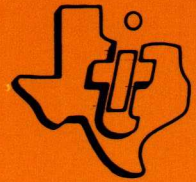


The Engineering Staff of  
TEXAS INSTRUMENTS INCORPORATED  
Semiconductor Group



**The  
Linear  
Control Circuits  
Data Book  
for  
Design Engineers**

**Second Edition**

**TEXAS INSTRUMENTS**  
INCORPORATED



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**The  
Linear  
Control Circuits  
Data Book**  
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**Design Engineers**

**Second Edition**



**TEXAS INSTRUMENTS**  
INCORPORATED

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## INTRODUCTION

In this 416-page data book, Texas Instruments is pleased to present important technical information on a broad line of linear control integrated circuits that includes operational amplifiers, voltage comparators, analog switches, timers, analog-to-digital converters, Hall-effect devices, and many others.

You will find specifications on device types initiated by TI (TL series) and on plug-in replacements for many competitive types. The functional indexes and selection guides provide the designer with rapid access to data sheets for specific applications, and the interchangeability guides show both direct and nearest replacement devices for many competitive parts. There are margin tabs to guide you quickly to general circuit categories, and the alphanumeric index lets you locate particular type numbers quickly.

The section on military products describes process and screening requirements for JAN, JAN-processed, /883B Class B, and standard device types.

This volume offers design data and specifications only for linear control integrated circuits, but complete technical data on any Texas Instruments semiconductor component is available from your nearest TI field sales office or authorized distributor and from: Marketing and Information Services, Texas Instruments Incorporated, P.O. Box 225012, MS 308, Dallas, Texas 75265.



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THE UNIVERSITY OF CHICAGO

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For information on other linear and interface integrated circuits manufactured by Texas Instruments, see the "Linear and Interface Circuits Master Selection Guide," "The Interface Circuits Data Book," and "The Voltage Regulator Handbook."

## SINGLE UNCOMPENSATED OPERATIONAL AMPLIFIERS

### Military Temperature Range (–55°C to 125°C)

$I_B$ nA	$V_{IO}$ mV	$I_{IO}$ nA	$A_{VD}$ V/mV	$B_1$ MHz	SR V/ $\mu$ s	$I_{CC}$ mA	$V_{CC}$ V		DESCRIPTION	DEVICE	PACKAGES	PAGE
MAX	MAX	MAX	MIN	TYP	TYP	MAX	MIN	MAX				
75	2	10	50	1	0.5	3	$\pm 5$	$\pm 22$	High Performance	LM101A	J, JG, U, W	59
0.2	6	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL060M	JG	115
0.2	6	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise	TL070M	JG	131
0.2	6	1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL080M	JG	139
10,000	5	2,000	1.4	0.5	1.7	6.7		–7, +14	General Purpose	TL702M	J, U, W	157
5,000	2	500	2.5	0.5	1.7	6.7		–7, +14	General Purpose	$\mu$ A702M	J, JG, U, W	163
200	2	50	25	1	0.3	3.6		$\pm 18$	General Purpose	$\mu$ A709AM	J, JG, U	167
500	5	200	25	1	0.3	5.5		$\pm 18$	General Purpose	$\mu$ A709M	J, JG	167
500	5	200	50	1	0.5	2.8	$\pm 2$	$\pm 22$	General Purpose	$\mu$ A748M	J, JG, U, W	181

1

### Industrial Temperature Range (–25°C to 85°C)

75	2	10	50	1	0.5	3	$\pm 5$	$\pm 22$	High Performance	LM201A	J, JG, N, P	59
0.2	6	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL060I	JG, P	115
0.2	6	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise	TL070I	JG, P	131
0.2	6	0.1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL080I	JG, P	115

### Commercial Temperature Range (0°C to 70°C)

250	7.5	50	25	1	0.5	3	$\pm 5$	$\pm 18$	High Performance	LM301A	J, JG, N, P	59
0.4	15	0.2	3	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL060C	JG, P	115
0.2	6	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL060AC	JG, P	115
0.4	15	0.05	25	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise	TL070C	JG, P	131
0.2	6	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise	TL070AC	JG, P	131
0.2	6	0.1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL080AC	JG, P	139
0.4	15	0.2	25	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL080C	JG, P	139
15,000	10	5,000	1	0.5	1.7	7		–7, +14	General Purpose	TL702C	J, JG, N	163
1,500	7.5	500	12	1	0.3	5.5		$\pm 18$	General Purpose	$\mu$ A709C	J, JG, N, P	167
500	6	200	20	1	0.5	2.8	$\pm 2$	$\pm 18$	General Purpose	$\mu$ A748C	J, JG, N, P	181
100	5	20	25	1	0.5	3.3	$\pm 5$	$\pm 22$	High Performance	$\mu$ A777C	J, JG, N, P	185

