

## Single-Ended Bus Transceiver

### DESCRIPTION

The Si9241AEY is a monolithic bus transceiver designed to provide bidirectional serial communication in automotive diagnostic applications.

The device incorporates protection against overvoltages and short circuits to  $V_{BAT}$ . The transceiver pin is protected and can be driven beyond the  $V_{BAT}$  voltage.

The Si9241AEY is built on the Vishay Siliconix BiC/DMOS process. An epitaxial layer prevents latchup.

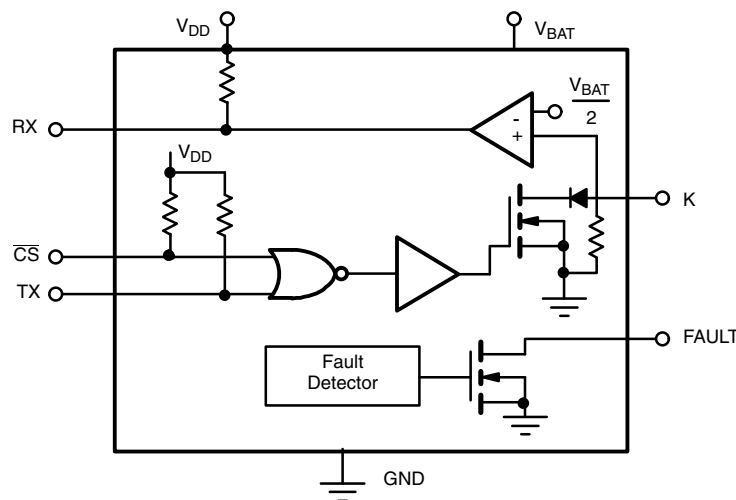
The RX output is capable of driving CMOS or 1 x LSTTL load.

The Si9241AEY is available in a space efficient 8-pin SO package. It operates reliably over the automotive temperature range (- 40 to 125 °C). The Si9241AEY is available in both standard and lead (Pb)-free packages.

### FEATURES

- Operating Power Supply Range  
 $6\text{ V} \leq V_{BAT} \leq 36\text{ V}$
- Reverse Battery Protection Down to  $V_{BAT} \geq -24\text{ V}$
- Standby Mode With Very Low Current Consumption  
 $I_{BAT(SB)} = 1\text{ }\mu\text{A}$  at  $V_{DD} = 0.5\text{ V}$
- Low Quiescent Current in OFF Condition  
 $I_{BAT} = 120\text{ }\mu\text{A}$  and  $I_{DD} \leq 10\text{ A}$
- ISO 9141 Compatible
- Overtemperature Shutdown Function For K Output
- Defined K Output OFF for Open GND
- Defined Receive Output Status for Open K Input
- Defined K Output OFF for TX Input Open
- Open Drain Fault Output
- 2 kV ESD
- Typical Transmit Speeds of 200 kBaud

### PIN CONFIGURATION AND FUNCTIONAL BLOCK DIAGRAM

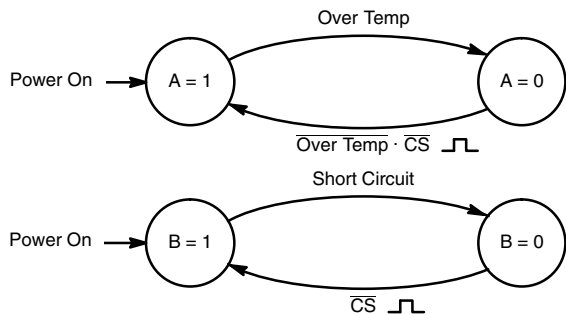


# Si9241A

Vishay Siliconix



## OUTPUT TABLE AND STATE DIAGRAMS



Note: Over Temp is an internal condition, not meant to be a logic signal.

| INPUTS          |    | STATE VARIABLE |   | OUTPUT TABLE |     |                    | Comments                   |
|-----------------|----|----------------|---|--------------|-----|--------------------|----------------------------|
| $\overline{CS}$ | TX | A              | B | RX           | K   | $\overline{FAULT}$ |                            |
| 0               | 0  | 1              | 1 | 0            | 0   | 1                  | Over Temp<br>Short Circuit |
| 0               | 1  | 1              | 1 | 1            | 1   | 1                  |                            |
| X               | X  | 0              | 1 | K            | HiZ | 0                  | Receive Mode               |
| 0               | X  | 1              | 0 | K            | HiZ | 0                  |                            |
| 1               | X  | 1              | 1 | 0            | 0   | 1                  | Receive Mode               |
| 1               | X  | 1              | 1 | 1            | 1   | 1                  |                            |

