4-Channel Constant Current LED Driver with EZDim™

FEATURES

- **Four LED current sinks with tight matching**
- **Low Dropout Driver 130mV at 30mA**
- **No switching noise**
- **Shutdown current < 1µA**
- **LED current set by external resistor**
- **Dimming via 1-wire EZDim™ interface**
- **Thermal shutdown protection**
- **RoHS Compliant**
- **8-lead 2mm x 3mm TDFN package**

APPLICATIONS

- **LCD Display Backlight**
- **Cellular Phones**
- **Digital Still Cameras**
- **Handheld Devices**

DESCRIPTION

The CAT4004 provides four matched low dropout current sources to drive LEDs. An external resistor on RSET sets the current in the LED channels. Each LED channel includes an individual control loop allowing the device to handle a wide range of LED forward voltages while still maintaining tight current matching.

The EN/DIM logic inputs supports device enable and a digital dimming interface for current setting of all LEDs. Six different current dimming ratios are available.

The device is aimed at “direct drive” battery applications. It is required that the battery or voltage source have enough headroom to drive the LED forward voltage and current sink (>150mV).

The device is available in a tiny 8-lead TDFN 2mm x 3mm package with a max height of 0.8mm.

ORDERING INFORMATION

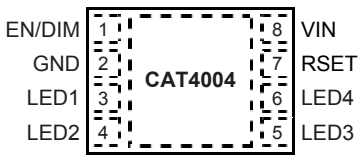
Part Number	Package	Package Marking
CAT4004VP2-T3	TDFN-8 2x3mm (1)	FT

Notes:
(1) Lead finish Matte-Tin
(2) Quantity per reel is 3000

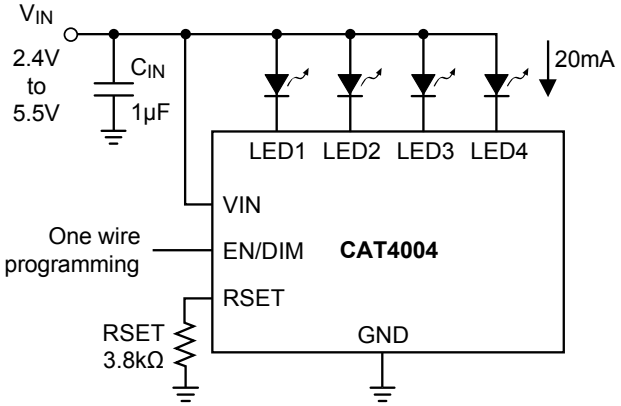
For Ordering Information details, see page 10.

PIN CONFIGURATION

8-lead TDFN Package
(Top View)



TYPICAL APPLICATION CIRCUIT



ABSOLUTE MAXIMUM RATINGS

Parameter	Rating	Unit
VIN, LEDx, RSET	6	V
EN/DIM Voltage	V_{IN} + 0.7	V
Storage Temperature Range	-65 to +160	°C
Junction Temperature Range	-40 to +125	°C
Lead Temperature	300	°C

RECOMMENDED OPERATING CONDITIONS

Parameter	Rating	Unit
V_{IN}	2.4 to 5.5[(1)]	V
Ambient Temperature Range	-40 to +85	°C
I_{LED} per LED pin	0 to 40	mA

Typical application circuit with external components is shown on page 1.

ELECTRICAL OPERATING CHARACTERISTICS

(over recommended operating conditions unless specified otherwise) V_{IN} = 4.0V, EN = High, T_{AMB} = 25°C

Symbol	Name	Conditions	Min	Typ	Max	Units
I_Q	Quiescent Current	No load, RSET = Float No load, RSET = 4.8kΩ		0.6 1.0		mA mA
I_{QSHDN}	Shutdown Current	V_{EN} = 0V			1	µA
$I_{LED-ACC}$	LED Current Accuracy	1mA ≤ I_{LED} ≤ 40mA		±1		%
$I_{LED-DEV}$	LED Channel Matching	$\frac{I_{LED} - I_{LEDAVG}}{I_{LED}}$	-5	±1	+5	%
V_{DOUT}	Dropout Voltage	I_{LED} = 30mA		130		mV
$R_{EN/DIM}$ V_{HI} V_{LO}	EN/DIM Pin • Internal pull-down resistor • Logic High Level • Logic Low Level		 1.3	100	 0.4	 kΩ V V
T_{SD}	Thermal Shutdown			150		°C
T_{HYS}	Thermal Hysteresis			20		°C
V_{UVLO}	Undervoltage lockout (UVLO) threshold			1.8		V

RECOMMENDED EN/DIM TIMING

For 2.4 ≤ V_{IN} ≤ 5.5V, over full ambient temperature range -40ºC to +85ºC.

