Modular 16x1 Video Multiplexers

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APPLICATION NOTE

INTRODUCTION

There are several important considerations that must be addressed when designing high performance video switching systems. These include the ease of input/output signal tracking, the ease of multiplexer expansion in order to form large routing matrices, system crosstalk and the repeatability of system parameters from channel to channel.

The modular multiplexers described in this application note, take these, as well as other points, into consideration and provide an optimal solution for the video design engineer. The 16x1 circuits are realised using four Gennum GX434 or GX214, 4x1 crosspoint ICs and two CMOS logic control ICs.

FUNCTIONAL DESCRIPTION

Figure 1 is a functional block diagram of the 16x1 module. The four 4x1 crosspoint ICs are multiplexed to form the 16x1 circuit. On-board chip select logic and enable logic is combined with a 4 bit latch in order to provide positive crosspoint selection. When the ENABLE line is HIGH, all crosspoint devices are disabled, producing a high impedance tri-state output.

Crosspoint selection is achieved by applying the appropriate four bit data to the address inputs, A0 through A3 and pulsing the STROBE input. When the STROBE is held LOW, the latches are transparent and the address data flows directly to the crosspoint devices. In this manner, synchronous switching is achieved by using both the ENABLE and STROBE inputs.

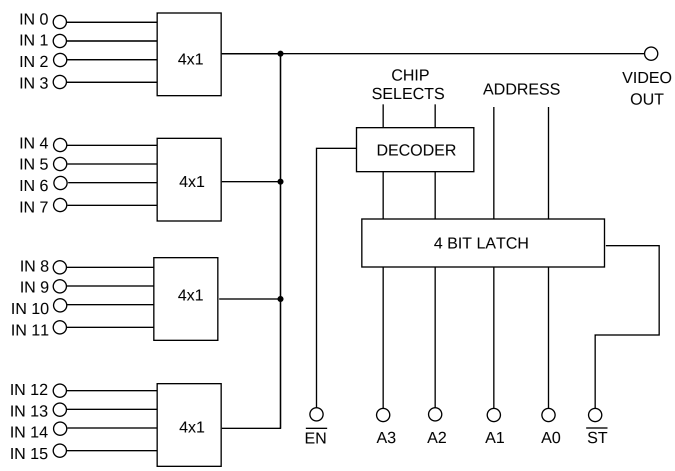

Fig. 1

CIRCUIT DESCRIPTION (see Figure 2, page 2)

1. CROSSPOINT DEVICES

Each GX434 or GX214 device, (IC1 through IC4) is a 4x1 video multiplexer having on-chip address decoding, and chip select logic. The unilateral signal path consists of emitter followers at the input and output with level shifting circuits in between. Extremely high off-isolation is achieved by internal clamping in the signal path. The input impedance at each buffered input is extremely high, allowing for multi-input bussing.

The inputs may be directly driven from cables if a terminating resistor, equal to the characteristic impedance of the cable is connected from the input to ground.

The output requires a high impedance load of at least 10 kΩ to maintain the high degree of differential gain and phase characteristic of the crosspoint devices. The use of any number of high performance video buffers will allow the module to drive low impedance loads.

The device data sheets are available from Gennum Corporation (order document number 510-38 for the GX434 devices and document number 510-55 for the GX214 devices). They fully describe the operation of the devices along with electrical characteristics and performance curves.

2. LOGIC DEVICES

IC5 is a 74HC139, 2 to 4 decoder, selecting which of the four crosspoint devices is to be enabled.

A logical LOW from the decoder outputs is applied to the appropriate CHIP-SELECT input on each device.

Address bits A2 and A3 control the decoder so that only one output goes low for any of the four address possibilities. Selection of the four crosspoint switches within each crosspoint device is determined by the two address bits A0 and A1.

An ENABLE input on the 74HC139 is used to disable the decoder inputs, resulting in all the outputs going to a logic HIGH state. This causes all the GX4 outputs to go to their high impedance state, effectively disabling the module, simplifying the multiplexing of additional modules.

All address bits are latched by IC6, an MC4042 4-bit latch. This device has a STROBE input which can either be positive or negative acting. The polarity is determined by the logic level on pin 6. In this circuit application, pin 6 is tied to ground resulting in the latching action occuring on the STROBE transition from LOW to HIGH.

