

## Precision Monolithic Quad SPST CMOS Analog Switches

### DESCRIPTION

The DG411 series of monolithic quad analog switches was designed to provide high speed, low error switching of precision analog signals. Combining low power (0.35  $\mu$ W) with high speed ( $t_{ON}$ : 110 ns), the DG411 family is ideally suited for portable and battery powered industrial and military applications.

To achieve high-voltage ratings and superior switching performance, the DG411 series was built on Vishay Siliconix's high voltage silicon gate process. An epitaxial layer prevents latchup.

Each switch conducts equally well in both directions when on, and blocks input voltages up to the supply levels when off.

The DG411, DG412 respond to opposite control logic as shown in the Truth Table. The DG413 has two normally open and two normally closed switches.

### FEATURES

- Halogen-free according to IEC 61249-2-21 Definition
- 44 V supply max. rating
- $\pm 15$  V analog signal range
- On-resistance -  $R_{DS(on)}$ : 25  $\Omega$
- Fast switching -  $t_{ON}$ : 110 ns
- Ultra low power -  $P_D$ : 0.35  $\mu$ W
- TTL, CMOS compatible
- Single supply capability
- Compliant to RoHS Directive 2002/95/EC



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**

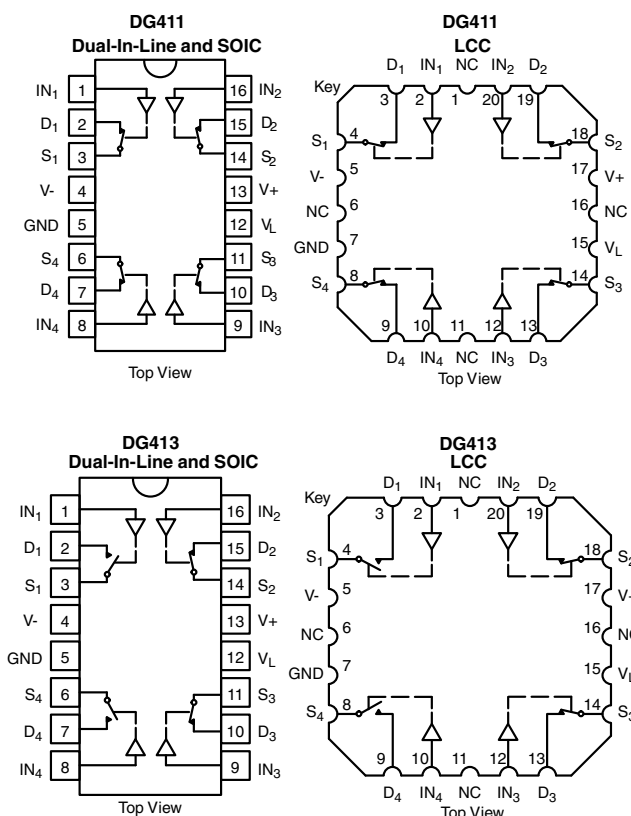
### BENEFITS

- Widest dynamic range
- Low signal errors and distortion
- Break-before-make switching action
- Simple interfacing

### APPLICATIONS

- Precision automatic test equipment
- Precision data acquisition
- Communication systems
- Battery powered systems
- Computer peripherals

### FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



#### TRUTH TABLE

| Logic | DG411 | DG412 |
|-------|-------|-------|
| 0     | ON    | OFF   |
| 1     | OFF   | ON    |

Logic "0"  $\leq 0.8$  V  
Logic "1"  $\geq 2.4$  V

#### TRUTH TABLE

| Logic | SW <sub>1</sub> , SW <sub>4</sub> | SW <sub>2</sub> , SW <sub>3</sub> |
|-------|-----------------------------------|-----------------------------------|
| 0     | OFF                               | ON                                |
| 1     | ON                                | OFF                               |

Logic "0"  $\leq 0.8$  V  
Logic "1"  $\geq 2.4$  V

| ORDERING INFORMATION |                    |                                                      |
|----------------------|--------------------|------------------------------------------------------|
| Temp. Range          | Package            | Part Number                                          |
| - 40 °C to 85 °C     | 16-pin plastic DIP | DG411DJ<br>DG411DJ-E3                                |
|                      |                    | DG412DJ<br>DG412DJ-E3                                |
|                      |                    | DG413DJ<br>DG413DJ-E3                                |
|                      | 16-pin narrow SOIC | DG411DY<br>DG411DY-E3<br>DG411DY-T1<br>DG411DY-T1-E3 |
|                      |                    | DG412DY<br>DG412DY-E3<br>DG412DY-T1<br>DG412DY-T1-E3 |
|                      |                    | DG413DY<br>DG413DY-E3<br>DG413DY-T1<br>DG413DY-T1-E3 |
|                      | 16-pin TSSOP       | DG411DQ-E3<br>DG411DQ-T1-E3                          |
|                      |                    | DG412DQ-E3<br>DG412DQ-T1-E3                          |
|                      |                    | DG413DQ-E3<br>DG413DQ-T1-E3                          |

| ABSOLUTE MAXIMUM RATINGS                                      |                                 |                                                         |      |
|---------------------------------------------------------------|---------------------------------|---------------------------------------------------------|------|
| Parameter                                                     |                                 | Limit                                                   | Unit |
| V + to V -                                                    |                                 | 44                                                      | V    |
| GND to V -                                                    |                                 | 25                                                      |      |
| V <sub>L</sub>                                                |                                 | (GND - 0.3) to (V+) + 0.3                               |      |
| Digital Inputs <sup>a</sup> , V <sub>S</sub> , V <sub>D</sub> |                                 | (V-) -2 to (V+) + 2<br>or 30 mA, whichever occurs first |      |
| Continuous Current (Any terminal)                             |                                 | 30                                                      | mA   |
| Peak Current, S or D (Pulsed at 1 ms, 10 % duty cycle)        |                                 | 100                                                     |      |
| Storage Temperature                                           | (AK, AZ suffix)                 | - 65 to 150                                             | °C   |
|                                                               | (DJ, DY suffix)                 | - 65 to 125                                             |      |
| Power Dissipation (Package) <sup>b</sup>                      | 16-pin plastic DIP <sup>c</sup> | 470                                                     | mW   |
|                                                               | 16-pin narrow SOIC <sup>d</sup> | 600                                                     |      |
|                                                               | 16-pin CerDIP <sup>e</sup>      | 900                                                     |      |
|                                                               | LCC-20 <sup>e</sup>             | 900                                                     |      |

