MP3359

4-Channel, Max 150mA/Channel, Boost WLED Driver with High Dimming Ratio

DESCRIPTION

The MP3359 is a step-up converter with four channel current sources. The device is designed to drive white LED (WLED) arrays as backlighting for small- or medium-sized LCD panels.

The MP3359 uses peak current mode as its pulse-width modulation (PWM) control architecture to regulate the boost converter. Four channel current sources are applied to the LED cathode to adjust LED brightness. The MP3359 regulates the current in each LED string to the value set by an external current-setting resistor, with 2.5% current regulation accuracy between strings.

A low on resistance ($R_{DS(ON)}$) MOSFET and low headroom voltage are provided to improve efficiency. The switching frequency (f_{SW}) can be configured via a resistor or external clock.

The MP3359 provides analog and PWM dimming with two separate input pins (EN/ADIM and PDIM). The device also has a fixed delay time between LED current channels to eliminate noise during PWM dimming.

Robust protections are included to guarantee safe device operation. Protection features include over-current protection (OCP), over-voltage protection (OVP), over-temperature protection (OTP), LED short protection, and LED open protection.

The MP3359 is available in a QFN-20 (3mmx4mm) package with wettable flanks.

FEATURES

- 3.5V to 40V Input Voltage (V_{IN}) Range
- 4 Channels with a Maximum of 150mA per Channel
- Internal 100mΩ, 50V MOSFET
- Configurable Switching Frequency (f_{SW}) Up to 2.2MHz
- External Sync Switching (SW) Function
- Pulse-Width Modulation (PWM) Dimming
- Analog Dimming
- Deep Dimming Ratio
- Excellent EMI Performance and Frequency Spread Spectrum (FSS)
- Fixed 100µs Delay Time between LED Current Channels during PWM Dimming (Replaces Phase Shift)
- 2.5% Current Matching
- Cycle-by-Cycle Current Limiting
- Disconnect VOUT from VIN
- LED Short/Open Protection, Over-Temperature Protection (OTP), Over-Current Protection (OCP), and Inductor/Diode Short Protection
- Fault Indicator Signal Output
- Available in a QFN-20 (3mmx4mm) Package with Wettable Flanks

APPLICATIONS

- Tablets
- Notebooks

TYPICAL APPLICATION

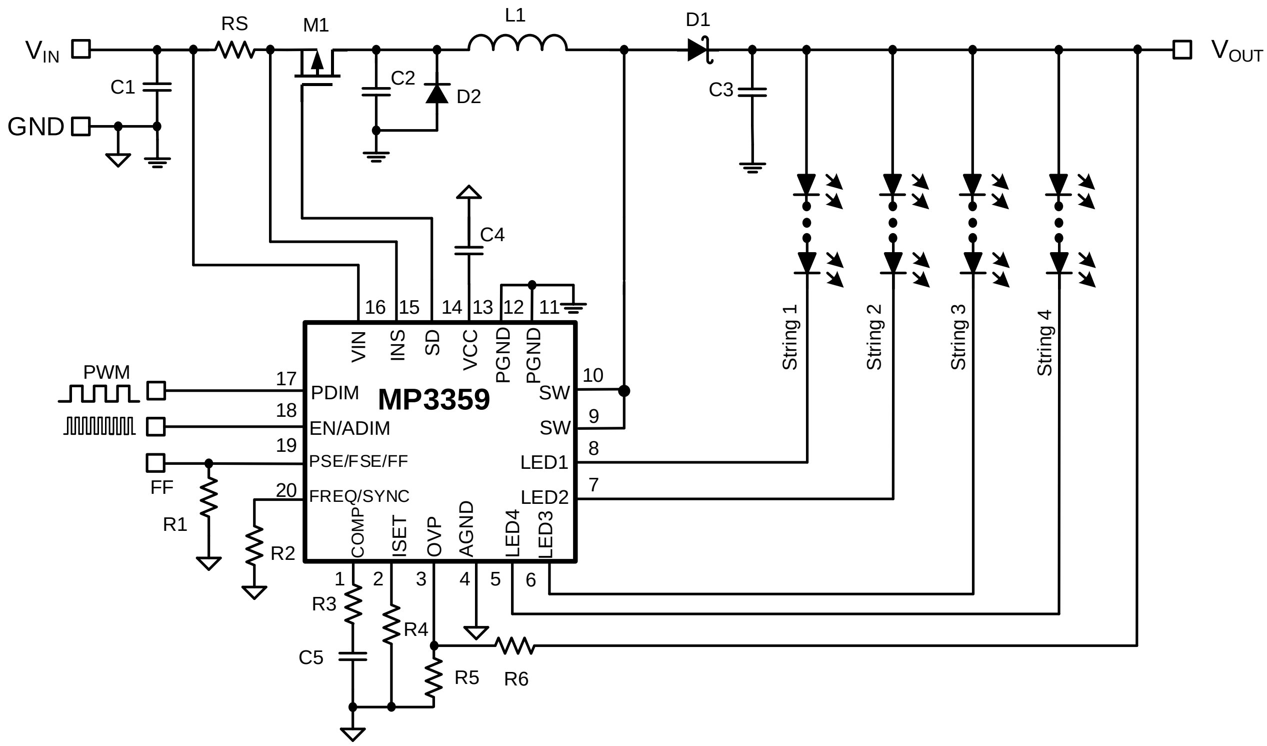


Figure 1: Typical Application Circuit (1) (2)

Notes:

1) For an application with one LED string load, tie the LED1~LED4 pins together as one LED channel.
2) For an application with two LED string loads, tie the LED1~LED2 pins together as one LED channel, and tie the LED3~LED4 pins together as another LED channel.

ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating
MP3359GLE*	QFN-20 (3mmx4mm) WF	*See Below*	1

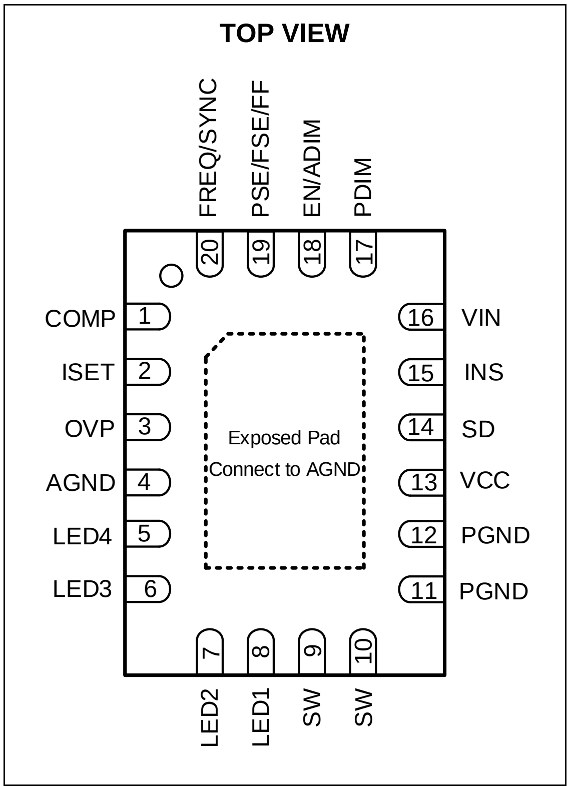
* For Tape & Reel, add suffix -Z (e.g. MP3359GLE-Z).