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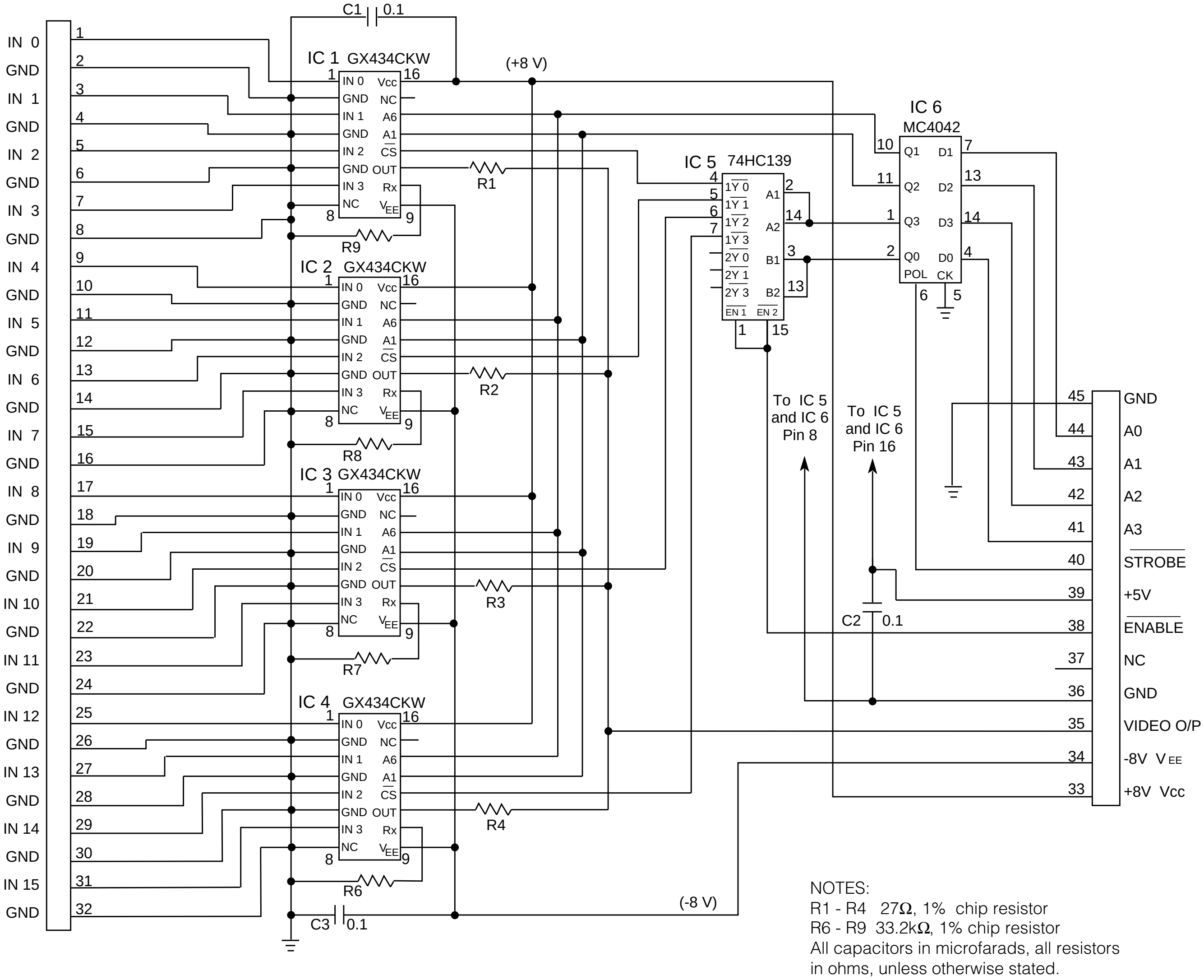


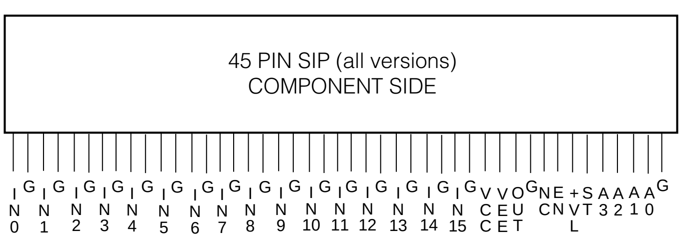
Fig. 2 16x1 Video Multiplexer Circuit

PIN CONNECTIONS

In designing this 16x1 video multiplexer, careful consideration was given to the assignment of pin connections. Figure 3 shows the resulting pin-outs. Each of the 16 inputs are separated by a ground pin in order to maintain a low degree of crosstalk.

