

## LM2485

# 220V Triple Bias Clamp with G1 Blank Amplifier

### General Description

The LM2485 is a triple channel clamp amplifier used to DC restore the AC coupled outputs of a DTV CRT driver and for cut-off adjustment. The LM2485 also has an integrated blanking amplifier that can be used to drive the G1 grid of a CRT negative for vertical retrace blanking. The blanking output has a selectable pulse amplitude of either 20V<sub>P-P</sub> or 40V<sub>P-P</sub> via the Pin 13 option. The blanking input pulse can be generated from a vertical flyback pulse or by a microcontroller.

The LM2485 can operate with a V<sub>CC</sub> supply of up to 220V and a V<sub>BB</sub> supply of either 8V or 12V. This V<sub>BB</sub> option, selectable via the Pin 12 option, ensures the LM2485 is compatible with any National Semiconductor DTV CRT driver sharing the same operating voltages in the application.

The IC is packaged in an industry standard 24-lead molded plastic dual-in-line package to meet high voltage spacing requirements.

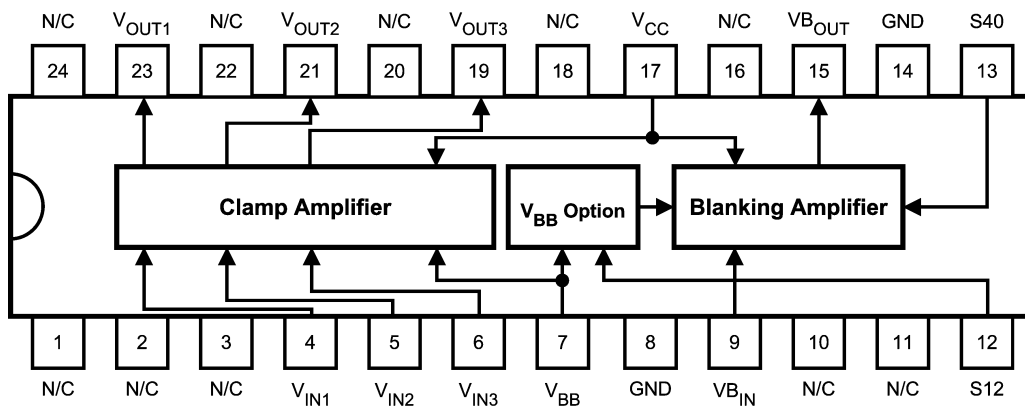
### Features

- V<sub>CC</sub> capable of up to 220V
- V<sub>BB</sub> selectable to 8V or 12V via Pin 12 option
- Wide bias output voltage range of over 100V
- Inverted output pulse suitable for G1 blanking, selectable to 20V<sub>P-P</sub> or 40V<sub>P-P</sub> via Pin 13 option

### Applications

- AC coupled CRT applications using DTV formats up to 1080i
- Well-matched to the NSC LM12XX Family of Preamplifiers and LM242X/3X/5X Family of DTV CRT Drivers

### Pinout and Internal Block Diagram



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FIGURE 1. Top View  
Order Number LM2485NA  
See NS Package Number N24C

**Absolute Maximum Ratings** (Notes 1,

3)

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

Supply Voltage, $V_{CC}$	250V
Bias Voltage, $V_{BB}$	15V
Input Voltage, $V_{IN}$	-0.5V to +6.5V
Blanking Input Voltage, $VB_{IN}$	-0.5V to +6.5V
Storage Temperature Range, $T_{STG}$	-65°C to +150°C
Lead Temperature (Soldering, <10sec.)	300°C
ESD Tolerance	
Human Body Model	2 kV
Machine Model	200V

Max Junction Temperature	150°C
$\theta_{JA}$ (Max at 0 LFPM)	68°C/W

**Operating Ranges** (Note 3)

$V_{CC}$	170V to 230V
$V_{BB}$ (Pin 12 floated)	7.5V to 8.5V
$V_{BB}$ (Pin 12 grounded)	11.5V to 12.5V
$V_{IN}$	0V to 5V
$V_{OUT}$	105V to 215V
$VB_{IN}$	0V to 5V
$VB_{OUT}$ ( $V_{CC} = 220V$ )	40V to 80V
$VB_{OUT}$ ( $V_{CC} = 180V$ )	25V to 65V
Ambient Temperature Range, $T_A$	-20°C to $T_{AMAX}$ (Note 5)

