5.5V, 2.1MHz, 5A High Efficiency Synchronous COT Control Step-Down Converter

FEATURES

- 2.7V to 5.5V Input Voltage Range
- 2.1MHz Switching Frequency
- Up to 5A Output Current
- COT Control with Fast Transient Performance
- Output Voltage as Low as 0.6V
- PFM Mode for High Efficiency in Light Load
- Low Quiescent Current: 50μA
- Short Circuit Protection
- Thermal Shutdown Protection
- Inrush Current Limit and Soft Start
- Input overvoltage protection (OVP)
- <1μA Shutdown Current
- DFN3x3-10 package

GENERAL DESCRIPTION

TMI3125 is a high efficiency, 2.1MHz, Synchronous Buck converter that operates in wide input voltage range from 2.7V to 5.5V. Very low standby current ensure high efficiency in light load PFM mode. A COT (Constant On-Time) structure is adaptive to achieve the fixed switching frequency and fast load transient response. TMI3125 provides up to 5A output current with Integrated 35mΩ (high side) and 25mΩ (low side) power switch typically. TMI3125 also implement an internal soft-start and cycle-by-cycle over current protection function. In addition, the input UVLO and OVP protection, Thermal shutdown protection. TMI3125 has power good function and it is offered in DFN3x3-10 package.

APPLICATIONS

- Wireless and DSL Modems
- PC and Notebook
- Digital and Video Cameras
- TV

TYPICAL APPILCATION

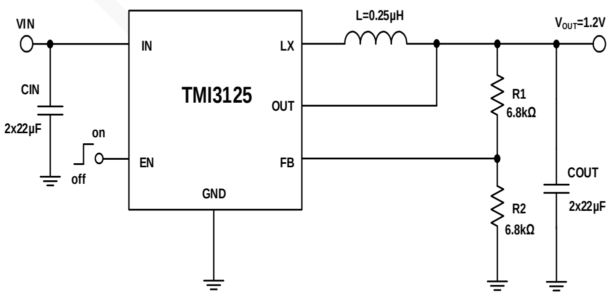
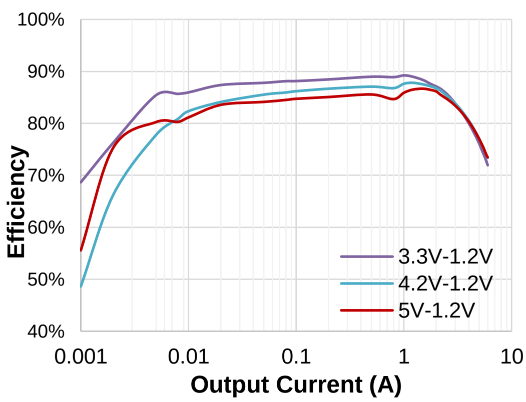


Figure 1. Basic Application Circuit

Efficiency

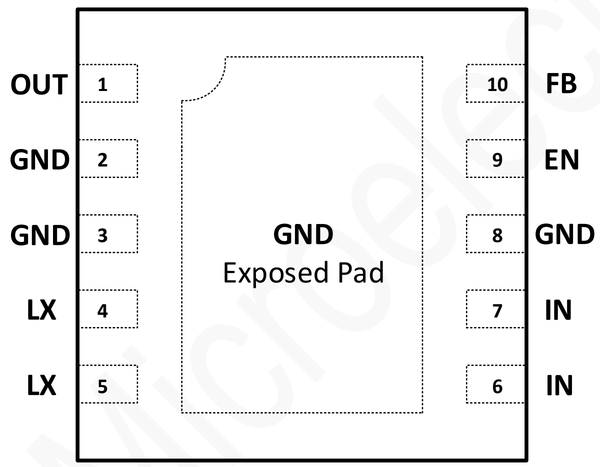
V_{OUT}=1.2V, L=1μH, T_A=25°C, I_O=1mA to 6A



ABSOLUTE MAXIMUM RATINGS(Note1)

Parameter	Min	Max	Unit
Input Supply Voltage	-0.3	6.5	V
LX Voltages	-0.3	6.5	V
LX Voltages (<10ns transient)	-2.5	7.5	V
LX Voltage (<5ns transient)	-3.5	7.5	V
EN, FB, OUT Voltage	-0.3	6	V
Junction Temperature (Note2)	-	160	°C
Power Dissipation	-	2.6	W
Lead Temperature (Soldering, 10s)	-	260	°C

PACKAGE/ORDER INFORMATION



DFN3x3-10 (Top View)

Top Mark: T3125/XXXXX (T3125: Device Code, XXXXX: Inside Code)

Part Number	Package	Top mark	Quantity/ Reel
TMI3125	DFN3x3-10	T3125 XXXXX	5000

TMI3125 devices are Pb-free and RoHS compliant.

PIN DESCRIPTIONS

Pin	Name	Function
1	OUT	Output Voltage Sense Pin.
2	GND	Ground Pin.
3		
4	LX	Power Switch Output. It is the switch node connection to Inductor. This pin connects to the drains of the internal P-ch and N-ch MOSFET switches.
5		
6	IN	Power Supply Input Pin.
7		
8	GND	Ground Pin.
9	EN	Enable Pin. Drive EN above EN high threshold to turn on the part. Drive EN below EN low threshold to turn it off. Do not leave EN floating.
10	FB	Output Voltage Feedback Pin.
11	GND	Ground Pin (Exposed Pad).

