National Semiconductor

September 1991

# LH2422/LH2424 CRT Video Amplifiers

## General Description

The LH2422 and LH2424 are wide bandwidth and high voltage CRT video amplifiers. These amplifiers are specifically designed to directly drive the cathode of high resolution CRT monitors. Both amplifiers work on the transimpedance principle, about ±6.5 mA input current results in an output swing of ±20V relative to the quiescent output DC level. These amplifiers can easily energize 10 ns pixels and are well suited for monitors with 1280 x 1024 or higher display resolutions. The LH2422 and LH2424 are identical except that the LH2424 has faster rise and fall times and wider bandwidth than LH2422. Both amplifiers can interface to National's LM1201 and LM1203 preamplifiers.

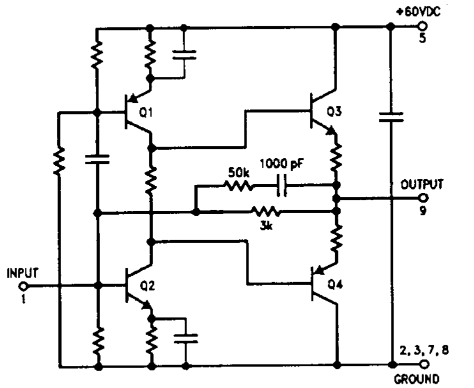
## Features

- LH2424: BW = 175 MHz
  Rise/Fall Time = 2 ns
- LH2422: BW = 120 MHz
  Rise/Fall Time = 3 ns
- Drives 8.5 pF capacitive load
- Pin compatible with CR2424
- DC coupled for output level adjust
- Output signal can swing 50V

## Applications

- CRT driver for color and monochrome monitors
- High voltage transimpedance amplifier

## Schematic and Connection Diagrams

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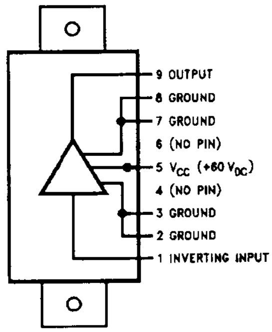


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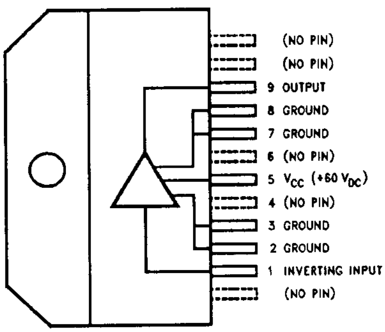
**Order Number LH2422AJ or LH2424AJ**
**See NS Package Number HY07A**

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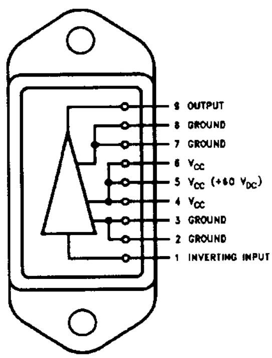
**Order Number LH2422S or LH2424S**
**See NS Package Number HY07B**

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**Order Number LH2422D-MIL**
**See NS Package Number HY09B**

## Absolute Maximum Ratings (Note 1)

**If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.**

| | |
|---|---|
| Supply Voltage, $V_{CC}$ | +70V |
| Storage Temperature Range, TSTG | −40°C to +125°C |
| Operating Temperature Range, $T_{case}$ | −20°C to +90°C |
| Lead Temperature (Soldering, <10 sec) | 300°C |
| ESD Tolerance | >4KV |

## DC Electrical Characteristics

Unless otherwise noted, the following specifications apply for $V_{CC}$ = +60V, R1 = 215Ω, C1 = 60 pF (for LH2422), C1 = 90 pF (for LH2424), $C_{LOAD}$ = 8.5 pF, 40 $V_{P-P}$ swing with 30 VDC offset, and $T_{CASE}$ = 25°C. See test circuit, *Figure 1*.

