

## Low Charge Injection 8-Channel High Voltage Analog Switches with Bleed Resistors

### Features

- ▶ HVCMOS® technology for high performance
- ▶ Very low quiescent power dissipation – 10µA
- ▶ Output On-resistance typically 22Ω
- ▶ Integrated bleed resistors on the outputs
- ▶ Low parasitic capacitances
- ▶ DC to 10MHz analog signal frequency
- ▶ -60dB typical output off isolation at 5.0MHz
- ▶ CMOS logic circuitry for low power
- ▶ Excellent noise immunity
- ▶ On-chip shift register, latch and clear logic circuitry
- ▶ Flexible high voltage supplies

### General Description

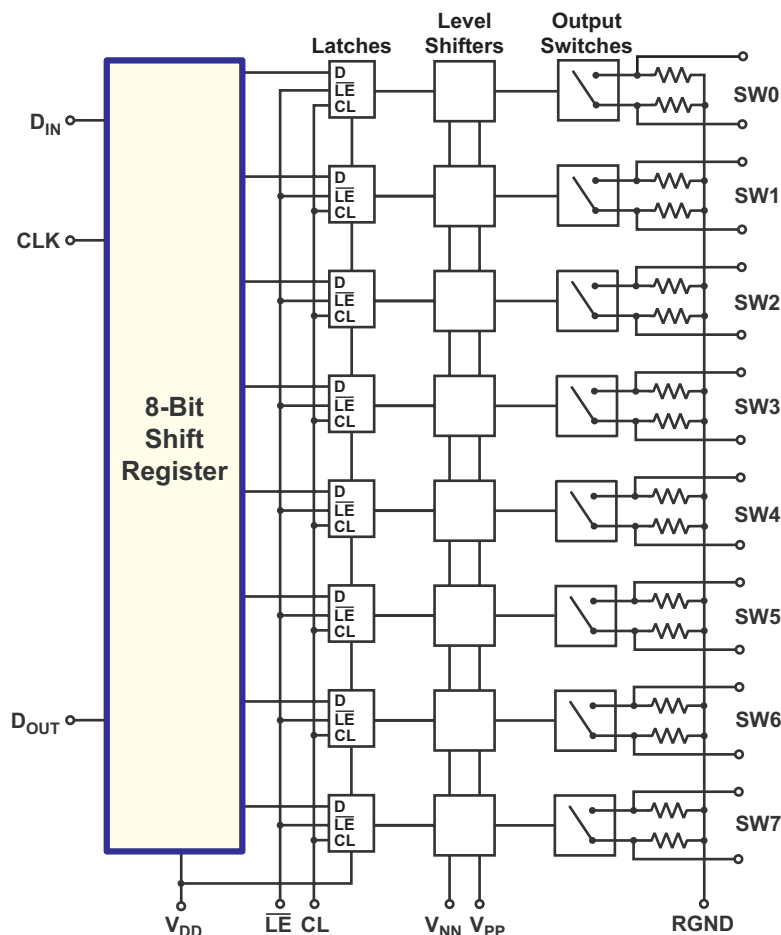
The Supertex HV230 and HV232 are low charge injection 8-channel high-voltage analog switch integrated circuits (ICs) with bleed resistors. These devices can be used in applications requiring high voltage switching controlled by low voltage control signals, such as ultrasound imaging and printers. The bleed resistors eliminate voltage built up on capacitive loads such as piezoelectric transducers. Input data is shifted into an 8-bit shift register which can then be retained in an 8-bit latch. To reduce any possible clock feed-through noise, Latch Enable Bar (LE) should be left high until all bits are clocked in. Using HVCMOS technology, this switch combines high voltage bilateral DMOS switches and low power CMOS logic to provide efficient control of high voltage analog signals.

### Applications

- ▶ Medical ultrasound imaging
- ▶ Piezoelectric transducer drivers

These ICs are suitable for various combinations of high voltage supplies, e.g.,  $V_{PP}/V_{NN}$ : +50V/-150V, or +100V/-100V.

