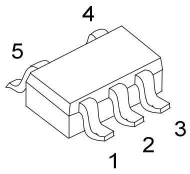
UD052015

CMOS IC

2A, 1.5MHZ SYNCHRONOUS STEP DOWN CONVERTER



SOT-25

■ DESCRIPTION

The UTC **UD052015** is a 2A synchronous DC-DC with current mode, PWM step-down converter. The device integrates a main switch and a synchronous rectifier for high efficiency.

The 2.5V to 5.5V input voltage range makes the UTC **UD052015** ideal for powering portable equipment. Switching frequency is internally set at 1.5MHz, allowing the use of small surface mount inductors and capacitors.

The internal synchronous switch increases efficiency while eliminates the need for an external Schottky diode. The UTC **UD052015** also includes input under- voltage lockout, output under-voltage protection, and over-temperature protection to provide safe and smooth operation in all working conditions.

■ FEATURES

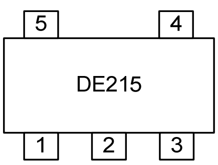
* 2.5V to 5.5V Input Voltage Range
* 2A Available Load Current
* 1.5MHz Switching Frequency in CCM
* Low R_{DSON} for Internal Switches:
  High-side: 125mΩ
  Low-side: 95mΩ
* Soft Start Time: 1ms
* 65μA Typical Quiescent Current
* Cycle-by-cycle Peak Current Limitation
* Input Over-Voltage Protection
* Input Under-Voltage Lockout
* Output Under-Voltage Lockout
* Short Circuit with Hiccup Mode
* Fast Transient Responses
* Optimized for Low-ESR Ceramic Output Capacitors
* Over-temperature Protection

■ ORDERING INFORMATION

Ordering Number		Package	Packing
Lead Free	Halogen Free		
UD052015L-AF5-R	UD052015G-AF5-R	SOT-25	Tape Reel

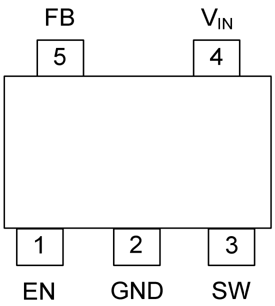
UD052015G-AF5-R	
(1)Packing Type	(1) R: Tape Reel
(2)Package Type	(2) AF5: SOT-25
(3)Green Package	(3) G: Halogen Free and Lead Free, L: Lead Free

■ MARKING



QW-R115-063.A

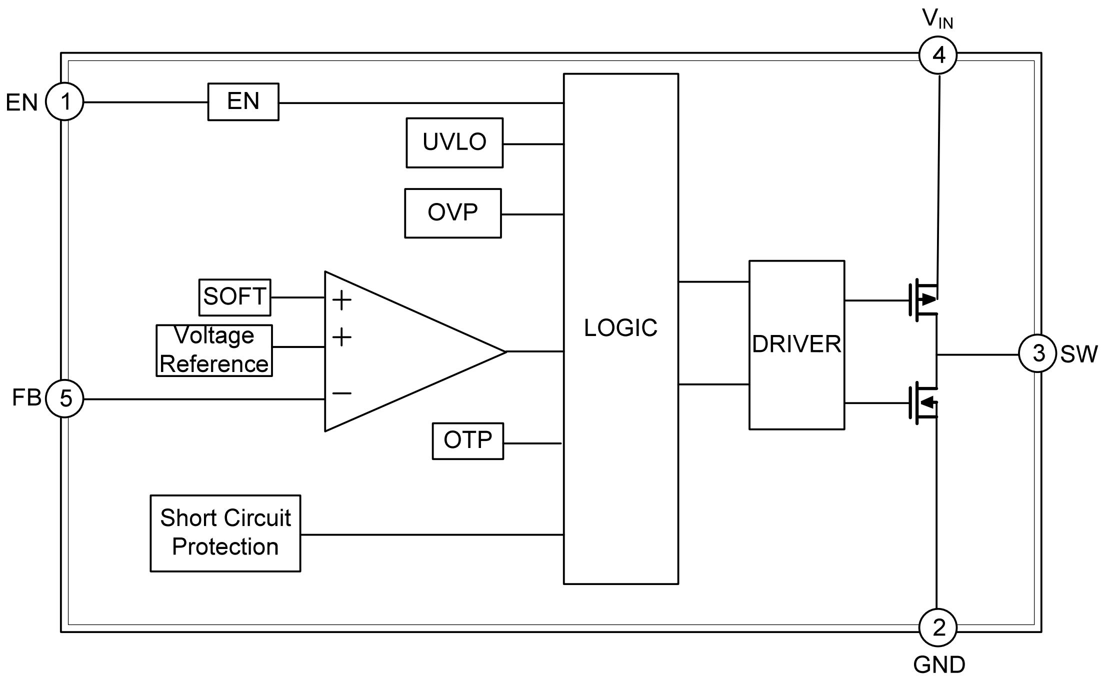
■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO.	PIN NAME	I/O	DESCRIPTION
1	EN	I	Enable control pin. Pull high to turn on.
2	GND	P	Ground pin.
3	SW	O	Switch node connection to inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.
4	V_{IN}	P	Supply voltage pin. Decouple this pin to the GND pin with at least a 22μF ceramic capacitor.
5	FB	I	Output Voltage Feedback Pin.

