

## Dual Output Power Switch

### FEATURES

- Two Output Power Switches
- Total Output Drive — 200 mA Continuous
- 9-V to 35-V Supply Voltage Range
- Low Side or High Side Switch Configuration
- Internal Output Over Voltage Clamp For Driving Inductive Loads
- Current Limit Protection



Pb-free  
Available

- Thermal Shutdown Protection
- UVLO With User Programmable Time Delay

### APPLICATIONS

- Optical Detectors for Factory Automation

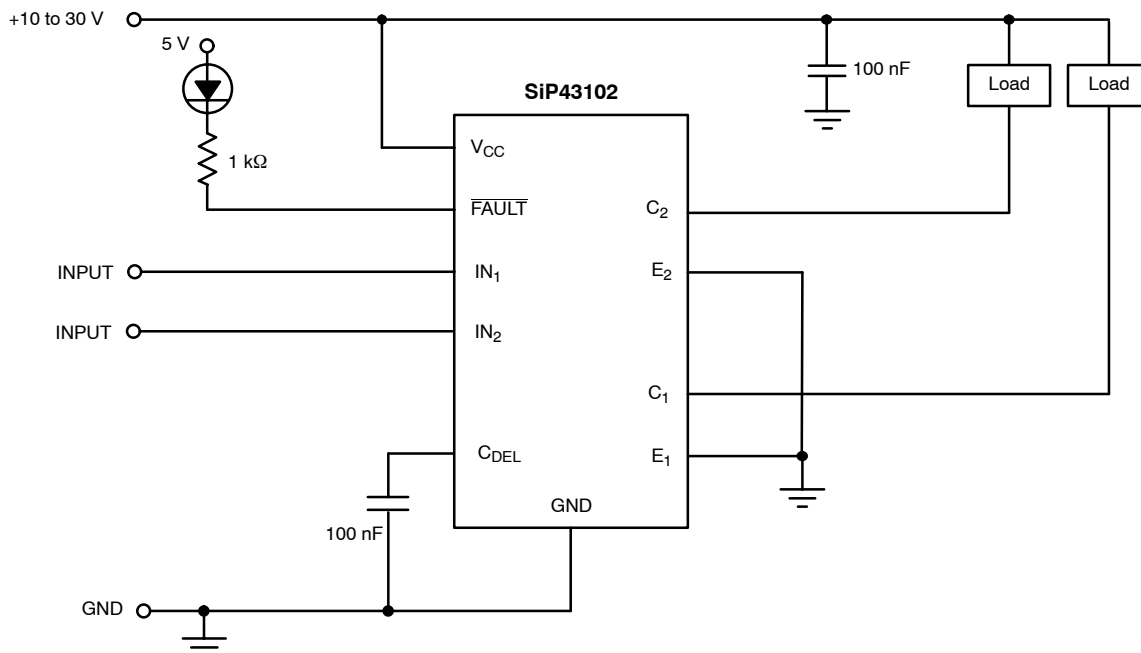
### DESCRIPTION

SiP43102 is a dual power switch IC which contains all control and power switching circuitry required to drive resistive and inductive loads in industrial applications. The output switches are NPN power transistors which can be configured as either high-side or low-side switches. These switches can operate from voltages as high as 35 V and have a continuous output current rating of 200 mA, combined or individually. Internal zener diodes are provided to clamp the power switch voltages to safe levels when driving inductive loads. The  $IN_1$  and  $IN_2$  pins are non-inverting inputs which control the output of switch 1 and switch 2 respectively. SiP43102 contains under

voltage lockout, UVLO, a user definable turn on delay, current limit, short circuit protection, and thermal shutdown.

The SiP43102 is available in 16-pin TSSOP and PowerPAK® MLP-44 packages, which are specified over the industrial, D suffix (–40 to 85°C) temperature range. Both standard and lead (Pb)-free options are available in the 16-pin TSSOP package.

