MxL76508

18V 700kHz 8A Fast-PWM Synchronous Step-Down Converter

Data Sheet

General Description

The MxL76508 is a fully integrated, high-efficiency synchronous step-down converter that requires a minimum number of external components. It offers a very compact solution with up to 8A continuous output current over a wide input range.

The MxL76508 uses a proprietary constant on-time (COT) control scheme that provides a superior transient response and maintains a constant switching frequency during continuous conduction mode (CCM) operation. The external ramp compensation network enables stable operation with ultra-low equivalent series resistance (ESR) output ceramic capacitors. An internal compensated error amplifier in the control loop provides excellent line and load regulation.

The MxL76508 integrates extensive protection functions, including 2.85V input under-voltage lockout (UVLO), thermal shutdown, input over-voltage protection (OVP), cycle-by-cycle current limiting, and short-circuit protection. An open-drain power good signal indicates that the output is within its regulation voltage range.

The MxL76508 offers three modes of operation, PFM (MxL76508N), UA (MxL76508U), and forced PWM—FPWM—(MxL76508A), to suit different applications. PFM mode provides high efficiency at light loads and low standby power. UA mode can operate in DCM at light load and in CCM at higher output power, and the lowest frequency at light load is limited to a frequency not lower than that of the sound wave to avoid buzzing noise. FPWM mode provides low ripple voltage and fast transient, even at light loads.

The converter is available in a small 16-pin 3mm×3mm QFN package.

Features

- Input voltage range: 3V to 18V
- 1% feedback voltage accuracy
- 8A continuous output current
- Supports 100% duty cycle low-dropout operation
- Stable operation with low ESR ceramic output capacitors
- Fast pulse-width modulation (PWM) COT control with superior transient performance
- Constant 700kHz switching frequency
- 14mW/8mW integrated high-side (HS)/low-side (LS) power switches
- Accurate 1.26V EN threshold with 260mV hysteresis
- High-efficiency operation at light load (MxL76508N)
- Ultra-sonic (UA) mode of operation (MxL76508U)
- FPWM mode of operation (MxL76508A)
- Low quiescent current of 200mA for MxL76508U_UA mode, low quiescent current of 150mA for MxL76508N_PFM mode
- Internal fixed or external programmable soft-start time
- Thermal shutdown
- Hiccup mode short-circuit protection
- Available in a 16-pin 3mm×3mm QFN package

Applications

- USB Type-C/PD docking stations
- Networking systems
- Laptop computers
- Flat panel television and monitors
- Distributed power systems

Typical Application

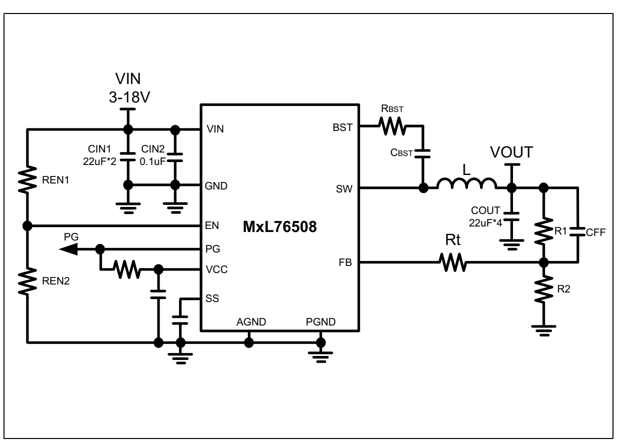

Figure 1: Typical Application Schematic

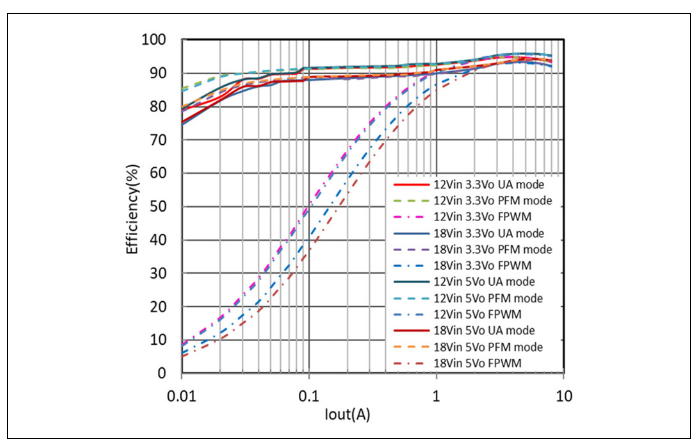

Figure 2: MxL76508 Efficiency

Revision History

Document No.	Release Date	Change Description
286DSR03	June 4, 2025	**Updated:** ■ "Ordering Information" table.
286DSR02	May 22, 2025	**Updated:** ■ Unit "KHz" replaced with "kHz" throughout the document.
286DSR01	March 7, 2025	Initial release.

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Specifications

Absolute Maximum Ratings

Important: The stresses above what is listed under the following table may cause permanent damage to the device. This is a stress rating only—functional operation of the device above what is listed under the following table or any other conditions beyond what MaxLinear recommends is not implied. Exposure to conditions above the recommended extended periods of time may affect device reliability.

Table 1: Absolute Maximum Ratings

Parameter	Min	Max	Units
Supply Voltage VIN to AGND	–0.3	22	V
Supply Voltage PGND to AGND	–0.3	0.3	V
SW to PGND (DC)	–0.3	V_{IN} + 0.3	V
Dynamic SW to AGND (30ns)	–3	V_{IN} + 3	V
BST to SW	–0.3	6	V
EN to AGND	–0.3	22	V
All Other Pins to AGND	–0.3	6	V
Junction Temperature Range	–40	150	°C
Storage Temperature Range	–65	150	°C
Lead Temperature (Soldering 10s)	-	260	°C

Note: The voltage measured across each pin to AGND should not exceed the maximum and minimum range.

Recommended Operating Conditions

Table 2: Recommended Operating Conditions

Symbol	Parameter	Min	Max	Units
V_{IN}	Supply Voltage	3	18	V
V_{OUT}	Output Voltage	0.6	18	V
T_J	Operating Junction Temperature Range	–40	125	°C

Note: The device is not guaranteed to function outside of the recommended operating conditions.

Thermal Specifications

Thermal information is measured on a 4-layer JESD51-7 PCB.

The maximum allowable power dissipation (T_A = 25°C) 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 $P_{D\_MAX} = (T_{J\_MAX} - T_A)/\theta_{JA}$. Exceeding the maximum allowable power dissipation causes excessive die temperature, and the regulator goes into thermal shutdown. The internal thermal shutdown circuitry protects the device from permanent damage.

