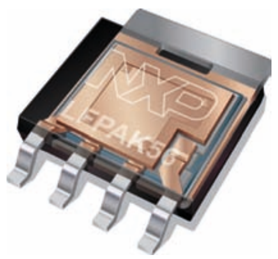
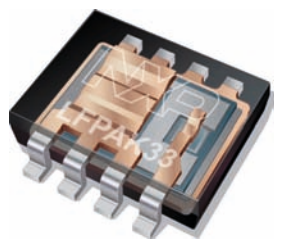

# Ultra-reliable LFPAK56 and LFPAK33

Tougher just got smaller

# NXP's LFPAK – Designed for reliability

Designing a complex automotive system, a high efficiency industrial power supply or a slimline portable PC? NXP has a range of smaller, faster, cooler MOSFETs to help you deliver maximum reliability.




Since 1999, NXP has led the way with LFPAK, our ground-breaking solution for high reliability, high performance MOSFETs in a variety of commercial, industrial and automotive applications.

The first products were in the Power-SO8 compatible LFPAK56, developed as a 'true' power package. Design and construction were optimized to give the best thermal and electrical performance, cost and reliability.

As industries trend toward miniaturization, LFPAK is still the answer and our LFPAK33 is the ideal solution for the popular 3.3 x 3.3 mm outline footprint.

**Thermal Performance**

- No wires, no glue
- 175 °C Tj max

**Electrical performance**

- Low package resistance and inductance
- Current handling up to 100 A

**Cost**

- Fewer manufacturing steps means cost-effective, high volume production

**Mechanical robustness**

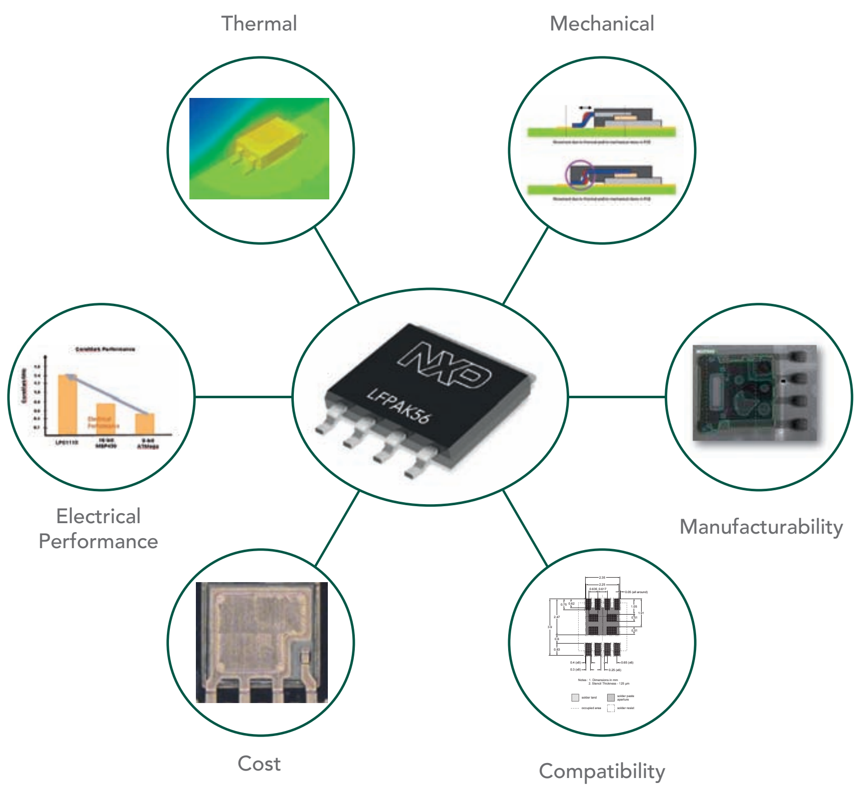
- Exposed leads absorb thermal and mechanical stresses

**Manufacturability**

- Easy optical inspection of solder joints
- Low package height
- Wave solderable (LFPAK56)

