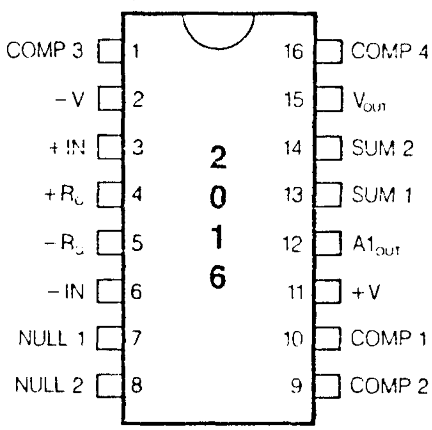
SSM 2016 – DIFFERENTIAL AUDIO PREAMPLIFIER

The SSM 2016 is an advanced differential device which can be used not only as a high gain microphone preamplifier, but also for signal summation and as a differential line receiver or low gain balanced input stage. Designed on a high voltage process, the 2016 can operate off split supplies from +/-9 to +/-36 volts. The output stage can source and sink a minimum of 40mA allowing a jack-field to be driven directly. The special package can dissipate 1.5 watts. The input referred noise of the device is 800pV/$\sqrt{Hz}$ yielding a noise figure of 1 dB when operated from a 150Ω source impedance.

FEATURES

* Ultra Low Voltage Noise (800pV/$\sqrt{Hz}$)
* Wide Bandwidth (500kHz @ G = 1000)
* High Slew Rate (10V/uS)
* Very Low Distortion (0.01% @ G = 1000)
* Full D.C. Coupling
* True Differential Inputs
* High Common Mode Rejection (100dB)
* 1/f Noise Corner < 5Hz
* No Crossover Distortion
* Symmetric Slew Rates



PIN OUT

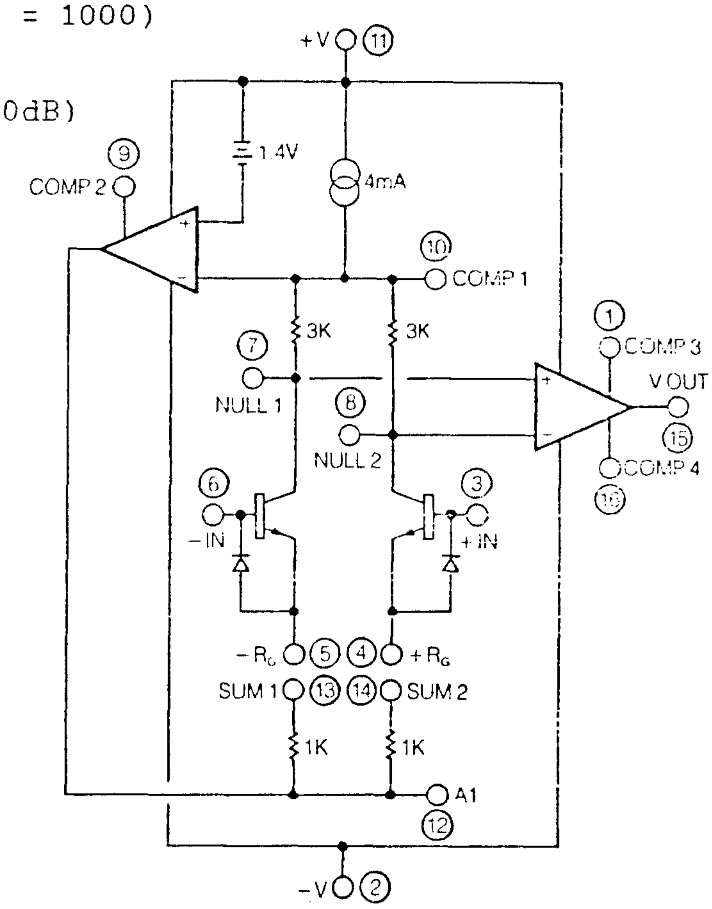


FIGURE 1. BLOCK DIAGRAM

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Absolute Maximum Ratings

Supply Voltage Range ..... +/- 38V
Current Into any Pin Except Pins 2, 11 and 12 ..... 40mA
Lead Temperature (soldering 60 sec.) ...... 300 degrees C
Storage Temperature ...... -65 degrees C to +150 degrees C
Package Dissapation (@25 degrees C) 2W
Short Circuit Duration ...... Indefinite provided dissipation limit is not exceeded.