Table 3: Thermal Performance

Symbol	Parameter	Package	Typ	Max	Units
-	Package Power Dissipation	FC-QFN3×3-16L	-	2.57	W
θ_{JA}	Junction-to-Ambient Thermal Resistance	FC-QFN3×3-16L	48.5	-	°C/W
θ_{JC}	Junction-to-Case Thermal Resistance	FC-QFN3×3-16L	28.6	-	°C/W

Electrical Characteristics

Electrical characteristics at V_{IN} = 12V, V_{EN} = 2V, V_{OUT} = 5V, T_A = 25°C, unless otherwise specified. The • denotes the specifications that apply over the temperature range of –40°C to 85°C, unless otherwise specified.

Table 4: Electrical Characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{IN}	Input Voltage Range	-		3.0	-	18	V
V_{INUVLO}	Input Under-Voltage Lockout Threshold Rising	25°C		2.75	2.85	2.95	V
		–40°C to 85°C	•	2.735	2.85	2.965	
$V_{UVLO-HYS}$	Input Under-Voltage Lockout Hysteresis	25°C		200	270	340	mV
		–40°C to 85°C	•	160	270	380	
V_{INOVP}	Input Over-Voltage Lockout Threshold Rising	25°C		20.5	21.5	22.5	V
		–40°C to 85°C	•	20.365	21.5	22.635	
$V_{OVP-HYS}$	Input Over-Voltage Lockout Hysteresis	25°C		1.7	1.85	2	V
		–40°C to 85°C	•	1.666	1.85	2.034	
I_{SHDN}	Shutdown Current	25°C		3.5	6	7.5	µA
		–40°C to 85°C	•	2.14	6	8.85	
I_Q	Quiescent Current (MxL76508N, PFM)	25°C		120	150	180	µA
		–40°C to 85°C	•	105.5	150	194.5	
I_Q	Quiescent Current (MxL76508U, UA)	25°C		160	200	240	µA
		–40°C to 85°C	•	148.5	200	251.5	
I_Q	Quiescent Current (MxL76508A, FPWM)	25°C		480	600	720	µA
		–40°C to 85°C	•	427	600	773	
V_{FB_REF}	Feedback Reference Voltage	25°C		594	600	606	mV
		–40°C to 85°C	•	592	600	608	
I_{FB}	Feedback Current	25°C		-	10	50	nA
		–40°C to 85°C	•	-	10	60.5	
T_{SS}	Internal Soft-Start Time	25°C		1.8	2.3	2.8	ms
		–40°C to 85°C	•	1.69	2.3	2.91	
I_{SS}	External Soft-Start Charging Current	25°C		5.2	6	6.8	µA
F_{SW}	Switching Frequency	25°C		600	700	800	kHz
T_{OFF_MIN}	Minimum Off Time (1)	25°C		100	130	160	ns
		–40°C to 85°C	•	72.5	130	187.5	
R_{ONHS}	High-side (HS) Switch-On Resistance	25°C		-	14	-	mΩ
I_{PK}	High-side (HS) Switch Peak Current Limit	25°C		9.5	13	16.5	A
I_{LKGHS}	High-side (HS) Switch Leakage Current	25°C		-	1	6	µA
		–40°C to 85°C	•	-	1	7	
R_{ONLS}	Low-side (LS) Switch-On Resistance	25°C		-	8	-	mΩ
I_{VALY}	Low-side (LS) Switch Valley Current Limit	25°C		8	10.5	13	A
I_{ZCX}	Low-side (LS) Switch Zero-Cross Current Threshold	25°C		–400	-	400	mA
		–40°C to 85°C	•	–480	-	480	

Table 4: Electrical Characteristics (Continued)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
I_{NEG}	Low-side (LS) Switch Negative Current Limit	25°C		–4	–3	–2	A
I_{LKGLS}	Low-side (LS) Switch Leakage Current	25°C		-	1	5	µA
PG_{UV_HI}	Power Good (PG) UV Rising Threshold	25°C		85	90	95	%
		–40°C to 85°C	•	83.3	90	96.6	
PG_{UV_LO}	Power Good (PG) UV Falling Threshold	25°C		79	83	87	%
		–40°C to 85°C	•	77.3	83	88.6	
PG_{OV_HI}	Power Good (PG) OV Rising Threshold	25°C		115	120	125	%
		–40°C to 85°C	•	113.3	120	126.7	
PG_{OV_LO}	Power Good (PG) OV Falling Threshold	25°C		105	110	115	%
		–40°C to 85°C	•	103.3	120	116.7	
PG_{TD}	PG Delay	25°C		30	50	70	µs
		–40°C to 85°C	•	28.2	50	71.8	
V_{PG}	Power Good (PG) Output Low Voltage	25°C		0.25	0.35	0.45	V
		–40°C to 85°C	•	0.225	0.35	0.475	
I_{PGLKG}	Power Good (PG) High-Z Leakage	25°C		-	10	50	nA
		–40°C to 85°C	•	-	10	60.7	
V_{IH}	EN On Threshold	25°C		1.23	1.26	1.29	V
		–40°C to 85°C	•	1.22	1.26	1.3	
V_{IL}	EN Off Threshold	25°C		0.97	1	1.03	V
		–40°C to 85°C	•	0.96	1	1.04	
R_{EN}	EN Internal Pull-Down Resistor	25°C		0.6	1	1.14	MΩ
V_{CC}	VCC Regulation Voltage	25°C		5.1	5.25	5.4	V
V_{CCDO}	VCC Dropout Voltage	V_{IN} = 4.5V; I_{CC} = 10mA, 25°C		120	200	280	mV
-	Thermal Shutdown	-		-	160	-	°C
-	Thermal Shutdown Hysteresis	-		-	30	-	°C

1. Guaranteed by design and engineering sample characterization.

Pin Information

Pin Configuration

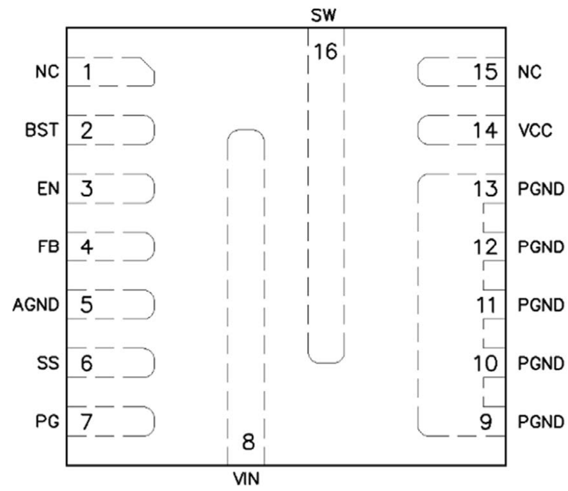


Figure 3: MxL76508 Pinout (Top View)

