CL7683BA

COT Mode, 3A, 4.2~18V, Synchronous, 650KHz, Step-Down DC/DC Converters

Description

The CL7683 is a wide input range, high-efficiency and high frequency DC-to-DC step-down switching regulator, capable of delivering up to 3A of output current. It adopts an adaptive COT control scheme that enables very fast transient response and provides a very smooth transition when the output varies from light load to heavy load. During light load, CL7683 goes into a PFM mode that saves switching loss, achieving high efficiency. The adaptive COT control also maintains a constant switching frequency across line and load.

The CL7683 requires a minimal number of readily available, external components and is available in a small package.

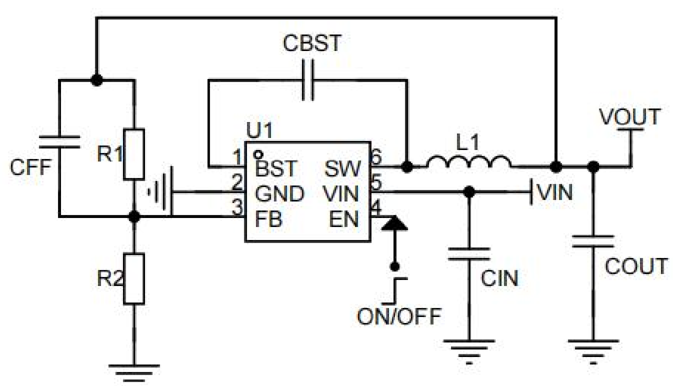
Features

- Wide 4.2V to 18V operating input range
- 3A continuous output current
- 650KHz switching frequency
- Short protection with hiccup-mode
- Built-in overcurrent limit
- High efficiency PFM mode at light load
- Integrated internal soft-start
- 73/40mΩ low RDS(ON) internal MOSFETs
- Output adjustable from 0.6V
- Low EMI signature
- 96% duty cycle max
- Built-in 1KΩ discharge resistor
- Thermal shutdown
- COT mode
- MSL3 package level

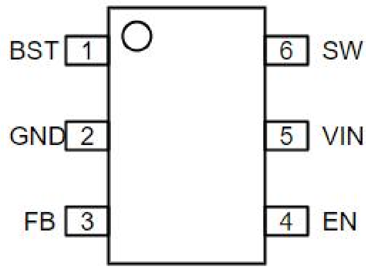
Applications

- Automotive Entertainment
- Wireless and DSL Modems
- Computer Entertainment
- IoT Applications
- Digital Still and Video Cameras
- Portable Instruments

Typical Application Circuit



Pin Configuration

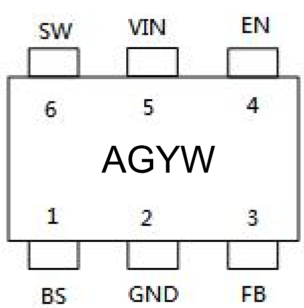


SOT23-6

Pin Assignment

Pin No.	Pin Name	Pin Function
1	BST	Bootstrap. A capacitor connected between SW and BS pins is required to form a floating supply across the high-side switch driver.
2	GND	Ground pin.
3	FB	Adjustable version feedback input. Connect FB to the center point of the external resistor divider.
4	EN	Drive this pin to a logic-high to enable the IC. Drive to a logic-low to disable the IC and enter micro-power shutdown mode.
5	VIN	Power supply pin.
6	SW	Switching pin.

Universal Naming Convention



Pinout	Top Mark	Mark Information
Left View	AG	Device Code
	YW	Year & Week

Part No.	Product Description
CL7683BA	B: OVP A: PFM

Absolute Maximum Ratings (Notes)

Parameter	Range	Unit
VIN voltage	-0.3 ~ 19	V
EN voltage	-0.3 ~ 19	V
SW voltage	-3.0 ~ VIN+3.0(<10nS)	V
BST voltage	~ Vsw+5.5	V
FB voltage	0.3 ~ 6.5	V
Operating junction temperature, T_J	-40 ~ +150	℃
Storage temperature, Tstg	-65 ~ +150	℃
Lead Temperature (Soldering, 10sec.)	260	℃

Note(1): Exceeding these ratings may damage the device.
Note(2): The device is not guaranteed to function outside of its operating conditions.

