Texas Instruments

Linear Circuits

Operational Amplifier Macromodels

Data Manual

1990

Linear Products

Linear Products Data Book Guide

Data Book	Contents	Document No.
• Linear Circuits Vol 1 Amplifiers, Comparators, and Special Functions	Operational Amplifiers Voltage Comparators Video Amplifiers Hall-Effect Devices Timers and Current Mirrors Magnetic-Memory Interface Frequency-to-Voltage Converters Sonar Ranging Circuits/Modules Sound Generators	SLYD003 1989
• Linear Circuits Vol 2 Data Acquisition and Conversion	A/D and D/A Converters DSP Analog Interface Analog Switches and Multiplexers Switched-Capacitor Filters	SLYD004 1989
• Linear Circuits Vol 3 Voltage Regulators and Supervisors	Supervisor Functions Series-Pass Voltage Regulators Shunt Regulators Voltage References DC-to-DC Converters PWM Controllers	SLYD005 1989
• Telecommunications Circuits	Equipment Line Interfaces Subscriber Line Interfaces Modems and Receivers/Transmitters Ringers, Detectors, Tone Encoders PCM Interface Transient Suppressors	SCTD001A 1988/89
• Optoelectronics and Image Sensors	Optocouplers CCD Image Sensors and Support Phototransistors IR-Emitting Diodes Hybrid Displays	SOYD002A 1990
• Interface Circuits	High-Voltage (Display) Drivers High-Power (Peripheral/Motor) Drivers Line Drivers, Receivers, Transceivers EIA RS-232, RS-422, RS-423, RS-485 IBM 360/370, IEEE 802.3, CCITT Military Memory Interface	SLYD002 1987
• Speech System Manuals	TSP50C4X Family	SPSS010 1990

November 1989

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Operational Amplifier Macromodels
Linear Circuits
Data Manual
1990

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Information contained in this data manual supersedes all data for this technology published by TI in the United States of America before January 1989.

INTRODUCTION

Texas Instruments offers an extensive line of operational amplifiers designed for applications that sense, amplify, and/or condition analog signals. The technologies represented by these op amps include traditional bipolar, BIFET, LinCMOS™, Advanced LinCMOS™, and the new Excalibur processes.

This data manual contains:

- a macromodel alphanumeric index,
- an operational-amplifier-to-macromodel cross-reference guide,
- an operational amplifier selection guide with page number reference to the appropriate macromodel,
- an operational amplifier cross-reference guide to competitive devices with a page number reference to the appropriate macromodel,
- a glossary of operational amplifier terms,
- a technical discussion of the macromodel concept and the major advantages and limitations of macromodels,
- a listing of sources for more information,
- a set of macromodel information sheets,
- and a floppy disk that contains all of the modeling parameters presented in the macromodel information sheets in an easy-to-use format.

The Spice macromodels contained in this manual represent our current line of operational amplifiers with the exception of the LM2900, the LM3900 (high-gain frequency-compensated Norton amplifiers), and the uA709 (a bipolar device with two frequency-compensation inputs), which cannot be modeled with *PSpice® Parts™*. It is important to note that *PSpice® Parts™* is also incapable of modeling input offset voltage and temperature range variations. Due to these limitations, different input offset and temperature range versions of the same device are represented by the base device macromodel.

This data manual offers modeling information on TI's Linear operational amplifier products. The resultant simulation may vary up to 20% from the data sheet typical specifications. It is therefore recommended that actual device performance specifications be consulted before a final design or purchase decision is made. Complete technical data for all Linear operational amplifiers is contained in Texas Instruments 1989 *Linear Circuits Data Book, Volume 1* (Literature Number SLYD003), with the exception of the following devices, for which the individual device data sheets must be consulted:

Device Part Number	Data Sheet Literature Number
LT1013	SLOS040
LTC1052	SLO3018
LTC7652	SLO3018
TLE2021	SLOS024A
TLE2022	SLOS027
TLE2024	SLOS028
TLE2061	SLOS045
TLE2062	SLOS044
TLE2064	SLOS048
TLE2161	SLOS049

While this data manual offers design and specification data for Linear operational amplifiers only, complete technical data for any TI semiconductor product is available from your nearest TI Field Sales Office, local authorized TI Distributor, or by writing directly to:

Texas Instruments Incorporated
LITERATURE RESPONSE CENTER
P.O. Box 809066
Dallas, TX 75380-9066

We sincerely feel that the new 1990 *Operational Amplifiers Macromodel Data Manual* will be a significant addition to your library of technical literature from Texas Instruments.

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General Information

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noncompensated, single

military temperature range

(Values specified for T_A = 25°C)

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/µs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
High Performance, Bipolar	±5	±22	2	75	50	1	0.5	LM101A	FK,JG,U,W	3-9
High Performance, Low Bias Current, Bipolar	±2	±20	2	2	50	1	0.3	LM108	L	3-13
High Performance, Low Bias Current, Bipolar	±2	±20	0.5	2	80	1	0.3	LM108A	L	3-13
BIFET, Low Power	±3.5	±18	6	0.2	4	1	3.5	TL060M	JG	3-47
BIFET, General Purpose	±3.5	±18	6	0.2	25	3	13	TL080M	JG	3-57
General Purpose,Precision Input, Bipolar	±9	±18	2	200	Typ 45	1	0.3	uA709AM	J,JG,U,W	–
General Purpose, Bipolar	±9	±18	5	500	Typ 45	1	0.3	uA709M	J,JG,U,W	–
General Purpose, Bipolar	±2	±22	5	500	50	1	0.5	uA748M	JG,U	3-108

industrial temperature range

(Values specified for T_A = 25°C)

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/µs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
High Performance, Bipolar	±5	±22	2	75	50	1	0.5	LM201A	D,JG,P	3-9
BIFET, Low Power	±3.5	±18	6	0.2	4	1	3.5	TL060I	D,JG,P	3-47
BIFET, Low Noise	±3.5	±18	6	200	50	3	13	TL070I	D,JG,P	3-52
BIFET, Low Power	±3.5	±18	6	400	25	3	13	TL080I	D,JG,P	3-57

noncompensated, single

commercial temperature range

(Values specified for T_A = 25°C)

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/µs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
High Performance	±5	±18	7.5	250	15	1	7.5	LM301A	D,JG,P	3-11
High Performance	±2	±18	7.5	2	25	1	0.3	LM308	D,JG,P	3-13
High Performance	±2	±18	0.5	2	80	1	0.3	LM308A	D,JG,P	3-13
BIFET, Low Power	±3.5	±18	6	0.2	4	1	3.5	TL060AC	D,JG,P	3-47
BIFET, Low Power	±3.5	±18	3	0.2	4	1	3.5	TL060BC	D,JG,P	3-47
BIFET, Low Power	±3.5	±18	15	0.4	3	1	3.5	TL060C	D,JG,P	3-47
BIFET, Low Noise	±3.5	±18	6	0.2	50	3	13	TL070AC	D,JG,P	3-52
BIFET, Low Noise	±3.5	±18	10	0.2	25	3	13	TL070C	D,JG,P	3-52
BIFET, General Purpose	±3.5	±18	6	0.2	50	3	13	TL080AC	D,JG,P	3-57
BIFET, General Purpose	±3.5	±18	15	0.4	25	3	13	TL080C	D,JG,P	3-57
General Purpose, Bipolar	±9	±18	7.5	1500	15	1	0.3	uA709C	D,JG,P	–
General Purpose, Bipolar	±2	±18	6	500	20	1	0.5	uA748C	D,JG,P	3-108

1 General Information

internally compensated, single

military temperature range (Values specified for $T_A = 25°C$)

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/μs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
High Performance	±5	±20	2	75	50	1	0.5	LM107	J,JG,U,W	3-10
Precision	±5	±22	0.015	2	450	0.8	0.25	LT1001AM	JG,L	3-18
Precision	±5	±22	0.06	4	400	0.8	0.25	LT1001M	JG,L	3-18
Low Noise, High Speed, Precision Input	±2.5	±22	0.025	35	7000	8	2.5	LT1007AM	JG,L	3-19
Low Noise, High Speed, Precision Input	±2.5	±22	0.060	55	5000	8	2.5	LT1007M	JG,P	3-19
Ultra Precision	±2.5	±20	0.035	0.1	300	0.8	2	LT1012M	L	3-21
Low Noise, High Performance	±4.5	±16	0.12	150	300	25	15	LT1028AM	D,JG,L,P	3-23
Low Noise, High Performance	±4.5	±20	0.18	300	200	25	15	LT1028M	D,JG,L,P	3-23
Low Noise, High Speed, Noncompensated, $A_{VL} \geq 5$	±2.5	±22	0.025	35	7000	60	15	LT1037AM	JG,L	3-24
Low Noise, High Speed, Noncompensated, $A_{VL} \geq 5$	±2.5	±22	0.060	55	5000	60	15	LT1037M	JG,L	3-24
Chopper-Stabilized	±1.9	±8	0.005	0.03	1000	1.2	4	LTC1052M	J,JG,L	3-25
Low Noise, High Speed	±3.5	±22	0.025	40	1000	8	2.8	OP-27A	JG,L	3-32
Low Noise, High Speed	±3.5	±22	0.1	80	700	8	2.8	OP-27C	JG,L	3-32
Low Noise, High Speed Noncompensated, $A_{VL} \geq 5$	±4	±22	0.025	40	1000	40	17	OP-37A	JG,L	3-35
Low Noise, High Speed, Noncompensated, $A_{VL} \geq 5$	±4	±22	0.1	80	700	40	17	OP-37C	JG,L	3-35
Low Noise, High Performance	±3	±22	2	800	50	10	13	SE5534	FK,JG	3-28
Low Noise, High Performance	±3	±22	2	800	50	10	13	SE5534A	FK,JG	3-28
BIFET, Low Power, Precision	±3.5	±18	0.8	0.2	5	1.1	2.9	TL031AM	FK,JG,L	3-40
BIFET, Low-Power, Precision	±3.5	±18	1.5	0.2	5	1.1	2.9	TL031M	FK,JG,L	3-40
BIFET, Precision	±3.5	±18	0.8	0.2	50	3.1	20	TL051AM	FK,JG,L	3-44
BIFET, Precision	±3.5	±18	1.5	0.2	50	3.1	20	TL051M	FK,JG,L	3-44
BIFET, Low Power	±1.5	±18	6	0.2	4	1	3.5	TL061M	FK,JG,U	3-48
BIFET, Adjustable, Low-Power	±1.2	±18	6	0.2	4	1	3.5	TL066M	FK,JG	3-51
BIFET, Low Noise	±3.5	±18	6	0.2	35	3	13	TL071M	FK,JG	3-53
BIFET, General Purpose	±3.5	±18	6	0.2	25	3	13	TL081M	FK,JG	3-58
BIFET, Low V_{IO}	±3.5	±18	3	0.4	50	3	13	TL088M	JG,U	3-64
LinCMOS, Programmable, Low Bias	4	18	10	Typ 0.007	50	0.11	0.04	TLC271M	FK,JG	3-80
LinCMOS, Programmable, Medium Bias	4	18	10	Typ 0.007	25	0.64	0.56	TLC271M	FK,JG	3-81
LinCMOS, Programmable, High Bias	4	18	10	Typ 0.007	10	2.2	4.6	TLC271M	FK,JG	3-79
LinCMOS, Low Noise, Precision	4.6	16	0.2	Typ 0.001	400	1.9	2.7	TLC2201AM	D,FK,JG,L,P	3-96

TEXAS INSTRUMENTS
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internally compensated, single

military temperature range **(Values specified for $T_A = 25°C$)**

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/µs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
LinCMOS, Low Noise, Precision, 100% Noise Tested	4.6	16	0.2	Typ 0.001	400	1.9	2.7	TLC2201BM	D,FK,JG,L,P	3-96
LinCMOS, Low Noise, Precision	4.6	16	0.5	Typ 0.001	400	1.9	2.7	TLC2201M	D,FK,JG,L,P	3-96
LinCMOS, Precision, Chopper Stablilized	3.8	16	0.001	Typ 0.004	5600	1.9	2.8	TLC2652AM	D,FK,J,JG, L,N,P	3-97
LinCMOS, Precision Chopper Stabilized	3.8	16	0.003	Typ 0.004	1000	1.9	2.8	TLC2652M	D,FK,J,JG, L,N,P	3-97
LinCMOS, Low Noise, Precision, Chopper Stabilized	4.6	16	0.01	Typ 0.05	5600	1.9	2	TLC2654AM	D,FK,J,JG, L,N,P	3-98
LinCMOS, Low Noise, Precision, Chopper Stabilized	4.6	16	0.02	Typ 0.05	1000	2.2	2	TLC2654M	D,FK,J,JG, L,N,P	3-98
Excalibur, High-Speed, Precision	4	40	0.5	25	1000	2	0.9	TLE2021M	D,FK,JG,L,P	3-99
General Purpose	±2	±22	5	500	50	1	0.5	uA741M	FK,J,JG,U	3-106

internally compensated, single

automotive temperature range **(Values specified for T_A = 25°C)**

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/µs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
High Performance	±5	±22	2	75	50	1	0.5	LM207	D,J,JG, N,P,W	3-10
High Performance	±5	±20	4	250	50	15	70	LM218	D,JG,P	3-14
Chopper-Stabilized	±1.9	±8	0.005	0.03	1000	1.2	4	LTC1052C	J,JG,L,N,P	3-25
Chopper-Stabilized	±1.9	±8	0.005	0.03	1000	1.2	4	LTC7652C	L	3-3
Low Noise, High Speed	±3.5	±22	0.025	40	1000	8	2.8	OP-27E	JG,L,P	3-33
Low Noise, High Speed	±3.5	±22	0.1	80	700	8	2.8	OP-27G	JG,L,P	3-34
Low Noise, High Speed Noncompensated, $A_{VL} \geq 5$	±4	±22	0.025	40	1000	40	17	OP-37E	JG,L,P	3-35
Low Noise, High Speed, Noncompensated, $A_{VL} \geq 5$	±4	±22	0.1	80	700	40	17	OP-37G	JG,P	3-35
BIFET, Low Power, Precision	±3.5	±18	0.8	0.2	5	1.1	2.9	TL031AI	D,JG,L,P	3-40
BIFET, Low Power, Precision	±3.5	±18	1.5	0.2	5	1.1	2.9	TL031I	D,JG,L,P	3-40
BIFET, Precision	±3.5	±18	0.8	0.2	50	3.1	20	TL051AI	D,JG,L,P	3-44
BIFET, Precision	±3.5	±18	1.5	0.2	50	3.1	20	TL051I	D,JG,L,P	3-44
BIFET, Low Power	±3.5	±18	6	0.2	4	1	3.5	TL061I	D,JG,P	3-48
BIFET, Adjustable, Low Power	±1.2	±18	6	0.2	4	1	3.5	TL066I	D,JG,P	3-51
BIFET, Low Noise	±3.5	±18	6	0.2	50	3	13	TL071I	D,JG,P	3-53
BIFET, General Purpose	±3.5	±18	6	0.2	50	3	13	TL081I	D,JG,P	3-58
BIFET, Low Offset Voltage	±3.5	±18	0.5	0.2	50	3	13	TL087I	D,JG,P	3-63
BIFET, Low Offset Voltage	±3.5	±18	1	0.2	50	3	13	TL088I	D,JG,P	3-64
LinCMOS, Programmable, Low Bias	4	18	5	Typ 0.007	50	0.11	0.04	TLC271AI	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	4	18	5	Typ 0.007	25	0.64	0.56	TLC271AI	D,JG,P	3-81
LinCMOS, Programmable, High Bias	4	18	5	Typ 0.007	10	2.2	4.6	TLC271AI	D,JG,P	3-79
LinCMOS, Programmable, Low Bias	4	18	2	Typ 0.007	50	0.11	0.04	TLC271BI	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	4	18	2	Typ 0.007	25	0.64	0.56	TLC271BI	D,JG,P	3-81
LinCMOS, Programmable, High Bias	4	18	2	Typ 0.007	10	2.2	4.6	TLC271BI	D,JG,P	3-79
LinCMOS, Programmable, Low Bias	4	18	10	Typ 0.007	50	0.11	0.04	TLC271I	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	4	18	10	Typ 0.007	25	0.64	0.56	TLC271I	D,JG,P	3-81
LinCMOS, Programmable, High Bias	4	18	10	Typ 0.007	10	2.2	4.6	TLC271I	D,JG,P	3-79
LinCMOS, Low Noise Precision	4.6	16	0.2	Typ 0.001	400	1.9	2.7	TLC2201AI	D,JG,L,P	3-96

internally compensated, single

automotive temperature range

(Values specified for $T_A = 25°C$)

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/μs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
LinCMOS, Low Noise Precision, 100% Noise Tested	4.6	16	0.2	Typ 0.001	400	1.9	2.7	TLC2201BI	D,JG,L,P	3-96
LinCMOS, Low Noise Precision	4.6	16	0.5	Typ 0.001	400	1.9	2.7	TLC2201I	D,JG,L,P	3-96
LinCMOS, Precision, Chopper Stabilized	3.8	16	0.001	Typ 0.004	5600	1.9	2.8	TLC2652AI	D,J,JG,L,N,P	3-97
LinCMOS, Precision, Chopper Stabilized	3.8	16	0.003	Typ 0.004	1000	1.9	2.8	TLC2652I	D,J,JG,L,N,P	3-97
LinCMOS, Low Noise, Precision, Chopper Stabilized	4.6	16	0.01	Typ 0.05	5600	1.9	2	TLC2654AI	D,J,JG,L,N,P	3-98
LinCMOS, Low Noise, Precision, Chopper Stabilized	4.6	16	0.02	Typ 0.05	1000	1.9	2	TLC2654I	D,J,JG,L,N,P	3-98
Excalibur, High-Speed, Precision	4	40	0.5	25	1000	2	0.9	TLE2021	D,FK,JG,L,P	3-99

OPERATIONAL AMPLIFERS SELECTION GUIDE

internally compensated, single

industrial temperature range **(Values specified for T_A = 25°C)**

DESCRIPTION	SUPPLY VOLTAGE (V) MIN	SUPPLY VOLTAGE (V) MAX	V_{IO} (mV) MAX	I_{IB} (nA) MAX	A_{VD} (V/mV) MIN	B_1 (MHz) TYP	SR (V/μs) TYP	TYPE	PACKAGES	PAGE NO.
Chopper-Stabilized	±1.9	±8	0.005	0.03	1000	1.2	4	LTC1052C	J,JG,L,N,P	3-25
Chopper-Stabilized	±1.9	±8	0.005	0.03	1000	1.2	4	LTC7652C	L	3-3
Low Noise, High Speed	±3.5	±22	0.025	40	1000	8	2.8	OP-27E	JG,L,P	3-33
Low Noise, High Speed	±3.5	±22	0.1	80	700	8	2.8	OP-27G	JG,L,P	3-34
Low Noise, High Speed, Bipolar, Noncompensated, $A_{VL} \geq 5$	±4	±22	0.025	40	1000	40	17	OP-37E	JG,L,P	3-35
Low Noise, High Speed, Bipolar, Noncompensated, $A_{VL} \geq 5$	±4	±22	0.1	80	700	40	17	OP-37G	JG,L,P	3-35
BIFET, Low Power, Precision	±3.5	±18	0.8	0.2	5	1.1	2.9	TL031AI	D,JG,L,P	3-40
BIFET, Low Power, Precision	±3.5	±18	1.5	0.2	5	1.1	2.9	TL031I	D,JG,L,P	3-40
BIFET, Precision	±3.5	±18	0.8	0.2	50	3.1	20	TL051AI	D,JG,L,P	3-44
BIFET, Precision	±3.5	±18	1.5	0.2	50	3.1	20	TL051I	D,JG,L,P	3-44
BIFET, Low Power	±3.5	±18	6	0.2	4	1	3.5	TL061I	D,JG,P	3-48
BIFET, Adjustable, Low-Power	±1.2	±18	6	0.2	4	1	3.5	TL066I	D,JG,P	3-51
BIFET, Low Noise	±3.5	±18	6	0.2	50	3	13	TL071I	D,JG,P	3-53
BIFET, General Purpose	±3.5	±18	6	0.2	50	3	13	TL081I	D,JG,P	3-58
BIFET, Low Offset Voltage	±3.5	±18	0.5	0.2	50	3	13	TL087I	D,JG,P	3-63
BIFET, Low Offset Voltage	±3.5	±18	1	0.2	50	3	13	TL088I	D,JG,P	3-64
Single LM324, High Performance — S/S	3	30	5	−150	50	0.6	0.3	TL321I	JG,P	3-68
Single LM324, High Performance — D/S	±1.5	±15								
LinCMOS, Programmable, Low Bias	4	18	5	Typ 0.007	50	0.11	0.04	TLC271AI	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	4	18	5	Typ 0.007	25	0.64	0.56	TLC271AI	D,JG,P	3-81
LinCMOS, Programmable, High Bias	4	18	5	Typ 0.007	10	2.2	4.6	TLC271AI	D,JG,P	3-79
LinCMOS, Programmable, Low Bias	4	18	2	Typ 0.007	50	0.11	0.04	TLC271BI	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	4	18	2	Typ 0.007	25	0.64	0.56	TLC271BI	D,JG,P	3-81
LinCMOS, Programmable, High Bias	4	18	2	Typ 0.007	10	2.2	4.6	TLC271BI	D,JG,P	3-79
LinCMOS, Programmable, Low Bias	4	18	10	Typ 0.007	50	0.11	0.04	TLC271I	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	4	18	10	Typ 0.007	25	0.64	0.56	TLC271I	D,JG,P	3-81
LinCMOS, Programmable, High Bias	4	18	10	Typ 0.007	10	2.2	4.6	TLC271I	D,JG,P	3-79
LinCMOS, Precision, Low Noise	4.6	16	0.2	Typ 0.001	400	1.9	2.7	TLC2201AI	D,JG,L,P	3-96
LinCMOS, Precision, Low Noise, 100% Noise Tested	4.6	16	0.2	Typ 0.001	400	1.9	2.7	TLC2201BI	D,JG,L,P	3-96
LinCMOS, Precision, Low Noise	4.6	16	0.5	Typ 0.001	400	1.9	2.7	TLC2201I	D,JG,L,P	3-96
LinCMOS, Precision, Chopper Stabililzed	3.8	16	0.001	Typ 0.004	5600	1.9	2.8	TLC2652AI	D,J,JG,L,N,P	3-97
LinCMOS, Precision, Chopper Stabilized	3.8	16	0.003	Typ 0.004	1000	1.9	2.8	TLC2652I	D,J,JG, L,N,P	3-97
LinCMOS, Low-Noise, Precision, Chopper Stabilized	4.6	16	0.01	Typ 0.05	5600	1.9	2	TLC2654AI	D,J,JG, L,N,P	3-98
LinCMOS, Low-Noise, Precision, Chopper Stabilized	4.6	16	0.02	Typ 0.05	1000	1.9	2	TLC2654I	D,J,JG, L,N,P	3-98
Excalibur, High-Speed, Precision	4	40	0.5	25	1000	2	0.9	TLE2021I	D,FK,JG,L,P	3-99

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

internally compensated, single

commercial temperature range **(Values specified for $T_A = 25°C$)**

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/μs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
BIFET	±3.5	±18	10	0.2	25	3	13	LF351	D,JG,P	3-5
BIFET	±3.5	±18	2	0.2	25	3	13	LF411C	D,JG,P	3-7
High Performance	±2	±18	7.5	250	25	1	0.5	LM307	D,J,JG, N,P,W	3-12
High Performance	±5	±20	10	250	25	15	70	LM318	D,JG,P	3-14
Precision	±5	±22	0.025	2	450	0.8	0.25	LT1001AC	JG,L,P	3-18
Precision	±5	±22	0.06	4	400	0.8	0.25	LT1001C	JG,L,P	3-18
Low Noise, High Speed, Precision Input	±2.5	±22	0.025	35	7000	8	1.7	LT1007AC	JG,P	3-19
Low Noise, High Speed, Precision Input	±2.5	±22	0.060	55	5000	8	1.7	LT1007C	JG,P	3-19
Ultra Precision	±2.5	±20	0.05	0.15	200	–	0.2	LT1012C	L,P	3-21
Low Noise, High Performance	±4.5	±18	0.08	120	500	75	15	LT1028AC	D,JG,L,P	3-23
Low Noise, High Performance	±4.5	±18	0.13	240	300	75	15	LT1028C	D,JG,L,P	3-23
Low Noise, High Speed, Noncompensated, $A_{VL} \geq 5$	±2.5	±22	0.025	35	7000	60	15	LT1037AC	JG,P	3-24
Low Noise, High Speed, Noncompensated, $A_{VL} \geq 5$	±2.5	±22	0.060	55	5000	60	15	LT1037C	JG,P	3-24
Low Noise, High Performance	±3	±22	4	1500	25	10	13	NE5534	D,JG,P	3-28
Low Noise, High Performance	±3	±22	4	1500	25	10	13	NE5534A	D,JG,P	3-28
Ultra-Low Offset Voltage	±3	±22	0.15	7	120	0.6	0.3	OP-07C	D,JG,P	3-29
Ultra-Low Offset Voltage	±3	±22	0.15	12	120	0.6	0.3	OP-07D	D,JG,P	3-30
Ultra-Low Offset Voltage	±3	±22	0.075	4	200	0.6	0.3	OP-07E	D,JG,P	3-31

internally compensated, single

commercial temperature range (Values specified for $T_A = 25°C$)

