Wide-Input Range CC/CV Step-Down Synchronous DC/DC Converter

FEATURES

- 36V Input Voltage Surge
- Wide input voltage: 8V~30V
- Up to 2.4A Output Current at 5V Output
- 130kHz~500kHz Adjustable Frequency
- ±6% CC Accuracy
- Internal Compensation
- 31V Input OVP Protection
- Output OVP Protection
- Efficiency up to 93% at 2.4A
- 0.2V~2V Output Line Drop Compensation
- ±2% Feedback Voltage Accuracy
- Integrated Soft Start
- Thermal Shutdown
- Secondary Cycle-by-Cycle Current Limit
- EMI Consideration
- ESOP8 Package

GENERAL DESCRIPTION

TMI2242D is a wide input voltage, high efficiency Active CC step-down DC/DC converter that operates in either CV (Constant Output Voltage) mode or CC (Constant Output Current) mode. TMI2242D provides up to total 2.4A output current at 5V output. Switching frequency can be set by external resistor. Maximum 93% efficient be obtained at 2.4A and 5V output. One current sensor pin ensures the channel CC control. TMI2242D internal Integrate 80mΩ internal high side and 60mΩ internal low side power MOSFET.

Advanced production features include UVLO, Thermal Shutdown, Soft Start, OVP.

APPLICATIONS

- Car Charger/ Adaptor
- Rechargeable Portable Devices
- General-Purpose CC/CV Supply

TYPICAL APPILCATION

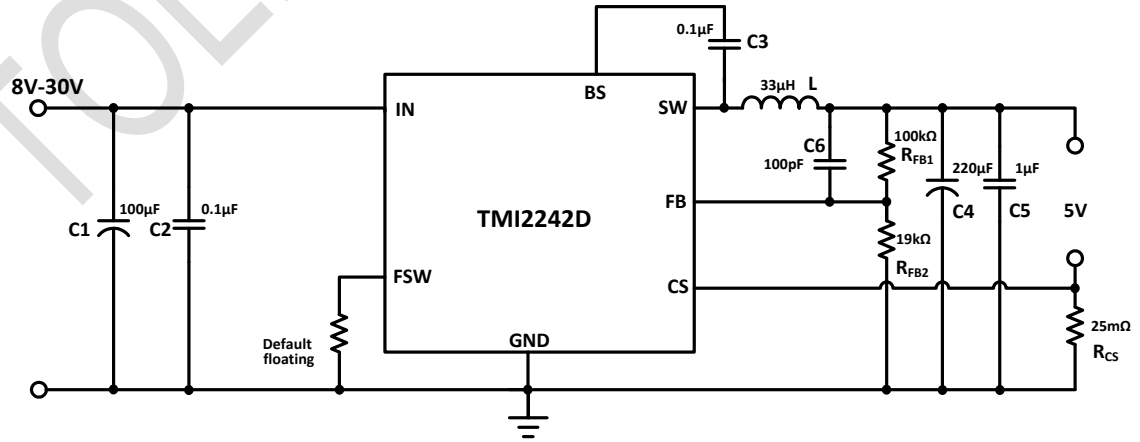


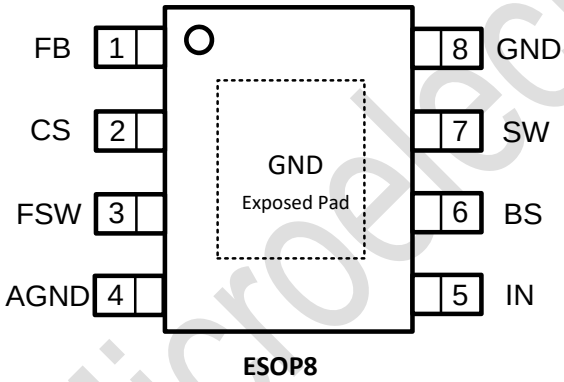
Figure 1. Basic Application Circuit

ABSOLUTE MAXIMUM RATINGS

Items	Description	Value	Unit
Voltage Range	IN, SW	-0.3~36	V
Voltage Range	BS to SW	-0.3~6	V
Voltage Range	All other Pins	-0.3~6	V
T_J	Junction Temperature	-40~150	°C
T_{stg}	Storage Temperature	-65~150	°C
θ_{JA}	Junction-to-ambient Thermal Resistance	60	°C/W
θ_{JC}	Junction-to-case Thermal Resistance	46	°C/W
P_D	Package Dissipation	2	W

Over operating free-air temperature range (unless otherwise noted)

PIN CONFIGURATION



ESOP8

Top Mark: T2242D YYXXX (T2242D: Device Code, YYXXX: Inside Code)

Part Number	Package	Top mark	Quantity/ Reel
TMI2242D	ESOP8	T2242D YYXXX	3000

TMI2242D devices are Pb-free and RoHS compliant.

