SIX-CHANNEL LINEAR LED DRIVER WITH THERMAL SHUNT AND INDIVIDUAL PWM DIMMING

GENERAL DESCRIPTION

The IS32LT3147 is a six-channel linear LED driver supporting a thermal shunt resistor for power dissipation to minimize the device thermal stress. Each channel has its own individual PWM control input. For added system reliability, the IS32LT3147 integrates fault detection circuitry for LED open/short circuit, single LED short circuit, thermal roll-off and thermal shutdown conditions. The FAULTB is a bi-directional open drain pin for reporting fault conditions and receiving system fault signal inputs. The FMODE pin configures the type of response to a fault signal, either “One Fail Other On” or “One Fail All Fail”. The IS32LT3147 device is available in an eTSSOP-20 package with exposed pad for enhanced thermal dissipation.

APPLICATIONS

- Sequential turn light
- Welcome light
- Rear light
- Stop or taillight
- Interior lighting

FEATURES

- Wide input voltage range: 5V~40V
- Thermal shunt resistor to optimize the device thermal stress
- 6-CH current source driver
- Parallel outputs for higher current using multiple channels of a single IC or multiple ICs
- Individual PWM dimming to each channel
- Adjustable constant output current set by reference resistor
  - Max. current: 75mA per channel
  - Max. current: 450mA in Parallel Operation
- Low headroom voltage
  - Max. headroom: 500mV at 25mA per channel
  - Max. headroom: 900mV at 75mA per channel
- Robust fault protection with reporting:
  - Fault modes selectable: “one fails all fail” or “one fails other on”
  - Single LED short - single resistor to set the detection threshold
  - LED string open/short
  - Current setting pin (ISET) open/short
  - Thermal shutdown
  - External UVLO setting for single LED short and LED string open detection
  - FAULTB pin for failure reporting, allowing parallel bus connection
- Current slew rate control to optimize EMI performance
- Thermal roll-off – over junction temperature current derating
- Operating junction temperature range -40°C to 150°C
- AEC-Q100 Qualified
Note 1: The $R_{\text{PWM1}}$~$R_{\text{PWM6}}$ resistors must always be installed to prevent the current flowing into the PWMx pins. Recommended value is 10kΩ.
PIN CONFIGURATION

<table>
<thead>
<tr>
<th>Package</th>
<th>Pin Configuration (Top View)</th>
</tr>
</thead>
<tbody>
<tr>
<td>eTSSOP-20</td>
<td>![Pin Diagram]</td>
</tr>
</tbody>
</table>

PIN DESCRIPTION

<table>
<thead>
<tr>
<th>No.</th>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UV</td>
<td>With an external resistor divider, it can set external UVLO for LED string open and single LED short fault detection.</td>
</tr>
<tr>
<td>2, 3</td>
<td>PWM6, PWM5</td>
<td>PWM dimming pin to OUT6 and OUT5. Pulling all PWM1~PWM6 pins low for &gt;tSD will force the device into shutdown mode.</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>Ground pin.</td>
</tr>
<tr>
<td>5</td>
<td>ISET</td>
<td>Resistor on this pin to GND sets the maximum output current for channel OUT1~OUT6.</td>
</tr>
<tr>
<td>6</td>
<td>SLSTH</td>
<td>Single LED short detection voltage setting pin. Connect a resistor to ground to set.</td>
</tr>
<tr>
<td>7</td>
<td>FMODE</td>
<td>Fault action modes select pin. Connect a proper value resistor to ground to select.</td>
</tr>
<tr>
<td>8~11</td>
<td>PMW4~PWM1</td>
<td>PWM dimming pin to OUT4<del>OUT1. Pulling all PWM1</del>PWM6 pins low for &gt;tSD will force the device into shutdown mode.</td>
</tr>
<tr>
<td>12</td>
<td>FAULTB</td>
<td>Open drain I/O diagnostic pin. Active low output driven by the device when it detects a fault condition. As an input (RFMODE=0Ω or 27kΩ), this pin will accept an externally generated FAULTB signal to disable the device output to satisfy the “One-Fail-All-Fail” function. Note this pin requires an external pull up resistor (RFAULTB).</td>
</tr>
<tr>
<td>13~18</td>
<td>OUT6~OUT1</td>
<td>Current output pin. Connect the anode of the LED string to this pin and cathode to GND.</td>
</tr>
<tr>
<td>19</td>
<td>VINA</td>
<td>Power supply pin.</td>
</tr>
<tr>
<td>20</td>
<td>VINB</td>
<td>Thermal shunt pin. Connect a power resistor from VINA to this pin to shunt the power dissipation on the device.</td>
</tr>
</tbody>
</table>

Thermal Pad
Must be connected to GND with sufficient copper for heat sink.
IS32LT3147

ORDERING INFORMATION
Automotive Range: -40°C to +125°C

<table>
<thead>
<tr>
<th>Order Part No.</th>
<th>Package</th>
<th>QTY/Reel</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS32LT3147-ZLA3-TR</td>
<td>eTSSOP-20, Lead-free</td>
<td>2500</td>
</tr>
</tbody>
</table>

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a.) the risk of injury or damage has been minimized;
b.) the user assume all such risks; and
c.) potential liability of Lumissil Microsystems is adequately protected under the circumstances.
### ABSOLUTE MAXIMUM RATINGS (NOTE 2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage at VINA and VINB pins</td>
<td>-0.3V ~ +45V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage at UV, PWM1<del>PWM6, FAULTB and OUT1</del>OUT6 pins</td>
<td>-0.3V ~ VINA+0.3V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage at ISET, SLSTH and FMODE pins</td>
<td>-0.3V ~ +7V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature, TA=TJ</td>
<td>-40°C ~ +150°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature, TSTG</td>
<td>-65°C ~ +150°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junction temperature, TJMAX</td>
<td>+150°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package thermal resistance, junction to ambient (4-layer standard test PCB based on JESD 51-2A), θJA</td>
<td>31.8°C/W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package thermal resistance, junction to thermal PAD (4-layer standard test PCB based on JESD 51-8), θJP</td>
<td>14.46°C/W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESD (HBM)</td>
<td>±2kV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESD (CDM)</td>
<td>±750V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note 2:** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### ELECTRICAL CHARACTERISTICS

