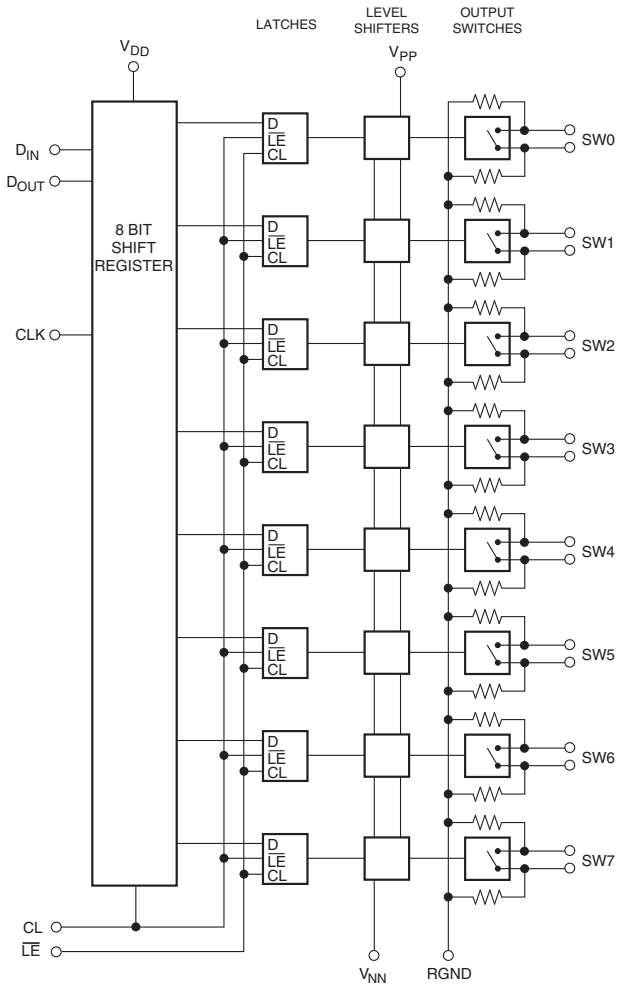
# CPC7232
## 8-Channel High Voltage Analog Switch with Built-in Bleeder Resistors

## Features
- Processed with BCDMOS on SOI (Silicon on Insulator)
- Flexible High Voltage Supplies up to $V_{PP}$-$V_{NN}$+200V
- Internal Output Bleeder Resistors
- DC to 10MHz Analog Signal Frequency
- -60dB Minimum Output-Off Isolation at 5MHz
- Low Quiescent Power Dissipation (< 1μA Typical)
- Output Switch On-Resistance Typically 20Ω
- TTL I/Os for 3.3V Interface
- Surface Mount Package

## Applications
- Ultrasound Imaging
- Printers
- Industrial Controls and Measurement
- Piezoelectric Transducer Drivers

### Figure 1. Block Diagram




## Description
The CPC7232 is a low charge injection 8-channel high-voltage analog switch integrated circuit (IC) for use in applications requiring high voltage switching. Bleeder resistors are incorporated into both terminals of each output switch. Control of the high voltage switching is via low voltage TTL logic level compatible inputs for direct connectivity to the system controller.

Switch manipulation is managed by an 8-bit serial to parallel shift register whose outputs are buffered and stored by an 8-bit transparent latch. Level shifters buffer the latch outputs and operate the high voltage switches.

Because the CPC7232 is capable of switching high load voltages and has a flexible load voltage range, e.g. $V_{PP}/V_{NN}$: +40V/160V or +100V/100V, it is well suited for many medical and industrial applications such as medical ultrasound imaging, printers, and industrial measurement equipment. The bleeder resistors enable the discharge of capacitive loads, such as piezoelectric transducers, connected to the output switches of the CPC7232.

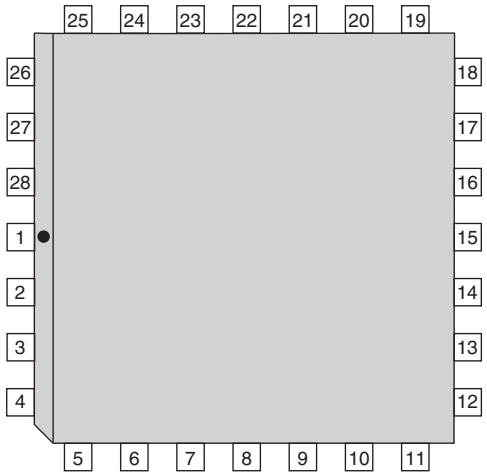
Construction of the high voltage switches using Clare's reliable BCDMOS process technology on SOI (Silicon On Insulator) allow the switches to be organized as solid state switches with direct gate drive.

