

Low Charge Injection 8-Channel High Voltage Analog Switches

Features

- ❑ HVCMOS® technology for high performance
- ❑ Very low quiescent power dissipation – 10µA
- ❑ Output on-resistance typically 22 ohms
- ❑ Low parasitic capacitances
- ❑ DC to 10MHz analog signal frequency
- ❑ -60dB typical output off isolation at 5MHz
- ❑ CMOS logic circuitry for low power
- ❑ Excellent noise immunity
- ❑ On-chip shift register, latch and clear logic circuitry
- ❑ Flexible high voltage supplies

Applications

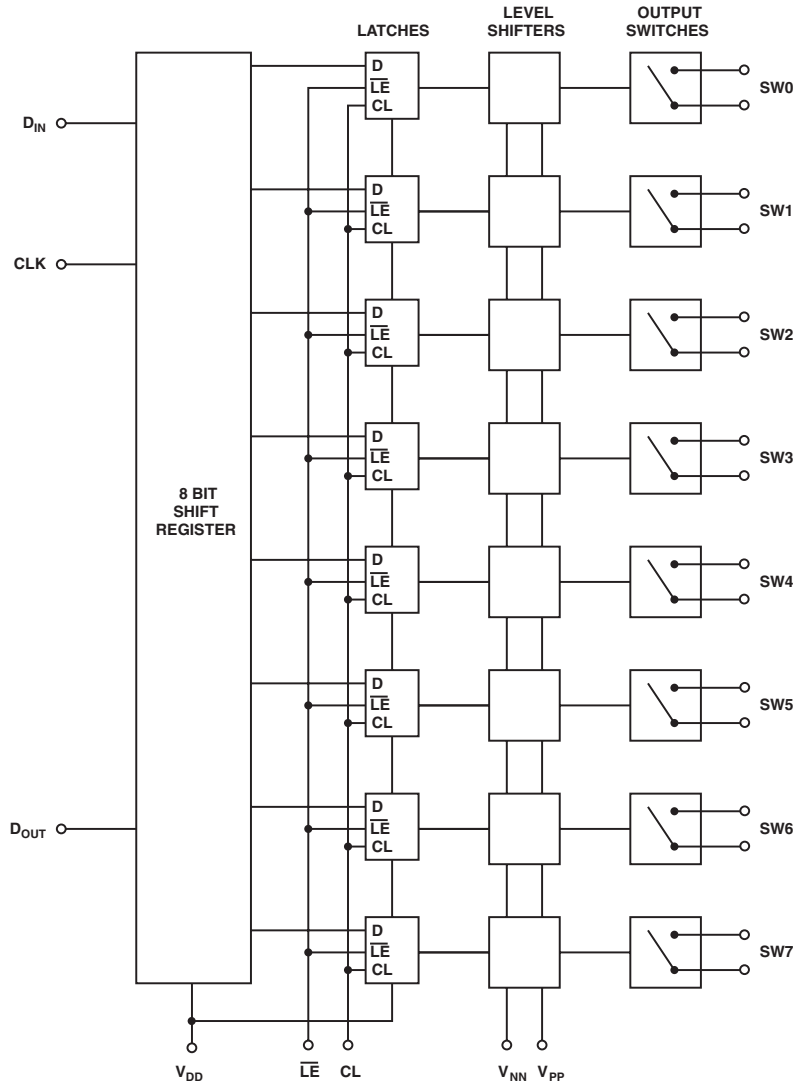
- ❑ Medical ultrasound imaging
- ❑ Piezoelectric transducer drivers

General Description

These devices are low charge injection 8-channel high-voltage analog switch integrated circuits (ICs) intended for use in applications requiring high voltage switching controlled by low voltage control signals, such as ultrasound imaging and printers. 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 (\overline{LE}) should be left high until all bits are clocked in. Using HVCMOS technology, these switches combine high voltage bilateral DMOS switches and low power CMOS logic to provide efficient control of high voltage analog signals.

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

Block Diagram



Absolute Maximum Ratings*

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 TQFP	1.0W
26-lead TAPP	1.0W
25-lead FPGA	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.

Ordering Information

Package Options					$V_{PP} - V_{NN}$
28-Lead plastic chip carrier	48-lead TQFP	26-lead TAPP	25-lead FPBGA	Die	
HV20220PJ	HV20220FG	-	-	HV20220X	200V
HV20320PJ	-	-	-	-	200V
-	-	HV220TA	HV220GA	-	200V

Operating Conditions

Symbol	Parameter	Value
V_{DD}	Logic power supply voltage ^{1,3}	4.5V to 13.2V
V_{PP}	Positive high voltage supply ^{1,3}	40V to $V_{NN} + 200V$
V_{NN}	Negative high voltage supply ^{1,3}	-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.

