# Using the GT4122 & GT4124 Video Mixer ICs

by Ian Ridpath, Senior Applications Engineer, Video & Broadcast Group

APPLICATION NOTE

## INTRODUCTION and DEVICE TOPOLOGY

The GT4122 and GT4124 are broadcast quality monolithic integrated circuits specifically designed to linearly mix two video signals under the control of a third channel.

Figures 1 and 2 show the functional block diagrams of the GT4122 and the GT4124 respectively. The corresponding external connections are shown in Figures 3 and 6.

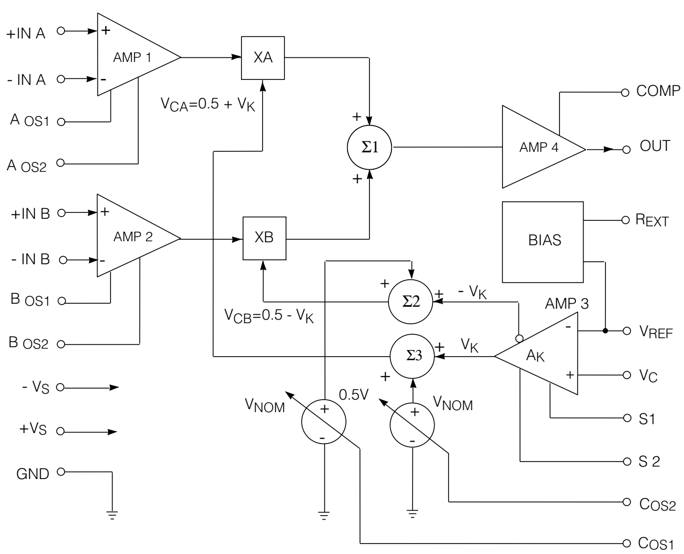



Fig. 1 Functional Block Diagram of the GT4122

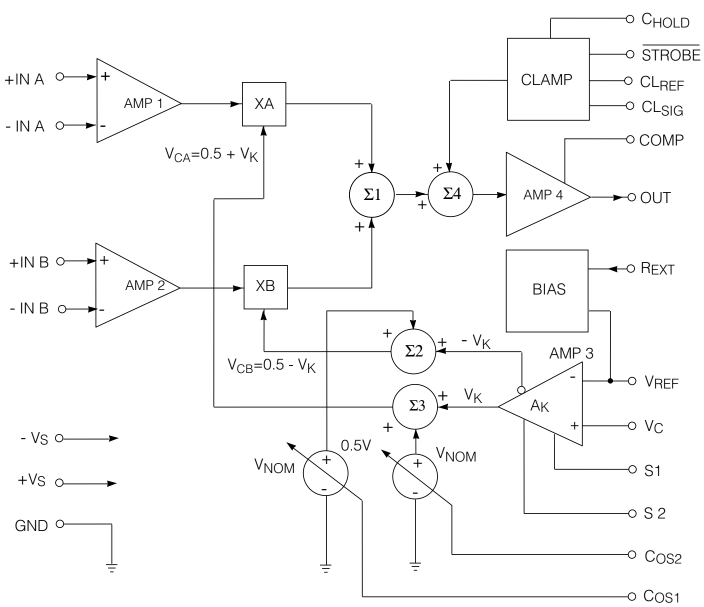



Fig. 2 Functional Block Diagram of the GT4124

For both devices, the input signals are applied to conventional differential amplifiers (AMP1 and AMP2). In the case of the GT4122, each amplifier has provisions for individually adjusting the DC offset (OFFSET). For the GT4124, these offsets are trimmed by on-chip resistors.

Following each input amplifier, the signals are applied to linear multiplier circuits (XA and XB) whose outputs are the product of the incoming signals and controlling voltages ($V_{CA}$) or ($V_{CB}$). The controlling voltage $V_{CA}$ is the sum of a nominal 0.5V source ($V_{NOM}$) and a variable source $V_K$ while $V_{CB}$ is made up of the sum of the nominal voltage $V_{NOM}$ and -$V_K$.

$V_K$ and -$V_K$ are themselves proportional to the difference between an externally applied reference voltage ($V_{REF}$) and an externally applied CONTROL voltage ($V_C$). The voltages $V_K$ and -$V_K$ are produced by a differential amplifier (AMP3) whose gain is $A_K$. This gain can be altered by two external resistors, $R_{EXT}$ and $R_{SPAN}$ according to the following formula:

$$A_K \approx \frac{0.85 \bullet R_{EXT}}{R_{SPAN}} \qquad [1k\Omega < R_{EXT} < 3k\Omega]$$

Note that $R_{EXT}$ is connected between the n and ground and $R_{SPAN}$ is connected between the pins S1 and S2.

Each of the voltages (+$V_K$ and -$V_K$) is applied to summing circuits (Σ2 and Σ3) whose second inputs are DC voltage sources that can also be slightly varied. The nominal value of these voltage sources is 0.5 volts. When they are exactly 0.5V and when $V_C$ = $V_{REF}$ then the gain of each signal channel of the mixer is 0.5 (50%).

By connecting the ends of an external potentiometer (CONTROL OFFSET) between the offset pins COS1 and COS2, the voltage sources can be altered differentially. If a second potentiometer (50% GAIN) is connected between the wiper of the CONTROL OFFSET potentiometer and the supply voltage, the voltage sources can be varied in a common mode fashion.

In this way not only can the control range of the mixer be varied but also the point at which 50% of each input signal appears at the output.

The outputs from the multiplier circuits (XA and XB) are then applied to a summing circuit (Σ1) whose output feeds a wideband amplifier (AMP4) and presents the mixed signals to the outside world.

Although there are two separate differential inputs, the usual operational amplifier gain-setting methods can be applied to determine the closed loop gain of the mixer. Usually the mixer will be configured for unity gain by connecting both inverting inputs (-IN A , -IN B) to the common output (OUT). In this case, the general transfer function is:

$V_O = V_A \bullet [V_{NOM} + A_K \bullet (V_C - V_{REF})] + V_B \bullet [V_{NOM} - A_K \bullet (V_C - V_{REF})]$
(Unity gain configuration)

Where $V_A$ and $V_B$ are the input analog signals applied to +IN A and +IN B respectively, and $V_C$ is the CONTROL voltage.

Note that $V_{NOM}$ ranges between $0.45V < V_{NOM} < 0.55$.

For normal video mixer operation, the control range (SPAN) is usually 0 to 1V and will occur when $A_K$=1, $V_{REF}$= 0.5V and $V_{NOM}$=0.5 volts. A change in $V_C$ from 0 to 1V will then produce an effect such that the output signal contains 100% of Channel B when $V_C$ is 0V and 100% of Channel A when $V_C$ is 1 volt. For the above conditions, the general unity gain transfer function reduces to:

$$V_O = V_A \bullet V_C + V_B \bullet (1 - V_C)$$

Since the operation of the mixer is limited to one quadrant, no signal inversions occur if the control voltage exceeds the range zero to one volt in either direction.

The topology is designed so that once the control voltage reaches either end of its range, the channel which is ON remains fully ON and the OFF channel remains fully OFF.

This is critical for good off-isolation performance.

Most of the internal circuitry of the GT4124 is identical to that of the GT4122. The unique feature of the GT4124 is the addition of an accurate and stable strobed clamp.

Figure 2, shows the topology of the GT4124 and includes the strobed clamp block. This circuit samples the OUTPUT signal when $CL_{SIG}$ is connected to the OUTPUT, and compares it to a CLAMP REFERENCE voltage which normally is set to 0V.

During the strobe period, which is usually the back porch period of the video signal, DC feedback is applied to the summing circuit Σ4 located between the output of the mixers and the input of the output amplifier such that the DC offset is held to within one or two millivolts of the clamp REFERENCE.

