

# Low Charge Injection, 8-Channel, Unipolar, Negative High Voltage, Analog Switch

## Features

- ▶ Low on-resistance, 14Ω max.
- ▶ HVCMOS technology for high performance
- ▶ 3.3 or 5.0V CMOS input logic level
- ▶ 20MHz data shift clock frequency
- ▶ Very low quiescent power dissipation (~10μA)
- ▶ Low parasitic capacitance
- ▶ **DC to 50MHz small signal frequency response**
- ▶ -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

- ▶ NDT metal flaw detection
- ▶ Medical ultrasound imaging
- ▶ Piezoelectric transducer drivers
- ▶ Inkjet printer heads
- ▶ Optical MEMS modules

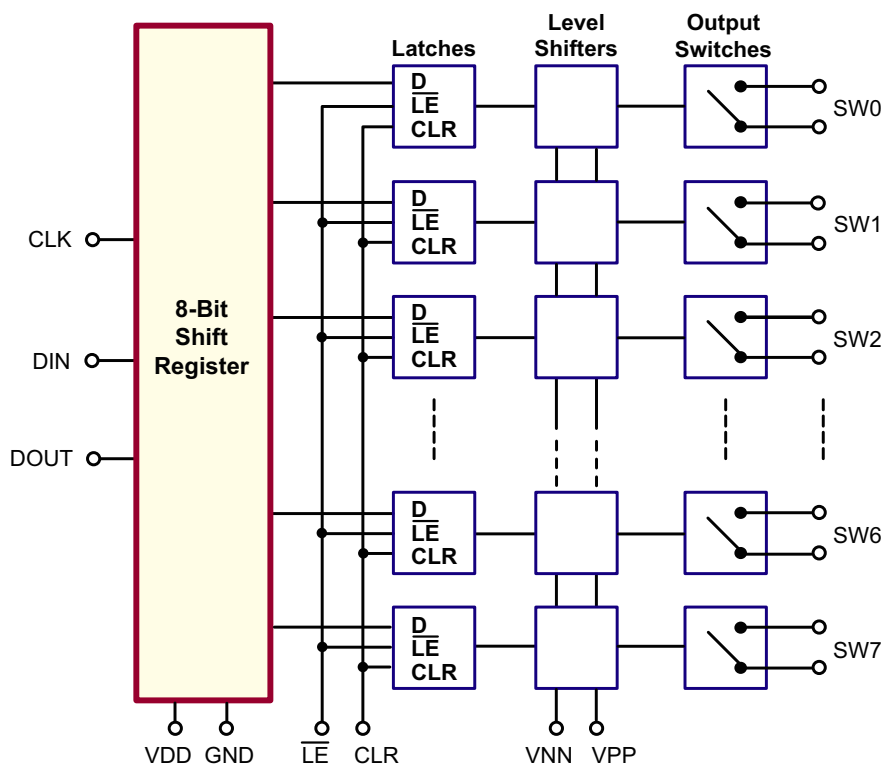
## General Description

The Supertex HV2221 is a low charge injection, 8-channel, unipolar, negative high voltage, analog switch integrated circuit (IC) intended for use in applications requiring high voltage switching controlled by low voltage control signals, such as NDT ultrasound flaw detection, medical ultrasound imaging, piezoelectric transducer drivers, and printers.

Data is input into an 8-bit shift register that can then be retained in an 8-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 is 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.

## Block Diagram



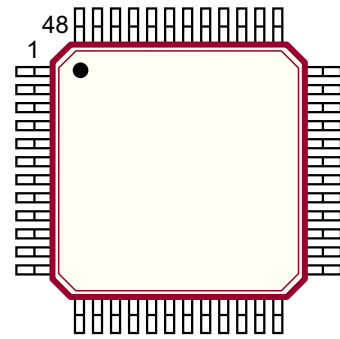
## Ordering Information

| Device | 48-Lead LQFP<br>7.00x7.00mm body<br>1.60mm height (max)<br>0.50mm pitch |
|--------|-------------------------------------------------------------------------|
| HV2221 | HV2221FG-G                                                              |

