



# Precision Low-Voltage, Low-Glitch CMOS Analog Switches

## DESCRIPTION

Using BiCMOS wafer fabrication technology allows the DG9421, DG9422 to operate on single and dual supplies.

Designed for optimal performance at single 5 V and dual ± 5 V, the DG9421, DG9422 combine low and flat on-resistance (3 Ω), fast speed (t<sub>ON</sub> = 38 ns) and is well suited for applications where signal switching accuracy, low noise and low distortion is critical.

The DG9421 and DG9422 respond to opposite control logic as shown in the Truth Table.

## FEATURES

- 2.7 V thru 12 V single supply or ± 2.7 V thru ± 6 V dual supply
- Low on-resistance - R<sub>DS(on)</sub>: 2 Ω at 12 V
- Fast switching - t<sub>ON</sub>: 22 ns  
- t<sub>OFF</sub>: 28 ns
- TTL and low voltage logic
- Low leakage: 10 pA (typ.)
- > 2000 V ESD protection
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



### Note

\* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non-RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details.

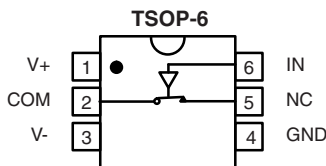
## BENEFITS

- High accuracy
- High speed, low glitch
- Single and dual supply capability
- Low R<sub>ON</sub> in small TSOP package
- Low leakage
- Low power consumption

## APPLICATIONS

- Automatic test equipment
- Data acquisition
- XDSL and DSLAM
- PBX systems
- Reed relay replacement
- Audio and video signal routing

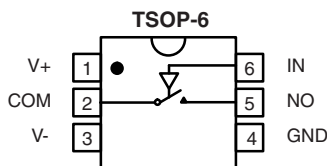
## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



Top View

Device Marking:

DG9421DV = 4Exxx



Top View

Device Marking:

DG9422DV = 4Fxxx

TRUTH TABLE		
LOGIC	DG9421	DG9422
0	ON	OFF
1	OFF	ON

### Notes

- Logic "0" ≤ 0.8 V
- Logic "1" ≥ 2.4 V
- Switches shown for logic "0" input

ORDERING INFORMATION		
TEMP. RANGE	PACKAGE	PART NUMBER
-40 °C to +85 °C	6 / Pin TSOP	DG9421DV-T1 DG9421DV-T1-E3
		DG9422DV-T1 DG9422DV-T1-E3



ABSOLUTE MAXIMUM RATINGS			
PARAMETER	LIMIT		UNIT
V+ to V-	-0.3 to +13		V
GND to V-	7		
V <sub>IN</sub> <sup>a</sup> , V <sub>S</sub> , V <sub>D</sub>	-0.3 to (V+ + 0.3) or 50 mA, whichever occurs first		V/mA
Continuous Current (any terminal)	50		mA
Peak Current, S or D (pulsed at 1 ms, 10 % duty cycle)	100		
Storage Temperature	-65 to +150		°C
Power Dissipation (Packages) <sup>b</sup>	6-Pin TSOP <sup>c</sup>	570	mW

**Notes**

- a. Signals on S<sub>X</sub>, D<sub>X</sub>, or IN<sub>X</sub> exceeding V+ or 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/°C above 25 °C.

SPECIFICATIONS <sup>a</sup> (Single Supply 12 V)							
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V+ = 12 V, V- = 0 V, V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup>	TEMP. <sup>b</sup>	LIMITS -40 °C to +85 °C			UNIT
				MIN. <sup>d</sup>	TYP. <sup>c</sup>	MAX. <sup>d</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>a</sup>	V <sub>ANALOG</sub>		Full	0	-	12	V
Drain-Source On-Resistance	R <sub>DS(on)</sub>	V+ = 10.8 V, V- = 0 V, I <sub>S</sub> = 5 mA, V <sub>D</sub> = 2 V/9 V	Room	-	2	3	Ω
			Full	-	2	3.4	
Switch Off Leakage Current	I <sub>S(off)</sub>	V <sub>D</sub> = 1/11 V, V <sub>S</sub> = 11 V/1 V	Room	-1	-	1	nA
			Full	-10	-	10	
	Room		-1	-	1		
	Full		-10	-	10		
Channel-On Leakage Current	I <sub>D(on)</sub>	V <sub>S</sub> = V <sub>D</sub> = 11 V/1 V	Room	-1	-	1	
			Full	-10	-	10	
<b>Digital Control</b>							
Input Current, V <sub>IN</sub> Low	I <sub>IL</sub>	V <sub>IN</sub> under test = 0.8 V	Full	-1	0.02	1	μA
Input Current, V <sub>IN</sub> High	I <sub>IH</sub>	V <sub>IN</sub> under test = 2.4 V	Full	-1	0.02	1	
<b>Dynamic Characteristics</b>							
Turn-On Time <sup>e</sup>	t <sub>ON</sub>	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF, V <sub>S</sub> = 5 V see figure 2	Room	-	20	45	ns
			Full	-	-	49	
Turn-Off Time <sup>e</sup>	t <sub>OFF</sub>		Room	-	25	47	
			Full	-	-	59	
Charge Injection <sup>e</sup>	Q	V <sub>g</sub> = 0 V, R <sub>g</sub> = 0 Ω, C <sub>L</sub> = 1 nF	Room	-	43	-	pC
Off-Isolation <sup>e</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room	-	-60	-	dB
Source Off Capacitance <sup>e</sup>	C <sub>S(off)</sub>	f = 1 MHz	Room	-	31	-	pF
Drain Off Capacitance <sup>e</sup>	C <sub>D(off)</sub>		Room	-	30	-	
Channel On Capacitance <sup>e</sup>	C <sub>D(on)</sub>		Room	-	71	-	
<b>Power Supplies</b>							
Positive Supply Current	I+	V <sub>IN</sub> = 0 V or 12 V	Room	-	0.020	1	μA
			Full	-	-	5	
Negative Supply Current	I-		Room	-1	-0.002	-	
			Full	-5	-	-	
Ground Current	I <sub>GND</sub>		Room	-1	-0.002	-	
			Full	-5	-	-	



