

## Low-Power, High-Speed CMOS Analog Switches

### DESCRIPTION

The DG401B, DG403B, DG405B monolithic analog switches are replacements for the popular DG401/403/405 analog switches and provide improved performance, combining high speed ( $t_{ON}$ : 100 ns, typ) with low power consumption make the DG401B series ideal for portable and battery powered applications.

Built on the Vishay Siliconix proprietary high-voltage silicon-gate process to achieve high voltage rating and superior switch on/off performance, break-before-make is guaranteed for the SPDT configurations.

Each switch conducts equally well in both directions when on, and blocks up to 30 V peak-to-peak when off. On-resistance is very flat over the full  $\pm 15$  V analog range. The DG401B has two independent SPST switches. The DG403B has four SPST switches in NO/NC combinations. The DG405B has four switches in two SPST pairs (see Functional Block Diagrams and Pin Configurations on pages 1 and 2.)

The DG401B, DG403B, DG405B is available in both 16-pin plastic dip and 16-pin SOIC packages.

As a committed partner to the community and the environment, Vishay Siliconix manufactures this product with the lead (Pb)-free device terminations. For analog switching products manufactured with 100 % matte tin device terminations, the lead (Pb)-free “-E3” suffix is being used as a designator.

### FEATURES

- 44 V supply max rating
- $\pm 15$  V analog signal range
- On-resistance -  $R_{DS(on)}$ : 23  $\Omega$
- Low leakage -  $I_{D(on)}$ : 40 pA
- Fast switching -  $t_{ON}$ : 100 ns
- Upgrade to DG401B, DG403B, DG405B
- TTL, CMOS compatible
- Single supply capability

### BENEFITS

- Wide dynamic range
- Break-before-make switching action (DG403B only)
- Simple interfacing

### APPLICATIONS

- Audio and video switching
- Sample-and-hold circuits
- Test equipment
- PBX, PABX

### FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



Two SPST Switches per Package

TRUTH TABLE	
Logic	Switch
0	OFF
1	ON

Logic "0"  $\leq 0.8$  V

Logic "1"  $\geq 2.4$  V

## FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



Four SPST Switches in Two Pairs per Package

TRUTH TABLE		
Logic	SW <sub>1</sub> , SW <sub>2</sub>	SW <sub>3</sub> , SW <sub>4</sub>
0	OFF	ON
1	ON	OFF

Logic "0" ≤ 0.8 V

Logic "1" ≥ 2.4 V



Four SPST Switches in Two Pairs per Package

TRUTH TABLE	
Logic	Switch
0	OFF
1	ON

Logic "0" ≤ 0.8 V

Logic "1" ≥ 2.4 V

### ORDERING INFORMATION

Standard Commercial Part Number	Lead (Pb)-free Commercial Part Number	Package	Temperature Range
DG401BDJ	DG401BDJ-E3	16-Pin Plastic Dip	- 40 to 85 °C
DG403BDJ	DG403BDJ-E3		
DG405BDJ	DG405BDJ-E3		
DG401BDY	DG401BDY-E3	16-Pin Narrow SOIC	
DG403BDY	DG403BDY-E3		
DG405BDY	DG405BDY-E3		
DG401BDY-T1	DG401BDY-T1-E3	16-Pin Narrow SOIC With Tape and Reel	
DG403BDY-T1	DG403BDY-T1-E3		
DG405BDY-T1	DG405BDY-T1-E3		



ABSOLUTE MAXIMUM RATINGS			
Parameter	Symbol	Limit	Unit
V+ to V-		44	V
GND to V-		25	
Digital Inputs <sup>a</sup> , V <sub>S</sub> , V <sub>D</sub>		(V-) - 0.3 V to (V+) + 0.3 V or 30 mA, whichever occurs first	
Current (Any Terminal) Continuous		30	mA
Current, S or D (Pulsed 1 ms 10 % duty)		100	
Storage Temperature	(DJ, DY Suffix)	- 65 to 125	°C
Power Dissipation (Package) <sup>b</sup>	16-Pin Plastic DIP <sup>c</sup>	450	mW
	16-Pin SOIC <sup>d</sup>	600	

Notes:

- a. Signals on S<sub>X</sub>, D<sub>X</sub>, or I<sub>NX</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 6 mW/°C above 75 °C.
- d. Derate 7.6 mW/°C above 75 °C.