DESCRIPTION	SUPPLY VOLTAGE (V) MIN	SUPPLY VOLTAGE (V) MAX	V_{IO} (mV) MAX	I_{IB} (nA) MAX	A_{VD} (V/mV) MIN	B_1 (MHz) TYP	SR (V/μs) TYP	TYPE	PACKAGES	PAGE NO.
BIFET, Low Power, Precision	±3.5	±18	0.8	0.2	5	1.1	2.9	TL031AC	D,FK,JG,L,P	3-40
BIFET, Low Power, Precision	±3.5	±18	1.5	0.2	5	1.1	2.9	TL031C	D,FK,JG,L,P	3-40
BIFET, Precision	±3.5	±18	0.8	0.2	50	3.1	20	TL051AC	D,FK,JG,L,P	3-44
BIFET, Precision	±3.5	±18	1.5	0.2	50	3.1	20	TL051C	D,FK,JG,L,P	3-44
BIFET, Low Power	±3.5	±18	6	0.2	4	1	3.5	TL061AC	D,JG,P	3-48
BIFET, Low Power	±3.5	±18	3	0.2	4	1	3.5	TL061BC	D,JG,P	3-48
BIFET, Low Power	±3.5	±18	15	0.2	3	1	3.5	TL061C	D,JG,P	3-48
BIFET, Adjustable, Low-Power	±1.2	±18	6	0.2	4	1	3.5	TL066AC	D,JG,P	3-51
BIFET, Adjustable, Low-Power	±1.2	±18	3	0.2	4	1	3.5	TL066BC	D,JG,P	3-51
BIFET, Adjustable, Low-Power	±1.2	±18	15	0.4	3	1	3.5	TL066C	D,JG,P	3-51
BIFET, Low Noise	±3.5	±18	6	0.2	50	3	13	TL071AC	D,JG,P	3-53
BIFET, Low Noise	±3.5	±18	3	0.2	50	3	13	TL071BC	D,JG,P	3-53
BIFET, Low Noise	±3.5	±18	10	0.2	25	3	13	TL071C	D,JG,P	3-53
BIFET, General Purpose	±3.5	±18	6	0.2	50	3	13	TL081AC	D,JG,P	3-58
BIFET, General Purpose	±3.5	±18	3	0.2	50	3	13	TL081BC	D,JG,P	3-58
BIFET, General Purpose	±3.5	±18	15	0.4	25	3	13	TL081C	D,JG,P	3-58
BIFET, Low V_{IO}	±3.5	±18	0.5	0.2	50	3	13	TL087C	D,JG,L,P	3-63
BIFET, Low V_{IO}	±3.5	±18	1	0.2	50	3	13	TL088C	D,JG,L,P	3-64
Single LM324, High Performance — S/S	3	30	7	−250	25	0.6	0.3	TL321C	JG,P	3-68
Single LM324, High Performance — D/S	1.5	15								
LinCMOS, Programmable, Low Bias	1.4	18	5	Typ 0.001	30	0.1	0.04	TLC251AC	D,JG,P	3-71
LinCMOS, Programmable, Medium Bias	1.4	18	5	Typ 0.001	20	0.7	0.6	TLC251AC	D,JG,P	3-72
LinCMOS, Programmable, High Bias	1.4	18	5	Typ 0.001	10	2.3	4.5	TLC251AC	D,JG,P	3-70
LinCMOS, Programmable, Low Bias	1.4	18	2	Typ 0.001	30	0.1	0.04	TLC251BC	D,JG,P	3-71
LinCMOS, Programmable, Medium Bias	1.4	18	2	Typ 0.001	20	0.7	0.6	TLC251BC	D,JG,P	3-72
LinCMOS, Programmable, High Bias	1.4	18	2	Typ 0.001	10	2.3	4.5	TLC251BC	D,JG,P	3-70
LinCMOS, Programmable, Low Bias	1.4	18	10	Typ 0.001	30	0.1	0.04	TLC251C	D,JG,P	3-71
LinCMOS, Programmable, Medium Bias	1.4	18	10	Typ 0.001	20	0.7	0.6	TLC251C	D,JG,P	3-72
LinCMOS, Programmable, High Bias	1.4	18	10	Typ 0.001	10	2.3	4.5	TLC251C	D,JG,P	3-70
LinCMOS, Programmable, Low Bias	3	18	5	Typ 0.007	50	0.11	0.04	TLC271AC	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	3	18	5	Typ 0.007	25	0.64	0.56	TLC271AC	D,JG,P	3-81
LinCMOS, Programmable, High Bias	3	18	5	Typ 0.007	10	2.2	4.6	TLC271AC	D,JG,P	3-79

internally compensated, single

commercial temperature range **(Values specified for T_A = 25°C**

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/μs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
LinCMOS, Programmable, Low Bias	3	18	2	Typ 0.007	50	0.11	0.04	TLC271BC	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	3	18	2	Typ 0.007	25	0.64	0.56	TLC271BC	D,JG,P	3-81
LinCMOS, Programmable, High Bias	3	18	2	Typ 0.007	10	2.2	4.6	TLC271BC	D,JG,P	3-79
LinCMOS, Programmable, Low Bias	3	18	10	Typ 0.007	50	0.11	0.04	TLC271C	D,JG,P	3-80
LinCMOS, Programmable, Medium Bias	3	18	10	Typ 0.007	25	0.64	0.56	TLC271C	D,JG,P	3-81
LinCMOS, Programmable, High Bias	3	18	10	Typ 0.007	10	2.2	4.6	TLC271C	D,JG,P	3-79
LinCMOS, Precision, Low Noise	4.6	16	0.2	Typ 0.001	400	1.9	2.7	TLC2201AC	D,JG,L,P	3-96
LinCMOS, Precision, Low Noise, 100% Noise Tested	4.6	16	0.2	Typ 0.001	400	1.9	2.7	TLC2201BC	D,JG,L,P	3-96
LinCMOS, Precision, Low Noise	4.6	16	0.5	Typ 0.001	400	1.9	2.7	TLC2201C	D,JG,L,P	3-96
LinCMOS, Precision, Chopper Stabilized	3.8	16	0.001	Typ 0.004	5600	1.9	2.8	TLC2652AC	D,J,JG,L,N,P	3-97
LinCMOS, Precision, Chopper Stabilized	3.8	16	0.003	Typ 0.004	1000	1.9	2.8	TLC2652C	D,J,JG,L,N,P	3-97
LinCMOS, Low-Noise, Precision, Chopper Stabilized	4.6	16	0.01	Typ 0.05	5600	1.9	2	TLC2654AC	D,J,JG,L,N,P	3-98
LinCMOS, Low-Noise, Precision, Chopper Stabilized	4.6	16	0.02	Typ 0.05	1000	1.9	2	TLC2654C	D,J,JG,L,N,P	3-98
Excalibur, High-Speed, Precision	4	40	0.5	25	1000	2	0.9	TLE2021C	D,FK,JG,L,P	3-99
General Purpose	±2	±18	6	500	20	1	0.5	uA741C	D,JG,P	3-106

internally compensated, dual

military temperature range **(Values specified for T_A = 25°C)**

DESCRIPTION		SUPPLY VOLTAGE (V) MIN	SUPPLY VOLTAGE (V) MAX	V_{IO} (mV) MAX	I_{IB} (nA) MAX	A_{VD} (V/mV) MIN	B_1 (MHz) TYP	SR (V/μs) TYP	TYPE	PACKAGES	PAGE NO.
High Gain, Low Power, Bipolar	S/S	3	30	5	−150	50	0.6	0.2	LM158	FK,JG,U	3-17
	D/S	±1.5	±15								
General Purpose		±2	±22	5	500	50	1	0.5	MC1558	FK,JG,U	3-26
Precision		±5	±22	0.15	20	1500	0.7	0.4	LT1013AM	JG,L	3-22
Precision		±5	±22	0.3	30	1200	0.7	0.4	LT1013M	JG,L	3-22
High Performance		±4	±22	5	500	50	3.5	1.7	RM4558	JG	3-37
Low Power		±2	±22	5	100	1	0.5	0.5	TL022M	U	3-39
BIFET, Low Power, Precision		±3.5	±18	0.8	0.2	5	1.1	2.9	TL032AM	FK,JG,L	3-41
BIFET, Low Power, Precision		±3.5	±18	1.5	0.2	5	1.1	2.9	TL032M	FK,JG,L	3-41
BIFET, Precision		±3.5	±18	0.8	0.2	50	3	16	TL052AM	FK,JG,L	3-45
BIFET, Precision		±3.5	±18	1.5	0.2	50	3	16	TL052M	FK,JG,L	3-45
BIFET, Low Power		±3.5	±18	6	0.2	4	1	3.5	TL062M	FK,JG,U	3-49
BIFET, Low Noise		±3.5	±18	6	0.2	35	3	13	TL072M	FK,JG	3-54
BIFET, General Purpose		±3.5	±18	16	0.2	25	3	13	TL082M	FK,JG	3-59
BIFET, General Purpose		±3.5	±18	6	0.2	25	3	13	TL083M	FK,J	3-60
BIFET, General Purpose		±3.5	±18	3	0.4	50	3	13	TL287M	JG,U	3-66
BIFET, General Purpose		±3.5	±18	3	0.4	50	3	13	TL288M	JG,U	3-67
LinCMOS, High Bias		4	18	10	Typ 0.005	10	2.2	5.3	TLC272M	FK,JG	3-82
LinCMOS, High Bias		4	18	0.5	Typ 0.005	10	2.2	5.3	TLC277M	FK,JG	3-84
LinCMOS, Low Bias		4	18	10	Typ 0.005	50	0.1	0.05	TLC27L2M	FK,JG	3-86
LinCMOS, Low Bias		4	18	0.5	Typ 0.005	50	0.1	0.05	TLC27L7M	FK,JG	3-88
LinCMOS, Medium Bias		4	18	10	Typ 0.005	25	0.6	0.6	TLC27M2M	FK,JG	3-90
LinCMOS, Medium Bias		4	18	0.5	Typ 0.005	25	0.6	0.6	TLC27M7M	FK,JG	3-92
LinCMOS, Micro Power, Precision		4	18	0.6	Typ 0.007	500	0.11	0.5	TLC1078M	FK,JG	3-94
Excalibur, High Speed, Precision		4	40	0.5	25	1000	2	0.9	TLE2022M	FK,JG,L	3-100

internally compensated, dual

automotive temperature range (Values specified for $T_A = 25°C$)

DESCRIPTION		SUPPLY VOLTAGE (V) MIN	SUPPLY VOLTAGE (V) MAX	V_{IO} (mV) MAX	I_{IB} (nA) MAX	A_{VD} (V/mV) MIN	B_1 (MHz) TYP	SR (V/μs) TYP	TYPE	PACKAGES	PAGE NO.
High Gain, Low Power, Bipolar	S/S	3	30	5	−150	50	0.6	0.2	LM258	D,JG,P,U	3-17
	D/S	±1.5	±1.5								
High Gain, Low Power, Bipolar	S/S	3	30	3	−80	50	0.6	0.2	LM258A	D,JG,P,U	3-17
	D/S	±1.5	±1.5								
High Gain, Low Power, Bipolar	S/S	3	26	7	−250	Typ 100	0.6	0.2	LM2904	D,JG,P,U	3-17
	D/S	±1.5	±13								
High Performance		±4	±18	6	−500	20	3	1.7	RV4558	D,JG,P	3-37
BIFET, Low Power, Precision		±3.5	±18	0.8	0.2	5	1.1	2.9	TL032AI	D,JG,L,P	3-41
BIFET, Low Power, Precision		±3.5	±18	1.5	0.2	5	1.1	2.9	TL032I	D,JG,L,P	3-41
BIFET, Precision		±3.5	±18	0.8	0.2	50	3	16	TL052AI	D,JG,L,P	3-45
BIFET, Precision		±3.5	±18	1.5	0.2	50	3	16	TL052I	D,JG,L,P	3-45
BIFET, Low Power		±3.5	±18	6	0.2	4	1	3.5	TL062I	D,JG,P	3-49
BIFET, Low Noise		±3.5	±18	6	0.2	50	3	13	TL072I	D,JG,P	3-54
BIFET, General Purpose		±3.5	±18	6	0.2	50	3	13	TL082I	D,JG,P	3-59
BIFET, General Purpose		±3.5	±18	6	0.2	50	3	13	TL083I	D,JG,P	3-60
BIFET, General Purpose		±3.5	±18	0.5	0.2	50	3	13	TL287I	D,JG,P	3-66
BIFET, General Purpose		±3.5	±18	1	0.2	50	3	13	TL288I	D,JG,P	3-67
Low Power		±1.5	±18	8	−500	20	1	0.6	TL322I	D,JG,P	3-69
LinCMOS, High Bias		4	18	5	Typ 0.005	10	2.2	5.3	TLC272AI	D,JG,P	3-82
LinCMOS, High Bias		4	18	2	Typ 0.005	10	2.2	5.3	TLC272BI	D,JG,P	3-82
LinCMOS, High Bias		4	18	10	Typ 0.005	10	2.2	5.3	TLC272I	D,JG,P	3-82
LinCMOS, High Bias		4	18	0.5	Typ 0.005	10	2.2	5.3	TLC277I	D,JG,P	3-84
LinCMOS, Low Bias		4	18	5	Typ 0.005	50	0.1	0.05	TLC27L2AI	D,JG,P	3-86
LinCMOS, Low Bias		4	18	2	Typ 0.005	50	0.1	0.05	TLC27L2BI	D,JG,P	3-86
LinCMOS, Low Bias		4	18	10	Typ 0.005	50	0.1	0.05	TLC27L2I	D,JG,P	3-86
LinCMOS, Low Bias		4	18	0.5	Typ 0.005	50	0.1	0.05	TLC27L7I	D,JG,P	3-88
LinCMOS, Medium Bias		4	18	5	Typ 0.005	25	0.6	0.6	TLC27M2AI	D,JG,P	3-90
LinCMOS, Medium Bias		4	18	2	Typ 0.005	25	0.6	0.6	TLC27M2BI	D,JG,P	3-90
LinCMOS, Medium Bias		4	18	10	Typ 0.005	25	0.6	0.6	TLC27M2I	D,JG,P	3-90
LinCMOS, Medium Bias		4	18	0.5	Typ 0.005	25	0.6	0.6	TLC27M7I	D,JG,P	3-92
LinCMOS, Micro Power, Precision		4	18	0.6	Typ 0.007	500	0.11	0.05	TLC1078I	D,JG,P	3-94
Excalibur, High Speed, Precision		4	40	0.5	25	1000	2	0.9	TLE2022I	D,JG,L,P	3-100

internally compensated, dual

industrial temperature range **(Values specified for T_A = 25°C**

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/µs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
BIFET, Low Power, Precision	±3.5	±18	0.8	0.2	5	1.1	2.9	TL032AI	D,JG,L,P	3-41
BIFET, Low Power, Precision	±3.5	±18	1.5	0.2	5	1.1	2.9	TL032I	D,JG,L,P	3-41
BIFET, Precision	±3.5	±18	0.8	0.2	50	3	16	TL052AI	D,JG,L,P	3-45
BIFET, Precision	±3.5	±18	1.5	0.2	50	3	16	TL052I	D,JG,L,P	3-45
BIFET, Low Power	±3.5	±18	6	0.2	4	1	3.5	TL062I	D,JG,P	3-49
BIFET, Low Noise	±3.5	±18	6	0.2	50	3	13	TL072I	D,JG,P	3-54
BIFET, General Purpose	±3.5	±18	6	0.2	50	3	13	TL082I	D,JG,P	3-59
BIFET, General Purpose	±3.5	±18	6	0.2	50	3	13	TL083I	D,JG,P	3-60
BIFET, General Purpose	±3.5	±18	0.5	0.2	50	3	13	TL287I	D,JG,P	3-66
BIFET, General Purpose	±3.5	±18	1	0.2	50	3	13	TL288I	D,JG,P	3-67
Low Power	±1.5	±18	8	-500	20	1	0.6	TL322I	D,JG,P	3-69
LinCMOS, High Bias	4	18	5	Typ 0.005	10	2.2	5.3	TLC272AI	D,JG,P	3-82
LinCMOS, High Bias	4	18	2	Typ 0.005	10	2.2	5.3	TLC272BI	D,JG,P	3-82
LinCMOS, High Bias	4	18	10	Typ 0.005	10	2.2	5.3	TLC272I	D,JG,P	3-82
LinCMOS, High Bias	4	18	0.5	Typ 0.005	10	2.2	5.3	TLC277I	D,JG,P	3-84
LinCMOS, Low Bias	4	18	5	Typ 0.005	50	0.1	0.05	TLC27L2AI	D,JG,P	3-86
LinCMOS, Low Bias	4	18	2	Typ 0.005	50	0.1	0.05	TLC27L2BI	D,JG,P	3-86
LinCMOS, Low Bias	4	18	10	Typ 0.005	50	0.1	0.05	TLC27L2I	D,JG,P	3-86
LinCMOS, Low Bias	4	18	0.5	Typ 0.005	50	0.1	0.05	TLC27L7I	D,JG,P	3-87
LinCMOS, Medium Bias	4	18	5	Typ 0.005	25	0.6	0.6	TLC27M2AI	D,JG,P	3-90
LinCMOS, Medium Bias	4	18	2	Typ 0.005	25	0.6	0.6	TLC27M2BI	D,JG,P	3-90
LinCMOS, Medium Bias	4	18	10	Typ 0.005	25	0.6	0.6	TLC27M2I	D,JG,P	3-90
LinCMOS, Medium Bias	4	18	0.5	Typ 0.005	25	0.6	0.6	TLC27M7I	D,JG,P	3-92
LinCMOS, Micro Power, Precision	4	18	0.6	Typ 0.007	500	0.11	0.05	TLC1078I	D,JG.P	3-94
Excalibur, High Speed, Precision	4	40	0.5	25	1000	2	0.9	TLE2022I	D,JG,L,P	3-100

internally compensated, dual

commercial temperature range **(Values specified for T_A = 25°C)**

DESCRIPTION		SUPPLY VOLTAGE (V) MIN	SUPPLY VOLTAGE (V) MAX	V_{IO} (mV) MAX	I_{IB} (nA) MAX	A_{VD} (V/mV) MIN	B_1 (MHz) TYP	SR (V/μs) TYP	TYPE	PACKAGES	PAGE NO.
BIFET, General Purpose		±3.5	±18	10	0.2	25	3	13	LF353	D,JG,P	3-6
BIFET, Low Offset		±3.5	±18	3	0.2	25	3	13	LF412C	D,JG,P	3-8
High Gain, Low Power, Bipolar	S/S	3	30	7	−250	25	0.6	0.2	LM358	D,JG,P,U	3-17
	D/S	±1.5	±15								
High Gain, Low Power, Bipolar	S/S	3	30	3	−100	25	0.6	0.2	LM358A	D,JG,P,U	3-17
	D/S	±1.5	±15								
Precision		±5	±22	0.15	20	1500	0.7	0.4	LT1013AC	JG,L,P	3-22
Precision		±5	±22	0.3	30	1200	0.7	0.4	LT1013C	JG,L,P	3-22
Precision		±5	±22	0.8	30	1200	0.7	0.4	LT1013D	D,JG,L,P	3-22
General Purpose		±1.5	±18	6	500	20	1	0.5	MC1458	D,JG,P,U	3-26
Low Noise		±3	±20	4	800	25	10	9	NE5532	JG,P	3-28
Low Noise		±3	±20	4	800	25	10	9	NE5532A	JG,P	3-28
High Performance		±4	±18	6	500	20	3	1.7	RC4558	D,JG,P	3-37
High Performance		±4	±18	6	250	20	4	2	RC4559	D,P	3-38
Low Power		±2	±18	5	250	1	0.5	0.5	TL022C	D,JG,P	3-39
BIFET, Low Power, Precision		±3.5	±18	0.8	0.2	5	1.1	2.9	TL032AC	D,JG,L,P	3-41
BIFET, Low Power, Precision		±3.5	±18	1.5	0.2	5	1.1	2.9	TL032C	D,JG,L,P	3-41
BIFET, Precision		±3.5	±18	1.5	0.2	50	3	16	TL052AC	D,JG,L,P	3-45
BIFET, Precision		±3.5	±18	4	0.2	50	3	16	TL052C	D,JG,L,P	3-45
BIFET, Low Power		±3.5	±18	6	0.2	4	1	3.5	TL062AC	D,JG,P	3-49
BIFET, Low Power		±3.5	±18	3	0.2	4	1	3.5	TL062BC	D,JG,P	3-49
BIFET, Low Power		±3.5	±18	15	0.4	3	1	3.5	TL062C	D,JG,P	3-49
BIFET, Low Noise		±3.5	±18	6	0.2	50	3	13	TL072AC	D,JG,P	3-54
BIFET, Low Noise		±3.5	±18	3	0.2	50	3	13	TL072BC	D,JG,P	3-54
BIFET, Low Noise		±3.5	±18	10	0.2	25	3	13	TL072C	D,JG,P	3-54
BIFET, General Purpose		±3.5	±18	6	0.2	50	3	13	TL082AC	D,JG,P	3-59
BIFET, General Purpose		±3.5	±18	3	0.2	50	3	13	TL082BC	D,JG,P	3-59
BIFET, General Purpose		±3.5	±18	15	0.4	25	3	13	TL082C	D,JG,P	3-59
BIFET, General Purpose		±3.5	±18	6	0.2	50	3	13	TL083AC	D,JG,N	3-60

internally compensated, dual

commercial temperature range (Values specified for T_A = 25°C)

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/μs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
BIFET, General Purpose	±3.5	±18	15	0.4	25	3	13	TL083C	D,JG,N	3-60
BIFET, General Purpose	±3.5	±18	0.5	0.2	50	3	13	TL287C	D,JG,P	3-66
BIFET, General Purpose	±3.5	±18	1	0.2	50	3	13	TL288C	D,JG,P	3-67
Low Power	±1.5	±18	10	-500	20	1	0.6	TL322C	D,JG,P	3-69
LinCMOS, High Bias	1.4	18	5	Typ 0.005	10	2.2	5.3	TLC252AC	D,JG,P	3-73
LinCMOS, High Bias	1.4	18	2	Typ 0.005	10	2.2	5.3	TLC252BC	D,JG,P	3-73
LinCMOS, High Bias	1.4	18	10	Typ 0.005	10	2.2	5.3	TLC252C	D,JG,P	3-73
LinCMOS, Low Bias	1.4	18	5	Typ 0.005	30	0.1	0.05	TLC25L2AC	D,JG,P	3-75
LinCMOS, Low Bias	1.4	18	2	Typ 0.005	30	0.1	0.05	TLC25L2BC	D,JG,P	3-75
LinCMOS, Low Bias	1.4	18	10	Typ 0.005	30	0.1	0.05	TLC25L2C	D,JG,P	3-75
LinCMOS, Medium Bias	1.4	18	5	Typ 0.005	20	0.6	0.6	TLC25M2AC	D,JG,P	3-77
LinCMOS, Medium Bias	1.4	18	2	Typ 0.005	20	0.6	0.6	TLC25M2BC	D,JG,P	3-77
LinCMOS, Medium Bias	1.4	18	10	Typ 0.005	20	0.6	0.6	TLC25M2C	D,JG,P	3-77
LinCMOS, High Bias	3	18	5	Typ 0.005	10	2.2	5.3	TLC272AC	D,JG,P	3-82
LinCMOS, High Bias	3	18	2	Typ 0.005	10	2.2	5.3	TLC272BC	D,JG,P	3-82
LinCMOS, High Bias	3	18	10	Typ 0.005	10	2.2	5.3	TLC272C	D,JG,P	3-82
LinCMOS, High Bias	3	18	0.5	Typ 0.005	10	2.2	5.3	TLC277C	D,JG,P	3-84
LinCMOS, Low Bias	3	18	5	Typ 0.005	50	0.1	0.05	TLC27L2AC	D,JG,P	3-86
LinCMOS, Low Bias	3	18	2	Typ 0.005	50	0.1	0.05	TLC27L2BC	D,JG,P	3-86
LinCMOS, Low Bias	3	18	10	Typ 0.005	50	0.1	0.05	TLC27L2C	D,JG,P	3-86
LinCMOS, Low Bias	3	18	0.5	Typ 0.005	50	0.1	0.05	TLC27L7C	D,JG,P	3-88
LinCMOS, Medium Bias	3	18	5	Typ 0.005	25	0.6	0.6	TLC27M2AC	D,JG,P	3-90
LinCMOS, Medium Bias	3	18	2	Typ 0.005	25	0.6	0.6	TLC27M2BC	D,JG,P	3-90
LinCMOS, Medium Bias	3	18	10	Typ 0.005	25	0.6	0.6	TLC27M2C	D,JG,P	3-90
LinCMOS, Medium Bias	3	18	0.5	Typ 0.005	25	0.6	0.6	TLC27M7C	D,JG,P	3-92
LinCMOS, Micro Power, Precision	1.4	18	0.6	Typ 0.007	500	0.11	0.05	TLC1078C	D,JG,P	3-94
Excalibur, High Speed, Precision	4	40	0.5	25	1000	2	0.9	TLE2022C	D,JG,L,P	3-100
General Purpose	±5	±22	6	500	25	1	0.5	uA747C	D,J,N	3-107

internally compensated, quad

military temperature range (Values specified for $T_A = 25°C$)

