

POWER MANAGEMENT

Features

- Wide current setting range — 31.25µA to 25mA
- Eight identical current drivers with independent control
- 5% current matching, 7% accuracy
- I²C interface for microprocessor control
- I²C slave address 1110 000x
- Less than 1µA quiescent current in shutdown
- Low dropout voltage — ≤ 150mV
- Over-temperature protection
- MLPQ-UT-16 package (3mm x 3mm)
- Ultra-thin 0.6mm maximum package height
- Fully WEEE and RoHS compliant

Applications

- LCD backlighting LED driver
- Multicolor and RGB LED driver
- General purpose current sink array
- General purpose digital output (open-drain) expander
- Auto-focus voice-coil driver

Description

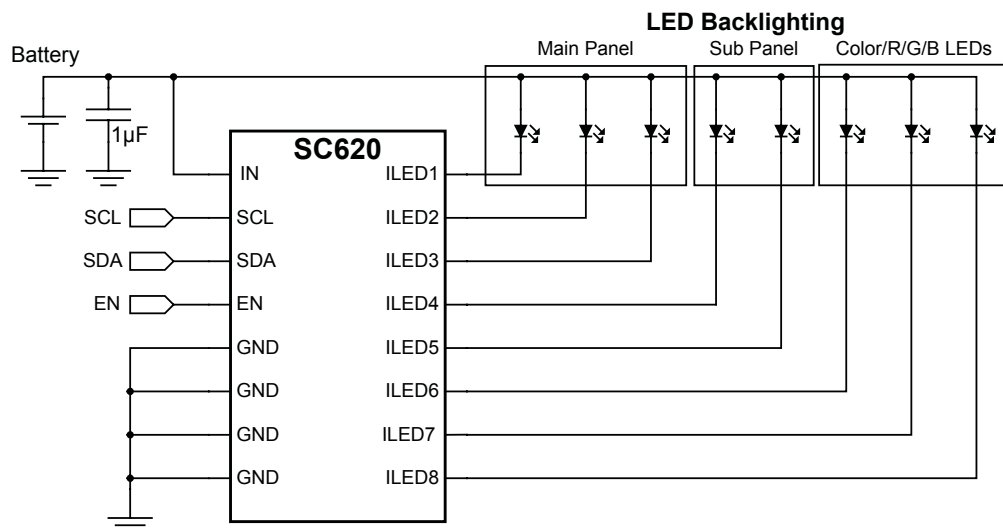
The SC620 is a multi-purpose LED driver with eight identical, independently controlled current sinks. Each current sink can drive an LED by connecting the LED's anode to the system power supply and the cathode to the current sink input pin. Any combination of outputs can be enabled or disabled for optimal design flexibility.

The SC620 also employs an adjustable global current gain setting register to allow the current setting step size to vary from 31.25µA to 500µA. This provides a wide range of options for LED variation and dimming functions. The maximum output is also scaled by this step size, with a maximum of 25mA at the highest step setting.

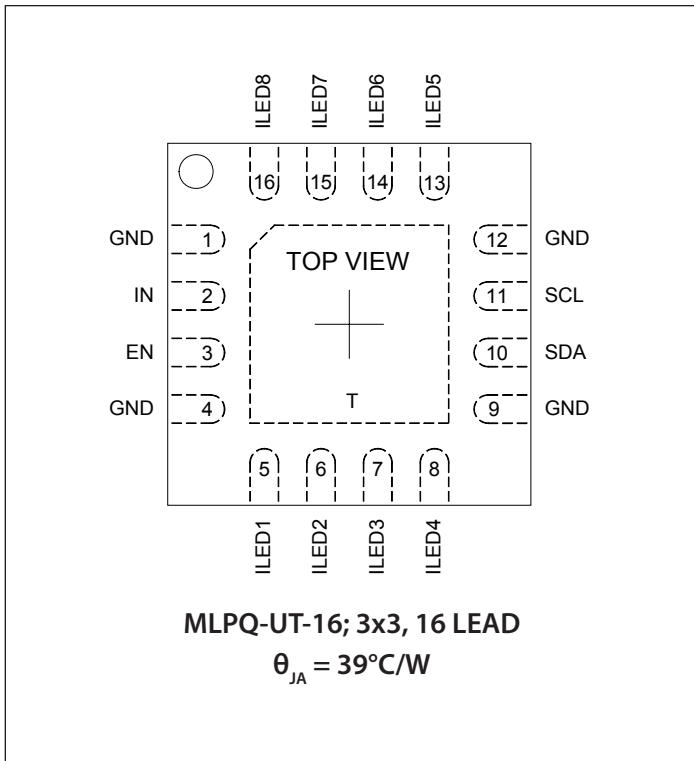
Multi-colored and white LEDs with different forward voltages can be driven using the same SC620 due to its floating cathode technology. This feature allows each output pin to vary in voltage from 150mV to $V_{IN} - 1.5V$.

All current control is programmed using an I²C interface bus. Only a single input bypass capacitor is required — no other external resistors or capacitors are needed. The 3mm x 3mm MLPQ package and minimal support components make the SC620 an ideal solution for low-cost, area-conscious backlighting designs.

Typical Application Circuit



Pin Configuration



Ordering Information

| Device | Package |
|------------------------------|-------------------------------|
| SC620ULTRT ⁽¹⁾⁽²⁾ | MLPQ-UT-16 3x3 ⁽²⁾ |
| SC620EVB | Evaluation Board |

Notes:

- (1) Available in tape and reel only. A reel contains 3,000 devices.
- (2) Lead-free package only. Device is WEEE and RoHS compliant.

Marking Information



Absolute Maximum Ratings

| | |
|--|------------------------|
| IN (V) | -0.3 to +6.0 |
| Pin Voltage — All Other Pins (V) | -0.3 to $V_{IN} + 0.3$ |
| ESD Protection Level ⁽¹⁾ (kV) | 2 |

Recommended Operating Conditions

Ambient Temperature Range (°C)..... -40 to +85

Thermal Information

| | |
|--|-------------|
| Thermal Resistance, Junction to Ambient ⁽²⁾ (°C/W) | 39 |
| Operating Junction Temperature (°C) | -40 to +150 |
| Storage Temperature Range (°C) | -65 to +150 |
| Peak IR Reflow Temperature (10s to 30s) (°C) | +260 |

Exceeding the above specifications may result in permanent damage to the device or device malfunction. Operation outside of the parameters specified in the Electrical Characteristics section is not recommended.

NOTES:

- (1) Tested according to JEDEC standard JESD22-A114-B.
- (2) Calculated from package in still air, mounted to 3 x 4.5 (in), 4 layer FR4 PCB with thermal vias under the exposed pad per JESD51 standards.

