# Low Voltage, Low On-Resistance, Dual DPDT/Quad SPDT Analog Switch 

## DESCRIPTION

The DG2788/DG2789 are monolithic CMOS analog switching products designed for high performance switching of analog signals. Combining low power, high speed, low onresistance and small physical size, the DG2788/DG2789 are ideal for portable and battery powered applications requiring high performance and efficient use of board space.
The DG2788/DG2789 are built on Vishay Siliconix's low voltage process. An epitaxial layer prevents latchup. Break-before-make is guaranteed.
The switch conducts equally well in both directions when on, and blocks up to the power supply level when off. The DG2788 is configured as a dual Double Pole Double Throw switches while the DG2789 is configured as a Quad Single Pole Double Throw. The DG2789 has one control pin for all four SPDT switches and also has an enable pin that can turn all switches off.
The DG2788 and DG2789 comes in a small miniQFN-16 lead package ( $2.6 \times 1.8 \times 0.75 \mathrm{~mm}$ ).
As a committed partner to the community and the environment, Vishay Siliconix manufactures this product with the lead (Pb)-free device terminations and is $100 \%$ RoHS compliant.

## FEATURES

- Low Voltage Operation (1.65 V to 4.3 V)
- Low On-Resistance - ron: $0.4 \Omega$ Typ. at 2.7 V
- Fast Switching: $\mathrm{t}_{\mathrm{ON}}=47 \mathrm{~ns}$

$$
\mathrm{t}_{\mathrm{OFF}}=15 \mathrm{~ns}
$$

RoHS complant

- miniQFN-16 Package
- Latch-Up Current > 300 mA (JESD78)


## BENEFITS

- Reduced Power Consumption
- High Accuracy
- Reduce Board Space
- TTL/1.8 V Logic Compatible
- High Bandwidth


## APPLICATIONS

- Cellular Phones
- Speaker Headset Switching
- Audio and Video Signal Routing
- PCMCIA Cards
- Battery Operated Systems


## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



Device Marking: Axx for DG2788
Bxx for DG2789
xx = Date/Lot Traceability Code Note: Pin 1 has long lead

| TRUTH TABLE DG2788 |  |  |
| :---: | :---: | :---: |
| Logic | NC1, 2, 3 and 4 | NO1, 2, 3 and 4 |
| 0 | ON | OFF |
| 1 | OFF | ON |


| TRUTH TABLE DG2789 |  |  |  |
| :---: | :---: | :---: | :---: |
| EN Logic | IN Logic | NC1, 2, 3 and 4 | NO1, 2, 3 and 4 |
| 0 | 0 | ON | OFF |
| 0 | 1 | OFF | ON |
| 1 | $x$ | OFF | OFF |


| ORDERING INFORMATION |  |  |
| :---: | :---: | :---: |
| Temp Range | Package | Part Number |
| -40 to $85^{\circ} \mathrm{C}$ | miniQFN-16 | DG2788DN-T1-E4 <br> DG2789DN-T1-E4 |


| ABSOLUTE MAXIMUM RATINGS $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$, unless otherwise noted |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Parameter |  | Symbol | Limit | Unit |
| Reference to GND | V+ |  | - 0.3 to 5.0 | V |
|  | IN, COM, NC, $\mathrm{NO}^{\text {a }}$ |  | -0.3 to (V++0.3) |  |
| Current (Any terminal except NO, NC or COM) |  |  | 30 | mA |
| Continuous Current (NO, NC, or COM) |  |  | $\pm 300$ |  |
| Peak Current (Pulsed at $1 \mathrm{~ms}, 10 \%$ duty cycle) |  |  | $\pm 500$ |  |
| Storage Temperature (D Suffix) |  |  | - 65 to 150 | ${ }^{\circ} \mathrm{C}$ |
| Package Solder Reflow Conditions ${ }^{\text {d }}$ | miniQFN-16 |  | 250 |  |
| Power Dissipation (Packages) ${ }^{\text {b }}$ | miniQFN-16 ${ }^{\text {c }}$ |  | 525 | mW |

