1.5MHz, 1.2A FPWM Synchronous Step-Down Converter with Small DFN1.6x1.6-6 Package

FEATURES

- 2.5V to 5.5V Input Voltage Range
- High Efficiency: Up to 96%(@3.3V)
- 1.5MHz Switching Frequency Operation
- Force PWM Operation
- Up to 1.2A Output Current with V_{IN}=5V
- No Schottky Diode Required
- 0.6V Feedback Voltage
- 100% Duty Cycle in Dropout
- Slope Compensated Current Mode Control for Excellent Line and Load Transient Response
- Short Circuit Protection
- Thermal Fault Protection
- Inrush Current Limit and Soft Start
- Input over voltage protection (OVP)
- <1μA Shutdown Current
- DFN1.6x1.6-6 Package

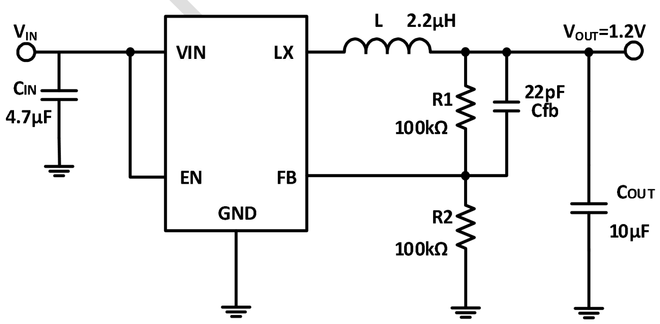
GENERAL DESCRIPTION

The TMI31601F is a constant switching frequency 1.5MHz, peak current mode step-down converter with force PWM operation mode. The devices integrate a main PMOSFET switch and a synchronous rectifier for high efficiency without an external Schottky diode. It is ideal for powering portable equipment that runs from a single cell Lithium-Ion (Li+) battery. This device offers two operation modes, Force PWM control Mode, which allows a high efficiency over the wider range of the load. TMI31601F adopts small size DFN1.6x1.6-6 package.

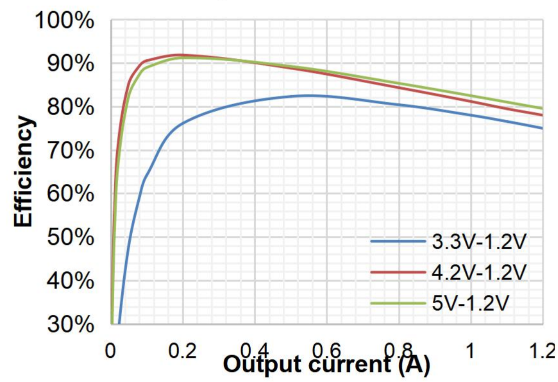
APPLICATIONS

- Cellular and Smart Phones
- Wireless and DSL Modems
- PDA/MID/PAD
- Digital Still and Video Cameras

TYPICAL APPILCATION



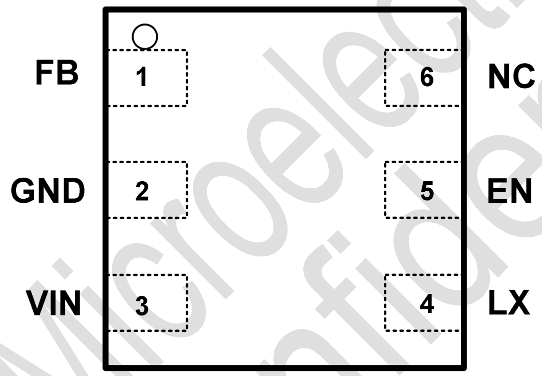
Efficiency
V_{OUT}=1.2V, L_{OUT}=2.2μH, T_A=25°C



ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Min	Max	Unit
Input Supply Voltages	-0.3	6.5	V
LX Voltages	-0.3	6.5	V
EN, FB Voltage	-0.3	6.5	V
LX Voltage (<10ns transient)	-2.5	7.0	V
LX Voltage (<5ns transient)	-3.5	7.5	V
Storage Temperature Range	-65	150	°C
Junction Temperature (Note 2)	-40	150	°C
Power Dissipation	-	600	mW
Lead Temperature Soldering,10sec	-	260	°C

PIN CONFIGURATION



DFN1.6x1.6-6
(Top View)

Top Mark: TDF/xxx (TDF: Device Code, xxx: Inside Code)

Part Number	Package	Top mark	Quantity/ Reel
TMI31601F	DFN1.6x1.6-6	TDF xxx	3000

TMI31601F devices are Pb-free and RoHS compliant.

