



# FAN5645

## Indicator LED Blinker with Single-Wire Interface

### Features

- Records and plays back blink patterns
- Single-wire digital control of LED blink rate and intensity
- Resistor-programmable LED maximum current
- High-side constant-current driver topology:
  - 20mA maximum output
  - 40mV typical dropout at 20mA
- 33µA operating current
- Standard 1.8V logic
- Short-circuit protection
- Thermal Shutdown Protection
- Under-Voltage Lockout Protection
- 6-pin 3.0 x 3.0mm MLP package

### Description

The FAN5645 is a flexible and compact solution for a blinking LED indicator. The internal programmable blink algorithm eliminates any need for continual system processor control. This means longer battery life for the hand-held system because the system processor is not awakened from sleep mode just to blink an LED.

Very low dropout of 40mV allows driving an LED without any inductors or switch capacitors.

An external resistor sets the LED output current level. LED blink rate and intensity is controlled by a simple one-wire interface. In shutdown mode, the supply current is reduced to 0.3µA (typical).

The FAN5645 is available in 6-pin molded leadless package (MLP).

### Applications

- Cell Phones, Smart-Phones
- Pocket PCs, Bluetooth® Headsets
- PDA, DSC, PMP, and MP3 Players
- Laptop Computers

### Typical Application

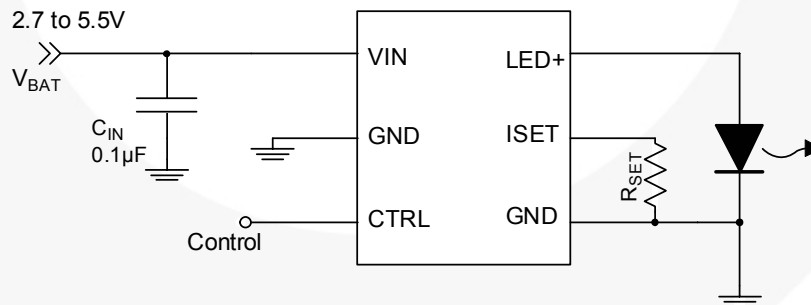


Figure 1. Typical Application for the FAN5645

### Ordering Information

Part Number	Package	Pb-Free	Operating Temperature Range	Packing Method
FAN5645MPX	MLP-6 3.0 x 3.0mm		-40°C to 85°C	Tape and Reel