### TYPICAL APPLICATION CIRCUIT



Both Switches Configured as Low-Side

## ABSOLUTE MAXIMUM RATINGS

|                                                    |                            |
|----------------------------------------------------|----------------------------|
| $V_{CC}$ .....                                     | 35 V                       |
| C1, E1, C2, E2 .....                               | 35 V                       |
| C1-E1, C2-E2 (clamped by internal circuitry) ..... | 52 V                       |
| Output Current                                     |                            |
| Continuous for one Output .....                    | 200 mA                     |
| Peak for one Output .....                          | 1.3 A                      |
| FAULT Output Current .....                         | 10 mA                      |
| FAULT Output Voltage .....                         | -0.3 V to $V_{CC} + 0.3$ V |
| $IN_1$ , $IN_{2A}$ , $IN_{2B}$ .....               | -0.3 V to $V_{CC} + 0.3$ V |
| Storage Temperature .....                          | -65 to 150°C               |
| Operating Junction Temperature .....               | 125°C                      |

|                                             |        |
|---------------------------------------------|--------|
| Power Dissipation                           |        |
| TSSOP-16 <sup>a</sup> @ 85°C .....          | 440 mW |
| PowerPAK MLP44-16 <sup>b</sup> @ 85°C ..... | 850 mW |
| Thermal Impedance ( $\theta_{JA}$ )         |        |
| TSSOP-16 <sup>c</sup> .....                 | 90°C/W |
| PowerPAK MLP44-16 <sup>d</sup> .....        | 47°C/W |

### Notes

- Derate 11.1 mW/°C
- Derate 21.3 mW/°C
- Device mounted on JEDEC compliant two layer test board.
- Device mounted on JEDEC compliant four layer test board.

Currents are positive into, negative out of the specified terminal.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## RECOMMENDED OPERATING RANGE

$V_{CC}$  .....

Operating Temperature Range ..... -40 to 85°C

| SPECIFICATIONS                         |             |                                                                                                                                                                    |                                     |                  |                  |               |
|----------------------------------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------------|------------------|---------------|
| Parameter                              | Symbol      | Test Conditions Unless Specified<br>$V_{CC} = 25\text{ V}$ , $IN_1, IN_2 = 0\text{ V}$ , $IN_1, IN_2, INV2 = 5\text{ V}$<br>$C_{DEL} = 10\text{ nF}$ , $T_A = T_J$ | Limits                              |                  |                  | Unit          |
|                                        |             |                                                                                                                                                                    | Min <sup>a</sup>                    | Typ <sup>b</sup> | Max <sup>a</sup> |               |
| Power Supply                           |             |                                                                                                                                                                    |                                     |                  |                  |               |
| Supply Voltage                         | $V_{CC}$    |                                                                                                                                                                    | 9                                   |                  | 32               | V             |
| Supply Current                         | $I_{CC}$    | -40 to 85°C, Both Inputs Enabled                                                                                                                                   |                                     | 6                | 9                | mA            |
| Logic Inputs ( $IN_1, IN_2$ )          |             |                                                                                                                                                                    |                                     |                  |                  |               |
| Digital Input High Level               | $V_{IH}$    |                                                                                                                                                                    | 3.5                                 |                  |                  | V             |
| Digital Input Low Level                | $V_{IL}$    |                                                                                                                                                                    |                                     |                  | 1.5              |               |
| Input Bias Current, Low Level          | $I_{IL}$    | $IN_1, IN_{2A}, IN_{2B} = 0\text{ V}$                                                                                                                              |                                     | -0.40            |                  | $\mu\text{A}$ |
| Input Bias Current, High Level         | $I_{IH}$    | $IN_1, IN_{2A}, IN_{2B} = 5\text{ V}$                                                                                                                              |                                     | 0.02             |                  |               |
| Switches 1&2 – High Side Configuration |             |                                                                                                                                                                    |                                     |                  |                  |               |
| Rise Time (Off to On)                  | $t_r$       | $R_{LOAD} = 250\ \Omega$ to GND, $C_1, C_2 = 25\text{ V}$                                                                                                          |                                     | 300              |                  | ns            |
| Rise Tiem (On to Off)                  | $t_f$       |                                                                                                                                                                    |                                     | 300              |                  |               |
| Saturation Voltage                     | $V_{SATHS}$ | $R_{LOAD} = 125\ \Omega$ to GND                                                                                                                                    | $T_A = 25\text{ }^{\circ}\text{C}$  |                  | 1.3              | V             |
|                                        |             |                                                                                                                                                                    | $T_A = -40\text{ }^{\circ}\text{C}$ |                  | 1.5              |               |
| Current Limit                          | $I_{LIMHS}$ | $R_{LOAD} = 0.25\ \Omega$ to GND, $T_A = 25\text{ }^{\circ}\text{C}$                                                                                               |                                     | 1.1              |                  | A             |
| Leakage Current                        | $I_{LHS}$   | $E_1, E_2 = \text{GND}$ , $C_1, C_2 = 25\text{ V}$ , $IN_1, IN_{2A}, IN_{2B} = 0\text{ V}$                                                                         |                                     |                  | 5                | $\mu\text{A}$ |
| Voltabe Clamp                          | $V_{CLHS}$  | Measure ( $V_{C1} - V_{E1}$ ) or ( $V_{C2} - V_{E2}$ )                                                                                                             |                                     | 52               |                  | V             |
| Switches 1&2 – Low Side Configuration  |             |                                                                                                                                                                    |                                     |                  |                  |               |
| Rise Time (On to Off)                  | $t_r$       | $R_{LOAD} = 250\ \Omega$ to $V_{CC}$ , $L_{LOAD} = 25\text{ V}$ to $C_1, C_2$                                                                                      |                                     | 400              |                  | ns            |
| Rise Tiem (Off to On)                  | $t_f$       |                                                                                                                                                                    |                                     | 350              |                  |               |
| Saturation Voltage                     | $V_{SATLS}$ | $R_{LOAD} = 125\ \Omega$ to $V_{CC}$                                                                                                                               | $T_A = 25\text{ }^{\circ}\text{C}$  |                  | 1.3              | V             |
|                                        |             |                                                                                                                                                                    | $T_A = -40\text{ }^{\circ}\text{C}$ |                  | 1.5              |               |
| Current Limit                          | $I_{LIMLS}$ | $R_{LOAD} = 0.25\ \Omega$ to $V_{CC}$ , $T_A = 25\text{ }^{\circ}\text{C}$                                                                                         |                                     | 1.1              |                  | A             |
| Leakage Current                        | $I_{LLS}$   | $E_1, E_2 = \text{GND}$ , $C_1, C_2 = 25\text{ V}$ , $IN_1, IN_{2A}, IN_{2B} = 0\text{ V}$                                                                         |                                     |                  | 5                | $\mu\text{A}$ |
| Voltage Clamp                          | $V_{CLLS}$  | Measure ( $V_{C1} - V_{E1}$ ) or ( $V_{C2} - V_{E2}$ )                                                                                                             |                                     | 52               |                  | V             |

