AH0605

DATA AND SPECIFICATIONS
DESCRIPTION AND INSTRUCTIONS

Optical Electronics Incorporated

WIDEBAND - FAST SETTLING OPERATIONAL AMPLIFIER

FEATURES

- FAST SETTLING: 400 nsec max to 0.1%
- WIDE BANDWIDTH: 400 MHz Gain - Bandwidth Product
- FAST SLEWING: 500 V/μsec slew rate. $A_{CL} \geqslant 50$
- LARGE OUTPUT CURRENT: ±30 mA at ±10V
- HIGH GAIN: 80 dB min at ±30 mA output

APPLICATIONS

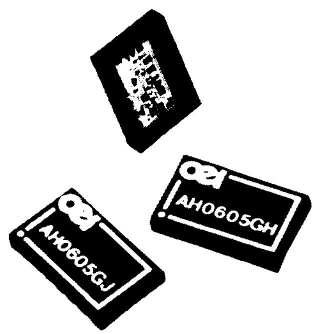
- PULSE AMPLIFIERS
- FAST D/A CONVERTERS
- LINE DRIVERS
- WAVEFORM GENERATORS
- HIGH SPEED TEST EQUIPMENT
- RADAR
- SONAR

DESCRIPTION

The AH0605 op amp is exceptionally well suited for both DC and AC applications. Its specifications are well balanced to allow easy applications in both domains. The design of the device provides versatility for fast settling time, wide bandwidth and steady state AC operations due to a single external compensation capacitor. Thus speed and stability can be optimized in any given application.

Since the AH0605 guarantees a minimum output current of ±30mA (at ±10V output voltage) the user can fully realize the high speed features of the AH0605. Most wideband integrated circuit op amps require current boosting in many applications. The high current output of this device eliminates additional booster circuitry in most applications.

The open loop gain (see appropriate performance curve) is guaranteed over the indicated frequency range with the full ±30mA output current. Also guaranteed is the settling time of 400 nsec maximum to 0.1% when a load of 330Ω is used.



DC performance of the AH0605 matches its outstanding AC performance. In addition to the wide bandwidth and very fast settling time characteristics, offset voltages are ±5mV maximum and offset voltage drift versus temperature is only 10μV/°C maximum, thus providing very good DC performance.

The AH0605 can be used in many cases where normally specialized devices would be needed. Applications range from very fast AC, such as pulse and fast D/A conversions to wave form generation and to audio, sonar and radar circuits.

SPECIFICATIONS

ELECTRICAL

Specifications at T_A = +25°C and $\pm V_{CC}$ = ±15VDC unless otherwise noted.