Pin Description

Table 5: Pin Description

Pin Number	Pin Name	Description
1, 15	NC	No Connection pins. The NC pins can be floating or connected to AGND.
2	BST	Bootstrap pin. The BST pin supplies power for the MxL76508 high-side switch driver. Connect a 100nF ceramic bypass capacitor between BST and SW. You can connect an optional BST resistor of 3.3Ω or less in series with the bypass capacitor.
3	EN	Enable pin. The MxL76508 device is enabled when the EN pin voltage is above 1.26V and disabled when the EN pin voltage is below 1.00V. When the EN pin voltage is below 400mV, the MxL76508 is in shutdown mode where it only consumes a few μA leakage current. There is an internal 1MΩ (typical) pull-down resistor from EN to AGND.
4	FB	Feedback pin. The FB pin is regulated at 0.6V. Connect FB to the resistor divider from the regulator output (VOUT) to AGND to set the output voltage. Use a feed-forward capacitor between VOUT and FB to ensure stable operation of the MxL76508.
5	AGND	Analog Ground pin. AGND is the internal reference of the MxL76508 device. Connect the FB resistor divider to AGND for optimum accuracy and load regulation. AGND is not connected to PGND internally. Make sure that AGND is connected to PGND on the PCB layout.
6	SS	Soft-Start pin. Connect a capacitor between SS and AGND to set the soft-start time. If left floating, the MxL76508 has a minimum soft-start time of 1.8ms defined by the internal circuit.
7	PG	Power Good Indicator pin. PG is an open-drain output. It has a High-Z state when FB is within ± 10% of regulation, and a low impedance to AGND if FB is outside the regulation window.
8	VIN	Input Supply pin. The VIN pin supplies power to the MxL76508. Place the input bypass capacitors close to the VIN and PGND pins.
9–13	PGND	Power Ground pins. Ground connection for the MxL76508 power stage.
14	VCC	Internal LDO Output pin. The VCC pin supplies power for the MxL76508 internal circuits. Connect a 1~10μF ceramic bypass capacitor from VCC to AGND.
16	SW	Switch Output pin. The SW pin is the switched output of the MxL76508 power stage. Connect SW to the power inductor with a wide and short PCB trace.

Block Diagram

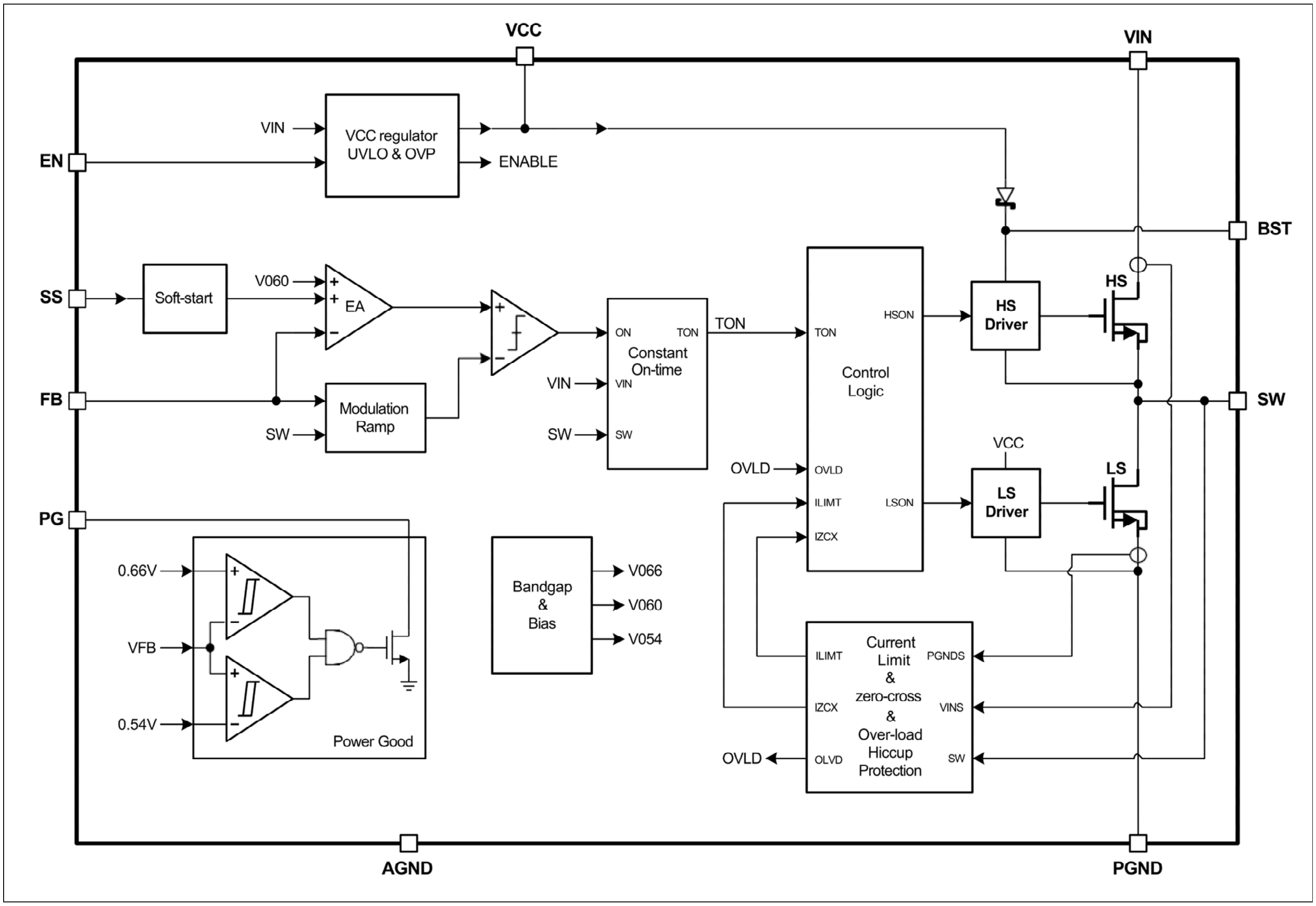


Figure 4: Functional Block Diagram

Typical Application Circuit

The following figure shows a typical application of the MxL76508.