Electrical Characteristics

Unless otherwise noted, $T_A = +25^\circ\text{C}$ for Typ, -40°C to 85°C for Min and Max, $V_{IN} = 2.7\text{V}$ to 5.5V , $C_{IN} = 1\mu\text{F}$, $\Delta V_F \leq 1.5\text{V}$

| Parameter | Symbol | Condition | Min | Typ | Max | Units |
|--|--------------------------------|--|-----|-------|-----|---------------|
| Maximum LED Current Setting ⁽¹⁾ | I_{LEDn} | | | 25 | | mA |
| LED Current Setting Accuracy ⁽¹⁾ | ΔI_{LEDn} | $I_{LEDn} = 15\text{mA}$, $V_F = 3.4\text{V}$, $V_{ILEDn} = 2\text{V}$, $T_A = 25^\circ\text{C}$ | -7 | | +7 | % |
| Load Regulation | $\Delta I_{LEDn} / \Delta V_F$ | $5\text{mA} < I_{LEDn} \leq 25\text{mA}$, $T_A = 25^\circ\text{C}$ | -2 | | 2 | %/V |
| LED Current Matching Accuracy ⁽¹⁾ | $I_{LED\text{-to-LED}}$ | $I_{LEDn} = 15\text{mA}$, $T_A = 25^\circ\text{C}$ | -5 | | +5 | % |
| Dropout Voltage | V_{DO} | $I_{LEDn} = 25\text{mA}$ | | | 150 | mV |
| Shutdown Current | I_{SHDN} | EN = GND | | 0.1 | 1 | μA |
| Current Step Size | I_{STEP} | Normal Mode ⁽³⁾ | | 500 | | μA |
| | | Low-Current Mode ⁽⁴⁾ | | 31.25 | | μA |
| Quiescent Current | I_Q | Standby: EN = V_{IN} , LED1-8 disabled ⁽²⁾ | | | 60 | μA |
| | | EN = V_{IN} , $I_{LED1-8} = 1.968\text{mA}$ ⁽⁴⁾ | | 720 | | μA |
| | | EN = V_{IN} , $I_{LED1-8} = 25\text{mA}$ ⁽³⁾ | | 4.5 | | mA |

Electrical Characteristics (continued)

| Parameter | Symbol | Condition | Min | Typ | Max | Units |
|---|---------------|------------------------------|------|-----|-----|--------------|
| Current Sink Turn-on Time | t_{ON} | from 0 to 95% of target | | | 1 | ms |
| Current Sink Turn-off Time | t_{OFF} | from 90% to 10% of set value | | 1 | | μ s |
| EN Input High Threshold | V_{IH} | $V_{IN} = 5.5V$ | 1.6 | | | V |
| EN Input Low Threshold | V_{IL} | $V_{IN} = 2.7V$ | | | 0.4 | V |
| EN Input High Current | I_{IH} | $V_{IN} = 5.5V$ | | | 2 | μ A |
| Over Temperature Protection ⁽⁵⁾ | T_{OTP} | | | 155 | | $^{\circ}$ C |
| I²C Interface⁽⁵⁾ | | | | | | |
| Interface complies with slave mode I ² C interface as described by Philips I ² C specification version 2.1 dated January, 2000. | | | | | | |
| Digital Input Voltage | V_{B-IL} | | | | 0.4 | V |
| | V_{B-IH} | | 1.6 | | | V |
| SDA Output Low Level | | $I_{DIN} (SDA) \leq 3mA$ | | | 0.4 | V |
| Digital Input Current | I_{B-IN} | | -0.2 | | 0.2 | μ A |
| Schmitt Trigger Input Hysteresis | V_{HYS} | | | 0.1 | | V |
| Maximum Glitch Pulse Rejection | t_{SP} | | | 50 | | ns |
| I/O Pin Capacitance | C_{IN} | | | 10 | | pF |
| I²C Timing | | | | | | |
| Clock Frequency | f_{SCL} | | | 400 | 440 | kHz |
| SCL Low Period | t_{LOW} | | 1.3 | | | μ s |
| SCL High Period | t_{HIGH} | | 0.6 | | | μ s |
| Data Hold Time | t_{HD_DAT} | | 0 | | | μ s |
| Data Setup Time | t_{SU_DAT} | | 100 | | | ns |
| Setup Time for Repeated START Condition | t_{SU_STA} | | 0.6 | | | μ s |
| Hold Time for Repeated START Condition | t_{HD_STA} | | 0.6 | | | μ s |
| Setup Time for STOP Condition | t_{SU_STO} | | 0.6 | | | μ s |

Electrical Characteristics (continued)

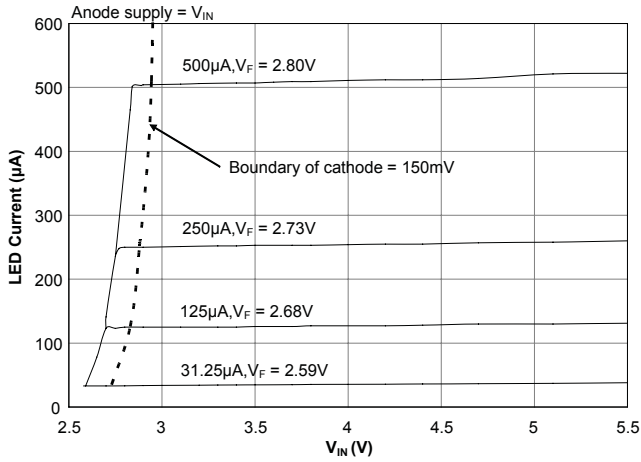
| Parameter | Symbol | Condition | Min | Typ | Max | Units |
|--|------------------|---|-----|-----|-----|---------------|
| I²C Timing (continued) | | | | | | |
| Bus-Free Time Between STOP and START | t_{BUF} | | 1.3 | | | μs |
| Interface Start-up Time | t_{EN} | Bus Start-up Time After EN Pin is Pulled High | | | 350 | μs |

Notes:

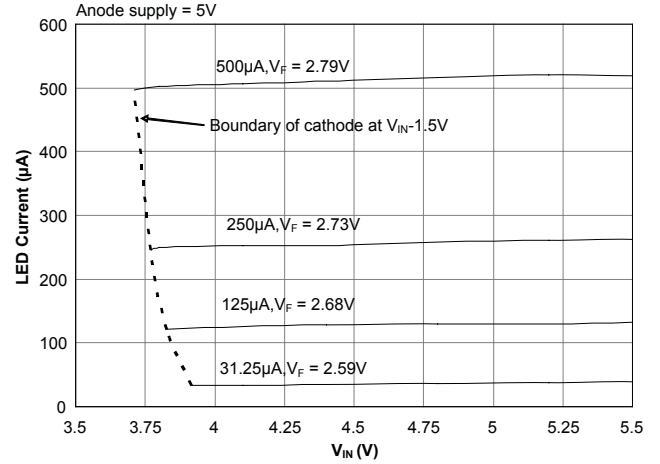
- (1) Current step size = 500 μA - See Table 1 for other step size options.
- (2) Outputs are disabled but I²C bus is active
- (3) Current gain register set to maximum value - see Control Register section for details.
- (4) Current gain register set to minimum value - see Control Register section for details.
- (5) Guaranteed by design.

