

Precision, Quad, SPST, Analog Switches
Features

- Low On-Resistance, (16Ω typ) Minimizes Distortion and Error Voltages
- Low On-Resistance Match Between Channels, <2Ω
- Guaranteed On-Resistance Flatness, <4Ω
- Low Charge Injection, <5pC typ.
- Improved Leakage Over Temperature, <2.5nA at +85°C
- ESD Rating >2000V per Method 3015.7
- Single-Supply Operation (+3V to +15V)
Bipolar-Supply Operation (±3V to ±8V)
- Low Power Consumption, <10μA
- TTL/CMOS Compatible

Applications

- Instrumentation
- Battery Powered Systems
- Audio Switching
- ±5V Data Acquisition Systems
- Sample-and-Hold Circuits
- Telecommunications Systems

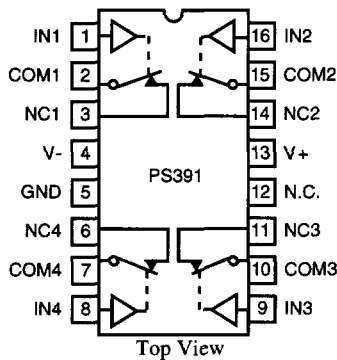
Description

The PS391/PS392/PS393 are improved, quad, single-pole single-throw (SPST) analog switches designed to operate with +3V to ±8V power supplies. The PS391 has four normally closed (NC) switches, the PS392 has four normally open (NO) switches. The PS393 has two NO and two NC switches. All three devices offer low leakage (<120pA typ) and fast switching speeds (t_{ON} <130ns). Power consumption is less than 1μA, ideal for battery-powered equipment.

With ±5V supplies, the PS391/PS392/PS393 guarantee <2Ω channel-to-channel matching, <30Ω on-resistance (R_{ON}), and <4Ω R_{ON} flatness over the specified range.

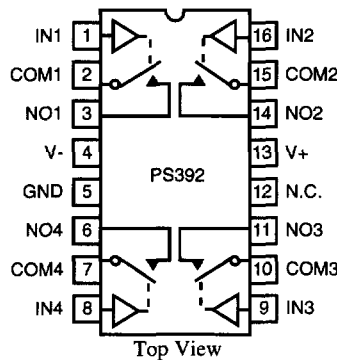
These switches are fully specified for single +5V operation, with <2Ω R_{ON} match, <45Ω R_{ON} , and <4Ω flatness.

For operation below 5V, the PI5A391A/PI5A392A/PI5A393A are also recommended.

Functional Diagrams, Pin Configurations, and Truth Tables


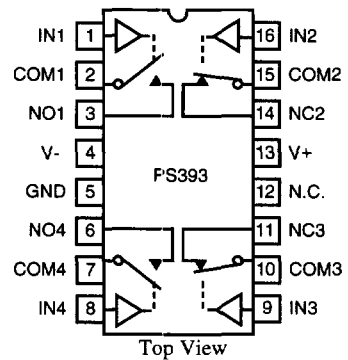
N.C. = No Connect.

PS391	
Logic	Switch
0	ON
1	OFF



Switches shown for logic "0" input

PS392	
Logic	Switch
0	OFF
1	ON



PS393		
Logic	Switches 1,4	Switches 2,3
0	OFF	ON
1	ON	OFF

Absolute Maximum Ratings

Voltages Referenced to V-

VCC	-0.3V to +17V
GND	-0.3V to +17V
GND	-0.3V to (V+) + 0.3V
V _{IN} , V _{COM} , V _{NC} , V _{NO} (Note 1)	(V-) -2V to V+ + 2V or 30mA, whichever occurs first
Current (any terminal)	30mA
Peak Current, COM, NO, NC (pulsed at 1ms, 10% duty cycle)	100mA
ESD per method 3015.7	>2000V

Thermal Information

Continuous Power Dissipation	
Plastic DIP (derate 10.5mW/°C above +70°C)	800mW
Narrow SO (derate 8.7mW/°C above +70°C)	650mW
Storage Temperature	-65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C

Note 1: Signals on NC, NO, COM, or IN exceeding V+ or V- are clamped by internal diodes. Limit forward diode current to maximum current rating

Caution: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied.

