

IH5208

4-Channel Differential Fault Protected CMOS Analog Multiplexer

GENERAL DESCRIPTION

The IH5208 is a dielectrically isolated CMOS monolithic analog multiplexer, designed as a plug-in replacement for the HI549 and similar devices, but adds fault protection to the standard performance. A unique serial MOSFET switch ensures that an OFF channel will remain OFF when the input exceeds the supply rails by up to $\pm 25V$, even with the supply voltage at zero. Further, an ON channel will be limited to a throughput of about 1.5V less than the supply rails, thus affording protection to any following circuitry such as op amps, D/A converters, etc.

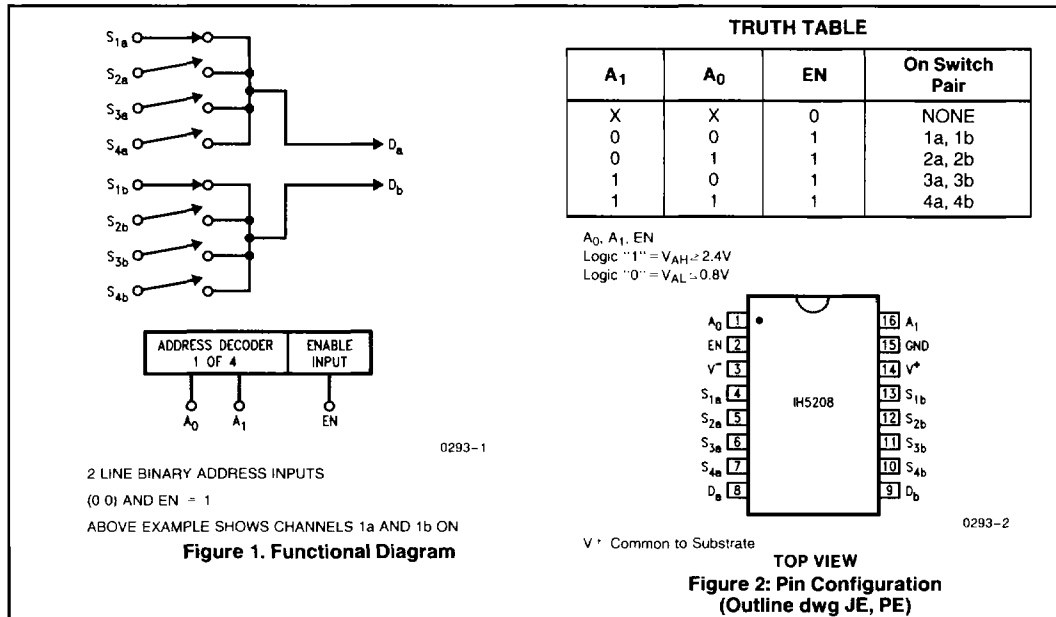
A binary 2-bit address code together with the ENable input allows selection of any channel pair or none at all. These 3 inputs are all TTL compatible for easy logic interface; the ENable input also facilitates MUX expansion and cascading.

ORDERING INFORMATION

| Part Number | Temperature Range | Package |
|-------------|-------------------|--------------------|
| IH5208MJE | -55°C to +125°C | 16 pin CERDIP |
| IH5208IJE | -25°C to +85°C | 16 pin CERDIP |
| IH5208CPE | 0°C to 70°C | 16 pin plastic DIP |

FEATURES

- All Channels OFF When Power OFF, for Analog Signals Up to $\pm 25V$
- Power Supply Quiescent Current Less Than $1\mu A$
- $\pm 13V$ Analog Signal Range
- No SCR Latchup
- Break-Before-Make Switching
- TTL and CMOS Compatible Strobe Control
- Pin Compatible With HI549
- Any Channel Turns OFF If Input Exceeds Supply Rails by Up to $\pm 25V$
- TTL and CMOS Compatible Binary Address and ENable Inputs



HARRIS SEMICONDUCTOR'S SOLE AND EXCLUSIVE WARRANTY OBLIGATION WITH RESPECT TO THIS PRODUCT SHALL BE THAT STATED IN THE WARRANTY ARTICLE OF THE CONDITION OF SALE. THE WARRANTY SHALL BE EXCLUSIVE AND SHALL BE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR USE.

