MPQ20082

40V, 300mA, Low-Quiescent Current, Adjustable Output Linear Regulator AEC-Q100 Qualified

DESCRIPTION

The MPQ20082 is a low-power linear regulator that supplies power to systems with high-voltage batteries. The MPQ20082 includes a wide 3V to 40V input voltage (V_{IN}) range, low-dropout voltage, and low quiescent supply current (I_Q). The low I_Q and low-dropout voltage allow for operation at extremely low power levels, making the MPQ20082 ideal for low-power microcontrollers (MCUs) and battery-powered equipment.

The MPQ20082 provides a 5V fixed output voltage (V_{OUT}) option, or adjustable-output options from 1.25V to 36V.

The regulator's output current (I_{OUT}) is limited internally, and the device is protected against short-circuit, overload, and over-temperature (OT) conditions. Full protection features include thermal shutdown (TSD), and current-limiting fault protection.

The MPQ20082 is available in an MSOP-8EP (3mmx4.85mm) package, and is AEC-Q100 qualified.

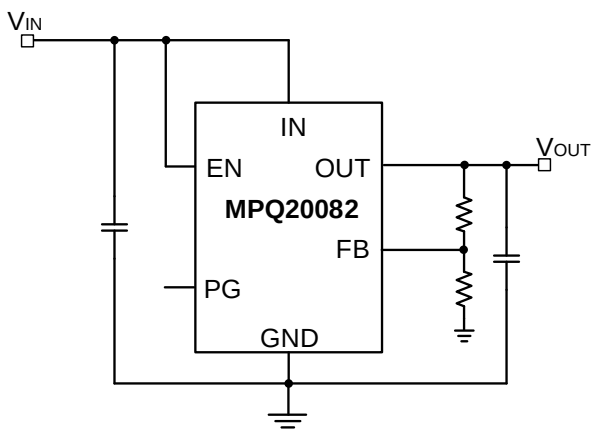
FEATURES

- Build to Handle Tough Automotive Transients
  - Guaranteed Industrial and Automotive Temperature
  - 3V to 40V Input Voltage (V_{IN}) Range
  - Adjustable 1.25V to 36V Output Voltage (V_{OUT})
  - ±2% Output Accuracy Over-Temperature
  - Stable with Low-Value Output Ceramic Capacitor (>0.47µF)
- Extends Vehicle Battery Life
  - 10µA Quiescent Supply Current (I_Q)
- Additional Features
  - 300mA Specified Current
  - Specified Current Limit
  - Power Good (PG)
  - Thermal Shutdown (TSD) and Short-Circuit Protection (SCP)
  - -40°C to +150°C Specified Junction Temperature (T_J) Range
  - Available in an MSOP-8EP (3mmx4.85mm) Package
  - Available in AEC-Q100 Grade 1

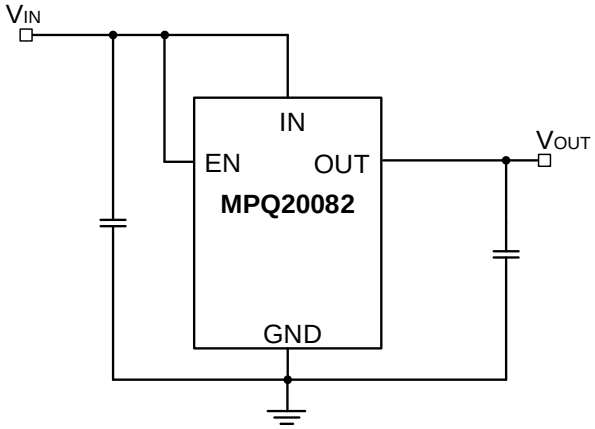
APPLICATIONS

- Industrial/Automotive Applications
- Portable/Battery-Powered Equipment
- Ultra-Low Power Microcontrollers (MCUs)
- Cellular Handsets
- Medical Imaging

TYPICAL APPLICATION



Adjustable-Output Version



Fixed-Output Version

ORDERING INFORMATION

Part Number*	Output Voltage	Package	Top Marking	MSL Rating**
MPQ20082GH-AEC1	Adjustable	MSOP-8EP	*See Below*	2
MPQ20082GH-5-AEC1	5.5V Fixed	MSOP-8EP		

* For Tape & Reel, add suffix -Z (e.g. MPQ20082GH-AEC1-Z).

** Moisture Sensitivity Level Rating

TOP MARKING (MPQ20082GH-AEC1)

YWLLL
20082

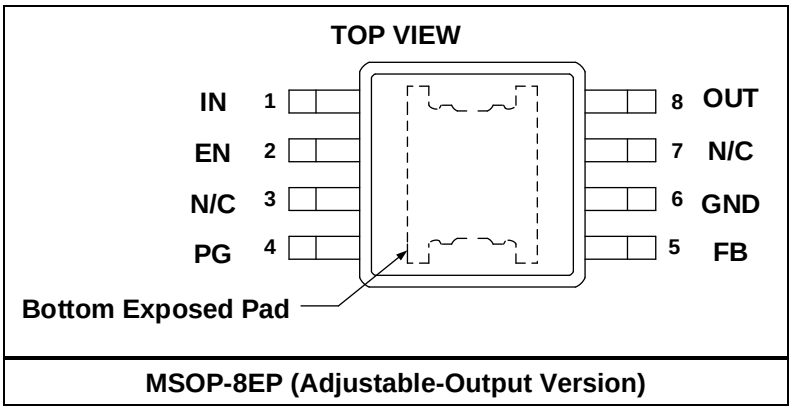
Y: Year code
W: Week code
LLL: Lot number
20082: Product code of MPQ20082GH-AEC1

TOP MARKING (MPQ20082GH-5-AEC1)

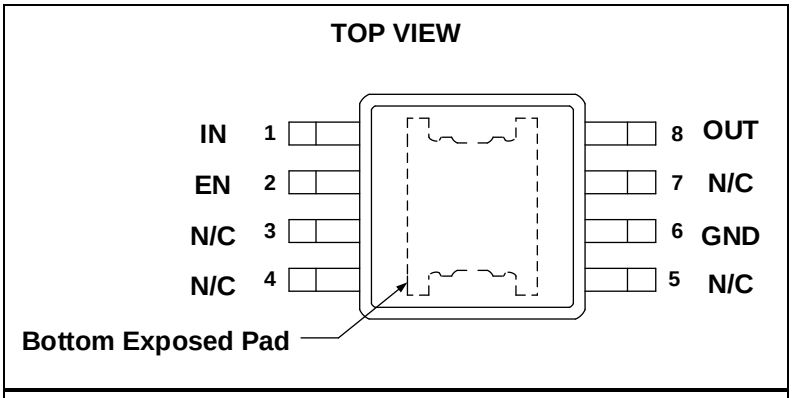
YWLLL
20082
5

Y: Year code
W: Week code
LLL: Lot number
20082: Product code of MPQ20082GH-5-AEC1
5: 5V fixed output

PACKAGE REFERENCE



MSOP-8EP (Adjustable-Output Version)



MSOP-8EP (Fixed-Output Version)

PIN FUNCTIONS

Pin #	Name	Description (Adjustable-Output Version)
1	IN	**Input supply.** This pin supplies all power to the device. Connect a 3V to 40V supply to the IN pin.
2	EN	**Enable.** Pull the EN pin above 1.8V to enable the device; pull it low (0.3V) to disable the device. Connect this pin to IN for automatic start-up.
3, 7	N/C	**No connection.** Leave these pins floating.
4	PG	**Power good (PG) indicator.** If not used, the PG pin can be left floating.
5	FB	**Feedback (FB) input.** Input to the control-loop error amplifier (EA). This pin is used to set the device's output voltage (V_{OUT}) with the use of external resistors. Do not float this pin. FB is regulated to 1.25V when the device is working normally.
6	GND	**Ground.** Connect the exposed pad and the GND pin to the same ground plane.
8	OUT	**Regulated output voltage.** A low-value ceramic capacitor (≥0.47μF) on the output must be placed for stability.
-	Exposed pad	The exposed pad (EP) has no internal electrical connection to GND. Connect EP to the ground plane to optimize thermal performance. If thermals are not critical, EP can be floated.