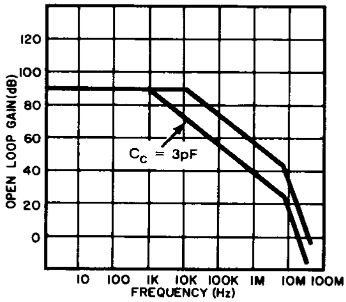
MODEL		AH0605GH			AH0605GJ			AH0605GK			
PARAMETER	**CONDITION**	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**UNITS**
OPEN-LOOP GAIN, DC											
Full Load	Vo = ±10V; RL = 330Ω	80	83		•	•		•	•		dB
No Load	Vo = ±10V		86			•			•		dB
RATED OUTPUT											
Voltage	Io = ±30mA	±10	±12		•	•		•	•		V
Current	Vo = ±10V	±30	±50		•	•		•	•		mA
Output Resistance	Open Loop		200			•			•		Ω
Short Circuit Current	Internal Limits			±100			•			•	mA
Capacitive Load A_{CL} = −1	C_c = 20pF	500			•			•			pF
DYNAMIC RESPONSE											
Gain Bandwidth Product											
A_{CL} = 1000	Cc = 1pF		400			•			•		MHz
A_{CL} = −1	Cc = 20pF		20			•			•		MHz
Slew Rate	R_L = 330Ω,Vo = ±10V										
A_{CL}≥50	Cc = 3pF	375	500		•	•		•	•		V/µsec
A_{CL} = −1	Cc = 20pF	210	230		•	•		•	•		V/µsec
Full Power Bandwidth	R_L = 330Ω, Vo = ±10V										
A_{CL} = −1	Cc = 20pF	3.4	3.7		•	•		•	•		MHz
Settling Time, Av = −1	Cc = 20pF, R_L = 500Ω										
A_{CL} = −1	C_L = 100pF, Vo = ±10V										
ε = 1%			70			•			•		nsec
ε = 0.1%			300	400		•	•		•	•	nsec
Small-Signal Overshoot A_{CL} = −1	Cc = 20pF, R_L = 500Ω, C_L = 100pF		0	20		•	•		•	•	%
INPUT OFFSET VOLTAGE											
Initial Offset	0°C to 70°C		±1.0	±5.0		±1.0	±5.0		±1.0	±5.0	mV
vs Temperature				±50			±25			±10	µV/°C
vs Supply Voltage			±30	±200		•	•		•	•	µV/V
Adjustment Range	Circuit in Connection Diagram		±9			•			•		mV
INPUT BIAS CURRENT											
Initial Bias			70	150		•	•		•	•	pA
vs Temperature	0°C to +70°C		Note 1			•			•		
vs Supply Voltage			0.2			•			•		pA/V
VOLTAGE NOISE DENSITY Rs ≤ 100Ω											
	fo = 100Hz		30			•			•		nV/√Hz
	fo = 1kHz		20			•			•		nV/√Hz
	fo = 10kHz		12			•			•		nV/√Hz
INPUT IMPEDANCE											
Differential											
Resistance			10^{11}			•			•		Ω
Capacitance			3			•			•		pF
Common-Mode											
Resistance			10^{11}			•			•		Ω
Capacitance			3			•			•		pF
INPUT VOLTAGE RANGE											
Common-Mode Voltage Range	Linear Operation	±10	±12		•	•		•	•		V
Common-Mode Rejection	1kHz	70			•			•			dB
POWER SUPPLY											
Rated Voltage		±8	±15	±20	•	•	•	•	•	•	VDC
Quiescent Current	Vcc = ±15VDC		±15	±19		•	•		•	•	mA
TEMPERATURE RANGE											
Specification											
H,J,K. Grades		0		+70	•		•	•		•	°C
Operating	Derated Peformance	-25		+100	•		•	•		•	°C
Storage		-50		+125	•		•	•		•	°C

Note: AH0605 1) Doubles approximately every 10°C.

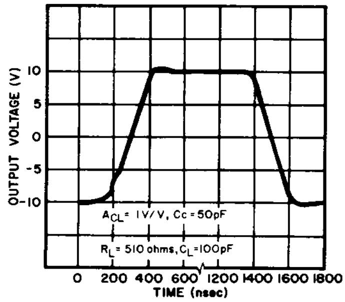
AH0605
TYPICAL PERFORMANCE CURVES

(T$_A$ = +25°C, V$_{CC}$ = ±15VDC unless otherwise noted)

