Ordering number : ENA2176

LV52204MU

Bi-CMOS IC

LED Boost Driver with PWM and 1-Wire Dimming

ON Semiconductor®

http://onsemi.com

Overview

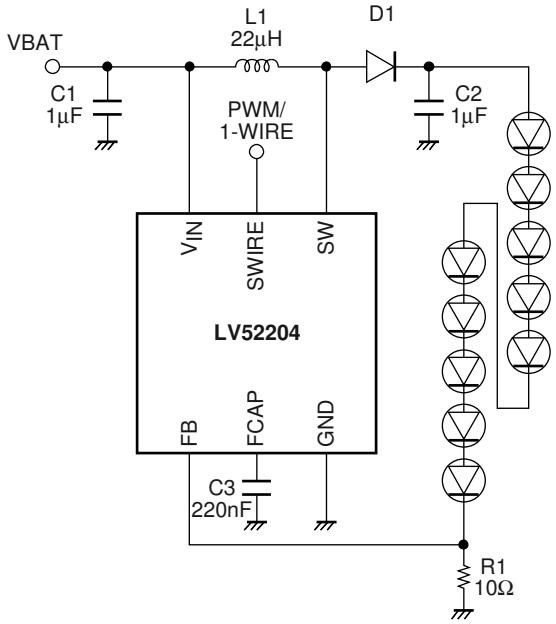
The LV52204MU is a high voltage boost driver for LED drive. LED current is set by the external resistor R1 and LED dimming can be done by changing FB voltage with PWM or 1-Wire.

Features

- Operating Voltage from 2.7V to 5.5V
- 1-Wire 32 level digital and PWM dimming
- Integrated 40V MOSFET
- 600kHz Switching Frequency

Typical Applications

- LED Display Backlight Control



Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{CC} max	V_{CC}	5.5	V
Maximum pin voltage1	V1 max	SW	40	V
Maximum pin voltage2	V2 max	Other pin	5.5	V
Allowable power dissipation	Pd max	Ta = 25°C *1	2.05	W
Operating temperature	Topr		-30 to +85	°C
Storage temperature	Tstg		-55 to +125	°C

*1 Mounted on a specified board: 70mm×50mm×1.2mm (4 layer glass epoxy)

Caution 1) Absolute maximum ratings represent the values which cannot be exceeded for any length of time.

Caution 2) Even when the device is used within the range of absolute maximum ratings, as a result of continuous usage under high temperature, high current, high voltage, or drastic temperature change, the reliability of the IC may be degraded. Please contact us for the further details.

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Recommendation Operating Condition at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range1	V_{CC} op	V_{CC}	2.7 to 5.5	V
PWM frequency	Fpwm	PWM MODE	300 to 100k	Hz

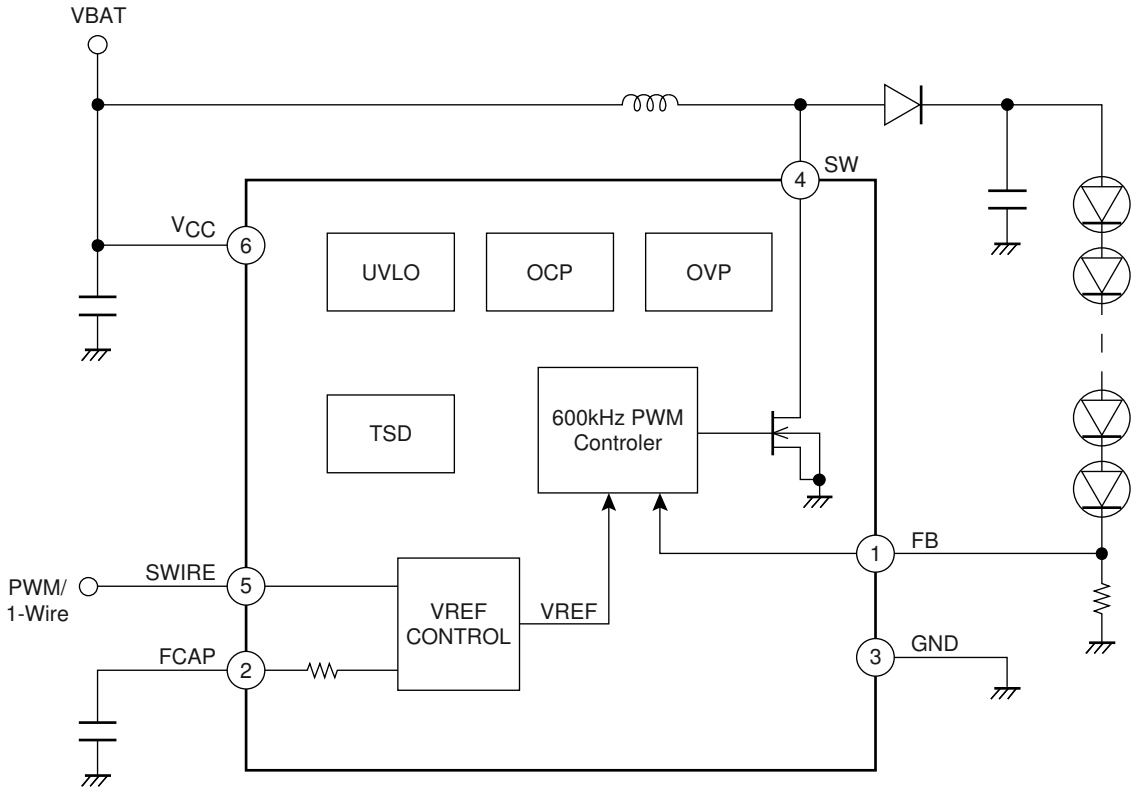
Electrical Characteristics Analog block at Ta = 25°C, V_{CC} = 3.6V, unless otherwise specified