Recommended Operating Conditions

Parameter	Range	Unit
Operating junction temperature (1)	-40 ~ 125	℃
Operating temperature range	-40 ~ 85	℃
Input voltage VIN	4.2 ~ 18	V
Output current	0 ~ 3	A

Note(1): All limits specified at room temperature (TA=25℃) unless otherwise specified. All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Thermal Information

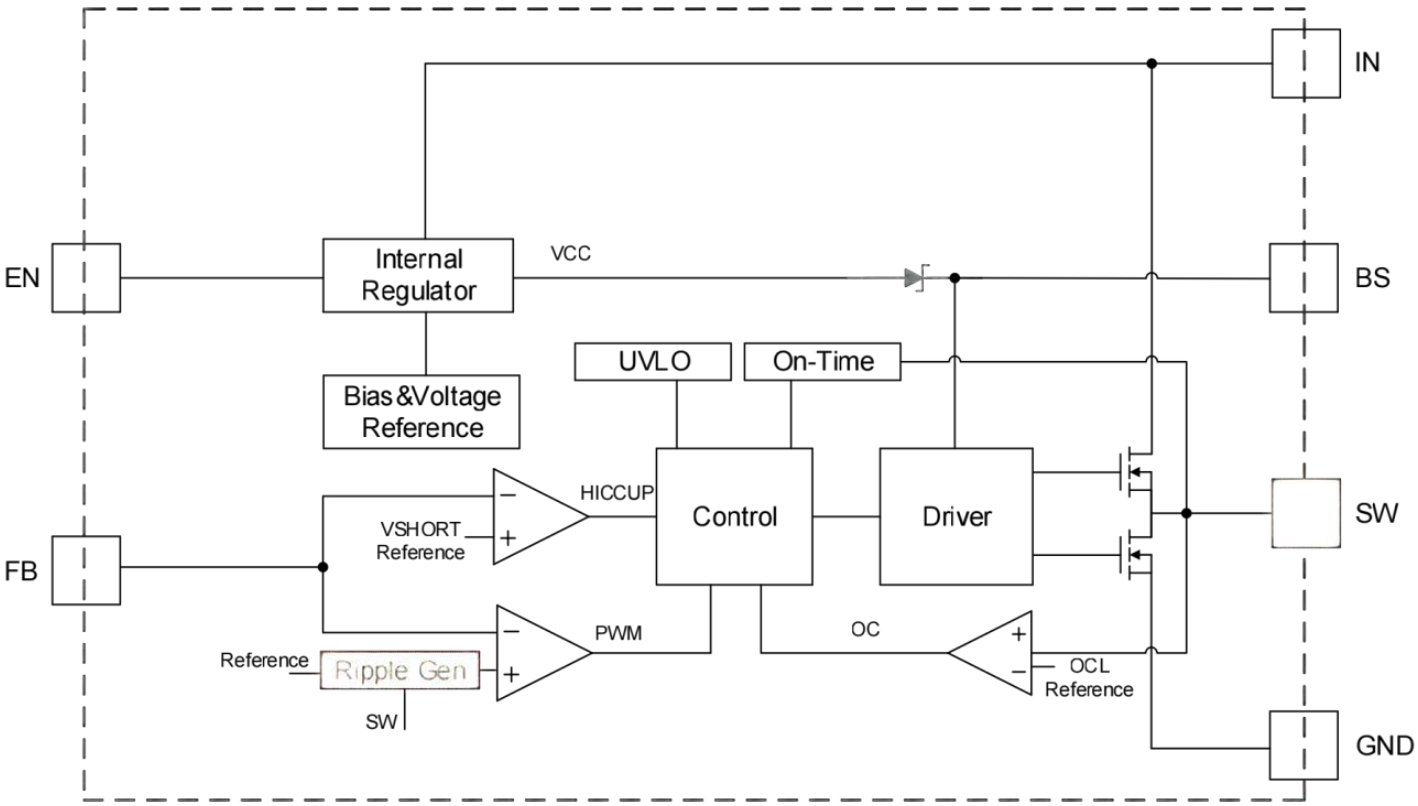
Parameter	Description	SOT23-6	Unit
RθJA	Junction-to-ambient thermal resistance (1)(2)	150	℃/W
RθJC(top)	Junction-to-case (top) thermal resistance	115	℃/W

Note(1): The package thermal impedance is calculated in accordance to JESD 51-7.
Note(2): Thermal Resistances were simulated on a 4-layer, JEDEC board.

