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Please note: As part of the Fairchild Semiconductor integration, some of the Fairchild orderable part numbers will need to change in order to meet ON Semiconductor’s system requirements. Since the ON Semiconductor product management systems do not have the ability to manage part nomenclature that utilizes an underscore (_), the underscore (_) in the Fairchild part numbers will be changed to a dash (-). This document may contain device numbers with an underscore (_). Please check the ON Semiconductor website to verify the updated device numbers. The most current and up-to-date ordering information can be found at www.onsemi.com. Please email any questions regarding the system integration to Fairchild_questions@onsemi.com.
FAN8831
Sinusoidal Piezoelectric Actuator Driver with Step-Up DC-DC Converter

Features

Step-Up DC-DC Converter
- Integrated Step-up Power Switch up to 36 V
- Wide Operating Voltage Range of 2.7 to 5.5 V
- Adjustable Step-up Output Voltage
- Adjustable Step-up Current Limit
- Zero Current Detector (ZCD)
- Internal Soft-Start
- Built-in Protection Circuit
  - Over Voltage Protection (OVP)
  - Thermal Shutdown (TSD)

Piezo Actuator Driver
- Integrated Full-Bridge Switches (VDS=75 V)
- Digitally Implemented Sine Modulator

Package Information
- Small 4.0 mm × 4.0 mm MLP

Applications
- Piezo Actuator

Description

The FAN8831 is a single-chip piezoelectric actuator driver consisting of step-up DC-DC converter with integrated 36 V boost switch and a full-bridge output stage. The device is capable of driving a Piezo bidirectionally at 120 V peak-to-peak from a single 3 V lithium cell. The step-up DC-DC converter operates in Critical Conduction Mode (CRM) and is optimized to work in a coupled inductor configuration to provide output voltages in excess of 60 V. Over-voltage protection, over-current protection and thermal shutdown are all provided. An internal ready is used to enable the full-bridge gate driver when step-up DC-DC converter output voltage reaches the proper level with hysteresis.

The boost voltage is set using external resistors, and step-up current limit is programmable via the external resistor at OCP pin.

The output H-bridge features four integrated 75 V P and N-channel for sine wave drive of the Piezo actuator.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Operating Temperature Range</th>
<th>Package</th>
<th>Packing Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAN8831MPX</td>
<td>-40°C to +125°C</td>
<td>24-Lead, MLP</td>
<td>Tape &amp; Reel</td>
</tr>
</tbody>
</table>
Application Diagram

![Application Diagram](image)

Figure 1. Typical Application Circuit for Piezo Actuator Driver

Internal Block Diagram

![Internal Block Diagram](image)