### Block Diagram



## Ordering Information

Device	Package Options			
	28-Lead PLCC	48-Lead LQFP/TQFP (1.4mm)	26-Lead BCC	26-Ball fpBGA
HV230	-	-	-	HV230GA
			HV230B1-G	HV230GA-G
HV232	HV232PJ	HV232FG	-	-
	HV232PJ-G	HV232FG-G		

-G indicates the part is RoHS compliant (Green)



## Absolute Maximum Ratings

Parameter	Value
$V_{DD}$ logic power supply voltage	-0.5V to +15V
$V_{PP} - V_{NN}$ supply voltage	220V
$V_{PP}$ positive high voltage supply	-0.5V to $V_{NN} + 200V$
$V_{NN}$ negative high voltage supply	+0.5V to -200V
Logic input voltages	-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:	
28-Lead PLCC	1.2W
48-Lead LQFP/TQFP(1.4mm)	1.0W
26-Lead BCC	1.0W
26-Ball fpBGA	1.0W

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.

## Operating Conditions

Symbol	Parameter	Value
$V_{DD}$	Logic power supply voltage <sup>1,3</sup>	4.5V to 13.2V
$V_{PP}$	positive high voltage supply <sup>1,3</sup>	40V to $V_{NN} + 200V$
$V_{NN}$	negative high voltage supply <sup>1,3</sup>	-40V to -160V
$V_{IH}$	High level input voltage	$V_{DD} - 1.5V$ to $V_{DD}$
$V_{IL}$	Low-level input voltage	0V to 1.5V
$V_{SIG}$	Analog signal voltage peak-to-peak	$V_{NN} + 10V$ to $V_{PP} - 10V^2$
$T_A$	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  $V_{NN} \leq V_{SIG} \leq V_{PP}$  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.

## Electrical Characteristics

**DC Characteristics** (over recommended operating conditions unless otherwise noted)

Characteristics	Sym	0°C		+25°C			+70°C		Units	Test Conditions	
		min	max	min	typ*	max	min	max			
Small Signal Switch (ON) Resistance	R <sub>ONS</sub>		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	V <sub>NN</sub> = -160V
			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	V <sub>NN</sub> = -100V
			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	V <sub>NN</sub> = -40V
Small Signal Switch (ON) Resistance Matching	ΔR <sub>ONS</sub>		20		5.0	20		20	%	I <sub>SW</sub> = 5mA, V <sub>PP</sub> = 100V, V <sub>NN</sub> = -100V	
Large Signal Switch (ON) Resistance	R <sub>ONL</sub>				15				Ω	V <sub>SIG</sub> = V <sub>PP</sub> - 10V, I <sub>SIG</sub> = 1A	
Output Switch Shunt Resistance	R <sub>INT</sub>			20	35	50			KΩ	Output switch to R <sub>GND</sub> I <sub>RINT</sub> = 0.5mA	
Switch Off Leakage Per Switch	I <sub>SOL</sub>		5.0		1.0	10		15	μA	V <sub>SIG</sub> = V <sub>PP</sub> - 10V	
DC Offset Switch Off			300		100	300		300	mV	No Load	
DC Offset Switch On			500		100	500		500	mV	No Load	
Pos. HV Supply Current	I <sub>PPQ</sub>				10	50			μA	ALL SWs OFF	
Neg. HV Supply Current	I <sub>NNQ</sub>				-10	-50			μA	ALL SWs OFF	
Pos. HV Supply Current	I <sub>PPQ</sub>				10	50			μA	ALL SWs ON, I <sub>SW</sub> = 5mA	
Neg. HV Supply Current	I <sub>NNQ</sub>				-10	-50			μA	ALL SWs ON, I <sub>SW</sub> = 5mA	
Switch Output Peak Current			3.0		3.0	2.0		2.0	A	V <sub>SIG</sub> duty cycle - 0.1%	
Output Switch Frequency	f <sub>SW</sub>					50			KHz	Duty Cycle = 50%	
I <sub>PP</sub> Supply Current	I <sub>PP</sub>		6.5			7.0		8.0	mA	V <sub>PP</sub> = 40V, V <sub>NN</sub> = -160V	50KHz Output Switching Frequency with no load
			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>NN</sub> Supply Current	I <sub>NN</sub>		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	
Logic Supply Average Current	I <sub>DD</sub>		4.0			4.0		4.0	mA	f <sub>CLK</sub> = 5MHz, V <sub>DD</sub> = 5.0V	
Logic Supply Quiescent Current	I <sub>DDQ</sub>		10			10		10	μA		
Data Out Source Current	I <sub>SOR</sub>	0.45		0.45	0.70		0.40		mA	V <sub>OUT</sub> = V <sub>DD</sub> - 0.7V	
Data Out Sink Current	I <sub>SINK</sub>	0.45		0.45	0.70		0.40		mA	V <sub>OUT</sub> = 0.7V	
Logic Input Capacitance	C <sub>IN</sub>		10			10		10	pF		