## Ordering Information

| Part Number | Description |
|---|---|
| CPC7232W | 28-Lead PLCC in Tubes (37/Tube) |
| CPC7232WTR | 28-Lead PLCC Tape & Reel (500/Reel) |
| CPC7232K | 48-Lead LQFP in Trays (250/Tray) |
| CPC7232KTR | 48-Lead LQFP Tape & Reel (1000/Reel) |

# 1. Specifications

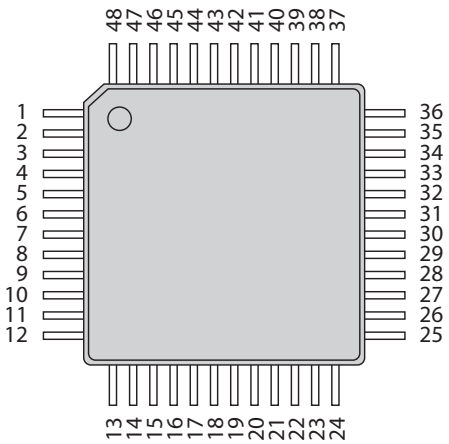
## 1.1 Package Pinout, PLCC-28




## 1.2 Pin Description

| Pin | Name | Description |
|---|---|---|
| 1 | SW3 | SW3 Output |
| 2 | SW3 | SW3 Output |
| 3 | SW2 | SW2 Output |
| 4 | SW2 | SW2 Output |
| 5 | SW1 | SW1 Output |
| 6 | SW1 | SW1 Output |
| 7 | SW0 | SW0 Output |
| 8 | SW0 | SW0 Output |
| 9 | N/C | No connection |
| 10 | $V_{PP}$ | Switch positive high voltage supply |
| 11 | $R_{GND}$ | Ground for bleed resistors |
| 12 | $V_{NN}$ | Switch negative high voltage supply |
| 13 | GND | Ground |
| 14 | $V_{DD}$ | Logic positive voltage supply |
| 15 | N/C | No connection |
| 16 | $D_{IN}$ | Serial data input |
| 17 | CLK | Clock input, positive edge trigger |
| 18 | $\overline{LE}$ | Latch enable, active low |
| 19 | CL | Latch clear, active high clears latches and opens switches |
| 20 | $D_{OUT}$ | Serial data output |
| 21 | SW7 | SW7 Output |
| 22 | SW7 | SW7 Output |
| 23 | SW6 | SW6 Output |
| 24 | SW6 | SW6 Output |
| 25 | SW5 | SW5 Output |
| 26 | SW5 | SW5 Output |
| 27 | SW4 | SW4 Output |
| 28 | SW4 | SW4 Output |

### 1.3 Package Pinout, LQFP-48




### 1.4 Pin Description

| Pin | Name | Description |
|---|---|---|
| 1 | SW5 | SW5 Output |
| 2 | N/C | No connection |
| 3 | SW4 | SW4 Output |
| 4 | N/C | No connection |
| 5 | SW4 | SW4 Output |
| 6 | N/C | No connection |
| 7 | N/C | No connection |
| 8 | SW3 | SW3 Output |
| 9 | N/C | No connection |
| 10 | SW3 | SW3 Output |
| 11 | N/C | No connection |
| 12 | SW2 | SW2 Output |
| 13 | N/C | No connection |
| 14 | SW2 | SW2 Output |
| 15 | N/C | No connection |
| 16 | SW1 | SW1 Output |
| 17 | N/C | No connection |
| 18 | SW1 | SW1 Output |
| 19 | N/C | No connection |
| 20 | SW0 | SW0 Output |
| 21 | N/C | No connection |
| 22 | SW0 | SW0 Output |
| 23 | N/C | No connection |
| 24 | $V_{PP}$ | Switch positive high voltage supply |
| 25 | $V_{NN}$ | Switch negative high voltage supply |
| 26 | N/C | No connection |
| 27 | $R_{GND}$ | Ground for bleed resistors |
| 28 | GND | Ground |
| 29 | $V_{DD}$ | Logic positive supply voltage |
| 30 | N/C | No connection |
| 31 | N/C | No connection |
| 32 | N/C | No connection |
| 33 | $D_{IN}$ | Serial data input |
| 34 | CLK | Clock input, positive edge trigger |
| 35 | $\overline{LE}$ | Latch enable, active low |
| 36 | CL | Latch clear, active high clears latches and opens switches |
| 37 | $D_{OUT}$ | Serial data output |
| 38 | N/C | No connection |
| 39 | SW7 | SW7 Output |
| 40 | N/C | No connection |
| 41 | SW7 | SW7 Output |
| 42 | N/C | No connection |
| 43 | SW6 | SW6 Output |
| 44 | N/C | No connection |
| 45 | SW6 | SW6 Output |
| 46 | N/C | No connection |
| 47 | SW5 | SW5 Output |
| 48 | N/C | No connection |

## 1.5 Absolute Maximum Ratings

Absolute maximum electrical ratings are at 25°C.

