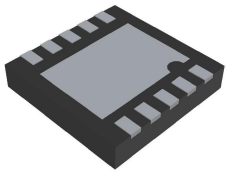
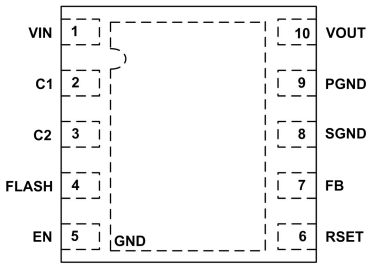
WD3620D

1000mA Buck/Boost
Charge Pump Flash LED Driver

Http//:www.sh-willsemi.com



DFN3x3-10L



Pin configuration (Top view)

WD3620D

3620 = Device code
DA = Special code
Y = Year code
W = Week code

Marking Information

Order Information

Device	Package	Shipping
WD3620D-10/TR	DFN3×3-10L	3000/Reel&Tape

Description

The WD3620D is a current-regulated charge pump ideal for powering high brightness LEDs for camera flash applications. The charge pump can be set to regulate two current levels for FLASH and TORCH modes.

The WD3620D incorporates a 1-wire interface to program the flash LED current at 8 levels and flash timeout at 2 levels.

The WD3620D supports PWM dimming. The supply voltage ranges from 2.7V to 5.5V and is ideally suited for all applications powered by a single LI-Ion battery cell or three to four NiCd, NiMH, or Alkaline battery cells.

The WD3620D also features a very low shutdown current, an automatic soft-start mode to limit inrush current, as well as over current, over voltage and over-Thermal shutdown control.

The WD3620D is available in Green DFN3×3-10L package. Standard products are Pb-free and Halogen-free.

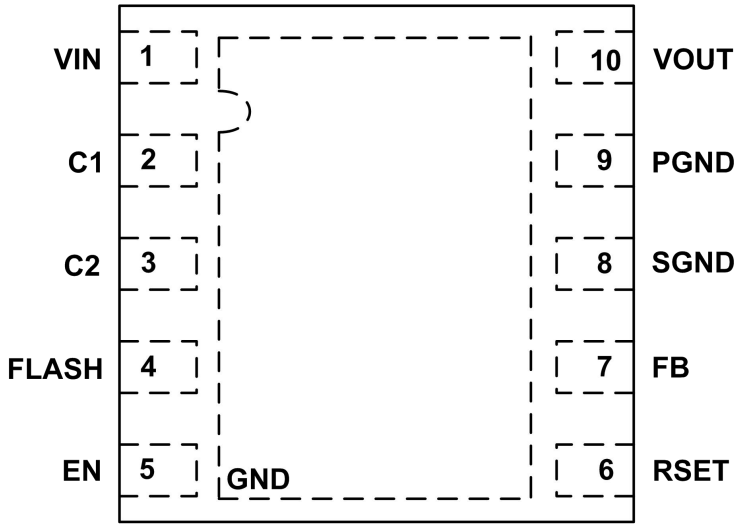
Features

- Output Current up to 1000mA
- 8 FLASH LED Current Levels Selectable by 1-wire Interface:
  100%*I_{FLASH},90%*I_{FLASH}……30%*I_{FLASH}
- 2 Flash Timeout Levels Selectable by 1-wire Interface: 220ms,1.1s
- Up to 95% Efficiency in Torch Mode
- Automatic Buck/Boost Mode Switchover
- Wide Input Voltage Range: 2.7V to 5.5V
- High Frequency Operation: 2.2MHz
- Low 50mV Reference for Low Loss Sensing
- PWM Dimming Control:2 methods
- Automatic Soft Start Limits Inrush Current
- Low Ripple and EMI

Applications

- Cellphones
- PADs

Pin configuration (Top view)



Pin descriptions

Symbol	DFN3x3-10L	Descriptions
VIN	1	Input voltage for the charge pump. Decouple with 4.7μF or 10μF ceramic capacitor close to the pins of the IC.
C1	2	Positive input for the external flying capacitor. Connect a ceramic 1μF capacitor close to the pins of the IC.
C2	3	Negative input for the external flying capacitor. Connect a ceramic 1μF capacitor close to the pins of the IC.
FLASH	4	Logic input to toggle operation between FLASH and TORCH mode. In TORCH mode FB is regulated to the internal 50mV reference. In FLASH mode FB reference voltage can be adjusted by changing the resistor from R_{SET} pin to ground. Choose the external current sense resistor (R_{SENSE}) based on desired current in TORCH mode and Flash mode.
EN	5	Shutdown control input. Connect to logic high for normal operation, and logic low for shutdown. In FLASH mode,the flash current and timeout period can be adjust by EN 1-wire pulse control signal.
R_{SET}	6	Connect a resistor from this pin to ground. When in FLASH mode (FLASH = High) this resistor sets the current regulation point according to the following: $VFB = (1.26V / R_{SET}) \times 10.2k\Omega$
FB	7	Feedback input for the current control loop. Connect directly to the current sense resistor.
SGND	8	Internal ground pin. Control circuitry returns current to this pin.
PGND	9	Power ground pin. Flying capacitor current returns through this pin.
VOUT	10	Charge Pump Output Voltage. Decouple with an external capacitor. At least 1μF is recommended. If Higher value capacitor is used, output ripple is smaller.

