The A6263 is a linear, programmable current regulator providing up to 100 mA from each of 4 outputs to drive arrays of high brightness LEDs. Outputs can be connected in parallel or left unused, as required. The regulated LED current from each output, accurate to 5%, is set by a single reference resistor. Current matching in each string is better than 10% without the use of ballast resistors. Driving LEDs with constant current ensures safe operation with maximum possible light output.

The IC provides protection against the following common faults:
- LED string shorted to GND
- Single or multiple LED short
- LED string open
- IC pin open/short
- Overtemperature

If one LED string is open or shorted to ground, the offending string is disabled, while other LED strings continue to work.

A temperature monitor is included to reduce the LED drive current if the chip temperature exceeds a thermal threshold. If necessary, this thermal derating threshold can be adjusted or disabled.

The device comes in an 8-pin SOIC (package LJ) with exposed pad for enhanced thermal dissipation. It is lead (Pb) free, with 100% matte tin leadframe plating.
**Selection Guide**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Ambient Operating Temperature, $T_A$ (°C)</th>
<th>Packing*</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>A6263KLJTR-T</td>
<td>–40 to 125</td>
<td>3000 pieces per 13-in. reel</td>
<td>8-pin SOICN with exposed thermal pad</td>
</tr>
</tbody>
</table>

*Contact Allegro™ for additional packing options.

**Absolute Maximum Ratings**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Notes</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Supply Voltage</td>
<td>$V_{IN}$</td>
<td></td>
<td>–0.3 to 50</td>
<td>V</td>
</tr>
<tr>
<td>Pins LA1 through LA2</td>
<td></td>
<td></td>
<td>–0.3 to 50</td>
<td>V</td>
</tr>
<tr>
<td>Pins IREF and THTH</td>
<td></td>
<td></td>
<td>–0.3 to 6.5</td>
<td>V</td>
</tr>
<tr>
<td>Ambient Operating Temperature Range</td>
<td>$T_A$</td>
<td>K temperature range</td>
<td>–40 to 125</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Continuous Junction Temperature</td>
<td>$T_J$ (max)</td>
<td>Overtemperature event not exceeding 10 s, lifetime duration not exceeding 10 h, guaranteed by design characterization</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Transient Junction Temperature</td>
<td>$T_{TU}$</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>$T_{Stg}$</td>
<td></td>
<td>–55 to 150</td>
<td>°C</td>
</tr>
</tbody>
</table>

*Stresses beyond those listed in this table may cause permanent damage to the device. The Absolute Maximum ratings are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the Electrical Characteristics table is not implied. Exposure to Absolute Maximum-rated conditions for extended periods may affect device reliability.

**Thermal Characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Test Conditions*</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package Thermal Resistance (Junction to Ambient)</td>
<td>$R_{JUA}$</td>
<td>On 4-layer PCB based on JEDEC standard</td>
<td>35</td>
<td>°C/W</td>
</tr>
<tr>
<td>Package Thermal Resistance (Junction to Pad)</td>
<td>$R_{JUP}$</td>
<td>On 2-layer generic test PCB with 0.8 in.² of copper area each side</td>
<td>62</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

*Additional thermal information available on the Allegro website.
Functional Block Diagram

Terminal List Table

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>THTH</td>
<td>Thermal Threshold. Short this pin to ground to disable thermal derating feature, or leave open to enable. (Thermal shutdown function is always enabled.)</td>
</tr>
<tr>
<td>2</td>
<td>IREF</td>
<td>Connect a reference resistor between this pin and GND to set the LED current.</td>
</tr>
<tr>
<td>3</td>
<td>LA1</td>
<td>LED anode (+) connection 1*</td>
</tr>
<tr>
<td>4</td>
<td>LA2</td>
<td>LED anode (+) connection 2*</td>
</tr>
<tr>
<td>5</td>
<td>LA3</td>
<td>LED anode (+) connection 3*</td>
</tr>
<tr>
<td>6</td>
<td>LA4</td>
<td>LED anode (+) connection 4*</td>
</tr>
<tr>
<td>7</td>
<td>VIN</td>
<td>Input power to the IC. All LED current sources are enabled while $V_{IN}$ is above UVLO level. Decouple with a 0.1 $\mu$F capacitor to GND near the IC.</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td>IC ground reference. Connect to ground plane(s) of the PCB using the shortest path possible.</td>
</tr>
<tr>
<td>–</td>
<td>PAD</td>
<td>Exposed pad of the package providing enhanced thermal dissipation. This pad must be connected to the ground plane(s) of the PCB with at least 8 vias located directly in the solder land for the pad.</td>
</tr>
</tbody>
</table>

* If any LAx pin is unused, tie it to the VIN pin. Do not leave it open or shorted to GND.
### ELECTRICAL CHARACTERISTICS

Valid at $T_A = 25°C$, $V_{IN} = 7$ to 40 V; • indicates specifications valid across the full operating temperature range with $T_A = T_J = -40°C$ to 125°C and typical specifications at $T_A = 25°C$; unless otherwise specified.