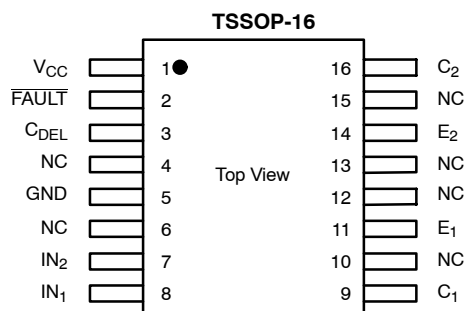
## SPECIFICATIONS

| Parameter                                | Symbol             | Test Conditions Unless Specified<br>V <sub>CC</sub> = 25 V, IN1, IN2 = 0 V, IN1, IN2, INV2 = 5 V<br>C <sub>DEL</sub> = 10 nF, T <sub>A</sub> = T <sub>J</sub> | Limits           |                  |                  | Unit |
|------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------|------------------|------|
|                                          |                    |                                                                                                                                                               | Min <sup>a</sup> | Typ <sup>b</sup> | Max <sup>a</sup> |      |
| Turn-On Delay                            |                    |                                                                                                                                                               |                  |                  |                  |      |
| C <sub>DEL</sub> Maximum Voltage         | V <sub>DEL</sub>   |                                                                                                                                                               |                  | 4.7              |                  | V    |
| C <sub>DEL</sub> Threshold               | V <sub>DELTH</sub> |                                                                                                                                                               |                  | 4                |                  |      |
| I <sub>CDEL</sub>                        | I <sub>CDEL</sub>  |                                                                                                                                                               |                  | 2.5              |                  | μA   |
| FAULT Output                             |                    |                                                                                                                                                               |                  |                  |                  |      |
| V <sub>CESAT</sub> Conducting State (On) | V <sub>SDON</sub>  | Load on $\overline{\text{FAULT}} \leq 10 \text{ mA}$                                                                                                          |                  | 0.4              |                  | V    |
| Operating Frequency                      |                    |                                                                                                                                                               |                  |                  |                  |      |
| Switching Frequency                      | f <sub>SW</sub>    |                                                                                                                                                               |                  |                  | 25               | kHz  |
| Under Voltage Lockout                    |                    |                                                                                                                                                               |                  |                  |                  |      |
| UVLO Threshold                           | V <sub>UVLO</sub>  |                                                                                                                                                               | 7.5              | 8                | 8.5              | V    |
| UVLO Hysteresis                          | V <sub>HYS</sub>   |                                                                                                                                                               | 0.4              | 0.5              | 0.6              |      |
| Thermal Shutdown                         |                    |                                                                                                                                                               |                  |                  |                  |      |
| Thermal Shutdown Threshold               | T                  |                                                                                                                                                               |                  | 160              |                  | °C   |
| Hysteresis                               | T <sub>HYS</sub>   |                                                                                                                                                               |                  | 20               |                  |      |

