August 1995, Rev. A FN7040

100MHz DC-Restored Video Amplifier

The EL2090 is the first complete DC-restored monolithic video amplifier sub-system. It contains a very high-quality video amplifier and a nulling sample-and-hold amplifier specifically designed to stabilize video performance. When the HOLD logic input is set to a logic 0 during a horizontal sync, the sample-and-hold amplifier may be used as a general-purpose op-amp to null the DC offset of the video amplifier. When the HOLD input goes to a logic 1 the sample-and-hold stores the correction voltage on the hold capacitor to maintain DC correction during the subsequent scan line.

The video amplifier is optimized for video characteristics, and performance at NTSC is nearly perfect. It is a current-feedback amplifier, so that -3dB bandwidth changes little at various closed-loop gains. The amplifier easily drives video signal levels into 75Ω loads. With 100MHz bandwidth, the EL2090 is also useful in HDTV applications.

The sample-and-hold is optimized for fast sync pulse response. The application circuit shown will restore the video DC level in five scan lines, even if the HOLD pulse is only 2µs long. The output impedance of the sample-and-hold is low and constant over frequency and load current so that the performance of the video amplifier is not compromised by connections to the DC restore circuitry.

The EL2090 is fabricated in Elantec's proprietary Complementary Bipolar process which produces NPN and PNP transistors with equivalent AC and DC performance. The EL2090 is specified for operation over the 0°C to 75 °C temperature range.

Features

- Complete video level restoration system
- 0.01% differential gain and 0.02° differential phase accuracy at NTSC
- 100MHz bandwidth
- 0.1dB flatness to 20MHz
- Sample-and-hold has 15nA typical leakage and 1.5pC charge injection
- System can acquire DC correction level in 10µs, or 5 scan lines of 2µs each, to 1/2 IRE
- V_S = ±5V to ±15V
- TTL/CMOS hold signal

Applications

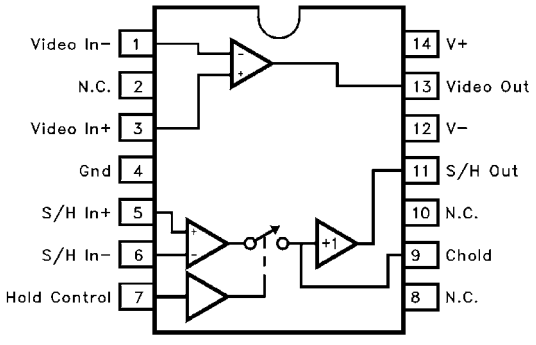
- Input amplifier in video equipment
- Restoration amplifier in video mixers

Ordering Information

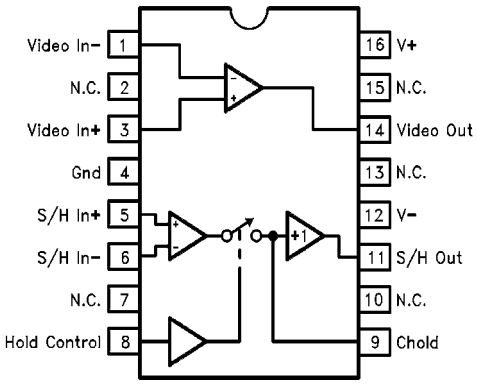
PART NUMBER	TEMP. RANGE	PACKAGE	PKG. NO.
EL2090CN	0℃ to +75°C	14-Pin PDIP	MDP0031
EL2090CM	0℃ to +75°C	16-Pin SOL	MDP0027

Pinouts

EL2090
(14-PIN DIP)
TOP VIEW



EL2090
(16-PIN SOL)
TOP VIEW



Absolute Maximum Ratings (T_A = 25°C)

Voltage between V+ and V- 36V
Voltage between V_{IN}+, S/H_{IN}+, S/H_{IN}-, C_{HOLD}, and GND pins (V+) . . . . . +0.5V to (V-) -0.5V
V_{OUT} Current 60mA
Current into V_{IN}- and HOLD Pins 5mA
Current S/H_{OUT} 16mA
Internal Power Dissipation . . . . . See Curves
Operating Ambient Temperature Range . . . . . 0°C to 7 5°C
Operating Junction Temperature Plastic DIP or SOL. . . . . 150°C
Storage Temperature Range . . . . . .-65°C to +15 0°C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

