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May 2016



# FAN5702 Configurable 180 mA 6-LED Driver with I<sup>2</sup>C Control

## Features

- Six (6) Parallel LEDs (up to 30 mA Each)
- Total Package Load Current Capability: 180 mA
- Group from 2 to 6 LEDs for Flexible Backlighting
- I2C Interface for Easy Programming
- >600:1 Dimming Ratio for 100 Hz PWM Frequency
- Logarithmically Controlled Dimming with 64 Steps
- Secondary Brightness Control Using PWM Dimming up to 20 kHz in Conjunction with I2C Dimming
  - Dynamic Backlight Control (DBC) to Reduce Current Consumption
- Up to 92% Efficiency
- Built-in 1.5x Charge Pump with Low Drop-Out Bypass Switch and automatic switching to 1x mode
- 1.2 MHz Switching Frequency for Small-Sized Capacitors
- 16-Bump 1.6 mm x 1.6 mm WLCSP (0.6 mm Height)
- 16-Lead 3.0 mm x 3.0 mm UMLP (0.55 mm Height)

## Applications

- LCD Backlighting
- Mobile Handsets / Smartphones
- Portable Media Players

## Description

The FAN5702 is a highly integrated and configurable charge-pump-based multi-LED driver. The device can drive up to six LEDs in parallel with a total output current of 180 mA. Regulated internal current sinks deliver excellent current and brightness matching to all LEDs.

The FAN5702 has an I<sup>2</sup>C interface that allows the user to independently control the brightness with a default grouping of 2,1,1,1,1 for a maximum of five independent lighting channels. The LED driver can be programmed in a multitude of configurations to address broad lighting requirements for different platforms. Each LED can be configured through I<sup>2</sup>C as five independent channels (Group A has two LEDs by default) or any additional LEDs can join Group A to increase the backlighting needs as the display size increases. The device offers a second dimming control using the EN/PWM pin. Applying a PWM dimming signal to this pin allows control of the dimming of Group A LEDs so that the average current is the linear value multiplied by the PWM dimming duty-cycle.

The device provides excellent efficiency, without an inductor, by operating the charge pump in 1.5x or pass-through mode.

The FAN5702 can be ordered with default I<sub>SET</sub> values of 30 mA, 20 mA, 15 mA, or 8 mA. The default I<sub>SET</sub> is always determined by the I<sub>SET</sub> ordered (see *Ordering Information*).

## Ordering Information

| Part Number   | LED Current (I <sub>SET</sub> ) | Temperature Range | Package                      | Packing       |
|---------------|---------------------------------|-------------------|------------------------------|---------------|
| FAN5702UC30X  | 30 mA                           | -40 to 85°C       | WLCSP-16, 0.4 mm Pitch       | Tape and Reel |
| FAN5702UC20X  | 20 mA                           |                   |                              |               |
| FAN5702UC15X  | 15 mA                           |                   |                              |               |
| FAN5702UC08X  | 8 mA                            |                   |                              |               |
| FAN5702UMP30X | 30 mA                           |                   | UMLP-16, 3.0 x 3.0 x 0.55 mm | Tape and Reel |
| FAN5702UMP20X | 20 mA                           |                   |                              |               |
| FAN5702UMP15X | 15 mA                           |                   |                              |               |
| FAN5702UMP08X | 8 mA                            |                   |                              |               |

Typical Application

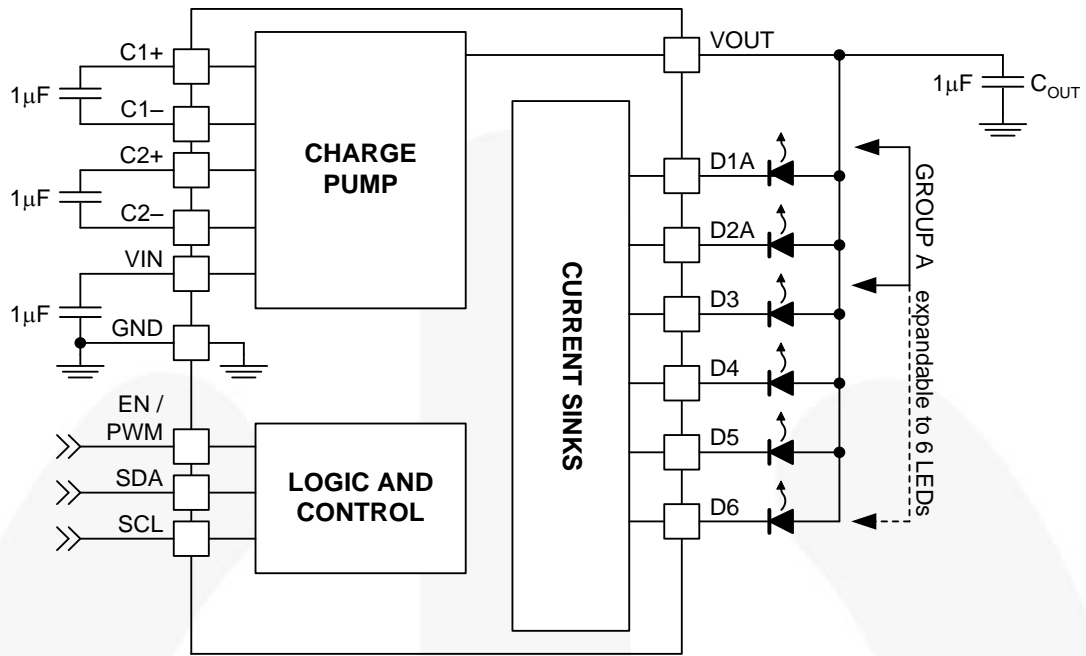


Figure 1. Typical Application

## WLCSP Pin Configuration

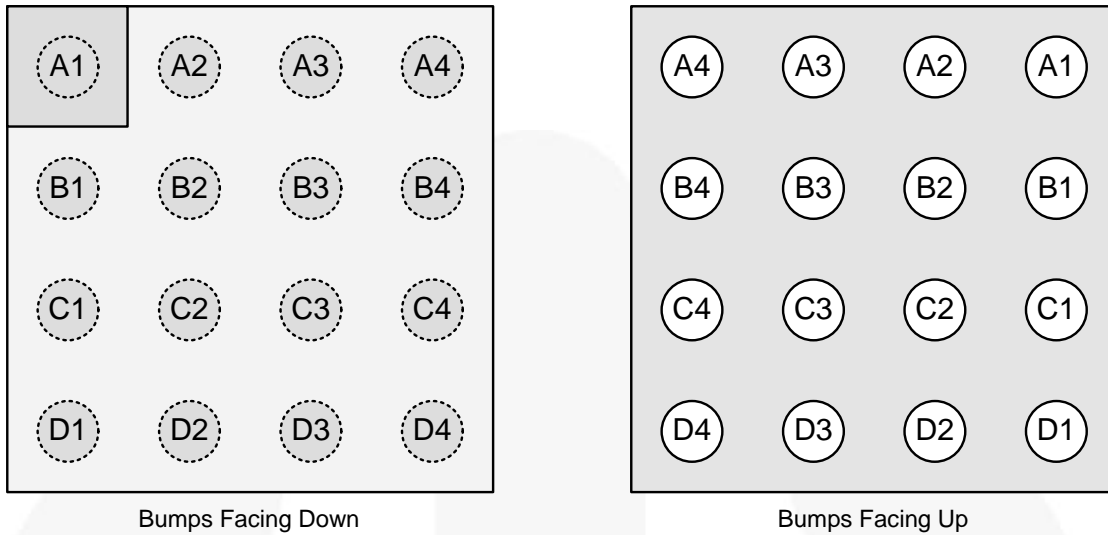


Figure 2. WLCSP-16, 0.4 mm Pitch, 1.61 x 1.61 mm

## Pin Definitions

| Pin #                   | Name                       | Description  |
|-------------------------|----------------------------|--|
| D2                      | VIN                        | <b>Input Supply Voltage.</b> Connect to 2.7 – 5.5 V <sub>DC</sub> input power source.  |
| B4                      | GND                        | <b>Ground</b>  |
| D1                      | VOUT                       | <b>Charge Pump Output Voltage.</b> Connect to LED anodes.  |
| D3 ,D4                  | C1+, C1–                   | Charge pump flying capacitor #1  |
| C3, C4                  | C2+, C2–                   | Charge pump flying capacitor #2  |
| A1,A2<br>B1,B2<br>C1,C2 | D2A, D1A<br>D4,D3<br>D6,D5 | <b>LED Outputs</b>   |
| A4                      | EN / PWM                   | <b>Enable / PWM</b> dimming input. By default, this pin acts as a simple enable / disable function. When this pin is HIGH, normal operation is enabled. When LOW, the IC is reset and all functions (including I <sup>2</sup> C communications) are disabled. By setting General Purpose register bit 7 = 1, the pin functions as a PWM dimming input for Group A. To restore the Enable function, the General Purpose register bit 7 must be set LOW. |
| B3                      | SDA                        | I <sup>2</sup> C interface serial data   |
| A3                      | SCL                        | I <sup>2</sup> C interface serial clock  |