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



## Pin Configuration



48-Lead LQFP (FG)  
(top view)

## Absolute Maximum Ratings

| Parameter                               | Value                   |
|-----------------------------------------|-------------------------|
| $V_{DD}$ logic supply                   | -0.5V to +7.0V          |
| $V_{PP}$ - $V_{NN}$ differential supply | 260V                    |
| $V_{PP}$ positive supply                | -0.5V to $V_{NN}$ +260V |
| $V_{NN}$ negative supply                | +0.5V to -250V          |
| Logic input voltage                     | -0.5V to $V_{DD}$ +0.3V |
| Analog signal range                     | $V_{NN}$ to $V_{PP}$    |
| Peak analog signal current/channel      | 4.5A                    |
| Storage temperature                     | -65°C to 150°C          |
| Power dissipation                       | 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.

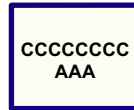
## Product Marking

Top Marking



YY = Year Sealed  
WW = Week Sealed  
L = Lot Number  
C = Country of Origin\*  
A = Assembler ID\*  
— = "Green" Packaging  
\*May be part of top marking

Bottom Marking



Package may or may not include the following marks: Si or

48-Lead LQFP (FG)

## Operating Conditions

| Sym                 | Parameter                          | Value                          |
|---------------------|------------------------------------|--------------------------------|
| $V_{DD}$            | Logic power supply voltage         | 3.0V to 5.5V                   |
| $V_{PP}$ - $V_{NN}$ | Supply voltage differential        | 240V                           |
| $V_{PP}$            | Positive driver supply             | +15V to +50V                   |
| $V_{NN}$            | Negative high voltage supply       | -100V to -225V                 |
| $V_{IH}$            | 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:

- Power up/down sequence is arbitrary except GND must be powered-up first and powered-down last.
- $V_{SIG}$  must be  $V_{NN} \leq V_{SIG} \leq V_{PP}$  or floating during power up/down transition.
- 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 operating conditions unless otherwise specified )

