MPQ5071

5.5V, 0.5A, Low $R_{DS(ON)}$ Load Switch with Programmable Current Limit, AEC-Q100 Qualified

DESCRIPTION

The MPQ5071 is a programmable load switch that provides 0.5A of load protection across a 0.5V to 5.5V voltage range. With low $R_{DS(ON)}$ in a tiny package, the MPQ5071 provides a highly efficient, space-saving solution for notebooks, tablets, and other portable device applications.

The MPQ5071's soft start (SS) function avoids inrush current during circuit start-up. The MPQ5071 also provides a programmable soft-start time, output discharge functions, over-current protection (OCP), and thermal shutdown.

The maximum load at the output source is current-limited, which is accomplished utilizing a sense MOSET topology.

The magnitude of the current limit is controlled by an external resistor from the ILIM pin to ground (GND).

An internal charge pump drives the power device gate, allowing a low on resistance DMOS power MOSET of just 50mΩ.

The MPQ5071 is available in a tiny, space-saving QFN-12 (2mmx2mm) package.

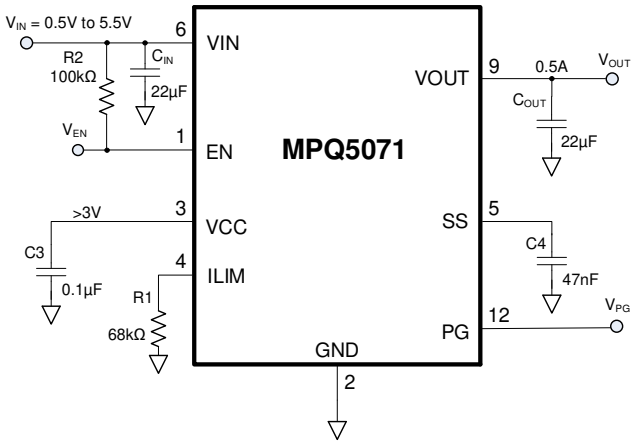
FEATURES

- Guaranteed Industrial/Automotive Temperature Range Limits
- 0.5V to 5.5V V_{IN} Range
- Shutdown Current <5μA
- Integrated 50mΩ Low $R_{DS(ON)}$ MOSETs
- 0.5A Load Current
- Push/Pull Power Good (PG) Indicator
- Adjustable Start-Up Slew Rate
- Output Discharge
- Short-Circuit Protection (SCP) <200ns
- Thermal Shutdown Protection
- Available in a Space-Saving QFN-12 (2mmx2mm) Package
- Available in AEC-Q100 Grade 1

APPLICATIONS

- Notebook and Tablet Computers
- Portable Devices
- Solid State Drives (SSDs)
- Handheld Devices

TYPICAL APPLICATION

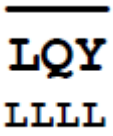


ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating
MPQ5071GG MPQ5071GG-AEC1	QFN-12 (2mmx2mm)	*See Below*	1

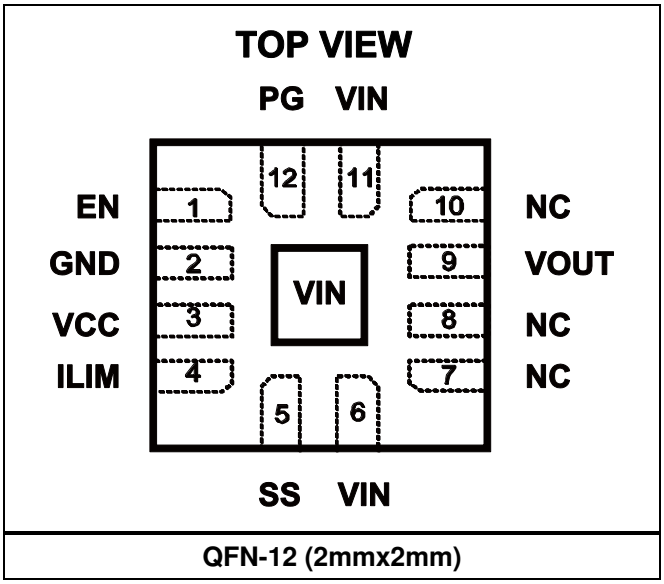
* For Tape & Reel, add suffix –Z (e.g. MPQ5071GG-AEC1–Z).

TOP MARKING



LQ: Product code of MPQ5071GG & MPQ5071GG-AEC1
Y: Year code
LLLL: Lot number

PACKAGE REFERENCE



QFN-12 (2mmx2mm)

PIN FUNCTIONS

Pin #	Name	Description
1	EN	**Enable input.** Pull EN below the specified threshold to shut down the chip.
2	GND	**Ground.**
3	VCC	**Supply voltage to the control circuitry.**
4	ILIM	**Output current limit configuration.** Place a resistor to GND to set the overload current limit level.
5	SS	**Soft start.** An external capacitor connected to the SS pin sets the slew rate for the output voltage soft-start period.
6, 11, exposed pad	VIN	**Input power supply.**
9	VOUT	**Output to the load.**
12	PG	**Power good.** Push/pull output.
7, 8, 10	NC	**Not connected.** It is recommended to connect this pin to VOUT to improve thermal performance.