The video output (pin 35), is separated from the inputs by the two crosspoint power supply pins. These supplies are normally ±8 V but can be as high as ±12 V.

The control logic inputs and the associated +5 V logic supply are all brought out at the opposite end of the video inputs. Inputs to other modules may be conveniently paralleled using this SIP format.



Key for Pin Connections

- IN = video input
- G = ground
- V_{CC} = positive supply voltage
- V_{EE} = negative supply voltage
- Out = video output
- NC = no connection
- V_L = logic supply voltage
- EN = enable
- ST = strobe
- A = address input

Fig. 3

MODULE OPERATION

The Truth Table shown in Figure 4 describes the operation of the module. A logic HIGH on the $\overline{\text{ENABLE}}$ input overrides all other control inputs, resulting in the module being disabled and the video output going to a high impedance state. Thus,other module outputs may be directly interconnected to form an expanded multiplexer such as a 32x1 etc.

When the module is enabled with a logic LOW on the $\overline{\text{ENABLE}}$ input, the output reflects the latched input selected by ADDRESS BITS A0 through A3 when the $\overline{\text{STROBE}}$ input is returned from a logic LOW to a logic HIGH. Since each video input is represented by a high impedance, several inputs may be bussed to form multi-input matrices. It is important in these situations to carefully layout the motherboard using sufficient groundplane.

The bussed inputs should be driven from a stable, low impedance buffer amplifier. In some cases a small-value series resistor at each video input will prevent unwanted RF oscillations.

EN	ST	A3	A2	A1	A0	O/P
1	X	X	X	X	X	HI - Z
0	0	0	0	0	0	IN 0
0	0	0	0	0	1	IN 1
0	0	0	0	1	0	IN 2
0	0	0	0	1	1	IN 3
0	0	0	1	0	0	IN 4
0	0	0	1	0	1	IN 5
0	0	0	1	1	0	IN 6
0	0	0	1	1	1	IN 7
0	0	1	0	0	0	IN 8
0	0	1	0	0	1	IN 9
0	0	1	0	1	0	IN 10
0	0	1	0	1	1	IN 11
0	0	1	1	0	0	IN 12
0	0	1	1	0	1	IN 13
0	0	1	1	1	0	IN 14
0	0	1	1	1	1	IN 15
0	↑	X	X	X	X	latch state

X = don't care

Fig. 4 Truth Table

PRINTED CIRCUIT BOARD AND CIRCUIT OPTIONS

The printed circuit board may be either 0.0625in. or 0.03125in. thick glass-epoxy, double sided material with one ounce copper. Figure 5 shows the traces on the two sides of the board. All components are surface mounted except for the 45 input/output pins. They are ‘finger’ type leadframes and are soldered to both the component and ‘copper’ side of the board. Figure 6 details the component placement. When the GX434 devices are used, resistors R6 through R9 are included to set up currents in the devices in order to match the signal path delays from chip to chip. They are not needed on the GX214 devices and are replaced by a short circuit.

R1 through R4 are used at the output of each GX434 in order to flatten the frequency response. The GX214 does not use these resistors and they are replaced by a short circuit as well.

This produces frequency peaking which is a characteristic ofthe crosspoint devices. In this case, the frequency response is flattened by using the roll-off characteristics of the external output buffer to compensate the natural peaking of the cross-points.

As well, R1 through R4 may be omitted on the GX 34 version and replaced with short circuits. Again this will result in frequency peaking but now at a high amplitude and at a higher frequency. This may be easily compensated, as before, by the external buffer but now producing an even wider bandwidth flat response.

