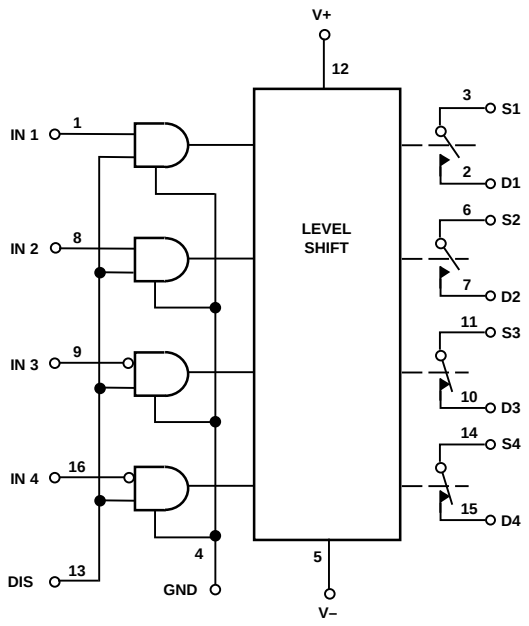
Quad SPST JFET Analog Switch

SW06

FEATURES

- Two Normally Open and Two Normally Closed SPST Switches with Disable
- Switches Can Be Easily Configured as a Dual SPDT or a DPDT
- Highly Resistant to Static Discharge Destruction
- Higher Resistance to Radiation than Analog Switches Designed with MOS Devices
- Guaranteed R_{ON} Matching: 10% max
- Guaranteed Switching Speeds
  - T_{ON} = 500 ns max
  - T_{OFF} = 400 ns max
- Guaranteed Break-Before-Make Switching
- Low "ON" Resistance: 80 Ω max
- Low R_{ON} Variation from Analog Input Voltage: 5%
- Low Total Harmonic Distortion: 0.01%
- Low Leakage Currents at High Temperature
  - T_A = +125°C: 100 nA max
  - T_A = +85°C: 30 nA max
- Digital Inputs TTL/CMOS Compatible and Independent of V+
- Improved Specifications and Pin Compatible to LF-11333/13333
- Dual or Single Power Supply Operation
- Available in Die Form

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The SW06 is a four channel single-pole, single-throw analog switch that employs both bipolar and ion-implanted FET devices. The SW06 FET switches use bipolar digital logic inputs which are more resistant to static electricity than CMOS devices. Ruggedness and reliability are inherent in the SW06 design and construction technology.

Increased reliability is complemented by excellent electrical specifications. Potential error sources are reduced by minimizing "ON" resistance and controlling leakage currents at high temperatures. The switching FET exhibits minimal R_{ON} variation over a 20 V analog signal range and with power supply voltage changes. Operation from a single positive power supply voltage is possible. With V+ = 36 V, V– = 0 V, the analog signal range will extend from ground to +32 V.

PNP logic inputs are TTL and CMOS compatible to allow the SW06 to upgrade existing designs. The logic "0" and logic "1" input currents are at microampere levels reducing loading on CMOS and TTL logic.

REV. A

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 617/329-4700 **Fax: 617/326-8703**

SW06–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (@ V+ = +15 V, V– = –15 V and T_A = +25°C, unless otherwise noted)

Parameter	Symbol	Conditions	SW06B Min	SW06B Typ	SW06B Max	SW06F Min	SW06F Typ	SW06F Max	SW06G Min	SW06G Typ	SW06G Max	Units
"ON" RESISTANCE	R_{ON}	V_S = 0 V, I_S = 1 mA V_S = ±10 V, I_S = 1 mA		60 65	80 80		60 65	100 100		100 100	150 150	Ω
R_{ON} MATCH BETWEEN SWITCHES	R_{ON} Match	V_S = 0 V, I_S = 100 μA[1]		5	10		5	20			20	%
ANALOG VOLTAGE RANGE	V_A	I_S = 1 mA[2] I_S = 1 mA[2]	+10 –10	+11 –15		+10 –10	+11 –15		+10 –10	+11 –15		V
ANALOG CURRENT RANGE	I_A	V_S = ±10 V	10	15		7	12		5	10		mA
ΔR_{ON} VS. APPLIED VOLTAGE	ΔR_{ON}	–10 V ≤ V_S ≤ 10 V, I_S = 1.0 mA		5	15		10	20		10	20	%
SOURCE CURRENT IN "OFF" CONDITION	$I_{S(OFF)}$	V_S = 10 V, V_D = –10 V[3]		0.3	2.0		0.3	2.0		0.3	10	nA
DRAIN CURRENT IN "OFF" CONDITION	$I_{D(OFF)}$	V_S = 10 V, V_D = –10 V[3]		0.3	2.0		0.3	2.0		0.3	10	nA
SOURCE CURRENT IN "ON" CONDITION	$I_{S(ON)+}$ $I_{D(ON)}$	V_S = V_D = ±10 V[3]		0.3	2.0		0.3	2.0		0.3	10	nA
LOGICAL "1" INPUT VOLTAGE	V_{INH}	Full Temperature Range[2, 4]	2.0			2.0			2.0			V
LOGICAL "0" INPUT VOLTAGE	V_{INL}	Full Temperature Range[2, 4]			0.8			0.8			0.8	V
LOGICAL "1" INPUT CURRENT	I_{INH}	V_{IN} = 2.0 V to 15.0 V[5]			5			5			10	μA
LOGICAL "0" INPUT	I_{INL}	V_{IN} = 0.8 V		1.5	5.0		1.5	5.0		1.5	10.0	μA
TURN-ON TIME	t_{ON}	See Switching Time Test Circuit[4, 6]		340	500		340	600		340	700	ns
TURN-OFF TIME	t_{OFF}	See Switching Time Test Circuit[4, 6]		200	400		200	400		200	500	ns
BREAK-BEFORE-MAKE TIME	t_{ON}–t_{OFF}	Note 7	50	140		50	140		50	140		ns
SOURCE CAPACITANCE	$C_{S(OFF)}$	V_S = 0 V[3]		7.0			7.0			7.0		pF
DRAIN CAPACITANCE	$C_{D(OFF)}$	V_S = 0 V[3]		5.5			5.5			5.5		pF
CHANNEL "ON" CAPACITANCE	$C_{D(ON)+}$ $C_{S(ON)}$	V_S = V_D = 0 V[3]		15			15			15		pF
"OFF" ISOLATION	$I_{SO(OFF)}$	V_S = 5 V rms, R_L = 680 Ω, C_L = 7 pF, f = 500 kHz[3]		58			58			58		dB
CROSSTALK	C_T	V_S = 5 V rms, R_L = 680 Ω, C_L = 7 pF, f = 500 kHz[3]		70			70			70		dB
POSITIVE SUPPLY CURRENT	I+	All Channels "OFF", DIS = "0"[3]		5.0	6.0		5.0	9.0		6.0	9.0	mA
NEGATIVE SUPPLY CURRENT	I–	All Channels "OFF", DIS = "0"[3]		3.0	5.0		4.0	7.0		4.0	7.0	mA
GROUND CURRENT	I_G	All Channels "ON" or "OFF"[3]		3.0	4.0		3.0	4.0		3.0	5.0	mA

