Dual Operational Transconductance Amplifiers With Linearizing Diodes and Buffers

Features

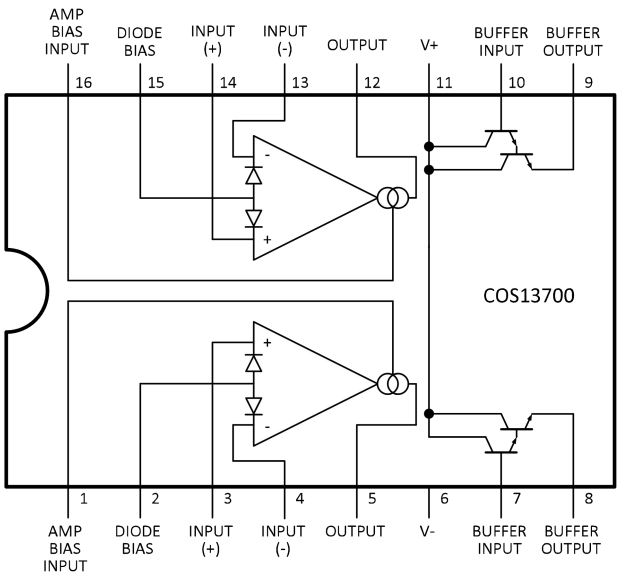
- Adjustable g_m Over 6 Decades
- Excellent g_m Linearity
- Excellent Matching Between Amplifiers
- Linearizing Diodes for Reduced Output Distortion
- High Impedance Buffers
- High Output signal-to-Noise Ratio
- Package : SOP16 / DIP16

Applications

- Stereo Audio Amplifiers
- Current-Controlled Amplifiers
- Current-Controlled Impedances
- Current-Controlled Filters
- Current-Controlled Oscillators
- Sample-and-Hold Circuits
- Multiplexers
- Timers

General Description

The COS13700 consists of two current-controlled transconductance amplifiers, each with differential inputs and a push-pull output. The two amplifiers share common supplies but otherwise operate independently. Linearizing diodes are provided at the inputs to reduce distortion and allow higher input levels. High impedance buffers are provided which are especially designed to complement the dynamic range of the amplifiers. The COS13700 can be used in a wide variety of applications, from voltage-controlled amplifiers and filters to stereo volume control.



Pin Diagram

Rev1.0

1. Pin Configuration and Functions

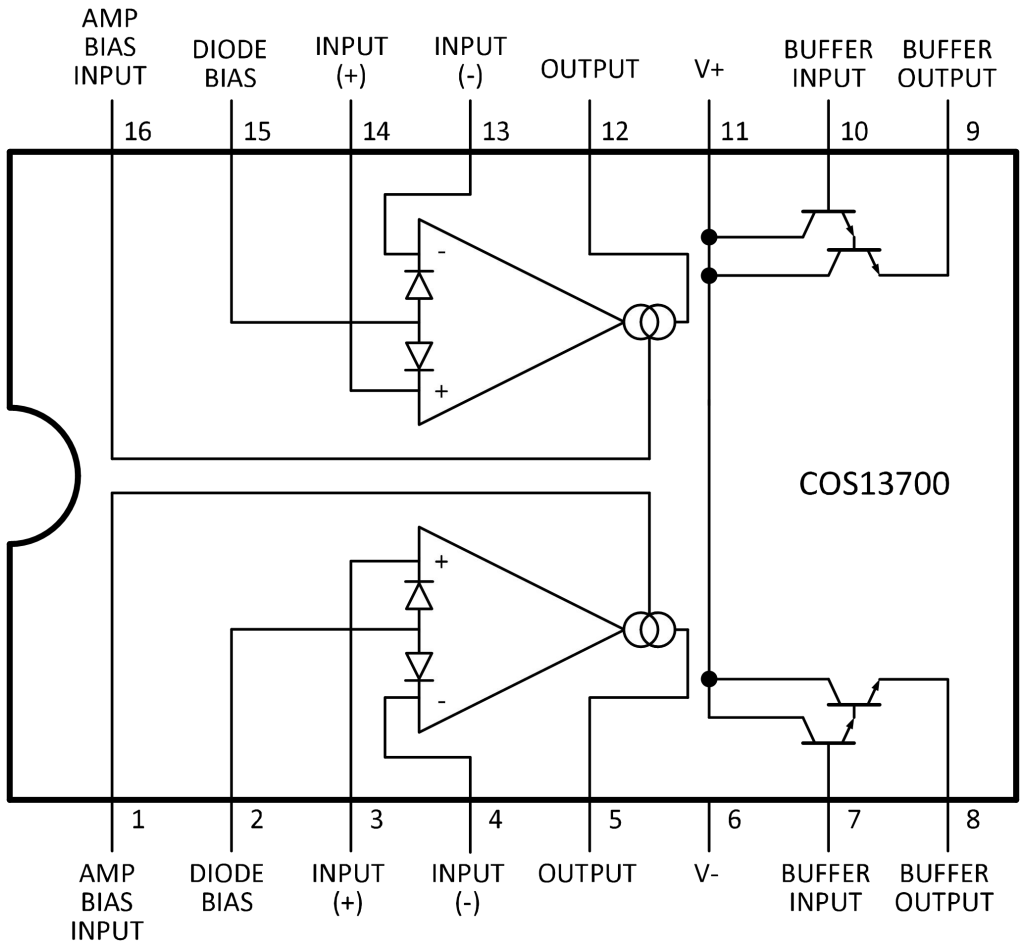


Figure 1 Pin Diagram (SOP16/DIP16 Top View)

Pin Functions

PIN Name	PIN Number	I/O	Description
Amp Bias Input	1, 16	A	Current bias input
Buffer Input	7, 10	A	Buffer amplifier input
Buffer Output	8, 9	A	Buffer amplifier output
Diode Bias	2, 15	A	Linearizing diode bias input
Input +	3, 14	A	Positive input
Input -	4, 13	A	Negative input
Output	5, 12	A	Unbuffered output
V+	11	P	Positive power supply
V-	6	P	Negative power supply

2. Product Specification

2.1 Absolute Maximum Ratings (1)

Parameter	Rating	Unit
Power Supply: +Vs to -Vs	36 or ±18	V
DC Input Voltage (2)	-Vs to +Vs	V
Differential Input Voltage	±5	V
Diode Bias Current (I_D)	2	mA
Amplifier Bias Current (I_{ABC})	2	mA
Buffer Output Current (3)	20	mA
Power Dissipation	570	mW
Output Short Circuit Duration	Continuous	
Storage Temperature Range	-65 to +150	°C

(1) Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.
(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.
(3) Buffer output current should be limited so as to not exceed package dissipation.