Valid at VINA=12V, unless noted otherwise. Refer to each condition description.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
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<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VINA</td>
<td>Operating input voltage range</td>
<td>Voltage rising</td>
<td>5.0</td>
<td>40</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VINA_UV</td>
<td>VIN undervoltage release</td>
<td>IC disabled</td>
<td>4.7</td>
<td>4.9</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VINA_UVHY</td>
<td>VIN undervoltage-lockout hysteresis</td>
<td>PWMx=High, RİSET=6.2kΩ, FAULTB=High</td>
<td>280</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>IN</td>
<td>Quiescent current (İVINA+İVINB)</td>
<td>PWMx=Low longer than tSD</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>mA</td>
</tr>
<tr>
<td>İSD</td>
<td>Shutdown current (İVINA+İVINB)</td>
<td>PWMx=Low, RİSET=0Ω, one fail all fail mode, FAULTB=Low</td>
<td>50</td>
<td>85</td>
<td>120</td>
<td>μA</td>
</tr>
<tr>
<td>İFAULT</td>
<td>Shutdown current in fault mode (İVINA+İVINB)</td>
<td>All PWM pins tied to VINA</td>
<td>1.4</td>
<td>2.2</td>
<td>3</td>
<td>mA</td>
</tr>
<tr>
<td>İON</td>
<td>Startup time from VIN rising edge to current rising edge after first power-up</td>
<td>All PWM pins tied to VINA</td>
<td>110</td>
<td>200</td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>İOUT_R</td>
<td>Output current range per channel</td>
<td>-75</td>
<td>-10</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>İSET</td>
<td>ISET pin reference voltage</td>
<td>RİSET=6.2kΩ, VINA=VINB, (VINA-VOUT)=1.5V</td>
<td>-81</td>
<td>-75</td>
<td>-69</td>
<td>mA</td>
</tr>
<tr>
<td>İOUT</td>
<td>Output current per channel</td>
<td>RİSET=18.6kΩ, VINA=VINB, (VINA-VOUT)=1.5V</td>
<td>-28</td>
<td>-25</td>
<td>-22</td>
<td>mA</td>
</tr>
<tr>
<td>EİOUT_M</td>
<td>OUT1~OUT6 current matching in one device</td>
<td>RİSET=6.2kΩ</td>
<td>-6</td>
<td>6</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>İOUT_L</td>
<td>Output current limit</td>
<td>İSET shorted to GND</td>
<td>-150</td>
<td>-112</td>
<td>-85</td>
<td>mA</td>
</tr>
<tr>
<td>VHR_MIN</td>
<td>Minimum headroom voltage from VINA to OUTx (VINB pin tied to VINA pin)</td>
<td>Measured at (VINA-VOUTx)</td>
<td>RİSET=6.2kΩ</td>
<td>900</td>
<td></td>
<td>mV</td>
</tr>
</tbody>
</table>

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Rev. A, 03/03/2022
### ELECTRICAL CHARACTERISTICS (CONTINUE)

Valid at $V_{IN}$= 12V, unless noted otherwise. Refer to each condition description.

*●* symbol indicates specifications across the full operating temperature range with $T_A= T_J= -40^\circ C$ to +150$^\circ C$, other specifications are at $T_A= T_J= 25^\circ C$; unless noted otherwise. (Note 4)

<table>
<thead>
<tr>
<th>Symbol</th>
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<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_{SL}$</td>
<td>Current rising/falling slew time (rising from 10% to 90% levels and falling from 90% to 10% levels)</td>
<td>$R_{\text{ISET}}=6.2k\Omega$</td>
<td>●</td>
<td>6</td>
<td>16</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$R_{\text{ISET}}=18.6k\Omega$</td>
<td>●</td>
<td>3</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>$V_{ABTR}$</td>
<td>The voltage threshold of current full transition from VINA to VINB</td>
<td>$R_{\text{ISET}}=6.2k\Omega$, measured at $(V_{INB}-V_{OUT_MAX})$</td>
<td>1.1</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{ABTR}$</td>
<td>The period time of 85% current full transition from VINA to VINB</td>
<td>$R_{\text{ISET}}=6.2k\Omega$</td>
<td>600</td>
<td>$\mu$s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Input and Output

<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>$V_{IL}$</td>
<td>PWMx and FAULTB pins input low voltage</td>
<td>Below $V_{IL}$ level, input voltage considered as logic LOW</td>
<td>●</td>
<td>0.7</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{IH}$</td>
<td>PWMx and FAULTB pins input high voltage</td>
<td>Above $V_{IH}$ level, input voltage considered as logic HIGH</td>
<td>●</td>
<td>2.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_{PD}$</td>
<td>PWMx pins internal pull-down current</td>
<td>Pin connected to 12V</td>
<td>●</td>
<td>4</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>$f_{PWM}$</td>
<td>Recommended PWM frequency at PWM pin</td>
<td>(Note 3)</td>
<td>1</td>
<td>kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t_{PWM_RD}$</td>
<td>Delay time of PWM rising edge to 10% output current</td>
<td>$R_{\text{ISET}}=6.2k\Omega$</td>
<td>●</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>$t_{PWM_FD}$</td>
<td>Delay time of PWM falling edge to 90% output current</td>
<td>$R_{\text{ISET}}=6.2k\Omega$</td>
<td>●</td>
<td>15</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td>$t_{SD}$</td>
<td>Duration time all PWM pins kept low to shutdown device</td>
<td></td>
<td>●</td>
<td>55</td>
<td>68</td>
<td>80</td>
</tr>
<tr>
<td>$V_{OL_FLTB}$</td>
<td>FAULTB pin output voltage</td>
<td>$I_{SINK}=1mA$</td>
<td>●</td>
<td>0.1</td>
<td>0.4</td>
<td>V</td>
</tr>
<tr>
<td>$V_{UVTH}$</td>
<td>UV pin threshold voltage</td>
<td>Voltage rising</td>
<td>●</td>
<td>1.13</td>
<td>1.24</td>
<td>1.35</td>
</tr>
<tr>
<td>$V_{UVTH_HY}$</td>
<td>UV pin threshold voltage hysteresis</td>
<td></td>
<td>●</td>
<td>30</td>
<td>mV</td>
<td></td>
</tr>
</tbody>
</table>

