Low-Voltage Single Asymmetrical SPDT Analog Switch

DESCRIPTION

The DG2020 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 DG2020 is ideal for portable and battery powered applications requiring high performance and efficient use of board space.

The DG2020 is built on Vishay Siliconix's low voltage JI2 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.

FEATURES

- Low voltage operation (2.7 V to 5.5 V)
- Low on-resistance - R_{ON}
  - NO = 0.8 Ω
  - NC = 1.2 Ω
- Low power consumption
- TTL/CMOS compatible
- TSOP-6 package

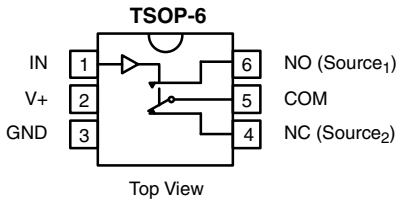
BENEFITS

- Reduced power consumption
- Simple logic interface
- High accuracy
- Reduce board space

APPLICATIONS

- Cellular phones
- Communication systems
- Portable test equipment
- Battery operated systems

FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



Device Marking: E3xxx

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	DG2020DV

ABSOLUTE MAXIMUM RATINGS			
PARAMETERS	CONDITIONS	LIMITS	UNIT
V+	Reference to GND	- 0.3 to 6	V
IN, COM, NC, NO[a]	Reference to GND	- 0.3 to (V+ + 0.3 V)	
Continuous Current (any terminal)	Reference to GND	± 50	mA
Peak Current (pulsed at 1 ms, 10 % duty cycle)	Reference to GND	± 200	
Storage Temperature (D suffix)	Reference to GND	- 65 to + 125	°C
TSOP-6[c]	Power Dissipation (packages)[b]	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/C above 25 °C.

SPECIFICATION (V+ = 3 V)							
PARAMETER	SYMBOL	TEST CONDITION UNLESS OTHERWISE SPECIFIED, V+ = 3 V, ± 10 %, V_{IN} = 0.4 V or 2 V[e]	TEMP.[a]	LIMITS (- 40 °C TO 85 °C) MIN.[b]	TYP.[c]	MAX.[b]	UNIT
Analog Signal Range[d]	V_{NO}, V_{NC}, V_{COM}		Full	0	-	V+	V
On-Resistance	$R_{ON(NO)}$	V+ = 2.7 V, V_{COM} = 1.5 V, I_{NO}, I_{NC} = 100 mA	Room	-	1.4	2	Ω
			Full	-	1.5	2.1	
	$R_{ON(NC)}$		Room	-	2.2	3.2	
			Full	-	2.3	3.3	
R_{ON} Flatness[d]	$R_{ON(NO)}$ Flatness	V+ = 2.7 V, V_{COM} = 0 V to V+, I_{NO}, I_{NC} = 100 mA	Room	-	0.42	-	
Switch Off Leakage Current[f]	$I_{NO(off)}$, $I_{NC(off)}$	V+ = 3.3 V, V_{NO}, V_{NC} = 1 V/3 V, V_{COM} = 3 V/1 V	Room	- 2.3	-	2.3	nA
			Full	- 60	-	60	
	$I_{COM (off)}$		Room	- 2.3	-	2.3	
			Full	- 60	-	60	
Channel-On Leakage Current[f]	$I_{COM(on)}$	V+ = 3.3 V, V_{NO}, V_{NC} = V_{COM} = 1 V/3 V	Room	- 2.3	-	2.3	
			Full	- 60	-	60	
Digital Control							
Input High Voltage	V_{INH}		Full	2	-	-	V
Input Low Voltage	V_{INL}		Full	-	-	0.4	
Input Capacitance	C_{IN}		Full	-	3.7	-	pF
Input Current	I_{NL} or I_{NH}	V_{IN} = 0 or V+	Full	1	-	1	µA
Dynamic Characteristics							
Turn-On Time	$t_{ON(NO)}$	V_{NO} or V_{NC} = 2 V, R_L = 300 Ω, C_L = 35 pF	Room	-	6	10	µs
			Full	-	-	11	
	$t_{ON(NC)}$		Room	-	5	7	
			Full	-	-	8	
Turn-Off Time	$t_{OFF(NO)}$		Room	-	2	5	
			Full	-	-	5.5	
	$t_{OFF(NC)}$		Room	-	2	4	
			Full	-	-	4.5	
Break-Before-Make Time	t_d	V_{NO} or V_{NC} = 2 V, R_L = 300 Ω, C_L = 35 pF	Full	1	3	-	
Charge Injection[d]	Q_{INJ}	C_L = 1 nF, V_{GEN} = 0 V, R_{GEN} = 0 Ω	Room	-	1	-	pC
Off-Isolation[d]	QIRR	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz	Room	-	- 52	-	dB
Crosstalk[d]	X_{TALK}		Room	-	- 53	-	
NO, NC Off Capacitance[d]	$t_{ON(NO)}$	V_{IN} = 0 or V+, f = 1 MHz	Room	-	75	-	pF
	$t_{ON(NC)}$		Room	-	34	-	
Channel-On Capacitance[d]	$t_{OFF(NO)}$		Room	-	88	-	
	$t_{OFF(NC)}$		Room	-	95	-	
Power Supply							
Power Supply Range	V+		-	2.7	-	3.3	V
Power Supply Current	I+	V_{IN} = 0 or V+	Full	-	0.2	1	µA
Power Consumption	P_C		Full	-	-	3.3	µW