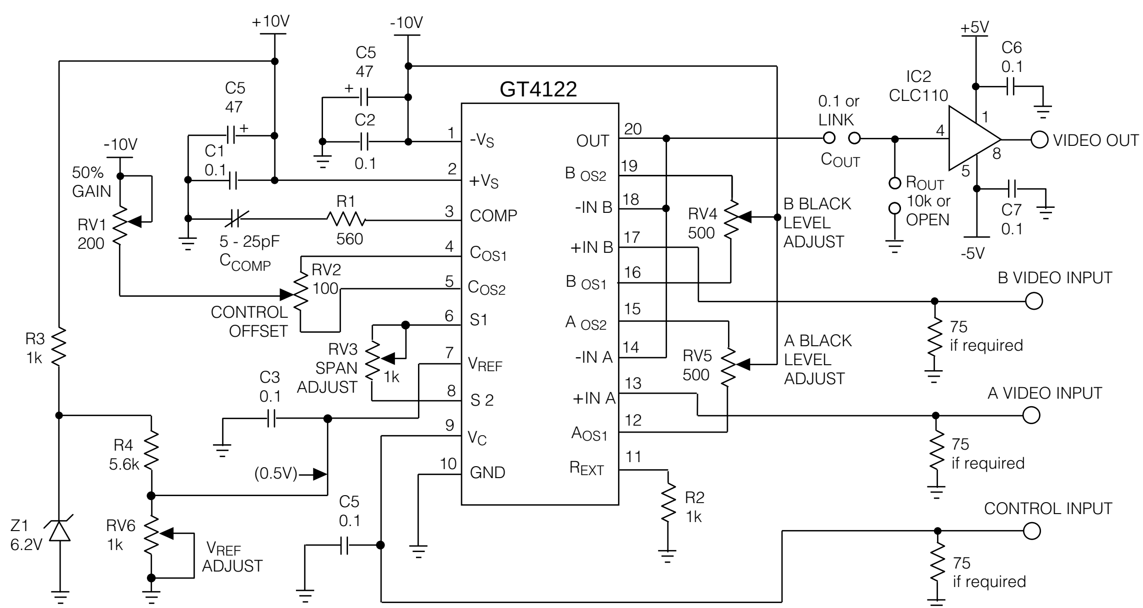
A holding capacitor $C_{HOLD}$ is used to assure effective clamp operation and filter residual noise.

## GT4122 CIRCUIT APPLICATIONS

Video applications for the GT4122, and GT4124 range from simple two input mixers using a single device to a multi-functional production switcher performing many video effects including fading, wiping and keying, by cascading several devices.

Figure 3 shows the GT4122 used as a two input video mixer. An evaluation PC board has been made and the artwork is included. Using this circuit, many of the critical circuit parameters can be measured including Crossfade Balance, Linearity, Bandwidth and Differential Gain and Phase.

An output amplifier is shown but is only necessary when driving low impedance loads such as co-axial cables. The load on the GT4122 output itself should be kept above 5kΩ.




**NOTE:** 1.C5 is used when the CONTROL VOLTAGE ($V_C$) is derived from a power supply.
2. All resistors in ohms, all capacitors in µF unless otherwise stated.

Fig. 3 GT4122 Test Circuit

The reference voltage $V_{REF}$ is derived from a simple Zener diode regulator from the +10V supply. It is important to maintain a constant reference voltage for repeatable performance. The circuit shown, or any other stabilized voltage source can be used. A 0.1µF capacitor (C3) is used to decouple any noise from the reference supply.

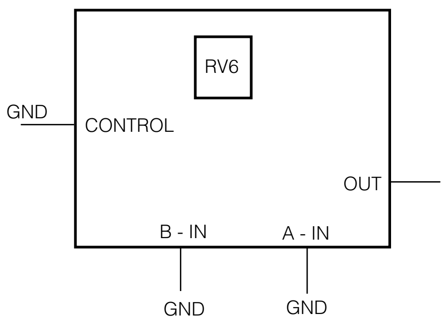
All adjustments are made using small trimmer potentiometers and it is critical that they be carbon or carbon film types. Ten turn potentiometers have too much inductance and will adversely affect the operation of the mixer.

The set up of the circuit is straightforward and is outlined below.

## TEST SET-UP FOR GT4122 VIDEO MIXER BOARD

NOTE: Initially set all trim pots to mid-position

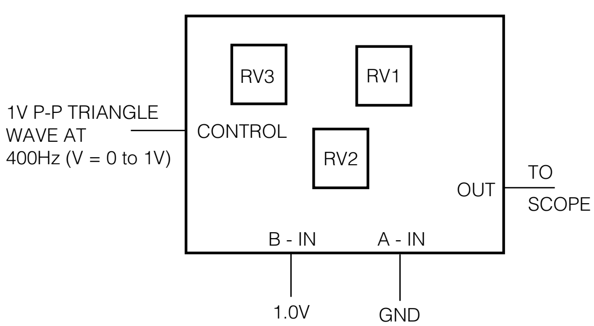
### 1) 0.5V Reference Adjustment




METHOD:

Adjust RV6 for 0.5V ± 0.005V at pin 11 of the GT4122 device.
[DO NOT touch this adjustment again.]

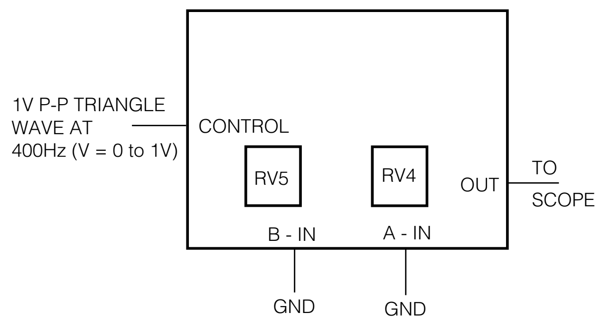
### 2) Span, Crossfade & Control Offset Adjustments




METHOD:

Adjust RV1, RV2 and RV3 to produce the best 0 to 1V (1V peak to peak) triangle waveform at the output. These adjustments interact and so should be repeated until the best waveform is obtained. (See Photographs 1 through 6).

### 3) A-B Null Adjustment

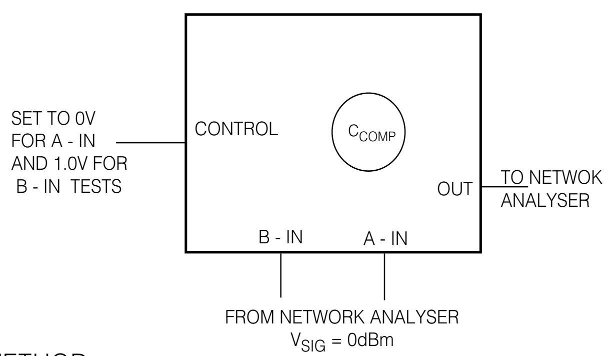



NOTE: $V_A$ and $V_B$ must be set to 0 volts.

METHOD:

Adjust RV4 and RV5 to produce the best null of the triangle wave at the output.

### 4) Frequency Compensation Adjustment

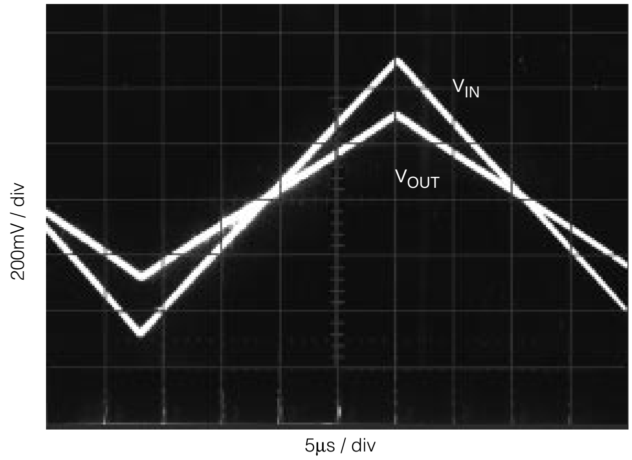



METHOD:

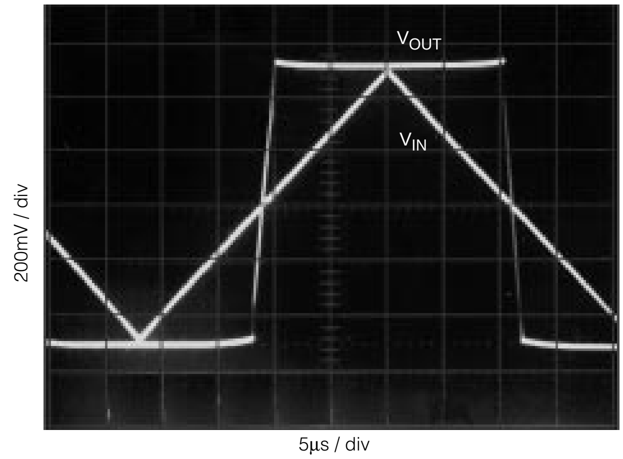
Connect either the A-IN or B-IN pins to the Network Analyser Output Port. Terminate these inputs with 50Ω resistors. Connect the OUTPUT to the Input Port of the Network Analyser. Set the voltage on the CONTROL to 1V in order to measure the frequency response of the A-INPUT. Conversely, set the CONTROL voltage to 0V for the B-INPUT measurement.

