1A, 1.6MHz, COT Synchronous Step-Down Converter

Features

- **Low Quiescent Current at Light Load**
- **Efficiency Up to 95%**
- **VIN Range 2.55V to 6V**
- **VREF 0.6V with ±1% Accuracy**
- **Constant-On-Time Control Scheme Design for Fast Transient Response, Stability with MLCC Output Capacitor**
- **Fixed Soft-Start 0.5ms**
- **Cycle-by-Cycle Over Current Protection**
- **Input Under Voltage Lockout**
- **Output Under Voltage Protection (UVP Hiccup)**
- **Thermal Shutdown Protection**

Applications

- **Portable and Mobile Devices**
- **Wireless and Networking Devices**
- **LCD TV Power Supply**

General Description

The M2261 is a high efficiency synchronous step-down DC/DC converter with built-in internal power MOSFETs. M2261 provides an adjustable regulated output voltage as low as 0.6V while delivering up to 1A of output current with input voltage from 2.55V to 6V.

The Constant-On-Time control scheme in M2261 provides fast transient response to be optimized over a wide range of loads and output capacitors. Thermal shutdown and cycle-by-cycle current limiting are used for protection.

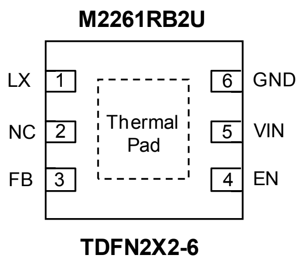
The M2261 is available in a small TDFN2X2-6 package.

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
M2261RB2U	221A	-40°C to +85°C	TDFN2X2-6

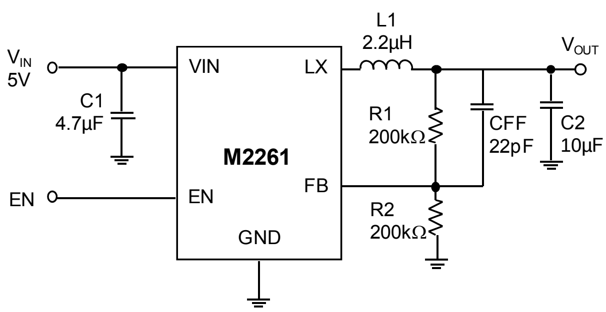
Note: RB: TDFN2X2-6
2: Bonding Code
U : Tape & Reel
Green: Lead Free / Halogen Free

Pin Configuration



Note: Recommend connecting the Thermal Pad to the Ground for excellent power dissipation.

Typical Application Circuit



Absolute Maximum Ratings

VIN, LX, EN, FB, OUT. . . . . -0.3V to 6V
Thermal Resistance of Junction to Ambient, (θ_{JA})
TDFN2X2-6. . . . . 165°C/W
Continuous Power Dissipation (T_A = +25°C)
TDFN2X2-6. . . . . 0.6W
Thermal Resistance of Junction to Ambient, (θ_{JC})
TDFN2X2-6. . . . . 63°C/W
Junction Temperature . . . . -40°C to150°C
Storage Temperature . . . . -65°C to 150°C
Reflow Temperature (soldering, 10sec) . . . . . . 260°C
ESD (HBM) 2KV

Recommended Operating Conditions

Supply Input Voltage. . . . . .2.5V to 6V
Ambient Temperature Range. . . . . -40°C to 85°C
Junction Temperature Range. . . . . -40°C to125°C

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Electrical Characteristics

(V_{IN}=3.6V, T_A=25°C)

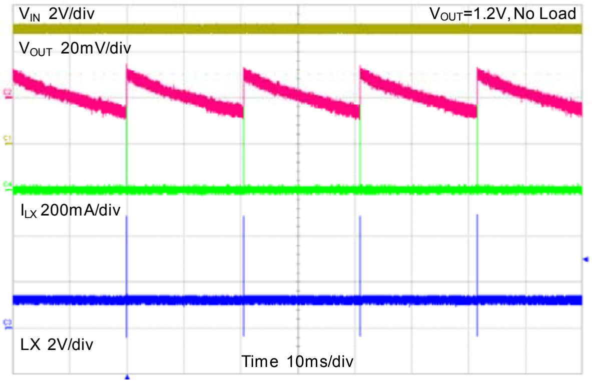
The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Input Voltage	V_{IN}		2.55	---	6	V
Feedback Reference Voltage	V_{REF}		0.594	0.6	0.606	V
Feedback Leakage Current	I_{FB}	V_{FB} = 3.3V	---	---	1	µA
DC Bias Current		Active, V_{FB} = 0.63V, not switching	---	20	25	µA
		V_{EN}=0V, shutdown	---	---	1	
Switching Leakage Current			---	---	1	µA
Switching Frequency			---	1.6	---	MHz
Switch On Resistance, High	R_{PMOS}	I_{LX} = 0.3A	---	120	---	mΩ
Switch On Resistance, Low	R_{NMOS}	I_{LX} = 0.3A	---	95	---	mΩ
PFET switch current limit	$I_{LIM(P)}$		---	2.4	---	A
NFET switch current limit	$I_{LIM(N)}$		---	1.5	---	A
VIN under voltage lock out threshold	V_{UVLO}	V_{IN} falling	---	2.4	2.45	V
VIN under voltage lock out hysteresis	V_{UVLO_HYS}	V_{IN} rising	---	100	---	mV
Over-Temperature Threshold			---	150	---	°C
Thermal Hysteresis			---	30	---	°C
EN Input Logic High Voltage	V_{IH}		1.2	---	---	V
EN Input Logic Low Voltage	V_{IL}		---	---	0.4	
EN Input Current	I_{EN}	V_{EN}=2V	---	1.2	---	µA
		V_{EN}=0V	---	0	---	µA
LX Discharge Resistor	R_{DIS}		---	20	50	Ω
Soft-Start Time	T_{SS}	VOUT rising from 10% to 90%	---	0.5	---	ms
Minimum Off Time	$T_{MIN-OFF}$		---	80	---	ns