Symbol	Name	Conditions	Min	Typ	Max	Units
T_{SETUP}	EN/DIM setup from shutdown		10			µs
T_{LO}	EN/DIM program low time		0.2		100	µs
T_{HI}	EN/DIM program high time		0.2			µs
T_{PWRDWN}	EN/DIM low time to shutdown		1.5			ms
T_{LED}	LED current settling time			40		µs

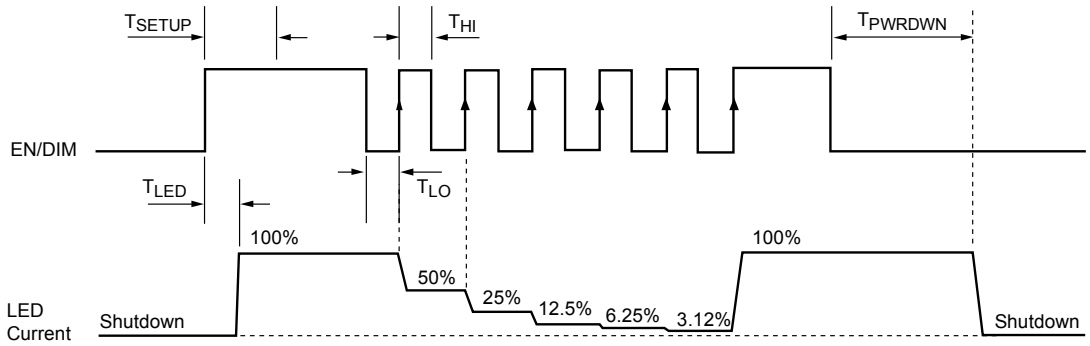


Figure 1. EN/DIM Dimming Timing Diagram

EN/DIM number of pulses *	R_{SET} Gain	LED Current
LOW	Shutdown mode	Zero
Transitions HIGH	132	132 x 0.6V/R_{SET}
1st	66	66 x 0.6V/R_{SET}
2nd	33	33 x 0.6V/R_{SET}
3rd	16.5	16.5 x 0.6V/R_{SET}
4th	8.25	8.25 x 0.6V/R_{SET}
5th	4.125	4.125 x 0.6V/R_{SET}
6th	132	132 x 0.6V/R_{SET}
xth	Device will keep cycling through gain selection	GAIN x 0.6V/R_{SET}

* The gain is changed on the rising edges of the EN/DIM input.

LED CURRENT SELECTION

At power-up, the initial LED current is set to full scale (100% brightness) by the external resistor RSET as follows:

$$\text{LED current} = 132 \times \frac{0.6V}{R_{SET}}$$

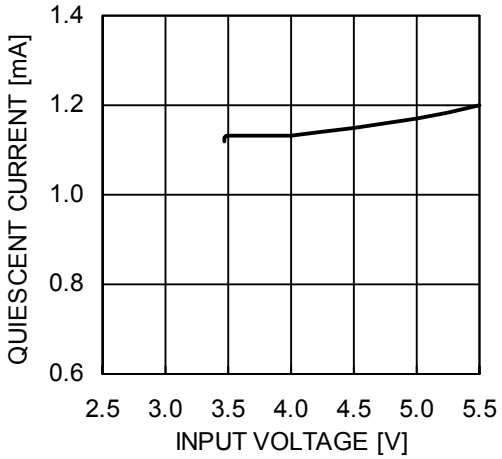
The EN/DIM pin has two primary functions. One function enables and disables the device. The other function is LED current dimming with six different levels by pulsing the input signal, as shown on Figure 3. On each consecutive pulse rising edge, the LED current is divided by half to 50%, then 25%, 12.5%, 6.25% and 3.125% dimming levels. Pulses faster than the minimum T_{LO} may be ignored and filtered by the device. Pulses longer than the maximum T_{LO} may shutdown the device.

The LED driver enters a “zero current” shutdown mode if EN/DIM is held low for 1.5ms or more.