# FUNCTIONAL INDEX

## SINGLE INTERNALLY COMPENSATED OPERATIONAL AMPLIFIERS

### Military Temperature Range (–55°C to 125°C)

$I_{IB}$ nA	$V_{IO}$ mV	$I_{IO}$ nA	$A_{VD}$ V/mV	$B_1$ MHz	SR V/ $\mu$ s	$I_{CC}$ mA	$V_{CC}$ V		DESCRIPTION	DEVICE	PACKAGE	PAGE
MAX	MAX	MAX	MIN	TYP	TYP	MAX	MIN	MAX				
75	2	10	50	1	0.5	3	$\pm 2$	$\pm 22$	High Performance	LM107	J, JG, U, W	62
800	2	200	50	10	13	6.5	$\pm 3$	$\pm 22$	Low Noise $V_n = 4 \text{ nV}/\sqrt{\text{Hz}}$ Typ	SE5534	JG	105
800	2	200	50	10	13	6.5	$\pm 3$	$\pm 22$	Low Noise $V_n = 4.5 \text{ nV}/\sqrt{\text{Hz}}$ Max	SE5534A	JG	
0.2	6	0.1	4	1	3.5	0.2	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL061M	JG, U	105
0.2	6	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL071M	JG	131
0.2	6	0.1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL081M	JG	139
0.2	2	0.1	50	3	13	2.8	$\pm 4$	$\pm 18$	BIFET, Low $V_{IO}$	TL088M	JG, U	
150	5	30	50	1	0.5	1.0	+3	+32	General Purpose,	TL321M	JG	151
500	5	200	50	1	0.5	2.8	$\pm 2$	$\pm 22$	General Purpose	uA741M	J, JG, U, W	173

### Industrial Temperature Range (–25°C to 85°C)

75	2	10	50	1	0.5	3	$\pm 2$	$\pm 22$	High Performance	LM207	N	62
250	4	50	50	15	70	8		$\pm 20$	High Performance	LM218I	JG, P	73
0.2	6	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL061I	JG, P	115
0.2	6	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL066I	JG, P	123
0.2	6	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise	TL071I	JG, P	131
0.2	6	0.1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL081I	JG, P	139
0.4	0.5	0.1	50	3	13	2.8	$\pm 4$	$\pm 18$	BIFET, Low Offset	TL087I	JG, P	147
0.4	3	0.1	50	3	13	2.8	$\pm 4$	$\pm 18$	BIFET, Low Offset	TL088I	JG, P	147
150	5	30	50	1	0.5	1	+3	+32	General Purpose	TL321I	JG, P	151

## SINGLE INTERNALLY COMPENSATED OPERATIONAL AMPLIFIERS

Commercial Temperature Range (0°C to 70°C)

$I_{IB}$ nA	$V_{IO}$ mV	$I_{IO}$ nA	AVD V/mV	$B_1$ MHz	SR V/ $\mu$ s	$I_{CC}$ mA	$V_{CC}$ V		DESCRIPTION	DEVICE	PACKAGES	PAGE
MAX	MAX	MAX	MIN	TYP	TYP	MAX	MIN	MAX				
250	7.5	50	25	1	0.5	3	$\pm 2$	$\pm 18$	High Performance	LM307	J, JG, N, P	62
500	10	200	25	15	70	10		$\pm 20$	High Performance	LM318	JG, N, P	73
1,500	4	300	25	10	13	8	$\pm 3$	$\pm 22$	Low Noise $V_n = 4 \text{ nV}/\sqrt{\text{Hz}}$ Typ	NE5534	JG, P	105
1,500	4	300	25	10	13	8	$\pm 3$	$\pm 22$	Low Noise $V_n = 4.5 \text{ nV}/\sqrt{\text{Hz}}$ Max	NE5534A	JG, P	105
0.2	6	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL061AC	JG, P	115
0.2	3	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL061BC	JG, P	115
0.4	15	0.2	3	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL061C	JG, P	115
0.2	6	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power with Power Control	TL066AC	JG, P	123
0.2	3	1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power with Power Control	TL066BC	JG, P	123
0.4	15	2	3	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power with Power Control	TL066C	JG, P	123
0.2	6	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL071AC	JG, P	131
0.2	3	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL071BC	JG, P	131
0.2	10	0.05	25	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL071C	JG, P	131
0.2	6	0.1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL081AC	JG, P	139
0.2	3	0.1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL081BC	JG, P	139
0.4	15	0.2	25	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL081C	JG, P	139
0.4	0.5	0.2	25	3	13	2.8	$\pm 4$	$\pm 18$	BIFET, Low $V_{IO}$	TL087C	JG, P	147
0.4	2	0.2	25	3	13	2.8	$\pm 4$	$\pm 18$	BIFET, Low $V_{IO}$	TL088C	JG, P	147
250	7	50	25	1	0.5	1.0	$\pm 3$	$\pm 32$	General Purpose,	TL321C	JG, P	151
500	6	200	20	1	0.5	2.8	$\pm 2$	$\pm 18$	General Purpose	uA741C	J, JG, N, P	173

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## DUAL OPERATIONAL AMPLIFIERS

