1.2MHz, 3.0A, High-Efficiency Synchronous-Rectified Buck Converter

General Description

The uP1728S is a high efficiency synchronous-rectified buck converter with internal power switches. Fixed 1.2MHz PWM operation allows possible smallest output ripple and external component size. With high conversion efficiency and small package, the uP1728S is ideally suitable for portable devices and USB/PCIE-based interface cards, where PCB area is especially concerned.

With internal low $R_{DS(ON)}$ switches, the uP1728S is capable of delivering 3.0A output current over a wide input voltage range from 2.6V to 5.5V. The output voltage is adjustable from 0.6V to V_{IN} by a voltage divider.

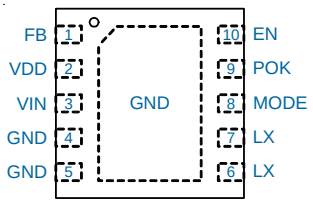
Other features include internal soft-start, chip enable, over-voltage, under-voltage, over-temperature and over-current protections. The uP1728S is available in a space-saving WDFN3x3-10L package.

Ordering Information

Order Number	Package Type	Top Marking
uP1728SDDA	WDFN3x3-10L	uP1728S

Note:
(1) Please check the sample/production availability with uPI representatives.
(2) uPI products are compatible with the current IPC/JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

Pin Configuration



WDFN3x3-10L

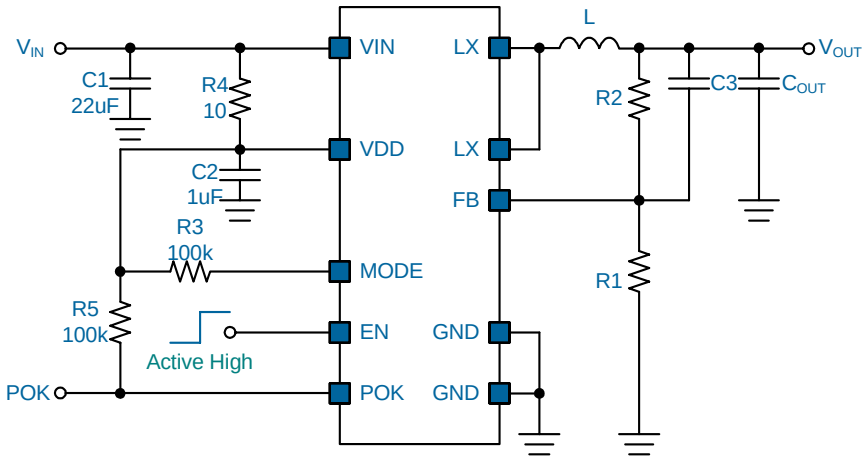
Features

- 2.6V to 5.5V Input Voltage Range
- Adjustable Output from 0.6V to V_{IN}
- Guaranteed 3.0A Output Current
- Accurate Reference: 0.6V (±1%)
- Up to 95% Conversion Efficiency
- Low Quiescent Current
- Integrated Low $R_{DS(ON)}$ Upper and Lower MOSFET Switches: 80mΩ and 60mΩ
- Current Mode PWM Operation
- Fixed Frequency : 1.2MHz
- 100% Maximum Duty Cycle for Lowest Dropout
- Internal Soft-Start
- Over Voltage and Under Voltage Protection
- Over Temperature and Over Current Protection
- WDFN3x3-10L Package
- RoHS Compliant and Halogen Free

