MP38876

10A, 28V, High Frequency Step-Down Converter with Synchronous Gate Driver

The Future of Analog IC Technology

DESCRIPTION

The MP38876 is a monolithic step-down switch mode converter with a built in internal power MOSFET. It achieves 10A continuous output current over a wide input supply range with excellent load and line regulation.

Current mode operation provides fast transient response and eases loop stabilization.

Fault condition protection includes cycle-by-cycle current limiting and thermal shutdown.

The MP38876 requires a minimum number of readily available standard external components and is available in a 20-pin 3mm x 4mm QFN package.

The MP38876 is ideal for a wide range of applications including distributed power systems, pre-regulator for linear regulators, compact DC-DC regulators for PCB space limited platforms.

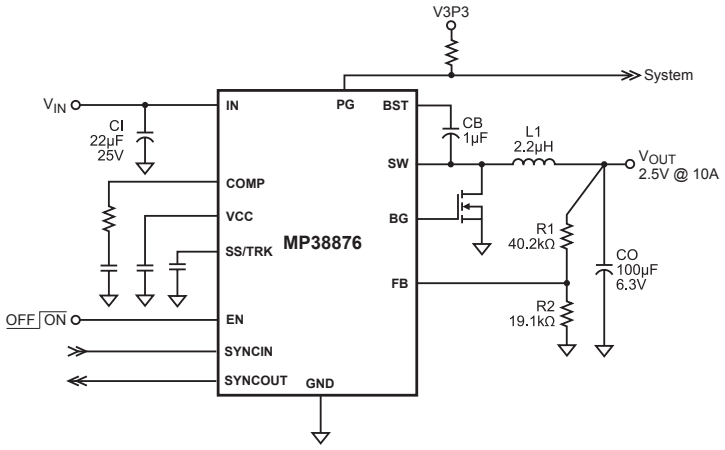
FEATURES

- Wide 4.5V to 28V Operating Input Range
- 10A Output Current
- 18mΩ Internal Power MOSFET Switch
- Synchronous Gate Driver Delivers up to 95% Efficiency
- Synch from 300HKz to > 1MHz External Clock
- Synch Output to Drive Another Regulator in Phase-Shift Operation
- Default 600KHz / 1.2MHz Switching Frequency
- Feedback Voltage Accuracy: 1.5%
- Programmable Soft-Start
- Startup Tracking
- EN and Power Good for Power Sequencing
- Cycle-by-Cycle Over Current Protection
- Thermal Shutdown
- Output Adjustable from 0.8V to 15V
- Stable with Low ESR Output Ceramic Capacitors
- Available in a 3mm x 4mm QFN Package

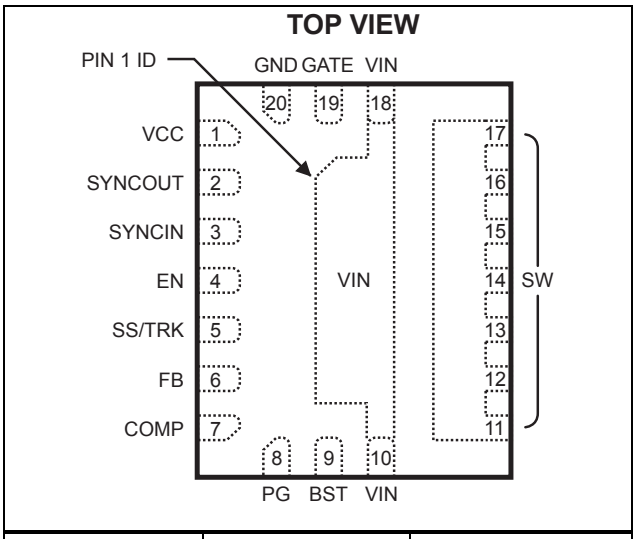
APPLICATIONS

- Distributed Power Systems
- Pre-Regulator for Linear Regulators
- Compact DC-DC Regulator for PCB Space Limited Platforms

TYPICAL APPLICATION



PACKAGE REFERENCE



Part Number*	Package	Temperature
MP38876DN	3mm x 4mm QFN	–40°C to +85°C

* For Tape & Reel, add suffix –Z (eg. MP38876DN–Z)
For RoHS compliant packaging, add suffix –LF
(eg. MP38876DN–LF–Z)

ABSOLUTE MAXIMUM RATINGS (1)

Supply Voltage V_{IN} 30V
V_{SW} ..... –0.3V to V_{IN} + 0.3V
V_{BS} ..... V_{SW} + 6V
All Other Pins ..... –0.3V to +6V
Junction Temperature ..... 150°C
Lead Temperature ..... 260°C
Storage Temperature ..... –65°C to +150°C

Recommended Operating Conditions (2)

Supply Voltage V_{IN} ..... 4.5V to 28V
Output Voltage V_{OUT} ..... 0.8V to V_{IN} -7V
Operating Temperature ..... –40°C to +85°C

Thermal Resistance (3)

	θ_{JA}	θ_{JC}	
QFN (3mm x 4mm)	48	11	°C/W

Notes:
1) Exceeding these ratings may damage the device.
2) The device is not guaranteed to function outside of its operating conditions.
3) Measured on approximately 1" square of 1 oz copper.

