Dual, USB 2.0 Full/Standby Power Controller with Supply Steering

Preliminary Technical Data — ADM1072

FEATURES

- 500mA Load Current (100mA in Standby Mode)
- 135mΩ On Resistance
- Switchable Current Limit
- 50µA Typical Quiescent Current
- 10nA Typical Shutdown Current
- 40nA Typical Switch Off Leakage
- Short-Circuit Protection
- Thermal Shutdown
- $\overline{\text{FLT}}$ Outputs
- Small, 16-Pin QSOP Package

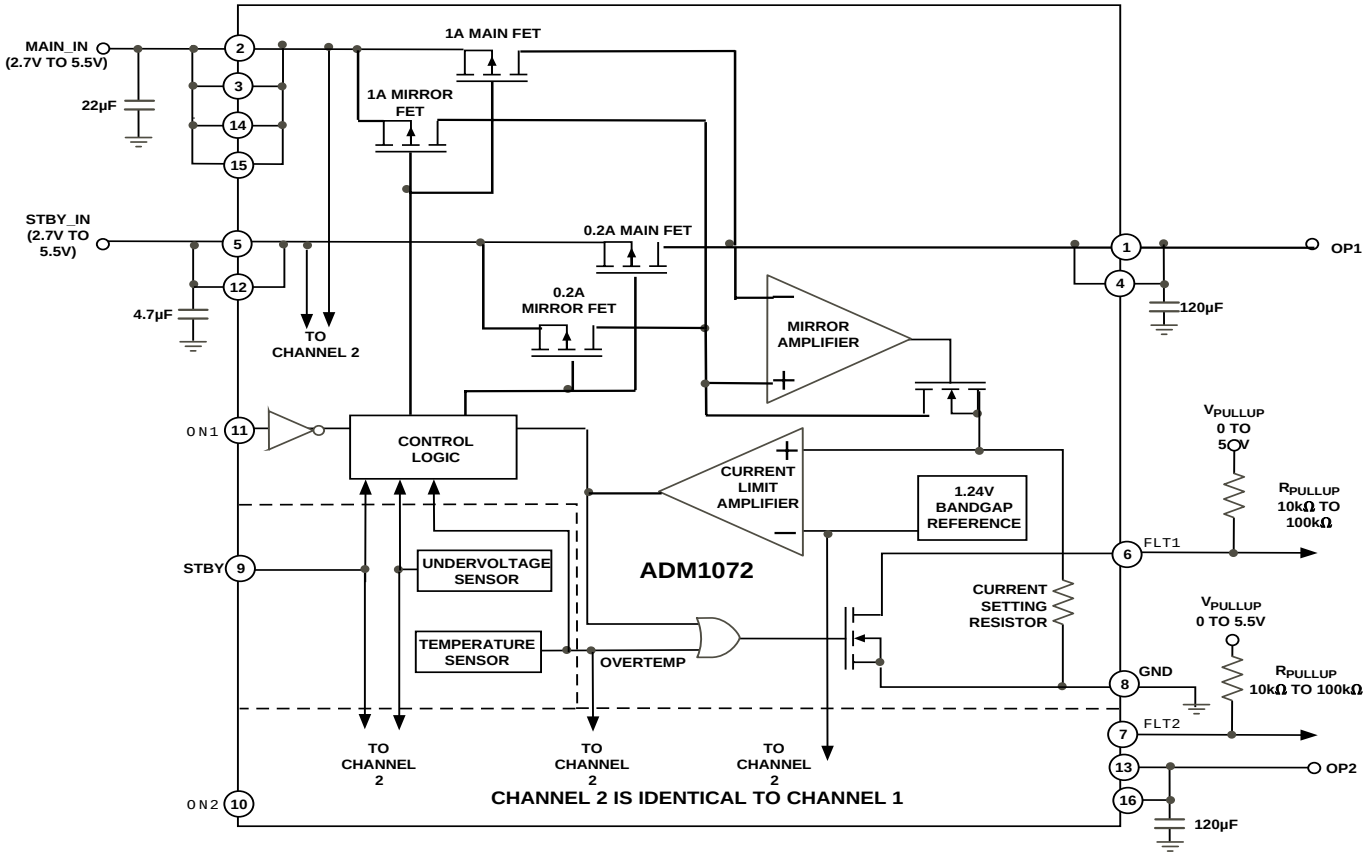
APPLICATIONS

- Desktop Computers
- Palmtop Computers
- Notebook Computers
- Hand-Held Instruments
- Universal Serial Bus (USB)

GENERAL DESCRIPTION

The ADM1072 is a logic controlled, dual P-channel switch with low on resistance and a built-in current limiter, capable of sourcing up to 1A from supply voltages between 2.7V and 5.5V. In addition to logic inputs that switch each channel on and off, the device has a standby input that switches the output current limit, making it ideal for use with USB peripherals. In normal operating mode and Standby mode the output current is typically limited to 500mA and 100mA respectively, as outlined by the USB2.0 Specification. This allows the system power supply to be protected against short-circuits and surge currents in peripheral USB devices powered via the ADM1072. Over-current and over-temperature conditions are signalled by a fault output ($\overline{\text{FLT}}$) for each channel.