*Absolute Maximum Ratings are stress ratings. Stresses in excess of these ratings can cause permanent damage to the device. Functional operation of the device at conditions beyond those indicated in the operational sections of this data sheet is not implied.*

| Parameter | Min | Max | Units |
|---|---|---|---|
| $V_{DD}$ Logic Power Supply Voltage | -0.5 | 6 | V |
| $V_{PP}$ - $V_{NN}$ Supply Voltage | - | 220 | V |
| $V_{PP}$ Positive High Voltage Supply | -0.5 | $V_{NN}$+200 | V |
| $V_{NN}$ Negative High Voltage Supply | -0.5 | $V_{PP}$-200 | V |
| Logic input voltages | -0.5 | $V_{DD}$+0.3 | V |
| Analog signal range | $V_{NN}$ | $V_{PP}$ | V |
| Peak analog signal current per channel | - | 1 | A |
| Power dissipation | | | W |
| 28-Lead PLCC | - | 2.5 | |
| 48-Lead LQFP | - | 2.3 | |
| Thermal Resistance, Junction to Ambient | | | °C/W |
| 28-Lead PLCC | - | 50 | |
| 48-Lead LQFP | - | 53 | |
| Storage temperature | -60 | +150 | °C |

## 1.6 Operating Conditions

| Parameter | Symbol | Value |
|---|---|---|
| Logic power supply voltage [1, 3] | $V_{DD}$ | 4.5V to 6V |
| Positive high voltage supply [1, 3] | $V_{PP}$ | 40V to $V_{NN}$ + 200V |
| Negative high voltage supply [1, 3] | $V_{NN}$ | -40V to -160V |
| Analog signal voltage, peak-to-peak [2] | $V_{SW}$ | $V_{NN}$+10V to $V_{PP}$-10V |
| Operating temperature | $T_A$ | 0°C to 70°C |

[1] Power up/down sequence is arbitrary except that GND must be powered-up first and powered-down last.

[2] $V_{SW}$ must be $V_{NN} \leq V_{SW} \leq V_{PP}$ 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 1ms.

## 1.7 Electrical Characteristics

### 1.7.1 Switch Characteristics (over recommended operating conditions unless otherwise noted)

| Parameter | Symbol | Test Conditions | 0°C | | +25°C | | | +70°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | min | max | min | typ | max | min | max | |
| Small signal switch on-resistance | $R_{ONS}$ | $V_{PP}$=40V, $V_{NN}$=-160V, $I_{SW}$=5mA | - | 30 | - | 21 | 38 | - | 48 | Ω |
| | | $V_{PP}$=40V, $V_{NN}$=-160V, $I_{SW}$=200mA | - | 25 | - | - | 27 | - | 32 | |
| | | $V_{PP}$=100V, $V_{NN}$=-100V, $I_{SW}$=5mA | - | 25 | - | 21 | 27 | - | 30 | |
| | | $V_{PP}$=100V, $V_{NN}$=-100V, $I_{SW}$=200mA | - | 18 | - | 16 | 24 | - | 27 | |
| | | $V_{PP}$=160V, $V_{NN}$=-40V, $I_{SW}$=5mA | - | 23 | - | 21 | 25 | - | 30 | |
| | | $V_{PP}$=160V, $V_{NN}$=-40V, $I_{SW}$=200mA | - | 22 | - | - | 25 | - | 27 | |
| Small signal switch on-resistance matching | $\Delta R_{ONS}$ | $I_{SW}$=5mA, $V_{PP}$=100V, $V_{NN}$=-100V | - | 20 | - | 4 | 20 | - | 20 | % |
| Large signal switch on-resistance | $R_{ONL}$ | $V_{SW}$=$V_{PP}$-10V, $I_{SW}$=0.8A | - | - | - | 16 | - | - | - | Ω |
| Output bleed resistors | $R_{INT}$ | Output switch to $R_{GND}$, $I_{RINT}$=0.5mA | - | - | 20 | 28 | 50 | - | - | kΩ |
| Switch off leakage per switch | $I_{SOL}$ | $V_{SW}$=$V_{PP}$-10V and $V_{NN}$+10V | - | 5 | - | 0.4 | 10 | - | 15 | µA |
| DC offset, switch off | - | $R_L$=100kΩ | - | 100 | - | 0.2 | 100 | - | 100 | mV |
| DC offset, switch on | - | $R_L$=100kΩ | - | 100 | - | 0.2 | 100 | - | 100 | |
| Switch output peak current | - | $V_{SW}$ duty cycle = 0.1% | - | - | - | - | 0.8 | - | - | A |
| Output switch frequency | $f_{SW}$ | Duty cycle = 50% | - | - | - | - | 50 | - | - | kHz |
| Maximum $V_{SW}$ slew rate | dV/dt | $V_{PP}$=160V, $V_{NN}$=-40V | - | 20 | - | - | 20 | - | 20 | V/ns |
| | | $V_{PP}$=100V, $V_{NN}$=-100V | | | | | | | | |
| | | $V_{PP}$=40V, $V_{NN}$=-160V | | | | | | | | |
| Off isolation | $K_O$ | f=5MHz, 1kΩ/15pF load | -30 | - | -30 | - | - | -30 | - | dB |
| | | f=5MHz, 50Ω load | -58 | - | -58 | - | - | -58 | - | |
| Switch crosstalk | $K_{CR}$ | f=5MHz, 50Ω load | -60 | - | -60 | - | - | -60 | - | dB |
| Output switch isolation diode current | $I_{ID}$ | 300ns pulse width, 2.0% duty cycle | - | 300 | - | - | 300 | - | 300 | mA |
| Off capacitance, SW to GND | $C_{SG(OFF)}$ | $V_{SW}$=0V, 1MHz | 5 | 17 | 5 | - | 25 | 5 | 20 | pF |
| On capacitance, SW to GND | $C_{SG(ON)}$ | $V_{SW}$=0V, 1MHz | 25 | 40 | 20 | - | 40 | 25 | 50 | |
| Output voltage spike | $+V_{SPK}$ | $V_{PP}$=40V, $V_{NN}$=-160V, $R_L$=50Ω | - | - | - | 37 | 150 | - | - | mV |
| | $-V_{SPK}$ | | | | | 93 | | | | |
| | $+V_{SPK}$ | $V_{PP}$=100V, $V_{NN}$=-100V, $R_L$=50Ω | - | - | - | 35 | 150 | - | - | |
| | $-V_{SPK}$ | | | | | 80 | | | | |
| | $+V_{SPK}$ | $V_{PP}$=160V, $V_{NN}$=-40V, $R_L$=50Ω | - | - | - | 46 | 150 | - | - | |
| | $-V_{SPK}$ | | | | | 72 | | | | |
| Charge injection | Q | $V_{PP}$=100V, $V_{NN}$=-100V, $V_{SW}$=0V | | | - | 880 | - | | | pC |