PIN FUNCTIONS

Pin	Name	Function
1	FB	Output Voltage Feedback Pin. It is connected to feedback divider resistor.
2	GND	Ground Pin
3	VIN	Power Supply Input. Must be closely decoupled to GND with a 4.7μF or greater ceramic capacitor.
4	LX	Power Switch Output. It is the switch node connection to Inductor.
5	EN	Chip 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.
6	NC	No Internal Connection.

ESD RATING

Items	Description	Value	Unit
V_{ESD_HBM}	Human Body Model for all pins	±2000	V
V_{ESD_CDM}	Charge Device Model for all pins	±1000	V

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
Voltage Range	IN	2.5	5.5	V
T_J	Operating Junction Temperature Range	-40	125	°C

THERMAL RESISITANCE (Note 3)

Items	Description	Value	Unit
θ_{JA}	Junction-to-ambient thermal resistance	140	°C/W
θ_{JC}	Junction-to-case thermal resistance	64	°C/W

ELECTRICAL CHARACTERISTICS

(V_{IN}=5V, V_{OUT}=1.8V, T_A = 25°C, unless otherwise noted.)

Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range		2.5		5.5	V
OVP Threshold	V_{IN} Rising	5.8	6.0	6.2	V
Input UVLO Threshold	V_{IN} Rising		2.4	2.5	V
Quiescent Current	V_{EN}=2.0V, V_{FB}=V_{REF}x105%		180	300	μA
Standby Current	V_{EN}=2.0V, I_{OUT}=0A		2	6	mA
Shutdown Current	V_{EN}=0V		0.1	5	μA
Feedback Voltage Accuracy	T_A = 25°C	588	600	612	mV
Oscillation Frequency	V_{OUT}=100%		1.5		MHz
	V_{OUT}=0V		400		kHz
On Resistance of PMOS	I_{LX}=100mA		0.29		Ω
On Resistance of NMOS	I_{LX}=-100mA		0.18		Ω
Peak Current Limit	V_{IN}=5V, V_{OUT}=1.2V, L=4.7μH/2A	1.5			A
Negative Current Limit of LS_MOSFET			-0.4		A
EN Input Logic Low Level				0.3	V
EN Input Logic High Level		1.5			V
EN Input Current			0.01	0.1	μA
LX Leakage Current	V_{EN}=0V, V_{IN}=V_{LX}=5V		0.1	1.0	μA
FB Leakage Current			0.01	0.1	μA
Thermal Shutdown Threshold (Note 4)			150		°C
Thermal Shutdown Hysteresis (Note 4)			25		°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: Measured on JESD51-7, 4-layer PCB.

Note 4: Guaranteed by design.

FUNCTION DESCRIPTION

The TMI31601F is a high performance 1A 1.5MHz high Switching frequency monolithic step-down converter with force PWM operation mode. The output voltage of TMI31601F can be programmed with external feedback voltage 0.6V to 100% duty of input voltage. It requires few external power components (C_{in}, C_{out} and L).

At dropout, the converter duty cycle increases to 100% and the output voltage tracks the input voltage minus the $R_{DS(ON)}$ drop of the high-side MOSFET.

The internal error amplifier and compensation provides excellent transient response, load, and line regulation. Soft start function prevents input inrush current and output overshoot during start up.