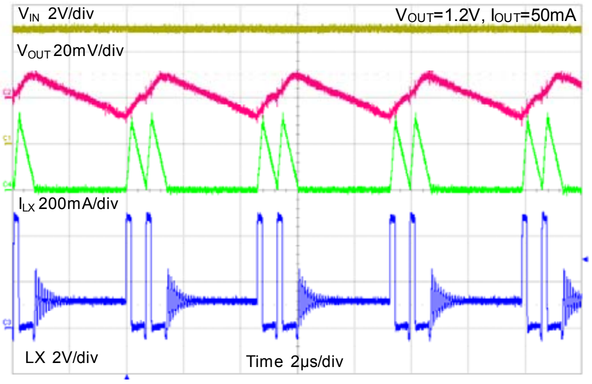
Typical Performance Characteristics

V_{IN}=5V, V_{OUT}=1.2V, C_{IN}=4.7µF, C_{OUT}=10µF, C_{FB}=22pF, L=2.2µH, T_A=25°C

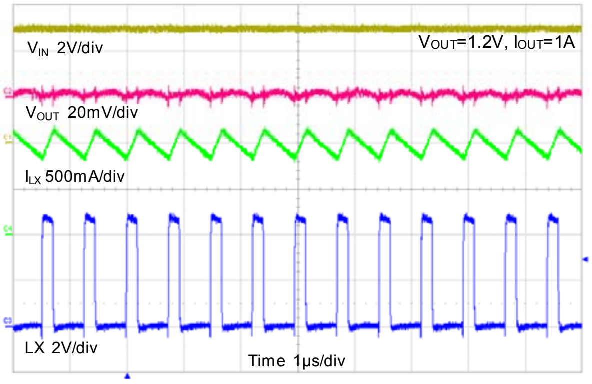
Steady State Operation



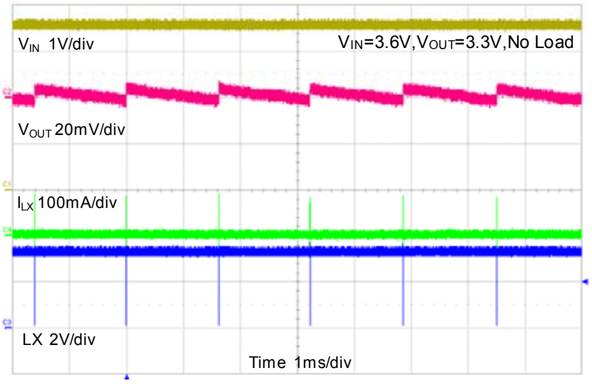
Steady State Operation



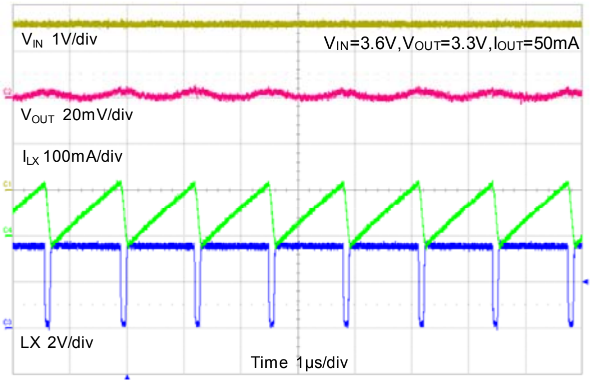
Steady State Operation



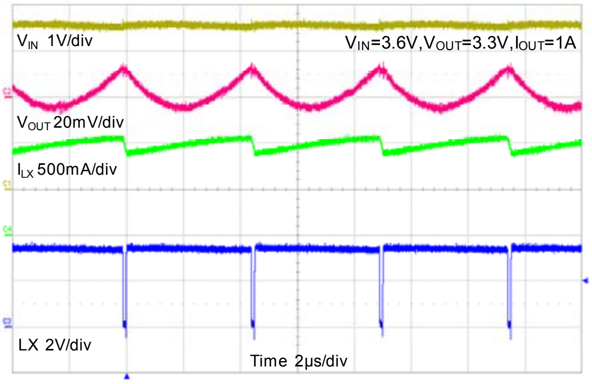
Steady State Operation



Steady State Operation

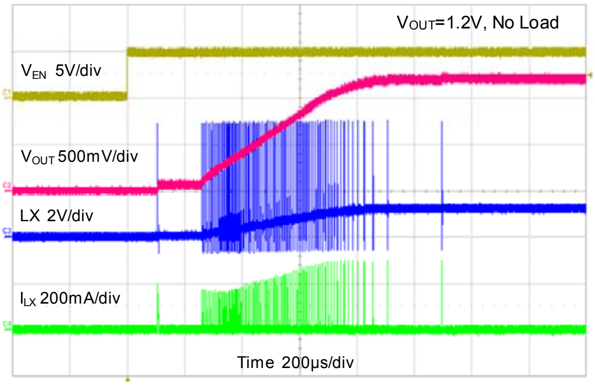


Steady State Operation