Notes:

a. Signals on S<sub>X</sub>, D<sub>X</sub>, or IN<sub>X</sub> exceeding V + or V - will be clamped by internal diodes. Limit forward diode current to maximum current ratings.

b. All leads welded or soldered to PC board.

c. Derate 6 mW/°C above 25 °C.

d. Derate 7.6 mW/°C above 75 °C.

e. Derate 12 mW/°C above 75 °C.



| SPECIFICATIONS <sup>a</sup>                  |                     |                                                                                                                                                            |                    |                   |                               |                   |                              |                   |      |
|----------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|-------------------------------|-------------------|------------------------------|-------------------|------|
| Parameter                                    | Symbol              | Test Conditions<br>Unless Specified<br>V <sub>+</sub> = 15 V, V <sub>-</sub> = - 15 V<br>V <sub>L</sub> = 5 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup> | Temp. <sup>b</sup> | Typ. <sup>c</sup> | A Suffix<br>- 55 °C to 125 °C |                   | D Suffix<br>- 40 °C to 85 °C |                   | Unit |
|                                              |                     |                                                                                                                                                            |                    |                   | Min. <sup>d</sup>             | Max. <sup>d</sup> | Min. <sup>d</sup>            | Max. <sup>d</sup> |      |
| Analog Switch                                |                     |                                                                                                                                                            |                    |                   |                               |                   |                              |                   |      |
| Analog Signal Range <sup>e</sup>             | V <sub>ANALOG</sub> |                                                                                                                                                            | Full               |                   | - 15                          | 15                | - 15                         | 15                | V    |
| Drain-Source<br>On-Resistance                | R <sub>DS(on)</sub> | V <sub>+</sub> = 13.5 V, V <sub>-</sub> = - 13.5 V<br>I <sub>S</sub> = - 10 mA, V <sub>D</sub> = ± 8.5 V                                                   | Room<br>Full       | 25                |                               | 35<br>45          |                              | 35<br>45          | Ω    |
| Switch Off Leakage<br>Current                | I <sub>S(off)</sub> | V <sub>+</sub> = 16.5, V <sub>-</sub> = - 16.5 V<br>V <sub>D</sub> = ± 15.5 V, V <sub>S</sub> = ± 15.5 V                                                   | Room<br>Full       | ± 0.1             | - 0.25<br>- 20                | 0.25<br>20        | - 0.25<br>- 5                | 0.25<br>5         | nA   |
|                                              | I <sub>D(off)</sub> |                                                                                                                                                            | Room<br>Full       | ± 0.1             | - 0.25<br>- 20                | 0.25<br>20        | - 0.25<br>- 5                | 0.25<br>5         |      |
| Channel On Leakage<br>Current                | I <sub>D(on)</sub>  | V <sub>+</sub> = 16.5 V, V <sub>-</sub> = - 16.5 V<br>V <sub>S</sub> = V <sub>D</sub> = ± 15.5 V                                                           | Room<br>Full       | ± 0.1             | - 0.4<br>- 40                 | 0.4<br>40         | - 0.4<br>- 10                | 0.4<br>10         |      |
| Digital Control                              |                     |                                                                                                                                                            |                    |                   |                               |                   |                              |                   |      |
| Input Current, V <sub>IN</sub> Low           | I <sub>IL</sub>     | V <sub>IN</sub> under test = 0.8 V                                                                                                                         | Full               | 0.005             | - 0.5                         | 0.5               | - 0.5                        | 0.5               | μA   |
| Input Current, V <sub>IN</sub> High          | I <sub>IH</sub>     | V <sub>IN</sub> under test = 2.4 V                                                                                                                         | Full               | 0.005             | - 0.5                         | 0.5               | - 0.5                        | 0.5               |      |
| Dynamic Characteristics                      |                     |                                                                                                                                                            |                    |                   |                               |                   |                              |                   |      |
| Turn-On Time                                 | t <sub>ON</sub>     | R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF<br>V <sub>S</sub> = ± 10 V, see figure 2                                                                    | Room<br>Full       | 110               |                               | 175<br>240        |                              | 175<br>220        | ns   |
| Turn-Off Time                                | t <sub>OFF</sub>    |                                                                                                                                                            | Room<br>Full       | 100               |                               | 145<br>160        |                              | 145<br>160        |      |
| Break-Before-Make<br>Time Delay              | t <sub>D</sub>      | DG413 only, V <sub>S</sub> = 10 V<br>R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF                                                                        | Room               | 25                |                               |                   |                              |                   |      |
| Charge Injection                             | Q                   | V <sub>g</sub> = 0 V, R <sub>g</sub> = 0 Ω<br>C <sub>L</sub> = 10 nF                                                                                       | Room               | 5                 |                               |                   |                              |                   | pC   |
| Off Isolation <sup>e</sup>                   | OIRR                | R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF,<br>f = 1 MHz                                                                                                 | Room               | 68                |                               |                   |                              |                   | dB   |
| Channel-to-Channel<br>Crosstalk <sup>e</sup> | X <sub>TALK</sub>   |                                                                                                                                                            | Room               | 85                |                               |                   |                              |                   |      |
| Source Off Capacitance <sup>e</sup>          | C <sub>S(off)</sub> | f = 1 MHz                                                                                                                                                  | Room               | 9                 |                               |                   |                              |                   | pF   |
| Drain Off Capacitance <sup>e</sup>           | C <sub>D(off)</sub> |                                                                                                                                                            | Room               | 9                 |                               |                   |                              |                   |      |
| Channel On<br>Capacitance <sup>e</sup>       | C <sub>D(on)</sub>  |                                                                                                                                                            | Room               | 35                |                               |                   |                              |                   |      |
| Power Supplies                               |                     |                                                                                                                                                            |                    |                   |                               |                   |                              |                   |      |
| Positive Supply Current                      | I <sub>+</sub>      | V <sub>+</sub> = 16.5 V, V <sub>-</sub> = - 16.5 V<br>V <sub>IN</sub> = 0 V or 5 V                                                                         | Room<br>Full       | 0.0001            |                               | 1<br>5            |                              | 1<br>5            | μA   |
| Negative Supply Current                      | I <sub>-</sub>      |                                                                                                                                                            | Room<br>Full       | - 0.0001          | - 1<br>- 5                    |                   | - 1<br>- 5                   |                   |      |
| Logic Supply Current                         | I <sub>L</sub>      |                                                                                                                                                            | Room<br>Full       | 0.0001            |                               | 1<br>5            |                              | 1<br>5            |      |
| Ground Current                               | I <sub>GND</sub>    |                                                                                                                                                            | Room<br>Full       | - 0.0001          | - 1<br>- 5                    |                   | - 1<br>- 5                   |                   |      |