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	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 switch 7 is on.
5. Shift register clocking has no effect on the switch states if \overline{LE} is H.
6. The clear input overrides all other inputs.

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 _{ONS}		30		26	38		48	ohms	I _{SIG} = 5mA	V _{PP} = 40V, V _{NN} = -160V
			25		22	27		32		I _{SIG} = 200mA	V _{NN} = -100V
			25		22	27		30		I _{SIG} = 5mA	V _{PP} = 100V, V _{NN} = -100V
			18		18	24		27		I _{SIG} = 200mA	V _{NN} = -100V
			23		20	25		30		I _{SIG} = 5mA	V _{PP} = 160V, V _{NN} = -40V
			22		16	25		27		I _{SIG} = 200mA	V _{NN} = -40V
Small Signal Switch (ON) Resistance Matching	ΔR _{ONS}		20		5.0	20		20	%	I _{SW} = 5mA, V _{PP} = 100V, V _{NN} = -100V	
Large Signal Switch (ON) Resistance	R _{ONL}				15				ohms	V _{SIG} = V _{PP} - 10V, I _{SIG} = 1A	
Switch Off Leakage Per Switch	I _{SOL}		5.0		1.0	10		15	μA	V _{SIG} = V _{PP} - 10V and V _{NN} +10V	
DC Offset Switch Off			300		100	300		300	mV	R _L = 100Ω	
DC Offset Switch On			500		100	500		500	mV	R _L = 100KΩ	
Pos. HV Supply Current	I _{PPQ}				10	50			μA	ALL SWs OFF	
Neg. HV Supply Current	I _{NNQ}				-10	-50			μA	ALL SWs OFF	
Pos. HV Supply Current	I _{PPQ}				10	50			μA	ALL SWs ON I _{SW} = 5mA	
Neg. HV Supply Current	I _{NNQ}				-10	-50			μA	ALL SWs ON I _{SW} = 5mA	
Switch Output Peak Current			3.0		3.0	2.0		2.0	A	V _{SIG} duty cycle ≤ 0.1%	
Output Switch Frequency	f _{SW}					50			KHz	Duty Cycle = 50%	
I _{PP} Supply Current	I _{PP}		6.5			7.0		8.0	mA	V _{PP} = 40V, V _{NN} = -160V	50KHz Output Switching Frequency with no load
			4.0			5.0		5.5		V _{PP} = 100V, V _{NN} = -100V	
			4.0			5.0		5.5		V _{PP} = 160V, V _{NN} = -40V	
I _{NN} Supply Current	I _{NN}		6.5			7.0		8.0	mA	V _{PP} = 40V, V _{NN} = -160V	
			4.0			5.0		5.5		V _{PP} = 100V, V _{NN} = -100V	
			4.0			5.0		5.5		V _{PP} = 160V, V _{NN} = -40V	
Logic Supply Average Current	I _{DD}		4.0			4.0		4.0	mA	f _{CLK} = 5MHz, V _{DD} = 5.0V	
Logic Supply Quiescent Current	I _{DDQ}		10			10		10	μA		
Data Out Source Current	I _{SOR}	0.45		0.45	0.70			0.40	mA	V _{OUT} = V _{DD} - 0.7V	
Data Out Sink Current	I _{SINK}	0.45		0.45	0.70			0.40	mA	V _{OUT} = 0.7V	
Logic Input Capacitance	C _{IN}		10			10		10	pF		

* Typical values are only for HV202/HV203

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}		150			150		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		50			50		50	ns	
Turn On Time	t_{ON}		5.0			5.0		5.0	μs	$V_{SIG} = V_{PP} - 10V$, $R_L = 10K\Omega$
Turn Off Time	t_{OFF}		5.0			5.0		5.0	μs	$V_{SIG} = V_{PP} - 10V$, $R_L = 10K\Omega$
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 Ω /15pF load
		-58		-58			-58		dB	$f = 5MHz$, 50 Ω load
Switch Crosstalk	K_{CR}	-60		-60	-70		-60		dB	$f = 5MHz$, 50 Ω 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