Notes:
a. Signals on NC, NO, or COM or IN exceeding V+ will be clamped by internal diodes. Limit forward diode current to maximum current ratings.
b. All leads welded or soldered to PC Board.
c. Derate $6.6 \mathrm{~mW} /{ }^{\circ} \mathrm{C}$ above $70^{\circ} \mathrm{C}$
d. Manual soldering with iron is not recommended for leadless components. The miniQFN-16 is a leadless package. The end of the lead terminal is exposed copper (not plated) as a result of the singulation process in manufacturing. A solder fillet at the exposed copper lip cannot be guaranteed and is not required to ensure adequate bottom side solder interconnection.

| SPECIFICATIONS (V+ = 3 V) |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Symbol | Test Conditions Otherwise Unless Specified$\mathrm{V}+=3 \mathrm{~V}, \pm 10 \%, \mathrm{~V}_{\mathrm{IN}}=0.5 \text { or } 1.4 \mathrm{~V}^{\mathrm{e}}$ | Temp ${ }^{\text {a }}$ | $\begin{gathered} \text { Limits } \\ -40 \text { to } 85^{\circ} \mathrm{C} \end{gathered}$ |  |  | Unit |
|  |  |  |  | Min ${ }^{\text {b }}$ | Typ ${ }^{\text {c }}$ | Max ${ }^{\text {b }}$ |  |
| Analog Switch |  |  |  |  |  |  |  |
| Analog Signal Range ${ }^{\text {d }}$ | $\begin{gathered} \mathrm{V}_{\mathrm{NO}}, \mathrm{~V}_{\mathrm{NC}}, \\ \mathrm{~V}_{\mathrm{COM}} \end{gathered}$ |  | Full | 0 |  | V+ | V |
| On-Resistance | $r^{\text {ON }}$ | $\mathrm{V}+=2.7 \mathrm{~V}, \mathrm{~V}_{\mathrm{COM}}=0.5 \mathrm{~V}, \mathrm{I}_{\mathrm{NO}}, \mathrm{I}_{\mathrm{NC}}=100 \mathrm{~mA}$ | Room |  | 0.4 | 0.5 | $\Omega$ |
|  |  | $\mathrm{V}+=2.7 \mathrm{~V}, \mathrm{~V}_{\mathrm{COM}}=1.5 \mathrm{~V}, \mathrm{I}_{\mathrm{NO}}, \mathrm{I}_{\mathrm{NC}}=100 \mathrm{~mA}$ |  |  | 0.33 |  |  |
|  |  |  | Full |  |  | 0.56 |  |
| ron Flatness ${ }^{\text {d }}$ | $\begin{aligned} & \text { ron } \\ & \text { Flatness } \end{aligned}$ | $\begin{gathered} \mathrm{V}+=2.7 \mathrm{~V}, \mathrm{~V}_{\mathrm{COM}}=0 \text { to } \mathrm{V}+, \\ \mathrm{I}_{\mathrm{NO}}, \mathrm{I}_{\mathrm{NC}}=100 \mathrm{~mA} \end{gathered}$ | Room |  | 0.1 | 0.15 |  |
| $\mathrm{r}_{\text {ON Match }}{ }^{\text {d }}$ | $\Delta \mathrm{r}_{\mathrm{ON}}$ |  | Room |  | 0.05 |  |  |
| Switch Off Leakage Current | $\mathrm{I}_{\mathrm{NO} \text { (off) }}$, $\mathrm{I}_{\mathrm{NC} \text { (offif) }}$ | $\begin{gathered} \mathrm{V}+=3.3 \mathrm{~V}, \mathrm{~V}_{\mathrm{NO}}, \mathrm{~V}_{\mathrm{NC}}=0.3 \mathrm{~V} / 3.0 \mathrm{~V}, \\ \mathrm{~V}_{\mathrm{COM}}=3.0 \mathrm{~V} / 0.3 \mathrm{~V} \end{gathered}$ | Room Full | $\begin{gathered} -1 \\ -10 \end{gathered}$ |  | $\begin{gathered} 1 \\ 10 \end{gathered}$ | nA |
|  | $\mathrm{I}_{\text {com(off) }}$ |  | Room Full | $\begin{gathered} \hline-1 \\ -10 \end{gathered}$ |  | $\begin{gathered} 1 \\ 10 \end{gathered}$ |  |