| 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          | -    | -   | -     | -    | 14  | -     | -   | Ω     | I <sub>SIG</sub> = 5.0mA                                                  | V <sub>PP</sub> = +50V                            |
|                      |                                            | -    | -   | -     | -    | 14  | -     | -   |       | I <sub>SIG</sub> = 200mA                                                  | V <sub>NN</sub> = -190V                           |
|                      |                                            | -    | -   | -     | -    | 15  | -     | -   |       | I <sub>SIG</sub> = 5.0mA                                                  | V <sub>PP</sub> = +40V                            |
|                      |                                            | -    | -   | -     | -    | 15  | -     | -   |       | I <sub>SIG</sub> = 200mA                                                  | V <sub>NN</sub> = -200V                           |
|                      |                                            | -    | -   | -     | -    | 23  | -     | -   |       | I <sub>SIG</sub> = 5.0mA                                                  | V <sub>PP</sub> = +15V                            |
|                      |                                            | -    | -   | -     | -    | 23  | -     | -   |       | I <sub>SIG</sub> = 200mA                                                  | V <sub>NN</sub> = -225V                           |
| ΔR <sub>ONS</sub>    | Small signal switch on-resistance matching | -    | 20  | -     | 5.0  | 20  | -     | 20  | %     | I <sub>SIG</sub> = 5.0mA, V <sub>PP</sub> = +40V, V <sub>NN</sub> = -200V |                                                   |
| R <sub>ONL</sub>     | Large signal switch on-resistance          | -    | -   | -     | 9.2  | -   | -     | -   | Ω     | V <sub>SIG</sub> = 0V, I <sub>SIG</sub> = -1.0A                           |                                                   |
| 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, V <sub>NN</sub> +10V             |                                                   |
| V <sub>OS(OFF)</sub> | DC offset switch off                       | -    | 300 | -     | 100  | 300 | -     | 300 | mV    | 100KΩ load                                                                |                                                   |
| V <sub>OS(ON)</sub>  | DC offset switch on                        | -    | 500 | -     | 100  | 500 | -     | 500 |       |                                                                           |                                                   |
| I <sub>DDQ</sub>     | Quiescent V <sub>DD</sub> supply current   | -    | -   | -     | -    | 50  | -     | -   | μA    | All switches off                                                          |                                                   |
| I <sub>PPQ</sub>     | Quiescent V <sub>PP</sub> supply current   | -    | -   | -     | -    | 50  | -     | -   |       |                                                                           |                                                   |
| I <sub>NNQ</sub>     | Quiescent V <sub>NN</sub> supply current   | -    | -   | -     | -    | -50 | -     | -   |       |                                                                           |                                                   |
| I <sub>DDQ</sub>     | Quiescent V <sub>DD</sub> supply current   | -    | -   | -     | -    | 50  | -     | -   | μA    | All switches on, I <sub>SW</sub> = 5.0mA                                  |                                                   |
| I <sub>PPQ</sub>     | Quiescent V <sub>PP</sub> supply current   | -    | -   | -     | -    | 50  | -     | -   |       |                                                                           |                                                   |
| I <sub>NNQ</sub>     | Quiescent V <sub>NN</sub> supply current   | -    | -   | -     | -    | -50 | -     | -   |       |                                                                           |                                                   |
| I <sub>SW</sub>      | Switch output peak current                 | -    | -   | -     | 4.5  | -   | -     | -   | A     | V <sub>SIG</sub> duty cycle < 0.1%, 1.0μs                                 | V <sub>PP</sub> = +50V<br>V <sub>NN</sub> = -190V |
|                      |                                            | -    | -   | -     | 4.0  | -   | -     | -   |       |                                                                           | V <sub>PP</sub> = +40V<br>V <sub>NN</sub> = -200V |
|                      |                                            | -    | -   | -     | 2.0  | -   | -     | -   |       |                                                                           | V <sub>PP</sub> = +15V<br>V <sub>NN</sub> = -225V |
| f <sub>SW</sub>      | Output switching frequency                 | -    | -   | -     | -    | 50  | -     | -   | kHz   | Duty cycle = 50%                                                          |                                                   |
| I <sub>PP</sub>      | Average V <sub>PP</sub> supply current     | -    | -   | -     | 5.6  | 7.5 | -     | -   | mA    | V <sub>PP</sub> = +40V<br>V <sub>NN</sub> = -200V                         | 50kHz output switching frequency with no load     |
|                      |                                            | -    | -   | -     | 5.6  | 7.5 | -     | -   |       | V <sub>PP</sub> = +50V<br>V <sub>NN</sub> = -190V                         |                                                   |
|                      |                                            | -    | -   | -     | 5.6  | 7.5 | -     | -   |       | V <sub>PP</sub> = +15V<br>V <sub>NN</sub> = -225V                         |                                                   |
| I <sub>NN</sub>      | Average V <sub>NN</sub> supply current     | -    | -   | -     | 5.8  | 7.5 | -     | -   | mA    | V <sub>PP</sub> = +40V<br>V <sub>NN</sub> = -200V                         | 50kHz output switching frequency with no load     |
|                      |                                            | -    | -   | -     | 5.8  | 7.5 | -     | -   |       | V <sub>PP</sub> = +50V<br>V <sub>NN</sub> = -190V                         |                                                   |
|                      |                                            | -    | -   | -     | 5.8  | 7.5 | -     | -   |       | V <sub>PP</sub> = +15V<br>V <sub>NN</sub> = -225V                         |                                                   |
| I <sub>DD</sub>      | Average V <sub>DD</sub> supply current     | -    | 4.5 | -     | -    | 4.5 | -     | 4.5 | mA    | f <sub>CLK</sub> = 5.0MHz, 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>     | D <sub>OUT</sub> 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>    | D <sub>OUT</sub> 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    | ---                                                                       |                                                   |