Applications

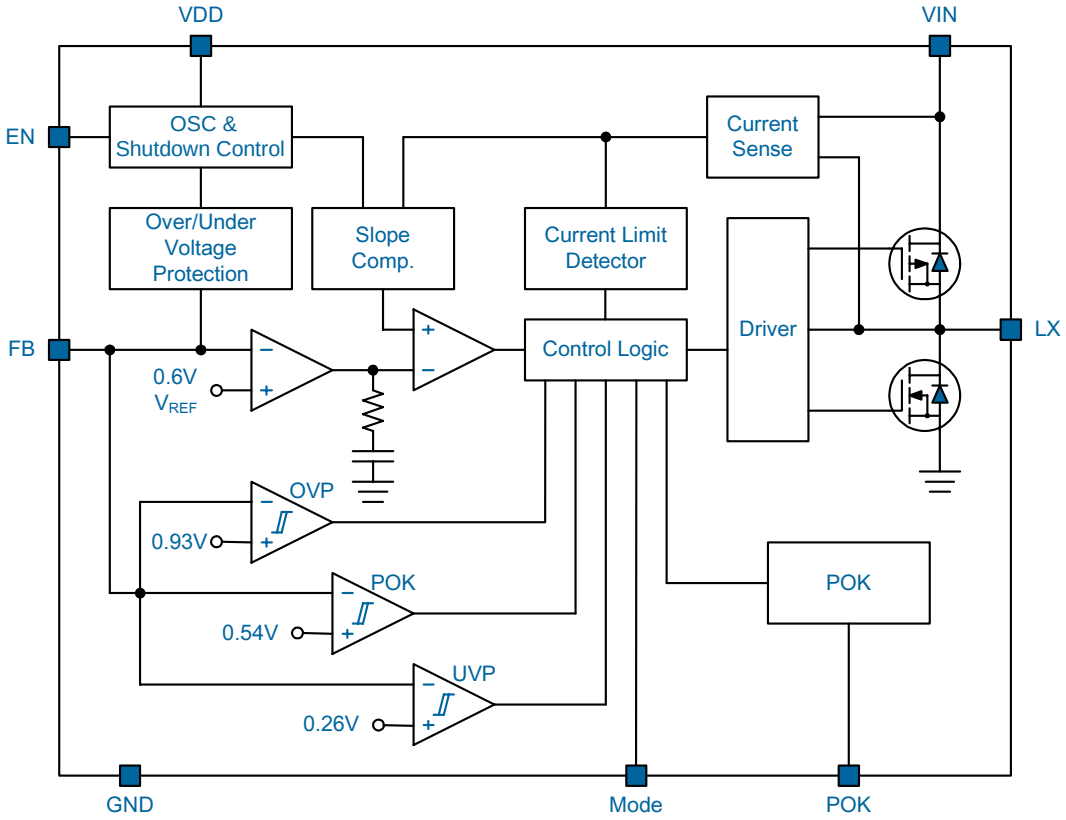
- Battery-Powered Portable Devices
  - MP3 Players
  - Notebook Computers
  - Wireless and DSL Modems
  - Personal Information Appliances
  - IP Phones
  - Digital Cameras
- 802.11 WLAN Power Supplies
- FPGA/ASIC Power Supplies
- Dynamically Adjustable Power Supply for CDMA/WCDMA Power Amplifiers
- USB-Based xDSL Modems and Other Network Interface Cards
- Point-of-Load Regulation

Typical Application Circuit



V_{IN}	V_{OUT}	L	C_{OUT}	R2	R1	C3
5V	1V	1.0uH	2 x 22uF	34K	51K	22pF
5V	1.8V	2.2uH	2 x 10uF	105K	51K	22pF
5V	2.5V	2.2uH	2 x 22uF	162K	51K	22pF
5V	3.3V	2.2uH	2 x 22uF	232K	51K	22pF

Functional Block Diagram



Functional Pin Description

No.	Pin Name	Pin Function
1	FB	**Feedback Input.** This pin is the inverting input of the error amplifier. FB senses the switcher output through an external resistor divider network.
2	VDD	**Bias Supply.** Supplies power for the internal circuitry. Connect to input power via low pass filter with decoupling to GND.
3	VIN	**Power Supply Input.** Input voltage that supplies current to the output voltage. Decouple this pin to GND with at least 10uF X5R or X7R ceramic capacitor.
4, 5	GND	**Ground.** Must be soldered to PCB and connected to ground plane .
6, 7	LX	**Internal Switches Output.** Connect these pins to the output inductor.
8	MODE	**Mode Selection.** This pin programs operation mode of the device. Tie this pin to GND for power saving and to VDD for CCM.
9	POK	**Power OK Indication.** This pin is set high impedance after soft start end and no fault occurs.
10	EN	**Chip Enable (Active High).** Logic low shuts down the converter. Do not leave floating.
Exposed Pad		**Ground.** The exposed pad GND must be soldered to PCB and connected to ground plane for optimal performance.

Functional Description

The uP1728S is a high efficiency synchronous-rectified buck converter with internal power switches. Fixed 1.2MHz PWM operation allows possible smallest output ripple and external component size. With high conversion efficiency and small package, the uP1728S is ideally suitable for portable devices and USB/PCIE-based interface cards where PCB area is especially concerned. With internal low $R_{DS(ON)}$ switches, the uP1728S is capable of delivering 3A output current over a wide input voltage range from 2.6V to 5.5V. The output voltage is adjustable from 0.6V to VIN by a voltage divider. Other features include internal soft-start, chip enable, over-voltage, under-voltage, over-temperature and over-current protections. The uP1728S is available in a space-saving WDFN3x3-10L package.