| Channel-On Leakage Current | $\mathrm{I}_{\text {COM(on) }}$ | $\mathrm{V}_{+}=3.3 \mathrm{~V}, \mathrm{~V}_{\mathrm{NO}}, \mathrm{V}_{\mathrm{NC}}=\mathrm{V}_{\mathrm{COM}}=0.3 \mathrm{~V} / 3.0 \mathrm{~V}$ | Room Full | $\begin{gathered} \hline-1 \\ -10 \end{gathered}$ |  | $\begin{gathered} \hline 1 \\ 10 \end{gathered}$ |  |
| Digital Control |  |  |  |  |  |  |  |
| Input High Voltage | $\mathrm{V}_{\text {INH }}$ |  | Full | 1.4 |  |  | V |
| Input Low Voltage | $\mathrm{V}_{\text {INL }}$ |  | Full |  |  | 0.5 |  |
| Input Capacitance | $\mathrm{C}_{\text {in }}$ |  | Full |  | 6 |  | pF |
| Input Current | $\mathrm{I}_{\text {INL }}$ or $\mathrm{I}_{\text {INH }}$ | $\mathrm{V}_{\text {IN }}=0$ or $\mathrm{V}+$ | Full | -1 |  | 1 | $\mu \mathrm{A}$ |
| Dynamic Characteristics |  |  |  |  |  |  |  |
| Turn-On Time | $\mathrm{t}_{\mathrm{ON}}$ | $\mathrm{V}_{\mathrm{NO}}$ or $\mathrm{V}_{\mathrm{NC}}=1.5 \mathrm{~V}, \mathrm{R}_{\mathrm{L}}=50 \Omega, \mathrm{C}_{\mathrm{L}}=35 \mathrm{pF}$ | Romm Full |  | 47 | 72 75 | ns |
| Turn-Off Time | $t_{\text {OFF }}$ |  | Room Full |  | 15 | $\begin{aligned} & \hline 43 \\ & 45 \end{aligned}$ |  |
| Break-Before-Make Time | $\mathrm{t}_{\mathrm{d}}$ |  | Full | 1 |  |  |  |
| Charge Injection ${ }^{\text {d }}$ | $\mathrm{Q}_{\text {INJ }}$ | $\mathrm{C}_{\mathrm{L}}=1 \mathrm{nF}, \mathrm{V}_{\mathrm{GEN}}=0 \mathrm{~V}, \mathrm{R}_{\mathrm{GEN}}=0 \Omega$ | Room |  | 87 |  | pC |
| Off-Isolation ${ }^{\text {d }}$ | OIRR | $\mathrm{R}_{\mathrm{L}}=50 \Omega, \mathrm{C}_{\mathrm{L}}=5 \mathrm{pF}, \mathrm{f}=100 \mathrm{kHz}$ | Room |  | -69 |  | dB |
|  |  | $\mathrm{R}_{\mathrm{L}}=50 \Omega, \mathrm{C}_{\mathrm{L}}=5 \mathrm{pF}, \mathrm{f}=1 \mathrm{MHz}$ |  |  | -49 |  |  |
| Crosstalk ${ }^{\text {d, f }}$ | $\mathrm{X}_{\text {TALK }}$ | $\mathrm{R}_{\mathrm{L}}=50 \Omega, \mathrm{C}_{\mathrm{L}}=5 \mathrm{pF}, \mathrm{f}=100 \mathrm{kHz}$ |  |  | -106 |  |  |
|  |  | $\mathrm{R}_{\mathrm{L}}=50 \Omega, \mathrm{C}_{\mathrm{L}}=5 \mathrm{pF}, \mathrm{f}=1 \mathrm{MHz}$ |  |  | -96 |  |  |
| $\mathrm{N}_{\mathrm{O}}, \mathrm{N}_{\mathrm{C}}$ Off Capacitance ${ }^{\text {d }}$ | $\mathrm{C}_{\mathrm{NO} \text { (off) }}$ | $\mathrm{f}=1 \mathrm{MHz}$ | Room |  | 81 |  | pF |
|  | $\mathrm{C}_{\mathrm{NC} \text { (off) }}$ |  | Room |  | 81 |  |  |
| Channel-On Capacitance ${ }^{\text {d }}$ | $\mathrm{C}_{\mathrm{NO} \text { (on) }}$ |  | Room |  | 186 |  |  |
|  | $\mathrm{C}_{\mathrm{NC} \text { (on) }}$ |  | Room |  | 186 |  |  |
| Power Supply |  |  |  |  |  |  |  |
| Power Supply Range | V+ |  |  | 2.7 |  | 3.3 | V |
| Power Supply Current | I+ | $\mathrm{V}_{\text {IN }}=0$ or $\mathrm{V}_{+}$ | Full |  |  | 1.0 | $\mu \mathrm{A}$ |


