

## GENERAL DESCRIPTION

The XRP7620 is a multi purpose 4-channel independently adjustable current sink driver. Optimized for LED backlighting and RGBW/RGBA color mixing applications, the XRP7620 can also be used as a generic software programmable current sink I/O expander.

Supporting an industry standard 2-wire I<sup>2</sup>C serial interface, the XRP7620 provides full independent control of each channel and can be programmed up to a current of 31.5mA in steps of 0.5mA. Uniform display brightness is ensured through better than 3% channel to channel current matching.

Five internal registers are provided to set operational configuration and individual channel current programming. A specific shutdown mode allows the device to retain the previously loaded configuration – operational and current programming – in order to be reused upon the next enabling.

The XRP7620 is designed to operate from a single cell lithium-ion battery or fixed 3.3V or 5.0V power rails and is available in a RoHS compliant, "green"/halogen free space saving 8-pin 2mmx3mm DFN package.

## APPLICATIONS

- **LCD Display & Keypad Backlighting**
- **Color Coded Indicator Lighting**
- **RGBW/RGBA Color Mixing**
- **Cell Phones & Handheld Devices**
- **Generic Current Sink I/O Expander**

## FEATURES

- **4-Channel LED Current Sink Driver**
- **Individual Channel Current Control**
  - Up to 31.5mA per channel / 0.5mA Steps
  - 100mV Channel Dropout Voltage
- **I<sup>2</sup>C Serial Interface**
- **2.7V - 5.5V Input Voltage Range**
- **3% Channel Current Matching**
- **Register Retention in Shutdown**
- **Shutdown Current <1 $\mu$ A**
- **Thermal and UVLO Built-in Protection**
- **RoHS Compliant, "Green"/Halogen Free 2x3mm 8-Pin DFN package**

## TYPICAL APPLICATION DIAGRAM

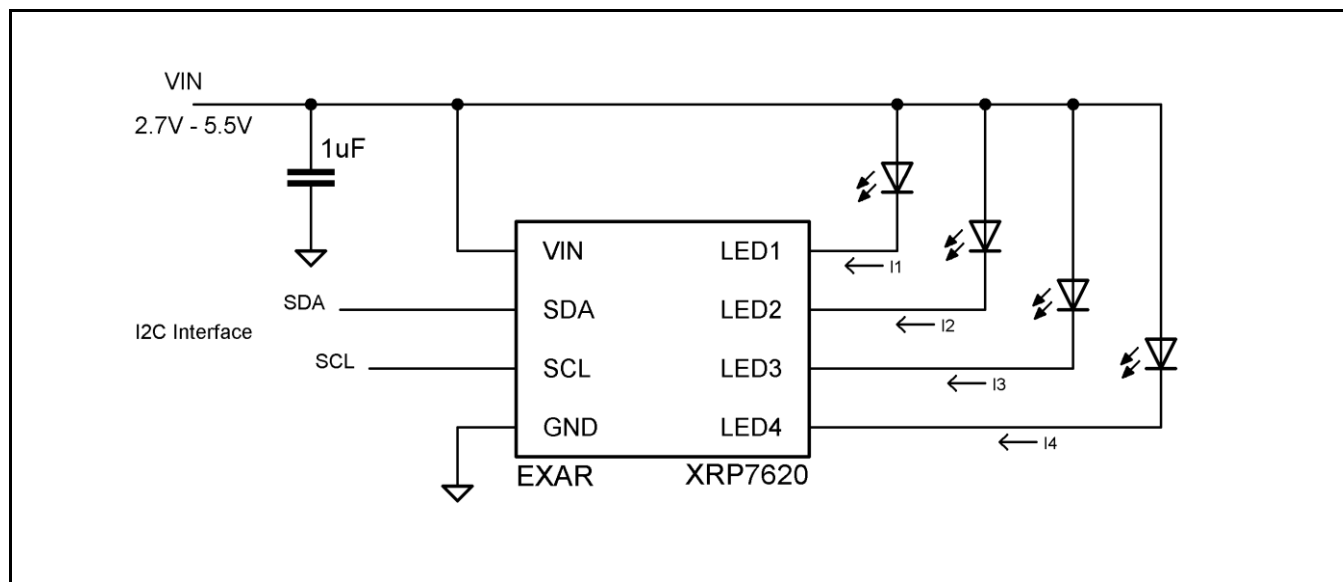


Fig. 1: XRP7620 Application Diagram

**4-Channel Adjustable Current I2C Controlled LED Driver****ABSOLUTE MAXIMUM RATINGS**

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

$V_{IN}$ , SDA, SCL, LEDx ..... -0.3V to 6.0V  
Storage Temperature ..... -65°C to 150°C  
Power Dissipation ..... Internally Limited (Note 1)  
Lead Temperature (Soldering, 10 sec) ..... 300°C  
ESD Rating (Human Body Model) ..... 2kV

**OPERATING RATINGS**

Input Voltage Range  $V_{IN}$  ..... 2.7V to 5.5V  
Junction Temperature Range ..... -40°C to 100°C  
Thermal Resistance  $\theta_{JA}$  ..... 59°C/W

**ELECTRICAL SPECIFICATIONS**

Specifications with standard type are for an Operating Junction Temperature of  $T_J = 25^\circ\text{C}$  only; limits applying over the full Operating Junction Temperature range are denoted by a "•". Minimum and Maximum limits are guaranteed through test, design, or statistical correlation. Typical values represent the most likely parametric norm at  $T_J = 25^\circ\text{C}$ , and are provided for reference purposes only. Unless otherwise indicated,  $V_{IN} = 2.7\text{V}$  to  $4.6\text{V}$ ,  $C_{IN} = 1\mu\text{F}$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ,  $T_J = -40^\circ\text{C}$  to  $100^\circ\text{C}$ .