<table>
<thead>
<tr>
<th>Characteristics</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><strong>Input Supply</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Input Voltage Range</td>
<td>$V_{IN}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiescent Current $I_{INQ}$</td>
<td>$I_{INQ}$</td>
<td>$I_{LAx}$ pins connected to $VIN$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Startup Time</td>
<td>$I_{ON}$</td>
<td>$VIN &gt; 7 V$ to $I_{LA1} &lt; -5 mA$, $R_{REF} = 125 Ω$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Current Regulation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference Voltage $V_{IREF}$</td>
<td>$V_{IREF}$</td>
<td>$0.7 mA &lt; I_{IREF} &lt; 8.8 mA$</td>
<td>1.15</td>
<td>1.2</td>
<td>1.25</td>
<td>V</td>
</tr>
<tr>
<td>Reference Current Ratio $G_H$</td>
<td>$G_H$</td>
<td>$6 V &lt; V_{IN} &lt; 40 V$</td>
<td></td>
<td>12.5</td>
<td></td>
<td>A/A</td>
</tr>
<tr>
<td>Current Accuracy $E_{ILAx}$</td>
<td>$E_{ILAx}$</td>
<td>$-10 mA &gt; I_{LAx} &gt; -100 mA$</td>
<td></td>
<td></td>
<td>-5</td>
<td>±4</td>
</tr>
<tr>
<td>Current Matching $E_{IMLAx}$</td>
<td>$E_{IMLAx}$</td>
<td>$-20 mA &gt; I_{LAx} &gt; -100 mA$, $V_{LAx}$ match to within 1 V</td>
<td></td>
<td></td>
<td>-5</td>
<td>5</td>
</tr>
<tr>
<td>Output Current $I_{LAx}$</td>
<td>$I_{LAx}$</td>
<td>$I_{REF} = 8 mA$</td>
<td></td>
<td></td>
<td>-105</td>
<td>-100</td>
</tr>
<tr>
<td>Maximum Output Current $I_{LAmx}$</td>
<td>$I_{LAmx}$</td>
<td>$I_{REF} = 9.2 mA$</td>
<td></td>
<td></td>
<td></td>
<td>-110</td>
</tr>
<tr>
<td>Minimum Drop-out Voltage $V_{DO}$</td>
<td>$V_{DO}$</td>
<td>$V_{IN} - V_{LAx} \cdot I_{LAx} = -100 mA$</td>
<td></td>
<td></td>
<td></td>
<td>-800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{IN} - V_{LAx} \cdot I_{LAx} = -40 mA$</td>
<td></td>
<td></td>
<td></td>
<td>-660</td>
</tr>
<tr>
<td><strong>Protection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short Detect Voltage $V_{SCD}$</td>
<td>$V_{SCD}$</td>
<td>Measured at LAx</td>
<td>1.2</td>
<td></td>
<td>1.8</td>
<td>V</td>
</tr>
<tr>
<td>Short Circuit Source Current $I_{SCS}$</td>
<td>$I_{SCS}$</td>
<td>Short present from LAx to GND</td>
<td></td>
<td>-2</td>
<td>-0.8</td>
<td>-0.5</td>
</tr>
<tr>
<td>Short Release Voltage $V_{SCR}$</td>
<td>$V_{SCR}$</td>
<td>Measured at LAx</td>
<td></td>
<td></td>
<td></td>
<td>1.9</td>
</tr>
<tr>
<td>Short Release Voltage Hysteresis</td>
<td>$V_{SChys}$</td>
<td>$V_{SCR} - V_{SCD}$</td>
<td>200</td>
<td></td>
<td>500</td>
<td>mV</td>
</tr>
<tr>
<td>Thermal Monitor Activation Temperature $T_{JM}$</td>
<td>$T_J$ with $I_{SEN} = 90%$</td>
<td>95</td>
<td>115</td>
<td>130</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Thermal Monitor Slope $dI_{SEN}/dT_J$</td>
<td>$I_{SEN} = 50%$</td>
<td>-3.5</td>
<td>-2.5</td>
<td>-1.5</td>
<td>%/°C</td>
<td></td>
</tr>
<tr>
<td>Thermal Monitor Low Current Temperature $T_{JL}$</td>
<td>$T_J$ at $I_{SEN} = 25%$</td>
<td>120</td>
<td>135</td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Overtemperature Shutdown $T_{JF}$</td>
<td>$T_{JF}$</td>
<td>Temperature increasing</td>
<td>170</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Overtemperature Hysteresis $T_{Jhys}$</td>
<td>$T_{Jhys}$</td>
<td>Recovery = $T_{JF} - T_{Jhys}$</td>
<td>15</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