2.2 Thermal Data

Parameter	Rating	Unit
Package Thermal Resistance, $R_{\theta JA}$ (Juntion-to-Ambient)	83 (SOP16) 44 (DIP16)	°C/W

2.3 Recommended Operating Conditions

Parameter	Min	Max	Unit
V+ (Single Supply Configuration)	9.5	32	V
V+ (Dual Supply Configuration)	4.75	16	V
V- (Dual Supply Configuration)	-16	-4.75	V
Operating Ambient Temperature	-20	85	°C

2.4 Electrical Characteristics

(V_S=±15V, T_A=+25°C, I_{ABC}=500μA, pin 2 and 15 open unless otherwise noted. The inputs to the buffers are grounded and outputs are open.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Offset Voltage	V_{OS}	Over specified temperature range		0.4	4	mV
		I_{ABC}=5μA		0.3	4	mV
Vos Including Diodes	V_{OS_D}	Diode bias current (I_D) =500μA		0.5	5	mV
Input Offset Change	ΔV_{OS}	5uA ≤ I_{ABC} ≤ 500uA		0.1	3	mV
Input Offset Current	I_{OS}			0.1	0.6	μA
Input Bias Current	I_B			0.4	5	μA
		Over specified temperature range		1	8	μA
Forward Transconductance	g_m		6700	9600	13000	μS
		Over specified temperature range	5400			μS
gm Tracking	g_{m_t}			0.3		dB
Peak Output Current	I_{PK}	R_L=0, I_{ABC}=5μA		5		μA
		R_L=0, I_{ABC}=500μA	350	500	650	μA
		R_L=0, Over specified temperature range	300			μA
Supply Current	I_{CC}	I_{ABC}=500μA, both channel		2.2		mA
CMRR	CMRR		80	110		dB
Common-mode Range	V_{ICR}		±12	±13.5		V
Crosstalk	P_X	Referred to input, 20Hz <f< 20kHz		100		dB
Differential Input Current	I_d	I_{ABC}=0, input = ±4V		0.02	100	nA
Leakage Current	I_{LEAK}	I_{ABC}=0		0.2	100	nA
Input Resistance	Z_{IN}		10	26		kΩ
Open-loop Bandwidth	BW			2		MHz
Slew Rate	SR	Unity gain compensated		50		V/μs
Buffer Input Current	I_{BUF}	See (1)		0.5	2	μA
Peak Buffer Output Voltage	I_{PKOUT_BUF}	See (1)	10			V

Peak Output Voltage	V_{OP}	Positive, R_L=∞, 5uA≤I_{ABC}≤500uA	12	14.2		V
	V_{ON}	Negative, R_L=∞, 5uA≤I_{ABC}≤500uA	-12	-14.2		V
V_{OS} Sensitivity		Positive, $\Delta V_{OS}/\Delta V^+$		20	150	μV/V
		Negative, $\Delta V_{OS}/\Delta V^-$		20	150	μV/V

(1) These specifications apply for VS=±15V, I_{ABC}=500μA, R_{OUT}=5kΩ connected from the buffer output to -Vs and the input of the buffer is connected to the transconductance amplifier output.

3.0 Typical Applications

Overview

The COS13700 is a two channel current controlled differential input transconductance amplifier with additional output buffers as shown in Figure 2. The inputs include linearizing diodes to reduce distortion, and the output current is controlled by a dedicated pin. The outputs can sustain a continuous short to ground. Each channel includes a separate output buffer which consists of a Darlington pair transistor that can drive up to 20mA.