Notes

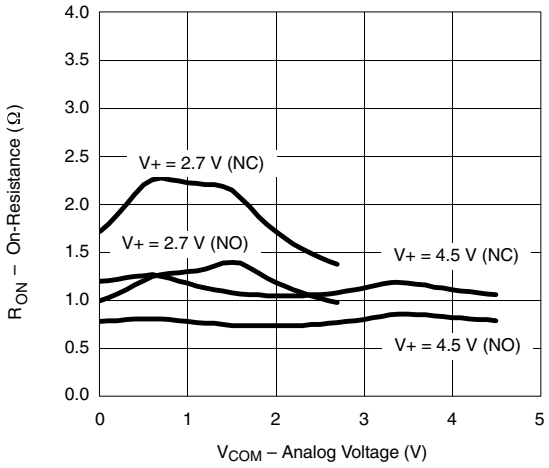
a. Room = 25 °C, Full = as determined by the operating suffix.
b. Typical values are for design aid only, not guaranteed nor subject to production testing.
c. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet.
d. Guarantee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

SPECIFICATION (V+ = 5 V)							
PARAMETER	SYMBOL	TEST CONDITION UNLESS OTHERWISE SPECIFIED, V+ = 5 V, ± 10 %, V_{IN} = 0.8 V or 2.4 V[e]	TEMP.[a]	LIMITS (- 40 °C TO 85 °C) MIN.[b]	TYP.[c]	MAX.[b]	UNIT
Analog Signal Range[d]	V_{NO}, V_{NC}, V_{COM}		Full	0	-	V+	V
On-Resistance	$R_{ON(NO)}$	V+ = 4.5 V, V_{COM} = 3 V, I_{NO}, I_{NC} = 100 mA	Room	-	0.8	1.1	Ω
			Full	-	0.9	1.2	
	$R_{ON(NC)}$		Room	-	1.2	1.6	
			Full	-	1.3	1.7	
R_{ON} Flatness[d]	$R_{ON(NO)}$ Flatness	V+ = 4.5 V, V_{COM} = 0 V to V+, I_{NO}, I_{NC} = 100 mA	Room	-	0.13	-	
Switch Off Leakage Current	$I_{NO(off)}$, $I_{NC(off)}$	V+ = 5.5 V, V_{NO}, V_{NC} = 1 V/4.5 V, V_{COM} = 4.5 V/1 V	Room	- 5.3	-	5.3	nA
			Full	- 98	-	98	
	$I_{COM (off)}$		Room	- 5.3	-	5.3	
			Full	- 98	-	98	
Channel-On Leakage Current	$I_{COM(on)}$	V+ = 5.5 V, V_{NO}, V_{NC} = V_{COM} = 1 V/4.5 V	Room	- 5.3	-	5.3	
			Full	- 98	-	98	
Digital Control							
Input High Voltage	V_{INH}		Full	2.4	-	-	V
Input Low Voltage	V_{INL}		Full	-	-	0.8	
Input Capacitance	C_{IN}		Full	-	3.5	-	pF
Input Current	I_{NL} or I_{NH}	V_{IN} = 0 or V+	Full	1	-	1	µA
Dynamic Characteristics							
Turn-On Time	$t_{ON(NO)}$	V_{NO} or V_{NC} = 3 V, R_L = 300 Ω, C_L = 35 pF	Room	-	3	6	µs
			Full	-	-	6.5	
	$t_{ON(NC)}$		Room	-	2	5	
			Full	-	-	5.5	
Turn-Off Time	$t_{OFF(NO)}$		Room	-	1	4	
			Full	-	-	4.5	
	$t_{OFF(NC)}$		Room	-	1	3	
			Full	-	-	3.5	
Break-Before-Make Time	t_d	V_{NO} or V_{NC} = 3 V, R_L = 300 Ω, C_L = 35 pF	Full	0.3	1.5	-	
Charge Injection[d]	Q_{INJ}	C_L = 1 nF, V_{GEN} = 0 V, R_{GEN} = 0 Ω	Room	-	5	-	pC
Off-Isolation[d]	QIRR	R_L = 50 Ω, C_L = 5 pF, f = 1 MHz	Room	-	- 53	-	dB
Crosstalk[d]	X_{TALK}		Room	-	- 54	-	
NO, NC Off Capacitance[d]	$t_{ON(NO)}$	V_{IN} = 0 or V+, f = 1 MHz	Room	-	65	-	pF
	$t_{ON(NC)}$		Room	-	32	-	
Channel-On Capacitance[d]	$t_{OFF(NO)}$		Room	-	90	-	
	$t_{OFF(NC)}$		Room	-	95	-	
Power Supply							
Power Supply Range	V+			4.5	-	5.5	V
Power Supply Current	I+	V_{IN} = 0 or V+	Full	-	0.2	1	µA
Power Consumption	P_C		Full	-	-	5.5	µW

