

**MAX4968B/MAX4968C****16-Channel, Linear, High-Voltage Analog Switches in BGA Package****General Description**

The MAX4968B/MAX4968C are 16-channel, high-linearity, high-voltage (HV), bidirectional SPST analog switches with 18Ω (typ) on-resistance. The devices are ideal for use in applications requiring high-voltage switching controlled by a low-voltage control signal, such as ultrasound imaging and industrial printing. The MAX4968C provides integrated 40kΩ bleed resistors on each switch terminal to discharge capacitive loads. Using HVCMOS technology, these switches combine high-voltage bilateral MOS switches and low-power CMOS logic to provide efficient control of high-voltage analog signals.

In typical ultrasound applications, the MAX4968B/MAX4968C do not require a dedicated HV supply, which implies a significant simplification of system requirements. The negative voltage supply can be shared with the transmitter and the positive voltage supply is typically +12V.

The devices are available in a 64-bump BGA package and are specified over the -40°C to +85°C extended temperature range.

**Applications**

- Medical Ultrasound Imaging
- Nondestructive Testing (NDT)
- Industrial Printing

**Ordering Information** appears at end of data sheet.

**Features**

- **Save Space**—Optimized for High-Channel-Count Systems
  - Small BGA Package
  - 16 Integrated Channels
- **High Performance**—Designed to Enhance Image Quality
  - True Linear Switching— $R_{ON}$  Flatness Guaranteed in Entire Input Range 46dB (typ) THD
  - Low Parasitic Capacitance Guarantees High Bandwidth
  - Low-Charge Injection and Voltage Spiking
  - 2nd Harmonic Distortion < -45dB at 2MHz ± 90V Pulse Analog Class AB
  - DC to 30MHz Small-Signal Analog Bandwidth ( $C_{LOAD} = 200pF$ )
  - 500kHz to 20MHz High-Signal Analog Bandwidth ( $C_{LOAD} = 200pF$ )
  - Extended Input Range Up to 210V<sub>P-P</sub>
  - -68dB (Typ) Off-Isolation at 5MHz (50Ω)
- **Increased Flexibility Saves Design Time**
  - No Dedicated High-Voltage Supplies Required
  - Daisy-Chainable Serial Interface
  - Asynchronous Set/Clear Input to Program All Switches Without Need for SPI
- **Superior Reliability**
  - Latch-Free SOI HVCMOS Process Technology for High Performance and Robustness
  - Integrated Overvoltage Protection

## Absolute Maximum Ratings

(All voltages referenced to GND.)

|                                               |                                                           |
|-----------------------------------------------|-----------------------------------------------------------|
| V <sub>DD</sub> Logic Supply Voltage          | .....-0.3V to +6V                                         |
| V <sub>P-P</sub> Supply Voltage               | .....-0.3V to +13V                                        |
| V <sub>NN</sub> Negative Supply Voltage       | .....+0.3V to -200V                                       |
| V <sub>CC10</sub> Input Voltage               | .....-0.3V to MAX (12V to V <sub>P-P</sub> + 0.3V)        |
| Logic Inputs Voltage (CLK, DIN, LE, CLR, SET) | ....-0.3V to +6V                                          |
| Logic Output Voltage (DOUT)                   | .....-0.3V to (V <sub>DD</sub> + 0.3V)                    |
| Analog Signal Range (SW <sub>-</sub> )        | .....(V <sub>NN</sub> - 0.3V) to (V <sub>NN</sub> + 214V) |

Continuous Power Dissipation (T<sub>A</sub> = +70°C)

|                                             |                      |
|---------------------------------------------|----------------------|
| 64-bump BGA (derate 30.30mW/°C above +70°C) | ..1969.7mW           |
| Operating Temperature Range                 | .....-40°C to +85°C  |
| Storage Temperature Range                   | .....-65°C to +150°C |
| Junction Temperature                        | .....+150°C          |
| Lead Temperature (soldering, 10s)           | .....+300°C          |
| Soldering Temperature (reflow)              | .....+260°C          |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## Package Thermal Characteristics (Note 1)

Junction-to-Ambient Thermal Resistance (θ<sub>JA</sub>) .....3.3°C/W

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

## Electrical Characteristics

(V<sub>DD</sub> = +2.37V to +5.5V, V<sub>P-P</sub> = +10V to +12.5V, V<sub>NN</sub> = 0 to -200V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are V<sub>DD</sub> = +3.3V, V<sub>NN</sub> = -100V, V<sub>P-P</sub> = +12V at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                                                            | SYMBOL             | CONDITIONS                                                                                                   | MIN  | TYP   | MAX  | UNITS |
|--------------------------------------------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------------------------|------|-------|------|-------|
| <b>POWER SUPPLIES</b>                                                                |                    |                                                                                                              |      |       |      |       |
| V <sub>DD</sub> Logic Supply Voltage                                                 | V <sub>DD</sub>    |                                                                                                              | 2.37 |       | 5.5  | V     |
| V <sub>NN</sub> Supply Voltage                                                       | V <sub>NN</sub>    |                                                                                                              | -200 |       | 0    | V     |
| V <sub>P-P</sub> Supply Voltage                                                      | V <sub>P-P</sub>   |                                                                                                              | 10   | 12    | 12.5 | V     |
| V <sub>DD</sub> Static Current                                                       | I <sub>DDS</sub>   |                                                                                                              |      | 25    | 50   | μA    |
| V <sub>DD</sub> Dynamic Current                                                      | I <sub>DD</sub>    | V <sub>DD</sub> = +5V, f <sub>CLK</sub> = 5MHz,<br>f <sub>DIN</sub> = 2.5MHz                                 |      | 100   | 200  | μA    |
| V <sub>NN</sub> Static Current                                                       | I <sub>NNS</sub>   | All switches remain on or off,<br>SW <sub>-</sub> = GND                                                      |      | 15    | 25   | μA    |
| V <sub>NN</sub> Supply Dynamic Current<br>(All Channel Switching<br>Simultaneously)  | I <sub>NN</sub>    | V <sub>P-P</sub> = +12V, V <sub>NN</sub> = -100V,<br>f <sub>TURN_ON/OFF</sub> = 50kHz, SW <sub>-</sub> = GND |      | 4.3   | 8    | mA    |
| V <sub>P-P</sub> Supply Static Current                                               | I <sub>PPS</sub>   | All switches remain on or off,<br>SW <sub>-</sub> = GND                                                      |      | 75    | 160  | μA    |
| V <sub>P-P</sub> Supply Dynamic Current<br>(All Channel Switching<br>Simultaneously) | I <sub>PP</sub>    | V <sub>P-P</sub> = +12V, V <sub>NN</sub> = -100V,<br>f <sub>TURN_ON/OFF</sub> = 50kHz, SW <sub>-</sub> = GND |      | 5.4   | 9    | mA    |
| V <sub>CC10</sub> Static Output Voltage                                              | V <sub>CC10s</sub> | V <sub>P-P</sub> = +12V, all switches remain on or<br>off, SW <sub>-</sub> = GND                             | 10   | 10.5  |      | V     |
| V <sub>CC10</sub> Dynamic Output<br>Voltage                                          | V <sub>CC10</sub>  | V <sub>P-P</sub> = +12V, I <sub>OUT</sub> = 30mA                                                             | 9.5  | 10.25 |      | V     |

## Electrical Characteristics (continued)

( $V_{DD} = +2.37V$  to  $+5.5V$ ,  $V_{P-P} = +10V$  to  $+12.5V$ ,  $V_{NN} = 0$  to  $-200V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are  $V_{DD} = +3.3V$ ,  $V_{NN} = -100V$ ,  $V_{P-P} = +12V$  at  $T_A = +25^{\circ}C$ .) (Note 2)

