RAYTHEON SEMICONDUCTOR Linear IC's

RAYTHEON

RAYTHEON SEMICONDUCTOR

JANUARY 1976

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*Wideband, low-noise version

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*Wideband, low-noise version

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SG305AT	LM305AH	
SG307M	LM307N	1-4
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SG741D	RM741DC	1-21
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SN72709P	RC709NB	
SN72709AJ	RC709AD	
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SN72741L	RC741T	
SN72741P	RC741NB	
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Dual Operational Amplifier Summary

	SYMBOL	RM/RC747			RM1537/RC1437			RM1558/RC1458			RC4558			RC4739			UNIT
Maximum Ratings																	
Supply Voltage	V_{CC}		±22/±18*			±18			±22/±18**			±18			±18		V
Differential Input Voltage	V_{ID}		±30			±5			±30			±30			±30		V
Input Voltage			±15			±10			±15			±15			±15		V
Power Dissipation	P_D		500			500			500			500			500		mW
Electrical Characteristics		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Test Conditions	V_{CC}		±15			±15			±15			±15			±15		
Input Offset Voltage	V_{ID}		1.0 2.0*	5.0 6.0*		1.0	5.0 7.5**		1.0 2.0***	5.0 6.0***		0.5	6.0		2.0	6.0	mV
Input Offset Current	I_{IO}		30	200		50	500/200		30	200		5.0	200		5.0	200	nA
Input Bias Current	I_{IB}		200	500		0.2/0.4	0.5/1.5		200	500		40	500		40	500	nA
Input Common Mode Voltage Range	V_{ICR}	±12	±13		±8	±10		±12	±13		±12	±14		±12	±14		V
Supply Current	I_D		3.3	5.6		5	7.5		3.3	5.6		3.5	5.6		3.5	5.6	mA
Open Loop Voltage Gain	A_{VOL}	50	200		25/10**	45	70	50	200		20	300		20	300		V/mV
Output Voltage Swing	V_{OR}	±12	±14		±12	±14		±12	±14		±12	±14		±12	±14		V
Common Mode Rejection Ratio	CMRR	70	90		70/65**	90		70	90		70	90		70	100		dB
Power Supply Rejection Ratio	PSSR		30	150			150 200**		30	150		30	150		10	150	μV/V
Unity Gain Bandwidth	BW		0.8						0.8			3.0			3.0		MHz
Slew Rate	SR		0.5						0.5			1.0			1.0		V/μs
Channel Separation			70			73			70			105			125		dB
Noise Voltage	V_N											10			2.5†		$nV(Hz)^{½}$
Operating Temperature Range	T_A		−55 0*	125 70*		−55 0**	125 70**		−55 0***	125 70***	0		70	0		70	°C
Package: Hermetic TO-5			TF						TE			T					
Hermetic Dip			DC			DC											
Plastic Dip			DB			DB			NB			NB			NB		

*RC747
**RC1437
***RC1458
†Broad Band noise voltage (μV_{RMS})

Quad Operational Amplifier Summary

	SYMBOL	RM4136/RC4136			LM124/LM224/LM324			LM2902			RM3503A/ RV3403A/RC3403A			LM2900/LM3900			RV3301/RC3401			UNIT
Maximum Ratings																				
Supply Voltage	V_{CC}	±22/±18*			+32 or ±16			+32 or ±16			+36 or ±18			+36 or ±18			+28/+18‡			V
Differential Input Voltage	V_{ID}	±30			32			26			36									V
Input Voltage		±15			32			26			36									V
Power Dissipation	P_D	800			Hermetic Package 900 Plastic Package 570			Plastic Package 570			Hermetic Package 650 Plastic Package 500			Plastic Package 570			Plastic Package 625			mW
Electrical Characteristics		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Test Condition V_{CC}:			±15			+5			+5			±15			±15			±15		
Input Offset Voltage	V_{IO}		0.5 0.5	5.0 6.0*		2	5 7**		2	10		2	4 6§							mV
Input Offset Current	I_{IO}		5	200		±3 ±3	±35 ±50**					±30	±50							nA
Input Bias Current	I_{IB}		40	500			300 500**		45	500		150	400 500§		30	200		50	300	nA
Input Common Mode Voltage Range	V_{ICR}	±12	±14			0 to +35			0 to +35		−15		+13							V
Supply Current	I_D		7	11.3		0.8	2		0.8	2		3	4/5§		6.2	10		6.9	10	mA
Open Loop Voltage Gain	A_{VOL}	50 20*	300			100			100		50 20§	100		1.2	2.8		1	2		V/mV
Output Voltage Swing	V_{OR}	±12	±14		0		$V^+ - 1.5$	0		$V^+ - 1.5$	±13	±14		13.5	14.2		13.5	14.2		V
Common Mode Rejection Ratio	CMRR	70	100			85		85			70	90								dB
Power Supply Rejection Ratio	PSRR		10 µV/V	150 µV/V		100 dB			100 dB			20 µV/V	50 µV/V 100 µV/V§		70 dB			55 dB		
Unity Gain Bandwidth	BW		3									1.0			2.5			4.0		MHz
Slew Rate	SR		1.5 1.0*			0.3						1.2			0.5			0.6		V/µs
Output Sink Current	I_{sink}					20		8	20		10	20		0.5	1.3		0.5	1.0		mA
Output Source Current	I_{source}				20	40		20	40		20	40		3	18		3.0	10		mA
Channel Separation			105			120			120			120						65		dB
Operating Temperature Range		−55 0	RM RC	+125 +70	−55 −25 0	LM124 LM224 LM324	+125 +85 +70	−40		+85	−55 −40 0	RM RV RC	+125 +85 +70	−40 0	2900 3900	+85 +70	−40 0	3301 3401	+85 +70	°C
Package: 14 pin Dip	Hermetic	DC			DC						DC									
	Plastic	DB			N			N			DB			N			DB			

*RC4136
**LM324
§RC/RV3403A
‡RC3401

Quad Comparators Summary

	SYMBOL	LM139			LM239/LM339			LM2901			RV3302			UNIT
Maximum Ratings														
Supply Voltage	V_{CC}	+36			+36			+36			+28 or ±14			V
Differential Input Voltage	V_{ID}	+36			+36			+36			+28			V
Input Voltage		+36			+36			+36			+28			V
Power Dissipation	P_D	800			800			570			625			mW
Electrical Characteristics		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Test Condition	V_{CC}		+5			+5			+5			+5/+15**		V
Input Offset Voltage	V_{IO}		2/1	5/2*		2/1	5/2*		2	7		3	20	mV
Input Offset Current	I_{IO}		3	25		5	50		5	50		±3	±100 —**	nA
Input Bias Current	I_{IB}		25	100		25	250		25	250		25/30**	500	nA
Input Common Mode Voltage Range	V_{ICR}	0		+3.5	0		+3.5	0		+3.5	0		+3.5 +13.5**	V
Supply Current	I_{OC}		0.8	2		0.8	2		0.8	2		0.7	1.5	nA
Open Loop Voltage Gain	A_{VOL}		200			200			200		2	30		V/mV
Common Mode Rejection Ratio	CMRR											60		dB
Slew Rate	SR											−200 +50		V/μs
Response Time	T_r		1.3			1.3			1.3			2.0		μs
Output Sink Current	I_{sink}	6	16		6	16		6	16		2	16		mA
Saturation Voltage	V_{sat}		0.2	0.4		0.2	0.4		0.2	0.4		0.25	0.5	V
Output Leak Current	I_{OL}		0.1			0.1			0.1				1.0	nA
Operating Temperature Range	T_A	−55		129	−25 0	239 339	85 70	−40		85	−40		85	°C
Package: 14 Pin Dip	Hermetic	DC			DC						DC			
	Plastic	DB			DB			DB			DB			

*A version

**3302

Quality and Reliability

RAYACT-883A PROGRAM

The Raytheon Acceptance Testing Program called Rayact-883A involves in-process inspections which assure compliance with MIL-STD-883A test methods and MIL-M-38510 Program Plan Requirements.

Table 1 defines the Standard Process Flow for Raytheon Semiconductor's Military Level Integrated Circuits. After completion of the in-process inspections and 100% production screens, each lot is subjected to a quality conformance inspection as defined in Table 2. The screening and acceptance testing outlined in Tables 1 and 2 are provided at no extra cost.

In addition to the Standard Process Flow and acceptance testing, Qualification Tests in accordance with MIL-STD-883A, Method 5005 are conducted every three months on each product line. Generic Summary Data of Groups A, B, and C testing (Table 3) is available upon request.

The level of reliability you desire can be selected from Table 4. These tests are conducted in accordance with Method 5004 of MIL-STD-883A.

APPLICABLE DOCUMENTS:

Military: MIL-STD-883A
MIL-M-38510

Raytheon Semiconductor:
Quality/Reliability Assurance Manual

Table 1—Standard Process Flow Summary for Integrated Circuits

MANUFACTURING OPERATION	MANUFACTURING INSPECTION	QUALITY/RELIABILITY INSPECTION
Manufacturing Stores	Purchased Item Verification	Receiving Inspection To Applicable M&SS and Blueprint Number
Mask Making	Mask Inspection	Mask Inspection
Materials Preparation	Wafer Preparation and Epitaxial Growing	Q.C. Monitor
Photoengraving and Diffusion	Electrical Probe Check and 100% Visual Inspection	Q.C. Monitor
Final Wafer Lot Acceptance	100% Visual Inspection	Q.C. Wafer Lot Acceptance
Electrical Test of Wafer	100% Electrical Test	Q.C. Monitor
Scribing and Dicing	100% Visual Inspection	Q.C. Monitor
Visual Die Sort MIL-STD-883A, Method 2010.2, Condition B	100% Die Sort Inspection	Dice Lot Acceptance
Die Attach	100% Visual Inspection	Q.C. Monitor
Lead Bond	100% Visual Inspection	Q.C. Monitor
Pre-Seal Inspection at 100X Magnification MIL-STD-883A, Method 2010, Condition B	100% Visual Inspection at High-Power Magnification	Q.C. Lot Acceptance
Pre-Seal Inspection at 30X Magnification MIL-STD-883A, Method 2010, Condition B	100% Visual Inspection at Low-Power Magnification	Q.C. Lot Acceptance

Table 1—Standard Process Flow Summary for Integrated Circuits (Cont.)

MANUFACTURING OPERATIONS	MANUFACTURING INSPECTION	QUALITY/RELIABILITY INSPECTION
Final Seal	Visual and Hermeticity	Q.C. Monitor
High-Temperature Bake $150^{\circ}C$ – 24 Hours Minimum (MIL-STD-883A, Method 1008, Condition C)	100% Processing	Q.C. Monitor
Temperature Cycling $-65^{\circ}C$ to $+150^{\circ}C$, 10 Cycles (MIL-STD-883A, Method 1010, Condition C)	100% Processing	Q.C. Monitor
Centrifuge 30 KG Minimum Y_1 Axis (MIL-STD-883A, Method 2001, Condition E)	100% Processing	Q.C. Monitor
Lead Form	100% Visual Inspection	Q.C. Monitor
Carrier Load	100% Visual Inspection	Q.C. Monitor
Hermeticity MIL-STD-883A, Method 1014		Q.C. Monitor
External Visual	100% Inspection	Q.C. Monitor
Electrical Test and Sort	100% Inspection	Q.C. Monitor

Table 2—Quality Conformance Inspection (Each Lot)

INSPECTION		LTPD/MAX. ACC. NO.	COMMENTS
External		7/2	MIL-STD-883A, Method 2009
Hermeticity Fine Leak Gross Leak		7/2	MIL-STD-883A, Method 1014, Condition A or B MIL-STD-883A, Mthod 1014, Condition C_2
Electrical			Per Applicable Electrical Test Specification
Static Parameters	$+25^{\circ}C$	5/1	
	$+125^{\circ}C$	7/1	
	$-55^{\circ}C$	7/1	
Dynamic Parameters	$+25^{\circ}C$	5/1	
	$+125^{\circ}C$	7/1	
	$-55^{\circ}C$	7/1	
Package and Ship		Quality Assurance Monitor	

NOTE:
Generic Qualification Data in accordance with MIL-STD-883A, Method 5005, can be supplied if negotiated prior to procurement.

Table 3A—Group A Electrical Tests—MIL-STD-883A

SUBGROUPS	CLASS A LTPD	CLASS B LTPD	CLASS C LTPD
Subgroup 1 Static tests at 25°C	5	5	5
Subgroup 2 Static tests at maximum rated operating temperature	5	7	10
Subgroup 3 Static tests at minimum rated operating temperature	5	7	10
Subgroup 4 Dynamic tests at 25°C	5	5	5
Subgroup 5 Dynamic tests at maximum rated operating temperature	5	7	10
Subgroup 6 Dynamic tests at minimum rated operating temperature	5	7	10
Subgroup 7 Functional tests at 25°C	3	5	5
Subgroup 8 Functional tests at maximum and minimum rated operating temperatures	5	10	15
Subgroup 9 Switching tests at 25°C	5	7	10
Subgroup 10 Switching tests at maximum rated operating temperature	5	10	15
Subgroup 11 Switching tests at minimum rated operating temperature	5	10	15

NOTE:
The specific parameters to be included for tests in each subgroup shall be as specified in the applicable reliability specification. Where no parameters have been identified in a particular subgroup or test within a subgroup, no group A testing shall be performed for that subgroup or test to satisfy group A requirements.

Table 3B—Group B Tests, MIL-STD-883A, Method 5005

	TEST	MIL-STD-883		CLASS A	CLASS B	CLASS C
		METHOD	CONDITION	LTPD	LTPD	LTPD
Subgroup 1	Physical dimensions	2016		10	15	20
Subgroup 2	Resistance to solvents	2015		3 devices (no failures)	3 devices (no failures)	3 devices (no failures)
	Visual and mechanical	2014	Criteria from design and construction requirements of applicable procurement document	1 device (no failures)	1 device (no failures)	1 device (no failures)
	Bond strength	2011		5	15	20
	Thermocompression		Test condition C or D			
	Ultrasonic or wedge		Test condition C or D			
Subgroup 3	Solderability	2003	Soldering temperature of 260°C ±10°	10	15	15
Subgroup 4	Lead fatigue	2004	Test condition B_2	10	15	15
	Seal: Fine, Gross	1014	As applicable			

Table 3C—Group C Tests, MIL-STD-883A, Method 5005

TEST	MIL-STD-883A		CLASS A LTPD	CLASS B LTPD	CLASS C LTPD
	METHOD	CONDITION			
Subgroup 1 (Note 1)					
Thermal shock	1011	Test condition B as a minimum.	10	15	15
Temperature cycling	1010	Test condition C			
Moisture resistance	1004				
Seal	1014	As applicable			
a. Fine					
b. Gross (Note 7)					
Visual examination (Note 2)					
End point electrical parameters		As specified in the applicable procurement document.			
Subgroup 2 (Note 1)					
Mechanical shock	2002	Test condition B	10	15	15
Vibration, variable frequency	2007	Test condition A			
Constant acceleration	2001	Test condition E			
Seal	1014	As applicable			
a. Fine					
b. Gross (Note 7)					
Visual examination (Note 3)					
End point electrical parameters		As specified in the applicable procurement document.			
Subgroup 3					
Salt atmosphere (Note 4)	1009	Test condition A	10	15	15
Visual examination (Note 5)					
Subgroup 4					
High temperature storage (Note 6)	1008	Test condition C 1000 hours.	7	7	7
End point electrical parameters		As specified in the applicable procurement document.			
Subgroup 5					
Operating life test (Note 6)	1005	Test condition to be specified in the applicable procurement document (1000 hours).	5	5	5
End point electrical parameters		As specified in the applicable procurement document.			
Subgroup 6					
Steady state reverse bias	1005	Test condition A, 72 hours at 150°C.	7	–	–
End point electrical parameters		As specified in the applicable procurement document.			

NOTES:

1. Devices used for environmental tests in subgroup 1 may be used for mechanical tests in subgroup 2.
2. Visual examination shall be in accordance with method 1010 or 1011 at a magnification of 5X to 10X.
3. Visual examination shall be performed at a magnification of 5X to 10X for evidence of defects of damage to case, leads, or seals resulting from testing (not fixturing) such damage shall consitute a failure.
4. Electrical reject devices from the same inspection lot may be used for samples.
5. Visual examination shall be performed in accordance with 3.3.1 of method 1009.
6. See 40.4 of appendix B of MIL-M-38510.
7. When fluorocarbon gross leak testing is utilized, test condition C_2 shall apply as minimum.

Table 4—Optional Screening—MIL-STD-883A, Method 5004

SCREEN	CLASS A		CLASS B		CLASS C	
	METHOD	REQUIREMENT	METHOD	REQUIREMENT	METHOD	REQUIREMENT
Internal visual (Precap)	2010 test condition A	100%	2010 test condition B	100%	2010 test condition B	100%
Stabilization bake	1008, 24 hrs. test condition C, 150°C	100%	1008, 24 hrs. test condition C, 150°C	100%	1008, 24 hrs. test condition C, 150°C	100%
Thermal shock	1011, test condition A, 0°C-100°C 15 cycles	100%	Not required		Not required	
Temperature cycling	1010 test condition C, −65°C to +150°C 10 cycles	100%	1010, test condition C, −65°C to +150°C 10 cycles	100%	1010, test condition C, −65°C to +150°C 10 cycles	100%
Mechanical shock	2002**	100%	Not required		Not required	
Constant Acceleration	2001, test condition E Y_2 plane, then Y_1 plane, 30,000 G's	100%	2001, test condition E Y_1 plane, 30,000 G's	100%	2001, test condition E Y_1 plane, 30,000 G's	100%
Seal Fine, Gross	1014, Condition A Condition C Hermetic devices only	100%	1014, Condition A Condition C• Hermetic devices only	100%	1014, Condition A Condition C Hermetic devices only	100%
Critical electrical parameters	*	100%	Go-No-Go		Not required	
Burn-in test	1015, 240 hrs. @ T_A = 125°C*	100%	1015, 168 hrs. @ T_A = 125°C*	100%	Not required	
Critical electrical parameters	*	100%	Not required		Not required	
Reverse bias burn-in	1015, test condition A or C, 72 hrs. @ 150°C	100%	Not required		Not required	
Final electrical test	*		*		*	
Static tests 25°C		100%		100%		100%
Maximum and minimum rated operating temp.		100%		100%		
Dynamic tests and switching tests 25°C		100%		100%		
Functional test 25°C (subgroup 7, table 1, 5005)		100%		100%		100%
Group A Testing	Per Table 3A		Per Table 3A		Per Table 3A	
Radiographic	2012	100%	Not required		Not required	
Qualification or quality conformance inspection Groups B and C optional, at extra cost	5005	*	5005	*	5005	*
External visual	2009	100%	2009	100%	2009	100%

*Per applicable procurement document
**Test Condition F one shock pulse in Y_1 plane only or five shock pulses at Condition B in Y_1 plane only.

SECTION 1

Operational Amplifiers

CONTENTS

GENERAL DESCRIPTION

The LM101A/LM201A and LM301A are general purpose, high performance operational amplifiers fabricated monolithically on a silicon chip by the planar epitaxial process. The units may be fully compensated with the addition of a 30pF capacitor stabilizing the circuit for all feedback configurations including capacitive loads.

The device may be operated as a comparator with a differential input as high as ±30V. Used as a comparator the output can be clamped at any desired level to make it compatible with logic circuits.

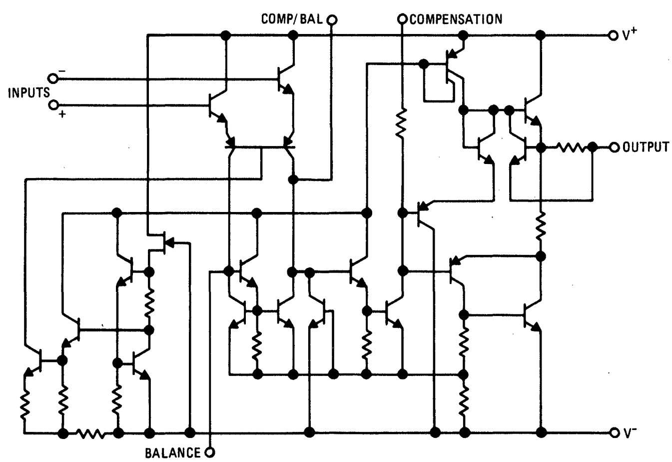
The LM101A operational amplifier will operate over the full military temperature range from −55°C to +125°C. The commercial version, the LM301A operates over a temperature range from 0°C to +70°C.

The LM201A is the same as the LM101A except its performance is guaranteed from −25°C to +85°C.

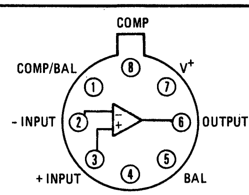
DESIGN FEATURES

- Offset Voltage 3mV Maximum Over Temperature
- Input Current 100nA Maximum Over Temperature
- Offset Current 20nA Maximum Over Temperature
- Offsets Guaranteed Over Entire Common-Mode Range
- Frequency Compensation 30pF
- Supply Voltage ±5V to ±20V
- Continuous Short Circuit Protection

SCHEMATIC DIAGRAM

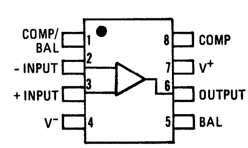


CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
LM101AH, LM201AH,
LM301AH



NB Dual In-line Package
(Top View)

Order Part No.:
LM301AN

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	101A, 201A: ±22V 301A: ±18V
Power Dissipation (Note 1)	500mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	
LM101A	−55°C to +125°C
LM201A	−25°C to +85°C
LM301A	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS LM101A, LM201A: $\pm 5V \leq V_S \leq \pm 20V$; LM301A: $\pm 5 \leq V_S \leq \pm 15V$ (Note 4)

PARAMETER	CONDITIONS	LM101A, LM201A			LM301A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 50\ k\Omega$		0.7	2.0		1.5	7.5	mV
Input Offset Current	$T_A = 25°C$		1.5	10		3	50	nA
Input Bias Current	$T_A = 25°C$		30	75		70	250	nA
Input Resistance	$T_A = 25°C$	1.5	4		0.5	2		MΩ
Supply Current	$T_A = 25°C$, $V_S = \pm 20V$		1.8	3.0		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$ $V_{OUT} = \pm 10V$, $R_L \geq 2\ k\Omega$	50	160		25	160		V/mV
Input Offset Voltage	$R_S \leq 50\ k\Omega$			3.0			10	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15		5.0	30	μV/°C
Input Offset Current				20			70	nA
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq 125°C$		0.01	0.1				nA/°C
	$25°C \leq T_A \leq 70°C$					0.01	0.3	nA/°C
	$-55°C \leq T_A \leq 25°C$		0.02	0.2				nA/°C
	$0°C \leq T_A \leq 25°C$					0.02	0.6	nA/°C
Input Bias Current				100			300	nA
Supply Current	$T_A = +125°C$, $V_S = \pm 20V$		1.2	2.5				mA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$	25			15			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	±12	±14		±12	±14		V
	$R_L = 2\ k\Omega$	±10	±13		±10	±13		V
Input Voltage Range	LM101A: $V_S = \pm 20V$; LM301A: $V_S = \pm 15V$	±15			±12			V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	80	96		70	96		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$	80	96		70	96		dB

NOTES:

1. For operating at elevated temperatures, the device must be derated based on +150°C for LM101A, +100°C for LM301A, maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Continuous short-circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C for LM101A, case temperatures to +70°C and ambient temperatures to +55°C for LM301A.
4. Specifications apply for temperature ranges: LM101A: −55°C to +125°C; LM201A: −25°C to +85°C; LM301A: 0°C to +70°C.

GENERAL DESCRIPTION

The LM107, LM207, and LM307 high-gain, general purpose operational amplifiers are monolithically constructed and internally compensated. The addition of a 30pF MOS capacitor guarantees unconditional stability eliminating the need for external frequency compensation. Input currents are a factor of ten lower than an industry standard device such as the 709, LM101, and 741.

This series offers all the best features of the LM101. In addition, the devices provide better accuracy and lower noise in high impedance circuitry.

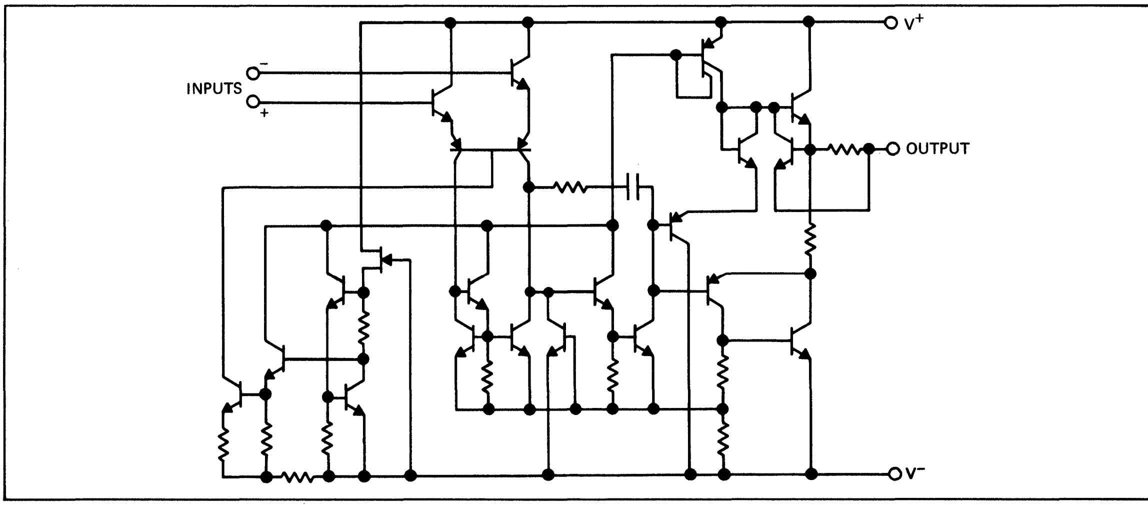
The LM107 operates over a temperature range of −55°C to +125°C. The LM307 operates from 0°C to +70°C.

The LM207 is the same as the LM107 except its performance is guaranteed from −20°C to +85°C.

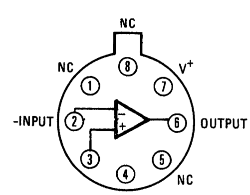
DESIGN FEATURES

- Offset Voltage 3mV Maximum Over Temperature
- Input Current 100nA Maximum Over Temperature
- Offset Current 20nA Maximum Over Temperature
- Offsets Guaranteed Over Entire Common-Mode Range
- Internal Frequency Compensation
- Supply Voltage ±5V to ±20V
- Continuous Short Circuit Protection

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part No.:
LM107H, LM207H, LM307H

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	101A, 201A: ±22V 301A: ±18V
Power Dissipation (Note 1)	500mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Output Short-Circuit Duration (Note 3)	Indefinite
Operating Temperature Range	
LM107	−55°C to +125°C
LM207	−25°C to +85°C
LM307	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS

LM101A, LM201A: $\pm5V \leq V_S \leq \pm20V$; LM301A: $\pm5 \leq V_S \leq \pm15V$ (Note 4)

PARAMETER	CONDITIONS	LM107			LM307 (Note 5)			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25^oC$, $R_S \leq 50\ k\Omega$		0.7	2.0		1.5	7.5	mV
Input Offset Current	$T_A = 25^oC$		1.5	10		3	50	nA
Input Bias Current	$T_A = 25^oC$		30	75		70	250	nA
Input Resistance	$T_A = 25^oC$	1.5	4		0.5	2		MΩ
Supply Current	$T_A = 25^oC$, $V_S = \pm20V$		1.8	3.0		1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25^oC$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \geq 2\ k\Omega$	50	160		25	160		V/mV
Input Offset Voltage	$R_S \leq 50\ k\Omega$			3.0			10	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15		5.0	30	μV/°C
Input Offset Current				20			70	nA
Average Temperature Coefficient of Input Offset Current	$25^oC \leq T_A \leq 125^oC$		0.01	0.1				nA/°C
	$25^oC \leq T_A \leq 70^oC$					0.01	0.3	nA/°C
	$-55^oC \leq T_A \leq 25^oC$		0.02	0.2				nA/°C
	$0^oC \leq T_A \leq 25^oC$					0.02	0.6	nA/°C
Input Bias Current				100			300	nA
Supply Current	$T_A = +125^oC$, $V_S = \pm20V$		1.2	2.5				mA
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$ $R_L \geq 2\ k\Omega$	25			15			V/mV
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10\ k\Omega$	±12	±14		±12	±14		V
	$R_L = 2\ k\Omega$	±10	±13		±10	±13		V
Input Voltage Range	$V_S = \pm20V$	±15			±12			V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	80	96		70	96		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$	80	96		70	96		dB

NOTES:

1. For operating at elevated temperatures, the device must be derated based on +150°C for LM107 or 100°C for LM307, maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Continuous short-circuit is allowed for case temperatures to +125°C and ambient temperatures to +70°C for LM107, case temperatures to +70°C and ambient temperatures to +55°C for LM307.
4. These specifications apply for $-55^oC < T_A < +125^oC$ LM107, -25^oC to $+85^oC$ LM207, and $5 < V_S < \pm20V$ unless otherwise specified.
5. These specifications apply for $0^oC < T_A < +70^oC$ and $\pm5 < V_S < \pm15V$ for LM307.

108/108A 208/208A 308/308A

Precision Operational Amplifiers

GENERAL DESCRIPTION

The LM108A/LM108, LM208A/LM208 and LM308A/LM308 are Super Beta operational amplifiers fabricated on single silicon chips using the planar epitaxial process.

The LM108A/LM108 offer specifications an order of magnitude better than FET amplifiers over a temperature range −55°C to +125°C.

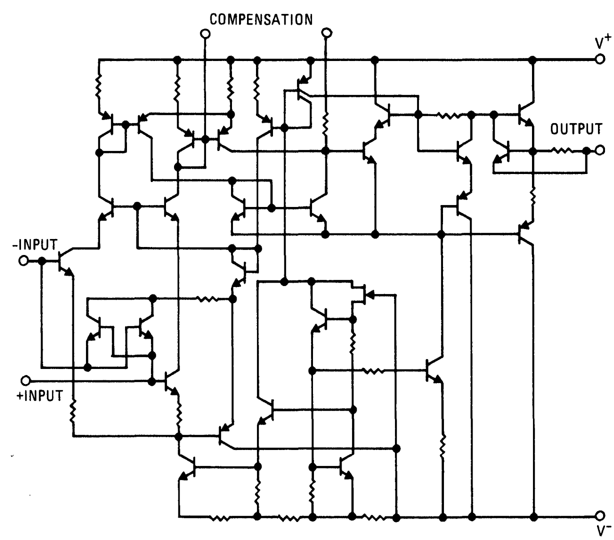
The LM208A/LM208 are identical to the LM108A/LM108 except their performance is guaranteed from −25°C to +85°C.

The LM308A/LM308 provide lower input offset voltage of 0.5mV maximum, and drift characteristics of 5.0μV/°C maximum. These devices can be conpensated by the conventional technique used with the LM101/LM101A series.

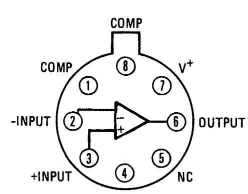
DESIGN FEATURES

- Offset Voltage Over Temperature Range 0.5mV Maximum
- Input Current Over Temperature Range 3.0nA Maximum
- Offset Current Over Temperature Range 400pA Maximum
- Supply Current Only 300μA
- Guaranteed Drift Characteristics 5.0μV/°C Maximum
- Supply Voltage ±2V to ±20V

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
LM108AH, LM208AH,
LM308AH, LM108H,
LM208H, LM308H

Precision Operational Amplifiers

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	LM108A/LM108: ±20V	Operating Temperature Range	
	LM308A/LM308: ±18V	LM108A/LM108	−55°C to +125°C
Power Dissipation (Note 1)	500mW	LM208A/LM208	−25°C to +85°C
Differential Input Current (Note 3)	±10mA	LM308A/LM308	0°C to +70°C
Input Voltage (Note 2)	±15V	Storage Temperature Range	−65°C to +150°C
Output Short-Circuit Duration	Indefinite	Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS (Notes 4 and 5)

PARAMETER	CONDITIONS	LM108A/LM208A			LM308A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	T_A=25°C		0.3	0.5		0.3	0.5	mV
Large Signal Voltage Gain	T_A=25°C, V_S=±15V, V_{out}=±10V, $R_L \geq 10k\Omega$	80	300		80	300		V/mV
Input Offset Voltage				1.0			0.73	mV
Average Temperature Coefficient of Input Offset Voltage			1.0	5.0		1.0	5.0	μV/°C
Large Signal Voltage Gain	V_S=±15V, V_{out}=±10V, $R_L \geq 10k\Omega$	40			60			V/mV
Common Mode Rejection Ratio		96	110		96	110		dB
Supply Voltage Rejection Ratio		96	110		96	110		dB

PARAMETER	CONDITIONS	LM108/LM208			LM308			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	T_A=25°C		0.7	2.0		2.0	7.5	mV
Input Offset Current	T_A=25°C		0.05	0.2		0.2	1.0	nA
Input Bias Current	T_A=25°C		0.8	2.0		1.5	7.0	nA
Input Resistance	T_A=25°C	30	70		10	40		MΩ
Supply Current	T_A=25°C		0.3	0.6		0.3	0.8	mA
Large Signal Voltage Gain	T_A=25°C, V_S=±15V, V_{out}=±10V, $R_L \geq 10k\Omega$	50	300		25	300		V/mV
Input Offset Voltage				3.0			10	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15		6.0	30	μV/°C
Input Offset Current				0.4			1.5	nA
Average Temperature Coeffiecient of Offset Current			0.5	2.5		2.0	10	pA/°C
Input Bias Current				3.0			10	nA
Supply Current	T_A=+125°C		0.15	0.4				mA
Large Signal Voltage Gain	V_S=±15V, V_{out}=+10V, $R_L \geq 10k\Omega$	25			15			V/mV
Output Voltage Swing	V_S=±15V, R_L=10kΩ	±13	±14		±13	±14		V
Input Voltage Range	V_S=±15V	±13.5			14			V
Common Mode Rejection Ratio		85	100		80	100		dB
Supply Voltage Rejection Ratio		80	96		80	96		dB

NOTES:

1. For operating at elevated temperatures, the device must be derated based on +150°C for LM108, +100°C for LM308 maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.
4. These specifications apply for ±5V < V_S < ±20V and −55°C < T_A ⩽ +125°C, LM108A/LM108; ±5V < V_S < ±20V and −25°C < T_A < +85°C, LM208A/LM208.
5. These specifications apply for ±5V < V_S < ±15V and 0°C < T_A < +70°C, LM308A/LM308.

GENERAL DESCRIPTION

The LM112, LM212, and LM312 are Super Beta operational amplifiers, each fabricated on a silicon chip by the planar epitaxial process.

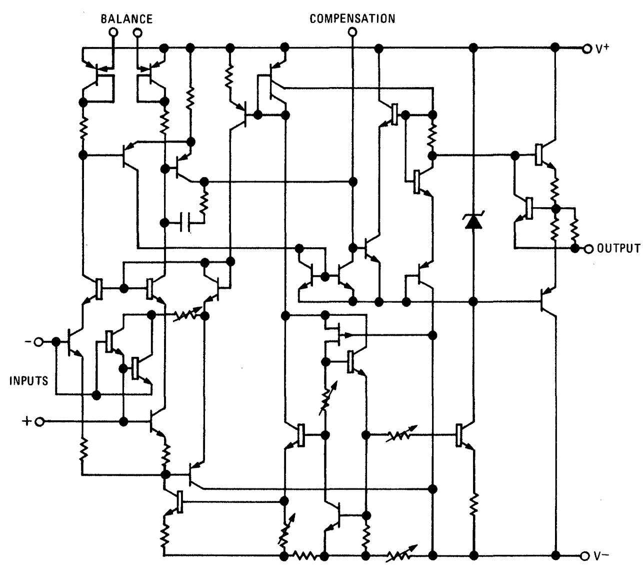
The LM112 offers specifications an order of magnitude better than FET amplifiers over a temperature range of −55°C to +125°C. The LM212 is the same as the LM112 except its performance is guaranteed from −25°C to +85°C. The LM312 is the commercial type which operates from 0°C to +70°C.

In addition to internal compensation, external compensation may be added by means of a capacitor to increase stability. They also feature offset null adjustment by use of a single potentiometer.

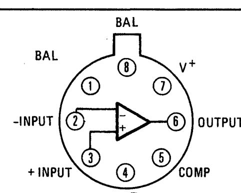
DESIGN FEATURES

- Input Bias Current 3.0nA Maximum Over Temperature Range
- Offset Current Less Than 400pA Over Temperature Range
- Low Noise
- Guaranteed Drift Specifications
- Supply Voltage Range ±2V to ±20V With Typical Quiescent Current of Only 300μA

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
LM112H, LM212H
LM312H

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . LM112: ±20V
LM312: ±18V
Power Dissipation (Note 1) 500mW
Differential Input Current (Note 2) . . . . ±10mA
Input Voltage (Note 3) . . . . ±15V
Output Short-Circuit Duration . . . . Indefinite

Operating Temperature Range
LM112 . . . . −55°C to +125°C
LM212 . . . . −25°C to +85°C
LM312 . . . . 0°C to +70°C
Storage Temperature Range . . . . −65°C to +150°C
Lead Temperature (Soldering, 10s) . . . . +300°C

ELECTRICAL CHARACTERISTICS (Note 4)

PARAMETER	CONDITIONS	LM112, LM212			LM312			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$		0.7	2.0		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		0.05	0.2		0.2	1.0	nA
Input Bias Current	$T_A = 25°C$		0.8	2.0		1.5	7.0	nA
Input Resistance	$T_A = 25°C$	30	70		10	40		MΩ
Supply Current	$T_A = 25°C$		0.3	0.6		0.3	0.8	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$, $V_{OUT} = \pm 10V$, $R_L = \geq 10k\Omega$	50	300		25	300		V/mV
Input Offset Voltage				3.0			10	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	15		6.0	30	μV/°C
Input Offset Current				0.4			1.5	nA
Average Temperature Coefficient of Input Offset Current			0.5	2.5		2.0	10	pA/°C
Input Bias Current				3.0			10	nA
Supply Current	$T_A = +125°C$		0.15	0.4				mA
Large Signal Voltage Gain	$V_S = \pm 15V$, $V_{OUT} = \pm 10V$ $R_L \geq 10k\Omega$	25			15			V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10k\Omega$	±13	±14		±13	±14		V
Input Voltage Range	$V_S = \pm 15V$	±13.5			±14			V
Common-Mode Rejection Ratio		85	100		80	100		dB
Supply Voltage Rejection Ratio		80	96		80	96		dB

NOTES:

1. The maximum junction temperature of the LM112 is +150°C, and +85°C for the LM312. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of +150°C/W, junction to ambient, or +45°C/W, junction to case.
2. The inputs are shunted with shunt diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.
3. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
4. These specifications apply for $\pm 5V \leq V_S \leq \pm 20V$ and $-55°C < T_A < +125°C$ for the LM112, unless otherwise specified, $\pm 5V \leq V_S \leq \pm 20V$ and $-25°C < T_A < +85°C$ for the LM212, $\pm 5V \leq V_S \leq \pm 15V$ and $0°C < T_A < +70°C$ for the LM312, unless otherwise specified.

GENERAL DESCRIPTION

The LM118, LM218, and LM318 are precision operational amplifiers which offer fast slewing and wide bandwidth. They feature internal frequency compensation and ten times the speed of general purpose amplifiers.

External feedforward compensation may be used for an additional increase in speed. For inverting applications this will increase the slew rate to more than 100V/μs and almost double the bandwidth. (Feedforward is not used for non-inverting or differential applications.)

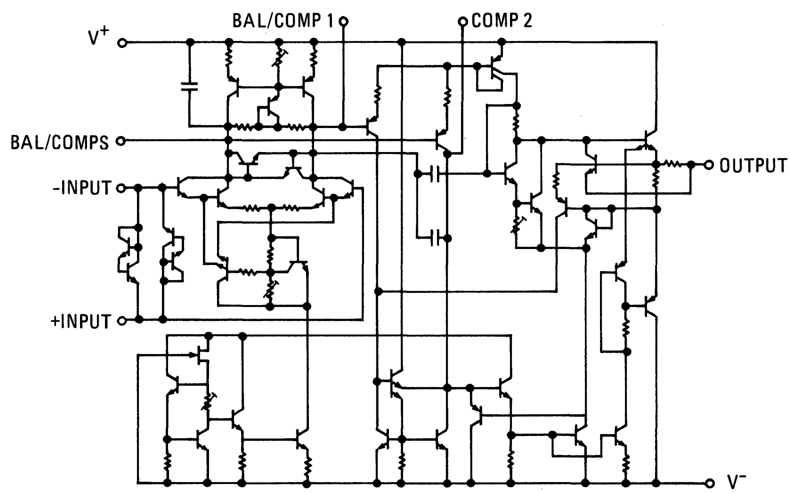
Their high speed and fast settling time make them ideal devices for A/D converters, oscillators, active filters, sample-and-hold circuits, as well as general purpose amplifiers.

The LM118 military version operates over a temperature range of −55°C to +125°C. The LM218 is the same as the LM118 except its performance is guaranteed from −25°C to +85°C. The LM318 operates from 0°C to +70°C.