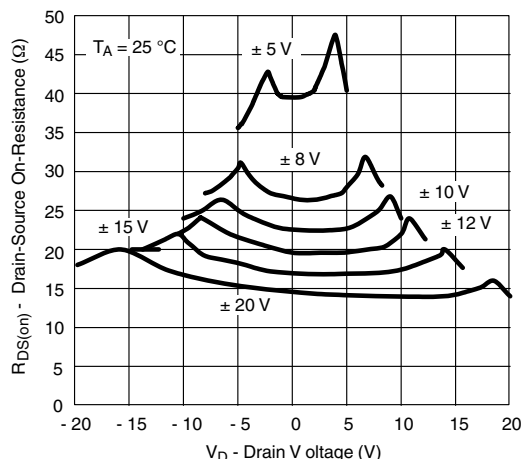
| SPECIFICATIONS <sup>a</sup> (for Unipolar Supplies) |                     |                                                                                                                                   |                    |                   |                               |                   |                              |                   |      |
|-----------------------------------------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|-------------------------------|-------------------|------------------------------|-------------------|------|
| Parameter                                           | Symbol              | Test Conditions<br>Unless Specified<br>V + = 12 V, V - = 0 V<br>V <sub>L</sub> = 5 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup> | Temp. <sup>b</sup> | Typ. <sup>c</sup> | A Suffix<br>- 55 °C to 125 °C |                   | D Suffix<br>- 40 °C to 85 °C |                   | Unit |
|                                                     |                     |                                                                                                                                   |                    |                   | Min. <sup>d</sup>             | Max. <sup>d</sup> | Min. <sup>d</sup>            | Max. <sup>d</sup> |      |
| Analog Switch                                       |                     |                                                                                                                                   |                    |                   |                               |                   |                              |                   |      |
| Analog Signal Range <sup>e</sup>                    | V <sub>ANALOG</sub> |                                                                                                                                   | Full               |                   |                               | 12                |                              | 12                | V    |
| Drain-Source<br>On-Resistance                       | R <sub>DS(on)</sub> | V + = 10.8 V,<br>I <sub>S</sub> = - 10 mA, V <sub>D</sub> = 3 V, 8 V                                                              | Room<br>Full       | 40                |                               | 80<br>100         |                              | 80<br>100         | Ω    |
| Dynamic Characteristics                             |                     |                                                                                                                                   |                    |                   |                               |                   |                              |                   |      |
| Turn-On Time                                        | t <sub>ON</sub>     | R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF<br>V <sub>S</sub> = 8 V, see figure 2                                              | Room<br>Hot        | 175               |                               | 250<br>400        |                              | 250<br>315        | ns   |
| Turn-Off Time                                       | t <sub>OFF</sub>    |                                                                                                                                   | Room<br>Hot        | 95                |                               | 125<br>140        |                              | 125<br>140        |      |
| Break-Before-Make<br>Time Delay                     | t <sub>D</sub>      | DG413 only, V <sub>S</sub> = 8 V<br>R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF                                                | Room               | 25                |                               |                   |                              |                   |      |
| Charge Injection                                    | Q                   | V <sub>g</sub> = 6 V, R <sub>g</sub> = 0 Ω, C <sub>L</sub> = 10 nF                                                                | Room               | 25                |                               |                   |                              |                   | pC   |
| Power Supplies                                      |                     |                                                                                                                                   |                    |                   |                               |                   |                              |                   |      |
| Positive Supply Current                             | I <sub>+</sub>      | V + = 13.5 V, V <sub>IN</sub> = 0 V or 5 V                                                                                        | Room<br>Hot        | 0.0001            |                               | 1<br>5            |                              | 1<br>5            | μA   |
| Negative Supply Current                             | I <sub>-</sub>      |                                                                                                                                   | Room<br>Hot        | - 0.0001          | - 1<br>- 5                    |                   | - 1<br>- 5                   |                   |      |
| Logic Supply Current                                | I <sub>L</sub>      |                                                                                                                                   | Room<br>Hot        | 0.0001            |                               | 1<br>5            |                              | 1<br>5            |      |
| Ground Current                                      | I <sub>GND</sub>    |                                                                                                                                   | Room<br>Hot        | - 0.0001          | - 1<br>- 5                    |                   | - 5                          |                   |      |

### Notes:

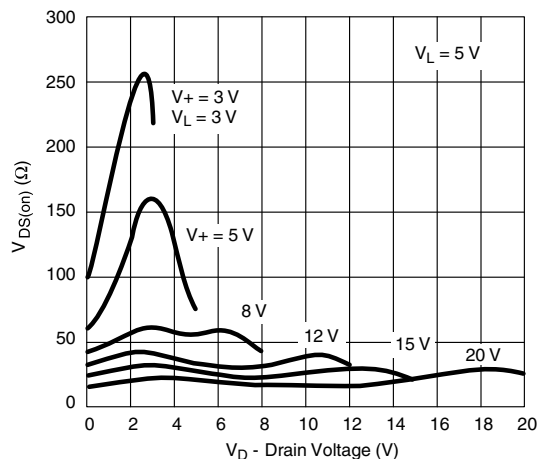
- Refer to process option flowchart.
- Room = 25 °C, Full = as determined by the operating temperature suffix.
- Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- Guaranteed by design, not subject to production test.
- $V_{IN}$  = input voltage to perform proper function.

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.

## TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)

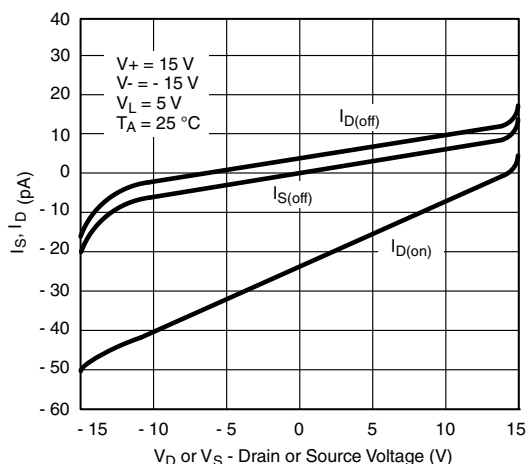


On-Resistance vs.  $V_D$  and Power Supply Voltage

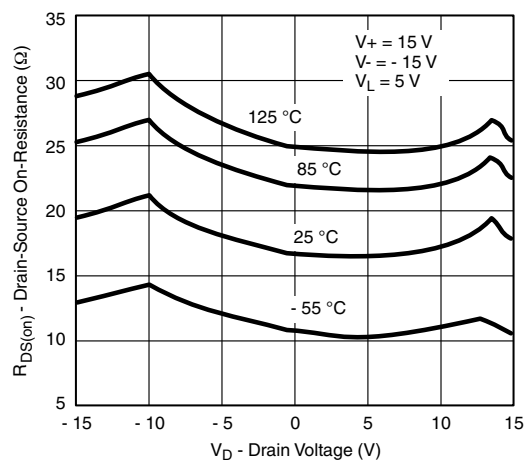


On-Resistance vs.  $V_D$  and Unipolar Supply Voltage

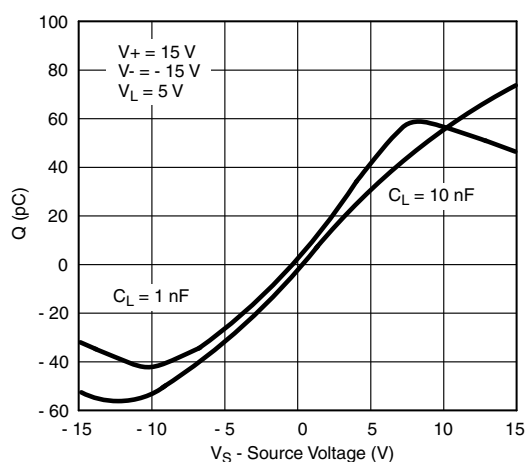
## TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



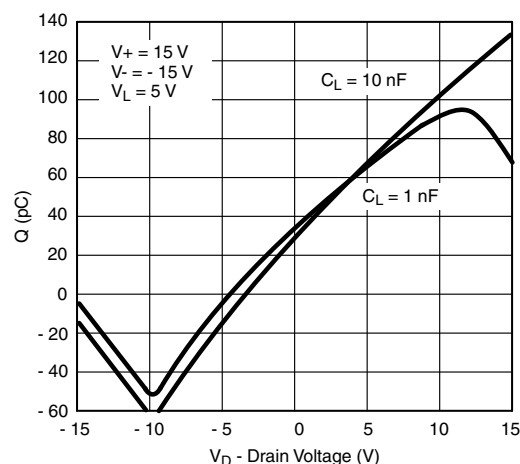
Leakage Current vs. Analog Voltage



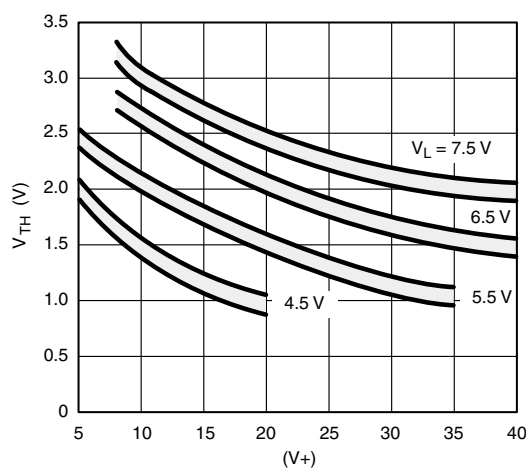
$I_D$ ,  $I_S$  Leakages vs. Temperature