| PARAMETER                             | SYMBOL           | CONDITIONS                                                                                                          | MIN             | TYP | MAX            | UNITS      |
|---------------------------------------|------------------|---------------------------------------------------------------------------------------------------------------------|-----------------|-----|----------------|------------|
| <b>SWITCH CHARACTERISTICS</b>         |                  |                                                                                                                     |                 |     |                |            |
| Analog Dynamic Signal Range           | $V_{SW\_}$       | AC operation only, $f > 500kHz$                                                                                     | $V_{NN}$        |     | $V_{NN} + 210$ | V          |
| Small-Signal On-Resistance            | $R_{ONS}$        | $V_{P-P} = +12V$ , $V_{NN} = -100V$ , $V_{SW\_} = 0V$ , $I_{SW\_} = 5mA$                                            |                 | 18  | 34             | $\Omega$   |
| Small-Signal On-Resistance Matching   | $\Delta R_{ONS}$ | $V_{P-P} = +12V$ , $V_{NN} = -100V$ , $I_{SW\_} = 5mA$                                                              |                 | 3   |                | %          |
| Small-Signal On-Resistance Flatness   | $R_{ONF}$        | AC measured, $f_{SW} = 0.5MHz$ , $V_{SW} = 80V_{P-P}$ , $R_{LOAD} = 50\Omega$ , $V_{P-P} = +12V$ , $V_{NN} = -100V$ |                 | 2   |                | %          |
| Output Switch Bleed Resistor          | $R_{INT}$        | MAX4968C only                                                                                                       | 30              | 40  | 50             | k $\Omega$ |
| Switch-Off Leakage                    | $I_{SW\_ (OFF)}$ | $V_{SW} = 0V$ , switch off (MAX4968B only)                                                                          |                 | 0   | 1              | $\Omega A$ |
| Switch-Off DC Offset                  |                  | $R_L = 100k\Omega$ on both sides                                                                                    | -15             |     | +15            | mV         |
| Switch-On DC Offset                   |                  | $R_L = 100k\Omega$ on both sides                                                                                    | -15             |     | +15            | mV         |
| Switch Output Isolation Diode Current |                  | 300ns pulse width, 2% duty cycle                                                                                    |                 | 3.0 |                | A          |
| <b>SWITCH DYNAMIC CHARACTERISTICS</b> |                  |                                                                                                                     |                 |     |                |            |
| Turn-On Time                          | $t_{ON}$         | $V_{SW\_} = +1V$ , $R_L = 100\Omega$ , $V_{NN} = -100V$ , from SET to $V_{SW\_} = +0.9V$                            |                 | 2   | 5              | $\mu s$    |
| Turn-Off Time                         | $t_{OFF}$        | $V_{SW\_} = +1V$ , $R_L = 100\Omega$ , $V_{NN} = -100V$ , from CLR to $V_{SW\_} = +0.9V$                            |                 | 2   | 3.5            | $\mu s$    |
| Maximum $V_{SW\_}$ Slew Rate          | $dV/dt$          | $C_L = 100pF$                                                                                                       | 20              |     |                | V/ns       |
| Off-Isolation                         | $V_{ISO}$        | $f = 5MHz$ , $R_L = 50\Omega$                                                                                       |                 | -68 |                | dB         |
| Crosstalk                             | $V_{CT}$         | $f = 5MHz$ , $R_L = 50\Omega$                                                                                       |                 | -69 |                | dB         |
| SW_ Off-Capacitance                   | $C_{SW\_ (OFF)}$ | $f = 1MHz$ , small signal close to zero                                                                             |                 | 8   |                | pF         |
| SW_ On-Capacitance                    | $C_{SW\_ (ON)}$  | $f = 1MHz$ , small signal close to zero                                                                             |                 | 14  |                | pF         |
| Output Voltage Spike                  | $V_{SPK}$        | $R_L = 50\Omega$                                                                                                    | -150            |     | +150           | mV         |
| Large-Signal Analog Bandwidth (-3dB)  | $f_{BW\_L}$      | $C_{LOAD} = 200pF$ , 60V amplitude sinusoidal burst, 1% duty cycle                                                  |                 | 30  |                | MHz        |
| Small-Signal Analog Bandwidth (-3dB)  | $f_{BW\_S}$      | $C_{LOAD} = 200pF$ , 100mV amplitude sinusoidal                                                                     |                 | 50  |                | MHz        |
| Charge Injection                      | Q                | $V_{NN} = -100V$ , Figure 1                                                                                         |                 | 150 |                | pC         |
| <b>LOGIC LEVELS</b>                   |                  |                                                                                                                     |                 |     |                |            |
| Logic-Input Low Voltage               | $V_{IL}$         |                                                                                                                     |                 |     | 0.75           | V          |
| Logic-Input High Voltage              | $V_{IH}$         |                                                                                                                     | $V_{DD} - 0.75$ |     |                | V          |
| Logic-Output Low Voltage              | $V_{OL}$         | $I_{SINK} = 1mA$                                                                                                    |                 |     | 0.4            | V          |

**Electrical Characteristics (continued)**

( $V_{DD} = +2.37V$  to  $+5.5V$ ,  $V_{P-P} = +10V$  to  $+12.5V$ ,  $V_{NN} = 0$  to  $-200V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are  $V_{DD} = +3.3V$ ,  $V_{NN} = -100V$ ,  $V_{P-P} = +12V$  at  $T_A = +25^{\circ}C$ .) (Note 2)

| PARAMETER                                | SYMBOL         | CONDITIONS                                   | MIN            | TYP | MAX | UNITS      |
|------------------------------------------|----------------|----------------------------------------------|----------------|-----|-----|------------|
| Logic-Output High Voltage                | $V_{OH}$       | $I_{SOURCE} = 1mA$                           | $V_{DD} - 0.4$ |     |     | V          |
| Logic-Input Capacitance                  | $C_{IN}$       |                                              |                | 5   |     | pF         |
| Logic-Input Leakage                      | $I_{IN}$       |                                              | -1             |     | +1  | $\mu A$    |
| Pulldown Resistor in SET Pin             | $R_{PULLDOWN}$ |                                              | 65             | 100 | 140 | k $\Omega$ |
| <b>TIMING CHARACTERISTICS (Figure 2)</b> |                |                                              |                |     |     |            |
| CLK Frequency                            | $f_{CLK}$      |                                              |                |     | 25  | MHz        |
| DIN-to-CLK Setup Time                    | $t_{DS}$       |                                              | 4              |     |     | ns         |
| DIN-to-CLK Hold Time                     | $t_{DH}$       |                                              | 4              |     |     | ns         |
| CLK to LE Setup Time                     | $t_{CS}$       |                                              | 28             |     |     | ns         |
| $\overline{LE}$ Low Pulse Width          | $t_{WL}$       |                                              | 12             |     |     | ns         |
| CLR High Pulse Width                     | $t_{WC}$       |                                              | 16             |     |     | ns         |
| SET High Pulse Width                     | $t_{WS}$       |                                              | 16             |     |     | ns         |
| CLK Rise and Fall Times                  | $t_R, t_F$     |                                              |                |     | 50  | ns         |
| CLK to DOUT Delay                        | $t_{DO}$       | $V_{DD} = +5V \pm 10\%$ , $C_{DOUT} = 15pF$  |                |     | 28  | ns         |
|                                          |                | $V_{DD} = +2.5V \pm 5\%$ , $C_{DOUT} = 15pF$ |                |     | 45  |            |

**Note 2:** All devices are 100% tested at  $T_A = +85^{\circ}C$ . Limits over the operating temperature range are guaranteed by design.

