OP AMP CHARTS GO ON-LINE!

By A. Boyle, L. Rothstein, D. Wilkins and the computer,
Staff, The Electronic Engineer

Again, we bring you our annual edition of The Electronic Engineer's "IC op amp selection charts," but this year we've done something quite unique. Every year, the task of compiling the material for these charts becomes more formidable. As new devices are introduced and more companies second source the more popular types, the number of op amps which we must process soon grows to amazing proportions. For this reason, no magazine can possibly announce all new op amps as they are introduced. So this year we asked the computer for help.

What you see below is a composite printout of that op amp information relevant to these charts. The information was extracted from a permanent data file on integrated circuit op amps. Because the greatest amount of activity is in the lower cost op amps, we have defined our data base as those products costing $30 and under (in quantities of 100), and we have asked the computer to sort them by construction type, that is, hybrid or monolithic. At present, our data base includes op amps introduced since July 1970, when we last published our op amp charts, plus previous models which have proven to be very popular with users (the 709, 741, and 101, for example).

Subscribe to our updating service

Throughout the coming year, we will continue to update our computerized files. We'll add new devices as they appear on the market, and we'll strike those that become obsolete. While we cannot republish these charts with each updating, we can offer you an opportunity to keep abreast of the latest in the field. Four times during the next 12 months (July and Oct. 1971, Jan. and April 1972) we will print out our updated op amp files. As in the printout below, this will list units by manufacturer, but will also include values for the three parameters included in our charts—input bias current, slew rate, and voltage drift—as well as current prices. For $5.00 we will send you these computer printouts on a quarterly basis for one year.

For an additional $2.00 per parameter you may select one or all of the three parameters and receive a printout which has sorted the op amps by that or those parameters you have chosen. The complete package costs $10, saving you $1. The following box explains how to order this service. Clip it out and mail it for your subscription to quarterly computer printouts.

Reading the op amp charts

Each of the following charts graphically illustrates the relationship between price and one of three important op amp parameters. The parameters we have selected are:

1). Input bias current
2). Slew rate
3). Input offset voltage temperature sensitivity

Each device in the chart guide has a number next to it. That number represents that op amp in all three charts. Please keep in mind that these charts generally represent typical values. Gene Tobey of Burr-Brown says ". . . the definition of 'typical' varies widely from one manufacturer to another (and from one production run to another for that matter), and the result is often misleading. For instance," he says, "a 741 at $3.00 with a voltage drift of $\pm 3\ \mu V/°C$ (typical) is rated on a par, for voltage drift, with the Burr-Brown 3054S/01 at $27.00 and $\pm 3\ \mu V/°C$ (max). The difference between the two amplifiers, as any user will soon discover, is that a relatively small percentage of 741's will meet the $\pm 3\ \mu V/°C$ specification, while all of the 3054S/01's will meet it. The reason is that the $\pm 3\ \mu V/°C$ specification is a 'typical' for the 741 and a 'maximum' for the 3054S/01. Many of the 741's may be expected to drift as much as $\pm 30\ \mu V/°C$. Similar comments apply to the other parameters (except price which is a 'maximum' in all cases)."

Input bias current (I_{IB})

Two definitions are frequently assigned to input bias current. The first (agreeing with the EIA glossary) states that it is the sum of the input bias current entering the two input terminals of a balanced amplifier, or, the bias current entering

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the input of a single-ended amplifier. Manufacturers of monolithic op amps generally agree to this definition and use it to specify their devices.

This definition, however, is far from universally accepted. In the case of a balanced amplifier, hybrid manufacturers take a different viewpoint. Their contention is that input bias current is the larger of the two currents rather than the average of both.

It's a good idea to keep this difference in terminology in mind when reading the bias current chart. A good rule of thumb is that if the op amp is monolithic, the bias is the average of the two inputs. If it's hybrid, in most cases the bias is the larger of the two inputs.

Slew Rate (SR)

Slew rate is the time rate of change of the closed-loop amplifier output voltage for a maximum-step signal input. (A maximum-step signal input is the largest input voltage step for which the amplifier performance remains linear.) This definition assumes that the amplifier is operating with unity amplification.

Offset voltage temperature sensitivity ($\Delta V_{IO}/\Delta T$)

The ratio of the change in input offset voltage to the change in circuit temperature for a constant output voltage defines this parameter. This is an average value for a specified temperature range.