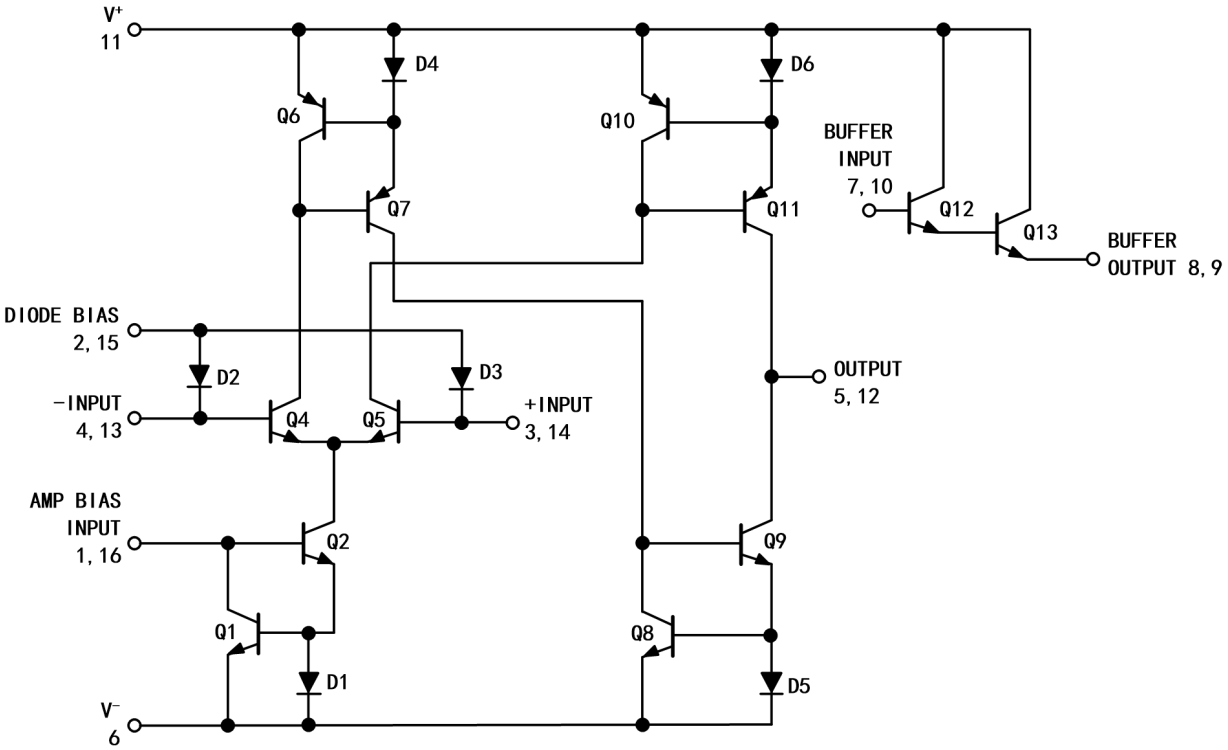


Figure 2. Operational Transconductance Amplifier (One Channel)

The COS13700 can be used in a wide variety of applications, from voltage-controlled amplifiers and filters to VCOs. The 2 well-matched, independent channels make the LM13700 well suited for stereo audio applications.

Voltage-Controlled Amplifiers

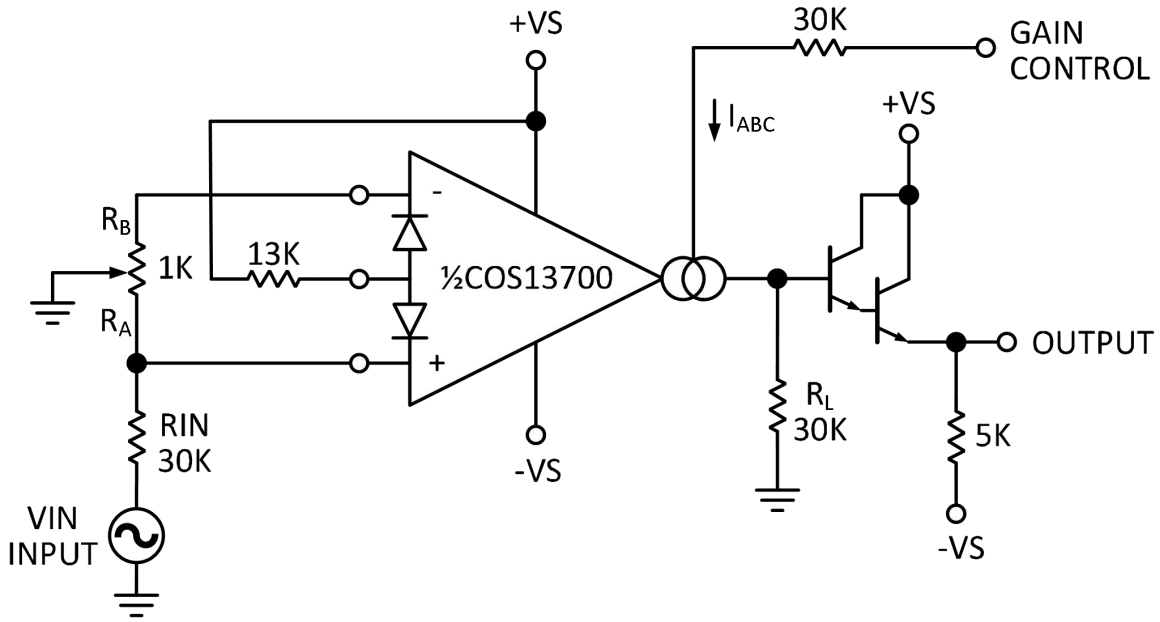


Figure 3. Voltage-Controlled Amplifier

Figure 3 shows an implementation example of voltage-controlled amplifier. The system requirement is to provide a volume control for a $1V_P$ input signal with a THD < 0.1% using ±15 V supplies. The volume control varies between -13 V and 15 V and needs to provide an adjustable gain range of >30dB as shown in Figure 4.

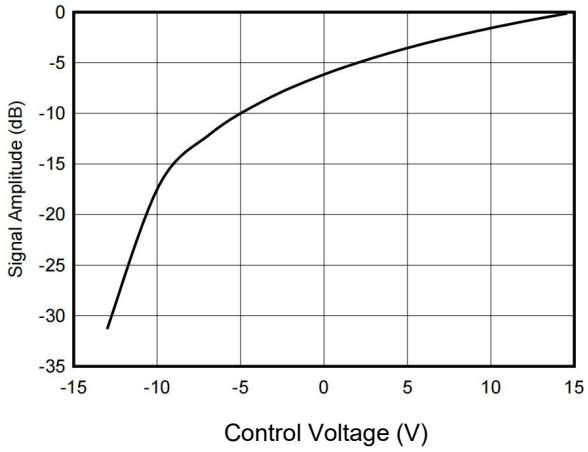


Figure 4. Signal Amplitude vs Control Voltage

Using the linearizing diodes is recommended for most applications, as they greatly reduce the output distortion. It is required that the diode bias current, I_D be greater than twice the input current, I_S. As the input voltage has a DC level of 0 V, the Diode Bias input pins are 1 diode drop above 0 V, which is +0.7 V. Tying the bias to the clean V+ supply, results in a voltage drop of 14.3V across R_D. Using the recommended 1mA for I_D is appropriate here, and with V_S=+15 V, the voltage drop is 14.3 V, and so using the standard value of 13-kΩ is acceptable and will provide the desired gain control.