| Symbol | Parameter | Conditions | Min (Note 3) | Typ (Note 2) | Max (Note 3) | Units |
|---|---|---|---|---|---|---|
| $I_{CC}$ | Supply Current | Input/Output Open Circuit | 35 | 43.5 | 47.5 | mA |
| $V_{INDC}$ | Input Offset Voltage (LH2422) | Input/Output Open Circuit | 1.15 | 1.55 | 1.7 | V |
| | Input Offset Voltage (LH2424) | Input/Output Open Circuit | 1.15 | 1.55 | 1.65 | V |
| $V_{OUTDC}$ | Output Offset Voltage | Input/Output Open Circuit | 26 | 30 | 34 | V |
| $P_D$ | Power Dissipation (LH2422)<br>Power Dissipation (LH2424) | 50 MHz Square Wave<br>50 MHz Square Wave | | 4.5<br>4 | 6<br>6 | W<br>W |
| LE | Linearity Error | $V_{OUT}$ from +5V to +55V | | 1 | 5 | % |

## AC Electrical Characteristics

Unless otherwise noted, the following specifications apply for $V_{CC}$ = +60V, R1 = 215Ω, C1 = 60 pF (for LH2422), C1 = 90 pF (for LH2424), $C_{LOAD}$ = 8.5 pF, 40 $V_{P-P}$ swing with 30 VDC offset, and $T_{CASE}$ = 25°C. See test circuit, *Figure 1*. (Note 1)

| Symbol | Parameter | Conditions | LH2422 | | | LH2424 | | | Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min (Note 3) | Typ (Note 2) | Max (Note 3) | Min (Note 3) | Typ (Note 2) | Max (Note 3) | |
| $t_R$ | Rise Time | 10% to 90% (Note 4) | | 3 | 4 | | 2 | 2.9 | ns |
| $t_F$ | Fall Time | 90% to 10% (Note 4) | | 3 | 4 | | 2 | 2.9 | ns |
| $V_{TILT}$ | Low Frequency Tilt Voltage | 1 kHz Square Wave | | 1.3 | | | 1.3 | | V |
| $f_{-3\,dB}$ | −3 dB Bandwidth | (Note 5) | | 120 | | | 175 | | MHz |
| $A_V$ | Voltage Gain | 50Ω Source Impedance (Note 6) | 11.5 | 13 | 14.5 | 11.5 | 13 | 14.5 | V/V |
| OS | Overshoot | | | 10 | | | 10 | | % |

## LH2422D-MIL (Note 7)

### DC Electrical Characteristics

Unless otherwise noted, the following specifications apply for $V_{CC}$ = +60V, R1 = 215Ω, C1 = 60 pF, $C_{LOAD}$ = 8.5 pF, 40 $V_{P-P}$ swing with 30 $V_{DC}$ offset. See test circuit, *Figure 1*.

| Symbol | Parameter | Conditions | $T_A$ = 0°C | | $T_A$ = +25°C | | $T_A$ = +70°C | | Units |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min (Note 3) | Max (Note 3) | Min (Note 3) | Max (Note 3) | Min (Note 3) | Max (Note 3) | |
| $I_{CC}$ | Supply Current | Input/Output Open Circuit | 32 | 47.5 | 35 | 47.5 | 32 | 47.5 | mA |
| $V_{INDC}$ | Input Offset Voltage | Input/Output Open Circuit | 1.15 | 1.8 | 1.15 | 1.7 | 1.15 | 1.8 | V |
| $V_{OUTDC}$ | Output Offset Voltage | Input/Output Open Circuit | 26 | 34 | 26 | 34 | 26 | 34 | V |
| $P_D$ | Power Dissipation | 50 MHz Square Wave | | 6 | | 6 | | 6 | W |
| LE | Linearity Error | $V_{OUT}$ from +5V to +55V | | 8 | | 5 | | 8 | % |

## LH2422D-MIL (Note 7)

### AC Electrical Characteristics

Unless otherwise noted, the following specifications apply for $V_{CC}$ = +60V, R1 = 215Ω, C1 = 60 pF, $C_{LOAD}$ = 8.5 pF, 40 $V_{P-P}$ swing with 30 $V_{DC}$ offset. See test circuit, *Figure 1*.

| Symbol | Parameter | Conditions | $T_A$ = +25°C | | Units |
|---|---|---|---|---|---|
| | | | Min (Note 8) | Max (Note 8) | |
| $t_R$ | Rise Time | 10% to 90% (Note 4) | | 4 | ns |
| $t_F$ | Fall Time | 90% to 10% (Note 4) | | 4 | ns |
| $A_V$ | Voltage Gain | 50Ω Source Impedance (Note 6) | 11.5 | 14.5 | V/V |