### Protection

<table>
<thead>
<tr>
<th>Symbol</th>
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<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{FMODE}$</td>
<td>FMODE pin output current</td>
<td></td>
<td>●</td>
<td>30</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$R_{FMODE1}$</td>
<td>FMODE pin resistance range for fault action mode 1</td>
<td></td>
<td>●</td>
<td>0</td>
<td>100</td>
<td>$\Omega$</td>
</tr>
<tr>
<td>$R_{FMODE2}$</td>
<td>FMODE pin resistance range for fault action mode 2</td>
<td></td>
<td>●</td>
<td>24</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>$R_{FMODE3}$</td>
<td>FMODE pin resistance range for fault action mode 3</td>
<td></td>
<td>●</td>
<td>58</td>
<td>62</td>
<td>66</td>
</tr>
<tr>
<td>$R_{FMODE4}$</td>
<td>FMODE pin resistance range for fault action mode 4</td>
<td></td>
<td>●</td>
<td>140</td>
<td>150</td>
<td>160</td>
</tr>
</tbody>
</table>
**ELECTRICAL CHARACTERISTICS (CONTINUE)**

Valid at $V_{IN}= 12V$, unless noted otherwise. Refer to each condition description.

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<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{\text{ISET~OC}}$</td>
<td>Maximum $R_{\text{ISET}}$ of ISET pin open circuit detection</td>
<td>Monitor FAULTB pin low</td>
<td>●</td>
<td>300</td>
<td>kΩ</td>
<td></td>
</tr>
<tr>
<td>$R_{\text{ISET~SC}}$</td>
<td>Minimum $R_{\text{ISET}}$ of ISET pin short circuit detection</td>
<td>Monitor FAULTB pin low</td>
<td>●</td>
<td>1</td>
<td>kΩ</td>
<td></td>
</tr>
<tr>
<td>$t_{\text{FBDT}}$</td>
<td>ISET pin open/short detection de-glitch time</td>
<td>Voltage falling, measured at OUTx to GND</td>
<td>●</td>
<td>40</td>
<td>µs</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{SCV}}$</td>
<td>LED string short detection voltage</td>
<td>$V_{UV}&gt;V_{UVTH}$, measured at $(V_{INB}-V_{OUTx})$, voltage falling</td>
<td>●</td>
<td>0.8</td>
<td>1</td>
<td>V</td>
</tr>
<tr>
<td>$V_{\text{SCV~HY}}$</td>
<td>LED string short detection voltage hysteresis</td>
<td>Measured at OUTx to GND</td>
<td>●</td>
<td>210</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$I_{\text{RTR}}$</td>
<td>Fault retry current</td>
<td></td>
<td>●</td>
<td>4</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{OCSV}}$</td>
<td>LED string open fault detection voltage</td>
<td>$V_{UV}&gt;V_{UVTH}$, measured at $(V_{INB}-V_{OUTx})$, voltage falling</td>
<td>●</td>
<td>29</td>
<td>40</td>
<td>49</td>
</tr>
<tr>
<td>$V_{\text{OCSV~HY}}$</td>
<td>LED string open fault detection voltage hysteresis</td>
<td>$V_{UV}&gt;V_{UVTH}$, measured at $(V_{INB}-V_{OUTx})$, voltage rising</td>
<td>●</td>
<td>20</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$I_{\text{SLSTH}}$</td>
<td>SLSTH pin output current</td>
<td></td>
<td>●</td>
<td>30</td>
<td>32</td>
<td>34</td>
</tr>
<tr>
<td>$V_{\text{SLSTH~RG}}$</td>
<td>Maximum voltage threshold of single LED short detection</td>
<td>(Note 3)</td>
<td></td>
<td>8.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{\text{SLSTH}}$</td>
<td>Single LED short detection voltage</td>
<td>Voltage falling, $R_{\text{SLSTH}}=30k\Omega$</td>
<td>●</td>
<td>2.64</td>
<td>2.88</td>
<td>3.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Voltage falling, $R_{\text{SLSTH}}=51k\Omega$</td>
<td>●</td>
<td>4.546</td>
<td>4.896</td>
<td>5.2</td>
</tr>
<tr>
<td>$V_{\text{SLSTH~HY}}$</td>
<td>Single LED short detection voltage hysteresis</td>
<td></td>
<td>●</td>
<td>100</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$t_{\text{FBDEL}}$</td>
<td>LED string open/short and single LED short fault reporting delay time</td>
<td>No PWM dimming and/or tester testing and correlation using Statistical methods</td>
<td>●</td>
<td>2.8</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>$T_{\text{RO}}$</td>
<td>Thermal roll-off activation temperature</td>
<td>(Note 3)</td>
<td></td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$T_{\text{SD}}$</td>
<td>Over temperature shutdown</td>
<td>Temperature increasing (Note 3)</td>
<td></td>
<td>175</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$T_{\text{SDHY}}$</td>
<td>Over temperature hysteresis</td>
<td>Recovery= $T_{\text{SD}}-T_{\text{SDHY}}$ (Note 3)</td>
<td></td>
<td>20</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

**Note 3:** Guaranteed by design.

**Note 4:** Limits are 100% production tested at -40°C, 25°C and 125°C. Limits over the full operating temperature range verified through either bench and/or tester testing and correlation using Statistical methods.
TYPICAL PERFORMANCE CHARACTERISTICS

