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IH6216

# IH6216

## 8-Channel Differential CMOS Analog Multiplexer



T-51-11

### GENERAL DESCRIPTION

The IH6216 is a CMOS 2 of 16 multiplexer. The part is a plug-in replacement for the DG507. Three line binary decoding is used so that the 16 channels can be controlled in pairs by the binary inputs; additionally a fourth input is provided to use as a system enable. When the ENable input is high (5V) the channels are sequenced by the 3 line binary inputs, and when low (0V), all channels are off. The 3 Address inputs are controlled by TTL logic or CMOS logic elements with a "0" corresponding to any voltage less than 0.8V and a "1" corresponding to any voltage greater than 3.0V. Note that the ENable input must be taken to 5V to enable the system and less than 0.8V to disable the system.

### ORDERING INFORMATION

| Part Number | Temperature Range | Package            |
|-------------|-------------------|--------------------|
| IH6216MJ    | -55°C to +125°C   | 28 pin Cerdip      |
| IH6216CJ    | 0°C to 70°C       | 28 pin Cerdip      |
| IH6216CPI   | 0°C to 70°C       | 28 pin Plastic DIP |

Ceramic package available as special order only (IH6216MDI/CDI)

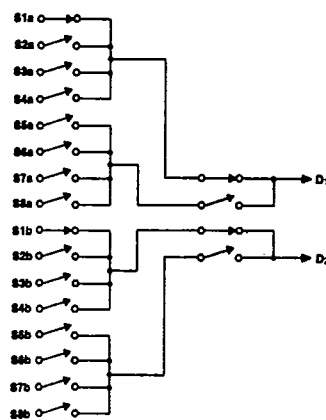
### FEATURES

- Pin Compatible With HI507, DG507A & AD7507
- $\pm 11V$  Analog Signal Range
- $r_{ps(on)} < 700$  Ohms Over Full Signal and Temperature Range
- Break-Before-Make Switching
- TTL and CMOS Compatible Address Control
- Binary Address Control (3 Address Inputs Control 2 Out of 16 Channels)
- Two Tier Submultiplexing to Facilitate Expandability
- Power Supply Quiescent Current Less Than 100  $\mu A$
- No SCR Latchup
- Very Low Leakage  $I_{D(OFF)} \leq 100pA$
- Internal Diode In Series With  $V^+$  for Fault Protection

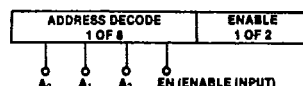
### DECODE TRUTH TABLE

| A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | EN | On Switch Pair |
|----------------|----------------|----------------|----|----------------|
| X              | X              | X              | 0  | NONE           |
| 0              | 0              | 0              | 1  | 1              |
| 0              | 0              | 1              | 1  | 2              |
| 0              | 1              | 0              | 1  | 3              |
| 0              | 1              | 1              | 1  | 4              |
| 1              | 0              | 0              | 1  | 5              |
| 1              | 0              | 1              | 1  | 6              |
| 1              | 1              | 0              | 1  | 7              |
| 1              | 1              | 1              | 1  | 8              |

LOGIC "1" =  $V_{AH} > 3V$   $V_{ENH} > 4.5V$   
 LOGIC "0" =  $V_{AL} < 0.8V$



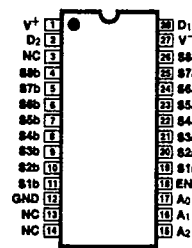
TO DECODE LOGIC  
CONTROLLING BOTH  
TIERS OF MIXING



3 LINE BINARY ADDRESS INPUTS  
(0 0 0) AND EN = 5V  
ABOVE EXAMPLE SHOWS CHANNELS 1a & 1b ON.

Figure 1: Functional Diagram

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TOP VIEW  
 $V^+$  COMMON TO SUBSTRATE

