# CAT4008

# 8-Channel Constant Current LED Driver

### Description

The CAT4008 is an 8 channel constant current driver for LED billboard and other general display applications. LED channel currents are programmed together via an external RSET resistor. Low output voltage operation on the LED channels as low as 0.4 V (for 2 to 100 mA LED current) allows for more power efficient designs.

A high−speed 4−wire serial interface of up to 25 MHz clock frequency controls each individual channel using a shift register and latch configuration. A serial output data pin (SOUT) allows multiple devices to be cascaded and programmed via one serial interface. The device also includes a blanking control pin (BLANK) that can be used to disable all channels independently of the interface.

Thermal shutdown protection is incorporated in the device to disable the LED outputs if the die temperature exceeds a set limit.

The device is available in the TSSOP package.

### Features

- 8 Constant Current−sink Channels
- Serial Interface up to 25 MHz Clock Frequency
- 3 V to 5.5 V Logic Supply
- LED Current Range from 2 mA to 100 mA
- LED Current set by External RSET Resistor
- 300 mV LED Dropout at 30 mA
- Thermal Shutdown Protection
- Available in 16−lead SOIC (150 and 300 mil wide), and TSSOP Packages
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

### Applications

- Billboard Display
- Marquee Display
- Instrument Display
- General Purpose Display

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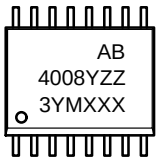
**TSSOP−16**
**Y SUFFIX**
**CASE 948AN**

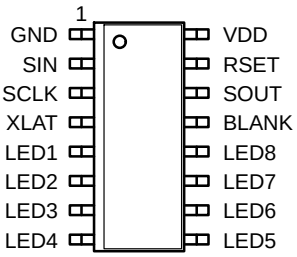
**MARKING DIAGRAM**




CAT4008Y−T2

A = Assembly Location
3 = Lead Finish − Matte−Tin
B = Product Revision (Fixed as “B”)
4008Y = Device Code
Z or ZZ = Leave Blank
Y = Production Year (Last Digit)
M = Production Month (1-9, A, B, C)
XXX or XXXX = Last Three of Four Digits of Assembly Lot Number

**PIN CONNECTIONS**




16−Lead TSSOP (Y)
(Top View)

**ORDERING INFORMATION**

See detailed ordering and shipping information in the package dimensions section on page 11 of this data sheet.

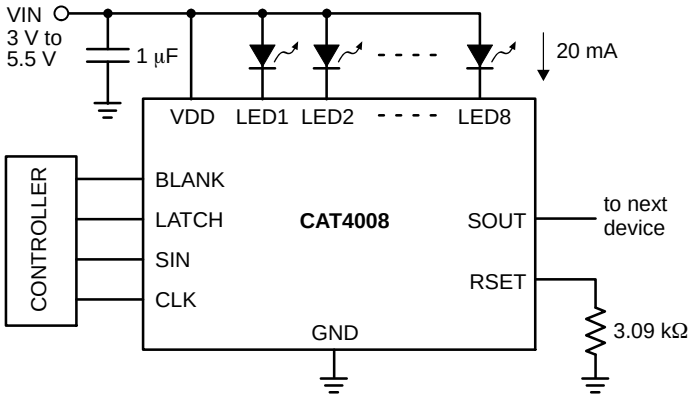



**Figure 1. Typical Application Circuit**

**Table 1. ABSOLUTE MAXIMUM RATINGS**

| Parameter | Rating | Units |
|---|---|---|
| $V_{DD}$ Supply Voltage | 6 | V |
| Logic input/output voltage (SIN, SOUT, CLK, BLANK, LATCH) | −0.3 V to $V_{DD}$+0.3 V | V |
| LEDn voltage | 6 | V |
| DC output current on LED1 to LED8 | 150 | mA |
| Storage Temperature Range | −55 to +160 | °C |
| Junction Temperature Range | −40 to +150 | °C |
| Lead Soldering Temperature (10 sec.) | 300 | °C |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

**Table 2. RECOMMENDED OPERATING CONDITIONS**

| Parameter | Range | Units |
|---|---|---|
| $V_{DD}$ | 3.0 to 5.5 | V |
| Voltage applied to LED1 to LED8 | 0.4 to 5.5 | V |
| LED current RSET control range | up to 100 | mA |
| Ambient Temperature Range | −40 to +85 | °C |

**Table 3. ELECTRICAL OPERATING CHARACTERISTICS**
($V_{DD}$ = 5.0 V, $T_{AMB}$ = 25°C, over recommended operating conditions unless specified otherwise.)