SPECIFICATIONS <sup>a</sup> (Dual Supply $\pm 5$ V)							
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED $V_+ = 5$ V, $V_- = -5$ V, $V_{IN} = 2.4$ V, $0.8$ V <sup>f</sup>	TEMP. <sup>b</sup>	LIMITS -40 °C to +85 °C			UNIT
				MIN. <sup>d</sup>	TYP. <sup>c</sup>	MAX. <sup>d</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>e</sup>	$V_{ANALOG}$		Full	-5	-	5	V
Drain-Source On-Resistance	$R_{DS(on)}$	$V_+ = 5$ V, $V_- = 5$ V $I_S = 5$ mA, $V_D = \pm 3.5$ V	Room	-	2.2	3.2	$\Omega$
			Full	-	-	3.6	
Switch Off Leakage Current <sup>g</sup>	$I_{S(off)}$	$V_+ = 5.5$ V, $V_- = 5.5$ V $V_D = \pm 4.5$ V, $V_S = \mp 4.5$ V	Room	-1	-	1	nA
			Full	-10	-	10	
	$I_{D(off)}$		Room	-1	-	1	
			Full	-10	-	10	
Channel-On Leakage Current <sup>g</sup>	$I_{D(on)}$	$V_+ = 5.5$ V, $V_- = -5.5$ V $V_S = V_D = \pm 4.5$ V	Room	-1	-	1	
			Full	-10	-	10	
<b>Digital Control</b>							
Input Current, $V_{IN}$ Low <sup>e</sup>	$I_{IL}$	$V_{IN}$ under test = 0.8 V	Full	-1	0.02	1	$\mu$ A
Input Current, $V_{IN}$ High <sup>e</sup>	$I_{IH}$	$V_{IN}$ under test = 2.4 V	Full	-1	0.02	1	
<b>Dynamic Characteristics</b>							
Turn-On Time	$t_{ON}$	$R_L = 300 \Omega$ , $C_L = 35$ pF, $V_S = \pm 3.5$ V see figure 2	Room	-	38	63	ns
			Full	-	-	68	
Turn-Off Time	$t_{OFF}$		Room	-	45	83	
			Full	-	-	97	
Charge Injection <sup>e</sup>	Q	$V_g = 0$ V, $R_g = 0 \Omega$ , $C_L = 1$ nF	Room	-	207	-	pC
Off-Isolation <sup>e</sup>	OIRR	$R_L = 50 \Omega$ , $C_L = 5$ pF, $f = 1$ MHz	Room	-	-57	-	dB
Source Off Capacitance <sup>e</sup>	$C_{S(off)}$	f = 1 MHz	Room	-	32	-	pF
Drain Off Capacitance <sup>e</sup>	$C_{D(off)}$		Room	-	31	-	
Channel On Capacitance <sup>e</sup>	$C_{D(on)}$		Room	-	71	-	
<b>Power Supplies</b>							
Positive Supply Current <sup>e</sup>	$I_+$	$V_{IN} = 0$ V or 5 V	Room	-	0.030	1	$\mu$ A
			Full	-	-	5	
Negative Supply Current <sup>e</sup>	$I_-$		Room	-1	-0.002	-	
			Full	-5	-	-	
Ground Current <sup>e</sup>	$I_{GND}$		Room	-1	-0.002	-	
			Full	-5	-	-	



SPECIFICATIONS <sup>a</sup> (Single Supply 5 V)							
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED $V_+ = 5\text{ V}, V_- = 0\text{ V}, V_{IN} = 2.4\text{ V}, 0.8\text{ V}^f$	TEMP. <sup>b</sup>	LIMITS -40 °C to +85 °C			UNIT
				MIN. <sup>d</sup>	TYP. <sup>c</sup>	MAX. <sup>d</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>e</sup>	$V_{ANALOG}$		Full	0	-	5	V
Drain-Source On-Resistance	$R_{DS(on)}$	$V_+ = 4.5\text{ V}, I_S = 5\text{ mA}, V_D = 1\text{ V}, 3.5\text{ V}$	Room	-	3.6	6	$\Omega$
			Full	-	-	6.6	
<b>Dynamic Characteristics</b>							
Turn-On Time <sup>e</sup>	$t_{ON}$	$R_L = 300\ \Omega, C_L = 35\text{ pF}, V_S = 3.5\text{ V},$ see figure 2	Room	-	43	67	ns
			Hot	-	-	74	
Turn-Off Time <sup>e</sup>	$t_{OFF}$		Room	-	30	67	
			Hot	-	-	80	
Charge Injection <sup>e</sup>	Q	$V_g = 0\text{ V}, R_g = 0\ \Omega, C_L = 1\text{ nF}$	Room	-	25	-	pC
<b>Power Supplies</b>							
Positive Supply Current <sup>e</sup>	I+	$V_{IN} = 0\text{ V or }5\text{ V}$	Room	-	0.020	1	$\mu\text{A}$
			Hot	-	-	5	
Negative Supply Current <sup>e</sup>	I-		Room	-1	-0.002	-	
			Hot	-5	-	-	
Ground Current <sup>e</sup>	$I_{GND}$		Room	-1	-0.002	-	
			Hot	-5	-	-	



