MPQ2177

5.5V, 1A, 2.4MHz, Synchronous Step-Down Converter with Power Good and Soft Start, AEC-Q100 Qualified

DESCRIPTION

The MPQ2177 is a monolithic, step-down, switch-mode converter with built-in internal power MOSFETs. It achieves 1A of continuous output current across a 2.5V to 5.5V input voltage (V_{IN}) range, with excellent load and line regulation. The output voltage (V_{OUT}) can be regulated to as low as 0.6V.

The constant-on-time (COT) control scheme provides fast transient response and eases loop stabilization. Fault protections include cycle-by-cycle current limiting and thermal shutdown.

The MPQ2177 is ideal for a wide range of applications, including automotive infotainment systems, clusters, and telematics.

The MPQ2177 requires a minimal number of readily available, standard external components, and is available in an ultra-small QFN-8 (1.5mmx2mm) package.

FEATURES

Designed for Automotive Applications

- Wide 2.5V to 5.5V Operating V_{IN} Range
- Up to 1A Output Current
- 1% FB Accuracy
- Junction Temperature Operation from -40°C to +150°C

High Performance for Improved Thermals

- 75mΩ and 45mΩ Internal Power MOSFETs

Optimized for EMC/EMI

- 2.4MHz Switching Frequency
- Forced Continuous Conduction Mode (CCM) across the Full Load Range
- MeshConnect™ Flip-Chip Package

Optimized for Board Size and BOM

- Built-In Internal Power MOSFETs
- Integrated Compensation Network
- Fixed Output Options

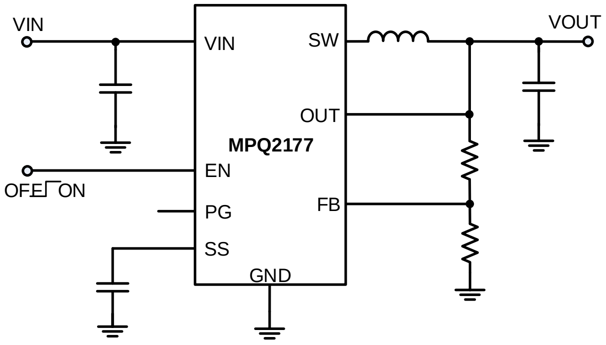
Additional Features

- EN for Power Sequencing
- Power Good (PG)
- 100% Duty On
- External Soft Start (SS) Control
- Output Discharge
- Output Over Voltage Protection (Vo OVP)
- Short-Circuit Protection (SCP) with Hiccup Mode
- Available in a QFN-8 (1.5mmx2mm) Package
- Available in a Wettable Flank Package
- Available in AEC-Q100 Grade 1

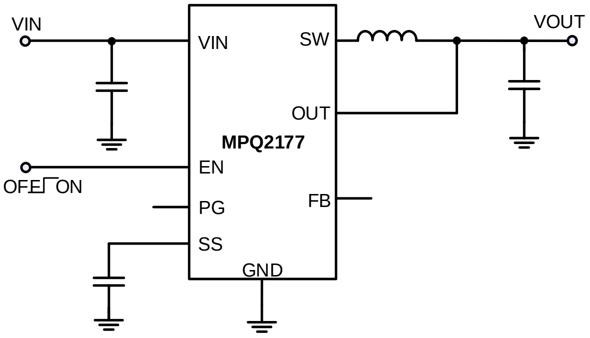
APPLICATIONS

- Automotive Infotainment
- Camera Modules
- Key Fobs
- Automotive Clusters
- Automotive Telematics
- Industrial Supplies
- Battery-Powered Devices

TYPICAL APPLICATION



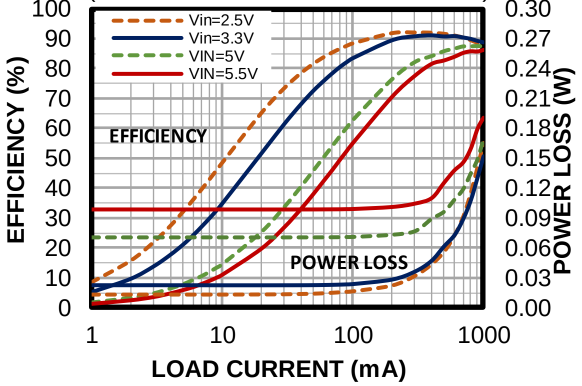
Adjustable Output Version



Fixed Output Version

Efficiency vs. Load Current vs. Power Loss

V_{OUT} = 1.2V, L = 2.2µH, (XFL4020-222MEB, DCR = 21.35mΩ)



ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating**
MPQ2177GQHE***	QFN-8 (1.5mmx2mm)	*See Below*	1
MPQ2177GQHE-AEC1***			
MPQ2177GQHE-12-AEC1***			
MPQ2177GQHE-18-AEC1***			

* For Tape & Reel, add suffix -Z (e.g. MPQ2177GQHE-AEC1-Z).

** Moisture Sensitivity Level Rating

*** Wettable flank

TOP MARKING

KR
LL

KR: Product code of MPQ2177GQHE and MPQ2177GQHE-AEC1
LL: Lot number

LG
LL

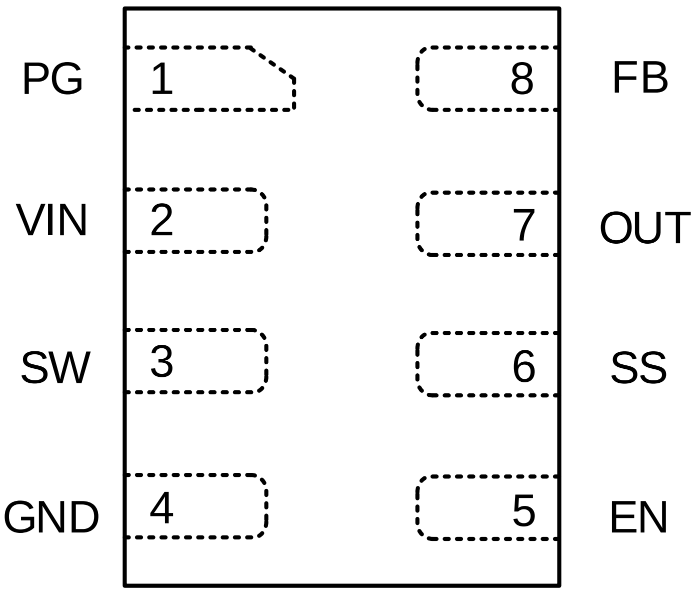
LG: Product code of MPQ2177GQHE-12-AEC1
LL: Lot number

LH
LL

LH: Product code of MPQ2177GQHE-18-AEC1
LL: Lot number

PACKAGE REFERENCE

TOP VIEW



QFN-8 (1.5mmx2mm)

PIN FUNCTIONS

Pin #	Name	Description
1	PG	**Power good indicator.** The output of this pin is an open drain. Connect PG to a voltage source using an external resistor. PG is pulled high when V_{FB} exceeds 90% of V_{REF}; PG is pulled low to GND if V_{FB} drops below 85% of V_{REF}. Float this pin if not used.
2	VIN	**Supply voltage.** The MPQ2177 operates from a 2.5V to 5.5V input. A decoupling capacitor is required to prevent large voltage spikes from appearing at the input.
3	SW	**Output switching node.** SW is the drain of the internal, high-side P-channel MOSFET. Connect the inductor to SW to complete the converter.
4	GND	**Ground.**
5	EN	**On/off control.** Pull EN below the falling threshold (0.65V) to shut down the chip. Pull EN above the rising threshold (0.9V) to enable the chip. There is an internal 2MΩ resistor from EN pin to ground.
6	SS	**Soft start.** Connect a capacitor across SS and GND to set the soft-start time (t_{SS}) to avoid start-up inrush current. The minimum recommended soft-start capacitance (C_{SS}) is 1nF.
7	OUT	**Output voltage.** The OUT pin is output voltage (V_{OUT}) for the power rail and input sense. Connect the load to this pin. An output capacitor is required to decrease the output voltage ripple.
8	FB	**Feedback pin.** An external resistor divider from the output to GND, tapped to the FB pin. The FB voltage (V_{FB}) is compared to the internal 0.6V reference voltage (V_{REF}) to set the regulation voltage. For the fixed output version of the MPQ2177, this pin can be floated.

ABSOLUTE MAXIMUM RATINGS (1)

All pins ....-0.3V to +6.5V
Junction temperature ....150°C
Lead temperature ....260°C
Continuous power dissipation (T_A = 25°C) (2) (4)
……………. 2.2W
Storage temperature................ -65°C to +150°C

ESD Ratings

Human body model (HBM) .... ±2000V
Charged device model (CDM) .... ±750V

Recommended Operating Conditions

Supply voltage (V_{IN}) ....2.5V to 5.5V
Output voltage (V_{OUT})................0.6V to V_{IN} - 0.5V
Operating junction temp (T_J).... -40°C to +150°C

