General description

The MX5052S high-side OR-ing works with an internal MOSFET and acts as an ideal diode rectifier when connected in series with the power supply. This OR-ing circuit enables MOSFETs to replace diode rectifiers in power distribution networks, reducing power loss and voltage drop.

The MX5052S controller provides charge pump gate drive for an internal N-channel MOSFET and fast response comparator to turn off the FET when current flows in reverse. The MX5052S can be connected to power supplies from 1V to 40V （a separate VS supply is needed when IN is 1V to 4V） and can withstand transient voltages up to 60V.

Features

- ♦ Wide operating input voltage range V_{IN}: 5V to 40V
- ♦60V transient voltage
- ♦ Charge pump gate driver for external N-channel MOSFET
- ♦ 50ns fast response to current reversal
- ♦2A peak gate off current internal
- ♦Ultra-small V_{DS} turn-off voltage reduces turn-off time
- ♦ 8-Pin SOP8L

Applications

Active OR-ing of redundant (N+1) power supplies

General information

Ordering information

Part Number	Description
MX5052S	SOP8L
MPQ	3000pcs

Package dissipation rating

Package	RθJA（℃/W）
SOP8L	108.1

Absolute maximum ratings

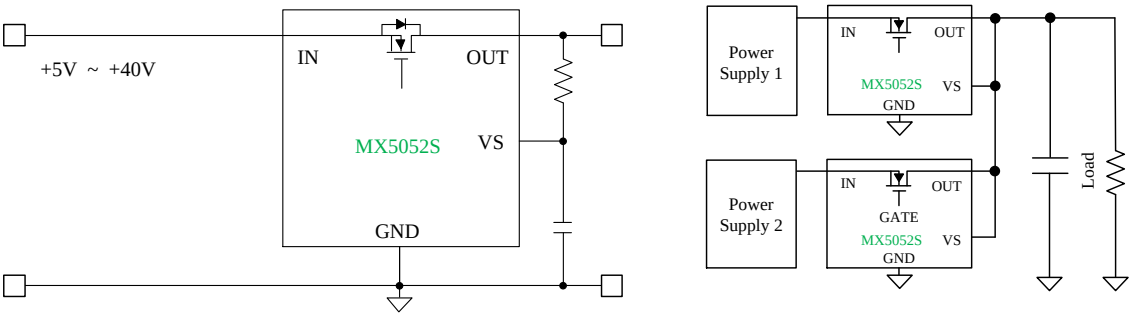
Parameter	Value
IN, OUT Pins to GND	-0.3 to 50V
GATE Pin to GND	-0.3 to 60V
VS Pin to Ground	-0.3 to 50V
OFF Pin to Ground	-0.3 to 7V
Internal MOSFET VDS	⩾60V
Junction temperature	150℃
Storage temperature, Tstg	-50 to 150℃
Leading temperature （soldering,10secs）	260℃
ESD Susceptibility HBM	±2000V

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

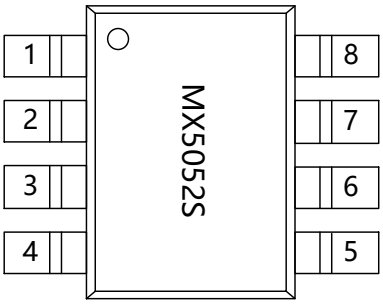
Recommended operating condition

Symbol	Range
IN, OUT Pins （VS⩾4.5V for IN＜4V）	1-40V
VS Pin	5-40V
OFF Pin	0-5.5V
Operating temperature	-40~125℃