## UMLP Pin Configuration

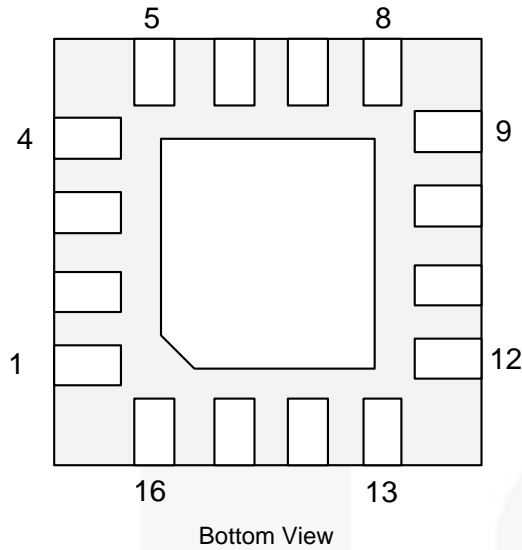


Figure 3. UMLP-16, 0.5 mm Pitch, 3 mm x 3 mm

## Pin Definitions

| Pin #                    | Name                         | Description  |
|--------------------------|------------------------------|--|
| 11                       | VIN                          | <b>Input Supply Voltage.</b> Connect to 2.7 – 5.5 V <sub>DC</sub> input power source.  |
| 6                        | GND                          | <b>Ground</b>  |
| 12                       | VOUT                         | <b>Charge Pump Output Voltage.</b> Connect to LED anodes.  |
| 10,9                     | C1+, C1–                     | Charge pump flying capacitor #1  |
| 8,7                      | C2+, C2–                     | Charge pump flying capacitor #2  |
| 1, 2<br>15, 16<br>13, 14 | D2A, D1A<br>D4, D3<br>D6, D5 | <b>LED Outputs</b>   |
| 4                        | EN / PWM                     | <b>Enable / PWM</b> dimming input. By default, this pin acts as a simple enable / disable function. When this pin is HIGH, normal operation is enabled. When LOW, the IC is reset and all functions (including I <sup>2</sup> C communications) are disabled. By setting General Purpose register bit 7 = 1, the pin functions as a PWM dimming input for Group A. To restore the Enable function, the General Purpose register bit 7 must be set LOW. |
| 5                        | SDA                          | I <sup>2</sup> C interface serial data   |
| 3                        | SCL                          | I <sup>2</sup> C interface serial clock  |

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

| Symbol           | Parameter                                | Min.                                 | Max.                  | Unit |
|------------------|--|--------------------------------------|-----------------------|------|
| V <sub>CC</sub>  | V <sub>IN</sub> , V <sub>OUT</sub> Pins  | -0.3                                 | 6.0                   | V    |
|                  | Other Pins <sup>(1)</sup>                | -0.3                                 | V <sub>IN</sub> + 0.3 | V    |
| ESD              | Electrostatic Discharge Protection Level | Human Body Model per JESD22-A114     | 3                     | kV   |
|                  |  | Charged Device Model per JESD22-C101 | 2                     |      |
| T <sub>J</sub>   | Junction Temperature                     | -40                                  | +150                  | °C   |
| T <sub>STG</sub> | Storage Temperature                      | -65                                  | +150                  | °C   |
| T <sub>L</sub>   | Lead Soldering Temperature, 10 Seconds   |                                      | +260                  | °C   |

### Note:

1. Lesser of V<sub>IN</sub> + 0.3 or 6.0 V.

## Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

| Symbol           | Parameter            | Min. | Max. | Unit |
|------------------|----------------------|------|------|------|
| V <sub>IN</sub>  | Supply Voltage       | 2.7  | 5.5  | V    |
| V <sub>LED</sub> | LED Forward Voltage  | 2    | 4    | V    |
| T <sub>A</sub>   | Ambient Temperature  | -40  | +85  | °C   |
| T <sub>J</sub>   | Junction Temperature | -40  | +125 | °C   |

## Thermal Properties

| Symbol          | Parameter                              | Min.  | Typ. | Max. | Unit |
|-----------------|--|-------|------|------|------|
| Θ <sub>JA</sub> | Junction-to-Ambient Thermal Resistance | WLCSP | 80   |      | °C/W |
|                 |  | UMLP  | 49   |      |      |

### Note:

2. Junction-to-ambient thermal resistance is a function of application and board layout. This data is measured with four-layer 2s2p boards in accordance to JEDEC standard. Special attention must be paid not to exceed junction temperature T<sub>J(max)</sub> at a given ambient temperature T<sub>A</sub>.

## Electrical Specifications

Unless otherwise specified:  $V_{IN} = 2.7\text{ V to }5.5\text{ V}$ ;  $T_A = -40^\circ\text{C to }+85^\circ\text{C}$ ; and ENA, EN3, EN4, EN5, and EN6 = 1. Typical values are  $V_{IN} = 3.6\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $I_{LED} = 20\text{ mA}$ , and LED cathode terminals = 0.4 V. Circuit and components are according to Figure 1.

| Symbol                                       | Parameter                            | Conditions  | Min. | Typ.      | Max.   | Unit             |
|--|--------------------------------------|---|------|-----------|--------|------------------|
| <b>Power Supplies and Thermal Protection</b> |                                      |   |      |           |        |                  |
| $I_Q$  | Quiescent Supply Current             | 1.5x Mode, No LEDs  |      | 4.4       |        | mA               |
|  |                                      | 1x Mode, No LEDs  |      | 0.3       |        |                  |
| $I_{SD}$                                     | Shutdown Supply Current              | EN = 0, $V_{IN} = 4.5\text{V}$ , $T_A = -40^\circ\text{C to }+85^\circ\text{C}$ |      | 0.1       | 2.0    | $\mu\text{A}$    |
| $V_{UVLO}$                                   | Under-Voltage Lockout Threshold      | $V_{IN}$ Rising   |      | 2.55      | 2.70   | V                |
|  |                                      | $V_{IN}$ Falling  | 2.20 | 2.40      |        |                  |
| $V_{UVHYST}$                                 | Under-Voltage Lockout Hysteresis     |   |      | 150       |        | mV               |
| $T_{LIMIT}$                                  | Thermal Shutdown                     |   |      | 150       |        | $^\circ\text{C}$ |
| $T_{HYST}$                                   | Thermal Shutdown Hysteresis          |   |      | 20        |        | $^\circ\text{C}$ |
| <b>LED Current Sinks</b>                     |                                      |   |      |           |        |                  |
| $I_{LED}$                                    | Absolute Current Accuracy            | $V_{CATHODE} = 0.4\text{ V}$ ; see options for $I_{SET}$                        | -10% | $I_{SET}$ | +10%   | mA               |
| $I_{LED(MAX)}$                               | Maximum Diode Current <sup>(3)</sup> | $I_{LED} = I_{SET}$   |      | 30        |        | mA               |
| $I_{LED\_MATCH}$                             | LED Current Matching <sup>(4)</sup>  | $V_{CATHODE} = 0.4\text{ V}$ , $I_{LED} = I_{SET}$                              |      | 0.4       | 3.0    | %                |
| $V_{DTH}$                                    | 1x to 1.5x Gain Transition Threshold | LED Cathode Voltage Falling   |      | 100       |        | mV               |
| $V_{HR}$                                     | Current Sink Headroom <sup>(5)</sup> | $I_{LED} = 90\% I_{LED(NOMINAL)}$   |      | 65        |        | mV               |
| <b>PWM Dimming</b>                           |                                      |   |      |           |        |                  |
| $f_{PWM}$                                    | PWM Switching Frequency              | $t_{ON\_LED(MINIMUM)} = 15\ \mu\text{s}$  |      |           | 20     | kHz              |
| $D_{PWM}$                                    | PWM Duty-Cycle                       | $f_{PWM} = 100\text{ Hz}$   | 0.15 |           | 100.00 | %                |
| <b>Charge Pump</b>                           |                                      |   |      |           |        |                  |
| $R_{OUT}$                                    | Output Resistance                    | 1.5x Mode   |      | 2.4       |        | $\Omega$         |
|  |                                      | 1x Mode   |      | 0.9       |        |                  |
| $f_{SW}$                                     | Switching Frequency                  |   | 0.9  | 1.2       | 1.5    | MHz              |
| $t_{START}$                                  | Startup Time                         | $V_{OUT} = 90\% \text{ of } V_{IN}$   |      | 250       |        | $\mu\text{s}$    |
| <b>Logic Inputs (EN, SDA, SCL)</b>           |                                      |   |      |           |        |                  |
| $V_{IH}$                                     | HIGH-Level Input Voltage             |   | 1.2  |           |        | V                |
| $V_{IL}$                                     | LOW-Level Input Voltage              |   |      |           | 0.4    | V                |
| $V_{IMAX}$                                   | Maximum Input Voltage                |   |      | 1.8       | 5.5    | V                |
| $I_{IN}$                                     | Input Bias Current                   | Input Tied to GND or $V_{IN}$   |      | 0.01      | 1.00   | $\mu\text{A}$    |