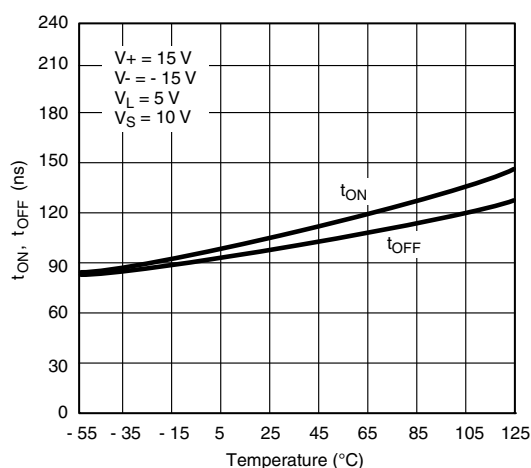
Charge Injection vs. Analog Voltage



Charge Injection vs. Analog Voltage

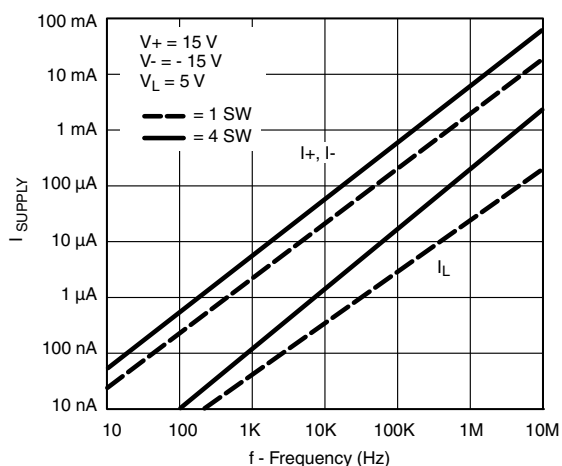


Input Switching Threshold vs. Supply Voltage



Switching Time vs. Temperature

## TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



Supply Current vs. Input Switching Frequency

## SCHEMATIC DIAGRAM (Typical Channel)

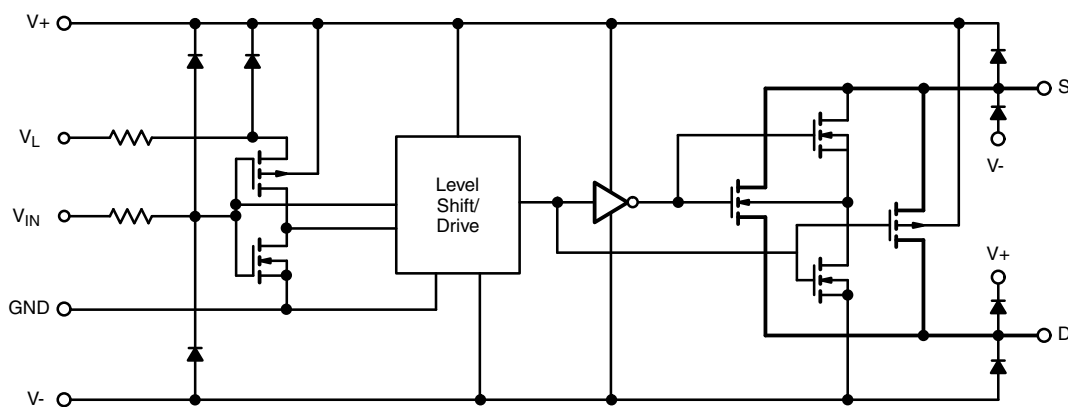
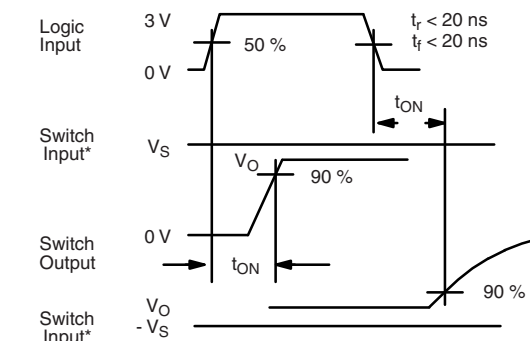
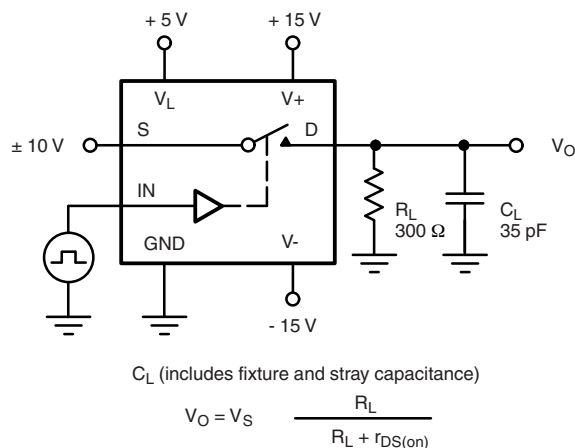


Figure 1.

## TEST CIRCUITS



\*  $V_S = 10 \text{ V}$  for  $t_{ON}$ ,  $V_S = -10 \text{ V}$  for  $t_{OFF}$

Note: Logic input waveform is inverted for switches that have the opposite logic sense control

Figure 2. Switching Time

## TEST CIRCUITS

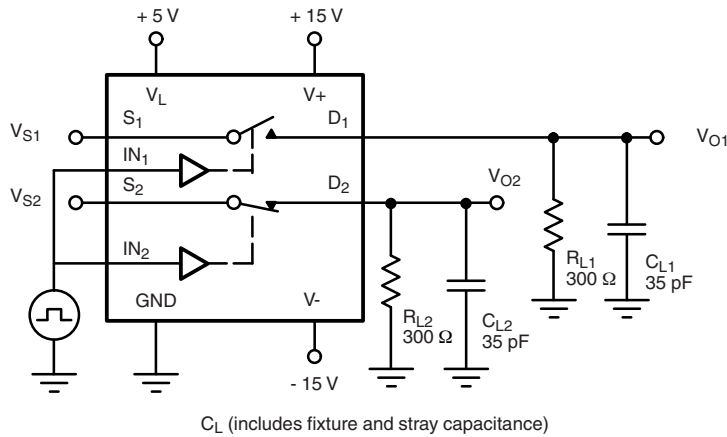
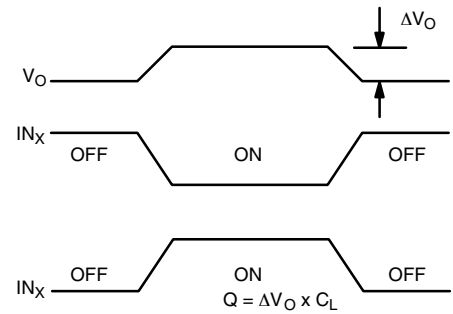
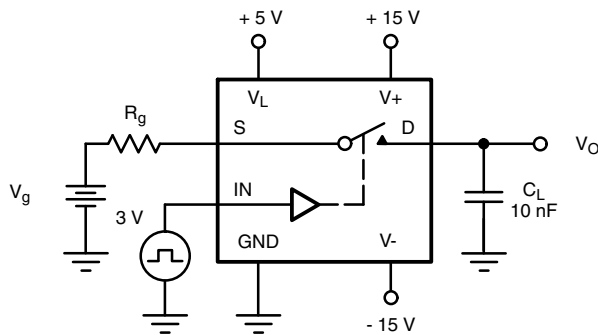


Figure 3. Break-Before-Make (DG413)



$IN_X$  dependent on switch configuration Input polarity determined by sense of switch.