\*Typical values only for HV232

## Electrical Characteristics

**AC Characteristics** (over operating conditions  $V_{DD} = 5V$ , unless otherwise noted)

Characteristics	Sym	0°C		+25°C			+70°C		Units	Test Conditions
		min	max	min	typ*	max	min	max		
Set Up Time Before $\overline{LE}$ Rises	$t_{SD}$	150		150			150		ns	
Time Width of $\overline{LE}$	$t_{WLE}$	150		150			150		ns	
Clock Delay Time to Data Out	$t_{DO}$	55	150	60		150	70	150	ns	
Time Width of CL	$t_{WCL}$	150		150			150		ns	
Set Up Time Data to Clock	$t_{SU}$	15		15	8.0		20		ns	
Hold Time Data from Clock	$t_h$	35		35			35		ns	
Clock Freq	$f_{CLK}$		5.0			5.0		5.0	MHz	50% duty cycle $f_{DATA} = f_{CLK}/2$
Clock Rise and Fall Times	$t_r, t_f$		1.0			1.0		1.0	$\mu s$	
Turn On Time	$t_{ON}$		5.0			5.0		5.0	$\mu s$	$V_{SIG} = V_{PP} - 10V$ , $R_L = 10K\Omega$
Turn Off Time	$t_{OFF}$		5.0			5.0		5.0	$\mu s$	$V_{SIG} = V_{PP} - 10V$ , $R_L = 10K\Omega$
Maximum $V_{SIG}$ Slew Rate	dv/dt		20			20		20	V/ns	$V_{PP} = 160V$ , $V_{NN} = -40V$
			20			20		20		$V_{PP} = 100V$ , $V_{NN} = -100V$
			20			20		20		$V_{PP} = 40V$ , $V_{NN} = -160V$
Off Isolation	KO	-30		-30	-33		-30		dB	f = 5MHz, 1K $\Omega$ /15pF load
		-58		-58			-58			f = 5MHz, 50 $\Omega$ load
Switch Crosstalk	$K_{CR}$	-60		-60	-70		-60		dB	f = 5MHz, 50 $\Omega$ load
Output Switch Isolation Diode Current	$I_{ID}$		300			300		300	mA	300ns pulse width, 2.0% duty cycle
Off Capacitance SW to GND	$C_{SG(OFF)}$	5.0	17	5.0	12	17	5.0	17	pF	0V, 1MHz
On Capacitance SW to GND	$C_{SG(ON)}$	25	50	25	38	50	25	50	pF	0V, 1MHz

\*Typical values only for HV232

## Electrical Characteristics

**AC Characteristics** (over operating conditions  $V_{DD} = 5V$ , unless otherwise noted)

Characteristics	Sym	+25°C			Units	Test Conditions
		min	typ*	max		
Output Voltage Spike	+ $V_{SPK}$			150	mV	$V_{PP} = 40V, V_{NN} = -160V, R_L = 50\Omega$
	- $V_{SPK}$			150		
	+ $V_{SPK}$			150		$V_{PP} = 100V, V_{NN} = -100V, R_L = 50\Omega$
	- $V_{SPK}$			150		
	+ $V_{SPK}$			150		$V_{PP} = 160V, V_{NN} = -40V, R_L = 50\Omega$
	- $V_{SPK}$			150		