ELECTRICAL CHARACTERISTICS

(@ V+ = +15 V, V– = –15 V, –55°C ≤ T_A ≤ +125°C for SW06BQ, –40°C ≤ T_A ≤ +85°C for SW06FQ and –40°C ≤ T_A ≤ +85°C for SW06GP/GS, unless otherwise noted)

Parameter	Symbol	Conditions	SW06B			SW06F			SW06G			Units
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
TEMPERATURE RANGE	T_A	Operating	–55		+125	–25		+85	0		70	°C
"ON" RESISTANCE	R_{ON}	V_S = 0 V, I_S = 1.0 mA V_S = ±10 V, I_S = 1.0 mA		75 80	110 110		75 80	125 125		75 80	175 175	Ω
ΔR_{ON} MATCH BETWEEN SWITCHES	R_{ON} Match	V_S = 0 V, I_S = 100 µA[1]		6	20		6	25		10		%
ANALOG VOLTAGE RANGE	V_A	I_S = 1.0 mA[2] I_S = 1.0 mA[2]	+10 –10	+11 –15		+10 –10	+11 –15		+10 –10	+11 –15		V
ANALOG CURRENT RANGE	I_A	V_S = ±10 V	7	12		5	11			11		mA
ΔR_{ON} WITH APPLIED VOLTAGE	ΔR_{ON}	–10 V ≤ V_S ≤ 10 V, I_S = 1.0 mA		10			12			15		%
SOURCE CURRENT IN "OFF" CONDITION	$I_{S(OFF)}$	V_S = 10 V, V_D = –10 V T_A = Max Operating Temp[3, 9]			60			30			60	nA
DRAIN CURRENT IN "OFF" CONDITION	$I_{D(OFF)}$	V_S = 10 V, V_D = –10 V T_A = Max Operating Temp[3, 9]			60			30			60	nA
LEAKAGE CURRENT IN "ON" CONDITION	$I_{S(ON)+}$ $I_{D(ON)}$	V_S = V_D = ±10 V T_A = Max Operating Temp[3, 9]			100			30			60	nA
LOGICAL "1" INPUT CURRENT	I_{INH}	V_{IN} = 2.0 V to 15.0 V[5]			10			10			15	µA
LOGICAL "0" INPUT CURRENT	I_{INL}	V_{IN} = 0.8 V		4	10		4	10		5	15	µA
TURN-ON TIME	t_{ON}	See Switching Time Test Circuit[4, 8]		440	900		500	900			1000	ns
TURN-OFF TIME	t_{OFF}	See Switching Time Test Circuit[4, 8]		300	500		330	500			500	ns
BREAK-BEFORE-MAKE TIME	t_{ON}–t_{OFF}	Note 7		70			70			50		ns
POSITIVE SUPPLY CURRENT	I+	All Channels "OFF," DIS = "0"[3]			9.0			13.5			13.5	mA
NEGATIVE SUPPLY CURRENT	I–	All Channels "OFF," DIS = "0"[3]			7.5			10.5			10.5	mA
GROUND CURRENT	I_G	All Channels "ON" or "OFF"[3]			6.0			7.5			7.5	mA

NOTES

[1]V_S = 0 V, I_S = 100 µA. Specified as a percentage of $R_{AVERAGE}$ where: $R_{AVERAGE} = \frac{R_{ON1} + R_{ON2} + R_{ON3} + R_{ON4}}{4}$.

[2]Guaranteed by R_{ON} and leakage tests. For normal operation maximum analog signal voltages should be restricted to less than (V+) –4 V.
[3]Switch being tested ON or OFF as indicated, V_{INH} = 2.0 V or V_{INL} = 0.8 V, per logic truth table.
[4]Also applies to disable pin.
[5]Current tested at V_{IN} = 2.0 V. This is worst case condition.
[6]Sample tested.
[7]Switch is guaranteed by design to provide break-before-make operation.
[8]Guaranteed by design.
[9]Parameter tested only at T_A = +125°C for military grade device.

Specifications subject to change without notice.