NOTE: All typical values have been characterized but are not tested

ABSOLUTE MAXIMUM RATINGS

| | | |
|----------------------------|-------|-----------------|
| V_{IN} (A, EN) to Ground | ..... | -15V, +15V |
| V_S or V_D to V^+ | ..... | +25V, -40V |
| V_S or V_D to V^- | ..... | -25V, +40V |
| V^+ to Ground | ..... | 20V |
| V^- to Ground | ..... | -20V |
| Current (Any Terminal) | ..... | 20mA |
| Operating Temperature | | |
| C Suffix | ..... | 0°C to +70°C |
| I Suffix | ..... | -25°C to +85°C |
| M Suffix | ..... | -55°C to +125°C |

Storage Temperature

| | | |
|--------------------------------------|-------|-----------------|
| C Suffix | ..... | -65°C to +125°C |
| I & M Suffix | ..... | -65°C to +150°C |
| Lead Temperature (Soldering, 10 sec) | ..... | 300°C |
| Power Dissipation* | | |
| CERDIP Package** | ..... | 900 mW |
| Plastic Package*** | ..... | 470 mW |

*Device mounted with all leads soldered or welded to PC board.

**Derate 12 mW/°C above 75°C

***Derate 6.3 mW/°C above 75°C

NOTE: Stresses above 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 above 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.

ELECTRICAL CHARACTERISTICS

$V^+ = 15V$, $V^- = -15V$, $V_{EN} = 2.4V$, unless otherwise specified.

| Characteristic | Measured Terminal | No Tests Per Temp | Test Conditions | Typ 25°C | Max Limits | | | | | | Units | |
|--|--|-------------------|--|--------------------------------------|------------|------|-----------|-----------|------|-----------|-----------|----------|
| | | | | | M Suffix | | | C Suffix | | | | |
| | | | | | -55°C | 25°C | 125°C | -25°C/0°C | 25°C | 85°C/70°C | | |
| SWITCH | | | | | | | | | | | | |
| $R_{DS(on)}$ | S to D | 8 | $V_D = 10V$, $I_S = -100\mu A$ | Sequence each switch on | 900 | 1200 | 1200 | 1800 | 1500 | 1500 | 2000 | Ω |
| | | 8 | $V_D = -10V$, $I_S = -100\mu A$ | $V_{AL} = 0.8V$, $V_{AH} = 2.4V$ | 900 | 1200 | 1200 | 1800 | 1500 | 1500 | 2000 | |
| $\Delta R_{DS(on)}$ | | | $\Delta R_{DS(on)} = \frac{R_{DS(on)max} - R_{DS(on)min}}{R_{DS(on)avg}}$ $V_S = \pm 10V$ | | 5 | | | | | | | % |
| $I_S(off)$ | S | 8 | $V_S = 10V$, $V_D = -10V$ | $V_{EN} = 0.8V$ | ± 0.02 | | ± 0.5 | ± 50 | | ± 1.0 | ± 50 | nA |
| | | 8 | $V_S = -10V$, $V_D = 10V$ | | ± 0.02 | | ± 0.5 | ± 50 | | ± 1.0 | ± 50 | |
| $I_D(off)$ | D | 1 | $V_D = 10V$, $V_S = -10V$ | | ± 0.02 | | ± 1.0 | ± 100 | | ± 2.0 | ± 100 | |
| | | 1 | $V_D = -10V$, $V_S = 10V$ | | ± 0.05 | | ± 1.0 | ± 100 | | ± 2.0 | ± 100 | |
| $I_D(on)$ | D | 8 | $V_{S(All)} = V_D = 10V$ | Sequence each switch on | ± 0.1 | | ± 2.0 | ± 100 | | ± 5.0 | ± 100 | |
| | | 8 | $V_{S(All)} = V_D = -10V$ | $V_{AL} = 0.8V$, $V_{AH} = 2.4V$ | ± 0.1 | | ± 2.0 | ± 100 | | ± 5.0 | ± 100 | |
| FAULT | | | | | | | | | | | | |
| I_S with Power OFF | S | 8 | $V_{SUPP} = 0V$, $V_{IN} = \pm 25V$, $V_{EN} = V_0 = 0V$, $A_0, A_1, A_2 = 0V$ | | ± 1.0 | | ± 2 | | | ± 5 | | μA |
| $I_S(off)$ with Overvoltage | S | 8 | $V_{IN} = \pm 25V$, $V_0 = \pm 10V$ | | ± 1.0 | | ± 5 | | | ± 10 | | μA |
| INPUT | | | | | | | | | | | | |
| $I_{EN(on)}$ / $I_{A(on)}$ or $I_{EN(off)}$ / $I_{A(off)}$ | A ₀ , A ₁ , A ₂ or EN | 4 | $V_A = 0V$ | | 0.01 | | -10 | -30 | | -10 | -30 | μA |
| | | 4 | $V_A = 15V$ | | 0.01 | | 10 | 30 | | 10 | 30 | |

NOTE: All typical values have been characterized but are not tested.

