GigaDevice Semiconductor Inc.

GD30DC2301x
36V High Current Boost Converter for LED Driver

Datasheet

Table of Contents

List of Figures

List of Tables

1 Features

- 2.5V to 18V Input Voltage Range
- 1MHz Fixed Switching Frequency
- Up to 36V Output Voltage
- Integrated 150mΩ Power MOSFET
- Internal 2A Switch Current Limit
- 200Hz to 200KHz PWM Dimming Frequency
- Thermal Shutdown Protection
- RoHS Compliant and Halogen Free
- Available in SOT23-6 Package

2 Applications

- LCD Backlight Application
- PADs and Smart Phones
- Portable electric devices
- Handheld Devices

3 General description

The GD30DC2301x is a high frequency, asynchronous boost converter. The internal MOSFET can support up to 10 White LEDs for backlighting or up to 36V, and the internal soft start function can reduce the inrush current. The device operates with 1MHz fixed switching frequency to allow small external components The LEDs connected in series are driven with a regulated current set by the external resistor. The GD30DC2301x is available in the tiny package type SOT-236.

4 Device overview

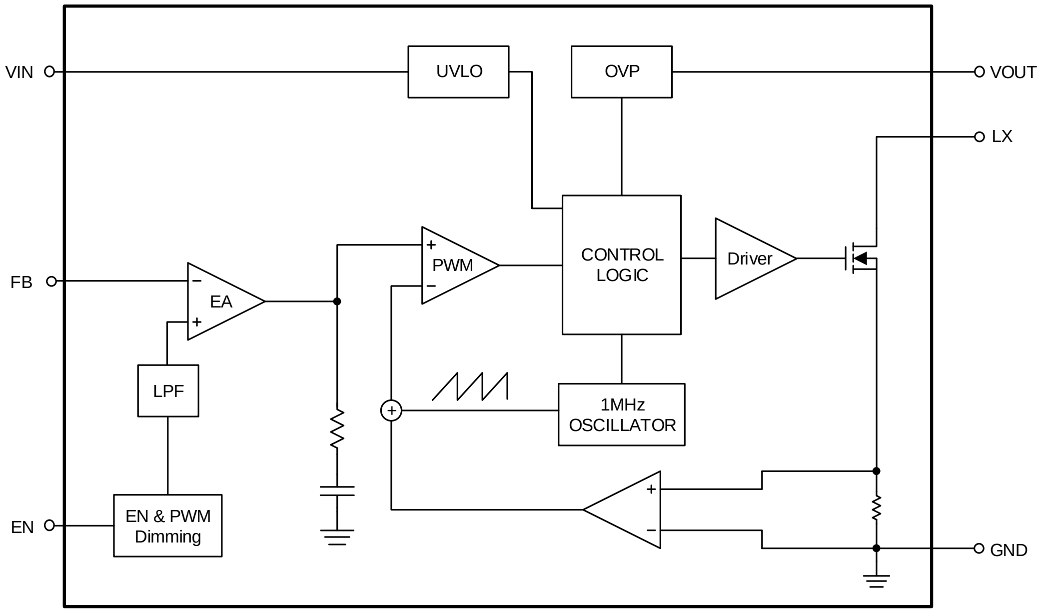
4.1 Device information

Table 4-1. GD30DC2301x SOT23-6 pin definitions

Part Number	Package	Function	Description
GD30DC2301x	SOT23-6	LED Driver	36V High Current Boost Converter

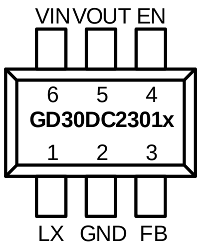
4.2 Block diagram

Figure 4-1 Block diagram for GD30DC2301x



4.3 Pinout and pin assignment

Figure 4-2 GD30DC2301x SOT23-6 pinouts



4.4 Pin definitions

Table 4-2. GD30DC2301x SOT23-6 pin definitions

Pin Name	Pins	Pin Type	Functions description
LX	1	P	Switch pin connected to the main switch and inductor terminal.
GND	2	G	Device ground.
FB	3	I	Feedback pin for the internal control loop. Connect this pin to the external feedback divider.
EN	4	I/O	Chip enable, pull high to enable the output.
VOUT	5	I	Output voltage power rail and input sense.
VIN	6	P	Power supply voltage input.