TOP MARKING (MP3359GLE)

MPYW
3359
LLL
E

MP: MPS prefix
Y: Year code
W: Week code
3359: Part number
LLL: Lot number
E: Wettable lead flank

PACKAGE REFERENCE



QFN-20 (3mmx4mm)

PIN FUNCTIONS

Pin #	Name	Description
1	COMP	**Compensation pin.**
2	ISET	**LED current setting.** Tie a current-setting resistor from ISET to GND to configure the current in each LED string.
3	OVP	**Over-voltage protection pin.** Connect a resistor divider from V_{OUT} to OVP via R6 and OVP to GND via R5 to configure the over-voltage protection (OVP) threshold.
4	AGND	**Analog ground.**
5	LED4	**LED string 4 current input.** Connect the LED string 4 cathode to this pin.
6	LED3	**LED string 3 current input.** Connect the LED string 3 cathode to this pin.
7	LED2	**LED string 2 current input.** Connect the LED string 2 cathode to this pin.
8	LED1	**LED string 1 current input.** Connect the LED string 1 cathode to this pin.
9,10	SW	**Drain for the internal low-side MOSFET (LS-FET) switch.** Connect the power inductor to the SW pin.
11, 12	PGND	**Power ground.**
13	VCC	**5V LDO output pin.** The VCC pin provides power to the internal logic and gate driver. Place a ceramic capacitor as close to this pin as possible to reduce noise.
14	SD	**External disconnect P-channel MOSFET gate drive pin.** The SD pin turns off the external P-channel MOSFET if a fault occurs. Float this pin if it is not used.
15	INS	**Input current-sense pin.** If the voltage across a current-sense resistor (R_S) exceeds the input over-current protection (OCP) threshold, the MP3359 turns off the P-channel MOSFET.
16	VIN	**Power supply input.** The VIN pin supplies power to the IC.
17	PDIM	**Pulse-width modulation (PWM) dimming signal input pin.** Apply a PWM signal on the PDIM pin for PWM dimming. PDIM is pulled low internally, and a 100Hz to 30kHz PWM signal is recommended.
18	EN/ADIM	**IC enable and analog dimming signal input pin.** Apply a PWM signal on the EN/ADIM pin for analog dimming. EN/ADIM is pulled low internally, and a >5kHz PWM signal is recommended. Pull this pin low for >30ms to shut down the IC.
19	PSE/FSE/FF	**Delay function enable, frequency spread spectrum (FSS) enable, and fault flag pin.** The PSE/FSE/FF pin is a current-source output (32µA). To configure the pin voltage, connect a resistor from this pin to GND. After VIN and EN turns on, the IC detects the PSE/FSE/FF pin's voltage to enable the corresponding functions: • >2.2V: Enable the delay and FSS functions. • 1.65V to 1.95V: Enable only the delay function. • 1.25V to 1.55V: Enable only the FSS function. • <1.14V: Disable the delay and FSS functions. If the delay function is enabled, there is a fixed 100µs delay between the LED current channels to reduce system stress and eliminate noise during PWM dimming. FSS improves EMI performance. The fault flag function indicates the fault status when a fault occurs, and the fault flag function is always enabled.
20	FREQ/SYNC	**Switching frequency (f_{SW}) setting and SYNC pin.** The FREQ/SYNC pin configures f_{SW}. Connect a resistor between FREQ/SYNC and GND to set f_{SW}, or connect an external clock to this pin to synchronize the boost f_{SW}.
Exposed pad	AGND	**Chip ground.** Connect the exposed pad to AGND.

ABSOLUTE MAXIMUM RATINGS (3)

Input voltage (V_{IN}) .... -0.3V to +42V
V_{SW}, V_{LED1} to V_{LED4} .... -0.5V to +50V
V_{SW} ....-1V for <100ns
V_{SD}, V_{INS}...................................... V_{IN} - 6V to V_{IN}
V_{SD}, V_{INS}.. > -0.3V
All other pins................................. -0.3V to +6V
Junction temperature (T_J) .... 150°C
Lead temperature .... 260°C
Storage temperature................ -65°C to +150°C
Continuous power dissipation (T_A = 25°C) (4)
QFN-20 (3mmx4mm)................................2.6W

ESD Ratings

Human body model (HBM)…………………±2kV
Charged-device model (CDM)……………..±2kV

Recommended Operating Conditions (5)

Input voltage (V_{IN}) .... 3.5V to 40V
Operating junction temp (T_J) .... -40°C to +125°C

Thermal Resistance (6)

Thermal Resistance (6)	θ_{JA}	θ_{JC}	
QFN-20 (3mmx4mm)	48	10	°C/W

Notes:

3) Exceeding these ratings may damage the device.
4) 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.
5) The device is not guaranteed to function outside of its operating conditions.
6) Measured on a JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, V_{EN} = 2V, T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Operating input voltage	V_{IN}		3.5		40	V
Quiescent supply current	I_Q	No switching		3		mA
Shutdown supply current	I_{ST}	V_{IN} = 12V, V_{EN} = 0V			1	µA
Input under-voltage lockout (UVLO) threshold	V_{IN_UVLO}	Rising edge		3.25	3.45	V
Input UVLO hysteresis				250		mV
Low-dropout (LDO) regulator output voltage	V_{CC}	V_{EN} = 2V, 6V < V_{IN} < 24V, 0mA < I_{VCC} < 10mA		5		V
EN on threshold	V_{EN_ON}	V_{EN} rising	1.4			V
EN off threshold	V_{EN_OFF}	V_{EN} falling			0.5	V
EN/ADIM and PDIM pull-down resistance	$R_{EN/ADIM}$			1		MΩ
PSE/FSE/FF source current	I_{PSE}		30	32	34	µA
Step-Up Converter						
Low-side MOSFET (LS-FET) on resistance	$R_{DS(ON)\_LS}$	V_{IN} = 12V		100		mΩ
SW leakage current	I_{SW_LK}	V_{SW} = 45V			4	µA
Switching frequency	f_{SW}	R_{FREQ} = 10kΩ	1.85	2.05	2.25	MHz
		R_{FREQ} = 50kΩ	400	440	480	kHz
FREQ voltage	V_{FREQ}		-5%	1.1	+5%	V
Maximum duty cycle	D_{MAX}	f_{SW} = 440kHz	92			%
Cycle-by-cycle current limiting	I_{SW_LIMIT}		5.5	7		A
Current-limit protection	I_{CL}	To trigger current-limit protection		12		A
SYNC low threshold	V_{SYNC_LO}	V_{SYNC} falling			0.5	V
SYNC high threshold	V_{SYNC_HI}	V_{SYNC} rising	1.4			V
COMP transconductance	G_{COMP}	$\Delta I_{COMP} \leq 10\mu A$		100		µA/V
COMP source current limit	I_{COMP_SO}			90		µA
COMP sink current limit	I_{COMP_SI}			90		µA
Current Dimming						
PDIM/ADIM input low threshold	V_{DIM_LO}	V_{DIM} falling			0.5	V
PDIM/ADIM input high threshold	V_{DIM_HI}	V_{DIM} rising	1.4			V

ELECTRICAL CHARACTERISTICS *(continued)*

V_{IN} = 12V, V_{EN} = 2V, T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
LED Current Regulator						
LEDx regulation voltage	V_{HD}	I_{LED} = 20mA		350		mV
		I_{LED} = 100mA		650		mV
Current matching (7)		I_{LED} = 20mA	-2.5		+2.5	%
		I_{LED} = 100mA	-2.5		+2.5	%
ISET voltage	V_{ISET}			1.2		V
LED current	I_{LED}	R_{ISET} = 12kΩ	97	100	103	mA
		R_{ISET} = 24kΩ, ADIM duty = 2%, I_{LED} = 1/50 x 50mA = 1mA	0.7	0.9	1.1	mA
Delay time	t_{DELAY}	Between LED current channels		100		µs
Protections						
Over-voltage protection (OVP) threshold	V_{OVP}		1.9	2	2.1	V
OVP hysteresis				200		mV
OVP UVLO threshold	V_{OVP_UV}	Step-up converter fails		100		mV
Input over-current protection (OCP) threshold	V_{INOCP}	Input current sense	80	100	120	mV
INS sink current			16	20	24	µA
LEDx over-voltage (OV) threshold	V_{LEDX_OV}			5		V
LEDx OV fault timer				7.7		ms
LEDx UVLO threshold	V_{LEDX_UV}			100		mV
Thermal shutdown threshold (8)	T_{ST}	Rising edge		170		°C
		Hysteresis		20		°C
SD pin pull-down current	I_{SD}			60		µA
SD pin voltage (respective to V_{IN})	V_{SD-IN}	V_{IN} = 12V, V_{IN} - V_{SD}		5.3		V

Notes:

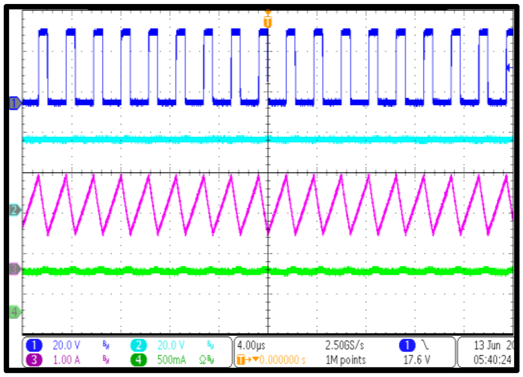
7) Matching is defined as the difference between the maximum and minimum current, divided by 2 times the average current.
8) Guaranteed by design.

TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 12V, 4 strings, 12 LEDs in series, 120mA/string, L = 15μH, f_{SW} = 440kHz, T_A = 25°C, unless otherwise noted.

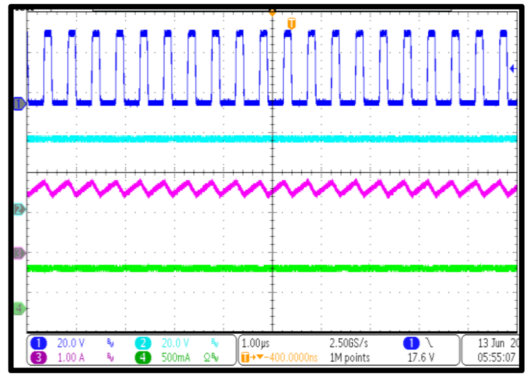
Steady State

f_{SW} = 440kHz

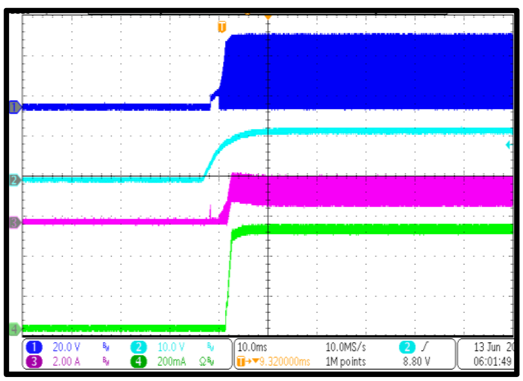


Steady State

f_{SW} = 2.2MHz

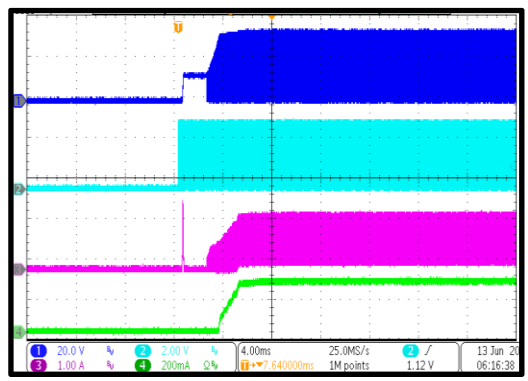


Start-Up through VIN



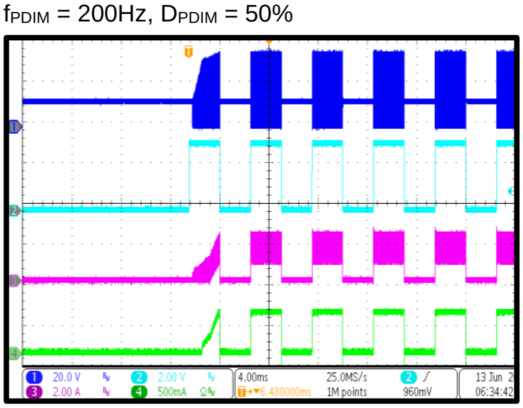
Start-Up through EN/ADIM

$f_{EN/ADIM}$ = 10kHz, $D_{EN/ADIM}$ = 50%



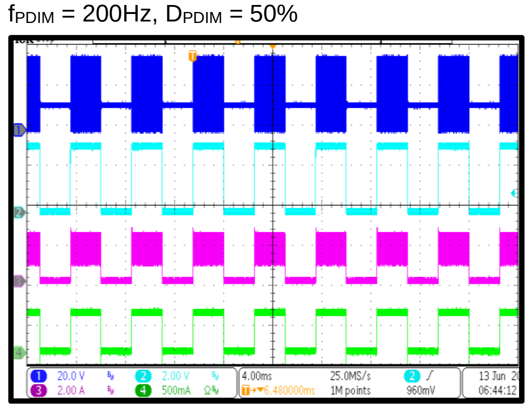
Start-Up through PDIM

f_{PDIM} = 200Hz, D_{PDIM} = 50%



PWM Dimming

f_{PDIM} = 200Hz, D_{PDIM} = 50%

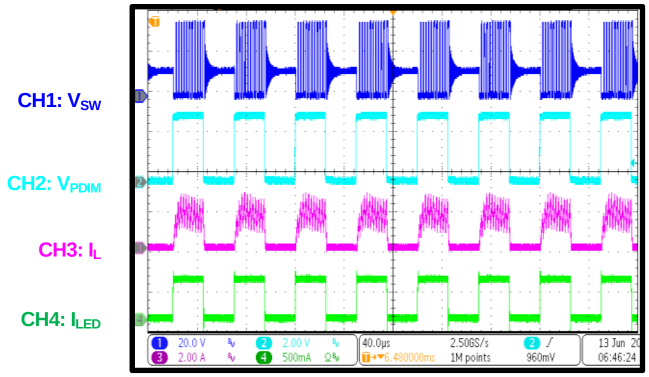


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 12V, 4 strings, 12 LEDs in series, 120mA/string, L = 15µH, f_{SW} = 440kHz, T_A = 25°C, unless otherwise noted.