Electrical Specifications - Dual Supplies

(V± = ±5V ±10%, GND = 0V, V_{INH} = 2.4V, V_{INL} = 0.8V)

Parameter	Symbol	Conditions	Temp. (°C)	Min ⁽²⁾	Typ ⁽¹⁾	Max ⁽²⁾	Units
Analog Switch							
Analog Signal Range ⁽³⁾	V _{ANALOG}		Full	V-		V _{CC}	V
On Resistance	R _{ON}	V+ = 4.5V, V- = -4.5V I _{COM} = -10mA, V _{NO} or V _{NC} = +3.5V	25		16	30	Ω
			Full			40	
On-Resistance Match Between Channels ⁽⁴⁾	DR _{ON}	V+ = 5V, V- = -5V I _{COM} = -10mA, V _{NO} or V _{NC} = ±3.5V	25		0.2	2	Ω
			Full			4	
On-Resistance Flatness ⁽⁵⁾	R _{FLAT(ON)}	V+ = 5V, V- = -5V, I _{COM} = -10mA, V _{NO} or V _{NC} = ±3.5V	25		1	4	Ω
			Full			6	
NO or NC Off Leakage Current ⁽⁶⁾	I _{NO(OFF)} or I _{NC(OFF)}	V+ = 5.5V, V- = 5.5V, V _{COM} = ±4.5V, V _{NO} or V _{NC} = ±4.5V	25	-0.1	-0.0004	0.1	nA
			Full	-2.5		2.5	
COM Off Leakage Current ⁽⁶⁾	I _{COM(OFF)}	V+ = 5.5V, V- = -5.5V V _{COM} = ±4.5V, V _{NO} or V _{NC} = ±4.5V	25	-0.1	-0.001	0.1	nA
			Full	-2.5		2.5	
COM On Leakage Current ⁽⁶⁾	I _{COM(ON)}	V+ = 5.5V, V- = -5.5V, V _{COM} = ±4.5V V _{NO} or V _{NC} = ±4.5V	25	-0.2	0.002	0.2	nA
			Full	-5		5	

Electrical Specifications - Dual Supplies (continued)

($V_{\pm} = \pm 5V \pm 10\%$, $GND = 0V$, $V_{INH} = 2.4V$, $V_{INL} = 0.8V$)

Parameter	Symbol	Conditions	Temp (°C)	Min ⁽¹⁾	Typ ⁽²⁾	Max ⁽¹⁾	Units
Logic Input							
Input Current with Input Voltage High	I_{INH}	$I_N = 2.4V$, all others = 0.8V	Full	-0.5	0.005	0.5	μA
Input Current with Input Voltage Low	I_{INL}	$I_N = 0.8V$, all others = 2.4V		-0.5	0.005	0.5	
Dynamic							
Turn-On Time	t_{ON}	$V_{COM} = \pm 3V$, Figure 1	25		51	130	ns
			Full			175	
Turn-Off Time	t_{OFF}		25		29	75	
			Full			100	
Break Before-Make Time Delay	t_b	PS393 only, $R_L = 300\Omega$, $C_L = 35pF$, Figure 2	Full	10	20		
Charge Injection ⁽³⁾	Q	$C_L = 1nF$, $V_{OEN} = 0V$, $R_{OEN} = 0\Omega$, Figure 3			3	5	pC
Off Isolation	OIRR	$R_L = 50\Omega$, $C_L = 5pF$, $f = 1MHz$, Figure 4			-65		dB
Crosstalk	X_{TALK}	$R_L = 50\Omega$, $C_L = 5pF$, $f = 1MHz$, Figure 5			-90		
NC or NO Capacitance	$C_{(OFF)}$	$f = 1MHz$, Figure 6			12		pF
COM Off Capacitance	$C_{COM(OFF)}$	$f = 1MHz$, Figure 6			12		
COM On Capacitance	$C_{COM(ON)}$	$f = 1MHz$, Figure 7			25		
Supply							
Power-Supply Range	V_+ , V_-			-8		8	V
Positive Supply Current	I_+	$V_+ = 5.5V$, $V_- = -5.5V$, $V_{IN} = 0V$ or V_+ , all channels on or off	Full	-1		1	μA
Negative Supply Current	I_-		Full	-1		1	

Notes:

1. The algebraic convention, where the most negative value is a minimum and the most positive is a maximum, is used in this data sheet.
2. Typical values are for DESIGN AID ONLY, not guaranteed or subject to production testing.
3. Guaranteed by design
4. $\Delta R_{ON} = R_{ON \max} - R_{ON \min}$
5. Flatness is defined as the difference between the maximum and minimum value of on-resistance measured.
6. Leakage parameters are 100% tested at maximum rated hot temperature and guaranteed by correlation at +25°C.
7. Off Isolation = $20 \log_{10} [V_{COM} / (V_{NC} \text{ or } V_{NO})]$; V_{COM} = Output, V_{NC} , V_{NO} = input to off switch
8. Between any two switches.

