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FAIRCHILD SEMICONDUCTOR®

March 2013

FAN5701 — Compact 6-LED Driver for Mobile Platforms

Features

- Six (6) Parallel LEDs (up to 30mA each)
- Total Package Load Current Capability: 180mA
- Two Default Groups of Four (4) and Two (2) LEDs for Main and Sub-Display Lighting with Individual PWM Dimming Controls that Operate up to 20kHz
- >600:1 Dimming Ratio for 100Hz PWM Frequency
- Up to 92% Efficiency
- Built-in 1.5x Charge Pump with Low-Dropout Bypass Switch
- Wide Input Range: 2.7V to 5.5V
- V_{OUT} Over-Voltage and Short-Circuit Protection
- Over-Temperature Protection
- 1.2MHz Switching Frequency for Small-Sized Capacitors
- 16-Bump 1.61mm x 1.61mm WLCSP (0.6mm Height)
- 16-Lead 3.0mm x 3.0mm UMLP (0.55mm Height)

Applications

- LCD Backlighting
- Keypad Backlighting
- Mobile Handsets
- Portable Media Player

Description

The FAN5701 is a highly integrated and efficient charge-pump-based multi-LED driver. The device can drive up to six LEDs in parallel with a total output current of 180mA.

The FAN5701 is capable of driving a primary display backlight requiring four to six LEDs. When more than four LEDs are needed for backlighting, the FAN5701's two PWM dimming inputs can be connected together to provide the proper dimming control for all six LEDs. When a primary and sub-display is needed, the FAN5701 can be controlled such that each group can be dimmed independently. For candy-bar phones requiring a primary display and keypad lighting, the FAN5701 offers a simple, and compact lighting solution.

Regulated internal current sinks deliver excellent current and brightness matching to all six LEDs. The device provides excellent efficiency without an inductor by operating the charge pump in 1.5x or pass-through modes.

The FAN5701 can be ordered with I_{SET} values of 30mA, 20mA, 15mA, or 8mA and available in WLCSP or ultra-thin UMLP package types. The default I_{SET} is always determined by the part number purchased *(see Ordering Information)*

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Ordering Information

Part Number	LED Current (I_{SET})	Temperature Range	Package	Packing
FAN5701UC30X	30mA	-40°C to 85°C	WLCSP-16, 0.4mm Pitch	Tape and Reel
FAN5701UC20X	20mA	-40°C to 85°C	WLCSP-16, 0.4mm Pitch	Tape and Reel
FAN5701UC15X	15mA	-40°C to 85°C	WLCSP-16, 0.4mm Pitch	Tape and Reel
FAN5701UC08X	8mA	-40°C to 85°C	WLCSP-16, 0.4mm Pitch	Tape and Reel
FAN5701UMP30X	30mA	-40°C to 85°C	UMLP-16, 3.0 x 3.0 x 0.55mm	Tape and Reel
FAN5701UMP20X	20mA	-40°C to 85°C	UMLP-16, 3.0 x 3.0 x 0.55mm	Tape and Reel
FAN5701UMP15X	15mA	-40°C to 85°C	UMLP-16, 3.0 x 3.0 x 0.55mm	Tape and Reel
FAN5701UMP08X	8mA	-40°C to 85°C	UMLP-16, 3.0 x 3.0 x 0.55mm	Tape and Reel