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby current dissipation	$I_{CC}1$	SHUTDOWN		0	5	μA
DC/DC current dissipation	$I_{CC}2$	V_{OUT} = 30V, I_{LED} = 20mA			1	mA
FB voltage	Vfb	PWM duty 100%	0.19	0.2	0.21	V
FB pin leak current	Ifb				1	μA
OVP voltage	Vovp	SW	37	38	39	V
SWOUT ON resistance	Ron	IL = 100mA		700		mΩ
NMOS switch current limit	ILIM	Vfb = 200mV		0.7		A
OSC frequency	Fosc			600		kHz
High level input voltage	V_{IN}H	SWIRE	1.5		V_{CC}	V
Low level input voltage	V_{IN}L	SWIRE	0		0.4	V
Under voltage lockout	Vuvlo	V_{IN} falling		2.2		V
SWIRE output voltage for Acknowledge	Vack	Rpullup = 15kΩ			0.4	V

Recommended SWIRE Timing at Ta = 25°C, V_{CC} = 3.6V, unless otherwise specified

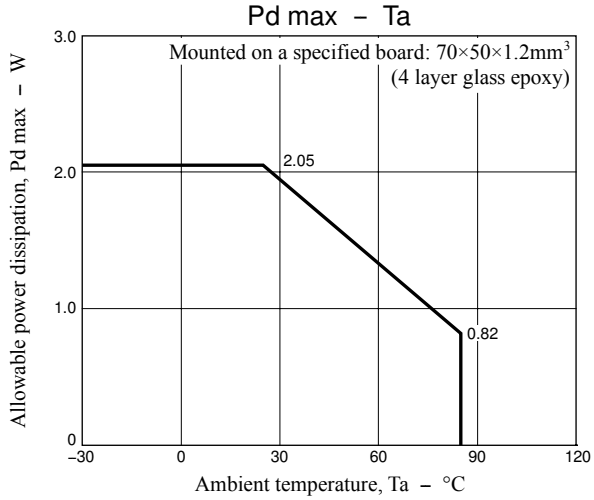
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
SWIRE setup time from shutdown	Ton		20			μs
SWIRE mode selectable time	Tsel		1		2.2	ms
SWIRE delay time to start digital mode detection	Tw0		100			μs
SWIRE low time to switch to digital mode	Tw1		260			μs
SWIRE low time to shutdown	Toff		8.9			ms
SWIRE start time for digital mode programming	Tstart		2			μs
SWIRE end time for digital mode programming	Tend		2		360	μs
SWIRE High time of bit 0	Th0	Bit detection = 0	2		180	μs
SWIRE Low time of bit 0	Tl0	Bit detection = 0	Th0 × 2		360	μs
SWIRE High time of bit 1	Th1	Bit detection = 1	Tl1 × 2		360	μs
SWIRE Low time of bit1	Tl1	Bit detection = 1	2		180	μs
DCDC startup delay	Tdel			2		ms
Delay time of Acknowledge	Tackd				2	μs
Duration of Acknowledge	Tack				512	μs

Block Diagram



Pin Function

PIN #	Pin Name	Description
1	FB	Feedback pin.
2	FCAP	Filtering capacitor terminal for PWM mode.
3	GND	Ground
4	SW	Switch pin. Drain of the internal power FET.
5	SWIRE	1-wire dimming control and PWM dimming input (active High).
6	V_{CC}	Supply voltage.
	Expose-pad	Connect to GND on PCB.



LED Current Setting

LED current is set by an external resistor connected between the FB pin and ground.

$$I_{LED} = V_{FB}/R_{FB}.$$

The V_{FB} can be controled by two dimming modes, PWM Mode or Digital Mode.In PWM mode, PWM input is converted into a near DC current by the internal resistor R that was equivalent to 60kΩ (±10%) and the external capacitor C_{FCAP} as a low pass filter with a cut-off frequency fc = $1/2\pi R_{FCAP}$. The V_{FB} can be adjusted by altering the duty cycle of the PWM signal (See Fig.1).

$$V_{FB} = 200\ (mV) \times PWM\ Duty\ (\%)$$

On the other hand, V_{FB} can be selected one from among 32steps in Digital Mode (See Fig.2).