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### Block Diagram

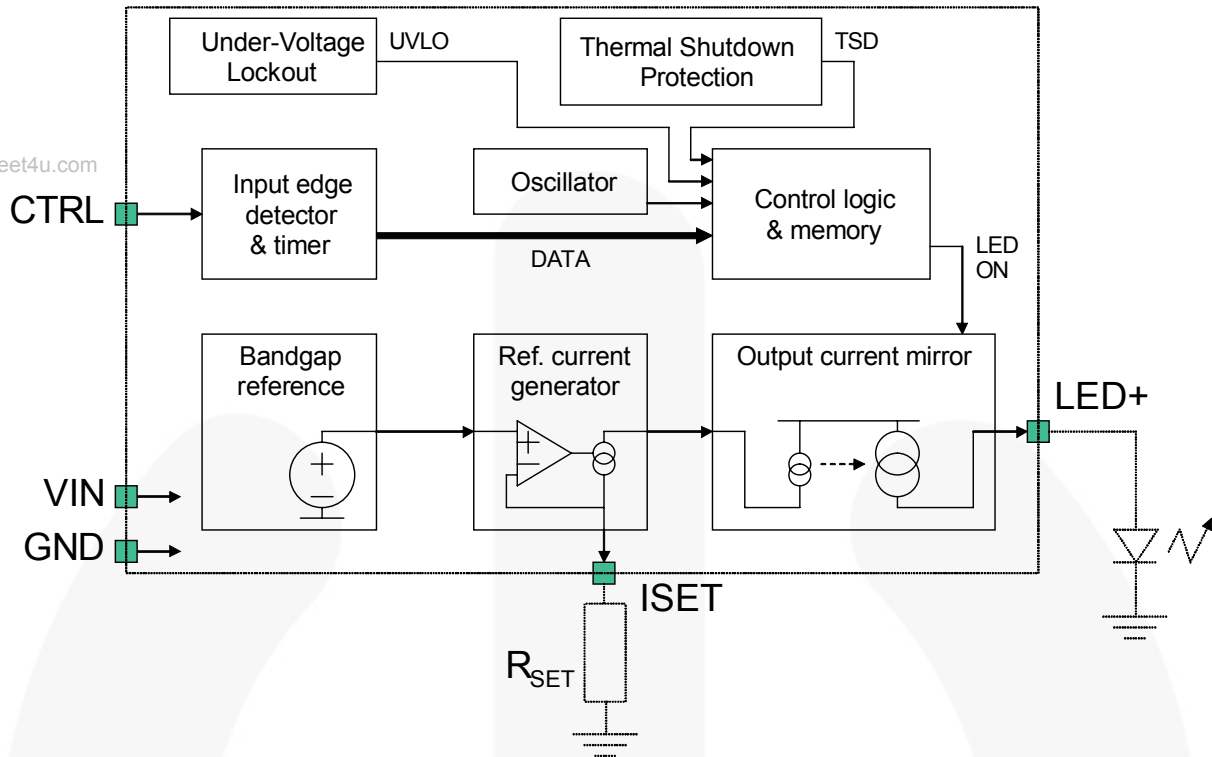


Figure 2. Block Diagram

### Pin Configuration

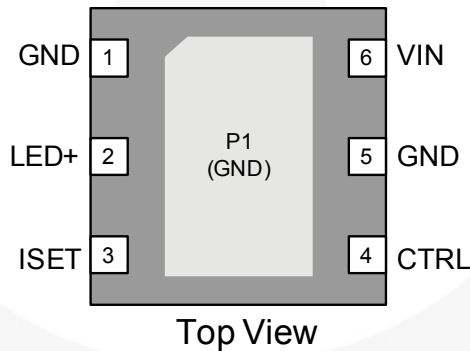


Figure 3. MLP Pin Assignments

### Pin Definitions

Pin #	Name	Description
1	GND	<b>Ground.</b> 0V reference for all voltages.
2	LED+	<b>LED output.</b> Connect to anode of LED.
3	ISET	<b>Current Set.</b> Resistor to GND sets maximum LED current 1:400.
4	CTRL	Digital single wire interface. Program STOP/TRAIN/RUN sequences.
5	GND	<b>Ground.</b> 0V reference for all voltages.
6	VIN	<b>Power input.</b>

## 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>IN</sub> , LED+, CTRL Voltage	-0.3	+6.0	V
	ISET Voltage	-0.3	V <sub>IN</sub> +0.2	V
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
ESD	Electrostatic Discharge Protection Level	HBM	7	kV
		CDM	2	
		HBM (on LED+ pin)	8	

## 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 <sub>IN</sub>	Power Supply Voltage Range	2.7	5.5	V
I <sub>OUT</sub>	Output Current	1	20	mA
R <sub>SET</sub>	Resistor Used to Set LED Current	24.7	494.0	kΩ
T <sub>A</sub>	Operating Ambient Temperature Range	-40	+85	°C
T <sub>J</sub>	Operating Junction Temperature Range	-40	+125	°C

## Electrical Specifications

$V_{IN} = 2.7V$  to  $5.5V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ ,  $V_f = 1.8V$  to  $(3.5V$  or  $V_{IN}-0.1V$ , whichever is smaller). Typical values are at  $T_A = 25^{\circ}C$ ,  $V_{IN} = 3.6V$ , and  $V_f = 2.5V$ .

