

### FEATURES

- Latch-up proof
- 8 kV human body model (HBM) ESD rating
- Low on resistance (<math><10 \Omega</math>)
- $\pm 9\text{ V}$  to  $\pm 22\text{ V}$  dual-supply operation
- 9 V to 40 V single-supply operation
- 48 V supply maximum ratings
- Fully specified at  $\pm 15\text{ V}$ ,  $\pm 20\text{ V}$ ,  $+12\text{ V}$ , and  $+36\text{ V}$
- $V_{SS}$  to  $V_{DD}$  analog signal range

### APPLICATIONS

- Relay replacement
- Automatic test equipment
- Data acquisition
- Instrumentation
- Avionics
- Audio and video switching
- Communication systems

### GENERAL DESCRIPTION

The [ADG5412/ADG5413](#) contain four independent single-pole/single-throw (SPST) switches. The [ADG5412](#) switches turn on with Logic 1. The [ADG5413](#) has two switches with digital control logic similar to that of the [ADG5412](#); however, the logic is inverted on the other two switches. Each switch conducts equally well in both directions when on, and each switch has an input signal range that extends to the supplies. In the off condition, signal levels up to the supplies are blocked.

The [ADG5412](#) and [ADG5413](#) do not have a  $V_L$  pin. The digital inputs are compatible with 3 V logic inputs over the full operating supply range.

The on-resistance profile is very flat over the full analog input range, which ensures good linearity and low distortion when switching audio signals. High switching speed also makes the devices suitable for video signal switching. The [ADG5413](#) exhibits break-before-make switching action for use in multiplexer applications.

### FUNCTIONAL BLOCK DIAGRAMS

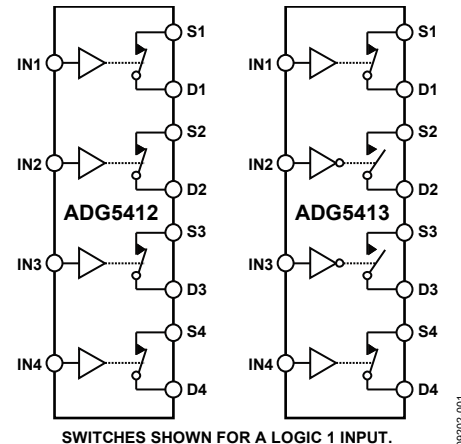


Figure 1.

### PRODUCT HIGHLIGHTS

1. Trench isolation guards against latch-up. A dielectric trench separates the P and N channel transistors thereby preventing latch-up even under severe overvoltage conditions.
2. Low  $R_{ON}$ .
3. Dual-supply operation. For applications where the analog signal is bipolar, the [ADG5412/ADG5413](#) can be operated from dual supplies up to  $\pm 22\text{ V}$ .
4. Single-supply operation. For applications where the analog signal is unipolar, the [ADG5412/ADG5413](#) can be operated from a single rail power supply up to 40 V.
5. 3 V logic compatible digital inputs:  $V_{INH} = 2.0\text{ V}$ ,  $V_{INL} = 0.8\text{ V}$ .
6. No  $V_L$  logic power supply required.

Rev. D

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## REVISION HISTORY

### 11/2017—Rev. C to Rev. D

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| Change to Source Off Leakage, $I_s$ (Off) Parameter and Drain<br>Off Leakage, $I_D$ (Off) Parameter, Table 1..... | 3  |
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### 9/2015—Rev. A to Rev. B

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### 6/2011—Rev. 0 to Rev. A

|  |   |
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|--|---|

### 7/2010—Revision 0: Initial Version

## SPECIFICATIONS

## ±15 V DUAL SUPPLY

$V_{DD} = +15\text{ V} \pm 10\%$ ,  $V_{SS} = -15\text{ V} \pm 10\%$ ,  $GND = 0\text{ V}$ , unless otherwise noted.

Table 1.

| Parameter   | +25°C      | -40°C to +85°C | -40°C to +125°C      | Unit              | Test Conditions/Comments   |
|---|------------|----------------|----------------------|-------------------|--|
| <b>ANALOG SWITCH</b>                                  |            |                |                      |                   |  |
| Analog Signal Range                                   |            |                | $V_{DD}$ to $V_{SS}$ | V                 |  |
| On Resistance, $R_{ON}$                               | 9.8        |                |                      | $\Omega$ typ      | $V_S = \pm 10\text{ V}$ , $I_S = -10\text{ mA}$ ; see Figure 24  |
| On-Resistance Match Between Channels, $\Delta R_{ON}$ | 11         | 14             | 16                   | $\Omega$ max      | $V_{DD} = +13.5\text{ V}$ , $V_{SS} = -13.5\text{ V}$  |
| On-Resistance Flatness, $R_{FLAT(ON)}$                | 0.35       |                |                      | $\Omega$ typ      | $V_S = \pm 10\text{ V}$ , $I_S = -10\text{ mA}$  |
|   | 0.7        | 0.9            | 1.1                  | $\Omega$ max      |  |
|   | 1.2        |                |                      | $\Omega$ typ      | $V_S = \pm 10\text{ V}$ , $I_S = -10\text{ mA}$  |
|   | 1.6        | 2              | 2.2                  | $\Omega$ max      |  |
| <b>LEAKAGE CURRENTS</b>                               |            |                |                      |                   |  |
| Source Off Leakage, $I_S$ (Off)                       | $\pm 0.05$ |                |                      | nA typ            | $V_{DD} = +16.5\text{ V}$ , $V_{SS} = -16.5\text{ V}$<br>$V_S = \pm 10\text{ V}$ , $V_D = \mp 10\text{ V}$ ; see Figure 27 |
| Drain Off Leakage, $I_D$ (Off)                        | $\pm 0.25$ | $\pm 0.75$     | $\pm 6$              | nA max            |  |
|   | $\pm 0.05$ |                |                      | nA typ            | $V_S = \pm 10\text{ V}$ , $V_D = \mp 10\text{ V}$ ; see Figure 27  |
| Channel On Leakage, $I_D$ (On), $I_S$ (On)            | $\pm 0.25$ | $\pm 0.75$     | $\pm 6$              | nA max            |  |
|   | $\pm 0.1$  |                |                      | nA typ            | $V_S = V_D = \pm 10\text{ V}$ ; see Figure 23  |
|   | $\pm 0.4$  | $\pm 2$        | $\pm 12$             | nA max            |  |
| <b>DIGITAL INPUTS</b>                                 |            |                |                      |                   |  |
| Input High Voltage, $V_{INH}$                         |            |                | 2.0                  | V min             |  |
| Input Low Voltage, $V_{INL}$                          |            |                | 0.8                  | V max             |  |
| Input Current, $I_{INL}$ or $I_{INH}$                 | 0.002      |                |                      | $\mu\text{A}$ typ | $V_{IN} = V_{GND}$ or $V_{DD}$   |
|   |            |                | $\pm 0.1$            | $\mu\text{A}$ max |  |
| Digital Input Capacitance, $C_{IN}$                   | 2.5        |                |                      | pF typ            |  |
| <b>DYNAMIC CHARACTERISTICS<sup>1</sup></b>            |            |                |                      |                   |  |
| $t_{ON}$  | 170        |                |                      | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$   |
|   | 202        | 236            | 262                  | ns max            | $V_S = 10\text{ V}$ ; see Figure 31  |
| $t_{OFF}$   | 120        |                |                      | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$   |
|   | 145        | 170            | 182                  | ns max            | $V_S = 10\text{ V}$ ; see Figure 31  |
| Break-Before-Make Time Delay, $t_D$<br>(ADG5413 Only) | 15         |                |                      | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$   |
| Charge Injection, $Q_{INJ}$                           | 240        |                | 6                    | ns min            | $V_{S1} = V_{S2} = 10\text{ V}$ ; see Figure 30  |
| Off Isolation   | -78        |                |                      | pC typ            | $V_S = 0\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 1\text{ nF}$ ; see Figure 32   |
| Channel-to-Channel Crosstalk                          | -70        |                |                      | dB typ            | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 100\text{ kHz}$ ; see Figure 26  |
| Total Harmonic Distortion + Noise                     | 0.009      |                |                      | dB typ            | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; see Figure 25  |
| -3 dB Bandwidth                                       | 167        |                |                      | % typ             | $R_L = 1\text{ k}\Omega$ , $15\text{ V p-p}$ , $f = 20\text{ Hz}$ to $20\text{ kHz}$ ; see Figure 28                       |
| Insertion Loss  | -0.7       |                |                      | MHz typ           | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; see Figure 29   |
| $C_S$ (Off)   | 18         |                |                      | dB typ            | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; see Figure 29  |
| $C_D$ (Off)   | 18         |                |                      | pF typ            | $V_S = 0\text{ V}$ , $f = 1\text{ MHz}$  |
| $C_D$ (On), $C_S$ (On)                                | 60         |                |                      | pF typ            | $V_S = 0\text{ V}$ , $f = 1\text{ MHz}$  |

| Parameter                 | +25°C | -40°C to +85°C | -40°C to +125°C | Unit              | Test Conditions/Comments  |
|---------------------------|-------|----------------|-----------------|-------------------|---|
| <b>POWER REQUIREMENTS</b> |       |                |                 |                   |   |
| $I_{DD}$                  | 45    |                |                 | $\mu\text{A typ}$ | $V_{DD} = +16.5\text{ V}$ , $V_{SS} = -16.5\text{ V}$<br>Digital inputs = 0 V or $V_{DD}$ |
| $I_{SS}$                  | 55    |                | 70              | $\mu\text{A max}$ |   |
|                           | 0.001 |                |                 | $\mu\text{A typ}$ | Digital inputs = 0 V or $V_{DD}$  |
|                           |       |                | 1               | $\mu\text{A max}$ |   |
| $V_{DD}/V_{SS}$           |       |                | $\pm 9/\pm 22$  | V min/V max       | GND = 0 V   |

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

## ±20 V DUAL SUPPLY

$V_{DD} = +20\text{ V} \pm 10\%$ ,  $V_{SS} = -20\text{ V} \pm 10\%$ , GND = 0 V, unless otherwise noted.