IMPORTANT NOTE: All parameters having Min/Max specifications are guaranteed. Typical values are for information purposes only. Unless otherwise noted, all tests are at the specified temperature and are pulsed tests, therefore: $T_J = T_C = T_A$

Open-Loop DC Electrical Specifications

V_S = ±15V; R_L = 150Ω, T_A = 25° C unless otherwise specified

PARAMETER	DESCRIPTION		TEMP	MIN	TYP	MAX	UNITS
I_S	Total Supply Current		Full		14	17	mA
VIDEO AMPLIFIER SECTION (NOT RESTORED)							
V_{OS}	Input Offset Voltage		Full		8	70	mV
I_{B+}	$+V_{IN}$ Input Bias Current		Full		2	15	µA
I_{B-}	$-V_{IN}$ Input Bias Current		Full		30	150	µA
R_{OL}	Transimpedance		25°C		300		V/mA
A_{VOL}	Open-Loop Voltage Gain; V_{OUT} = ±2V		Full	56	65		dB
V_O	Output Voltage Swing	V_S = ±15V; R_L = 2kΩ	Full	±12	±13		V
		V_S = ±5V; R_L = 150Ω	Full	±3.0	±3.5		V
I_{SC}	Short-Circuit Current; $+V_{IN}$ Set to ±2V; $-V_{IN}$ to Ground through 1kΩ		25°C	±50	±90	±160	mA
SAMPLE-AND-HOLD SECTION							
V_{OS}	Input Offset Voltage		Full		2	10	mV
I_B	Input Bias Current		Full		0.5	2.5	µA
I_{OS}	Input Offset Current		Full		0.05	0.5	µA
$R_{IN, DIFF}$	Input Differential Resistance		25°C		200		kΩ
$R_{IN, COMM}$	Input Common-Mode Resistance		25°C		100		MΩ
V_{CM}	Common-Mode Input Range		Full	±11	±12.5		V
SAMPLE-AND-HOLD SECTION							
A_{VOL}	Large Signal Voltage Gain		Full	15k	50k		V/V
CMRR	Common-Mode Rejection Ratio; V_{CM} = ±11V		Full	75	95		dB
PSRR	Power-Supply Rejection Ratio; V_S = ±5V to ±15V		Full	75	95		dB
V_{THRESH}	HOLD Pin Logic Threshold		Full	0.8	1.4	2.0	V
I_{DROOP}	Hold Mode Droop Current		Full		10	50	nA
I_{CHARGE}	Charge Current Available to Chold		Full	±90	±135		µA
V_O	Output Swing; R_L = 2k		Full	±10	±13		V
I_{SC}	Short-Circuit Current		25°C	±10	±17	±40	mA

Closed-Loop AC Electrical Specifications V_S = ±15V; C_L = 15pF; C_{STRAY} ($-V_{IN}$) = 2.5pF; R_F = R_G = 300Ω; R_L = 150Ω; C_{HOLD} = 100pF; T_A = 25°C

PARAMETER	DESCRIPTION		MIN	TYP	MAX	UNITS
VIDEO AMPLIFIER SECTION						
SR	SlewRate; V_{OUT} from -2 to +2V			600		V/µs
BW	Bandwidth;	-3dB	75	100		MHz
		±1dB	35	60		MHz
		±0.1dB	10	20		MHz
dG (Peaking)	Differential Gain; V_{IN} from -0.7V to 0.7V; F = 3.58MHz			0.01		%
dθ (Peaking)	Differential Phase; V_{IN} from -0.7V to 0.7V; F = 3.58MHz			0.02		°
SAMPLE-AND-HOLD SECTION						
BW	Gain-Bandwidth Product			1.3		MHz
Q	Sample to Hold Charge Injection (Note 1)			1.5	5	pC
T	Sample to Hold or Hold to Sample Delay Time			20		ns
T_S	Sample to Hold Settling Time to 2mV			200		ns

NOTE:

1. The logic input is between 0V and 5V, with a 220Ω resistor in series with the HOLD pin and 39pF capacitor from HOLD pin to ground.