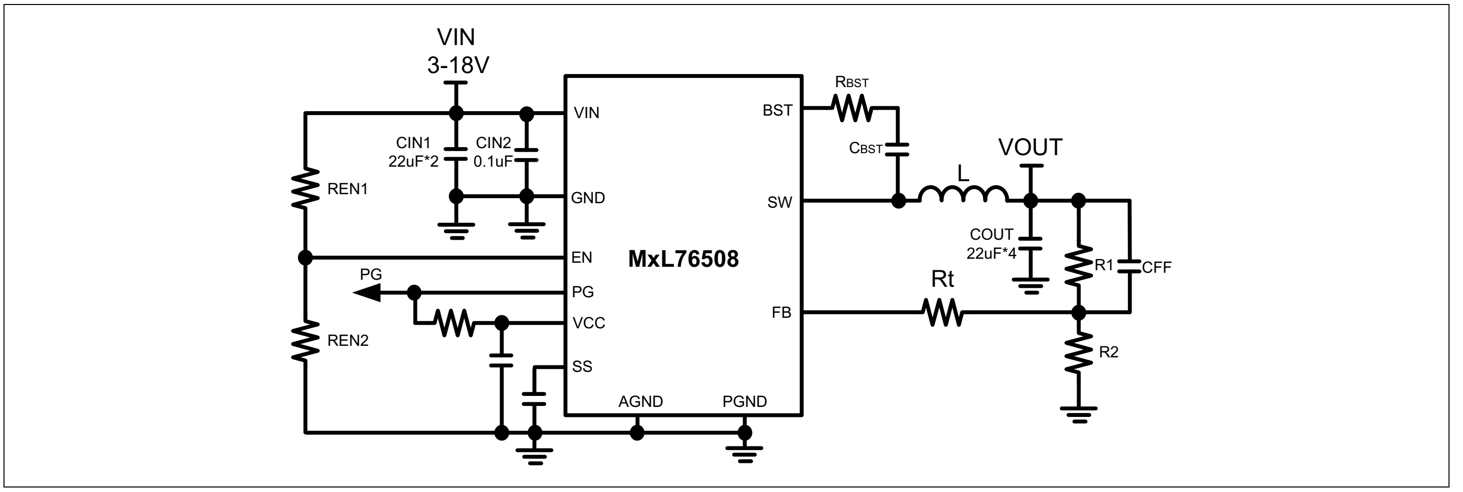


Figure 5: MxL76508 Typical Application

Typical Performance Characteristics

C_{IN} = 2×22µF, C_{OUT} = 4×22µF, L= 1.2µH, T_J = 25°C, unless otherwise specified.

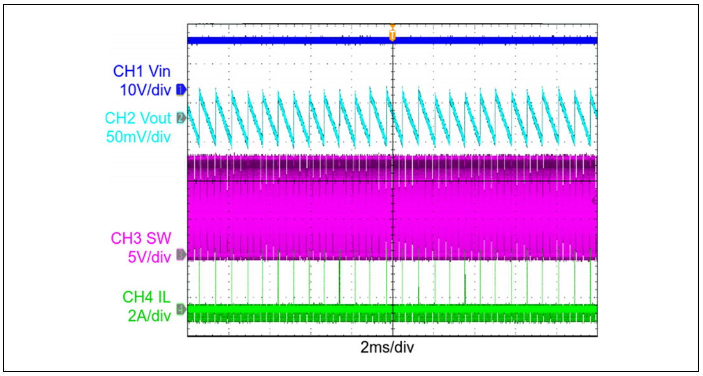


Figure 6: Steady State Test—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 0A

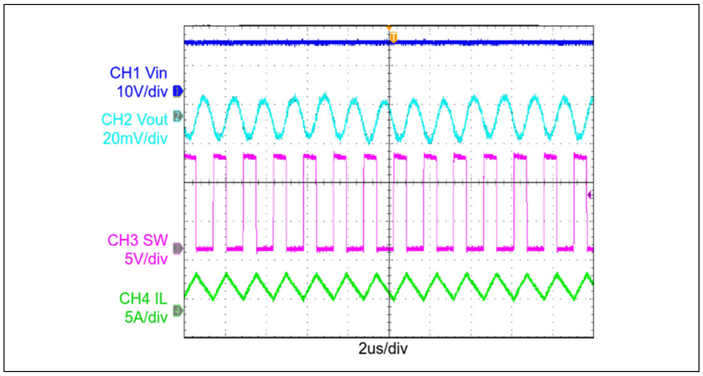


Figure 7: Steady State Test—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 3A

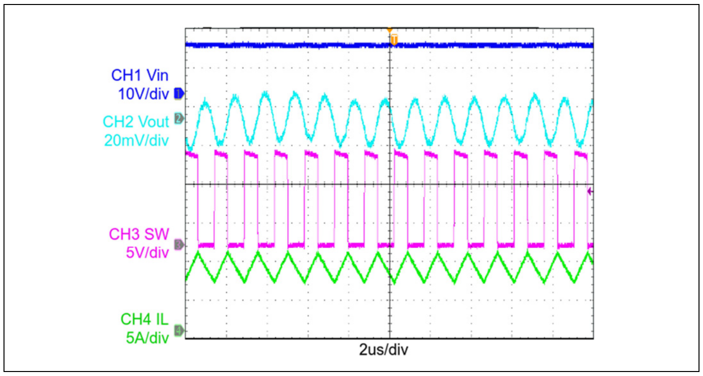


Figure 8: Steady State Test—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 8A

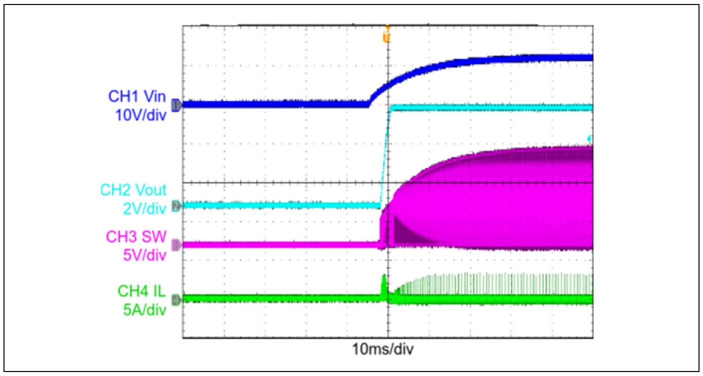


Figure 9: V_{IN} Power On—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 0A

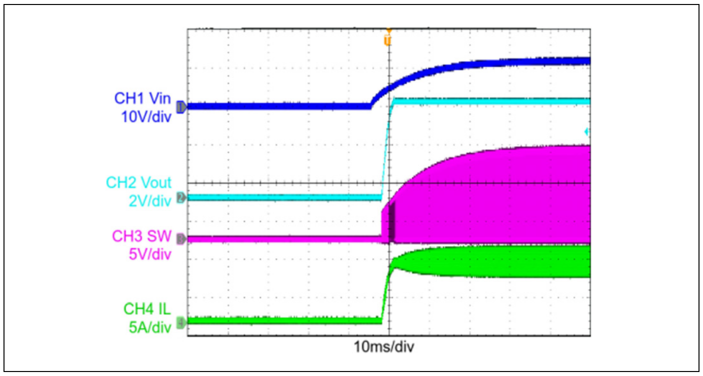


Figure 10: V_{IN} Power On—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 8A

