

## Low-Voltage Single SPDT Analog Switch

### DESCRIPTION

The DG2001 is a single-pole/double-throw monolithic CMOS analog switch designed for high performance switching of analog signals. Combining low power, high speed, low on-resistance and small physical size, the DG2001 is ideal for portable and battery powered applications requiring high performance and efficient use of board space.

The DG2001 is built on Vishay Siliconix's low voltage J12 process. The DG2001 has a minimum 2000 V, ESD protection, per Method 3015.7. 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.

### FEATURES

- **Halogen-free according to IEC 61249-2-21 Definition**
- Low Voltage Operation (1.8 V to 5.5 V)
- Low On-Resistance -  $R_{ON}$ : 3  $\Omega$
- Fast Switching -  $t_{ON}$ : 20 ns,  $t_{OFF}$ : 10 ns
- Low Leakage -  $I_{COM}$ : 0.2 nA
- Low Charge Injection -  $Q_{INJ}$ : 5 pC
- Low Power Consumption
- TTL/CMOS Compatible
- ESD Protection > 2000 V (Method 3015.7)
- TSOP-6 Package
- **Compliant to RoHS Directive 2002/95/EC**



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

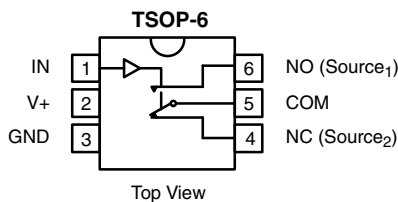
### BENEFITS

- Reduced Power Consumption
- Simple Logic Interface
- High Accuracy
- Reduce Board Space

### APPLICATIONS

- Cellular Phones
- Communication Systems
- Portable Test Equipment
- Battery Operated Systems
- Sample and Hold Circuits

### FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



### TRUTH TABLE

Logic	NC	NO
0	ON	OFF
1	OFF	ON

### ORDERING INFORMATION

Temp Range	Package	Part Number
- 40 °C to 85 °C	TSOP-6	DG2001DV-T1
		DG2001DV-T1-E3



<b>ABSOLUTE MAXIMUM RATINGS</b> ( $T_A = 25^\circ\text{C}$ , unless otherwise noted)			
Parameter	Symbol	Limit	Unit
Referenced $V_+$ to GND		- 0.3 to + 6	V
IN, COM, NC, $\text{NO}^a$		- 0.3 to ( $V_+ + 0.3$ )	
Continuous Current (Any Terminal)		$\pm 50$	mA
Peak Current (Pulsed at 1 ms, 10 % duty cycle)		$\pm 200$	
ESD (MIL-STD-883B, Method 3015.7)		> 2000	V
Storage Temperature (D Suffix)		- 65 to 125	$^\circ\text{C}$
Power Dissipation (Packages) <sup>b</sup>	TSOP-6 <sup>c</sup>	570	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 7 mW/ $^\circ\text{C}$  above  $25^\circ\text{C}$ .