**Electrical Characteristics**

(See Figure 2 and Figure 3 for Test Circuits)

Unless otherwise noted:  $V_{CC} = 220V$ ,  $V_{BB} = 8V$ ,  $V_{IN} = 2.5V_{DC}$ ,  $T_A = 20^\circ C$ , Pin 12 floated, Pin 13 grounded.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$I_{CC}$	Supply Current	All channels, not including pull-up resistor currents		3.1	4.2	mA
$I_{BB-8}$	Bias Supply Current	All channels, $V_{BB} = 8V$		6.0	10.0	mA
$I_{BB-12}$	Bias Supply Current	All channels, Pin 12 grounded, $V_{BB} = 12V$		9.0	13.0	mA
$V_{OUT}$	Clamp Output Voltage		170	175	180	$V_{DC}$
$V_{OUT-Range}$	Clamp Output Voltage Range	$V_{IN-Range} = 1.5V$ to 4.5V		75		V
$A_V$	Clamp Output DC Voltage Gain	$1.0V \leq V_{IN} \leq 5.0V$	-23	-25	-27	V/V
LE	Clamp Output Linearity Error	(Note 4)		5		%
$VB_{OUT-High}$	Blanking Output High Level	$VB_{IN} \leq 0.5V$		80		$V_{DC}$
$VB_{OUT-Low1}$	Blanking Output Low Level 1	$VB_{IN} \geq 4.5V$ , Pin 13 floated		60		$V_{DC}$
$VB_{OUT-Low2}$	Blanking Output Low Level 2	$VB_{IN} \geq 4.5V$		40		$V_{DC}$
$t_R$	Blanking Output Rise Time	$VB_{IN} = 0V-5V$ Logic Pulse at 8.6% duty cycle (480p), $VB_{OUT} = 40V_{P-P}$ (40V-80V)		2.0		us
$t_F$	Blanking Output Fall Time	$VB_{IN} = 0V-5V$ Logic Pulse at 8.6% duty cycle (480p), $VB_{OUT} = 40V_{P-P}$ (40V-80V)		4.5		us

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.

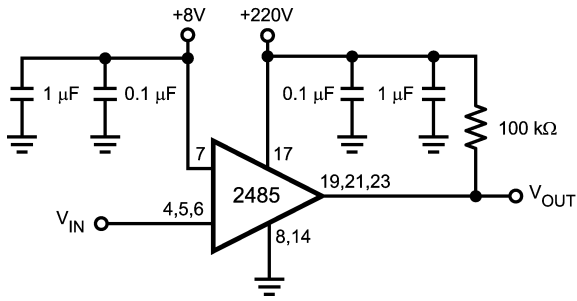
**Note 2:** Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and the test conditions, see the Electrical Characteristics. Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may change when the device is not operated under the listed test conditions.

**Note 3:** All voltages are measured with respect to GND, unless otherwise specified.

**Note 4:** Linearity Error is the variation in DC gain from  $V_{IN} = 1.0V$  to 5.0V measured at the points 1.0V, 1.5V, 4.5V, and 5.0V.

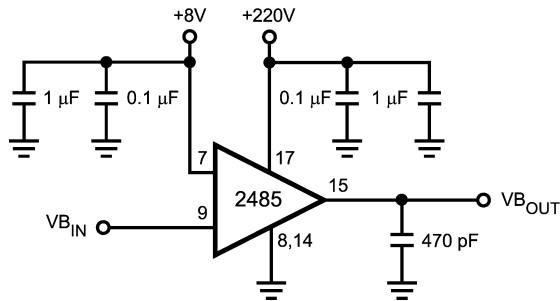
**Note 5:** See Section *THERMAL CONSIDERATIONS* to calculate  $T_{AMAX}$ .