Pin #	Name	Description (Fixed-Output Version)
1	IN	**Input supply.** This pin supplies all power to the device. Connect a 3V to 40V supply to the IN pin.
2	EN	**Enable.** Pull the EN pin above 1.8V to enable the device; pull it low (0.3V) to disable the device. Connect this pin to IN for automatic start-up.
3, 4, 5, 7	N/C	**No connection.** Leave these pins floating.
6	GND	**Ground.** Connect the exposed pad and the GND pin to the same ground plane.
8	OUT	**Regulated output voltage.** A low-value ceramic capacitor (≥0.47μF) on the output must be placed for stability.
-	Exposed pad	The exposed pad (EP) has no internal electrical connection to GND. Connect EP to the ground plane to optimize thermal performance. If thermals are not critical, EP can be floated.

ABSOLUTE MAXIMUM RATINGS (1)

IN, EN ..... -0.3V to +42V
OUT ..... -0.3V to +40V
PG ..... -0.3V to +15V
FB ..... -0.3V to +6V
Junction temperature (T_J) ..... +150°C
Lead temperature ..... +260°C
Storage temperature (T_{STG}) ..... -65°C to +150°C
Continuous power dissipation 3.125W (2)

ESD Ratings

Human body model (HBM) ..... Class 2 (3)
Charged-device model (CDM) ..... Class C2b (4)

Recommended Operating Conditions

Supply voltage (V_{IN}) ..... 3V to 40V
Output voltage (V_{OUT}) ..... 1.25V to 36V
Operating junction temp (T_J) .... -40°C to +150°C

Thermal Resistance θ_{JA} θ_{JC}

MSOP-8EP (3mmx4.85mm)
JESD51-7……..….49.4.….10.6…°C/W (5)
EVQ20082-H-00A……....40…….....°C/W (6)

Ψ_{JT}

JESD51-7…….……....24.6…...°C/W (5)
EVQ20082-H-00A…….....29.....°C/W (6)

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 produce an excessive die temperature, which may cause the regulator to go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) Per AEC-Q100-002.
4) Per AEC-Q100-011.
5) Measured on a 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. The value of θ_{JC} shows the thermal resistance from junction-to-case bottom. The value of Ψ_{JT} shows the characterization parameter from junction-to-case top.
6) Measured on an MPS MPQ20082 standard EVB: 6.35cmx6.35cm, 2oz copper thickness, 2-layer PCB. The value of Ψ_{JT} shows the characterization parameter from junction-to-case top.

.

ELECTRICAL CHARACTERISTICS

V_{IN} = V_{EN} = 13.5V, T_J = -40°C to +150°C, typical values are at T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition		Min	Typ	Max	Units
Input voltage	V_{IN}			3		40	V
Output voltage range	V_{OUT}			1.25		36	V
Ground current	I_{GND}	MPQ20082GH	0A < I_{LOAD} < 1mA		10	15	µA
			1mA<I_{LOAD} < 30mA		15	21	
			30mA < I_{LOAD} < 300mA		65	95	
		MPQ20082GH-5	0A < I_{LOAD} < 1mA		12	16	µA
			1mA < I_{LOAD} < 30mA		16	22	
			30mA < I_{LOAD} < 300mA		65	95	
Shutdown supply current	I_{SD}	V_{EN} = 0V				1	µA
Load current limit	I_{LIMIT}	V_{IN} = 7V, V_{OUT} = 0V, T_A = 25°C		600	1000	1350	mA
Feedback (FB) voltage	V_{FB}	MPQ20082GH	FB = OUT, I_{LOAD} = 5mA	1.225	1.25	1.275	V
FB input current	I_{FB}	MPQ20082GH	V_{FB} = 1.3V			50	nA
V_{OUT} accuracy		MPQ20082GH-5, I_{LOAD} = 5mA		4.85	5	5.15	V
Low-dropout voltage (7)	$V_{DROPOUT}$	MPQ20082GH	V_{OUT} = 5V, I_{LOAD} = 150mA		200	400	mV
			T_A = 25°C, V_{OUT} = 5V, I_{LOAD} = 300mA		420	550	
		MPQ20082GH-5	V_{OUT} = 5V, I_{LOAD} = 150mA		230	430	
			T_A = 25°C, V_{OUT} = 5V, I_{LOAD} = 300mA		480	640	
Line regulation		MPQ20082GH	V_{IN} = 3V to 40V, I_{LOAD} = 5mA, V_{OUT} = V_{FB}	-10	1	+10	mV
		MPQ20082GH-5	V_{IN} = 6V to 40V, I_{LOAD} = 5mA, V_{OUT} = 5V	-10	1	+10	
Load regulation		MPQ20082GH	I_{LOAD} = 5mA to 300mA, V_{OUT} = 5V,T_A = +25°C		1	15	mV
		MPQ20082GH-5	I_{LOAD} = 5mA to 300mA, V_{OUT} = 5V,T_A = +25°C		1	15	
V_{OUT} PSRR (8)		100Hz, C_{OUT} = 10µF, I_{LOAD} = 10mA			57		dB
		1kHz, C_{OUT} = 10µF, I_{LOAD} = 10mA			45		
		100kHz, C_{OUT} = 10µF, I_{LOAD} = 10mA			51		
Start-up response time		MPQ20082GH	R_{LOAD} = 500Ω, V_{OUT} = 5V, C_{OUT} = 22µF, V_{OUT} from 10% to 90%		0.9	1.5	ms
		MPQ20082GH-5	R_{LOAD} = 500Ω, V_{OUT} = 5V, C_{OUT} = 22µF, V_{OUT} from 10% to 90%		0.9	1.5	
EN threshold voltage	V_{IL}					0.3	V
	V_{IH}			1.8			V

ELECTRICAL CHARACTERISTICS *(continued)*

V_{IN} = V_{EN} = 13.5V, T_J = -40°C to +150°C, typical values are at T_J = 25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
EN input current		EN = 0V or 15V		0.1	0.5	µA
Thermal shutdown (8)	T_{SD}			165		°C
Thermal shutdown hysteresis (8)	ΔT_{SD}			30		°C
PG Function (Only Applicable for the MPQ20082GH)						
PG rising threshold			89%	93%	97%	V_{FB}
PG rising threshold hysteresis				5%		V_{FB}
PG low voltage		Sink 1mA current		0.1	0.4	V
PG leakage current		V_{PG} = 5V			1	µA

Notes:

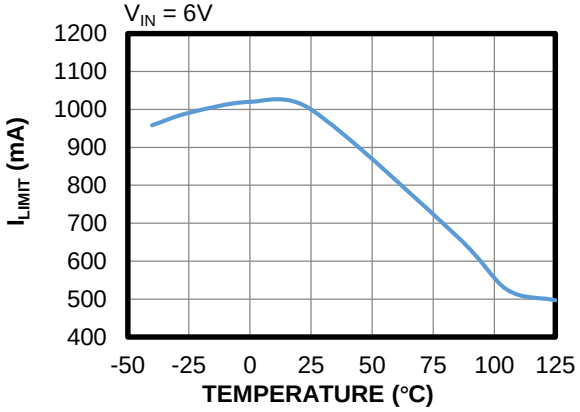
7) Low-dropout voltage: Measured when V_{OUT} has dropped 100mV from the nominal value obtained at V_{IN} = 13.5V.
8) Derived from bench characterization. Not tested in production.

TYPICAL CHARACTERISTICS

V_{IN} = 13.5V, T_J = -40°C to +150°C, unless otherwise noted.