Recommended Operating Conditions

Supply Voltage Range ...... +/- 9 to +/- 36V DC
Ambient Temperature Range ...... -25 degrees C to + 55 degrees C

SPECIFICATIONS
Following specifications apply for Vs=+/-18V, Ta=25 degrees C, R1=R2=5kΩ, R3=R4=2kΩ; unless otherwise stated.

PARAMETER	MIN	TYP	MAX	UNITS	CONDITIONS
Total Harmonic Distortion (THD) (Note 1)					
RL=2KΩ:					
G=1000					
@ 1kHz		0.009	0.015	%	Vout=10V RMS
@ 10kHz		0.015	0.02	%	Vout=10V RMS
G=100					
@ 1kHz		0.003	0.005	%	Vout=10V RMS
@ 10kHz		0.005	0.007	%	Vout=10V RMS
G=10					
@ 1kHz		0.002	0.003	%	Vout=10V RMS
@ 10kHz		0.003	0.005	%	Vout=10V RMS
RL=600Ω; Vs=+/-20V:					
G=1000					
@ 1kHz		0.025	0.04	%	Vout=10V RMS
@ 10kHz		0.06	0.09	%	Vout=10V RMS
G=100					
@ 1kHz		0.008	0.015	%	Vout=10V RMS
@ 10kHz		0.02	0.04	%	Vout=10V RMS
G=10					
@ 1kHz		0.005	0.008	%	Vout=10V RMS
@ 10kHz		0.008	0.015	%	Vout=10V RMS
Input Referred Voltage Noise (Note 1)					
G=1000		0.11	0.16	uV RMS	20kHz Bandwidth
G=100		0.2	0.3	uV RMS	20kHz Bandwidth
G=10		0.8	1.2	uV RMS	20kHz Bandwidth
Input Current Noise (In)(Note 1)		350	550	pA RMS	20kHz Bandwidth

PARAMETER	MIN	TYP	MAX	UNITS	CONDITIONS
Gain Equation (G)		$G = \frac{10k\Omega}{Rg} + 3.5$			R1=R2=5kΩ R3=R4=2kΩ
Error from Gain Equation (G)		0.1	0.3	dB	
Input Offset Voltage (Vos)					
G=1000		0.5	2.5	mV	
G=100		1.5	5	mV	
G=10		5	20	mV	
Input Bias Current		9	25	uA	Vcm = 0V
Input Offset Current		1.5	4.5	uA	Vcm = 0V
Common Mode Rejection Ratio (CMRR)					
G=1000	90	100		dB	
G=100	70	95		dB	
G=10	60	75		dB	
Power Supply Rejection Ratio	90	100		dB	Vs=+/-9 to +/-36V
Common Mode Voltage Range (CMVR)	+/-7	+/-10		V	
Common Mode Input Impdedance		20		MΩ	
Differential Mode Input Impedance					
G=1000		0.3		MΩ	
G=100		3		MΩ	
G=10		10		MΩ	
Output Voltage Swing	+/-15	+/-17		V	Rl=2kΩ
	+/-15	+/-17		V	Rl=600Ω; Vs=+/-20V
Output Current (Iout)(Note 2)					
Source	40	70		mA	
Sink	40	70		mA	
-3dB Bandwidth (GBW)(Note 3)					
G=1000		500		kHz	
G≤100		>1		MHz	
Slew Rate (SR)		10		V/uS	
Supply Current (Isy)		12	16	mA	

Note 1 - Parameter is sample tested to maximum limits.
Note 2 - Output is protected from short circuits to ground or either supply.
Note 3 - Bandwidth will be slew-rate limited at high output levels.