| Symbol | Name | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **DC CHARACTERISTICS** | | | | | | |
| $I_{LED-ACC}$ | LED Current (any channel) | $V_{LED}$ = 1 V, $R_{SET}$ = 3.08 kΩ | 18 | 20 | 22 | mA |
| | | $V_{LED}$ = 1 V, $R_{SET}$ = 1.54 kΩ | 36 | 40 | 44 | |
| | | $V_{LED}$ = 1 V, $R_{SET}$ = 769 Ω | | 80 | | |
| $I_{LED-MAT}$ | LED Current Matching ($I_{LED}$ − $I_{LEDAVR}$) / $I_{LEDAVR}$ | $V_{LED}$ = 1 V, $R_{SET}$ = 3.08 kΩ | | ±1.5 | | % |
| | | $V_{LED}$ = 1 V, $R_{SET}$ = 1.54 kΩ | −6.0 | ±1.5 | +6.0 | |
| | | $V_{LED}$ = 1 V, $R_{SET}$ = 769 Ω | | ±2.0 | | |
| $\Delta I_{VDD}$ | LED current regulation vs. $V_{DD}$ | $V_{DD}$ within 4.5 V and 5.5 V LED current 30 mA | | ±0.1 | | % / V |
| $\Delta I_{VLED}$ | LED current regulation vs. $V_{LED}$ | $V_{LED}$ within 1 V and 3 V LED current 30 mA | | ±0.05 | | % / V |
| $I_{DDOFF}$ | Supply Current (all outputs off) | $R_{SET}$ = 3.08 kΩ | | 2 | 8 | mA |
| | | $R_{SET}$ = 769 Ω | | 5.5 | | |
| $I_{DDON}$ | Supply Current (all outputs on) | $R_{SET}$ = 3.08 kΩ | | 2.5 | 9 | mA |
| | | $R_{SET}$ = 769 Ω | | 6.2 | | |
| $I_{LKG}$ | LEDn output Leakage | $V_{LED}$ = 5 V, outputs off | −1 | | 1 | μA |
| $R_{LATCH}$ | LATCH Pull−down Resistance | | 100 | 180 | 300 | kΩ |
| $R_{BLANK}$ | BLANK Pull−up Resistance | | 100 | 180 | 300 | kΩ |
| $V_{IH}$<br>$V_{IL}$ | Logic high input voltage<br>Logic low input voltage | | 0.7x$V_{DD}$ | | <br>0.3x$V_{DD}$ | V |
| $V_{HYS}$ | Logic input hysteresis voltage | | | 0.1x$V_{DD}$ | | V |
| $I_{IL}$ | Logic Input leakage current (CLK, SIN) | $V_I$ = $V_{DD}$ or GND | −5 | 0 | 5 | μA |
| $V_{OH}$<br>$V_{OL}$ | SOUT logic high output voltage<br>SOUT logic low output voltage | $I_{OH}$ = −1 mA<br>$I_{OL}$ = 1 mA | $V_{CC}$−0.3 V | | <br>0.3 | V |
| $V_{RSET}$ | RSET Regulated Voltage | BLANK high, outputs off | 1.17 | 1.20 | 1.23 | V |
| $T_{SD}$ | Thermal Shutdown | | | 160 | | °C |
| $T_{HYST}$ | Thermal Hysteresis | | | 20 | | °C |

**Table 4. TIMING CHARACTERISTICS**
(For 3.0 V ≤ $V_{DD}$ ≤ 5.5 V, $T_{AMB}$ = 25°C, unless specified otherwise.)

| Symbol | Name | Conditions | Min (Note 1) | Typ (Note 2) | Max (Note 1) | Units |
|---|---|---|---|---|---|---|
| **CLK** | | | | | | |
| $f_{clk}$ | CLK Clock Frequency | | | | 25 | MHz |
| $t_{cwh}$ | CLK Pulse Width High | | 20 | | | ns |
| $t_{cwl}$ | CLK Pulse Width Low | | 20 | | | ns |
| **SIN** | | | | | | |
| $t_{ssu}$ | Setup time SIN to CLK | | 4 | | | ns |
| $t_{sh}$ | Hold time SIN to CLK | | 4 | | | ns |
| **LATCH** | | | | | | |
| $t_{lwh}$ | LATCH Pulse width | | 20 | | | ns |
| $T_{lh}$ | Hold time LATCH to CLK | | 4 | | | ns |
| $T_{lsu}$ | Setup time LATCH to CLK | Channel Stagger Delay | 400 | | | ns |
| **LEDn** | | | | | | |
| $t_{ld}$ | LED1 Propagation delay | LATCH to LED1 off/on | | 40 | 300 | ns |
| $t_{ls}$ | LED Propagation delay stagger | LED(n) to LED(n+1) | | 17 | 40 | ns |
| $t_{lst}$ | LED Propagation delay stagger total | LED1 to LED8 | | 120 | | ns |
| $t_{bd}$ | BLANK Propagation delay | BLANK to LED(n) off/on | | 60 | 300 | ns |
| $t_{lr}$ | LED rise time (10% to 90%) | Pull−up resistor = 50 Ω to 3.0 V | | 40 | 200 | ns |
| $t_{lf}$ | LED fall time (90% to 10%) | Pull−up resistor = 50 Ω to 3.0 V | | 30 | 250 | ns |
| **SOUT** | | | | | | |
| $t_{or}$ | SOUT rise time (10% to 90%) | $C_L$ = 15 pF | | 5 | | ns |
| $t_{of}$ | SOUT fall time (90% to 10%) | $C_L$ = 15 pF | | 5 | | ns |
| $t_{od}$ | Propagation delay time SOUT | CLK to SOUT | 8 | 15 | 25 | ns |