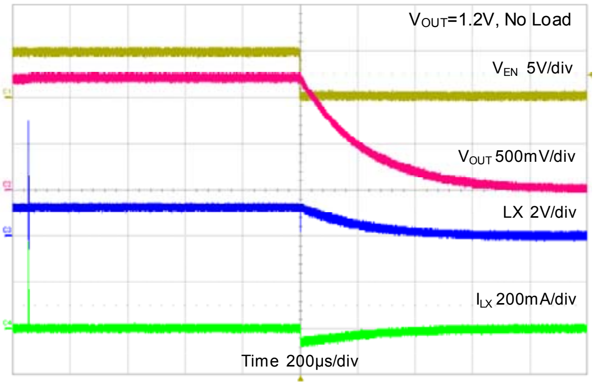


Typical Performance Characteristics (continued)

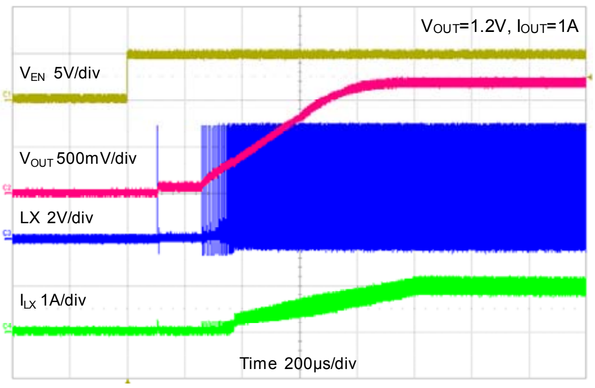
Start-up Through Enable



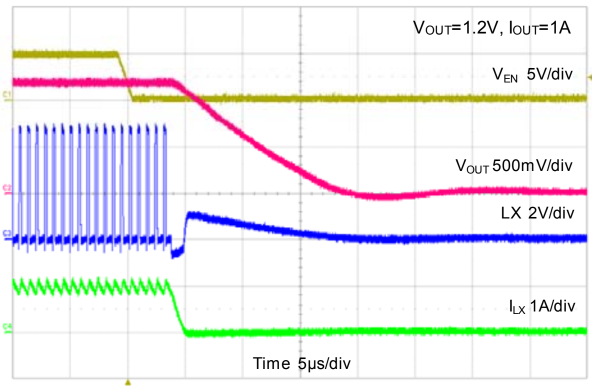
Start-down Through Enable



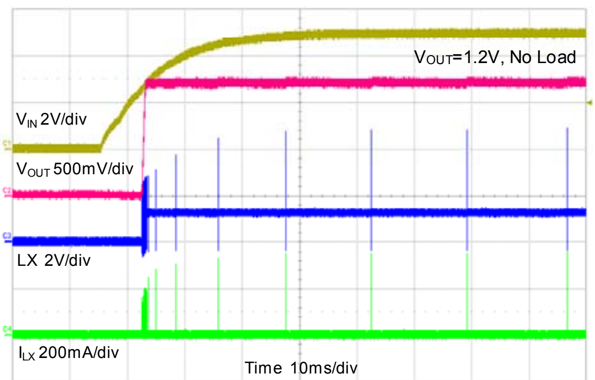
Start-up Through Enable



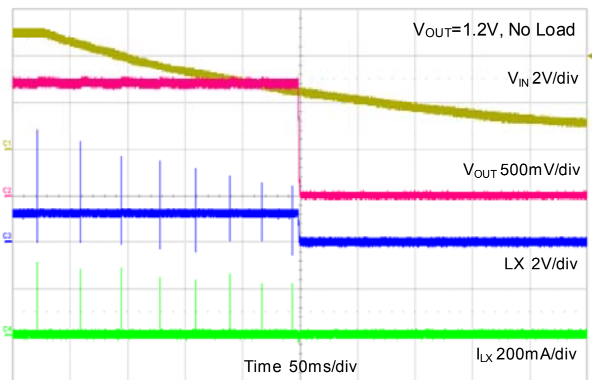
Start-down Through Enable



Start-up Through VIN

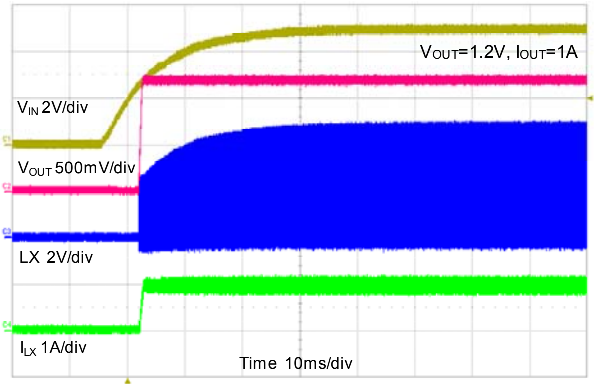


Start-down Through VIN

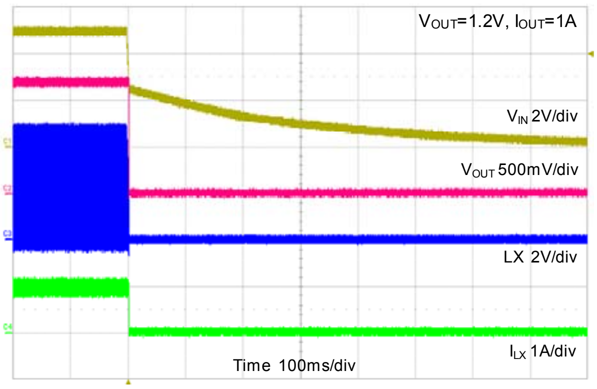


Typical Performance Characteristics (continued)