Adjust the compensating capacitor $C_{COMP}$ for the flattest frequency response on both channels.

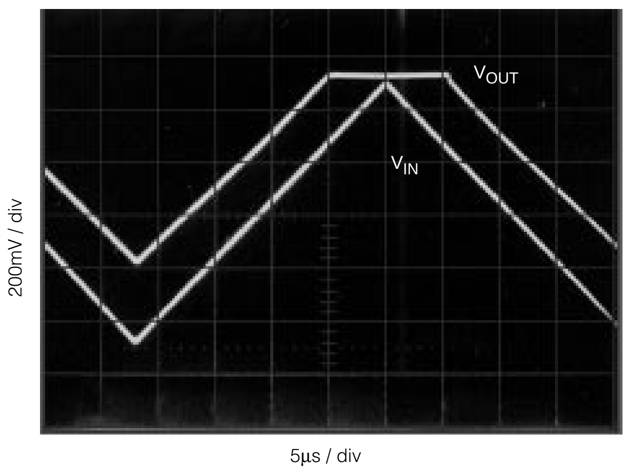
Photographs showing the effects of varying the SPAN, CONTROL OFFSET and 50% GAIN potentiometers.



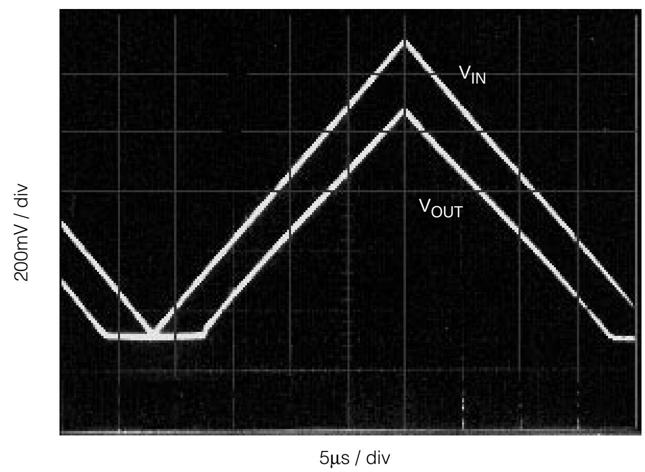

Photograph 1.  SPAN ADJUST (RV3) - fully c.w. (min)



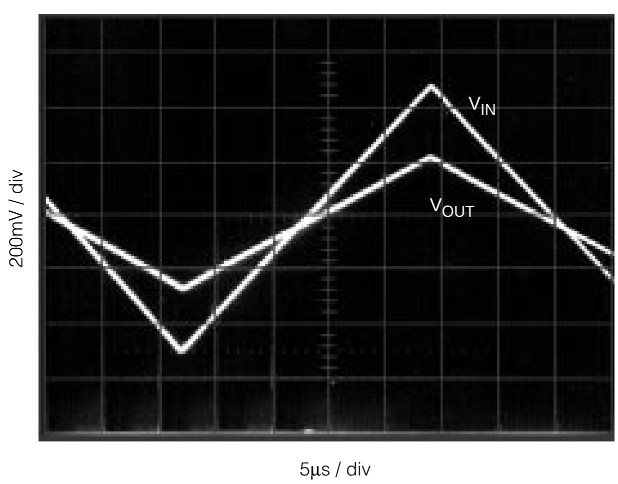

Photograph 2.  SPAN ADJUST (RV3) - fully  c.c.w.(max)



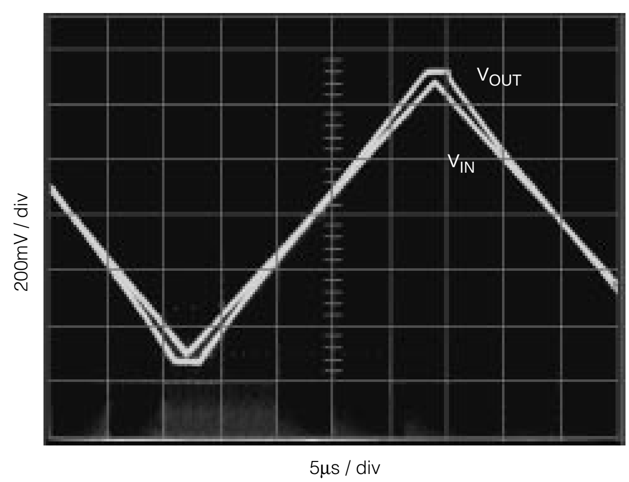

Photograph 3.  CONTROL OFFSET (RV2) fully c.w.




Photograph 4.  CONTROL OFFSET (RV2) - fully c.c.w.




Photograph 5.  50% GAIN (RV1) - fully c.c.w. (min)



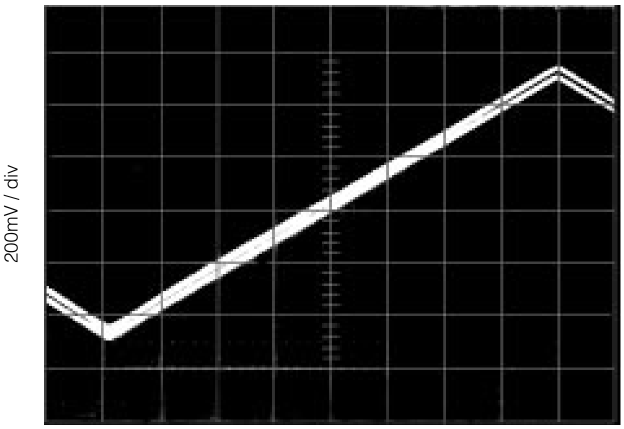

Photograph 6.  50% GAIN (RV1) - fully c.w. (max)

Once the board has been set up using the above procedures, other tests such as Linearity and Differential Gain and Phase can be performed.

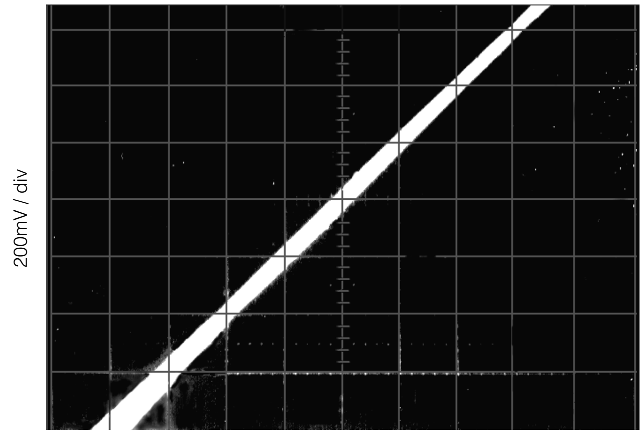
Photograph 7 shows the input and output triangle waveforms slightly offset from each other. This clearly shows the excellent linearity of the GT4122 control characteristics. The CONTROL signal itself is a 1V peak to peak triangle wave.

The output signal (top trace, Photo 7) indicates less than 1% non-linearity over the control range. Photograph 8 shows a closer view of the output signal with a vertical scale of 20 mV/div.

Tracking of the control characteristics from one device to another indicates approximately 1 IRE variation is possible making the GT4122 suitable for R-G-B and multi-signal mixing systems.




Photograph 7. Comparison of Input and Output Triangle Wave




Photograph 8. Close Up View of Output Triangle Wave

## DIFFERENTIAL GAIN AND PHASE MEASUREMENTS

Differential gain and differential phase can be accurately measured using a Network Analyser and S-parameter test set. Vectorscopes do not provide enough accuracy at the component level.

Under software control, an input carrier is stepped from a zero volt DC level to a 0.714V DC level and back again many times. The resulting changes in gain and phase at the output are averaged over a long time period by taking several hundred samples.

The results of this test method, with accuracies of better than 0.001% and 0.001 degree, form the basis of all differential gain and phase tests at GENNUM.

Appendix A is a program listing used in the HP-4195 Network Analyser to measure differential gain and differential Phase. This method is now becoming a standard with component manufacturers.

An earlier methodology is fully described in Information Note No. 510 - 14 which forms part of the GENNUM IC Data Book.