ESD RATING

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	2.7	5.5	V
T_J	Operating Junction Temperature Range	-40	125	°C
T_A	Operating Ambient Temperature Range	-40	85	°C

THERMAL RESISTANCE

Items	Description	Value	Unit
θ_{JA}	Junction-to-ambient thermal resistance	48	°C/W
θ_{JC_B}	Junction-to-case(bottom) thermal resistance	8	°C/W
θ_{JC_T}	Junction-to-case(top) thermal resistance	21	°C/W

ELECTRICAL CHARACTERISTICS

(V_{IN}=V_{EN}=3.6V, V_{OUT}=1.8V, T_A = 25°C, unless otherwise noted.)

Parameter	Conditions	Min	Typ	Max	Unit
Input Voltage Range		2.7		5.5	V
Input OVP Threshold	V_{IN} Rising		5.9		V
Input UVLO Threshold	V_{IN} Rising		2.45		V
Input UVLO Hysteresis			0.15		V
Quiescent Current	V_{EN} =2.0V, I_{OUT}=0A, V_{FB}=V_{REF} x 105%		50		µA
Shutdown Current	V_{EN} = 0V		0.5		µA
Regulated Feedback Voltage V_{FB}	I_{OUT}=0A, T_A = 25°C (V_{OUT}=1.8V)	0.588	0.600	0.612	V
Oscillation Frequency	V_{OUT}=1.8V		2.1		MHz
On Resistance of PMOS	I_{LX}=100mA		35		mΩ
On Resistance of NMOS	I_{LX}=-100mA		25		mΩ
Peak Current Limit	V_{IN}= 5V, V_{FB}=90% x V_{REF}		6.5		A
EN High Level Input Voltage		1.2			V
EN Low Level Input Voltage				0.4	V
EN Leakage Current				1.0	µA
LX Leakage Current	V_{EN} = 0V, V_{IN} = V_{LX} = 5V			1.0	µA
Maximum Duty Cycle			80		%
Minimum On-Time			45		ns
Minimum Off-Time			75		ns
Thermal Shutdown Threshold (Note 3)			165		°C
Thermal Shutdown Hysteresis (Note 3)			20		°C

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + (P_D) \times \theta_{JA}$.

Note 3: Thermal shutdown threshold and hysteresis are guaranteed by design.

OPERATION

Overview

The TMI3125 is a high output current monolithic switch mode step-down DC-DC converter. The devices operate at a 2.1MHz switching frequency, and uses a COT control mode architecture.

This step-down DC-DC converter can supply up to 5A output current and has an input voltage range from 2.7V to 5.5V. It minimizes external component size and optimizes efficiency at the heavy load range. The slope compensation allows the device to remain stable over a wider range of inductor values so that smaller values with lower DCR can be used to achieve higher efficiency. Only a small bypass input capacitor is required at the output.

The adjustable output voltage can be programmed with external feedback dividers, ranging from 0.6V to 3.3V. It uses internal MOSFETs to achieve high efficiency and can generate very low output voltages by using an internal reference of 0.6V. At dropout operation, the output voltage tracks the input voltage minus the low $R_{DS(ON)}$ drop of the P-channel high-side MOSFET and the inductor DCR. The internal error amplifier and compensation provides excellent transient response, load and line regulation. Internal soft start eliminates any output voltage overshoot when the device is enabled or the input voltage is applied.

Input Over Voltage Protection

TMI3125 has input side over voltage protection function. When input voltage is higher than input OVP threshold 5.9V typical, TMI3125 stops switching operation to protect device works with high input voltage. When input voltage is recovered from OVP and drops down input OVP threshold with OVP hysteresis typical 350mV, the device starts to switch as normal operation automatically. This function protects device from switching in abnormal high input voltage and input surge condition.

Input Under Voltage Lockout

TMI3125 implements input under voltage lockout function to avoid mis-operation at low input voltages. When the input voltage is lower than input UVLO threshold with UVLO hysteresis, the device is shut down. The typical 150mV input UVLO hysteresis value of TMI3125 is useful to prevent device from abnormal switching caused by input voltage oscillation around UVLO threshold during input voltage power-up and power-down with high load condition.

Soft Start

TMI3125 has built-in soft-start circuits to control output voltage rise rate to avoids excessive inrush current during IC start up. The typical soft-start time is 0.2ms.

Over Current Limit and Output Short Protection

TMI3125 has cycle-by-cycle current limit function and prevents the device from high load current condition. The typical high side peak current limit value is 6.5A. When output load current increases and inductor current peak value reaches peak current limit value, high side MOSFET is turned off immediately and the output voltage drops down according to load condition. If output voltage keeps falling down, the device enters into output short protection condition.

Thermal Shutdown

TMI3125 enters into thermal shutdown once the junction temperature exceeds thermal shutdown threshold 165°C typically. Once the device junction temperature falls below the threshold with hysteresis, TMI3125 returns to normal operation automatically.