X = "1" or "0"  
HiZ = High Impedance State

| ABSOLUTE MAXIMUM RATINGS                                  |                                    |      |
|---|------------------------------------|------|
| Parameter   | Limit                              | Unit |
| <b>Voltages Referenced to Ground</b>                      |                                    |      |
| Voltage On $V_{BAT}$                                      | - 24 to 45                         | V    |
| Voltage K   | - 16 to ( $V_{BAT} + 1$ )          |      |
| Voltage Difference $V_{(VBAT, K)}$                        | 55                                 |      |
| Voltage or Max. Current On Any Pin (Except $V_{BAT}$ , K) | - 0.3 to ( $V_{DD} + 0.3$ V) or 10 | mA   |
| Voltage on $V_{DD}$                                       | 7                                  | V    |
| K Pin Only, Short Circuit Duration (to $V_{BAT}$ or GND)  | Continuous                         |      |
| Operating Temperature ( $T_A$ )                           | - 40 to 125                        | °C   |
| Junction and Storage Temperature                          | - 55 to 150                        |      |
| Thermal Impedance ( $\Theta_{JA}$ )                       | 125                                | °C/W |

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          |               |      |
|--------------------------------------|---------------|------|
| Parameter                            | Limit         | Unit |
| <b>Voltages Referenced to Ground</b> |               |      |
| $V_{DD}$                             | 4.5 to 5.5    | V    |
| $V_{BAT}$                            | 6 to 36       |      |
| K                                    | 6 to 36       |      |
| Digital Inputs                       | 0 to $V_{DD}$ |      |