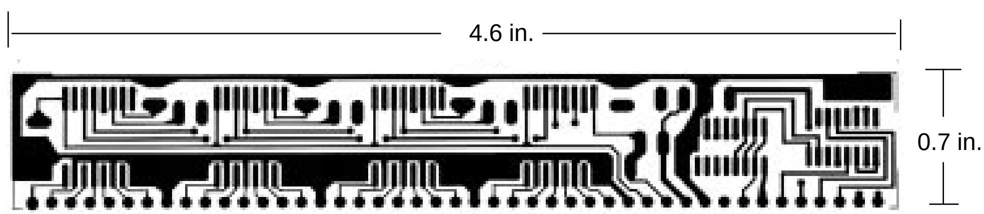


Fig. 5A COMPONENT SIDE

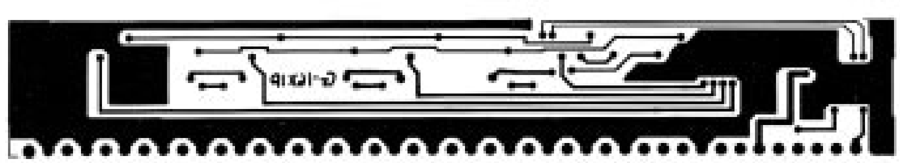


Fig. 5B COPPER SIDE

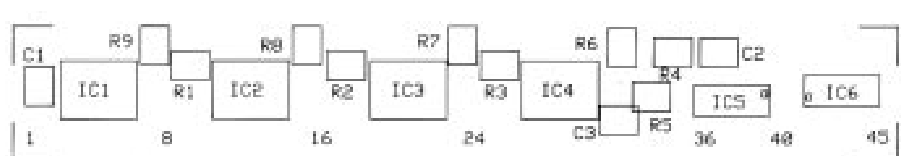


Fig. 6 COMPONENT LAYOUT

TESTING AND PERFORMANCE EVALUATION

Once the assembly of the modules is complete, the task of testing and evaluating the performance can be achieved using a suitable test jig.

The jig should itself be constructed using careful R.F. design techniques for the video signal paths. Suitable power supply decoupling capacitors should be used for each of the three supplies. Address selection can be made using toggle, DIP or decoded thumbwheel switches. Each one of the logic inputs requires a 10k Ω pull-up resistor.

Critical measurements of differential gain and phase can be done using a wideband network analyser such as the Hewlett Packard 4195A. A video vectorscope can also be used but will result in a less accuate measurement.

As far as the frequency response is concerned, the network analyser can be used to produce extremely accurate results. The advantage of using a network analyser such as the 4195A is that a hardcopy plot may be obtained for any measurement made. Also, the measurement set-up data can be stored for repeated tests.

Figure 7 shows the circuit of the test jig used in the lab at Gennum.

The buffer amplifier shown is a CLC410 video driver. Other amplifiers, such as the Elantec EL2030 as well as the VTC VA708 have been used and have given similar results. (It should be remembered that the signal path is initially normalised before measurements are taken with the network analyser).

In order to measure off-isolation and all hostile crosstalk, of the module itself, the inputs must be extremely well shielded and careful attention must be paid to lead dress. When using the network analyser, the measurements involve applying a +15 dBm signal to the OFF switch in order to maintain the noise floor below 100 dB. This level must be reduced to -20 dBm for tests on ON switches.

The following graphs are typical results obtained from measuring 15 engineering prototypes. Both the GX434 and GX214 modules were tested using the same jig. The GX214 version requires an external 1500 resistor from the Video O/P to V_{EE}.

Note: This current source is internal on the GX434 devices. Also, the 1500 Ω resistor (R5) can be mounted as a chip resistor on the GX214 module itself if no other modules, with their own resistors, are to be paralleled.