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

**Note 2:** Typical specifications are at +25°C and represent the most likely parametric norm.

**Note 3:** Min/Max limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

**Note 4:** Input signal $t_r$, $t_f$ < 1 ns.

**Note 5:** −3 dB bandwidth is calculated from the equation; $f_{-3\ dB} = 0.35/t_R$.

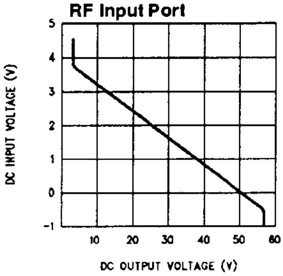
**Note 6:** Voltage gain is the ratio of the output voltage to the voltage at the RF input port (*Figure 1*).

**Note 7:** A military RETS specification is available on request. At the time of printing, LH2422D-Mil RETS specification complied with the limits in this Electrical Characteristics table.

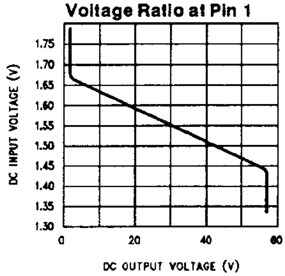
**Note 8:** Min and Max limits are 100% tested.

# Typical Performance Characteristics

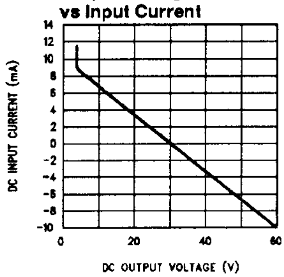
**Voltage Ratio at RF Input Port**



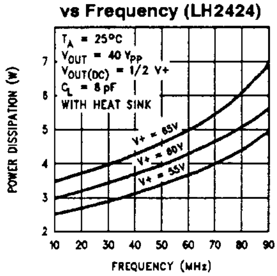

**Voltage Ratio at Pin 1**



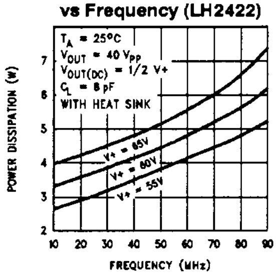

**Output Voltage vs Input Current**




**Power Dissipation vs Frequency (LH2424)**




**Power Dissipation vs Frequency (LH2422)**

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# Application Hints

### OUTPUT INFORMATION

The LH2422 and LH2424 are wide bandwidth high voltage amplifiers that can directly drive the cathode of high resolution Cathode Ray Tubes (CRTs). The outputs of both amplifiers are biased at half the supply voltage. With a +60V supply, an output swing of ±20V relative to a 30V output DC bias can easily be achieved. When driving an 8.5 pF capacitance the typical rise and fall times of 2 ns and 3 ns were measured for the LH2424 and LH2422 respectively. During normal CRT operation, tube arcing may occasionally occur. Spark gap protectors are widely used to limit the voltage at the output of the amplifier. In addition a 50Ω to 100Ω resistor is also used in series with the output of the amplifier so as to limit the arc current. This current limiting resistor and the capacitive load offered by the CRT's cathode will degrade the effective rise and fall times at the cathode. Adding a small inductor in series with the amplifier's output will increase the rise and fall times at the cathode due to high frequency peaking of the amplifier's pulse response. This inductor is often referred to as a peaking inductor or peaking coil. At best, the value of the inductor is empericaly determined. For the LH2422 and LH2424, a 100 nH to 200 nH inductor is quite adequate.

### SHORT CIRCUIT PROTECTION

The LH2424 and LH2422 do not include short circuit protection. If the amplifiers are used to drive a resistive load connected to either ground or $V_{CC}$ then the load must be greater than 600Ω.

### INPUT INFORMATION

The "Output Voltage vs Input Current" graph shows that a ±20V swing (from a 30V output DC bias) can be achieved with an input current swing of only ±6.5 mA. For the circuit shown in *Figure 1*, the "Voltage Ratio at RF Input Port" graph relates the input voltage as measured at the RF input port to the voltage at the output; note that the amplifier is phase inverting. With 215Ω for R1 in *Figure 1*, the voltage gain is approximately 13.5, and the low frequency input impedance at the RF input port is approximately 230Ω. The "Voltage Ratio at Pin 1" graph relates the voltage at the input of the amplifier (pin 1) to the output voltage, the output voltage to input voltage ratio is approximately 240V and the low frequency input impedance is approximately 13Ω. With the RF input port open circuited and $V_{CC}$ = 60V, the input of the amplifer (pin 1) is self biased at typically 1.55V while the output is biased at 30V.