1. All min and max values are guaranteed by design.
2. $V_{DD}$ = 5 V, LED current 30 mA.

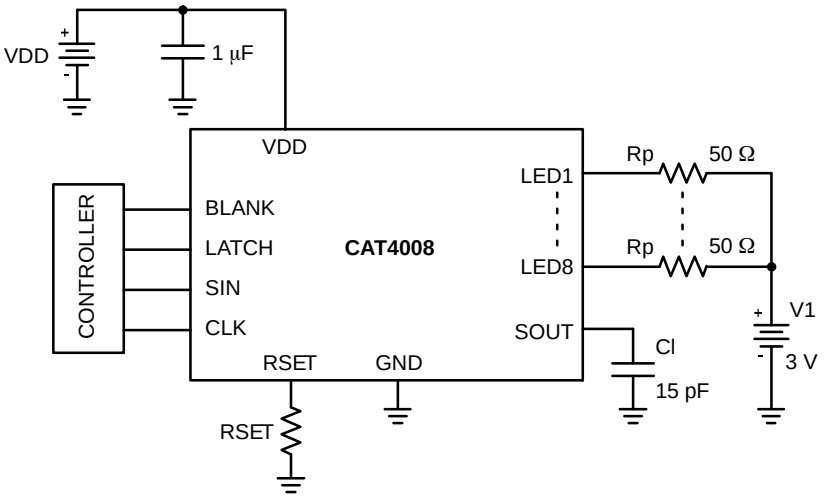



**Figure 2. Test Circuit for AC Characteristics**

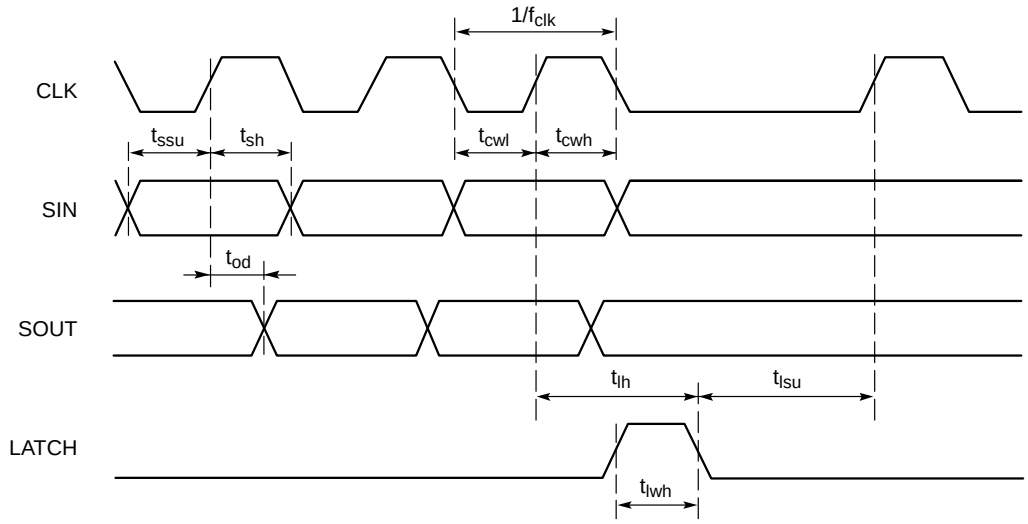



**Figure 3. Serial Input Timing Diagram**

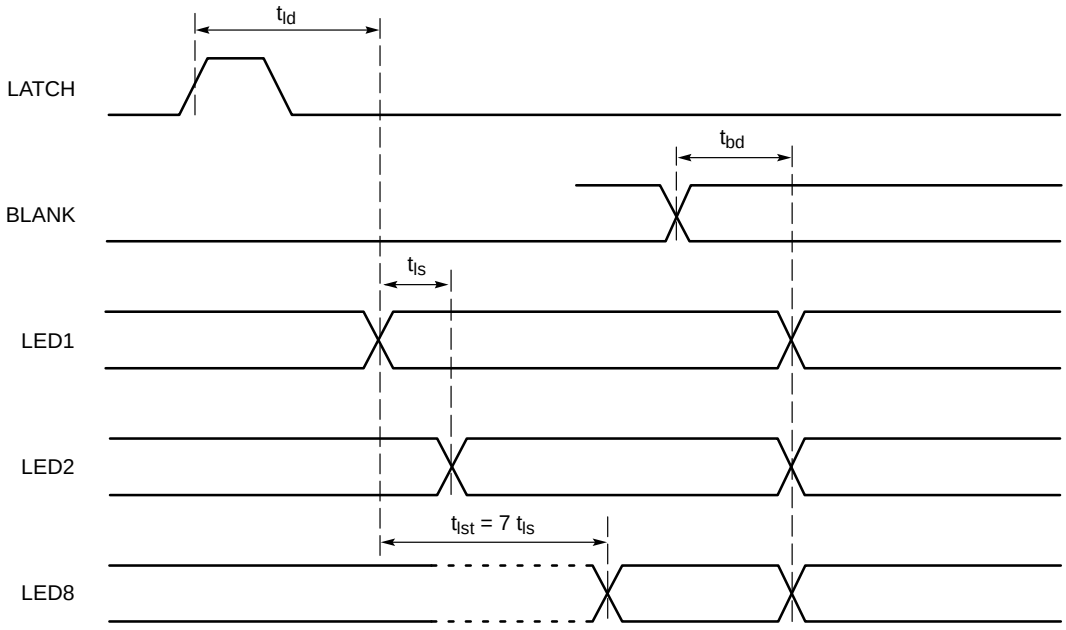



**Figure 4. LED Output Timing Diagram**

## TYPICAL PERFORMANCE CHARACTERISTICS

($V_{DD}$ = 5.0 V, LED current 30 mA, all LEDs On, $T_{AMB}$ = 25°C unless otherwise specified.)