## Test Circuits



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FIGURE 2. Clamp Amplifier Test Circuit



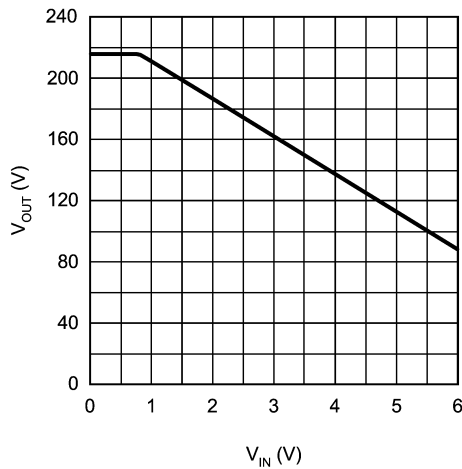
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FIGURE 3. Blanking Amplifier Test Circuit

Figure 2 shows the test circuit used to evaluate the LM2485 clamp amplifier. A high impedance voltmeter ( $>10M\Omega$ ) is used to measure the DC voltages at the  $V_{OUT}$  output pins. Figure 3 shows the test circuit used to evaluate the LM2485 blanking amplifier. An oscilloscope and a scope probe are used to measure the pulse amplitude at the  $V_{B_{OUT}}$  output pin.

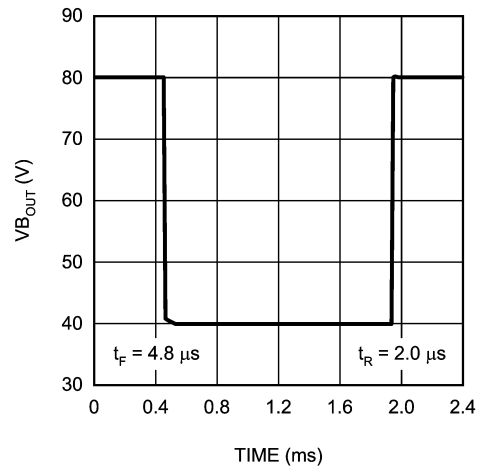
## Typical Performance Characteristics

( $V_{CC} = 220V$ ,  $V_{BB} = 8V$ ,  $V_{B_{IN}} = 0V-5V$  Logic Pulse at 8.6% duty cycle, Pin 12 floated, Pin 13 grounded, Test Circuits - Figure 2 and Figure 3)



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FIGURE 4.  $V_{OUT}$  vs.  $V_{IN}$



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FIGURE 5.  $V_{B_{OUT}}$  (40V<sub>P-P</sub>)

## Theory of Operation

The pinout and internal block diagram of the LM2485 is shown in *Figure 1*.

The LM2485 is a triple channel bias clamp amplifier used to DC restore the AC coupled outputs of a DTV CRT driver and for cut-off adjustment. The clamp circuit amplifies the DC inputs,  $V_{IN}$ , by the internally fixed gain of  $-25$ . Each DC clamp output,  $V_{OUT}$ , will require a pull-up resistor to  $V_{CC}$ . The clamp DC transfer function is shown in *Figure 4*.

The LM2485 also has an integrated blanking amplifier that takes a positive-going 5V input pulse,  $VB_{IN}$ , and outputs a negative-going pulse,  $VB_{OUT}$ , with a selectable amplitude of either  $20V_{P-P}$  or  $40V_{P-P}$  via the Pin 13 (S40) option. If Pin 13 is floated, the  $VB_{OUT}$  pulse amplitude is  $20V_{P-P}$ ; if Pin 13 is grounded, the amplitude is  $40V_{P-P}$  (see *Figure 5*). With a simple clamp circuit, this inverted pulse can be used to drive the G1 grid of a CRT negative to blank the horizontal retrace lines during the vertical flyback period. The input pulse can be generated from a vertical flyback pulse or by a microcontroller.