FUNCTIONAL BLOCK DIAGRAM

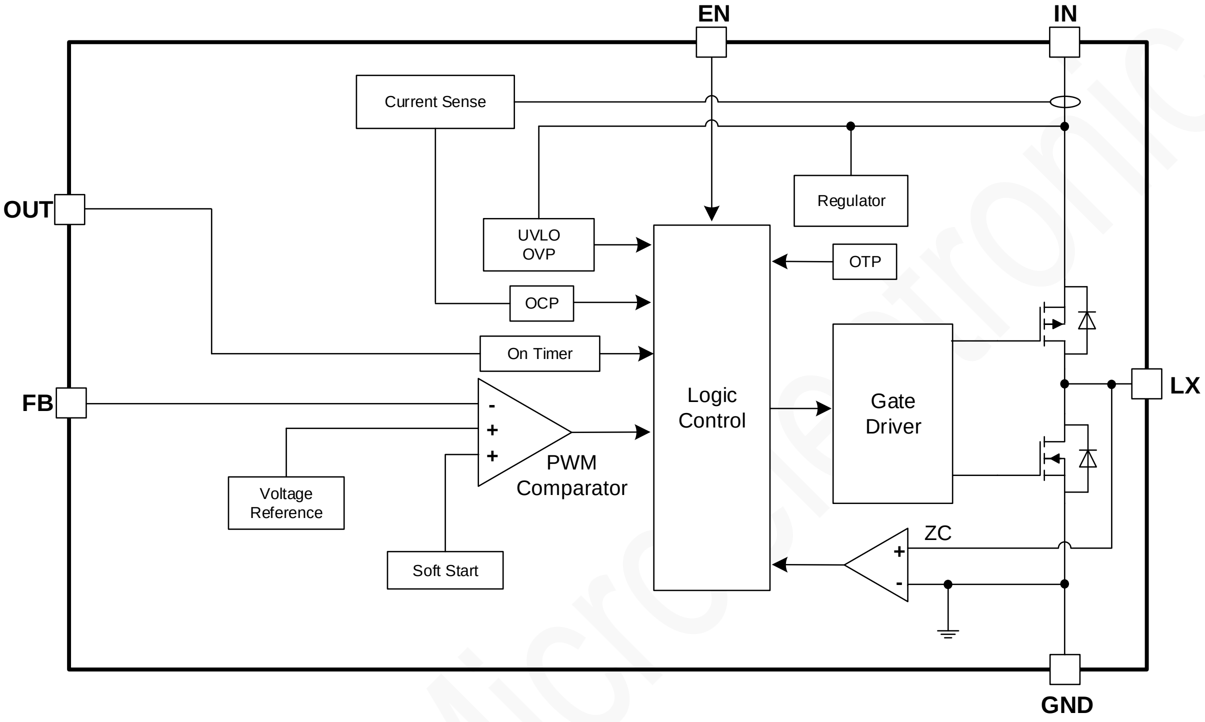


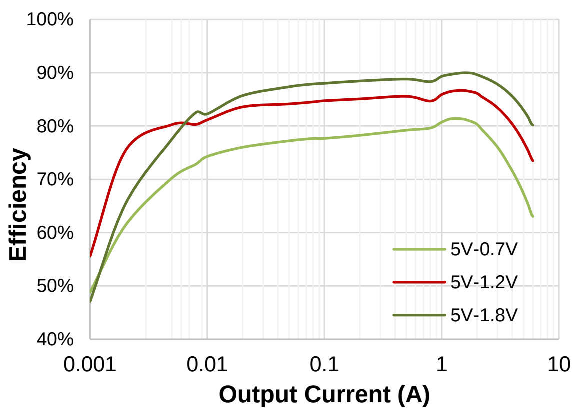
Figure 2. TMI3125 Block Diagram

TYPICAL PERFORMANCE CHARACTERISTICS

Test condition: V_{IN}=5V, V_{OUT}=1.2V, L=0.25µH, T_A=25°C, unless other noted.

