transmission, steering and braking applications
- Supported by substantial industrial and supply chain organisation
- Meeting total automotive requirements: AEC-Q101 and beyond



Automotive Power – Market Fit



“NXP aim to offer the broadest low voltage MOSFET portfolio in the market, providing a solution for the majority of sockets”

High Power Products



KGD



D²PAK



P²PAK
TO220

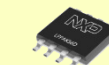
Space and Cost Saving Products



DPAK



LFPAK56



LFPAK56D



LFPAK33

Focus on LFPAK

- Industry leading package
- Largest portfolio in 5x6
- Strong market growth
- Benchmark reliability
- Cost competitive
- Single and dual MOSFETs
- 3x3 footprint coming soon

NXP – Commitment To Automotive

- **Quality**

- Committed to providing <<<1ppm quality levels
- Our General Quality Specification (GQS) is based on AEC-Q101
- New technologies are reliability tested to 2000Hrs to meet mission profile

- **Product Withdrawal**

- NXP do not withdraw old technologies without good prior warning
- Provide long last-time buy window
- Keep technologies running at customer request

- **Qualification**

- Commitment to ensure products meet automotive standards and customer qualification criteria
- Provision of supporting data in the form of qualification packs and PPAP documents

NXP – Quality Awards

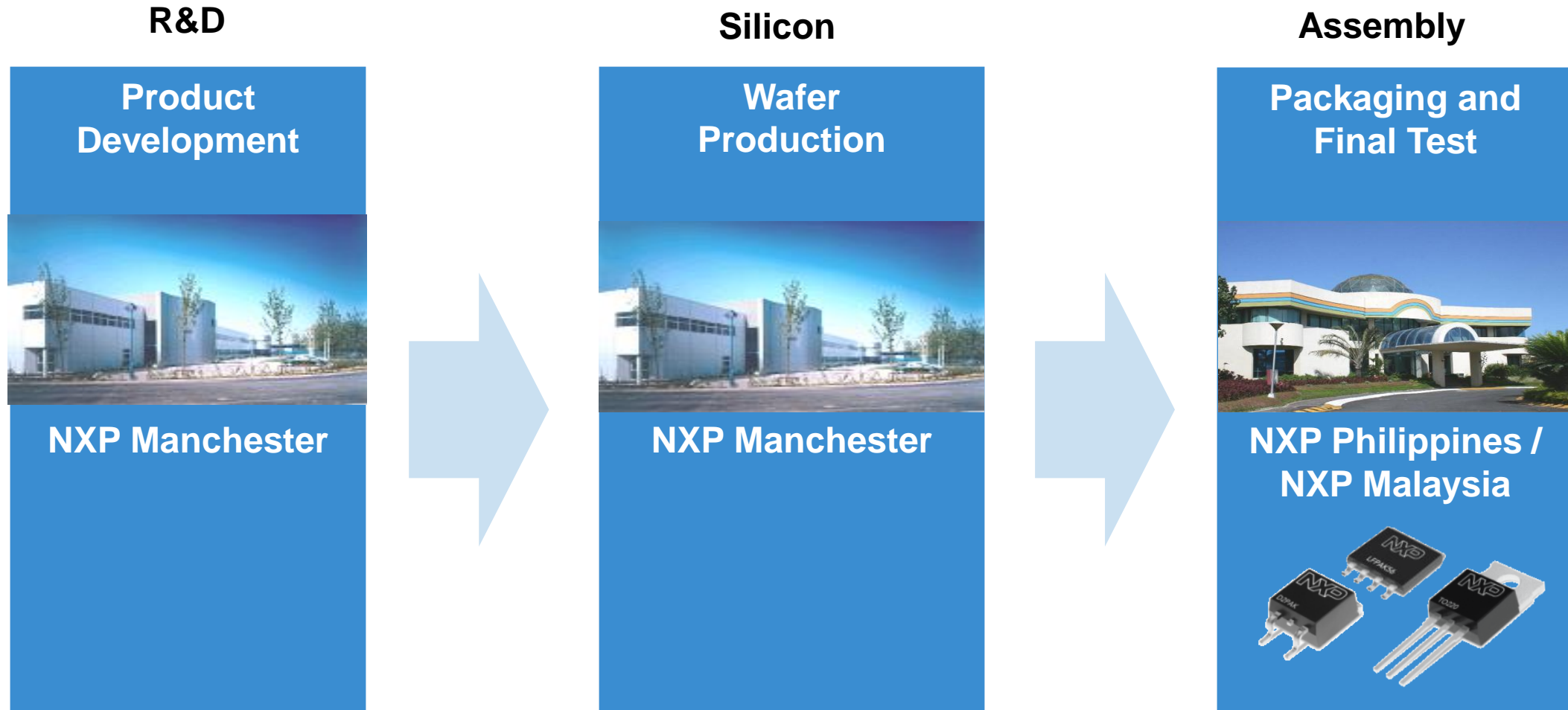
- ISO9001 Quality systems
- ISO/TS16949 certified
- ISO 14001 certified
- All manufacturing sites are VDA6.3 audited
- ESD control programme in accordance with ANSI ESD S20.20
- Zero defect programme in place
- 2011 Bosch Supplier Award in the ‘Electronics and Electromechanical components’ category
- 2012 ‘Best quality supplier for discrete’ at Continental
- 2013 Automotive Quality <0.65 ppm
- 2014 “Outstanding Co-operation” award at Delphi
- 2014 Continental ‘Supplier of the Year’ in the power category



Customer Profile



BL Power – Design and Manufacturing Process Flow



PORTFOLIO OVERVIEW

Strategic Product Focus

- **30V to 100V Power MOSFET**

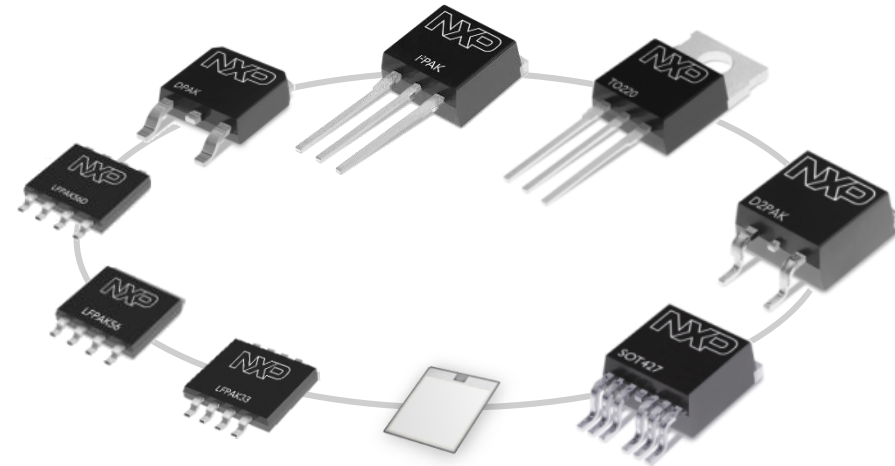
- N-channel
- Multiple technologies

- **Product development**

- Reducing on-resistance
- Ruggedness capability
- Switching capability
- Linear mode operation