Electrical Specifications - Single +5V Supply

($V_+ = +5V \pm 10\%$, $V_- = 0V$, $GND = 0V$, $V_{INH} = 2.4V$, $V_{INL} = 0.8V$)

Parameter	Description	Conditions	Temp (°C)	Min ⁽¹⁾	Typ ⁽²⁾	Max ⁽¹⁾	Units	
Analog Switch								
V_{COM}, V_{NO}, V_{NC}	Analog Switch Range ⁽³⁾			0		V_+	V	
R_{ON}	On-Resistance	$V_+ = 4.5V, I_{COM} = -10mA,$ V_{NO} or $V_{NC} = 3.5V$	25		23	45	Ω	
			Full			60		
DR_{ON}	On-Resistance Match Between Channels ⁽⁴⁾	$V_+ = 5V, I_{COM} = -1mA,$ V_{NO} or $V_{NC} = 3V$	25		0.3	2		
			Full			4		
$R_{FLAT(ON)}$	On-Resistance Flatness ^(3,5)	$V_+ = 5V, I_{COM} = -1mA,$ V_{NO} or $V_{NC} = 1V, 4V$	25		1	4		
			Full			6		
$I_{NO(OFF)}$ or $I_{NC(OFF)}$	NO or NC Off Leakage Current ⁽⁹⁾	$V_+ = 5.5V, V_{COM} = 0V,$ V_{NO} or $V_{NC} = 4.5V$	25	-0.1	0.0004	0.1	nA	
			Full	-2.5		2.5		
$I_{COM(OFF)}$	COM Off Leakage Current ⁽⁹⁾	$V_+ = 5.5V, V_{COM} = 0V,$ V_{NO} or $V_{NC} = 4.5V$	25	-0.1	-0.001	0.1		
			Full	-2.5		2.5		
$I_{COM(ON)}$	COM On Leakage Current ⁽⁹⁾	$V_+ = 5.5V, V_{COM} = 4.5V$	25	-0.2	0.002	0.2		
			Full	-5		5		
Dynamic								
t_{ON}	Turn-On Time	V_{NO} or $V_{NC} = 3V$	25		63	170	ns	
			Full			240		
t_{OFF}	Turn-Off Time		25		34	50		
			Full			100		
t_D	Break-Before-Make Time Delay ⁽³⁾		PS393 only, $R_L = 300\Omega, C_L = 35pF$	Full	10	20		
Q	Charge Injection ⁽³⁾		$C_L = 1nF, V_{GEN} = 0V,$ $R_{GEN} = 0V$, Figure 4	25		0		5
Supply								
I+	Positive Supply Current	$V_+ = 5.5V, V_{IN} = 0V$ or V_+ , all channels on or off	Full	-1		1	μA	
I-	Negative Supply Current		Full	-1		1		

Electrical Specifications - Single +3.3V Supply

(V+ = +3V to 3.6V, GND = 0V, V_{NH} = 2.4V, V_{INL} = 0.8V)

