HDTV 8x1 and 10x1 Modular Multiplexers

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APPLICATION NOTE

INTRODUCTION

High definition TV places additional requirements on crosspoint performance in video switching systems. These include a wider flat frequency response and better high frequency off–isolation and crosstalk performance. In larger routing matrices, such considerations as ease of I/O connections, expandability and repeatability of system parameters fromchannel to channel, become even more important.

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 multiplexers are realised using Gennum's GX4201 wideband 1x1 crosspoint IC.

FUNCTIONAL DESCRIPTION

Figures 1 and 2 are functional block diagrams of the 8x1 and 10x1 modules. In both cases, the 1x1 crosspoint ICs are multiplexed to form the desired circuit configuration.

On the 8x1 version, a single CMOS device performs 3 to 8 line decoding as well as latching using a $\overline{\text{STROBE}}$ input. The $\overline{\text{ENABLE}}$ input allows the entire module to be selected or disabled in order to facilitate the multiplexing of other modules.

The 10x1 module uses a single BCD-to-decimal decoder for crosspoint selection. By applying a binary code greater than 1 0 0 1 (9), all crosspoint devices can be turned off. This as in the 8x1 module, effectively turns off all crosspoints. Both modules use ±5 V supplies for the crosspoints. The logic ICs require +5 V only.

CIRCUIT DESCRIPTION

CROSSPOINT DEVICES (see Figures 3 and 4)

Each GX4201 device is a 1x1 video crosspoint characterised by a low distortion, unilateral signal path consisting of emitter followers at the input and output with level shifting circuits in between.

Extemely high off-isolation in the order of 80 dB at 100 MHz is achieved by internal clamping in the signal path. The input impedance is extremely high and constant, allowing for multi-input bussing.

The input may be directly driven from cables if a terminating resistor, equal to the characteristic impedance of the cable, is connected from 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 device data sheet is available from Gennum corporation by ordering document number 510-74. It fully describes the operation of the device along with electrical characteristics and performance curves.

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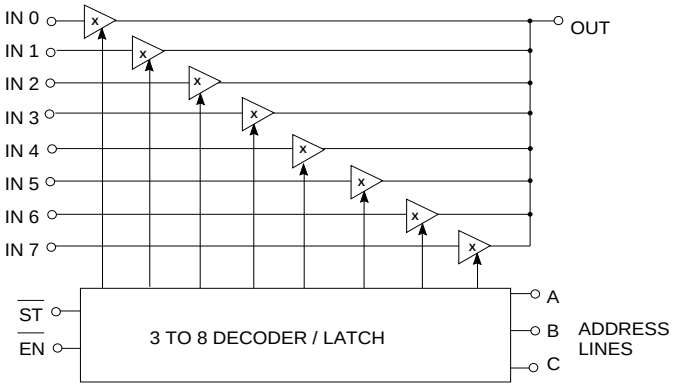