**Figure 2**  $\text{I}_{\text{IN}}$ vs. $\text{V}_{\text{INA}}$

**Figure 3**  $\text{ISD}$ vs. $\text{V}_{\text{INA}}$

**Figure 4**  $\text{I}_{\text{FAULT}}$ vs. $\text{V}_{\text{INA}}$

**Figure 5**  $\text{I}_{\text{OUT}}$ vs. $\text{V}_{\text{INA}}$

**Figure 6**  $\text{I}_{\text{OUT}}$ vs. $\text{V}_{\text{INA}}$

**Figure 7**  $\text{I}_{\text{OUT}}$ vs. $\text{V}_{\text{INA}}$
Figure 8  $I_{\text{OUT}}$ vs. $V_{HR}$

Figure 9  $I_{\text{OUT}}$ vs. $V_{HR}$

Figure 10  $I_{\text{OUT}}$ vs. $V_{HR}$

Figure 11  $I_{\text{OUT}}$ vs. Temperature (Thermal Roll-Off)

Figure 12  $I_{\text{OUT,L}}$ vs. Temperature

Figure 13  $V_{UVTH}$ vs. Temperature
Figure 14  $I_{\text{MODE}}$ vs. Temperature

Figure 15  $V_{\text{IN, UV}}$ vs. Temperature

Figure 16  $V_{\text{SLSTH}}$ vs. Temperature

Figure 17  $I_{\text{SLSTH}}$ vs. Temperature

Figure 18  $V_{\text{SET}}$ vs. Temperature

Figure 19  $V_{\text{SLSTH}}$ vs. $R_{\text{SLSTH}}$
Figure 20  $I_{OUT}$ vs. $R_{SET}$

Figure 21  $I_{OUT}$ vs. Duty Cycle

Figure 22  $I_{OUT}$ vs. Duty Cycle

Figure 23  $I_{OUT}$ vs. Duty Cycle

Figure 24  $I_{OUT}$ vs. Duty Cycle

Figure 25  $I_{OUT}$ vs. Duty Cycle
Figure 38  PWM Off
APPLICATION INFORMATION

The IS32LT3147 device is a six-channel linear LED driver with individual PWM dimming. A single resistor sets the output current for all six channels. Each channel has up to 75mA current capability, resulting in a 450mA current capability when paralleled. A current source output architecture allows LED common-cathode connection to ground. The thermal shunt mechanism helps to efficiently optimize the thermal stress on the driver.

UNDERVOLTAGE-LOCKOUT (UVLO)

IS32LT3147 features an undervoltage-lockout (UVLO) function on the VINA pin to prevent indeterminate operation at too low input voltages. UVLO threshold is an internally fixed value and cannot be adjusted. The device is enabled when the VINA voltage exceeds $V_{INA,UV}$ (Typ. 4.7V) and disabled when the VINA voltage falls below $(V_{INA,UV}-V_{INA,UVHY})$ (Typ. 4.42V).

OUTPUT CURRENT SETTING

The regulated LED current (up to 75mA) per channel is set by a resistor ($R_{ISET}$) from ISET pin to GND. The programming resistor is computed using the following Equation:

$$R_{ISET} = \frac{V_{SET}}{I_{OUT}} \times 404 \quad (1)$$

(6.2k$\Omega \leq R_{ISET} \leq 46.5k\Omega$) and $V_{SET} = 1.15V$ (Typ.). Where, $R_{ISET}$ is in $\Omega$ and $I_{OUT}$ is the desired current of each channel in Amps.

It is recommended that $R_{ISET}$ be a 1% accuracy resistor with good temperature characteristics to ensure a stable output current. The $R_{ISET}$ resistor must be placed as close as possible to the ISET pin on PCB layout to avoid noise interference and ground bounce.

The device is protected from an output overcurrent condition caused by the $R_{ISET}$ resistor. The output channel current is limited to an $I_{OUT,L}$ value of 120mA (Typ.) should the ISET pin be shorted or if a low value resistor is connected to the ISET pin.

Unused channel(s) must have its corresponding PWM pin connected to GND to disable it and its corresponding OUTx pin connected to the VINB pin to avoid a false fault detection.

THERMAL SHUNT MECHANISM

For any linear constant current LED driver, the power dissipation on the driver always depends on the voltage drop on the driver and the output current.

As Figure 40, the power dissipation on the driver can be calculated by following equation:

$$P_{DRIVER} = V_{HR} \times I_{OUT} = (V_{BAT} - V_{STRING}) \times I_{OUT} \quad (2)$$

According to above equation, a higher input voltage will result in more power dissipation on the driver. A power resistor, $R_s$, can be added to shunt some power from the driver. The power dissipation on the driver becomes:

$$P_{DRIVER} = V_{HR} \times I_{OUT} = (V_{BAT} - R_s \times I_{OUT} - V_{STRING}) \times I_{OUT} \quad (3)$$

Since the internal circuit current consumption of the linear LED driver is negligible compared to $I_{OUT}$, therefore $V_{VIN}$ is equal to $I_{OUT}$.

A large $R_s$ value is able to significantly lower the power dissipation on the driver for high voltage inputs. Note the automotive battery voltage range of 9V to 16V requires careful consideration of $R_s$ value.
large Rs will result in insufficient headroom operating voltage (V_{HR}) for the driver at the low input voltage causing a drop in the output current. To solve this, the IS32LT3147 features a thermal shunt mechanism of two current input paths, VINA pin and VINB pin. VINA is connected directly to the power supply and VINB is connected to the power supply via a thermal shunt resistor in series. As below Figure 41.

The thermal shunt mechanism default current path is through the VINB pin. However, when the input voltage, V_{BAT}, is at the low level, the thermal shunt resistor R_{SHUNT} will limit the current through the VINB path so the majority of current will instead flow through the VINA path. Diverting current to the VINA path will ensure sufficient headroom operating voltage (V_{HR}) so the driver can maintain a constant output current. As the V_{BAT} input voltage increases, the device gradually diverts more input current from the VINA path to the VINB path. The resistor R_{SHUNT} can significantly shunt power from the driver at high input voltages to maintain the driver’s junction temperature at a reasonable level. If the thermal shunt mechanism is not implemented, connect both VINA and VINB pins to the power supply.