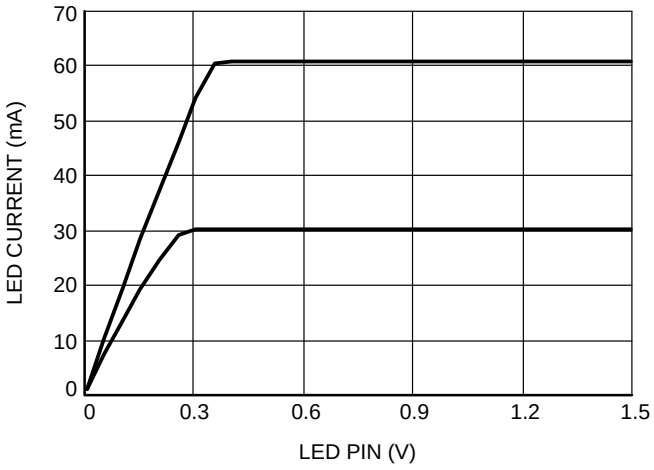



**Figure 5. LED Current vs. LED Pin Voltage**

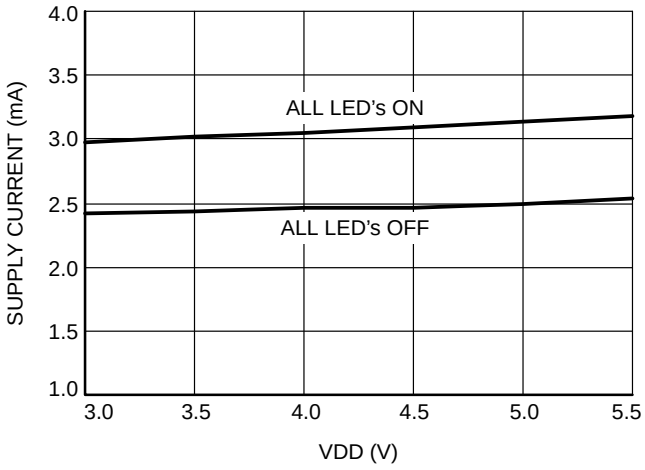



**Figure 6. Supply Current vs. VDD Pin Voltage**

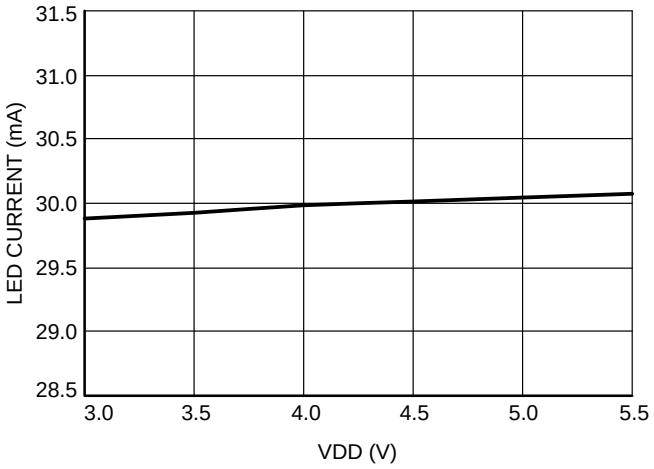



**Figure 7. LED Current vs. VDD Pin Voltage**

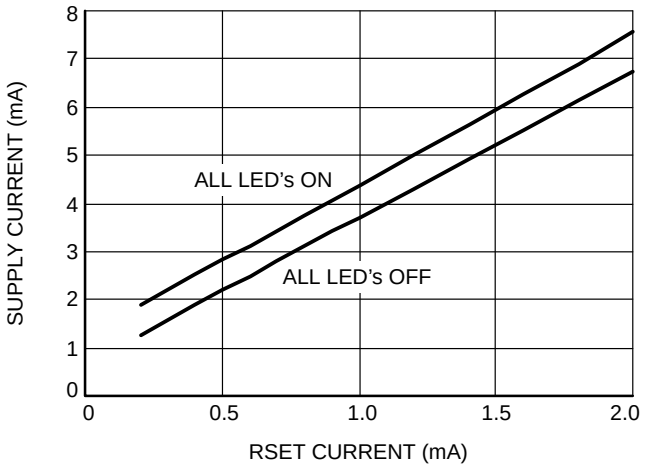



**Figure 8. Supply Current vs. RSET Current**

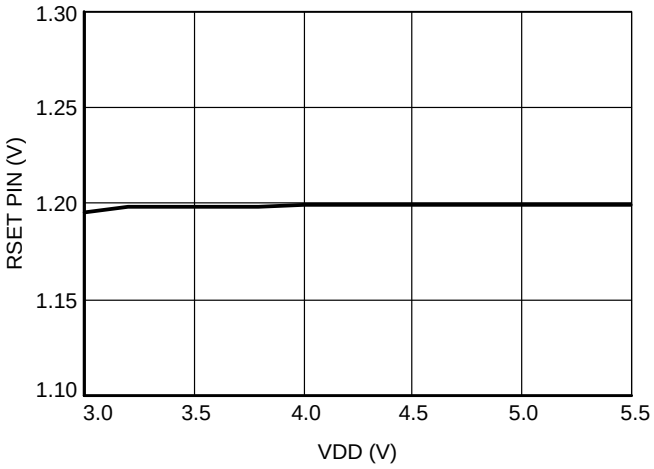



**Figure 9. RSET Voltage vs. VDD Pin Voltage**

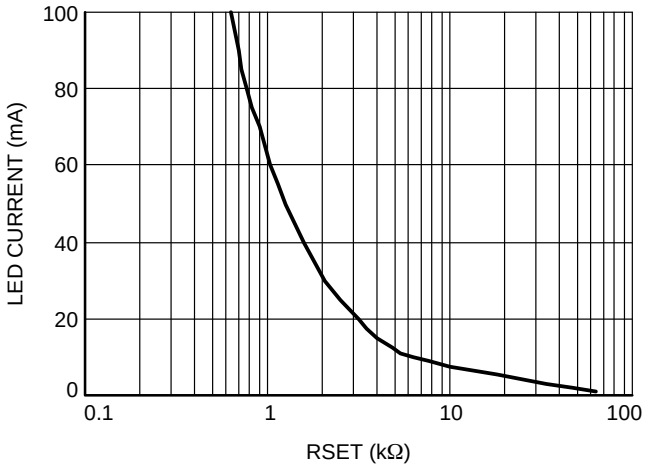



**Figure 10. LED Current vs. RSET Resistor**

## TYPICAL PERFORMANCE CHARACTERISTICS

($V_{DD}$ = 5.0 V, LED current 30 mA, all LEDs On, $T_{AMB}$ = 25°C unless otherwise specified.)