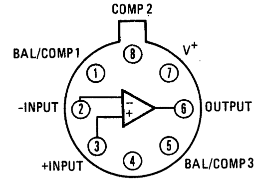
DESIGN FEATURES

- 15MHz Small Signal Bandwidth
- Guaranteed 50V/μs Slew Rate
- Operates from ±5V to ±18V Supply
- Internal Frequency Compensation
- Input and Output Overload Protected
- Pin Compatible With General Purpose Op Amps

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



T (TO-5) Metal Can
(Top View)

Order Part Nos.:
LM118H, LM218H, LM318H

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18V
Power Dissipation (Note 1)	500mW
Differential Input Current (Note 2)	±10mA
Input Voltage (Note 3)	±15
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	
LM118	−55°C to +125°C
LM218	−25°C to +85°C
LM318	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10s)	+300°C

ELECTRICAL CHARACTERISTICS (Note 4)

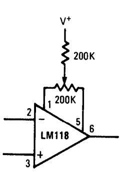
PARAMETER	CONDITIONS	LM118/LM218	LM318	UNITS	
Input Offset Voltage	$T_A = 25°C$	4	10	mV	Max.
Input Offset Current	$T_A = 25°C$	50	200	nA	Max.
Input Bias Current	$T_A = 25°C$	250	600	nA	Max.
Input Resistance	$T_A = 25°C$	1	0.5	MΩ	Min.
Supply Current	$T_A = 25°C$	8	10	mA	Max.
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$, $V_{OUT} = \pm10V$, $R_L \geqslant 2k$	50	25	V/mV	Min.
Input Offset Voltage		6	15	mV	Max.
Small Signal Bandwidth	$T_A = 25°C$, $V_S = \pm15V$	15	15	MHz	Typ.
Slew Rate	$T_A = 25°C$, $V_S = \pm15V$, $A_V = 1$, $R_S = 10k\Omega$	50	50	V/µs	Min.
Input Offset Current		100	300	nA	Max.
Input Bias Current		500	1000	nA	Max.
Supply Current	$T_A = T_{MAX}$	7	10	mA	Max.
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$, $R_L \geqslant 2k$	25	20	V/mV	Min.
Output Voltage Swing	$V_S = \pm15V$, $R_L = 2k\Omega$	±12	±12	V	Min.
Input Voltage Range	$V_S = \pm15V$	±11.5	±11.5	V	Min.
Common Mode Rejection Ratio		80	70	dB	Min.
Supply Voltage Rejection Ratio		70	65	dB	Min.

NOTES:

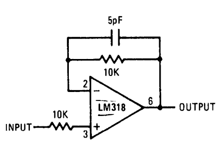
1. The maximum junction temperature of the LM118 is +150°C, and +85°C for the LM318. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case.
2. The inputs are shunted with shunt diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.
3. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
4. These specifications apply for $\pm5V \leqslant V_S \leqslant \pm18V$ and $-55°C \leqslant T_A \leqslant +125°C$ for the LM118; $\pm15V \leqslant V_S \leqslant \pm18V$ and $-20°C \leqslant T_A \leqslant +85°C$ for the LM218; $\pm5V \leqslant V_S \leqslant \pm15V$ and $0°C \leqslant T_A \leqslant +70°C$ for the LM318. Also, power supplies must be bypassed with 0.1µF ceramic disc capacitors.

TYPICAL APPLICATIONS

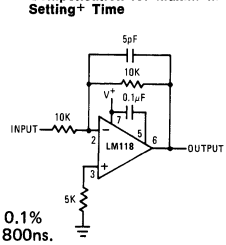
Offset Balancing



Fast Voltage Follower

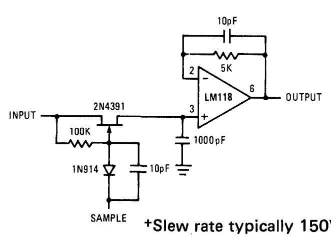


Compensation for Maximum Setting+ Time

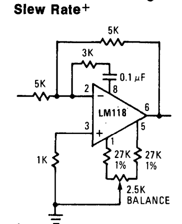


+Slew and setting time to 0.1% for a 10V step change is 800ns.

Fast Sample and Hold



Feedforward Compensation for Greater Inverting Slew Rate+



+Slew rate typically 150V/µs

GENERAL DESCRIPTION

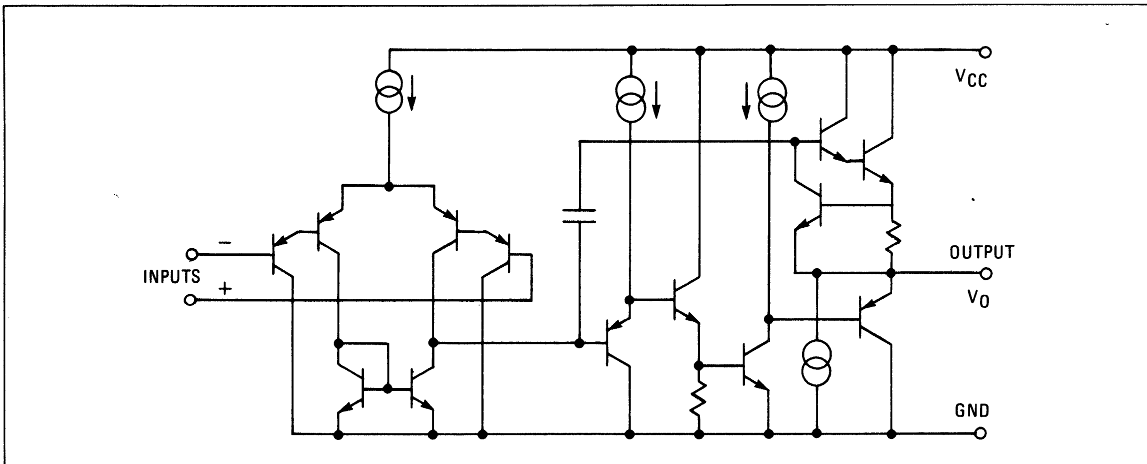
Each of the devices in this series consists of four independent, high-gain, operational amplifiers that are designed for single-supply operation. Operation from split power supplies is also possible and the low power supply drain is independent of the magnitude of the power supply voltage.

Used with a dual supply, the circuit will operate over a wide range of supply voltages. However, a large amount of crossover distortion may occur with loads to ground. An external current-sinking resistor to $-V_{CC}$ will reduce crossover distortion. There is no crossover distortion problem in single supply operation if the load is direct-coupled to ground.

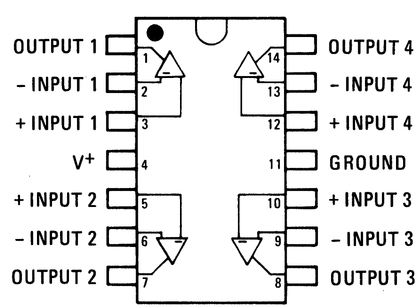
DESIGN FEATURES

- Large DC Voltage Gain 100 dB
- Compatible with All Forms of Logic
- Temperature Compensated
- Wide Bandwidth at Unity Gain Frequency 1 MHz
- Large Output Voltage Swing: 0 V_{DC} to V^+ –1.5 V_{DC}
- Input Common Mode Voltage Range Includes Ground

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DB and DC
Dual In-Line Packages
(Top View)

Order Part Nos.:
LM124D, LM224D, LM324D, LM2902D,
LM224N, LM324N, LM2902N

Quad Single-Supply Operational Amplifier

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V^+ . . . . 32 V or ±16 V
Differential Input Voltage
LM124 . . . . 32 V
LM2902 . . . . −0.3 V to +26 V
Input Voltage . . . . −0.3 V to +32 V
Power Dissipation (Note 1)
Molded DIP . . . . LM324N, LM2902N: 570 mW
Cavity DIP . LM124D, LM224D & LM324D: 900 mW

Output Short-Circuit to GND (Note 2) . . . . Continuous
Operating Temperature Range . LM324: 0°C to +70°C
LM224: −25°C to +85°C
LM124: −55°C to +125°C
LM2902: −40°C to +85°C
Storage Temperature Range . . . . −65°C to +150°C
Lead Temperature (Soldering, 60s) . . . . 300°C

ELECTRICAL CHARACTERISTICS (V^+ = + 5 V and T_A = 25°C unless otherwise noted)

PARAMETER	CONDITIONS	LM124			LM224, LM324			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S = 0\Omega$ (Note 5)		2	5		2	7	mV
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		±3	±30		±5	±50	nA
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$		45	150		45	250	nA
Common Mode Range	(Note 4)	0		V^+−1.5	0		V^+−1.5	V
Supply Current	$R_L = \infty$		0.8	2		0.8	2	mA
Large Signal Voltage Gain	$R_L \geqslant 2k\Omega$	50	100		25*	100		V/mV
Output Voltage Swing	$R_L = 2k\Omega$	0		V^+−1.5	0		V^+−1.5	V
Common Mode Rejection Ratio	DC	70	85	65*		85		dB
Power Supply Rejection Ratio	DC		100			100		dB
Channel Separation	f = 1kHZ to 20kHz (Input Referred) (Note 7)		−120			−120		dB
Output Source Current	$V_{IN}^+ = +1V$ $V_{IN}^- = 0V$	20	40		20	40		mA
Output Sink Current	Vol > 1V		20			20		mA

NOTES

1. For operating at high temperatures, the LM324 must be derated based on a +125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board operating in a still air ambient. The LM224 and LM124 can be derated based upon a +150°C maximum junction temperature.
2. Short circuits from the output to V^- can cause excessive heating and eventual destruction. The maximum output current is approximately 40mA independent of the magnitude of V^+. At values of supply voltage in excess of $+15V_{CC}$, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.
3. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, indepedent of the state of the output so no loading change exists on the input lines.
4. The input common-mode voltage on either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V^+−1.5V, but either or both inputs can go to $+30V_{DC}$ without damage.
5. $V_O \cong 1.4\ V_{DC}$, $R_S = 0\Omega$ with V^+ from $5V_{DC}$ to $30V_{DC}$; and over the full input common-mode range ($0V_{DC}$ to $V^+-1.5V_{DC}$).
6. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
7. Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitive coupling increases at higher frequencies.

ELECTRICAL CHARACTERISTICS

$V^+ = +5V_{DC}$ and $-55^oC \leqslant T_A \leqslant +125^oC$, unless otherwise stated. With the LM224, all temperature specifications are limited to $-25^oC \leqslant T_A \leqslant +85^oC$ and the LM324 temperature specifications are limited to $0^oC \leqslant T_A \leqslant +70^oC$.

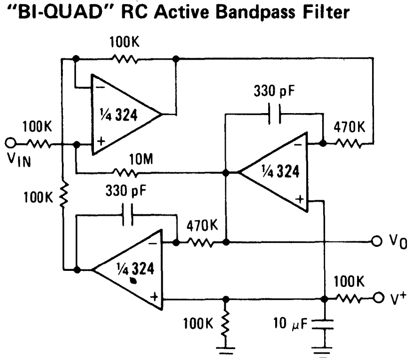
PARAMETER	CONDITIONS	LM124			LM224, LM324			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	(Note 5)			7			9	mV
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$			±100			±150	nA
Input Bias Current				300			500	nA
Common Mode Range	$V^+ = 30V$ (Note 4)	0		V^+-2	0		V^+-2	V
Voltage Gain	$V^+ = 15V$, $R_L = 2k\Omega$	25			15			V/mV
Output Voltage Swing	$V^+ = 30V$, $R_L = 2k\Omega$	26			26			V
	$V^+ = 5V$, $R_L = 10k\Omega$		5	20		5	20	mV
Output Source Current	$V_{IN} = 1V$, $V^+ = 15V$	10	20		10	20		mA
Output Sink Current		5	8		5	8		mA

LM 2902
ELECTRICAL CHARACTERISTICS ($V^+ = +5V_{DC}$ and $T_A = 25^oC$ unless otherwise noted)

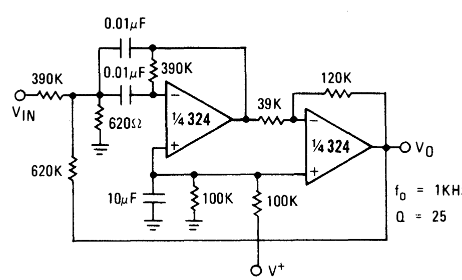
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input offset Voltage	$R_S = 0\Omega$		2	10	mV_{DC}
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$		45	500	nA_{DC}
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		±5	±50	nA_{DC}
Common-Mode Range	(Note 4)	0		$V^+ - 1.5$	V_{DC}
Supply Current	$R_L = \infty$		0.8	2	mA_{DC}
Large Signal Voltage Gain	$R_L \geqslant 2k\Omega$		100		V/mV
Output Voltage Swing	$R_L = 2k\Omega$	0		$V^+ - 1.5$	V_{DC}
Common Mode Rejection Ratio	DC		85		dB
Power Supply Rejection Ratio	DC		100		dB
Amplifier-to-Amplifier Coupling	f=1kHz to 20kHz (Input Referred)		-120		dB
Output Current Source	$V_{IN}^+ = +1V_{DC}$, $V_{IN}^- = 0V_{DC}$	20	40		mA_{DC}
Output Current Sink	$V_{IN}^- = +1V_{DC}$, $V_{IN}^+ = 0V_{DC}$	8	20		mA_{DC}

324 TYPICAL APPLICATIONS

"BI-QUAD" RC Active Bandpass Filter



Bandpass Active Filter



Precision Operational Amplifiers

GENERAL DESCRIPTION

The LM216A/LM216 and LM316A/LM316 are precision, high input impedance operational amplifiers ideally suited for applications requiring extremely low input current errors. Super Beta transistors are used in a Darlington input stage to obtain input bias currents equal to high quality FET amplifiers.

They are frequency compensated internally, and allow offset balancing with an external potentiometer. The MOS compensation capacitor is protected to prevent catastrophic failure due to overvoltage spikes on the supplies.

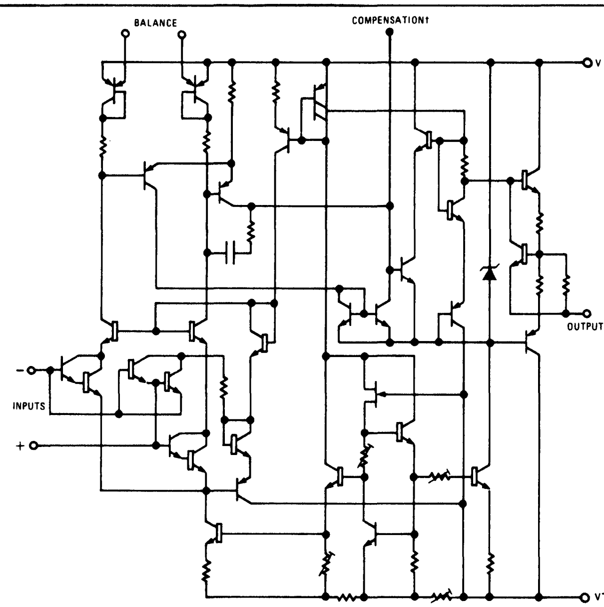
The low current error of these amplifiers permits many designs previously impractical with monolithic devices. They can operate from 100MΩ source resistances, introducing less error than general purpose amplifiers with 10kΩ sources. Also integrators with worst-case drifts of less than 10μV/s and analog time delays in excess of one day can be made using capacitors no larger than 1μF.

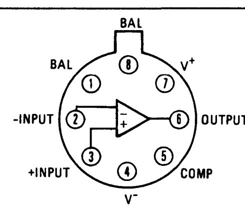
The LM216A/LM216 are specified for operation from −25°C to +85°C. The LM316A/LM316 operates over a range of 0°C to +55°C.

DESIGN FEATURES

- Guaranteed Bias Currents as Low as 50pA
- Maximum Offset Currents as Low as 15pA
- Operates from ±3V to ±20V Supplies
- Supply Current Only 300μA

SCHEMATIC DIAGRAM





NOTE: Pin 4 connected to case.

TE (TO-5) Metal Can
(Top View)

Order Part Nos.:
LM216H, LM216AH,
LM316H, LM316AH

Precision Operational Amplifiers

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±20V
Power Dissipation (Note 1)	500mW
Differential Input Current (Note 2)	±10mA
Input Voltage (Note 3)	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	
LM216A/216	−25°C to +85°C
LM316A/316	0°C to +55°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10s)	300°C

ELECTRICAL CHARACTERISTICS (Note 4)

PARAMETER	CONDITIONS	LM216	LM216A	LM316	LM316A	UNITS
Input Offset Voltage	$T_A = 25°C$	10	3	10	3	mV max
Input Offset Current	$T_A = 25°C$	50	15	50	15	pA max
Input Bias Current	$T_A = 25°C$	150	50	150	50	pA max
Input Resistance	$T_A = 25°C$	1	5	1	5	GΩ typ
Supply Current	$T_A = 25°C$	0.8	0.6	0.8	0.6	mA max
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$, $V_{OUT} = \pm10V$, $R_L \geqslant 10k\Omega$	20	40	20	40	V/mV min
Input Offset Voltage		15	6	15	6	mV max
Input Offset Current		100	30	100	30	pA max
Input Bias Current		250	100	250	100	pA max
Supply Current	$T_A = T_{MAX}$		0.5		0.5	mA max
Large Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$, $R_L \geqslant 10k\Omega$	10	20	15	30	V/mV min
Output Voltage Swing	$V_S = \pm15V$, $R_L = 10k\Omega$	±13	±13	±13	±13	V min
Input Voltage Range	$V_S = \pm15V$	±13	±13	±13	±13	V min
Common Mode Rejection Ratio		80	80	80	80	dB min
Supply Voltage Rejection Ratio		80	80	80	80	dB min

NOTES:

1. The maximum junction temperature of the LM216 and LM216A is 100°C, while that of the LM316 and LM316A is 70°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case.
2. The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.
3. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
4. These specifications apply for $\pm5V \leqslant V_S \leqslant \pm20V$ and $-25°C \leqslant T_A \leqslant 85°C$, unless otherwise specified. With the LM316 and LM316A, however, all temperature specifications are limited to $0°C \leqslant T_A \leqslant +70°C$.

High-Gain Operational Amplifiers

GENERAL DESCRIPTION

The RM709A/RM709 and RC709 are monolithic, high gain DC operational amplifiers fabricated on a single silicon chip by the planar process.

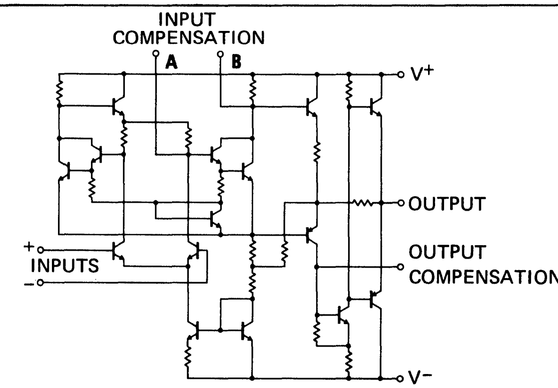
These devices are designed for use in operational amplifier signal processing, low level instrumentation, control systems and for the generation of special linear and non-linear transfer functions.

The RM709A/RM709 operate over the full military temperature range from −55°C to +125°C. The RC709 is the commercial device intended to operate over a temperature range of 0°C to +70°C.

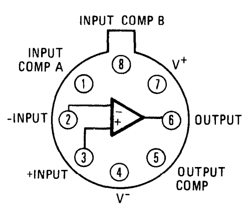
DESIGN FEATURES

- Low Input Offset Voltage ±1.0mV Maximum
- Low Temperature Drift of Input Offset Voltage ±6μV/°C Maximum
- Low Temperature Drift of Input Offset Current (+25°C to +125°C) 0.3nA/°C Maximum (−55°C to +25°C) 1.0nA/°C Maximum
- Low Power Consumption 90mW Maximum
- High Performance Open Loop Gain Characteristics 45k Typical

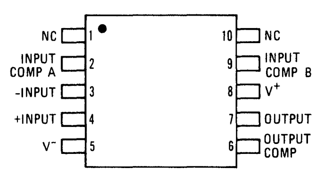
SCHEMATIC DIAGRAM

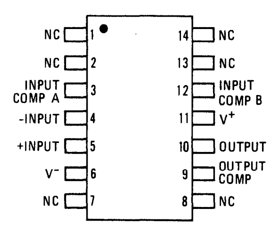


CONNECTION INFORMATION



NOTE: Pin 4 connected to case.





NOTE: Pin 7 connected to bottom of package.

TE (TO-5) Metal Can
(Top View)

Order Part Nos.:
RM709AT, RM709T, RC709T

Q Flat Package
(Top View)

Order Part Nos.:
RM709AQ, RM709Q

DC Dual In-line Package
(Top View)

Order Part Nos.:
RM709ADC, RM709DC, RC709DC

High-Gain Operational Amplifiers

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18V
Differential Input Voltage	±5V
Input Voltage	±10V
Power Dissipation (Note)	
Dual In-line Package	300mW
TO-5 Package	300mW
Flat Package	250mW
Output Short-Circuit Duration (T_A = 25°C)	5 sec
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	
RM709/709A	−55°C to +125°C
RC709	0°C to +70°C
Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS (±9 ≤ V_S ≤ ±15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM709A			RM709			RC709			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	R_S ≤ 10kΩ		0.2	1.0		1.0	3.0		2.0	7.5	mV
Input Offset Current			10	50		25	100		100	500	nA
Input Bias Current			100	200		180	300		300	1500	nA
Input Resistance		350	700		220	400		50	250		kΩ
Output Resistance			150			150			150		Ω
Supply Current	V_S = ±15V		2.3	3.0		2.6	4.0				mA
Power Consumption	V_S = ±15V		70	90		80	120		80	200	mW
Transient Response	R_L = 2kΩ, V_S = ±15V, V_{IN} = 20mV										
Rise Time	C_1 = 5nF, R_1 = 1.5k, C_2 = 200pF, R_2 = 50Ω		0.3	1.0		0.3	1.0		0.3	1.0	µs
Overshoot	C_L ≤ 100pF		10	30		10	30		10	30	%
Slew Rate	V_S = ±15V, R_L ≥ 10kΩ, A_V = 1	0.2	0.4		0.15	0.4			0.4		V/µs
Large Signal Voltage Gain	V_S=±15V, R_L=2k, V_{OUT}=±10V							15	45		kV/V
The following specifications apply for −55°C ≤ T_A ≤ +125°C for RM; 0°C ≤ T_A ≤ 70°C for RC.											
Large Signal Voltage Gain	V_S=±15V, R_L ≥ 2k, V_{OUT}=±10V	25	45	70	25	45	70	12			kV/V
Input Offset Voltage	R_S ≤ 10kΩ			2.0			4.0			10	mV
Input Offset Current	T_A = max		3.0	50		10	100				nA
	T_A = min		30	250		50	300			750	
Input Bias Current	T_A = min		300	600		400	1000			2000	nA
Average Temperature of Coefficient of Input Offset Voltage	R_S = 50Ω, T_A = 25°C to T_A = max		1.0	6.0		1.8	10				µV/°C
	R_S = 50Ω, T_A = 25°C to T_A = min		1.0	6.0		1.8	10				
	R_S = 10k, T_A = 25°C to T_A = max		1.6	9.0		2.0	15				
	R_S = 10k, T_A = 25°C to T_A = min		3.0	16		6.0	15				
Average Temperature Coefficient of Input Offset Current	T_A = +25°C to max		0.06	0.3							nA/°C
	T_A = +25°C to min		0.2	1.0							
Input Voltage Range	V_S = ±15V	±8.0	±10		±8.0	±10		±8.0	±10		V
Output Voltage Swing	V_S = ±15V, R_L ≥ 10kΩ	±12	±14		±12	±14		±12	±14		V
	V_S = ±15V, R_L ≥ 2kΩ	±10	±13		±10	±13		±10	±13		
Input Resistance	T_A = min	85	170		50	125		35	125		kΩ
Common Mode Rejection Ratio	R_S ≤ 10kΩ	80	90		70	90		65	90		dB
Supply Voltage Rejection Ratio	R_S ≤ 10kΩ		40	75		25	150		25	200	µV/V
Supply Current	V_S = ±15V, T_A = max		2.0	2.7							mA
	V_S = ±15V, T_A = min		2.6	3.9							
Power Consumpstion	V_S = ±15V, T_A = max		60	81							mW
	V_S = ±15V, T_A = min		78	117							

NOTE:

Derate linearly the maximum power dissipation of the dual in-line package at 8.6mW/°C for ambient temperature above +115°C, of the TO-5 package at 5.6mW/°C for ambient temperature above +95°C and of the flat package at 5.4mW/°C for ambient temperature above +103°C. For RC709, rating applies for case temperatures to +70°C.

GENERAL DESCRIPTION

The RM725 and RC725 are high performance, high gain operational amplifiers on a silicon planar epitaxial processed chip.

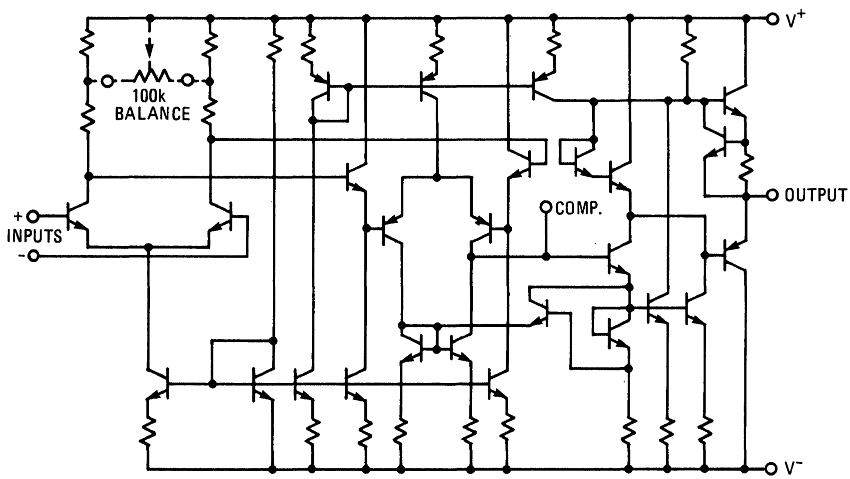
The RM725 military version operates over full temperature range from −55°C to +125°C. The commercial RC725 operates from 0°C to +70°C.

The RM725 and RC725 offer offset null capability, very high voltage gain and low power consumption over a wide power supply voltage range. They are used for all instrumentation applications requiring precise, low level signal amplification, low noise, low drift and accurate closed loop gain.

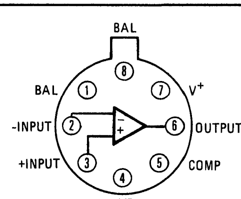
DESIGN FEATURES

- Low Input Noise Current 0.15pA/√Hz
- High Open Loop Gain 3,000,000
- Low Input Offset Current 2nA
- Low Input Voltage Drift 0.6μV/°C
- High Common-Mode Rejection 120dB
- High Input Voltage Range ±14V
- Wide Power Supply Range ±3V to ±22V
- Offset Null Capability

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



Note: Pin 4 connected to case

TE Metal Can Package
(Top View)

Order Part Nos.:
RM725T, RC725T

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±22V
Internal Power Dissipation (Note 1)	500mW
Differential Input Voltage (Note 2)	±22V
Input Voltage (Note 3)	±22V
Voltage Between Offset Null and V^+	±0.5V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	
RM725	−55°C to +125°C
RC725	0°C to +70°C
Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS (V_S = ±15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM725			RC725			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage (without external trim)	$R_S \leqslant 10k\Omega$		0.5	1.0		0.5	2.5	mV
Input Offset Current			2.0	20		2.0	35	nA
Input Bias Current			42	100		42	125	nA
Input Noise Voltage	f_o = 10Hz		15			15		nV/$\sqrt{Hz}$
	f_o = 100Hz		9.0			9.0		
	f_o = 1kHz		8.0			8.0		
Input Noise Current	f_o = 10Hz		1.0			1.0		pA/$\sqrt{Hz}$
	f_o = 100Hz		0.3			0.3		
	f_o = 1kHz		0.15			0.15		
Input Resistance			1.5			1.5		MΩ
Input Voltage Range		±13.5	±14		±13.5	±14		V
Large Signal Voltage Gain	$R_L \geqslant 2k\Omega$, V_{out}=±10V	1,000,000	3,000,000		250,000	3,000,000		
Common Mode Rejection Ratio	$R_S \leqslant 10k\Omega$	110	120		94	120		dB
Power Supply Rejection Ratio	$R_S \leqslant 10k\Omega$		2.0	10		2.0	35	μV/V
Output Voltage Swing	$R_L \geqslant 10k\Omega$	±12	±13.5		±12	±13.5		V
	$R_L \geqslant 2k\Omega$	±10	±13.5		±10	±13.5		
Output Resistance			150			150		Ω
Power Consumption			80	105		80	150	mW
The following specifications apply for −55°C ⩽ T_A ⩽ +125°C for RM725; 0°C ⩽ T_A ⩽ +70°C for RC725.								
Input Offset Voltage (without external trim)	$R_S \leqslant 10k\Omega$			1.5			3.5	mV
Average Input Offset Voltage Drift (without external trim)	R_S = 50Ω		2.0	5.0		2.0		μV/°C
Average Input Offset Voltage Drift (with external trim)	R_S = 50Ω		0.6		0.6			μV/°C
Input Offset Current	T_A=125°C;70°C		1.2	20		1.2	3.5	nA
	T_A=−55°C;0°C		7.5	40		4.0	50	
Average Input Offset Current Drift			35	150		10		pA/°C
Input Bias Current	T_A=125°C;70°C		20	100			125	nA
	T_A=−55°C;0°C		80	200			250	
Large Signal Voltage Gain	T_A=125°C;70°C	1,000,000			125,000			
	T_A=−55°C;0°C	250,000			125,000			
Common Mode Rejection Ratio	$R_S \leqslant 10k\Omega$	100				115		dB
Power Supply Rejection Ratio	$R_S \leqslant 10k\Omega$			20		20		μV/V
Output Voltage Swing	$R_L \geqslant 2k\Omega$	±10			±10			V

NOTES:

1. Rating applies for case temperature to +125°C; derate linearly at 6.5 mW/°C for ambient temperature above +75°C.
2. Rating applies for 5 ms pulses with 10% duty cycle, derate to ±5V for continuous operation.
3. For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

GENERAL DESCRIPTION

The RM741 and RC741 integrated circuits are high performance, high gain internally compensated monolithic operational amplifiers fabricated on a single silicon chip using the planar epitaxial process.

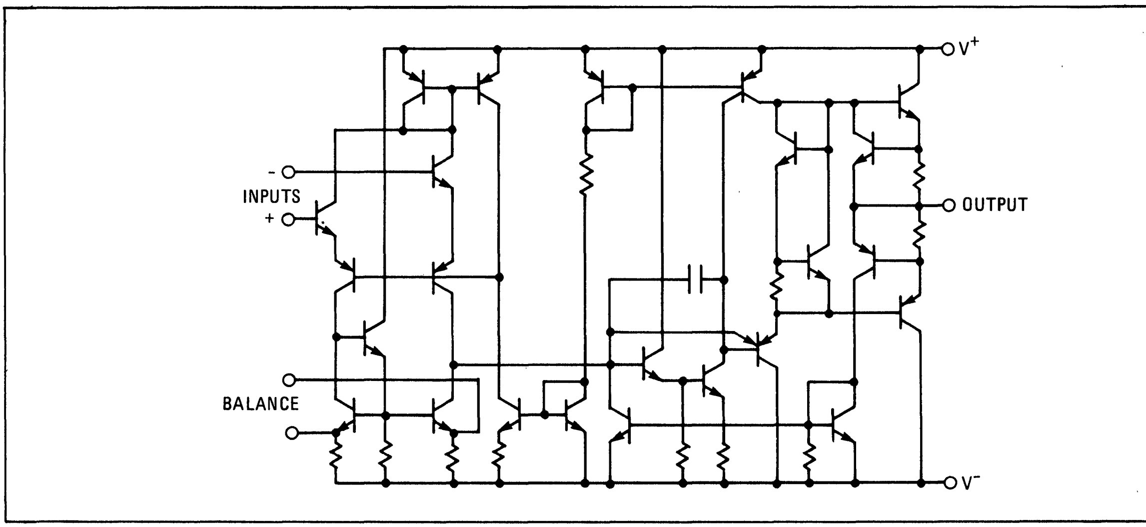
High common-mode voltage range and absence of latch-up tendencies make the RM741 and RC741 ideal for use as a voltage follower. High gain and wide ranges of operating voltages provide superior performance in integrator, summary amplifier and general feedback applications.

Both RM741 and RC741 are pin compatible with the RM709, RM101 and the LH101. The military version, RM741 operates over a temperature range from −55°C to +125°C. The commercial version RC741 operates from 0°C to +70°C.

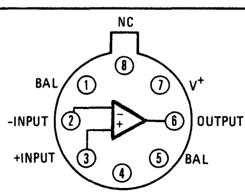
DESIGN FEATURES

- Supply Voltage ±22V RM741, ±18V RC741
- Offset Voltage Null Capability
- Continuous Short-Circuit Protection
- No Frequency Compensation Required
- No Latch-up
- Large Common-Mode and Differential Voltage Ranges
- Low Power Consumption

SCHEMATIC DIAGRAM

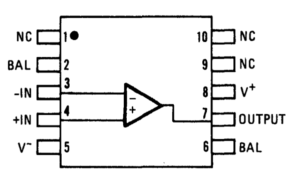


CONNECTION INFORMATION



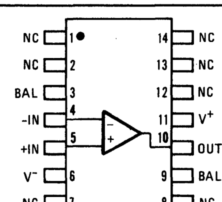
TE Metal Can Package
(Top View)

Order Part Nos.:
RM741T, RC741T

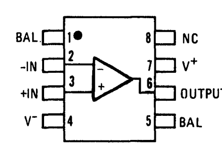


Q
Flat Package
(Top View)

Order Part No.:
RM741Q



D and DB
Dual In-line Packages
(Top View)
Order Part Nos.:
RM741D, RC741D,
RC741DB



DN
Dual In-line Package
(Top View)
Order Part No.:
RC741DN

ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... RM741: ±22V
RC741: ±18V
Internal Power Dissipation (Note 1) 500mW
Differential Input Voltage .... ±30V
Input Voltage (Note 2) .... ±15V
Storage Temperature Range .... −65°C to +150°C

Operating Temperature Range
RM741 .... −55°C to +125°C
RC741 .... 0°C to +70°C
Lead Temperature (Soldering, 60s) .... 300°C
Output Short-Circuit Duration (Note 3) ..... Indefinite

ELECTRICAL CHARACTERISTICS (V_S = ±15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM741			RC741			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leqslant 10k\Omega$		1.0	5.0		2.0	6.0	mV
Input Offset Current			30	200		30	200	nA
Input Bias Current			200	500		200	500	nA
Input Resistance		0.3	1.0		0.3	1.0		MΩ
Large-Signal Voltage Gain	$R_L \geqslant 2k\Omega$, V_{out} = ±10V	50,000	200,000		20,000	100,000		
Output Voltage Swing	$R_L \geqslant 10k\Omega$	±12	±14		±12	±14		V
	$R_L \geqslant 2k\Omega$	±10	±13		±10	±13		V
Input Voltage Range		±12	±13		±12	±13		V
Common Mode Rejection Ratio	$R_S \leqslant 10k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leqslant 10k\Omega$		30	150		30	150	μV/V
Power Consumption			50	85		50	85	mW
Transient Response (unity gain)	V_{in} = 20mV, R_L = 2kΩ, $C_L \leqslant$ 100pF							
Risetime			0.3			0.3		μs
Overshoot			5.0			5.0		%
Slew Rate (unity gain)	$R_L \geqslant 2k\Omega$		0.5			0.5		V/μs
The following specifications apply for −55°C ≤ T_A ≤ +125°C for RM741; 0°C ≤ T_A ≤ +70°C for RC741.								
Input Offset Voltage	$R_S \leqslant 10k\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1500			800	nA
Large-Signal Voltage Gain	$R_L \geqslant 2k\Omega$, V_{out} = ±10V	25,000			15,000			
Output Voltage Swing	$R_L \geqslant 2k\Omega$	±10			±10			V
Common Mode Rejection Ratio	$R_S \leqslant 10k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leqslant 10k\Omega$		30	150		30	150	μV/V

NOTES:

1. Rating applies for case temperatures to +125°C; derate linearly at 6.5 mW/°C for ambient temperatures above +75°C for RM741.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature for RM741.

Dual General Purpose Operational Amplifier 747

GENERAL DESCRIPTION

The RM747 and RC747 integrated circuits are high gain operational amplifiers internally compensated and constructed on a single silicon chip using the planar epitaxial process.

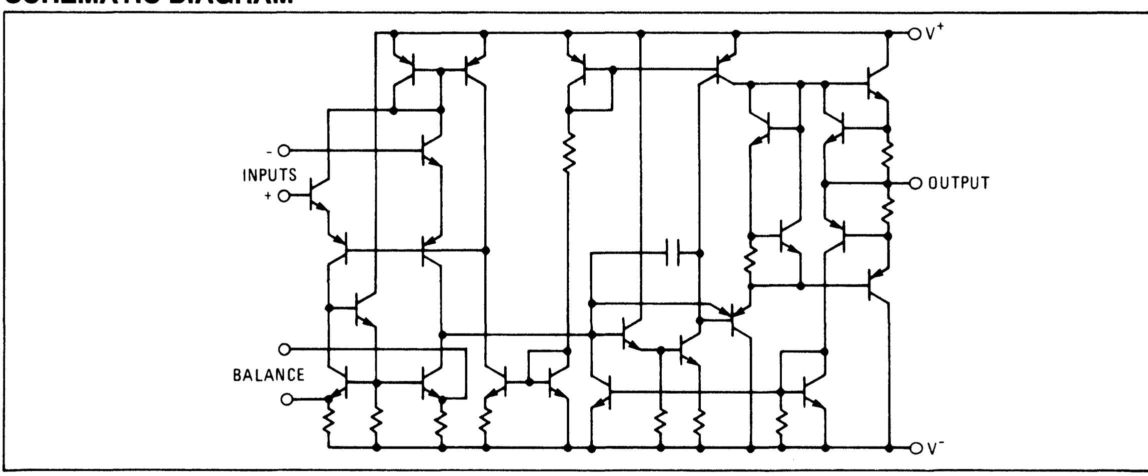
The military version, RM747, operates over a temperature range from −55°C to +125°C. The commercial version, RC747, operates from 0°C to +70°C.

Combining all of the outstanding features of the 741 with the close parameter matching and tracking of a dual device on a monolithic chip results in unique performance characteristics. Excellent channel separation allows the use of the dual device in all single 741 operational amplifier applications providing the highest possible packaging density. It is especially well suited for applications in differential-in, differential-out as well as in potentiometric amplifiers and where gain and phase matched channels are mandatory.

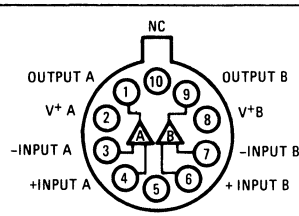
DESIGN FEATURES

- Supply Voltage ±22 V for RM747
  ±18 V for RC747
- Continuous Short-Circuit Protection
- No Frequency Compensation Required
- No Latch-Up
- Large Common-Mode and Differential Voltage Ranges
- Low Power Consumption
- Parameter Tracking Over Temperature Range
- Gain and Phase Match Between Amplifiers

SCHEMATIC DIAGRAM

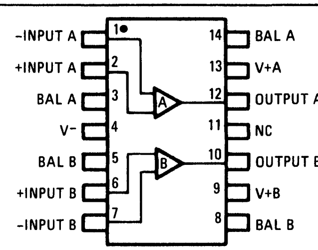


CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
RM747T, RC747T



DB and DC
Dual In-line Packages
(Top View)

Order Part Nos.:
RM747DC, RC747DC
RC747DB

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . RM747: ±22 V
RC747: ±18 V
Internal Power Dissipation (Note 1) . . . . 500 mW
Differential Input Voltage . . . . ±30 V
Input Voltage (Note 2) . . . . ±15 V
Storage Temperature Range . . . . −65°C to +150°C
Operating Temperature Range . RM747: −55°C to +125°C
RC747: 0°C to +70°C
Lead Temperature (Soldering, 60s) . . . . 300°C
Output Short-Circuit Duration (Note 3) . . . . . Indefinite

ELECTRICAL CHARACTERISTICS (V_{CC} = ±15V, T_A = 25°C unless otherwise noted)

PARAMETER	CONDITIONS	RM747			RC747			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 10\ k\Omega$		1.0	5,0		2.0	6.0	mV
Input Offset Current			30	200		30	200	nA
Input Bias Current			200	500		200	500	nA
Input Resistance		0.3	1.0		0.3	1.0		MΩ
Large-Signal Voltage Gain	$R_L \geq 2\ k\Omega$, V_{out} = ±10V	50,000	200,000		50,000	200,000		V/V
Output Voltage Swing	$R_L \geq 10\ k\Omega$	±12	±14		±12	±14		V
	$R_L \geq 2\ k\Omega$	±10	±13		±10	±13		V
Input Voltage Range		±12	±13		±12	±13		V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$		30	150		30	150	μV/V
Power Consumption			100	170		100	170	mW
Transient Response (unity gain)	V_{in} = 20 mV, R_L = 2 kΩ, $C_L \leq 100$ pF							
Risetime			0.3			0.3		μs
Overshoot			5.0			5.0		%
Slew Rate (unity gain)	$R_L \geq 2\ k\Omega$		0.5			0.5		V/μs
Channel Separation (open loop)	f = 10 kHz, R_S = 1 kΩ		70			70		dB
(Gain = 100)	f = 10 kHz, R_S = 1 kΩ		83			83		dB
The following specifications apply for −55°C ≤ T_A ≤ +125°C for RM747; 0°C ≤ T_A ≤ +70°C for RC747.								
Input Offset Voltage	$R_S \leq 10\ k\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1.5			800	nA
Large-Signal Voltage Gain	$R_L \geq 2\ k\Omega$, V_{out} = ±10V	25,000			25,000			V/V
Output Voltage Swing	$R_L \geq 2\ k\Omega$	±10	±13		±10	±13		V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$		30	150		30	150	μV/V
Power Consumption	V_S = ±15V, T_A = +125°C		90	150		90	150	mW
	T_A = −55°C		120	200		120	200	mW

NOTES:

1. Rating applies for case temperatures to +125°C; derate linearly at 6.5 mW/°C for ambient temperatures above +75°C for RM747.
2. For supply voltages less than ±15V the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature for RC747.

GENERAL DESCRIPTION

The RM748 and RC748 integrated circuits are high performance, high gain internally compensated monolithic operational amplifiers fabricated on a single silicon chip using the planar epitaxial process.

