High Voltage 4-CH LED Driver

General Description
The RT8577A is an 4-CH LED driver capable of delivering 120mA for each channel. The RT8577A is a current mode boost converter with an adjustable switching frequency via the RT pin from 200kHz to 2.1MHz and a wide VIN range from 5.5V to 40V.

The PWM output voltage loop selects and regulates the LED pin with the highest voltage string to 0.6V, hence allowing voltage mismatches between LED strings. The RT8577A automatically detects and disconnects any unconnected and/or broken strings during operation from PWM loop to prevent VOUT from over voltage. The 1.5% matched LED currents on all channels are simply programmed with a resistor. A very high contrast ratio true digital PWM dimming can be achieved by driving the PWM pin with a PWM signal.

When an abnormal situation (OVP/short/OTP) occurs, a status signal will be sent to the system to shut down the IC.

Features
- Wide Input Supply Voltage Range : 5.5V to 40V
- Adjustable Boost Controller Switching Frequency from 200kHz to 2.1MHz
- Programmable Channel Current
- Channel Current Matching : ±1.5%
- External Dimming Control
- Boost MOSFET Over Current Protection
- Automatic LED Open/Short Protection to Avoid Output Over Voltage
- VCC Under Voltage Lockout
- Adjustable Over Voltage Protection
- Thermal Shutdown Protection
- Abnormal Status Indicator for OVP/Short/OTP Condition
- AEC-Q100 Grade 3 Certification
- RoHS Compliant and Halogen Free

Applications
- Automotive Infotainment
- LCD TV, Monitor Display Backlight
- LED Driver Application
- General Purpose Constant Current Source

Ordering Information
RT8577A

Note:
Richtek products are:
¬ RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
¬ Suitable for use in SnPb or Pb-free soldering processes.

Packaging Information
RT8577AGQW : Product Number
YMDNN : Date Code

Marking Information

Features
- Wide Input Supply Voltage Range : 5.5V to 40V
- Adjustable Boost Controller Switching Frequency from 200kHz to 2.1MHz
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Pin Configuration
# Functional Pin Description

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Pin Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3, 21 (Exposed pad)</td>
<td>GND</td>
<td>Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.</td>
</tr>
<tr>
<td>4, 5</td>
<td>LED4, LED3</td>
<td>Channel 3 and channel 4 LED current sinks. Leave the pins unconnected if not used.</td>
</tr>
<tr>
<td>6</td>
<td>OVP</td>
<td>Over-voltage detection input. The Boost converter turns off when VOVP goes higher than 2V.</td>
</tr>
<tr>
<td>7</td>
<td>RISET</td>
<td>LED current set pin. A resistor or a current from DAC on this pin programs the full LED current.</td>
</tr>
<tr>
<td>8</td>
<td>RT</td>
<td>Switching frequency set. Connect a resistor between RT and GND to set the boost converter switching frequency.</td>
</tr>
<tr>
<td>9</td>
<td>EN</td>
<td>Enable control input. When EN is pulled low, the chip will be shut down.</td>
</tr>
<tr>
<td>10</td>
<td>SEN</td>
<td>Current sense input. During normal operation, this pin senses the voltage across the external inductor current sensing resistor for peak current mode control and also to limit the inductor current during every switching cycle.</td>
</tr>
<tr>
<td>11</td>
<td>DRV</td>
<td>Boost converter power switch gate output. This pin drives the external power N-MOSFET device.</td>
</tr>
<tr>
<td>12</td>
<td>CREG</td>
<td>Regulator output for chip internal use only. A 1(\mu)F capacitor should be placed on this pin to stabilize the 5V output of the internal regulator.</td>
</tr>
<tr>
<td>13, 18</td>
<td>NC</td>
<td>No internal connection.</td>
</tr>
<tr>
<td>14</td>
<td>VCC</td>
<td>Power supply of the chip. For good bypass, a low ESR capacitor close to the pin is required.</td>
</tr>
<tr>
<td>15</td>
<td>STATUS</td>
<td>Status indicator output. This pin will be pulled to low if fault happens.</td>
</tr>
<tr>
<td>16</td>
<td>VC</td>
<td>PWM boost converter loop compensation node.</td>
</tr>
<tr>
<td>17</td>
<td>PWM</td>
<td>Dimming control input.</td>
</tr>
<tr>
<td>19</td>
<td>LED1</td>
<td>Channel 1 LED current sink, leave this pin unconnected if it is not used.</td>
</tr>
<tr>
<td>20</td>
<td>LED2</td>
<td>Channel 2 LED current sink, leave this pin unconnected if it is not used.</td>
</tr>
</tbody>
</table>
**Operation**