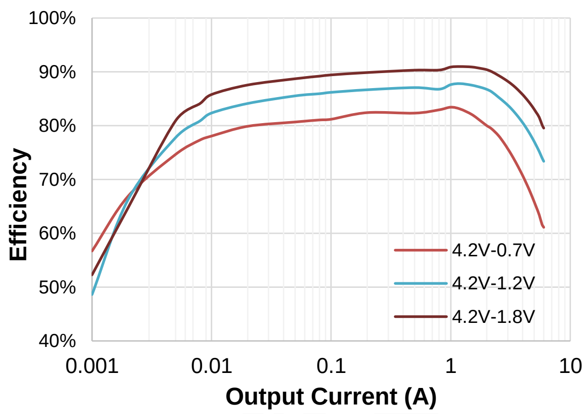
Efficiency at V_{IN} = 5V

V_{IN} =5V, L=0.25µH



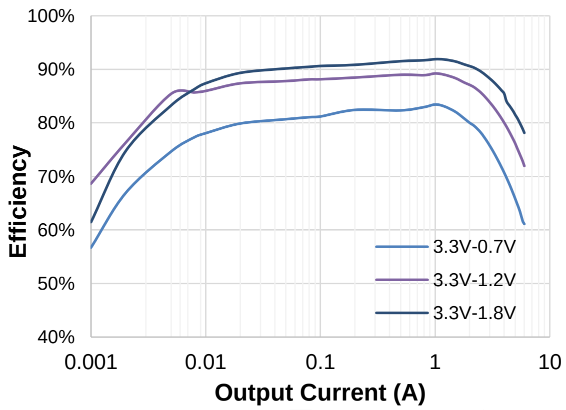
Efficiency at V_{IN} = 4.2V

V_{IN} =4.2V, L=0.25µH



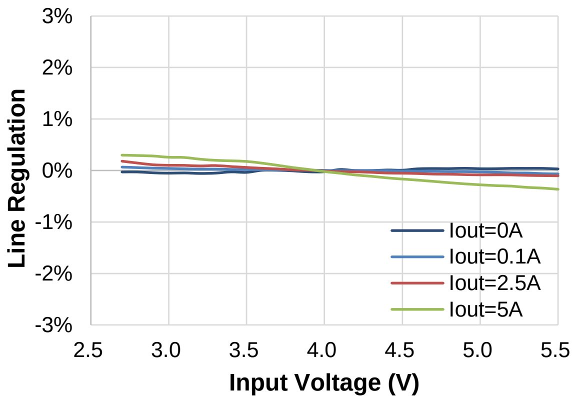
Efficiency at V_{IN} = 3.3V

V_{IN} =3.3V, L=0.25µH



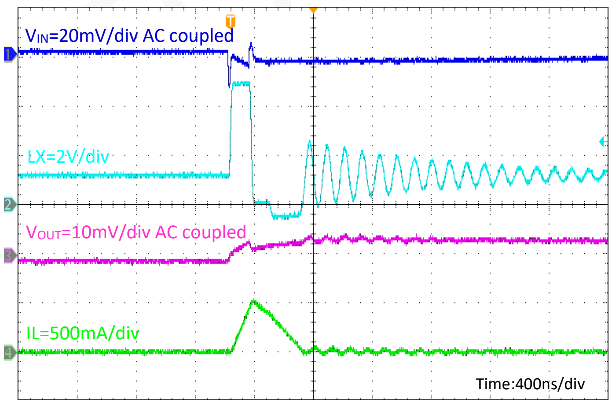
Line Regulation at V_{OUT}=1.2V

V_{OUT} =1.2V, L=0.25µH



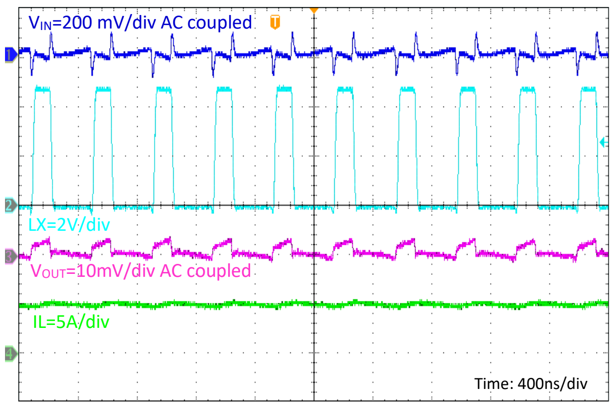
Steady State Operation

V_{IN} =5V, V_{OUT} =1.2V, No Load



Steady State Operation

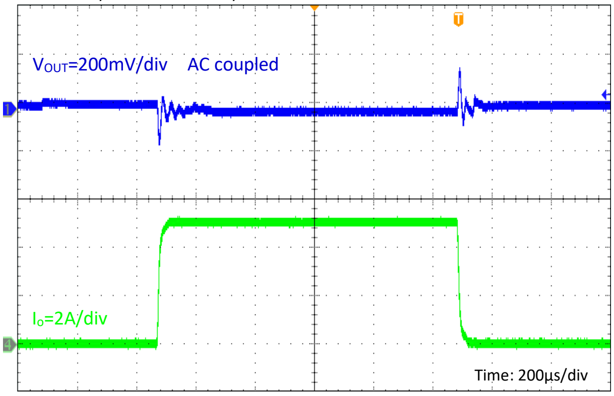
V_{IN} =5V, V_{OUT} =1.2V, I_o=5A



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

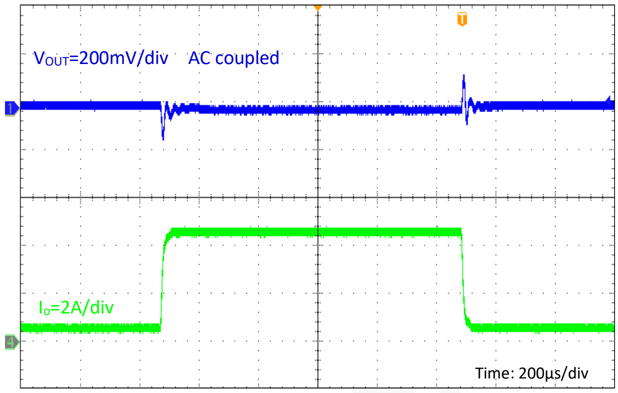
Load Transient

V_{IN} =5V, V_{OUT} =1.2V, I_o = 0A to 5A



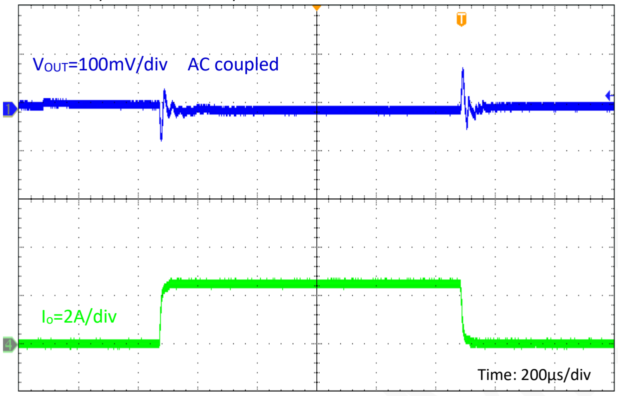
Load Transient

V_{IN} =5V, V_{OUT} =1.2V, I_o = 0.5A to 4.5A



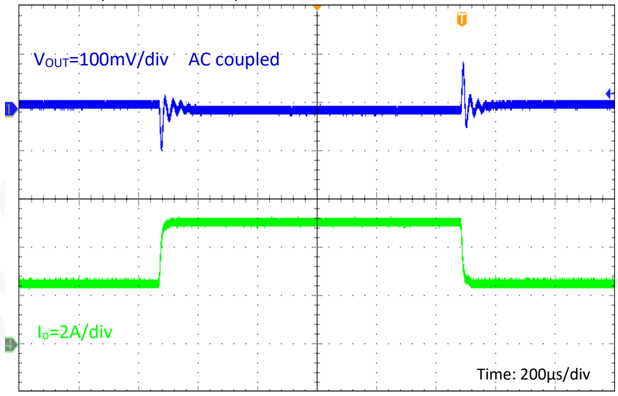
Load Transient

V_{IN} =5V, V_{OUT} =1.2V, I_o = 0A to 2.5A



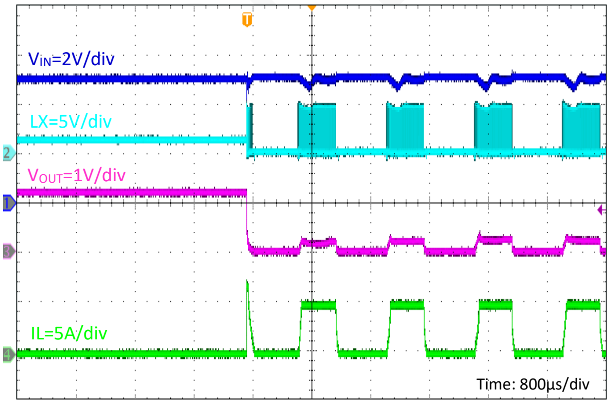
Load Transient

V_{IN} =5V, V_{OUT} =1.2V, I_o = 2.5A to 5A