Table 2.

| Parameter   | +25°C      | -40°C to +85°C | -40°C to +125°C      | Unit              | Test Conditions/Comments  |
|---|------------|----------------|----------------------|-------------------|---|
| <b>ANALOG SWITCH</b>                                  |            |                |                      |                   |   |
| Analog Signal Range                                   |            |                | $V_{DD}$ to $V_{SS}$ | V                 |   |
| On Resistance, $R_{ON}$                               | 9          |                |                      | $\Omega$ typ      | $V_S = \pm 15\text{ V}$ , $I_S = -10\text{ mA}$ ;<br>see Figure 24  |
|   | 10         | 13             | 15                   | $\Omega$ max      | $V_{DD} = +18\text{ V}$ , $V_{SS} = -18\text{ V}$   |
| On-Resistance Match Between Channels, $\Delta R_{ON}$ | 0.35       |                |                      | $\Omega$ typ      | $V_S = \pm 15\text{ V}$ , $I_S = -10\text{ mA}$   |
|   | 0.7        | 0.9            | 1.1                  | $\Omega$ max      |   |
| On-Resistance Flatness, $R_{FLAT(ON)}$                | 1.5        |                |                      | $\Omega$ typ      | $V_S = \pm 15\text{ V}$ , $I_S = -10\text{ mA}$   |
|   | 1.8        | 2.2            | 2.5                  | $\Omega$ max      |   |
| <b>LEAKAGE CURRENTS</b>                               |            |                |                      |                   |   |
| Source Off Leakage, $I_S$ (Off)                       | $\pm 0.05$ |                |                      | nA typ            | $V_{DD} = +22\text{ V}$ , $V_{SS} = -22\text{ V}$<br>$V_S = \pm 15\text{ V}$ , $V_D = \mp 15\text{ V}$ ;<br>see Figure 27 |
|   | $\pm 0.25$ | $\pm 0.75$     | $\pm 6$              | nA max            |   |
| Drain Off Leakage, $I_D$ (Off)                        | $\pm 0.05$ |                |                      | nA typ            | $V_S = \pm 15\text{ V}$ , $V_D = \mp 15\text{ V}$ ;<br>see Figure 27  |
|   | $\pm 0.25$ | $\pm 0.75$     | $\pm 6$              | nA max            |   |
| Channel On Leakage, $I_D$ (On), $I_S$ (On)            | $\pm 0.1$  |                |                      | nA typ            | $V_S = V_D = \pm 15\text{ V}$ ; see<br>Figure 23  |
|   | $\pm 0.4$  | $\pm 2$        | $\pm 12$             | nA max            |   |
| <b>DIGITAL INPUTS</b>                                 |            |                |                      |                   |   |
| Input High Voltage, $V_{INH}$                         |            |                | 2.0                  | V min             |   |
| Input Low Voltage, $V_{INL}$                          |            |                | 0.8                  | V max             |   |
| Input Current, $I_{INL}$ or $I_{INH}$                 | 0.002      |                |                      | $\mu\text{A typ}$ | $V_{IN} = V_{GND}$ or $V_{DD}$  |
|   |            |                | $\pm 0.1$            | $\mu\text{A max}$ |   |
| Digital Input Capacitance, $C_{IN}$                   | 2.5        |                |                      | pF typ            |   |
| <b>DYNAMIC CHARACTERISTICS<sup>1</sup></b>            |            |                |                      |                   |   |
| $t_{ON}$  | 158        |                |                      | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$  |
|   | 187        | 217            | 240                  | ns max            | $V_S = 10\text{ V}$ ; see Figure 31   |
| $t_{OFF}$   | 110        |                |                      | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$  |
|   | 138        | 154            | 170                  | ns max            | $V_S = 10\text{ V}$ ; see Figure 31   |
| Break-Before-Make Time Delay, $t_D$<br>(ADG5413 Only) | 12         |                |                      | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$  |
|   |            |                | 5                    | ns min            | $V_{S1} = V_{S2} = 10\text{ V}$ ; see<br>Figure 30  |
| Charge Injection, $Q_{INJ}$                           | 310        |                |                      | pC typ            | $V_S = 0\text{ V}$ , $R_S = 0\ \Omega$ , $C_L = 1\text{ nF}$ ;<br>see Figure 32   |
| Off Isolation   | -78        |                |                      | dB typ            | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 100\text{ kHz}$ ;<br>see Figure 26  |
| Channel-to-Channel Crosstalk                          | -70        |                |                      | dB typ            | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ;<br>see Figure 25  |

| Parameter                         | +25°C | −40°C to +85°C | −40°C to +125°C | Unit              | Test Conditions/Comments   |
|-----------------------------------|-------|----------------|-----------------|-------------------|--|
| Total Harmonic Distortion + Noise | 0.007 |                |                 | % typ             | $R_L = 1\text{ k}\Omega$ , 20 V p-p, $f = 20\text{ Hz}$ to 20 kHz; see Figure 28 |
| −3 dB Bandwidth                   | 160   |                |                 | MHz typ           | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ ; see Figure 29                         |
| Insertion Loss                    | −0.6  |                |                 | dB typ            | $R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ ; see Figure 29    |
| $C_S$ (Off)                       | 17    |                |                 | pF typ            | $V_S = 0\text{ V}$ , $f = 1\text{ MHz}$  |
| $C_D$ (Off)                       | 17    |                |                 | pF typ            | $V_S = 0\text{ V}$ , $f = 1\text{ MHz}$  |
| $C_D$ (On), $C_S$ (On)            | 60    |                |                 | pF typ            | $V_S = 0\text{ V}$ , $f = 1\text{ MHz}$  |
| <b>POWER REQUIREMENTS</b>         |       |                |                 |                   |  |
| $I_{DD}$                          | 50    |                |                 | $\mu\text{A}$ typ | $V_{DD} = +22\text{ V}$ , $V_{SS} = -22\text{ V}$                                |
|                                   | 70    |                | 110             | $\mu\text{A}$ max | Digital inputs = 0 V or $V_{DD}$   |
| $I_{SS}$                          | 0.001 |                |                 | $\mu\text{A}$ typ | Digital inputs = 0 V or $V_{DD}$   |
|                                   |       |                | 1               | $\mu\text{A}$ max |  |
| $V_{DD}/V_{SS}$                   |       |                | $\pm 9/\pm 22$  | V min/V max       | GND = 0 V  |

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

## 12 V SINGLE SUPPLY

$V_{DD} = 12\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ , GND = 0 V, unless otherwise noted.

Table 3.