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
<b>Power Supplies</b>						
$I_{SD}$	Shutdown current in STOP (sleep) mode	$V_{IN} = 3.6V$		0.30	0.75	$\mu A$
$I_{IN}$	Operating current in RUN, TRAINING, RUN_ONCE, RESET_FOLLOW modes	$V_{IN} = 3.6V$ , $I_{LED} = 0mA$		33	55	$\mu A$
$V_{IH}$	Control high-level input voltage		1.2			V
$V_{IL}$	Control low-level input voltage				0.4	V
$I_{IH}$	Control pin input current	CTRL = 1.8V		1	100	nA
$V_{UVLO}$	Under-voltage lockout threshold	$V_{IN}$ Rising		2.5		V
		$V_{IN}$ Falling		2.2		V
<b>Regulation</b>						
$I_{OUT}$	Maximum regulated output current	Sourced from LED+ pin	20			mA
	Minimum regulated output current	Sourced from LED+ pin			1	
$I_{OUT\_RIPPLE}$	Maximum LED ripple current <sup>(1)</sup>	$\Delta V_{IN} = 700mV$ , $t_{rise} = t_{fall} = 10\mu s$ , $T = 570\mu s$		0.5		% p-p
$\Delta I_{SET}$	$I_{SET}$ accuracy	$T_A = 25^{\circ}C$ , $I_{LED} = 1mA-20mA$	-3		+3	%
$I_{SET\_LINEARITY}$	$I_{SET}$ linearity	$I_{LED} = 1mA-20mA$		5		%
$\Delta I_{OUT\_LOAD}$	$I_{OUT}$ load regulation	LED $V_f = 1.8$ to $3.5V$ , $V_{IN} = 3.6V$	-3		+3	%
$\Delta I_{OUT\_LINE}$	$I_{OUT}$ line regulation	$V_{IN} = 2.7$ to $4.8V$ , $V_f = 2.5V$	-3		+3	%
$V_{ISET}$	$I_{SET}$ voltage	$24k\Omega \leq R_{SET} \leq 494k\Omega$		1.235		V
$I_{SET\_LIM}$	$I_{SET}$ current limit	$V_{LED+} = 0V$ , $V_{ISET} = 0V$		150		$\mu A$
	Current mirror ratio	$I_{OUT} / I_{SET}$		400		
$V_{DROPOUT}$	Dropout voltage	$I_{LED} = 20mA$ , -10% drop		40		mV
$I_{SC}$	Short-circuit current limit	$R_{SET}$ or $I_{OUT}$ w.r.t GND		60	80	mA
TSD	Thermal shutdown	Rising Temperature at Junction		150		$^{\circ}C$
		Hysteresis		20		$^{\circ}C$
<b>Timing</b>						
$f_{OSC}$	Internal oscillator frequency	$V_{IN} = 3.6V$	51	64	77	kHz
$T_{OSC}$	Oscillator stability		-3		3	%
$t_{ON}$	LED on-time resolution <sup>(1)</sup>			1		ms
$t_{OFF}$	LED off-time resolution <sup>(1)</sup>			10		ms

### Note:

1. Guaranteed by design; not tested in production.

## Circuit Description

### Operational Modes

At power up, the device is in STOP (“SLEEP”) mode until a rising edge of a CTRL signal is detected and the device goes into active mode. Depending upon the signal applied to CTRL, active mode can be TRAINING, RUN, RUN ONCE, or FOLLOW AFTER RESET.

#### Initialization

The reference and the circuit remain in SLEEP mode until  $V_{IN}$  crosses the UVLO threshold and a rising edge on the CTRL pin is detected. When the IC is in SLEEP mode, all internal bias circuits are disabled. The training registers are all reset to 0 at power up.

#### Training Mode

The IC can record a pattern of up to three distinct HIGH ( $T_{ON}$ ) and LOW ( $T_{OFF}$ ) times. These times are recorded during training in six internal 8-bit counters, one counter for each distinct  $T_{ON}$  and  $T_{OFF}$  time. If the training pulse ON or OFF time exceeds the maximum clock counts, the value is held at the maximum.