## Pin Test Circuits/Timing Diagrams

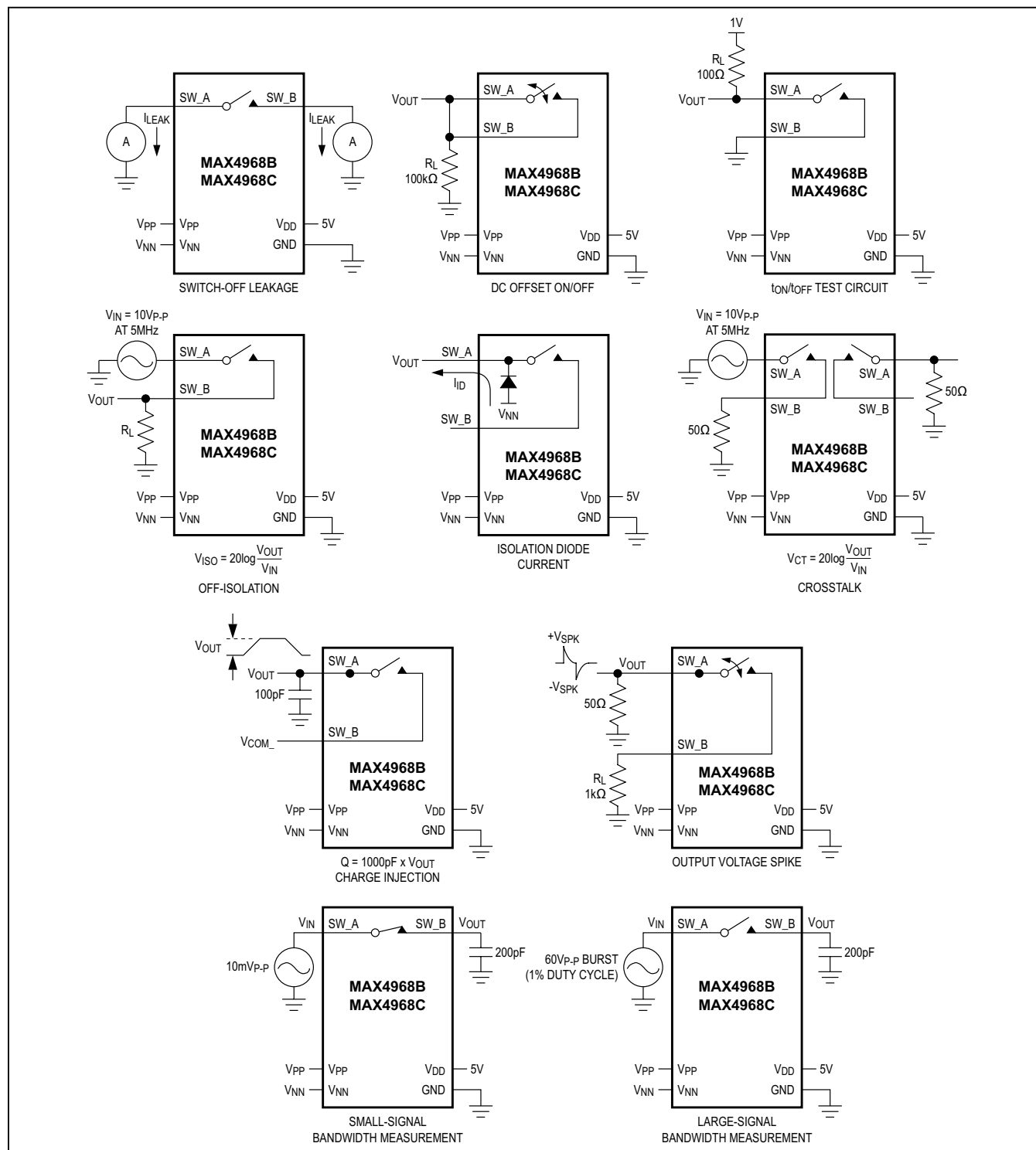


Figure 1. Test Circuits

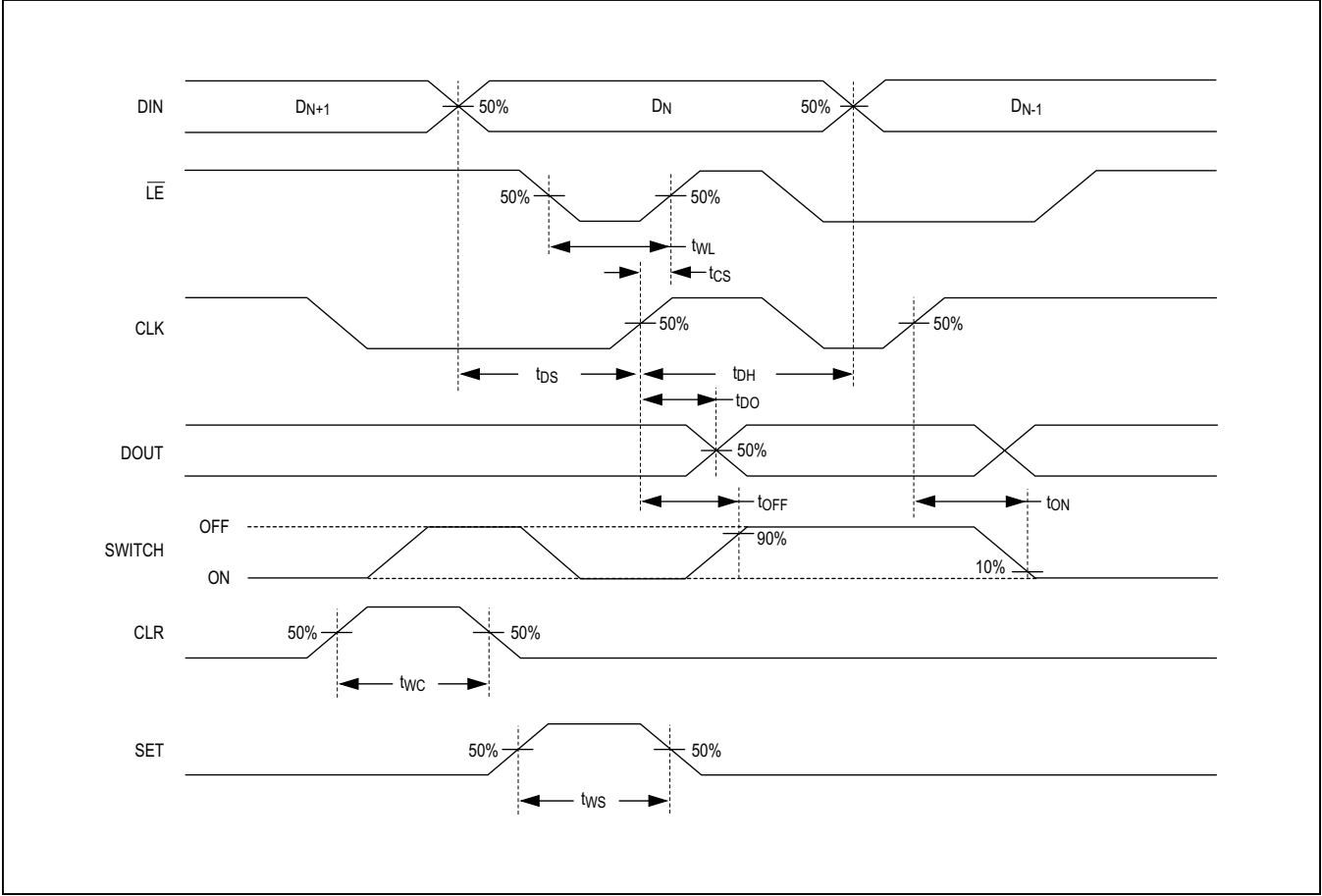
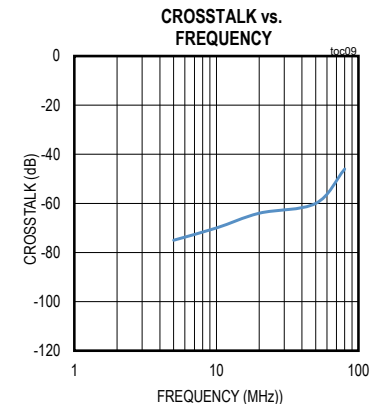
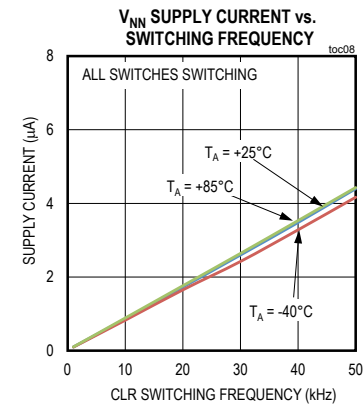
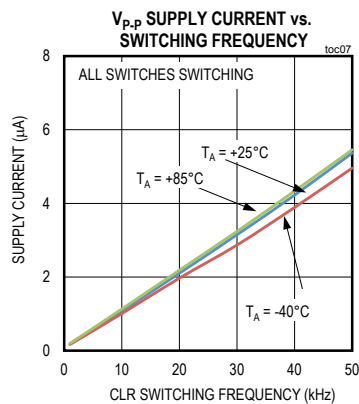
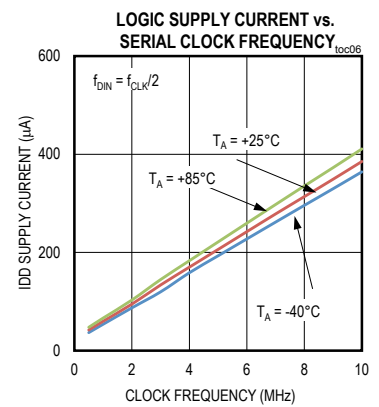
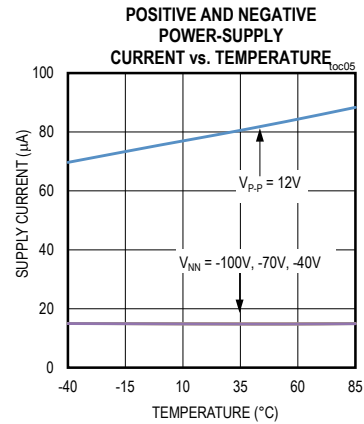
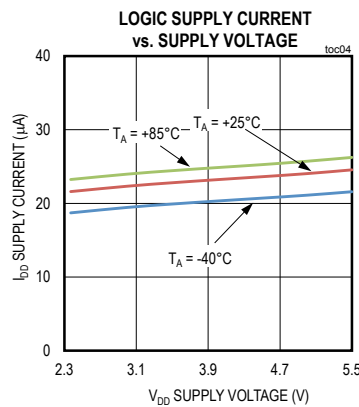
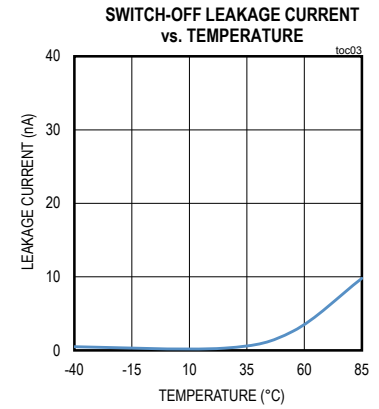
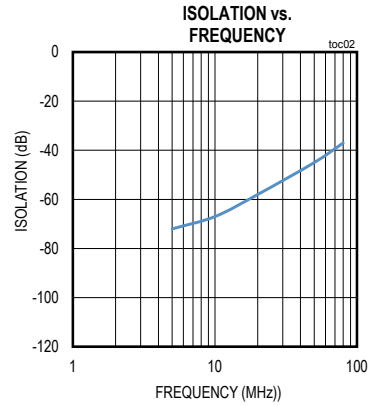
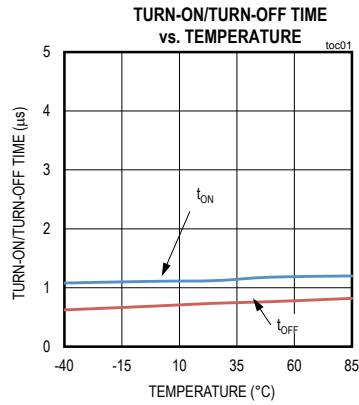