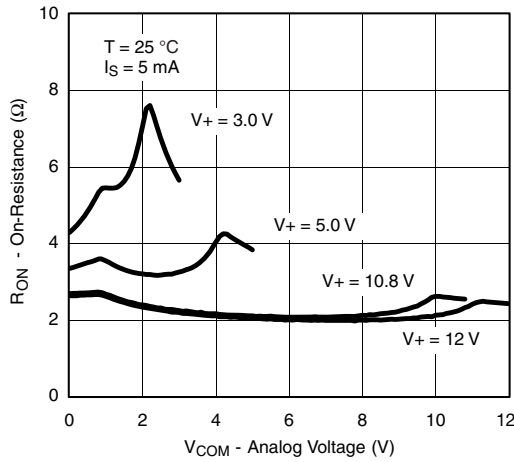
SPECIFICATIONS <sup>a</sup> (Single Supply 3 V)							
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED $V_+ = 3\text{ V}, V_- = 0\text{ V}, V_{IN} = 0.4\text{ V}^f$	TEMP. <sup>b</sup>	LIMITS -40 °C to +85 °C			UNIT
				MIN. <sup>d</sup>	TYP. <sup>c</sup>	MAX. <sup>d</sup>	
<b>Analog Switch</b>							
Analog Signal Range <sup>e</sup>	$V_{ANALOG}$		Full	0	-	3	V
Drain-Source On-Resistance	$R_{DS(on)}$	$V_+ = 2.7\text{ V}, V_- = 0\text{ V}$ $I_S = 5\text{ mA}, V_D = 0.5\text{ V}, 2.2\text{ V}$	Room	-	7.3	8.8	$\Omega$
			Full	-	-	10.1	
Switch Off Leakage Current <sup>g</sup>	$I_{S(off)}$	$V_+ = 3.3\text{ V}, V_- = 0\text{ V}$ $V_S = 1, 2\text{ V}, V_D = 2\text{ V}, 1\text{ V}$	Room	-1	-	1	nA
			Full	-10	-	10	
	Room		-1	-	1		
	Full		-10	-	10		
Channel-On Leakage Current <sup>g</sup>	$I_{D(on)}$	$V_+ = 3.3\text{ V}, V_- = 0\text{ V}$ $V_D = V_S = 1\text{ V}, 2\text{ V}$	Room	-1	-	1	
			Full	-10	-	10	
<b>Digital Control</b>							
Input Current, $V_{IN}$ Low <sup>e</sup>	$I_{IL}$	$V_{IN}$ under test = 0.4 V	Full	-1	0.02	1	$\mu\text{A}$
Input Current, $V_{IN}$ High <sup>e</sup>	$I_{IH}$	$V_{IN}$ under test = 2.4 V	Full	-1	0.02	1	
<b>Dynamic Characteristics</b>							
Turn-On Time	$t_{ON}$	$R_L = 300\ \Omega, C_L = 35\text{ pF}, V_S = 1.5\text{ V}$ see figure 2	Room		90	110	ns
			Full			125	
Turn-Off Time	$t_{OFF}$		Room		32	84	
			Full			99	
Charge Injection <sup>e</sup>	Q	$V_g = 0\text{ V}, R_g = 0\ \Omega, C_L = 1\text{ nF}$	Room		31		pC
Off-Isolation <sup>e</sup>	OIRR	$R_L = 50\ \Omega, C_L = 5\text{ pF}, f = 1\text{ MHz}$	Room		-60		dB
Source Off Capacitance <sup>e</sup>	$C_{S(off)}$	f = 1 MHz	Room		35		pF
Drain Off Capacitance <sup>e</sup>	$C_{D(off)}$		Room		34		
Channel On Capacitance <sup>e</sup>	$C_{D(on)}$		Room		77		

**Notes**

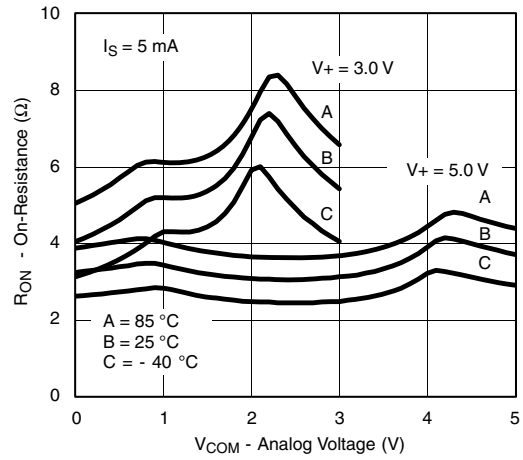
- a. Refer to PROCESS OPTION FLOWCHART.
- b. Room = 25 °C, Full = as determined by the operating temperature suffix.
- c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- d. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- e. Guaranteed by design, not subject to production test.
- f.  $V_{IN}$  = input voltage to perform proper function.
- g. Leakage parameters are guaranteed by worst case test conditions and not subject to test.