ABSOLUTE MAXIMUM RATINGS (1)

V_{IN} .....-0.3V to +6.5V
V_{CC} .....-0.3V to +6.5V
V_{OUT}.....-0.3V to +6.5V
EN, SS, ILIM .....-0.3V to V_{CC} +0.3 V
Junction temperature .....150°C
Lead temperature .....260°C
Continuous power dissipation (2)
QFN-12 (2mmx2mm) 1.6W

ESD Ratings

Human body model (HBM) .....±2kV
Charged device model (CDM) ..... ±750V

Recommended Operating Conditions (3)

Supply voltage (V_{IN}) .....0.5V to 5.5V
Supply voltage (V_{CC}) .....3V to 5.5V
Output voltage (V_{OUT}).....0.5V to 5.5V
Operating junction temp (T_J) .... -40°C to +125°C

Thermal Resistance (4) θ_{JA} θ_{JC}

QFN-12 (2mmx2mm)..... 80..... 16... °C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX) - T_A) / θ_{JA}. Exceeding the maximum allowable power dissipation can cause excessive die temperature, and the device may go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{IN} = 3.6V, V_{CC} = 3.6V, T_J = -40ºC to +125°C, typical values are at T_J = 25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Input and Supply Voltage Range						
Input voltage	V_{IN}		0.5		5.5	V
Supply voltage	V_{CC}		3		5.5	V
Supply Current						
Off-state leakage current	I_{OFF}	V_{IN} = 5V, EN = 0, T_J = 25°C			1	µA
		V_{IN} = 5V, EN = 0, -40°C < T_J < +125°C			5	µA
V_{CC} standby current	I_{STBY}	V_{CC} = 5V, EN = 0		0.1	1	µA
		V_{CC} = 5V, enable, no load, T_J = 25°C		180	230	
		V_{CC} = 5V, enable, no load, -40°C < T_J < +125°C		180	250	
Power MOSET						
On resistance	$R_{DS(ON)}$	V_{CC} = 5.0V, T_J = 25°C		50	70	mΩ
		V_{CC} = 5.0V, -40°C < T_J < +125°C		50	80	
		V_{CC} = 3.3V, T_J = 25°C		60	80	
		V_{CC} = 3.3V, -40°C < T_J < +125°C		60	90	
Thermal Shutdown and Recovery (5)						
Shutdown temperature	T_{STD}			150		°C
Hysteresis	T_{HYS}			30		°C
Under-Voltage Protection						
VCC under-voltage lockout (UVLO) threshold	V_{CC_UVLO}	UVLO rising threshold		2.6	2.95	V
UVLO hysteresis	V_{UVLO_HYS}			200		mV
Soft Start (SS)						
SS pull-up current	I_{SS}	Fixed slew rate	4	11	17	µA
Enable (EN)						
EN rising threshold	V_{ENH}		1.3	1.5	1.7	V
EN hysteresis	V_{EN_HYS}			200		mV
ILIM						
Current limit	I_{OUT}	R_{LIM} = 24kΩ, ramp I_{OUT} records the peak current limit value		1.4		A
Discharge Resistance						
Discharge resistance	R_{DIS}			200		Ω
Power Good (PG)						
PG rising threshold	V_{PG_R}	Voltage gap between V_{OUT} and V_{IN}	140	280	450	mV
PG threshold	V_{PG_HYS}			60		mV
PG delay	t_{PG_D}			50		µs
PG high	V_{PG_H}	V_{CC} = 3.3V	3.2			V
PG low	V_{PG_L}	Sink 1mA			0.3	V

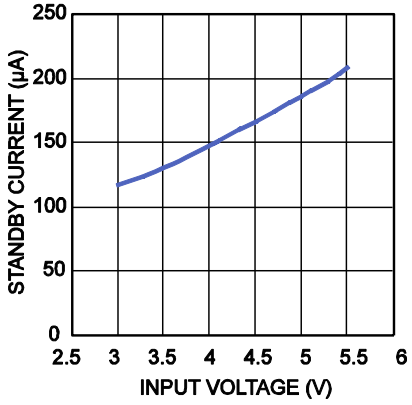
Notes:

5) Guaranteed by design.

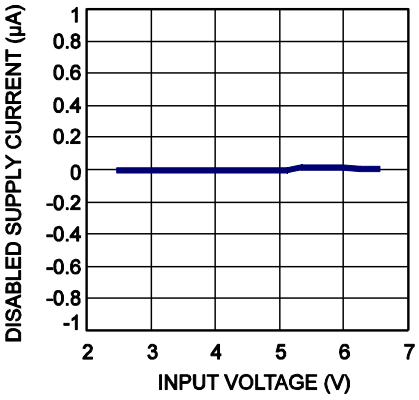
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 3.6V, V_{CC} = 3.6V, R_{ILIM} = 13kΩ, T_A = 25°C, unless otherwise noted.

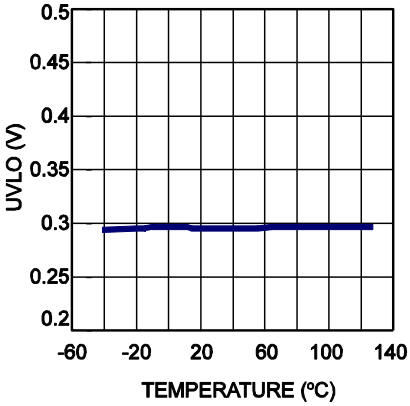
Quiescent Current



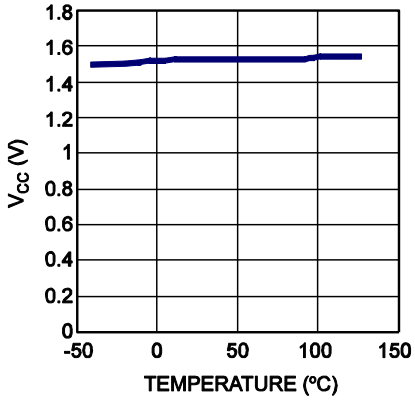
Disabled Supply Current vs. Input Voltage