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING (T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	RATINGS	UNIT
V_{IN}, EN Voltages		-0.3 ~ 6.5	V
SW Voltage	V_{SW}	-0.3 ~ 6.5	V
SW Voltage (Less than 40ns)	V_{SW}	-3 ~ 7	V
FB Voltage	V_{FB}	-0.3 ~ 6.5	V
Operating Junction Temperature	T_J	-40 ~ +150	°C
Storage Temperature	T_{STG}	-65 ~ +150	°C

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V_{IN}	2.5 ~ 5.5	V
Ambient Temperature Range	T_A	-40 ~ +85	°C
Operation Junction Temperature Range	T_J	-40 ~ +125	°C

■ THERMAL DATA

PARAMETER	SYMBOL	RATINGS	UNIT
Junction to Ambient	θ_{JA}	250	°C/W
Junction to Case	θ_{JC}	130	°C/W

■ ELECTRICAL CHARACTERISTICS (V_{IN}=5V, V_{OUT}=2.5V, T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
GENERAL SECTION						
Input Voltage Range	V_{IN}		2.5		2.5	V
Quiescent Current	I_Q	V_{FB}=0.65V, SW Open		65		μA
Shutdown Supply Current	I_{SD}	V_{EN}=0V, V_{IN}=5V		0.1	10	μA
THRESHOLD VOLTAGE						
EN High-Level Input Voltage	V_{ENH}		1.15	1.25	1.35	V
EN Low-Level Input Voltage	V_{ENL}			1		V
Wake up V_{IN} Voltage	V_{UVLOH}			2.4		V
Input UVLO Hysteresis	V_{UVLO_HY}			150		mV
SOFT START						
Turn-On Delay	T_{ON_MIN}			0.5		ms
Soft-Start Time	T_{SS}			1		ms
ON-TIME TIMER CONTROL						
Minimum On-Time	T_{ON_MIN}			50		ns
MODULATOR CONTROL SECTION						
Regulated Feedback Voltage	V_{FB}		0.588	0.6	0.612	V
Switching Frequency	F_{SW}	CCM Mode	1.0	1.5	2.0	MHz
INTERNAL MOSFET						
High-Side Switch Resistance	R_{DSON_H}	V_{GS}=5V, V_{DS}=0.1V		125		mΩ
Low-Side Switch Resistance	R_{DSON_L}	V_{GS}=5V, V_{DS}=0.1V		95		mΩ
CURRENT LIMIT						
High-Side Switch Current Limit	I_{LIM_H}			3.5		A
PROTECTION SECTION						
Output Under-Voltage	V_{UVP}	Hiccup Detect		66		V_{FB}%
Input Over-Voltage Protection	V_{INOVP}			6		V
Input Over-Voltage Protection Hysteresis	V_{INOVP_HY}			0.25		V
Hiccup ON-Time	T_{HICCUP_ON}			3		ms
Hiccup OFF-Time	T_{HICCUP_OFF}			15		ms
Over-Temperature Protection Threshold	OTP			160		°C
Over-Temperature Protection Hysteresis	OTP_{Hy}			20		°C

■ FUNCTION DESCRIPTION

The **UD052015** is a 2A synchronous step- down DC-DC converter with an input voltage range of 2.5V to 5.5V and output voltage as low as 0.6V. The **UD052015** adopts the Peak current architecture to achieve fast transient responses for high voltage step down applications. This device operates at 1.5MHz operating frequency to ensure a compact, high efficiency design with excellent AC and DC performance.

Input Under-Voltage Lockout

Input under-voltage lockout (UVLO) monitors the input voltage. When the input voltage is higher than the UVLO threshold voltage (typ.2.4V), the device will turn on. Once the input voltage drops below the threshold with hysteresis (typ.150mV), the device will shut down.