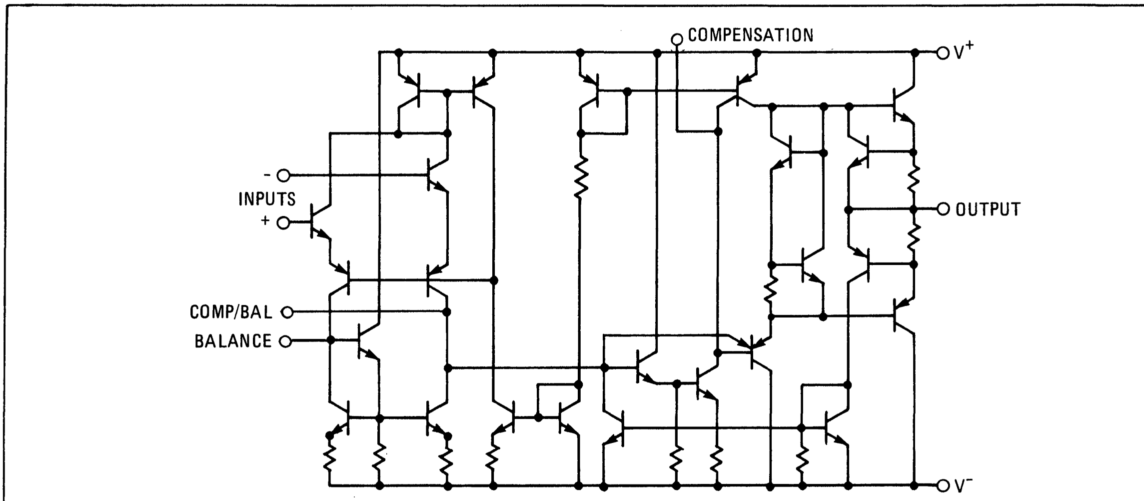
High common-mode voltage range and absence of latch-up tendencies make the RM748 and RC748 ideal for use as a voltage follower. High gain and wide ranges of operating voltages provide superior performance in integrator, summary amplifier and general feedback applications. Unity gain compensation is achieved by means of a single 30pF capacitor.

Both RM748 and RC748 are pin compatible with the RM709, LM101 and RM4101. The military version, RM748 operates over a temperature range from −55°C to +125°C while the commercial version RC748 operates from 0° to +70°C.

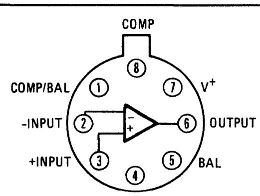
DESIGN FEATURES

- Supply Voltage ±22V RM748, ±18V RC748
- Offset Voltage Null Capability
- Continuous Short-Circuit Protection
- No Latch-up
- Large Common-Mode and Differential Voltage Ranges
- Low Power Consumption

SCHEMATIC DIAGRAM (Each Side)



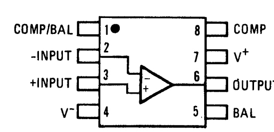
CONNECTION INFORMATION



Note: Pin 4 connected to case

TE Metal Can Package
(Top View)

Order Part Nos.:
RM748T, RC748T



NB
Dual In-line Packages
(Top View)

Order Part No.:
RC748NB

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . RM748: ±22V
RC748: ±18V
Internal Power Dissipation (Note 1) 500mW
Differential Input Voltage . . . . ±30V
Input Voltage (Note 2) . . . . ±15V
Storage Temperature Range . . . . −65°C to +150°C

Operating Temperature Range
RM748 . . . . −55°C to +125°C
RC748 . . . . 0°C to +70°C
Lead Temperature (Soldering, 60s) . . . . 300°C
Output Short-Circuit Duration (Note 3) . . . . . Indefinite

ELECTRICAL CHARACTERISTICS (V_S = ±15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM748 MIN	RM748 TYP	RM748 MAX	RC748 MIN	RC748 TYP	RC748 MAX	UNITS
Input Offset Voltage	$R_S \leq 10k\Omega$		1.0	5.0		2.0	6.0	mV
Input Offset Current			30	200		30	200	nA
Input Bias Current			200	500		200	500	nA
Input Resistance		0.3	1.0		0.3	1.0		MΩ
Large-Signal Voltage Gain	$R_L \geq 2k\Omega$, V_{out} = ±10V	50,000	200,000		20,000	100,000		
Output Voltage Swing	$R_L \geq 10k\Omega$	±12	±14		±12	±14		V
	$R_L \geq 2k\Omega$	±10	±13		±10	±13		V
Input Voltage Range		±12	±13		±12	±13		V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$		30	150		30	150	μV/V
Power Consumption			50	85		50	85	mW
Transient Response (unity gain)	V_{in} = 20mV, R_L = 2kΩ, $C_L \leq 100pF$							
Risetime			0.3			0.3		μs
Overshoot			5.0			5.0		%
Slew Rate (unity gain)	$R_L \geq 2k\Omega$		0.5			0.5		V/μs
The following specifications apply for −55°C ≤ T_A ≤ +125°C for RM748; 0°C ≤ T_A ≤ +70°C for RC748.								
Input Offset Voltage	$R_S \leq 10k\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1500			800	nA
Large-Signal Voltage Gain	$R_L \geq 2k\Omega$, V_{out} = ±10V	25,000			15,000			
Output Voltage Swing	$R_L \geq 2k\Omega$	±10			±10			V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$		30	150		30	150	μV/V

NOTES:

1. Rating applies for case temperatures to +125°C; derate linearly at 6.5 mW/°C for ambient temperatures above +75°C for RM748.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature for RM748.

Dual High-Gain Operational Amplifier

GENERAL DESCRIPTION

The RC1437 and RM1537, previously referred to as the 4709, integrated circuits are monolithic dual high gain operational amplifiers. The device is composed of two 709 operational amplifiers fabricated on a single silicon chip. It has all the outstanding features of the 709.

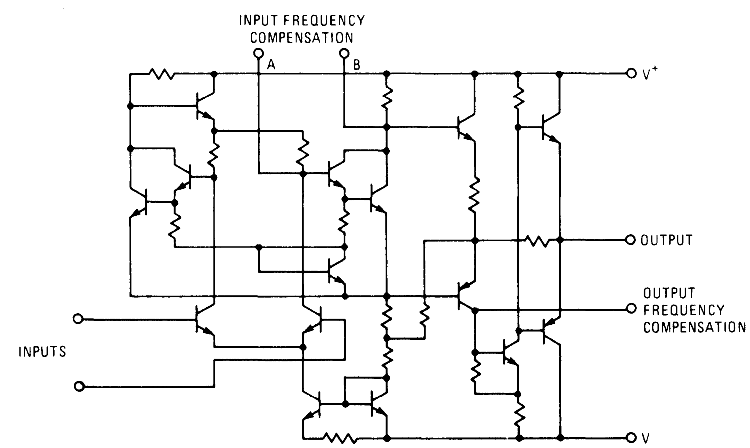
Due to the inherent matching and tracking of parameters, the 1537/1437 has several unique applications: differential in/out amplifiers, non-inverting amplifiers, gain and phase matched channels.

The RM1537 operates over a temperature range of −55°C to +125°C. RC 1437 is the commercial temperature range device for operation from 0°C to +75°C.

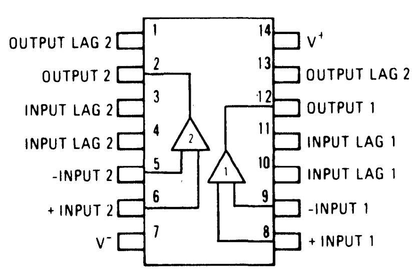
DESIGN FEATURES

- Gain and Phase Matching Between Amplifiers
- Low Temperature Drift ±3 μV/°C
- Large Output Voltage Swing ±14 V Typical

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DC and DB
Dual In-line Packages
(Top View)
Order Part Nos.:
RM1537DC, RC1437DC,
RC1437DB

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18 V
Differential Mode Input Voltage	±5 V
Common Mode Input Voltage	±10 V
Power Dissipation	500 mW
Derate above 75°C	5.0 mW/°C
Operating Temperature Range . RM1537:	-55°C to +125°C
RC1437:	0°C to +75°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS (RM1537: -55°C to +125°C; RC1437: 0°C to +75°C, unless otherwise noted)

PARAMETER	CONDITIONS	RM1537			RC1437			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$50\Omega \leq R_S \leq 10k\Omega$ $T_A = 25°C$		1.0	5.0		1.0	7.5	mV
	$\pm9V < V^+ < 15V$			6.0			10	
Input Offset Current	$\pm9V < V^+ < \pm15V$ RM1537: +25°C to +125°C RC1437: +25°C to +75°C		50	200		50	750	nA
	RM1537: -55°C RC1437: 0°C		100	500			750	
Input Bias Current	$\pm9V < V^+ < \pm15V$ RM1537: +25°C to +125°C RC1437: +25°C to +75°C		0.2	0.5		0.4	1.5	μA
	RM1537: -55°C RC1437: 0°C		0.5	1.5			2.0	
Input Resistance	$+9V < V^+ < \pm15V$	150	400		50	150		kΩ
Output Resistance	$+9V < V^+ < \pm15V$		150			150		Ω
Power Consumption	$V^+ = \pm15V$, $R_L = \infty$		160	225		160	225	mW
Large Signal Voltage Gain	$V^+ = \pm15V$, $V_O = \pm10V$, $R_L \geq 2\ k\Omega$	25	45	70	15	45		KV/V
Output Voltage Swing	$V^+ = \pm15V$ $R_L \geq 10\ k\Omega$	±12	±14		±12	±14		V
	$R_L \geq 2\ k\Omega$	±10	±13		±10	±13		
Input Common Mode Voltage	$V^+ = \pm15V$	±8	±10		±8	±10		V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$, $+9V < V^+ < \pm15V$	70	90		65	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$, $+9V < V^+ < \pm15V$			150			200	μV/V
Transient Response	$V^+ = \pm15V$, $V_{in} = 20$ mV, $R_L = 2\ k\Omega$, $C_L = 5$ nF, $R_1 = 1.5\ k\Omega$, $C_2 = 200$ pF, $R_2 = 50\ \Omega$							
Rise Time			0.3	1.0		0.3	1.0	μs
Overshoot				30			30	%
Average Temperature Coefficient of Input Offset Voltage	$+9V < V^+ < \pm15V$ $R_S = 50\ \Omega$		1.5			1.5		μV/°C
	$R_S = 10\ k\Omega$		3.0			3.0		
Average Temperature Coefficient of Input Offset Current	$+9 < V^+ < \pm15V$		0.6			0.7		nA/°C
Separation, f = 10kHz Open Loop	$+9V < V^+ < \pm15V$		73			73		dB

MATCHING CHARACTERISTICS ($T_A = 25°C$, $\pm9V < V^+ < \pm15V$ unless otherwise noted)

PARAMETER	RM1537			RC1437			UNITS
	MIN	TYP	MAX	MIN	TYP	MAX	
Voltage Gain		±0.5			±1.0		dB
Input Bias Current		±100			±150		nA
Input Offset Current		±15			±20		nA
Input Offset Voltage		±0.15			±0.2		mV
Average Temperature Coefficient of Input Offset Voltage		±0.5			±0.5		μV/°C
Average Temperature Coefficient of Input Offset Current		±0.2			±0.2		nA/°C

Dual 741 General Purpose Operational Amplifier

GENERAL DESCRIPTION

The RM1558 and RC1458 integrated circuits are high gain operational amplifiers internally compensated and constructed on a single silicon chip using the planar epitaxial process.

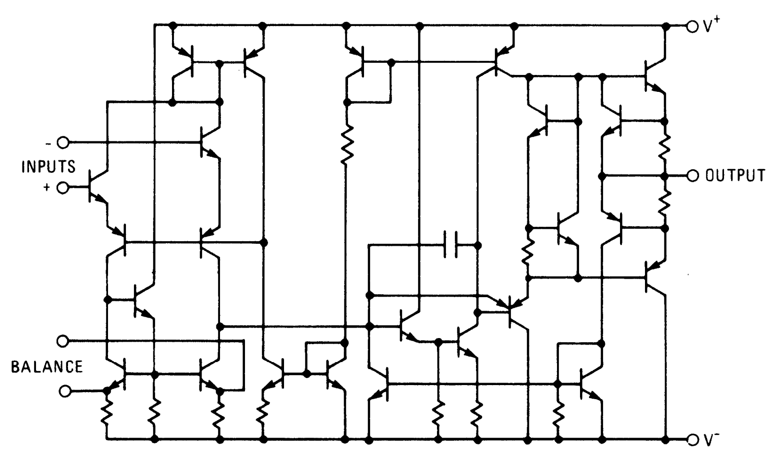
The military version, RM1558, operates over a temperature range from −55°C to +125°C. The commercial version, RC1458, operates from 0°C to +70°C.

Combining all of the outstanding features of the 741 with the close parameter matching and tracking of a dual device on a monolithic chip results in unique performance characteristics. Excellent channel separation allows the use of the dual device in all single 741 operational amplifier applications providing the highest possible packaging density. It is especially well suited for applications where gain and phase matched channels are mandatory.

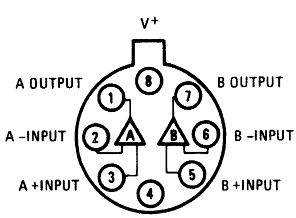
DESIGN FEATURES

- Continuous Short-Circuit Protection
- No Frequency Compensation Required
- No Latch-Up
- Large Common-Mode and Differential Voltage Ranges
- Low Power Consumption
- Parameter Tracking Over Temperature Range
- Gain and Phase Match Between Amplifiers

SCHEMATIC DIAGRAM

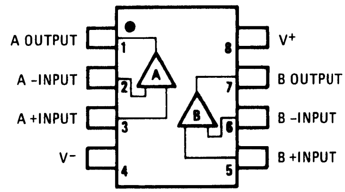


CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
RM1558T, RC1458T



NB Dual In-line Package
(Top View)

Order Part No.:
RC1458NB

Dual 741 General Purpose Operational Amplifier

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . RM1558: ±22 V
RC1458: ±18 V
Internal Power Dissipation (Note 1) . . . . 500 mW
Differential Input Voltage . . . . ±30 V
Input Voltage (Note 2) . . . . ±15 V

Storage Temperature Range . . . . −65°C to +150°C
Operating Temperature Range . RM1558: −55°C to +125°C
RC1458: 0°C to +70°C
Lead Temperature (Soldering, 60s) . . . . 300°C
Output Short-Circuit Duration (Note 3) . . . . . Indefinite

ELECTRICAL CHARACTERISTICS (V_{CC} = ±15V, T_A = 25°C unless otherwise noted)

PARAMETER	CONDITIONS	RM1558			RC1458			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 10$ kΩ		1.0	5.0		2.0	6.0	mV
Input Offset Current			30	200		30	200	nA
Input Bias Current			200	500		200	500	nA
Input Resistance		0.3	1.0		0.3	1.0		MΩ
Large-Signal Voltage Gain	$R_L \geq 2$ kΩ, V_{out} = ±10V	50,000	200,000		50,000	200,000		V/V
Output Voltage Swing	$R_L \geq 10$ kΩ	±12	±14		±12	±14		V
	$R_L \geq 2$ kΩ	±10	±13		±10	±13		V
Input Voltage Range		±12	±13		±12	±13		V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10$ kΩ		30	150		30	150	μV/V
Power Consumption			100	170		100	170	mW
Transient Response (unity gain)	V_{in} = 20mV, R_L = 2 kΩ, $C_L \leq$ 100pF							
Risetime			0.3			0.3		μs
Overshoot			5.0			5.0		%
Slew Rate (unity gain)	$R_L \geq 2$ kΩ		0.5			0.5		V/μs
Channel Separation (open loop)	f = 10 kHz, R_S = 1 kΩ		70			70		dB
(Gain = 100)	f = 10 kHz, R_S = 1 kΩ		83			83		dB
The following specifications apply for −55°C ≤ T_A ≤ +125°C for RM1558; 0°C ≤ T_A ≤ +70°C for RC1458.								
Input Offset Voltage	$R_L \leq 10$ kΩ			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1500			800	nA
Large-Signal Voltage Gain	$R_L \geq 2$ kΩ, V_{out} = ±10V	25,000			25,000			
Output Voltage Swing	$R_L \geq 2$ kΩ	±10			±10			V
Power Consumption	V_S = ±15V, T_A = +125°C		90	150		90	150	mW
	T_A = −55°C		120	200		120	200	

NOTES:

1. Rating applies for case temperatuers to +125°C; derate linearly at 6.5 mW/°C for ambient temperatures above +75°C for RM1558.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature for RC1458.

High-Performance Operational Amplifiers — 1556 / 1556A

GENERAL DESCRIPTION

The RM1556A/RC1556A and RM1556/RC1556 are high performance, high gain operational amplifiers. Each amplifier is internally compensated and fabricated on a single silicon chip by the planar epitaxial process.

These amplifiers feature high common-mode and differential voltage range, very low input bias current, optimum performance over a wide range of supply voltage, and freedom from "latch-up." They are ideal for use as voltage followers, comparators, integrators, summing and general purpose amplifiers.

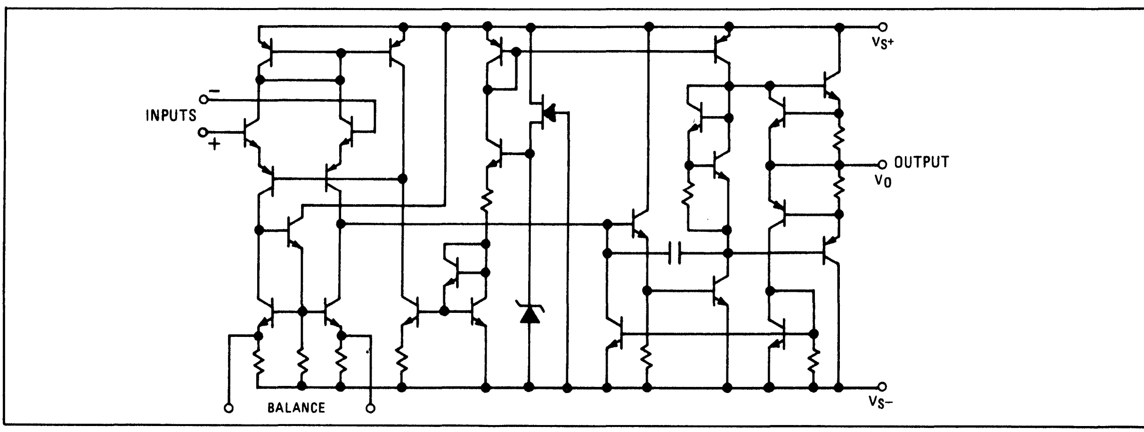
The RM1556A/RC1556A offers features beyond that of super Beta amplifiers. These include exceptional improvements in the input offset voltage, bandwidth, slew rate, and noise characteristics.

The RM types operate over a temperature range of −55°C to +125°C. The RC types operate from 0°C to +70°C. Each device is available in the 8-pin TO-5, 8 or 14-pin dual in-line packages.

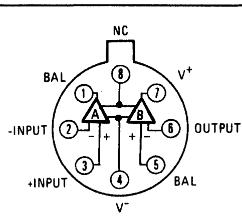
DESIGN FEATURES

- Input Bias Current 15nA Maximum
- Input Offset Current 2nA Maximum
- Input Offset Voltage 2mV Maximum
- At ±15V Current Drain 1.0mA
- Offset Voltage Nulling (10k pot)
- Slew Rate 2.0V/μs
- Unity Gain Bandwidth 4MHz
- Gain Variation 3dB from ±3V to ±20V
- Open Loop Voltage Gain 106dB

SCHEMATIC DIAGRAM

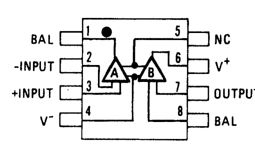


CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
RM1556AT, RM1556T,
RC1556AT, RC1556T



NB Dual In-line Plastic Package
(Top View)

Order Part Nos.:
RC1556NB, RC1556NB

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . RM1556A, RM1556: ±22V
RC1556: ±18V
Internal Power Dissipation (Note 1) 500mW
Differential Input Voltage . . . . ±30V
Input Voltage (Note 2) . . . . ±15V
Storage Temperature Range . . . . −65°C to +150°C
Operating Temperature Range
RM1556A, RM1556 . . . . −55°C to +125°C
RC1556A, RC1556 . . . . 0°C to +70°C
Lead Temperature (Soldering, 60s) . . . . 300°C
Output Short-Circuit Duration (Note 3) . . . . . . Indefinite

RM1556 AND RC1556 ELECTRICAL CHARACTERISTICS

($RM1556: -55°C \leq T_A \leq 125°C$; $RC1556: 0°C \leq T_A \leq 70°C$; $V_S = \pm 15V$)

PARAMETER	CONDITIONS	RM1556			RC1556			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$, $R_S \leq 50k\Omega$		2.0	4.0		5.0	10	mV
Input Offset Current	$T_A = 25°C$		1.0	2.0		5.0	10	nA
Input Bias Current	$T_A = 25°C$		8.0	15		15	30	nA
Input Resistance	$T_A = 25°C$		5.0			3.0		MΩ
Supply Current	$T_A = 25°C$		1.0	1.5		1.3	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$ $V_{OUT} = \pm 10V$, $R_L > 2k\Omega$	100	200		70	100		V/mV
Input Offset Voltage	$R_S \leq 50k\Omega$			6.0			14	mV
Input Offset Current	$+25°C$ to T_H			3.0			14	nA
	T_L to $+25°C$			5.0			14	
Input Bias Current				30			40	nA
Supply Current				1.9			2.5	mA
Slew Rate (Unity Gain)	$T_A = 25°C$, $R_L \geq 2k\Omega$		2.0			2.0		V/μs
Bandwidth (Unity Gain)	$T_A = 25°C$, $R_L \geq 2k\Omega$		4			4		MHz
Large Signal Voltage Gain	$R_L \geq 2k\Omega$, $V_{OUT} = \pm 10V$	40			40			V/mV
Output Voltage Swing	$T_A = 25°C$, $R_L \geq 2k\Omega$, $V_S = \pm 15V$	±12	±13		±11	±12		V
Input Voltage Range		±12	±13		±11	±12		V
Input Noise Voltage	$R_S = 10k\Omega$, f = 1.0kHz, AV = 100, BW = 1.0Hz		25			25		$nV/\sqrt{Hz}$
Common-Mode Rejection Ratio	$R_S \leq 50k\Omega$	80	110		70	110		dB
Supply Voltage Rejection Ratio	$R_L \leq 50k\Omega$	80	86		74	83		dB

NOTES:
1. For operating at elevated temperatures, the device must be derated based on 150°C for RM1556A and RM1556; 100°C for RC1556 maximum junction temperature and a thermal resistance of 150°C/W junction to ambient or 45°C/W junction to case.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit to ground rating applies to +125°C case temperature or +75°C ambient temperature for RM1556A and RM1556.

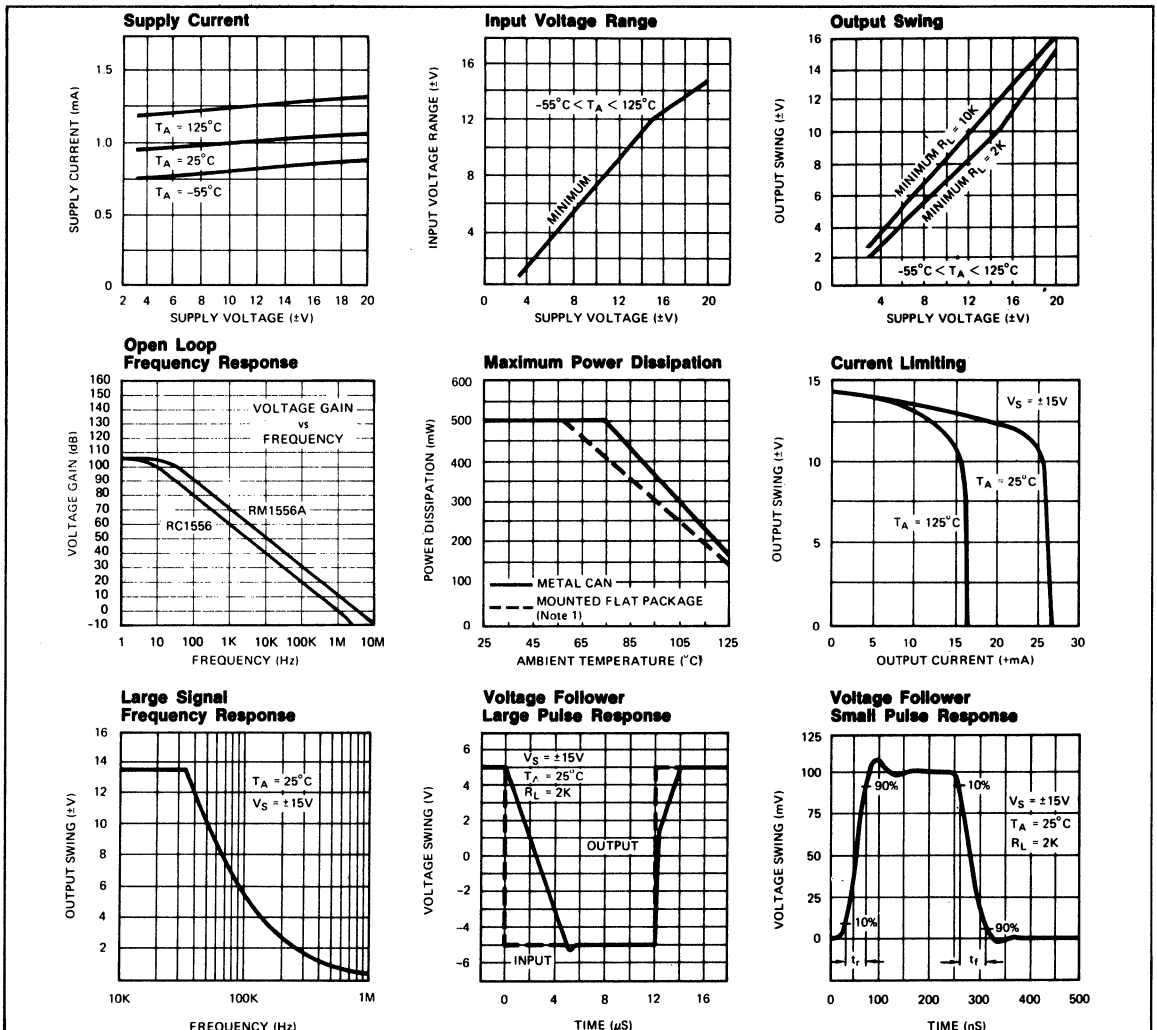
High-Performance Operational Amplifiers

RM1556A AND RC1556A ELECTRICAL CHARACTERISTICS

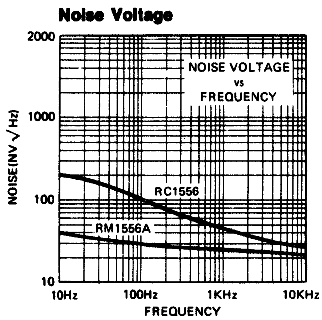
(All other electrical characteristics are listed with RM1556 and RC1556)

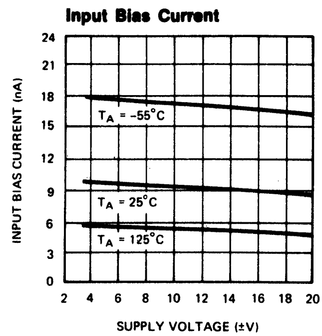
PARAMETER	CONDITIONS	RM1556A			RC1556A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$, $R_S \leqslant 50k\Omega$		0.7	2.0		1.5	5.0	mV
	$R_S \leqslant 50k\Omega$, $-55°C \leqslant T_A \leqslant 125°C$		1.0	3.0				
	$R_S \leqslant 50k\Omega$, 0°C to +70°C					1.0	6.0	
Slew Rate (Unity Gain)	$T_A = 25°C$, $R_L = 2k\Omega$, $V_S = \pm15V$		2.0			2.0		V/µs
Bandwidth (Unity Gain)	$T_A = 25°C$, $R_L = 2k\Omega$		4.0			4.0		MHz

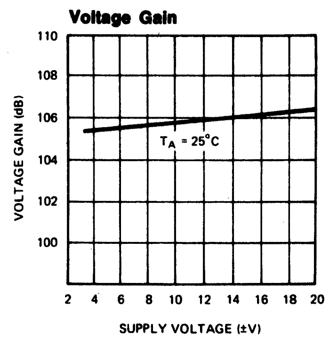
TYPICAL ELECTRICAL DATA



TYPICAL ELECTRICAL DATA (Cont.)







Quad Current Mode Single-Supply Operational Amplifier

LM2900 LM3900

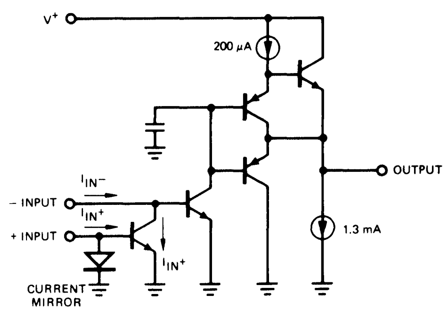
GENERAL DESCRIPTION

The LM2900 and LM3900 consist of four independent, dual input, internally compensated amplifiers which were designed specifically to operate off a single power supply voltage and to provide a large output voltage swing. These amplifiers make use of a current mirror to achieve the non-inverting input function. Application areas include: AC amplifiers, RC active filters; low frequency triangle, squarewave and pulse waveform generation circuits, tachometers and low speed, high voltage digital logic gates.

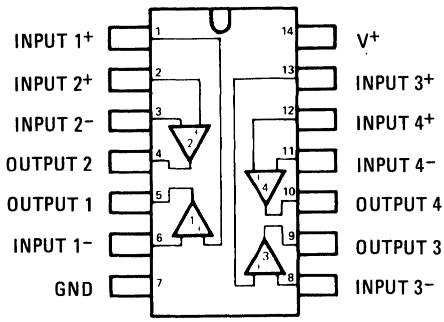
DESIGN FEATURES

- Wide Single Supply Voltage Range 4V to 36V
- Supply Current Drain Independent of Supply Voltage
- Low Input Biasing Current 30 nA
- High Open-loop Gain 70 dB
- Wide Bandwidth 2.5MHz (Unity Gain)
- Larger Gain-Bandwidth Product in Non-Inverting Mode (A_V = 100 @ f = 1 MHz)
- Large Output Voltage Swing, $(V^+-1)V_{p\text{-}p}$
- Internally Frequency Compensated for Unity Gain
- Output Short-Circuit Protection

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DB
Dual In-line Package

Order Part Nos.:
LM2900N, LM3900N

Quad Current Mode Single-Supply Operational Amplifier

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (LM 2900) .... +36V
(LM 3900) .... +32V
Supply Voltage .... ±18V
Power Dissipation (T_A = 25°C)(Note 1) 570mW
Input Currents, $I_{IN}+$ or $I_{IN}-$ 20mA

Output Short Circuit Duration — .... Continuous
One Amplifier, T_A = 25°C
Operating Temperature Range (LM 2900) . −40°C to +85°C
Operating Temperature Range (LM 3900) . . 0°C to +70°C
Storage Temperature Range .... −65°C to +150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

ELECTRICAL CHARACTERISTICS (V_{CC} = +15V, T_A = +25°C unless otherwise noted.)

PARAMETER	CONDITIONS	LM 2900/LM 3900 MIN	TYP	MAX	UNITS
Open Loop					
Voltage Gain	f = 100 Hz	1200	2800		V/V
Input Resistance	Inverting Input		1		MΩ
Output Resistance			8		kΩ
Unity Gain Bandwidth	Inverting Input (Note 2)		2.5		MHz
Input Bias Current	Inverting Input		30	200	nA
Slew Rate	Positive Output Swing		0.5		V/μs
	Negative Output Swing		20		V/μs
Supply Current	R_L = ∞ On All Amplifiers		6.2	10	mA
Output Voltage Swing R_L = 5.1 k					
V_{OUT} High	$I_{IN}-$ = 0, $I_{IN}+$ = 0	13.5	14.2		V
V_{OUT} Low	$I_{IN}-$ = 10 μA, $I_{IN}+$ = 0		0.09	0.2	V
Output Current Capability					
	Source	3	18		mA
	Sink (Note 3)	0.5	1.3		mA
Power Supply Rejection	f = 100 Hz		70		dB
Mirror Gain	$I_{IN}+$ = 200 μA (Note 4)	0.90	1	1.1	μA/μA
Mirror Current	(Note 5)		10	500	μA
Negative Input Current	(Note 6)		1.0		mA

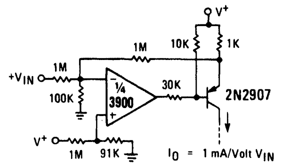
NOTES:

1. For operating at high temperatures, the device must be derated based on a 125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient.
2. When used as a "non-inverting amplifier" (see bottom of page), the gain-bandwidth product is not limited to 2.5 MHz. The isolation provided by the "current mirror" allows a constant unity voltage gain feedback for the main inverting amplifier. This means that large values of gain can be achieved at high frequencies and the dominate limit is due to the slew rate of the amplifier. For example: a voltage gain of 100 is easily obtained at 1 MHz and an output voltage swing of 160 mVp-p can be achieved prior to slew rate limiting. This operational mode is useful for signal frequencies in the 50 kHz to 1 MHz range as would be encountered in IF or carrier frequency applications.
3. The output current sink capability can be increased for large signal conditions by overdriving the inverting input.
4. This spec indicates the current gain of the current mirror which is used as the non-inverting input.
5. Input V_{BE} match between the non-inverting and the inverting inputs occurs for a mirror-current (non-inverting input current) of approximately 10 μA. This is therefore a typical design center for many of the application circuits.
6. Clamp transistors are included on the IC to prevent the input voltages from swinging below ground more than approximately −0.3 V_{DC}. The negative input currents which may result from large signal overdrive with capacitance input coupling need to be externally limited to values of approximately 1 mA. Negative input currents in excess of 4 mA will cause the output voltage to drop to a low voltage. This maximum current applies to any one of the input terminals. If more than one of the input terminals are simultaneously driven, negative smaller maximum currents are allowed. Common-mode current biasing can be used to prevent negative input voltages; for example, see the "Differentiator Circuit" in the applications section.

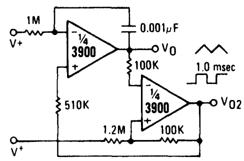
Quad Current Mode Single-Supply Operational Amplifier

3900 TYPICAL APPLICATIONS ($V^+ = 15V$)

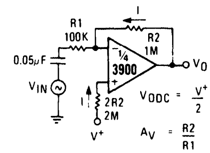
Voltage-Controlled Current Source (Transconductance Amplifier)



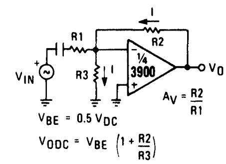
Triangle/Square Generator



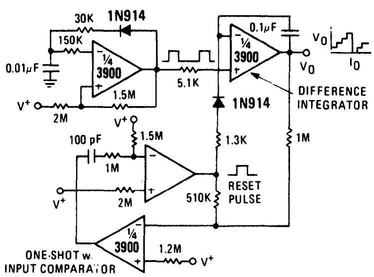
Inverting Amplifier



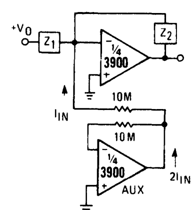
VBE Biasing



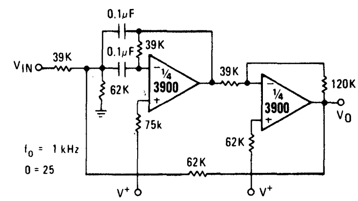
Free-Running Staircase Generator/Pulse Counter



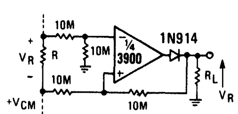
Supplying I_{IN} with Aux. Amp (to Allow High Z Feedback Networks)



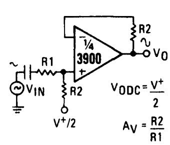
Bandpass Active Filter



Ground Referencing a Differential Input Signal

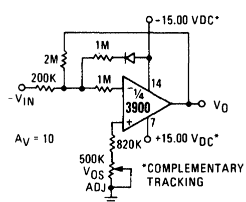


Non-Inverting Amplifier

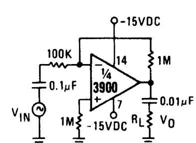


Split Supply ($V^+ = +15V_{DC}$ & $V^- = -15V_{DC}$)

Non-Inverting DC Gain



AC Amplifier



Quad Operational Amplifiers

GENERAL DESCRIPTION

The RV3301 and RC3401 consist of four independent amplifiers, with internal frequency compensation, designed to operate from a single power supply.

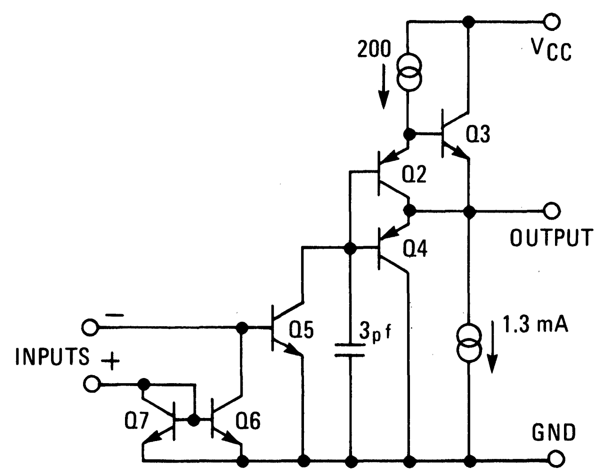
These amplifiers employ a current mirror to achieve the non-inverting inputs.

The current-differencing inputs allow a variety of applications in automotive instrumentation, industrial and consumer circuits for performing active filtering and pulse and waveform generation and processing.

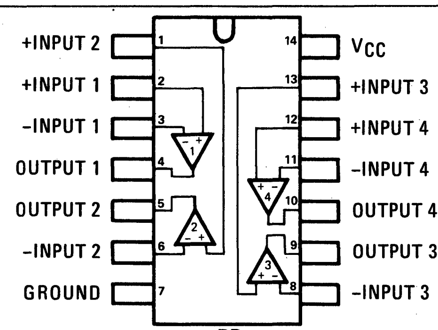
DESIGN FEATURES

- Wide Supply Voltage Range 4 to 28 V
- Wide Operating Temperature Range −40°C to +85°C
- Wide Bandwidth Unity Gain 4 MHz
- Low Input Bias Current 50 nA

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DB
Dual In-line Package
(Top View)

Order Part Nos.:
RV3301DB, RC3401DB

Quad Operational Amplifiers

ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage		Power Dissipation (Package Limitation)	625 mW
3301	+28V	Derate above T_A = +25°C	5 mW/°C
3401	+18V	Operating Temperature Range	3301: −40°C to +85°C
Non Inverting Input Current	5 mA		3401: 0°C to +75°C
Sink Current	50 mA	Storage Temperature Range	−65°C to +150°C
Source Current	50 mA	Lead Temperature (Soldering, 10s)	300°C

ELECTRICAL CHARACTERISTICS (V_{CC} = +15V, R_L = 5.0KΩ, T_A = +25°C unless otherwise noted.)

Characteristic	Conditions	NOTE	3301 MIN	3301 TYP	3301 MAX	3401 MIN	3401 TYP	3401 MAX	UNIT
Open-Loop Voltage Gain		1							V/V
	T_A = +25°C		1000	2000		1000	2000		
	−40°C ≤ T_A ≤ 75°C			1600					
	0°C ≤ T_A ≤ 75°C					800			
Quiescent Power Supply Current (Total for 4 amplifiers)		2							mA
Noninverting inputs open				6.9	10		6.9	10	
Noninverting inputs grounded				7.8	14		7.8	14	
Input Bias Current	R_L = ∞	3							nA
	T_A = +25°C			50	300		50	300	
	−40°C ≤ T_A ≤ +85°C			100					
	0°C ≤ T_A ≤ +75°C							500	
Current Mirror Gain	I_r = 200μA	4	0.80	0.98	1.16				A/A
Current Mirror Gain Drift									%
	−40°C ≤ T_A ≤ +85°C			±2.5					
Output Current		5							mA
Source Capability	(V_{OH} = 0.4V)		3.0	10		5.0	10		
	(V_{OH} = 9.0V)			7.0					
Sink Capability	(V_{OL} = 0.4V)		0.5	0.87		0.5	1.0		
Output Voltage		6							V
High Voltage			13.5	14.2		13.5	14.2		
Low Voltage	(Inverting Input Driven)			0.03	0.1		0.03	0.1	
	(Noninverting Input Driven)			0.6					
Undistorted Output Swing	(0°C < T_A < +75°C)	7				10	13.5		V(p-p)
Input Resistance	(Inverting input only)		0.1	1.0		0.1	1.0		MΩ
Slew Rate	(C_L = 100 pF, R_L = 5.0 k)			0.6			0.6		V/μs
Unity Gain Bandwidth		8		4.0			5.0		MHz
Phase Margin		8		70			70		Degrees
Power Supply Rejection	(f = 100 Hz)	9		55			55		dB
Channel Separation	(f = 1.0 kHz)			65			65		dB

NOTES:
1. Open loop voltage gain is defined as the voltage gain from the inverting input to the output.
2. The quiescent current will increase approximately 0.3 mA for each noninverting input which is grounded. Leaving the noninverting input open causes the apparent input bias current to increase slightly (100 nA) at high temperatures.
3. Input bias current can be defined only for the inverting input. The noninverting input is not a true "differential input"—as with a conventional IC operational amplifier. As such this input does not have a requirement for input bias current.
4. Current mirror gain is defined as the current demanded at the inverting input divided by the current into the noninverting input.
5. Sink current is specified for linear operation. When the device is used as a gate or a comparator (non-linear operation), the sink capability of the device is approximately 5.0 milliamperes.
6. When used as a noninverting amplifier, the minimum output voltage is the V_{BE} of the inverting input transistor.
7. Peak-to-peak restrictions are due to the variations of the quiescent dc output voltage in the standard configuration.
8. Bandwidth and phase margin are defined with respect to the voltage gain from the inverting input to the output.
9. Power supply rejection is specified at closed loop unity gain, and therefore indicates the supply rejection of both the biasing circuitry and the feedback amplifier.

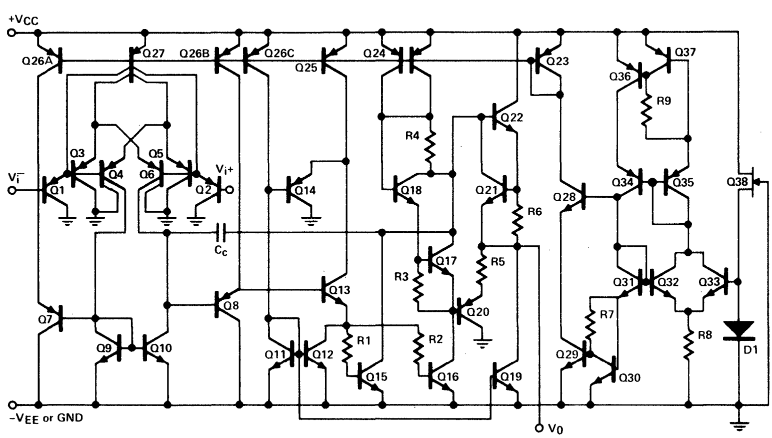
GENERAL DESCRIPTION

The 3403A high performance quad op-amp features improved large signal bandwidth and worst case DC specs equal to or better than the standard 741 type general purpose op-amp. The device uses a newly developed type of ground-sensing differential input stage which provides increased slew rate.