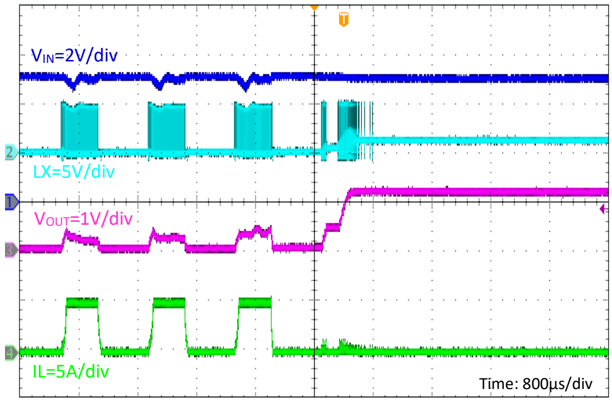
Output Short Entry

V_{IN} =5V, V_{OUT} =1.2V, I_o = No Load



Output Short Recovery

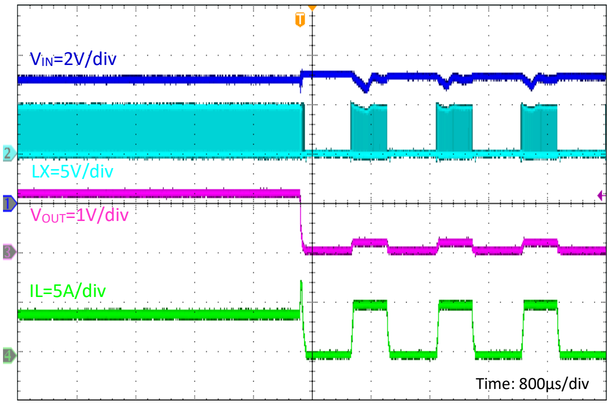
V_{IN}=5V, V_{OUT} =1.2V, I_o = No Load



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

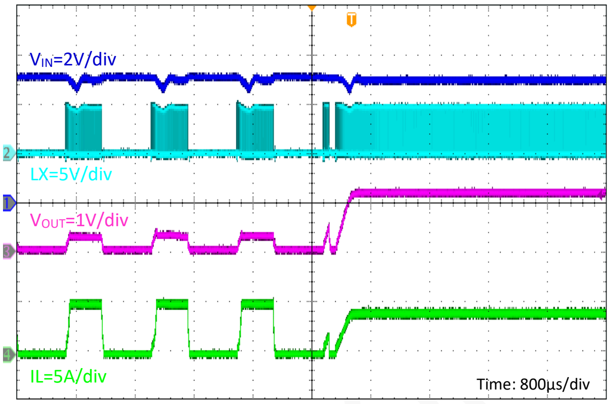
Output Short Entry

V_{IN} =5V, V_{OUT} =1.2V, I_o =5A



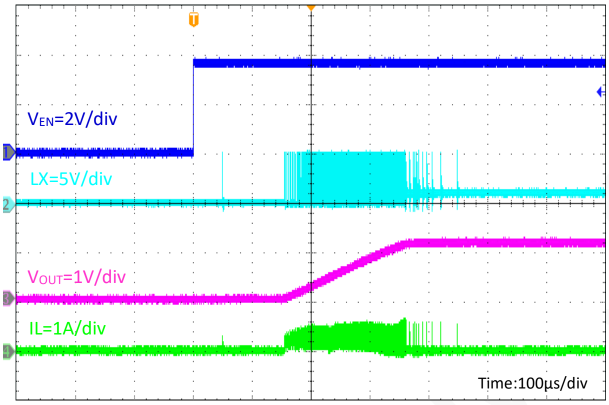
Output Short Recovery

V_{IN}=5V, V_{OUT} =1.2V, I_o = 5A



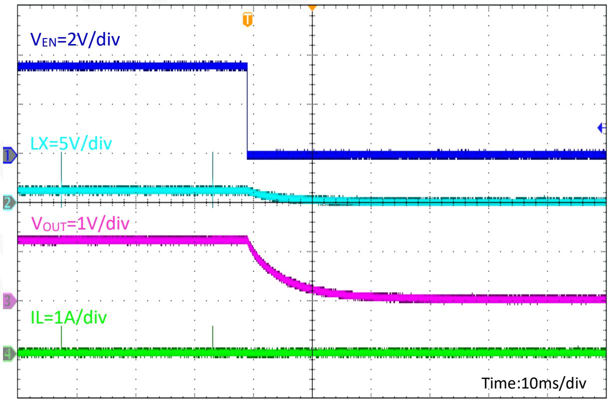
EN Enable Power On

V_{IN} =5V, V_{OUT} =1.2V, No Load



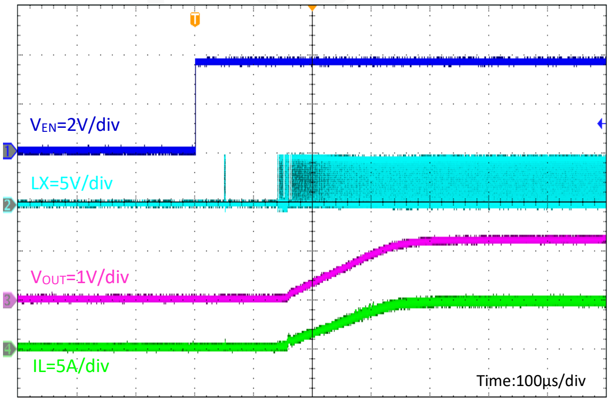
EN Disable Power down

V_{IN} =5V, V_{OUT} =1.2V, No Load



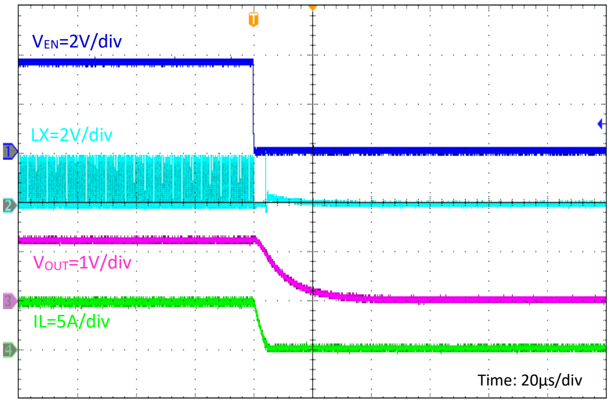
EN Enable Power On

V_{IN} =5V, V_{OUT} =1.2V, I_o =5A



EN Disable Power down

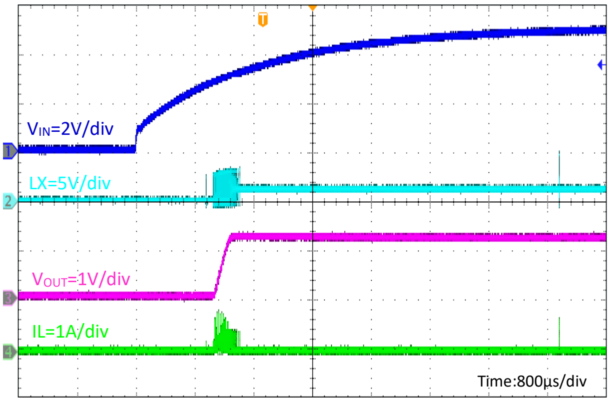
V_{IN} =5V, V_{OUT} =1.2V, I_o =5A



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

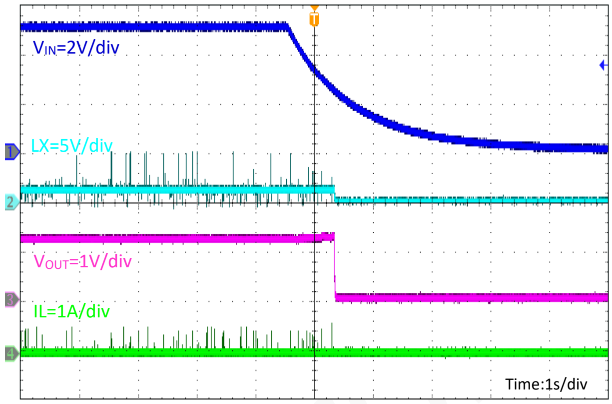
Input Power On

V_{IN} =5V, V_{OUT} =1.2V, No Load