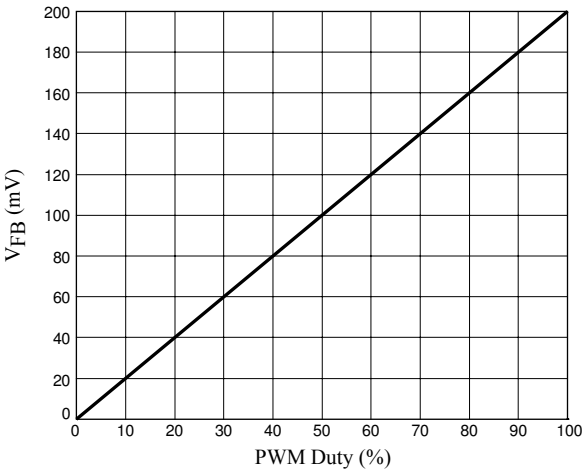


Fig1. V_{FB} *vs. PWM Duty (PWM mode)*

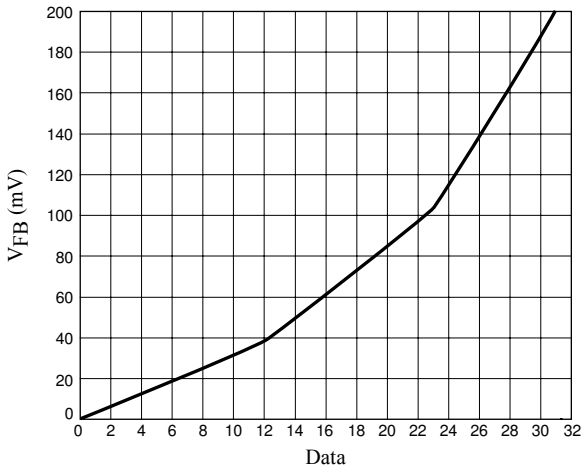


Fig2. V_{FB} *vs. Data Register Value (Digital mode)*

Dimming Mode Selection

Dimming Mode is selected by a specific pattern of the SWIRE within Tsel (1ms) from the startup of the device every time. In order to startup the device, the SWIRE must keep high for longer than Ton.

PWM Mode

The dimming mode is set to PWM mode when it is not recognized as a digital mode within Tsel. To enter Digital Mode, the SWIRE is required keeping in low state for Tw1 (See Fig.4). If the PWM frequency is used faster than 6.6kHz, the dimming mode is set to PWM mode only. But slower than 6.6kHz, it is necessary to avoid entering the digital mode condition, such as SWIRE keeps high for longer than Tsel. PWM is enabled after Tdel from Tsel.

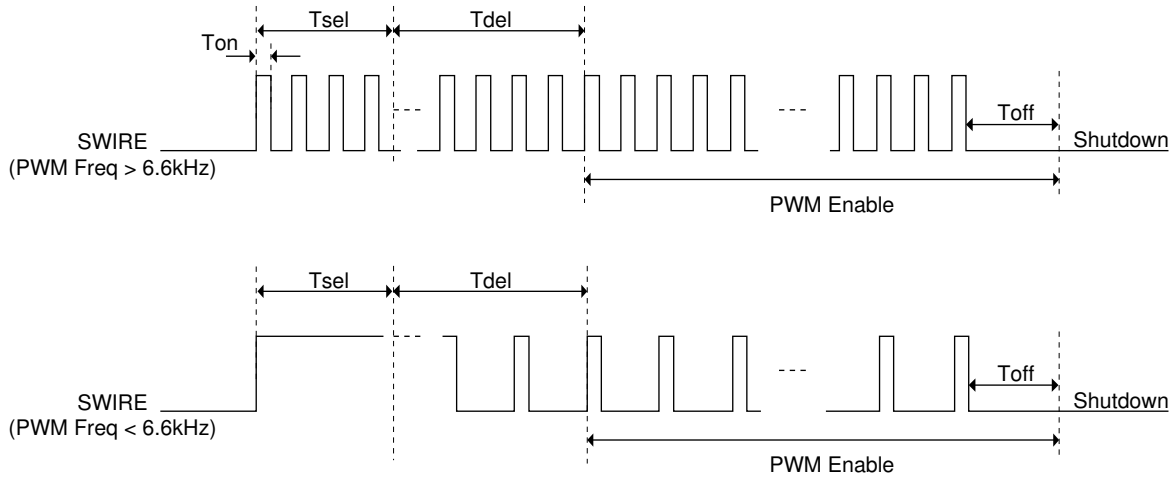


Fig3. SWIRE Timing Diagram in PWM mode

Digital Mode

To enter Digital Mode, SWIRE should be taken high for more than Tw0 (100µs) from the first rising edge and keep low state for Tw1(260µs) before Tsel(1ms).