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/μs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
General Purpose	3	30	5	−150	50	0.6	0.13	LM124	FK,J,W	3-15
General Purpose	±4	±22	5	100	50	1	0.5	LM148	FK,J	3-16
QUAD uA741, High Performance	±4	±22	4	400	50	3.5	1.7	RM4136	FK,J,W	3-36
BIFET, Low Power, Precision	±3.5	±18	1.5	0.2	5	1.1	2.9	TL034AM	FK,J	3-42
BIFET, Low Power, Precision	±3.5	±18	4	0.2	5	1.1	2.9	TL034M	FK,J	3-42
Low Power	±2	±22	5	100	72	0.5	0.5	TL044M	FK,J,W	3-43
BIFET, Precision	±3.5	±18	1.5	0.2	50	2.7	16	TL054AM	FK,J	3-46
BIFET, Precision	±3.5	±18	4	0.2	50	2.7	16	TL054M	FK,J	3-46
BIFET, Low Power	±3.5	±18	9	0.2	4	1	3.5	TL064M	FK,J,W	3-50
BIFET, Low Noise	±3.5	±18	9	0.2	35	3	13	TL074M	FK,J,W	3-55
BIFET, General Purpose	±3.5	±18	9	0.2	25	3	13	TL084M	FK,J,W	3-61
LinCMOS, High Bias	4	18	10	Typ 0.005	10	2.2	5.3	TLC274M	FK,J	3-83
LinCMOS, High Bias	4	18	1.2	Typ 0.005	10	2.2	5.3	TLC279M	FK,J	3-85
LinCMOS, Low Bias	4	18	10	Typ 0.005	50	0.1	0.05	TLC27L4M	FK,J	3-87
LinCMOS, Low Bias	4	18	0.9	Typ 0.005	50	0.1	0.05	TLC27L9M	FK,J	3-89
LinCMOS, Medium Bias	4	18	10	Typ 0.005	20	0.6	0.6	TLC27M4M	FK,J	3-91
LinCMOS, Medium Bias	4	18	0.9	Typ 0.005	20	0.6	0.6	TLC27M9M	FK,J	3-93
LinCMOS, Micro Power, Precision	4	18	1.15	Typ 0.007	500	0.11	0.05	TLC1079M	D,JG,P	3-95
Excalibur, High Speed, Precision	4	40	0.5	25	1000	2	0.9	TLE2024M	FK,J	3-101

internally compensated, quad

automotive temperature range **(Values specified for T_A = 25°C)**

DESCRIPTION		SUPPLY VOLTAGE (V) MIN	SUPPLY VOLTAGE (V) MAX	V_{IO} (mV) MAX	I_{IB} (nA) MAX	A_{VD} (V/mV) MIN	B_1 (MHz) TYP	SR (V/μs) TYP	TYPE	PACKAGES	PAGE NO.
Norton Amplifier, Bipolar	S/S	4.5	32	–	200	1.2	2.5	0.5	LM2900	J,N	–
	D/S	±2.2	±16								
Extended Temperature Range LM324		3	26	7	−250	Typ 100	0.6	0.3	LM2902	D,J,N,W	3-15
Low Power, Bipolar	S/S	3	36	8	−500	20	1	0.6	MC3303	D,J,N	3-27
	D/S	±1.5	±18								
Quad uA741		±4.5	±18	6	500	20	3	1.7	RV4136	D,J,N,W	3-36
BIFET, Low Power, Precision		±3.5	±18	1.5	0.2	5	1.1	2.9	TL034AI	D,J,N	3-42
BIFET, Low Power, Precision		±3.5	±18	4	0.2	5	1.1	2.9	TL034I	D,J,N	3-42
BIFET, Precision		±3.5	±18	1.5	0.2	50	2.7	16	TL054AI	D,J,N	3-46
BIFET, Precision		±3.5	±18	4	0.2	50	2.7	16	TL054I	D,J,N	3-46
BIFET, Low Power, Precision		±3.5	±18	6	0.2	4	1	3.5	TL064I	D,J,N	3-50
BIFET, Low Noise, Precision		±3.5	±18	6	0.2	50	3	13	TL074I	D,J,N	3-55
BIFET, General Purpose		±3.5	±18	6	0.2	50	3	13	TL084I	D,J,N	3-61
LinCMOS, High Bias		4	18	5	Typ 0.001	10	2.2	5.3	TLC274AI	D,J,N	3-83
LinCMOS, High Bias		4	18	2	Typ 0.001	10	2.2	5.3	TLC274BI	D,J,N	3-83
LinCMOS, High Bias		4	18	10	Typ 0.001	10	2.2	5.3	TLC274I	D,J,N	3-83
LinCMOS, High Bias		4	18	1.2	Typ 0.005	10	2.2	5.3	TLC279I	D,J,N	3-85
LinCMOS, Low Bias		4	18	5	Typ 0.005	50	0.1	0.05	TLC27L4AI	D,J,N	3-87
LinCMOS, Low Bias		4	18	2	Typ 0.005	50	0.1	0.05	TLC27L4BI	D,J,N	3-87
LinCMOS, Low Bias		4	18	10	Typ 0.005	50	0.1	0.05	TLC27L4I	D,J,N	3-87
LinCMOS, Low Bias		4	18	0.9	Typ 0.005	50	0.1	0.05	TLC27L9I	D,J,N	3-89
LinCMOS, Medium Bias		4	18	5	Typ 0.005	25	0.6	0.6	TLC27M4AI	D,J,N	3-91
LinCMOS, Medium Bias		4	18	2	Typ 0.005	25	0.6	0.6	TLC27M4BI	D,J,N	3-91
LinCMOS, Medium Bias		4	18	10	Typ 0.005	25	0.6	0.6	TLC27M4I	D,J,N	3-91
LinCMOS, Medium Bias		4	18	0.9	Typ 0.005	25	0.6	0.6	TLC27M9I	D,J,N	3-93
LinCMOS, Micro Power, Precision		4	18	1.15	Typ 0.007	500	0.11	0.05	TLC1079I	D,JG,P	3-95
Excalibur, High Speed, Precision		4	40	0.5	25	1000	2	0.9	TLE2024I	DW,FK,J,N	3-101

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

internally compensated, quad

industrial temperature range (Values specified for $T_A = 25°C$)

DESCRIPTION		SUPPLY VOLTAGE (V) MIN	SUPPLY VOLTAGE (V) MAX	V_{IO} (mV) MAX	I_{IB} (nA) MAX	A_{VD} (V/mV) MIN	B_1 (MHz) TYP	SR (V/μs) TYP	TYPE	PACKAGES	PAGE NO.
General Purpose, Bipolar		3	30	5	−150	50	0.6	0.3	LM224	D,J,N,W	3-15
General Purpose, Bipolar		3	30	3	−80	50	0.6	0.3	LM224A	D,J,N,W	3-15
General Purpose, Bipolar		±4	±18	6	200	25	1	0.5	LM248	D,J,N	3-16
High Gain, Low Power, Bipolar	S/S	3	32	5	−150	50	0.6	0.2	LM258	D,J,N	3-17
	D/S	±1.5	±22								
High Gain, Low Power, Bipolar	S/S	3	32	3	−80	50	0.6	0.2	LM258A	D,J,N	3-17
	D/S	±1.5	±22								
Single Supply, Norton Amplifier, Bipolar	S/S	4	32	—	200	1.2	2.5	0.5	LM2900	D,J,N	—
	D/S	±2	±16								
BIFET, Low Power		±3.5	±18	1.5	0.2	5	1.1	2.9	TL034AI	D,J,N	3-42
BIFET, Low Power		±3.5	±18	4	0.2	5	1.1	2.9	TL034I	D,J,N	3-42
BIFET, Precision		±3.5	±18	1.5	0.2	50	2.7	16	TL054AI	D,J,N	3-46
BIFET, Precision		±3.5	±18	4	0.2	50	2.7	16	TL054I	D,J,N	3-46
BIFET, Low Power, Precision		±3.5	±18	6	0.2	4	1	3.5	TL064I	D,J,N	3-50
BIFET, Low Noise, Precision		±3.5	±18	6	0.2	50	3	13	TL074I	D,J,N	3-55
BIFET, General Purpose		±3.5	±18	6	0.2	50	3	13	TL084I	D,J,N	3-61
LinCMOS, High Bias		4	18	5	Typ 0.001	10	2.2	5.3	TLC274AI	D,J,N	3-83
LinCMOS, High Bias		4	18	2	Typ 0.001	10	2.2	5.3	TLC274BI	D,J,N	3-83
LinCMOS, High Bias		4	18	10	Typ 0.001	10	2.2	5.3	TLC274I	D,J,N	3-83
LinCMOS, High Bias		4	18	0.9	Typ 0.005	10	2.2	5.3	TLC279I	D,J,N	3-85
LinCMOS, Low Bias		4	18	5	Typ 0.005	50	0.1	0.05	TLC27L4AI	D,J,N	3-87
LinCMOS, Low Bias		4	18	2	Typ 0.005	50	0.1	0.05	TLC27L4BI	D,J,N	3-87
LinCMOS, Low Bias		4	18	10	Typ 0.005	50	0.1	0.05	TLC27L4I	D,J,N	3-87
LinCMOS, Low Bias		4	18	0.9	Typ 0.005	50	0.1	0.05	TLC27L9I	D,J,N	3-89
LinCMOS, Medium Bias		4	18	5	Typ 0.005	25	0.6	0.6	TLC27M4AI	D,J,N	3-91
LinCMOS, Medium Bias		4	18	2	Typ 0.005	25	0.6	0.6	TLC27M4BI	D,J,N	3-91
LinCMOS, Medium Bias		4	18	10	Typ 0.005	25	0.6	0.6	TLC27M4I	D,J,N	3-91
LinCMOS, Medium Bias		4	18	0.9	Typ 0.005	25	0.6	0.6	TLC27M9I	D,J,N	3-93
LinCMOS, Micro Power, Precision		4	18	1.15	Typ 0.007	500	0.11	0.05	TLC1079I	D,JG,P	3-95
Excalibur, High Speed, Precision		4	40	0.5	25	1000	2	0.9	TLE2024I	DW,FK,J,N	3-101

internally compensated, quad

commercial temperature range **(Values specified for $T_A = 25\,°C$)**

DESCRIPTION		SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/μs)	TYPE	PACKAGES	PAGE NO.
		MIN	MAX	MAX	MAX	MIN	TYP	TYP			
BIFET, General Purpose		±3.5	±18	10	0.2	25	3	13	LF347	D,J,N	3-4
General Purpose		3	30	7	−250	25	0.6	0.3	LM324	D,J,N,W	3-15
General Purpose		3	30	3	−100	25	0.6	0.3	LM324A	D,J,N,W	3-15
General Purpose		±4	±18	6	200	25	1	0.5	LM348	D,J,N	3-16
Single Supply, Norton Amplifier, Bipolar	S/S	4	32	—	200	1.2	2.5	0.5	LM3900	D,J,N	—
	D/S	±2	±16								
Low Power, Bipolar	S/S	3	36	10	−500	20	1	0.6	MC3403	D,J,N	3-27
	D/S	±1.5	±18								
Quad uA741, High Performance		±4	±18	6	500	20	3	1.7	RC4136	D,J,N,W	3-36
BIFET, Low Power, Precision		±3.5	±18	1.5	0.2	5	1.1	2.9	TL034AC	D,J,N	3-42
BIFET, Low Power, Precision		±3.5	±18	4	0.2	5	1.1	2.9	TL034C	D,J,N	3-42
General Purpose		±2	±18	5	250	60	0.5	0.5	TL044C	J,N,W	3-43
BIFET, Precision		±3.5	±18	1.5	0.2	50	2.7	16	TL054AC	D,J,N	3-46
BIFET, Precision		±3.5	±18	4	0.2	50	2.7	16	TL054C	D,J,N	3-46
BIFET, Low Power		±3.5	±18	6	0.2	4	1	3.5	TL064AC	D,J,N	3-50
BIFET, Low Power		±3.5	±18	3	0.2	4	1	3.5	TL064BC	D,J,N	3-50
BIFET, Low Power		±3.5	±18	15	0.4	3	1	3.5	TL064C	D,J,N	3-50
BIFET, Low Noise		±3.5	±18	6	0.2	50	3	13	TL074AC	D,J,N	3-55
BIFET, Low Noise		±3.5	±18	3	0.2	50	3	13	TL074BC	D,J,N	3-55
BIFET, Low Noise		±3.5	±18	10	0.2	50	3	13	TL074C	D,J,N	3-55
BIFET, Low Noise		±3.5	±18	10	0.2	25	3	13	TL075C	J,N	3-56
BIFET, General Purpose		±3.5	±18	6	0.2	50	3	13	TL084AC	D,J,N	3-61
BIFET, General Purpose		±3.5	±18	3	0.2	50	3	13	TL084BC	D,J,N	3-61
BIFET, General Purpose		±3.5	±18	15	0.4	25	3	13	TL084C	D,J,N	3-61
BIFET, General Purpose		±3.5	±18	15	0.4	25	3	13	TL085C	J,N	3-62
High Performance, Bipolar		±4	±18	6	500	20	3	2	TL136C	N	3-65
LinCMOS, High Bias		1.4	18	5	Typ 0.005	10	2.2	5.3	TLC254AC	D,J,N	3-74
LinCMOS, High Bias		1.4	18	2	Typ 0.005	10	2.2	5.3	TLC254BC	D,J,N	3-74
LinCMOS, High Bias		1.4	18	10	Typ 0.005	10	2.2	5.3	TLC254C	D,J,N	3-74
LinCMOS, Low Bias		1.4	18	5	Typ 0.005	30	0.1	0.05	TLC25L4AC	D,J,N	3-76
LinCMOS, Low Bias		1.4	18	2	Typ 0.005	30	0.1	0.05	TLC25L4BC	D,J,N	3-76
LinCMOS, Low Bias		1.4	18	10	Typ 0.005	30	0.1	0.05	TLC25L4C	D,J,N	3-76
LinCMOS, Medium Bias		1.4	18	5	Typ 0.005	20	0.6	0.6	TLC25M4AC	D,J,N	3-78
LinCMOS, Medium Bias		1.4	18	2	Typ 0.005	20	0.6	0.6	TLC25M4BC	D,J,N	3-78
LinCMOS, Medium Bias		1.4	18	10	Typ 0.005	20	0.6	0.6	TLC25M4C	D,J,N	3-78

internally compensated, quad

commercial temperature range **(Values specified for T_A = 25°C)**

DESCRIPTION	SUPPLY VOLTAGE (V)		V_{IO} (mV)	I_{IB} (nA)	A_{VD} (V/mV)	B_1 (MHz)	SR (V/μs)	TYPE	PACKAGES	PAGE NO.
	MIN	MAX	MAX	MAX	MIN	TYP	TYP			
LinCMOS, High Bias	3	18	5	Typ 0.005	10	2.2	5.3	TLC274AC	D,J,N	3-83
LinCMOS, High Bias	3	18	2	Typ 0.005	10	2.2	5.3	TLC274BC	D,J,N	3-83
LinCMOS, High Bias	3	18	10	Typ 0.005	10	2.2	5.3	TLC274C	D,J,N	3-83
LinCMOS, High Bias	3	18	0.9	Typ 0.005	10	2.2	5.3	TLC279C	D,J,N	3-85
LinCMOS, Low Bias	3	18	5	Typ 0.005	50	0.1	0.05	TLC27L4AC	D,J,N	3-87
LinCMOS, Low Bias	3	18	2	Typ 0.005	50	0.1	0.05	TLC27L4BC	D,J,N	3-87
LinCMOS, Low Bias	3	18	10	Typ 0.005	50	0.1	0.05	TLC27L4C	D,J,N	3-87
LinCMOS, Low Bias	3	18	0.9	Typ 0.005	50	0.1	0.05	TLC27L9C	D,J,N	3-89
LinCMOS, Medium Bias	3	18	5	Typ 0.005	25	0.6	0.6	TLC27M4AC	D,J,N	3-91
LinCMOS, Medium Bias	3	18	2	Typ 0.005	25	0.6	0.6	TLC27M4BC	D,J,N	3-91
LinCMOS, Medium Bias	3	18	10	Typ 0.005	25	0.6	0.6	TLC27M4C	D,J,N	3-91
LinCMOS, Medium Bias	3	18	0.9	Typ 0.005	25	0.7	0.6	TLC27M9C	D,J,N	3-93
LinCMOS, Micro Power, Precision	1.4	18	1.15	Typ 0.007	500	0.11	0.05	TLC1079C	D,J,N	3-95
Excalibur, High Speed, Precision	4	40	0.5	25	1000	2	0.9	TLE2024C	DW,FK,J,N	3-101

Replacements are 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.

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Manufacturers are arranged in alphabetical order.

ADVANCED LINEAR DEVICES	SUGGESTED TI REPLACEMENT	PAGE NO.
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ANALOG DEVICES	SUGGESTED TI REPLACEMENT	PAGE NO.
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uA741	uA741		3-106
uA747	uA747		3-107
uA748	uA748		3-108
uA771		TLO71	3-53
uA771A		TLO71B or TLO81B	3-53 or 3-58
uA771B		TLO71A or TLO81A	3-53 or 3-58
uA771L		TLO81	3-58
uA772		TLO72	3-54
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GENERAL ELECTRIC	SUGGESTED TI REPLACEMENT	PAGE NO.
ICL7611, or ICL7612, or ICL7613	TLC271	3-79,3-80,3-81
ICL7621	TLC272	3-82
ICL7641	TLC274 or TLC27L9	3-83 or 3-89
ICL7642	TLC27M9	3-93

HARRIS	SUGGESTED TI REPLACEMENT	PAGE NO.
HA2515	LM318	3-14
HA5130-5	OP-07E	3-31
HA5135-5	OP-07C	3-29

INTERSIL	SUGGESTED TI REPLACEMENT	PAGE NO.
ICL7611, or ICL7612, or ICL7613	TLC271	3-79,3-80,3-81
ICL7621	TLC272	3-82
ICL7641	TLC274 or TLC27L9	3-83 or 3-89
ICL7642	TLC27M9	3-93

LINEAR TECHNOLOGY	DIRECT TI REPLACEMENT	SUGGESTED TI REPLACEMENT	PAGE NO.
LT1001	LT1001	OP-07C, OP-07D, or OP-07E	3-18,3-29,3-30, or 3-31
LT1007	LT1007		3-19
LT1007A	LT1007A		3-19
LT1037	LT1037		3-24
LT1037A	LT1037A		3-24

MAXIM	SUGGESTED TI REPLACEMENT	PAGE NO.
ICL7611, or ICL7612, or ICL7613	TLC271	3-79,3-80,3-81
ICL7621	TLC272	3-82
ICL7641	TLC274 or TLC27L9	3-83 or 3-89
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MOTOROLA	DIRECT TI REPLACEMENT	SUGGESTED TI REPLACEMENT	PAGE NO.
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MC1458	MC1458		3-26
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MC1741	uA741		3-106
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MC4558	RC4558		3-37
MC4741	LM348		3-16
MC34001		TL071 or LF351	3-53 or 3-5
MC34002		TL072 or LF353	3-54 or 3-6
MC34004		TL074 or LF347	3-55 or 3-4
MC34004B		TL074A or LF347B	3-55 or 3-4

NATIONAL	DIRECT TI REPLACEMENT	SUGGESTED TI REPLACEMENT	PAGE NO.
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LF347B	LF347B	TL074A, TL074B, or TL084A	3-4,3-55,3-55 or 3-61
LF351	LF351	TL071 or TL081A	3-5,3-53 or 3-58
LF353	LF353	TL072, TL072A, or TL082A	3-6,3-54,3-54, or 3-59
LF411	LF411	TL081A	3-7,3-58
LF411A		TL071A, TL071B, TL081A, or TL081B	3-53,3-53, 3-58, or 3-58
LF412	LF412	TL072A, TL082A, or TL082B	3-8,3-54,3-59, or 3-59
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NATIONAL	DIRECT TI REPLACEMENT	SUGGESTED TI REPLACEMENT	PAGE NO.
LM301A	LM301A		3-11
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LM318	LM318		3-14
LM324	LM324		3-15
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LM709	uA709		—
LM741	uA741		3-106
LM883		RC4558	3-37
LM1458	MC1458		3-26
LM2900	LM2900		—
LM2902	LM2902		3-15
LM2904	LM2904		3-17
LM3900	LM3900		—
LMC660		TLC274	3-83

NEC	SUGGESTED TI REPLACEMENT	PAGE NO.
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uPC251	MC1458	3-26
uPC354	OP-07	3-29,3-30,3-31
uPC801	TL071, TL081A, or LF351	3-53,3-58, or 3-5

PMI	DIRECT TI REPLACEMENT	SUGGESTED TI REPLACEMENT	PAGE NO.
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OP-07D	OP-07D		3-30
OP-07E	OP-07E		3-31
OP-07F		RC4136	3-36
OP-14C or OP-14E		MC1458	3-26
OP-14J		MC1558	3-26
OP-15F		TL071, TL081A, or LF351	3-53,3-58, or 3-5
OP-27E	OP-27E		3-33
OP-27G	OP-27G		3-34
OP-37E	OP-37E		3-35
OP-37G	OP-37G		3-35
OP-215F		TL072, TL082A, or LF353	3-54,3-58, or 3-6

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RAYTHEON	DIRECT TI REPLACEMENT	SUGGESTED TI REPLACEMENT	PAGE NO.
RC4136	RC4136		3-36
RC4156		LM348	3-16
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RC4558	RC4558		3-37
RC4559	RC4559		3-38

RCA	SUGGESTED TI REPLACEMENT	PAGE NO.
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CA081A	TL081A	3-58
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CA084	TL084	3-61

SIGNETICS	DIRECT TI REPLACEMENT	SUGGESTED TI REPLACEMENT	PAGE NO.
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TS27L4A	TLC27L4A	3-87
TS27L4B	TLC27L4B	3-87
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TS27M2A	TLC27M2A	3-90
TS27M2B	TLC27M2B	3-90
TS27M4	TLC27M4	3-91
TS27M4A	TLC27M4A	3-91
TS27M4B	TLC27M4B	3-91

Input Offset Voltage (V_{IO})

The d-c voltage that must be applied between the input terminals to force the quiescent d-c output voltage to zero or other level, if specified.

Average Temperature Coefficient of Input Offset Voltage (αV_{IO})

The ratio of the change in input offset voltage to the change in free-air temperature. This is an average value for the specified temperature range.

$$\alpha V_{IO} = \left[\frac{(V_{IO} \text{ @ } T_{A(1)}) - (V_{IO} \text{ @ } T_{A(2)})}{T_{A(1)} - T_{A(2)}} \right]$$ where $T_{A(1)}$ and $T_{A(2)}$ are the specified temperature extremes.

Input Offset Current (I_{IO})

The difference between the currents into the two input terminals with the output at zero volts.

Average Temperature Coefficient of Input Offset Current (αI_{IO})

The ratio of the change in input offset current to the change in free-air temperature. This is an average value for the specified temperature range.

$$\alpha I_{IO} = \left[\frac{(I_{IO} \text{ @ } T_{A(1)}) - (I_{IO} \text{ @ } T_{A(2)})}{T_{A(1)} - T_{A(2)}} \right]$$ where $T_{A(1)}$ and $T_{A(2)}$ are the specified temperature extremes.

Input Bias Current (I_{IB})

The average of the currents into the two input terminals with the output at zero volts.

Common-Mode Input Voltage (V_{IC})

The average of the two input voltages.

Common-Mode Input Voltage Range (V_{ICR})

The range of common-mode input voltage that if exceeded will cause the amplifier to cease functioning properly.

Differential Input Voltage (V_{ID})

The voltage at the noninverting input with respect to the inverting input.

Maximum Peak Output Voltage Swing (V_{OM})

The maximum positive or negative peak output voltage that can be obtained without waveform clipping when the quiescent d-c output voltage is zero.

Maximum Peak-to-Peak Output Voltage Swing (V_{OPP})

The maximum peak-to-peak output voltage that can be obtained without waveform clipping when the quiescent d-c output voltage is zero.

Large-Signal Voltage Amplification (A_V)

The ratio of the peak-to-peak output voltage swing to the change in input voltage required to drive the output.

Differential Voltage Amplification (A_{VD})

The ratio of the change in output voltage to the change in differential input voltage producing it.

Maximum-Output-Swing Bandwidth (B_{OM})

The range of frequencies within which the maximum output voltage swing is above a specified value.

Unity-Gain Bandwidth (B_1)

The range of frequencies within which the open-loop voltage amplification is greater than unity.

Phase Margin (ϕ_m)

The absolute value of the open-loop phase shift between the output and the inverting input at the frequency at which the modulus of the open-loop amplification is unity.

Gain Margin (A_m)

The reciprocal of the open-loop voltage amplification at the lowest frequency at which the open-loop phase shift is such that the output is in phase with the inverting input.

Input Resistance (r_i)

The resistance between the input terminals with either input grounded.

Differential Input Resistance (r_{id})

The small-signal resistance between the two ungrounded input terminals.

Output Resistance (r_o)

The resistance between the output terminal and ground.

Input Capacitance (C_i)

The capacitance between the input terminals with either input grounded.

Common-Mode Input Impedance (z_{ic})

The parallel sum of the small-signal impedance between each input terminal and ground.

Output Impedance (z_o)

The small-signal impedance between the output terminal and ground.

Common-Mode Rejection Ratio (k_{CMR}, CMRR)

The ratio of differential voltage amplification to common-mode voltage amplification.
NOTE: This is measured by determining the ratio of a change in input common-mode voltage to the resulting change in input offset voltage.

Supply Voltage Sensitivity (k_{SVS}, $\Delta V_{IO}/\Delta V_{CC}$)

The absolute value of the ratio of the change in input offset voltage to the change in supply voltages producing it.
NOTES: 1. Unless otherwise noted, both supply voltages are varied symmetrically.
2. This is the reciprocal of supply voltage rejection ratio.

Supply Voltage Rejection Ratio (k_{SVR}, $\Delta V_{CC}/\Delta V_{IO}$)

The absolute value of the ratio of the change in supply voltages to the change in input offset voltage.
NOTES: 1. Unless otherwise noted, both supply voltages are varied symmetrically.
2. This is the reciprocal of supply voltage sensitivity.

Equivalent Input Noise Voltage (V_n)

The voltage of an ideal voltage source (having an internal impedance equal to zero) in series with the input terminals of the device that represents the part of the internally generated noise that can properly be represented by a voltage source.

Equivalent Input Noise Current (I_n)

The current of an ideal current source (having an internal impedance equal to infinity) in parallel with the input terminals of the device that represents the part of the internally generated noise that can properly be represented by a current source.

Average Noise Figure (F)

The ratio of (1) the total output noise power within a designated output frequency band when the noise temperature of the input termination(s) is at the reference noise temperature, T_O, at all frequencies to (2) that part of (1) caused by the noise temperature of the designated signal-input termination within a designated signal-input frequency band.

Short-Circuit Output Current (I_{OS})

The maximum output current available from the amplifier with the output shorted to ground, to either supply, or to a specified point.

Supply Current (I_{CC})

The current into the V_{CC} or V_{CC+} terminal of an integrated circuit.

Total Power Dissipation (P_D)

The total d-c power supplied to the device less any power delivered from the device to a load.
NOTE: At no load: $P_D = V_{CC+} \cdot I_{CC+} + V_{CC-} \cdot I_{CC-}$.

Crosstalk Attenuation (V_{o1}/V_{o2})

The ratio of the change in output voltage of a driven channel to the resulting change in output voltage of another channel.

Rise Time (t_r)

The time required for an output voltage step to change from 10% to 90% of its final value.

Total Response Time (Settling Time) (t_{tot})

The time between a step-function change of the input signal level and the instant at which the magnitude of the output signal reaches for the last time a specified level range ($\pm\epsilon$) containing the final output signal level.

Overshoot Factor

The ratio of (1) the largest deviation of the output signal value from its final steady-state value after a step-function change of the input signal, to (2) the absolute value of the difference between the steady-state output signal values before and after the step-function change of the input signal.

Slew Rate (SR)

The average time rate of change of the closed-loop amplifier output voltage for a step-signal input.

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Macromodel Data Floppy Disk 4

getting started

If you are familiar with *PSpice*® and would like to use some of the models on the accompanying macromodel data floppy disk, you need to know the following:

- The macromodels use the nodal assignments shown in Figure 2-4. Only models for devices with external compensation use nodes 6 and 7.
- All devices are modeled as one op amp. To model a dual op amp (such as the TLE2062), use two macromodels in your simulation. To model a quad op amp (such as the TLE2064), use four macromodels.

introduction

While simulation of analog and mixed-mode systems is becoming more common, one major impediment to widespread analog simulation has been the significant amount of computing time necessary for transistor-level simulations of the analog components. Although the computing power available at engineers' workstations has increased, this advance has been overshadowed by the need to simulate more complex systems.

In response to the need for reduced simulation time and computing power, many simulation tool suppliers have developed compressed versions of transistor-level products such as the operational amplifier. The term coined for this compressed tool is "macromodel". The macromodel allows more efficient simulation and gives the designer a fairly accurate portrayal of the actual device. Very simply, the macromodel is a pin-out representation of a specific function. While the macromodel does not take into account all parameters necessarily associated with a function, it is still an effective tool.