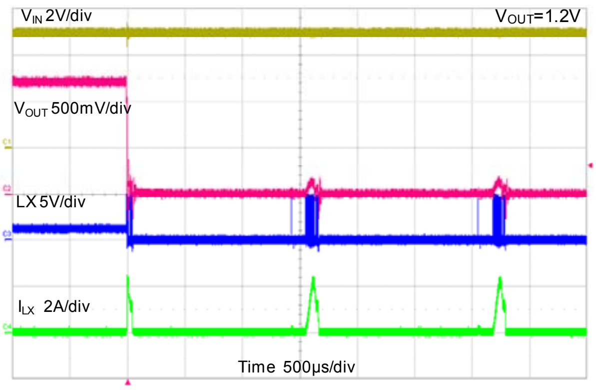
Start-up Through VIN



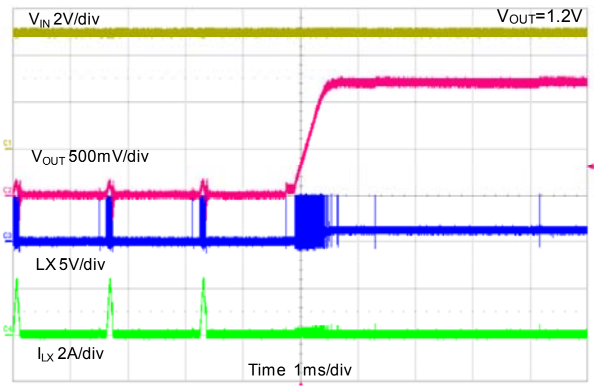
Start-down Through VIN



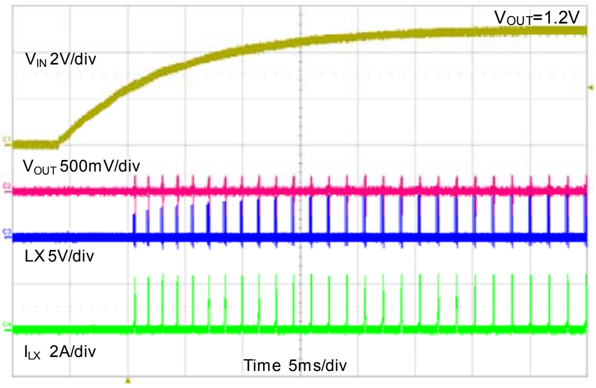
Short Circuit Waveform



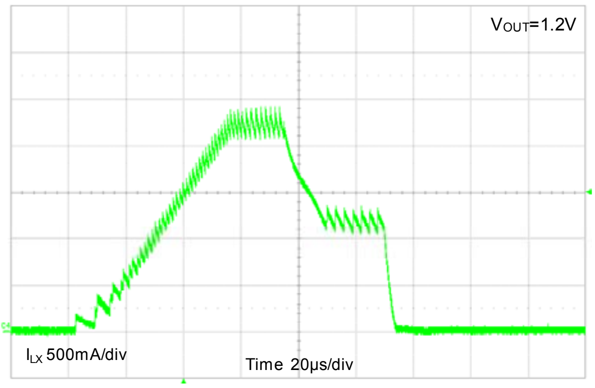
Short Circuit Recovery



Short Circuit Waveform

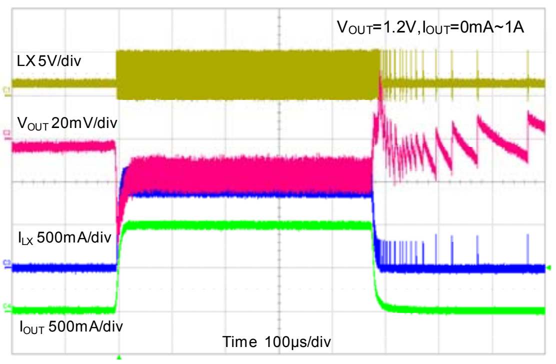


Current Limit

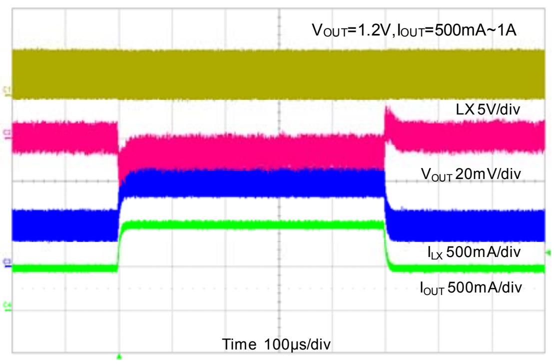


Typical Performance Characteristics (continued)