Notes:

(1) Type: I = input, O = output, OD = open drain output, I/O = input or output, P = power, G = Ground.

5 Functional description

The GD30DC2301x is a current mode step-up DCDC converter with 1MHz operation frequency. The input voltage range is 2.5V to 18V and the output voltage up to 36V. The GD30DC2301x automatically transits from PWM to PSM during light load condition which can maintain a high efficiency.

5.1 Chip enable

When the input voltage is greater than the under-voltage lockout (UVLO) threshold 2.2V (typical), the GD30DC2301x can be enabled by pulling EN higher than 1.5V. Pulling it down to ground disables the GD30DC2301x.

5.2 Current limit

The GD30DC2301x has a typical 2A switch current limit, once the inductor exceeds the current limit, the internal LX switch turns off immediately and shortens the duty cycle. The switch current limit prevents the device from high inductor current and drawing excessive current from a battery or input voltage rail. Excessive current might occur with a heavy load or shorted output circuit condition.

5.3 Under voltage lockout

To avoid malfunction of the device at low input voltages, the GD30DC2301x shuts down at voltages lower than 2.2V(typical) with 200mV(typical) hysteresis.

5.4 Thermal shutdown

The GD30DC2301x enters thermal shutdown once the junction temperature exceeds 150°C (typical). Once the device temperature falls below the threshold with 20°C (typical), the device returns to normal operation automatically.

6 Application information

6.1 LED Current Setting

The GD30DC2301x will keep the FB pin voltage equal to the reference voltage V_{FB}. The LED current is programmed by resistor from the FB pin to ground. In order to have accurate LED current, precision resistors are preferred. The LED current can be set by the following equation:

$$I_{LED} = \frac{200mV}{R_1}$$

6.2 Selecting the External Capacitors

The best capacitors for use with the GD30DC2301x are ceramic capacitors. These capacitors have the lowest ESR and highest resonance frequency which makes them optimum for use with high-frequency switching converters.

When selecting a ceramic capacitor, only ceramic capacitors with X5R and X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. Other types such as Z5U and Y5F have such severe loss of capacitance due to effects of temperature variation and applied voltage, they may provide as little as 20% of rated capacitance in many typical applications. Always consult capacitor manufacturer's data curves before selecting a capacitor. High-quality ceramic capacitors can be obtained from Taiyo-Yuden, Murata, and TDK.

6.2.1 Input capacitor selection

The input current to the step-up converter is discontinuous and therefore requires a capacitor to supply AC current to the step-down converter while maintaining the DC input voltage. For best performance, use extremely low ESR capacitors. For most applications, GD recommends a nominal value of 10uF, but lager values can be used.

The input capacitor requires an adequate ripple current rating since it absorbs the input switching current. For simplification, choose an input capacitor with an RMS current rating greater than half of the maximum load current.

6.2.2 Output capacitor selection

The output capacitor is selected to handle the output ripple noise requirements. Both steady state ripple and transient requirements must be taken into consideration when selecting this capacitor. For the best performance, it is recommended to use X5R or X7R ceramic capacitor with one 10uF or lager values.

6.3 Diode selection

Schottky diode is a good choice for high efficiency operation because of its low forward voltage drop and fast reverse recovery. The schottky diode average current rating must be greater than the maximum load current expected, and the peak current rating must be greater than the peak inductor current. During short circuit testing, or if short circuit conditions are possible in the application, the diode current rating must exceed the switch current limit. The schottky diode reverse breakdown voltage should be larger than output voltage.

6.4 Inductor selection

The recommended value of inductor for 10 WLEDs applications is from 10μH to 47μH.The inductor parameters, current rating, DCR and physical size, should be considered. The DCR of inductor affects the efficiency of the converter. The inductor with lowest DCR is chosen for highest efficiency. The saturation current rating of inductor must be greater than the switch peak current, typically 2A. These factors affect the efficiency, output load capability, output voltage ripple, and cost.

The inductor selection depends on the switching frequency and current ripple by the following formula:

$$L \geq \frac{V_{IN}}{F_{SW} \times \Delta I_L}\left(1 - \frac{V_{IN}}{V_{OUT}}\right)$$

Where F_{SW} is the 1MHz switching frequency. ΔI_L is the inductor ripple current.

