

## FEATURES

- ±2 V to ±6 V dual supply
- 2 V to 12 V single supply
- Automotive temperature range –40°C to +125°C
- <0.1 nA leakage currents
- 45 Ω on resistance over full signal range
- Rail-to-rail switching operation
- Single 8-to-1 multiplexer **ADG658**
- Differential 4-to-1 multiplexer **ADG659**
- 16-lead LFCSP/TSSOP/QSOP packages
- Typical power consumption <0.1 μW
- TTL/CMOS compatible inputs
- Package upgrades to 74HC4051/74HC4052 and  
MAX4051/MAX4052/MAX4581/MAX4582

## APPLICATIONS

- Automotive applications
- Automatic test equipment
- Data acquisition systems
- Battery-powered systems
- Communication systems
- Audio and video signal routing
- Relay replacement
- Sample-and-hold systems
- Industrial control systems

## GENERAL DESCRIPTION

The **ADG658** and **ADG659** are low voltage, CMOS analog multiplexers comprised of eight single channels and four differential channels, respectively. The **ADG658** switches one of eight inputs (S1–S8) to a common output, D, as determined by the 3-bit binary address lines A0, A1, and A2. The **ADG659** switches one of four differential inputs to a common differential output, as determined by the 2-bit binary address lines A0 and A1. An  $\overline{\text{EN}}$  input on both devices enables or disables the device. When disabled, all channels are switched off.

These devices are designed on an enhanced process that provides lower power dissipation yet gives high switching speeds. These devices can operate equally well as either multiplexers or demultiplexers and have an input range that extends to the supplies. All channels exhibit break-before-make switching action, preventing momentary shorting when switching channels. All digital inputs have 0.8 V to 2.4 V logic thresholds, ensuring TTL/CMOS logic compatibility when using single +5 V or dual ±5 V supplies.

## FUNCTIONAL BLOCK DIAGRAM

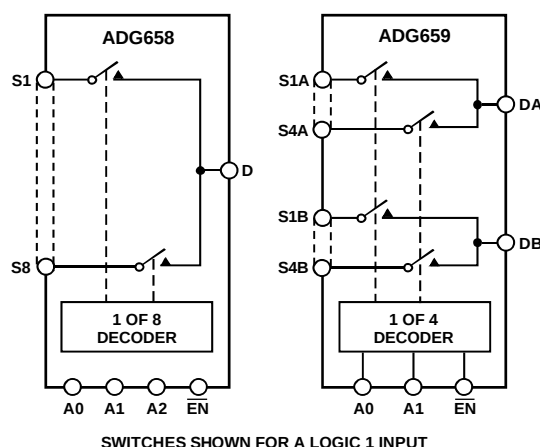


Figure 1.

The **ADG658** and **ADG659** are available in 16-lead TSSOP/QSOP packages and 16-lead 4 mm × 4 mm LFCSP packages.

## PRODUCT HIGHLIGHTS

1. Single- and dual-supply operation. The **ADG658** and **ADG659** offer high performance and are fully specified and guaranteed with ±5 V, +5 V, and +3 V supply rails.
2. Automotive temperature range –40°C to +125°C.
3. Low power consumption, typically <0.1 μW.
4. 16-lead 4 mm × 4 mm LFCSP packages, 16-lead TSSOP package and 16-lead QSOP package.

Rev. D

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## REVISION HISTORY

### 11/2016—Rev. C to Rev. D

|                                       |    |
|---------------------------------------|----|
| Changes to Figure 3 and Table 7 ..... | 11 |
| Updated Outline Dimensions .....      | 19 |
| Changes to Ordering Guide .....       | 20 |

### 9/2014—Rev. B to Rev. C

|                                  |    |
|----------------------------------|----|
| Moved Terminology Section .....  | 15 |
| Updated Outline Dimensions ..... | 19 |
| Changes to Ordering Guide .....  | 20 |

### 2/2009—Rev. A to Rev. B

|                                 |    |
|---------------------------------|----|
| Changes to Ordering Guide ..... | 20 |
|---------------------------------|----|

### 7/2004—Rev. 0 to Rev. A

|                                  |           |
|----------------------------------|-----------|
| Updated Format .....             | Universal |
| Added QSOP Package Outline ..... | 20        |
| Changes to Ordering Guide .....  | 20        |
| 3/03—Rev. 0: Initial Version     |           |

## SPECIFICATIONS

## DUAL SUPPLY

$V_{DD} = +5\text{ V} \pm 10\%$ ,  $V_{SS} = -5\text{ V} \pm 10\%$ , GND = 0 V, unless otherwise noted.

Table 1.

| Parameter                                                | +25°C                                 | B Version<br>–40°C<br>to +85°C | Y Version<br>–40°C<br>to +125°C | Unit                                   | Test Conditions/Comments                                                                                                   |
|----------------------------------------------------------|---------------------------------------|--------------------------------|---------------------------------|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| ANALOG SWITCH                                            |                                       |                                |                                 |                                        |                                                                                                                            |
| Analog Signal Range                                      |                                       |                                | $V_{SS}$ to $V_{DD}$            | V                                      | $V_{DD} = +4.5\text{ V}$ , $V_{SS} = -4.5\text{ V}$                                                                        |
| On Resistance ( $R_{ON}$ )                               | 45<br>75                              | 90                             | 100                             | $\Omega$ typ<br>$\Omega$ max           | $V_S = \pm 4.5\text{ V}$ , $I_S = 1\text{ mA}$ ; see Figure 21                                                             |
| On Resistance Match between Channels ( $\Delta R_{ON}$ ) | 1.3<br>3                              | 3.2                            | 3.5                             | $\Omega$ typ<br>$\Omega$ max           | $V_S = 3.5\text{ V}$ , $I_S = 1\text{ mA}$                                                                                 |
| On Resistance Flatness ( $R_{FLAT(ON)}$ )                | 10<br>16                              | 17                             | 18                              | $\Omega$ typ<br>$\Omega$ max           | $V_{DD} = +5\text{ V}$ , $V_{SS} = -5\text{ V}$ ;<br>$V_S = \pm 3\text{ V}$ , $I_S = 1\text{ mA}$                          |
| LEAKAGE CURRENTS                                         |                                       |                                |                                 |                                        |                                                                                                                            |
| Source OFF Leakage $I_S$ (OFF)                           | $\pm 0.005$<br>$\pm 0.2$              |                                | $\pm 5$                         | nA typ<br>nA max                       | $V_{DD} = +5.5\text{ V}$ , $V_{SS} = -5.5\text{ V}$<br>$V_D = \pm 4.5\text{ V}$ , $V_S = \mp 4.5\text{ V}$ ; see Figure 22 |
| Drain OFF Leakage $I_D$ (OFF)                            | $\pm 0.005$<br>$\pm 0.2$              |                                | $\pm 5$                         | nA typ<br>nA max                       | $V_D = \pm 4.5\text{ V}$ , $V_S = \mp 4.5\text{ V}$ ; see Figure 23                                                        |
| ADG658                                                   | $\pm 0.1$                             |                                | $\pm 2.5$                       | nA max                                 |                                                                                                                            |
| ADG659                                                   | $\pm 0.1$                             |                                | $\pm 2.5$                       | nA max                                 |                                                                                                                            |
| Channel ON Leakage $I_D$ , $I_S$ (ON)                    | $\pm 0.005$<br>$\pm 0.2$<br>$\pm 0.1$ |                                | $\pm 5$<br>$\pm 2.5$            | nA typ<br>nA max<br>nA max             | $V_D = V_S = \pm 4.5\text{ V}$ ; see Figure 24                                                                             |
| ADG658                                                   |                                       |                                |                                 |                                        |                                                                                                                            |
| ADG659                                                   |                                       |                                |                                 |                                        |                                                                                                                            |
| DIGITAL INPUTS                                           |                                       |                                |                                 |                                        |                                                                                                                            |
| Input High Voltage, $V_{INH}$                            |                                       |                                | 2.4                             | V min                                  |                                                                                                                            |
| Input Low Voltage, $V_{INL}$                             |                                       |                                | 0.8                             | V max                                  |                                                                                                                            |
| Input Current<br>$I_{INL}$ or $I_{INH}$                  | 0.005                                 |                                | $\pm 1$                         | $\mu\text{A}$ typ<br>$\mu\text{A}$ max | $V_{IN} = V_{INL}$ or $V_{INH}$                                                                                            |
| $C_{IN}$ , Digital Input Capacitance                     | 2                                     |                                |                                 | pF typ                                 |                                                                                                                            |
| DYNAMIC CHARACTERISTICS <sup>1</sup>                     |                                       |                                |                                 |                                        |                                                                                                                            |
| $t_{TRANSITION}$                                         | 80<br>115                             | 140                            | 165                             | ns typ<br>ns max                       | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$<br>$V_S = 3\text{ V}$ ; see Figure 25                                           |
| $t_{ON}(\overline{EN})$                                  | 80<br>115                             | 140                            | 165                             | ns typ<br>ns max                       | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$<br>$V_S = 3\text{ V}$ ; see Figure 27                                           |
| $t_{OFF}(\overline{EN})$                                 | 30<br>45                              | 50                             | 55                              | ns typ<br>ns max                       | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$<br>$V_S = 3\text{ V}$ ; see Figure 27                                           |
| Break-Before-Make Time Delay, $t_{BBM}$                  | 50                                    |                                | 10                              | ns typ<br>ns min                       | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$<br>$V_{S1} = V_{S2} = 3\text{ V}$ ; see Figure 26                               |
| Charge Injection                                         | 2<br>4                                |                                |                                 | pC typ<br>pC max                       | $V_S = 0\text{ V}$ , $R_S = 0\ \Omega$ ,<br>$C_L = 1\text{ nF}$ ; see Figure 28                                            |
| Off Isolation                                            | –90                                   |                                |                                 | dB typ                                 | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; see Figure 29                                              |
| Total Harmonic Distortion, THD + N                       | 0.025                                 |                                |                                 | % typ                                  | $R_L = 600\ \Omega$ , 2 V p-p, $f = 20\text{ Hz}$ to 20 kHz                                                                |
| Channel-to-Channel Crosstalk<br>(ADG659)                 | –90                                   |                                |                                 | dB typ                                 | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; see Figure 31                                              |
| –3 dB Bandwidth                                          | 210<br>400                            |                                |                                 | MHz typ<br>MHz typ                     | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; see Figure 30                                                                   |
| ADG658                                                   |                                       |                                |                                 |                                        |                                                                                                                            |
| ADG659                                                   |                                       |                                |                                 |                                        |                                                                                                                            |