SW06

WAFER TEST LIMITS (@ V+ = +15 V, V– = –15 V, T_A = +25°C, unless otherwise noted)

Parameter	Symbol	Conditions	SW06N Limit	SW06G Limit	Units
"ON" RESISTANCE	R_{ON}	$-10\ V \le V_A \le 10\ V$, $I_S \le 1$ mA	80	100	Ω max
R_{ON} MATCH BETWEEN SWITCHES	R_{ON} Match	V_A = 0 V, $I_S \le 100$ µA	15	20	% max
ΔR_{ON} VS. V_A	ΔR_{ON}	$-10\ V \le V_A \le 10\ V$, $I_S \le 1$ mA	10	20	% max
POSITIVE SUPPLY CURRENT	I+	Note 1	6.0	9.0	mA max
NEGATIVE SUPPLY CURRENT	I–	Note 1	5.0	7.0	mA max
GROUND CURRENT	I_G	Note 1	4.0	4.0	mA max
ANALOG VOLTAGE RANGE	V_A	I_S = 1 mA	±10.0	±10.0	V min
LOGIC "1" INPUT VOLTAGE	V_{INH}	Note 2	2.0	2.0	V min
LOGIC "0" INPUT VOLTAGE	V_{INL}	Note 2	0.8	0.8	V max
LOGIC "0" INPUT CURRENT	I_{INL}	$0\ V \le V_{IN} \le 0.8\ V$	5.0	5.0	µA max
LOGIC "1" INPUT CURRENT	I_{INH}	$2.0\ V \le V_{IN} \le 15\ V$[3]	5	5	µA max
ANALOG CURRENT RANGE	I_A	V_S = ±10 mV	10	7	mA min

NOTE
Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

TYPICAL ELECTRICAL CHARACTERISTICS (@ V+ = +15 V, V– = –15 V, T_A = +25°C, unless otherwise noted)

Parameter	Symbol	Conditions	SW06N Typical	SW06G Typical	Units
"ON" RESISTANCE	R_{ON}	$-10\ V \le V_A \le 10\ V$, $I_S \le 1$ mA	60	60	Ω
TURN-ON TIME	t_{ON}		340	340	ns
TURN-OFF TIME	t_{OFF}		200	200	ns
DRAIN CURRENT IN "OFF" CONDITION	$I_{D(OFF)}$	V_S = 10 V, V_D = –10 V	0.3	0.3	nA
"OFF" ISOLATION	$I_{SO(OFF)}$	f = 500 kHz, R_L = 680 Ω	58	58	dB
CROSSTALK	C_T	f = 500 kHz, R_L = 680 Ω	70	70	dB

NOTES
[1]Power supply and ground current specified for switch "ON" or "OFF."
[2]Guaranteed by R_{ON} and leakage tests.
[3]Current tested at V_{IN} = 2.0 V. This is worst case condition.

ABSOLUTE MAXIMUM RATINGS[1]

Operating Temperature Range
- SW06BQ, BRC ..... –55°C to +125°C
- SW06FQ ..... –40°C to +85°C
- SW06GP, GS ..... –40°C to +85°C

Storage Temperature Range ..... –65°C to +150°C
Lead Temperature (Soldering, 60 sec) ..... +300°C
Maximum Junction Temperature ..... +150°C
V+ Supply to V– Supply ..... +36 V
V+ Supply to Ground ..... +36 V
Logic Input Voltage ..... (–4 V or V–) to V+ Supply
Analog Input Voltage Range
- Continuous ..... V– Supply to V+ Supply +20 V

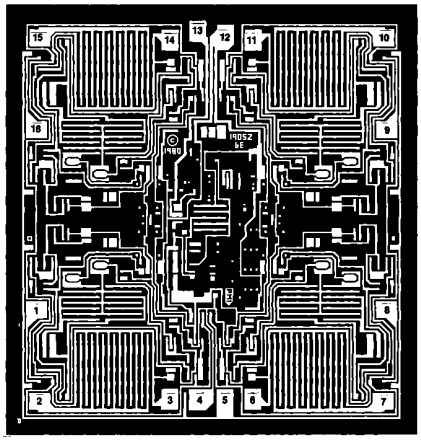
Maximum Current Through
- Any Pin Including Switch ..... 30 mA

Package Type	θ_{JA}[2]	θ_{JC}	Units
16-Pin Hermetic DIP (Q)	100	16	°C/W
16-Pin Plastic DIP (P)	82	39	°C/W
20-Contact LCC (RC)	98	38	°C/W
16-Pin SOL (S)	98	30	°C/W

NOTES
[1]Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.
[2]θ_{JA} is specified for worst case mounting conditions, i.e., θ_{JA} is specified for device in socket for Cerdip, P-DIP, and LCC packages; θ_{JA} is specified for device soldered to printed circuit board for SO package.

DICE CHARACTERISTICS

Die Size 0.101 × 0.097 inch, 9797 sq. mils
(2.565 × 2.464 mm, 6320 sq. mm)



ORDERING GUIDE

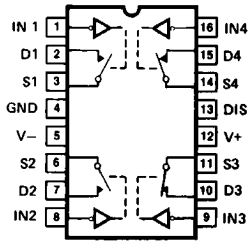
Model	Temperature Range	Package Description	Package Option
SW06BQ	–55°C to +125°C	Cerdip	Q-16
SW06BRC	–55°C to +125°C	LCC	E-20A
SW06FQ	–40°C to +85°C	Cerdip	Q-16
SW06GP	–40°C to +85°C	Plastic DIP	N-16
SW06GS	–40°C to +85°C	SOL	R-16

TRUTH TABLE

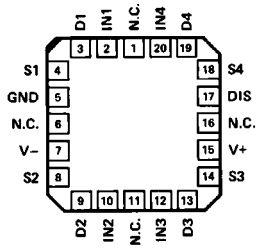
Disable Input	Logic Input	Switch State Channels 1 & 2	Switch State Channels 3 & 4
0	X	OFF	OFF
1 or NC	0	OFF	ON
1 or NC	1	ON	OFF