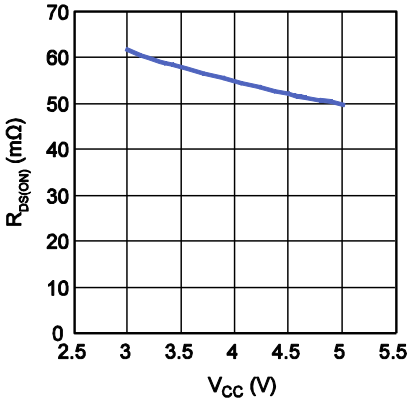
UVLO vs. Temperature



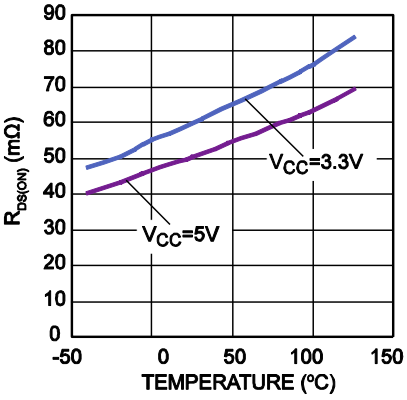
EN Rising Threshold vs. Temperature



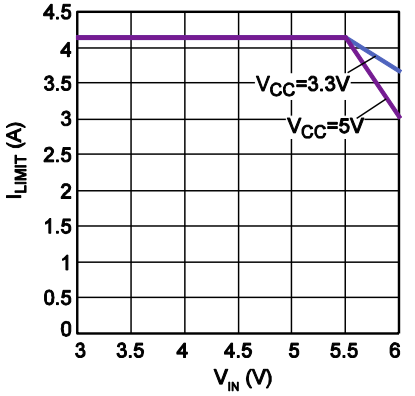
$R_{DS(ON)}$ vs. V_{CC}



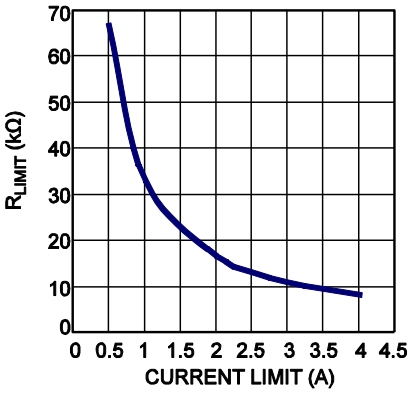
$R_{DS(ON)}$ vs. Temperature



Maximum Current Limit vs. V_{IN}

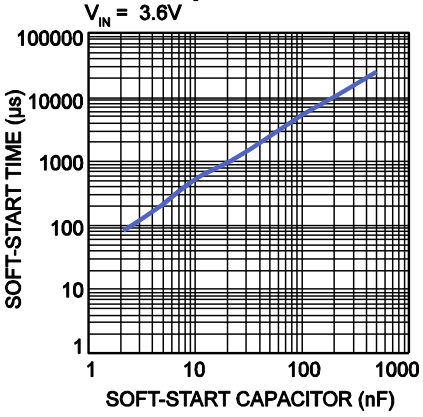


R_{LIMIT} vs. Current Limit



Soft-Start Time vs. Soft-Start Capacitor

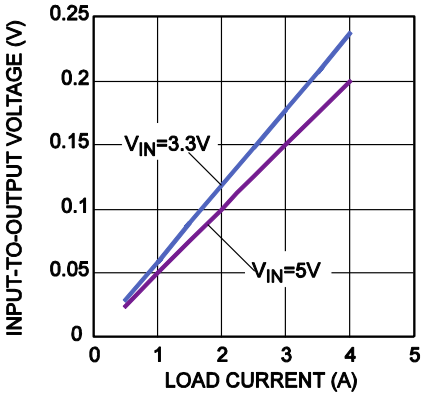
V_{IN} = 3.6V



TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

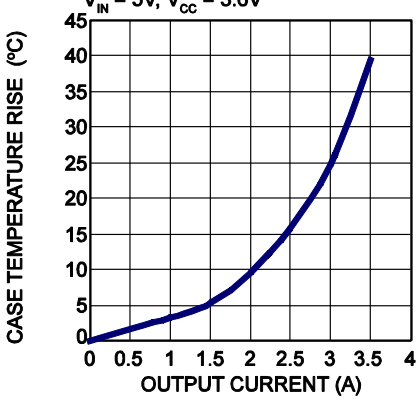
V_{IN} = 3.6V, V_{CC} = 3.6V, R_{ILIM} = 13kΩ, T_A = 25°C, unless otherwise noted.

Input-to-Output Voltage vs. Load Current



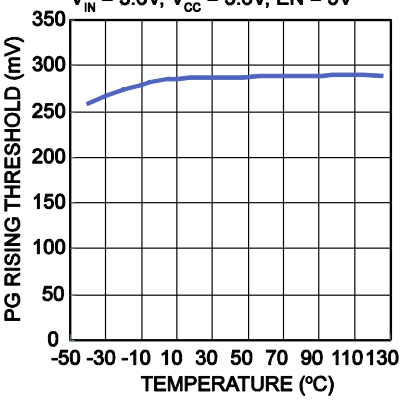
Case Temperature Rise vs. Output Current