The RT8577A integrated a current-mode Boost PWM controller and 4 LED drivers. When EN and PWM are high and VIN is higher than the UVLO threshold voltage, the controller starts operation. In normal operation, the DRV pin turns high when the gate driver is set by the oscillator and the DRV pin turns low when the gate driver is reset by the current comparator. When the DRV pin turns high to turn on the external MOSFET, the inductor current will rise up. Once the SEN pin voltage reaches the level of the VC pin, the current comparator will reset the gate driver and turn off the MOSFET. The DRV pin is then set to high again by OSC and repeats in the next switching cycle. The oscillator frequency can be set by an external resistor at the RT pin.

The output voltage of the Boost converter supports LED current and regulation voltage at the LEDx pin. The LED current is set by an external resistor at the RISET pin. A PWM dimming function is provided to control the LED brightness through the PWM pin. If OVP, OTP or shorted LED happens, the STATUS pin will be pulled to low as a fault indicator.
Absolute Maximum Ratings  (Note 1)

- Supply Voltage, VCC, STATUS  
  
- LED1 to LED4  
  
- PWM, EN, DRV, SEN, VC, RT, CREG, OVP, RISET  
  
- Power Dissipation, Pd @ TA = 25°C  
  WQFN-20L 5x5  

- Package Thermal Resistance  (Note 2)  
  WQFN-20L 5x5, θJA  
  
- Junction Temperature  
  
- Lead Temperature (Soldering, 10 sec.)  
  
- Storage Temperature Range  
  
- ESD Susceptibility  (Note 3)  
  HBM (Human Body Model)  
  
  MM (Machine Model)  

Recommended Operating Conditions  (Note 4)

- Supply Voltage, VCC  
  
- LED1 to LED4  
  
- ILED1 to ILED4  
  
- Junction Temperature Range  
  
- Ambient Temperature Range  

Electrical Characteristics

(VCC = 12V, TA = −40°C to 85°C, unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>VCC</td>
<td>Switching Off</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>mA</td>
</tr>
<tr>
<td>Shutdown Current</td>
<td>I SHDN</td>
<td>VEN &lt; 0.7V</td>
<td>0.5</td>
<td>10</td>
<td>30</td>
<td>μA</td>
</tr>
<tr>
<td>VDD LDO Output</td>
<td>VC REG</td>
<td></td>
<td>4.5</td>
<td>5</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>VDD LDO Capability</td>
<td>IC REG</td>
<td></td>
<td>30</td>
<td>75</td>
<td>150</td>
<td>mA</td>
</tr>
<tr>
<td>VCC UVLO Threshold</td>
<td>UV LO</td>
<td>VCC rising</td>
<td>3.8</td>
<td>4.5</td>
<td>4.8</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hysteresis</td>
<td>0.1</td>
<td>0.3</td>
<td>0.7</td>
<td>V</td>
</tr>
<tr>
<td>EN Threshold Voltage</td>
<td>VENH</td>
<td>Logic-High</td>
<td>1.5</td>
<td>--</td>
<td>--</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>VENL</td>
<td>Logic-Low</td>
<td>--</td>
<td>0.8</td>
<td>0.8</td>
<td>V</td>
</tr>
</tbody>
</table>