| Parameter                            | +25°C | B Version<br>–40°C<br>to +85°C | Y Version<br>–40°C<br>to +125°C | Unit   | Test Conditions/Comments                           |
|--------------------------------------|-------|--------------------------------|---------------------------------|--------|----------------------------------------------------|
| C <sub>S</sub> (OFF)                 | 4     |                                |                                 | pF typ | f = 1 MHz                                          |
| C <sub>D</sub> (OFF)                 |       |                                |                                 |        |                                                    |
| ADG658                               | 23    |                                |                                 | pF typ | f = 1 MHz                                          |
| ADG659                               | 12    |                                |                                 | pF typ | f = 1 MHz                                          |
| C <sub>D</sub> , C <sub>S</sub> (ON) |       |                                |                                 |        |                                                    |
| ADG658                               | 28    |                                |                                 | pF typ | f = 1 MHz                                          |
| ADG659                               | 16    |                                |                                 | pF typ | f = 1 MHz                                          |
| POWER REQUIREMENTS                   |       |                                |                                 |        | V <sub>DD</sub> = +5.5 V, V <sub>SS</sub> = –5.5 V |
| I <sub>DD</sub>                      | 0.01  |                                |                                 | μA typ | Digital Inputs = 0 V or 5.5 V                      |
|                                      |       |                                | 1                               | μA max |                                                    |
| I <sub>SS</sub>                      | 0.01  |                                |                                 | μA typ | Digital Inputs = 0 V or 5.5 V                      |
|                                      |       |                                | 1                               | μA max |                                                    |

<sup>1</sup> Guaranteed by design; not subject to production test.

**5 V SINGLE SUPPLY**

$V_{DD} = 5\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ , GND = 0 V, unless otherwise noted.

**Table 2.**

| Parameter                                  | +25°C       | B Version<br>–40°C<br>to +85°C | Y Version<br>–40°C<br>to +125°C | Unit              | Test Conditions/Comments                                                                                   |
|--------------------------------------------|-------------|--------------------------------|---------------------------------|-------------------|------------------------------------------------------------------------------------------------------------|
| <b>ANALOG SWITCH</b>                       |             |                                |                                 |                   |                                                                                                            |
| Analog Signal Range                        |             |                                | 0 to $V_{DD}$                   | V                 | $V_{DD} = 4.5\text{ V}$ , $V_{SS} = 0\text{ V}$                                                            |
| On Resistance ( $R_{ON}$ )                 | 85          |                                |                                 | $\Omega$ typ      | $V_S = 0\text{ V}$ to $4.5\text{ V}$ , $I_S = 1\text{ mA}$ ; see Figure 21                                 |
|                                            | 150         | 160                            | 200                             | $\Omega$ max      |                                                                                                            |
| On Resistance Match between                | 4.5         |                                |                                 | $\Omega$ typ      | $V_S = 3.5\text{ V}$ , $I_S = 1\text{ mA}$                                                                 |
| Channels ( $\Delta R_{ON}$ )               | 8           | 9                              | 10                              | $\Omega$ max      |                                                                                                            |
| On Resistance Flatness ( $R_{FLAT(ON)}$ )  | 13          | 14                             | 16                              | $\Omega$ typ      | $V_{DD} = 5\text{ V}$ , $V_{SS} = 0\text{ V}$ , $V_S = 1.5\text{ V}$ to $4\text{ V}$ , $I_S = 1\text{ mA}$ |
| <b>LEAKAGE CURRENTS</b>                    |             |                                |                                 |                   |                                                                                                            |
| Source OFF Leakage $I_S$ (OFF)             | $\pm 0.005$ |                                |                                 | nA typ            | $V_{DD} = 5.5\text{ V}$                                                                                    |
|                                            | $\pm 0.2$   |                                | $\pm 5$                         | nA max            | $V_S = 1\text{ V}/4.5\text{ V}$ , $V_D = 4.5\text{ V}/1\text{ V}$ ; see Figure 22                          |
| Drain OFF Leakage $I_D$ (OFF)              | $\pm 0.005$ |                                |                                 | nA typ            | $V_S = 1\text{ V}/4.5\text{ V}$ , $V_D = 4.5\text{ V}/1\text{ V}$ ; see Figure 23                          |
| ADG658                                     | $\pm 0.2$   |                                | $\pm 5$                         | nA max            |                                                                                                            |
| ADG659                                     | $\pm 0.1$   |                                | $\pm 2.5$                       | nA max            |                                                                                                            |
| Channel ON Leakage $I_D$ , $I_S$ (ON)      | $\pm 0.005$ |                                |                                 | nA typ            | $V_S = V_D = 1\text{ V}$ or $4.5\text{ V}$ , see Figure 24                                                 |
| ADG658                                     | $\pm 0.2$   |                                | $\pm 5$                         | nA max            |                                                                                                            |
| ADG659                                     | $\pm 0.1$   |                                | $\pm 2.5$                       | nA max            |                                                                                                            |
| <b>DIGITAL INPUTS</b>                      |             |                                |                                 |                   |                                                                                                            |
| Input High Voltage, $V_{INH}$              |             |                                | 2.4                             | V min             |                                                                                                            |
| Input Low Voltage, $V_{INL}$               |             |                                | 0.8                             | V max             |                                                                                                            |
| Input Current                              |             |                                |                                 |                   |                                                                                                            |
| $I_{INL}$ or $I_{INH}$                     | 0.005       |                                |                                 | $\mu\text{A}$ typ | $V_{IN} = V_{INL}$ or $V_{INH}$                                                                            |
|                                            |             |                                | $\pm 1$                         | $\mu\text{A}$ max |                                                                                                            |
| $C_{IN}$ , Digital Input Capacitance       | 2           |                                |                                 | pF typ            |                                                                                                            |
| <b>DYNAMIC CHARACTERISTICS<sup>1</sup></b> |             |                                |                                 |                   |                                                                                                            |
| $t_{TRANSITION}$                           | 120         |                                |                                 | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$                                                                 |
|                                            | 200         | 270                            | 300                             | ns max            | $V_S = 3\text{ V}$ ; see Figure 25                                                                         |
| $t_{ON}(\overline{EN})$                    | 120         |                                |                                 | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$                                                                 |
|                                            | 190         | 245                            | 280                             | ns max            | $V_S = 3\text{ V}$ ; see Figure 27                                                                         |
| $t_{OFF}(\overline{EN})$                   | 35          |                                |                                 | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$                                                                 |
|                                            | 50          | 60                             | 70                              | ns max            | $V_S = 3\text{ V}$ ; see Figure 27                                                                         |
| Break-Before-Make Time Delay, $t_{BBM}$    | 100         |                                |                                 | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$                                                                 |
|                                            |             |                                | 10                              | ns min            | $V_{S1} = V_{S2} = 3\text{ V}$ ; see Figure 26                                                             |
| Charge Injection                           | 0.5         |                                |                                 | pC typ            | $V_S = 2.5\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 1\text{ nF}$ ; see Figure 28                             |
|                                            | 1           |                                |                                 | pC max            |                                                                                                            |
| Off Isolation                              | –90         |                                |                                 | dB typ            | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; see Figure 29                              |
| Channel-to-Channel Crosstalk               | –90         |                                |                                 | dB typ            | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; $f = 1\text{ MHz}$ ; see Figure 31                              |
| (ADG659)                                   |             |                                |                                 |                   |                                                                                                            |
| –3 dB Bandwidth                            |             |                                |                                 |                   |                                                                                                            |
| ADG658                                     | 180         |                                |                                 | MHz typ           | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; see Figure 30                                                   |
| ADG659                                     | 330         |                                |                                 | MHz typ           |                                                                                                            |
| $C_S$ (OFF)                                | 5           |                                |                                 | pF typ            | $f = 1\text{ MHz}$                                                                                         |
| $C_D$ (OFF)                                |             |                                |                                 |                   |                                                                                                            |
| ADG658                                     | 29          |                                |                                 | pF typ            | $f = 1\text{ MHz}$                                                                                         |
| ADG659                                     | 15          |                                |                                 | pF typ            | $f = 1\text{ MHz}$                                                                                         |