V_{IN} = 5V, V_{CC} = 3.6V



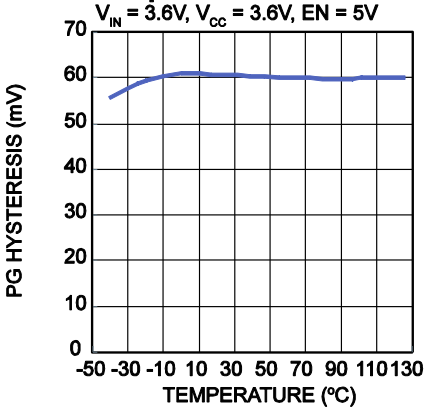
PG Rising Threshold vs. Temperature

V_{IN} = 3.6V, V_{CC} = 3.6V, EN = 5V



PG Hysteresis vs. Temperature

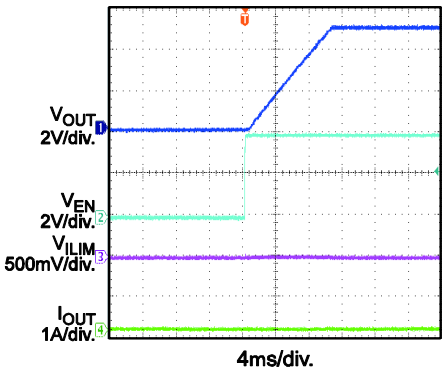
V_{IN} = 3.6V, V_{CC} = 3.6V, EN = 5V



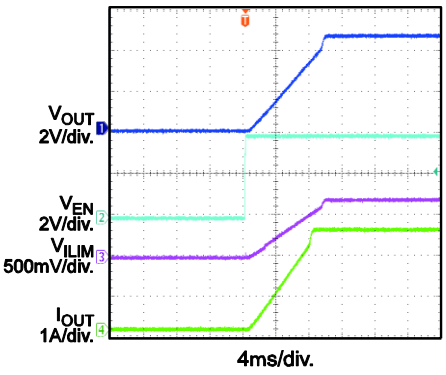
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 3.6V, V_{CC} = 3.6V, EN = 4V, R_{ILIM} = 13kΩ, T_A = 25°C, unless otherwise noted.

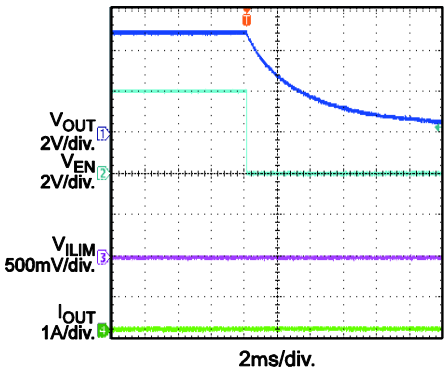
Start-Up through EN
V_{IN} = 5V, V_{CC} = 3.6V, no load



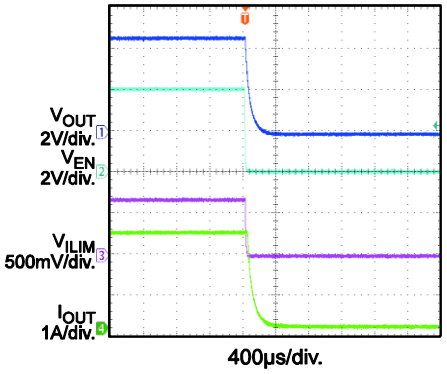
Start-Up through EN
V_{IN} = 5V, V_{CC} = 3.6V, 2.5A load



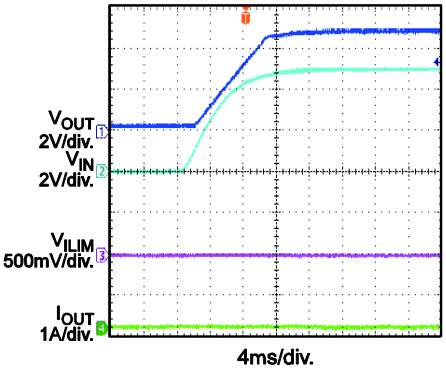
Shutdown through EN
V_{IN} = 5V, V_{CC} = 3.6V, no load



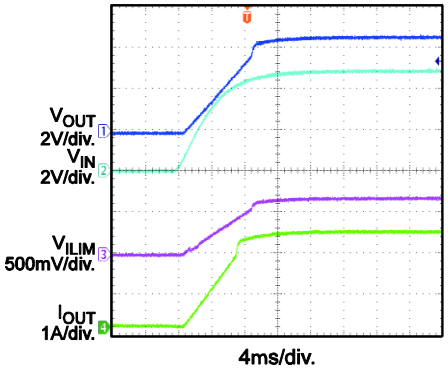
Shutdown through EN
V_{IN} = 5V, V_{CC} = 3.6V, 2.5A load



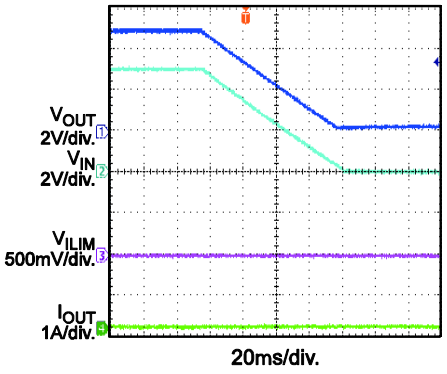
Start-Up
V_{IN} = 5V, V_{CC} = 3.6V, I_{OUT} = 0A



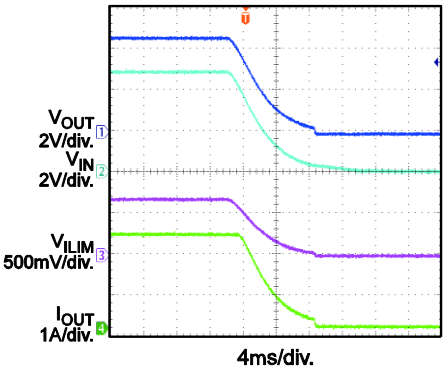
Start-Up
V_{IN} = 5V, V_{CC} = 3.6V, I_{OUT} = 2.5A