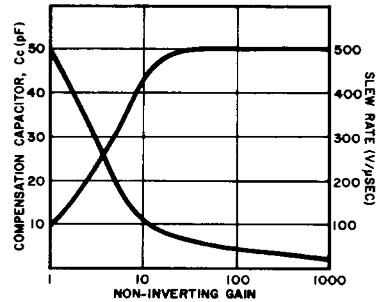
OPEN LOOP GAIN
VS. FREQUENCY



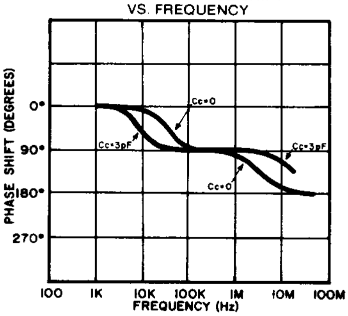
LARGE SIGNAL TRANSIENT RESPONSE



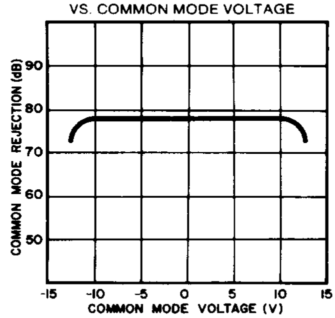
COMPENSATION CAPACITANCE AND
SLEW RATE VS. NON-INVERTING GAIN



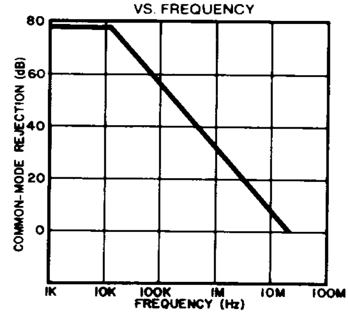
OPEN LOOP PHASE SHIFT
VS. FREQUENCY



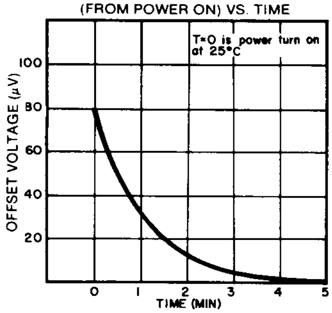
COMMON MODE REJECTION
VS. COMMON MODE VOLTAGE



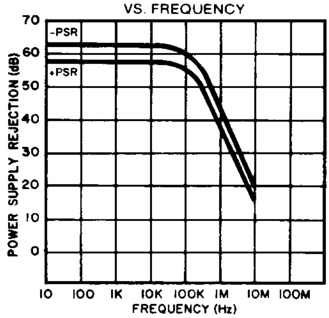
COMMON MODE REJECTION
VS. FREQUENCY



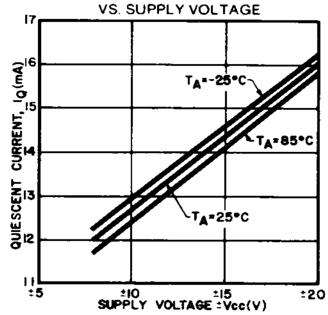
CHANGE IN OFFSET VOLTAGE
(FROM POWER ON) VS. TIME



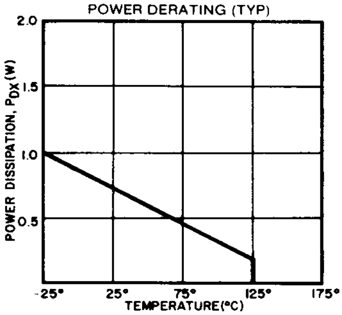
POWER SUPPLY REJECTION
VS. FREQUENCY



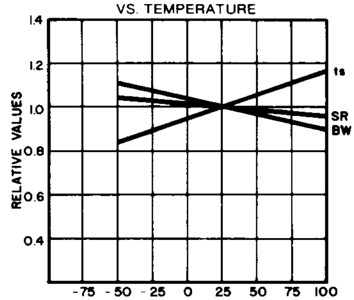
QUIESCENT CURRENT
VS. SUPPLY VOLTAGE



POWER DERATING (TYP)

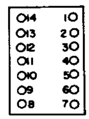


AC PARAMETERS
VS. TEMPERATURE



PIN CONNECTIONS
1 NO CONNECTION
2 NO CONNECTION
3 OFFSET ADJUST
4 INVERTING INPUT
5 NON-INVERTING INPUT
6 −Vcc
7 NO CONNECTION
8 NO CONNECTION
9 OFFSET ADJUST
10 OUTPUT
11 +Vcc
12 FREQUENCY COMPENSATION
13 NO CONNECTION
14 NO CONNECTION