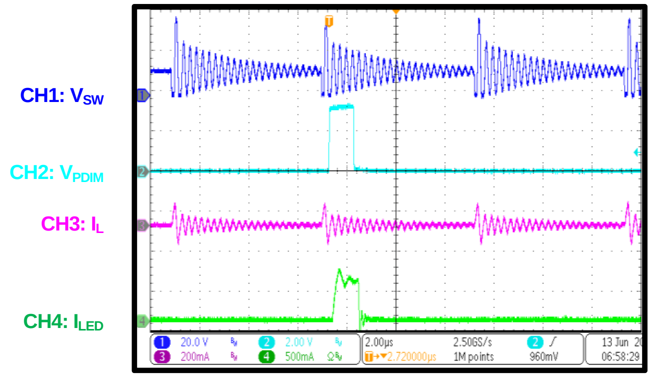
PWM Dimming

f_{PDIM} = 20kHz, D_{PDIM} = 50%



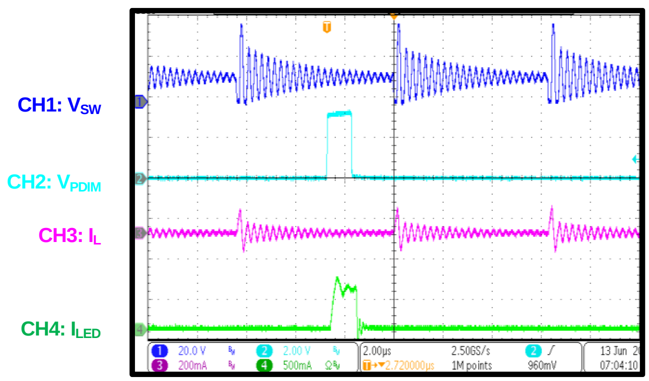
PWM Dimming

f_{PDIM} = 200Hz, D_{PDIM} = 0.02%



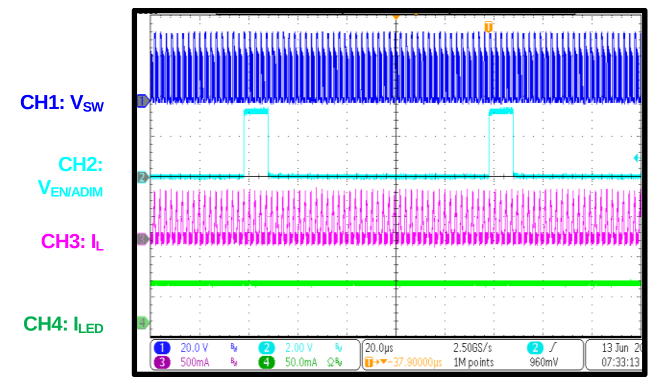
PWM Dimming

f_{PDIM} = 100Hz, D_{PDIM} = 0.01%



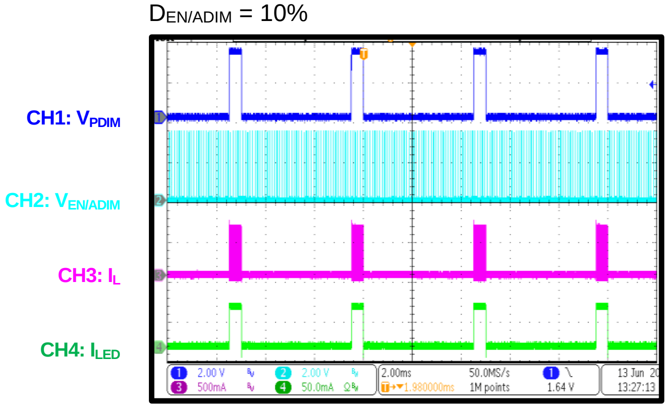
Analog Dimming

$f_{EN/ADIM}$ = 10kHz, $D_{EN/ADIM}$ = 10%



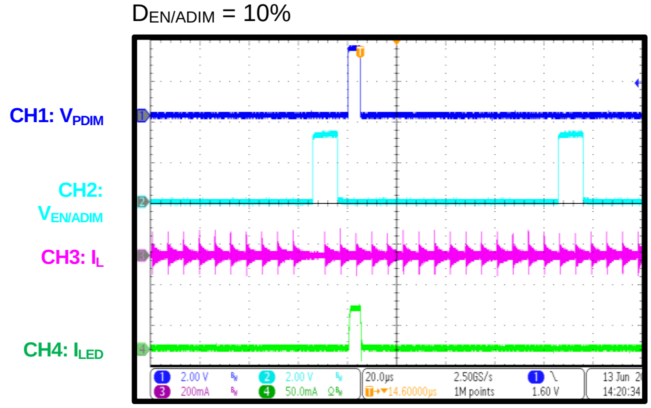
PWM Dimming and Analog Dimming

f_{PDIM} = 200Hz, D_{PDIM} = 10%, $f_{EN/ADIM}$ = 10kHz, $D_{EN/ADIM}$ = 10%



PWM Dimming and Analog Dimming

f_{PDIM} = 200Hz, D_{PDIM} = 0.1%, $f_{EN/ADIM}$ = 10kHz, $D_{EN/ADIM}$ = 10%

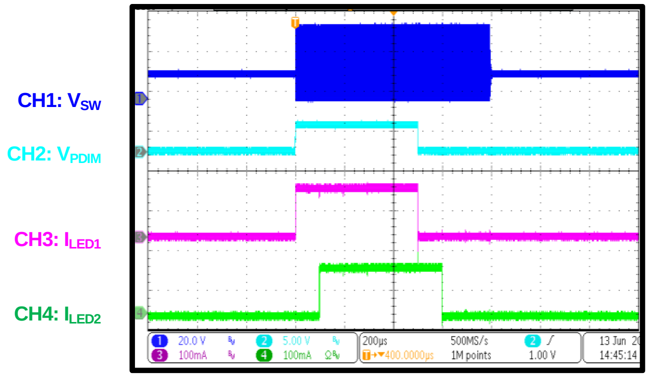


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

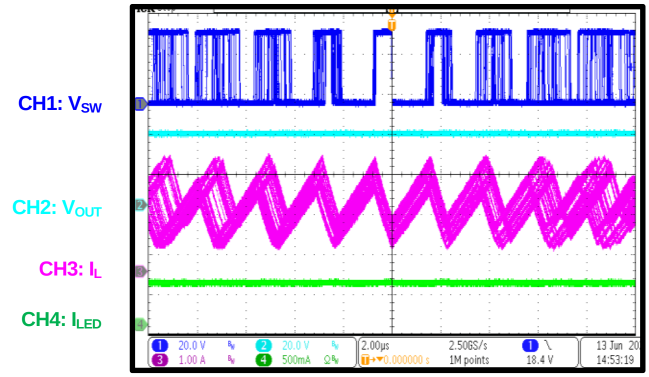
V_{IN} = 12V, 4 strings, 12 LEDs in series, 120mA/string, L = 15µH, f_{SW} = 440kHz, T_A = 25°C, unless otherwise noted.

PWM Dimming with 100µs Delay

f_{PDIM} = 200Hz, D_{PDIM} = 10%

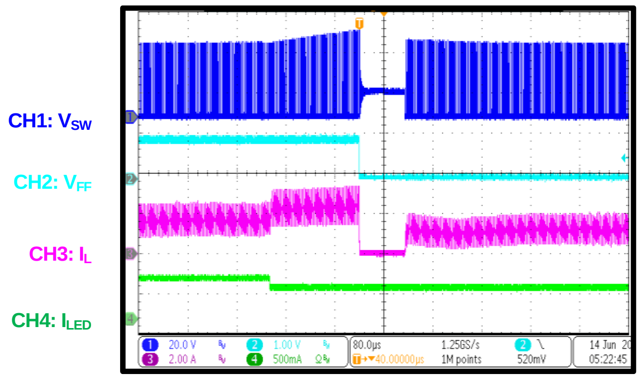


Frequency Spread Spectrum



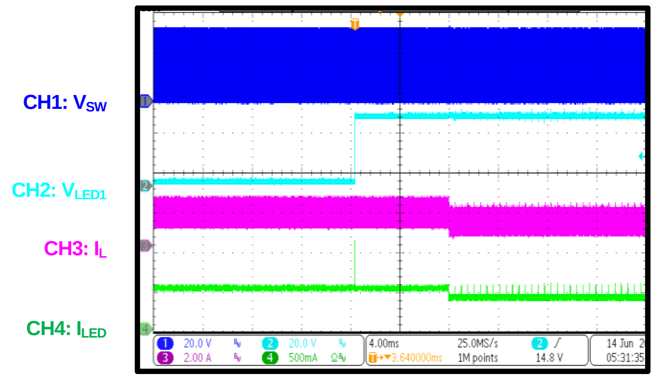
LED Open Protection

LED1 open during normal operation



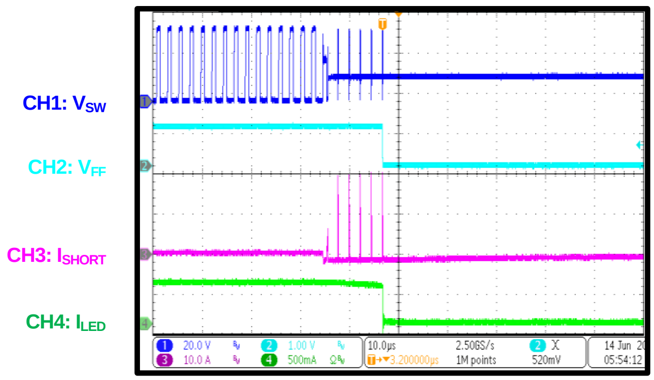
LED Short Protection

LED1 shorts during normal operation



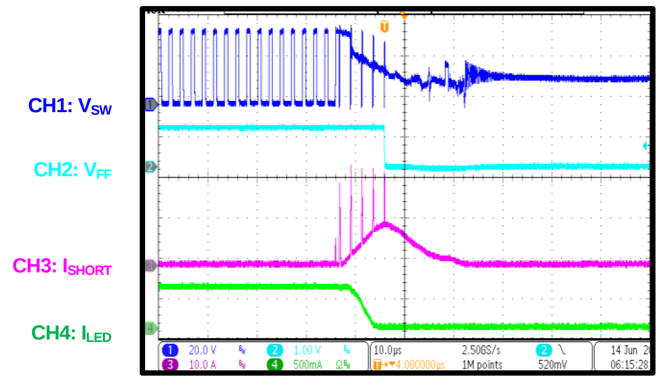
Inductor Short Protection

Inductor shorts during normal operation



Diode Short Protection

Diode shorts during normal operation

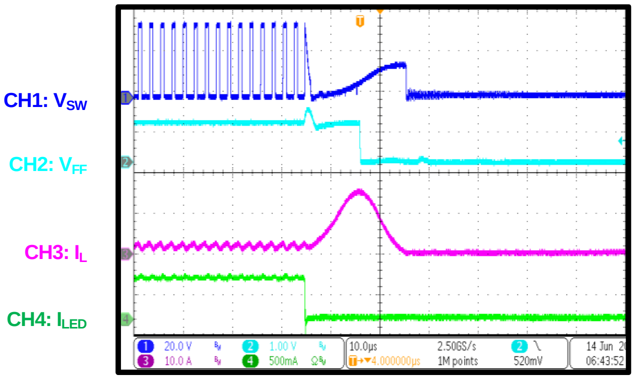


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 12V, 4 strings, 12 LEDs in series, 120mA/string, L = 15µH, f_{SW} = 440kHz, T_A = 25°C, unless otherwise noted.

