

## Dual Output Power Switch with Inverting Input

### 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
- User Programmable Phasing of Output Switches
- Internal Output Over Voltage Clamp For Driving Inductive Loads



Pb-free Available

- Current Limit Protection
- Thermal Shutdown Protection
- UVLO With User Programmable Time Delay

### APPLICATIONS

- Optical Detectors for Factory Automation

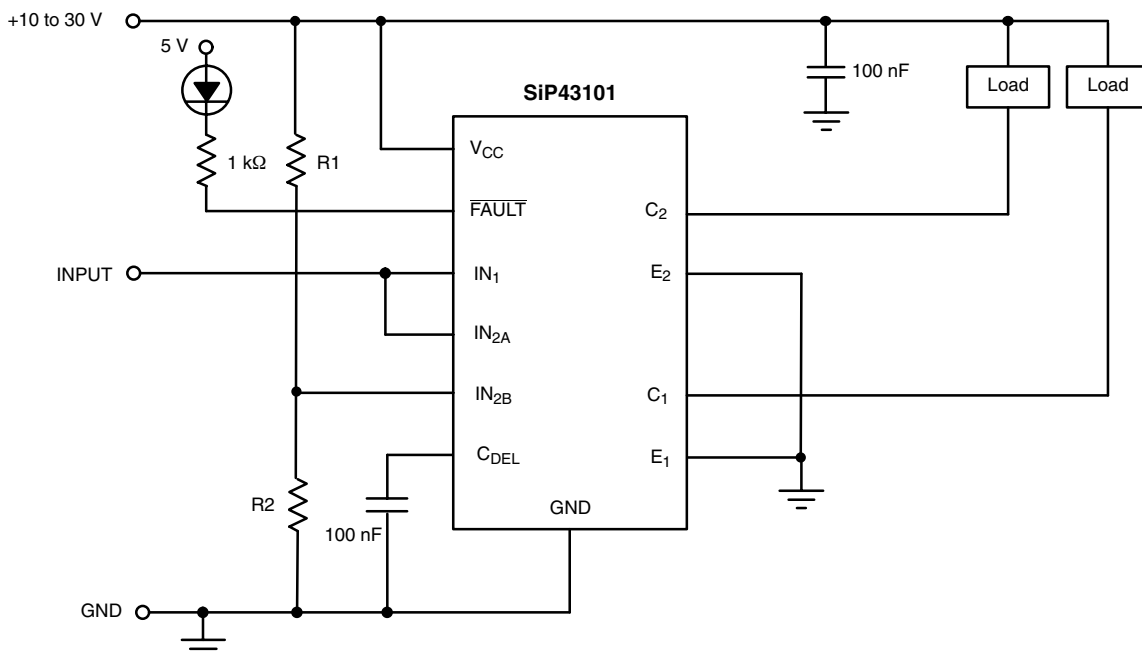
### DESCRIPTION

SiP43101 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 IN1 pin is a non-inverting input which controls the output of switch 1. A 2-input Exclusive OR gate input controls switch 2, allowing

switch 2 to be controlled by either an inverting or non-inverting control signal. SiP43101 contains under voltage lockout, UVLO, a user definable turn on delay, current limit, short circuit protection, and thermal shutdown.

The SiP43101 is available in both standard and lead (Pb)-free 16-pin TSSOP and PowerPAK® MLP-44 packages, which are specified over the industrial, D suffix (–40 to 85°C) temperature range.

### TYPICAL APPLICATION CIRCUIT



Both Switches Configured as Low-Side, Switch 2 Inverted With Respect to Switch 1, R1 +R2 Set Logic High