Chart Guide to Manufacturers and Devices

HYBRID OP AMPS

UNIT NO.	MODEL	COST($/100)
AMPEREX		
1	ATF401	17.00
2	ATF404	20.00
ANALOG DEVICES		
3	AD503J	9.90
4	ADP511A	14.00
5	AD511A	14.00
6	AD503K	14.00
7	AD513J	15.00
8	ADP511B	17.00
9	AD511B	17.00
10	AD513K	17.50
11	AD506J	18.00
12	AD503S	18.00
13	ADP511C	21.00
14	AD511C	21.00
15	AD506K	21.00
16	AD516J	21.50
17	AD513S	21.50
18	AD516K	25.00
19	AD506S	26.00
20	AD516S	30.00
BURR-BROWN		
21	3227/03	9.50
22	3503A	9.90
23	3226/03	13.00
24	3503R	13.50
25	3503B	14.00
26	3503C	17.00
27	3503S	17.30
28	3352/03	17.50
29	3350/03	22.00
30	3503T	22.70
31	3349/03	30.00
BDC		
32	0-557C	9.00
33	1-557C	9.00
34	0-578C-2	10.00
35	1-578C-2	10.00
36	0-557B	11.00
37	1-557B	11.00
38	0-578C-1	12.00
39	1-578C-1	12.00
40	0-557A	13.00
41	1-557A	13.00
42	H50C-2	15.00
43	0-578B-3	18.00
44	1-578B-3	18.00
45	0-578B-2	20.00
46	1-578B-2	20.00
47	0-578B-1	21.00
48	1-578B-1	21.00
49	H50C-1	21.00
50	0-557A-4	22.00
51	1-557A-4	22.00
52	H50B-3	25.00
53	0-578A-2	29.00
54	1-578A-2	29.00
INTERSIL		
55	8500	28.25
56	8500A	29.75
MOTOROLA		
57	MCH2870CR	8.50
58	MCH1439G	12.00
59	MCH1539G	15.00
60	MCH2870MR	16.00
NATIONAL SEMICONDUCTOR		
61	LH0005C	7.00
62	LH0002C	8.50
63	LH740AC	9.00
64	LH0005	13.00
65	LH0020C	14.00
66	LH0002	14.00
67	LH0004C	16.50
68	LH0001C	17.00
69	LH0022C	18.00
70	LH0021C	18.50
71	LH740A	19.00
72	LH0033C	20.00
73	LH0024C	20.00
74	LH0003C	22.00
75	LH0020	26.50
76	LH0033	28.00
77	LH0032C	28.00
78	LH0005A	30.00
OPTICAL ELECTRONICS		
79	9406	19.00
80	9412	32.00
PRECISION MONOLITHICS		
81	SSS1458	2.80
82	SSS1558	5.45
83	MONMP04GQ	*****
84	MONOP04CQ	*****
SILICONIX		
85	L137CA	18.40
86	L137AA	26.25
TELEDYNE PHILBRICK		
87	1413	8.00
88	1019	*****
89	1025	*****
90	1420	15.75
91	1408-10	23.00
92	1408	23.00
93	1408-11	27.00
94	1408-01	27.00
TELEDYNE SEMICONDUCTOR		
95	2741CF	10.80
96	2740CE	10.80
97	2809CG	17.00
98	2709CG	17.00
99	2841CF	21.60
100	2740RF	22.00
101	2741CH	22.00
102	2741RF	22.00
103	2809RG	25.00
104	2741RH	25.00
105	2709RG	25.00
106	2841BE	26.60
ZELTEX		
107	ZC741E1	20.00
108	ZA801D1	25.00
109	ZA801E1	25.00
110	ZC741E6	26.00