## AC Electrical Characteristics

(Over recommended operating conditions:  $V_{DD} = +5.0V$ ,  $t_R = t_F \leq 5.0ns$ , 50% duty cycle,  $V_{PP} = +40V$ ,  $V_{NN} = -200V$ ,  $C_{LOAD} = 20pF$ , unless otherwise specified)

| Sym           | Parameter                                | 0°C |     | +25°C |      |     | +70°C |     | Units   | Conditions                                                       |
|---------------|------------------------------------------|-----|-----|-------|------|-----|-------|-----|---------|------------------------------------------------------------------|
|               |                                          | Min | Max | Min   | Typ  | Max | Min   | Max |         |                                                                  |
| $t_{SD}$      | Set up time before $\overline{LE}$ rises | -   | -   | 25    | -    | -   | -     | -   | ns      | ---                                                              |
| $t_{WLE}$     | Time width of $\overline{LE}$            | -   | -   | -     | 56   | -   | -     | -   | ns      | $V_{DD} = 3.0V$                                                  |
|               |                                          | -   | -   | -     | 12   | -   | -     | -   |         | $V_{DD} = 5.0V$                                                  |
| $t_{DO}$      | Clock delay time to data out             | -   | -   | -     | 78   | -   | -     | -   | ns      | $V_{DD} = 3.0V$                                                  |
|               |                                          | -   | -   | -     | 30   | -   | -     | -   |         | $V_{DD} = 5.0V$                                                  |
| $t_{WCL}$     | Time width of CLR                        | -   | -   | 55    | -    | -   | -     | -   | ns      | ---                                                              |
| $t_{SU}$      | Set up time data to clock                | -   | -   | -     | 21   | -   | -     | -   | ns      | $V_{DD} = 3.0V$                                                  |
|               |                                          | -   | -   | -     | 7.0  | -   | -     | -   |         | $V_{DD} = 5.0V$                                                  |
| $t_H$         | Hold time data from clock                | 2.0 | -   | 2.0   | -    | -   | 2.0   | -   | ns      | $V_{DD} = 3.0$ or $5.0V$                                         |
| $f_{CLK}$     | Clock frequency                          | -   | -   | -     | -    | 8.0 | -     | -   | MHz     | $V_{DD} = 3.0V$                                                  |
|               |                                          | -   | -   | -     | -    | 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 | $\mu s$ | $V_{SIG} = -100V$ ,<br>$R_{LOAD} = 10k\Omega$ to GND             |
| $t_{OFF}$     | Turn off time                            | -   | 5.0 | -     | -    | 5.0 | -     | 5.0 |         |                                                                  |
| dv/dt         | Maximum $V_{SIG}$ slew rate              | -   | 20  | -     | -    | 20  | -     | 20  | V/ns    | $V_{PP} = +40V$ , $V_{NN} = -200V$                               |
|               |                                          | -   | 20  | -     | -    | 20  | -     | 20  |         | $V_{PP} = +50V$ , $V_{NN} = -190V$                               |
|               |                                          | -   | 20  | -     | -    | 20  | -     | 20  |         | $V_{PP} = +15V$ , $V_{NN} = -225V$                               |
| $K_O$         | Off isolation                            | -30 | -   | -30   | -33  | -   | -30   | -   | dB      | $f = 5.0MHz$ , $V_{OFFSET} = -15V$ ,<br>1.0K $\Omega$ /15pF load |
|               |                                          | -58 | -   | -58   | -    | -   | -58   | -   |         | $f = 5.0MHz$ , $V_{OFFSET} = -15V$ ,<br>50 $\Omega$ load         |
| $K_{CR}$      | Switch crosstalk                         | -   | -   | -60   | -    | -   | -     | -   | dB      | $f = 5.0MHz$ , $V_{OFFSET} = -15V$ ,<br>50 $\Omega$ load         |
| $I_{ID}$      | Output switch isolation diode current    | -   | 300 | -     | -    | 300 | -     | 300 | mA      | 300ns pulse width,<br>2.0% duty cycle                            |
| $C_{SG(OFF)}$ | Off capacitance SW to GND                | -   | -   | -     | 18   | -   | -     | -   | pF      | $f = 1.0MHz$ , $V_{OFFSET} = -15V$                               |
| $C_{SG(ON)}$  | On capacitance SW to GND                 | -   | -   | -     | 70   | -   | -     | -   | pF      | $f = 1.0MHz$ , $V_{OFFSET} = -15V$                               |
| $+V_{SPK}$    | Output voltage spike                     | -   | -   | -     | 59   | -   | -     | -   | mV      | $V_{PP} = +40V$ , $V_{NN} = -200V$ ,<br>$R_{LOAD} = 50\Omega$    |
| $-V_{SPK}$    |                                          | -   | -   | -     | 115  | -   | -     | -   |         |                                                                  |
| $+V_{SPK}$    |                                          | -   | -   | -     | 71   | -   | -     | -   |         | $V_{PP} = +50V$ , $V_{NN} = -190V$ ,<br>$R_{LOAD} = 50\Omega$    |
| $-V_{SPK}$    |                                          | -   | -   | -     | 115  | -   | -     | -   |         |                                                                  |
| $+V_{SPK}$    |                                          | -   | -   | -     | 56   | -   | -     | -   |         | $V_{PP} = +15V$ , $V_{NN} = -225V$ ,<br>$R_{LOAD} = 50\Omega$    |
| $-V_{SPK}$    |                                          | -   | -   | -     | 115  | -   | -     | -   |         |                                                                  |
| QC            | Charge injection                         | -   | -   | -     | 1950 | -   | -     | -   | pC      | $V_{PP} = +40V$ , $V_{NN} = -200V$ ,<br>$V_{SIG} = 0V$           |
|               |                                          | -   | -   | -     | 1890 | -   | -     | -   |         | $V_{PP} = +50V$ , $V_{NN} = -190V$ ,<br>$V_{SIG} = 0V$           |
|               |                                          | -   | -   | -     | 2110 | -   | -     | -   |         | $V_{PP} = +15V$ , $V_{NN} = -225V$ ,<br>$V_{SIG} = 0V$           |