## 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

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

## SPECIFICATIONS

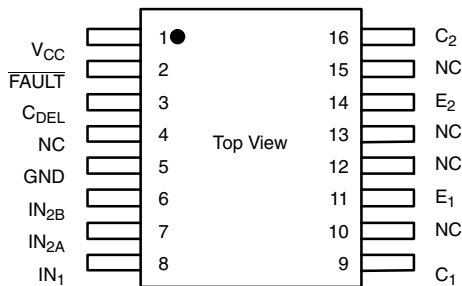
Parameter	Symbol	Test Conditions Unless Specified $V_{CC} = 25\text{ V}, IN_1, IN_2 = 0\text{ V}, IN_1, IN_2, INV2 = 5\text{ V}$ $C_{DEL} = 10\text{ nF}, T_A = T_J$	Limits			Unit
			Min <sup>a</sup>	Typ <sup>b</sup>	Max <sup>a</sup>	
<b>Turn-On Delay</b>						
$C_{DEL}$ Maximum Voltage	$V_{DEL}$			4.7		V
$C_{DEL}$ Threshold	$V_{DELTH}$			4		
$I_{CDEL}$	$I_{CDEL}$			2.5		$\mu\text{A}$
<b>FAULT Output</b>						
$V_{CESAT}$ Conducting State (On)	$V_{SDON}$	Load on FAULT $\leq 10\text{ mA}$		0.4		V
<b>Operating Frequency</b>						
Switching Frequency	$f_{SW}$			25		kHz
<b>Under Voltage Lockout</b>						
UVLO Threshold	$V_{UVLO}$		7.5	8	8.5	V
UVLO Hysteresis	$V_{HYS}$		0.4	0.5	0.6	
<b>Thermal Shutdown</b>						
Thermal Shutdown Threshold	T			160		$^{\circ}\text{C}$
Hysteresis	$T_{HYS}$			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

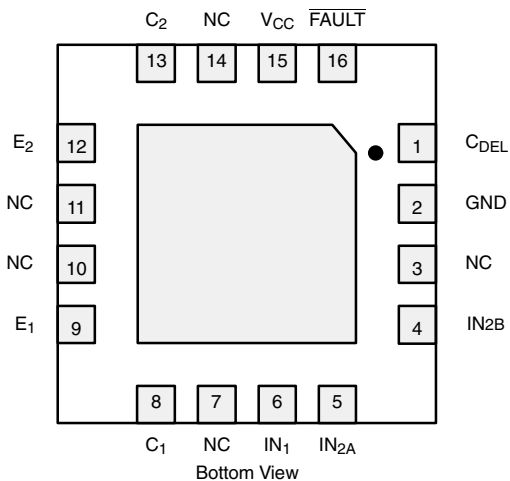
**TSSOP-16**



### TSSOP-16 ORDERING INFORMATION

Standard Part Number	Lead (Pb)-Free Part Number	Temperature Range	Marking
SiP43101DQ-T1	SiP43101DQ-T1-E3	$-40$ to $85^{\circ}\text{C}$	43101

**PowerPAK MLP-44**



### PowerPAK MLP-44 ORDERING INFORMATION

Standard Part Number	Lead (Pb)-Free Part Number	Temperature Range	Marking
SiP43101DLP-T1	SiP43101DLP-T1-E3	$-40$ to $85^{\circ}\text{C}$	43101



PIN DESCRIPTION			
Pin Number		Name	Function
TSSOP-16	MLP44-16		
1	15	V <sub>CC</sub>	Positive Supply Voltage
2	16	FAULT	Open collector output that is switched low on in the event of Short Circuit or Thermal Shut Down.
3	1	C <sub>DEL</sub>	Connection for the external capacitor controlling the turn on delay.
4, 10, 12, 13, 15	3, 7, 10, 11, 14	NC	No connection
5	2	GND	Ground Pin.
6	4	IN <sub>2B</sub>	Input to the Exclusive OR controlling power switch 2.
7	5	IN <sub>2A</sub>	Input to the Exclusive OR controlling power switch 2.
8	6	IN <sub>1</sub>	Input controlling power switch 1.
9	8	C <sub>1</sub>	Collector of power switch 1.
11	9	E <sub>1</sub>	Emitter of power switch 1.
14	12	E <sub>2</sub>	Emitter of power switch 2.
16	13	C <sub>2</sub>	Collector of power switch 2.

## DETAILED PIN DESCRIPTION

### C<sub>DEL</sub>

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<sub>1</sub>

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<sub>2A</sub>, IN<sub>2B</sub>

These pins are the inputs to the Exclusive OR gate that controls the state of the output NPN switch 2. This allows the use of either a non-inverting or an inverted signal to control the switch. Refer to the truth table for the logic function description.

IN <sub>2A</sub>	IN <sub>2B</sub>	SWITCH 2
Low	Low	Off
Low	High	On
High	Low	On
High	High	Off

### E<sub>1</sub>

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<sub>2</sub>

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<sub>1</sub>

This pin is the collector of switch 1. This pin is connected to the V<sub>CC</sub> in the High-Side switch configuration, and is connected to the load in the Low-Side configuration.