| Parameter   | +25°C      | −40°C to +85°C | −40°C to +125°C | Unit              | Test Conditions/Comments  |
|---|------------|----------------|-----------------|-------------------|---|
| <b>ANALOG SWITCH</b>                                  |            |                |                 |                   |   |
| Analog Signal Range                                   |            |                | 0 V to $V_{DD}$ | V                 |   |
| On Resistance, $R_{ON}$                               | 19         |                |                 | $\Omega$ typ      | $V_S = 0\text{ V}$ to 10 V, $I_S = -10\text{ mA}$ ; see Figure 24               |
| On-Resistance Match Between Channels, $\Delta R_{ON}$ | 22         | 27             | 31              | $\Omega$ max      | $V_{DD} = 10.8\text{ V}$ , $V_{SS} = 0\text{ V}$                                |
|   | 0.4        |                |                 | $\Omega$ typ      | $V_S = 0\text{ V}$ to 10 V, $I_S = -10\text{ mA}$                               |
| On-Resistance Flatness, $R_{FLAT(ON)}$                | 0.8        | 1              | 1.2             | $\Omega$ max      |   |
|   | 4.4        |                |                 | $\Omega$ typ      | $V_S = 0\text{ V}$ to 10 V, $I_S = -10\text{ mA}$                               |
|   | 5.5        | 6.5            | 7.5             | $\Omega$ max      |   |
| <b>LEAKAGE CURRENTS</b>                               |            |                |                 |                   |   |
| Source Off Leakage, $I_S$ (Off)                       | $\pm 0.05$ |                |                 | nA typ            | $V_{DD} = 13.2\text{ V}$ , $V_{SS} = 0\text{ V}$                                |
|   | $\pm 0.25$ | $\pm 0.75$     | $\pm 6$         | nA max            | $V_S = 1\text{ V}/10\text{ V}$ , $V_D = 10\text{ V}/1\text{ V}$ ; see Figure 27 |
| Drain Off Leakage, $I_D$ (Off)                        | $\pm 0.05$ |                |                 | nA typ            | $V_S = 1\text{ V}/10\text{ V}$ , $V_D = 10\text{ V}/1\text{ V}$ ; see Figure 27 |
| Channel On Leakage, $I_D$ (On), $I_S$ (On)            | $\pm 0.25$ | $\pm 0.75$     | $\pm 6$         | nA max            |   |
|   | $\pm 0.1$  |                |                 | nA typ            | $V_S = V_D = 1\text{ V}/10\text{ V}$ ; see Figure 23                            |
|   | $\pm 0.4$  | $\pm 2$        | $\pm 12$        | nA max            |   |
| <b>DIGITAL INPUTS</b>                                 |            |                |                 |                   |   |
| Input High Voltage, $V_{INH}$                         |            |                | 2.0             | V min             |   |
| Input Low Voltage, $V_{INL}$                          |            |                | 0.8             | V max             |   |
| Input Current, $I_{INL}$ or $I_{INH}$                 | 0.002      |                |                 | $\mu\text{A}$ typ | $V_{IN} = V_{GND}$ or $V_{DD}$  |
|   |            |                | $\pm 0.1$       | $\mu\text{A}$ max |   |
| Digital Input Capacitance, $C_{IN}$                   | 2.5        |                |                 | pF typ            |   |
| <b>DYNAMIC CHARACTERISTICS<sup>1</sup></b>            |            |                |                 |                   |   |
| $t_{ON}$  | 225        |                |                 | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$                                      |
|   | 296        | 358            | 403             | ns max            | $V_S = 8\text{ V}$ ; see Figure 31  |
| $t_{OFF}$   | 150        |                |                 | ns typ            | $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$                                      |
|   | 187        | 222            | 247             | ns max            | $V_S = 8\text{ V}$ ; see Figure 31  |

| Parameter   | +25°C | -40°C to +85°C | -40°C to +125°C | Unit              | Test Conditions/Comments  |
|---|-------|----------------|-----------------|-------------------|---|
| Break-Before-Make Time Delay, $t_D$<br>(ADG5413 Only) | 70    |                |                 | ns typ            | $R_L = 300 \Omega$ , $C_L = 35 \text{ pF}$  |
| Charge Injection, $Q_{INJ}$                           | 95    |                | 38              | ns min<br>pC typ  | $V_{S1} = V_{S2} = 8 \text{ V}$ ; see Figure 30<br>$V_S = 6 \text{ V}$ , $R_S = 0 \Omega$ , $C_L = 1 \text{ nF}$ ;<br>see Figure 32 |
| Off Isolation   | -78   |                |                 | dB typ            | $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ ;<br>$f = 100 \text{ kHz}$ ; see Figure 26   |
| Channel-to-Channel Crosstalk                          | -70   |                |                 | dB typ            | $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ , $f = 1 \text{ MHz}$ ;<br>see Figure 25   |
| Total Harmonic Distortion + Noise                     | 0.07  |                |                 | % typ             | $R_L = 1 \text{ k}\Omega$ , $6 \text{ V p-p}$ , $f = 20 \text{ Hz}$<br>to $20 \text{ kHz}$ ; see Figure 28                          |
| -3 dB Bandwidth                                       | 180   |                |                 | MHz typ           | $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ ; see<br>Figure 29   |
| Insertion Loss  | -1.3  |                |                 | dB typ            | $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ , $f = 1 \text{ MHz}$ ;<br>see Figure 29   |
| $C_S$ (Off)   | 22    |                |                 | pF typ            | $V_S = 6 \text{ V}$ , $f = 1 \text{ MHz}$   |
| $C_D$ (Off)   | 22    |                |                 | pF typ            | $V_S = 6 \text{ V}$ , $f = 1 \text{ MHz}$   |
| $C_D$ (On), $C_S$ (On)                                | 58    |                |                 | pF typ            | $V_S = 6 \text{ V}$ , $f = 1 \text{ MHz}$   |
| <b>POWER REQUIREMENTS</b>                             |       |                |                 |                   |   |
| $I_{DD}$  | 40    |                |                 | $\mu\text{A}$ typ | $V_{DD} = 13.2 \text{ V}$<br>Digital inputs = $0 \text{ V}$ or $V_{DD}$   |
|   |       |                | 65              | $\mu\text{A}$ max |   |
| $V_{DD}$  |       |                | 9/40            | V min/V max       | $\text{GND} = 0 \text{ V}$ , $V_{SS} = 0 \text{ V}$   |

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

### 36 V SINGLE SUPPLY

$V_{DD} = 36 \text{ V} \pm 10\%$ ,  $V_{SS} = 0 \text{ V}$ ,  $\text{GND} = 0 \text{ V}$ , unless otherwise noted.

Table 4.

| Parameter  | +25°C                    | -40°C to +85°C | -40°C to +125°C           | Unit   | Test Conditions/Comments   |
|--|--------------------------|----------------|---------------------------|--|--|
| <b>ANALOG SWITCH</b>                                     |                          |                |                           |  |  |
| Analog Signal Range                                      |                          |                | $0 \text{ V}$ to $V_{DD}$ | V  |  |
| On Resistance, $R_{ON}$                                  | 10.6                     |                |                           | $\Omega$ typ                                 | $V_S = 0 \text{ V}$ to $30 \text{ V}$ , $I_S = -10 \text{ mA}$ ;<br>see Figure 24  |
| On-Resistance Match Between Channels,<br>$\Delta R_{ON}$ | 12<br>0.35               | 15             | 17                        | $\Omega$ max<br>$\Omega$ typ                 | $V_{DD} = 32.4 \text{ V}$ , $V_{SS} = 0 \text{ V}$<br>$V_S = 0 \text{ V}$ to $30 \text{ V}$ , $I_S = -10 \text{ mA}$                         |
| On-Resistance Flatness, $R_{FLAT(ON)}$                   | 0.7<br>2.7<br>3.2        | 0.9<br>3.8     | 1.1<br>4.5                | $\Omega$ max<br>$\Omega$ typ<br>$\Omega$ max | $V_S = 0 \text{ V}$ to $30 \text{ V}$ , $I_S = -10 \text{ mA}$   |
| <b>LEAKAGE CURRENTS</b>                                  |                          |                |                           |  |  |
| Source Off Leakage, $I_S$ (Off)                          | $\pm 0.05$               |                |                           | nA typ                                       | $V_{DD} = 39.6 \text{ V}$ , $V_{SS} = 0 \text{ V}$<br>$V_S = 1 \text{ V}/30 \text{ V}$ , $V_D = 30 \text{ V}/1 \text{ V}$ ;<br>see Figure 27 |
| Drain Off Leakage, $I_D$ (Off)                           | $\pm 0.25$<br>$\pm 0.05$ | $\pm 0.75$     | $\pm 6$                   | nA max<br>nA typ                             | $V_S = 1 \text{ V}/30 \text{ V}$ , $V_D = 30 \text{ V}/1 \text{ V}$ ;<br>see Figure 27   |
| Channel On Leakage, $I_D$ (On), $I_S$ (On)               | $\pm 0.25$<br>$\pm 0.1$  | $\pm 0.75$     | $\pm 6$                   | nA max<br>nA typ                             | $V_S = V_D = 1 \text{ V}/30 \text{ V}$ ; see<br>Figure 23  |
|  | $\pm 0.4$                | $\pm 2$        | $\pm 12$                  | nA max                                       |  |