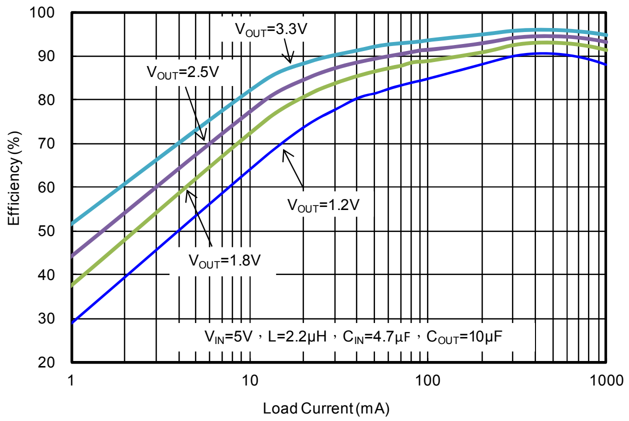
Load Transient Response



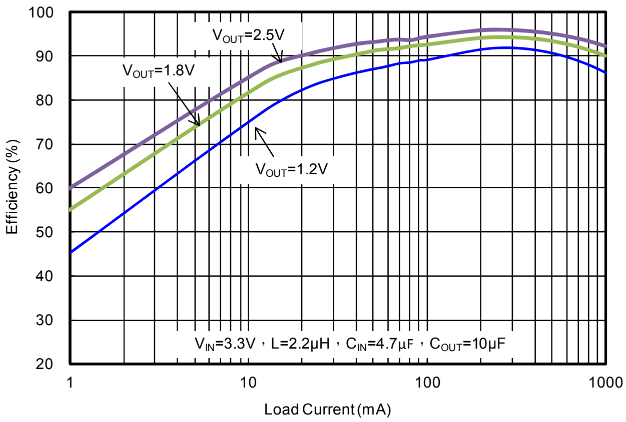
Load Transient Response



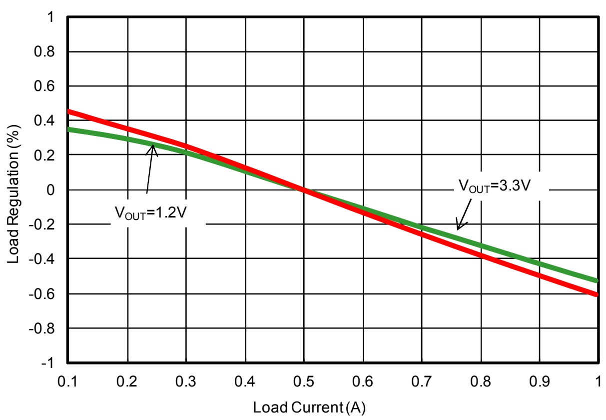
Efficiency vs. Load Current



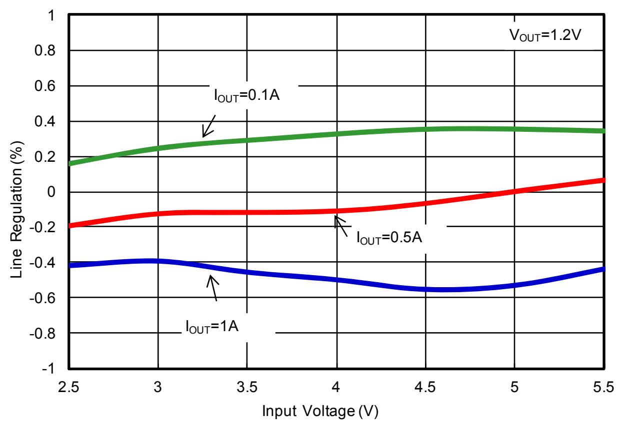
Efficiency vs. Load Current



Load Regulation

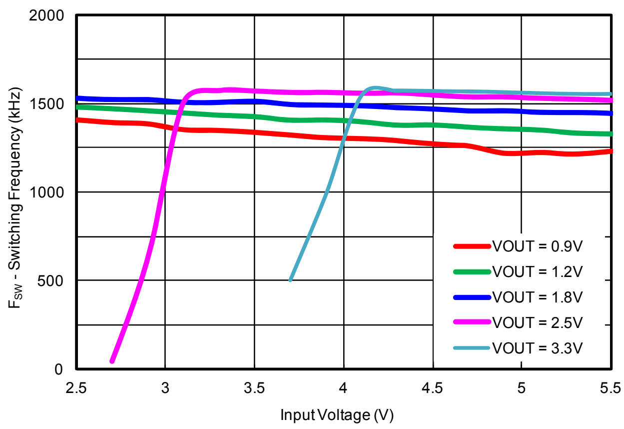


Line Regulation

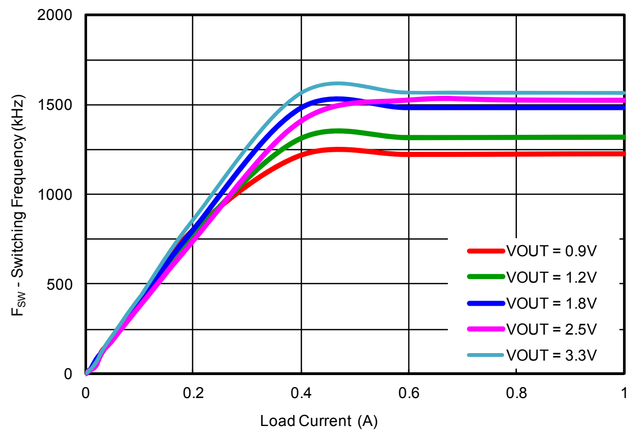


Typical Performance Characteristics (continued)