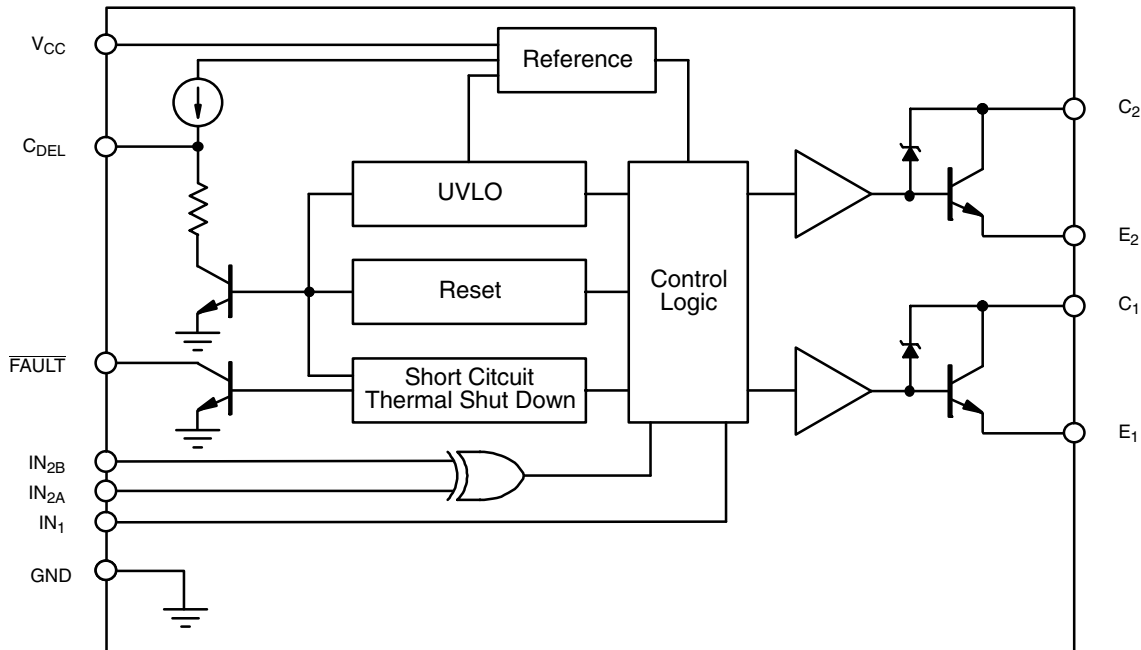
### C<sub>2</sub>

This pin is the collector of switch 2. This pin is connected to the V<sub>CC</sub> in the High-Side switch configuration, and is connected to the load in the Low-Side configuration.

### 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. Subsequently, an 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**