Figure 2. Serial Interface Timing

## Typical Operating Characteristics

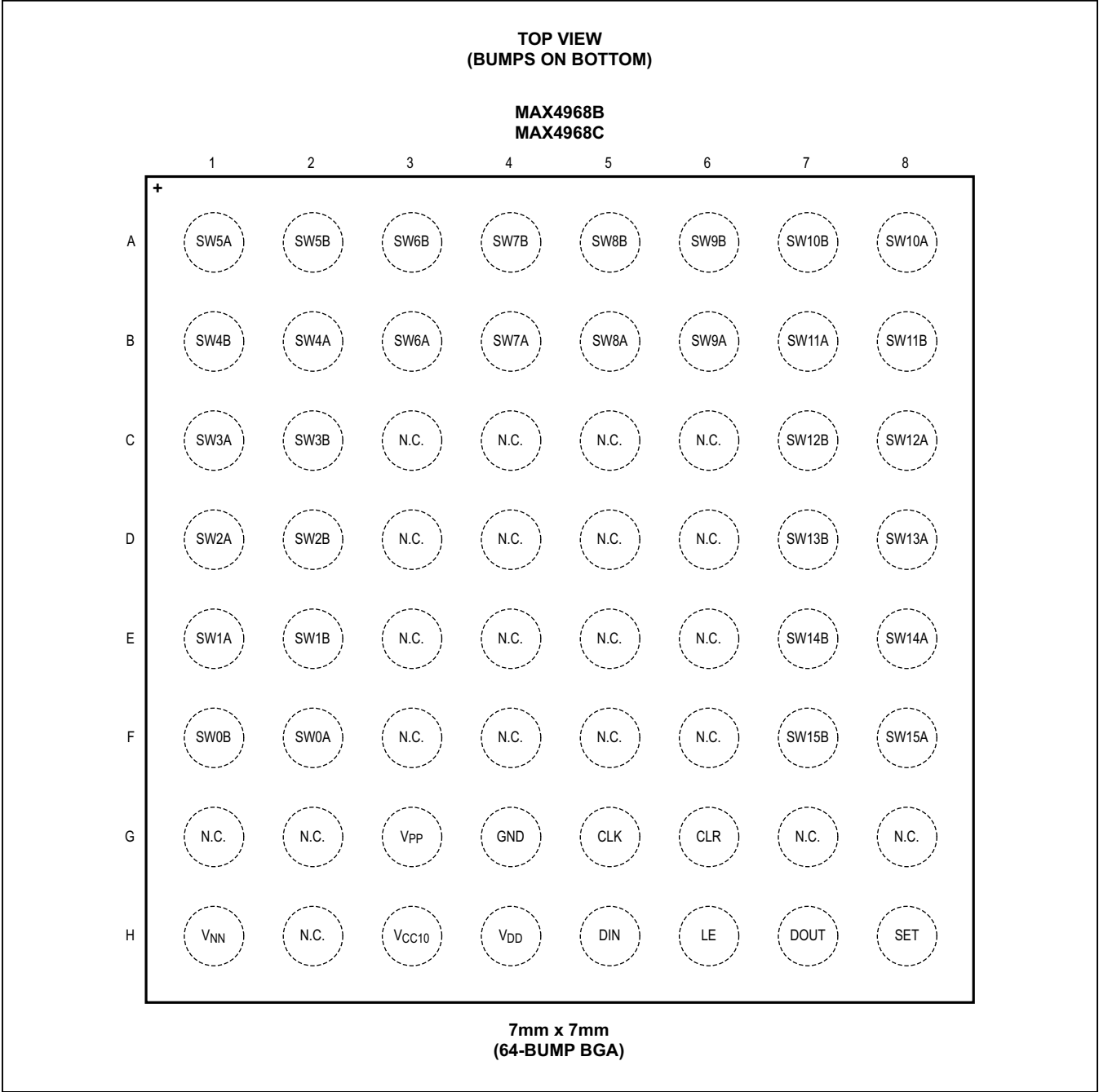
( $V_{DD} = +3V$ ,  $V_{P-P} = +12V$ ,  $V_{NN} = -100V$ ,  $R_L = 100\Omega$ ,  $C_L = 100pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



MAX4968B/MAX4968C

16-Channel, Linear, High-Voltage Analog Switches  
in BGA Package

Pin Configuration





## Pin Description

| PIN                                                  | NAME            | FUNCTION                                                                                           |
|------------------------------------------------------|-----------------|----------------------------------------------------------------------------------------------------|
| A1                                                   | SW5A            | Analog Switch 5 – Terminal                                                                         |
| A2                                                   | SW5B            | Analog Switch 5 – Terminal                                                                         |
| A3                                                   | SW6B            | Analog Switch 6 – Terminal                                                                         |
| A4                                                   | SW7B            | Analog Switch 7 – Terminal                                                                         |
| A5                                                   | SW8B            | Analog Switch 8 – Terminal                                                                         |
| A6                                                   | SW9B            | Analog Switch 9 – Terminal                                                                         |
| A7                                                   | SW10B           | Analog Switch 10 – Terminal                                                                        |
| A8                                                   | SW10A           | Analog Switch 10 – Terminal                                                                        |
| C3-C6, D3-D6,<br>E3-E6, F3-F6, G1,<br>G2, G7, G8, H2 | N.C.            | No Connection. Not connected internally.                                                           |
| B1                                                   | SW4B            | Analog Switch 4 – Terminal                                                                         |
| B2                                                   | SW4A            | Analog Switch 4 – Terminal                                                                         |
| B3                                                   | SW6A            | Analog Switch 6 – Terminal                                                                         |
| B4                                                   | SW7A            | Analog Switch 7 – Terminal                                                                         |
| B5                                                   | SW8A            | Analog Switch 8 – Terminal                                                                         |
| B6                                                   | SW9A            | Analog Switch 9 – Terminal                                                                         |
| B7                                                   | SW11A           | Analog Switch 11 – Terminal                                                                        |
| B8                                                   | SW11B           | Analog Switch 11 – Terminal                                                                        |
| C1                                                   | SW3A            | Analog Switch 3 – Terminal                                                                         |
| C2                                                   | SW3B            | Analog Switch 3 – Terminal                                                                         |
| C7                                                   | SW12B           | Analog Switch 12 – Terminal                                                                        |
| C8                                                   | SW12A           | Analog Switch 12 – Terminal                                                                        |
| D1                                                   | SW2A            | Analog Switch 2 – Terminal                                                                         |
| D2                                                   | SW2B            | Analog Switch 2 – Terminal                                                                         |
| D7                                                   | SW13B           | Analog Switch 13 – Terminal                                                                        |
| D8                                                   | SW13A           | Analog Switch 13 – Terminal                                                                        |
| E1                                                   | SW1A            | Analog Switch 1 – Terminal                                                                         |
| E2                                                   | SW1B            | Analog Switch 1 – Terminal                                                                         |
| E7                                                   | SW14B           | Analog Switch 14 – Terminal                                                                        |
| E8                                                   | SW14A           | Analog Switch 14 – Terminal                                                                        |
| F1                                                   | SW0B            | Analog Switch 0 – Terminal                                                                         |
| F2                                                   | SW0A            | Analog Switch 0 – Terminal                                                                         |
| F7                                                   | SW15B           | Analog Switch 15 – Terminal                                                                        |
| F8                                                   | SW15A           | Analog Switch 15 – Terminal                                                                        |
| G3                                                   | V <sub>PP</sub> | Positive Voltage Supply. Bypass V <sub>P-P</sub> to GND with a 0.1μF or greater ceramic capacitor. |