ESD Ratings

Parameter	Description	Value	Unit
HBM	Human-body model, pre ANS/ESDA/JEDEC JS-001	±2000	V
CDM	Charge-device model, pre ANS/ESDA/JEDEC JS-002	±1000	V

Function Block Diagram



Electrical Characteristics

VIN=12V, TJ=25℃, unless otherwise specified

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage Range		4.2		18	V
OVP Threshold				19		V
V_{IN_UVLO}	VIN under-voltage lockout threshold			3.8	4.2	V
V_{IN_HYS}	VIN under-voltage lockout threshold-hysteresis			400		mV
I_Q	Quiescent current into VIN	V_{IN}=12V, V_{OUT}=5V, I_{LOAD}=0A		400	500	μA
I_{SD}	Shutdown current into VIN pin	V_{EN}=0V, V_{IN}=12V			8	μA
V_{FB}	Regulated feedback voltage	V_{IN}=12V, T_J=25℃	0.590	0.600	0.612	V
$\triangle V_{LINE\_VIN}$	Output voltage line regulation	V_{IN}=4.5V to 18V			0.5	%
$\triangle V_{LOAD}$	Output voltage load regulation	V_{IN}=12V, Vout=5V, ΔV_{LOAD}(0-3A)			1	%
	Oscillation frequency	V_{IN}=12V, Vout=5V, I_{LOAD}=1A	500	650	800	KHz
R_{DSON}	ON resistance of NMOS (HS)	I_{SW}=100mA		73		mΩ
R_{DSON}	ON resistance of NMOS (LS)	I_{SW}=-100mA		40		mΩ
	High-side switch current limit	V_{IN}=12V, FB=90%		5		A
	Low-side switch current limit	V_{IN}=12V, FB=90%		4		A
V_{EN_H}	EN rising threshold		1.5			V
V_{EN_L}	EN falling threshold				0.4	V
V_{EN_HYS}	EN threshold hysteresis			200		mV
I_{EN}	EN leakage current				1	μA
I_{SW}	SW leakage current	V_{EN}=0V, V_{IN}=V_{SW}=12V			1	μA
T_{SS}	Soft start		0.7	1.2	1.5	mS
R_{DIS}	Output discharger resistance	V_{IN}=12V, EN=0V		1000		Ω
T_{SD}	Thermal shutdown			160		℃
T_{SD_HYS}	Thermal hysteresis			10		℃

Functions Description

Internal Regulator

The CL7683 is a COT mode step down DC/DC converter that provides excellent transient response with no extra external compensation components. This device contains an internal, low resistance, high voltage power MOSFET, and operates at a high 650KHz operating frequency to ensure a compact, high efficiency design with excellent AC and DC performance.

Error Amplifier

The error amplifier compares the FB pin voltage with the internal FB reference (VFB) and outputs a current proportional to the difference between the two. This output current is then used to charge or discharge the internal compensation network, which is used to control the power MOSFET current. The optimized internal compensation network minimizes the external component counts and simplifies the control loop design.

Under-Voltage Lockout (UVLO)

Under-voltage lockout (UVLO) protects the chip from operating at an insufficient supply voltage. UVLO protection monitors the internal regulator voltage. When the voltage is lower than UVLO threshold voltage, the device is shut off. When the voltage is higher than UVLO threshold voltage, the device is enabled again.

Thermal Shutdown

Thermal shutdown prevents the chip from operating at exceedingly high temperatures. When the silicon die temperature exceeds 160℃, it shuts down the whole chip. When the temperature falls below its lower threshold (Typ. 150℃), the chip is enabled again.

Internal Soft-Start

The soft-start is implemented to prevent the converter output voltage from overshooting during startup. When the chip starts, the internal circuitry generates a soft-start voltage (SS) ramping up from 0V to 0.6V. When it is lower than the internal reference (REF), SS overrides REF so the error amplifier uses SS as the reference. When SS is higher than REF, REF regains control. The SS time is internally max to 1.5ms.

Startup and Shutdown

If both VIN and EN are higher than their appropriate thresholds, the chip starts. The reference block starts first, generating stable reference voltage and currents, and then the internal regulator is enabled. The regulator provides stable supply for the remaining circuitries. Three events can shut down the chip: EN low, VIN low and thermal shutdown. In the shutdown procedure, the signaling path is first blocked to avoid any fault triggering. The comp voltage and the internal supply rail are then pulled down. The floating driver is not subject to this shutdown command.