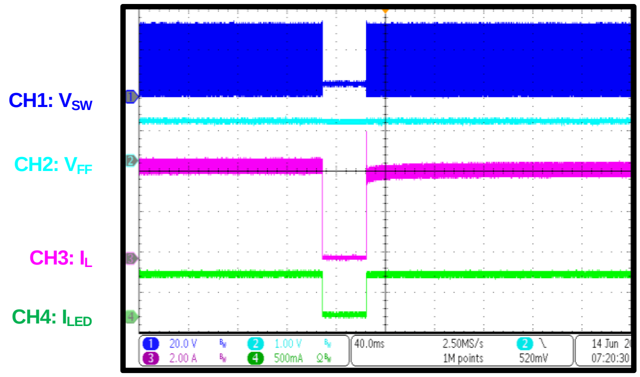
Short VOUT to GND Protection

Input OCP threshold = 10A



Over-Temperature Protection

V_{IN} = 6V



FUNCTIONAL BLOCK DIAGRAM

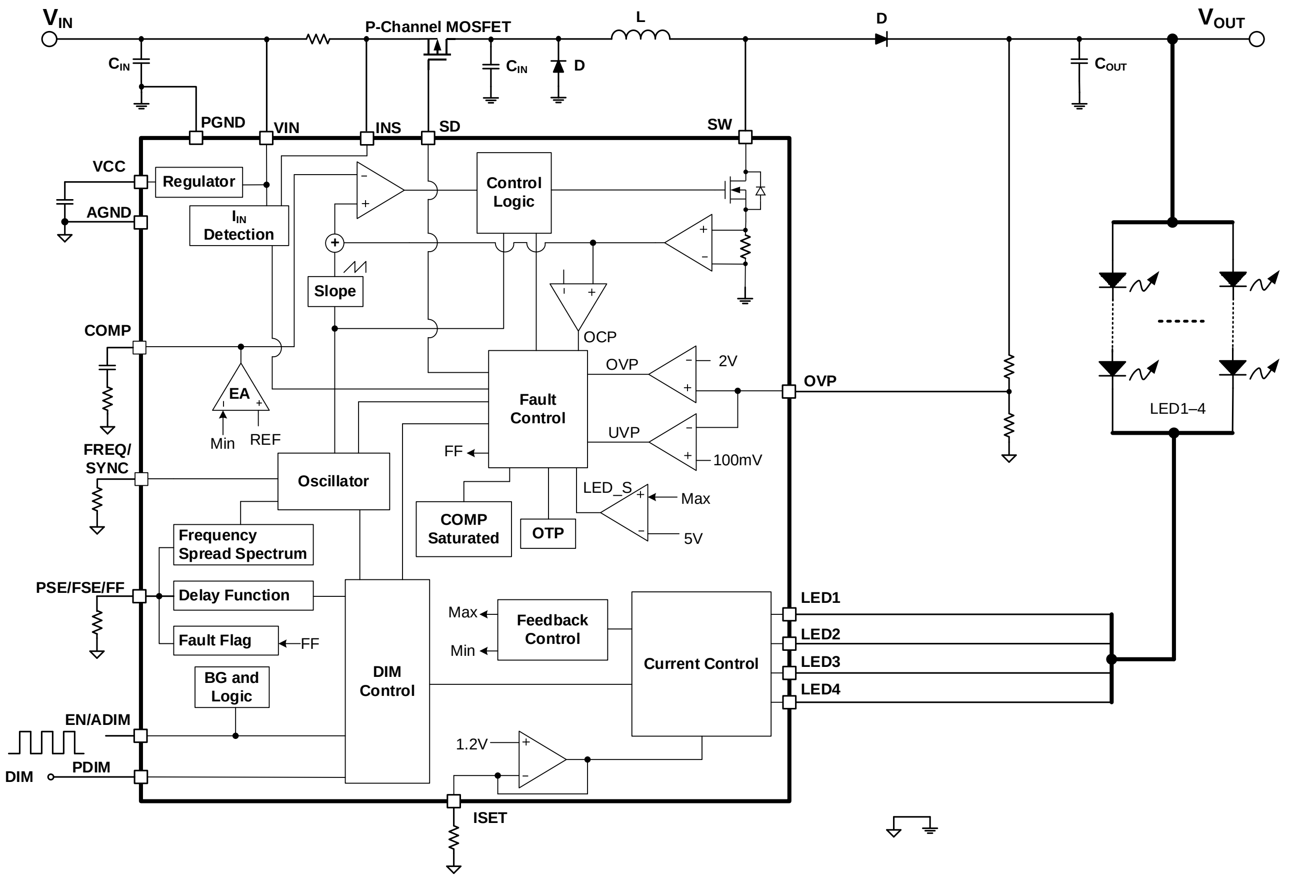


Figure 2: Functional Block Diagram

OPERATION

The MP3359 is a configurable, fixed-frequency, peak current mode control boost converter with up to four channels of regulated current sources to drive an array of white LEDs (WLEDs).

Internal 5V Regulator

The MP3359 features an internal linear regulator (VCC). When the input voltage (V_{IN}) exceeds 6V, this regulator provides a 5V power supply to the internal MOSFET switch gate driver and the internal control circuitry. When the device shuts down, the VCC voltage (V_{CC}) drops to 0V. The device remains disabled until V_{CC} exceeds the under-voltage lockout (UVLO) threshold.

System Start-Up

Once enabled, the MP3359 checks the topology connection. The IC draws current from the SD pin to turn on the P-channel MOSFET if it is used. After a 500µs delay, the device monitors the OVP pin to see if the output is shorted to GND. If the OVP voltage (V_{OVP}) is below 100mV, the device is disabled and latches off. Then, the MP3359 continues to check other safety limits (e.g. over-voltage protection (OVP)). If all protection tests pass, the IC starts boosting the step-up converter.

The recommended start-up sequence is listed below:

1. V_{IN}
2. EN/ADIM
3. PWM dimming signal for the PDIM pin (the PWM on pulse must be ≥7µs when starting up)

Step-Up Converter

The MP3359 employs peak current mode control to regulate the output voltage. At the beginning of each switching cycle, the internal clock turns on the internal N-channel MOSFET. During normal operation, the minimum turn-on time is about 100ns. A stabilizing ramp is added to the current-sense (CS) amplifier's output to prevent subharmonic oscillations when the duty cycle exceeds 50%. This result is fed into the pulse-width modulator (PWM) comparator. When the summed voltage reaches the error amplifier's (EA's) output, the internal MOSFET turns off.

The internal EA's output is an amplified signal of the difference between the reference voltage (V_{REF}) and the feedback voltage (V_{FB}). The converter automatically chooses the lowest active LEDx pin voltage to provide a sufficient output voltage (V_{OUT}) for all the LED arrays.

If V_{FB} drops below V_{REF}, the EA's output increases. Then more current flows through the MOSFET, which increases the power delivered to the output. This forms a closed loop that regulates the converter's V_{OUT}.

Under light-load operation (e.g. when V_{OUT} is almost equal to V_{IN}), the converter runs in pulse-skip mode (PSM). In this mode, the MOSFET turns on for a minimum on time, then the converter discharges power to its output for the remaining period. The MOSFET remains off until V_{OUT} requires another boost.

Dimming Control

The MP3359 provides analog and PWM dimming with two separated EN/ADIM and PDIM input pins.

Pulse-Width Modulation (PWM) Dimming Mode

When a PWM signal is applied to the PDIM pin, the LED current (I_{LED}) amplitude remains at the full-scale I_{LED}, and the I_{LED} duty is the same as the input PWM signal duty. The I_{LED} duty cycle follows the PWM input duty cycle, and the I_{LED} frequency is the same as the PWM input.