6.5 Dimming Control

6.5.1 Using a PWM Signal to EN Pin

The LED current can be set by modulating the EN pin with a PWM signal. The GD30DC2301x provides typically 200mV feedback voltage when the EN pin is pulled constantly high. However, EN pin allows a PWM signal to reduce this regulation voltage by changing the PWM duty cycle to achieve LED brightness dimming control. The relationship between the duty cycle and FB voltage can be calculated as following equation:

$$V_{FB} = Duty \times V_{REF}$$

$$Duty = duty\ \ cycle\ \ of\ \ the\ \ PWM\ \ signal$$

The PWM signal frequency range is 200Hz to 200kHz.

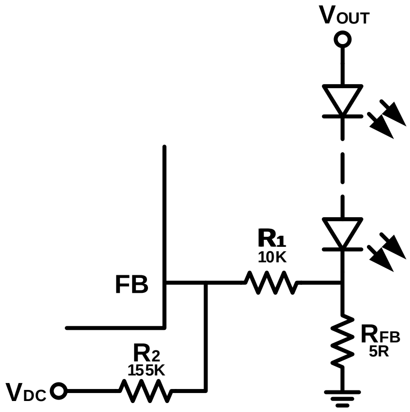
6.5.2 Using a DC Voltage

Using a variable DC voltage to adjust the brightness is a popular method as shown in Figure 6-1. The LED current decreases as the DC voltage rises. The LED current can be calculated by the following equation.

$$I_{LED} = \frac{V_{REF} \times (R_1 + R_2) - V_{DC} \times R_1}{R_{FB} \times R_2}$$

Where V_{REF} is the 200mV internal reference voltage, V_{DC} is the dimming DC voltage. If the V_{DC} range is from 0V to 3.3V, the selection of resistors in Figure 6-1 sets the LED current from 42.58mA to 0mA.

Figure 6-1 Dimming Control Using a DC Voltage



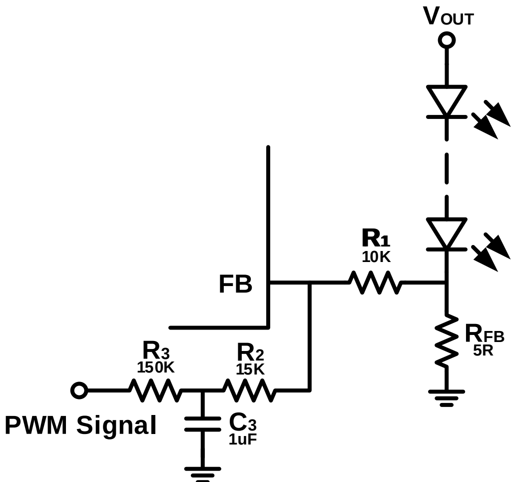
6.5.3 Using a Filtered PWM signal

A filtered PWM signal can be used to substituted the DC input as shown in Figure 6-2. For smaller output voltage ripple, the recommended frequency of PWM signal should be above 2kHz. The LED current decreases as the duty cycle increases. And the LED current can be calculated by the following equation:

$$I_{LED} = \frac{V_{REF} \times (R_1 + R_2 + R_3) - Duty \times V_{PWM} \times R_1}{R_{FB} \times (R_2 + R_3)}$$

Where V_{REF} is the 200mV internal reference voltage, V_{PWM} is the high voltage level of PWM signal, Duty is the duty cycle of PWM signal.

Figure 6-2 Dimming Control Using a Filtered PWM Signal



7 Electrical characteristics

7.1 Absolute maximum ratings

The maximum ratings are the limits to which the device can be subjected without permanently damaging the device. Note that the device is not guaranteed to operate properly at the maximum ratings. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

Table 7-1 Absolute maximum ratings

Symbol	Parameter	Min	Max	Unit
V_{VIN}	Power supply pin	–0.3	20	V
V_{EN}	EN pin voltage	–0.3	20	V
V_{LX}	Switching node voltage	–0.3	45	V
V_{OUT}	Output pin voltage	–0.3	45	V
V_{FB}	FB pin voltage	–0.3	6	V
Thermal characteristics				
T_J	Operating junction temperature		150	°C
T_{stg}	Storage temperature	–55	150	°C
P_{max}	Maximum power dissipation @T_A=25°C	—	0.4	W

