MLX160A0XY3-SRZ Non-Isolated DC-DC Power Module

7.0\textsubscript{DC} - 14\textsubscript{DC} input; 0.45\textsubscript{DC} to 2.0\textsubscript{DC} output; 160A Output Current

RoHS Compliant

Applications
- High performance ASIC with dual power rails
- Networking processor power (Broadcom, Cavium, Marvell, NXP)
- High current FPGA power (Xilinx, Intel)
- High performance ARM processor power
- Telecommunications and networking equipment
- Servers and storage applications
- Test and Measurement equipment
- Industrial equipment

Features
- Compliant to IPC-9592 (Sept. 2008), Category 2, Class 2
- Compliant to REACH Directive (EC) No 1907/2006
- Compatible with a Pb-free or SnPb reflow soldering process
- Wide Input voltage range: 7.0\textsubscript{DC}-14\textsubscript{DC}
- Output voltage programable from 0.45\textsubscript{DC} to 2.0\textsubscript{DC} via PMBus\textsuperscript{™}
- Delivers up to 160 A\textsubscript{DC} output current
- Supports Voltage Rails requiring 3% tolerance
- Operation of up to 4 Satellite phases in parallel(160A) as a common or separate bus.
- PID control and multi-phase operation provides fast transient response, reduced output capacitance, and stability.
- Tightly regulated output voltage
- Low output ripple and noise
- Fixed switching frequency
- Small size: 12.9 mm x 39 mm x 11.05 mm
- 0.507 in x 1.535 in x 0.435 in
- Digital interface compliant to PMBus\textsuperscript{™} Rev.1.3 protocol
- Programmable enable logic with On/Off Control
- Protections: OVP, UVP, OCP, OTP
- Cycle-by-cycle output current monitoring and protection
- Over temperature protection
- Wide operating temperature range -40°C to 85°C
- Excellent Thermal Performance – Module delivers full output @12V\textsubscript{IN}, 1V\textsubscript{OUT}, 70°C ambient and 200 LFM (1m/ s) airflow
- Power Stages are Interleaved to reduce input and output ripple.
- UL* 62368-1, 3rd Ed. Recognized, and VDE (EN62368-1 3rd Ed.) Licensed
- ISO** 9001 and ISO14001 certified manufacturing facilities

* UL is a registered trademark of Underwriters Laboratories, Inc.
† CSA is a registered trademark of Canadian Standards Association.
‡ VDE is a trademark of Verband Deutscher Elektrotechniker e.V.
** ISO is a registered trademark of the International Organization of Standards.
* The PMBus name and logo are registered trademarks of the System Management Interface Forum (SMIF).
**Technical Specifications**

### Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only. Operational functionality of the device is not implied at these or any other conditions in the excess of those given in the operations sections of the data sheet. Exposure to the absolute maximum ratings for extended periods may adversely affect the device reliability.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage (continuous)</td>
<td>(V_{\text{IN}})</td>
<td>-0.3</td>
<td>14.5</td>
<td>V</td>
</tr>
<tr>
<td>Operating Ambient Temperature</td>
<td>(T_{\text{A}})</td>
<td>-40°</td>
<td>85°</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td></td>
<td>-55°</td>
<td>125°</td>
<td>°C</td>
</tr>
</tbody>
</table>

* At \(-40°C\) and \(7\text{Vin}\), module may experience a few hiccup cycles before starting into full load

**CAUTION: This power module is not internally fused. An input line fuse must always be used.**

This power module can be used in a wide variety of applications, ranging from simple standalone operation to an integrated part of sophisticated power architecture. To preserve maximum flexibility, internal fusing is not included, however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require fast-acting fuses with a maximum rating of 60 A and two x 40A in the ungrounded input. Two x 40A fuses are recommended for input voltage <8A (see Safety Considerations section). Based on the information provided in this Data Sheet on inrush energy and maximum dc input current, the same type of fuse with a lower rating can be used. Refer to the fuse manufacturer’s Data Sheet for further information.

### Recommended Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{\text{OUTx_SENx, IMON_SATx, TSEN, PWM_SATx, VRRDYx, VR_ENx, PROG, VRHOT, WARN#/GP}})</td>
<td></td>
<td>0</td>
<td>4</td>
<td>V</td>
</tr>
<tr>
<td>(\text{SM_DAT, SM_CLK, SM_ALERT#})</td>
<td></td>
<td>0</td>
<td>5.5</td>
<td>V</td>
</tr>
</tbody>
</table>

### Electrical Specifications

Unless otherwise indicated, specifications apply for all operating input voltages, resistive load and temperature conditions.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Input Voltage</td>
<td>All</td>
<td>(V_{\text{IN}})</td>
<td>7.0</td>
<td>14</td>
<td>V_{\text{DC}}</td>
<td></td>
</tr>
<tr>
<td>Maximum Input Current</td>
<td>All</td>
<td>(I_{\text{IN,max}})</td>
<td>49.2</td>
<td>A_{\text{DC}}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>((V_{\text{IN}}) = 7.0V to 14V, (I_{\text{O}}) = (I_{\text{O,max}}))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input No Load Current</td>
<td>(V_{\text{O,set}} = 0.45V_{\text{DC}})</td>
<td>(I_{\text{IN,load}})</td>
<td>182</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>((V_{\text{IN}}) = 12V_{\text{DC}}, (I_{\text{O}}) = 0, module enabled)</td>
<td>(V_{\text{O,set}} = 2.0V_{\text{DC}})</td>
<td>(I_{\text{IN,load}})</td>
<td>282</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Stand-by Current</td>
<td>All</td>
<td>(I_{\text{IN,stand-by}})</td>
<td>52</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>((V_{\text{IN}}) = 12V_{\text{DC}}, module disabled)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inrush Transient</td>
<td>All</td>
<td>(I_{\text{t}})</td>
<td>1.26</td>
<td>A_{p}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Reflected Ripple Current</td>
<td>All</td>
<td>(I_{\text{O,peak}})</td>
<td>42</td>
<td>mA_{p}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak-to-peak (5Hz to 20MHz, 1(\mu)H source impedance; (V_{\text{IN}}) = 7.0 to 14V, (I_{\text{O}}) = (I_{\text{O,max}}))</td>
<td>See Test Configurations</td>
<td>(I_{\text{O,peak}})</td>
<td>53.4</td>
<td>dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Ripple Rejection (120Hz)</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.6/+1.8</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage Set-point accuracy over entire output range</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 0.45</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.6/+/1.8</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 0.6</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.6/+/1.3</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 0.7</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.5/+/1.1</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 0.8</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.5/+/0.9</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 0.9</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.4/+/0.8</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 1.0</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.4/+/0.7</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 1.2</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.3/+/0.5</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 1.8</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.3/+/0.2</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 85°C, (V_{\text{O}}) = 2.0</td>
<td>All</td>
<td>(V_{\text{O, set}})</td>
<td>-0.4/+/0.2</td>
<td>%(V_{\text{O, set}})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Technical Specifications (continued)

Electrical Specifications (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage Set-point accuracy over entire output range</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-1.9/+1.8</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 0.45$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-1.5/+1.3</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 0.6$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-1.3/+1.1</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 0.7$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-1.2/+0.9</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 0.8$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-1.0/+0.8</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 0.9$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-1.0/+0.7</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 1.0$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-0.8/+0.5</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 1.2$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-0.7/+0.2</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 1.8$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-0.7/+0.2</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40 to 85°C, $V_o = 2.0$</td>
<td>All</td>
<td>$V_{o, \text{set}}$</td>
<td>-0.7/+0.2</td>
<td>%$V_{o, \text{set}}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
The 5.5V and 3.3V Voltage rails on the module are only to be used to power Satellite units (SLX series) and pull-up resistors needed for the POL module. Use with Pull-up resistors as recommended in the datasheet. Do not use these voltage rails for any other purpose.
### Electrical Specifications (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Regulation</td>
<td>All</td>
<td>$V_{\text{OUT}} &lt; 1\text{V}$</td>
<td>$0.2$</td>
<td>$0.09$</td>
<td>$0.4$</td>
<td>%$V_{\text{O, set}}$</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>$V_{\text{OUT}} \geq 1\text{V}$</td>
<td>$0.2$</td>
<td>$0.09$</td>
<td>$0.4$</td>
<td>%$V_{\text{O, set}}$</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>All</td>
<td>$I_{\text{O, min}}$ to $I_{\text{O, max}}$, $V_{\text{IN}} = \text{V}_{\text{IN, nom}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>$V_{\text{O, set}} &lt; 1\text{V}$</td>
<td>$0.2$</td>
<td>$0.09$</td>
<td>$0.4$</td>
<td>%$V_{\text{O, set}}$</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>All</td>
<td>$I_{\text{O, min}}$ to $I_{\text{O, max}}$, $V_{\text{IN}} = \text{V}_{\text{IN, nom}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMBus Adjustable Output Voltage Range</td>
<td>All</td>
<td></td>
<td>$V_{\text{O, set}}$</td>
<td>$0.45$</td>
<td>$2.00$</td>
<td>DC</td>
</tr>
<tr>
<td>PMBus Output Voltage Adjustment Step Size</td>
<td>All</td>
<td></td>
<td></td>
<td>$3.904$</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Remote Sense Range</td>
<td>All</td>
<td></td>
<td></td>
<td>$0.5$</td>
<td>V DC</td>
<td></td>
</tr>
</tbody>
</table>

### Feature Specifications

Unless otherwise indicated, specifications apply for all operating input voltages, resistive load and temperature conditions. See Feature Descriptions for additional information.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Device</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>On/Off Signal Interface (Negative Logic)#</td>
<td>All</td>
<td>$I_{\text{IH}}$</td>
<td>$1.97$</td>
<td>$5$</td>
<td>$142$</td>
<td>μA, V</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>$V_{\text{IH}}$</td>
<td></td>
<td>$3.3$</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Input High Current</td>
<td>All</td>
<td>$I_{\text{IL}}$</td>
<td>$0$</td>
<td>$5$</td>
<td></td>
<td>μA, V</td>
</tr>
<tr>
<td>Input High Voltage</td>
<td>All</td>
<td>$V_{\text{IL}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logic Low (Module ON)</td>
<td>All</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Low Current</td>
<td>All</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Low Voltage</td>
<td>All</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-On Delay and Rise Times</td>
<td>All</td>
<td>$T_{\text{delay}}$</td>
<td>$2.4$</td>
<td></td>
<td></td>
<td>msec</td>
</tr>
<tr>
<td>(V IN= V IN, nom, IO= I O, max, VO= V O, set) to within ±1% of steady state</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 1: Input power is applied for at least one second and then the On/Off input is enabled (delay from instant at which Von/Off is enabled until VO= 10% of VO, set)</td>
<td>All</td>
<td>$T_{\text{delay}}$</td>
<td>$2.4$</td>
<td></td>
<td></td>
<td>msec</td>
</tr>
<tr>
<td>Case 2: On/Off input is enabled and then input power is applied (delay from instant when V IN= V IN, min until VO= 10% of VO, set)</td>
<td>All</td>
<td>$T_{\text{delay}}$</td>
<td>$1.1$</td>
<td></td>
<td></td>
<td>msec</td>
</tr>
<tr>
<td>Output voltage Rise time (time for VO to rise from 10% of VO, set to 90% of VO, set)</td>
<td>All</td>
<td>$T_{\text{rise}}$</td>
<td>$11.9$</td>
<td></td>
<td></td>
<td>msec</td>
</tr>
<tr>
<td>Output voltage overshoot (TA = 25°C</td>
<td>All</td>
<td></td>
<td></td>
<td>$4.3$</td>
<td>%$V_{\text{O, set}}$</td>
<td></td>
</tr>
</tbody>
</table>

© 2023 OmniOn Power Inc. All rights reserved
Technical Specifications (continued)

Feature Specifications (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over Temperature Protection (See Thermal Considerations section)</td>
<td>All</td>
<td>$T_{OT}$</td>
<td>125</td>
<td>125</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>PMBus Over Temperature Warning Threshold *</td>
<td>All</td>
<td>$T_{WARN}$</td>
<td>110</td>
<td>110</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Input Undervoltage Lockout Turn-on Threshold</td>
<td>All</td>
<td>$V_{DC}$</td>
<td>6.25</td>
<td>6.25</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Input Undervoltage Lockout Turn-off Threshold</td>
<td>All</td>
<td>$V_{DC}$</td>
<td>5.75</td>
<td>5.75</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Hysteresis</td>
<td>All</td>
<td></td>
<td>0.5</td>
<td>0.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>PMBus Input Under Voltage Lockout Thresholds (Do not change)</td>
<td>All</td>
<td>$V_{DC}$</td>
<td>5.75</td>
<td>14</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Resolution of Input Under Voltage Threshold</td>
<td>All</td>
<td></td>
<td>250</td>
<td>250</td>
<td>mV</td>
<td></td>
</tr>
</tbody>
</table>

VRRDYx – PGOOD Equivalent
Signal Interface Open Drain, $V_{supply} \leq 3.6V_{DC}$, Recommended pull-up circuit: 10K resistor with 3.3Vsupply
Output Low voltage (4mA Drive) All | 0.3 | V |
Output Leakage ($V_{pad} = 0$ to 3.6V) All | ±5 | μA |

* Over temperature Warning – Warning may not activate before alarm and unit may shutdown before warning.

General Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Device</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculated MTBF (IO=0.8IO, max, TA=40°C) Telecordia Issue 4 Method 1 Case 3</td>
<td>All</td>
<td>16,811,807</td>
<td></td>
<td>Hours</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>12.6 (0.444)</td>
<td></td>
<td>g (oz.)</td>
<td></td>
</tr>
</tbody>
</table>

Digital Interface Specifications

Unless otherwise indicated, specifications apply for all operating input voltages, resistive load and temperature conditions. See Feature Descriptions for additional information.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMBus Signal Interface Characteristics</td>
<td></td>
<td>$V_{IH}$</td>
<td>2.1</td>
<td>5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Input Low Voltage ($SM_{DAT}, SM_{ALERT}$)</td>
<td></td>
<td>$V_{IL}$</td>
<td>0.8</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Input Leakage ($SM_{DAT}, SM_{CLK}, VR_{ENx}$)</td>
<td>$V_{pad} = 0$ to $3.6V$</td>
<td>$I_{IH}$</td>
<td>-1</td>
<td>1</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>Output Low Voltage (Open-Drain Outputs – 4mA drive, $SM_{DAT}, SM_{ALERT}$)</td>
<td>$I_{OUT}=4mA$</td>
<td>$V_{OL}$</td>
<td>0.3</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Output Leakage (Open-drain outputs – 4mA drive, VRRDYx, $SM_{DAT}, SM_{ALERT}$)</td>
<td>$V_{OUT}= 0$ to $3.6V$</td>
<td>$I_{OH}$</td>
<td>-5</td>
<td>5</td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>Pin capacitance</td>
<td></td>
<td>$C_{O}$</td>
<td>0.7</td>
<td></td>
<td>pF</td>
<td></td>
</tr>
<tr>
<td>PMBus Operating frequency range</td>
<td></td>
<td></td>
<td>10</td>
<td>1000</td>
<td>kHz</td>
<td></td>
</tr>
</tbody>
</table>

Measurement System Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output current measurement range</td>
<td></td>
<td>$I_{OUT(max)}$</td>
<td>0</td>
<td>51.5</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Output current measurement accuracy -40 to 85°C</td>
<td></td>
<td>$I_{ACC}$</td>
<td>-12</td>
<td>3.5</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Output Current Resolution (Settable in PMBus)</td>
<td></td>
<td></td>
<td>0.25</td>
<td>0.5</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Temperature measurement accuracy @$12V_{IN}$, 25°C to 85°C</td>
<td></td>
<td>$T_{ACC}$</td>
<td>7</td>
<td></td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Temperature measurement resolution</td>
<td></td>
<td>$T_{MEAS(res)}$</td>
<td>1</td>
<td></td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$V_{IN}$ measurement range</td>
<td></td>
<td>$V_{IN(max)}$</td>
<td>0</td>
<td>16.8</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{IN}$ measurement accuracy</td>
<td></td>
<td>$V_{IN, ACC}$</td>
<td>±2.5</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>$V_{IN}$ measurement resolution</td>
<td></td>
<td>$V_{IN, RES}$</td>
<td>31.25</td>
<td></td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$V_{OUT}$ measurement range</td>
<td></td>
<td>$V_{OUT(max)}$</td>
<td>0</td>
<td>2.55</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{OUT}$ measurement resolution</td>
<td></td>
<td>$V_{OUT, RES}$</td>
<td>4</td>
<td></td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$V_{OUT}$ measurement accuracy</td>
<td></td>
<td>$V_{OUT, ACC}$</td>
<td>±2</td>
<td></td>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>
Technical Specifications (continued)

Characteristic Curves

The following figures provide typical characteristics for the 160A Master DLynxIII™ module at 0.45Vo and 25°C.

Figure 1. Converter Efficiency versus Output Current.

Figure 2. Derating Output Current versus Ambient Temperature and Airflow.

Figure 3. Typical output ripple (Cобщ = 4x0.047µF + 4x0.1µF + 15x22µF + 73x47µF + 6x470µF polymer, V_i = 12V, I_o = I_{o,max}).

Figure 4. Trans. Resp. to 10A/µs Load Change from 25% to 75% at 12V_i, Cобщ = 4x0.047µF + 4x0.1µF + 15x22µF + 73x47µF + 6x470µF polymer.

Figure 5. Typical Start-up Using On/Off Voltage (I_o = I_{o,max}).

Figure 6. Typical Start-up Using Input Voltage (V_{i} = 12V, I_o = I_{o,max}).
Technical Specifications (continued)

Characteristic Curves

The following figures provide typical characteristics for the 160A Master DLynxIII™ module at 1.0V_o and 25°C.

Figure 7. Converter Efficiency versus Output Current.

Figure 8. Derating Output Current versus Ambient Temperature and Airflow.

Figure 9. Typical output ripple ($C_o = 4x0.047\mu F + 4x0.1\mu F + 15x22\mu F + 73x47\mu F + 6x470\mu F$ polymer, $V_{in} = 12V, I_o = I_{o,max}$).

Figure 10. Trans. Resp. to 100A/\mu s Load Change from 25% to 75% at $12V_{in}, C_o = 4x0.047\mu F + 4x0.1\mu F + 15x22\mu F + 73x47\mu F + 6x470\mu F$ polymer.

Figure 11. Typical Start-up Using On/Off Voltage ($I_o = I_{o,max}$).

Figure 12. Typical Start-up Using Input Voltage ($V_{in} = 12V, I_o = I_{o,max}$).
Technical Specifications (continued)

Characteristic Curves

The following figures provide typical characteristics for the 160A Master DLynxIII™ module at 1.5V₀ and 25°C.

![Figure 13. Converter Efficiency versus Output Current.](image)

![Figure 14. Derating Output Current versus Ambient Temperature and Airflow.](image)

![Figure 15. Typical output ripple(C₁₀ø=4x0.047µF +4x0.1µF + 15x22µF + 73x47µF + 6x470µF polymer, V₁₀ = 12V, I₀ = I₀max).](image)

![Figure 16. Trans. Resp. to 100A/µs Load Change from 25% to 75% at 12V₁₀, C₁₀ø=4x0.047µF +4x0.1µF + 15x22µF + 73x47µF + 6x470µF polymer.](image)

![Figure 17. Typical Start-up Using On/Off Voltage (I₀ = I₀max).](image)

![Figure 18. Typical Start-up Using Input Voltage (V₁₀ = 12V, I₀ = I₀max).](image)
TechnicalSpecifications (continued)

Characteristic Curves

The following figures provide typical characteristics for the 160A Master DLynxIII™ module at 2V_o and 25°C.

Figure 19. Converter Efficiency versus Output Current.

Figure 20. Derating Output Current versus Ambient Temperature

Figure 21. Typical output ripple (C_o=4x0.047µF +4x0.1µF +15x22µF +73x47µF +6x470µF polymer, V_IN = 12V, I_o = I_o, max).

Figure 22. Trans. Resp. to 100A/µs Load Change from 25% to 75% at 12V_IN, C_o=4x0.047µF +4x0.1µF +15x22µF +73x47µF +6x470µF polymer.

Figure 23. Typical Start-up Using On/Off Voltage (I_o = I_o, max).

Figure 24. Typical Start-up Using Input Voltage (V_IN = 12V, I_o = I_o, max).
Technical Specifications (continued)

Design Considerations

Input Filtering

To minimize input voltage ripple, ceramic capacitors are recommended at the input of the module. Figure 25 shows the input ripple voltage for various output voltages at 100% of load current with different input capacitor combinations to achieve 1.5% and lower input ripple. Since voltage used was 12Vin, all the curves stayed below the 180mV(1.5%) threshold.

These caps were placed at the bottom of the board and directly under each of the phases as shown in the layout of the evaluation board (Fig. 31). Each phase had a minimum of 2x1uF and 3x10uF closest to the pins.

Output Filtering

These modules are designed for low output ripple voltage and will meet stringent output ripple. Figure 26 provides output ripple information various output voltages and full load current for different levels of capacitance. Ceramic capacitance will reduce output ripple and improve the transient performance of the module.

Transient Testing

Module performance for different transient conditions at rated output capacitance.

<table>
<thead>
<tr>
<th>Voltage Rail (volts)</th>
<th>Step Load (%) of full load</th>
<th>Load Slew Rate (A/µsec)</th>
<th>ΔV Variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45V</td>
<td>50</td>
<td>10</td>
<td>-2.37% to 2.82%</td>
</tr>
<tr>
<td>1V</td>
<td>50</td>
<td>10</td>
<td>-0.84% to 1.21%</td>
</tr>
<tr>
<td>1.5V</td>
<td>50</td>
<td>10</td>
<td>-0.77% to 0.67%</td>
</tr>
<tr>
<td>2V</td>
<td>50</td>
<td>10</td>
<td>-0.65% to 0.44%</td>
</tr>
</tbody>
</table>

Kp=42, Ki=22, Kd=58, Kpole1=5, Kpole2=7 for above tests.
Safety Considerations

For safety agency approval, the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standards, i.e., UL* 62368-1, 3rd Ed. Recognized, and VDE (EN62368-1, 3rd Ed.) Licensed.

For the converter output to be considered meeting the requirements of safety extra-low voltage (SELV) or ESI, the input must meet SELV/ESI requirements. The power module has extra low voltage (ELV) outputs when all inputs are ELV.

The MLX160A0X model was tested using an external Littelfuse 456 series 60A and two 40A, fast-acting fuses in the ungrounded input. Two 40A fuses are recommended for input voltages <8Vdc. The use of no fuse or a higher rated fuse should be evaluated in the end-use equipment. The maximum hot spot temperature on IC200/C202 shall not exceed 120/115°C.

Remote On/Off

The NexGen module can be turned ON and OFF either by using the ON/OFF pin (Analog interface) or through the PMBus interface (Digital). The module can be configured in a number of ways through the PMBus interface to react to the ON/OFF input:

- Module ON/OFF can controlled only through the analog interface (digital interface ON/OFF commands are ignored).
- Module ON/OFF can controlled only through the PMBus interface (analog interface is ignored).
- Module ON/OFF can be controlled by either the analog or digital interface.

The default state of the module (as shipped from the factory) is to be controlled by the PMBus interface and analog interface. Module control through the digital interface must be made through PMBus. These changes can be made and written to non-volatile memory on the module so that it is remembered for subsequent use.

The ON/OFF pin should not be left floating and must be pulled either high or low.

Digital On/Off

Please see the Digital Feature Descriptions section.