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.

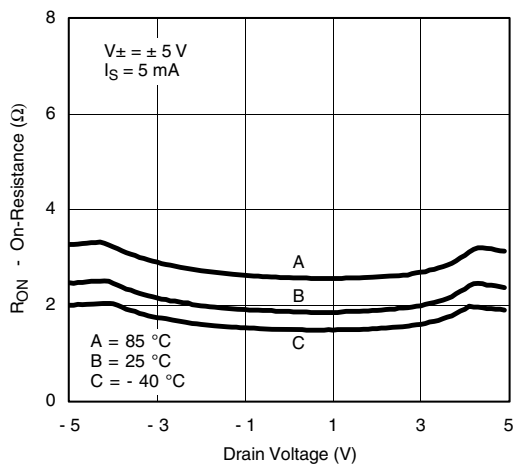
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



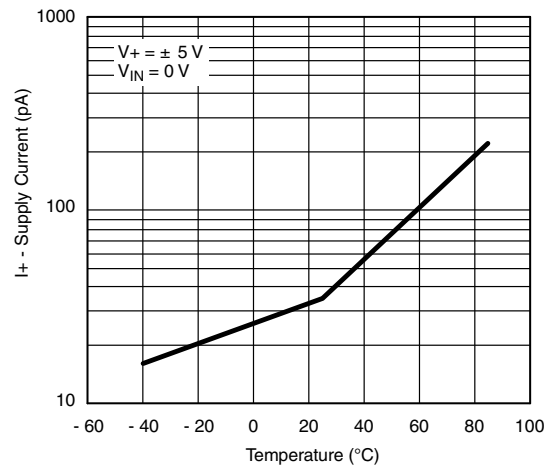
**RON vs. VCOM and Supply Voltage**



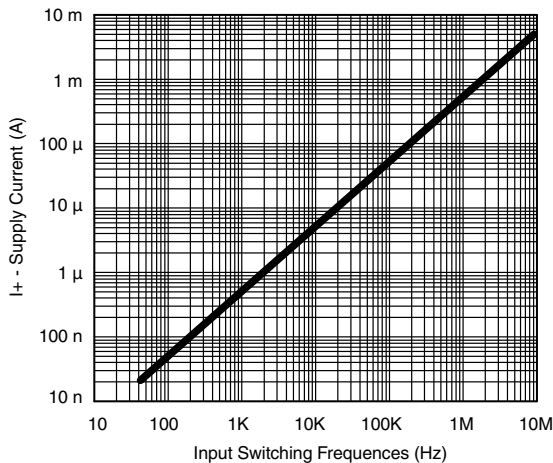
**RON vs. Analog Voltage and Temperature**



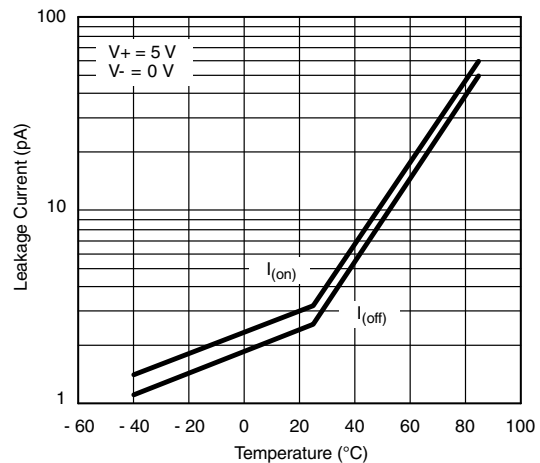
**RON vs. Analog Voltage and Temperature**