Block Diagram

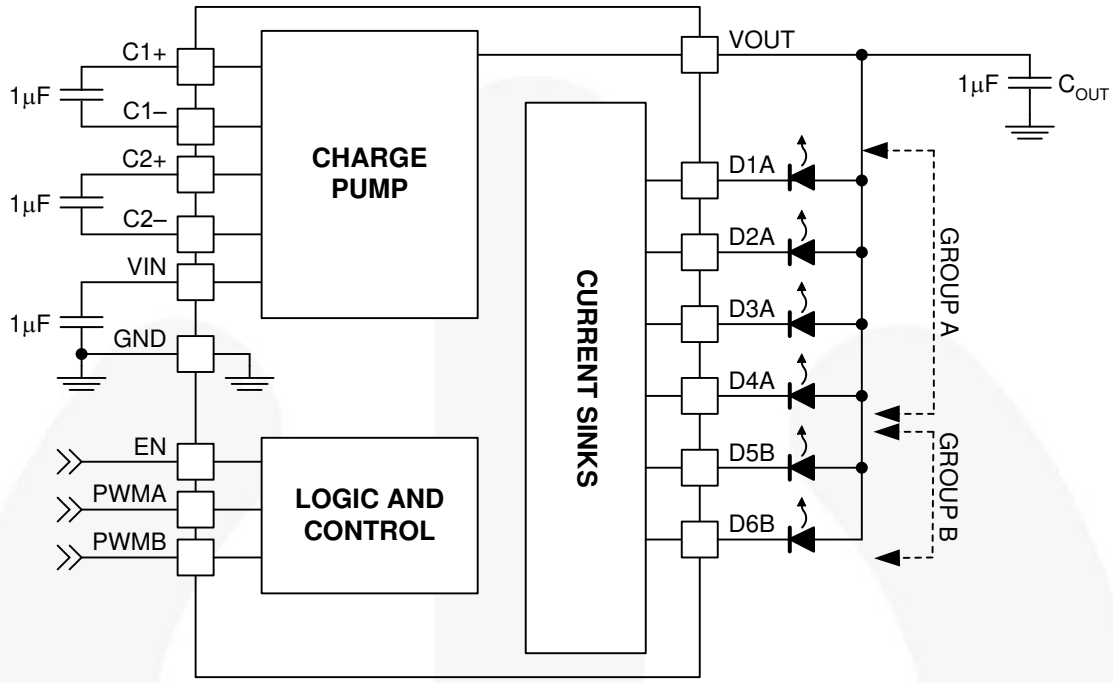
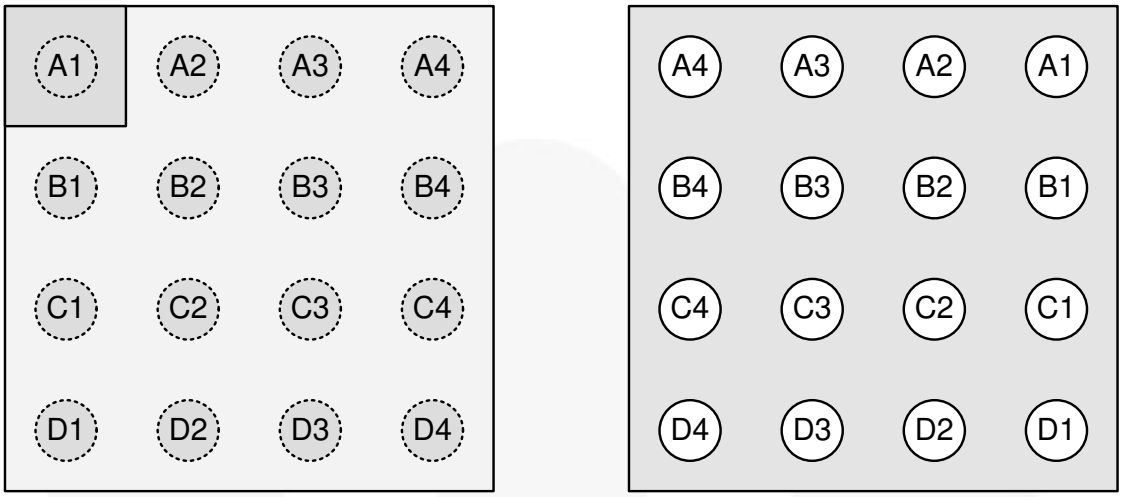


Figure 1. Typical Application

WLCSP Pin Configuration



Bumps Facing Down

Bumps Facing Up

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

Pin Definitions

Pin #	Name	Description
D2	VIN	**Input Voltage**. Connect to 2.7 – 5.5V_{DC} input power source.
B4	GND	**Ground**
D1	VOUT	**Charge Pump Output Voltage**. Connect to LED Anodes.
D3,D4	C1+, C1–	**C1**. Charge pump flying capacitor #1.
C3,C4	C2+, C2–	**C2**. Charge pump flying capacitor #2.
A1, A2, B1, B2, C1, C2	D2A, D1A, D4A, D3A, D6B, D5B	**LED Outputs**
A4	EN	**Enable**. When this pin is HIGH, normal operation is enabled. When LOW, the IC is reset and all functions are disabled.
B3	PWMA	**Group-A PWM Dimming Input**
A3	PWMB	**Group-B PWM Dimming Input**

UMLP Pin Configuration

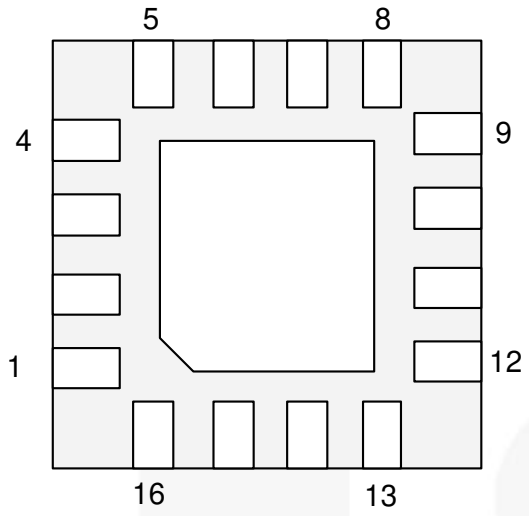


Figure 3. UMLP-16, 0.5mm Pitch, 3mm x 3mm (Bottom View)