The ADM1072 also offers low quiescent current of typically 50µA and shutdown current of typically 10nA.



FUNCTIONAL BLOCK DIAGRAM

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ADM1072–SPECIFICATIONS

(Specification for either channel 1 or channel 2, V_{IN} = +5.0V, T_A = -40 to +85°C, unless otherwise noted.)

Parameter	Min	Typ	Max	Units	Test Conditions/Comments
Operating Voltage Range	+2.7		+5.5	Volts	
Quiescent Current (Total Device)		50		µA	V_{IN} = 5V, $\overline{ON1}$,$\overline{ON2}$ = GND, I_{OUT} = 0A
Shutdown Supply Current (Total Device)		0.01	2	µA	$\overline{ON1}$,$\overline{ON2}$ = V_{IN} = 5.5V, V_{OUT} = 0V
Undervoltage Lockout	2.0	2.3	2.6	V	V_{STBY_IN}, Rising Edge, 1% Hysteresis
On Resistance		? ?	135 ?	mΩ mΩ	V_{IN} = 4.75V V_{IN} = 3.0V
NOMINAL CURRENT-LIMIT Full Power Mode Standby Mode	 0.8 160	 1.0 200	 1.2 240	 A mA	 STBY Low Note 1 STBY High Note 1
$\overline{ON1}$,$\overline{ON2}$, STBY Input Low Voltage, V_{IL}			0.8	V	V_{IN} = 2.7V to 5.5V
$\overline{ON1}$,$\overline{ON2}$, STBY Input High Voltage, V_{IH}	2.4			V	V_{IN} = 2.7V to 5.5V
$\overline{ON1}$,$\overline{ON2}$, STBY Input Leakage		0.01	±1	µA	$V_{\overline{ON}}$, V_{STBY} = 5.5V
$\overline{FLT1}$,$\overline{FLT2}$ Logic Output Low Voltage			0.4	V	I_{SINK} = 1mA
$\overline{FLT1}$,$\overline{FLT2}$ Output High Leakage Current		0.05	1	µA	V_{FAULT} = 5.5V
Turn-On Time			4 4	ms ms	V_{IN} = 5V, I_{OUT} = 500mA V_{IN} = 3V, I_{OUT} = 500mA
Turn-Off Time	?	?	20	µs	V_{IN} = 5V, I_{OUT} = 500mA

Notes

[1]Current limit is specified with V_{OUT} = 4.5V.

[2]Guaranteed by design. Derived from the I_{SET} current ratio, current-limit amplifier and internal set resistor accuraciues.

[3]Tested with I_{OUT} = 200mA and V_{SET} adjusted until (V_{IN} - V_{OUT}) ≥ 0.8V.

[4]Specifications to -40°C are guaranteed by design, not tested.

ABSOLUTE MAXIMUM RATINGS*
(T_A = +25°C unless otherwise noted)

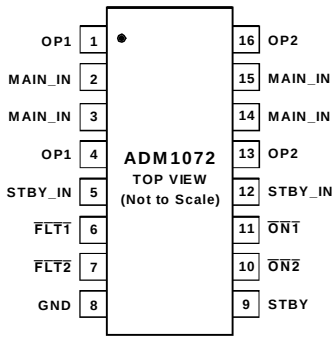
MAIN_IN to GND ..... –0.3V to +6V
$\overline{ON1}$,$\overline{ON1}$,$\overline{FLT1}$, $\overline{FLT2}$ to GND ..... –0.3V to +6V
$\overline{OP1}$,$\overline{OP2}$ to GND .....+0.3 V to (V_{IN} + 0.3V)
Maximum Switch Current
Full Power Mode 1A
Standby Power Mode 200mA
Continuous Power Dissipation (TA = +70°C) 667mW
QSOP (derate 8.3mW/°C above +70°C)
Operating Temperature Range
Industrial (A Version) ..... –40°C to +85°C
Storage Temperature Range ..... –65°C to +150°C
Lead Temperature (Soldering, 10 sec) ..... +300°C

*This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

THERMAL CHARACTERISTICS
16-Pin QSOP Package:
θ_{JA} = 105°C/Watt, θ_{JC} = 40°C/Watt