Typical Characteristics

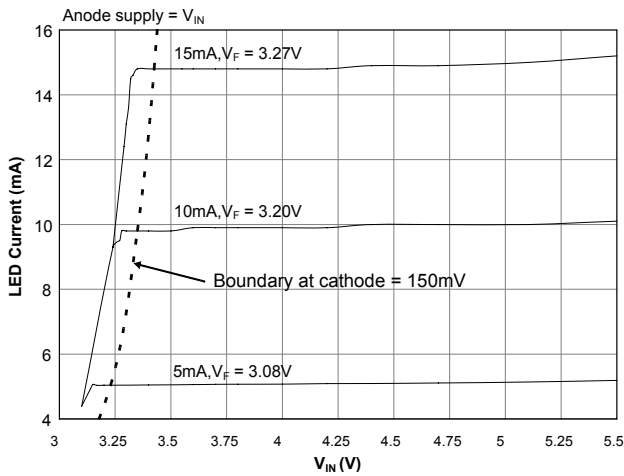
Low Current Settings with Anode = V_{IN}



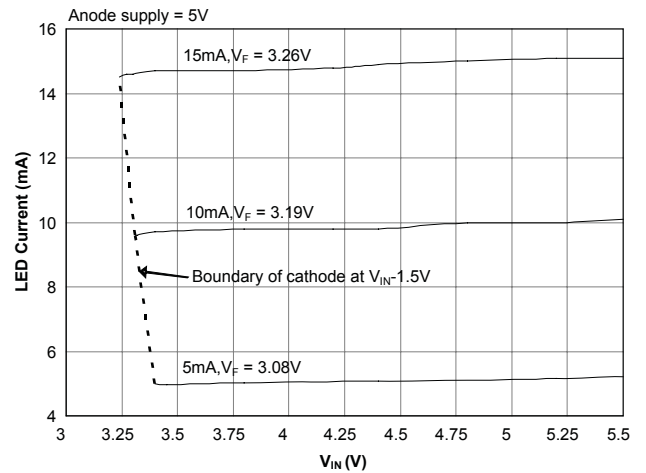
Low Current Settings with Anode = 5V



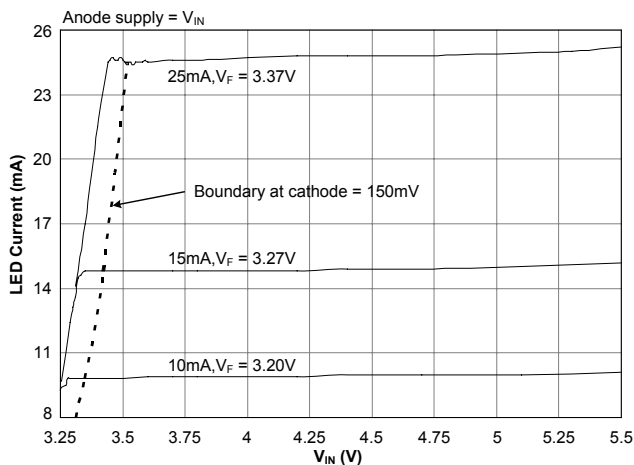
Mid Current Settings with Anode = V_{IN}



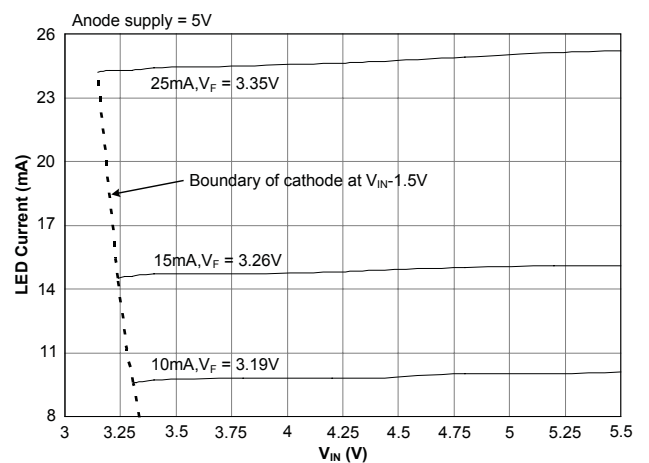
Mid Current Settings with Anode = 5V



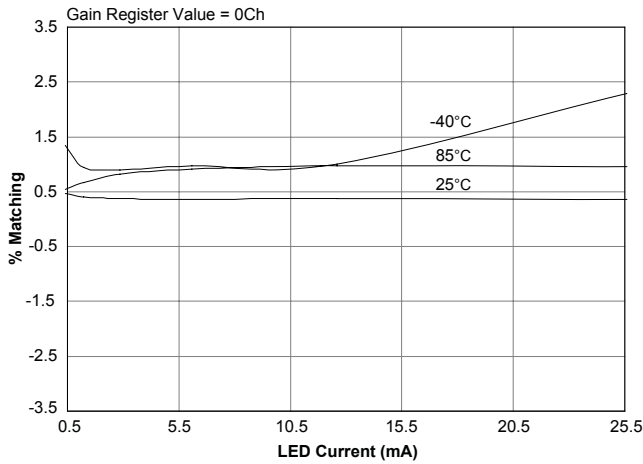
High Current Settings with Anode = V_{IN}



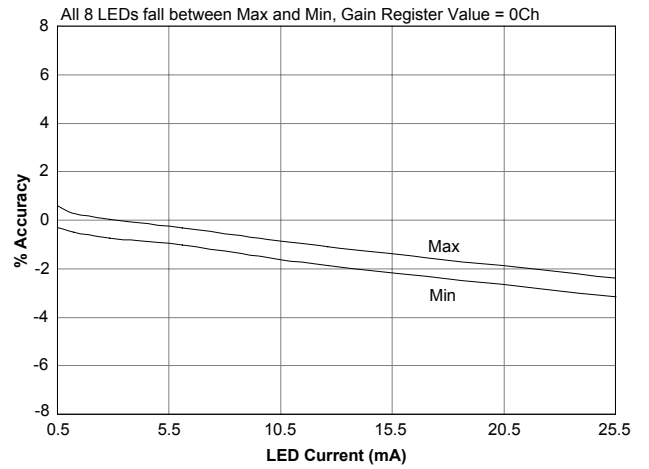
High Current Settings with Anode = 5V



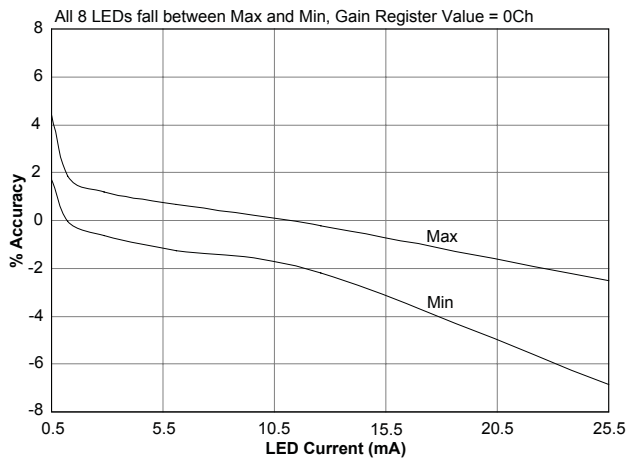
Typical LED Current Matching



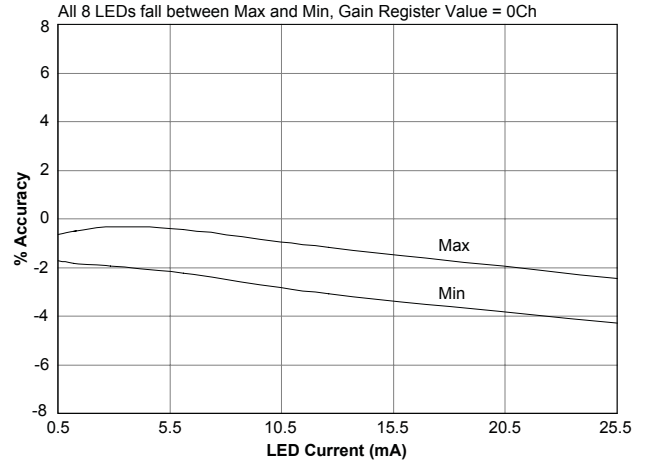
Typical LED Current Accuracy (25°C)



