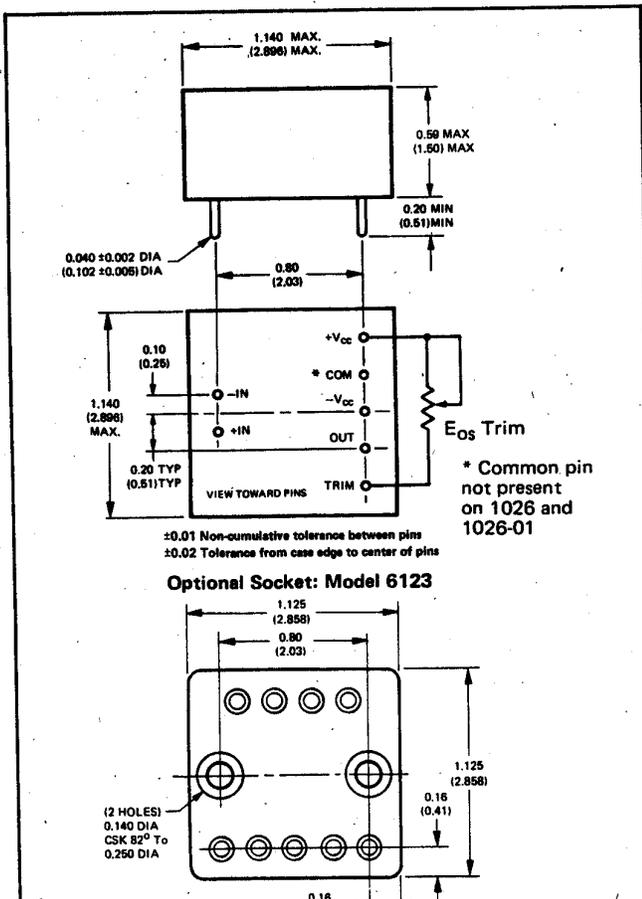
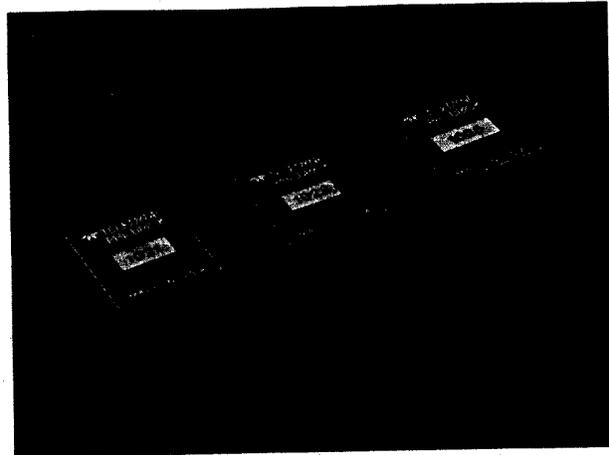


# 1021/1023/1026 HIGH PERFORMANCE FET OPERATIONAL AMPLIFIERS

The Teledyne Philbrick Models 1021, 1023, and 1026 comprise a family of Operational Amplifiers with price/performance characteristics unavailable in Integrated Circuit devices.

The 1021 and 1023, in particular, have a guaranteed dc CMRR of 100 dB (typically 120 dB). This ability to reject common mode voltages extends to 100 Hz, at which frequency it starts rolling off at 6 dB per octave. These amplifiers, therefore, still have a CMRR of 80 dB at 10 kHz, and 60 dB at 100 kHz. See Figure 1. (The dc CMRR of many IC FET Op Amps is less than 80 dB.)

High CMRR is combined with low  $E_{OS/TC}$  and low  $I_{bias}$  in the 1023 and 1023-01, making these amplifiers ideal for linear amplifications of signals from high impedance bridges (thermistor, photo diode) in a noisy (thermal and electrical) environment. Such signals can be millivolts full scale in the presence of volts of dc common mode voltage. A piezo electric vibration or shock transducer needs an amplifier with similar characteristics and, in addition, requires the 1023's capability to provide 100 kHz full power response and ability to drive 20 mA into a low impedance line.