Monotonic Start-up and Shutdown

The module has monotonic start-up and shutdown behavior on the output for any combination of rated input voltage, output current, and operating temperature range.

Startup into Pre-biased Output

The module will start into a pre biased output on output as long as the pre bias voltage is 15% less than the set output voltage.

Remote Sense

The power module has a differential Remote Sense feature to minimize the effects of distribution losses by regulating the voltage between the sense pins (VS+ and VS-) for the output. The voltage drop between the sense pins and the VOUT and GND pins of the module should not exceed 100mV.
Technical Specifications (continued)

Overcurrent Protection (OCP)
To provide protection in a fault (output overload) condition, the unit is equipped with internal current limiting circuitry on the output and can endure current limiting continuously. The module’s overcurrent response is to hiccup forever. OCP response can be changed with a PMBus command.

Overtemperature Protection
To provide protection in a fault condition, the unit has a thermal shutdown circuit. The unit will shut down if the overtemperature threshold of 125°C (typ) is exceeded at the thermal reference point Tref. Once the unit goes into thermal shutdown, it will wait to cool down to 97% of set limit before attempting to restart.

Power Good
Power good needs external pull up resistor. The pins are called VRRDY1 and VRRDY2 (loop1/loop2) and their thresholds are specified via PMBus.

An example of Power Good / VRRDY behavior is shown below. The top green waveform is the slowly rising input voltage and the bottom brown waveform is the output voltage. As soon as the output voltage crosses the VRRDY1 threshold, the pin is pulled high as seen in the scope capture.

Start-up procedure
ON/OFF
The MLX160A0XY3-SRZ is a programmable ON/OFF logic power module. The default state of the module is Negative Logic. The module is ON when the ON/OFF pin is at a “logic low” state, and OFF when it is at “logic high” state. Positive ON/OFF logic can be implemented through PMBus control.

The module could be turned ON and OFF from an external enable signal or by the OPERATION 0x01 command. Desired behavior is set by ON_OFF_CONFIG 0x02 command.

Input overvoltage and undervoltage protections
The input overvoltage and undervoltage protections prevent the MLX160A0XY3-SRZ from operating when the input is above or falls below preset thresholds.

The customers are strongly advised not to increase the preset input overvoltage limit or decrease input undervoltage limit as it may result in compromising product safety. This is a violation of the module’s absolute maximum and minimum ratings which will void the product warranty.

The input overvoltage and undervoltage protections could be adjusted by the following commands:
- VIN_OV_FAULT_RESPONSE 0x56
- VIN_OV_FAULT_LIMIT 0x55
- VIN_UV_WARN_LIMIT 0x58

See commands description for more details.

Output overvoltage and undervoltage protections
The MLX160A0XY3-SRZ offers an internal output overvoltage protection circuit that can be used to protect sensitive load circuitry from being subjected to a voltage higher than its prescribed limits.

The MLX160A0XY3-SRZ overvoltage and undervoltage behavior can be configured through the following commands:
- VOUT_OV_FAULT_RESPONSE 0x41
- VOUT_UV_FAULT_RESPONSE 0x45
- VOUT_OV_FAULT_LIMIT 0x40
- VOUT_OV_WARN_LIMIT 0x42
- VOUT_UV_WARN_LIMIT 0x43
- VOUT_UV_FAULT_LIMIT 0x44

See commands description for more details.

Output overcurrent protection
Output overcurrent protection prevents excessive forward current through the module and the load during abnormal operation. Overcurrent protection is cycle-by-cycle in nature. This is managed by IOUT_OC_FAULT_LIMIT 0x46.

Customers are strongly advised not to increase the preset output overcurrent limits or decrease output undercurrent limits as it may result in compromising product safety. This is a violation of the module’s absolute maximum and minimum ratings which will void the product warranty.
Technical Specifications (continued)

The output overcurrent warning limits and fault response can be managed by:

IOUT_OC_WARN_LIMIT 0xA,
IOUT_OC_FAULT_RESPONSE 0x47.

Non-volatile memory management
The MLX160A0XY3-SRZ has internal non-volatile memory where the module's configurations are stored.

During the initialization process, the MLX160A0XY3-SRZ checks for stored values contained in its internal non-volatile memory. The MLX160 offers up to 24 writes to configure basic module parameters such as output voltage setpoint, fault operation settings, etc. It also allows loading of pre-installed configuration file from up to 15 options to help set multiple MLX modules powering different rails on a common PMBus.

Overtemperature protection
The MLX160A0XY3-SRZ overtemperature protection ensures that the temperature inside the module is below all the component's temperature maximum limit.

The overtemperature protections are managed by the following commands: OT_FAULT_RESPONSE 0x50, OT_WARN_LIMIT 0x51.

Monitoring through SMBAlert or SALERT pin
The MLX160A0XY3-SRZ controller can report fault conditions by changing the state of the SMBALERT pin, which is asserted when any number of preconfigured fault conditions occur. The module can also be monitored continuously for any number of power conversion parameters. Some of most useful fault monitoring commands are:
STATUS_BYTE 0x78, STATUS_WORD 0x79,
STATUS_VOUT 0x7A, STATUS_IOUT 0x7B,
STATUS_INPUT 0x7C, STATUS_TEMPERATURE 0x7D.

Layout considerations
The evaluation board layout and schematic files are available for interested users. These can be downloaded through the webpage or by contacting OmniOn Power through the web request or helpline.

Control loop tuning
The heart of MLX160A0XY3-SRZ is a fully digital controller IC with state-of-the-art PID Control. By default, this control loop is stable for recommended output capacitance and loads. However, it may be further tuned to achieve higher performance under more specific application requirements. Since the control scheme is digital from end to end, there is no dependence upon external compensation networks. This simplifies the design process by removing such considerations as temperature and process variation of passive components. Control parameters are set through the 0xD0 PMBus command.
Technical Specifications (continued)

**Digital Compensator**

The MLX160 module uses digital control to regulate the output voltage. As with all POL modules, external capacitors are usually added to the output of the module for two reasons: to reduce output ripple and noise and to reduce output voltage deviations from the steady-state value in the presence of dynamic load current changes.

The MLX160 comes with default compensation values programmed into the non-volatile memory of the module. These digital compensation values can be adjusted externally to optimize transient response and ensure stability for a wide range of external capacitance, and with different types of output capacitance.

<table>
<thead>
<tr>
<th>Components</th>
<th>Control Loop Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Capacitors</td>
<td>KPole1</td>
</tr>
<tr>
<td>15x22uF + 24x47uF + 4x470uF</td>
<td>5</td>
</tr>
<tr>
<td>15x22uF + 65x47uF + 4x470uF</td>
<td>5</td>
</tr>
<tr>
<td>15x22uF + 73x47uF + 6x470uF</td>
<td>5</td>
</tr>
</tbody>
</table>

**Power Module Wizard**

Designers can access a free, web-based, easy to use tool that helps users simulate and tune the MLX160A0XY3-SRZ feedback loop parameters. Go to http://OmniOn Power.transim.com and sign up for a free account to use the module selector tool. The tool also offers online Simplis/Simetrix models that can be used to assess transient performance, module stability, etc.

**Digital Power Insight (DPI)**

DPI is a software tool that helps users evaluate and simulate the PMBus performance of the MLX160A0XY3A modules without the need to write software. The software can be downloaded for free from our webpage. A USB to I²C adapter and associated cable set are required for proper functioning of the software suite. For first time users, we recommend using the DPI Evaluation Kit, which can be purchased from any of the leading distributors. Please ensure that the USB to I²C adapter being used/purchased is Version 2.2 or higher. Part Numbers are available in the last few pages of this datasheet.
Technical Specifications (continued)

**PMBus use guidelines**

An I²C or PMBus interface is used to communicate with the module. These two-wire serial interfaces consist of clock and data signals and operate as fast as 1 MHz with proper signal integrity. 400kHz is the typical operating frequency. The bus provides read and write access to the internal registers for configuration and monitoring of operating parameters. The bus is also used to program on-chip non-volatile memory (MTP) to store operating parameters. To ensure operation with multiple devices on the bus, an exclusive address for the module is programmed into MTP. To protect customer configuration and information, the I²C interface can be configured for either limited access or locked with a 16-bit software password. Limited access includes both write and read protection options. In addition, there is a telemetry-only mode which only allows reads from the telemetry registers. The module supports the Packet Error Checking (PEC) protocol and a number of PMBus commands to monitor voltages and currents.

**PMBus data format**

**Linear-11**

The L11 data format uses 5-bit two's complement exponent (N) and 11-bit two's complement mantissa (Y) to represent a real world decimal value (X). The formula to calculate the real world decimal value is: \( X = Y \cdot 2^N \).

**Linear-16**

The L16u data format uses a fixed exponent (hard-coded to \( N = -xxh \)) and a 16-bit unsigned integer mantissa (Y) to represent real world decimal value (X). The formula to calculate the real world decimal value is: \( X = Y \cdot 2^{-xx} \).

**Linear-16 Signed**

The L16s data format uses a fixed exponent (hard-coded to \( N = -xxh \)) and a 16-bit two's complement mantissa (Y) to represent real world decimal value (X). The formula to calculate the real world decimal value is: \( X = Y \cdot 2^{-xx} \).

**Bit Field**

A description of the Bit Field format is provided in each command details.

**Custom**

A description of the Custom data format is provided in each command details. A combination of Bit Field and integer are common type of Custom data format.

**ASCII (ASC)**

A variable length string of text characters in the ASCII data format.

**PMBus Addressing**

The power module is addressed through the PMBus using a device address. The default module address is 0x40. The module supports 15 possible offset addresses (0x40 to 0x55). If multiple modules are used on the same bus, user must power up each module individually, change the module address, and then move on to the next module to repeat the process. If this is not possible, a pre-defined resistor can be connected to the PROG pin to provide an offset to the default address yielding a different address for each module on the same bus as described later in this document.
PMBus Addressing

The module simultaneously supports I²C and PMBus through the use of exclusive addressing. By using a 7-bit address, the user can configure the device to any one of 127 different I²C/PMBus addresses. Once the address is set, it can be locked to protect it from being overridden. Optionally, a resistor can be tied to the PROG pin to generate an offset as shown in Table below (note that a 0.01 µF capacitor is required across the resistor). The base I²C address is 0x10 and Base PMBus address is 0x40. For default programmed devices, the I²C/PMBus address can be temporarily forced to 0x0A for I²C and 0x0D for PMBus by driving the PROG pin high (3.3 V).

The module supports 15 possible offset addresses (0x40 to 0x55) through resistor connection to the PROG pin. If multiple modules are used on the same bus without different PROG pin resistors, user must power up each module individually, change the module address and then move on to the next module and repeat the process. (See Quick Start Process in this datasheet).

Example for 3 MLX modules on the same PMBus channel. Select a 0.845 kΩ resistor on program pin of module 1, 1.3 kΩ resistor on module 2 and a 1.78 kΩ resistor on module 3.

This results in:

Module 1 : I²C address is 10h+0h=10h, PMBus address is 40h+0h=40h
Module 2 : I²C address is 10h+1h=11h, PMBus address is 40h+1h=41h
Module 3 : I²C address is 10h+2h=12h, PMBus address is 40h+2h=42h

<table>
<thead>
<tr>
<th>PROG RESISTOR</th>
<th>I²C Address Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.845 kΩ</td>
<td>+0</td>
</tr>
<tr>
<td>1.3 kΩ</td>
<td>+1</td>
</tr>
<tr>
<td>1.78 kΩ</td>
<td>+2</td>
</tr>
<tr>
<td>2.32 kΩ</td>
<td>+3</td>
</tr>
<tr>
<td>2.87 kΩ</td>
<td>+4</td>
</tr>
<tr>
<td>3.48 kΩ</td>
<td>+5</td>
</tr>
<tr>
<td>4.12 kΩ</td>
<td>+6</td>
</tr>
<tr>
<td>4.75 kΩ</td>
<td>+7</td>
</tr>
<tr>
<td>5.49 kΩ</td>
<td>+8</td>
</tr>
<tr>
<td>6.19 kΩ</td>
<td>+9</td>
</tr>
<tr>
<td>6.98 kΩ</td>
<td>+10</td>
</tr>
<tr>
<td>7.87 kΩ</td>
<td>+11</td>
</tr>
<tr>
<td>8.87 kΩ</td>
<td>+12</td>
</tr>
<tr>
<td>10.00 kΩ</td>
<td>+13</td>
</tr>
<tr>
<td>11.00 kΩ</td>
<td>+14</td>
</tr>
<tr>
<td>12.10 kΩ</td>
<td>+15</td>
</tr>
</tbody>
</table>
Technical Specifications (continued)

Summary of Supported PMBus Commands

This section provides a summary of the MLX160AOXY3 commands followed by their detailed description. The commands are outlined in the order of increasing command codes. Since there are 2 Loops, the commands are presented for each Loop for completeness.