### Notes:

- The maximum total output current for the IC should be limited to 180 mA. The total output current can be split between the two groups ( $IDxA = IDxB = 30\text{ mA}$  maximum). Under maximum output current conditions, special attention must be given to input voltage and LED forward voltage to ensure proper current regulation. See the *Maximum Output Current* section of the datasheet for more information.
- For the two groups of current sinks on a part (group A and group B), the following are determined: the maximum sink current in the group (MAX), the minimum sink current in the group (MIN), and the average sink current of the group (AVG). For each group, two matching numbers are calculated:  $(MAX-AVG)/AVG$  and  $(AVG-MIN)/AVG$ . The largest number of the two (worst case) is considered the matching value for the group. The matching value for a given part is considered to be the highest matching value of the two groups. The typical specification provided is the most likely norm of the matching value for all parts.
- For each Dxx pin, headroom voltage is the voltage across the internal current sink connected to that pin.  $V_{HRx} = V_{OUT} - V_{LED}$ . If headroom voltage requirement is not met, LED current regulation is compromised.

## Typical Characteristics

$V_{IN} = 3.6\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $I_{LED} = 20\text{ mA}$ , and LED cathode terminals = 0.4 V.

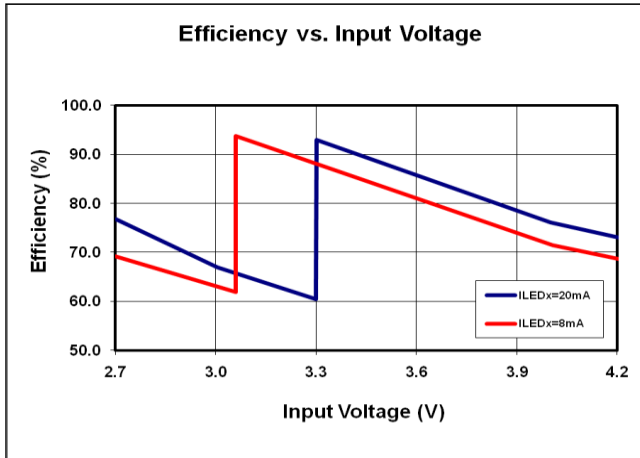


Figure 4. Efficiency with LED Current of 8 mA and 20 mA

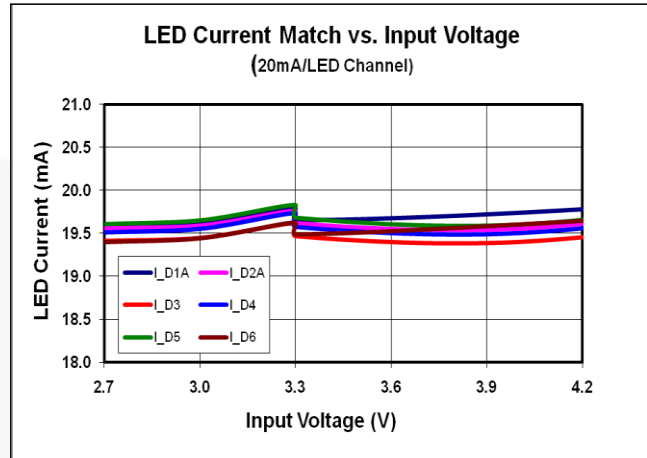


Figure 5. LED Current Match for all 6 LED Channels at  $I_{LED}=20\text{ mA}$

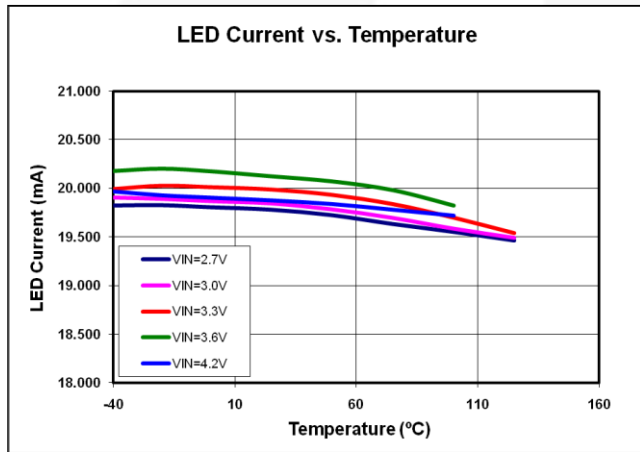


Figure 6. LED Current Variation vs. Temperature

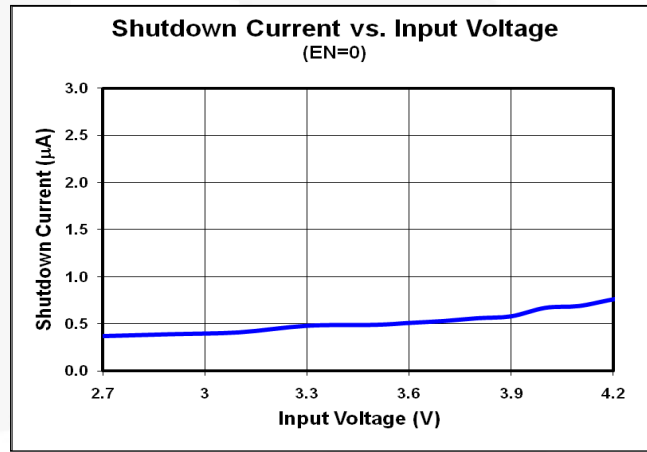


Figure 7. Shutdown Current vs. Input Voltage

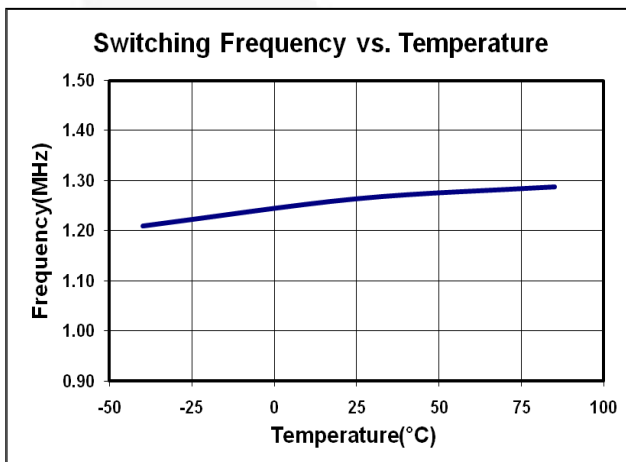
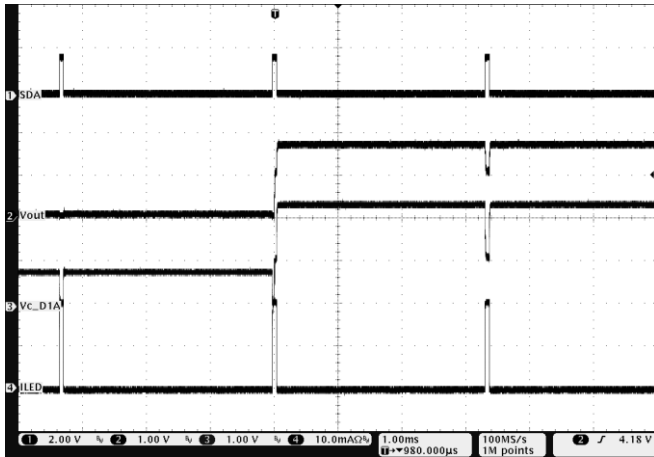