## FEATURES

- Low Cost
- High CMRR vs Frequency
- Low Initial  $E_{OS} < 500 \mu V$
- Low  $I_{bias} < 1 pA$
- Low  $E_{OS/TC} < 2 \mu V/^{\circ}C$

## APPLICATIONS

- pH Meters
- Bridge Amplifiers
- Photo Transducer Amplifier
- Pico-Amp/Micro Volt-Input signals to 20 mA @ 20 V Linear Power Out

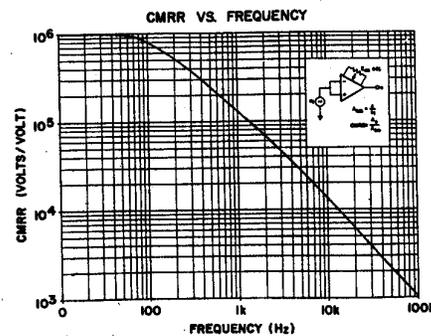


Figure 1. CMRR Vs. Frequency  
1021/1023

SPECIFICATIONS @ 25°C,  $V_{CC} = \pm 15V$ , Rated Load, unless otherwise specified

	1021		1023		1026	
	Typical	Guaranteed	Typical	Guaranteed	Typical	Guaranteed
<b>OUTPUT RANGE</b>						
Voltage (Peak)	$\pm 11 V$	$\pm 10 V$	$\pm 11 V$	$\pm 10 V$	$\pm 11.5 V$	$\pm 10 V$
Current	$\pm 25 mA$	$\pm 20 mA$	$\pm 25 mA$	$\pm 20 mA$	$\pm 7.5 mA$	$\pm 5 mA$
<b>VOLTAGE GAIN (dc, Open Loop)</b>						
Rated Load	106 dB	100 dB	120 dB	100 dB	116 dB	100 dB
10 K Load	120 dB	---	---	---	---	---
<b>FREQUENCY-TIME-RESPONSE (Inverting)</b>						
Small Signal (Unity Gain, Open Loop)	4 MHz	2 MHz	4 MHz	2 MHz	3 MHz	1 MHz
Max Sine Power Out (3 to 5% distortion)	---	100 kHz	---	100 kHz	150 kHz	100 kHz
Max Peak to Peak Out (Triangle Wave)	150 kHz	---	150 kHz	---	200 kHz	150 kHz
Slew Rate	---	6 V/ $\mu$ sec	---	6 V/ $\mu$ sec	15 V/ $\mu$ sec	10 V/ $\mu$ sec
Settling Time to +0.1% (step input)	10 $\mu$ sec	---	10 $\mu$ sec	---	10 $\mu$ sec	---
Overload Recovery Time (step input)	1 msec	---	1 msec	---	200 $\mu$ sec	---
Max. Capacity Loading without causing instability	0.001 $\mu$ F	---	0.001 $\mu$ F	---	0.002 $\mu$ F	---
<b>INPUT VOLTAGE RANGE</b>						
Common Mode (dc Linear Operation)	$\pm 11 V$	$\pm 10 V$	$\pm 11 V$	$\pm 10 V$	$\pm 11 V$	$\pm 10 V$
Common Mode Fault	$\pm V_{CC}$	$\pm 15 V$	$\pm V_{CC}$	$\pm 15 V$	$\pm V_{CC}$	$\pm 15 V$
Differential (between inputs)	$+V_{CC} - (-V_{CC})$	30 V	$+V_{CC} - (-V_{CC})$	30 V	$+V_{CC} - (-V_{CC})$	30 V
Common Mode Rejection Ratio (CMV = $\pm 5 V$ )	120 dB	100 dB	120 dB	100 dB	94 dB	86 dB
<b>INPUT OFFSET VOLTAGE</b>						
Initial (trim pin must be connected to $+V_{CC}$ for operation) $\odot$	$\pm 5 mV$	---	$\pm 0.3 mV$	$\pm 0.7 mV$	$\pm 5 mV$	---
Zero Adjust (optional)	---	2 k $\Omega$ pot	---	2 k $\Omega$ pot $\odot$	---	1 k $\Omega$ pot
Offset vs. Temp						
(Avg. -25°C to +85°C)	$\pm 15 \mu V/^\circ C$	$\pm 50 \mu V/^\circ C$	---	---	$\pm 25 \mu V/^\circ C$	$\pm 50 \mu V/^\circ C$
(Avg. -25°C to +85°C) 1026-01	---	---	---	---	---	$\pm 20 \mu V/^\circ C$
(Avg. -10°C to +60°C) 1023	---	---	$\pm 3 \mu V/^\circ C$	$\pm 5 \mu V/^\circ C$	---	---
(Avg. -10°C to +60°C) 1023-01	---	---	$\pm 1 \mu V/^\circ C$	$\pm 2 \mu V/^\circ C$	---	---
<b>INPUT BIAS CURRENT</b>						
Initial @ 25°C	-1 pA	-5 pA	-0.5 pA	-3 pA	25 pA	50 pA