PIN FUNCTIONS

Pin	Name	Function
1	FB	Feedback pin
2	CS	Output current sense pin
3	FSW	Switching Frequency set pin, connect a resistor to ground, or floating: Fs=130kHz, Short to GND: 500kHz
4	AGND	Analog Ground
5	IN	Power Input pin
6	BS	High side Gate Driver bias pin, Provide supply to high-side nLDMOS Gate Driver. Connect a 100nF capacitor between BS and SW
7	SW	Switch Pin, Connect to external Inductor
8	GND	Power Ground
9	GND	Ground (Exposed PAD)

ESD RATINGS

Items	Description	Value	Unit
V_{ESD}	Human Body Model for all pins	±2000	V

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
Voltage Range	IN	8	30	V
Current Range	Output Current	0	2.4	A
T_J	Operating Junction Temperature Range	-40	125	°C

ELECTRICAL CHARACTERISTICS

(V_{IN}=12V, V_{OUT}=5V, T_A = 25°C, unless otherwise noted.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN}		8		30	V
Input Voltage Surge	V_{IN}				36	V
Under Voltage Lockout	V_{UVLO}	V_{IN} rising		7.2		V
UVLO Hysteresis	V_{UVLO_HY}			0.6		V
Quiescent Supply Current	I_{CCQ}	no load, V_{FB} = 0.9V		1		mA
Standby Supply Current	I_{STBY}	V_{OUT} = 5V, No Load		10	15	mA
Feedback Threshold Voltage	V_{FBTH}		784	800	816	mV
FB Pin input current	I_{FB}		-50		50	nA
Input OVP Voltage	V_{INOVP}		31.5			V
Output OVP Voltage	V_{OUTOVP}			10	20	%
Soft start Time	T_{SST}			4		ms
CS Current limit Voltage	V_{LIM_CS}			65.5		mV
SW leakage	I_{SW_LEAK}				10	μA
Maximum Duty Cycle	D_{DUTY}	F_S=130kHz			90	%
Switching Frequency	F_S	R_{FSW}=300kΩ		300		kHz
		FSW pin floating		130		kHz
		FSW short to GND		500		kHz
Switch On-Resistance (high side)	R_{ON_HS}			80		mΩ
Switch On-Resistance (low side)	R_{ON_LS}			60		mΩ
Short circuit Frequency	F_{SC}	V_{FB}=0V		35		kHz
Minimum Turn-on Time	T_{ON_MIN}			200		ns
Thermal Shutdown Threshold	T_{SDN}	Guaranteed by design		155		°C
Thermal Shutdown Hysteresis	T_{SDN_HY}	Guaranteed by design		20		°C

FUNCTIONAL DESCRIPTION

TMI2242D is a peak current mode pulse width modulation (PWM) converter with CC and CV control. The converter operates as follows:

A switching cycle starts when the rising edge of the Oscillator clock output causes the High-Side Power Switch to turn on and the Low-Side Power Switch to turn off. With the SW side of the inductor now connected to IN, the inductor current ramps up to store energy in the magnetic field. The inductor current level is measured by the Current Sense Amplifier and added to the Oscillator ramp signal. If the resulting summation is higher than the COMP voltage, the output of the PWM Comparator goes high. When this happens or when Oscillator clock output goes low, the High-Side Power Switch turns off.

At this point, the SW side of the inductor swings to a diode voltage below ground, causing the inductor current to decrease and magnetic energy to be transferred to output. This state continues until the cycle starts again. The High-Side Power Switch is driven by logic using BS as the positive rail. This pin is charged to V_{SW} + 5V when the Low-Side Power Switch turns on. The COMP voltage is the integration of the error between FB input and the internal 0.8V reference. If FB is lower than the reference voltage, COMP tends to go higher to increase current to the output. Output current will increase until it reaches the CC limit set by the CS resistor. At this point, the device will transition from regulating output voltage to regulating output current, and the output voltage will drop with increasing load.