Fig. 1

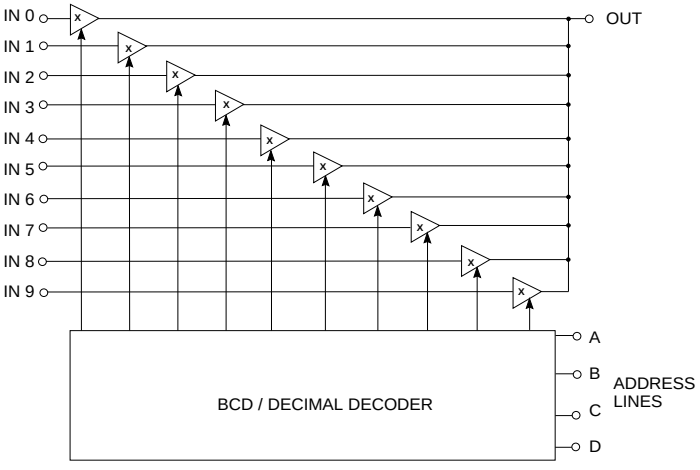
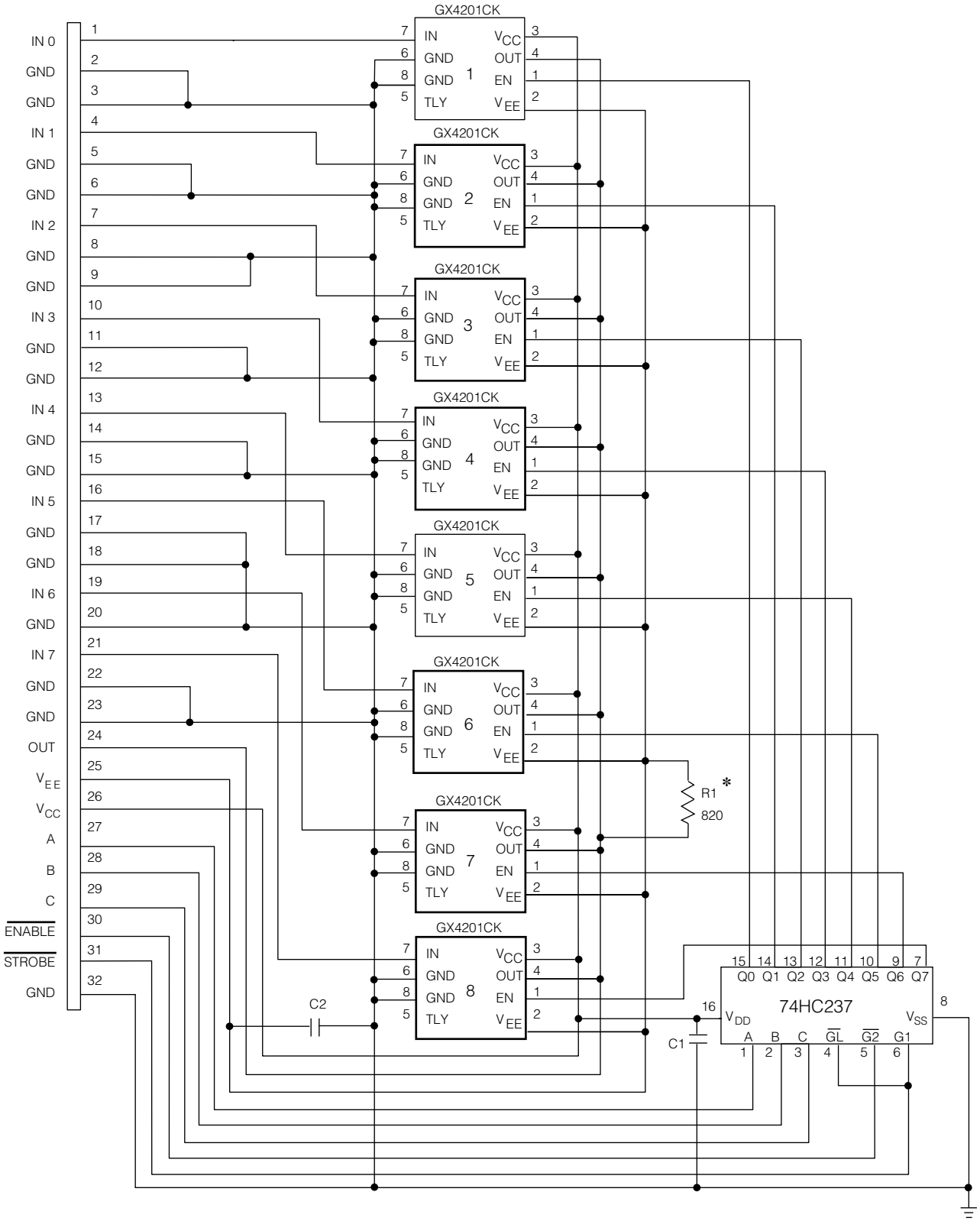