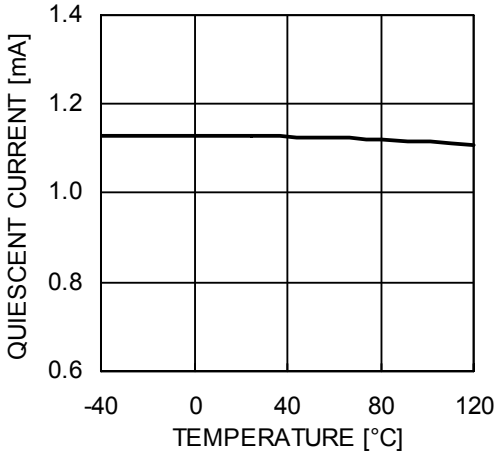
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 4V, V_F = 3.3V, I_{OUT} = 80mA (4 LEDs at 20mA), C_{IN} = 1µF, T_{AMB} = 25°C unless otherwise specified.

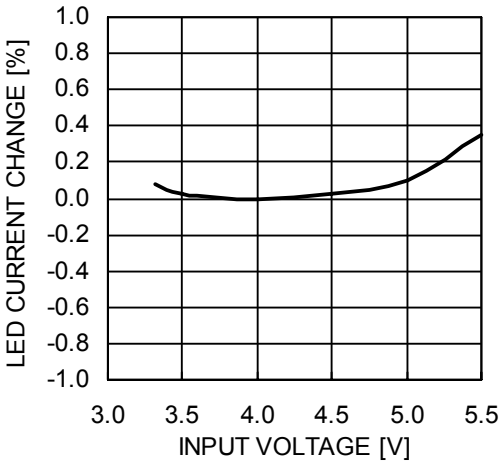
Quiescent Current vs. Input Voltage



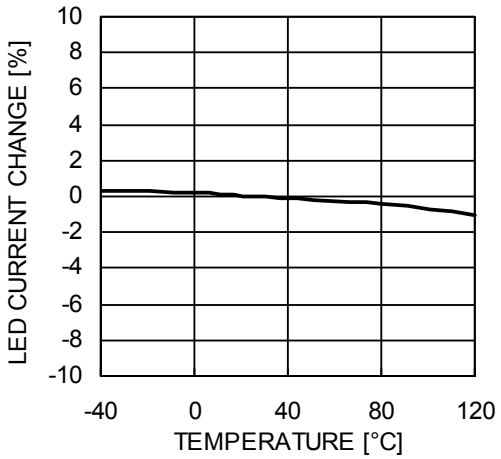
Quiescent Current vs. Temperature



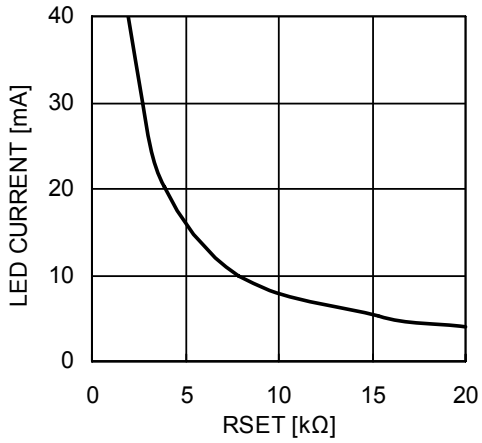
LED Current Change vs. Input Voltage



LED Current Change vs. Temperature



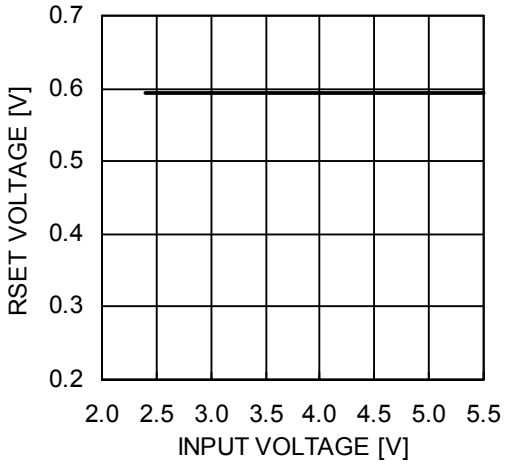
LED Current vs. RSET Resistor



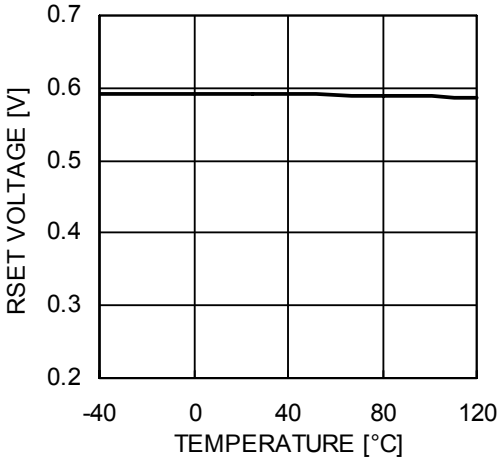
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 4V, V_F = 3.3V, I_{OUT} = 80mA (4 LEDs at 20mA), C_{IN} = 1µF, T_{AMB} = 25°C unless otherwise specified.