Table 2 - LOOP 1 / OUTPUT 1 Commands

<table>
<thead>
<tr>
<th>PMBUS CMD</th>
<th>CMD CODE</th>
<th>DATA BYTES</th>
<th>DATA FORMAT</th>
<th>DATA UNITS</th>
<th>TRANSFER TYPE</th>
<th>DEFAULT</th>
<th>MIN/MAX VALUES or RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAGE</td>
<td>0x00</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>00</td>
<td>01 / FF</td>
<td></td>
</tr>
<tr>
<td>OPERATION</td>
<td>0x01</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>80</td>
<td>00/40/80/94/98/A4/A8</td>
<td></td>
</tr>
<tr>
<td>ON_OFF_CONFIG</td>
<td>0x02</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>1C</td>
<td>02/14/15/16/17/18/1C/1D/1E/1F</td>
<td></td>
</tr>
<tr>
<td>CLEAR_FAULTS</td>
<td>0x03</td>
<td>0</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRITE_PROTECT</td>
<td>0x10</td>
<td>1</td>
<td>Bit field</td>
<td>W</td>
<td>0x00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESTORE_DEFAULT_ALL</td>
<td>0x12</td>
<td>0</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STORE_USER_ALL</td>
<td>0x15</td>
<td>0</td>
<td>W</td>
<td></td>
<td></td>
<td>CAN USE ONLY 24 TIMES</td>
<td></td>
</tr>
<tr>
<td>RESTORE_USER_ALL</td>
<td>0x16</td>
<td>0</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAPABILITY</td>
<td>0x19</td>
<td>1</td>
<td>bit field</td>
<td>R</td>
<td>0xB0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMBALERT_MASK</td>
<td>0x1B</td>
<td>2</td>
<td>Bit field</td>
<td>R/W</td>
<td>000000000100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOUT_MODE</td>
<td>0x20</td>
<td>1</td>
<td>mode + exp</td>
<td>R/W</td>
<td>0x18 (-8 Exponent)</td>
<td>-8, -9, -12</td>
<td></td>
</tr>
<tr>
<td>VOUT_COMMAND</td>
<td>0x21</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0073 (0.449V)</td>
<td>0.45 – 2.0</td>
</tr>
<tr>
<td>VOUT_TRIM</td>
<td>0x22</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0.000V</td>
<td>-2 to 2</td>
</tr>
<tr>
<td>VOUT_MAX</td>
<td>0x24</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>021A (2.102V)</td>
<td>0.45 to 2.102</td>
</tr>
<tr>
<td>VOUT_MARGIN_HIGH</td>
<td>0x25</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0000</td>
<td>0 to 2.102</td>
</tr>
<tr>
<td>VOUT_MARGIN_LOW</td>
<td>0x26</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0000</td>
<td>0 to 2.102</td>
</tr>
<tr>
<td>VOUT_TRANSITION_RATE</td>
<td>0x27</td>
<td>2</td>
<td>11-bit linear</td>
<td>V/m</td>
<td>R/W</td>
<td>0xE808 (1mV/µs)</td>
<td>0 to 127.875mV/usec</td>
</tr>
<tr>
<td>VOUT_DROOP</td>
<td>0x28</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0000</td>
<td>0 to 9.98mΩ</td>
</tr>
<tr>
<td>VOUT_MIN</td>
<td>0x2B</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0040 (0.25V)</td>
<td>0 to 2.102</td>
</tr>
<tr>
<td>FREQUENCY_SWITCH</td>
<td>0x33</td>
<td>2</td>
<td>11-bit linear</td>
<td>kHz</td>
<td>R/W</td>
<td>0244 (580kHz)</td>
<td></td>
</tr>
<tr>
<td>POWER_MODE</td>
<td>0x34</td>
<td>2</td>
<td>bit field</td>
<td>R/W</td>
<td>0x0003</td>
<td>0, 3, 4, 5</td>
<td></td>
</tr>
<tr>
<td>V IN _ ON</td>
<td>0x35</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>F019 (6.25)</td>
<td>6.25—14</td>
</tr>
<tr>
<td>V IN _ OFF</td>
<td>0x36</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>F017 (5.75)</td>
<td>5.75—14</td>
</tr>
<tr>
<td>IOUT _ CAL _ GAIN</td>
<td>0x38</td>
<td>2</td>
<td>11-bit linear</td>
<td>mΩ</td>
<td>R/W</td>
<td>Vary</td>
<td></td>
</tr>
<tr>
<td>IOUT _ CAL _ OFFSET</td>
<td>0x39</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>R/W</td>
<td>Vary</td>
<td></td>
</tr>
<tr>
<td>VOUT_OV_FAULT_LIMIT</td>
<td>0x40</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>010D (1.051V)</td>
<td>0.45—2.102</td>
</tr>
<tr>
<td>VOUT_OV_FAULT_RESPONSE</td>
<td>0x41</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>80 (Shutdown)</td>
<td>Ignore (00), Sdown(B0)</td>
<td></td>
</tr>
<tr>
<td>VOUT_OV_WARN_LIMIT</td>
<td>0x42</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0200 (2.000)</td>
<td>0.45—2.102</td>
</tr>
<tr>
<td>VOUT_UV_LIMIT</td>
<td>0x43</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0073 (0.449)</td>
<td>0.45—2.102</td>
</tr>
<tr>
<td>VOUT_UV_FAULT_LIMIT</td>
<td>0x44</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>009A (0.602)</td>
<td>50mV to 400mV from Vout</td>
</tr>
<tr>
<td>VOUT_UV_FAULT_RESPONSE</td>
<td>0x45</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>80 (shutdown)</td>
<td>Ignore (00), Sdown(B0)</td>
<td></td>
</tr>
<tr>
<td>IOUT_OC_FAULT_LIMIT</td>
<td>0x46</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>R/W</td>
<td>085B (162)</td>
<td>0 to 510</td>
</tr>
<tr>
<td>IOUT_OC_FAULT_RESPONSE</td>
<td>0x47</td>
<td>1</td>
<td>Bit field</td>
<td>r/W</td>
<td>F8 (Hiccup)</td>
<td>Sdown(C0), hiccup 6 then Sdown(F0), F8</td>
<td></td>
</tr>
<tr>
<td>IOUT_OC_WARN_LIMIT</td>
<td>0x48</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>R/W</td>
<td>083C (120)</td>
<td>0 to 510</td>
</tr>
<tr>
<td>OT_FAULT_LIMIT</td>
<td>0x4F</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>R/W</td>
<td>0070 (125)</td>
<td>0 to 255</td>
</tr>
<tr>
<td>OT_FAULT_RESPONSE</td>
<td>0x50</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>C0 (Autorestart)</td>
<td>Ignore (00), Sdown(B0), (C0)</td>
<td></td>
</tr>
<tr>
<td>OT_WARN_LIMIT</td>
<td>0x51</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>R/W</td>
<td>006E (110)</td>
<td>64 to 255</td>
</tr>
<tr>
<td>VIN_OV_FAULT_LIMIT</td>
<td>0x55</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>E0E9 (14.563)</td>
<td>0 to 63.9375</td>
</tr>
<tr>
<td>VIN_OV_FAULT_RESPONSE</td>
<td>0x56</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>80 (Shutdown)</td>
<td>Ignore (00), Sdown(B0)</td>
<td></td>
</tr>
<tr>
<td>VIN_UV_WARN_LIMIT</td>
<td>0x5B</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>E0E6 (6.5)</td>
<td>0 to 63.9375</td>
</tr>
<tr>
<td>IIN_OC_WARN_LIMIT</td>
<td>0x5D</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>F852 (41)</td>
<td>0 to 127.5</td>
</tr>
<tr>
<td>POWER_GOOD_ON</td>
<td>0x5E</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0065 (0.395)</td>
<td>0.395 to 2.102</td>
</tr>
<tr>
<td>POWER_GOOD_OFF</td>
<td>0x5F</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R/W</td>
<td>0065 (0.395)</td>
<td>0.395 to 2.102</td>
</tr>
</tbody>
</table>

* Cannot be stored in NVM. Module will accept Write command but will not transfer to NVM when STORE_USER_ALL is used

† Cannot be stored in NVM. Module will hold any written value till power cycle. Cannot use RESTORE_USER_ALL to revert to default value
### Table 2 - LOOP 1 / OUTPUT 1 Commands (continued)