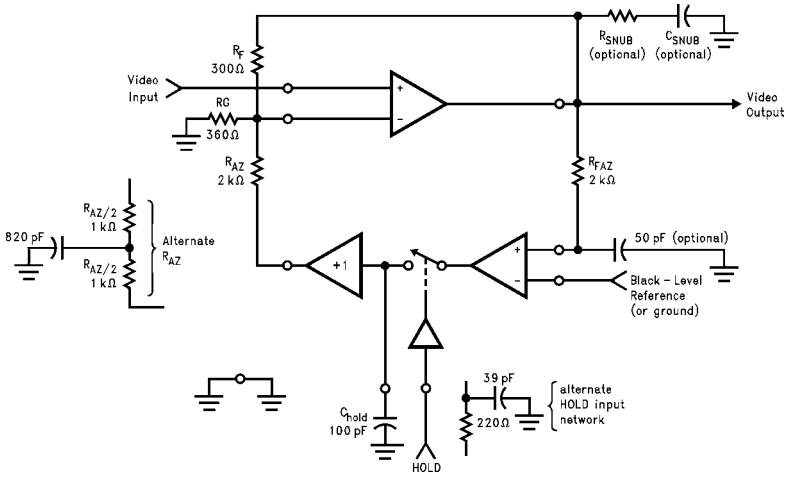
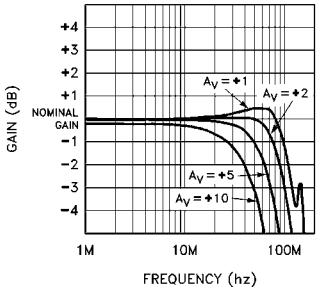


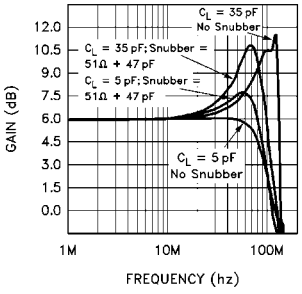
FIGURE 1. TYPICAL APPLICATION (A_V = +2)

Typical Performance Curves

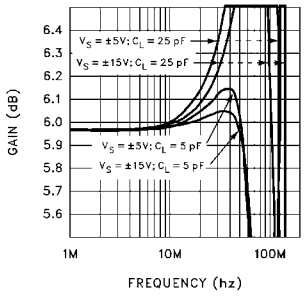
Relative Frequency Response for Various Gains



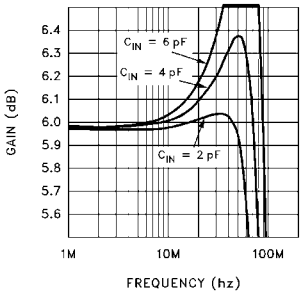
Frequency Response with Different Loads (A_V = +2)



Frequency Response Flatness for Various Load and Supply Conditions

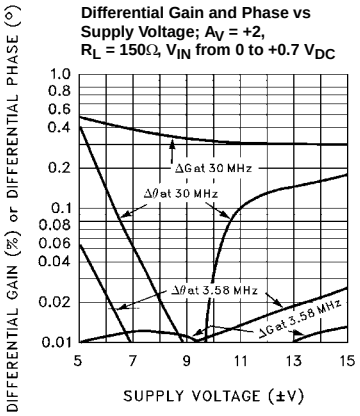


Frequency Response Flatness vs C_{IN-}, A_V = +2

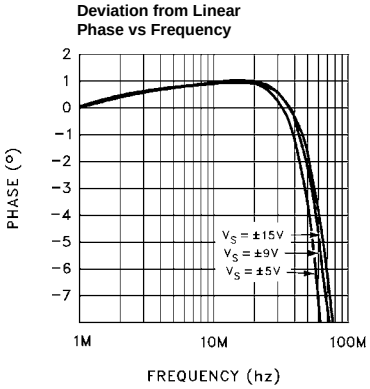


Typical Performance Curves (Continued)

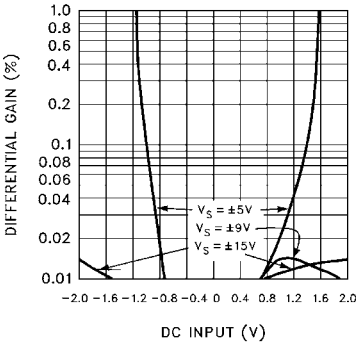
Differential Gain and Phase vs Supply Voltage; A_V = +2, R_L = 150Ω, V_{IN} from 0 to +0.7 V_{DC}