| Parameter                                                | B Version |                   | Y Version          |                  | Unit      | Test Conditions/Comments      |
|----------------------------------------------------------|-----------|-------------------|--------------------|------------------|-----------|-------------------------------|
|                                                          | +25°C     | –40°C<br>to +85°C | –40°C<br>to +125°C |                  |           |                               |
| C <sub>D</sub> , C <sub>S</sub> (ON)<br>ADG658<br>ADG659 | 30        |                   |                    | pF typ           | f = 1 MHz |                               |
|                                                          | 16        |                   |                    | pF typ           | f = 1 MHz |                               |
| POWER REQUIREMENTS                                       |           |                   |                    |                  |           | V <sub>DD</sub> = 5.5 V       |
| I <sub>DD</sub>                                          | 0.01      |                   | 1                  | μA typ<br>μA max |           | Digital Inputs = 0 V or 5.5 V |

<sup>1</sup> Guaranteed by design; not subject to production test.

**2.7 V TO 3.6 V SINGLE SUPPLY**

$V_{DD} = 2.7$  to  $3.6$  V,  $V_{SS} = 0$  V, GND = 0 V, unless otherwise noted.

**Table 3.**

| Parameter                                  | +25°C       | B Version<br>–40°C<br>to +85°C | Y Version<br>–40°C<br>to +125°C | Unit         | Test Conditions/Comments                                        |
|--------------------------------------------|-------------|--------------------------------|---------------------------------|--------------|-----------------------------------------------------------------|
| <b>ANALOG SWITCH</b>                       |             |                                |                                 |              |                                                                 |
| Analog Signal Range                        |             |                                | 0 to $V_{DD}$                   | V            | $V_{DD} = 2.7$ V, $V_{SS} = 0$ V                                |
| On Resistance ( $R_{ON}$ )                 | 185         |                                |                                 | $\Omega$ typ | $V_S = 0$ V to 2.7 V, $I_S = 0.1$ mA; see Figure 21             |
|                                            | 300         | 350                            | 400                             | $\Omega$ max |                                                                 |
| On Resistance Match between                | 2           |                                |                                 | $\Omega$ typ | $V_S = 1.5$ V, $I_S = 0.1$ mA                                   |
| Channels ( $\Delta R_{ON}$ )               | 4.5         | 6                              | 7                               | $\Omega$ max |                                                                 |
| <b>LEAKAGE CURRENTS</b>                    |             |                                |                                 |              | $V_{DD} = 3.3$ V                                                |
| Source OFF Leakage $I_S$ (OFF)             | $\pm 0.005$ |                                |                                 | nA typ       | $V_S = 1$ V/3 V, $V_D = 3$ V/1 V; see Figure 22                 |
|                                            | $\pm 0.2$   |                                | $\pm 5$                         | nA max       |                                                                 |
| Drain OFF Leakage $I_D$ (OFF)              | $\pm 0.005$ |                                |                                 | nA typ       | $V_S = 1$ V/3 V, $V_D = 3$ V/1 V; see Figure 23                 |
| ADG658                                     | $\pm 0.2$   |                                | $\pm 5$                         | nA max       |                                                                 |
| ADG659                                     | $\pm 0.1$   |                                | $\pm 2.5$                       | nA max       |                                                                 |
| Channel ON Leakage $I_D$ , $I_S$ (ON)      | $\pm 0.005$ |                                |                                 | nA typ       | $V_S = V_D = 1$ V or 3 V, see Figure 24                         |
| ADG658                                     | $\pm 0.2$   |                                | $\pm 5$                         | nA max       |                                                                 |
| ADG659                                     | $\pm 0.1$   |                                | $\pm 2.5$                       | nA max       |                                                                 |
| <b>DIGITAL INPUTS</b>                      |             |                                |                                 |              |                                                                 |
| Input High Voltage, $V_{INH}$              |             |                                | 2.0                             | V min        |                                                                 |
| Input Low Voltage, $V_{INL}$               |             |                                | 0.5                             | V max        |                                                                 |
| Input Current                              |             |                                |                                 |              |                                                                 |
| $I_{INL}$ or $I_{INH}$                     | 0.005       |                                |                                 | $\mu$ A typ  | $V_{IN} = V_{INL}$ or $V_{INH}$                                 |
|                                            |             |                                | $\pm 1$                         | $\mu$ A max  |                                                                 |
| $C_{IN}$ , Digital Input Capacitance       | 2           |                                |                                 | pF typ       |                                                                 |
| <b>DYNAMIC CHARACTERISTICS<sup>1</sup></b> |             |                                |                                 |              |                                                                 |
| $t_{TRANSITION}$                           | 200         |                                |                                 | ns typ       | $R_L = 300$ $\Omega$ , $C_L = 35$ pF                            |
|                                            | 370         | 440                            | 490                             | ns max       | $V_S = 1.5$ V; see Figure 25                                    |
| $t_{ON}(\overline{EN})$                    | 230         |                                |                                 | ns typ       | $R_L = 300$ $\Omega$ , $C_L = 35$ pF                            |
|                                            | 370         | 440                            | 490                             | ns max       | $V_S = 1.5$ V; see Figure 27                                    |
| $t_{OFF}(\overline{EN})$                   | 50          |                                |                                 | ns typ       | $R_L = 300$ $\Omega$ , $C_L = 35$ pF                            |
|                                            | 80          | 90                             | 110                             | ns max       | $V_S = 1.5$ V; see Figure 27                                    |
| Break-Before-Make Time Delay, $t_{BBM}$    | 200         |                                |                                 | ns typ       | $R_L = 300$ $\Omega$ , $C_L = 35$ pF                            |
|                                            |             |                                | 10                              | ns min       | $V_{S1} = V_{S2} = 1.5$ V; see Figure 26                        |
| Charge Injection                           | 1           |                                |                                 | pC typ       | $V_S = 1.5$ V, $R_S = 0$ $\Omega$ , $C_L = 1$ nF; see Figure 28 |
|                                            | 2           |                                |                                 | pC max       |                                                                 |
| Off Isolation                              | –90         |                                |                                 | dB typ       | $R_L = 50$ $\Omega$ , $C_L = 5$ pF, $f = 1$ MHz; see Figure 29  |
| Channel-to-Channel Crosstalk               | –90         |                                |                                 | dB typ       | $R_L = 50$ $\Omega$ , $C_L = 5$ pF; $f = 1$ MHz; see Figure 31  |
| (ADG659)                                   |             |                                |                                 |              |                                                                 |
| –3 dB Bandwidth                            |             |                                |                                 |              |                                                                 |
| ADG658                                     | 160         |                                |                                 | MHz typ      | $R_L = 50$ $\Omega$ , $C_L = 5$ pF; see Figure 30               |
| ADG659                                     | 300         |                                |                                 | MHz typ      |                                                                 |
| $C_S$ (OFF)                                | 5           |                                |                                 | pF typ       | $f = 1$ MHz                                                     |
| $C_D$ (OFF)                                |             |                                |                                 |              |                                                                 |
| ADG658                                     | 29          |                                |                                 | pF typ       | $f = 1$ MHz                                                     |
| ADG659                                     | 15          |                                |                                 | pF typ       | $f = 1$ MHz                                                     |