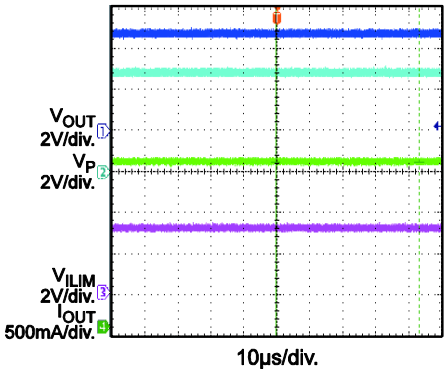
Shutdown
V_{IN} = 5V, V_{CC} = 3.6V, I_{OUT} = 0A



Shutdown
V_{IN} = 5V, V_{CC} = 3.6V, I_{OUT} = 2.5A



Steady State
V_{IN} = 5V, V_{CC} = 3.6V, I_{OUT} = 2A

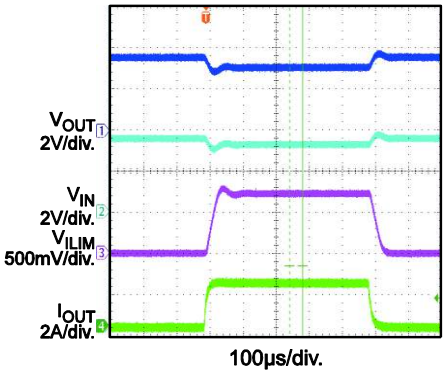


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 3.6V, V_{CC} = 3.6V, EN = 4V, R_{ILIM} = 13kΩ, T_A = 25°C, unless otherwise noted.