<table>
<thead>
<tr>
<th>PMBUS CMD</th>
<th>CMD CODE</th>
<th>DATA BYTES</th>
<th>DATA FORMAT</th>
<th>DATA UNITS</th>
<th>TRANSFER TYPE</th>
<th>DEFAULT VALUE</th>
<th>MIN/MAX VALUES or RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TON_DELAY</td>
<td>0x60</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>R/W</td>
<td>F800 (0)</td>
<td>0 to 63.5</td>
</tr>
<tr>
<td>TON_RISE</td>
<td>0x61</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>R/W</td>
<td>F03C (15)</td>
<td>0 to 31.75</td>
</tr>
<tr>
<td>TON_MAX_FAULT_LIMIT</td>
<td>0x62</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>R/W</td>
<td>F000 (0)</td>
<td>0 to 31.75</td>
</tr>
<tr>
<td>TON_MAX_FAULT_RESPONSE</td>
<td>0x63</td>
<td>1</td>
<td>11-bit linear</td>
<td>ms</td>
<td>R/W</td>
<td>00 (Ignore)</td>
<td>Ignore (00),</td>
</tr>
<tr>
<td>TOFF_DELAY</td>
<td>0x64</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>R/W</td>
<td>F000 (0)</td>
<td>0 to 31.75</td>
</tr>
<tr>
<td>TOFF_FALL</td>
<td>0x65</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>R/W</td>
<td>F800 (0)</td>
<td>0 to 31.75</td>
</tr>
<tr>
<td>POUT_OP_WARN_LIMIT</td>
<td>0x6A</td>
<td>2</td>
<td>16-bit linear</td>
<td>Watts</td>
<td>R/W</td>
<td>01FF (511)</td>
<td></td>
</tr>
<tr>
<td>POUT_OP_WARN_LIMIT</td>
<td>0x6B</td>
<td>2</td>
<td>16-bit linear</td>
<td>Watts</td>
<td>R/W</td>
<td>01FF (511)</td>
<td></td>
</tr>
<tr>
<td>STATUS_BYTE</td>
<td>0x78</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td>Varies (03)</td>
</tr>
<tr>
<td>STATUS_WORD</td>
<td>0x79</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td>Varies (A003)</td>
</tr>
<tr>
<td>STATUS_VOUT</td>
<td>0x7A</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td>Varies (20)</td>
</tr>
<tr>
<td>STATUS_IOUT</td>
<td>0x7B</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td>Varies (00)</td>
</tr>
<tr>
<td>STATUS_INPUT</td>
<td>0x7C</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td>Varies (20)</td>
</tr>
<tr>
<td>STATUS_TEMPERATURE</td>
<td>0x7D</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td>Varies (00)</td>
</tr>
<tr>
<td>STATUS_CML</td>
<td>0x7E</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td>Varies (02)</td>
</tr>
<tr>
<td>STATUS_MFR_SPECIFIC</td>
<td>0x80</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td>Varies (00)</td>
</tr>
<tr>
<td>READ_VIN</td>
<td>0x88</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R</td>
<td></td>
<td>Varies</td>
</tr>
<tr>
<td>READ_IIN</td>
<td>0x89</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>R</td>
<td>Varies</td>
<td>max register limit</td>
</tr>
<tr>
<td>READ_VOUT</td>
<td>0x8B</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>READ_IOUT</td>
<td>0x8C</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>R</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>READ_TEMPERATURE_1</td>
<td>0x8D</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>R</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>READ_DUTY_CYCLE</td>
<td>0x94</td>
<td>2</td>
<td>11-bit linear</td>
<td>%</td>
<td>R</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>READ_POUT</td>
<td>0x96</td>
<td>2</td>
<td>11-bit linear</td>
<td>W</td>
<td>R</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>READ_PIN</td>
<td>0x97</td>
<td>2</td>
<td>11-bit linear</td>
<td>W</td>
<td>R</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>PMBUS_REVISION</td>
<td>0x98</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>MFR_ID</td>
<td>0x99</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td>4952</td>
<td></td>
</tr>
<tr>
<td>MFR_MODEL</td>
<td>0x9A</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td>00A0</td>
<td></td>
</tr>
<tr>
<td>MFR_REVISION</td>
<td>0x9B</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td>Varies (0012)</td>
<td></td>
</tr>
<tr>
<td>MFR_DATE</td>
<td>0x9D</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>IC_DEVICE_ID</td>
<td>0xAD</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td>6C</td>
<td></td>
</tr>
<tr>
<td>IC_DEVICE_REV</td>
<td>0xAE</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td>01</td>
<td></td>
</tr>
<tr>
<td>MFR_READ_VAUX</td>
<td>0xC4</td>
<td>32</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_VIN_PEAK</td>
<td>0xC5</td>
<td>32</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_VOUT_PEAK</td>
<td>0xC6</td>
<td>32</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_IOUT_PEAK</td>
<td>0xC7</td>
<td>2</td>
<td>bit field</td>
<td>A</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_TEMP_PEAK</td>
<td>0xCB</td>
<td>2</td>
<td>bit field</td>
<td>C</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_VIN_VALLEY</td>
<td>0xC9</td>
<td>2</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_VOUT_VALLEY</td>
<td>0xCA</td>
<td>2</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_IOUT_VALLEY</td>
<td>0xCB</td>
<td>2</td>
<td>bit field</td>
<td>A</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_TEMP_VALLEY</td>
<td>0xCC</td>
<td>2</td>
<td>bit field</td>
<td>C</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_REG_ADDRESS</td>
<td>0xD0</td>
<td>7</td>
<td>bit field</td>
<td></td>
<td></td>
<td>R-2/W-5*</td>
<td>Varies</td>
</tr>
<tr>
<td>MFR_IC_ADDRESS</td>
<td>0xD6</td>
<td>7</td>
<td>bit field</td>
<td></td>
<td></td>
<td>R/W</td>
<td>10 (10)</td>
</tr>
</tbody>
</table>

*R-2/W-5* refers to the number of data bytes in the command, 5 data bytes for a Write and 2 data bytes for a Read
Table 3 - LOOP 2 / OUTPUT 2 – USE ONLY WHEN SATELLITE IS USED

<table>
<thead>
<tr>
<th>PMBUS CMD</th>
<th>CMD CODE</th>
<th>DATA BYTES</th>
<th>DATA FORMAT</th>
<th>DATA UNITS</th>
<th>TRANSFER TYPE</th>
<th>DEFAULT VALUE</th>
<th>MIN/MAX VALUES or RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAGE</td>
<td>0x01</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>01</td>
<td>01/FF</td>
<td></td>
</tr>
<tr>
<td>OPERATION</td>
<td>0x01</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>80</td>
<td>00/40/80/94/98/A4/A8</td>
<td></td>
</tr>
<tr>
<td>ON_OFF_CONFIG</td>
<td>0x02</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>1C</td>
<td>02/14/15/16/17/18/1C/1D/1E/1F</td>
<td></td>
</tr>
<tr>
<td>CLEAR_FAULTS</td>
<td>0x03</td>
<td>0</td>
<td></td>
<td></td>
<td>W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRITE_PROTECT</td>
<td>0x10</td>
<td>1</td>
<td>Bit field</td>
<td>W</td>
<td>0x00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESTORE_DEFAULT_ALL</td>
<td>0x12</td>
<td>0</td>
<td></td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STORE_USER_ALL</td>
<td>0x15</td>
<td>0</td>
<td></td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESTORE_USER_ALL</td>
<td>0x16</td>
<td>0</td>
<td></td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAPABILITY</td>
<td>0x19</td>
<td>1</td>
<td>bit field</td>
<td>R</td>
<td>0x84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMBALERT_MASK</td>
<td>0x1B</td>
<td>1</td>
<td>Bit field</td>
<td>R/W</td>
<td>0001000000100</td>
<td>-8,-9,-12</td>
<td></td>
</tr>
<tr>
<td>VOUT_MODE</td>
<td>0x20</td>
<td>1</td>
<td>mode + exp</td>
<td>R/W</td>
<td>0x18 (-B Exponent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOUT_COMMAND</td>
<td>0x21</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>0073 (0.449V)</td>
<td>0.45 ~2.0</td>
<td></td>
</tr>
<tr>
<td>VOUT_TRIM</td>
<td>0x22</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>0.000V</td>
<td>-2 to 2</td>
<td></td>
</tr>
<tr>
<td>VOUT_MAX</td>
<td>0x24</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>021A (2.02V)</td>
<td>0.45 to 2.102</td>
<td></td>
</tr>
<tr>
<td>VOUT_MARGIN_HIGH</td>
<td>0x25</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>0000</td>
<td>0 to 2.102</td>
<td></td>
</tr>
<tr>
<td>VOUT_MARGIN_LOW</td>
<td>0x26</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>0000</td>
<td>0 to 2.102</td>
<td></td>
</tr>
<tr>
<td>VOUT_TRANSITION_RATE</td>
<td>0x27</td>
<td>2</td>
<td>11-bit linear</td>
<td>V/ms</td>
<td>0xE80 (1mV/µs)</td>
<td>0 to 127.875mV/µsec</td>
<td></td>
</tr>
<tr>
<td>VOUT_DROOP</td>
<td>0x2B</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>0000</td>
<td>0 to 9.98mΩ</td>
<td></td>
</tr>
<tr>
<td>VOUT_MIN</td>
<td>0x2B</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>0040 (0.25V)</td>
<td>0 to 2.102</td>
<td></td>
</tr>
<tr>
<td>FREQUENCY_SWITCH</td>
<td>0x33</td>
<td>2</td>
<td>11-bit linear</td>
<td>kHz</td>
<td>0244 (580kHz)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POWER_MODE</td>
<td>0x34</td>
<td>2</td>
<td>bit field</td>
<td>R/W</td>
<td>0x0003 (Max Power)</td>
<td>0, 3, 4, 5</td>
<td></td>
</tr>
<tr>
<td>VIN_ON</td>
<td>0x35</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>F019 (6.25)</td>
<td>6.25~14</td>
<td></td>
</tr>
<tr>
<td>VIN_OFF</td>
<td>0x36</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>F017 (5.75)</td>
<td>5.75~14</td>
<td></td>
</tr>
<tr>
<td>IOUT_CAL_GAIN</td>
<td>0x38</td>
<td>2</td>
<td>11-bit linear</td>
<td>mΩ</td>
<td>Vary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IOUT_CAL_OFFSET</td>
<td>0x39</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>Vary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOUT_OV_FAULT_LIMIT</td>
<td>0x40</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>010D (1.051V)</td>
<td>0.45~2.102</td>
<td></td>
</tr>
<tr>
<td>VOUT_OV_FAULT_RESPONSE</td>
<td>0x41</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>80 (Shutdown)</td>
<td>Ignore (00), Sdown(80)</td>
<td></td>
</tr>
<tr>
<td>VOUT_OV_WARN_LIMIT</td>
<td>0x42</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>0200 (2.000)</td>
<td>0.45~2.102</td>
<td></td>
</tr>
<tr>
<td>VOUT_OV_FAULT_LIMIT</td>
<td>0x43</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>0073 (0.449)</td>
<td>0.45~2.102</td>
<td></td>
</tr>
<tr>
<td>VOUT_OV_FAULT_RESPONSE</td>
<td>0x44</td>
<td>2</td>
<td>16-bit linear</td>
<td>V</td>
<td>009A (0.602)</td>
<td>50mV to 400mV from Vout</td>
<td></td>
</tr>
<tr>
<td>IOUT_OC_FAULT_LIMIT</td>
<td>0x45</td>
<td>1</td>
<td>bit field</td>
<td>R/W</td>
<td>80 (shutdown)</td>
<td>Ignore (00), Sdown(80)</td>
<td></td>
</tr>
<tr>
<td>IOUT_OC_FAULT_RESPONSE</td>
<td>0x46</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>085B (182)</td>
<td>0 to 510</td>
<td></td>
</tr>
<tr>
<td>OT_FAULT_LIMIT</td>
<td>0x50</td>
<td>1</td>
<td>bit field</td>
<td>°C</td>
<td>006E (110)</td>
<td>64 to 255</td>
<td></td>
</tr>
<tr>
<td>OT_FAULT_RESPONSE</td>
<td>0x51</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>006E (110)</td>
<td>64 to 255</td>
<td></td>
</tr>
<tr>
<td>OT_WARN_LIMIT</td>
<td>0x55</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>006E (14.563)</td>
<td>0 to 63.9375</td>
<td></td>
</tr>
<tr>
<td>VOUT_OV_FAULT_RESPONSE</td>
<td>0x56</td>
<td>1</td>
<td>bit field</td>
<td>°C</td>
<td>0068 (6.5)</td>
<td>0 to 63.9375</td>
<td></td>
</tr>
<tr>
<td>VOUT_UV_FAULT_LIMIT</td>
<td>0x57</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>0068 (6.5)</td>
<td>0 to 63.9375</td>
<td></td>
</tr>
<tr>
<td>POWER_GOOD_ON</td>
<td>0x58</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>F852 (41)</td>
<td>0 to 127.5</td>
<td></td>
</tr>
<tr>
<td>POWER_GOOD_OFF</td>
<td>0x59</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>0065 (0.395)</td>
<td>0.395 to 2.102</td>
<td></td>
</tr>
<tr>
<td>TON_DELAY</td>
<td>0x60</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>F800 (0)</td>
<td>0 to 63.5</td>
<td></td>
</tr>
<tr>
<td>TON_RISE</td>
<td>0x61</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>F035 (15)</td>
<td>0 to 31.75</td>
<td></td>
</tr>
<tr>
<td>TON_MAX_FAULT_LIMIT</td>
<td>0x62</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>F000 (0)</td>
<td>0 to 31.75</td>
<td></td>
</tr>
<tr>
<td>TON_MAX_FAULT_RESPONSE</td>
<td>0x63</td>
<td>1</td>
<td>11-bit linear</td>
<td>ms</td>
<td>00 (Ignore)</td>
<td>Ignore (00), Sdown(80)</td>
<td></td>
</tr>
<tr>
<td>TOFF_DELAY</td>
<td>0x64</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>0ms</td>
<td>0 to 63.5</td>
<td></td>
</tr>
<tr>
<td>TOFF_FALL</td>
<td>0x65</td>
<td>2</td>
<td>11-bit linear</td>
<td>ms</td>
<td>F800 (0)</td>
<td>0 to 31.75</td>
<td></td>
</tr>
</tbody>
</table>