- **Package focus**

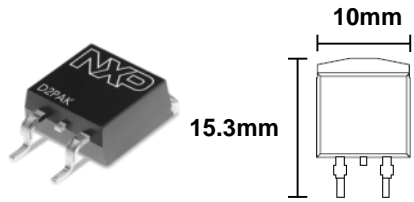
- Industry standard: D2PAK, DPAK, I2PAK, TO-220
- Innovation: Copper Clip Technology, LFPAK33, LFPAK56(D), KGD



NXP see package innovation as key focus for future

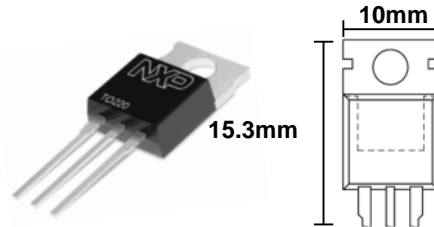
Automotive Packages

D²PAK



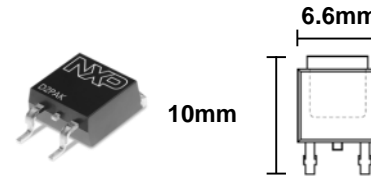
- ✓ Best thermal performance
- ✓ Surface mount

TO220 and I²PAK



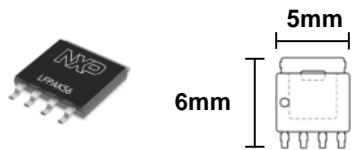
- ✓ Best thermal performance
- ✓ Through hole

DPAK



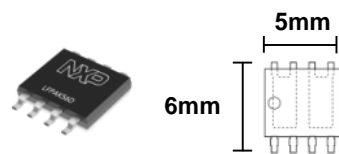
- ✓ Industry standard
- ✓ Low R_{DSon}

LFPAK56



- ✓ Small footprint
- ✓ Ultra low R_{DSon}

LFPAK56D



- ✓ Space saving
- ✓ Dual MOSFETs

LFPAK33



- ✓ Ultra compact footprint
- ✓ Low R_{DSon}

NXP can also provide 'Known Good Die' (KGD) solutions for hybrid assembly in order to achieve optimum use of space and ultra low R_{DSon} values








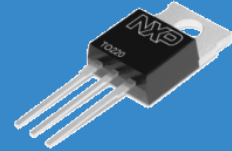

Automotive Market Trends

| Package | LFPAK56 | LFPAK56D | LFPAK33 | DPAK | D ² PAK | D ² PAK-7 | Bare Die | TO-220 |
|--------------------|---------|----------|---------|------|--------------------|----------------------|----------|--------|
| Max I _D | 100A | 40A | 70A | 100A | 120A | 190A | >400A | 120A |
| Market Trend | ↑ | ↑ | ↑ | ↓ | ↑ | — | ↑ | ↓ |



Automotive MOSFET Portfolio

Fully AEC-Q101 qualified to 175°C

| Package / V_{DSS} |  LFPAK56 |  LFPAK56D |  DPAK |  D2PAK |  D2PAK-7 |  TO-220 |  SOT223 |
|---------------------|---|--|--|---|---|--|--|
| 30V | 6.0 – 20 | 5.1 – 5.8 | 4.5 – 14 | 1.6 – 7 | - | 2.2 – 7 | - |
| 40V | 2.4 – 29 | 5.8 – 24 | 5.0 – 18 | 1.4 – 8 | - | 1.8 – 8 | - |
| 55V..60V | 4.8 – 59 | 9.3 – 52 | 7.8 – 150 | 2.3 – 75 | 2.3 | 2.6 – 13 | 29 – 150 |
| 75V..80V | 7.8 – 107 | - | 11 – 46 | 3.8 – 23 | 3.4 | 4.0 – 14 | - |
| 100V | 12 – 153 | 24 – 154 | 27 – 75 | 5.0 - 173 | - | 5.2 - 75 | 72 - 173 |

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

Released products as of Q4 2015

NXP Automotive PowerMOS

Naming Convention

7 = Standard Level, 9 = Logic

9R2 = 9.2mΩ ; 12 = 12mΩ

Voltage e.g. 40V

BUK9M9R2-40E

BUK = Automotive

Package

Y = LFPAK56
K = LFPAK56D (Dual)
M = LFPAK33
2 = DPAK
6 = D2PAK
C = D2PAK-7
5 = TO220
E = I2PAK

Technology Generation

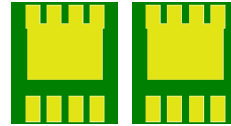
E = Trench 6
C = Trench 4
B = Trench 3
A = Trench 2