### Notes

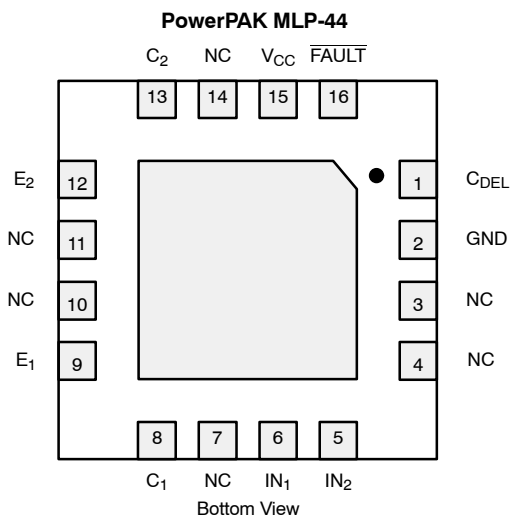
- a. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum ( $-40^{\circ}$  to  $85^{\circ}\text{C}$ ).
- b. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing and are measured at  $V_{CC} = 12\text{ V}$  unless otherwise noted.

## PIN CONFIGURATION



### TSSOP-16 ORDERING INFORMATION

| Standard-Part Number | Lead (Pb)-Free Part Number | Temperature Range             | Marking |
|----------------------|----------------------------|-------------------------------|---------|
| SiP43102DQ-T1        | SiP43102DQ-T1—E3           | $-40$ to $85^{\circ}\text{C}$ | 43102   |



### PowerPAK MLP-44 ORDERING INFORMATION

| Standard Part Number | Temperature Range             | Marking |
|----------------------|-------------------------------|---------|
| SiP43102DLP-T1       | $-40$ to $85^{\circ}\text{C}$ | 43102   |

| PIN DESCRIPTION      |                     |                    |                                                                                                   |
|----------------------|---------------------|--------------------|---------------------------------------------------------------------------------------------------|
| Pin Number           |                     | Name               | Function                                                                                          |
| TSSOP-16             | MLP44-16            |                    |                                                                                                   |
| 1                    | 15                  | $V_{CC}$           | Positive Supply Voltage                                                                           |
| 2                    | 16                  | $\overline{FAULT}$ | Open collector output that is switched low on in the event of Short Circuit or Thermal Shut Down. |
| 3                    | 1                   | $C_{DEL}$          | Connection for the external capacitor controlling the turn on delay.                              |
| 4, 6, 10, 12, 13, 15 | 3, 4, 7, 10, 11, 14 | NC                 | No connection                                                                                     |
| 5                    | 2                   | GND                | Ground Pin.                                                                                       |
| 7                    | 5                   | $IN_2$             | Input to the Exclusive OR controlling power switch 2.                                             |
| 8                    | 6                   | $IN_1$             | Input controlling power switch 1.                                                                 |
| 9                    | 8                   | $C_1$              | Collector of power switch 1.                                                                      |
| 11                   | 9                   | $E_1$              | Emitter of power switch 1.                                                                        |
| 14                   | 12                  | $E_2$              | Emitter of power switch 2.                                                                        |
| 16                   | 13                  | $C_2$              | Collector of power switch 2.                                                                      |

## DETAILED PIN DESCRIPTION

### $C_{DEL}$

A capacitor connected to this pin is used to set the duration the turn on delay. The delay starts after the UVLO threshold has been reached.

### $IN_1$

This pin controls the state of the output NPN switch 1. A Logic 0 holds the switch off while a Logic 1 turns the switch on.

### $IN_2$

This pin controls the state of the output NPN switch 2. A Logic 0 holds the switch off while a Logic 1 turns the switch on.

### $E_1$

This pin is the emitter of switch 1. This pin is connected to the load in the High-Side switch configuration, and is connected to Ground in the Low-Side configuration.