Figure 4. Charge Injection

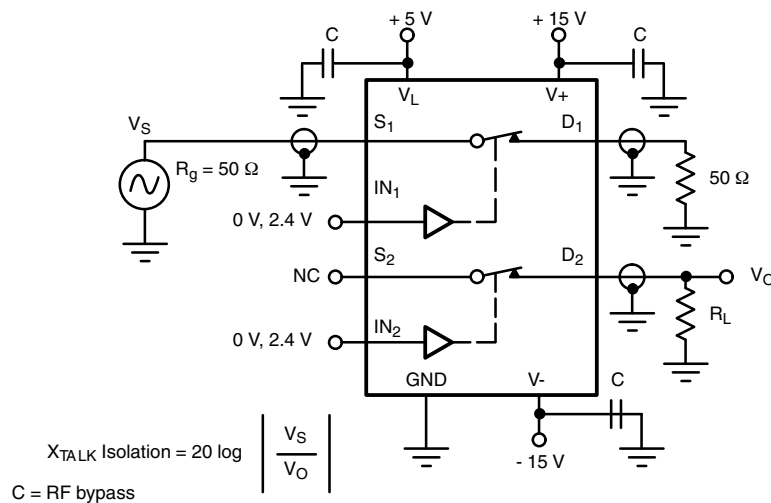


Figure 5. Crosstalk

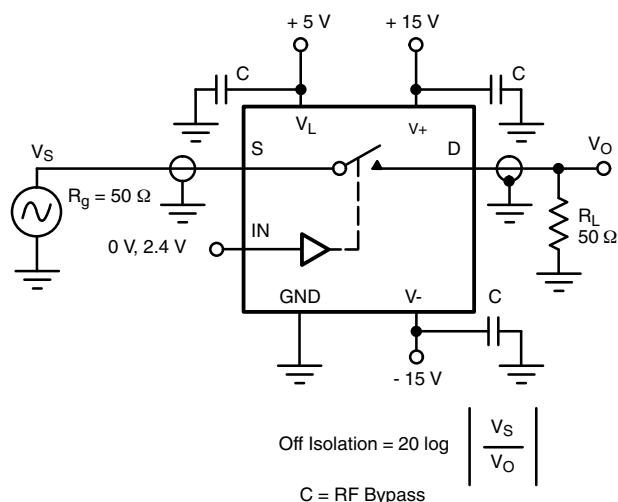


Figure 6. Off Isolation

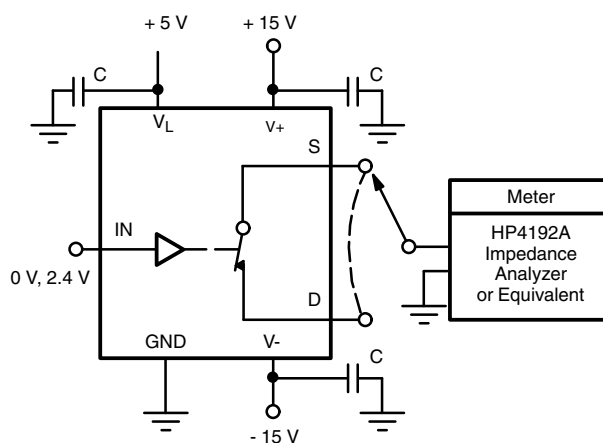


Figure 7. Source/Drain Capacitances

## APPLICATIONS

### Single Supply Operation:

The DG411, DG412, DG413 can be operated with unipolar supplies from 5 V to 44 V. These devices are characterized and tested for unipolar supply operation at 12 V to facilitate the majority of applications. In single supply operation, V+ is tied to VL and V- is tied to 0 V. See Input Switching Threshold vs. Supply Voltage curve for VL versus input threshold requirements.

### Summing Amplifier

When driving a high impedance, high capacitance load such as shown in figure 8, where the inputs to the summing amplifier have some noise filtering, it is necessary to have shunt switches for rapid discharge of the filter capacitor, thus preventing offsets from occurring at the output.

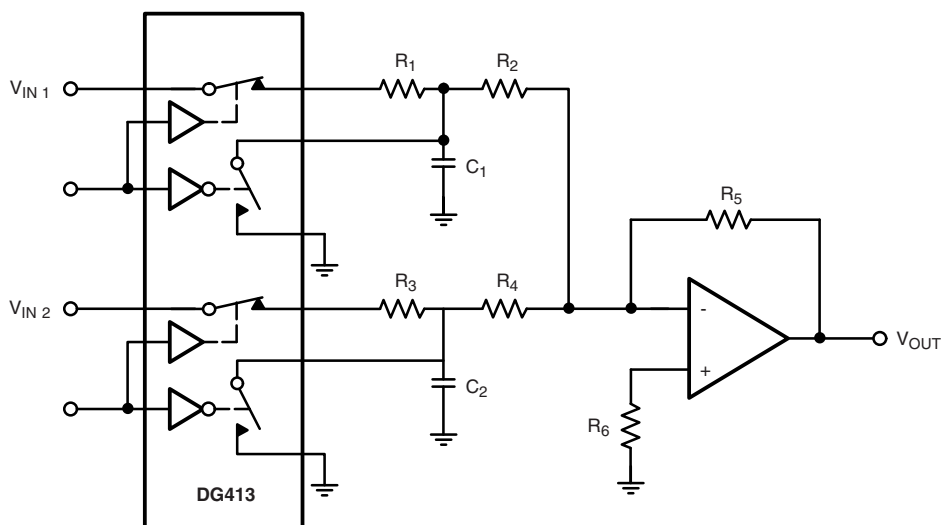


Figure 8. Summing Amplifier

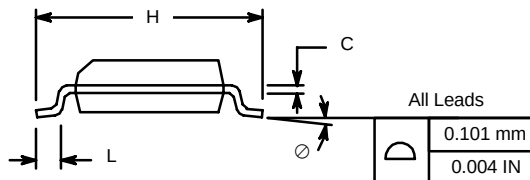
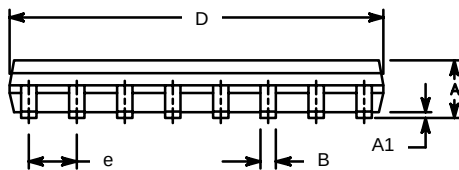
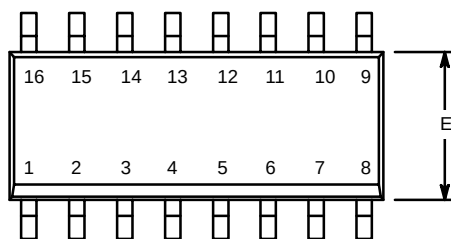
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### SOIC (NARROW): 16-LEAD