**Pin Description (continued)**

| PIN | NAME            | FUNCTION                                                                                              |
|-----|-----------------|-------------------------------------------------------------------------------------------------------|
| G4  | GND             | Ground                                                                                                |
| G5  | CLK             | Serial-Clock Input                                                                                    |
| G6  | CLR             | Latch Clear Input                                                                                     |
| H1  | $V_{NN}$        | Negative High-Voltage Supply. Bypass $V_{NN}$ to GND with a 0.1 $\mu$ F or greater ceramic capacitor. |
| H3  | $V_{CC10}$      | +10V LDO Output. Bypass $V_{CC10}$ to GND with a 0.1 $\mu$ F or greater ceramic capacitor.            |
| H4  | $V_{DD}$        | Logic Supply Voltage. Bypass $V_{DD}$ to GND with a 0.1 $\mu$ F or greater ceramic capacitor.         |
| H5  | DIN             | Serial-Data Input                                                                                     |
| H6  | $\overline{LE}$ | Active-Low Latch-Enable Input                                                                         |
| H7  | DOUT            | Serial-Data Output                                                                                    |
| H8  | SET             | Latch-Set Input. Pulldown resistor 100k $\Omega$ .                                                    |

**Detailed Description**

The MAX4968B/MAX4968C are 16-channel, high-linearity, high-voltage, bidirectional SPST analog switches with 18 $\Omega$  (typ) on-resistance. The devices are ideal for use in applications requiring high-voltage switching controlled by a low-voltage control signal, such as ultrasound imaging and industrial printing. The MAX4968C provides integrated 40k $\Omega$  bleed resistors on each switch terminal to discharge capacitive loads. Using HVCMOS technology, these switches combine high-voltage, bilateral MOS switches and low-power CMOS logic to provide efficient control of high-voltage analog signals.

In typical ultrasound applications, the MAX4968B/MAX4968C do not require a dedicated HV supply, which implies a significant simplification of system requirements. The negative voltage supply can be shared with the transmitter and the positive voltage supply is typically +12V.

**Analog Switch**

The devices can transmit analog signals up to 210V<sub>P-P</sub>, with an analog signal range from  $V_{NN}$  to  $V_{NN} + 210V$ . Before starting the high-voltage burst transmission ( $V_{P-P} > +20V$ ), the input voltage must be close to GND to allow a proper settling of the pass FET. The high-voltage burst frequency must be greater than 500kHz.

Extremely long high-voltage bursts ( $V_{P-P} > 10V$ ) with duty cycle greater than 20% could result in signal degradation, especially for unipolar transmission. In general, this applies for burst transmission with a nonzero DC content.

Low-voltage signals ( $V_{P-P} < 10V$ ) continuous wave bipolar transmission is supported for frequencies greater than 500kHz. For very small signals, such as the small echoes in typical ultrasound imaging systems ( $V_{P-P} < 10V$ ), the devices are not limited to a low-frequency bandwidth and can transmit DC signals.

**Voltage Supplies**

The devices operate with a high voltage supply  $V_{NN}$  from -200V to 0,  $V_{P-P}$  supply of +12V (typ), and a logic supply  $V_{DD}$  (+2.37V to +5.5V).

**Bleed Resistors (MAX4968C)**

The MAX4968C features integrated 40k $\Omega$  bleed resistors to discharge capacitive loads such as piezoelectric transducers. Each analog switch terminal is connected to GND with a bleed resistor.

**Serial Interface**

The MAX4968B/MAX4968C are controlled by a serial interface with a 16-bit serial shift register and transparent latch. Each of the 16 data bits controls a single analog switch (see Table 1). Data on DIN is clocked with the most significant bit (MSB) first into the shift register on the rising edge of CLK. Data is clocked out of the shift register onto DOUT on the rising edge of CLK. DOUT reflects the status of DIN, delayed by 16 clock cycles (see [Figure 2](#) and [Figure 3](#)).

**Latch Enable ( $\overline{LE}$ )**

Drive  $\overline{LE}$  logic-low to change the contents of the latch and update the state of the high-voltage switches (Figure 3); drive  $\overline{LE}$  logic-high to freeze the contents of the latch and prevent changes to the switch states. To reduce noise due to clock feedthrough, drive  $\overline{LE}$  logic-high while data is clocked into the shift register. After the data shift register is loaded with valid data, pulse  $\overline{LE}$  logic-low to load the contents of the shift register into the latch.

**Latch Clear (CLR)**

The MAX4968B/MAX4968C feature a latch-clear input. Drive CLR logic-high to reset the contents of the latch to zero and open all switches simultaneously. CLR does not affect the contents of the data shift register. Pulse  $\overline{LE}$  logic-low to reload the contents of the shift register into the latch.

**Latch Set (SET)**

The MAX4968B/MAX4968C feature a latch-set input. Drive SET logic-high to set the contents of the latch to logic-high and close all switches simultaneously. SET does not affect the contents of the data shift register. Pulse  $\overline{LE}$  logic-low to reload the contents of the shift register into the latch. CLR is dominant with respect to SET.

**Power-On Reset**

The MAX4968B/MAX4968C feature a power-on-reset circuit to ensure all switches are open at power-on. The internal 16-bit serial shift register and latch are set to zero on power-up.

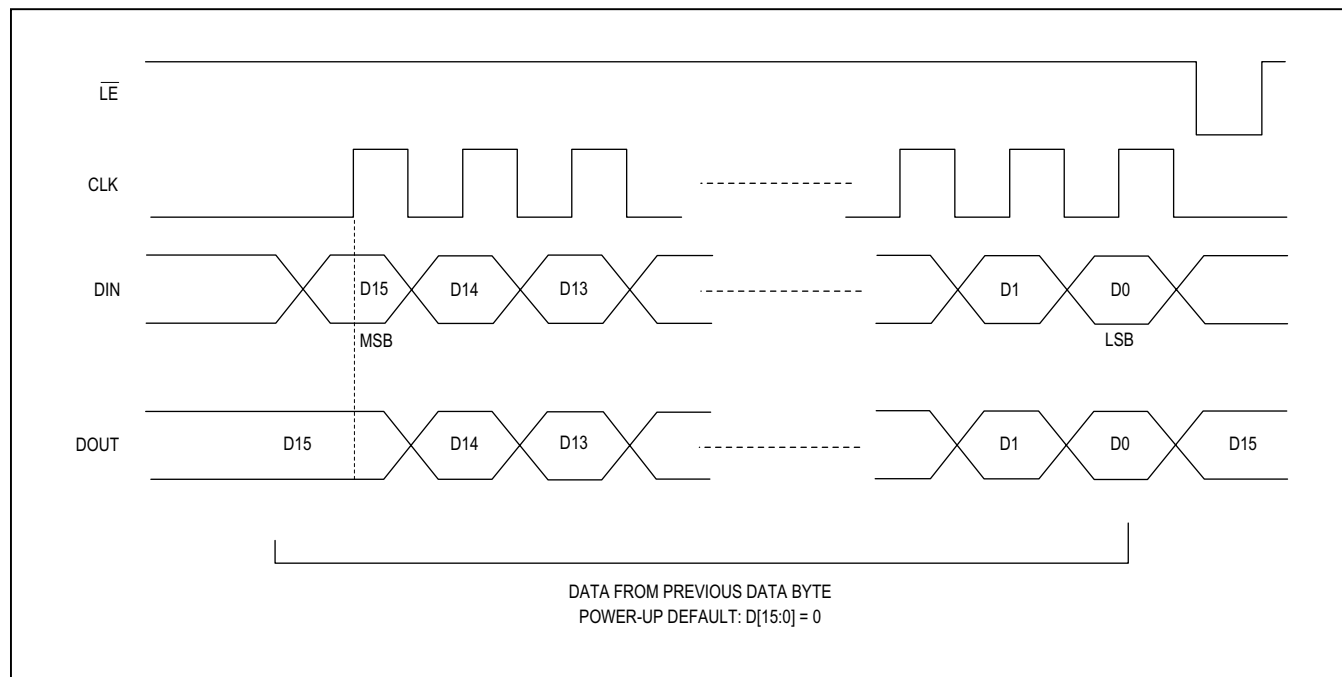


Figure 3. Latch-Enable Interface Timing

Table 1. Serial Interface Programming (Notes 3–8)