Figure 8. Switching Frequency Over-Temperature with LED Current at 20 mA

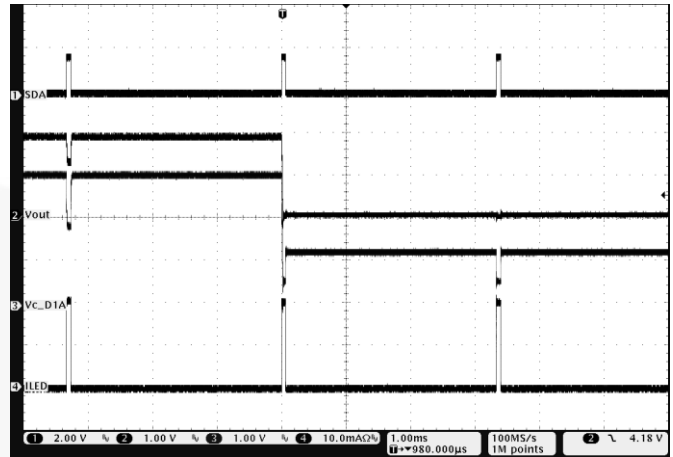


## Typical Characteristics

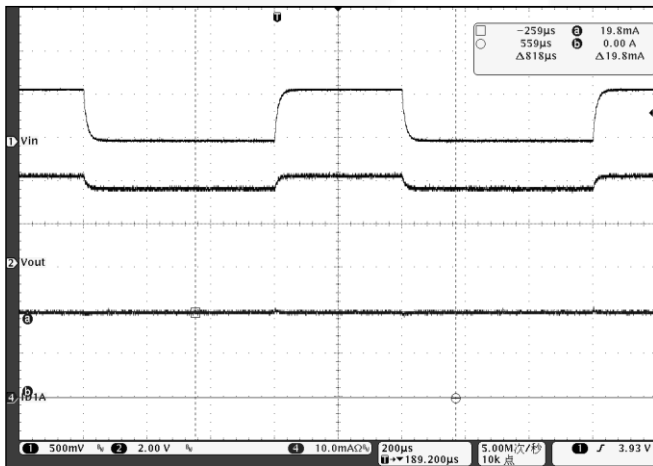
$V_{IN} = 3.6\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $I_{LED} = 20\text{ mA}$ , and LED cathode terminals =  $0.4\text{ V}$ .



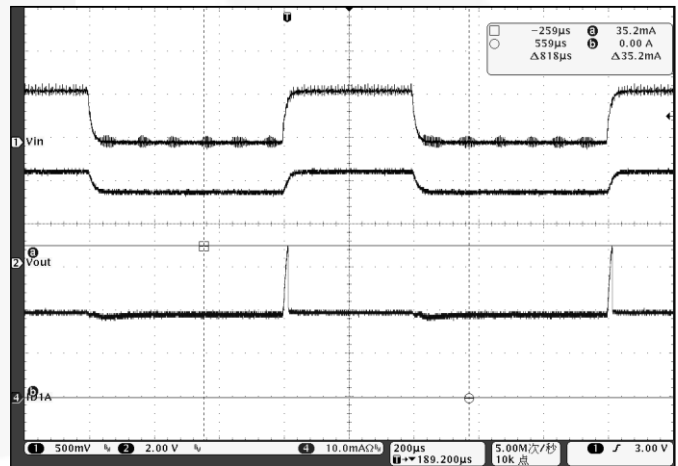
**Figure 9. Mode Transition from 1x to 1.5x Mode Using PWM Control ( $V_{CATHODE}$  Ramp Up) at 2% Duty Cycle**



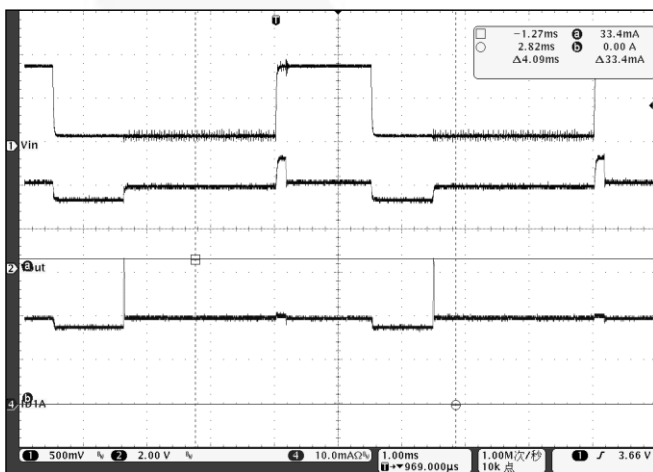
**Figure 10. Mode Transition from 1.5x to 1x Mode Using PWM Control ( $V_{CATHODE}$  Ramp Down) at 2% Duty Cycle**



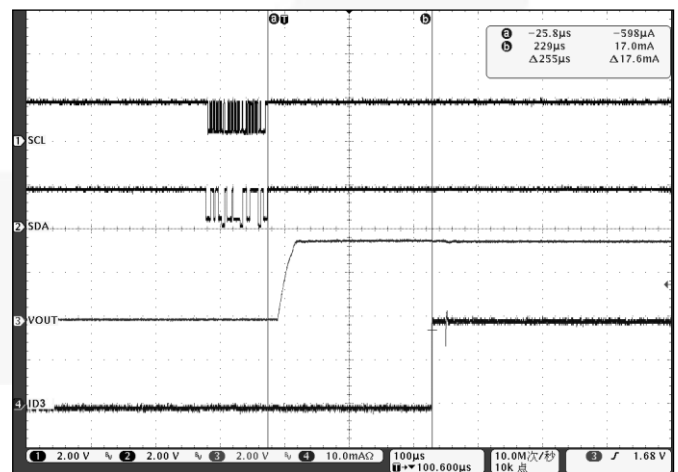
**Figure 11. Line Transient Response in 1x Mode,  $V_{IN}=3.6\text{ V} - 4.2\text{ V}$ ,  $I_{LEDx}=20\text{ mA}$**



**Figure 12. Line Transient Response in 1.5x Mode,  $V_{IN}=2.7\text{ V} - 3.3\text{ V}$ ,  $I_{LED}=20\text{ mA}$**



**Figure 13. Line Transient from 1x to 1.5x Mode,  $V_{IN}=3.2\text{ V} - 4.1\text{ V}$ ,  $I_{LEDx}=20\text{ mA}$**



**Figure 14. Soft-Start with SDA and SCL**

Typical Characteristics

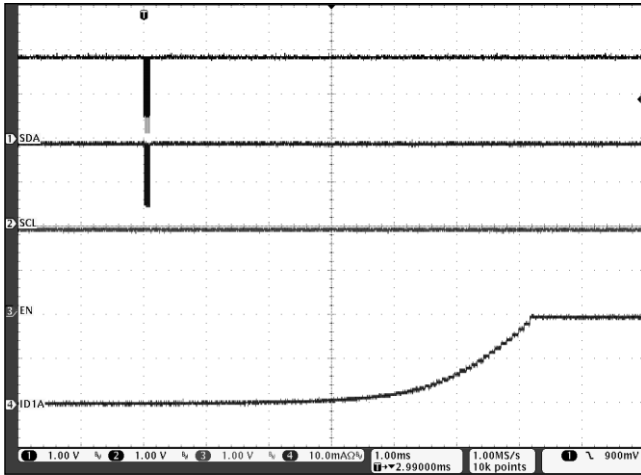


Figure 15. Linear Dimming via I<sup>2</sup>C Interface,  $V_{IN}=3.6\text{ V}$ ,  $I_{LEDx}=20\text{ mA}$ , and  $t_{RAMP}=6.4\text{ ms}$