Typical application



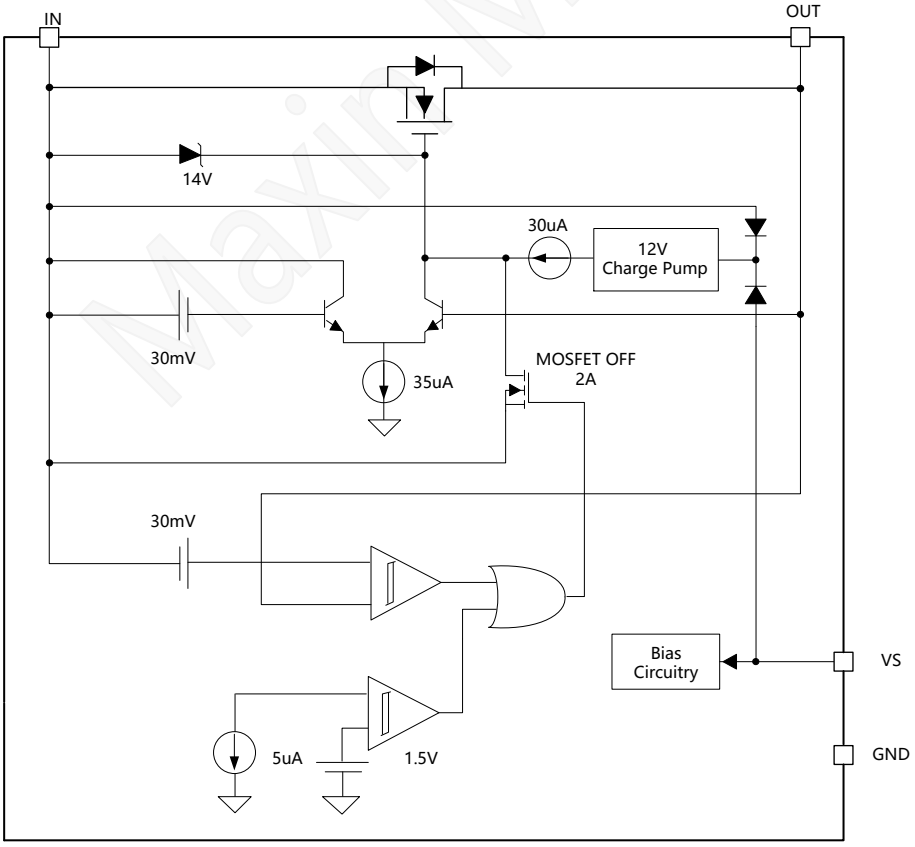
Terminal assignments



Pin information

PIN NO.	PIN name	Description
1	VS	The main supply pin for all internal biasing and an auxiliary supply for the internal gate drive charge pump. Typically connected to either V_{OUT} or V_{IN}; a separate supply can also be used.
2	GND	Ground return for the controller
3、4	IN	Voltage sense connection to the external MOSFET Source pin.
5~8	OUT	Voltage sense connection to the external MOSFET Drain pin.

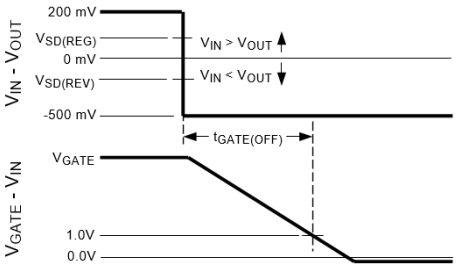
Block diagram



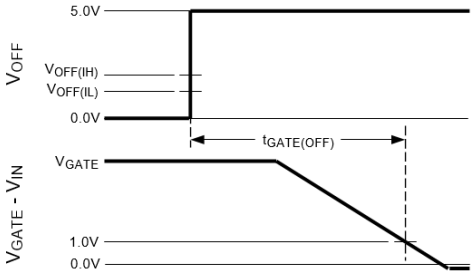
Electrical characteristics

（V_{IN} =12V, V_{VS} = V_{IN}, V_{OUT} = V_{IN}, V_{OFF} = 0V, C_{GATE} = 47nF, TA = 25℃, unless otherwise noted）