### Military Temperature Range (–55°C to 125°C)

I <sub>IB</sub> nA	V <sub>IO</sub> mV	I <sub>IO</sub> nA	A <sub>VD</sub> V/mV	B <sub>1</sub> MHz	SR V/μs	I <sub>CC</sub> mA	V <sub>CC</sub> V		DESCRIPTION	DEVICE	PACKAGES	PAGE
MAX	MAX	MAX	MIN	TYP	TYP	MAX	MIN	MAX				
150	5	30	50	1	0.3	0.6	+3	+32	General Purpose	LM158	JG	71
500	5	200	50	1	0.6	2.8	±2	±22	General Purpose	MC1558	JG, U	85
500	5	200	50	3	1.5	2.8		±22	High Performance	RM4558	JG	103
100	5	40	4	0.5	0.5	0.1	±2	±22	Low Power	TL022M	JG, U	109
0.2	6	0.1	4	1	3.5	0.2	±1.5	±18	BIFET, Low Power	TL062M	JG, U	115
0.2	6	0.05	50	3	13	2.5	±3.5	±18	BIFET, Low Noise			
									V <sub>n</sub> = 18 nV/√Hz Typ	TL072M	JG	131
0.2	6	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL082M	JG	139
0.2	6	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL083M	J	139
500	5	50	50	1	0.6	4	+3	+36	General Purpose	TL322M	JG	153
500	5	200	50	1	0.5	2.8	±2	±22	General Purpose	uA747M	J, W	177

### Automotive Temperature Range (–40°C to 85°C)

500	10	50	100	1	0.3	0.6	±3	±26	General Purpose	LM2904	JG, P, U	83
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### Industrial Temperature Range (–25°C to 85°C)

150	5	30	50	1	0.3	0.6	+3	+32	General Purpose,	LM258	JG, P, U	71
500	8	75	20	1	0.6	4	+3	+36	General Purpose	TL322I	JG, P	153
0.2	6	0.1	4	1	3.5	0.25	±1.5	±18	BIFET, Low Power	TL062I	JG, P	115
0.2	6	0.05	50	3	13	2.5	±3.5	±18	BIFET, Low Noise	TL072I	JG, P	131
0.2	6	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL082I	JG, P	139
0.2	6	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL083I	J, N	139
0.4	0.5	0.1	50	3	13	2.8	±3.5	±18	BIFET, Low Offset	TL287I	JG, P	147
0.4	3	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL288I	JG, P	147

## DUAL OPERATIONAL AMPLIFIERS

Commercial Temperature Range (0°C to 70°C)

I <sub>B</sub> nA	V <sub>IO</sub> mV	I <sub>IO</sub> nA	A <sub>VD</sub> V/mV	B <sub>1</sub> MHz	SR V/μs	I <sub>CC</sub> mA	V <sub>CC</sub> V		DESCRIPTION	DEVICE	PACKAGES	PAGE
							MIN	MAX				
250	7	50	25	1	0.3	0.6	+3	+32	General Purpose	LM358	JG, P	71
500	6	200	20	1	0.6	2.8	±2	±18	General Purpose	MC1458	JG, P	85
800	4	150	25	10	9	8		±22	Low Noise			
									$V_n = 5 \text{ nV}/\sqrt{\text{Hz}}$ Typ	NE5532	JG, P	93
800	4	150	25	10	9	8		±22	Low Noise			
									$V_n = 5 \text{ nV}/\sqrt{\text{Hz}}$ Typ	NE5532A	JG, P	93
1500	4	300	25	10	13	8		±22	Low Noise			
									$V_n = 4 \text{ nV}/\sqrt{\text{Hz}}$ Typ	NE5533	J, N	97
1500	4	300	25	10	13	8		±22	Low Noise			
									$V_n = 3.5 \text{ nV}/\sqrt{\text{Hz}}$ Typ	NE5533A	J, N	97
500	6	200	20	3	1	2.8		±18	High Performance	RC4558	JG, P	103
250	5	80	1	0.5	0.5	0.125	±2	±18	Low Power	TL022C	JG, P	109
0.2	6	0.1	4	1	3.5	0.25	±1.5	±18	BIFET, Low Power	TL062AC	JG, P	115
0.2	3	0.1	4	1	3.5	0.25	±1.5	±18	BIFET, Low Power	TL062BC	JG, P	115
0.4	15	0.2	3	1	3.5	0.25	±1.5	±18	BIFET, Low Power	TL062C	JG, P	115
0.2	6	0.05	50	3	13	2.5	±3.5	±18	BIFET, Low Noise			
									$V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL072AC	JG, P	131
0.2	3	0.05	50	3	13	2.5	±3.5	±18	BIFET, Low Noise			
									$V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL072BC	JG, P	131
0.2	10	0.05	25	3	13	2.5	±3.5	±18	BIFET, Low Noise			
									$V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL072C	JG, P	131
0.2	6	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL082AC	JG, P	139
0.2	3	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL082BC	JG, P	139
0.4	15	0.2	25	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL082C	JG, P	139
0.2	6	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL083AC	J, N	139
0.4	15	0.2	25	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL083C	J, N	139
0.4	0.5	0.1	25	3	13	2.8	±4	±18	BIFET, Low Offset	TL287C	JG, P	147
0.4	3	0.1	25	3	13	2.8	±4	±18	BIFET, General Purpose	TL288C	JG, P	147
500	10	50	20	1	0.6	4	+3	+36	General Purpose	TL322C	JG, P	153
500	6	200	25	1	0.5	2.8	±2	±18	General Purpose	uA747C	J, N	177

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## QUADRUPLE OPERATIONAL AMPLIFIERS