### SETTING UP GAIN

The LH2424 and LH2422 work on the transimpedance principle. An internal 3 kΩ feedback resistor connected between the input and output converts the input current to output voltage.

For the circuit in *Figure 1*, ±1.43V (referenced to 1.55 $V_{DC}$) across the 214Ω input resistor results in ±6.65 mA. This current flowing through the 3 kΩ internal feedback resistor results in a ±20V swing at the output.

## Application Hints (Continued)

### TYPICAL TEST CIRCUIT

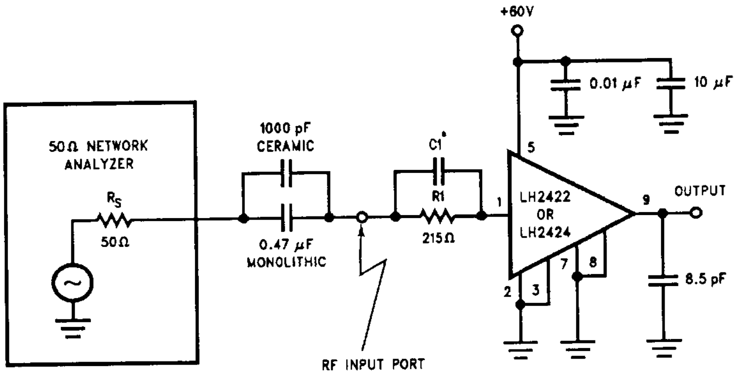
The test circuit in *Figure 1* is driven from either a fast pulse generator with a 50Ω output impedance or network analyzer. The cable between the generator and DUT should be of minimum length. The generator's DC level should be about 1.55V. Use a FET probe with 100X attenuation when using an oscilloscope. Total load capacitance (including probe capacitance) should be limited to 8.5 pF.

The input circuit RC network is tuned to produce peaking when driven from a 50Ω source.

## Thermal Considerations

The LH2422 and LH2424 require that the package be heatsunk for proper operation under any condition. Maximum ratings require that the device case temperature be limited to 90°C maximum. Thus at 50°C maximum ambient temperature and 6W maximum power dissipation, the thermal resistance of the heat sink should be less than (90−50)°C/6W = 6.7°C/W. Several approaches to heat sinking may be taken. The simplest is a sheet of aluminum with a volume of 4 cubic inches or an area of 32 sq. inches and a thickness of 0.125 inches.

Commercially available heatsinks such as Thermalloy 15509 extrusion would result in size reduction. *Figures 2* and *3* show the two approaches for proper heat sinking. Note that an aluminum spacer must be placed between the package and the heatsink block so as to prevent the device output from being shorted to ground. In the absence of a series current limiting resistor at the output, the device will be destroyed if the output is inadvertently shorted to ground or V+.