| DATA BITS |    |     |     |     |     |     |           | CONTROL BITS    |     |     | FUNCTION            |     |      |      |      |      |      |      |
|-----------|----|-----|-----|-----|-----|-----|-----------|-----------------|-----|-----|---------------------|-----|------|------|------|------|------|------|
| D0 (LSB)  | D1 | D2  | D3  | D4  | D5  | D6  | D7        | $\overline{LE}$ | CLR | SET | SW0                 | SW1 | SW2  | SW3  | SW4  | SW5  | SW6  | SW7  |
| L         |    |     |     |     |     |     |           | L               | L   | L   | OFF                 |     |      |      |      |      |      |      |
| H         |    |     |     |     |     |     |           | L               | L   | L   | ON                  |     |      |      |      |      |      |      |
|           | L  |     |     |     |     |     |           | L               | L   | L   |                     | OFF |      |      |      |      |      |      |
|           | H  |     |     |     |     |     |           | L               | L   | L   |                     | ON  |      |      |      |      |      |      |
|           |    | L   |     |     |     |     |           | L               | L   | L   |                     |     | OFF  |      |      |      |      |      |
|           |    | H   |     |     |     |     |           | L               | L   | L   |                     |     | ON   |      |      |      |      |      |
|           |    |     | L   |     |     |     |           | L               | L   | L   |                     |     |      | OFF  |      |      |      |      |
|           |    |     | H   |     |     |     |           | L               | L   | L   |                     |     |      | ON   |      |      |      |      |
|           |    |     |     | L   |     |     |           | L               | L   | L   |                     |     |      |      | OFF  |      |      |      |
|           |    |     |     | H   |     |     |           | L               | L   | L   |                     |     |      |      | ON   |      |      |      |
|           |    |     |     |     | L   |     |           | L               | L   | L   |                     |     |      |      |      | OFF  |      |      |
|           |    |     |     |     | H   |     |           | L               | L   | L   |                     |     |      |      |      | ON   |      |      |
|           |    |     |     |     |     | L   |           | L               | L   | L   |                     |     |      |      |      |      | OFF  |      |
|           |    |     |     |     |     | H   |           | L               | L   | L   |                     |     |      |      |      |      | ON   |      |
|           |    |     |     |     |     |     | L         | L               | L   | L   |                     |     |      |      |      |      |      | OFF  |
|           |    |     |     |     |     |     | H         | L               | L   | L   |                     |     |      |      |      |      |      | ON   |
|           |    |     |     |     |     |     |           | L               | L   | L   |                     |     |      |      |      |      |      | OFF  |
|           |    |     |     |     |     |     |           | H               | L   | L   |                     |     |      |      |      |      |      | ON   |
| X         | X  | X   | X   | X   | X   | X   | X         | H               | L   | L   | HOLD PREVIOUS STATE |     |      |      |      |      |      |      |
| X         | X  | X   | X   | X   | X   | X   | X         | X               | H   | X   | OFF                 | OFF | OFF  | OFF  | OFF  | OFF  | OFF  | OFF  |
| X         | X  | X   | X   | X   | X   | X   | X         | X               | L   | H   | ON                  | ON  | ON   | ON   | ON   | ON   | ON   | ON   |
| DATA BITS |    |     |     |     |     |     |           | CONTROL BITS    |     |     | FUNCTION            |     |      |      |      |      |      |      |
| D8        | D9 | D10 | D11 | D12 | D13 | D14 | D15 (MSB) | $\overline{LE}$ | CLR | SET | SW8                 | SW9 | SW10 | SW11 | SW12 | SW13 | SW14 | SW15 |
| L         |    |     |     |     |     |     |           | L               | L   | L   | OFF                 |     |      |      |      |      |      |      |
| H         |    |     |     |     |     |     |           | L               | L   | L   | ON                  |     |      |      |      |      |      |      |
|           | L  |     |     |     |     |     |           | L               | L   | L   |                     | OFF |      |      |      |      |      |      |
|           | H  |     |     |     |     |     |           | L               | L   | L   |                     | ON  |      |      |      |      |      |      |
|           |    | L   |     |     |     |     |           | L               | L   | L   |                     |     | OFF  |      |      |      |      |      |
|           |    | H   |     |     |     |     |           | L               | L   | L   |                     |     | ON   |      |      |      |      |      |
|           |    |     | L   |     |     |     |           | L               | L   | L   |                     |     |      | OFF  |      |      |      |      |
|           |    |     | H   |     |     |     |           | L               | L   | L   |                     |     |      | ON   |      |      |      |      |
|           |    |     |     | L   |     |     |           | L               | L   | L   |                     |     |      |      | OFF  |      |      |      |
|           |    |     |     | H   |     |     |           | L               | L   | L   |                     |     |      |      | ON   |      |      |      |
|           |    |     |     |     | L   |     |           | L               | L   | L   |                     |     |      |      |      | OFF  |      |      |

**Table 1. Serial Interface Programming (Notes 3–8) (continued)**

| DATA BITS |    |     |     |     |     |     |           | CONTROL BITS    |     |     | FUNCTION            |     |      |      |      |      |      |      |
|-----------|----|-----|-----|-----|-----|-----|-----------|-----------------|-----|-----|---------------------|-----|------|------|------|------|------|------|
| D8        | D9 | D10 | D11 | D12 | D13 | D14 | D15 (MSB) | $\overline{LE}$ | CLR | SET | SW8                 | SW9 | SW10 | SW11 | SW12 | SW13 | SW14 | SW15 |
|           |    |     |     |     | H   |     |           | L               | L   | L   |                     |     |      |      |      | ON   |      |      |
|           |    |     |     |     |     | L   |           | L               | L   | L   |                     |     |      |      |      |      | OFF  |      |
|           |    |     |     |     |     | H   |           | L               | L   | L   |                     |     |      |      |      |      | ON   |      |
|           |    |     |     |     |     |     | L         | L               | L   | L   |                     |     |      |      |      |      |      | OFF  |
|           |    |     |     |     |     |     | H         | L               | L   | L   |                     |     |      |      |      |      |      | ON   |
| X         | X  | X   | X   | X   | X   | X   | X         | H               | L   | L   | HOLD PREVIOUS STATE |     |      |      |      |      |      |      |
| X         | X  | X   | X   | X   | X   | X   | X         | X               | H   | X   | OFF                 | OFF | OFF  | OFF  | OFF  | OFF  | OFF  | OFF  |
| X         | X  | X   | X   | X   | X   | X   | X         | X               | L   | H   | ON                  | ON  | ON   | ON   | ON   | ON   | ON   | ON   |

*X = Don't care.*

**Note 3:** The 16 switches operate independently.

**Note 4:** Serial data is clocked in on the rising edge of CLK.

**Note 5:** The switches go to a state retaining their present condition on the rising edge of  $\overline{LE}$ . When  $\overline{LE}$  is low, the shift register data flows through the latch.

**Note 6:** DOUT is high when switch 15 is on.

**Note 7:** Shift register clocking has no effect on the switch states if  $\overline{LE}$  is high.

**Note 8:** The CLR input overrides all other inputs.

## Applications Information

In typical ultrasound applications, the MAX4968B/MAX4968C do not require dedicated high-voltage supplies; the negative voltage supply can be shared with the transmitter and the positive voltage supply is typically +12V. See [Figure 4](#), [Figure 5](#), and [Figure 6](#) for medical ultrasound applications.

### Logic Levels

The MAX4968B/MAX4968C digital interface inputs (CLK, DIN,  $\overline{LE}$ , CLR, and SET) operate on the  $V_{DD}$  logic supply voltage.

### Daisy-Chaining Multiple Devices

Digital output DOUT is provided to allow the connection of multiple MAX4968B/MAX4968C devices by daisy-chaining (Figure 8). Connect each DOUT to the DIN of

the subsequent device in the chain. Connect CLK,  $\overline{LE}$ , CLR, and SET inputs of all devices, and drive  $\overline{LE}$  logic-low to update all devices simultaneously. Drive CLR high to open all the switches simultaneously. Drive SET high to close all the switches simultaneously. Additional shift registers can be included anywhere in series with the MAX4968B/MAX4968C data-chain.

### Supply Sequencing and Bypassing

The MAX4968B/MAX4968C do not require special sequencing of the  $V_{DD}$ ,  $V_{P-P}$  and  $V_{NN}$  supply voltages. Bypass  $V_{DD}$ ,  $V_{P-P}$ , and  $V_{NN}$  to GND with a 0.1 $\mu$ F ceramic capacitor as close as possible to the device.