Input Supply Voltages, VIN & VDD

The uP1728S features separate power supply and ground pins for power stages and control circuit, isolating the control circuit from noise associated with the power MOSFET switching. The VIN pins provide current to the power stage. The supply voltage range is from 2.6V to 5.5V. The uP1728S draws pulsed current with sharp edges from VIN each time the upper switch turns on, resulting in voltage ripples and spikes at supply input. A minimum 10uF ceramic capacitor with shortest PCB trace is highly recommended for bypassing the supply input. The VDD pin provides currents for the internal control circuit. A power on reset (POR) continuously monitors the input supply voltage. The POR level is typically 2.4V at VDD rising. Use low pass filter R4 and C3 as shown in the Typical Application Circuit to filter the input noise associated with the power switching.

Chip Enable/Disable and Soft-Start

The uP1728S features an EN pin for enable/disable control of the output voltage. Pulling the EN pin lower than 0.4V shuts down the uP1728S and reduces its quiescent current lower than 1uA. In the shutdown mode, both upper and lower switches are turned off. Pulling EN pin higher than 1.5V enables the uP1728S. Once the chip is enabled, the VDD POR is granted. The internal soft-start capacitor becomes charged and generates a linear ramping up voltage across the capacitor. This voltage clamps the voltage at the FB pin causing PWM pulse width to increase slowly and in turn reduce the output surge current. The internal 0.6V reference takes over the loop control once the internal ramping-up voltage becomes higher than 0.6V.

When there is pre-charged output voltage before the uP1728S is enabled, the uP1728S will enter pre-bias soft start mode which avoids unnecessary discharge at VOUT. During pre-bias soft start, the uP1728S compares the FB voltage with the reference voltage, and if the FB voltage is higher than the reference voltage, LX will be forced at high impedance state until V_{FB} intersects V_{REF}. After V_{FB} intersects reference voltage, the uP1728S resumes normal regulation until POK is asserted.

PWM Operation

The uP1728S adopts slope-compensated, current mode PWM control capable of achieving 100% duty cycle. During normal operation, the uP1728S operates at PWM mode to regulate output voltage by transferring the power to the output voltage cycle by cycle at a constant 1.2MHz frequency. The uP1728S turns on the upper switch at each rising edge of the internal oscillator allowing the inductor current to ramp up linearly. The switch remains on until either the current-limit is tripped or the PWM comparator turns off the switch for regulating output voltage. The upper switch current is sensed, slope compensated and compared with the error amplifier output COMP to determine the adequate duty cycle. The VOUT pin senses output feedback voltage from an external resistive divider. When the load current increases, it causes a slight decrease in the feedback voltage relative to the 0.6V reference, which in turn, causes the error amplifier output voltage to increase until the average inductor current matches the new load current.

Low Dropout Mode

The uP1728S increases duty cycle to maintain output voltage within its regulation as the supply input drops gradually in the battery-powered applications. The uP1728S operates with 100% duty cycle and enters low dropout mode as the supply input approaches the output voltage. This maximizes the battery life.

Output Voltage Setting and Feedback Network

The output voltage can be set from VREF to VIN by a voltage divider as:

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

The internal VREF is 0.6V with 1% accuracy. In real applications, a 22pF feed-forward ceramic capacitor is recommended in parallel with R2 for better transient response.

Current Limit Function

The uP1728S continuously monitors the inductor current for current limit by sensing the voltage drop across the upper switch when it turns on. When the inductor current is higher than current limit threshold (6A typical), the current limit function activates and forces the upper switch turning off to limit inductor current cycle by cycle. If the load continuously demands more current than what uP1728S could provide, uP1728S can not regulate the output voltage. Eventually under voltage protection will be triggered and shuts down the uP1728S if VOUT is too low.

Under Voltage Protection

Under voltage Protection is triggered if the FB voltage is lower than 0.26V. Once UVP is triggered , the uP1728S turn off high-side and low-side MOSFET. The under voltage protection is latch-off function and can only be reset by toggling EN threshold or re-POR.

Over Voltage Protection

Over voltage protection (OVP) is triggered if the FB voltage is higher than 0.93V. Once OVP is triggered, the uP1728S turn on low-side MOSFET and turn off high-side MOSFET. The over voltage protection is latch-off function and can only be reset by toggling EN threshold or re-POR.

Over Temperature Protection (OTP)

The OTP is triggered and shuts down the uP1728S if the junction temperature is higher than 150^{O}C. The OTP is a non-latch type protection. The uP1728S automatically initiates another soft start cycle if the junction temperature drops below 130^{O}C.