LED Current Programming

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED Current Accuracy</td>
<td></td>
<td></td>
<td>76</td>
<td>80</td>
<td>84</td>
<td>mA</td>
</tr>
<tr>
<td>LED Current Matching (Note5)</td>
<td></td>
<td></td>
<td>--</td>
<td>±1.5</td>
<td>±3</td>
<td>%</td>
</tr>
</tbody>
</table>
### LED1 to LED4 Regulation Voltage

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED1 to LED4 Regulation Voltage</td>
<td>I&lt;sub&gt;LED = 80mA&lt;/sub&gt;</td>
<td>0.75</td>
<td>0.86</td>
<td>1</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

### V<sub>L</sub>E<sub>D</sub> Threshold

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;L&lt;/sub&gt;E&lt;sub&gt;D&lt;/sub&gt; Threshold</td>
<td>No connection</td>
<td>0.05</td>
<td>0.1</td>
<td>0.36</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

### RISET Pin Voltage

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>RISET Pin Voltage</td>
<td>0.8</td>
<td>1.2</td>
<td>1.5</td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

### Dimming

#### PWM Threshold Voltage

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic-High</td>
<td>V&lt;sub&gt;PWMH&lt;/sub&gt;</td>
<td>1.2</td>
<td>--</td>
<td>--</td>
<td>V</td>
</tr>
<tr>
<td>Logic-Low</td>
<td>V&lt;sub&gt;PWMl&lt;/sub&gt;</td>
<td>--</td>
<td>--</td>
<td>0.52</td>
<td>V</td>
</tr>
</tbody>
</table>

#### PWM Boost Controller

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching Frequency</td>
<td>f&lt;sub&gt;SW&lt;/sub&gt;</td>
<td>R&lt;sub&gt;RT = 20kΩ&lt;/sub&gt;</td>
<td>1.8</td>
<td>2.1</td>
<td>2.4</td>
<td>MHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R&lt;sub&gt;RT = Open&lt;/sub&gt;</td>
<td>50</td>
<td>200</td>
<td>350</td>
<td>kHz</td>
</tr>
<tr>
<td>Minimum On Time (Note 5)</td>
<td>t&lt;sub&gt;ON&lt;/sub&gt;</td>
<td>Working</td>
<td>0</td>
<td>40</td>
<td>60</td>
<td>ns</td>
</tr>
<tr>
<td>Maximum Duty Cycle</td>
<td>D&lt;sub&gt;max&lt;/sub&gt;</td>
<td>80</td>
<td>--</td>
<td>100</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>SEN Current Sense Limit (Note 5)</td>
<td>Input current limit</td>
<td>0.1</td>
<td>0.5</td>
<td>0.6</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Gate Driver Source</td>
<td>0.9</td>
<td>2.5</td>
<td>3.5</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate Driver Sink</td>
<td>1.6</td>
<td>3</td>
<td>7</td>
<td>A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### OVP, SCP, OTP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVP Threshold (Note 5)</td>
<td>V&lt;sub&gt;OVP&lt;/sub&gt;</td>
<td>1.9</td>
<td>2</td>
<td>2.1</td>
<td>V</td>
</tr>
<tr>
<td>SCP Threshold</td>
<td>V&lt;sub&gt;SCP&lt;/sub&gt;</td>
<td>LED1 to LED4</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>STATUS Low Voltage</td>
<td>V&lt;sub&gt;STATUS&lt;/sub&gt;</td>
<td>Open drain at 10mA</td>
<td>0</td>
<td>--</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Note 1.** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

**Note 2.** θ<sub>JA</sub> is measured at T<sub>A</sub> = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7. θ<sub>JC</sub> is measured at the exposed pad of the package.