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, T_A = +25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Feedback Voltage	V_{FB}	4.5V ≤ V_{IN} ≤ 28V	0.798	0.810	0.822	V
Feedback Current	I_{FB}	V_{FB} = 0.8V		10		nA
Switch On Resistance (4)	$R_{DS(ON)}$			18		mΩ
Switch Leakage		V_{EN} = 0V, V_{SW} = 0V		0	10	μA
Current Limit (4)			12	15	18	A
Oscillator Frequency	f_{SW}	V_{FB} = 0.6V, $SYNC_{IN}$ = 5V		600		KHz
Fold-back Frequency		V_{FB} = 0V		150		KHz
Maximum Duty Cycle		V_{FB} = 0.6V		90		%
Minimum On Time	t_{ON}	V_{FB} = 1V		100		ns
Soft-Start Charging Current	I_{SS}	V_{SS} = 0V		2.2		μA
COMP Threshold for Switching	V_{COMP_LOW}			TBD		V
Maximum COMP Level	V_{COMP_MAX}	V_{FB} = 0.6V		TBD		V
Gain of Error Amplifier	G_{EA}	V_{COMP} = 1.5V		2.4		mA/V
Error Amplifier Sink Current		V_{COMP} = 1.5V		–200		μA
Error Amplifier Source Current		V_{COMP} = 1.5V		+200		μA
Gain of Internal Current Sense	G_{CS}			TBD		A/V
Slope Compensation	V_{SLOPE}			TBD		V
Power Good Ramp Up Threshold				90		%
Power Good Ramp Down Threshold				85		%

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, T_A = +25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Power Good Delay				20		µs
Power Good Sink Current Capability	V_{PG}	Sink 4mA			0.4	V
Power Good Leakage Current	I_{PG_LEAK}	V_{PG} = 3.3V			10	nA
V_{CC} Tolerance	V_{CC}	I_{CC} = 0mA	4.5	5	5.5	V
V_{CC} Regulation		I_{CC} = 0~20mA		5		%
Sync Frequency	F_{SYNC}		0.3		TBD	MHz
SYNCIN Bias Current	I_{SYNCIN}			10		nA
SYNCIN Logic High Voltage			1.2			V
SYNCIN Logic Low Voltage					0.4	V
SYNCHOUT High Level		V_{CC} = 5V, Source 5mA		4.6		V
SYNCHOUT Low Level		V_{CC} = 5V, Sink 5mA		0.4		V
Under Voltage Lockout Threshold Rising			3.75	4.0	4.25	V
Under Voltage Lockout Threshold Hysteresis				880		mV
EN Input Low Voltage					0.4	V
En Input High Voltage			1.2			V
EN Input Current		V_{EN} = 2V		2		µA
		V_{EN} = 0V		0		
Supply Current (Shutdown)		V_{EN} = 0V		0		µA
Supply Current (Quiescent)		V_{EN} = 2V, V_{FB} = 1V			1.2	mA
Thermal Shutdown				150		°C
Gate Driver Sink Impedance	R_{SINK}			1		Ω
Gate Driver Source Impedance	R_{SOURCE}			4		Ω
Gate Drive Current Sense Trip Threshold				20		mV
Gate Drive Non-Overlap Time (see Figure 1)	T_{d1}	From BG low to SW high		10		ns
	T_{d2}	From SW low to BG high		10		ns

Note:

4) Guaranteed by design.