Symbol	Parameter	Test condition	Min	Typ.	Max	Unit
VS PIN						
V_{VS}	Operating Supply Voltage Range		5		40	V
I_{VS}	Operating Supply Current	V_{VS} = 5V, V_{IN} = 5V, V_{OUT} = V_{IN} - 100mV		50	70	uA
		V_{VS} = 12V, V_{IN} = 5V, V_{OUT} = V_{IN} - 100mV		55	70	
		V_{VS} = 40V, V_{IN} = 5V, V_{OUT} = V_{IN} - 100mV		60	100	
IN PIN						
V_{IN}	Operating Input Voltage Range		5		40	V
I_{IN}	IN Pin current	V_{IN} =5V, V_{VS} = V_{IN}, V_{OUT} = V_{IN} -100mV	150	240	300	uA
		V_{IN} = 12V to 40V, V_{VS} = V_{IN}, V_{OUT} = V_{IN} - 100mV	200	300	350	
OUT PIN						
V_{OUT}	Operating Output Voltage Range		5		40	V
I_{OUT}	OUT Pin Current	V_{IN} = 5V to 40V, V_{VS} = V_{IN}, V_{OUT} = V_{IN} - 100mV		3.2	8	uA
INTERNAL REGULATOR						
$I_{GATE(OFF)}$	Internal Sink Current	V_{GATE} = V_{IN} + 3V, V_{OUT} > V_{IN} + 100mV, t ≤ 10ms		2		A
$V_{SD(REV)}$	Reverse V_{SD} Threshold V_{IN} < V_{OUT}	V_{IN} - V_{OUT}	-40	–28	-20	mV
$\Delta V_{SD(REV)}$	Reverse V_{SD} Hysteresis			10		mV
$V_{SD(REG)}$	Regulated Forward V_{SD} Threshold V_{IN} > V_{OUT}	V_{IN} = 5V, V_{VS} = V_{IN}, V_{IN} - V_{OUT}	1	30	40	mV
		V_{IN} = 12V, V_{VS} = V_{IN}, V_{IN} - V_{OUT}	5	60	80	
INTERNAL MOSFET						
VDS	Drain to source voltage	IDS=250uA	60			V
RON	On resistance	ID=1A		8	12	mΩ