| SPECIFICATIONS                                      |                |  |  |                          |                   |                   |               |
|---|----------------|--|--|--------------------------|-------------------|-------------------|---------------|
| Parameter   | Symbol         | Test Conditions Unless Specified<br>$V_{DD} = 4.5 \text{ V to } 5.5 \text{ V}$<br>$V_{BAT} = 6 \text{ V to } 36 \text{ V}$ | Temp. <sup>a</sup>                                   | Limits<br>- 40 to 125 °C |                   |                   | Unit          |
|   |                |  |  | Min. <sup>b</sup>        | Typ. <sup>c</sup> | Max. <sup>b</sup> |               |
| <b>Transmitter and Logic Levels</b>                 |                |  |  |                          |                   |                   |               |
| $\overline{CS}$ , TX Input Low Voltage              | $V_{ILT}$      |  | Full   |                          |                   | 1.5               | V             |
| $\overline{CS}$ , TX Input High Voltage             | $V_{IHT}$      |  | Full   | 3.5                      |                   |                   |               |
| TX Input Capacitance <sup>d</sup>                   | $C_{INT}$      |  | Full   |                          |                   | 10                | pF            |
| $\overline{CS}$ , TX Input Pull-up Resistance       | $R_{TX}$       | $V_{DD} = 5.5 \text{ V}$ , TX or $\overline{CS} = 1.5 \text{ V}$ , 3.5 V   | Full   | 10                       | 20                | 40                | k $\Omega$    |
| <b>K Transmit</b>                                   |                |  |  |                          |                   |                   |               |
| K Output Low Voltage                                | $V_{OLK}$      | $R_L = 510 \Omega \pm 5\%$ , $V_{BAT} = 6$ to 18   | Full   |                          |                   | $0.2 V_{BAT}$     | V             |
|   |                | $R_L = 1 \text{ k}\Omega \pm 5\%$ , $V_{BAT} = 16$ to 36   | Full   |                          |                   | $0.2 V_{BAT}$     |               |
|   |                | $R_L = 510 \Omega \pm 5\%$ , $V_{BAT} = 4.5$   | Full   |                          |                   | 1.2               |               |
| K Output High Voltage                               | $V_{OHK}$      | $R_L = 510 \Omega \pm 5\%$ , $V_{BAT} = 4.5$ to 18   | Full   | $0.95 V_{BAT}$           |                   |                   | V             |
|   |                | $R_L = 1 \text{ k}\Omega \pm 5\%$ , $V_{BAT} = 16$ to 36   | Full   | $0.95 V_{BAT}$           |                   |                   |               |
| K Rise, Fall Times                                  | $t_{r, ff}$    | See Test Circuit   | Full   |                          |                   | 9.6               | $\mu\text{s}$ |
| K Output Sink Resistance                            | $R_{si}$       | $\overline{CS} = 0 \text{ V}$ , TX = 0 V   | Full   |                          |                   | 110               | $\Omega$      |
| K Output Capacitance <sup>d</sup>                   | $C_O$          |  | Full   |                          |                   | 20                | pF            |
| <b>Receiver</b>                                     |                |  |  |                          |                   |                   |               |
| K Input Low Voltage                                 | $V_{ILK}$      |  | Full   |                          |                   | $0.35 V_{BAT}$    | V             |
| K Input High Voltage                                | $V_{IHK}$      |  | Full   | $0.65 V_{BAT}$           |                   |                   |               |
| K Input Hysteresis <sup>c, d</sup>                  | $V_{HYS}$      |  | Full   |                          | $0.05 V_{BAT}$    |                   |               |
| K Input Currents                                    | $I_{IHK}$      | $\overline{CS} = 4$  | Full   | $V_{IHK} = V_{BAT}$      |                   | 20                | $\mu\text{A}$ |
| RX Output Low Voltage                               | $V_{OLR}$      |  | $V_{ILK} = 0.35 V_{BAT}$<br>$I_{OLR} = 1 \text{ mA}$ | Full                     |                   |                   | 0.4           |
| RX Pull-up Resistance                               | $R_{RX}$       |  | Full   | 5                        |                   | 20                | k $\Omega$    |
| RX Turn On Delay                                    | $t_{d(on)}$    | $R_L = 510 \Omega \pm 5\%$ , $V_{BAT} = 6 \text{ V to } 18 \text{ V}$<br>$C_L = 10 \text{ nF}$ , See Test Circuit          | Full   |                          | 3                 | 10                | $\mu\text{s}$ |
|   |                | $R_L = 1 \text{ k}\Omega \pm 5\%$ , $V_{BAT} = 16 \text{ V to } 36 \text{ V}$<br>$C_L = 4.7 \text{ nF}$ , See Test Circuit | Full   |                          | 3                 | 10                |               |
| RX Turn Off Delay                                   | $t_{d(off)}$   | $R_L = 510 \Omega \pm 5\%$ , $V_{BAT} = 6 \text{ V to } 18 \text{ V}$<br>$C_L = 10 \text{ nF}$ , See Test Circuit          | Full   |                          | 3                 | 10                | $\mu\text{s}$ |
|   |                | $R_L = 1 \text{ k}\Omega \pm 5\%$ , $V_{BAT} = 16 \text{ V to } 36 \text{ V}$<br>$C_L = 4.7 \text{ nF}$ , See Test Circuit | Full   |                          | 3                 | 10                |               |
| <b>Supplies</b>                                     |                |  |  |                          |                   |                   |               |
| Bat Supply Current On                               | $I_{BAT(on)}$  | $\overline{CS} = TX = 0 \text{ V}$ , $V_{BAT} \leq 16 \text{ V}$   | Full   |                          | 1.2               | 3                 | mA            |
| Bat Supply Current Off                              | $I_{BAT(off)}$ | $\overline{CS} = \text{High}$ , $V_{BAT} \leq 12 \text{ V}$ , TX = High <sup>f</sup>                                       | Full   |                          | 120               | 220               | $\mu\text{A}$ |
| Bat Supply Current Standby                          | $I_{BAT(SB)}$  | $V_{DD} \leq 0.5 \text{ V}$ , $V_{BAT} \leq 12 \text{ V}$  | Full   |                          | < 1               | 10                |               |
| Logic Supply Current On                             | $I_{DD(on)}$   | $V_{DD} \leq 5.5 \text{ V}$ , TX = 0 V   | Full   |                          | 1.4               | 2.3               | mA            |
| Logic Supply Current Off                            | $I_{DD(off)}$  | $\overline{CS} = \text{High}$ , $V_{BAT} \leq 12 \text{ V}$ , TX = High <sup>f</sup>                                       | Full   |                          |                   | 10                | $\mu\text{A}$ |
| <b>Miscellaneous</b>                                |                |  |  |                          |                   |                   |               |
| TX Transmit Baud Rate                               | $BR_T$         | $R_L = 510 \Omega$ , $C_L = 10 \text{ nF}$   | Full   | 10.4                     |                   |                   | kBaud         |
| RX Receive Baud Rate <sup>c</sup>                   | $BR_R$         | $6 \text{ V} < V_{BAT} < 16 \text{ V}$ , $C_{RX} = 20 \text{ pF}$  | Full   |                          | 200               |                   |               |
| Transmission Frequency                              | $f_{K-RXK}$    | $6 \text{ V} < V_{BAT} < 16 \text{ V}$ , $R_K = 510 \Omega$ , $C_K \leq 1.3 \text{ nF}$                                    | Full   | 50                       | 200               |                   | kHz           |
| Fault Output Low Voltage                            | $V_{OLF}$      | $\overline{CS} = TX = 0$ , $K = V_{BAT}$ , $I_{OLF} = 1 \text{ mA}$  | Full   |                          |                   | 0.4               | V             |
| $\overline{CS}$ Minimum Pulse Width <sup>d, e</sup> | $t_{cs}$       |  | Full   | 1                        |                   |                   | $\mu\text{s}$ |
| Over Temperature Shutdown <sup>d</sup>              | $T_{SHUT}$     | Temperature Rising   |  | 160                      | 180               |                   | °C            |
| Temperature Shutdown Hysteresis <sup>c</sup>        | $T_{HYST}$     |  |  |                          | 30                |                   |               |

