Dual-span-to-op operational amplifier with linear diode and buffer

Overview

The LM13700 series includes two flow-controlled amplifiers, each with a differential input and a push-pull output. The two op amps share a power supply, but can work separately. Linear diodes at the input reduce distortion and allow for higher input voltages. The results can improve the signal-to-noise ratio of 10dB under 0.5% THD. To complement the dynamic response range of the amplifier, a high-impedance buffer is specially designed. Unlike the LM13600's output buffer controlled by the i nput bias current Iabc, the LM13700's output buffer operates independently of the Iabc (and the outp ut DC level is also), so it is better than the LM13600 in audio applications.

Features

Transconductance gm tunability exceeds 1 0 Decades Excellent transconductance g m linearity Excellent matching between a mplifiers

Internal linear diodes reduce output distor tion High impedance buffer High output signal-to-noise ratio

application

Current control amplifier

Stereo audio amplifier

Flow-controlled impedance circuit

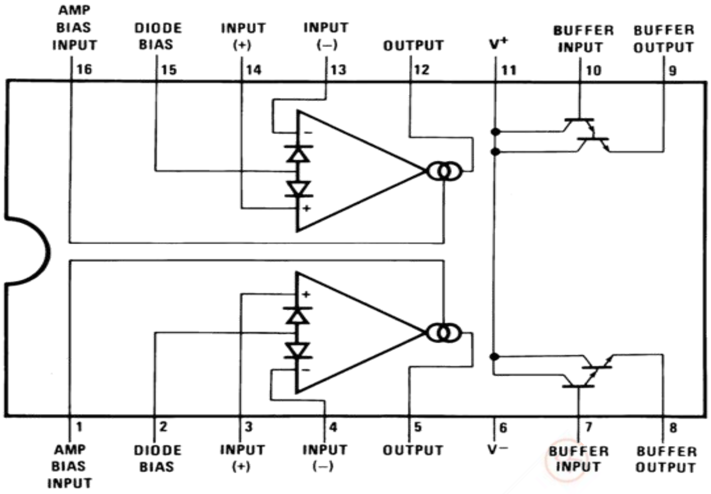
Flow-controlled filter

Flow-controlled os cillator Multiplexe r Timer Sampling and Holding Circui t

Product Ordering Information

产品名称	封装	打印名称	包装	包装数量
LM13700N	DIP16	LM13700	管装	1000 只/盒
LM13700M/TR	SOP16	LM13700	编带	2500 只/盘
LM13700MT/TR	TSSOP16	13700	编带	2500 只/盘

Pin diagram



Pin Description

管脚名称	序号	I/O	描述
Amp Bias Input	1,16	I	电流偏置输入端
Buffer Input	7,10	I	缓冲器运放输入端
Buffer Output	8,9	O	缓冲器输出端
Diode Bias	2,15	I	线性二极管偏置输入端
Input（+）	3,14	I	正相输入端
Input（-）	4,13	I	反相输入端
Output	5,12	O	无缓冲器输出端
Vs+	11	P	电源正端供电
Vs-	6	P	电源负端供电

Extreme parameters

参数	最小值	最大值	单位
供电源		36dc or ±18	V
直流输入电压	+Vs	-Vs	V
差分输入电压		±5	V
二极管偏置电流（Id）		2	mA
运放偏置电流（Iabc）		2	mA
缓冲器输出电流		20	mA
功率损耗（Ta=25℃）		570	mW
输出短路持续时间	一直		
最小/最大存储温度	-65	150	℃

Recommended working conditions

参数	最小值	最大值	单位
Vs（单电源）	9.5	32	V
Vs+（双电源）	4.75	16	V
Vs-（双电源）	-16	-4.75	V
工作温度范围	0	70	℃

Electrical Characteristics Vs=±15V,Iabc=500uA,Ta=25℃,无特殊说明 PIN2/15 悬空,BufferInput 接地,BufferOutput

参数	标识	测试条件及说明	最小	典型	最大	单位
输入失调电压	Vios	Over specified temperature range		0.56	3	mV
	Vios	Iabc=5uA		1.12	4	
输入失调电压(含二极管)	Vios_D	Diode 编置电流 Id=500uA		0.45	5	mV
输入失调电压变化	△Vios	5uA≤Iabc≤500uA		0.5	3	mV
输入失调电流	Iios			0.033	0.6	uA
输入偏置电流	Iib			0.116	5	uA
	Iib	Over specified temperature range		0.220	8	
正向跨到	gm	取 100 和 25mV 算	6700	9600	13000	uS
		Over specified temperature range	5400			
gm tracking	gm_t			0.3		dB
峰值输出电流	Ipk	RL=0,Iabc=5uA	4.3	5		uA
		RL=0,Iabc=500uA	450	500	650	
		RL=0	300			
工作电流	Icc	Iabc=500uA,双通道（测试盒测）		2.2		mA
共模抑制比	CMRR		80	110		dB
共模范围			±12	±13.5		V
串扰	crosstalk	(1),20Hz<f<20KHz		100		dB
差分输入电流	Idin	Iabc=0,input=±4V		0.02	100	nA
漏电流	Ileak	Iabc=0		0.2	100	nA
输入阻抗	Zin		10	26		kΩ
开环带宽				2		MHz
转换速率	slew rate	单位增益补偿	4.3	50		V/uS
缓冲器输入电流	Ibin	(1)		0.5	2	uA
峰值缓冲器输出电压	Ipkout_buffer	(1)	10			V
峰值输出电压						
正电压	VOP	R=∞,5uA≤Iabc≤500uA	12	14.2		V
负电压	VON	R=∞,5uA≤Iabc≤500uA	-12	-14.2		V
失调电压敏感度 Vios sensitivity						
正向		△Vios/△V+		20	150	uV/V
反向		△Vios/△V-		20	150	uV/V