Applications Information

Setting the Output Voltage

CL7683 require an input capacitor, an output capacitor and an inductor. These components are critical to the performance of the device. CL7683 are internally compensated and do not require external components to achieve stable operation. The output voltage can be programmed by resistor divider.

$$V_{OUT} = V_{FEEDBACK} \times \frac{R1+R2}{R2}$$

Example of Resistor Selection

VOUT	R1(KΩ)	R2 (KΩ)	L1(TYP)	CBST	Cff	CIN	COUT
1.05V	51	68	2.2μH	0.1μF	10-100pF	20-47μF	20-68μF
1.2V	51	51	2.2μH	0.1μF	10-100pF	20-47μF	20-68μF
1.5V	51	33	3.3μH	0.1μF	10-100pF	20-47μF	20-68μF
3.3V	51	11.3	4.7μH	0.1μF	10-100pF	20-47μF	20-68μF
5.0V	51	6.8	4.7μH	0.1μF	10-100pF	20-47μF	20-68μF

Selecting the Inductor

The recommended inductor values are shown in the Application Diagram. It is important to guarantee the inductor core does not saturate during any foreseeable operational situation. The inductor should be rated to handle the peak load current plus the ripple current. Care should be taken when reviewing the different saturation current ratings that are specified by different manufacturers. Saturation current ratings are typically specified at 25°C, so ratings at maximum ambient temperature of the application should be requested from the manufacturer.

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔIL is the inductor ripple current. Choose inductor ripple current to be approximately 30% if the maximum load current. The maximum inductor peak current is:

$$IL(MAX) = IL(OAD) + \frac{\Delta I_L}{2}$$

Under light load conditions below 100mA, larger inductance is recommended for improved efficiency.

Selecting the Output Capacitor

Special attention should be paid when selecting these components. The DC bias of these capacitors can result in a capacitance value that falls below the minimum value given in the recommended capacitor specifications table.

The ceramic capacitor's actual capacitance can vary with temperature. The capacitor type X7R, which operates over a temperature range of −55℃ to +125℃, will only vary the capacitance to within ±15%. The capacitor type X5R has a similar tolerance over a reduced temperature range of −55℃ to +85℃. Many large value ceramic capacitors, larger than 1uF are manufactured with Z5U or Y5V temperature characteristics. Their capacitance can drop by more than 50% as the temperature varies from 25℃ to 85℃. Therefore X5R or X7R is recommended over Z5U and Y5V in applications where the ambient temperature will change significantly above or below 25℃.

Tantalum capacitors are less desirable than ceramic for use as output capacitors because they are more expensive when comparing equivalent capacitance and voltage ratings in the 10uF to 44uF range.

Another important consideration is that tantalum capacitors have higher ESR values than equivalent size ceramics. This means that while it may be possible to find a tantalum capacitor with an ESR value within the stable range, it would have to be larger in capacitance (which means bigger and more costly) than a ceramic capacitor with the same ESR value. It should also be noted that the ESR of a typical tantalum will increase about 2:1 as the temperature goes from 25℃ down to −40℃, so some guard band must be allowed.

PCB Layout Example & Guidelines

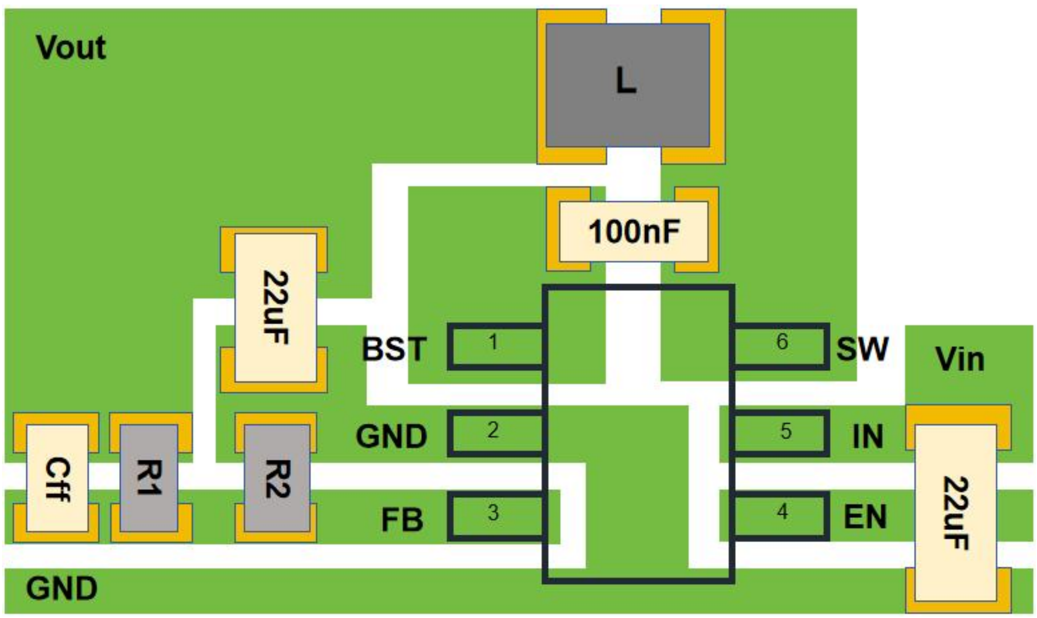
The PCB layout is an important step to maintain the high performance of the CL7683 device.