PACKAGE FOCUS

LFPAK



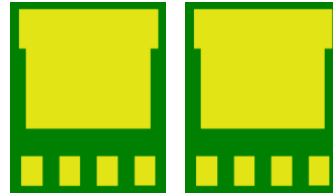
Shrinking the Power Footprint



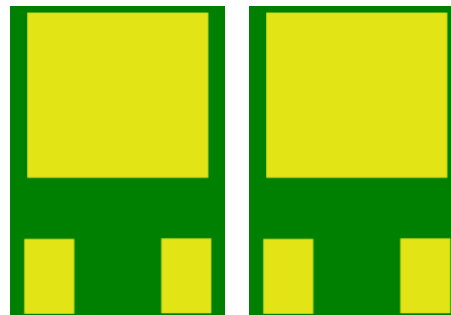
22mm²



31mm²



62mm²

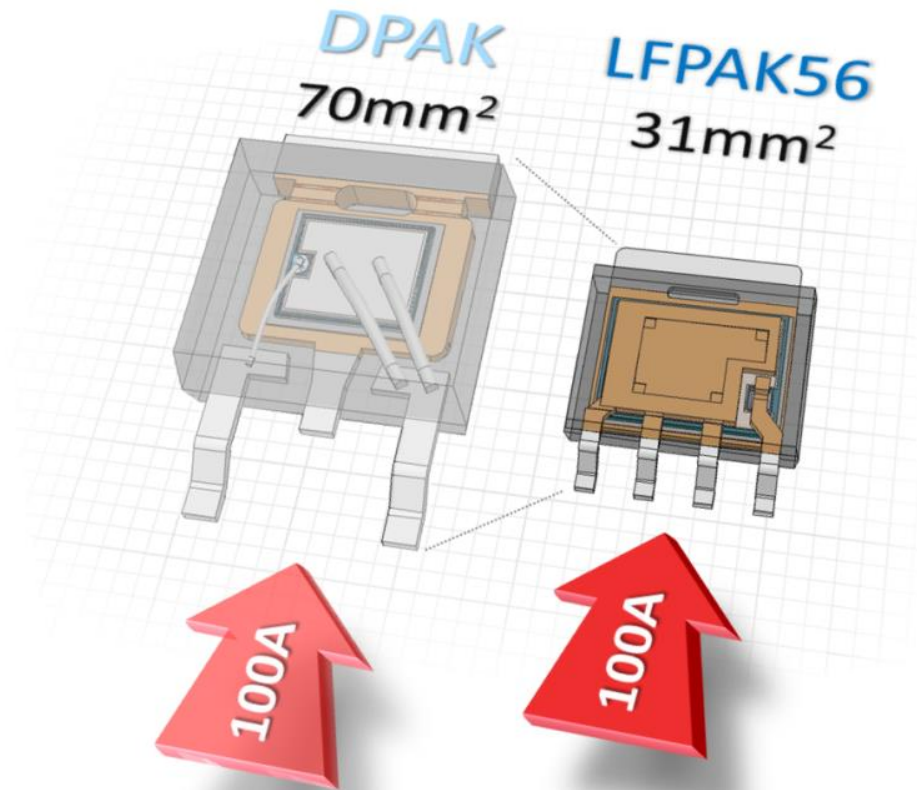


140mm²

DPAK

- Industry standard
- Ageing portfolios
- Sub-optimal use of space
- Wire-bond

MARKET TREND



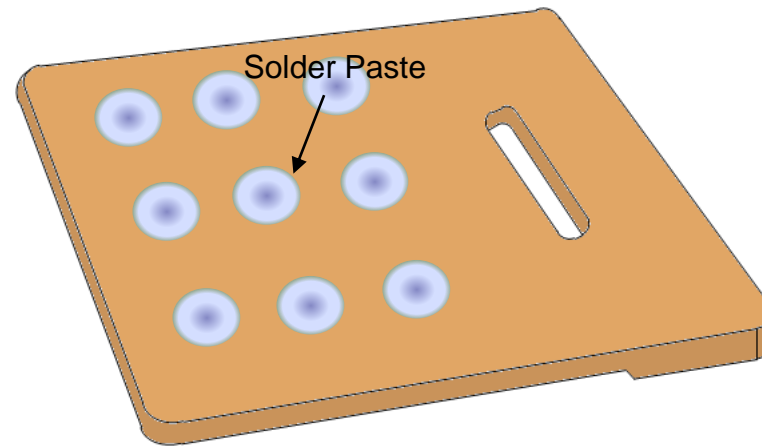
LFPAK56

- Space saving
- Improved cost position
- Improved power density
- Multiple 2nd sources
- Similar max die size as DPAK
- Wide portfolio for cost optimisation