<b>SPECIFICATIONS</b> ( $V_+ = 2\text{ V}$ )							
Parameter	Symbol	Test Conditions Unless Otherwise Specified $V_+ = 2\text{ V}, \pm 10\%$ $V_{IN} = 0.4\text{ V}$ or $1.6\text{ V}^e$	Temp. <sup>a</sup>	Limits - 40 $^\circ\text{C}$ to 85 $^\circ\text{C}$			Unit
				Min. <sup>b</sup>	Typ. <sup>c</sup>	Max. <sup>b</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>d</sup>	$V_{NO}, V_{NC}$ $V_{COM}$		Full	0		$V_+$	V
On-Resistance	$R_{ON}$	$V_+ = 1.8\text{ V}, V_{COM} = 1\text{ V}, I_{NO}, I_{NC} = 10\text{ mA}$	Room Full		15 17	30 32	$\Omega$
$R_{ON}$ Flatness <sup>d</sup>	$R_{ON}$ Flatness	$V_+ = 1.8\text{ V}, V_{COM} = 0\text{ V}$ to $V_+, I_{NO}, I_{NC} = 10\text{ mA}$	Room		5		
Switch Off Leakage Current <sup>g</sup>	$I_{NO(off)}$ $I_{NC(off)}$	$V_+ = 2.2\text{ V}$ $V_{NO}, V_{NC} = 0.5\text{ V}/1.5\text{ V}, V_{COM} = 1.5\text{ V}/0.5\text{ V}$	Room Full	- 300 - 3.5		300 3.5	pA nA
	$I_{COM(off)}$		Room Full	- 300 - 3.5		300 3.5	pA nA
Channel-On Leakage Current <sup>g</sup>	$I_{COM(on)}$	$V_+ = 2.2\text{ V}, V_{NO}, V_{NC} = V_{COM} = 0.5\text{ V}/1.5\text{ V}$	Room Full	- 350 - 3.5		300 3.5	pA nA
<b>Digital Control</b>							
Input High Voltage	$V_{INH}$		Full	1.6			V
Input Low Voltage	$V_{INL}$		Full			0.4	
Input Capacitance	$C_{in}$		Full		4		pF
Input Current	$I_{INL}$ or $I_{INH}$	$V_{IN} = 0\text{ V}$ or $V_+$	Full	1		1	$\mu\text{A}$
<b>Dynamic Characteristics</b>							
Turn-On Time	$t_{ON}$	$V_{NO}$ or $V_{NC} = 1.5\text{ V}, R_L = 300\ \Omega, C_L = 35\text{ pF}$	Room Full		30	50 53	ns
Turn-Off Time	$t_{OFF}$		Room Full		15	30 33	
Break-Before-Make Time	$t_d$		Room	1	15		
Charge Injection <sup>d</sup>	$Q_{INJ}$	$C_L = 1\text{ nF}, V_{GEN} = 0\text{ V}, R_{GEN} = 0\ \Omega$	Room		1	10	pC
Off-Isolation <sup>d</sup>	OIRR	$R_L = 50\ \Omega, C_L = 5\text{ pF}, f = 1\text{ MHz}$	Room		- 71		dB
Crosstalk <sup>d</sup>	$X_{TALK}$		Room		- 70		
$N_O, N_C$ Off Capacitance <sup>d</sup>	$C_{NO(off)}$ $C_{NC(off)}$	$V_{IN} = 0\text{ V}$ or $V_+, f = 1\text{ MHz}$	Room		17		pF
Channel-On Capacitance <sup>d</sup>	$C_{ON}$		Room		50		
<b>Power Supply</b>							
Power Supply Range	$V_+$			1.8		2.20	V
Power Supply Current	$I_+$	$V_{IN} = 0\text{ V}$ or $V_+$			0.01	1	$\mu\text{A}$
Power Consumption	$P_C$						2.2



SPECIFICATIONS (V+ = 3 V)							
Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 3 V, ± 10 % VIN = 0.4 V or 2 V <sup>e</sup>	Temp. <sup>a</sup>	Limits - 40 °C to 85 °C			Unit
				Min. <sup>b</sup>	Typ. <sup>c</sup>	Max. <sup>b</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>d</sup>	V <sub>NO</sub> , V <sub>NC</sub> , V <sub>COM</sub>		Full	0		V+	V
On-Resistance	R <sub>ON</sub>	V+ = 2.7 V, V <sub>COM</sub> = 1.5 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room Full		5 6	9.2 10.2	Ω
R <sub>ON</sub> Flatness <sup>d</sup>	R <sub>ON</sub> Flatness	V+ = 2.7 V, V <sub>COM</sub> = 0 V to V+, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room		3		
Switch Off Leakage Current <sup>g</sup>	I <sub>NO(off)</sub> , I <sub>NC(off)</sub>	V+ = 3.3 V V <sub>NO</sub> , V <sub>NC</sub> = 1 V/3 V, V <sub>COM</sub> = 3 V/1 V	Room Full	- 400 - 4.5		400 4.5	pA nA
	I <sub>COM(off)</sub>		Room Full	- 400 - 4.5		400 4.5	pA nA
Channel-On Leakage Current <sup>g</sup>	I <sub>COM(on)</sub>	V+ = 3.3 V, V <sub>NO</sub> , V <sub>NC</sub> = V <sub>COM</sub> = 1 V/3 V	Room Full	- 450 - 4.5		400 4.5	pA nA
<b>Digital Control</b>							
Input High Voltage	V <sub>INH</sub>		Full	2			V
Input Low Voltage	V <sub>INL</sub>		Full			0.4	
Input Capacitance	C <sub>in</sub>		Full		4		pF
Input Current	I <sub>INL</sub> or I <sub>INH</sub>	V <sub>IN</sub> = 0 V or V+	Full	1		1	μA
<b>Dynamic Characteristics</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>NO</sub> or V <sub>NC</sub> = 2 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room Full		24 45 48		ns
Turn-Off Time	t <sub>OFF</sub>		Room Full		12 30 33		
Break-Before-Make Time	t <sub>d</sub>		Room	1	13		
Charge Injection <sup>d</sup>	Q <sub>INJ</sub>	C <sub>L</sub> = 1 nF, V <sub>GEN</sub> = 0 V, R <sub>GEN</sub> = 0 Ω	Room		3	10	pC
Off-Isolation <sup>d</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room		- 71		dB
Crosstalk <sup>d</sup>	X <sub>TALK</sub>		Room		- 70		
N <sub>O</sub> , N <sub>C</sub> Off Capacitance <sup>d</sup>	C <sub>NO(off)</sub> , C <sub>NC(off)</sub>	V <sub>IN</sub> = 0 V or V+, f = 1 MHz	Room		17		pF
Channel-On Capacitance <sup>d</sup>	C <sub>ON</sub>		Room		50		
<b>Power Supply</b>							
Power Supply Range	V+			2.7		3.3	V
Power Supply Current	I+	V <sub>IN</sub> = 0 V or V+			0.01	1	μA
Power Consumption	P <sub>C</sub>						3.3