7.2 Recommended operation conditions

Table 7-2 Recommended operation conditions

Symbol	Parameter	Min	Typ	Max	Unit
V_{VIN}	Power supply pin	2.5	—	18	V
V_{LX}	Switching node voltage (LX)	—	—	36	V
V_{IO}	I/O pin voltage (FB)	0	—	5.5	V
	I/O pin voltage (EN)	0	—	18	V
Thermal characteristics					
T_J	Operating junction temperature	–40	—	125	°C

7.3 Electrical sensitivity

The device is strained in order to determine its performance in terms of electrical sensitivity. Electrostatic discharges (ESD) are applied directly to the pins of the sample. Static latch-up (LU) test is based on I-test methods.

Table 7-3 Electrostatic Discharge and Latch-up characteristics

Symbol	Parameter	Conditions	Value	Unit
$V_{ESD(HBM)}$	Electrostatic discharge voltage (human body model)	T_A = 25 °C; JS-001-2017	±2000	V
$V_{ESD(CDM)}$	Electrostatic discharge voltage (charge device model)	T_A = 25 °C; JS-002-2018	±1000	V

7.4 Power supplies voltages and currents

Table 7-4 Power supplies voltages and currents

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_Q	Quiescent current	V_{VIN} = 5V, No switching, T_J =25°C	—	110	200	μA
I_{SHDN}	Shutdown current	EN=0, VIN=2.5 to 5.5V	—	1.5	10	μA
V_{UVLO}	VIN under voltage lockout	VIN voltage falling	—	2.2		V
V_{UVLO_HYS}	VIN under voltage lockout hysteresis	VIN rising to falling threshold	—	200	—	mV

7.5 EN characteristics

Table 7-5 EN characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{ENL}	EN logic low voltage	—	—	—	0.4	V
V_{ENH}	EN logic high voltage	—	1.5	—	—	V
I_{EN}	EN pin current	—	—	0.3	1	uA

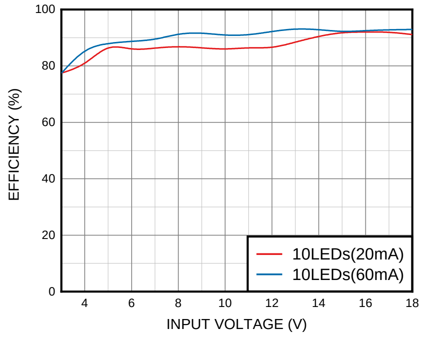
7.6 Switching regulator characteristics

Table 7-6 Switching regulator characteristics

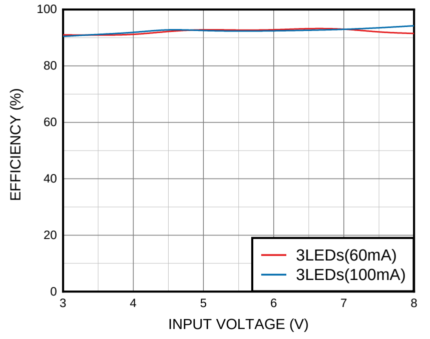
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{FB}	Feedback voltage	VIN=2.5 to 5.5V, T_J =25°C	0.194	0.2	0.206	V
I_{FB}	FB leakage current	—	—	—	50	nA
R_{NMOS}	Main NMOS switch	VIN=5V, T_J =25°C	—	150	250	mΩ
F_{SW}	Switching frequency	VIN=2.5 to 5.5V, T_J =25°C	—	1	—	MHz
D_{MAX}	Max duty	—	85	88	—	%
V_{OVP}	V_{OUT} OVP Threshold	FB=0V	37	39	41	V

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{LIM}	NMOS peak current limit	sourcing	—	2	—	A
T_{OT}	Thermal shutdown temperature	Die temperature, T_J	—	160	—	°C
T_{HYS}	Thermal hysteresis	Die temperature, T_J	—	20	—	°C