The following discussion highlights the macromodel concept and the major advantages and limitations of macromodels.

the macromodel

Many available references provide an in-depth technical discussion of the macromodel. The Boyle, *et. al.*, paper is probably one of the better-known references on the subject of op amp macromodels. Please refer to the end of this section for complete paper references.

The macromodel uses ideal elements in Spice to simulate certain op amp characteristics. This is coupled with actual transistors in the input stages of the op amp to yield the op amp macromodel. Figures 2-1 through 2-3 show the macromodels for JFET-, NPN-, and PNP-input op amps. These particular macromodels were derived from MicroSim Corporation's *PSpice*® *Parts*™ simulation software. The *PSpice*® manual available from MicroSim contains a detailed discussion of the elements in each of the macromodels shown in Figures 2-1, 2-2, and 2-3. Table 2-1 provides a reference for the terminology used in all of the macromodel listings in Section 3 of this manual. Table 2-2 lists and describes the components shown in Figures 2-1, 2-2, and 2-3. Figure 2-4 shows the nodal assignments for the op amp macromodel that would interface with other components in a simulation environment. Only models for devices with external compensation use nodes 6 and 7.

the macromodel subcircuit

The macromodel subcircuit is a listing of the code that the simulation software uses to model the device. The macromodel subcircuits in Section 3 of this manual were created using *Parts*™ software running on an IBM-compatible PC. The parameters listed in Table 2-3 were input to the software, and *Parts*™ generated the values required for the subcircuit. In creating the 106 subcircuits in Section 3, typical data sheet values or typical laboratory data were used. These typical values were derived from an extensive characterization process and truly represent the "typical device".

Figure 2-5 shows typical *Parts*™ code for a subcircuit from Section 3. This same format resides on the macromodel data floppy disk that can be found at the back of this manual.

PSpice is a registered trademark of MicroSim Corporation.
Parts is a trademark of MicroSim Corporation.

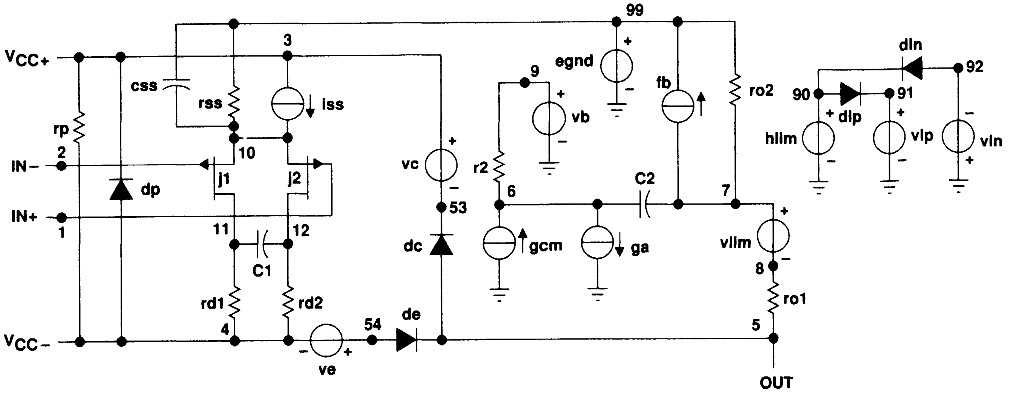

FIGURE 2-1. *PSpice*® MACROMODEL – JFET INPUTS

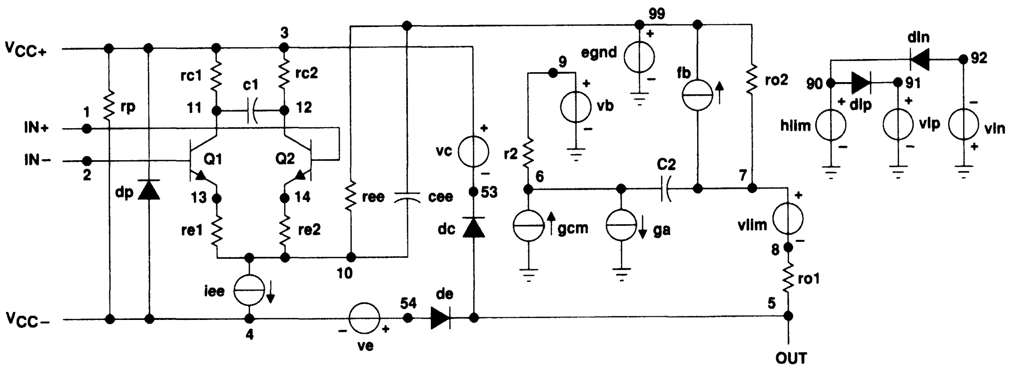

FIGURE 2-2. *PSpice*® MACROMODEL – NPN INPUTS

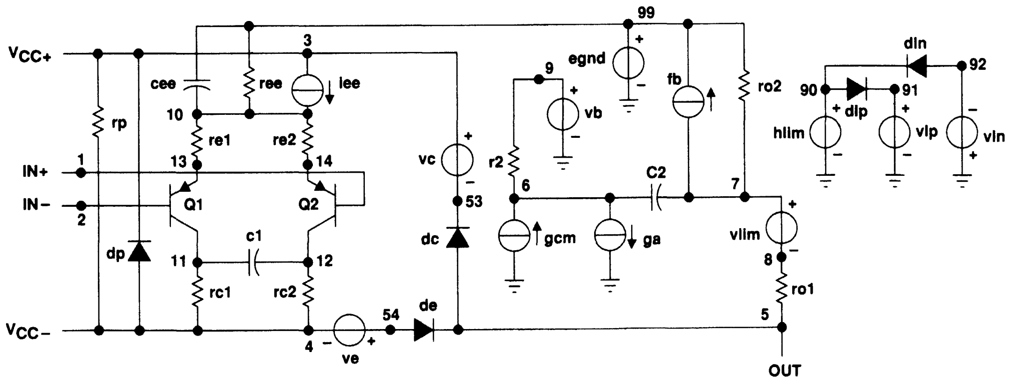

FIGURE 2-3. *PSpice*® MACROMODEL – PNP INPUTS

TABLE 2-1. MACROMODEL COMPONENT PREFIX DEFINITIONS†

PREFIX	DEFINITION
c	capacitor
d	diode
e	voltage-controlled voltage source
f	current-controlled current source
g	voltage-controlled current source
h	current-controlled voltage source
j	junction FET
q	bipolar transistor
r	resistor
v	independent voltage source and stimulus

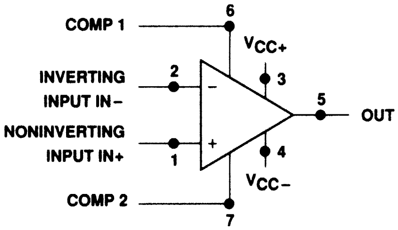

FIGURE 2-4. OP AMP NODAL ASSIGNMENT

TABLE 2-2. MACROMODEL COMPONENTS†

COMPONENT	DESCRIPTION
c1	phase-control capacitor
c2	compensation capacitor
cee, css	slew-rate limiting capacitor
dp	substrate junction
egnd	voltage-controlled voltage source
fb	output device
ga	interstage transconductance
gcm	common-mode transconductance
iee, iss	input-stage current
hlim	voltage-limiting device
j1, j2	input transistors
q1, q2	input transistors
r2	interstage resistance
rc1, rc2	input-stage load resistance
rd1, rd2	input-stage load resistance
re1, re2	input-stage emitter resistance
ree, rss	input-stage current-source output resistance
ro1	output resistor #1
ro2	output resistor #2
rp	power dissipation
vb	independent voltage source
vc, dc	output offset limiter (to Vcc)
ve, de	output offset limiter (to Vee)
vlim	output current-limiting sensor
vln, dln	negative supply limit
vlp, dlp	positive supply limit

TABLE 2-3. *PSpice*® INPUTS†

SYMBOL	MACROMODEL DESIGNATION	DEFINITION
V_{CC+}, V_{DD+}	+ Vpwr	positive power supply
V_{CC-}, V_{DD-}	− Vpwr	negative power supply
V_{OM+}	+ Vout	maximum positive output swing
V_{OM-}	− Vout	maximum negative output swing
SR+	+ SR	positive-going slew rate
SR−	− SR	negative-going slew rate
I_{IB}	Ib	input bias current
A_{VD}	Av-dc	open-loop voltage amplification (dc)
B_1	F-0db	unity-gain frequency
CMRR	CMRR	common-mode rejection ratio
ϕ_m	Phi	phase margin (in degrees) at unity-gain frequency
r_o	Ro-dc	dc output resistance
z_o	Ro-ac	ac output impedance
I_{OS}	Ios	short-circuit output current
C_c	Cc	compensation capacitance

†Adapted from *PSpice*, MicroSim Corporation, Irvine, CA, 1989.

```
.subckt TLE2021  1 2 3 4 5
*
  c1    11 12 6.244E-12
  c2     6  7 13.4E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2)  (3,0)  (4,0)  0  .5  .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 547.3E6 -500E6 500E6 500E6 -500E6
  ga     6  0 11 12 188.5E-6
  gcm    0  6 10 99 335.2E-12
  iee    3 10 dc 15.67E-6
  hlim 90   0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 5.305E3
  rc2    4 12 5.305E3
  re1   13 10 1.467E3
  re2   14 10 1.467E3
  ree   10 99 14.76E6
  ro1    8  5 62
  ro2    7 99 63
  rp     3  4 160.9E3
  vb     9  0 dc 0
  vc     3 53 dc 1.400
  ve    54  4 dc 1.600
  vlim   7  8 dc 0
  vlp   91  0 dc 3.200
  vln    0 92 dc 3.200
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=270)
.ends
```

FIGURE 2-5. EXAMPLE OF *Parts*™ OUTPUT FOR TLE2021, TLE2021A, TLE2021B

complexity

One of the main benefits of using macromodels for simulation is their reduced complexity, which in turn reduces simulation time and/or required computing power. Figure 2-6 illustrates the complexity of a typical schematic when simulating each component in an op amp. Figure 2-1, in contrast, shows the reduced complexity of the macromodel equivalent of the same circuit. Compared to Figure 2-6, the branch and node count in Figure 2-1 is reduced 5 to 10 times, and the number of p-n junctions is reduced 10 to 20 times. These reductions yield a 5X improvement in macromodel simulation run times compared to device-level simulation run times.

When simulating op amps, this reduced complexity can lead to increased productivity in the initial design phase of a program. Design ideas can be loaded quickly into the simulator and evaluated without actual bench-time analysis. Additionally, device types can be exchanged via software, which also saves considerable time.

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performance and accuracy

Counting elements in Figures 2-6 and 2-7 reveals that the TL062 is a relatively simple op amp while the TLE2062 is relatively complex. However, when both are simulated using macromodels, there is no difference in complexity and simulation time. The true difference is revealed in a significant enhancement in performance when the TLE2062 is used during system simulation.

To check the relative accuracy of the subcircuit representation of the real op amp, simulations were compared to actual bench measurements. Figures 2-8 through 2-15 show the circuit configurations used for this check. To perform these comparisons, the data sheet typical parameters were first entered into *Parts*™. *Parts*™ then generated the subcircuit, which was placed in a simulation environment as shown in Figures 2-8 through 2-15. The resulting simulation data were then compared against bench data. If the correlation was not satisfactory, the parametric data input into *Parts*™ were adjusted and the process repeated until satisfactory correlation was achieved. Table 2-4 shows the correlation between the macromodel-derived data and bench data for the TL062 and TLE2062.

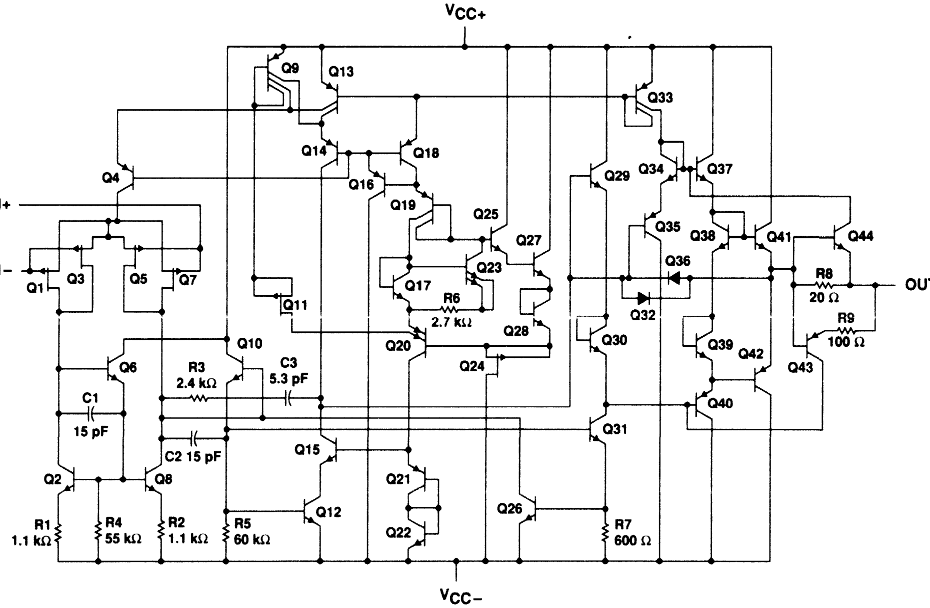

FIGURE 2-6. TLE2062 EQUIVALENT SCHEMATIC (per amplifier)

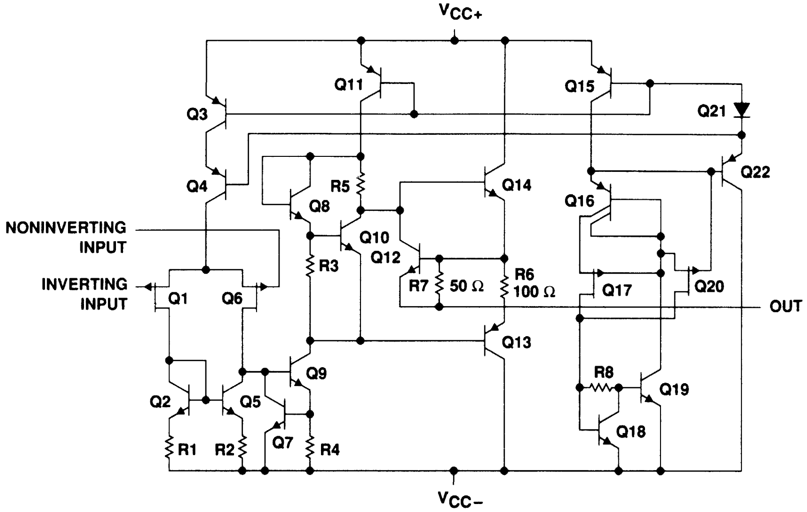

FIGURE 2-7. TL062 EQUIVALENT SCHEMATIC (per amplifier)

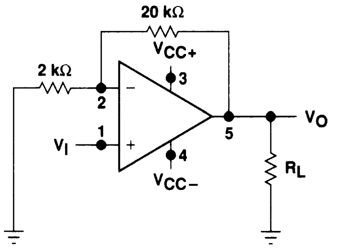

FIGURE 2-8. DC OUTPUT VOLTAGE SWING

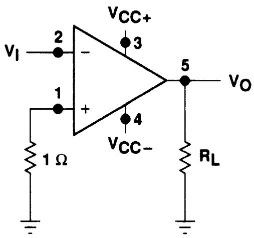

FIGURE 2-9. A_{VD}

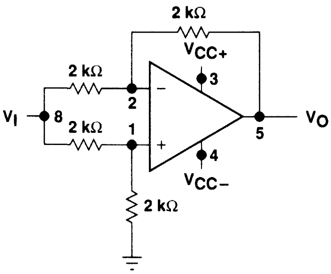

FIGURE 2-10. CMRR

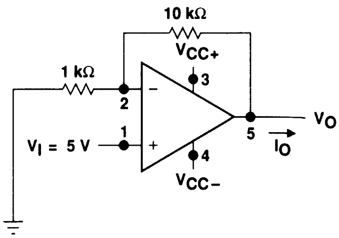

FIGURE 2-11. I_{OS+}

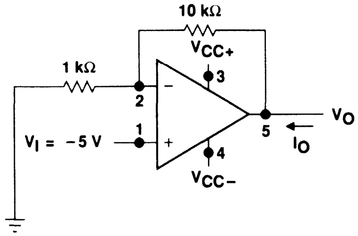

FIGURE 2-12. I_{OS-}

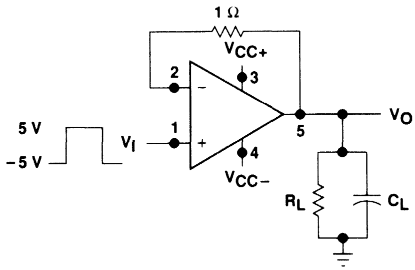

FIGURE 2-13. SLEW RATE

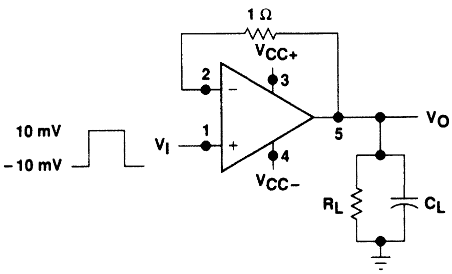

FIGURE 2-14. t_r, t_f, OVERSHOOT

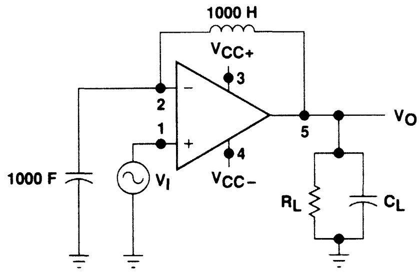

FIGURE 2-15. GAIN/PHASE vs FREQUENCY

TABLE 2-4. DATA SHEET vs MACROMODEL PARAMETRIC COMPARISON FOR THE TL062 and TLE2062

PARAMETER	FIGURE	TL062		TLE2062		UNIT
		DATA SHEET TYPICAL	MACROMODEL SIMULATION	DATA SHEET TYPICAL	MACROMODEL SIMULATION	
V_{OM+}	2-8	13.5	13.4	13.7	13.65	V
V_{OM-}	2-8	13.5	13.4	13.7	13.65	V
A_{VD}	2-9	6	6.3	230	240	V/mV
CMRR	2-10	86	90	90	90.5	dB
I_{OS}	2-11, 2-12		15	50	50	mA
SR +	2-13	3.5	3.4	3.4	3.3	V/μs
SR −	2-13	3.5	3.4	3.4	3.3	V/μs
t_r and t_f	2-14	200	208		100	ns
Overshoot factor	2-14	10%	9.6%		8.2%	
B_1	2-15	1	0.975	2	2	MHz
ϕ_m	2-15		66°	60°	60°	

limitations

These macromodels are intended to help engineers evaluate system designs and make initial product selections in the beginning stages of the design process. Because of their reduced complexity, the macromodels do not comprehend or do not accurately represent many device characteristics. For example, the macromodels do not simulate variations in parametric values due to temperature. While different values could be substituted to simulate performance at a specific temperature, the macromodels in this manual provide only 25°C performance characteristics. An abbreviated list of common op amp parameters that are not modeled are listed below:

input offset voltage
temperature coefficient of input offset voltage
input offset current
common-mode input voltage range
equivalent input noise voltage
equivalent input noise current
temperature effect on component stability

Macromodels are used for board-level simulations, which frequently include digital components. Because digital components have well-defined I/O specs with only two states, digital macromodels often contain tolerances for timing and other parameters. Analog components, however, have an infinite number of possible I/O states that are affected by temperature, supply voltages, and loading considerations. While the digital model may provide a valid design evaluation for worst-case limits, this is beyond what any one analog model can do.

Macromodels can very accurately reflect a small set of parameters (e.g., bandwidth or settling time), but since a macromodel only represents one operating point, this "accurate" model only provides more precision on a typical specification. Several analog macromodels would be required to support this kind of simulation, and considering the simplifications in the model, the accuracy may not be sufficient. Thus, TI has chosen to provide only typical models at room temperature. These macromodels give a fairly good first- and second-order simulation of the actual devices. Good design practice dictates the use of minimum and maximum parametric values over the intended operating temperature range including a thorough evaluation of breadboard circuits and prototypes. Refer to the device data sheet for complete characterization data.

macromodel references

G. R. Boyle, B. M. Cohn, D. Pederson, and J. E. Solomon, "Macromodeling of integrated circuit operational amplifiers," *IEEE Journal of Solid-State Circuits*, vol. SC-9, pp. 353-364, 1974.

G. Krajewska and F. E. Holmes, "Macromodeling of FET/bipolar operational amplifiers," *IEEE Journal of Solid-State Circuits*, vol. SC-14, pp. 1083-1087, 1979.

C. Turchetti and G. Masetti, "A macromodel for integrated all-MOS operational amplifiers," *IEEE Journal of Solid-State Circuits*, vol. SC-18, pp. 389-395, 1983.

PSpice, MicroSim Corporation, 20 Fairbanks, Irvine, California 92718, 1989. General offices: (714) 770-3022.

For up-to-date information or assistance on these Macromodels or any Amplifier Products such as:

Operational Amplifiers
Comparators
Timers

Call: 1-214-997-3389

Operational Amplifier Applications Hotline

Technical data for any TI semiconductor product is available from your nearest TI Field Sales Office, local authorized TI Distributor, or by writing directly to:

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P.O. Box 809066
Dallas, TX 75380-9066

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[illegible] 4

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- Extremely Low Offset Voltage . . . 5 µV Max
- Extremely Low Change In Offset Voltage with Temperature . . . 0.003 µV/°C Typ
- Low Input Offset Current . . . 30 pA Max
- A_{VD} . . . 120 dB Min
- CMRR and k_{SVR} . . . 110 dB Min
- Single-Supply Operation
- Common-Mode Input Voltage Range Includes the Negative Rail
- No Noise Degradation with External Capacitors Connected to V_{DD-}

macromodel – applies to ICL7652, LTC7652

```
.subckt ICL7652  1 2 3 4 5
*
  c1    11 12 4.354E-12
  c2     6  7 15.00E-12
  css   10 99 1.607E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.070E9 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 179.1E-6
  gcm    0  6 10 99 17.91E-12
  iss    3 10 dc 46.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 5.584E3
  rd2    4 12 5.584E3
  ro1    8  5 165
  ro2    7 99 165
  rp     3  4 6.667E3
  rss   10 99 4.301E6
  vb     9  0 dc 0
  vc     3 53 dc .9
  ve    54  4 dc .8
  vlim   7  8 dc 0
  vlp   91  0 dc 3
  vln    0 92 dc 3
.model dx D(Is=800.0E-18)
.model jx PJF(Is=2.000E-12 Beta=500E-6 Vto=0.05)
.ends
```


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LF347
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Input Bias Current . . . 50 pA Typ
- Low Input Noise Current . . . 0.01 pA/√Hz Typ
- Low Total Harmonic Distortion
- Low Supply Current . . . 8 mA Typ
- Wide Gain Bandwidth . . . 3 MHz Typ
- High Slew Rate . . . 13 V/μs Typ
- Pin Compatible with the LM348

macromodel – applies to LF347, LF347B

```
.subckt LF347    1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 14.15E6 -10E6 10E6 10E6 -10E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 1.590E-9
  iss    3 10 dc 195.0E-6
  hlim 90   0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 50
  ro2    7 99 25
  rp     3  4 15.00E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=25.00E-12 Beta=235.1E-6 Vto=-1)
.ends
```


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- Low Input Bias Current ... 50 pA Typ
- Low Input Noise Voltage ... 18 nV/√Hz Typ
- Low Input Noise Current ... 0.01 pA/√Hz
- Low Supply Current ... 1.8 mA Typ
- High Input Impedance ... 10^{12} Ω
- Low Total Harmonic Distortion
- Internally Trimmed Offset Voltage ... 10 mV Typ
- High Slew Rate ... 13 V/μs Typ
- Wide Gain Bandwidth ... 3 MHz Typ
- Pin Compatible with Standard 741

macromodel – applies to LF351

```
.subckt LF351       1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 28.29E6 -30E6 30E6 30E6 -30E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 1.590E-9
  iss    3 10 dc 195.0E-6
  hlim 90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 50
  ro2    7 99 25
  rp     3  4 15.00E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model jx PJF(Is=12.50E-12 Beta=250.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

LF353
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Input Bias Current . . . 50 pA Typ
- Low Input Noise Current . . . 0.01 pA/$\sqrt{Hz}$ Typ
- Low Input Noise Voltage . . . 18 nV/$\sqrt{Hz}$ Typ
- Low Supply Current . . . 3.6 mA Typ
- High Input Impedance . . . 10^{12} Ω Typ
- Internally Trimmed Offset Voltage
- Wide Gain Bandwidth . . . 3 MHz Typ
- High Slew Rate . . . 13 V/μs Typ

macromodel – applies to LF353

```
.subckt LF353      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 28.29E6 -30E6 30E6 30E6 -30E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 1.590E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 50
  ro2    7 99 11.62
  rp     3  4 15.00E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model jx PJF(Is=12.50E-12 Beta=250.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Low Input Bias Current . . . 50 pA Typ
- Low Input Noise Current . . . 0.01 pA/√Hz Typ
- Low Supply Current . . . 2.0 mA Typ
- High Input Impedance . . . 10^{12} Ω Typ
- Low Total Harmonic Distortion
- Low 1/f Noise Corner . . . 50 Hz Typ

macromodel – applies to LF411C

```
.subckt LF411C   1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 28.29E6 -30E6 30E6 30E6 -30E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 1.590E-9
  iss    3 10 dc 195.0E-6
  hlim 90   0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 50
  ro2    7 99 25
  rp     3  4 15.00E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model jx PJF(Is=12.50E-12 Beta=250.1E-6 Vto=-1)
.ends
```

LF412C
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Low Input Bias Current . . . 50 pA Typ**
- **Low Input Noise Current . . . 0.01 pA/√Hz Typ**
- **Low Supply Current . . . 4.5 mA Typ**
- **High Input Impedance . . . 10^{12} Ω Typ**
- **Internally Trimmed Offset Voltage**
- **Wide Gain Bandwidth . . . 3 MHz Typ**
- **High Slew Rate . . . 13 V/μs Typ**

macromodel – applies to LF412C

```
.subckt LF412C      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 28.29E6 -30E6 30E6 30E6 -30E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 1.590E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 50
  ro2    7 99 25
  rp     3  4 15.00E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model jx PJF(Is=12.50E-12 Beta=250.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Low Input Currents
- Low Input Offset Parameters
- Adjustable Frequency and Transient Response Characteristics
- Short-Circuit Protection
- Offset-Voltage Null Capability
- No Latch-Up
- Wide Common-Mode and Differential Voltage Ranges
- Same Pin Assignments as uA709
- Designed to be Interchangeable with National Semiconductor LM101A and LM301A

macromodel – applies to LM101A, LM201A