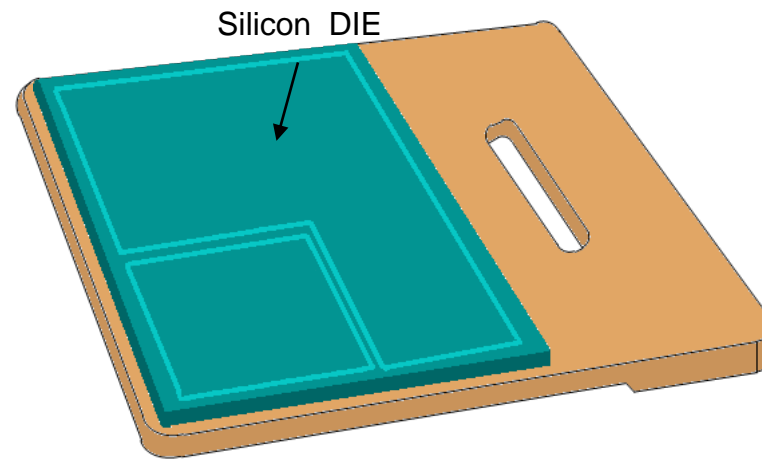
LFP56 – Package Construction



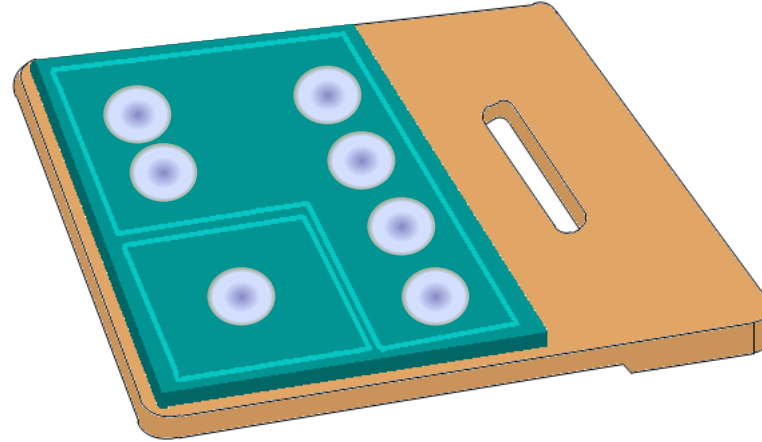
LFPAK56 – Package Construction



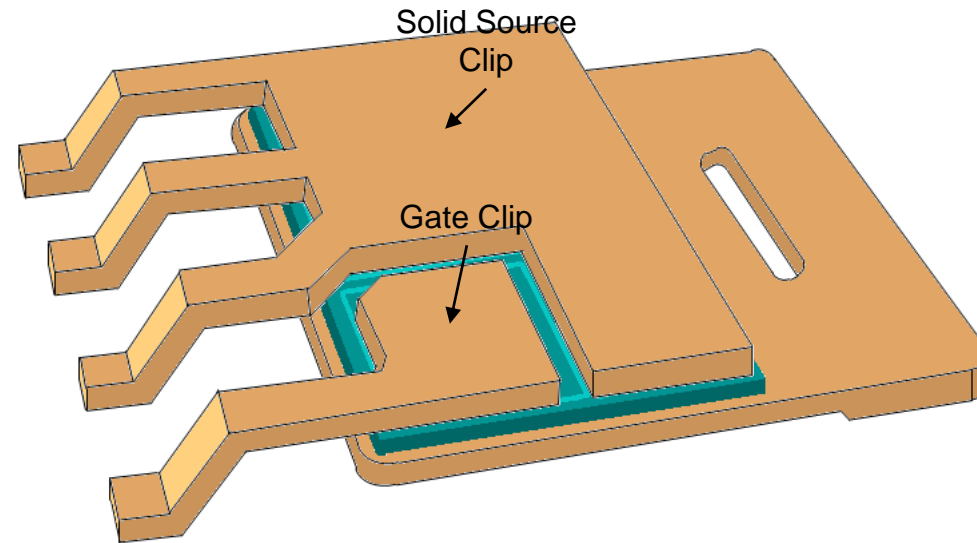
LFPAK56 – Package Construction



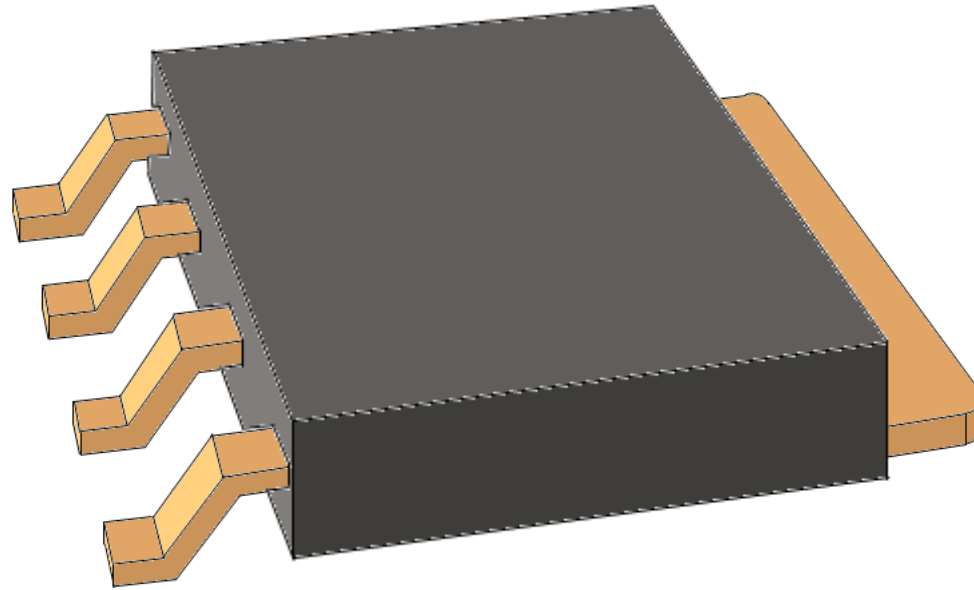
LFP56 – Package Construction



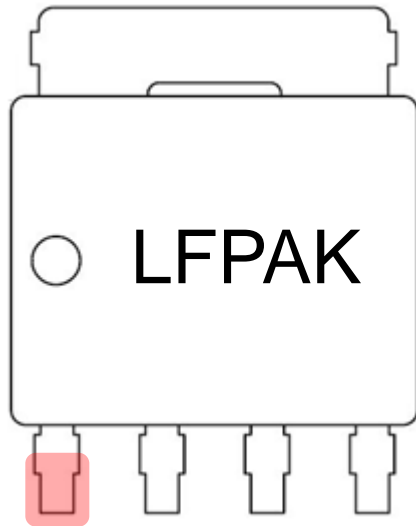
LFPAK56 – Package Construction



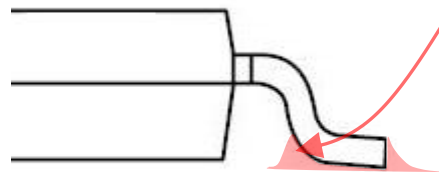
LFPAK56 – Package Construction



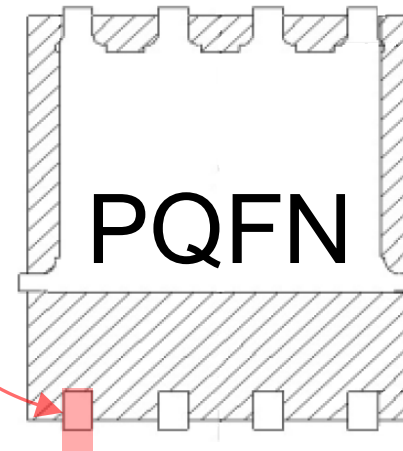
LFPAK56 – Solder Joint Reliability



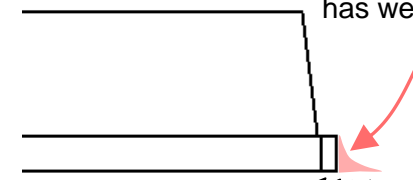
Gull wing lead style allows for a much greater area of contact between the leads and the solder



Solder can wet to the sides of the pins, end of pin and underneath lead bend



Area available for solder wetting is limited by the casing



End of pin wetting is only possible if the part has wettable flanks

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

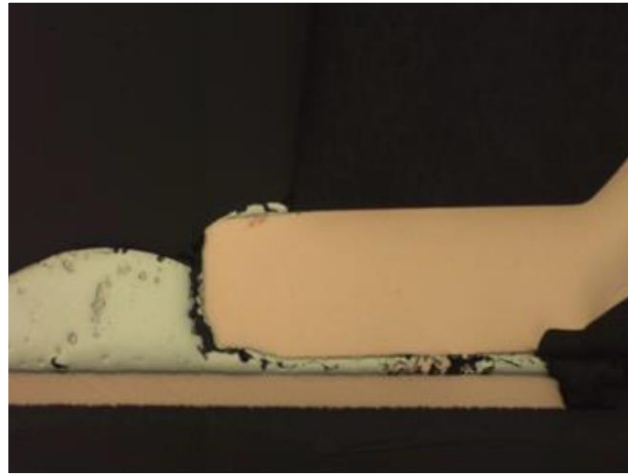
Board Level Reliability

The images below show x-sections through pins for three different types of Power-SO8 package (NXP, On Semi, ST) after 2000 temperature cycles

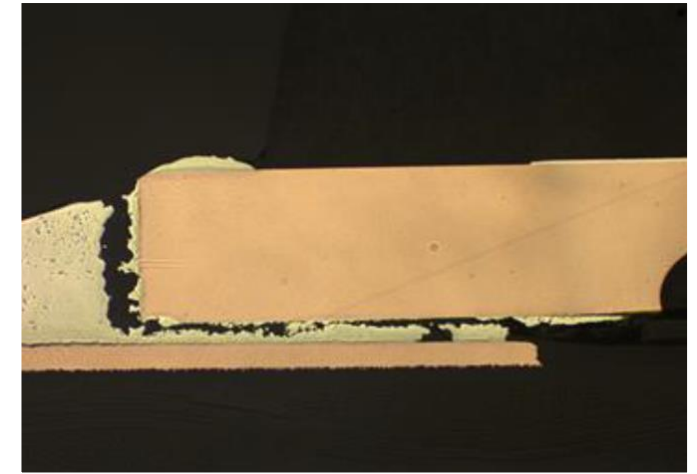
LFPAK56 is well suited to applications needing high reliability in thermally demanding environments



NXP – BUK7Y3R5-40E



On Semi – NVMFS5830NLWFT3G



ST – STL130N8F7

LFPAK56 passed the reliability testing with no issues. Both package parts from On Semi and ST failed according to the board level reliability test criteria

Trench 6 LFPAK56 (POWER SO-8) Portfolio



| | | | | | | | | |
|------|-------|-------|-------|-------|-------|------|-------|-------|
| 40V | | 3.0mΩ | 3.5mΩ | 4.4mΩ | 7.6mΩ | 12mΩ | 21mΩ | 29mΩ |
| 60V | 4.8mΩ | 6.0mΩ | 7.2mΩ | 8.7mΩ | 15mΩ | 25mΩ | 43mΩ | 59mΩ |
| 80V | 7.8mΩ | 9.9mΩ | 12mΩ | 14mΩ | 25mΩ | 41mΩ | 72mΩ | 98mΩ |
| 100V | 12mΩ | 15mΩ | 19mΩ | 22mΩ | 38mΩ | 65mΩ | 113mΩ | 153mΩ |