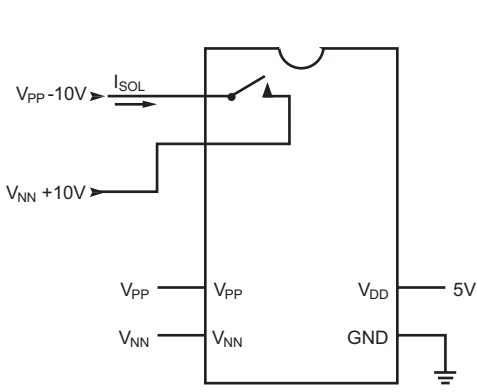
Electrical Characteristics

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

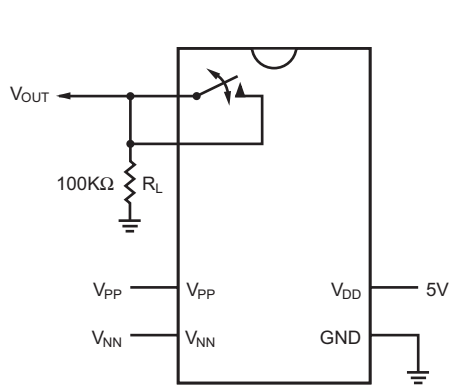
Characteristics	Sym	+25°C			Units	Test Conditions
		min	typ*	max		
Output Voltage Spike	$+V_{SPK}$			150	mV	$V_{PP} = 40V, V_{NN} = -160V, R_L = 50\Omega$
	$-V_{SPK}$			150		
	$+V_{SPK}$			150		$V_{PP} = 100V, V_{NN} = -100V, R_L = 50\Omega$
	$-V_{SPK}$			150		
	$+V_{SPK}$			150		$V_{PP} = 160V, V_{NN} = -40V, R_L = 50\Omega$
	$-V_{SPK}$			150		
Charge Injection	Q		820		pC	$V_{PP} = 40V, V_{NN} = -160V, V_{SIG} = 0V$
			600			$V_{PP} = 100V, V_{NN} = -100V, V_{SIG} = 0V$
			350			$V_{PP} = 160V, V_{NN} = -40V, V_{SIG} = 0V$

* Typical values are only for HV202/HV203

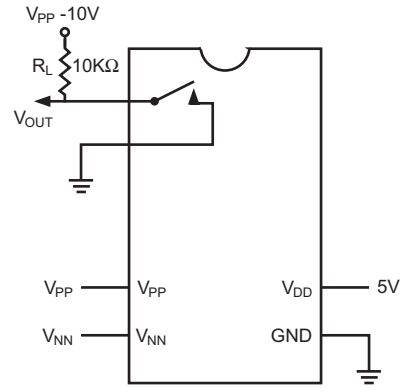
Test Circuits



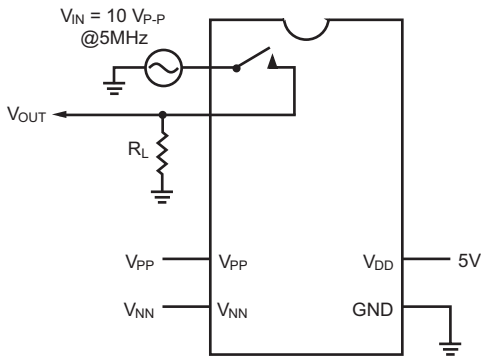
Switch OFF Leakage



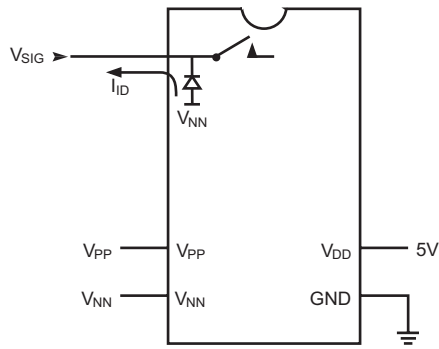
DC Offset ON/OFF



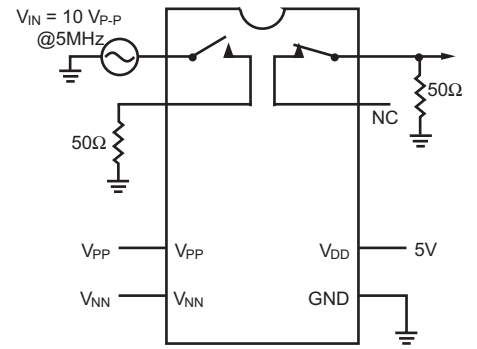
T_{ON}/T_{OFF} Test Circuit



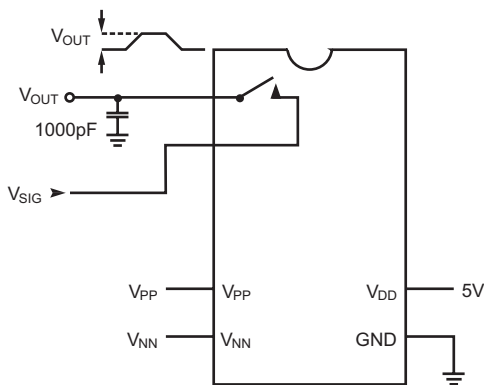
$K_O = 20 \log \frac{V_{OUT}}{V_{IN}}$
OFF Isolation