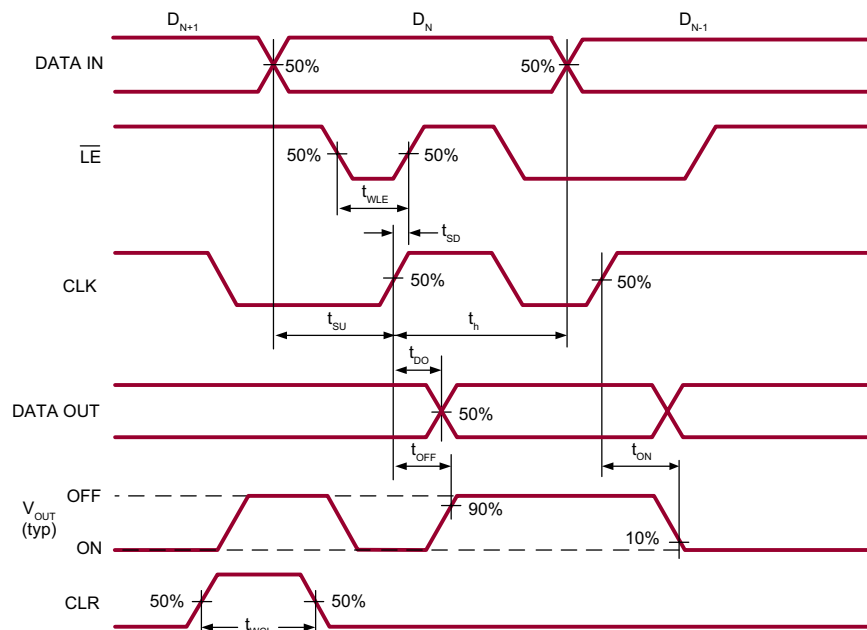
## Truth Table

| D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | $\overline{LE}$ | CLR | 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   | All Switches Off    |     |     |     |     |     |     |     |