Initial @ 25°C (1026-01, 1023-01)	---	---	-0.5 pA	-2 pA	10 pA	20 pA
Vs. Temperature (avg. -25 to +85°C) $\odot$	---	$\pm 1 pA/^\circ C$	---	---	doubles each 10°C	---
Vs. Temperature (avg. -10 to +60°C) $\odot$	---	---	---	$\pm 1 pA/^\circ C$	---	---
Vs. Power Supply	$\pm 5 pA/V$	---	$\pm 5 pA/V$	---	1 pA/V	---
Vs. Time (per 24 hours)	---	---	$\pm 0.5 pA$	---	---	---
Offset (Tracking)	$\pm 3 pA$	---	$\pm 3 pA$	---	20 pA	---
<b>INPUT IMPEDANCE <math>\odot</math> dc</b>						
Differential	$10^{11} \Omega \parallel 10 pF$	---	$10^{11} \Omega \parallel 10 pF$	---	$10^{11} \Omega \parallel 5 pF$	---
Common Mode (either input to common)	$10^{12} \Omega \parallel 10 pF$	---	$10^{12} \Omega \parallel 10 pF$	---	$10^{12} \Omega \parallel 5 pF$	---
<b>NOISE (Referred to Input)</b>						
Flicker (0.016 to 1.6 Hz)						
Voltage p-p	1.5 $\mu V$	---	1.5 $\mu V$	---	10 $\mu V$	---
Current p-p	0.1 pA	---	0.1 pA	---	0.1 pA	---
Midband (1.6 to 160 Hz)						
Voltage rms	4 $\mu V$	---	4 $\mu V$	---	3 $\mu V$	---
Current rms	---	---	0.7 pA	---	---	---
Broadband (160 Hz to 16 kHz)						
Voltage rms	4 $\mu V$	---	4 $\mu V$	---	8 $\mu V$	---
Current rms	---	---	1 pA	---	---	---
Wideband (5 Hz to 50 kHz)	7.5 $\mu V$	---	7.5 $\mu V$	---	---	---
<b>POWER REQUIREMENTS</b>						
Voltage Range	$\pm 12$ to $\pm 18 V$	---	$\pm 12$ to $\pm 18 V$	---	$\pm 12$ to $\pm 18 V$	---
Current: Quiescent	---	$\pm 5 mA$	---	$\pm 6 mA$	---	$\pm 10 mA$
<b>TEMPERATURE RANGE (degrees C)</b>						
Operating: Rated	---	-25 to +85°C	---	-10 to +60°C	---	-25 to +85°C
Storage	---	-55 to +125°C	---	-55 to +125°C	---	-55 to +125°C
MTBF	370,000 hrs.	---	370,000 hrs.	---	---	---

$\odot$  1021, 1023, 1023-01: Slope at +25°C, doubles every +10°C, max.  $I_{bias}$  @ +85°C = 0.6 nA.

$\odot$  1021 - 5 mV typical with 1% fixed 1 k $\Omega$  resistor from trim to  $+V_{CC}$ .  
1023 & 1023-01 - 700  $\mu V$  guaranteed with fixed resistor supplied (value stamped on side).  
1026 - 5 mV typical with 1% fixed 499  $\Omega$  resistor from trim to  $+V_{CC}$ .

$\odot$  Supplied resistor can be replaced with 2 k $\Omega$  pot, degraded offset voltage drift.

The input circuits of these units are protected to  $\pm V_{CC}$ . Output circuits are short-circuit protected to ground.

Recommended Power Supply: Teledyne Philbrick Model 2211

Teledyne Philbrick makes no representation that use of its modules in the circuits described herein, or use of other technical information contained herein will not infringe on existing or future patent rights nor do the descriptions contained herein imply the granting of licenses to make, use, or sell equipment constructed in accordance therewith.