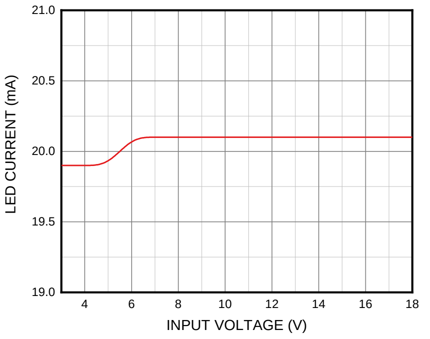
7.7 Typical characteristics



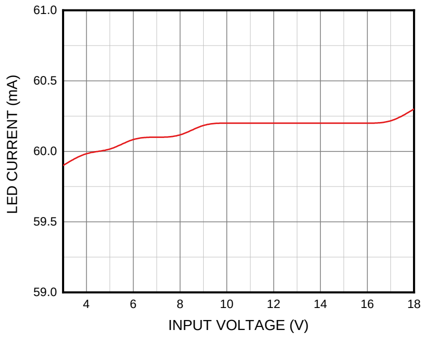
Efficiency vs. Input Voltage, 10LEDs



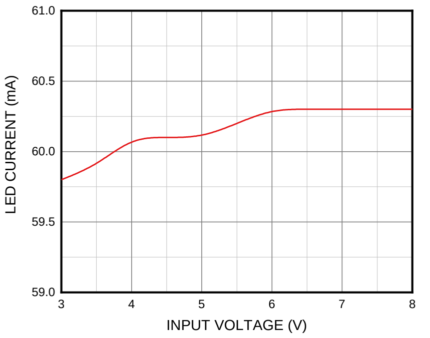
Efficiency vs. Input Voltage, 3LEDs



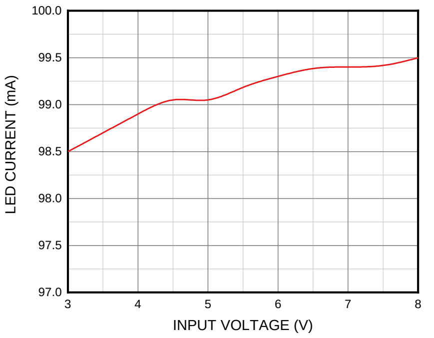
Current vs. Input Voltage, 10LEDs 20mA



Current vs. Input Voltage, 10LEDs 60mA

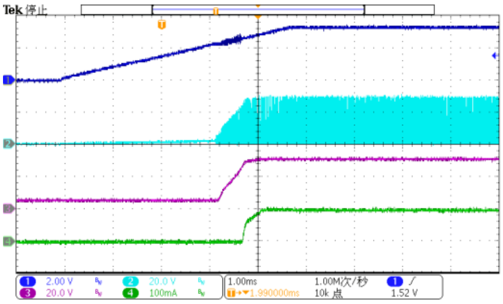


Current vs. Input Voltage, 3LEDs 60mA



Current vs. Input Voltage, 3LEDs 100mA

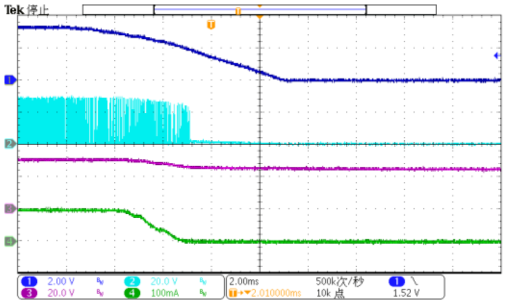
Typical Characteristics (continued)