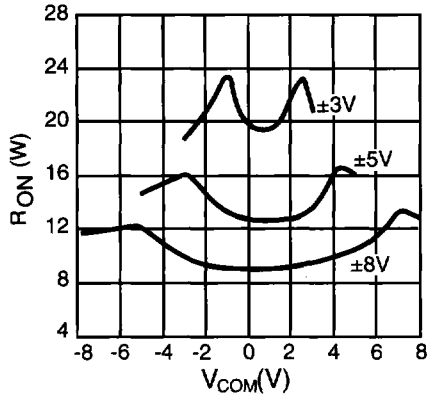
Parameter	Symbol	Conditions	Temp ^o C	Min ⁽²⁾	Typ ⁽²⁾	Max ⁽²⁾	Units
Analog Switch							
Analog Switch Range ⁽³⁾	V _{COM} , V _{NO} , V _{NC}			0		V+	V
Channel On-Resistance	R _{ON}	V+ = 3V, I _{COM} = -1mA, V _{NO} or V _{NC} = 1.5V	25		62	175	Ω
			Full			275	
Dynamic							
Turn-On-Time ⁽³⁾	t _{ON}	V _{NO} or V _{NC} = 1.5V	25		97	400	ns
			Full			500	
Turn-Off-Time ⁽³⁾	t _(OFF)	V _{NO} or V _{NC} = 1.5V	25		53	125	
			Full			175	
Break-Before-Make Time Delay ⁽³⁾	t _D	PS393 only, R _L = 300Ω, C _L = 35pF	25	20			
Charge Injection ⁽³⁾	Q	C _L = 1.0nF, V _{GEN} = 0V, R _{GEN} = 0Ω	Full		1	5	pC
Supply							
Positive Supply Current	I+	V+ = 3.6V, V _{IN} = 0V or V+, all channels on or off	Full	-1		1	μA
Negative Supply Current	I-			-1		1	

Notes:

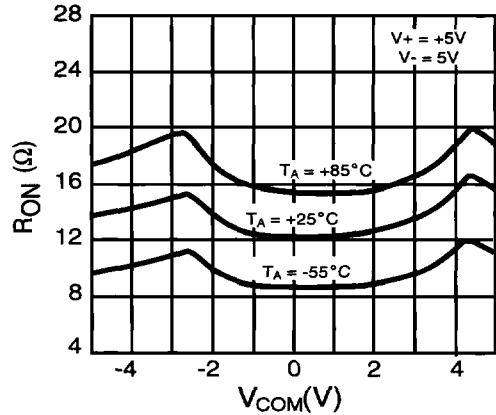
1. The algebraic convention, where the most negative value is a minimum and the most positive is a maximum, is used in this data sheet.
2. Typical values are for DESIGN AID ONLY, not guaranteed or subject to production testing.
3. Guaranteed by design
4. ΔR_{ON} = R_{ON} max - R_{ON} min
5. Flatness is defined as the difference between the maximum and minimum value of on-resistance measured.
6. Leakage parameters are 100% tested at maximum rated hot temperature and guaranteed by correlation at +25°C.
7. Off Isolation = 20log₁₀ [V_{COM} / (V_{NC} or V_{NO})], V_{COM} = Output, V_{NC}, V_{NO} = input to off switch
8. Between any two switches.
9. Leakage testing at single supply is guaranteed by testing with dual supplies.

Typical Operating Characteristics ($T_A = +25^\circ\text{C}$, unless otherwise noted)

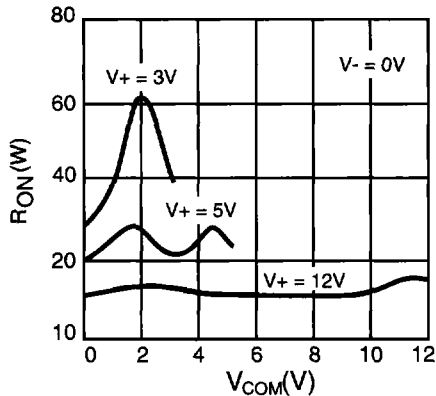
R_{ON} vs. V_{COM} & Supply Voltages



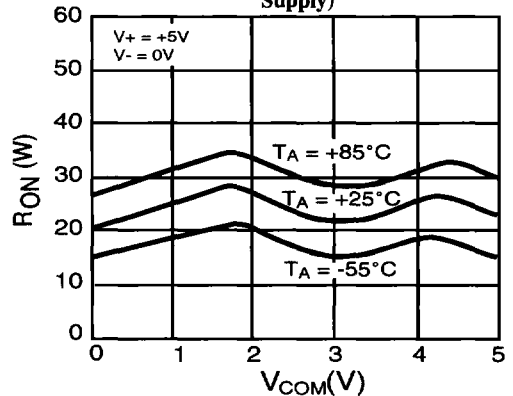
R_{ON} vs. V_{COM} & Supply Voltages



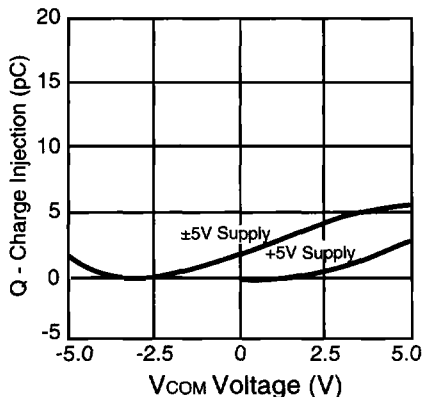
R_{ON} vs. V_{COM} (Single Supply)