0301-2

Figure 2: Pin Configuration

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## ABSOLUTE MAXIMUM RATINGS

|                            |                |
|----------------------------|----------------|
| $V_{IN}$ (A, EN) to Ground | $-15V_0 - V_1$ |
| $V_S$ or $V_D$ to $V^+$    | 0, $-36V$      |
| $V_S$ or $V_D$ to $V^-$    | 0, $36V$       |
| $V^+$ to Ground            | $16V$          |
| $V^-$ to Ground            | $-16V$         |
| Current (Any Terminal)     | $30mA$         |

|                                     |                        |
|-------------------------------------|------------------------|
| Current (Analog Source or Drain)    | $20mA$                 |
| Operating Temperature               | $-55$ to $125^\circ C$ |
| Storage Temperature                 | $-65$ to $150^\circ C$ |
| Lead Temperature (Soldering, 10sec) | $300^\circ C$          |
| Power Dissipation (Package)*        | $1200mW$               |

\* All leads soldered or welded to PC board. Derate  $10mW/^\circ C$  above  $70^\circ C$ .

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

$V^+ = 15V$ ,  $V^- = -15V$ ,  $V_{EN} = +5V$  (Note 1), Ground =  $0V$ , unless otherwise specified.

| Characteristic        | Measured Terminal                                              | No Tests Per Temp | Typ 25°C | Test Conditions                                                                                      | Max Limits                                   |                      |       |          |      |      | Units |    |  |
|-----------------------|----------------------------------------------------------------|-------------------|----------|------------------------------------------------------------------------------------------------------|----------------------------------------------|----------------------|-------|----------|------|------|-------|----|--|
|                       |                                                                |                   |          |                                                                                                      | M Suffix                                     |                      |       | C Suffix |      |      |       |    |  |
|                       |                                                                |                   |          |                                                                                                      | -55°C                                        | 25°C                 | 125°C | 0°C      | 25°C | 70°C |       |    |  |
| SWITCH                |                                                                |                   |          |                                                                                                      |                                              |                      |       |          |      |      |       |    |  |
| r <sub>DS(ON)</sub>   | S to D                                                         | 16                | 480      | V <sub>D</sub> = -10V, I <sub>S</sub> = -1mA                                                         | Sequence each switch on                      | 600                  | 600   | 700      | 650  | 650  | 750   | Ω  |  |
|                       |                                                                | 16                | 300      | V <sub>D</sub> = -10V, I <sub>S</sub> = -1mA                                                         | V <sub>AL</sub> = 0.8V, V <sub>AH</sub> = 3V | 600                  | 600   | 700      | 650  | 650  | 750   |    |  |
| Δr <sub>DS(ON)</sub>  |                                                                |                   | 20       | Δr <sub>DS(on)</sub> = $\frac{r_{DS(on)max} - r_{DS(on)min}}{r_{DS(on)avg}}$ V <sub>S</sub> = ±10V   |                                              |                      |       |          |      |      |       | %  |  |
| I <sub>S(OFF)</sub>   | S                                                              | 16                | 0.01     | V <sub>S</sub> = 10V, V <sub>D</sub> = -10V                                                          | V <sub>EN</sub> = 0.8V                       |                      | ±5    | 50       |      | ±1   | 50    | nA |  |
|                       |                                                                | 16                | 0.01     | V <sub>S</sub> = -10V, V <sub>D</sub> = 10V                                                          |                                              |                      | ±5    | 50       |      | ±1   | 50    |    |  |
| I <sub>D(OFF)</sub>   | D                                                              | 2                 | 0.1      | V <sub>D</sub> = 10V, V <sub>S</sub> = -10V                                                          |                                              |                      | ±2    | 100      |      | ±5   | 100   |    |  |
|                       |                                                                | 2                 | 0.1      | V <sub>D</sub> = -10V, V <sub>S</sub> = 10V                                                          |                                              |                      | ±2    | 100      |      | ±5   | 100   |    |  |
| I <sub>D(ON)</sub>    | D                                                              | 16                | 0.1      | V <sub>S(ALL)</sub> = V <sub>D</sub> = 10V                                                           | Sequence each switch on                      |                      | ±2    | 100      |      | ±5   | 100   |    |  |
|                       |                                                                | 16                | 0.1      | V <sub>S(ALL)</sub> = V <sub>D</sub> = -10V                                                          | V <sub>AL</sub> = 0.8V, V <sub>AH</sub> = 3V |                      | ±2    | 100      |      | ±5   | 100   |    |  |
| INPUT                 |                                                                |                   |          |                                                                                                      |                                              |                      |       |          |      |      |       |    |  |
