

# Low Charge Injection 16-Channel High Voltage Analog Switch with Bleed Resistors

## Features

- ❑ HVCMOS technology for high performance
- ❑ Integrated bleed resistors on the outputs
- ❑ 16 Channels of high voltage analog switch
- ❑ 3.3V input logic level compatible
- ❑ 20MHz data shift clock frequency
- ❑ Very low quiescent power dissipation-10µA
- ❑ Low parasitic capacitance
- ❑ DC to 10MHz analog signal frequency
- ❑ -60dB typical off-isolation at 5MHz
- ❑ CMOS logic circuitry for low power
- ❑ Excellent noise immunity
- ❑ Cascadable serial data register with latches
- ❑ Flexible operating supply voltages

## Applications

- ❑ Medical ultrasound imaging
- ❑ NDT metal flaw detection
- ❑ Piezoelectric transducer drivers
- ❑ Optical MEMS modules

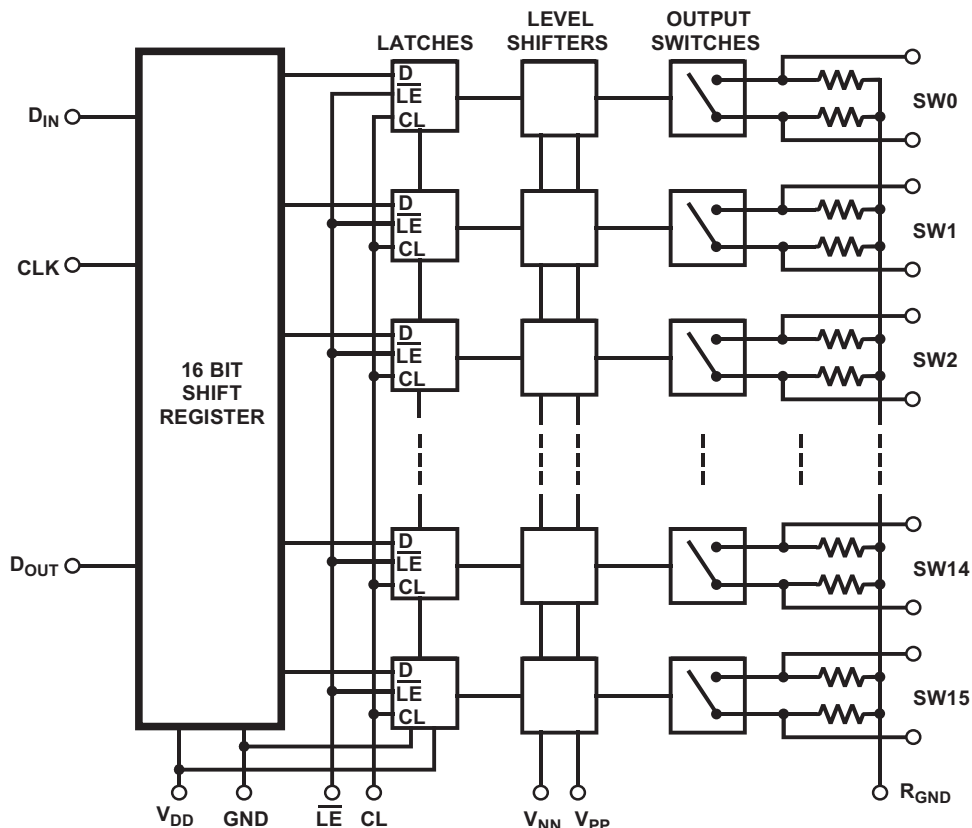
## General Description

The Supertex HV2701 is a low charge injection 16-channel high voltage analog switch integrated circuit (IC) with bleed resistors. The device can be used in applications requiring high voltage switching controlled by low voltage control signals, such as medical ultrasound imaging and piezoelectric transducer drivers. The bleed resistors eliminate voltage built up on capacitive loads such as piezoelectric transducers.

Input data is shifted into a 16-bit shift register that can then be retained in a 16-bit latch. To reduce any possible clock feed through noise, the latch enable bar should be left high until all bits are clocked in. Data are clocked in during the rising edge of the clock. Using HVCMOS technology, this device combines high voltage bilateral DMOS switches and low power CMOS logic to provide efficient control of high voltage analog signals.

The device is suitable for various combinations of high voltage supplies, e.g.,  $V_{PP}/V_{NN}$ : +40V/-160V, +100V/-100V, and +160V/-40V.