Fig. 2

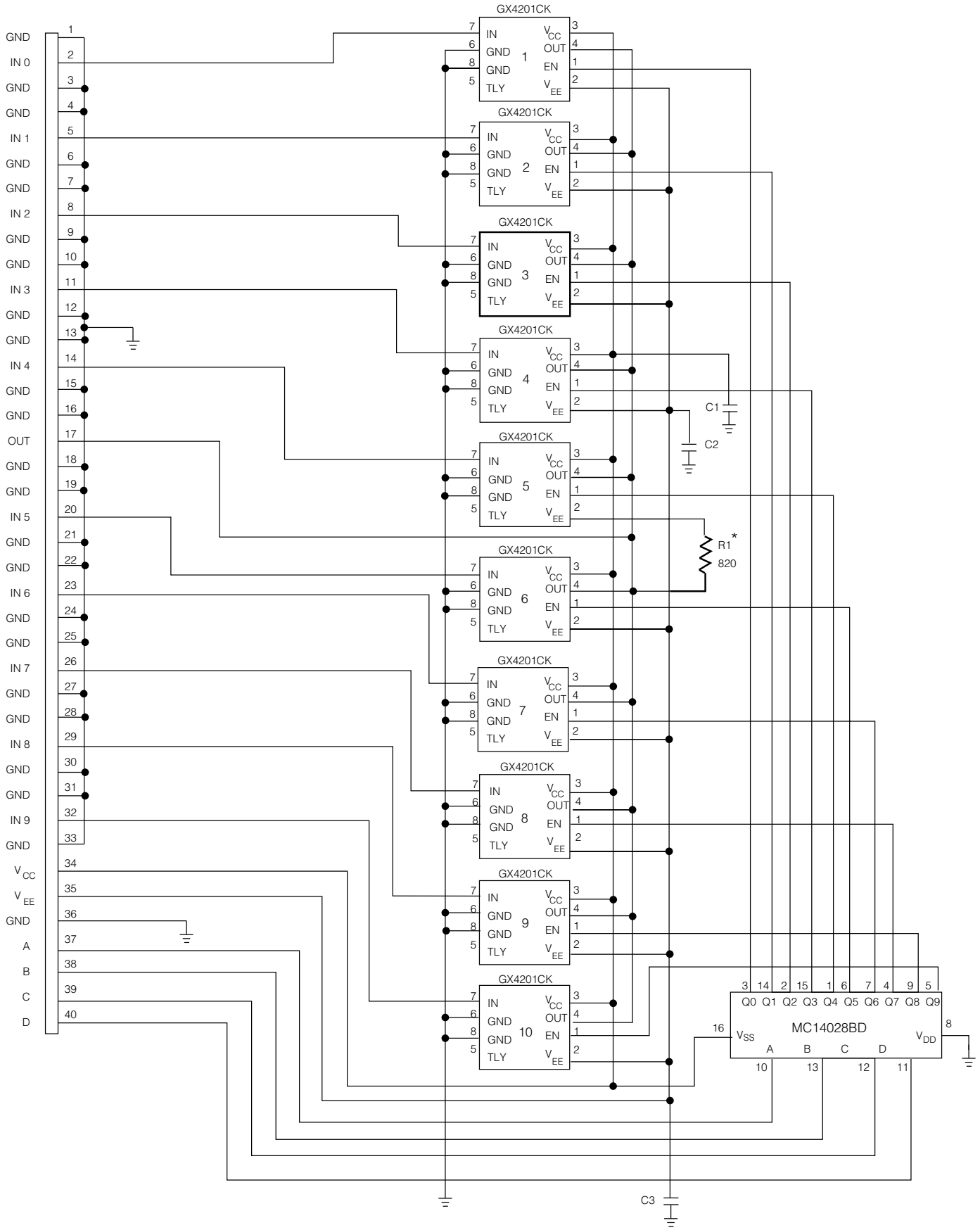
Revision Date: January 1994.



Unless otherwise shown, all capacitors are chip type, 0.1µF / 50 V, all resistors in ohms.

* This resistor may be external or an external 6mA current source may be used.

Fig. 3 8x1 Multiplexer Module



Unless otherwise shown, all capacitors are chip type, 0.1µF / 50 V, all resistors in ohms.

* This resistor may be external or an external 6mA current source may be used.

Fig. 4 10x1 Multiplexer Module

LOGIC DEVICES

The 8x1 module uses a CMOS 74HC237 combination 3 to 8 decoder/latch for crosspoint selection, the 10x1 module uses a Motorola MC14028B BCD-to-decimal decoder.

Figure 3 shows the eight GX4201 devices with their outputs tied together effectively forming an 8x1 multiplexer. Pin 1 of each device is an ENABLE input requiring a logic HIGH level in order to turn on the crosspoint. The logic level is provided by the 74HC237 device.

Address A, B and C control the decoder so that only one output goes HIGH for any of the eight address possibilities.

An $\overline{\text{ENABLE}}$ input on the 74HC237 is used to disable the decoder inputs resulting in all the outputs going to a logic LOW state. This causes all the GX4201 outputs to go to their high impedance state, effectively disabling the module, simplifying the multiplexing of additional modules.

All address bits are internally latched by the 74HC237. The $\overline{\text{STROBE}}$ input is used as the clock for the latches and operates on the transition from logic LOW to HIGH.