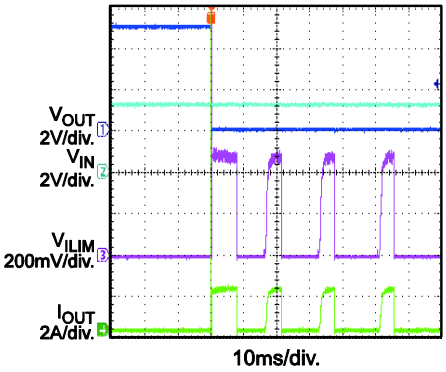
Load Transient Response

V_{IN} = 3.6V, V_{CC} = 3.6V, I_{OUT} = 0A to 2.5A



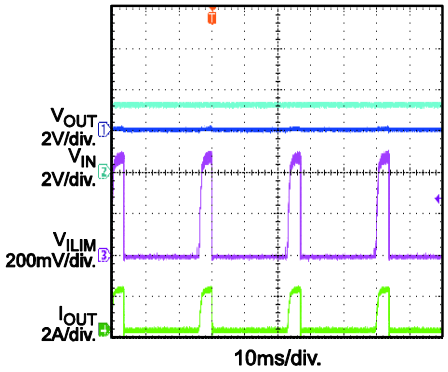
SCP Entry

V_{IN} = 5V, V_{CC} = 3.6V



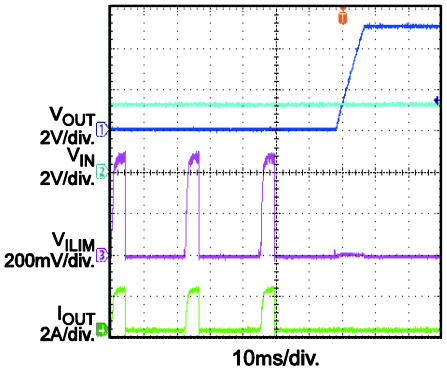
SCP Steady State

V_{IN} = 5V, V_{CC} = 3.6V



SCP Recovery

V_{IN} = 5V, V_{CC} = 3.6V



FUNCTIONAL BLOCK DIAGRAM

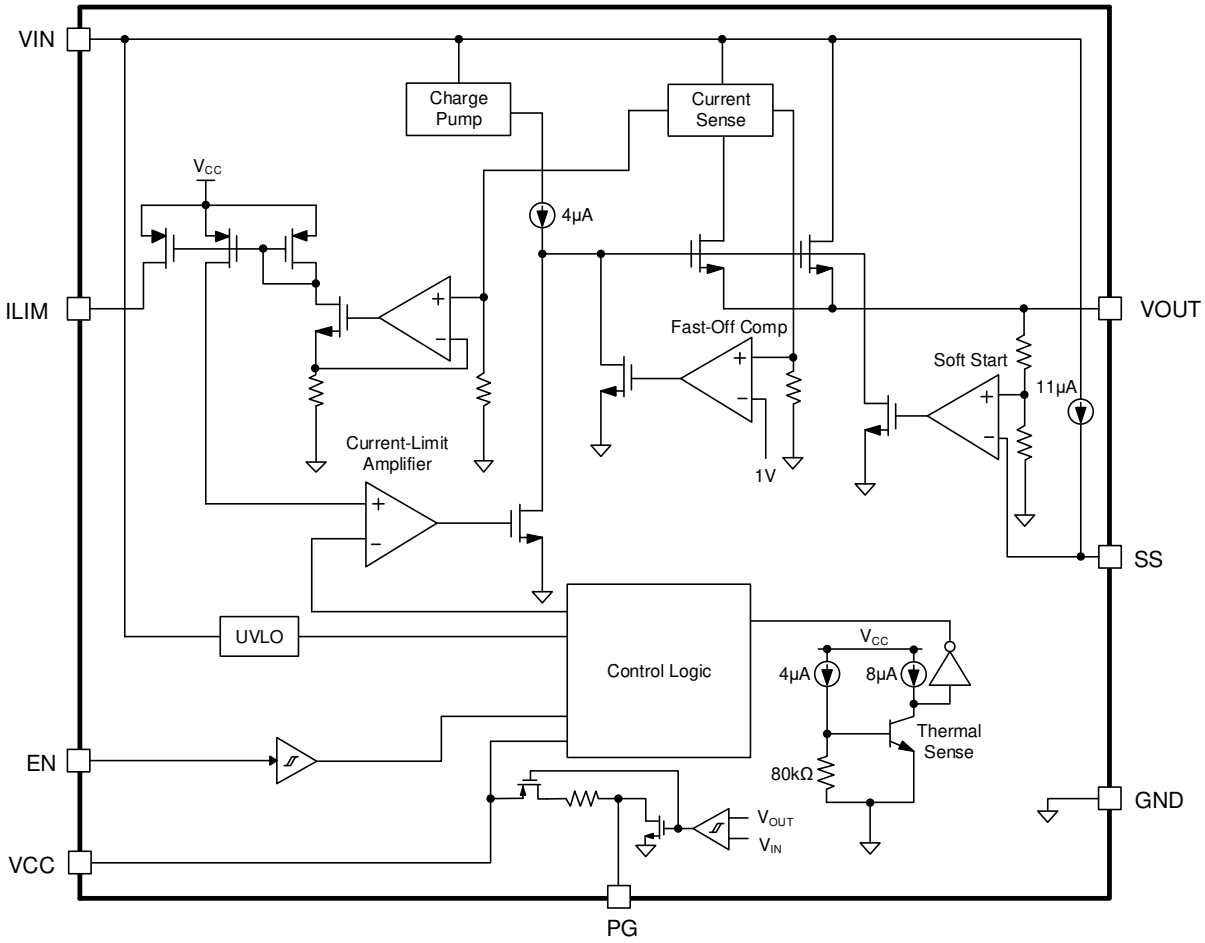


Figure 1: Functional Block Diagram

OPERATION

The MPQ5071 is designed to limit the inrush current to the load when a circuit card is inserted into a live backplane power source, limiting the backplane's voltage drop and the slew rate of the voltage to the load. The MPQ5071 provides an integrated solution that monitors the input voltage, output voltage, and output current — eliminating the need for an external current power MOSFET and a current-sense device.

Enable (EN)

The MPQ5071 is enabled when the input voltage exceeds the under-voltage lockout (UVLO) threshold (typically 0.5V), and the enable (EN) pin is pulled above 1.5V. Pulling the voltage down to ground (GND) disables the MPQ5071.

Current Limit

The MPQ5071 provides a constant current limit programmed by an external resistor. Once the device reaches its current limit threshold, the IC regulates the gate voltage to hold a constant current in the power MOSET. The typical response time is about 20µs. During the response time, a small overshoot in the output current may occur. The preset current limit value can be calculated with Equation (1):

$$I_{LIMIT} = (1 / R_{ILIM}) \times S \quad (1)$$

Where S is the current-sense ratio of the MPQ5071, and the typical value is 33000 when V_{IN} = 3.6V.

If the current limit block starts regulating the output current, power loss in the power MOSFET causes the IC temperature to rise. If the junction temperature rises too high, the MPQ5071 goes into thermal shutdown. After thermal shutdown, the output is disabled until the over-temperature (OT) fault is removed. The OT threshold is 150°C, and the hysteresis is 30°C.

Power Good (PG)

The power good (PG) pin is the push/pull of a MOSFET that can be pulled high to V_{CC}. The MOSFET turns on when an input voltage is applied that pulls the PG pin to GND. Once the voltage gap between V_{IN} and V_{OUT} is less than 280mV, the PG pin is pulled high after a 50µs delay. Once the voltage gap is exceeds 340mV, the PG pin is pulled low.

Short-Circuit Protection (SCP)

If a short circuit causes the load current to rapidly increase, the current may exceed its limit threshold. If the current reaches the internal secondary current limit (about 7A), a fast turn-off circuit shuts off the power MOSET, limiting the peak current through the switch and the input voltage drop. The total short circuit response time is about 200ns. If the fast turn-off succeeds, the power MOSET remains off for 80µs. After the 80µs, the power MOSET turns back on. If the short circuit remains, the MPQ5071 reduces and holds the current limit until the part is hot enough to trigger thermal shutdown. Once the short circuit condition is removed, the current limit automatically recovers to the preset value.

Output Discharge

The MPQ5071 has an output discharge function. This function discharges V_{OUT} with an internal pull-down resistor when the IC is disabled and the load is very light.

Soft Start (SS)

The capacitor connected to the SS pin determines the soft-start time. An internal, 11µA constant-current source charges the SS capacitor and ramps up the voltage on the SS pin. The output voltage rises at five times the slew rate of the SS voltage.

The soft-start time can be calculated with Equation (2):

$$t_{SS}(ms) = \frac{1}{5} \times \frac{V_{OUT}(V) \times C_{SS}(nF)}{I_{SS}(\mu A)} \quad (2)$$

Where t_{SS} is the soft-start time, I_{SS} is the internal 11µA constant current, and C_{SS} is the external SS capacitor.

The suggested minimum capacitance is no less than 4.7nF. If the SS pin is floating or SS capacitor is too small, the V_{OUT} rise time is limited by the power MOSFET charge time.

APPLICATION INFORMATION

COMPONENT SELECTION

Selecting the ILIM Resistor

The current limit value is set by the ILIM resistor (R_{ILIM}). The current limit can be calculated with Equation (1) on page 10.

The suggested current limit threshold should be 10% to 20% greater than maximum load current. For example, if a system's full load is 0.5A, set the current limit to 0.55A.

Selecting the ILIM Capacitor

The internal, advanced auto-zero comparator offers high-accuracy current monitoring, though it causes a small amount of jitter on the ILIM pin. To stabilize the ILIM pin, mount a small ceramic capacitor between the ILIM pin and GND. It is recommended to use a capacitor that is less than 1nF.

Selecting the SS Capacitor

An internal, 11µA constant-current source charges the SS capacitor, which ramps up the voltage on the SS pin. The output voltage follows the SS voltage slew rate.