```
.subckt LM101A     1 2 3 4 5 6 7
*
  c1    11 12 6.996E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 53.05E6 -50E6 50E6 50E6 -50E6
  ga     6  0 11 12 156.8E-6
  gcm    0  6 10 99 2.682E-9
  iee   10  4 dc 15.06E-6
  hlim 90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 6.631E3
  rc2    3 12 6.631E3
  re1   13 10 3.169E3
  re2   14 10 3.169E3
  ree   10 99 13.28E6
  ro1    8  5 50
  ro2    7 99 25
  rp     3  4 16.81E3
  vb     9  0 dc 0
  vc     3 53 dc 2.700
  ve    54  4 dc 2.700
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=250)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

LM107
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Input Currents
- No Frequency Compensation Required
- Low Input Offset Parameters
- Short-Circuit Protection
- No Latch-Up
- Wide Common-Mode and Differential Voltage Ranges

macromodel – applies to LM107, LM207

```
.subckt LM107    1 2 3 4 5
*
  c1   11 12 6.996E-12
  c2    6  7 30.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 53.05E6 -50E6 50E6 50E6 -50E6
  ga    6  0 11 12 156.8E-6
  gcm   0  6 10 99 2.682E-9
  iee  10  4 dc 15.06E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 6.631E3
  rc2   3 12 6.631E3
  re1  13 10 3.169E3
  re2  14 10 3.169E3
  ree  10 99 13.28E6
  ro1   8  5 50
  ro2   7 99 25
  rp    3  4 16.81E3
  vb    9  0 dc 0
  vc    3 53 dc 2.700
  ve   54  4 dc 2.700
  vlim  7  8 dc 0
  vlp  91  0 dc 25
  vln   0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=250)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

LM301A
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Input Currents
- Low Input Offset Parameters
- Adjustable Frequency and Transient Response Characteristics
- Short-Circuit Protection
- Offset-Voltage Null Capability
- No Latch-Up
- Wide Common-Mode and Differential Voltage Ranges
- Same Pin Assignments as uA709
- Designed to be Interchangeable with National Semiconductor LM101A and LM301A

macromodel – applies to LM301A

```
.subckt LM301A   1 2 3 4 5 6 7
*
  c1    11 12 7.977E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 42.44E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 188.5E-6
  gcm    0  6 10 99 3.352E-9
  iee   10  4 dc 15.14E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 5.305E3
  rc2    3 12 5.305E3
  re1   13 10 1.839E3
  re2   14 10 1.839E3
  ree   10 99 13.21E6
  ro1    8  5 50
  ro2    7 99 25
  rp     3  4 16.81E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=107.1)
.ends
```

LM307
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Input Currents
- No Frequency Compensation Required
- Low Input Offset Parameters
- Short-Circuit Protection
- No Latch-Up
- Wide Common-Mode and Differential Voltage Ranges

3

Operational Amplifier Macromodels

macromodel – applies to LM307

```
.subckt LM307    1 2 3 4 5
*
  c1   11 12 8.887E-12
  c2    6  7 30.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 42.44E6 -40E6 40E6 40E6 -40E6
  ga    6  0 11 12 188.5E-6
  gcm   0  6 10 99 3.352E-9
  iee  10  4 dc 15.14E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 5.305E3
  rc2   3 12 5.305E3
  re1  13 10 1.839E3
  re2  14 10 1.839E3
  ree  10 99 13.21E6
  ro1   8  5 50
  ro2   7 99 25
  rp    3  4 16.81E3
  vb    9  0 dc 0
  vc    3 53 dc 2.600
  ve   54  4 dc 2.600
  vlim  7  8 dc 0
  vlp  91  0 dc 25
  vln   0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=107.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Input Offset Current . . . 200 pA Max at 25°C for LM108, LM108A
- Input Bias Current . . . 2 nA Max at 25°C for LM108, LM108A
- Supply Current . . . 600 μA Max at 25°C for LM108, LM108A
- Input Offset Voltage . . . 500 μV Max at T_A = 25°C for LM108A, LM308A
- Offset Voltage Temperature Coefficient . . . 5 μV/°C Max for LM108A, LM308A
- Supply Voltage Range . . . ±2 V to ±18 V
- Applications:
  - Integrators
  - Transducer Amplifiers
  - Analog Memories
  - Light Meters
- Designed To Be Interchangeable with National LM108 Series and Linear Technology LM108 Series

macromodel – applies to LM108, LM108A, LM308, LM308A

```
.subckt LM308    1 2 3 4 5 6 7
*
  c1    11 12 6.887E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 19.59E6 -20E6 20E6 20E6 -20E6
  ga     6  0 11 12 122.5E-6
  gcm    0  6 10 99 6.891E-9
  iee   10  4 dc 6.003E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 8.161E3
  rc2    3 12 8.161E3
  re1   13 10 -460.3
  re2   14 10 -460.3
  ree   10 99 33.32E6
  ro1    8  5 125
  ro2    7 99 125
  rp     3  4 102.0E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 6
  vln    0 92 dc 6
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=2.000E3)
.ends
```

LM318
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Small-Signal Bandwidth . . . 15 MHz Typ
- Slew Rate . . . 50 V/µs Min
- Bias Current . . . 250 nA Max (LM218)
- Supply Voltage Range . . . ±5 V to ±20 V
- Internal Frequency Compensation
- Input and Output Overload Protection
- Same Pin Assignments as General-Purpose Operational Amplifiers

macromodel – applies to LM218, LM318

```
.subckt LM318    1 2 3 4 5
*
  c1   11 12 8.50E-12
  c2    6  7 25.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 1.697E6 -2E6 2E6 2E6 -2E6
  ga    6  0 11 12 2.474E-3
  gcm   0  6 10 99 13.25E-9
  iee  10  4 dc 1.750E-3
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 424.4
  rc2   3 12 424.4
  re1  13 10 394.7
  re2  14 10 394.7
  ree  10 99 114.3E3
  ro1   8  5 50
  ro2   7 99 50
  rp    3  4 9.231E3
  vb    9  0 dc 0
  vc    3 53 dc 2.700
  ve   54  4 dc 2.700
  vlim  7  8 dc 0
  vlp  91  0 dc 21
  vln   0 92 dc 21
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=5.833E3)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Wide Range of Supply Voltages:
  Single Supply . . . 3 V to 30 V
  (LM2902 . . . 3 V to 26 V)
  or Dual Supplies
- Low Supply Current Drain Independent of Supply Voltage . . . 0.8 mA Typ
- Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground
- Internal Frequency Compensation
- Low Input Bias and Offset Parameters:
  Input Offset Voltage . . . 3 mV Typ
  A Versions . . . 2 mV Typ
  Input Offset Current . . . 2 nA Typ
  Input Bias Current . . . 20 nA Typ
  A Versions . . . 15 nA Typ
- Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . . 32 V (26 V for LM2902)
- Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ

macromodel – applies to LM124, LM224, LM224A, LM324, LM324A, LM2902

```
.subckt LM324    1 2 3 4 5
*
  c1    11 12 5.544E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 15.91E6 -20E6 20E6 20E6 -20E6
  ga     6  0 11 12 125.7E-6
  gcm    0  6 10 99 7.067E-9
  iee    3 10 dc 10.04E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 7.957E3
  rc2    4 12 7.957E3
  re1   13 10 2.773E3
  re2   14 10 2.773E3
  ree   10 99 19.92E6
  ro1    8  5 50
  ro2    7 99 50
  rp     3  4 30.31E3
  vb     9  0 dc 0
  vc     3 53 dc 2.100
  ve    54  4 dc .6
  vlim   7  8 dc 0
  vlp   91  0 dc 40
  vln    0 92 dc 40
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=250)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

LM348
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **uA741 Operating Characteristics**
- **Low Supply Current Drain . . . 0.6 mA Typ (per amplifier)**
- **Low Input Offset Voltage**
- **Low Input Offset Current**
- **Class AB Output Stage**
- **Input/Output Overload Protection**
- **Designed to be Interchangeable with National LM148, LM248, and LM348.**

macromodel – applies to LM148, LM248, LM348

```
.subckt LM348    1 2 3 4 5
*
  c1    11 12 9.461E-12
  c2     6  7 30.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 256.2E-6
  gcm    0  6 10 99 4.023E-9
  iee   10  4 dc 15.06E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 4.420E3
  rc2    3 12 4.420E3
  re1   13 10 968
  re2   14 10 968
  ree   10 99 13.28E6
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 51.28E3
  vb     9  0 dc 0
  vc     3 53 dc 3.600
  ve    54  4 dc 3.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=250)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Wide Range of Supply Voltages:
  Single Supply . . . 3 V to 30 V
  (LM2904 . . . 3 V to 26 V)
  or Dual Supplies
- Low Supply Current Drain Independent of Supply Voltage . . . 0.7 mA Typ
- Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground
- Internal Frequency Compensation
- Low Input Bias and Offset Parameters:
  Input Offset Voltage . . . 3 mV Typ
  A Versions . . . 2 mV Typ
  Input Offset Current . . . 2 nA Typ
  Input Bias Current . . . 20 nA Typ
  A Versions . . . 15 nA Typ
- Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . . ±32 V (±26 V for LM2904)
- Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ

macromodel – applies to LM158, LM258, LM258A, LM358, LM358A, LM2904

```
.subckt LM358      1 2 3 4 5
*
  c1    11 12 5.544E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 15.91E6 -20E6 20E6 20E6 -20E6
  ga     6  0 11 12 125.7E-6
  gcm    0  6 10 99 7.067E-9
  iee    3 10 dc 10.04E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 7.957E3
  rc2    4 12 7.957E3
  re1   13 10 2.773E3
  re2   14 10 2.773E3
  ree   10 99 19.92E6
  ro1    8  5 50
  ro2    7 99 50
  rp     3  4 30.31E3
  vb     9  0 dc 0
  vc     3 53 dc 2.100
  ve    54  4 dc .6
  vlim   7  8 dc 0
  vlp   91  0 dc 40
  vln    0 92 dc 40
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=250)
.ends
```

LT1001
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Low Input Offset Voltage:**
  LT1001AM . . . 15 µV Max
  LT1001AC . . . 25 µV Max
  LT1001M, LT1001C . . . 60 µV Max
- **Low Offset Voltage Temperature Coefficient:**
  LT1001AM, LT1001AC . . . 0.6 µV/°C Max
  LT1001M, LT1001C . . . 1 µV/°C Max
- **Low Input Bias Current:**
  LT1001AM, LT1001AC . . . ±2 nA Max
  LT1001M, LT1001C . . . ±4 nA Max
- **Low Common-Mode Rejection Ratio:**
  LT1001AM, LT1001AC . . . 114 dB Min
  LT1001M, LT1001C . . . 110 dB Min
- **Low Supply Voltage Rejection Ratio:**
  LT1001AM, LT1001AC . . . 110 dB Min
  LT1001M, LT1001C . . . 106 dB Min
- **Low Power Dissipation:**
  LT1001AM, LT1001AC . . . 75 mW Max
  LT1001M, LT1001C . . . 80 mW Max
- **Low Peak-to-Peak Equivalent Input Noise Voltage . . . 0.3 µV Typ**

macromodel – applies to LT1001, LT1001A

```
.subckt LT1001   1 2 3 4 5
*
  c1    11 12 3.822E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 117.9E6 -100E6 100E6 100E6 -100E6
  ga     6  0 11 12 84.81E-6
  gcm    0  6 10 99 21.25E-12
  iee   10  4 dc 3.751E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 13.26E3
  rc2    3 12 13.26E3
  re1   13 10 -532.7
  re2   14 10 -532.7
  ree   10 99 53.32E6
  ro1    8  5 90
  ro2    7 99 90
  rp     3  4 19.61E3
  vb     9  0 dc 0
  vc     3 53 dc 1.700
  ve    54  4 dc 1.700
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=3.750E3)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- **Maximum Equivalent Input Noise Voltage:**
  3.8 nV/√Hz at 1 kHz
  4.5 nV/√Hz at 10 Hz
- **Low Peak-to-Peak Equivalent Input Noise Voltage . . . 60 nV Typ from 0.1 Hz to 10 Hz**
- **Slew Rate . . . 2.5 V/μs Typ**
- **Differential Voltage Amplification:**
  5 V/μV Min, R_L = 2 kΩ
  3.5 V/μV Min, R_L = 600 Ω
- **Input Offset Voltage . . . 60 μV Max**
- **Average Temperature Coefficient of Input Offset Voltage . . . 1 μV/°C Max**
- **Common-Mode Rejection Ratio . . . 110 dB Min**

macromodel – applies to LT1007, LT1007A

```
.subckt LT1007   1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 241.1E6 -200E6 200E6 200E6 -200E6
  ga     6  0 11 12 800.1E-6
  gcm    0  6 10 99 212.5E-12
  iee   10  4 dc 37.53E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 1.326E3
  rc2    3 12 1.326E3
  re1   13 10 -53.24
  re2   14 10 -53.24
  ree   10 99 5.329E6
  ro1    8  5 110
  ro2    7 99 110
  rp     3  4 11.41E3
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=1.250E3)
.ends
```

LT1008
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Input Bias Current . . . ±30 pA Typ, ±100 pA Max at 25°C
- Input Offset Voltage . . . 30 µV Typ, 120 µV Max at 25°C
- Offset Voltage Temperature Coefficient . . . 1.5 µV/°C Max
- Low Peak-to-Peak Noise Voltage . . . 0.5 µV at 0.1 Hz to 10 Hz
- Low Supply Current . . . 380 µA Typ, 600 µA Max at 25°C
- Supply Voltage Rejection Ratio . . . 114 dB Min at 25°C
- Common-Mode Rejection Ratio . . . 114 dB Min at 25°C
- High Voltage Amplification with 5-mA Load Current
- Applications:
  - Precision Instrumentation
  - Charge Integrators
  - Wide-Dynamic-Range Logarithmic Amplifiers
  - Light Meters
  - Low-Frequency Active Filters
  - Standard Cell Buffers
  - Thermocouple Amplifiers

macromodel – applies to LT1008

```
.subckt LT1008   1 2 3 4 5 6 7
*
  c1   11 12 6.887E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 141.5E6 -100E6 100E6 100E6 -100E6
  ga    6  0 11 12 113.1E-6
  gcm   0  6 10 99 15.98E-12
  iee  10  4 dc 6.000E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 8.841E3
  rc2   3 12 8.841E3
  re1  13 10 219.5
  re2  14 10 219.5
  ree  10 99 33.33E6
  ro1   8  5 125
  ro2   7 99 125
  rp    3  4 80.21E3
  vb    9  0 dc 0
  vc    3 53 dc 1.600
  ve   54  4 dc 1.600
  vlim  7  8 dc 0
  vlp  91  0 dc 8
  vln   0 92 dc 8
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=100.0E3)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Internally Compensated
- Input Offset Voltage:
  LT1012M . . . 35 µV Max
  LT1012C . . . 50 µV Max
- Input Bias Current (LT1012M):
  100 pA Max at 25°C
  600 pA Max from −55°C to 125°C
- α_{VIO} . . . 1.5 µV/°C Max
- Peak-to-Peak Noise Voltage . . .
  0.5 µV Typ at f = 0.1 Hz to 10 Hz
- Low Supply Current . . . 600 µA Max
- CMRR . . . 114 dB Min (LT1012M)
- k_{SVR} . . . 114 dB Min (LT1012M)
- 5-mA Load Current with Voltage Gain of 200,000 Min (LT1012M)

macromodel – applies to LT1012

```
.subckt LT1012   1 2 3 4 5
*
  c1    11 12 6.887E-12
  c2     6  7 30.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 108.8E6 -100E6 100E6 100E6 -100E6
  ga     6  0 11 12 122.5E-6
  gcm    0  6 10 99 17.31E-12
  iee   10  4 dc 6.000E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 8.161E3
  rc2    3 12 8.161E3
  re1   13 10 -460.6
  re2   14 10 -460.6
  ree   10 99 33.33E6
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 80.21E3
  vb     9  0 dc 0
  vc     3 53 dc 1.600
  ve    54  4 dc 1.600
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=100.0E3)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

LT1013
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Single-Supply Operation:**
  Input Voltage Range Extends to Ground
  Output Swings to Ground While Sinking Current
- **Input Offset Voltage . . . 150 μA Max at 25°C for LT1013A**
- **Offset Voltage Temperature Coefficient . . . 2 μV/°C Max for LT1013A**
- **Input Offset Current . . . 0.8 nA Max at 25°C for LT1013A**
- **High Gain . . . 1.5 V/μV Min (R_L = 2 kΩ), 0.8 V/μV Min (R_L = 600 Ω) for LT1013A**
- **Low Supply Current . . . 0.5 mA Max at 25°C for LT1013A**
- **Low Peak-to-Peak Noise Voltage . . . 0.55 μV Typ**
- **Low Current Noise . . . 0.07 pA/√Hz Typ**

macromodel – applies to LT1013, LT1013A, LT1013D

```
.subckt LT1013   1 2 3 4 5
*
  c1    11 12 6.495E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 3.865E9 -4E9 4E9 4E9 -4E9
  ga     6  0 11 12 87.97E-6
  gcm    0  6 10 99 98.71E-12
  iee    3 10 dc 8.030E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 11.37E3
  rc2    4 12 11.37E3
  re1   13 10 4.883E3
  re2   14 10 4.883E3
  ree   10 99 24.91E6
  ro1    8  5 50
  ro2    7 99 25
  rp     3  4 87.72E3
  vb     9  0 dc 0
  vc     3 53 dc 1.600
  ve    54  4 dc 1.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
 .model dx D(Is=800.0E-18)
 .model qx PNP(Is=800.0E-18 Bf=266.7)
 .ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Very Low Input Noise Voltage . . . 1.1 nV/√Hz Max, 0.85 nV/√Hz Typ at 1 kHz for LT1028AM, LT1028AC
- Low Peak-to-Peak Input Noise Voltage . . . 35 nV Typ at f = 0.1 Hz to 10 Hz
- Noise Voltage and Current 100% Tested
- Gain-Bandwidth Product . . . 50 MHz Min
- Slew Rate . . . 11 V/µs Min
- Input Offset Voltage . . . 40 µV Max at 25°C for LT1028AM, LT1028AC
- Offset Voltage Temperature Coefficient . . . 0.8 µV/°C Max for LT1028AM, LT1028AC
- Applications:
  - Low-Noise Frequency Synthesizers
  - High-Quality Audio
  - Infrared Detectors
  - Accelerometer and Gyro Amplifiers
  - 350-Ω Bridge Signal Conditioning
  - Magnetic Search Coil Amplifiers
  - Hydrophone Amplifiers

macromodel – applies to LT1028, LT1028A

```
.subckt LT1028   1 2 3 4 5
*
  c1    11 12 168.4E-12
  c2     6  7 30.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 61.89E6 -60E6 60E6 60E6 -60E6
  ga     6  0 11 12 14.14E-3
  gcm    0  6 10 99 3.985E-9
  iee   10  4 dc 450.1E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 70.73
  rc2    3 12 70.73
  re1   13 10 -44.22
  re2   14 10 -44.22
  ree   10 99 444.4E3
  ro1    8  5 40
  ro2    7 99 40
  rp     3  4 4.196E3
  vb     9  0 dc 0
  vc     3 53 dc 2.700
  ve    54  4 dc 2.700
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=7.500E3)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

LT1037
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Maximum Equivalent Input Noise Voltage:**
  3.8 nV/√Hz at 1 kHz
  4.5 nV/√Hz at 10 Hz
- **Low Peak-to-Peak Equivalent Input Noise Voltage . . . 60 nV Typ from 0.1 Hz to 10 Hz**
- **Slew Rate . . . 11 V/μs Min for LT1037 and LT1037A**
- **High Voltage Amplification:**
  7 V/μV Min, R_L = 2 kΩ
  3 V/μV Min, R_L = 600 Ω
- **Low Input Offset Voltage . . . 25 μV Max**
- **Low Input Offset Voltage Temperature Coefficient . . . 0.6 μV/°C Max**
- **Common-Mode Rejection Ratio . . . 117 dB Min**

macromodel – applies to LT1037, LT1037A

```
.subckt LT1037   1 2 3 4 5
*
  c1    11 12 16.49E-12
  c2     6  7 12.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 126.3E6 -100E6 100E6 100E6 -100E6
  ga     6  0 11 12 4.524E-3
  gcm    0  6 10 99 1.275E-9
  iee   10  4 dc 180.0E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 221
  rc2    3 12 221
  re1   13 10 -66.35
  re2   14 10 -66.35
  ree   10 99 1.111E6
  ro1    8  5 35
  ro2    7 99 35
  rp     3  4 11.31E3
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=6.000E3)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Input Offset Voltage . . . 5 μV Max at 25°C
- Temperature Coefficient of Input Offset Voltage . . . 0.01 μV/°C Typ
- Long-Term Drift of Input Offset Voltage . . . 100 nV/mo Typ
- Input Bias Current . . . 30 pA Max at 25°C
- Differential Voltage Amplification Over Full Temperature Range . . . 120 dB Min
- Common-Mode Rejection Ratio Over Full Temperature Range . . . 120 dB Min
- Supply Voltage Rejection Ratio Over Full Temperature Range . . . 120 dB Min
- Single-Supply Operation from 4.75 V to 16 V (Input Voltage Range Extends to Ground)
- External Capacitors Can Be Returned to V_{DD-} with No Noise Degradation

macromodel – applies to LTC1052, LTC7652

```
.subckt LTC1052  1 2 3 4 5
*
  c1    11 12 4.354E-12
  c2     6  7 15.00E-12
  css   10 99 1.607E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.070E9 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 179.1E-6
  gcm    0  6 10 99 17.91E-12
  iss    3 10 dc 46.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 5.584E3
  rd2    4 12 5.584E3
  ro1    8  5 165
  ro2    7 99 165
  rp     3  4 6.667E3
  rss   10 99 4.301E6
  vb     9  0 dc 0
  vc     3 53 dc .9
  ve    54  4 dc .8
  vlim   7  8 dc 0
  vlp   91  0 dc 3
  vln    0 92 dc 3
.model dx D(Is=800.0E-18)
.model jx PJF(Is=2.000E-12 Beta=500E-6 Vto=0.05)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

MC1458
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Short-Circuit Protection
- Wide Common-Mode and Differential Voltage Ranges
- No Frequency Compensation Required
- Low Power Consumption
- No Latch-Up
- Designed to be Interchangeable with Motorola MC1558/MC1458 and Signetics S5558/N5558

macromodel – applies to MC1458, MC1558

```
.subckt MC1458     1 2 3 4 5
*
  c1   11 12 4.664E-12
  c2    6  7 20.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
  ga    6  0 11 12 137.7E-6
  gcm   0  6 10 99 2.574E-9
  iee  10  4 dc 10.16E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 7.957E3
  rc2   3 12 7.957E3
  re1  13 10 2.740E3
  re2  14 10 2.740E3
  ree  10 99 19.69E6
  ro1   8  5 150
  ro2   7 99 150
  rp    3  4 18.11E3
  vb    9  0 dc 0
  vc    3 53 dc 2.600
  ve   54  4 dc 2.600
  vlim  7  8 dc 0
  vlp  91  0 dc 25
  vln   0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=62.50)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Wide Range of Supply Voltages:
  Single Supply . . . 3 V to 36 V
  or Dual Supplies
- Class AB Output Stage
- True Differential Input Stage
- Low Input Bias Current
- Internal Frequency Compensation
- Short-Circuit Protection
- Designed to be Interchangeable with Motorola MC3303, MC3403

macromodel – applies to MC3303, MC3403

```
.subckt MC3403   1 2 3 4 5
*
  c1    11 12 7.544E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 42.44E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 130.7E-6
  gcm    0  6 10 99 2.235E-9
  iee    3 10 dc 12.40E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 7.957E3
  rc2    4 12 7.957E3
  re1   13 10 3.529E3
  re2   14 10 3.529E3
  ree   10 99 16.13E6
  ro1    8  5 37.50
  ro2    7 99 37.50
  rp     3  4 43.62E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=30)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

NE5534
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Equivalent Input Noise Voltage . . . 3.5 nV/√Hz Typ
- Unity-Gain Bandwidth . . . 10 MHz Typ
- Common-Mode Rejection Ratio . . . 100 dB Typ
- High DC Voltage Gain . . . 100 V/mV Typ
- Peak-to-Peak Output Voltage Swing . . . 32 V Typ with $V_{CC\pm}$ = ±18 V and R_L = 600 Ω
- High Slew Rate . . . 13 V/μs Typ
- Wide Supply Voltage Range . . . ±3 V to ±20 V
- Low Harmonic Distortion
- Designed to be Interchangeable with Signetics SE5534, SE5534A, NE5534, and NE5534A

macromodel – applies to NE5532, NE5532A, NE5534, NE5534A, SE5534, SE5534A

```
.subckt NE5534   1 2 3 4 5 6 7
*
  c1    11 12 7.703E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 2.893E6 -3E6 3E6 3E6 -3E6
  ga     6  0 11 12 1.382E-3
  gcm    0  6 10 99 13.82E-9
  iee   10  4 dc 133.0E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 723.3
  rc2    3 12 723.3
  re1   13 10 329
  re2   14 10 329
  ree   10 99 1.504E6
  ro1    8  5 50
  ro2    7 99 25
  rp     3  4 7.757E3
  vb     9  0 dc 0
  vc     3 53 dc 2.700
  ve    54  4 dc 2.700
  vlim   7  8 dc 0
  vlp   91  0 dc 38
  vln    0 92 dc 38
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=132)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

- Input Offset Voltage . . . 60 μV Typ
- Temperature Coefficient of Input Offset Voltage . . . 0.5 μV/°C Typ
- Ultralow Noise
- No External Components Required
- Lower Cost Replacement for Chopper Amplifiers
- Single-Chip Monolithic Fabrication
- Wide Input Voltage Range . . . 0 to ±14 V Typ
- Wide Supply Voltage Range . . . ±3V to ±18 V
- Essentially Equivalent to Fairchild μA714 Operational Amplifiers
- Direct Replacement for PMI OP-07C

macromodel – applies to OP-07C

```
.subckt OP-07C     1 2 3 4 5
*
  c1    11 12 2.887E-12
  c2     6  7 30.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 147.3E6 -100E6 100E6 100E6 -100E6
  ga     6  0 11 12 113.1E-6
  gcm    0  6 10 99 56.69E-12
  iee   10  4 dc 7.501E-6
  hlim 90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 8.841E3
  rc2    3 12 8.841E3
  re1   13 10 1.943E3
  re2   14 10 1.943E3
  ree   10 99 26.66E6
  ro1    8  5 30
  ro2    7 99 30
  rp     3  4 12.04E3
  vb     9  0 dc 0
  vc     3 53 dc 2.900
  ve    54  4 dc 2.900
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=5.357E3)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