Pin Definitions

Pin #	Name	Description
11	VIN	**Input Voltage**. Connect to 2.7 – 5.5V_{DC} input power source.
6	GND	**Ground**
12	VOUT	**Charge Pump Output Voltage**. Connect to LED Anodes.
10,9	C1+, C1–	**C1**. Charge pump flying capacitor #1.
8,7	C2+, C2–	**C2**. Charge pump flying capacitor #2.
1 ,2, 15, 16, 13, 14	D2A, D1A, D4A, D3A, D6B, D5B	**LED Inputs**
4	EN	**Enable**. When this pin is HIGH, normal operation is enabled. When LOW, the IC is reset and all functions are disabled.
5	PWMA	**Group-A PWM Dimming Input**
3	PWMB	**Group-B PWM Dimming Input**

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.	Units
V_{CC}	VIN, VOUT Pins			–0.3	6.0	V
	Other Pins[1]			–0.3	AV_{IN} + 0.3	V
ESD	Electrostatic Discharge Protection Level	Human Body Model, JESD22-A114		3		kV
		Charged Device Model, JESD22-C101	UMLP16	2		
		Charged Device Model, JESD22-C101	WLCSP-16	1		
T_J	Junction Temperature			–40	+150	°C
T_{STG}	Storage Temperature			–65	+150	°C
T_L	Lead Soldering Temperature, 10 Seconds				+260	°C

Note:
1. Lesser of V_{IN} + 0.3 or 6.0V.

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.	Units
V_{IN}	Supply Voltage	2.7	5.5	V
V_{LED}	LED Forward Voltage	2	4	V
T_A	Ambient Temperature	–40	+85	°C
T_J	Junction Temperature	–40	+125	°C

Thermal Properties

Symbol	Parameter		Min.	Typ.	Max.	Units
Θ_{JA}	Junction-to-Ambient Thermal Resistance[2]	WLCSP		80		°C/W
		UMLP		49		°C/W

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 JESD51- JEDEC standard. Special attention must be paid not to exceed junction temperature $T_{J(max)}$ at a given ambient temperate T_A.

Electrical Specifications

Unless otherwise specified; V_{IN} = 2.7V to 5.5V, T_A = -40°C to +85°C, and EN = V_{IN}. Typical values are V_{IN} = 3.6V, T_A = 25°C, I_{LED} = 20mA, and LED cathode terminals = 0.4V. Circuit and components are according to Figure 1.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
Power Supplies and Thermal Protection						
I_Q	Quiescent Supply Current	1.5x Mode, No LEDs		4.4		mA
		1x Mode, No LEDs		0.7		mA
I_{SD}	Shutdown Supply Current	EN = 0, V_{IN} = 4.5V, T_A=-40°C to +85°C		1.5	4.0	µA
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
OVP	Over-Voltage Protection			6		V
T_{LIMIT}	Thermal Shutdown			150		°C
T_{HYST}	Thermal Shutdown Hysteresis			20		°C
LED Current Sinks						
I_{LED}	Absolute Current Accuracy	$V_{CATHODE}$=0.4V, *See Options for I_{SET}*	–10%	I_{SET}	+10%	mA
$I_{LED(MAX)}$	Maximum Diode Current (3)	I_{LED}= I_{SET}		30		mA
I_{LED_MATCH}	LED Current Matching (4)	$V_{CATHODE}$=0.4V, 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 (5)	I_{LED} = 90% $I_{LED(NOMINAL)}$		65		mV
Charge Pump						
R_{OUT}	Output Resistance	1.5x Mode		2.4		Ω
		1x Mode		0.9		Ω
f_{SW}	Switching Frequency		0.9	1.2	1.5	MHz
t_{START}	Startup Time	V_{OUT} = 90% of Steady State		250		µs
PWM Dimming						
f_{PWM}	PWM Dimming Frequency	t_{ON_LED} = 15µs (Minimum)			20	kHz
D_{PWM}	PWM Duty-Cycle	f_{PWM} = 100Hz	0.15		100.00	%
Logic Inputs (EN, PWMA, PWMB)						
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	µA

Notes:

3. The maximum total output current for the IC should be limited to 180mA. The total output current can be split between the two groups (IDxA = IDxB = 30mA 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*.
4. For the two groups of current sinks on a part (GroupA and GroupB), 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 figure for the group. The matching figure for a given part is considered to be the highest matching figure of the two groups. The typical specification provided is the most likely norm of the matching figure for all parts.
5. 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} = 3.6V, T_A = 25°C, I_{LED} = 20mA, and LED cathode terminals = 0.4V.