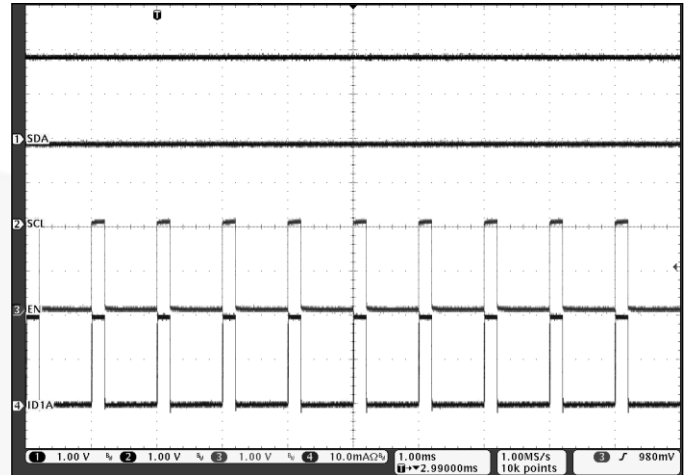


Figure 16. PWM Dimming,  $V_{IN}=3.6\text{ V}$ ,  $I_{LEDx}=20\text{ mA}$ , and  $EN=1\text{ kHz}$  with 20% Duty Cycle

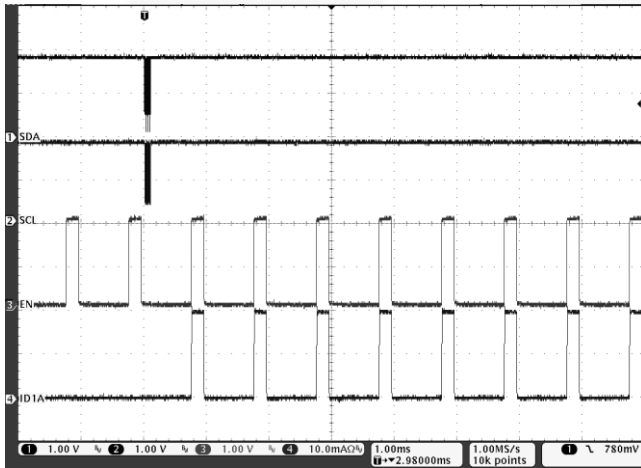


Figure 17. PWM and Linear (via I<sup>2</sup>C) Dimming,  $V_{IN}=3.6\text{ V}$ ,  $I_{LEDx}=20\text{ mA}$ , and  $EN=1\text{ kHz}$  with 20% Duty Cycle

## I<sup>2</sup>C Timing Specifications

Guaranteed by design.

| Symbol              | Parameter                                       | Conditions    | Min.                 | Typ.  | Max.   | Unit |
|---------------------|---|---------------|----------------------|-------|--------|------|
| f <sub>SCL</sub>    | SCL Clock Frequency                             | Standard Mode |                      |       | 100    | kHz  |
|                     |   | Fast Mode     |                      |       | 400    |      |
| t <sub>BUF</sub>    | Bus-Free Time between STOP and START Conditions | Standard mode |                      | 4.7   |        | μs   |
|                     |   | Fast Mode     |                      | 1.3   |        |      |
| t <sub>HD,STA</sub> | START or Repeated START Hold Time               | Standard Mode |                      | 4     |        | μs   |
|                     |   | Fast Mode     |                      | 600   |        | ns   |
| t <sub>LOW</sub>    | SCL LOW Period                                  | Standard Mode |                      | 4.7   |        | μs   |
|                     |   | Fast Mode     |                      | 1.3   |        | ns   |
| t <sub>HIGH</sub>   | SCL HIGH Period                                 | Standard Mode |                      | 4     |        | μs   |
|                     |   | Fast Mode     |                      | 600   |        | ns   |
| t <sub>SU,STA</sub> | Repeated START Setup Time                       | Standard Mode |                      | 4.7   |        | μs   |
|                     |   | Fast Mode     |                      | 600.0 |        | ns   |
| t <sub>SU,DAT</sub> | Data Setup Time                                 | Standard Mode |                      | 250   |        | ns   |
|                     |   | Fast Mode     |                      | 100   |        | ns   |
| t <sub>HD,DAT</sub> | Data Hold Time                                  | Standard Mode | 0                    |       | 3.45   | μs   |
|                     |   | Fast Mode     | 0                    |       | 900.00 | ns   |
| t <sub>RCL</sub>    | SCL Rise Time                                   | Standard Mode | 20+0.1C <sub>B</sub> |       | 1000   | ns   |
|                     |   | Fast Mode     | 20+0.1C <sub>B</sub> |       | 300    | ns   |
| t <sub>FCL</sub>    | SCL Fall Time                                   | Standard Mode | 20+0.1C <sub>B</sub> |       | 300    | ns   |
|                     |   | Fast Mode     | 20+0.1C <sub>B</sub> |       | 300    | ns   |
| t <sub>RDA</sub>    | SDA Rise Time <sup>(6)</sup>                    | Standard Mode | 20+0.1C <sub>B</sub> |       | 1000   | ns   |
|                     |   | Fast Mode     | 20+0.1C <sub>B</sub> |       | 300    | ns   |
| t <sub>FDA</sub>    | SDA Fall Time                                   | Standard Mode | 20+0.1C <sub>B</sub> |       | 300    | ns   |
|                     |   | Fast Mode     | 20+0.1C <sub>B</sub> |       | 300    | ns   |
| t <sub>SU,STO</sub> | Stop Condition Setup Time                       | Standard Mode |                      | 4     |        | μs   |
|                     |   | Fast Mode     |                      | 600   |        | ns   |
| C <sub>B</sub>      | Capacitive Load for SDA and SCL                 |               |                      |       | 400    | pF   |

**Note:**

6. Rise time of SCL after a repeated START condition and after an ACK bit.

### Timing Diagram

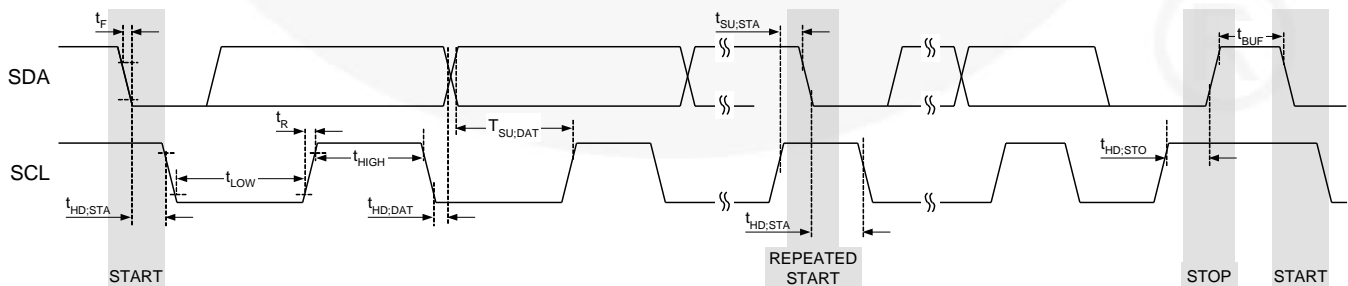


Figure 18. I<sup>2</sup>C Interface Timing for Fast and Slow Modes

## Circuit Description

The FAN5702 is a white LED driver system based on an adaptive 1.5x charge pump capable of supplying up to 180 mA of total output current. The tightly matched current sinks ensure uniform brightness between the LEDs. Each LED has a common anode configuration with its peak drive current set during manufacturing (see *Ordering Information and I<sub>SET</sub>*). An I<sup>2</sup>C-compatible interface is used to vary the brightness within the individual current sinks as well as configure the grouping. Each LED is controlled with 64 exponentially spaced analog brightness control levels through I<sup>2</sup>C, as indicated in Table 1. For maximum flexibility, the FAN5702 can be programmed with five independently controlled LED banks; by default, arranged as 2,1,1,1,1 (first two LEDs represent Group A). Through I<sup>2</sup>C, the device can be reconfigured to add up to six LEDs to Group A as needed by application requirements.

## Charge Pump

The charge pump operates in either 1x mode, where V<sub>OUT</sub> is connected to V<sub>IN</sub> through a bypass switch, or in 1.5x mode. The circuit operates in 1x mode until the LED with the highest forward voltage (V<sub>LED(MAX)</sub>) can no longer maintain current regulation. At that point, 1.5x Mode begins. If the lowest active cathode voltage is greater than 1.8 V, the charge pump switches back to 1x Mode.

## IC Enable

By default the General Purpose register bit 7 = 0, the EN pin functions as enable/disable. When the EN pin is LOW, all circuit functions, including I<sup>2</sup>C, are disabled and the registers are set to their default values.