The LM2485 can operate with a  $V_{CC}$  supply of up to 220V and a selectable  $V_{BB}$  supply of either 8V or 12V via the Pin 12 (S12) option. If Pin 12 is floated, then 8V is expected at the  $V_{BB}$  pin; if Pin 12 is grounded, then 12V is expected. This  $V_{BB}$  option ensures the LM2485 is compatible with any National Semiconductor DTV CRT driver sharing the same operating voltages in the application. Note that using a  $V_{BB}$  supply of 12V will increase the input offset of the clamp circuit, which would have the effect of shifting the DC transfer function slightly to the right. Also, if the  $V_{BB}$  option is incorrectly matched to the actual  $V_{BB}$  supply voltage, an incorrect  $VB_{OUT}$  amplitude will be produced. Therefore, it is important to ensure that the appropriate  $V_{BB}$  option is used and the  $V_{BB}$  supply is within the range stated in the *Section Operating Ranges*.

## Application Information

### INTRODUCTION

National Semiconductor (NSC) is committed to provide application information that assists our customers in obtaining the best performance possible from our products. The following information is provided in order to support this commitment. The reader should be aware that the optimization of performance was done using a specific printed circuit board designed at NSC. Variations in performance can be realized due to physical changes in the printed circuit board and the application. Therefore, the designer should know that component value changes may be required in order to optimize performance in a given application. The values shown in this document can be used as a starting point for evaluation purposes.

### POWER SUPPLY BYPASS

The LM2485 should have proper power supply bypassing for optimal arc protection and performance. A 0.1  $\mu\text{F}$  capacitor should be connected from each of the supply pins,  $V_{CC}$  and  $V_{BB}$ , to ground, as close to the supply and ground pins as possible. Additionally, a 1  $\mu\text{F}$  electrolytic capacitor should be connected from each supply to the LM2485 ground and placed reasonably close to both supply pins.

### ARC PROTECTION

During normal CRT operation, internal arcing may occasionally occur. To protect the LM2485 against arcing, it is important that the recommended applications circuit is used and good layout practices are followed. Please refer to the *Section NSC Demonstration Board* for a detailed example on arc protection and PCB layout considerations.

### THERMAL CONSIDERATIONS

#### Determining Maximum Power Dissipation and Ambient Temperature

Power dissipation within an integrated circuit package is a very important parameter. An incorrect maximum power dissipation calculation may result in excessive thermal stress to the device, affecting its reliability and performance. To estimate the maximum power dissipation of the LM2485, the following system parameters should be determined first.

- Maximum  $V_{CC}$  and  $V_{BB}$  supply voltages
- Average CRT cut-off voltages
- Maximum average beam currents
- Highest duty cycle

Once these parameters are known, the system designer can then calculate the maximum ambient temperature surrounding the LM2485 without a heat sink. A small, low-cost heat sink may be used if the calculated maximum ambient temperature does not satisfy the worst-case operating temperature inside the TV.

The following example shows how to determine the maximum power dissipation and maximum ambient temperature and assumes the recommended application circuit is used (see *Figure 6*).

#### Example

The LM2485 uses 1.0W of static power from the 220V and 8V supplies, assuming the worst-case supply currents. If the average CRT cut-off voltage of all channels is 180V and each LM2485 output sinks a maximum average beam current of 1.0 mA at 77% duty cycle (480p format) at the highest brightness setting, the LM2485 will dissipate:

$$P_{DISS} = P_{STATIC} + 3 \times (V_{CUT-OFF} \times I_{AVGMAX}) \times \delta, \text{ or}$$

$$P_{DISS} = 1.0W + 3 \times (180V \times 1.0 \text{ mA}) \times 0.77 = 1.42W.$$

The maximum thermal resistance from junction-to-air,  $\theta_{JA}$ , and maximum junction temperature,  $T_{JMAX}$ , are stated in the *Section Absolute Maximum Ratings*. Therefore, the maximum ambient temperature surrounding the LM2485 can be calculated:

$$T_{AMAX} = T_{JMAX} - (P_{DISS} \times \theta_{JA}), \text{ or}$$

$$T_{AMAX} = 150^{\circ}\text{C} - (1.42W \times 68^{\circ}\text{C/W}) = 53^{\circ}\text{C}.$$

### TYPICAL APPLICATION

Used in conjunction with NSC's LM12XX Preamplifier and LM24XX CRT Driver, a complete analog video solution from the preamplifier input to the CRT cathode can be achieved. The LM2485 can support any AC coupled DTV application using formats up to 1080i with proper selection of a preamplifier and CRT drivers.