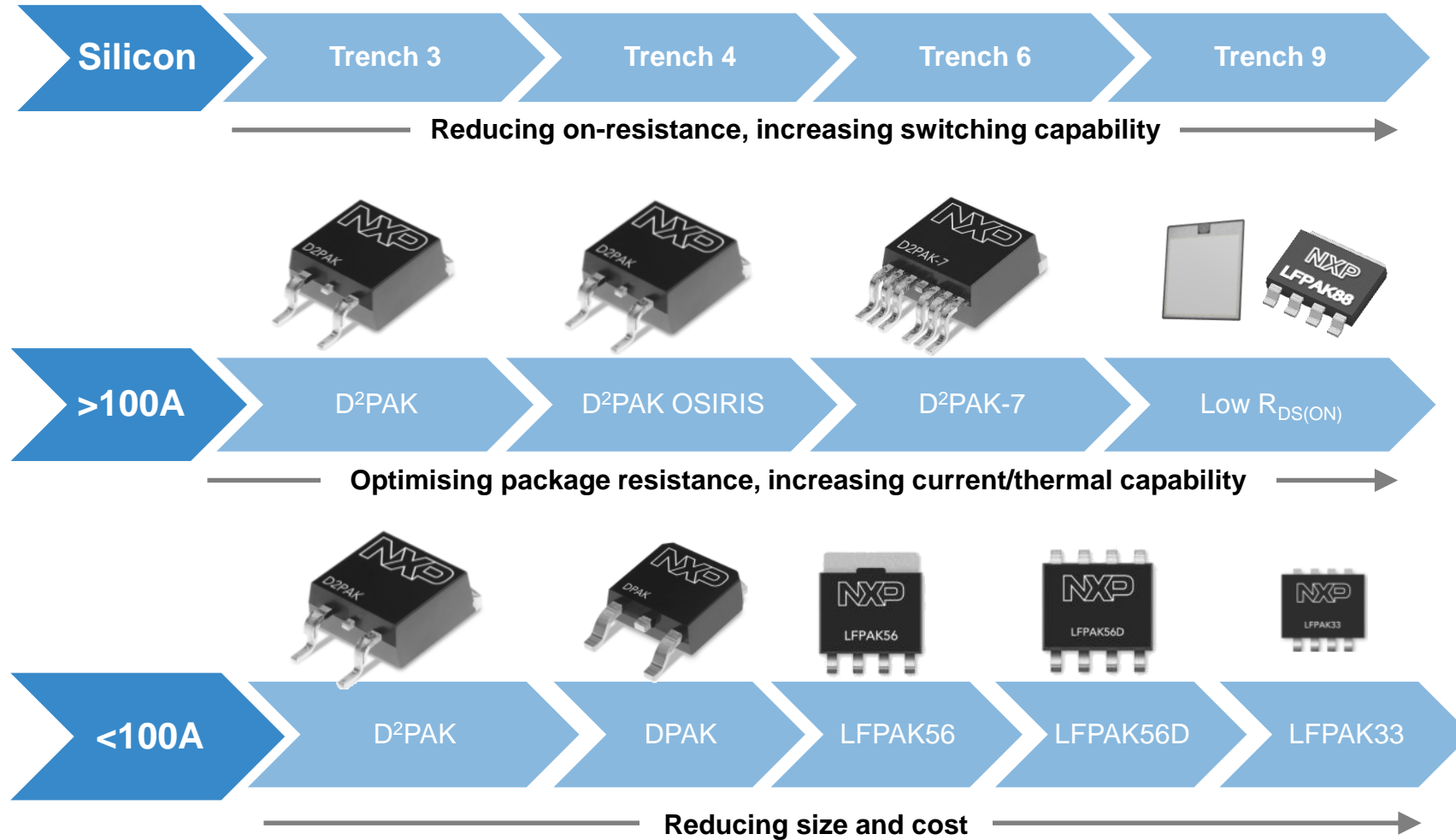
* Values shown above are for standard level devices. $R_{DS(on)}$ max @10V

59 devices offering wide application fit and cost flexibility in standard and logic level.