When the EN pin HIGH, I<sup>2</sup>C interface is enabled. The LEDs can be turned on/off by writing to the General Purpose register. The user can always communicate via I<sup>2</sup>C with the device to change register settings regardless of whether any LED is on or off.

## PWM Dimming

By programming the General Purpose register bit 7 = 1, the EN pin is reappropriated to a PWM dimming input. Applying a PWM signal to this pin controls the LED current waveform to be ON when the PWM dimming pin is HIGH and OFF when the PWM dimming pin is LOW. By using this pin in conjunction with the I<sup>2</sup>C register dimming, the part can achieve higher dimming resolution. For instance, an 8-bit PWM dimming signal applied along with the 6-bit register dimming yields better than 14 bits of resolution

To change the PWM dimming pin back to the EN function, set the General Purpose register bit 7 to 0.

## Register Controlled Brightness

The DC value of the LED current is modulated according to the values in Table 1. Current is expressed as a percentage of the full scale current and is illustrated with a 20 mA I<sub>SET</sub>.

**Table 1. Brightness Control**

| Dimming Code (Bx5-Bx0) | Current Level | I <sub>LED</sub> (mA) (I <sub>SET</sub> =20 mA) |
|------------------------|---------------|---|
| 000000                 | 0.125%        | 0.025   |
| 000001                 | 0.188%        | 0.038   |
| 000010                 | 0.249%        | 0.050   |
| 000011                 | 0.312%        | 0.063   |
| 000100                 | 0.374%        | 0.075   |
| 000101                 | 0.438%        | 0.088   |
| 000110                 | 0.499%        | 0.100   |
| 000111                 | 0.560%        | 0.113   |
| 001000                 | 0.622%        | 0.125   |
| 001001                 | 0.692%        | 0.138   |
| 001010                 | 0.750%        | 0.150   |
| 001011                 | 0.810%        | 0.163   |
| 001100                 | 0.875%        | 0.175   |
| 001101                 | 0.938%        | 0.188   |
| 001110                 | 1.004%        | 0.200   |
| 001111                 | 1.124%        | 0.225   |
| 010000                 | 1.250%        | 0.250   |
| 010001                 | 1.375%        | 0.275   |
| 010010                 | 1.499%        | 0.300   |
| 010011                 | 1.625%        | 0.325   |
| 010100                 | 1.750%        | 0.350   |
| 010101                 | 1.881%        | 0.375   |
| 010110                 | 2.063%        | 0.413   |
| 010111                 | 2.249%        | 0.450   |
| 011000                 | 2.438%        | 0.488   |
| 011001                 | 2.687%        | 0.538   |
| 011010                 | 2.939%        | 0.588   |
| 011011                 | 3.186%        | 0.638   |
| 011100                 | 3.562%        | 0.713   |
| 011101                 | 3.936%        | 0.788   |
| 011110                 | 4.310%        | 0.863   |
| 011111                 | 4.813%        | 0.963   |
| 100000                 | 5.314%        | 1.063   |
| 100001                 | 5.936%        | 1.188   |
| 100010                 | 6.565%        | 1.313   |
| 100011                 | 7.313%        | 1.463   |
| 100100                 | 8.059%        | 1.613   |
| 100101                 | 8.938%        | 1.788   |
| 100110                 | 9.876%        | 1.975   |
| 100111                 | 10.874%       | 2.175   |
| 101000                 | 12.005%       | 2.400   |
| 101001                 | 13.253%       | 2.650   |
| 101010                 | 14.618%       | 2.925   |
| 101011                 | 16.124%       | 3.225   |
| 101100                 | 17.881%       | 3.575   |
| 101101                 | 19.875%       | 3.975   |
| 101110                 | 22.121%       | 4.425   |
| 101111                 | 24.621%       | 4.925   |
| 110000                 | 27.376%       | 5.475   |
| 110001                 | 30.373%       | 6.075   |
| 110010                 | 33.623%       | 6.725   |
| 110011                 | 37.124%       | 7.425   |
| 110100                 | 40.873%       | 8.175   |
| 110101                 | 44.875%       | 8.975   |
| 110110                 | 49.124%       | 9.825   |
| 110111                 | 53.624%       | 10.725  |
| 111000                 | 58.375%       | 11.675  |
| 111001                 | 63.378%       | 12.675  |
| 111010                 | 68.625%       | 13.725  |
| 111011                 | 74.122%       | 14.825  |
| 111100                 | 79.874%       | 15.975  |
| 111101                 | 85.873%       | 17.175  |
| 111110                 | 92.373%       | 18.475  |
| 111111                 | 100.000%      | 20.000  |

### Brightness Ramp Control

When changing the group A brightness, the IC steps through the brightness table at rate programmed by the RAMP register, indicated in Table 2.

**Table 2. Group A Brightness Ramp Control**

| RAMP[1:0] | Time per Step | Full-Scale Ramp Time |
|-----------|---------------|----------------------|
| 00        | 0.1 ms        | 6.4 ms               |
| 01        | 25 ms         | 1600 ms              |
| 10        | 50 ms         | 3200 ms              |
| 11        | 100 ms        | 6400 ms              |

### V<sub>OUT</sub> Short-Circuit Protection

The FAN5702 has integrated protection circuitry to prevent the device from being short circuited when the output voltage falls below 2 V. If this occurs, FAN5702 turns off the charge pump and the LED driver outputs, but a small bypass switch is left on. The device monitors the output voltage to determine if it is still in short circuit condition and, once it has passed, soft-starts and returns to normal operation.

### V<sub>OUT</sub> Over-Voltage Protection

If the output voltage goes above 6 V, the FAN5702 shuts down until this condition has passed. The charge pump and LED driver outputs are turned off. Once this condition has passed, the FAN5702 soft-starts into normal operation.

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

The FAN5702's serial interface is compatible with standard and fast I<sup>2</sup>C bus specifications. The FAN5702's SCL line is an input and its SDA line is a bi-directional open-drain output, meaning that it can only pull down the bus when active. The SDA line only pulls LOW during data reads and when signaling ACK. All data is shifted in MSB (bit 7) first.

### Slave Address

The FAN5702's slave address is 6CH.

**Table 3. I<sup>2</sup>C Slave Address**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0   |
|---|---|---|---|---|---|---|-----|
| 0 | 1 | 1 | 0 | 1 | 1 | 0 | R/W |

### Register Addressing

The FAN5702 has six user-accessible registers.

**Table 4. I<sup>2</sup>C Register Addresses**

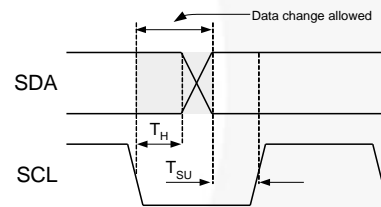
|         | Default Value |          |   |   |   |   |   | Address |     |
|---------|---------------|----------|---|---|---|---|---|---------|-----|
|         | 7             | 6        | 5 | 4 | 3 | 2 | 1 | 0       | HEX |
| GENERAL | 0             | 0        | 0 | 0 | 0 | 0 | 0 | 0       | 10  |
| CONFIG  | 0             | 0        | 0 | 0 | 0 | 0 | 0 | 0       | 20  |
| CHA     | <b>1</b>      | <b>1</b> | 1 | 1 | 1 | 1 | 1 | 1       | A0  |
| CH3     | <b>1</b>      | <b>1</b> | 1 | 1 | 1 | 1 | 1 | 1       | 30  |
| CH4     | <b>1</b>      | <b>1</b> | 1 | 1 | 1 | 1 | 1 | 1       | 40  |
| CH5     | <b>1</b>      | <b>1</b> | 1 | 1 | 1 | 1 | 1 | 1       | 50  |
| CH6     | <b>1</b>      | <b>1</b> | 1 | 1 | 1 | 1 | 1 | 1       | 60  |

**Note:**

7. Bold identifies bits that cannot be overwritten.

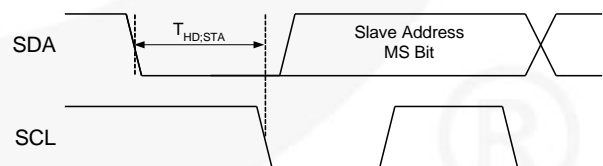
### Bus Timing

As shown in Figure 19 data is normally transferred when SCL is LOW. Data is clocked in to the FAN5702 on the rising edge of SCL. Typically, data transitions shortly at or after the falling edge of SCL to allow ample time for the data to set up before the next SCL rising edge.