Figure 2. Functional Block Diagram
Pin Configuration

Figure 3. Pin Assignments

Pin Definitions

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td>PGND1</td>
<td>Power Ground 1. It is connected to the source of the step-up switch.</td>
</tr>
<tr>
<td>3</td>
<td>VDD</td>
<td>Power supply of step-up DC-DC converter.</td>
</tr>
<tr>
<td>4</td>
<td>SGND</td>
<td>Signal Ground. The signal ground for step-up DC-DC converter circuitry.</td>
</tr>
<tr>
<td>5</td>
<td>ZCD</td>
<td>The input of the zero current detection.</td>
</tr>
<tr>
<td>6</td>
<td>FB</td>
<td>Step-up DC-DC converter output voltage feedback input.</td>
</tr>
<tr>
<td>7</td>
<td>COMP</td>
<td>Output of the transconductance error amplifier.</td>
</tr>
<tr>
<td>8</td>
<td>OCP</td>
<td>Sets Step-up DC-DC converter current limit.</td>
</tr>
<tr>
<td>9</td>
<td>FO</td>
<td>Fault Output.</td>
</tr>
<tr>
<td>10</td>
<td>EN</td>
<td>Enable pin to turn on and off the overall system. (Active Low Shutdown Mode)</td>
</tr>
<tr>
<td>11</td>
<td>INPUT</td>
<td>Logic input for sinusoidal waveform.</td>
</tr>
<tr>
<td>12</td>
<td>ADJ</td>
<td>Output voltage adjust control pin. Connect to internal current source to change output voltage using an external resistor. Connect a small capacitor (1 nF).</td>
</tr>
<tr>
<td>13</td>
<td>RT</td>
<td>Oscillator frequency control pin.</td>
</tr>
<tr>
<td>14</td>
<td>OVP</td>
<td>Voltage sense input of Step-up DC-DC converter for Over-Voltage Protection.</td>
</tr>
<tr>
<td>15</td>
<td>AGND</td>
<td>Analog Ground. The signal ground for full-bridge driver circuitry.</td>
</tr>
<tr>
<td>16</td>
<td>VIN</td>
<td>Power supply of 5 V LDO.</td>
</tr>
<tr>
<td>17</td>
<td>VDRV</td>
<td>Power supply of full-bridge driver.</td>
</tr>
<tr>
<td>18</td>
<td>PGND2</td>
<td>Power Ground 2. The power ground for full-bridge driver.</td>
</tr>
<tr>
<td>19</td>
<td>NC</td>
<td>Not Connected</td>
</tr>
<tr>
<td>20</td>
<td>OUT2</td>
<td>Output 2 for full-bridge driver.</td>
</tr>
<tr>
<td>21</td>
<td>OUT1</td>
<td>Output 1 for full-bridge driver.</td>
</tr>
<tr>
<td>22</td>
<td>NC</td>
<td>Not Connected</td>
</tr>
<tr>
<td>23, 24</td>
<td>LX</td>
<td>Switch Node. This pin is connected to the inductor.</td>
</tr>
</tbody>
</table>
### Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DRV}$</td>
<td>DC Link Input Voltage Drain-Source Voltage of each MOSFET</td>
<td>75</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{DD}$</td>
<td>DC Supply Voltage for DC-DC Converter</td>
<td>-0.3</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IN,DCDC}$</td>
<td>EN, INPUT, FB and COMP to SGND</td>
<td>-0.3</td>
<td>$V_{DD}+0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IN}$</td>
<td>DC Supply Voltage for LDO</td>
<td>-0.3</td>
<td>75</td>
<td>V</td>
</tr>
<tr>
<td>$V_{LX}$</td>
<td>LX to PGND</td>
<td>-0.3</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>$P_D$</td>
<td>Power Dissipation</td>
<td>0.98</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>$\theta_{JA}$</td>
<td>Thermal Resistance Junction-Air</td>
<td>2.9</td>
<td>°C/W</td>
<td></td>
</tr>
<tr>
<td>$T_A$</td>
<td>Operating Ambient Temperature Range</td>
<td>-40</td>
<td>125</td>
<td>°C</td>
</tr>
<tr>
<td>$T_J$</td>
<td>Operating Junction Temperature</td>
<td>-55</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{STG}$</td>
<td>Storage Temperature Range</td>
<td>-55</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>ESD</td>
<td>Electrostatic Discharge Capability</td>
<td>2</td>
<td>KV</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. All voltage values, except differential voltages, are given with respect to SGND, AGND and PGND pin.
2. JEDEC standard: JESD51-2, JESD51-3. Mounted on 76.2×114.3×1.6mm PCB (FR-4 glass epoxy material).
3. 1S0P with thermal vias: one signal layer with zero power plane and thermal vias.
4. 1S2P with thermal vias: one signal layer with two power plane and thermal vias.

### Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DRV}$</td>
<td>Supply Voltage for Full-Bridge Driver</td>
<td>30</td>
<td>60</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{LX}$</td>
<td>Boost Switch Voltage</td>
<td>10</td>
<td>30</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{DD}$</td>
<td>Operating Voltage for DC-DC Converter</td>
<td>2.7</td>
<td>3.0</td>
<td>3.3</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IN}$</td>
<td>Operating Voltage for Voltage Regulator</td>
<td>10</td>
<td>60</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$R_{OCP}$</td>
<td>Current Limit Control Resistor</td>
<td>7.0</td>
<td>150</td>
<td>kΩ</td>
<td></td>
</tr>
</tbody>
</table>
# Electrical Characteristics

$V_{DD}=3.0 \, \text{V}, \, V_{IN}=15.0 \, \text{V}, \, V_{DRV}=60 \, \text{V}, \, R_{T}=70 \, \text{k}\Omega \, \text{and} \, T_{A}=-40^\circ\text{C} \, \text{to} \, +125^\circ\text{C}$. Typical values $T_{A}=25^\circ\text{C}$, unless otherwise specified.