Thermal Resistance

	θ_{JA}	*θ_{JC}*	
QFN-8 (1.5mmx2mm)			
JESD51-7 (3)	130	25	°C/W
EVQ2177-LE-00A (4)	59	14	°C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX) - T_A) / θ_{JA}. Exceeding the maximum allowable power dissipation can cause excessive die temperature, and the regulator may go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) Measured on JESD51-7, 4-layer PCB. The values given in this table are only valid for comparison with other packages and cannot be used for design purposes. These values were calculated in accordance with JESD51-7, and simulated on a specified JEDEC board. They do not represent the performance obtained in an actual application.
4) Measured on EVQ2177-LE-00A, 2oz per layer, 6.3cmx6.3cm, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{IN} = 3.6V, T_J = -40°C to +150°C, typical value tested at T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
V_{IN} range			2.5		5.5	V
Under-voltage lockout (UVLO) rising threshold				2.3	2.45	V
UVLO threshold hysteresis				200		mV
Shutdown supply current		V_{EN} = 0V, T_J = 25°C		0.01	1	μA
		V_{EN} = 0V, T_J = -40°C to +125°C (6)			3	μA
		V_{EN} = 0V, T_J = -40°C to +150°C			20	μA
Quiescent supply current		V_{EN} = 2V, V_{FB} = 0.63V, V_{IN} = 3.6V, T_J = 25°C		460	650	μA
Feedback voltage	V_{FB}	T_J = 25°C	594	600	606	mV
		T_J = -40°C to +150°C	591	600	609	
Feedback current	I_{FB}	V_{FB} = 0.63V, adjustable output		50	100	nA
		V_{FB} = 0.63V, 1.2V fixed output		3	8	μA
		V_{FB} = 0.63V, 1.8V fixed output		5	10	μA
Output regulation voltage (fixed output version)	V_{OUT_REG}	1.2V fixed output	1.176	1.2	1.224	V
		1.8V fixed output	1.764	1.8	1.836	V
P-channel MOSFET on resistance	$R_{DS(ON)\_P}$	V_{IN} = 5V		75	110	mΩ
N-channel MOSFET on resistance	$R_{DS(ON)\_N}$	V_{IN} = 5V		45	70	mΩ
Switch leakage		V_{EN} = 0V, V_{IN} = 6V V_{SW} = 0V or 6V, T_J = 25°C		0	1	μA
		V_{EN} = 0V, V_{IN} = 6V, V_{SW} = 0V or 6V, T_J = -40°C to +125°C (6)			30	μA
Switching frequency	f_{SW}	V_{IN} = 5V, V_{OUT} = 1.2V, CCM	2000	2400	2640	kHz
Minimum on time (6)	t_{MIN_ON}	V_{IN} = 5V		50		ns
Minimum off time (6)	t_{MIN_OFF}	V_{IN} = 5V		80		ns
P-channel MOSFET peak current limit			1.6	2.5	3.4	A
N-channel MOSFET valley current limit			0.4	1	1.6	A
Soft-start current	I_{SS_ON}		1.5	3	4.5	μA
Maximum duty cycle				100		%
Power good (PG) under-voltage (UV) rising threshold		FB rising edge	87	90	93	%
PG UV falling threshold		FB falling edge	82	85	88	%
PG delay	t_{PGD}	PG rising/falling edge		80		μs

ELECTRICAL CHARACTERISTICS *(continued)*

V_{IN} = 3.6V, T_J = -40°C to +150°C, typical value tested at T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
PG sink current capability	V_{PG_L}	Sink 1mA			0.4	V
PG logic high voltage	V_{PG_H}	V_{IN} = 5V, V_{FB} = 0.6V	4.9			V
Self-bias PG (5)					0.7	V
PG leakage current/logic high		5V logic high			100	nA
EN turn-on delay		EN on to SW active		100		µs
EN turn-off delay		EN off to when switching stops		30		µs
EN input logic low voltage			0.4	0.65		V
EN input logic high voltage				0.9	1.2	V
EN pull-down resistor				2		MΩ
Output discharge resistor	R_{DIS}	V_{EN} = 0V, V_{OUT} = 1.2V		150		Ω
EN input current		V_{EN} = 2V		1.2		µA
		V_{EN} = 0V		0		µA
Output over-voltage (OV) rising threshold	V_{OVP}		110	115	120	%V_{FB}
Output OV hysteresis	V_{OVP_HYS}			10		%V_{FB}
Output OV delay				2		µs
Low-side current limit		Current flow from SW to GND		1.2		A
Absolute V_{IN} OVP		After V_{OUT} OVP enable		6.1		V
Absolute V_{IN} OVP hysteresis				160		mV
Thermal shutdown (6)				170		°C
Thermal shutdown hysteresis (6)				20		°C

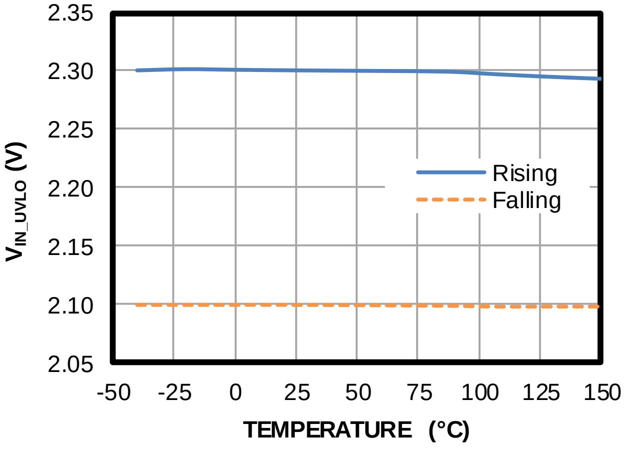
Notes:

5) V_{IN} = 0V, EN = 0V, PG pulled up to 3V to 5.5V with a 100kΩ resistor.
6) Guaranteed by design and bench characterization. Not tested in production.

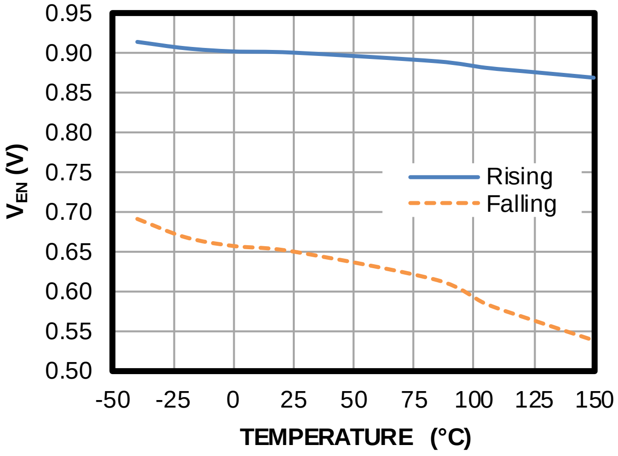
TYPICAL CHARACTERISTICS

V_{IN} = 3.6V, T_J = -40°C to +150°C, unless otherwise noted.

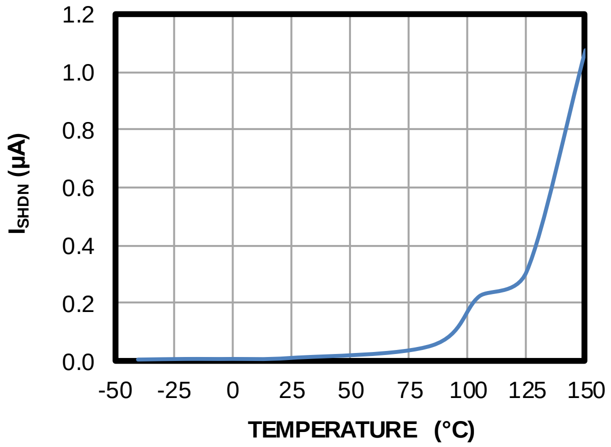
V_{IN} UVLO Threshold vs. Temperature



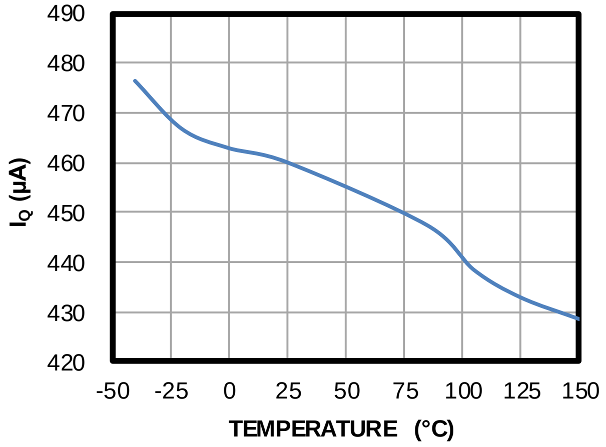
EN Rising and Falling Threshold vs. Temperature