Input Over-Voltage Protection

Input over-voltage protection (OVP) monitors the input voltage. When the input voltage is above the OVP threshold voltage (typ.6V), the device shuts down. Once the input voltage drops below the threshold with hysteresis (typ.0.25V), the **UD052015** will return to normal operation automatically.

Soft Start

The **UD052015** provides an internal soft-start from overshooting during startup. This scheme ensures that the converters ramp up smoothly. The output voltage starts to rise in 0.5ms from EN rising, and the soft-start ramp-up time (V_{FB} from 0V to 0.6V) is 1ms, the devices initiate switching and start ramping up only after the internal reference voltage becomes greater than the feedback voltage V_{FB}.

Maximum Duty Cycle Operation

The **UD052015** is designed to operate in dropout at the high duty cycle approaching 100%. The **UD052015** implements skip off- time function to achieve high duty approaching 100%. Therefore, the maximum output voltage is near the minimum input supply voltage of the application for input voltage momentarily falls down to the normal output voltage requirement. The input voltage at which the devices enter dropout changes depending on the input voltage, output voltage, switching frequency, load current, and the efficiency of the design.

Power Saving Mode

When the **UD052015** is in the normal CCM operating mode and the switch current falls to 0A, the **UD052015** begins operating in pulse skipping eco-mode. Each switching cycle is followed by a period of energy saving sleep time. The sleep time ends when the V_{FB} voltage falls below the eco-mode threshold voltage. As the output current decreases, the perceived time between switching pulses increases.

EN Enable

The EN pin is provided to control the device turn-on and turn-off. When the EN pin voltage is above the V_{ENH} threshold (typ.1.25V), the device is enabled. When the EN pin voltage falls below the V_{ENL} threshold (typ.1V), the **UD052015** is disabled and enters shutdown mode.

Output Under-Voltage Protection

The **UD052015** detects output under-voltage by monitoring the feedback voltage on the FB pin. When the feedback voltage is below 66%V_{FB}, the IC enters hiccup mode to periodically disable and restart the switch operation.

Output Over-Voltage Protection

The **UD052015** includes an output over- voltage protection (OUTOVP) circuit to limit output voltage and minimize output voltage overshoot. If the V_{FB} goes above the 115% of the reference voltage, the high-side MOSFET will be forced off to limit the output voltage, When the V_{FB} drops to 110% of the reference voltage, the control of the high-side MOSFET will be released.

Over Current Limit Protection and Output Short Protection

The **UD052015** has cycle-by-cycle peak current limit function. When the inductor current peak value is larger than the peak current limit during high side MOSFET on state, the device enters into peak over current protection mode and low side MOSFET keeps on state until inductor current drops down to the value equal or lower than the peak current limit, and then on time pulse could be generated and high side MOSFET could turn on again. If the output is short to GND and the output voltage drop until feedback voltage V_{FB} is below the output under- voltage threshold which is typically 66% of reference voltage, The **UD052015** enters into hiccup mode to periodically disable and restart switching operation. The hiccup mode helps to reduce power dissipation and thermal rise during output short condition. The period of **UD052015** hiccup mode is typically 18ms. The switching operation time in hiccup mode is 3ms. The hiccup mode helps to reduce power dissipation and thermal rising during output short condition.

FUNCTION DESCRIPTION (Cont.)

Over-Temperature Protection

The **UD052015** includes over-temperature Protection function. When the junction temperature exceeds about 160°C, the OTP will turn off the switch operation. Once the junction temperature drops to about 140°C, the IC will resume normal operation.

APPLICATION INFORMATION

Output Voltage Setting

Figure 1 shows the output voltage setting circuit of **UD052015**. The external resistance voltage divider can set the output voltage according to equation (1).

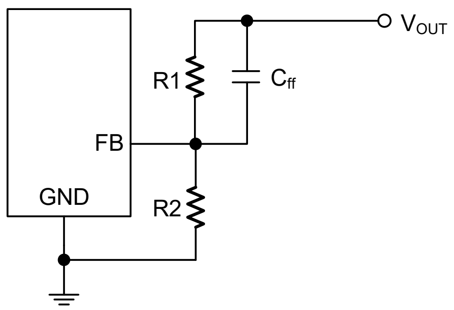


Figure. 1 Output Voltage Setting Circuits

$$V_{OUT}=V_{FB}\times(1+\frac{R1}{R2})=0.6V\times(1+\frac{R1}{R2}) \quad (1)$$

Current consumption and noise sensitivity need to be considered in the selection of resistance R2. A feed forward capacitor Cff improves the loop bandwidth to make a fast transient response, but using a larger Cff brings stability problems.