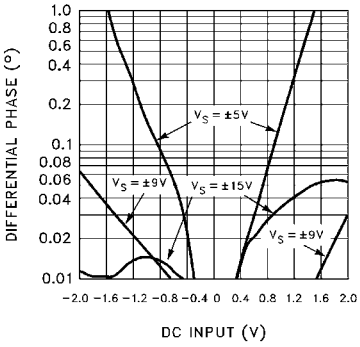
Deviation from Linear Phase vs Frequency



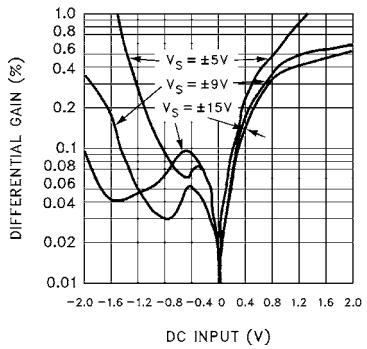
Differential Gain vs DC Input Offset; A_V = +2, F_O = 3.58MHz, R_L = 150Ω



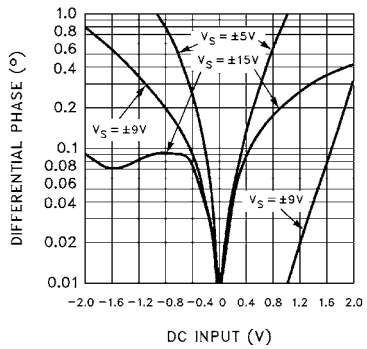
Differential Phase vs DC Input Offset; A_V = +2, F_O = 3.58MHz, R_L = 150Ω



Differential Gain vs DC Input Offset; A_V = +2 and F_O = 30MHz, R_L = 150Ω

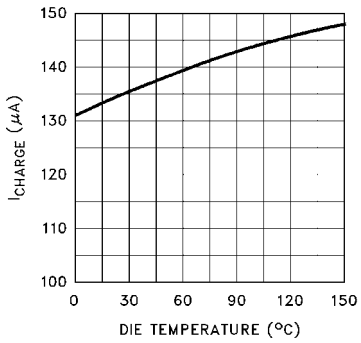


Differential Phase vs DC Input Offset; A_V = +2, F_O = 30MHz, R_L = 150Ω

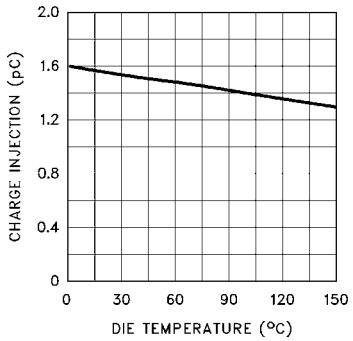


Typical Performance Curves (Continued)

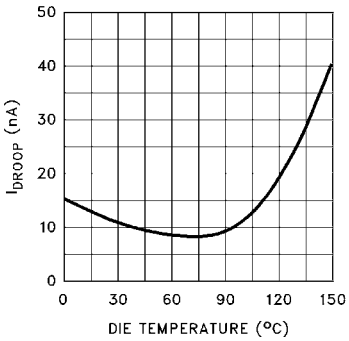
S/H Available Charge Current vs Temperature



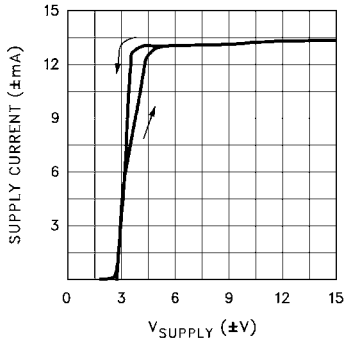
Sample-to-Hold Change Injection vs Temperature



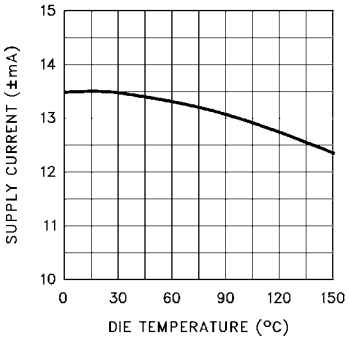
Typical Droop Current vs Temperature, V_S = ±15V



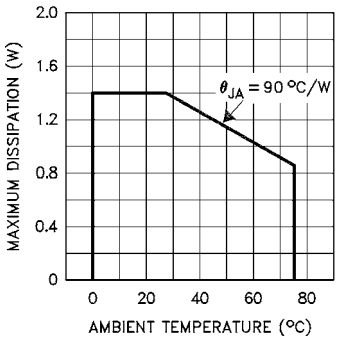
Supply Current vs Supply Voltage



Supply Current vs Temperature; V_S = ±15V



Maximum Power Dissipation vs Ambient Temperature— 14-Pin PDIP and 16-Pin SOL



Applications Information

The EL2090 is a general purpose component and thus the video amplifier and sample-and-hold pins are uncommitted. Therefore much of the ultimate performance as a DC-restored video amplifier will be set by external component values and parasitics. Some application considerations will be offered here.