* Cannot be stored in NVM. Module will accept Write command but will not transfer to NVM when STORE_USER_ALL is used

* Cannot be stored in NVM. Module will hold any written value till power cycle. Cannot use RESTORE_USER_ALL to revert to default value.
## Technical Specifications (continued)

### Table 3 - LOOP 2 / OUTPUT 2 – USE ONLY WHEN SATELLITE IS USED (continued)

<table>
<thead>
<tr>
<th>PMBUS CMD</th>
<th>CMD CODE</th>
<th>DATA BYTES</th>
<th>DATA FORMAT</th>
<th>DATA UNITS</th>
<th>TRANSFER TYPE</th>
<th>DEFAULT VALUE</th>
<th>MIN/MAX VALUES or RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>POUT_OP_WARN_LIMIT</td>
<td>0x6A</td>
<td>2</td>
<td>16-bit linear</td>
<td>Watts</td>
<td>R/W</td>
<td>01FF (511)</td>
<td></td>
</tr>
<tr>
<td>PIN_OP_WARN_LIMIT</td>
<td>0x6B</td>
<td>2</td>
<td>16-bit linear</td>
<td>Watts</td>
<td>R/W</td>
<td>01FF (511)</td>
<td></td>
</tr>
<tr>
<td>STATUS_BYTE</td>
<td>0x7B</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS_WORD</td>
<td>0x79</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS_VOUT</td>
<td>0x7A</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS_IOUT</td>
<td>0x7B</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS_INPUT</td>
<td>0x7C</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS_TEMPERATURE</td>
<td>0x7D</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS_CML</td>
<td>0x7E</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS_MFR_SPECIFIC</td>
<td>0x80</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ_VIN</td>
<td>0x8B</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ_IIN</td>
<td>0x89</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ_VOUT</td>
<td>0x8B</td>
<td>2</td>
<td>11-bit linear</td>
<td>V</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ_IOUT</td>
<td>0x8C</td>
<td>2</td>
<td>11-bit linear</td>
<td>A</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ_TEMPERATURE_1</td>
<td>0x8D</td>
<td>2</td>
<td>11-bit linear</td>
<td>°C</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ_DUTY_CYCLE</td>
<td>0x94</td>
<td>2</td>
<td>11-bit linear</td>
<td>%</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ_POUT</td>
<td>0x96</td>
<td>2</td>
<td>11-bit linear</td>
<td>W</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READ_PIN</td>
<td>0x97</td>
<td>2</td>
<td>11-bit linear</td>
<td>W</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMBUS_REVISION</td>
<td>0x98</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFR_ID</td>
<td>0x99</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td>R/W 4952</td>
<td></td>
</tr>
<tr>
<td>MFR_MODEL</td>
<td>0x9A</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td>R/W 00A0</td>
<td></td>
</tr>
<tr>
<td>MFR_REVISION</td>
<td>0x9B</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td>R/W Varies (0012)</td>
<td></td>
</tr>
<tr>
<td>MFR_DATE</td>
<td>0x9D</td>
<td>2</td>
<td>bit field</td>
<td></td>
<td></td>
<td>R/W Varies</td>
<td></td>
</tr>
<tr>
<td>IC_DEVICE_ID</td>
<td>0xAD</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td>R 6C</td>
<td></td>
</tr>
<tr>
<td>IC_DEVICE_REV</td>
<td>0xAE</td>
<td>1</td>
<td>bit field</td>
<td></td>
<td></td>
<td>R 01</td>
<td></td>
</tr>
<tr>
<td>MFR_READ_VAUX</td>
<td>0xC4</td>
<td>32</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_VIN_PEAK</td>
<td>0xC5</td>
<td>32</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_VOUT_PEAK</td>
<td>0xC6</td>
<td>32</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_IOUT_PEAK</td>
<td>0xC7</td>
<td>32</td>
<td>bit field</td>
<td>A</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_TEMP_PEAK</td>
<td>0xC8</td>
<td>32</td>
<td>bit field</td>
<td>C</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_VIN_VALLEY</td>
<td>0xC9</td>
<td>32</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_VOUT_VALLEY</td>
<td>0xCA</td>
<td>32</td>
<td>bit field</td>
<td>V</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_IOUT_VALLEY</td>
<td>0xCB</td>
<td>32</td>
<td>bit field</td>
<td>A</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_TEMP_VALLEY</td>
<td>0xCC</td>
<td>32</td>
<td>bit field</td>
<td>C</td>
<td>R/W</td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_REG_ACCESS</td>
<td>0xD0</td>
<td>7</td>
<td>bit field</td>
<td>R-2/W-5</td>
<td></td>
<td>Varies</td>
<td></td>
</tr>
<tr>
<td>MFR_IPC_ADDRESS</td>
<td>0xD6</td>
<td>7</td>
<td>bit field</td>
<td>R/W</td>
<td>10 (10)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Technical Specifications (continued)

Quick Start process—Single MLX160 on PMBus with external ENABLE
1. Keep VR_EN pulled High to keep Output OFF.
2. Power up module.
3. Configure required output voltage through PAGE 0x00 and VOUT_COMMAND 0x21.
4. Configure the following if needed:
   - VOUT_OV_FAULT_RESPONSE 0x41
   - VOUT_OV_FAULT_LIMIT 0x40
   - VOUT_OV_WARN_LIMIT 0x42
5. If Module has to be turned on using ON/OFF command use ON_OFF_CONFIG 0x02 to change setting.
6. Pull VR_EN low to turn on module output.

Quick Start process—Single MLX160 on PMBus with no external ENABLE control and two level voltage setup
1. VR_EN is tied to GND as instructed in this document.
2. Power up module.
3. Module will start-up to 0.45V.
4. Configure required output voltage through PAGE 0x00 and VOUT_COMMAND 0x21.
5. Configure the following if needed:
   - VOUT_OV_FAULT_RESPONSE 0x41
   - VOUT_OV_FAULT_LIMIT 0x40
   - VOUT_OV_WARN_LIMIT 0x42
6. If Module has to be turned on using ON/OFF command use ON_OFF_CONFIG 0x02 to change setting to 0x18 which will turn on or off module whenever commanded through the OPERATION COMMAND and ignore the ENABLE Pin.
7. If OPERATION COMMAND has been left at Always ON then module will turn on unless the OPERATION COMMAND was previously changed to OFF.
8. If Changes are final and Configuration has to be stored in NVM use, STORE_USER_ALL 0x15.
9. Issue ON Command through OPERATION COMMAND (if it was previously set to OFF) to turn on module OUTPUT.
Technical Specifications (continued)

Example for 3 modules on same PMBus Channel

Quick Start process—Multiple MLX modules on same PMBus, same fixed offset resistor—0.845kΩ

1. Power up module 1.
2. Configure address using advanced D0 command also explained in MLX/SLX PMBus application note. Set register 0x0020[14:18]=12h and register 0x0020[6:0] =42h, to assign module 1 with I2C address=12h and PMBus address =42h.
3. Configure required output voltage through PAGE 0x00 and VOUT_COMMAND 0x21.
4. Configure the following if needed:
   - VOUT_OV_FAULT_RESPONSE 0x41
   - VOUT_OV_FAULT_LIMIT 0x40
   - VOUT_OV_WARN_LIMIT 0x42
5. If Module default ON/OFF operation has to be changed, use ON_OFF_CONFIG 0x02 to change setting
6. If Changes are final and Configuration has to be stored in NVM, use STORE_USER_ALL 0x15.
7. Power up module 2.
   Module 2—set register 0x0020[14:18]=11h and register 0x0020[6:0]=41h, to assign module 2 with I2C address=11h and PMBus address =41h.
8. Configure required output voltage through PAGE 0x00 and VOUT_COMMAND 0x21.
9. Configure the following if needed:
   - VOUT_OV_FAULT_RESPONSE 0x41
   - VOUT_OV_FAULT_LIMIT 0x40
   - VOUT_OV_WARN_LIMIT 0x42
10. If Module default ON/OFF operation has to be changed, use ON_OFF_CONFIG 0x02 to change setting
11. If Changes are final and Configuration has to be stored in NVM, use STORE_USER_ALL 0x15.
12. Power up module 3.
   Keep default I2C address=10h and PMBus address =40h.
13. Configure required output voltage through PAGE 0x00 and VOUT_COMMAND 0x21.
14. Configure the following if needed:
   - VOUT_OV_FAULT_RESPONSE 0x41
   - VOUT_OV_FAULT_LIMIT 0x40
   - VOUT_OV_WARN_LIMIT 0x42
15. If Changes are final and Configuration has to be stored in NVM, use STORE_USER_ALL 0x15.
Technical Specifications (continued)

Layout considerations

The evaluation board layout and schematic files are available for interested users. These can be downloaded through the webpage or by contacting our Field Applications Engineer through the help section of the webpage. The electrical and the thermal characterization of the MLX160A0XY3-SRZ module has been done on evaluation boards with layout as shown in Fig28.

The entire MLX series has a central controller section and symmetrical power switching sections on each side of the controller depending on the power rating.

For Thermal and Current Carrying reasons, it is recommended to have four 20 mil heavy plated filled vias on each of the power pins. Copper plating of vias should be 2 mils if possible.

1. 12 mil vias are recommended for all Signal Pins.
2. Additional thermal vias can be placed on ground plane around module and signal pins.
3. Input Voltage for each of the phases can be laid out on the same layer as shown below:

![Figure 28. Example of Pad Layout with Vias](image1)

![Figure 29. Example of Pad Layout with Vias](image2)
5. It is possible to split the grounds at this location based on customer design layout practices; the POL module has a single ground.

Place a minimum of 10uf and 1uf input capacitor on the bottom side of the customer board directly under Vin and keep additional input capacitance as close to Vin under each of the phases. Additional input capacitance can be placed on top surface of board. All phases need to have same amount of input capacitance.

Figure 30. Example of split input-output ground

Figure 31. Example of Input capacitor placement and routing
Technical Specifications (continued)

**Layout considerations (continued)**

7. Input capacitance for each of the phases is recommended to be as close as possible to the Vin of the module.

![Figure 32. Input Capacitor Placing](image-url)
Technical Specifications (continued)

Layout considerations (continued)

8. Sense traces must be routed differentially with a 5mil air gap spacing. Also provide ground plane under remote sensing pairs.