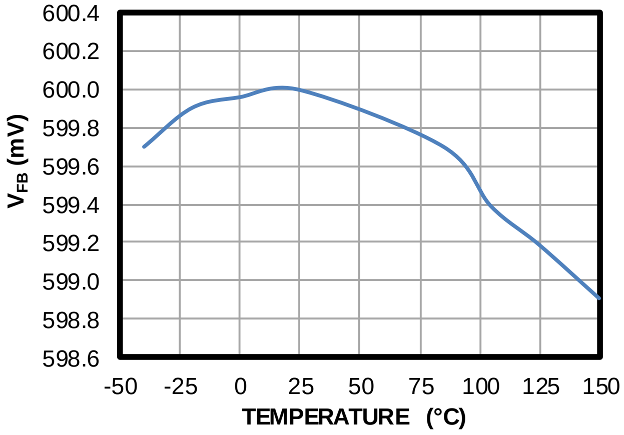
Shutdown Current vs. Temperature



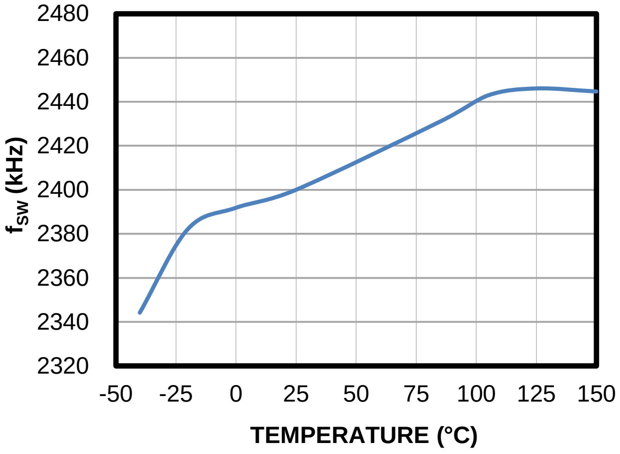
Quiescent Current vs. Temperature



V_{FB} vs. Temperature

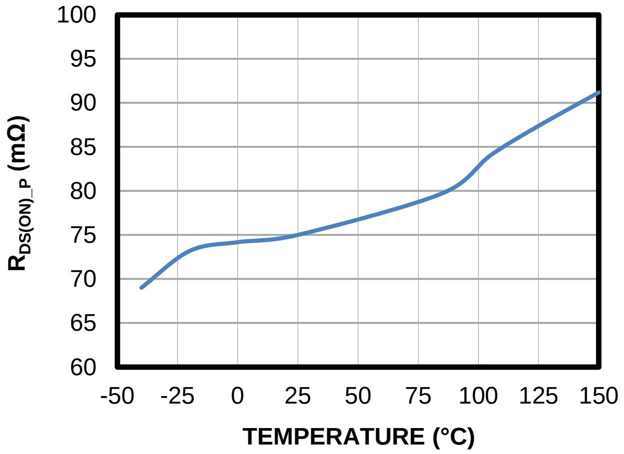


Switching Frequency vs. Temperature

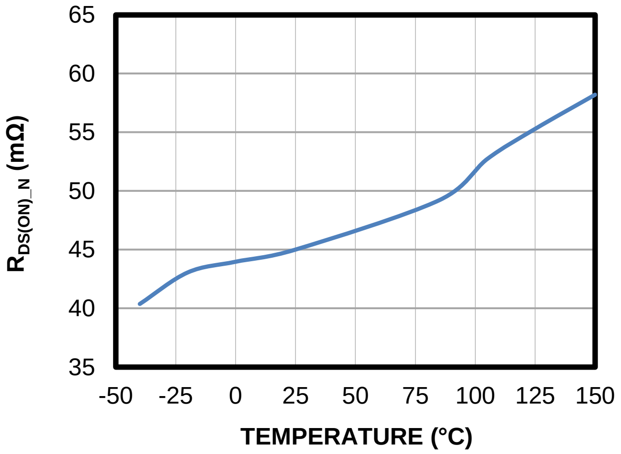


TYPICAL CHARACTERISTICS *(continued)*

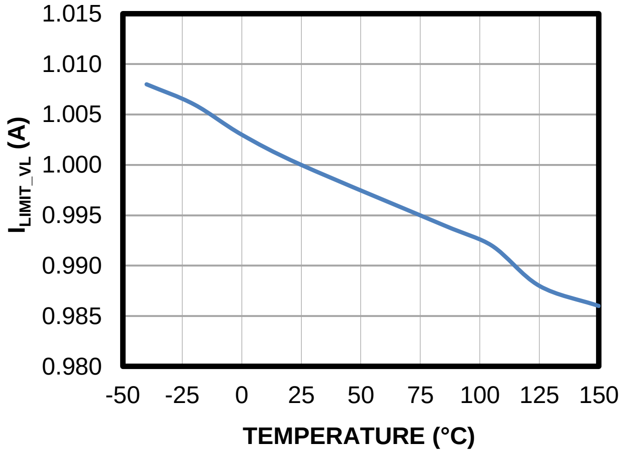
V_{IN} = 3.6V, T_J = -40°C to +150°C, unless otherwise noted.



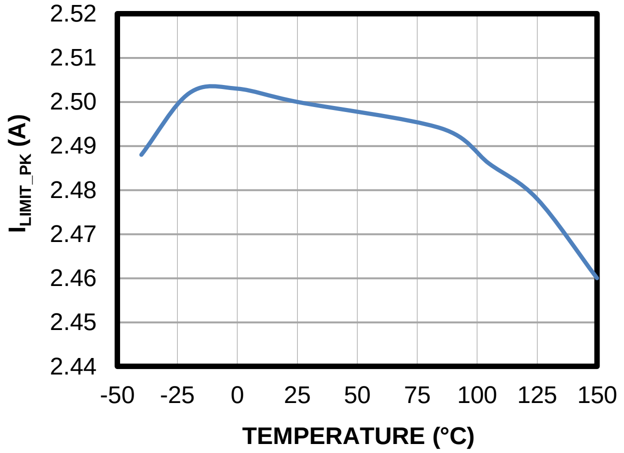
$R_{DS(ON)\_P}$ vs. Temperature



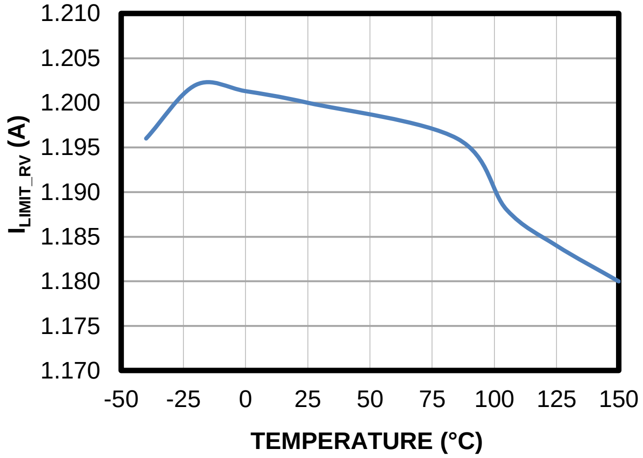
$R_{DS(ON)\_N}$ vs. Temperature



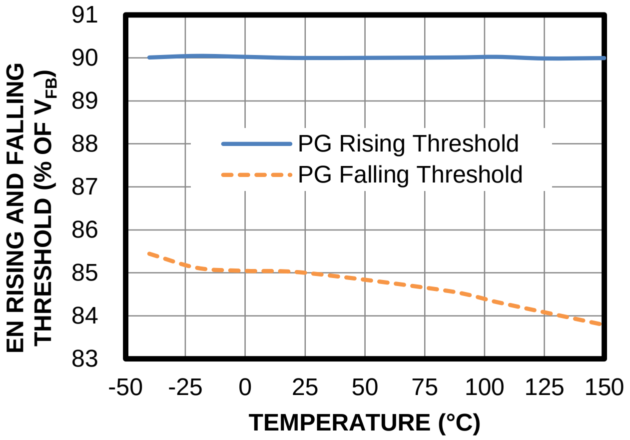
N-Channel MOSFET Valley Current Limit vs. Temperature



P-Channel MOSFET Peak Current Limit vs. Temperature



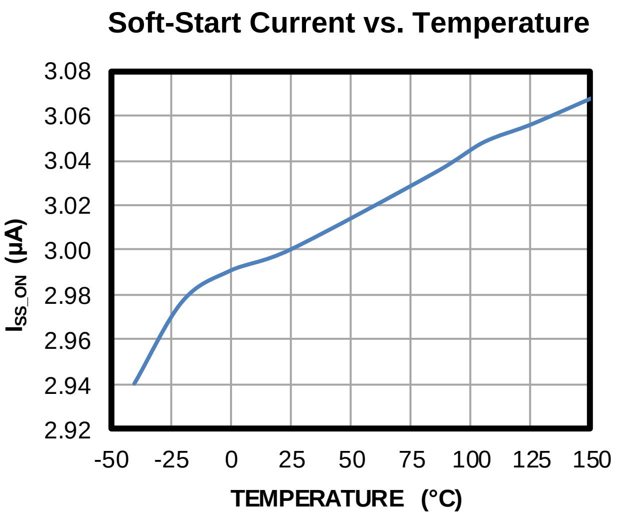
Low-Side Reverse Current Limit vs. Temperature



PG Rising and Falling Threshold vs. Temperature

TYPICAL CHARACTERISTICS *(continued)*

V_{IN} = 3.6V, T_J = -40°C to +150°C, unless otherwise noted.

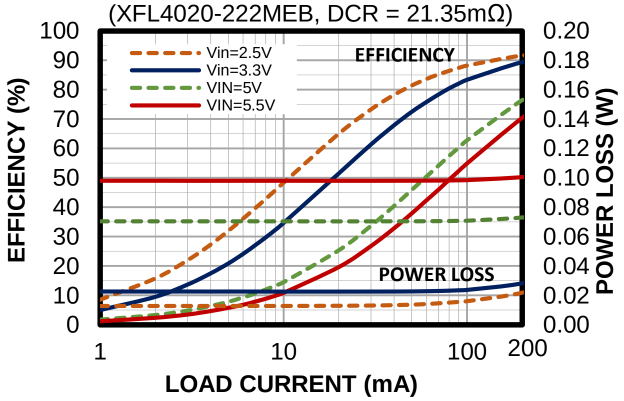


TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 3.6V, T_J = -40°C to +150°C, unless otherwise noted.

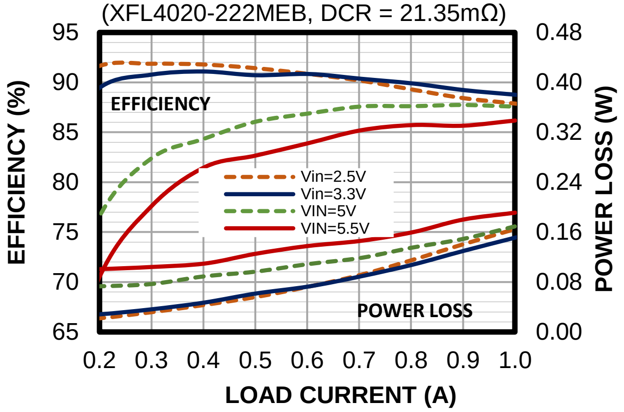
Efficiency vs. Load Current vs. Power Loss

V_{OUT} = 1.2V, L = 2.2μH, (XFL4020-222MEB, DCR = 21.35mΩ)



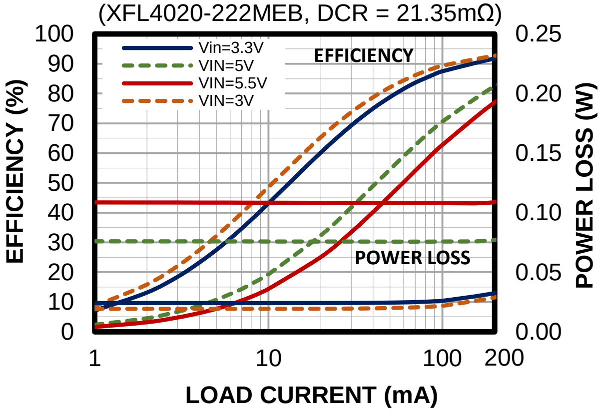
Efficiency vs. Load Current vs. Power Loss

V_{OUT} = 1.2V, L = 2.2μH, (XFL4020-222MEB, DCR = 21.35mΩ)



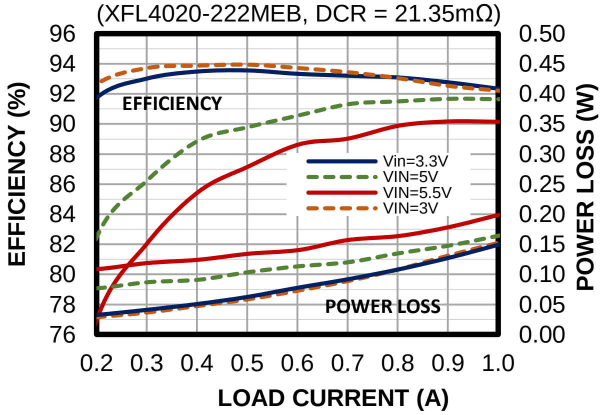
Efficiency vs. Load Current vs. Power Loss

V_{OUT} = 1.8V, L = 2.2μH, (XFL4020-222MEB, DCR = 21.35mΩ)