PIN CONNECTIONS

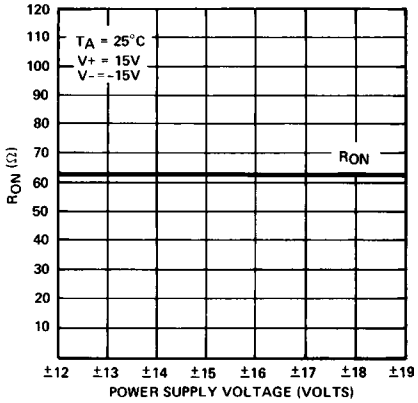
16-Pin DIP (Q or P-Suffix)
16-Pin SOL (S-Suffix)



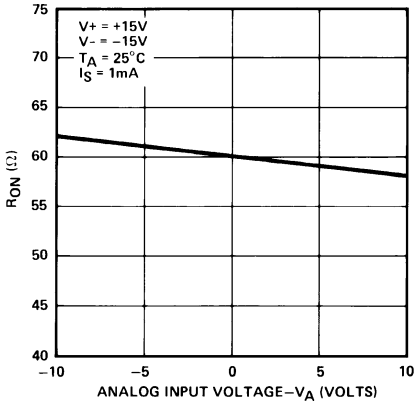
SW06BRC/883
LCC Package
(RC-Suffix)



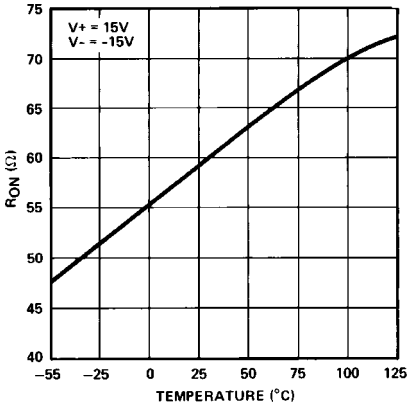
SW06–Typical Performance Characteristics



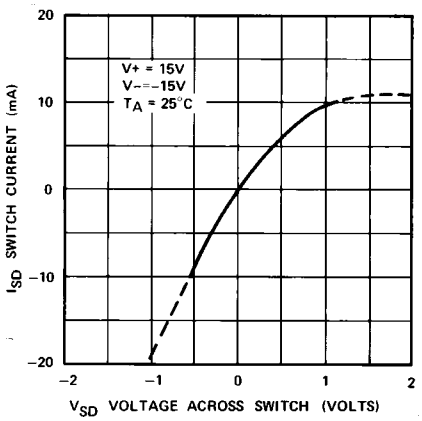
"ON" Resistance vs. Power Supply Voltage