Inductor Selection

Inductance value, switching frequency, input voltage and output voltage together determine the ripple of inductance current and then affect the output ripple. The ripple of the inductor current can be obtained by Equation (2).

$$\Delta I_L=V_{OUT}\times\frac{1-\frac{V_{OUT}}{V_{IN}}}{L\times F_{SW}} \quad (2)$$

Where ΔI_L is the inductor current ripple, F_{SW} is the switching frequency.

To calculate the maximum inductor current under static load conditions, Equation (3) is given:

$$I_{L\_MAX}=I_{OUT\_MAX}+\frac{\Delta I_L}{2} \quad (3)$$

Table 1. Recommended Components Selection

VOUT (V)	R1 (kΩ)	R2 (kΩ)	Cff (pF)	L (µH)	COUT (µF)
3.3	100	22.1	22	2.2	44-88
1.8	100	49.9	22	2.2	44-88
1.5	100	66.5	22	2.2	44-88
1.2	100	100	100	2.2	44-88
1.05	100	133	100	2.2	44-88
1	100	150	100	1	44-88
0.9	100	200	100	1	44-88

■ APPLICATION INFORMATION (Cont.)

Input Capacitor Selection

The input capacitor C_{IN} is needed to filter the fluctuations caused by the pulsating current at the drain of the high-side power MOSFET. Ceramic capacitors with X5R or a better grade ceramic capacitor dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 22μF ceramic capacitor for most applications is sufficient. A large value may be used for improved input voltage filtering. In applications, place the input capacitor C_{IN} as close as possible to the V_{IN} pin and GND pin of the IC.

Output Capacitor Selection

The output voltage ripple at the switching frequency is a function of the inductor current ripple going through the output capacitor's impedance. The output peak-to-peak ripple voltage ΔV_{OUT}, caused by the inductor current ripple, is composed of ESR ripple ΔV_{ESR} and capacitor ripple ΔV_{Cap}. The functional relationship of the output ripple is expressed by Equation (4):

$$\Delta V_{OUT}=\Delta V_{ESR}+\Delta V_{Cap}=\Delta I_L\times R_{ESR}+\frac{\Delta I_L}{8\times C_{OUT}\times F_{SW}} \quad (4)$$

Where R_{ESR} is equivalent impedance on capacitor.

Two 22μF ceramic capacitors can satisfy most applications.

■ TYPICAL APPLICATION CIRCUIT

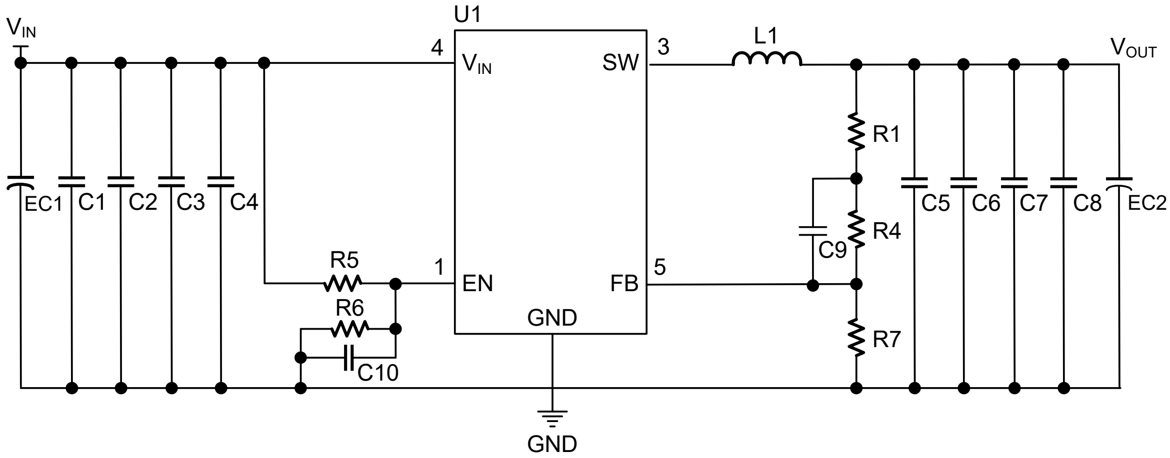
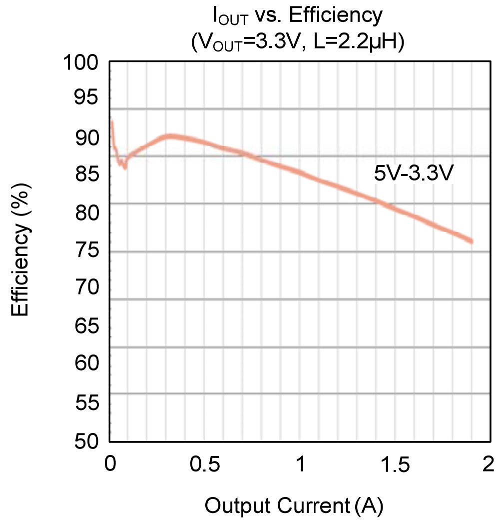