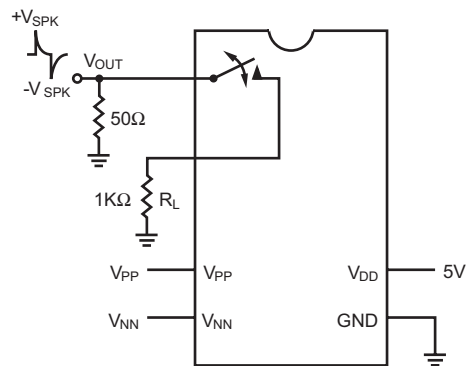
Isolation Diode Current



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

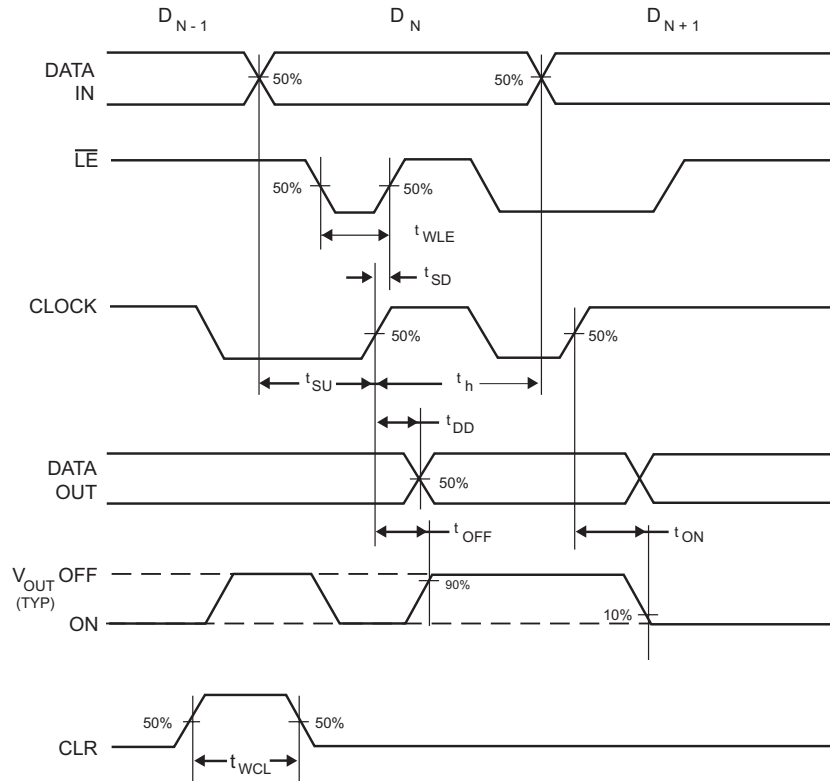


$Q = 1000pF \times V_{OUT}$
Charge Injection

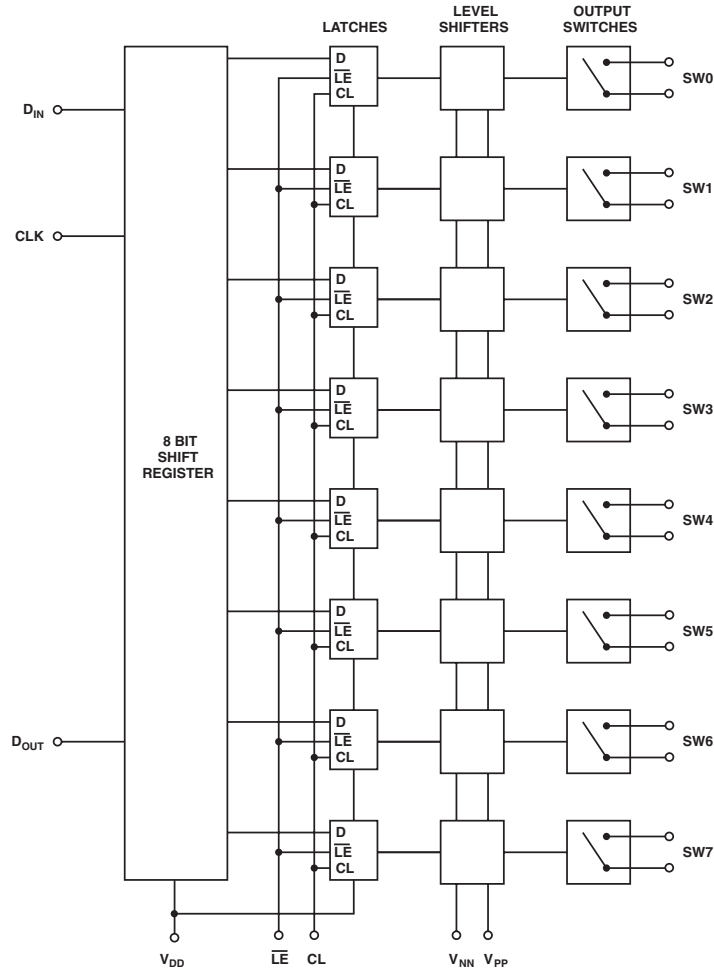


Output Voltage Spike