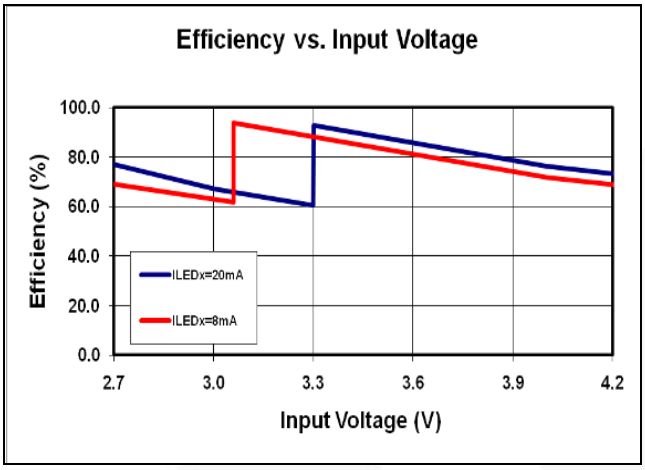


Figure 4. Efficiency with LED Current of 8mA and 20mA

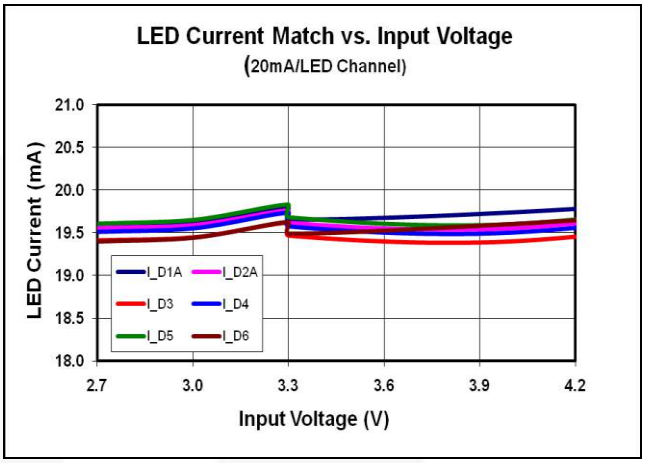


Figure 5. LED Current Match for all Six LED Channels at I_{LED}=20mA

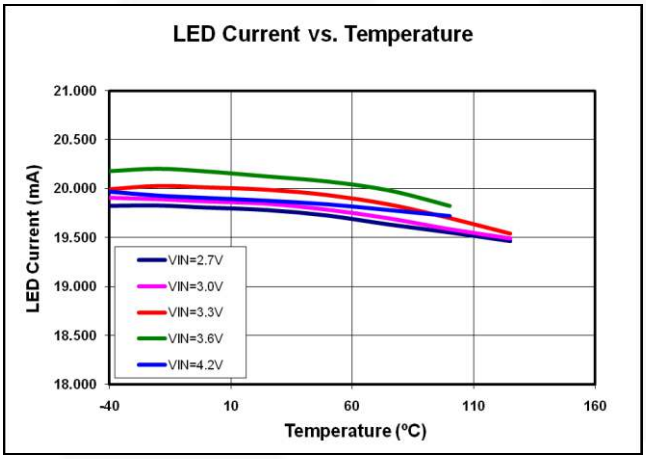


Figure 6. LED Current Variation vs. Temperature

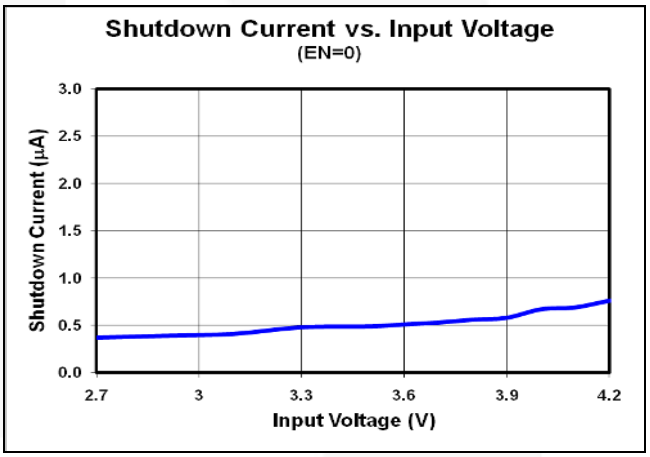


Figure 7. Shutdown Current vs. Input Voltage

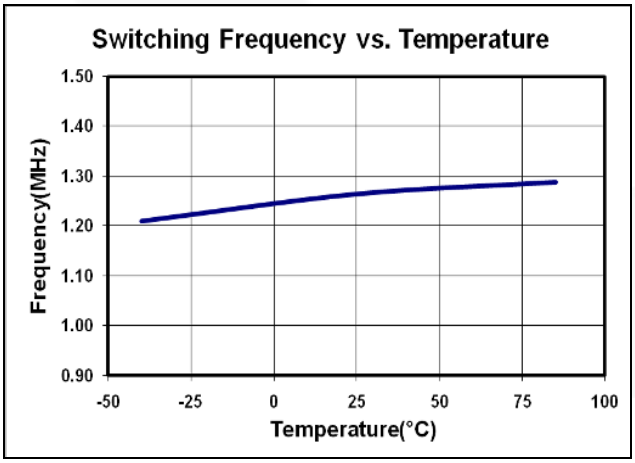


Figure 8. Switching Frequency vs. Temperature with LED Current of 20mA