**Compatibility**

- 100% compatible with industry-standard footprints



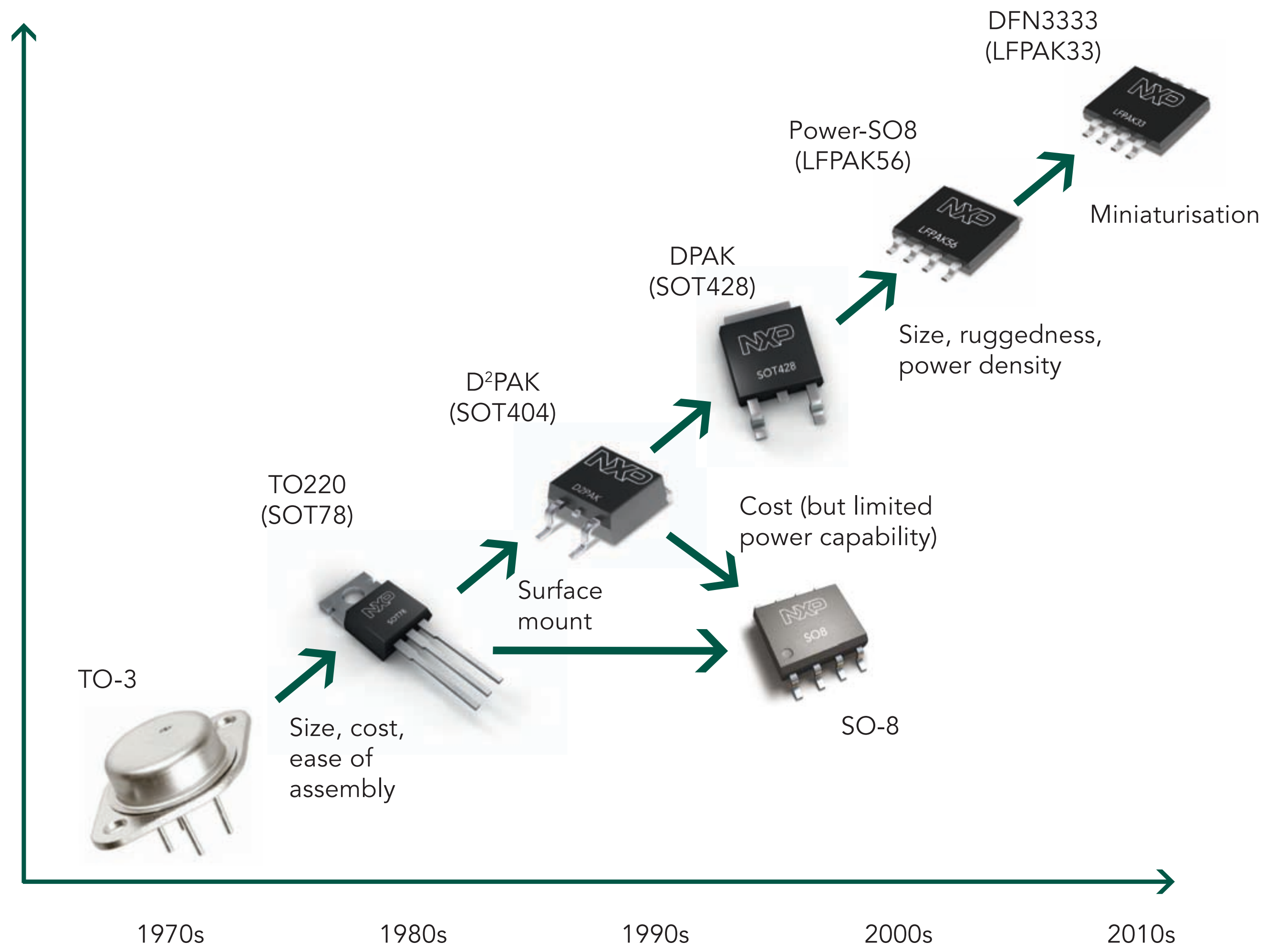

# MOSFET package evolution

MOSFET packaging technology has changed enormously over the last 40 years in line with ever increasing demands for smaller, more capable electronic devices.

The first TO220 device was introduced in the 1980s, providing a package that was smaller, less expensive and easier to assemble than its predecessors. With the rise of surface mount technology towards the end of the decade, a new leadframe was developed and the D2PAK was born.

The industry then split in two. Some manufacturers preferred the lower cost but more limited options afforded by high volume IC packages such as the SO8. Others simply shrank the D2PAK in size and developed the DPAK.

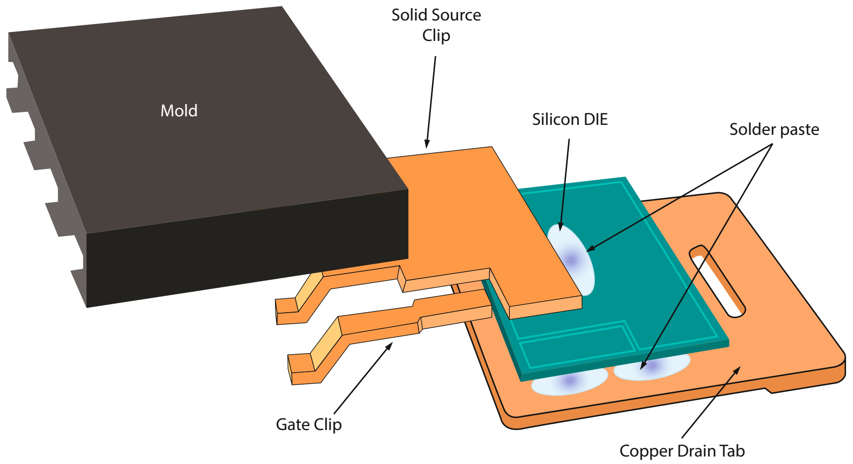
At the turn of the century NXP introduced the LFPAK56, which has similar dimensions to an SO8 but was specifically designed to deliver maximum performance in power applications. Such was its success that it became the first Power-SO8 package to achieve AEC Q101 qualification. Building on this heritage, NXP has now introduced a miniaturized version, the LFPAK33.



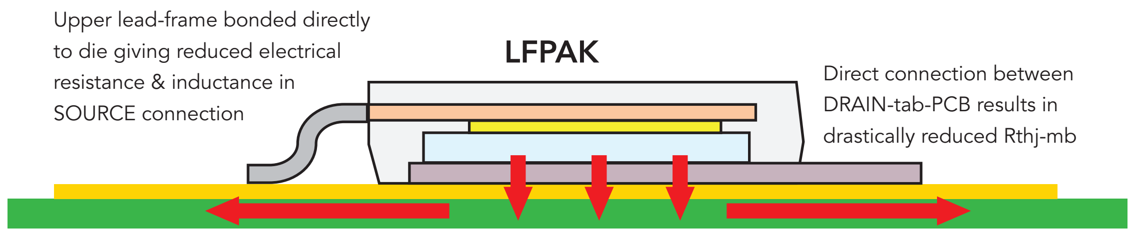
# LFPAK rugged construction

**Innovative clip-bonding**

The silicon die is soldered to the drain tab forming the electrical drain connection. Then the top-clip is soldered to the silicon die to provide source and gate connections, eliminating bond wires and reducing package resistance and inductance.




The drain tab is soldered directly to the PCB to provide a low electrical resistance path and also low thermal resistance between the MOSFET and the PCB.