1.7.2 Logic DC Characteristics (over recommended operating conditions unless otherwise noted)

| Parameter | Symbol | Test Conditions | 0°C | | +25°C | | | +70°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | min | max | min | typ | max | min | max | |
| $D_{OUT}$ source capability | $V_{OH}$ | $I_{OUT}$= -400µA | - | - | $V_{DD}$-0.7 | $V_{DD}$-0.1 | - | - | - | V |
| $D_{OUT}$ sink capability | $V_{OL}$ | $I_{OUT}$= +400µA | - | - | - | 0.04 | 0.7 | - | - | |
| Logic input capacitance | $C_{IN}$ | - | - | 10 | - | - | 10 | - | 10 | pF |
| Logic input high | $V_{IH}$ | 4.75V < $V_{DD}$ < 5.25V | 2 | - | 2 | - | - | 2 | - | V |
| Logic input low | $V_{IL}$ | 4.75V < $V_{DD}$ < 5.25V | - | 0.8 | - | - | 0.8 | - | 0.8 | |

1.7.3 Logic Timing Characteristics (over recommended operating conditions unless otherwise noted)

| Parameter | Symbol | Test Conditions | 0°C | | +25°C | | | 70°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | min | max | min | typ | max | min | max | |
| Setup time before $\overline{LE}$ rises | $t_{SD}$ | - | 150 | - | 150 | - | - | 150 | - | ns |
| Time width of $\overline{LE}$ | $t_{WLE}$ | - | 150 | - | 150 | - | - | 150 | - | |
| Clock delay time to Data Out | $t_{DO}$ | - | - | 150 | - | 62 | 150 | - | 150 | |
| Time width of CL | $t_{WCL}$ | - | 150 | - | 150 | - | - | 150 | - | |
| Setup time, data to clock | $t_{SU}$ | - | 15 | - | 15 | 8 | - | 20 | - | |
| Hold time, data from clock | $t_H$ | - | 35 | - | 35 | - | - | 35 | - | |
| Clock frequency | $f_{CLK}$ | 50% duty cycle, $f_{DATA}$=$f_{CLK}$/2 | - | 5 | - | - | 5 | - | 5 | MHz |
| Clock rise and fall times | $t_R$, $t_F$ | - | - | 50 | - | - | 50 | - | 50 | ns |
| Turn-on time | $t_{ON}$ | $V_{SW}$=$V_{PP}$-10V, RL=10kΩ | - | 5 | - | 2 | 5 | - | 5 | µs |
| Turn-off time | $t_{OFF}$ | | | | | 3 | | | | |