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# OPERATIONAL AMPLIFIERS

All Specifications GUARANTEED @ 25°C, ±15 V Unless Marked Typical (t) or Otherwise Noted

	Model	Features	Output Range ±V/±mA	Open Loop Gain dB	Frequency Response			Settling Time		Input Voltage Range		Input Voltage Offset				
					Unity Gain MHz	Full Output kHz	Slew Rate V/μsec	Typical (unless marked G)		ECM ±V	DC CMRR dB	Initial @25°C ±mV	Vs. Temp. ±μV/°C	Vs. Time Typ. μV/day		
								to .1% μsec	to .01% μsec							
GENERAL PURPOSE	FET	1021	20 mA out, High CMRR Low Bias Current	10/20	100	2	100	6	10	10	100	5(t)Ⓞ	50	20		
		1026	High Gain, High Slew Rate	10/5	100	1	100	10	10	10	86	trimpot 1K	50	10		
		1028-01										15	50	10		
		1421										15	50	10		
		1421-01	Low Noise IC's	10/10	94	1	50	3	---	3	12	72	15	25	10	
	Bipolar	1424	Lowest Cost FET IC	10/5	86	1(t)	100(t)	6	---	3	10	70	50	75	50	
		1024	20 mA Output	10/20	94	2(t)	250(t)	6	5	---	10	86(t)	10(t)	20	50	
		1028	High Gain	10/5	108	1	70(t)	6	3	---	10	80	50k pot	20	10	
		1319	Guaranteed Low ΔEos	10/5	94	1(t)	8	0.6(t)	---	---	12	100(t)	5	25	5	
		1319-01	Guar. Low Ib, Low ΔEos										2	15	5	
1339		Uncompensated Low Eos, Low ΔEos IC's	10/5	94	100(t)	350(t)	34	---	---	11	80	7.5	12(t)	10		
1339-01			10/10	92	GBW @					11	80	7.5	5(t)	10		
1339-02			10/10	94	@100	A=100	A=100	---	---	11	80	3	5(t)	10		
1020		Bipolar Diff. Input, Low Eos, ΔEos, Ib	10/5	106	0.5	10	0.3	---	40	10	100(t)	3	5	5		
HIGH ACCURACY		Low Voltage Drift	1020-01										0.5	1.5	5	
	1701		Chopper, 5 μV/year	12/5	140	1(t)	20	1.2	---	---	---	15 μV	0.25	5 μV/yr		
	1701-01		Lowest ΔEos, Chopper										15 μV	0.1	5 μV/yr	
	1703		Low Cost Chopper	10/5	140	1(t)	4.5	0.25	---	---	---		40 μV	1	5 μV/yr	
	1703-01		Lowest ΔIb Chopper										15 μV	0.3	5 μV/yr	
	1340	Diff. Input Chopper IC	10/7	174(t)	3(t)	40(t)	2.5(t)	---	---	10	120	0.2	0.2(t)	5 μV/yr		
	FET Low Bias Current	1023	Lowest ΔEos FET, 100 kHz Full Power 20 mA	10/20	100	2	100	6	10	---	10	100	0.7	5	20	
		1023-01										0.7	2	20		
		1426	Low Initial Eos Low Ib IC's	10/5	100	1	50	3	3	---	12	80	2	50	25	
		1426-01		10/10(t)								1	25	25		
1426-02											1	10	25			
Instrumentation	Electrometer Δ 1pA Bias Current	1036	Lowest Ib FET	10/5	100	0.3(t)	50(t)	0.3(t)	5	15	10	80(t)	2	50	25	