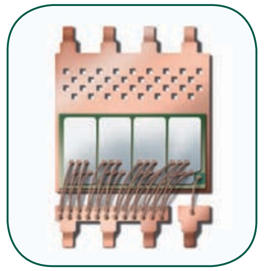

**MOSFET assembly techniques**

Compare the LFPAK with competitor Power-SO8 types which are often constructed using wire bonding as shown right. LFPAK uses a combined copper clip which is soldered in a single operation to the gate and source. This reduces spreading resistance, and gives LFPAK superior electrical and thermal characteristics as well as increased reliability.

LFPAK eliminates wire-bonding used in many competitor devices.
The combined gate and source clip with soldered die-attach delivers:

- maximum mechanical ruggedness and reliability
- lowest electrical resistance
- lowest thermal resistance
- simplified manufacturing process

Cu wire-bonding



# Resilient to mechanical and thermal stress

Customer feedback consistently shows that LFPAK is more reliable and rugged than competitor QFN and other micro-lead devices. The LFPAK56 meets full automotive qualification (AEC Q101), clear proof of its superior ruggedness and reliability in the toughest conditions.

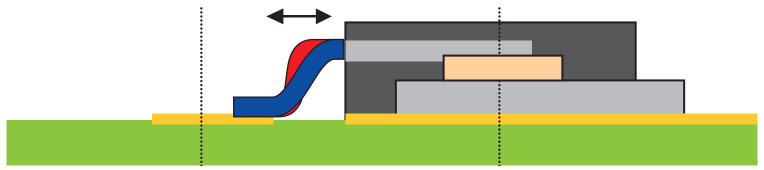
The following diagram shows the mechanical stresses that can occur when a device is rapidly heated and cooled. Different rates of expansion and contraction of the PCB and the MOSFET package can cause cracking of the MOSFET moulding as well as solder joint failures on a QFN device. LFPAK's construction allows the gate and source pins to 'flex' and safely absorb these stresses.

Solder joint inspection of QFN & micro-lead devices often requires costly X-ray analysis and specialist SMT rework equipment. LFPAK solder joints can be visually inspected and, if necessary, it is possible to rework an LFPAK device using simple, low-cost tools.

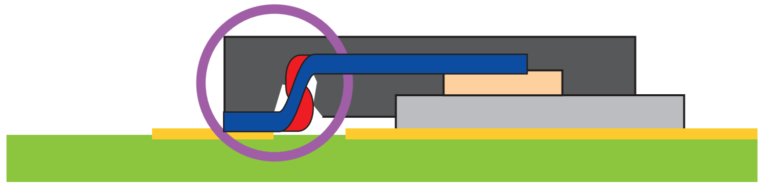
Mechanical stresses occur when a SMT device is subject to rapid temperature change or if the PCB bends due to mechanical strain or vibration.

The LFPAK's exposed lead-frame provides compliance and allows for movement caused by thermal expansion and mechanical strain.

QFN sawn & micro-lead packages are fully encapsulated and do not allow for movement due to thermal expansion or mechanical strain. Mechanical & thermal stresses can lead to solder-joint failures
Cracking can also occur in the mould material around the pins which can lead to moisture ingress & ionic contamination, causing degradation and early failure of the MOSFET.



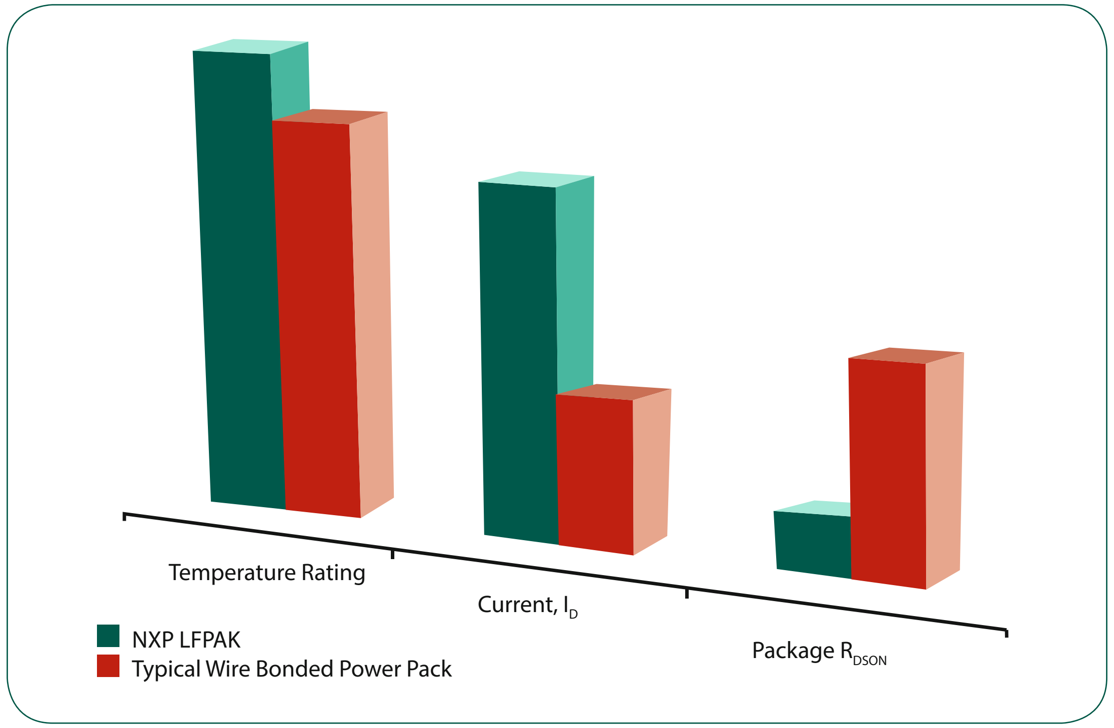
Movement due to thermal and/or mechanical stress in PCB



Movement due to thermal and/or mechanical stress in PCB

# Superior thermal and electrical performance

The LFPAK was developed as a true power package. Package design has been optimized for thermal and electrical performance, cost and reliability.