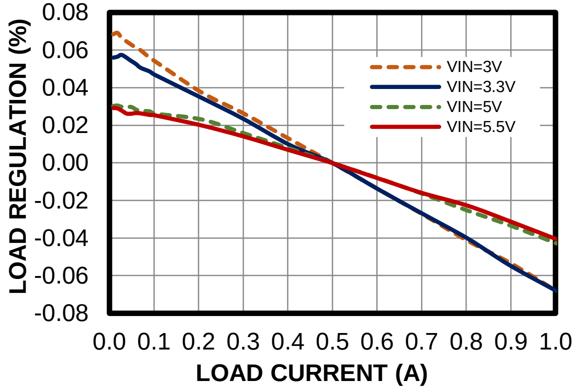
Efficiency vs. Load Current vs. Power Loss

V_{OUT} = 1.8V, L = 2.2μH, (XFL4020-222MEB, DCR = 21.35mΩ)



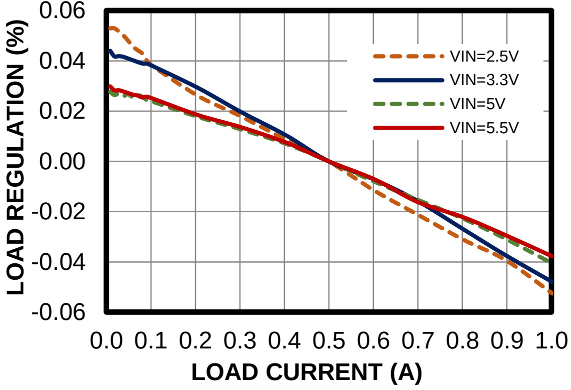
Load Regulation

V_{OUT} = 1.8V



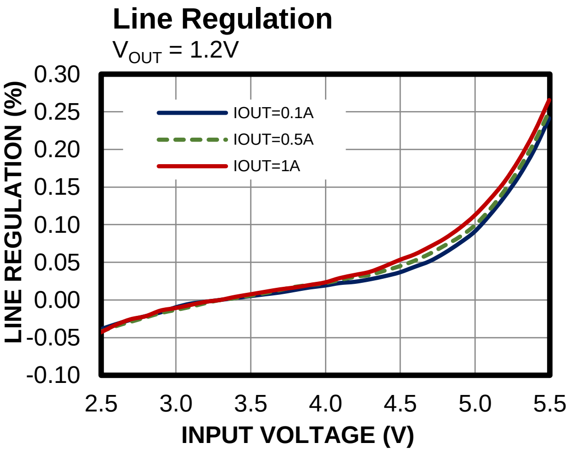
Load Regulation

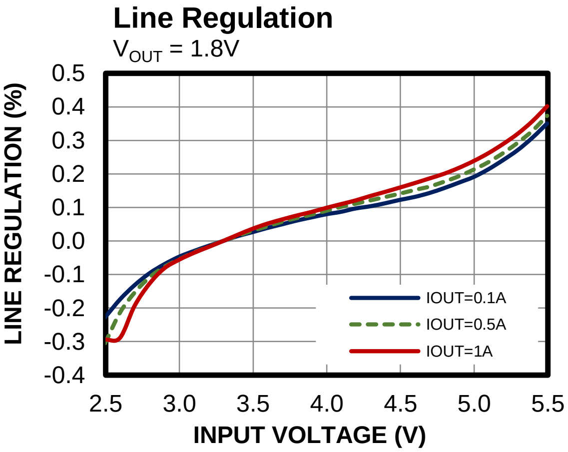
V_{OUT} = 1.2V



TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 3.6V, T_J = -40°C to +150°C, unless otherwise noted.



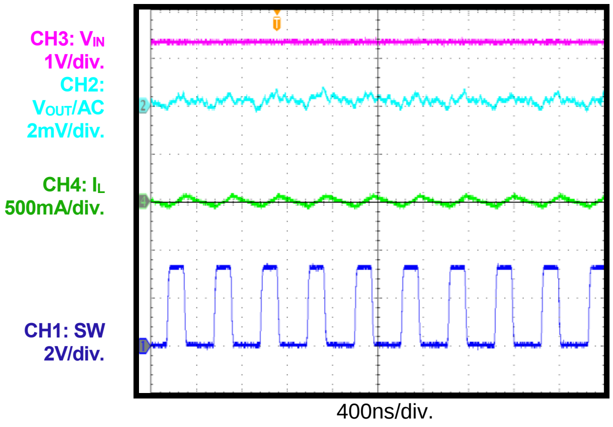


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 3.3V, V_{OUT} = 1.2V, L = 2.2µH, C_{OUT} = 22µF, T_A = 25°C, unless otherwise noted.

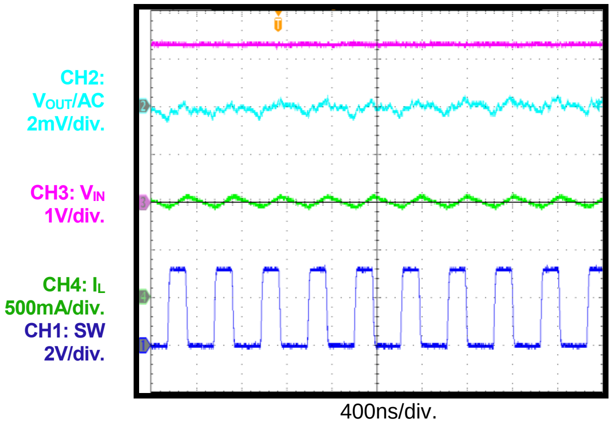
Steady State

I_{OUT} = 0A



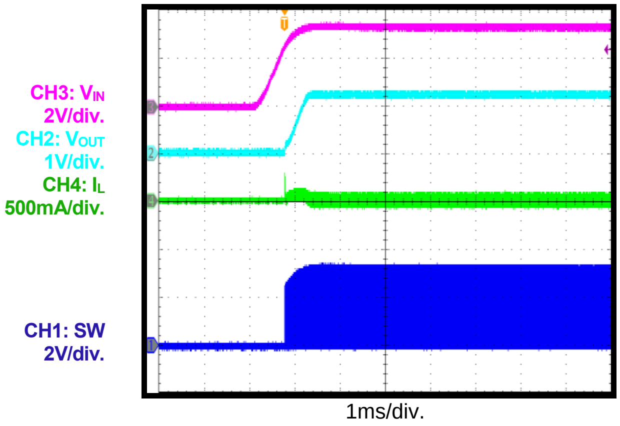
Steady State

I_{OUT} = 1A



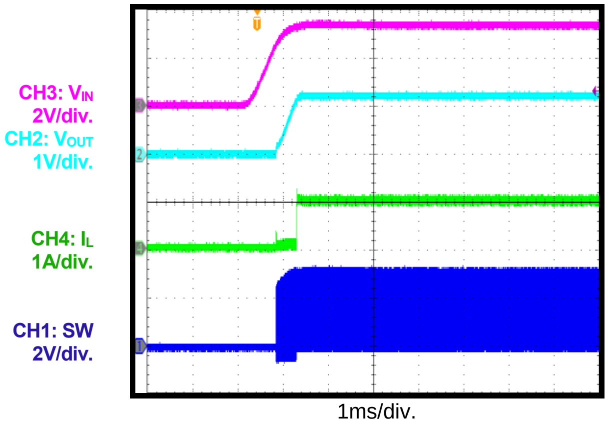
Start-Up through VIN

I_{OUT} = 0A



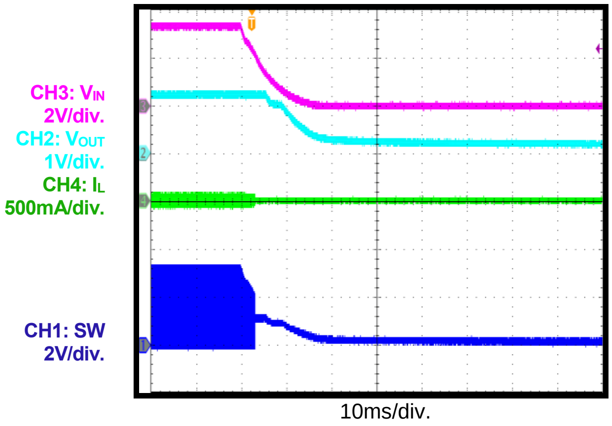
Start-Up through VIN

I_{OUT} = 1A



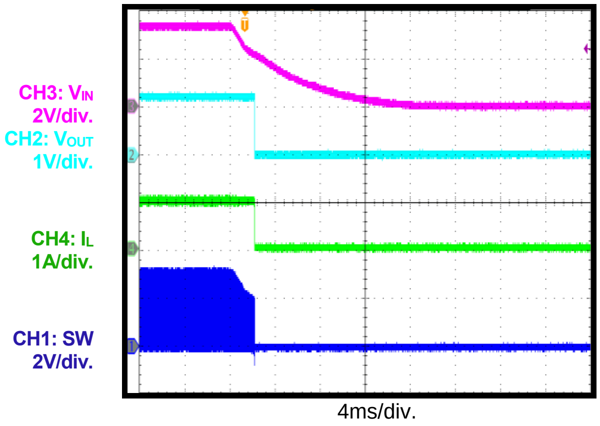
Shutdown through VIN

I_{OUT} = 0A



Shutdown through VIN

I_{OUT} = 1A

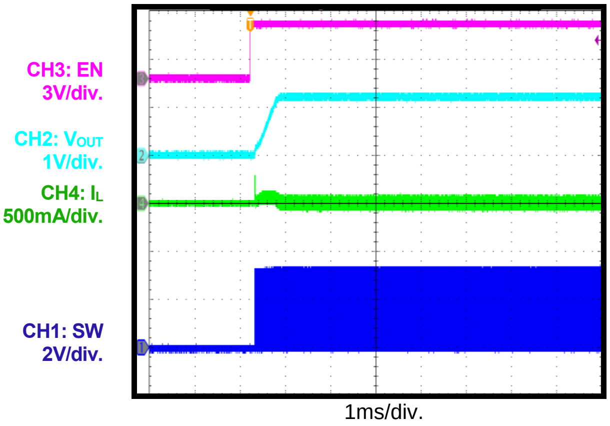


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 3.3V, V_{OUT} = 1.2V, L = 2.2µH, C_{OUT} = 22µF, T_A = 25°C, unless otherwise noted.