## NSC Demonstration Board

Figure 6 shows the recommended application schematic for the NSC Demonstration Board that can be used to evaluate the LM2423/LM2485 AC coupled solution in a Direct-View CRT Digital TV application. Figure 7 shows the routing and component placement on the NSC LM2423/LM2485 Demonstration Board. This board provides a good example of a PCB layout that was designed for robust arc protection and optimal video performance.

### PCB LAYOUT CONSIDERATIONS

Note that the NSC Demonstration Board complies with the layout guidelines outlined below. For convenience, the component names are shown in parenthesis to cross-reference with the schematic and layout images provided.

#### Power Supplies and Grounds

- 0.1 $\mu$ F bypass capacitors (C3 and C6) should be placed very close to  $V_{BB}$  and  $V_{CC}$  of the LM2485. These capacitors should have a short, direct return to the LM2485 ground.
- 1 $\mu$ F electrolytic capacitors (C1 and C2) should also be placed reasonably close to both supply pins.
- GND Pins 8 and 14 should connect to a solid ground plane under the LM2485. The LM2485 ground plane should connect directly to the CRT Driver ground at one point (above C21). Do not connect the LM2485 ground plane directly to CRT ground to protect the LM2485 from arcing.

#### Inputs

- The LM2485 input traces should be routed away from all output traces of the CRT Driver. This will help protect the video preamplifier and LM2485 from high frequency, large amplitude video coupling and potential damage from arcing at the cathodes.
- If the LM2485 inputs are coming from the main board, 0.1 $\mu$ F capacitors (C4, C5, C7) should be placed at the  $V_{IN}$  pins of the input connector. If a LM12XX preamplifier is placed on the neck board, these 0.1 $\mu$ F capacitors should be placed very close to its DAC output pins to protect it during arcing. In both cases, these capacitors should be connected to the LM2485 ground and should not be connected directly to CRT ground.
- 1k $\Omega$  series resistors (R1, R3, R4) should be placed close to the  $V_{IN}$  pins and a small resistor may also be placed close to the  $V_{B_{IN}}$  pin. These resistors will protect the preamplifier in the event that the LM2485 fails.