| Parameter   | +25°C | −40°C to +85°C | −40°C to +125°C | Unit                                 | Test Conditions/Comments  |
|---|-------|----------------|-----------------|--------------------------------------|---|
| <b>DIGITAL INPUTS</b>                                 |       |                |                 |                                      |   |
| Input High Voltage, $V_{INH}$                         |       |                | 2.0             | V min                                | $V_{IN} = V_{GND}$ or $V_{DD}$  |
| Input Low Voltage, $V_{INL}$                          |       |                | 0.8             | V max                                |   |
| Input Current, $I_{INL}$ or $I_{INH}$                 | 0.002 |                |                 | $\mu\text{A}$ typ                    |   |
| Digital Input Capacitance, $C_{IN}$                   | 2.5   |                | $\pm 0.1$       | $\mu\text{A}$ max<br>$\text{pF}$ typ |   |
| <b>DYNAMIC CHARACTERISTICS<sup>1</sup></b>            |       |                |                 |                                      |   |
| $t_{ON}$  | 180   |                |                 | ns typ                               | $R_L = 300 \Omega$ , $C_L = 35 \text{ pF}$<br>$V_S = 18 \text{ V}$ ; see Figure 31  |
|   | 220   | 230            | 248             | ns max                               |   |
| $t_{OFF}$   | 130   |                |                 | ns typ                               | $R_L = 300 \Omega$ , $C_L = 35 \text{ pF}$<br>$V_S = 18 \text{ V}$ ; see Figure 31  |
|   | 169   | 167            | 174             | ns max                               |   |
| Break-Before-Make Time Delay, $t_D$<br>(ADG5413 Only) | 25    |                |                 | ns typ                               | $R_L = 300 \Omega$ , $C_L = 35 \text{ pF}$  |
| Charge Injection, $Q_{INJ}$                           | 280   |                | 8               | ns min<br>$\text{pC}$ typ            | $V_{S1} = V_{S2} = 18 \text{ V}$ ; see Figure 30<br>$V_S = 18 \text{ V}$ , $R_S = 0 \Omega$ , $C_L = 1 \text{ nF}$ ;<br>see Figure 32 |
| Off Isolation   | −78   |                |                 | dB typ                               | $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ ,<br>$f = 100 \text{ kHz}$ ; see Figure 26   |
| Channel-to-Channel Crosstalk                          | −70   |                |                 | dB typ                               | $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ , $f = 1 \text{ MHz}$ ;<br>Figure 25   |
| Total Harmonic Distortion + Noise                     | 0.03  |                |                 | % typ                                | $R_L = 1 \text{ k}\Omega$ , 18 V p-p, $f = 20 \text{ Hz}$<br>to 20 kHz; see Figure 28   |
| −3 dB Bandwidth                                       | 174   |                |                 | MHz typ                              | $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ ; see<br>Figure 29   |
| Insertion Loss  | −0.8  |                |                 | dB typ                               | $R_L = 50 \Omega$ , $C_L = 5 \text{ pF}$ , $f = 1 \text{ MHz}$ ;<br>see Figure 29   |
| $C_S$ (Off)   | 18    |                |                 | $\text{pF}$ typ                      | $V_S = 18 \text{ V}$ , $f = 1 \text{ MHz}$  |
| $C_D$ (Off)   | 18    |                |                 | $\text{pF}$ typ                      | $V_S = 18 \text{ V}$ , $f = 1 \text{ MHz}$  |
| $C_D$ (On), $C_S$ (On)                                | 58    |                |                 | $\text{pF}$ typ                      | $V_S = 18 \text{ V}$ , $f = 1 \text{ MHz}$  |
| <b>POWER REQUIREMENTS</b>                             |       |                |                 |                                      |   |
| $I_{DD}$  | 80    |                |                 | $\mu\text{A}$ typ                    | $V_{DD} = 39.6 \text{ V}$<br>Digital inputs = 0 V or $V_{DD}$   |
|   | 100   |                | 130             | $\mu\text{A}$ max                    |   |
| $V_{DD}$  |       |                | 9/40            | V min/V max                          | $GND = 0 \text{ V}$ , $V_{SS} = 0 \text{ V}$  |

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

## CONTINUOUS CURRENT PER CHANNEL, Sx OR Dx

Table 5.

| Parameter   | 25°C | 85°C | 125°C | Unit       |
|---|------|------|-------|------------|
| <b>CONTINUOUS CURRENT, Sx OR Dx</b>                 |      |      |       |            |
| $V_{DD} = +15 \text{ V}$ , $V_{SS} = -15 \text{ V}$ |      |      |       |            |
| TSSOP ( $\theta_{JA} = 112.6^\circ\text{C/W}$ )     | 89   | 59   | 37    | mA maximum |
| LFCSP ( $\theta_{JA} = 30.4^\circ\text{C/W}$ )      | 160  | 94   | 49    | mA maximum |
| $V_{DD} = +20 \text{ V}$ , $V_{SS} = -20 \text{ V}$ |      |      |       |            |
| TSSOP ( $\theta_{JA} = 112.6^\circ\text{C/W}$ )     | 95   | 63   | 39    | mA maximum |
| LFCSP ( $\theta_{JA} = 30.4^\circ\text{C/W}$ )      | 170  | 98   | 50    | mA maximum |
| $V_{DD} = 12 \text{ V}$ , $V_{SS} = 0 \text{ V}$    |      |      |       |            |
| TSSOP ( $\theta_{JA} = 112.6^\circ\text{C/W}$ )     | 61   | 43   | 29    | mA maximum |
| LFCSP ( $\theta_{JA} = 30.4^\circ\text{C/W}$ )      | 110  | 70   | 42    | mA maximum |
| $V_{DD} = 36 \text{ V}$ , $V_{SS} = 0 \text{ V}$    |      |      |       |            |
| TSSOP ( $\theta_{JA} = 112.6^\circ\text{C/W}$ )     | 80   | 54   | 35    | mA maximum |
| LFCSP ( $\theta_{JA} = 30.4^\circ\text{C/W}$ )      | 144  | 87   | 47    | mA maximum |

## ABSOLUTE MAXIMUM RATINGS

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

Table 6.

| Parameter                                     | Rating   |
|---|--|
| $V_{DD}$ to $V_{SS}$                          | 48 V   |
| $V_{DD}$ to GND                               | -0.3 V to +48 V  |
| $V_{SS}$ to GND                               | +0.3 V to -48 V  |
| Analog Inputs <sup>1</sup>                    | $V_{SS} - 0.3\text{ V}$ to $V_{DD} + 0.3\text{ V}$ or<br>30 mA, whichever occurs first |
| Digital Inputs <sup>1</sup>                   | $V_{SS} - 0.3\text{ V}$ to $V_{DD} + 0.3\text{ V}$ or<br>30 mA, whichever occurs first |
| Peak Current, Sx or Dx Pins                   | 278 mA (pulsed at 1 ms, 10%<br>duty cycle maximum)                                     |
| Continuous Current, Sx or Dx <sup>2</sup>     | Data + 15%   |
| Temperature Range                             |  |
| Operating                                     | -40°C to +125°C  |
| Storage                                       | -65°C to +150°C  |
| Junction Temperature                          | 150°C  |
| Thermal Impedance, $\theta_{JA}$              |  |
| 16-Lead TSSOP (4-Layer Board)                 | 112.6°C/W  |
| 16-Lead LFCSOP (4-Layer Board)                | 30.4°C/W   |
| Reflow Soldering Peak<br>Temperature, Pb Free | 260(+0/-5)°C   |

<sup>1</sup> Overvoltages at the INx, Sx, and Dx pins are clamped by internal diodes.  
Limit current to the maximum ratings given.

<sup>2</sup> See Table 5.

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

Only one absolute maximum rating can be applied at any one time.

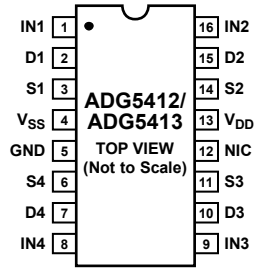
### ESD CAUTION



**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.



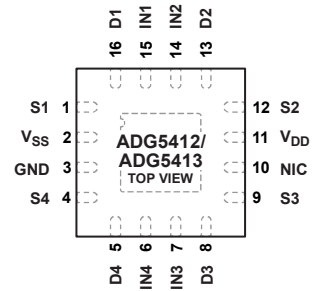
### PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS



NOTES  
1. NIC = NOT INTERNALLY CONNECTED. LEAVE THIS PIN FLOATING.

0102.02-002

Figure 2. TSSOP Pin Configuration



NOTES  
1. NIC = NOT INTERNALLY CONNECTED. LEAVE THIS PIN FLOATING.  
2. THE EXPOSED PAD IS CONNECTED INTERNALLY. FOR INCREASED RELIABILITY OF THE SOLDER JOINTS AND MAXIMUM THERMAL CAPABILITY, IT IS RECOMMENDED THAT THE PAD BE SOLDERED TO THE SUBSTRATE, V<sub>SS</sub>.