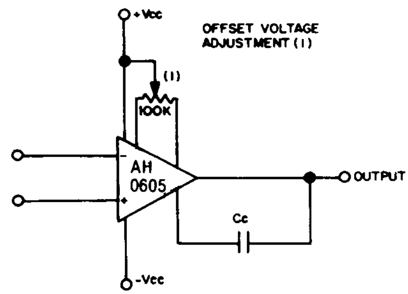
AH0605



(Bottom View)

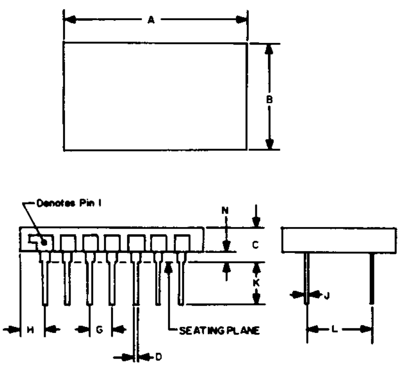
Pin Numbers shown for reference only. Numbers are not marked on Package.

OFFSET VOLTAGE ADJUSTMENT



MECHANICAL DESCRIPTION

The AH0605 is a standard 14 pin DIP. Pins are compatible with standard 0.3 inch dual in-line sockets. The case is made of ceramic and is sealed with a ceramic lid.



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.770	.810	19.56	20.57
B	.480	.500	12.19	12.70
C	.155	.215	3.94	5.46
D	.016	.020	.41	.51
G	.100 NOM.		2.54 NOM.	
H	.080	.110	2.03	2.79
J	.009	.012	.23	.30
K	.150	.210	3.81	5.33
L	.300 NOM		7.62 NOM.	
N	.015	.035	.38	.89

NOTES:
1. LEADS IN TRUE POSITION WITHIN .010" (.255mm)

ABSOLUTE MAXIMUM RATINGS

Supply	±20VDC
Internal Power Dissipation	(1)
Differential Input Voltage(2)	±20VDC
Input Voltage, Either Input(1)	±20VDC
Storage Temperature Range	−55°C to +125°C
Operating Temperature Range	−55°C to +125°C
Lead Temperature (soldering 10 seconds)	+300°C
Output Short-Circuit Duration(3)	Continuous

NOTES:
1. Package must be derated according to details in the Applications information section.
2. For supply voltages less than ±20VDC, the absolute maximum input is equal to the supply voltage.
3. Short circuit to ground only. See Short Circuit Protection discussion in the Application Information section.

BANDWIDTH

The open loop frequency response of an op amp determines the closed loop bandwidth which is a small signal parameter. The frequency response in turn is dependent on the value of the compensation capacitor C_C and the remaining circuitry of the closed loop external to the amplifier. Usually it is desirable to have a wide bandwidth and high frequency stability simultaneously, which are two requirements that cause opposing restrictions as far as the circuitry is concerned. The selection of final values of circuit components is usually the result of a compromise between these two parameters, while still considering the predominant aspects of the application.

SLEW RATE

Contrary to bandwidth, the slew rate is a large signal output parameter. It is dependent mostly on the value of the compensation capacitor C_C and is nearly independent of changes in either the gain or the bandwidth. As with bandwidth, increases in slew rate may result in a decrease of frequency stability. Typical compensation capacitor values are shown in the Typical Performance Curves section. When designing a circuit with the AH0605, care should be taken to limit stray capacitances as they can appear as added compensation to the amplifier. These stray capacitances will then degrade or limit the device's slew rate.

SETTLING TIME

The definition of settling time is the time required for the amplifier output voltage to reach a specified value after an input step voltage has been applied. The settling value is usually given as an error band around the final value. This error band is defined as a percentage of the full scale output voltage (10V for the AH0605) and for an output transition from 0 V to either +10V or −10V.

The settling time is a composite time which is dependent on slew rate and the time required to settle to the final output value after the slewing portion of the voltage swing is completed. As discussed above the time is dependent on the closed-loop bandwidth as well as the closed-loop gain of the circuit under investigation. Settling time therefore is dependent on the compensation capacitor C_C because it is a function of the open-loop frequency compensation and the closed-loop circuit configuration. Small gains will generally provide fastest settling times.