If the inrush of the output current reaches the current limit during start-up (e.g. if there is a large output capacitor or large load), the MPQ5071 limits the output current, and the soft-start time increases simultaneously (see Figure 2 and Figure 3).

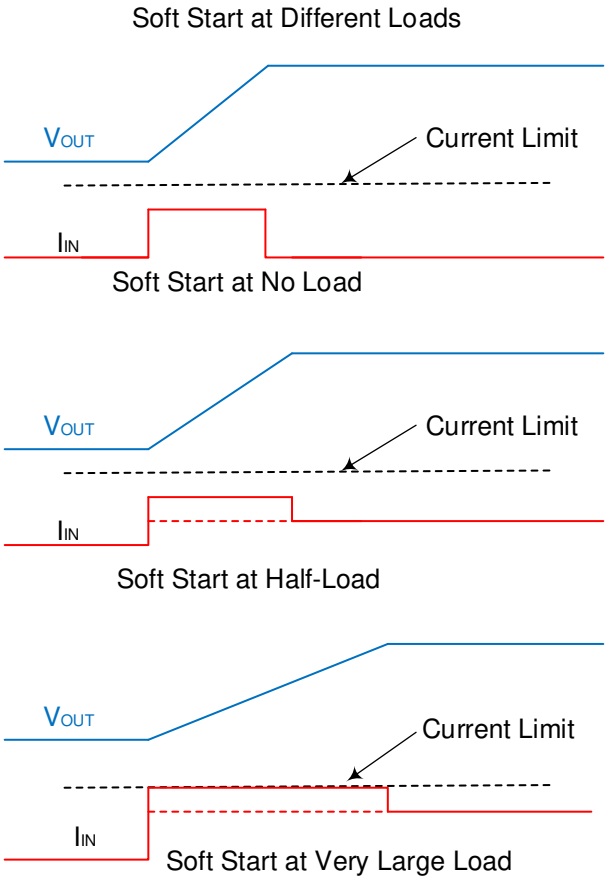


Figure 2: Soft Start at Different Loads

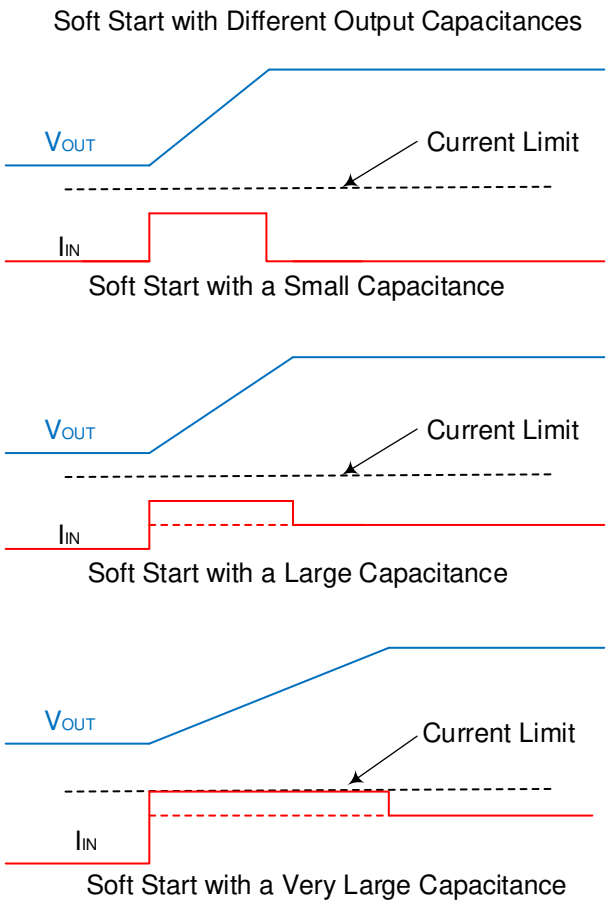


Figure 3: Soft Start at Different Output Capacitances

Design Example

Table 1 and Figure 5 provide details for design examples.

Table 1: Components Selection Guide

V_{IN} (V)	3.6	3.6	3.6
Max Load Range (A)	0.5	1	2
R_{LIMIT} (kΩ)	47	27.4	15
SS Capacitance (nF)	22	47	100
SS Time (ms)	1	2.4	5.4

PCB Layout Guidelines

Efficient PCB layout is critical for stable operation. For the best results, refer to Figure 4 and follow the guidelines below:

1. Place R_{ILIM} close to the ILIM pin.
2. Place the input capacitor close to the VCC pin.
3. Place vias around the IC to improve thermal performance.