1. The input/output capacitors and the inductor should be placed as close as possible to the IC. This keeps the power traces short. Routing these power traces direct and wide results in low trace resistance and low parasitic inductance.

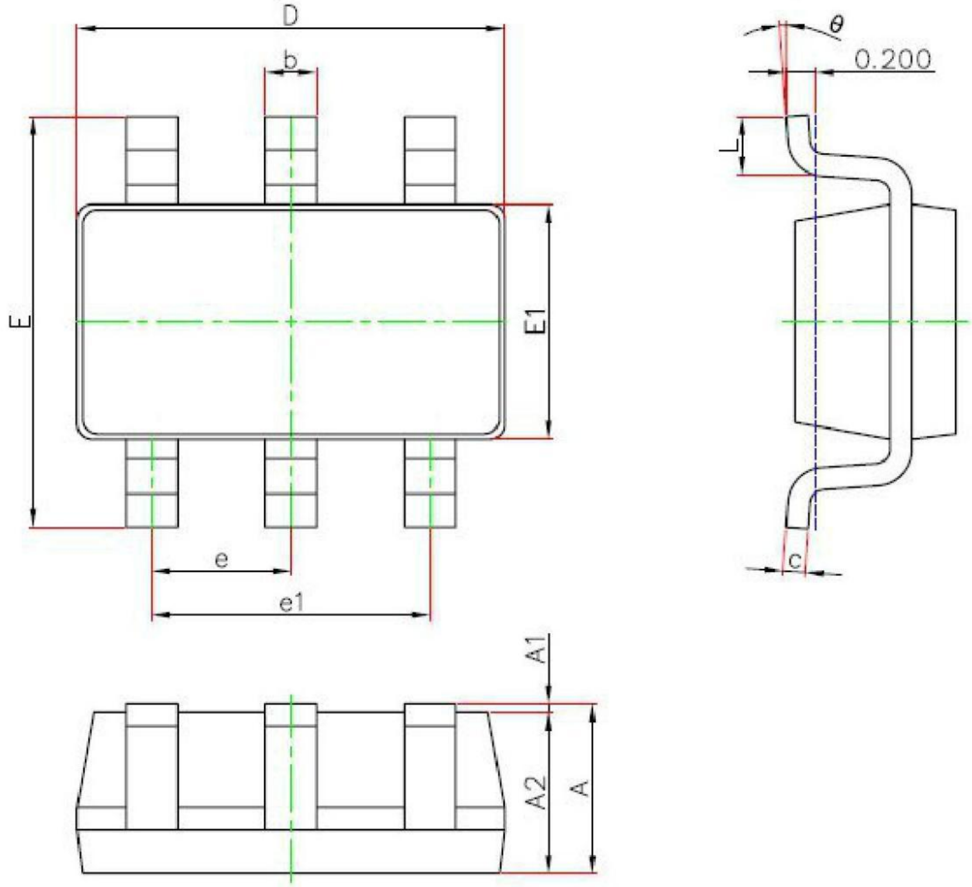
2. The low side of the input and output capacitors must be connected properly to the power GND to avoid a GND potential shift.

3. The sense traces connected to FB are signal traces. Special care should be taken to avoid noise being induced. Keep these traces away from SW nodes.

4. GND layers might be used for shielding.



Package Information: SOT23-6



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°