1 For input and output current specifications, negative current is defined as coming out of (sourcing) the specified device pin.
2 Function is correct but parameters are not guaranteed outside the general limits (7 to 40 V).
3 Ensured by design and characterization, not production tested.
4 $E_{ILAx} = 100 × \left( |I_{LAx}| × \left| R_{REF} \right| / 15 \right) - 1$, with $I_{LAx}$ in mA and $R_{REF}$ in kΩ.
5 $E_{IMLA} = 100 × \max \left( |I_{LAx} - I_{LA(AV)}| \right) / I_{LA(AV)}$, where $I_{LA(AV)}$ is the average current of all active outputs.
The A6263 is a linear current regulator that is designed to provide drive current and protection for parallel strings of series-connected high brightness LEDs. It provides up to 4 matched programmable current outputs at up to 100 mA, with low minimum dropout voltages below the main supply voltage. For 12 V power net applications, optimum performance is achieved when driving 4 strings of 1 to 3 LEDs, at current up to 100 mA per string.

Current regulation is maintained and the LEDs protected during a short-to-ground at any point in the LED string. A short-to-ground on any regulator output terminal disables that offending string only. Similarly, in the case of an open output pin or an open-LED fault, all other LED strings remain in regulation. Individual outputs can be disabled by connecting the output to VIN. Multiple outputs can be connected in parallel to drive higher current LED strings.

Integrated thermal management reduces the regulated current level at high internal junction temperatures to limit power dissipation. This thermal threshold is programmable and can be disabled if necessary.

Pin Functions

**VIN** Supply to the control circuit and current regulators. A small value ceramic bypass capacitor, typically 100 nF, should be connected from close to this pin to the GND pin.

**GND** Ground reference connection. Should be connected directly to the ground plane of the circuit board.

**IREF** 1.2 V reference to set LED current. Connect resistor, RREF, to GND to set reference current and thereby LED current.

**THTH** Sets the thermal monitor threshold, TJM, where the output current starts to reduce with increasing temperature. Connecting THTH directly to GND will disable the thermal monitor function.

**LA[1:4]** Current source connected to the anode of the first LED in each string. Connect directly to VIN to disable the respective output. In this document “LAX” indicates any one of the outputs.

**LED Current Level**
The LED current is controlled by 4 matching linear current regulators, between the VIN pin and each of the LAX outputs. The basic equation that determines the nominal output current at each LAX pin is:

$$I_{LAX} = \frac{15}{R_{REF}}$$  \hspace{1cm} (1)

where \(I_{LAX}\) is in mA and \(R_{REF}\) is in kΩ.

The output current may be reduced from the set level by the thermal monitor circuit. Conversely the reference resistors may be calculated from:

$$R_{REF} = \frac{15}{I_{LAX}}$$  \hspace{1cm} (2)

where \(I_{LAX}\) is in mA and \(R_{REF}\) is in kΩ.

For example, where the required current is 90 mA for both channels the resistor value will be:

$$R_{REF} = \frac{15}{90} = 0.167 \text{ kΩ}$$

These equations completely define the output currents with respect to the setting resistors. However, for further reference, a more detailed description of the internal reference current calculations is included below.

It is important to note that because the A6263 is a linear regulator, the maximum regulated current is limited by the power dissipation and the thermal management in the application. All current calculations assume adequate heatsinking for the dissipated power. Thermal management is at least as important as the electrical design in all applications. In high current high ambient temperature applications the thermal management is the most important aspect of the systems design. The application section below provides further detail on thermal management and the associated limitations.