FUNCTIONAL BLOCK DIAGRAM

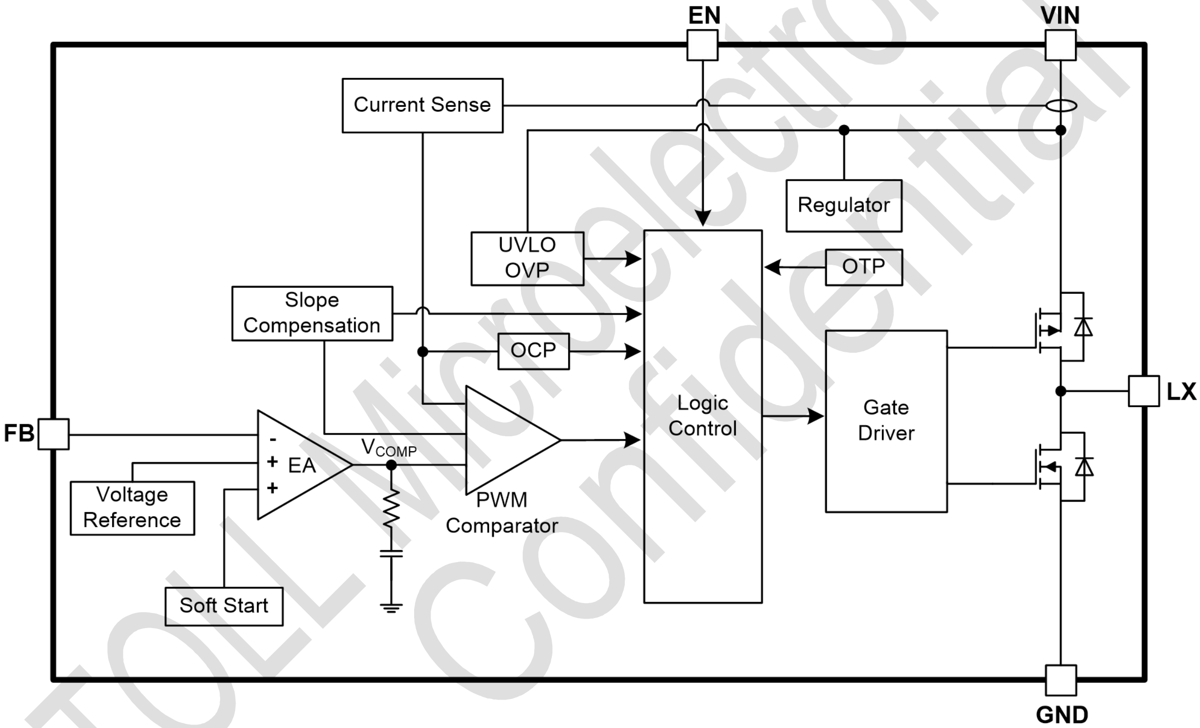


Figure 2. TMI31601F Block Diagram

APPLICATION INFORMATION

Setting the Output Voltage

Figure 1 shows the basic application circuit for the TMI31601F. The TMI31601F can be externally programmed. Resistors R1 and R2 in Figure 1 program the output to regulate at a voltage higher than 0.6V. The external resistor sets the output voltage according to the following equation:

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

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

Inductor Selection

For most designs, 2.2μH 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:

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

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. TMI31601F is force PWM operation mode. In dull load condition, the average inductor current is zero and valley inductor current is $-\Delta I_L/2$. The larger inductance value, the more negative valley inductor current. Because of the negative valley inductor current limitation, the recommended smallest inductance value for TMI31601F application is 2.2μH or larger inductance.

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. A 4.7μF ceramic capacitor for most applications is sufficient. A large value may be used for improved input voltage filtering.

Output Capacitor Selection

The output capacitor is 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 V_{OUT} is determined by:

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

An effective 10μF ceramic can satisfy most applications.

Layout Consideration

When laying out the printed circuit board, the Following checking should be used to ensure proper operation of the TMI31601F. Check the following in your layout:

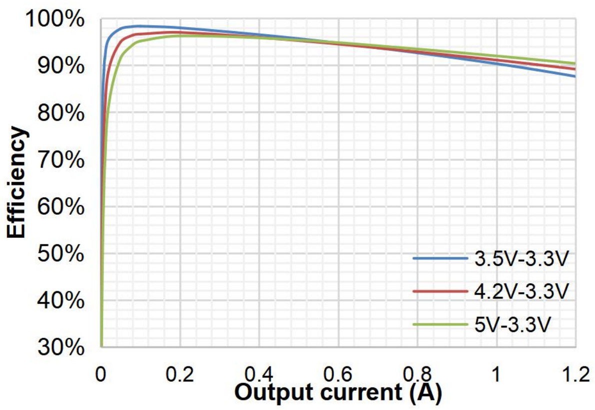
1. The power traces, consisting of the GND trace, the LX trace and the IN trace should be kept short, direct and wide.
2. Does the (+) plates of C_{in} connect to IN as closely as possible. This capacitor provides the AC current to the internal power MOSFETs.
3. Keep the switching node, LX, away from the sensitive VOUT node.
4. Keep the (-) plates of C_{in} and C_{out} as close as possible

TYPICAL PERFORMANCE CHARACTERISTICS

Test condition: V_{IN}=5V, V_{OUT}=1.2V, L=2.2μH, T_A=+25°C, unless other noted.