Absolute Maximum Rating

(Note 1)

Supply Input Voltage, V_{IN} ---------- -0.3V to +6.5V

LX Pin Voltage

DC ---------- -0.3V to +(V_{IN} +0.3V)

<50ns ---------- -5V to +(V_{IN} +5V)

Other Pins ---------- -0.3V to (V_{DD} + 0.3V)

Storage Temperature Range ---------- -65°C to +150°C

Junction Temperature ---------- 150°C

Lead Temperature (Soldering, 10 sec) ---------- 260°C

ESD Rating (Note 2)

HBM (Human Body Mode) ---------- 2kV

MM (Machine Mode) ---------- 200V

Thermal Information

Package Thermal Resistance (Note 3)

WDFN3x3-10L θ_{JA} ---------- 68°C/W

WDFN3x3-10L θ_{JC} ---------- 6°C/W

Power Dissipation, P_D @ T_A = 25°C

WDFN3x3 -10L ---------- 1.47W

Recommended Operation Conditions

(Note 4)

Operating Junction Temperature Range ---------- -40°C to +12°°C

Operating Ambient Temperature Range ---------- -40°C to +85°C

Supply Input Voltage, V_{IN} ---------- +2.6V to +5.5V

Electrical Characteristics

(V_{IN} = 5V, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Current						
Supply Voltage Range	V_{IN}	V_{IN} = V_{DD}	2.6	--	5.5	V
Under Voltage Lockout	V_{UVLO}	V_{DD} Rising, V_{EN} = V_{DD}	2.5	--	--	V
		V_{DD} Falling V_{EN} = V_{DD}	--	--	1.8	V
Quiescent Current	I_Q	Mode = GND, V_{FB} = 0.8V, I_{OUT} = 0mA	--	100	--	uA
Shutdown Current	I_{SHDN}	V_{EN} = 0V	--	0.01	1	uA
Reference						
Reference Voltage	V_{REF}	I_{OUT} = 0mA	0.594	0.60	0.606	V
Output Voltage Line Regulation	ΔV_{OUT}	V_{IN} = 2.6V to 5.5V, I_{OUT} = 0A	--	0.3	--	%/V
Output Voltage Load Regulation	ΔV_{OUT}	I_{OUT} = 0A ~3A	-1	--	+1	%
Oscillator						
Switching Frequency Range	f_{OSC}		1.0	1.2	1.4	MHz
Maximum Duty Cycle	DC	V_{IN} = V_{OUT}, V_{FB} = 0.55V	100	--	--	%

Electrical Characteristics

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Power Switches						
$R_{DS(ON)}$ of Upper Switch	R_{P_FET}	V_{IN} = 3.6V, I_{LX} = 100mA	--	80	--	mΩ
$R_{DS(ON)}$ of Lower Switch	R_{N_FET}	V_{IN} = 3.6V, I_{LX} = -100mA	--	60	--	mΩ
Logic Input						
EN Logic Low Threshold	V_{IL}	V_{IN} = 2.6V to 5.5V, Shutdown	--	--	0.4	V
EN Logic High Threshold	V_{IH}	V_{IN} = 2.6V to 5.5V, Enable	1.5	--	--	V
EN Pull Low Resistance	R_{EN}		--	500	--	kΩ
Power OK Output						
Logic High Leakage Current	I_{POK}	V_{POK} = V_{DD} = 5V	--	--	1	uA
Logic Low Voltage	V_{POK}	I_{POK} = 1mA	--	--	0.2	V
POK Output High Threshold		Measured FB with Respect to VREF	85	90	--	%
POK Hysteresis			--	5	--	%
Power ON/OFF						
Soft-Start Time	T_{SS}	EN to POK high	--	--	200	us
V_{OUT} Discharge Resistance			--	100	--	Ω
Protection						
V_{OUT} Under Voltage Protection (Latch-Off)			--	44	50	%
V_{OUT} Over Voltage Protection (Latch-Off, Delay Time =10us)			150	155	--	%
P-MOSFET Current Limit	I_{PLIM}		5	6	--	A
Thermal Shutdown Temperature	T_{SHDN}	By design	--	150	--	°C
Thermal Shutdown Hysteresis	ΔT_{SHDN}	By design	--	20	--	°C

Note 1. Stresses listed as the above " Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. 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 remain possibility to affect device reliability.