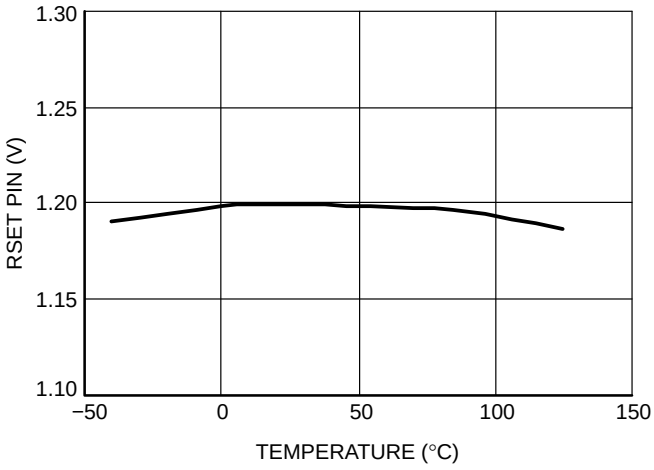



**Figure 11. RSET Voltage vs. Temperature**

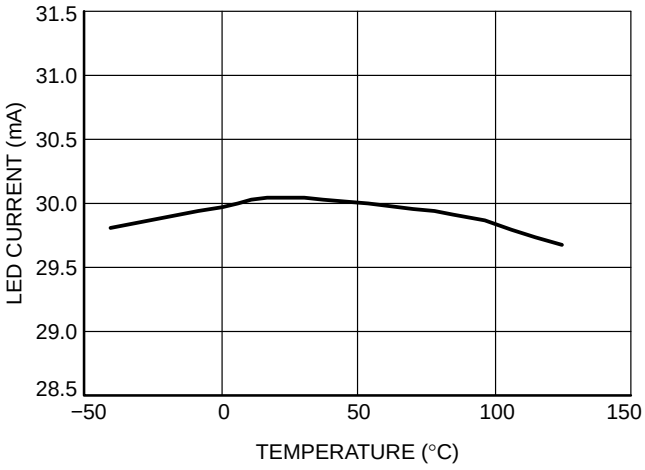



**Figure 12. LED Current vs. Temperature**

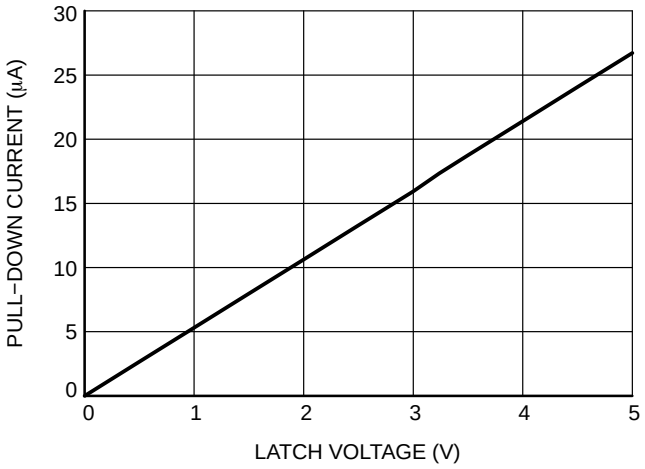



**Figure 13. Internal Pull−Down Current (LATCH Pin)**

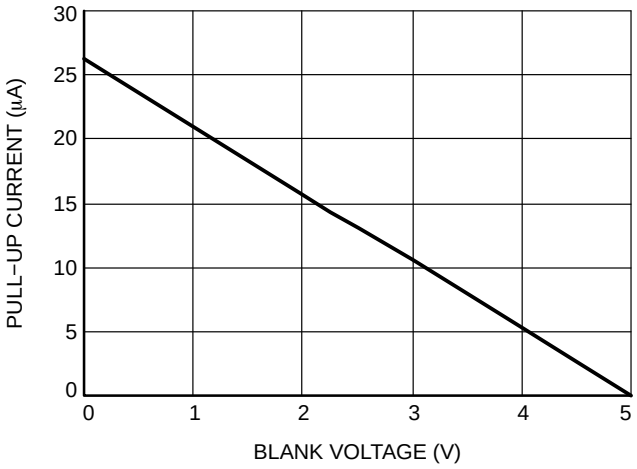



**Figure 14. Internal Pull−Up Current (BLANK Pin)**

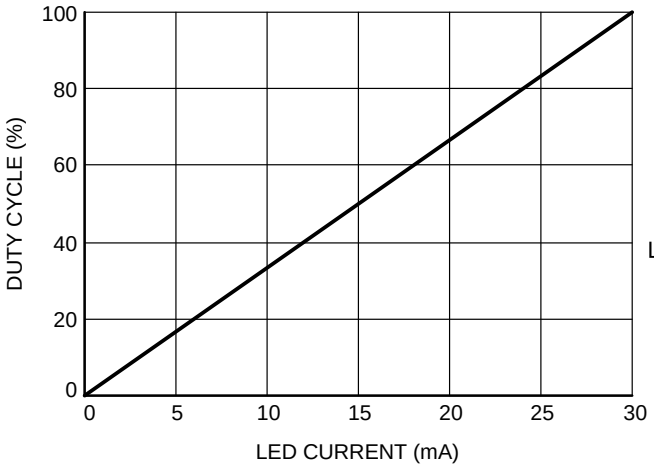



**Figure 15. PWM Dimming on BLANK Pin (f = 10 kHz)**

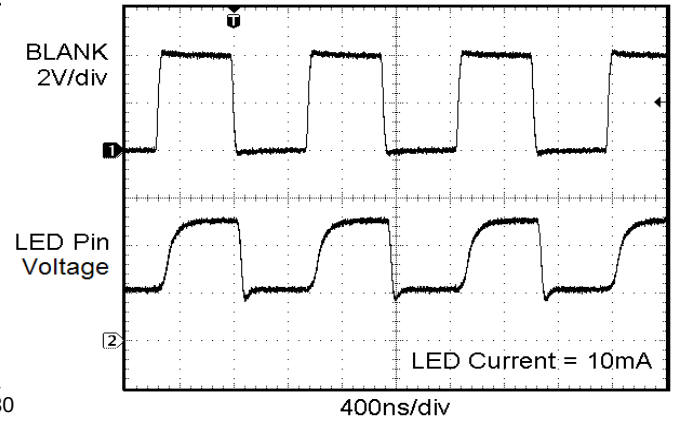



**Figure 16. BLANK Transient Response**

**Table 5. PIN DESCRIPTION**

| Name | Function |
|---|---|
| GND | Ground |
| SIN | Serial data input pin |
| CLK | Serial clock input pin |
| LATCH | Latch serial data to output registers |
| LED1−LED8 | LED channel 1 to 8 cathode terminals |
| BLANK | Enable / disable all channels |
| SOUT | Serial data output pin. |
| RSET | LED current set pin |
| VDD | Positive supply Voltage |

## Pin Function

**GND** is the ground reference pin for the device. This pin must be connected to the ground plane on the PCB.

**SIN** is the serial data input. Data is loaded into the internal register on each rising edge of CLK.

**CLK** is the serial clock input. On each rising CLK edge, data is transferred from SIN to the internal 8−bit serial shift register.