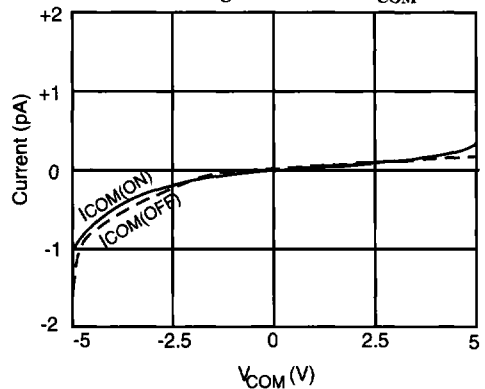
R_{ON} vs. V_{COM} and Temperature (Single Supply)

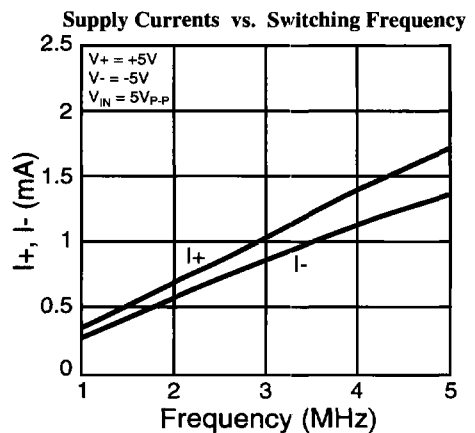
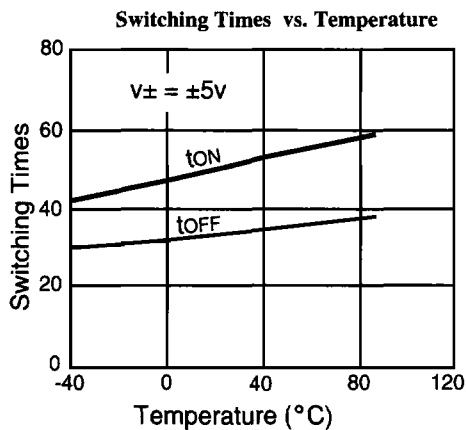
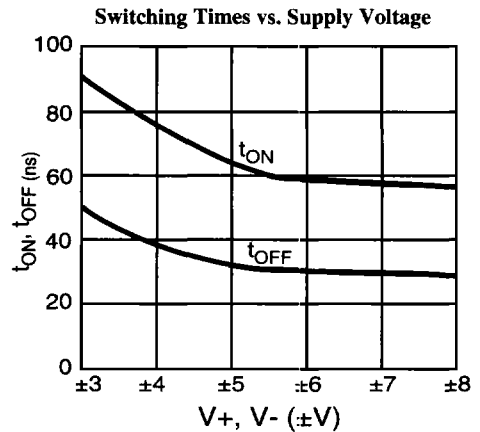
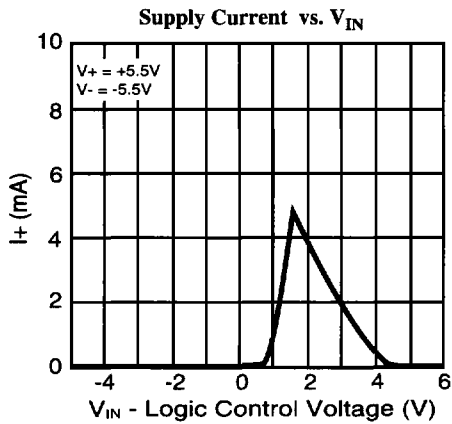
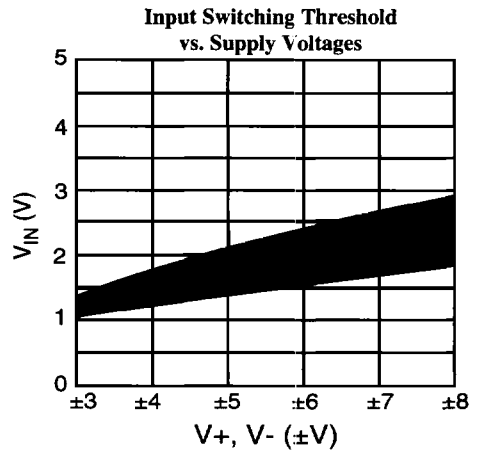
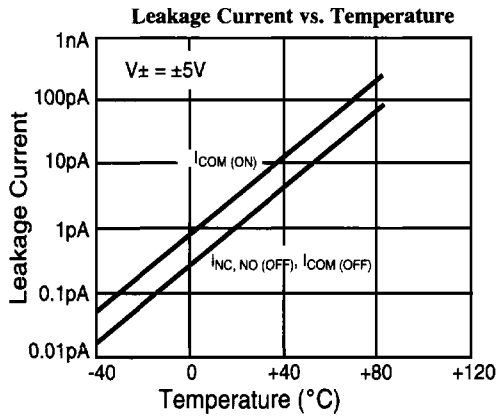