\*Typical values only for HV232

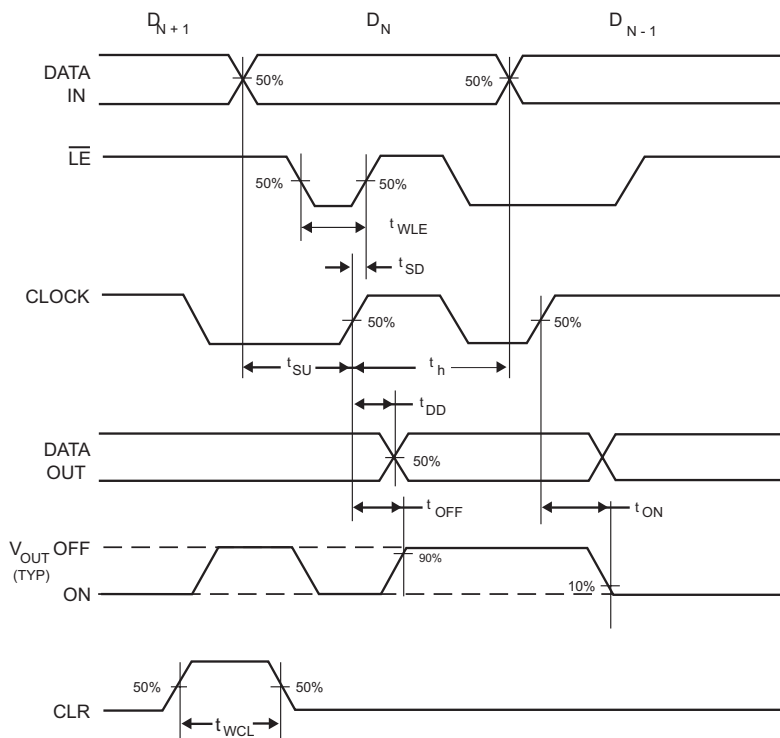
### Truth Table

D0	D1	D2	D3	D4	D5	D6	D7	$\overline{LE}$	CL	SW0	SW1	SW2	SW3	SW4	SW5	SW6	SW7
L								L	L	OFF							
H								L	L	ON							
	L							L	L		OFF						
	H							L	L		ON						
		L						L	L			OFF					
		H						L	L			ON					
			L					L	L				OFF				
			H					L	L				ON				
				L				L	L					OFF			
				H				L	L					ON			
					L			L	L						OFF		
					H			L	L						ON		
						L		L	L							OFF	
						H		L	L							ON	
							L	L	L								OFF
							H	L	L								ON
X	X	X	X	X	X	X	X	H	L	HOLD PREVIOUS STATE							
X	X	X	X	X	X	X	X	X	H	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

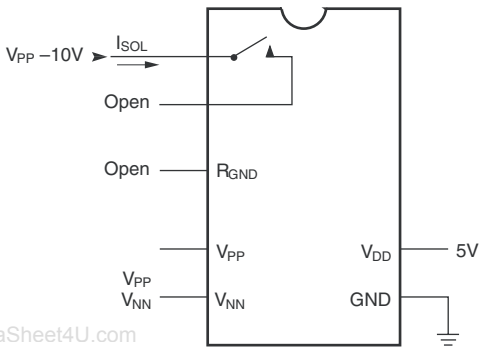
Notes:

1. The eight switches operate independently.
2. Serial data is clocked in on the L to H transition CLK.
3. The switches go to a state retaining their present condition at the rising edge of  $\overline{LE}$ . When  $\overline{LE}$  is low the shift register data flows through the latch.
4.  $D_{OUT}$  is high when data in shift register 7 is high.
5. Shift register clocking has no effect on the switch states if  $\overline{LE}$  is H.
6. The clear input overrides all other inputs.