| Parameter                            | B Version |                   | Y Version          | Unit             | Test Conditions/Comments      |
|--------------------------------------|-----------|-------------------|--------------------|------------------|-------------------------------|
|                                      | +25°C     | –40°C<br>to +85°C | –40°C<br>to +125°C |                  |                               |
| C <sub>D</sub> , C <sub>S</sub> (ON) |           |                   |                    |                  |                               |
| ADG658                               | 30        |                   |                    | pF typ           | f = 1 MHz                     |
| ADG659                               | 16        |                   |                    | pF typ           | f = 1 MHz                     |
| POWER REQUIREMENTS                   |           |                   |                    |                  | V <sub>DD</sub> = 3.6 V       |
| I <sub>DD</sub>                      | 0.01      |                   | 1                  | μA typ<br>μA max | Digital Inputs = 0 V or 3.6 V |

<sup>1</sup> Guaranteed by design; not subject to production test.

## ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$ , unless otherwise noted.

**Table 4.**

| Parameter                                                    | Rating                                                                     |
|--------------------------------------------------------------|----------------------------------------------------------------------------|
| $V_{DD}$ to $V_{SS}$                                         | 13 V                                                                       |
| $V_{DD}$ to GND                                              | −0.3 V to +13 V                                                            |
| $V_{SS}$ to GND                                              | +0.3 V to −6.5 V                                                           |
| Analog Inputs <sup>1</sup>                                   | $V_{SS} - 0.3\text{ V}$ to $V_{DD} + 0.3\text{ V}$                         |
| Digital Inputs <sup>1</sup>                                  | GND − 0.3 V to $V_{DD} + 0.3\text{ V}$<br>or 10 mA, whichever occurs first |
| Peak Current, S or D<br>(Pulsed at 1 ms, 10% duty cycle max) | 40 mA                                                                      |
| Continuous Current, S or D                                   | 20 mA                                                                      |
| Operating Temperature Range                                  |                                                                            |
| Automotive (Y Version)                                       | −40°C to +125°C                                                            |
| Industrial (B Version)                                       | −40°C to +85°C                                                             |
| Storage Temperature Range                                    | −65°C to +150°C                                                            |
| Junction Temperature                                         | 150°C                                                                      |
| $\theta_{JA}$ Thermal Impedance                              |                                                                            |
| 16-Lead QSOP                                                 | 104°C/W                                                                    |
| 16-Lead TSSOP                                                | 150.4°C/W                                                                  |
| 16-Lead LFCSP (4-Layer Board)                                | 70°C/W                                                                     |
| Lead Temperature, Soldering                                  |                                                                            |
| Vapor Phase (60 sec)                                         | 215°C                                                                      |
| Infrared (15 sec)                                            | 220°C                                                                      |
| ESD                                                          | 5.5 kV                                                                     |

<sup>1</sup> Over voltages at  $A_X$ ,  $\overline{EN}$ , S, or D are clamped by internal diodes. Current must be limited to the maximum ratings.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### ESD CAUTION



#### ESD (electrostatic discharge) sensitive device.

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

Table 5. ADG658 Truth Table

| A2             | A1             | A0             | $\overline{\text{EN}}$ | Switch Condition |
|----------------|----------------|----------------|------------------------|------------------|
| X <sup>1</sup> | X <sup>1</sup> | X <sup>1</sup> | 1                      | None             |
| 0              | 0              | 0              | 0                      | 1                |
| 0              | 0              | 1              | 0                      | 2                |
| 0              | 1              | 0              | 0                      | 3                |
| 0              | 1              | 1              | 0                      | 4                |
| 1              | 0              | 0              | 0                      | 5                |
| 1              | 0              | 1              | 0                      | 6                |
| 1              | 1              | 0              | 0                      | 7                |
| 1              | 1              | 1              | 0                      | 8                |

<sup>1</sup> X = Don't Care

Table 6. ADG659 Truth Table

| A1             | A0             | $\overline{\text{EN}}$ | On Switch Pair |
|----------------|----------------|------------------------|----------------|
| X <sup>1</sup> | X <sup>1</sup> | 1                      | None           |
| 0              | 0              | 0                      | 1              |
| 0              | 1              | 0                      | 2              |
| 1              | 0              | 0                      | 3              |
| 1              | 1              | 0                      | 4              |

<sup>1</sup> X = Don't Care

## PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

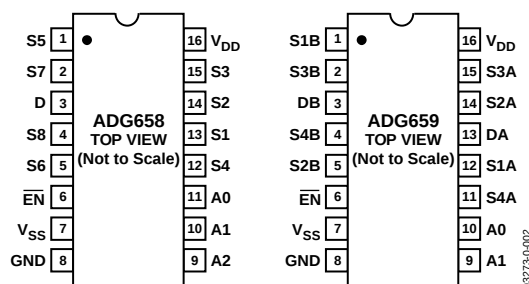
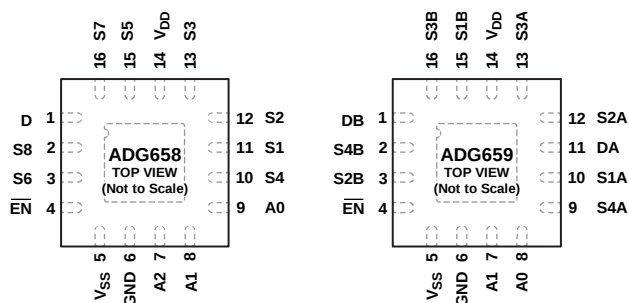


Figure 2. 16-Lead TSSOP/QSOP Pin Configuration



## NOTES

1. EXPOSED PAD. THE EXPOSED PAD MUST BE LEFT FLOATING.

Figure 3. 16-Lead, 4 mm × 4 mm LFCSP Pin Configuration

Table 7. Pin Function Descriptions

| Parameter         | Description                                                                                                                         |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| $V_{DD}$          | Most Positive Power Supply Potential.                                                                                               |
| $V_{SS}$          | Most Negative Power Supply Potential.                                                                                               |
| $I_{DD}$          | Positive Supply Current.                                                                                                            |
| $I_{SS}$          | Negative Supply Current.                                                                                                            |
| GND               | Ground (0 V) Reference.                                                                                                             |
| S                 | Source Terminal. Can be an input or output.                                                                                         |
| D                 | Drain Terminal. Can be an input or output.                                                                                          |
| $A_X$             | Logic Control Input.                                                                                                                |
| $\overline{EN}$   | Active Low Digital Input. When high, device is disabled and all switches are OFF. When low, $A_X$ logic inputs determine ON switch. |
| EPAD (LFCSP Only) | Exposed Pad. The exposed pad must be left floating.                                                                                 |