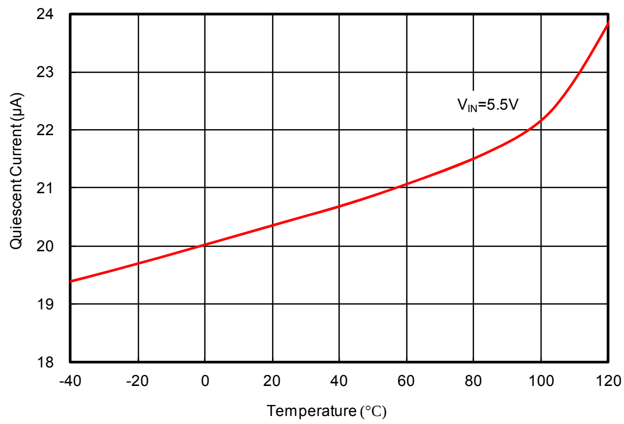
Switching Frequency vs. Input Voltage



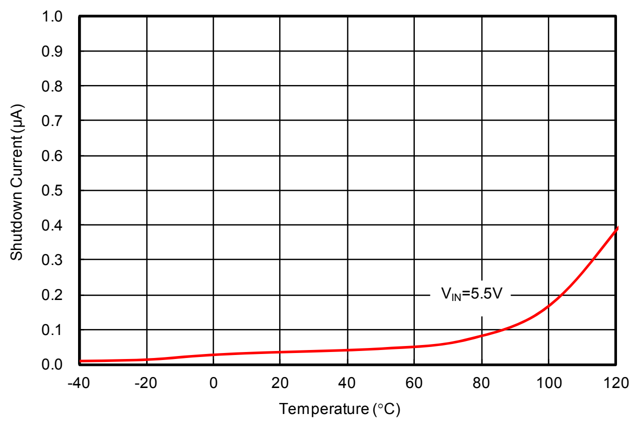
Switching Frequency vs. Load Current



Quiescent Current vs.Temperature



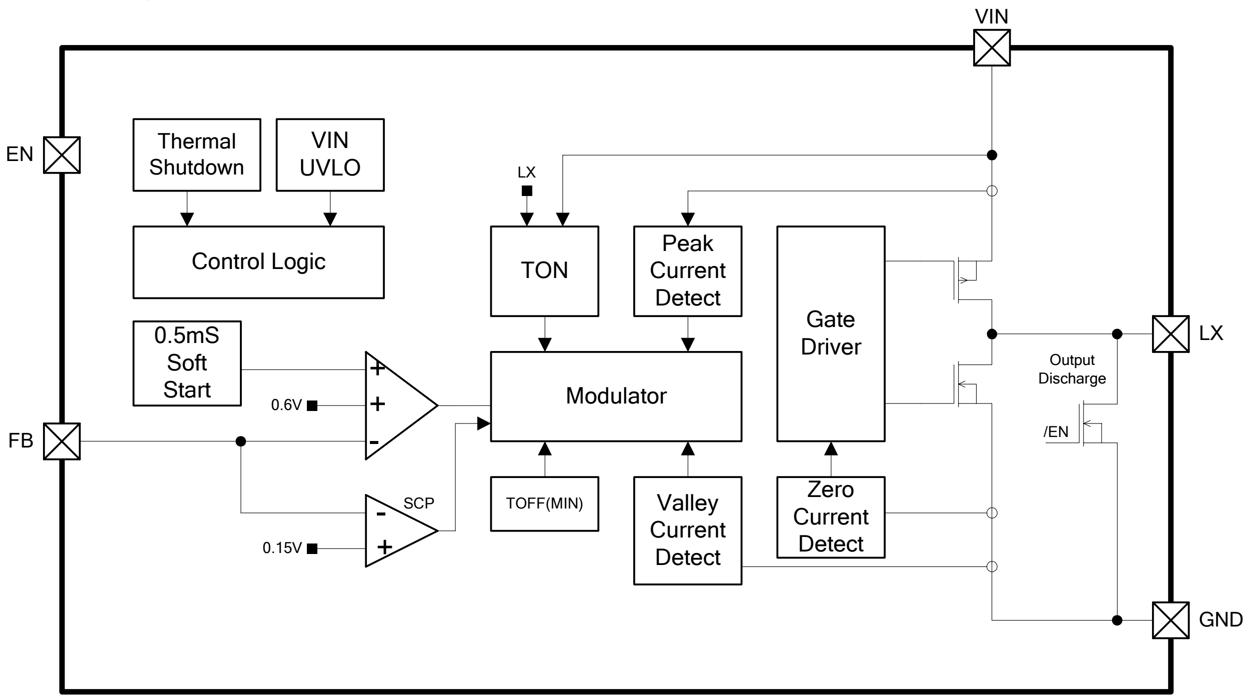
Shutdown Current vs.Temperature



Pin Description

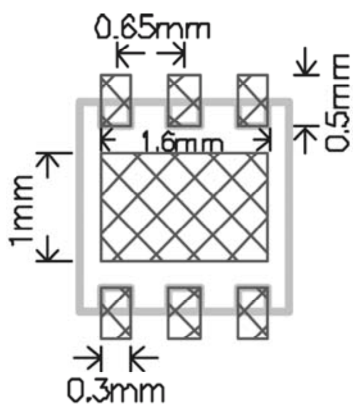
PIN	NAME	FUNCTION
1	LX	Switch Node.
2	NC	No Connection.
3	FB	An external resistor divider from the output to GND, tapped to the FB pin, sets the output voltage.
4	EN	Enable Control Input.
5	VIN	Supply Voltage Input. The M2261 operates from a 2.55V to 6V input.
6	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum thermal dissipation.
Thermal Pad		Must be soldered to achieve appropriate power dissipation. Should be connected to GND.