Figure 4 shows a typical plot of Differential Gain and Differential Phase versus Frequency using the Network Analyser method.

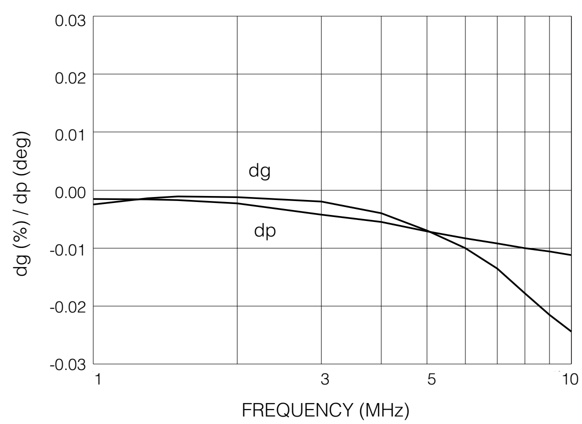


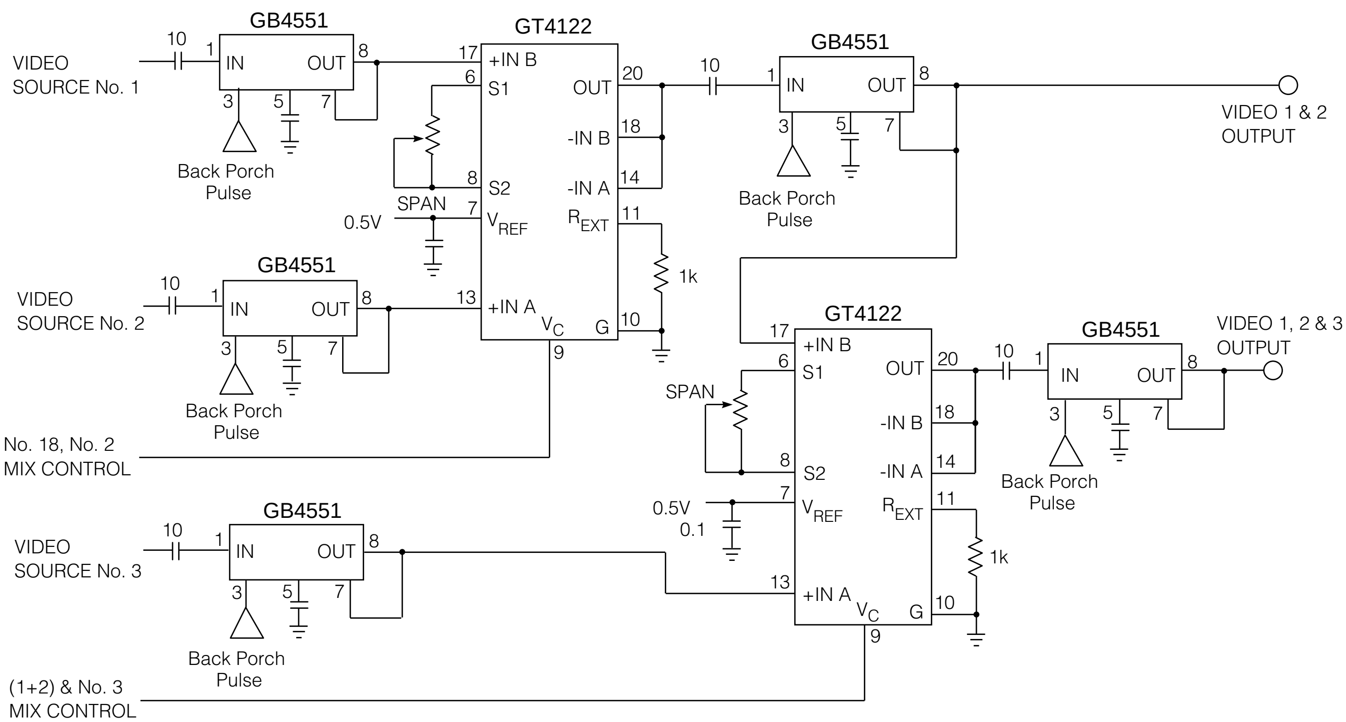

Fig. 4 Typical dg / dp Plot

## THREE LEVEL VIDEO MIXER - GT4122

Figure 5 shows an implementation of the GT4122 as a 3-level mixer incorporating external clamping circuits made up of GB4551 high performance, back-porch clamps. These devices are available from GENNUM Corporation. In this circuit, three video signals are combined by cascading two GT4122 devices.

The control signal circuitry is not included in this circuit and would depend on each individual requirement.

The input signals could be BORDER video, BACKGROUND video or even a PREVIOUS video signal. In any case, full control is achieved with a high degree of accuracy by providing the appropriate KEY signals to the CONTROL inputs of the two GT4122 devices.




**NOTES:** **1.** All non-marked capacitors connected to GROUND are 470pF.
**2.** All resistors are in ohms, all capacitors in μF unless otherwise shown.
**3.** For clarity, power supply and offset adjustments are not shown.

Fig. 5 Three Level Mixer using Two GT4122 Devices

## GT4124 CIRCUIT APPLICATIONS

Figure 6 shows a test circuit for the GT4124. It is very similar to the GT4122 circuit shown in Figure 3.

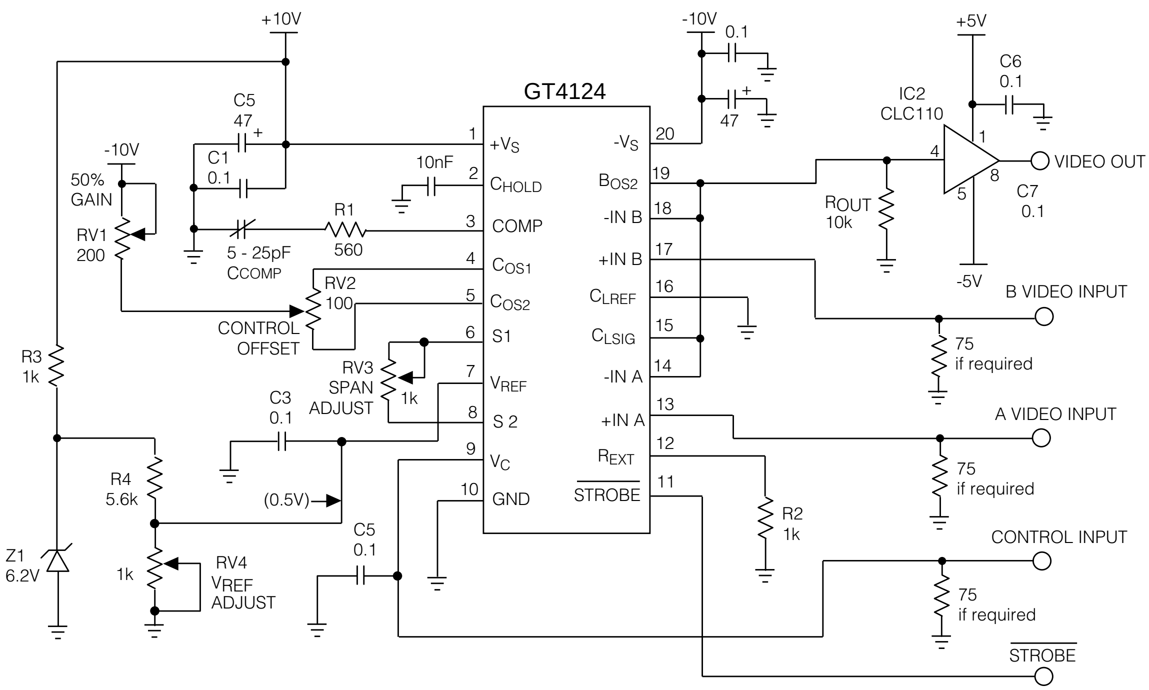
In this circuit, there are no DC offset adjustments required for the two video input channels. The 0.5V REFERENCE adjustment as well as the SPAN, 50% GAIN and CONTROL OFFSET adjustments are identical to those used on the GT4122 board.

The major difference in this circuit is the need for an active low STROBE pulse in order to activate the on-board clamp.

The test set up shown, uses a low frequency triangle waveform for the signal sources, and derives a triggered negative going pulse from the same generator to act as the STROBE input.

If actual video is used, the STROBE pulse can be obtained from the output of a sync separator circuit. In either case, the performance of the clamp can be evaluated using this test board.