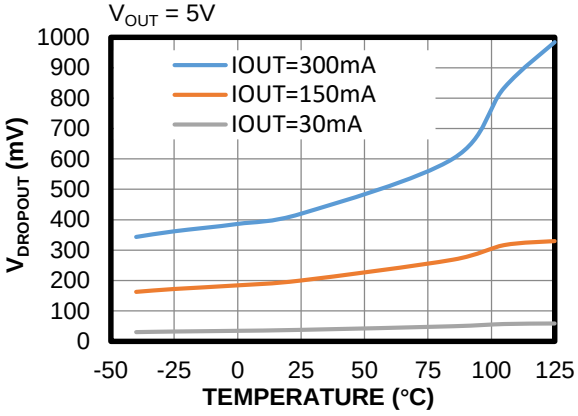
Load Current Limit vs. Temperature

V_{IN} = 6V



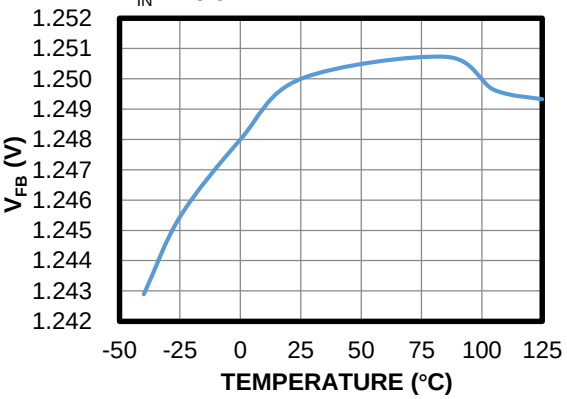
Low-Dropout Voltage vs. Temperature

V_{OUT} = 5V



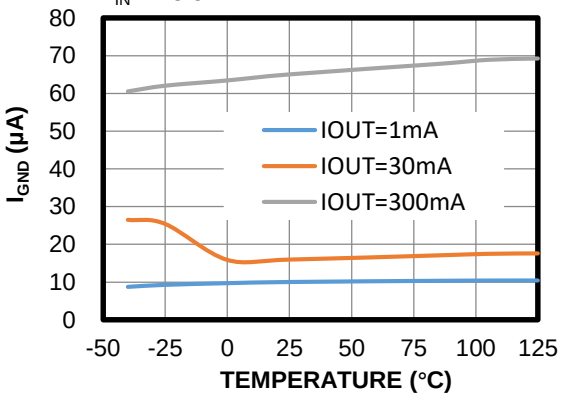
Feedback Voltage vs. Temperature

V_{IN} = 13.5V



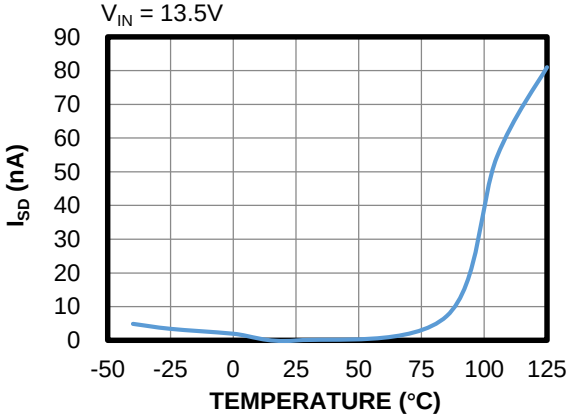
Ground Current vs. Temperature

V_{IN} = 13.5V



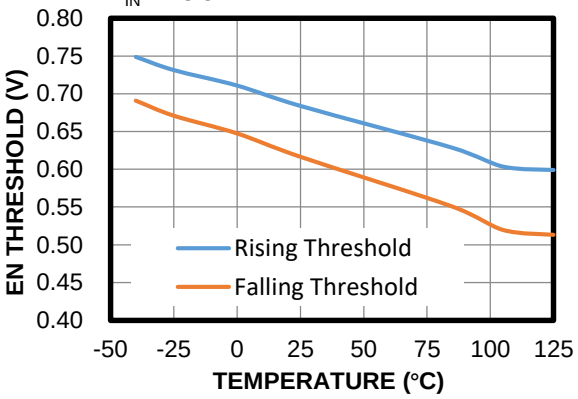
Shutdown Current vs.Temperature

V_{IN} = 13.5V



EN Threshold vs.Temperature

V_{IN} = 13.5V

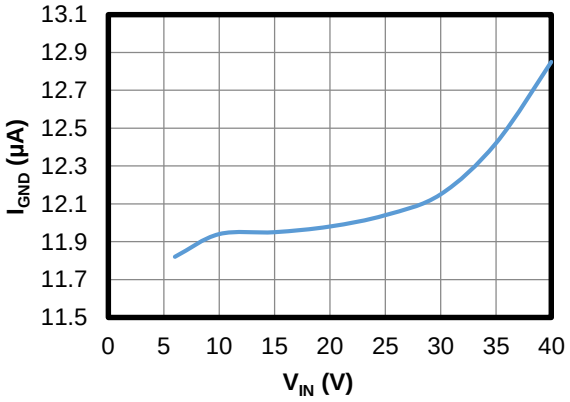


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 13.5V, C_{OUT} = 22µF, T_A = 25°C, unless otherwise noted.