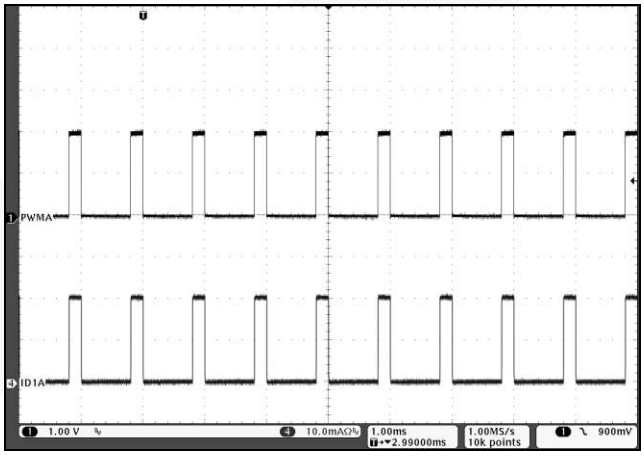


Figure 9. PWM Dimming V_{IN}=3.6V, I_{LEDx}=20mA, EN=1kHz with 20% Duty Cycle

Typical Characteristics (Continued)

V_{IN} = 3.6V, T_A = 25°C, I_{LED} = 20mA, and LED cathode terminals = 0.4V.

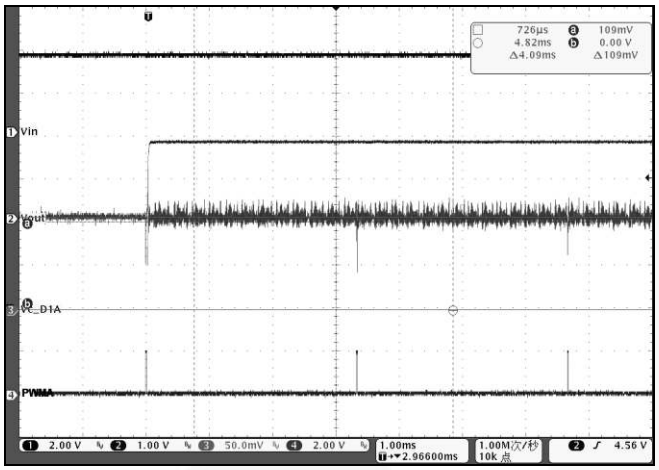


Figure 10. Mode Transition from 1x to 1.5x Mode, V_{IN}=3.6V ($V_{CATHODE}$ Ramp Up)

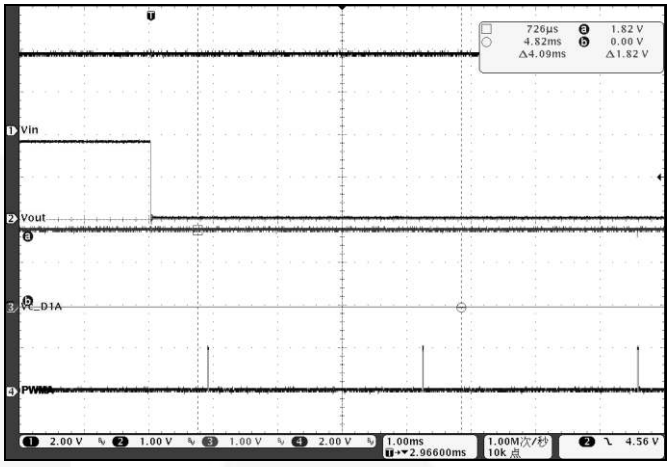


Figure 11. Mode Transition from 1.5x to 1x Mode, V_{IN}=3.6V ($V_{CATHODE}$ Ramp Down)