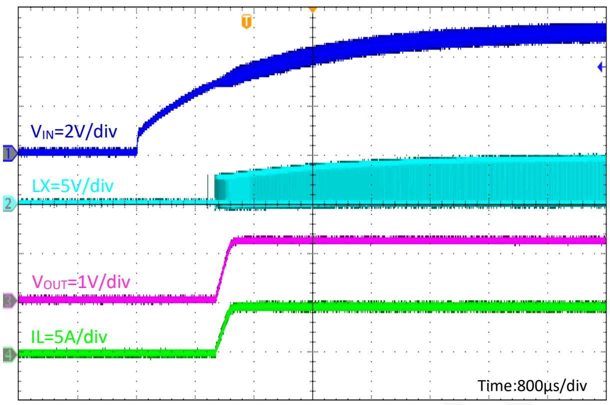
Input Power Down

V_{IN} =5V, V_{OUT} =1.2V, No Load



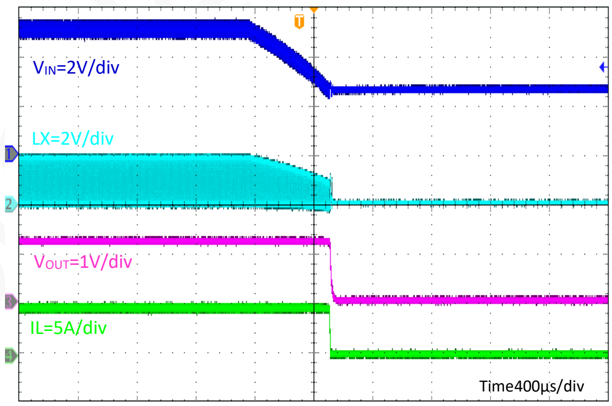
Input Power On

V_{IN} =5V, V_{OUT} =1.2V, I_o =5A



Input Power Down

V_{IN} =5V, V_{OUT} =1.2V, I_o =5A



APPLICATION INFORMATION

Setting the Output Voltage

In the first page, the typical application circuit for the TMI3125 is shown. The output voltage of TMI3125 can be externally programmed. Resistors R1 and R2 in typical application program the output to regulate at a voltage higher than 0.6V. Recommend resistance value of R1 and R2 is K ohm level and minimum output load current is 100μA in order to better improve the dynamic performance

The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 0.6 \times (1 + \frac{R_1}{R_2})$$

$$R_1 = (V_{OUT} / 0.6 - 1) \times R_2$$

TMI3125 adopts COT control mode and has internal ripple injection for control loop stability. The ripple injection has effects on output voltage accuracy in high output voltage applicaton. The recommended output range is 0.6V to 1.8V.