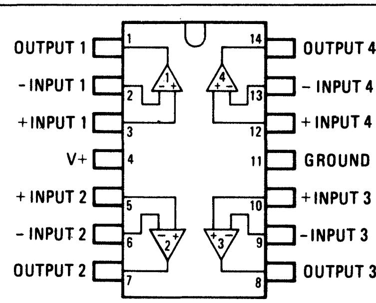
DESIGN FEATURES

- Class AB Output State; No Crossover Distortion
- Output Voltage Swings to Ground in Single Supply Operations
- High Slew Rate 1.2 V/μs
- Single or Split Supply Operation
- Wide Supply Operation 2.5 V to +36 V or ±1.25 V to ±18 V
- Pin Compatible with LM324 and 3403
- Low Power Consumption 0.8 mA/amplifier

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DB and DC
Dual In-line Packages
(Top View)

Order Part Nos.:
RC3403ADB, RC3403ADC, RV3403ADB, RV3403ADC, RM3503ADC

Total Quad Operational Amplifiers

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V^+ . . . . . 36 V or ±18 V	Operating Temperature Range
Differential Input Voltage . . . . . 36 V	RM3503A . . . . . −55°C to +125°C
Input Voltage . . . . . −0.3 V to +36 V	RC3403A . . . . . 0°C to +70°C
Power Dissipation	RV3403A . . . . . −40°C to +85°C
"DB" package . . . . 500 MW (molded DIP epoxy "B")	Storage Temperature Range . . . . . −65°C to +150°C
"DC" package . . . . . 650 mW (hermetic DIP)	Lead Temperature (Soldering, 60s) . . . . . 300°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_{CC} = ±15V unless otherwise noted)

PARAMETER	CONDITIONS	RM3503A			RC/RV3403A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S = 0$		2	4*		2	6*	mV
Input Offset Current	I_{in-} or I_{in+}		±30	±50		±30	±50	nA
Input Bias Current	I_{in-} or I_{in+}		−150	−400*		−150	−500	nA
Input Common Mode Voltage Range		0		$V^+ - 2$	0		$V^+ - 2$	V
Supply Current	$R_L = \infty$ on all op-amps		3	4		3	5*	mA
Large Signal Voltage Gain	$R_L > 2K\Omega$	50	100		25*	100		V/mV
Output Voltage Swing	$R_L = 2K\Omega$	±13	±14		±13	±14		V
Common Mode Rejection Ratio	DC	70	90		70	90		dB
Channel Separation	±1kHz to 20 kHz (in ref)		−120			−120		dB
Output Source Current	$V_{IN+} = 1$ V, $V_{IN-} = 0$ V	20	40		20	40		mA
Output sink current		10	20		10	20		mA
Small signal bandwidth			1			1		MHz
Slew Rate	$A_V = 1$, $-10 < V_i < +10$		1.2*			1.2*		V/µs
Distortion (Crossover)	f = 20 kHz, VO = $10V_{pp}$		1			1		%
Power Bandwidth	VO = $10V_{pp}$		40			40		kHz
Power Supply Rejection Ratio			20	50		20	100	µV/V

*Significantly inproved performance

ELECTRICAL CHARACTERISTICS GUARANTEED OVER TEMPERATURE

Range: RM3503A: −55°C to +125°C
RC3403A: 0°C to +70°C
RV3403A: −40°C to +85°C

PARAMETER	RM3503A		RC3403A		RV3403A		UNITS
	MIN	MAX	MIN	MAX	MIN	MAX	
Input Offset Voltage	–	6.0	–	10.0	–	10.0	mV
Input Offset Current	–	200	–	200	–	200	nA
Input Bias Current	–	−1500	–	−800	–	−1500	nA
Large Signal Voltage Gain	25	–	15	–	15	–	V/mV
Output Voltage Swing	±10	–	±10	–	±10	–	V

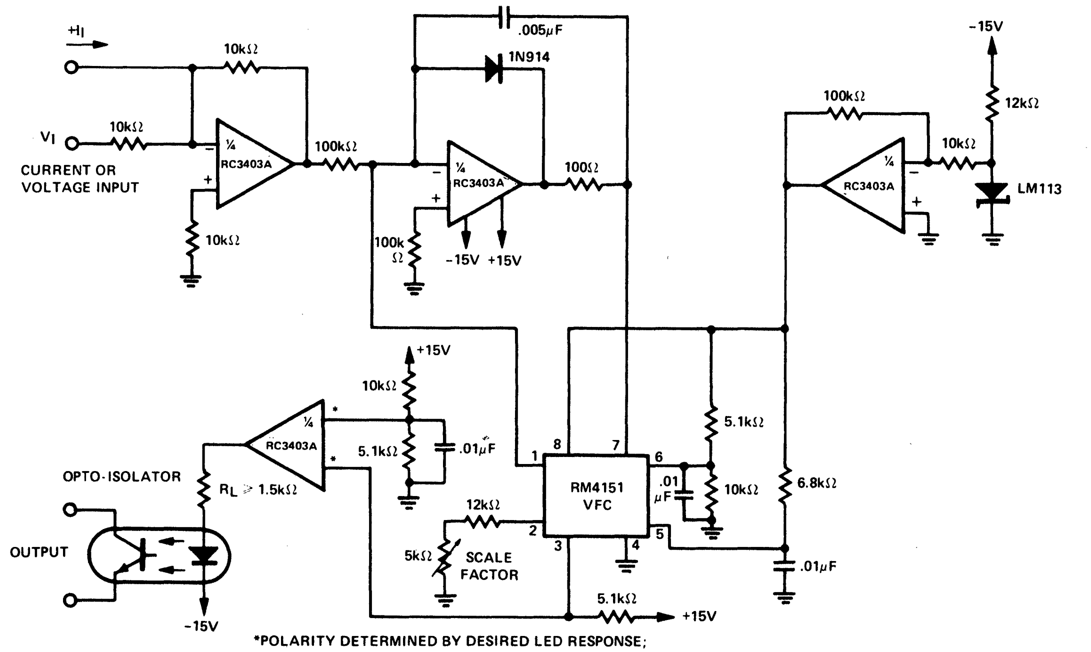
LOW VOLTAGE ELECTRICAL CHARACTERISTICS (V_{CC} = +5V, V_{EE} = GND, T_A = +25°C unless otherwise noted.)

PARAMETER	CONDITIONS	RM3503A MIN	RM3503A TYP	RM3503A MAX	RC/RV3403A MIN	RC/RV3403A TYP	RC/RV3403A MAX	UNITS
Input Offset Voltage	$R_S = 0\Omega$		2.0	5.0		2.0	10	mV
Input Offset Current	$I_{in-} - I_{in+}$		30	50		30	50	nA
Input Bias Current	$I_{in-} + I_{in+}/2$		−150	−500		−150	−500	nA
Large Signal Voltage Gain	$R_L = 2K\Omega$	20	200		20	200		V/mW
Power Supply Rejection Ratio				50			150	μV/V
Output Voltage Range[1]	$R_L = 10K\Omega$	3.5			3.5			$V_{p\text{-}p}$
Power Supply Current	$R_L = \infty$, all amplifiers		2.5	4.0		2.5	5.0*	mA
Channel Separation	1KHz≤f≤.2MHz (input referred)		−120			−120		dB

[1] Output will swing to ground.

*Significantly improved performance.

3403A TYPICAL APPLICATIONS



*POLARITY DETERMINED BY DESIRED LED RESPONSE;
I.E., LED ON FOR DATA HIGH, OR LED HIGH FOR DATA LOW.

PRECISION POSITIVE-INPUT, ISOLATED OUTPUT
VOLTAGE FREQUENCY CONVERTER

ELECTRICAL CHARACTERISTICS COMPARISON
RC3403A, RC3403, LM324

	RC3403A			RC3403			LM324			Units
Maximum Ratings										
Supply Voltage	+36 or ±18			+36 or ±18			+32 or ±16			V
Differential Input Voltage	36			36			32			V
Input Voltage	36			36			32			V
Power Dissipation	DC 650 DB 500			DC 650 DB 500			N 570			mW
Electrical Characteristics	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	
Test Conditions		±15			±15			+5		V
Input Offset Voltage		2	6		2	8		2	7	mV
Input Offset Current		±30	±50		±30	±50		±5	±50	nA
Input Bias Current		150	500		200	500		45	500	nA
Input Common Mode Voltage Range	0		$V^{+}-2$				0		$V^{+}-1.5$	V
Supply Current		3	5		2.8	7.0		0.8	2	mA
Open Loop Voltage Gain	25	100		20	200			100		V/mV
Output Voltage Swing	±13	±14		±10	±13				$V^{+}-1.5$	V
Common Mode Rejection Ratio	70	90		70	90			85		dB
Power Supply Rejection Ratio		20	100		30	150		100dB		μV/V
Unity Gain Bandwidth		1.0			1.0					MHz
Slew Rate		1.2			0.6					V/μs
Output Sink Current	10	20						20		mA
Output Source Current	20	40					20	40		mA
Channel Separation		120			120			120		dB
Distortion (crossover)		1.0			1.0					%

GENERAL DESCRIPTION

The RC4131/RM4131 are high performance, high gain, internally compensated operational amplifiers fabricated on a single silicon chip using the planar epitaxial process.

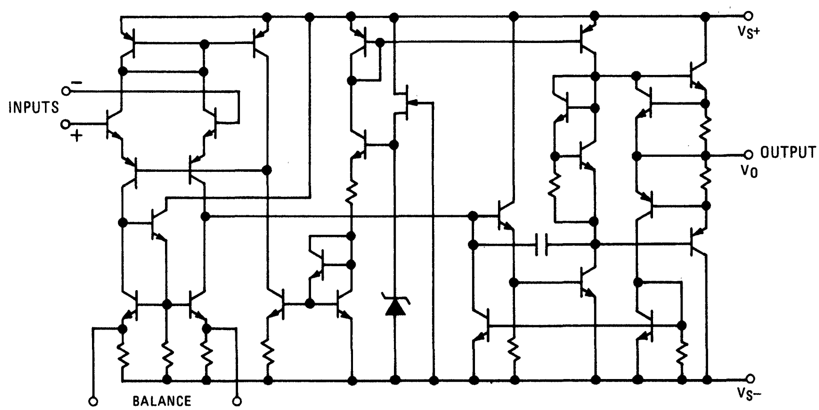
Designed as a pin for pin replacement for the RM709, they are also direct replacements for the 741 and LM107. Relative to these latter units, the RC4131/RM4131 features four times the slew rate, and ½ the power dissipation at ±20V.

High common-mode and differential voltage range, very low input bias current, optimum performance over a very wide range of supply voltage, freedom from "latch-up," and operation over the full military temperature range from −55°C to +125°C make the RM4131 ideal for use as a voltage follower, comparator, integrator, and summing or general purpose feedback amplifier. The RC4131 operates over a temperature range of 0°C to +70°C.

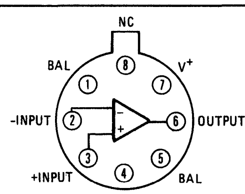
DESIGN FEATURES

- 50nA Maximum Input Bias Current
- 10nA Maximum Input Offset Current
- 2mV Maximum Input Offset Voltage
- 1.1mA Current Drain at ±20V
- Offset Voltage Nulling (10kΩ pot.)
- 2.0V/μs Slew Rate
- 4MHz Unity Gain Bandwidth
- 3dB Gain. Variation From ±3V to ±20V
- 88dB Minimum Gain ±3V to ±20V, −55°C to +125°C

SCHEMATIC DIAGRAM

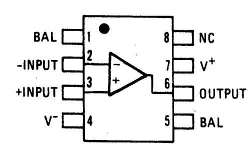


CONNECTION INFORMATION



TE Metal Can
(Top View)

Order Part Nos.:
RM4131T, RC4131T



NB Miniature Dual In-line
(Top View)

Order Part Nos.:
RC4131NB

ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... RM4131: ±22V
RC4131: ±18V
Internal Power Dissipation (Note 1) 500mW
Differential Input Voltage .... ±30V
Input Voltage (Note 2) .... ±15V
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range
RM4131 .... −55°C to +125°C
RC4131 .... 0°C to +70°C
Lead Temperature (Soldering, 60s) .... 300°C
Output Short-Circuit Duration (Note 3) ...... Indefinite

ELECTRICAL CHARACTERISTICS

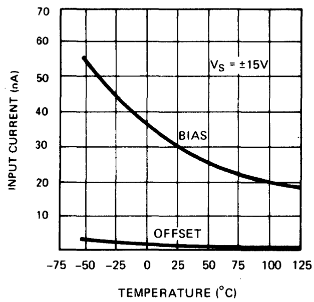
RM4131: $\pm3V < V_S < \pm20V$, $-55°C \leq T_A \leq +125°C$, unless otherwise specified.
RC4131: $\pm3V < V_S < \pm15V$, $0°C \leq T_A \leq +70°C$, unless otherwise specified.

PARAMETER	CONDITIONS	RM4131			RC4131			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 10k\Omega$, $T_A = +25°C$		0.7	2.0		1.5	5.0	mV
	$R_S \leq 10k\Omega$			3.0			6.0	
Input Offset Current	$T_A = +25°C$		1.5	10		3.0	20	nA
				20			30	
Input Bias Current	$T_A = +25°C$		30	50		70	150	nA
				100			200	
Input Resistance		2.2	3.5		0.7	3.0		MΩ
Large-Signal Voltage Gain	$R_L \geq 2k\Omega$ (Note 4), $T_A = +25°C$	50			35			V/mV
	$R_L \geq 2k\Omega$ (Note 4)	25	160		25	160		
Output Voltage Swing RM4131: $V_S = \pm20V$ RC4131: $V_S = \pm15V$	$R_L \geq 10k\Omega$	±16			±12			V
	$R_L \geq 2k\Omega$	±15			±10			V
Input Voltage Range	RM4131: $V_S = \pm20V$ RC4131: $V_S = \pm15V$	±15			±11			V
Common-Mode Rejection Ratio	$R_S \leq 10k\Omega$	80	100		70	100		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$	80	100		70	100		dB
Supply Current	$R_L = \infty$, $T_A = +25°C$		1.1	1.6		1.3	1.9	mA
	$R_L = \infty$			1.9				
Average Temperature Coefficient of Input Offset Voltage			3.0	15		5.0	20	µV/°C
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq 125°C$		0.01	0.1				nA/°C
	$-55°C \leq T_A \leq 25°C$		0.02	0.2				
	$25°C \leq T_A \leq 70°C$					0.01	0.1	
	$0°C \leq T_A \leq 25°C$					0.02	0.2	
Slew Rate (Unity Gain)	$R_L \geq 2k\Omega$		2.0			2.0		V/µs
Bandwidth (Unity Gain)			4.0			4.0		MHz

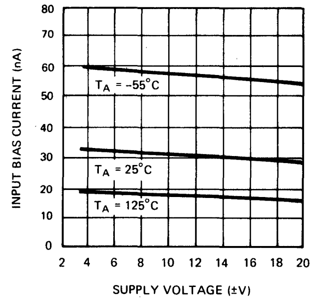
NOTES:
1. Rating applies for case temperatures to +125°C; derate linearly at 6.5 mW/°C for ambient temperatures above +75°C.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short circuit may be to ground or either supply. Rating applies to +125°C case temperature of +75°C ambient temperature.
4. RM4131: $V_S = \pm1.3V$, $V_O = \pm1.3V$; $V_S = \pm20V$, $V_O = \pm15V$. RC4131: $V_S = \pm3V$, $V_O = \pm1.3V$; $V_S = \pm15V$, $V_O = \pm10V$.

TYPICAL ELECTRICAL DATA

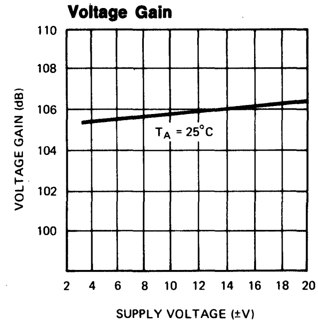
Input Current



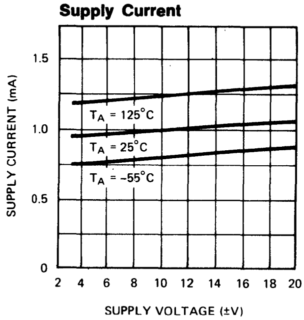
Input Bias Current



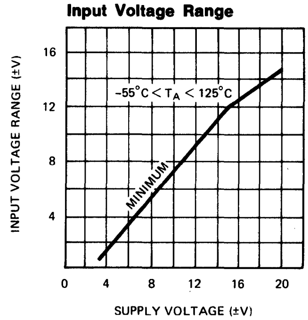
Voltage Gain



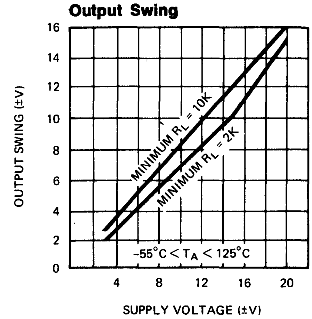
Supply Current



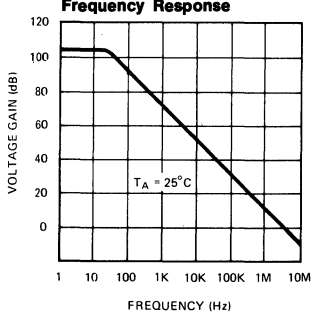
Input Voltage Range



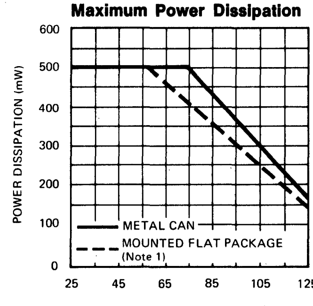
Output Swing



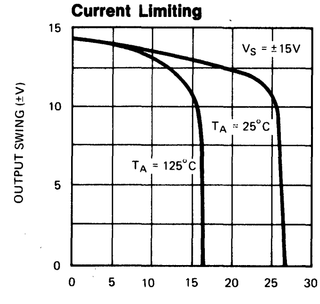
Open Loop Frequency Response



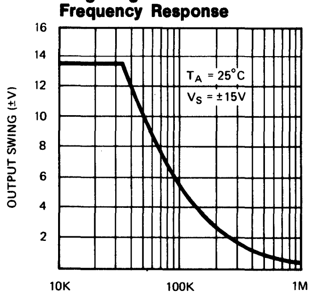
Maximum Power Dissipation



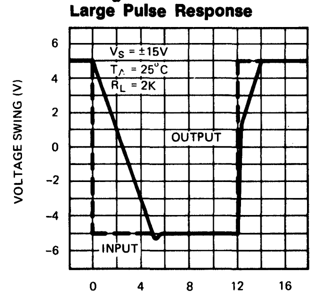
Current Limiting



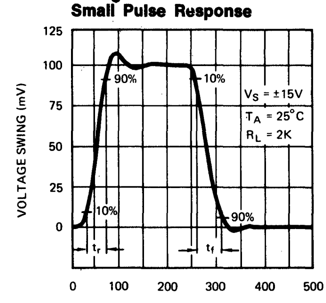
Large Signal Frequency Response



Voltage Follower Large Pulse Response

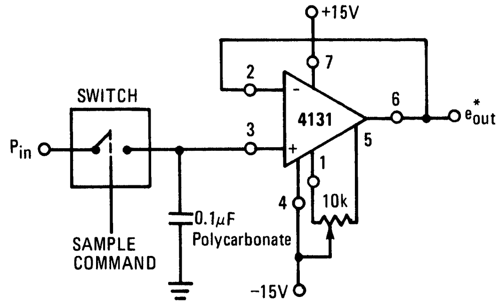


Voltage Follower Small Pulse Response

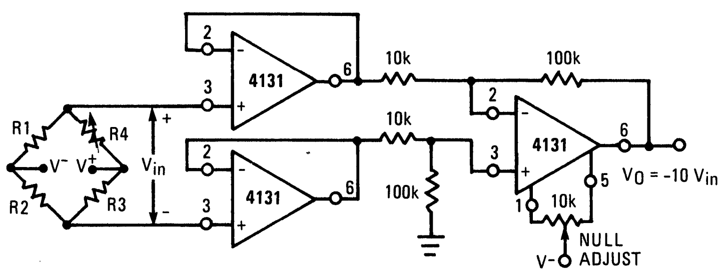


TYPICAL APPLICATIONS

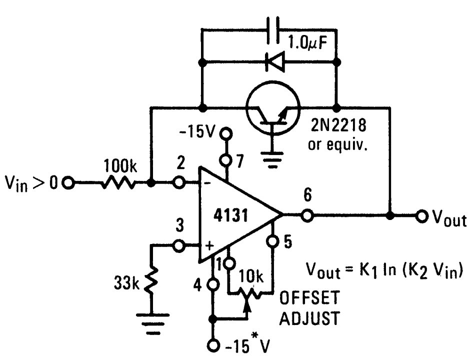
Low Drift Sample and Hold



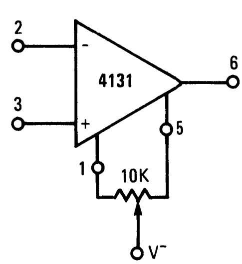
High Impedance Bridge Amplifier



Logarithmic Amplifier



Voltage Offset Null Circuit



GENERAL DESCRIPTION

The RM4136 and RC4136 include four independent high gain operational amplifiers internally compensated and constructed on a single silicon chip using the planar epitaxial processes.

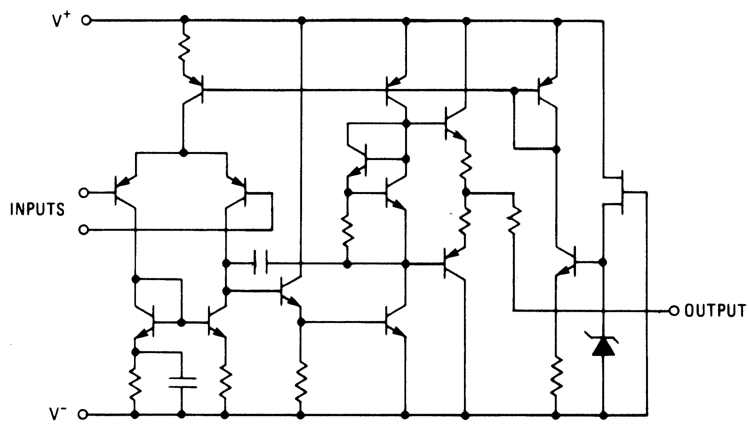
These amplifiers meet or exceed all specifications for 741 type amplifiers. Excellent channel separation allows the use of the 4136 quad amplifier in all 741 operational amplifier applications providing the highest possible packaging density.

The specially designed low noise input transistors allow the 4136 to be used in low noise signal processing applications such as audio preamplifiers and signal conditioners.

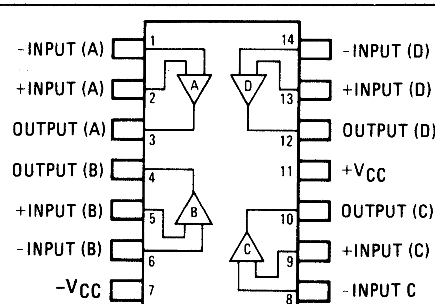
DESIGN FEATURES

- Unity Gain Bandwidth, 3MHz
- Continuous Short Circuit Protection
- No Frequency Compensation Required
- No Latch-up
- Large Common Mode and Differential Voltage Ranges
- Low Power Consumption
- Parameter Tracking Over Temperature Range
- Gain and Phase Match Between Amplifiers

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DC and DB
Dual In-line Packages
(Top View)

Order Part Nos.:
RM4136DC, RV4136 DB,
RC4136DC, RC4136DC

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . . RM4136: ±22V	Storage Temperature Range . . . . . −65°C to +150°C
RV4136, RC4136: ±18V	Operating Temperature Range . . RM4136: −55°C to +125°C
Internal Power Dissipation (Note 1) 800mW	RC4136: 0°C to +70°C
Differential Input Voltage . . . . . ±30V	RV4136: −40°C to +85°C
Input Voltage (Note 2) . . . . . ±15V	Lead Temperature (Soldering, 60s) . . . . . 300°C
	Output Short-Circuit Duration (Note 3) . . . . . Indefinite

ELECTRICAL CHARACTERISTICS (V_{CC} = ±15V, T_A = +25°C unless otherwise noted.)

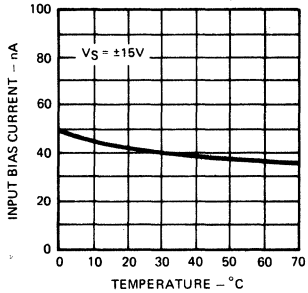
PARAMETER	CONDITIONS	RM4136			RV4136, RC4136			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leqslant 10\ k\Omega$		0.5	5.0		0.5	6.0	mV
Input Offset Current			5.0	200		5.0	200	nA
Input Bias Current			40	500		40	500	nA
Input Resistance		0.3	5.0		0.3	5.0		MΩ
Large-Signal Voltage Gain	$R_L \geqslant 2\ k\Omega$, V_{out} = ±10V	50,000	300,000		20,000	300,000		V/V
Output Voltage Swing	$R_L \geqslant 10\ k\Omega$	±12	±14		±12	±14		V
	$R_L \geqslant 2\ k\Omega$	±10	±13		±10	±13		V
Input Voltage Range		±12	±14		±12	±14		V
Common Mode Rejection Ratio	$R_S \leqslant 10\ k\Omega$	70	100		70	100		dB
Supply Voltage Rejection Ratio	$R_S \leqslant 10\ k\Omega$		10	150		10	150	µV/V
Power Consumption	$R_L = \infty$, All Outputs		210	340		210	340	mW
Transient Response (unity gain)	V_{in} = 20 mV, R_L = 2 kΩ, $C_L \leqslant 100$ pF							
Risetime			0.13			0.13		µs
Overshoot			5.0			5.0		%
Unity Gain Bandwidth			3.0			3.0		MHz
Slew Rate (unity gain)	$R_L \geqslant 2\ k\Omega$		1.5			1.0		V/µs
Channel Separation (open loop)	f = 10 kHz, R_S = 1 kΩ		105			105		dB
(Gain = 100)	f = 10 kHz, R_S = 1 kΩ		105			105		dB
The following specifications apply for −55°C ⩽ T_A ⩽ +125°C for RM4136; 0°C ⩽ T_A ⩽ +70°C for RC4136.								
Input Offset Voltage	$R_S \leqslant 10\ k\Omega$			6.0			7.5	mV
Input Offset Current				500			300	nA
Input Bias Current				1500			800	nA
Large-Signal Voltage Gain	$R_L \geqslant 2\ k\Omega$, V_{out} = ±10V	25,000			15,000			V/V
Output Voltage Swing	$R_L \geqslant 2\ k\Omega$	±10			±10			V
Power Consumption	T_A = High		180	300		180	300	mW
	T_A = Low		240	400		240	400	mW

NOTES:

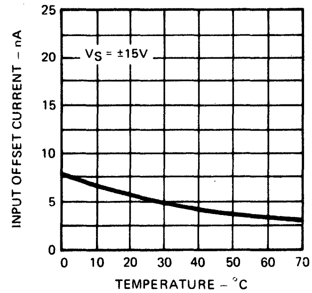
1. Rating applies for case temperature to +25°C; derate linearly at 6.4 mW/°C for ambient temperatures above +25°C.
2. For supply voltages less than ±15V the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground or one amplifier only. I_{CC} = 45mA (typical).

TYPICAL ELECTRICAL DATA

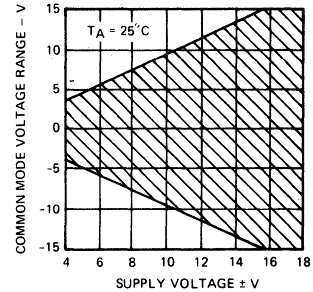
Input Bias Current as a Function of Ambient Temperature



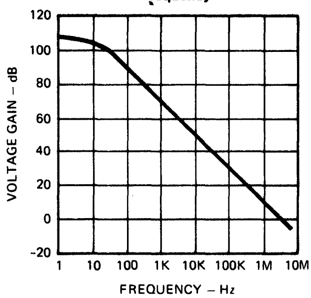
Input Offset Current as a Function of Ambient Temperature



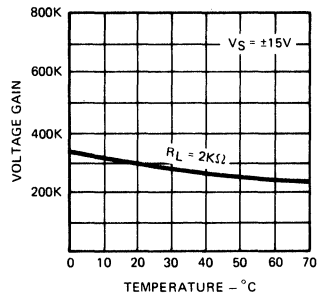
Common Mode Range as a Function of Supply Voltage



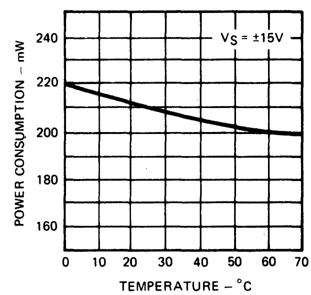
Open Loop Voltage Gain as a Function of Frequency



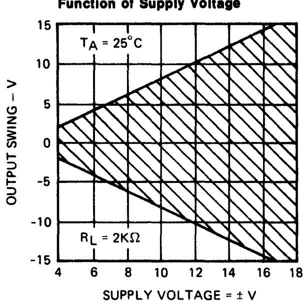
Open Loop Gain as a Function of Temperature



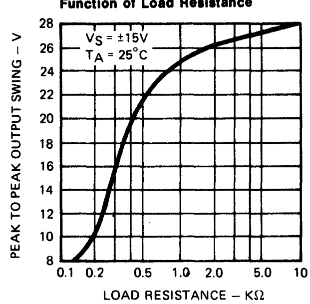
Power Consumption as a Function of Ambient Temperature



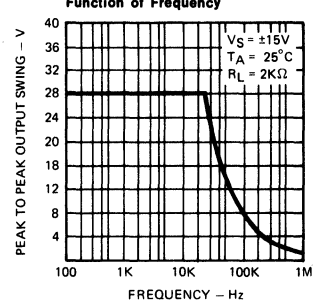
Typical Output Voltage as a Function of Supply Voltage



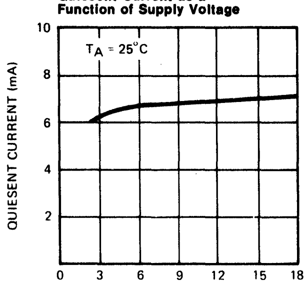
Output Voltage Swing as a Function of Load Resistance



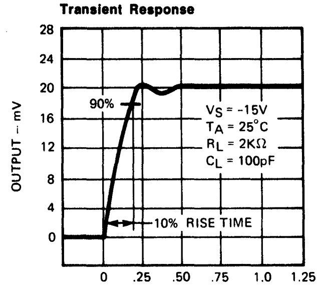
Output Voltage Swing as a Function of Frequency



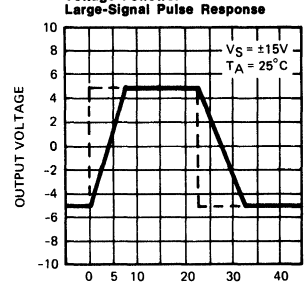
Quiesent Current as a Function of Supply Voltage



Transient Response

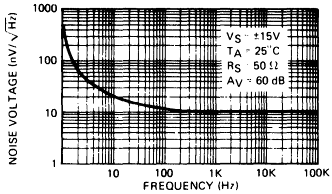


Voltage Follower Large-Signal Pulse Response

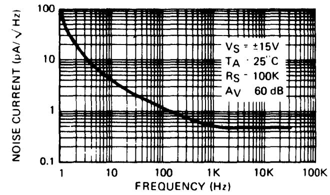


TYPICAL ELECTRICAL DATA

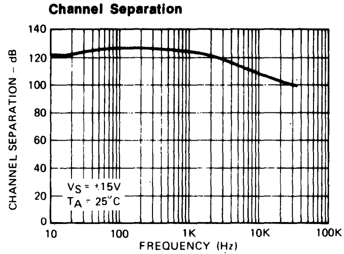
Input Noise Voltage as a Function of Frequency



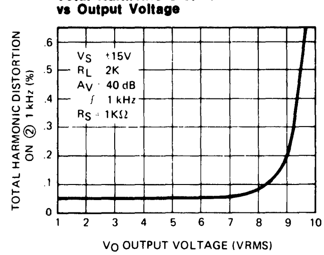
Input Noise Current as a Function of Frequency



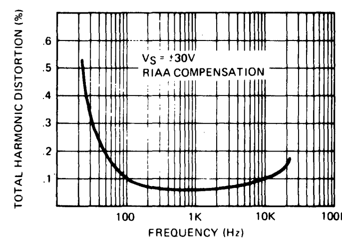
Channel Separation



Total Harmonic Distortion vs Output Voltage



Distortion vs Frequency Vo = 1vrms



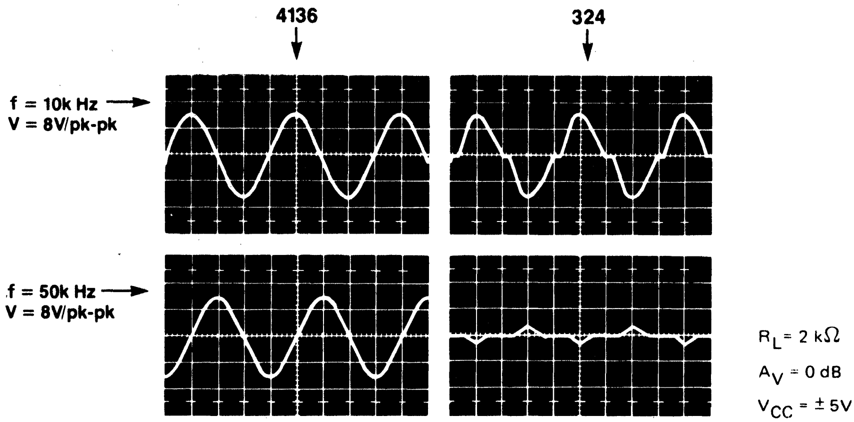
ELECTRICAL CHARACTERISTICS COMPARISON (V_{CC} = ±15V, T_A = +25°C)

PARAMETER		RC4136 (typ)	RC741 (typ)	LM324 (typ)	UNIT
Input Offset Voltage		0.5	2.0	2	mV
Input Offset Current		5	10	5	nA
Input Bias Current		40	80	55	nA
Input Resistance		5	2		MΩ
Large-Signal Voltage Gain (R_L = 2 kΩ)		300,000	200,000	100,000	V/V
Output Voltage Swing (R_L = 2 kΩ)		±13V	±13V	$\|+V_{CC} - 1.2V\|$ to $-V_{CC}$	V
Input Voltage Range		±14V	±13V	$\|+V_{CC} - 1.5V\|$ to $-V_{CC}$	V
Common-Mode Rejection Ratio		100	90	85	dB
Supply Voltage Rejection Ratio		10	30	10	µV/V
Transient Response (gain = 1)	Risetime	0.13	0.3		µs
	Overshoot	5	5		%
Unity-Gain Bandwidth		3	0.8	0.8	MHz
Unity-Gain Slew Rate		1.0	0.5	0.5	V/µs
Input Noise Voltage (f_O = 1 kHz)		10	22.5		nV/√Hz
Output Short-Circuit Current		±45	±25		mA

4136 vs. 741

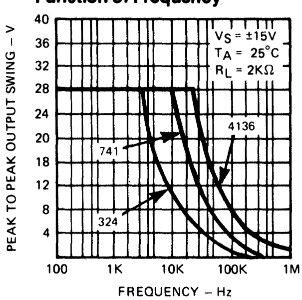
Although the 324 is an excellent device for single-supply applications where ground-sensing is important, it is a poor substitute for four 741's in split-supply circuits.

The simplified input circuit of the 4136 exhibits much lower noise than that of the 324 and exhibits no crossover distortion as compared with the 324 (see illustration). The 324 shows serious crossover distortion and pulse delay in attempting to handle a large-signal input pulse.