## TYPICAL PERFORMANCE CHARACTERISTICS

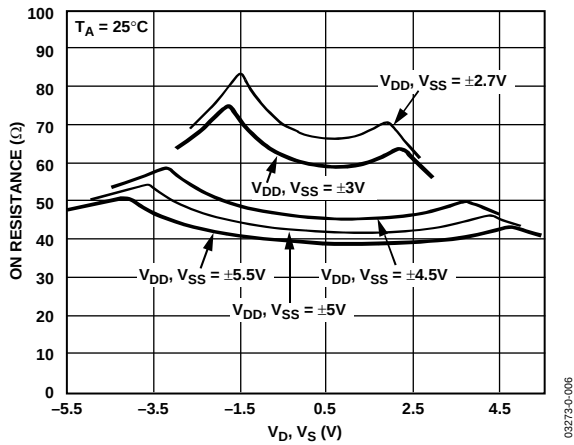
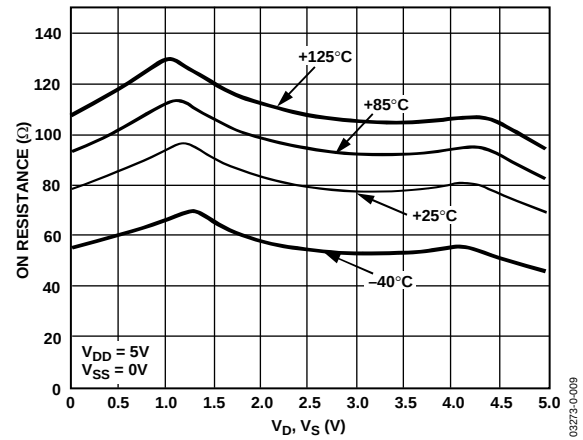
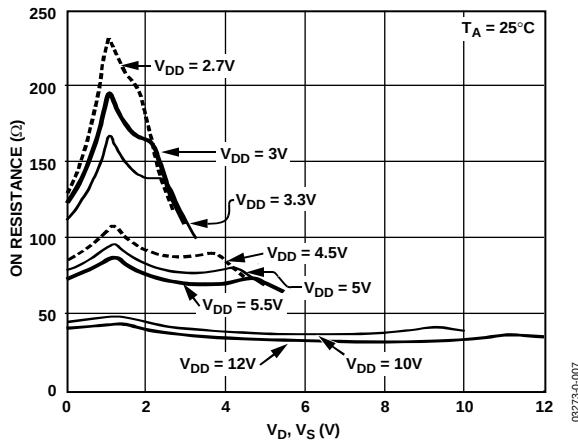
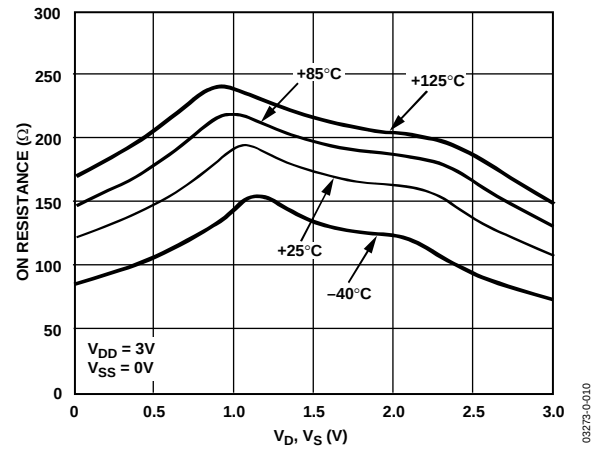
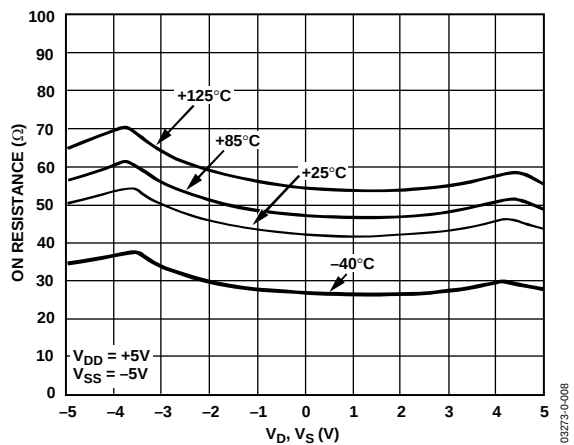
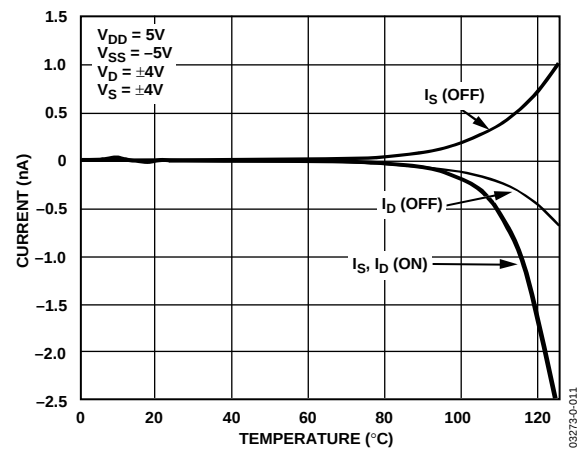
Figure 4. On Resistance vs.  $V_D$  ( $V_S$ ) for Dual SupplyFigure 7. On Resistance vs.  $V_D$  ( $V_S$ ) for Different Temperatures (Single Supply)Figure 5. On Resistance vs.  $V_D$  ( $V_S$ ) for Single SupplyFigure 8. On Resistance vs.  $V_D$  ( $V_S$ ) for Different Temperatures (Single Supply)Figure 6. On Resistance vs.  $V_D$  ( $V_S$ ) for Different Temperatures (Dual Supply)

Figure 9. Leakage Current vs. Temperature (Dual Supply)

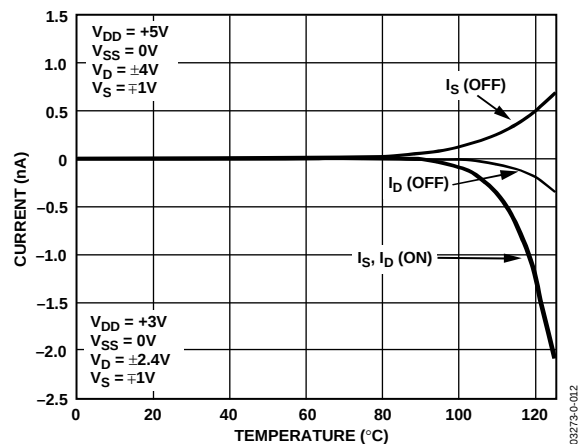


Figure 10. Leakage Current vs. Temperature (Single Supply)

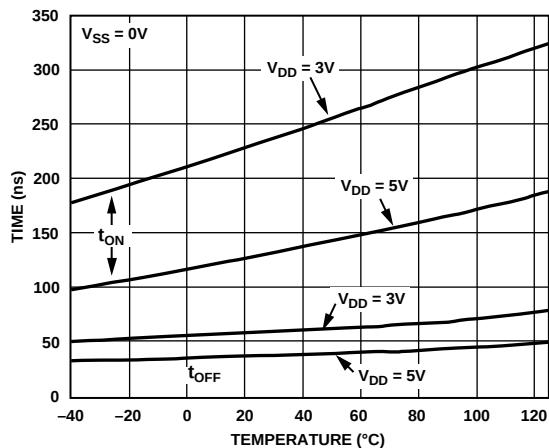
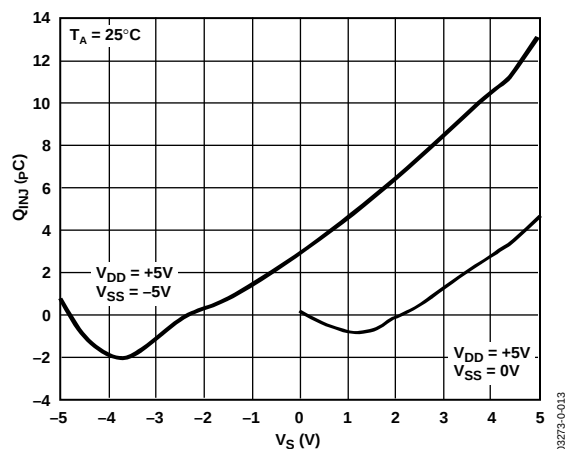
Figure 13.  $t_{ON}/t_{OFF}$  Times vs. Temperature (Single Supply)