As well, parameters such as Frequency Response, Linearity and Differential Gain and Phase can be measured. An artwork for this board is included in this application note.



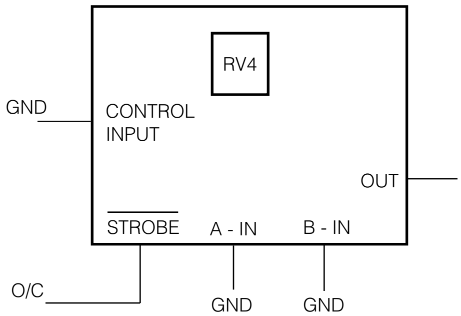

**NOTE:** **1.** All resistors in ohms, all capacitors in µF unless otherwise stated.
**2.** C5 is used when the CONTROL VOLTAGE ($V_C$) is derived from a power supply.

Fig. 6 GT4124 Test Circuit

## TEST SET-UP FOR GT4124 MIXER BOARD

NOTE: Initially set all trim pots to mid-position.

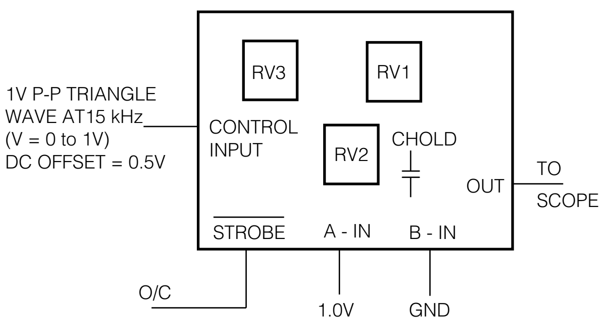
1) 0.5V Reference Adjustment (RV4)




METHOD:

Adjust RV4 for 0.5V ± 0.005V at pin 7 of the GT4124 device.
[DO NOT touch this adjustment again.]

2) Span, 50% Gain & Control Offset (RV1, RV2 & RV3)




METHOD:

Temporarily put a short circuit across the $C_{HOLD}$ capacitor on pin 2 of the device. This will disable the clamping action.

Apply 1.0V DC to A-INPUT and 0V to INPUT-B (this may be done by leaving INPUT-B open with the 75Ω resistor connected to ground).

Adjust RV1, RV2 and RV3 to produce the best 0 to 1V (1V peak to peak) triangle waveform at the output. These adjustments interact and so should be repeated until the best waveform is obtained.

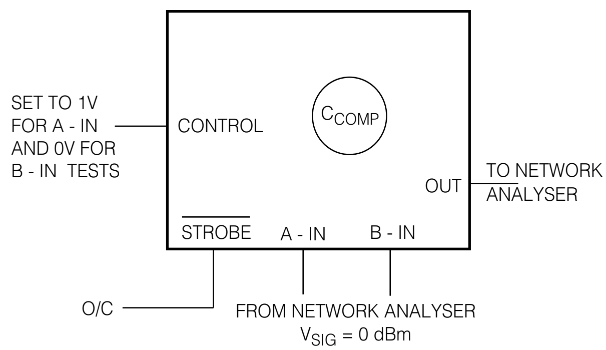
Remove the short across $C_{HOLD}$.

3) Crossfade Balance (No adjustments)

METHOD:

The crossfade balance (control breakthrough) is measured over frequency by using a Network Analyser or Waveform Generator. Both INPUT-A and INPUT-B are terminated with their 75Ω resistors. The control voltage of 0-1V p-p with a 0.5V DC offset is swept over the frequency range desired.

4) Frequency compensation ($C_{COMP}$)



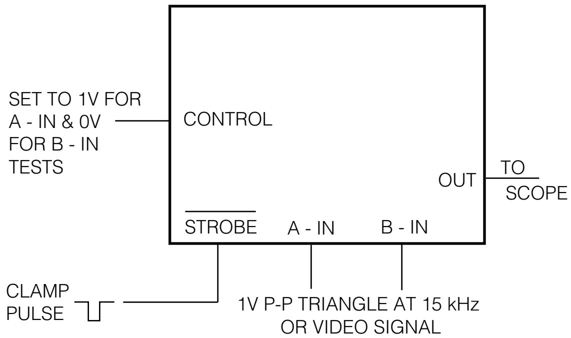

METHOD:

Connect either the A-IN or B-IN pins to the Network Analyser Output Port. Terminate these inputs with 50Ω resistors. Connect the OUTPUT to the Input Port of the Network Analyser.

Set the voltage on the CONTROL to 1V in order to measure the frequency response of the A-INPUT.

Conversely, set the CONTROL voltage to 0V for the B-INPUT measurement. Adjust the compensating capacitor $C_{COMP}$ for the flattest frequency response on both channels.

5) Clamp Operation (No adjustments)




METHOD:

Connect either the A-IN or B-IN pins to the Waveform Generator or video source. Terminate these inputs with 50Ω resistors. Connect the OUTPUT to the Input of the Oscilloscope. Set the voltage on the CONTROL to 1V in order to observe the clamping accuracy of the A-INPUT.

Conversely, set the INPUT voltage to 0V for the B-INPUT measurement. Apply a 1µs, 15kHz negative pulse triggered by the Waveform Generator (or a burst pulse from a sync separator if a video signal is used) to the STROBE INPUT and observe that the output is clamped to within 1mV of 0V DC.

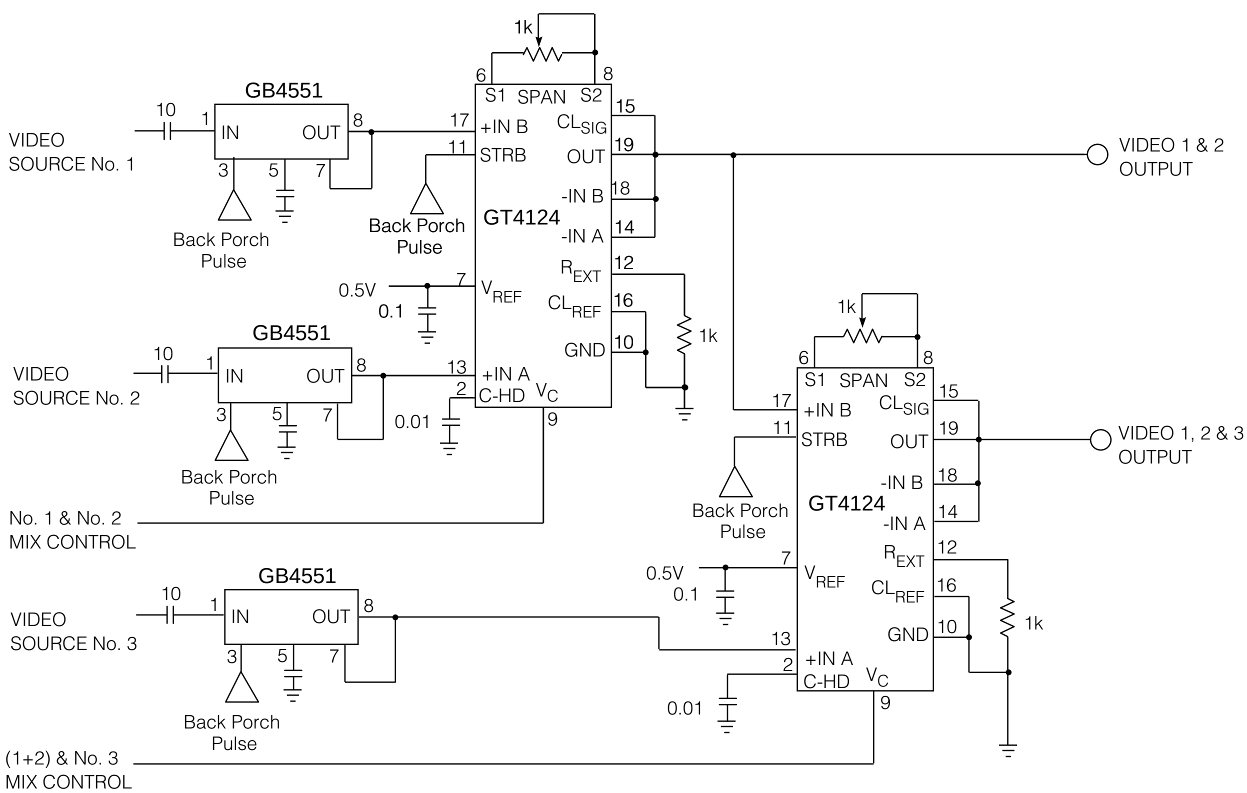
## THREE LEVEL VIDEO MIXER - GT4124

Figure 7 shows an implementation of the GT4124 as a three-level video mixer incorporating two mixers and three back porch clamps. In this case, the GB4551 clamps are only used at the video inputs. Since the GT4124 devices have on-board clamps themselves, subsequent circuit clamps are not needed.