MONOLITHIC OP AMPS

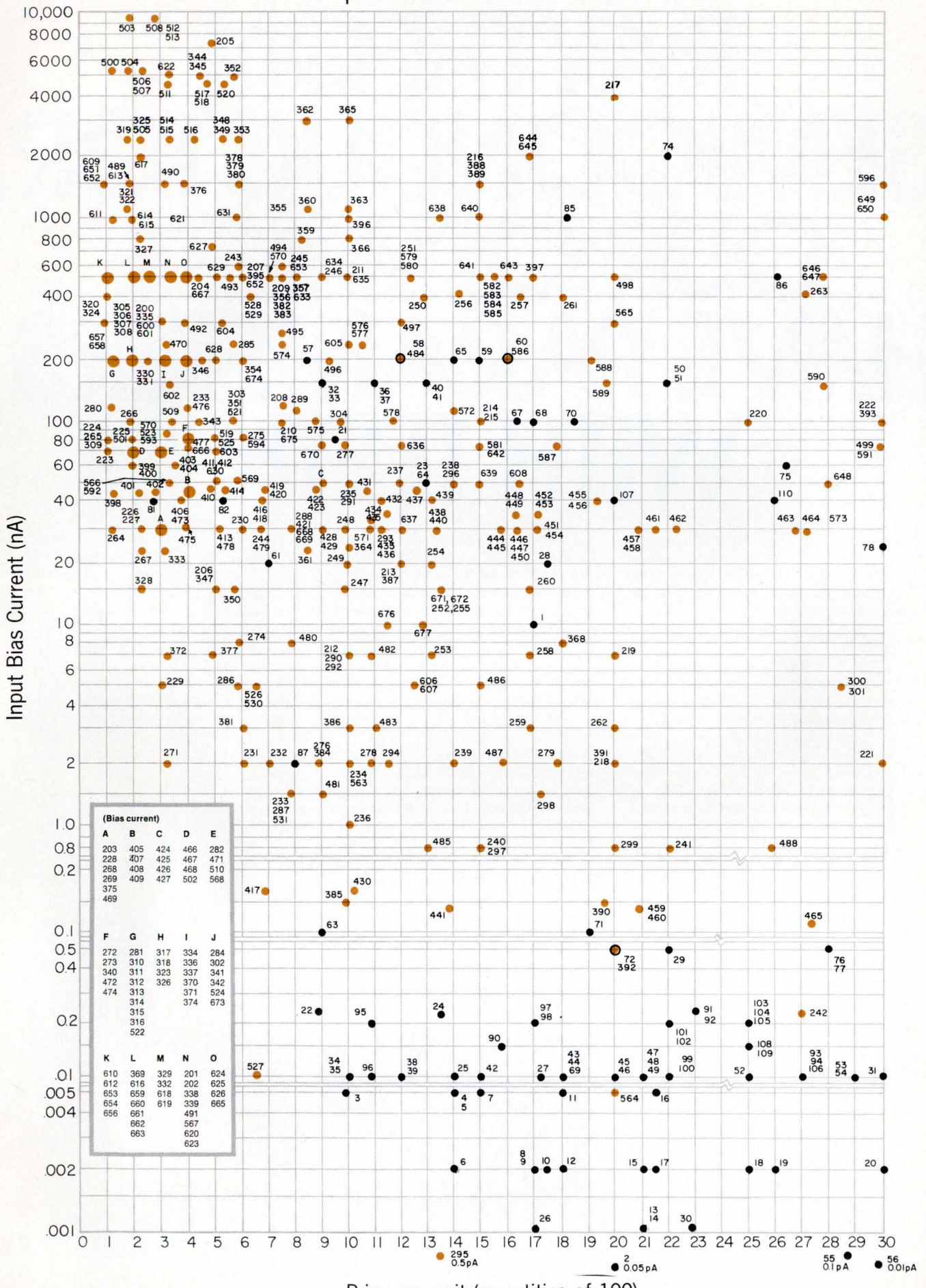
UNIT NO.	MODEL	COST($/100)
ADVANCED MICRO DEVICES		
200	307	2.75
201	301	3.25
202	741C	3.25
203	301A	3.45
204	747C	4.50
205	715C	4.95
206	AM1660	5.00
207	741	5.95
208	725C	7.50
209	201	7.50
210	207	7.60
211	747	9.95
212	308	10.00
213	201A	12.00
214	107	15.00
215	725B	15.00
216	101	15.00
217	715	20.00
218	208	20.00
219	308A	20.00
220	725	25.00
221	108	30.00
222	101A	30.00
ANALOG DEVICES		
223	AD301A	1.00
224	AD741C	1.00
225	AD741	2.00
226	AD741K	2.25
227	AD201A	2.75
228	AD101A	3.00
229	AD502JH	3.00
230	AD741L	6.00
231	AD502KH	6.00
232	AD502SH	7.00
233	AD308	8.00
234	AD502AH	9.75
235	AD505J	10.00
236	AD502LH	10.00
237	AD505K	12.00
238	AD505S	14.00
239	AD502BH	14.00
240	AD208	15.00
241	AD108	22.00
242	AD501A	27.00
BURR-BROWN		
243	3057/01	5.95
244	3500A	6.70
245	3053/01	7.50
246	3056/01	9.00
247	3501A	9.90
248	3500R	9.90
249	3500B	9.90
250	3055/01	12.75
251	3052/01	12.75
252	3501R	13.30
253	3501B	13.30
254	3500S	13.30
255	3500C	13.30
256	3054/01	14.25
257	3051/01	16.50
258	3501S	16.70
259	3501C	16.70
260	3500T	16.70
261	3050/01	18.00
262	3501T	20.00
263	3054S/01	27.00
FAIRCHILD		
264	MUA301A	1.10
265	MUA201	1.25
266	MUA709C	1.90
267	MUA777C	2.35
268	MUA201A	3.05
269	MUA101A	3.25
270	MUA741C	3.25
271	MUA776C	3.28
272	MUA101	3.95
273	MUA709	3.95
274	MUA777A	5.95
275	MUA741	5.95
276	MUA776	8.83
277	MUA709A	9.95
HARRIS		
278	RA-2625	10.70
279	RA-2620	17.85
INTERSIL		
280	748C	1.10
281	741C	1.25
282	301A	3.30
283	748	3.95
284	741	3.95
285	201	5.65
286	8008C	5.80
287	308	8.00
288	201A	8.00
289	101	8.00
290	8021C	10.00
291	8017C	10.00
292	4250C	10.00
293	101A	11.35
294	8008M	11.50
295	8007C	13.50
296	8017M	14.00
297	208	15.00
298	308A	17.35
299	108	20.00
300	8021M	28.50
301	4250	28.50
ITT		
302	MIC709	3.90
303	MIC741	5.95
304	MIC709A	9.60
MOTOROLA		
305	MC1709CP1	0.80
306	MC1709CP2	0.85
307	MC1709CL	0.98
308	MC1709CG	0.98
309	MC1748CG	1.25
310	MC1741CP1	1.40
311	MC1741CG	1.45
312	MC1709CF	1.50
313	MC1741CL	1.60
314	MC1741CP2	1.75
315	MC1709L	1.75
316	MC1709G	1.75
317	MC1439G	1.80
318	MCRC1709	1.85
319	MC1712CF	1.85
320	MC1437P	1.87
321	MC1435L	1.90
322	MC1435G	1.90
323	MC1439L	2.00
324	MC1437L	2.20
325	MC1712CL	2.25
326	MC1458CG	2.25
327	MC1420G	2.25
328	MC1456CG	2.35
329	MC1433L	2.45
330	MC1539L	2.50
331	MC1539G	2.50
332	MC1433G	2.65
333	MC1436CG	3.10
334	MC1458G	3.12
335	MC1709F	3.25
336	MC1537L	3.25
337	MC1741CF	3.50
338	MC1533L	3.50
339	MC1533G	3.50
340	MC1748G	3.85
341	MC1741G	3.90
342	MC1741L	4.00
343	MC1431G	4.35
344	MC1430P	4.35
345	MC1430G	4.35
346	MC1741F	4.50
347	MC1456G	4.90
348	MC1712L	5.25
349	MC1712G	5.25
350	MC1436G	5.60
351	MC1431F	5.60
352	MC1430F	5.60
353	MC1712F	5.70
354	MCR1709F	6.25