## HV2701 Block Diagram



Ordering Information

DEVICE	Package Options
	48-Lead TQFP (1.4mm)
HV2701	HV2701FG-G



-G indicates package is RoHS compliant ('Green')

Absolute Maximum Ratings

$V_{DD}$ Logic supply	-0.5V to +7V
$V_{PP}$ - $V_{NN}$ differential supply	220V
$V_{PP}$ Positive supply	-0.5V to $V_{NN}$ +200V
$V_{NN}$ Negative supply	+0.5V to -200V
Logic input voltage	-0.5V to $V_{DD}$ +0.3V
Analog signal range	$V_{NN}$ to $V_{PP}$
Peak analog signal current/channel	3.0A
Storage temperature	-65°C to 150°C
Power dissipation	1W

\*Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied. Continuous operation of the device at the absolute rating level may affect device reliability. All voltages are referenced to device ground.

Operation Conditions

Symbol	Parameter	Value
$V_{DD}$	Logic power supply voltage	3.0V to 5.5V
$V_{PP}$	Positive high voltage supply	40V to $V_{NN}$ +200V
$V_{NN}$	Negative high voltage supply	-40V to -160V
$V_{IH}$	High level input voltage	$0.9V_{DD}$ to $V_{DD}$
$V_{IL}$	Low level input voltage	0V to $0.1V_{DD}$
$V_{SIG}$	Analog signal voltage peak-to-peak	$V_{NN}$ +10V to $V_{PP}$ -10V
$T_A$	Operating free air temperature	0°C to 70°C

- Notes:
- 1 Power up/down sequence is arbitrary except GND must be powered-up first and powered-down last.
  - 2  $V_{SIG}$  must be within  $V_{NN}$  and  $V_{PP}$ , or floating during power up/down transition.
  - 3 Rise and fall times of power supplies  $V_{DD}$ ,  $V_{PP}$  and  $V_{NN}$  should not be less than 1.0msec.

## DC Electrical Characteristics

(over recommended operating conditions unless otherwise noted)

Sym	Parameter	0°C		+25°C			+70°C		Units	Conditions	
		Min	Max	Min	Typ	Max	Min	Max			
R <sub>ONS</sub>	Small Signal Switch On-Resistance		30		26	38		48	Ω	I <sub>SIG</sub> = 5mA	V <sub>PP</sub> = +40V V <sub>NN</sub> = -160V
			25		22	27		32		I <sub>SIG</sub> = 200mA	
			25		22	27		30		I <sub>SIG</sub> = 5mA	V <sub>PP</sub> = +100V V <sub>NN</sub> = -100V
			18		18	24		27		I <sub>SIG</sub> = 200mA	
			23		20	25		30		I <sub>SIG</sub> = 5mA	V <sub>PP</sub> = +160V V <sub>NN</sub> = -40V
			22		16	25		27		I <sub>SIG</sub> = 200mA	
ΔR <sub>ONS</sub>	Small Signal Switch On-Resistance Matching		20		5.0	20		20	%	I <sub>SIG</sub> = 5mA, V <sub>PP</sub> = +100V, V <sub>NN</sub> = -100V	
R <sub>ONL</sub>	Large Signal Switch On-Resistance				15				Ω	V <sub>SIG</sub> = V <sub>PP</sub> - 10V, I <sub>SIG</sub> = 1A	
R <sub>INT</sub>	Value of output Bleed Resistor			20	35	50			kΩ	Output Switch to RGND I <sub>RINT</sub> = 0.5mA	
I <sub>SOL</sub>	Switch Off Leakage per Switch*		5.0		1.0	10		15	μA	V <sub>SIG</sub> = V <sub>PP</sub> - 10V and V <sub>NN</sub> + 10V	
V <sub>OS</sub>	DC Offset Switch off*		300		100	300		300	mV	No Load	
	DC Offset Switch on*		500		100	500		500	mV		
I <sub>PPQ</sub>	Quiescent V <sub>PP</sub> supply current				10	50			μA	All switches off	
I <sub>NNQ</sub>	Quiescent V <sub>NN</sub> supply current				-10	-50			μA	All switches off	
I <sub>PPQ</sub>	Quiescent V <sub>PP</sub> supply current				10	50			μA	All switches on, I <sub>SW</sub> = 5mA	
I <sub>NNQ</sub>	Quiescent V <sub>NN</sub> supply current				-10	-50			μA	All switches on, I <sub>SW</sub> = 5mA	
I <sub>SW</sub>	Switch output peak current		3.0		3.0	2.0		2.0	A	V <sub>SIG</sub> duty cycle < 0.1%	
f <sub>SW</sub>	Output switching frequency					50			kHz	Duty cycle = 50%	
I <sub>PP</sub>	Average V <sub>PP</sub> supply current		6.5			7.0		8.0	mA	V <sub>PP</sub> = +40V V <sub>NN</sub> = -160V	All output switches are turning On and Off at 50KHz with no load.
			4.0			5.5		5.5		V <sub>PP</sub> = +100V V <sub>NN</sub> = -100V	
			4.0			5.0		5.5		V <sub>PP</sub> = +160V V <sub>NN</sub> = -40V	
I <sub>NN</sub>	Average V <sub>NN</sub> supply current		6.5			7.0		8.0	mA	V <sub>PP</sub> = +40V V <sub>NN</sub> = -160V	
			4.0			5.0		5.5		V <sub>PP</sub> = +100V V <sub>NN</sub> = -100V	
			4.0			5.0		5.5		V <sub>PP</sub> = +160V V <sub>NN</sub> = -40V	
I <sub>DD</sub>	Average V <sub>DD</sub> supply current		4.0			4.0		4.0	mA	f <sub>CLK</sub> = 5MHz, V <sub>DD</sub> = 5.0V	
I <sub>DDQ</sub>	Quiescent V <sub>DD</sub> supply current		10			10		10	μA	All logic inputs are static	
I <sub>SOR</sub>	Data out source current	0.45		0.45	0.70		0.40		mA	V <sub>OUT</sub> = V <sub>DD</sub> - 0.7V	
I <sub>SINK</sub>	Data out sink current	0.45		0.45	0.70		0.40		mA	V <sub>OUT</sub> = 0.7V	
C <sub>IN</sub>	Logic input capacitance		10			10		10	pF		