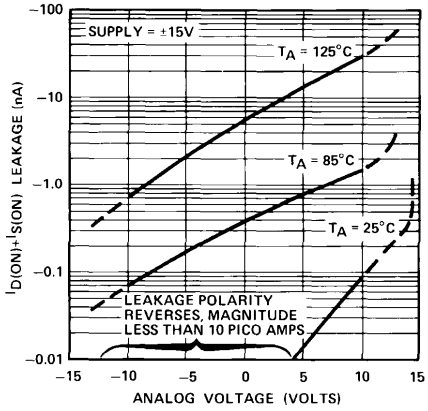
"ON" Resistance vs. Analog Voltage



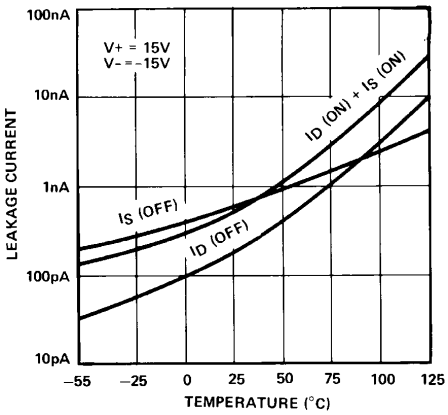
R_{ON} vs. Temperature



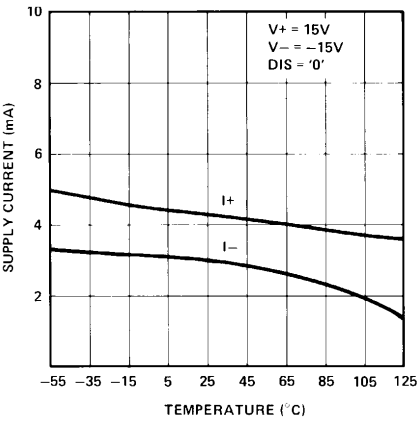
Switch Current vs. Voltage



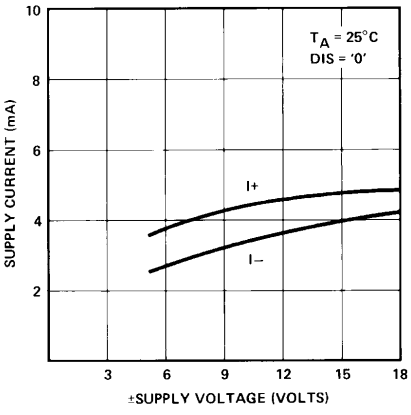
Leakage Current vs. Analog Voltage



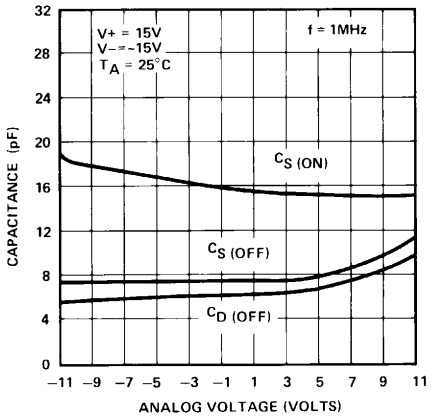
Leakage Current vs. Temperature



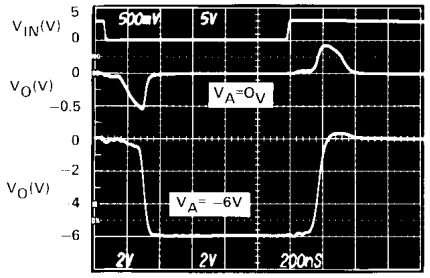
Supply Current vs. Temperature



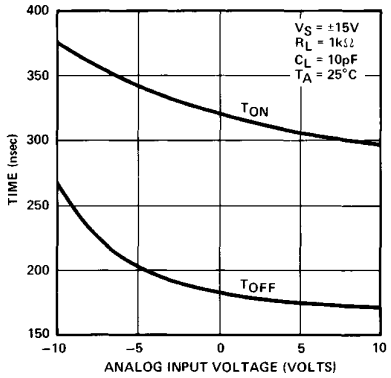
Supply Current vs. Supply Voltage



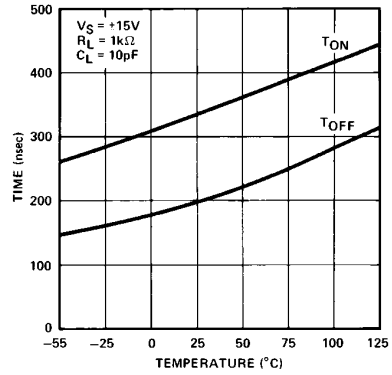
Switch Capacitance vs. Analog Voltage



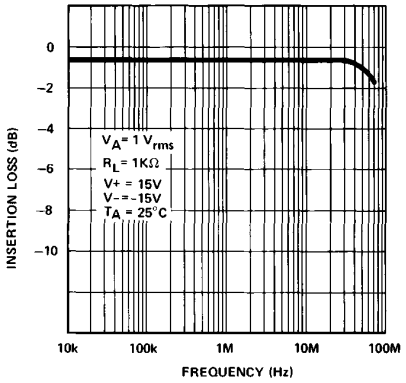
T_{ON}/T_{OFF} Switching Response



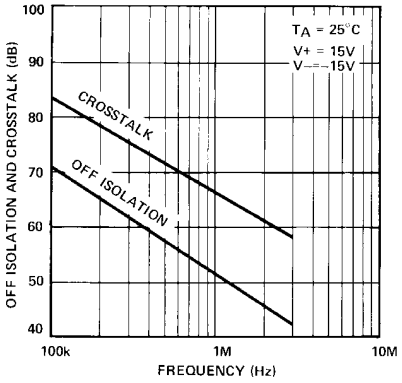
Switching Time vs. Analog Voltage



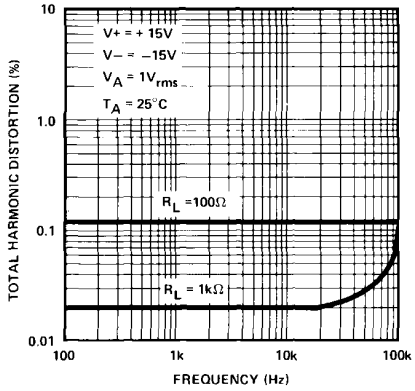
Switching Time vs. Temperature



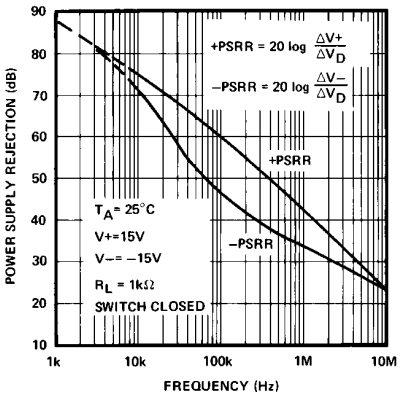
Insertion Loss vs. Frequency



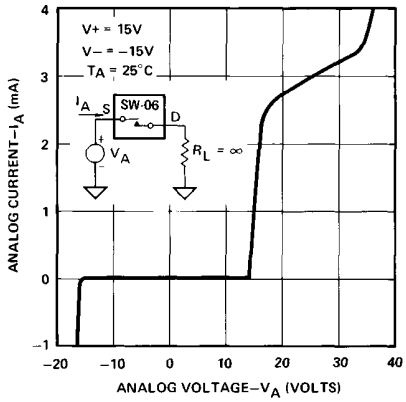
Crosstalk and "OFF" Isolation vs. Frequency



Total Harmonic Distortion

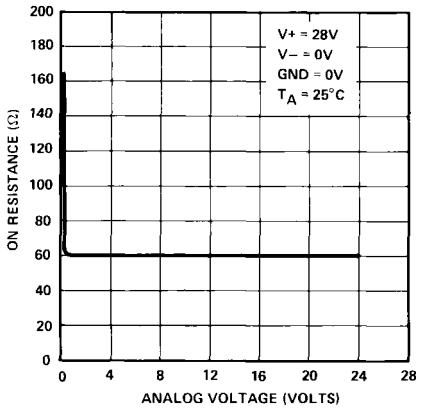


Power Supply Rejection vs. Frequency

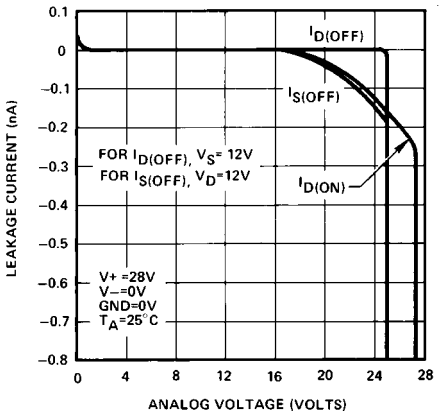


Overvoltage Characteristics

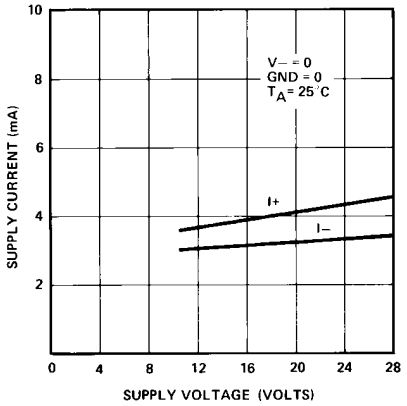
SW06–Typical Performance Characteristics (Operating and Single Supply)