### Military Temperature Range (–55°C to 125°C)

$I_{IB}$ nA	$V_{IO}$ mV	$I_{IO}$ nA	$A_{VD}$ V/mV	$B_1$ MHz	$SR$ V/ $\mu$ s	$I_{CC}$ mA	$V_{CC}$ V		DESCRIPTION	DEVICE	PACKAGES	PAGE
MAX	MAX	MAX	MIN	TYP	TYP	MAX	MIN	MAX				
150	5	30	50	1	0.5	0.5	+3	+32	General Purpose	LM124	J, U	65
500	5	200	50	3.5	1.5	2.8	$\pm 4$	$\pm 22$	High Performance	RM4136	J, U	101
100	5	40	4	0.5	0.5	0.1	$\pm 2$	$\pm 22$	Low Power	TL044M	J, U	112
0.2	9	0.1	4	1	3.5	0.2	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL064M	J, W	115
0.2	9	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise			
									$V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL074M	J, W	131
0.2	9	0.1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL084M	J, W	139
100	5	25	50	1	0.5	3.6	$\pm 22$		General Purpose	LM148	J	67
100			2	2.5	0.5	12	+4.5	+36	General Purpose	LM1900	J	77
500	5	50	50	1	0.6	4	+3	+36	General Purpose	MC3503	J	89

### Automotive Temperature Range (–40°C to 85°C)

200			1.2	2.5	0.5	10	+4.5	+32	General Purpose	LM2900	J, N	77
500	10	50	100	5	1	5	+3	+26	General Purpose	LM2902	J, N	81
500	8	75	20	1	0.6	7	+3	+36	General Purpose	MC3303	J, N	89

### Industrial Temperature Range (–25°C to 85°C)

250	7	50	25	1	0.5	3	+3	+32	General Purpose,	LM224	J, N	65
200	6	50	25	1	0.5	4.5		$\pm 18$	General Purpose	LM248	J, N	67
0.2	6	0.1	4	1	3.5	0.25	$\pm 1.5$	$\pm 18$	BIFET, Low Power	TL064I	J, N	115
0.2	6	0.05	50	3	13	2.5	$\pm 3.5$	$\pm 18$	BIFET, Low Noise	TL074I	J, N	131
0.2	6	0.1	50	3	13	2.8	$\pm 3.5$	$\pm 18$	BIFET, General Purpose	TL084I	J, N	139

## QUADRUPLE OPERATIONAL AMPLIFIERS

Commercial Temperature Range (0°C to 70°C)

I <sub>B</sub> nA	V <sub>IO</sub> mV	I <sub>IO</sub> nA	A <sub>VD</sub> V/mV	B <sub>1</sub> MHz	SR V/μs	I <sub>CC</sub> mA	V <sub>CC</sub> V		DESCRIPTION	DEVICE	PACKAGES	PAGE
MAX	MAX	MAX	MIN	TYP	TYP	MAX	MIN	MAX				
250	7	50	25	1	0.5	0.5	+3	+32	General Purpose	LM324	J, N	65
200	6	50	25	1	0.5	4.5		±18	General Purpose	LM348	J, N	67
200			1.2	2.5	0.5	10	+4.5	+32	General Purpose	LM3900	J, N	77
500	10	50	20	1	0.6	7	+3	+36	General Purpose	MC3403	J, N	89
500	6	200	20	3	1	2.8	±4	±18	High Performance	RC4136	J, N	101
250	5	80	1	0.5	0.5	0.125	±2	±18	Low Power	TL044C	J, N	112
0.2	6	0.1	4	1	3.5	0.25	±1.5	±18	BIFET, Low Power	TL064AC	J, N	115
0.2	3	0.1	4	1	3.5	0.25	±1.5	±18	BIFET, Low Power	TL064BC	J, N	115
0.4	15	0.2	3	1	3.5	0.25	±1.5	±18	BIFET, Low Power	TL064C	J, N	115
0.2	6	0.05	50	3	13	2.5	±3.5	±18	BIFET, Low Noise $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL074AC	J, N	131
0.2	3	0.05	50	3	13	2.5	±3.5	±18	BIFET, Low Noise $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL074BC	J, N	131
0.2	10	0.05	25	3	13	2.5	±3.5	±18	BIFET, Low Noise $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL074C	J, N	131
0.2	10	0.05	25	3	13	2.5	±3.5	±18	BIFET, Low Noise $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$ Typ	TL075C	N	131
0.2	6	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL084AC	J, N	139
0.2	3	0.1	50	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL084BC	J, N	139
0.4	15	0.2	25	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL084C	J, N	139
0.4	15	0.2	25	3	13	2.8	±3.5	±18	BIFET, General Purpose	TL085C	N	139