Inductor Selection

For most designs, 0.25μH inductance can satisfy most application conditions. Inductance value is related to inductor ripple current value, input voltage, output voltage setting and switching frequency. The inductor value can be derived from the following equation:

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

Where ΔI_L is inductor ripple current. Large value inductors result in lower ripple current and small value inductors result in high ripple current, so inductor value has effect on output voltage ripple value. DC resistance of inductor which has impact on efficiency of DC/DC converter should be taken into account when selecting the inductor,We generally recommend the use range of inductance from 0.25μH to 0.33μH.

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency should be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. Two 22μF effective capacitance value ceramic capacitors for most applications is sufficient. A large value may be used for improved input voltage filtering.

Output Capacitor Selection

The output capacitors are required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current ratings. The output ripple $\triangle V_{OUT}$ is determined by:

$$\Delta V_{OUT} \le \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR + \frac{1}{8 \times f_{osc} \times C3} \right)$$

Two 22µF effective capacitance value ceramic capacitors can satisfy most applications.DC voltage derating of ceramic capacitor must be considered in applications, Larger output capacitance is help to reduce output ripple during load transient condition.

Layout Consideration

PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance. If change is necessary, please follow these guidelines and take Figure 3 for reference.

1. The power traces, consisting of the GND trace, the LX trace and the IN trace should be kept short, direct and wide.
2. Does the (+) plates of C_{IN} connect to VIN as closely as possible. This capacitor provides the AC current to the internal power MOSFETs.
3. Keep the switching node, LX, away from the sensitive FB node.
4. Keep the (-) plates of C_{IN} and C_{OUT} as close as possible.
5. As shown in the following table, under normal application, we recommend 2*22µF for C_{IN} and C_{OUT}, and the inductance range is 0.25µH~0.33µH.

Table 1: Selection for Common Output Voltages(V_{FB}=0.6V)

V_{OUT}	L	C_{IN}	C_{OUT}	R_H	R_L
1.2V	0.25µH	2*22µF	2*22µF	100K	100K
1.8V	0.25µH	2*22µF	2*22µF	100K	50K

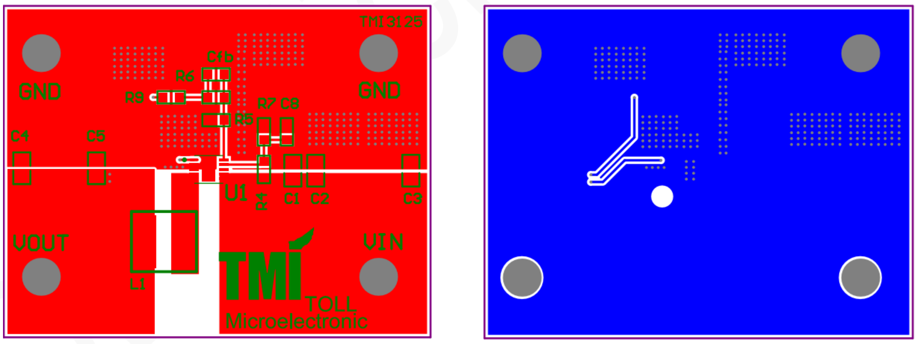
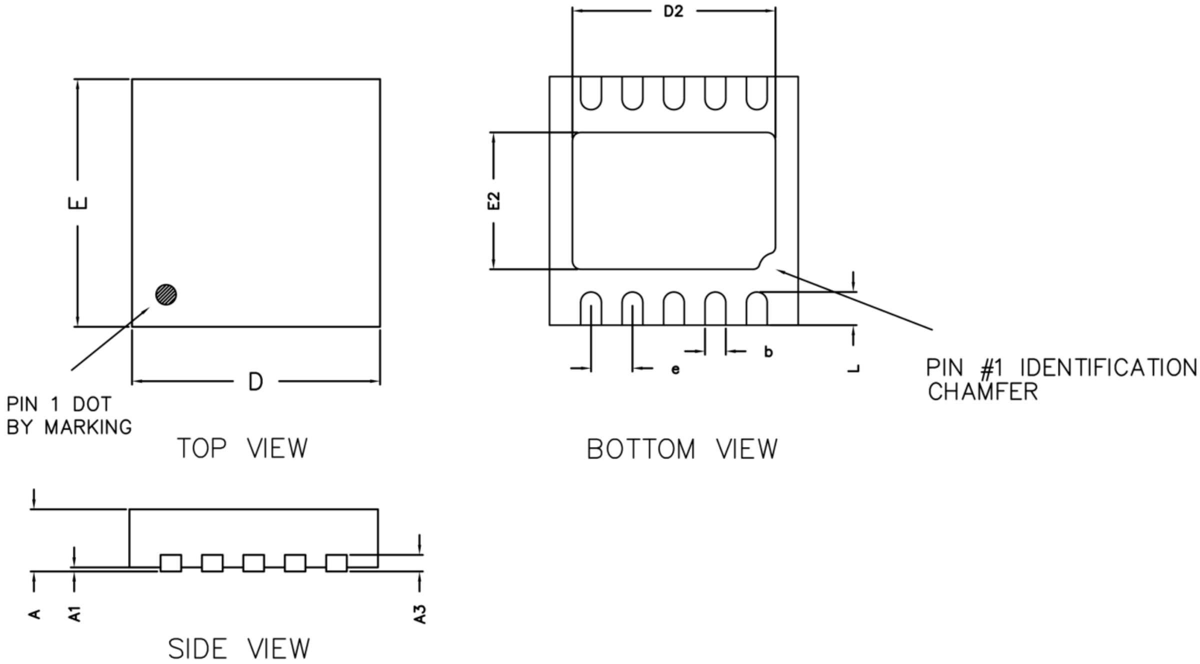