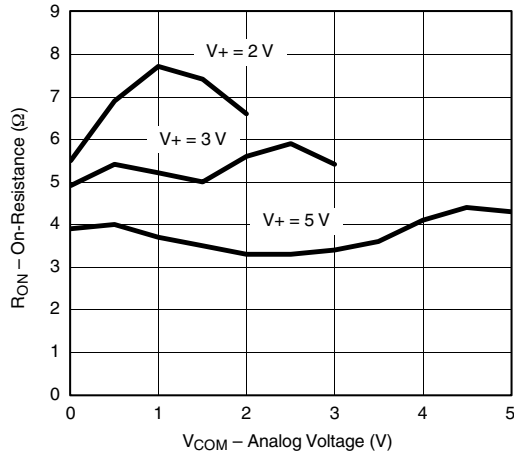
SPECIFICATIONS (V+ = 5 V)							
Parameter	Symbol	Test Conditions Unless Otherwise Specified V+ = 5 V, ± 10 % VIN = 0.8 V or 2.4 V <sup>e</sup>	Temp. <sup>a</sup>	Limits - 40 °C to 85 °C			Unit
				Min. <sup>b</sup>	Typ. <sup>c</sup>	Max. <sup>b</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>d</sup>	V <sub>NO</sub> , V <sub>NC</sub> V <sub>COM</sub>		Full	0		V+	V
On-Resistance	R <sub>ON</sub>	V+ = 4.5 V, V <sub>COM</sub> = 3 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room Full		3 4	7 8	Ω
R <sub>ON</sub> Flatness <sup>d</sup>	R <sub>ON</sub> Flatness	V+ = 4.5 V, V <sub>COM</sub> = 0 V to V+, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room		2		
Switch Off Leakage Current <sup>d</sup>	I <sub>NO(off)</sub> I <sub>NC(off)</sub>	V+ = 5.5 V V <sub>NO</sub> , V <sub>NC</sub> = 1 V/4.5 V, V <sub>COM</sub> = 4.5 V/1 V	Room Full	- 900 - 5.5		900 5.5	pA nA
	I <sub>COM(off)</sub>		Room Full	- 900 - 5.5		900 5.5	pA nA
Channel-On Leakage Current <sup>d</sup>	I <sub>COM(on)</sub>	V+ = 5.5 V, V+ = 5.5 V V <sub>NO</sub> , V <sub>NC</sub> = V <sub>COM</sub> = 1 V/4.5 V	Room Full	- 1000 - 5.5		1000 5.5	pA nA
<b>Digital Control</b>							
Input High Voltage	V <sub>INH</sub>		Full	2.4			V
Input Low Voltage	V <sub>INL</sub>		Full			0.8	
Input Capacitance	C <sub>in</sub>		Full		4		pF
Input Current	I <sub>INL</sub> or I <sub>INH</sub>	V <sub>IN</sub> = 0 V or V+	Full	1		1	μA
<b>Dynamic Characteristics</b>							
Turn-On Time	t <sub>ON</sub>	V <sub>NO</sub> or V <sub>NC</sub> = 3 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room Full		20	37 40	ns
Turn-Off Time	t <sub>OFF</sub>		Room Full		10	27 30	
Break-Before-Make Time	t <sub>d</sub>		Room	1	10		
Charge Injection <sup>d</sup>	Q <sub>INJ</sub>	C <sub>L</sub> = 1 nF, V <sub>GEN</sub> = 0 V, R <sub>GEN</sub> = 0 Ω	Room		7	10	pC
Off-Isolation <sup>d</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room		- 71		dB
Crosstalk <sup>d</sup>	X <sub>TALK</sub>		Room		- 70		
Source-Off Capacitance <sup>d</sup>	C <sub>NO(off)</sub> C <sub>NC(off)</sub>	V <sub>IN</sub> = 0 V or V+, f = 1 MHz	Room		17		pF
Channel-On Capacitance <sup>d</sup>	C <sub>ON</sub>		Room		50		
<b>Power Supply</b>							
Power Supply Range	V+			4.5		5.5	V
Power Supply Current	I+	V <sub>IN</sub> = 0 V or V+			0.01	1	μA
Power Consumption	P <sub>C</sub>						5.5