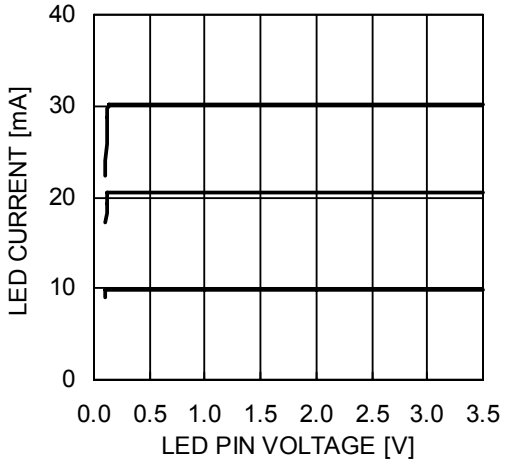
RSET Pin Voltage vs. Input Voltage



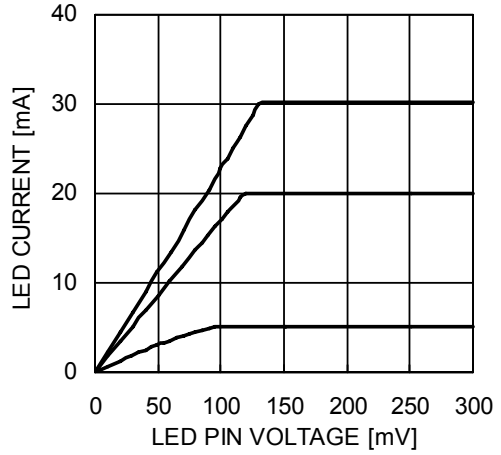
RSET Pin Voltage vs. Temperature



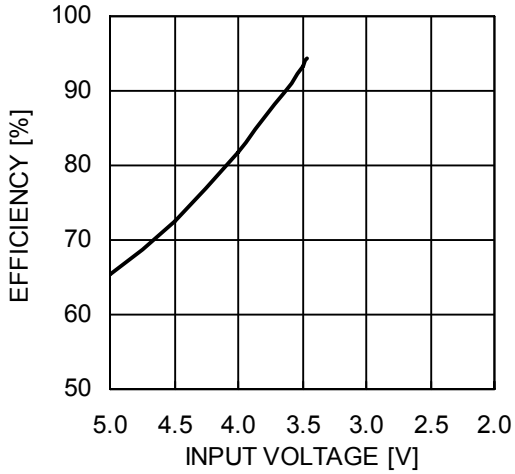
LED Current vs. LED Pin Voltage



Dropout Characteristics



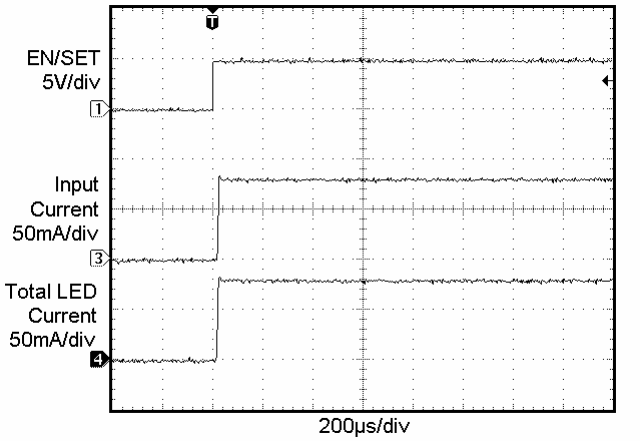
Efficiency vs. Input Voltage



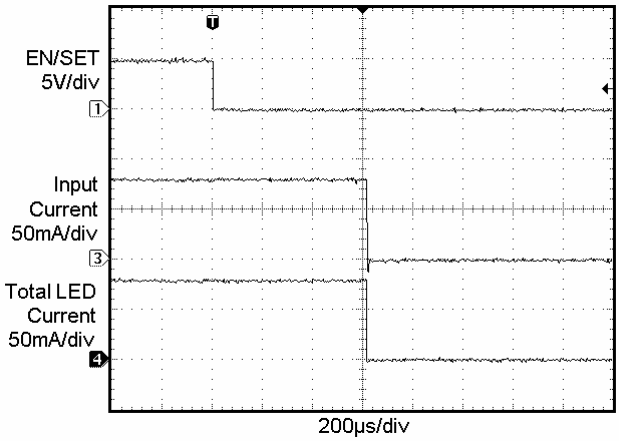
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 4V, V_F = 3.3V, I_{OUT} = 80mA (4 LEDs at 20mA), C_{IN} = 1µF, T_{AMB} = 25°C unless otherwise specified.

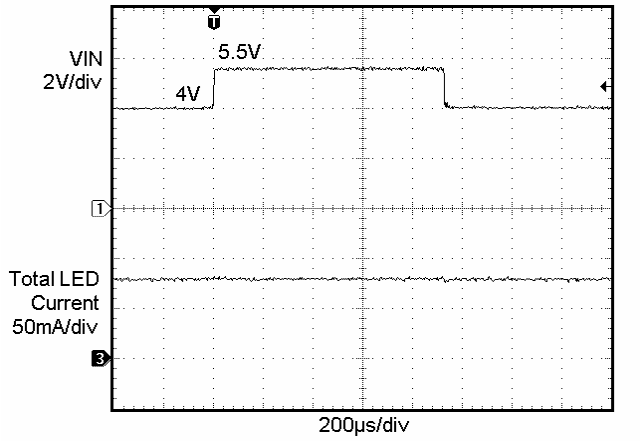
Power Up Waveform



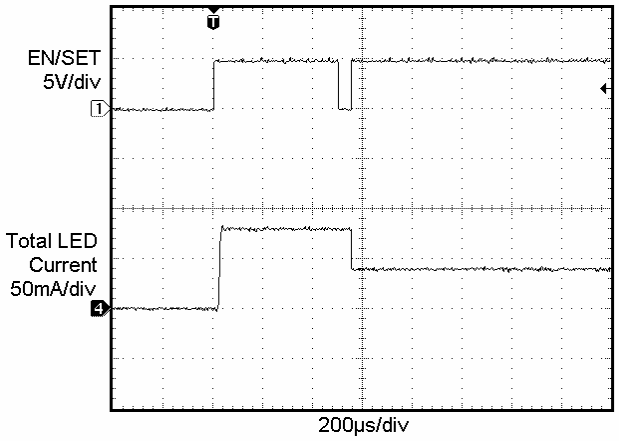
Power Down Waveform



Line Transient Waveform 4V to 5.5V



Dimming Waveform 80mA to 40mA



PIN DESCRIPTIONS

Pin #	Name	Function
1	EN/DIM	Device enable (active high) and dimming control
2	GND	Ground reference
3	LED1	LED1 cathode terminal
4	LED2	LED2 cathode terminal
5	LED3	LED3 cathode terminal
6	LED4	LED4 cathode terminal
7	RSET	RSET external LED mirror gain 128
8	VIN	Device supply input, connect to battery or supply
TAB	TAB	Connect to GND on the PCB

PIN FUNCTION

VIN is the supply pin for the charge pump. A small 1µF ceramic bypass capacitor is required between the VIN pin and ground near the device. The operating input voltage range is from 2.5V to 5.5V. Whenever the input supply falls below the under-voltage threshold (1.8V), all the LED channels are disabled and the device enters shutdown mode.

EN/DIM is the enable and one wire dimming input for all LED channels. Levels of logic high and logic low are set at 1.3V and 0.4V respectively. When EN/DIM is initially taken high, the device becomes enabled and all LED currents are set to the full scale according to the resistor R_{SET}. To place the device into “zero current” shutdown mode, the EN/DIM pin must be held low for at least 1.5ms.

LED1 to LED4 provide the internal regulated current for each of the LED cathodes. There pins enter a high impedance zero current state whenver the device is placed in shutdown mode.