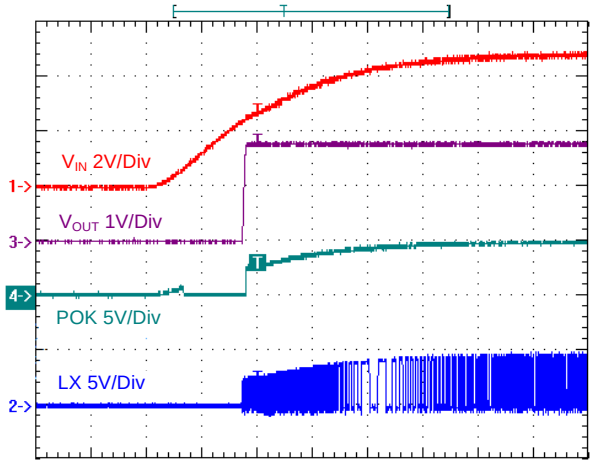
Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Note 4. The device is not guaranteed to function outside its operating conditions.

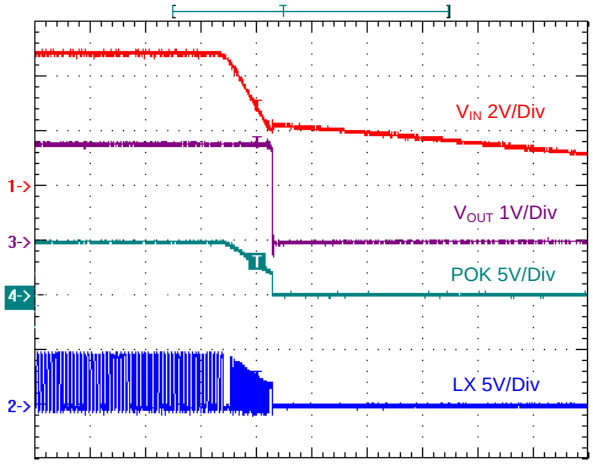
Typical Operation Characteristics

Power On from V_{IN}



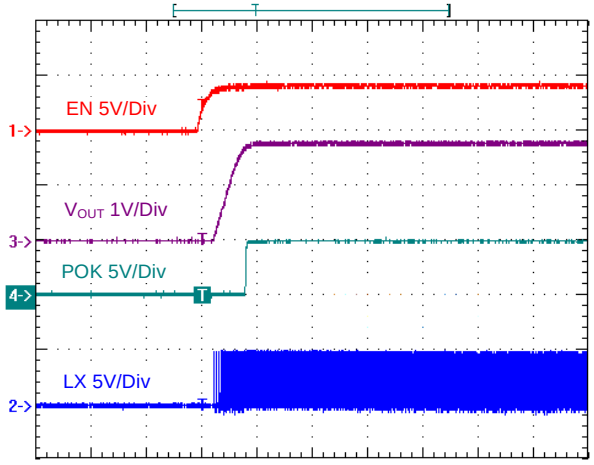
Time (2ms/Div)
V_{IN} = 5V, V_{OUT} = 1.8V, I_{OUT} = 3A

Power Off from V_{IN}



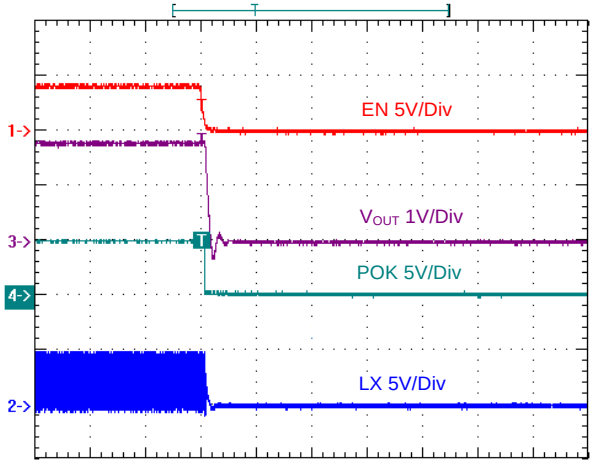
Time (4ms/Div)
V_{IN} = 5V, V_{OUT} = 1.8V, I_{OUT} = 3A

EN Turn On



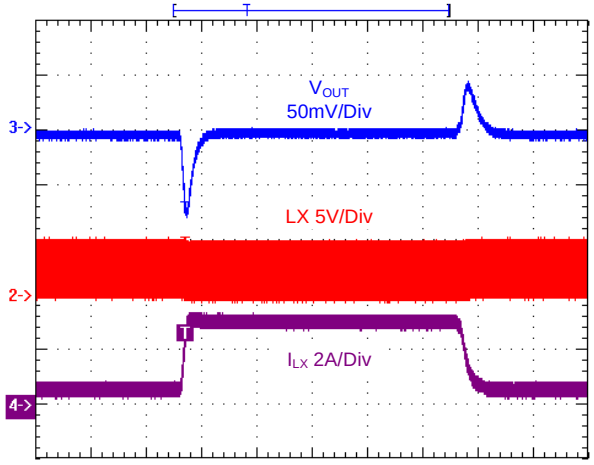
Time (200us/Div)
V_{IN} = 5V, V_{OUT} = 1.8V, I_{OUT} = 3A