Typical applications

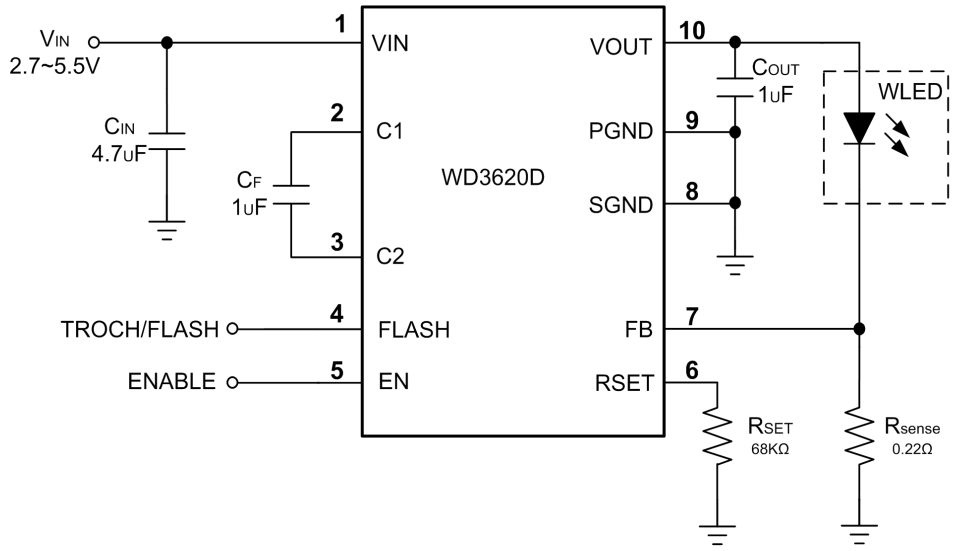


Figure1. Single LED flash circuit @ 850mA flash current

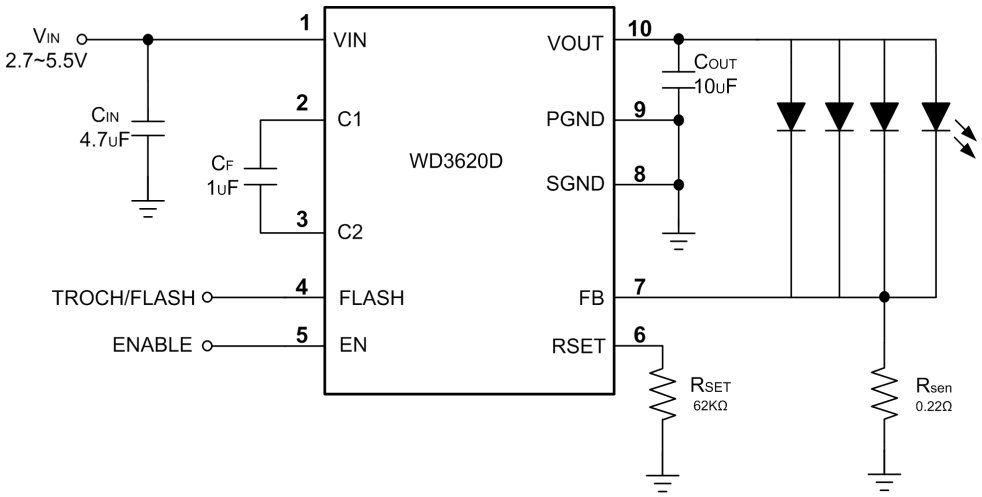
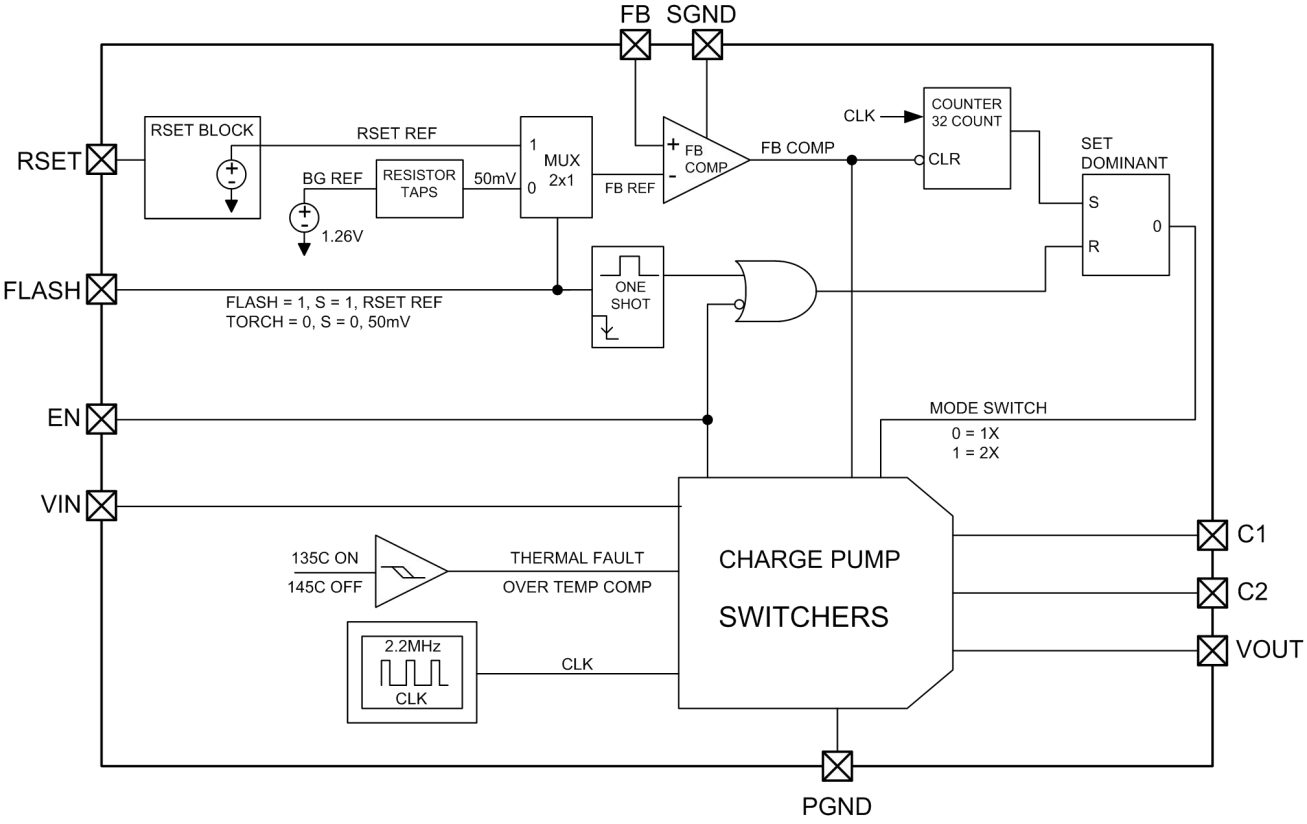


Figure 2. Multiple LED flash circuit @1000mA flash current

Block diagram



Absolute maximum ratings

Parameter	Symbol	Value	Unit
VIN,VOUT pin voltage range	V	-0.3～6	V
EN, FB pin voltage range	-	-0.3～5.5	V
Output Current Pulse(Flash)	$I_{O(Flash)}$	1.5	A
Output Current Continuous(Torch)	$I_{O(Torch)}$	0.4	A
Power Dissipation (Note 1)		3	W
Junction to Ambient Thermal Resistance (Note 1)	$R_{\theta JA}$	57	°C/W
Junction temperature	T_J	150	°C
Lead temperature(Soldering, 10s)	T_L	260	°C
Operating ambient temperature	Topr	-40 ~ 85	°C
Storage temperature	Tstg	-55 ~ 150	°C
ESD Ratings	HBM	8000	V
	MM	400	V

These are stress ratings only. Stresses exceeding the range specified under “Absolute Maximum Ratings” may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Note 1: Surface mounted on FR-4 Board using 1 square inch pad size, dual side, 1oz copper