Feature map

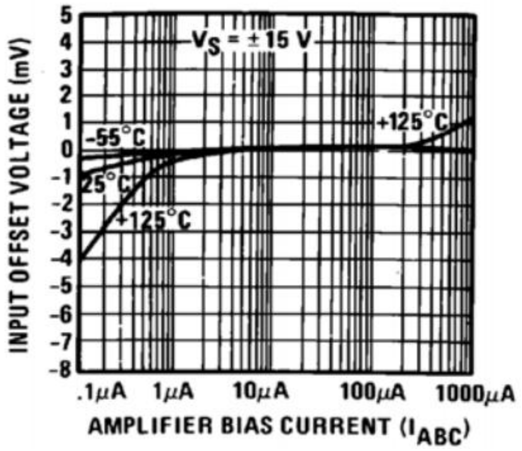


Figure 1 Input E-modulation voltage

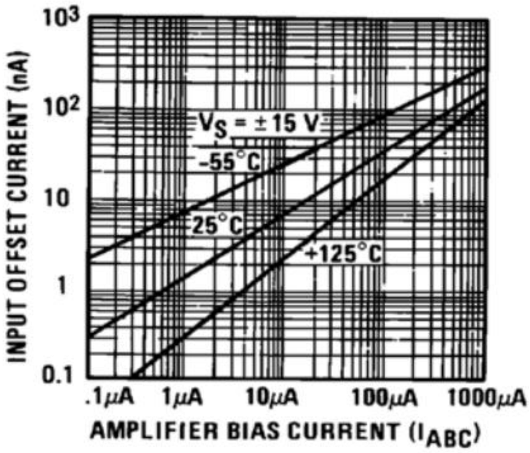


Figure 2 Input E-modulation current

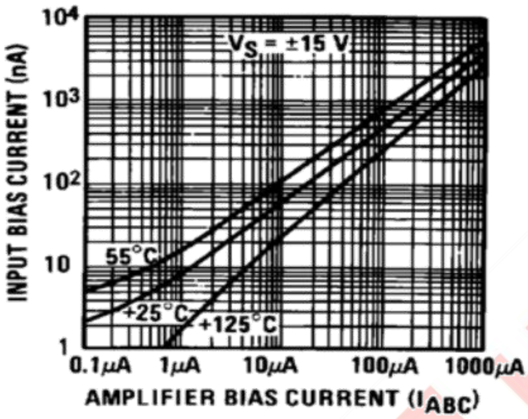


Figure 3 Input bias current

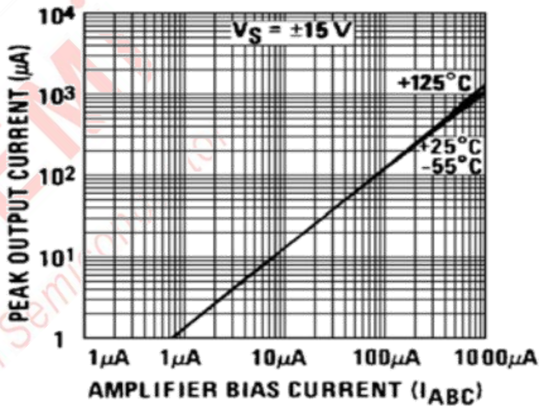


Figure 4 Output peak current

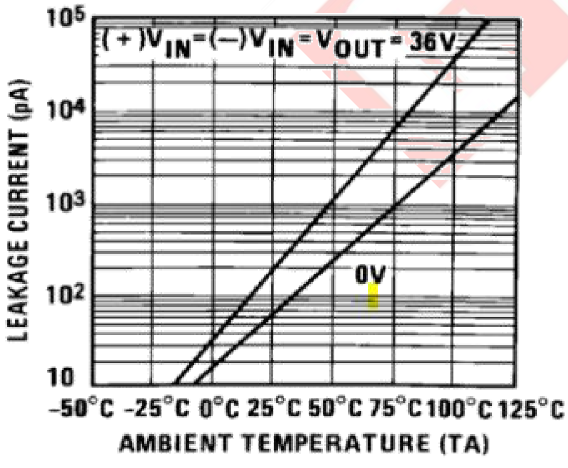


Figure 5 Leakage Current

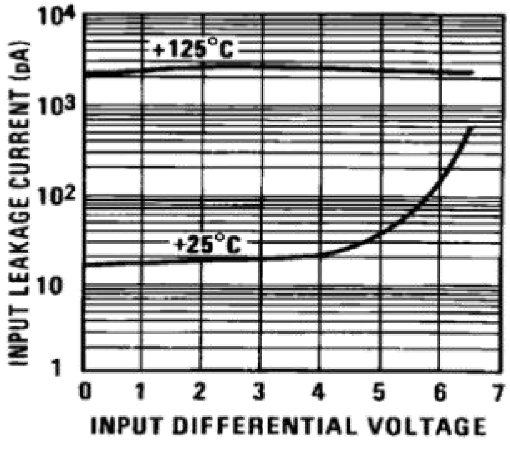


Figure 6 Input leakage current

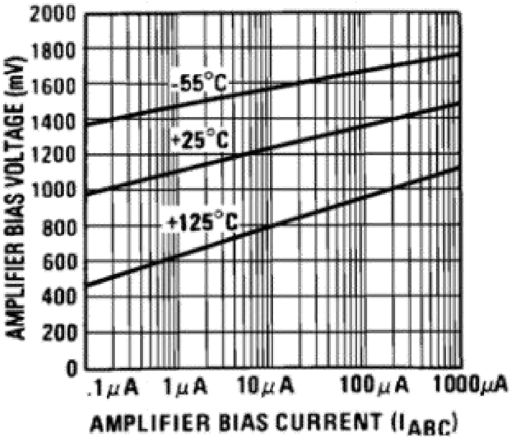


Figure 7 Op amp bias voltage and Iabc

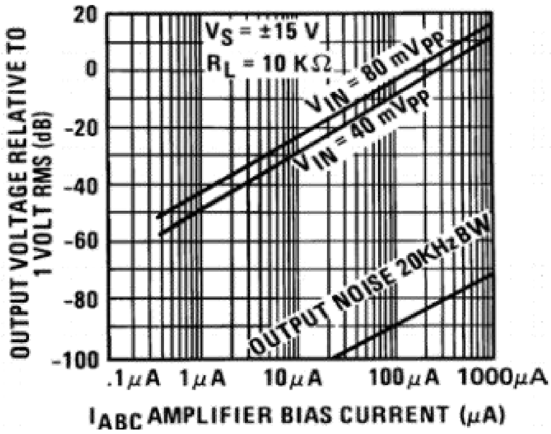


Figure 8 Output voltage and op amp bias current

Functional Overview

The LM13700 is a two-channel differential input flow-controlled transconductance operational amplifier with an output buffer. The input is linear diode characteristic, which reduces distortion while the output current is also controlled by this port. The output port can also be continuously protected in the case of short circuits to ground.

Internal circuit block diagram

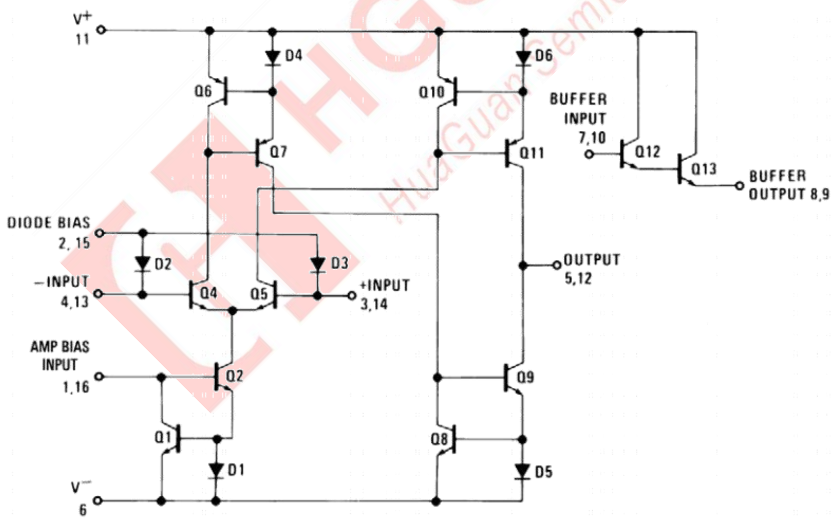


Figure 9 A transconductance operational amplifier

Feature Description

Circuit description: Q4 and Q5 are differential pairs of differential input stages. They form a transconductance stage, and their collector current ratio is defined by the differential input voltage according to the transfer function as follows:

$$V_{IN} = \frac{KT}{q} \ln \frac{I5}{I4} \qquad (1)$$

Here Vin is the input differential voltage, kT/q is 26mV at 25℃, and I5 and I4 are the collector c urrents of Q5 and Q4. Except for Q12 and Q13, all transistors and diodes are the same. Q1, Q2, and D 1 form a Wilson current source, whose current comes from the sum of I5 and I4 and is equal to Iabc:

$$I4+I5=IABC \quad (2)$$

Here Iabc is obtained from the AMP Bias Input port. For small differential input volt ages, the difference ratio of I5 and I4 can be uniformly used to approximate the functional relationship between the Taylor series:

$$\frac{KT}{q}\ln\frac{I5}{I4} \approx \frac{KT}{q}\,\frac{I5-I4}{I4}$$

$$I_4 \approx I_5 \approx \frac{IABC}{2} \qquad (3)$$

$$V_{IN}\left[\frac{IABCq}{2kT}\right]= I_5 - I_4 \qquad (4)$$

I5 and I4 are not too useful themselves, they need to subtract an electric current from other direc tions. The remaining transistors and diodes form a three-current mirror, which will produce a differen ce of output current equal to I5 and I4.

$$V_{IN}\left[\frac{IABCq}{2kT}\right]= I_{OUT} \qquad (5)$$

The value in brackets is the transconductance of the operational amplifier, which is proportional to Iabc.