0102.02-003

Figure 3. LFCSP Pin Configuration

Table 7. Pin Function Descriptions

| Pin No. |       | Mnemonic        | Description  |
|---------|-------|-----------------|--|
| TSSOP   | LFCSP |                 |  |
| 1       | 15    | IN1             | Logic Control Input 1.   |
| 2       | 16    | D1              | Drain Terminal 1. This pin can be an input or output.  |
| 3       | 1     | S1              | Source Terminal 1. This pin can be an input or output.   |
| 4       | 2     | V <sub>SS</sub> | Most Negative Power Supply Potential.  |
| 5       | 3     | GND             | Ground (0 V) Reference.  |
| 6       | 4     | S4              | Source Terminal 4. This pin can be an input or output.   |
| 7       | 5     | D4              | Drain Terminal 4. This pin can be an input or output.  |
| 8       | 6     | IN4             | Logic Control Input 4.   |
| 9       | 7     | IN3             | Logic Control Input 3.   |
| 10      | 8     | D3              | Drain Terminal 3. This pin can be an input or output.  |
| 11      | 9     | S3              | Source Terminal 3. This pin can be an input or output.   |
| 12      | 10    | NIC             | Not Internally Connected. Leave this pin floating.   |
| 13      | 11    | V <sub>DD</sub> | Most Positive Power Supply Potential.  |
| 14      | 12    | S2              | Source Terminal 2. This pin can be an input or output.   |
| 15      | 13    | D2              | Drain Terminal 2. This pin can be an input or output.  |
| 16      | 14    | IN2             | Logic Control Input 2.   |
|         | EP    | Exposed Pad     | The exposed pad is connected internally. For increased reliability of the solder joints and maximum thermal capability, it is recommended that the pad be soldered to the substrate, V <sub>SS</sub> . |

Table 8. ADG5412 Truth Table

| INx | Switch Condition |
|-----|------------------|
| 1   | On               |
| 0   | Off              |

Table 9. ADG5413 Truth Table

| INx | S1, S4 | S2, S3 |
|-----|--------|--------|
| 0   | Off    | On     |
| 1   | On     | Off    |

TYPICAL PERFORMANCE CHARACTERISTICS

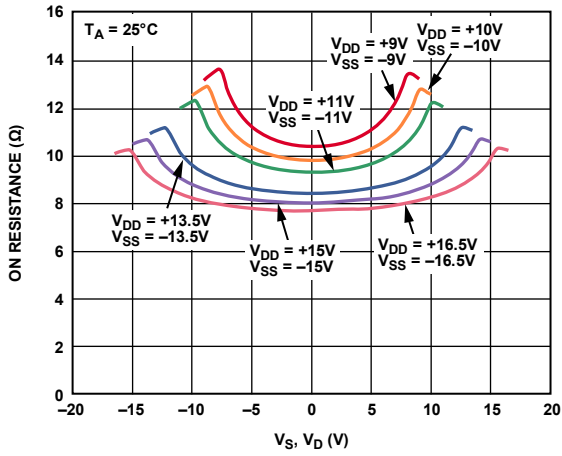


Figure 4.  $R_{ON}$  as a Function of  $V_S, V_D$  (Dual Supply)

09202-034

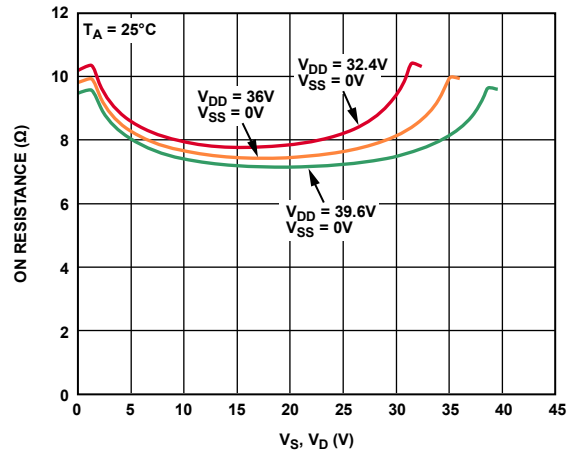


Figure 7.  $R_{ON}$  as a Function of  $V_S, V_D$  (Single Supply)

09202-033

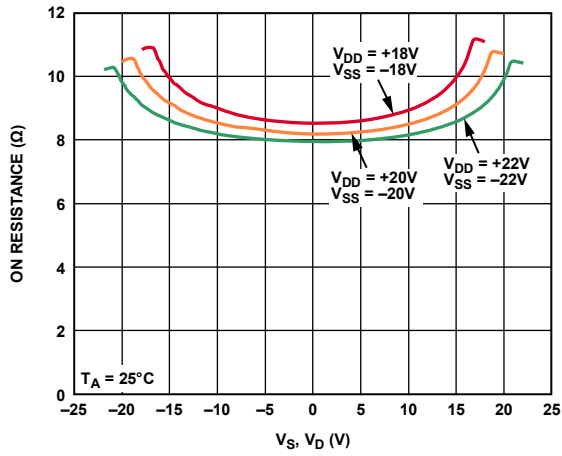


Figure 5.  $R_{ON}$  as a Function of  $V_S, V_D$  (Dual Supply)

09202-035

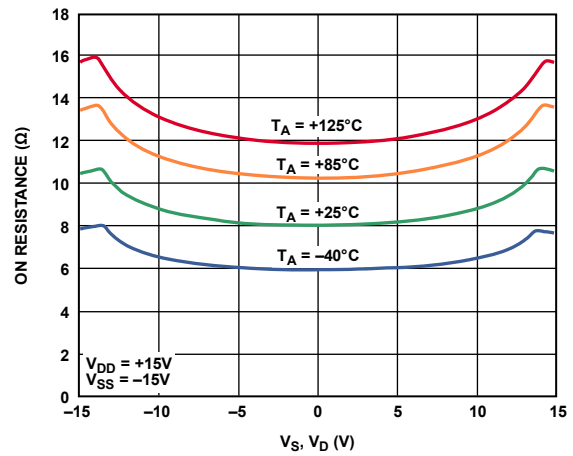


Figure 8.  $R_{ON}$  as a Function of  $V_S (V_D)$  for Different Temperatures,  $\pm 15$  V Dual Supply

09202-040

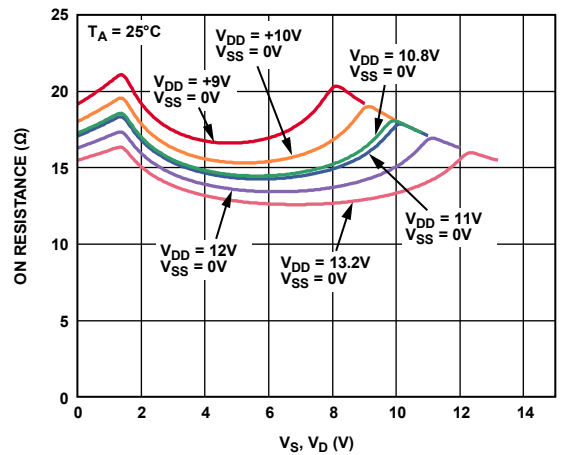


Figure 6.  $R_{ON}$  as a Function of  $V_S, V_D$  (Single Supply)

09202-032

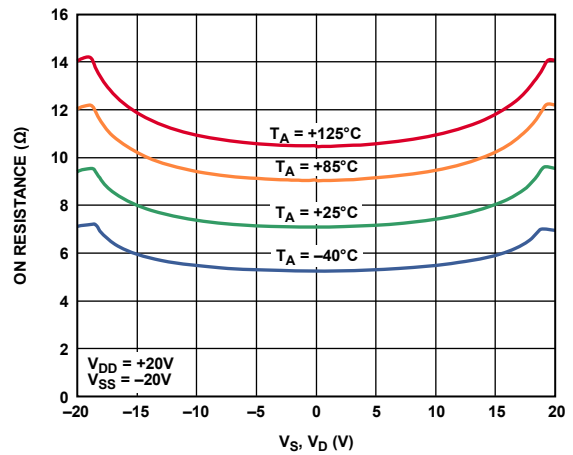


Figure 9.  $R_{ON}$  as a Function of  $V_S (V_D)$  for Different Temperatures,  $\pm 20$  V Dual Supply

09202-041

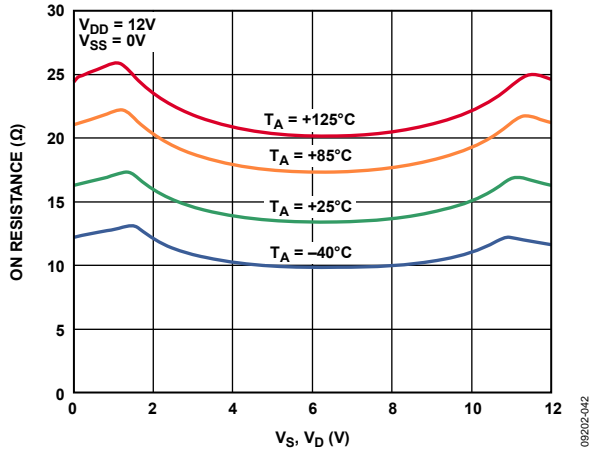


Figure 10.  $R_{ON}$  as a Function of  $V_S$  ( $V_D$ ) for Different Temperatures, 12 V Single Supply

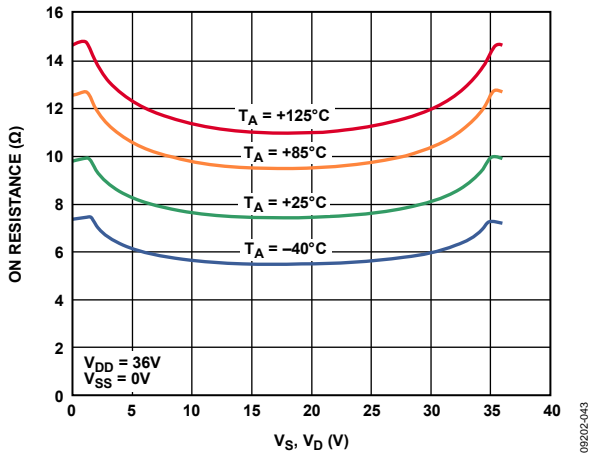


Figure 11.  $R_{ON}$  as a Function of  $V_S$  ( $V_D$ ) for Different Temperatures, 36 V Single Supply