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## VOLTAGE COMPARATORS

### Military Temperature Range (–55°C to 125°C)

	I <sub>B</sub> μA MAX	V <sub>IO</sub> mV MAX	I <sub>IO</sub> μA MAX	A <sub>VD</sub>	I <sub>OL</sub> mA MIN	RESPONSE TIME ns	POWER SUPPLIES	DEVICE	PACKAGE	PAGE
Single	45	3	7	40,000 TYP	16	40 MAX	12 V, –3 V to –12 V	LM106	J, JG, W	195
	0.15	4	0.02	200,000 TYP	8	140 TYP	15 V, –15 V	LM111	J, JG	201
	0.05	4	0.02	200,000 TYP	8	210 TYP	15 V, –15 V	TL111	J, JG, N, P	219
	0.1	5	0.025	200,000 TYP	6	1300 TYP	2 V to 36 V	TL331M	JG	223
	25	3	7	10,000 MIN	0.5	80 MAX	12 V, –6 V	TL510M	J, JG, U	233
	150	6	20	500 MIN	1.6	40 TYP	12 V, –6 V	TL710M	J, JG, U	239
	25	3	7	10,000 MIN	0.5	80 MAX	12 V, –6 V	TL810M	J, JG, U	245
	20	2	3	1250 MIN	2	40 TYP	12 V, –6 V	uA710M	J, JG, U	259
Dual	0.1	5	0.025	200,000 TYP	6	1300 TYP	2 V to 36 V	LM193 <sup>†</sup>	JG, U	211
	45	3	7	40,000 TYP	16	40 MAX	12 V, –3 V to –12 V	TL506M	J, W	227
	25	3	7	10,000 MIN	0.5	80 MAX	12 V, –6 V	TL514M	J, W	237
	25	3	7	10,000 MIN	0.5	80 MAX	12 V, –6 V	TL820M	J	255
Dual-Channel	30	6	5	8,000 MIN	0.5	80 MAX	12 V, –6 V	TL811M	J, U	249
	150	6	20	500 MIN	0.5	80 MAX	12 V, –6 V	uA711M	J, U	263
Quad	0.1	5	0.025	200,000 TYP	6	1300 TYP	2 V to 36 V	LM139 <sup>†</sup>	J, W	209
Hex	0.1	5	0.025	200,000 TYP	6	1300 TYP	2 V to 36 V	TL336M <sup>†</sup>	J	225

### Automotive Temperature Range (–40°C to 85°C)

Dual	0.25	7	0.05	100,000 TYP	6	1300 TYP	2 V to 36 V	LM2903 <sup>†</sup>	JG, P	215
Quad	0.25	7	0.05	100,000 TYP	6	1300 TYP	2 V to 36 V	LM2901 <sup>†</sup>	J, N	213
	0.5	20	0.1	30,000 TYP	6	1300 TYP	2 V to 28 V	LM3302 <sup>†</sup>	J, N	217

<sup>†</sup>Capable of operating with a single 5-volt supply.

## VOLTAGE COMPARATORS

### Industrial Temperature Range (–25°C to 85°C)

	I <sub>IB</sub> μA MAX	V <sub>IO</sub> mV MAX	I <sub>IO</sub> μA MAX	A <sub>VD</sub>	I <sub>OL</sub> mA MIN	RESPONSE TIME ns	POWER SUPPLIES	DEVICE	PACKAGE	PAGE
Single	45	3	7	40,000 TYP	16	40 MAX	12 V, –3 V to –12 V	LM206	J, JG, N, P	195
	0.15	4	0.2	200,000 TYP	8	140 TYP	15 V, –15 V	LM211†	J, JG, P	201
	0.1	5	0.025	200,000 TYP	6	1300 TYP	2 V to 36 V	TL3111†	JG, P	223
	0.1	5	0.025	200,000 TYP	6	1300 TYP	2 V to 36 V	TL3311†	JG, P	223
Dual	0.25	5	0.005	200,000 TYP	6	1300 TYP	2 V to 36 V	LM293†	JG, P	211
Quad	0.25	5	0.05	200,000 TYP	6	1300 TYP	2 V to 36 V	LM239†	J, N	209
Hex	0.1	5	0.025	200,000 TYP	6	1300 TYP	2 V to 36 V	TL3361†	J, N	225

### Commercial Temperature Range (0°C to 70°C)

Single	40	6.5	7.5	40,000 TYP	16	28 TYP	12 V, –3 V to –12 V	LM306	J, JG, N, P	195
	0.3	10	0.07	200,000 TYP	8	165 TYP	15 V, –15 V	LM311†	J, JG, N, P	201
	0.01	13	0.004	200,000 TYP	8	210 TYP	15 V, –15 V	TL311†	N, P	219
	0.01	10	0.004	200,000 TYP	8	210 TYP	15 V, –15 V	TL311A†	N, P	219
	0.25	5	0.05	200,000 TYP	6	1300 TYP	2 V to 36 V	TL331C†	JG, P	223
	30	4.5	7.5	8000 MIN	0.5	80 MAX	12 V, –6 V	TL510C	J, JG, N, P	233
	150	10	25	500 MIN		40 MAX	12 V, –6 V	TL710C	J, JG, N, P	239
	30	4.5	7.5	8000 MIN	0.5	80 MAX	12 V, –6 V	TL810C	J, JG, N, P	245
	25	5	5	1000 MIN	1.6	40 TYP	12 V, –6 V	uA710C	J, JG, N, P	259
Dual	0.25	5	0.05	200,000 TYP	6	1300 TYP	2 V to 36 V	LM393†	JG, P	211
	40	6.5	7.5	40,000 TYP	16	28 TYP	12 V, –3 V to –12 V	TL506C	J, N	227
	30	4.5	7.5	8000 MIN	0.5	80 MAX	12 V, –6 V	TL514C	J, N	237
	30	4.5	7.5	8000 MIN	0.5	80 MAX	12 V, –6 V	TL820C	J, N	255
Dual Channel	50	10	10	5000 MIN	0.5	33 TYP	12 V, –6 V	TL810C	J, JG, N, P	245
	150	10	25	500 MIN	0.5	40 TYP	12 V, –6 V	uA711C	J, N	263
Quad	0.25	5	0.05	200,000 TYP	6	1300 TYP	2 V to 36 V	LM339†	J, N	209
Hex	0.25	5	0.05	200,000 TYP	6	1300 TYP	2 V to 36 V	TL336C†	N	225