OP-07D
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Input Offset Voltage . . . 60 µV Typ
- Temperature Coefficient of Input Offset Voltage . . . 0.7 µV/°C Typ
- Ultralow Noise
- No External Components Required
- Lower Cost Replacement for Chopper Amplifiers
- Single-Chip Monolithic Fabrication
- Wide Input Voltage Range . . . 0 to ±14 V Typ
- Wide Supply Voltage Range . . . ±3V to ±18 V
- Essentially Equivalent to Fairchild µA714 Operational Amplifiers
- Direct Replacement for PMI OP-07D

macromodel – applies to OP-07D

```
.subckt OP-07D   1 2 3 4 5
*
  c1    11 12 6.996E-12
  c2     6  7 30.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 115.9E6 -100E6 100E6 100E6 -100E6
  ga     6  0 11 12 115.0E-6
  gcm    0  6 10 99 204.5E-12
  iee   10  4 dc 9.004E-6
  hlim 90   0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 8.696E3
  rc2    3 12 8.696E3
  re1   13 10 2.947E3
  re2   14 10 2.947E3
  ree   10 99 22.21E6
  ro1    8  5 30
  ro2 7 99 31.2
  rp     3  4 11.29E3
  vb     9  0 dc 0
  vc     3 53 dc 2.800
  ve    54  4 dc 2.800
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=2.250E3)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

- Ultralow Offset Voltage . . . 30 μV Typ
- Ultralow Offset Voltage Temperature Coefficient . . . 0.3 μV/°C Typ
- Ultralow Noise
- No External Components Required
- Lower Cost Replacement for Chopper Amplifiers
- Single-Chip Monolithic Fabrication
- Wide Input Voltage Range . . . 0 to ±14 V Typ
- Wide Supply Voltage Range . . . ±3V to ±18 V
- Essentially Equivalent to Fairchild μA714 Operational Amplifiers
- Direct Replacement for PMI OP-07E

macromodel – applies to OP-07E

```
.subckt OP-07E     1 2 3 4 5
*
  c1   11 12 2.887E-12
  c2    6  7 30.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 147.3E6 -100E6 100E6 100E6 -100E6
  ga    6  0 11 12 113.1E-6
  gcm   0  6 10 99 56.69E-12
  iee  10  4 dc 7.501E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 8.841E3
  rc2   3 12 8.841E3
  re1  13 10 1.943E3
  re2  14 10 1.943E3
  ree  10 99 26.66E6
  ro1   8  5 30
  ro2   7 99 30
  rp    3  4 12.04E3
  vb    9  0 dc 0
  vc    3 53 dc 2.900
  ve   54  4 dc 2.900
  vlim  7  8 dc 0
  vlp  91  0 dc 20
  vln   0 92 dc 20
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=5.357E3)
.ends
```

OP-27C
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Direct Replacement for PMI and LTC OP-27 Series**
- **Maximum Equivalent Input Noise Voltage:**
  4.5 nV/√Hz at 1 kHz
  8 nV/√Hz at 10 Hz
- **Very Low Peak-to-Peak Noise Voltage . . . 90 nV Typ at 0.1 Hz to 10 Hz**
- **Input Offset Voltage . . . 100 μV Max**
- **High Voltage Amplification . . . 700 V/mV Min**

macromodel – applies to OP-27A, OP-27C

```
.subckt OP-27C     1 2 3 4 5
*
  c1   11 12 2.730E-12
  c2    6  7 15.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 22.86E6 -20E6 20E6 20E6 -20E6
  ga    6  0 11 12 852.1E-6
  gcm   0  6 10 99 754.1E-12
  iee  10  4 dc 42.03E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 1.326E3
  rc2   3 12 1.326E3
  re1  13 10 94.44
  re2  14 10 94.44
  ree  10 99 4.759E6
  ro1   8  5 88
  ro2   7 99 87
  rp    3  4 10.14E3
  vb    9  0 dc 0
  vc    3 53 dc 2.200
  ve   54  4 dc 2.200
  vlim  7  8 dc 0
  vlp  91  0 dc 40
  vln   0 92 dc 40
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=1.400E3)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- **Direct Replacement for PMI and LTC OP-27 Series**
- **Maximum Equivalent Input Noise Voltage:**
  3.8 nV/√Hz at 1 kHz
  5.5 nV/√Hz at 10 Hz
- **Very Low Peak-to-Peak Noise Voltage . . . 80 nV Typ at 0.1 Hz to 10 Hz**
- **Low Input Offset Voltage . . . 25 μV Max**
- **High Voltage Amplification . . . 1 V/μV Min**

macromodel – applies to OP-27E

```
.subckt OP-27E   1 2 3 4 5
*
  c1    11 12 2.730E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 67.36E6 -70E6 70E6 70E6 -70E6
  ga     6  0 11 12 763.5E-6
  gcm    0  6 10 99 215.2E-12
  iee   10  4 dc 42.02E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 1.310E3
  rc2    3 12 1.310E3
  re1   13 10 78.10
  re2   14 10 78.10
  ree   10 99 4.760E6
  ro1    8  5 35
  ro2    7 99 37
  rp     3  4 9.810E3
  vb     9  0 dc 0
  vc     3 53 dc 1.800
  ve    54  4 dc 1.800
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=2.100E3)
.ends
```

OP-27G
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Direct Replacement for PMI and LTC OP-27 Series
- Maximum Equivalent Input Noise Voltage:
  4.5 nV/$\sqrt{Hz}$ at 1 kHz
  8.0 nV/$\sqrt{Hz}$ at 10 Hz
- Very Low Peak-to-Peak Noise Voltage . . . 90 nV Typ at 0.1 Hz to 10 Hz
- Input Offset Voltage . . . 100 µV Max
- High Voltage Amplification . . . 700 V/mV Min

macromodel – applies to OP-27G

```
.subckt OP-27G     1 2 3 4 5
*
  c1    11 12 2.730E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 22.86E6 -20E6 20E6 20E6 -20E6
  ga     6  0 11 12 852.1E-6
  gcm    0  6 10 99 754.1E-12
  iee   10  4 dc 42.03E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 1.326E3
  rc2    3 12 1.326E3
  re1   13 10 94.44
  re2   14 10 94.44
  ree   10 99 4.759E6
  ro1    8  5 88
  ro2    7 99 87
  rp     3  4 10.14E3
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 40
  vln    0 92 dc 40
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=1.400E3)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Direct Replacement for PMI and LTC OP-27 Series
- Maximum Equivalent Input Noise Voltage:
  3.8 nV/√Hz at 1 kHz
  5.5 nV/√Hz at 10 Hz
- Very Low Peak-to-Peak Noise Voltage . . . 80 nV Typ at 0.1 Hz to 10 Hz
- Low Input Offset Voltage . . . 25 µV Max
- High Voltage Amplification . . . 1 V/µV Min

macromodel – applies to OP-37A, OP-37C, OP-37E, OP-37G

```
.subckt OP37A    1 2 3 4 5
*
  c1    11 12 25.166E-12
  c2     6  7 30.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 5.683E6 -6E6 6E6 6E6 -6E6
  ga     6  0 11 12 7.541E-3
  gcm    0  6 10 99 2.125E-9
  iee   10  4 dc 510.0E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 132.6
  rc2    3 12 132.6
  re1   13 10 31.18
  re2   14 10 31.18
  ree   10 99 392.1E3
  ro1    8  5 35
  ro2    7 99 35
  rp     3  4 12.05E3
  vb     9  0 dc 0
  vc     3 53 dc 1.900
  ve    54  4 dc 1.900
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=25.50E3)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

RC4136
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Continuous Short-Circuit Protection
- Wide Common-Mode and Differential Voltage Ranges
- No Frequency Compensation Required
- Low Power Consumption
- No Latch-Up
- Unity Gain Bandwidth . . . 3 MHz Typ
- Gain and Phase Match Between Amplifiers
- Designed to be Interchangeable with Raytheon RM4136, RV4136, and RC4136
- Low Noise . . . 8 nV/√Hz Typ at 1 kHz

macromodel – applies to RC4136, RM4136, RV4136

```
.subckt RC4136   1 2 3 4 5
*
  c1    11 12 2.664E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 6.365E6 -6E6 6E6 6E6 -6E6
  ga     6  0 11 12 418.0E-6
  gcm    0  6 10 99 6.705E-9
  iee    3 10 dc 34.28E-6
  hlim 90   0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 2.652E3
  rc2    4 12 2.652E3
  re1   13 10 1.122E3
  re2   14 10 1.122E3
  ree   10 99 5.834E6
  ro1    8  5 125
  ro2    7 99 125
  rp     3  4 24.67E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=121.4)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Continuous Short-Circuit Protection
- Wide Common-Mode and Differential Voltage Ranges
- No Frequency Compensation Required
- Low Power Consumption
- No Latch-Up
- Unity Gain Bandwidth . . . 3 MHz Typ
- Gain and Phase Match Between Amplifiers
- Low Noise . . . 8 nV/√Hz Typ at 1 kHz
- Designed to be Interchangeable with Raytheon RM4558, RV4558, and RC4558

macromodel – applies to RC4558, RM4558, RV4558

```
.subckt RC4558     1 2 3 4 5
*
  c1    11 12 2.664E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 6.365E6 -6E6 6E6 6E6 -6E6
  ga     6  0 11 12 418.0E-6
  gcm    0  6 10 99 6.705E-9
  iee    3 10 dc 34.28E-6
  hlim 90   0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 2.652E3
  rc2    4 12 2.652E3
  re1   13 10 1.122E3
  re2   14 10 1.122E3
  ree   10 99 5.834E6
  ro1    8  5 125
  ro2    7 99 125
  rp     3  4 24.67E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=121.4)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

RC4559
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Matched Gain and Offset Between Amplifiers
- Unity-Gain Bandwidth . . . 3 MHz Min
- Slew Rate . . . 1.5 V/μs Min
- Low Equivalent Input Noise Voltage . . . 2 nV/√Hz Max (20 Hz to 20 kHz)
- No Frequency Compensation Required
- No Latch-Up
- Wide Common-Mode Voltage Range
- Low Power Consumption
- Designed to be Interchangeable with Raytheon RC4559

macromodel – applies to RC4559

```
.subckt RC4559   1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 7.233E6 -7E6 7E6 7E6 -7E6
  ga     6  0 11 12 404.0E-6
  gcm    0  6 10 99 2.120E-9
  iee    3 10 dc 30.08E-6
  hlim  90  0 vlim 1K
  q1    11  2 13A qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 2.652E3
  rc2    4 12 2.652E3
  re1   13 10 925.5
  re2   14 10 925.5
  ree   10 99 6.649E6
  ro1    8  5 110
  ro2    7 99 110
  rp     3  4 18.52E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=375)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Very Low Power Consumption
- Power Dissipation with ± 2-V Supplies . . . 170 μW Typ
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Input Offset Voltage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- Popular Dual Op Amp Pin-Out

TL022M IS NOT RECOMMENDED FOR NEW DESIGNS

macromodel – applies to TL022M, TL022C

```
.subckt TL022C   1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.697E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 47.13E-6
  gcm    0  6 10 99 6.657E-9
  iee    3 10 dc 7.700E-6
  hlim 90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 21.22E3
  rc2    4 12 21.22E3
  re1   13 10 13.95E3
  re2   14 10 13.95E3
  ree   10 99 25.97E6
  ro1    8  5 125
  ro2    7 99 125
  rp     3  4 245.1E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 6
  vln    0 92 dc 6
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=37.50)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TL031
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Maximum Offset Voltage . . . 800 μV**
- **High Slew Rate . . . 2.9 V/μs Typ**
- **Low Input Bias Current . . . 2 pA Typ**
- **Very Low Power Consumption . . . 6.5 mW Typ**
- **Output Short-Circuit Protection**

macromodel – applies to TL031, TL031A

```
.subckt TL031    1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  css   10 99 11.38E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 936.5E3 -900E3 900E3 900E3 -900E3
  ga     6  0 11 12 113.1E-6
  gcm    0  6 10 99 2.257E-9
  iss    3 10 dc 76.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 8.841E3
  rd2    4 12 8.841E3
  ro1    8  5 135
  ro2    7 99 135
  rp     3  4 138.5E3
  rss   10 99 2.614E6
  vb     9  0 dc 0
  vc     3 53 dc 1.700
  ve    54  4 dc 1.800
  vlim   7  8 dc 0
  vlp   91  0 dc 8
  vln    0 92 dc 8
.model dx D(Is=800.0E-18)
.model jx PJF(Is=1.000E-12 Beta=140e-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Maximum Offset Voltage . . . 800 μV
- High Slew Rate . . . 2.9 V/μs Typ
- Low Input Bias Current . . . 2 pA Typ
- Very Low Power Consumption . . . 13 mW Typ
- Output Short-Circuit Protection

macromodel – applies to TL032, TL032A

```
.subckt TL032      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  css   10 99 11.38E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 936.5E3 -900E3 900E3 900E3 -900E3
  ga     6  0 11 12 113.1E-6
  gcm    0  6 10 99 2.257E-9
  iss    3 10 dc 76.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 8.841E3
  rd2    4 12 8.841E3
  ro1    8  5 135
  ro2    7 99 135
  rp     3  4 138.5E3
  rss   10 99 2.614E6
  vb     9  0 dc 0
  vc     3 53 dc 1.700
  ve    54  4 dc 1.800
  vlim   7  8 dc 0
  vlp   91  0 dc 8
  vln    0 92 dc 8
.model dx D(Is=800.0E-18)
.model jx PJF(Is=1.000E-12 Beta=140e-6 Vto=-1)
.ends
```

TL034
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Maximum Offset Voltage . . . 1.5 mV
- High Slew Rate . . . 2.9 V/µs Typ
- Low Input Bias Current . . . 2 pA Typ
- Very Low Power Consumption . . . 26 mW Typ
- Output Short-Circuit Protection
- Monolithic Construction

macromodel – applies to TL034, TL034A

```
.subckt TL034      1 2 3 4 5
*
  c1   11 12 3.498E-12
  c2    6  7 15.00E-12
  css  10 99 11.38E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 936.5E3 -900E3 900E3 900E3 -900E3
  ga    6  0 11 12 113.1E-6
  gcm   0  6 10 99 2.257E-9
  iss   3 10 dc 76.50E-6
  hlim 90  0 vlim 1K
  j1   11  2 10 jx
  j2   12  1 10 jx
  r2    6  9 100.0E3
  rd1   4 11 8.841E3
  rd2   4 12 8.841E3
  ro1   8  5 135
  ro2   7 99 135
  rp    3  4 138.5E3
  rss  10 99 2.614E6
  vb    9  0 dc 0
  vc    3 53 dc 1.700
  ve   54  4 dc 1.800
  vlim  7  8 dc 0
  vlp  91  0 dc 8
  vln   0 92 dc 8
.model dx D(Is=800.0E-18)
.model jx PJF(Is=1.000E-12 Beta=140e-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Very Low Power Consumption
- Typical Power Dissipation with ±2-V Supplies . . . 340 μW
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Input Offset Voltage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- Power Applied in Pairs

TL044M IS NOT RECOMMENDED FOR NEW DESIGNS

macromodel – applies to TL044M, TL044C

```
.subckt TL044C     1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.697E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 47.13E-6
  gcm    0  6 10 99 6.657E-9
  iee    3 10 dc 7.700E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 21.22E3
  rc2    4 12 21.22E3
  re1   13 10 13.95E3
  re2   14 10 13.95E3
  ree   10 99 25.97E6
  ro1    8  5 125
  ro2    7 99 125
  rp     3  4 245.1E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 6
  vln    0 92 dc 6
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=37.50)
.ends
```

TL051
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Maximum Offset Voltage . . . 800 μV (TL051A)**
- **High Slew Rate . . . 19.8 V/μs Typ at 25°C**
- **Low Total Harmonic Distortion . . . 0.003% Typ at R_L = 2 kΩ**
- **Low Noise Voltage . . . 18 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Currents . . . 30 pA Typ**

macromodel – applies to TL051, TL051A

```
.subckt TL051    1 2 3 4 5
*
  c1   11 12 3.988E-12
  c2    6  7 15.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 2.875E6 -3E6 3E6 3E6 -3E6
  ga    6  0 11 12 292.2E-6
  gcm   0  6 10 99 6.542E-9
  iss   3 10 dc 300.0E-6
  hlim 90  0 vlim 1K
  j1   11  2 10 jx
  j2   12  1 10 jx
  r2    6  9 100.0E3
  rd1   4 11 3.422E3
  rd2   4 12 3.422E3
  ro1   8  5 125
  ro2   7 99 125
  rp    3  4 11.11E3
  rss  10 99 666.7E3
  vb    9  0 dc 0
  vc    3 53 dc 3
  ve   54  4 dc 3.700
  vlim  7  8 dc 0
  vlp  91  0 dc 28
  vln   0 92 dc 28
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=185.2E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Maximum Offset Voltage . . . 800 μV (TL052A)
- High Slew Rate . . . 17.8 V/μs Typ at 25°C
- Low Total Harmonic Distortion . . . 0.003% Typ at R_L = 2 kΩ
- Low Noise Voltage . . . 19 nV/√Hz Typ at f = 1 kHz
- Low Input Bias Currents . . . 30 pA Typ

macromodel – applies to TL052, TL052A

```
.subckt TL052      1 2 3 4 5
*
  c1    11 12 3.988E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 2.875E6 -3E6 3E6 3E6 -3E6
  ga     6  0 11 12 292.2E-6
  gcm    0  6 10 99 6.542E-9
  iss    3 10 dc 300.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.422E3
  rd2    4 12 3.422E3
  ro1    8  5 125
  ro2    7 99 125
  rp     3  4 11.11E3
  rss   10 99 666.7E3
  vb     9  0 dc 0
  vc     3 53 dc 3
  ve    54  4 dc 3.700
  vlim   7  8 dc 0
  vlp   91  0 dc 28
  vln    0 92 dc 28
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=185.2E-6 Vto=-1)
.ends
```

TL054
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Maximum Offset Voltage . . . 1.5 mV (TL054A)**
- **High Slew Rate . . . 15.9 V/μs Typ at 25°C**
- **Low Total Harmonic Distortion . . . 0.003% Typ at R_L = 2 kΩ**
- **Low Noise Voltage . . . 21 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Currents . . . 30 pA Typ**
- **Monolithic Construction**

macromodel – applies to TL054, TL054A

```
.subckt TL054      1 2 3 4 5
*
  c1   11 12 3.988E-12
  c2    6  7 15.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 2.875E6 -3E6 3E6 3E6 -3E6
  ga    6  0 11 12 292.2E-6
  gcm   0  6 10 99 6.542E-9
  iss   3 10 dc 300.0E-6
  hlim 90  0 vlim 1K
  j1   11  2 10 jx
  j2   12  1 10 jx
  r2    6  9 100.0E3
  rd1   4 11 3.422E3
  rd2   4 12 3.422E3
  ro1   8  5 125
  ro2   7 99 125
  rp    3  4 11.11E3
  rss  10 99 666.7E3
  vb    9  0 dc 0
  vc    3 53 dc 3
  ve   54  4 dc 3.700
  vlim  7  8 dc 0
  vlp  91  0 dc 28
  vln   0 92 dc 28
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=185.2E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Very Low Power Consumption
- Supply Current . . . 200 µA Typ (per Amplifier)
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Common-Mode Input Voltage Range Includes V_{CC+}
- Output Short-Circuit Protection
- High Input Impedance . . . JFET-Input Stage
- Latch-Up-Free Operation
- High Slew Rate . . . 3.5 V/µs Typ

macromodel – applies to TL060, TL060A, TL060B

```
.subckt TL060    1 2 3 4 5 6 7
*
  c1   11 12 2.332E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 477.4E3 -500E3 500E3 500E3 -500E3
  ga    6  0 11 12 62.84E-6
  gcm   0  6 10 99 2.178E-9
  iss   3 10 dc 35.00E-6
  hlim 90  0 vlim 1K
  j1   11  2 10 jx
  j2   12  1 10 jx
  r2    6  9 100.0E3
  rd1   4 11 15.91E3
  rd2   4 12 15.91E3
  ro1   8  5 200
  ro2   7 99 200
  rp    3  4 150.0E3
  rss  10 99 5.714E6
  vb    9  0 dc 0
  vc    3 53 dc 2.130
  ve   54  4 dc 2.130
  vlim  7  8 dc 0
  vlp  91  0 dc 15
  vln   0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=64E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Very Low Power Consumption
- Supply Current . . . 200 µA Typ (per Amplifier)
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Common-Mode Input Voltage Range Includes V_{CC+}
- Output Short-Circuit Protection
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 3.5 V/µs Typ

macromodel – applies to TL061, TL061A, TL061B

```
.subckt TL061    1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 318.3E3 -300E3 300E3 300E3 -300E3
  ga     6  0 11 12 94.26E-6
  gcm    0  6 10 99 1.607E-9
  iss    3 10 dc 52.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 10.61E3
  rd2    4 12 10.61E3
  ro1    8  5 200
  ro2    7 99 200
  rp     3  4 150.0E3
  rss   10 99 3.810E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=100.5E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Very Low Power Consumption
- Supply Current . . . 200 μA Typ (per Amplifier)
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Common-Mode Input Voltage Range Includes V_{CC+}
- Output Short-Circuit Protection
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 3.5 V/μs Typ

macromodel – applies to TL062, TL062A, TL062B

```
.subckt TL062      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 318.3E3 -300E3 300E3 300E3 -300E3
  ga     6  0 11 12 94.26E-6
  gcm    0  6 10 99 1.607E-9
  iss    3 10 dc 52.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 10.61E3
  rd2    4 12 10.61E3
  ro1    8  5 200
  ro2    7 99 200
  rp     3  4 150.0E3
  rss   10 99 3.810E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=100.5E-6 Vto=-1)
.ends
```

TL064
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Very Low Power Consumption
- Supply Current . . . 200 µA Typ (per Amplifier)
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Common-Mode Input Voltage Range Includes V_{CC+}
- Output Short-Circuit Protection
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 3.5 V/µs Typ

macromodel – applies to TL064, TL064A, TL064B

```
.subckt TL064      1 2 3 4 5
*
  c1   11 12 3.498E-12
  c2    6  7 15.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 318.3E3 -300E3 300E3 300E3 -300E3
  ga    6  0 11 12 94.26E-6
  gcm   0  6 10 99 1.607E-9
  iss   3 10 dc 52.50E-6
  hlim 90  0 vlim 1K
  j1   11  2 10 jx
  j2   12  1 10 jx
  r2    6  9 100.0E3
  rd1   4 11 10.61E3
  rd2   4 12 10.61E3
  ro1   8  5 200
  ro2   7 99 200
  rp    3  4 150.0E3
  rss  10 99 3.810E6
  vb    9  0 dc 0
  vc    3 53 dc 2.200
  ve   54  4 dc 2.200
  vlim  7  8 dc 0
  vlp  91  0 dc 15
  vln   0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=100.5E-6 Vto=-1)
.ends
```

- Very Low, Adjustable ("Programmable") Power Consumption
- Adjustable Supply Current . . . 5 µA to 200 µA
- Very Low Input Bias and Offset Currents
- Wide Supply Range . . . ±1.2 V to ±18 V
- Wide Common-Mode and Differential Voltage Range
- Output Short-Circuit Protection
- High Input Impedance . . . JFET-Input Stage
- Unity-Gain Bandwidth . . . 1 MHz Typ (100 kHz at 25 µW)
- High Slew Rate . . . 3.5 V/µs Typ
- Internal Frequency Compensation
- Latch-Up Free Operation
- Common-Mode Input Voltage Range Includes V_{CC+}

macromodel – applies to TL066M, TL066I, TL066C, TL066AC, TL066BC

```
.subckt TL066    1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 318.3E3 -300E3 300E3 300E3 -300E3
  ga     6  0 11 12 94.26E-6
  gcm    0  6 10 99 1.171E-8
  iss    3 10 dc 52.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 10.61E3
  rd2    4 12 10.61E3
  ro1    8  5 200
  ro2    7 99 200
  rp     3  4 150.0E3
  rss   10 99 3.810E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=100.5E-6 Vto=-1)
.ends
```

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- Common-Mode Input Voltage Range Includes V_{CC+}
- Low Noise . . . 18 nV/√Hz Typ
- High Input Impedance . . . JFET-Input Stage
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ

macromodel – applies to TL070, TL070A

```
.subckt TL070    1 2 3 4 5 6 7
*
  c1    11 12 5.197E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 3.929E6 -4E6 4E6 4E6 -4E6
  ga     6  0 11 12 361.3E-6
  gcm    0  6 10 99 1.908E-9
  iss    3 10 dc 234.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 2.947E3
  rd2    4 12 2.947E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 21.43E3
  rss   10 99 854.7E3
  vb     9  0 dc 0
  vc     3 53 dc 2.180
  ve    54  4 dc 2.180
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=32.50E-12 Beta=311E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- Common-Mode Input Voltage Range Includes V_{CC+}
- Low Noise . . . 18 nV/$\sqrt{Hz}$ Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ

macromodel – applies to TL071, TL071A, TL071B

```
.subckt TL071      1 2 3 4 5
*
  c1   11 12 3.498E-12
  c2    6  7 15.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga    6  0 11 12 282.8E-6
  gcm   0  6 10 99 8.942E-9
  iss   3 10 dc 195.0E-6
  hlim 90  0 vlim 1K
  j1   11  2 10 jx
  j2   12  1 10 jx
  r2    6  9 100.0E3
  rd1   4 11 3.536E3
  rd2   4 12 3.536E3
  ro1   8  5 150
  ro2   7 99 150
  rp    3  4 2.143E3
  rss  10 99 1.026E6
  vb    9  0 dc 0
  vc    3 53 dc 2.200
  ve   54  4 dc 2.200
  vlim  7  8 dc 0
  vlp  91  0 dc 25
  vln   0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```

TL072
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- Common-Mode Input Voltage Range Includes V_{CC+}
- Low Noise . . . 18 nV/√Hz Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ

macromodel – applies to TL072, TL072A, TL072B

```
.subckt TL072      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 8.942E-9
  iss    3 10 dc 195.0E-6
  hlim 90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 2.143E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- Common-Mode Input Voltage Range Includes V_{CC+}
- Low Noise . . . 18 nV/√Hz Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/µs Typ

macromodel – applies to TL074, TL074A, TL074B

```
.subckt TL074      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 8.942E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 2.143E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TL075
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- Common-Mode Input Voltage Range Includes V_{CC+}
- Low Noise . . . 18 nV/√Hz Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ

macromodel – applies to TL075

```
.subckt TL075      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 8.942E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 2.143E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ
- Common-Mode Input Voltage Range Includes V_{CC+}

macromodel – applies to TL080, TL080A