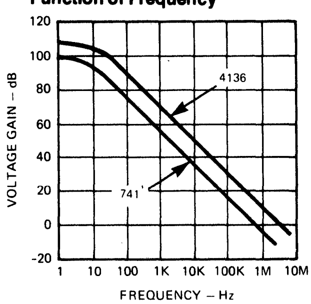


Comparative Cross-over Distortion

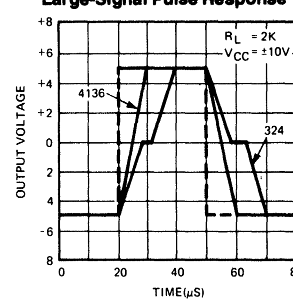
Output Voltage Swing as a Function of Frequency



Open Loop Voltage Gain as a Function of Frequency

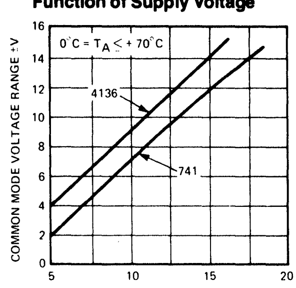


Voltage Follower Large-Signal Pulse Response

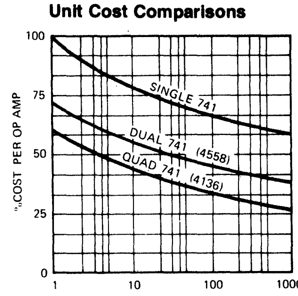


Typical Characteristics Curves Comparison

Input Common Mode Voltage Range as a Function of Supply Voltage

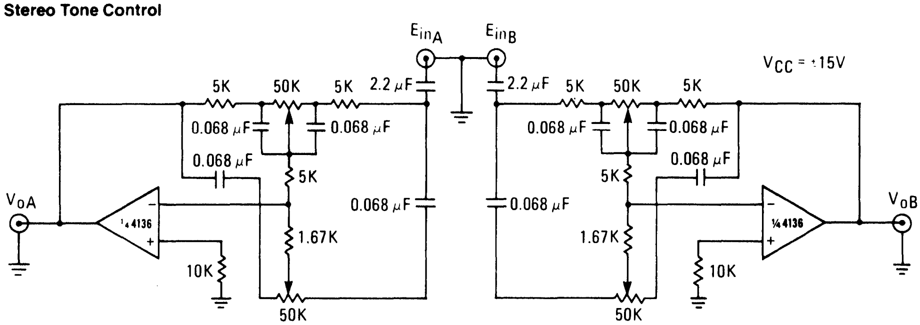


Unit Cost Comparisons

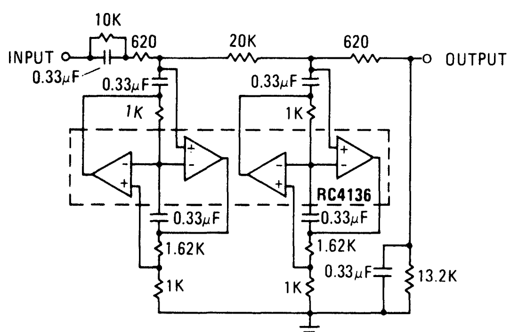


4136 TYPICAL APPLICATIONS

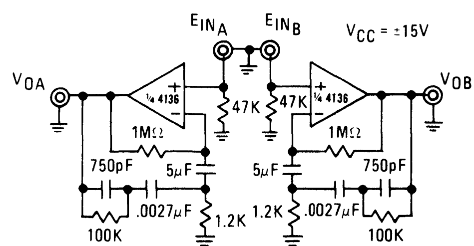
Stereo Tone Control



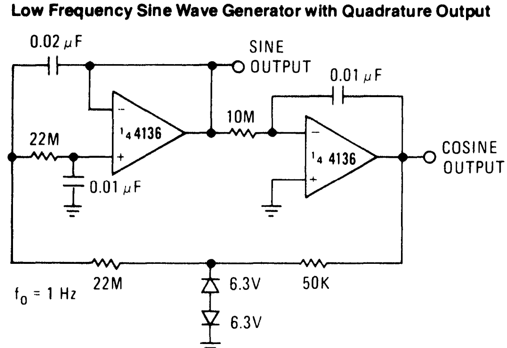
400 Hz Lowpass Butterworth Active Filter



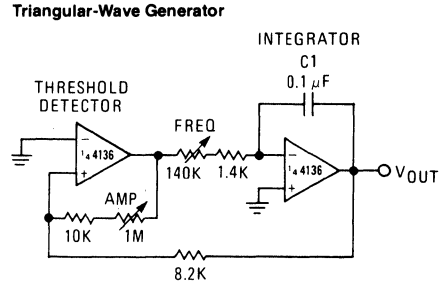
RIAA Preamplifier



Low Frequency Sine Wave Generator with Quadrature Output

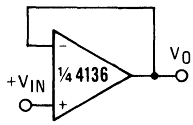


Triangular-Wave Generator

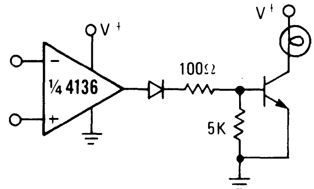


4136 TYPICAL APPLICATIONS

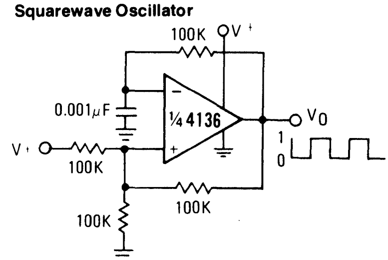
Voltage Follower



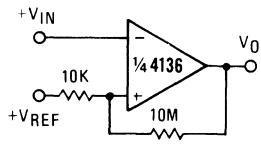
Lamp Driver



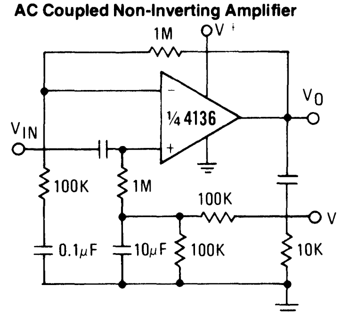
Squarewave Oscillator



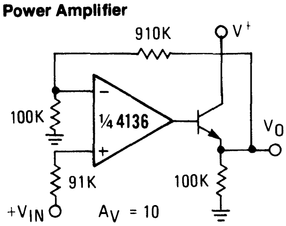
Comparator With Hysteresis



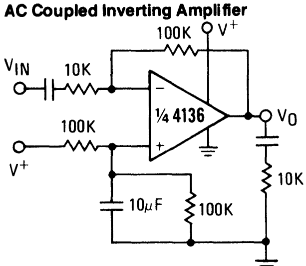
AC Coupled Non-Inverting Amplifier



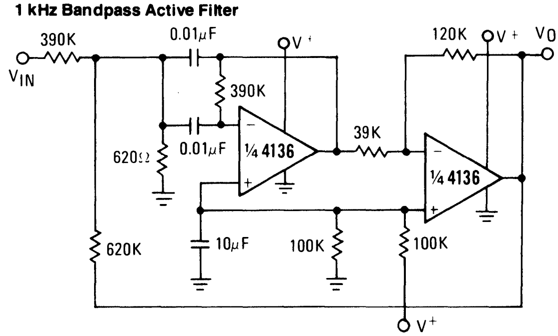
Power Amplifier



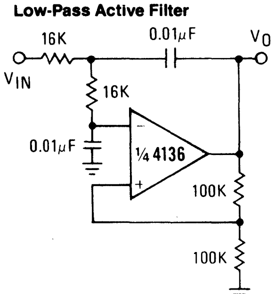
AC Coupled Inverting Amplifier



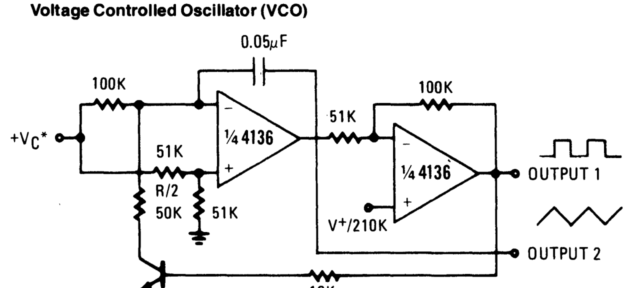
1 kHz Bandpass Active Filter



DC Coupled 1 kHz
Low-Pass Active Filter



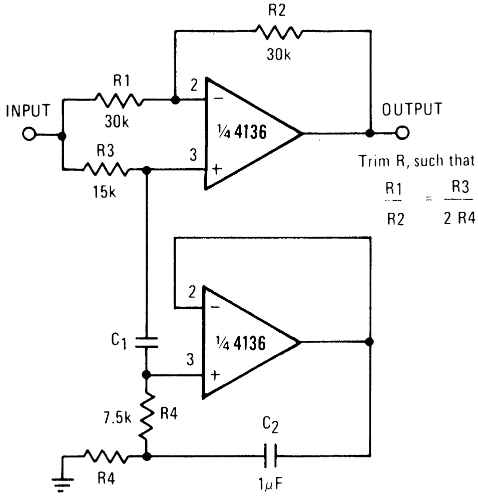
Voltage Controlled Oscillator (VCO)



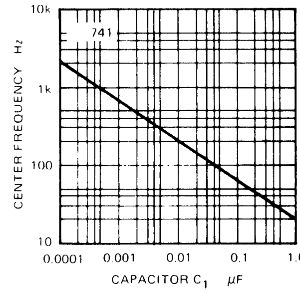
*Wide Control Voltage Range: 0 $V_{DC} < V_C < 2\ (V^+ - 1.5\ V_{DC})$

4136 TYPICAL APPLICATIONS

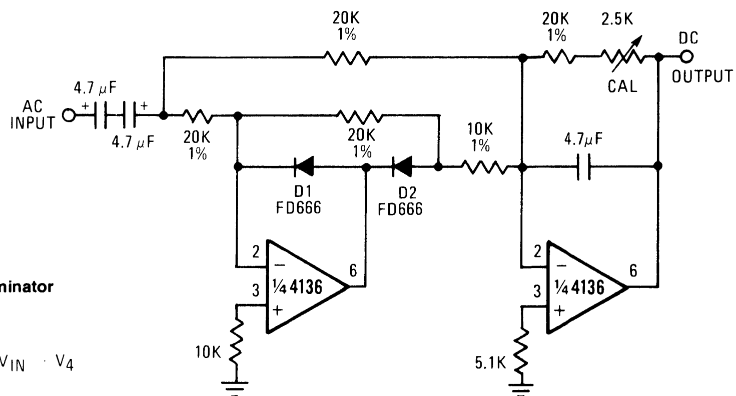
Notch Filter Using the 4136 as a Gyrator



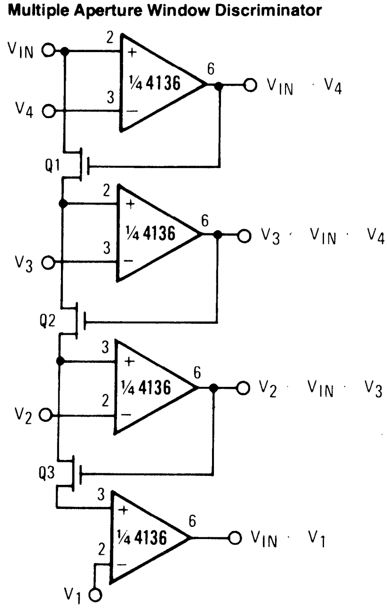
Notch Frequency as a Function of C_1



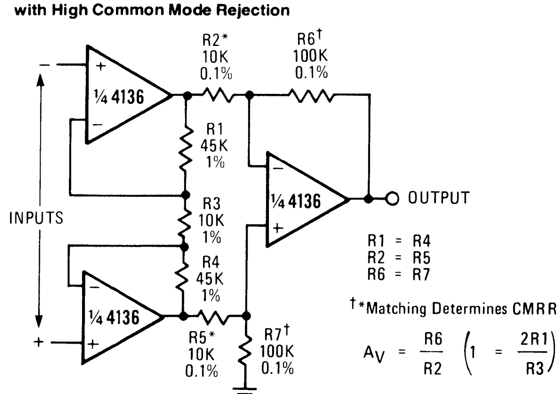
Full-Wave Rectifier and Averaging Filter



Multiple Aperture Window Discriminator



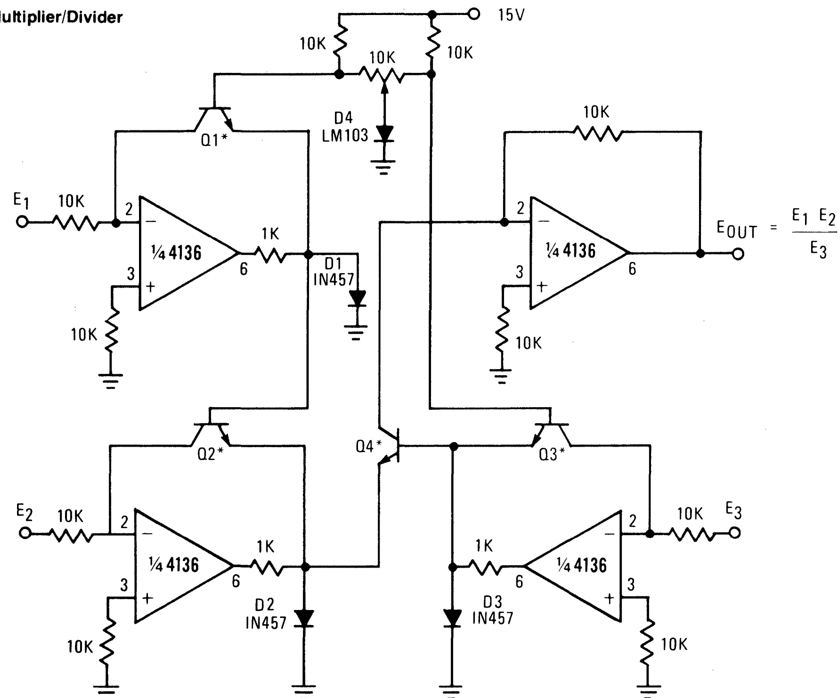
Differential Input Instrumentation Amplifier with High Common Mode Rejection



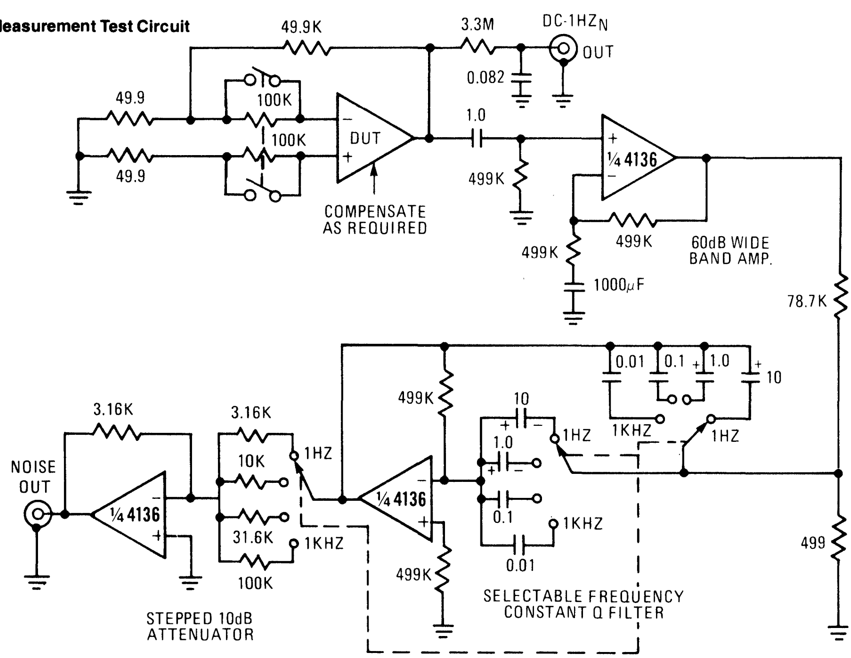
$$A_V = \frac{R6}{R2}\left(1 = \frac{2R1}{R3}\right)$$

4136 TYPICAL APPLICATIONS

Analog Multiplier/Divider



Noise Measurement Test Circuit



High Slew Rate Operational Amplifiers 4531

GENERAL DESCRIPTION

The RM4531 and RC4531 are high slew rate operational amplifiers intended for applications requiring slew rates up to 30V/μs while keeping the DC performance of the 741.

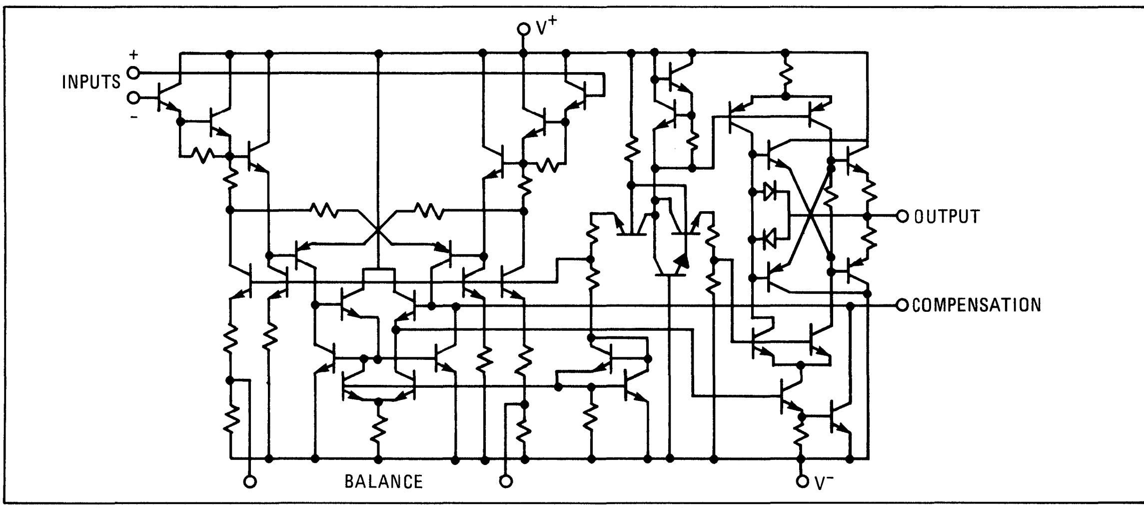
The RM4531 military version operates over a temperature range from −55°C to +125°C. The RC4531 operates from 0°C to +70°C.

High slew rates are achieved through use of an improved input stage which tends to retain small signal characteristics when subjected to large differential input signals. Advanced integrated circuit layout techniques are used to eliminate thermal feedback. The RM4531 and RC4531 feature offset null capability, high gain, and each can be compensated with an external 100pF capacitor connected between the output and compensation terminals.

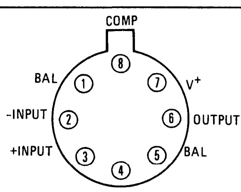
DESIGN FEATURES

- Slew Rate 35V/μs
- Small Signal Bandwidth 1MHz
- Large Signal Bandwidth 500kHz
- Supply Voltage ±6V to ±18V
- Pin-for-Pin Replacement for 709, LM101A, 741
- Low Drift Offset-Null Circuitry
- Compensated with Single Capacitor

SCHEMATIC DIAGRAM

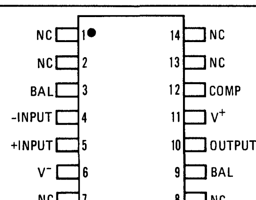


CONNECTION INFORMATION



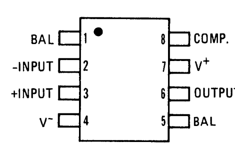
TE Metal Can Package
(Top View)

Order Part Nos.:
RM4531T, RC4531T



D Dual In-line Package
(Top View)

Order Part Nos.:
RM4531D, RC4531D



DN Dual In-line Plastic Package
(Top View)

Order Part No.:
RC4531DN

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . RM4531: ±22V
RC4531: ±18V
Internal Power Dissipation (Note 1) 500mW
Differential Input Voltage . . . . ±15V
Input Voltage (Note 2) . . . . −12.5V, +15V
Storage Temperature Range . . . . −65°C to +150°C

Operating Temperature Range
RM4531 . . . . −55°C to +125°C
RC4531 . . . . 0°C to +70°C
Lead Temperature (Soldering, 60s) . . . . 300°C
Output Short-Circuit Duration (Note 3) . . . . . Indefinite

ELECTRICAL CHARACTERISTICS (V_S = ±15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM4531			RC4531			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leqslant 10k\Omega$		2.0	5.0		2.0	6.0	mV
Input Offset Current			30	200		50	200	nA
Input Bias Current			300	500		400	1500	nA
Input Resistance		0.3	20		0.3	20		MΩ
Large-Signal Voltage Gain	$R_S \geqslant 2k\Omega$, V_{out} = ±10V	50,000	100,000		20,000	60,000		
Input Votlage Range (Note 2)		±10			±10			V
Common Mode Rejection Ratio	$R_S \leqslant 10k\Omega$				70	100		dB
Supply Voltage Rejection Ratio	$R_S \leqslant 10k\Omega$					10	150	μV/V
Output Resistance			75			75		Ω
Supply Current			5.5	7.0		5.5	10	mA
Power Consumption			165	210		165	300	mW
Setting Time, 1%	A_V = +1, V_{IN} = ±10V		1.5			1.5		μs
Setting Time, .01%	A_V = +1, V_{IN} = ±10V		2.5			2.5		μs
Large Signal Overshoot	A_V = +1, V_{IN} = ±10V		2.0			2.0		%
Small Signal Risetime	A_V = +1, V_{IN} = 400mV		300			300		ns
Small Signal Overshoot	A_V = +1, V_{IN} = 400mV		5.0			5.0		%
Slew Rate	A_V = 100		35			35		V/μs
	A_V = 10		35			35		V/μs
	A_V = 1 (non-inv.)		30			30		V/μs
	A_V = 1 (inv.)		35			35		V/μs
The following specifications apply for −55°C ⩽ T_A ⩽ +125°C for RM4531; 0°C ⩽ T_A ⩽ +70°C for RC4531.								
Input Offset Voltage	$R_S \leqslant 10k\Omega$			6.0			7.5	mV
Input Offset Current	$T_A = T_{min}$			500			300	nA
	$T_A = T_{max}$			200			200	nA
Input Bias Current	$T_A = T_{min}$			1.5			2.0	μA
	$T_A = T_{max}$			0.5			1.5	μA
Large-Signal Voltage Gain	$R_L > 2k\Omega$, V_{out} = +10V	25,000			15,000			
Output Voltage Swing	$R_L \geqslant 2k\Omega$	±10	±13		±10	±13		V
Common Mode Rejection Ratio	$R_S \leqslant 10k\Omega$	70	90					dB
Supply Voltage Rejection Ratio	$R_S \leqslant 10k\Omega$		10	150				μV/V
Supply Current	$T_A = T_{max}$		4.5	5.5		4.5	5.5	mA

NOTES:
1. Rating applies for case temperatures to +125°C; derate linearly at 6.5 mW/°C for ambient temperatures above +75°C for RM4531.
2. For supply voltages less than ±15V, the absolute maximum positive input voltage is equal to the supply votlage. The absolute maximum negative input voltage decreased by 1 volt for every 1 volt decrease in the negative supply voltage.
3. Short-circuit may be to ground to either supply Rating applies to +125°C case temperature or +75°C ambient temperature for RM4531.

GENERAL DESCRIPTION

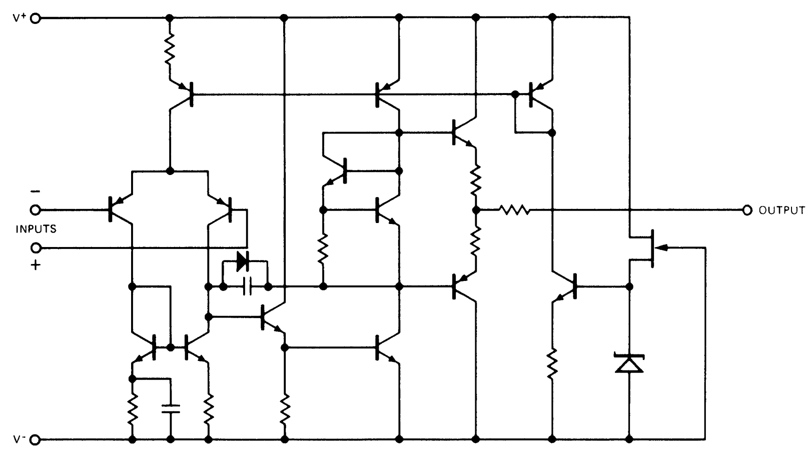
The 4558 integrated circuit is a high gain operational amplifier internally compensated and constructed on a single silicon chip using the planar epitaxial process.

Combining all of the outstanding features of the 741 with the close parameter matching and tracking of a dual device on a monolithic chip results in unique performance characteristics. Excellent channel separation allows the use of the dual device in all single 741 operational amplifier applications providing the highest possible packaging density. It is especially well suited for applications in differential-in, differential-out as well as in potentiometric amplifiers and where gain and phase matched channels are mandatory.

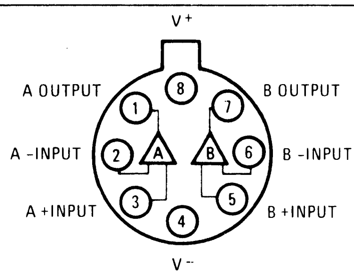
DESIGN FEATURES

- Supply Voltage ±18 V
- Continuous Short-Circuit Protection
- No Frequency Compensation Required
- No Latch-Up
- Unity Gain Bandwidth 3 MHz
- Large Common-Mode and Differential Voltage Ranges
- Low Power Consumption
- Parameter Tracking Over Temperature Range
- Gain and Phase Match Between Amplifiers

SCHEMATIC DIAGRAM

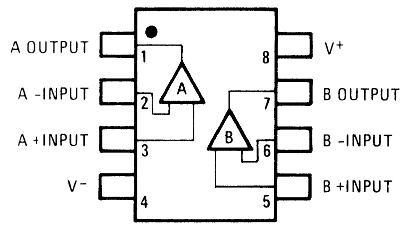


CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
RC4558T, RM4558T



NB Dual In-line Plastic Package
(Top View)

Order Part Nos.:
RC4558NB, RV4558T

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	RM4558: ±22V RC4558: ±18V
Internal Power Dissipation (Note 1)	500mW
Differential Input Voltage	±30V
Input Voltage (Note 2)	±15V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	RM4558: −55°C to +125°C RV4558: −40°C to +85°C RC4558: 0°C to +70°C
Lead Temperature (Soldering, 60s)	300°C
Output Short-Circuit Duration (Note 3)	Indefinite

ELECTRICAL CHARACTERISTICS (V_{CC} = ±15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM4558 MIN	RM4558 TYP	RM4558 MAX	RV/RC4558 MIN	RV/RC4558 TYP	RV/RC4558 MAX	UNITS
Input Offset Voltage	$R_S \leq 10k\Omega$		1.0	5.0		2.0	6.0	mV
Input Offset Current			30	200		30	200	nA
Input Bias Current			200	500		200	500	nA
Input Resistance		0.3	1.0		0.3	1.0		MΩ
Large-Signal Voltage Gain	$R_L \geq 2k\Omega$ V_{out} = ±10V	50,000	200,000		20,000	100,000		
Output Voltage Swing	$R_L \geq 10k\Omega$	±12	±14		±12	±14		V
	$R_L \geq 2k\Omega$	±10	±13		±10	±13		V
Input Voltage Range		±12	±13		±12	±13		V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	70	90		70	90		dB
Supply Voltage Rejection Ratio	$R_S \leq 10k\Omega$		30	150		30	150	μV/V
Power Consumption			100	170		100	170	mW
Transient Response (unity gain)	V_{IN} = 20mV R_L = 2kΩ $C_L \leq 100pF$							
Risetime			0.3			0.3		μs
Overshoot			5.0			5.0		%
Slew Rate (unity gain)	$R_L \geq 2k\Omega$		0.5			0.5		V/μs
Channel Separation (open loop)	f = 10kHz R_S = 1kΩ		70			70		dB
(Gain = 100)	f = 10kHz R_S = 1kΩ		83			83		dB
The following specifications apply for −55°C ≤ T_A ≤ +125°C for RM4558; 0°C ≤ T_A ≤ +70°C for RC4558; −40°C ≤ T_A ≤ +85°C for RV4558								
Input Offset Voltage	$R_S \leq 10k\Omega$			6.0			7.5	mV
Input Offset Current				500			300/500*	nA
Input Bias Current				1.5			.8/1.5*	nA
Large-Signal Voltage Gain	$R_L \geq 2k\Omega$ V_{out} = ±10V	25,000			15,000			
Output Voltage Swing	$R_L \geq 2k\Omega$	±10			±10			V
Power Consumption	V_S = ±15V T_A = +125°C T_A = −55°C		90 120	150 200		90 120	150 200	mW

*RV4558

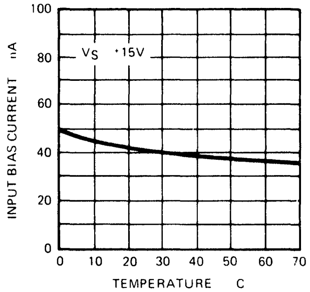
MATCHING CHARACTERISTICS (V_{CC} = ±15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM4558 TYP	RC4558 TYP	UNITS
Voltage Gain	$R_L \geq 2k\Omega$	±.5	±1.0	dB
Input Bias Current		±15	±15	nA
Input Offset Current		±7.5	±7.5	nA
Input Offset Voltage	$R_S \geq 10k\Omega$	±.1	±.2	mV

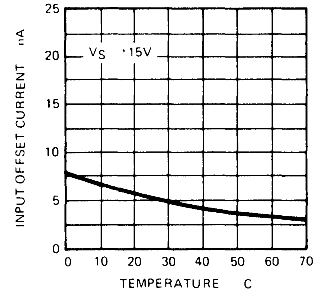
NOTE 1: Rating applies for case temperatures to 125°C; derate linearly at 6.5mW/°C for ambient temperatures above +75°C for RM4558.
NOTE 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
NOTE 3: Short circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature for RC4558 and to +85°C ambient temperature for RV4558.

TYPICAL ELECTRICAL DATA

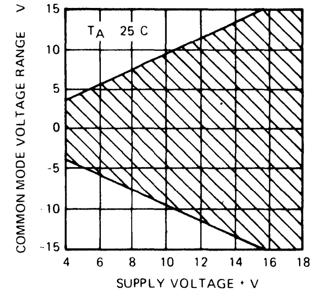
Input Bias Current as a Function of Ambient Temperature



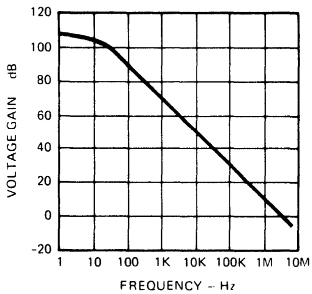
Input Offset Current as a Function of Ambient Temperature



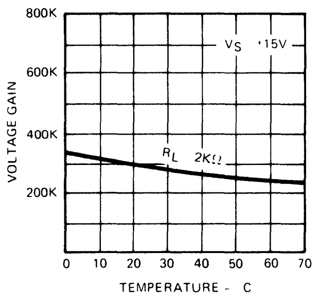
Common Mode Range as a Function of Supply Voltage



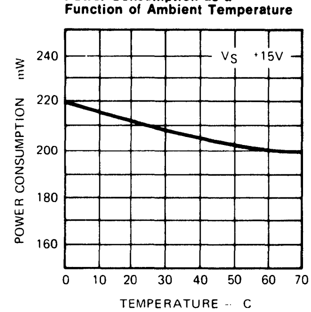
Open Loop Voltage Gain as a Function of Frequency



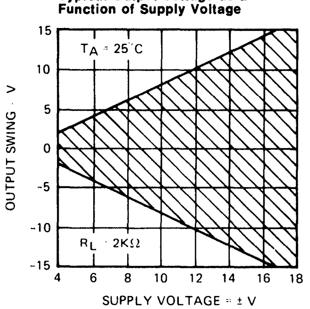
Open Loop Gain as a Function of Temperature



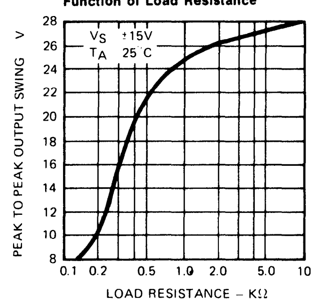
Power Consumption as a Function of Ambient Temperature



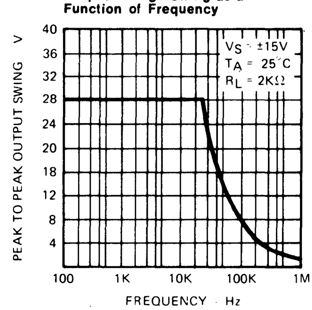
Typical Output Voltage as a Function of Supply Voltage



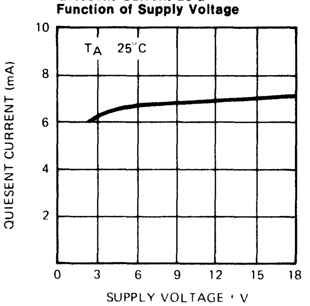
Output Voltage Swing as a Function of Load Resistance



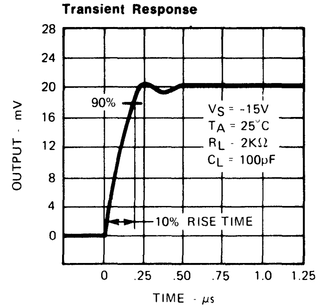
Output Voltage Swing as a Function of Frequency



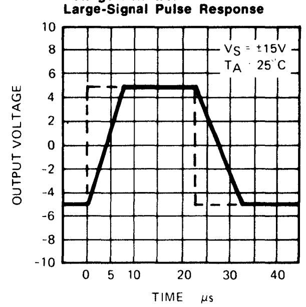
Quiesent Current as a Function of Supply Voltage



Transient Response

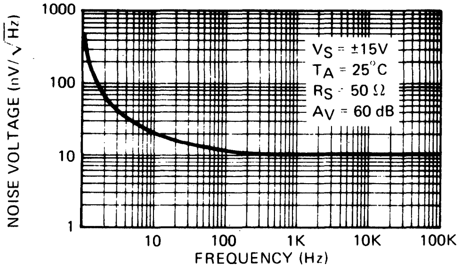


Voltage Follower Large-Signal Pulse Response

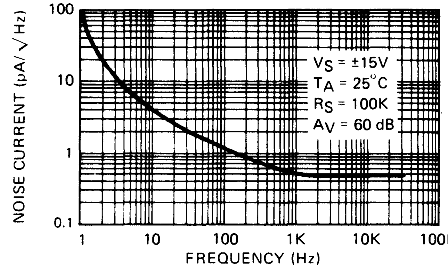


TYPICAL ELECTRICAL DATA

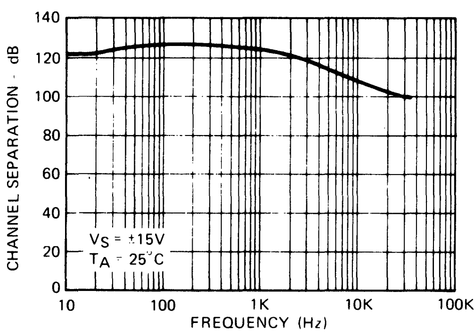
Input Noise Voltage as a Function of Frequency



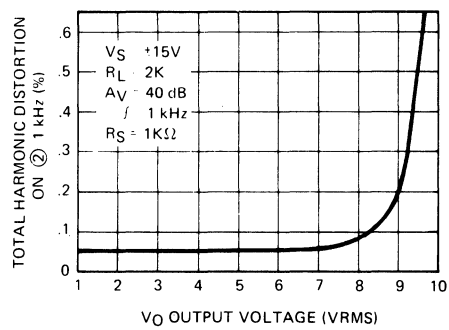
Input Noise Current as a Function of Frequency



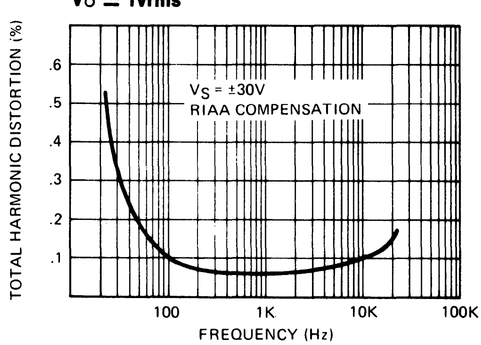
Channel Separation



Total Harmonic Distortion vs Output Voltage



Distortion vs Frequency Vo = 1vrms



1

GENERAL DESCRIPTION

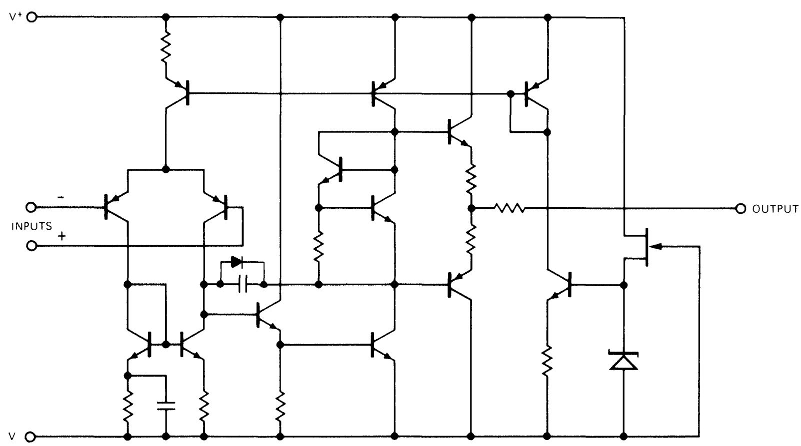
The RC4739 dual low-noise operational amplifier is fabricated on a single silicon chip using the planar epitaxial process. It was designed primarily for preamplifiers in consumer and industrial signal processing equipment. The device is pin compatible with the μA739 and MC1303, however, compensation is internal. This permits a lowered external parts count and simplfied application.

The RC4739 is available in molded dual in-line 14-pin package and operated over the commercial temperature range from 0°C to +70°C.

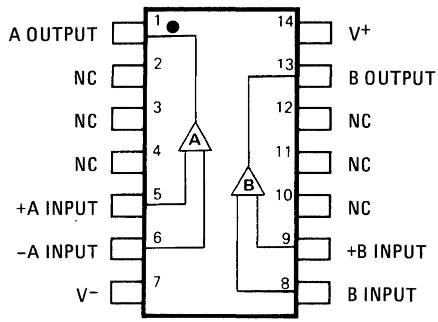
DESIGN FEATURES

- Internally Compensated Replacement for μA739 and MC1303
- Signal-to-Noise Ratio 76 dB (RIAA 10 mV ref.)
- Channel Separation 125 dB
- Unity Gain Bandwidth 3MHz
- Output Short-Circuit Protected
- 0.1% Distortion at 8.5 V RMS Output into 2 kΩ Load

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DB Dual In-line Plastic Package
(Top View)

Order Part No.:
RC4739DB

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18 V	Storage Temperature Range	−65°C to +150°C
Internal Power Dissipation (Note 1)	500 mW	Operating Temperature Range	0°C to +70°C
Differential Input Voltage	±30 V	Lead Temperature (Soldering, 60s)	300°C
Input Voltage (Note 2)	±15 V	Output Short-Circuit Duration (Note 3)	Indefinite

ELECTRICAL CHARACTERISTICS (V_{CC} = ±15V, T_A = +25°C unless otherwise noted.)

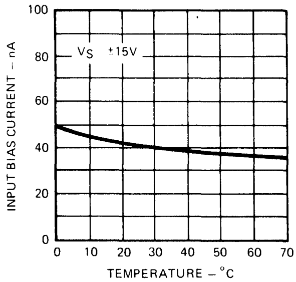
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$R_S \leq 10\ k\Omega$		2.0	6.0	mV
Input Offset Current			5.0	200	nA
Input Bias Current			40	500	nA
Input Resistance		0.3	5.0		MΩ
Large-Signal Voltage Gain	$R_L \geq 2\ k\Omega$, V_{out} = ±10V	20,000	300,000		V/V
Output Voltage Swing	$R_L \geq 10\ k\Omega$	±12	±14		V
	$R_L \geq 2\ k\Omega$	±10	±13		V
Input Voltage Range		±12	±14		V
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70	100		dB
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$		10	150	μV/V
Power Consumption			105	170	mW
Transient Response (unity gain) Risetime	V_{in} = 20 mV, R_L = 2 kΩ, $C_L \leq$ 100pF		0.15		μs
Transient Response (unity gain) Overshoot	V_{in} = 20 mV, R_L = 2 kΩ, $C_L \leq$ 100 pF		10		%
Slew Rate (unity gain)	$R_L \geq 2\ k\Omega$		1.0		V/μs
Broadband Noise Voltage	B_W = 10-30 KHz, R_S = 1 kΩ		2.5		μV_{RMS}
Channel Separation	f = 1.0 kHz, A_V = 40 dB, R_S = 1 kΩ		125		dB
The following specification apply for 0°C $\leq T_A \leq$ 70°C unless otherwise specified.					
Input Offset Voltage	$R_S \leq 10\ k\Omega$		3.0	7.5	mV
Input Offset Current			7.0	300	nA
Input Bias Current			50	800	nA
Large-Signal Voltage Gain	$R_L \geq 2\ k\Omega$, V_{out} = ±10V	15,000	200,000		
Output Voltage Swing	$R_L \geq 2\ k\Omega$	±10	±13		V
Power Consumption	V_S = ±15V				
	T_A = 70°C		100	150	mW
	T_A = 0°C		110	220	mW

NOTES:

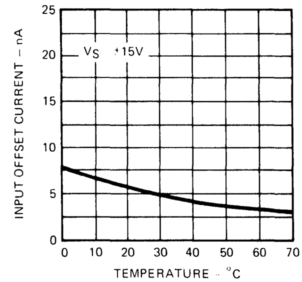
1. Rating applies for ambient temperatures below +70°C.
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground, typically 45 mA. Rating applies to +125°C case temperature or +75°C ambient temperature.
4. Refer to RC 4558 data sheet for RC 4739 typical characteristic curves.

TYPICAL ELECTRICAL DATA

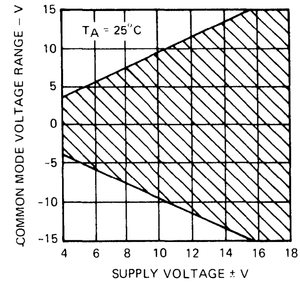
Input Bias Current as a Function of Ambient Temperature



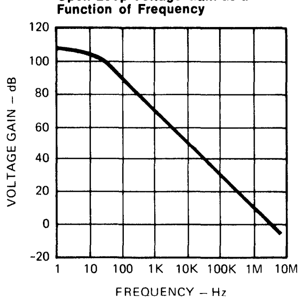
Input Offset Current as a Function of Ambient Temperature



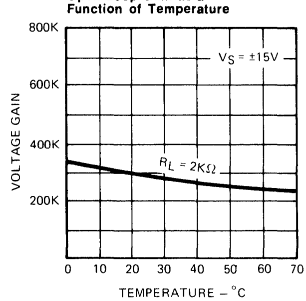
Common Mode Range as a Function of Supply Voltage



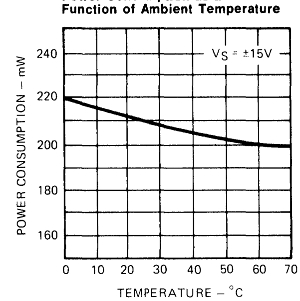
Open Loop Voltage Gain as a Function of Frequency



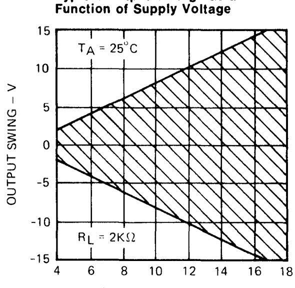
Open Loop Gain as a Function of Temperature



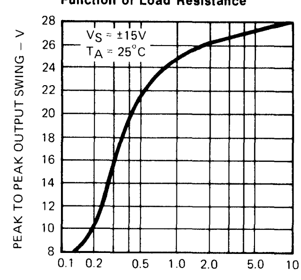
Power Consumption as a Function of Ambient Temperature



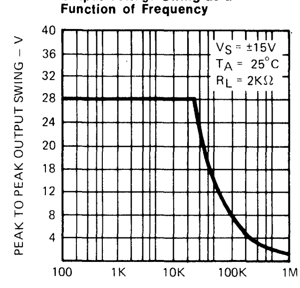
Typical Output Voltage as a Function of Supply Voltage



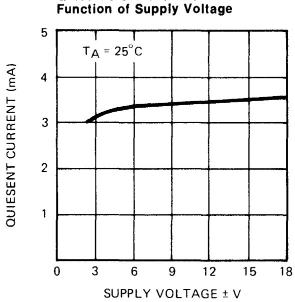
Output Voltage Swing as a Function of Load Resistance



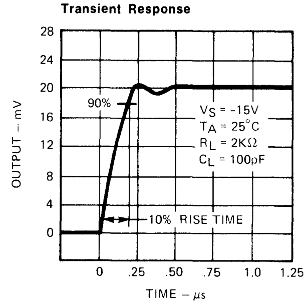
Output Voltage Swing as a Function of Frequency



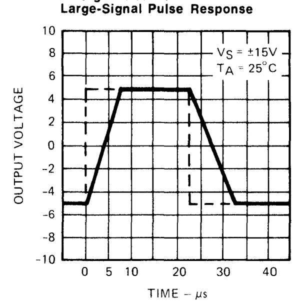
Quiesent Current as a Function of Supply Voltage



Transient Response

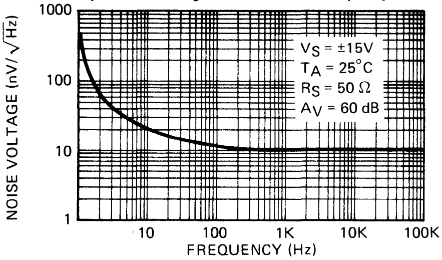


Voltage Follower Large-Signal Pulse Response

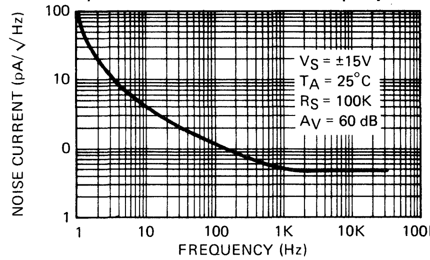


TYPICAL ELECTRICAL DATA

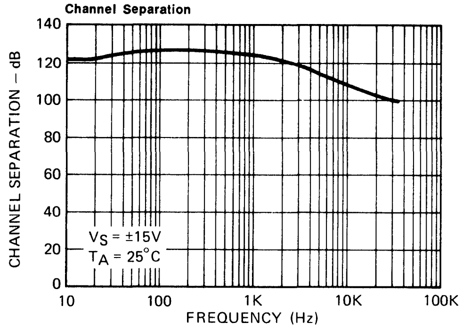
Input Noise Voltage as a Function of Frequency



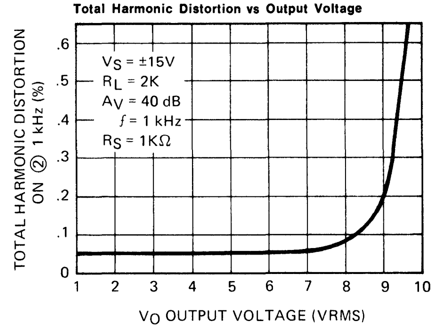
Input Noise Current as a Function of Frequency



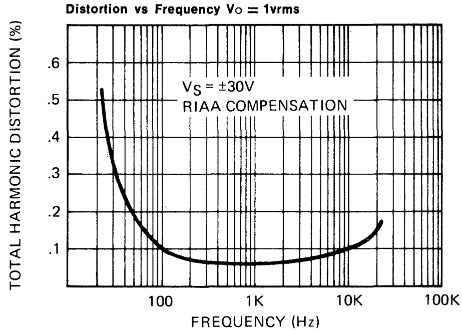
Channel Separation



Total Harmonic Distortion vs Output Voltage

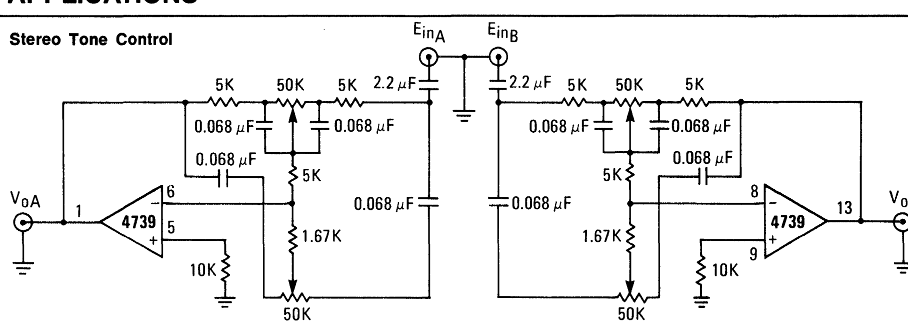


Distortion vs Frequency Vo = 1vrms



TYPICAL APPLICATIONS

Stereo Tone Control



SECTION 2

Wideband Amplifiers

2

CONTENTS

GENERAL DESCRIPTION

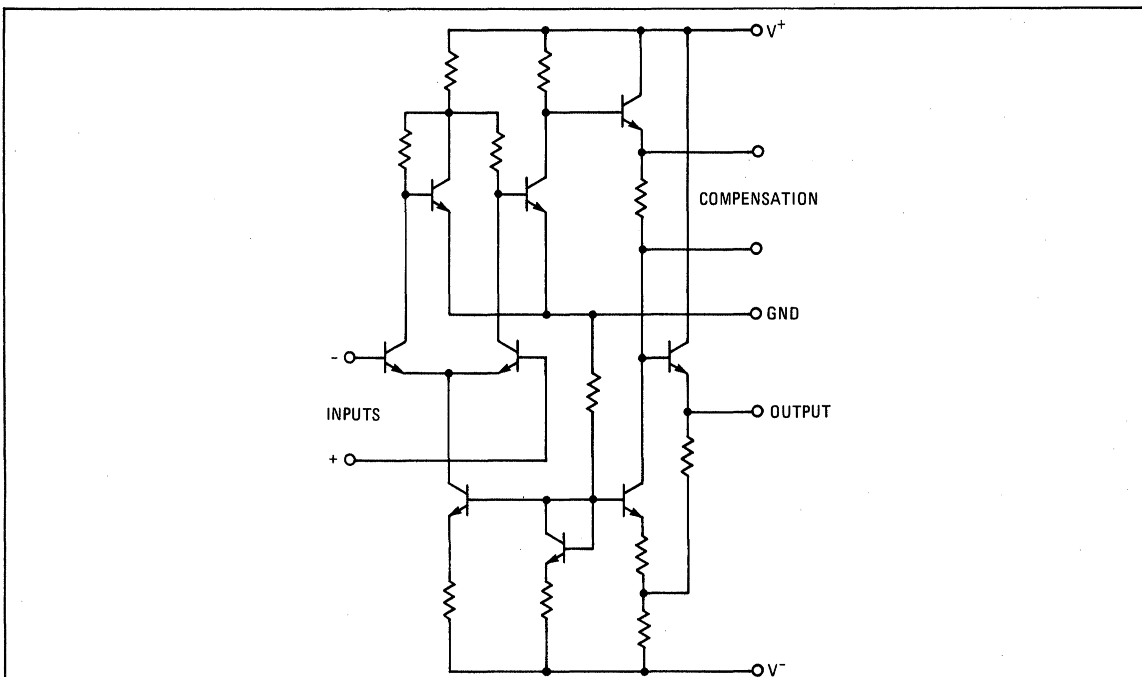
The RM702 and RC702 are complete DC amplifiers constructed on a single silicon chip, using the planar epitaxial process. They are intended for use as operational amplifiers in miniaturized analog computers, as precision instrumentation amplifiers, or in other applications requiring a feedback amplifier useful from DC to 30MHz.