Figure 33: VSense Traces
Technical Specifications (continued)

Recommended Pad Layout and Pin Description
### Technical Specifications (continued)

#### Pin Assignment Table

<table>
<thead>
<tr>
<th>Pin</th>
<th>Label</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>2</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>3</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>4</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>5</td>
<td>WARN#/GP</td>
<td>Alarm</td>
<td>Open-drain active low alert pin to indicate Output Over-current Warning. Can use V3.3V from module to pullup using a resistor.</td>
</tr>
<tr>
<td>6</td>
<td>PROG</td>
<td>Analog</td>
<td>Configuration Pointer: A resistor to ground on this pin points to the specific configuration file to be loaded into the OTP during power up (along with a 0.01 μF cap in parallel with the resistor).</td>
</tr>
<tr>
<td>7</td>
<td>IMON7_SAT_L1/IMON2_SAT_L2</td>
<td>O</td>
<td>IMON: [Analog output current monitor]: This pin provides an analog output voltage proportional to the average output current. The full-scale IMON voltage is 2.55 V. 0 A corresponds to 5 mV voltage at IMON.</td>
</tr>
<tr>
<td>8</td>
<td>VSV</td>
<td>O</td>
<td>Voltage Regulator Ready Output (Loop #2): Open-drain output that asserts high when the VR has completed soft-start to Loop #2 boot voltage. Pull up to an external voltage through a resistor.</td>
</tr>
<tr>
<td>9</td>
<td>VRRDY2</td>
<td>Alarm</td>
<td>Enable Input for Loop #2. Cannot be left floating. Must be pulled high or low.</td>
</tr>
<tr>
<td>10</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>11</td>
<td>IMON8_SAT_L1/IMON1_SAT_L2</td>
<td>O</td>
<td>IMON: [Analog output current monitor]: This pin provides an analog output voltage proportional to the average output current. The full-scale IMON voltage is 2.55 V. 0 A corresponds to 5 mV voltage at IMON.</td>
</tr>
<tr>
<td>12</td>
<td>IMON6_SAT_L1/IMON3_SAT_L2</td>
<td>O</td>
<td>IMON: [Analog output current monitor]: This pin provides an analog output voltage proportional to the average output current. The full-scale IMON voltage is 2.55 V. 0 A corresponds to 5 mV voltage at IMON.</td>
</tr>
<tr>
<td>13</td>
<td>IMON5_SAT_L1/IMON4_SAT_L2</td>
<td>O</td>
<td>IMON: [Analog output current monitor]: This pin provides an analog output voltage proportional to the average output current. The full-scale IMON voltage is 2.55 V. 0 A corresponds to 5 mV voltage at IMON.</td>
</tr>
<tr>
<td>14</td>
<td>VR_EN2</td>
<td>Input</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>15</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>16</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>17</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>18</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>19</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>20</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>21</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>22</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>23</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>24</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>25</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>26</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>27</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>28</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>29</td>
<td>VIN3</td>
<td>Input</td>
<td>Input voltage rail. Recommended total input capacitance 4 x 560uF (electrolytic), 16 x 22 μF, 16x 10μF, 8x 1 µF.</td>
</tr>
<tr>
<td>30</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>31</td>
<td>VIN2</td>
<td>Input</td>
<td>Input voltage rail. Recommended total input capacitance 4 x 560uF (electrolytic), 16 x 22 μF, 16x 10μF, 8x 1 µF.</td>
</tr>
<tr>
<td>32</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>33</td>
<td>VOUT2 SAT_L2 SEN_P</td>
<td>Input</td>
<td>Differential remote sense input for Loop 2/Satellite. Connect to positive output regulation point for Loop2/Satellite output if used. Route differentially with VOUT2 SAT_L2 SEN_N.</td>
</tr>
<tr>
<td>34</td>
<td>VOUT2 SAT_L2 SEN_N</td>
<td>Input</td>
<td>Differential remote sense input for Loop 2/Satellite. Connect to negative output regulation point for Loop2/Satellite if used. Route differentially with VOUT2 SAT_L2 SEN_N.</td>
</tr>
<tr>
<td>35</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>36</td>
<td>VOUT1 SEN_N</td>
<td>Input</td>
<td>Differential remote sense input for Loop 1. Connect to negative output regulation point. Route differentially with VOUT1 SEN_P.</td>
</tr>
<tr>
<td>37</td>
<td>VOUT1 SEN_P</td>
<td>Input</td>
<td>Differential remote sense input for Loop 1. Connect to positive output regulation point. Route differentially with VOUT1 SEN_N.</td>
</tr>
<tr>
<td>38</td>
<td>VIN1</td>
<td>Input</td>
<td>Input voltage rail. Recommended total input capacitance 4 x 560uF (electrolytic), 16 x 22 μF, 16x 10μF, 8x 1 µF.</td>
</tr>
</tbody>
</table>

See Application Circuit and Layout Guidelines in this Datasheet for more information.
Technical Specifications (continued)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Label</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>40</td>
<td>VIN4</td>
<td>Input</td>
<td>Input voltage rail. Recommended total input capacitance 4 x 560µF (electrolytic), 16 x 22 µF, 16x 10µF, 8x 1 µF.</td>
</tr>
<tr>
<td>41</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>42</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>43</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>44</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>45</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>46</td>
<td>TSEN_SAT_L2</td>
<td>Input</td>
<td>External Temperature sense input (NTC network) for Satellite Unit / Loop 2. Ground if no satellite connected.</td>
</tr>
<tr>
<td>47</td>
<td>TSEN1</td>
<td>Input</td>
<td>External Temperature sense input (NTC network) for Satellite Unit on Loop 1. Leave floating if no satellites are connected. If Satellite present on Loop1 connect this pin to TSEN_SAT in satellite.</td>
</tr>
<tr>
<td>48</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>49</td>
<td>VR_EN1</td>
<td>Input</td>
<td>VR Enable Input (Loop #1). VR ENABLE is used to power-on the regulator. Cannot be left floating. Must be pulled high or low. Can use 3.3V from module to pullup using a resistor.</td>
</tr>
<tr>
<td>50</td>
<td>VRHOT</td>
<td>Output</td>
<td>VRHOT# Output. Active low alert pin that can be programmed to assert if Temperature exceeds threshold. Can use 3.3V from module to pullup using a resistor.</td>
</tr>
<tr>
<td>51</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>52</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>53</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>54</td>
<td>PGND</td>
<td>PWR</td>
<td>Ground Reference for the module, Rail Return.</td>
</tr>
<tr>
<td>55</td>
<td>VOUT</td>
<td>Output</td>
<td>Output voltage rail. Connect to output filter capacitors. Recommended total output capacitance 6 x 470µF (polymer), 73x 47 µF, 15x 22 µF, 4x 0.1µF, 4x 0.047µF, 1 x 0.022µF, 1 x 2200pF, 1 x 1500pF.</td>
</tr>
<tr>
<td>56</td>
<td>VOUT</td>
<td>Output</td>
<td>Output voltage rail. Connect to output filter capacitors. Recommended total output capacitance 6 x 470µF (polymer), 73x 47 µF, 15x 22 µF, 4x 0.1µF, 4x 0.047µF, 1 x 0.022µF, 1 x 2200pF, 1 x 1500pF.</td>
</tr>
<tr>
<td>57</td>
<td>VOUT</td>
<td>Output</td>
<td>Output voltage rail. Connect to output filter capacitors. Recommended total output capacitance 6 x 470µF (polymer), 73x 47 µF, 15x 22 µF, 4x 0.1µF, 4x 0.047µF, 1 x 0.022µF, 1 x 2200pF, 1 x 1500pF.</td>
</tr>
<tr>
<td>58</td>
<td>VOUT</td>
<td>Output</td>
<td>Output voltage rail. Connect to output filter capacitors. Recommended total output capacitance 6 x 470µF (polymer), 73x 47 µF, 15x 22 µF, 4x 0.1µF, 4x 0.047µF, 1 x 0.022µF, 1 x 2200pF, 1 x 1500pF.</td>
</tr>
<tr>
<td>59</td>
<td>CFILT</td>
<td>Output</td>
<td>1.8 V Decoupling. A 1 µF capacitor on this pin provides decoupling for the internal 1.8 V supply.</td>
</tr>
<tr>
<td>60</td>
<td>PWM7_SAT_L1/</td>
<td>Output</td>
<td>Pulse Width Modulation Output for external Power stage in Satellite. Use as Loop 2 Phase 2 or Loop 1 Phase 7.</td>
</tr>
<tr>
<td></td>
<td>PWM2_SAT_L2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>PWM6_SAT_L1/</td>
<td>Output</td>
<td>Pulse Width Modulation Output for external Power stage in Satellite. Use as Loop 2 Phase 3 or Loop 1 Phase 6.</td>
</tr>
<tr>
<td></td>
<td>PWM3_SAT_L2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>SM_DAT</td>
<td>Output</td>
<td>Serial data. Connect to external host and/or to other devices. Requires a pull-up resistor to a V3.3V or 5V source. Can use V3.3V from module to pullup using a resistor.</td>
</tr>
<tr>
<td>63</td>
<td>VR_RDY1</td>
<td>Output</td>
<td>Voltage Regulator Ready Output (Loop #1). Open-drain output that asserts high when the module has completed soft-start to Loop #1 setpoint voltage. Can use V3.3V from module to pullup using a resistor.</td>
</tr>
<tr>
<td>64</td>
<td>V3.3V</td>
<td>Output</td>
<td>Auxiliary V3.3V low power bus.</td>
</tr>
<tr>
<td>65</td>
<td>PWM8_SAT_L1/</td>
<td>Output</td>
<td>Pulse Width Modulation Output for external Power stage in Satellite. Use as Loop 2 Phase 1 or Loop 1 Phase 8.</td>
</tr>
<tr>
<td></td>
<td>PWM1_SAT_L2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>PWM5_SAT_L1/</td>
<td>Output</td>
<td>Pulse Width Modulation Output for external Power stage in Satellite. Use as Loop 2 Phase 4 or Loop 1 Phase 5.</td>
</tr>
<tr>
<td></td>
<td>PWM4_SAT_L2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>SM_CLK</td>
<td>I/O</td>
<td>Serial clock. Connect to external host and/or to other modules. Can use V3.3V from module to pullup using a resistor.</td>
</tr>
<tr>
<td>68</td>
<td>SM_ALERT</td>
<td>I/O</td>
<td>Serial alert. Connect to external host if desired. Can use V3.3V from module to pullup using a resistor. If not used, GND this pin</td>
</tr>
<tr>
<td>69</td>
<td>VOUT</td>
<td>Output</td>
<td>Output voltage rail. Connect to output filter capacitors. Recommended total output capacitance 6 x 470µF (polymer), 73x 47 µF, 15x 22 µF, 4x 0.1µF, 4x 0.047µF, 1 x 0.022µF, 1 x 2200pF, 1 x 1500pF.</td>
</tr>
<tr>
<td>70</td>
<td>VOUT</td>
<td>Output</td>
<td>Output voltage rail. Connect to output filter capacitors. Recommended total output capacitance 6 x 470µF (polymer), 73x 47 µF, 15x 22 µF, 4x 0.1µF, 4x 0.047µF, 1 x 0.022µF, 1 x 2200pF, 1 x 1500pF.</td>
</tr>
<tr>
<td>71</td>
<td>VOUT</td>
<td>Output</td>
<td>Output voltage rail. Connect to output filter capacitors. Recommended total output capacitance 6 x 470µF (polymer), 73x 47 µF, 15x 22 µF, 4x 0.1µF, 4x 0.047µF, 1 x 0.022µF, 1 x 2200pF, 1 x 1500pF.</td>
</tr>
<tr>
<td>72</td>
<td>VOUT</td>
<td>Output</td>
<td>Output voltage rail. Connect to output filter capacitors. Recommended total output capacitance 6 x 470µF (polymer), 73x 47 µF, 15x 22 µF, 4x 0.1µF, 4x 0.047µF, 1 x 0.022µF, 1 x 2200pF, 1 x 1500pF.</td>
</tr>
</tbody>
</table>

Page 29
© 2023 OmniOn Power Inc. All rights reserved MLX160_DS Revision 1.12
Technical Specifications (continued)

Physical dimensions

BOTTOM VIEW (ENLARGED for READABILITY)
Application Circuit (Based on Evaluation Board)

\[ V_{IN} = 12V \]
\[ V_{out} = 1V \]

CI1 – 4 banks (1µF + 1µF ceramic) – 8 caps total
CI2 – 4 Banks (4 x 10µF ceramic) – 16 caps total
CI3 – 4 Banks (4 x 22µF ceramic) – 16 caps total
CI4 – 4 Banks (1 x 560µF electrolytic) – 4 caps total
CO1 – 4 x 0.047µF+ 4 x 0.1µF - ceramic
CO2 – 15 x 22µFceramic + 73 x 47µFceramic +6x470µF polymer or electrolytic
CO3 – 1 x 1500pF(0402) + 1 x 2200pF(0402) +1 x 0.022µF(0402) + 0.1uF(0402) – all ceramic R8 based on Q1
R1, R2, R3 = 10K
R4, R5, R6 – based on PMBus controller / dongle being used
R7 = 845Ω

C5 – 1x10µF + 1x 22µF
CP – 0.01µF

TSEN1 is to be left floating if no Satellite on Loop 1
TSEN_SAT_L2 to be connected to Ground if no Satellite on Loop 2
SM_ALERT to be connected to Ground if not being used/monitored
PWMx_SATx_ are to be used only if Satellite is being used
IMONx_SATx are to be used only if Satellite is being used
VOUT2_SAT_L2_SEN_x are to be used only if Satellite is being used
CFILT, VR_EN2 are to be used only if Satellite is being used
VR_EN1 and VR_EN2 cannot be left floating
Technical Specifications (continued)

Thermal Considerations

Power modules operate in a variety of thermal environments; however, sufficient cooling should always be provided to help ensure reliable operation. Considerations include ambient temperature, airflow, module power dissipation, and the need for increased reliability. A reduction in the operating temperature of the module will result in an increase in reliability. The thermal data presented here is based on physical measurements taken in a wind tunnel. The test set-up is shown in Figure 28. The preferred airflow direction for cooling the module and the thermal reference points, Tref used in the specifications are shown in Figure 29. For reliable operation the temperatures at these points should not exceed 120°C (IC300) and 115°C (C202). The output power of the module should not exceed the rated power of the module (Vo,set x Io,max). Please refer to the Application Note “Thermal Characterization Process for Open-Frame Board-Mounted Power Modules” for a detailed discussion of thermal aspects including maximum device temperatures. Increased airflow over the module enhances the heat transfer via convection. The thermal derating of figures 2, 8, 14 and 20 show the maximum output current that can be delivered by each module in the indicated orientation without exceeding the maximum Tref temperature versus local ambient temperature (TA) for several airflow conditions. The thermal derating curves were generated using a 12 layer evaluation board with 3oz copper in inner layers and 2 oz in outer layers.