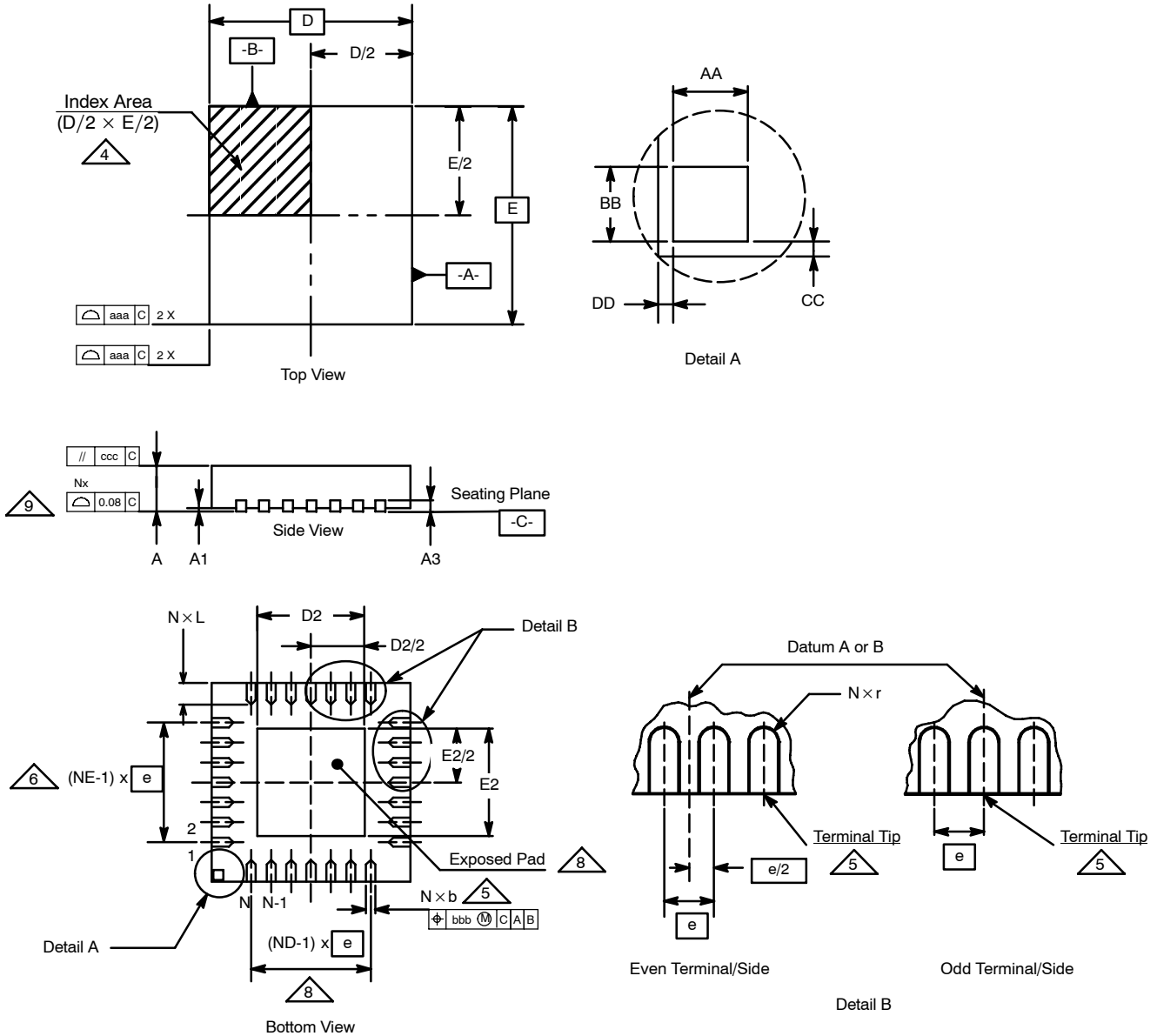
When an overcurrent or short circuit condition occurs on either switch, the SiP43101 enters a hiccup current limiting mode. In this mode, the capacitor on  $C_{DEL}$  is discharged down to 3 V, thus turning off the output switches, and then is charged up to 4 V by a 2.5- $\mu$ A internal current source, 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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**PowerPAK® MLP44-16 (POWER IC ONLY)**  
JEDEC Part Number: MO-220



### PowerPAK® MLP44-16 (Power IC Only)

JEDEC Part Number: MO-220

Dim	MILLIMETERS*			INCHES			Notes
	Min	Nom	Max	Min	Nom	Max	
A	0.80	0.90	1.00	0.0315	0.0354	0.0394	
A1	0	0.02	0.05	0	0.0008	0.0020	
A3	-	0.20 Ref	-	-	0.0079	-	
AA	-	0.345	-	-	0.0136	-	
aaa	-	0.15	-	-	0.0059	-	
BB	-	0.345	-	-	0.0136	-	
b	0.25	0.30	0.35	0.0098	0.0118	0.138	5
bbb	-	0.10	-	-	0.0039	-	
CC	-	0.18	-	-	0.0071	-	
ccc	-	0.10	-	-	0.0039	-	
D	4.00 BSC			0.1575 BSC			
D2	2.55	2.7	2.8	0.1004	0.1063	0.1102	
DD	-	0.18	-	-	0.0071	-	
E	4.00 BSC			0.1575 BSC			
E2	2.55	2.7	2.8	0.1004	0.1063	0.1102	
e	0.65 BSC			0.0256 BSC			
L	0.3	0.4	0.5	0.0118	0.0157	0.0197	
N	16			16			3, 7
ND	-	4	-	-	4	-	6
NE	-	4	-	-	4	-	6
r	b(min)/2	-	-	b(min)/2	-	-	