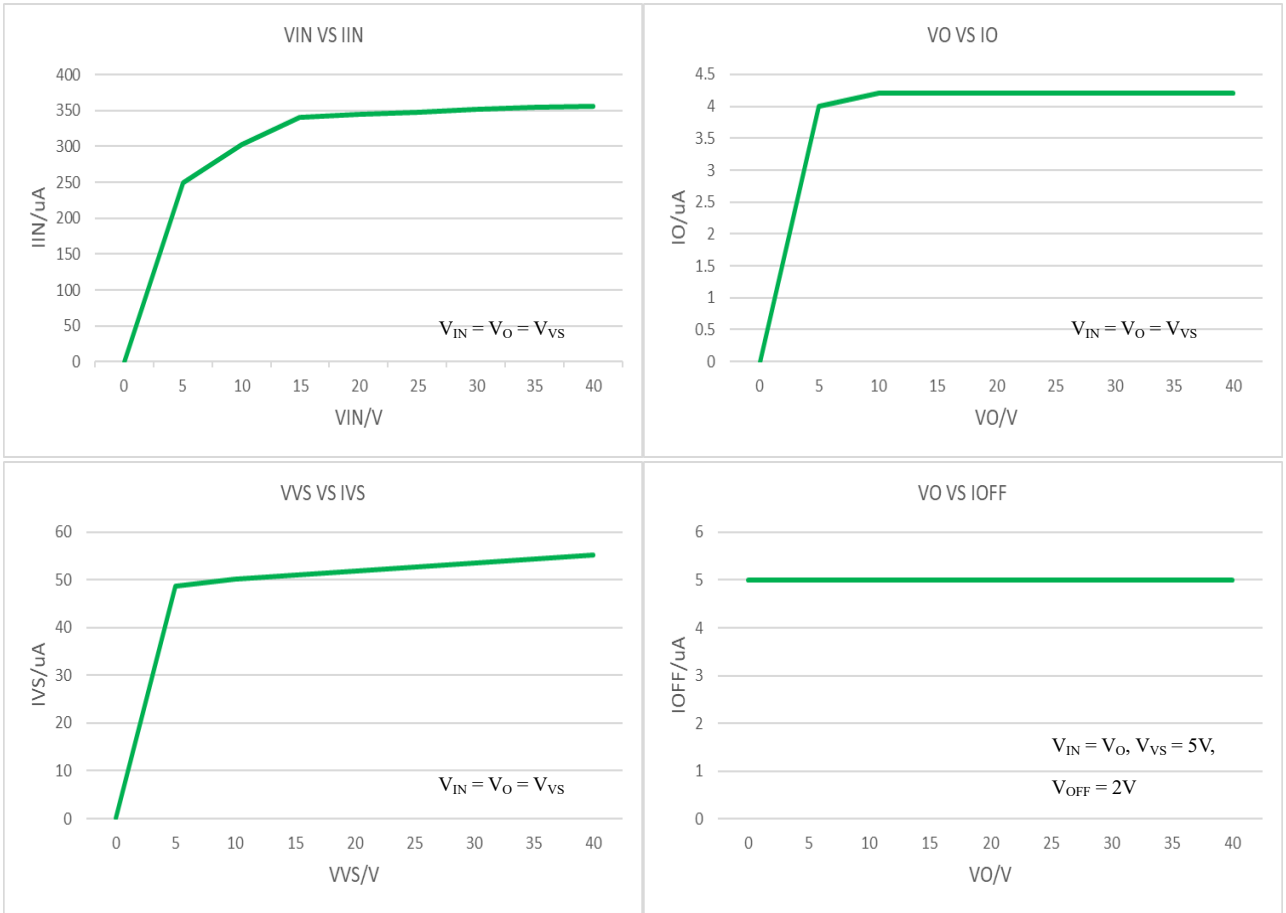
Gate OFF Timing for Forward to Reverse Transition