†Capable of operating with a single 5-volt supply.

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ADC0816	: Successive-approximation converter	272
ADC0817	: Successive-approximation converter with 8-bit resolution	272
TL500	: Dual-slope-converter analog processor with 14-bit resolution	357
TL501	: Dual-slope-converter analog processor with 13-bit resolution	357
TL502	: Dual-slope-converter digital processor with 4½-digit capability, seven-segment-display outputs	357
TL503	: Dual-slope-converter digital processor with 4½-digit capability, BCD outputs	357
TL505	: Dual-slope-converter analog processor with 10-bit resolution	369
TL507	: Pulse-width modulator with 7-bit resolution	377

### Zero-Crossing Detector

TL440		319
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### Doubly-Balanced Mixer

TL442		333
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### Precision Level Detector

TL560		381
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### Overvoltage Sensing Circuits

MC3423		279
MC3523		279

### 3-Channel Stepper-Motor Controller

TL376		315
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## SPECIAL FUNCTIONS

### Analog Switches With 30-mA Capability (Bi-MOS)

DEVICE	FUNCTION	$Z_{sw}$ (TYP)	ANALOG RANGE	SUPPLIES	PAGE
TL182	Twin SPST	100 $\Omega$	$\pm 10$ V	$\pm 15$ , +5	303
TL185	Twin DPST	150 $\Omega$	$\pm 10$ V	$\pm 15$ , +5	306
TL188	Dual Complementary SPST	100 $\Omega$	$\pm 10$ V	$\pm 15$ , +5	309
TL191	Twin Dual Complementary SPST	150 $\Omega$	$\pm 10$ V	$\pm 15$ , +5	312

### Analog Switches With 10-mA Capability (P-MOS)

DEVICE	FUNCTION	$Z_{sw}$ (TYP)	ANALOG RANGE	SUPPLIES	PAGE
TL601	SPDT	200 $\Omega$	$\pm 10$ V	+10, -20	387
TL604	Complementary SPST	200 $\Omega$	$\pm 10$ V	+10, -20	387
TL607	SPDT	200 $\Omega$	$\pm 10$ V	+10, -20	387
TL610	SPST	100 $\Omega$	$\pm 10$ V	+10, -20	387

### Hall-Effect Devices

DEVICE	DESCRIPTION	ON	OFF	HYSTERESIS	PAGE
TL170	General purpose switch	>+350 G	<-350 G	200 G	293
TL172	Normally-off switch	>+600 G	<+100 G	230 G	295
TL175	Latch	>+350 G	<-350 G	400 G	299
TL176	Normally-off switch (Automotive Temp. Range)	>+500 G	<+100 G	75 G	301
TL173	Linear sensor	1.5 mV/G Sensitivity			297

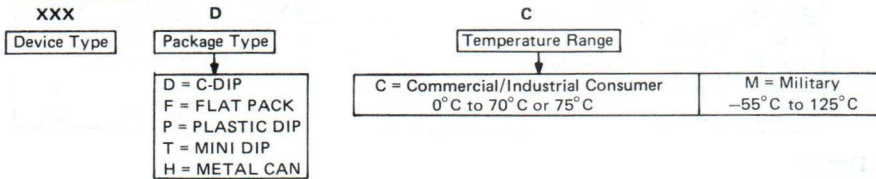
## INTERCHANGEABILITY GUIDE (ALPHABETICALLY BY MANUFACTURERS)

Direct replacements were based on similarity of electrical and mechanical characteristics as shown in currently published data. Interchangeability in particular applications is not guaranteed. Before using a device as a substitute, the user should compare the specifications of the substitute device with the specifications of the original.

Texas Instruments makes no warranty as to the information furnished and buyer assumes all risk in the use thereof. No liability is assumed for damages resulting from the use of the information contained in this list.