Linear diode: When the differential voltage is greater than a few mV, equation (3) is not very suitable and transconductance becomes increasingly nonlinear. Figure 19 shows how internal circuits use diode s to linearize the functions of compensation amplifiers. For convenience, assuming that the diode para noid current source and input signal exist in the form of current, since the sum of I5 and I4 is equal to I abc, the difference is equal to the output current, I5 and I4 can be expressed as follows:

$$I_4= \frac{IABC}{2} - \frac{IOUT}{2},\ I_5= \frac{IABC}{2} + \frac{IOUT}{2} \qquad (6)$$

Since the diode and the input transistor have similar geometry and have similar voltage and temperature characte

$$\frac{KT}{q}\ln\frac{\frac{ID}{2}+IS}{\frac{ID}{2}-IS} = \frac{KT}{q}\ln\frac{\frac{IABC}{2}+\frac{IOUT}{2}}{\frac{IABC}{2}-\frac{IOUT}{2}} \qquad (7)$$

$$\therefore IOUT=IS\left(\frac{21ABC}{ID}\right) \text{ for } |IS| < \frac{ID}{2}$$

Note that in Program 7, no approximation is made, nor does the temperature dependency case be considered. The limitation is that the current of the signal does not exceed Id/2 and the diode current is also biased. In fact, using resistors instead of current sources will cause considerable errors.

Device function mode:

Used in single-ended or double-ended power supplies may require a little change. The output can s upport continuous ground short circuit protection. Note that using ±5V to power the LM13700 may red uce its dynamic response range because the PNP transistor has a higher Vbe than the NPN transistor.

Output Buffer: Each channel contains a separate output buffer consisting of Darlington tubes tha t can drive up to 20mA current

Application information:

The transconductance op amp is a multifunctional building block-like analog element that can b e called an ideal transistor. The LM13700 has a wide range of application scenarios, from voltage-co ntrolled op amps, filters to voltage-controlled oscillators, etc. Its unique independent channel is better used in stereo audio amplifiers.

Typical Applications

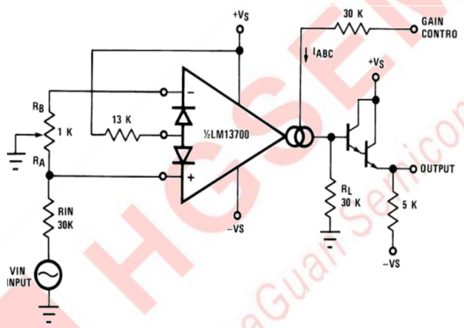


Figure 10 Air compressor amplifier

Design requirements:

For this example application, the supply voltage is ±15V and the system needs to provide a 1Vp p volume control input signal with a distortion THD<0.1%. The volume control range is between -13 V~15V and requires a signal with an adjustable range of more than 30dB.

Detailed design process:

Linear diodes are recommended in most applications because they greatly reduce output distorti on. The input diode bias current ID is required to be greater than twice the input current Is, because w hen the input voltage is 0V, the voltage drop of the input bias diode is not 0V but 0.7V.

When connecting the bias port to V+, a 14.3V voltage drop will be obtained through Rd. It is ap propriate to use the recommended Id=1mA, here Vs+=15V and the voltage drop is 14.3V, then conne cting a standard 13KΩ resistor will be able to get the desired gain control.

In order to meet the THD<0.1% requirement, when the linear diode is used, the differential inp ut voltage must be less than 60mVpp. The input divider at the input port will reduce 1Vpp to 33mVp p, which is within the required range.

Next, set the bias current. Bias current input pins (PIN1 and PIN16) are the two diode voltage drops and pov

V-, so Vbias=2Vbe+V-, since this application V-=-13.6V, and Vc=15V, a 28.6K resistor can be connected in series to get a current of 1mA. Of course, 30KΩ is the standard resistance value, and the gain is proportional to the applied voltage.