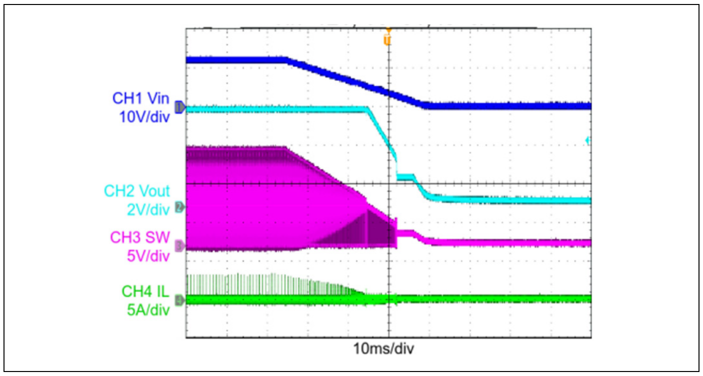


Figure 11: V_{IN} Power Off—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 0A

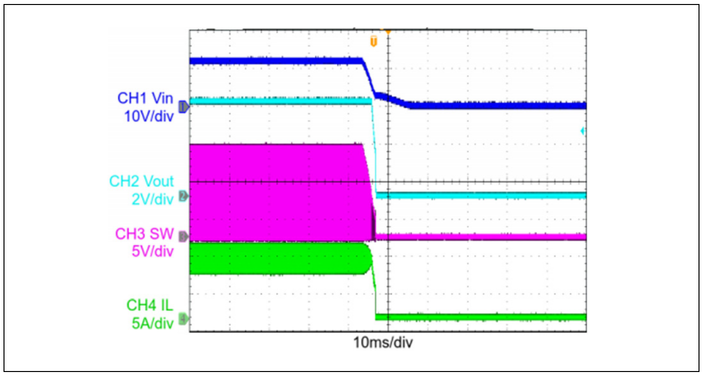


Figure 12: V_{IN} Power Off—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 8A

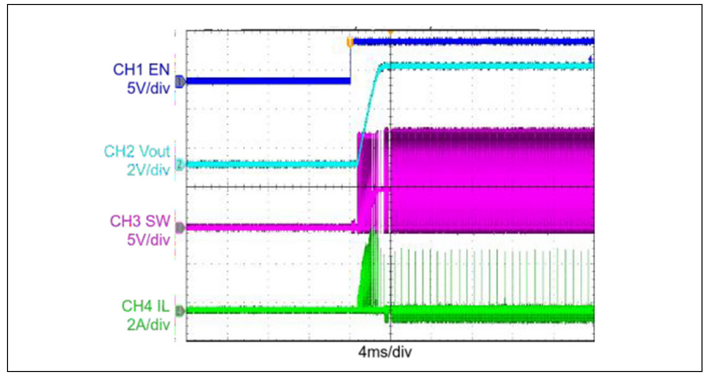


Figure 13: EN Power On—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 0A

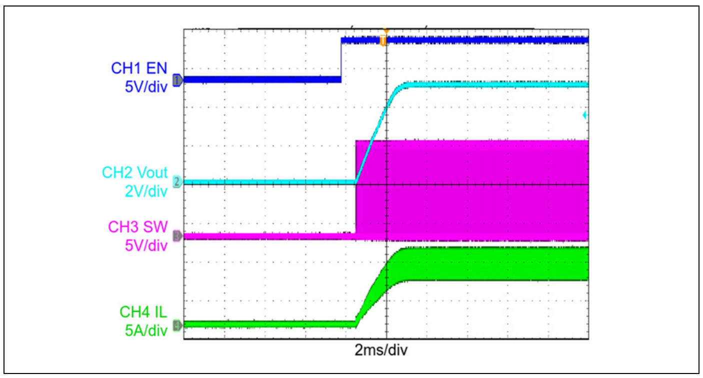


Figure 14: EN Power On—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 8A

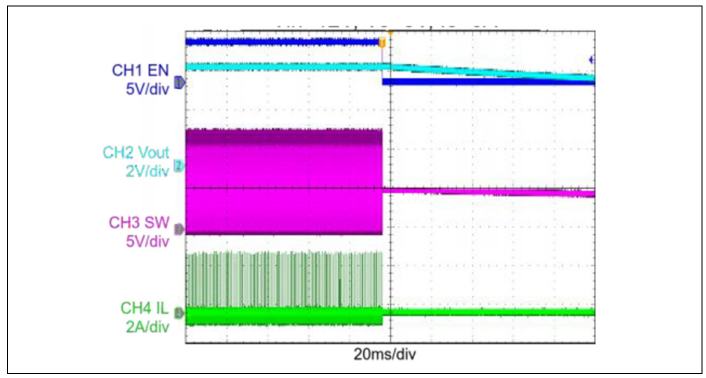


Figure 15: EN Power Off—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 0A

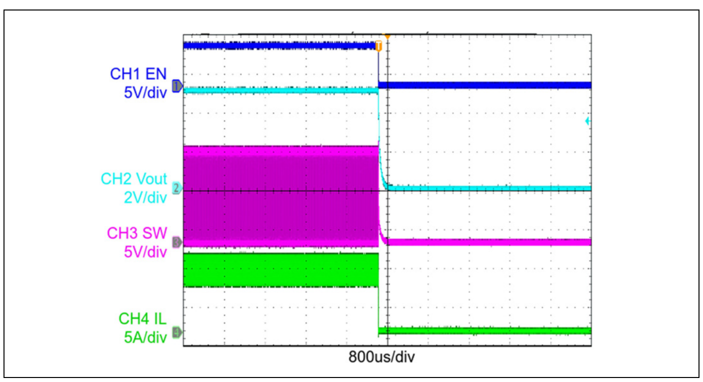


Figure 16: EN Power Off—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 8A

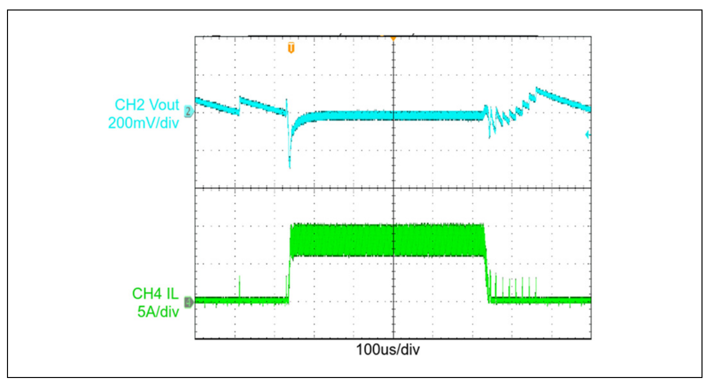


Figure 17: Load Transient Response—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 0A–8A