JEDEC Part Number: MS-012

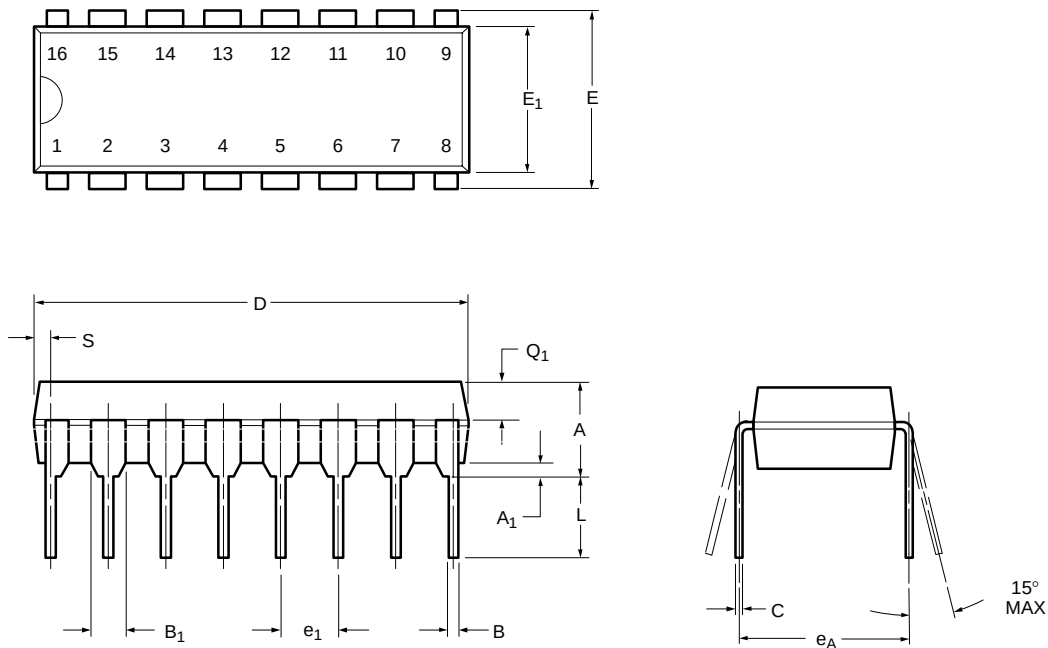


| Dim            | MILLIMETERS |       | INCHES    |       |
|----------------|-------------|-------|-----------|-------|
|                | Min         | Max   | Min       | Max   |
| A              | 1.35        | 1.75  | 0.053     | 0.069 |
| A <sub>1</sub> | 0.10        | 0.20  | 0.004     | 0.008 |
| B              | 0.38        | 0.51  | 0.015     | 0.020 |
| C              | 0.18        | 0.23  | 0.007     | 0.009 |
| D              | 9.80        | 10.00 | 0.385     | 0.393 |
| E              | 3.80        | 4.00  | 0.149     | 0.157 |
| e              | 1.27 BSC    |       | 0.050 BSC |       |
| H              | 5.80        | 6.20  | 0.228     | 0.244 |
| L              | 0.50        | 0.93  | 0.020     | 0.037 |
| Ø              | 0°          | 8°    | 0°        | 8°    |

ECN: S-03946—Rev. F, 09-Jul-01  
DWG: 5300



**PDIP: 16-LEAD**

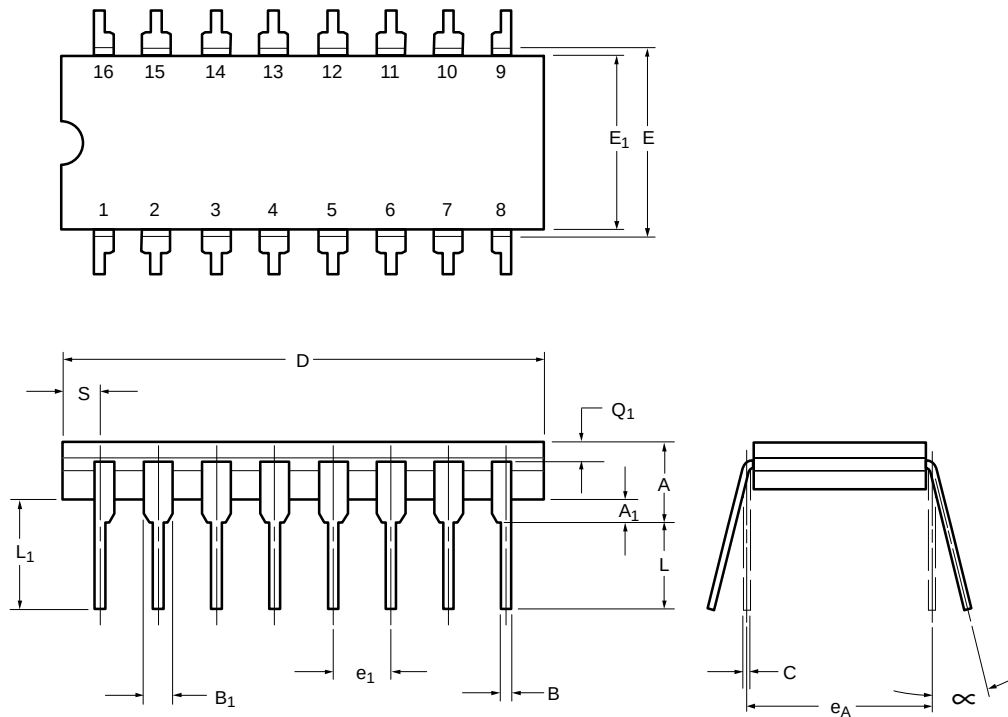


| Dim            | MILLIMETERS |       | INCHES |       |
|----------------|-------------|-------|--------|-------|
|                | Min         | Max   | Min    | Max   |
| A              | 3.81        | 5.08  | 0.150  | 0.200 |
| A <sub>1</sub> | 0.38        | 1.27  | 0.015  | 0.050 |
| B              | 0.38        | 0.51  | 0.015  | 0.020 |
| B <sub>1</sub> | 0.89        | 1.65  | 0.035  | 0.065 |
| C              | 0.20        | 0.30  | 0.008  | 0.012 |
| D              | 18.93       | 21.33 | 0.745  | 0.840 |
| E              | 7.62        | 8.26  | 0.300  | 0.325 |
| E <sub>1</sub> | 5.59        | 7.11  | 0.220  | 0.280 |
| e <sub>1</sub> | 2.29        | 2.79  | 0.090  | 0.110 |
| e <sub>A</sub> | 7.37        | 7.87  | 0.290  | 0.310 |
| L              | 2.79        | 3.81  | 0.110  | 0.150 |
| Q <sub>1</sub> | 1.27        | 2.03  | 0.050  | 0.080 |
| S              | 0.38        | 1.52  | .015   | 0.060 |