As with the GT4122 three-level mixer circuit (Figure 5), control, power and offset circuitry are not included for clarity.

The control channels are identical for both the GT4122 and GT4124 in terms of SPAN range and frequency response.

Since the STROBE inputs to the GT4124 and the GB4551 are both active low, these inputs can be paralleled and driven from any conventional sync separator circuit.




**NOTE:** **1.** All non marked capacitors connected to GROUND are 470 pF.
**2.** All resistors in ohms, all capacitors in µF unless otherwise shown.
**3.** For clarity, power supply and offset adjustments are not shown.

Fig. 7 Three Level Mixer Using Two GT4124 Devices

## NON - VIDEO APPLICATIONS

The previous applications use the GT4122 as an overall unity gain, non-inverting system. With this same configuration it is possible to make a simple Amplitude Modulator. It is also possible to configure either input stage as an inverting amplifier and produce anti-phase signals which are then applied to the internal summing circuits. This allows the device to be used as a Double Sideband Balanced Modulator. Both of these applications are described below.

### AMPLITUDE MODULATOR

An Amplitude Modulator circuit is shown in Figure 8 and produces an output spectrum as shown in Figure 9. The resulting envelope waveform is shown in Photograph 9. For this application, a 1V peak to peak, 1 MHz carrier is applied to the non-inverting B-INPUT.

A 3kHz, 1V peak to peak audio signal is applied to the CONTROL input superimposed on a +0.5V DC bias. The bias centres the CONTROL signal with respect to the 0.5V DC REFERENCE voltage.

Modulation is achieved by varying the CONTROL signal at the audio rate which in turn allows more or less of the carrier, appearing on B-INPUT, through to the OUTPUT.

Post mixing of this signal would place the carrier on any desired RF channel.

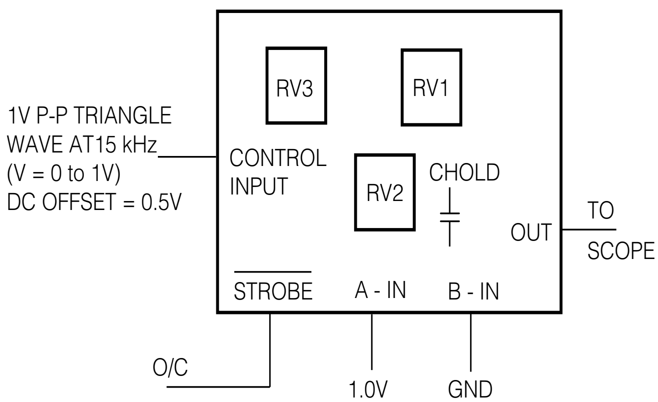



Fig. 8 Amplitude Modulator Circuit

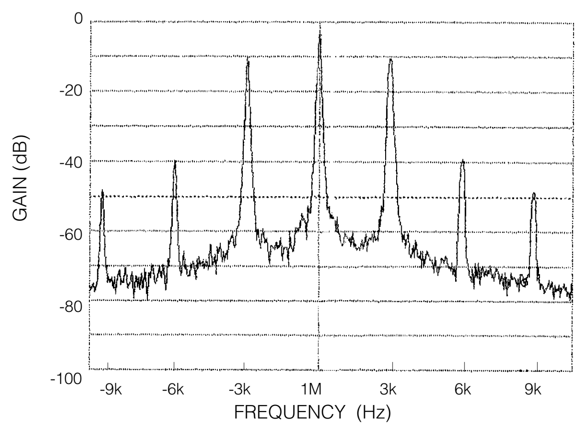
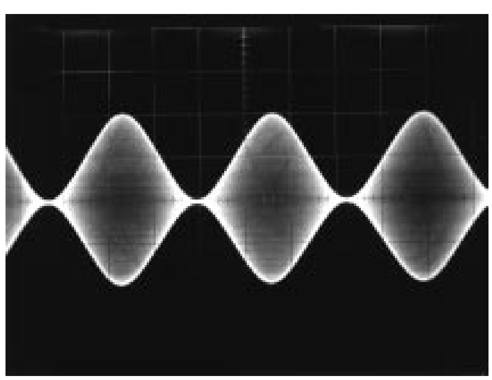



Fig. 9 Spectrum of A.M. Signal



Photograph 9. Envelope Waveform of A.M. Signal

In order to produce a suppressed carrier signal, mixing must occur between in-phase and anti-phase signals. To achieve this, the A-INPUT is configured as an inverting amplifier with unity gain by using two 2.2kΩ resistors in the feedback loop. This is illustrated in Figure 10.

The audio signal is now applied to both the A-INPUT and the B-INPUT. The signals reach the summing circuits within the device 180° out of phase. The carrier applied to the CONTROL input modulates these signals and produces a suppressed carrier output.

The spectrum is shown in Figure 11 and indicates a carrier null of at least 50dB.

The carrier is a 1V peak to peak, 1MHz signal superimposed on a +0.5V bias. The audio level is varied to control the amount of modulation.

Photograph 10 shows the resulting envelope waveform. Again, this signal may be prescaled to place it on any desired channel. One sideband may also be filtered in order to produce a Single Sideband Suppressed Carrier signal.

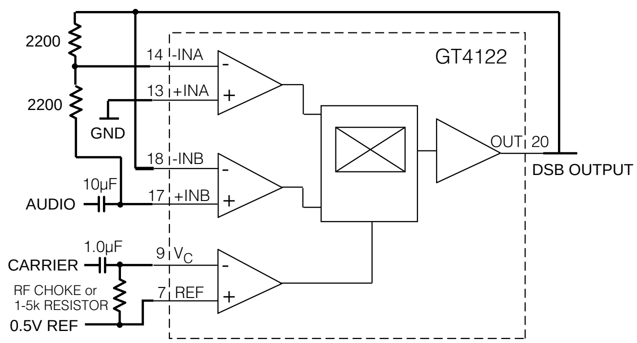



Fig. 10 Double Sideband Modulator Circuit

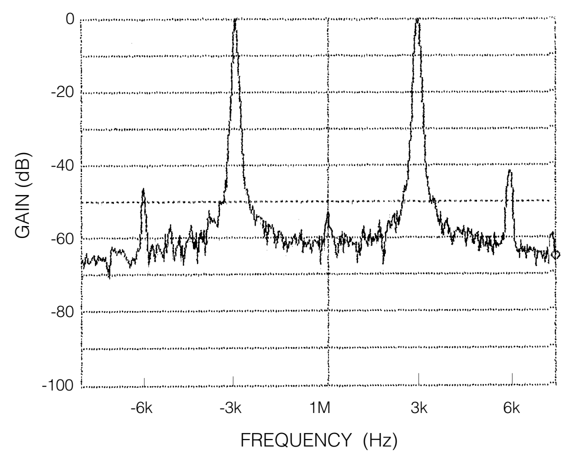
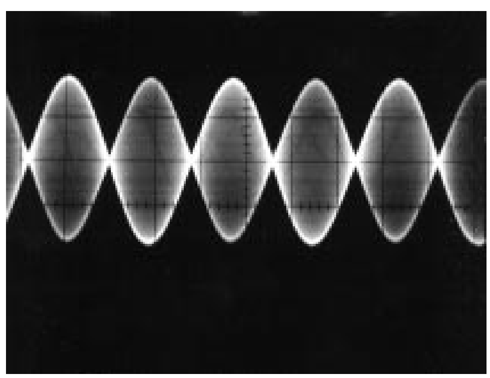



Fig. 11 Spectrum of Double Sideband Signal



Photograph 10. Envelope Waveform of Double Sideband Signal

## CONCLUSION

The GT4122 and GT4124 are available in both 20 pin PDIP and 20 pin SOIC packaging. They each represent a dedicated video mixer function in one package and offer professional video mixing with very few external parts. These devices are specifically designed for the professional broadcast market and are used in Production Switchers (Vision Mixers) and Multilayer Keyers.