\* See Test Circuits on page 5

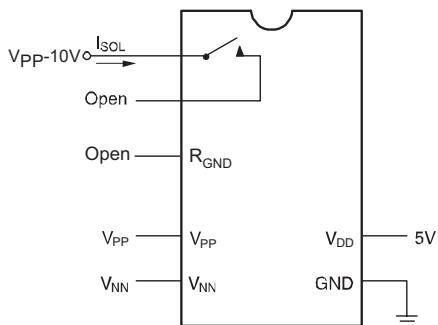
**AC Electrical Characteristics**

(over recommended operating conditions,  $V_{DD} = 5.0V$ ,  $t_R = t_F \leq 5ns$ , 50% duty cycle,  $C_{LOAD} = 20pF$  unless otherwise noted)

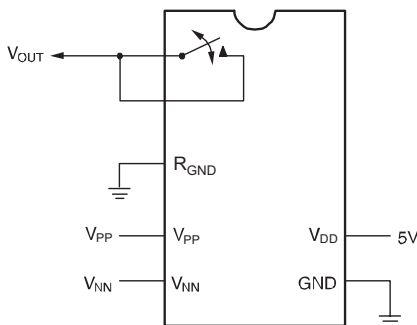
Sym	Parameter	0°C		+25°C			+70°C		Units	Conditions
		Min	Max	Min	Typ	Max	Min	Max		
$t_{SD}$	Set Up Time Before LE Rises	25		25			25		ns	
$t_{WLE}$	Time Width of LE	56			56		56		ns	$V_{DD} = 3.0V$
		12			12		12			$V_{DD} = 5.0V$
$t_{DO}$	Clock Delay Time to Data Out	50	100	50	78	100	50	100	ns	$V_{DD} = 3.0V$
		15	40	15	30	40	15	40		$V_{DD} = 5.0V$
$t_{WCL}$	Time Width of CL	55		55			55		ns	
$t_{SU}$	Set Up Time Data to Clock	21			21		21		ns	$V_{DD} = 3.0V$
		7			7		7			$V_{DD} = 5.0V$
$t_H$	Hold Time Data from Clock	2		2			2		ns	$V_{DD} = 3.0$ or $5.0V$
$f_{CLK}$	Clock Frequency		8			8		8	MHz	$V_{DD} = 3.0V$
			20			20		20		$V_{DD} = 5.0V$
$t_R, t_F$	Clock Rise and Fall Times		50			50		50	ns	
$T_{ON}$	Turn ON Time*		5.0			5.0		5.0	$\mu s$	$V_{SIG} = V_{PP} - 10V, R_{LOAD} = 10K\Omega$
$T_{OFF}$	Turn OFF Time*		5.0			5.0		5.0	$\mu s$	$V_{SIG} = V_{PP} - 10V, R_{LOAD} = 10K\Omega$
dv/dt	Maximum $V_{SIG}$ Slew Rate		20			20		20	v/ns	$V_{PP} = +40V, V_{NN} = -160V$
			20			20		20		$V_{PP} = +100V, V_{NN} = -100V$
			20			20		20		$V_{PP} = +160V, V_{NN} = -40V$
$K_O$	Off Isolation*	-30		-30	-33		-30		dB	$f = 5.0MHz, 1K\Omega/15pF$ load
		-58		-58			-58			$f = 5.0MHz, 50\Omega$ load
$K_{CR}$	Switch Crosstalk*	-60		-60	-70		-60		dB	$f = 5.0MHz, 50\Omega$ load
$I_{ID}$	Output Switch Isolation Diode Current		300			300		300	mA	300ns pulse width, 2.0% duty cycle
$C_{SG(OFF)}$	Off Capacitance SW to GND	5.0	17	5.0	12	17	5.0	17	pF	0V, $f = 1.0MHz$
$C_{SG(ON)}$	On Capacitance SW to GND	25	50	25	38	50	25	50	pF	0V, $f = 1.0MHz$
$+V_{SPK}$	Output Voltage Spike*					150			mV	$V_{PP} = +40V, V_{NN} = -160V, R_{LOAD} = 50ohm$
$-V_{SPK}$						150				$V_{PP} = +100V, V_{NN} = -100V, R_{LOAD} = 50ohm$
$+V_{SPK}$						150				$V_{PP} = +160V, V_{NN} = -40V, R_{LOAD} = 50ohm$
$-V_{SPK}$										
$+V_{SPK}$										
$-V_{SPK}$										
QC	Charge Injection*				820				pC	$V_{PP} = +40V, V_{NN} = -160V, V_{SIG} = 0V$
					600					$V_{PP} = +100V, V_{NN} = -100V, V_{SIG} = 0V$
					350					$V_{PP} = +160V, V_{NN} = -40V, V_{SIG} = 0V$