As shown in Figure 42, the IS32LT3147 has different operating areas when using the thermal shunt mechanism. Within the Low Headroom Area, the input voltage is too low for current regulation. Even though all input current flows through the VINA path, the headroom voltage is insufficient to reach the operating value. So the power dissipation on the driver is minimal. When the input voltage rises above (V_{OUT\_MAX}+V_{HR\_MIN}), the transition voltage V_{TR} splits the operation into two areas: Thermal Shunt Area and Thermal Increasing Area.

Thermal Shunt Area:
The IS32LT3147 channels operate in constant regulator mode when the input voltage rises above (V_{OUT\_MAX}+V_{HR\_MIN}). The majority of input current is gradually transferred from the VINA path to the VINB path. Therefore, the power dissipation on R_{SHUNT} increases and the power dissipation on the driver remains at a reasonable low level. The VINB path current can be calculated by:

\[ I_{VINB} = \frac{V_{BAT} - V_{OUT\_MAX} - V_{HR\_MIN}}{R_{SHUNT}} \]  

Where, \( V_{OUT\_MAX} \) is the maximum voltage of all OUTx pins. \( V_{HR\_MIN} \) is the minimum headroom voltage.

The VINA path current is:

\[ I_{VINA} = (I_{OUT} \times N - I_{VINB}) + I_{IN} \]  

Where, \( I_{IN} \) is the power supply quiescent current. \( N \) is the number of the channels in use.

The power dissipation on the R_{SHUNT} resistor is:

\[ P_{SHUNT} = \frac{(V_{BAT} - V_{OUT\_MAX} - V_{HR\_MIN})^2}{R_{SHUNT}} \]  

The power dissipation on the IS32LT3147 is:

\[ P_{3147\_TS4} = V_{BAT} \times (I_{OUT} \times N + I_{IN}) - \frac{(V_{BAT} - V_{OUT\_MAX} - V_{HR\_MIN})^2}{R_{SHUNT}} \]

\[ \sum_{x=1}^{N} (I_{OUT} \times V_{OUTx}) \]

Thermal Increasing Area:
When the input voltage is equal or greater than the Transition Voltage V_{TR}, all the input current flows through R_{SHUNT} into the VINB pin. The power dissipation on the R_{SHUNT} resistor is constant. And the power dissipation on the driver increases linearly. V_{TR} voltage point can be adjusted by the resistance value of R_{SHUNT}.

\[ V_{TR} = R_{SHUNT} \times I_{OUT} \times N + V_{OUT\_MAX} + V_{ABTR} \]  

To optimize the power dissipation on the driver, R_{SHUNT} value should be chosen to make sure the V_{TR} is equal to the maximum input voltage, typically 16V for 12V automotive system applications.

\[ R_{SHUNT\_16V} = \frac{16V - V_{OUT\_MAX} - V_{ABTR}}{I_{OUT} \times N} \]

Where, R_{SHUNT\_16V} is the thermal shunt resistor value to make V_{TR}=16V. V_{ABTR} is the voltage threshold of input current full transition from VINA path to VINB path. N is the number of the channels in use.
However, a large $R_{SHUNT}$ value with low $V_{INA}$ results in a low drop output voltage from the VINB pin to the OUTx pin. Since the LED string open protection is achieved by detecting this drop out (refer to the "LED STRING OPEN PROTECTION" section), a large $R_{SHUNT}$ value could falsely trigger the LED string open protection at low input voltages. To prevent false triggering, the fault undervoltage-lockout voltage threshold $V_{FLT_UVLO}$ should be set so that the maximum OUTx voltage plus 1.5V margin is > than 9V (refer to the "UV PIN FUNCTION" section). Therefore, the maximum power shunt resistor value is limited by the $V_{FLT_UVLO}$ value. It can be calculated by:

$$R_{SHUNT(MAX)} = \frac{V_{FLT_UVLO} - V_{OUT_MAX}}{6mA \times N}$$  \hspace{1cm} (10)

Where, 6mA is a typical output current level, below which the drop output voltage ($V_{INB} - V_{OUT}$) would be too low and falsely trigger the LED string open fault protection. N is the number of the channels in use.

If the calculated $R_{SHUNT_16V}$ is lower than the calculated $R_{SHUNT_MAX}$, the final $R_{SHUNT}$ value should be $R_{SHUNT_16V}$ otherwise choose $R_{SHUNT_MAX}$.

The power dissipation on the $R_{SHUNT}$ resistor is constant at maximum value which can be calculated by:

$$P_{SHUNT_MAX} = R_{SHUNT} \times (I_{OUT} \times N)^2$$  \hspace{1cm} (12)

The power rating of $R_{SHUNT}$ should be carefully considered. A single high wattage resistor or several small wattage resistors in parallel can be used to sustain the power dissipation.

**DEVICE ENABLE AND SHUTDOWN**

The device doesn’t have a dedicated enable pin however pull all PWMx pins below $V_{IL}$ to turn off all channels. Keep the PWMx pins low for longer than $t_{SD}$ to force the device into shutdown mode with a low standby current. When any PWMx pin is pulled high (> $V_{IH}$), the device will be enabled.

**PWM DIMMING**

The device features a dedicated PWM pin for each output channel to control the current source. The voltage at the PWM pin should be higher than $V_{IH}$ to enable the corresponding output channel and lower than $V_{IL}$ to disable it.

An external PWM signal on the PWMx pins can be used to modulate the output current to dim the LED light output. The PWM dimming output current is based on the PWM signal’s duty cycle and can be calculated by the following Equation:

$$I_{OUT\_PWM} = I_{OUT} \times D_{PWM}$$  \hspace{1cm} (13)

Where $D_{PWM}$ is the duty cycle of the PWM signal.

The recommended frequency range of the external PWM signal is 100Hz~1kHz and the duty cycle range can be from 0 to 100%. Due to the output current slew rate control for EMI consideration plus propagation delay time from PWM rising edge to the output activity, a lower frequency PWM will provide a better dimming linearity and contrast ratio.

