High-Speed, Low-Glitch D/CMOS Analog Switches

FEATURES
- Fast Switching — $t_{ON}$: 12 ns
- Low Charge Injection: $\pm 2 \text{ pC}$
- Wide Bandwidth: 500 MHz
- 5-V CMOS Logic Compatible
- Low $r_{DS(on)}$: 18 $\Omega$
- Low Quiescent Power: 1.2 nW
- Single Supply Operation

BENEFITS
- Minimal Data Throughput
- Improved Switching Transients
- Improved System Performance
- Easily Interfaced
- Low Insertion Loss
- Minimal Power Consumption

APPLICATIONS
- Fast Sample-and-Holds
- Synchronous Demodulators
- Pixel-Rate Video Switching
- Disk/Tape Drives
- DAC Deglitching
- Switched Capacitor Filters
- GaAs FET Drivers
- Satellite Receivers

DESCRIPTION

The DG611/612/613 feature high-speed low-capacitance lateral DMOS switches. Charge injection has been minimized to optimize performance in fast sample-and-hold applications.

Each switch conducts equally well in both directions when on and blocks up to 16 $V_{pp}$ when off. Capacitances have been minimized to ensure fast switching and low-glitch energy. To achieve such fast and clean switching performance, the DG611/612/613 are built on the Vishay Siliconix proprietary D/CMOS process. This process combines n-channel DMOS switching FETs with low-power CMOS control logic and drivers. An epitaxial layer prevents latchup.

The DG611 and DG612 differ only in that they respond to opposite logic levels. The versatile DG613 has two normally open and two normally closed switches. It can be given various configurations, including four SPST, two SPDT, one DPDT.

For additional information see Applications Note AN207 (FaxBack number 70605).

FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION

![Functional Block Diagram and Pin Configuration](image)

TRUTH TABLE

<table>
<thead>
<tr>
<th>Logic</th>
<th>DG611</th>
<th>DG612</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>1</td>
<td>OFF</td>
<td>ON</td>
</tr>
</tbody>
</table>

Logic "0" $\leq 1 \text{ V}$
Logic "1" $\geq 4 \text{ V}$
**functional block diagram and pin configuration**

**ordering information**

<table>
<thead>
<tr>
<th>Temp Range</th>
<th>Package</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>−40 to 85°C</td>
<td>16-Pin Plastic DIP</td>
<td>DG611DJ</td>
</tr>
<tr>
<td></td>
<td>16-Pin Narrow SOIC</td>
<td>DG612DJ</td>
</tr>
<tr>
<td>−55 to 125°C</td>
<td>16-Pin CerDIP</td>
<td>DG611AK/883, 5962-9325501MEA</td>
</tr>
<tr>
<td></td>
<td>LCC-20</td>
<td>DG611AZ/883, 5962-9325502MEA</td>
</tr>
<tr>
<td></td>
<td>16-Pin Plastic DIP</td>
<td>DG613DJ</td>
</tr>
<tr>
<td>−40 to 85°C</td>
<td>16-Pin Narrow SOIC</td>
<td>DG613DJY</td>
</tr>
<tr>
<td>−55 to 125°C</td>
<td>16-Pin CerDIP</td>
<td>DG613AK/883, 5962-9325503MEA</td>
</tr>
<tr>
<td></td>
<td>LCC-20</td>
<td>DG613AZ/883, 5962-9325503M2A</td>
</tr>
</tbody>
</table>

**absolute maximum ratings**

- $V_+$ to $V_-$: $-0.3$ V to $21$ V
- $V_+$ to GND: $-0.3$ V to $21$ V
- $V_-$ to GND: $-19$ V to $0$ V
- $V_L$ to GND: $-1$ V to $(V_+)+1$ V
- $V_{IN}$: $(V_-)-1$ V to $(V_+)+1$ V
- $V_B, V_D$: $(V_+)-0.3$ V to $(V_-)+16$ V
- Continuous Current (Any Terminal): $\pm 30$ mA
- Current, S or D (Pulsed at 1 μs, 10% Duty Cycle): $\pm 100$ mA
- Storage Temperature: CerDIP: $-65$ to $150$ °C
- Plastic: $-65$ to $125$ °C