ECN: S-03946—Rev. D, 09-Jul-01  
DWG: 5482



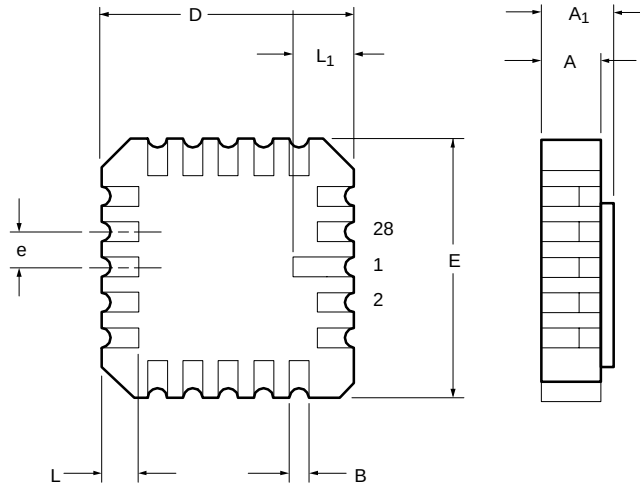
**CERDIP: 16-LEAD**



| Dim                                         | MILLIMETERS |       | INCHES    |       |
|---------------------------------------------|-------------|-------|-----------|-------|
|                                             | Min         | Max   | Min       | Max   |
| A                                           | 4.06        | 5.08  | 0.160     | 0.200 |
| A <sub>1</sub>                              | 0.51        | 1.14  | 0.020     | 0.045 |
| B                                           | 0.38        | 0.51  | 0.015     | 0.020 |
| B <sub>1</sub>                              | 1.14        | 1.65  | 0.045     | 0.065 |
| C                                           | 0.20        | 0.30  | 0.008     | 0.012 |
| D                                           | 19.05       | 19.56 | 0.750     | 0.770 |
| E                                           | 7.62        | 8.26  | 0.300     | 0.325 |
| E <sub>1</sub>                              | 6.60        | 7.62  | 0.260     | 0.300 |
| e <sub>1</sub>                              | 2.54 BSC    |       | 0.100 BSC |       |
| e <sub>A</sub>                              | 7.62 BSC    |       | 0.300 BSC |       |
| L                                           | 3.18        | 3.81  | 0.125     | 0.150 |
| L <sub>1</sub>                              | 3.81        | 5.08  | 0.150     | 0.200 |
| Q <sub>1</sub>                              | 1.27        | 2.16  | 0.050     | 0.085 |
| S                                           | 0.38        | 1.14  | 0.015     | 0.045 |
| ∞                                           | 0°          | 15°   | 0°        | 15°   |
| ECN: S-03946—Rev. G, 09-Jul-01<br>DWG: 5403 |             |       |           |       |

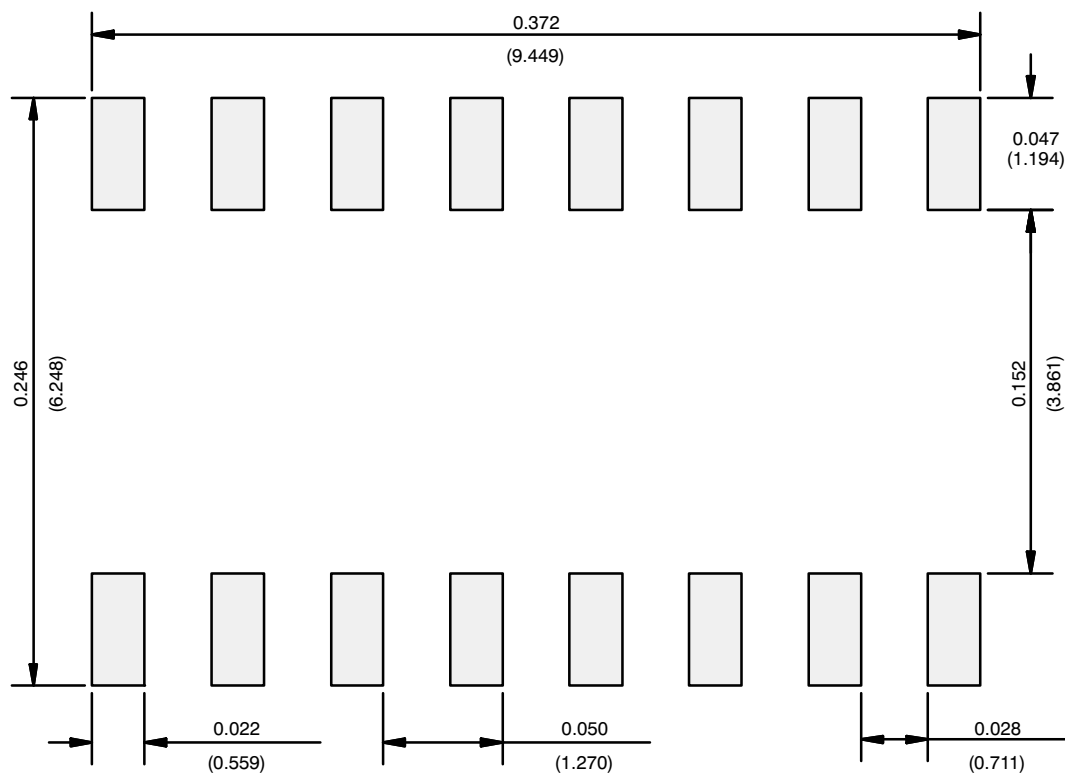


## 20-LEAD LCC



| Dim                                         | MILLIMETERS |      | INCHES    |       |
|---------------------------------------------|-------------|------|-----------|-------|
|                                             | Min         | Max  | Min       | Max   |
| <b>A</b>                                    | 1.37        | 2.24 | 0.054     | 0.088 |
| <b>A<sub>1</sub></b>                        | 1.63        | 2.54 | 0.064     | 0.100 |
| <b>B</b>                                    | 0.56        | 0.71 | 0.022     | 0.028 |
| <b>D</b>                                    | 8.69        | 9.09 | 0.342     | 0.358 |
| <b>E</b>                                    | 8.69        | 9.09 | 0.442     | 0.358 |
| <b>e</b>                                    | 1.27 BSC    |      | 0.050 BSC |       |
| <b>L</b>                                    | 1.14        | 1.40 | 0.045     | 0.055 |
| <b>L<sub>1</sub></b>                        | 1.96        | 2.36 | 0.077     | 0.093 |
| ECN: S-03946—Rev. B, 09-Jul-01<br>DWG: 5321 |             |      |           |       |

## RECOMMENDED MINIMUM PADS FOR SO-16



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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