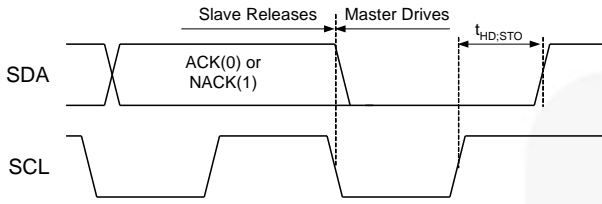
**Figure 19. Data Transfer Timing**

Each bus transaction begins and ends with SDA and SCL HIGH. A transaction begins with a START condition, which is defined as SDA transitioning from 1 to 0 with SCL HIGH, as shown in Figure 20.



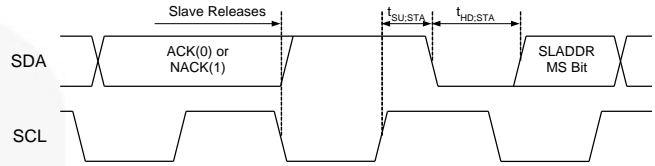
**Figure 20. Start Bit**

A transaction ends with a STOP condition, which is defined as SDA transitioning from 0 to 1 with SCL HIGH, as shown in Figure 21.



**Figure 21. Stop Bit**

During a read from the FAN5702 (Figure 24, the master issues a “Repeated Start” after sending the register address and before resending the slave address. The “Repeated Start” is a 1-to-0 transition on SDA while SCL is HIGH, as shown in Figure 22.



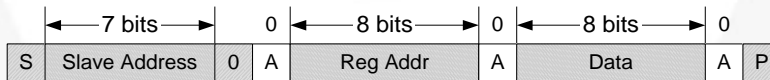
**Figure 22. Repeated Start Timing**

### Read and Write Transactions

The following figures outline the sequences for data read and write. Bus control is signified by the shading of the packet, defined as Master Drives Bus and Slave Drives Bus. All addresses and data are MSB first.

**Table 5. I<sup>2</sup>C bit Definitions for Figure 23 and Figure 24.**

| Symbol    | Definition  |
|-----------|---|
| S         | START. See Figure 20.   |
| A         | ACK. The slave drives SDA to 0 to acknowledge the preceding packet. |
| $\bar{A}$ | NACK. The slave sends a 1 to NACK the preceding packet.             |
| R         | Repeated START. See Figure 22                                       |
| P         | STOP. See Figure 21.  |



**Figure 23. Write Transaction**



**Figure 24. Read Transaction**

## Register Descriptions

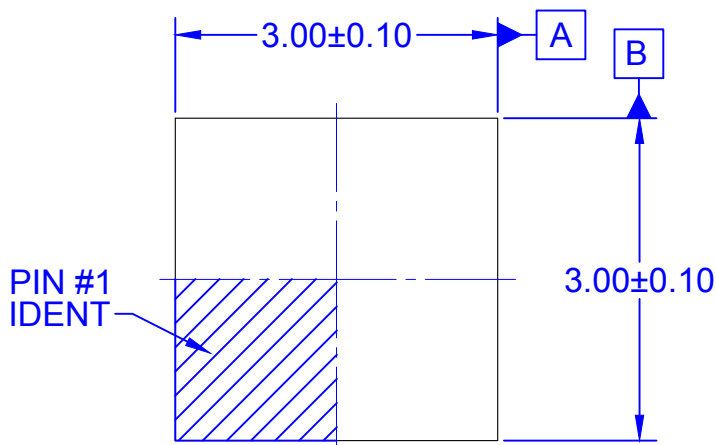
The following tables define the operation of each register bit. **Bold** values are power-up defaults. These values apply only to I<sup>2</sup>C version of the part.

| Bit   | Name         | Default Value                    | Description   |
|---|--------------|----------------------------------|---|
| <b>GENERAL</b> Default: 00H      General Purpose Register      ADDR = 10H |              |                                  |   |
| 7   | PWM          | <b>0</b>                         | Setting this bit=1 changes the EN pin to function as a PWM dimming input for group A LEDs. This bit must be set to zero for the chip to be disabled.  |
| 6,5   | FS1, FS2     | <b>00</b>                        | 00=20 mA (default), 01=30 mA, 10=15 mA, 11=8 mA when I <sup>2</sup> C is used.  |
| 4   | EN6          | <b>0</b>                         | Default=0 (Off), LED Channel Active=1   |
| 3   | EN5          | <b>0</b>                         | Default=0 (Off), LED Channel Active=1   |
| 2   | EN4          | <b>0</b>                         | Default=0 (Off), LED Channel Active=1   |
| 1   | EN3          | <b>0</b>                         | Default=0 (Off), LED Channel Active=1   |
| 0   | ENA          | <b>0</b>                         | Default=0 (Off), LED Channel Active=1   |
| <b>CONFIG</b> Default: 00H      Configuration Register      ADDR = 20H    |              |                                  |   |
| 7   | T56          | <b>0</b>                         | Tie channel 5 and 6 together. Default=0 (Separate). Group 5&6 =1. Both currents are set by CH5 register. T56 is overwritten by either S5A or S6A.     |
| 6   | T34          | <b>0</b>                         | Tie channel 3 and 4 together. Default=0 (Separate). Group 3&4 =1. Both currents are set by the CH3 register. T34 is overwritten by either S3A or S4A. |
| 5   | S6A          | <b>0</b>                         | CH6 group configuration. Independent=0 (default); part of group A=1.  |
| 4   | S5A          | <b>0</b>                         | CH5 group configuration. Independent=0 (default); part of group A=1.  |
| 3   | S4A          | <b>0</b>                         | CH4 group configuration. Independent=0 (default); part of group A=1.  |
| 2   | S3A          | <b>0</b>                         | CH3 group configuration. Independent=0 (default); part of group A=1.  |
| 1,0   | RS1, RS0     | <b>00</b>                        | Sets current ramp rate for group A channels   |
| <b>CHA</b> Default: FFH      Group A Brightness Control      ADDR = A0H   |              |                                  |   |
| 7:6   | Reserved     | <b>11</b>                        | Vendor ID bits. These bits can be used to distinguish between vendors via I <sup>2</sup> C. Writing to these bits does not change their value.        |
| 5:0   | Brightness A | <b>0 – 63</b><br><b>00 – 3FH</b> | 6-bit value that controls group A brightness per values in Table 1  |
| <b>CH3</b> Default:      Channel 3 Brightness Control      ADDR=30H       |              |                                  |   |
| 7:6   | Reserved     | <b>11</b>                        | Writing to these bits does not change their value.  |
| 5:0   | Brightness 3 | <b>0 – 63</b><br><b>00 – 3FH</b> | 6-bit value that controls channel 3 brightness per values in Table 1  |
| <b>CH4</b> Default: FFH      Channel 4 Brightness Control      ADDR = 40H |              |                                  |   |
| 7:6   | Reserved     | <b>11</b>                        | Writing to these bits does not change their value.  |
| 5:0   | Brightness 4 | <b>0 – 63</b><br><b>00 – 3FH</b> | 6-bit value that controls channel 3 brightness per values in Table 1  |
| <b>CH5</b> Default: FFH      Channel 5 Brightness Control      ADDR = 50H |              |                                  |   |
| 7:6   | Reserved     | <b>11</b>                        | Writing to these bits does not change their value.  |
| 5:0   | Brightness 5 | <b>0 – 63</b><br><b>00 – 3FH</b> | 6-bit value that controls channel 3 brightness per values in Table 1  |
| <b>CH6</b> Default: FFH      Channel 6 Brightness Control      ADDR = 60H |              |                                  |   |
| 7:6   | Reserved     | <b>11</b>                        | Writing to these bits does not change their value.  |
| 5:0   | Brightness 6 | <b>0 – 63</b><br><b>00 – 3FH</b> | 6-bit value that controls channel 3 brightness per values in Table 1  |

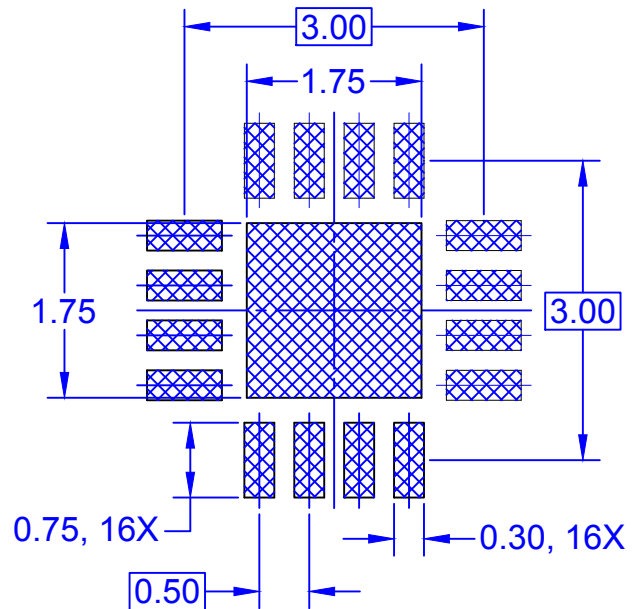
The table below pertains to the Marketing Outline drawing on the following page...