\* See Test Circuits on page 5

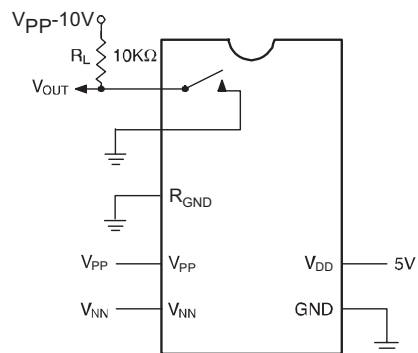
HV2701 Test Circuits



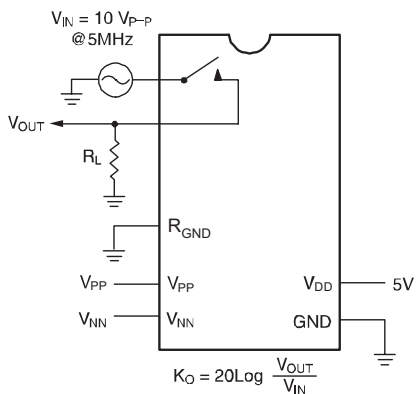
Switch Off Leakage per Switch



DC Offset Switch ON/OFF

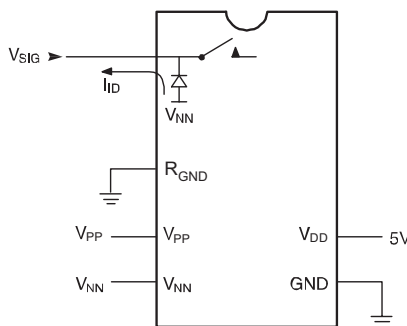


TURN (TON/TOFF) ON/OFF TIME

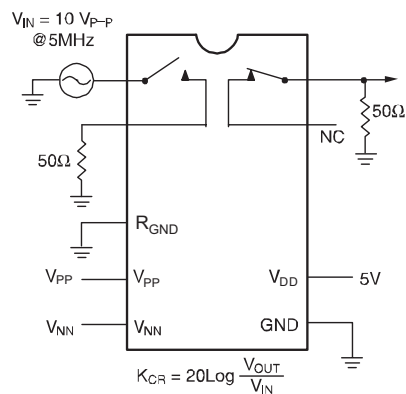


$$K_O = 20 \text{Log} \frac{V_{OUT}}{V_{IN}}$$

OFF Isolation

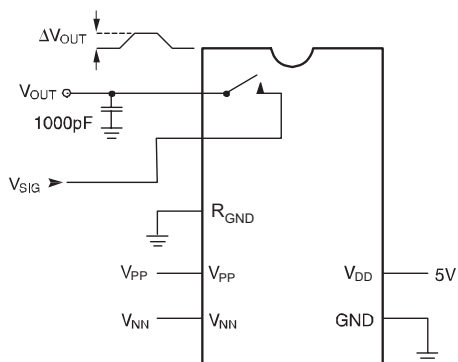


Output Switch Isolation Diode Current



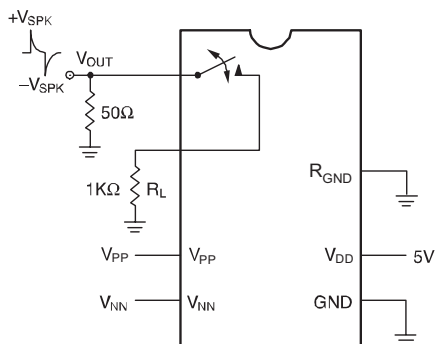
$$K_{CR} = 20 \text{Log} \frac{V_{OUT}}{V_{IN}}$$

Switch Crosstalk



$$Q = 1000\text{pF} \times \Delta V_{OUT}$$

Charge Injection