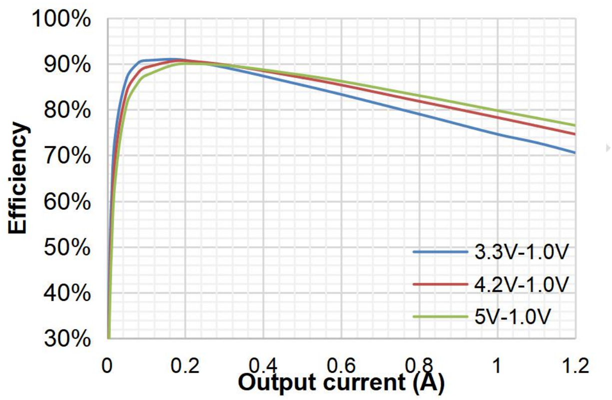
Efficiency at V_{OUT} = 3.3V

V_{OUT}=3.3V, T_A=25°C



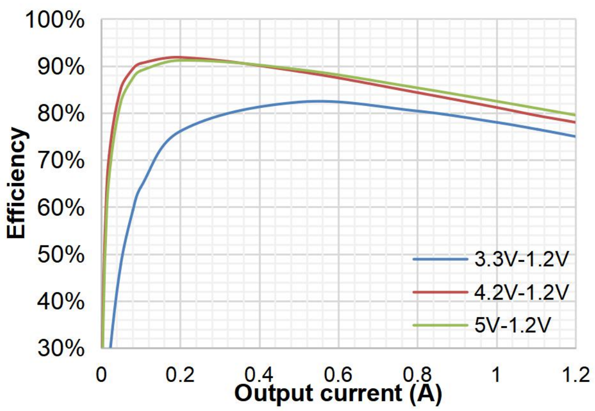
Efficiency at V_{OUT} = 1V

V_{OUT}=1V, T_A=25°C



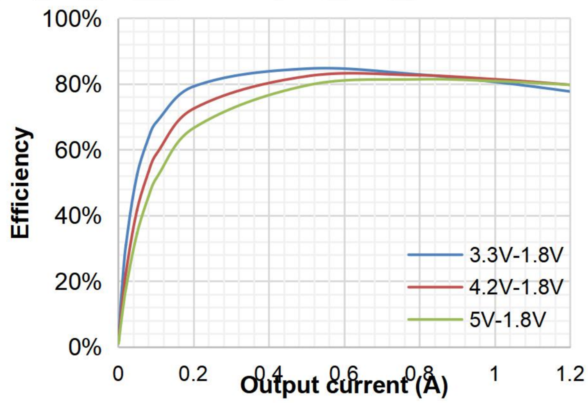
Efficiency at V_{OUT} = 1.2V

V_{OUT}=1.2V, T_A=25°C



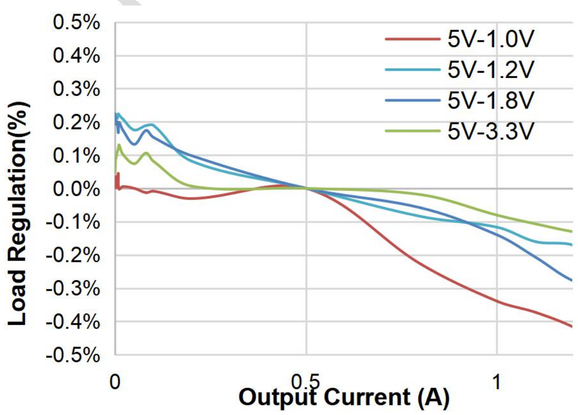
Efficiency at V_{OUT} = 1.8V

V_{OUT}=1.8V, T_A=25°C



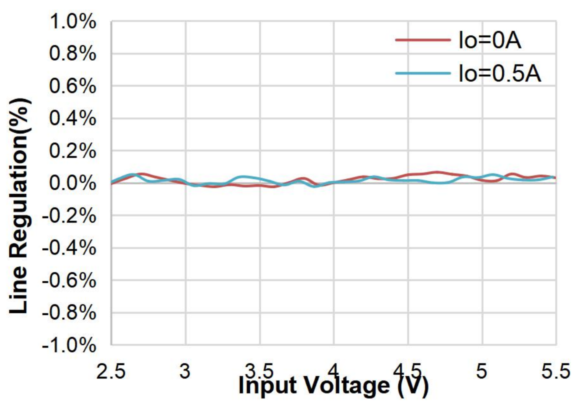
Load Regulation

V_{IN}=5V, L=2.2μH, DCR=20mΩ



Line Regulation at V_{OUT} = 1.2V