CH1=Vin, CH2=LX, CH3=Vout, CH4=ILED

Vin=3.3V, 10 LEDs, ILED=100mA

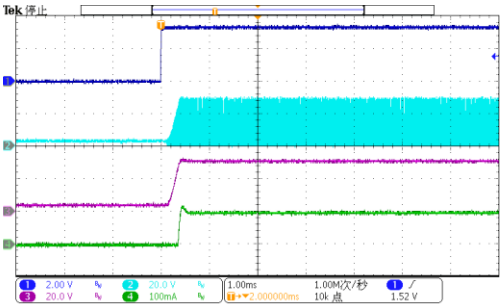
Start-Up through Input Voltage



CH1=Vin, CH2=LX, CH3=Vout, CH4=ILED

Vin=3.3V, 10 LEDs, ILED=100mA

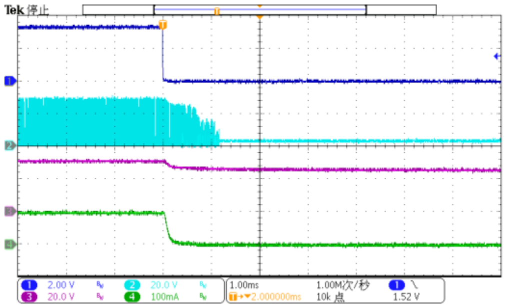
Shutdown through Input Voltage



CH1=Vin, CH2=LX, CH3=Vout, CH4=ILED

Vin=3.3V, 10 LEDs, ILED=100mA

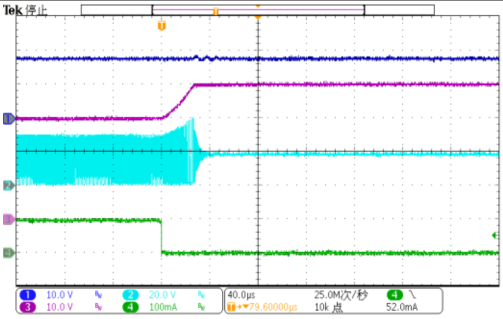
Start-Up through Enable



CH1=Vin, CH2=LX, CH3=Vout, CH4=ILED

Vin=3.3V, 10 LEDs, ILED=100mA

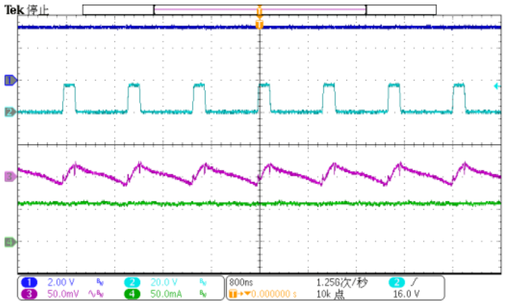
Shutdown through Enable



CH2=Vin, CH2=Vout, CH3=LX, CH4=ILED

Vin=18V, 10 LEDs, ILED=100mA

Open LED Protection



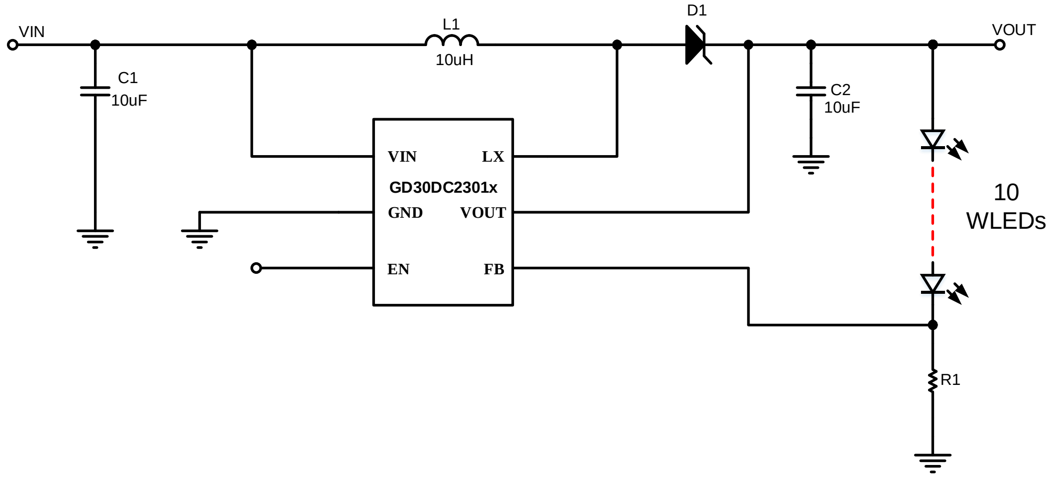
CH2=Vin, CH2=Vout/AC, CH4=ILED

Vin=3.3V, 6 LEDs, ILED=60mA

Output Voltage Ripple

8 Typical application circuit

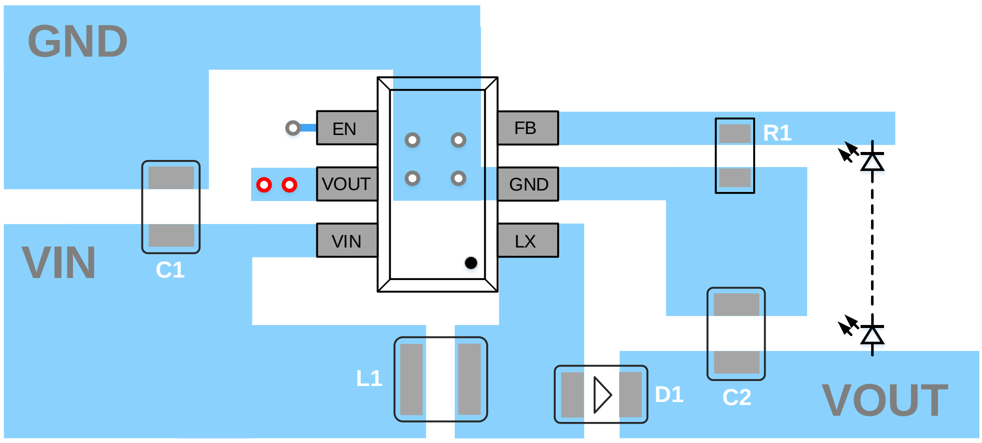
Figure 8-1 Typical GD30DC2301x application circuit