Final specifications may be subject to change

Principle of Operation

The 2016 operates as a true differential amplifier with feedback returned directly to the emitters of the input stage transistors by R1. This system produces both optimum noise and common mode rejection while retaining a very high input impedance. An internal "servo" amplifier is used to control the input stage current independently of common mode voltage and its output is accessible via pin 12. Normally, Pin 12 is connected to pins 4 and 5 by resistors R3 and R4.

Gain Setting

The nominal gain of the 2016 is given by:

$$G = \frac{R1 + R2}{Rg} + \frac{R1 + R2}{R3 + R4} + 1, \text{ or } G = \frac{10k\Omega}{Rg} + 3.5 \text{ for } R1=R2=5k\Omega; \; R3=R4=2k\Omega$$

R1 and R2 should be equal to 5kΩ for best results. It is vital that good quality resistors be used in the gain setting network, since low quality types (notably carbon composition) can generate significant amounts of distortion and, under some conditions, low frequency noise. The 2016 will function at gains down to 3.5 at full performance. Gain range can be extended funther by increasing R3 and R4, but at the penalty of reduced common mode input range. Gains below 2.5 are not practical unless the negative supply voltage is increased.

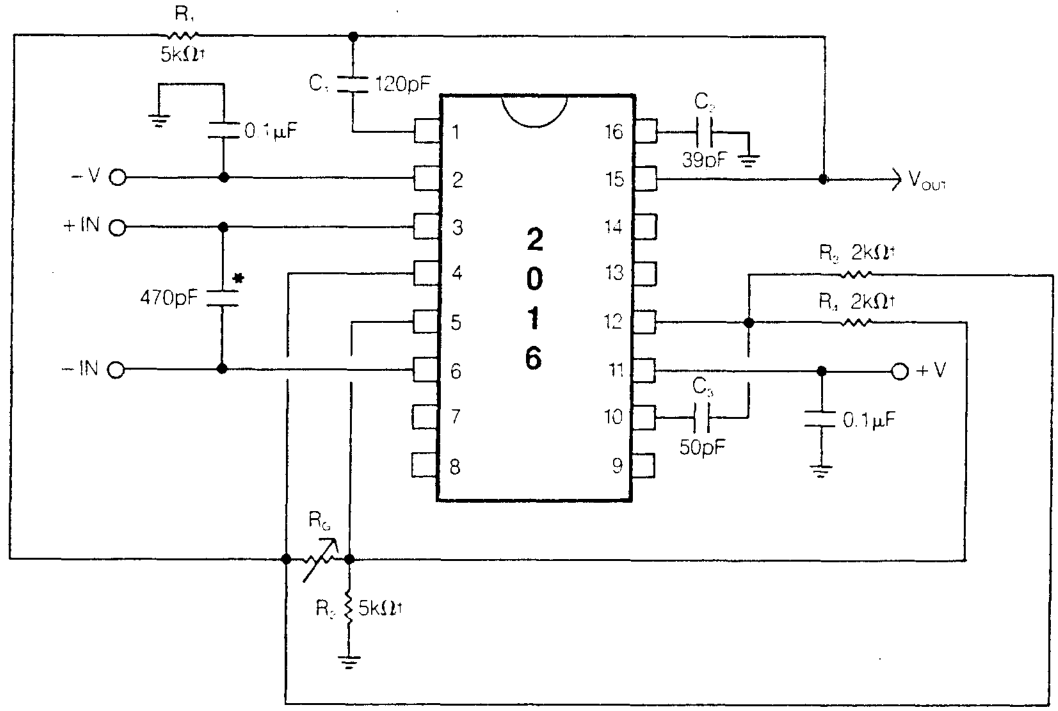
Note that the tolerance of R1 - R4 directly affects gain error and also that good matching between R1 and R2 and R3 and R4 is essential if common mode rejection performance is not to be degraded. Internal 1kΩ resistors are provided to replace R3 and R4 in non-critical applications where distortion is not too important. The tolerance of the internal resistors is +/- 30%.