All PWMx pins are high-voltage tolerant, however if the voltage applied on them is possibly higher than the $V_{INA}$ and VINB pins voltage at any time, a series resistor (recommended value is 10kΩ) for each PWM pin is required to limit the current flowing into it. Since the VINB pin voltage may be regulated down close to the LED string forward voltage by the thermal shunt mechanism, a series resistor for each PWM pin must be added in most applications. If the PWM dimming function of any channel is not implemented, connect its corresponding PWM pin to the $V_{INA}$ pin via a 10kΩ series resistor. As shown in Figure 44.
FAULT PROTECTION AND REPORTING

For robust system reliability, the IS32LT3147 integrates detection circuitry to protect various fault conditions and report the fault conditions on the FAULTB pin which can be monitored by an external host. The fault protections include LED string open/shorted, single LED shorted, ISET pin open/shorted, thermal roll-off (not reported) and thermal shutdown. The FAULTB pin will go low when the device detects a fault condition.

The FMODE is a fault action mode set pin. Connecting a proper value resistor, $R_{FMODE}$, from this pin to GND to select various modes of the action when a fault being detected. Refer to Table 1 ~ Table 3. If $R_{FMODE} = 0\, \Omega$ or $27\, \Omega$, the fault action is in “One Fail All Fail” mode which means if any channel encounters a fault then all other normal channels will be turned off. In this mode, the FAULTB pin supports both input and output functions. If $R_{FMODE} = 62\, \Omega$ or $150\, \Omega$, the fault action is in “One Fail Other On” mode which means if any channel encounters a fault then all other normal channels will continue normal operation. In this mode, the FAULTB pin supports output function only.

### Table 1 $R_{FMODE}$ Resistance Versus Fault Actions

<table>
<thead>
<tr>
<th>$R_{FMODE}(\Omega)$</th>
<th>Fault Action</th>
<th>Single LED Short</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>One Fail All Fail Mode</td>
<td>Retry Current in Faulty Channel</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>Latched Off Device</td>
</tr>
<tr>
<td>62</td>
<td>One Fail Other On Mode</td>
<td>Retry Current in Faulty Channel</td>
</tr>
<tr>
<td>150</td>
<td></td>
<td>Fully On</td>
</tr>
</tbody>
</table>

In the “One Fail All Fail” mode, the FAULTB pin supports both input and output functions. Externally pulling FAULTB pin low will disable all outputs, so the FAULTB pin is not allowed to float in this mode. An external resistor, $R_{FAULTB}$, must be added to pull up FAULTB pin above 2.3V for normal operation. The recommended resistor value is $47\, \Omega$. For lighting systems with multiple IS32LT3147 drivers which requires the complete lighting system be shut down when a fault is detected, the FAULTB pin can be used in a parallel connection. A fault output by one device will pull low the FAULTB pins of the other parallel connected devices and simultaneously turn them all off. This satisfies the multiple devices “One Fail All Fail” operating requirement.

**UV PIN FUNCTION**

The UV pin with a resistor divider from VINA is to program an undervoltage-lockout threshold for LED string open and single LED shorted fault detections. This helps to prevent false fault detection due to the insufficient power supply voltage, such as caused by a power rail transient. The UV pin voltage must be higher than $V_{UVTH}$ to enable fault detection and lower than $(V_{UVTH}-V_{UVTH, HY})$ to disable.

### LED STRING OPEN PROTECTION

The LED string open detection is enabled after VINA voltage rising above a setting fault undervoltage-lockout threshold, $V_{FLT_UVLO}$. If any LED string is open, the corresponding OUTx pin will be pulled up close to VINB by its internal current source. When $V_{INAX,FLT_UVLO}$ and the drop out voltage from the VINB pin to the OUTx pin, $(V_{INB,OUTx})$, falls below the LED string open detection voltage, $V_{OCDV}$, and persists for longer than the fault reporting delay time $t_{DEL}$ (2.5ms when PWM is 100% on or 8 continuous PWM cycles when the PWM dimming is implementing), the LED string open fault protection will be triggered and the FAULTB pin will go low to report the fault condition.
The faulty channel will reserve a retry current \( I_{RTR} \) for recovery detection. The \( R_{FMODE} \) value on the FMODE pin decides the fault action. If the \( R_{FMODE} = 0 \) or 27k\( \Omega \), the fault protection mode is “One Fail All Fail” mode, so all other normal channels will be turned off. If the \( R_{FMODE} = 62k \Omega \) or 150k\( \Omega \), the fault protection mode is “One Fail Other On” mode which means that all other normal channels will keep normal operation. No matter in which fault protection mode, the device recovers to normal operation and the FAULTB pin will go back to high impedance once the open condition is removed. (\( V_{INB}-V_{OUTx} \) rising above the LED string open detection voltage, \( V_{OCV}+V_{OCV HY} \)).

**LED STRING SHORT PROTECTION**

The LED string short condition is detected if any one of the OUTx pin voltage is lower than LED string short detection voltage, \( V_{SCV} \). Once a short condition occurs and persists for longer than the fault reporting delay time \( t_{FBDEL} \) (2.5ms when PWM is 100\% on or 8 continuous PWM cycles when the PWM dimming is implementing), the LED string short protection will be triggered and the FAULTB pin will go low to report the fault condition. The faulty channel will reserve a retry current \( I_{RTR} \) for recovery detection. The fault action is decided by the \( R_{FMODE} \) resistor as well. If the \( R_{FMODE} = 0 \) or 27k\( \Omega \), the fault protection mode is “One Fail All Fail” mode, so all other normal channels will be turned off. If the \( R_{FMODE} = 62k \Omega \) or 150k\( \Omega \), the fault protection mode is “One Fail Other On” which means that all other normal channels will keep normal operation. No matter in which fault mode, the device will recover to normal operation and the FAULTB pin will go back to high impedance once the short condition is removed, the OUTx pin voltage rising above the LED string short detection voltage, \( V_{SCV}+V_{SCV HY} \).