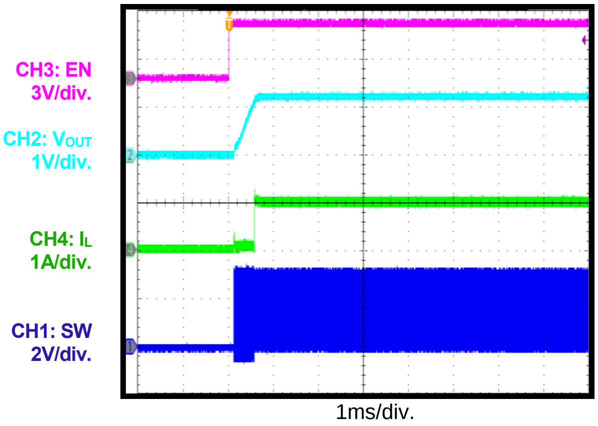
Start-Up through EN

I_{OUT} = 0A



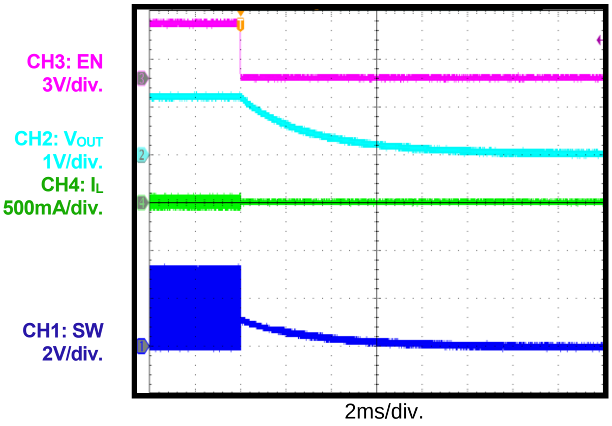
Start-Up through EN

I_{OUT} = 1A



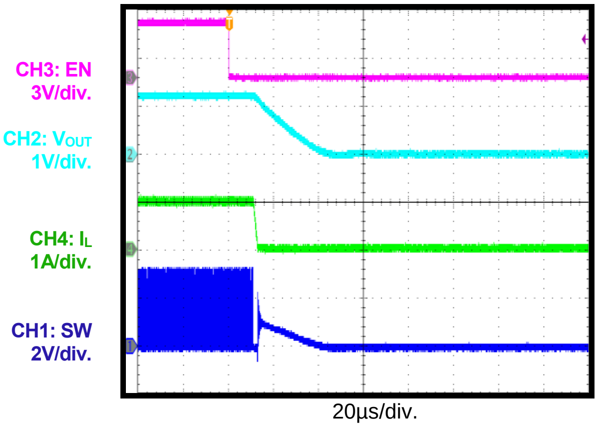
Shutdown through EN

I_{OUT} = 0A



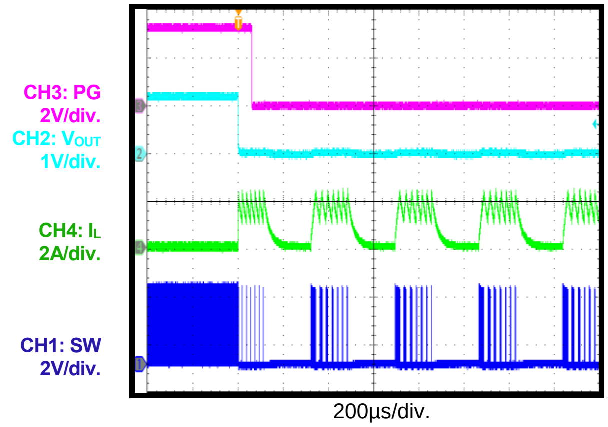
Shutdown through EN

I_{OUT} = 1A



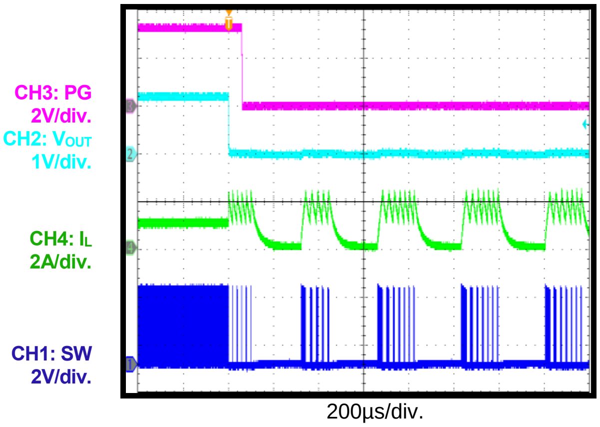
SCP Entry

I_{OUT} = 0A



SCP Entry

I_{OUT} = 1A

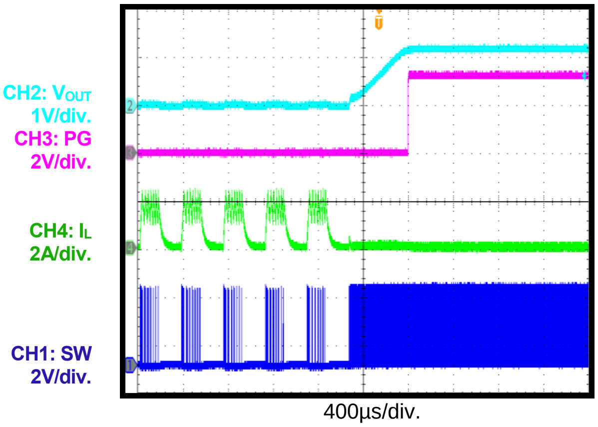


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 3.3V, V_{OUT} = 1.2V, L = 2.2µH, C_{OUT} = 22µF, T_A = 25°C, unless otherwise noted.

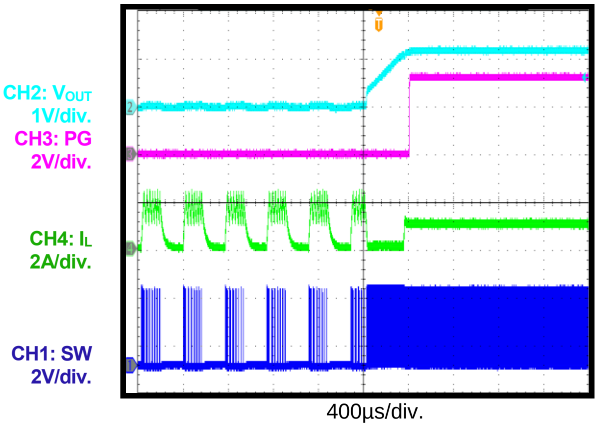
SCP Recovery

I_{OUT} = 0A

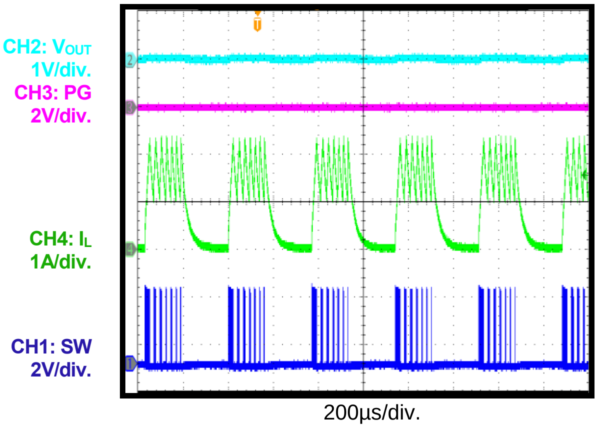


SCP Recovery

I_{OUT} = 1A

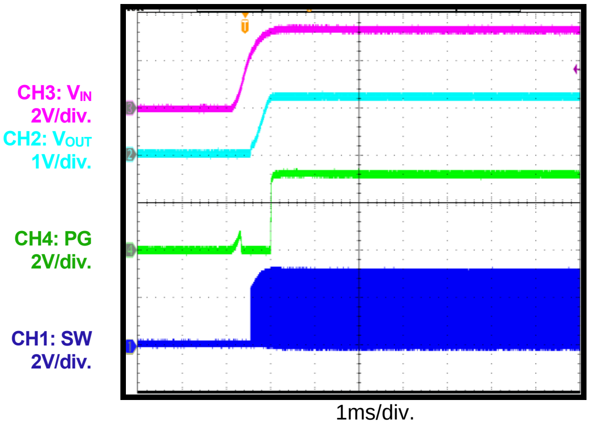


Short Circuit



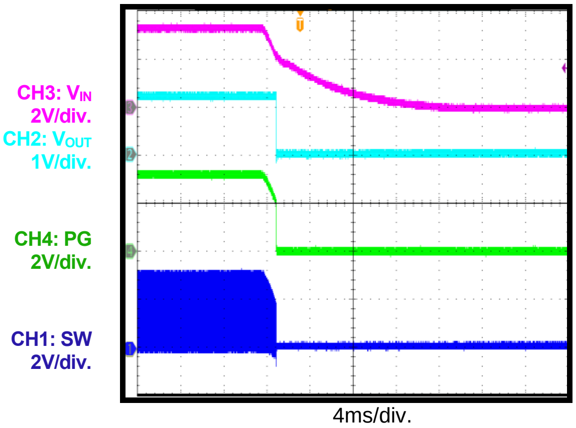
PG in Start-Up through VIN

I_{OUT} = 1A



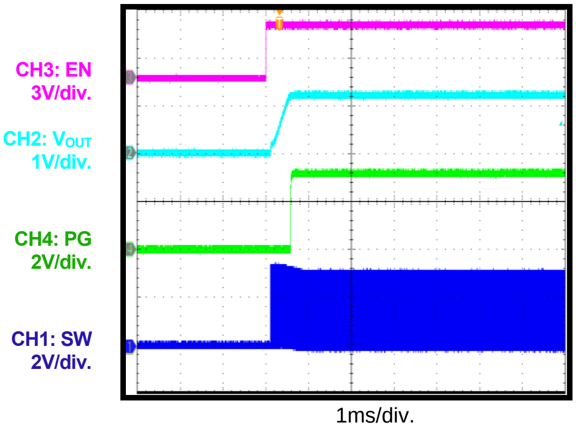
PG in Shutdown through VIN

I_{OUT} = 1A



PG in Start-Up through EN

I_{OUT} = 1A

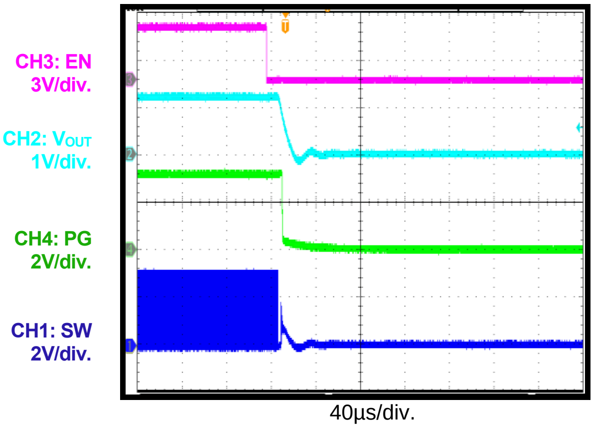


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 3.3V, V_{OUT} = 1.2V, L = 2.2µH, C_{OUT} = 22µF, T_A = 25°C, unless otherwise noted.