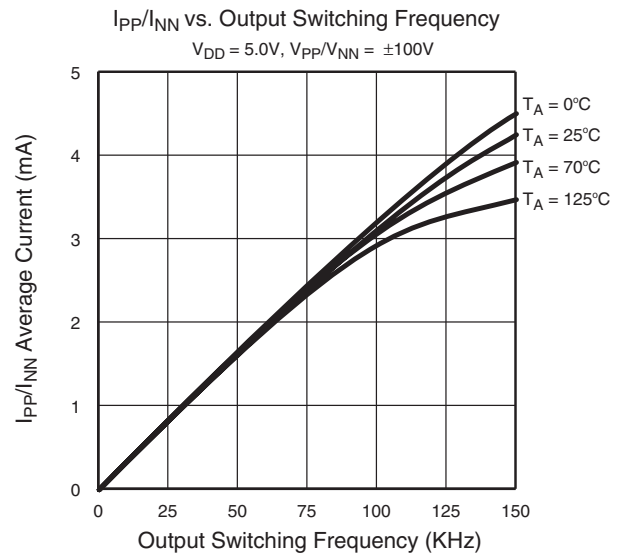
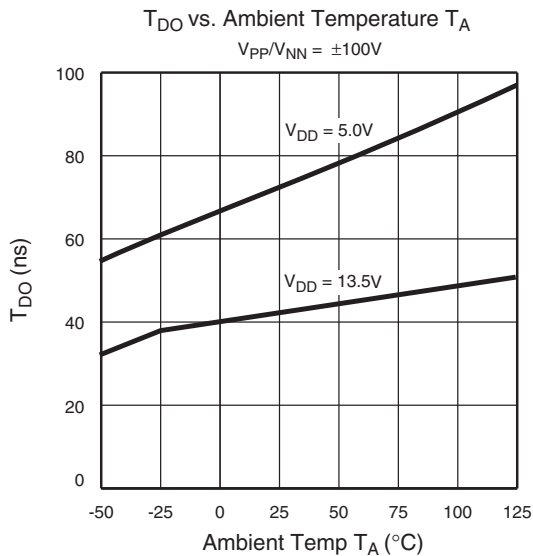
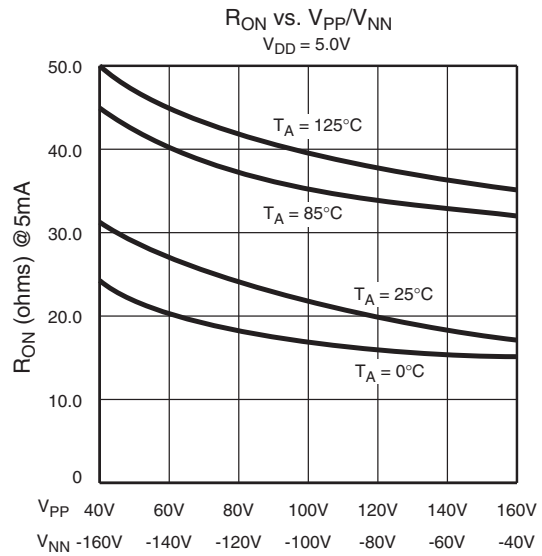
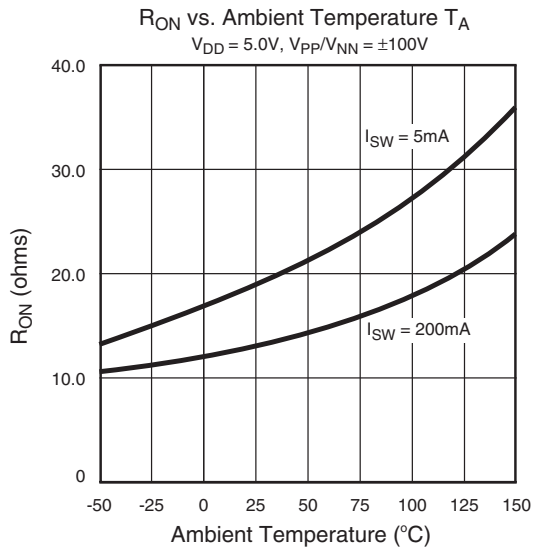
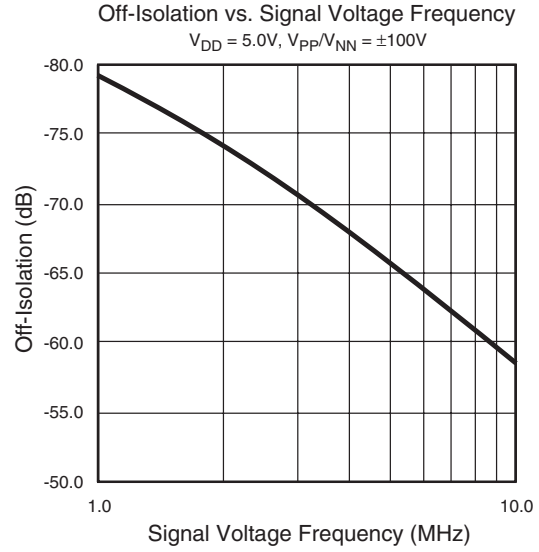
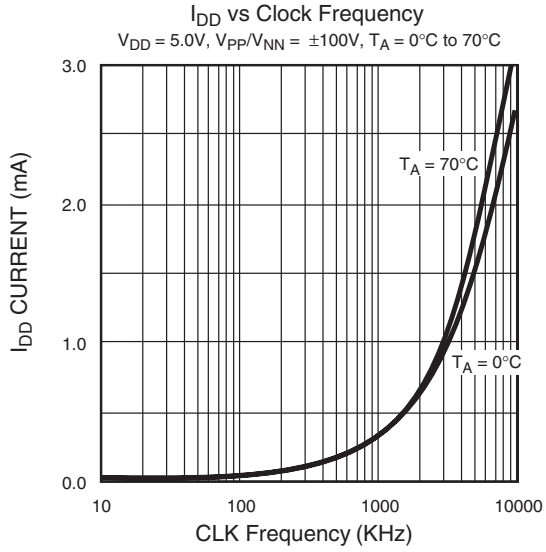
Logic Timing Waveforms