355	MC1435F	6.85
356	MC1433F	7.35
357	MC1533F	8.00
358	MC1438R	8.10
359	MC1520G	8.10
360	MC1535G	8.50
361	MC1531G	8.50
362	MC1530G	8.50
363	MC1535F	10.00
364	MC1531F	10.00
365	MC1530F	10.00
366	MC1520F	10.00
367	MC1538R	14.00
368	MC1536G	18.00
	NATIONAL SEMICONDUCTOR	
369	LM709C	1.90
370	LM1558	3.25
371	LM747C	3.25
372	LM310	3.25
373	LM301AN	3.25
374	LM741C	3.25
375	LM301A	3.45
376	LM709	3.90
377	LM312	4.95
378	LM1458	5.95
379	LM747	5.95
380	LM741	5.95
381	LM210	6.00
382	LH201	7.50
383	LM201	7.50
384	LM212	8.50
385	LM316	9.95
386	LM110	10.00
387	LM201A	12.00
388	LH101	15.00
389	LM101	15.00
390	LM216	19.50
391	LM112	19.50
392	LM316A	20.00
393	LM101A	30.00
	OPTICAL ELECTRONICS	
394	9300	4.90
395	9314	6.00
396	9302	10.00
397	9308	17.00
	PRECISION MONOLITHICS	
398	SSS741CJ	1.40
399	SSS301AJ	1.90
400	SSS307J	1.90
401	SSS841CJ	2.20
402	SSS747CK	2.80
403	SSS301AP	3.50
404	SSS307P	3.50
405	SSS741CP	3.50
406	MONOP01CJ	3.65
407	SSS741GJ	3.95
408	SSS841CP	4.05
409	SSS747CP	4.05
410	SSS841GJ	4.95
411	SSS201AJ	5.05
412	SSS207J	5.05
413	SSS741BJ	5.10
414	SSS747GK	5.45
415	MONOP01HJ	6.60
416	SSS725CJ	6.75
417	MONOP08CJ	6.75
418	MONOP01GJ	6.80
419	SSS741GL	6.80
420	SSS741GP	6.80
421	SSS747BK	7.50
422	SSS841GL	8.75
423	SSS841GP	8.75
424	SSS201AL	9.00
425	SSS201AP	9.00
426	SSS207L	9.00
427	SSS207P	9.00
428	SSS741BL	9.00
429	SSS741BP	9.00
430	MONOP08CP	10.15
431	SSS747GP	10.60
432	SSS725CP	11.30
433	SSS841J	11.50
434	SSS101AJ	11.50
435	SSS107J	11.50
436	SSS741J	11.50
437	SSS747GM	12.70
438	SSS747BP	13.25
439	MONOP01CP	13.35
440	SSS725BJ	13.95
441	MONOP08BJ	13.95
442	MONOP-01J	14.35
443	MONOP01HP	15.25
444	SSS747K	15.80
445	SSS747BM	15.90
446	SSS725EJ	16.30
447	SSS841P	16.45
448	SSS101AP	16.45
449	SSS107P	16.45
450	SSS741P	16.45
451	SSS841L	17.05
452	SSS101AL	17.05
453	SSS107L	17.05
454	SSS741L	17.05
455	MONOP01GL	19.45
456	MONOP01GP	19.45
457	SSS725BL	20.95
458	SSS725BP	20.95
459	MONOP08BL	20.95
460	MONOP08BP	20.95
461	SSS725J	21.60
462	SSS747P	22.40
463	SSS747M	26.80
464	SSS725EP	27.30
465	MONOP-08J	27.55
	QUALIDYNE	
466	QC301-G	1.89
467	QC307-G	1.89
468	QC741C	1.89
469	QC301A	2.85
470	QC201	3.25
471	QC207-G	3.35
472	QC748-G	3.85
473	QC1456-G	3.90
474	QC741-G	3.99
475	QC107-G	3.99
476	QC101	3.99
477	QC741	3.99
478	QC201A	5.53
479	QC1100C-G	6.70
480	QC1556-G	7.82
481	QC308-G	9.05
482	QC308A-G	10.85
483	QC101A	11.06
484	QC747-J	12.00
485	QC208-G	13.06
486	QC1735-1G	15.00
487	QC208A-G	15.70
488	QC108-G	25.80
	RAYTHEON	
489	RC709	1.90
490	RC4709	3.25
491	RC741	3.25
492	RM709	3.90
493	RM741	5.45
494	RC4741	7.00
495	RC101A	7.50
496	RM709A	9.35
497	RM4709	12.00
498	RM4741	20.00
499	RM101A	30.00
	RCA	
500	CA3029	1.18
501	CA3056	1.78
502	CA3047	1.90
503	CA3030	1.90
504	CA3010	1.90
505	CA3029A	2.28
506	CA3037	2.28
507	CA3008	2.52
508	CA3015	2.88
509	CA3047A	3.48
510	CA3033	3.48
511	CA3030A	3.48
512	CA3038	3.48
513	CA3016	3.48
514	CA3037A	3.48