Charge Injection vs. Analog Voltage



Leakage Current vs. V_{COM}



Typical Operating Characteristics (continued)


Test Circuits/Timing Diagrams

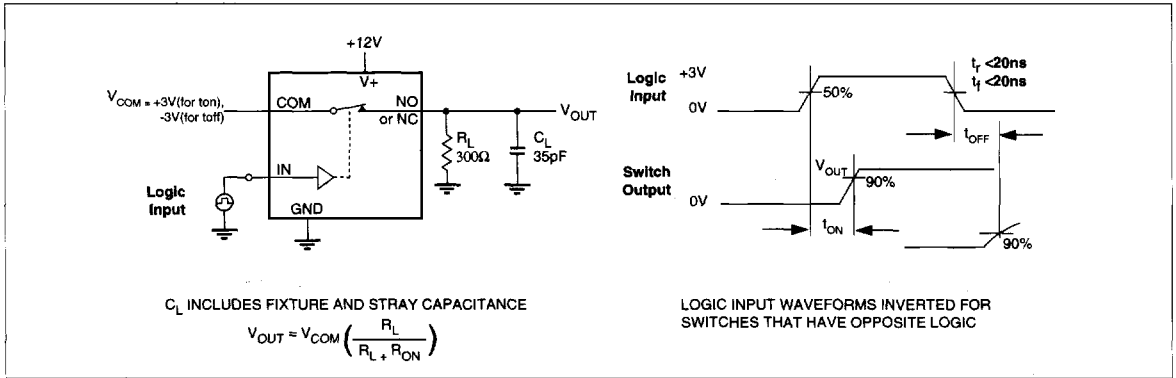


Figure 1. Switching Time

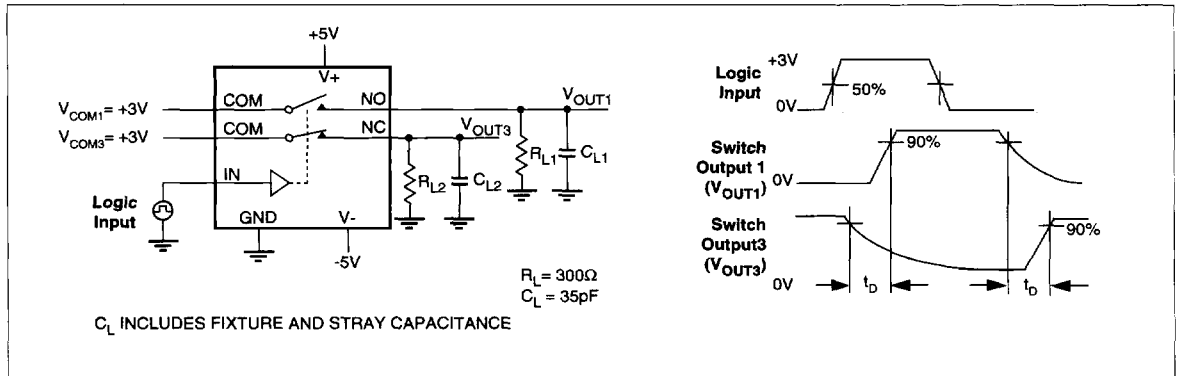


Figure 2. Break-Before-Make Interval (PS393 only)