An 820 Ω resistor is connected from the negative power supply rail to the output. This is a current source for the GX4201 devices.

Video is applied to pin 7 of each crosspoint. The adjacent pins are connected to ground in order to maintain a high degree of channel to channel isolation. The output of each device (pin 4) is connected to the corresponding output of the other seven switches.

Both positive and negative supply voltages are routed to each device. Capacitors C1, C2 and C3 function as supply rail decoupling capacitors.

The 10x1 circuit, Figure 4, is very similar to the 8x1circuit. In this case, two additional GX4201 crosspoint devices have been added and the decoding function is performed by the MC14028B. Address bits A,B,C and D are used for crosspoint selection. As in the 8x1 circuit, the functions of the 820 Ω resistor and the 3 capacitors are identical.

PIN CONNECTIONS

In designing these video multiplexers, careful consideration was given to assignment of pin connections. Figures 5 and 6 show the resulting pin outs.

Ground pins separate each video input, and the video inputs are situated to one end and in the middle of each module. It is therefore, straightforward to parallel additional module inputs.

The video output pin on the 10x1 module is separated from any input by two ground pins. Furthermore, the output is brought out midway between the inputs to maintain somewhat equal signal path lengths.

All power supply and logic functions are brought out at one end of each module. This allows for simplified multiplexing of additional modules.

MODULE OPERATION

The Truth Tables shown in Figures 7 and 8 describe the operation of the modules.

B	C	A	$\overline{\text{EN}}$	$\overline{\text{ST}}$	OUT
X	X	X	1	X	HI - Z
X	X	X	X	0	HI - Z
0	0	0	0	↓	IN 0
0	0	1	0	↓	IN 1
0	1	0	0	↓	IN 2
0	1	1	0	↓	IN 3
1	0	0	0	↓	IN 4
1	0	1	0	↓	IN 5
1	1	0	0	↓	IN 6
1	1	1	0	↓	IN 7

X DON'T CARE

Fig. 7

D	C	B	A	OUT
0	0	0	0	IN 0
0	0	0	1	IN 1
0	0	1	0	IN 2
0	0	1	1	IN 3
0	1	0	0	IN 4
0	1	0	1	IN 5
0	1	1	0	IN 6
0	1	1	1	IN 7
1	0	0	0	IN 8
1	0	0	1	IN 9
1	0	1	0	HI - Z
1	0	1	1	HI - Z
1	1	0	0	HI - Z
1	1	0	1	HI - Z
1	1	1	0	HI - Z
1	1	1	1	HI - Z

Fig. 8

Fig. 5

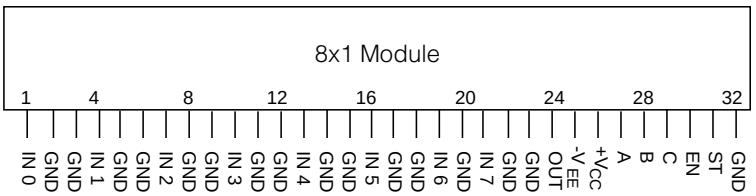
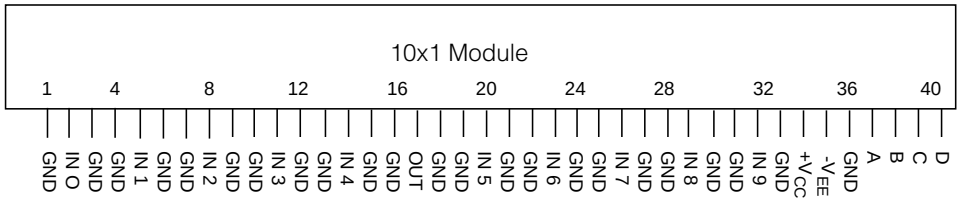


Fig. 6



For the 8x1 version, the module is enabled with a logic LOW on the ENABLE input, the output reflects the latched input selected by ADDRESS BITS A, B and C when the STROBE input is returned from a logic LOW to a logic HIGH.

In the 10x1 version, there is no latching and the module is disabled by applying a binary code greater than 9 to the address inputs A, B, C and D.

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 follow careful motherboard layout, as well as use ample groundplane.

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

PRINTED CIRCUIT BOARDS

The printed circuit boards are 0.03125 inch glass epoxy, double-sided material with one ounce copper.

All components are surface mounted except for the input/ output pins, which are 'finger' type leadframes and are soldered to both the component and 'copper' side of the board.