COMPENSATION

The AH0605 is designed to allow external frequency compensation. This gives the designer the freedom to optimize his circuit for the specific application. Bandwidth, slew rate, settling time and frequency stability must be considered separately and as functions of the other parameters. Compensation capacitor values then become compromises between the desired speed and the necessary frequency stability. If small C_C values are used then higher speeds are achieved; however frequency stability of the circuit suffers. To aid the designer in the selection of the compensation capacitor, several Typical Performance Curves are provided for different values of C_C. Further, the following circuit diagrams are provided as an aid.

Figure 1 shows a typical unity gain follower circuit. As in all applications, the amount of negative feedback determines the value of compensation needed to retain frequency stability. If β were called "feedback factor" then $1/\beta$ would characterize the function of this relationship.

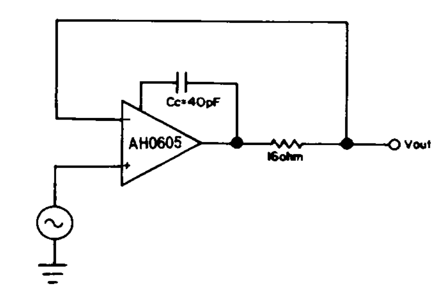


FIGURE 1: BASIC CONNECTIONS

In the inverting case of figure 2 this value ($1/\beta$) is also equal to the gain of the circuit. This second case requires a smaller value of C_C as can be seen from the figures.

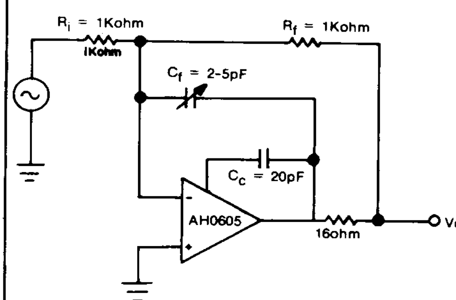


FIGURE 2: INVERTING METHOD

Normally, the use of a compensation capacitor is recommended. When used, it should be connected between pins 10 and 12. Frequency stability with large capacitive loads can be improved considerably if in addition to C_C a small resistor is connected in series with the output. A value of 16 Ω is recommended as is shown in all circuit diagrams herein.

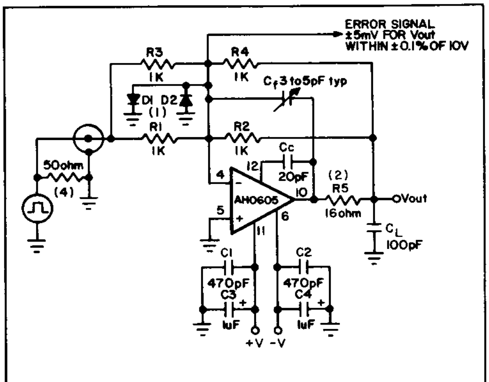
Closed-loop frequency response can be considerably improved if a small capacitor is connected in parallel to the feedback resistor. This capacitor will also reduce peaking at high frequencies. The capacitor (C_f in the figures) will compensate for the high frequency closed-loop transfer function zero which is formed by the capacitance of the input and feedback resistors. This capacitor can be fixed or variable (trimmer) or can be planned as part of the printed circuit board layout. Typical values range from 1 pF to 5 pF.

CIRCUIT LAYOUT

During circuit layout special attention should be given to grounding, since this is a most important consideration. Commonly known good grounding practices should be applied. When a printed circuit board is laid out, the ground plane should cover all areas of the board not otherwise used. This ground plane (on the pattern side) will then provide low resistance and low impedance paths for all signal and power common returns.

When circuits are laid out for point to point wiring and therefore no ground plane is available, a single point ground should be used. This is to say that all signal input, signal output and all power supply returns should be made to the same physical point. This will eliminate ground loops or common current paths that could influence circuit performance by unwanted signal modulation or feedback.