```
.subckt TL080    1 2 3 4 5 6 7
*
  c1   11 12 5.197E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 3.803E6 -4E6 4E6 4E6 -4E6
  ga    6  0 11 12 377.6E-6
  gcm   0  6 10 99 9.882E-9
  iss   3 10 dc 234.0E-6
  hlim 90  0 vlim 1K
  j1   11  2 10 jx
  j2   12  1 10 jx
  r2    6  9 100.0E3
  rd1   4 11 2.852E3
  rd2   4 12 2.852E3
  ro1   8  5 150
  ro2   7 99 150
  rp    3  4 21.43E3
  rss  10 99 854.7E3
  vb    9  0 dc 0
  vc    3 53 dc 2.200
  ve   54  4 dc 2.200
  vlim  7  8 dc 0
  vlp  91  0 dc 25
  vln   0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=332E-6 Vto=-1)
.ends
```

TL081
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ
- Common-Mode Input Voltage Range Includes V_{CC+}

macromodel – applies to TL081, TL081A, TL081B

```
.subckt TL081    1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 8.942E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 2.143E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ
- Common-Mode Input Voltage Range Includes V_{CC+}

macromodel – applies to TL082, TL082A, TL082B

```
.subckt TL082       1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 8.942E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 2.143E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```

TL083
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ
- Common-Mode Input Voltage Range Includes V_{CC+}

macromodel – applies to TL083, TL083A

```
.subckt TL083      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 8.942E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 2.143E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ
- Common-Mode Input Voltage Range Includes V_{CC+}

macromodel – applies to TL084, TL084A, TL084A

```
.subckt TL084      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 8.942E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 2.143E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TL085
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ
- Common-Mode Input Voltage Range Includes V_{CC+}

macromodel – applies to TL085

```
.subckt TL085      1 2 3 4 5
*
  c1    11 12 3.498E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.715E6 -5E6 5E6 5E6 -5E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 8.942E-9
  iss    3 10 dc 195.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 2.143E3
  rss   10 99 1.026E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=270.1E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Low Input Offset Voltage . . . 0.5 mV Max
- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 18 V/µs Typ
- Low Total Harmonic Distortion . . . 0.003% Typ

macromodel – applies to TL087

```
.subckt TL087    1 2 3 4 5
*
  c1    11 12 3.887E-12
  c2     6  7 12.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 6.189E6 -6E6 6E6 6E6 -6E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 3.560E-9
  iss    3 10 dc 270.0E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 60
  ro2    7 99 60
  rp     3  4 11.54E3
  rss   10 99 740.7E3
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=165.3E-6 Vto=-1)
.ends
```

TL088
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Input Offset Voltage . . . 0.5 mV Max
- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 18 V/μs Typ
- Low Total Harmonic Distortion . . . 0.003% Typ

macromodel – applies to TL088

```
.subckt TL088      1 2 3 4 5
*
  c1   11 12 3.887E-12
  c2    6  7 12.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 6.189E6 -6E6 6E6 6E6 -6E6
  ga    6  0 11 12 282.8E-6
  gcm   0  6 10 99 3.560E-9
  iss   3 10 dc 270.0E-6
  hlim 90  0 vlim 1K
  j1   11  2 10 jx
  j2   12  1 10 jx
  r2    6  9 100.0E3
  rd1   4 11 3.536E3
  rd2   4 12 3.536E3
  ro1   8  5 60
  ro2   7 99 60
  rp    3  4 11.54E3
  rss  10 99 740.7E3
  vb    9  0 dc 0
  vc    3 53 dc 2.200
  ve   54  4 dc 2.200
  vlim  7  8 dc 0
  vlp  91  0 dc 30
  vln   0 92 dc 30
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=165.3E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Continuous-Short Circuit Protection
- Wide Common-Mode and Differential Voltage Ranges
- No Frequency Compensation Required
- Low Power Consumption
- No Latch-Up
- Unity-Gain Bandwidth . . . 3 MHz Typ
- Gain and Phase Match Between Amplifiers

macromodel – applies to TL136C

```
.subckt TL136      1 2 3 4 5
*
  c1    11 12 2.664E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 6.365E6 -6E6 6E6 6E6 -6E6
  ga     6  0 11 12 418.0E-6
  gcm    0  6 10 99 6.705E-9
  iee    3 10 dc 34.28E-6
  hlim 90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 2.652E3
  rc2    4 12 2.652E3
  re1   13 10 1.122E3
  re2   14 10 1.122E3
  ree   10 99 5.834E6
  ro1    8  5 125
  ro2    7 99 125
  rp     3  4 24.67E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=121.4)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TL287
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Low Input Offset Voltage . . . 0.5 mV Max
- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 18 V/µs Typ
- Low Total Harmonic Distortion . . . 0.003% Typ

macromodel – applies to TL287

```
.subckt TL287      1 2 3 4 5
*
  c1    11 12 3.887E-12
  c2     6  7 12.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 6.189E6 -6E6 6E6 6E6 -6E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 3.560E-9
  iss    3 10 dc 270.0E-6
  hlim 90   0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 60
  ro2    7 99 60
  rp     3  4 11.54E3
  rss   10 99 740.7E3
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=165.3E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Input Offset Voltage . . . 1 mV Max
- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 18 V/μs Typ
- Low Total Harmonic Distortion . . . 0.003% Typ

macromodel – applies to TL288

```
.subckt TL288      1 2 3 4 5
*
  c1    11 12 3.887E-12
  c2     6  7 12.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 6.189E6 -6E6 6E6 6E6 -6E6
  ga     6  0 11 12 282.8E-6
  gcm    0  6 10 99 3.560E-9
  iss    3 10 dc 270.0E-6
  hlim 90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.536E3
  rd2    4 12 3.536E3
  ro1    8  5 60
  ro2    7 99 60
  rp     3  4 11.54E3
  rss   10 99 740.7E3
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc 2.200
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model jx PJF(Is=15.00E-12 Beta=165.3E-6 Vto=-1)
.ends
```

TL321C
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Wide Range of Supply Voltages:**
  Single Supply . . . 3 V to 30 V
  or Dual Supplies
- **Low Supply Current Drain Independent of Supply Voltage . . . 0.8 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing near Ground**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**
- **Low Input Bias and Offset Parameters:**
  Input Offset Voltage . . . 2 mV Typ
  Input Offset Current . . . 3 nA Typ (TL321I)
  Input Bias Current . . . 45 nA Typ
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . . ±32 V**

macromodel – applies to TL321C, TL321I

```
.subckt TL321    1 2 3 4 5
*
  c1    11 12 4.664E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 15.91E6 -20E6 20E6 20E6 -20E6
  ga     6  0 11 12 132.7E-6
  gcm    0  6 10 99 3.974E-9
  iee    3 10 dc 10.09E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 7.957E3
  rc2    4 12 7.957E3
  re1   13 10 2.759E3
  re2   14 10 2.759E3
  ree   10 99 19.82E6
  ro1    8  5 50
  ro2    7 99 50
  rp     3  4 15.08E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc .6
  vlim   7  8 dc 0
  vlp   91  0 dc 40
  vln    0 92 dc 40
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=111.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Wide Range of Supply Voltages:
  Single Supply . . . 3 V to 36 V
  or Dual Supplies
- Class AB Output Stage
- True Differential Input Stage
- Low Input Bias Current
- Internal Frequency Compensation
- Short-Circuit Protection

macromodel – applies to TL322C, TL322I

```
.subckt TL322      1 2 3 4 5
*
  c1    11 12 7.544E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 42.44E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 130.7E-6
  gcm    0  6 10 99 2.235E-9
  iee    3 10 dc 12.40E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 7.957E3
  rc2    4 12 7.957E3
  re1   13 10 3.529E3
  re2   14 10 3.529E3
  ree   10 99 16.13E6
  ro1    8  5 37.50
  ro2    7 99 37.50
  rp     3  4 43.62E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 30
  vln    0 92 dc 30
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=30)
.ends
```

TLC251C (HIGH BIAS) OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Wide Range of Supply Voltages . . . 1.4 V to 16 V
- True Single-Supply Operation
- Common-Mode Input Voltage Range Includes the Negative Rail
- Low Noise . . . 30 nV/√Hz Typ at 1 kHz

macromodel – applies to TLC251, TLC251A, TLC251B

```
.subckt TLC251H  1 2 3 4 5
*
  c1    11 12 8.392E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.845E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 289.1E-6
  gcm    0  6 10 99 6.471E-9
  iss    3 10 dc 90.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.459E3
  rd2    4 12 3.459E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 10.00E3
  rss   10 99 2.222E6
  vb     9  0 dc 0
  vc     3 53 dc 1.400
  ve    54  4 dc 1.400
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=504E-6 Vto=-.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Wide Range of Supply Voltages . . . 1.4 V to 16 V
- True Single-Supply Operation
- Common-Mode Input Voltage Range Includes the Negative Rail
- Equivalent Input Noise Voltage . . . 70 nV/√Hz Typ at 1 kHz

macromodel – applies to TLC251, TLC251A, TLC251B

```
.subckt TLC251L  1 2 3 4 5
*
  c1    11 12 10.73E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 530.5E6 -500E6 500E6 500E6 -500E6
  ga     6  0 11 12 12.57E-6
  gcm    0  6 10 99 281.4E-12
  iss    3 10 dc 800.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 79.57E3
  rd2    4 12 79.57E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 1.000E6
  rss   10 99 250.0E6
  vb     9  0 dc 0
  vc     3 53 dc 1.300
  ve    54  4 dc 1.300
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=197E-6 Vto=-.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TLC251C (MEDIUM BIAS) OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Wide Range of Supply Voltages . . . 1.4 V to 16 V**
- **True Single-Supply Operation**
- **Common-Mode Input Voltage Range Includes the Negative Rail**
- **Low Noise . . . 38 nV/√Hz Typ at 1 kHz**

macromodel – applies to TLC251, TLC251A, TLC251B

```
.subckt TLC251M  1 2 3 4 5
*
  c1    11 12 10.73E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 42.44E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 87.97E-6
  gcm    0  6 10 99 1.970E-9
  iss    3 10 dc 12.00E-6
  hlim 90   0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 11.37E3
  rd2    4 12 11.37E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 66.67E3
  rss   10 99 16.67E6
  vb     9  0 dc 0
  vc     3 53 dc 1.300
  ve    54  4 dc 1.300
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=460E-6 Vto=-.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- A-Suffix Versions Offer 5-mV V_{IO}
- B-Suffix Versions Offer 2-mV V_{IO}
- Wide Range of Supply Voltages . . . 1.4 V to 16 V
- True Single-Supply Operation
- Common-Mode Input Voltage Includes the Negative Rail
- Low Noise . . . 25 nV/√Hz Typ at f = 1 kHz

macromodel – applies to TLC252, TLC252A, TLC252B

```
.subckt TLC252C  1 2 3 4 5
*
  c1    11 12 8.392E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.845E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 289.1E-6
  gcm    0  6 10 99 6.471E-9
  iss    3 10 dc 90.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.459E3
  rd2    4 12 3.459E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 10.00E3
  rss   10 99 2.222E6
  vb     9  0 dc 0
  vc     3 53 dc 1.400
  ve    54  4 dc 1.400
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=504E-6 Vto=-.1)
.ends
```

TLC254C
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- A-Suffix Versions Offer 5-mV V_{IO}
- B-Suffix Versions Offer 2-mV V_{IO}
- Wide Range of Supply Voltages . . . 1.4 V to 16 V
- True Single-Supply Operation
- Common-Mode Input Voltage Includes the Negative Rail
- Low Noise . . . 25 nV/√Hz Typ at f = 1 kHz

macromodel – applies to TLC254, TLC254A, TLC254B

```
.subckt TLC254C  1 2 3 4 5
*
  c1    11 12 8.392E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.845E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 289.1E-6
  gcm    0  6 10 99 6.471E-9
  iss    3 10 dc 90.00E-6
  hlim 90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.459E3
  rd2    4 12 3.459E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 10.00E3
  rss   10 99 2.222E6
  vb     9  0 dc 0
  vc     3 53 dc 1.400
  ve    54  4 dc 1.400
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=504E-6 Vto=-.1)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- A-Suffix Versions Offer 5-mV V_{IO}
- B-Suffix Versions Offer 2-mV V_{IO}
- Wide Range of Supply Voltages . . . 1.4 V to 16 V
- True Single-Supply Operation
- Common-Mode Input Voltage Includes the Negative Rail
- Equivalent Input Noise Voltage . . . 68 nV/√Hz Typ at f = 1 kHz

macromodel – applies to TLC25L2, TLC25L2A, TLC25L2B

```
.subckt TLC25L2C 1 2 3 4 5
*
  c1    11 12 10.73E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 530.5E6 -500E6 500E6 500E6 -500E6
  ga     6  0 11 12 12.57E-6
  gcm    0  6 10 99 281.4E-12
  iss    3 10 dc 800.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 79.57E3
  rd2    4 12 79.57E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 1.000E6
  rss   10 99 250.0E6
  vb     9  0 dc 0
  vc     3 53 dc 1.300
  ve    54  4 dc 1.300
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=197E-6 Vto=-.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- A-Suffix Versions Offer 5-mV V_{IO}
- B-Suffix Versions Offer 2-mV V_{IO}
- Wide Range of Supply Voltages . . . 1.4 V to 16 V
- True Single-Supply Operation
- Common-Mode Input Voltage Includes the Negative Rail
- Equivalent Input Noise Voltage . . . 68 nV/√Hz Typ at f = 1 kHz

macromodel – applies to TLC25L4, TLC25L4A, TLC25L4B

```
.subckt TLC25L4C 1 2 3 4 5
*
  c1    11 12 10.73E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 530.5E6 -500E6 500E6 500E6 -500E6
  ga     6  0 11 12 12.57E-6
  gcm    0  6 10 99 281.4E-12
  iss    3 10 dc 800.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 79.57E3
  rd2    4 12 79.57E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 1.000E6
  rss   10 99 250.0E6
  vb     9  0 dc 0
  vc     3 53 dc 1.300
  ve    54  4 dc 1.300
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=197E-6 Vto=-.1)
.ends
```

JANUARY 1990

- A-Suffix Versions Offer 5-mV V_{IO}
- B-Suffix Versions Offer 2-mV V_{IO}
- Wide Range of Supply Voltages . . . 1.4 V to 16 V
- True Single-Supply Operation
- Common-Mode Input Voltage Includes the Negative Rail
- Low Noise . . . 32 nV/√Hz Typ at f = 1 kHz

macromodel – applies to TLC25M2, TLC25M2A, TLC25M2B

```
.subckt TLC25M2C 1 2 3 4 5
*
  c1    11 12 10.73E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 42.44E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 87.97E-6
  gcm    0  6 10 99 1.970E-9
  iss    3 10 dc 12.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 11.37E3
  rd2    4 12 11.37E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 66.67E3
  rss   10 99 16.67E6
  vb     9  0 dc 0
  vc     3 53 dc 1.300
  ve    54  4 dc 1.300
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=460E-6 Vto=-.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TLC25M4C
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- A-Suffix Versions Offer 5-mV V_{IO}
- B-Suffix Versions Offer 2-mV V_{IO}
- Wide Range of Supply Voltages . . . 1.4 V to 16 V
- True Single-Supply Operation
- Common-Mode Input Voltage Includes the Negative Rail
- Low Noise . . . 32 nV/√Hz Typ at f = 1 kHz

macromodel – applies to TLC25M4, TLC25M4A, TLC25M4B

```
.subckt TLC25M4C 1 2 3 4 5
*
  c1    11 12 10.73E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 42.44E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 87.97E-6
  gcm    0  6 10 99 1.970E-9
  iss    3 10 dc 12.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 11.37E3
  rd2    4 12 11.37E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 66.67E3
  rss   10 99 16.67E6
  vb     9  0 dc 0
  vc     3 53 dc 1.300
  ve    54  4 dc 1.300
  vlim   7  8 dc 0
  vlp   91  0 dc 15
  vln    0 92 dc 15
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=460E-6 Vto=-.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TLC271C (HIGH BIAS) OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Input Offset Voltage Drift . . . 0.1 μV/moTyp, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  - −55°C to 125°C . . . 5 V to 16 V
  - −40°C to 85°C . . . 4 V to 16 V
  - 0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . 25 nV/√Hz at f = 1 kHz
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC271, TLC271A, TLC271B

```
.subckt TLC271H  1 2 3 4 5
*
  c1    11 12 8.0E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.819E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 263.9E-6
  gcm    0  6 10 99 14.84E-9
  iss    3 10 dc 69.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.789E3
  rd2    4 12 3.789E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 10.53E3
  rss   10 99 2.899E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=530E-6 Vto=0)
.ends
```

TLC271C (LOW BIAS) OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Input Offset Voltage Drift . . . 0.1 µV/moTyp, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  - −55°C to 125°C . . . 5 V to 16 V
  - −40°C to 85°C . . . 4 V to 16 V
  - 0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Equivalent Input Noise Voltage . . . 68 nV/√Hz at f = 1 kHz
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC271, TLC271A, TLC271B

```
.subckt TLC271L  1 2 3 4 5
*
  c1    11 12 9.602E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.119E9 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 10.37E-6
  gcm    0  6 10 99 82.36E-12
  iss    3 10 dc 600.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 96.45E3
  rd2    4 12 96.45E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 714.3E3
  rss   10 99 333.3E6
  vb     9  0 dc 0
  vc     3 53 dc 1.800
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=130.4E-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

- **Input Offset Voltage Drift . . . 0.1 μV/moTyp, Including the First 30 Days**
- **Wide Range of Supply Voltages over Specified Temperature Range:**
  - **−55°C to 125°C . . . 5 V to 16 V**
  - **−40°C to 85°C . . . 4 V to 16 V**
  - **0°C to 70°C . . . 3 V to 16 V**
- **Single-Supply Operation**
- **Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)**
- **Low Noise . . . 32 nV/√Hz at f = 1 kHz**
- **Output Voltage Range Includes Negative Rail**
- **High Input Impedance . . . 10^{12} Ω Typ**
- **ESD-Protection Circuitry**
- **Small-Outline Package Option Also Available in Tape and Reel**
- **Designed-In Latch-Up Immunity**

macromodel – applies to TLC271, TLC271A, TLC271B

```
.subckt TLC271M  1 2 3 4 5
*
  c1    11 12 12.044E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 38.90E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 94.26E-6
  gcm    0  6 10 99 1.058E-9
  iss    3 10 dc 8.400E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 10.61E3
  rd2    4 12 10.61E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 69.93E3
  rss   10 99 23.81E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=515E-6 Vto=0.05)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Input Offset Voltage:
  TLC272B . . . 2 mV Max at 25°C,
  V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 µV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  −55°C to 125°C . . . 4 V to 16 V
  −40°C to 85°C . . . 4 V to 16 V
  0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . 25 nV/√Hz at f = 1 kHz
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC272, TLC272A, TLC272B

```
.subckt TLC272      1 2 3 4 5
*
  c1    11 12 8.0E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.819E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 263.9E-6
  gcm    0  6 10 99 14.84E-9
  iss    3 10 dc 69.00E-6
  hlim 90   0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.789E3
  rd2    4 12 3.789E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 10.53E3
  rss   10 99 2.899E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=530E-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TLC274
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Input Offset Voltage:
  TLC274B . . . 2 mV Max at 25°C,
  V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 μV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  −55°C to 125°C . . . 4 V to 16 V
  −40°C to 85°C . . . 4 V to 16 V
  0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . 25 nV/√Hz at f = 1 kHz
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC274, TLC274A, TLC274B

```
.subckt TLC274     1 2 3 4 5
*
  c1    11 12 8.0E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2)  (3,0)  (4,0)  0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.819E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 263.9E-6
  gcm    0  6 10 99 14.84E-9
  iss    3 10 dc 69.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.789E3
  rd2    4 12 3.789E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 10.53E3
  rss   10 99 2.899E6
  vb     9  0 dc 0
  vc     3 53 dc 2.200
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=530E-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TLC277
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Trimmed Offset Voltage . . . 500 μV Max at 25°C, V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 μV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  - −55°C to 125°C . . . 4 V to 16 V
  - −40°C to 85°C . . . 4 V to 16 V
  - 0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . 25 nV/√Hz at f = 1 kHz
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC277

```
.subckt TLC277   1 2 3 4 5
*
  c1    11 12  6.521E-12
  c2     6  7  15.00E-12
  dc     5 53  dx
  de    54  5  dx
  dlp   90 91  dx
  dln   92 90  dx
  dp     4  3  dx
  egnd  99  0  poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99  poly(5) vb vc ve vlp vln 0 1.664E6 -2E6 2E6 2E6 -2E6
  ga     6  0  11 12 254.5E-6
  gcm    0  6  10 99 14.31E-9
  iss    3 10  dc 69.00E-6
  hlim  90  0  vlim 1K
  j1    11  2  10 jx
  j2    12  1  10 jx
  r2     6  9  100.0E3
  rd1    4 11  3.929E3
  rd2    4 12  3.929E3
  ro1    8  5  85
  ro2    7 99  85
  rp     3  4  10.53E3
  rss   10 99  2.899E6
  vb     9  0  dc 0
  vc     3 53  dc 2.20
  ve    54  4  dc 0.7
  vlim   7  8  dc 0
  vlp   91  0  dc 20
  vln    0 92  dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=600E-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Trimmed Offset Voltage . . . 900 μV Max at 25°C, V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 μV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  - −55°C to 125°C . . . 4 V to 16 V
  - −40°C to 85°C . . . 4 V to 16 V
  - 0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . 25 nV/√Hz at f = 1 kHz
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC279

```
.subckt TLC279     1 2 3 4 5
*
  c1    11 12 6.521E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.664E6 -2E6 2E6 2E6 -2E6
  ga     6  0 11 12 254.5E-6
  gcm    0  6 10 99 14.31E-9
  iss    3 10 dc 69.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 3.929E3
  rd2    4 12 3.929E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 10.53E3
  rss   10 99 2.899E6
  vb     9  0 dc 0
  vc     3 53 dc 2.20
  ve    54  4 dc 0.7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=600E-6 Vto=0)
.ends
```

TLC27L2
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Input Offset Voltage:
  TLC27L2B . . . 2 mV Max at 25°C,
  V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 µV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  −55°C to 125°C . . . 4 V to 16 V
  −40°C to 85°C . . . 4 V to 16 V
  0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Ultralow Power . . . 100 µW Typ at 25°C, V_{DD} = 5 V
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC27L2, TLC27L2A, TLC27L2B

```
.subckt TLC27L2  1 2 3 4 5
*
  c1    11 12 8.002E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 975.8E6 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 10.37E-6
  gcm    0  6 10 99 146.5E-12
  iss    3 10 dc 600.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 96.45E3
  rd2    4 12 96.45E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 689.7E3
  rss   10 99 333.3E6
  vb     9  0 dc 0
  vc     3 53 dc 1.650
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=200E-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Input Offset Voltage:
  TLC27L4B . . . 2 mV Max at 25°C,
  V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 µV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  −55°C to 125°C . . . 4 V to 16 V
  −40°C to 85°C . . . 4 V to 16 V
  0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Ultralow Power . . . 195 µW Typ at 25°C, V_{DD} = 5 V
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC27L4, TLC27L4A, TLC27L4B

```
.subckt TLC27L4  1 2 3 4 5
*
  c1    11 12 8.002E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 975.8E6 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 10.37E-6
  gcm    0  6 10 99 146.5E-12
  iss    3 10 dc 600.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 96.45E3
  rd2    4 12 96.45E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 689.7E3
  rss   10 99 333.3E6
  vb     9  0 dc 0
  vc     3 53 dc 1.650
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=200E-6 Vto=0)
.ends
```

3

Operational Amplifier Macromodels

TLC27L7
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Trimmed Offset Voltage . . . 500 μV Max at 25°C, V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 μV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  - −55°C to 125°C . . . 4 V to 16 V
  - −40°C to 85°C . . . 4 V to 16 V
  - 0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Ultralow Power . . . 100 μW Typ at 25°C, V_{DD} = 5 V
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

3

Operational Amplifier Macromodels

macromodel – applies to TLC27L7

```
.subckt TLC27L7  1 2 3 4 5
*
  c1    11 12 8.002E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 975.8E6 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 10.37E-6
  gcm    0  6 10 99 146.5E-12
  iss    3 10 dc 600.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 96.45E3
  rd2    4 12 96.45E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 689.7E3
  rss   10 99 333.3E6
  vb     9  0 dc 0
  vc     3 53 dc 1.650
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=200E-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Trimmed Offset Voltage . . . 900 μV Max at 25°C, V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 μV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  - −55°C to 125°C . . . 4 V to 16 V
  - −40°C to 85°C . . . 4 V to 16 V
  - 0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Ultralow Power . . . 195 μW Typ at 25°C, V_{DD} = 5 V
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC27L9

```
.subckt TLC27L9  1 2 3 4 5
*
  c1    11 12 8.002E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 975.8E6 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 10.37E-6
  gcm    0  6 10 99 146.5E-12
  iss    3 10 dc 600.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 96.45E3
  rd2    4 12 96.45E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 689.7E3
  rss   10 99 333.3E6
  vb     9  0 dc 0
  vc     3 53 dc 1.650
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=200E-6 Vto=0)
.ends
```

TLC27M2
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- **Input Offset Voltage:**
  TLC27M2B . . . 2 mV Max at 25°C,
  V_{DD} = 5 V
- **Input Offset Voltage Drift . . . 0.1 µV/mo Typ, Including the First 30 Days**
- **Wide Range of Supply Voltages over Specified Temperature Range:**
  −55°C to 125°C . . . 4 V to 16 V
  −40°C to 85°C . . . 4 V to 16 V
  0°C to 70°C . . . 3 V to 16 V
- **Single-Supply Operation**
- **Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)**
- **Low Noise . . . 32 nV/√Hz Typ at f = 1 kHz**
- **Output Voltage Range Includes Negative Rail**
- **High Input Impedance . . . 10^{12} Ω Typ**
- **ESD-Protection Circuitry**
- **Small-Outline Package Option Also Available in Tape and Reel**
- **Designed-In Latch-Up Immunity**

macromodel – applies to TLC27M2, TLC27M2A, TLC27M2B

```
.subckt TLC27M2  1 2 3 4 5
*
  c1    11 12 12.044E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 38.14E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 84.83E-6
  gcm    0  6 10 99 1.693E-9
  iss    3 10 dc 8.400E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 11.79E3
  rd2    4 12 11.79E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 69.93E3
  rss   10 99 23.81E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=50.00E-15 Beta=475E-6 Vto=0)
.ends
```