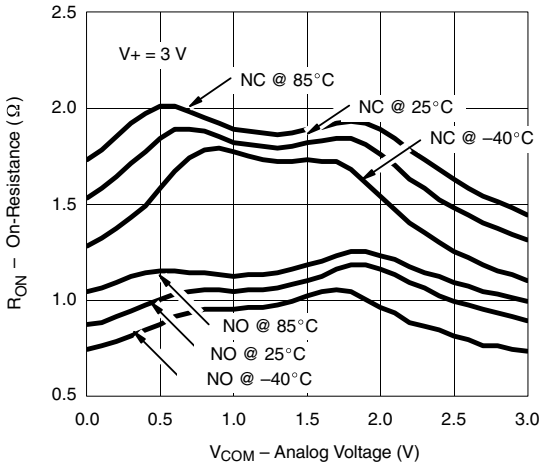
Notes

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

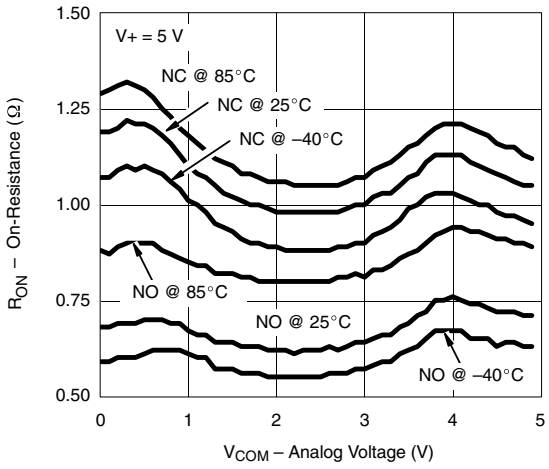
TYPICAL CHARACTERISTICS (T_A = 25 °C, unless otherwise noted)



