ADVANCED LINEAR DEVICES, INC.

ALD1706A/ALD1706B
ALD1706/ALD1706G

ULTRA MICROPOWER RAIL-TO-RAIL CMOS OPERATIONAL AMPLIFIER

GENERAL DESCRIPTION

The ALD1706 is a monolithic CMOS ultra micropower high slew-rate, high performance operational amplifier intended for a broad range of analog applications using ±1V to ±6V dual power supply systems, as well as +2V to +12V battery operated systems. All device characteristics are specified for +5V single supply or ±2.5V dual supply systems. Supply current is 40µA maximum at 5V supply voltage. It is manufactured with Advanced Linear Devices' enhanced ACMOS silicon gate CMOS process.

The ALD1706 is designed to offer high performance for a wide range of applications requiring very low power dissipation. It offers the popular industry standard single operational amplifier pin configuration.

The ALD1706 has been developed specifically for the +5V single battery or ±1V to ±6V dual battery user. Several important characteristics of the device make application easier to implement at those voltages. First, the operational amplifier can operate with rail to rail input and output voltages. This means the signal input voltage and output voltage can be close to or equal to the positive and negative supply voltages. This feature allows numerous analog serial stages and flexibility in input signal bias levels. Secondly, the device was designed to accommodate mixed applications where digital and analog circuits may operate off the same power supply or battery. Thirdly, the output stage can typically drive up to 25pF capacitive and 20KΩ resistive loads. These features, combined with extremely low input currents, high open loop voltage gain of 100V/mV, useful bandwidth of 400KHz, a slew rate of 0.17V/µs, low offset voltage and temperature drift, make the ALD1706 a versatile, micropower operational amplifier.

The ALD1706, designed and fabricated with silicon gate CMOS technology, offers 0.1pA typical input bias current. On chip offset voltage trimming allows the device to be used without nulling in most applications.

FEATURES

- 20µA supply current
- All parameters specified for +5V single supply or ± 2.5V dual supply systems
- Rail to rail input and output voltage ranges
- No frequency compensation required -- unity gain stable
- Extremely low input bias currents -- 0.1pA typical (30pA max.)
- Ideal for high source impedance applications
- Dual power supply ±1.0V to ±6.0V operation
- Single power supply +2V to +12V operation
- High voltage gain – typically 100V/mV @ ±2.5V (100dB)
- Drive as low as a 20KΩ load
- Output short circuit protected
- Unity gain bandwidth of 0.4MHz
- Slew rate of 0.17V/µs

APPLICATIONS

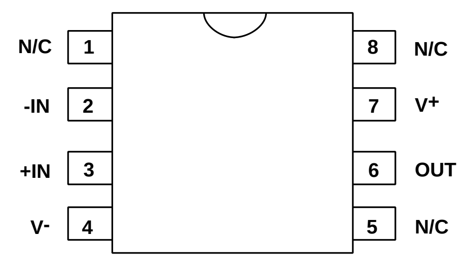
- Voltage amplifier
- Voltage follower/buffer
- Charge integrator
- Photodiode amplifier
- Data acquisition systems
- High performance portable instruments
- Signal conditioning circuits
- Sensor and transducer amplifiers
- Low leakage amplifiers
- Active filters
- Sample/Hold amplifier
- Picoammeter
- Current to voltage converter

ORDERING INFORMATION

Operating Temperature Range		
-55°C to +125°C	0°C to +70°C	0°C to +70°C
8-Pin CERDIP Package	8-Pin Small Outline Package (SOIC)	8-Pin Plastic Dip Package
ALD1706A DA	ALD1706A SA	ALD1706A PA
ALD1706B DA	ALD1706B SA	ALD1706B PA
ALD1706 DA	ALD1706 SA	ALD1706 PA
		ALD1706G PA

* Contact factory for industrial temperature range

PIN CONFIGURATION



TOP VIEW
DA, PA, SA PACKAGE

* N/C Pin is connected internally. Do not connect externally.