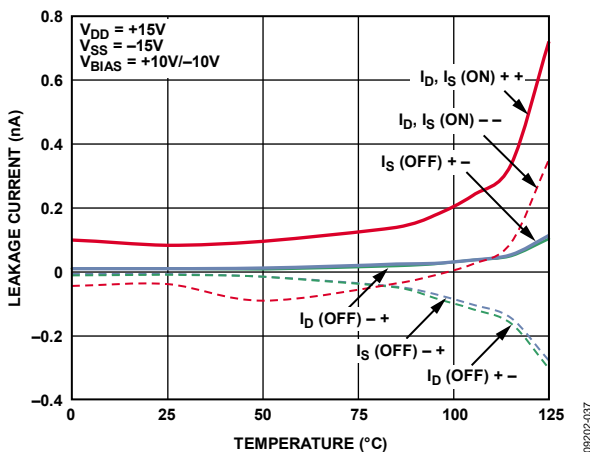


Figure 12. Leakage Currents vs. Temperature, ±15 V Dual Supply

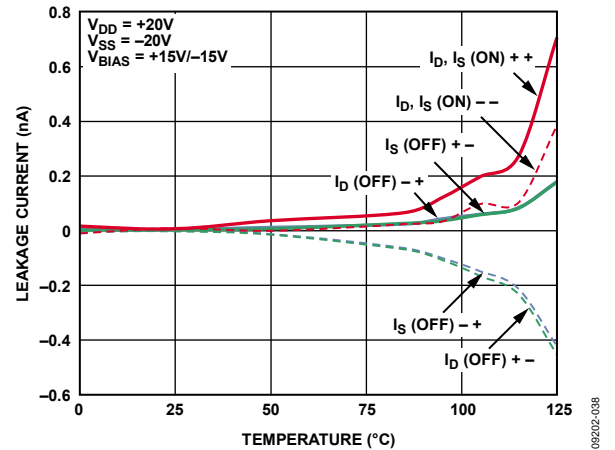


Figure 13. Leakage Currents vs. Temperature, ±20 V Dual Supply

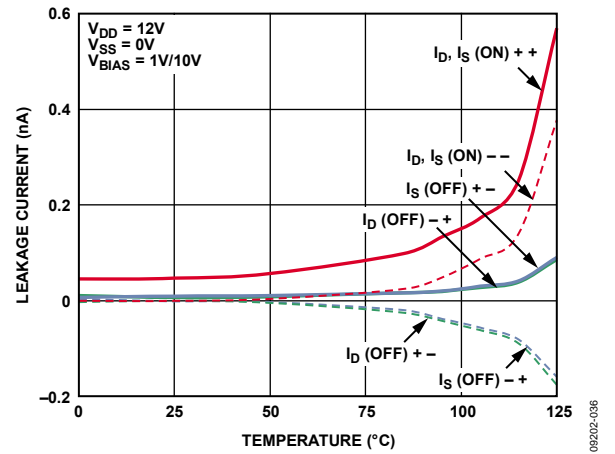


Figure 14. Leakage Currents vs. Temperature, 12 V Single Supply

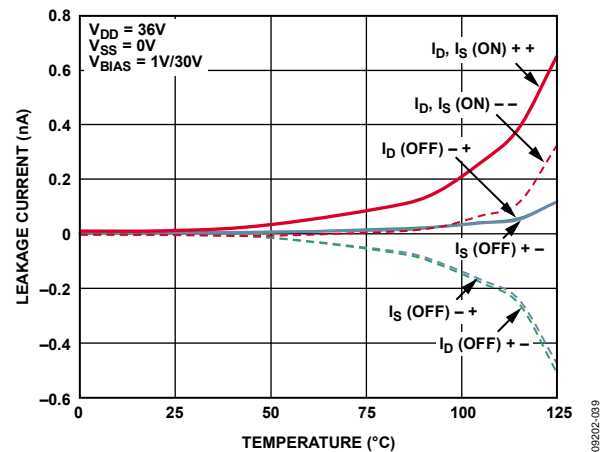


Figure 15. Leakage Currents vs. Temperature, 36 V Single Supply

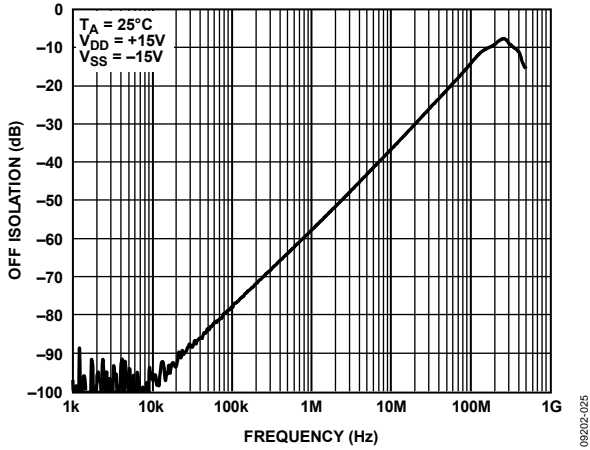


Figure 16. Off Isolation vs. Frequency, ±15 V Dual Supply

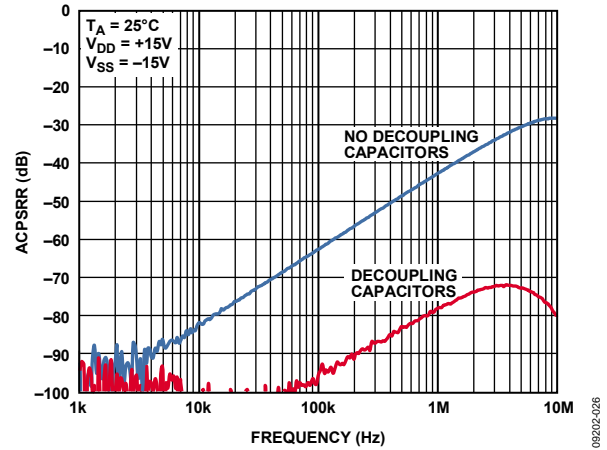


Figure 19. ACPSRR vs. Frequency, ±15 V Dual Supply

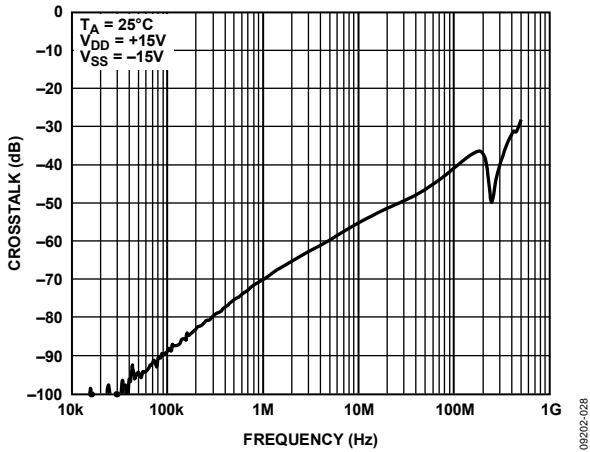


Figure 17. Crosstalk vs. Frequency, ±15 V Dual Supply

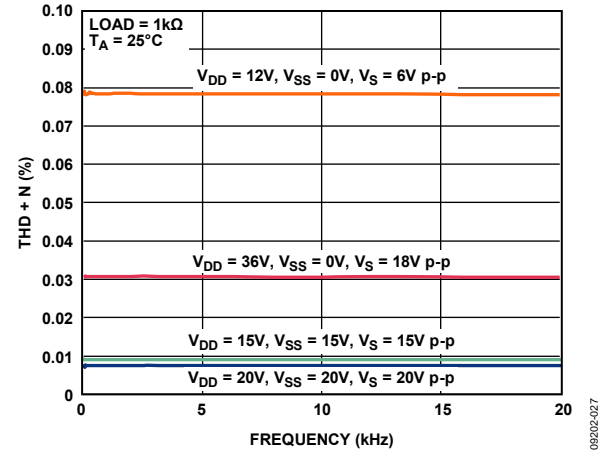


Figure 20. THD + N vs. Frequency, ±15 V Dual Supply

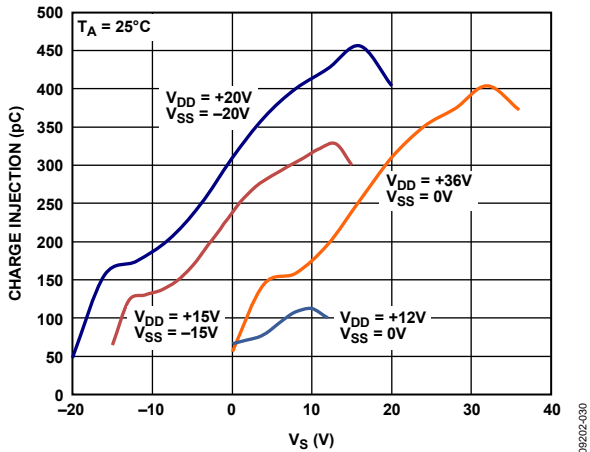


Figure 18. Charge Injection vs. Source Voltage

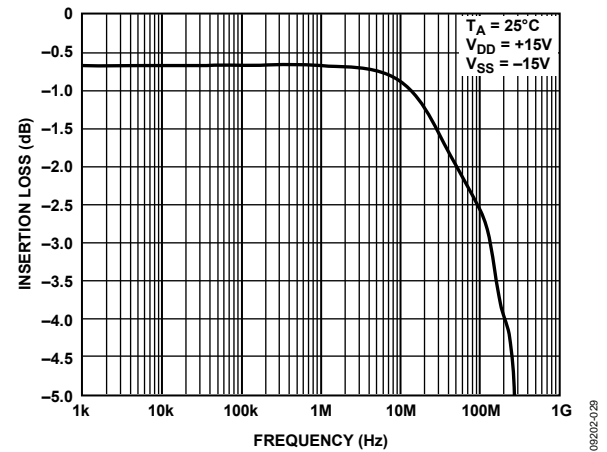


Figure 21. Bandwidth

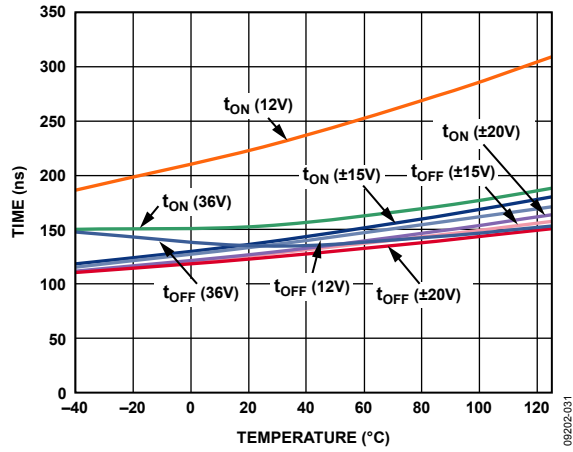


Figure 22. t<sub>ON</sub>, t<sub>OFF</sub> Times vs. Temperature