Electronics Characteristics

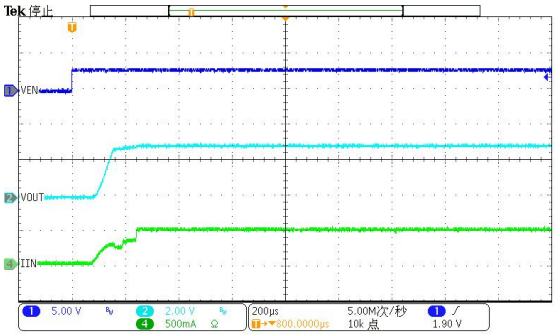
(Full= -40℃ to +85℃， V_{IN}= 3.6V, C_{IN} = 4.7uF, C_F = C_{OUT} = 1uF, V_{EN}= V_{IN}, typical values at +25℃，unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Voltage Range	V_{IN}		2.7		5.5	V
Quiescent Current	I_Q	V_{IN}=2.7V-5.5V FLASH=GND, 1X Mode I_{LOAD}=100uA		0.3		mA
	I_Q	FLASH = High, 2x mode		2		mA
Shutdown Supply Current	I_{SHDN}	V_{EN} = 0V, V_{IN}=5.5V			1	uA
Feedback reference Voltage	V_{FB}	FLASH = V_{IN}, R_{SET} = 68kΩ	175	190	205	mV
		FLASH = GND	45	50	55	mV
FB Pin Current	I_{FB}	V_{FB} = 0.3V			1	uA
Oscillator Frequency	f_{OSC}			2.2		MHz
Charge Pump Equivalent Resistance (1× mode)		V_{IN} = 5V		0.6	0.8	Ω
Charge Pump Equivalent Resistance (2× mode)		V_{IN} = 3.6V		5		Ω
EN, FLASH Logic Low	$V_{EN,FLASH\ H}$				0.4	V
EN, FLASH Logic High	$V_{EN,FLASH\ L}$		1.2			V
EN, FLASH Pin Current	$I_{EN,FLASH}$			5		uA
V_{OUT} Turn-on Time		V_{IN} = 3.6V, FB within 90% of regulation		150		us
Current Limit	I_{limit}	1X Mode	1.1	1.5	1.9	A
T_{FLASH}	Flash Timeout Period	FLASH time out 1 wire pulse rise edge number:1~8	160	220	280	ms
		FLASH time out 1 wire pulse rise edge number:9~16	0.8	1.1	1.4	s
Thermal Shutdown Temperature	T_{SHDN}			150		°C

Typical Characteristics (Ta=25°C, C_{IN} = 10uF, C_{OUT} = 4.7uF, C_F=1uF, unless otherwise noted)