Notes:

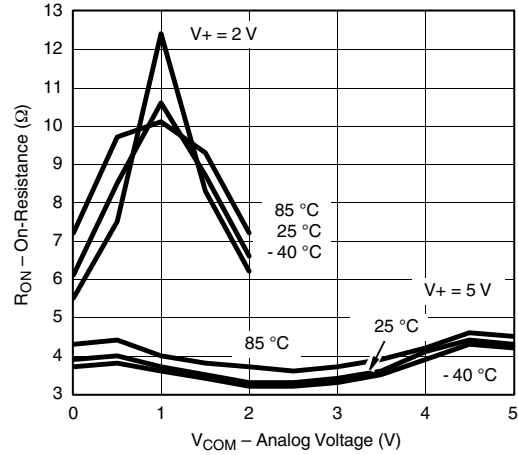
- a. Room = 25 °C, Full = as determined by the operating suffix.
- b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- c. Typical values are for design aid only, not guaranteed nor subject to production testing.
- d. Guarantee by design, nor subjected to production test.
- e. V<sub>IN</sub> = input voltage to perform proper function.
- f. Guaranteed by 5 V leakage testing, not production tested.

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

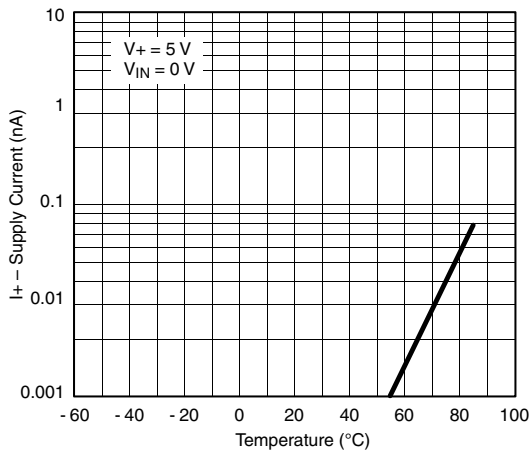
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



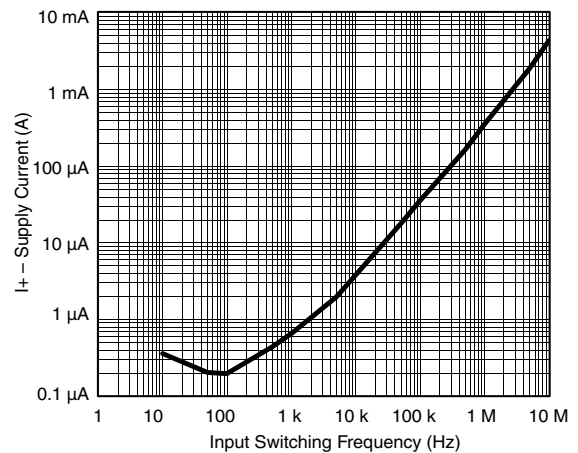
**RON vs. VCOM and Supply Voltage**



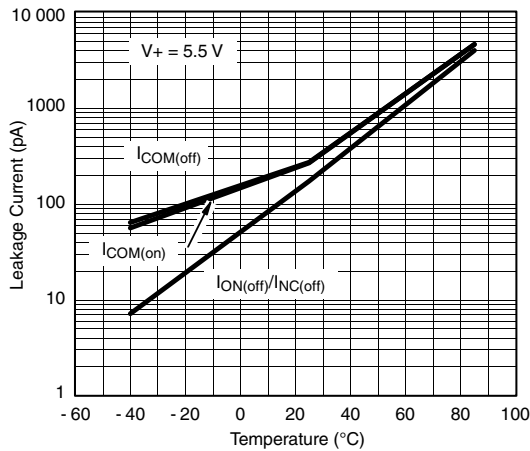
**RON vs. Analog Voltage and Temperature**