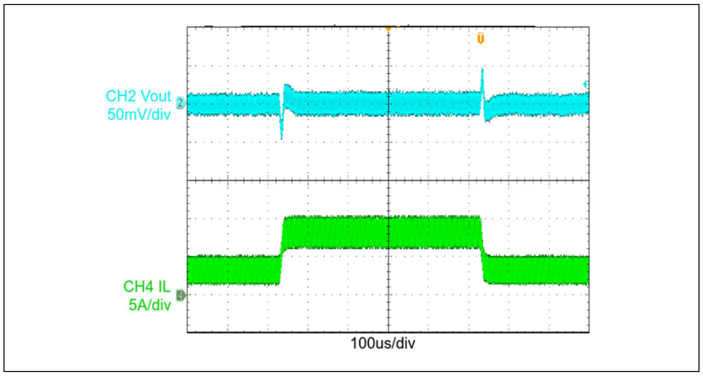


Figure 18: Load Transient Response—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 3A–8A

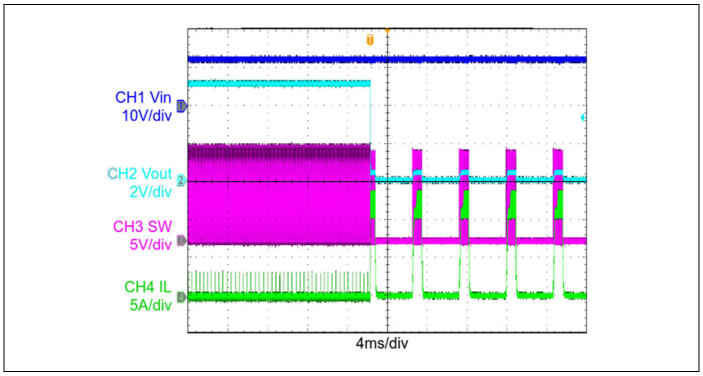


Figure 19: Short Protection—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 0A–Short

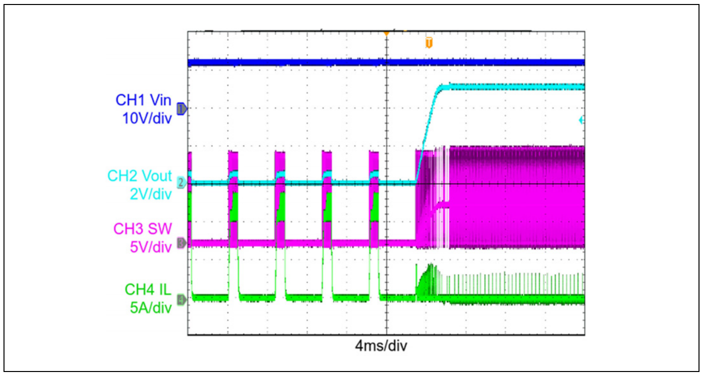


Figure 20: Short Protection—V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = Short–0A

Operation

The MxL76508 device is a fully integrated synchronous step-down converter that uses an advanced constant on-time (COT) control scheme to achieve superior transient performance. With the compensation ramp of the control loop set by the feed-forward capacitor, the MxL76508 achieves adjustable loop compensation, allowing it to be optimized to have the best transient response for a wide range of applications.

Fast-PWM Constant On-Time Control

The MxL76508 uses Maxlinear's proprietary COT control (fast-pulse-width modulation or fast-PWM) to achieve superior transient response. The controller compares the feedback voltage V_{FB} with an internal reference voltage V_{REF}. When V_{FB} drops below the V_{REF} level, the high-side (HS) switch is immediately turned on for a predetermined time (on-time) to ramp up the inductor current. When the on-time ends, the HS switch is turned off and the low-side (LS) switch is turned on to ramp down the inductor current. The LS switch remains on until the inductor current reaches zero (MxL76508N/MxL76508U) or until the next time V_{FB} drops below V_{REF}, in which case the LS switch is turned off and the HS switch is turned on again. In steady-state operation, the controller modulates the turn-off time point of the LS switch so that the inductor current always ramps up and ramps down with exactly the same amplitude and the cycle repeats.

The MxL76508 uses a proprietary algorithm to calculate the on-time based on the input voltage, output voltage, and load current to achieve a nearly constant switching frequency (F_{SW}) of 700kHz over the entire continuous conduction load current range.
The on-time can be estimated as:

$$T_{ON} = \frac{V_{OUT}}{V_{IN} \times F_{SW}} = \frac{V_{OUT}}{V_{IN}} \times 1.428\mu s$$

Due to its immediate response to the FB voltage drop and simplified loop compensation, the MxL76508 offers superior transient response compared to traditional fixed-frequency PWM control converters.

Light Load Operation

The MxL76508N and MxL76508U operate in pulse-frequency modulation (PFM) mode to achieve high efficiency under light load conditions. As the load current decreases from a medium or heavy load, the MxL76508N/MxL76508U transitions from 700kHz continuous conduction mode (CCM) to discontinuous conduction mode (DCM), where the inductor current drops to zero between pulses and the switching frequency begins to decrease. Once the inductor current reaches zero, the MxL76508N/MxL76508U turns off the LS switch and the SW node switches to the High-Z state until the next cycle, when the HS switch is turned on again. The HS switch on-time in DCM mode is the same as in CCM mode, so each switching pulse in DCM mode supplies the same amount of energy to the converter output. As the load current continues to decrease, the switching pulses also become proportionally less frequent. When the switching frequency drops to a sufficiently low level, the device enters sleep mode to reduce most of its quiescent current to further reduce power consumption.

The critical load current I_{CRIT} at the boundary of CCM mode and DCM mode is determined by the inductor ripple current, which depends on the inductor value, input voltage, and output voltage. Typically, this critical load current level is estimated as:

$$I_{CRIT} = \frac{1}{2} \times \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{L \times F_{SW} \times V_{IN}}$$

When the load current is below this I_{CRIT} level, the MxL76508N/MxL76508U operates in PFM mode.

In PFM mode, the SW node is at output voltage level when the HS and LS switches are turned off. To maintain the floating supply voltage of the HS driver on the BST capacitor, the MxL76508N/MxL76508U refreshes the BST capacitor voltage by turning on the LS switch for approximately 130ns for a fixed duration when there are no switching pulses on SW. For the MxL76508N, this duration is approximately 150µs. For the MxL76508U, this duration is about 30µs, which is above the audible frequency range.

The MxL76508A always operates in continuous conduction mode (CCM) regardless of the load current level, also known as forced-PWM mode (FPWM). In FPWM mode, the switching frequency is maintained at a constant value of 700kHz over the entire load range. The FPWM mode is suitable for applications requiring tight control of the switching frequency and small output voltage ripple, at the cost of significantly lower efficiency under light load conditions.