**power dissipation (package)**

- 16-Pin Plastic DIP: $470$ mW
- 16-Pin Narrow SOIC: $600$ mW
- 16-Pin CerDIP: $900$ mW
- 20-Pin LCC: $900$ mW

**recommended operating range**

- $V_+$: $5$ V to $21$ V
- $V_-$: $10$ V to $0$ V
- $V_L$: $4$ V to $V_+$
- $V_{IN}$: $0$ V to $V_L$
- $V_{ANALOG}$: $V_-$ to $(V_+)-5$ V

Notes:

- Signals on $S_X, D_X, or IN_X$ exceeding $V_+$ or $V_-$ will be clamped by internal diodes. Limit forward diode current to maximum current ratings.
- All leads welded or soldered to PC Board.
- Derate $6$ mW/°C above $75$ °C
- Derate $7.6$ mW/°C above $75$ °C
- Derate $12$ mW/°C above $75$ °C
### SPECIFICATIONS

#### Test Conditions
- Unless Otherwise Specified
- $V_+ = 15 \text{ V}$, $V_- = -3 \text{ V}$
- $V_L = 5 \text{ V}$, $V_{IN} = 4 \text{ V}$, $1 \text{ V}$

#### Analog Switch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>$V_+ = 15 \text{ V}$, $V_- = -3 \text{ V}$</th>
<th>Temp</th>
<th>Typ</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Signal Range</td>
<td>$V_{ANALOG}$</td>
<td>$V_- = -5 \text{ V}$, $V_+ = 12 \text{ V}$</td>
<td>Full</td>
<td>18</td>
<td>-5</td>
<td>7</td>
<td>-5</td>
</tr>
<tr>
<td>Switch On-Resistance Match Bit Ch.</td>
<td>$\Delta V_{DS(on)}$</td>
<td>$I_S = -1 \text{ mA}$, $V_D = 0 \text{ V}$</td>
<td>Room</td>
<td>2</td>
<td>-0.001</td>
<td>-0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Source Off Leakage</td>
<td>$I_{S(off)}$</td>
<td>$V_S = 0 \text{ V}$, $V_D = 10 \text{ V}$</td>
<td>Room</td>
<td>4</td>
<td>-0.25</td>
<td>0.25</td>
<td>-0.25</td>
</tr>
<tr>
<td>Drain Off Leakage Current</td>
<td>$I_{D(off)}$</td>
<td>$V_S = 10 \text{ V}$, $V_D = 0 \text{ V}$</td>
<td>Room</td>
<td>4</td>
<td>-0.4</td>
<td>0.4</td>
<td>-0.4</td>
</tr>
<tr>
<td>Switch On Leakage Current</td>
<td>$I_{D(on)}$</td>
<td>$V_S = V_D = 0 \text{ V}$</td>
<td>Room</td>
<td>4</td>
<td>-0.4</td>
<td>0.4</td>
<td>-0.4</td>
</tr>
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</table>