Figure 3. Sample of PCB Layout

PACKAGE INFORMATION

DFN3x3-10

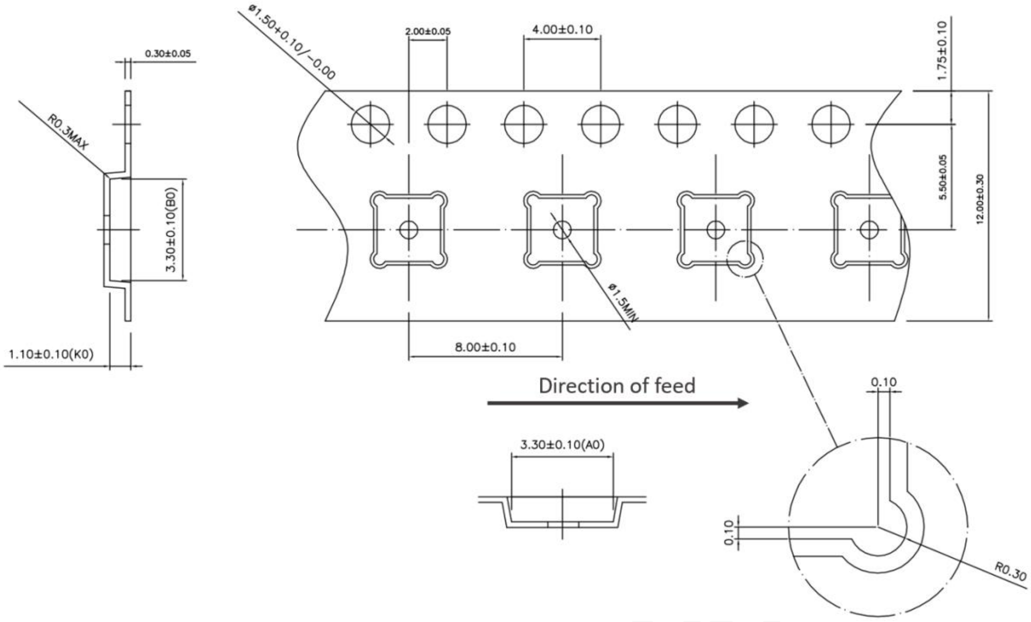


Unit: mm

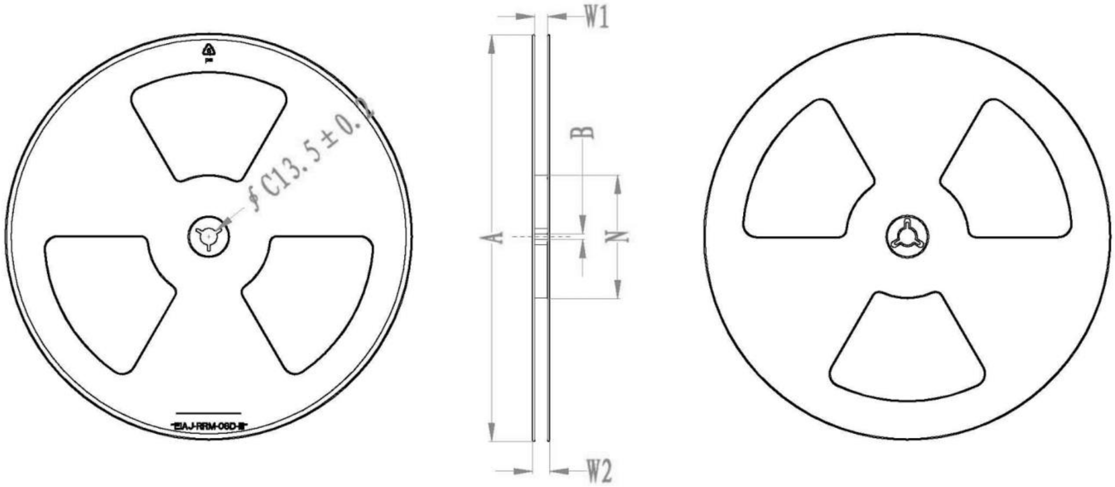
Symbol	Dimensions In Millimeters			Symbol	Dimensions In Millimeters		
	Min	Nom	Max		Min	Nom	Max
A	0.70	0.75	0.80	b	0.18	0.23	0.28
A1	0.00	-	0.05	L	0.30	0.40	0.50
A3	0.2 REF			D2	2.30	2.45	2.55
D	2.95	3.00	3.05	E2	1.50	1.65	1.75
E	2.95	3.00	3.05	e	0.50 BSC		

TAPE AND REEL INFORMATION

TAPE DIMENSIONS:



REEL DIMENSIONS:



Unit: mm

Ø A	Ø C	B	W1	W2	N
330±1.0	13.5±0.2	4.7±0.5	13.4±0.5	17.4±0.5	100±0.5

Note:

1) All Dimensions are in Millimeter
2) Quantity of Units per Reel is 5000
3) MSL level is level 3.

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