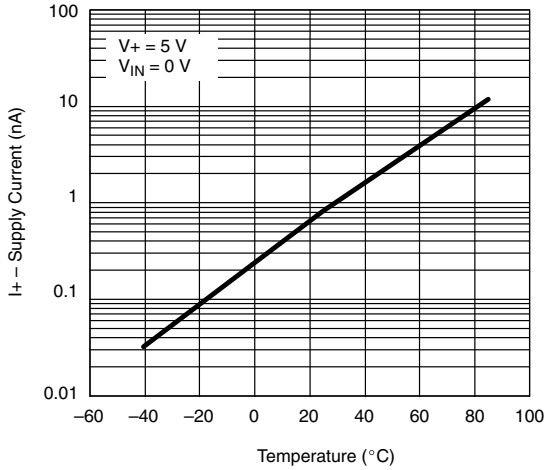
R_{ON} vs. V_{COM} and Supply Voltage



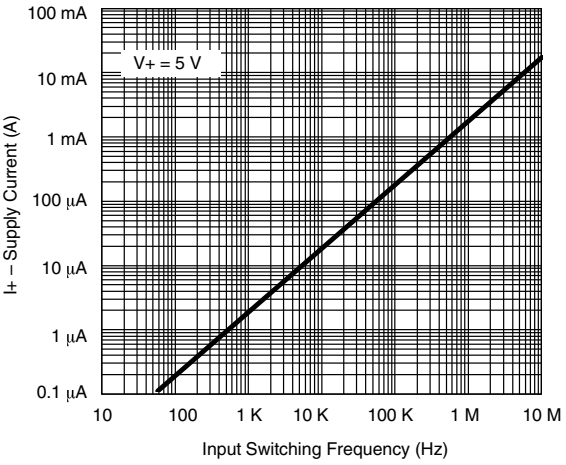
R_{ON} vs. Analog Voltage and Temperature



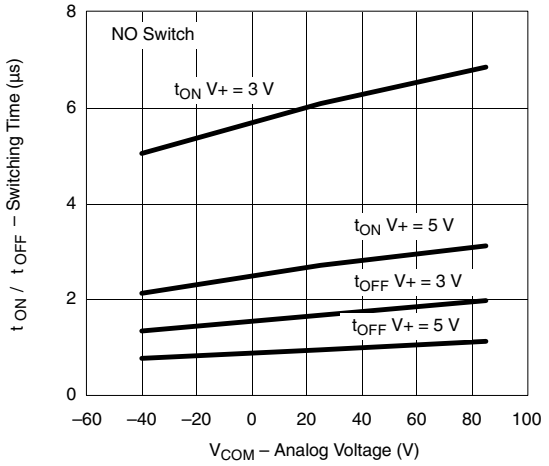
R_{ON} vs. Analog Voltage and Temperature



Supply Current vs. Temperature

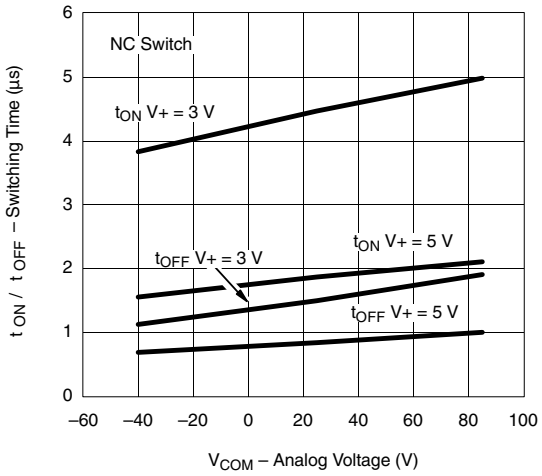


Supply Current vs. Input Switching Frequency

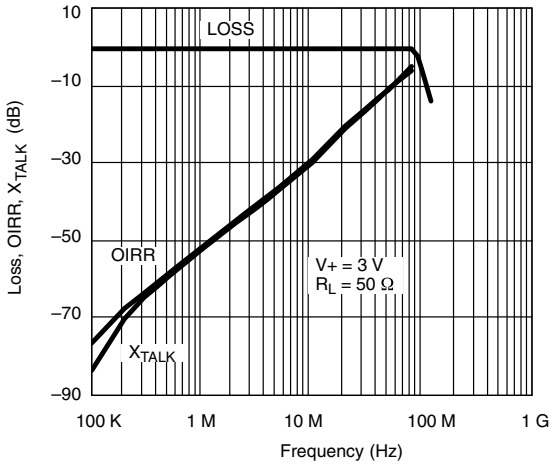


Switching Time vs. Temperature and Supply Voltage

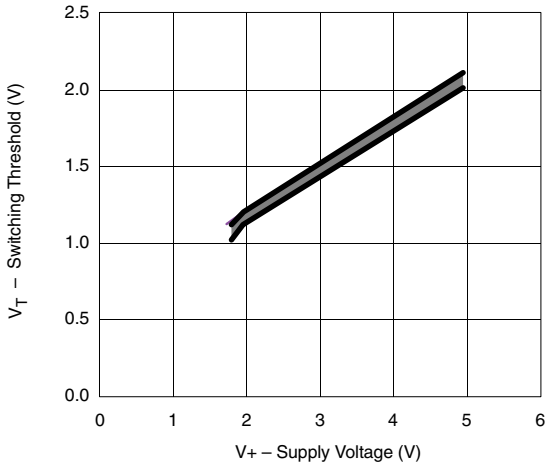
TYPICAL CHARACTERISTICS (T_A = 25 °C, unless otherwise noted)