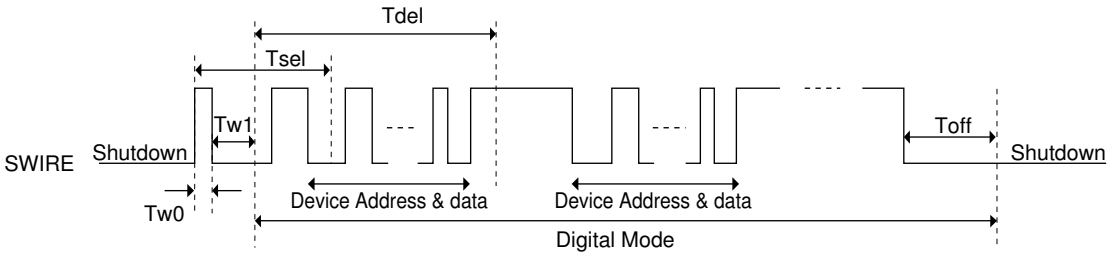


Fig4. SWIRE Timing Diagram in Digital mode

It is required sending the device address byte and the data byte to select V_{FB}. The bit detection is determined by the ratio of Th and Tl (See Fig6). The start condition for the bit transmission required SWIRE high for at least Tstart. The end condition is required SWIRE low for at least Tend.When data is not being transferred, SWIRE is set in the "H" state. These registers are initialized with POR (Power On Reset).
In the LV52204MU, the device address (DA7 to DA0) is specified as "01110010". D7 is setting for the acknowledge response. If the device address and the data byte are transferred on D7 = 1, the ACK signal is sent from the receive side to the send side. The acknowledge signal is issued when SWIRE on the send side is released and SWIRE on the receive side is set to low state. D6 and D5 need to send 0. D4 to D0 allow to changing the FB voltage.

	Register	BIT	Description
Device Address	DA7	7	0
	DA6	6	1
	DA5	5	1
	DA4	4	1
	DA3	3	0
	DA2	2	0
	DA1	1	1
	DA0	0	0

Table1. Device Address Description

	Register	BIT	Description
Data	D7	7	0 = Acknowledge disabled 1 = Acknowledge enabled
	D6	6	0
	D5	5	0
	D4	4	Data bit 4
	D3	3	Data bit 3
	D2	2	Data bit 2
	D1	1	Data bit 1
	D0	0	Data bit 0