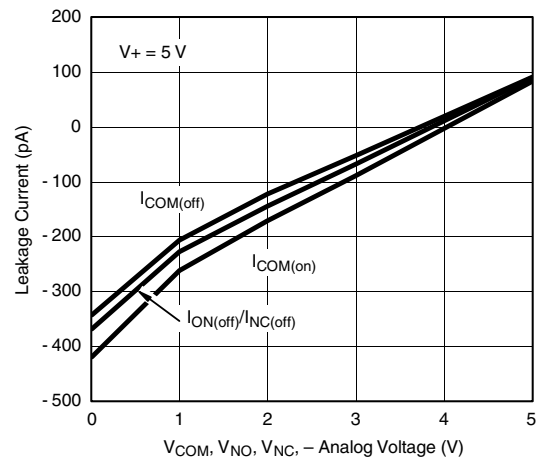
**Supply Current vs. Temperature**



**Supply Current vs. Input Switching Frequency**

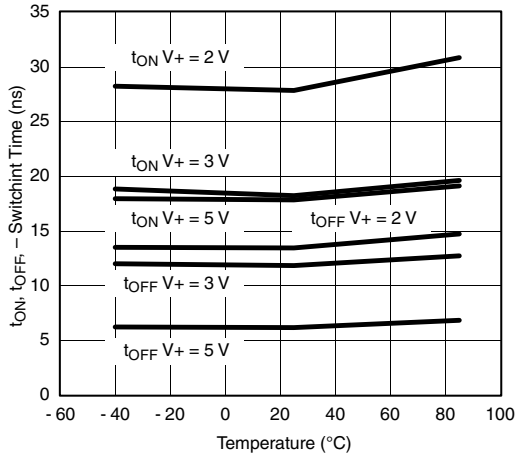


**Leakage Current vs. Temperature**

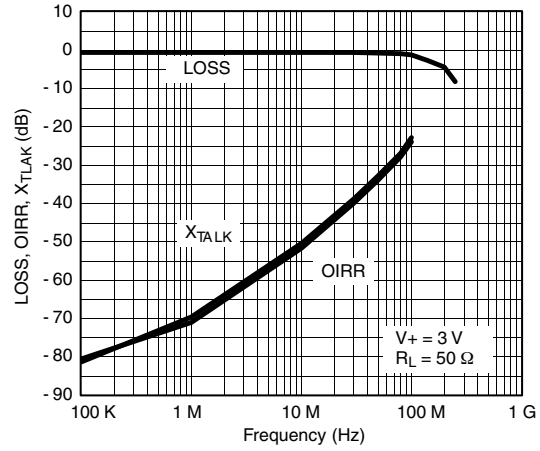


**Leakage vs. Analog Voltage**

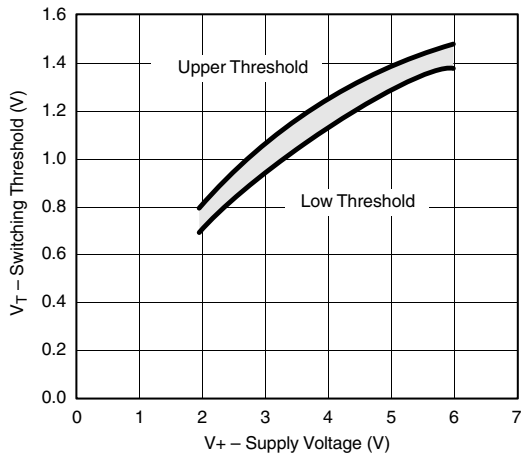
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