## Notes:

a. Room = 25 °C, Cold and Hot = as determined by the operating temperature suffix.

b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.

c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.

d. Guaranteed by design, not subject to production test.

e. Minimum pulse width to reset a fault condition.

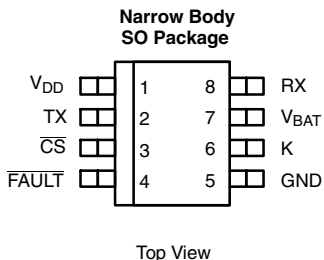
f. High refers to Logic High and Low refers to Logic Low.

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Vishay Siliconix



## PIN CONFIGURATION



| ORDERING INFORMATION             |                   |
|----------------------------------|-------------------|
| Part Number                      | Temperature Range |
| Si9241AEY-T1                     | - 40 °C to 125 °C |
| Si9241AEY-T1-E3 (Lead (Pb)-free) |                   |

| PIN DESCRIPTION |                    |                                 |
|-----------------|--------------------|---------------------------------|
| Pin Number      | Symbol             | Description                     |
| 1               | V <sub>DD</sub>    | Positive Power Supply           |
| 2               | TX                 | Transmit, Input                 |
| 3               | $\overline{CS}$    | Chip Select, Input              |
| 4               | $\overline{FAULT}$ | Fault, Open Drain Output        |
| 5               | GND                | Ground Connection               |
| 6               | K                  | Transmit/Receive, Bidirectional |
| 7               | V <sub>BAT</sub>   | Battery Power Supply            |
| 8               | RX                 | Receiver, Output                |

## FUNCTIONAL DESCRIPTION

The Si9241AEY can be either in transmit or receive mode and it contains over temperature, and short circuit V<sub>BAT</sub> fault detection circuits.

The voltage on K is internally compared to V<sub>BAT/2</sub>. If the voltage on the K pin is less than V<sub>BAT/2</sub> then RX output will be "low". If the voltage on the K pin is greater than V<sub>BAT/2</sub> then RX output will be "high".

In order to be in transmit mode,  $\overline{CS}$  must be set "low". When  $\overline{CS}$  and TX are set "low" the internal MOSFET will turn on, causing the K pin to be "low". In the transmit mode, the processor monitors RX and TX. When the two mirror each other there is no fault. In the event of over temperature, or short circuit to V<sub>BAT</sub>, the Si9241AEY will turn off the K output to protect the IC and the external open drain FAULT pin will