Output Voltage Setting

The connections for setting the output voltage shows in Figure 1. Select the proper ratio of the two feedback resistors R_{FB1} and R_{FB2} based on the output voltage. Adding a capacitor in parallel with R_{FB1} helps the system stability. Typically, use R_{FB1} ≈100kΩ and determine R_{FB2} from the following equation:

$$R_{FB2}=R_{FB1} / \left(\frac{V_{OUT}}{0.8}-1\right)$$

Limit Current Setting

TMI2242D constant current value is set by a sensing resistor connected between the CS pin and GND. The CC output current theoretical typical value is calculated by $I_{LIM}= V_{LIM\_CS} /Rcs$. Please note the effect of impedance of PCB GND trace from sensing resistance to TMI2242D GND pin on real current limit. Since the output current is flowing through the PCB GND trace from sensing resistance to IC GND, the impedance of the PCB GND trace increases the actual value of sensing resistance and it results in actual current limit value is a little lower than the equation $I_{LIM}= V_{LIM\_CS} /Rcs$. Please use the whole and large GND copper plane to keep the impedance of PCB GND trace from sensing resistance to TMI2242D GND pin as small as possible. In practical application, impedance of PCB GND trace could be evaluated by measuring voltage drop between IC GND pad and GND pad of sensing resistor and output current value. Meanwhile, since the CS pin is high input impedance pin, the CS trace is noise sensitive and please keep CS trace far away from high frequency switching noise source such as SW trace and inductor.

Over Voltage Protection

The thresholds of input OVP circuit include are minimum 31.2V. Once the input voltage is higher than the threshold, the high-side MOSFET is turned off. When the input voltage drops lower than the threshold, the high-side MOSFET will be enabled again.

Thermal Shutdown

The TMI2242D disables switching when its junction temperature exceeds 155°C and resumes when the temperature has dropped by 20°C.

Setting the switching frequency

The Oscillator normally switches at 130kHz~650kHz, which is set by FSW resistance as Table 1.

FSW pin floating	R_{FSW}= 100kΩ	R_{FSW}= 200kΩ	R_{FSW}=300kΩ	FSW short to GND
130kHz	650kHz	400kHz	300kHz	500kHz

Table 1. Switching frequency vs. Resistance on FSW pin

Setting the Cable Compensation

TMI2242D provides programmable cable voltage drop compensation using the impedance at the FB pin to compensate voltage drop across the charger's output cable when load current is larger than 0.5A. The cable compensation voltage can be expressed as: $V_{comp}=I_{load} \times 1.5 \times 10^{-6} \times R_{FB1} - 0.07$. By adjusting the value of R_{FB1}, the cable compensation voltage can be programmed.

EMI Consideration

Since parasitic inductance and capacitance effects in PCB circuitry would cause a spike voltage on SW node when high-side MOSFET is turned on/off, this spike voltage on SW may impact on EMI performance in the system. In order to enhance EMI performance, there are two methods to suppress the spike voltage. One is to place an RC snubber between SW and GND and make them as close as possible to the high-side MOSFET's source and low-side MOSFET's drain. Another method is to add a resistor in series with the bootstrap capacitor C3. But this method will decrease the driving capability to the high-side MOSFET. It is strongly recommended to reserve the RC snubber during PCB layout for EMI improvement. Moreover, reducing the PHASE trace area and keeping the main power in a small loop will be helpful on EMI performance.

PC Board Layout Guidance

When laying out the printed circuit board, the Following checklist should be used to ensure proper operation of the IC.

1) Arrange the power components to reduce the AC loop size consisting of C_{IN}, IN pin, SW pin.

2) Place input decoupling ceramic capacitor C_{IN} as close to IN pin as possible. C_{IN} is connected power GND with vias or short and wide path.

3) Return FB to signal GND pin, and connect the GND pin and AGND pin at a single point to exposed pad of the IC directly best noise immunity. Connect exposed pad to power ground copper area with copper and use vias to connect exposed pad to GND copper plane for best heat dissipation and noise immunity.

4) Place feedback resistor close to FB pin.

5) Use short trace connecting BS-C_{BS}-SW loop.