| Parameter                                          | Min.  | Typ.  | Max.  | Units            | Conditions                                                                                                                                                                                                                            |
|----------------------------------------------------|-------|-------|-------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operating Input Voltage Range                      | 2.7   |       | 5.5   | V                | •                                                                                                                                                                                                                                     |
| Operating Input Current<br>DAC=000000              |       | 30    | 50    | $\mu\text{A}$    | • $I_{LEDX}=0$ , $V_{IN}=4.2\text{V}$                                                                                                                                                                                                 |
| Operating Input Current                            |       | 450   | 600   | $\mu\text{A}$    | • $I_{LED1}=I_{LED2}=I_{LED3}=I_{LED4}=10\text{mA}$ , $V_{IN}=4.2\text{V}$                                                                                                                                                            |
| LED Current accuracy<br>(includes Line Regulation) | -0.3  |       | 0.3   | mA               | • $V_{LED} = 0.2\text{V}$ to $2.7\text{V}$<br>$I_{LEDX} \leq 6\text{mA}$                                                                                                                                                              |
|                                                    | -5    |       | 5     | %                | $V_{LED} = 0.2\text{V}$ to $2.7\text{V}$                                                                                                                                                                                              |
|                                                    | -8    |       | 8     | %                | • $I_{LEDX} > 6\text{mA}$                                                                                                                                                                                                             |
| LED Current Matching                               | -3    |       | 3     | %                | • For same DAC setting<br>$V_{LED} = 0.2\text{V}$ to $2.7\text{V}$ , Note 2                                                                                                                                                           |
| Line Regulation                                    |       |       | 1     | %/V              | • Measured as $\Delta I_{OUT}/I_{OUT\_AVG}/\Delta V$<br>$V_{LED} = 0.2\text{V}$ to $2.7\text{V}$ , Note 3                                                                                                                             |
| Current DAC Resolution                             |       | 6     |       | Bit              |                                                                                                                                                                                                                                       |
| Current for DAC=000000                             |       |       | 2     | $\mu\text{A}$    | • Applies to all LEDs                                                                                                                                                                                                                 |
| Current for DAC=000001                             | 0.35  | 0.50  | 0.65  | mA               | Applies to all LEDs                                                                                                                                                                                                                   |
| Maximum LED Current<br>DAC=111111                  | 30.50 | 31.75 | 33.00 | mA               | Applies to all LEDs                                                                                                                                                                                                                   |
| Maximum Current Change<br>Settling Time            |       |       | 2     | $\mu\text{s}$    | • For changes between any DAC code<br>000001 and higher. Current must change<br>within this time after the last bit of LED<br>data. $V_{IN}=2.7$ to $5.5\text{V}$                                                                     |
|                                                    |       | 60    | 150   | $\mu\text{s}$    | Applies to changes between DAC code<br>000000 and higher or change from 0 to 1<br>for STATUS bits B5-B2 (channel enable).<br>Current must change within this time<br>after the last bit of LED data. $V_{IN}=2.7$ to<br>$5.5\text{V}$ |
| Current Source Dropout Voltage                     |       | 0.1   | 0.15  | V                | • $I_{LED}=20\text{mA}$ ;<br>The voltage where LED current decreases<br>3% from nominal value at $V_{LED} = 1\text{V}$ .<br>$V_{IN}=2.7$ to $5.5\text{V}$                                                                             |
| Shutdown Supply Current                            |       | 0.01  | 1     | $\mu\text{A}$    | $V_{IN}=4.2\text{V}$                                                                                                                                                                                                                  |
| Shutdown Supply Current                            |       |       | 5     | $\mu\text{A}$    | $V_{IN}=4.2\text{V}$ , $T_A=85^\circ\text{C}$                                                                                                                                                                                         |
| Thermal Shutdown Die<br>Temperature                | 125   | 150   | 175   | $^\circ\text{C}$ | Regulator turns off                                                                                                                                                                                                                   |

| Parameter                         | Min. | Typ. | Max. | Units |   | Conditions         |
|-----------------------------------|------|------|------|-------|---|--------------------|
| Thermal Shutdown Hysteresis       |      | 15   |      | °C    |   | Regulator turns on |
| SDA, SCL Input Logic Low Voltage  |      |      | 0.4  | V     | • |                    |
| SDA, SCL Input Logic High Voltage | 1.6  |      |      | V     | • |                    |
| SDA, SCL Timeout for Shutdown     |      | 90   | 150  | ms    |   |                    |