RSET is connected to the resistor (R_{SET}) to set the full scale current for the LEDs. The voltage at this pin is regulated to 0.6V. The ground side of the external resistor should be star connected back to the GND of the PCB. In shutdown mode, RSET beomes high impedance.

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

TAB is the exposed pad underneath the package. For best thermal performance, the tab should be soldered to the PCB and connected to the ground plane.

BLOCK DIAGRAM

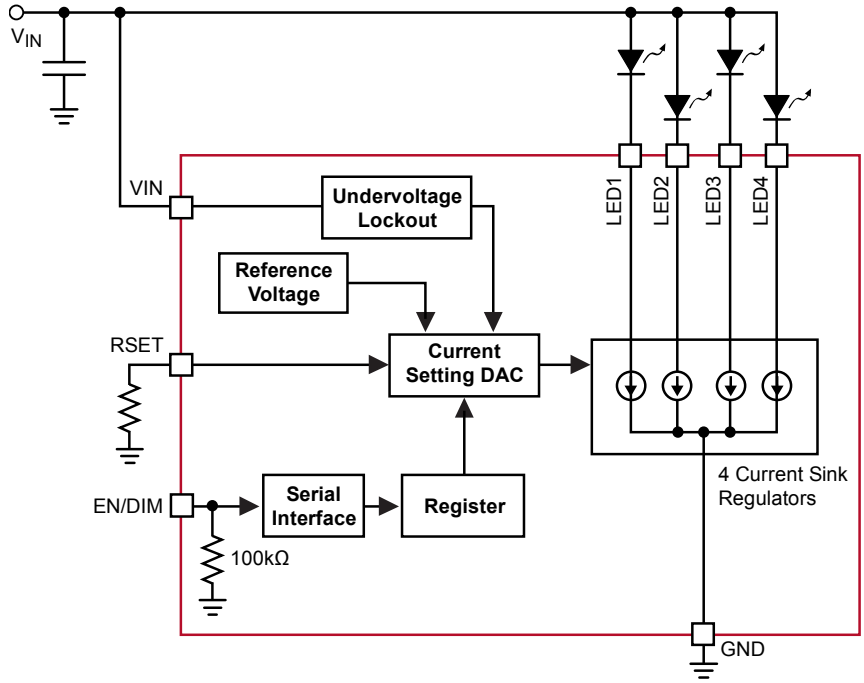


Figure 2. CAT4004 Functional Block Diagram

BASIC OPERATION

The CAT4004 uses four tightly matched current sinks to accurately regulate LED current in each channel proportional to the current sourced from the RSET pin.