#### Outputs

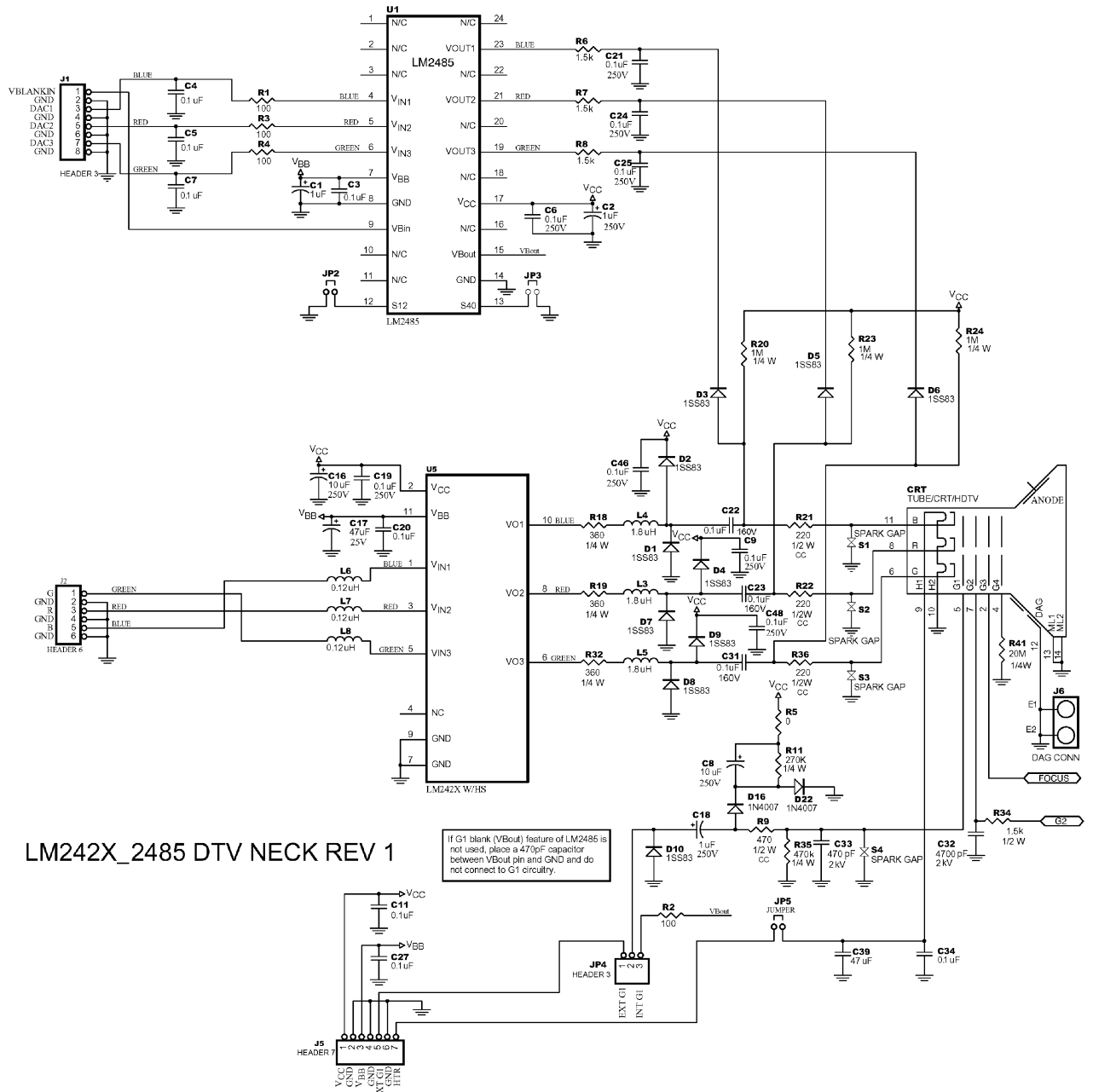
- 1.5k $\Omega$  resistors (R6, R7, R8) and 0.1 $\mu$ F capacitors (C21, C24, C25) should be placed near the  $V_{OUT}$  pins to limit the current and voltage surges on the outputs during an arc event. These bypass capacitors should have a short, direct return to the LM2485 ground.

- Because the clamp outputs carry DC, the clamp output traces routed to each AC coupled video output can be long. Avoid cutting a ground trace(s) simply to route clamp output traces and use wire jumpers, if necessary.
- Clamp diodes (D3, D5, D6) and pull-up resistors (R20, R23, R24) should be placed closest to the video output traces to minimize the size of the video nodes and reduce parasitic capacitance on the video outputs. The clamp diodes must be 1SS83 or equivalent diodes; do not use 1N4148 type diodes. These diodes must have a fast transient response, low shunt capacitance, low series impedance, and a high peak current rating to clamp the video output voltage to the  $V_{CC}$  supply during an arc event.
- 0.1 $\mu$ F bypass capacitors (C46, C48, C9) should be placed very close to the 1SS83 type arc protection diodes (D1/D2, D4/D7, D8/D9) between  $V_{CC}$  and ground. The ground connection should have a short, direct path to CRT ground. Therefore, arc currents shunted by the protection diodes can return to the CRT DAG (J6).
- 300V spark gaps (S1, S2, S3, S4) are strongly recommended and should be placed very close to the cathode and G1 pins and grounded directly to the CRT ground plane, so arc current can return to the nearby CRT DAG. Spark gaps help to minimize voltage stress on the CRT Driver and LM2485.
- If the G1 blanking feature is used, all G1 circuit components should be placed as close as possible to the G1 pin of the CRT connector, with the exception of a small resistor (R2) placed close to the  $V_{B_{OUT}}$  pin to limit any current toward the LM2485. The sequence of circuit components from the  $V_{B_{OUT}}$  pin to the G1 pin is recommended to protect the LM2485 against arcing. All these components must be grounded directly to the CRT ground plane. Therefore, arc currents can easily return to the CRT DAG. Do not omit any of the components in the G1 circuit as they are required to protect the LM2485 against arcing and for correct G1 blank operation.
- If the G1 blanking feature is not used, simply place a 470pF capacitor from the  $V_{B_{OUT}}$  pin to LM2485 ground and do not connect the output to the G1 circuitry.