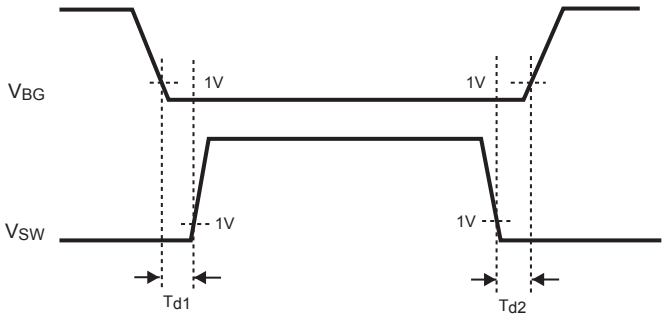


Figure 1—Gate Drive Non-Overlap Time Diagram

PIN FUNCTIONS

Pin #	Name	Description
1	VCC	BG Driver Bias Supply. Decouple with a 1µF ceramic capacitor.
2	SYNCOUT	Timing output to drive another MP38876 (or similar device) SYNCIN for phase-shift operation.
3	SYNCIN	External Frequency Synchronization / Frequency Select Input. Connect to V_{CC} for 600KHz or connect to ground for 1.2MHz.
4	EN	On/Off Control.
5	SS/TRK	Soft-Start/Track Input. Connect a capacitor to ground.
6	FB	Feedback. An external resistor divider from the output to GND, tapped to the FB pin, sets the output voltage. To prevent current limit run away during a short circuit fault condition the frequency foldback comparator lowers the oscillator frequency when the FB voltage is below 400mV.
7	COMP	Compensation. Connect R/C network to ground.
8	PG	Power Good Indicator. The output of this pin is an open drain if the output voltage is within 10% of the nominal voltage, otherwise it is LOW. Optional: If PG is initially at open drain, there is a 20µs delay to pull PG if the output voltage is less than 10% regulation window.
9	BST	Bootstrap. This capacitor is needed to drive the power switch's gate above the supply voltage. It is connected between SW and BS pins to form a floating supply across the power switch driver.
10, 18, Exposed Pad	VIN	Supply Voltage. The MP38876 operates from a +4.5V to +28V unregulated input. C1 is needed to prevent large voltage spikes from appearing at the input.
11-17	SW	Switch Output. These pins are fused together.
19	GATE	Gate Driver Output. Connect this pin to the synchronous MOSFET.
20	GND	Ground.

OPERATION

The MP38876 is a current mode buck regulator. That is, the EA output voltage is proportional to the peak inductor current.

At the beginning of a cycle, SW is off. The EA output voltage is higher than the current sense amplifier output, and the current comparator's output is low. The rising edge of the 600KHz CLK signal sets the RS Flip-Flop. Its output turns on SW thus connecting the SW pin and inductor to the input supply.

The increasing inductor current is sensed and amplified by the Current Sense Amplifier. Ramp compensation is summed to Current Sense Amplifier output and compared to the Error Amplifier output by the Current Comparator. When the sum of the Current Sense Amplifier and the Slope Compensation signal exceeds the EA output voltage, the RS Flip-Flop is reset and the MP38876 reverts to its initial SW off state.

If the sum of the Current Sense Amplifier and the Slope Compensation signal does not exceed the COMP voltage, then the falling edge of the CLK resets the Flip-Flop.

The output of the Error Amplifier integrates the voltage difference between the feedback and the 0.8V bandgap reference. The polarity is such that a FB pin voltage lower than 0.8V increases the EA output voltage. Since the EA output voltage is proportional to the peak inductor current, an increase in its voltage increases current delivered to the output.

An external synchronous MOSFET supplies the inductor current when the switch is off.