### FAIRCHILD ORDER INFORMATION

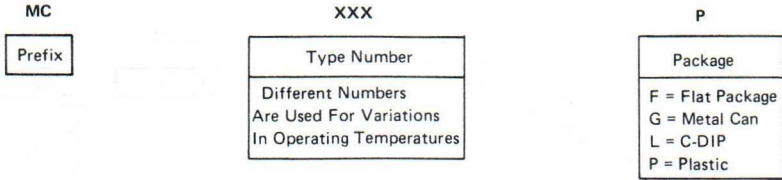
**EXAMPLE OF ORDER CODE:**



FAIRCHILD	TI DIRECT <u>REPLACEMENT</u>	TI CLOSEST <u>REPLACEMENT</u>	FAIRCHILD	TI DIRECT <u>REPLACEMENT</u>	TI CLOSEST <u>REPLACEMENT</u>
μA101A	LM101A		μA710	uA710	
μA107	LM107		μA711	uA711	
μA111	LM111		μA733	uA733	
μA139	LM139		μA734		LM111
μA201A	LM201A		μA741	uA741	
μA207	LM207		μA742		TL440
μA301A	LM301A		μA747	uA747	
μA304	LM304		μA748	uA748	
μA307	LM307		μA776		uA777
μA311	LM311		μA777	uA777	
μA555	SE555		μA2240C	uA2240C	
μA556C	NE556		μA3302C	LM3302	
μA556M	SE556		μA3403	MC3403	
μA702	uA702		μA4136C	RC4136	
μA709	uA709		μA4136M	RM4136	
μA709A	uA709A				

# MOTOROLA ORDER INFORMATION

**EXAMPLE OF ORDER CODE:**

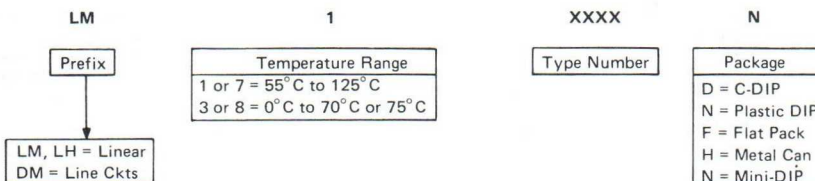


1

MOTOROLA	<u>TI DIRECT REPLACEMENT</u>	<u>TI CLOSEST REPLACEMENT</u>	MOTOROLA	<u>TI DIRECT REPLACEMENT</u>	<u>TI CLOSEST REPLACEMENT</u>
MLM101A	LM101A		MC1545	MC1545	
MLM107	LM107		MC1539		LM101A
MLM111	LM111		MC1555	SE555	
MLM201A	LM201A		MC1558	MC1558	
MLM207	LM207		MC1709	uA709	
MLM211	LM211		MC1710	uA710	
MLM301A	LM301A		MC1711	uA711	
MLM307	LM307		MC1712	uA702	
MLM311	LM311		MC1733	uA733	
MC1414	TL514		MC1741	uA741	
MC1420		uA733	MC1747	uA747	
MC1430		uA702	MC1748	uA748	
MC1431		uA702	MC3302	LM3302	
MC1433		LM301A	MC3302P	LM339	
MC1439		LM301A	MC3303	MC3303	
MC1445	MC1445		MC3403	MC3403	
MC1455	NE555		MC3423	MC3423	
MC1458	MC1458		MC3503	MC3503	
MC1514	TL442		MC3523	MC3523	
MC1530		uA702	MC4558	RM4558	
MC1531		uA702	MC4558C	RC4558	
MC1533		LM101A			

## NATIONAL ORDER INFORMATION

**EXAMPLE OF ORDER CODE:**

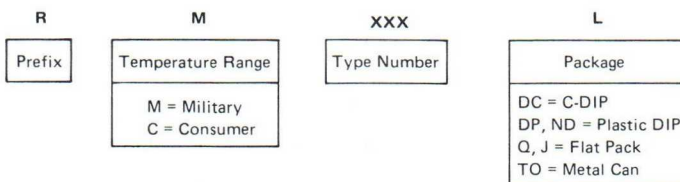


NATIONAL	<u>TI DIRECT REPLACEMENT</u>	<u>TI CLOSEST REPLACEMENT</u>		NATIONAL	<u>TI DIRECT REPLACEMENT</u>	<u>TI CLOSEST REPLACEMENT</u>
ADC0808	ADC0808			LM348	LM348	
ADC0809	ADC0809			LM358	LM358	
ADC0816	ADC0816			LM393	LM393	
ADC0817	ADC0817			LM555C	NE555	
DS5534	NE5534			LM555M	SE555	
LM101A	LM101A			LM556	SE556	
LM102	LM102			LM556C	NE556	
LM106	LM106			LM709	uA709	
LM107	LM107			LM709A	uA709A	
LM110	LM110			LM709C	uA709C	
LM111	LM111			LM710	uA710	
LM112	LM112			LM710C	uA710C	
LM118		LM218		LM711	uA711	
LM124	LM124			LM711C	uA711C	
LM139	LM139			LM733	uA733	
LM148	LM148			LM733C	uA733C	
LM158	LM158			LM741	uA741	
LM193	LM193			LM741C	uA741C	
LM201A	LM201A			LM747	uA747	
LM206	LM206			LM747C	uA747C	
LM207	LM207			LM748	uA748	
LM211	LM211			LM748C	uA748C	
LM218	LM218			LM1414N	TL514C	
LM224	LM224			LM1458	MC1558	
LM239	LM239			LM1514	TL514M	
LM248	LM248			LM1558	MC1558	
LM258	LM258			LM1900	LM1900	
LM293	LM293			LM2900	LM2900	
LM301A	LM301A			LM2901	LM2901	
LM306	LM306			LM2902	LM2902	
LM307	LM307			LM2903	LM2903	
LM311	LM311			LM2904	LM2904	
LM318	LM318			LM3302	LM3302	
LM324	LM324			LM3900	LM3900	
LM339	LM339			LM3905		