The RM702 operates over a temperature range of –55°C to +125°C. The RC702 operates over a range of 0°C to +70°C.

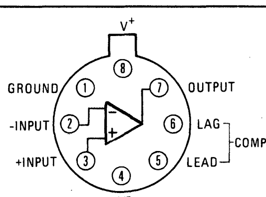
DESIGN FEATURES

- Low Offset Voltage
- Low Offset Voltage Drift
- Wide Bandwidth 30MHz Typical
- High Slew Rate 5.0V/µs Typical

SCHEMATIC DIAGRAM

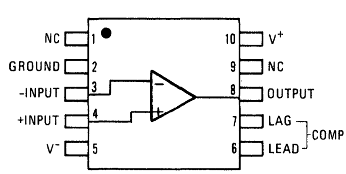


CONNECTION INFORMATION



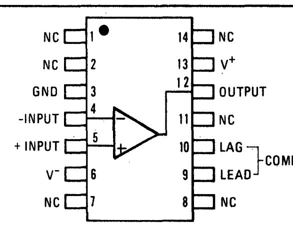
TE Metal Can Package
(Top View)

Order Part Nos.:
RM702T, RC702T



Q
Flat Package
(Top View)

Order Part No.:
RM702Q



DC Dual In-line Package
(Top View)

Order Part Nos.:
RM702DC, RC702DC

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±8.0V	Operating Temperature Range	
Differential Input Voltage	±5.0V	RM733	−55°C to +125°C
Common Mode Input Voltage	±6.0V	RC733	0°C to +70°C
Output Current	10mA	Storage Temperature Range	−65°C to +150°C
Internal Power Dissipation (Note 1)	500mW	Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS RC702 (T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	V^+ = 12.0V, V^- = −6.0V			V^+ = 6.0V, V^- = −3.0V			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 2k\Omega$		1.5	5.0		1.7	6.0	mV
Input Offset Current			0.5	2.0		0.3	2.0	μA
Input Bias Current			2.5	7.5		1.5	5.0	μA
Input Resistance		10	32		16	55		kΩ
Input Voltage Range		−4.0		+0.5	−1.5		+0.5	V
Common Mode Rejection Ratio	$R_S \leq 2k\Omega$, $f \leq 1kHz$	70	92		70	92		dB
Large Signal Voltage Gain	$R_L \geq 100k\Omega$, V_{OUT} = ±5.0V	2000	3400	6000				
	$R_L \geq 100k\Omega$, V_{OUT} = ±2.5V				500	800	1500	
Output Resistance			200	500		300	800	Ω
Supply Current	V_{OUT} = 0		5.0	6.7		2.1	3.3	mA
Power Consumption	V_{OUT} = 0		90	120		19	30	mW
Transient Response (unity-gain) Risetime	C_I = 0.01μF, R_I = 20Ω,, $R_L \leq 100k\Omega$, V_{IN} = 10mV		25	120				ns
Overshoot	$C_L \geq 100pF$		10	50				%
Transient Response (x100 gain) Risetime	C_3 = 50pF, $R_L \geq 100k\Omega$,		10	30				ns
Overshoot	V_{IN} = 1mV		20	40				%
The following specifications apply for 0°C ≤ T_A ≤ +70°C.								
Input Offset Voltage	$R_S \leq 2k\Omega$			6.5			7.5	mV
Average Temperature Coefficient of Input Offset Voltage	R_S = 50Ω, T_A = +70°C to 0°C		5.0	20		7.5	25	μV/°C
Input Offset Current				2.5			2.5	μA
Average Temperature Coefficient	T_A = 25°C to +70°C		4.0	10		3.0	8.0	nA/°C
of Input Offset Current	T_A = 25°C to 0°C		6.0	20		5.5	18	nA/°C
Input Bias Current	T_A = 0°C		4.0	12		2.7	8	μA
Input Resistance		6.0	18		9.0	27		kΩ
Common Mode Rejection Ratio	$R_S \leq 2k\Omega$, $f \leq 1kHz$	65	86		65	86		dB
Supply Voltage Rejection Ratio	V^+=12V, V^-= 6V to V^+=6V, V^- = 3V, $R_S \leq 2k\Omega$		90	300		90	300	μV/V
Large Signal Voltage Gain	$R_L \geq 100k\Omega$, V_{OUT} = ±5.0V	1500		7000				
	$R_L \geq 100k\Omega$, V_{OUT} = ±2.5V				400		1750	
Output Voltage Swing	$R_L \geq 100k\Omega$	±5.0	±5.3		±2.5	±2.7		V
	$R_L \geq 10k\Omega$	±3.5	±4.0		±1.5	±2.0		V
Supply Current	V_{OUT} = 0		5.0	7.0		2.1	3.9	mA
Power Consumption	V_{OUT} = 0		90	125		19	35	mW

ELECTRICAL CHARACTERISTICS RM702 (T_A = 25°C unless otherwise specified)

PARAMETER		CONDITIONS	V^+ = 12.0V, V^- = -6.0V			V^+ = 6.0V, V^- = -3.0V			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage		$R_S \leq 2k\Omega$		0.5	2.0		0.7	3.0	mV
Input Offset Current				180	500		120	500	nA
Input Bias Current				2.0	5.0		1.2	3.5	µA
Input Resistance			16	40		22	67		kΩ
Input Voltage Range			–4.0		+0.5	–1.5		+0.5	V
Common Mode Rejection Ratio		$R_S \leq 2k\Omega$, $f \leq 1kHz$	80	100		80	100		dB
Large Signal Voltage Gain		$R_L \geq 100k\Omega$, V_{OUT} = ±5.0V	2500	3600	6000				
		$R_L \geq 100k\Omega$, V_{OUT} = ±2.5V				600	900	1500	
Output Resistance				200	500		300	700	Ω
Supply Current		V_{OUT} = 0		5.0	6.7		2.1	3.3	mA
Power Consumption		V_{OUT} = 0		90	120		19	30	mW
Transient Response (unity-gain)	Risetime	$C_I = 0.01\mu F$, $R_I = 20\Omega$, $R_L \geq 100k\Omega$, V_{IN} = 10mV		25	120				ns
	Overshoot	$C_L \geq 100pF$		10	50				%
Transient Response (x100 gain)	Risetime	C_3 = 50pF, $R_L \geq 100k\Omega$,		10	30				ns
	Overshoot	V_{IN} = 1mV		20	40				%
The following specifications apply for $-55°C \leq T_A \leq +125°C$.									
Input Offset Voltage		$R_S \leq 2k\Omega$			3.0			4.0	mV
Average Temperature Coefficient of Input Offset Voltage		$R_S = 50\Omega$, T_A=25°C to +125°C		2.5	10		3.5	15	µV/°C
		$R_S = 50\Omega$, T_A=25°C to –55°C		2.0	10		3.0	15	µV/°C
Input Offset Current		T_A = +125°C		80	500		50	500	nA
		T_A = –55°C		400	1500		280	1500	nA
Average Temperature Coefficient of Input Offset Current		T_A = 25°C to +125°C		1.0	5.0		0.7	4.0	nA/°C
		T_A = 25°C to –55°C		3.0	16		2.0	13	nA/°C
Input Bias Current		T_A = –55°C		4.3	10		2.6	7.5	µA
Input Resistance			6.0			8.0			kΩ
Common Mode Rejection Ratio		$R_S \leq 2k\Omega$, $f \leq 1kHz$	70	95		70	95		dB
Supply Voltage Rejection Ratio		V^+ = 12V, V^- = –6V to V^+ = 6V, V^- = –3V $R_S \leq 2k\Omega$		75	200		75	200	µV/V
Large Signal Voltage Gain		$R_L \geq 100k\Omega$, V_{OUT} = ±5.0V	2000		7000				
		$R_L \geq 100k\Omega$, V_{OUT} = ±2.5V				500		1750	
Output Voltage Swing		$R_L \geq 100k\Omega$	±5.0	±5.3		±2.5	±2.7		V
		$R_L \geq 10k\Omega$	±3.5	±4.0		±1.5	±2.0		V
Supply Current		T_A = +125°C, V_{OUT} = 0		4.4	6.7		1.7	3.3	mA
		T_A = –55°C, V_{OUT} = 0		5.0	7.5		2.1	3.9	mA
Power Consumption		T_A = +125°C V_{OUT} = 0		80	120		15	30	mW
		T_A = –55°C, V_{OUT} = 0		90	135		19	35	mW

GENERAL DESCRIPTION

The RM733/RC733 integrated circuit is a monolithic video amplifier with differential inputs and differential outputs. It offers three selectable voltage gains of 10, 100, or 400 and adjustable gain of 10 to 400 using a single resistor. No external frequency compensation is necessary for any gain option. The circuit and process designs are optimized to give a stable gain (±10%), wide bandwidth (DC to 120MHz), high input resistance (250kΩ), and low phase shift that is linear up to 10MHz (2° per MHz).

The RM733/RC733 is designed for use as a read head amplifier for magnetic tape, drum, or disc memories using phase of NRZ encoding. It will also function as a preamplifier for high speed film or plated wire memory systems; as a video or pulse amplifier, pulse height detector, peak detector.

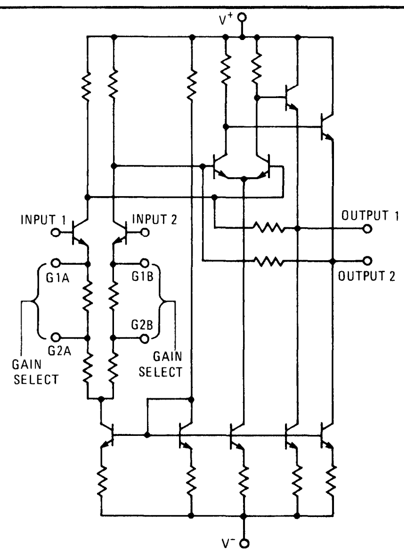
Applications for the RM733/RC733 include bulk computer memory systems, very high speed random access memory systems, communications systems, nuclear event instrumentation, frequency counters, and other systems where the specific design features of the RM733/RC733 are required.

The RM733 video amplifier will operate over the complete military temperature range from −55°C to +125°C while the commercial version, the RC733, operates from 0°C to +70°C.

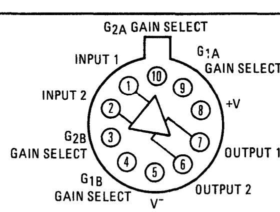
DESIGN FEATURES

- Wide Bandwidth DC to 120MHz
- Low Linear Phase Shift 2τ/MHz to 10MHz
- Selectable Voltage Gains 10, 100, or 400
- Excellent Pulse Characteristics
- High Input Resistance 250kΩ

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



NOTE: Pin 5 connected to case.

TF Metal Can Package
(Top View)

Order Part Nos.:
RM733T
RC733T

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±8.0V
Differentail Input Voltage	±5.0V
Common Mode Input Voltage	±6.0V
Input Current	10mA
Internal Power Dissipation (Note 1)	500mW
Operating Temperature Range	
RM733	−55°C to +125°C
RC733	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	(Note 3)	CONDITIONS	RM733 MIN	RM733 TYP	RM733 MAX	RC733 MIN	RC733 TYP	RC733 MAX	UNITS
Differential Voltage Gain	Gain 1		300	400	500	250	400	600	
	Gain 2		90	100	110	80	100	120	
	Gain 3		9.0	10	11	8.0	10	12	
Bandwidth	Gain 1	$R_S = 50\Omega$		40			40		MHz
	Gain 2			90			90		
	Gain 3			120			120		
Risetime	Gain 1	$R_S = 50\Omega$, $V_{OUT} = 1V_{PP}$		10.5			10.5		ns
	Gain 2			4.5	10		4.5	12	
	Gain 3			2.5			2.5		
Propagation Delay	Gain 1	$R_S = 50\Omega$, $V_{OUT} = 1V_{PP}$		7.5			7.5		ns
	Gain 2			6.0	10		6.0	10	
	Gain 3			3.6			3.6		
Input Resistance	Gain 1			4.0			4.0		kΩ
	Gain 2		20	30		10	30		
	Gain 3			250			250		
Input Capacitance		Gain 2		2.0			2.0		pF
Input Offset Current				0.4	3.0		0.4	5.0	μA
Input Bias Current				9.0	20		9.0	30	μA
Input Noise Voltage		$R_S = 50\Omega$, BW = 1kHz to 10MHz		12			12		μVrms
Input Voltage Range			±1.0			±1.0			V
Common Mode Rejection Ratio	Gain 2	$V_{CM} = \pm1V$, $R \leqslant 100kHz$	60	86		60	86		dB
		$V_{CM} = \pm1V$, f = 5MHz		60			60		
Supply Voltage Rejection Ratio	Gain 2	$\Delta V_S = \pm0.5V$	50	70		50	70		dB
Output Offset Voltage	Gain 1			0.6	1.5		0.6	1.5	V
	Gain 2 Gain 3			0.35	1.0		0.35	1.5	
Output Common Mode Voltage			2.4	2.9	3.4	2.4	2.9	3.4	V
Output Voltage Swing			3.0	4.0		3.0	4.0		V_{PP}
Output Sink Current			2.5	3.6		2.5	3.6		mA
Output Resistance				20			20		Ω
Power Supply Current				18	24		18	24	mA

NOTES:

1. For RM733 the rating applies for case temperature to +125°C; derate linearly at 6.5 mW/°C for ambient temperature above 75°C. For RC733, the rating applies for ambient temperatures to 70°C.
2. $V_S = \pm6.0V$; $T_A = 25°C$ unless otherwise noted.
3. Gain 1: G1A and G1B connected together; Gain 2: G2A and G2B connected together; Gain 3: Gain select pins open.

ELECTRICAL CHARACTERISTICS

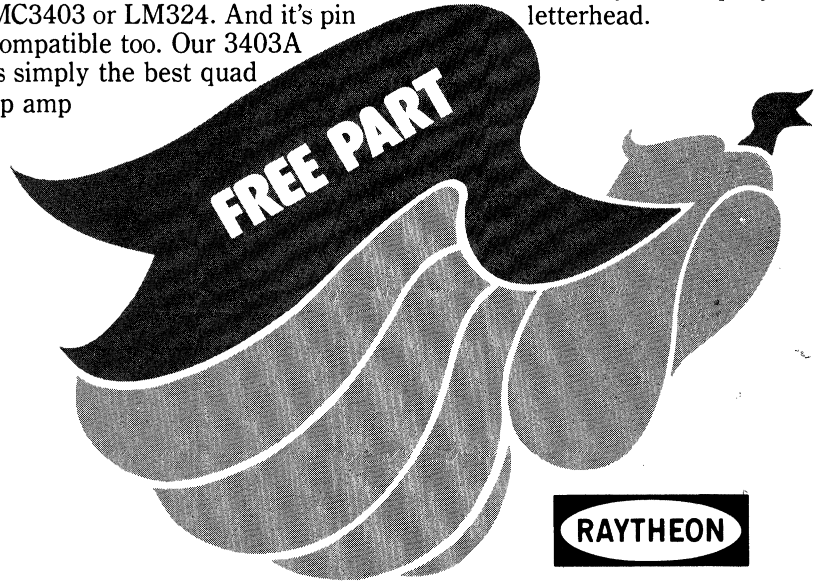
(The following specifications apply for $-55°C \leq T_A \leq 125°C$ for the RM733 and $0°C \leq T_A \leq 70°C$ for the RC733, $V_S = \pm 6.0V$)

PARAMETER	CONDITIONS	LM733			LM733C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Differential Voltage Gain								
Gain 1		200		600	250		600	
Gain 2		80		120	80		120	
Gain 3		8.0		12.0	8.0		12.0	
Input Resistance Gain 2		8			8			kΩ
Input Offset Current				5			6	μA
Input Bias Current				40			40	μA
Input Voltage Range		±1			±1			V
Common-Mode Rejection Ratio Gain 2		50			50			dB
Supply Voltage Rejection Ratio Gain 2		50			50			db
Output Offset Voltage								
Gain 1				1.5			1.5	V
Gain 2 and 3				1.2			1.5	V
Output Voltage Swing		2.5			2.8			V p-p
Output Sink Current		2.2			2.5			mA
Power Supply Current				27			27	mA

THE NEW 3403A. OUTPERFORMS ALL QUAD OP AMPS. FASTER SLEW RATE. DISTORTION FREE.

Raytheon Semiconductor's new 3403A Quad Op Amp gives you a faster slew rate and absolutely no output distortion, plus other improved AC and DC characteristics. The 3403A is significantly better than either the standard MC3403 or LM324. And it's pin compatible too. Our 3403A is simply the best quad op amp from the leader in linear quads.

For complete details and your own Quad/Dual brochure, contact Raytheon Semiconductor or your local distributor. For your *free sample,* write Raytheon Semiconductor on your company letterhead.



RAYTHEON

RAYTHEON SEMICONDUCTOR

SECTION 3

Voltage Regulators

CONTENTS

3

GENERAL DESCRIPTION

The LM104, LM204, and LM304 are precision voltage regulators which provide programmable output voltage levels. With an external resistor the voltage levels can be programmed from 40V down to 0V.

These devices are primarily designed for systems requiring regulated negative voltages which have a common ground with the unregulated supply. They are complements of the LM105/LM305 positive regulators.

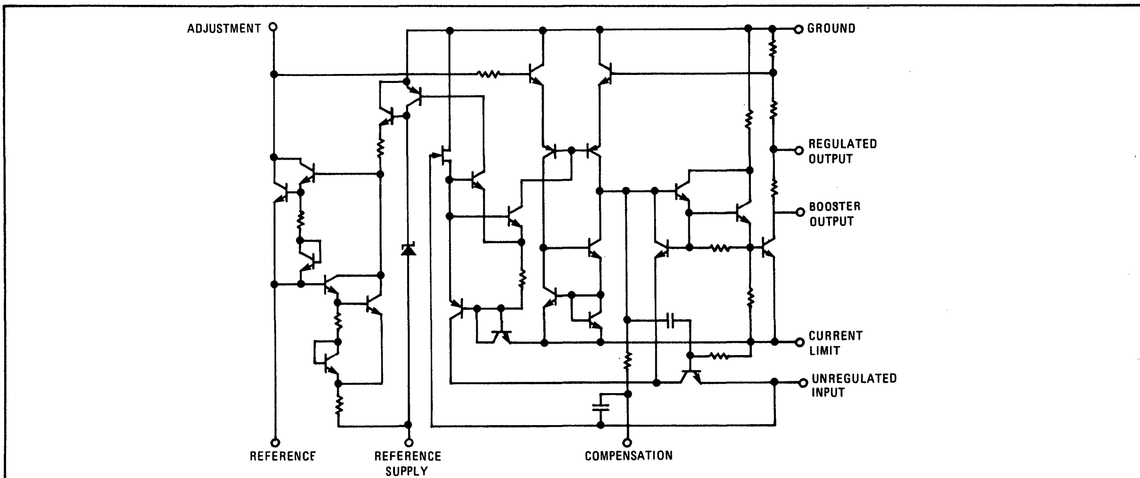
The LM104 series can also be used as switching or current regulators, or in a variety of control applications. Both constant and foldback current limiting are available.

The LM104 operates over the military temperature range of −55°C to +125°C. The LM304 is the commercial version which operates from 0°C to +70°C. The LM204 is the same as the LM104 except its performance is guaranteed from −25°C to +85°C.

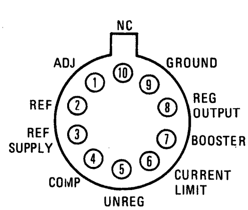
DESIGN FEATURES

- No-Load to Full-Load Regulation 1mV
- Line Regulation 0.01%/V
- Ripple Rejection 0.2mV/V
- Temperature Stability 0.3% from −55°C to +125°C

SCHEMATIC DIAGRAM



CONNECTION INFORMATION

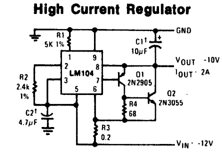


TF Package
(Top View)

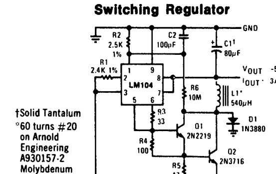
Order Part Nos.:
LM104H, LM204H,
LM304H

TYPICAL APPLICATIONS

High Current Regulator



Switching Regulator



ABSOLUTE MAXIMUM RATINGS

Input Voltage	LM104/LM204: 50V
	LM304: 40V
Input-Output Voltage Differential	LM104/LM204: 50V
	LM304: 40V
Power Dissipation (Note 1)	500mW
Operating Temperature Range	
LM104	−55°C to +125°C
LM204	−25°C to +85°C
LM304	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10s)	300°C

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS	LM104/LM204			LM304			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Voltage Range		−50		−8	−40		−8	V
Output Voltage Range		−40		−0.015	−30		−0.035	V
Output-Input Voltage Differential (Note 3)	I_O = 20mA	2.0		50	2.0		40	V
	I_O = 5 mA	0.5		50	0.5		40	V
Load Regulation (Note 4)	$0 \leqslant I_O \leqslant 20mA$, $R_{SC} = 15\Omega$		1	5		1	5	mV
Line Regulation (Note 5)	$V_{OUT} \leqslant -5V$, $\Delta V_{IN} = 0.1\ V_{IN}$		0.056	0.1		0.056	0.1	%
Ripple Rejection	$C_{19} = 10\mu F$, f = 120Hz, $V_{IN} < -15V$		0.2	0.5		0.2	0.5	mV/V
	$-7V \geqslant V_{IN} \geqslant -15V$		0.5	1.0		0.5	1.0	mV/V
Output Voltage Scale Factor	R_{23} = 2.4k	1.8	2.0	2.2	1.8	2.0	2.2	V/kΩ
Temperature Stability	$V_O \leqslant -1V$		0.3	1.0				%
	$V_O \leqslant -1V, 0°C \leqslant T_A \leqslant 70°C$					0.3	1.0	%
Output Noise Voltage	$10Hz \leqslant f \leqslant 10kHz$, $V_O \leqslant -5V, C_{19} = 0$		0.007			0.007		%
	$C_{19} = 10\mu F$		15			15		μV
Standby Current Drain	$I_L = 5mA, V_O = 0$		1.7	2.5		1.7	2.5	mA
	$V_O = -40V$		3.6	5.0				mA
	$V_O = -30V$					3.6	5.0	mA
Long Term Stability	$V_O \leqslant -1V$		0.1	1.0		0.1	1.0	%

NOTES:

1. The maximum junction temperature of the LM104 is 150°C and the LM304 +85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of +150°C/W, junction to ambient, or +45°C, junction to case. For the flat package, the derating is based on a thermal resistance of +185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors.
2. These specifications apply for junction temperatures between −55°C and +150°C (between 0°C and +85°C for the LM304) and for input and output voltages within the ranges given, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.
3. When external booster transistors are used, the minimum output-input voltage differential is increased, in the worst case, by approximately 1V.
4. The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.
5. With zero output, the dc line regulation is determined from the ripple rejection. Hence, with output voltages between 0V and −5V, a dc output variation, determined from the ripple rejection, must be added to find the worst case line regulation.

GENERAL DESCRIPTION

The LM105 series are positive voltage regulators, each constructed on a silicon chip by the planar epitaxial process.

They are similar to the LM100, except for an extra gain stage to improve regulation. In both linear and switching regulator circuits with outputs greater than 4.5V, these devices are direct plug-in replacements for the LM100.

The LM105 military version operates from −55°C to +125°C. The LM305/LM305A are commercial versions which operate from 0°C to +70°C.

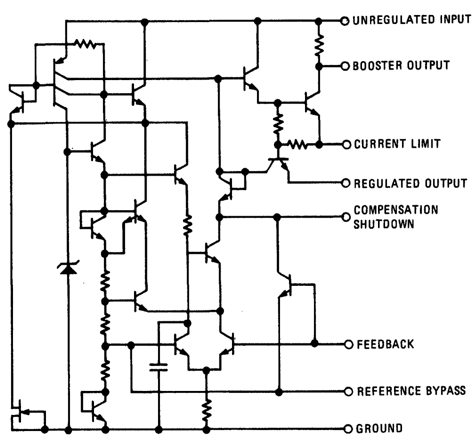
These regulators feature fast response to load and line transients, freedom from oscillations with varying resistive and reactive loads, and reliable starts on any load within ratings.

The LM205 is the same as the LM105 except its performance is guaranteed from −25°C to +85°C.

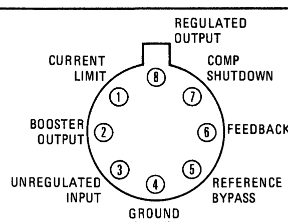
DESIGN FEATURES

- Output Voltage Adjustable from 4.5V to 40V
- Output Currents in Excess of 10A by Adding External Transistors
- Load Regulation Better Than 0.1%, Full Load With Current Limiting
- DC Line Regulation Guaranteed at 0.03%/V
- Ripple Rejection of 0.01%/V
- 45mA Output Current Without External Pass Transistor

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
LM105H, LM205H,
LM305H, LM305AH

Positive Voltage Regulators

ABSOLUTE MAXIMUM RATINGS

Input Voltage LM105, LM205, LM305A: 50V
LM305: 40V
Input-Output Voltage Differential 40V
Power Dissipation (Note 1)
LM105, LM205, LM305A 800mW
LM305 .... 500mW

Operating Temperature Range
LM105 .... −55°C to +150°C
LM205 .... −25°C to +85°C
LM305/305A .... 0°C to +70°C
Storage Temperature Range .... −65°C to +150°C
Lead Temperature (Soldering, 10s) .... 300°C

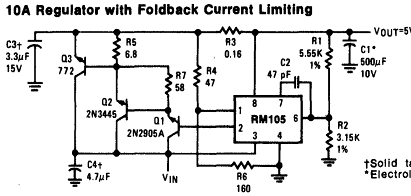
ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	LM105/205/305A		8.5		50	V
	LM305		8.5		40	
Output Voltage Range	LM105/205/305A		4.5		40	V
	LM305		4.5		30	
Output-Input Voltage Differential			3.0		30	V
Load Regulation (Note 3)	LM105	$0 \leq I_O \leq 12mA$				%
		R_{SC} = 10Ω, T_A = 25°C		0.02	0.05	
		R_{SC} = 10Ω, T_A = 125°C		0.03	0.1	
		R_{SC} = 10Ω, T_A = −55°C		0.03	0.1	
	LM205	$0 \leq I_O \leq 12mA$				%
		R_{SC} = 10Ω, T_A = 25°C		0.02	0.05	
		R_{SC} = 10Ω, T_A = 85°C		0.03	0.1	
		R_{SC} = 10Ω, T_A = −25°C		0.03	0.1	
	LM305A	$0 \leq I_O \leq 45mA$				%
		R_{SC} = 0Ω, T_A = 25°C		0.02	0.2	
		R_{SC} = 0Ω, T_A = 70°C		0.03	0.4	
		R_{SC} = 0Ω, T_A = 0°C		0.03	0.4	
	LM305	$0 \leq I_O \leq 12mA$				%
		R_{SC} = 10Ω, T_A = 25°C		0.02	0.05	
		R_{SC} = 15Ω, T_A = 70°C		0.03	0.1	
		R_{SC} = 10Ω, T_A = 0°C		0.03	0.1	
Line Regulation		$V_{IN} - V_{OUT} \leq 5V$		0.025	0.06	%/V
		$V_{IN} - V_{OUT} > 5V$		0.015	0.03	
Ripple Rejection		C_{REF} = 10μF, F = 120Hz		0.003	0.01	%/V
Temperature Stability	LM105	$-55°C \leq T_A \leq 125°C$		0.3	1.0	%
	LM205	$-25°C \leq T_A \leq 85°C$		0.3	1.0	
	LM305/LM305A	$0°C \leq T_A \leq 70°C$		0.3	1.0	
Current Limit Sense Voltage (Note 4)		R_{SC} = 10Ω, T_A = 25°C, V_{OUT} = 0V	225	300	375	mV
Feedback Sense Voltage	LM105/205/305		1.63	1.7	1.81	V
	LM305A		1.55	1.7	1.85	
Output Noise Voltage		$10Hz \leq f \leq 10kHz$				%
		C_{REF} = 0		0.005		
		C_{REF} > 0.1μF		0.002		
Standby Current Drain	LM305	V_{IN} = 40V		0.8	2.0	mA
	LM105/205/305A	V_{IN} = 50V		0.8	2.0	
Long Term Stability				0.1	1.0	%

See Notes on following page.

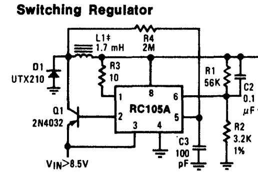
TYPICAL APPLICATIONS

10A Regulator with Foldback Current Limiting



†Solid tantalum
*Electrolytic

Switching Regulator



†Solid tantalum
‡125 turns = 22 on Arnold Engineering A262123-2 molybdenum permalloy core.

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	LM105/205/305A		8.5		50	V
	LM305		8.5		40	
Output Voltage Range	LM105/205/305A		4.5		40	V
	LM305		4.5		30	
Output-Input Voltage Differential			3.0		30	V
Load Regulation (Note 3)	LM105	$0 \leq I_O \leq 12mA$				%
		$R_{SC} = 10\Omega$, $T_A = 25^oC$		0.02	0.05	
		$R_{SC} = 10\Omega$, $T_A = 125^oC$		0.03	0.1	
		$R_{SC} = 10\Omega$, $T_A = -55^oC$		0.03	0.1	
	LM205	$0 \leq I_O \leq 12mA$				%
		$R_{SC} = 10\Omega$, $T_A = 25^oC$		0.02	0.05	
		$R_{SC} = 10\Omega$, $T_A = 85^oC$		0.03	0.1	
		$R_{SC} = 10\Omega$, $T_A = -25^oC$		0.03	0.1	
	LM305A	$0 \leq I_O \leq 45mA$				%
		$R_{SC} = 0\Omega$, $T_A = 25^oC$		0.02	0.2	
		$R_{SC} = 0\Omega$, $T_A = 70^o$		0.03	0.4	
		$R_{SC} = 0\Omega$, $T_A = 0^oC$		0.03	0.4	
	LM305	$0 \leq I_O \leq 12mA$				%
		$R_{SC} = 10\Omega$, $T_A = 25^oC$		0.02	0.05	
		$R_{SC} = 15\Omega$, $T_A = 70^oC$		0.03	0.1	
		$R_{SC} = 10\Omega$, $T_A = 0^oC$		0.03	0.1	
Line Regulation		$V_{IN} - V_{OUT} \leq 5V$		0.025	0.06	%/V
		$V_{IN} - V_{OUT} > 5V$		0.015	0.03	
Ripple Rejection		$C_{REF} = 10\mu F$, F = 120 Hz		0.003	0.01	%/V
Temperature Stability	LM105	$-55^oC \leq T_A \leq 125^oC$		0.3	1.0	%
	LM205	$-25^oC \leq T_A \leq 85^oC$		0.3	1.0	
	LM305/LM305A	$0^oC \leq T_A \leq 70^oC$		0.3	1.0	
Current Limit Sense Voltage (Note 4)		$R_{SC} = 10\Omega$, $T_A = 25^oC$ $V_{OUT} = 0V$	225	300	375	mV
Feedback Sense Voltage	LM105/205/305		1.63	1.7	1.81	V
	LM305A		1.55	1.7	1.85	
Output Noise Voltage		$10Hz \leq f \leq 10kHz$				%
		$C_{REF} = 0$		0.005		
		$C_{REF} > 0.1\mu F$		0.002		
Standby Current Drain	LM305	$V_{IN} = 40V$		0.8	2.0	mA
	LM105/205/305A	$V_{IN} = 50V$		0.8	2.0	
Long Term Stability				0.1	1.0	%

NOTES:

1. The maximum junction temperature of the LM105 is 150°C and 85°C for the LM305. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W junction to ambient, or 45°C/W junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors. Peak dissipations to 1W are allowable providing the dissipation rating is not exceeded with the power averaged over a five second interval, for the LM105, and averaged over a two second inverval for the LM305.
2. These specifications apply for input and output voltages within the ranges given, and for a divider impedance seen by the feedback terminal of 2kΩ, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.
3. The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.
4. No external pass transistor.

GENERAL DESCRIPTION

The LM109 and LM309 are monolithic 5V regulators each constructed on a single silicon chip. They incorporate current limiting to limit the peak output current to a safe value. Also to prevent damage from excessive internal heat, the regulators include thermal shutdown circuits.

The military version, LM109 operates from −55°C to +150°C. The LM309, the commercial version, operates from 0°C to +125°C. The LM209 is the same as the LM109 except its performance is guaranteed from −25°C to +85°C.

These devices are designed for local regulation on digital logic cards, eliminating distribution problems associated with single-point regulation. To simplify their application, the regulators require a minimum number of external parts. Input bypassing may be required when the regulators are situated an appreciable distance away from the power supply filter capacitors.

To improve transient response, output bypassing can be incorporated.

The regulators may be set to regulate voltages above 5V.

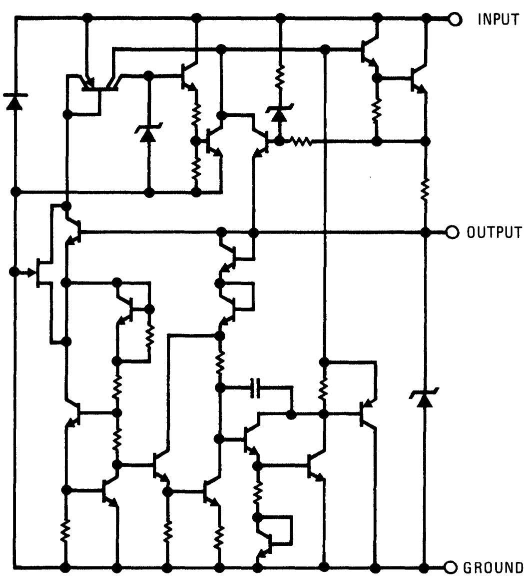
The LM109, LM209, and LM309 are available in the solid-kovar TO-5 header and the TO-3 power package. The TO-5 package can handle currents in excess of 200mA with adequate heat sinking. The TO-3 package can handle currents in excess of 1A.

DESIGN FEATURES

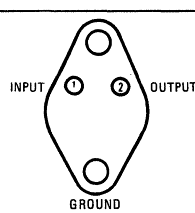
- Output Current in Excess of 1A
- Internal Thermal Overload Protection
- No External Components Required
- Specified Compatible, Worst Case, with TTL and DTL

3

SCHEMATIC DIAGRAM

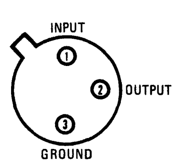


CONNECTION INFORMATION



LK (TO-3) Package
(Bottom View)

Order Part Nos.:
LM109K, LM209K,
LM309K



TH (TO-5) Package
(Top View)

Order Part Nos.:
LM109H, LM209H,
LM309H

ABSOLUTE MAXIMUM RATINGS

Input Voltage	35V
Power Dissipation	Internally Limited
Storage Temperature	−65°C to +150°C
Lead Temperature (Soldering, 10s)	+300°C
Operating Junction Temperature	
LM109	−55°C to +150°C
LM209	−25°C to +150°C
LM309	0°C to +125°C

ELECTRICAL CHARACTERISTICS

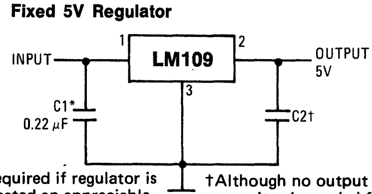
PARAMETER		CONDITIONS	LM109			LM309			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage		$T_j = 25°C$	4.7	5.05	5.3	4.8	5.05	5.2	V
Line Regulation		$T_j = 25°C$ $7.0V \leqslant V_{IN} \leqslant 25V$		4.0	50		4.0	50	mV
Load Regulation	LM109H	$T_j = 25°C$ $5mA \leqslant I_{OUT} \leqslant 0.5A$		20	50		20	50	mV
	LM109K	$5mV \leqslant I_{OUT} \leqslant 1.5A$		50	100		50	100	mV
Output Voltage		$7.0V \leqslant V_{IN} \leqslant 25V$ $5mA \leqslant I_{OUT} \leqslant I_{MAX}$ $P < P_{MAX}$	4.6		5.4	4.75		5.25	V
Quiescent Current		$7.0V \leqslant V_{IN} \leqslant 25V$		5.2	10		5.2	10	mA
Quiescent Current Change		$7.0V \leqslant V_{IN} \leqslant 25V$			0.5			0.5	mA
		$5mA \leqslant I_{OUT} \leqslant I_{MAX}$			0.8			0.8	mA
Output Noise Voltage		$T_A = 25°C$ $10Hz \leqslant f \leqslant 100kHz$		40			40		µV
Long Term Stability					10			20	mV

NOTES:

1. Unless otherwise specified, these specifications apply for $-55°C \leqslant T_j \leqslant 150°C$ ($0°C \leqslant T_j \leqslant 125°C$, for the LM309), $V_{IN} = 10V$ and $I_{OUT} = 0.1A$ for the TO-5 package, or $I_{OUT} = 0.5A$ for the TO-3 package. For the TO-5 package, $I_{MAX} = 0.2A$ and $P_{MAX} = 2.0W$. For the TO-3 package, $I_{MAX} = 1.0A$ and $P_{MAX} = 20W$.
2. Without a heat sink, the thermal resistance of the TO-5 package is about 150°C/W, while that of the TO-3 package is approximately 35°C/W.

TYPICAL APPLICATIONS

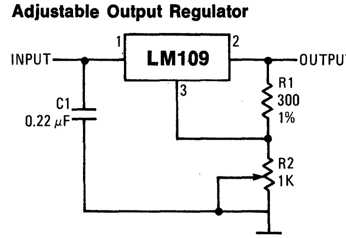
Fixed 5V Regulator



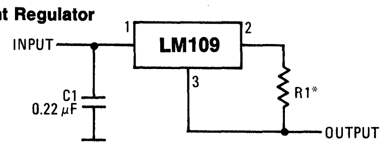
*Required if regulator is located an appreciable distance from power supply filter.

†Although no output capacitor is needed for stability, it does improve transient response.

Adjustable Output Regulator



Current Regulator



*Determines output current.

GENERAL DESCRIPTION

The RM723/RC723 integrated circuits are monolithic voltage regulators constructed on a single silicon chip. They consist of a temperature compensated reference amplifier, error amplifier, a power series pass transistor capable of 150mA, and current limiting circuitry.

They feature low standby current drain, low temperature drift and high ripple rejection.