As shown in the example below, each power supply lead should be bypassed as closely as possible to the appropriate pins of the AH0605.



NOTES:
1. FAST RECOVERY DIODES, HP5082-2811
2. R5 OPTIONAL, IMPROVES FREQUENCY STABILITY WHEN DRIVING LARGE CAPACITIVE LOADS.
3. RESISTIVE LOAD AT V_{out} IS 500Ω DUE TO 1K FEEDBACK RESISTORS.
4. NOT INCLUDED ON PRINTED CIRCUIT LAYOUT

FIGURE 3

In general the layout should be as small as is practical. Connections whether wire or printed path should be as short as possible and provide low impedance connections. (Wide traces on a PC board). Pin 4, the inverting input, is the most sensitive to stray capacitances. In general, stray capacitances should be minimized. It is recommended to design input and feedback resistors with values below 5.6 KΩ if possible. The smaller the values of R_F the smaller the limitations in performance of the time constants formed by these resistors.

A dynamic test circuit is given in the diagram in figure 4. Its layout should closely resemble the one given for the breadboard circuit where the wiring and design precautions given above have been incorporated.

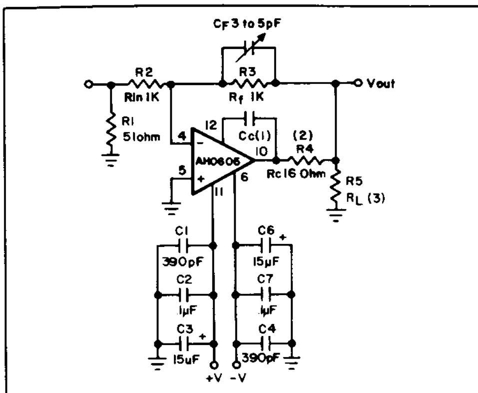
SHORT CIRCUIT PROTECTION

Internal current limiting resistors provide short circuit protection to the common line. These resistors provide some short circuit protection to either supply but a short can destroy the device.

Power derating constraints must be considered in the short circuit case. For additional information see Typical Performance Curves.

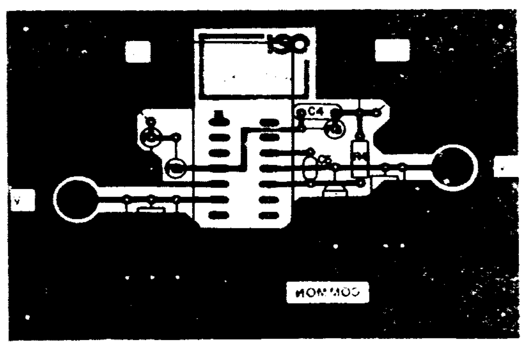
BREADBOARD CIRCUIT

The figures below show a circuit diagram for a typical wide bandwidth, high slew rate application. Also shown is a recommended layout for this application. Included are all power supply decoupling elements.



(1) Cc IS RECOMMEND TO BE 40pF FOR UNITY GAIN, AND 3pF FOR LARGER GAIN.
(2) Rc IS AN OPTION WHICH CAN BE USED TO IMPROVE SETTLING TIME AND STABILITY.
(3) THE LOAD CAN BE CAPACITIVE OR RESISTIVE.

FIGURE 4



VIEW FROM COMPONENT SIDE

FIGURE 5

INSTRUMENTATION AMPLIFIER

An ideal instrumentation operational amplifier produces very high gain, zero offset voltage, no voltage drift, superior common mode rejection, very low noise, wide bandwidth and fast slewing rates, which allows very accurate reproduction and amplification of the values measured. Use of the AH0605 in this application combines a number of advantages that makes this circuit a close contender to the ideal. The circuit shown in Figure 6 provides the designer with a very high speed instrumentation amplifier, because of the device's high slew rate and wide bandwidth. The gain can be programmed to high values, the low offset voltage and drift reduce adjustment problems, and the common mode rejection helps to produce an excellent low noise design. The overall system gain can be calculated by:

$$\text{Gain} = \left(1 + \frac{2mR_1}{R_1}\right) \quad \text{for } mR_1 = nR_1;\ K = 1$$

The usual compensation and circuit layout precautions apply, if full advantage is to be taken of the capabilities of the AH0605.