<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>$I_{Q,DD}$</td>
<td>Quiescent Current for $V_{DD}$&lt;sup&gt;(5)&lt;/sup&gt;</td>
<td>$V_{EN}=V_{COMP}=V_{DD}$, $V_{FB}=1.0 , \text{V}$</td>
<td>700</td>
<td>1200</td>
<td></td>
<td>$\mu\text{A}$</td>
</tr>
<tr>
<td>$I_{Q,IN}$</td>
<td>Quiescent Current for $V_{IN}$</td>
<td>$V_{FB}=1.0 , \text{V}$, Device not switching</td>
<td>300</td>
<td>500</td>
<td></td>
<td>$\mu\text{A}$</td>
</tr>
<tr>
<td>$I_{Q,DRV}$</td>
<td>Quiescent Current for $V_{DRV}$</td>
<td>$V_{EN}=0 , \text{V}$, $V_{DD}=V_{IN}=V_{DRV}=3 , \text{V}$</td>
<td>200</td>
<td>300</td>
<td></td>
<td>$\mu\text{A}$</td>
</tr>
<tr>
<td>$I_{SD,DD}$</td>
<td>Shutdown Current for $V_{DD}$</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>$\mu\text{A}$</td>
</tr>
<tr>
<td>$I_{SD,IN}$</td>
<td>Shutdown Current for $V_{IN}$</td>
<td>$V_{DD}=V_{IN}=V_{DRV}=3 , \text{V}$</td>
<td>1</td>
<td></td>
<td>1</td>
<td>$\mu\text{A}$</td>
</tr>
<tr>
<td>$I_{SD,DRV}$</td>
<td>Shutdown Current for $V_{DRV}$</td>
<td>$V_{EN}=0 , \text{V}$</td>
<td>5</td>
<td>10</td>
<td></td>
<td>$\mu\text{A}$</td>
</tr>
<tr>
<td>$V_{DDSTART}$</td>
<td>Start Threshold Voltage</td>
<td></td>
<td>2.6</td>
<td>2.7</td>
<td>2.8</td>
<td>$\text{V}$</td>
</tr>
<tr>
<td>$V_{DADOVHY}$</td>
<td>$V_{DD}$ UVLO Hysteresis Voltage</td>
<td></td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>$\text{V}$</td>
</tr>
<tr>
<td>$V_{FB}$</td>
<td>Feedback Reference Voltage</td>
<td>$T_{A}=25^\circ\text{C}$</td>
<td>0.99</td>
<td>1.0</td>
<td>1.01</td>
<td>$\text{V}$</td>
</tr>
<tr>
<td>$I_{FB}$</td>
<td>FB pin Bias Current</td>
<td>$V_{FB}=0 , \text{V} , \text{to} , 2 , \text{V}$</td>
<td>1</td>
<td></td>
<td></td>
<td>$\mu\text{A}$</td>
</tr>
<tr>
<td>$\Delta V_{FB1}$</td>
<td>Feedback Voltage Line Regulation&lt;sup&gt;(6)&lt;/sup&gt;</td>
<td>$2.7 , \text{V} &lt; V_{DD} &lt; 5 , \text{V}$</td>
<td>0.5</td>
<td>1.5</td>
<td></td>
<td>$%/$$\text{V}$</td>
</tr>
<tr>
<td>$G_{in}$</td>
<td>Transconductance</td>
<td>$T_{A}=25^\circ\text{C}$</td>
<td>800</td>
<td></td>
<td></td>
<td>$\mu\text{mho}$</td>
</tr>
<tr>
<td>$V_{ZCD}$</td>
<td>Input Voltage Threshold&lt;sup&gt;(7)&lt;/sup&gt;</td>
<td>$T_{A}=25^\circ\text{C}$</td>
<td>1.65</td>
<td>1.83</td>
<td>2.00</td>
<td>$\text{V}$</td>
</tr>
<tr>
<td>$V_{CLAMPH}$</td>
<td>Input High Clamp Voltage</td>
<td></td>
<td>3.0</td>
<td>3.5</td>
<td>4.0</td>
<td>$\text{V}$</td>
</tr>
<tr>
<td>$V_{CLAMPL}$</td>
<td>Input Low Clamp Voltage</td>
<td>$I_{DET}=2.3 , \text{mA}$</td>
<td>-0.30</td>
<td>0.12</td>
<td>0.50</td>
<td>$\text{V}$</td>
</tr>
<tr>
<td>$I_{ZCD,SR}$</td>
<td>Source Current Capability</td>
<td></td>
<td>-2.3</td>
<td></td>
<td></td>
<td>$\text{mA}$</td>
</tr>
<tr>
<td>$I_{ZCD,SK}$</td>
<td>Sink Current Capability</td>
<td></td>
<td>2.3</td>
<td></td>
<td></td>
<td>$\text{mA}$</td>
</tr>
<tr>
<td>$t_{ZCD,D}$</td>
<td>Delay From ZCD to Output Turn-On&lt;sup&gt;(7)&lt;/sup&gt;</td>
<td></td>
<td>50</td>
<td>200</td>
<td></td>
<td>$\text{ns}$</td>
</tr>
<tr>
<td>$t_{ON,MAX}$</td>
<td>Maximum On-Time</td>
<td></td>
<td>15</td>
<td>25</td>
<td>35</td>
<td>$\mu\text{s}$</td>
</tr>
<tr>
<td>$t_{REST}$</td>
<td>Restart Timer</td>
<td></td>
<td>15</td>
<td>25</td>
<td>35</td>
<td>$\mu\text{s}$</td>
</tr>
<tr>
<td>$f_{MAX}$</td>
<td>Maximum Switching Frequency&lt;sup&gt;(7)&lt;/sup&gt;</td>
<td></td>
<td>900</td>
<td>1000</td>
<td></td>
<td>$\text{KHz}$</td>
</tr>
<tr>
<td>$t_{SS}$</td>
<td>Internal Soft-Start</td>
<td></td>
<td>16</td>
<td>28</td>
<td>40</td>
<td>$\text{ms}$</td>
</tr>
<tr>
<td>$I_{OCP}$</td>
<td>OCP Trip Current</td>
<td>$R_{OCP}=3.3 , \text{k}\Omega, , V_{DD}=3.3 , \text{V}$</td>
<td>1.85</td>
<td>2.00</td>
<td>2.15</td>
<td>$\text{A}$</td>
</tr>
<tr>
<td>$I_{OCP}$</td>
<td></td>
<td>$R_{OCP}=22 , \text{k}\Omega, , V_{DD}=3.3 , \text{V}$</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td>$\text{A}$</td>
</tr>
<tr>
<td>$t_{CLAMPH}$</td>
<td>Comparator Leading-Edge Blanking Time&lt;sup&gt;(7)&lt;/sup&gt;</td>
<td></td>
<td>800</td>
<td>130</td>
<td>180</td>
<td>$\text{ns}$</td>
</tr>
</tbody>
</table>