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
ADM1072ARQ	-40°C to +85°C	16-Pin QSOP	RQ-16 Package



Pin Configuration

PIN FUNCTION DESCRIPTION

Pin	Mnemonic	Function
2, 3, 14, 15	MAIN_IN	Input to MAIN P-channel MOSFET source (both channels). Bypass MAIN_IN with a 22µF capacitor to ground.
5, 12	STBY_IN	Input to Standby P-channel MOSFET source (both channels) and supply to chip circuitry. Bypass STBY_IN with a 4.7µF capacitor to ground.
1, 4	OP1	Output from channel 1, P-channel MOSFET drains. Bypass OP1 with a 120µF capacitor to ground.
13, 16	OP2	Output from channel 2, P-channel MOSFET drains. Bypass OP2 with a 120µF capacitor to ground.
6	$\overline{FLT1}$	Open-Drain Digital Output. $\overline{FLT1}$ goes low when the channel 1 current limit is exceeded for 10mS or the die temperature exceeds +150°C. During startup, $\overline{FLT1}$ remains low for the turn-on time.
7	$\overline{FLT2}$	Open-Drain Digital Output. $\overline{FLT2}$ goes low when the channel 2 current limit is exceeded for 10mS or the die temperature exceeds +150°C. During startup, $\overline{FLT2}$ remains low for the turn-on time.
8	GND	Ground pin for all chip circuits.
9	STBY	Digital Input. Active high standby mode input. STBY = 0 sets normal operating mode with 500mA current limit. STBY = 1 sets standby mode with 100mA current limit.
10	$\overline{ON2}$	Digital Input. Active-low switch enable for channel 2 (logic 0 turns the switch on).
11	$\overline{ON1}$	Digital Input. Active-low switch enable for channel 1 (logic 0 turns the switch on).

Typical Performance Curves

Figure 1. Quiescent Current vs. Input Voltage

Figure 4. Off-Switch Current vs. Temperature

Figure 2. Quiescent Current vs. Temperature

Figure 5. Normalized On Resistance vs. Temperature

Figure 3. Off-Supply Current vs. Temperature

Figure 6. I_{OUT}/I_{SET} Ratio vs Switch Current

Typical Performance Curves

Figure 7. Normalized Output Current vs. Output Voltage

Figure 10. Fast Current-Limit Response

Figure 8. Turn-On Time vs. Temperature

Figure 11. Slow Current-Limit Response

Figure 9. Turn-Off Time vs. Temperature

Figure 12. Load Transient Response

Typical Performance Curves

Figure 13. Switch Turn-On Time

Figure 15. USB Circuit Output Rise Time

Figure 14. Switch Turn-Off Time

Figure 16 USB Circuit output Fall Time

FUNCTIONAL DESCRIPTION

The ADM1072 is a dual, logic-controlled P-channel switch. Each channel of the ADM1072 comprises two P-channel switches. The source of one switch is connected to the "MAIN_IN" input pins and can switch up to 1A. The second switch is conected to the "STBY_IN" pins and can switch up to 200mA. The device is rated to provide 500mA continuously in full power mode and 100mA continuously in STBY mode. The STBY_IN inputs also provide the power for the chip circuitry and so must be connected to a supply at all times.

When STBY is low the MAIN switch is active and when STBY is high the Standby switch is active.

Each channel is individually controlled by an active-low logic input $\overline{ON1}$ (pin 11) and $\overline{ON2}$ (pin 10). When either $\overline{ON1}$ or $\overline{ON2}$ is low, the internal circuitry of the ADM1072 is powered up and the output of the corresponding current-limit amplifier is low, providing gate drive to the switching FET, thus turning it on. When both $\overline{ON}$ inputs are high, the internal circuitry is powered down and the current consumption is typically 10nA.

It should be noted that the ADM1072 is not a bi-directional switch, so V_{IN} must always be higher than V_{OUT}.

TABLE 1. Truth Table for $\overline{ON1}$, $\overline{ON2}$ and STBY

$\overline{ON1}$	$\overline{ON2}$	STBY	Channel 1	Channel 2
0	0	0	500mA	500mA
0	0	1	100mA	100mA
0	1	0	500mA	OFF
0	1	1	100mA	OFF
1	0	0	OFF	500mA
1	0	1	OFF	100mA
1	1	X	BOTH SHUT DOWN	

X = don't care

CURRENT LIMIT

When either the Main or Standby switch is turned on a smaller mirror switch passes a proportionate current equal to I_{OUT}/1000. The mirror amplifier maintains this relationship by keeping the drain of the mirror FET at the same voltage as the main FET, and drives the mirror current through an internal current-limit resistor, which is connected between the non-inverting input of the current limit amplifier and ground. An on-chip bandgap reference of 1.24V is connected to the inverting input of the current-limit amplifier. When the load current exceeds the preset limit, the voltage across the current-limit resistor exceeds 1.24V and the output voltage of the current-limit amplifier rises, reducing the gate drive to the FETs.