Table2. Data Description

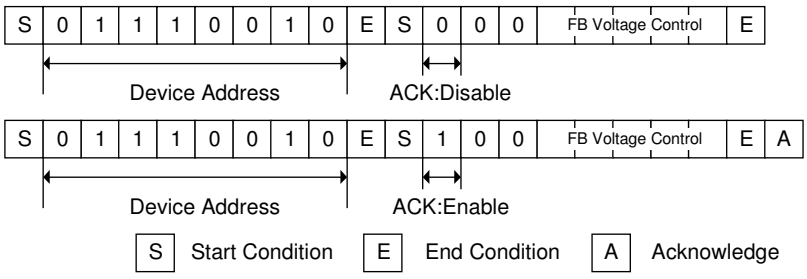


Fig5. Example of writing data

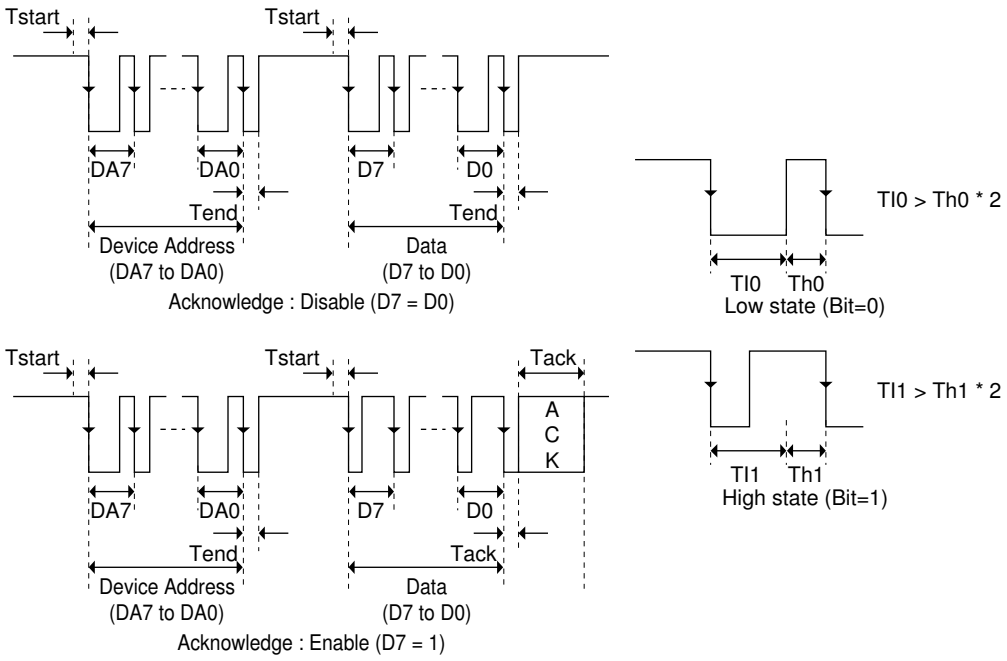


Fig6.Bit detection Diagram

	D7	D6	D5	D4	D3	D2	D1	D0	FB voltage (mV)
0	1/0	0	0	0	0	0	0	0	0
1	1/0	0	0	0	0	0	0	1	5
2	1/0	0	0	0	0	0	1	0	8
3	1/0	0	0	0	0	0	1	1	11
4	1/0	0	0	0	0	1	0	0	14
5	1/0	0	0	0	0	1	0	1	17
6	1/0	0	0	0	0	1	1	0	20
7	1/0	0	0	0	0	1	1	1	23
8	1/0	0	0	0	1	0	0	0	26
9	1/0	0	0	0	1	0	0	1	29
10	1/0	0	0	0	1	0	1	0	32
11	1/0	0	0	0	1	0	1	1	35
12	1/0	0	0	0	1	1	0	0	38
13	1/0	0	0	0	1	1	0	1	44
14	1/0	0	0	0	1	1	1	0	50
15	1/0	0	0	0	1	1	1	1	56
16	1/0	0	0	1	0	0	0	0	62
17	1/0	0	0	1	0	0	0	1	68
18	1/0	0	0	1	0	0	1	0	74
19	1/0	0	0	1	0	0	1	1	80
20	1/0	0	0	1	0	1	0	0	86
21	1/0	0	0	1	0	1	0	1	92
22	1/0	0	0	1	0	1	1	0	98
23	1/0	0	0	1	0	1	1	1	104
24	1/0	0	0	1	1	0	0	0	116
25	1/0	0	0	1	1	0	0	1	128
26	1/0	0	0	1	1	0	1	0	140
27	1/0	0	0	1	1	0	1	1	152
28	1/0	0	0	1	1	1	0	0	164
29	1/0	0	0	1	1	1	0	1	176
30	1/0	0	0	1	1	1	1	0	188
31	1/0	0	0	1	1	1	1	1	*200

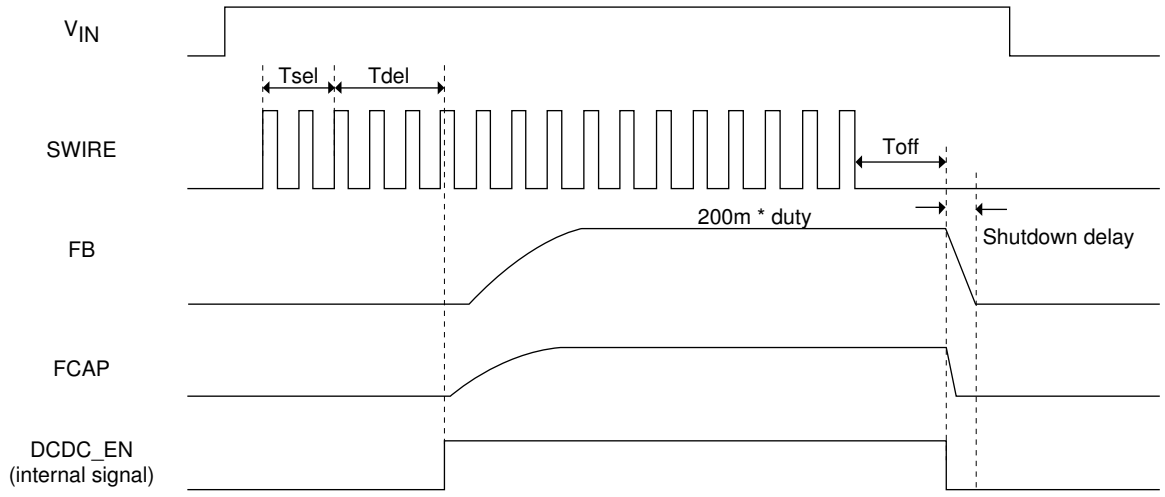
(*Default)

Table3. Data Register vs. FB Voltage

Start up and Shutdown

The device becomes enabled when SWIRE is initially taken high.The dimming mode is determined within Tsel and the boost converter start up after Tdel. To place the device into shutdown mode, the SWIRE must be held low for Toff.