## Notes:

5. This is the VDD current consumed when active but not switching. Does not include gate-drive current

\[
\frac{\Delta V_{OUT}}{V_{OUT}} \times \frac{1}{\Delta V_{IN}}
\]

6. The line regulation is calculated based on

7. This parameter, although guaranteed by design, is not tested in production.
## Electrical Characteristics

$V_{DD}=3.0 \, \text{V}$, $V_{IN}=15.0 \, \text{V}$, $V_{DRV}=60 \, \text{V}$, $R_T=70 \, \text{K}\Omega$ and $T_A=-40^\circ\text{C}$ to $+125^\circ\text{C}$. Typical values $T_A=25^\circ\text{C}$, unless otherwise specified.

### Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit
--- | --- | --- | --- | --- | --- | ---

#### Step-Up Switch Section

- $R_{DSON}$ N-Channel On Resistance $V_{DD}=3.3 \, \text{V}$, $T_A=25^\circ\text{C}$ $0.2$ $0.5$ $\Omega$
- $I_{LK,LX}$ LX Leakage Current $V_{LX}=36 \, \text{V}$ $1.0$ $\mu\text{A}$

#### Oscillator Section

- $f_{OSC}$ Operating Frequency $R_T=58 \, \text{K}\Omega$ $40$ $50$ $60$ $\text{KHz}$
- $f_{OSC}$ Operating Frequency $R_T=121 \, \text{K}\Omega$ $20$ $25$ $30$ $\text{KHz}$

#### Logic (EN and INPUT) Section

- $V_{INPUT+}$ INPUT Logic High Threshold Voltage $1.34$ $\text{V}$
- $V_{INPUT-}$ INPUT Logic Low Threshold Voltage $0.5$ $\text{V}$
- $I_{INPUT+}$ Input Low Current for INPUT and EN $V_{EN}=0 \, \text{V}$ $1$ $\mu\text{A}$
- $I_{INPUT+}$ Input High Current for INPUT and EN $V_{EN}=V_{DD}$ $8$ $12$ $16$ $\mu\text{A}$
- $R_{INPUT}$ Input Logic Pull-Down Resistance $V_{EN}=V_{INPUT}=3 \, \text{V}$ $250$ $375$ $\text{K}\Omega$
- $I_{INPUT+}$ Input Low Current for INPUT and EN $V_{EN}=V_{INPUT}=3 \, \text{V}$ $1$ $\mu\text{A}$
- $I_{INPUT+}$ Input High Current for INPUT and EN $V_{EN}=V_{INPUT}=3 \, \text{V}$ $8$ $12$ $16$ $\mu\text{A}$
- $R_{INPUT}$ Input Logic Pull-Down Resistance $V_{EN}=V_{INPUT}=3 \, \text{V}$ $250$ $375$ $\text{K}\Omega$