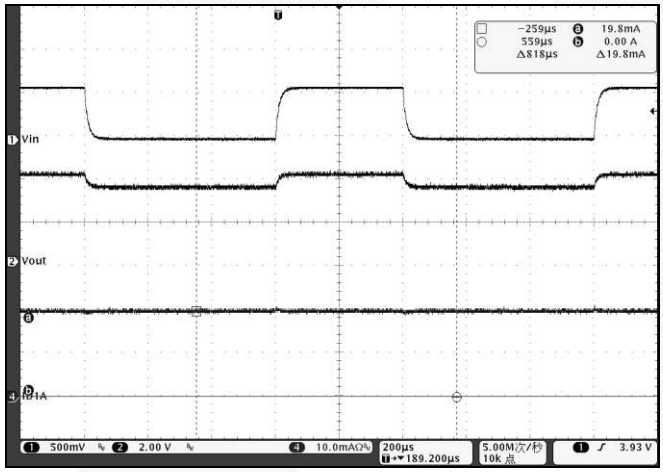


Figure 12. Line Transient Response in 1x Mode, V_{IN}=3.6V – 4.2V, I_{LEDx}=20mA

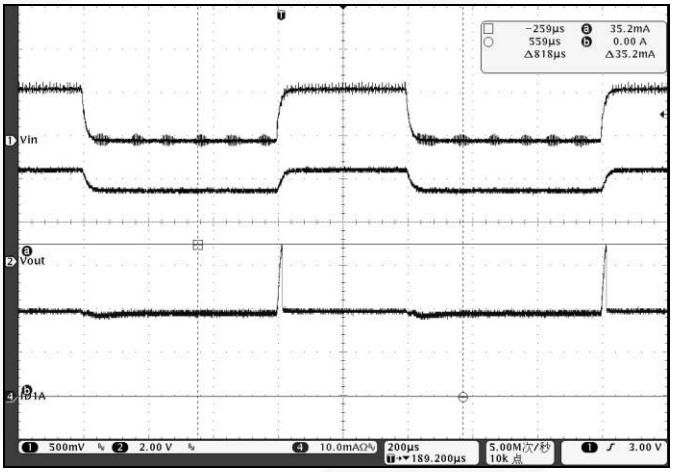


Figure 13. Line Transient Response in 1.5x Mode, V_{IN}=2.7V – 3.3V, I_{LED}=20mA

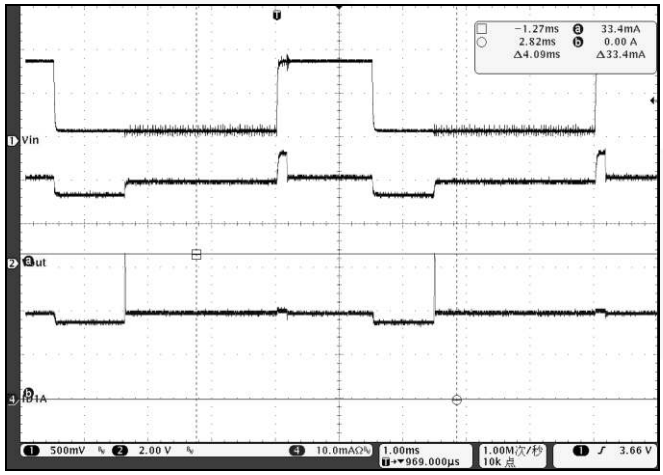


Figure 14. Line Transient from 1x to 1.5x Mode, V_{IN}=3.2V – 4.1V, I_{LEDx}=20mA

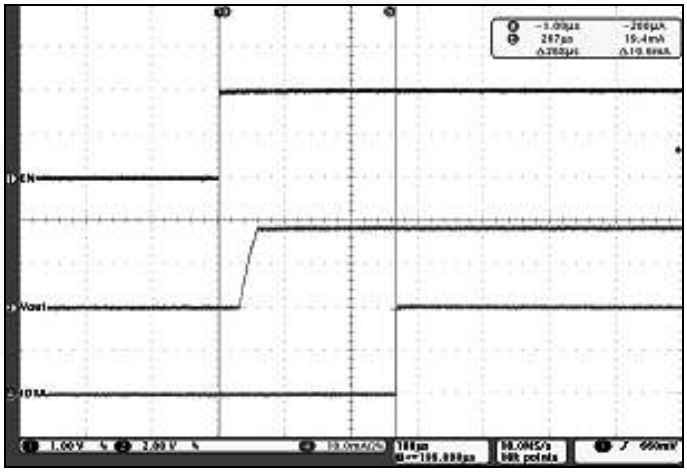


Figure 15. Soft-Start with EN, V_{IN}=3.6V, I_{LEDx}=20mA

Circuit Description

The FAN5701 is a white LED driver system based upon an adaptive 1.5x/1x charge pump capable of supplying up to 180mA of total output current. The tightly matched current sinks ensure uniform brightness across the LEDs. Each LED is configured in a common anode configuration with its peak drive current set during manufacturing (*see Ordering Information and I_{SET}*).