Typical LED Current Accuracy (-40°C)



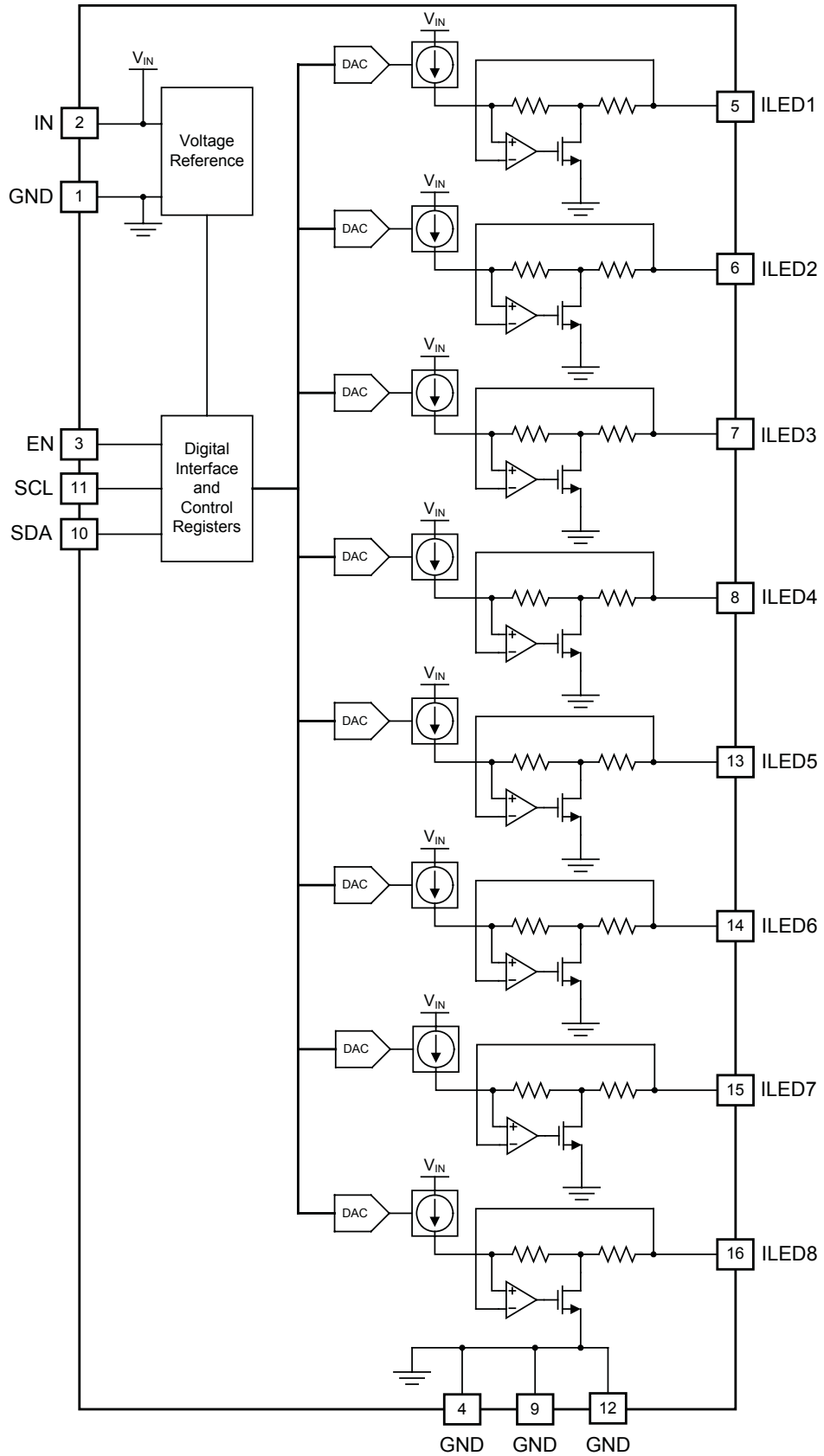
Typical LED Current Accuracy (85°C)



Pin Descriptions

| Pin # | Pin Name | Pin Function |
|-------|-------------|--|
| 1 | GND | Ground |
| 2 | IN | Input voltage supply |
| 3 | EN | Enable input — active high |
| 4 | GND | Ground |
| 5 | ILED1 | Current sink input for LED 1 |
| 6 | ILED2 | Current sink input for LED 2 |
| 7 | ILED3 | Current sink input for LED 3 |
| 8 | ILED4 | Current sink input for LED 4 |
| 9 | GND | Ground |
| 10 | SDA | I ² C serial data pin (bi-directional) |
| 11 | SCL | I ² C clock input |
| 12 | GND | Ground |
| 13 | ILED5 | Current sink input for LED 5 |
| 14 | ILED6 | Current sink input for LED 6 |
| 15 | ILED7 | Current sink input for LED 7 |
| 16 | ILED8 | Current sink input for LED 8 |
| T | Thermal Pad | Thermal pad for heatsinking purposes. Connect to ground plane using multiple vias. Not connected internally. |

Block Diagram



Applications Information

General Description

The SC620 includes eight independently controlled current sinks designed to control LED backlighting for mobile phones and other battery-operated handheld devices. As LED forward voltages decrease for white, blue, and other colored LEDs, there is less need for voltage boosting devices for powering backlight and indicator LEDs. In these types of systems where there is a fixed supply voltage large enough to supply the LEDs or where the LEDs can be powered over the entire battery range, the SC620 provides a simple low-cost driver alternative to charge pump or inductor-based switching boost converters.

Current Sink Design

Each current sink is designed for a pin voltage range between 150mV and $V_{IN} - 1.5V$. This feature allows the system to operate backlight LEDs with constant current without interference caused by blinking indicator LEDs or driving LEDs with various forward voltages and currents.

Protection Circuitry

The SC620 contains protection circuitry that prevents damage from operating in an unspecified state. These features include:

- Under-voltage Lockout Protection
- Over-temperature Protection
- Short-circuit Protection

Under-Voltage Lockout

An Under-Voltage Lockout Protection (UVLO) circuit disables the device in the event that the input voltage falls below the threshold. UVLO typically occurs at 2V. Hysteresis is provided to prevent chatter.