| SPECIFICATIONS (V+ = 4.3 V) |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Parameter | Symbol | Test Conditions Otherwise Unless Specified $\mathrm{V}+=4.3 \mathrm{~V}, \mathrm{~V}_{\mathrm{IN}}=0.5$ or $1.6 \mathrm{~V}^{\mathrm{e}}$ | Temp ${ }^{\text {a }}$ | $\begin{gathered} \text { Limits } \\ -40 \text { to } 85^{\circ} \mathrm{C} \end{gathered}$ |  |  | Unit |
|  |  |  |  | Min ${ }^{\text {b }}$ | Typ ${ }^{\text {c }}$ | Max ${ }^{\text {b }}$ |  |
| Analog Switch |  |  |  |  |  |  |  |
| Analog Signal Range ${ }^{\text {d }}$ | $\begin{gathered} \mathrm{V}_{\mathrm{NO}}, \mathrm{~V}_{\mathrm{NC}}, \\ \mathrm{~V}_{\mathrm{COM}} \end{gathered}$ |  | Full | 0 |  | V+ | V |
| On-Resistance | ${ }^{\text {ron }}$ | $\mathrm{V}+=4.3 \mathrm{~V}, \mathrm{~V}_{\mathrm{COM}}=0.9 \mathrm{~V}, \mathrm{I}_{\mathrm{NO}}, \mathrm{I}_{\mathrm{NC}}=100 \mathrm{~mA}$ | Room |  | 0.32 | 0.45 | $\Omega$ |
|  |  | $\mathrm{V}+=4.3 \mathrm{~V}, \mathrm{~V}_{\mathrm{COM}}=2.5 \mathrm{~V}, \mathrm{I}_{\mathrm{NO}}, \mathrm{I}_{\mathrm{NC}}=100 \mathrm{~mA}$ |  |  | 0.27 |  |  |
|  |  |  | Full |  |  | 0.5 |  |
| $\mathrm{r}_{\text {ON }}$ Flatness ${ }^{\text {d }}$ | ron Flatness | $\mathrm{V}_{+}=4.3 \mathrm{~V}, \mathrm{~V}_{\mathrm{COM}}=0 \text { to } \mathrm{V}+\text {, }$ | Room |  | 0.1 | 0.15 |  |
| $\mathrm{r}_{\text {ON Match }}{ }^{\text {d }}$ | ${ }^{\text {r }}$ ON |  | Room |  | 0.03 |  |  |
| Switch Off Leakage Current ${ }^{\text {d }}$ | ${ }^{\mathrm{I} O(\text { (off) })}$ $\mathrm{I}_{\mathrm{NC} \text { (offiF) }}$ | $\begin{gathered} \mathrm{V}_{+}=4.3 \mathrm{~V}, \mathrm{~V}_{\mathrm{NO}}, \mathrm{~V}_{\mathrm{NC}}=0.3 \mathrm{~V} / 4.0 \mathrm{~V}, \\ \mathrm{~V}_{\mathrm{COM}}=4.0 \mathrm{~V} / 0.3 \mathrm{~V} \end{gathered}$ | Room Full | $\begin{gathered} \hline-10 \\ -100 \end{gathered}$ |  | $\begin{gathered} 10 \\ 100 \end{gathered}$ | nA |
|  | $\mathrm{I}_{\text {com(off) }}$ |  | Room Full | $\begin{gathered} -10 \\ -100 \end{gathered}$ |  | $\begin{gathered} 10 \\ 100 \end{gathered}$ |  |
| Channel-On Leakage Current ${ }^{\text {d }}$ | $\mathrm{I}_{\text {Com(on) }}$ | $\mathrm{V}_{+}=4.3 \mathrm{~V}, \mathrm{~V}_{\mathrm{NO}}, \mathrm{V}_{\mathrm{NC}}=\mathrm{V}_{\mathrm{COM}}=3.0 \mathrm{~V} / 4.0 \mathrm{~V}$ | Room Full | $\begin{gathered} -10 \\ -100 \end{gathered}$ |  | $\begin{gathered} 10 \\ 100 \end{gathered}$ |  |
| Digital Control |  |  |  |  |  |  |  |
| Input High Voltage | $\mathrm{V}_{\text {INH }}$ |  | Full | 1.6 |  |  | V |