Block Diagram



Minimum Footprint PCB Layout Section

TDFN2X2-6



Operation

The M2261 is a high efficiency synchronous step-down DC/DC converter. M2261 provides an adjustable regulated output voltage from 0.6V to VIN while delivering up to 1A of output current with input voltage from 2.55V to 6V.

The M2261 uses the constant on-time control scheme. In normal operation, the high side P-MOSFET is turned on when the switch controller is set by the comparator and is turned off when the Ton comparator resets the switch controller.

Low side MOSFET vally current is measured. The error amplifier adjusts COMP voltage by comparing the feedback signal (VFB) from the output voltage with the internal 0.6V reference. When the load current increases, it causes a drop in the feedback voltage relative to the reference, then the COMP voltage rises to allow higher inductor current to match the load current.

Enable

When the input voltage is greater than the under voltage lockout threshold, a logic-high (>1.2V) enables the converter; a logic-low (<0.4V) or floating forces the IC into shutdown mode. There is an internal 1.6Meg Ohm resistor from EN pin to GND.
When the device is disabled, there is a 20 Ohm resistive discharge path from LX pin.

Soft-Start (SS)

There is an internal built-in soft-start to ramp the output voltage at a fixed slew rate to avoid in-rush current. The typical soft-start time is 0.5ms.

Over Current Protection (OCP)

The M2261 provides the over current protection by detecting the high side MOSFET peak inductor current (2.4A typ.) and the low-side MOSFET valley inductor current (1.5A typ.). If the inductor current is over the peak current limit threshold, the high-side MOSFET is turned off and the low-side MOSFET is turned on. Once the inductor current is larger than the valley current limit, the next switching cycle is not allowed. This avoids increasing the inductor current and protects the components.

HICCUP Protection

When the inductor current limit is triggered 8 times, the inductor current limit is reduced to half for the next 8 cycles, and then the device stops switching to protect the components. After a delay of 1ms, M2261 automatically starts a new start-up procedure. Therefore, Hiccup protection is achieved and repeated until the high load condition is removed.

Thermal Shutdown (OTP)

The device implements an internal thermal shutdown function when the junction temperature exceeds 150°C. The thermal shutdown forces the device to stop switching when the junction temperature exceeds the thermal shutdown threshold. Once the die temperature decreases below the hysteresis of 30°C, the device reinstates the power up sequence.

Application Information

The M2261 is a single-phase buck converter. It provides single feedback loop, constant on-time control with fast transient response, and high efficiency. An internal 0.6V reference allows the low output voltage application. Over current protection, under voltage protection, and over temperature protection are all provided by M2261.

Output Voltage Setting

Connect a resistive voltage divider at the FB between V_{OUT} and GND to adjust the output voltage. The output voltage is set by the following equation:

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R1}{R2}\right)$$

where V_{REF} is the feedback reference voltage 0.6V (typ.).

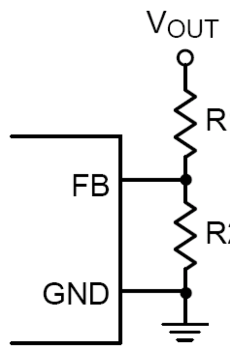


Figure 1. Setting V_{OUT} with a Voltage Divider

Inductor Selection

For high efficiency application, an inductor with a DC resistance less than 15mOhm is recommended. Estimate the inductor value by the following equation :

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{f_{SW} \times LIR \times I_{LOAD(MAX)} \times V_{IN}}$$

where LIR is the ratio of the peak-to-peak ripple current to the average inductor current. Find a low loss inductor with the lowest possible DC resistance leading to high performance.

To avoid inductor saturation, the core must be large enough for the peak inductor current (I_{PEAK}) :

$$I_{PEAK} = I_{LOAD(MAX)} + \left(\frac{LIR}{2} \times I_{LOAD(MAX)}\right)$$

Input Capacitor Selection

High quality ceramic input decoupling capacitor, such as X5R or X7R, with values greater than 10uF are recommended for the input capacitor. Ceramic capacitors with X5R and X7R are highly recommended due to the low ESR, less capacitance variation, and more temperature stability. For most applications, a 4.7uF capacitor is sufficient. Higher output voltages may require a 10uF capacitor to increase system stability.

Voltage rating and current rating are the key parameters when selecting an input capacitor. Generally, selecting an input capacitor with voltage rating 1.5 times greater than the maximum input voltage is a conservatively safe design.