Short-Circuit Protection

The output sink pins ILED1 through ILED8 are protected against shorting to V_{IN} , prevent device damage in the event of a shorted LED. The source lead of each sink is connected to ground, so the output sink pins do not require protection against being externally shorted to ground, as this would result in zero potential across the sink device.

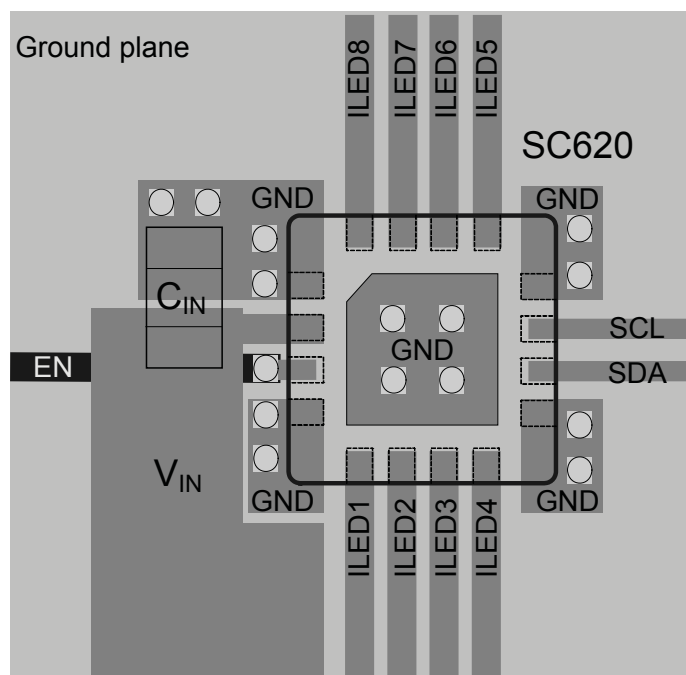
Over-Temperature Protection

The Over-temperature Protection circuit helps prevent the device from overheating and experiencing a catastrophic

failure. When the junction temperature exceeds 155°C, the device is disabled and remains disabled until the junction temperature is reduced.

Layout Considerations

The MLPQ-UT-16 package has a thermal die attach pad located at the center. This pad must be connected to the ground plane through multiple vias as shown (illustration not to scale).



For low noise, four ground pins are located at the corner pins 1, 4, 9 and 12. Connect each of the ground pins directly to the ground plane as shown.

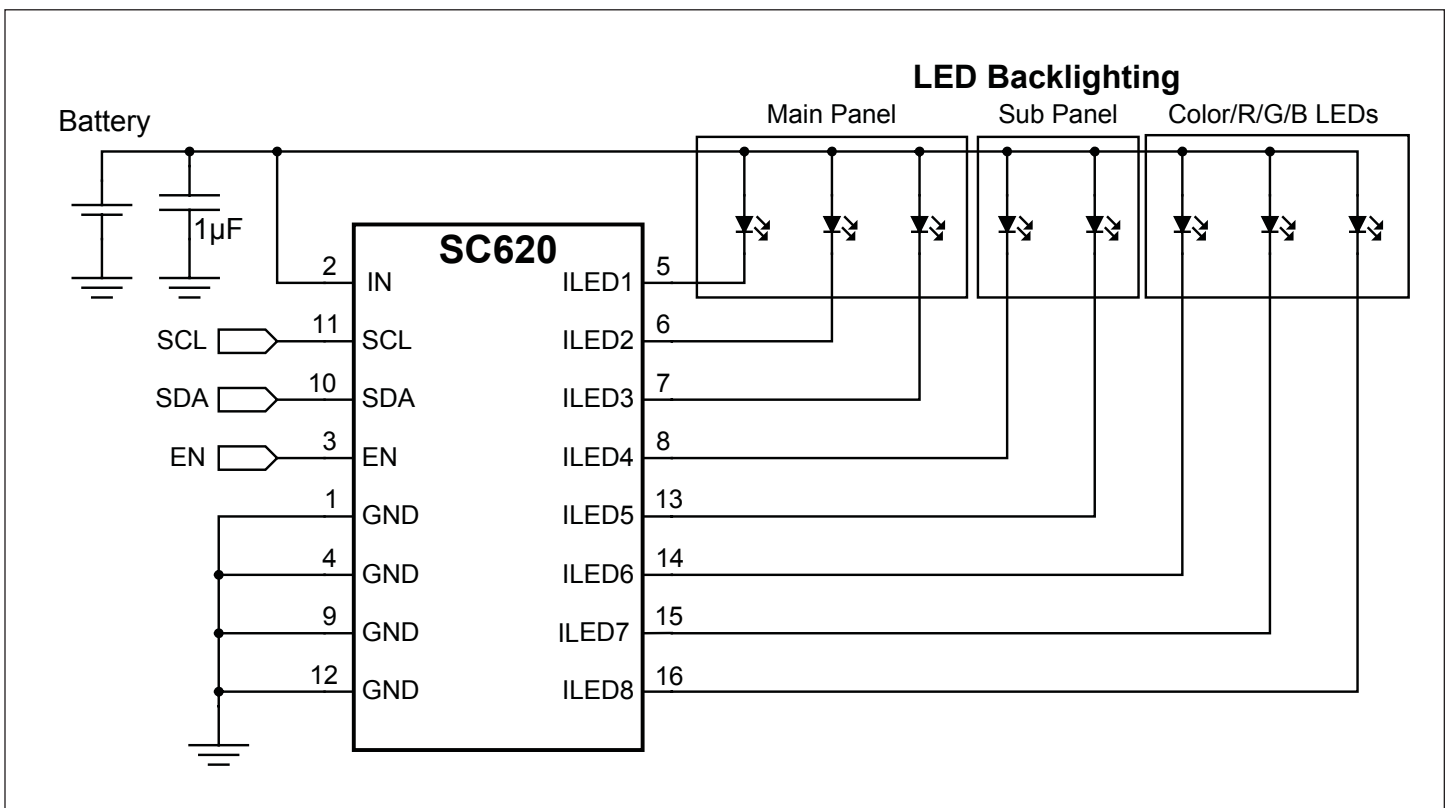
The layout is simple and requires very few components in addition to the LEDs that it will drive. A 1µF decoupling capacitor at the IN pin is required. Place this capacitor near pin 2, and ground it close to the SC620 as shown.