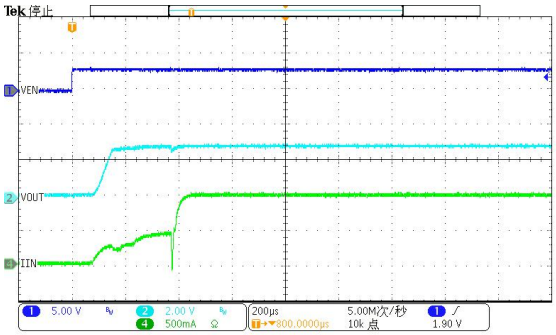
Soft start

V_{IN}=4.2V, 1X Mode, Flash, I_{OUT}=500mA



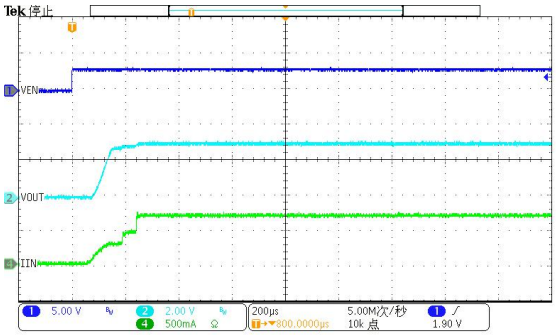
Soft start

V_{IN}=3.2V, 2X Mode, Flash, I_{OUT}=500mA



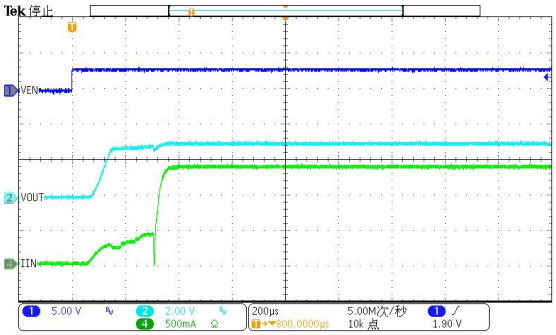
Soft start

V_{IN}=4.2V, 1X Mode, Flash, I_{OUT}=700mA



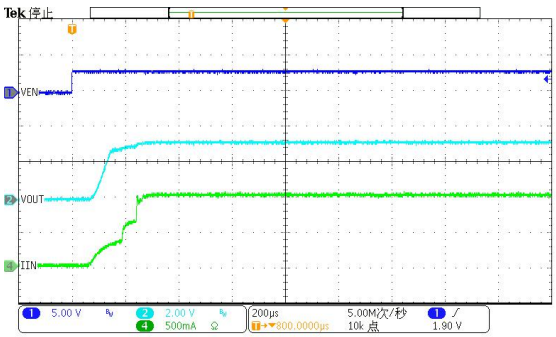
Soft start

V_{IN}=3.2V, 2X Mode, Flash, I_{OUT}=700mA



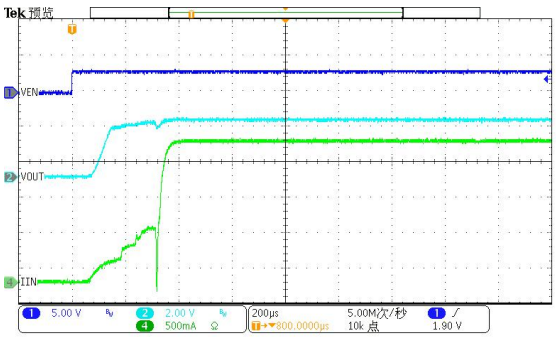
Soft start

V_{IN}=4.2V, 1X Mode, Flash, I_{OUT}=1A



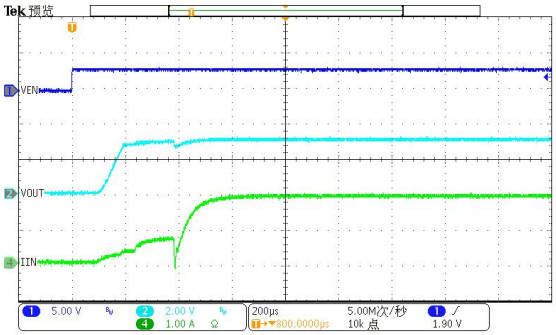
Soft start

V_{IN}=3.6V, 2X Mode, Flash, I_{OUT}=1A



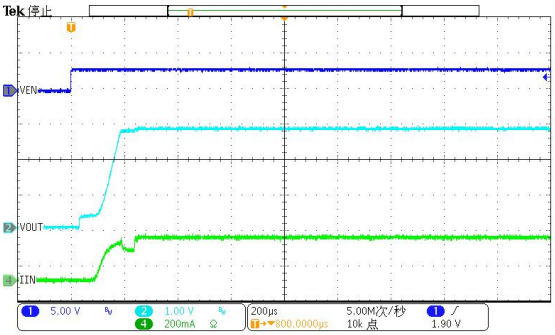
Soft start

V_{IN}=3.4V, 2X Mode, Torch, I_{OUT}=1A



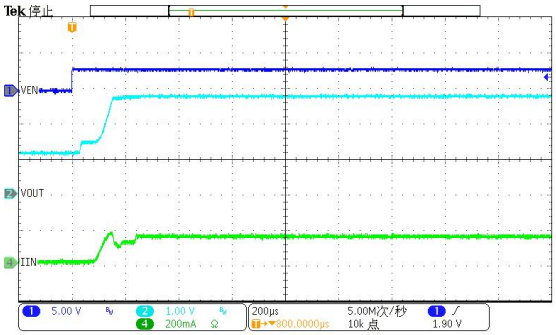
Soft start

V_{IN}=3.6V, 1X Mode, Torch, I_{OUT}=214mA



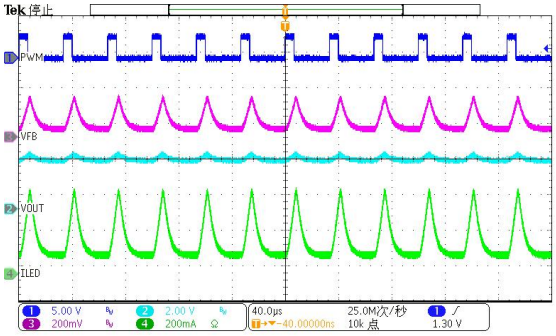
Soft start

V_{IN}=3.6V, 1X Mode, Torch, I_{OUT}=140mA



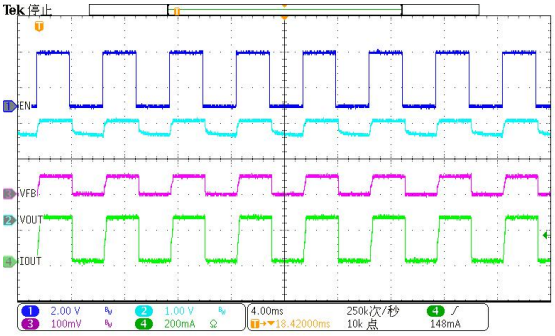
PWM Dimming for Torch Current(For FLASH PIN)

V_{IN}=4.2V, I_{FLASH}=1A, I_{TORCH}=0.1A, Duty=20%



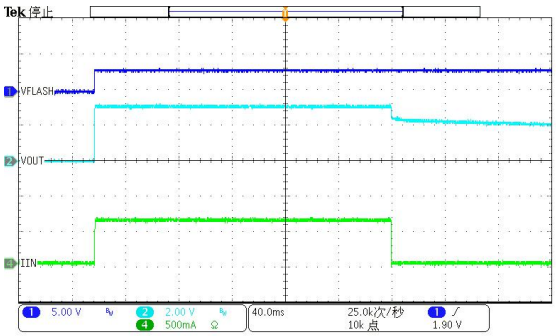
PWM Dimming for Torch Current(For EN PIN)