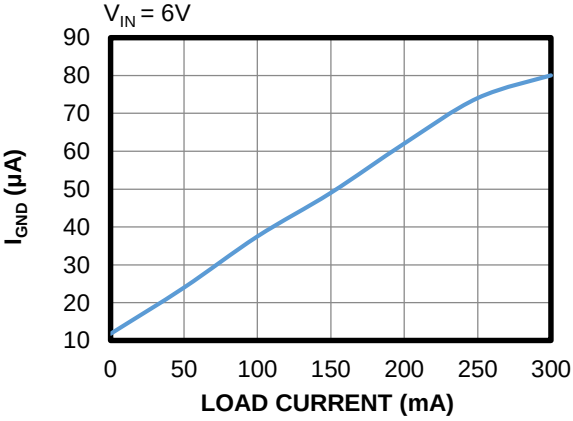
Ground Current vs. Input Voltage

I_{OUT} = 0mA



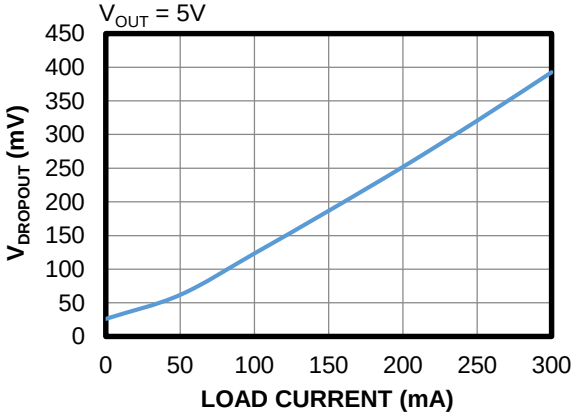
Ground Current vs. Load Current

V_{IN} = 6V



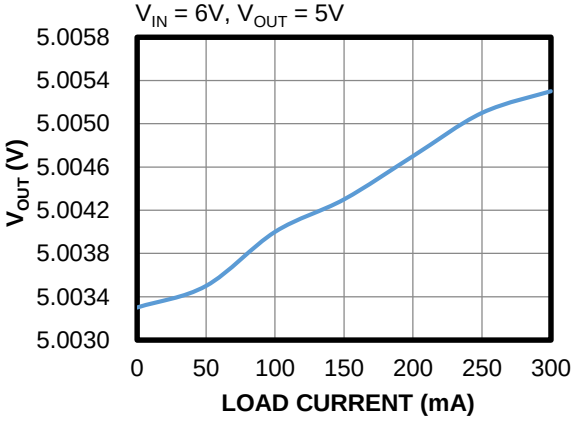
Low-Dropout Voltage vs. Load Current

V_{OUT} = 5V



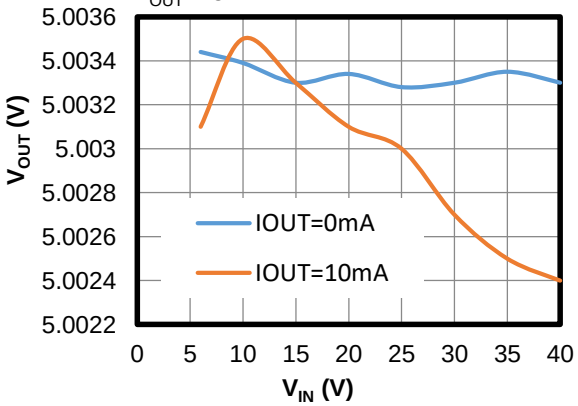
Output Voltage vs. Load Current

V_{IN} = 6V, V_{OUT} = 5V



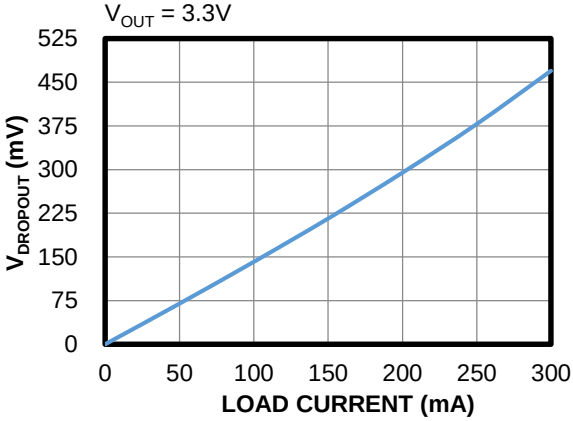
Output Voltage vs. Input Voltage

V_{OUT} = 5V



Low-Dropout Voltage vs. Load Current

V_{OUT} = 3.3V

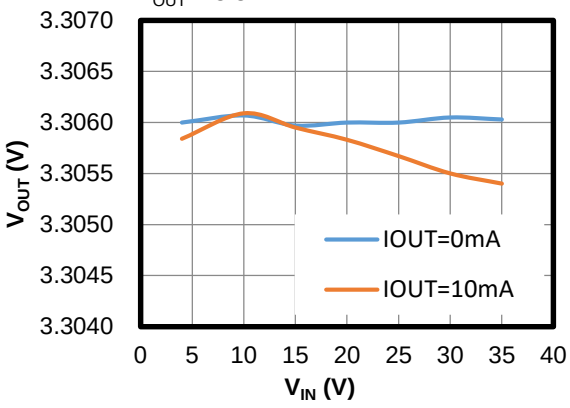


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 13.5V, C_{OUT} = 22µF, T_A = 25°C, unless otherwise noted.

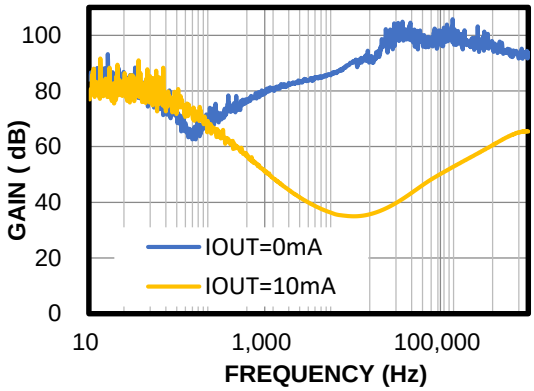
Output Voltage vs. Input Voltage

V_{OUT} = 3.3V



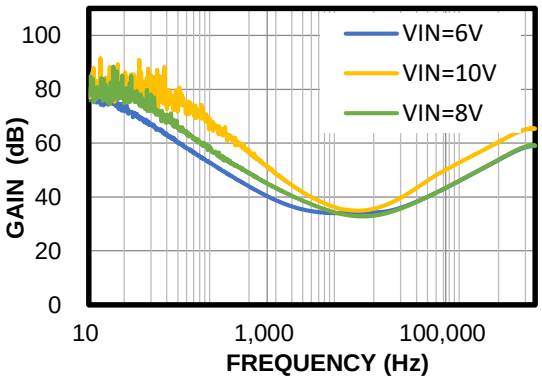
PSRR vs. Frequency

V_{OUT} = 5V



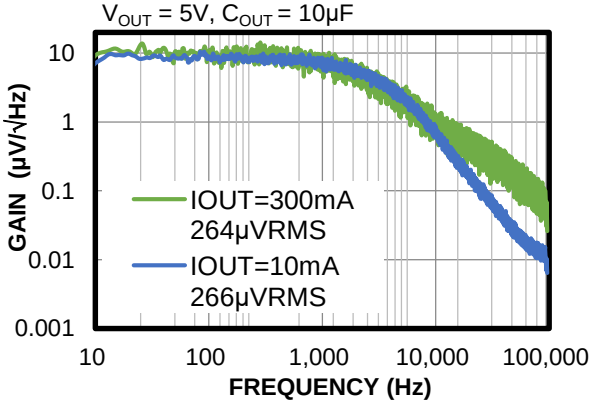
PSRR vs. Frequency

I_{OUT} = 10mA



Noise vs. Frequency

V_{OUT} = 5V, C_{OUT} = 10µF

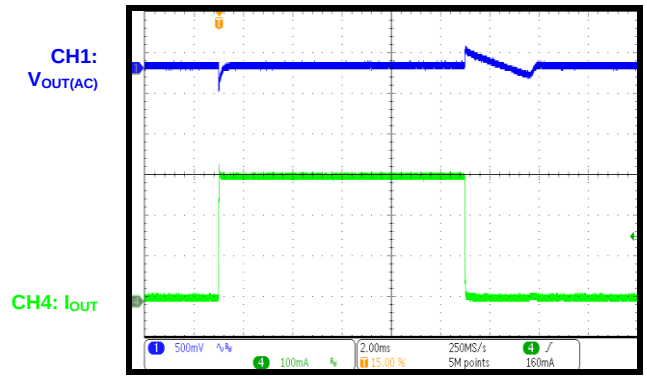


TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN} = 1µF, C_{OUT} = 22µF, V_{OUT} = 5V, unless otherwise noted.