Signal and control voltage relationship diagram

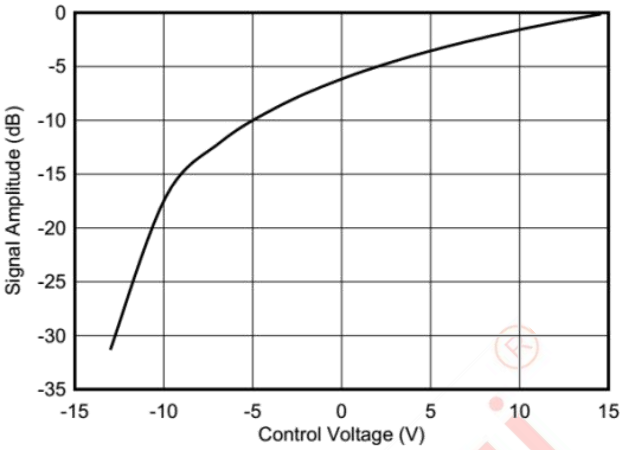


Figure 11 Signal amplitude and control voltage

System application example

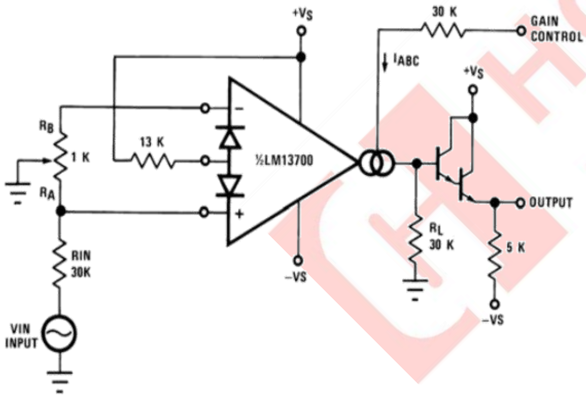


Figure 12 Voltage Control Amplifier

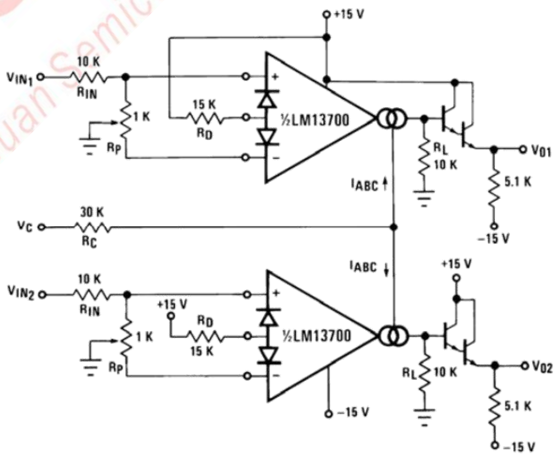


Figure 13 Stereo Amplifier

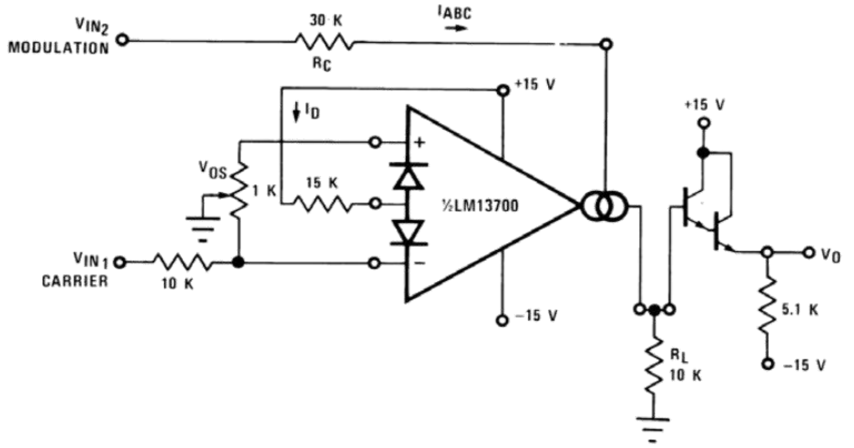


Figure 14 Amplitude modulator

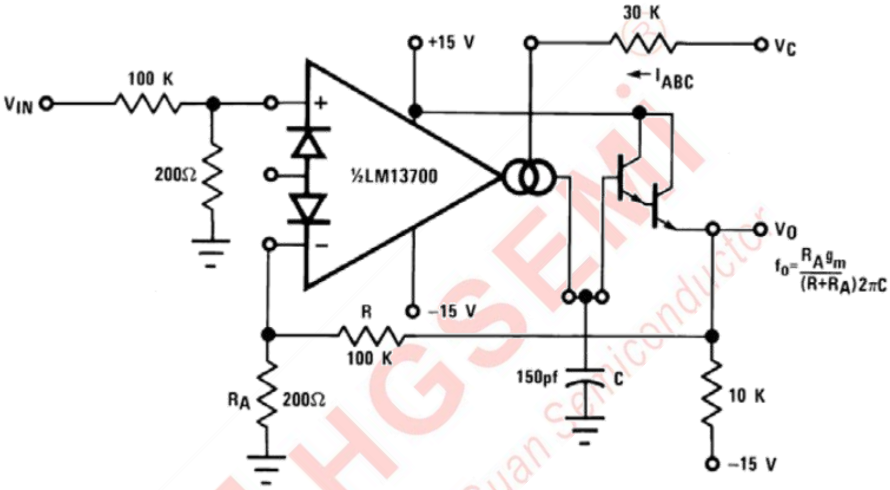


Figure 15 Voltage controlled low-pass filter

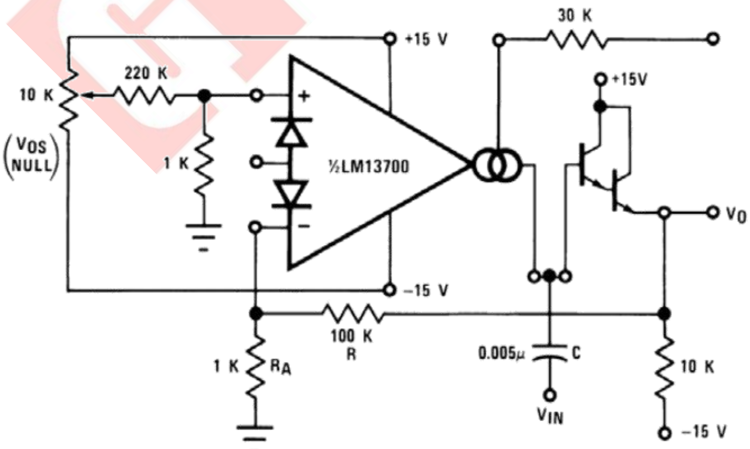