To obtain the <0.1% THD requirement, the differential input voltage must be <60mVpp when the linearizing diodes are used. The input divider on the input will reduce the 1 V_P input to 33mV_{PP}, which is within the desired spec.

Next, set I_{BIAS}. The Bias Input pins (pins 1 or 16), are 2 diode drops above the negative supply, and therefore V_{BIAS} = 2(V_{BE}) + V- , which for this application is -13.6 V. To set I_{BIAS} to 1mA when VC =15 V requires a 28.6-kΩ; 30-kΩ is a standard value and is used for this application. The gain will be linear with the applied voltage.

Other Application Examples

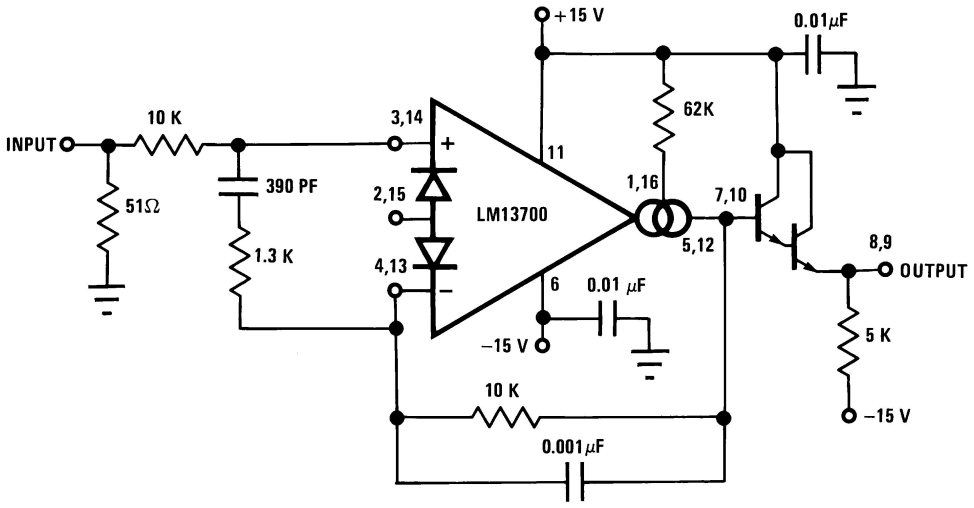


Figure 5. Unity Gain Follower

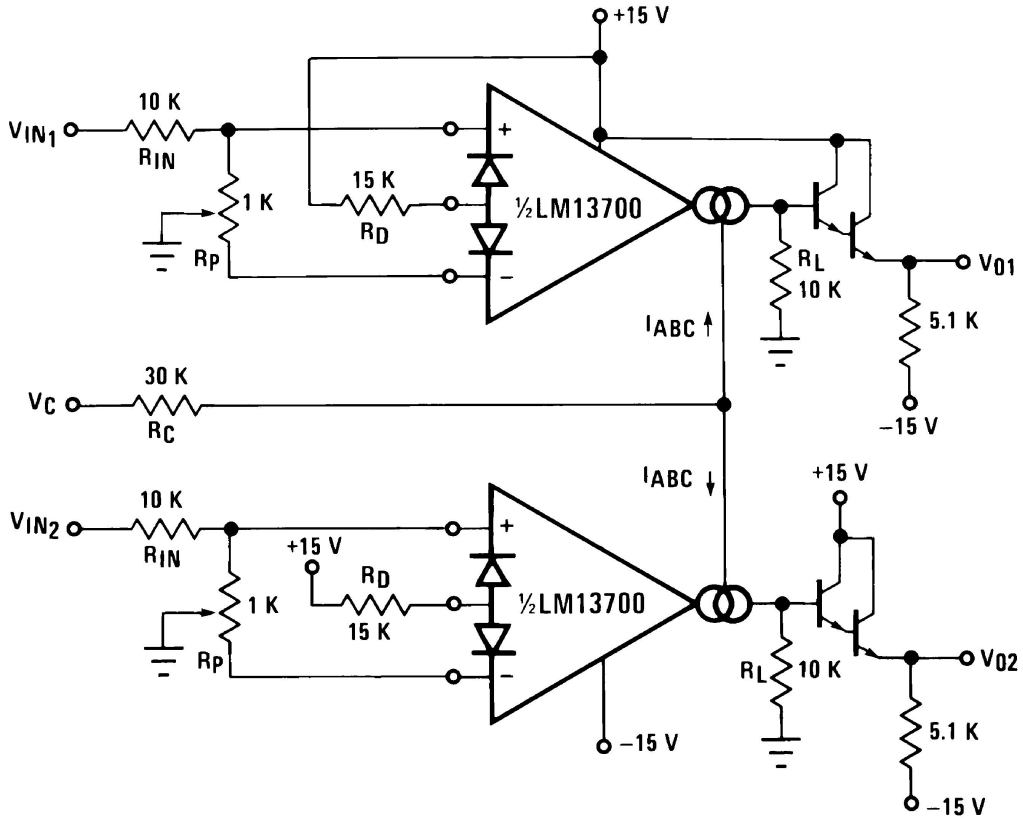


Figure 6. Stereo Volume Control