Frequency Compensation

The internal "servo" amplifier is compensated by C3, while C1 and C2 compensate the overall amplifier. The values shown maintain a very wide bandwidth with a good symmetric slew rate. Bandwidth can be reduced, if desired, by increasing the value of C1.

Noise

The 2016 is optimized for source impedances below 1kΩ and under these conditions yields a noise performace equal to the best discrete component designs. With 150Ω microphones, for example, the noise figure is typically 1dB which under practical conditions makes the 2016 virtually transparent. Care must be taken, however, to avoid degrading the noise performance.



$$\text{VOLTAGE GAIN} = \frac{10k\Omega}{R_G} + 3.5$$

*470pF CAP MOUNTED CLOSE TO PACKAGE.
† SEE TEXT.

FIGURE 2. TYPICAL PREAMPLIFIER APPLICATION.

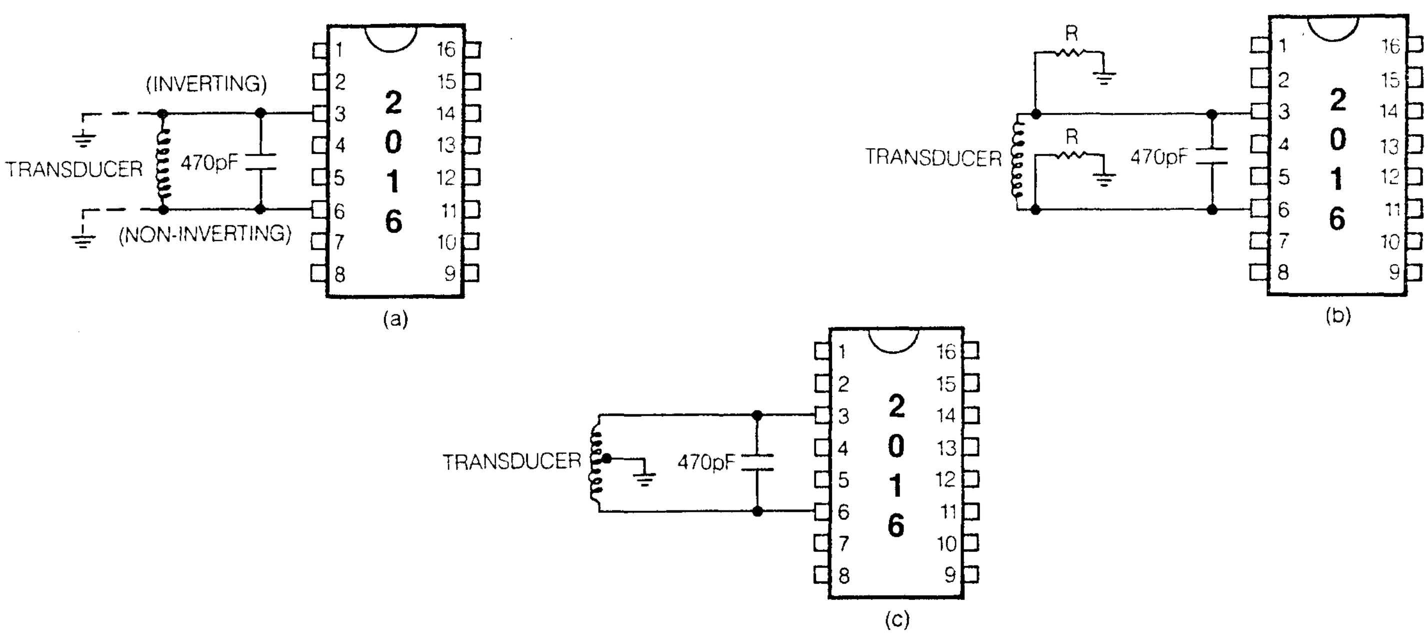


FIGURE 3. THREE WAYS OF INTERFACING TRANSDUCERS FOR HIGH NOISE IMMUNITY.