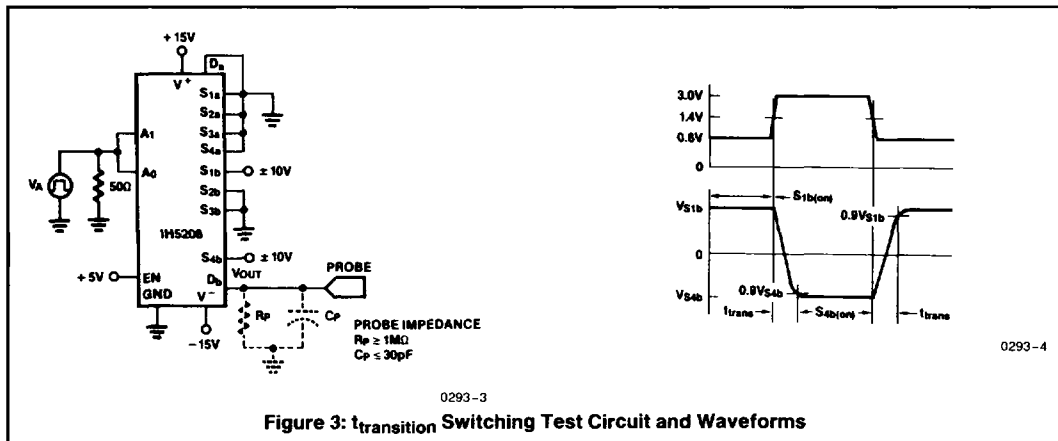
ELECTRICAL CHARACTERISTICS

$V^+ = 15V$, $V^- = -15V$, $V_{EN} = 2.4V$, unless otherwise specified. (Continued)

| Characteristic | Measured Terminal | No Tests Per Temp | Test Conditions | Typ 25°C | Max Limits | | | | | | Units |
|---|-------------------|-------------------|--|------------------------------------|------------|------|-------|-----------|------|-----------|---------|
| | | | | | M Suffix | | | C Suffix | | | |
| | | | | | -55°C | 25°C | 125°C | -20°C/0°C | 25°C | 85°C/70°C | |
| DYNAMIC | | | | | | | | | | | |
| $t_{transition}$ | D | | See Figure 3 | 0.3 | | | | | | | μs |
| t_{open} | D | | See Figure 4 | 0.2 | | | | | | | |
| $t_{on(EN)}$ | D | | See Figure 5 | 0.6 | | 1.5 | | | | | |
| $t_{off(EN)}$ | D | | | 0.4 | | 1 | | | | | |
| $t_{on-to-off}$ Break-Before-Make Delay Settling Time | D | | $V_{EN} = +5V$, A_0, A_1, A_2 Strobed $V_{IN} = \pm 10V$, See Figure 6 | 10 | | | | | | | ns |
| "OFF" Isolation | D | | $V_{EN} = 0V$, $R_L = 200\Omega$, $C_L = 3pF$, $V_S = 3V_{RMS}$, $f = 500kHz$ | 60 | | | | | | | dB |
| $C_{s(off)}$ | S | | $V_S = 0V$ | 5 25 1 | | | | | | | pF |
| $C_{D(off)}$ | D | | $V_D = 0V$ | | | | | | | | |
| $C_{DS(off)}$ | D to S | | $V_S = 0V, V_D = 0V$ | | | | | | | | |
| SUPPLY | | | | | | | | | | | |
| Supply Current | + | I+ | 1 | $V_{EN} = 5V$ All $V_A = 0V/5V$ | 0.5 | 0.7 | 0.6 | 0.5 | | 1.0 | mA |
| | - | I- | 1 | | 0.02 | 0.7 | 0.6 | 0.5 | | 1.0 | |