		1036-02										1	5	25		
	1702	Lowest Ib Op Amp, ±100 V CMV	10/5	100	1 kHz(t)	40 Hz	2.5V/ms	---	---	100	100	5	30	20		
	1702-01										5	10	20			
	4263	High CMRR, Low ΔEos, FET Instrumentation Amp	10/5	CL 1 to 5000	3 dB Response A < 1-10, 75 kHz A = 100, 40 kHz A = 1000, 5 kHz				10	114	1	2	5			
	WIDEBAND	Guaranteed Fast Settling Precision	1025	300 ns to .01%, 50 mA out.	10/50	100	50	5MHz	500	.075	0.3(G)	4	80(t)	10	50	50
			1027	1 μs to .01%	10/20	100	10	0.5MHz	80	---	1(G)	10	80	15	50	50
			1027-01	1 μs to .01%, 15 μV/°C										15	15	50
			1030	Fastest Diff. Input FET	10/20	100	100	5MHz	850(t)	0.2	0.5(G)	10	94	5	25	100
			1414-83	Mil 883 Processing	10/20	100	8	500	50	---	1.0(G)	10	60	5	50	---
Mil Video		1430-83	Fast Settling Hybrid	10/50	106	80	5MHz	500(t)	0.1	0.2(G)	15V(dc)	---	2	75	100	
		1435	GHz Bandwidth, 50 nsec Settling, Mil 883 Processing	5/10	80	500	8MHz	250	.06(G)	.075(G) (.025%)	10	80(70 t@1M)	5	25	---	
		1322	Fast Slew IC	10/10	86(t)	20(t)	1.2MHz	80	0.3	3	10	90(t)	10	30(t)	15	
		1322-01	Fast Slew, MIL 1322													
		1434	Fast Slew FET IC	10/10	84(t)	20(t)	1 MHz	60	0.4	2	10	90(t)	14	75(t)	30(t)	
HIGH OUTPUT	High Frequency IC's	1434-01	MIL 1434									14	35(t)	30(t)		
		1321	High Gain, High Out. IC	20/20(t)	98	100(t)	320	35(t)	0.5	3.5	12	100(t)	5	30(t)	15	
		1321-01	MIL 1321													
		1433	High Gain, Low Ib, FET IC	10/10	98	100(t)	250	35(t)	0.8	4	10	90(t)	15(t)	70(t)	30	
		1433-01	MIL 1433										15(t)	30(t)	30	
	High Output Voltage	1022	High Gain, CMV (Eos=140V)	Vcc-10/20	120	1	50	30	7	15	Vcc-15	106	1	50	100	
		1032	Low Cost Eo ± 115 V	Vcc-8/10	100	1	10	6	25	40	Vcc-15	94	5	50	100	
		1034	Process Control Amp	20/22	100	1	35(t)Ⓞ	6Ⓞ	5	---	20	86	50k pot	15	25	
		1037	±140 V Out	140/10	120	1(t)	30	12(t)	---	15	95 V @ Vcc=±110 Volts	90	2	50	---	
		1037-20	MIL Processing													
Current	1332	High Voltage IC	35/10	100	4(t)	23(t)	5	---	---	35	74	6	20	---		
	1017	Low Cost, 125 mA Out.	10/125	86	1	15	0.3	15	---	10	60	6	45	10		
	1036	50 mA Out.	10/50	95	1(t)	15(t)Ⓞ	9Ⓞ	---	---	10	90	10(t)Ⓞ	10	25		
	1036-20	MIL Processing														
Micro-power IC	1323	I <sub>o</sub> = 20 mA, I <sub>cc</sub> = 80 μA	12/10	106	1(t)	25(t)	10	10	---	11	106(t)	5	30(t)	10		