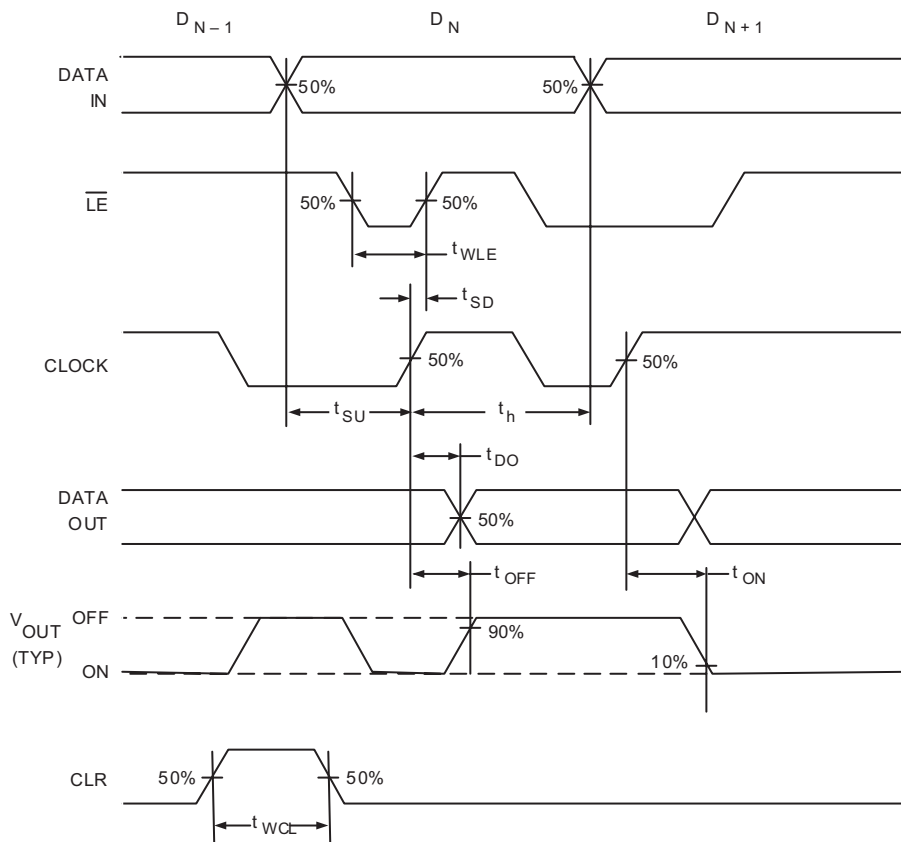
Output Voltage Spike

# Logic Function Table

INPUT DATA							LATCH ENABLE	CLOCK	OUTPUT SWITCH						
D0	D1	...	D7	D8	...	D15	LE	CL	SW0	SW1	...	SW7	SW8	...	SW15
L							L	L	OFF						
H							L	L	ON						
	L						L	L		OFF					
	H						L	L		ON					
							L	L							
			L				L	L				OFF			
			H				L	L				ON			
		...		L			L	L					OFF	...	
				H			L	L					ON		
							L	L							
							L	L							
							L	L							
							L	L							
							L	L							
							L	L							
						L	L	L							OFF
						H	L	L							ON
X	X	X	X	X	X	X	H	L	HOLD PREVIOUS STATE						
X	X	X	X	X	X	X	X	H	ALL SWITCHES OFF						