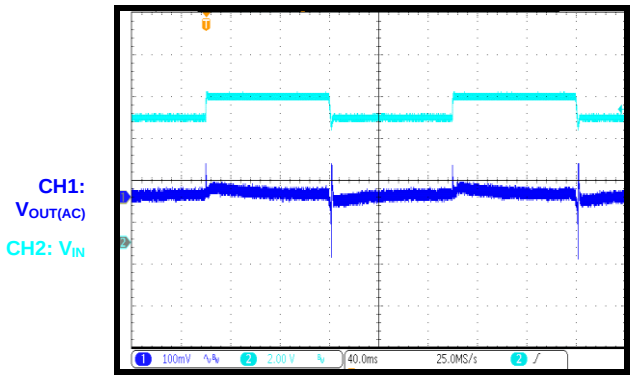
Load Transient

V_{IN} = 12V, I_{OUT} = 0A to 300mA



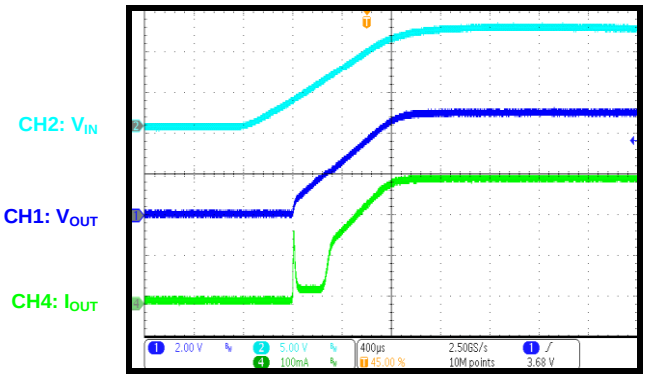
Line Transient

V_{IN} = 6V to 7V, I_{OUT} = 300mA



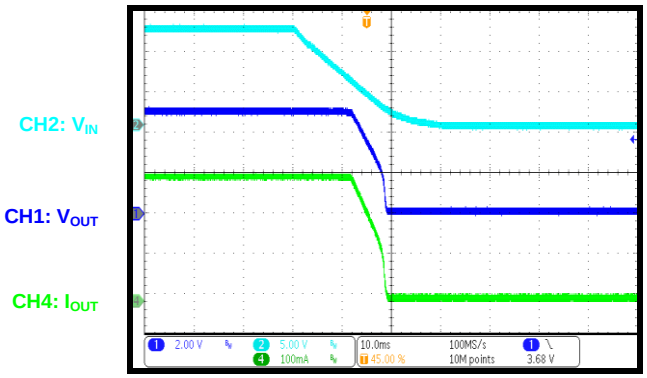
Start-up through VIN

V_{IN} = 12V, I_{OUT} = 300mA



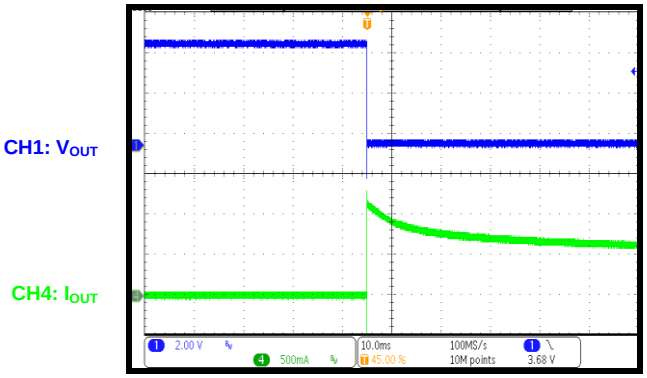
Shutdown through VIN

V_{IN} = 12V, I_{OUT} = 300mA



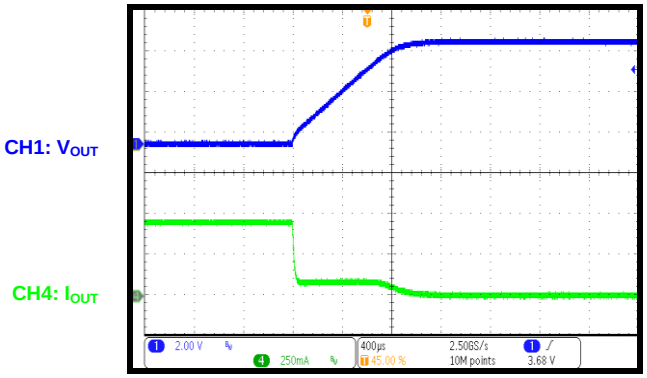
Short-Circuit Protection Entry

V_{IN} = 12V, I_{OUT} = 0mA to short circuit



Short-Circuit Protection Recovery

V_{IN} = 12V, short circuit to I_{OUT} = 0mA

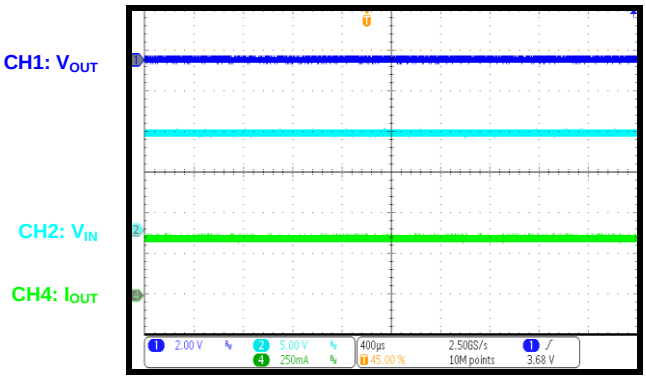


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

C_{IN} = 1µF, C_{OUT} = 22µF, V_{OUT} = 5V, unless otherwise noted.

Short-Circuit Protection Steady State

V_{IN} = 12V



FUNCTIONAL BLOCK DIAGRAM

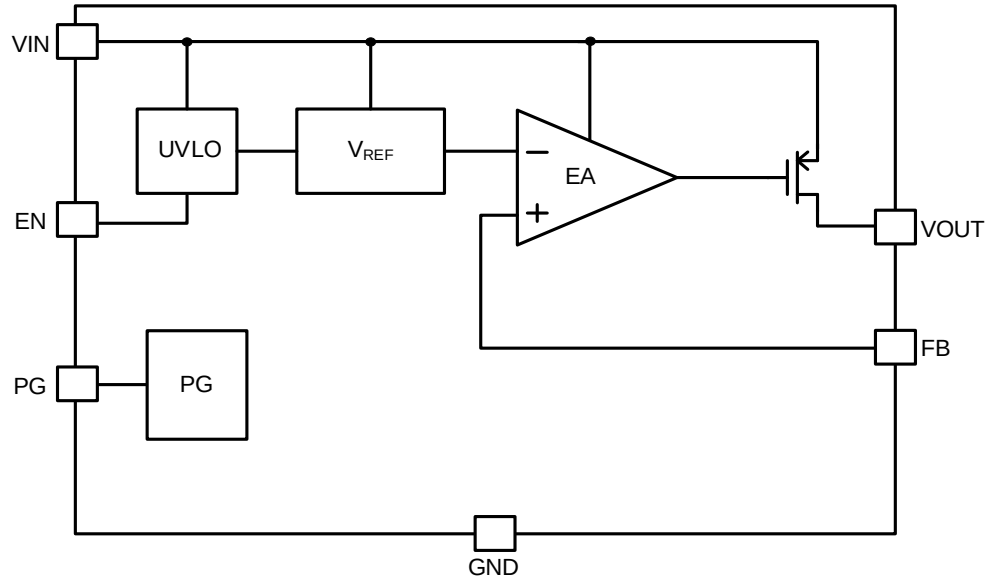


Figure 1: Functional Block Diagram (Adjustable-Output Version)

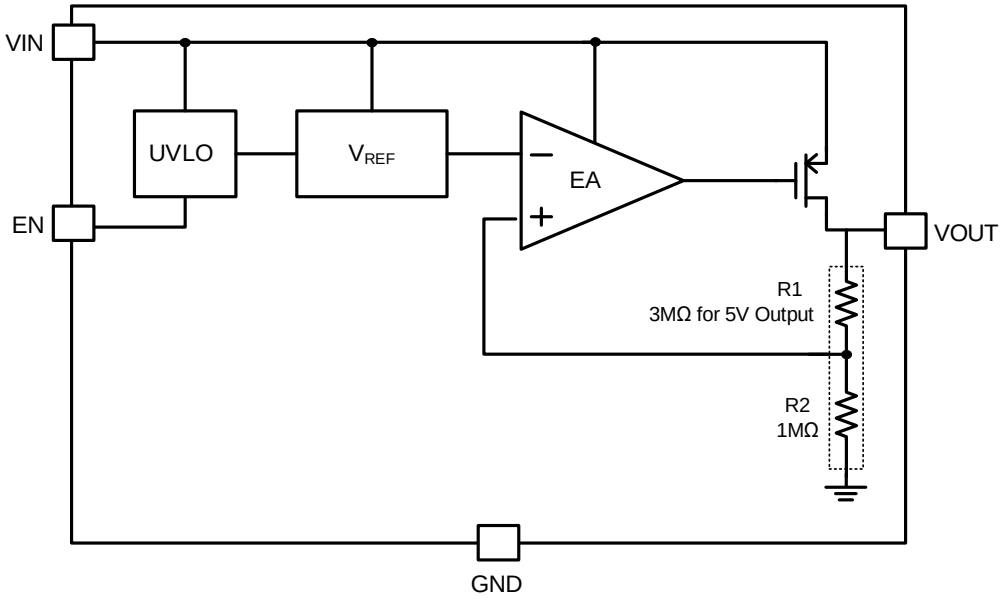


Figure 2: Functional Block Diagram (Fixed-Output Version)

OPERATION

The MPQ20082 is a linear regulator that supplies power to systems with high-voltage (HV) batteries. It includes a wide 3V to 40V input voltage (V_{IN}) range, low-dropout voltage, and low quiescent current (I_Q). Figure 1 and Figure 2 on page 14 show the MPQ20082's operation.

The MPQ20082's output voltage (V_{OUT}) is adjustable from 1.25V to 36V with a simple resistor divider. The IC uses external feedback, allowing the user to set V_{OUT} with an external resistor divider. The FB voltage (V_{FB}) threshold is typically 1.25V. The MPQ20082 also provides a 5V fixed V_{OUT} option.

If EN goes below 0.3V, the IC enters shutdown mode. In shutdown mode, the pass transistor, control circuitry, internal reference voltage (V_{REF}), and all biases are turned off. This reduces I_Q to less than 1µA. Connect EN to IN for automatic start-up.

The regulator's output current (I_{OUT}) is limited internally, and the device is protected against short-circuit, overload, and over-temperature (OT) conditions (see Figure 3 on page 16).

The peak I_{OUT} is limited to about 1000mA, which exceeds the recommended 300mA continuous I_{OUT}.

If the junction temperature (T_J) exceeds 165°C, the thermal sensor sends a signal to the control logic that shuts down the IC. Once the temperature has cooled sufficiently, the IC restarts and resumes normal operation.

The maximum I_{OUT} is a function of the package's maximum power dissipation for a given temperature.