## I<sup>2</sup>C SPECIFICATION

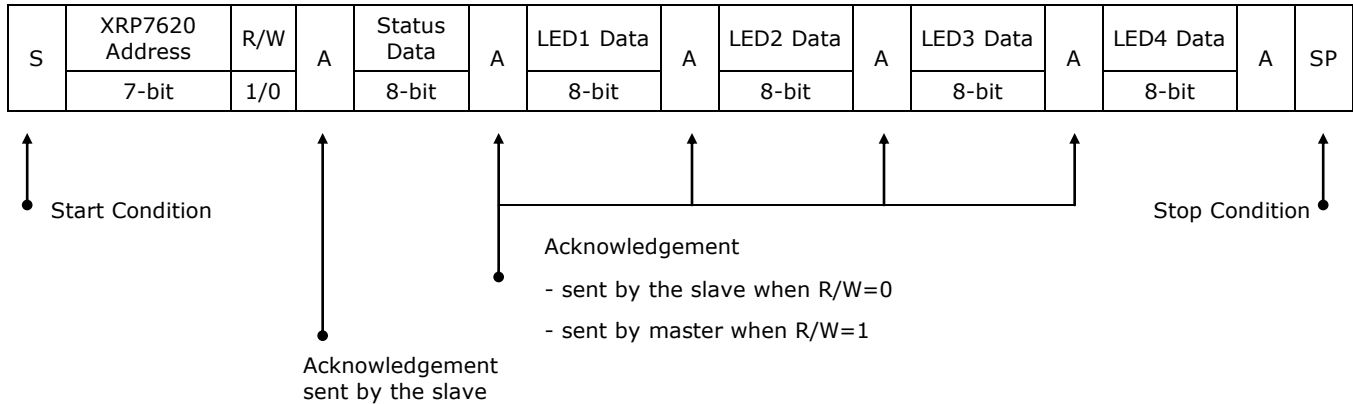


Fig. 2: Data Input Format

## I<sup>2</sup>C TIMING CHARACTERISTICS

Unless otherwise indicated,  $V_{IN} = 2.7V$  to  $4.6V$ ,  $C_{IN} = 1\mu F$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$ ,  $T_J = -40^{\circ}C$  to  $100^{\circ}C$ .

| Parameter                                        | Symbol             | Min.        | Typ. | Max. | Units   | Conditions  |
|--------------------------------------------------|--------------------|-------------|------|------|---------|-------------|
| Serial Clock Frequency                           | $f_{SCL}$          |             |      | 400  | KHz     |             |
| Bus Free Time between a STOP and a START         | $t_{BUF}$          | 1.3         |      |      | $\mu s$ |             |
| Hold Time, Repeated START Condition              | $t_{HD\_STA}$      | 0.6         |      |      | $\mu s$ |             |
| STOP Condition Setup Time                        | $t_{SU\_STO}$      | 0.6         |      |      | ms      |             |
| Data Hold Time                                   | $t_{HD\_DAT(OUT)}$ | 225         |      | 900  | ns      |             |
| Input Data Hold Time                             | $t_{HD\_DAT(IN)}$  | 0           |      | 900  | ns      |             |
| Data Setup Time                                  | $t_{SU\_DAT}$      | 100         |      |      | ns      |             |
| SCL Clock Low Period                             | $t_{LOW}$          | 1.3         |      |      | ms      |             |
| SCL Clock High Period                            | $t_{HIGH}$         | 0.6         |      |      | ms      |             |
| Rise Time of Both SDA and SCL Signals, receiving | $t_R$              | $20+0.1C_b$ |      | 300  | ns      | Note 4,5    |
| Fall Time of Both SDA and SCL Signals, Receiving | $t_F$              | $20+0.1C_b$ |      | 300  | ns      | Note 4,5    |
| Fall Time of SDA Transmitting                    | $t_{F\_TX}$        | $20+0.1C_b$ |      | 250  | ns      | Note 4,5, 6 |
| Pulse Width of Spike Suppressed                  | $t_{SP}$           | 0           |      | 50   | ns      | Note 7      |
| Capacitive Load for each Bus Line                | $C_b$              |             |      | 400  | pF      | Note 4      |
| I <sup>2</sup> C Startup Time after UVLO clears  | $t_{SRT}$          |             |      | 1    | $\mu s$ | Note 4      |

Note 1: All parameters tested at  $T_A = 25^{\circ}C$ . Specifications over temperature are guaranteed by design.

Note 2: LED current matching is calculated by this equation:

$$\frac{I_{LED} - I_{AVG}}{I_{AVG}} \times 100\% \text{ Where } I_{AVG} \text{ is the average current of 4 channels.}$$

Note 3: Ling regulation is calculated by this equation:

$$\frac{I_2 - I_1}{I_{AVG}} \times \frac{1}{\Delta V} \times 100\%$$

Where  $I_1$  and  $I_2$  is the current at different  $V_{IN}$ .

Note 4: Guaranteed by design.

Note 5:  $C_b$  = total capacitance of one bus line in pF.  $t_R$  and  $t_F$  measured between  $0.3 \times V_{DD}$  and  $0.7 \times V_{DD}$ .

Note 6:  $I_{SINK} \leq 6mA$ .  $C_b$  =total capacitance of one bus line in pF.  $t_R$  and  $t_F$  measured between  $0.3 \times V_{DD}$  and  $0.7 V_{DD}$ .

Note 7: Input filters on the SDA and SCL inputs suppress noise spikes less than 50ns.