515	CA3010A	3.48
516	CA3008A	4.08
517	CA3038A	4.68
518	CA3015A	4.68
519	CA3056A	4.74
520	CA3016A	5.30
521	CA3033A	5.88
	SIGNETICS	
522	N5709	1.65
523	N5741	3.00
524	S5709	3.75
525	S5741	5.00
526	NE533V	6.35
527	NE536T	6.50
528	NE531V	6.50
529	NE531T	6.50
530	NE533T	6.85
531	NE537T	7.50
532	S5748T	*****
533	N5748T	*****
534	N5748V	*****
535	N5748A	*****
536	N5741T	*****
537	N5741V	*****
538	N5709T	*****
539	N5709V	*****
540	S5741T	*****
541	S5709T	*****
542	N5741A	*****
543	N5709A	*****
544	N5740T	*****
545	N555AV	*****
546	N5558T	*****
547	S5558T	*****
548	N5556V	*****
549	N5556T	*****
550	S5556T	*****
551	N53A8T	*****
552	N5308T	*****
553	N53A1V	*****
554	N53A1T	*****
555	S5201V	*****
556	S5201A	*****
557	S5201T	*****
558	S51A8T	*****
559	S5108T	*****
560	S5107T	*****
561	S51A1T	*****
562	S5101T	*****
563	SE533T	10.00
564	SU536T	20.00
565	SE531T	20.00
	SILICON GENERAL	
566	SG741C	3.05
567	SG301	3.20
568	SG301A	3.25
569	SG741	5.80
570	SG201	7.00
571	SG201A	10.80
572	SG101	14.00
573	SG101A	28.00
	SILICONIX	
574	LM201H	7.50
575	L140CA	8.80
576	LM201D	10.50
577	LM201F	10.50
578	L140CL	11.80
579	LM101H	12.50
580	LH101H	12.50
581	L140AA	14.70
582	LM101D	15.50
583	LM101F	15.50
584	LH101D	15.50
585	LH101F	15.50
586	L143CL	16.10
587	L140AL	17.70
588	L143CP	19.10
589	L130BA	19.70
590	L143AL	27.75
591	L1300A	29.50
	SOLITRON	
592	UC4301A	3.25
593	UC4741C	3.25
594	UC4741	5.95
595	UC4250	*****
596	UC4101A	30.00
	SPRAGUE	
597	ULN-2741M	2.10
598	ULN-2741D	2.25
599	ULS-2741D	4.95
	TELEDYNE PHILBRICK	
600	1303	3.10
601	1301	3.10
602	1339	3.35
603	1319	5.00
604	1300	5.20
605	1317	10.00
606	1323	12.50
607	1321	12.50
608	1322	16.50
	TELEDYNE SEMICONDUCTOR	
609	709CE	0.90
610	748CE	1.20
611	MC1439CE	1.40
612	741CE	1.45
613	MC1437CJ	1.70
614	749CJ	1.90
615	811CE	1.95
616	709BE	2.00
617	739CJ	2.20
618	MC1458CE	2.50
619	MC1539BE	2.50
620	MC1537BL	3.10
621	810CJ	3.25
622	813CJ	3.25
623	841CE	3.25
624	748BE	3.90
625	747CE	3.90
626	741BE	3.90
627	749BN	4.90
628	709AE	5.00
629	MC1558BE	5.00
630	844CE	5.00
631	809CE	5.85
632	841BE	5.95
633	809BE	7.95
634	811BE	8.75
635	747BE	9.90
636	LM207CE	12.00
637	844BE	12.00
638	806CE	13.50
639	808BE	15.00
640	805CE	15.00
641	810BN	15.00
642	LM107BE	15.00
643	819BE	16.00
644	801DE	16.75
645	800DE	16.75
646	806BE	27.80
647	805BE	27.80
648	808AE	28.00
649	800BE	29.80
650	801BE	29.80
	TEXAS INSTRUMENTS	
651	SN72709P	0.88
652	SN72709N	0.90
653	SN72748P	0.94
654	SN72741P	0.94
655	SN72702N	0.96
656	SN72741N	1.06
657	SN72307P	1.14
658	SN72301A	1.14
659	SN72558P	1.68
660	SN72747N	1.73
661	SN52709L	1.87
662	SN52748L	2.03
663	SN52741L	2.03
664	SN52702L	2.04
665	SN52558L	3.66
666	SN52101AL	4.08
667	SN52747J	4.38
668	SN72771P	7.50
669	SN72770P	7.50
670	SN52107L	9.00
671	SN52771L	13.50
672	SN52770L	13.50
	TRANSITRON	
673	TOA1709	3.70
674	TOA1741	5.75
675	TOA4709	7.50
676	TOA7741	11.50
677	TOA7709	12.80