**Supply Current vs. Temperature**

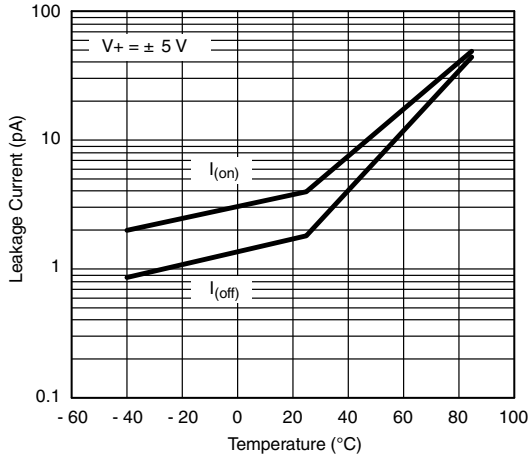


**Supply Current vs. Input Switching Frequency**

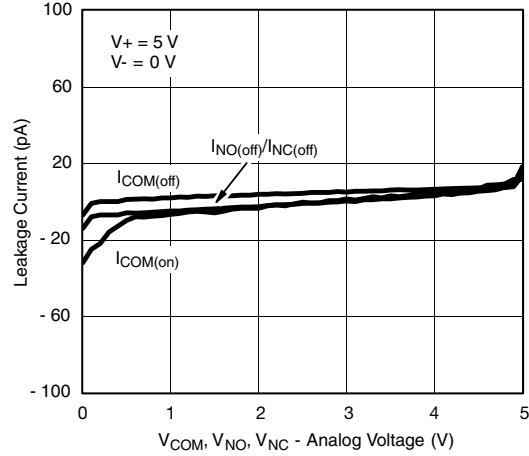


**Leakage Current vs. Temperature**

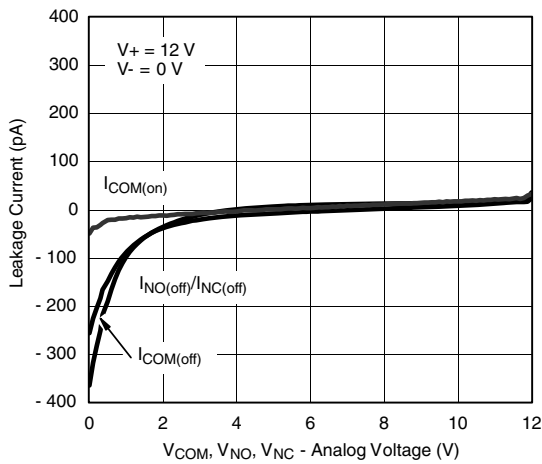
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