(a) Single ended. (b) Pseudo differential. (c) True differential.

Obviously, high source impedances will increase the noise figure of the 2016 and for such sources the SSM 2015 or SSM 2011 preamplifiers are recommended. A more subtle source of degradation is power dissipation since a temperature rise will increase the noise due to basic semiconductor physics (this effect is more pronounced at high gains). The 2016 uses a copper lead-frame package which greatly helps the dissipation, but even so the best noise performance will be obtained at low supply voltages while driving light loads.

Drive Capability

The 2016 has a powerful output stage designed to drive a jack-field directly. Although +/- 18V supplies typically ensure that a 600Ω load can be driven to a 10V RMS sine wave, 20V or greater supplies are recommended to give a more comfortable headroom. Care should be taken to stay within package dissipation limits at higher values of supply voltage.

2016 Inputs

Although the 2016 inputs are fully floating, care must be exercised to ensure that both inputs have a DC bias connection capable of maintaining them within the input common mode range. The usual method of achieving this is to ground one side of the transducer as in figure 3(a), but an alternative way is to float the transducer and use two resistors to set the bias point as in figure 3(b). The value of these resistors can be up to 10kΩ or so, but they should be kept as small as possible to limit common mode noise. Noise performance in the resistors themselves is negligible since it is attenuated by the transducer impedance. Balanced transducers give the best noise immunity, and interface directly as in figure 3(c).

Phantom Power

A typical phantom powering circuit is shown in figure 4. Usually, zener clamps are present at the inputs of microphone preamplifiers to provide transient protection when microphones are plugged in and out. The 2016, however, has internal clamping and the extra clamps are only necessary if the transient current exceeds 40mA.

Trimming

Gain trim on the 2016 is readily accomplished by adjusting Rg, but three other trims may be desirable: high gain offset, low gain offset, and common mode rejection. All three can be accomplished with the circuit of figure 5.

VR2 adjusts high gain offset, VR3 low gain offset, and VR1 common mode rejection. Common mode rejection is best adjusted by applying an 8V p-p 60Hz (50Hz in Europe!) sine wave to both inputs and adjusting VR1 for minimum output. Interaction is minimized by trimming high gain

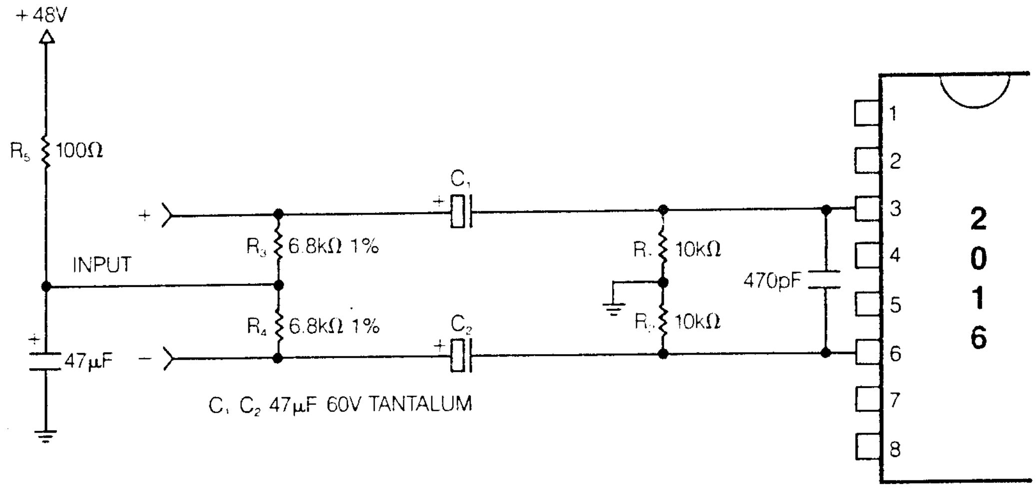


FIGURE 4. 2016 WITH PHANTOM POWER.