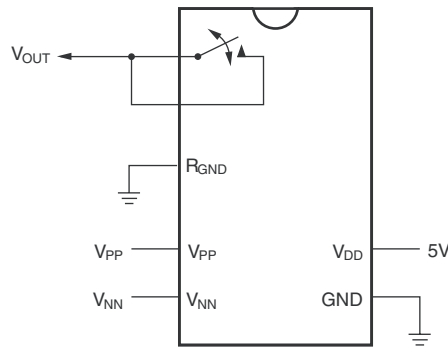
### Logic Timing Waveforms



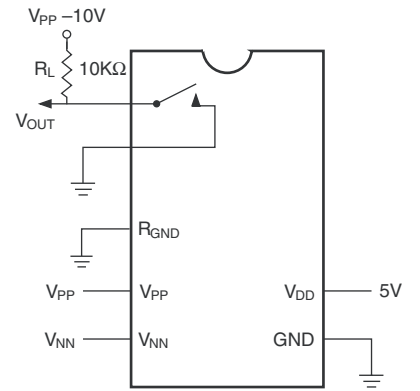
Test Circuits



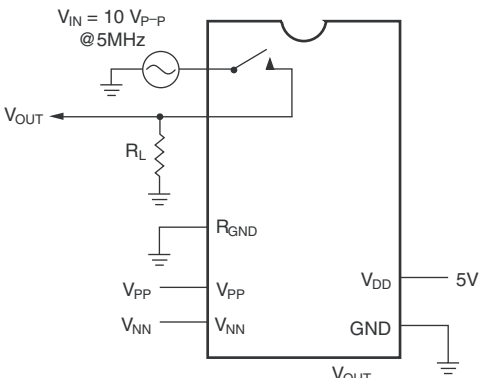
Switch OFF Leakage



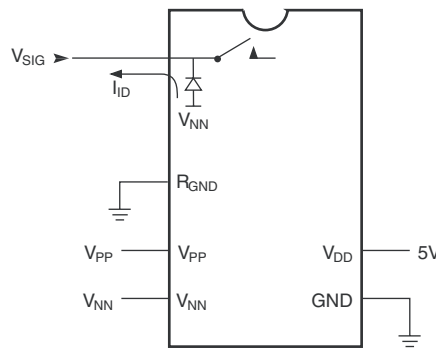
DC Offset ON/OFF



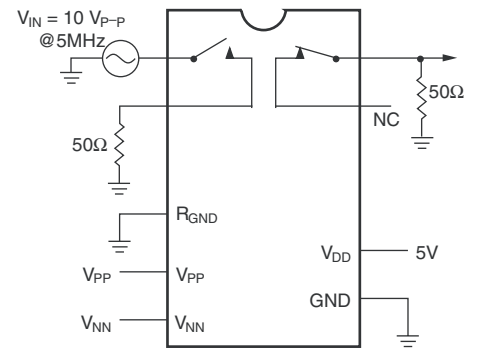
T<sub>ON</sub>/T<sub>OFF</sub> Test Circuit



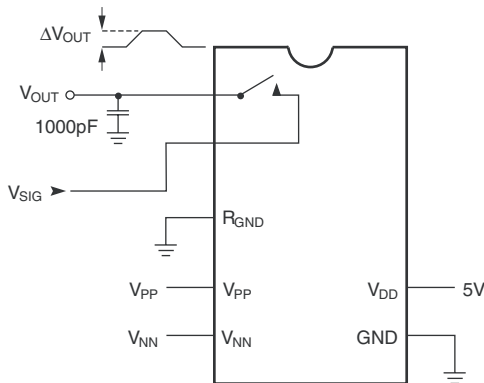
$K_O = 20 \text{Log} \frac{V_{OUT}}{V_{IN}}$   
OFF Isolation