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.

SPECIFICATIONS <sup>a</sup>							
Parameter	Symbol	Test Conditions Unless Specified V+ = 15 V, V- = - 15 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>e</sup>	V <sub>ANALOG</sub>		Full	-15		15	V
Drain-Source On-Resistance	R <sub>DS(on)</sub>	I <sub>S</sub> = - 10 mA, V <sub>D</sub> = ± 10 V V+ = 13.5 V, V- = - 13.5 V	Room Full		23	45 55	Ω
Δ Drain-Source On-Resistance	ΔR <sub>DS(on)</sub>	I <sub>S</sub> = - 10 mA, V <sub>D</sub> = ± 5 V, 0 V V+ = 16.5 V, V- = - 16.5 V	Room Full		0.72	3 5	
Switch Off Leakage Current	I <sub>S(off)</sub>	V+ = 16.5, V- = - 16.5 V V <sub>D</sub> = ± 15.5 V, V <sub>S</sub> = ± 15.5 V	Room Hot	- 0.5 - 5	- 0.01	0.5 5	nA
	I <sub>D(off)</sub>		Room Hot	- 0.5 - 5	- 0.01	0.5 5	
Channel On Leakage Current	I <sub>D(on)</sub>	V+ = 16.5 V, V- = - 16.5 V V <sub>S</sub> = V <sub>D</sub> = ± 15.5 V	Room Hot	- 1 - 10	- 0.04	1 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, all other = 2.4 V	Full	- 1	0.005	1	μA
Input Current V <sub>IN</sub> High	I <sub>IH</sub>	V <sub>IN</sub> under test = 2.4 V, all other = 0.8 V	Full	- 1	0.005	1	
<b>Dynamic Characteristics</b>							
Turn-On Time	t <sub>ON</sub>	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF see figure 2	Room		100	150	ns
Turn-Off Time	t <sub>OFF</sub>		Room		60	100	
Break-Before-Make Time Delay (DG403B)	t <sub>D</sub>	R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	5	12		
Charge Injection	Q	C <sub>L</sub> = 10 000 pF, V <sub>gen</sub> = 0 V, R <sub>gen</sub> = 0 Ω	Room		60		pC
Off Isolation Reject Ratio	OIRR	R <sub>L</sub> = 100 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room		- 81.7		dB
Channel-to-Channel Crosstalk	X <sub>TALK</sub>		Room		- 94.8		
Source Off Capacitance	C <sub>S(off)</sub>	f = 1 MHz, V <sub>S</sub> = 0 V	Room		12		pF
Drain Off Capacitance	C <sub>D(off)</sub>		Room		12		
Channel On Capacitance	C <sub>D</sub> , C <sub>S(on)</sub>		Room		39		

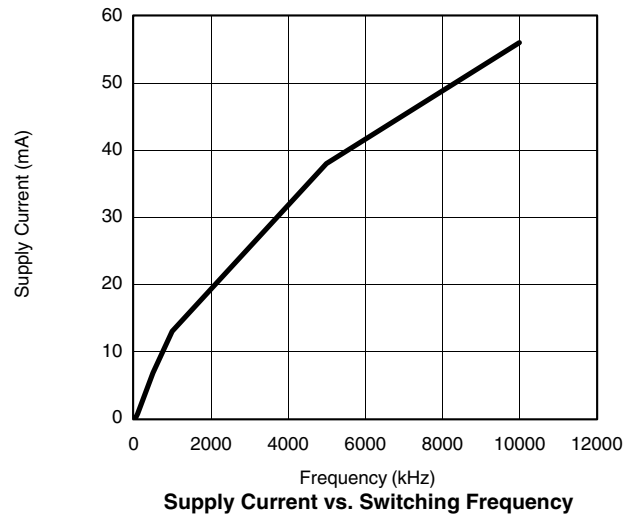
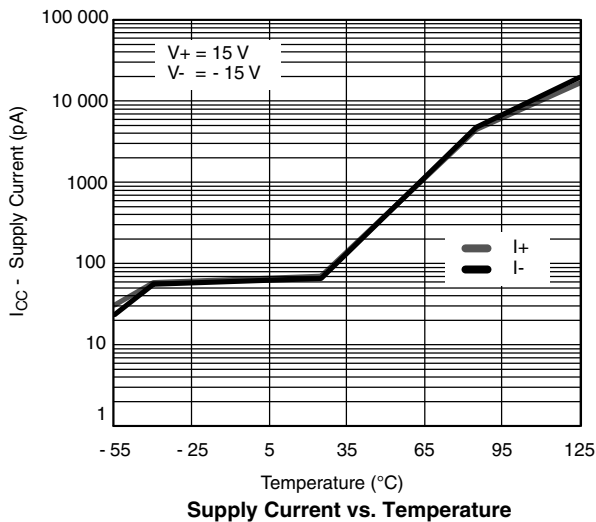