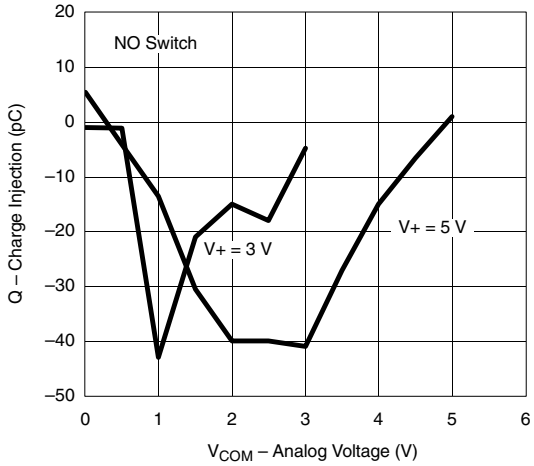
Switching Time vs. Temperature and Supply Voltage



Insertion Loss, Off-Isolation Crosstalk vs. Frequency

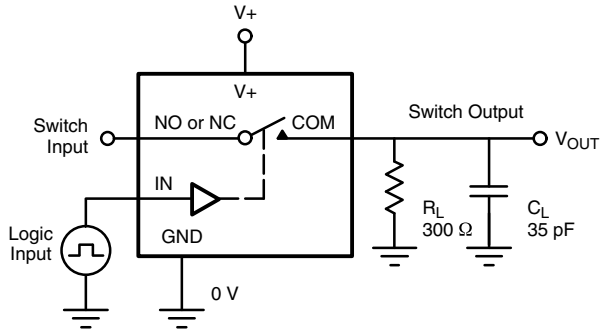


Switching Threshold vs. Supply Voltage



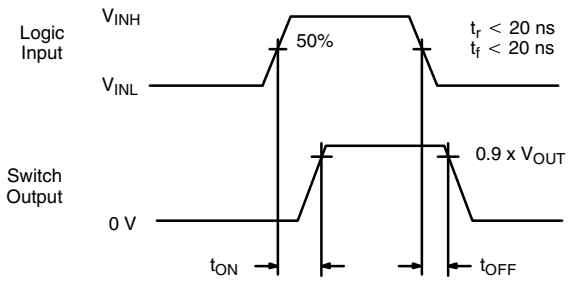
Charge Injection vs. Analog Voltage

TEST CIRCUITS



C_L (includes fixture and stray capacitance)

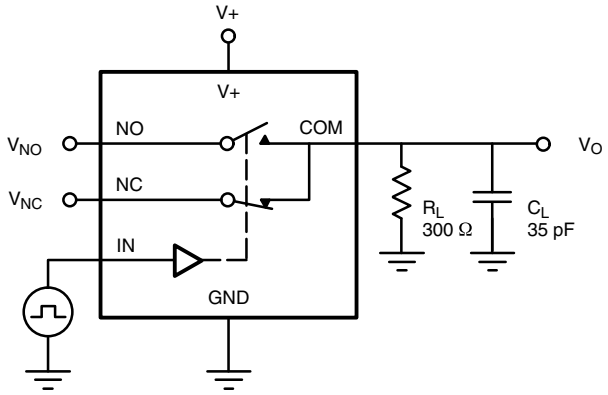
$$V_{OUT} = V_{COM}\left(\frac{R_L}{R_L + R_{ON}}\right)$$



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

Fig. 1 - Switching Time

TEST CIRCUITS



C_L (includes fixture and stray capacitance)