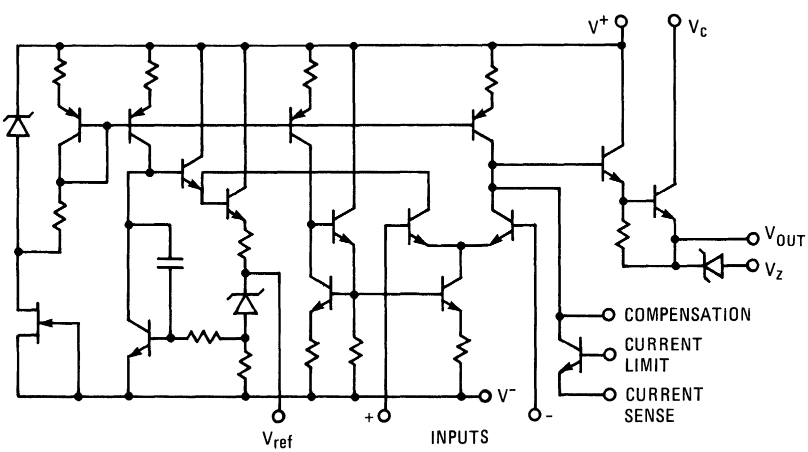
These devices are designed for use as a logic card regulator, small instrument power supply, or, by use of an external pass transistor, as a negative or floating regulator. They may also be used where local voltage supply regulation is required for linear and digital circuits. Provision is made for adjustable current limiting and remote shutdown.

The RM723 operates over the full military temperature range from −55°C to +125°C. The RC723 operates from 0°C to +70°C.

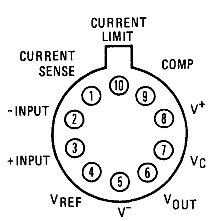
DESIGN FEATURES

- Positive or Negative Supply Operation
- Series, Shunt, Switching or Floating Operation
- 0.01% Line and Load Regulation
- Output Voltage Adjustable from 2V to 37V
- Output Current to 150mA Without External Pass Transistor

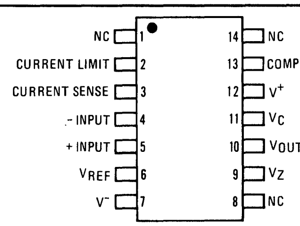
SCHEMATIC DIAGRAM



CONNECTION INFORMATION



TF Metal Can Package
(Top View)
Order Part Nos.:
RM723T, RC723T



DC and DB
Dual In-line Package
(Top View)
Order Part Nos.:
RM723DC, RC723DC,
RC723DB

ABSOLUTE MAXIMUM RATINGS

Pulse Voltage from V^+ to V^- (50 ms) RM723: 50V
Continuous Voltage from V^+ to V^- 40V
Input-Output Voltage Differential 40V
Maximum Output Current 150mA
Current from V_Z 25mA
Current from V_{REF} 15mA
Internal Power Dissipation-Metal Can (Note 1) ... 900mW
Internal Power Dissipation—DIP (Note 1) 900mW
Operating Temperature Range
RC723 .... 0°C to +70°C
RM723 .... −55°C to +125°C
Storage Temperature Range .... −65°C to +150°C
Lead Temperature (Soldering, 60s) .... 300°C

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER	CONDITIONS	RM723			RC723			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Line Regulation	V_{IN} = 12V to V_{IN} = 15V		0.01	0.1		0.01	0.1	% V_{OUT}
	V_{IN} = 12V to V_{IN} = 40V		0.02	0.2		0.1	0.5	
	−55°C ≤ T_A ≤ +125°C, V_{IN} = 12V to V_{IN} = 15V			0.3			0.3	
Load Regulation	I_L = 1mA to I_L = 50mA		0.03	0.15		0.03	0.2	% V_{OUT}
	−55°C ≤ T_A ≤ +125°C, I_L = 1mA to I_L = 50mA			0.6			0.6	
Ripple Rejection	f = 50Hz to 10kHz, C_{REF} = 0		74			74		dB
	f = 50Hz to 10kHz, C_{REF} = 5μF		86			86		
Average Temperature Coeffieient of Output Voltage	−55°C ≤ T_A ≤ +125°C (RM) 0°C ≤ T_A ≤ 70°C (RC)		0.002	0.015		0.003	0.015	%/°C
Short Circuit Current Limit	R_{SC} = 10Ω, V_{OUT} = 0		65			65		mA
Reference Voltage		6.95	7.15	7.35	6.80	7.15	7.50	V
Output Noise Voltage	BW = 100Hz to 10kHz, C_{REF} = 0		20			20		μVrms
	BW = 100Hz to 10kHz, C_{REF} = 5μF		2.5			2.5		
Long Term Stability			0.1			0.1		%/1000 hr
Standby Current Drain	I_L = 0, V_{IN} = 30V, V_O = V_{REF}		2.3	3.5		2.3	4.0	mA
Input Voltage Range		9.5		40	9.5		40	V
Output Voltage Range		2.0		37	2.0		37	V
Input-Output Voltage Differential		3.0		38	3.0		38	V

NOTES:
1. Derate metal can package at 6.8mW/°C and dual in-line package at 7.8mW/°C for operation at ambient temperatures above +25°C.
2. Unless otherwise specified, T_A = 25°C, V_{IN} = V^+ = V_C = 12V, V^- = 0, V_{OUT} = 5V, I_L = 1mA, R_{SC} = 0, C_i = 100pF, C_{REF} = 0, divider impedance as seen by error amplifier ≤10kΩ.
3. For metal can applications where V_Z is required, an external 6.2 zener should be connected in series with V_{OUT}.

GENERAL DESCRIPTION

The RM4194 and RC4194 are dual polarity tracking regulators designed to provide balanced or unbalanced positive and negative output voltages at currents to 200mA. A single external resistor adjustment can be used to change both outputs between the limits of ±50mV and ±42V.

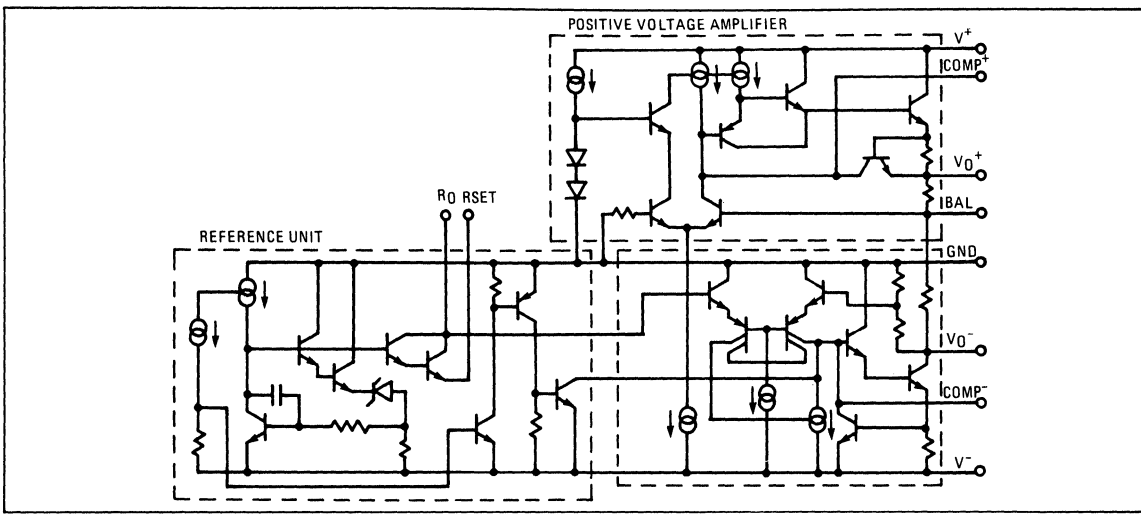
These devices are designed for local "on-card" regulation, eliminating distribution problems associated with single-point regulation. To simplify application the regulators require a minimum number of external parts.

The device is available in two package types to accommodate various power requirements. The TK (TO-66) power package can dissipate up to 3W at T_A = 25°C. The D 14-pin dual in-line will dissipate up to 900mW.

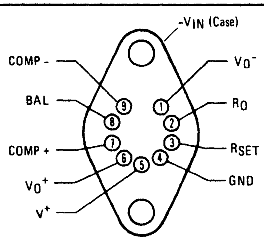
DESIGN FEATURES

- Simultaneously Adjustable Outputs With One Resistor to ±42V
- Load Current ±200mA with 0.2% Load Regulation
- Internal Thermal Shutdown at T_j = 175°C
- External Balance for $\pm V_0$ Unbalancing
- 3W Power Dissipation

SCHEMATIC DIAGRAM

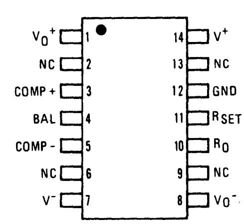


CONNECTION INFORMATION



TK (TO-66) Package
(Bottom View)

Order Part Nos.:
RC4194TK, RM4194TK



D Dual In-line Package
(Top View)

Order Part Nos.:
RC4194D, RM4194D

ABSOLUTE MAXIMUM RATINGS

Input Voltage ±V to Ground .... RM4194: ±45V
RC4194: ±35V
Input-Output Voltage Differentail ..... RM4194: ±45V
RC4194: ±35V
Power Dissipation at $T_A = 25^oC$
D Package 900mW
TK Package 3.0W

Load Current
D Package 150mA
TK Package 250mA
Operation Junction Temperature Range
RM4194 .... -55^oC to $+150^oC$
RC4194 .... 0^oC to $+125^oC$
Storage Temperature Range .... -65^oC to $+150^oC$
Lead Temperature (Soldering, 10s) .... $+300^oC$

ELECTRICAL CHARACTERISTICS ($\pm 5 \leqslant V_{OUT} \leqslant V_{MAX}$; RM4194: $-55^oC \leqslant T_j \leqslant +125^oC$; RC4194: $0^oC \leqslant T_j \leqslant +70^oC$)

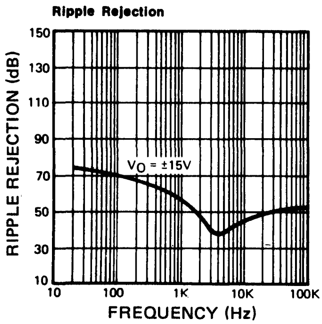
PARAMETER	CONDITIONS	RM4194			RC4194			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Line Regulation	$\Delta V_{IN} = 0.1 V_{IN}$		0.02	0.1		0.02	0.1	% V_{OUT}
Load Regulation	4194TK: I_L = 1 to 200mA 4194D: I_L = 1 to 100mA		0.001	0.002		0.001	0.004	% V^o/mA
TC of Output Voltage			0.002	0.015		0.003	0.015	%/^oC
Stand-By Current Drain (Note 1)	$V_{IN} = V_{MAX}$, $V_o = 0V$		+0.3	+1.0		+0.3	+1.5	mA
	$V_{IN} = V_{MAX}$, $V_o = 0V$		-1.2	-2.0		-1.2	-3.0	
Input Voltage Range		±9.5		±45	±9.5		±35	V
Output Voltage Scale Factor	R_{set} = 71.5K, $T_j = 25^oC$	2.45	2.5	2.55	2.38	2.5	2.62	KΩ/V
Output Voltage Range	R_{set} = 71.5K	0.05		±42	0.05		±32	V
Output Voltage Tracking				1.0			2.0	%
Ripple Rejection	f = 120Hz, $T_j = 25^oC$		70			70		dB
Input-Output Voltage Differential	I_L = 50mA	3.0			3.0			V
Output Short Circuit Current	V_{IN} = ±30V Max.		300			300		mA
Output Noise Voltage	$C_L = 4.7\mu F$, $V_o = \pm 15V$ f = 10Hz to 100KHz		250			250		µV RMS
Internal Thermal Shutdown			175			175		^oC

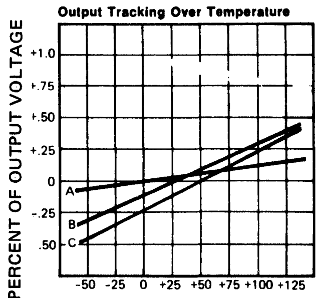
THERMAL CHARACTERISTICS

PARAMETER	CONDITIONS	PACKAGE	
		D	TK (TO-66)
Power Dissipation	$T_A = 25^oC$	900mW	3W
	$T_C = 25^oC$	2.2W	17.5W
Thermal Resistance	Junction to Ambient, θ_{J-A}	128^oC/W	41.6^oC/W
	Junction to Case, θ_{J-C}	55^oC/W	7.15^oC/W

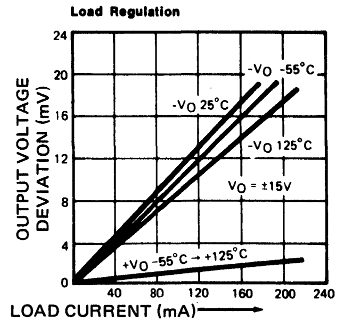
NOTE:
$\pm I_{Quiescent}$ will increase by $50\mu A/V_{OUT}$ on positive side and $100\mu A/V_{OUT}$ on negative side.

TYPICAL ELECTRICAL TEST DATA



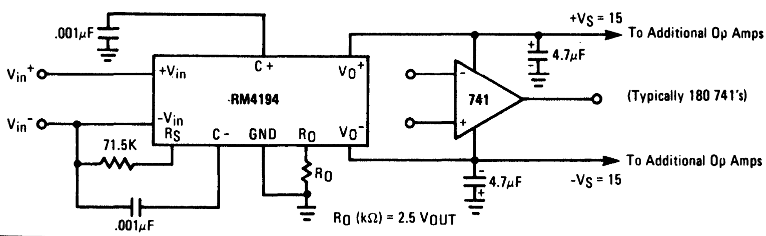


A = % Tracking of outputs vs. temperature
B = T.C. for positive regulator
C = T.C. for negative regulator

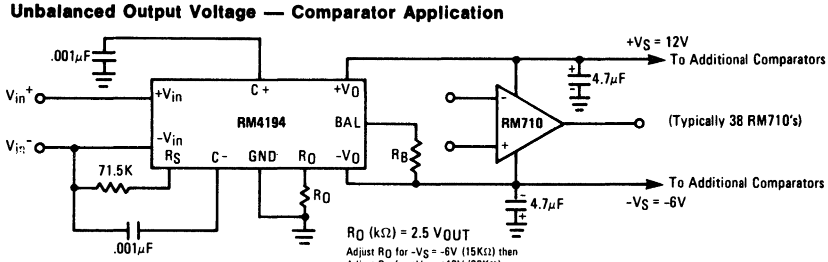


TYPICAL APPLICATIONS

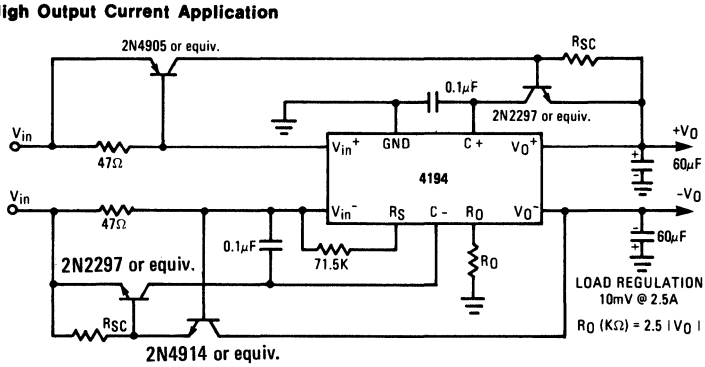
Balanced Output Voltage — Op Amp Application



Unbalanced Output Voltage — Comparator Application



High Output Current Application



GENERAL DESCRIPTION

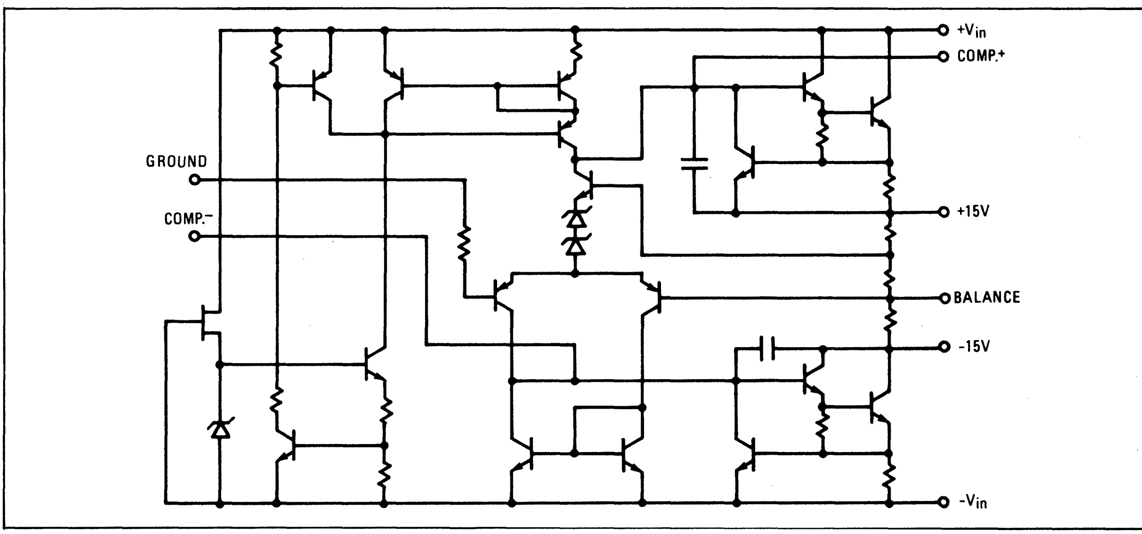
The RM4195 and RC4195 are dual polarity tracking regulators designed to provide balanced positive and negative 15V output voltages at currents to 100mA. These devices are designed for local "on-card" regulation eliminating distribution problems associated with single point regulation. The regulator is intended for ease of application. Only two external components are required for operation (two 10μF bypass capacitors).

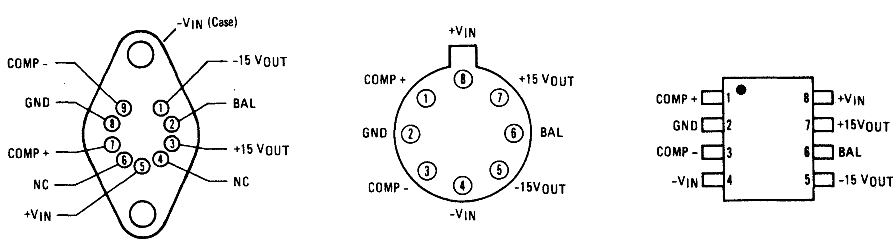
The device is available in three package types to accommodate various applications requiring economy, high power dissipation, and reduced component density.

DESIGN FEATURES

- ±15V Operational Amplifier Power at Reduced Cost and Component Density
- Thermal Shutdown at T_j = +175°C in Addition to Short-Circuit Protection
- Output Currents to 100mA
- May be Used as Single Output Regulator with up to +50V Output
- Available in TO-66, TO-99, and 8-Pin Plastic Mini-DIP

SCHEMATIC DIAGRAM





TK (TO-66) Power Package
(Bottom View)

Order Part Nos.:
RC4195TK, RM4195TK

TE Metal Can Package
(Top View)

Order Part Nos.:
RC4195T, RM4195T

NB Dual In-line
(Top View)

Order Part No.:
RC4195NB

ABSOLUTE MAXIMUM RATINGS

Input Voltage ±V to Ground . . . . ±30V
Power Dissipation @ T_A = +25°C
TK Package 2.4W
T Package 800mW
NB Package 600mW
Load Current
TK Package 150mA
T, and NB Package 100mA

Operating Junction Temperature Range
RM4195 . . . . −55°C to +150°C
RC4195 . . . . 0°C to +125°C
Storage Junction Temperature Range
RM4195 . . . . −65°C to +150°C
RC4195 . . . . −65°C to +125°C
Lead Temperature (Soldering, 10s) . . . . +300°C

ELECTRICAL CHARACTERISTICS (I_L = 1mA, V_{CC} = ±20V, C_L = 10μF unless otherwise specified)

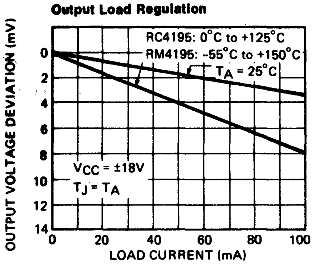
PARAMETER	CONDITIONS	RM4195			RC4195			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Line Regulation	V_{IN} = ±18 to ±30V		2	20		2	20	mV
Load Regulation	I_L = 1 to 100mA		5	30		5	30	mV
Output Voltage Temperature Stability			0.005	0.015		0.005	0.015	%/°C
Standby Current Drain	V_{IN} = ±30V, I_L = 0mA		±1.5	±2.5		±1.5	±3.0	mA
Input Voltage Range		18		30	18		30	V
Output Voltage	T_j = +25°C	14.8	15	15.2	14.5	15	15.5	V
Output Voltage Tracking			±50	±150		±50	±300	mV
Ripple Rejection	f = 120Hz, T_j = +25°C		75			75		dB
Input-Output Voltage Differential	I_L = 50mA	3			3			V
Short-Circuit Current	T_j = +25°C		220			220		mA
Output Noise Voltage	T_j = +25°C, f = 100Hz to 10kHz		60			60		μV RMS
Internal Thermal Shutdown			175			175		°C

THERMAL CHARACTERISTICS

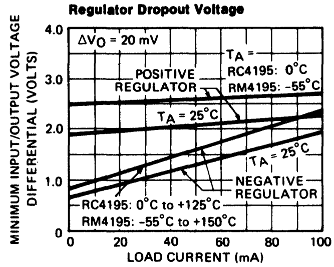
PARAMETER	CONDITIONS	PACKAGE			UNITS
		NB	T (TO-99)	TK (TO-66)	
Power Dissipation	T_A = 25°C	0.6	0.8	2.4	W
	T_C = 25°C		2.1	9	
Thermal Resistance	θ_{J-C}		70	17	°C/W
	θ_{J-A}	210	185	62	

TYPICAL ELECTRICAL TEST DATA

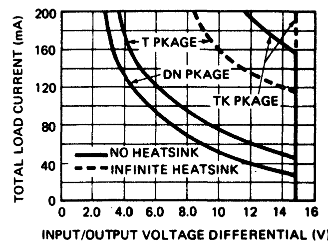
Output Load Regulation



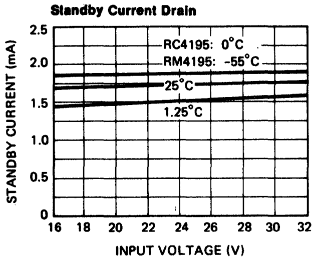
Regulator Dropout Voltage



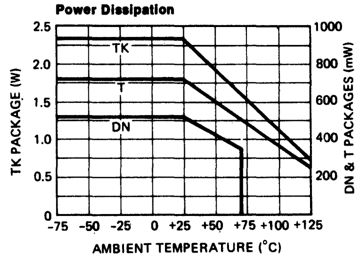
Maximum Current Capability



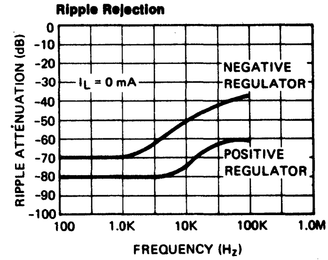
Standby Current Drain



Power Dissipation

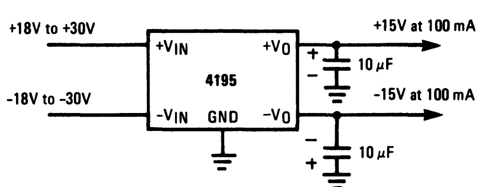


Ripple Rejection

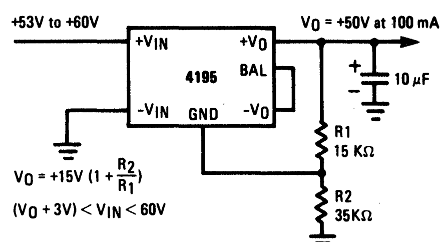


TYPICAL APPLICATIONS

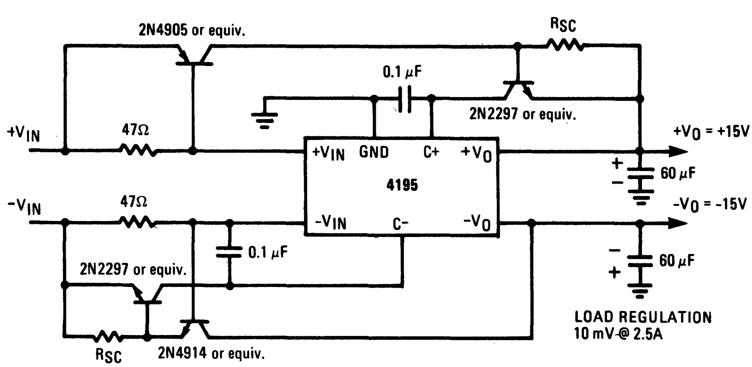
Balanced Output (Vo = ±15V)



Positive Single Supply (+15V < Vo < +50V)



High Output Current



SECTION 4

Comparators

CONTENTS

4

GENERAL DESCRIPTION

The LM106, LM206, and LM306 are high-speed voltage comparators designed to accurately detect low-level analog signals and drive a digital load. They are equivalent to an RC710, combined with a two input NAND gate and an output buffer. The circuits can drive RTL, DTL or TTL integrated circuits directly. Furthermore, their outputs can switch voltages up to 24V at currents as high as 100mA.

The devices have short-circuit protection which limits the inrush current when it is used to drive loads such as incandescent lamps, in addition to preventing damage if it is accidently short-circuited. The speed is equivalent to that of an RC710. However, it is even faster where buffers and additional logic circuitry can be eliminated by the increased flexibility of the LM106, LM206, and LM306. They can also be operated from any negative supply voltage between −3V and −12V with little effect on performance.

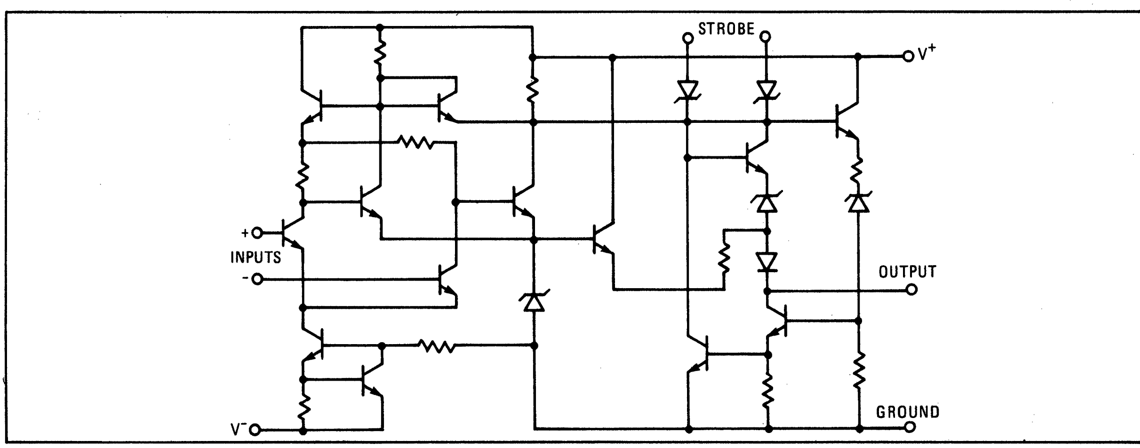
Operating temperature ranges are: LM106, −55°C to +125°C; LM206, −25°C to +85°C; LM306, 0°C to +70°C.

The LM206 is the same as the LM106 except its performance is guaranteed from −25°C to +85°C.

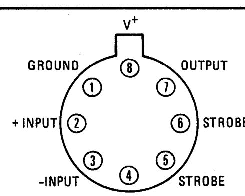
DESIGN FEATURES

- Improved Accuracy 2mV (Max) Offset, 40,000 Gain
- Fan-Out of 10 with DTL or TTL
- Useful as Relay or Lamp Driver
- Plug-in Replacement for RC710

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
LM106H, LM206H, LM306H

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±15V
Output Voltage	24V
Output to Negative Supply Voltage	30V
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Power Dissipation (Note 1)	600mW
Output Short-Circuit Duration	10s
Operating Temperature Range	
LM106	−55°C to +125°C
LM206	−25°C to +85°C
LM306	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60s)	300°C

ELECTRICAL CHARACTERISTICS (Notes 2,5)

PARAMETER	CONDITIONS	LM106, LM206			LM306			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	Notes 2 and 3		0.5	2.0		1.6	5.0	mV
Input Offset Current	Notes 2 and 3		0.7	3.0		1.8	5.0	μA
Input Bias Current	Note 2		10	20		16	25	μA
Voltage Gain	Note 2		40			40		V/mV
Response Time	Notes 2 and 4, R_L = 390Ω, C_L = 15pF		28	40		28	40	ns
Saturation Voltage	Note 2, $V_{IN} \leqslant -5mV$, I_{sink} = 100mA		1.0	1.5		0.8	2.0	V
Output Leakage Current	Note 2, $V_{IN} \geqslant 5mV$, $8V \leqslant V_{OUT} \leqslant 24V$		0.02	1.0		0.02	2.0	μA
Input Offset Voltage	Note 3			3.0			6.5	mV
Average Temperature Coefficient of Input Offset Voltage			3.0	10		5.0	20	μV/°C
Input Offset Current	Note 3, $T_L \leqslant T_A \leqslant +25°C$		1.8	7.0		2.4	7.5	pA
	Note 5, $+25°C \leqslant T_A \leqslant T_H$		0.25	3.0			5.0	
Average Temperature Coefficient of Input Offset Current	Note 5, $T_L \leqslant T_A \leqslant +25°C$		15	75		24	100	nA/°C
	Note 5, $+25°C \leqslant T_A \leqslant T_H$		5.0	25		15	50	
Input Bias Current	Note 5, $T_L \leqslant T_A \leqslant +25°C$			45		25	40	pA
	Note 5, $+25°C \leqslant T_A \leqslant T_H$			20			25	
Input Voltage Range	$-7V \geqslant V^- \geqslant -12V$	±5.0			±5.0			V
Differential Input Voltage Range		±5.0			±5.0			V
Saturation Voltage	$V_{IN} \leqslant -5mV$, I_{sink} = 50mA			1.0			1.0	V
Saturation Voltage	$V_{IN} \leqslant -5mV$, $I_{sink} \leqslant 16mA$			0.4			0.4	V
Positive Output Level	$V_{IN} \geqslant 5mV$, I_{OUT} = 400μA	2.5		5.5	2.5		5.5	V
Output Leakage Current	$V_{IN} \geqslant 5mV$, $8V \leqslant V_O \leqslant 24V$, Note 5			100			100	μA
Strobe Current	V_{strobe} = 0.4V		−1.7	−3.2		−1.7	−3.2	mA
Strobe ON Voltage		0.9	1.4		0.9	1.4		V
Strobe OFF Voltage	$I_{sink} \leqslant 16mA$		1.4	2.2		1.4	2.2	V
Positive Supply Current	V_{IN} = −5mV		5.5	10		5.5	10	mA
Negative Supply Current			−1.5	−3.6		−1.5	−3.6	mA

NOTES:

1. The maximum junction temperatures are as follows: LM106 +150°C, LM206 +110°C, LM306 +85°C. For operating at elevated temperatures, devices in the TE package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. For the flat package, the derating is based on a thermal resistance of 185°C/W when mounted on a 1/16-inch-thick epoxy glass board with ten, 0.03-inch-wide, 2-ounce copper conductors.
2. These specifications apply for $-3V \geqslant V^- \geqslant -12V$, V^+ = 12V and T_A = 25°C unless otherwise specified.
3. The offset voltages and offset currents given are the maximum values required to drive the output down to 0.5V or up to 5.0V. Thus, these parameters actually define an error band and take into account the worst-case effects of voltage gain and input impedance.
4. The response time specified (see definitions) is for a 100mV input step with 5mV overdrive.
5.

	T_L	T_H
LM106	−55°C	+125°C
LM206	−25°C	+85°C
LM306	0°C	+70°C

GENERAL DESCRIPTION

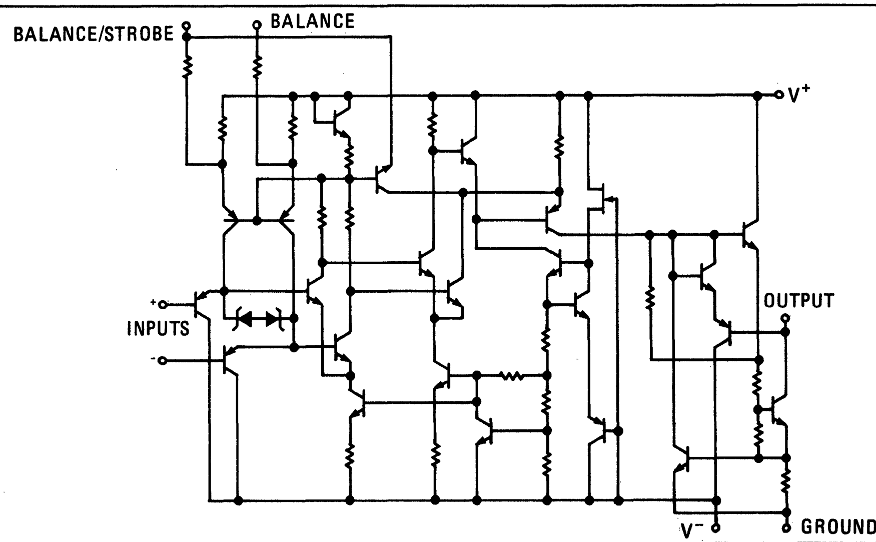
The LM111, LM211, and LM311 are voltage comparators with about one-thousandth the input current of the LM106 and LM107. These comparators are designed to operate from standard ±15V operational amplifier supplies to a single +5V supply used for IC logic. Their outputs are compatible with DTL, RTL, TTL, and MOS devices. Offset balancing is provided, and the outputs can be OR wired.

The LM111 operates over the full military temperature range of −55°C to +125°C. The LM211 is the same as the LM111 except its performance is guaranteed from −25°C to +85°C. The LM311 is the commercial version which operates from 0°C to +70°C.

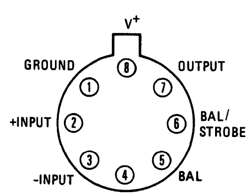
DESIGN FEATURES

- Input Current 150nA Maximum
- Operates from +5V Supply
- Offset Current 20nA Maximum

SCHEMATIC DIAGRAM



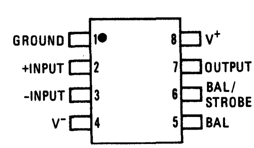
CONNECTION INFORMATION



NOTE: Pin 4 connected to case.

TE Metal Can Package
(Top View)

Order Part Nos.:
LM111H, LM211H,
LM311H



NB Dual In-line Package
(Top View)

Order Part No.:
LM311NB

ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V_{84})	36V
Output to Negative Supply (V_{74})	LM111/LM211: 50V LM311: 40V
Ground to Negative Supply Voltage (V_{14})	30V
Differential Input Voltage	±30V
Input Voltage (Note 1)	±15V
Power Dissipation (Note 2)	500mW
Output Short-Circuit Duration	10s
Operating Temperature Range	
LM111	−55°C to +125°C
LM221	−25°C to +85°C
LM311	0°C to +70°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10s)	300°C

ELECTRICAL CHARACTERISTICS (Note 3)

PARAMETER	CONDITIONS	LM111/211		LM311		UNITS
		TYP	MAX	TYP	MAX	
Input Offset Voltage (Note 4)	T_A = 25°C, $R_S \leq$ 50k	0.7	3.0	2.0	7.5	mV
Input Offset Current (Note 4)	T_A = 25°C	4.0	10	6.0	50	nA
Input Bias Current	T_A = 25°C	60	100	100	250	nA
Voltage Gain	T_A = 25°C		200	200		V/mV
Response Time (Note 5)	T_A = 25°C		200	200		ns
Saturation Voltage	$V_{IN} \leq$ −5mV, I_{OUT} = 50mA, T_A = 25°C	0.75	1.5	0.75	1.5	V
Strobe On Current	T_A = 25°C	3.0		3.0		mA
Output Leakage Current	$V_{IN} \geq$ 5mV, V_{OUT} = 35V, T_A = 25°C	0.2	10	0.2	50	nA
Input Offset Voltage (Note 4)	$R_S \leq$ 50k		4.0		10	mV
Input Offset Current (Note 4)			20		70	nA
Input Bias Current			150		300	nA
Input Voltage Range		±14		±14		V
Saturation Voltage	$V^+ \geq$ 4.5V, V^- = 0, $V_{IN} \leq$ −6mV, $I_{SINK} \leq$ 8mA	0.23	0.4	0.23	0.4	V
Output Leakage Current	$V_{IN} \geq$ 5mV, V_{OUT} = 35V	0.1	0.5			μA
Positive Supply Current	T_A = 25°C	5.1	6.0	5.1	7.5	mA
Negative Supply Current	T_A = 25°C	4.1	5.0	4.1	5.0	mA

NOTES:

1. This rating applies for ±15V supplies. The positive input voltage limit is 30V above the negative supply. The negative input voltage limit is equal to the negative supply voltage of 30V below the positive supply, whichever is less.
2. The maximum junction temperature of the LM111 is 150°C, while that of the LM311 is +85°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case.
3. These specifications apply for V_S = ±15V and −55°C ≤ T_A ≤ +125°C, unless otherwise stated. With the LM311, however, all temperature specifications are limited to 0°C ≤ T_A ≤ +70°C. The offset voltage, offset current and bias current specifications apply for any supply voltage from a single 5V supply up to ±15V supplies.
4. The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.
5. The response time specified (see definitions) is for a 100mV input step with 5mV overdrive.

Quad Single-Supply Comparators

GENERAL DESCRIPTION

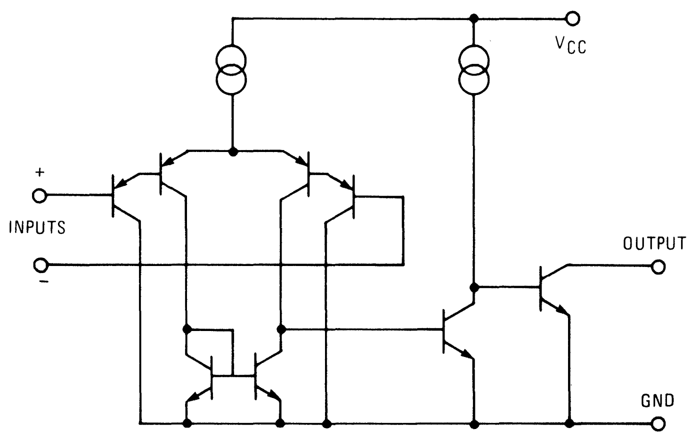
These devices offer higher frequency operation and faster switching than can be had from internally compensated quad op amps. Intended for single-supply applications, the Darlington PNP input stage allows them to compare voltages that include ground. The two-stage common-emitter output circuit provides gain and output sink capacity of 3 μA at an output level of 400 mV. The output collector is left open, permitting the designer to drive devices in the range of 2 V to 36 V.

They are intended for commercial and industrial applications not needing response time less than 20 ns, but demanding excellent op amp input parameters of offset voltage and current, and bias current, to insure accurate comparison with reference voltage.

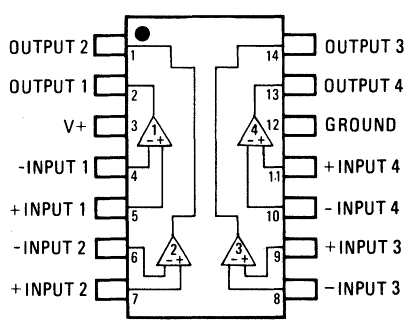
DESIGN FEATURES

- Input Common Mode Voltage Range Includes Ground
- Wide Single Supply Voltage Range, 2 to 36V
- Output Compatible with TTL, DTL, ECL, MOS and CMOS Logic Systems
- Very Low Supply Current Drain (.8mA) Independent of Supply Voltage

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DC and DB
Dual In-line Packages
(Top View)

Order Part Nos.:
LM139D, LM239D, LM339N
LM2901N, RC3302DB

Quad Single-Supply Comparators

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V^+ . . . . 36 V or ±18 V	Operating Temperature Range . LM339: 0°C to +70°C
Differential Input Voltage . . . . 36 V	LM239: −25°C to +85°C
Input Voltage . . . . −0.3 V to +36 V	LM2901: −40°C to +85°C
Power Dissipation (Note 1)	LM139: −55°C to +125°C
Molded DIP . . LM339N, LM2901N: 570 mW	Storage Temperature Range . . . . −65°C to +150°C
Cavity DIP . . . LM139D, LM239D & LM339D: 900 mW	Lead Temperature (Soldering, 10s) . . . . 300°C
Output Short-Circuit to GND (Note 2) . . . . Continuous	

ELECTRICAL CHARACTERISTICS (139, 239, 339, 2901) (V^+ = +5V and T_A = +25°C unless otherwise noted.)