SPECIFICATIONS <sup>a</sup>							
Parameter	Symbol	Test Conditions Unless Specified V <sub>+</sub> = 15 V, V <sub>-</sub> = - 15 V V <sub>IN</sub> = 2.4 V, 0.8 V <sup>f</sup>	Temp. <sub>b</sub>	Limits - 40 °C to 85 °C			Unit
				Min. <sup>d</sup>	Typ. <sup>c</sup>	Max. <sup>d</sup>	
<b>Power Supplies</b>							
Positive Supply Current	I <sub>+</sub>	V <sub>+</sub> = 16.5 V, V <sub>-</sub> = - 16.5 V V <sub>IN</sub> = 0 or 5 V	Room Full		0.250	0.5	mA
Negative Supply Current	I <sub>-</sub>		Room Full	- 0.5 - 1	0.25		
Ground Current	I <sub>GND</sub>		Room Full	- 0.5 - 1	0.25		

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<sub>IN</sub> = input voltage to perform proper function.

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



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



**$R_{ON}$  vs. Analog Voltage and Supply Voltage**



**$R_{ON}$  vs. Analog Voltage and Single Supply Voltage**



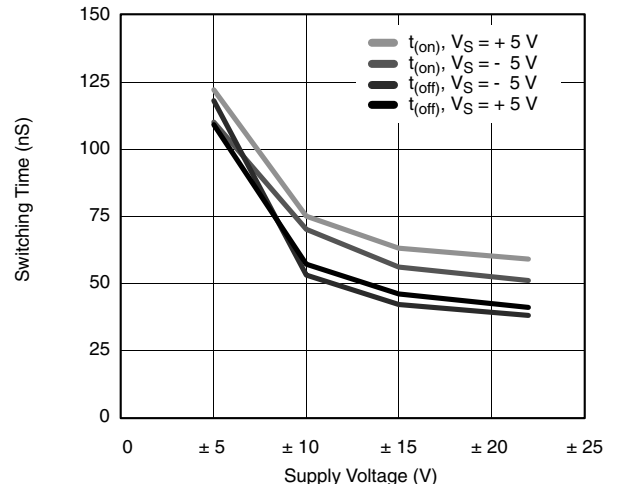
**$R_{ON}$  vs. Analog Voltage and Temperature**