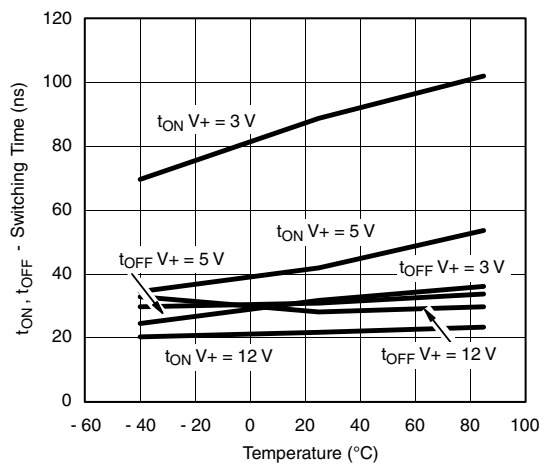
**Leakage Current vs. Temperature**



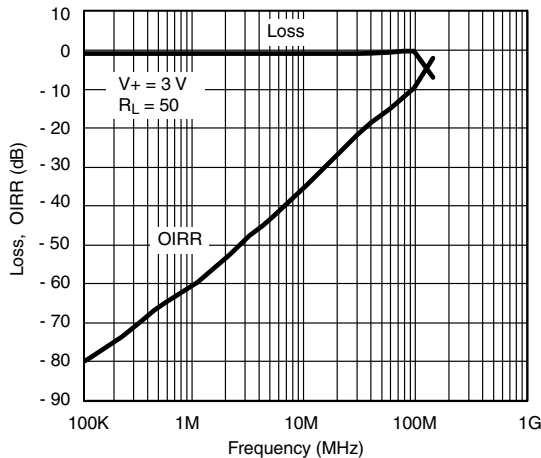
**Leakage vs. Analog Voltage**



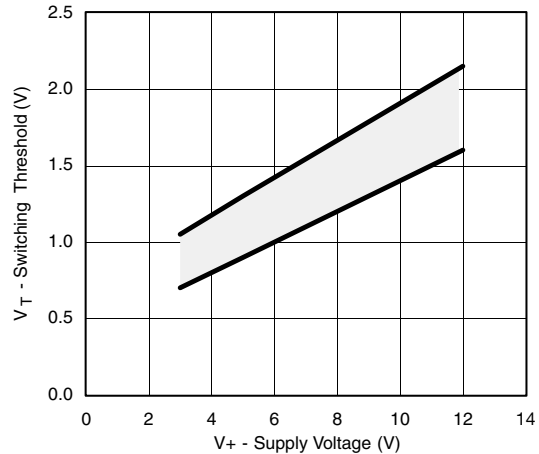
**Leakage vs. Analog Voltage**



**Switching Time vs. Temperature and Supply Voltage (DG9421)**

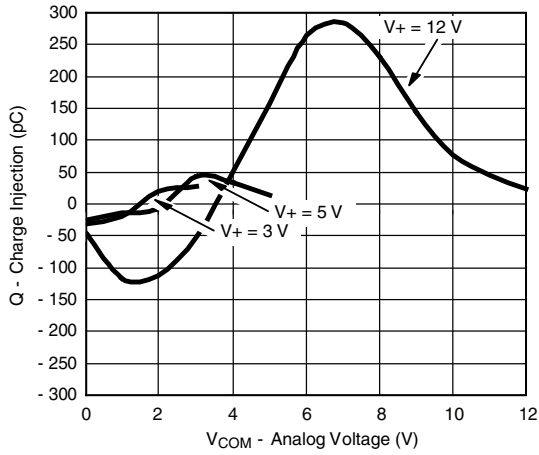


**Insertion Loss, Off Isolation vs. Frequency**

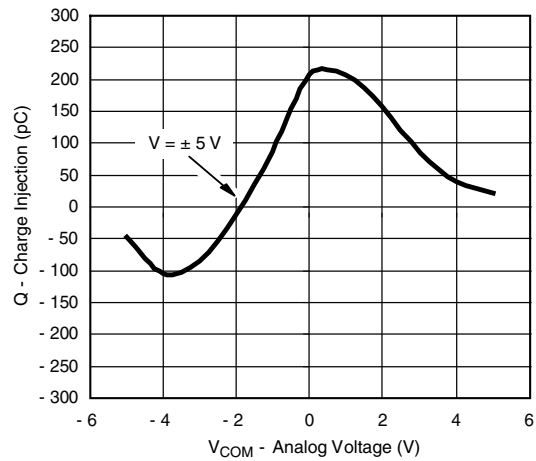


**Switching Threshold vs. Supply Voltage**

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



Charge Injection vs. Analog Voltage



Charge Injection vs. Analog Voltage

**SCHEMATIC DIAGRAM** (Typical Channel)

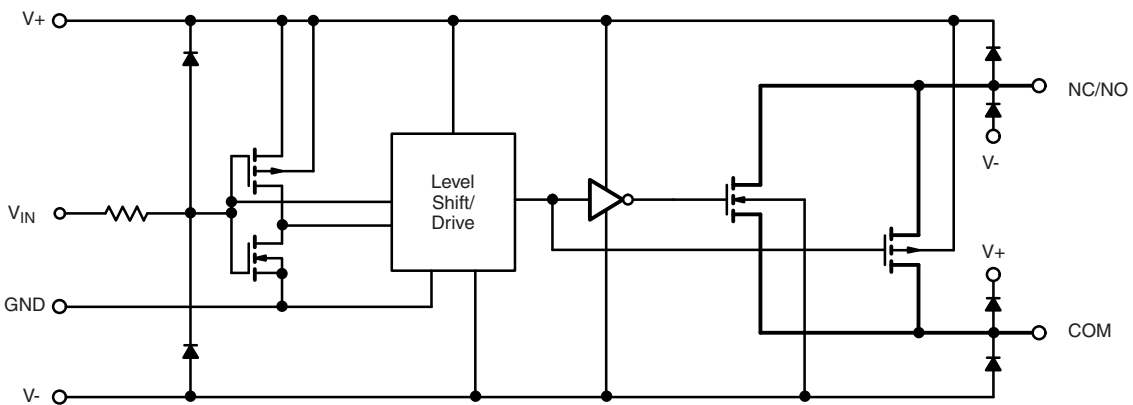
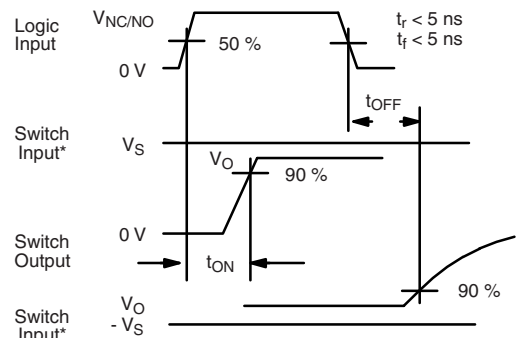
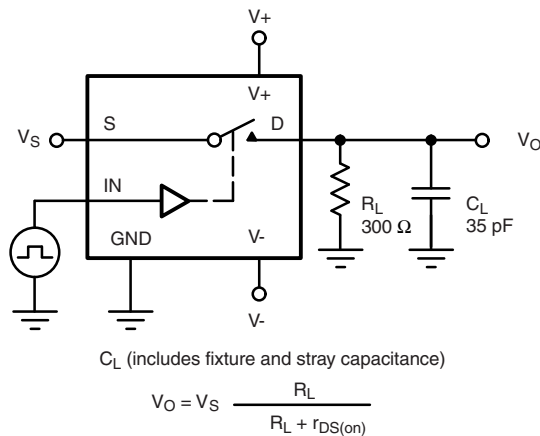


Fig. 1

**TEST CIRCUITS**

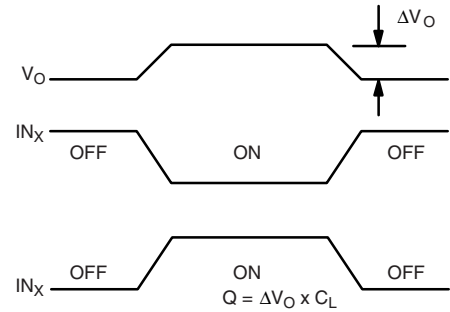
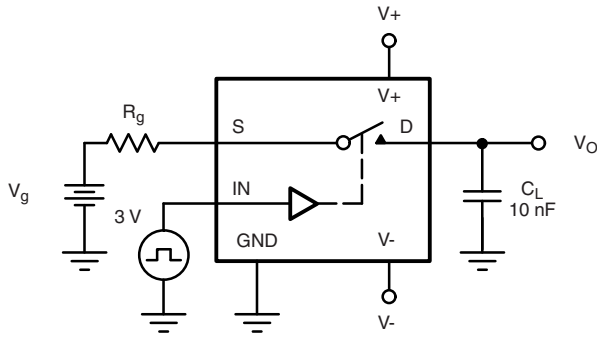


Note: \* Logic input waveform is inverted for switches that have the opposite logic sense control

Fig. 2 - Switching Time



TEST CIRCUITS



IN<sub>x</sub> dependent on switch configuration Input polarity determined by sense of switch.