Fig. 9 Component Side 8x1

Fig. 10 Copper Side 8x1

NOTE;
All layouts are shown in actual size.

Fig. 11 Component Layout 8x1

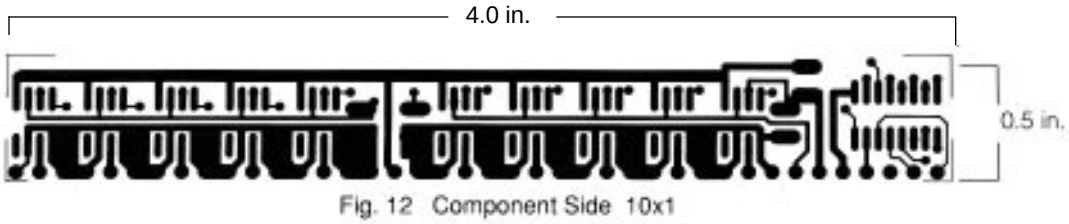


Fig. 12 Component Side 10x1

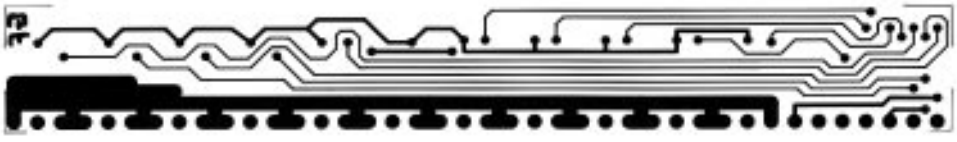


Fig. 13 Copper Side 10x1

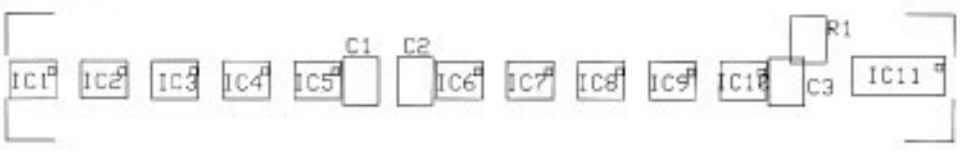


Fig. 14 Component Layout 10x1

TESTING PERFORMANCE

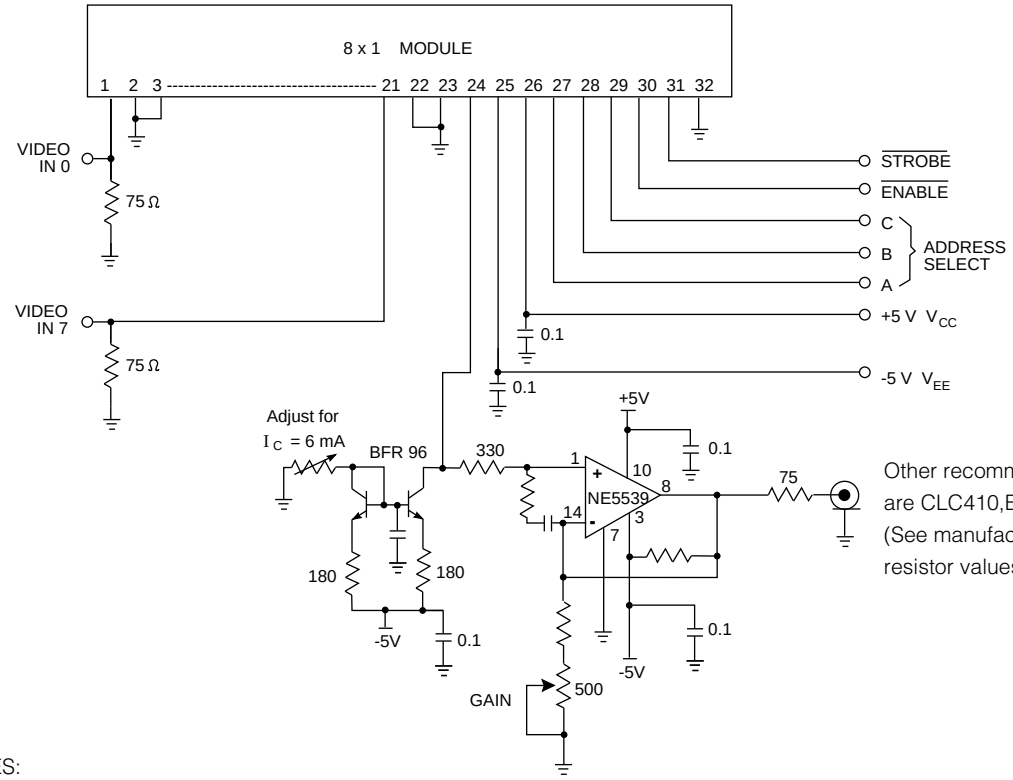
Once the assembly of the modules is complete, the task of testing and evaluating the performance can be achieved using a suitable test jig.