### $E_2$

This pin is the emitter of switch 2. This pin is connected to the load in the High-Side switch configuration, and is connected to Ground in the Low-Side configuration.

### $C_1$

This pin is the collector of switch 1. This pin is connected to the  $V_{CC}$  in the High-Side switch configuration, and is connected to the load in the Low-Side configuration.

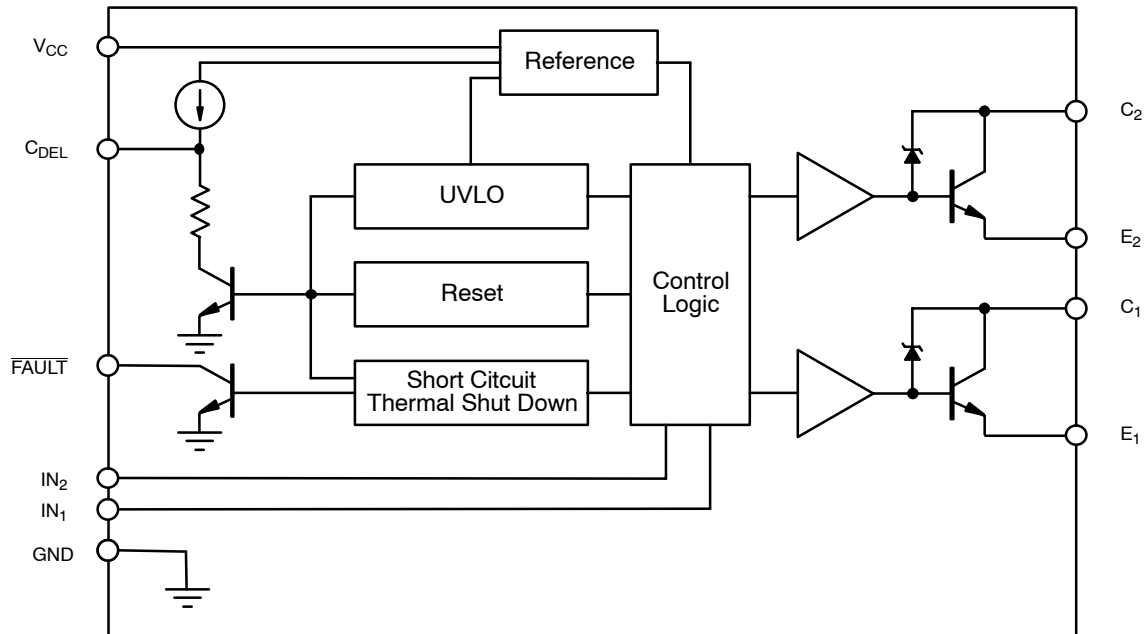
### $C_2$

This pin is the collector of switch 2. This pin is connected to the  $V_{CC}$  in the High-Side switch configuration, and is connected to the load in the Low-Side configuration.

### $\overline{FAULT}$

This pin is an open collector output that is pulled to Ground in the event of a short circuit, an overcurrent, or a thermal shut down.

## FUNCTIONAL BLOCK DIAGRAM



## DETAILED OPERATION

### Turn On Delay

The turn on delay prohibits the output switches from being turned on for a period of time after  $V_{CC}$  has passed through 8 V and the undervoltage condition no longer exists. The UVLO function keeps the external  $C_{DEL}$  capacitor discharged until  $V_{CC}$  is greater than 8 V. After that occurs, internal 2.5- $\mu A$  current source charges the capacitor from GND to 4.7 V. A comparator detects when the voltage on  $C_{DEL}$  passes through 4 V and enables the output switches. The delay time is a function of the capacitor value and is defined as 1.6 ms/nF.

An external switch can be connected across the capacitor to disable the output switches and reset the time delay.

### Short Circuit and Overcurrent indication

When an overcurrent or short circuit condition occurs on either switch, the SiP43102 enters a hiccup current limiting mode. In this mode, the capacitor on  $C_{DEL}$  is discharged down to 3 V, thus turning off the output switches, and then is charged up to 4 V by a 2.5- $\mu A$  internal current source, thus turning the switches on again. If the overcurrent or short circuit condition remains this cycle will continue. The switches are enabled at a very low duty cycle, minimizing the power dissipation and protecting the switches from damage.

The FAULT output will switch to GND, indicating that an overload condition or short circuit condition exists.



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