Full data is available from the device data sheets in the GENNUM Data Book. Applications engineers at GENNUM will be pleased to answer technical questions about any of the wide range of Video & Broadcast products made by GENNUM Corporation.

## APPENDIX A

Program Listing for Differential Gain and Phase Measurements using the HP-4195 Network Analyser.

```
10    !GDP - VS FREQUENCY
15    RST !RESET
20    !NETWORK; PORTS T2/R1; T/R()-(DEG)
30    FNC1;PORT2;GPP2
40    !LOG SCALE
50    SWT2
60    !DEFINE SWEEP TABLE
65    CPL0
67    RBW=1KHZ !BANDWIDTH
70    PTSET
80    PTN=1
90    PTCLR
100   PTSWP=1
110   POINT=1.000 MHZ
120   POINT=1.295 MHZ
130   POINT=1.585 MHZ
140   POINT=1.995 MHZ
150   POINT=2.215 MHZ
160   POINT=3.162 MHZ
170   POINT=3.580 MHZ
175   POINT=3.981 MHZ
180   POINT=4.430 MHZ
190   POINT=5.012 MHZ
200   POINT=6.310 MHZ
210   POINT=7.943 MHZ
220   POINT=10.00 MHZ
230   PTEND
240   ! SET UP GRAPHICS
250   CMT “DG & DP VS. FREQUENCY” !COMMENT
      LINE ON SCREEN
260   SCL1 !SCALE 1
265   REF=0.05
270   BTM=-0.05
280   SCL2!SCALE2
290   REF=0.05
300   BTM=-0.05
330   !SET SWEEP PARAMETERS
340   VFTR1
350   PPM1
352   !SET MARKERS
354   MCF2;MKCR1;MKACT1;MKCR2;MKACT0
356   MKR=3.58M;SMKR=3.58M
360   !DEFINE MATH
370   MTHA1;DMA=I
380   MTHB1;DMB=J
382   PRMA”DG”;UNIT”%”
384   PRMB”DP”;UNITB””
390   !CLEAR REGISTERS
400   A=0;B=0;E=0;F=0;G=0;H=0
410   I=0;J=0;RA=0;RB=0
420   !SET SIGNAL LEVEL
422   OSC1=0.4 V;ATR1=0;ATT2=10
425   DISP “PRESS CONT(INUE) WHEN READY”
430   BEEP
440   PAUSE
445   GOSUB 1000
450   MKR=3.58M;SMKR=3.58M
460   END
1000  !MEASUREMENT
1010  FOR R0=1 TO 1000
1050  BIAS=0 !EDIT FOR BLANKING LEVEL
1060  WAIT 200
1065  SWTRG
1070  E=MA
1080  F=MB
1090  BIAS=0.75 !EDIT FOR LUMINANCE LEVEL
1100  WAIT
1105  SWTRG
1110  G=G+100 *(E-MA)/E
1120  H=H+F-MB
1130  I=G/R0
1140  J=H/R0
1150  NEXT R0
1200  RETURN
```