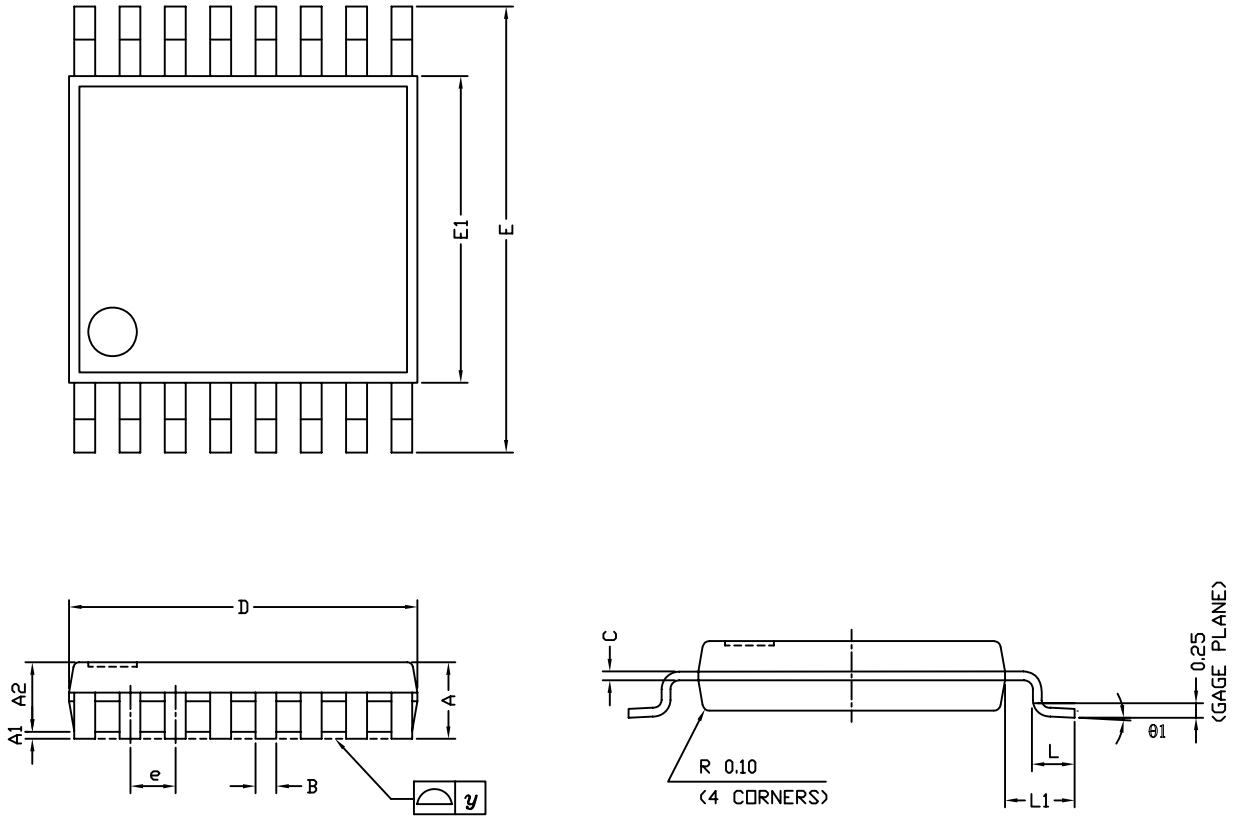
\* Use millimeters as the primary measurement.

ECN: S-50794—Rev. B, 16-May-05  
DWG: 5905

#### NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5M-1994.
2. All dimensions are in millimeters. All angles are in degrees.
3. N is the total number of terminals.
4. The terminal #1 identifier and terminal numbering convention shall conform to JESD 95-1 SPP-012. Details of terminal #1 identifier are optional, but must be located within the zone indicated. The terminal #1 identifier may be either a molded or marked feature. The X and Y dimension will vary according to lead counts.
5. Dimension b applies to metallized terminal and is measured between 0.25 mm and 0.30 mm from the terminal tip.
6. ND and NE refer to the number of terminals on the D and E side respectively.
7. Depopulation is possible in a symmetrical fashion.
8. Variation HHD is shown for illustration only.
9. Coplanarity applies to the exposed heat sink slug as well as the terminals.

## TSSOP: 16-LEAD



Symbols	DIMENSIONS IN MILLIMETERS		
	Min	Nom	Max
A	-	1.10	1.20
A1	0.05	0.10	0.15
A2	-	1.00	1.05
B	0.22	0.28	0.38
C	-	0.127	-
D	4.90	5.00	5.10
E	6.10	6.40	6.70
E1	4.30	4.40	4.50
e	-	0.65	-
L	0.50	0.60	0.70
L1	0.90	1.00	1.10
y	-	-	0.10
theta 1	0°	3°	6°

ECN: S-61920-Rev. D, 23-Oct-06  
DWG: 5624





## RECOMMENDED MINIMUM PAD FOR TSSOP-16



Recommended Minimum Pads  
Dimensions in inches (mm)



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