ABSOLUTE MAXIMUM RATINGS

Supply voltage, V^+		13.2V
Differential input voltage range		-0.3V to V^+ +0.3V
Power dissipation		600 mW
Operating temperature range	PA, SA package	0°C to +70°C
	DA package	-55°C to +125°C
Storage temperature range		-65°C to +150°C
Lead temperature, 10 seconds		+260°C

OPERATING ELECTRICAL CHARACTERISTICS
T_A = 25°C V_S = ±2.5V unless otherwise specified

Parameter	Symbol	1706A			1706B			1706			1706G			Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max		
Supply Voltage	V_S V^+	±1.0 2.0		±6.0 12.0	±1.0 2.0		±6.0 12.0	±1.0 2.0		±6.0 12.0	±1.0 2.0		±6.0 12.0	V V	Dual Supply Single Supply
Input Offset Voltage	V_{OS}			0.9 1.7			2.0 2.8			4.5 5.3			10.0 11.0	mV mV	$R_S \leq 100K\Omega$ 0°C ≤ T_A ≤ +70°C
Input Offset Current	I_{OS}		0.1	25 240		0.1	25 240		0.1	25 240		0.1	30 450	pA pA	T_A = 25°C 0°C ≤ T_A ≤ +70°C
Input Bias Current	I_B		0.1	30 300		0.1	30 300		0.1	30 300		0.1	50 600	pA pA	T_A = 25°C 0°C ≤ T_A ≤ +70°C
Input Voltage Range	V_{IR}	-0.3 -2.8		5.3 2.8	-0.3 -2.8		5.3 2.8	-0.3 -2.8		5.3 2.8	-0.3 -2.8		5.3 2.8	V V	V^+ = +5V V_S = ±2.5V
Input Resistance	R_{IN}		10^{12}			10^{12}			10^{12}			10^{12}		Ω	
Input Offset Voltage Drift	TCV_{OS}		7			7			7			10		µV/°C	$R_S \leq 100K\Omega$
Power Supply Rejection Ratio	PSRR	70 70	80 80		65 65	80 80		65 65	80 80		60 60	80 80		dB dB	$R_S \leq 100K\Omega$ 0°C ≤ T_A ≤ +70°C
Common Mode Rejection Ratio	CMRR	70 70	83 83		65 65	83 83		65 65	83 83		60 60	83 83		dB dB	$R_S \leq 100K\Omega$ 0°C ≤ T_A ≤ +70°C
Large Signal Voltage Gain	A_V	32 20	100		32 20	100		32 20	100		20 10	80		V/ mV V/ mV	R_L = 1MΩ R_L = 1MΩ 0°C ≤ T_A ≤ +70°C
Output Voltage Range	V_O low V_O high	 4.99	0.001 4.999	0.01	 4.99	0.001 4.999	0.01	 4.99	0.001 4.999	0.01	 4.99	0.001 4.999	0.01	V V	R_L =1MΩ 0°C ≤ T_A ≤ +70°C
	V_O low V_O high	 2.30	-2.40 2.40	-2.30	 2.30	-2.40 2.40	-2.30	 2.30	-2.40 2.40	-2.30	 2.30	-2.40 2.40	-2.30	V V	R_L =100KΩ 0°C ≤ T_A ≤ +70°C
Output Short Circuit Current	I_{SC}		200			200			200			200		µA	
Supply Current	I_S		20	40		20	40		20	40		20	50	µA	V_{IN} = 0V No Load
Power Dissipation	P_D			200			200			200			250	µW	V_S = ±2.5V

OPERATING ELECTRICAL CHARACTERISTICS (cont'd)
T_A = 25°C V_S = ±2.5V unless otherwise specified

Parameter	Symbol	1706A Min	1706A Typ	1706A Max	1706B Min	1706B Typ	1706B Max	1706 Min	1706 Typ	1706 Max	1706G Min	1706G Typ	1706G Max	Unit	Test Condition
Input Capacitance	C_{IN}		1			1			1			1		pF	
Bandwidth	B_W		400			400			400			400		KHz	
Slew Rate	S_R		0.17			0.17			0.17			0.17		V/µs	A_V = +1 R_L = 1MΩ
Rise time	t_r		1.0			1.0			1.0			1.0		µs	R_L = 1MΩ
Overshoot Factor			20			20			20			20		%	R_L =1MΩ C_L = 25pF
Settling Time	t_s		10.0			10.0			10.0			10.0		µs	0.1% A_V = -1 R_L=1MΩ C_L =25pF