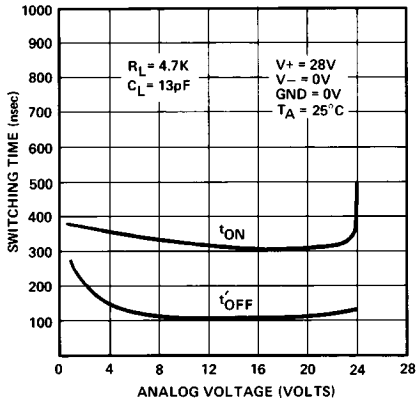
"On" Resistance vs. Analog Voltage



Leakage Current vs. V_{ANALOG}



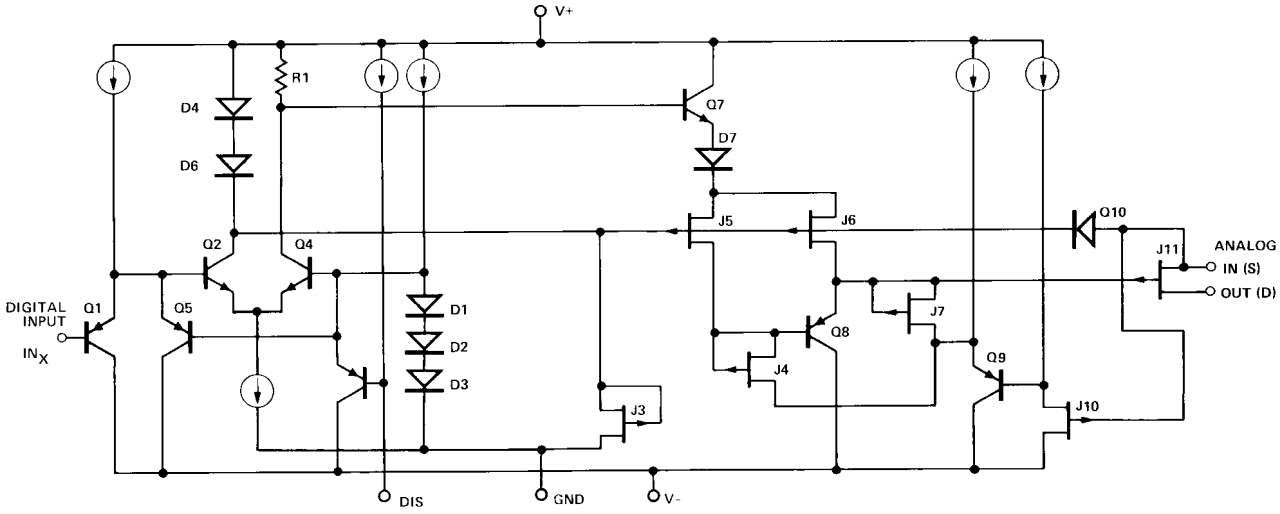
Supply Current vs. Supply Voltage



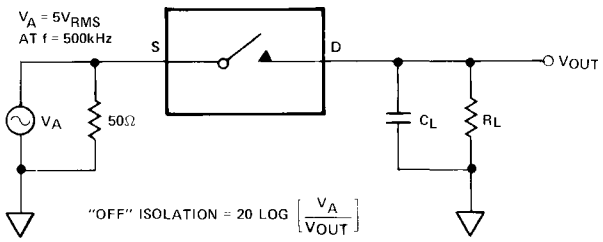
Switching Time vs. Supply Voltage

NOTE

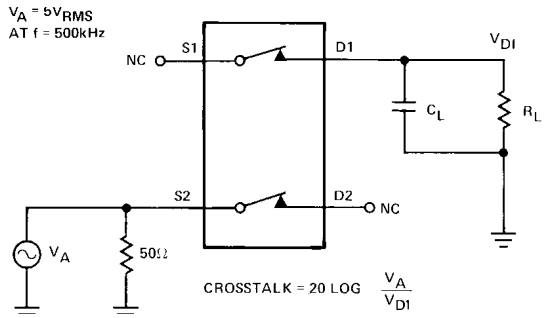
These single-supply-operation characteristic curves are valid when the negative power supply V– is tied to the logic ground reference pin "GND." TTL input compatibility is still maintained when "GND" is the same potential as the TTL ground. t_{OFF} is measured from 50% of logic input waveform to 0.9 V_O. The analog voltage range extends from 0 V to V+ –4 V; the switch will no longer respond to logic control when V_A is within 4 volts of V+.