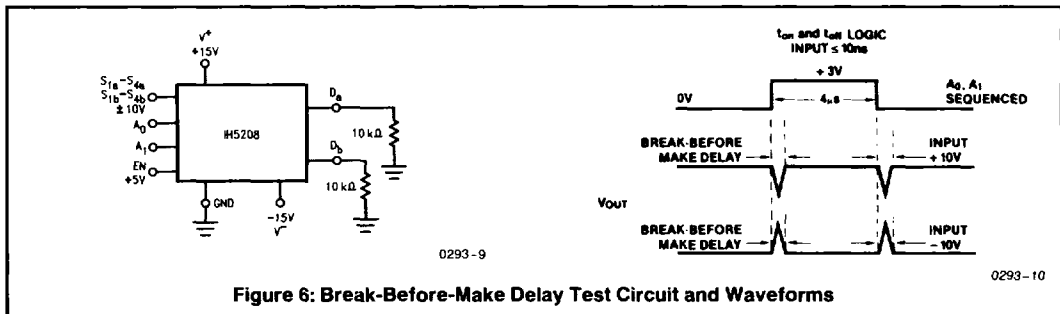
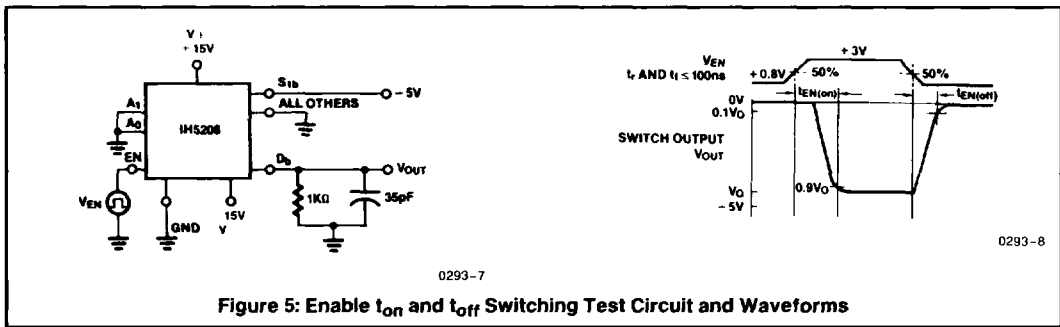
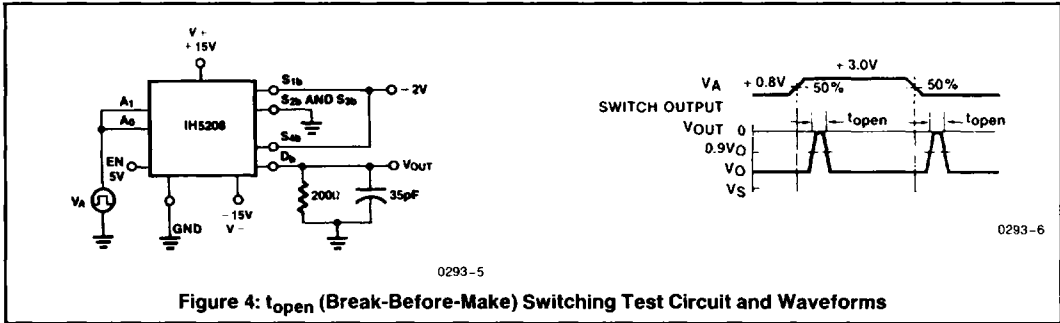
Note 1. Readings taken 400ms after the overvoltage occurs.

SWITCHING INFORMATION



NOTE: All typical values have been characterized but are not tested.

SWITCHING INFORMATION (Continued)

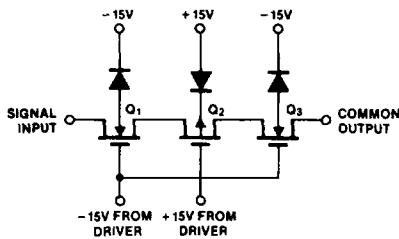


NOTE: All typical values have been characterized but are not tested.

DETAILED DESCRIPTION

The IH5208, like all Harris' multiplexers, contains a set of CMOS switches that form the channels, and driver and decoder circuitry to control which channel turns ON, if any. In addition, the IH5208 contains an internal regulator which provides a fully TTL compatible ENable input that is identical in operation to the Address inputs. This does away with the special conditions that many multiplexer enable inputs require for proper logic swings. The identical circuit conditions of the ENable and Address lines also helps ensure the extension of break-before-make switching to wider multiplexer systems (see applications section).