**LFPAK summary**

| Parameter | LFPAK56 * | LFPAK33 ** |
|---|---|---|
| Junction temperature | 175 °C | 175 °C |
| $I_D$ (max) | 100 A | 70 A |
| Rth (j-c) typ / (max) | 0.40 K/W (0.45) | 1.44 K/W (1.65) |
| Maximum power dissipation | 137 W | 91 W |
| SOA ($I_D$ at 10 V / 100 μs) | 325 A | 105 A |
| $R_{DSon}$ (typ, at $V_{GS}$ = 10 V) | 0.75 mΩ | 2.45 mΩ |
| Height | 1.0 mm | 0.85 mm |
| External leads for optical inspection and reduced stress | √ | √ |
| Industry standard footprint | √ | √ |

* Based on PSMN0R9-25YLC
** Based on PSMN2R9-30MLC

# Manufacturing and quality

High volume electronics manufacturing environments make use of sophisticated optical inspection equipment to monitor the quality of their output. Solder joints in particular, are subject to stringent rules and manufacturing results are continuously fed back into the process control system.

The fully encapsulated nature of QFN and DFN type devices mean that only part of the solder joint is visible without the use of expensive X-ray equipment. In contrast, the exposed leads of LFPAK are available for detailed solder joint inspection and assessment.

**LFPAK56 – Automotive Qualified**

NXP Automotive Power MOSFETs are commonly deployed in many critical applications such as braking, power steering and engine management, where quality and reliability requirements are paramount.

The LFPAK56's copper source clip design overcomes the limitations of SO8 and Power-SO8 packages and has been fully qualified to the stringent AEC Q101 standard for discrete devices.

## LFPAK56 (SOT669) soldering and footprint compatibility

There are many power MOSFETs available in the Power-SO8 family. However as there is no generic JEDEC standard for Power-SO8 devices, each device generally has a different PCB footprint. None of the manufacturers' devices are guaranteed to be interchangeable with other devices.

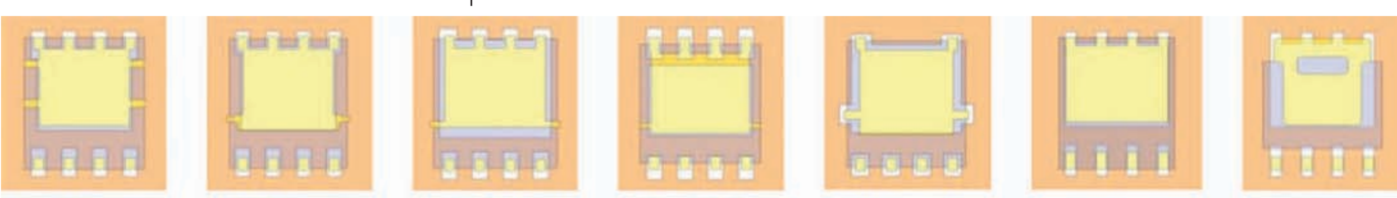
The following diagram shows that the package styles and recommended PCB footprints differ significantly from each manufacturer.

| Fairchild Power 56 | Vishay PowerPak SO8 | Infineon Super SO8 | NEC HVSON-8 | ON Semi DFN6 | STM PowerFlat 6x5 | **NXP LFPAK** |
|---|---|---|---|---|---|---|



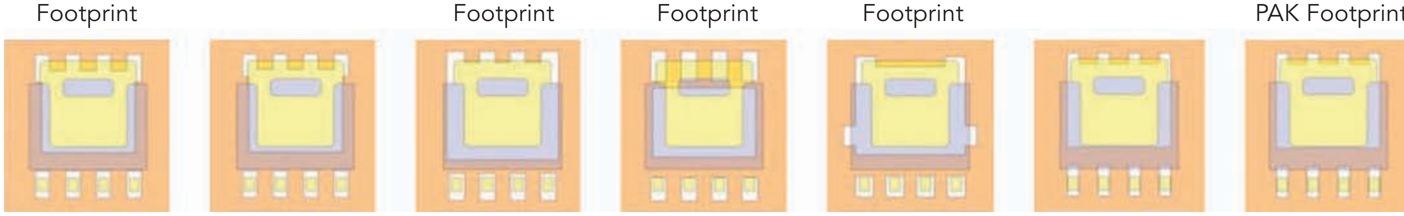
NXP's LFPAK56 (SOT669 & SOT1023) does achieve electrical and mechanical compatibility with these Power-SO8 types. Each variant may require a different solder-resist, solder-stencil and machine programming unless careful consideration has been made in advance to design a universal footprint which will allow multiple devices to be fitted to the PCB. The following diagram shows each manufacturer's original footprint with their Power-SO8 mounted on it.

| Fairchild Power 56 | Vishay PowerPak SO8 | Infineon Super SO8 | NEC HVSON-8 | ON Semi DFN6 | STM PowerFlat | **Renesas LFPAK** |
|---|---|---|---|---|---|---|



The diagram below shows the manufacturers footprint with an LFPAK56 mounted. This shows how it is possible to fit an LFPAK56 packaged product instead of a competitor device.