9 Layout guideline

Figure 9-1 Typical GD30DC2301x layout guideline

Efficient PCB layout is critical for stable operation. For the high-frequency switching converter, a poor layout design can result in poor line or load regulation and stability issues. For best results, follow the guidelines below.



Notes:

1) Place the high-current paths (GND, VIN, and LX) very close to the device with short, direct, and wide traces.
2) Place the input capacitor as close to VIN and GND as possible.
3) Place the external feedback resistors next to FB.
4) Keep the switching node LX short and away from the feedback network.
5) Keep the VOUT sense line as short as possible or keep it away from the power inductor.

10 Package information

10.1 SOT23-6 package outline dimensions

Figure 10-1 SOT23-6 package outline

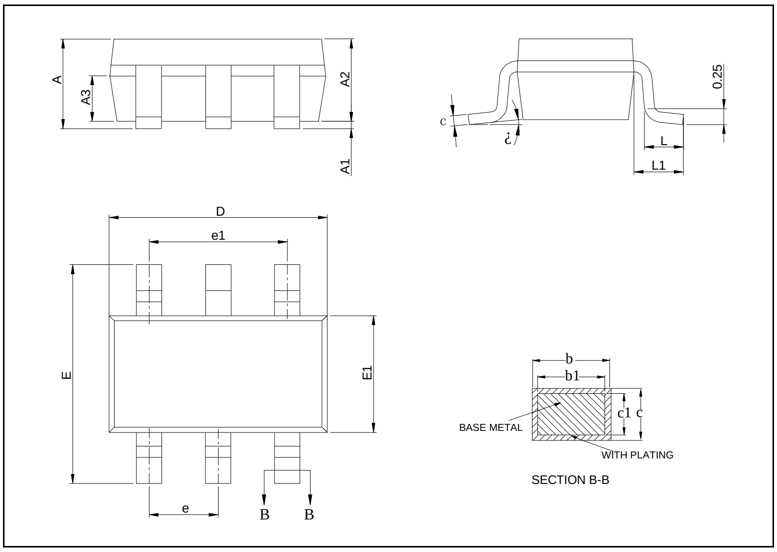
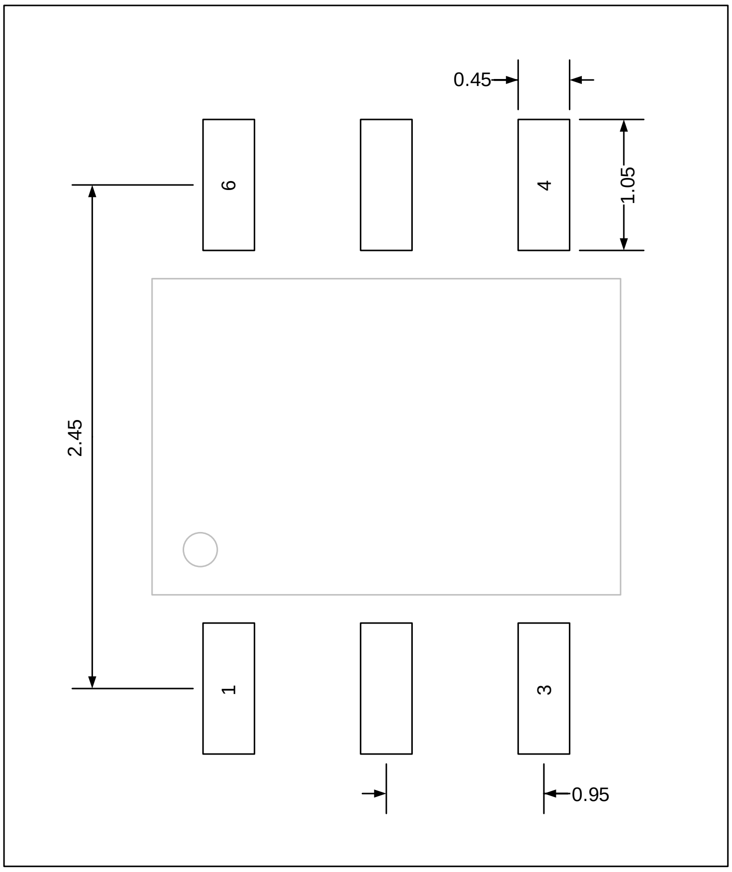