EN Turn Off



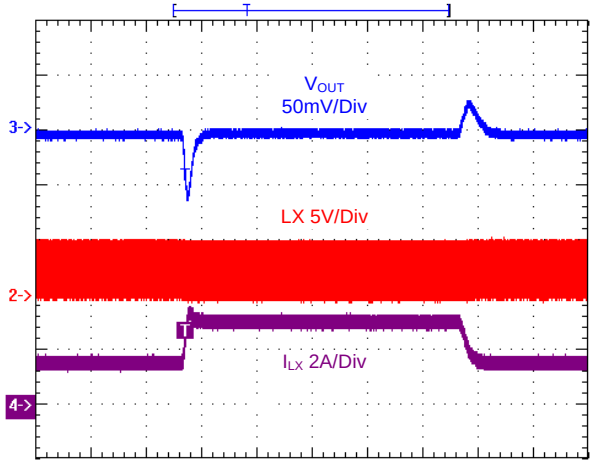
Time (200us/Div)
V_{IN} = 5V, V_{OUT} = 1.8V, I_{OUT} = 3A

Load Transient



Time (100us/Div)
V_{IN} = 5.0V, V_{OUT} = 1.8V, I_{OUT} = 0A ~ 3A

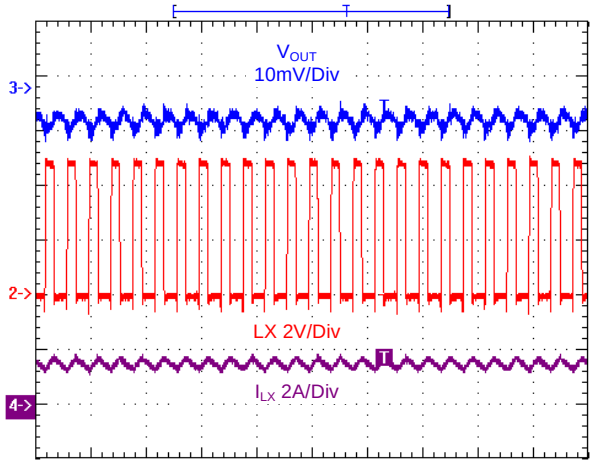
Load Transient



Time (100us/Div)
V_{IN} = 5.0V, V_{OUT} = 1.8V, I_{OUT} = 1.5A ~ 3A

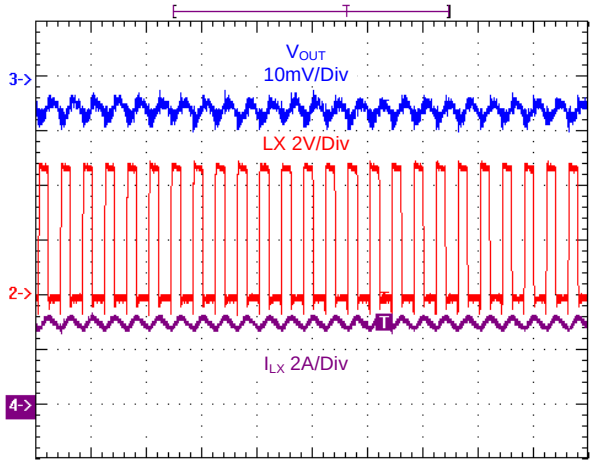
Typical Operation Characteristics

Switching



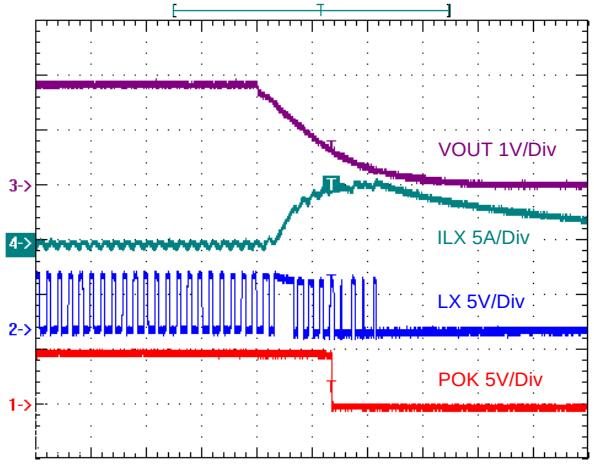
Time (2us/Div)
V_{IN} = 5.0V, V_{OUT} = 1.8V, I_{OUT} = 1.5A