## BLOCK DIAGRAM

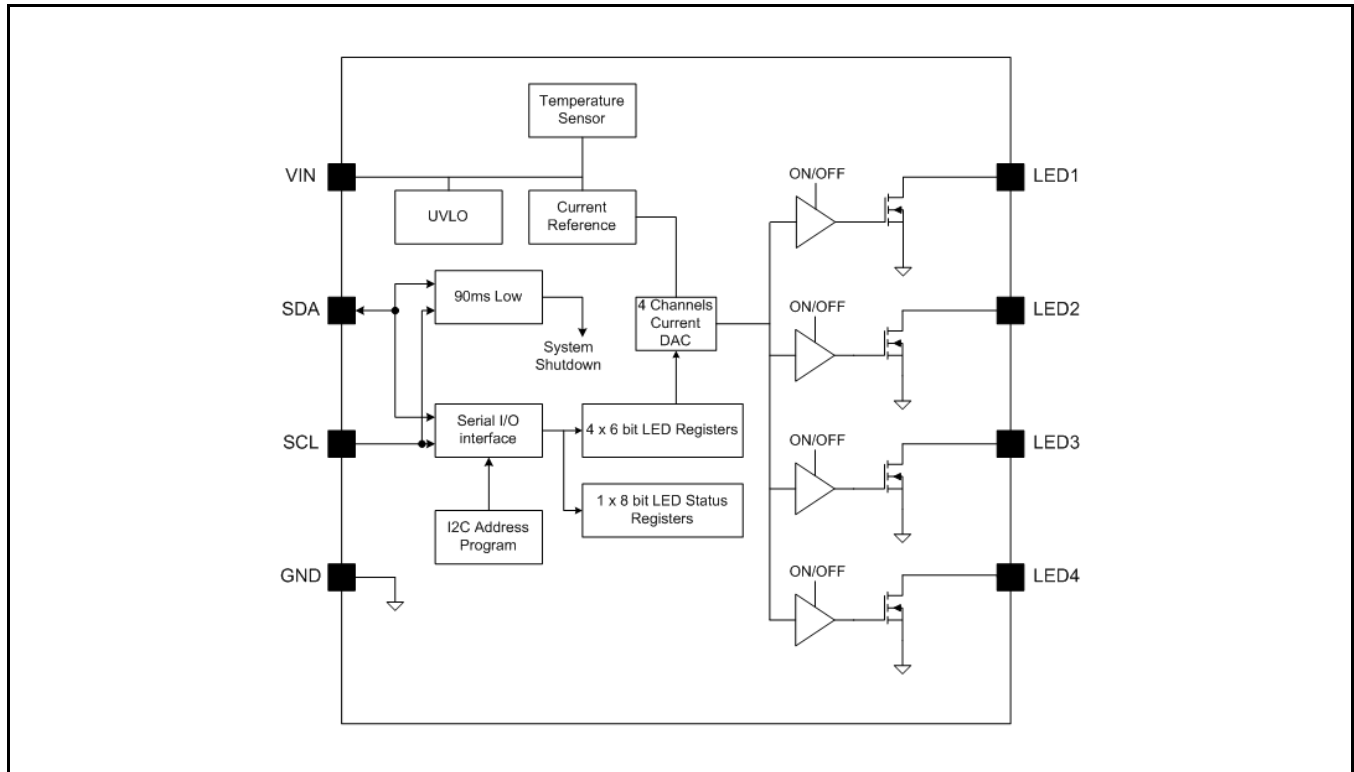


Fig. 3: XRP7620 Block Diagram

## PIN ASSIGNMENT

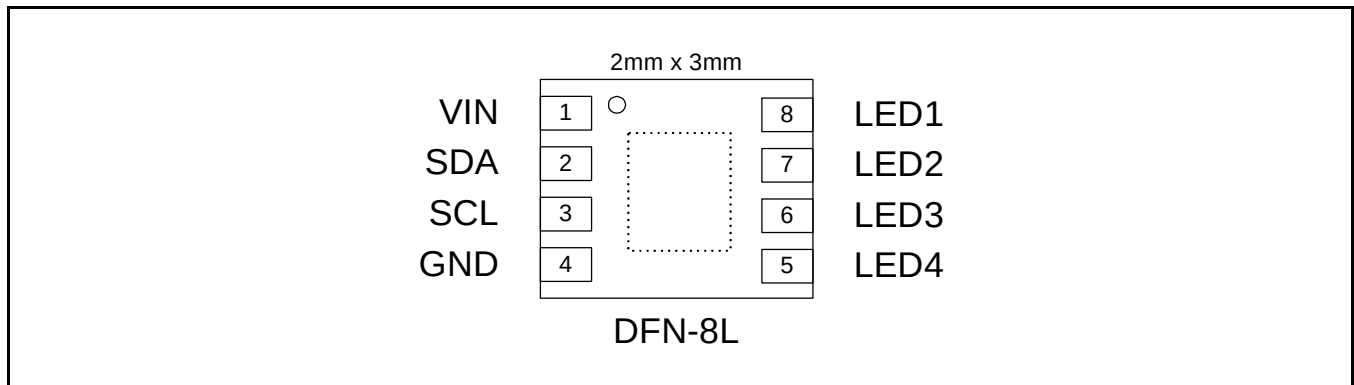


Fig. 4: XRP7620 Pin Assignment

**PIN DESCRIPTION**

| Name | Pin Number | Description                                                                                           |
|------|------------|-------------------------------------------------------------------------------------------------------|
| VIN  | 1          | Connect a 1 $\mu$ F decoupling capacitor between this pin and the ground pin (pin 4).                 |
| SDA  | 2          | I2C Interface Serial Data Input-Output.                                                               |
| SCL  | 3          | I2C Interface Serial Clock Input.                                                                     |
| GND  | 4          | Ground Signal.                                                                                        |
| LED4 | 5          | LED 4 Input.<br>Connect a LED between this pin and VIN. Current Value is set by the serial interface. |
| LED3 | 6          | LED 3 Input.<br>Connect a LED between this pin and VIN. Current Value is set by the serial interface. |
| LED2 | 7          | LED 2 Input.<br>Connect a LED between this pin and VIN. Current Value is set by the serial interface. |
| LED1 | 8          | LED 1 Input.<br>Connect a LED between this pin and VIN. Current Value is set by the serial interface. |
| GND  | Exp. Pad   | Ground Signal.                                                                                        |