TRAINING mode contains the following sequence:

1. Two control pulses, finished within  $T_{CMD1}$ . The HIGH time of the control pulses should be greater than  $2\mu s$  and less than  $55\mu s$ . The LOW time between two control pulses should be greater than  $2\mu s$ .
2. CTRL held LOW, for at least  $T_{FTPR(MIN)}$ , but less than  $T_{FTPR(MAX)}$ , measured from the first rising edge of the control pulse.
3. Between one and three sets of training pulses, where a training pulse defines the LED's on time  $T_{ON}$  and off-time  $T_{OFF}$ .
4. Three control pulses finished within  $T_{CMD2}$  to signify end of training. The HIGH time of the control pulses should be greater than  $2\mu s$  and less than  $55\mu s$ . The LOW time between two control pulses should be greater than  $2\mu s$ .
5. The IC enters STOP (SLEEP) mode and is able to receive a new command only after  $T_{CMD2}$  expires.
6. If no end-of-training controls pulses are received after  $T_{OFF3}$  maximizes out, the IC enters STOP (SLEEP) mode automatically.

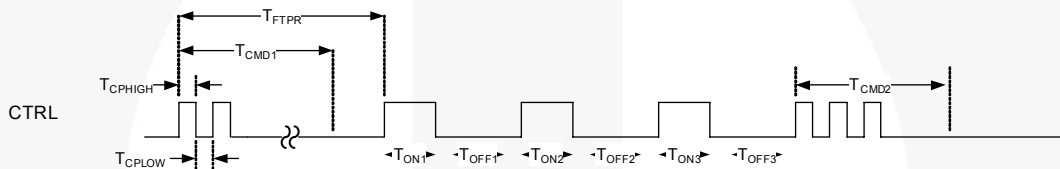


Figure 4. TRAINING Mode

#### RUN Mode

When CTRL is raised and held HIGH, and training registers are not all zeros, repetitive playback of the trained sequence commences. The delay between CTRL HIGH and LED on is  $T_{DLY1}$ . When CTRL

subsequently goes LOW, the IC turns off the LED and enters STOP (SLEEP) mode. After a  $T_{CMD2}$  time, a new command can be processed.

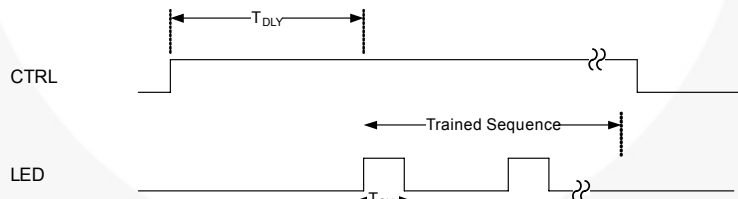


Figure 5. RUN Mode

#### Run Once Mode

When the IC receives four consecutive control pulses within  $T_{CMD1}$ , followed by CTRL going HIGH after at least  $T_{FTPR(MIN)}$ , but less than  $T_{FTPR(MAX)}$ , the IC plays

back the trained pattern once, then enters STOP (SLEEP) mode after the trained sequence is completed. This assumes that training registers are not all zeros.

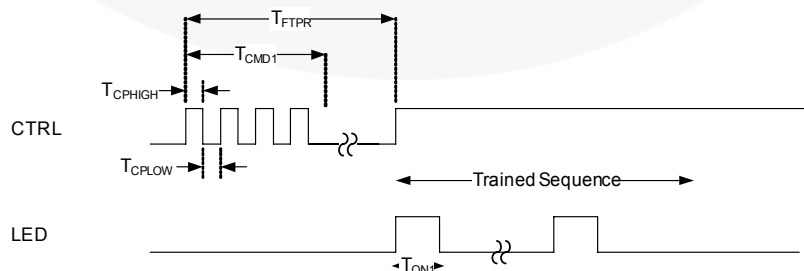


Figure 6. RUN ONCE Mode

### RESET and FOLLOW Modes

Reset mode consists of two control pulses, then CTRL goes LOW for longer than  $T_{TIMEOUT}$ . The IC clears all training registers to zero, then enters STOP (SLEEP) mode.