**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

**Note 4.** The device is not guaranteed to function outside its operating conditions..
## Typical Application Circuit

![Typical Application Circuit Diagram]

### Table: LED Current and Resistor Values

<table>
<thead>
<tr>
<th>$I_{LED}$ (Note 6)</th>
<th>$R_{ISET}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>120mA</td>
<td>10kΩ</td>
</tr>
<tr>
<td>80mA</td>
<td>15kΩ</td>
</tr>
<tr>
<td>20mA</td>
<td>68kΩ</td>
</tr>
</tbody>
</table>

---

**Note:**

1. VIN: 5.5V to 40V
2. D1: 10µH
3. CIN: 20µF
4. ROVP1: 100k
5. ROVP2: 2.1M
6. RSET: 9.1k
7. RT: 56k
8. RSENSE: 100m
9. RDRV: 1k
10. RSENSE: 100m
11. VRCC: 560V
12. VCC: 10µH
13. L1: 56k
14. COUT: 4.7µF x 6
Timing Diagram

Power On/Off Sequence

LED driver is without power sequence concern. Mode1, Mode2 and Mode3 are different power sequences respectively. There is no concern in the above condition.

**Mode1 : Delay Time of PWM vs VOUT**

![Diagram showing Mode1](image1)

**Mode2 : Delay Time of EN vs VOUT**

![Diagram showing Mode2](image2)

**Mode3 : Delay Time of VIN vs VOUT**

![Diagram showing Mode3](image3)

Figure 1. Power On/Off Sequence
Typical Operating Characteristics

LED Current vs. Input Voltage

LED Current vs. PWM Duty Cycle

Efficiency vs. Input Voltage

Start up with Minimum PWM Duty

OVP Protection

LED Short Delay Time
LED Short Protection

Power Off from VIN

Power On from EN

Power Off from EN

Power On from VIN

Power Off from VIN
Power On from PWM

Power Off from PWM

VIN = 12V, 48LEDs, RSET = 10kΩ

V_IN = 12V, 48LEDs, RSET = 10kΩ
Application information

The RT8577A is an 4-CH driver controller that delivers well matched LED current to each channel of LED strings. The external N-MOSFET current source will accommodate the power dissipation difference among channels resulting from the forward voltage difference between the LED strings. With high speed current source N-MOSFET drivers, the RT8577A features highly accurate current matching, while also providing very fast turn-on and turn-off times. This allows a very narrow minimum on or off pulse. The RT8577A integrates adjustable switching frequency and provides circuitry for over temperature, over voltage, under voltage and current limit protection.

Compensation

The regulator loop can be compensated by adjusting the external components connected to the VC pin. The VC pin is the output of the internal error amplifier. The compensation capacitor will adjust the integrator zero to maintain stability and the resistor value will adjust the frequency integrator gain for fast transient response. Typical values of the compensation components are $R_C = 560\, \Omega$, $C_C = 0.22\, \mu F$.

LED Connection

The RT8577A equips 4-CH LED drivers and each channel supports up to 15 LEDs. The LED strings are connected from the output of the boost converter to pin LEDx (x = 1 to 4) respectively. If one of the LED channel is not in use, the LED pin should be opened directly.

Setting and Regulation of LED current

The LED current can be calculated by the following equation:

\[
I_{LED} = \begin{cases} 
\frac{1200}{R_{RSET}} & (40\, mA < I_{LED} \leq 120\, mA) \\
\frac{1360}{R_{RSET}} & (20\, mA < I_{LED} \leq 40\, mA)
\end{cases}
\]

where $R_{RSET}$ is the resistor between the RISET pin and GND. This setting is the reference for the LED current at pin LEDx and represents the sensed LED current for each string. The DC/DC converter regulates the LED current according to the setting.