#### Digital Control

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>$V_+ = 15 \text{ V}$, $V_- = -3 \text{ V}$</th>
<th>Typ</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage High</td>
<td>$V_{IH}$</td>
<td></td>
<td>Full</td>
<td>4</td>
<td>4</td>
<td>V</td>
</tr>
<tr>
<td>Input Voltage Low</td>
<td>$V_{IL}$</td>
<td></td>
<td>Full</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Input Current</td>
<td>$I_{IN}$</td>
<td>Room</td>
<td>0.005</td>
<td>-1</td>
<td>20</td>
<td>-1</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>$C_{IN}$</td>
<td>Room</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Dynamic Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>$V_+ = 15 \text{ V}$, $V_- = -3 \text{ V}$</th>
<th>Temp</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off State Input Capacitance</td>
<td>$C_{S(off)}$</td>
<td>$V_S = 0 \text{ V}$</td>
<td>Room</td>
<td>3</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Off State Output Capacitance</td>
<td>$C_{D(off)}$</td>
<td>$V_D = 0 \text{ V}$</td>
<td>Room</td>
<td>2</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>On State Input Capacitance</td>
<td>$C_{S(on)}$</td>
<td>$V_S = V_D = 0 \text{ V}$</td>
<td>Room</td>
<td>10</td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>$BW$</td>
<td>$R_L = 50 \text{ Ω}$</td>
<td>Room</td>
<td>500</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>Turn-On Time</td>
<td>$t_{ON}$</td>
<td>$R_L = 300 \text{ Ω}$, $C_L = 3 \text{ pF}$, $V_S = \pm 2 \text{ V}$ See Test Circuit, Figure 2</td>
<td>Room</td>
<td>12</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Turn-Off Time</td>
<td>$t_{OFF}$</td>
<td></td>
<td>Room</td>
<td>8</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Turn-On Time</td>
<td>$t_{ON}$</td>
<td>$R_L = 300 \text{ Ω}$, $C_L = 75 \text{ pF}$</td>
<td>Room</td>
<td>19</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Turn-Off Time</td>
<td>$t_{OFF}$</td>
<td>See Test Circuit, Figure 2</td>
<td>Room</td>
<td>16</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Charge Injection</td>
<td>$Q$</td>
<td>$C_L = 1 \text{ nF}$, $V_S = 0 \text{ V}$</td>
<td>Room</td>
<td>4</td>
<td></td>
<td>pC</td>
</tr>
<tr>
<td>Ch. Injection Change</td>
<td>$\Delta Q$</td>
<td>$C_L = 1 \text{ nF}$, $</td>
<td>V_S</td>
<td>\leq 3 \text{ V}$</td>
<td>Room</td>
<td>3</td>
</tr>
<tr>
<td>Off Isolation</td>
<td>$OIRR$</td>
<td>$R_{IN} = 50 \text{ Ω}$, $R_L = 50 \text{ Ω}$, $f = 5 \text{ MHz}$</td>
<td>Room</td>
<td>74</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Crosstalk</td>
<td>$X_{TALK}$</td>
<td>$R_{IN} = 10 \text{ Ω}$, $R_L = 50 \text{ Ω}$, $f = 5 \text{ MHz}$</td>
<td>Room</td>
<td>87</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Power Supplies

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>$V_+ = 15 \text{ V}$, $V_- = -3 \text{ V}$</th>
<th>Temp</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Supply Current</td>
<td>$I_+$</td>
<td>$V_{IN} = 0 \text{ V}$ or $5 \text{ V}$</td>
<td>Room</td>
<td>0.005</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Negative Supply Current</td>
<td>$I_-$</td>
<td></td>
<td>Room</td>
<td>-0.005</td>
<td>-1</td>
<td>-5</td>
</tr>
<tr>
<td>Logic Supply Current</td>
<td>$I_L$</td>
<td></td>
<td>Room</td>
<td>0.005</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Ground Current</td>
<td>$I_{GND}$</td>
<td></td>
<td>Room</td>
<td>-0.005</td>
<td>-1</td>
<td>-5</td>
</tr>
</tbody>
</table>

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DG611/612/613
Vishay Siliconix
Document Number: 70057
www.vishay.com FaxBack 408-970-5600
4-3
## SPECIFICATIONS\(^a\) FOR UNIPOLAR SUPPLIES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions Unless Otherwise Specified</th>
<th>Temp(^b)</th>
<th>Typ(^c)</th>
<th>A Suffix (-55) to (\pm 125)°C</th>
<th>D Suffix (-40) to (85)°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Switch</td>
<td></td>
<td>(V^+ = 15) V, (V^- = -3) V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(V_L = 5) V, (V_{IN} = 4) V, (1) V(^f)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog Signal Range(^a)</td>
<td>(V_{ANALOG})</td>
<td></td>
<td>Full</td>
<td></td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Switch On-Resistance</td>
<td>(t_{DS(on)})</td>
<td></td>
<td>Room</td>
<td>25</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Dynamic Characteristics</td>
<td></td>
<td>(I_S = -1) mA, (V_D = 1) V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-On Time(^a)</td>
<td>(t_{ON})</td>
<td>(R_L = 300) Ω, (C_L = 3) pF, (V_S = 2) V</td>
<td>Room</td>
<td>15</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Turn-Off Time(^a)</td>
<td>(t_{OFF})</td>
<td>See Test Circuit, Figure 2</td>
<td>Room</td>
<td>10</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