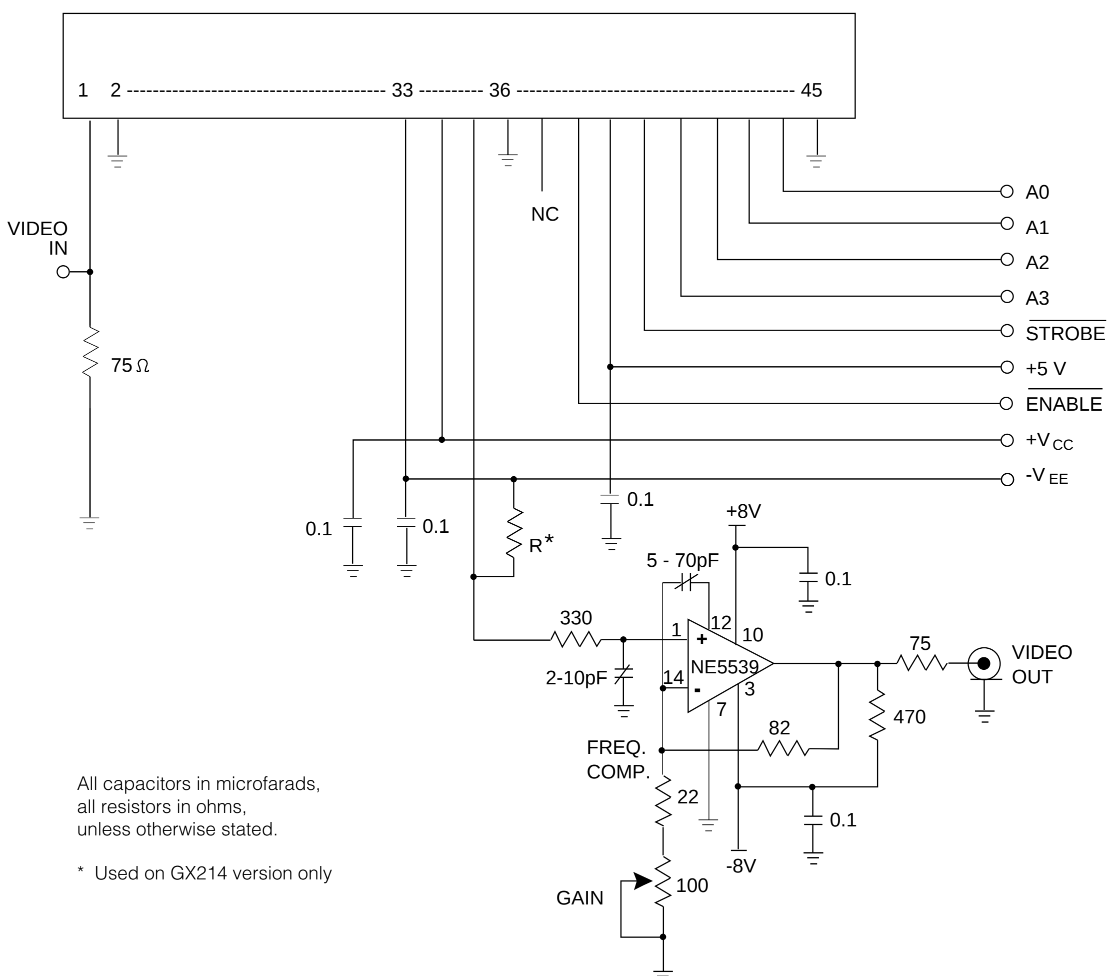


Fig. 7 Test Jig Circuit

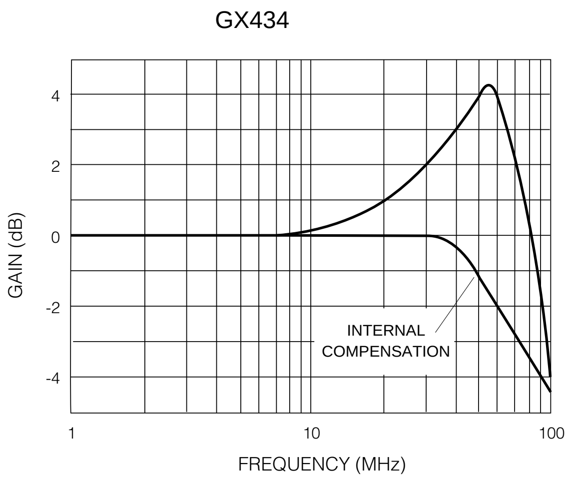


Fig. 8A Frequency Response

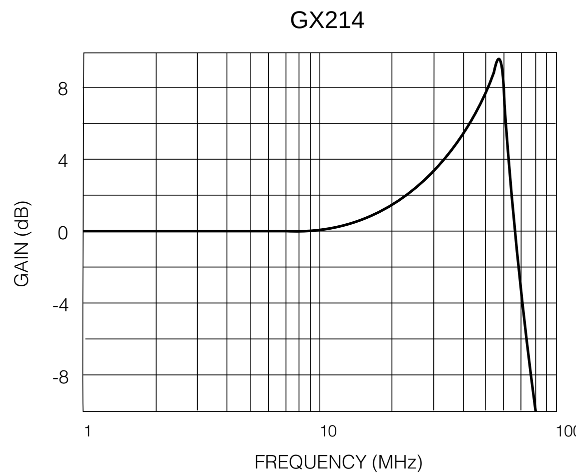


Fig. 8B Frequency Response

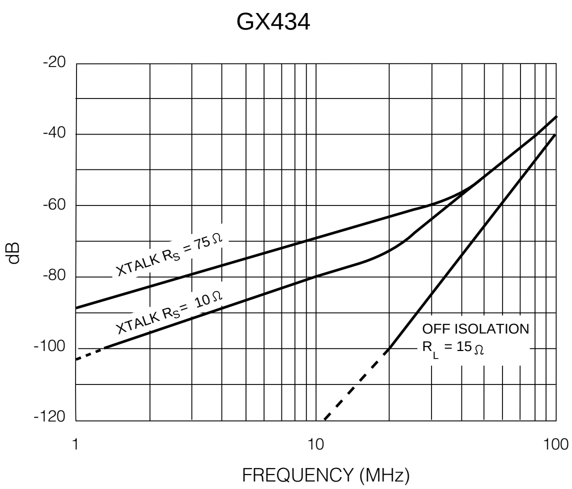


Fig. 8C Off-isolation and All Hostile Crosstalk

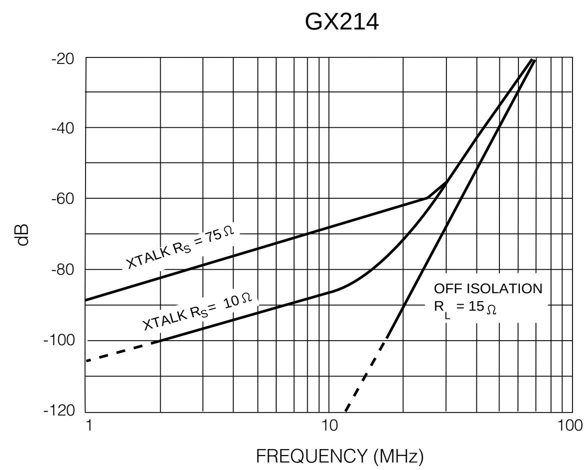


Fig. 8D Off-isolation and All Hostile Crosstalk

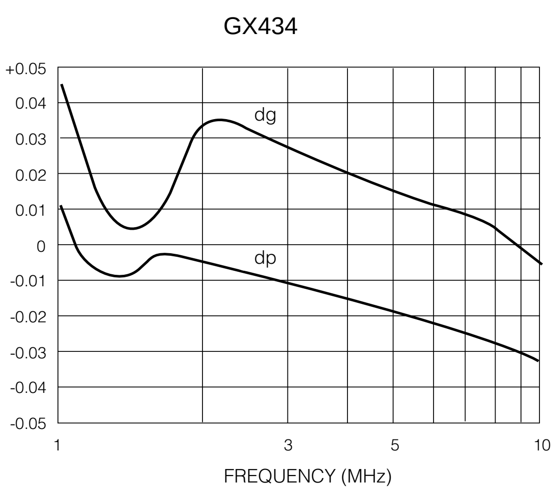


Fig. 8E Differential Gain and Phase

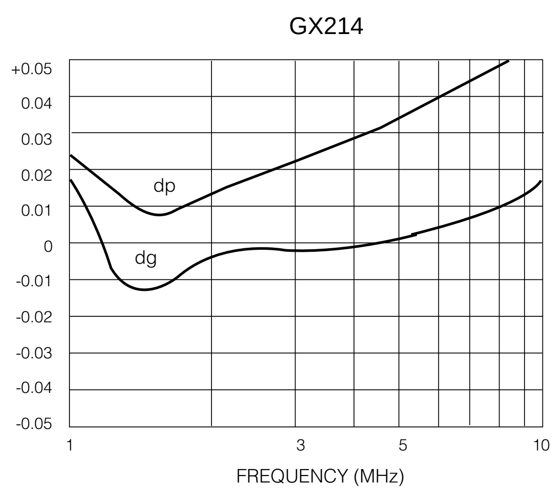


Fig. 8F Differential Gain and Phase

Fig. 8 Typical Test Results for the GX434 and GX214 Modular 16x1 Multiplexer

APPLICATION CIRCUITS AND INFORMATION

A basic 16x1 video multiplexer can be implemented using a circuit similar to the test jig shown in Figure 7. Figures 9 , 10 and 11 show circuits of the three different output buffers used to evaluate the module. All of them have good differential gain and phase performance combined with a wide flat bandwidth. The gain of each amplifier was set to +6 dB in order to compensate for the loss through the combination of the 75 Ω back matching resistor and the75 Ω load.

In this 16x1 application, each VIDEO INPUT must be tied to ground with a low value resistance, usually equal to the characteristic impedance of the input cable from the connector back plane. In this case the video can be either AC or DC coupled.

In many applications however, DC restoration takes place before the signal goes into the crosspoint switch.