T_A = 25°C V_S = ±1.0V unless otherwise specified

Parameter	Symbol	1706A Min	1706A Typ	1706A Max	1706B Min	1706B Typ	1706B Max	1706 Min	1706 Typ	1706 Max	1706G Min	1706G Typ	1706G Max	Unit	Test Condition
Power Supply Rejectio Ratio	PSRR		70			70			70			70		dB	R_S ≤ 1MΩ
Common Mode Rejection Ratio	CMRR		70			70			70			70		dB	R_S ≤ 1MΩ
Large Signal Voltage Gain	A_V		50			50			50			50		V/ mV	R_L =1MΩ
Output Voltage Range	V_O low V_O high	 0.9	-0.95 0.95	-0.9	 0.9	-0.95 0.95	-0.9	 0.9	-0.95 0.95	-0.9	 0.9	-0.95 0.95	-0.9	V V	R_L =1MΩ
Bandwidth	B_W		0.3			0.3			0.3			0.3		MHz	
Slew Rate	S_R		0.17			0.17			0.17			0.17		V/µs	A_V = +1 C_L = 25pF

V_S = ±2.5V -55°C ≤ T_A ≤ +125°C unless otherwise specified

Parameter	Symbol	1706B DA Min	1706B DA Typ	1706B DA Max	1706 DA Min	1706 DA Typ	1706 DA Max	Unit	Test Conditions
Input Offset Voltage	V_{OS}			3.0			6.5	mV	R_S ≤ 100KΩ
Input Offset Current	I_{OS}			8.0			8.0	nA	
Input Bias Current	I_B			10.0			10.0	nA	
Power Supply Rejection Ratio	PSRR	60	75		60	75		dB	R_S ≤ 1MΩ
Common Mode Rejection Ratio	CMRR	60	83		60	83		dB	R_S ≤ 1MΩ
Large Signal Voltage Gain	A_V	15	50		15	50		V/ mV	R_L = 1MΩ
Output Voltage Range	V_O low V_O high	 2.30	-2.40 2.40	-2.30	 2.30	-2.40 2.40	-2.30	V V	R_L = 1MΩ

Design & Operating Notes:

1. The ALD1706 CMOS operational amplifier uses a 3 gain stage architecture and an improved frequency compensation scheme to achieve large voltage gain, high output driving capability, and better frequency stability. In a conventional CMOS operational amplifier design, compensation is achieved with a pole splitting capacitor together with a nulling resistor. This method is, however, very bias dependent and thus cannot accommodate the large range of supply voltage operation as is required from a stand alone CMOS operational amplifier. The ALD1706 is internally compensated for unity gain stability using a novel scheme that does not use a nulling resistor. This scheme produces a clean single pole roll off in the gain characteristics while providing for more than 70 degrees of phase margin at the unity gain frequency.

2. The ALD1706 has complementary p-channel and n-channel input differential stages connected in parallel to accomplish rail-to-rail input common mode voltage range. This means that with the ranges of common mode input voltage close to the power supplies, one of the two differential stages is switched off internally. To maintain compatibility with other operational amplifiers, this switching point has been selected to be about 1.5V below the positive supply voltage. Since offset voltage trimming on the ALD1706 is made when the input voltage is symmetrical to the supply voltages, this internal switching does not affect a large variety of applications such as an inverting amplifier or non-inverting amplifier with a gain larger than 2.5 (5V operation), where the common mode voltage does not make excursions above this switching point. The user should however, be aware that this switching does take place if the operational amplifier is connected as a unity gain buffer and should make provision in his design to allow for input offset voltage variations.

3. The input bias and offset currents are essentially input protection diode reverse bias leakage currents, and are typically less than 1pA at room temperature. This low input bias current assures that the analog signal from the source will not be distorted by input bias currents. Normally, this extremely high input impedance of greater than $10^{12}\Omega$ would not be a problem as the source impedance would limit the node impedance. However, for applications where source impedance is very high, it may be necessary to limit noise and hum pickup through proper shielding.