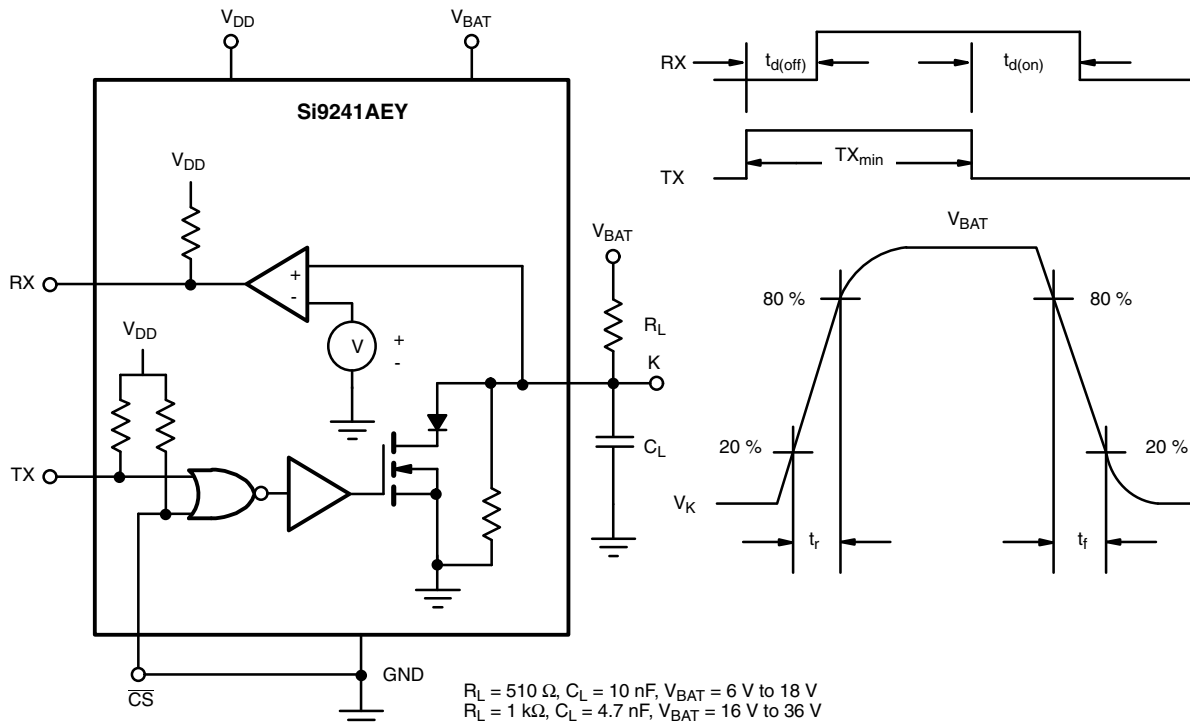
be asserted. The K pin will stay in high impedance and RX will follow the K pin. The fault will be reset when  $\overline{CS}$  is toggled high. RX,  $\overline{CS}$  and TX pins have an internal pull up resistor to V<sub>DD</sub> while the K pin has internal pull down resistors. When any one of the TX, V<sub>BAT</sub> or GND pins is open the K output is off.

When  $\overline{CS}$  is set "high" the Si9241AEY is in receive mode and the internal MOSFET for the K pin is turned off. The RX output will follow the K pin. If  $\overline{CS}$  is "low" while the IC is receiving data, an incorrect fault signal will occur.

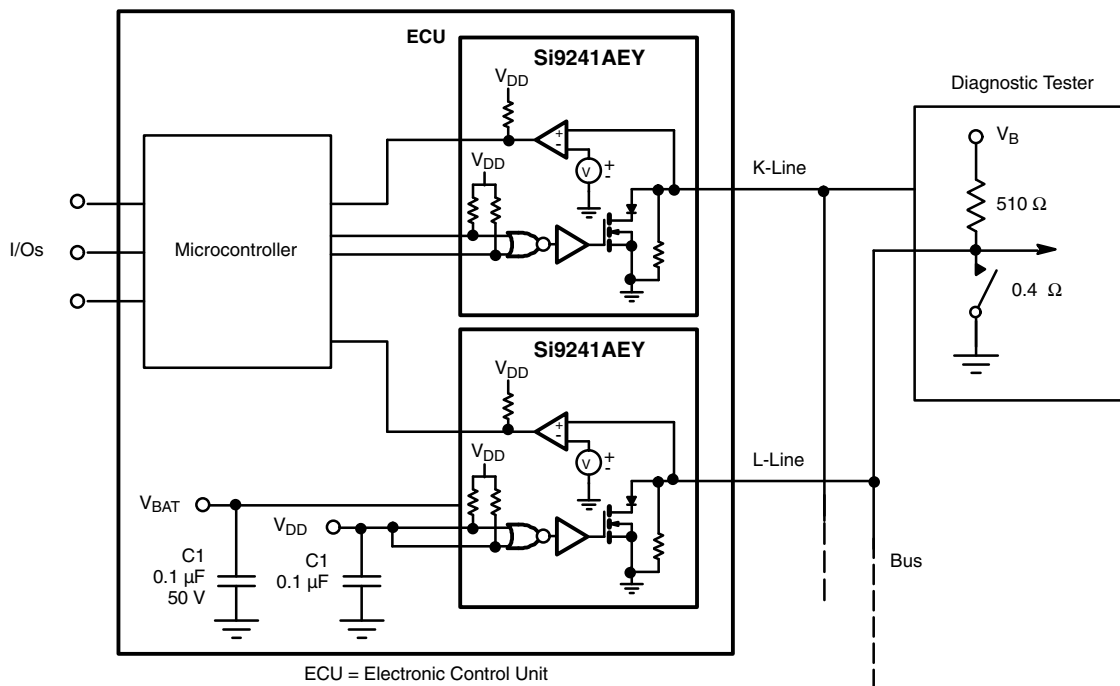
To inhibit the short detect, tie  $\overline{CS}$  and TX together.