Charge Pump

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

In addition to hysteresis, a 1ms transition delay is provided for the device to ignore short-duration input voltage drops in deciding mode transitions.

IC Enable

When the EN pin is LOW, all circuit functions are disabled. When the EN pin HIGH, the entire chip is enabled. Both PWM inputs are now functional.

PWM Dimming

External PWM inputs (group A and group B) directly modulate output currents in their corresponding LED channels to vary the perceived LED brightness. Two PWM inputs are provided to control two independent groups of LEDs, such as that of a main display panel and a secondary panel. They can also be connected to a single input to simultaneously dim all six LED outputs.

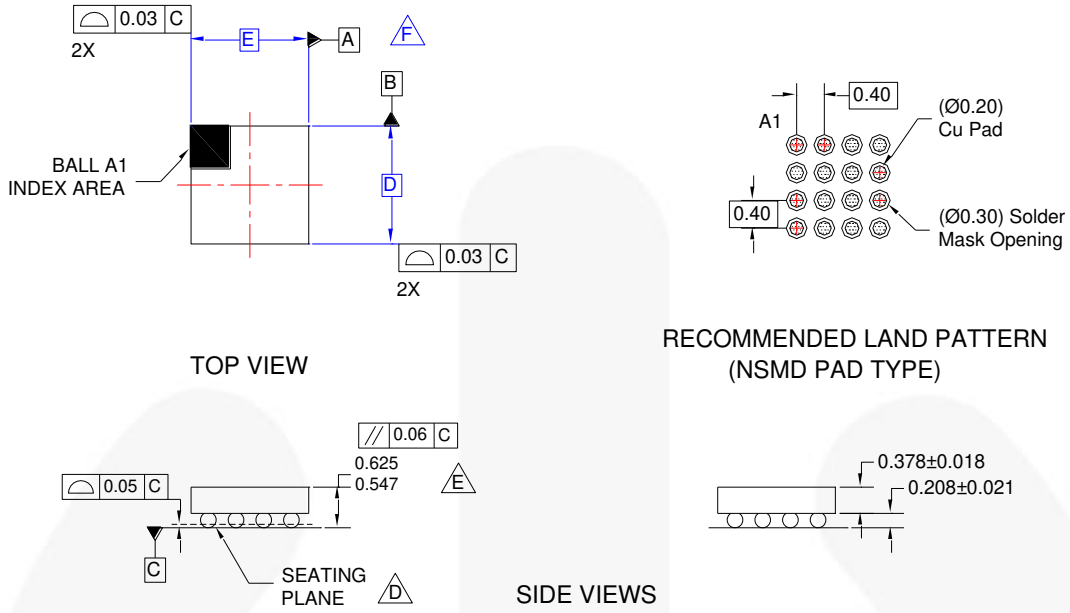
V_{OUT} Short-Circuit Protection

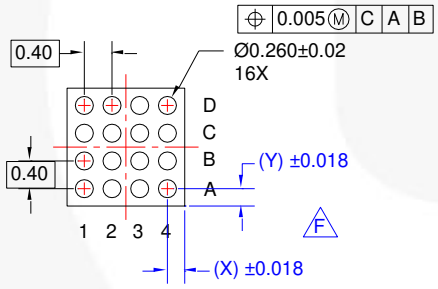
The FAN5701 has integrated protection circuitry to prevent the device from being short circuited when the output voltage falls below 2V. If this occurs FAN5701 turns off the charge pump and the LED driver outputs, but a small bypass switch is left on. The device monitors the output voltage to determine if it is still in short circuit condition and, once it has passed, FAN5701 soft-starts and returns to normal operation.

V_{OUT} Over-Voltage Protection

If the output voltage goes above 6V, the FAN5701 shuts down until this condition has passed. The charge pump and LED driver outputs are turned off. Once this condition has passed, FAN5701 soft-starts into normal operation.

Physical Dimensions





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-UC016AArev2.

Figure 16. Wafer-Level Chip-Scale Package (WLCSP)

Product-Specific Dimensions

Product	D	E	X	Y
FAN5701UCxx	1.610mm	1.610mm	0.205mm	0.205mm

Package drawings are provided as a service to customers considering Fairchild components. Drawings may change in any manner without notice. Please note the revision and/or date on the drawing and contact a Fairchild Semiconductor representative to verify or obtain the most recent revision. Package specifications do not expand the terms of Fairchild's worldwide terms and conditions, specifically the warranty therein, which covers Fairchild products.