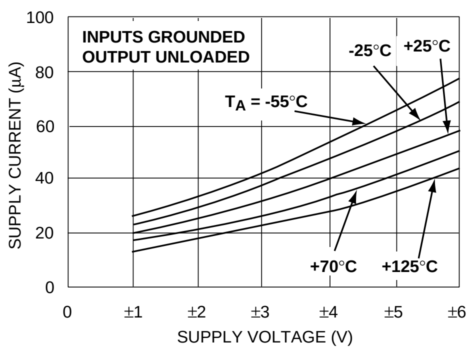
4. The output stage consists of class AB complementary output drivers, capable of driving a low resistance load. The output voltage swing is limited by the drain to source on-resistance of the output transistors as determined by the bias circuitry, and the value of the load resistor. When connected in the voltage follower configuration, the oscillation resistant feature, combined with the rail to rail input and output feature, makes an effective analog signal buffer for medium to high source impedance sensors, transducers, and other circuit networks.

5. The ALD1706 operational amplifier has been designed to provide full static discharge protection. Internally, the design has been carefully implemented to minimize latch up. However, care must be exercised when handling the device to avoid strong static fields that may degrade a diode junction, causing increased input leakage currents. In using the operational amplifier, the user is advised to power up the circuit before, or simultaneously with, any input voltages applied and to limit input voltages to not exceed 0.3V of the power supply voltage levels.

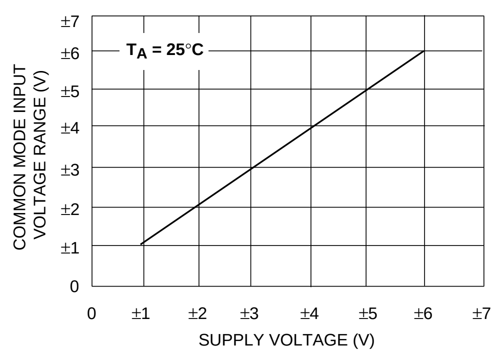
6. The ALD1706, with its micropower operation, offers numerous benefits in reduced power supply requirements, less noise coupling and current spikes, less thermally induced drift, better overall reliability due to lower self heating, and lower input bias current. It requires practically no warm up time as the chip junction heats less than 0.1°C above ambient temperature under most operating conditions.

TYPICAL PERFORMANCE CHARACTERISTICS

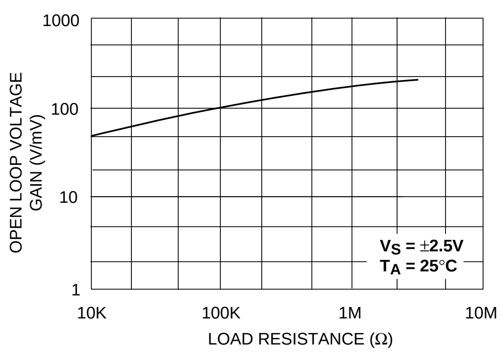
SUPPLY CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



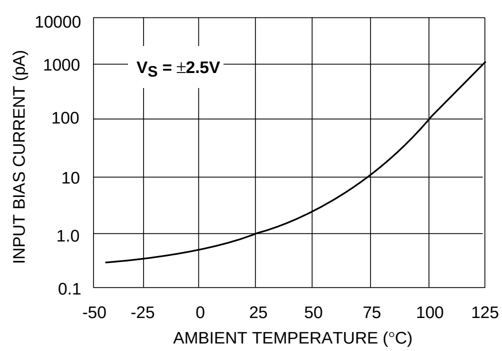
COMMON MODE INPUT VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



