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#### **Automotive ASFETs for Repetitive Avalanche**

How to maintain reliability and performance in Automotive Applications using repetitive avalanche MOSFETs

September 2021

# Introduction

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#### **Automotive ASFETs for Repetitive Avalanche**

Maintaining reliability and performance in solenoid drives

- What is avalanche?
- Application fit & Portfolio
- Enhanced datasheets
- Worked examples
- Design in support tools

#### What is Avalanche?

# **Avalanching a MOSFET**

How does the circuit work?



## **Avalanche Definitions**

Nexperia have an offering to cover both single shot and repetitive events

#### Single Shot avalanche:

- A random occurrence of an over voltage transient (fault condition)
- Possibly the result of a failure within the application
- Low frequency of occurrence during the MOSFET's lifetime



#### Repetitive avalanche:

- The avalanche event has been designed into the application
- The MOSFET can be expected to go into avalanche on a regular basis for numerous cycles



## **Application Fit & Portfolio**

## **Solenoid control**

Multiple circuit topologies to control solenoids (actuators)



- Most efficient
- High cost and complexity



- Lowest efficiency
- Lower cost and complexity



- More efficient vs Freewheel
- Timing critical to ensure within MOSFET SOA



- Similar efficiency to active clamp
- Simplest design
- Lower BOM cost
- Smaller module

\*typical profiles are 1bn cycles for fuel injection and <100M for others

## **Application Fit**

Repetitive Avalanche MOSFETs



## **Repetitive Avalanche MOSFETs**

Portfolio value proposition



Silicon Technology	Performance	No of Types	40V	60V
Repetitive Avalanche rugged	$R_{DS(on)}$ max [m $\Omega$ ]	4	25	13 - 52

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#### **Enhanced Datasheets**

#### **Typical MOSFET Datasheet** BUK764R0-55B

- All Automotive MOSFET datasheets contain single shot avalanche curve
- Graph contains single shot capability for  $T_j = 150^{\circ}$ C and  $T_j = 25^{\circ}$ C
- Graph also includes repetitive avalanche capability
- Based on using 5K temperature rise and significantly de-rated



Single-shot (initial T<sub>j</sub> = 25 °C and 150 °C) and repetitive (Rep. Ava) avalanche ruggedness SOAR curves of BUK764R0-55B limited to a  $T_{j(max)}$  of 175 °C and  $T_{j(avg)}$  of 170 °C, respectively

## **Repetitive Avalanche MOSFETs**

Enhanced datasheets

Based on  $T_j$  rise of 30°C (previously 5°C)

- Stay within (under) repetitive avalanche Safe Operating Area curve
- 2. Stay within (under) cycle limit
- 3. Stay below 175°C T<sub>j</sub> max



## **Repetitive Avalanche MOSFETs**

Enhanced MOSFET datasheets

- As part of repetitive avalanche functions there is a penalty in terms of  $R_{DS(on)}$
- At 10% of intended number of avalanche cycles  $R_{DS(on)}$  will increase by ~25%
- By device failure there will be 45% increase in  $R_{DS(on)}$



#### **Worked Examples**

## **Repetitive Avalanche in Solenoid Drives**

• Avalanche mode of operation appears during turn off



# **Designing in RA MOSFETs – Fuel Injection**

Example A solenoid drive



# **Designing in RA MOSFETs**

Example B ABS valves



# **Thermal Simulation**

- Thermal simulation link in description
- PartQuest: New tool to adapt to customer application
- Voltage source to guide current reference
- MOSFETS selectable from list or implemented from Nexperia website
- Cauer model of MOSFETs available on request or online
- Cauer model of PCB to be supplied by costumer



#### Materials

# **Available online content**

Please visit <u>Nexperia.com/asfets</u>

#### News and blogs



Videos

Press release Dec 9, 2020 Rugged AEC-Q101 MOSFETs from Nexperia offer ...



Blog article Dec 7, 2020 How to save space, reduce component count and ...



#### Interactive application notes

IAN50003 - Driving solenoids in automotive applications

#### Datasheets

#### Explande dive current marginaria Reschilde schemet Reschilde scheme

Quick Learning: how to select a power MOSFET for your ...



Quick Learning: four ways to control automotive ...



Quick Learning: Single shot avalanche ruggedness of MOSFETs



#### **BUK9K13-60RA**

Dual N-channel 60 V, 12.5 mOhm logic level MOSFET in LFPAK56D using Repetitive Avalanche technology 2 December 2020 Product data sheet

#### 1. General description

Dual, logic level N-channel MOSFET in an LFPAK56D package, using Application Specific (ASFET) repetitive avalanche silicon technology. This product has been designed and qualified to AEC-Q101 for use in repetitive avalanche applications.

#### 2. Features and benefits

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# Please share your questions and insights



#### EFFICIENCY WINS.