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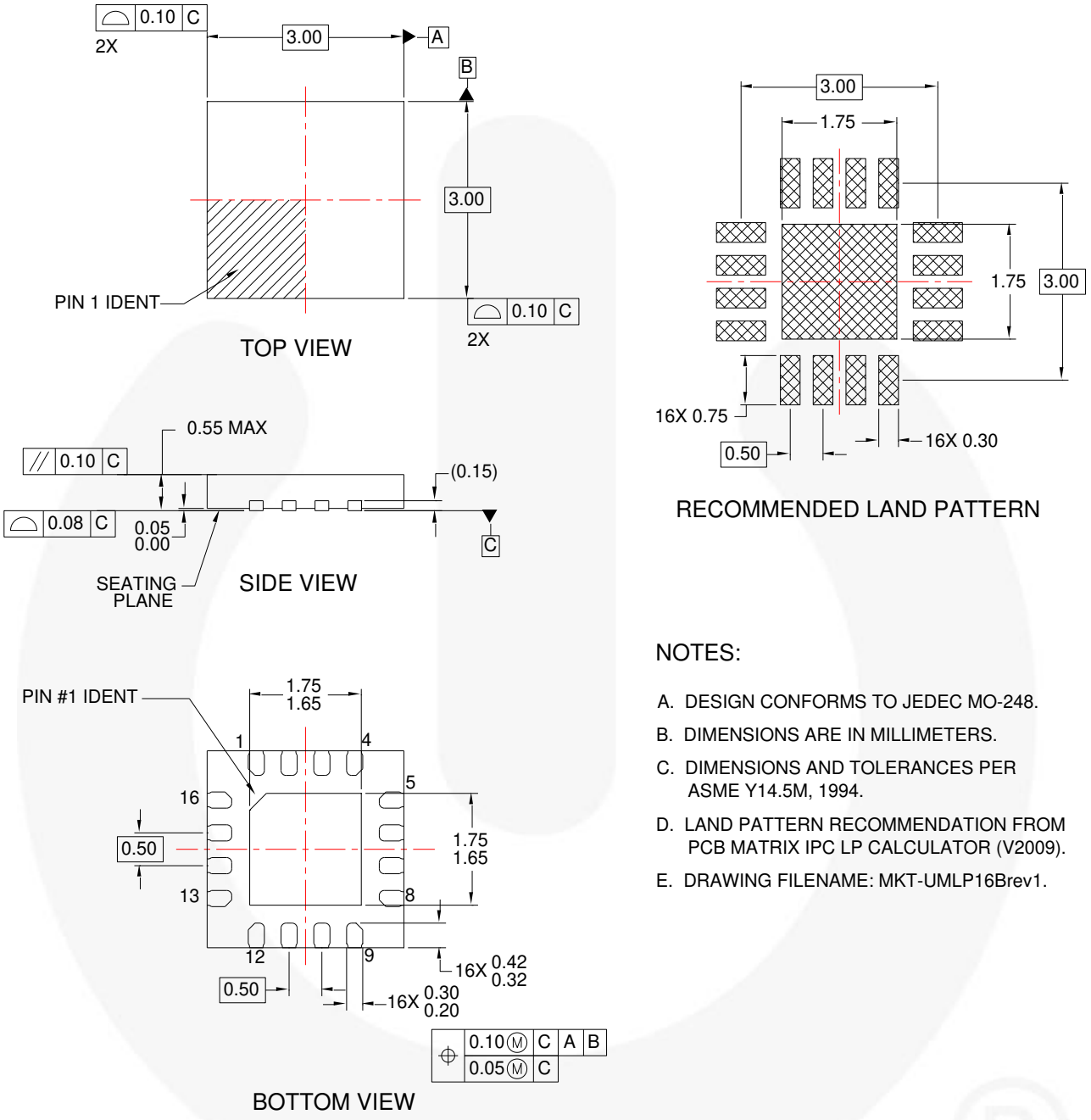
http://www.fairchildsemi.com/packaging/.

Physical Dimensions (Continued)



NOTES:

A. DESIGN CONFORMS TO JEDEC MO-248.

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.

D. LAND PATTERN RECOMMENDATION FROM PCB MATRIX IPC LP CALCULATOR (V2009).

E. DRAWING FILENAME: MKT-UMLP16Brev1.

Figure 17. UMLP-16 Dimensions

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Green FPS™ e-Series™
G*max*™
GTO™
IntelliMAX™
ISOPLANAR™
MegaBuck™
MICROCOUPLER™
MicroFET™
MicroPak™
MicroPak2™
MillerDrive™
MotionMax™
Motion-SPM™
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SuperSOT™-3
SuperSOT™-6
SuperSOT™-8
SupreMOS®
SyncFET™
Sync-Lock™
SYSTEM ®* GENERAL
The Power Franchise®
the power franchise
TinyBoost™
TinyBuck™
TinyCalc™
TinyLogic®
TINYOPTO™
TinyPower™
TinyPWM™
TinyWire™
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As used herein:

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PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

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