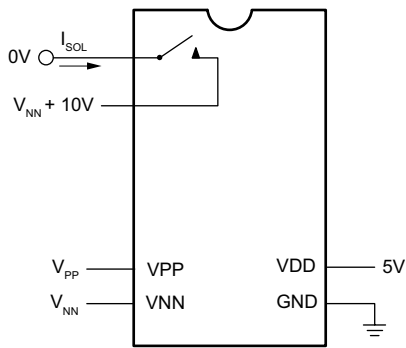
### Notes:

1. The eight switches operate independently.
2. Serial data is clocked in on the L to H transition of the 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 flow through the latch.
4.  $D_{OUT}$  is high when data in the shift register 7 is high.
5. Shift register clocking has no effect on the switch states if  $\overline{LE}$  is high.
6. The CLR clear input overrides all other inputs.

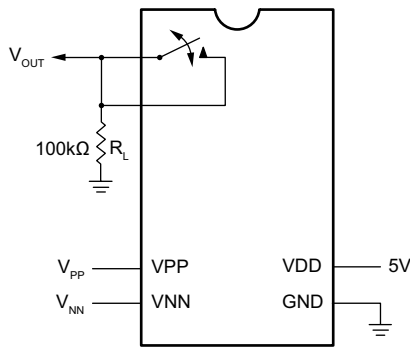
## Logic Timing Waveforms



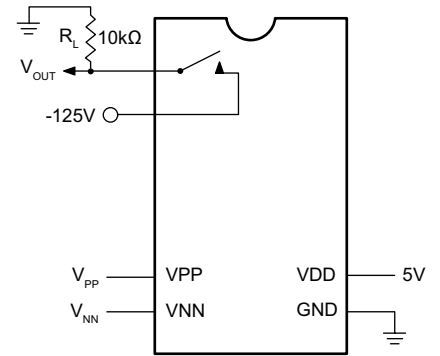
## Test Circuits



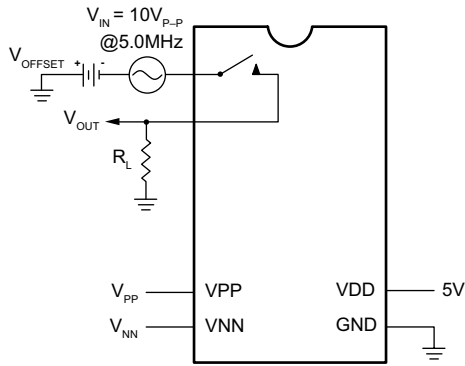
Switch OFF Leakage



DC Offset ON/OFF

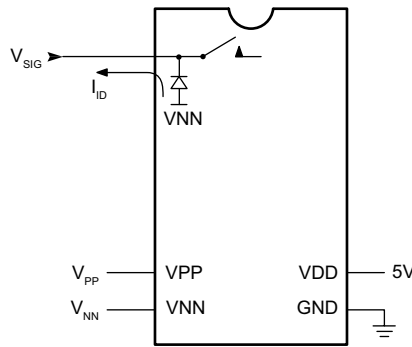


$T_{ON}/T_{OFF}$  Test Circuit

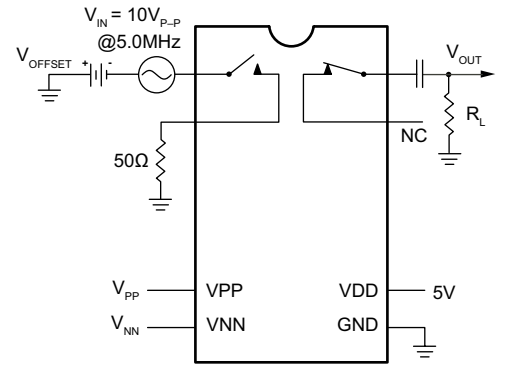


$$K_O = 20 \log \frac{V_{OUT}}{V_{IN}}$$

OFF Isolation

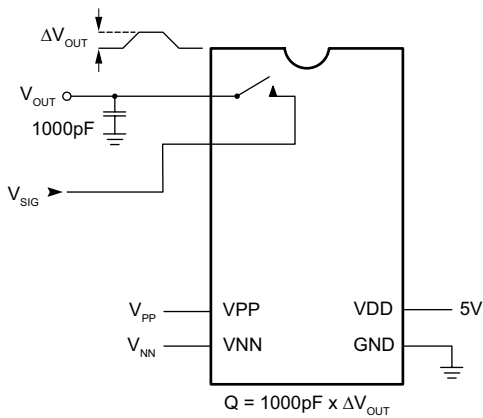


Isolation Diode Current



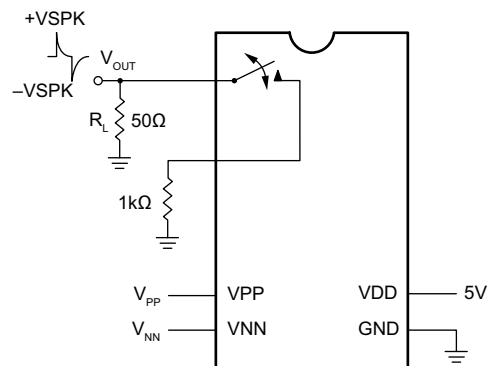
$$K_{CR} = 20 \log \frac{V_{OUT}}{V_{IN}}$$