FUNCTIONAL BLOCK DIAGRAM

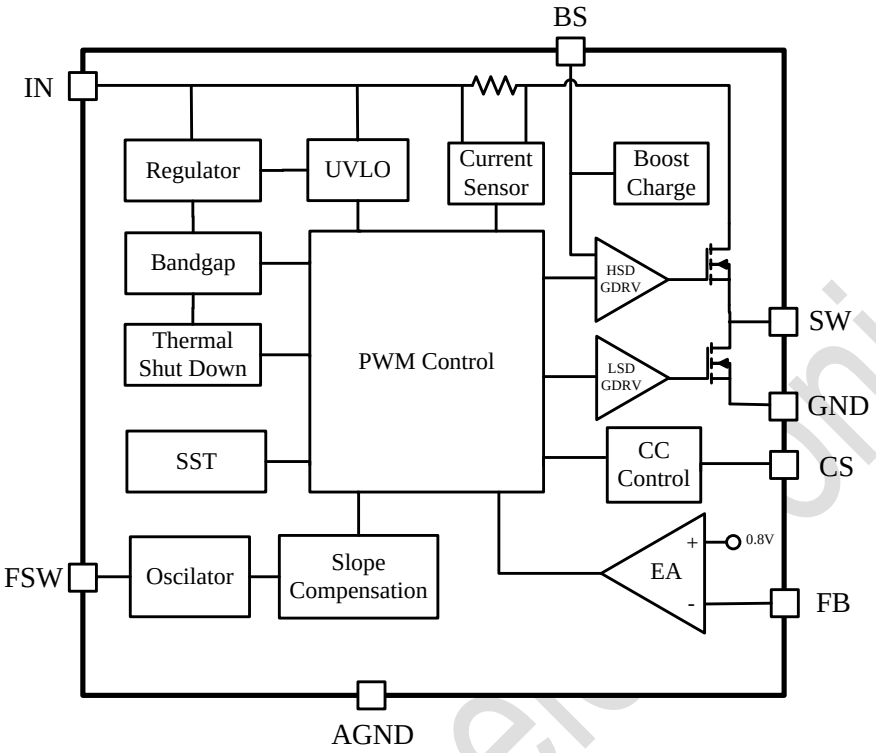
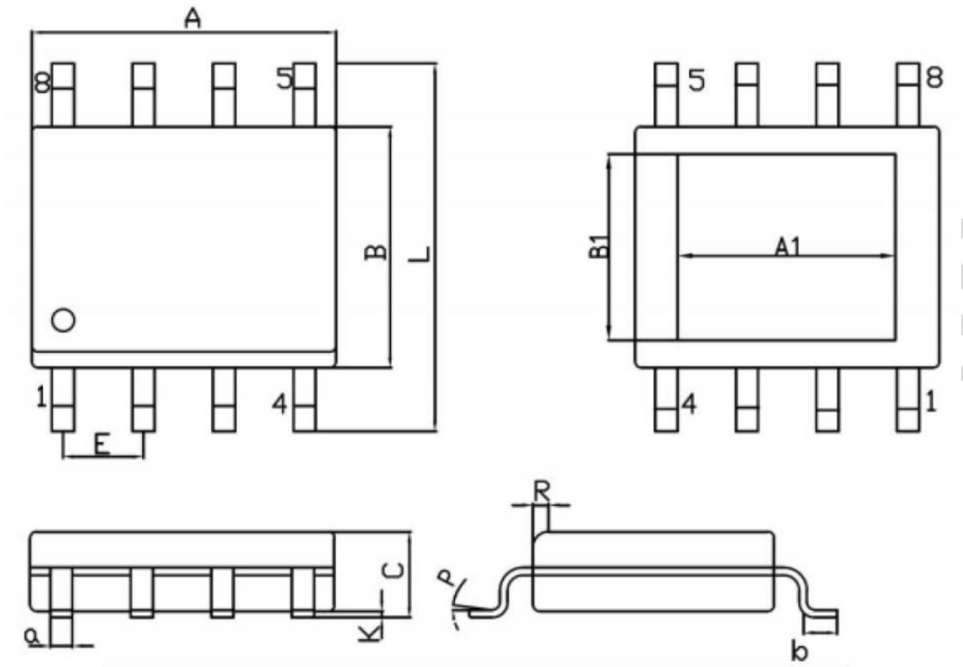