**Leakage Current vs. Analog Voltage**

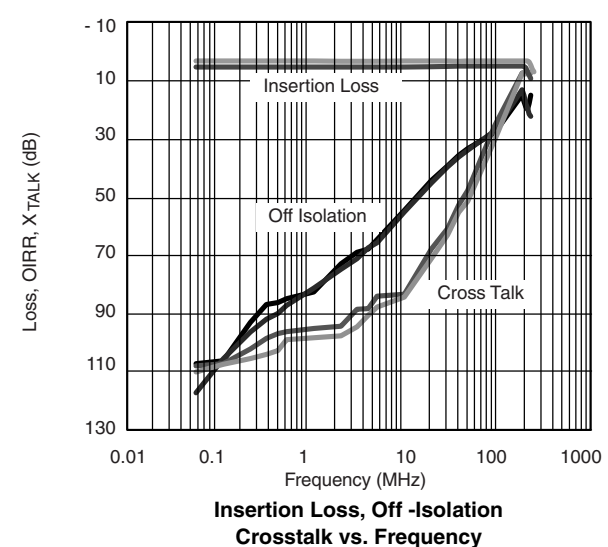
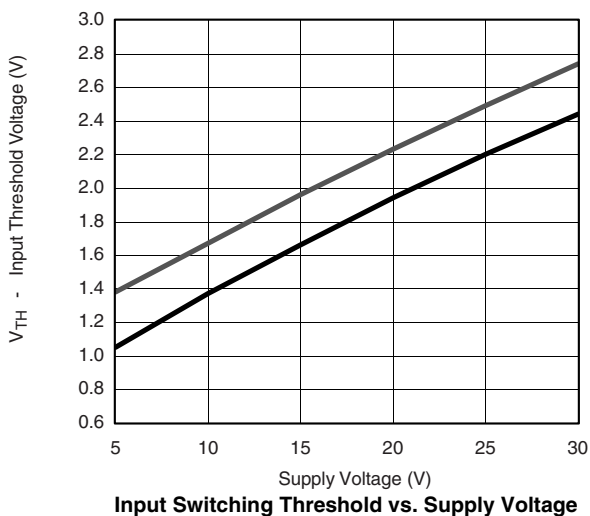
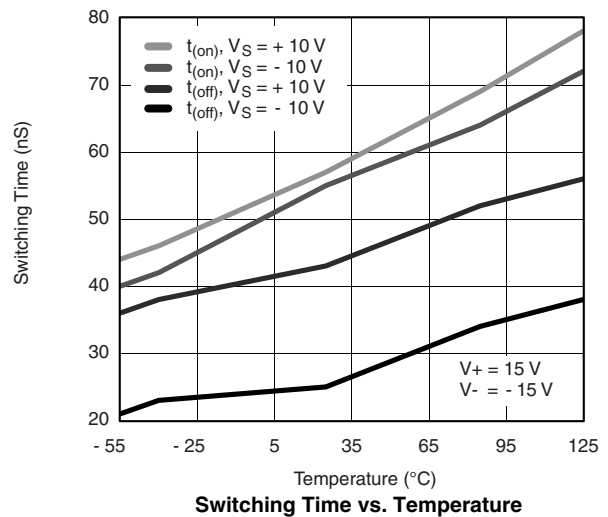


**Leakage Current vs. Temperature**



**Switching Time vs. Supply Voltage**

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



## SCHEMATIC DIAGRAM (Typical Channel)

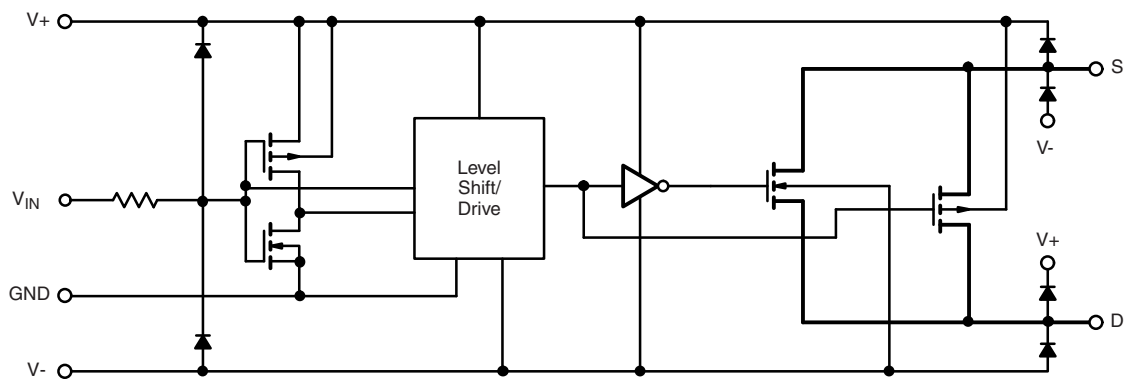
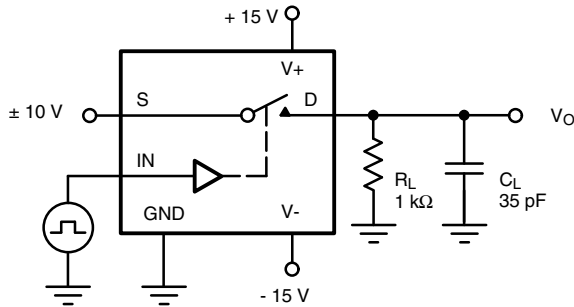


Figure 1.