**ORDERING INFORMATION**

| Part Number   | Temperature Range               | Marking         | Package | Packing Quantity | Note 1                | I <sup>2</sup> C Address |
|---------------|---------------------------------|-----------------|---------|------------------|-----------------------|--------------------------|
| XRP7620IH-F   | -40°C ≤ T <sub>J</sub> ≤ +100°C | 7620I<br>YYWWFX | DFN-8L  | Bulk             | Green<br>Halogen Free | 0x70                     |
| XRP7620IHTR-F | -40°C ≤ T <sub>J</sub> ≤ +100°C | 7620I<br>YYWWFX | DFN-8L  | 3K/Tape & Reel   | Green<br>Halogen Free | 0x70                     |
| XRP7620EVB    | XRP7620 Evaluation Board        |                 |         |                  |                       |                          |

“YY” = Year – “WW” = Work Week – “F” = Green/Halogen Free Package – “X” = Lot Number

XRP7620 may be ordered with alternative I<sup>2</sup>C addresses – Contact your Exar Sales Representative for further information.

### Typical Performance Characteristics

All data taken at  $V_{IN} = 2.7V$  to  $5.5V$ ,  $T_J = T_A = 25^\circ C$ , unless otherwise specified - Schematic and BOM from Application Information/Theory of Operation section of this datasheet.

$CH_1 = SDA$ ,  $CH_2 = SCL$ ,  $CH_4 = I_{LED} = 20mA/div$

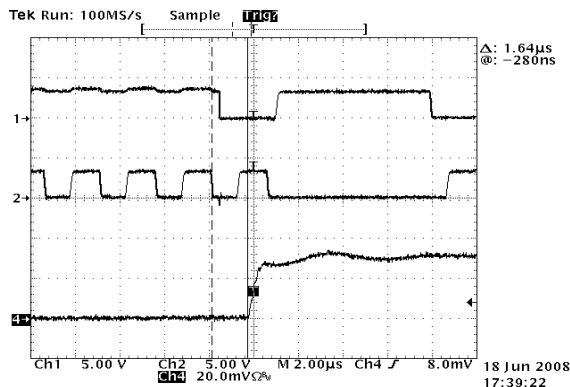


Fig. 5: LED Current Change Settling Time From 0.5mA to 31.5mA

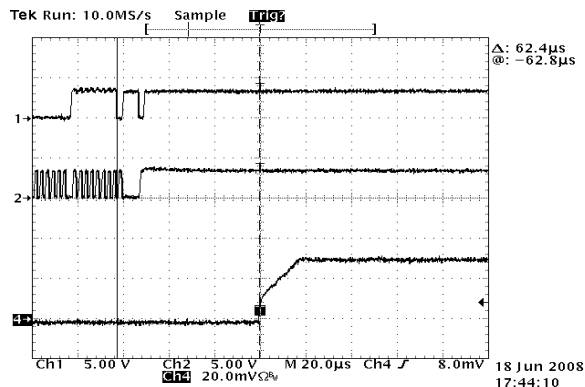


Fig. 6: LED Current Change Settling Time From 0mA to 31.5mA

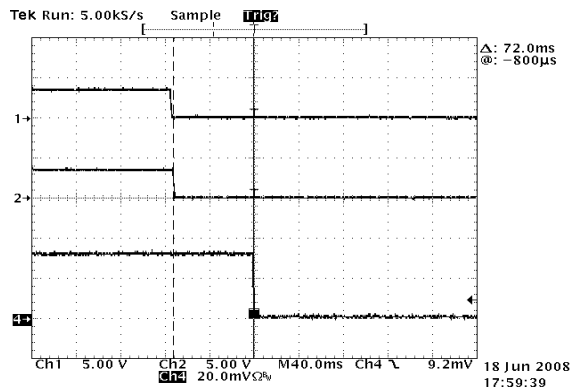


Fig. 7: SDA, SCL Timeout for Shutdown

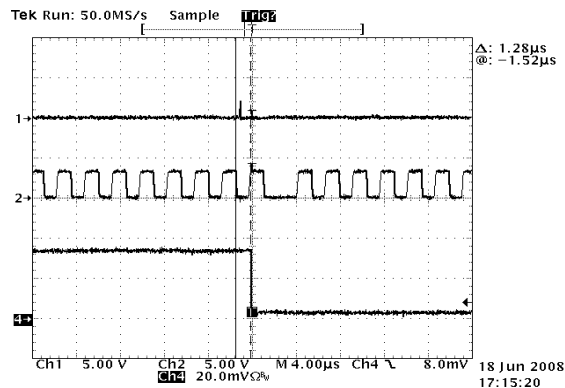


Fig. 8: LED Current Change Settling Time From DAC 31.5mA to 0mA

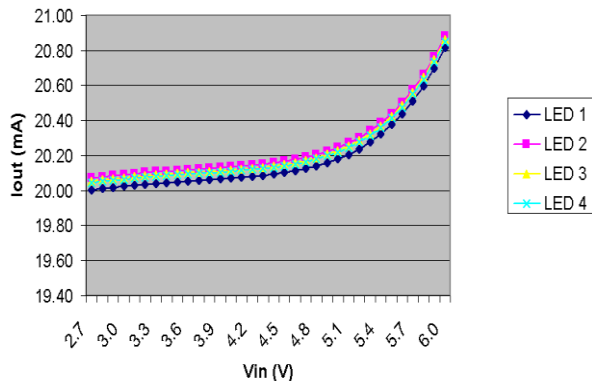


Fig. 9: Line Regulation DAC = 101000 (20mA)