The DC restorer quite often has an op-amp at its output. This amplifier can be tied directly to the VIDEO INPUT pin of the module without using a terminating resistor.

A word of caution must be said at this point. The internal circuitry of the GX434 limits the useful input signal excursions. In a positive direction, the maximum voltage should not exceed +2 V and the negative excursion should not exceed -1.2 volts. The device specifications indicate that the absolute maximum limits are +2.4 and -4 volts. It is important then, to never allow the output of any driver stage to exceed these limits. This may occur if one of the power supplies feeding the amplifier, fails. It is recommended that some form of clamping or protection is considered in these applications

The situation for the GX214 devices is not as critical since the maximum positive signal excursion is +5 V. The maximum negative excursion remains the same.

One solution is to clamp the video at the output rather than at the input. The variation in DC offset from one crosspoint to another in the module is only ±7 mV, centred around +7 mV for the GX434 version.

The DC offset for the GX214 module is much wider, ranging from -45 to -120 mV. Thus, output DC clamping is imperative.

Since the VIDEO OUTPUT from the modules is high impedance when the module is disabled, it is very easy to connect one output to another to form a wider, n x1 multiplexer.

Figure 12 shows a 32 x1 set-up using two modules. A few points are worth mentioning when multiplexing additional modules.

The typical output capacitance of the GX434 module is 60 pF. The same parameter for the GX214 module is 48 pF. Therefore, any additional module connected to the output bus will add the amount of capacitance mentioned.