The maximum power dissipation is dependent on the thermal resistance of the case and the PCB, the temperature difference between the die junction and the ambient air, and the rate of airflow. The GND pin and the exposed pad must be connected to the ground plane for proper dissipation.

The MPQ20082 has one power good (PG) pin. The PG pin is the open drain of an internal MOSFET. It should be connected to V_{OUT} or an external voltage source (<15V) through a resistor (e.g. 100kΩ). After V_{FB} reaches 93% of its nominal value, the MOSFET turns off and PG is pulled to high by V_{OUT} or an external voltage source. When V_{FB} drops to 88% of its nominal value, the PG voltage is pulled to GND.

Figure 3 on page 16 shows the PG timing.

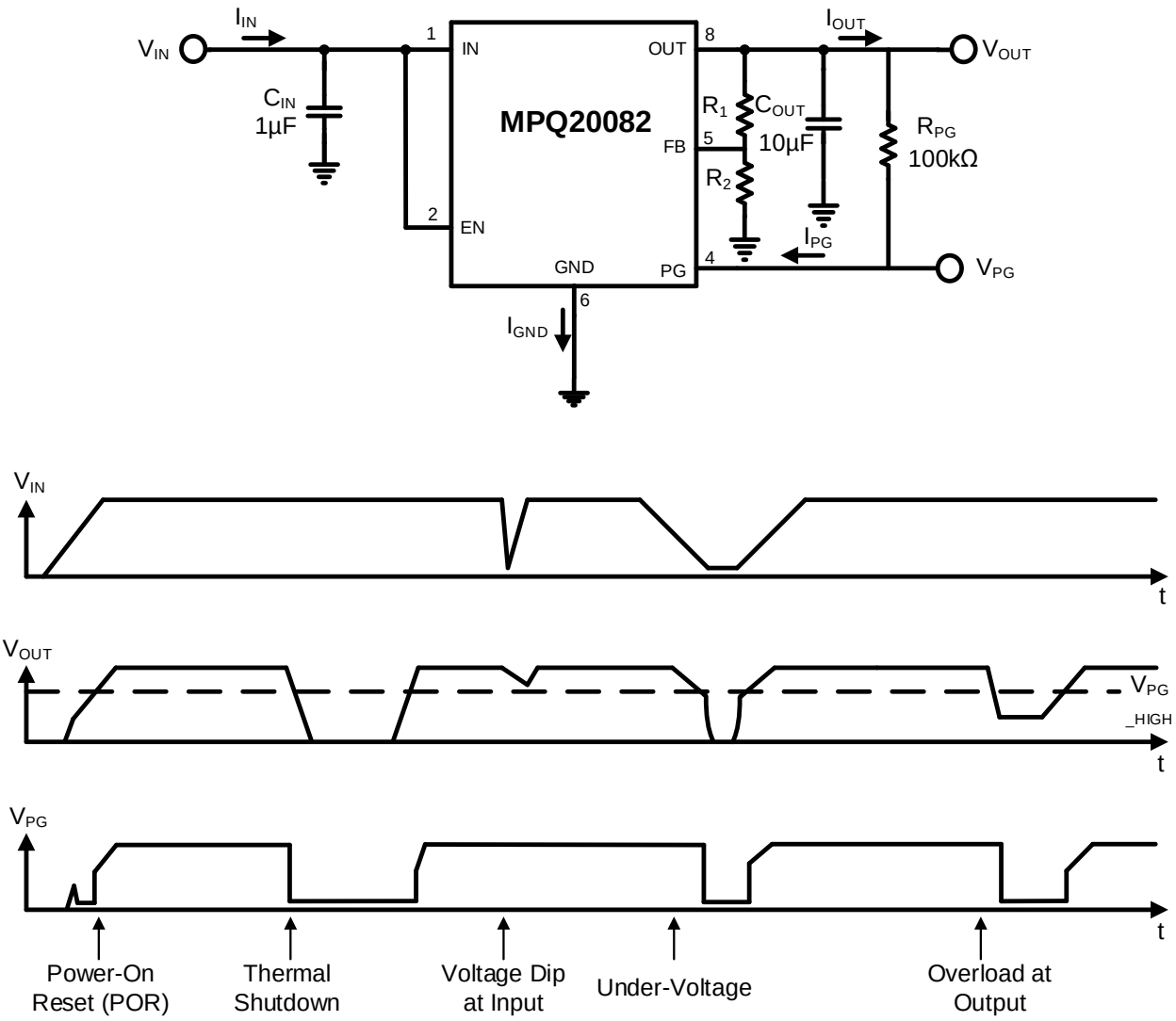


Figure 3: Power Good Timing

APPLICATION INFORMATION

Figure 4 and Figure 5 show typical application circuits for the MPQ20082. Table 1 shows the design guide index.

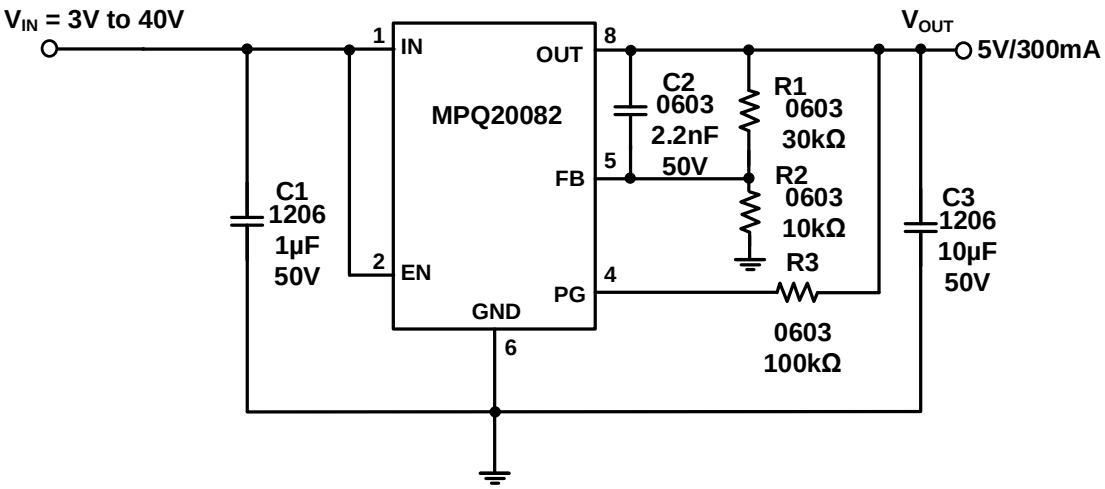


Figure 4: Typical Application Circuit (V_{OUT} = 5V, Adjustable-Output Version)

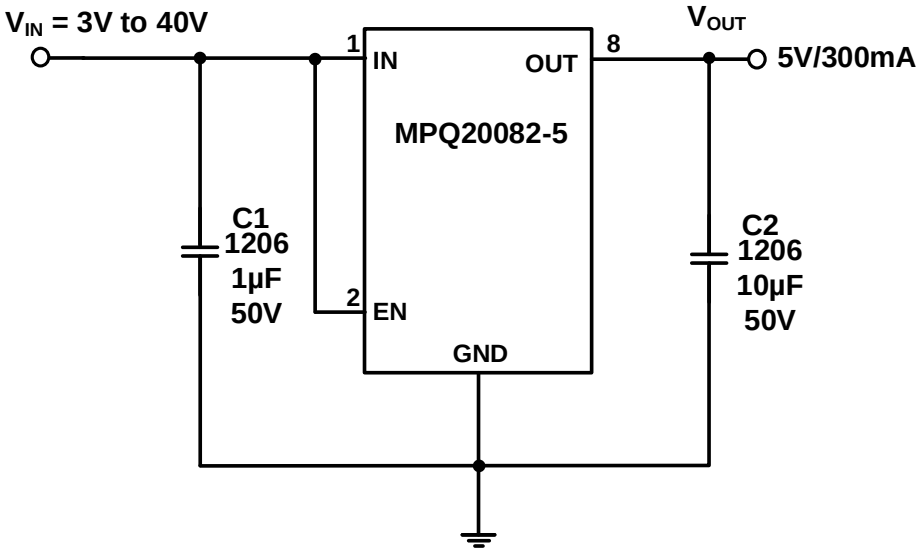


Figure 5: Typical Application Circuit (V_{OUT} = 5V, Fixed-Output Version)

Table 1: Design Guide Index

Pin #	Pin Name	Component	Design Guide Index
1	IN	C1	Selecting the input capacitor (IN, Pin 1)
2	EN	-	Enable Control (EN, Pin 2)
4	PG	R3	Selecting the PG Pull-Up Resistor (PG, Pin 4)
5	FB	R1, R2, C3	Selecting the FB Resistors and Capacitor (FB, Pin 5)
6	GND	-	Ground Connection (GND, Pin 6)
8	OUT	C2	Selecting the Output Capacitor (OUT, Pin 8)

Selecting the Input Capacitor (IN, Pin 1)

For efficient operation, it is recommended to place a 1µF to 10µF, X5R or X7R dielectric, ceramic capacitor (C1) between the IN pin and ground to stabilize the input voltage (V_{IN}). Larger capacitances in this range improve line transient response.