Figure 11. Charge Injection vs. Source Voltage

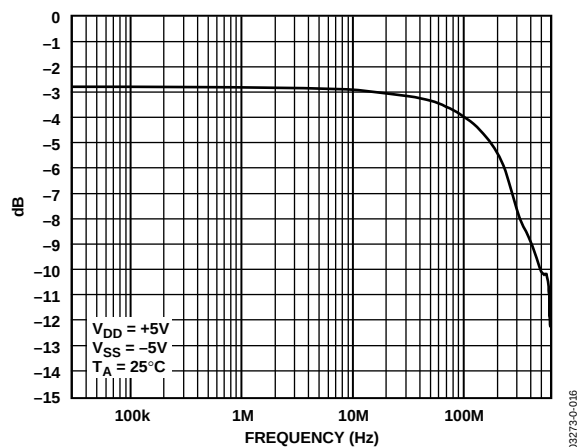


Figure 14. ON Response vs. Frequency (ADG658)

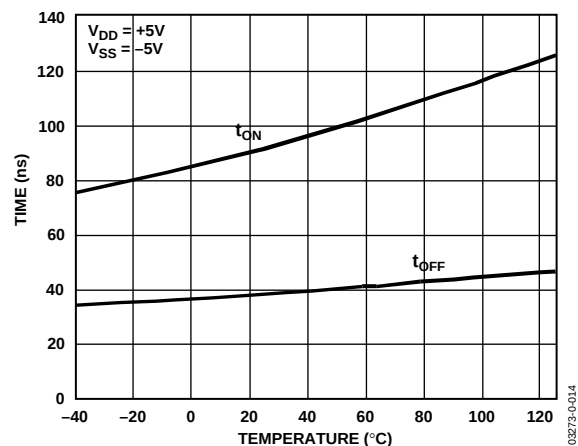
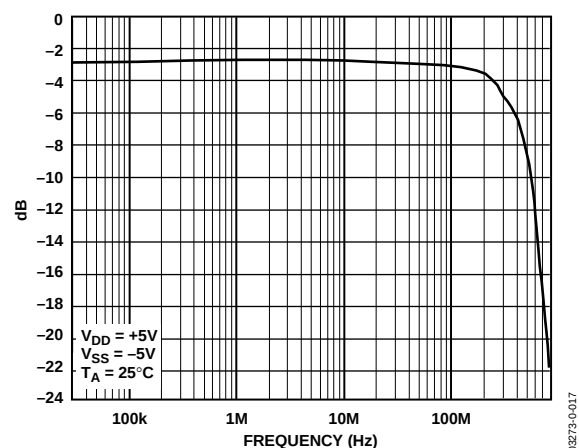
Figure 12.  $t_{ON}/t_{OFF}$  Times vs. Temperature (Dual Supply)

Figure 15. ON Response vs. Frequency (ADG659)

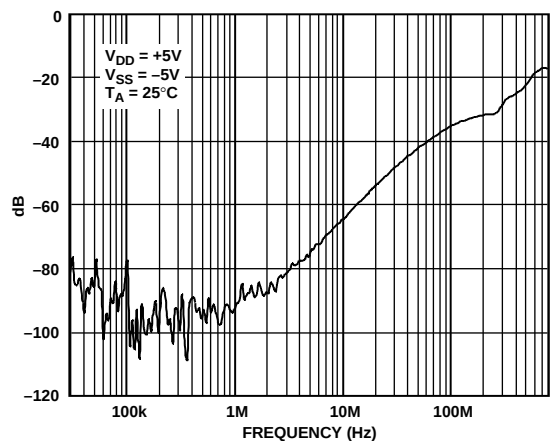


Figure 16. OFF Isolation vs. Frequency

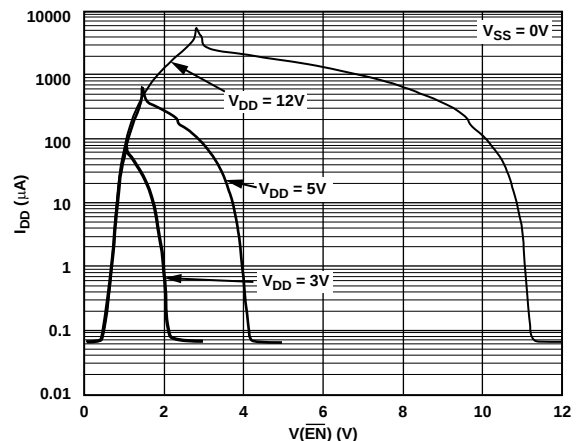


Figure 19.  $V_{DD}$  Current vs. Logic Level

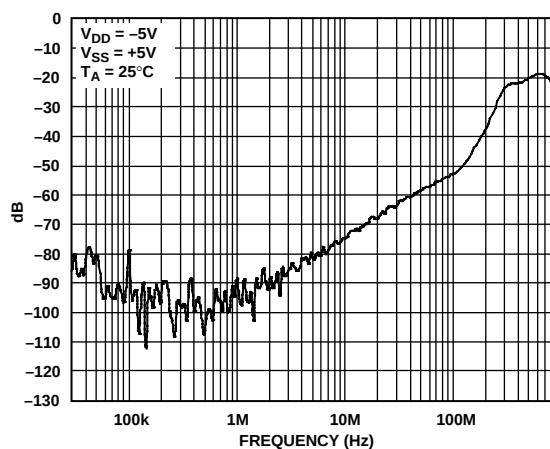


Figure 17. Crosstalk vs. Frequency

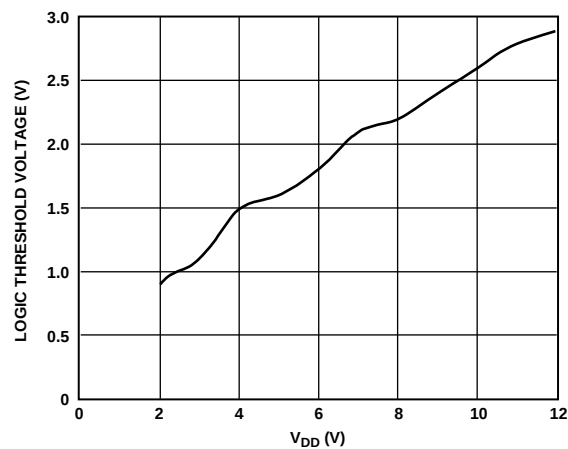


Figure 20. Logic Threshold Voltage vs. Supply Voltage

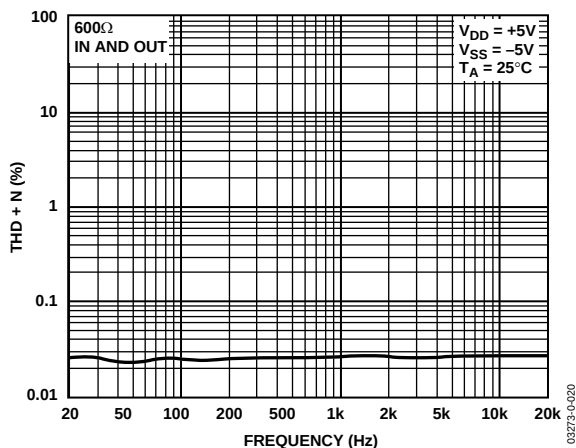


Figure 18. THD + Noise

## TERMINOLOGY

### $V_D (V_S)$

Analog Voltage on Terminals D, S.

### $R_{ON}$

Ohmic Resistance between D and S.

### $\Delta R_{ON}$

On Resistance Match between Any Two Channels, i.e.,  $R_{ONmax} - R_{ONmin}$ .

### $R_{FLAT(ON)}$

Flatness is defined as the difference between the maximum and minimum value of ON Resistance as measured over the specified analog signal range.

### $I_S (OFF)$

Source Leakage Current with the Switch OFF.

### $I_D (OFF)$

Drain Leakage Current with the Switch OFF.

### $I_D, I_S (ON)$

Channel Leakage Current with the Switch ON.

### $V_{INL}$

Maximum Input Voltage for Logic 0.

### $V_{INH}$

Minimum Input Voltage for Logic 1.

### $I_{INL} (I_{INH})$

Input Current of the Digital Input.

### $C_S (OFF)$

OFF Switch Source Capacitance. Measured with reference to ground.

### $C_D (OFF)$

OFF Switch Drain Capacitance. Measured with reference to ground.

### $C_D, C_S (ON)$

ON Switch Capacitance. Measured with reference to ground.

### $C_{IN}$

Digital Input Capacitance.

### $t_{ON}$

Delay between Applying the Digital Control Input and the Output Switching ON. See Figure 27.

### $t_{OFF}$

Delay between Applying the Digital Control Input and the Output Switching OFF.

### $t_{BEM}$

ON Time. Measured between 80% points of both switches when switching from one address state to another.