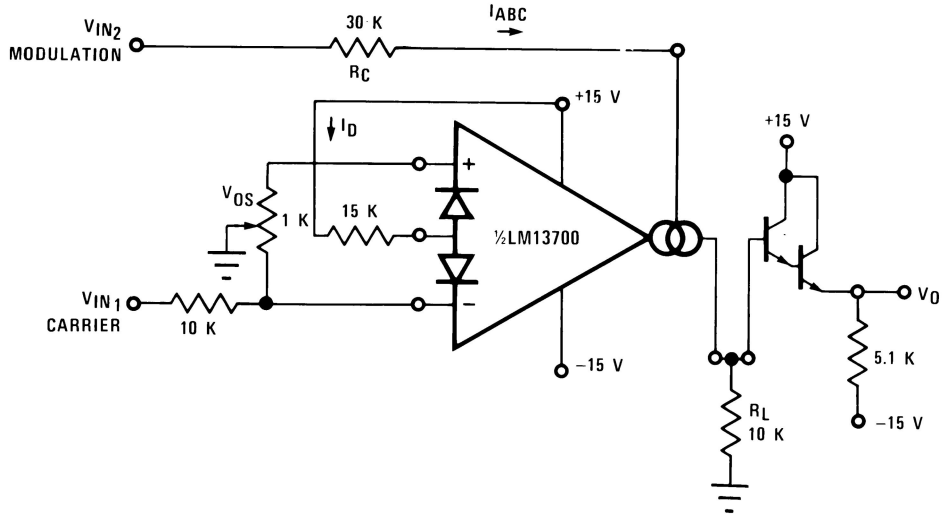


Figure 7. Amplitude Modulator

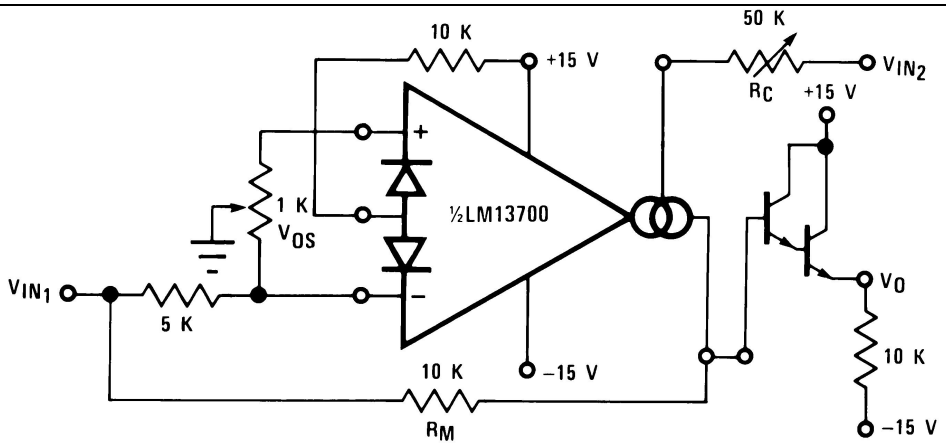


Figure 8. Four-Quadrant Multiplier

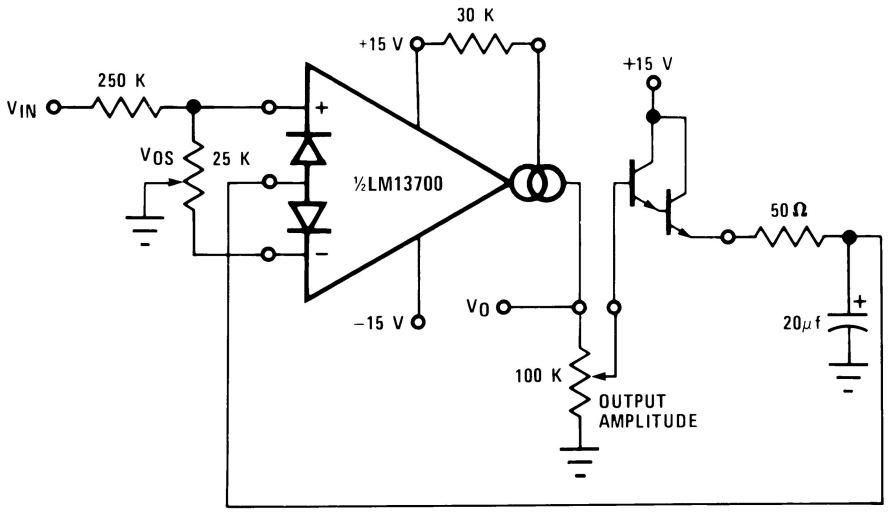


Figure 9. AGC Amplifier

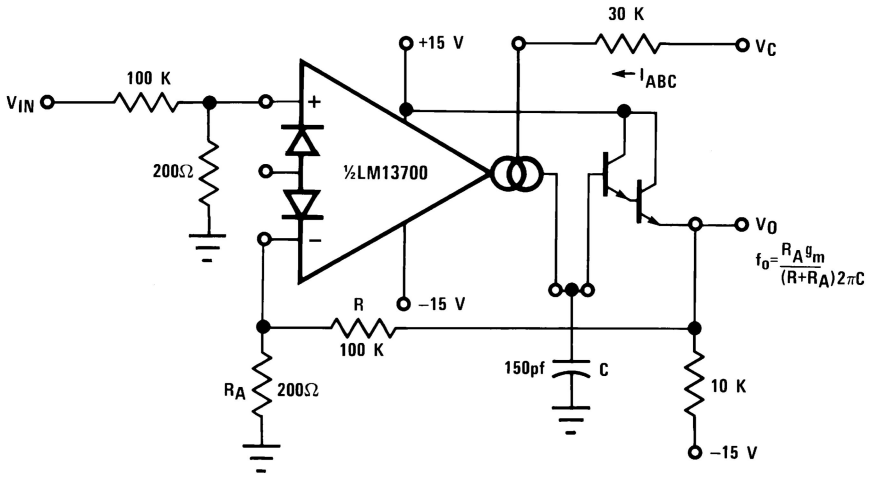


Figure 10. Voltage-Controlled Low-Pass Filter

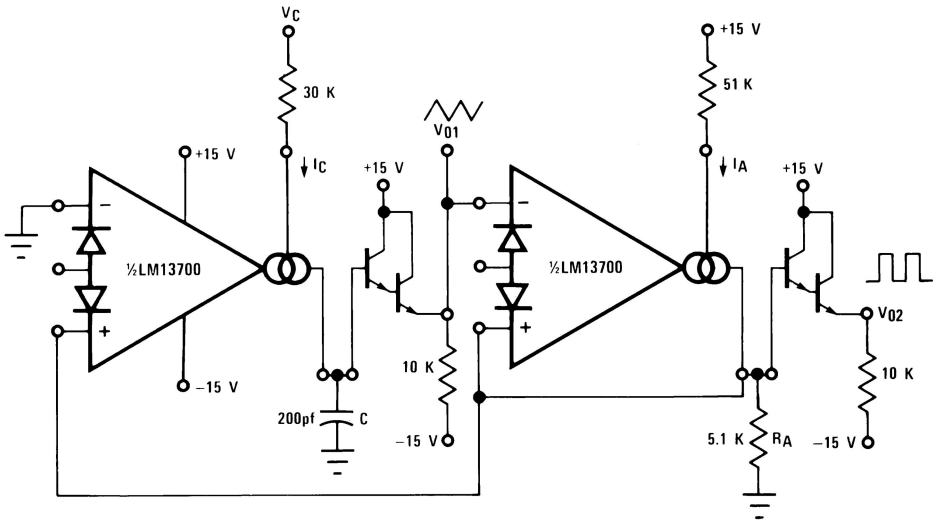


Figure 11. Triangular/Square-Wave VCO

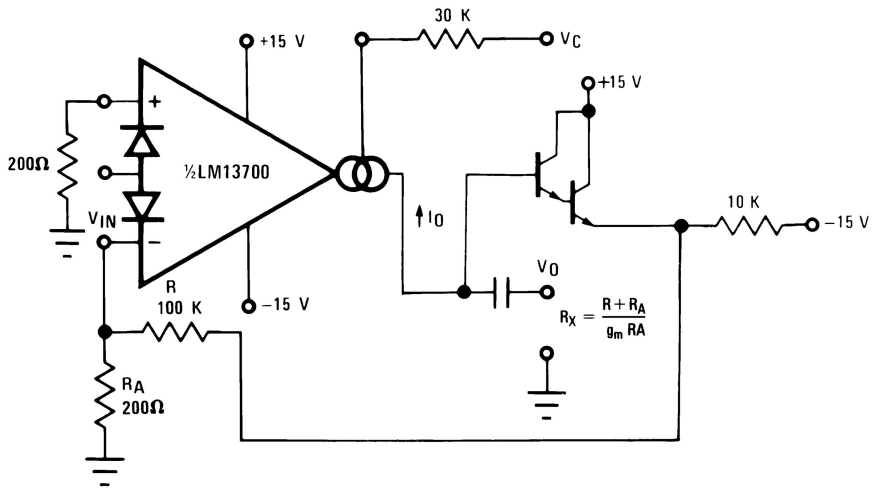


Figure 12. Voltage-Controlled Resistor, Single-Ended

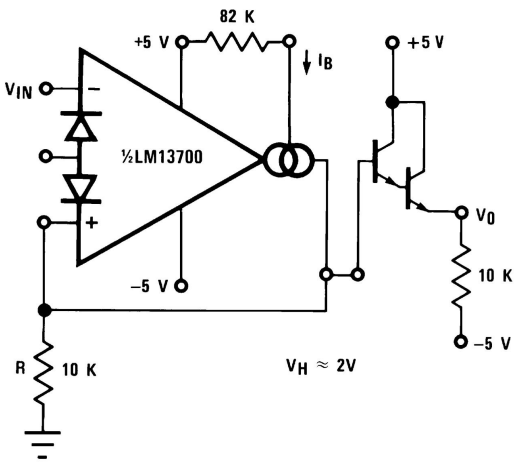


Figure 13. Schmitt Trigger

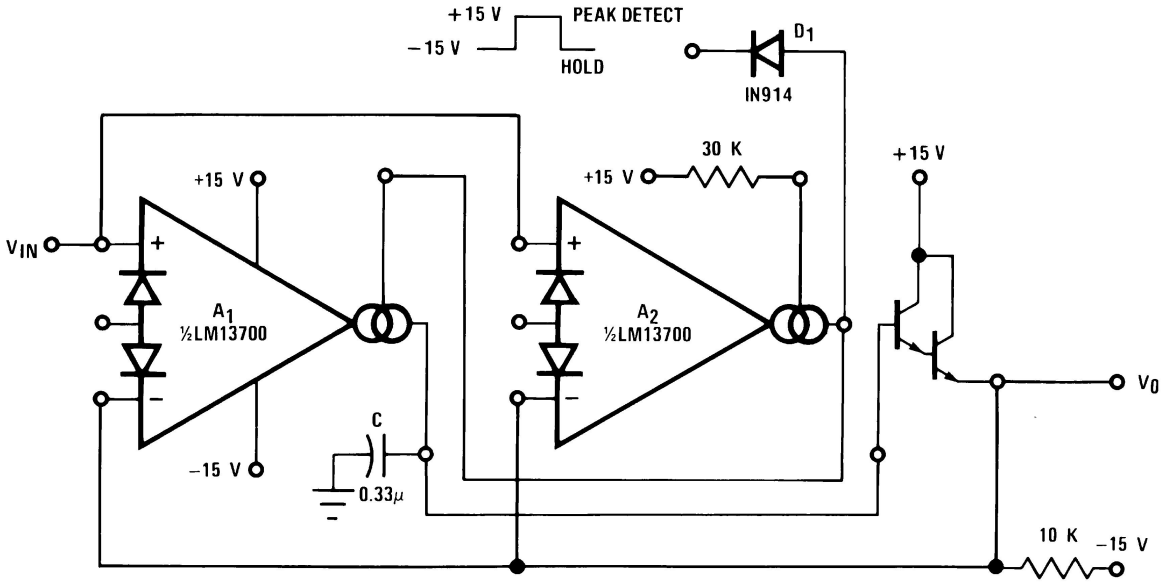


Figure 14. Peak Detector and Hold Circuit

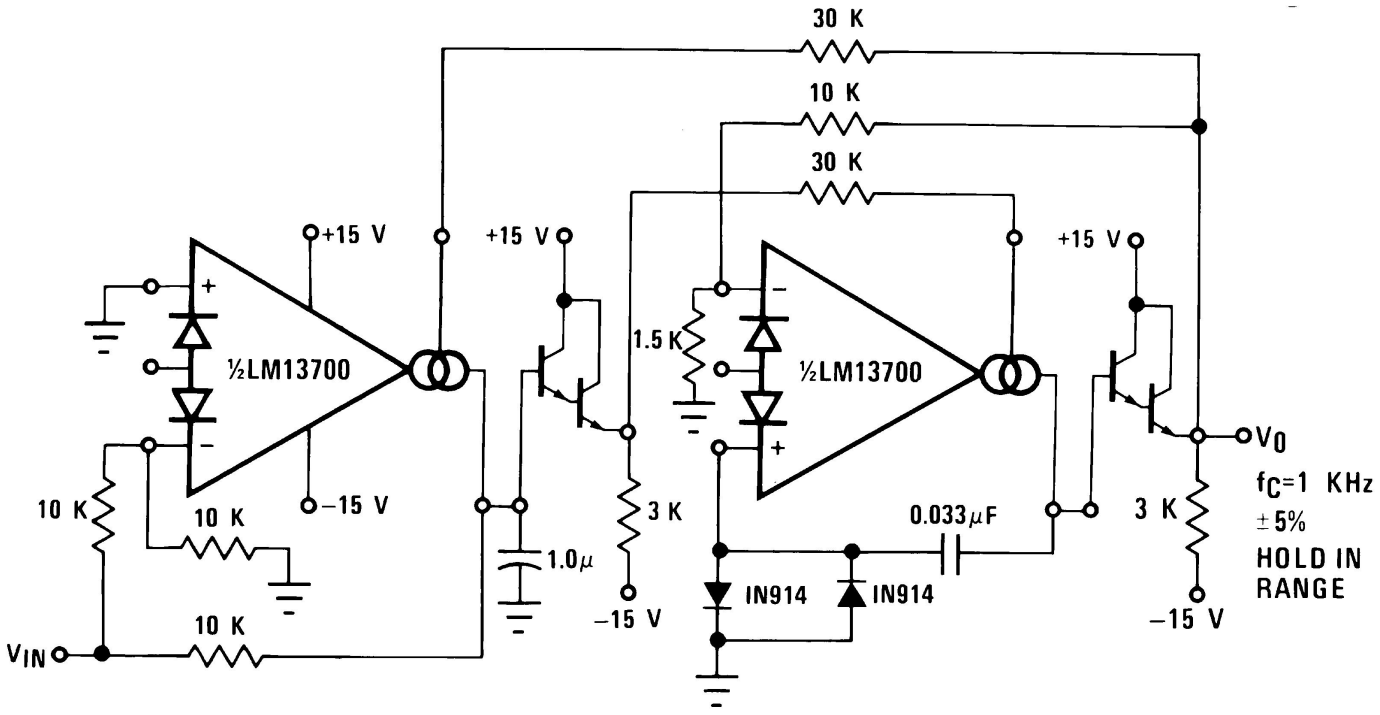


Figure 15. Phase Lock Loop

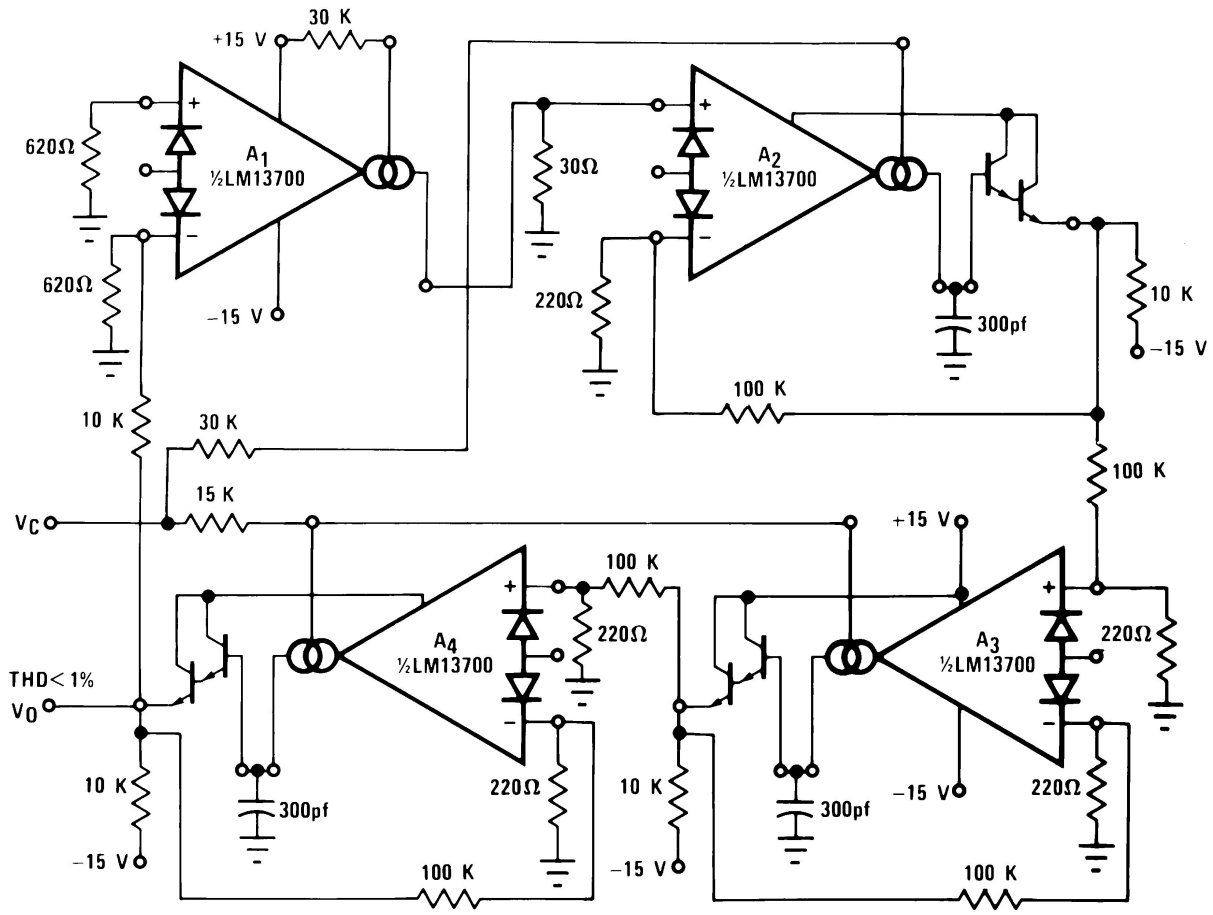


Figure 16. Sinusoidal VCO