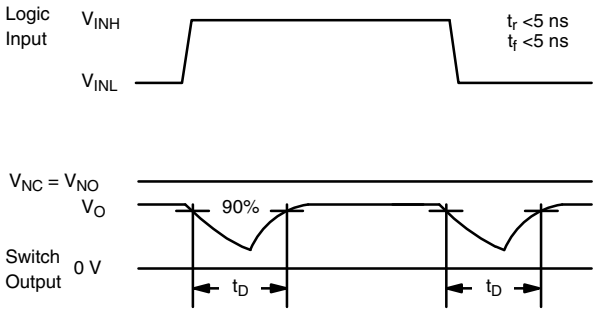
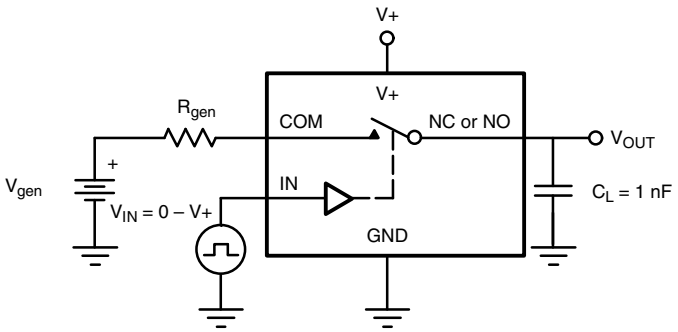
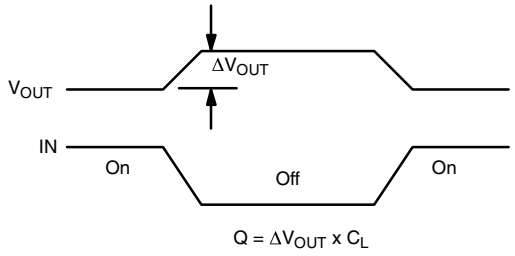


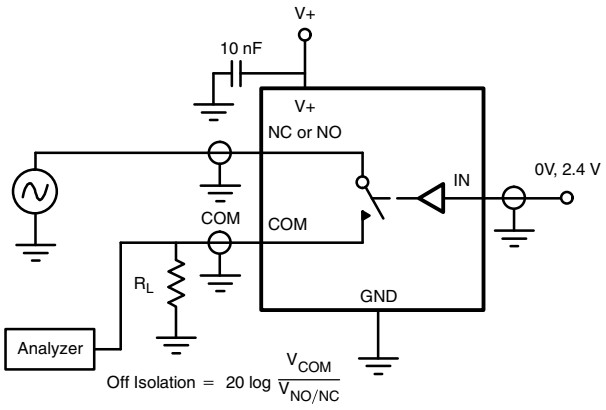
Fig. 2 - Break-Before-Make Interval





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

Fig. 3 - Charge Injection



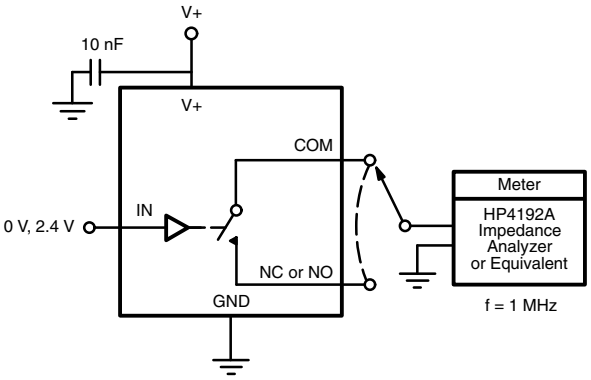


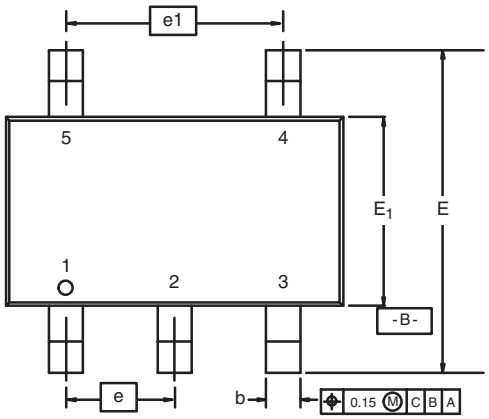
Fig. 4 - Off-Isolation

Fig. 5 - Channel off/on Capacitance

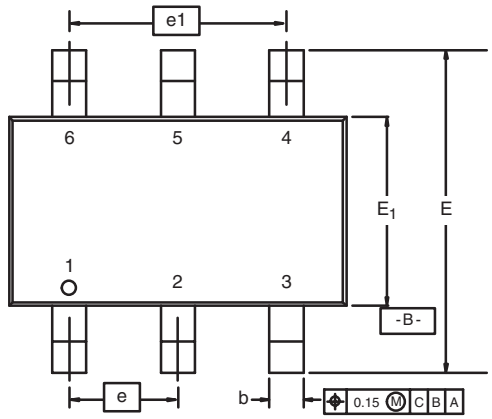
Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see www.vishay.com/ppg?71676.