V_{IN}=3.6V, I_{TORCH}=0.25A, Duty=50%, freq:200Hz



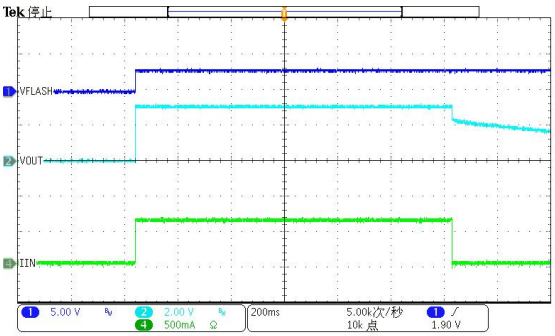
Flash time 220ms

V_{IN}=4.2V, I_{FLASH}=1A



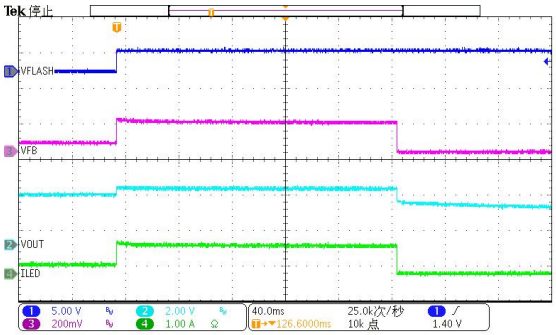
Flash time 1.1s

V_{IN}=4.2V, I_{FLASH}=1A



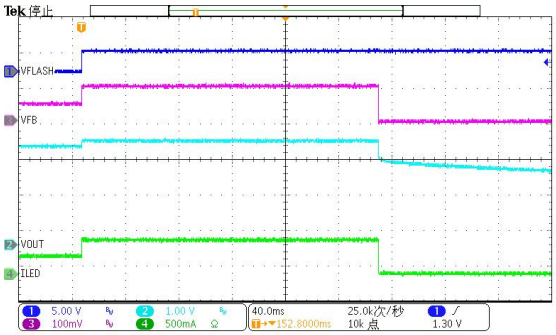
Torch 1X to Flash 2X

V_{IN}=3.2V, I_{FLASH}=1A, I_{TORCH}=214mA



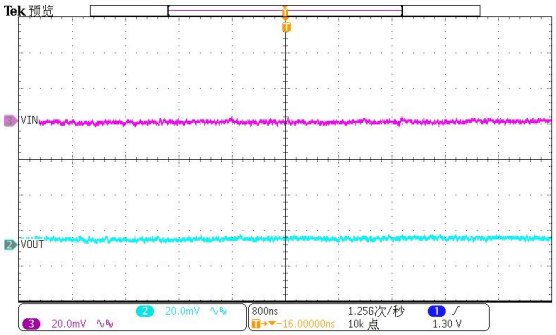
Torch 1X to Flash 2X

V_{IN}=4.2V, I_{FLASH}=500mA, I_{TORCH}=214mA



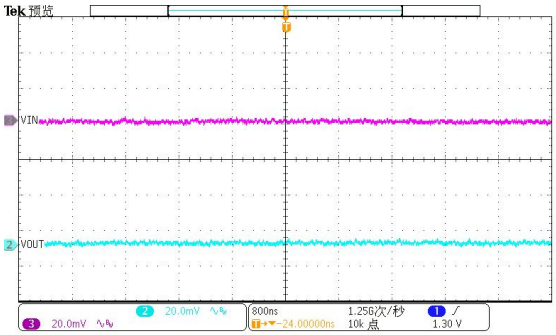
Output Ripple

V_{IN}=4.2V, 1X Mode, Torch, I_{LED}=214mA



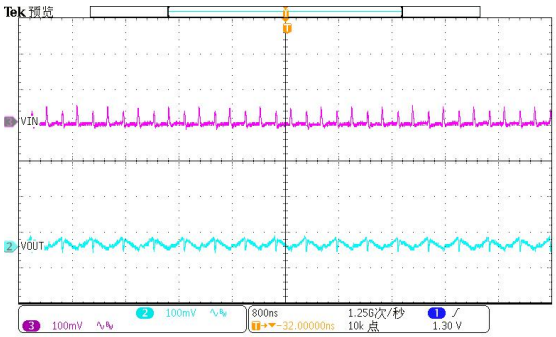
Output Ripple

V_{IN}=4.2V, 1X Mode, Flash, I_{LED}=500mA



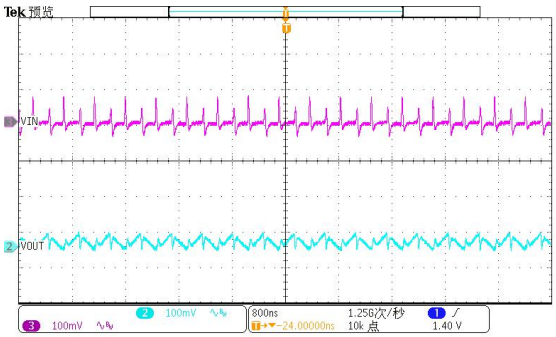
Output Ripple

V_{IN}=3.2V, 2X Mode, Flash, I_{LED}=500mA

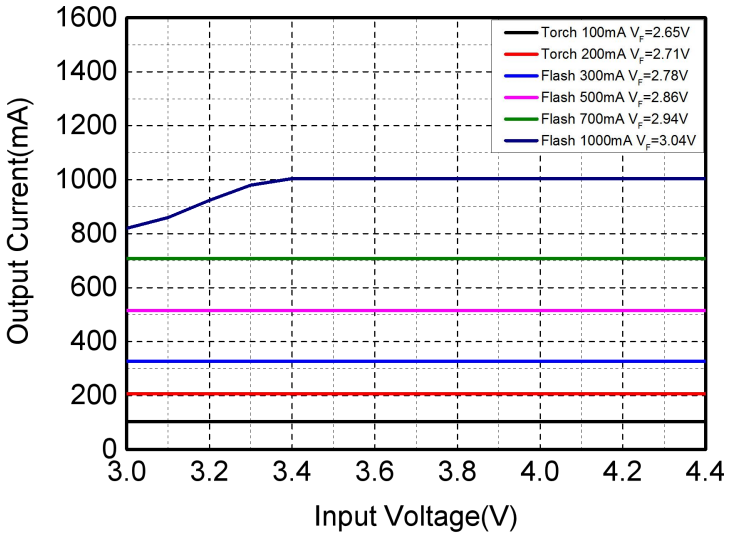


Output Ripple

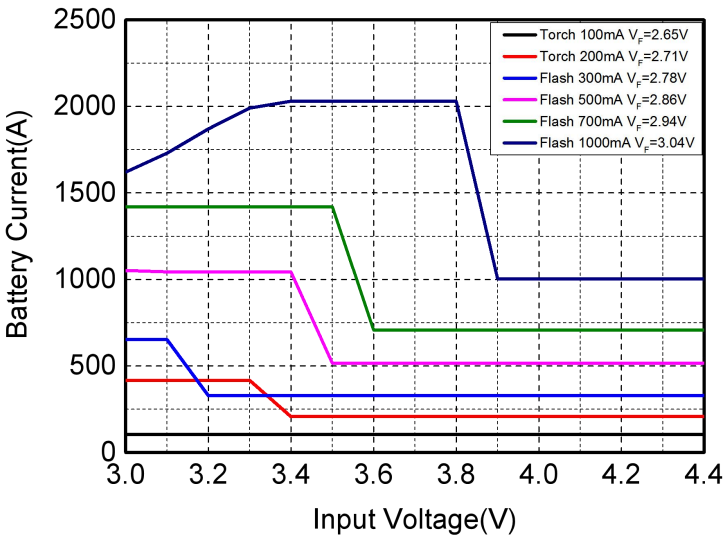
V_{IN}=3.2V, 2X Mode, Flash, I_{LED}=1A



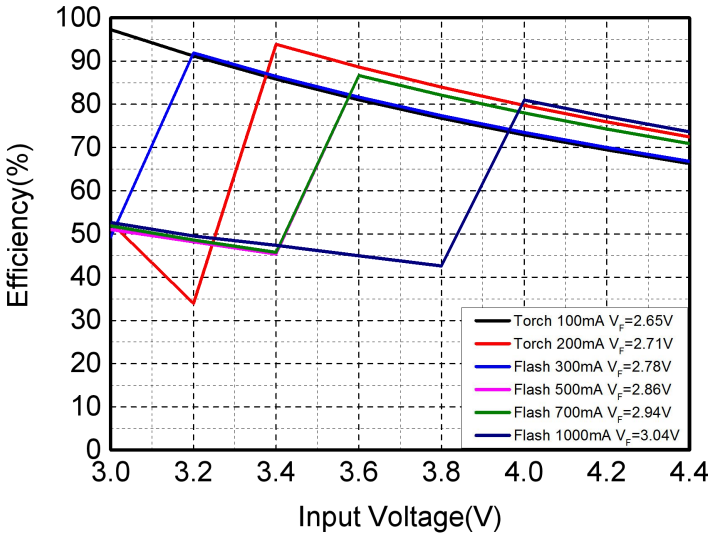
Output Current vs. Input Voltage



Battery Current vs. Input Voltage



Efficiency vs. Input Voltage



Operation Information

The WD3620D is a charge pump regulator designed for converting a Li-Ion battery voltage of 2.7V to 4.2V to drive a white LED used in digital still camera Flash and Torch applications. Flash mode of WD3620D is usually used with a pulse about 1.1s or 220ms to generate a high intensity Flash. Torch of WD3620D can be used continuously at a lower output current than Flash and is often used for several seconds in a digital still camera “movie” mode.