## Application Diagrams

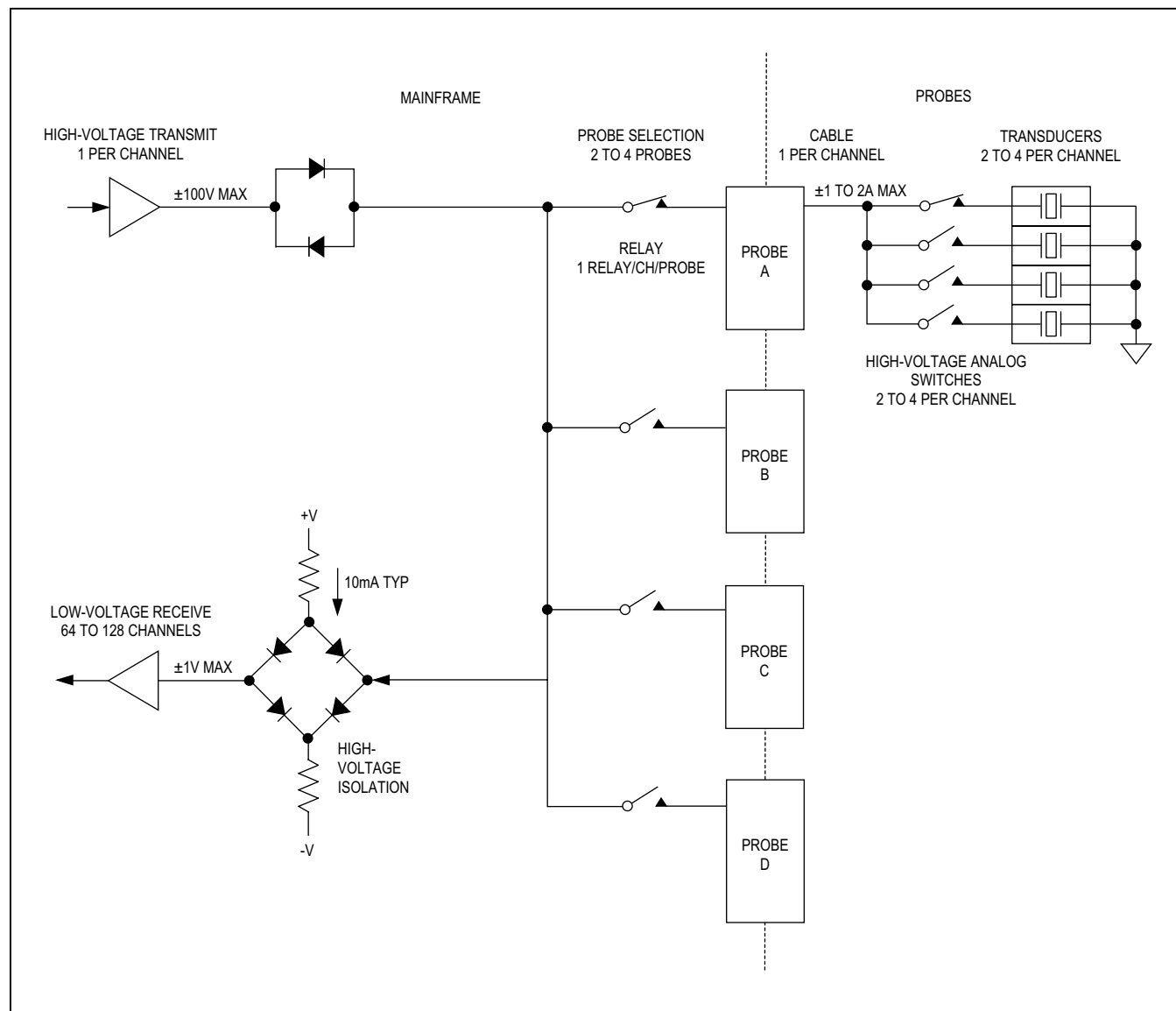


Figure 4. Medical Ultrasound Application — High-Voltage Analog Switches in Probe

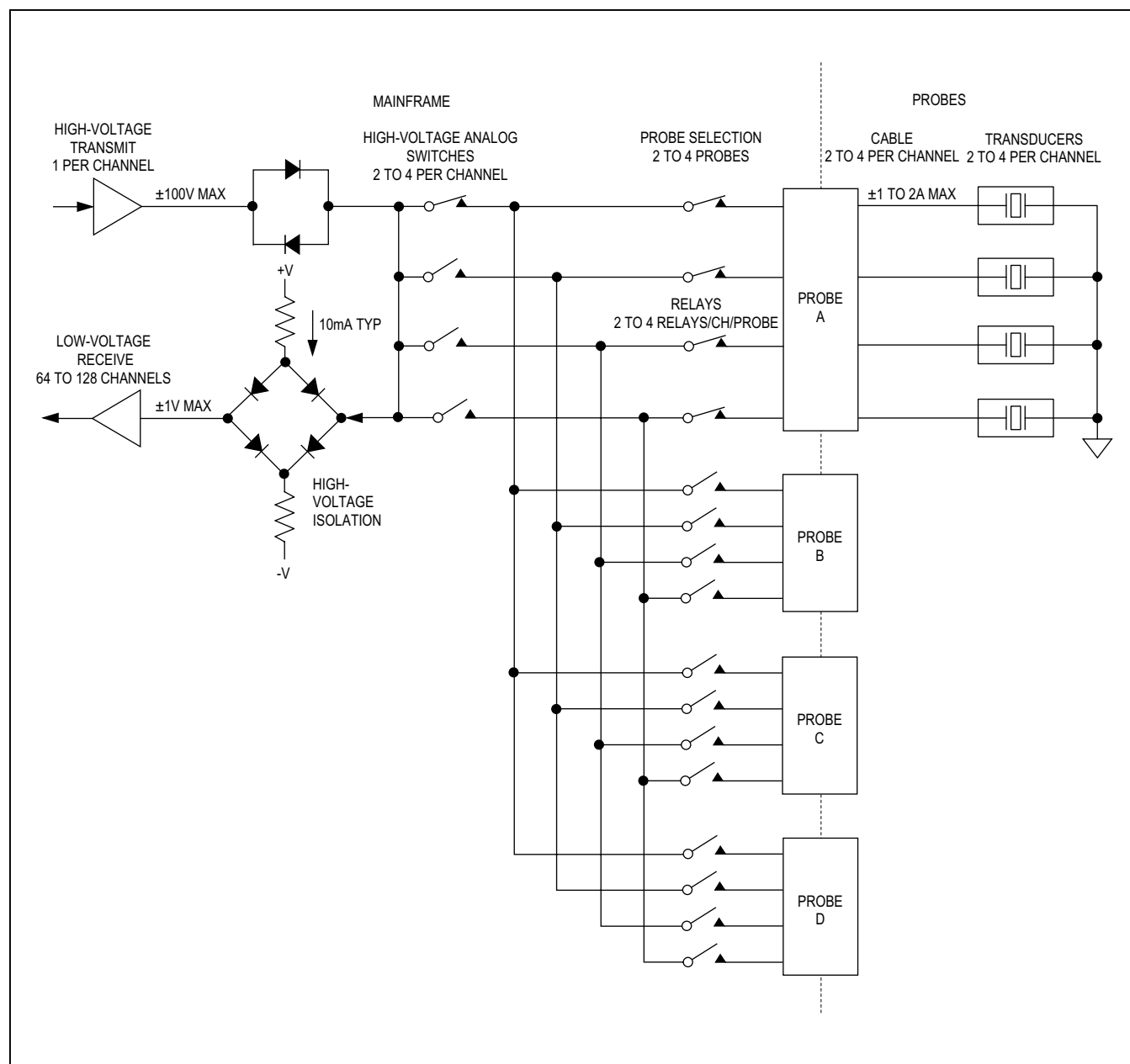


Figure 5. Medical Ultrasound Application — High-Voltage Analog Switches in Mainframe