- Ⓞ With 1% fixed 1KΩ resistor from trim to +Vcc
- Ⓢ Inverting
- Ⓣ With 24.9K 1% resistor

# NONLINEAR MODULES

## MULTIPLIER/DIVIDERS

Teledyne Philbrick offers a full range of Multiplier/Dividers to solve your nonlinear application problems.

Models 4454 and 4455: High Accuracy  
 Models 4456 and 4457: High Speed  
 Model 4450: General Purpose  
 Model 4452: General Purpose, Economy

## MULTIFUNCTION MODULES

Models 4371 and 4371-01 compute  $V_O = V_Y \left( \frac{V_Z}{V_X} \right)^m$  where the exponent m is externally programmable for any value between 0.2 and 5.

## LOGARITHMIC AMPLIFIERS

Logarithmic amplifiers provide an output proportional to the log or antilog of their input signals. Models 4357 and 4358 are basic log elements that produce an accurate, temperature-compensated log-ratio amplifier when used with two low-bias current op amps.

Models 4350 and 4362 compute the logarithm of a positive voltage or current or solve for the positive antilog of an input voltage.

The models 4351 and 4363 compute the logarithm of a negative voltage or current or solve for the negative antilog of the input voltage.

Models 4366 and 4367 provide an output voltage which is a function of the log-ratio of two input currents and/or voltages. 4366 is designed for positive signals, while 4367 accepts negative signals.

The model 4356 compresses the range of an analog input signal by providing an output voltage proportional to the inverse hyperbolic sine ( $\text{Sinh}^{-1}$ ). The device can be considered as an AC logarithmic amplifier useful where very wide dynamic range signals must be recorded or transmitted. The inverse function can also be generated.

## RMS MODULES

MODEL	OUTPUT FUNCTION	INPUT VOLTAGE	ACCURACY	BAND-WIDTH -3dB	TEMP. STABILITY
4362	AVERAGE	±10 V (Y)	±1% F.S.	20 kHz	±0.1%/°C F.S.
	RMS	±10 V (X)	±3% F.S.	20 kHz	±0.1%/°C F.S.
	VECTOR	±10 V ( $\sqrt{X^2+Y^2}$ )	±1% F.S.	1 kHz	±0.1%/°C F.S.
4370	RMS	±10 V	5 mVDC	200 kHz	100 μV/°C

MODEL	PAGE	MODEL	PAGE
4350	58	4367	72
4351	58	4370	74
4352	60	4371/-01	67
4356	62	4450	78
4357	66	4452	80
4358	66	4454	82
4362	68	4455	82
4363	68	4456	82
4366	72	4457	82

Input Bias Current	Vs. Temp.	Page	Model	
10 pA	x2/10 (t)	10	1021	FET
50 pA	x2/10 (t)	10	1026	
20 pA			1026-01	
50 pA			1421	
15 pA	x2/10 (t)	36	1421-01	
10 pA			1421-02	
50 pA	x2/10 (t)	36	1424	Bipolar
50 nA	3 nA	14	1024	
35 nA	0.5 nA	14	1028	
250 nA	30 pA		1319	
50 nA	Offset	24	1319-01	
1000 nA	200 pA	30	1339	
600 nA	Offset		1339-01	
500 nA			1339-02	
25 nA	0.5 nA	8	1020	Low Voltage Drift
			1020-01	
50 pA	1 pA	50	1701	
			1701-01	
50 pA	2 pA	50	1703	
50 pA	0.5 pA		1703-01	
50 (t)	6 pA (t)	32	1340	FET Low Bias Current
5	x2/10 (t)	10	1023	
2	x2/10 (t)		1023-01	
10	x2/10 (t)		1425	
5	x2/10 (t)	36	1425-01	
5	x2/10 (t)		1425-02	
25	x2/10 (t)		1426	
10	x2/10 (t)	36	1426-01	
25	x2/10 (t)		1426-02	
25	x2/10 (t)		1426-03	
0.15 pA	x2/10 (t)	20	1035	Electrometer < 1pA Bias Current
0.075 pA	x2/10 (t)		1035-02	
0.005 pA	0.0002 pA	54	1702	
10 pA	x2/10 (t)	56	4253	Instrumentation
20 pA	x2/10 (t)	16	1025	Guaranteed Fast Settling Precision
50 pA	x2/10 (t)	16	1027	
			1027-01	
20 pA	x2/10 (t)	16	1030	
100 pA	x2/10 (t)	34	1414-83	
500 pA	x2/10 (t)	40	1430/-83	Mil Video
20 μA	100 nA	46	1435	
			1435-83	
250 nA	0.5 nA	28	1322	High Slow Rate IC's
	Offset		1322-01	
20 pA	x2/10 (t)	44	1434	
			1434-01	
25 nA	0.8 nA	28	1321	High Frequency IC's
	Offset		1321-01	
1 (t)	x2/10 (t)	44	1433	
			1433-01	
30 pA	x2/10 (t)	12	1022	High Output Voltage
10 pA	x2/10 (t)	12	1032	
50 nA	0.4 nA	14	1034	
30 pA	x2/10 (t)	22	1037	
			1037-20	
30 nA	0.4 nA	24	1332	Current
100 nA	3 nA	6	1017	
50 pA	1 nA	22	1036	
			1036-20	
40 nA	0.4 nA	24	1323	Micro-power IC
	Offset			