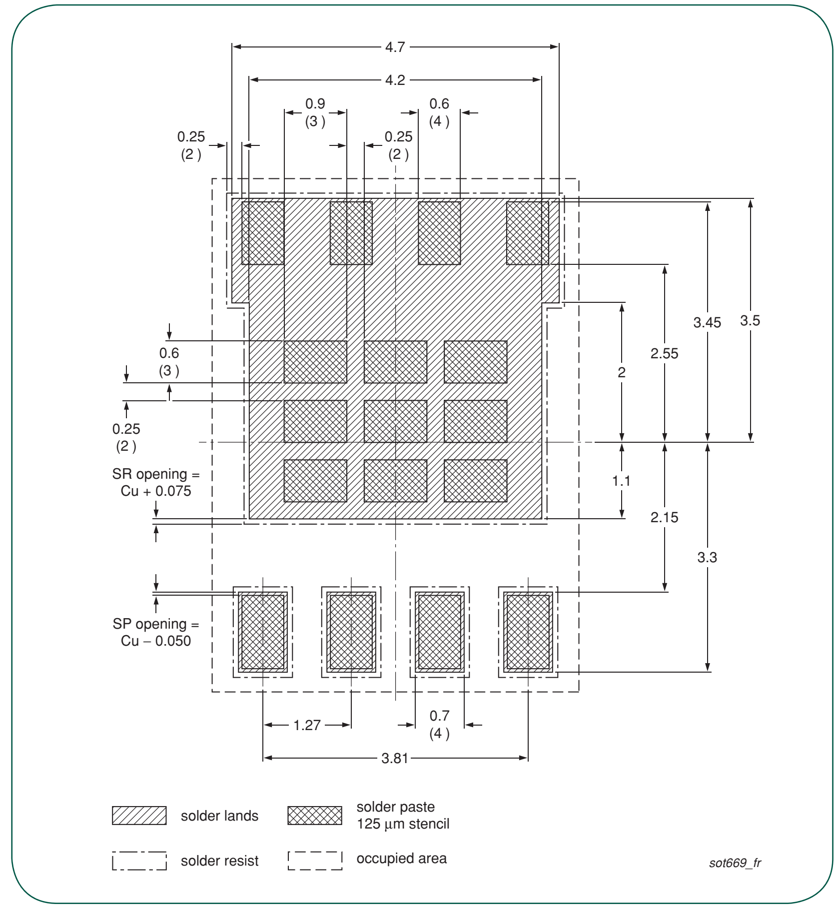
| LFPAK56 on Fairchild Footprint | LFPAK56 on Vishay Footprint | LFPAK56 on Infineon Footprint | LFPAK56 on Renesas Footprint | LFPAK56 on On-Semi Footprint | LFPAK56 on FST Footprint | LFPAK56 on Renesas LF-PAK Footprint |
|---|---|---|---|---|---|---|



Comprehensive study reports are available on request for LFPAK56 and LFPAK33 packages showing more detailed proof of compatibility with competitor footprints.

## LFPAK56 universal footprint design

Through careful design of the PCB footprint, it is possible to design a universal footprint, such as the one shown below, that meets the requirements of various Power-SO8 manufacturers. This universal footprint example shows the solder resist and solder stencil details that allow a PCB designer to create a footprint compatible the majority of Power-SO8 types.




**Universal footprint for reflow soldering**

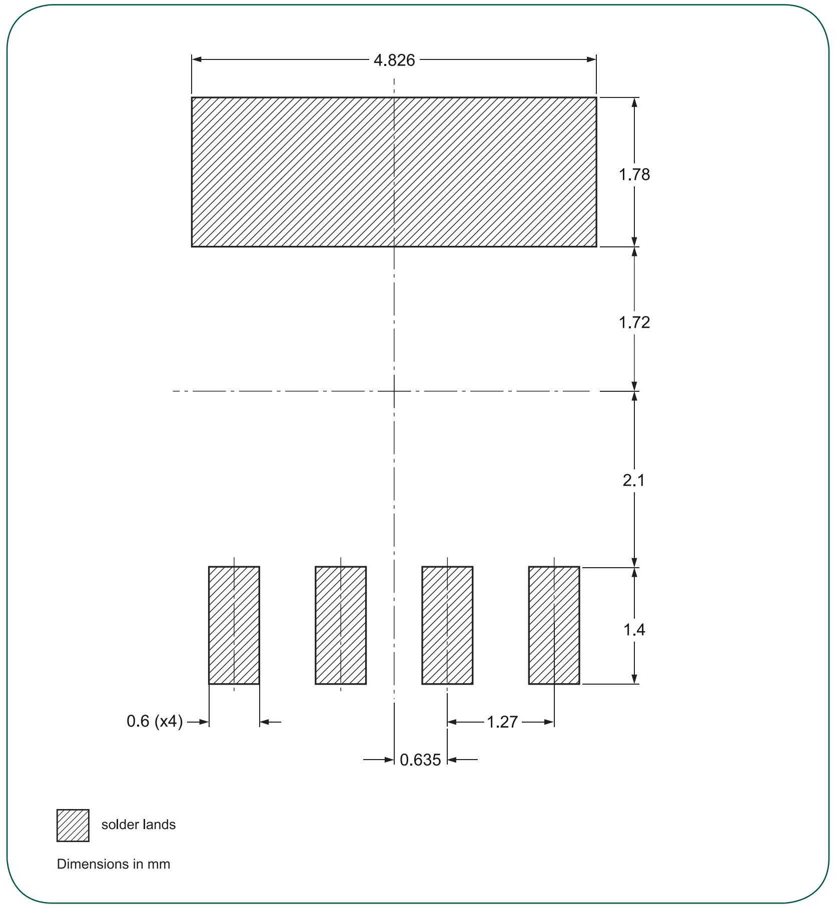
Recommended universal Power-SO8 and LFPAK footprint allows the following device types to be mounted to a single PCB design:

- NXP LFPAK (SOT669 & SOT1023)
- Infineon PG-TDSON-8
- Fairchild Power 56
- Vishay PowerPAK SO-8
- NEC 8-pin HVSON
- ON Semi SO−8 FL
- STM PowerFLAT (6x5)
- Renesas LFPAK