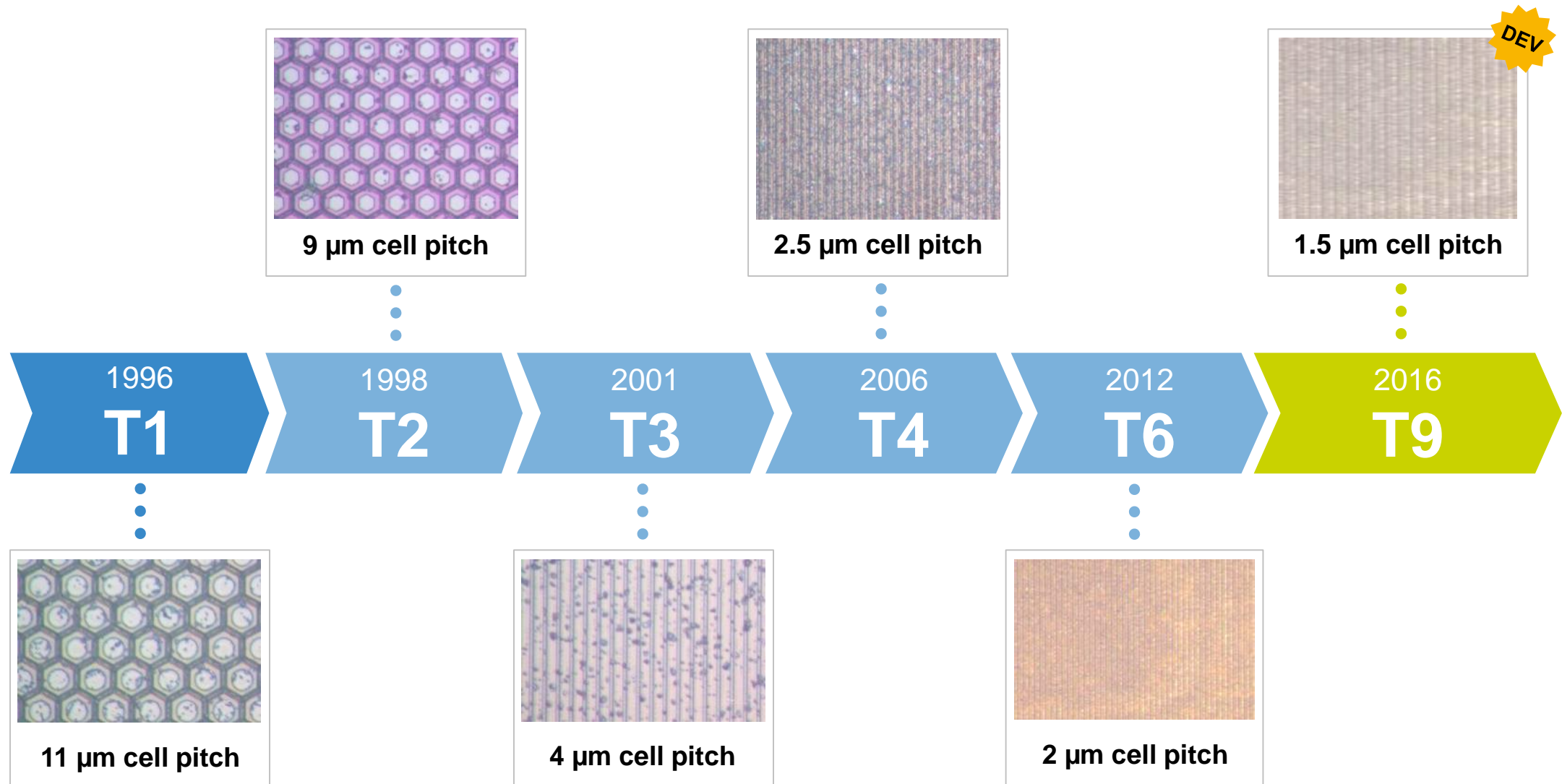
STRATEGIC ROADMAP AND SILICON OVERVIEW



Strategic Roadmap Overview

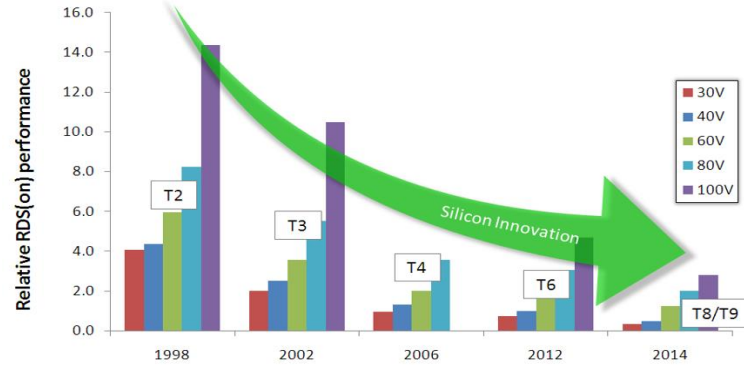


NXP Automotive TrenchMOS Platforms

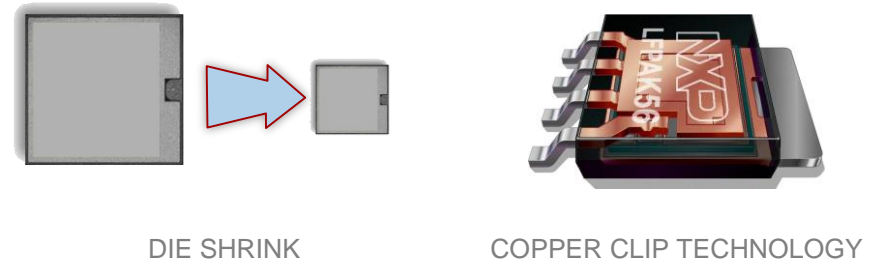


Benefits of Trench 9 Automotive

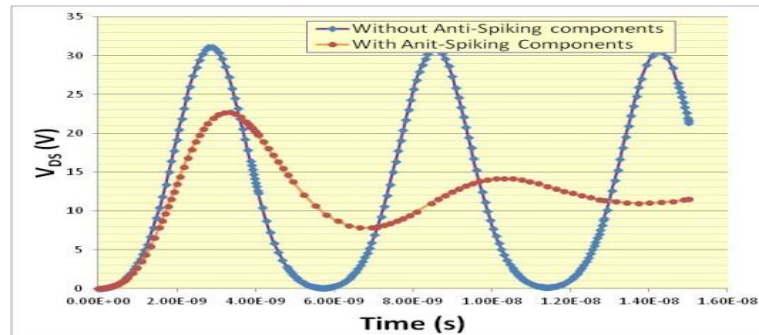
UP TO 30% IMPROVEMENT RDSON PERFORMANCE



INCREASED COMPETITIVENESS – FOOTPRINT REDUCTION



SOFT SWITCHING FOR IMPROVED EMC



BROAD PORTFOLIO

Automotive MOSFETs

Overview Products

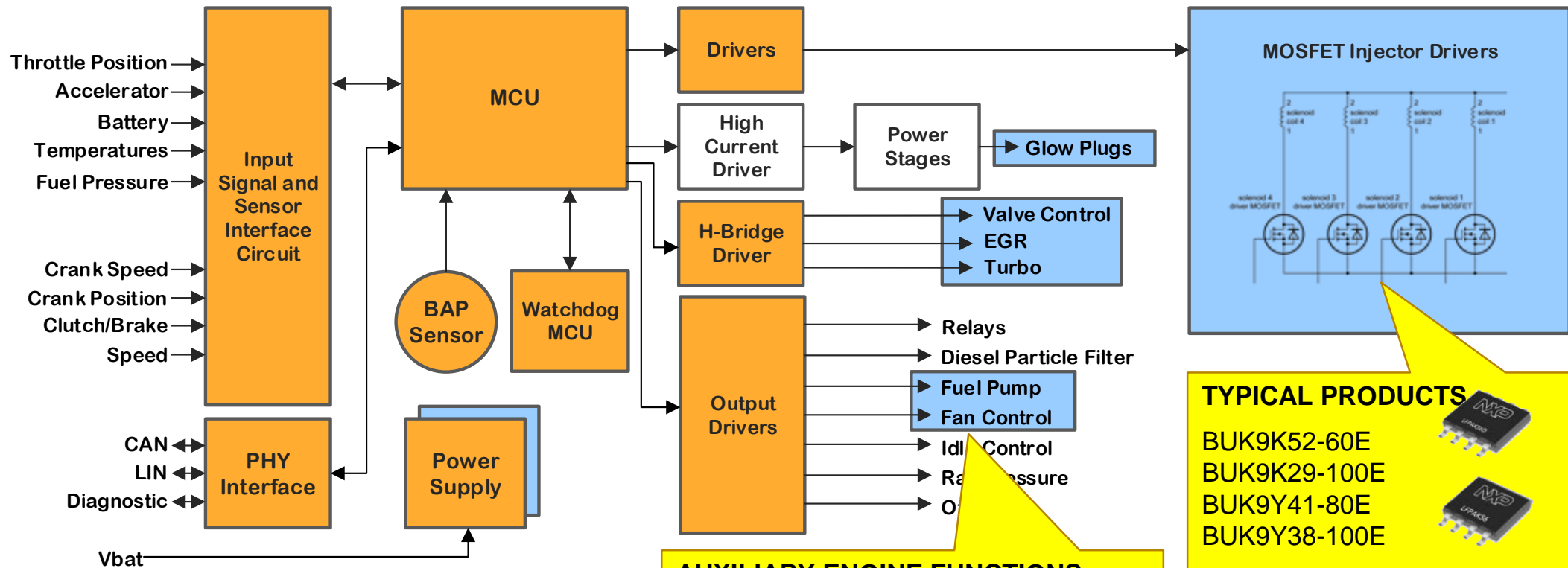
Download XLS Download PDF Email Link

| Products/Parts | Order | Package version | Package name | Product status | Channel type |
|----------------------------------|--------------------------------------|---------------------------------|--------------------------------------|--|------------------------------|
| 470 | | | | | |
| Show/Hide Parameters (13 Hidden) | <input type="checkbox"/> Distributor | <input type="checkbox"/> SOT23 | <input type="checkbox"/> D2PAK | <input type="checkbox"/> Not for design in | <input type="checkbox"/> N |
| Reset Filters | | <input type="checkbox"/> SOT78A | <input type="checkbox"/> D2PAK-7 | <input type="checkbox"/> Production | <input type="checkbox"/> N/P |
| Compare Selected | | <input type="checkbox"/> SOT223 | <input type="checkbox"/> DFN1006-3 | | <input type="checkbox"/> P |
| | | <input type="checkbox"/> SOT226 | <input type="checkbox"/> DFN2020MD-6 | | |