Figure 28. Thermal Test Setup.

Figure 29. Preferred airflow direction and the location of the thermal reference points.
Technical Specifications (continued)

Packaging Details
The MLX160 Open Frame modules are supplied in tape & reel as standard. Modules are shipped in quantities of 160 modules per reel. All Dimensions are in millimeters and (in inches).

Reel Dimensions:
Outside Dimensions: 330.2mm (13”)
Inside Dimensions: 177.8 mm (7”)
Tape Width: 56.00mm (2.205”)
Surface Mount Information

Pick and Place

The MLX160 Open Frame modules use an open frame construction and are designed for a fully automated assembly process. The modules are fitted with a label designed to provide a large surface area for pick and place operations. The label meets all the requirements for surface mount processing, as well as safety standards, and is able to withstand reflow temperatures of up to 300 °C. The label also carries product information such as product code, serial number and the location of manufacture.

Nozzle Recommendations

Stencil thickness of 5 mils minimum must be used for this product. The module weight has been kept to a minimum by using open frame construction. Variables such as nozzle size, tip style, vacuum pressure and placement speed should be considered to optimize this process. The minimum recommended inside nozzle diameter for reliable operation is 3mm. The maximum nozzle outer diameter, which will safely fit within the allowable component spacing, is 7 mm.

Bottom Side / First Side Assembly

This module is not recommended for assembly on the bottom side of a customer board. If such an assembly is attempted, components may fall off the module during the second reflow process.

Lead Free Soldering

The modules are lead-free (Pb-free) and RoHS compliant and fully compatible in a Pb-free soldering process. Failure to observe the instructions below may result in the failure of or cause damage to the modules and can adversely affect long-term reliability.

Pb-free Reflow Profile

Power Systems will comply with J-STD-020 Rev. D (Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices) for both Pb-free solder profiles and MSL classification procedures. This standard provides a recommended forced-air-convection reflow profile based on the volume and thickness of the package (table 4-2). The suggested Pb-free solder paste is Sn/Ag/Cu (SAC). The recommended linear reflow profile using Sn/Ag/Cu solder is shown in Fig. 30. Soldering outside of the recommended profile requires testing to verify results and performance.

Figure 30. Recommended linear reflow profile using Sn/Ag/Cu solder
Technical Specifications (continued)

Surface Mount Information (continued)

MSL Rating

The MLX160A0XY3-SRZ Open Frame modules have a MSL rating of 2A.

Storage and Handling

The recommended storage environment and handling procedures for moisture-sensitive surface mount packages is detailed in J-STD-033 Rev. A (Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices). Moisture barrier bags (MBB) with desiccant are required for MSL ratings of 2 or greater. These sealed packages should not be broken until time of use. Once the original package is broken, the floor life of the product at conditions of 30°C and 60% relative humidity varies according to the MSL rating (see J-STD-033A). The shelf life for dry packed SMT packages will be a minimum of 12 months from the bag seal date, when stored at the following conditions: < 40°C, < 90% relative humidity.

Post Solder Cleaning and Drying Considerations

Post solder cleaning is usually the final circuit-board assembly process prior to electrical board testing. The result of inadequate cleaning and drying can affect both the reliability of a power module and the testability of the finished circuit-board assembly. For guidance on appropriate soldering, cleaning and drying procedures, refer to Board Mounted Power Modules: Soldering and Cleaning Application Note (AN04-001).
Family Options

Approved Combinations:

<table>
<thead>
<tr>
<th>Output Current</th>
<th>Output Configuration</th>
<th>in Master + Satellite Combination</th>
<th>Master Series</th>
<th>Satellite Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Single Output</td>
<td>MLX040</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>40 + 40*</td>
<td>Dual Output</td>
<td>MLX040</td>
<td>SLX040</td>
<td></td>
</tr>
<tr>
<td>40 + 2 x 40*</td>
<td>Dual Output</td>
<td>MLX040</td>
<td>2 X SLX040</td>
<td></td>
</tr>
<tr>
<td>40 + 3 x 40*</td>
<td>Dual Output</td>
<td>MLX040</td>
<td>3 X SLX040</td>
<td></td>
</tr>
<tr>
<td>40 + 160*</td>
<td>Dual Output</td>
<td>MLX040</td>
<td>SLX160</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>Single Output</td>
<td>MLX080</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>80 + 40*</td>
<td>Dual Output</td>
<td>MLX080</td>
<td>SLX040</td>
<td></td>
</tr>
<tr>
<td>80 + 2 x 40*</td>
<td>Dual Output</td>
<td>MLX080</td>
<td>2 X SLX040</td>
<td></td>
</tr>
<tr>
<td>80 + 3 x 40*</td>
<td>Dual Output</td>
<td>MLX080</td>
<td>3 X SLX040</td>
<td></td>
</tr>
<tr>
<td>80 + 160*</td>
<td>Dual Output</td>
<td>MLX080</td>
<td>SLX160</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>Single Output</td>
<td>MLX120</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>120 + 40*</td>
<td>Dual Output</td>
<td>MLX120</td>
<td>SLX040</td>
<td></td>
</tr>
<tr>
<td>120 + 2 x 40*</td>
<td>Dual Output</td>
<td>MLX120</td>
<td>2 X SLX040</td>
<td></td>
</tr>
<tr>
<td>120 + 3 x 40*</td>
<td>Dual Output</td>
<td>MLX120</td>
<td>3 X SLX040</td>
<td></td>
</tr>
<tr>
<td>120 + 160*</td>
<td>Dual Output</td>
<td>MLX120</td>
<td>SLX160</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>Single Output</td>
<td>MLX160</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>200*</td>
<td>Single Output</td>
<td>MLX160</td>
<td>SLX040</td>
<td></td>
</tr>
<tr>
<td>240*</td>
<td>Single Output</td>
<td>MLX160</td>
<td>2 X SLX040</td>
<td></td>
</tr>
<tr>
<td>280*</td>
<td>Single Output</td>
<td>MLX160</td>
<td>3 X SLX040</td>
<td></td>
</tr>
<tr>
<td>320</td>
<td>Single Output</td>
<td>MLX160</td>
<td>SLX160</td>
<td></td>
</tr>
<tr>
<td>160 + 40</td>
<td>Dual Output</td>
<td>MLX160</td>
<td>SLX040</td>
<td></td>
</tr>
<tr>
<td>160 + 2 x 40*</td>
<td>Dual Output</td>
<td>MLX160</td>
<td>2 X SLX040</td>
<td></td>
</tr>
<tr>
<td>160 + 3 x 40*</td>
<td>Dual Output</td>
<td>MLX160</td>
<td>3 X SLX040</td>
<td></td>
</tr>
<tr>
<td>160 + 160*</td>
<td>Dual Output</td>
<td>MLX160</td>
<td>SLX160</td>
<td></td>
</tr>
</tbody>
</table>

* Verified by design. Test data not available for these individual combinations.
Technical Specifications (continued)

Ordering Information
Please contact our Sales Representative for pricing, availability, and optional features.

Table 5. Device Codes

<table>
<thead>
<tr>
<th>Device Code</th>
<th>Type</th>
<th>Input Voltage Range</th>
<th>Output Voltage</th>
<th>Output Current</th>
<th>On/Off Logic</th>
<th>Ordering code</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLX160A0XY3-SRZ</td>
<td>Master</td>
<td>7 – 14Vdc</td>
<td>0.45 – 2 Vdc</td>
<td>160A</td>
<td>Programmable</td>
<td>1600374230A</td>
</tr>
</tbody>
</table>

Table 6. Coding Scheme

<table>
<thead>
<tr>
<th>Module type Identifier</th>
<th>Family</th>
<th>Sequencing Option</th>
<th>Output current</th>
<th>Output voltage</th>
<th>On/Off logic</th>
<th>Remote Sense</th>
<th>Options</th>
<th>ROHS Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>M=master</td>
<td>L = DLynx III</td>
<td>X=without sequencing</td>
<td>160A</td>
<td>X = programmable output</td>
<td>Y = programmable enable logic</td>
<td>3 = Remote Sense</td>
<td>S = Surface Mount</td>
<td>R = Tape &amp; Reel</td>
</tr>
</tbody>
</table>

Table 7 Orderable Accessories

<table>
<thead>
<tr>
<th>Manufacturer Part Number</th>
<th>Ordering Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVAL MLX160</td>
<td>1600374232A</td>
<td>Evaluation Board with MLX160A module</td>
</tr>
<tr>
<td>EVAL MLX160 SLX040 DUAL OUTPUT</td>
<td>1600374232A</td>
<td>Evaluation Board with MLX160A module AND 40A SLX module</td>
</tr>
<tr>
<td>EVAL MLX160 SLX160 SINGLE OUTPUT</td>
<td>1600374233A</td>
<td>Evaluation Board with MLX160A module AND 160A SLX module</td>
</tr>
<tr>
<td>DIGITAL_POL_EVAL_KIT</td>
<td>CC109164430</td>
<td>Digital Power Insights (DPI) it with USB dongle, needed cables, and a digital POL evaluation board (PDT012 or PJT020) and quick guide</td>
</tr>
<tr>
<td>I2C_USB_DONGLE_2.x</td>
<td>1600218857A</td>
<td>USB dongle required for use of Digital Power Insights software. Other contents of the DIGITAL_POL_EVAL_KIT are not included</td>
</tr>
</tbody>
</table>


Contact Us
For more information, call us at
USA/Canada:
+1 888 546 3243, or +1 972 244 9288
Asia-Pacific:
+86-21-53899666
Europe, Middle-East and Africa:
+49.89.878067-280
## Change History (excludes grammar & clarifications)

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Description of the change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.10</td>
<td>09/26/2023</td>
<td>Updated Family output description</td>
</tr>
<tr>
<td>1.11</td>
<td>11/03/2023</td>
<td>Updated as per OmniOn template</td>
</tr>
<tr>
<td>1.12</td>
<td>01/19/2024</td>
<td>Updated Class to 2 on Page 1</td>
</tr>
</tbody>
</table>
We reserve the right to make technical changes or modify the contents of this document without prior notice. OmniOn Power does not accept any responsibility for errors or lack of information in this document and makes no warranty with respect to and assumes no liability as a result of any use of information in this document.

We reserve all rights in this document and in the subject matter and illustrations contained therein. Any reproduction, disclosure to third parties or utilization of its contents – in whole or in parts – is forbidden without prior written consent of OmniOn Power. This document does not convey license to any patent or any intellectual property right. Copyright© 2023 OmniOn Power Inc.

All rights reserved.