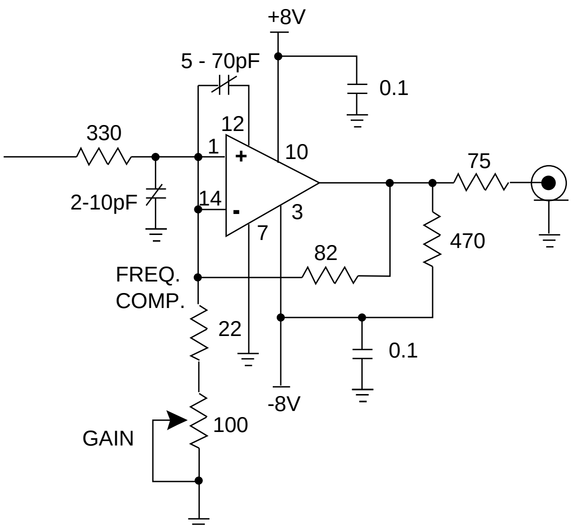


Fig. 9 NE5539 Buffer Amplifier Circuit

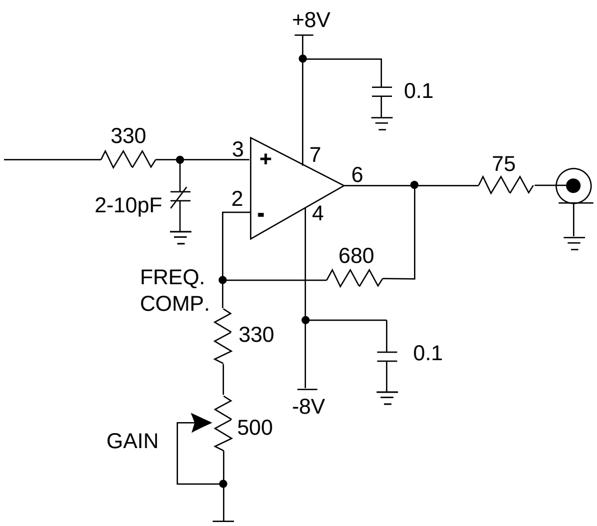


Fig. 10 EL2030 Buffer Amplifier Circuit

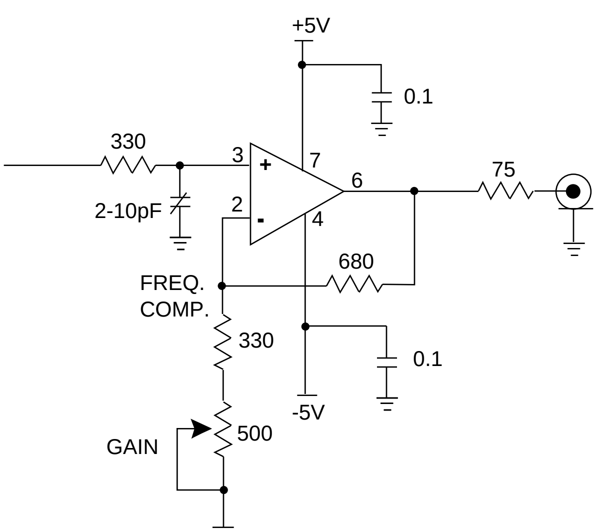


Fig. 11 VA708 Buffer Amplifier Circuit

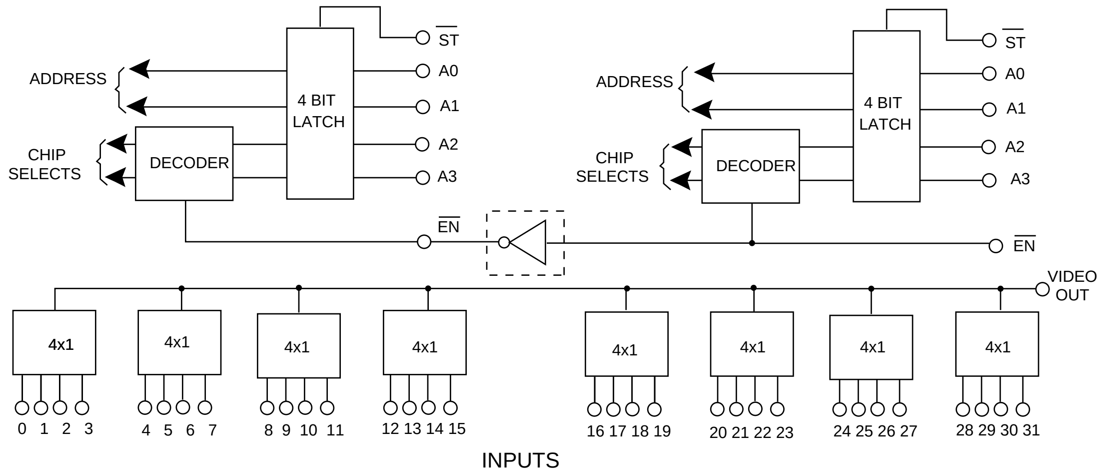


Fig. 12   32x1 Multiplexer using Two Modules

Since the amount of peaking in an emitter-follower is affected by the load capacitance, any other modules on the output will alter the new system frequency response. If no on-board frequency peaking compensation is included on the modules, then the final frequency response can still be tailored by the roll-off frequency response of the output amplifier.

For the compensated GX434 module, this cannot be done. The 27 Ω on-board resistors that were used at the output of each GX434 device, were chosen to flatten the response while the module was driving a high impedance buffer amplifier with virtually no input capacitance.

Now, however, if an extra 60 pF is connected to the output, the response will roll-off at a much lower frequency. It is recommeneded that the on-board resistors be removed from the GX434 module when it is to be used as part of a wider nx1 multiplexer system.

On the other hand, when the modules are to be used in a 16 x n matricies, the above problem does not occur because each output is from only one module. The only problems that may occur for wide-input matricies are, the possibility of instability due to poor input driver performance, or, long input cable or lead lengths.

As mentioned before, this problem can usually be over-come by adding a small series resistor (100 Ω max.) as close as possible to each input.

The convenient SIP pin-outs on the module mean that all inputs can be easily paralleled from one module to another. As long as sufficient groundplane is provided along the input bus paths, these modules may be used in wide input/output matricies. A practical example would be a 16 x16 system.

In this case, module selection would be controlled from a microprocessor using the $\overline{\text{ENABLE}}$ and $\overline{\text{STROBE}}$ inputs with appropriate buffering and data latching.

It is possible with the modules described, to produce a 16 x16 router core with dimensions. of only 5 x 7 inches, excluding input/output buffers and logic.

CONCLUSIONS

The modules described in this application note can be used as stand-alone multiplexers for both broadcast and CCTV applications. In addition, by virtue of their size, performance and SIP pin outs, they may be used to form larger n x m, professional video matrices.

Additional information on the various crosspoint products manufactured by Gennum Corporation maybe obtained from the Application Engineer of the Video and Broadcast Products Group.

References

GENNUM Data Sheets:

GX434: Document No. 510-38

GX214: Document No. 510-55

GENNUM Application Notes:

Frequency Peaking Compensation:

Document No. 510-39

16 x 1 Video Crosspoint EvaluationBoard;

Document No. 510-48

Other Data Sheets:

EL2030: Elantec Incorporated

VA708: VTC Corporation

NE5539: Signetics Corporation.