Applications Information (continued)

Application Circuit Examples

Main Backlight Plus Sub-panel Backlight Plus Single RGB LED

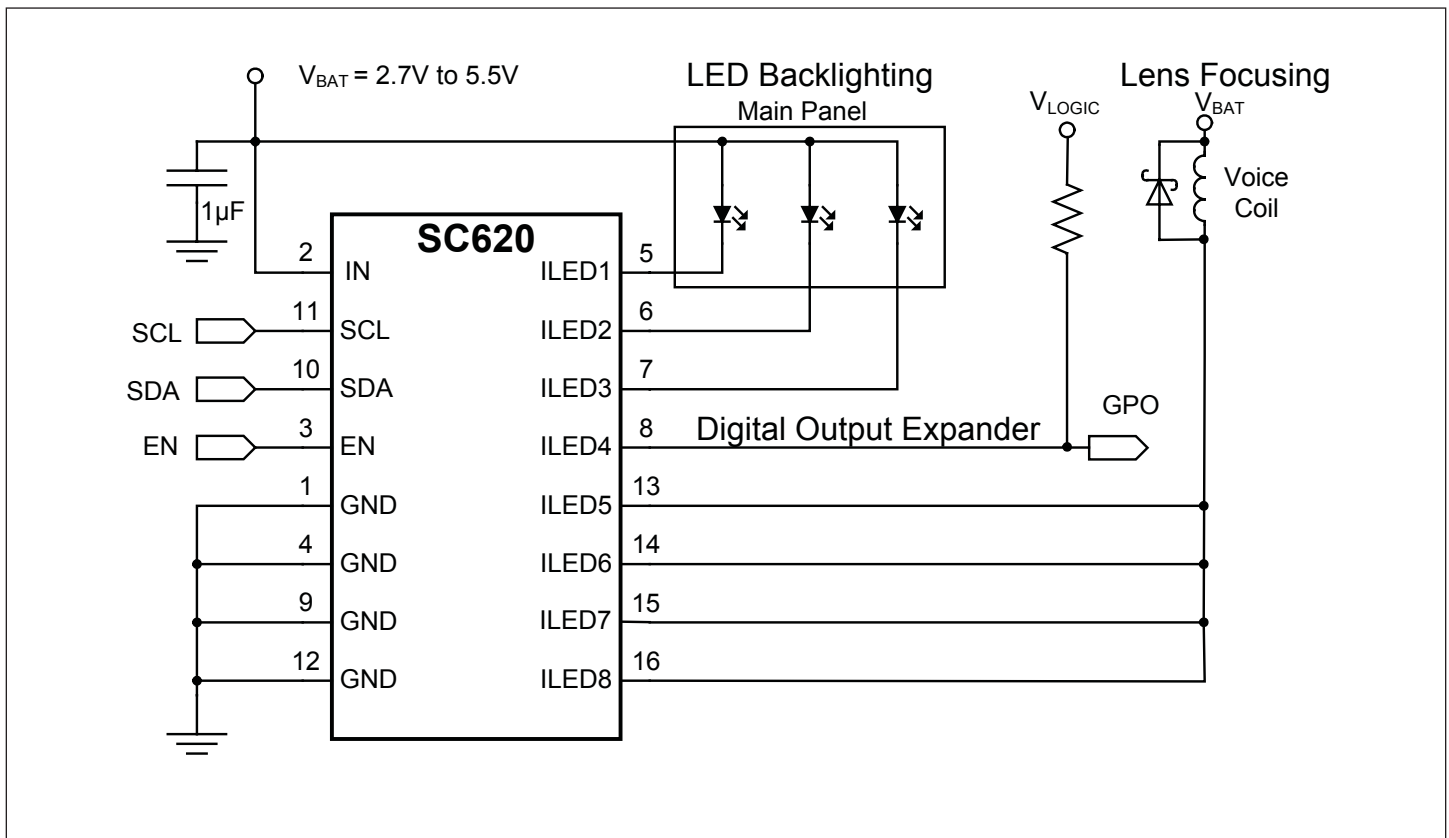
This example uses the SC620 to drive a main display, a sub-panel display, and an RGB LED. Independent outputs allow these functions to be supported simultaneously at different intensities. The V_{IN} supply is typically single cell Li-Ion or 5.0V. V_{IN} supply and LED anode voltage may be from different sources. The operating voltage limit of ($V_{IN} - 1.5V$) at the sink pins must be observed to achieve the specified accuracy of the device.



Applications Information (continued)

Backlighting Three LEDs of Any Color Combination Plus Lens Voice Coil Drive and One GPO

This example uses the SC620 to drive 3 backlight LEDs, plus a voice coil actuator for lens auto-focus and one open-drain digital output. Independent outputs allow these functions to be supported simultaneously. The V_{IN} supply is typically single cell Li-Ion or 5.0V. V_{IN} and the LED anode voltage may be supplied by different sources. The operating voltage limit of $(V_{IN} - 1.5V)$ at the sink pins must be observed to achieve the specified accuracy of the device.



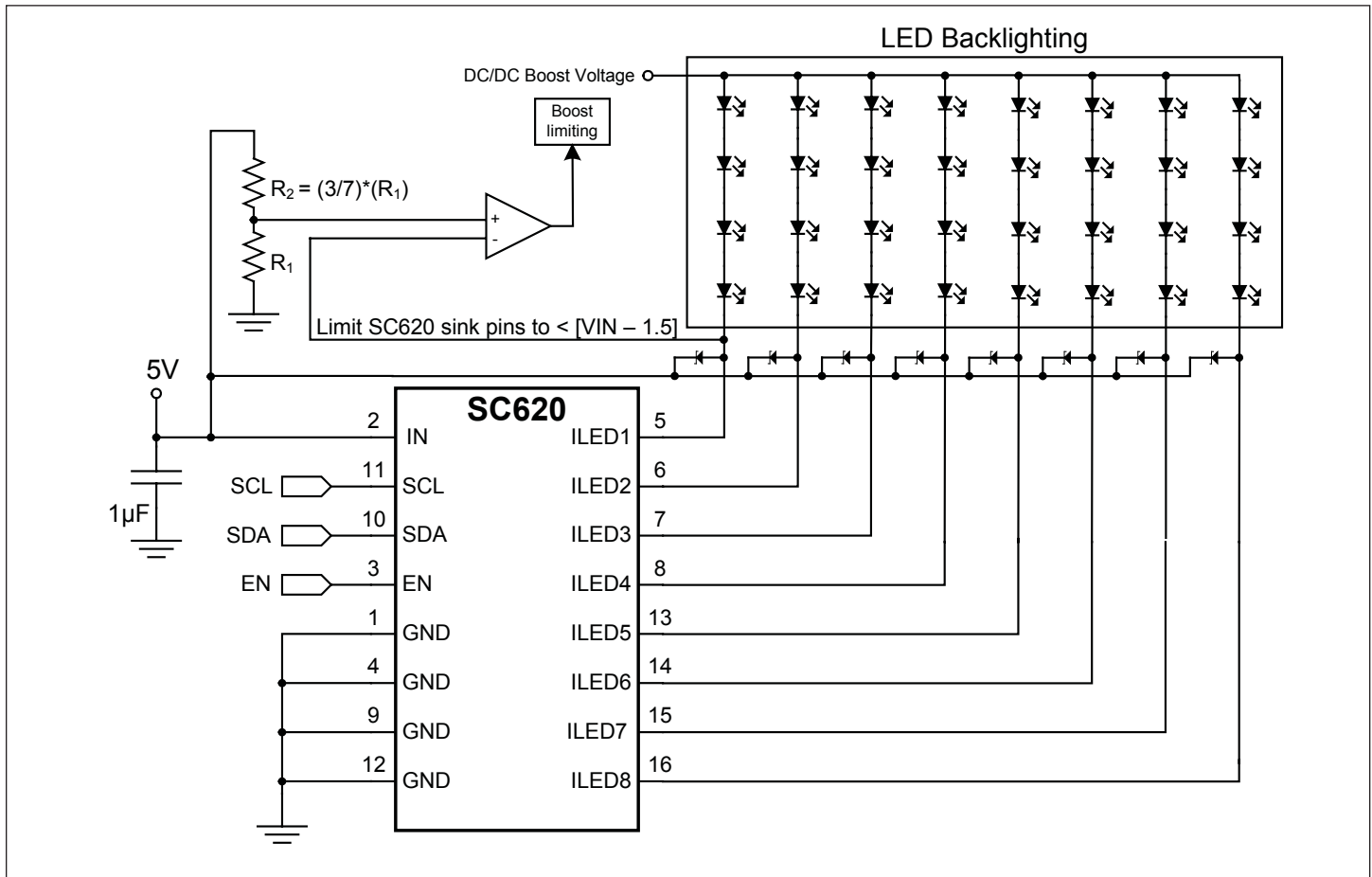
Applications Information (continued)