*C1 = 60 pF for LH2422
C1 = 90 pF for LH2424

**FIGURE 1. Typical AC Test Circuit**

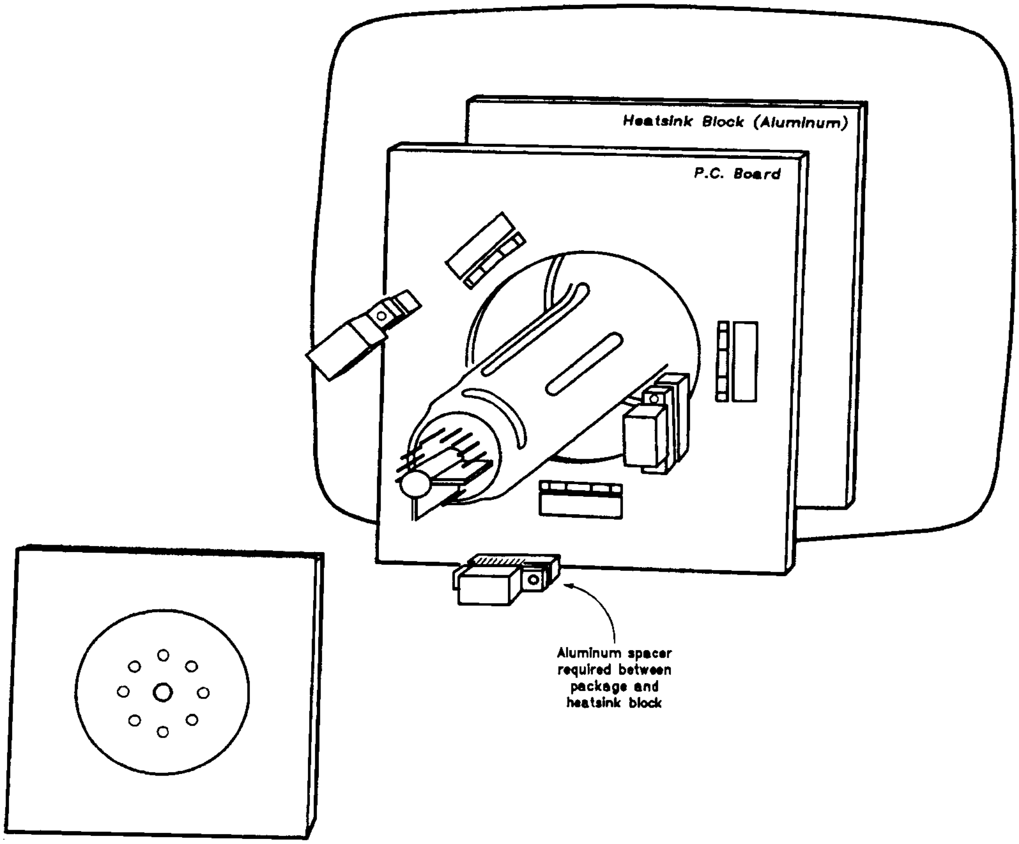



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**FIGURE 2. Heat Sinking with an Aluminum Block**

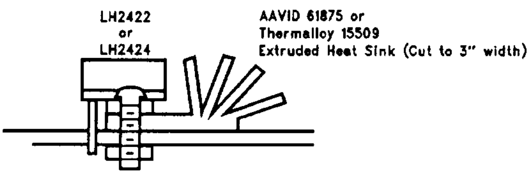


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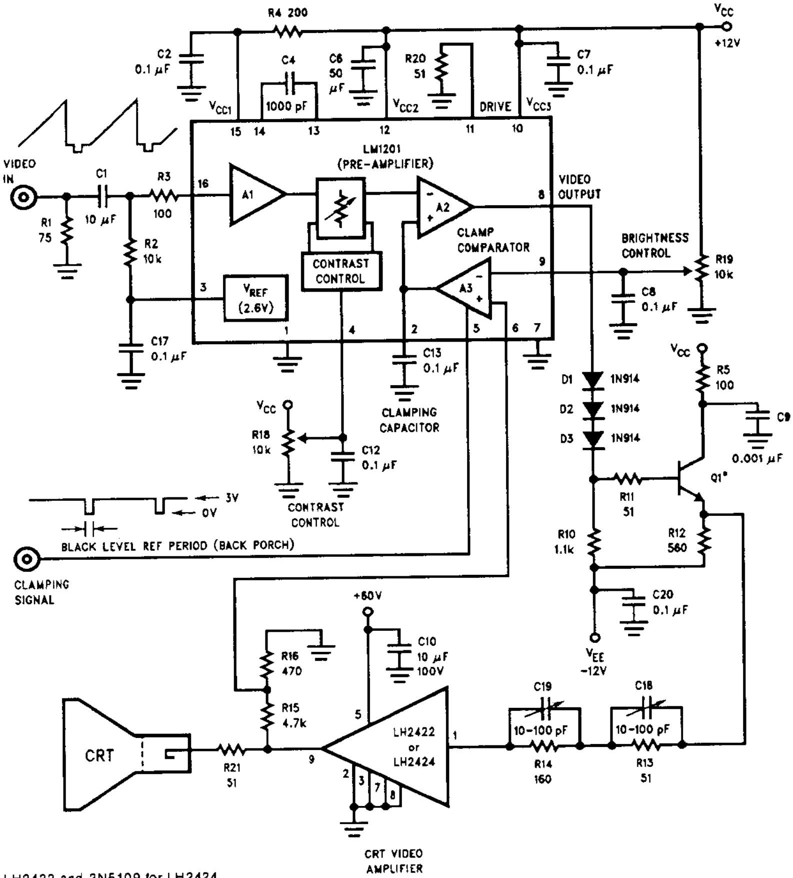
**FIGURE 3. Heat Sinking with the Thermalloy 15509 Extrusion**