TEST CIRCUITS

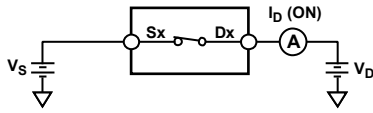


Figure 23. On Leakage

09202-016

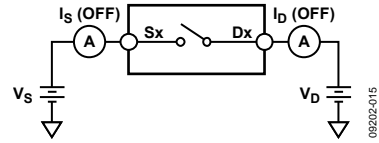


Figure 27. Off Leakage

09202-015

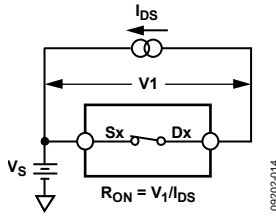


Figure 24. On Resistance

09202-014

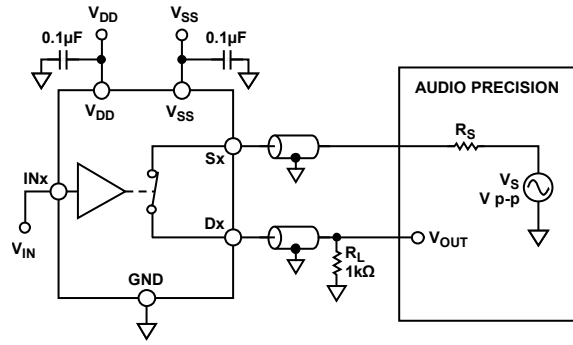
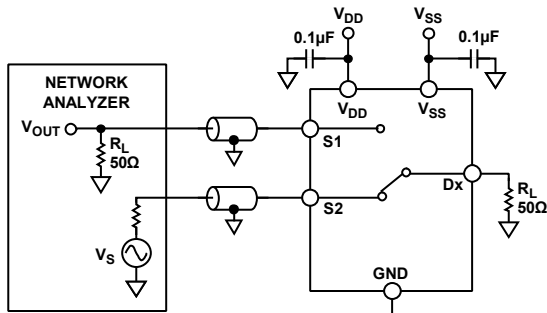


Figure 28. THD + Noise

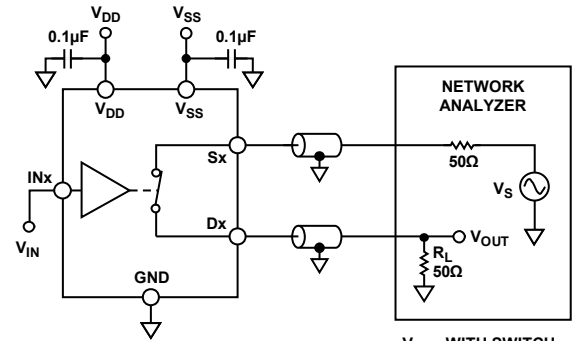
09202-024



CHANNEL-TO-CHANNEL CROSSTALK =  $20 \log \frac{V_{OUT}}{V_S}$

Figure 25. Channel-to-Channel Crosstalk

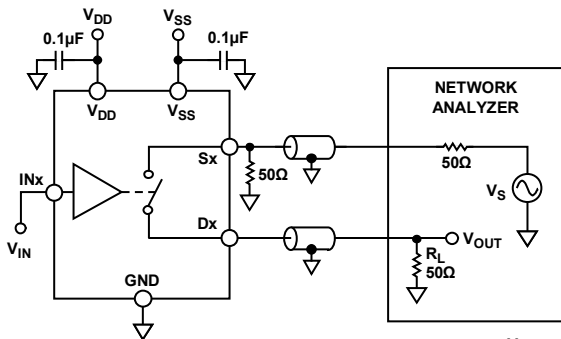
09202-021



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

Figure 29. Bandwidth

09202-023



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

Figure 26. Off Isolation

09202-020

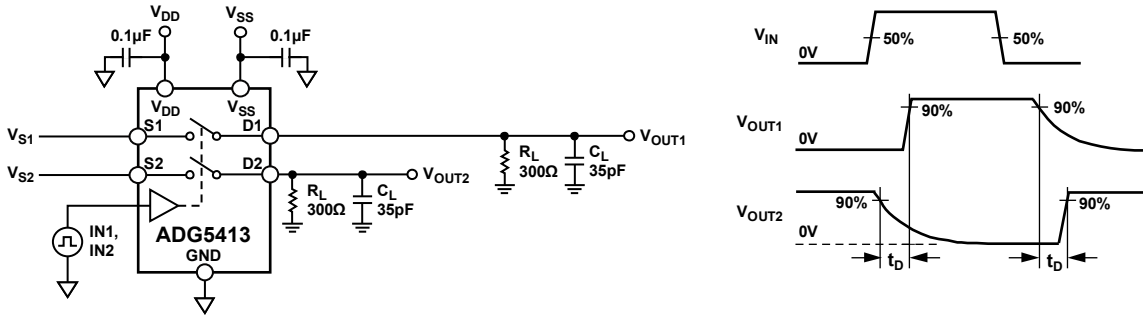


Figure 30. Break-Before-Make Time Delay,  $t_d$

09202-017

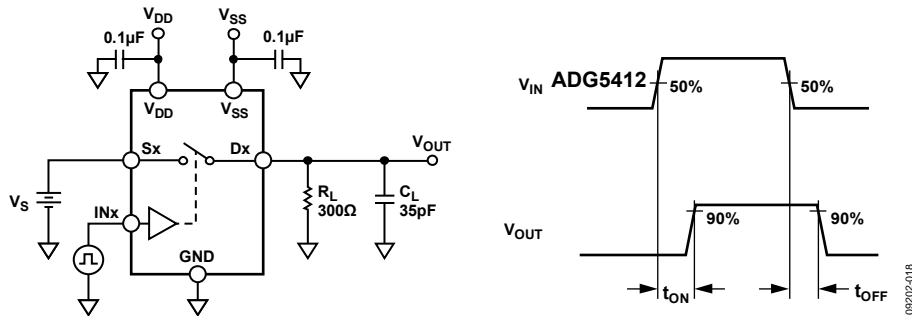


Figure 31. Switching Times

09202-018

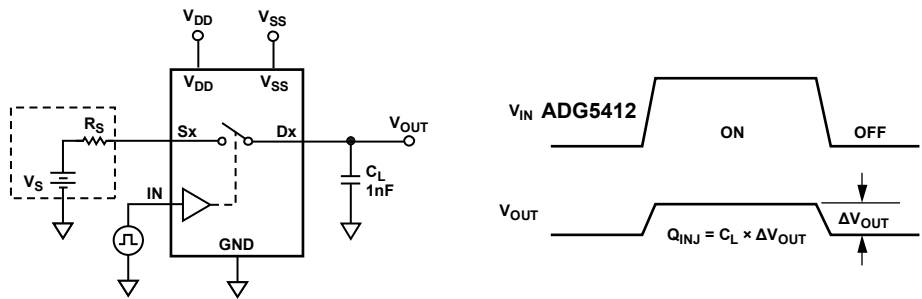


Figure 32. Charge Injection

09202-019

## TERMINOLOGY

### $I_{DD}$

$I_{DD}$  represents the positive supply current.