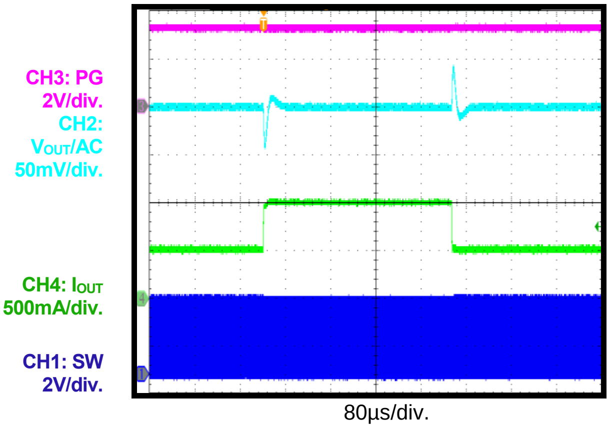
PG in Shutdown through EN

I_{OUT} = 1A



Load Transient

I_{OUT} = 0.5A to 1A, 1A/µs



FUNCTIONAL BLOCK DIAGRAM

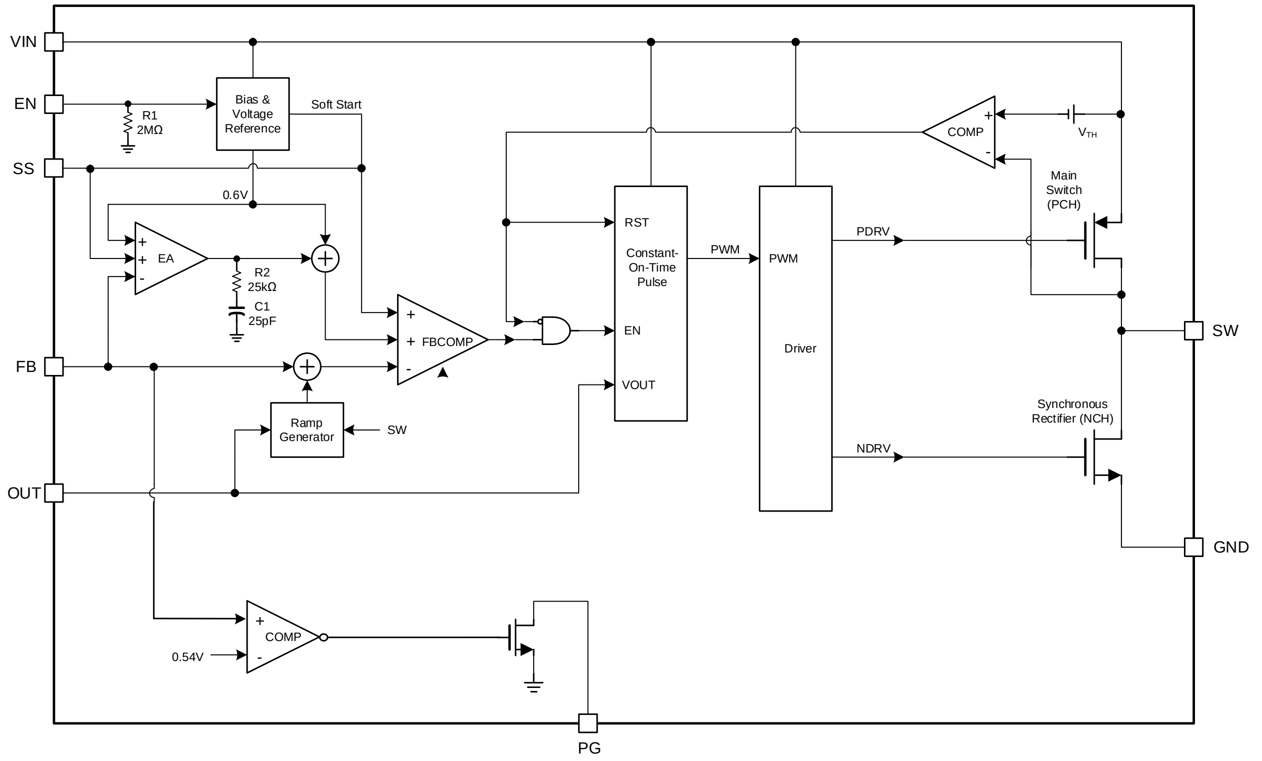


Figure 1: Functional Block Diagram of Adjustable Output Version

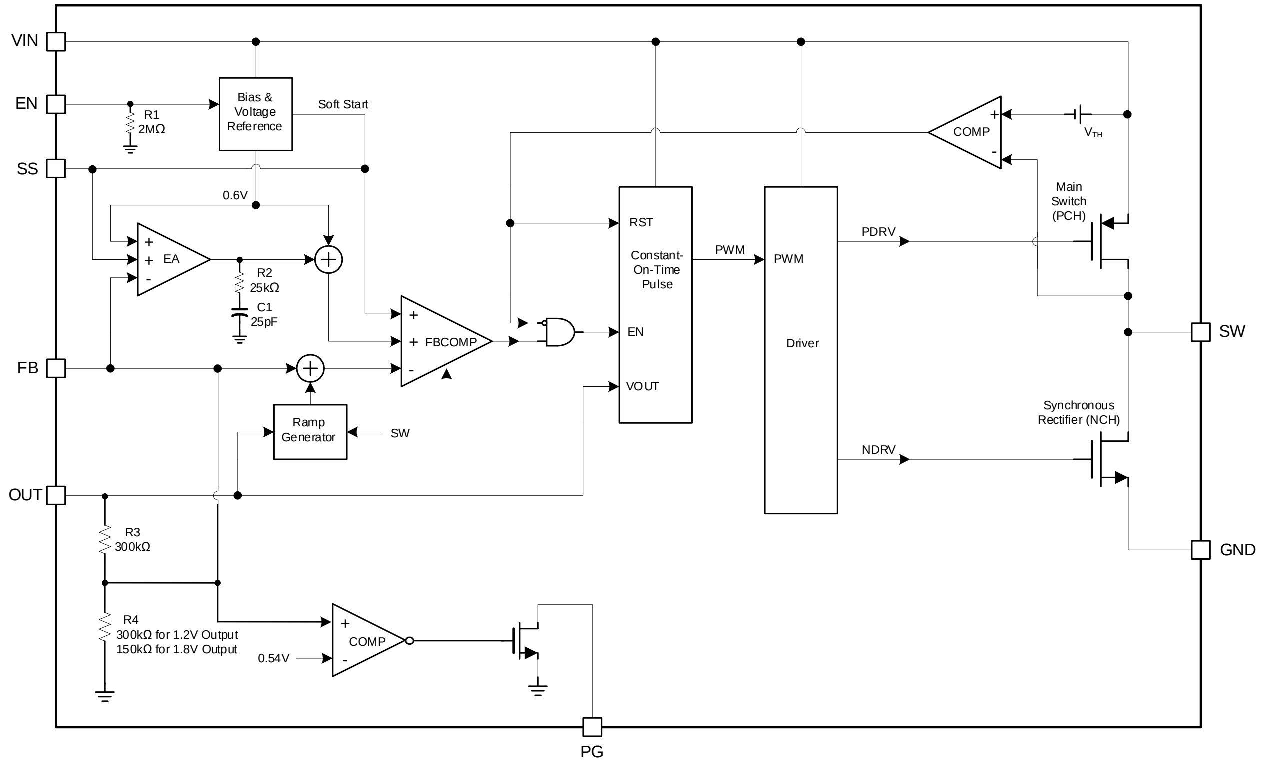


Figure 2: Functional Block Diagram of Fixed Output Version

OPERATION

The MPQ2177 uses constant-on-time (COT) control with input voltage (V_{IN}) feed-forward to stabilize the switching frequency (f_{SW}) across the full input range. It achieves 1A of continuous output current (I_{OUT}) across a 2.5V to 5.5V V_{IN} range, with excellent load and line regulation. The output voltage (V_{OUT}) can be regulated to as low as 0.6V for the adjustable output version. The MPQ2177 is capable of reaching 100% maximum duty cycle in low-dropout mode.

Constant-On-Time (COT) Control

Compared to fixed-frequency pulse-width modulation (PWM) control, COT control offers a simpler control loop and faster transient response. To prevent inductor current (I_L) runaway during load transient, the MPQ2177's MOSFET has a fixed minimum off time. When low-side N-channel MOSFET (LS-FET) turns on, it remains on for at least t_{MIN_OFF}. Then the high-side P-channel MOSFET (HS-FET) turns on when the feedback voltage (V_{FB}) drops below the reference voltage (V_{REF}), which indicates an insufficient V_{OUT}. By using V_{IN} feed-forward, the MPQ2177 maintains a nearly constant f_{SW} across the input and load ranges. The switching pulse on time (t_{ON}) can be estimated with Equation (1):

$$t_{ON} = \frac{V_{OUT}}{V_{IN}} \times 400\text{ns} \tag{1}$$

In order to improve frequency stability and the reduce output voltage ripple, the MPQ2177 operates in forced continuous conduction mode (FCCM).

Enable

EN is a digital control pin that turns the MPQ2177 on and off. Pull EN above the EN rising threshold (0.9V) to turn the device on; pull EN below the falling threshold (0.65V) to turn it off. Leaving EN floating or pulling it down to ground disables the MPQ2177. There is an internal 2MΩ resistor from the EN pin to ground.

Output Discharge

When the device is disabled, the part automatically goes into output discharge mode and the internal discharge MOSFET provides a resistive discharge path from the OUT pin to GND for the output capacitor (C_{OUT}). Output discharge mode can be blocked by adding an external capacitor between V_{OUT} and the OUT pin. See the Output Discharge Blocking section on page 21 for more details.

Soft Start (SS)

The MPQ2177 has an external SS pin that ramps up V_{OUT} at a controlled slew rate to avoid overshoot during start-up. The SS pin charge current is typically 3µA. The soft-start time (t_{SS}) is decided by the soft-start capacitor (C_{SS}), and can be calculated with Equation (2):

$$t_{SS}(\text{ms}) = \frac{C_{SS}(\text{nF}) \times 0.6\text{V}}{I_{SS}(\mu\text{A})} \tag{2}$$

Where C_{SS} is the external soft-start capacitor, and I_{SS} is the internal 3µA SS charge current.