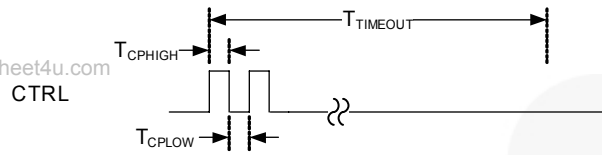


Figure 7. RESET Mode

After the IC goes through RESET mode; if CTRL goes HIGH again for longer than  $T_{DLY}$ , the IC begins Follow mode, which causes the LED to be turned ON when CTRL is HIGH. The IC delays turning on the LED after the rising edge of CTRL by  $T_{DLY}$  to determine whether the CTRL rising edge is to be interpreted as a command to turn the LED ON or the beginning of a new

set of control pulses. When the CTRL signal goes LOW, LED current is turned off and the IC enters STOP (SLEEP) mode. A  $T_{CMD2}$  waiting period, after the last trailing edge of the CTRL input, is necessary before a new command can be received and processed.

Note that FOLLOW mode can be entered upon power up as well, because all registers are cleared on power up and the device acts as if in RESET mode.

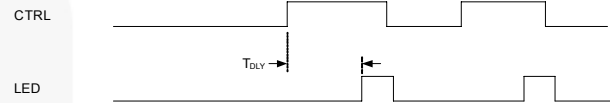


Figure 8. FOLLOW Mode

### Timing

Symbol	Description	Min.	Typ.	Max.	Units
$T_{CMD1}$	Maximum time window in which starting control pulses must be finished			0.8	ms
$T_{FTPR}$	Time window from first control pulse rising edge to first rising edge of training pulse	1.5		1.7	ms
$T_{CMD2}$	Maximum time window in which ending control pulses must be finished			0.85	ms
$T_{TIMEOUT}$	Minimum time window CTRL line has to stay LOW after control pulses to enter and finish RESET mode (starting from the first rising edge of the control pulse)	4.0			ms
$T_{DLY}$	Time delay in playback or follow mode b/t rising edge of CTRL line to when LED turns ON for the first time	0.95	1.10	1.45	ms
$T_{CPHIGH}$	Control pulse HIGH width	2		55	$\mu$ s
$T_{CPLow}$	Control pulse LOW width	2			$\mu$ s
$T_{ON1}$	LED ON time in Run modes	1.0		255.0	ms
$T_{OFF1}$	LED OFF time in Run modes	10		2550	ms
$T_{RESTART}$	Over-temperature or over-current fault time in Follow mode		10		ms

### Over-Current, Over-Temperature, and Under-Voltage Faults

An over-current fault occurs if the ISET pin is shorted to GND or the  $R_{SET}$  resistor value is too low. If the resulting LED current is greater than three times the maximum programmed output current (60mA), the IC shuts down its output current and disables the reference voltage developed on the ISET pin.

An over-temperature fault occurs when the IC exceeds 150°C, which also causes the IC to shut down its output current and disable the reference voltage developed on the ISET pin until the IC cools by about 20°C.

If either fault occurs, the IC turns off the output LED current and disables the reference voltage developed

on the ISET pin. If a short-circuit or over-temperature fault occurs during playback modes, playback is retried when the next playback pulse ( $T_{ON}$ ) comes. If a short-circuit or over-temperature fault occurs during Follow mode, the LED turns off for  $T_{RESTART}$ , then Follow mode tries to resume the LED current according to the current state of the CTRL line.

If an under-voltage fault occurs, the IC turns off the LED and enters SLEEP mode until the next control pulse comes, at which point the IC tries to wake up.