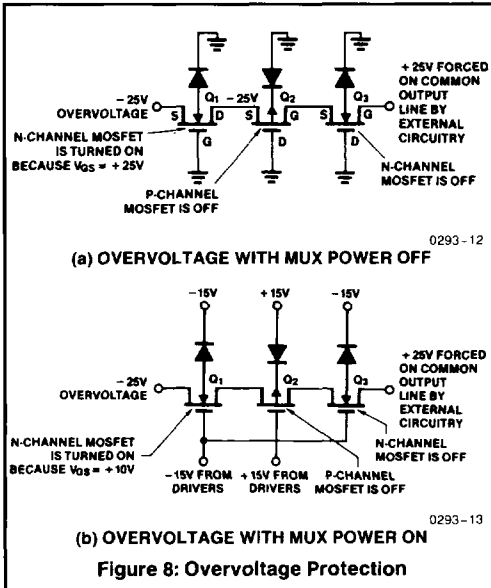
Another, and more important difference lies in the switching channel. Previous devices have used parallel n- and p-channel MOSFET switches. While this scheme yields reasonably good ON resistance characteristics and allows the switching of rail-to-rail input signals, it also has a number of drawbacks. The sources and drains of the switch transistors will conduct to the substrate if the input goes outside the supply rails, and even careful use of diodes cannot avoid channel-to-output and channel-to-channel coupling in cases of input overrange. The IH5208 uses a novel series arrangement of the p- and n-channel switches (Figure 7) combined with the dielectrically isolated process to eliminate these problems.



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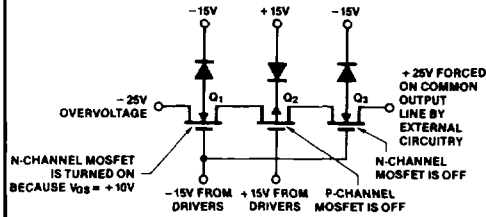
Figure 7: Series Connection of Channel Switches

Within the normal analog signal range, the inherent variation of switch ON resistance will balance out almost as well as the customary parallel configuration, but as the analog signal approaches either supply rail, even for an ON channel, either the p- or the n-channel will become a source follower, disconnecting the channel (Figure 8). Thus protection is provided for any input or output channel against overvoltage, even in the absence of multiplexer supply voltages. This applies up to the breakdown voltage of the respective switches. Figure 9 shows a more detailed schematic of the channel switches, including the back-gate driver devices which ensure optimum channel ON resistances and breakdown voltage under the various conditions.



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(a) OVERVOLTAGE WITH MUX POWER OFF



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(b) OVERVOLTAGE WITH MUX POWER ON

Figure 8: Overvoltage Protection

Under some circumstances, if the logic inputs are present but the multiplexer supplies are not, the circuit will use the logic inputs as a sort of phantom supply; this could result in an output up to that logic level. To prevent this from occurring, simply ensure that the ENable pin is LOW any time the multiplexer supply voltages are missing (Figure 10).