1.7.4 Supply DC Characteristics (over recommended operating conditions unless otherwise noted)

| Parameter | Symbol | Test Conditions | | 0°C | | +25°C | | | +70°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | min | max | min | typ | max | min | max | |
| $V_{PP}$ quiescent supply current | $I_{PPQ}$ | All switches off | | - | - | - | 0.1 | 10 | - | - | µA |
| | | All switches on, $I_{SW}$=5mA | | | | | | | | | |
| $V_{NN}$ quiescent supply current | $I_{NNQ}$ | All switches off | | - | - | - | -0.1 | -10 | - | - | |
| | | All switches on, $I_{SW}$=5mA | | | | | | | | | |
| $V_{PP}$ operating supply current | $I_{PP}$ | $V_{PP}$=40V, $V_{NN}$=-160V | 50kHz output switching frequency with no load | - | 6.5 | - | - | 7 | - | 8 | mA |
| | | $V_{PP}$=100V, $V_{NN}$=-100V | | - | 5 | - | - | 5.5 | - | 5.5 | |
| | | $V_{PP}$=160V, $V_{NN}$=-40V | | - | 5 | - | - | 5 | - | 5.5 | |
| $V_{NN}$ operating supply current | $I_{NN}$ | $V_{PP}$=40V, $V_{NN}$=-160V | 50kHz output switching frequency with no load | - | 6.5 | - | - | 7 | - | 8 | mA |
| | | $V_{PP}$=100V, $V_{NN}$=-100V | | - | 5 | - | - | 5.5 | - | 5.5 | |
| | | $V_{PP}$=160V, $V_{NN}$=-40V | | - | 5 | - | - | 5 | - | 5.5 | |
| $V_{DD}$ average supply current | $I_{DD}$ | $f_{CLK}$=5MHz, $V_{DD}$=5V | | - | 4 | - | - | 4 | - | 4 | mA |
| $V_{DD}$ quiescent supply current | $I_{DDQ}$ | - | | - | 10 | - | 0.03 | 10 | - | 10 | µA |

## 2. Functional Description

The CPC7232 takes a serial stream of input data along with a synchronous clock signal. As the clock transits from low to high, the data at the input of each shift register is shifted through from SR(n) to SR(n+1). A high data bit, a "1," represents an ON switch; a low data bit, a "0," represents an OFF switch. Data is input and shifted through the internal shift register until all eight shift register positions, SR0 through SR7, are in the desired state.

**DIN:** The data-in line presents data bits to the CPC7232 to be shifted through the internal shift register.

**CLK:** The clock signal's rising edge is associated only with shifting data into and through the shift register.

**CL:** The clear line overrides all other inputs. When CL is high, the shift register is cleared to all 0s and all latches are set low, which causes all output switches to be turned OFF immediately. When CL is low, all output switches remain in whatever state they are in, ON or OFF, in response to CLK, latch inputs, and the LE signal.

**$\overline{\text{LE}}$:** latch enable controls the state of the latches and thus the state of the eight switches. If LE is high, then the latches do not change states, but retain their most recent status: either ON or OFF. With LE high, input data and CLK have no effect on the state of the output switches. If LE is low, then all latch outputs and their switch states follow the inputs from the shift register. LE is overridden by CL: no matter what state LE is in, CL clears the latches. See **"Truth Table" on page 10**.

**DOUT:** The data-out pin is the output of SR7. After eight clock pulses, the first bit of eight input data bits is shifted to SR7 and appears on DOUT.

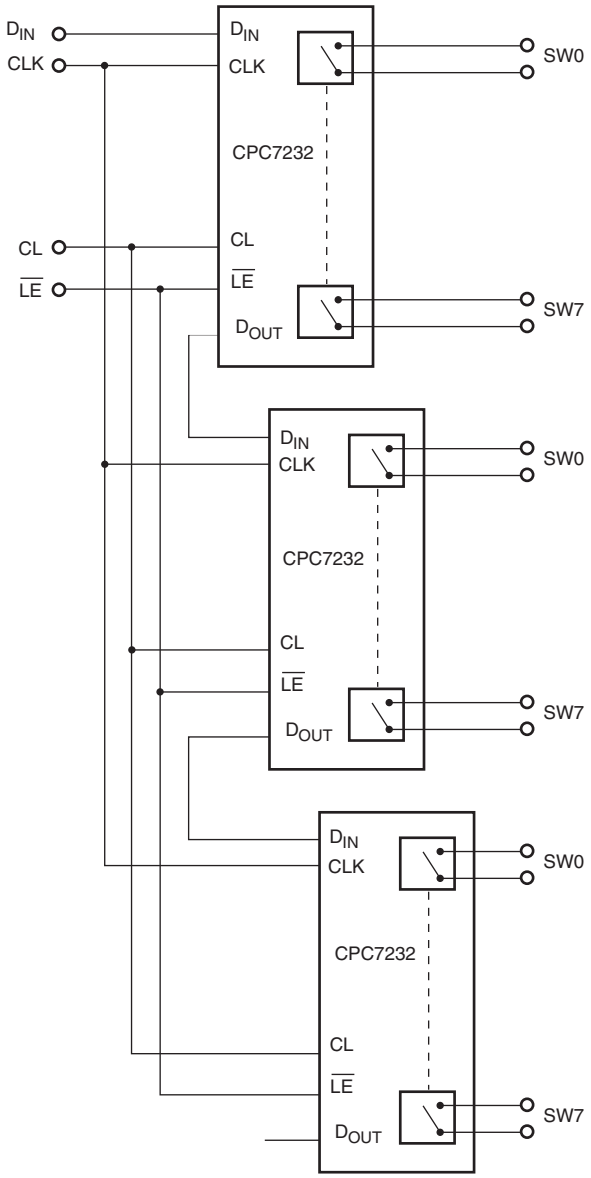
**SW0 - SW7:** The CPC7232 provides eight high-voltage SPST output switches with a typical on-resistance of 20Ω. The two connections of each switch are not polarity-sensitive.