| Input Low Voltage | $\mathrm{V}_{\text {INL }}$ |  | Full |  |  | 0.5 |  |
| Input Capacitance | $\mathrm{C}_{\text {in }}$ |  | Full |  | 6 |  | pF |
| Input Current | $\mathrm{I}_{\mathrm{INL}}$ or $\mathrm{I}_{\text {INH }}$ | $\mathrm{V}_{\text {IN }}=0$ or $\mathrm{V}_{+}$ | Full | -1 |  | 1 | $\mu \mathrm{A}$ |
| Dynamic Characteristics |  |  |  |  |  |  |  |
| Charge Injection ${ }^{\text {d }}$ | $\mathrm{Q}_{\text {INJ }}$ | $\mathrm{C}_{\mathrm{L}}=1 \mathrm{nF}, \mathrm{V}_{\mathrm{GEN}}=0 \mathrm{~V}, \mathrm{R}_{\mathrm{GEN}}=0 \Omega$ | Room |  | 105 |  | pC |
| $\mathrm{N}_{\mathrm{O}}, \mathrm{N}_{\mathrm{C}}$ Off Capacitance ${ }^{\text {d }}$ | $\mathrm{C}_{\mathrm{NO} \text { (off) }}$ | $\mathrm{f}=1 \mathrm{MHz}$ | Room |  | 79 |  | pF |
|  | $\mathrm{C}_{\mathrm{NC} \text { (off) }}$ |  | Room |  | 79 |  |  |
| Channel-On Capacitance ${ }^{\text {d }}$ | $\mathrm{C}_{\mathrm{NO} \text { (on) }}$ |  | Room |  | 183 |  |  |
|  | $\mathrm{C}_{\mathrm{NC} \text { (on) }}$ |  | Room |  | 183 |  |  |
| Power Supply |  |  |  |  |  |  |  |
| Power Supply Range | V+ |  |  |  |  | 4.3 | V |
| Power Supply Current | I+ | $\mathrm{V}_{\text {IN }}=0$ or $\mathrm{V}_{+}$ | Full |  |  | 1.0 | $\mu \mathrm{A}$ |

Notes:
a. Room $=25^{\circ} \mathrm{C}$, Full = as determined by the operating suffix.
b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
c. Typical values are for design aid only, not guaranteed nor subject to production testing.
d. Guarantee by design, not subjected to production test.
e. $\mathrm{V}_{\mathrm{IN}}=$ input voltage to perform proper function.
f. Crosstalk measured between channels.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

TYPICAL CHARACTERISTICS $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$, unless otherwise noted


TYPICAL CHARACTERISTICS $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$, unless otherwise noted



Charge Injection vs. Analog Voltage

## TEST CIRCUITS




Logic "1" = Switch On
Logic input waveforms inverted for switches that have the opposite logic sense.

$$
v_{\text {OUT }}=v_{\text {COM }}\left(\frac{R_{L}}{R_{L}+R_{\mathrm{ON}}}\right)
$$

Figure 1. Switching Time


Figure 2. Break-Before-Make Interval


IN depends on switch configuration: input polarity determined by sense of switch.

Figure 3. Charge Injection

## TEST CIRCUITS



Figure 4. Off-Isolation


Figure 5. Channel Off/On Capacitance

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## Disclaimer

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