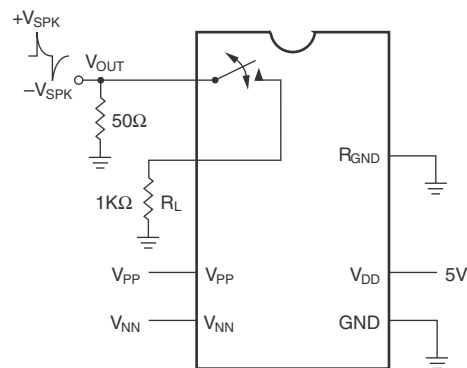
Isolation Diode Current



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

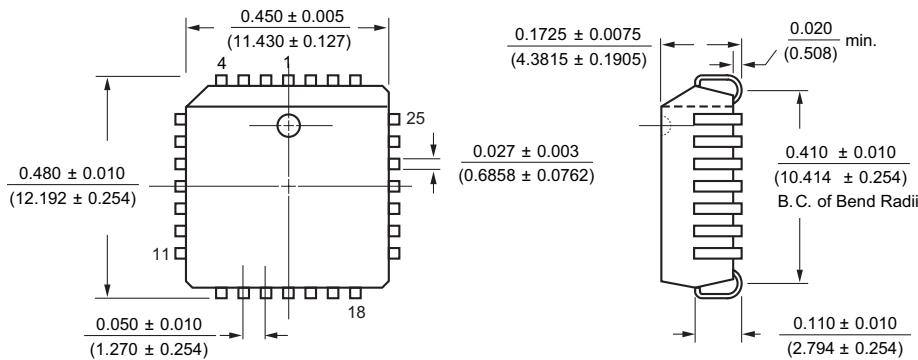


$Q = 1000 \text{pF} \times \Delta V_{OUT}$   
Charge Injection



Output Voltage Spike

### 28-Lead (J-Lead) PLCC Package Outline (PJ)

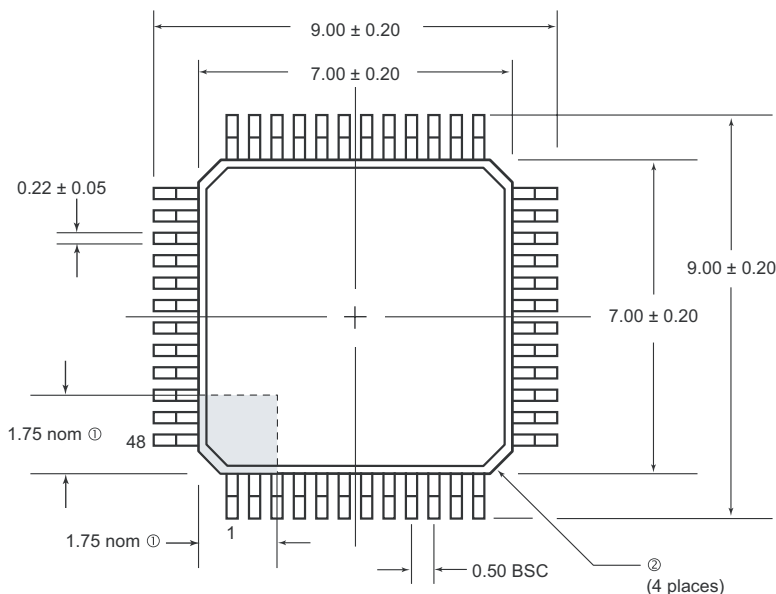


Measurement Legend =  $\frac{\text{Dimensions in Inches}}{\text{(Dimensions in Millimeters)}}$

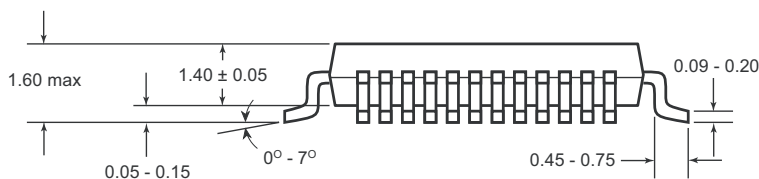
### Pin Description

Pin	Function	Pin	Function
1	SW3	15	N/C
2	SW3	16	D <sub>IN</sub>
3	SW2	17	CLK
4	SW2	18	$\overline{\text{LE}}$
5	SW1	19	CL
6	SW1	20	D <sub>OUT</sub>
7	SW0	21	SW7
8	SW0	22	SW7
9	N/C	23	SW6
10	V <sub>PP</sub>	24	SW6
11	R <sub>GND</sub>	25	SW5
12	V <sub>NN</sub>	26	SW5
13	GND	27	SW4
14	V <sub>DD</sub>	28	SW4