The WD3620D also has two modes of operation to control the output current: the 1X mode and 2X mode. Operation begins after the enable pin EN receives a logic high, and then WD3620D goes through a soft-start mode designed to reduce inrush current. The WD3620D starts in the 1X mode, which acts like a linear regulator to control the output current by continuously monitoring the feedback pin FB. In 1X mode, as FB pin is below the regulation point, the WD3620D automatically switches to the 2X mode. The WD3620D remains in the 2X mode until one of four things happens:

1) The enable pin EN has been toggled.
2) The Flash pin has changed from high to low.
3) VIN is cycled or VIN recovers
4) A thermal fault occurs.

The 2X mode is the charge pump mode where the output can be pumped as high as two times the input voltage, provided the output does not exceed the maximum voltage for the WD3620D, which is internally limited to about 5.5V. In the 2X mode, as in the 1X mode, the output current is regulated by the voltage at the FB pin.

In the Torch mode, (Flash = “GND”) the Flash pin is set to logic low and the WD3620D FB pin regulates to typical 50mV output:

$$V_{FB} = 50mV \text{ (Torch Mode)}$$

When in Flash mode, (Flash = “High”), the FB regulation voltage is set by the resistor R_{SET} connected between the R_{SET} pin and SGND and the equation:

$$V_{FB} = (1.26V / R_{SET}) \times 10.2k\Omega \text{(Flash Mode)}$$

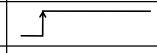
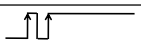
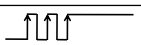
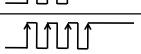
The output current is then set in either Flash or Torch mode by the equation:

$$I_{OUT} = V_{FB} / R_{SENSE}$$

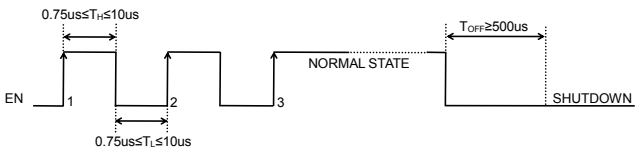
Typical values of R_{SET} are 68kΩ to 150kΩ for a range of VFB = 205mV to 93mV in Flash mode.

The WD3620D incorporates a 1-wire interface to program the flash LED current at 8 levels and flash timeout at 2 levels.

The relationship between the number of 1-wire pulse rising edge and flash LED current and flash timeout is shown in below table:

Pulse	EN Waveform	Flash Timeout	Flash Current
1		220ms	100%*I_{FLASH}
2			90%*I_{FLASH}
3			80%*I_{FLASH}
4			70%*I_{FLASH}
5	·····		60%*I_{FLASH}
6	·····		50%*I_{FLASH}
7	·····		40%*I_{FLASH}
8	·····		30%*I_{FLASH}
9	·····	1.1s	100%*I_{FLASH}
10	·····		90%*I_{FLASH}
11	·····		80%*I_{FLASH}
12	·····		70%*I_{FLASH}
13	·····		60%*I_{FLASH}
14	·····		50%*I_{FLASH}
15	·····		40%*I_{FLASH}
16	·····		30%*I_{FLASH}

1-wire pulse timing sequence is shown below:



Application Information

Flash timeout protection

Due to the high currents typically available in Flash mode, it is necessary to protect the white LED from damage if left on too long. The WD3620D provides 2 flash timeout levels (220ms/1.1s) by 1-wire interface in the EN pin. Operation will not begin again in Flash mode until the Enable pin or Flash pin have been set Low and then High again.

Over Temperature Protection

When the temperature of WD3620D rises above 150℃, the over temperature protection circuitry turns off the output switches to prevent damage to the device. If the temperature drops back down below 135℃, the part automatically recovers and executes a soft start cycle.

Over Voltage Protection

The WD3620D has over voltage protection. If the output voltage rises above the 5.5V threshold, the over voltage protection shuts off all of the output switches to prevent the output voltage from rising further. When the output decreases below 5.3V, the device resumes normal operation.

Over Current Protection

The over current protection circuitry monitors the average current out of the V_{OUT} pin. If the average output current exceeds approximately 1.5Amp, then the over current protection circuitry shuts off the output switches to protect the chip.

PWM Dimming

For FLASH Pin
Dimming control can be achieved by applying a PWM control signal to the Flash pin. In this condition, the WD3620D switches between FLASH mode and TORCH mode. For WD3620D, the dimming frequency is recommended between 20kHz to 50kHz. The relationship between the output current I_{OUT} and the duty cycle of PWM signal D is written as below:

$$I_{TORCH\_PWM}=I_{FLASH}*D+I_{TORCH}*(1-D)$$

In which I_{FLASH} is output current setting for FLASH mode and I_{TORCH} is output current setting for TORCH mode.

For EN Pin
Dimming control can be achieved by applying a PWM control signal to the EN pin. The brightness of the white LEDs is controlled by increasing and decreasing the duty cycle of the PWM signal. While the operating frequency range of the PWM control is from 70Hz to 700Hz, the recommended maximum brightness frequency range of the PWM signal is from 70Hz to 200Hz. A repetition rate of at least 70Hz is required to prevent flicker.

Component Selection

The WD3620D charge pump circuit requires 3 capacitors (recommended values): 4.7μF input, 4.7μF output and 1μF flying capacitors. For the input capacitor, a larger value of 10μF will help reduce input voltage ripple for applications sensitive to ripple on the battery voltage. All the capacitors should be surface mount ceramic for low lead inductance necessary at the 2.2MHz switching frequency of the WD3620D and to obtain low ESR, which improves bypassing on the input and output and improves output voltage drive by reducing output resistance. Ceramic capacitors with X5R or X7R temperature grade are recommended for most applications. A selection of recommended capacitors included in below table:

Part Number	Capacitance /voltage	CapacitorSize /Type /Thickness	ESR @100K
C1005X5R0I105M	1uF/6.3V	0402/X5R/0.5mm	0.03
C1608X5R0J475K	4.7uF/6.3V	0603/X5R/0.9mm	0.02
C2012X5R0J106M	10uF/6.3V	0805/X5R/1.35mm	0.02
GRM155R60J105KE19B	1uF/6.3V	0402/X5R/0.55mm	0.03
GRM188R60J475KE19	4.7uF/6.3V	0603/X5R/0.9mm	0.02
GRM21BR60J106KE19L	10uF/6.3V	0805/X5R/1.35mm	0.02

The input and output capacitors should be located as close to the V_{IN} and V_{OUT} pins as possible to obtain best bypassing, and the returns should be connected directly to the PGND pin or to the thermal pad ground located under the WD3620D. The flying

capacitor should be located as close to the C1 and C2 pins as possible. To obtain lower output ripple, the C_{OUT} value can be increased from 1μF to 2.2μF or 4.7μF with a corresponding decrease in output ripple. For output currents of 500mA to 1000mA, the recommended C_F flying capacitor value of 1μF should be used.