**LATCH** is the latch data input. On the rising edge of LATCH, data is loaded from the 8−bit serial shift register into the output register latch. On the falling edge, this data is latched in the output register and isolated from the state of the serial shift register.

**LED1 – LED8** are the LED current sink channels. These pins are connected to the LED cathodes. The current sinks drive the LEDs with a current equal to about 51 times RSET pin current. For the LED sink to operate correctly, the voltage on the LED pin must be above 0.4 V.

**BLANK** is the LED channel enable and disable input pin. When low, LEDs are enabled according to the output latch register content. When high, all LEDs are off, while preserving the data in the output latch register.

**SOUT** is the serial data output of the 8−bit serial shift register. This pin is used to cascade several devices on the serial bus. The SOUT pin is then connected to the SIN input of the next device on the serial bus to cascade.

**RSET** is the LED current setting pin. A resistor is connected between this pin and ground. Each LED channel current is set to about 51 times the current pulled out of the pin. The RSET pin voltage is regulated to 1.2 V.

**VDD** is the positive supply pin voltage for the entire device. A small 1 μF ceramic is recommended close to pin.

## Current Setting Resistor

Table 6 lists standard resistor values for various LED current settings.

**Table 6. LED CURRENT AND RSET RESISTOR VALUES**

| LED Current [mA] | $R_{SET}$ [kΩ] |
|---|---|
| 10 | 6.19 |
| 20 | 3.09 |
| 30 | 2.05 |
| 40 | 1.54 |
| 60 | 1.02 |
| 80 | 0.768 |

## Block Diagram

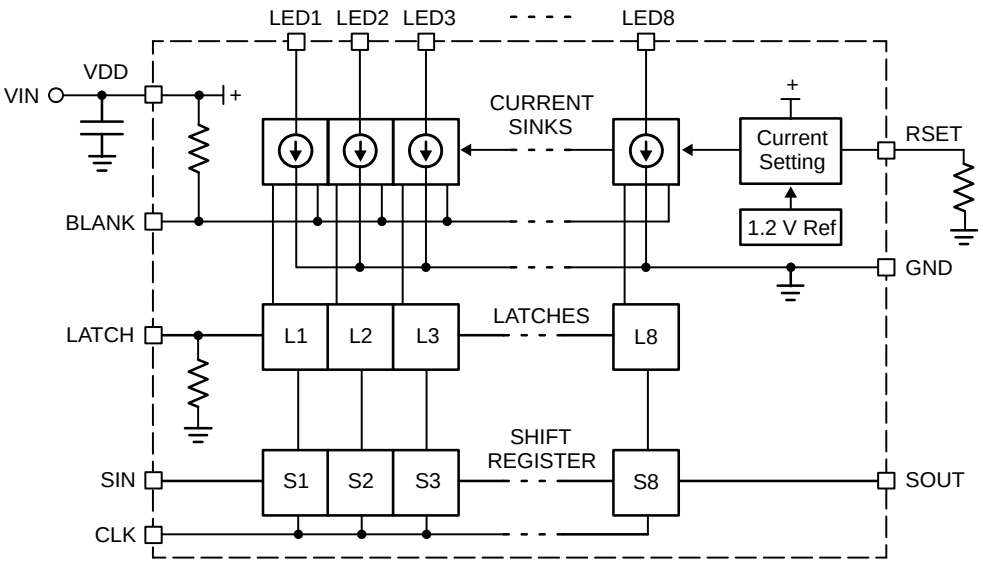



**Figure 17. CAT4008 Functional Block Diagram**

## Basic Operation

The CAT4008 uses 8 tightly matched current sinks to accurately regulate the LED current in each channel. The external resistor, $R_{SET}$, is used to set the LED channel current to about 51 times the current in $R_{SET}$.

$$\text{LED current} \cong 51 \times \frac{1.2}{R_{SET}}$$

Tight current regulation for all channels is possible over a wide range of input and LED voltages due to independent current sensing circuitry on each channel. The LED channels have a maximum dropout of 0.4 V for most current and supply voltage conditions. This helps improve the heat dissipation and efficiency of the LED driver.

Upon power−up, an under−voltage lockout circuit clears all latches and shift registers and sets all outputs to off. Once the under−voltage lockout threshold has been reached the device can be programmed.