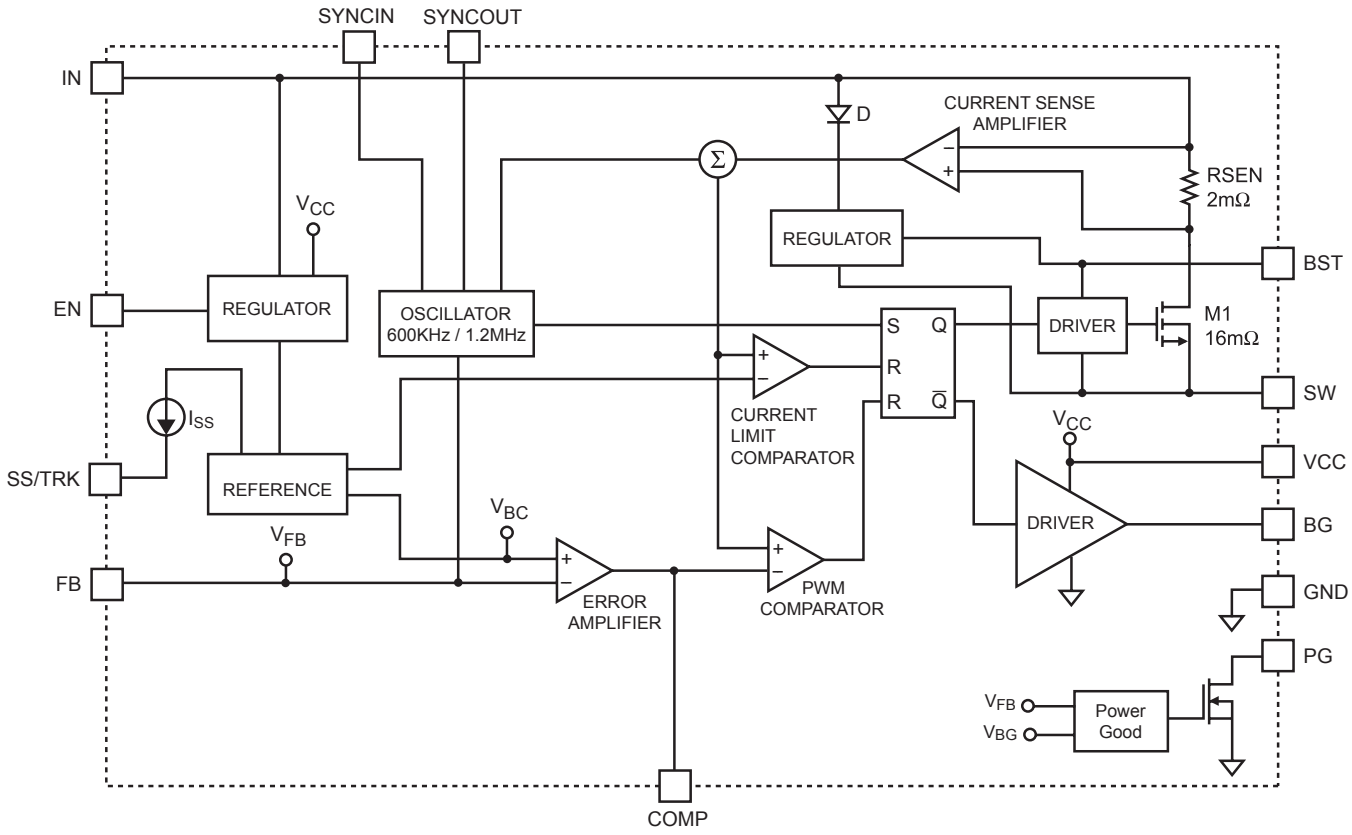


Figure 2—Functional Block Diagram

APPLICATION INFORMATION

Setting the Output Voltage

The external resistor divider is used to set the output voltage (see the Typical Application Circuit on the front page). The feedback resistor R1 also sets the feedback loop bandwidth with the internal compensation capacitor (see Figure 1). Choose R1 to be around 40.2kΩ for optimal transient response. R2 is then given by:

$$R2 = \frac{R1}{\frac{V_{OUT}}{0.8V} - 1}$$

Table 1—Resistor Selection for Common Output Voltages

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)
1.8	40.2 (1%)	32.4 (1%)
2.5	40.2 (1%)	19.1 (1%)
3.3	40.2 (1%)	13 (1%)
5	40.2 (1%)	7.68 (1%)

Selecting the Inductor

A 1μH to 10μH inductor with a DC current rating of at least 25% percent higher than the maximum load current is recommended for most applications. For highest efficiency, the inductor DC resistance should be less than 7mΩ. For most designs, the inductance value can be derived from the following equation.

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is the inductor ripple current.

Choose inductor current to be approximately 30% if the maximum load current, 10A. The maximum inductor peak current is:

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

Under light load conditions below 200mA, larger inductance is recommended for improved efficiency.

Synchronous MOSFET

The external synchronous MOSFET is used to supply current to the inductor when the internal high-side switch is off. It reduces the power loss significantly when compared against a Schottky rectifier.

Table 2 lists example synchronous MOSFETs and manufacturers.

Table 2—Diode Selection Guide

Manufacture	Part No.
Siliconix	TBD
IR	TBD

Selecting the Input Capacitor

The input capacitor reduces the surge current drawn from the input and also the switching noise from the device. The input capacitor impedance at the switching frequency should be less than the input source impedance to prevent high frequency switching current from pass to the input. 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.

Selecting the Output Capacitor

The output capacitor keeps output voltage small and ensures regulation loop stability. The output capacitor impedance should be low at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended.

PC Board Layout

The high current paths (GND, IN and SW) should be placed very to the device with short, direct and wide traces. The input capacitor needs to be as close as possible to the IN and GND pins. The external feedback resistors should be placed next to the FB pin. Keep the switching node SW short and away from the feedback network.