**$V_{PP}$ and $V_{NN}$:** Voltage inputs to the level shifters for each switch channel that translate the voltage level of the latch output signals to an appropriate level for the voltages being switched.

The high-voltage output switches are turned on and off in response to the data sent into the latches from the shift register: data 0 turns a switch OFF, data 1 turns a switch ON.

Two or more CPC7232 devices can be cascaded to form an n-switch arrangement. The DOUT pin of the first is connected to the DIN pin of the next in the series. All devices are connected to the same clock (CLK) signal. LE of all devices would normally be connected, as would CL, but this is not necessary.

The first data bit applied to DIN of the CPC7232, whether it's a single device or several cascaded devices, ripples through to the last switch output in line after the application of a full clocking sequence of 8 clock pulses per CPC7232. Setting the serial I/O device to output the most significant bit (MSB) first, results in the MSB appearing on SW7 of the last device in line after a full clocking sequence.



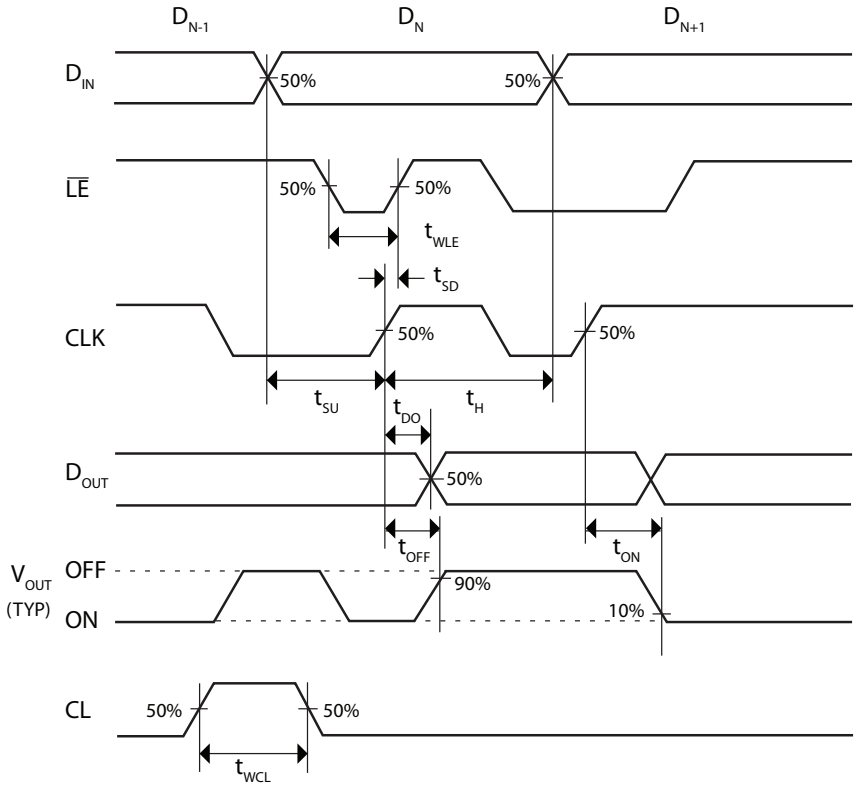
## 2.1 Truth Table

| 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? 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.