The original document can be downloaded at:
http://www.nxp.com/documents/reflow_soldering/sot669_fr.pdf

# LFPAK56 Wave Soldering

Due to its exposed, gull-wing leads, LFPAK56 is the only Power-S08 package that can be wave soldered.
The wave soldering footprint can be downloaded at: http://www.nxp.com/documents/wave_soldering/sot669_fw.pdf

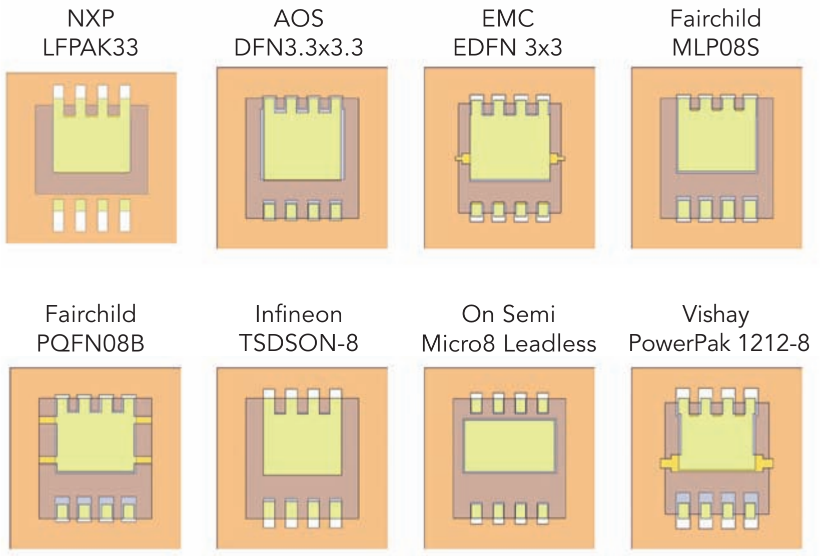



NXP has worked with an independent consultancy to determine a recommended wave soldering process and associated parameters. This document is available upon request.

# LFPAK33 (SOT1210) soldering and footprint compatibility

**3.3 x 3.3 mm PCB footprints with package mounted**

Through careful design of the PCB footprint, it is possible to design a universal footprint, such as the one shown below, that meets the requirements of various Power-SO8 manufacturers. This universal footprint example shows the solder resist and solder stencil details that allow a PCB designer to create a footprint compatible the majority of Power-SO8 types.



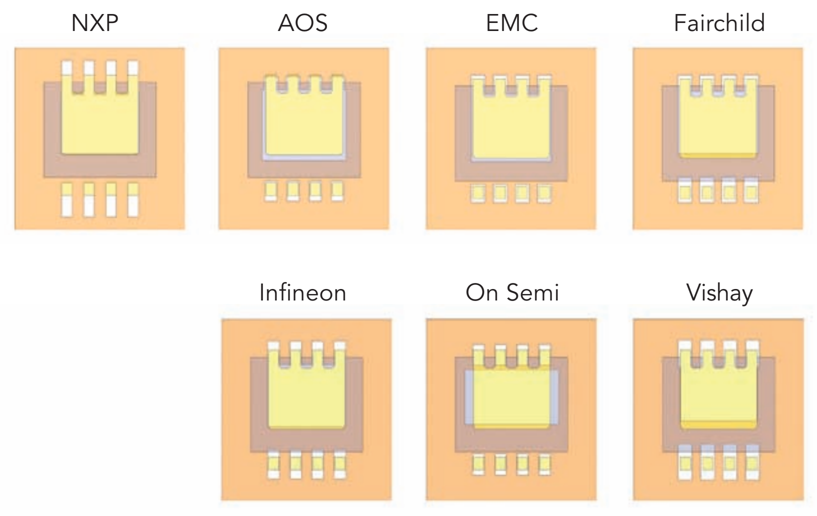

An independent study has been performed by Norcott Technologies (www.norcott.co.uk) to check compatibility:

- Placement of competitors on NXP universal SOT1210 footprint
- Placement of SOT1210 package on competitor footprints

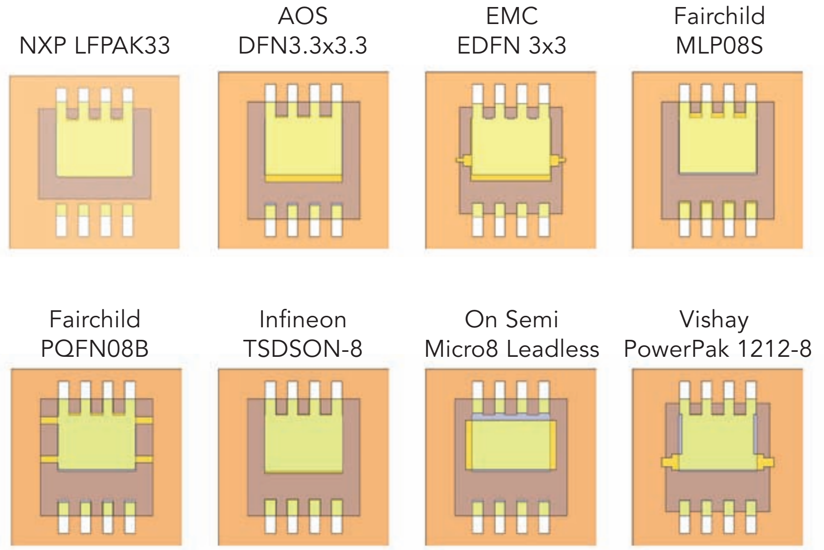
The conclusion of the study is that LFPAK33 is compatible in both scenarios above. The report is available upon request.