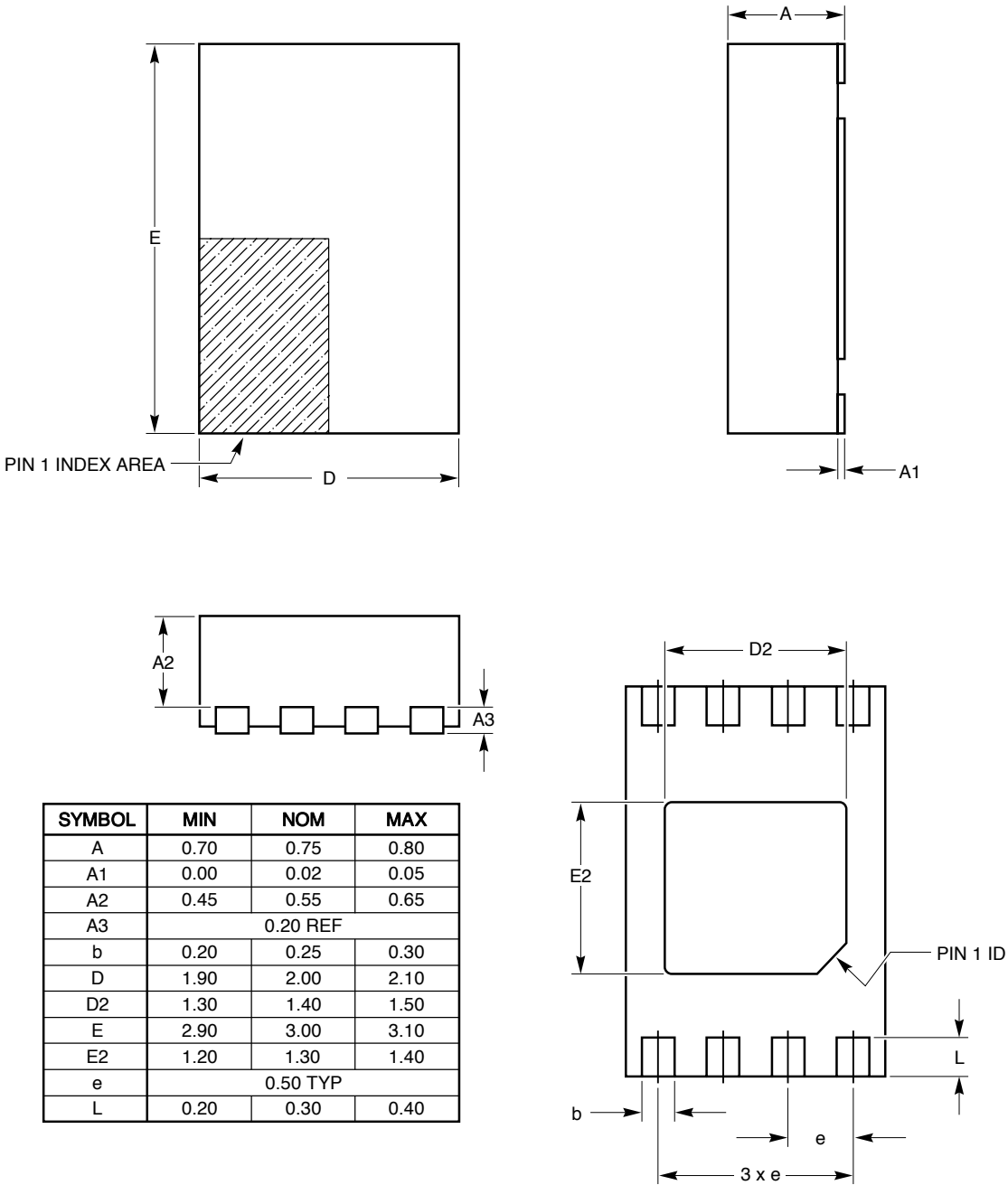
$$I_{LED} = GAIN \times \frac{0.6V}{R_{SET}}$$

There are six different gain settings for LED brightness that can be set through the EN/DIM pin. The default gain on power-up is 132. 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.

Each LED channel needs a minimum of 150mV headroom to sink constant regulated current. If the input supply falls below 1.8V, the under-voltage lockout circuit disables all LED channels and resets the circuit to default values. Any unused LED channels should be left open.

PACKAGE OUTLINES

8 LEAD TDFN (VP2) 2mm x 3mm

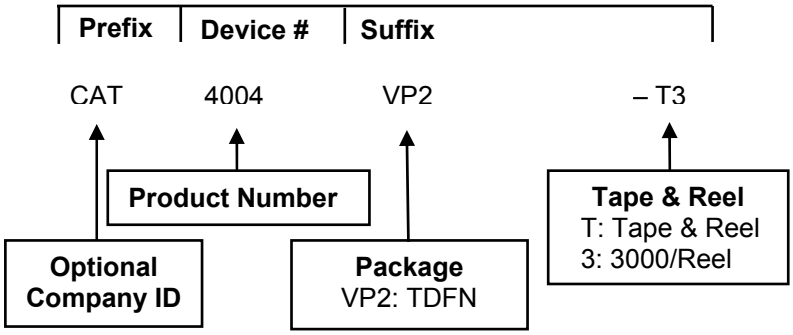


SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	0.45	0.55	0.65
A3		0.20 REF	
b	0.20	0.25	0.30
D	1.90	2.00	2.10
D2	1.30	1.40	1.50
E	2.90	3.00	3.10
E2	1.20	1.30	1.40
e		0.50 TYP	
L	0.20	0.30	0.40

For current Tape & Reel information, download the pdf file from:
http://www.catsemi.com/documents/tapeandreel.pdf

Notes:
(1) All dimensions are in millimeters, angles in degrees.
(2) Complies with JEDEC Standard MO-229

EXAMPLE OF ORDERING INFORMATION



Notes:

(1) All packages are RoHS-compliant (Lead-free, Halogen-free).

(2) The standard lead finish is Matte-Tin.

(3) The device used in the above example is a CAT4004VP2-T3 (TDFN, Tape & Reel).

(4) For additional package and temperature options, please contact your nearest Catalyst Semiconductor Sales office.

REVISION HISTORY

Date	Rev.	Reason
03/15/2007	A	Initial Issue

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