1. General description

Logic level N-channel MOSFET in an LFPAK33 (Power33) package using TrenchMOS technology. This product has been designed and qualified to AEC Q101 standard for use in high performance automotive applications.

2. Features and benefits

- Q101 compliant
- Repetitive avalanche rated
- Suitable for thermally demanding environments due to 175 °C rating
- True logic level gate with $V_{GS(th)}$ rating of greater than 0.5 V at 175 °C

3. Applications

- 12 V automotive systems
- Motors, lamps and solenoid control
- Transmission control
- Ultra high performance power switching

4. Quick reference data

<table>
<thead>
<tr>
<th>Table 1. Quick reference data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Symbol</strong></td>
</tr>
<tr>
<td>$V_{DS}$</td>
</tr>
<tr>
<td>$I_D$</td>
</tr>
<tr>
<td>$P_{tot}$</td>
</tr>
</tbody>
</table>

**Static characteristics**

| $R_{DSon}$ | drain-source on-state resistance | $V_{GS} = 5 \, \mathrm{V}; I_D = 5 \, \mathrm{A}; T_j = 25 \, ^{\circ}\mathrm{C}; \text{Fig. 11}$ | - | 34 | 42 | mΩ |

**Dynamic characteristics**

| $Q_{GD}$ | gate-drain charge | $I_D = 5 \, \mathrm{A}; V_{DS} = 48 \, \mathrm{V}; V_{GS} = 5 \, \mathrm{V}; T_j = 25 \, ^{\circ}\mathrm{C}; \text{Fig. 13}; \text{Fig. 14}$ | - | 3.4 | - | nC |
5. Pinning information

Table 2. Pinning information

<table>
<thead>
<tr>
<th>Pin</th>
<th>Symbol</th>
<th>Description mass</th>
<th>Simplified outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S</td>
<td>Source</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>S</td>
<td>Source</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>S</td>
<td>Source</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>G</td>
<td>Gate</td>
<td></td>
</tr>
<tr>
<td>mb</td>
<td>D</td>
<td>Mounting base; connected to drain</td>
<td>LFPAK33 (SOT1210)</td>
</tr>
</tbody>
</table>

6. Ordering information

Table 3. Ordering information

<table>
<thead>
<tr>
<th>Type number</th>
<th>Package</th>
<th>Description mass</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUK9M42-60E</td>
<td>LFPAK33</td>
<td>Plastic, single ended surface mounted package (LFPAK33); 8 leads; 0.65 mm pitch</td>
<td>SOT1210</td>
</tr>
</tbody>
</table>

7. Marking

Table 4. Marking codes

<table>
<thead>
<tr>
<th>Type number</th>
<th>Marking code</th>
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</thead>
<tbody>
<tr>
<td>BUK9M42-60E</td>
<td>94260E</td>
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</tbody>
</table>

8. Limiting values

Table 5. Limiting values

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DS}$</td>
<td>drain-source voltage</td>
<td>$25 \ ^\circ C \leq T_j \leq 175 \ ^\circ C$</td>
<td>-</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>$V_{DGR}$</td>
<td>drain-gate voltage</td>
<td>$R_{GS} = 20 \ \text{k\Omega}$</td>
<td>-</td>
<td>60</td>
<td>V</td>
</tr>
<tr>
<td>$V_{GS}$</td>
<td>gate-source voltage</td>
<td>DC; $T_j \leq 175 \ ^\circ C$</td>
<td>-10</td>
<td>12</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pulsed; $T_j \leq 175 \ ^\circ C$</td>
<td>-15</td>
<td>15</td>
<td>V</td>
</tr>
<tr>
<td>$P_{tot}$</td>
<td>total power dissipation</td>
<td>$T_{mb} = 25 \ ^\circ C$; [Fig. 1]</td>
<td>-</td>
<td>44</td>
<td>W</td>
</tr>
<tr>
<td>$I_D$</td>
<td>drain current</td>
<td>$V_{GS} = 5 \ \text{V}; T_{mb} = 25 \ ^\circ C$; [Fig. 2]</td>
<td>-</td>
<td>22</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{GS} = 5 \ \text{V}; T_{mb} = 100 \ ^\circ C$; [Fig. 2]</td>
<td>-</td>
<td>15.2</td>
<td>A</td>
</tr>
<tr>
<td>$I_{DM}$</td>
<td>peak drain current</td>
<td>pulsed; $t_p \leq 10 \ \mu s$; $T_{mb} = 25 \ ^\circ C$; [Fig. 3]</td>
<td>-</td>
<td>86</td>
<td>A</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>storage temperature</td>
<td>-55 to 175 °C</td>
<td>-55</td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td>$T_j$</td>
<td>junction temperature</td>
<td>-55 to 175 °C</td>
<td>-55</td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td>Source-drain diode</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_S$</td>
<td>source current</td>
<td>$T_{mb} = 25 \ ^\circ C$</td>
<td>-</td>
<td>22</td>
<td>A</td>
</tr>
<tr>
<td>$I_{SM}$</td>
<td>peak source current</td>
<td>pulsed; $t_p \leq 10 \ \mu s$; $T_{mb} = 25 \ ^\circ C$</td>
<td>-</td>
<td>86</td>
<td>A</td>
</tr>
</tbody>
</table>
Symbol | Parameter | Conditions | Min | Max | Unit
--- | --- | --- | --- | --- | ---
\( E_{DS(AlS)} \) | non-repetitive drain-source avalanche energy | \( I_D = 22 \, A; \, V_{sup} \leq 60 \, V; \, R_{GS} = 50 \, \Omega; \, V_{GS} = 5 \, V; \, T_{j(init)} = 25 \, ^{\circ}C; \) unclamped; | [3] [4] | - | 11.7 mJ