Figure 2. TMI2242D Block Diagram

PACKAGE INFORMATION

ESOP8



Unit: mm

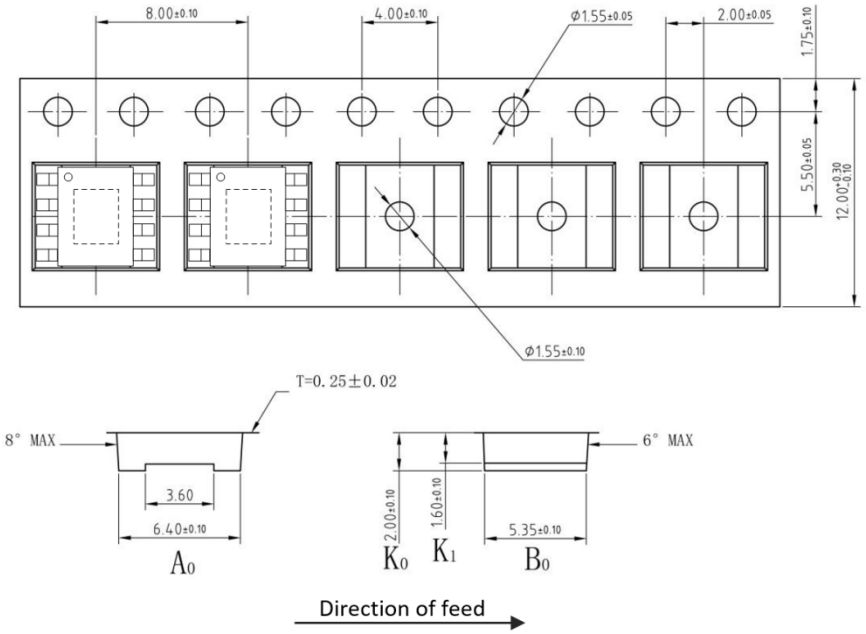
Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
A	4.70	5.10	C	1.35	1.75
B	3.70	4.10	a	0.35	0.49
L	6.00	6.40	R	0.30	0.60
E	1.27 BSC		P	0°	7°
K	0.02	0.10	b	0.40	1.25
A1	3.1	3.5	B1	2.2	2.6

Note:

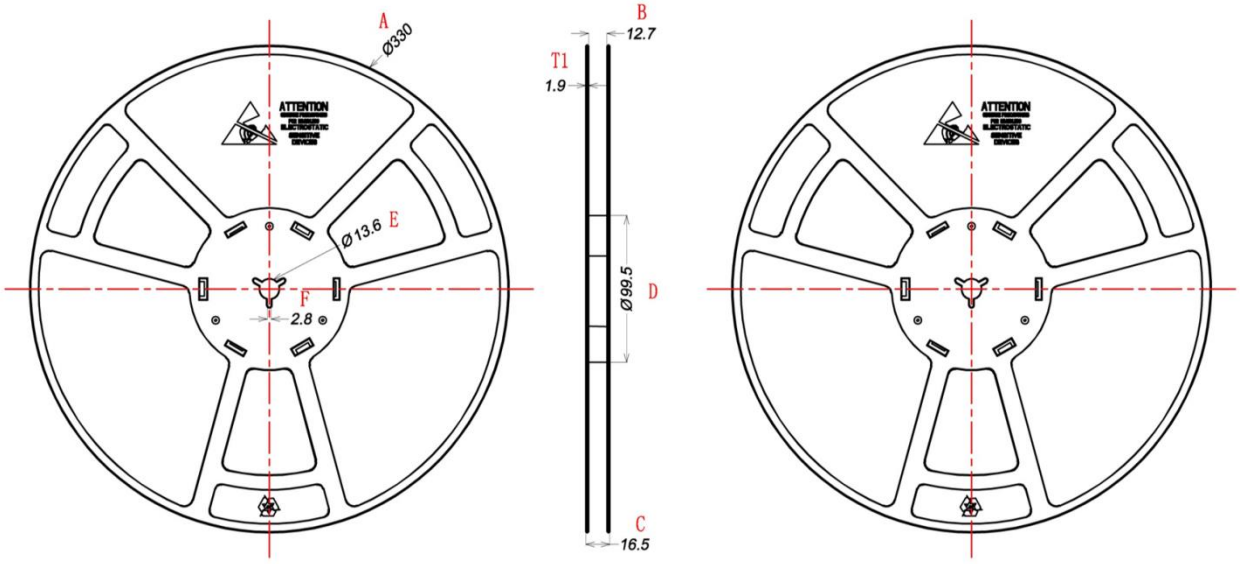
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top mark from left to right.

TAPE AND REEL INFORMATION

TAPE DIMENSIONS:



REEL DIMENSIONS:



Unit: mm

A	B	C	D	E	F	T1
Ø 330±1	12.7±0.5	16.5±0.3	Ø 99.5±0.5	Ø 13.6±0.2	2.8±0.2	1.9±0.2

Note:

1) All Dimensions are in Millimeter
2) Quantity of Units per Reel is 3000
3) MSL level is level 3.