Fig. 3 - Charge Injection

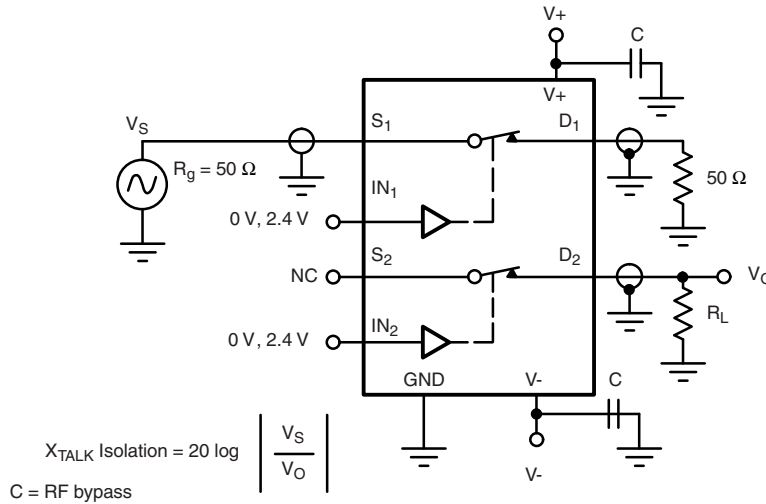


Fig. 4 - Crosstalk

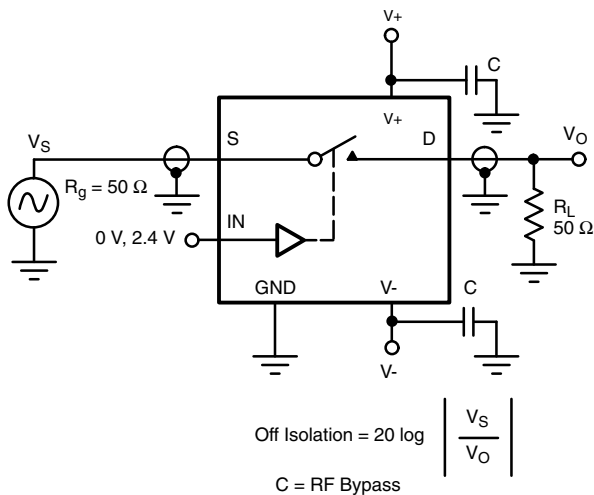


Fig. 5 - Off Isolation

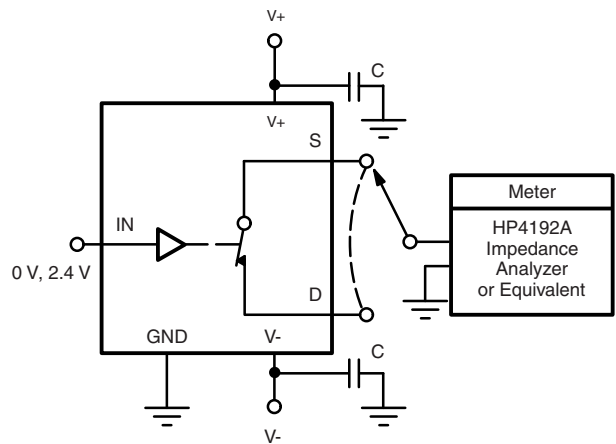
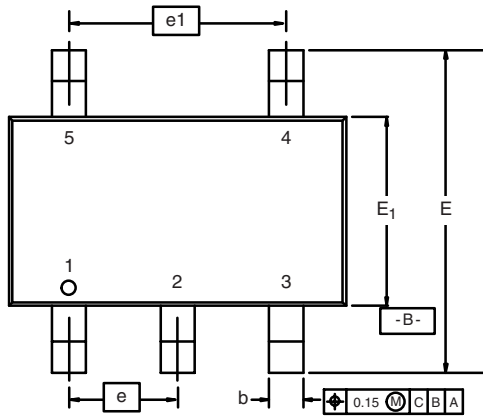


Fig. 6 - Source/Drain Capacitances

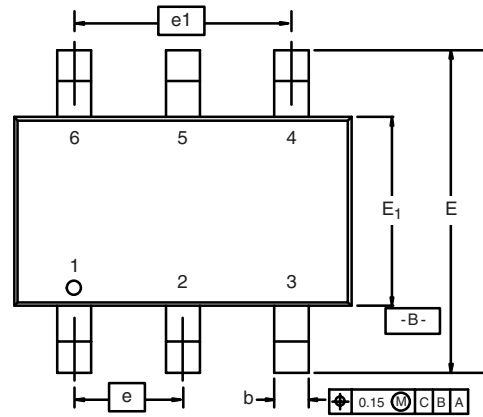
Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see [www.vishay.com/ppg?70679](http://www.vishay.com/ppg?70679).

## TSOP: 5/6-LEAD

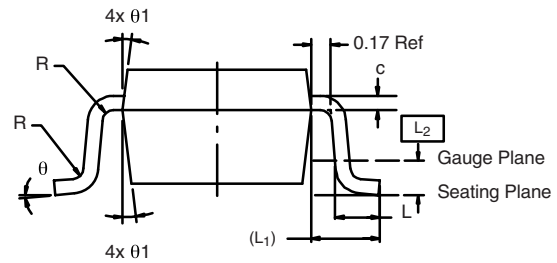
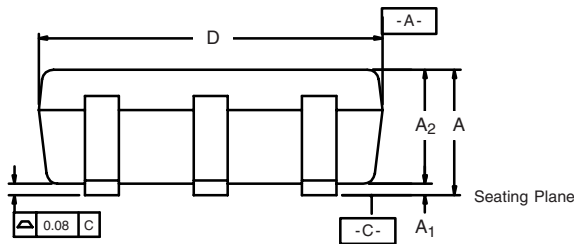
JEDEC Part Number: MO-193C



5-LEAD TSOP



6-LEAD TSOP



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

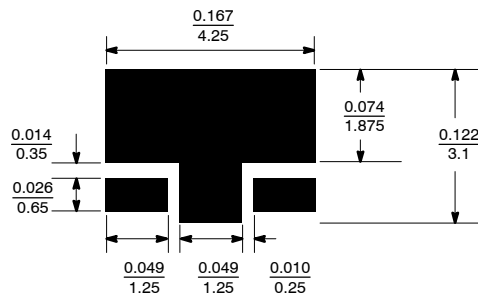
# Mounting LITTLE FOOT<sup>®</sup> TSOP-6 Power MOSFETs

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.