| I <sub>A(on)</sub> or |                                                                | 3                 | 0.01     | V <sub>A</sub> = 3.0V                                                                                |                                              |                      | -10   | -30      |      | -10  | -30   | μA |  |
| I <sub>A(off)</sub>   |                                                                | 3                 | 0.01     | V <sub>A</sub> = 14V                                                                                 |                                              |                      | 10    | 30       |      | 10   | 30    |    |  |
| I <sub>A</sub>        | A <sub>0</sub> A <sub>1</sub><br>A <sub>2</sub> A <sub>3</sub> | 3                 |          | V <sub>EN</sub> = 5V                                                                                 | All V <sub>A</sub> = 0                       |                      | -10   | -30      |      | -10  | -30   |    |  |
|                       | EN                                                             | 1                 |          | V <sub>EN</sub> = 0                                                                                  |                                              |                      | -10   | -30      |      | -10  | -30   |    |  |
| DYNAMIC               |                                                                |                   |          |                                                                                                      |                                              |                      |       |          |      |      |       |    |  |
| t <sub>trans</sub>    | D                                                              |                   | 0.6      | See Fig. 3                                                                                           |                                              | 1                    |       |          |      |      |       | μs |  |
| t <sub>open</sub>     | D                                                              |                   | 0.2      | See Fig. 4                                                                                           |                                              |                      |       |          |      |      |       |    |  |
| t <sub>on(EN)</sub>   | D                                                              |                   | 0.8      | See Fig. 5                                                                                           |                                              | 1.5                  |       |          |      |      |       |    |  |
| t <sub>off(EN)</sub>  | D                                                              |                   | 0.3      |                                                                                                      |                                              | 1                    |       |          |      |      |       |    |  |
| "OFF" Isolation       | D                                                              |                   | 60       | V <sub>EN</sub> = 0, R <sub>L</sub> = 200Ω, C <sub>L</sub> = 3pF, V <sub>S</sub> = 3VRMS, f = 500kHz |                                              |                      |       |          |      |      |       | dB |  |
| C <sub>s</sub>        | S                                                              |                   | 5        | V <sub>S</sub> = 0                                                                                   | V <sub>EN</sub> = 0, f = 140kHz to 1MHz      |                      |       |          |      |      |       | pF |  |
| C <sub>d(off)</sub>   | D                                                              |                   | 20       | V <sub>D</sub> = 0                                                                                   |                                              |                      |       |          |      |      |       |    |  |
| C <sub>ds</sub>       | D to S                                                         |                   | 1        | V <sub>S</sub> = 0, V <sub>D</sub> = 0                                                               |                                              |                      |       |          |      |      |       |    |  |
| SUPPLY                |                                                                |                   |          |                                                                                                      |                                              |                      |       |          |      |      |       |    |  |
| Supply                | +                                                              | V <sup>+</sup>    | 1        | 55                                                                                                   | All V <sub>A</sub> = 0 or 5V                 |                      | 200   |          |      | 1000 |       | μA |  |
| Current               | -                                                              | V <sup>-</sup>    | 1        | 2                                                                                                    |                                              | V <sub>EN</sub> = 5V |       | 100      |      |      | 1000  |    |  |
| Standby               | +                                                              | V <sup>+</sup>    | 1        | 1                                                                                                    |                                              | V <sub>EN</sub> = 0  |       | 100      |      |      | 1000  |    |  |
| Current               | -                                                              | V <sup>-</sup>    | 1        | 1                                                                                                    |                                              | V <sub>EN</sub> = 0  |       | 100      |      |      | 1000  |    |  |

NOTE 1: See Enable Input Strobing Levels, Section 1.