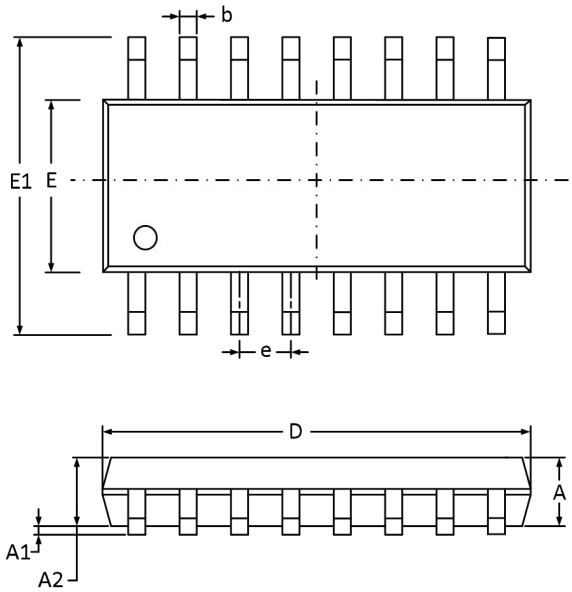
Power-Supply Bypassing and Layout

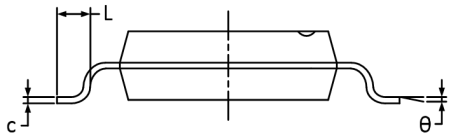
The COS13700 operates from a single supply or dual supplies. For single-supply operation, bypass the power supply +Vs with a 0.1μF ceramic capacitor which should be placed close to the +Vs pin. For dual-supply operation, both the +Vs and the -Vs supplies should be bypassed to ground with separate 0.1μF ceramic capacitors. 2.2μF tantalum capacitor can be added for better performance.

The length of the current path is directly proportional to the magnitude of parasitic inductances and thus the high frequency impedance of the path. High speed currents in an inductive ground return create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance. Thus a ground plane layer is important for high speed circuit design.