**Operation with Fewer LED Strings or Higher Currents**
The A6263 may be configured to use fewer than all four LED strings, either by connecting outputs together for higher currents, or by connecting the output directly to VIN to disable the regulator for that output. It is also acceptable, though not recommended, to leave an unused LAX pin floating.
Safety Features
The A6263 includes several features to ensure safe operation and to protect the LEDs and the IC:

- The current regulators between VIN and each LAx output provide a natural current limit due to the regulation.
- Each LAx output includes a short-to-ground detector that will disable the output to limit the dissipation.
- An open circuit on any output will disable the affected string only.
- The thermal monitor reduces the regulated current as the temperature rises above a programmable thermal threshold.
- Thermal shutdown completely disables the outputs under extreme overtemperature conditions.

Temperature Monitor
A temperature monitor function reduces the LED current as the silicon junction temperature of the IC increases (see figure 2). By mounting the A6263 on the same thermal substrate as the LEDs, this feature can also be used to limit the dissipation of the LEDs.

As the junction temperature of the A6263 increases, the regulated current level is reduced, reducing the dissipated power in the A6263 and in the LEDs. The current is reduced from the 100% level at typically 2.5% per degree Celsius until the point at which the current drops to 25% of the full value, defined at TJL. Above this temperature the current will continue to reduce at a lower rate until the temperature reaches the overtemperature shutdown threshold temperature, TJF.

The temperature at which the current reduction begins can be adjusted by changing the voltage on the THTH pin. When THTH is left open the temperature at which the current reduction begins is defined as the thermal monitor activation temperature, TJM, and is specified, in the Electrical Characteristics table, at the 90% current level.

\[
T_{JM} = \frac{1.46 - V_{THTH}}{0.0039} \quad (^\circ C)
\] (3)

A resistor connected between THTH and GND will reduce \(V_{THTH}\) and increase \(T_{JM}\). A resistor connected between THTH and a reference supply greater than 1 V will increase \(V_{THTH}\) and reduce \(T_{JM}\).

Figure 3 shows how the nominal value of the thermal monitor activation temperature varies with the voltage at THTH and with either a pull-down resistor, \(R_{TH}\), to GND or with a pull-up resistor, \(R_{TH}\), to 3 V and to 5 V.

In extreme cases, if the chip temperature exceeds the overtemperature limit, TJF, all regulators will be disabled. The temperature will continue to be monitored and the regulators re-activated when the temperature drops below the threshold provided by the specified hysteresis.
Fault Cases

Case A: Any LED cathode short to GND
Outcome: IC continues to regulate current through all LED strings. Current matching may suffer.

Case B: LAx pin or high-side of LED string shorted to GND
Outcome: IC detects pin-to-GND short before enabling current regulators. Offending LED string disabled. All other strings remain active.

Case C: Single LED in a string shorted
Outcome: IC continues to regulate current through all LED strings. Current matching may suffer.

Case D: Short between LED strings
Outcome: LED current regulators continue to operate normally, but current matching between LED strings will be affected.

Case E: LAx pin or high-side of LED string open
Outcome: No current through the offending LED string. All other strings remain active.
Application Information

**Power Dissipation**
The most critical design considerations when using a linear regulator such as the A6263 are the power produced internally as heat and the rate at which that heat can be dissipated.

There are three sources of power dissipation in the A6263:

- The quiescent power to run the control circuits
- The power in the reference circuit
- The power due to the regulator voltage drop

The elements relating to these dissipation sources are illustrated in figure 4.

**Quiescent Power** The quiescent power is the product of the quiescent current, $I_{INQ}$, and the supply voltage, $V_{IN}$, and is not related to the regulated current. The quiescent power, $P_Q$, is therefore defined as:

$$P_Q = V_{IN} \times I_{INQ}$$

**Reference Power** The reference circuit draws the reference current from the supply and passes it through the reference resistor to ground. The reference current is 8% of the output current on any one active output. The reference circuit power is the product of the reference current and the difference between the supply voltage and the reference voltage, typically 1.2 V. The reference power, $P_{REF}$, is therefore defined as:

$$P_{REF} = \frac{(V_{IN} - V_{REF}) \times V_{REF}}{R_{REF}}$$

**Regulator Power** In most application circuits the largest dissipation will be produced by the output current regulators. The power dissipated in each current regulator is simply the product of the output current and the voltage drop across the regulator.

The total current regulator dissipation is the sum of the dissipation in each output regulator. The regulator power for each output is defined as:

$$P_{REGx} = (V_{IN} - V_{LEDX}) \times I_{LEDX}$$

where $x$ is 1, 2, 3, or 4.

Note that the voltage drop across the regulator, $V_{REG}$, is always greater than the specified minimum drop-out voltage, $V_{DO}$. The output current is regulated by making this voltage large enough to provide the voltage drop from the supply voltage to the total forward voltage of all LEDs in series, $V_{LED}$.