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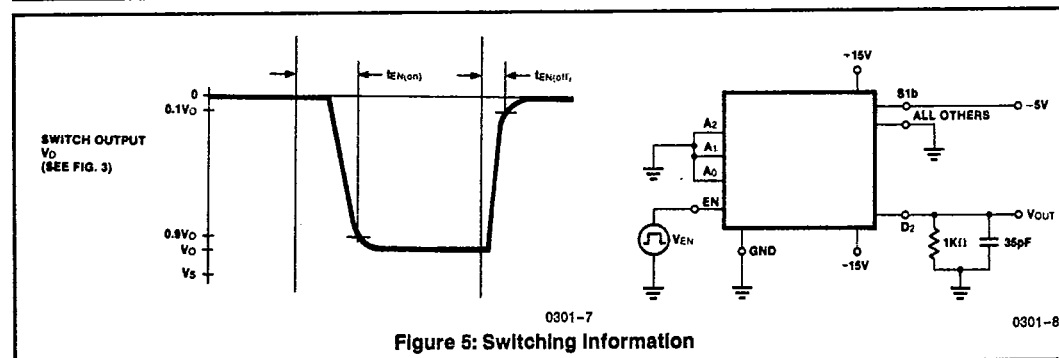
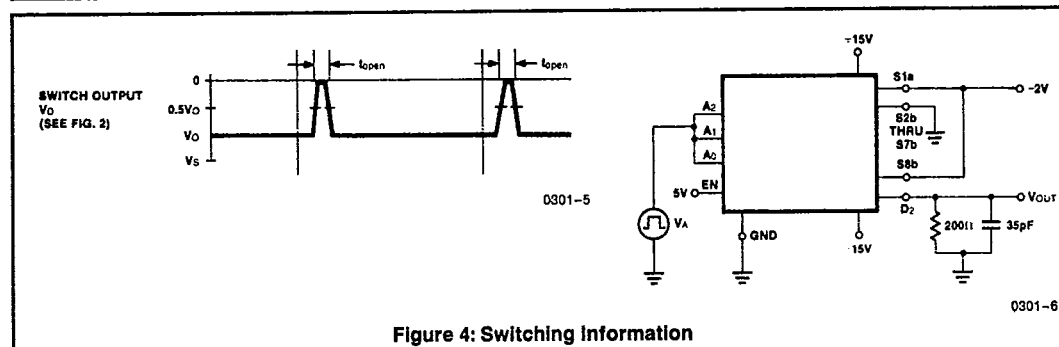
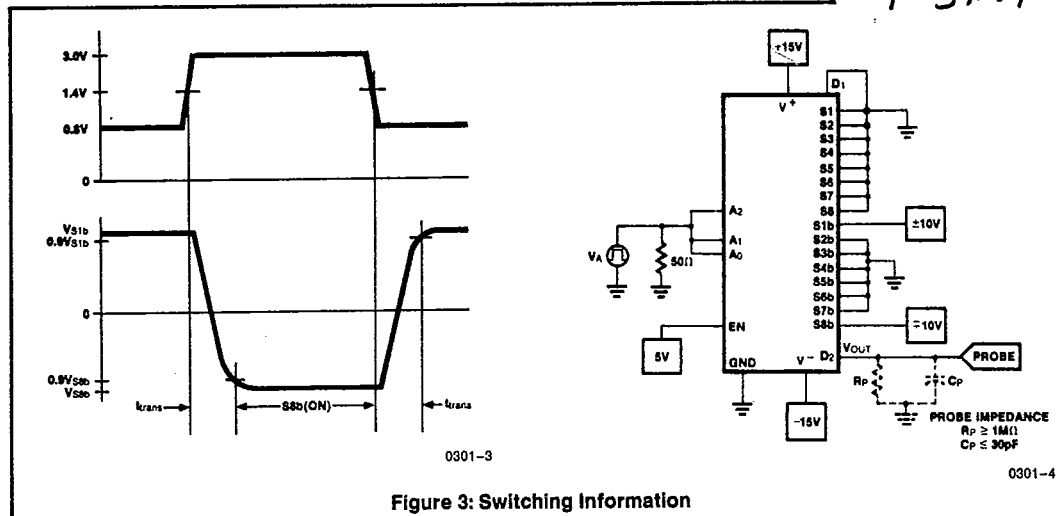
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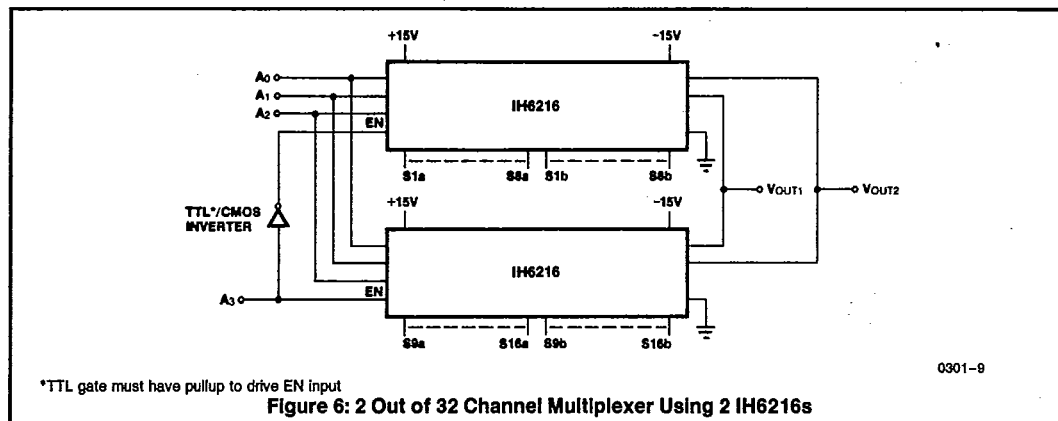