# LFPAK33 Soldering & Footprint Compatibility

**NXP LFPAK33 on competitors' 3.3x3.3 package footprints**




**Competitors' 3.3x3.3 package on NXP LFPAK33 footprint**

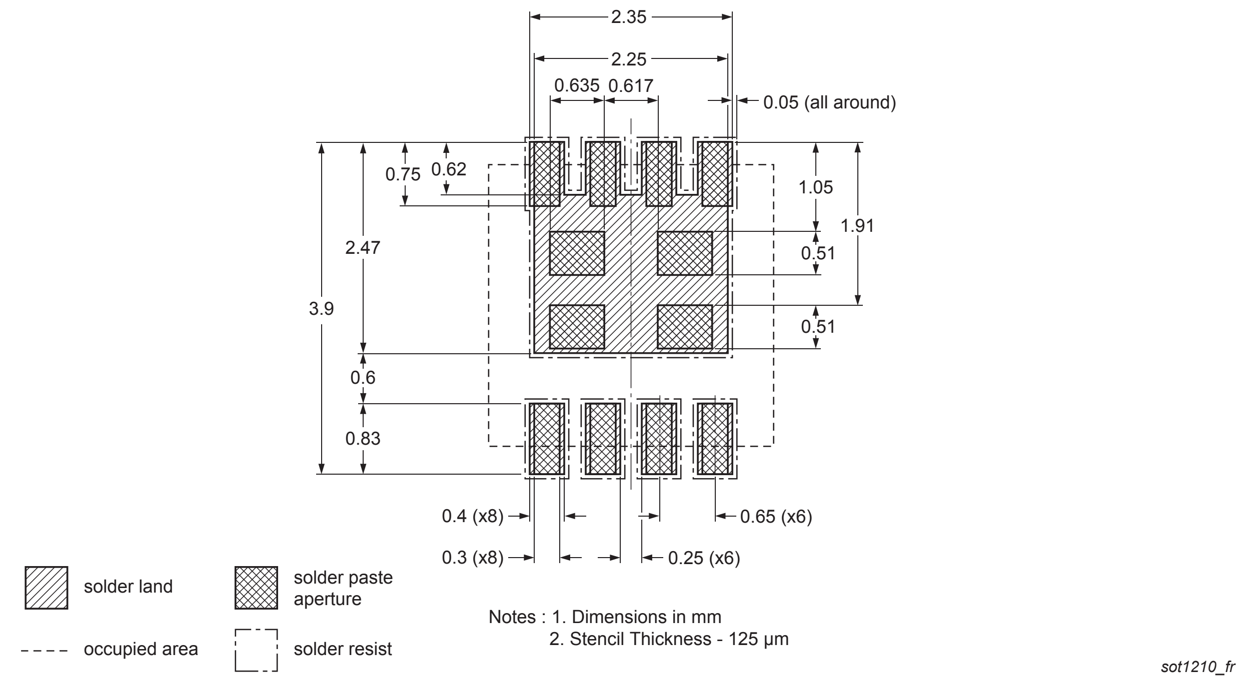



# LFPAK33 universal footprint design

The LFPAK33 footprint allows for one PCB design to accommodate:

- NXP - LFPAK33 (SOT1210)
- NXP - DFN3333-8 (SOT873)
- Fairchild - MLP 3.3x3.3
- Vishay - POWERPAK® 1212-8
- Infineon - PG-TSDSON-8 3.3x3.3
- ON SEMI - WDFN8 3.3x3.3
- STM - POWERFlat® 3.3x3.3
- IR - PQFN 3x3

Other manufacturers' devices may also  be  compatible, but have not been verified by this trial.

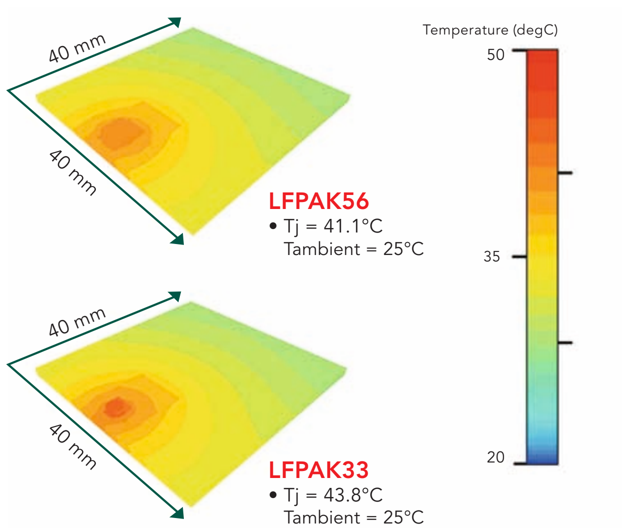


# Two sizes – One performance

LFPAK's unique construction means that miniaturization does not require a compromise on performance. Thermal simulations show that LFPAK33 can replace LFPAK56 in a typical application with only a small resultant temperature rise in the silicon.