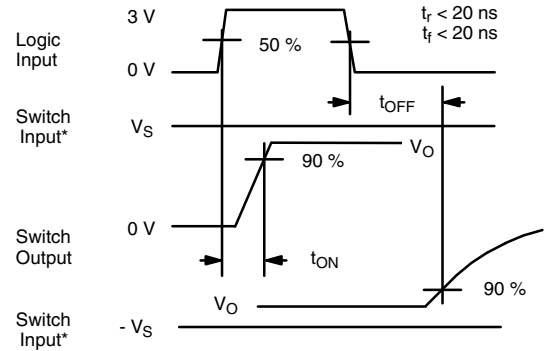
## TEST CIRCUITS

$V_O$  is the steady state output with the switch on. Feedthrough via switch capacitance may result in spikes at the leading and trailing edge of the output waveform.



$C_L$  (includes fixture and stray capacitance)

$$V_O = V_S \frac{R_L}{R_L + R_{DS(on)}}$$



\*  $V_S = 10\text{ V}$  for  $t_{ON}$ ,  $V_S = -10\text{ V}$  for  $t_{OFF}$

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

Figure 2. Switching Time



$C_L$  (includes fixture and stray capacitance)

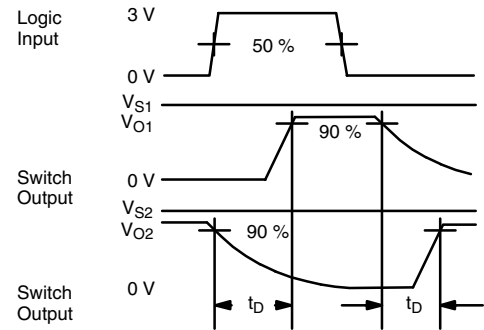


Figure 3. Break-Before-Make

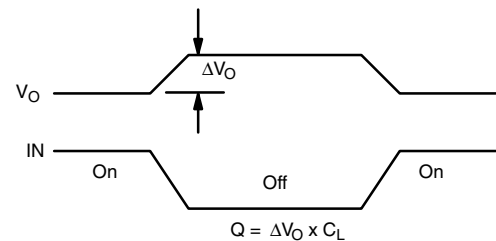
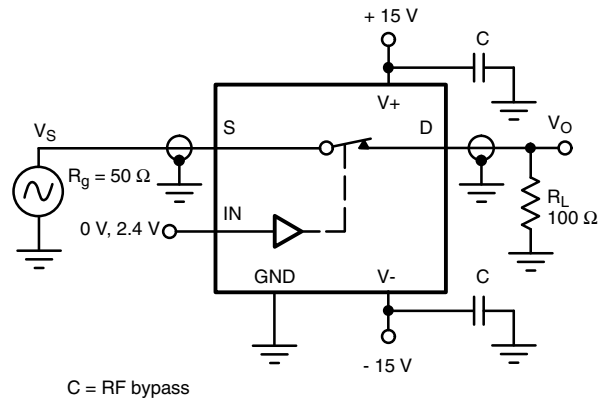