Analog Dimming Mode

The PWM input signal is connected to the EN/ADIM pin. The I_{LED} amplitude is equal to I_{SET} x D_{DIM}, where I_{SET} is the full-scale I_{LED}, and D_{DIM} is the duty of the input PWM signal. To improve analog dimming performance, a PWM signal above 5kHz is recommended.

To ensure good performance with a small dimming ratio, the minimum LEDx voltage (V_{LEDX}) rises to 1.2V when the dimming duty cycle is below 10%. Analog dimming supports a 200:1 dimming ratio.

Deep Dimming Ratio for PWM Dimming

When the PWM signal on time is less than 5μs, V_{OUT} is regulated to be 93% of V_{OVP} (see Figure 3).

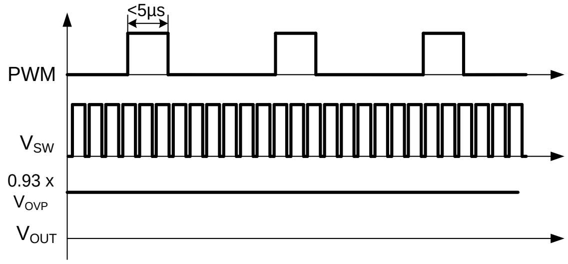


Figure 3: Deep Dimming Ratio for PWM Dimming

Delay Time Function

To reduce inrush current and audible noise during PWM dimming, the MP3359 employs a delay time function. There is a 100μs delay time between the LED channels (see Figure 4).

When operating in delay time mode, the recommended I_{LED} pulse on time is ≥10μs.

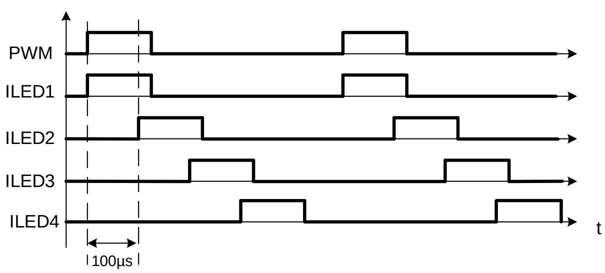


Figure 4: 100μs Delay Time with 4 Channels

Frequency Spread Spectrum (FSS)

The MP3359 uses switching frequency (f_{SW}) jitter (f_{JITTER}) to spread the f_{SW} spectrum. This reduces the spectrum spike around f_{SW} and its harmonic frequencies.

The frequency jitter range is ±10% of f_{SW}.

The modulation frequency is fixed at 24kHz.

Protections

The MP3359 provides LED open protection, LED short protection, latch-off current-limit protection, input over-current protection (OCP), VOUT-to-GND short protection, and thermal protection. If any of the above protections are triggered (excluding thermal protection), PSE/FSE/FF is pulled to GND. After the IC recovers from a protection, PSE/FSE/FF is pulled high again. To ensure the correct logic for the FF pin, follow the configurations below:

- For an application with one LED string load, tie the LED1~LED4 pins together as one LED channel.
- For an application with two LED string loads, tie the LED1~LED2 pins together as one LED channel, and tie the LED3~LED4 pins together as another LED channel.

LED Open Protection

LED open protection is achieved by detecting the voltage on the OVP pin and LEDx pins. If one string is open during normal operation, the respective V_{LEDx} drops low to ground, and the IC keeps charging V_{OUT} until it reaches the OVP threshold.

If OVP is triggered, the chip stops switching and marks off the fault string, which has a V_{LEDx} below 100mV. The remaining LED strings force V_{OUT} back into normal regulation. The string with the largest voltage drop determines the output regulation value.

Every 500μs, the LEDx pin that was marked off turns on for 16μs to check whether the open fault has been removed.

If all used strings are open, the IC latches off and cannot recover until VIN or EN is reset.

LED Short Protection

The MP3359 monitors all LEDx voltages to determine whether a short string fault has occurred. If one or more strings are shorted, the shorted LEDx pins tolerate the high voltage stress. If any V_{LEDx} voltage exceeds the short protection threshold, an internal counter starts counting.

If the fault condition lasts for 7.7ms (D_{PWM} = 100%), then the fault string is marked off and disconnects from the V_{OUT} loop until the short fault is removed.

Every 500μs, the LEDx pin that was marked off turns on for 16μs to check whether the short fault has been removed.

If all of the active LEDx pins' voltages exceed the threshold for 480ms (D_{PWM} = 100%), then all strings are marked off and the IC latches off.

To avoid mistriggering short LED protection, LED short protection is disabled when an open LED condition occurs.

VOUT-to-GND Short Protection

If VOUT is shorted to GND, V_{OUT} decreases. If V_{OVP} reaches the under-voltage lockout (UVLO) threshold for 10µs, VOUT-to-GND short protection triggers. To turn off the external P-channel MOSFET, SD is pulled high. Then VOUT disconnects from V_{IN}, and the IC latches off.

Cycle-by-Cycle Current Limit

To prevent internal or external components from exceeding the current stress rating, the IC features cycle-by-cycle current-limit protection. If the current exceeds the current limit value, the IC stops switching until the next clock cycle.

Latch-Off Current-Limit Protection

The device can be damaged by extreme conditions, such as if an inductor or diode short fault occurs. To prevent damage, the MP3359 provides latch-off current-limit protection. If the current flowing through the internal MOSFET reaches 12A and lasts for 5 switching cycles, current-limit protection is triggered. The external P-channel MOSFET turns off, and the MP3359 latches off.

Input Over-Current Protection (OCP)

To prevent the input current (I_{IN}) from exceeding the current stress rating, the INS pin detects the voltage across the input sense resistor (R_S). If the voltage between VIN and INS exceeds the protection threshold for 3µs, then the external P-channel MOSFET turns off and the MP3359 latches off.

To choose R_S flexibly, the INS pin has a 20µA sink current ability. It is possible to add a resistor (R_{REG}); in this scenario, the voltage between VIN and INS is equal to the summed voltage of (R_S + R_{REG}). Figure 5 shows the I_{IN} detection circuit.

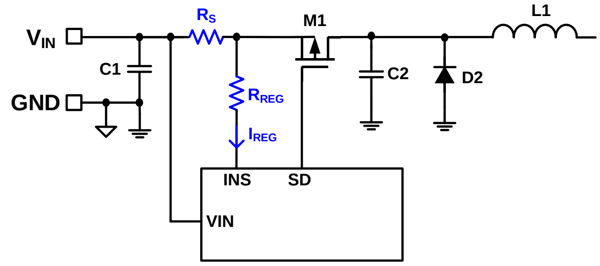


Figure 5: Typical Input Current Detection Circuit

If the external P-channel MOSFET (M1) is used, diode (D2) must be mounted.

Thermal Shutdown

If the die temperature exceeds the upper threshold (T_{ST}), the IC shuts down. Once the temperature drops below the lower threshold, the IC recovers. The hysteresis is about 20°C.

Fault Flag Level Shift Circuit

The PSE/FSE/FF pin voltage is determined by the resistor placed between this pin and GND. To make the fault flag voltage compatible with the user's microcontroller (MCU), use a circuit to convert the high level of the fault flag from 0.96V to 3.3V or 5V (see Figure 6).

The transistor's (M1) base current is recommended to be below 0.5µA.

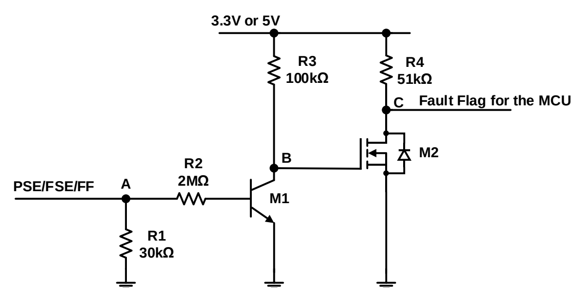


Figure 6: Circuit to Shift the Fault Flag Level

APPLICATION INFORMATION

LED Current Setting

The LED current (I_{LED}) amplitude is set by an external resistor (R_{ISET}) connected from ISET to GND. I_{LED} can be calculated with Equation (1):

$$I_{LED}(mA) = \frac{1200}{R_{ISET}(k\Omega)} \quad (1)$$

For example, if R_{ISET} = 10kΩ, then I_{LED} is 120mA.