Over Voltage Protection

The RT8577A integrates Over Voltage Protection (OVP). When the voltage at the OVP pin rises above the threshold voltage of approximately 2V, the internal switch will be turned off and STATUS pin will be pulled low. The internal switch will be turned on again once the voltage at the OVP pin returns to normal range. The output voltage can be clamped at a certain voltage level and can be calculated by the following equation:

\[
V_{OUT(OVP)} = V_{OVP} \times \left(1 + \frac{R_{OVP2}}{R_{OVP1}}\right)
\]

where $R_{OVP1}$ and $R_{OVP2}$ are the resistors in the resistive voltage divider connected to the OVP pin. If at least one string is in normal operation, the controller will automatically ignore the open strings and continue to regulate the current for the strings in normal operation. Suggested value for $R_{OVP2}$ is up to 3.6M\,\Omega to prevent loading effect.

LED Short Circuit Protection

The RT8577A integrates LED Short Circuit Protection (SCP). If one of the LED1 to LED4 pin voltages exceeds a threshold of approximately 7V during normal operation, the STATUS pin will be pulled low for a fault signal.

STATUS

The RT8577A provides a fault status indicator with an open drain STATUS pin. If fault condition (LED Short/OVP/OTP) occurs, the STATUS will be reset after $V_{IN}$ or EN is re-applied.

Setting the Switching Frequency

The RT8577A switching frequency is programmable from 200kHz to 2.1MHz by adjusting the oscillator resistor, $R_{RT}$. The switching frequency can be calculated by the following equation:

\[
f_{SW} = 200k + \frac{38 \times 10^9}{R_{RT}}
\]
Current Limit Protection
The RT8577A can sense the $R_{\text{SENSE}}$ voltage between the SEN pin and GND to achieve over current protection. The boost converter senses the inductor current during the on period. The duty cycle depends on the current signal and internal slope compensation compared with the error signal. The external switch will be turned off when the current signal is larger than the internal slope compensation. In the off period, the inductor current will decrease until the internal switch is turned on by the oscillator. The current limit value can be calculated by the following equation:

$$\text{Current Limit (A)} \approx \frac{0.5V}{R_{\text{SENSE}}}$$

Brightness Control
The RT8577A features a digital dimming control scheme. A very high contrast ratio true digital PWM dimming is achieved by driving the PWM pin with a PWM signal. The recommended PWM frequency is 100Hz to 10kHz, but the LED current cannot be 100% proportional to duty cycle, especially for high frequency and low duty ratio because of physical limitation caused by inductor rising time. Please refer to Table 1.

$$\text{Brightness Control}$$

The RT8577A has over temperature protection function to prevent the IC from overheating due to excessive power dissipation. The IC will shut down and the STATUS pin will be pulled low when junction temperature exceeds 150°C. Main converter starts switching after junction temperature cools down by approximately 20°C.

Over Temperature Protection

$$L = \frac{D \times (1-D)^2 \times V_{\text{OUT}}}{2 \times f \times I_{\text{OUT}}},$$

The duty cycle can be calculated as the following equation:

$$D = \frac{V_{\text{OUT}} - V_{\text{IN}}}{V_{\text{OUT}}}$$

where $V_{\text{OUT}}$ is the maximum output voltage, $V_{\text{IN}}$ is the minimum input voltage, $f$ is the operating frequency, and $I_{\text{OUT}}$ is the sum of current from all LED strings.

The boost converter operates in DCM over the entire input voltage range when the inductor value is less than this value, $L$. With an inductance greater than $L$, the converter operates in CCM at the minimum input voltage and may be discontinuous at higher voltages.

The inductor must be selected with a saturated current rating that is greater than the peak current as provided by the following equation:

$$I_{\text{PEAK}} = \frac{V_{\text{OUT}} \times I_{\text{OUT}}}{\eta \times V_{\text{IN}}} + \frac{V_{\text{IN}} \times D \times T}{2 \times L}$$

where $\eta$ is the efficiency of the power converter.