NE555

## RAYTHEON ORDER INFORMATION

EXAMPLE OF ORDER CODE:

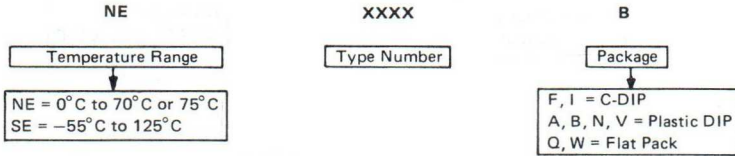


1

RAYTHEON	<u>TI DIRECT</u> <u>REPLACEMENT</u>	<u>TI CLOSEST</u> <u>REPLACEMENT</u>	RAYTHEON	<u>TI DIRECT</u> <u>REPLACEMENT</u>	<u>TI CLOSEST</u> <u>REPLACEMENT</u>
LM101A	LM101A		RC556	NE556	
LM106	LM106		RC702	uA702C	
LM107	LM107		RC709	uA709C	
LM111	LM111		RC710	uA710C	
LM118		LM218	RC711	uA711C	
LM124	LM124		RC733	uA733C	
LM139	LM139		RC741	uA741C	
LM158	LM158		RC747	uA747C	
LM201A	LM201A		RC748	uA748C	
LM206	LM206		RC1458	MC1458	
LM207	LM207		RC3302	LM3302	
LM211	LM211		RC3403	MC3403	
LM218	LM218		RC4136	RC4136	
LM224	LM224		RC4558	RC4558	
LM239	LM239		RM555	SE555	
LM258	LM258		RM556	SE556	
LM301A	LM301A		RM702	uA702M	
LM306	LM306		RM709	uA709M	
LM307	LM307		RM710	uA710M	
LM311	LM311		RM711	uA711M	
LM318	LM318		RM733	uA733M	
LM324	LM324		RM741	uA741M	
LM339	LM339		RM747	uA747M	
LM358	LM358		RM748	uA748M	
LM1900	LM1900		RM1514	TL514M	
LM2900	LM2900		RM1558	MC1558	
LM3900	LM3900		RM4136	RM4136	
RC555	NE555		RM4558	RM4558	

## SIGNETICS ORDER INFORMATION

**EXAMPLE OF ORDER CODE:**



SIGNETICS	<u>TI DIRECT</u> <u>REPLACEMENT</u>	<u>TI CLOSEST</u> <u>REPLACEMENT</u>		SIGNETICS	<u>TI DIRECT</u> <u>REPLACEMENT</u>	<u>TI CLOSEST</u> <u>REPLACEMENT</u>
LM101A	LM101A			NE5533	NE5533	
LM107	LM107			NE5533A	NE5533A	
LM111	LM111			NE5534	NE5534	
LM124	LM124			NE5534A	NE5534A	
LM139	LM139			SE532	LM158	
LM201A	LM201A			SE555	SE555	
LM207	LM207			SE556	SE556	
LM211	LM211			SE5534	SE5534	
LM224	LM224			SE5534A	SE5534A	
LM239	LM239			SE5733	uA733M	
LM301A	LM301A			uA709	uA709	
LM307	LM307			uA709A	uA709A	
LM311	LM311			uA710	uA710M	
LM324	LM324			uA710C	uA710C	
LM339	LM339			uA711	uA711M	
MC3302	LM3302			uA711C	uA711C	
NE532	LM358			uA741	uA741M	
NE555	NE555			uA741C	uA741C	
NE556	NE556			uA747C	uA747C	
NE5532	NE5532			uA748	uA748M	
NE5532A	NE5532A			uA748C	uA748C	

# Thermal Information

# THERMAL INFORMATION

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## THERMAL CONSIDERATIONS

The power dissipation capability of semiconductor devices is limited by the maximum allowable virtual junction temperature, the ambient temperature, and the thermal resistance between the virtual junction and the ambient environment.

The temperature difference between the junction and the ambient environment is

$$T_J - T_A = P_D R_{\theta JA} \quad (1)$$

where  $T_J$  = virtual junction temperature, °C

$T_A$  = ambient temperature, °C

$P_D$  = power dissipated in the device, W

$R_{\theta JA}$  = thermal resistance, junction to ambient, °C/W

Solving for  $T_J$ ,

$$T_J = T_A + P_D R_{\theta JA} \quad (2)$$

The rating curves that follow assume the ambient environment is still air, that no heat sink is used, and that the junction temperature should not exceed 150°C.

$R_{\theta JA}$  may be reduced by the use of a heat sink.

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CA} \quad (3)$$

where  $R_{\theta JC}$  = thermal resistance, junction to case, and  $R_{\theta CA}$  = thermal resistance, case to ambient.  $R_{\theta CA}$  is a function of the heat sink, mounting technique, and air velocity.

Substituting equation (3) into equation (1) and solving for  $P_D$ ,

$$P_D = \frac{T_J - T_A}{R_{\theta JC} + R_{\theta CA}} \quad (4)$$