Block Diagram



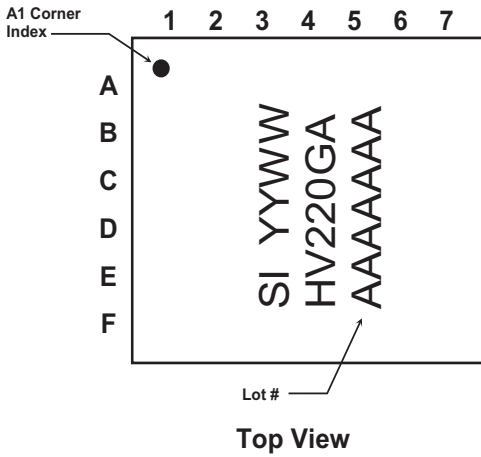
Typical Performance Curves for HV20220 & HV20320



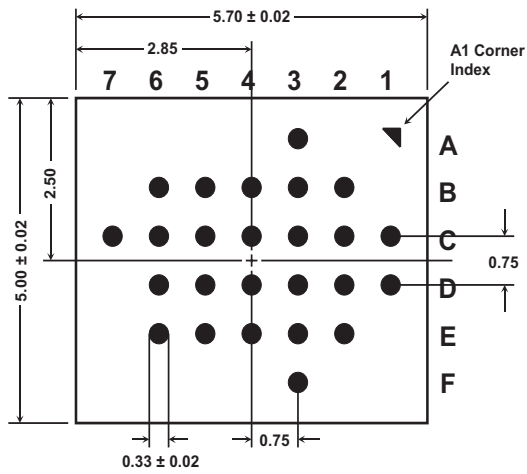
HV220GA Package Outline (FPBGA)