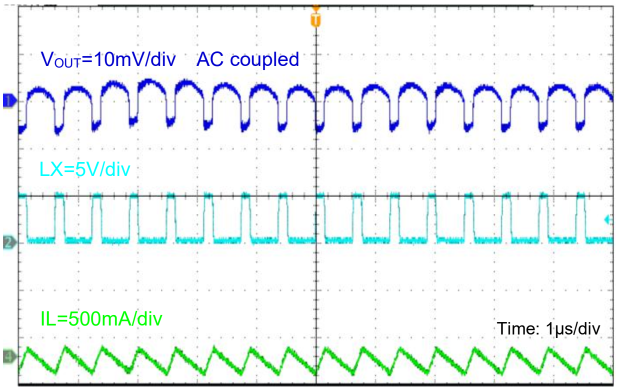
V_{OUT} =1.2V, L=2.2μH, T_A=25°C



TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

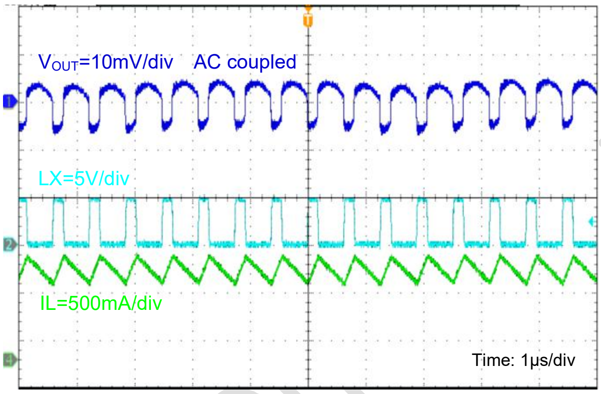
Steady State Operation

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



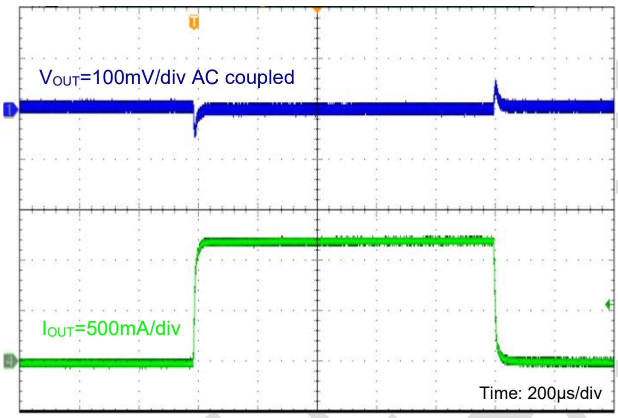
Steady State Operation

V_{IN} =5V, V_{OUT} =1.2V, I_o=1A



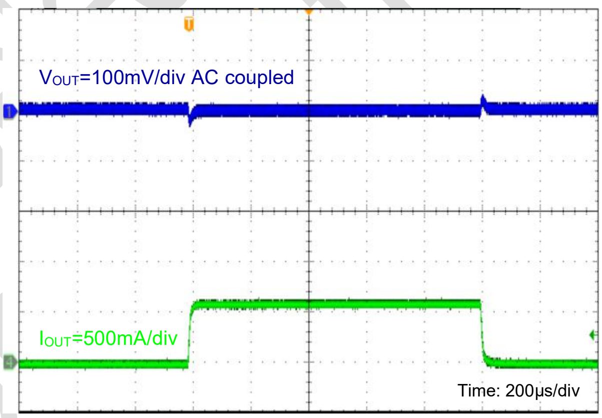
Load Transient

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



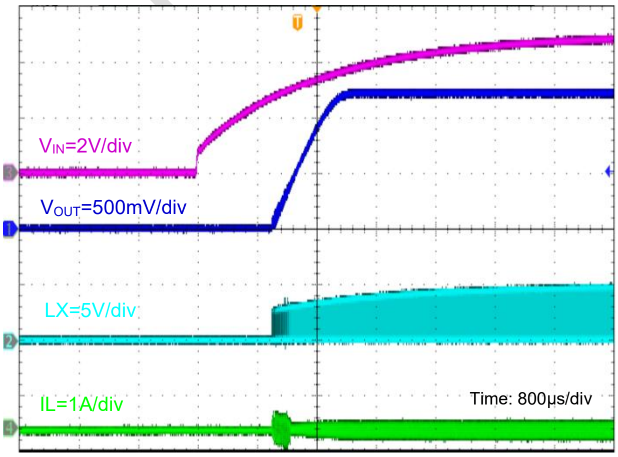