4. Package Information

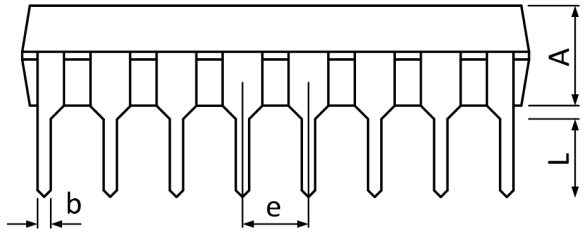
4.1 SOP-16 (Package Outline Dimensions)

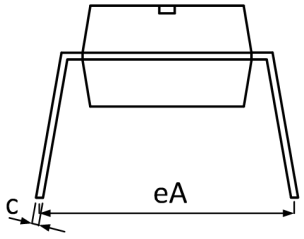


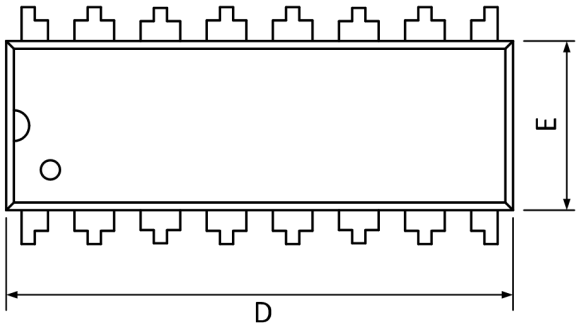


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	9.800	10.20	0.386	0.402
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

4.2 DIP16 (Package Outline Dimensions)







Symbol	Millimeter		
	MIN	NOM	MAX
A	3.20	3.30	3.40
b	0.44	---	0.53
c	0.25	---	0.30
D	18.95	19.05	19.15
E	6.25	6.35	6.45
e	2.54BSC		
eA	8.30	8.80	9.30
L	3.00	---	---

5. Package and Ordering Information

Model	Package	Order Number	Package Option	Marking Information
COS13700	SOP-16	COSLM13700SR	Tape and Reel, 3000	COS1370SR
	DIP-16	COSLM13700DR	Tube, 500	COS13700

6. Related Parts

Part Number	Description
COS6042	24kHz, 0.5μA, Nano-Power Op Amps, 1.4V to 5.5V Supply
COS8042	170MHz, 6.1mA, High Speed Op Amps, 3.2V to 12V Supply
COS2172	10MHz, 1.2mA, RRIO Op Amps, 4.5 to 40V Supply
COS2333	350kHz, 18μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS8552	1.5MHz, 55μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS2388	9MHz, 570μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS2227	10MHz, 1.3mA, Precision Op Amps, 4.5 to 36V Supply, Vos<50μV
COS2182	5MHz, 580μA, RRIO Precision Op Amps, 4.5 to 40V Supply, Vos<50μV
COS620	1.5MHz, 1.3mA, Instrumentation Amps, 4.5 to 36V Supply, Vos<50μV
COSINA333	150kHz, 65μA, Instrumentation Amps, 1.8 to 5.5V Supply, Vos<25μV