Crosstalk



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

Charge Injection

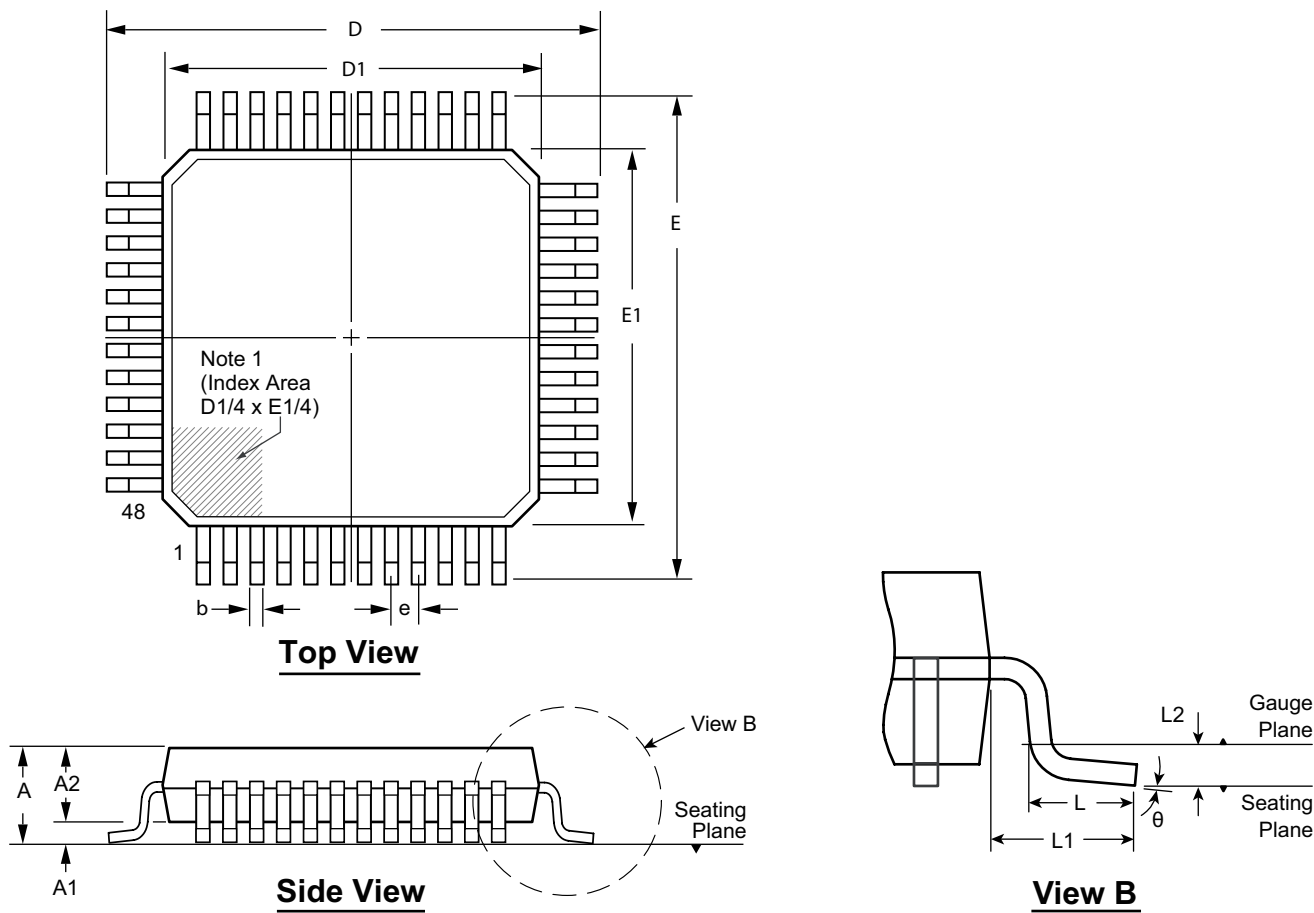


Output Voltage Spike

## Pin Configuration - 48-Lead LQFP (FG)

| Pin # | Pin Name | Pin # | Pin Name               |
|-------|----------|-------|------------------------|
| 1     | SW5      | 25    | VNN                    |
| 2     | NC       | 26    | NC                     |
| 3     | SW4      | 27    | NC                     |
| 4     | NC       | 28    | GND                    |
| 5     | SW4      | 29    | VDD                    |
| 6     | NC       | 30    | NC                     |
| 7     | NC       | 31    | NC                     |
| 8     | SW3      | 32    | NC                     |
| 9     | NC       | 33    | DIN                    |
| 10    | SW3      | 34    | CLK                    |
| 11    | NC       | 35    | $\overline{\text{LE}}$ |
| 12    | SW2      | 36    | CLR                    |
| 13    | NC       | 37    | DOUT                   |
| 14    | SW2      | 38    | NC                     |
| 15    | NC       | 39    | SW7                    |
| 16    | SW1      | 40    | NC                     |
| 17    | NC       | 41    | SW7                    |
| 18    | SW1      | 42    | NC                     |
| 19    | NC       | 43    | SW6                    |
| 20    | SW0      | 44    | NC                     |