#### Full-Bridge Switch Section

- $R_{DS,ONP}$ Output Upper-Side On Resistance $T_A=25^\circ\text{C}$ $3.0$ $5.0$ $\Omega$
- $R_{DS,ONN}$ Output Low-Side On Resistance $T_A=25^\circ\text{C}$ $3.0$ $5.0$ $\Omega$

#### Output Control Section

- $V_{ADJ,MAX}$ Analog Output Control Maximum Voltage $V_{DRV}=100\%$ of Target $1.0$ $\text{V}$
- $V_{ADJ,MIN}$ Analog Output Control Minimum Voltage $0.1$ $\text{V}$
- $I_{ADJ+}$ Internal Current Source for ADJ Pin $T_A=25^\circ\text{C}$ $9$ $10$ $11$ $\mu\text{A}$

#### Protection (Ready, OVP and TSD)

- $V_{READY}$ Output Ready Threshold Voltage $0.75$ $0.80$ $0.85$ $\text{V}$
- $HY_{READY}$ Output Ready Hysteresis $0.2$ $\text{V}$
- $V_{OVP,FB}$ OVP Threshold Voltage at FB Pin $1.05$ $1.10$ $1.15$ $\text{V}$
- $HY_{OVP,FB}$ OVP Hysteresis Voltage at FB Pin $0.1$ $\text{V}$
- $V_{OVP,OVP}$ OVP Threshold Voltage at OVP Pin $1.10$ $1.15$ $1.20$ $\text{V}$
- $HY_{OVP,OVP}$ OVP Hysteresis Voltage at OVP Pin $0.15$ $\text{V}$
- $T_{SD}$ Thermal Shutdown Temperature $150$ $^\circ\text{C}$
- $T_{HYS}$ Hysteresis Temperature of TSD $50$ $^\circ\text{C}$
- $T_{FD}$ Fault Output Duration $20$ $30$ $\mu\text{s}$
- $V_{FOL}$ Fault Output Low Level Voltage $R_{PU}=50 \, \text{K}\Omega$, $V_{PU}=3 \, \text{V}$ $0.1$ $0.4$ $\text{V}$

### Note:

8. This parameter, although guaranteed by design, is not tested in production.
Typical Performance Characteristics

Figure 4. Reference Voltage vs. Temperature

Figure 5. Shutdown Current for $V_{\text{DRV}}$ & $V_{\text{IN}}$ vs. Temperature

Figure 6. $V_{\text{DD}}$ UVLO vs. Temperature

Figure 7. ADJ Current vs. Temperature

Figure 8. Quiescent Current for $V_{\text{DD}}$, $V_{\text{DRV}}$, & $V_{\text{IN}}$ vs. Temperature

Figure 9. OCP Current vs. Temperature

Figure 10. Operating Current for $V_{\text{DD}}$, $V_{\text{DRV}}$, & $V_{\text{IN}}$ vs. Temperature

Figure 11. ZDC Clamp Voltage vs. Temperature
Typical Performance Characteristics

Figure 12. Maximum On-Time vs. Temperature

Figure 13. First OVP (FB) vs. Temperature

Figure 14. Restart-Time vs. Temperature

Figure 15. Second (OVP) vs. Temperature

Figure 16. Soft-Start Time vs. Temperature

Figure 17. Ready Voltage vs. Temperature

Figure 18. Enable (EN) Threshold Voltage vs. Temperature

Figure 19. INPUT Threshold Voltage vs. Temperature
Typical Performance Characteristics

Figure 20. Boost Switch $R_{DSON}$ vs. Temperature

Figure 21. % of Target Voltage vs. $R_{ADJ}$

Figure 22. Full-Bridge Switch $R_{DSON}$ vs. Temperature

Figure 23. $f_{OSC}$ vs. $RT$

Figure 24. $I_{OCP}$ vs. $R_{OCP}$
NOTES:

A. CONFORMS TO JEDEC REGISTRATION 
MO-220, VARIATION WGGD-6.
B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS AND TOLERANCES PER 
D. LAND PATTERN IPC REFERENCE:
QFN50P400X400X80-25W6N.