**SINGLE LED SHORT DETECTION**

The IS32LT3147 supports single LED short detection which is implemented by detecting the OUTx pins voltage. The detection is enabled/disabled by UV pin as well to prevent insufficient power supply VIN voltage. The detection is enabled/disabled by UV pin which is implemented by detecting the OUTx pins open protection will be triggered. All channels will be turned off and the FAULTB pin will go low to report the fault condition. The fault action also is decided by the \( R_{FMODE} \) resistor. As Table 1.

In the “One Fail All Fail” mode, all other normal channels will be turned off. If the \( R_{FMODE} = 0 \), the faulty channel will reserve a retry current \( I_{RTR} \) for recovery detection. If \( R_{FMODE} = 27k \Omega \), the device will latch in completely off state, including the faulty channel, until power cycle.

In the “One Fail Other On” mode, all other normal channels will keep normal operation. If the \( R_{FMODE} = 62k \Omega \), the faulty channel will reserve a retry current \( I_{RTR} \) for recovery detection as well. If the \( R_{FMODE} = 150k \Omega \), the faulty channel will be fully on that means all channels are fully on and report the fault condition only. Besides the latched off mode of \( R_{FMODE}=27k \Omega \), the device will recover to normal operation and the FAULTB pin will go back to high impedance once the single LED short condition is removed, \( V_{OUTx} \) rising above the single LED short detection voltage, \( V_{SLSTH}+V_{SLSTH HY} \).

If the single LED short protection is unused, please connect the SLSTH pin to ground.

**ISET PIN OPEN/SHORT PROTECTION**

If the ISET pin is left open or a large value resistor \( (>R_{SET OC}) \) is connected to it, and persists for longer than fault detection deglitch time \( t_{FBOT} \), the ISET pin open protection will be triggered. All channels will be turned off and the FAULTB pin will go low to report the fault condition.

The device is protected from an output overcurrent condition caused by \( R_{SET} \) resistor. All output current is limited to an \( I_{OUT L} \) value of 120mA in case of the ISET pin is shorted or too low value resistor \( (<R_{SET SC}) \) is connected to the ISET pin. If the condition persists for longer than \( t_{FBOT} \), the ISET pin short protection will be triggered. All channels will be turned off and the FAULTB pin will go low to report the fault condition.

Once the resistance from the ISET pin to GND resumes to a normal range, all channels will recover to normal operation and the FAULTB pin will go back to high impedance.

**THERMAL ROLL-OFF PROTECTION**

The output current will be equal to the set value as long as the junction temperature of the IC remains below \( T_{RO} \) (Typ. 150°C). If the junction temperature...
exceeds this threshold, the output current of all channels will begin to reduce at a rate of about 3.7%/°C until thermal shutdown protection following the junction temperature ramping up. Thermal roll-off protection won’t be reported by the FAULTB pin.

THERMAL SHUTDOWN PROTECTION

In the event that the junction temperature exceeds $T_{SD}$ (Typ. 175˚C), all channels will go to the “OFF” state and FAULTB pin will pull low to report the fault condition. At this point, the IC presumably begins to cool off. Any attempt to toggle the outputs back to the source condition before the IC cooled to below ($T_{SD}$ - $T_{SDHY}$) (Typ. 155˚C) will be blocked and the IC will not be allowed to restart. The FAULTB pin will recover to high impedance once the IC has cooled down.
## Table 2  “One Fail All Fail” Mode Fault Actions

<table>
<thead>
<tr>
<th>UV Pin</th>
<th>Fault Type</th>
<th>Fault Condition</th>
<th>Output State</th>
<th>FAULTB Pin (with Input Function)</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED string open</td>
<td>V_{UV}&lt;\left(V_{UV_{TH}}-V_{UV_{TH_{HY}}}/2\right)</td>
<td>Disabled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED string short</td>
<td>V_{OUT}&lt;V_{SCV}</td>
<td>Faulty channel outputs (I_{\text{TR}}) for recovery detection and other channels off</td>
<td>Pull low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED string short</td>
<td>V_{OUT}&gt;\left(V_{SCV}+V_{SCV_{HY}}\right)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single LED short</td>
<td>ISET pin to GND resistance&gt;(R_{\text{SET,OC}})</td>
<td>All channels off</td>
<td>Pull low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single LED short</td>
<td>ISET pin to GND resistance&lt;(R_{\text{SET,SC}})</td>
<td>All channels off</td>
<td>ISET pin to GND resistance resumes to normal range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shutdown</td>
<td>T_{J}&gt;T_{SD}</td>
<td>All channels off</td>
<td>High impedance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal rolloff</td>
<td>T_{J}&gt;T_{RO}</td>
<td>Output current of all channels linearly decreases toward zero following (T_J) increasing</td>
<td>(T_{J}&lt;T_{RO})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED string open</td>
<td>(V_{INB}-V_{OUT})&lt;V_{OCV}</td>
<td>Faulty channel outputs (I_{\text{TR}}) for recovery detection and other channels off</td>
<td>V_{OUT}&gt;(V_{SCV}+V_{SCV_{HY}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED string short</td>
<td>V_{OUT}&lt;V_{SCV}</td>
<td>Faulty channel outputs (I_{\text{TR}}) for recovery detection and other channels off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single LED short</td>
<td>V_{OUT}&lt;V_{ILSTH}</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shutdown</td>
<td>T_{J}&gt;T_{SD}</td>
<td>All channels off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal rolloff</td>
<td>T_{J}&gt;T_{RO}</td>
<td>Output current of all channels linearly decreases toward zero following (T_J) increasing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Table 3  “One Fail Other On” Mode Fault Actions