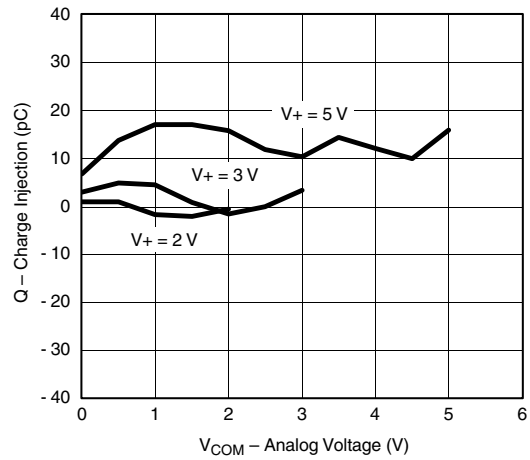
**Switching Time vs. Temperature and Supply Voltage**



**Insertion Loss, Off-Isolation Crosstalk vs. Frequency**

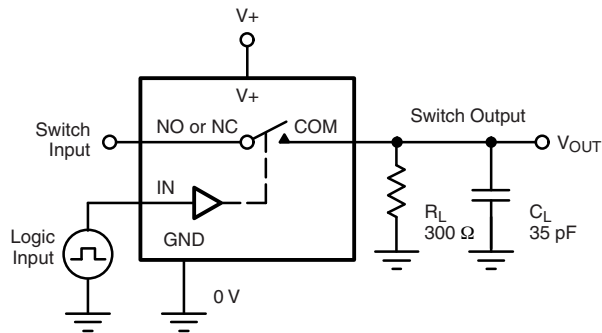


**Switching Threshold vs. Supply Voltage**



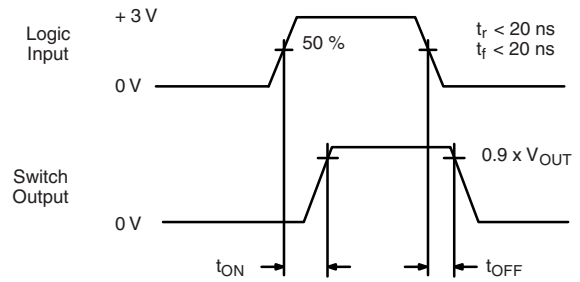
**Charge Injection vs. Analog Voltage**

TEST CIRCUITS



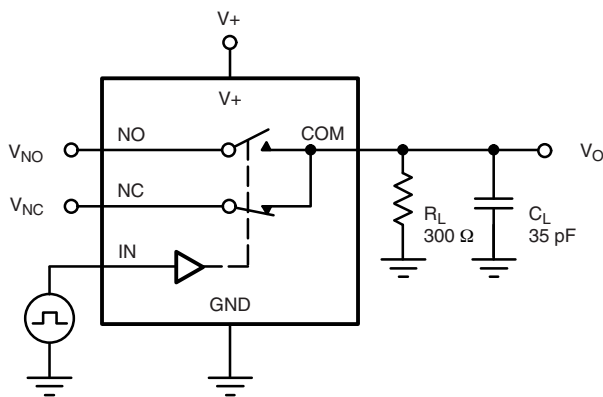
$C_L$  (includes fixture and stray capacitance)

$$V_{OUT} = V_{COM} \left( \frac{R_L}{R_L + R_{ON}} \right)$$



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

Figure 1. Switching Time



$C_L$  (includes fixture and stray capacitance)

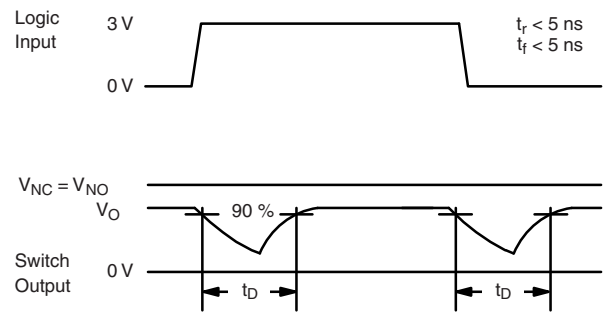
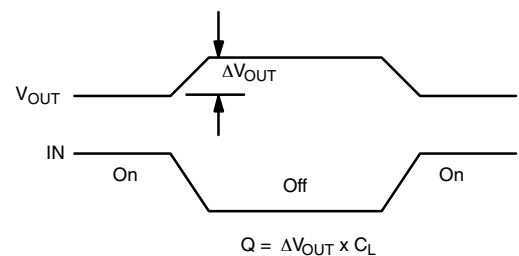
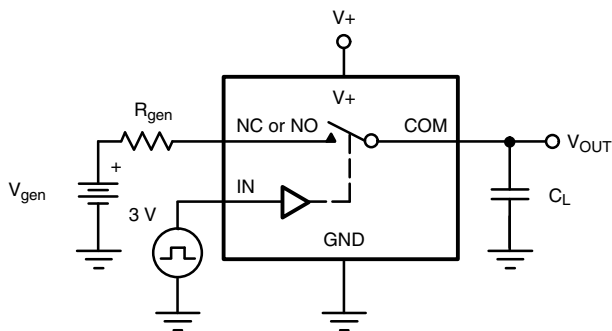