Load Transient

V_{IN} =5V, V_{OUT} =1.2V, I_o =0A to 0.6A



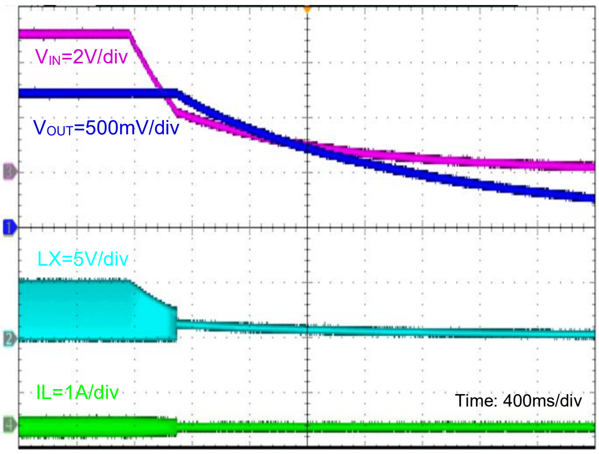
Input Power On

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



Input Power Down

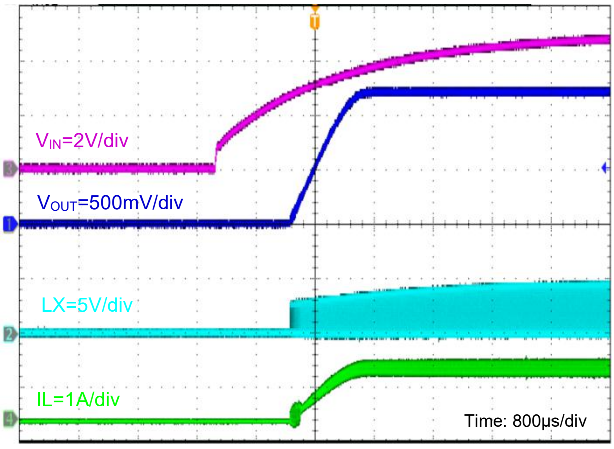
V_{IN} =5V, V_{OUT} =1.2V, I_o =0A



TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

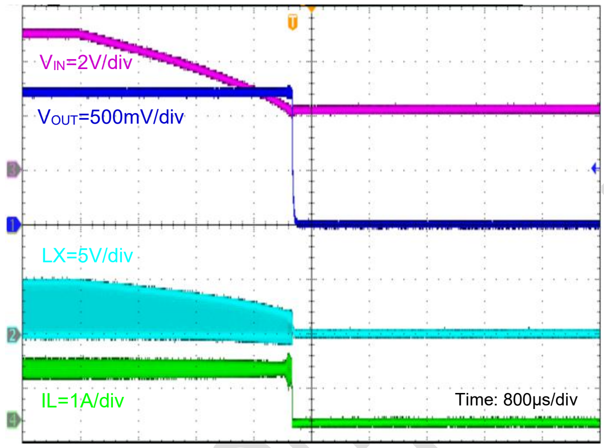
Input Power On

V_{IN} =5V, V_{OUT} =1.2V, R_o =1.2Ω



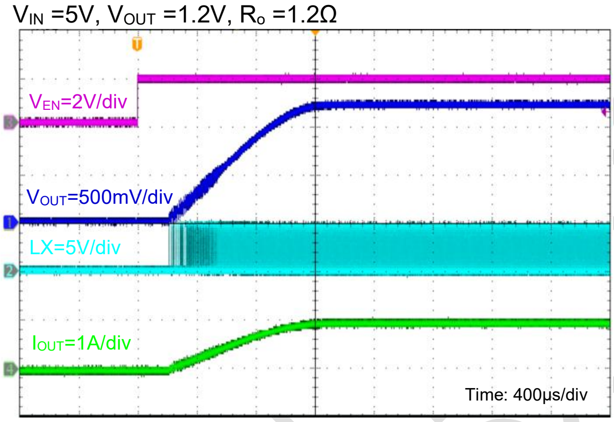
Input Power Down