The DC feedback from the sample-and-hold can be applied to either positive or negative inputs of the video amplifier (with appropriate phasing of the sample-and-hold amplifier inputs). We will consider feedback to the inverting video input. During a sample mode (the HOLD input at a logic low), the sample-and-hold acts as a simple nulling op-amp.

Ideally, the DC feedback resistor Raz is a high value so as not to couple a large amount of the AC signal on the video input back to the sample-and-hold amplifier output. The sample-and-hold output is a low impedance at high frequencies, but variations of the DC operating point will change the output impedance somewhat. No more than a few ohms output impedance change will occur, but this can cause gain variations in the 0.01% realm. This DC-dependent gain change is in fact a differential gain effect. Some small differential phase error will also be added. The best approach is to maximize the DC feedback resistor value so as to isolate the sample-and-hold from the video path as much as possible. Values of 1kΩ or above for Raz will cause little to no video degradation.

This suggests that the largest applicable power supply voltages be used so that the output swing of the sample-and-hold can still correct for the variations of DC offset in the video input with large values of Raz. The typical application circuit shown will allow correction of ±1V inputs with good isolation of the sample-and-hold output. Good isolation is defined as no video degradation due to the insertion of the sample-and-hold loop. Lower supply voltages will require a smaller value of DC feedback resistor to retain correction of the full input DC variation. The EL2090 differential phase performance is optimum at ±9V supplies, and differential gain only marginally improves above this voltage. Since all video characteristics mildly degrade with increasing die temperature, the ±9V levels are somewhat better than ±15V supplies. However, ±15V supplies are quite usable.

Ultimate video performance, especially in HDTV applications, can also be optimized by setting the black-level reference such that the signal span at the video amplifier's output is set to its optimum range. For instance, setting the span to ±1V of output is preferable to a span of 0V to +2V. The curves of differential gain and phase versus input DC offset will serve as guides.

The DC feedback resistor may be split so that a bypass capacitor is added to reduce the initially small sample-and-hold transients to even smaller levels. The corruption can be reduced to as low as 1mV peak seen at the video amplifier output. The size of the capacitor should not be so large as to de-stabilize the sample-and-hold feedback loop, nor so small as to reduce the video amplifier's gain flatness. A resistor or some other video isolation network should be inserted between the video amplifier output and the sample-and-hold input to prevent excessive video from bleeding through the autozero section, as well as preventing spurious DC correction due to video signals confusing the sample-and-hold during autozero events. Figure 1 shows convenient component values. A full 3.58MHz trap is not necessary for suppressing NTSC chroma burst interaction with the sample-and-hold input; the simple R-C network suggested in Figure 1 suffices.

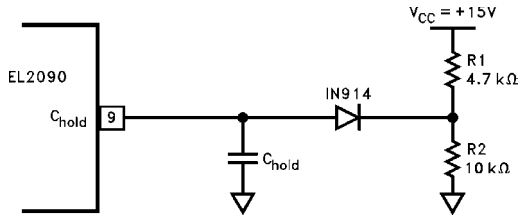
The HOLD input to the sample-and-hold has a 1.4V threshold and is clamped to a diode below ground and 6V above ground. The hold step characteristics are not sensitive to logic high nor low levels (within TTL or CMOS swings), but logic slewrates greater than 1000V/µs can couple noise and hold step into the sample-to-hold output waveforms. The logic slewrate should be greater than 50V/µs to avoid hold jitter. To avoid artificially high droop in hold mode, the Chold pin and Chold itself should be guarded with circuit board traces connected to the output of the sample-and-hold. Low-leakage hold capacitors should be used, such as mica or mylar, but not ceramic. The excellent properties of more expensive polystyrene, polypropylene, or teflon capacitors are not needed.