By selecting between the Standby and Main FETs and their associated mirror FETs, the STBY input allows the two different values of current limit specified by USB2.0 to be selected.

This feature is particularly useful when driving USB peripherals from a host system such as a PC that can go into a power-saving mode, since it limits the current that the peripherals can attempt to draw from the host power supply.

SHORT-CIRCUIT PROTECTION

The proportional relationship between the main FET and the mirror FET is only maintained down to an output voltage of about 1.6V. Below this voltage the output current is limited to approximately 1.2 x I_{LIMIT}.

In the event of a high dV/dt across the switching FET during a short-circuit, the switch will turn off and disconnect the input from the output. The switch is then turned on slowly with the current limited to the short-circuit value.

THERMAL SHUTDOWN

The thermal shutdown operates when the die temperature exceeds +150°C, turning off both channels. The thermal shutdown circuit has built-in hysteresis of 10°C, so the switch will not turn on again until the die temperature falls to +140°C. If the fault condition is not removed, the switch will pulse on and off as the temperature cycles between these limits.

UNDERVOLTAGE LOCKOUT

The undervoltage sensor monitors the input supply voltage (ie) the voltage on STBY_IN. The outputs will not turn on until the supply voltage is sufficient for the chip circuits to operate reliably. Undervoltage lockout occurs at between 2.0 and 2.6V.

$\overline{FLT}$ OUTPUTS

The ADM1072 has active-low fault outputs for each channel, $\overline{FLT1}$ (pin 6) and $\overline{FLT2}$ (pin 7). If the current limit is exceeded for greater than 10mS, the corresponding $\overline{FLT}$ output will pull low. If the thermal shutdown is activated, both $\overline{FLT}$ outputs will pull low. The $\overline{FLT}$ outputs are open-drain and require a pullup resistor of between 10kΩ and 100kΩ. Several $\overline{FLT}$ outputs may be wire-OR'd to form a common interrupt line, as shown in Figure 17 or $\overline{FLT}$ outputs may be wire-OR'd to an existing interrupt line that has a resistive pullup.

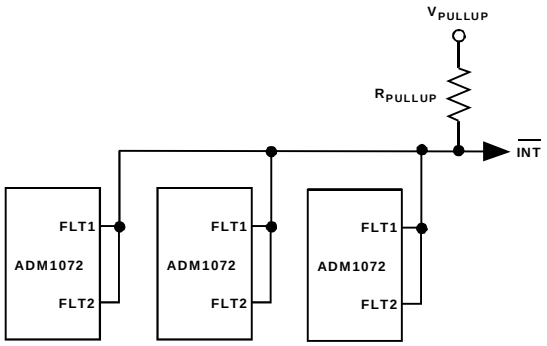


Figure 17. Wire Or'ing FAULT Outputs

During startup, the FLT output goes low for the turn-on time.

APPLICATIONS INFORMATION

INPUT FILTERING

To prevent the input voltage being pulled below the minimum operating voltage under transient short-circuit conditions, before the current limit has had time to operate, a reservoir capacitor should be connected from MAIN_IN to GND. This does not need to be large, but should have a low ESR. A value of around 10 - 22µF is suitable. Larger values will reduce the voltage drop still further. The STBY_IN input requires a proportionately smaller value, typically 2.2 to 4.7µF.

OUTPUT CAPACITANCE

120µF capacitors should be connected between OP1 and OP2 and GND to prevent the back e.m.f. of parasitic inductance from pulling OP1 and OP2 below ground during turn-off and to provide adequate turn- on current for Universal Serial Bus (USB) applications that are hot plugged to OP! or OP2. This causes the output rise and fall times to be longer, as shown in the typical operating characteristics, but does not affect the turn-off time of the ADM1072 itself.

LAYOUT CONSIDERATIONS

Printed circuit board tracks to and from the ADM1072 should be as thick and as short as possible to minimise parasitic inductance and take full advantage of the fast response time of the switch. Input and output capacitors should be placed as close to the device as possible (less than 5mm).

THERMAL CONSIDERATIONS

Under normal operating conditions, the worst-case power dissipation will be 135mW with the 135mΩ on resistance and 3V supply ($W = (1A)^2 \times 0.135\Omega$). The package is capable of handling and dissipating this power, but heat dissipation can further be improved by providing a large area of copper in contact with the device pins, particularly MAIN_IN and OP1,OP2.

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

16-Pin QSOP Package (RQ-16)