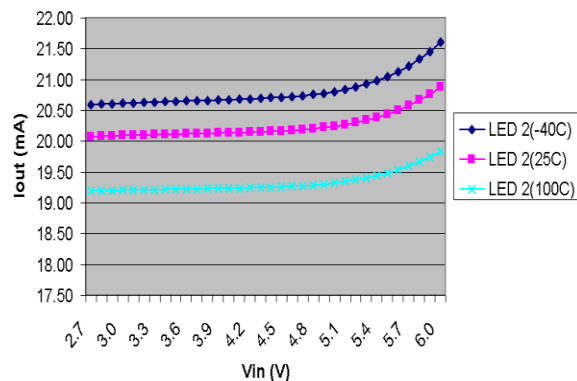


Fig. 10: Line Regulation LED1 DAC = 101000 (20mA)

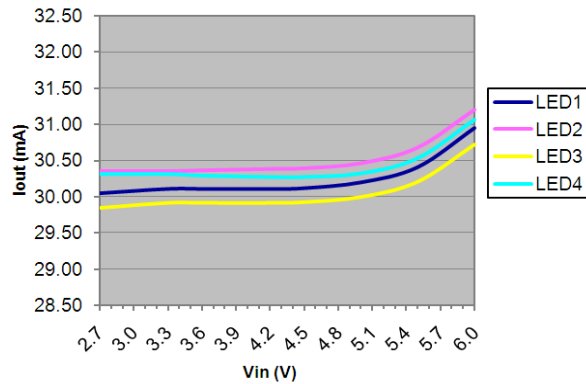


Fig. 11: Line Regulation @  $T_A = 25^\circ\text{C}$   
DAC = 111100 (30mA)

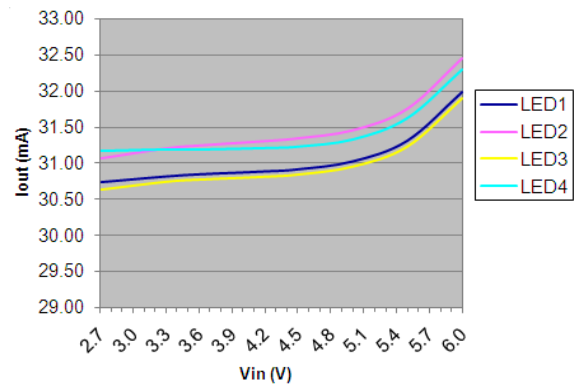


Fig. 12: Line Regulation @  $T_A = -40^\circ\text{C}$   
DAC = 111100 (30mA)

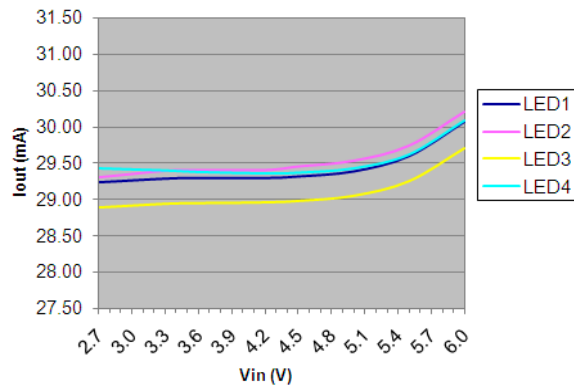


Fig. 13: Line Regulation @  $T_A = 85^\circ\text{C}$   
DAC = 111100 (30mA)

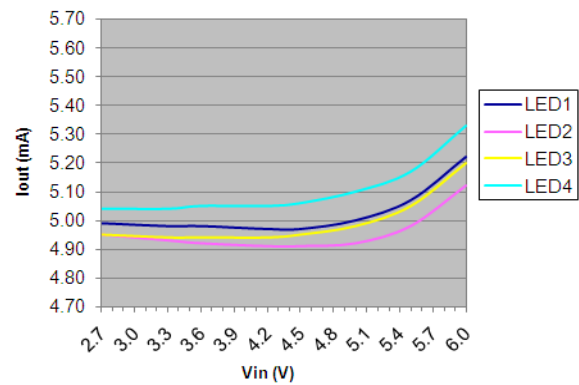


Fig. 14: Line Regulation @  $T_A = 25^\circ\text{C}$   
DAC = 001010 (5mA)

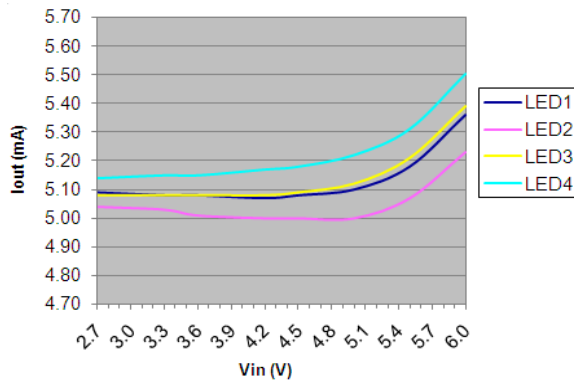


Fig. 15: Line Regulation @  $T_A = -40^\circ\text{C}$   
DAC = 001010 (5mA)