Enable Control (EN, Pin 2)

EN is a digital control pin that turns the regulator on and off. When EN is pulled below 0.3V, the chip shuts down. When EN is pulled above 1.8V, the chip starts up. If this function is not used, connect this pin to V_{IN} for automatic start-up.

Selecting the PG Pull-Up Resistor (PG, Pin 4)

The PG pull-up resistor is recommended to be 100kΩ. PG is powered by V_{OUT}, and monitors the status of the part.

Selecting the FB Resistors and Capacitor (FB, Pin 5)

For the adjustable-output version, V_{OUT} voltage can be set using a resistor divider (see Figure 6).

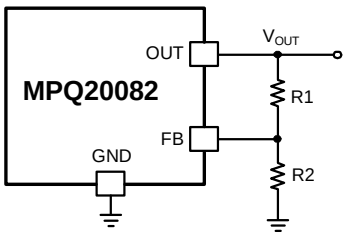


Figure 6: External Resistor Divider

If R2 is known, R1 can be calculated with Equation (1):

$$R1 = R2 \times \left(\frac{V_{OUT}}{1.25V} - 1 \right) \quad (1)$$

For the fixed-output version, V_{OUT} can also be adjusted by adding an external resistor divider. When choosing an external divider, be sure to take the internal feedback (FB) resistor divider into consideration (see Figure 7).

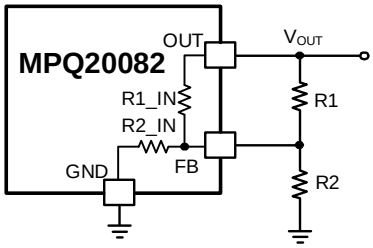


Figure 7: FB Divider for the Fixed-Output Version

When R2 is selected, R1 can be calculated with Equation (2):

$$R1 = \frac{R1\_IN}{\frac{1.25 \times R1\_IN \times (R2 + R2\_IN)}{(V_{OUT} - 1.25) \times R2 \times R2\_IN} - 1} \quad (2)$$

Table 2 shows the internal FB resistor dividers for the fixed-output version.

Table 2: Internal FB Resistor Divider

Fixed V_{OUT}	R1_IN	R2_IN
5V	3MΩ	1MΩ

Table 3 shows an example of various V_{OUT} values using an external FB resistor divider.

Table 3: Output External FB Resistor Divider

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)
10	69.8	10
8.5	57.6	10
8	53.6	10
6.5	42.2	10
5	30	10

To improve load transient response, add a 2.2nF, ceramic (X5R, X7R, or Y5V dielectric), feed-forward capacitor (C3) in parallel with R1. C3 is not required for stable operation.

GND Connection (GND, Pin 6)

Ground connection. See the PCB Layout Guidelines section on page 19 for more details.

Selecting the Output Capacitor (OUT, Pin 8)

For stable operation, place a 1µF to 22µF, X5R or X7R type ceramic capacitor (C2) as close as possible to the IC. A 10µF is typically sufficient to stabilize V_{OUT}. Larger values in this range improve load transient response and reduce noise. Output capacitors of other dielectric types may be used but are not recommended, as their capacitance can deviate greatly from their rated value over-temperature.

Output Noise

The MPQ20082 exhibits noise on the output during normal operation. This noise is negligible for most applications. However, in applications that include analog-to-digital converters (ADCs)of more than 12 bits, consider the ADC's power supply rejection specifications. C3 across R1 significantly reduces output noise.

External Reverse-Voltage Protection (RVP)

In some situations (e.g. if a backup battery is connected as the MPQ20082's load), V_{OUT} may be held up while V_{IN} is pulled to ground, pulled to some intermediate voltage, or is floating. In this circumstance, V_{OUT} exceeds V_{IN}. Since the MPQ20082's P-channel MOSFET pass element has a body diode, a current is conducted from the output to input and is not internally limited. To avoid this unlimited reverse current potentially damaging the IC, it is recommended to place an external diode at the input (see Figure 8).

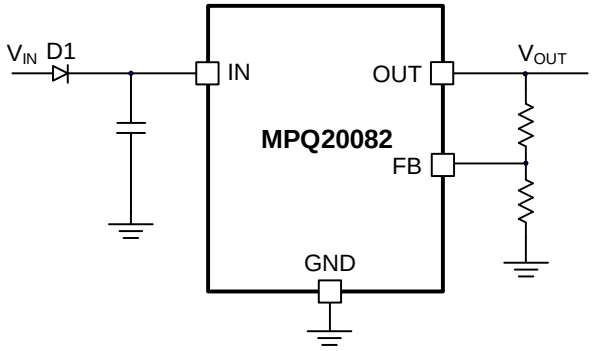
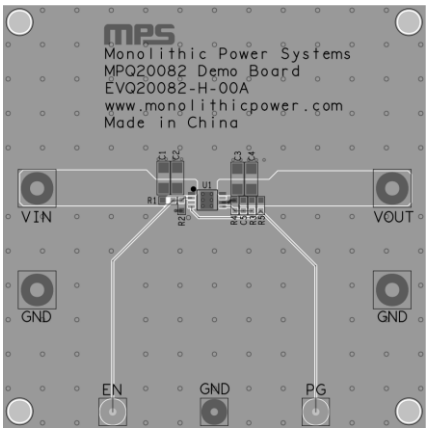


Figure 8: Adding an Input Diode

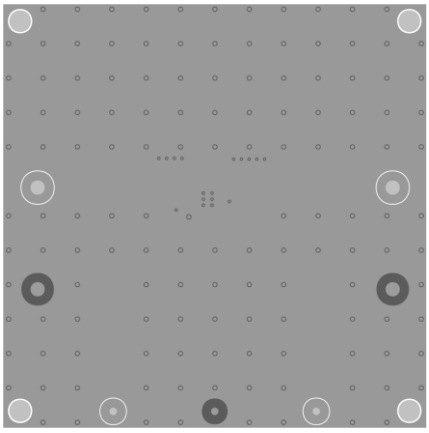
PCB Layout Guidelines

Efficient PCB layout is critical to achieve good regulation, ripple rejection, transient response, and thermal performance. It is recommended to duplicate the EVB layout for optimal performance. If changes are necessary, refer to Figure 9 and follow the guidelines below.

1. Place the input and output bypass ceramic capacitors close to IN and OUT, respectively.
2. Ensure that all feedback (FB) connections are short and direct. Place the FB resistors and compensation components as close to the chip as possible.
3. Connect IN, OUT, and especially GND to a large copper area to cool the chip. This improves thermal performance and long-term reliability.