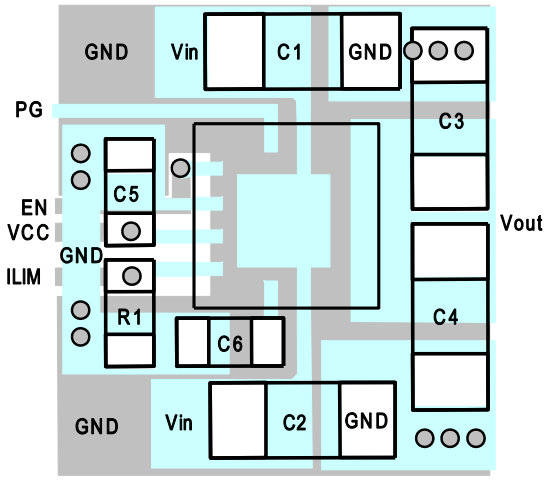


Figure 4: Recommended PCB Layout

TYPICAL APPLICATION CIRCUIT

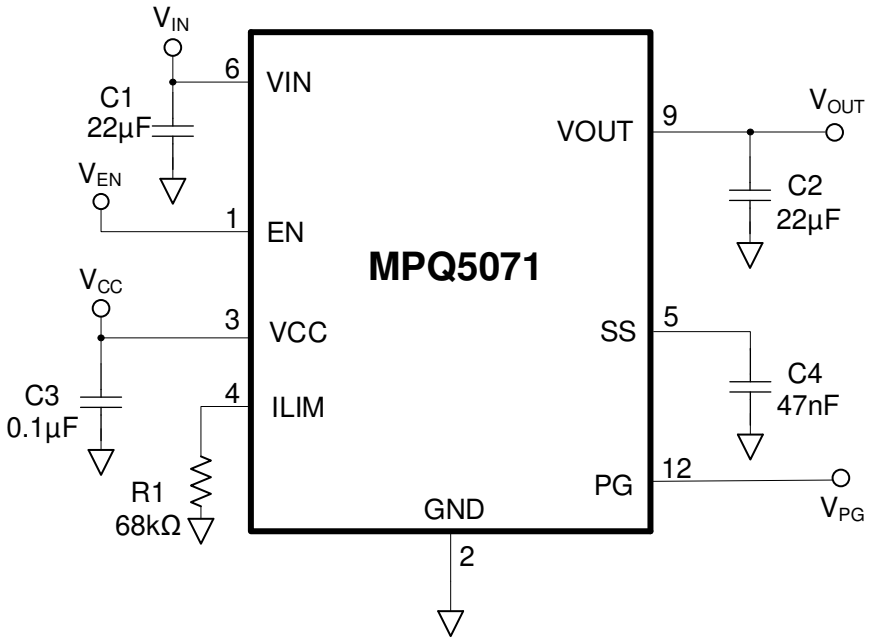
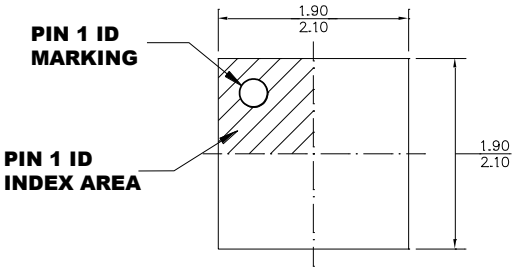


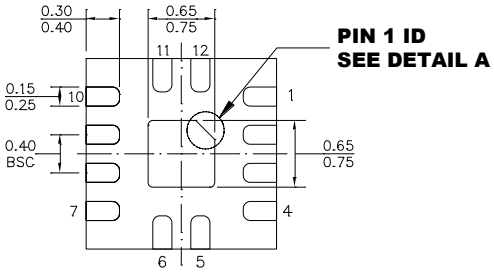
Figure 5: Typical Application Circuit

PACKAGE INFORMATION

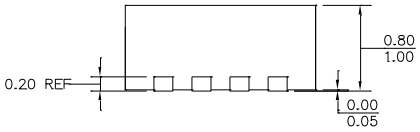
QFN-12 (2mmx2mm)



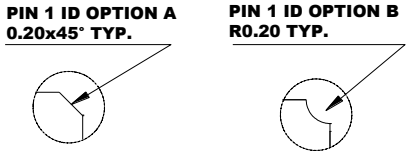
TOP VIEW



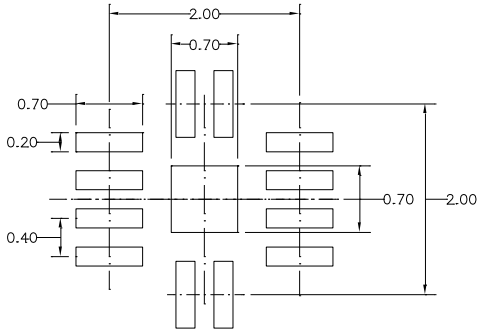
BOTTOM VIEW



SIDE VIEW



DETAIL A

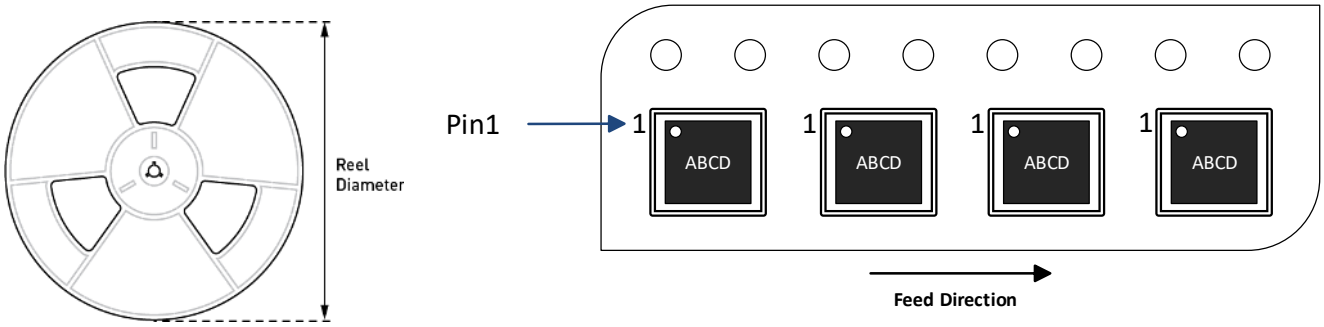


RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETERS MAX.
4) JEDEC REFERENCE IS MO-229.
5) DRAWING IS NOT TO SCALE.

CARRIER INFORMATION



Part Number	Package Description	Quantity /Reel	Quantity /Tube	Quantity /Tray	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch
MPQ5071GG–Z MPQ5071GG-AEC1–Z	QFN-12 (2mmx2mm)	5000	N/A	N/A	13in	12mm	8mm

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	1/11/2021	Initial Release	-