[1] Accumulated pulse duration up to 50 hours delivers zero defect ppm.
[2] Significantly longer life times are achieved by lowering \( T_j \) and or \( V_{GS} \).
[3] Single-pulse avalanche rating limited by maximum junction temperature of 175 °C.
[4] Refer to application note AN10273 for further information.

Fig. 1. Normalized total power dissipation as a function of mounting base temperature

\[ P_{der} = \frac{P_{tot}}{P_{tot(25^\circ C)}} \times 100\% \]

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

\[ V_{GS} \geq 5 \, V \]

\[ I_D = 22A \times \sqrt{\frac{175^\circ C - T_{mb}}{150^\circ C}} \quad \text{for} \quad T_{mb} \geq 25^\circ C \]

Fig. 3. Safe operating area; continuous and peak drain currents as a function of drain-source voltage

\[ T_{mb} = 25 \, ^{\circ}C; \, I_{DM} \text{ is a single pulse} \]
9. Thermal characteristics

Table 6. Thermal characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th(j-mb)}$</td>
<td>thermal resistance from junction to mounting base</td>
<td>Fig. 5</td>
<td>-</td>
<td>2.77</td>
<td>3.4</td>
<td>K/W</td>
</tr>
</tbody>
</table>

Fig. 5. Transient thermal impedance from junction to mounting base as a function of pulse duration

10. Characteristics

Table 7. Characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{(BR)DSS}$</td>
<td>drain-source breakdown voltage</td>
<td>$I_D = 250 , \mu A; , V_{GS} = 0 , V; , T_j = 25 , ^\circ C$</td>
<td>60</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_D = 250 , \mu A; , V_{GS} = 0 , V; , T_j = -55 , ^\circ C$</td>
<td>54</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Symbol</td>
<td>Parameter</td>
<td>Conditions</td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
<td>Unit</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>$V_{GS(th)}$</td>
<td>gate-source threshold voltage</td>
<td>$I_D = 1\ mA; V_{DS} = V_{GS}; T_j = 25\ ^\circ C; \text{Fig. 9}; \text{Fig. 10}$</td>
<td>1.4</td>
<td>1.7</td>
<td>2.1</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_D = 1\ mA; V_{DS} = V_{GS}; T_j = -55\ ^\circ C; \text{Fig. 10}$</td>
<td>-</td>
<td>-</td>
<td>2.45</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_D = 1\ mA; V_{DS} = V_{GS}; T_j = 175\ ^\circ C; \text{Fig. 10}$</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>$I_{DSS}$</td>
<td>drain leakage current</td>
<td>$V_{DS} = 60\ V; V_{GS} = 0\ V; T_j = 25\ ^\circ C$</td>
<td>-</td>
<td>0.01</td>
<td>1</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DS} = 60\ V; V_{GS} = 0\ V; T_j = 175\ ^\circ C$</td>
<td>-</td>
<td>-</td>
<td>500</td>
<td>µA</td>
</tr>
<tr>
<td>$I_{GSS}$</td>
<td>gate leakage current</td>
<td>$V_{GS} = 12\ V; V_{DS} = 0\ V; T_j = 25\ ^\circ C$</td>
<td>-</td>
<td>2</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{GS} = -10\ V; V_{DS} = 0\ V; T_j = 25\ ^\circ C$</td>
<td>-</td>
<td>2</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td>$R_{DSSon}$</td>
<td>drain-source on-state resistance</td>
<td>$V_{GS} = 5\ V; I_D = 5\ A; T_j = 25\ ^\circ C; \text{Fig. 11}$</td>
<td>-</td>
<td>34</td>
<td>42</td>
<td>mΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{GS} = 10\ V; I_D = 5\ A; T_j = 25\ ^\circ C; \text{Fig. 11}$</td>
<td>-</td>
<td>30</td>
<td>37</td>
<td>mΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{GS} = 5\ V; I_D = 5\ A; T_j = 175\ ^\circ C; \text{Fig. 12}$</td>
<td>-</td>
<td>-</td>
<td>95</td>
<td>mΩ</td>
</tr>
</tbody>
</table>