PWM MODE



Digital MODE

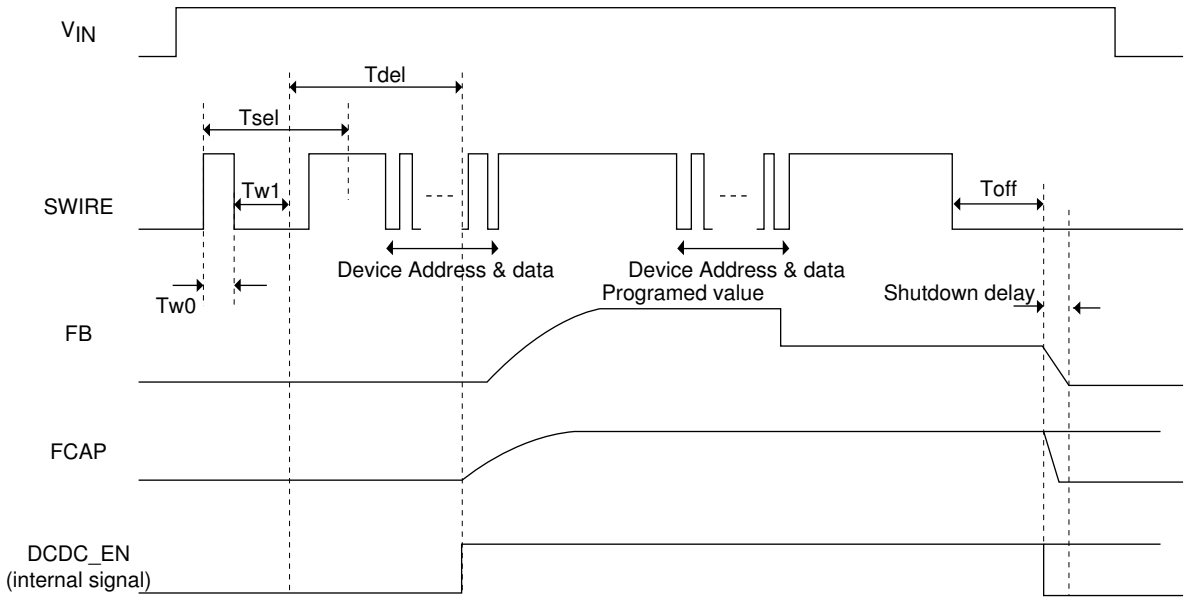


Fig7.Start up and shutdown diagram

Open LED Protection

If SW terminal voltage exceeds a threshold Vovp (38V typ) for 8 cycles, boost converter enters shutdown mode. In order to restart the IC, SWIRE signal is required again.

Over Current Protection

Current limit value for built-in power MOS is around 0.7A. The power MOS is turned off for each switching cycle when peak current through it exceeds the limit value.

Under Voltage Lock Out (UVLO)

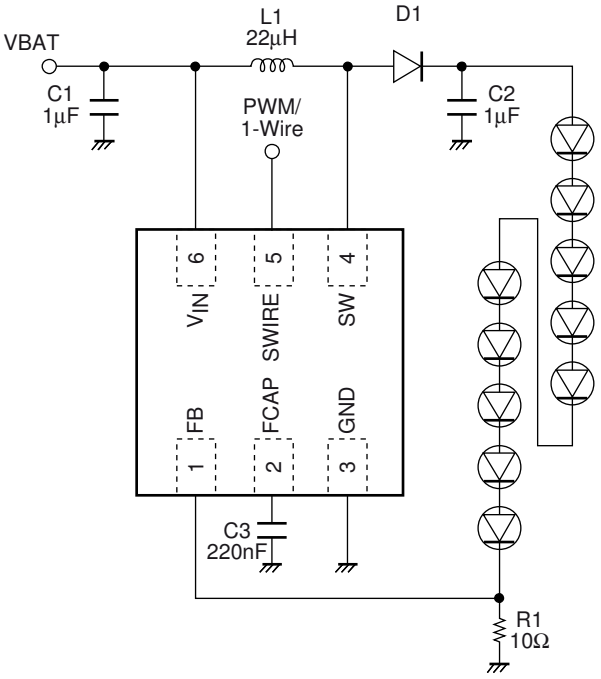
UVLO operation works when V_{IN} terminal voltage is below 2.2V.

Thermal Shutdown

When chip temperature is too high, boost converter is stopped.

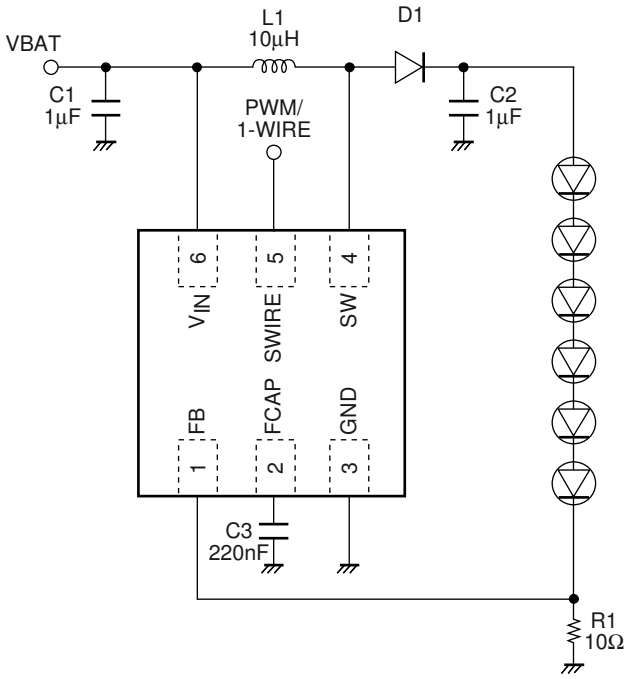
Application Circuit Diagram

10LEDs



L1: VLS3012T-220M49 (TDK), VLF504015MT-220M (TDK)
D1: MBR0540T1 (ON semi), NSR05F40 (ONsemi)
C2: GRM21BR71H105K (Murata), C1608X5R1H105K (TDK)