## Application Circuits




*Q1 is 2N5770 for LH2422 and 2N5109 for LH2424.

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**FIGURE 4. Circuit shows how the LM1201 pre-amplifier and LH2422/LH2424 CRT Video Amplifier may be used to build a 100 MHz Monochrome Monitor**

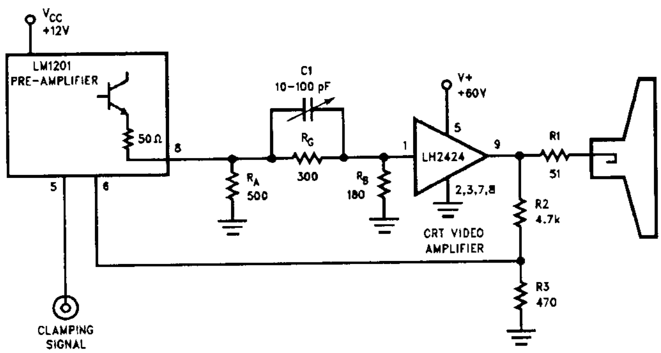


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**FIGURE 5. Circuit shows a simple RC interface network which eliminates the need for a level shift stage and additional $V_{EE}$ supply of *Figure 4*.**

## Evaluation Board

The evaluation board is intended to demonstrate the capabilities of the LH2422 CRT Video Amplifier. The board may be used to interface the amplifier to a CRT display or to evaluate the frequency response or pulse response in a 50Ω system.

*Figure 6* shows the schematic of the LH2422 evaluation board. R1 sets the overall gain of the fixture. The test circuit used 220Ω to provide a gain of 13.5. C1 is a 10 pF–100 pF variable capacitor. Adjust this capacitor to optimize pulse response.

A large bypass capacitor, C2, is needed to reduce lower frequency ringing caused by the power supply wires.

The input is designed to be fed from a 50Ω generator, however, the input impedance at $V_{IN}$ is not well matched to 50Ω and if a long cable is used between the generator and the input, reflections will occur giving unpredictable responses. Two things can be done to get around this problem:

1. Use a very short connector (less than 2 inches) between the generator and the input.
2. Use a 6 dB pad between the cable and the input. This will reduce reflections and provide a 50Ω source to the circuit board.

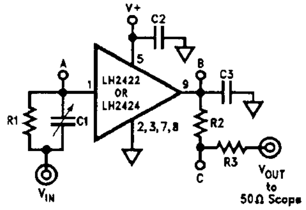


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**FIGURE 6. Schematic of LH2422 Evaluation Circuit**

The output of the amplifier can drive the CRT cathode directly from point B, while R2 and R3 are used as a 100 to 1 (40 dB) attenuator to a 50Ω scope or network analyzer input. Two resistors are used in series to reduce capacitance and attempt to compensate the frequency response. The layout of the board *(Figure 7)* includes a trace at point C to connect R2 and R3; unfortunately, the capacitance to ground at this point is about 0.6 pF, enough to cause a 20% bandwidth reduction in the response of the attenuator resistors. The resistors should be wired "floating" above the board.

Capacitor C3 is used to simulate the input capacitance at the CRT cathode. The board exhibits about 4.5 pF at the output node of the LH2422. A capacitor of 4 pF will increase it to the specified value of 8.5 pF.