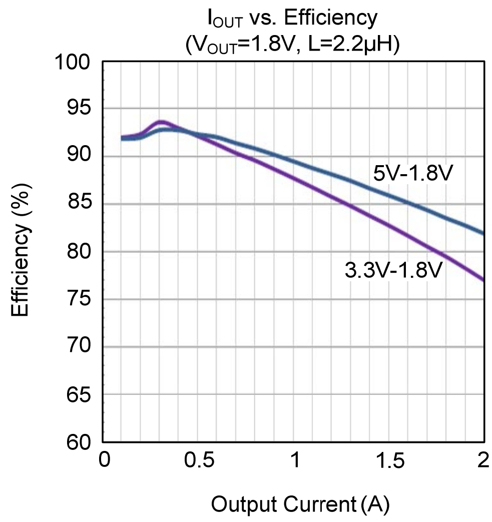
Table 2. Recommended Component Values

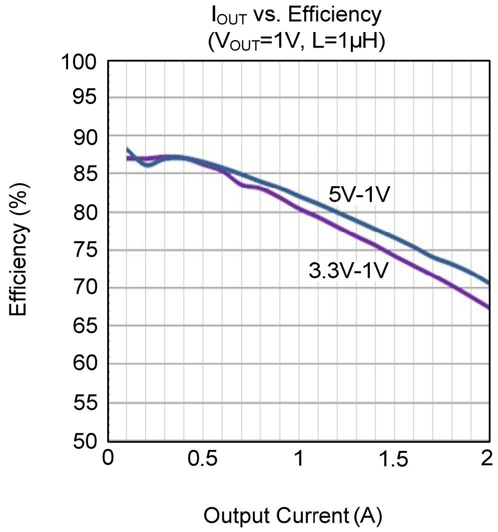
Qty	Ref	Value	
1	C3	22μF	
1	C4	0.1μF	
1	C5	22μF	
1	C9	V_{OUT}=3.3V	22pF
		V_{OUT}=1V	100pF
0	C1, C2, C6, C7, C8, C10	NC	
0	EC1, EC2	NC	
0	R6	NC	
1	R5	100kΩ	
1	R1	0Ω	
1	R4	100kΩ	
1	R7	V_{OUT}=3.3V	22.1kΩ
		V_{OUT}=1V	150kΩ
1	L1	V_{OUT}=3.3V	2.2μH
		V_{OUT}=1V	1μH
1	U1	/	