Figure 2. Break-Before-Make Interval



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

Figure 3. Charge Injection

TEST CIRCUITS

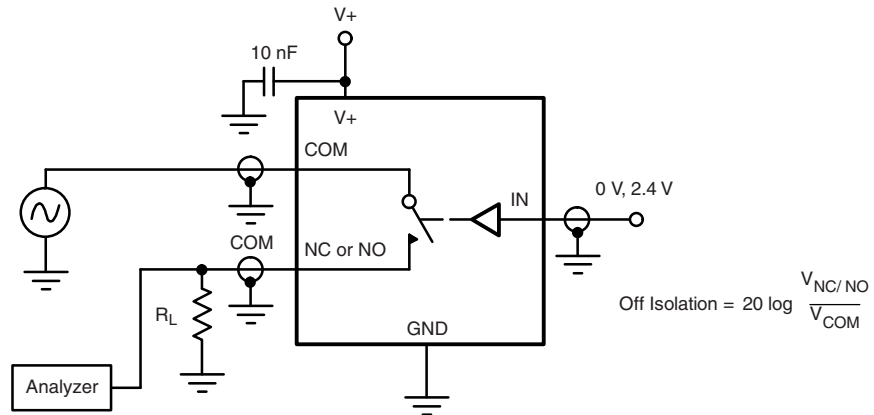


Figure 4. Off-Isolation

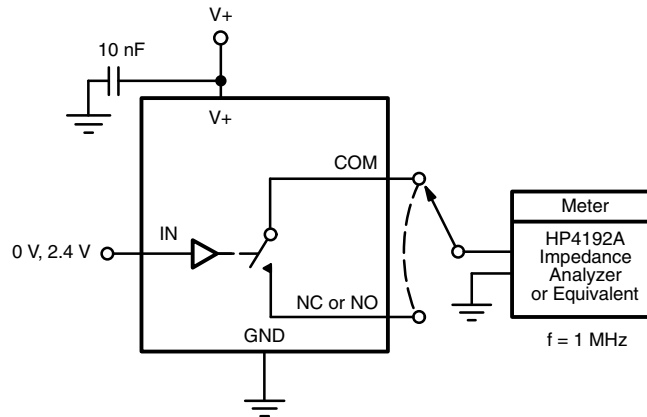


Figure 5. Channel Off/On Capacitance

Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see [www.vishay.com/ppg?71398](http://www.vishay.com/ppg?71398).



## TSOP: 5/6-LEAD

JEDEC Part Number: MO-193C



5-LEAD TSOP



6-LEAD TSOP



Dim	MILLIMETERS			INCHES		
	Min	Nom	Max	Min	Nom	Max
A	0.91	-	1.10	0.036	-	0.043
A <sub>1</sub>	0.01	-	0.10	0.0004	-	0.004
A <sub>2</sub>	0.90	-	1.00	0.035	0.038	0.039
b	0.30	0.32	0.45	0.012	0.013	0.018
c	0.10	0.15	0.20	0.004	0.006	0.008
D	2.95	3.05	3.10	0.116	0.120	0.122
E	2.70	2.85	2.98	0.106	0.112	0.117
E <sub>1</sub>	1.55	1.65	1.70	0.061	0.065	0.067
e	0.95 BSC			0.0374 BSC		
e <sub>1</sub>	1.80	1.90	2.00	0.071	0.075	0.079
L	0.32	-	0.50	0.012	-	0.020
L <sub>1</sub>	0.60 Ref			0.024 Ref		
L <sub>2</sub>	0.25 BSC			0.010 BSC		
R	0.10	-	-	0.004	-	-
θ	0°	4°	8°	0°	4°	8°
θ <sub>1</sub>	7° Nom			7° Nom		
ECN: C-06593-Rev. I, 18-Dec-06						
DWG: 5540						

## Mounting LITTLE FOOT<sup>®</sup> TSOP-6 Power MOSFETs

Surface mounted power MOSFET packaging has been based on integrated circuit and small signal packages. Those packages have been modified to provide the improvements in heat transfer required by power MOSFETs. Leadframe materials and design, molding compounds, and die attach materials have been changed. What has remained the same is the footprint of the packages.