Figure 4. Charge Injection

## TEST CIRCUITS



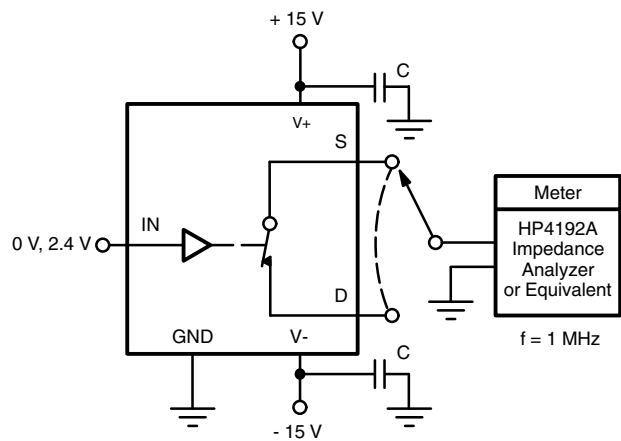
**Figure 5. Off Isolation**



**Figure 6. Insertion Loss**



**Figure 7. Crosstalk**



**Figure 8. Capacitances**



## APPLICATIONS

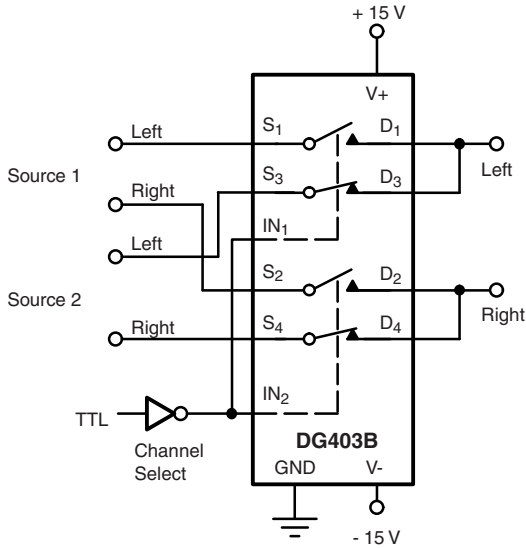


Figure 9. Stereo Source Selector

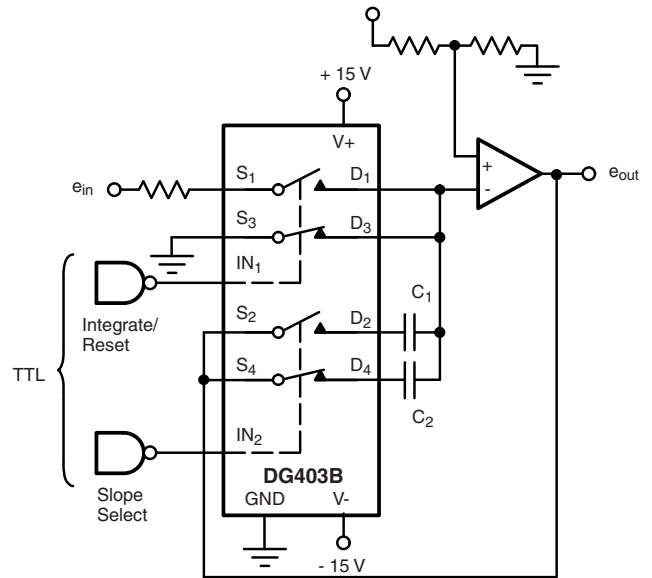


Figure 10. Dual Slope Integrator

### Dual Slope Integrators

The DG403B is well suited to configure a selectable slope integrator. One control signal selects the timing capacitor  $C_1$  or  $C_2$ . Another one selects  $e_{in}$  or discharges the capacitor in preparation for the next integration cycle.

### Band-Pass Switched Capacitor Filter

Single-pole double-throw switches are a common element for switched capacitor networks and filters. The fast switching times and low leakage of the DG403B allow for higher clock rates and consequently higher filter operating frequencies.

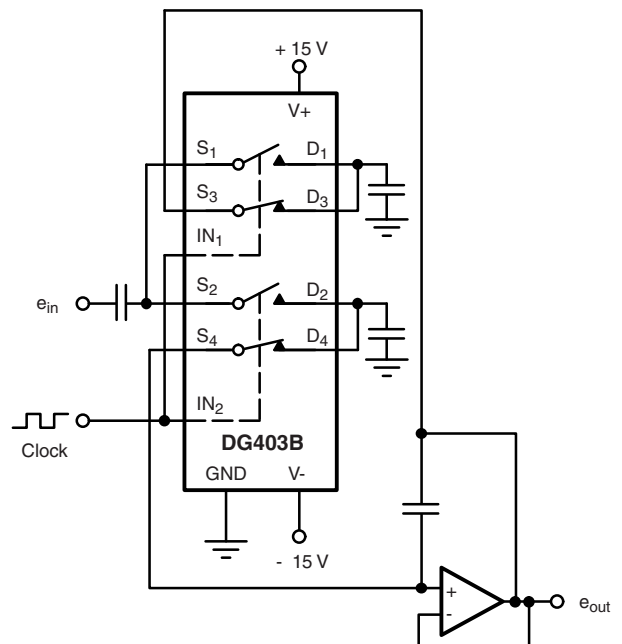


Figure 11. Band-Pass Switched Capacitor Filter

## APPLICATIONS

### Peak Detector

$A_3$  acting as a comparator provides the logic drive for operating  $SW_1$ . The output of  $A_2$  is fed back to  $A_3$  and compared to the analog input  $e_{in}$ . If  $e_{in} > e_{out}$  the output of  $A_3$  is high keeping  $SW_1$  closed. This allows  $C_1$  to charge up to