### 48-Lead LQFP/TQFP (1.4mm) Package Outline (FG)



Top View



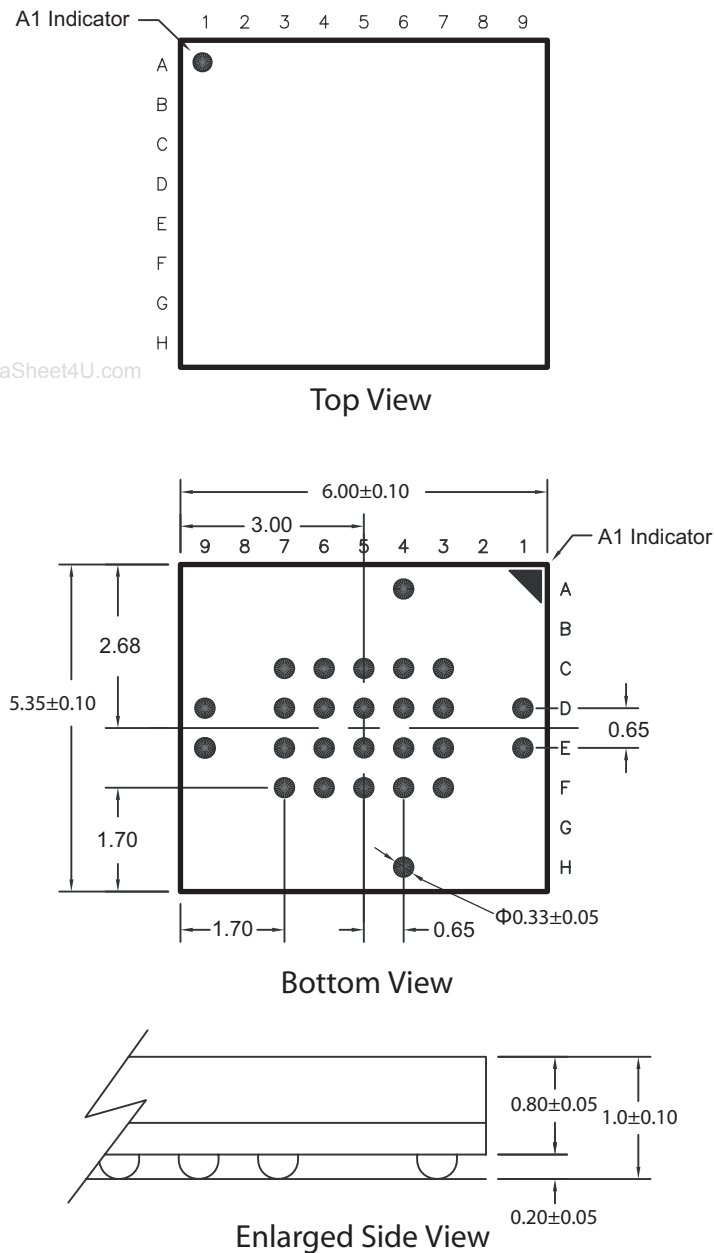
Side View

Linear dimensions in millimeters.  
 Angular dimensions in degrees  
 ① Pin 1 identifier located within the area indicated  
 ② Corner shape may differ from drawing.