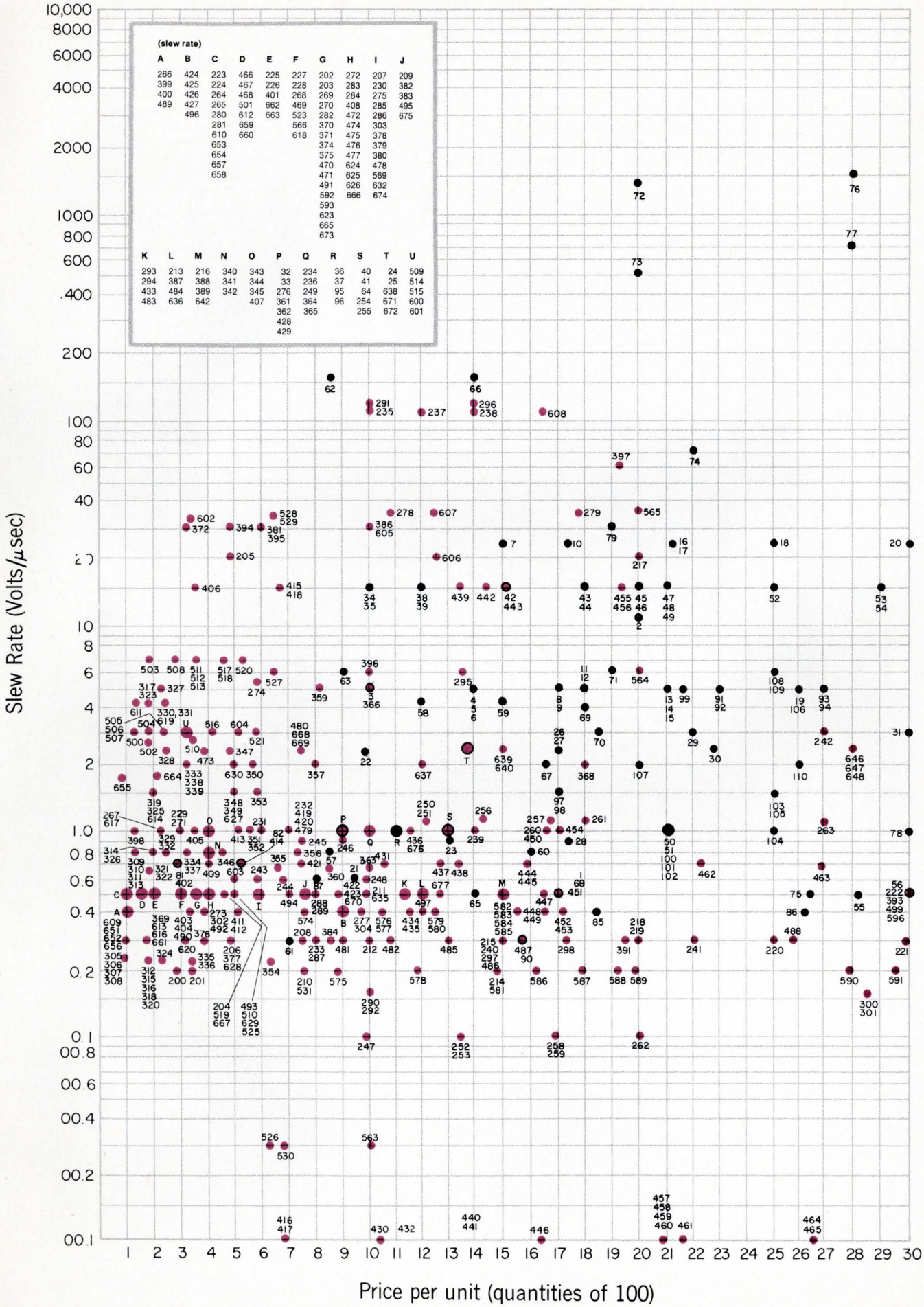
For further information on the manufacturers and their products, circle the following numbers on your reader service card:

Advanced Micro Devices	201
Amperex	202
Analog Devices	203
Burr-Brown	204
DDC	205
Fairchild	206
Harris	207
Intersil	208
ITT	209
Motorola	210
National Semiconductor	211
Optical Electronics	212
Precision Monolithics	213
Qualidyne	214
Raytheon	215
RCA	216
Signetics	217
Silicon General	218
Siliconix	219
Solitron Devices	220
Sprague	221
Teledyne Philbrick	222
Teledyne Semiconductor	223
Texas Instruments	224
Transitron	225
Zeltex	226

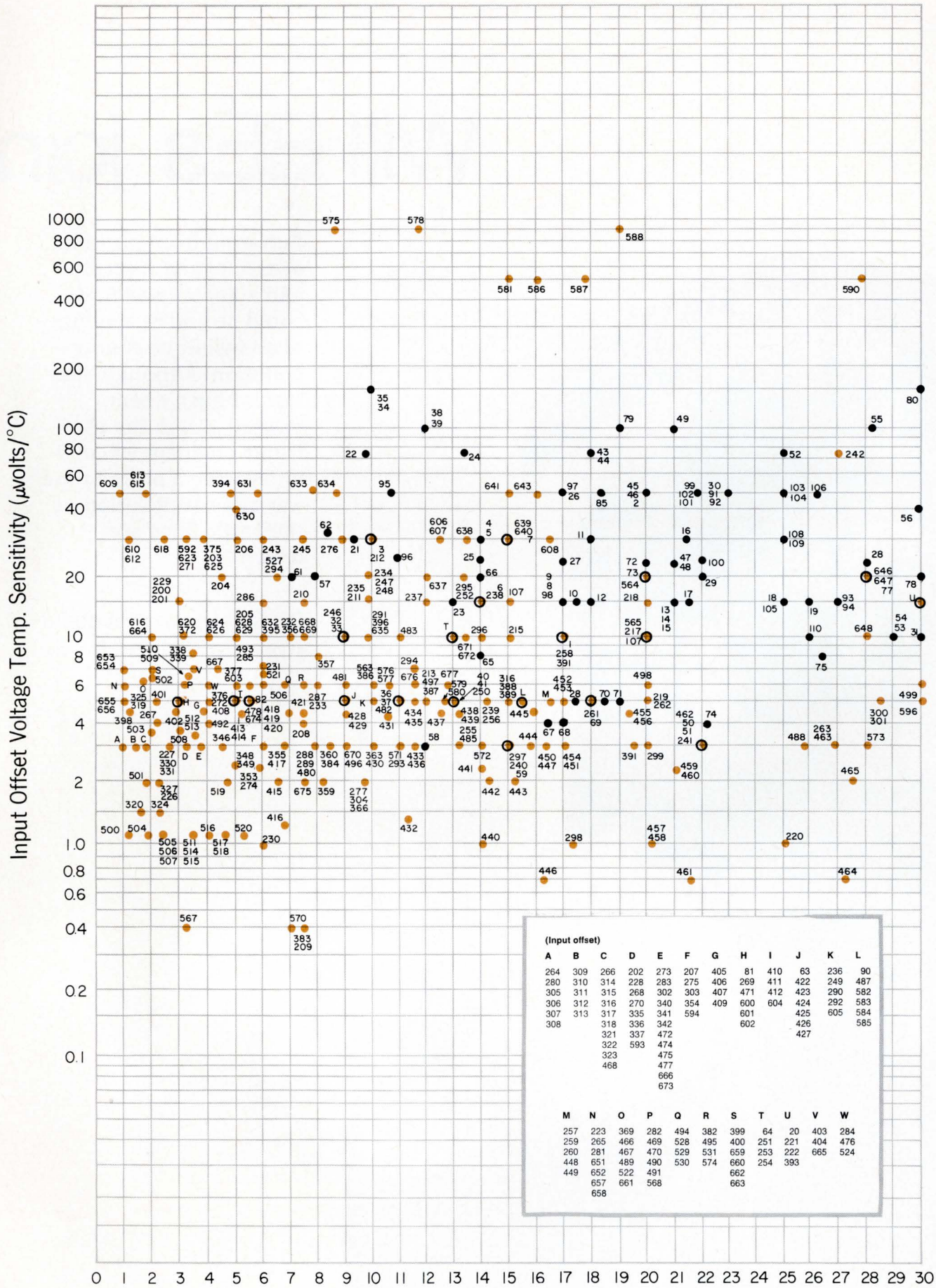
For a copy of this article circle 227 on your reader service card