The basis of the pad design for surface mounted power MOSFET is the basic footprint for the package. For the TSOP-6 package outline drawing see <http://www.vishay.com/doc?71200> and see <http://www.vishay.com/doc?72610> for the minimum pad footprint. In converting the footprint to the pad set for a power MOSFET, you must remember that not only do you want to make electrical connection to the package, but you must make thermal connection and provide a means to draw heat from the package, and move it away from the package.

In the case of the TSOP-6 package, the electrical connections are very simple. Pins 1, 2, 5, and 6 are the drain of the MOSFET and are connected together. For a small signal device or integrated circuit, typical connections would be made with traces that are 0.020 inches wide. Since the drain pins serve the additional function of providing the thermal connection to the package, this level of connection is inadequate. The total cross section of the copper may be adequate to carry the current required for the application, but it presents a large thermal impedance. Also, heat spreads in a circular fashion from the heat source. In this case the drain pins are the heat sources when looking at heat spread on the PC board.

Figure 1 shows the copper spreading recommended footprint for the TSOP-6 package. This pattern shows the starting point for utilizing the board area available for the heat spreading copper. To create this pattern, a plane of copper overlays the basic pattern on pins 1,2,5, and 6. The copper plane connects the drain pins electrically, but more importantly provides planar copper to draw heat from the drain leads and start the process of spreading the heat so it can be dissipated into the ambient air. Notice that the planar copper is shaped like a "T" to move heat away from the drain leads in all directions. This pattern uses all the available area underneath the body for this purpose.



**FIGURE 1.** Recommended Copper Spreading Footprint

Since surface mounted packages are small, and reflow soldering is the most common form of soldering for surface mount components, "thermal" connections from the planar copper to the pads have not been used. Even if additional planar copper area is used, there should be no problems in the soldering process. The actual solder connections are defined by the solder mask openings. By combining the basic footprint with the copper plane on the drain pins, the solder mask generation occurs automatically.

A final item to keep in mind is the width of the power traces. The absolute minimum power trace width must be determined by the amount of current it has to carry. For thermal reasons, this minimum width should be at least 0.020 inches. The use of wide traces connected to the drain plane provides a low impedance path for heat to move away from the device.

### REFLOW SOLDERING

Vishay Siliconix surface-mount packages meet solder reflow reliability requirements. Devices are subjected to solder reflow as a test preconditioning and are then reliability-tested using temperature cycle, bias humidity, HAST, or pressure pot. The solder reflow temperature profile used, and the temperatures and time duration, are shown in Figures 2 and 3.



Ramp-Up Rate	+6°C/Second Maximum
Temperature @ 155 ± 15°C	120 Seconds Maximum
Temperature Above 180°C	70 – 180 Seconds
Maximum Temperature	240 +5/-0°C
Time at Maximum Temperature	20 – 40 Seconds
Ramp-Down Rate	+6°C/Second Maximum

**FIGURE 2.** Solder Reflow Temperature Profile



FIGURE 3. Solder Reflow Temperature and Time Durations

### THERMAL PERFORMANCE

A basic measure of a device’s thermal performance is the junction-to-case thermal resistance,  $R_{\theta_{JC}}$ , or the junction-to-foot thermal resistance,  $R_{\theta_{JF}}$ . This parameter is measured for the device mounted to an infinite heat sink and is therefore a characterization of the device only, in other words, independent of the properties of the object to which the device is mounted. Table 1 shows the thermal performance of the TSOP-6.

TABLE 1.	
Equivalent Steady State Performance—TSOP-6	
Thermal Resistance $R_{\theta_{JF}}$	30°C/W

### SYSTEM AND ELECTRICAL IMPACT OF TSOP-6

In any design, one must take into account the change in MOSFET  $r_{DS(on)}$  with temperature (Figure 4).



FIGURE 4. Si3434DV

## RECOMMENDED MINIMUM PADS FOR TSOP-6



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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