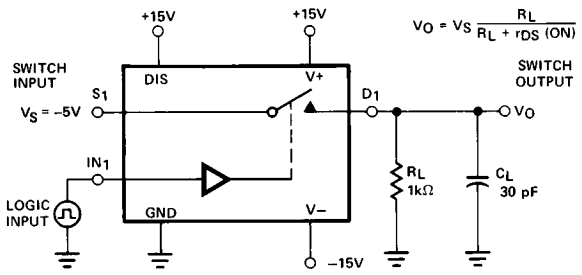
Simplified Schematic Diagram (Typical Switch)

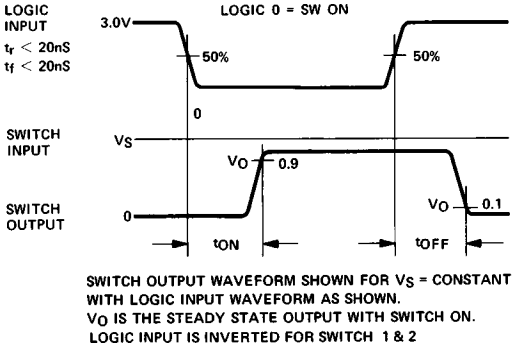


"Off" Isolation Test Circuit



Crosstalk Test Circuit





Switching Time Test Circuit

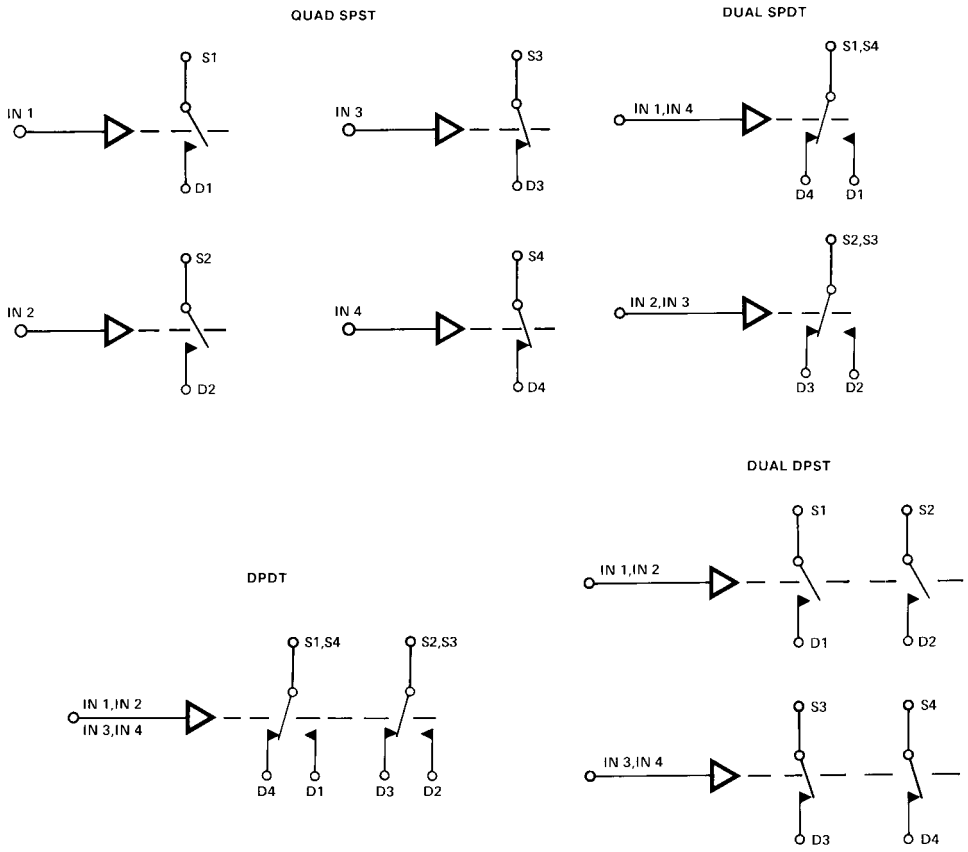


Figure 1. Functional Applications of SW06

APPLICATIONS INFORMATION

The single analog switch product configures, by appropriate pin connections, into four switch applications. As shown in Figure 1, the SW06 connects as a QUAD SPST, a DUAL SPDT, a DUAL DPST, or a DPDT analog switch. This versatility increases further when taking advantage of the disable input (DIS) which turns all switches OFF when taken active low.

Ion-implantation of the JFET analog switch achieves low ON resistance and tight channel-to-channel matching. Combining the low ON resistance and low leakage currents results in a worst case voltage error figure V_{ERROR} @ +125°C = $I_{D(ON)} \times R_{SD(ON)}$ = 100 nA × 100 Ω = 11 microvolts. This amount of error is negligible considering dissimilar-metal thermally-induced offsets will be in the 5 to 15 microvolt range.

LOGIC INPUTS

The logic inputs (IN_X) and disable input (DIS) are referenced to a TTL logic threshold value of two forward diode drops (1.4 V at +25°C) above the GND terminal. These inputs use PNP transistors which draw maximum current at a logic "0" level and drops to a leakage current of a reverse biased diode as the logic input voltage raises above 1.4 volts. Any logic input voltage greater than 2.0 volts becomes logic "1," less than 0.8 volts becomes logic "0" resulting in full TTL noise immunity not available from similar CMOS input analog switches. The PNP transistor inputs require such low input current that the SW06 approaches fan-ins of CMOS input devices. These bipolar logic inputs exceed any CMOS input circuit in resistance to static voltage and radiation susceptibility. No damage will occur to the SW06 if logic high voltages are present when the SW06 power supplies are OFF. When the V+ and V– supplies are OFF, the logic inputs present a reverse bias diode loading to active logic inputs. Input logic thresholds are independent of V+ and V– supplies making single V+ supply operation possible by simply connecting GND and V– together to the logic ground supply.

ANALOG VOLTAGE AND CURRENT

ANALOG VOLTAGE

These switches have constant ON resistance for analog voltages from the negative power supply (V–) to within 4 volts of the positive power supply. This characteristic shown in the plots results in good total harmonic distortion, especially when compared to CMOS analog switches that have a 20 to 30 percent variation in ON resistance versus analog voltage. Positive analog input voltage should be restricted to 4 volts less than V+ assuring the switch remains open circuit in the OFF state. No increase in switch ON resistance occurs when operating at supply voltages less than ±15 volts (see plot). Small signals have a 3 dB down frequency of 70 MHz (see insertion loss versus frequency plot).