The user should be aware of a combination of conditions that may make the EL2090 operate incorrectly upon power-up. The fault condition can be described by noticing that the sample-and-hold output (pin 11) appears locked at a voltage close to V_{CC}. This voltage is maintained regardless of changes at the inputs to the sample-and-hold (pins 5 and 6) or to the HOLD control input (pin 7). Two conditions must occur to bring this about:

1. A large value of Chold_usually values of 1000pF or more. This is not an unusual situation. Many users want to reduce the size of the hold step and increasing Chold is the most direct way to do this. Increasing Chold also reduces the slew rate of the sample and hold section but because of the limited size of the video signal, this is usually not a limitation.
2. A sampling interval (dictated by the HOLD pin) that is too small. By small, we mean less than 2µs.

For a sampling interval that is wide enough, there is enough time for the loop to close and for the amplifier to discharge whatever charge was dumped onto Chold it during the initial power spike and to then ramp up (or down) to the voltage that is proper for a balanced loop. When the sampling interval is too small, there is insufficient time for internal devices to recover from their initial saturated state from power-up because the feedback is not closed long enough. Therefore, typical recovery times for the loop are 2µs or greater. Summarizing, the two things that could prevent proper saturation recovery are (as mentioned above) too

large a capacitor which slows the charge and discharge rate of the stored voltage at Chold and too small a sampling interval in which the entire feedback loop is closed.



The circuit shown above prevents the fault condition from occurring by preventing the node from ever saturating. By clamping the value of Chold to some value lower than the supply voltage less a saturation voltage, we prevent this node from approaching the positive rail. The maximum voltage is set by the resistive voltage divider (between V+ and GND) R1 and R2 plus a diode. This value can be adjusted if the maximum size of the input signal is known. The diode used is an off-the-shelf 1N914 or 1N916.

As is true of all 100MHz amplifiers, good bypassing of the supplies to ground is mandatory. 1µF tantalums are sufficient, and 0.01µF leaded chip capacitors in parallel with medium value electrolytics are also good. Pins longer than 1/2 can induce a characteristic 150MHz resonance and ringing.

The V_{IN-} of the video amplifier should have the absolute minimum of parasitic capacitance. Stray capacitance of more than 3pF will cause peaking and compromise the gain flatness. The bandwidth of the amplifier is fundamentally set by the value of Rf. As demonstrated by the frequency response versus gain graph, the peaking and bandwidth is a weak function of gain. The EL2090 was designed for Rf = 300Ω giving optimum gain flatness at Av = +2. Unity-gain response is flattest for Rf = 360Ω; gains of +5 can use Rf = 270Ω. In situations where the peaking is accentuated by load capacitance or -input capacitance the value of Rf will have to be increased, and some bandwidth will be sacrificed.

The V_{IN+} of the video amplifier should not look into an inductive source impedance. If the source is physically remote and a terminated input line is not provided, it may be necessary to connect an input “snubber” to ground. A snubber is a resistor in series with a capacitor which de-Q's the input resonance. Typical values are 100Ω and 30pF.

The output of the video amplifier is sensitive to capacitive loads greater than 25pF, and a snubber to ground or a resistor in series with the output is useful to isolate reactive loads.

EL2090 Macromodel

```
* Revision A, October 1992
.param vclamp = {-0.002 * (TEMP-25)}
*
* Connections:      Vidin+
*                   |    Vidin-
*                   |    |     +Vsupply
*                   |    |     |     -Vsupply
*                   |    |     |     |     Vid Out
*                   |    |     |     |     |     S/H In+
*                   |    |     |     |     |     |     S/H In-
*                   |    |     |     |     |     |     |     S/H Out
*                   |    |     |     |     |     |     |     |     Hold Control
*                   |    |     |     |     |     |     |     |     |     Chold
*                   |    |     |     |     |     |     |     |     |     |
.subckt EL2090/EL 3    1    14    12    13    5    6    11    7    9
*
******** Video Amplifier ********************
*
e1 20 0 3 0 1.0
vis 20 34 0V
h2 34 38 vxx 1.0
r10 1 36 25
l1 36 38 20nH
iinp 3 0 10µA
iinm 1 0 5µA
h1 21 0 vis 600
r2 21 22 1K
d1 22 0 dclamp
d2 0 22 dclamp
e2 23 0 22 0 0.00166666666
l5 23 24 0.7µH
c5 24 0 0.5pF
r5 24 0 600
g1 0 25 24 0 1.0
rol 25 0 400K
cdp 25 0 7.7pF
q1 12 25 26 qp
q2 14 25 27 qn
q3 14 26 28 qn
q4 12 27 29 qp
r7 28 13 4
r8 29 13 4
ios1 14 26 2.5mA
ios2 27 12 2.5mA
ips 14 12 7.2mA
ivos 0 33 5mA
vxx 33 0 0V
r11 33 0 1K
*
************ Sample & Hold **************************
*
g40 49 0 5 6 1e-3
vcur 49 42 0v
r43 6 0 100Meg
r44 5 0 100Meg
r40 42 0 4K
d41 50 42 diode
d42 42 51 diode
v41 50 0 {vclamp}
```