The jig itself should 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 10 kΩ pull-up resistor.

The two test jigs used are shown in Figures 15 and 16.

Critical measuements of differential gain and phase can be taken using a wideband network analyser such as the Hewlett-Packard 4195A. A video vectorscope can also be used but will result in a less accurate 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.



Other recommended amplifiers are CLC410,EL2030 (See manufacturer's data sheets for resistor values).

NOTES:

1. All logic inputs require a 10 kΩ pull-up resistor.
2. The BFR 96 current source circuit may be replaced with an 820 Ω resistor to V_{EE}. This will result in a slight increase in insertion loss.
3. All capacitors are chip type, 0.1 μF/50 V.

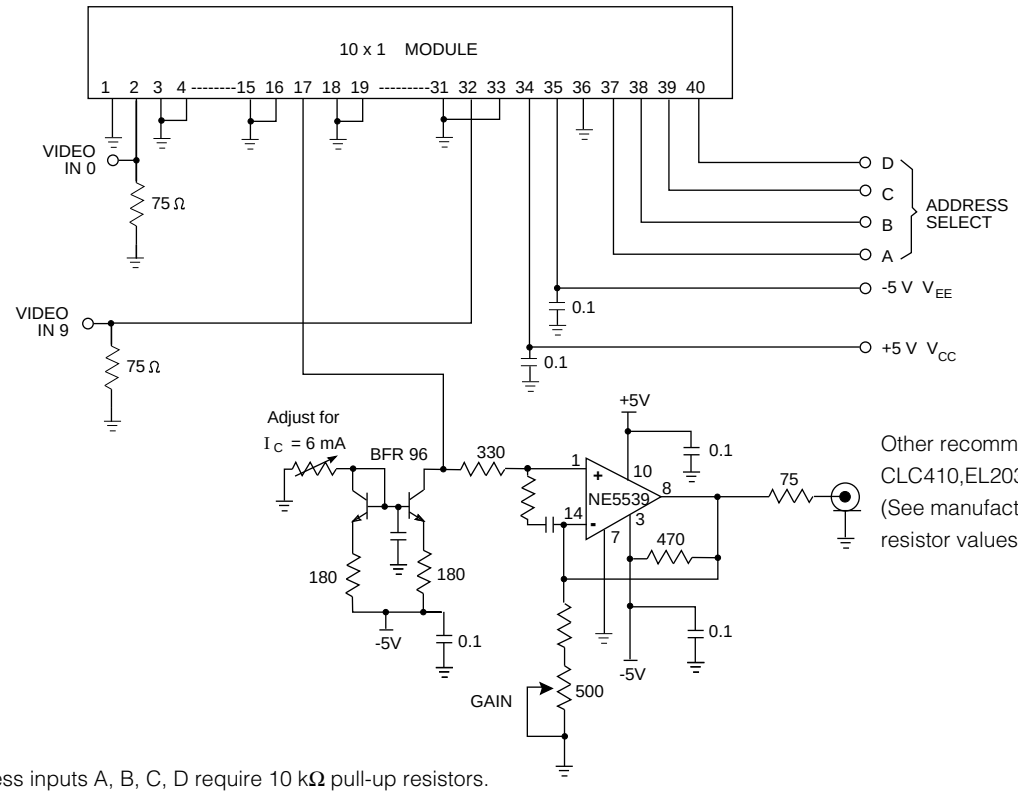
Fig. 15 Test Jig 8x1

The buffer amplifier shown is an NE5539 ultra wideband operational amplifier. Other amplifiers such as the Elantec EL2030 and the Comlinear CLC110 unity gain buffer and the CL410 video output buffer gave similar results. (It should be remembered that the signal path without the modules is initially normalised before any measurements are taken with the network analyser).

Where this is not the case, the amplifier should be adjusted to have a flat frequency response, to at least 100 MHz.