OPEN LOOP VOLTAGE GAIN AS AFUNCTION OF LOAD RESISTANCE

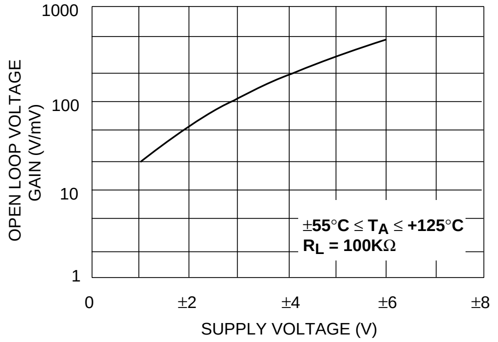


INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE

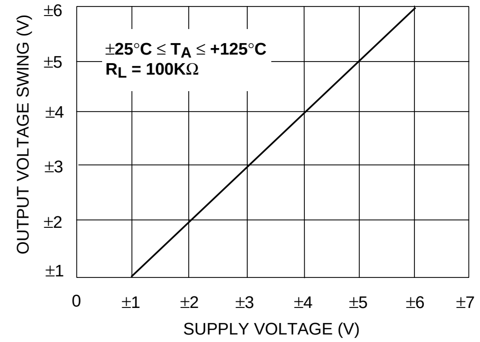


TYPICAL PERFORMANCE CHARACTERISTICS

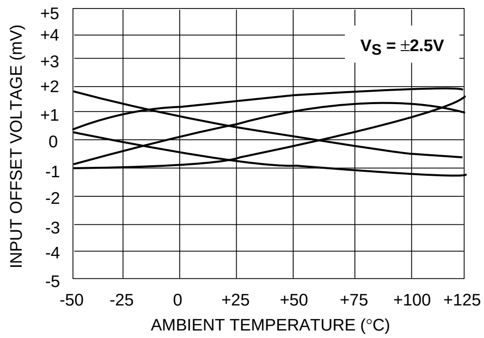
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE AND TEMPERATURE



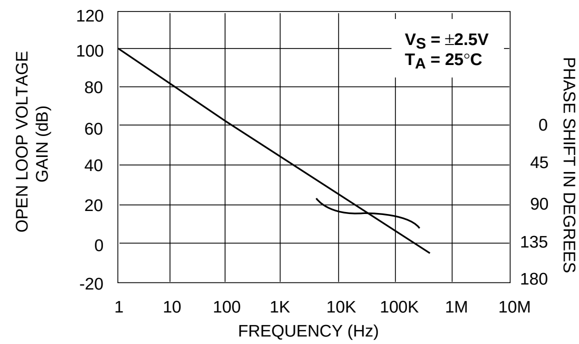
OUTPUT VOLTAGE SWING AS A FUNCTION OF SUPPLY VOLTAGE



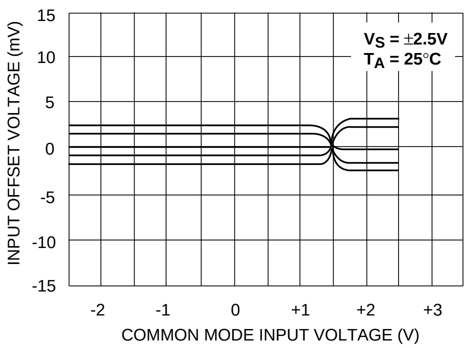
INPUT OFFSET VOLTAGE AS A FUNCTION OF AMBIENT TEMPERATURE REPRESENTATIVE UNITS



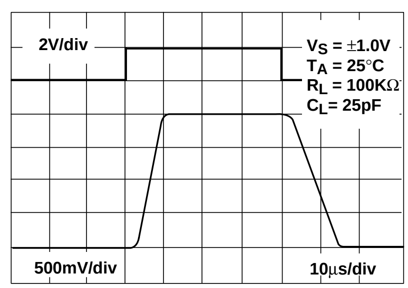
OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