Switching



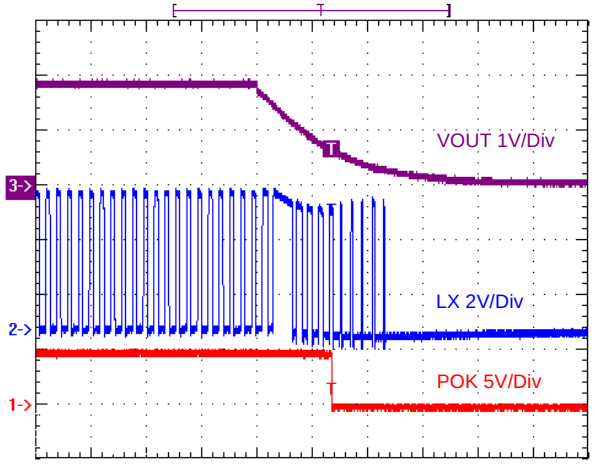
Time (2us/Div)
V_{IN} = 5.0V, V_{OUT} = 1.8V, I_{OUT} = 3A

Over Current Protection



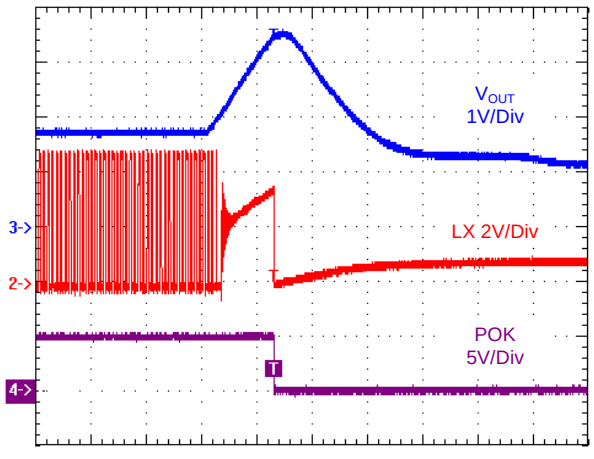
Time (4us/Div)
V_{IN} = 5.0V, V_{OUT} = 1.8V

Under Voltage Protection



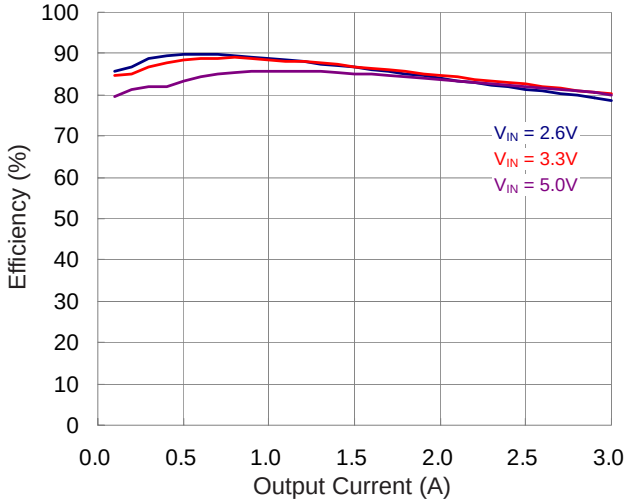
Time (4us/Div)
V_{IN} = 5.0V, V_{OUT} = 1.8V

Over Voltage Protection



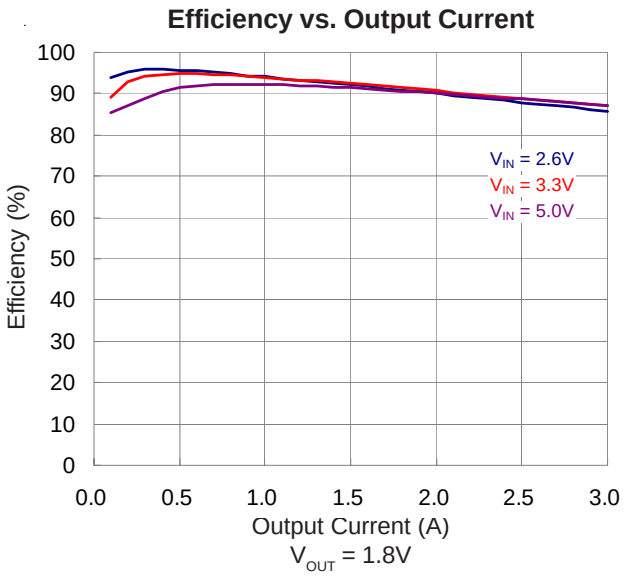
Time (10us/Div)
V_{IN} = 5.0V, V_{OUT} = 1.8V