### Charge Injection

Measure of the Glitch Impulse Transferred from the Digital Input to the Analog Output during Switching.

### Off Isolation

Measure of Unwanted Signal Coupling through an OFF Switch.

### Crosstalk

Measure of Unwanted Signal Coupled through from One Channel to Another as a Result of Parasitic Capacitance.

### Bandwidth

The Frequency at which the Output is Attenuated by 3 dB.

### On Response

The Frequency Response of the ON Switch.

### Insertion Loss

The Loss Due to the ON Resistance of the Switch.

# TEST CIRCUITS

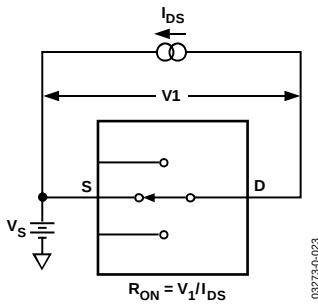


Figure 21. ON Resistance

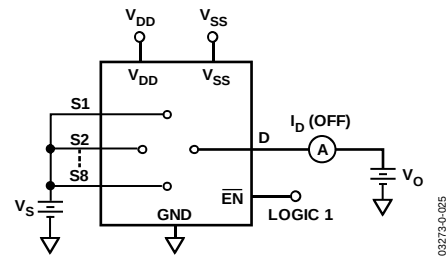


Figure 23.  $I_D$  (OFF)

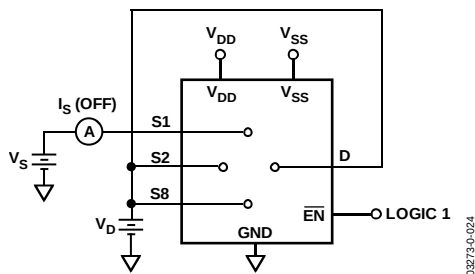


Figure 22.  $I_S$  (OFF)

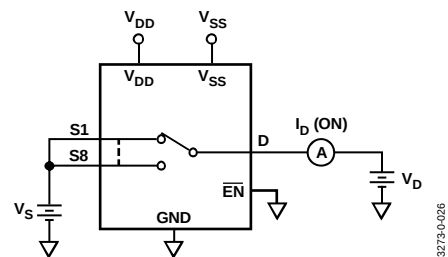


Figure 24.  $I_D$  (ON)

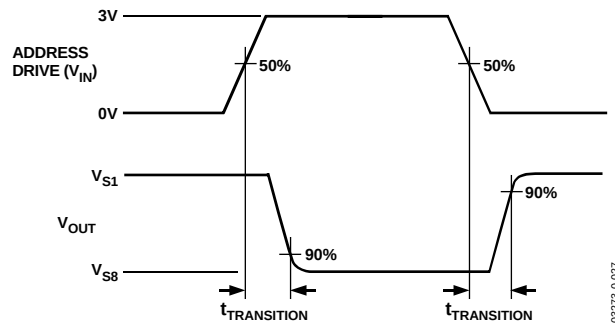
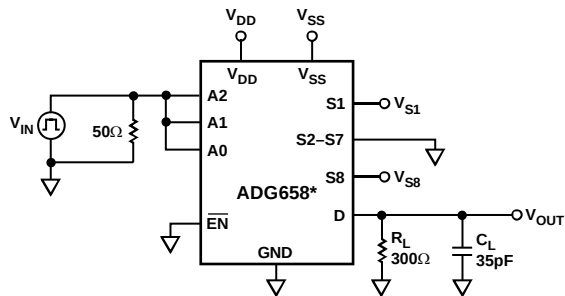


Figure 25. Switching Time of Multiplexer,  $t_{\text{TRANSITION}}$

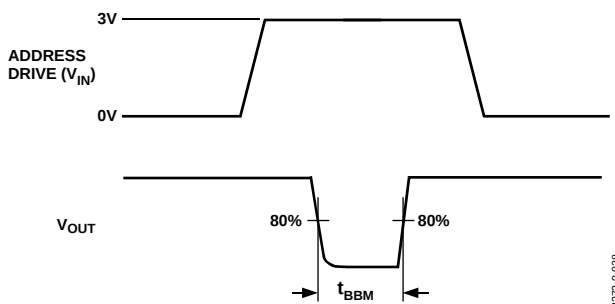
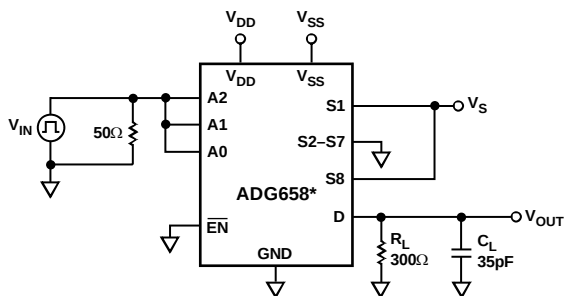
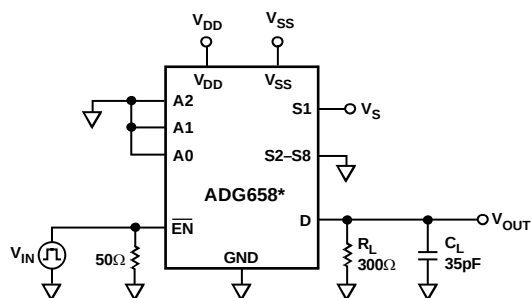
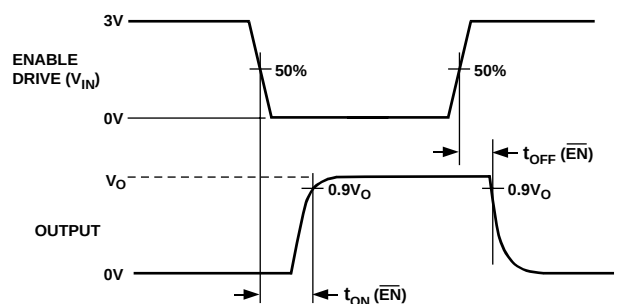


Figure 26. Break-Before-Make Delay,  $t_{\text{BBM}}$

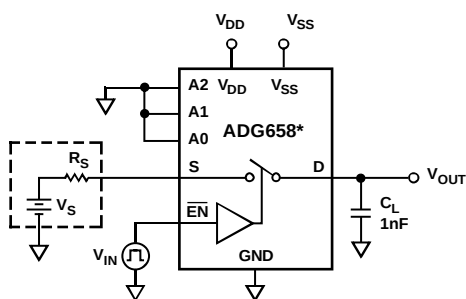


\*SIMILAR CONNECTION FOR ADG659

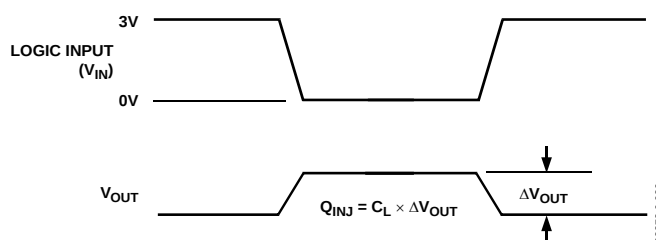


03273-0-029

Figure 27. Enable Delay,  $t_{ON}(\overline{EN})$ ,  $t_{OFF}(\overline{EN})$

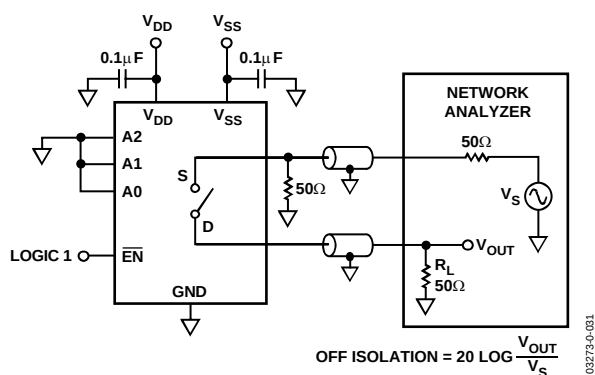


\*SIMILAR CONNECTION FOR ADG659



03273-0-030

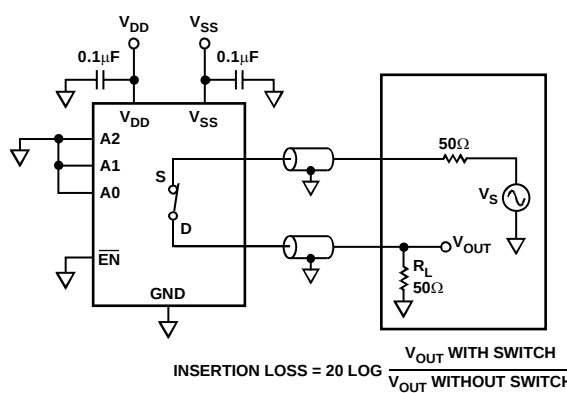
Figure 28. Charge Injection



$$\text{OFF ISOLATION} = 20 \log \frac{V_{OUT}}{V_S}$$

03273-0-031

Figure 29. Off Isolation



$$\text{INSERTION LOSS} = 20 \log \frac{V_{OUT \text{ WITH SWITCH}}}{V_{OUT \text{ WITHOUT SWITCH}}}$$