Figure 16 Voltage controlled high-pass filter

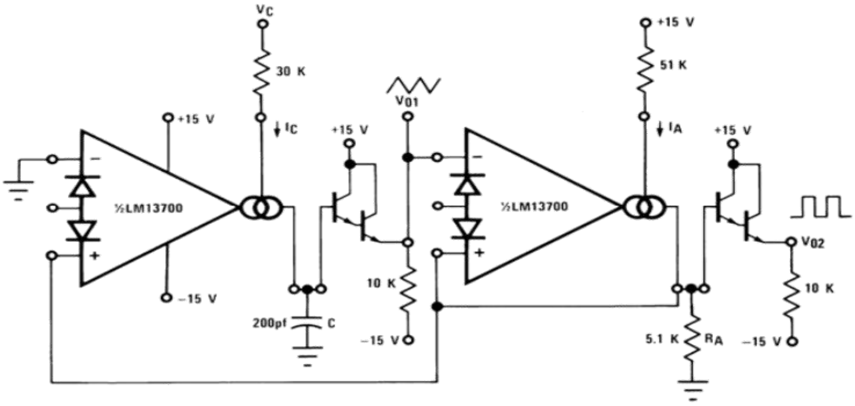


Figure 17 Triangular wave/rectangular wave voltage controlled oscillator

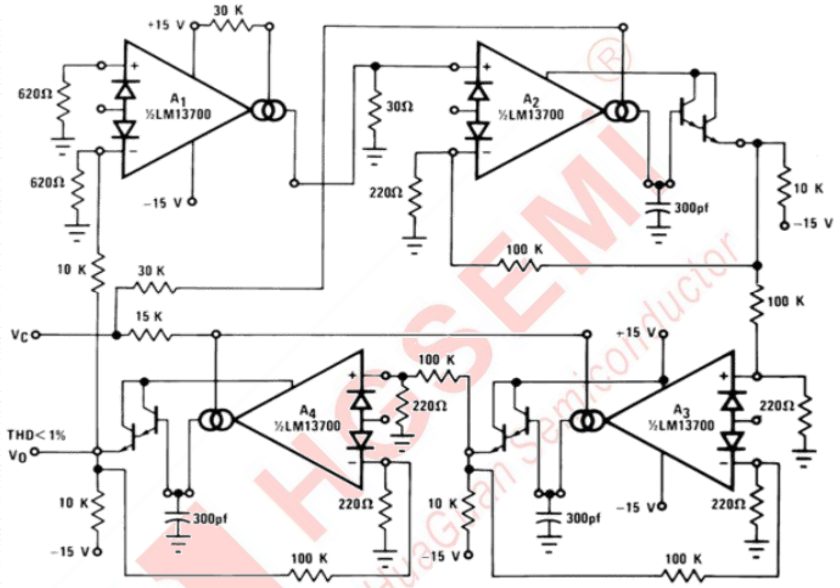


Figure 18 Positive wave voltage controlled oscillator

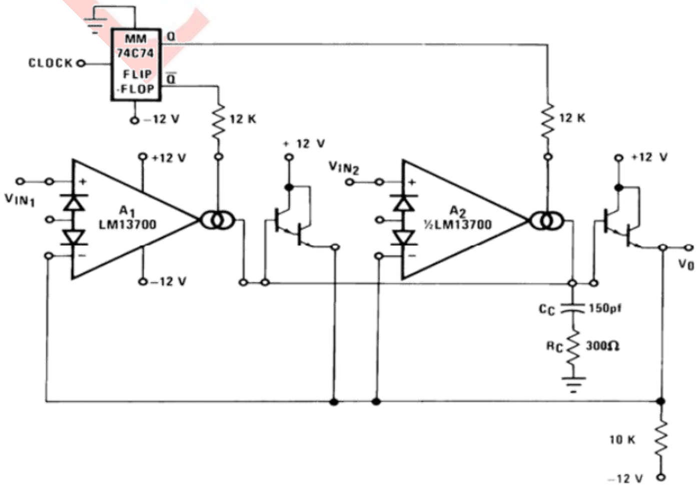


Figure 19 Multiplexer

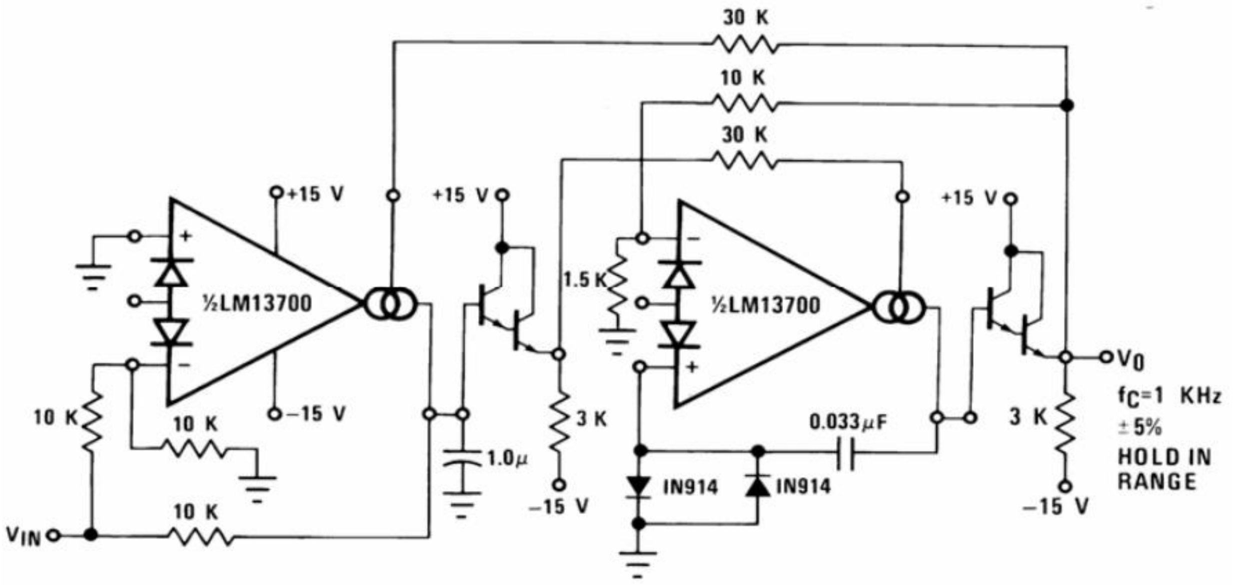


Figure 20 Phase-locked loop

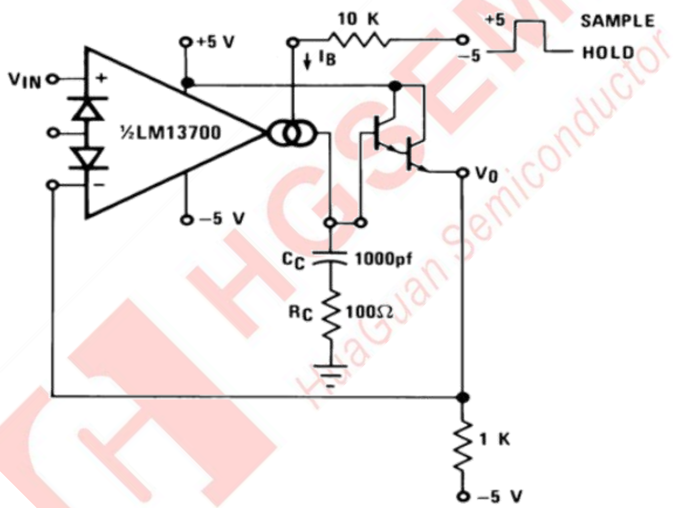


Figure 21 Sampling and Holding Circuit