<table>
<thead>
<tr>
<th>UV Pin</th>
<th>Fault Type</th>
<th>Fault Condition</th>
<th>Output State</th>
<th>FAULTB Pin (without Input Function)</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED string open</td>
<td>V_{UV}&lt;(V_{UV,TH})</td>
<td>Disabled</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED string short</td>
<td>V_{OUTx}&lt;V_{SCV}</td>
<td>Faulty channel outputs l_{TH} for recovery detection and other channels on</td>
<td>Pull low</td>
<td>V_{OUTx}&gt;(V_{SCV}+V_{SCV,H})</td>
</tr>
<tr>
<td></td>
<td>Single LED short</td>
<td>V_{UV}&lt;V_{UV,TH}</td>
<td>Disabled</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ISET open</td>
<td>ISET pin to GND resistance&gt; R_{SET,OC}</td>
<td>All channels off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ISET short</td>
<td>ISET pin to GND resistance&lt; R_{SET,SC}</td>
<td>All channels off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal shutdown</td>
<td>T_J&gt;T_{SD}</td>
<td>All channels off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal roll-off</td>
<td>T_J&gt;T_{RO}</td>
<td>Output current of all channels linearly decreases toward zero following T_J increasing</td>
<td>High impedance</td>
<td>T_J&lt;T_{RO}</td>
</tr>
<tr>
<td></td>
<td>LED string open</td>
<td>(V_{INB}-V_{OUTx})&lt;V_{OCV}</td>
<td>Faulty channel outputs l_{TH} for recovery detection and other channels on</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED string short</td>
<td>V_{OUTx}&lt;V_{SCV}</td>
<td>Faulty channel outputs l_{TH} for recovery detection and other channels on</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Single LED short</td>
<td>V_{OUTx}&lt;V_{BLSTH}</td>
<td>R_{MODE} = 62kΩ</td>
<td>Faulty channel outputs l_{TH} for recovery detection and other channels on</td>
<td>Pull low</td>
</tr>
<tr>
<td></td>
<td>ISET open</td>
<td>ISET pin to GND resistance&gt; R_{SET,OC}</td>
<td>All channels off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ISET short</td>
<td>ISET pin to GND resistance&lt; R_{SET,SC}</td>
<td>All channels off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal shutdown</td>
<td>T_J&gt;T_{SD}</td>
<td>All channels off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermal roll-off</td>
<td>T_J&gt;T_{RO}</td>
<td>Output current of all channels linearly decreases toward zero following T_J increasing</td>
<td>High impedance</td>
<td>T_J&lt;T_{RO}</td>
</tr>
</tbody>
</table>

**THERMAL CONSIDERATIONS**

The package thermal resistance, θ_{JA}, determines the amount of heat that can pass from the silicon die to the surrounding ambient environment. The θ_{JA} is a measure of the temperature rise created by power dissipation and is usually measured in degree Celsius per watt (°C/W). The junction temperature, T_J, can be calculated by the rise of the silicon temperature, ΔT, the power dissipation on IS32LT3147, P_{3147}, and the package thermal resistance, θ_{JA}, as in Equation (18):

\[
T_J = T_A + ΔT = T_A + P_{3147} × θ_{JA}
\]  

(18)

The P_{3147} is described in the “Thermal Shunt Mechanism” section.

When operating the chip at high ambient temperatures, or when the supply voltage is high, care must be taken to avoid exceeding the package power dissipation limits. The maximum power dissipation at T_A=25°C can be calculated using the following Equation (19):

\[
T_J = T_A + ΔT = T_A + P_{3147} × θ_{JA}
\]  

(19)
\[ P_{D(MAX)} = \frac{150^\circ C - 25^\circ C}{\theta JA} \] (19)

So,
\[ P_{D(MAX)} = \frac{150^\circ C - 25^\circ C}{31.8^\circ C/W} \approx 3.93W \]

for eTSSOP-20 package.

Figure 46, shows the power derating of the IS32LT3147 on a JEDEC board (in accordance with JESD 51-5 and JESD 51-7) standing in still air.

In the thermal shunt application, the \( R_p \) will share quite a lot power dissipation; therefore its package power rating should be sufficient to prevent heat run away.
## CLASSIFICATION REFLOW PROFILES

<table>
<thead>
<tr>
<th>Profile Feature</th>
<th>Pb-Free Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preheat &amp; Soak</strong></td>
<td></td>
</tr>
<tr>
<td>Temperature min (Tmin)</td>
<td>150°C</td>
</tr>
<tr>
<td>Temperature max (Tmax)</td>
<td>200°C</td>
</tr>
<tr>
<td>Time (Tmin to Tmax) (ts)</td>
<td>60-120 seconds</td>
</tr>
<tr>
<td>Average ramp-up rate (Tmax to Tp)</td>
<td>3°C/second max.</td>
</tr>
<tr>
<td>Liquidous temperature (TL)</td>
<td>217°C</td>
</tr>
<tr>
<td>Time at liquidous (tL)</td>
<td>60-150 seconds</td>
</tr>
<tr>
<td>Peak package body temperature (Tp)*</td>
<td>Max 260°C</td>
</tr>
<tr>
<td>Time (tp)** within 5°C of the specified classification temperature (Tc)</td>
<td>Max 30 seconds</td>
</tr>
<tr>
<td>Average ramp-down rate (Tp to Tmax)</td>
<td>6°C/second max.</td>
</tr>
<tr>
<td>Time 25°C to peak temperature</td>
<td>8 minutes max.</td>
</tr>
</tbody>
</table>

---

**Figure 48** Classification Profile
PACKAGE INFORMATION

eTSSOP-20

NOTES:
1) The thermal pad shows different shape among different factories.
2) Controlling dimension: mm
3) Reference document: JEDEC MO-153
IS32LT3147

RECOMMENDED LAND PATTERN

eTSSOP-20

Note:
1. Land pattern complies to IPC-7351.
2. All dimensions in MM.
3. This document (including dimensions, notes & specs) is a recommendation based on typical circuit board manufacturing parameters. Since land pattern design depends on many factors unknown (eg. user’s board manufacturing specs), user must determine suitability for use.
### REVISION HISTORY

<table>
<thead>
<tr>
<th>Revision</th>
<th>Detail Information</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Initial release</td>
<td>2022.03.03</td>
</tr>
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