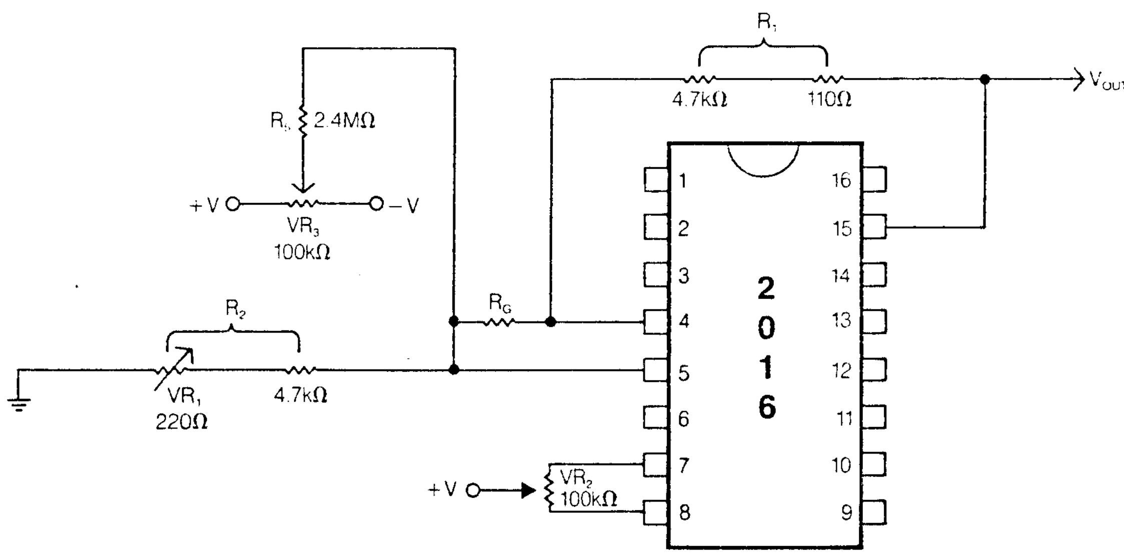


FIGURE 5. TRIMMING THE SSM 2016.

offset first, followed by CMRR and finally low gain offset. A two-pass trim is recommended for best results. Note that the overall gain has been reduced slightly to allow convenient values of resistor.

If the low gain offset trim is not used, then gain control feedthrough can still be reduced by adjusting high gain offset to equal low gain offset by means of VR2.