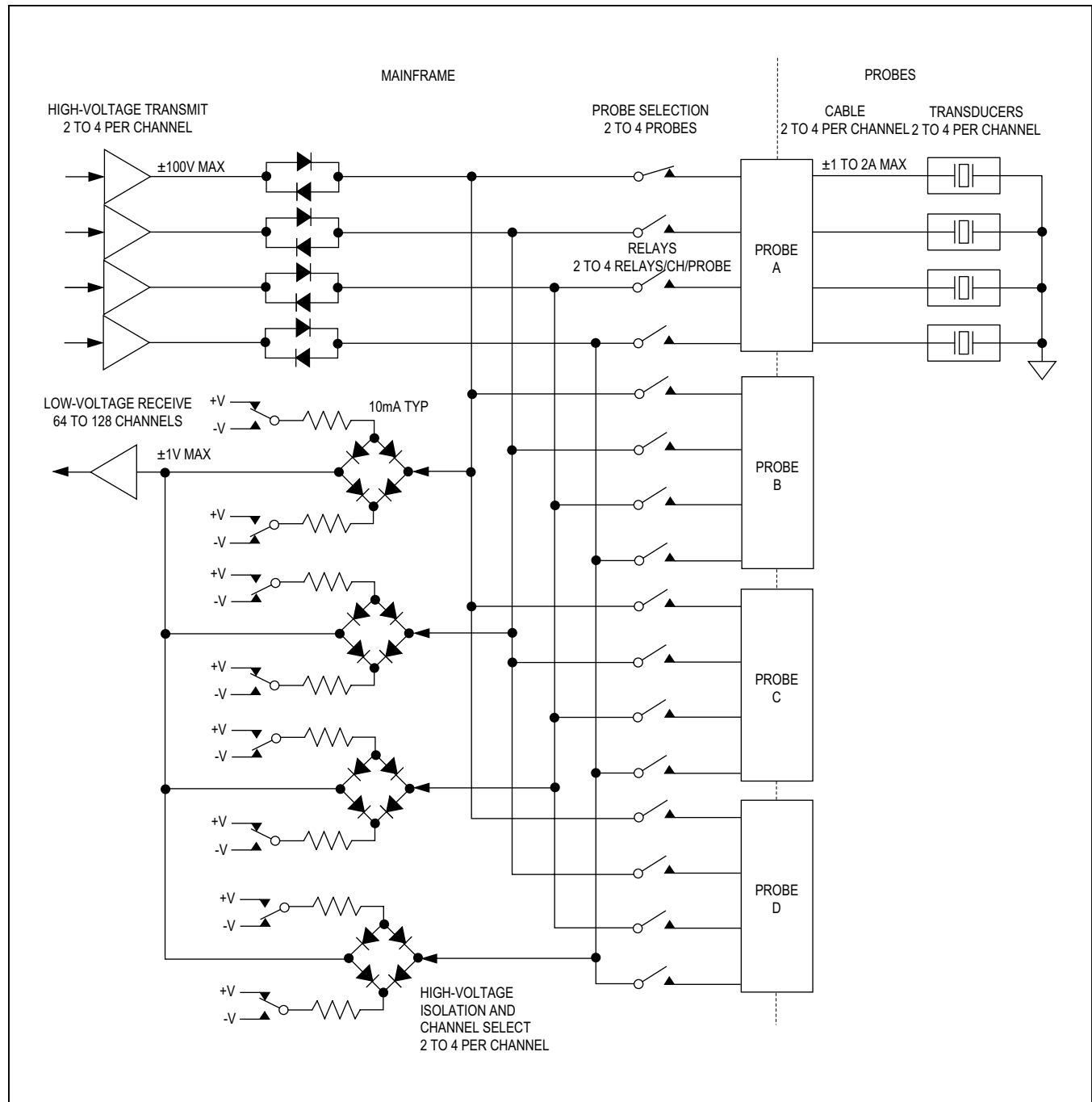


Figure 6. Medical Ultrasound Application — Multiple Transmit and Isolation per Receiver Channel



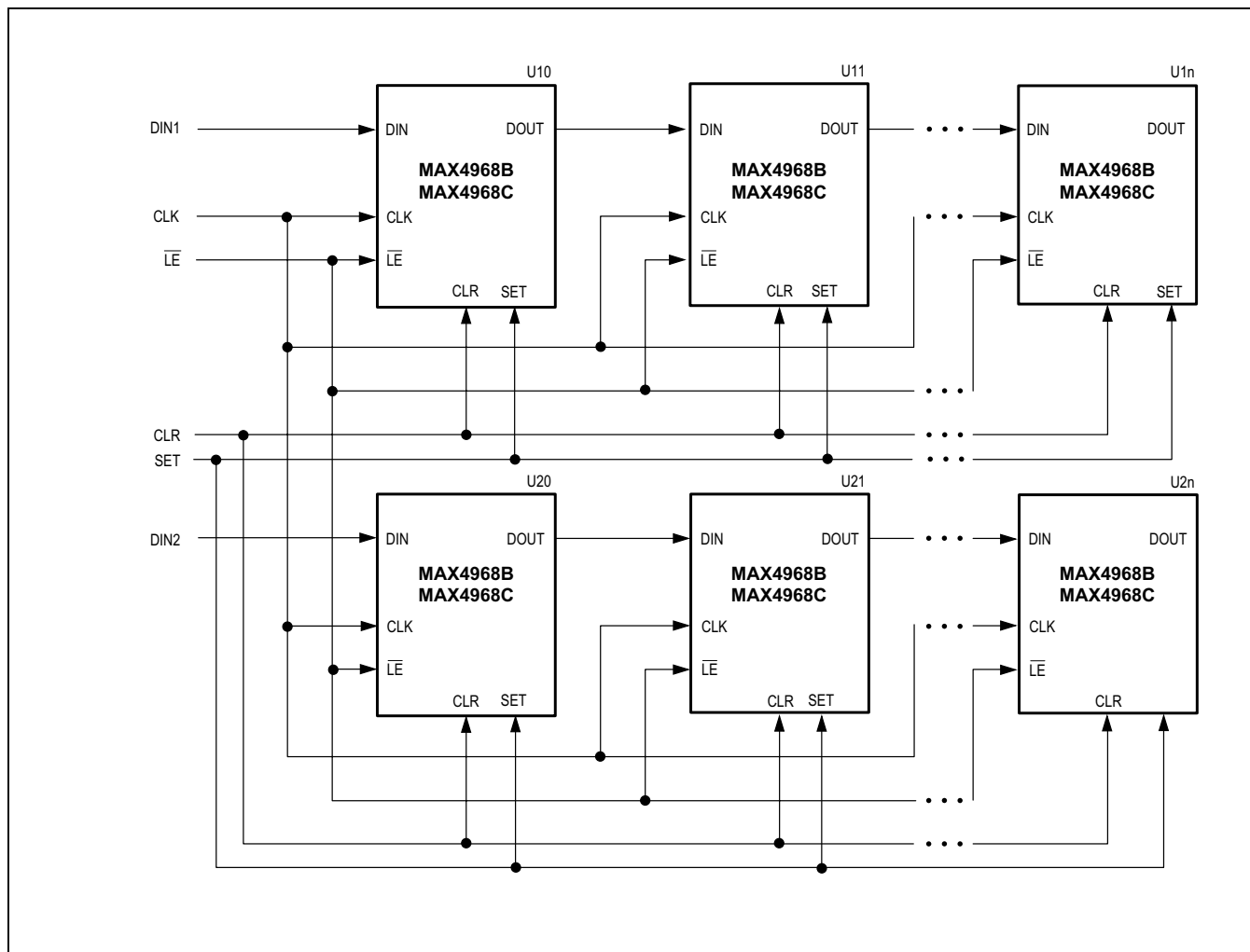


Figure 7. Interfacing Multiple Devices by Daisy-Chaining

# 16-Channel, Linear, High-Voltage Analog Switches in BGA Package

The diagram illustrates the internal architecture of the MAX4968B and MAX4968C. It features a central 16-BIT SHIFT REGISTER connected to various control and data pins. The control pins include CLR, SET, DIN, CLK, DOUT, and  $\overline{LE}$ . The power pins are  $V_{DD}$ ,  $V_{PP}$ , GND, and  $V_{NN}$ . The output stage consists of two LATCH blocks and two LEVEL SHIFTER blocks, which drive the SW0B, SW0A, SW15B, and SW15A pins. Each output pin is connected to a bleed resistor (marked with an asterisk) and a diode to  $V_{NN}$ . The diagram is labeled MAX4968B and MAX4968C.

| PART         | TEMP RANGE     | PIN-PACKAGE           | SWITCH CHANNELS | BLEED RESISTOR |
|--------------|----------------|-----------------------|-----------------|----------------|
| MAX4968BEXB+ | -40°C to +85°C | 64 BGA<br>(7mm x 7mm) | 16              | No             |
| MAX4968CEXB+ | -40°C to +85°C | 64 BGA<br>(7mm x 7mm) | 16              | Yes            |

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.    | LAND PATTERN NO.                                   |
|--------------|--------------|----------------|----------------------------------------------------|
| 64 BGA       | X6477+2      | <u>21-0461</u> | Refer to<br><u>Application</u><br><u>Note 1891</u> |

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION     | PAGES<br>CHANGED |
|--------------------|------------------|-----------------|------------------|
| 0                  | 3/14             | Initial release | —                |

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