**TEST CIRCUIT AND TIMING DIAGRAMS (TRANSMIT ONLY)**



**APPLICATIONS CIRCUIT**

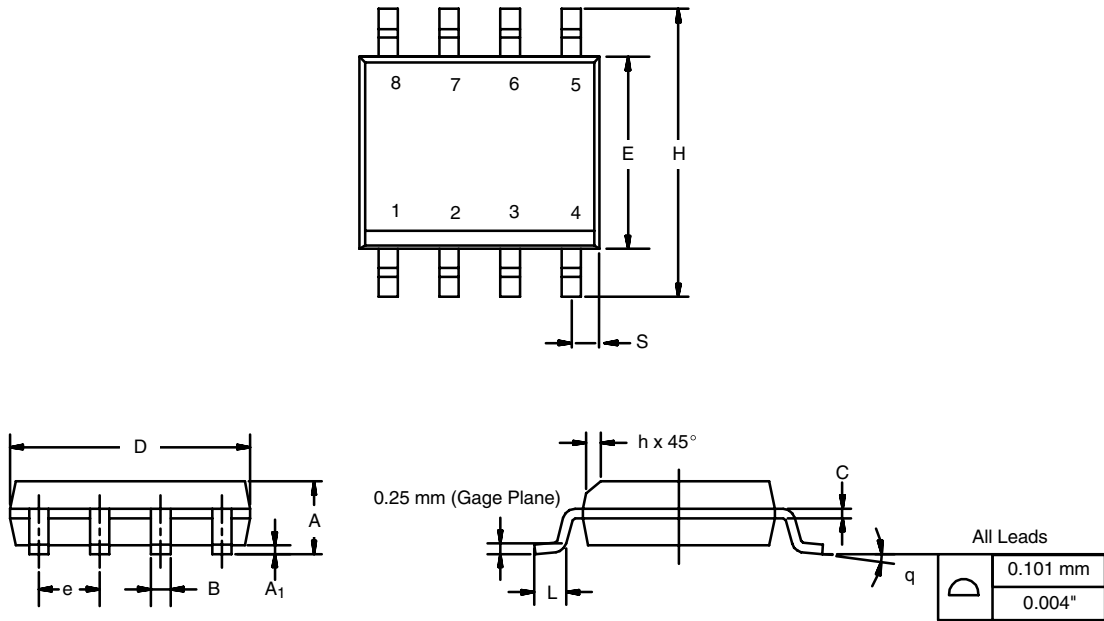


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**SOIC (NARROW): 8-LEAD**

JEDEC Part Number: MS-012



| DIM   | MILLIMETERS |      | INCHES    |       |
|---|-------------|------|-----------|-------|
|   | Min         | Max  | Min       | Max   |
| A   | 1.35        | 1.75 | 0.053     | 0.069 |
| A <sub>1</sub>                              | 0.10        | 0.20 | 0.004     | 0.008 |
| B   | 0.35        | 0.51 | 0.014     | 0.020 |
| C   | 0.19        | 0.25 | 0.0075    | 0.010 |
| D   | 4.80        | 5.00 | 0.189     | 0.196 |
| E   | 3.80        | 4.00 | 0.150     | 0.157 |
| e   | 1.27 BSC    |      | 0.050 BSC |       |
| H   | 5.80        | 6.20 | 0.228     | 0.244 |
| h   | 0.25        | 0.50 | 0.010     | 0.020 |
| L   | 0.50        | 0.93 | 0.020     | 0.037 |
| q   | 0°          | 8°   | 0°        | 8°    |
| S   | 0.44        | 0.64 | 0.018     | 0.026 |
| ECN: C-06527-Rev. I, 11-Sep-06<br>DWG: 5498 |             |      |           |       |



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