## TEST BOARD ARTWORKS

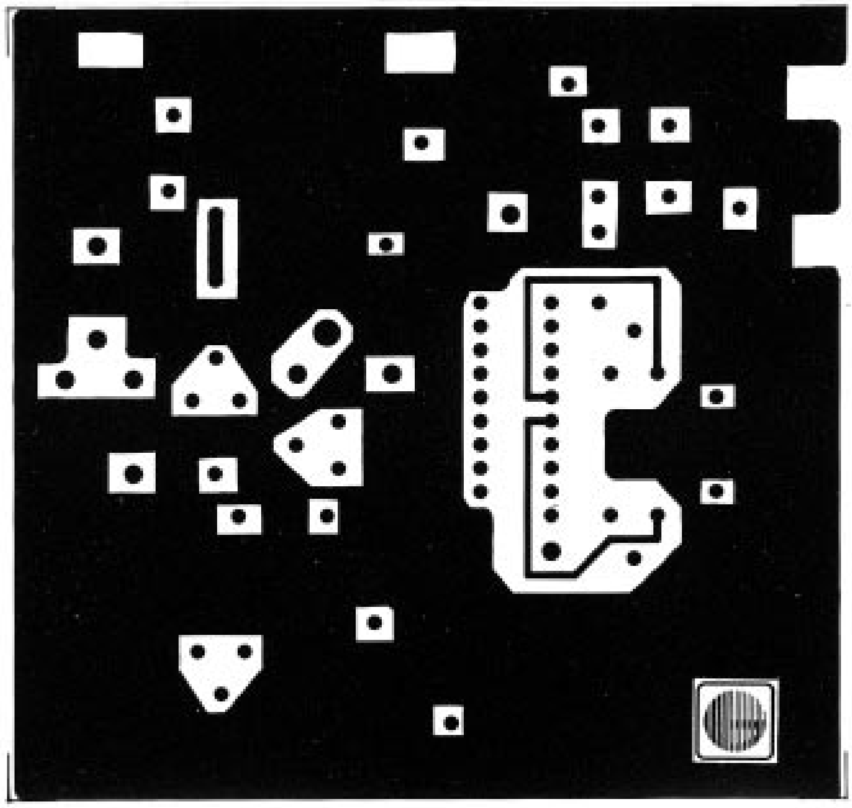


Fig. 12   Component Side Artwork for GT4122 Test Board

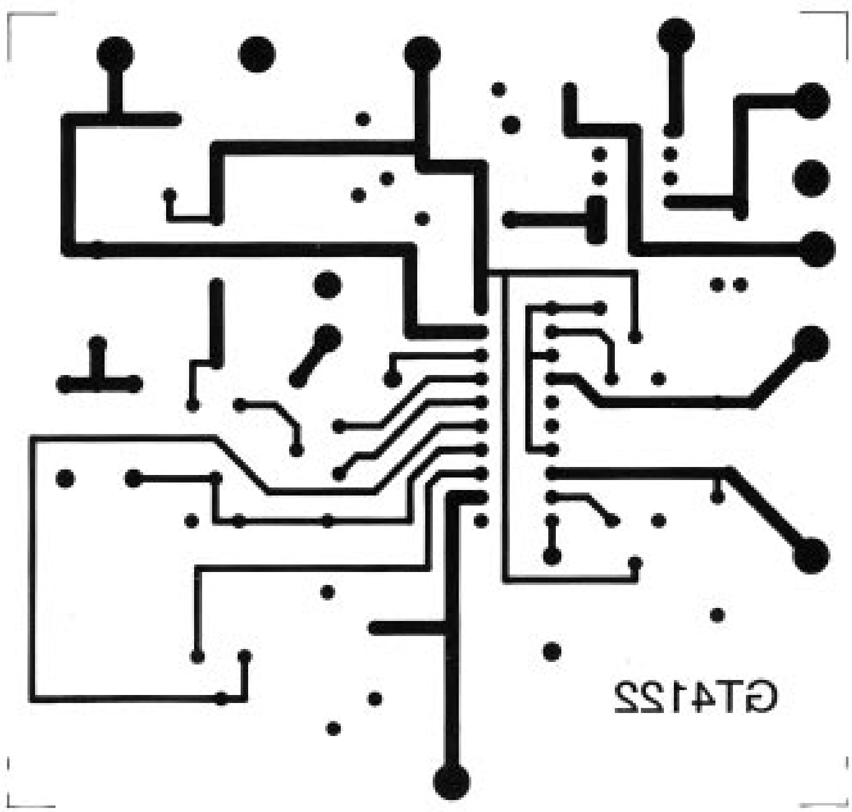



Fig. 13   Copper Side Artwork for GT4122 Test Board

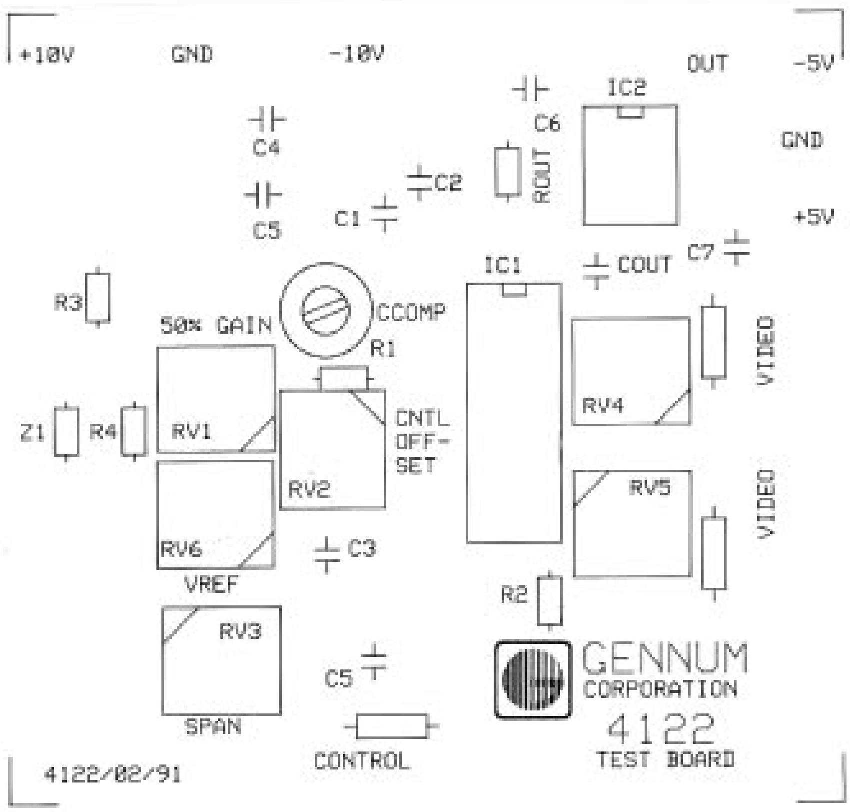



Fig. 14 Component Silkscreen for GT4122 Test Board

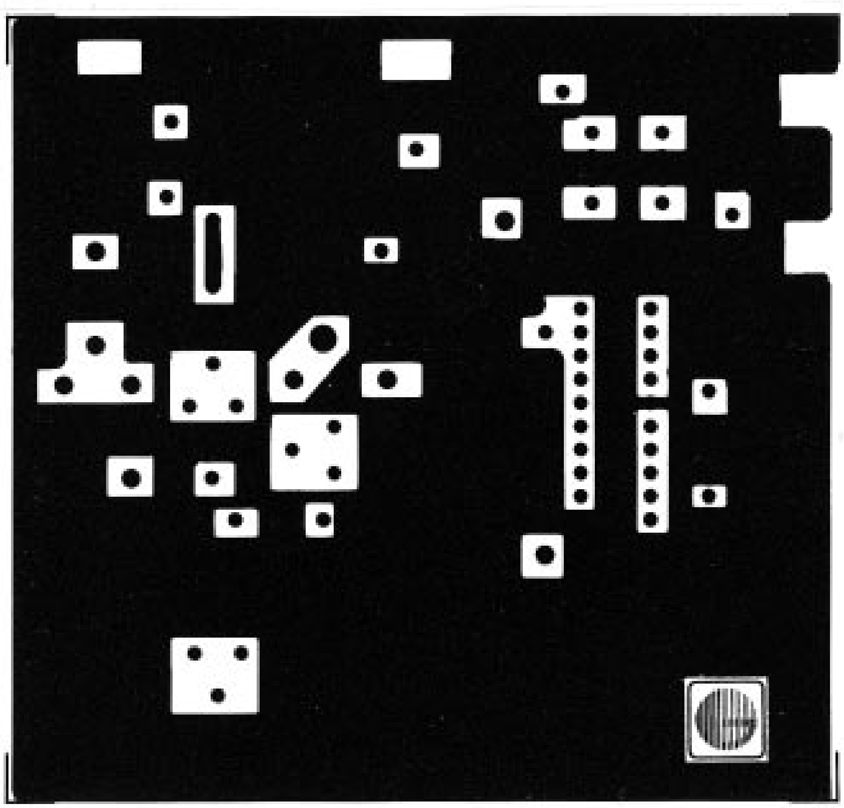


Fig. 15 Component Side Artwork for GT4124 Test Board

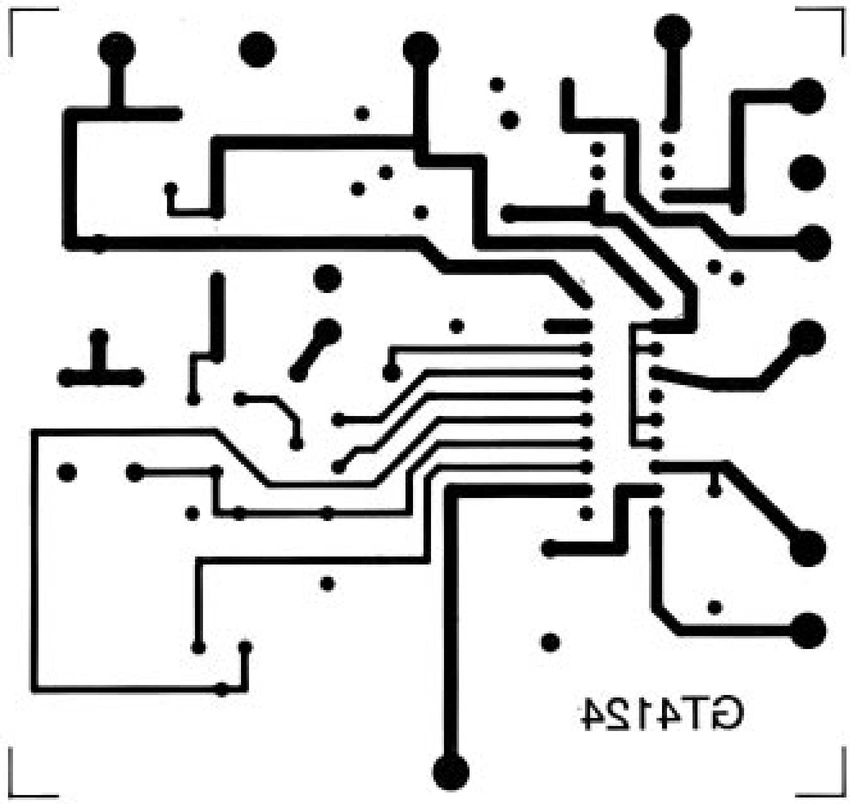


Fig. 16 Copper Side Artwork for GT4124 Test Board

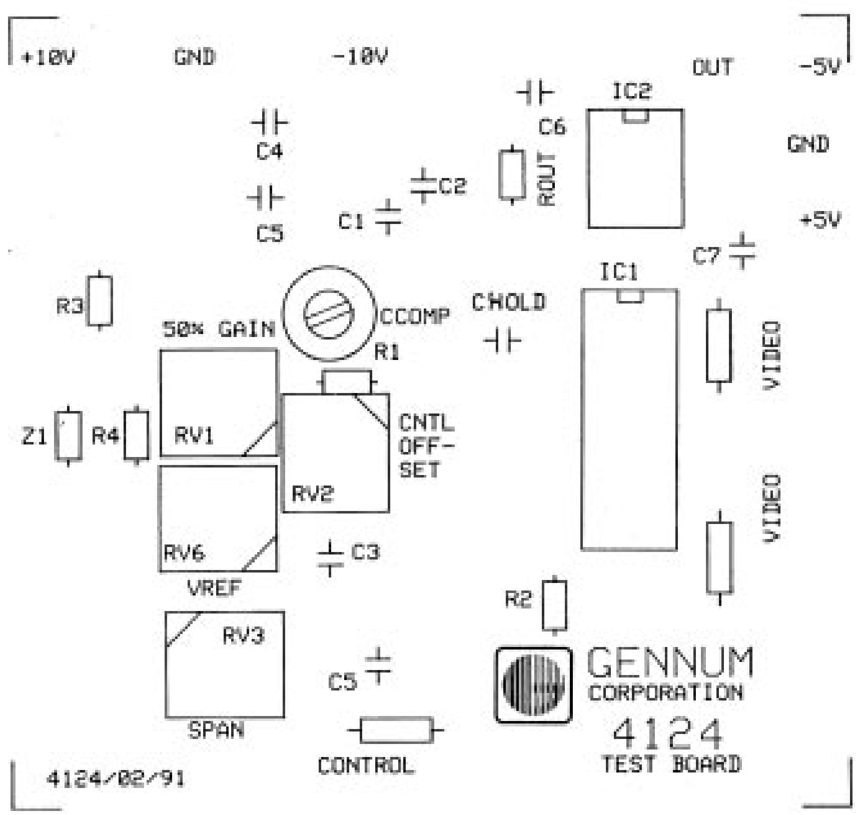



Fig. 17 Component Silkscreen for GT4124 Test Board