In order to measure off-isolation and all-hostile crosstalk, of the modules themselves, the inputs must be extremely well shielded and careful attention must be paid to the 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.

Figure 17a through 17f show typical results obtained using the test jigs described here.



Other recommended amplifiers are CLC410,EL2030 (See manufacturer's data sheets for resistor values).

NOTES:

1. Address inputs A, B, C, D require 10 kΩ pull-up resistors.
2. The BFR 96 current source circuit may be replaced with an 820 Ω resistor to V_{EE}. This will result in a slight increase in insertion loss.
3. All capacitors are chip type, 0.1 µF/50 V.

Fig. 16 Test Jig 10x1

Typical Test Results for the 8x1 and 10x1 Modular Multiplexers

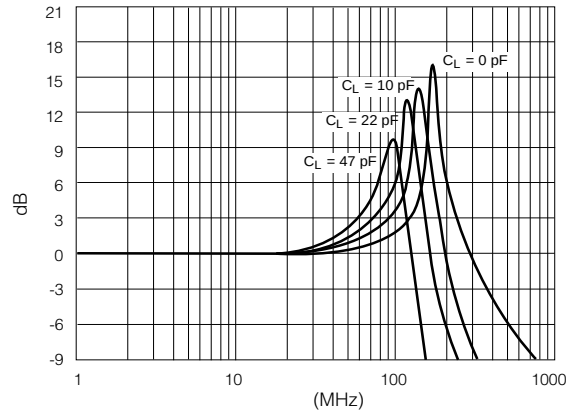


Fig. 17a Frequency Response 8x1

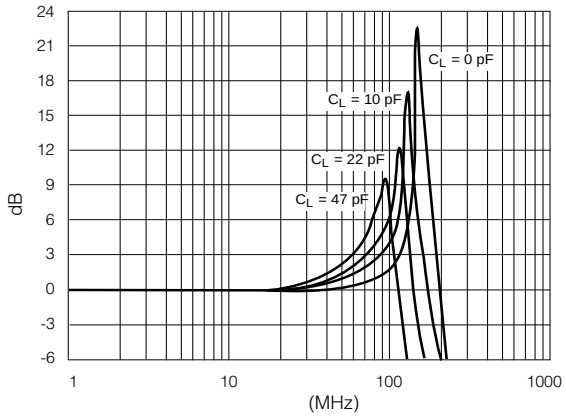


Fig. 17b Frequency Response 10x1

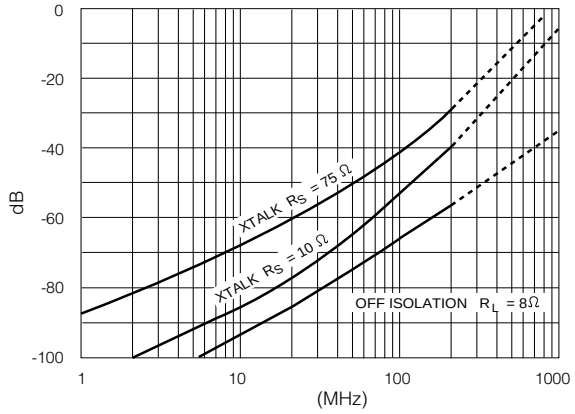


Fig. 17c Off-isolation and All Hostile Crosstalk 8x1

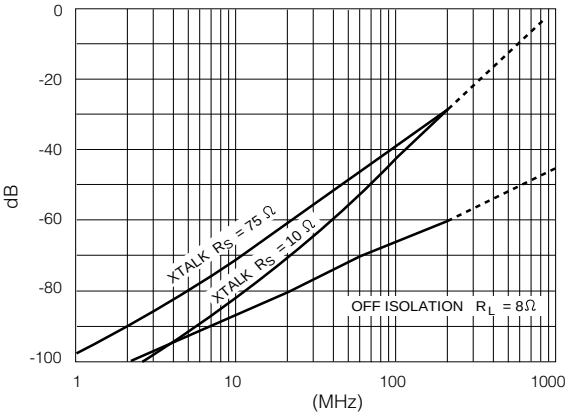


Fig. 17d Off-isolation and All Hostile Crosstalk 10x1

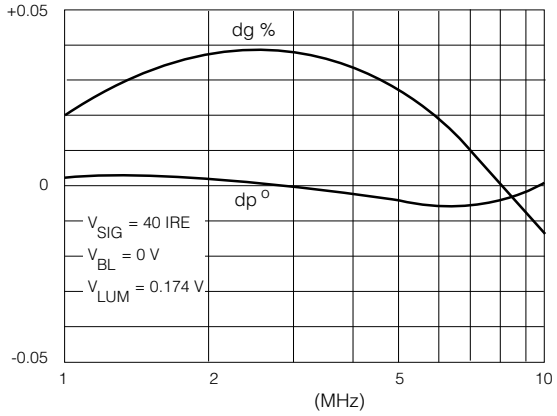


Fig.17e dg / dp vs frequency 8x1

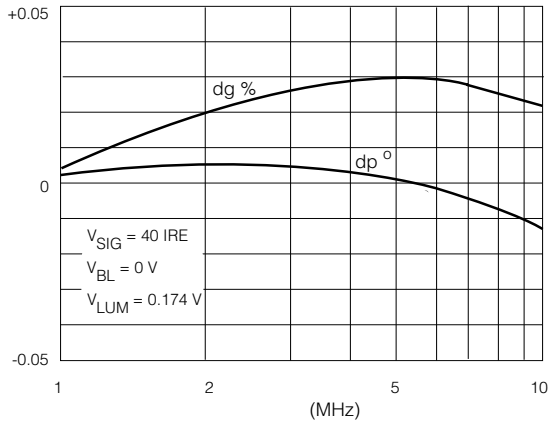


Fig.17f dg / dp vs frequency 10x1

APPLICATION CIRCUIT INFORMATION

Basic 8x1 and 10x1 video multiplexers can be implemented using circuits similar to the test jigs. Figures 18, and 19 show circuits of two other output buffers that can be used with the modules.

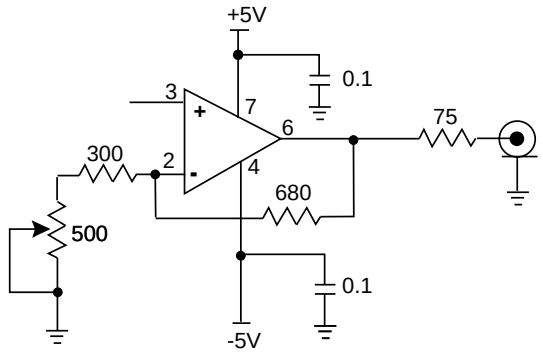


Fig.18 EL2030 Buffer Amplifier Circuit

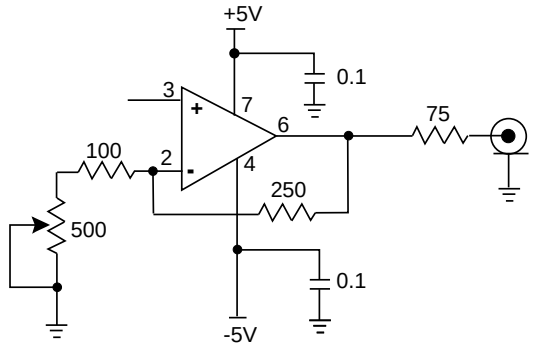


Fig. 19 CLC410 Buffer Amplifier Circuit