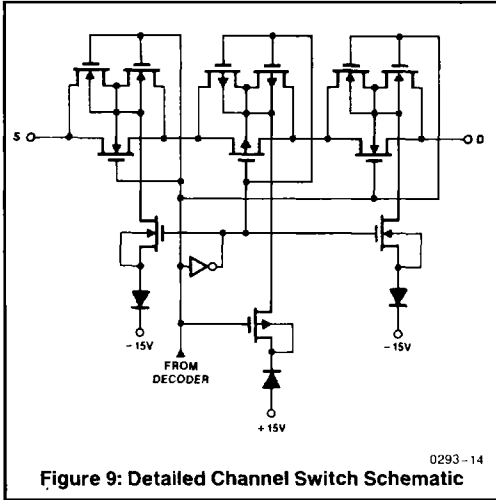


Figure 9: Detailed Channel Switch Schematic

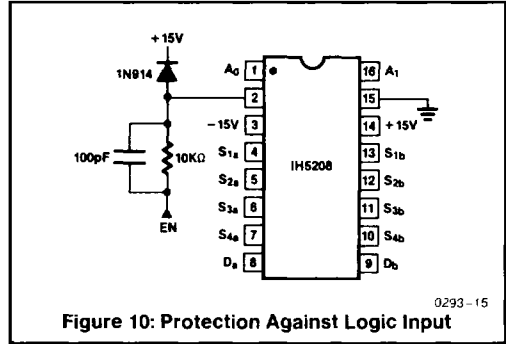


Figure 10: Protection Against Logic Input

MAXIMUM SIGNAL HANDLING CAPABILITY

The IH5208 is designed to handle signals in the $\pm 10V$ range, with a typical $r_{DS(on)}$ of 900Ω ; it can successfully handle signals up to $\pm 12V$, however, $r_{DS(on)}$ will increase to about $1.8k\Omega$. Beyond $\pm 12V$ the device approaches an open circuit, and thus $\pm 12V$ is about the practical limit, see Figure 11.

Figure 12 shows the input/output characteristics of an ON channel, illustrating the inherent limiting action of the series switch connection (see Detailed Description), while Figure 13 gives the ON resistance variation with temperature.

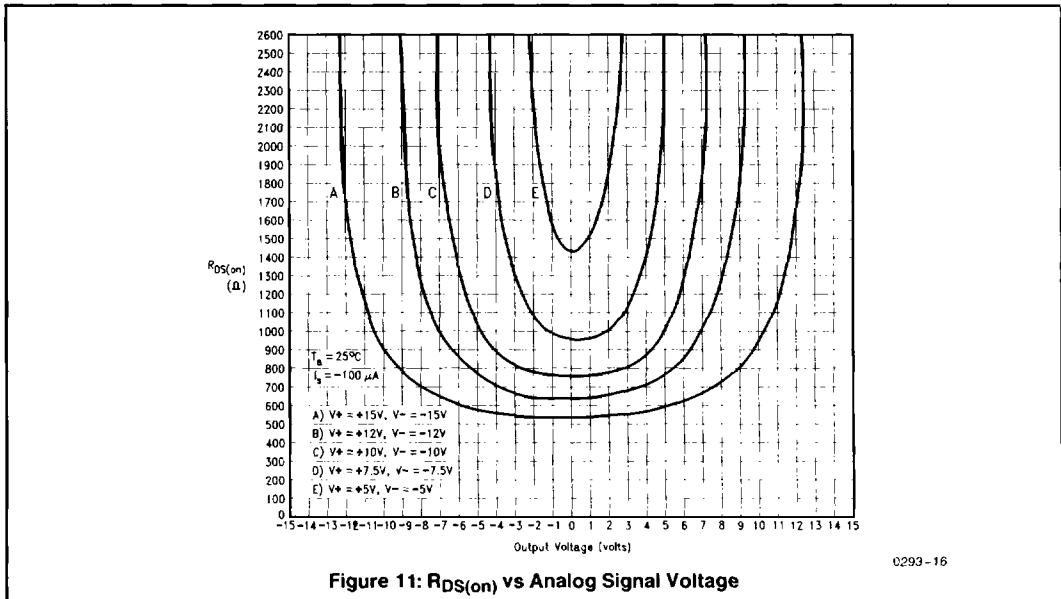


Figure 11: $R_{DS(on)}$ vs Analog Signal Voltage

NOTE: All typical values have been characterized but are not tested

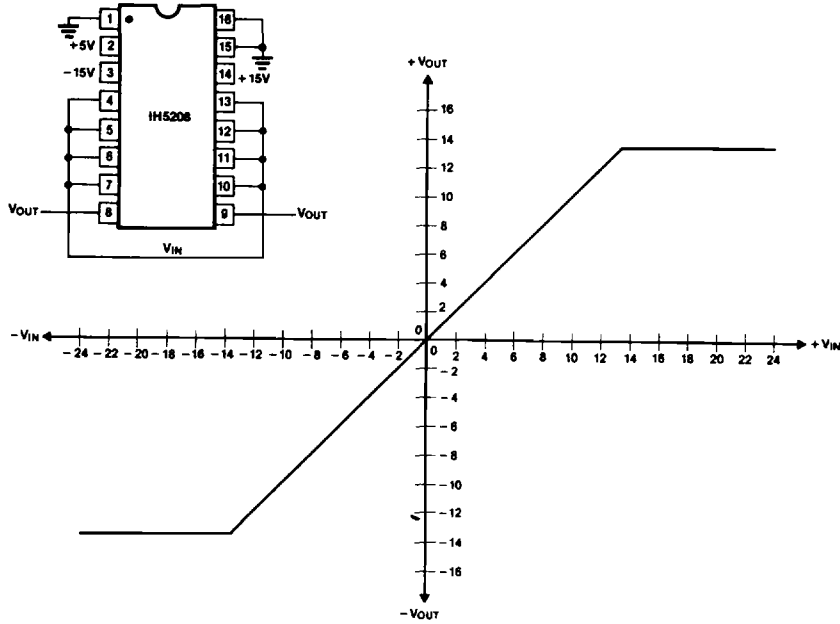


Figure 12: MUX Output Voltage vs Input Voltage Channel 1 Shown; All Channels Similar