ANALOG CURRENT

The analog switches in the ON state are JFETs biased in their triode region and act as switches for analog current up to the I_A specification (see plot of I_{DS} vs V_{DS}). Some applications require pulsed currents exceeding the I_A spec. For example, an integrator reset switch discharging a shunt capacitor will produce a peak current of $I_{A(PEAK)} = V_{CAP}/R_{DS(ON)}$. In this application, it is best to connect the source to the most positive end of the capacitor, thereby achieving the lowest switch resistance and

fastest reset times. The switch can easily handle any amount of capacitor discharge current subject only to the maximum heat dissipation of the package and the maximum operating junction temperature from which repetition can be established.

SWITCHING

Switching time t_{ON} and t_{OFF} characteristics are plotted versus V_{ANALOG} and temperature. In all cases, t_{OFF} is designed faster than t_{ON} to ensure a break-before-make interval for SPDT and DPDT applications. The disable input (DIS) has the same switching times (t_{ON} and t_{OFF}) as the logic inputs (IN_X).

Switching transients occurring at the source and drain contacts results from ac coupling of the switching FETs gate-to-source and gate-to-drain coupling capacitance. The switch turn ON will cause a negative going spike to occur and the turn OFF will cause a positive spike to occur. These spikes can be reduced by additional capacitance loading, lower values of R_L, or switching an additional switch (with its extra contact floating) to the opposite state connected to the spike sensitive node.

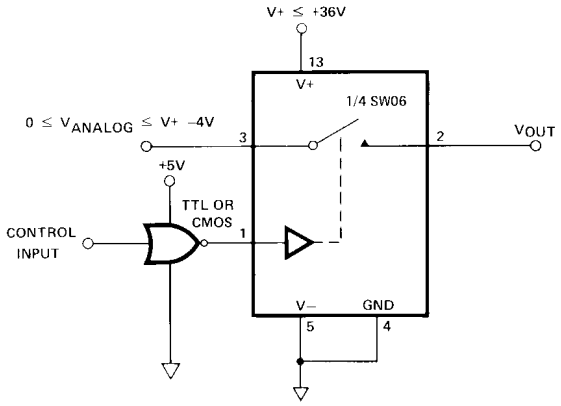
DISABLE NODE

This TTL compatible node is similar to the logic inputs IN_X but has an internal 2 µA current source pull-up. If disable is left unconnected, it will assume the logic "1" state, then the state of the switches is controlled only by the logic inputs IN_X.

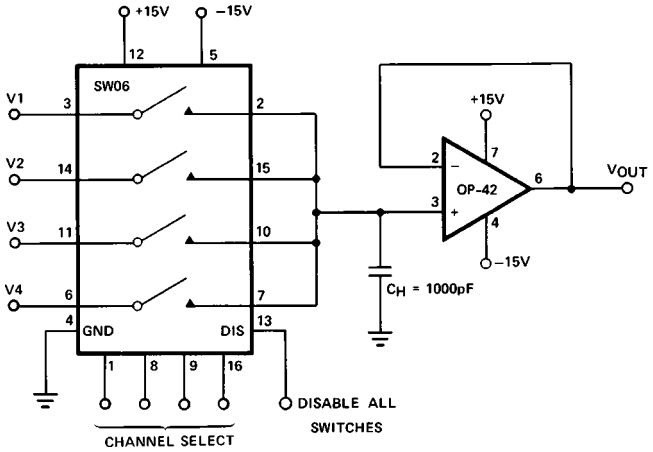
POWER SUPPLIES

This product operates with power supply voltages ranging from ±12 to ±18 volts; however, the specifications only guarantee device parameters with ±15 volt ±5% power supplies. The power supply sensitive parameters have plots to indicate effects of supply voltages other than ±15 volts.

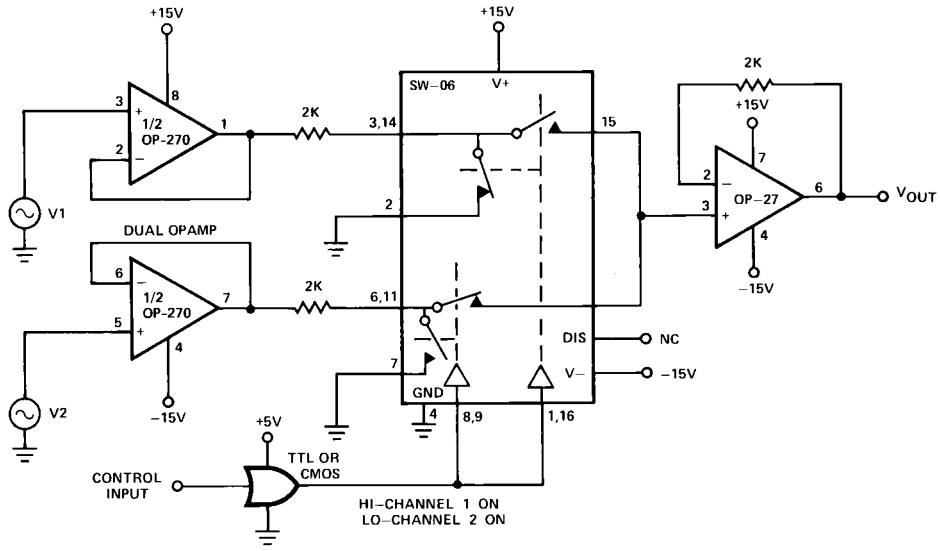
Typical Applications



Operation from Single Positive Power Supply



4-Channel Sample Hold Amplifier



THIS SWITCH ARRANGEMENT IMPROVES OFF ISOLATION BY 30dB

High Off Isolation Selector Switch (Shunt-Series Switch)