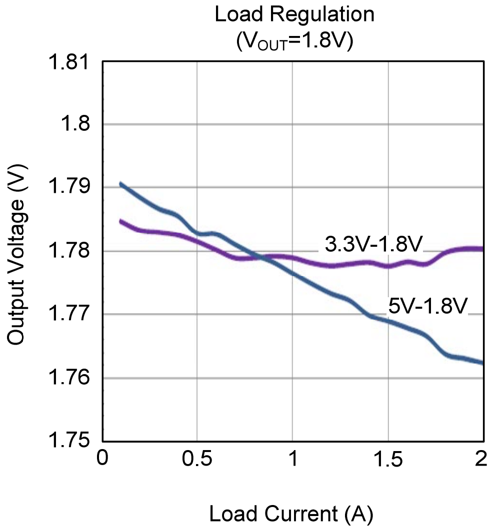
■ TYPICAL CHARACTERISTICS

Test condition: V_{IN}=5V, V_{OUT}=1.8V



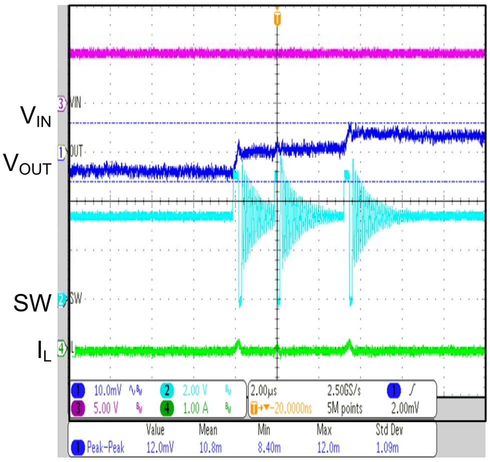




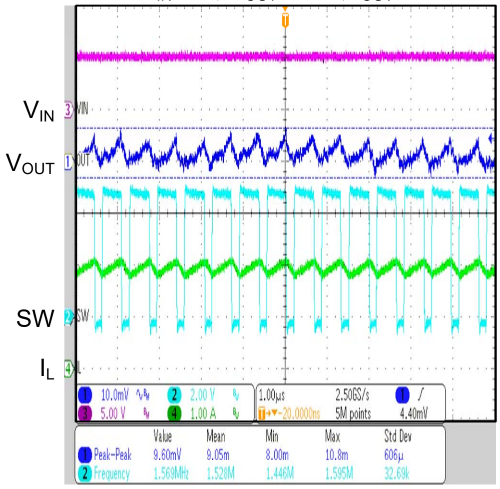


■ TYPICAL CHARACTERISTICS (Cont.)

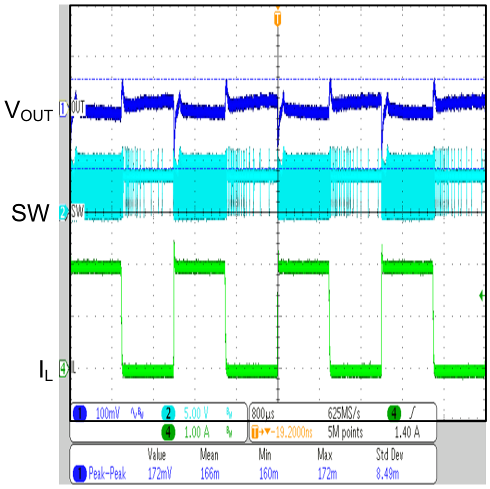
Steady State Operation
V_{IN}=5V, V_{OUT}=3.3A, I_{OUT}=0A



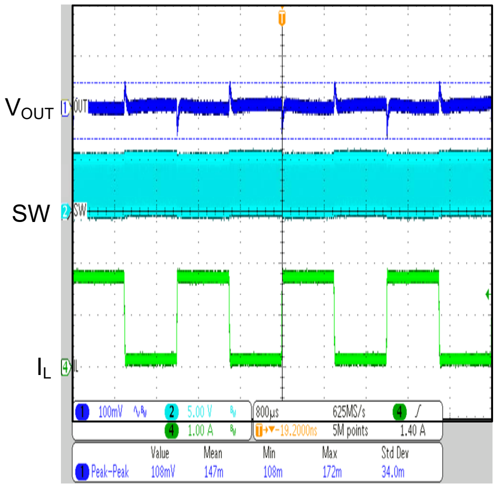
Steady State Operation
V_{IN}=5V, V_{OUT}=3.3A, I_{OUT}=2A



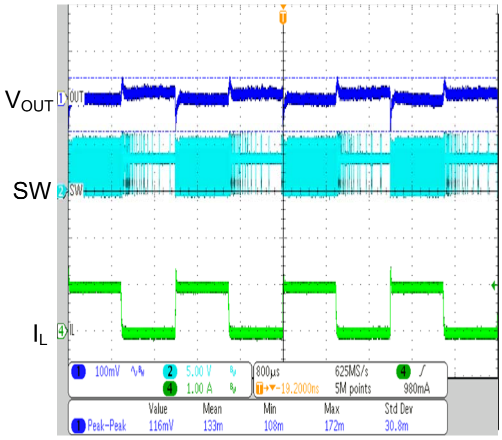
Load Transient
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0A to 2A)



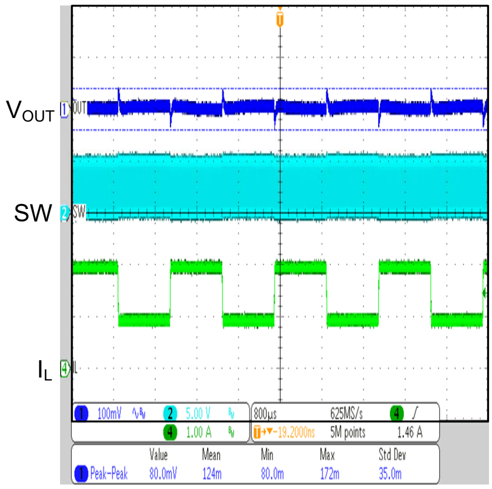
Load Transient
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0.2A to 1.8A)



Load Transient
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0A to 1A)