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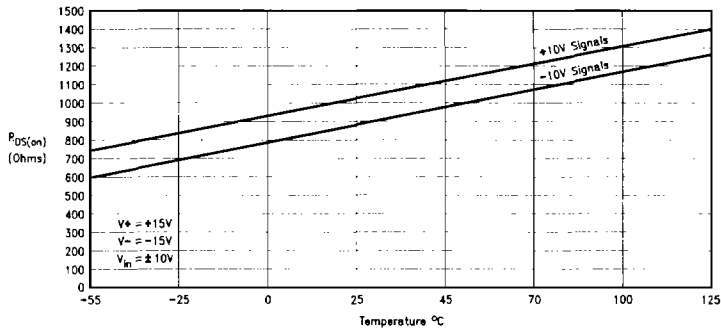


Figure 13: Typical $R_{DS(on)}$ Variation with Temperature

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NOTE All typical values have been characterized but are not tested

USING THE IH5208 WITH SUPPLIES OTHER THAN $\pm 15V$

The IH5208 will operate successfully with supply voltages from $\pm 5V$ to $\pm 15V$, however $r_{DS(on)}$ increases as supply voltage decreases, as shown in Figure 11. Leakage currents, on the other hand, decrease with a lowering of supply voltage, and therefore the error term product of $r_{DS(on)}$ and leakage current remains reasonably constant. $r_{DS(on)}$ also decreases as signal levels decrease. For high system accuracy [acceptable levels of $r_{DS(on)}$] the maximum input signal should be 3V less than the supply voltages. The logic thresholds remain TTL compatible.

APPLICATION NOTES

Further information may be found in:

- A003** "Understanding and Applying the Analog Switch"
- A006** "A New CMOS Analog Gate Technology"
- A020** "A Cookbook Approach to High Speed Data Acquisition and Microprocessor Interfacing"