Table 10-1 SOT23-6 dimensions

Symbol	Min	Nom	Max
A	—	—	1.25
A1	0.04	—	0.10
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.33	—	0.41
b1	0.32	0.35	0.38
c	0.15	—	0.19
c1	0.14	0.15	0.16
D	2.82	2.92	3.02
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
e	0.95BSC		
e1	1.90BSC		
L	0.30	—	0.60
L1	0.60REF		
θ	0°	—	8°

(Original dimensions are in millimeters)

Figure 10-2 SOT23-6 recommend footprint



(Original dimensions are in millimeters)

10.2 Thermal characteristics

Thermal resistance is used to characterize the thermal performance of the package device, which is represented by the Greek letter "Θ". For semiconductor devices, thermal resistance represents the steady-state temperature rise of the chip junction due to the heat dissipated on the chip surface.

Θ_{JA}: Thermal resistance, junction-to-ambient.

Θ_{JB}: Thermal resistance, junction-to-board.

Θ_{JC}: Thermal resistance, junction-to-case.

Ψ_{JB}: Thermal characterization parameter, junction-to-board.

Ψ_{JT}: Thermal characterization parameter, junction-to-top center.

$\Theta_{JA} = (T_J - T_A)/P_D$

$\Theta_{JB} = (T_J – T_B)/P_D$

$\Theta_{JC} = (T_J – T_C)/P_D$

Where, T_J = Junction temperature.

T_A = Ambient temperature

T_B = Board temperature

T_C = Case temperature which is monitoring on package surface

P_D = Total power dissipation

Θ_{JA} represents the resistance of the heat flows from the heating junction to ambient air. It is an indicator of package heat dissipation capability. Lower Θ_{JA} can be considerate as better overall thermal performance. Θ_{JA} is generally used to estimate junction temperature.

Θ_{JB} is used to measure the heat flow resistance between the chip surface and the PCB board.

Θ_{JC} represents the thermal resistance between the chip surface and the package top case. Θ_{JC} is mainly used to estimate the heat dissipation of the system (using heat sink or other heat dissipation methods outside the device package).

Table 10-2. Package thermal characteristics(1)

Symbol	Condition	Package	Value	Unit
Θ_{JA}	Natural convection, 2S2P PCB	SOT23-6	104.1	°C/W
Θ_{JB}	Cold plate, 2S2P PCB	SOT23-6	64.1	°C/W
Θ_{JC}	Cold plate, 2S2P PCB	SOT23-6	46.1	°C/W
Ψ_{JB}	Natural convection, 2S2P PCB	SOT23-6	63.9	°C/W
Ψ_{JT}	Natural convection, 2S2P PCB	SOT23-6	2.69	°C/W

(1) Thermal characteristics are based on simulation, and meet JEDEC specification.

11 Ordering information

Table 11-1 Part order code for GD30DC2301x devices

Ordering Code	Package	Package Type	Packing Type	MOQ	Temperature Junction Range
GD30DC2301SSTR-N	SOT23-6	Green	Tape&Reel	3000	–20°C to +85°C

12 Revision history

Table 12-1 Revision history

Revision No.	Description	Date
1.0	Initial Release	2023

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