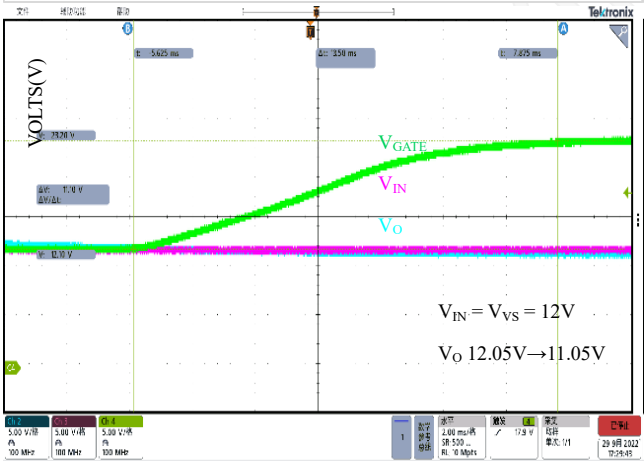


Gate OFF Timing for OFF Pin Low to High Transition

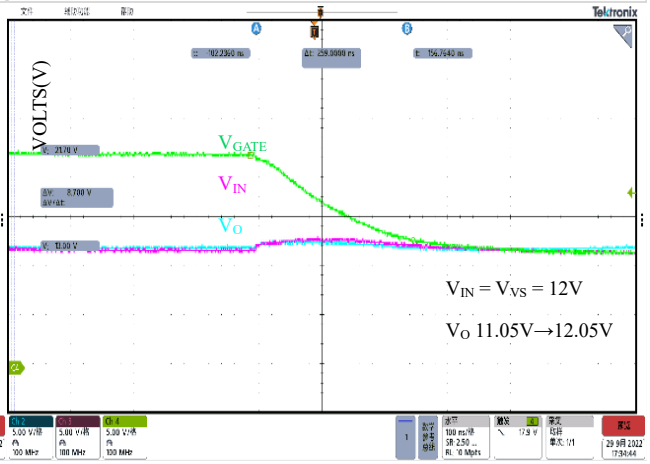
Characteristic plots

（V_{IN} = V_{VS} = V_{OUT}, TA = 25℃, unless otherwise noted）





Time 2ms/div



Time 100ns/div

Operation description

IN and OUT Pins

When power is initially applied, the load current will flow from source to drain through the body diode of the MOSFET. Once the voltage across the body diode exceeds $V_{SD(REG)}$ then the MX5052S begins charging the internal MOSFET gate through a 30 µA (typical) charge pump current source. In forward operation, the gate of the internal MOSFET is charged. The MX5052S is designed to regulate the MOSFET gate-to-source voltage. If the MOSFET current decreases to the point that the voltage across the MOSFET falls below the $V_{SD(REG)}$ voltage regulation point of 30mV (typical), the GATE pin voltage will be decreased until the voltage across the MOSFET is regulated at 30mV. If the source-to-drain voltage is greater than the $V_{SD(REG)}$ voltage, the gate-to-source voltage will increase and eventually reach the 12V GATE to IN pin Zener clamp level.

If the MOSFET current reverses, possibly due to failure of the input supply, such that the voltage across the MX5052S IN and OUT pins is more negative than the $V_{SD(REV)}$ voltage of -28mV (typical), the MX5052S will quickly discharge the MOSFET gate through a strong GATE to IN pin discharge transistor. If the input supply fails abruptly, as would occur if the supply was shorted directly to ground, a reverse current will temporarily flow through the MOSFET until the gate can be fully discharged. This reverse current is sourced from the load capacitance and from the parallel connected supplies. The MX5052S responds to a voltage reversal condition typically within 18ns. The actual time required to turn off the MOSFET will depend on the charge held by the gate capacitance of the MOSFET being used. For MX5052S, the gate capacitance of the internal MOSFET is 4.6nF and the typical turn off time is 25ns. This fast turnoff time minimizes voltage disturbances at the output, as well as the current transients from the redundant supplies.

VS Pin

The VS pin of MX5052S is the main supply pin for all internal biasing and an auxiliary supply for the internal gate drive charge pump.

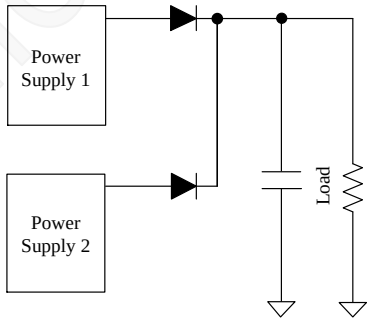
For typical MX5052S applications, the VS pin can be connected directly to the OUT pin. The capacitor value should be the lowest value that produces acceptable filtering of the voltage noise.

If VS is powered while IN is floating or grounded, then about 0.5 mA will leak from the VS pin into the IC and about 2mA will leak from the OUT pin into the IC.

Application and Implementation

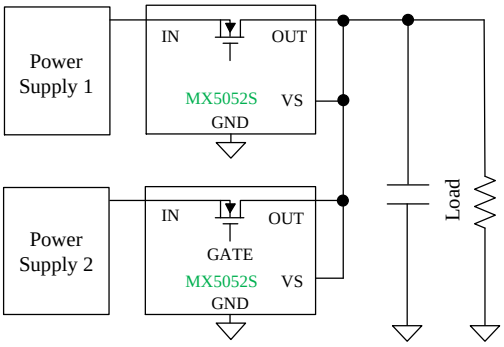
Application Information

Systems that require high availability often use multiple, parallel-connected redundant power supplies to improve reliability. Schottky OR-ing diodes are typically used to connect these redundant power supplies to a common point at the load. The disadvantage of using OR-ing diodes is the forward voltage drop, which reduces the available voltage and the associated power losses as load currents increase. Using an N-channel MOSFET to replace the OR-ing diode requires a small increase in the level of complexity, but reduces, or eliminates, the need for diode heat sinks or large thermal copper area in circuit board layouts for high power applications.