IH5208 APPLICATIONS INFORMATION

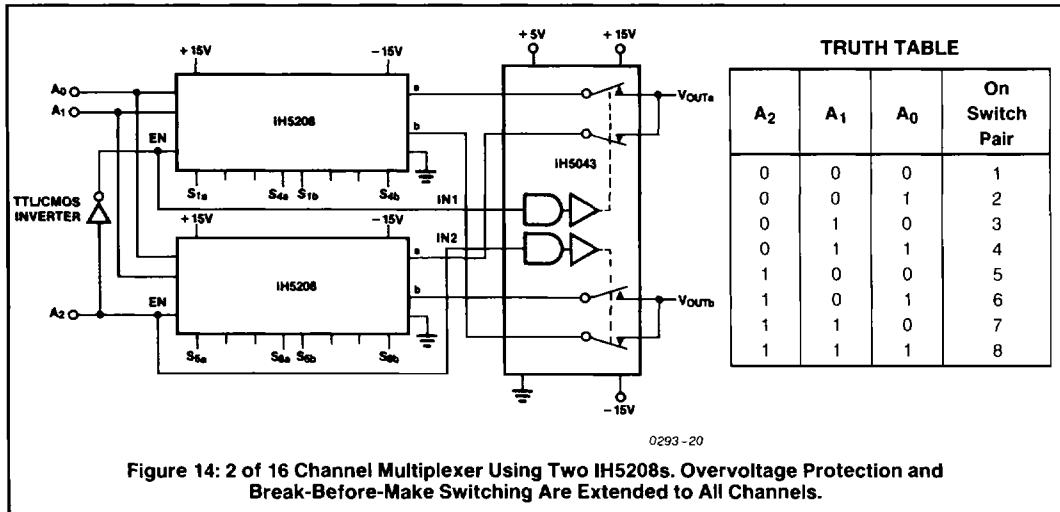
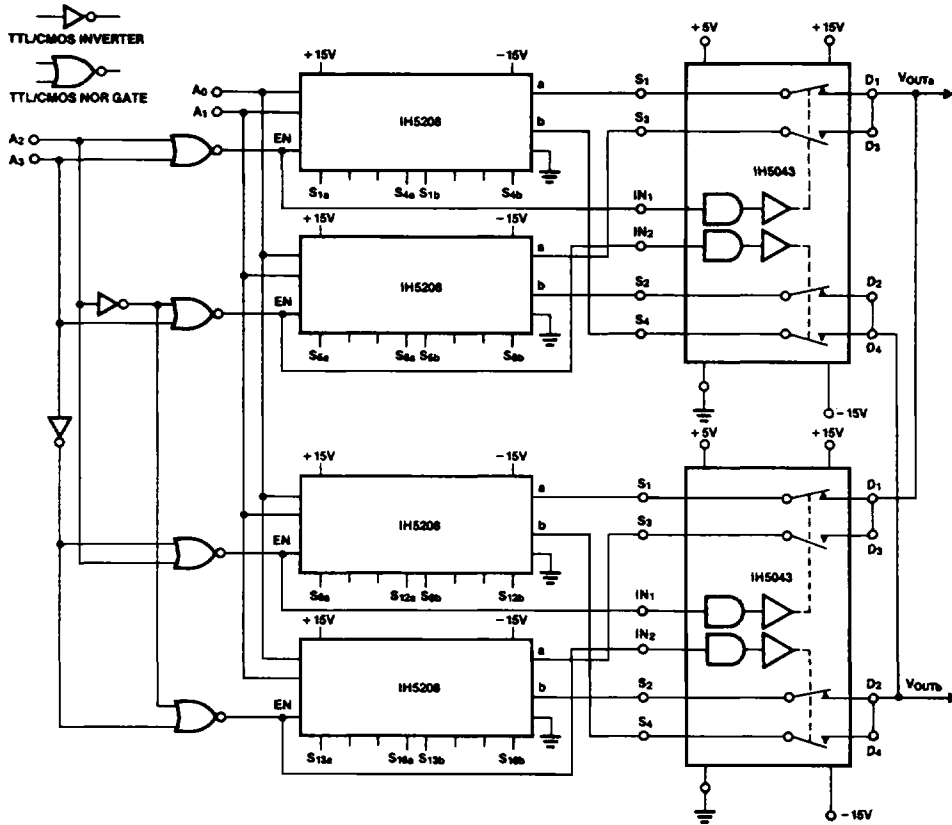


Figure 14: 2 of 16 Channel Multiplexer Using Two IH5208s. Overvoltage Protection and Break-Before-Make Switching Are Extended to All Channels.

NOTE: All typical values have been characterized but are not tested.

IH5208 APPLICATIONS INFORMATION (Continued)



TRUTH TABLE

| A ₃ | A ₂ | A ₁ | A ₀ | On Switch | | On Switch | |
|----------------|----------------|----------------|----------------|-----------|-------------------|-----------|-------------------|
| 0 | 0 | 0 | 0 | S1a | V _{OUTa} | S1b | V _{OUTb} |
| 0 | 0 | 0 | 1 | S2a | | S2b | |
| 0 | 0 | 1 | 0 | S3a | | S3b | |
| 0 | 0 | 1 | 1 | S4a | | S4b | |
| 0 | 1 | 0 | 0 | S5a | | S5b | |
| 0 | 1 | 0 | 1 | S6a | | S6b | |
| 0 | 1 | 1 | 0 | S7a | | S7b | |
| 0 | 1 | 1 | 1 | S8a | | S8b | |
| 1 | 0 | 0 | 0 | S9a | | S9b | |
| 1 | 0 | 0 | 1 | S10a | | S10b | |
| 1 | 0 | 1 | 0 | S11a | | S11b | |
| 1 | 0 | 1 | 1 | S12a | | S12b | |
| 1 | 1 | 0 | 0 | S13a | | S13b | |
| 1 | 1 | 0 | 1 | S14a | | S14b | |
| 1 | 1 | 1 | 0 | S15a | | S15b | |
| 1 | 1 | 1 | 1 | S16a | | S16b | |

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Figure 15: Submultiplexed 2 of 32 System. The Two IH5043s Are Overvoltage Protected By The IH5208s. Submultiplexing Reduces Output Capacitance and Leakage Currents.

NOTE All typical values have been characterized but are not tested.