V_{IN} =5V, V_{OUT} =1.2V, R_o =1.2Ω



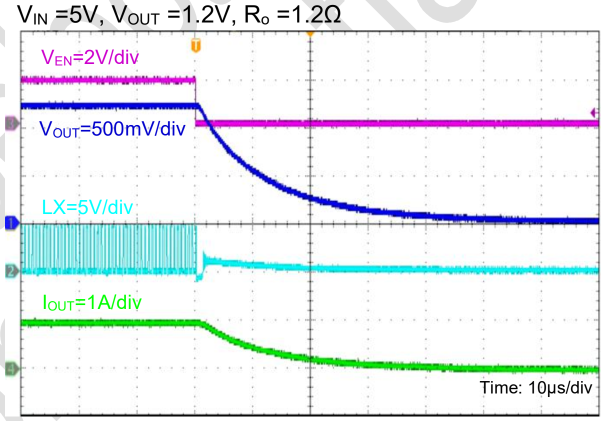
EN Enable

V_{IN} =5V, V_{OUT} =1.2V, R_o =1.2Ω



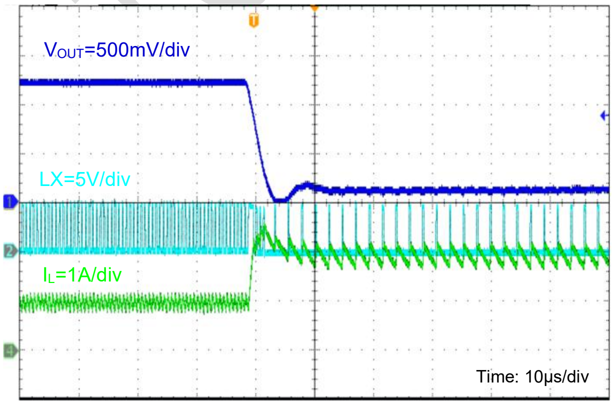
EN Disable

V_{IN} =5V, V_{OUT} =1.2V, R_o =1.2Ω



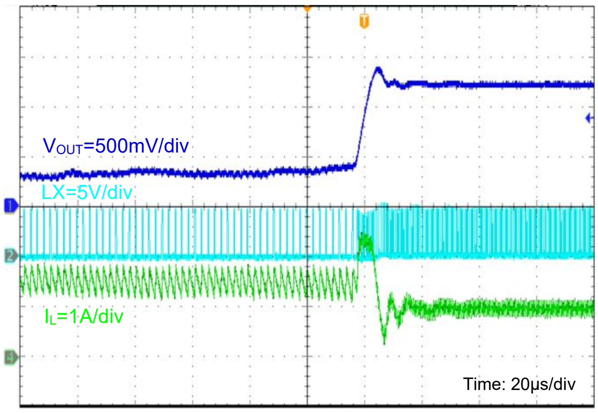
Output Short Entry

V_{IN} =5V, V_{OUT} =1.2V, I_{OUT} =1A



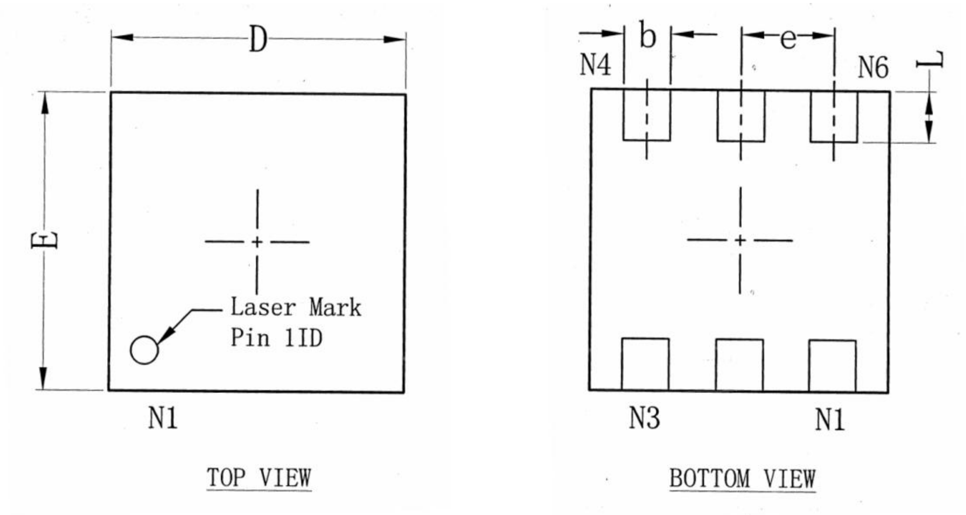
Output Short Recovery

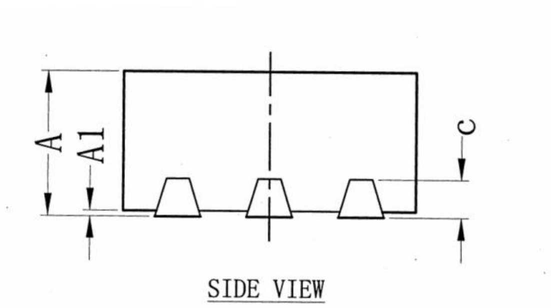
V_{IN} =5V, V_{OUT} =1.2V, I_{OUT} =1A



PACKAGE INFORMATION