EL2090 Macromodel (Continued)

```
v42 0 51 {vclamp}
g41 44 0 42 0 200e-6
r42 44 0 31Meg
d45 9 14 diode
d46 12 9 diode
s1 44 9 48 0 swa
e40 46 0 9 0 0.95
i40 0 9 10nA
r45 46 47 70
l40 47 11 70nH
c40 7 9 0.32pF
r47 7 48 10K
c41 48 0 3pF
*
* Models
*
.model qn npn(is=5e-15 bf=500 tf=0.1nS)
.model qp pnp(is=5e-15 bf=500 tf=0.1nS)
.model dclamp d(is=1e-30 ibv=0.02 bv=2.75 n=4)
.model diode d
.model swa vswitch(von=1.2v voff=1.6v roff=1e12 ron=100)
.ends
```

EL2090 Macromodel (Continued)

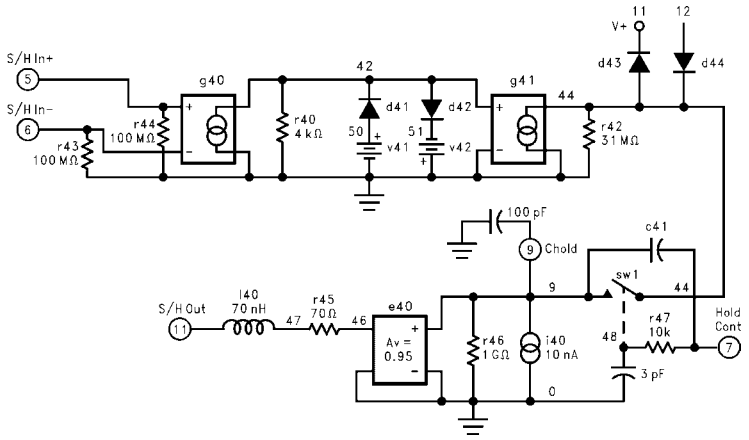


FIGURE 2. SAMPLE AND HOLD AMPLIFIER

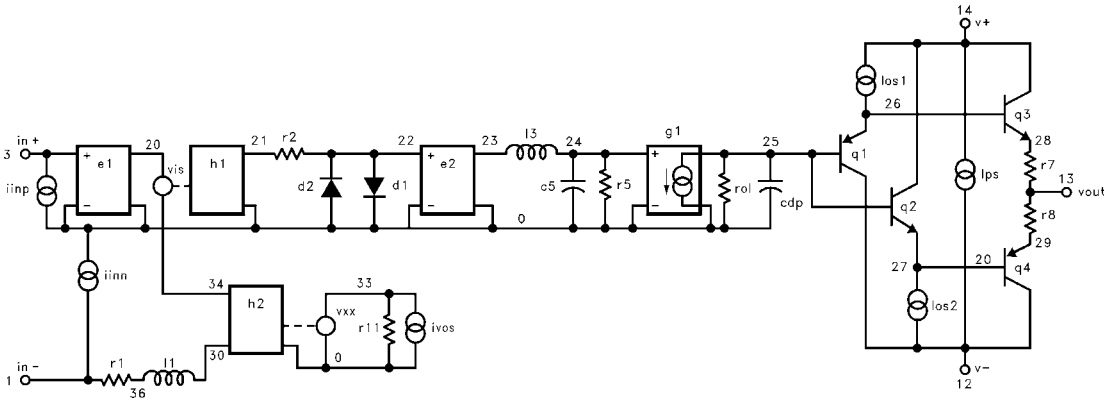


FIGURE 3. VIDEO AMPLIFIER