Resistor Selection

The sense resistor R_{SENSE} is determined by the value needed in the Torch mode for the desired output current by the equation:

$R_{SENSE} = V_{FB}/ I_{OUT}$ where V_{FB} = 50mV (Torch Mode).

Once the R_{SENSE} resistor has been selected for Torch mode, the V_{FB} voltage can be selected for Flash mode using the following equation:

$V_{FB} = I_{OUT} \times R_{SENSE}$ (Flash Mode) where I_{OUT} is for Flash Mode.

Next, the R_{SET} resistor can be selected for Flash mode using the following equation:

$$R_{SET} = (1.26V/VFB)x10.2k\Omega(\text{Flash Mode})$$

For an example of 200mA Torch mode and 600mA Flash mode, the values R_{SENSE} = 0.25Ω, V_{FB} = 150mV (Flash, Mode), and R_{SET} = 86.6kΩ are calculated. The power，obtained in the Flash mode would be:

$$P_{FLASH} = V_{FB} \times I_{OUT} = 150mV \times 600mA = 90mW$$

The normal 0603 surface mount resistor is rated as 0.1 Watt for continuous power and 0.2 Watt for pulsed power, and the normal 0805 surface mount resistor is rated as 0.125 Watt for continuous power and 0.25 Watt for pulsed power, the power 0805 surface mount resistor is rated as 0.25 Watt for continuous power and 0.5 Watt for pulsed power. The range of typical resistor values and sizes are shown in below table:

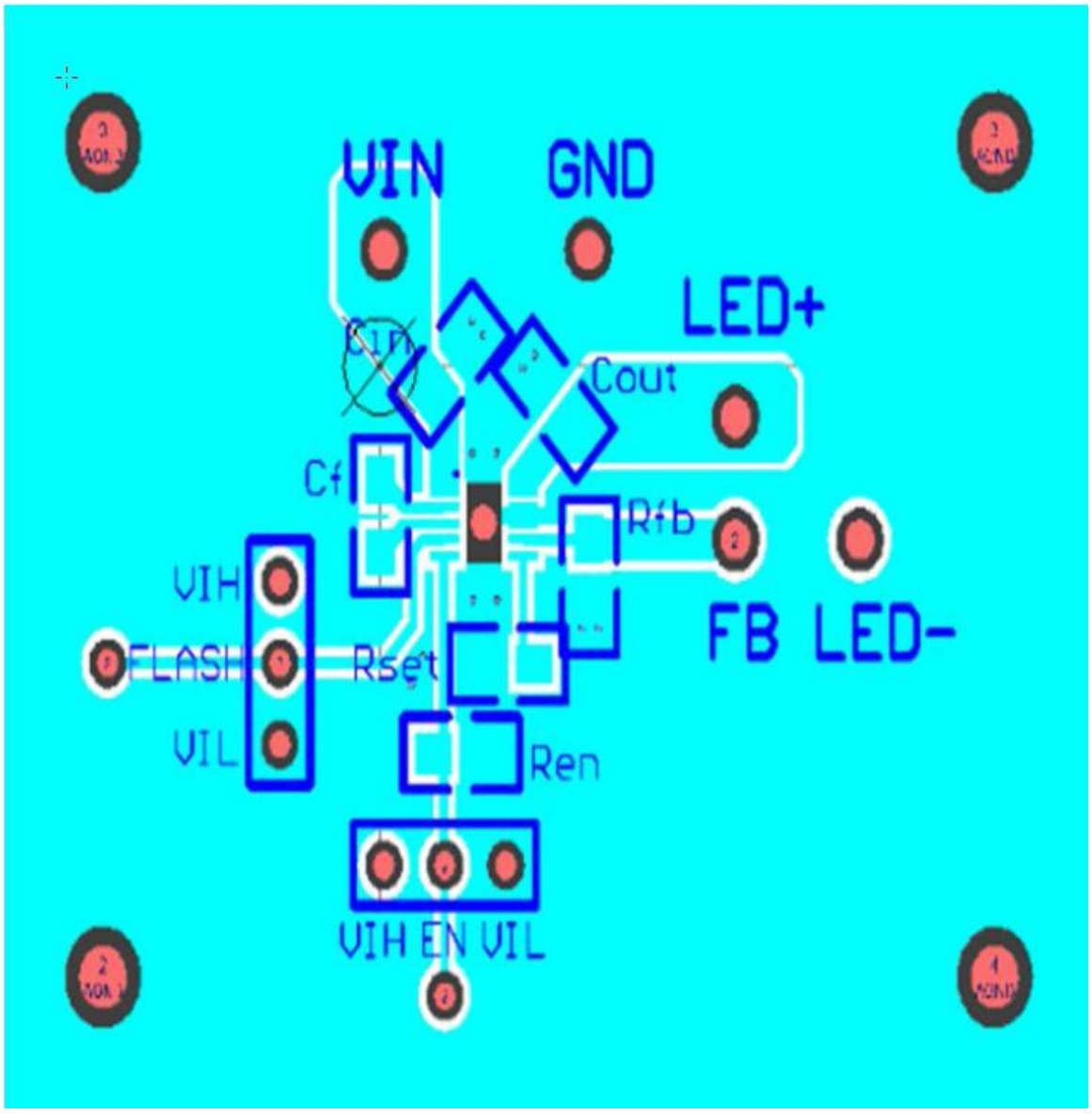
Reference R_{SET} Resistor:

Part Reference	Value (Ω)	Tolerance	Package Size	Vendor
R_{SET}	56K	1%	0402	EYANG or Murata
R_{SET}	61K	1%	0402	EYANG or Murata
R_{SET}	68K	1%	0402	EYANG or Murata
R_{SET}	75K	1%	0402	EYANG or Murata
R_{SET}	82K	1%	0402	EYANG or Murata
R_{SET}	91K	1%	0402	EYANG or Murata
R_{SET}	100K	1%	0402	EYANG or Murata
R_{SET}	110K	1%	0402	EYANG or Murata
R_{SET}	120K	1%	0402	EYANG or Murata
R_{SET}	130K	1%	0402	EYANG or Murata
R_{SET}	140K	1%	0402	EYANG or Murata
R_{SET}	150K	1%	0402	EYANG or Murata

Reference R_{SENSE} Resistor:

Part Reference	Value (Ω)	Tolerance	I_{FLASH}(A)	P_{RSENSE}(W)	Type	Package Size
R_{SENSE}	0.22	1%	0.5	0.055	Normal	0603
R_{SENSE}	0.22	1%	0.7	0.108	Normal	0805
R_{SENSE}	0.22	1%	1.0	0.22	Power	0805
R_{SENSE}	0.33	1%	0.5	0.083	Normal	0805
R_{SENSE}	0.33	1%	0.7	0.16	Power	0805
R_{SENSE}	0.47	1%	0.5	0.12	Normal	0805
R_{SENSE}	0.47	1%	0.7	0.23	Power	0805