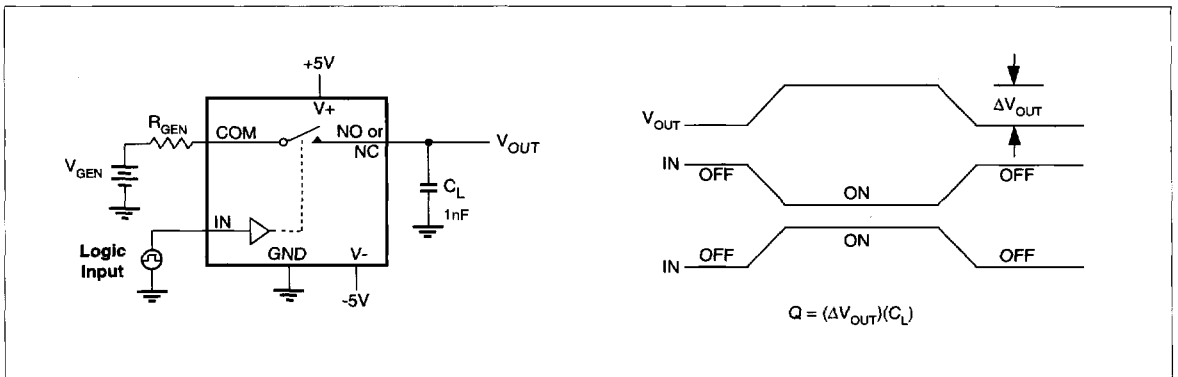


Figure 3. Charge Injection

Test Circuits/Timing Diagrams (continued)

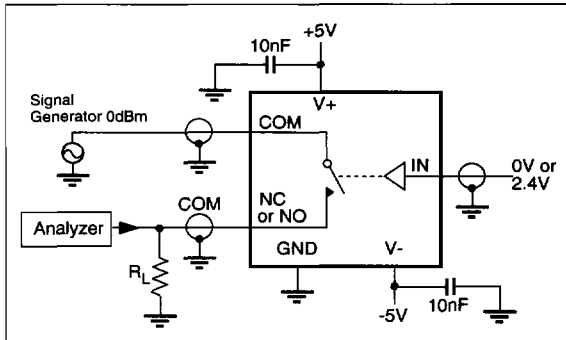


Figure 4. Off Isolation

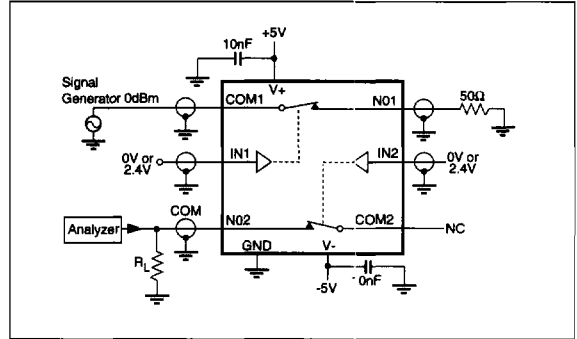


Figure 5. Crosstalk

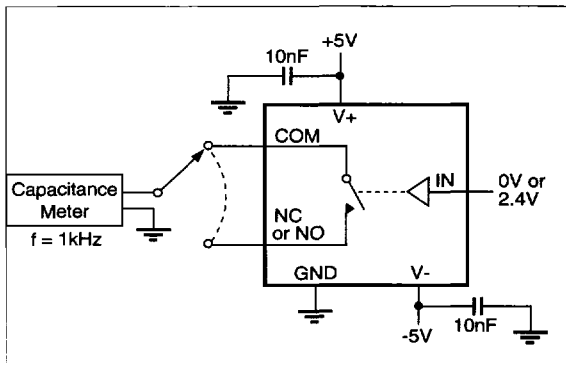


Figure 6. Channel-Off Capacitance

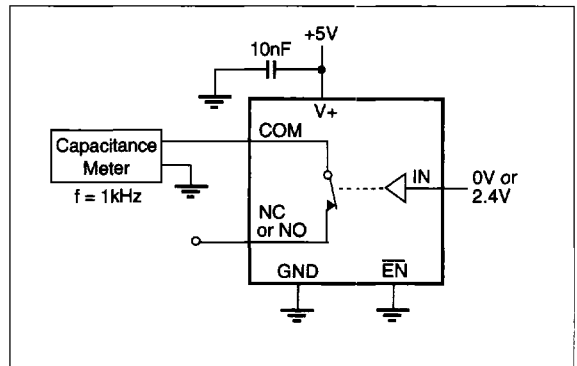


Figure 7. Channel-On Capacitance

Applications

As illustrated in Figure 8, PS391 can be used to insert various capacitors (C1, C2) and set proper RC times for integration. The resistors R1 and R2 set initial gain. The R_{IN} resistor x C1 or C2 sets the RC time. The reset switch discharges the hold capacitor through R_{IN} .