### Notes:

a. Refer to PROCESS OPTION FLOWCHART.
b. Room = 25°C, Full = as determined by the operating temperature suffix.
c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
d. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum.
e. Guaranteed by design, not subject to production test.
f. \(V_{IN}\) = input voltage to perform proper function.
g. \(\Delta Q = |Q\) at \(V_S = 3\) V \(– Q\) at \(V_S = -3\) V\).
**TYPICAL CHARACTERISTICS (25°C UNLESS NOTED)**

---

**r\(_{DS(on)}\) vs. \(V_D\) and Power Supply Voltages**

- \(V_+ = 5\) V
- \(V_- = -5\) V
- \(V_+ = 12\) V
- \(V_- = -5\) V
- \(V_+ = 15\) V
- \(V_- = -3\) V

\(I_S = -1\) mA

---

**r\(_{DS(on)}\) vs. \(V_D\) and Temperature**

- \(V_+ = 15\) V
- \(V_- = -3\) V
- \(I_S = -1\) mA

---

**Leakage Current vs. Analog Voltage**

- \(V_+ = 15\) V
- \(V_- = -3\) V

---

**Leakage Currents vs. Temperature**

- \(V_+ = 15\) V
- \(V_- = -3\) V

---

**Input Switching Threshold vs. \(V_L\)**

- \(V_+ = 15\) V
- \(V_- = -3\) V

---

**Switching Times vs. Temperature**

- \(V_+ = 15\) V
- \(V_- = -3\) V

---
**TYPICAL CHARACTERISTICS (25°C UNLESS NOTED)**

**Charge Injection vs. Analog Voltage**

Charge (pC) vs. $V_{ANALOG}$ – Analog Voltage (V)

$V_+ = 15 \, \text{V}$

$V_- = -3 \, \text{V}$

$Q_d$

$Q_s$

**Crosstalk and Off Isolation vs. Frequency**

(dB) vs. f – Frequency (MHz)

$V_+ = 15 \, \text{V}$

$V_- = -3 \, \text{V}$

**Supply Currents vs. Switching Frequency**

(f – Frequency (Hz))

$I_+$

$I_-$(mA)

$V_L = 5 \, \text{V}$

$C_X = 0.5 \, \text{V}$

**SCHEMATIC DIAGRAM (TYPICAL CHANNEL)**

![Schematic Diagram](image)

**FIGURE 1.**
TEST CIRCUITS

APPLICATIONS

High-Speed Sample-and-Hold

In a fast sample-and-hold application, the analog switch characteristics are critical. A fast switch reduces aperture uncertainty. A low charge injection eliminates offset (step) errors. A low leakage reduces droop errors. The CLC111, a fast input buffer, helps to shorten acquisition and settling times. A low leakage, low dielectric absorption hold capacitor must be used. Polycarbonate, polystyrene and polypropylene are good choices. The JFET output buffer reduces droop due to its low input bias current. (See Figure 5.)

Pixel-Rate Switch

Windows, picture-in-picture, title overlays are economically generated using a high-speed analog switch such as the DG613. For this application the two video sources must be sync locked. The glitch-less analog switch eliminates halos. (See Figure 6.)

GaAs FET Drivers

Figure 7 illustrates a high-speed GaAs FET driver. To turn the GaAs FET on 0 V are applied to its gate via $S_1$, whereas to turn it off, $-8$ V are applied via $S_2$. This high-speed, low-power driver is especially suited for applications that require a large number of RF switches, such as phased array radars.
FIGURE 5. High-Speed Sample-and-Hold

FIGURE 6. A Pixel-Rate Switch Creates Title Overlays

FIGURE 7. A High-Speed GaAs FET Driver that Saves Power
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