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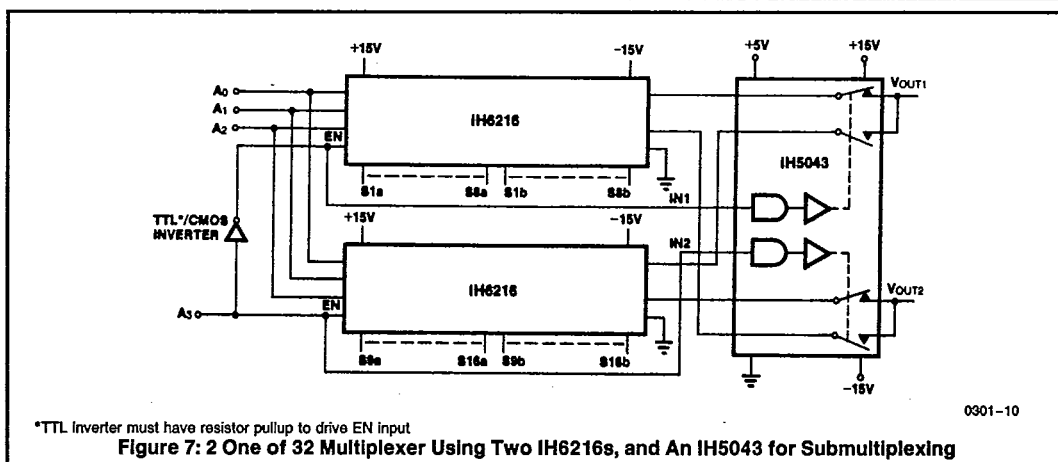
**IH6216 APPLICATIONS****Figure 6: 2 Out of 32 Channel Multiplexer Using 2 IH6216s****DECODE TRUTH TABLE**