The input capacitor is used to supply the input RMS current, which can be approximately calculated using the following equation :

$$I_{IN\_RMS} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} X \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

The input capacitor requires an adequate ripple current rating due to the absorption of the input switching current. The input capacitance value determines the input ripple voltage of the regulator. The input voltage ripple caused by capacitor can be approximately calculated using the following equation:

$$\Delta V_{IN} = \frac{I_{OUT(MAX)}}{C_{IN} \times f_{SW}} X \frac{V_{OUT}}{V_{IN}} X \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Output Capacitor Selection

The output voltage ripple (VP-P) can be calculated by the following equation:

$$V_{P\_P} = LIR \times I_{LOAD(MAX)} \times \left(ESR + \frac{1}{8 \times C_{OUT} \times f_{SW}}\right)$$

Selecting the low ESR capacitor is preferred to limit the output voltage ripple.

During load transient, the output capacitor supplies the load current before the control loop can response. Therefore, the ESR will dominate the output voltage sag during load transient. The output voltage undershoot (VSAG) can be calculated by the following equation:

$$V_{SAG} = \Delta I_{LOAD} \times ESR$$

For a given output voltage sag specification, the ESR value can be determined.

The equivalent series inductance (ESL) also has influence on VSAG when the rapid change in load current results in di/dt during transient. Using a capacitor with low ESL can obtain better transient performance.

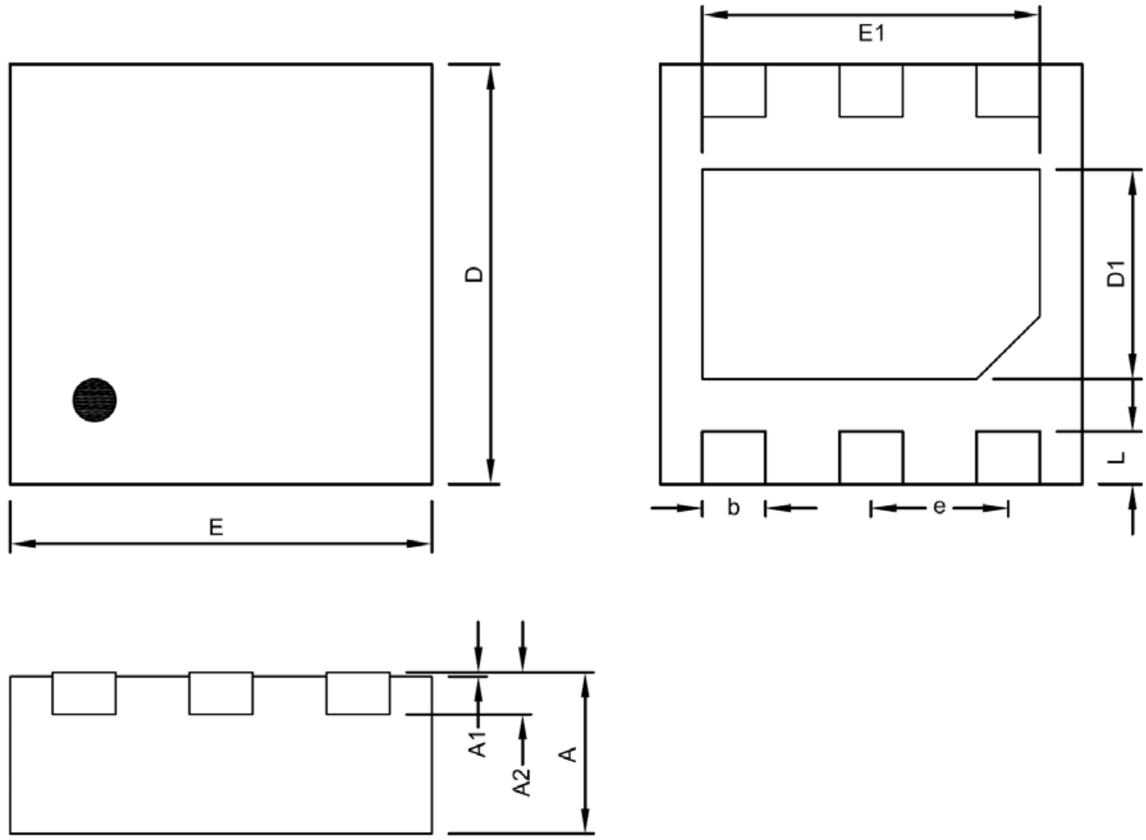
Thermal Considerations

The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following equation:

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance. θ_{JA}, is layout dependent.

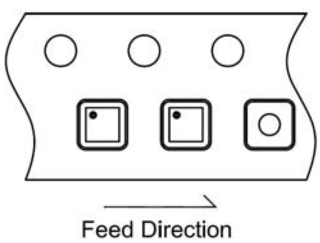
Package Information



TDFN2X2-6 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	- - -	0.05	0.0000	- - -	0.0020
A2	0.20 REF			0.0079 REF		
D	1.95	2.00	2.05	0.0768	0.0787	0.0807
E	1.95	2.00	2.05	0.0768	0.0787	0.0807
D1	0.90	1.00	1.10	0.0354	0.0394	0.0433
E1	1.55	1.60	1.65	0.0610	0.0630	0.0650
b	0.25	0.30	0.35	0.0098	0.0118	0.0138
e	0.65 BSC			0.0256 BSC		
L	0.20	0.25	0.30	0.0079	0.0098	0.0118

Taping Specification



PACKAGE	Q'TY/REEL
TDFN2X2-6	3,000 ea