External Bootstrap Diode

It is recommended that an external bootstrap diode be added when the system has a 5V fixed input or the power supply generates a 5V output. This helps improve the efficiency of the regulator. The bootstrap diode can be a low cost one such as IN4148 or BAT54.

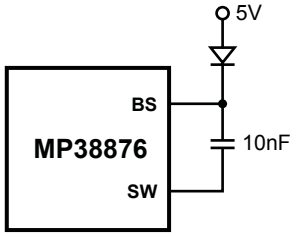
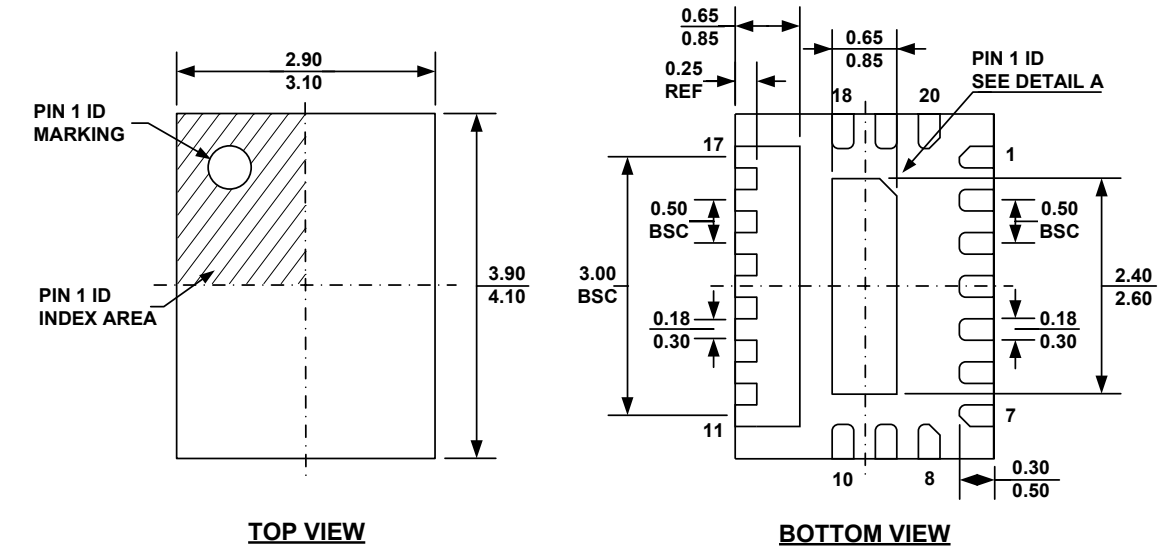


Figure 3—External Bootstrap Diode

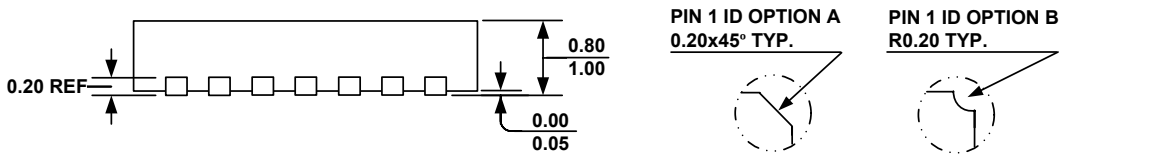
This diode is also recommended for high duty cycle operation (when $\frac{V_{OUT}}{V_{IN}}$ >65%) and high output voltage (V_{OUT}>12V) applications.

PACKAGE INFORMATION

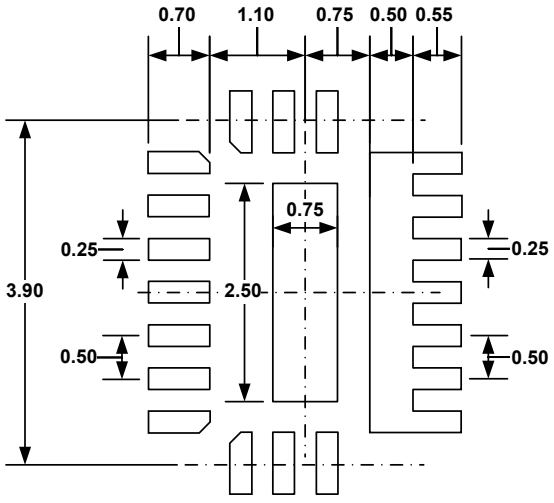
QFN20 (3mm x 4mm)



TOP VIEW **BOTTOM VIEW**



SIDE VIEW **DETAIL A**



RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX.
4) JEDEC REFERENCE IS MO-220, VARIATION VGED.
5) DRAWING IS NOT TO SCALE.