## Application Information

### Setting the LED Current

The LED forward current is established by the external resistor,  $R_{SET}$ , according to:

$$I_{LED} = 400 \cdot 1.235V / R_{SET} \quad \text{EQ.1}$$

where

$$1.235V = \text{Typical } I_{SET} \text{ voltage, and}$$

$$400 = \text{Typical current mirror ratio.}$$

The  $I_{LED}$  accuracy is determined by the tolerance of the above parameters over the input voltage and the ambient temperature range as well the tolerance of the  $R_{SET}$  resistance. For best accuracy,  $R_{SET}$  should be a precision resistor, connected close to the IC pins, so that the voltage across  $R_{SET}$  is identical to the voltage between the ISET and GND pins.

Programming the LED ON times below 20 - 30ms appears as a flash, rather than as a blink with an observable ON time, to the observer. The brightness of such a flash is determined by the energy delivered during the flash. It is possible to change the apparent brightness by varying the ON / OFF time ratio, keeping the frequency higher than 40Hz.

Since the resolution of the ON time is in 1ms increments, a dimming function for 20 discrete levels of brightness can be implemented via software.

### Selecting External Components

A ceramic capacitor of 0.1 $\mu$ F or more can be added between  $V_{IN}$  and GND to reduce the electrical noise at the power supply line.

The minimum value of  $V_{IN}$  should exceed  $V_f$  by as little as 40mV to ensure the LED current is regulated at the right value. Conversely, the LED should be selected to have the  $V_f$  at the specified current, at least 40mV lower than the minimum  $V_{IN}$ .

The LEDs utilized as blinking indicators, driven by the FAN5645, may be white or any color. The forward current voltage characteristics and the absolute maximum ratings are provided by the manufacturer in their technical specifications. The typical forward voltage at 15mA current is 1.9V for red and orange, 2V for yellow, 2.1V for green, and 3.3V for bright white, bright non-yellowish green, and most blue types.

Meet the maximum rated current of the LED only under favorable conditions with little or no heat buildup. Some LED current ratings assume really favorable test conditions - such as surrounded by air no warmer than 25°C and decent thermal conduction from where the leads are mounted. Running LEDs at specified laboratory conditions used for maximum current rating can cause LEDs to lose half the light output after rated life expectancy (20,000 to 100,000 hours), best-case.

## Typical Performance Characteristics

Unless otherwise noted,  $V_{IN} = V_{EN} = 3.6V$ ,  $T_A = 25^\circ C$ , white LED with  $V_f = 3.3V$  at  $I_{LED} = 20mA$ .