### Table 1.

<table>
<thead>
<tr>
<th>Dimming Frequency (Hz)</th>
<th>Duty (Min.)</th>
<th>Duty (Max.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 &lt; $f_{\text{PWM}} \leq$ 500</td>
<td>0.2%</td>
<td>100%</td>
</tr>
<tr>
<td>500 &lt; $f_{\text{PWM}} \leq$ 1k</td>
<td>0.4%</td>
<td>100%</td>
</tr>
<tr>
<td>1k &lt; $f_{\text{PWM}} \leq$ 2k</td>
<td>0.8%</td>
<td>100%</td>
</tr>
<tr>
<td>2k &lt; $f_{\text{PWM}} \leq$ 5k</td>
<td>1.5%</td>
<td>100%</td>
</tr>
<tr>
<td>5k &lt; $f_{\text{PWM}} \leq$ 10k</td>
<td>3%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note: The minimum duty in Table 1 is based on the application circuit and does not consider the deviation of current linearity.
Diode Selection
Schottky diodes are recommended for most applications because of their fast recovery time and low forward voltage. Power dissipation, reverse voltage rating, and pulsating peak current are important parameters for consideration when making a Schottky diode selection. Make sure that the diode's peak current rating exceeds $I_{PEAK}$ and reverse voltage rating exceeds the maximum output voltage.

Capacitor Selection
The input capacitor reduces current spikes from the input supply and minimizes noise injection to the converter. For general applications, six 4.7μF ceramic capacitors are sufficient. A value higher or lower may be used depending on the noise level from the input supply and the input current to the converter.

It is recommended to choose a ceramic capacitor based on the output voltage ripple requirements. The minimum value of the output capacitor, $C_{OUT}$, can be calculated by the following equation:

$$C_{OUT} = \frac{I_{OUT} \times D}{\Delta V_{OUT} \times f}$$

where $\Delta V_{OUT}$ is the peak-to-peak ripple voltage at the output.

Thermal Considerations
For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula:

$$P_{D(MAX)} = (T_{J\,(MAX)} - T_{A}) / \theta_{JA}$$

where $T_{J\,(MAX)}$ is the maximum junction temperature, $T_{A}$ is the ambient temperature, and $\theta_{JA}$ is the junction to ambient thermal resistance.

For recommended operating condition specifications, the maximum junction temperature is 125°C and $T_{A}$ is the ambient temperature. The junction to ambient thermal resistance, $\theta_{JA}$, is layout dependent. For WQFN-20L 5x5 packages, the thermal resistance, $\theta_{JA}$, is 28.2°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at $T_{A} = 25°C$ can be calculated by the following formula:

$$P_{D\,(MAX)} = (125°C - 25°C / (28.2°C/W) = 3.54W$$

for WQFN-20L 5x5 package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J\,(MAX)}$ and thermal resistance, $\theta_{JA}$. The derating curve in Figure 2 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

![Figure 2. Derating Curve of Maximum Power Dissipation](image)

Layout Considerations
Careful PCB layout is very important for designing switching power converter circuits. The following layout guidelines should be strictly followed for best performance of the RT8577A.

- The power components L1, D1, CIN, COUT must be placed as close as possible to the IC to reduce current loop. The PCB trace between power components must be as short and wide as possible.
- The compensation circuit should be kept away from the power loops and shielded with a ground trace to prevent any noise coupling. Place the compensation components, $R_C$ and $C_C$, as close as possible to pin 9.
- The exposed pad of the chip should be connected to ground plane for thermal consideration.
OVP Protection

1. **VIN**
2. **PWM**
3. **STATUS**
4. **VOUT**
5. **OVP**
6. **EN**
7. **DRV**

**Delay time 50µs**

Status latch until EN goes low

**SW Frequency = 2.1MHz**

**Delay time 50µs**

Time

Short Protection

1. **VIN**
2. **PWM**
3. **ILEDX(1)**
4. **ILEDX(2)**
5. **STATUS**
6. **VLEDX(1)**
7. **VLEDX(2)**
8. **EN**
9. **DRV**

**10µs**

**10µs**

**Delay time 50µs**

Status latch until EN goes low

**LED SHORT**

**SW Frequency = 2.1MHz**

Time
### OTP Function

**Description**
- **LED Short**: Detect $V_{\text{LED}_x}$ voltage. Triggered if $V_{\text{LED}_x} > 7V$.
- **OVP**: Use OVP pin voltage for detection. Triggered if OVP pin voltage $> 2V$.
- **OTP**: Triggered if $T_J > 150°C$
- **Fault Indicator**: STATUS pin is used as fault indicator. Fault and pull low.