| A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | On Switch |       |
|----------------|----------------|----------------|----------------|-----------|-------|
| 0              | 0              | 0              | 0              | S1a       | VOUT1 |
| 0              | 0              | 0              | 1              | S2a       |       |
| 0              | 0              | 1              | 0              | S3a       |       |
| 0              | 0              | 1              | 1              | S4a       |       |
| 0              | 1              | 0              | 0              | S5a       |       |
| 0              | 1              | 0              | 1              | S6a       |       |
| 0              | 1              | 1              | 0              | S7a       |       |
| 0              | 1              | 1              | 1              | S8a       |       |
| 1              | 0              | 0              | 0              | S9a       |       |
| 1              | 0              | 0              | 1              | S10a      |       |
| 1              | 0              | 1              | 0              | S11a      |       |
| 1              | 0              | 1              | 1              | S12a      |       |
| 1              | 1              | 0              | 0              | S13a      |       |
| 1              | 1              | 0              | 1              | S14a      |       |
| 1              | 1              | 1              | 0              | S15a      |       |
| 1              | 1              | 1              | 1              | S16a      |       |

**DECODE TRUTH TABLE**

| A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | On Switch |       |
|----------------|----------------|----------------|----------------|-----------|-------|
| 0              | 0              | 0              | 0              | S1b       | VOUT2 |
| 0              | 0              | 0              | 1              | S2b       |       |
| 0              | 0              | 1              | 0              | S3b       |       |
| 0              | 0              | 1              | 1              | S4b       |       |
| 0              | 1              | 0              | 0              | S5b       |       |
| 0              | 1              | 0              | 1              | S6b       |       |
| 0              | 1              | 1              | 0              | S7b       |       |
| 0              | 1              | 1              | 1              | S8b       |       |
| 1              | 0              | 0              | 0              | S9b       |       |
| 1              | 0              | 0              | 1              | S10b      |       |
| 1              | 0              | 1              | 0              | S11b      |       |
| 1              | 0              | 1              | 1              | S12b      |       |
| 1              | 1              | 0              | 0              | S13b      |       |
| 1              | 1              | 0              | 1              | S14b      |       |
| 1              | 1              | 1              | 0              | S15b      |       |
| 1              | 1              | 1              | 1              | S16b      |       |

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**Figure 7: 2 One of 32 Multiplexer Using Two IH6216s, and An IH5043 for Submultiplexing**

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**General note on expandability of IH6216**

The IH6216 is a two tier multiplexer, where 8 pairs of input channels are routed to a pair of outputs in blocks of 4. Each block of 4 input channels is routed to one common output channel, and thus the submultiplexed system looks like 4 blocks of 4 inputs routed to 4 different outputs with the 4 outputs tied in pairs. Thus 20 switches are needed to handle the 16 channels of information. The advantages of this are lower output capacitance and leakage than would be possible using a system with all 8 channels tied to one common output. Also the expandability into 2 out of 32, 64, 128, etc. is facilitated. Figures 6, 7, and 8 show how the IH6216 is expanded.

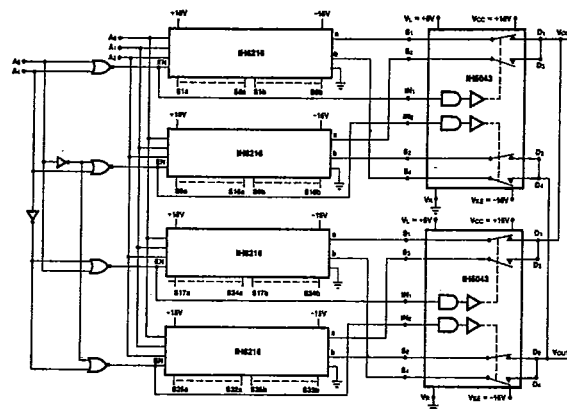
Figure 6 shows a 2 of 32 multiplexer, using 2 IH6216s. Since the 6216 is itself a 2 tier MUX, the system as shown is basically a 2 tier system. Corresponding output points of each of the 6216 are connected together, and the ENable input strobe is used as the  $A_3$  input. Since each output (pins 2 and 28) corresponds to an "ON" FET and an "OFF" FET, the overall system looks like 1 "ON" FET and 3 "OFF" FETs for each of the  $V_{out1}$  and  $V_{out2}$  outputs. Thus the output leakage will be  $1 I_{D(on)}$  plus 3  $I_{D(off)}$ s or about 0.4nA at room temperature. Throughput speed will be typically 0.8 $\mu$ s for  $t_{on}$  and 0.3 $\mu$ s for  $t_{off}$ , with throughput channel resistance in the 500 $\Omega$  area.