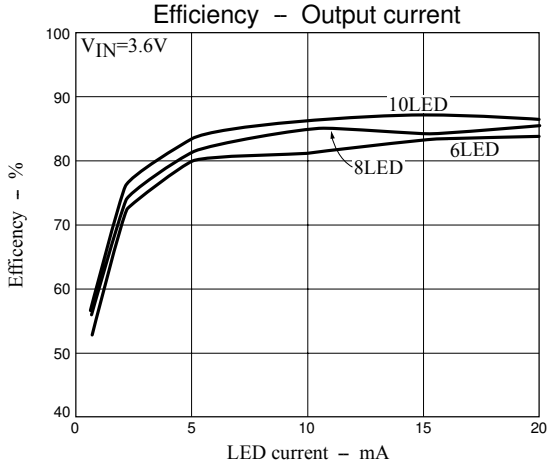
6LEDs



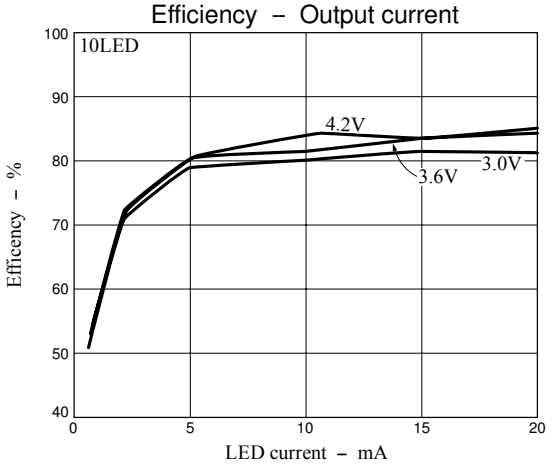
L1: VLS3012T-100M72 (TDK), VLF302512M-100M (TDK)
D1: MBR0540T1 (ON semi), NSR05F40 (ONsemi)
C2: GRM21BR71H105K (Murata), C1608X5R1H105K (TDK)

Typical Characteristics (V_{IN} = 3.6V, L = 22µH, T = 25°C, unless otherwise specified)