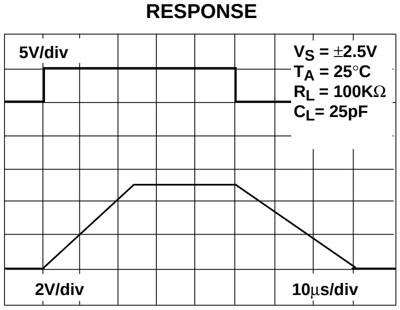
INPUT OFFSET VOLTAGE AS A FUNCTION OF COMMON MODE INPUT VOLTAGE



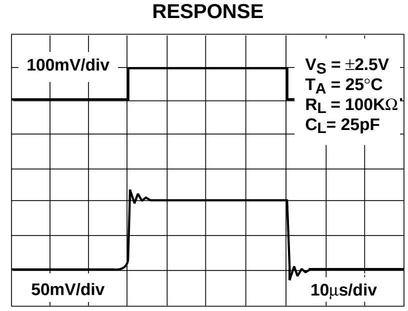
LARGE - SIGNAL TRANSIENT RESPONSE



LARGE - SIGNAL TRANSIENT RESPONSE

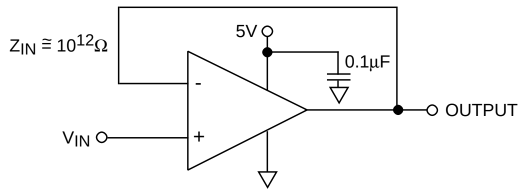


SMALL - SIGNAL TRANSIENT RESPONSE



TYPICAL APPLICATIONS

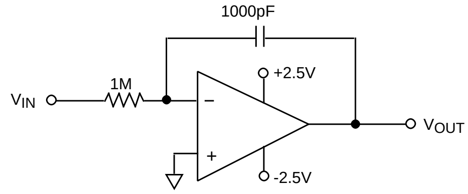
RAIL-TO-RAIL VOLTAGE FOLLOWER/BUFFER



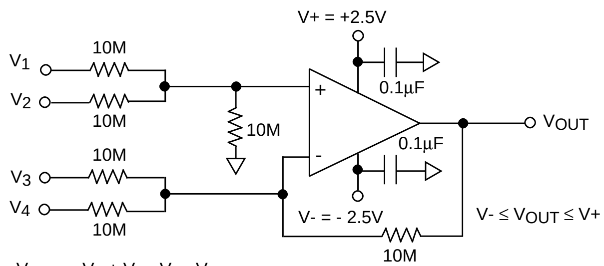
$0 \le V_{IN} \le 5V$

* See Rail to Rail Waveform

CHARGE INTEGRATOR



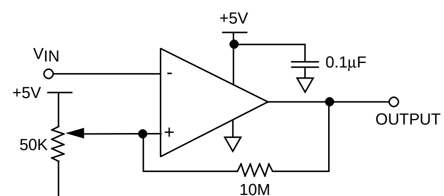
HIGH INPUT IMPEDANCE RAIL-TO-RAIL PRECISION DC SUMMING AMPLIFIER



$V_{OUT} = V_1 + V_2 - V_3 - V_4$

$R_{IN} = 10M\Omega$ Accuracy limited by resistor tolerances and input offset voltage

RAIL-TO-RAIL VOLTAGE COMPARATOR



$0 \le V_{IN} \le V^+$

HIGH IMPEDANCE NON-INVERTING AMPLIFIER

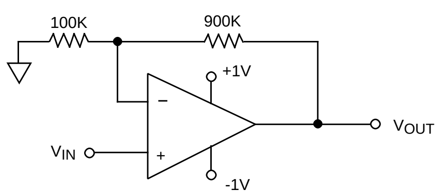
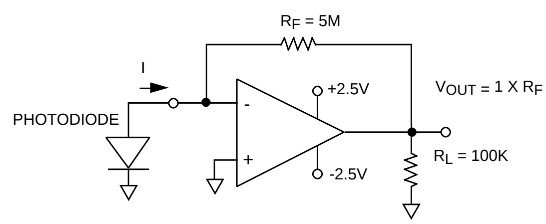
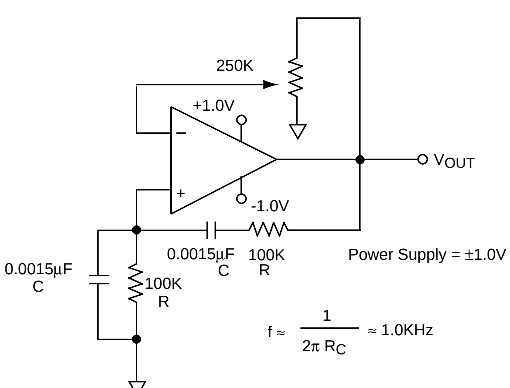


PHOTO DETECTOR CURRENT TO VOLTAGE CONVERTER

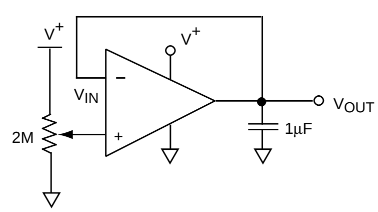


WIEN BRIDGE OSCILLATOR



V_{OUT} = SINEWAVE 2V Peak to Peak

MICROPOWER BUFFERED VARIABLE VOLTAGE SOURCE



$2.0V \le V^+ \le 12.0V$
$0.1 \le V_{OUT} \le (V^+ - 0.1)$ V
OUPUT CURRENT ±200µA