### Pin Description

Pin	Function	Pin	Function
1	SW5	25	V <sub>NN</sub>
2	N/C	26	N/C
3	SW4	27	R <sub>GND</sub>
4	N/C	28	GND
5	SW4	29	V <sub>DD</sub>
6	N/C	30	N/C
7	N/C	31	N/C
8	SW3	32	N/C
9	N/C	33	D <sub>IN</sub>
10	SW3	34	CLK
11	N/C	35	$\overline{\text{LE}}$
12	SW2	36	CLR
13	N/C	37	D <sub>OUT</sub>
14	SW2	38	N/C
15	N/C	39	SW7
16	SW1	40	N/C
17	N/C	41	SW7
18	SW1	42	N/C
19	N/C	43	SW6
20	SW0	44	N/C
21	N/C	45	SW6
22	SW0	46	N/C
23	N/C	47	SW5
24	V <sub>PP</sub>	48	N/C

### 26-Ball fpBGA Package Outline (GA)



### Pin Configuration

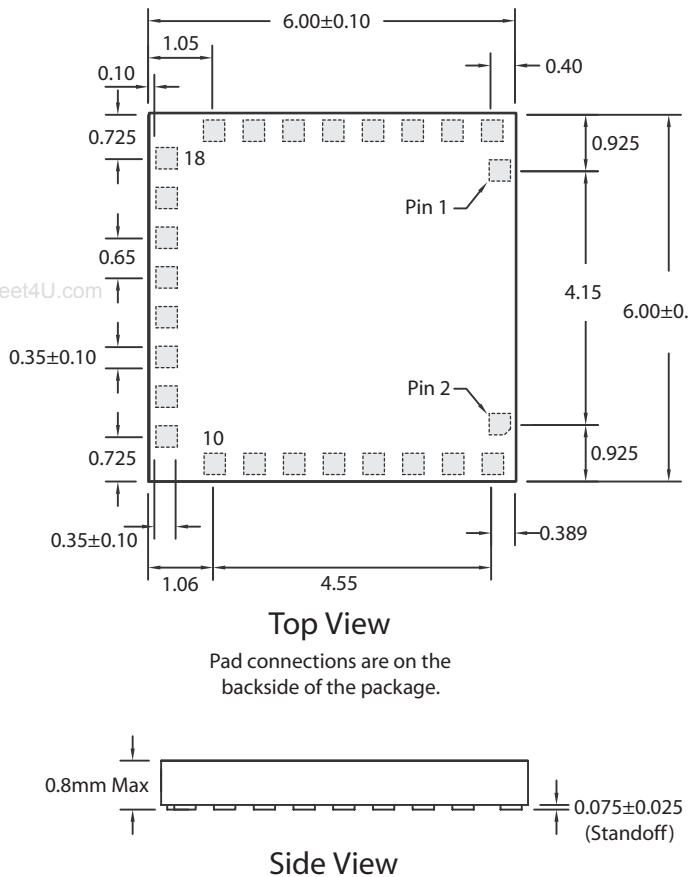
Ball Location	Function
A4	SW1
C3	SW2
C4	SW1
C5	SW0
C6	V <sub>PP</sub>
C7	V <sub>NN</sub>
D1	SW3
D3	SW3
D4	SW2
D5	SW0
D6	R <sub>GND</sub>
D7	GND
D9	V <sub>DD</sub>
E1	SW4
E3	SW4
E4	SW5
E5	SW7
E6	$\overline{LE}$
E7	CLK
E9	D <sub>IN</sub>
F3	SW5
F4	SW6
F5	SW7
F6	D <sub>OUT</sub>
F7	CLR
H4	SW6

Note:  
All dimensions are in millimeters



## 26-Lead BCC Package Outline (B1)

### HV230B1 Package Outline



### Pin Description

Pin	Function
1	SW4
2	SW3
3	SW3
4	SW2
5	SW2
6	SW1
7	SW1
8	SW0
9	SW0
10	V <sub>PP</sub>
11	V <sub>NN</sub>
12	R <sub>GND</sub>
13	GND
14	V <sub>DD</sub>
15	D <sub>IN</sub>
16	CLK
17	$\overline{\text{LE}}$
18	CLR
19	D <sub>OUT</sub>
20	SW7
21	SW7
22	SW6
23	SW6
24	SW5
25	SW5
26	SW4

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to <http://www.supertex.com/packaging.html>.)

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