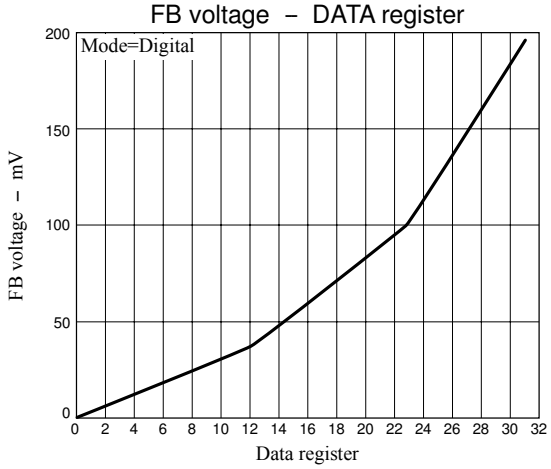
Efficiency – Output current



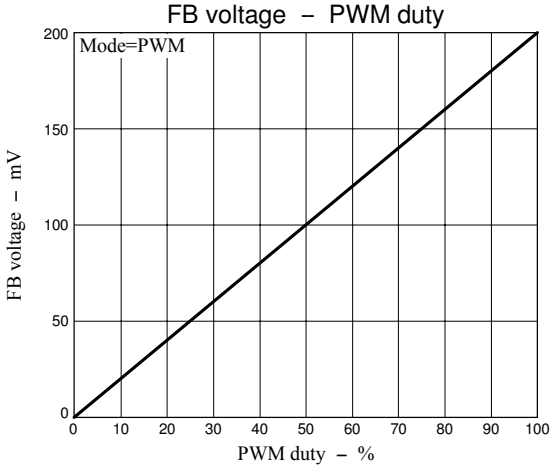
Efficiency – Output current



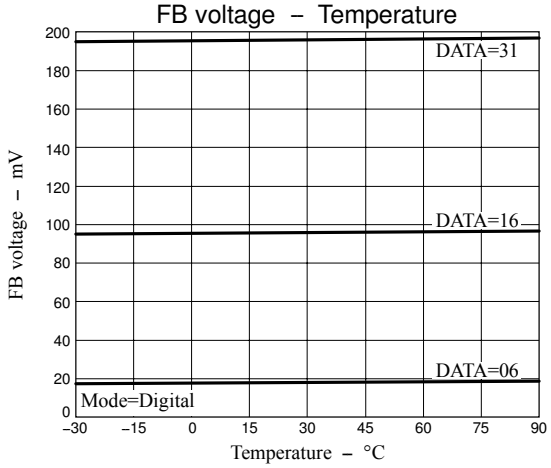
FB voltage – DATA register



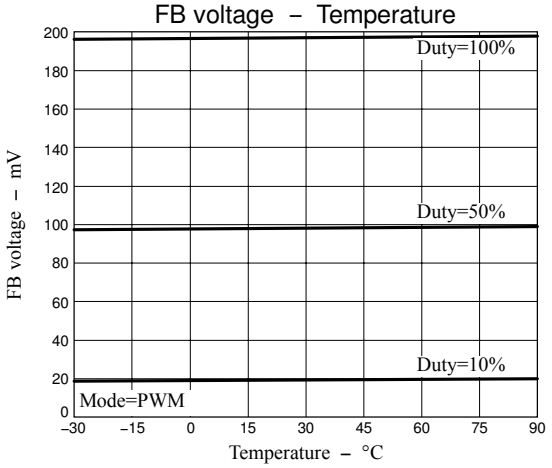
FB voltage – PWM duty



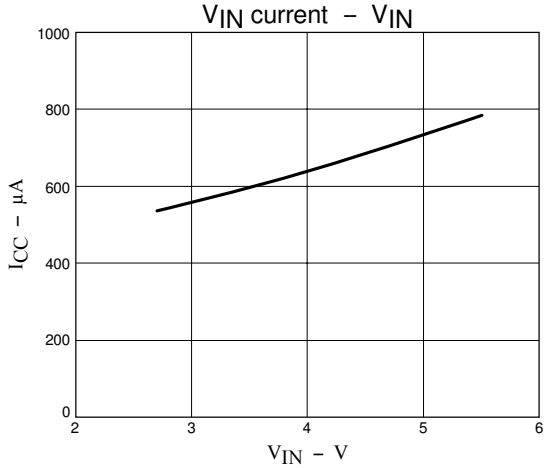
FB voltage – Temperature



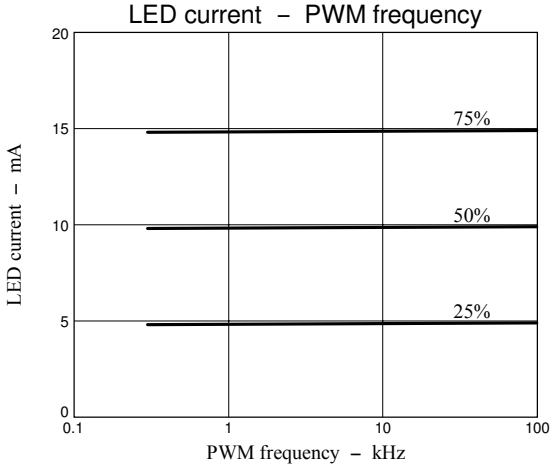
FB voltage – Temperature



V_{IN} current – V_{IN}



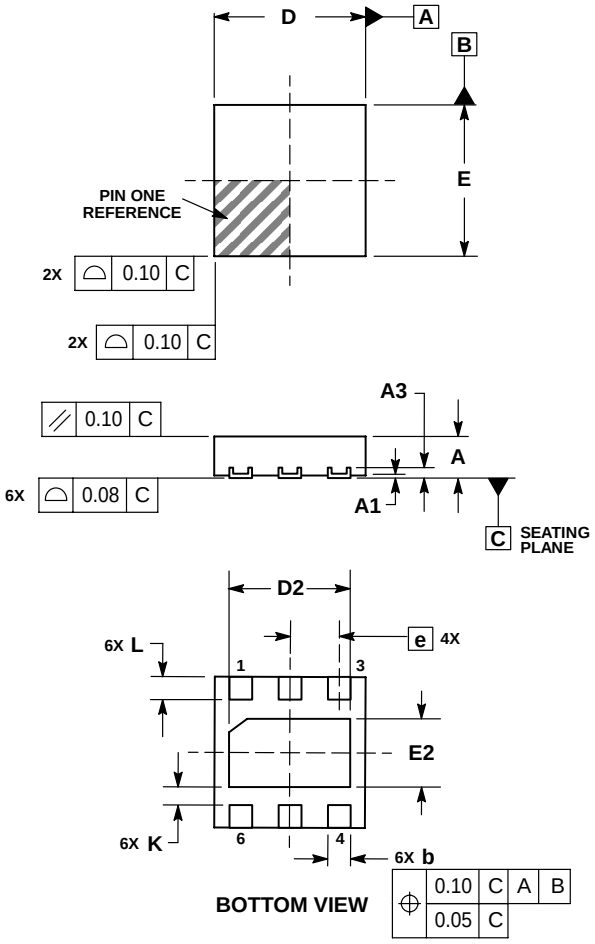
LED current – PWM frequency



PACKAGE DIMENSIONS

UDFN6 2x2, 0.65P

CASE 517AB

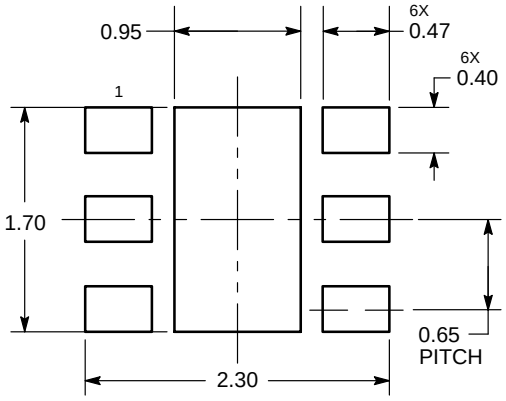


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

	MILLIMETERS	
DIM	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.127 REF	
b	0.25	0.35
D	2.00 BSC	
D2	1.50	1.70
E	2.00 BSC	
E2	0.80	1.00
e	0.65 BSC	
K	0.20	---
L	0.25	0.35

SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.