TSOP: 5/6–LEAD

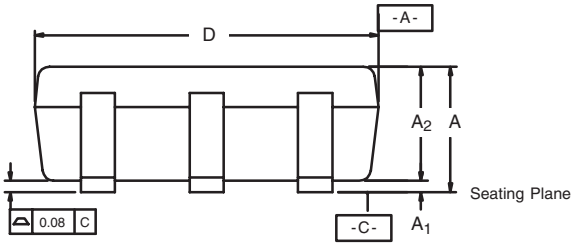
JEDEC Part Number: MO-193C

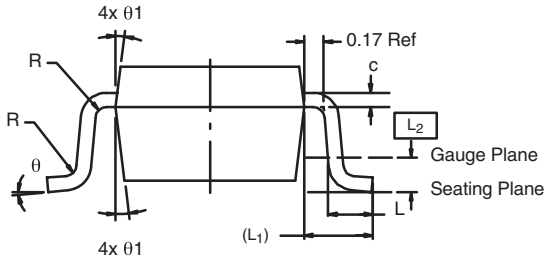


5-LEAD TSOP



6-LEAD TSOP





Dim	MILLIMETERS			INCHES		
	Min	Nom	Max	Min	Nom	Max
A	0.91	-	1.10	0.036	-	0.043
A_1	0.01	-	0.10	0.0004	-	0.004
A_2	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_1	1.55	1.65	1.70	0.061	0.065	0.067
e	0.95 BSC			0.0374 BSC		
e_1	1.80	1.90	2.00	0.071	0.075	0.079
L	0.32	-	0.50	0.012	-	0.020
L_1	0.60 Ref			0.024 Ref		
L_2	0.25 BSC			0.010 BSC		
R	0.10	-	-	0.004	-	-
θ	0°	4°	8°	0°	4°	8°
θ_1	7° Nom			7° Nom		
ECN: C-06593-Rev. I, 18-Dec-06 DWG: 5540						

Mounting LITTLE FOOT® 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 made 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.

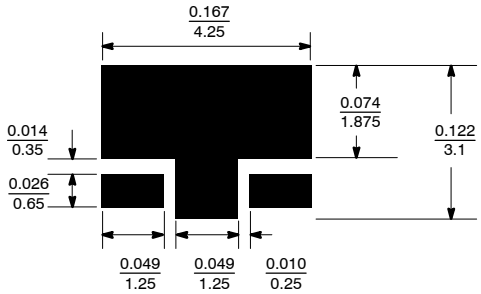


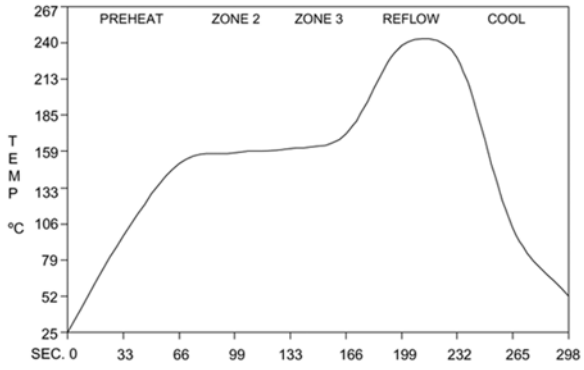
FIGURE 1. Recommended Copper Spreading Footprint

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

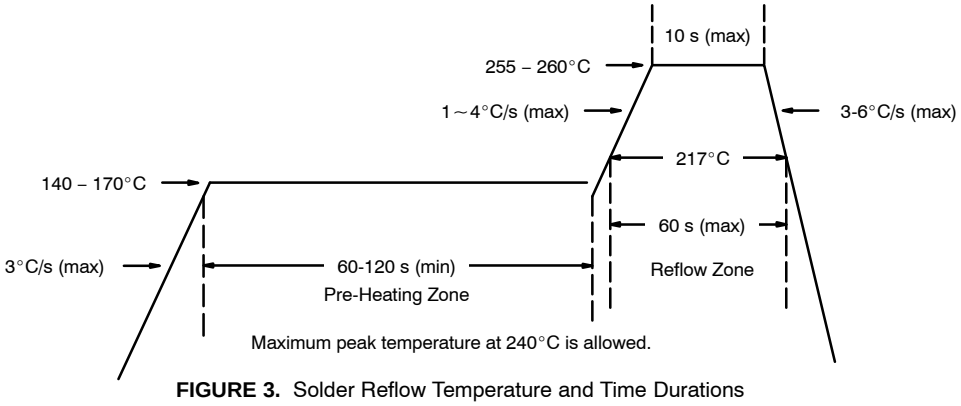


FIGURE 3. Solder Reflow Temperature and Time Durations

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).