SYSTEM SOLUTIONS



Diesel Engine Management



AUXILIARY ENGINE FUNCTIONS
 Multiple opportunities for MOSFETs in support of a growing number of auxiliary functions under full electric control

TYPICAL PRODUCTS

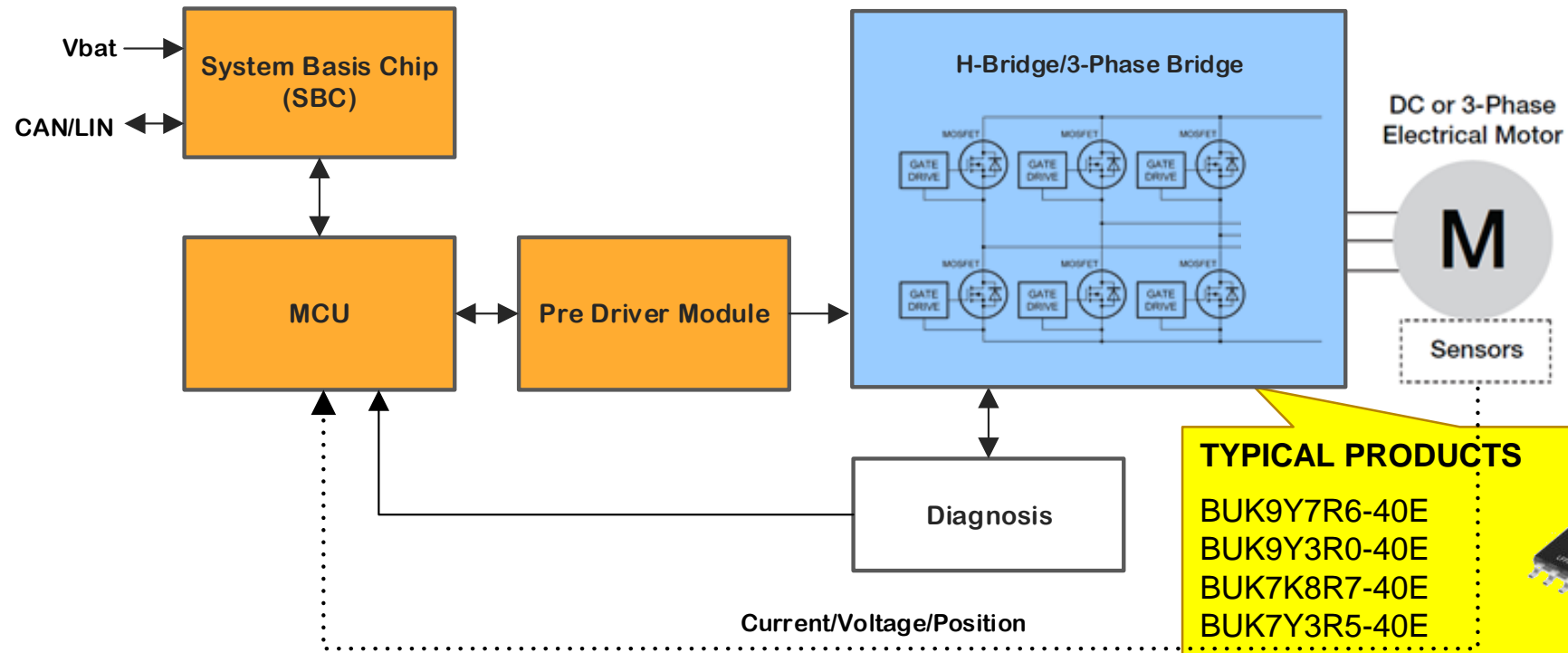
- BUK9K52-60E
- BUK9K29-100E
- BUK9Y41-80E
- BUK9Y38-100E

LFPAC products fit perfectly into engine management systems offering space saving and high reliability

Legacy Freescale NXP Power MOSFET Technology




Electric Pumps, Motor Control and Auxiliaries



TYPICAL PRODUCTS

- BUK9Y7R6-40E
- BUK9Y3R0-40E
- BUK7K8R7-40E
- BUK7Y3R5-40E

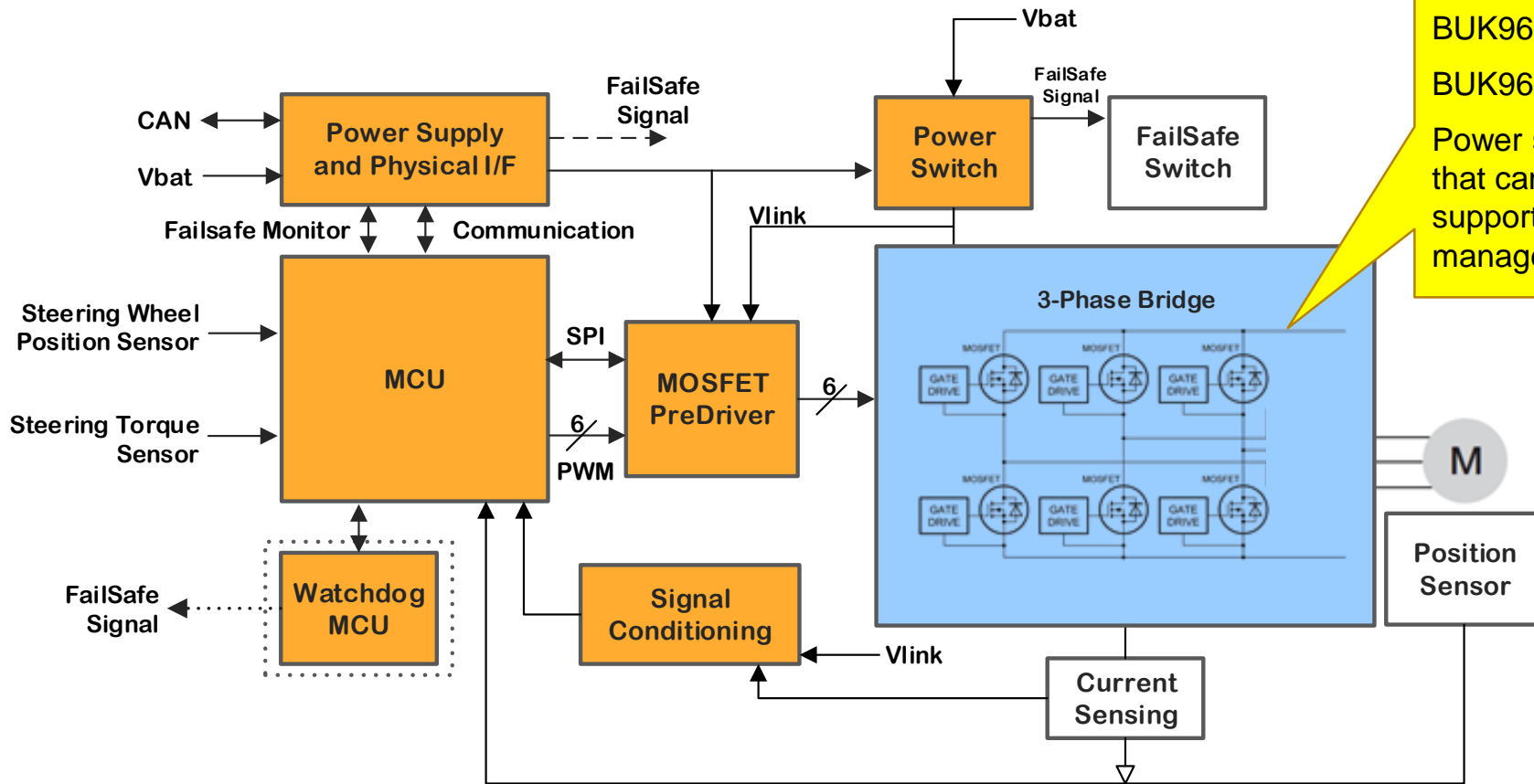


40V Power MOSFETS in LFPAK56 offer a perfect fit over a range of power requirements. The broad portfolio allows for commercial optimisation to fit multiple applications.