**Dynamic characteristics**

- $Q_{G(tot)}$: total gate charge:
  - $I_D = 5\ A; V_{DS} = 48\ V; V_{GS} = 5\ V$;
  - $T_j = 25\ ^\circ C$; \text{Fig. 13}; \text{Fig. 14}
  - Min: - 8.3, Typ: - nC
- $Q_{GS}$: gate-source charge:
  - Min: - 1.7, Typ: - nC
- $Q_{GD}$: gate-drain charge:
  - Min: - 3.4, Typ: - nC
- $C_{iss}$: input capacitance:
  - $V_{DS} = 25\ V; V_{GS} = 0\ V$; $f = 1\ MHz$;
  - $T_j = 25\ ^\circ C$; Fig. 15
  - Min: - 652, Typ: - 867 pF
- $C_{oss}$: output capacitance:
  - Min: - 75, Typ: - 90 pF
- $C_{rss}$: reverse transfer capacitance:
  - Min: - 47, Typ: - 64 pF
- $t_{d(on)}$: turn-on delay time:
  - $V_{DS} = 45\ V$; $R_L = 5\ \Omega$; $V_{GS} = 5\ V$;
  - $R_{G(Ext)} = 5\ \Omega$; $T_j = 25\ ^\circ C$
  - Min: - 6.2, Typ: - ns
- $t_r$: rise time:
  - Min: - 9.7, Typ: - ns
- $t_{d(off)}$: turn-off delay time:
  - Min: - 12.9, Typ: - ns
- $t_f$: fall time:
  - Min: - 8.4, Typ: - ns

**Source-drain diode**

- $V_{SD}$: source-drain voltage:
  - $I_S = 5\ A$; $V_{GS} = 0\ V$; $T_j = 25\ ^\circ C$; \text{Fig. 16}
  - Min: - 0.82, Typ: - 1.2 V
- $t_{rr}$: reverse recovery time:
  - $I_S = 5\ A$; $dI_S/dt = -100\ \text{A/µs}$; $V_{GS} = 0\ V$;
  - $V_{DS} = 25\ V$; $T_j = 25\ ^\circ C$
  - Min: - 15.6, Typ: - ns
- $Q_r$: recovered charge:
  - Min: - 11.4, Typ: - nC

---

**Fig. 6.** Output characteristics; drain current as a function of drain-source voltage; typical values

**Fig. 7.** Drain-source on-state resistance as a function of gate-source voltage; typical values
Fig. 8. Transfer characteristics; drain current as a function of gate-source voltage; typical values

V_{DS} = 12 V

Fig. 9. Sub-threshold drain current as a function of gate-source voltage

T_{J} = 25 °C; V_{DS} = 5 V

Fig. 10. Gate-source threshold voltage as a function of junction temperature

I_{D} = 1mA; V_{DS} = V_{GS}

Fig. 11. Drain-source on-state resistance as a function of drain current; typical values

T_{J} = 25 °C
Fig. 12. Normalized drain-source on-state resistance factor as a function of junction temperature

\[ a = \frac{R_{DS(on)}}{R_{DS(on)(25^\circ C)}} \]

Fig. 13. Gate-source voltage as a function of gate charge; typical values

\[ T_j = 25^\circ C; I_D = 5 \text{ A} \]

Fig. 14. Gate charge waveform definitions

Fig. 15. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values

\[ V_{GS} = 0 \text{ V}; f = 1 \text{ MHz} \]
Fig. 16. Source-drain (diode forward) current as a function of source-drain (diode forward) voltage; typical values

11. Application information

For guidance on how to use and understand this datasheet, please refer to application note AN11158 "Understanding power MOSFET datasheet parameters".
12. Package outline

Plastic single ended surface mounted package (LFPAK33): 8 leads SOT1210

Fig. 17. Package outline LFPAK33 (SOT1210)
13. Soldering

Footprint information for reflow soldering of LFPAK33 package

Fig. 18. Reflow soldering footprint for LFPAK33 (SOT1210)
14. Legal information

Data sheet status

<table>
<thead>
<tr>
<th>Document status</th>
<th>Product status</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preliminary [short] data sheet</td>
<td>Qualification This document contains data from the preliminary specification.</td>
</tr>
<tr>
<td></td>
<td>Product [short] data sheet</td>
<td>Production This document contains the product specification.</td>
</tr>
</tbody>
</table>

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