The driver delays the activation of each consecutive LED output channel by 17 ns (typical). Relative to LED1, LED2 is delayed by 17 ns, LED3 by 34 ns and LED8 by 120 ns typical. The delay is introduced when LATCH is activated. The delay minimizes the inrush current on the LED supply by staggering the turn on and off current spikes over a period of time and therefore allowing usage of smaller bypass capacitors.

Pull−up and pull−down resistors are internally provided to set the state of the BLANK and LATCH pins to the off−state when not externally driven.

### Serial Interface

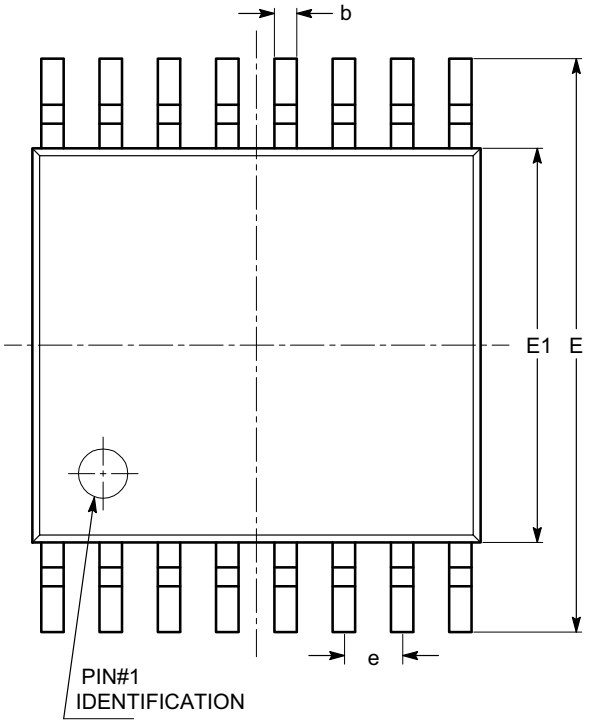
A high−speed serial 4−wire interface is provided to program the state of each LED on or off. The interface contains an 8−bit serial to parallel shift register (S1−S8) and an 8−bit latch (L1−L8). Programming the serial to parallel register is accomplished via SIN and CLK input pins. On each rising edge of the CLK signal, the data from SIN is moved through the shift register serially. Data is also moved out of SOUT which can be connected to a next device if programming more than one device on the same interface.

On the rising edge of LATCH, the data contents of the serial to parallel shift register is reflected in the latches. On the falling edge of LATCH, the state of the serial to parallel register at that particular time is saved in the latches and does not change irrespective of the contents of the serial to parallel register.

BLANK is used to disable all LEDs (turn off) simultaneously while maintaining the same data in the latch register. When low, the LED outputs reflect the data in the latches. When high, all outputs are high impedance (zero current).

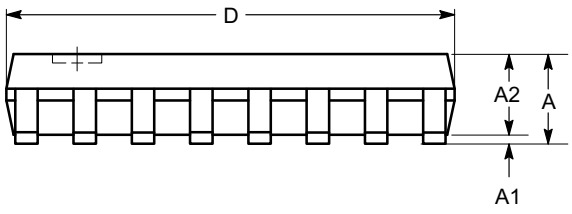
## PACKAGE DIMENSIONS

**TSSOP16, 4.4x5**
CASE 948AN
ISSUE O

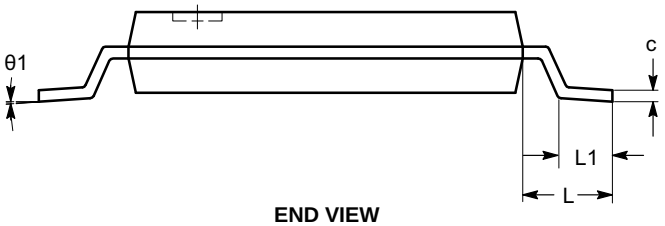



**TOP VIEW**

| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | | | 1.10 |
| A1 | 0.05 | | 0.15 |
| A2 | 0.85 | | 0.95 |
| b | 0.19 | | 0.30 |
| c | 0.13 | | 0.20 |
| D | 4.90 | | 5.10 |
| E | 6.30 | | 6.50 |
| E1 | 4.30 | | 4.50 |
| e | 0.65 BSC | | |
| L | 1.00 REF | | |
| L1 | 0.45 | | 0.75 |
| θ | 0° | | 8° |




**SIDE VIEW**




**END VIEW**

**Notes:**
(1) All dimensions are in millimeters. Angles in degrees.
(2) Complies with JEDEC MO-153.

**Table 7. ORDERING INFORMATION**

| Part Number | Marking | Package | Shipping† |
|---|---|---|---|
| CAT4008Y-T2 | CAT4008Y | TSSOP16 (Pb−Free) | 2,000 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



**PUBLICATION ORDERING INFORMATION**

**LITERATURE FULFILLMENT**:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
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**Fax**: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
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**Europe, Middle East and Africa Technical Support:**
Phone: 421 33 790 2910
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