Switching Frequency (f_{SW}) Setting

f_{SW} can be configured via a resistor or an external clock.

When f_{SW} is configured via an external resistor on FREQ/SYNC, then f_{SW} can be estimated with Equation (2):

$$f_{SW}(kHz) = \frac{22000}{R_{FREQ}(k\Omega)} \quad (2)$$

For example, if R_{FREQ} = 44.2kΩ, then f_{SW} is set to 500kHz.

There may be some deviation between the actual f_{SW} and the calculated value from Equation (2). R_{FREQ} = 50kΩ is recommended for a typical f_{SW} of 440kHz, and R_{FREQ} = 9.1kΩ is recommended for a typical f_{SW} of 2.2MHz.

To improve EMI, efficiency, and thermal performance, synchronize f_{SW} with an external clock. A ≥250kHz external clock frequency is recommended for the external SYNC SW function.

If the external clock is used on the FREQ/SYNC pin, do not stop the clock during operation, or the IC will not operate normally.

Selecting the Input Capacitor

The input capacitor (C_{IN}) reduces the surge current drawn from the input supply and the switching noise from the device. To prevent the high-frequency switching current from passing through to the input, the C_{IN} impedance at f_{SW} should be less than the input source impedance. Use ceramic capacitors with X5R or X7R dielectrics for their low ESR and small temperature coefficients. For most applications, a 10μF ceramic capacitor is sufficient.

Selecting the Inductor

The MP3359 requires an inductor to supply a higher V_{OUT} while being driven by V_{IN}. A larger-value inductor results in less ripple current, lower peak inductor current (I_L), and less stress on the internal N-channel MOSFET. However, the larger-value inductor has a larger physical size, higher series resistance, and lower saturation current.

Choose an inductor that does not saturate under the worst-case load conditions. Select the minimal inductance to ensure that the boost converter works in continuous conduction mode (CCM) with high efficiency and excellent EMI performance.

Calculate the required inductance (L) with Equation (3):

$$L \geq \frac{\eta \times V_{OUT} \times D \times (1-D)^2}{2 \times f_{SW} \times I_{LOAD}} \quad (3)$$

Where I_{LOAD} is the LED load current, η is the efficiency, and D is the switching duty cycle, which can be estimated with Equation (4):

$$D = 1 - \frac{V_{IN}}{V_{OUT}} \quad (4)$$

With the given inductance, the inductor's DC current rating should be at least 40% greater than the maximum input peak I_L for most applications. The inductor's DC resistance should be as small as possible for higher efficiency.

Selecting the Output Capacitor

The output capacitor (C_{OUT}) keeps the V_{OUT} ripple (ΔV_{OUT}) small and ensures feedback loop stability. The C_{OUT} impedance must be low at f_{SW}. Ceramic capacitors with X7R dielectrics are recommended for their low-ESR characteristics. For most applications, a 10μF ceramic capacitor is sufficient.

PCB Layout Guidelines

Efficient PCB layout is critical to reduce EMI noise and achieve stable operation. For the best results, refer to Figure 7 and follow the guidelines below:

1. The high-frequency switching current flows through the loop between the SW pin, output diode (D1), output capacitor (C1 and C2), and PGND. Keep this loop as short as possible to reduce noise and EMI.
2. Internally connect the IC's exposed pad to the AGND pin, and refer all logic signals to AGND.
3. Externally connect PGND to AGND, routing PGND away from the logic signals.
4. Place the ceramic capacitors for the VIN and VCC pins as close to the IC as possible.

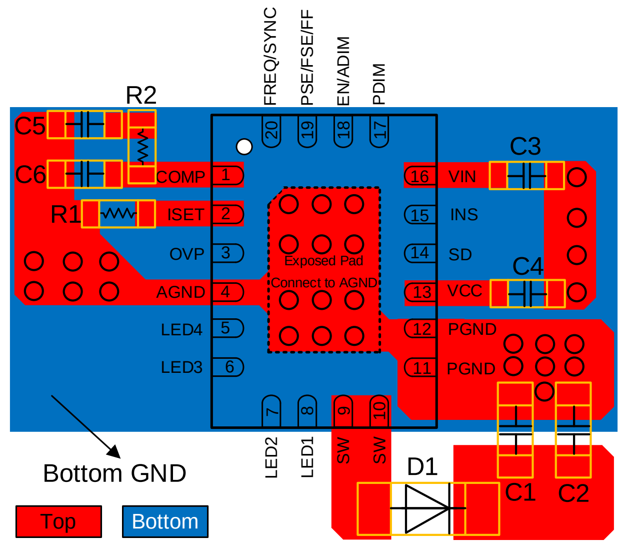


Figure 7: Recommended PCB Layout

TYPICAL APPLICATION CIRCUITS

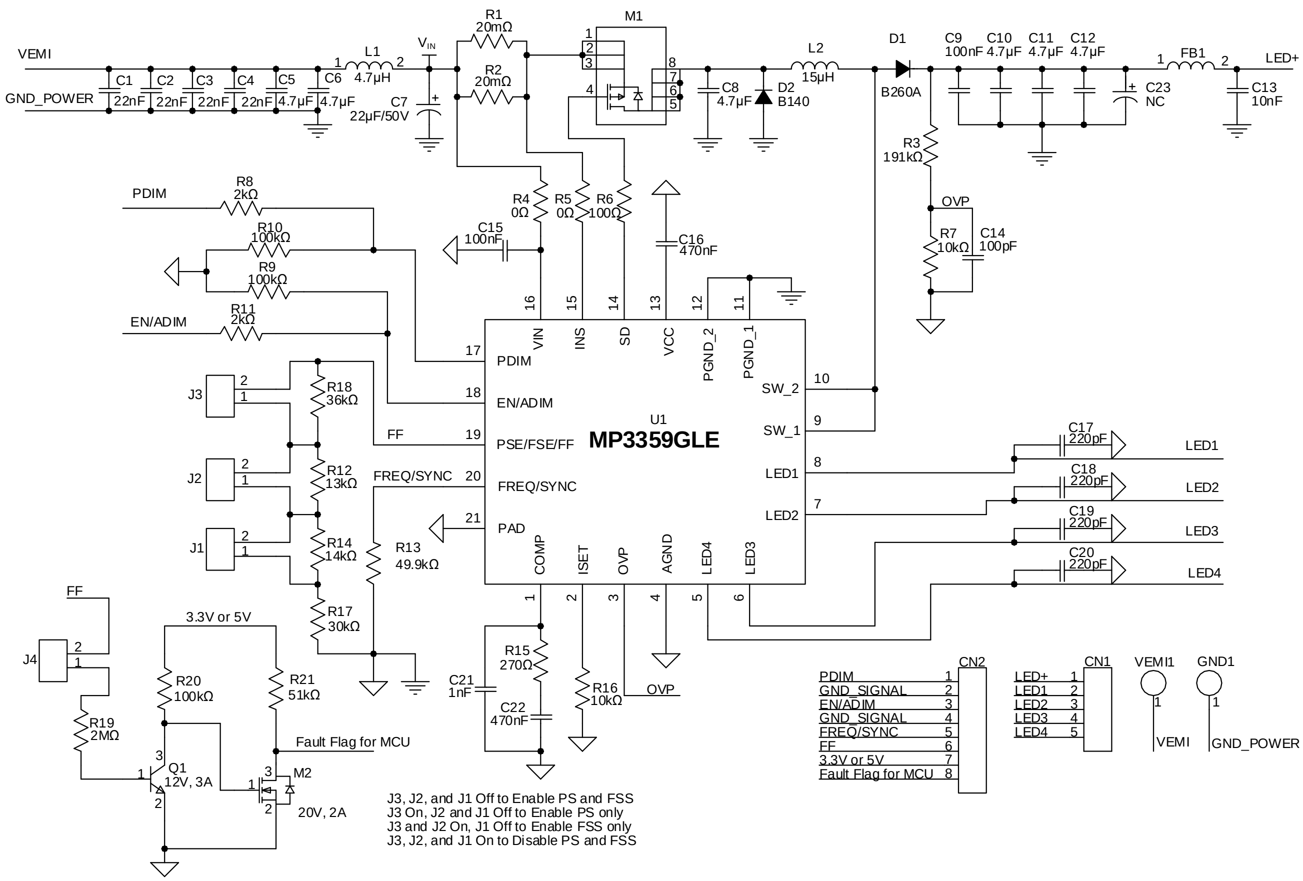


Figure 8: Typical Application Circuit (Boost)