Both of them have exceptional 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 the 75 Ω load.

In both applications, each VIDEO INPUT on the modules 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 uses an operational amplifier at it's output. This amplifier can be tied directly to the VIDEO INPUT pin of the module without using a terminating resistor. A word of caution however, must be said at this point.

The internal circuitry of the GX4201 limits the useful input signal excursions. In a positive direction, the maximum voltage should not exceed +3 V and the negative excursion should not exceed -2 V. The device specifications indicate that the absolute maximum limits are +5.5 and -5.5 V.

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.

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 x 1 multiplexer.

It is possible with the modules described, to produce wider matrices for router cores. The 8x1 modules can be expanded to form, for example, 8x8 systems. Similarly, the 10x1 modules can be used to produce physically small sized 10x10 matrices.

Conclusions

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

The high quality characteristics of the GX4201 devices assure virtually 'straight wire' performance of any video switcher in which they are used.

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

References

GENNUM Data Sheets:
GX4201 Video Crosspoint Switch
Document No. 510-74

GENNUM Application Notes:
Modular 16 x 1 Video Multiplexers
Document No. 510-85
Other Data Sheets:
EL2030: Elantec Incorporated
CLC110: Comlinear Corporation
CLC410: Comlinear Corporation
NE5539: Signetics Corporation.