### Product-Specific Dimensions

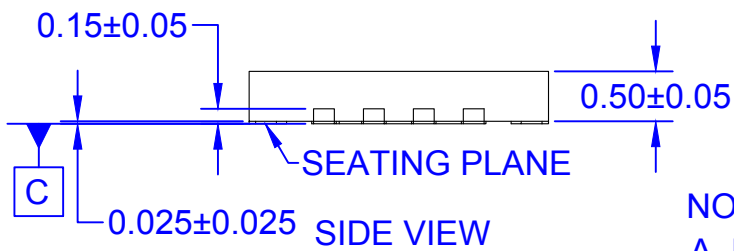
| Product     | D        | E        | X        | Y        |
|-------------|----------|----------|----------|----------|
| FAN5702UCxx | 1.610 mm | 1.610 mm | 0.205 mm | 0.205 mm |



TOP VIEW



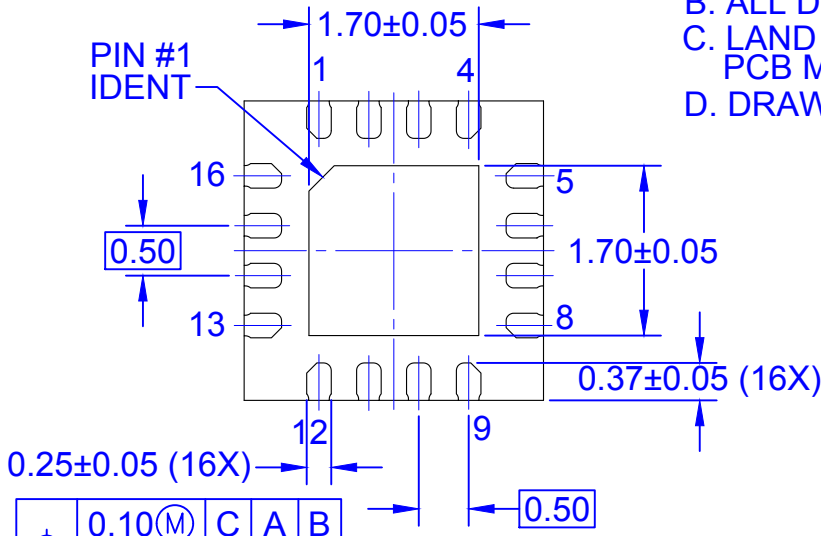
LAND PATTERN RECOMMENDATION



SIDE VIEW

NOTES:

- A. DESIGN CONFORMS TO JEDEC MO-248
- B. ALL DIMENSIONS ARE IN MILLIMETERS
- C. LAND PATTERN RECOMMENDATION FROM PCB MATRIX IPC LP CALCULATOR (V2009)
- D. DRAWING FILENAME: MKT-UMLP16BrevB



BOTTOM VIEW

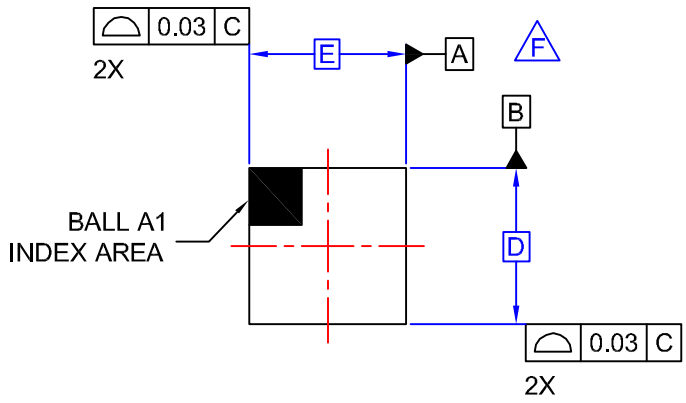
|   |         |   |   |   |
|---|---------|---|---|---|
| ⊕ | 0.10(M) | C | A | B |
|   | 0.05(M) | C |   |   |

**ON Semiconductor**

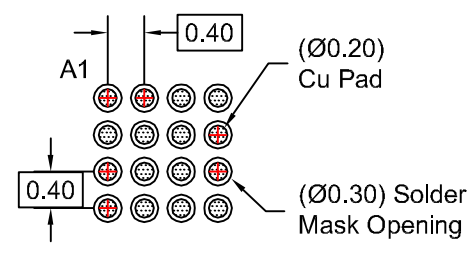




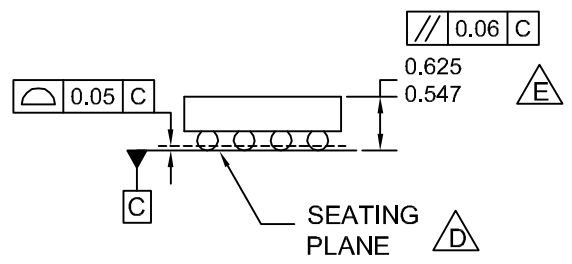
| REVISIONS |   |         |                   |
|-----------|---|---------|-------------------|
| REV       | DESCRIPTION   | DATE    | APP'D / SITE      |
| 1         | Initial drawing release.  | 3-31-08 | L. England        |
| 2         | Changed land pad solder mask to individual pad openings. Other general updates for drawing consistency. | 3-31-08 | L. England / FSME |



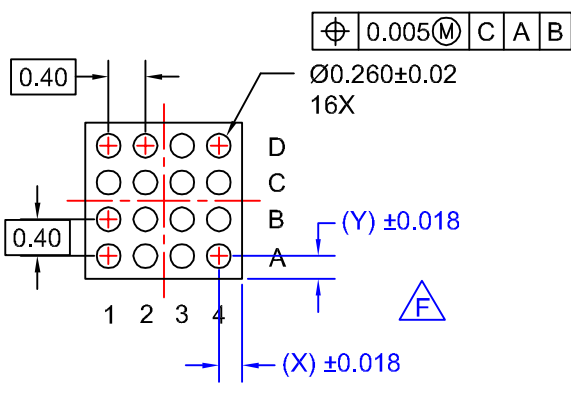
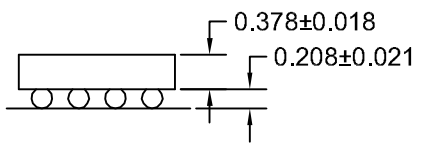
TOP VIEW



RECOMMENDED LAND PATTERN (NSMD PAD TYPE)



SIDE VIEWS



BOTTOM VIEW

NOTES:

- A. NO JEDEC REGISTRATION APPLIES.
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCE PER ASME Y14.5M, 1994.
- D. DATUM C IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.
- E. PACKAGE NOMINAL HEIGHT IS 586 MICRONS ±39 MICRONS (547-625 MICRONS).
- F. FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.
- G. DRAWING FILNAME: MKT-UC016Arev2.

|                  |            |             |                      |      |                |     |
|------------------|------------|-------------|----------------------|------|----------------|-----|
| <b>APPROVALS</b> |            | <b>DATE</b> |                      |      |                |     |
| DRAWN            | L. England | 10-26-09    |                      |      |                |     |
| DFTG. CHK.       | E. Shacham | 10-26-09    |                      |      |                |     |
| ENGR. CHK.       |            |             |                      |      |                |     |
|                  |            |             | SCALE                | SIZE | DRAWING NUMBER | REV |
|                  |            |             | N/A                  | N/A  | MKT-UC016AA    | 2   |
|                  |            |             | DO NOT SCALE DRAWING |      | SHEET 1 of 1   |     |

16BALL WLCSP, 4X4 ARRAY  
0.4MM PITCH, 250UM BALL

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