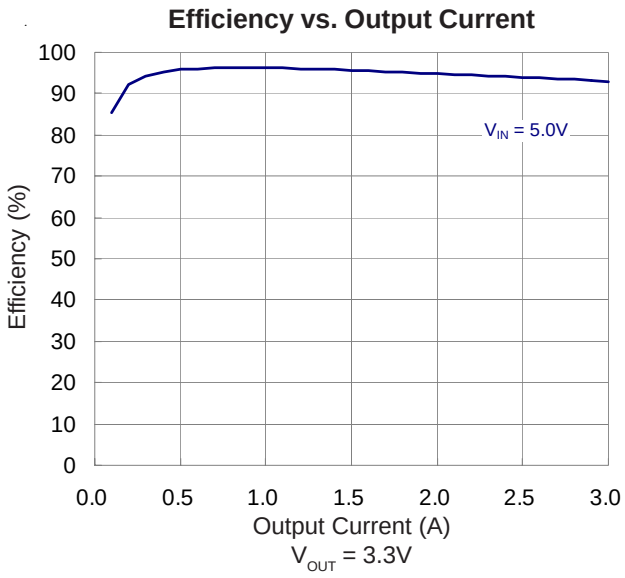
Efficiency vs. Output Current



V_{OUT} = 1.05V

Typical Operation Characteristics





Application Information

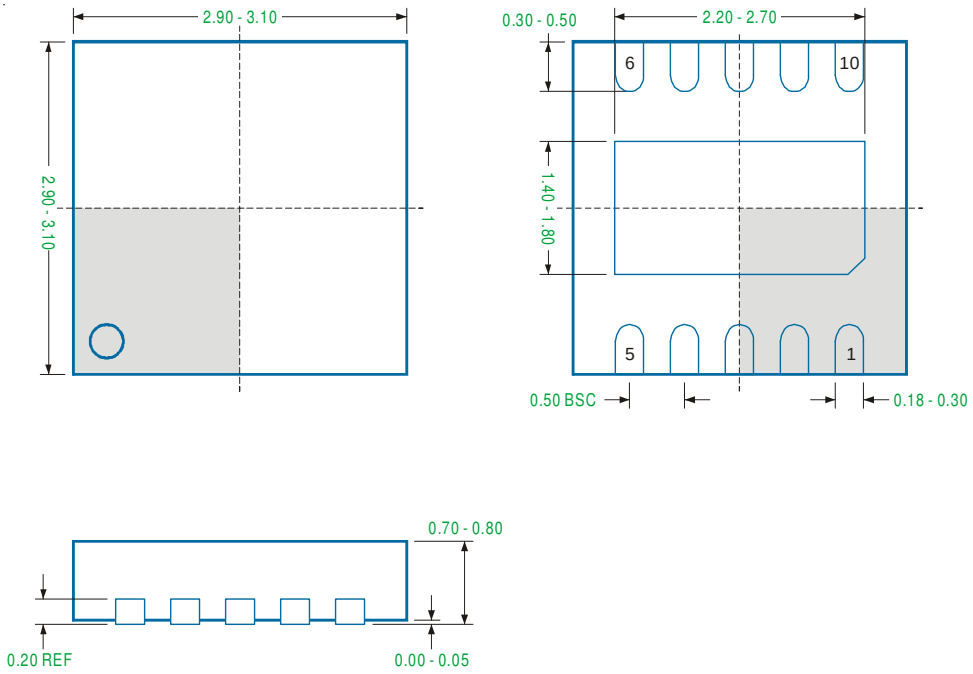
PCB Layout Considerations

High switching frequencies and relatively large peak currents make the PCB layout a very important part of switching mode power supply design. Good design minimizes excessive EMI on the feedback paths and voltage gradients in the ground plane, both of which can result in instability or regulation errors. Follow the PCB layout guidelines for optimal performance.

1. For the main current paths, keep their traces short, direct and wide.
2. Put the input/output capacitors as close as possible to the device pins.
3. LX node is with high frequency voltage swing and should be kept small area. Keep analog components away from LX node to prevent stray capacitive noise pick-up.
4. Connect feedback network behind the output capacitors. Place the feedback components near the IC and keep the loop area small.
5. A ground plane is preferred, but if not available, keep the signal and power grounds separated with small signal components returning to the GND pin at one point. They should not share the high current path of CIN or COUT.
6. Flood all unused areas on all layers with copper. Flooding with copper will reduce the temperature rise of power components. These copper areas should be connected to VIN or GND.

Package Information

WDFN3x3-10L



Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

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