#### Pin Options and No Connects

- Depending on the pin options required, Pin 12 and Pin 13 can be connected to ground via a ground plane, trace, or jumper wire. See the *Section Theory of Operation* to determine the appropriate pin option for the application.
- The "No Connect" or N/C pins (pins 16, 18, 20, 22, 24) are not connected to the die internally in order to achieve larger spacing between the high voltage  $V_{CC}$  and  $V_{OUT}$  pins. These N/C pins should not be used to route other traces through.

# NSC Demonstration Board (Continued)



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FIGURE 6. NSC Demonstration Board — Recommended Application Schematic

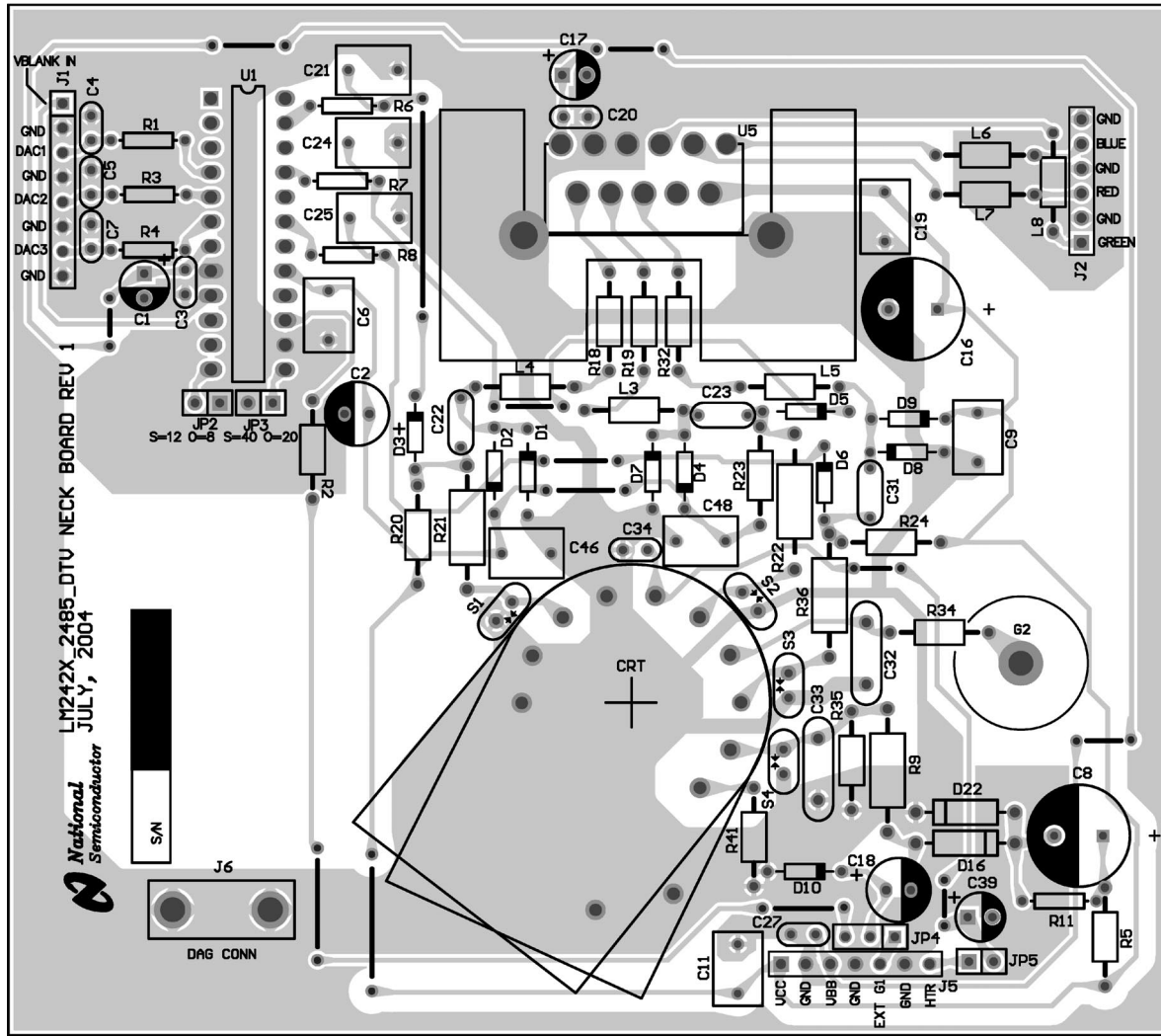
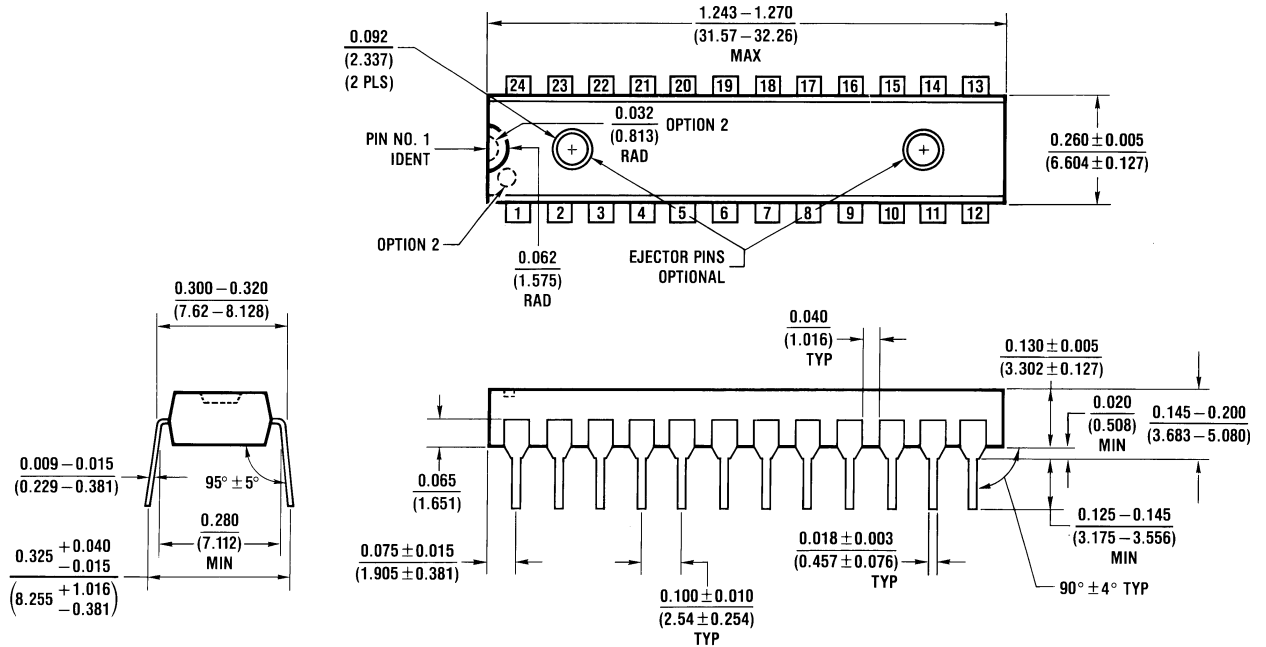


FIGURE 7. NSC Demonstration Board — PCB Layout

## Physical Dimensions inches (millimeters)

unless otherwise noted



N24C (REV F)

Note: Information contained in this data sheet is preliminary and may be subject to change without notice.

**Molded Dual-In-Line Package**  
**Order Number LM2485NA**  
**NS Package Number N24C**

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