TYPICAL APPLICATION CIRCUITS *(continued)*

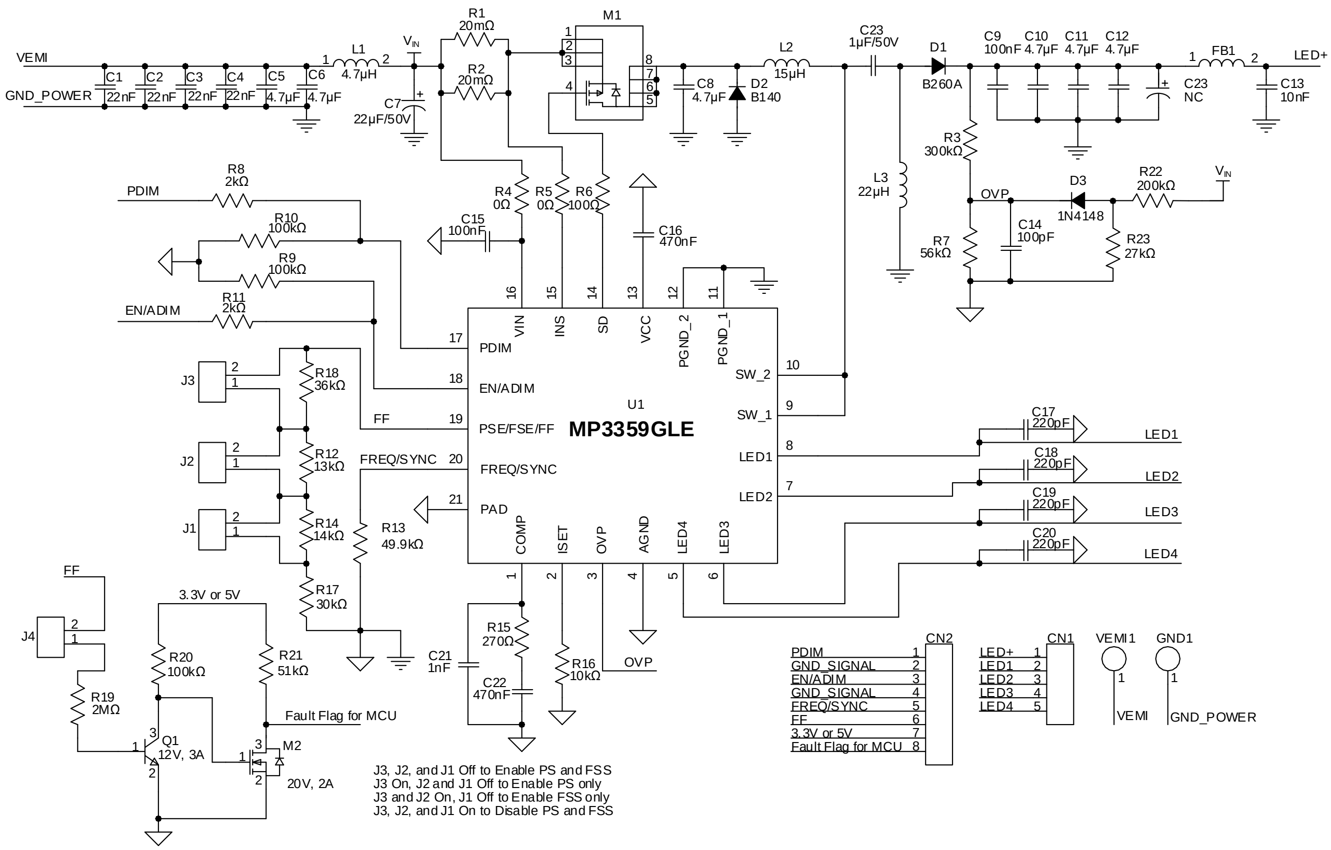
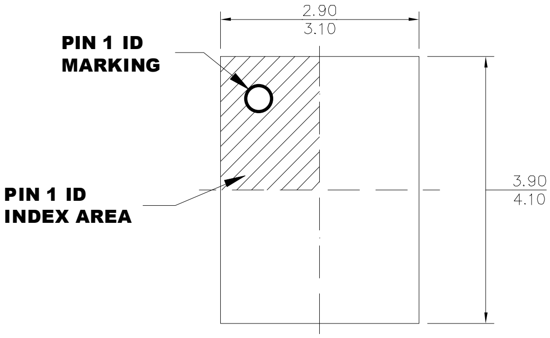


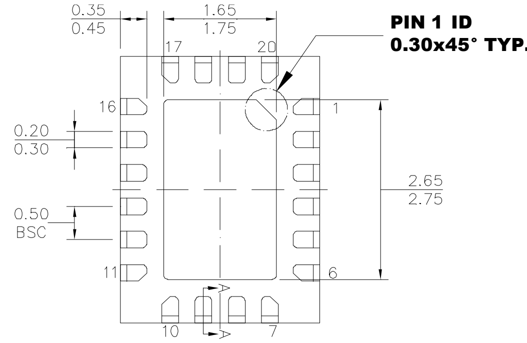
Figure 9: Typical Application Circuit (SEPIC)

PACKAGE INFORMATION

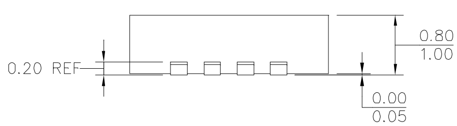
QFN-20 (3mmx4mm)
Wettable Flank



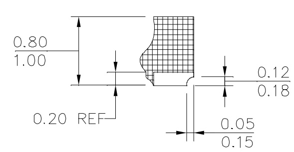
TOP VIEW



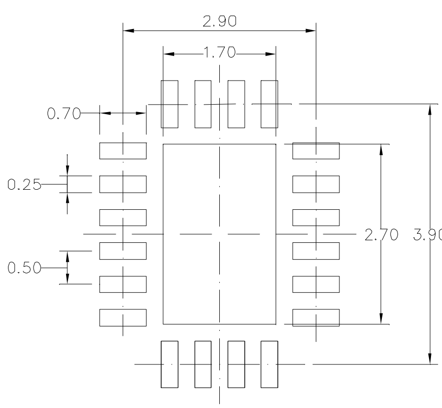
BOTTOM VIEW



SIDE VIEW



SECTION A-A

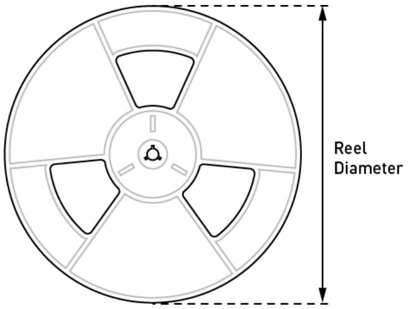


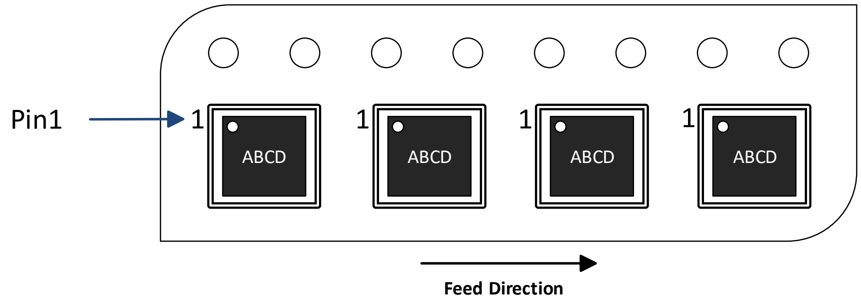
RECOMMENDED LAND PATTERN

NOTE:

1) THE LEAD SIDE IS WETTABLE.
2) ALL DIMENSIONS ARE IN MILLIMETERS.
3) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
4) LEAD COPLANARITY SHALL BE 0.08 MILLIMETERS MAX.
5) JEDEC REFERENCE IS MO-220.
6) 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
MP3359GLE-Z	QFN-20 (3mmx4mm) WF	5000	N/A	N/A	13in	12mm	8mm

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	7/31/2024	Initial Release	-