100% Duty Cycle Low-Dropout Operation

When the input voltage drops approaching the output voltage, the MxL76508 device extends the HS switch on-time accordingly or beyond the normal switching period to meet the duty cycle requirement to regulate the output voltage. If the input drops further to or below the target output level, the MxL76508 extends the HS switch on-time to the maximum duration of 30μs to achieve effective 100% duty cycle operation. When the maximum on-time times out, the HS switch is turned off and the LS switch is turned on for approximately 120ns to refresh the BST capacitor voltage. Once this refresh pulse completes, the HS switch is immediately turned on for another maximum on-time of 30μs. By periodically refreshing the BST capacitor voltage, the floating supply of the HS switch driver is maintained at a sufficient voltage level in 100% operation mode.

Input Under-Voltage Lockout and Over-Voltage Protection

The MxL76508 device has built-in input under-voltage lockout (UVLO) and over-voltage protection (OVP). When the input voltage (V_{IN}) is lower than the UVLO threshold voltage or higher than the OVP threshold voltage, the MxL76508 stops operating to prevent malfunction or damage. The UVLO rising threshold voltage is 2.85V with a hysteresis of 270mV, and the OVP rising threshold voltage is 21.5V with a hysteresis of 1.85V.

Enable Control

When the input supply (V_{IN}) is withing the valid range, that is, above the UVLO threshold and below the OVP threshold, the MxL76508 can be enabled or disabled by the enable pin (EN). When the EN pin voltage is below 400mV, the MxL76508 is in shutdown mode, consuming only 5μA of current.

The MxL76508 offers an accurate EN pin enable threshold, which is typically 1.26V on threshold and 1.00V off threshold. The MxL76508 is enabled by pulling up the EN pin voltage above 1.26V and it is disabled by pulling down the EN pin voltage below 1.00V. The accurate EN pin threshold allows you to program the input startup threshold (higher than the built-in UVLO) with a resistor divider from input to ground.

To calculate the programmed input startup threshold, use the following equation:

$$V_{IN-START} = 1.26V \times \frac{R_{TOP} + R_{BOT} \| 1M\Omega}{R_{BOT} \| 1M\Omega}$$

Where 1MΩ is the internal pull-down resistor from the EN pin to ground.

Soft-Start

The MxL76508 features a soft-start (SS) pin for external programmable soft-start. If the SS pin is left floating, the MxL76508 has an internal built-in soft-start time of 1.8ms. During the soft-start period, the output voltage is ramped up linearly to the regulation voltage, independent of the load current level and output capacitor value.

The SS pin provides a constant 6μA pull-up current, so the external soft-start time can be programmed by connecting a capacitor between the SS pin and GND. The programmed soft-start time can be calculated as:

$$T_{SS} = max\left(\frac{C_{SS} \times 0.6V}{6\mu A} \times 1.8ms\right)$$

Power Good Indication

The MxL76508 has an open-drain power good (PG) indication pin. The PG pin is the drain of an internal pull-down MOSFET and should be connected to VCC or another voltage source (< 5.5V) with a pull-up resistor. MaxLinear recommends a resistor value of 10KΩ to 500KΩ.

When the feedback pin voltage (V_{FB}) rises above 90% of regulation or falls below 100% of regulation, the PG pin is pulled high by the external resistor. When V_{FB} drops below 80% of regulation or rises above 120% of regulation, the PG is pulled low by the internal pull-down MOSFET. To prevent glitching, the upper and lower PGs have a hysteresis of approximately 10%.

Over-Current Protection and Short-Circuit Fault Protection

The MxL76508 features a built-in cycle-by-cycle current-limit protection to prevent the inductor current from operating at an abnormally high or even saturated current in any fault condition. The MxL76508 continuously monitors the inductor peak and valley current during its operation. Once the peak current exceeds the peak limit level, the MxL76508 immediately turns off the HS switch and turns on the LS switch and waits for the inductor current to drop down to a predetermined level before the HS switch can be turned on again. If this current-limit condition is repeated for a long, extended period of time, the MxL76508 considers the output to be overloaded or short-circuited. In either case, the MxL76508 enters hiccup mode, where it stops switching for a predetermined period of time before automatically trying to start up again. It always starts up with a soft-start to limit the inrush current and avoid output overshoot.

Thermal Shutdown

The MxL76508 features an internal thermal shutdown to prevent the device from overheating. When the device junction temperature reaches the threshold temperature of 160°C, the device stops switching and waits for the junction to cool down. When the junction temperature drops to 130°C, the device resumes operation with a soft-start.

Application Information

Output Voltage Setting

External feedback resistors set the output voltage. MaxLinear recommends resistors of 1% to maintain output voltage accuracy. Figure 21 shows the feedback network. The top feedback resistor R1 has an impact on the loop stability. MaxLinear recommends the range of 20KΩ~100KΩ for R1. Choose a value of approximately 50KΩ for R1 as a starting point. For any chosen R1, the bottom feedback resistor R2 can be calculated as:

$$R2 = \frac{R1}{\frac{V_{OUT}}{0.600} - 1}$$

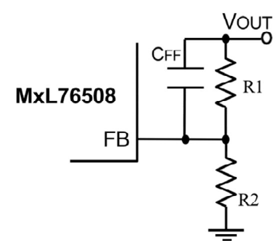


Figure 21: Feedback Network

MaxLinear recommends adding a feed-forward capacitor C_{FF} 20 (pF/V) * V_{OUT} (V). The C_{FF} 56pF is suitable for most applications to provide appropriate external ramp compensation.

Inductor

The inductor is necessary to supply a constant current to the output load while being driven by the switched input voltage. A higher-value inductor results in a lower ripple current, which results in a lower output ripple voltage. However, a higher-value inductor has a larger physical footprint, higher series resistance, and/or lower saturation current. To determine the inductance value, MaxLinear recommends designing the peak-to-peak ripple current in the inductor so that it ranges from 30% to 50% of the maximum output current, and the peak inductor current is below the maximum switching current limit. The inductance value can be calculated by:

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

Where ΔI_L is the peak-to-peak inductor ripple current and the switching frequency F_{SW} is typically 700kHz.

To avoid overheating and poor efficiency, you must choose an inductor with an RMS current rating greater than the maximum expected output load of the application. Additionally, the saturation current (typically referred to as *Isat*) rating of the inductor must be higher than the maximum load current plus half of the inductor's ripple current.

The peak inductor current can be calculated by:

$$I_{L-PEAK} = I_{OUT-MAX} + \frac{V_{OUT}}{2F_{SW} \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

The current flowing through the inductor is the inductor ripple current plus the output current. During power-up, faults, or transient load conditions, the inductor current can increase beyond the peak inductor current level calculated above. Under transient conditions, the inductor current can increase up to the switching current limit of the device. For this reason, the most conservative approach is to specify an inductor with a saturation current rating equal to or greater than the switching current limit rather than the peak inductor current.