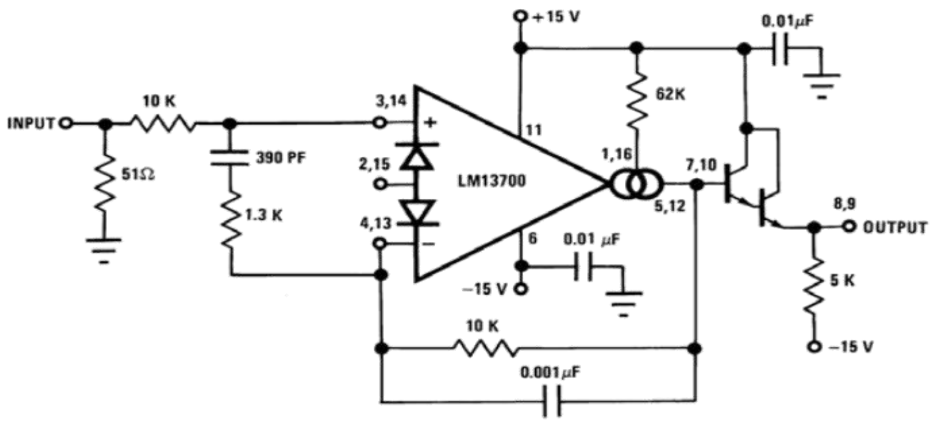


Figure 22 Unit Gain Follower

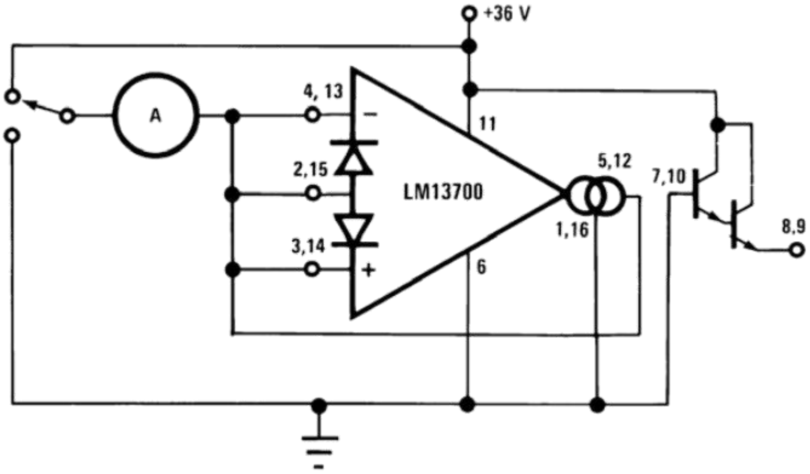


Figure 23 Leakage current test circuit

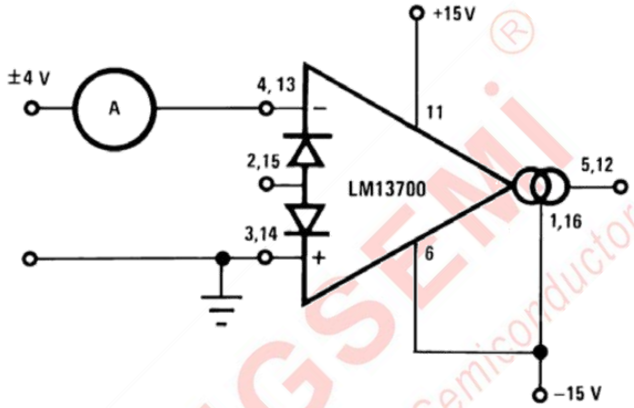
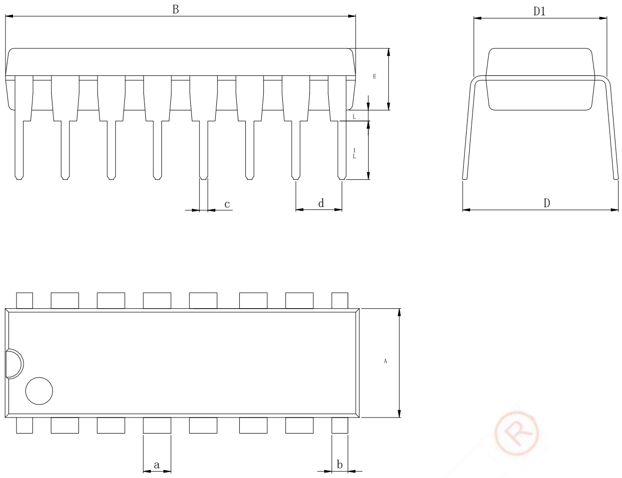


Figure 23 Differential input current test circuit

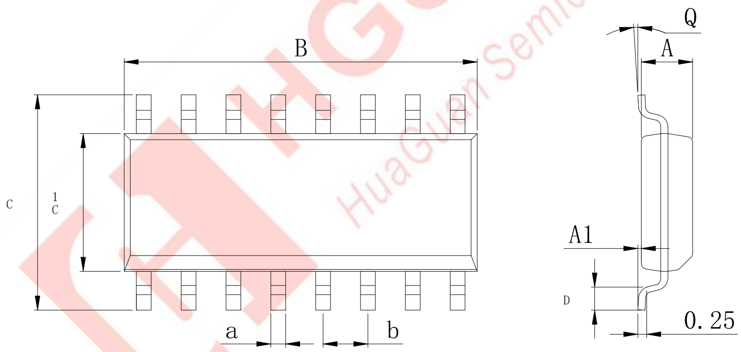
Package size

DIP16



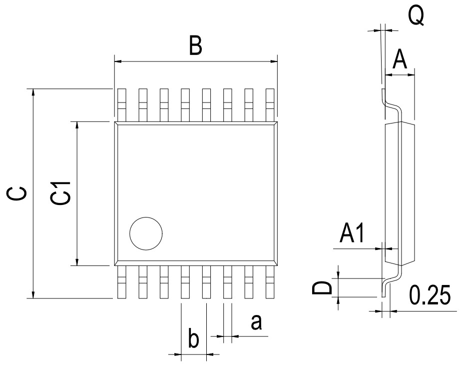
Dimensions In Millimeters(DIP16)											
Symbol:	A	B	D	D1	E	L	L1	a	b	c	d
Min:	6.10	18.94	8.40	7.42	3.10	0.50	300	1.50	0.85	0.40	2.54 BSC
Max:	6.68	19.56	9.00	7.82	3.55	0.70	3.60	1.55	0.90	0.50	

SOP16



Dimensions In Millimeters(SOP16)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	1.35	0.05	9.80	5.80	3.80	0.40	0°	0.35	1.27 BSC
Max:	1.55	0.20	10.0	6.20	4.00	0.80	8°	0.45	

TSSOP16



Dimensions In Millimeters (TSSOP16)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	0.85	0.05	4.90	6.20	4.30	0.40	0°	0.20	0.65 BSC
Max:	0.95	0.20	5.10	6.60	4.50	0.80	8°	0.25	

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