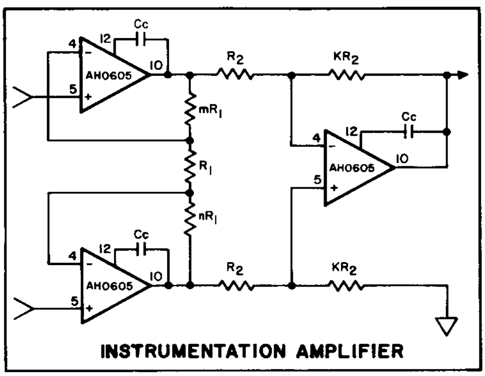


FIGURE 6

MULTIPLEXED HIGH SPEED LINE DRIVER

This application exemplifies how several of the characteristics of the AH0605 can be employed. In this case, it is assumed that video signals are being multiplexed onto one line. (Figure 7)

Since video signals usually appear at voltages of ≤2V p-p the AH0605 can be applied in its small signal mode, thus taking advantage of its wide bandwidth capability. The fast settling time helps to preserve the wave shape of the input signal. Since the device has an FET front end, no appreciable load is placed on the input lines, even though the output of this circuit is designed for ±10V and a 200Ω load. The high current drive capability makes the AH0605 a perfect line driver even for long signal lines. Additionally the device can be programmed for any gain within its design limits, while still preserving the ±30mA drive capability. Thus this application will find excellent use for line drivers in high speed test equipment as well as for pulse and video signal processing.

In all these applications it is important to observe the guidelines given in the previous section for compensation of the amplifier. The compensation capacitor C_C must be chosen as a compromise between speed and frequency stability. Generally line drivers are designed as unity gain amplifiers. This improves high speed performance and allows C_C to be made somewhat larger with a consequent improvement in frequency stability. Naturally, the circuit can also be designed with the AH0605 in the noninverting mode of operation.

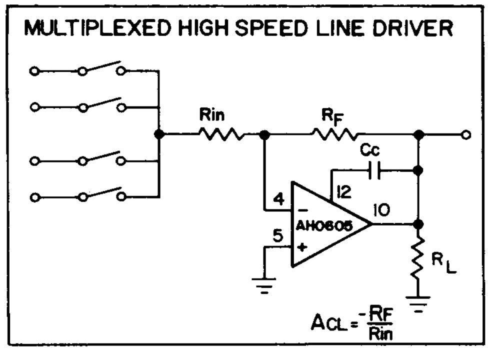


FIGURE 7

DIGITALLY CONTROLLABLE FUNCTION GENERATOR

The function generator shown in Figure 8 can be designed to span a very wide frequency range. Depending on values chosen, frequencies near DC and up to 3MHz can be obtained. Because of the use of a multiplying Digital to Analog Converter (DAC) the frequency can be selected by appropriate choice of a multi-bit digital control word.

The functional description of this circuit is best started at the multiplying DAC. The AC 7533 (Analog Devices) is a 10 bit, 4 quadrant multiplying DAC and can be obtained with non-linearity specifications of ±1.2%, ±0.1% and ±0.05%. Its highly stable R-2R ladder and 10 CMOS current switches provide binarily weighted currents between the OUT 1, and OUT 2 lines. OUT 1 is connected to the inverting input of the first AH0605 which provides a triangular wave at its output due to the integrator action. C_t together with R_t are the coarse frequency determining elements. The second AH0605 is connected as a voltage comparator and thus provides a square wave at its output. The output of this second amplifier is in turn connected to the reference input of the DAC. Since the AD 7533 operates in its bipolar mode, the triangular and the square wave outputs are both referenced to zero as positive and negative going voltages.