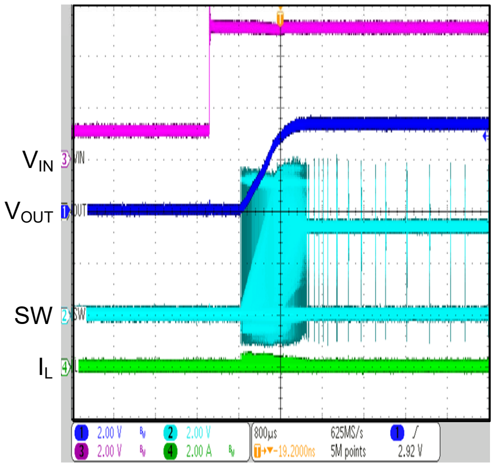


Load Transient
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=1A to 2A)

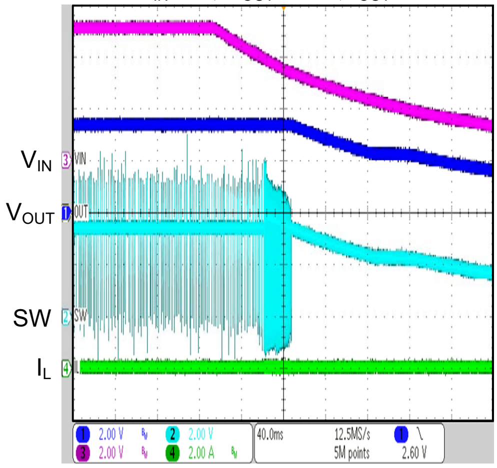


■ TYPICAL CHARACTERISTICS (Cont.)

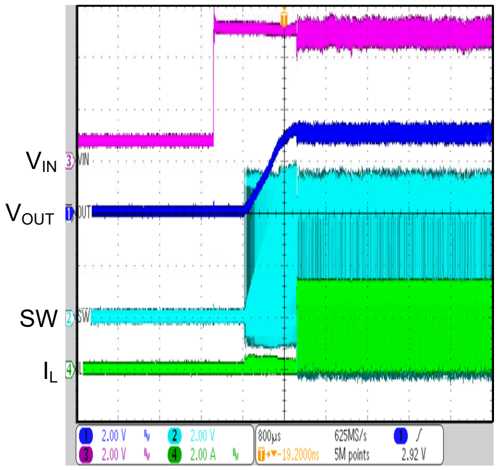
Input Power On
V_{IN}=5V, V_{OUT}=3.3A, I_{OUT}=0A



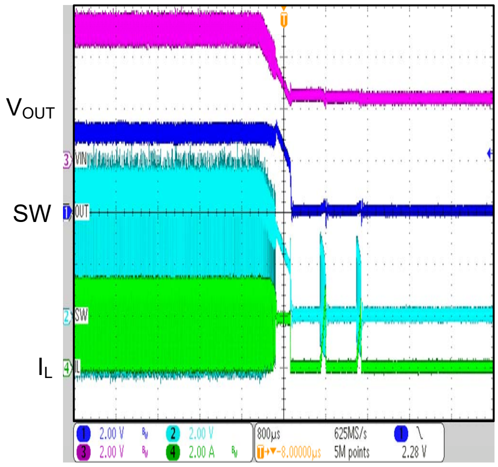
Input Power Off
V_{IN}=5V, V_{OUT}=3.3A, I_{OUT}=0A



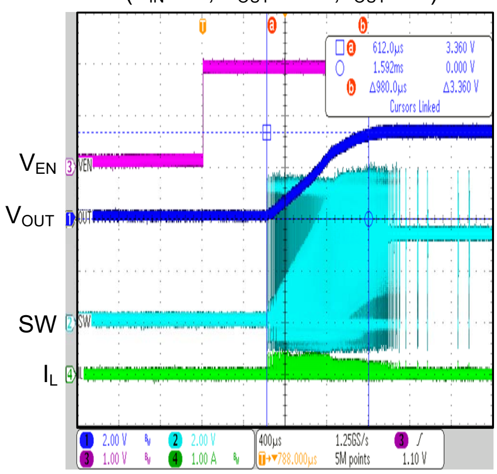
Input Power On
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=2A)



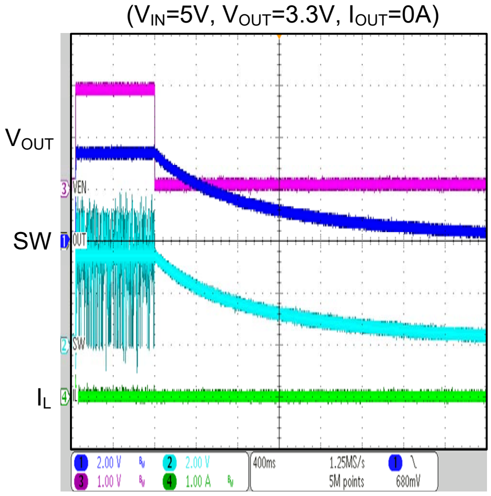
Input Power Off
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=2A)