DFN1.6x1.6-6





Unit: mm

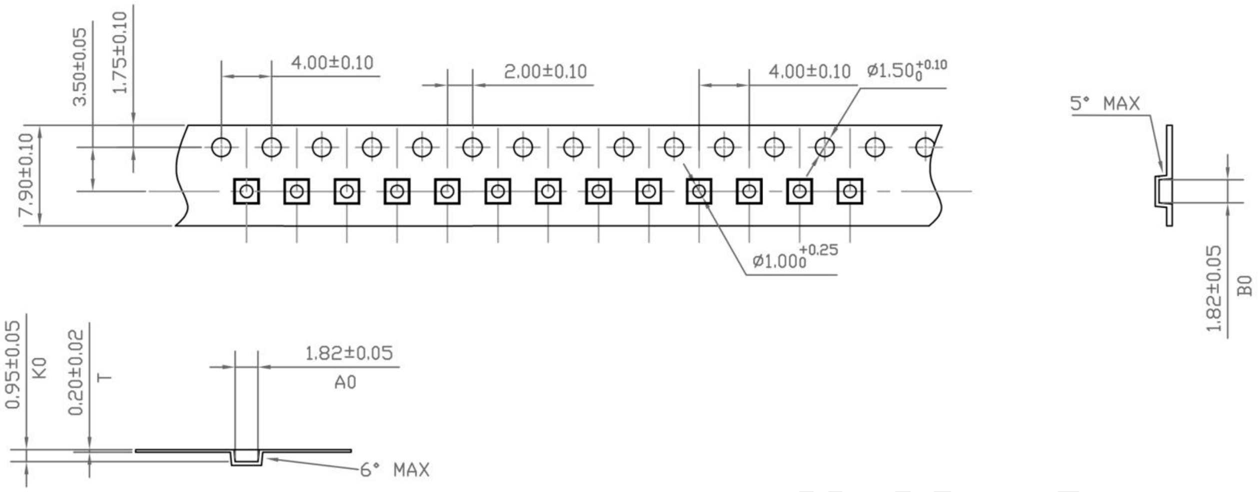
Symbol	Dimensions In Millimeters			Symbol	Dimensions In Millimeters		
	Min	Typ	Max		Min	Typ	Max
A	0.70	0.75	0.80	D	1.5	1.6	1.65
A1	0.00	0.03	0.05	e	0.50 TYP		
b	0.20	0.25	0.30	E	1.5	1.6	1.65
c	0.203 REF			L	0.23	0.275	0.33

Note:

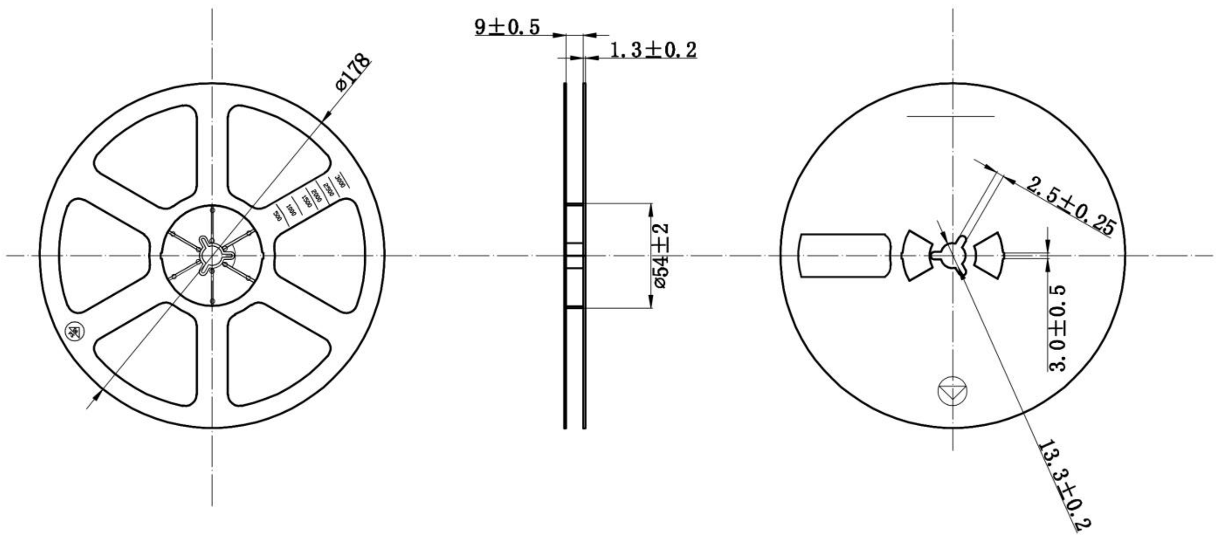
1) All dimensions are in millimeters.

TAPE AND REEL INFORMATION

TAPE DIMENSIONS:



REEL DIMENSIONS:



Note:

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