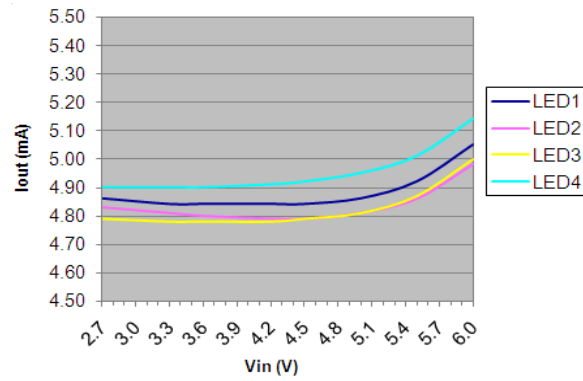


Fig. 16: Line Regulation @  $T_A = 85^\circ\text{C}$   
DAC = 001010 (5mA)

## THEORY OF OPERATION

### I<sup>2</sup>C SERIAL INTERFACE

The XRP7620 has five data registers which can be programmed serially through the I<sup>2</sup>C interface. The first register is a status register which has two bits used for shutdown/power up options, 4 bits used for individual LED ON/OFF control, one bit for over-temperature readback and one bit for undervoltage lockout readback. The next four registers are used to set the brightness levels of the four LEDs.

|        | B7 | B6 | B5   | B4   | B3   | B2   | B1  | B0  |
|--------|----|----|------|------|------|------|-----|-----|
| Status | WZ | WP | LED4 | LED3 | LED2 | LED1 | OVT | UVL |
| LED1   | D5 | D4 | D3   | D2   | D1   | D0   | -   | -   |
| LED2   | D5 | D4 | D3   | D2   | D1   | D0   | -   | -   |
| LED3   | D5 | D4 | D3   | D2   | D1   | D0   | -   | -   |
| LED4   | D5 | D4 | D3   | D2   | D1   | D0   | -   | -   |

Table 1: XRP7620 I<sup>2</sup>C Register Bit Map

### Status Register

#### Status register bits B7 and B6

The following table defines the states for bits B7 and B6 of the STATUS register. They are used to put the XRP7620 into shutdown, standby, or active mode.

| WZ | WP | State                                    | I <sub>Q</sub> | LED Driver |
|----|----|------------------------------------------|----------------|------------|
| 0  | 0  | Shutdown and reset registers to 00000000 | 0μA            | Off        |
| 0  | 1  | Shutdown<br>Keeps registers contents     | 0μA            | Off        |
| 1  | 0  | Standby<br>Keeps registers contents      | 30μA           | Off        |
| 1  | 1  | Active                                   | Active         | On         |

Table 2: XRP7620 Status Register Bits B7 and B6

#### Status register bits B5-B2

These bits are to control the LED On/Off individually. Putting 1 (logic high) will enable the driver and putting 0 (logic low) will disable the driver.

#### Status register bits B1 and B0

These bits are the readback bits. Their values are 0 for normal operations. If over-temperature is detected, B1=1, and If undervoltage is detected, B0=1. The UVL threshold is approximately 2.4V.

### LED Registers (x4)

#### LED register bits B7-B2

In LED registers bits B7, B6, B5, B4, B3 and B2 represent the DAC codes D5-D0 used to set the LED current in the four LEDs, and B1 and B0 are not used. The following table lists the DAC codes and the corresponding current for each channel in mA:

| B7-B2  | Current mA | B7-B2  | Current mA |
|--------|------------|--------|------------|
| 000000 | 0          | 100000 | 16.0       |
| 000001 | 0.5        | 100001 | 16.5       |
| 000010 | 1.0        | 100010 | 17.0       |
| 000011 | 1.5        | 100011 | 17.5       |
| 000100 | 2.0        | 100100 | 18.0       |
| 000101 | 2.5        | 100101 | 18.5       |
| 000110 | 3.0        | 100110 | 19.0       |
| 000111 | 3.5        | 100111 | 19.5       |
| 001000 | 4.0        | 101000 | 20.0       |
| 001001 | 4.5        | 101001 | 20.5       |
| 001010 | 5.0        | 101010 | 21.0       |
| 001011 | 5.5        | 101011 | 21.5       |
| 001100 | 6.0        | 101100 | 22.0       |
| 001101 | 6.5        | 101101 | 22.5       |
| 001110 | 7.0        | 101110 | 23.0       |
| 001111 | 7.5        | 101111 | 23.5       |
| 010000 | 8.0        | 110000 | 24.0       |
| 010001 | 8.5        | 110001 | 24.5       |
| 010010 | 9.0        | 110010 | 25.0       |
| 010011 | 9.5        | 110011 | 25.5       |
| 010100 | 10.0       | 110100 | 26.0       |
| 010101 | 10.5       | 110101 | 26.5       |
| 010110 | 11.0       | 110110 | 27.0       |
| 010111 | 11.5       | 110111 | 27.5       |
| 011000 | 12.0       | 111000 | 28.0       |
| 011001 | 12.5       | 111001 | 28.5       |
| 011010 | 13.0       | 111010 | 29.0       |
| 011011 | 13.5       | 111011 | 29.5       |
| 011100 | 14.0       | 111100 | 30.0       |
| 011101 | 14.5       | 111101 | 30.5       |
| 011110 | 15.0       | 111110 | 31.0       |
| 011111 | 15.5       | 111111 | 31.5       |

Table 3: LED Current DAC Settings



**Addressing and Writing Data**

To write data to the XRP7620 one of the following two cycles must be followed:

Easy shutdown/startup sequence

[Slave Address with write bit][Data for Status]

Full shutdown/startup sequence

[Slave Address with write bit][Data for Status][Data for LED1][Data for LED2][Data for LED3][Data for LED4]

**Addressing and Reading Data**

To read data from the XRP7620 the following data cycle must be obeyed:

[Slave Address with read bit][Data for Status][Data for LED1][Data for LED2][Data for LED3][Data for LED4]

**SHUTDOWN OPTIONS**

The XRP7620 can be placed in shutdown mode by holding both the SDA and SCL lines low for a minimum of typically 90ms. This puts a zero in bit 7 and bit 6 of the status register, which in turn will reset all bits of all registers. After any shutdown, the part can only be restarted through the I<sup>2</sup>C bus.