**Protection**
- **V**

**Behavior**
- If one of LED1 to LED4 pin voltages exceeds a threshold of approximately 7V during normal operation, the STATUS pin will be pulled to low for a fault signal. Internal switching does not stop.
- The internal switch will be turned off and STATUS pin will be pulled to low. The Internal switch will be turned on again once the voltage at the OVP pin returns to normal range.
- The IC will shut down and the STATUS pin will be pulled to low when junction temperature exceeds 150°C and IC returns to normal operation when temperature falls to 130°C.
- If fault condition (LED short, OVP or OTP) occurs, the STATUS pin will be pulled to low. It will be reset after VIN or EN is re-applied.

### Protection Functions

<table>
<thead>
<tr>
<th>Description</th>
<th>Protection</th>
<th>Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED Short</td>
<td>$V$</td>
<td>If one of LED1 to LED4 pin voltages exceeds a threshold of approximately 7V during normal operation, the STATUS pin will be pulled to low for a fault signal. Internal switching does not stop.</td>
</tr>
<tr>
<td>OVP</td>
<td>$V$</td>
<td>The internal switch will be turned off and STATUS pin will be pulled to low. The Internal switch will be turned on again once the voltage at the OVP pin returns to normal range.</td>
</tr>
<tr>
<td>OTP</td>
<td>$V$</td>
<td>The IC will shut down and the STATUS pin will be pulled to low when junction temperature exceeds 150°C and IC returns to normal operation when temperature falls to 130°C.</td>
</tr>
<tr>
<td>Fault Indicator</td>
<td>$V$</td>
<td>If fault condition (LED short, OVP or OTP) occurs, the STATUS pin will be pulled to low. It will be reset after VIN or EN is re-applied.</td>
</tr>
</tbody>
</table>
Separate power ground (PGND) and analog ground (AGND). Connect AGND and PGND islands at a single end. Make sure there are no other connections between these separate ground planes. The PGND should be wide and short enough to connect ground plane.

The compensation circuit and $R_{SET}$ resistor should be kept away from the power loops and should be shielded with a ground trace to prevent any noise coupling.

Locate the $CVCC$ as close to VCC as possible.

Place the power components as close as possible. The traces should be wide and short especially for the high current loop.

The exposed pad of the chip should be connected to ground plane for thermal consideration.

Figure 3. PCB Layout Guide
**Outline Dimension**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Dimensions In Millimeters</th>
<th>Dimensions In Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>A</td>
<td>0.700</td>
<td>0.800</td>
</tr>
<tr>
<td>A1</td>
<td>0.000</td>
<td>0.050</td>
</tr>
<tr>
<td>A3</td>
<td>0.175</td>
<td>0.250</td>
</tr>
<tr>
<td>b</td>
<td>0.250</td>
<td>0.350</td>
</tr>
<tr>
<td>D</td>
<td>4.900</td>
<td>5.100</td>
</tr>
<tr>
<td>D2</td>
<td>3.100</td>
<td>3.200</td>
</tr>
<tr>
<td>E</td>
<td>4.900</td>
<td>5.100</td>
</tr>
<tr>
<td>E2</td>
<td>3.100</td>
<td>3.200</td>
</tr>
<tr>
<td>e</td>
<td>0.650</td>
<td>0.600</td>
</tr>
<tr>
<td>L</td>
<td>0.500</td>
<td>0.600</td>
</tr>
</tbody>
</table>

W-Type 20L QFN 5x5 Package

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