Legacy Freescale
 NXP Power MOSFET Technology



Electric Power Steering (EPS)

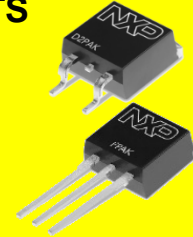


TYPICAL PRODUCTS

BUK7E1R9-40E

BUK962R0-40E

BUK961R7-40E



Power steering requires products that can handle high power and support sophisticated thermal management strategies

 Legacy Freescale

 NXP Power MOSFET Technology

TOOLS AND INFO



Tools – NXP PowerMOS on the Web

- Full parametric search
- Datasheets
- Application notes
- Device models
- Footprint and package data
- Samples

The screenshot shows the NXP website's product selector for Automotive MOSFETs. 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 'Automotive MOSFETs' and includes a 'Products' tab. A sidebar on the left lists various product categories, with 'Automotive MOSFETs' selected. The main content area displays a table of products with columns for 'Products/Parts', 'Order', 'Package version', 'Package name', 'Product status', 'Channel type', and 'Number of transistors'. The table shows 84 of 415 products, with a 'Buy Options' button for each row. The table data is as follows:

| Products/Parts | Order | Package version | Package name | Product status | Channel type | Number of transistors |
|--|-----------------------------|-----------------|--------------------|----------------|--------------|-----------------------|
| <input type="checkbox"/> BUK7Y07-30B | Buy Options | SOT669 | LFPAK56; Power-SO8 | Production | N | 1 |
| <input type="checkbox"/> BUK7Y08-40B | Buy Options | SOT669 | LFPAK56; Power-SO8 | Production | N | 1 |
| <input type="checkbox"/> BUK7Y10-30B | Buy Options | SOT669 | LFPAK56; Power-SO8 | Production | N | 1 |
| <input type="checkbox"/> BUK7Y102-100B | Buy Options | SOT669 | LFPAK56; Power-SO8 | Production | N | 1 |
| <input type="checkbox"/> BUK7Y113-100E | Buy Options | SOT669 | LFPAK56; Power-SO8 | Production | N | 1 |
| <input type="checkbox"/> BUK7Y12-100E | Buy Options | SOT669 | LFPAK56; Power-SO8 | Production | N | 1 |
| <input type="checkbox"/> BUK7Y12-40E | Buy Options | SOT669 | LFPAK56; Power-SO8 | Production | N | 1 |

Application Notes

AN11599
Using power MOSFETs in parallel
Rev. 1 — 7 July 2015 Application note

AN11158
Understanding power MOSFET data sheet parameters
Rev. 4 — 4 February 2014 Application note

AN11156
Using Power MOSFET Z_{th} Curves
Rev. 1 — 28 September 2012 Application note

AN11261
Using RC Thermal Models
Rev. 2 — 19 May 2014 Application note

TN00008
Power MOSFET frequently asked questions and answers
Rev. 1 — 6 May 2015 Technical note

| Document information | |
|----------------------|--|
| Info | Content |
| Keywords | MOSFET, GEN 3, GEN 0 |
| Abstract | This document provides answers to frequently asked questions regarding automotive MOSFET platforms, devices functionality and reliability. It is also applicable to non-automotive applications. |

AN11160
Designing RC snubbers
Rev. 1 — 25 April 2012 Application note

AN11243
Failure signature of electrical overstress on power MOSFETs
Rev. 01 — 29 October 2012 Application note

AN10874
LFPK MOSFET thermal design guide
Rev. 02 — 27 January 2011 Application note

AN11113
LFPK MOSFET thermal design guide - Part 2
Rev. 2 — 16 November 2011 Application note

| Document information | |
|----------------------|--|
| Info | Content |
| Keywords | LFPK, MOSFET, thermal analysis, design and performance, thermal considerations, thermal resistance, thermal vias, SMD, surface-mount, PCB design, enclosure, bottom-side cooling, top-side cooling |
| Abstract | Thermal aspects are an important concern when designing for power MOSFETs. Part 1 of this design guide (AN10874) describes the impact of various PCB and device configurations on thermal behavior in free air and at 20 °C ambient temperature. Part 2 discusses how the construction and configuration of an enclosure influences the operating temperatures of the power MOSFET devices within. |

Brochures and Ruler



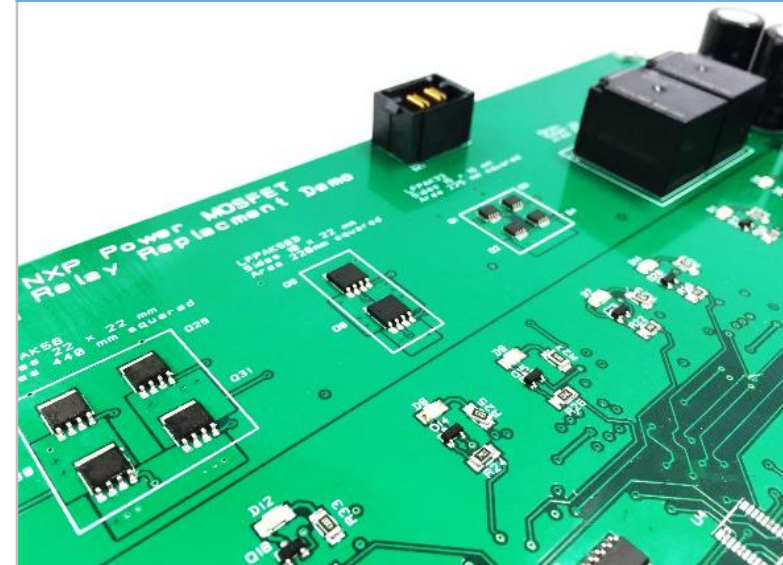
Demonstrator Boards

Injector Demo



The injector demonstrator shows the impressive thermal performance of the LFPAK packages when compared to the larger DPAK package. The injector demo MOSFET boards have been updated to include LFPAK33.

Relay Replacement



The relay replacement demo is aimed at demonstrating how large relays, typically used for driving motors in body control applications, can be replaced with small MOSFETs in LFPAK56, LFPAK56D and LFPAK33



SECURE CONNECTIONS
FOR A SMARTER WORLD

ATTRIBUTION STATEMENT

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