Top Silk and Top Layer



Bottom Layer and Bottom Silk

Figure 9: Recommended PCB Layout

TYPICAL APPLICATION CIRCUITS

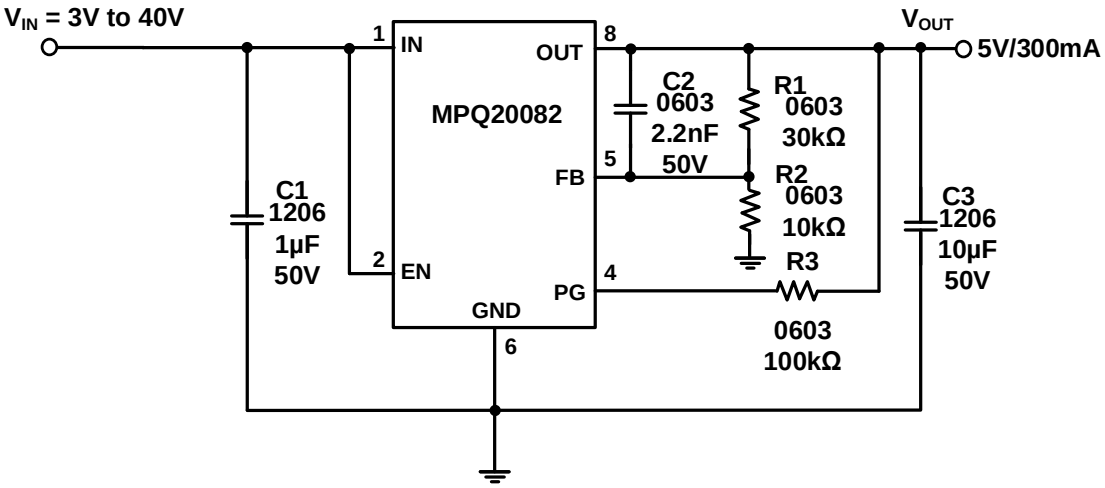


Figure 10: Typical Application Circuit (V_{OUT} = 5V, Adjustable-Output Version)

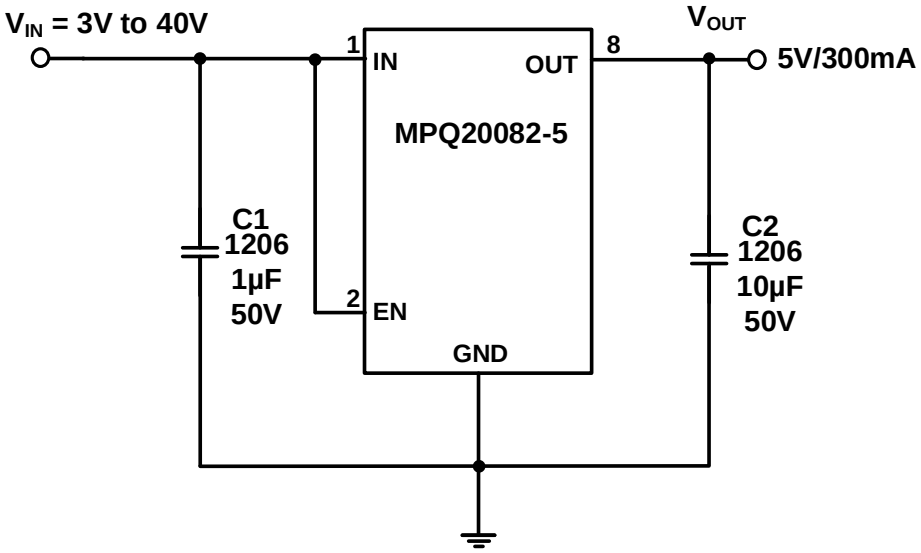
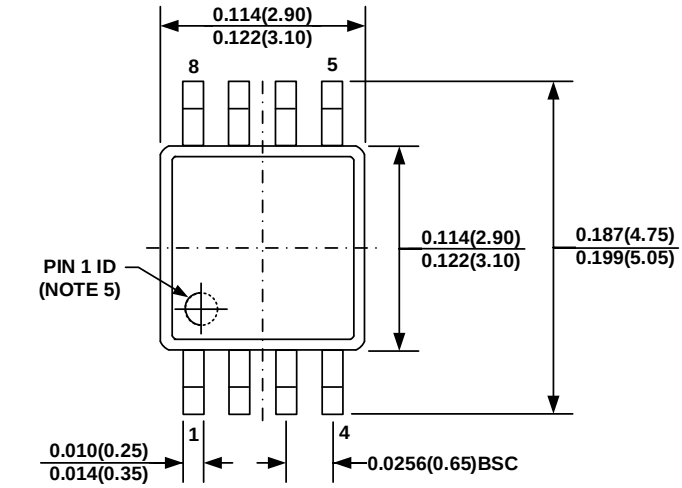


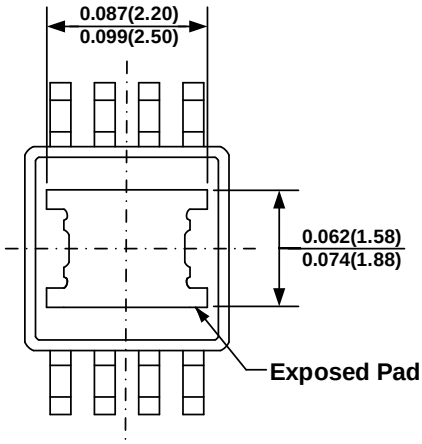
Figure 11: Typical Application Circuit (V_{OUT} = 5V, Fixed-Output Version)

PACKAGE INFORMATION

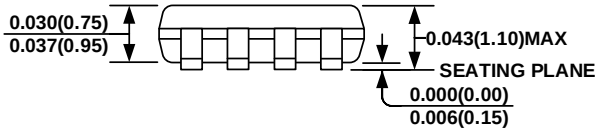
MSOP-8EP



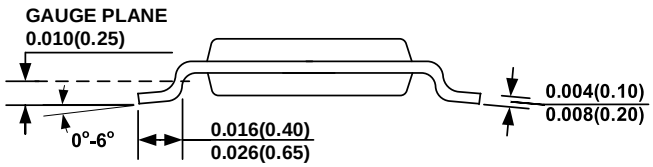
TOP VIEW



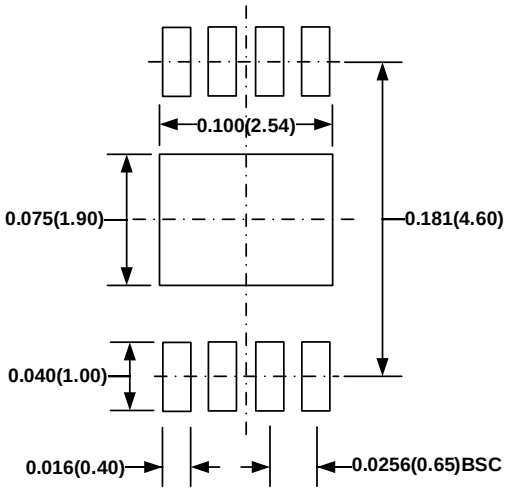
BOTTOM VIEW



FRONT VIEW



SIDE VIEW

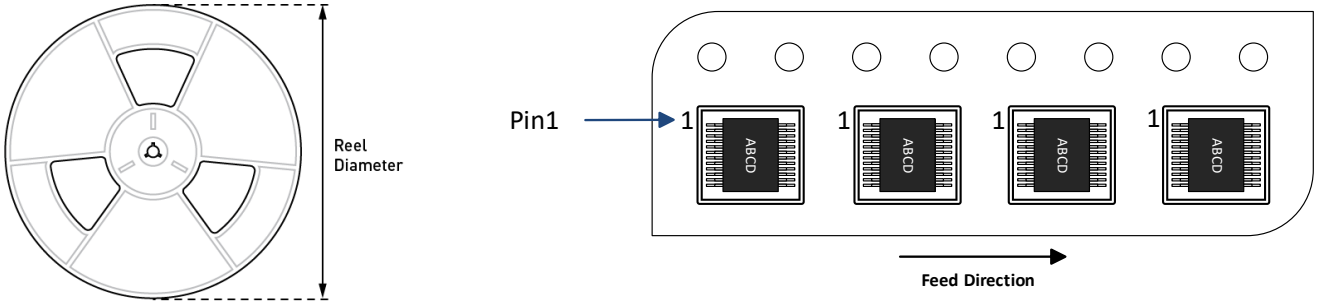


RECOMMENDED LAND PATTERN

NOTE:

1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURR.
3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.
4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5) PIN 1 IDENTIFICATION HAS HALF OR FULL CIRCLE OPTION.
6) DRAWING MEETS JEDEC MO-187, VARIATION AA-T.
7) 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
MPQ20082GH-AEC1-Z	MSOP-8EP	2500	N/A	N/A	13in	12mm	8mm
MPQ20082GH-5-AEC1-Z							

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	12/3/2024	Initial Release	-