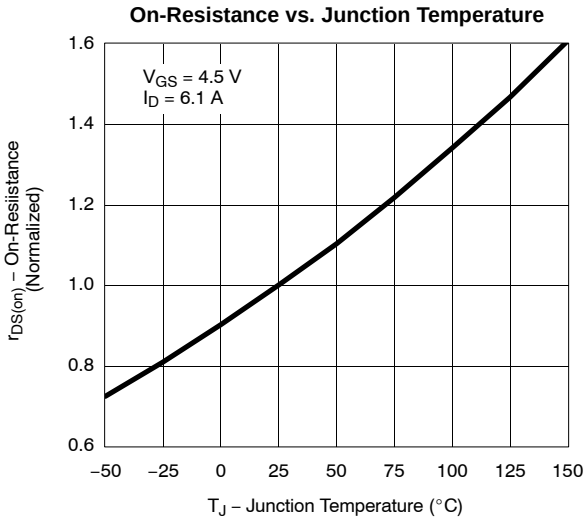
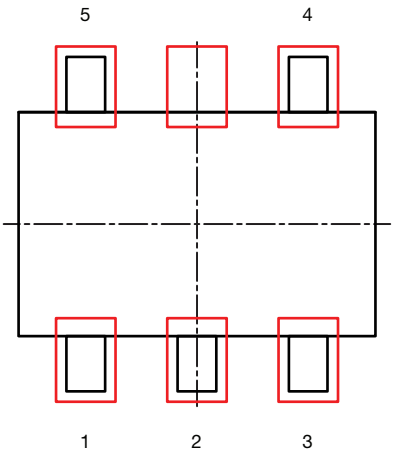
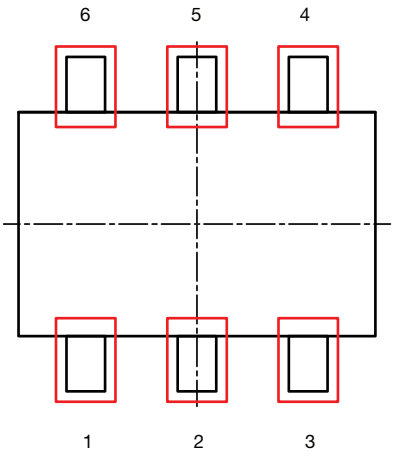


FIGURE 4. Si3434DV

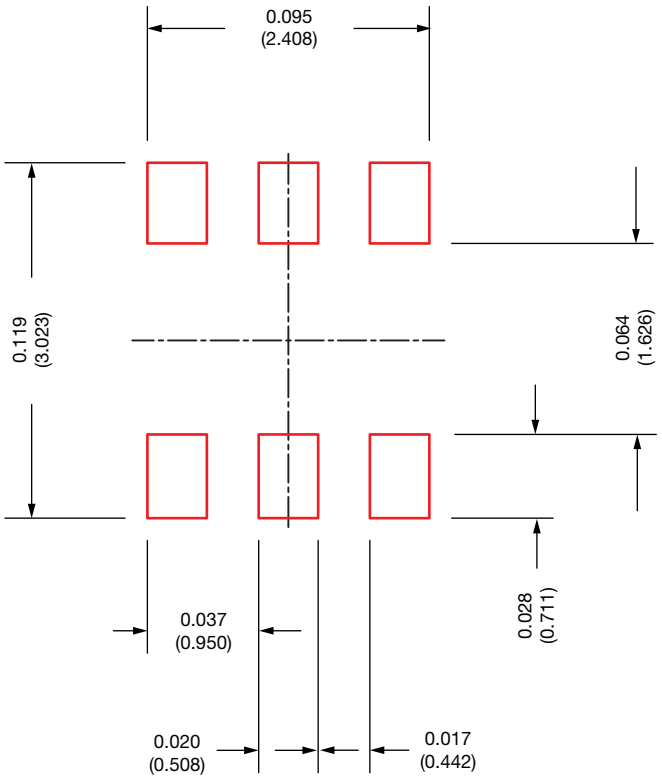
Recommended Land Pattern For TSOP-5L / TSOP-6L



TSOP-5L



TSOP-6L



Note

- All dimensions are in inches (millimeter)

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