The total power dissipated in the A6263 is the sum of the quiescent power, the reference power, and the power in each of the four regulators:

$$P_{DIS} = P_Q + P_{REF} + P_{REGA} + P_{REGB} + P_{REGC} + P_{REGD}$$

The power that is dissipated in each string of LEDs is:

$$P_{LEDX} = V_{LEDX} \times I_{LEDX}$$

where $x$ is A, B, C, or D, and $V_{LEDX}$ is the voltage across all LEDs in the string.

From these equations it can be seen that, if the power in the A6263 is not limited, then it will increase as the supply voltage increases but the power in the LEDs will remain constant.

![Figure 4. Internal power dissipation sources.](image-url)
Dissipation Limits
There are two features limiting the power that can be dissipated by the A6263: thermal shutdown and thermal foldback.

Thermal Shutdown
If the thermal foldback feature is disabled by connecting the THTH pin to GND, or if the thermal resistance from the A6263 to the ambient environment is high, then the silicon temperature will rise to the thermal shutdown threshold and the current will be disabled. After the current is disabled the power dissipated will drop and the temperature will fall. When the temperature falls by the hysteresis of the thermal shutdown circuit, then the current will be re-enabled and the temperature will start to rise again. This cycle will repeat continuously until the ambient temperature drops or the A6263 is switched off. The period of this thermal shutdown cycle will depend on several electrical, mechanical, and thermal parameters, and could be from a few milliseconds to a few seconds.

Thermal Foldback
If there is a good thermal connection to the A6263, then the thermal foldback feature will have time to act. This will limit the silicon temperature by reducing the regulated current and therefore the dissipation. The thermal monitor will reduce the LED current as the temperature of the A6263 increases above the thermal monitor activation temperature, $T_{JM}$.

Thermal Dissipation
The amount of heat that can pass from the silicon of the A6263 to the surrounding ambient environment depends on the thermal resistance of the structures connected to the A6263. The thermal resistance, $R_{θJA}$, is a measure of the temperature rise created by power dissipation and is usually measured in degrees Celsius per watt ($°C/W$).

The temperature rise, $ΔT$, is calculated from the power dissipated, $P_D$, and the thermal resistance, $R_{θJA}$, as:

$$ΔT = P_D × R_{θJA}$$  \hspace{1cm} (9)

A thermal resistance from silicon to ambient, $R_{θJA}$, of approximately 35°C/W can be achieved by mounting the A6263 on a standard FR4 double-sided printed circuit board (PCB) with a copper area of a few square inches on each side of the board under the A6263. Additional improvements in the range of 20% may be achieved by optimizing the PCB design.

Optimizing Thermal Layout
The features of the printed circuit board, including heat conduction and adjacent thermal sources such as other components, have a very significant effect on the thermal performance of the device. To optimize thermal performance, the following should be taken into account:

- The device exposed thermal pad should be connected to as much copper area as is available.
- Copper thickness should be as high as possible (for example, 2 oz. or greater for higher power applications).
- The greater the quantity of thermal vias, the better the dissipation. If the expense of vias is a concern, studies have shown that concentrating the vias directly under the device in a tight pattern, as shown in figure 5, has the greatest effect.
- Additional exposed copper area on the opposite side of the board should be connected by means of the thermal vias. The copper should cover as much area as possible.
- Other thermal sources should be placed as remote from the device as possible.

![Figure 5. Suggested PCB layout for thermal optimization (maximum available bottom-layer copper recommended)](image_url)
Package LJ, 8-Pin SOICN with Exposed Thermal Pad

For Reference Only; not for tooling use (reference MS-012BA)
Dimensions in millimeters
Dimensions exclusive of mold flash, gate burns, and dambar protrusions
Exact case and lead configuration at supplier discretion within limits shown

Terminal #1 mark area
Exposed thermal pad (bottom surface)
Reference land pattern layout (reference IPC7351)
SOIC127P600X175-9AM): all pads a minimum of 0.20 mm from all
adjacent pads: adjust as necessary to meet application process
requirements and PCB layout tolerances; when mounting on a multilayer
PCB, thermal vias at the exposed thermal pad land can improve thermal
dissipation (reference EIA/JEDEC Standard JESD51-5)
Protected LED Array Driver

A6263

Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Revision Date</th>
<th>Description of Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>June 25, 2015</td>
<td>Temperature Monitor text on page 6 updated to match EC table: derating slope is -2.5% per °C</td>
</tr>
</tbody>
</table>

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