EVALUATION BOARD LAYOUT



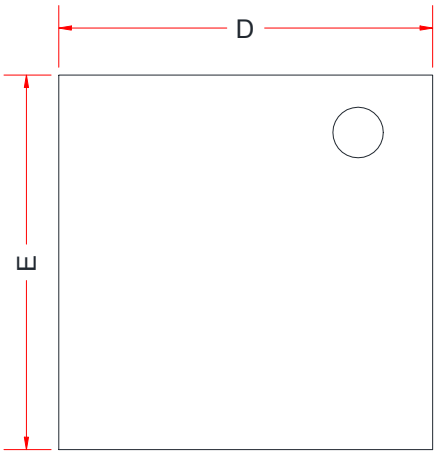
Printed Circuit Board Layout Recommendations

Follow the PCB layout guidelines for optimal performance:

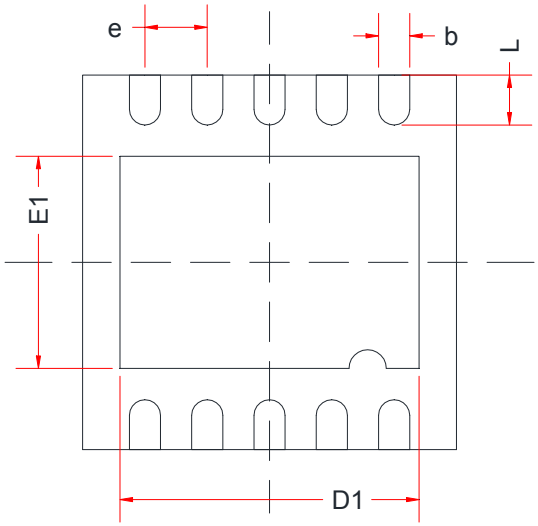
1. Place the flying capacitor CF as close to the chip as possible as possible; otherwise 2x mode performance will be compromised. Also keep analog components away from this capacitor.
2. Place input and output decoupling capacitors as close to the chip as possible to reduce switching noise and output ripple.
3. The power traces, consisting of the VIN/GND trace, the VOUT trace and the WLED trace should be kept short and wide. Also minimize the feedback loop area (consisting of WLED/FB) small.
4. Connect the exposed pad to the GND plane to achieve the best power dissipation.

PACKAGE OUTLINE DIMENSIONS

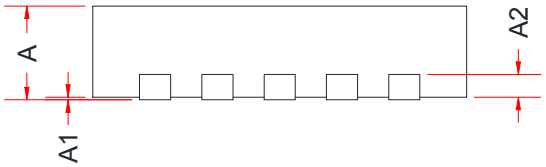
DFN3x3-10L



TOP VIEW



BOTTOM VIEW

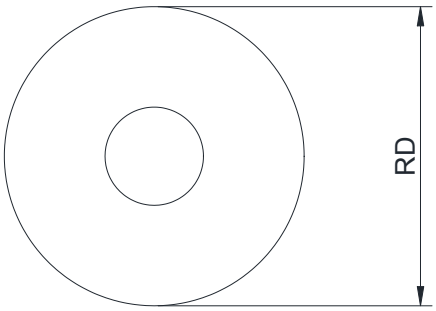


SIDE VIEW

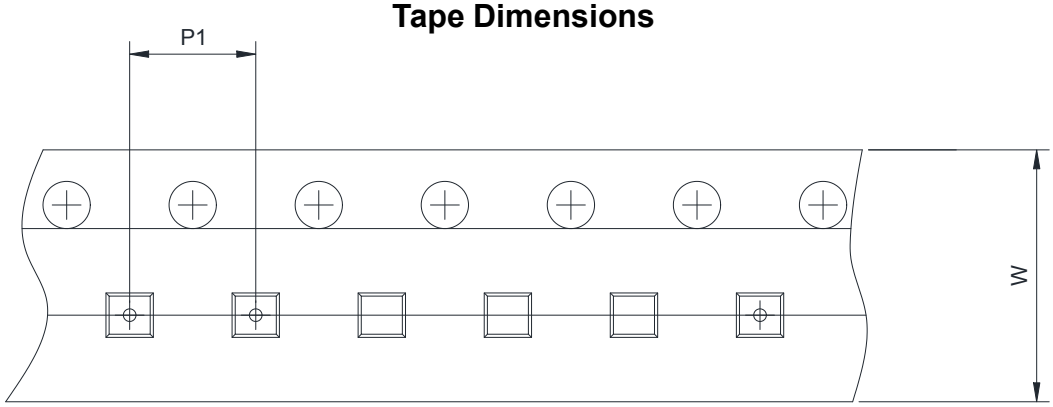
Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2		0.20 Ref.	
D	2.90	3.00	3.10
E	2.90	3.00	3.10
D1	2.30	2.40	2.50
E1	1.60	1.70	1.80
b	0.20	0.25	0.30
e		0.50 Typ.	
L	0.32	0.40	0.48

TAPE AND REEL INFORMATION

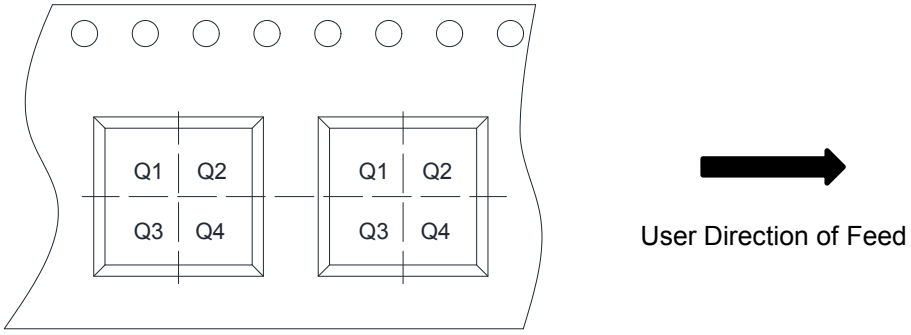
Reel Dimensions



Tape Dimensions



Quadrant Assignments For PIN1 Orientation In Tape



RD	Reel Dimension	☐ 7inch	☑ 13inch		
W	Overall width of the carrier tape	☐ 8mm	☑ 12mm	☐ 16mm	
P1	Pitch between successive cavity centers	☐ 2mm	☐ 4mm	☑ 8mm	
Pin1	Pin1 Quadrant	☑ Q1	☐ Q2	☐ Q3	☐ Q4