**DECODE TRUTH TABLE**

| $A_3$ | $A_2$ | $A_1$ | $A_0$ | On Switch |       |
|-------|-------|-------|-------|-----------|-------|
| 0     | 0     | 0     | 0     | S1a       | VOUT1 |
| 0     | 0     | 0     | 1     | S2a       |       |
| 0     | 0     | 1     | 0     | S3a       |       |
| 0     | 0     | 1     | 1     | S4a       |       |
| 0     | 1     | 0     | 0     | S5a       |       |
| 0     | 1     | 0     | 1     | S6a       |       |
| 0     | 1     | 1     | 0     | S7a       |       |
| 0     | 1     | 1     | 1     | S8a       |       |
| 1     | 0     | 0     | 0     | S9a       |       |
| 1     | 0     | 0     | 1     | S10a      |       |
| 1     | 0     | 1     | 0     | S11a      |       |
| 1     | 0     | 1     | 1     | S12a      |       |
| 1     | 1     | 0     | 0     | S13a      |       |
| 1     | 1     | 0     | 1     | S14a      |       |
| 1     | 1     | 1     | 0     | S15a      |       |
| 1     | 1     | 1     | 1     | S16a      |       |

**DECODE TRUTH TABLE**

| $A_3$ | $A_2$ | $A_1$ | $A_0$ | On Switch |       |
|-------|-------|-------|-------|-----------|-------|
| 0     | 0     | 0     | 0     | S1b       | VOUT2 |
| 0     | 0     | 0     | 1     | S2b       |       |
| 0     | 0     | 1     | 0     | S3b       |       |
| 0     | 0     | 1     | 1     | S4b       |       |
| 0     | 1     | 0     | 0     | S5b       |       |
| 0     | 1     | 0     | 1     | S6b       |       |
| 0     | 1     | 1     | 0     | S7b       |       |
| 0     | 1     | 1     | 1     | S8b       |       |
| 1     | 0     | 0     | 0     | S9b       |       |
| 1     | 0     | 0     | 1     | S10b      |       |
| 1     | 0     | 1     | 0     | S11b      |       |
| 1     | 0     | 1     | 1     | S12b      |       |
| 1     | 1     | 0     | 0     | S13b      |       |
| 1     | 1     | 0     | 1     | S14b      |       |
| 1     | 1     | 1     | 0     | S15b      |       |
| 1     | 1     | 1     | 1     | S16b      |       |

**Figure 8: 2 One of 64 Multiplexer Using 4 IH6216s and 2 IH5043s as Submultiplexers**

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Figure 7 shows the 2 of 32 MUX of Figure 6, with a third tier of submultiplexing added to further reduce leakage and output capacitance. The IH5043 has typical ON resistance of 50Ω (max. is 75Ω) so it only increases throughput channel resistance from the 500 ohms of Figure 6 to about 550 ohms for Figure 7. Throughput channel speed is a little slower by about 0.5μs for both ON and OFF time, and output leakage is about 0.2nA.

Figure 8 shows a 2 of 64 MUX using 3 tier MUXing (similar to Figure 7). The Intersil IH5043 is used for the third tier of MUXing. Each  $V_{out}$  point will see 3 OFF channels and 1 ON channel at anytime, so that the typical leakages will be about 0.4nA. Throughput channel resistance will be in the 550Ω area and throughput switching speeds about 1.3μs for ON time and 0.8μs for OFF time.

The IH5043 was chosen as the third tier of the MUX because it will switch the same AC signals as the IH6216 (typically plus and minus 15V) and uses break before make switching. Also power supply quiescent currents are typically 1-2μA so that no excessive system power is generated. Note that the logic of the 5043 is such that it can be tied directly to the ENable input (as shown in the figures) with no extra logic being required.

**Enable input strobing levels**

The ENable input acts as an enabling or disabling pin for the IH6216 when used as a 2 out of 16 channel MUX, however when expanding the MUX to more than 16 channels, the EN pin acts as another address input. Figures 6 and 7 show the EN pin used as the  $A_3$  input.

For the system to function properly the EN input (pin 18) must go to 5V  $\pm 5\%$  for the high state and less than 0.8V for the low state. When using TTL logic, a pull-up of 1kΩ or less resistor should be used to pull the output voltage up to 5V. When using CMOS logic, the high state goes to the power supply so no pull-up is required.

If used on high voltage logic supplies, EN should be at least 0.7V below  $V^+$  at all times. See IH6208 data sheet for details.

**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"
- R009** "Reduce CMOS Multiplexer Troubles Through Proper Device Selection"

**NOTE:** This multiplexer does not require external resistors and/or diodes to eliminate what is commonly known as a latch up or SCR action. Because of this fact, the  $r_{DS(ON)}$  of the switch is maintained at specified values.

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