the analog input voltage. When  $e_{in}$  goes below  $e_{out}$   $A_3$  goes negative, turning  $SW_1$  off. The system will therefore store the most positive analog input experienced.

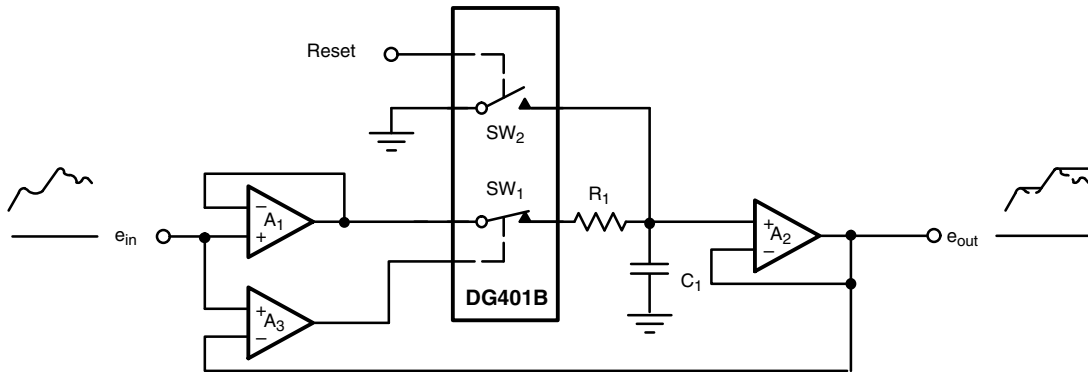


Figure 12. Positive Peak Detector



**SOIC (NARROW): 16-LEAD**  
JEDEC Part Number: MS-012



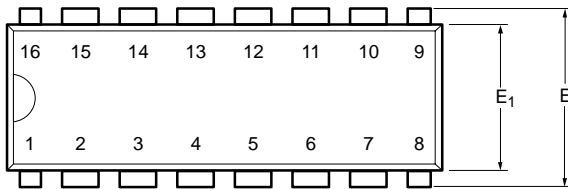
Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A <sub>1</sub>	0.10	0.20	0.004	0.008
B	0.38	0.51	0.015	0.020
C	0.18	0.23	0.007	0.009
D	9.80	10.00	0.385	0.393
E	3.80	4.00	0.149	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
L	0.50	0.93	0.020	0.037
∅	0°	8°	0°	8°

ECN: S-03946—Rev. F, 09-Jul-01  
DWG: 5300





**PDIP: 16-LEAD**



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
<b>A</b>	3.81	5.08	0.150	0.200
<b>A<sub>1</sub></b>	0.38	1.27	0.015	0.050
<b>B</b>	0.38	0.51	0.015	0.020
<b>B<sub>1</sub></b>	0.89	1.65	0.035	0.065
<b>C</b>	0.20	0.30	0.008	0.012
<b>D</b>	18.93	21.33	0.745	0.840
<b>E</b>	7.62	8.26	0.300	0.325
<b>E<sub>1</sub></b>	5.59	7.11	0.220	0.280
<b>e<sub>1</sub></b>	2.29	2.79	0.090	0.110
<b>e<sub>A</sub></b>	7.37	7.87	0.290	0.310
<b>L</b>	2.79	3.81	0.110	0.150
<b>Q<sub>1</sub></b>	1.27	2.03	0.050	0.080
<b>S</b>	0.38	1.52	.015	0.060

ECN: S-03946—Rev. D, 09-Jul-01  
DWG: 5482

## RECOMMENDED MINIMUM PADS FOR SO-16



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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