Backlighting with Series Connected LEDs connected to a Boosted Output Voltage

This example uses the SC620 to drive 32 LEDs in a 4-in-series by 8-in-parallel arrangement. Other arrangements of series and parallel combinations are possible.

To prevent the boost voltage from illuminating the LEDs while the current sinks are off, the boost voltage must follow the SC620 in the start-up sequence. The boost voltage must also power-off before the current sinks turn off in the shut-down sequence. Protection diodes may be necessary to protect the current sinks from destructive voltage levels produced by the boost voltage supply. Schottky diodes are shown in the schematic for the purpose of voltage clamping. These diodes prevent damage to the current sinks in the event that the sink turns off while the boost circuit is on.

The operating voltage limit of ($V_{IN} - 1.5V$) at the sink pins must be observed to achieve the specified accuracy of the device.



Register Map

| Address | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Description | Default ⁽¹⁾ |
|---------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------|------------------------|
| 00h | L8_EN 1 = on 0 = off | L7_EN 1 = on 0 = off | L6_EN 1 = on 0 = off | L5_EN 1 = on 0 = off | L4_EN 1 = on 0 = off | L3_EN 1 = on 0 = off | L2_EN 1 = on 0 = off | L1_EN 1 = on 0 = off | LED on/off control | 00h |
| 01h | X | X | L1_5 | L1_4 | L1_3 | L1_2 | L1_1 | L1_0 | LED1 dimming control | 01h |
| 02h | X | X | L2_5 | L2_4 | L2_3 | L2_2 | L2_1 | L2_0 | LED2 dimming control | 01h |
| 03h | X | X | L3_5 | L3_4 | L3_3 | L3_2 | L3_1 | L3_0 | LED3 dimming control | 01h |
| 04h | X | X | L4_5 | L4_4 | L4_3 | L4_2 | L4_1 | L4_0 | LED4 dimming control | 01h |
| 05h | X | X | L5_5 | L5_4 | L5_3 | L5_2 | L5_1 | L5_0 | LED5 dimming control | 01h |
| 06h | X | X | L6_5 | L6_4 | L6_3 | L6_2 | L6_1 | L6_0 | LED6 dimming control | 01h |
| 07h | X | X | L7_5 | L7_4 | L7_3 | L7_2 | L7_1 | L7_0 | LED7 dimming control | 01h |
| 08h | X | X | L8_5 | L8_4 | L8_3 | L8_2 | L8_1 | L8_0 | LED8 dimming control | 01h |
| 09h | X | X | X | X | G4 | G3 | G2 | G1 | gain register | 08h |

Note

(1) Default value is the register contents immediately following a high transition at the enable pin.

SC620 Slave Address

Following a start condition, the bus master outputs the address of the slave device. The 7 bit slave address for the SC620 is 1110 000x. The eighth bit is the data direction bit and also the least significant bit (LSB). E0h is used for a write operation, and E1h is used for a read operation.

| DEVICE ADDRESS | | | | | | | R/W |
|----------------|---|---|---|---|---|---|-----|
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1/0 |

Dimming Control Register Description

The dimming control registers set the multiplier used to determine the absolute current setting. Current setting for each current sink is determined by multiplying the current step size (as described in Table 1) by the decimal multiplier in each dimming control register. For example, if the current step size is set to 500 μ A and the L1 Dimming Control Register bits (L1_5 through L1_0) are set to 010100 (20 decimal), then the output current for ILED1 is set to 20 x 500 μ A = 10mA. Note that the maximum current setting occurs when the dimming control register bits are set to 110010 (50 decimal) - any bit combination larger than this one will default to the maximum setting.

Table 1 - Gain Setting Values (default = 1000)

| G4 | G3 | G2 | G1 | Current Step Size (μ A) |
|----|----|----|----|------------------------------|
| 0 | 0 | 0 | 0 | 31.25 |
| 0 | 0 | 0 | 1 | 62.5 |
| 0 | 0 | 1 | 0 | 93.75 |
| 0 | 0 | 1 | 1 | 125 |
| 0 | 1 | 0 | 0 | 156.25 |
| 0 | 1 | 0 | 1 | 187.5 |
| 0 | 1 | 1 | 0 | 218.75 |
| 0 | 1 | 1 | 1 | 250 |
| 1 | 0 | 0 | 0 | 281.25 |
| 1 | 0 | 0 | 1 | 312.5 |
| 1 | 0 | 1 | 0 | 343.75 |
| 1 | 0 | 1 | 1 | 375 |
| 1 | 1 | 0 | 0 | 406.25 |
| 1 | 1 | 0 | 1 | 437.5 |
| 1 | 1 | 1 | 0 | 468.75 |
| 1 | 1 | 1 | 1 | 500 |

Using the I²C Serial Port

The I²C General Specification

The SC620 is a read-write slave-mode I²C device and complies with the Philips I²C standard Version 2.1 dated January, 2000. The SC620 has eight user-accessible internal 8-bit registers. While there is no auto increment/decrement capability in the SC620 I²C logic, a tight software loop can be designed to randomly access the next register independent of which register you begin accessing. The start and stop commands frame the data-packet and the repeat start condition is allowed if necessary.

SC620 Limitations to the I²C Specifications

Seven bit addressing is used and ten bit addressing is not allowed. Any general call address will be ignored by the SC620. The SC620 is not CBUS compatible. The SC620 can operate in standard mode (100kbit/s) or fast mode (400kbit/s).

Supported Formats:

Direct Format — Write

The simplest format for an I²C write is Direct Format. After the start condition [S], the slave address is sent, followed by an eighth bit indicating a write. The SC620 I²C then acknowledges that it is being addressed, and the master responds with an 8 bit data byte consisting of the register address. The slave acknowledges and the master sends the appropriate 8 bit data byte. Once again the slave acknowledges and the master terminates the transfer with the stop condition [P].