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POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Input Offset Voltage:
  TLC27M4B . . . 2 mV Max at 25°C,
  V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 μV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  −55°C to 125°C . . . 4 V to 16 V
  −40°C to 85°C . . . 4 V to 16 V
  0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . 32 nV/√Hz Typ at f = 1 kHz
- Low Power . . . 2.1 mW Typ at 25°C, V_{DD} = 5 V
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC27M4, TLC27M4A, TLC27M4B

```
.subckt TLC27M4  1 2 3 4 5
*
  c1    11 12 12.044E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 38.14E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 84.83E-6
  gcm    0  6 10 99 1.693E-9
  iss    3 10 dc 8.400E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 11.79E3
  rd2    4 12 11.79E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 69.93E3
  rss   10 99 23.81E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=50.00E-15 Beta=475E-6 Vto=0)
.ends
```

TLC27M7
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Trimmed Offset Voltage . . . 500 μV Max at 25°C, V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 μV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  - −55°C to 125°C . . . 4 V to 16 V
  - −40°C to 85°C . . . 4 V to 16 V
  - 0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . 32 nV/√Hz Typ at f = 1 kHz
- Low Power . . . 2.1 mW Typ at 25°C, V_{DD} = 5 V
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC27M7

```
.subckt TLC27M7  1 2 3 4 5
*
  c1    11 12 12.044E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 38.14E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 84.83E-6
  gcm    0  6 10 99 1.693E-9
  iss    3 10 dc 8.400E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 11.79E3
  rd2    4 12 11.79E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 69.93E3
  rss   10 99 23.81E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=50.00E-15 Beta=475E-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Trimmed Offset Voltage . . . 900 µV Max at 25°C, V_{DD} = 5 V
- Input Offset Voltage Drift . . . 0.1 µV/mo Typ, Including the First 30 Days
- Wide Range of Supply Voltages over Specified Temperature Range:
  −55°C to 125°C . . . 4 V to 16 V
  −40°C to 85°C . . . 4 V to 16 V
  0°C to 70°C . . . 3 V to 16 V
- Single-Supply Operation
- Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)
- Low Noise . . . 32 nV/√Hz Typ at f = 1 kHz
- Low Power . . . 2.1 mW Typ at 25°C, V_{DD} = 5 V
- Output Voltage Range Includes Negative Rail
- High Input Impedance . . . 10^{12} Ω Typ
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel
- Designed-In Latch-Up Immunity

macromodel – applies to TLC27M9

```
.subckt TLC27M9  1 2 3 4 5
*
  c1    11 12 12.044E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 38.14E6 -40E6 40E6 40E6 -40E6
  ga     6  0 11 12 84.83E-6
  gcm    0  6 10 99 1.693E-9
  iss    3 10 dc 8.400E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 11.79E3
  rd2    4 12 11.79E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 69.93E3
  rss   10 99 23.81E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=50.00E-15 Beta=475E-6 Vto=0)
.ends
```

TLC1078 OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Power Dissipation as Low as 10 µW Typ per Amplifier
- Operates on a Single Silver-Oxide Watch Battery, V_{DD} = 1.4 V Min
- V_{IO} . . . 450 µV Max in DIP and Small-Outline Package
- Input Offset Voltage Drift . . . 0.1 µV/mo Typ, Including the First 30 Days
- High-Impedance LinCMOS™ Inputs . . . I_{IB} = 0.6 pA Typ
- High Open-Loop Gain . . . 850,000 Typ
- Output Drive Capability > 20 mA
- Slew Rate . . . 47 V/ms Typ
- Common-Mode Input Voltage Range Extends Below the Negative Rail
- Output Voltage Range Includes Negative Rail
- ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel

macromodel – applies to TLC1078

```
.subckt TLC1078  1 2 3 4 5
*
  c1    11 12 14.602E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 522.8E6 -500E6 500E6 500E6 -500E6
  ga     6  0 11 12 21.68E-6
  gcm    0  6 10 99 172.2E-12
  iss    3 10 dc 705.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 46.13E3
  rd2    4 12 46.13E3
  ro1    8  5 75
  ro2    7 99 75
  rp     3  4 689.7E3
  rss   10 99 283.7E6
  vb     9  0 dc 0
  vc     3 53 dc 1.600
  ve    54  4 dc 0.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=340E-6 Vto=0)
.ends
```

- Power Dissipation as Low as 10 µW Typ per Amplifier
- Operates on a Single Silver-Oxide Watch Battery, V_{DD} = 1.4 V Min
- V_{IO} . . . 850 µV Max in DIP and Small-Outline Package
- Input Offset Voltage Drift . . . 0.1 µV/mo Typ, Including the First 30 Days
- High-Impedance LinCMOS™ Inputs . . . I_{IB} = 0.6 pA Typ
- High Open-Loop Gain . . . 850,000 Typ
- Output Drive Capability > 20 mA
- Slew Rate . . . 47 V/ms Typ
- Common-Mode Input Voltage Range Extends Below the Negative Rail
- Output Voltage Range Includes Negative Rail
- ESD-Protection Circuitry
- 14-Pin Small-Outline Package Option Also Available in Tape and Reel

macromodel – applies to TLC1079

```
.subckt TLC1079  1 2 3 4 5
*
  c1    11 12 8.002E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 975.8E6 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 10.37E-6
  gcm    0  6 10 99 146.5E-12
  iss    3 10 dc 600.0E-9
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 96.45E3
  rd2    4 12 96.45E3
  ro1    8  5 85
  ro2    7 99 85
  rp     3  4 689.7E3
  rss   10 99 333.3E6
  vb     9  0 dc 0
  vc     3 53 dc 1.650
  ve    54  4 dc .7
  vlim   7  8 dc 0
  vlp   91  0 dc 20
  vln    0 92 dc 20
.model dx D(Is=800.0E-18)
.model jx PJF(Is=350.0E-15 Beta=200E-6 Vto=0)
.ends
```

TLC2201
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- TLC2201B is 100% Tested for Noise:
  25 nV/√Hz Max at f = 10 Hz
  12 nV/√Hz Max at f = 1 kHz
- Low Input Offset Voltage . . . 200 μV Max
- Excellent Offset Voltage Stability with Temperature . . . 0.5 μV/°C Typ
- Low Input Bias Current . . . 1 pA Typ at T_A = 25°C
- Fully Specified for Both Single-Supply and Split-Supply Operation
- Common-Mode Input Voltage Range Includes the Negative Rail

macromodel – applies to TLC2201, TLC2201A, TLC2201B

```
.subckt TLC2201  1 2 3 4 5
*
  c1    11 12 4.054E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 2.986E6 -3E6 3E6 3E6 -3E6
  ga     6  0 11 12 179.1E-6
  gcm    0  6 10 99 318.5E-12
  iss    3 10 dc 40.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 5.584E3
  rd2    4 12 5.584E3
  ro1    8  5 188
  ro2    7 99 187
  rp     3  4 9.091E3
  rss   10 99 4.938E6
  vb     9  0 dc 0
  vc     3 53 dc .9
  ve    54  4 dc .8
  vlim   7  8 dc 0
  vlp   91  0 dc 3
  vln    0 92 dc 3
.model dx D(Is=800.0E-18)
.model jx PJF(Is=500.0E-15 Beta=600E-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- Extremely Low Offset Voltage . . . 1 µV Max
- Extremely Low Change in Offset Voltage with Temperature . . . 0.003 µV/°C Typ
- Low Input Offset Current . . . 500 pA Max at T_A = −55°C to 125°C
- A_{VD} . . . 135 dB Min
- CMRR and k_{SVR} . . . 120 dB Min
- Single-Supply Operation
- Common-Mode Input Voltage Range Includes the Negative Rail
- No Noise Degradation with External Capacitors Connected to V_{DD-}

macromodel – applies to TLC2652, TLC2652A

```
.subckt TLC2652  1 2 3 4 5
*
  c1    11 12 4.354E-12
  c2     6  7 15.00E-12
  css   10 99 1.607E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2)  (3,0)  (4,0)  0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.070E9 -1E9 1E9 1E9 -1E9
  ga     6  0 11 12 179.1E-6
  gcm    0  6 10 99 17.91E-12
  iss    3 10 dc 46.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 5.584E3
  rd2    4 12 5.584E3
  ro1    8  5 165
  ro2    7 99 165
  rp     3  4 6.667E3
  rss   10 99 4.301E6
  vb     9  0 dc 0
  vc     3 53 dc .9
  ve    54  4 dc .8
  vlim   7  8 dc 0
  vlp   91  0 dc 3
  vln    0 92 dc 3
.model dx D(Is=800.0E-18)
.model jx PJF(Is=2.000E-12 Beta=500E-6 Vto=0.05)
.ends
```

JANUARY 1990

- Input Noise Voltage:
  0.5 µV p-p Typ, f = 0 to 1 Hz
  1.5 µV p-p Typ, f = 0 to 10 Hz
  47 nV/√Hz Typ, f = 10 Hz
  13 nV/√Hz Typ, f = 1 kHz
- High Chopping Frequency . . . 10 kHz Typ
- No Clock Noise Below 10 kHz
- No Intermodulation Error Below 5 kHz
- Low Input Offset Voltage . . . 10 µV Max
- Excellent Offset Voltage Stability with Temperature . . . 0.3 µV/°C Max
- A_{VD} . . . 135 dB Min
- CMRR . . . 110 dB Min
- k_{SVR} . . . 120 dB Min
- Single-Supply Operation
- Common-Mode Input Voltage Range Includes the Negative Rail
- No Noise Degradation with External Capacitors Connected to V_{DD-}

macromodel – applies to TLC2654, TLC2654A

```
.subckt TLC2654  1 2 3 4 5
*
  c1    11 12 4.354E-12
  c2     6  7 15.00E-12
  css   10 99 12.75E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2)  (3,0)  (4,0)  0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 1.903E9 -2E9 2E9 2E9 -2E9
  ga     6  0 11 12 179.1E-6
  gcm    0  6 10 99 100.7E-12
  iss    3 10 dc 55.50E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 5.584E3
  rd2    4 12 5.584E3
  ro1    8  5 165
  ro2    7 99 165
  rp     3  4 6.667E3
  rss   10 99 3.604E6
  vb     9  0 dc 0
  vc     3 53 dc .9
  ve    54  4 dc .8
  vlim   7  8 dc 0
  vlp   91  0 dc 3
  vln    0 92 dc 3
.model dx D(Is=800.0E-18)
.model jx PJF(Is=25.00E-12 Beta=400e-6 Vto=0)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

available features

- Supply Current . . . 230 μA Max
- High Unity-Gain Bandwidth . . . 2 MHz Typ
- High Slew Rate . . . 0.7 V/μs Min
- Supply Current Change Over Military Temp Range . . . 10 μA Typ
- Specified for Both 5-V Single-Supply and ± 15 V Operation
- Phase-Reversal Protection
- High Open-Loop Gain . . . 6.5 V/μV (136 dB) Typ
- Low Offset Voltage . . . 100 μV Max
- Offset Voltage Drift with Time . . . 0.005 μV/mo Typ
- Low Input Bias Current . . . 50 nA Max
- Low Noise Voltage . . . 19 nV/√Hz typ at f = 10 Hz

macromodel – applies to TLE2021, TLE2021A, TLE2021B

```
.subckt TLE2021  1 2 3 4 5
*
  c1    11 12 6.244E-12
  c2     6  7 13.4E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 547.3E6 -500E6 500E6 500E6 -500E6
  ga     6  0 11 12 188.5E-6
  gcm    0  6 10 99 335.2E-12
  iee    3 10 dc 15.67E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 5.305E3
  rc2    4 12 5.305E3
  re1   13 10 1.467E3
  re2   14 10 1.467E3
  ree   10 99 14.76E6
  ro1    8  5 62
  ro2    7 99 63
  rp     3  4 160.9E3
  vb     9  0 dc 0
  vc     3 53 dc 1.400
  ve    54  4 dc 1.600
  vlim   7  8 dc 0
  vlp   91  0 dc 3.200
  vln    0 92 dc 3.200
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=270)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

available features

- Supply Current . . . 500 μA Max
- High Unity-Gain Bandwidth . . . 2.8 MHz Typ
- High Slew Rate . . . 0.7 V/μs Min
- Supply Current Change Over Military Temp Range . . . 37 μA Typ
- Specified for Both 5-V Single-Supply and ±15 V Operation
- Phase-Reversal Protection
- High Open-Loop Gain . . . 10 V/μV (140 dB) Typ
- Low Offset Voltage . . . 150 μV Max
- Offset Voltage Drift with Time . . . 0.005 μV/mo Typ
- Low Input Bias Current . . . 50 nA Max
- Low Noise Voltage . . . 19 nV/√Hz typ at f = 10 Hz

macromodel – applies to TLE2022, TLE2022A, TLE2022B

```
.subckt TLE2022  1 2 3 4 5
*
  c1    11 12 6.814E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 45.47E6 -50E6 50E6 50E6 -50E6
  ga     6  0 11 12 377.9E-6
  gcm    0  6 10 99 7.84E-10
  iee    3 10 dc 18.07E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 2.842E3
  rc2    4 12 2.842E3
  re1   13 10 -31.95
  re2   14 10 -31.95
  ree   10 99 11.07E6
  ro1    8  5 250
  ro2    7 99 250
  rp     3  4 137.2E3
  vb     9  0 dc 0
  vc     3 53 dc 1.300
  ve    54  4 dc 1.500
  vlim   7  8 dc 0
  vlp   91  0 dc 3
  vln    0 92 dc 3
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=257.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

available features

- Supply Current . . . 1 mA Max
- High Unity-Gain Bandwidth . . . 2.8 MHz Typ
- High Slew Rate . . . 0.7 V/μs Min
- Supply Current Change Over Military Temp Range . . . 50 μA Typ
- Specified for Both 5-V/Gnd and ±15 V Operation
- Phase-Reversal Protection
- High Open-Loop Gain . . . 7 V/μV (137 dB) Typ
- Low Offset Voltage . . . 500 μV Max
- Offset Voltage Drift with Time . . . 0.005 μV/mo Typ
- Low Input Bias Current . . . 50 nA Max
- Low Noise Voltage . . . 19 nV/√Hz typ at f = 10 Hz

macromodel – applies to TLE2024, TLE2024A, TLE2024B

```
.subckt TLE2024  1 2 3 4 5
*
  c1    11 12 6.814E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 22.73E6 -20E6 20E6 20E6 -20E6
  ga     6  0 11 12 372.9E-6
  gcm    0  6 10 99 1.572E-9
  iee    3 10 dc 18.10E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    4 11 2.842E3
  rc2    4 12 2.842E3
  re1   13 10 -31.90
  re2   14 10 -31.90
  ree   10 99 11.05E6
  ro1    8  5 250
  ro2    7 99 250
  rp     3  4 137.2E3
  vb     9  0 dc 0
  vc     3 53 dc 1.500
  ve    54  4 dc 1.500
  vlim   7  8 dc 0
  vlp   91  0 dc 3
  vln    0 92 dc 3
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=180)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

TLE2061
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

available features

- Excellent Output Drive Capability:
  V_O = ± 2.5 V Min at R_L = 100 Ω,
  $V_{CC\pm}$ = ± 5 V
  V_O = ± 12.5 V Min at R_L = 600 Ω,
  $V_{CC\pm}$ = ± 15 V
- Low Supply Current . . . 255 µA Typ
- High Unity-Gain Bandwidth . . . 2.1 MHz Typ
- High Slew Rate . . . 3.4 V/µs Typ
- Wide Operating Supply Voltage Range . . .
  $V_{CC\pm}$ = ± 3.5 V to ± 20V
- High Open-Loop Gain . . . 280 V/mV Typ
- Low Offset Voltage . . . 500 µV Max
- Low Offset Voltage Drift with Time . . .
  0.04 µV/mo Typ
- Low Input Bias Current . . . 5 pA Typ

macromodel – applies to TLE2061, TLE2061A, TLE2061B

```
.subckt TLE2061  1 2 3 4 5
*
  c1    11 12 1.457E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.357E6 -4E6 4E6 4E6 -4E6
  ga     6  0 11 12 188.5E-6
  gcm    0  6 10 99 3.352E-9
  iss    3 10 dc 51.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 5.305E3
  rd2    4 12 5.305E3
  ro1    8  5 280
  ro2    7 99 280
  rp     3  4 113.2E3
  rss   10 99 3.922E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc 2
  vlim   7  8 dc 0
  vlp   91  0 dc 50
  vln    0 92 dc 50
.model dx D(Is=800.0E-18)
.model jx PJF(Is=2.000E-12 Beta=423E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

available features

- Excellent Output Drive Capability:
  V_O = ± 2.5 V Min at R_L = 100 Ω,
  $V_{CC\pm}$ = ± 5 V
  V_O = ± 12.5 V Min at R_L = 600 Ω,
  $V_{CC\pm}$ = ± 15 V
- Low Supply Current . . . 280 µA Typ per Amplifier
- High Unity-Gain Bandwidth . . . 2.1 MHz Typ
- High Slew Rate . . . 3.4 V/µs Typ
- Wide Operating Supply Voltage Range . . . $V_{CC\pm}$ = ± 3.5 V to ± 20V
- High Open-Loop Gain . . . 280 V/mV Typ
- Low Offset Voltage . . . 1 mV Max
- Low Offset Voltage Drift with Time . . . 0.04 µV/mo Typ
- Low Input Bias Current . . . 5 pA Typ

macromodel – applies to TLE2062, TLE2062A, TLE2062B

```
.subckt TLE2062  1 2 3 4 5
*
  c1    11 12 1.457E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.357E6 -4E6 4E6 4E6 -4E6
  ga     6  0 11 12 188.5E-6
  gcm    0  6 10 99 3.352E-9
  iss    3 10 dc 51.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 5.305E3
  rd2    4 12 5.305E3
  ro1    8  5 280
  ro2    7 99 280
  rp     3  4 113.2E3
  rss   10 99 3.922E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc 2
  vlim   7  8 dc 0
  vlp   91  0 dc 50
  vln    0 92 dc 50
.model dx D(Is=800.0E-18)
.model jx PJF(Is=2.000E-12 Beta=423E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

available features

- Excellent Output Drive Capability:
  V_O = ± 2.5 V Min at R_L = 100 Ω,
  $V_{CC\pm}$ = ± 5 V
  V_O = ± 12.5 V Min at R_L = 600 Ω,
  $V_{CC\pm}$ = ± 15 V
- Low Supply Current . . . 280 µA Typ per Amplifier
- High Unity-Gain Bandwidth . . . 2.1 MHz Typ
- High Slew Rate . . . 3.4 V/µs Typ
- Wide Operating Supply Voltage Range . . . $V_{CC\pm}$ = ± 3.5 V to ± 20V
- High Open-Loop Gain . . . 280 V/mV Typ
- Low Offset Voltage . . . 1.5 mV Max
- Low Offset Voltage Drift with Time . . . 0.04 µV/mo Typ
- Low Input Bias Current . . . 5 pA Typ

macromodel – applies to TLE2064, TLE2064A, TLE2064B

```
.subckt TLE2064  1 2 3 4 5
*
  c1    11 12 1.457E-12
  c2     6  7 15.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd 99   0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.357E6 -4E6 4E6 4E6 -4E6
  ga     6  0 11 12 188.5E-6
  gcm    0  6 10 99 3.352E-9
  iss    3 10 dc 51.00E-6
  hlim 90   0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 5.305E3
  rd2    4 12 5.305E3
  ro1    8  5 280
  ro2    7 99 280
  rp     3  4 113.2E3
  rss   10 99 3.922E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc 2
  vlim   7  8 dc 0
  vlp   91  0 dc 50
  vln    0 92 dc 50
.model dx D(Is=800.0E-18)
.model jx PJF(Is=2.000E-12 Beta=423E-6 Vto=-1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

available features

- Excellent Output Drive Capability:
  V_O = ± 2.5 V Min at R_L = 100 Ω,
  $V_{CC\pm}$ = ± 5 V
  V_O = ± 12.5 V Min at R_L = 600 Ω,
  $V_{CC\pm}$ = ± 15 V
- Low Supply Current . . . 255 µA Typ
- Decompensated for High Slew Rate and Gain-Bandwidth Product:
  A_{VD} = 5 Min
  Slew Rate = 10 V/µs Typ
  Gain-Bandwidth Product = 6.5 MHz Typ
- Wide Operating Supply Voltage Range . . .
  $V_{CC\pm}$ = ± 3.5 V to ± 20V
- High Open-Loop Gain . . . 280 V/mV Typ
- Low Offset Voltage . . . 500 µV Max
- Low Offset Voltage Drift with Time . . .
  0.04 µV/mo Typ
- Low Input Bias Current . . . 5 pA Typ

macromodel – applies to TLE2161, TLE2161A, TLE2161B

```
.subckt TLE2161  1 2 3 4 5
*
  c1    11 12 125.4E-14
  c2     6  7 5.000E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 4.085E6 -4E6 4E6 4E6 -4E6
  ga     6  0 11 12 201.1E-6
  gcm    0  6 10 99 3.576E-9
  iss    3 10 dc 45.00E-6
  hlim  90  0 vlim 1K
  j1    11  2 10 jx
  j2    12  1 10 jx
  r2     6  9 100.0E3
  rd1    4 11 4.973E3
  rd2    4 12 4.973E3
  ro1    8  5 280
  ro2    7 99 280
  rp     3  4 113.2E3
  rss   10 99 4.444E6
  vb     9  0 dc 0
  vc     3 53 dc 2
  ve    54  4 dc 2
  vlim   7  8 dc 0
  vlp   91  0 dc 50
  vln    0 92 dc 50
.model dx D(Is=800.0E-18)
.model jx PJF(Is=1.000E-12 Beta=480E-6 Vto=-1)
.ends
```

uA741C OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Short-Circuit Protection
- Offset-Voltage Null Capability
- Large Common-Mode and Differential Voltage Ranges
- No Frequency Compensation Required
- Low Power Consumption
- No Latch-Up
- Designed to be Interchangeable with Fairchild μA741M, μA741C

macromodel – applies to uA741

```
.subckt UA741    1 2 3 4 5
*
  c1    11 12 4.664E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
  ga     6  0 11 12 137.7E-6
  gcm    0  6 10 99 2.574E-9
  iee   10  4 dc 10.16E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 7.957E3
  rc2    3 12 7.957E3
  re1   13 10 2.740E3
  re2   14 10 2.740E3
  ree   10 99 19.69E6
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 18.11E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=62.50)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

JANUARY 1990

- No Frequency Compensation Required
- Low Power Consumption
- Short-Circuit Protection
- Offset-Voltage Null Capability
- Wide Common-Mode and Differential Voltage Ranges
- No Latch-Up
- Designed to be Interchangeable with Fairchild μA747M, μA747C

macromodel – applies to uA747

```
.subckt UA747      1 2 3 4 5
*
  c1    11 12 4.664E-12
  c2     6  7 20.00E-12
  dc     5 53 dx
  de    54  5 dx
  dlp   90 91 dx
  dln   92 90 dx
  dp     4  3 dx
  egnd  99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb     7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
  ga     6  0 11 12 137.7E-6
  gcm    0  6 10 99 2.574E-9
  iee   10  4 dc 10.16E-6
  hlim  90  0 vlim 1K
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2     6  9 100.0E3
  rc1    3 11 7.957E3
  rc2    3 12 7.957E3
  re1   13 10 2.740E3
  re2   14 10 2.740E3
  ree   10 99 19.69E6
  ro1    8  5 150
  ro2    7 99 150
  rp     3  4 18.11E3
  vb     9  0 dc 0
  vc     3 53 dc 2.600
  ve    54  4 dc 2.600
  vlim   7  8 dc 0
  vlp   91  0 dc 25
  vln    0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=62.50)
.ends
```

uA748C
OPERATIONAL AMPLIFIER MACROMODEL

JANUARY 1990

- Frequency and Transient Response Characteristics Adjustable
- Short-Circuit Protection
- Offset-Voltage Null Capability
- Wide Common-Mode and Differential Voltage Ranges
- Low Power Consumption
- No Latch-Up
- Same Pin Assignments as uA709

macromodel – applies to uA748

```
.subckt UA748      1 2 3 4 5 6 7
*
  c1   11 12 7.977E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 42.44E6 -40E6 40E6 40E6 -40E6
  ga    6  0 11 12 188.5E-6
  gcm   0  6 10 99 3.352E-9
  iee  10  4 dc 15.14E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 5.305E3
  rc2   3 12 5.305E3
  re1  13 10 1.839E3
  re2  14 10 1.839E3
  ree  10 99 13.21E6
  ro1   8  5 50
  ro2   7 99 25
  rp    3  4 16.81E3
  vb    9  0 dc 0
  vc    3 53 dc 2.600
  ve   54  4 dc 2.600
  vlim  7  8 dc 0
  vlp  91  0 dc 25
  vln   0 92 dc 25
.model dx D(Is=800.0E-18)
.model qx NPN(Is=800.0E-18 Bf=107.1)
.ends
```


TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Macromodel Data Floppy Disk 4

general information

The files on the accompanying disk can be used to simulate any of the conventional operational amplifiers in TI's broad product line. Since each of these models simulates the total op amp and not just the individual circuit components that make up an op amp, the simulation time and the size of the computer required to perform the simulation are both dramatically reduced. In fact, these models can be used on systems as small as a PC running *PSpice*®, which allows the design engineer to take advantage of the more readily available simulation systems and save simulation time without sacrificing accuracy. To gain these advantages, the macromodel does not model all data sheet parameters. This limitation is certainly offset by the performance and accuracy of the many device characteristics that can be simulated. Refer to the technical discussion in Section 2 for more detailed information about macromodels and their advantages and limitations.

copying this disk

Please feel free to distribute copies of this disk to your colleagues and associates.

data manual orders and updates

To receive updates to this manual as they are developed or to order another data manual for a colleague or associate, please fill in and mail the accompanying business reply card.

minimum system requirements

- IBM PC, XT, AT, or compatible
- DOS
- Appropriate Spice simulator (e.g., *PSpice*®)
- 360K-byte floppy disk drive

getting started

To use the models on the accompanying disk, you need to know the following:

- The macromodels use the nodal assignments shown in Figure 2-4. Only models for devices with external compensation use nodes 6 and 7.
- All devices are modeled as one op amp. To model a dual op amp (such as the TLE2062), use two macromodels in your simulation. To model a quad op amp (such as the TLE2064), use four macromodels.

to view available files

- Insert diskette in drive A.
- After the A> prompt, enter: DIR
- Select desired file and enter: TYPE filename.MOD

to use files

The files contained on the accompanying macromodel data floppy disk are ASCII files. Follow the instructions that came with your simulator to access and use these models.

4

Macromodel Data Floppy Disk

NOTES

NOTES

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