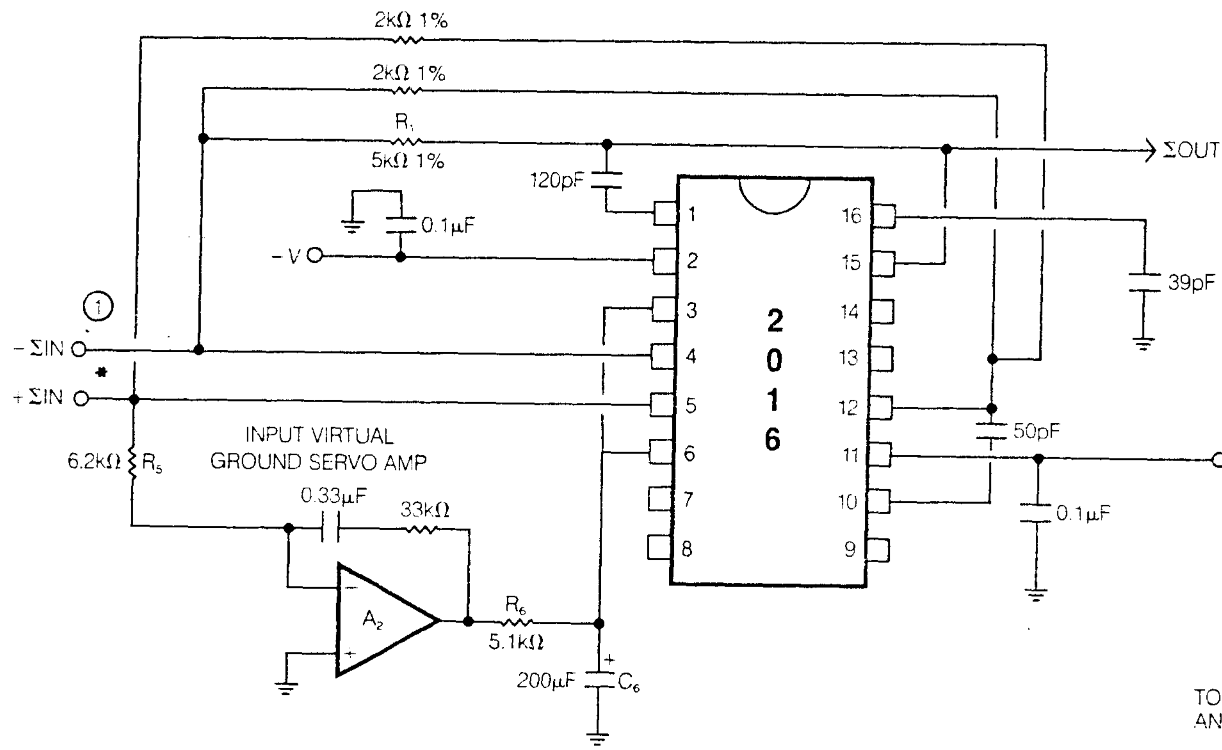
Bus Summing Amplifier

In addition to its use as a microphone preamplifier, the 2016 can be used as a very low noise summing amplifier. Such a circuit is particularly useful when many medium impedance outputs are summed together to produce a high effective noise gain.

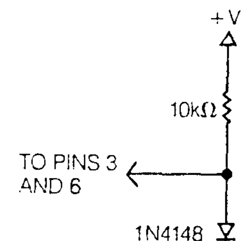
The principle of the summing amplifier is to ground the 2016 inputs. Under these conditions, pins 4 and 5 are A.C. virtual grounds sitting about 0.65V below ground. Any currents injected into these points must flow through the feedback resistor (R1) and hence are amplified to appear the output. Moreover, both positive (pin 5) and negative (pin 6) transfer characteristics are available simultaneously in contrast to the usual "inverting only" configuration.

To remove the 0.65V offset, the circuit of figure 6 is recommended.

A2 forms a "servo" amplifier feeding the (normal) 2016 inputs. This places pins 4 and 5 at a true D.C. virtual ground. R6 in conjunction with C6 remove the voltage noise of A2 and in fact just about any op-amp will work well here since it is removed from the signal path. If the D.C. offset at pins 4 and 5 is not too critical, then the servo loop can be replaced by the diode biasing scheme of figure 6A. If A.C. coupling is used throughout then pins 3 and 6 may be directly grounded.



*NOTE: TOTAL INPUT CURRENT MUST BE LESS THAN CAN BE SUPPLIED BY 5kΩ FEEDBACK RESISTOR.



INPUT BIAS CIRCUIT TO REPLACE SERVO AMP IN NON-CRITICAL APPLICATIONS.

FIGURE 6(a).

FIGURE 6. 2016 DIFFERENTIAL BUS SUMMING AMP.

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