Input Capacitor

The input current to the step-down converter is discontinuous and therefore requires a capacitor to supply the AC current to the step-down converter while maintaining the DC input voltage. MaxLinear recommends using high-quality input decoupling ceramic capacitors of at least 15μF of effective capacitance for best performance and placing them as close to the VIN pin as possible. MaxLinear recommends capacitors with X5R and X7R ceramic dielectrics because they are fairly stable with temperature fluctuations. In some applications, additional bulk capacitance may be required for the VIN input. The effective capacitance includes any DC bias and temperature de-rate effects. The voltage rating of the input capacitor must be greater than the maximum input voltage.

The capacitors must also have a ripple current rating greater than the maximum input ripple current of the converter. The input ripple current can be estimated as:

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

The worst-case condition occurs at $V_{IN} = 2^*V_{OUT}$, where:

$$I_{CIN} = \frac{I_{OUT}}{2}$$

To simplify, choose the input capacitor with an RMS current rating greater than half of the maximum load current. The input capacitance value determines the input voltage ripple of the converter. If the system must meet an input voltage ripple, choose the input capacitor that meets the specification. The input voltage ripple can be estimated as:

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

Under worst-case conditions where $V_{IN} = 2^*V_{OUT}$:

$$\Delta V_{IN} = \frac{1}{4} \times \frac{I_{OUT}}{F_{SW} \times C_{IN}}$$

Output Capacitor

The output capacitor has two essential functions:

- Together with the inductor, it filters the square wave generated by the MxL76508 to produce the DC output. In this role, it determines the output ripple, thus a low impedance at the switching frequency is important.
- It stores energy to satisfy transient loads and stabilize the MxL76508's control loop. X5R or X7R-type ceramic capacitors have very low equivalent series resistance (ESR) and provide low output ripple and good transient response. Transient performance can be improved with a higher value output capacitor and the addition of a feed-forward capacitor C_{FF} placed between V_{OUT} and FB.

Increasing the output capacitance also decreases the output voltage ripple. You can use a lower value output capacitor to save space and cost, but transient performance suffers and can cause loop instability. When choosing a capacitor, particular attention should be paid to this data sheet to calculate the effective capacitance under the relevant operating conditions of voltage bias and temperature. A physically larger capacitor or one with a higher voltage rating may be required.

The output voltage ripple can be estimated using this equation:

$$\Delta V_{OUT} = \frac{V_{OUT}}{F_{SW} \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times F_{SW} \times C_{OUT}}\right)$$

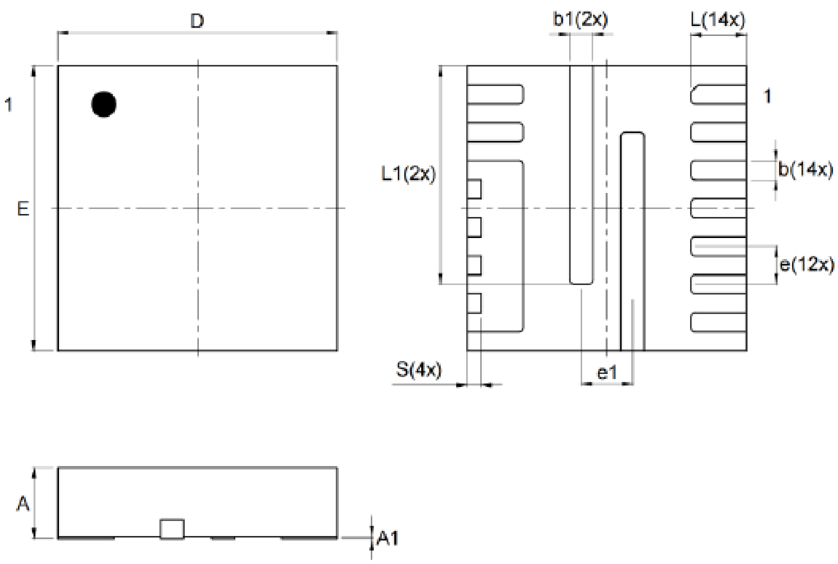
With ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance.

The value of a ceramic capacitor varies significantly depending on the temperature and the amount of DC bias applied to the capacitor. To minimize the capacitance variations due to temperature, select a temperature-stable dielectric material. X5R and X7R ceramic dielectrics are usually selected for power regulator capacitors because they have a high capacitance-to-volume ratio and are fairly stable over temperature. You must also select the output capacitor taking into account the DC bias. The capacitance value of a capacitor decreases as the DC bias across a capacitor increases. For USB Type-C/PD application design, MaxLinear recommends using two 22µF ceramic capacitors with a voltage rating of 35V or more in parallel to support the maximum input voltage of 24V.

Mechanical Dimensions

FC-QFN3×3-16L

QFN3X3_16L PACKAGE OUTLINE DIMENSIONS



SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
b	0.15	0.25	0.006	0.010
b1	0.20	0.30	0.008	0.012
E	2.90	3.10	0.114	0.122
D	2.90	3.10	0.114	0.122
e	0.40 BSC		0.016 BSC	
e1	0.55 BSC		0.022 BSC	
L	0.55	0.65	0.022	0.026
L1	2.25	2.35	0.089	0.093
S	0.15 REF		0.006 REF	

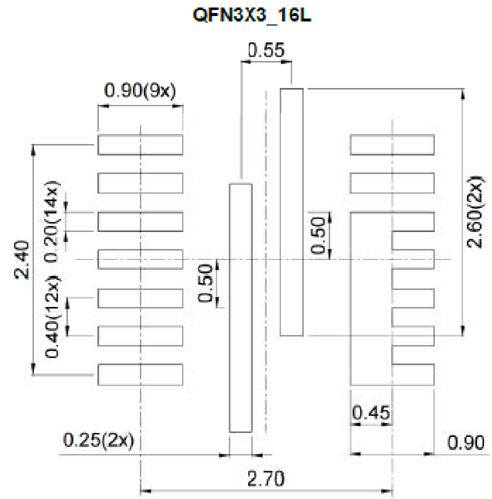
Drawing No.: POD-00000181
Revision: A.1

Figure 22: Mechanical Dimensions—FC-QFN3×3-16L

Recommended Land Pattern and Stencil

FC-QFN3×3-16L

LAND PATTERN INFORMATION



Note:

- Dimensions in mm.
- For reference only.

Drawing No.: POD-00000181
Revision: A.1

Figure 23: Recommended Land Pattern and Stencil—FC-QFN3×3-16L

Ordering Information

Table 6: Ordering Information

Ordering Part Number	Operating Temperature Range	Remark	Package	Packaging
MXL76508N-AQF-R	–40°C to 85°C	PFM mode	FC-QFN3X3-16L	5000/Reel
MXL76508A-AQF-R	–40°C to 85°C	FPWM mode	FC-QFN3X3-16L	5000/Reel
MXL76508U-AQF-R	–40°C to 85°C	UA mode	FC-QFN3X3-16L	5000/Reel

Note: For more information about part numbers, as well as the most up-to-date ordering information and additional information on environmental rating, go to www.maxlinear.com/MxL76508.

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