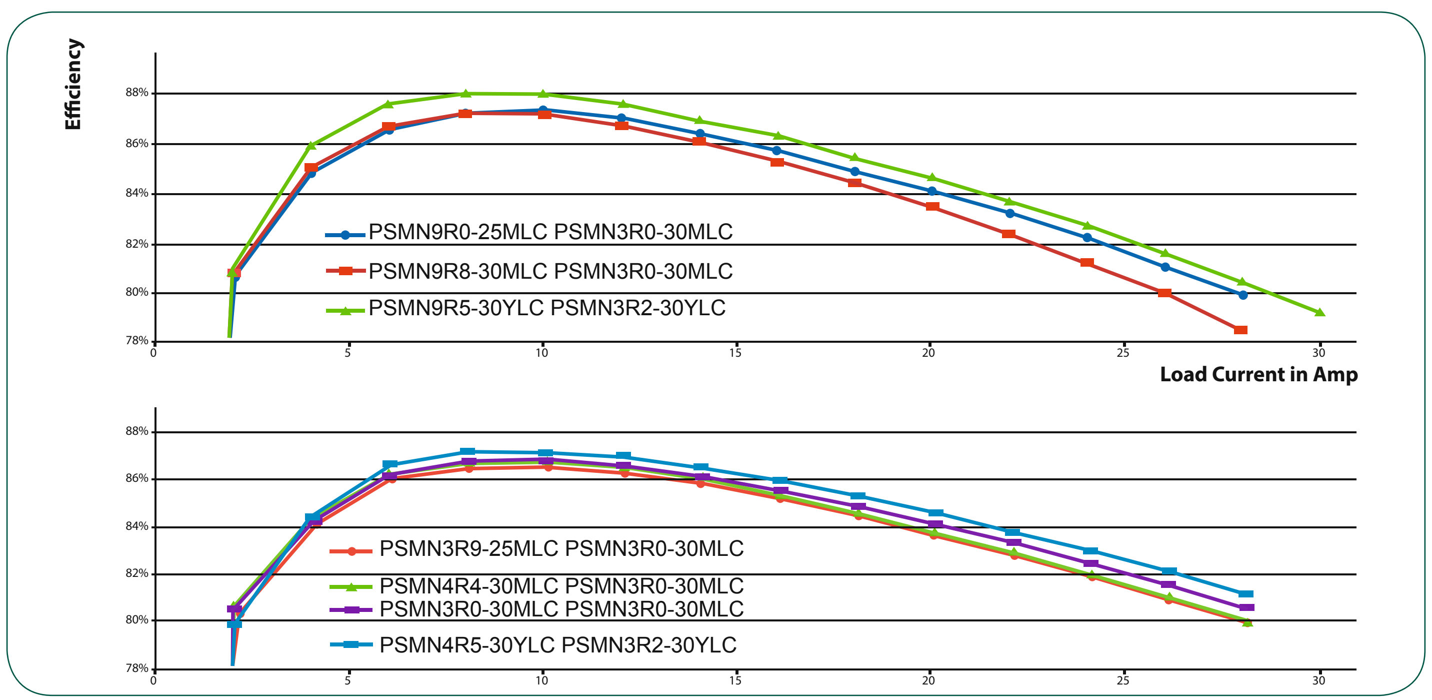
The following images show relative junction temperatures when the MOSFET is mounted on a 10 x 10 mm copper pad, with power dissipation of 0.5 W in the MOSFET.

The PCB's stack-up and copper pad dimensions remain as the dominant factor for system thermal resistance.




**Efficiency – LFPAK33 versus LFPAK56**

Where space is at a premium, LFPAK33 offers similar efficiency to the LFPAK56.




# How to order standard MOSFETs

| Prefix | | | N-channel | $R_{DSon}$ with Vgs = 10 V | | | - | $B_{VDSS\ Voltage}$ | | | Package Type | Gate threshold voltage | Technology family |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | S | M | N | 4 | R | 0 | - | | 3 | 0 | Y | L | D |
| | | | **N** = N-ch | **R95** = 0.95mΩ | | | - | **25** = 25 V | | | **B** = D²PAK | **L** = Logic-level (16 V Vgs) | **C** = NextPower |
| | | | | **4R0** = 4.0mΩ | | | - | **30** = 30 V | | | **D** = DPAK | **S** = Standard-level (<20 V Vgs) | **D** = NextPowerS3 |
| | | | | **014** = 14mΩ | | | - | **40** = 40 V | | | **E** = I²PAK | | **E** = NextPower Live |
| | | | | **125** = 125mΩ | | | - | **60** = 60 V | | | **K** = SO8 | | |
| Power Silicon Max | | | | | | | - | **80** = 80 V | | | **M = LFPAK33** | | |
| | | | | | | | - | **100** = 100 V | | | **N** = QFN2020 | | |
| | | | | | | | - | **110** = 110 V | | | **P** = TO220 | | |
| | | | | | | | - | **120** = 120 V | | | **X** = TO220F (FULLPACK) | | |
| | | | | | | | - | **150** = 150 V | | | **Y = LFPAK56** | | |
| | | | | | | | - | **200** = 200 V | | | | | |

# How to order automotive MOSFETs

| Prefix | | | Gate threshold voltage | Package Type | MOSFET on-resistance $R_{DSon}$ | | | - | $B_{VDSS\ Voltage}$ | | | Trench Generation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | U | K | 7 | Y | 7 | R | 6 | - | | 4 | 0 | E |
| | | | **7** = Standard Level | **M = LFPAK33 SOT1210** | 7R6 = 7.6mΩ | | | - | **30** = 30 V | | | A = Generation 2 |
| | | | **6** = Intermediate Level | **Y =LFPAK56 SOT669** | 12 = 12mΩ | | | - | **40** = 40 V | | | B = Generation 3 |
| | | | **9** = Logic Level | **K = LFPAK56D SOT1205** | 150 = 150mΩ | | | - | **55** = 55 V | | | C = Generation 4 |
| | | | | **8** = SOT223 | | | | - | **60** = 60 V | | | E = Generation 6 |
| NXP Automotive MOSFET | | | | **2** = DPAK SOT428 | | | | - | **75** = 75 V | | | |
| | | | | **6** = D2PAK SOT404 | | | | - | **80** = 80 V | | | |
| | | | | **E** = I²PAK SOT226 | | | | - | **100** = 100 V | | | |
| | | | | **5** = TO220 SOT78 | | | | - | **150** = 150 V | | | |

# Available Resources

Internet - www.nxp.com/mosfets

- Only two clicks to any MOSFET product information
- On-line cross references
- Datasheets
- Spice models, for non-NXP simulation tools
- Thermal models
- Chemical content
- Application notes
- Thermal design guides
- YouTube videos

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