C_{SS} should be 1nF minimum.

The MPQ2177 offers a pre-biased start-up function. Once EN is enabled, the device starts up even if there is a pre-biased voltage on the output. Pre-biased start-up works regardless of whether output discharge mode is blocked.

Peak and Valley Current Limit

Both the HS-FET and LS-FET have current limit protection. When I_L reaches the HS-FET's peak current limit (typical 2.5A) during the HS-FET on time, the HS-FET immediately turns off to prevent the current from rising further, and the LS-FET turns on to discharge the energy. The HS-FET does not turn again until I_L drops below the valley current limit threshold (typically 1A). This current limit scheme helps prevent current runaway during overload and short circuit events.

Short-Circuit Protection (SCP) and Recovery

If V_{OUT} is shorted to ground and the MPQ2177 reaches its current limit, then the device enters short-circuit protection (SCP) and tries to recover with hiccup mode. The IC disables the output power stage, begins discharging the SS voltage (V_{SS}), and restarts with a full soft start once V_{SS} is fully discharged. This hiccup process repeats until the fault is removed.

Over-Voltage Protection (OVP)

The MPQ2177 monitors a resistor-divided feedback voltage to detect over-voltage (OV) conditions. If V_{FB} exceeds 115% of V_{REF}, the controller enters the dynamic regulation period. During this period, the LS-FET remains on until the LS-FET current reaches -1.2A; this process discharges V_{OUT} and tries to keep it within the normal range. If the OV condition still remains, the LS-FET turns on again after a 1.5µs delay. Once V_{FB} falls below 105% of V_{REF}, the MPQ2177 exits this regulation period. If the dynamic regulation period cannot prevent V_{OUT} from increasing and a 6.1V V_{IN} is detected, the over-voltage protection (OVP) occurs. The MPQ2177 stops switching until V_{IN} drops below 6V; once this occurs, the MPQ2177 resumes normal operation.

Power Good (PG) Indicator

The MPQ2177 has one power good (PG) output to indicate normal operation after soft start. PG is the open drain of an internal MOSFET, for which the maximum $R_{DS(ON)}$ must be below 400Ω. PG can be connected to V_{IN} or an external voltage source through an external resistor (10kΩ to 100kΩ). After V_{IN} is applied, the MOSFET turns on and PG is pulled to GND before SS is ready. After V_{FB} reaches 90% of V_{REF}, PG is pulled high by the external voltage source. When V_{FB} drops to 85% of V_{REF}, the PG voltage (V_{PG}) is pulled to GND to indicate an output failure.

If V_{IN} and EN are not available and PG is pulled up by an external power supply, then PG will self-bias and assert. If a 100kΩ pull-up resistor is used, the voltage on the PG pin is less than 0.7V.

APPLICATION INFORMATION

Setting the Output Voltage

The external resistor divider sets V_{OUT} for the adjustable output version of the MPQ2177. Select the feedback resistor (R1) that reduces the V_{OUT} leakage current (typically between 10kΩ and 100kΩ). R2 can then be calculated with Equation (3):

$$R2 = \frac{R1}{\frac{V_{OUT}}{0.6} - 1} \qquad (3)$$

Figure 3 shows the feedback circuit.

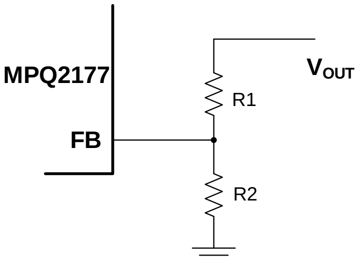


Figure 3: Feedback Network

Table 1 lists the recommended resistor values for common output voltages.

Table 1: Resistor Values for Common Output Voltages

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)
1.0	30.9 (1%)	47 (1%)
1.2	100 (1%)	100 (1%)
1.8	36 (1%)	18 (1%)
2.5	51 (1%)	16 (1%)
3.3	68 (1%)	15 (1%)

Frequency Scaling at Low Input Voltages

Under heavy-load conditions, the HS-FET voltage drops as t_{ON} increases and the duty is extended. At low input voltages and heavy-load conditions, if the minimum off time (t_{MIN_OFF}) is reached, then the frequency scales down. To keep f_{SW} constant, a higher V_{OUT} requires a higher V_{IN} under heavy loads. For a 1.8V V_{OUT}, V_{IN} should be above 2.7V to keep f_{SW} above 2MHz at a 1A load. When the frequency starts to scale down, estimate V_{IN} with Equation (4):

$$V_{IN} = \frac{V_{OUT} + R_{DS(ON)\_P} \times I_{OUT}}{1 - \frac{t_{MIN\_OFF}}{400 \times 10^{-9}}} \qquad (4)$$

Where the maximum t_{MIN_OFF} is 125ns.(7)

Note:

7) Guaranteed by design and bench characterization. Not tested in production.

Selecting the Inductor

A 0.47µH to 2.2µH inductor is recommended for most applications. Select an inductor with a DC resistance below 25mΩ to optimize efficiency.

High-frequency, switch-mode power supplies with magnetic devices such as the MPQ2177 can have strong electromagnetic inference (EMI). Unshielded power inductor should be avoided, as they provide poor magnetic shielding. Shielded inductor, such as metal alloy or multiplayer chip power inductors, are recommended, as they effectively reduce EMI.

For most designs, the inductance (L_1) can be estimated with Equation (5):

$$L_1 = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{SW}} \qquad (5)$$

Where ΔI_L is the inductor ripple current.

Choose an inductor ripple current that is approximately 30% of the maximum load current. The maximum inductor peak current ($I_{L(MAX)}$) can be calculated with Equation (6):

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2} \qquad (6)$$

Selecting the Input Capacitor

The step-down converter has a discontinuous input current, and requires a capacitor to supply AC current to the converter while maintaining the DC input voltage. Use low-ESR capacitors for the best performance. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. For most applications, a 10µF capacitor is sufficient. Higher output voltages may require a 22µF capacitor to increase system stability.

The input capacitor (C1) requires an adequate ripple current rating because it absorbs the input switching current.

Estimate the RMS current in the input capacitor using Equation (7):

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)} \qquad (7)$$

The worst case occurs at $V_{IN} = 2 \times V_{OUT}$, calculated with Equation (8):

$$I_{C1} = \frac{I_{LOAD}}{2} \qquad (8)$$

For simplification, choose an input capacitor with an RMS current rating greater than half of the maximum load current.

C1 can be electrolytic, tantalum, or ceramic. When using electrolytic or tantalum capacitors, add a small, high-quality, ceramic 0.1µF capacitor as close to the IC as possible. When using ceramic capacitors, ensure that they have enough capacitance to prevent excessive voltage ripple at the input. The input voltage ripple (ΔV_{IN}) caused by the capacitance can be estimated with Equation (9):

$$\Delta V_{IN} = \frac{I_{LOAD}}{f_{SW} \times C1} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \qquad (9)$$

Selecting the Output Capacitor

The output capacitor (C2) stabilizes the DC output voltage. Ceramic capacitors are recommended. Low-ESR capacitors are ideal because they effectively limit the output voltage ripple. Estimate the output voltage ripple (ΔV_{OUT}) with Equation (10):

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_{SW} \times L_1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_{SW} \times C2}\right) \qquad (10$$

)

Where L_1 is the inductance, and R_{ESR} is the equivalent series resistance (ESR) of the output capacitor.

When using ceramic capacitors, the capacitance dominates the impedance at the switching frequency and causes the majority of the output voltage ripple.

For simplification, the output voltage ripple (ΔV_{OUT}) can be estimated with Equation (11):

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_{SW}^{\ 2} \times L_1 \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \qquad (11)$$

Ceramic capacitors with X7R or X5R dielectrics are highly recommended because of their low ESR and small temperature coefficients.

For tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output voltage ripple (ΔV_{OUT}) can be estimated with Equation (12):

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_{SW} \times L_1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR} \qquad (12)$$

The characteristics of the output capacitor also affect the stability of the regulation system.

Output Discharge Blocking

When the device is disabled, an internal resistive discharge path from OUT pin to GND is enabled to discharge the output capacitor (C2). The discharge path can be blocked by adding an external capacitor between V_{OUT} and the OUT pin (see Figure 4).

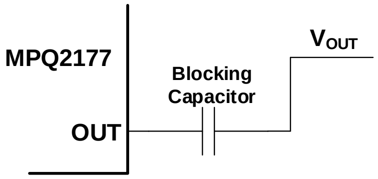


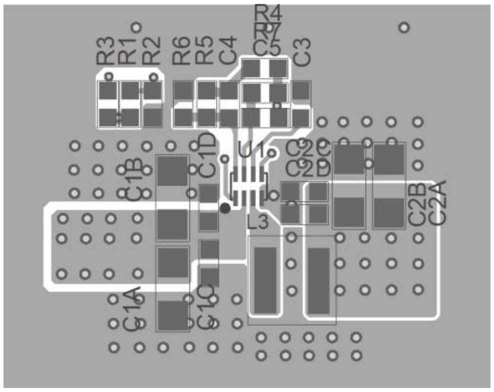
Figure 4: Circuit with V_{OUT} Discharge Blocking Capacitor

In order to avoid influencing the loop and load transient, the blocking capacitor should be at least 10nF. Larger-value blocking capacitors have no impact on loop performance, but are not necessary and have greater costs. A capacitor between 10nF and 100nF is recommended.

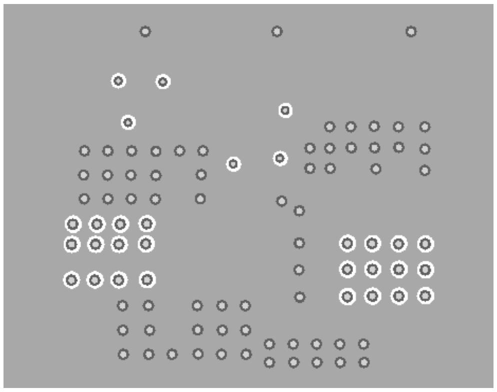
PCB Layout Guidelines

Efficient PCB layout is critical for proper function. Poor layout design can result in poor line or load regulation and stability issues. For the best results, refer to Figure 5 and follow the guidelines below:

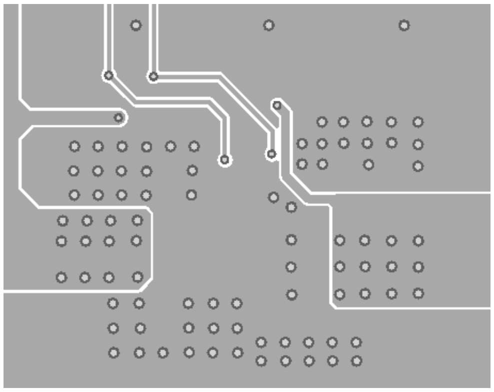
1. Place the high-current paths (GND, V_{IN}, and SW) very close to the device with short, direct, and wide traces.
2. Place the input capacitor (C1) as close as possible to the VIN and GND pins.
3. Place the output capacitor GND needs to close the chip's GND pins.
4. For the adjustable output version, place the external feedback resistors next to the FB pin.
5. Keep the switching node (SW) short and away from the feedback network.
6. Keep the V_{OUT} sense line as short as possible, and place it as far away from the power inductor as possible. It must not surround the inductor or be close to SW.