| 21    | NC       | 45    | SW6                    |
| 22    | SW0      | 46    | NC                     |
| 23    | NC       | 47    | SW5                    |
| 24    | VPP      | 48    | NC                     |

**48-Lead LQFP Package Outline (FG)**  
**7.00x7.00mm body, 1.60mm height (max), 0.50mm pitch**



**Note:**  
 1. A Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/identifier; an embedded metal marker; or a printed indicator.

| Symbol         |     | A     | A1   | A2   | b    | D     | D1    | E     | E1    | e        | L    | L1       | L2       | θ    |
|----------------|-----|-------|------|------|------|-------|-------|-------|-------|----------|------|----------|----------|------|
| Dimension (mm) | MIN | 1.40* | 0.05 | 1.35 | 0.17 | 8.80* | 6.80* | 8.80* | 6.80* | 0.50 BSC | 0.45 | 1.00 REF | 0.25 BSC | 0°   |
|                | NOM | -     | -    | 1.40 | 0.22 | 9.00  | 7.00  | 9.00  | 7.00  |          | 0.60 |          |          | 3.5° |
|                | MAX | 1.60  | 0.15 | 1.45 | 0.27 | 9.20* | 7.20* | 9.20* | 7.20* |          | 0.75 |          |          | 7°   |

JEDEC Registration MS-026, Variation BBC, Issue D, Jan. 2001.  
 \* This dimension is not specified in the JEDEC drawing.

Drawings are not to scale.  
 Supertex Doc. #: DSPD-48LQFPFG Version, D041309.

(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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