OR-ing with Diodes

The MX5052S is a positive voltage (that is, high-side) OR-ing controller that will drive an external N-channel MOSFET to replace an OR-ing diode. The voltage across the MOSFET source and drain pins is monitored by the MX5052S at the IN and OUT pins, while the GATE pin drives the MOSFET to control its operation based on the monitored source-drain voltage. The resulting behavior is that of an ideal rectifier with source and drain pins of the MOSFET acting as the anode and cathode pins of a diode respectively.



OR-ing With internal MOSFETs

Short Circuit Failure of an Input Supply

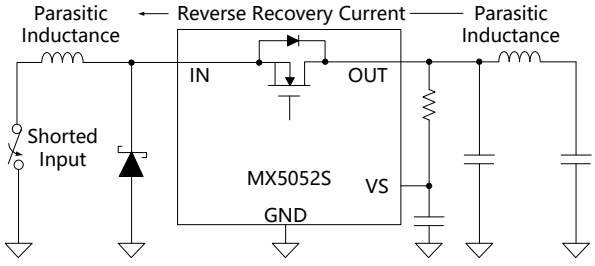
An abrupt 0Ω short circuit across the input supply will cause the highest possible reverse current to flow while the internal MX5052S control circuitry discharges the gate of the MOSFET. During this time, the reverse current is limited only by the $R_{DS(ON)}$ of the MOSFET, along with parasitic wiring resistances and inductances. Worst case instantaneous reverse current would be limited to:

$I_{D(REV)} = (V_{OUT} - V_{IN}) / R_{DS(ON)}$ (1)

The internal Reverse Comparator will react, and will start the process of discharging the Gate, when the reverse current reaches:

$I_{D(REV)} = V_{SD(REV)} / R_{DS(ON)}$ (2)

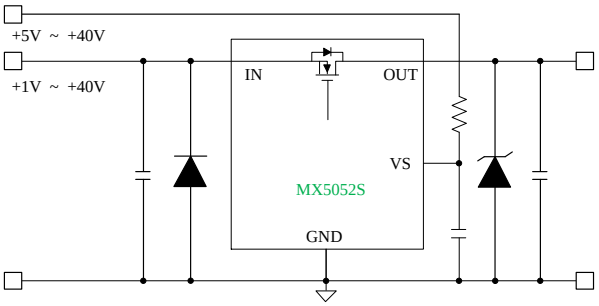
When the MOSFET is finally switched off, the energy stored in the parasitic wiring inductances will be transferred to the rest of the circuit. As a result, the MX5052S IN pin will see a negative voltage spike while the OUT pin will see a positive voltage spike. The IN pin can be protected by diode clamping the pin to GND in the negative direction. The OUT pin can be protected with a TVS protection diode, a local bypass capacitor, or both. In low voltage applications, the MOSFET drain to-source breakdown voltage rating may be adequate to protect the OUT pin (that is, $V_{IN} + V_{(BR)DSS(MAX)} < 40V$), but most MOSFET data sheets do not ensure the maximum breakdown rating, so this method should be used with caution.