### $I_{SS}$

$I_{SS}$  represents the negative supply current.

### $V_D, V_S$

$V_D$  and  $V_S$  represent the analog voltage on Terminal D and Terminal S, respectively.

### $R_{ON}$

$R_{ON}$  represents the ohmic resistance between Terminal D and Terminal S.

### $\Delta R_{ON}$

$\Delta R_{ON}$  represents the difference between the  $R_{ON}$  of any two channels.

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

Flatness that is defined as the difference between the maximum and minimum value of on resistance measured over the specified analog signal range is represented by  $R_{FLAT(ON)}$ .

### $I_S$ (Off)

$I_S$  (Off) is the source leakage current with the switch off.

### $I_D$ (Off)

$I_D$  (Off) is the drain leakage current with the switch off.

### $I_D$ (On), $I_S$ (On)

$I_D$  (On) and  $I_S$  (On) represent the channel leakage currents with the switch on.

### $V_{INL}$

$V_{INL}$  is the maximum input voltage for Logic 0.

### $V_{INH}$

$V_{INH}$  is the minimum input voltage for Logic 1.

### $I_{INL}, I_{INH}$

$I_{INL}$  and  $I_{INH}$  represent the low and high input currents of the digital inputs.

### $C_D$ (Off)

$C_D$  (Off) represents the off switch drain capacitance, which is measured with reference to ground.

### $C_S$ (Off)

$C_S$  (Off) represents the off switch source capacitance, which is measured with reference to ground.

### $C_D$ (On), $C_S$ (On)

$C_D$  (On) and  $C_S$  (On) represent on switch capacitances, which are measured with reference to ground.

### $C_{IN}$

$C_{IN}$  is the digital input capacitance.

### $t_{ON}$

$t_{ON}$  represents the delay between applying the digital control input and the output switching on.

### $t_{OFF}$

$t_{OFF}$  represents the delay between applying the digital control input and the output switching off.

### $t_D$

$t_D$  represents the off time measured between the 80% point of both switches when switching from one address state to another.

### Off Isolation

Off isolation is a measure of unwanted signal coupling through an off switch.

### Charge Injection

Charge injection is a measure of the glitch impulse transferred from the digital input to the analog output during switching.

### Crosstalk

Crosstalk is a measure of unwanted signal that is coupled through from one channel to another as a result of parasitic capacitance.

### Bandwidth

Bandwidth is the frequency at which the output is attenuated by 3 dB.

### On Response

On response is the frequency response of the on switch.

### Insertion Loss

Insertion loss is the loss due to the on resistance of the switch.

### Total Harmonic Distortion + Noise (THD + N)

The ratio of the harmonic amplitude plus noise of the signal to the fundamental is represented by THD + N.

### AC Power Supply Rejection Ratio (ACPSRR)

ACPSRR is the ratio of the amplitude of signal on the output to the amplitude of the modulation. This is a measure of the ability of the part to avoid coupling noise and spurious signals that appear on the supply voltage pin to the output of the switch. The dc voltage on the device is modulated by a sine wave of 0.62 V p-p.



## TRENCH ISOLATION

In the [ADG5412](#) and [ADG5413](#), an insulating oxide layer (trench) is placed between the NMOS and the PMOS transistors of each CMOS switch. Parasitic junctions, which occur between the transistors in junction isolated switches, are eliminated, and the result is a completely latch-up proof switch.

In junction isolation, the N and P wells of the PMOS and NMOS transistors form a diode that is reverse-biased under normal operation. However, during overvoltage conditions, this diode can become forward-biased. A silicon controlled rectifier (SCR) type circuit is formed by the two transistors causing a significant amplification of the current that, in turn, leads to latch-up. With trench isolation, this diode is removed, and the result is a latch-up proof switch.

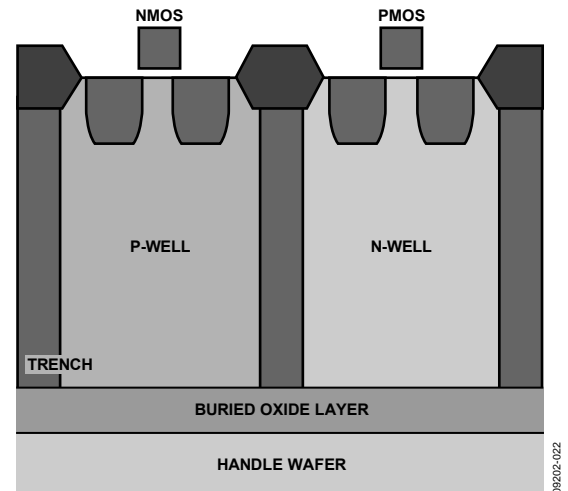


Figure 33. Trench Isolation

## APPLICATIONS INFORMATION

The high voltage latch-up proof family of switches and multiplexers provide a robust solution for instrumentation, industrial, automotive, aerospace, and other harsh environments that are prone to latch-up, which is an undesirable high current state that can lead to device failure and persists until the power supply is turned off. The [ADG5412/ADG5413](#) high voltage switches allow

single-supply operation from 9 V to 40 V and dual-supply operation from  $\pm 9$  V to  $\pm 22$  V. The [ADG5412/ADG5413](#) (as well as other select devices within the same family) achieve an 8 kV human body model ESD rating, which provides a robust solution eliminating the need for separate protect circuitry designs in some applications.

### OUTLINE DIMENSIONS

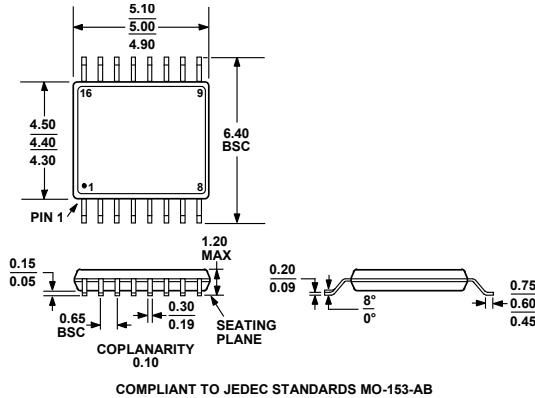


Figure 34. 16-Lead Thin Shrink Small Outline Package [TSSOP] (RU-16)  
Dimensions shown in millimeters

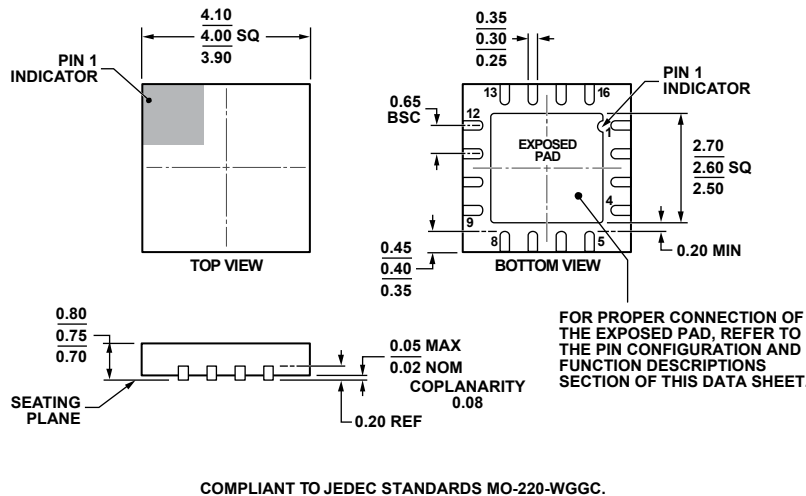


Figure 35. 16-Lead Lead Frame Chip Scale Package [LFCSP] 4 mm x 4 mm Body and 0.75 mm Package Height (CP-16-17)  
Dimensions shown in millimeters

### ORDERING GUIDE

| Model <sup>1,2</sup> | Temperature Range | Package Description                               | Package Option |
|----------------------|-------------------|---|----------------|
| ADG5412BRUZ          | -40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG5412BRUZ-REEL7    | -40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG5412BCPZ-REEL7    | -40°C to +125°C   | 16-Lead Lead Frame Chip Scale Package [LFCSP]     | CP-16-17       |
| ADG5413BRUZ          | -40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG5413BRUZ-REEL7    | -40°C to +125°C   | 16-Lead Thin Shrink Small Outline Package [TSSOP] | RU-16          |
| ADG5413BCPZ-REEL7    | -40°C to +125°C   | 16-Lead Lead Frame Chip Scale Package [LFCSP]     | CP-16-17       |
| EVAL-16TSSOPEBZ      |                   | Evaluation Board                                  |                |

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

<sup>2</sup> The EVAL-16TSSOPEBZ can be used to test the ADG5412 and the ADG5413.