**PARTS LIST**

RESISTORS:

R1 220Ω, ¼W, 5%

R2 2.2 kΩ, ¼W, 5%

R3 2.7 kΩ, ¼W, 5%

CAPACITORS:

C1 10 pF – 120 pF (muRata ERIE P/N TZ03R121E)

C2 10 μF, 100V, 10%

C3 4 pF, 50V, 10%

HARDWARE:

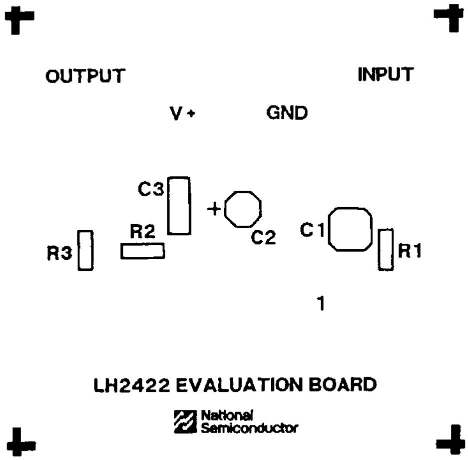
BNC CONNECTORS (KINGS P/N KC-79-237-MO6)

BANANA JACKS (JOHNSON P/N 108-09XX-001)

HOLTITE SOCKET (AUGAT P/N 8134-HC-5P2)

## Evaluation Board (Continued)

(a) Component Placement Guide

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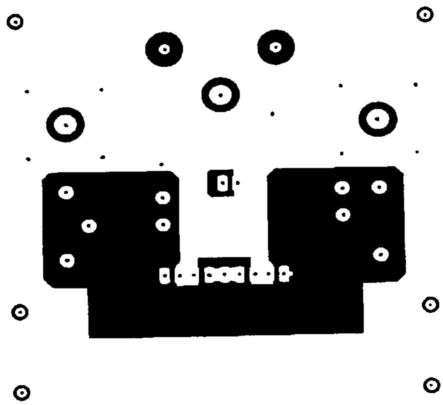
(b) Component (Top) Side