## 2.2 Logic Timing Waveforms

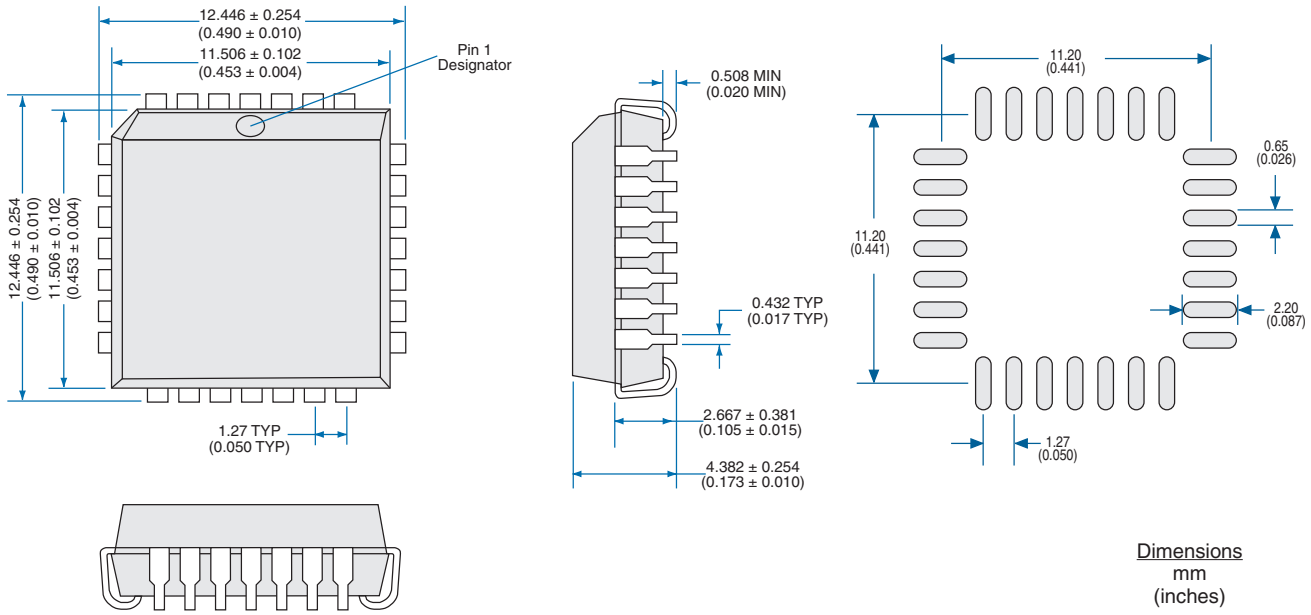


# 3. Manufacturing Information

## 3.1 Mechanical Dimensions

### 3.1.1 28-Pin PLCC Package

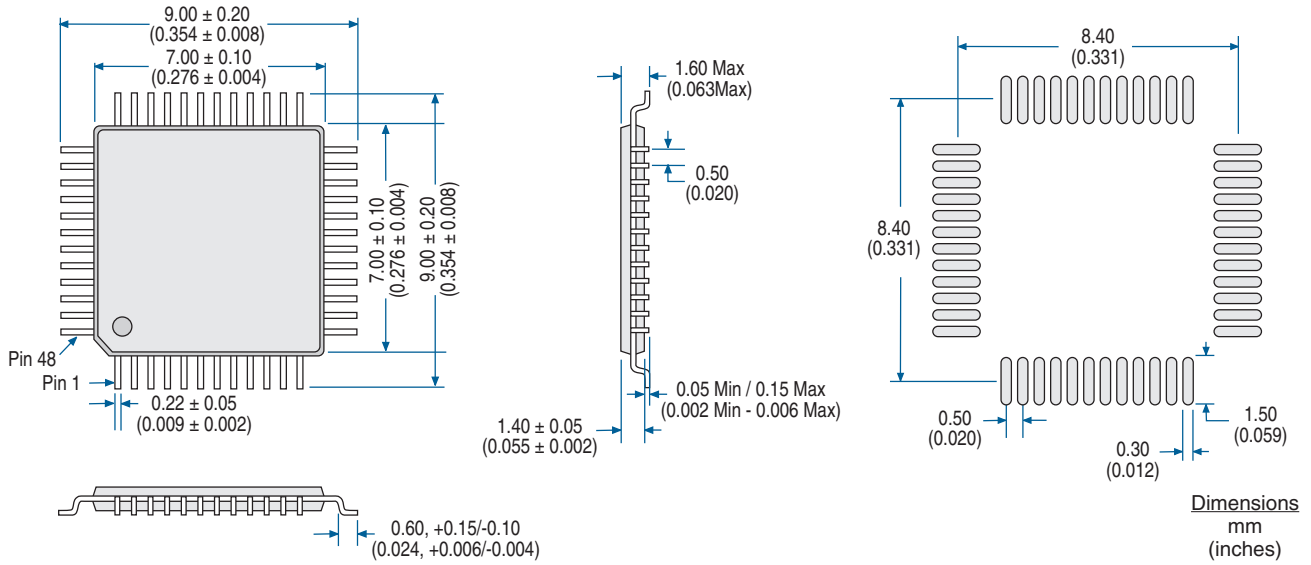
**Recommended PCB Land Pattern**




Dimensions
mm
(inches)