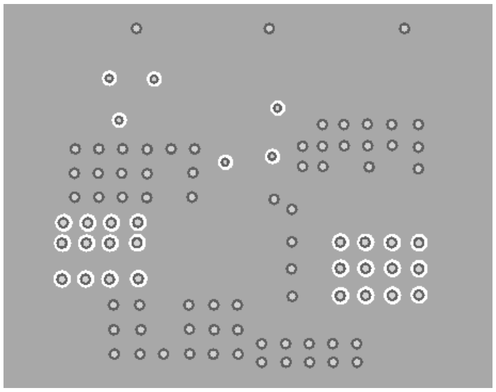
Top Layer



Mid-Layer 1



Mid-Layer 2



Bottom Layer

Figure 5: Recommended PCB Layout

TYPICAL APPLICATION CIRCUITS

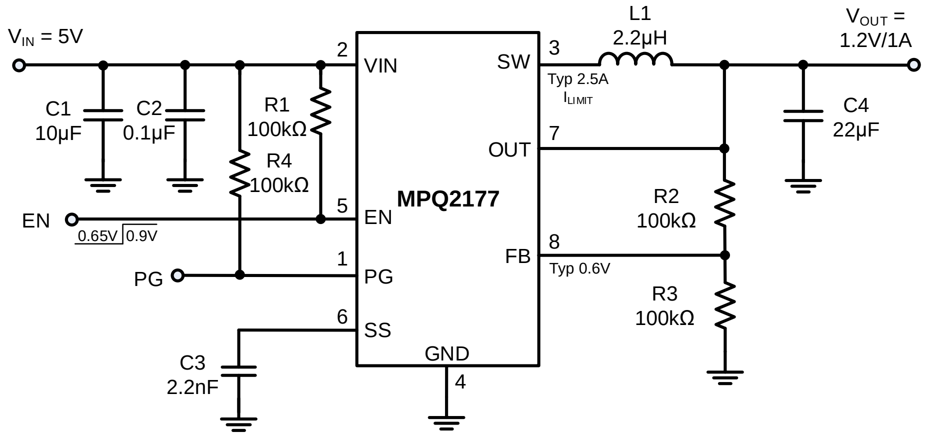


Figure 6: 1.2V Output Application Circuit for Adjustable Output Version

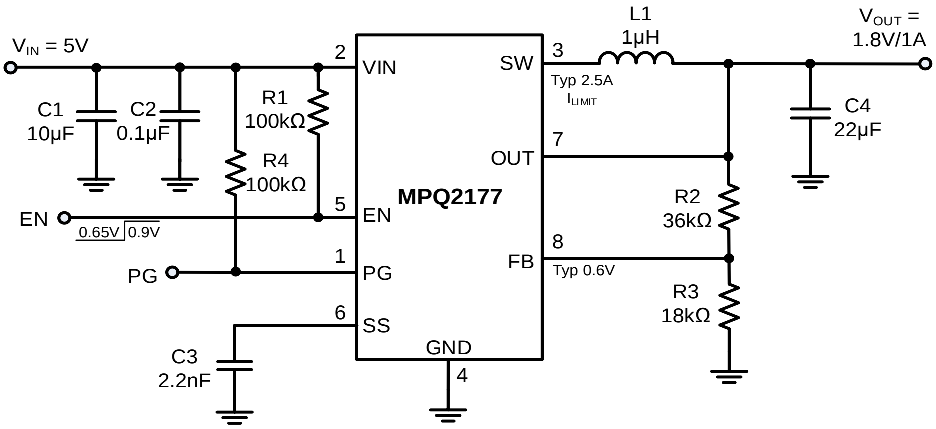


Figure 7: 1.8V Output Application Circuit for Adjustable Output Version

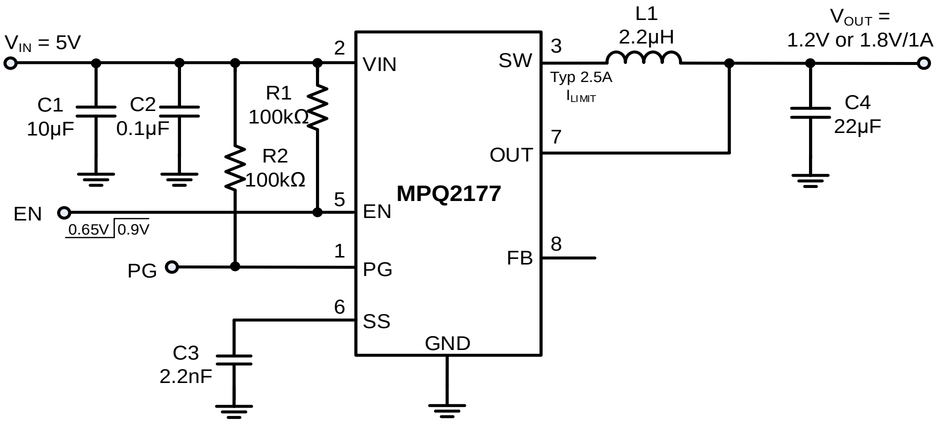
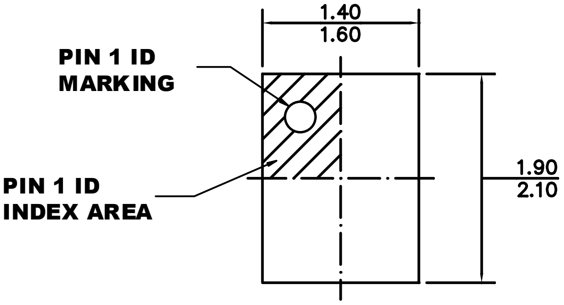


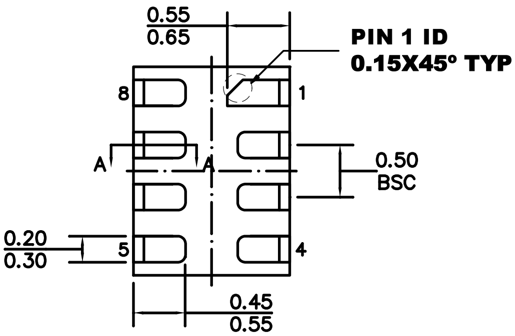
Figure 8: Application Circuit for Fixed Output Version

PACKAGE INFORMATION

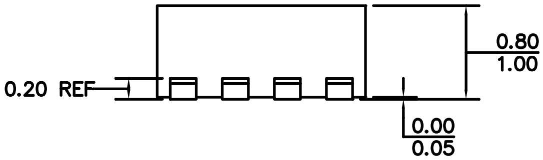
QFN-8 (1.5mmx2mm)
Wettable Flank



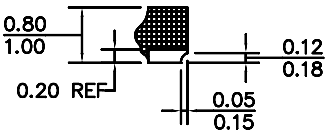
TOP VIEW



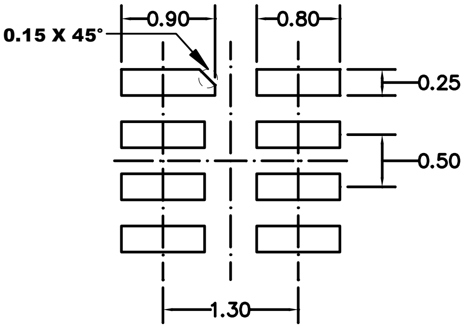
BOTTOM VIEW



SIDE VIEW



SECTION A-A

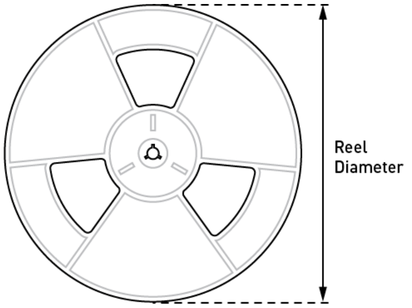


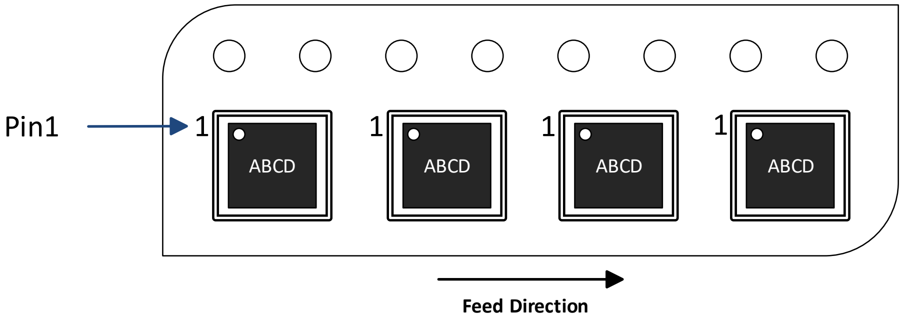
RECOMMENDED LAND PATTERN

NOTE:

1) THE LEAD SIDE IS WETTABLE.
2) ALL DIMENSIONS ARE IN MILLIMETERS.
3) LEAD COPLANARITY SHALL BE 0.08 MILLIMETERS MAX.
4) JEDEC REFERENCE IS MO-220.
5) DRAWING IS NOT TO SCALE.

CARRIER INFORMATION





Part Number	Package Description	Quantity /Reel	Quantity /Tube	Quantity /Tray	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch
MPQ2177GQHE-Z	QFN-8 (1.5mmx2mm)	5000	N/A	N/A	13in	8mm	4mm
MPQ2177GQHE-AEC1-Z							
MPQ2177GQHE-12-AEC1-Z							
MPQ2177GQHE-18-AEC1-Z							

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	4/30/2021	Initial Release	-