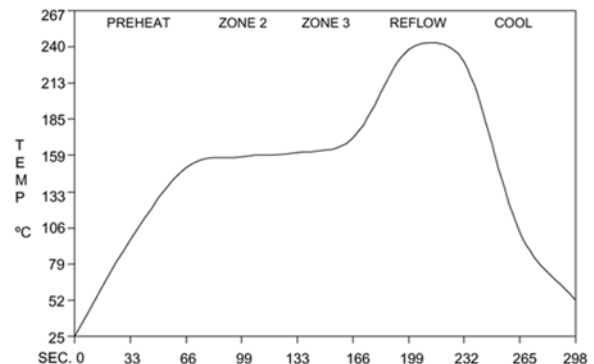
**FIGURE 1.** Recommended Copper Spreading Footprint

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

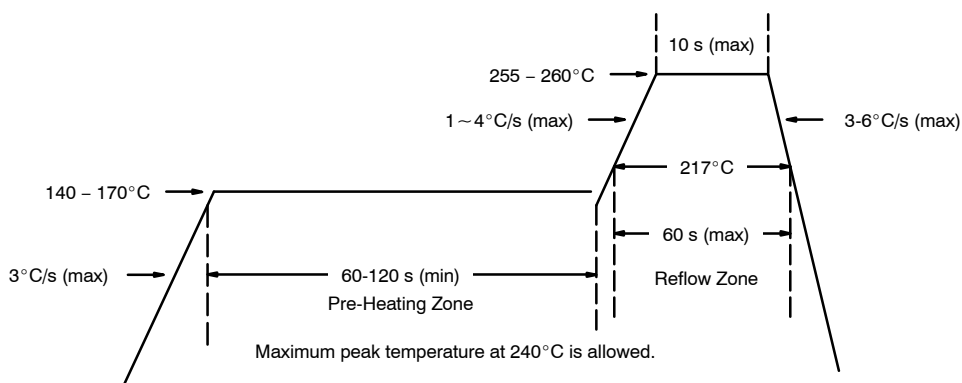


FIGURE 3. Solder Reflow Temperature and Time Durations

## 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).

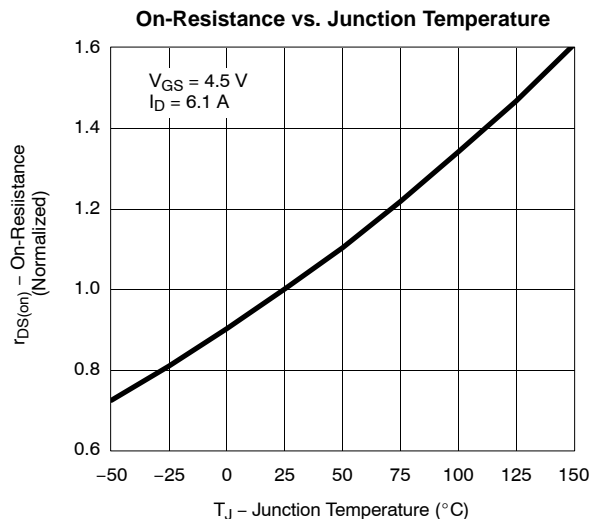
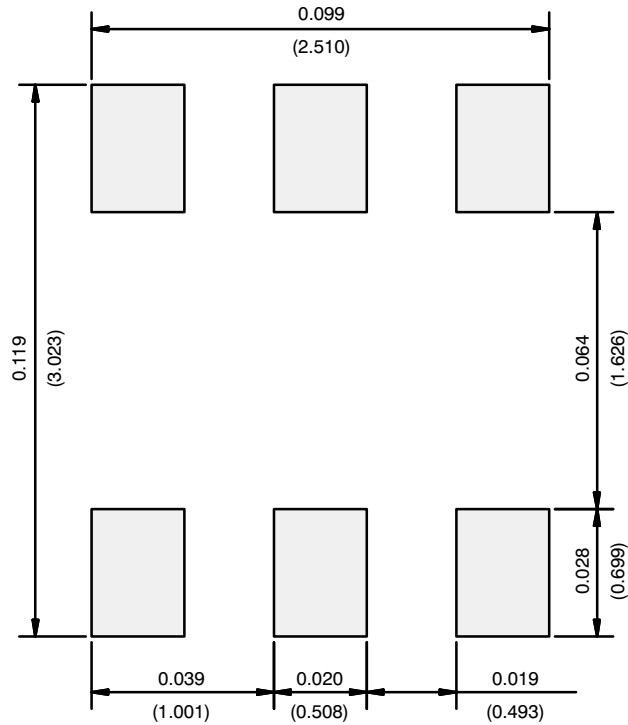


FIGURE 4. Si3434DV

## RECOMMENDED MINIMUM PADS FOR TSOP-6



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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