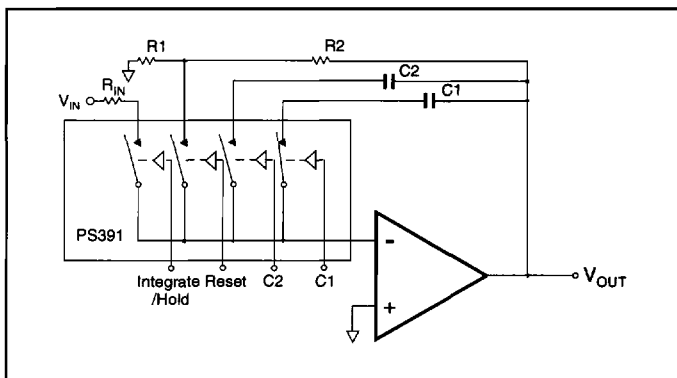


Figure 8. Programmable Integrator and Sample/Hold

Overvoltage Protection

Proper power-supply sequencing is recommended for all CMOS devices. Do not exceed the absolute maximum ratings, because stresses beyond the listed ratings may cause permanent damage to the devices. Always sequence $V+$ on first, followed by $V-$, and then logic inputs. If power-supply sequencing is not possible, add two small signal diodes or two current limiting resistors in series with the supply pins for overvoltage protection (Figure 9). Adding diodes reduces the analog signal range, but low switch resistance and low leakage characteristics are unaffected.

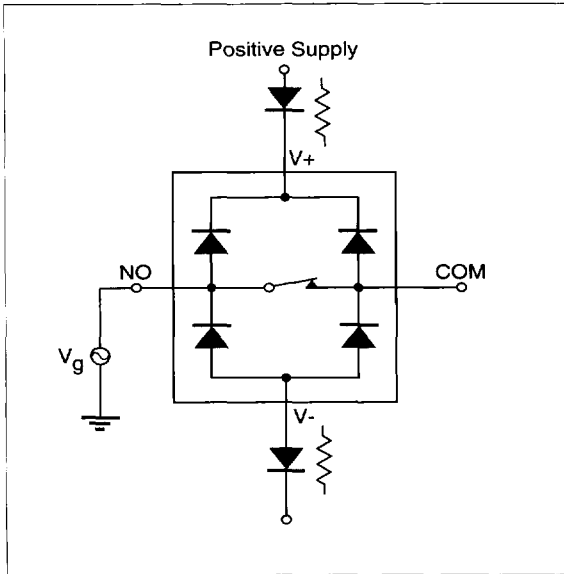


Figure 9. Overvoltage protection is accomplished using two external blocking diodes or two current limiting resistors.

Ordering Information

Part Number	Temperature - Range	Package
PS391CPE	0°C to + 70°C	16 Ld PDIP
PS391CSE	0°C to + 70°C	16 Narrow SOIC
PS391EPE	-40°C to + 85°C	16 Ld PDIP
PS391ESE	-40°C to + 85°C	16 Narrow SOIC
PS391EEE	-40°C to + 85°C	16 QSOP
PS392CPE	0°C to + 70°C	16 Ld PDIP
PS392CSE	0°C to + 70°C	16 Narrow SOIC
PS392EPE	-40°C to + 85°C	16 Ld PDIP
PS392ESE	-40°C to + 85°C	16 Narrow SOIC
PS392EEE	-40°C to + 85°C	16 QSOP
PS393CPE	0°C to + 70°C	16 Ld PDIP
PS393CSE	0°C to + 70°C	16 Narrow SOIC
PS393EPE	-40°C to + 85°C	16 Ld PDIP
PS393ESE	-40°C to + 85°C	16 Narrow SOIC
PS393EEE	-40°C to + 85°C	16 QSOP