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(c) Solder (Bottom) Side

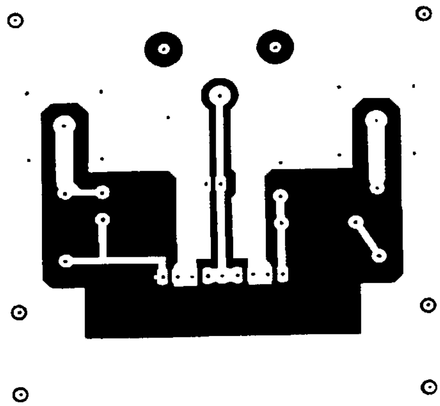

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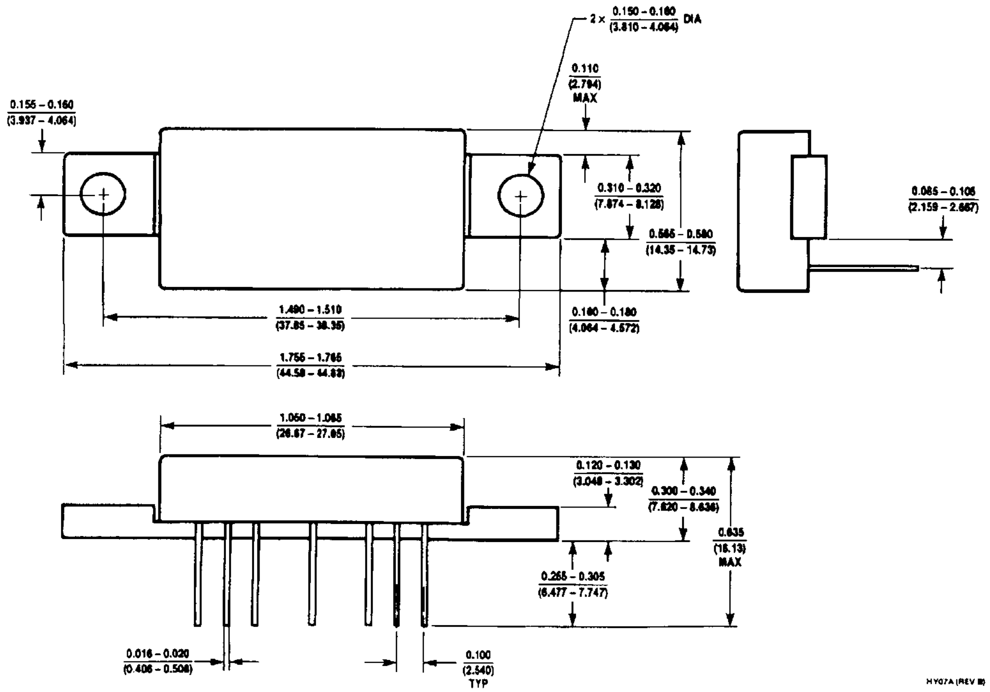
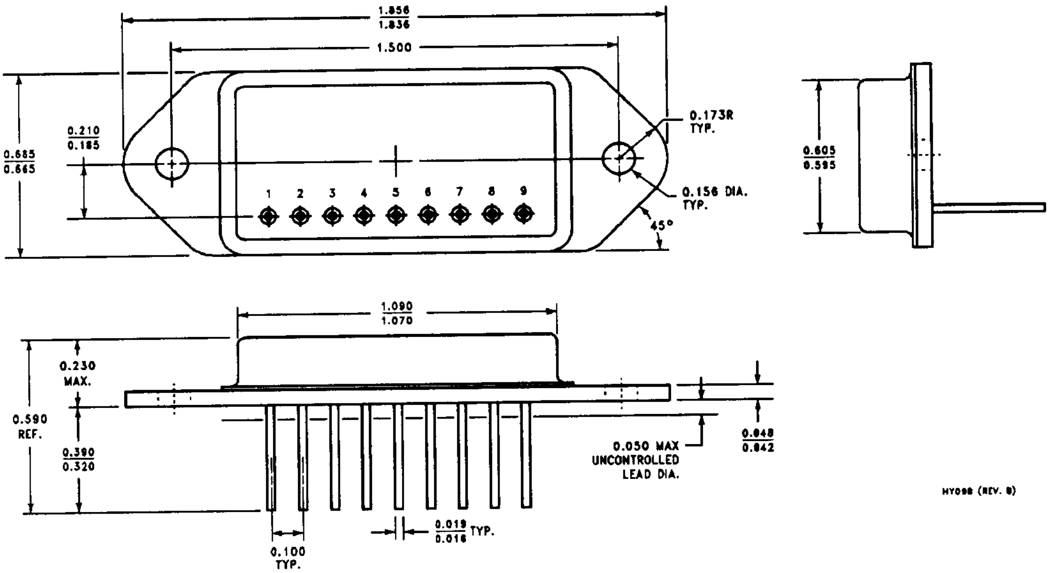
**FIGURE 7. PC Board Layout and Component Placement Guide**

## Physical Dimensions inches (millimeters)



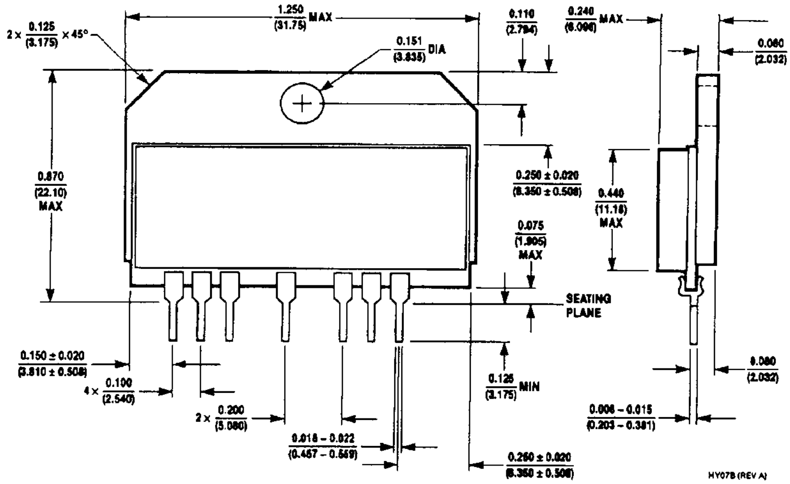

**7-Lead SIP Hybrid Package (J)**
**Order Number LH2422AJ or LH2424AJ**
**NS Package Number HY07A**

## Physical Dimensions inches (millimeters) (Continued)




**9-Lead Hybrid Metal Can (D)**
**Order Number LH2422D-MIL**
**NS Package Number HY09B**

## Physical Dimensions inches (millimeters) (Continued)




**9-Lead Single-In-Line Package (S)**
**Order Number LH2422S or LH2424S**
**NS Package Number HY07B**

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