**SHORTED LEDs**

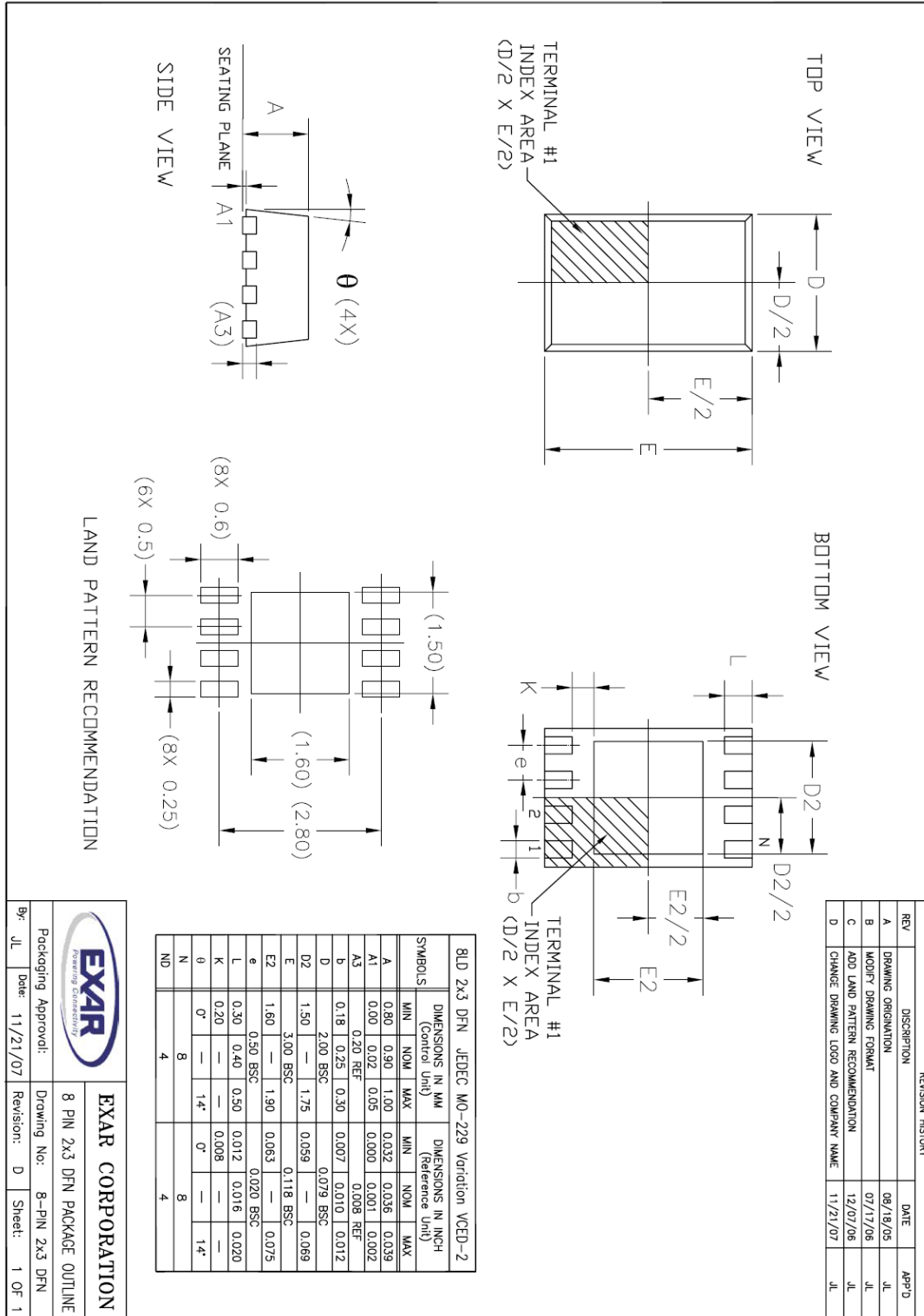
If an LED shorts to the extent that the LED pin comes within 0.7V of  $V_{IN}$  the LED channel may turn off because the drive circuitry effectively is in a dropout condition. The exact voltage will vary with programmed LED current.

**PARALELLING CURRENT SINKS**

The maximum programmable current per LED pin is 31.5mA. If a higher current is desired, 2, 3, or all 4 LED pins may be connected to share current. Although it is technically possible to program the channels to different values to add up to the desired total, it is recommended that paralleled channels be programmed to the same value.

**PACKAGE SPECIFICATION**

**8-PIN DFN**



**REVISION HISTORY**

| Revision | Date       | Description                                           |
|----------|------------|-------------------------------------------------------|
| 1.0.0    | 06/04/2009 | Initial release of datasheet                          |
| 1.1.0    | 06/12/2012 | Added Exposed Pad description in Pin Assignment table |
|          |            |                                                       |

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48720 Kato Road

Fremont, CA 94538 – USA

Tel.: +1 (510) 668-7000

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