03273-0-032

Figure 30. Bandwidth

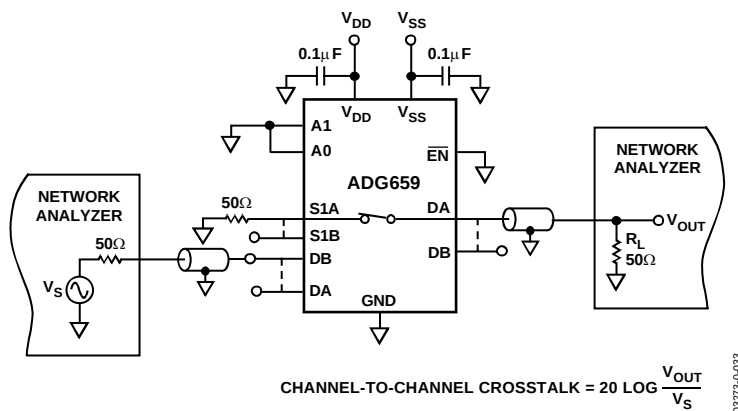
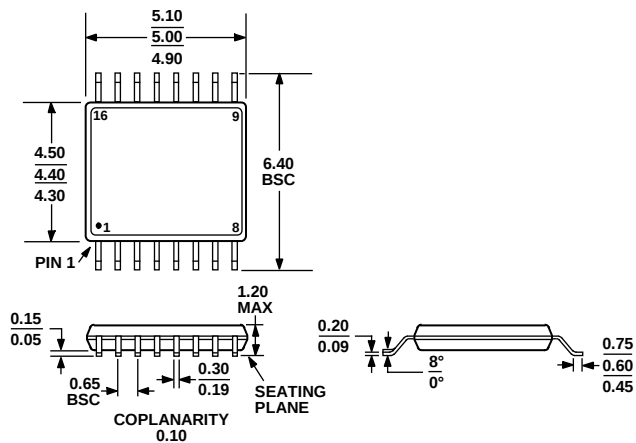


Figure 31. Channel-to-Channel Crosstalk

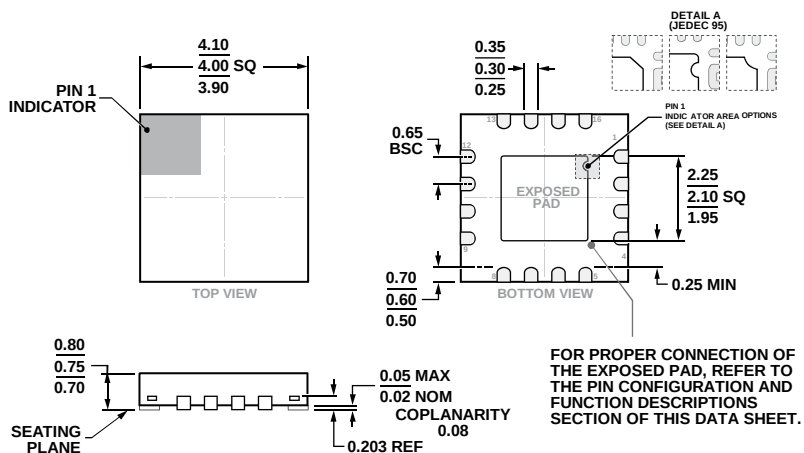
## OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-153-AB

Figure 32. 16-Lead Thin Shrink Small Outline Package [TSSOP]  
(RU-16)

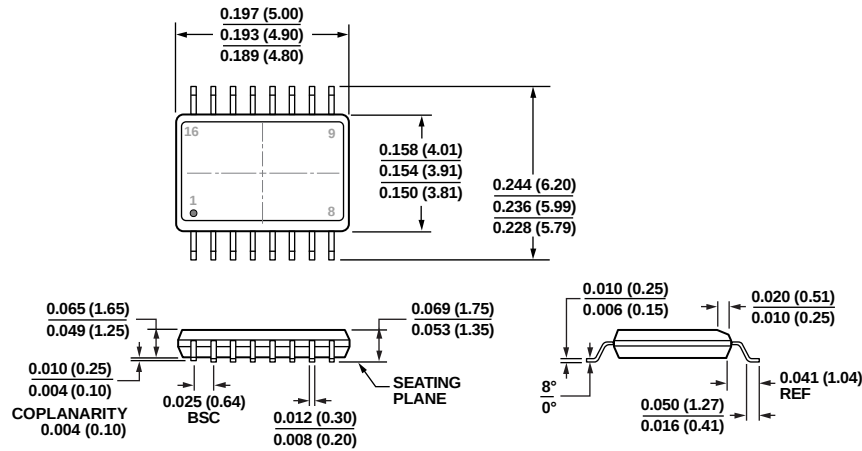
Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-220-WGGC.

Figure 33. 16-Lead Lead Frame Chip Scale Package [LFCSP]  
4 mm × 4 mm Body and 0.75 mm Package Height  
(CP-16-23)

Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-137-AB  
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS  
(IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR  
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 34. 16-Lead Shrink Small Outline Package [QSOP]  
(RQ-16)

Dimensions shown in inches and (millimeters)

09-12-2014-A

## ORDERING GUIDE

| Model <sup>1, 2</sup> | Temperature Range | Package Description                               | Package Option |
|-----------------------|-------------------|---------------------------------------------------|----------------|
| ADG658YRU             | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG658YRU-REEL7       | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG658YRUZ            | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG658YRUZ-REEL7      | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG658YCPZ            | −40°C to +85°C    | 16-Lead Lead Frame Chip Scale Package [LFCSP]     | CP-16-23       |
| ADG658YCPZ-REEL7      | −40°C to +85°C    | 16-Lead Lead Frame Chip Scale Package [LFCSP]     | CP-16-23       |
| ADG658YRQ             | −40°C to +125°C   | 16-Lead Shrink Small Outline Package [QSOP]       | RQ-16          |
| ADG658YRQZ            | −40°C to +125°C   | 16-Lead Shrink Small Outline Package [QSOP]       | RQ-16          |
| ADG658YRQZ-REEL7      | −40°C to +125°C   | 16-Lead Shrink Small Outline Package [QSOP]       | RQ-16          |
| ADW54003-0            | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADW54003-0RL7         | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG659YRU             | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG659YRUZ            | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG659YRUZ-REEL7      | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG659YRUZ-REEL7      | −40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG659YCPZ            | −40°C to +85°C    | 16-Lead Lead Frame Chip Scale Package [LFCSP]     | CP-16-23       |
| ADG659YCPZ-REEL7      | −40°C to +85°C    | 16-Lead Lead Frame Chip Scale Package [LFCSP]     | CP-16-23       |
| ADG659YRQZ            | −40°C to +125°C   | 16-Lead Shrink Small Outline Package [QSOP]       | RQ-16          |

<sup>1</sup> Z = RoHS Compliant Part.

<sup>2</sup> W = Qualified for Automotive Applications.

## AUTOMOTIVE PRODUCTS

The ADW54003 models are available with controlled manufacturing to support the quality and reliability requirements of automotive applications. Note that these automotive models may have specifications that differ from the commercial models; therefore, designers should review the Specifications section of this data sheet carefully. Only the automotive grade products shown are available for use in automotive applications. Contact your local Analog Devices account representative for specific product ordering information and to obtain the specific Automotive Reliability reports for these models.