Reverse Recovery Current Generates Spikes at V_{IN} and V_{OUT}

A Separate VS Supply for Low Vin Operation

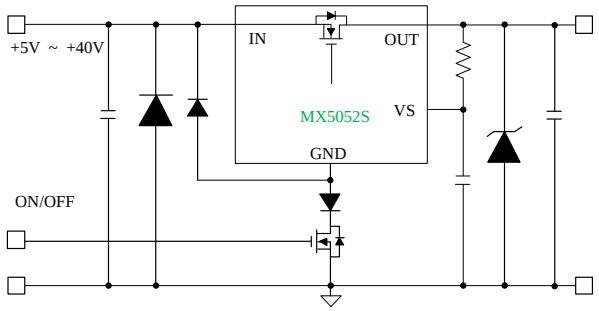
In some applications, it is desired to operate MX5052S from low supply voltage. The MX5052S can operate with a 1V rail voltage, provides its VS pin is biased from 5Vto 40. The detail of such application is depicted in the next figure.



Reverse Input Voltage Protection with IQ Reduction

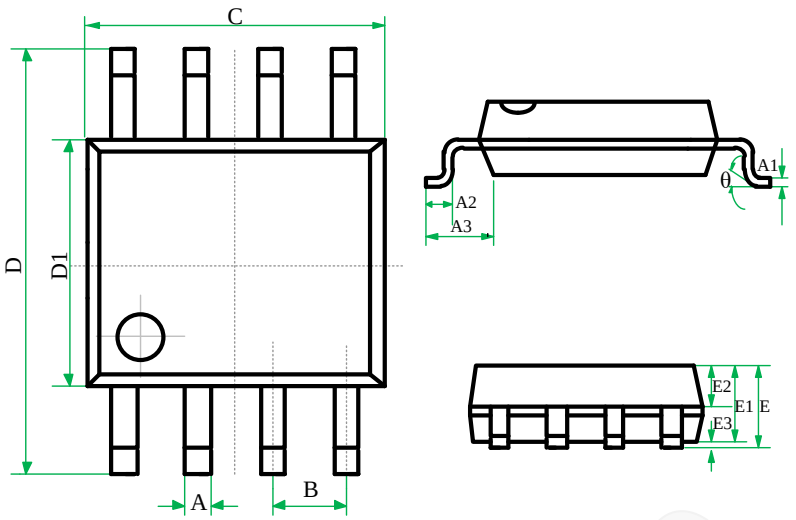
If VS is powered while IN is floating or grounded, then about 0.5mA will leak from the VS pin into the IC and about 3mA will leak from the OUT pin into the IC. From this leakage, about 0.05mA will flow out of the IN pin and the rest will flow to ground. This does not affect long term reliability of the IC, but may influence circuit design.

In battery powered applications, whenever MX5052S functionality is not needed, the supply to the MX5052S can be disconnected by turning OFF Q2, as shown in the following figure. This disconnects to the ground path of the MX5052S and eliminates the current leakage from the battery.



Reverse input voltage protection with IQ reduction schematic

Package information



SYMBOL	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.39	-	0.48	0.0154	-	0.0189
A1	0.21	-	0.28	0.008	-	0.011
A2	0.50	-	0.80	0.020	-	0.031
A3	1.05BSC			0.041BSC		
B	1.27BSC			0.050BSC		
C	4.70	4.90	5.10	0.185	0.193	0.201
D	5.80	6.00	6.20	0.228	0.236	0.244
D1	3.70	3.90	4.10	0.146	0.154	0.161
E	-	-	1.75	-	-	0.069
E1	1.30	1.40	1.50	0.051	0.055	0.059
E2	0.60	0.65	0.70	0.024	0.026	0.028
E3	0.10	-	0.225	0.004	-	0.009
θ	0	-	8°	0	-	8°

SOP8 for MX5052S

Restrictions on Product Use

◆ MAXIN micro is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing MAXIN products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such MAXIN products could cause loss of human life, bodily injury or damage to property.

◆ In developing your designs, please ensure that MAXIN products are used within specified operating ranges as set forth in the most recent MAXIN products specifications.

◆ The information contained herein is subject to change without notice.

Version update record:

V10 The original version （preliminary）

V11 separate VS supply and reverse protection with IQ reduction were added.