- Notes:
1. Th 16 switches operate independently.
  2. Serial data is clocked in on the L to H transition of the CLK.
  3. All 16 switches go to a state retaining their latched condition at the rising edge of LE. When LE is low the shift registers data flow through the latch.
  4.  $D_{out}$  is high when data in the register 15 is high.
  5. Shift registers clocking has no effect on the switch states if LE is high.
  6. The CL clear input overrides all other inputs.

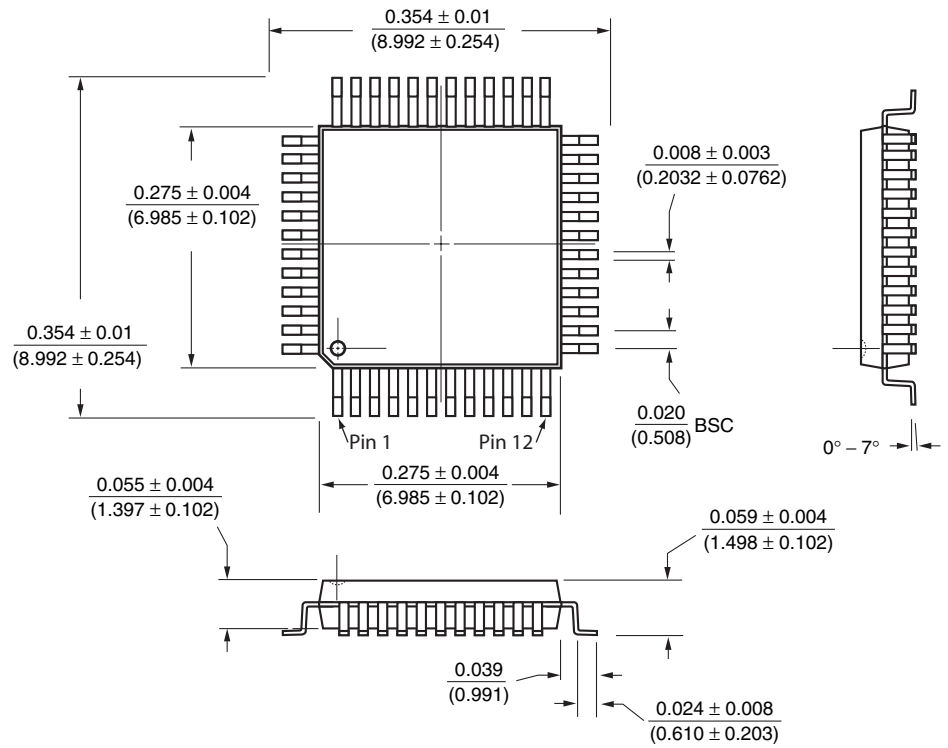
# Logic Timing Waveforms



Pin Configuration and Package Outline - 48-Lead TQFP (1.4mm) (FG)

Pin Name	TQFP-48
SW4B	3
SW4A	4
SW3B	5
SW3A	6
SW2B	7
SW2A	8
SW1B	9
SW1A	10
SW0B	11
SW0A	12
V <sub>NN</sub>	13
V <sub>PP</sub>	15
GND	17
V <sub>DD</sub>	18
D <sub>IN</sub>	19
CLK	20
$\overline{LE}$	21
CLR	22
D <sub>OUT</sub>	23
RGND	24
SW15B	25
SW15A	26
SW14B	27
SW14A	28
SW13B	29
SW13A	30
SW12B	31
SW12A	32
SW11B	33
SW11A	34
SW10B	37
SW10A	38
SW9B	39
SW9A	40
SW8B	41
SW8A	42
SW7B	43
SW7A	44
SW6B	45
SW6A	46
SW5B	47
SW5A	48
NC	1,2,14,16,35,36

NC = No Internal Connection.



Measurement Legend =  $\frac{\text{Dimensions in Inches}}{\text{Dimensions in Millimeters}}$

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