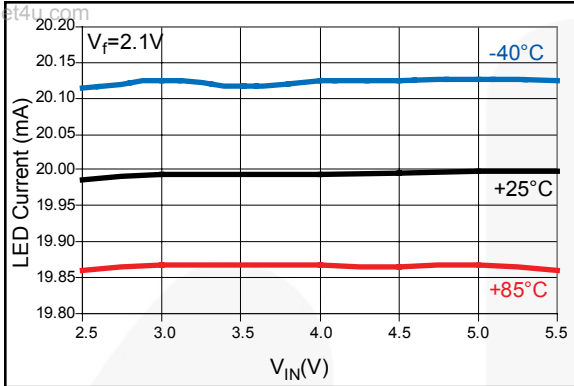


Figure 9. Line Regulation

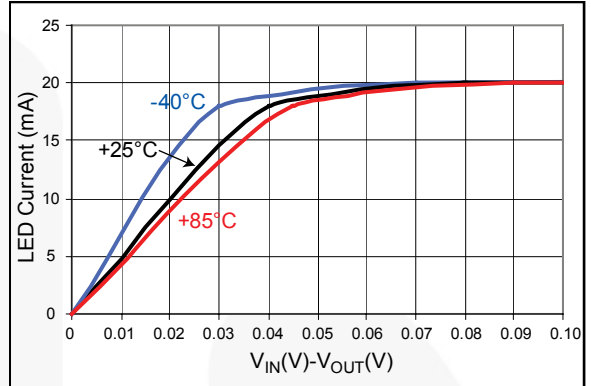


Figure 10. LED Current vs. Headroom Voltage

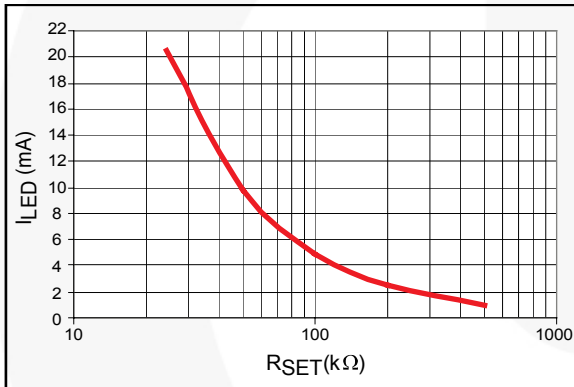


Figure 11. LED Current vs. RSET Resistance

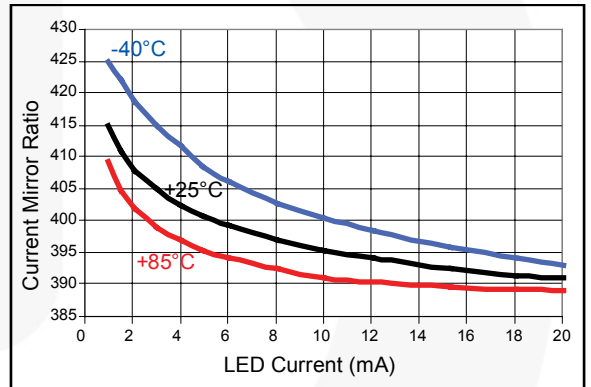


Figure 12. Current Mirror Ratio vs. Output Current

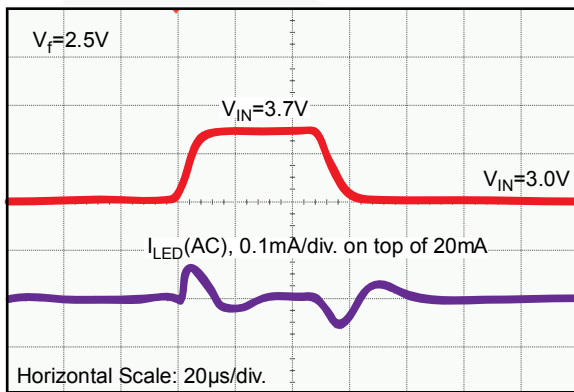


Figure 13. Line Transient Response

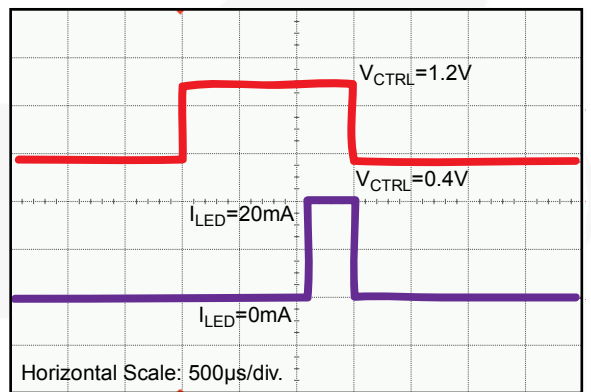
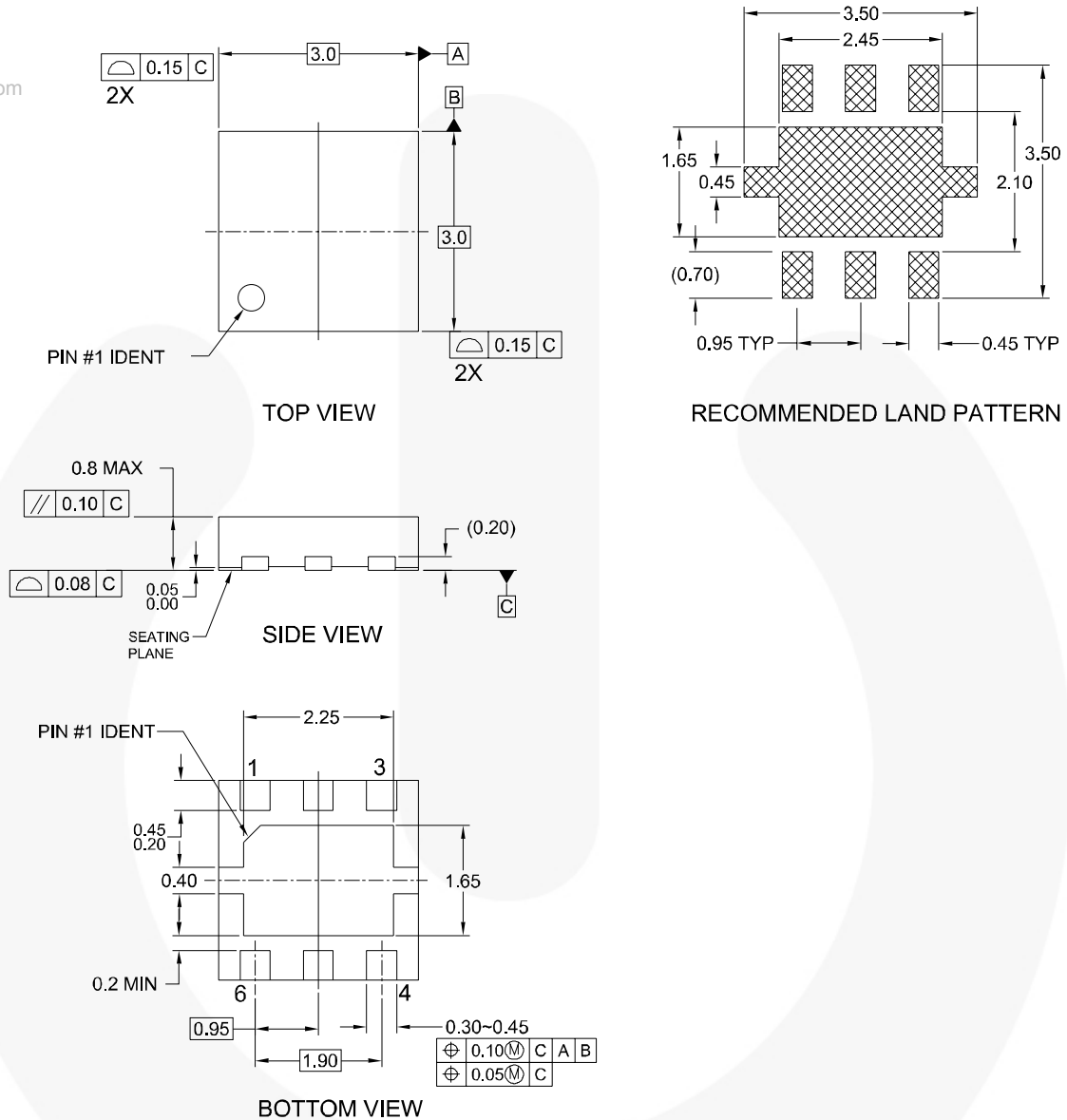


Figure 14. Active Modes Delay



Physical Dimensions

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NOTES:

- A. CONFORMS TO JEDEC REGISTRATION MO-229, VARIATION WEEA, DATED 11/2001 EXCEPT FOR DAP EXTENSION TABS
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994


MLP06FrevA

Figure 15. 6-Pin Molded Leadless Package



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| FPS <sup>™</sup>                     |  <sup>®</sup> | SuperSOT <sup>™</sup> -3               | VCX <sup>™</sup>                 |
| FRFET <sup>®</sup>                   | PDP-SPM <sup>™</sup>   | SuperSOT <sup>™</sup> -6               |                                  |
| Global Power Resource <sup>SM</sup>  | Power220 <sup>®</sup>  |  |                                  |

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**PRODUCT STATUS DEFINITIONS**

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Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This 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	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
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