Input Bias Current vs Price
Input Bias Current (nA)
Price per unit (quantities of 100)
(Bias current)
A 203 228 268 269 375 469
B 405 407 408 409
C 424 425 426 427
D 466 467 468 502
E 282 471 510 568
F 272 273 340 472 474
G 281 310 311 312 313 314 315 316 522
H 317 318 323 326
I 334 336 337 370 371 374
J 284 302 341 342 524 673
K 610 612 653 654 656
L 369 616 659 660 661 662 663
M 329 332 618 619
N 201 202 338 339 491 567 620 623
O 624 625 626 665
295 0.5pA
2 0.05pA
55 0.1pA
56 0.01pA

Slew Rate vs Price



Input Offset Voltage Temperature Sensitivity vs Price



RAYTHEON SEMICONDUCTOR. OUR OP AMPS HAVE PARAMETERS WITH TEETH.

Our new products are taking a chunk out of the operational amplifier market with parameters that are easy on designers and tough on competition. All of our dc parameters are specified over the entire voltage range — with no fall-off.

The new RM4131. It's unique in bipolar IC's, with input offset voltage of 2 mV maximum and 0.7 mV typical. Input offset current of 10 namp maximum and 2 namp typical. This high gain op amp has slew rates four times that of 709's and 741's. Typically 2 volts per microsecond with unity gain bandwidth of 4 MHz. And if low current drain at 20 V of 1.6 milliamps maximum is still not enough to put the RM4131 on your purchase order the large voltage signal gain should. It's typically 106 db from 3 to 20 volts.

The new RM4132. It cuts power dissipation by two orders of magnitude and needs no external bias or compensation. This proprietary micropower op amp has typical current drain as low as 22 μA. At maximum, 35 μA. Input offset current is reduced to 0.7 namp. It maintains unity gain bandwidth of 150 KHz. And it means further perfection in your battery operated circuits.

Proprietary linear circuits is one of our great strengths. But it's not our only strength. We're rapidly adding to our extensive line of off-the-shelf linear circuits as well. We provide the tightest parameter specs you can get in monolithic op amps, differential and dual comparators, voltage regulators, line receivers, and sense amplifiers. All available now at franchised Raytheon Semiconductor distributors.

Raytheon Semiconductor has changed. We have a new technical team. And new development programs providing new design tools. We're working on things like new digital analog interfacing that allow active switching and amplifying. Greater integration of external parts in voltage regulators. Greater circuit stability from improvements in temperature tracking. And we're going beyond the parameters established for slew rates, offset voltage, noise, bias current and offset current.

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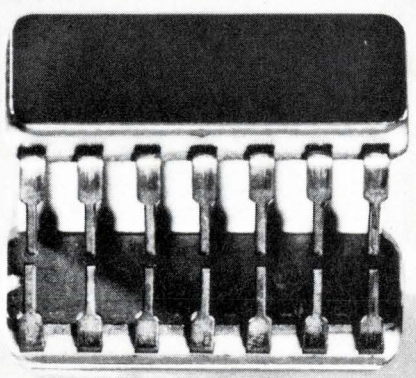

Circle Reader Service #26