EN Power On
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0A)

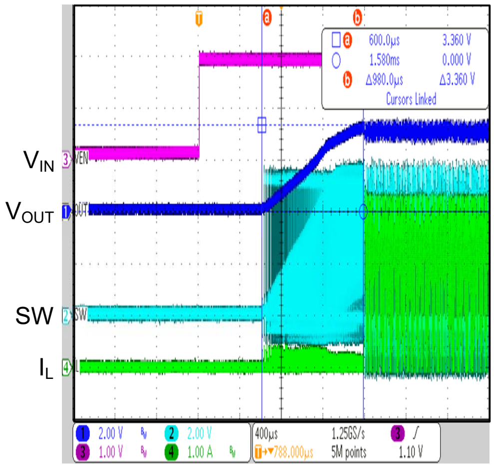


EN Power Off
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0A)

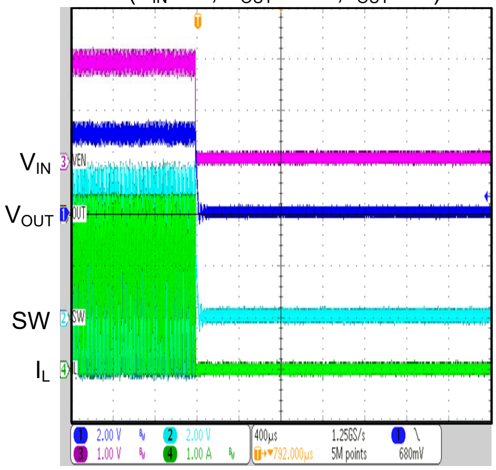


■ TYPICAL CHARACTERISTICS (Cont.)

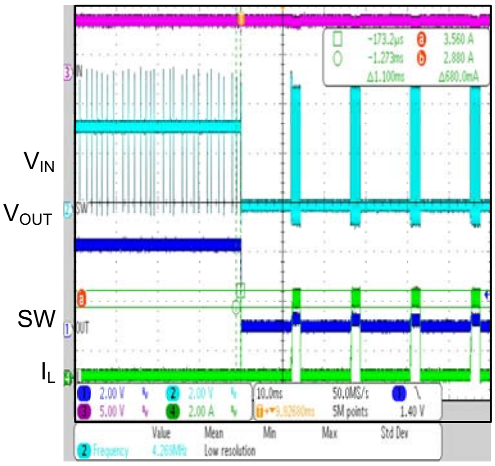
EN Power On
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=2A)



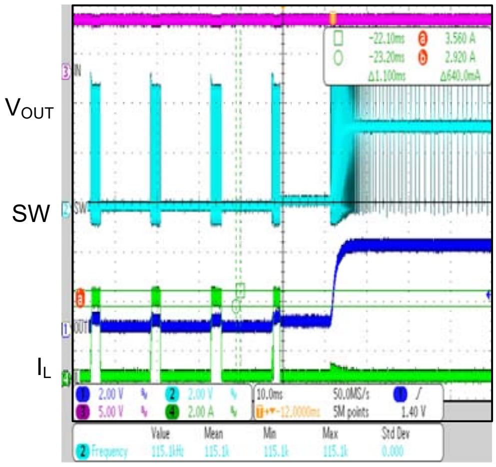
EN Power Off
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=2A)



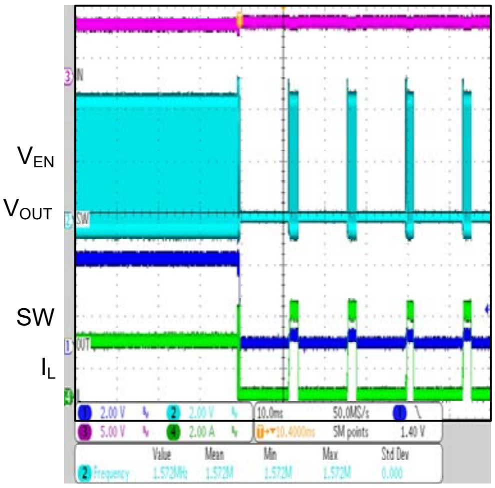
Output Short Entry
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0A)



Output Short Recovery
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=0A)



Output Short Entry
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=2A)



Output Short Recovery
(V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=2A)