Pin Configuration

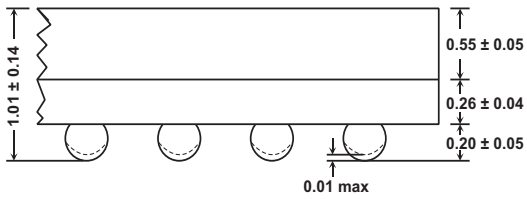
All dimensions are in millimeters



Top View



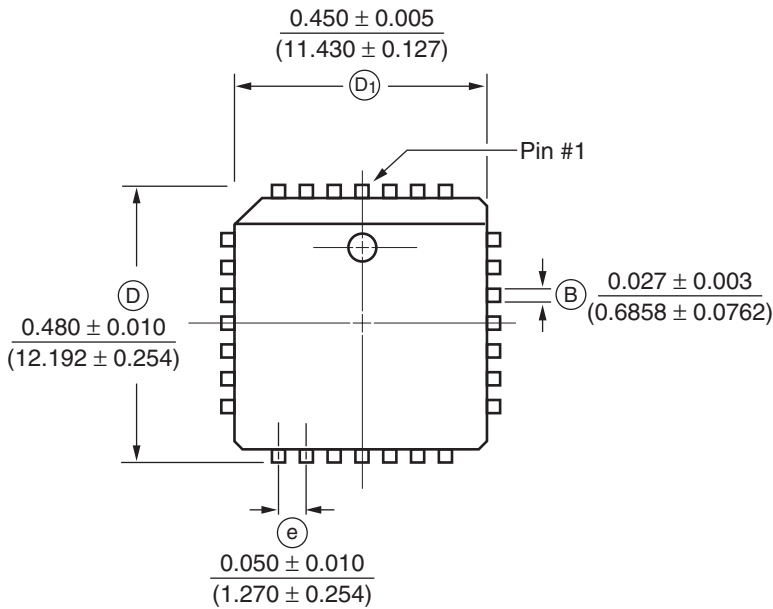
Bottom View



Enlarged Side View

Ball Location	Function
A3	SW1
B2	SW2
B3	SW1
B4	SW0
B5	SW0
B6	V _{NN}
C1	SW3
C2	SW3
C3	SW2
C4	V _{PP}
C5	GND
C6	D _{IN}
C7	V _{DD}
D1	SW4
D2	SW4
D3	SW5
D4	SW7
D5	LE
D6	CLK
E2	SW5
E3	SW6
E4	SW7
E5	D _{OUT}
E6	CLR
F3	SW6

HV202/HV203 28-Pin J-lead Package Outline



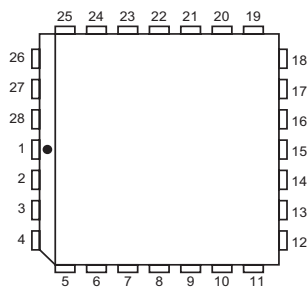
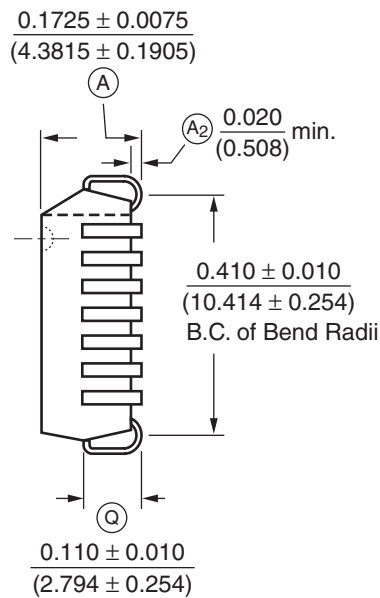
Pin Configuration