As mentioned above, coarse frequency calibration can be accomplished by selection of the 10 bit digital control word and can be calculated by:

$$f = N\left(\frac{1}{8R_tC_t}\right) \text{ where } R_t = 10K\Omega$$

and $0 < N \leq (1 - 2^{-10})$

With appropriate selection, frequencies of ~ 1Hz to 1MHz can easily be obtained and frequencies to 3MHz are possible. Due to the rapid response of the AH0605, high linearities for the triangular and the square wave can be obtained. The 500Ω resistor provides for short circuit protection. C_C is the compensation capacitor mentioned earlier. If necessary, the AC 7533 can be replaced with a faster DAC to obtain even higher output frequencies.

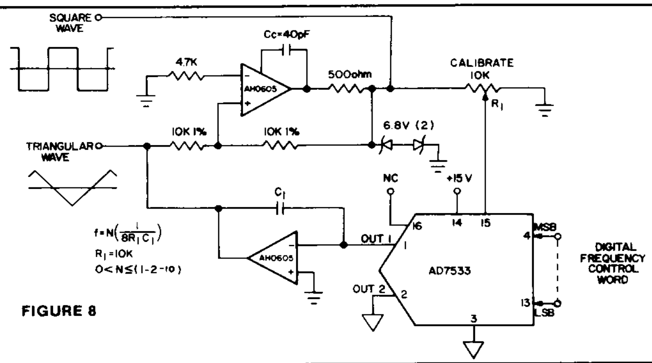


FIGURE 8

CURRENT-TO-VOLTAGE CONVERSION
For a Multiplying DAC

Multiplying Digital to Analog Converters (DAC) are commonly used in either the current or the voltage switching mode. The voltage switching mode requires a stable voltage reference, a condition that can not always be met. Therefore, the current steering mode has some advantages. Frequently, however, it is necessary to transform the current output of the DAC into an equivalent voltage. For this application, and particularly if high speed conversion is required, the AH0605 is an ideal candidate. A further advantage this device offers is its inherently high drive capability. Where necessary, the design with the AH0605 allows for very high gain.

In the example of Figure 9, an AM 6012 Advanced Micro Device, 12 bit multiplying DAC has been used. Since the I_O terminal is at ground (current steering mode) the operational amplifier maintains I_O at the same voltage (virtual ground). The binary-weighted currents through the R-2R legs are thus independent of the switch position. Also the FET front end of the AH0605 prevents loading of the ladder. It is self-evident that either the inverting (shown) or non-inverting input of the operational amplifier could be used, depending on application. The AH0605 is employed as a transimpedance amplifier. This mode enhances this high speed DAC because of the inherently high speed, fast settling time and high drive capability. With the values shown, 250 nanoseconds settling time and an output current of 4mA at the full ±10V output voltage can be realized. The load resistor R_L can be chosen anywhere within the design specifications of the AH0605, and with a value of 200Ω will provide ±50mA output drive current. Since the input voltage reference can take on any waveshape (within DAC specifications) this circuit can be used in virtually any application where digital control is needed.

CURRENT TO VOLTAGE CONVERSION FOR A HIGH SPEED MULTIPLING DAC

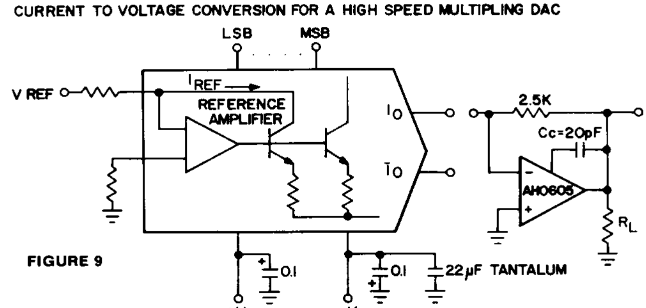


FIGURE 9

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