### 3.1.2 48-Pin LQFP Package

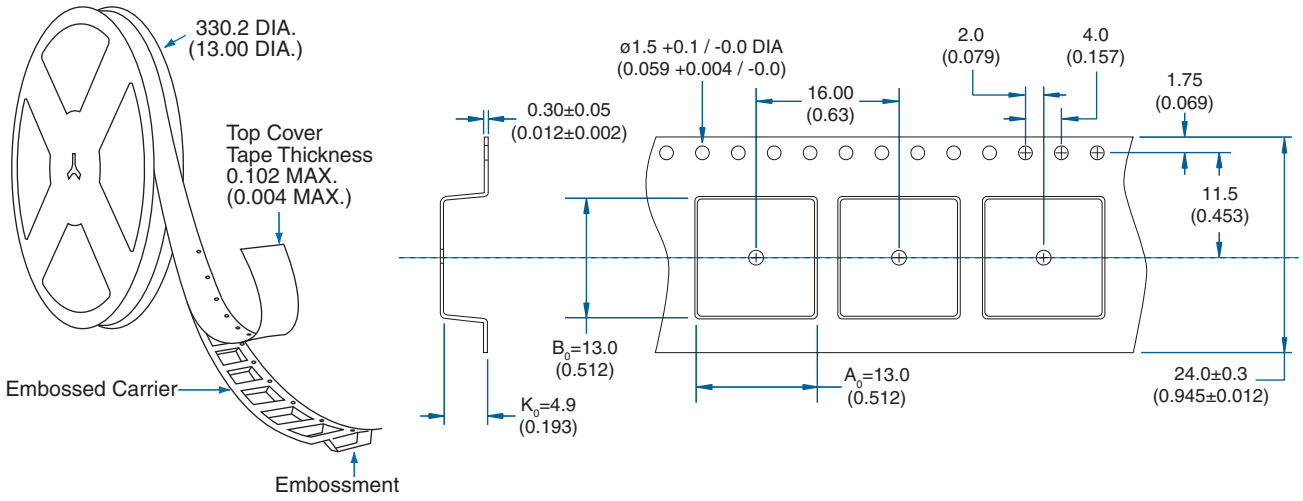
**Recommended PCB Land Pattern**




Dimensions
mm
(inches)

## 3.2 Tape and Reel Specifications

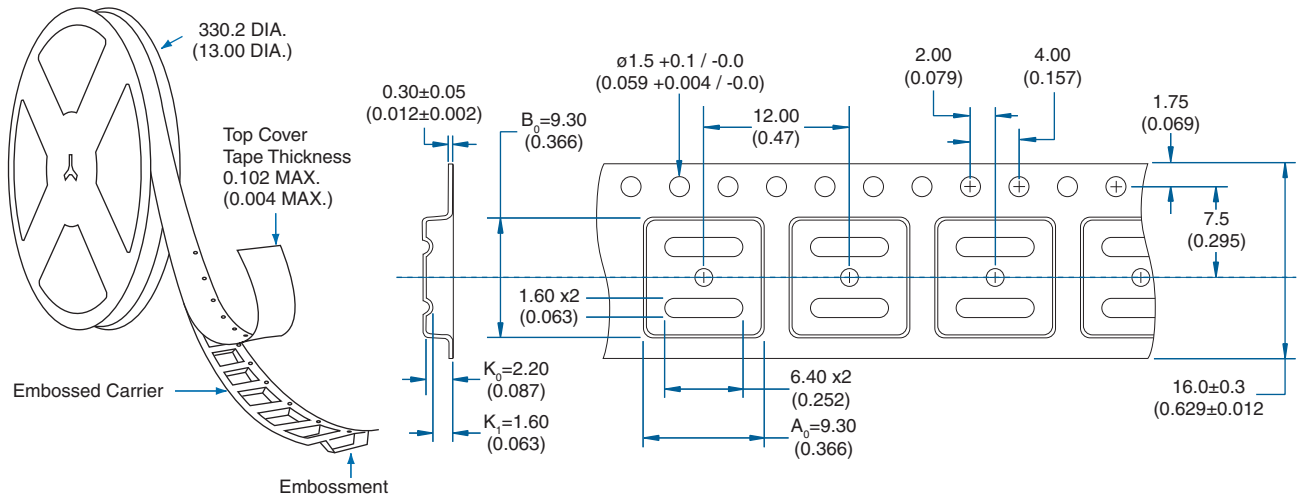
### 3.2.1 PLCC-28




NOTES:
1. 10 sprocket hole pitch cumulative tolerance ±0.2 (0.008)
2. Camber not to exceed 1mm in 100mm
3. Material: conductive black polystyrene
4. $A_0$ and $B_0$ measured on a plane 0.3mm above the bottom of the pocket
5. $K_0$ measured from a plane on the inside bottom of the pocket to the top surface of the carrier
6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole
7. Unless otherwise noted, tolerance ±0.1 (0.004)

Dimensions
mm
(inches)

### 3.2.2 LQFP-48




NOTES:
1. 10 sprocket hole pitch cumulative tolerance ±0.2
2. Camber in compliance with EIA 481
3. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole
4. Unless otherwise specified, tolerance ±0.1 (0.004)

Dimensions
mm
(inches)

### 3.3 Soldering

For proper assembly, the component must be processed in accordance with the current revision of IPC/JEDEC standard, J-STD-020. Failure to follow the recommended guidelines may cause permanent damage to the device resulting in impaired performance and/or a reduced lifetime expectancy.

### 3.4 Washing

Clare does not recommend ultrasonic cleaning of this part.


**For additional information please visit www.clare.com**



Specification: DS-DS-CPC7232-R00F

11/30/09