HV202 28 Pin J-Lead

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

HV203 28 Pin J-Lead

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

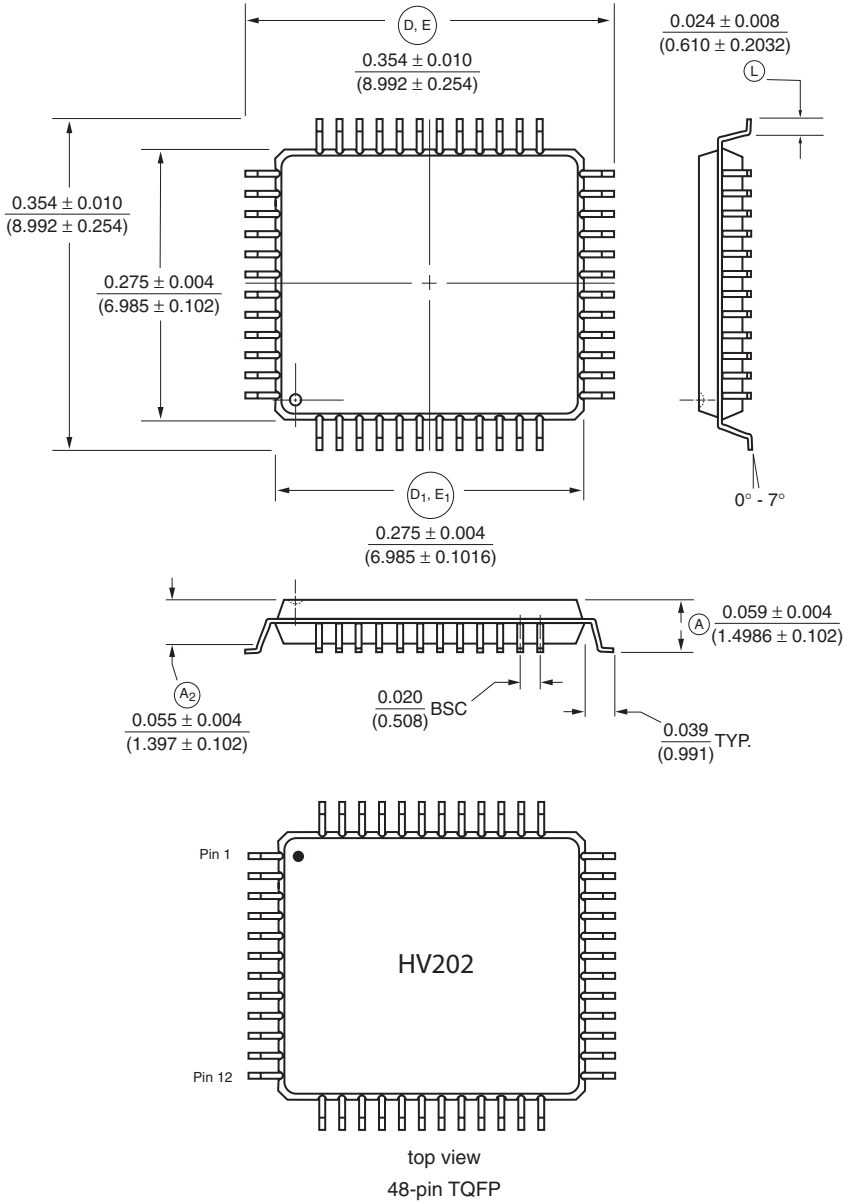


Top View
28-Pin J-Lead Package

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

HV202 48-Pin TQFP

Pin Configuration



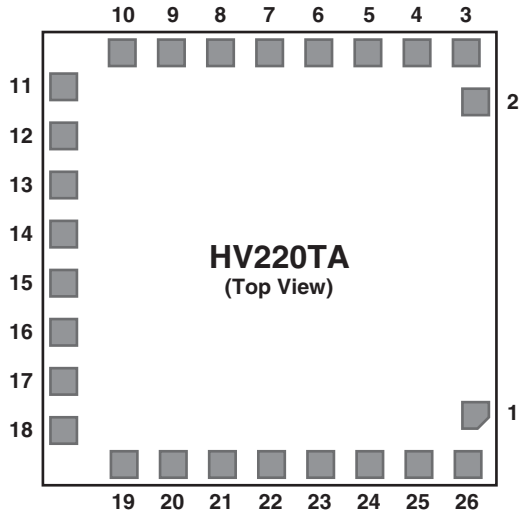
HV202 48-Pin TQFP

Pin	Function	Pin	Function
1	SW5	25	V _{NN}
2	N/C	26	N/C
3	SW4	27	N/C
4	N/C	28	GND
5	SW4	29	V _{DD}
6	N/C	30	N/C
7	N/C	31	N/C
8	SW3	32	N/C
9	N/C	33	D _{IN}
10	SW3	34	CLK
11	N/C	35	\overline{LE}
12	SW2	36	CLR
13	N/C	37	D _{OUT}
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 _{PP}	48	N/C

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

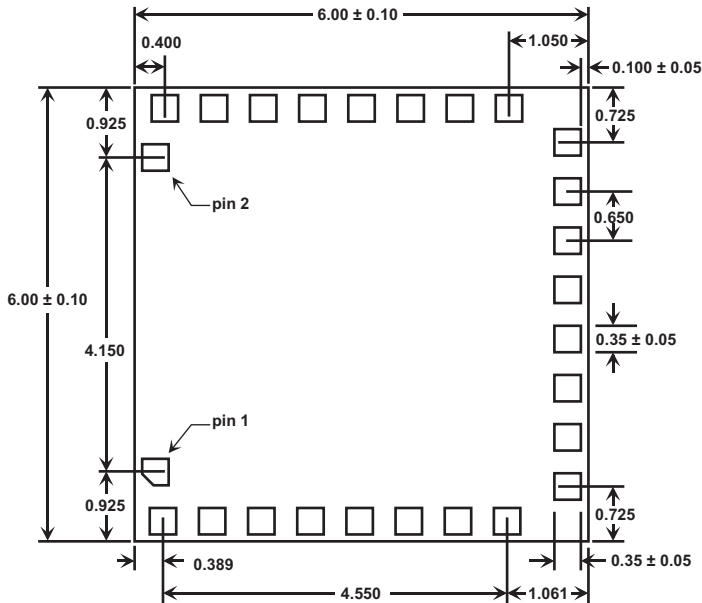
HV220TA Package Outline

Pin Configuration



Pad connections are on the
backside of the package

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



Bottom View
Dimensions are in mm



Side View
Dimensions are in mm

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