Combined Format — Read

After the start condition [S], the slave address is sent, followed by an eighth bit indicating a write. The SC620 I²C then acknowledges that it is being addressed, and the master responds with an 8 bit data byte consisting of the register address. The slave acknowledges and the master sends the repeated start condition [Sr]. Once again, the slave address is sent, followed by an eighth bit indicating a read. The slave responds with an acknowledge and the previously addressed 8 bit data byte; the master then sends a non-acknowledge (NACK). Finally, the master terminates the transfer with the stop condition [P].

Stop Separated Reads

Stop separated reads can also be used. This format allows a master to set up the register address pointer for a read and return to that slave at a later time to read the data. In this format the slave address followed by a write command are sent after a start [S] condition. The SC620 then acknowledges it is being addressed, and the master responds with the 8-bit register address. The master sends a stop or restart condition and may then address another slave. After performing other tasks, the master can send a start or restart condition to the device with a read command. The SC620 acknowledges this request and returns the data from the register location that had previously been set up.

Using the I²C Serial Port (continued)

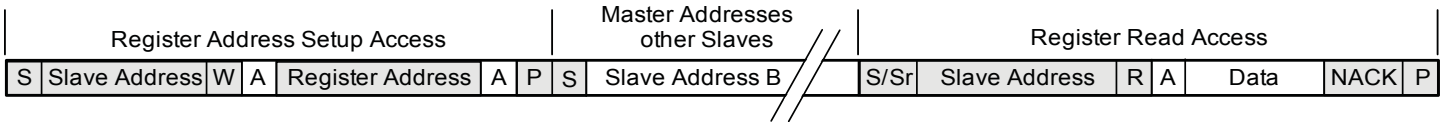
I²C Direct Format Write



S – Start Condition
 W – Write = '0'
 A – Acknowledge (sent by slave)
 P – Stop condition

Slave Address – 7-bit
 Register address – 8-bit
 Data – 8-bit

I²C Stop Separated Format Read



S – Start Condition
 W – Write = '0'
 R – Read = '1'
 A – Acknowledge (sent by slave)
 NAK – Non-Acknowledge (sent by master)
 Sr – Repeated Start condition
 P – Stop condition

Slave Address – 7-bit
 Register address – 8-bit
 Data – 8-bit

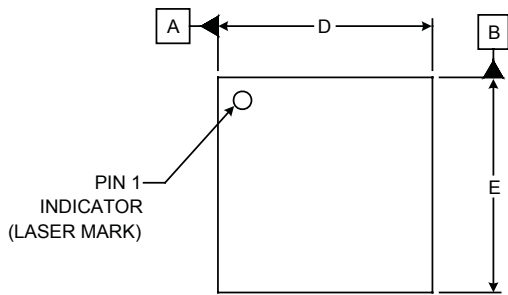
I²C Combined Format Read



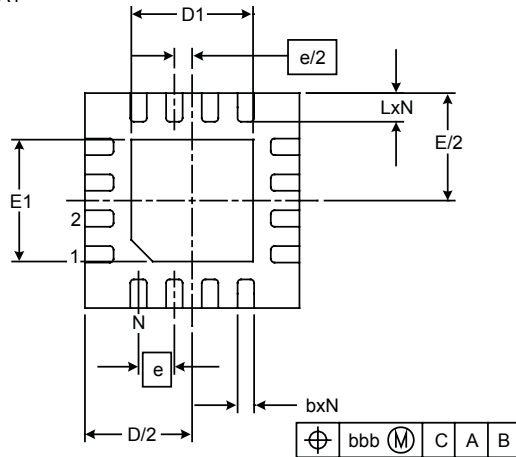
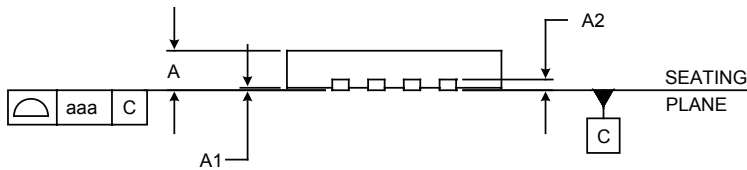
S – Start Condition
 W – Write = '0'
 R – Read = '1'
 A – Acknowledge (sent by slave)
 NAK – Non-Acknowledge (sent by master)
 Sr – Repeated Start condition
 P – Stop condition

Slave Address – 7-bit
 Register address – 8-bit
 Data – 8-bit

Outline Drawing — MLPQ-UT-16 3x3



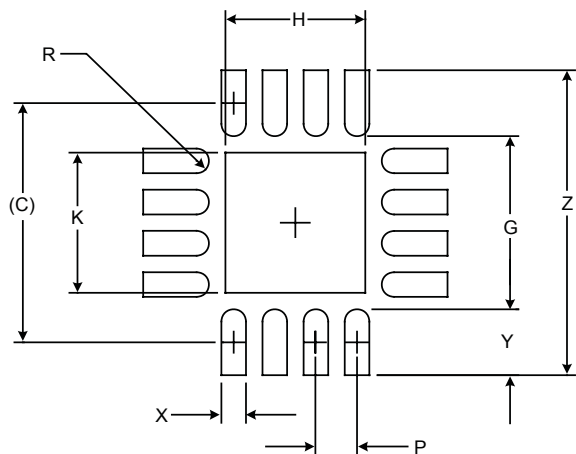
| DIM | INCHES | | | MILLIMETERS | | |
|-----|----------|------|------|-------------|------|------|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | .018 | - | .024 | 0.45 | - | 0.60 |
| A1 | .000 | - | .002 | 0.00 | - | 0.05 |
| A2 | (.006) | | | (0.1524) | | |
| b | .007 | .009 | .012 | 0.18 | 0.23 | 0.30 |
| D | .114 | .118 | .122 | 2.90 | 3.00 | 3.10 |
| D1 | .061 | .067 | .071 | 1.55 | 1.70 | 1.80 |
| E | .114 | .118 | .122 | 2.90 | 3.00 | 3.10 |
| E1 | .061 | .067 | .071 | 1.55 | 1.70 | 1.80 |
| e | .020 BSC | | | 0.50 BSC | | |
| L | .012 | .016 | .020 | 0.30 | 0.40 | 0.50 |
| N | 16 | | | 16 | | |
| aaa | .003 | | | 0.08 | | |
| bbb | .004 | | | 0.10 | | |



NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

Land Pattern — MLPQ-UT-16 3x3



| DIMENSIONS | | |
|------------|--------|-------------|
| DIM | INCHES | MILLIMETERS |
| C | (.114) | (2.90) |
| G | .083 | 2.10 |
| H | .067 | 1.70 |
| K | .067 | 1.70 |
| P | .020 | 0.50 |
| R | .006 | 0.15 |
| X | .012 | 0.30 |
| Y | .031 | 0.80 |
| Z | .146 | 3.70 |

NOTES:

1. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.
2. THERMAL VIAS IN THE LAND PATTERN OF THE EXPOSED PAD SHALL BE CONNECTED TO A SYSTEM GROUND PLANE. FAILURE TO DO SO MAY COMPROMISE THE THERMAL AND/OR FUNCTIONAL PERFORMANCE OF THE DEVICE.

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