PARAMETER	CONDITIONS	LM139			LM2901, LM239, LM339			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	At Output Switch Point, $V_O \cong 1.4V$ V_{REF} = +1.4V, R_S = 0Ω		2	5		2	5	mV
	LM 2901					2	7	mV
Input Bias Current (Note 3)	$I_{IN(+)}$ or $I_{IN(-)}$ With Output in Linear Range		25	100		25	250	nA
Input Offset Current	$I_{IN(+)} - I_{IN(-)}$		3	25		5	50	nA
Input Common-Mode Voltage Range (Note 4)		0		V^+−1.5	0		V^+−1.5	V
Supply Current	$R_L = \infty$ On All Comparators		0.8	2		0.8	2	mA
Voltage Gain	R_L = 15 kΩ		200			200		V/mV
Response Time (Note 5)	V_{RL} = 5.0V and R_L = 5.1 kΩ		1.3			1.3		μs
Output Sink Current	$V_{IN(-)}$ = +1V, $V_{IN(+)}$ = 0, $V_O \leqslant$ +1.5V	6	16		6	16		mA
Saturation Voltage	$V_{IN(-)}$ = +1V, $V_{IN(+)}$ = 0, I_{SINK} = 3 mA		200	400		200	400	mV
Output Leakage Current	$V_{IN(+)}$ = +1V, $V_{IN(-)}$ = 0, V_{OUT} = 5V		0.1			0.1		nA

NOTES:
1. For operating at high temperatures, the LM339 and the LM2901 must be derated based on a +125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board operating in a still air ambient. The LM239 and LM139 must be derated based on a +150°C maximum junction temperature. The low bias dissipation and the ON-OFF characteristic of the outputs keeps the chip dissipation very small (Pd ⩽ 100mW), provided the transistors are allowed to saturate.
2. Short circuits from the output to V^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 20mA independent of the magnitude of V^+.
3. The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the reference or input lines.
4. The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V^+−1.5V, but either or both inputs can go to +30V_{DC} without damage.
5. The response time specified is for a 100mV input step with 5mV overdrive. For larger overdirve signals 300 ns can be obtained, see typical performance characteristics section.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	+2.0 V to +28 V
Output Sink Current (Note 1)	20 mA
Internal Power Dissipation (Note 1)	625 mW
Differential Input Voltage	±2.0 V to ±28 V
Input Voltage (Note 2)	−0.3 V $\pm V_{CC}$
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−40°C to +85°C
Lead Temperature (Soldering, 60s)	300°C
Output Short-Circuit Duration (Note 2)	Continuous

ELECTRICAL CHARACTERISTICS (V^+ = +15V and T_A = +25°C unless otherwise noted.)

Characteristic	Conditions	Symbol	3302 Min	3302 Typ	3302 Max	Unit
Input Offset Voltage	(V_{ref} = 1.2V)	V_{IO}				mV
	(T_A = +25°C)		–	3.0	20	
	(T_A = −40° to +85°C)		–	–	40	
Input Offset Current		I_{IO}	–	3.0	–	nA
Input Bias Current		I_{IB}				nA
	(T_A = +25°C)		–	30	500	
	(T_A = −40°C to +85°C)		–	–	1000	
Voltage Gain	(R_L = 15 kΩ)	A_{vol}	2,000	30,000	–	V/V
Transconductance		gm	–	2.0	–	mhos
Differential Input Voltage Range		V_{IDR}	$\pm V_{CC}$	–	–	V
Output Leakage Current (Output Voltage High)		I_{off}	–	–	1.0	µA
Negative Output Voltage	(I_S = 2.0mA, V_{CC} = +5.0 to +28V)	V_{OL}	–	150	400	mV
Output Sink Current		I_S				mA
	(V_{CC} = +5.0V)					
	(T_A = +25°C, V_{OL} = 400mV)		–	6.0	–	
	(T_A = −40°C to +85°C, V_{OL} = 800mV)		2.0	–	–	
Input Common-Mode Range		V_{ICR}				Volts
	(V_{CC} = +28V)		0.26	–	–	
Common Mode Rejection Ratio		CMRR	–	60	–	dB
Propagation Delay Time For Positive and Negative Going Input Pulse		$t_{PHL/LH}$	–	2.0	–	µs
Slew Rate	(R_L = 15kΩ)	t_{SR-}	–	200	–	V/µs
		t_{SR+}	–	50	–	
Power Supply Current (Total of four comparators)	(I_S = 0, V_{CC} = +5.0 to +28V)	I_D	–	0.7	1.5	mA

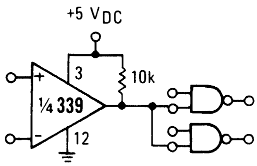
NOTES:

1. Requires an external resistor, R_L, to limit current below maximum rating.
2. If either (+) or (–) inputs of any comparator go more than several tenths of a volt below ground, a parasitic transistor turns "on," causing high input current and possible faulty outputs.

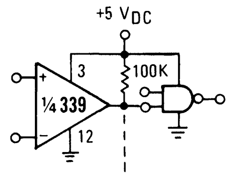
339 TYPICAL APPLICATIONS

Single Supply ($V^+ = 15V_{DC}$)

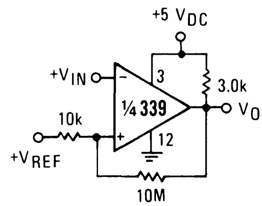
Driving TTL



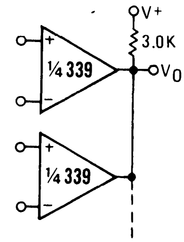
Driving CMOS



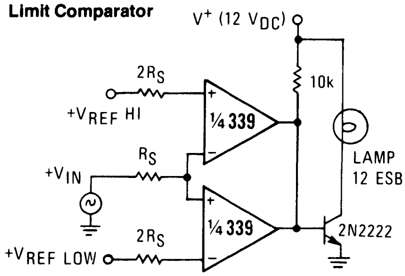
Comparator with Hysteresis



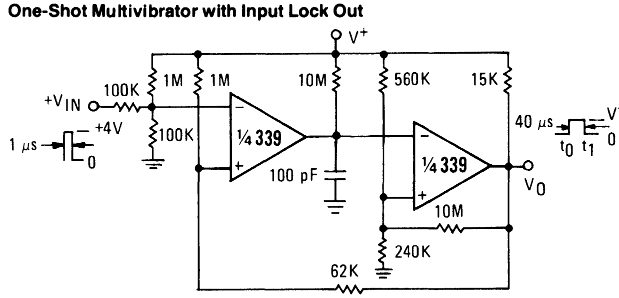
ORing the Outputs



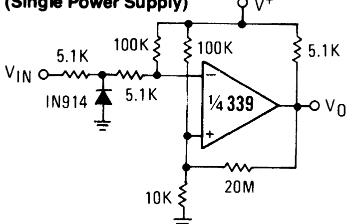
Limit Comparator



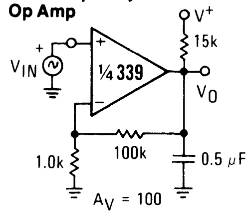
One-Shot Multivibrator with Input Lock Out



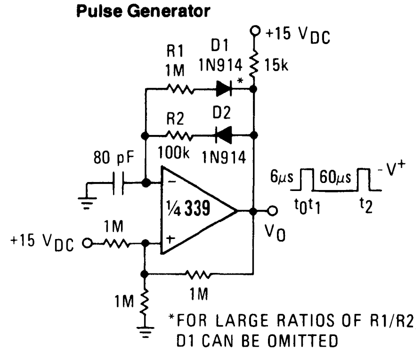
Zero Crossing Detector (Single Power Supply)



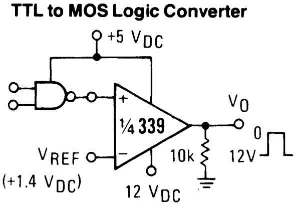
Low Frequency Op Amp



Pulse Generator

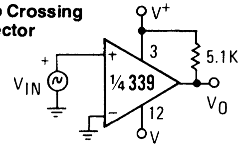


TTL to MOS Logic Converter

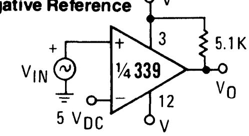


Split Supply ($V^+ = +15V_{DC}$ & $V^- = -15V_{DC}$)

Zero Crossing Detector



Comparator With a Negative Reference



High-Speed Differential Voltage Comparators

GENERAL DESCRIPTION

The RM710/RM710A and RC710 integrated circuits are monolithic, high speed, differential voltage comparators. Manufactured by the planar process, component matching is inherent. Characteristic of the devices is low offset voltage and low drift parameters as well as high accuracy and fast response.

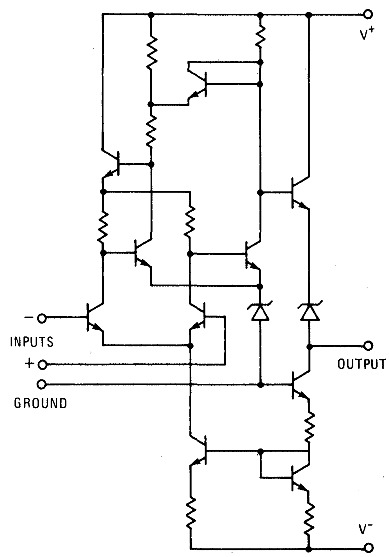
These voltage comparators are specially designed for a variety of applications such as high speed A/D converter, memory sense amplifier, zero crossing detector, amplitude discriminator and variable threshold Schmitt trigger.

The RM710/RM710A operate over the full military temperature range from −55°C to +125°C. The RC710, commercial equivalent of the RM710, operates over a temperature from 0°C to +70°C.

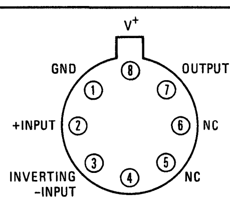
DESIGN FEATURES

- Low Offset Voltage and Drift Over Entire Temperature Range
- Fast Response Time
- Output Logic Compatible With All Existing Integrated Logic Forms
- Meets or Exceeds All Environmental Requirements of MIL-S-19500, MIL-STD-202, and MIL-STD-750

SCHEMATIC DIAGRAM

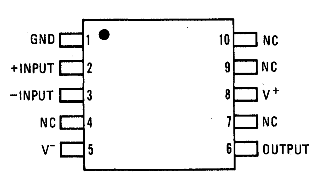


CONNECTION INFORMATION



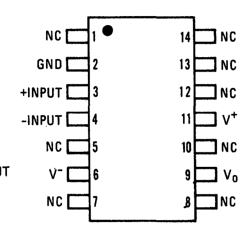
TE
Metal Can Package
(Top View)

Order Part Nos.:
RM710AT, RM710T,
RC710T



Q
Flat Package
(Top View)

Order Part Nos.:
RM710AQ, RM710Q



DC
Dual In-line Packages
(Top View)

Order Part Nos.:
RM710ADC, RM710DC,
RC710DC

High-Speed Differential Voltage Comparators

ABSOLUTE MAXIMUM RATINGS

Positive Supply Voltage	+14V	Operating Temperature Range	
Negative Supply Voltage	−7.0V	RM710, RM710A	−55°C to +125°C
Peak Output Current	10.0mA	RC710	0°C to +70°C
Differential Input Voltage	±5.0V	Internal Power Dissipation (Note 1)	
Input Voltage	±7.0V	TO-5	300mW
Storage Temperature Range	−65°C to +150°C	Flat Package	200mW
Lead Temperature (Soldering, 60s)	300°C		

ELECTRICAL CHARACTERISTICS (V^+ = 12.0V, V^- = −6.0V, T_A = +25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM710A			RM710			RC710			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage (Note 3)	$R_S \leq 200\Omega$		0.3	1.0		0.6	2.0		1.6	5.0	mV
Input Offset Current (Note 3)			0.3	1.0		0.75	3.0		1.8	5.0	μA
Input Bias Current			10	15		13	20		16	25	μA
Voltage Gain		1400	1700		1250	1700		1000	1500		V/V
Output Resistance			200			200			200		Ω
Output Sink Current	$\Delta V_{in} \geq 5mV$, $V_{out} = 0$	2.0	2.5		2.0	2.5		1.6	2.5		mA
Response Time (Note 2)			40	60		40	60		40		ns
The following specifications apply for −55°C ≤ T_A ≤ +125°C.								**The following specifications apply for 0°C ≤ T_A ≤ +70°C.**			
Input Offset Voltage (Note 3)	$R_S \leq 200\Omega$			1.5			3.0			6.5	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S = 20\Omega$, T_A = Low to T_A = High, $R_S = 20\Omega$		3.5	5.0		3.5	10		5.0	20	μV/°C
	T_A = 25°C to T_A = Low		2.7	5.0		2.7	10				
Input Offset Current (Note 3)	T_A = +125°C		0.15	2.0		0.25	3.0				μA
	T_A = Low		1.0	5.0		1.8	7.0			7.5	
Average Temperature Coefficient of Input Offset Current	T_A = 25°C to T_A = High		2.0	10		5.0	25		15	50	nA/°C
	T_A = 25°C to T_A = Low		9.0	50		15	75		24	100	
Input Bias Current	T_A = Low		20	28		27	45		25	40	μA
Input Voltage Range	$V^- = -7.0V$	±5.0			±5.0			±5.0			V
Common Mode Rejection Ratio	$R_S \leq 200\Omega$	90	100		80	100		70	98		dB
Differential Input Voltage Range		±5.0			±5.0			±5.0			V
Voltage Gain		1100			1000			800			
Positive Output Level	$\Delta V_{in} \geq 5mV$, $0 \leq I_{out} \leq 5.0mA$	2.5	3.2	4.0	2.5	3.2	4.0	2.5	3.2	4.0	V
Negative Output Level	$\Delta V_{in} \geq 5mV$	−1.0	−0.5	0	−1.0	−0.5	0	−1.0	−0.5	0	V
Output Sink Current	T_A = Low, $\Delta V_{in} \geq 5mV$, $V_{out} = 0$	0.5	2.3		0.5	2.3		0.5			mA
	T_A = High, $\Delta V_{in} \geq 5mV$, $V_{out} = 0$	1.0	1.7		0.5	1.7		0.5			
Positive Supply Current	$V_{out} \leq 0$		5.2	9.0		5.2	9.0		5.2	9.0	mA
Negative Supply Current			4.6	7.0		4.6	7.0		4.6	7.0	mA
Power Consumption			90	150		90	150		90	150	mW

NOTES:

1. The thermal characteristics are based on a maximum chip temperature of 160°C. Derate maximum power dissipation of TO-5 Can by 6.7mW/°C for $T_A \geq 114°C$, of Flat Pak by 5.3mW/°C for $T_A \geq 103°C$, and of Dip Pak by 9.6mW/°C for $T_A \geq 118°C$. The ratings apply for $-55° \leq T_A \leq +125°C$.
2. The response time specified (see definitions) is for a 100mV input step with 5mV overdrive.
3. The input offset voltage and input offset current are specified for a logic threshold voltage as follows: For RM710/710A grade 1.8V at −55°C, 1.4V at +25°C and 1.0V at +125°C. For RC710 grade 1.5V at +25°C and 1.2V at +70°C.

Dual Differential Voltage Comparators

GENERAL DESCRIPTION

The Raytheon RM711A, RM711, and RC711 integrated circuit is a monolithic dual differential voltage comparator fabricated on a single silicon chip. Component matching inherent with the planar process yields a comparator of high performance and characteristics.

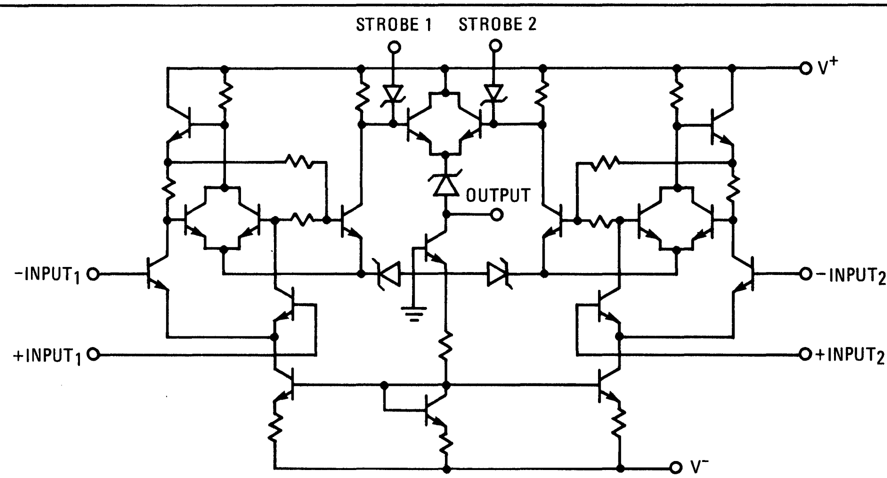
It is ideally suited for a number of applications such as: core-memory sense amplifier, high speed voltage comparator in A/D converters, zero crossing detector, and double ended limit detector for automatic Go/No-Go test equipment.

The RM711 and RM711A operate over the full military temperature range from −55°C to +125°C. The RC711 operates over a temperature range from 0°C to +70°C.

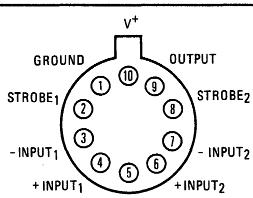
DESIGN FEATURES

- High Accuracy, Fast Response Time and Wide Threshold Range
- Inherently OR'd Outputs
- Independent Strobing of Either Side of the Device
- Low Power Dissipation
- Low Offsets and Thermal Drift
- Compatible With All Forms of Logic
- Meets or Exceeds All Environmental Requirements of MIL-S-19500, MIL-STD-202, MIL-STD-883

SCHEMATIC DIAGRAM

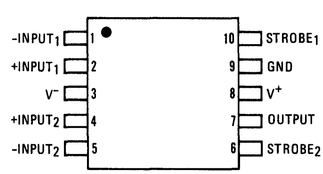


CONNECTION INFORMATION



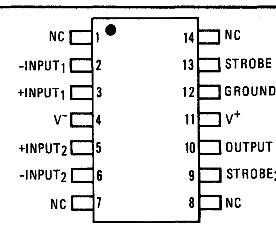
TE Metal Can Package
(Top View)

Order Part No.:
RC711T



Q
Flat Package
(Top View)

Order Part Nos.:
RM711Q



DC
Dual In-line Packages
(Top View)
Order Part Nos.:
RM711DC, RC711DC

Dual Differential Voltage Comparators

ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage	+14V
Negative Supply Voltage	–7.0V
Peak Output Current	50mA
Differential Input Voltage	±5.0V
Input Voltage	±7.0V
Strobe Voltage	0 to +6.0V
Storage Temperature Range	–65°C to +150°C
Lead Temperature (Soldering, 60s)	300°C
Operating Temperature Range	
RM711	–55°C to +125°C
RC711	0°C to +70°C
Internal Power Dissipation (Note 1)	
TO-5 Package	300mW
Flat Package	300mW
Dual In-line Package	400mW

ELECTRICAL CHARACTERISTICS ($V^+ = 12V$, $V^- = -6.0V$, $T_A = 25°C$ unless otherwise specified)

PARAMETER	CONDITIONS		RM711 MIN	RM711 TYP	RM711 MAX	RC711 MIN	RC711 TYP	RC711 MAX	UNITS
Input Offset Voltage	(Note 3)	$R_S \leq 200\Omega$, $V_{CM} = 0$		1.0	3.5		1.0	5.0	mV
		$R_S \leq 200\Omega$		1.0	5.0		1.0	7.5	
Input Offset Current	(Note 3)			0.5	10		0.5	15	μA
Input Bias Current				25	75		25	100	μA
Voltage Gain			750	1500		750	1500		V/V
Output Sink Current	$\Delta V_{IN} \geq 10mV$, $V_{OUT} \leq 0V$		0.68			0.68			mA
Strobe Current	$V_{strobe} = 100mV$			1.15	2.5		1.15	2.5	mA
Response Time	(Note 2)			40			40		ns
Output Resistance				200			200		Ω
Strobe Release Time				12			12		ns
Positive Output Level	$\Delta V_{IN} \geq 10mV$, $I_o = 5.0mA$		2.5	3.5		2.5	3.5		V
The following specifications apply for $T_L \leq T_A \leq T_H$ (Note 5)									
Input Offset Voltage	(Note 3)	$R_S \leq 200\Omega$, $V_{CM} = 0V$			4.5			6.0	mV
		$R_S \leq 200\Omega$			6			10	
Inptu Bias Current					150			150	μA
Input Offset Current	(Note 3)				20			25	μA
Voltage Gain			500			500			
Loaded Positive Output Level	$\Delta V_{IN} \geq 10mV$		2.5	4.5	5.0	2.5	4.5	5.0	V
Negative Output Level (Note 4)	$\Delta V_{IN} \geq 10mV$, $I_o = 0$		–1.0	–0.5	0	–1.0	–0.5	0	V
Input Voltage Range	$V^- = -7.0V$		±5.0			±5.0			V
Differential Input Voltage Range			±5.0			±5.0			V
Average Temperature Coefficient of Input Offset Voltage	$R_S = 20\Omega$, T_L to T_H			5.0	20		5.0	20	μV/°C
Average Temperature Coefficient of Input Offset Current	+25°C to T_H			15	50		15	50	nA/°C
	+25°C to T_L			24	100		24	100	
Strobed Output Level	$V_{strobe} \leq 0.3V$		–1.0	–0.3		–1.0	–0.3	0	V
Positive Supply Current	$V_{out} \leq 0$			7.2	12		7.2	12	mA
Negative Supply Current				3.7	6.0		3.7	6.0	mA
Common Mode Rejection Ratio			70	90		70	90		dB
Power Consumption				130	180		130	180	mW

NOTES:

1. Thermal characteristics based on maximum chip temperature of +160°C. Derate maximum power dissipation for TO-5 by 6.7mW/°C for $T_A \geq +114°C$, Flat Pack by 5.3mW/°C for $T_A \geq +103°C$, Dip Pack by 9.6mW/°C for $T_A \geq +118°C$. Ratings apply for $-55°C \leq T_A \leq +125°C$.
2. The response time specified (see definitions) is for a 100mV input step with 5mV overdrive.
3. Input offset voltage and input offset current are specified for a logic threshold voltage as follows: For RM711, 1.8V at –55°C, 1.4V at +25°C, and 1.0V at +125°C; RC711, 1.5V at +25°C and 1.2V at +70°C.
4. Negative output level is measured at $\Delta V_{IN} = 5V$.
5.

	T_L	T_H
RM711	–55°C	+125°C
RC711	0°C	+70°C

1414
1514 Monolithic Dual Differential Voltage Comparators

GENERAL DESCRIPTION

The RM1514 and RC1414 are monolithic high-speed, differential voltage comparators manufactured by the planar process. Component matching is inherent.

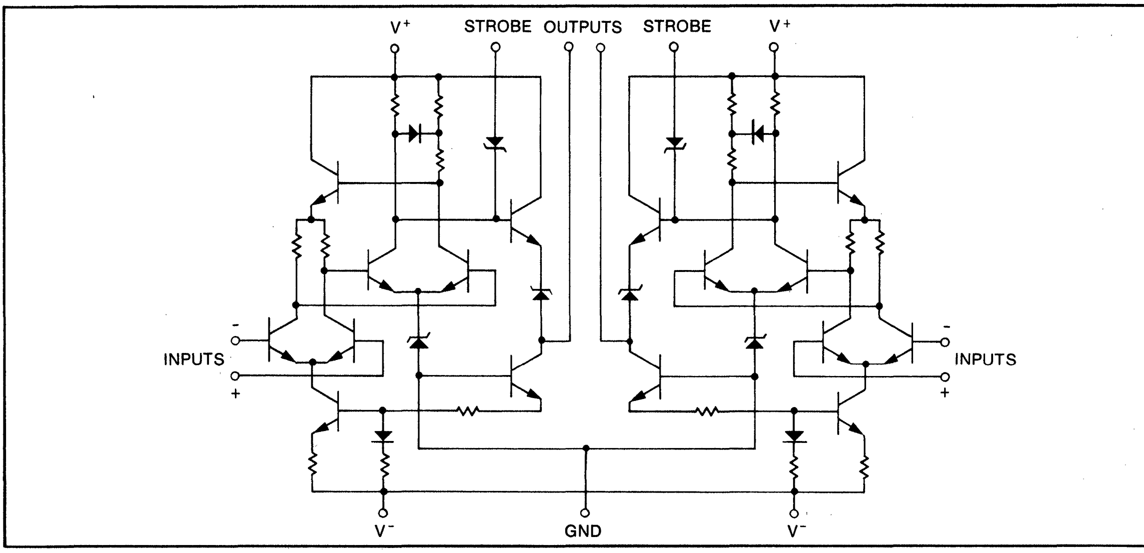
They were designed for low-level sensing and memory sense amplifier applications, as well as A/D converters, Schmitt triggers, and zero crossing detectors.

The RM1514 military version operates over a temperature range of −55°C to +125°C. The RC1414 is the commercial type which operates from 0°C to +70°C.

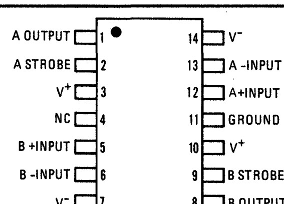
DESIGN FEATURES

- Two Separate Outputs
- Strobe Capability
- High Output Sink Current 2.8mA Minimum Each Comparator
- Input Offset Voltage 1.0mV
- Offset Voltage 3.0µV/°C
- Short Propagation Delay Time 40ns
- Output Compatible With All Saturating Logic Forms: V_{OUT} is +3.2V to −0.5V Typical

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



DC Dual In-line Packages
(Top View)

Order Part Nos.:
RM1514DC, RC1414DC

Monolithic Dual Differential Voltage Comparators

ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage	+14V, −7.0V	Operating Temperature Range	
Differential Input Signal	±5.0V	RM1514	−55°C to +125°C
Common-Mode Input Swing	±7.0V	RC1414	0°C to +75°C
Peak Load Current	10mA	Storage Temperature Range	−65°C to +150°C
Internal Power Dissipation (Note)	RM1514: 1000mW RM1414: 625mW		

ELECTRICAL CHARACTERISTICS (V^+ = +12Vdc, V^- = −6Vdc, T_A = 25°C unless otherwise noted; each compator.)

PARAMETER	CONDITIONS	RM1514			RC1414			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage ($R_S \leq 200\Omega$)	V_{OUT} = 1.4Vdc, T_A = 25°C		1.0	2.0		1.5	5.0	
	V_{OUT} = 1.8Vdc, T_A = Min.			3.0			6.5	mV
	V_{OUT} = 1.0Vdc, T_A = Max.			3.0			6.5	
Temperature Coefficient of Input Offset Voltage			3.0			5.0		μV/°C
Input Offset Current	V_{OUT} = 1.4Vdc, T_A = 25°C		1.0	3.0		1.0	5.0	
	V_{OUT} = 1.8Vdc, T_A = Min.			7.0			7.5	μA
	V_{OUT} = 1.0Vdc, T_A = Max.			3.0			7.5	
Input Bias Current	V_{OUT} = 1.4Vdc, T_A = 25°C		12	20		15	25	
	V_{OUT} = 1.8Vdc, T_A = Min.			45		18	40	μA
	V_{OUT} = 1.0Vdc, T_A = Max.			20			40	
Open Loop Voltage Gain	T_A = 25°C	1250	1700		1000	1500		V/V
	T_A = Min. to Max.	1000			800			
Output Resistance			200			200		ohms
Differential Voltage Range		±5.0			±5.0			V
Positive Output Voltage	$V_{IN} \geq 5.0mV$, $0 \leq I_O \leq 5.0mA$	2.5	3.2	4.0	2.5	3.2	4.0	V
Negative Output Voltage	$V_{IN} \geq -5.0mV$	−1.0	−0.5	0	−1.0	−0.5	0	V
Output Sink Current	$V_{IN} \geq -5.0mV$, $V_{OUT} \geq 0$, T_A = Min. to Max.	2.8	3.4		1.6	2.5		mA
Input Common Mode Range	V^- = −7.0Vdc	±5.0			±5.0			V
Common Mode Rejection Ratio	V^- = −7.0Vdc, $R_S \leq 200\Omega$	80	100		70	100		dB
Propagation Delay Time For Positive and Negative Going Input Pulse	V overdrive = 5mV		40			40		ns
Total Power Supply Current	$V_{OUT} \leq 0Vdc$		12.8	18		12.8	18	mA
			11	14		11	14	
Total Power Consumption			230	300		230	300	mW

NOTE:
Derate above T_A = 25°C.
DC Package: 6.0mW/°C. DB Package: 5.0mW/°C.

SECTION 5

Line Drivers and Receivers

CONTENTS

DESCRIPTION

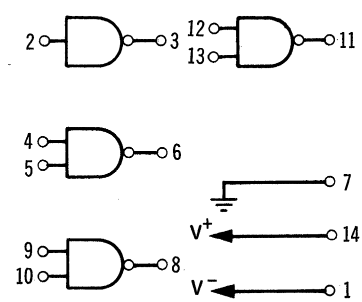
The RC1488 is a monolithic quad line driver designed to interface data terminal equipment with data communications equipment in conformance with the specifications of EIA standard number RS-232-C. This standard specifies not only the number and type of interface leads, but also the voltage levels to be used.

The RC1488 and its companion circuit, the RC1489/RC1489A quad line receiver, provide a complete interface system between DTL and TTL logic levels and the RS-232-C defined levels.

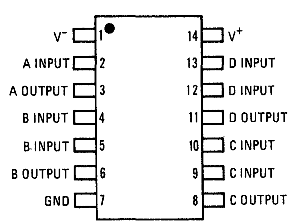
DESIGN FEATURES

- Current Limited Output 10mA Typical
- Power-off Source Impedance 300 Ohms Minimum
- Simple Slew Rate Control With External Capacitor
- Flexible Operating Supply Range
- Compatible With All DTL and TTL Logic

LOGIC DIAGRAM



CONNECTION INFORMATION



DC Dual In-line Package
(Top View)

Order Part No.:
RC1488DC

ABSOLUTE MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)

RATING	SYMBOL	VALUE	UNIT
Power Supply Voltage	V^+	+15	V
	V^-	−15	
Input Signal Voltage	V_{in}	$-15 \leqslant V_{in} \leqslant 7.0$	V
Output Signal Voltage	V_O	±15	V
Power Derating (Package Limitation, Ceramic Dual In-Line Package)	P_D	1000	mW
Derate above T_A = +25°C	$1/\theta_{JA}$	6.7	mW/°C
Operating Temperature Range	T_A	0 to +75	°C
Storage Temperature Range	T_{stg}	−65 to +175	°C

ELECTRICAL CHARACTERISTICS (V^+ = +9.0 ±1% Vdc, V^- = −9.0 ±1% Vdc, T_A = 0°C to +75°C unless otherwise noted)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Forward Input Current	I_F	V_{in} = 0V		1.0	1.3	mA
Reverse Input Current	I_R	V_{in} = +5.0V			10	μA
Output Voltage High	V_{OH}	V_{in}=0.8V, R_L=3.0kΩ, V^+=+9.0V, V^-= −9.0V	+6.0	+7.0		V
		V_{in}=0.8V, R_L=3.0kΩ, V^+=+13.2V, V^-=−13.2V	+9.0	+10.5		
Output Voltage Low	V_{OL}	V_{in}=1.9Vdc, R_L=3.0kΩ, V^+=+9.0V, V^-=−9.0V	−6.0	−7.0		V
		V_{in}=1.9Vdc, R_L=3.0kΩ, V^+=+13.2V, V^- = −13.2V	−9.0	−10.5		
Positive Output Short-Circuit Current	I_{SC+}		+6.0	+10	+12	mA
Negative Output Short-Circuit Current	I_{SC-}		−6.0	−10	−12	mA
Output Resistance	R_O	$V^+ = V^- = 0$, $\|V_O\|$ = ±2.0V	300			Ω
Positive Supply Current ($R_l = \infty$)	I^+	V_{in} = 1.9Vdc, V^+ = +9.0V		+15	+20	mA
		V_{in} = 0.8Vdc, V^+ = +9.0V		+4.5	+6.0	
		V_{in} = 1.9Vdc, V^+ = +12V		+19	+25	
		V_{in} = 0.8Vdc, V^+ = +12V		+5.5	+7.0	
		V_{in} = 1.9Vdc, V^+ = +15V			+34	
		V_{in} = 0.8Vdc, V^+ = +15V			+12	
Negative Supply Current ($R_L = \infty$)	I^-	V_{in} 1.9Vdc, V^- = −9.0V		−13	−17	mA
		V_{in} = 0.8Vdc, V^- = −9.0V		0	0	
		V_{in} = 1.9Vdc, V^- = −12V		−18	−23	
		V_{in} = 0.8Vdc, V^- = −12V		0	0	
		V_{in} = 1.9Vdc, V^- = −15V			−34	
		V_{in} = 0.8Vdc, V^- = −15V			−2.5	
Power Dissipation	P_D	V^+ = 9.0Vdc, V^- = −9.0V			333	mW
		V^+ = 12Vdc, V^- = −12V			576	

SWITCHING CHARACTERISTICS (V^+ = +9.0 ±1% Vdc, V^- = −9.0 ±1% Vdc, T_A = 25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Porpagation Delay Time	t_{pd+}	Z_L = 3.0k and 15pF		150	200	ns
Fall Time	t_f	Z_L = 3.0k and 15pF		45	75	ns
Propagation Delay Time	t_{pd-}	Z_L = 3.0k and 15pF		65	120	ns
Rise Time	t_r	Z_L - 3.0k and 15pF		55	100	ns

GENERAL DESCRIPTION

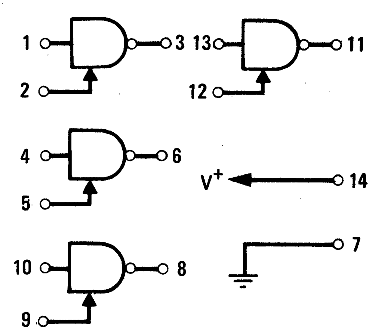
The RC1489 and RC1489A are monolithic quad line receivers designed to interface data terminal equipment in conformance with the specifications of EIA standard number RS-232-C. This standard specifies not only the number and type of interface leads, but also the voltage levels to be used.

The RC1488 quad driver and its companion circuit, the RC1489/RC1489A quad receiver, provide a complete interface system between DTL or TTL logic levels and the RS-232-C defined levels.

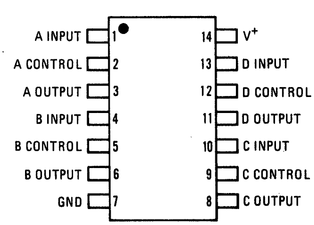
DESIGN FEATURES

- Input Resistance 3k to 7k
- Input Signal Range ±30V
- Built-in Input Threshold Hysteresis
- Response Control: Logic Threshold Shifting and Input Noise Filtering

LOGIC DIAGRAM



CONNECTION INFORMATION



DC Dual In-line Package
(Top View)

Order Part Nos.:
RC1489DC, RC1489ADC

Quad Line Receivers

ABSOLUTE MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)

RATING	SYMBOL	VALUE	UNIT
Power Supply Voltage	V^+	+10	V
Input Signal Range	V_{in}	±30	V
Output Load Current	I_L	20	mA
Power Dissipation (Package Limitation, Ceramic Dual In-Line Package)	P_D	1000	mW
Derate above T_A = +25°C	$1/\theta_{JA}$	6.7	mW/°C
Operating Temperature Range	T_A	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS

(Response control pin is open. V^+=+5.0Vdc ±1%, T_A=0°C to +75°C unless otherwise noted)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Positive Input Current	I_{IH}	V_{in} = +25V	3.6		8.3	mA
		V_{in} = +3.0V	0.43			
Negative Input Current	I_{IL}	V_{in} = −25V	−3.6		−8.3	mA
		V_{in} = −3.0V	−0.43			
Input Turn-On Threshold Voltage	V_{IH}	T_A = +25°C, $V_{OL} \leq 0.45V$ RC1489	1.0		1.5	V
		RC1489A	1.75	1.95	2.25	
Input Turn-Off Threshold Voltage	V_{IL}	T_A = +25°C, $V_{OH} \geq 2.5V$, I_L = −0.5mA RC1489	0.75		1.25	V
		RC1489A	0.75	0.8	1.25	
Output Voltage High	V_{OH}	V_{in} = 0.75V, I_L = −0.5mA	2.6	4.0	5.0	V
		Input Open Circuit, I_L = −0.5mA	2.6	4.0	5.0	
Output Voltage Low	V_{OL}	V_{in} = 3.0V, I_L = 10mA		0.2	0.45	V
Output Short-Cirucuit Current	I_{SC}			3.0		mA
Power Supply Current	I^+	V_{in} = +5.0V		20	26	mA
Power Dissipation	P_D	V_{in} = +5.0V		100	130	mW

SWITCHING CHARACTERISTICS (V^+ = +5.0 Vdc ±1%, T_A = +25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Propagation Delay Time	t_{pd+}	R_L = 3.9Ω		25	85	ns
Rise Time	t_r	R_L = 3.9Ω		120	175	ns
Propagation Delay Time	t_{pd-}	R_L = 390Ω		25	50	ns
Fall Time	t_f	R_L = 390Ω		10	20	ns

GENERAL DESCRIPTION

The RM9622 and RC9622 are dual line receivers designed to discriminate a worst-case logic swing of 2V from a ±10V common-mode noise signal or ground shift. To provide a CCSL-compatible threshold voltage and maximum noise immunity, the differential amplifier has a built-in threshold of 1.5V. The offset is obtained by use of current sources and matched resistors, and varies only ±5% (75mV) over the military and commercial temperature ranges.

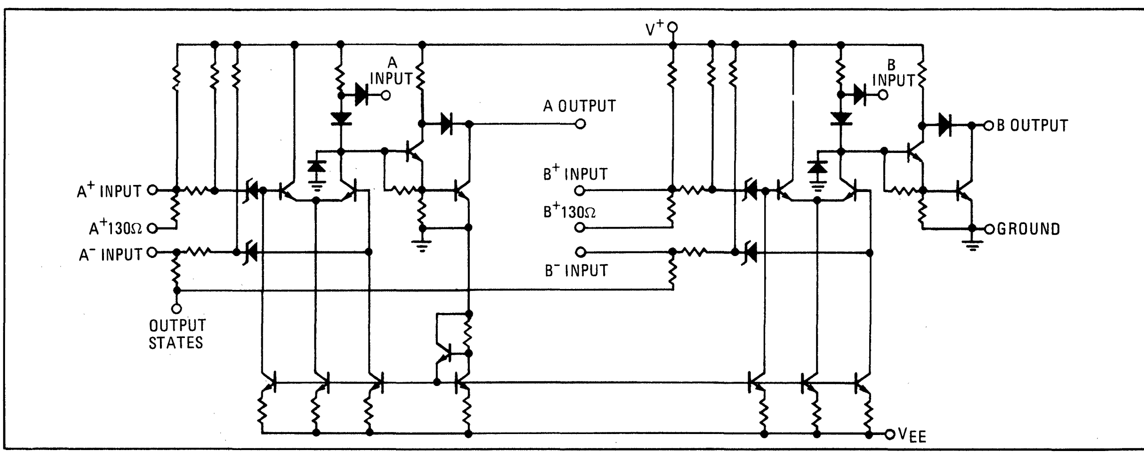
The RM9622 military version operates over a temperature range of −55°C to +125°C. The RC9622 is the commercial type which operates from 0°C to +70°C.

These dual line receivers offer a choice of output states with the inputs open, without affecting circuit performance by use of S3. At the input of each line receiver a 130-ohm terminating resistor is provided. The output is CCSL-compatible. And the output high level can be increased to +12V by connecting to a positive supply through a resistor. The outputs can be wired OR.

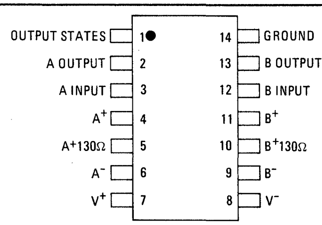
DESIGN FEATURES

- CCSL-Compatible Threshold Voltage
- Input Terminating Resistors
- Choice of Output State With Inputs Open
- CCSL-Compatible Output
- High Common-Mode
- Wire-OR Capability
- Enable Inputs
- Full Military Temperature Range
- Logic Compatible Supply Voltages

SCHEMATIC DIAGRAM

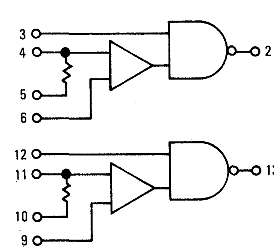


CONNECTION INFORMATION



DC Dual In-line Package
(Top View)
Order Part Nos.:
RM9622DC, RC9622DC

LOGIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

V_{CC}, Pin Potential to Ground Pin	−0.5V to +7V
Input Voltage	±15V
Voltage Applied to Outputs for High Output State	−0.5V to +13.2V
V_{EE} Pin Potential to Ground Pin	−0.5V to −12V
Enable Pin Potential to Ground Pin	−0.5V to −15V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	
RM9622	−55°C to +125°C
RC9622	0°C to +70°C

ELECTRICAL CHARACTERISTICS (−55°C to +125°C, V_{CC} = 5.0V ±10%, V_{EE} = −10V ±10%)

SYMBOL	CHARACTERISTICS	CONDITIONS & COMMENTS	LIMITS −55°C MIN	−55°C MAX	+25°C MIN	+25°C TYP	+25°C MAX	+125°C MIN	+125°C MAX	UNITS
V_{OL}	Output Low Voltage	V_{CC} = 4.5V, V_{EE} = −11V, $^*V_{DIFF}$ = 2.0V, I_{OL} = 12.4mA		0.40		0.25	0.40		0.40	V
V_{OH}	Output High Voltage	V_{CC} = 4.5V, V_{EE} = −9.0V, $^*V_{DIFF}$ = 1.0V, I_{OH} = −0.2mA	2.8		3.0	3.3		2.9		V
I_{CEX}	Output Leakage Current	V_{CC} = 4.5V, V_{EE} = −11V, $^*V_{DIFF}$ = 1.0V, V_{CEX} = 12V		50			100		200	μA
I_{SC}	Output Shorted Current	V_{CC} = 5.0V, V_{EE} = −10V, $^*V_{DIFF}$ = 1.0V, V_{SC} = 0V	−1.3	−3.1	−1.4	−2.15	−3.1	−1.3	−3.1	mA
$I_{R(ENABLE)}$	Enable Input Leakage Current	V_{CC} = 4.5V, V_{EE} = −11V, S_3 = 4.5V, V_R = 4.0V					2.0		5.0	μA
$I_{F(ENABLE)}$	Enable Input Forward Current	V_{CC} 5.5V, V_{EE} = −9.0V, S_3 = 0V, V_F = 0V		−1.5		−0.96	−1.5		−1.5	mA
$I_{F(+ INPUT)}$	+ Input Forward Current	V_{CC} = 5.0V, V_{EE} = −10V, −Input = Gnd, V_F = 0V		−2.3		−1.67	−2.1		−2.0	mA
$I_{F(- INPUT)}$	− Input Forward Current	V_{CC}, S_3 = 5.0V, V_{EE} = −10V, + Input = Gnd, V_F = 0V		−2.6		−1.87	−2.4		−2.3	mA
$V_{IL(ENABLE)}$	Input Low Voltage	V_{CC} = 5.0V ±10%, V_{EE} = −10V ±10%		1.3		1.4	1.0		0.7	V
V_{th}	Differential Input Threshold Voltage	V_{CC} = 5.0V ±10%, V_{EE} = −10V ±10%	1.0	2.0	1.0	1.5	2.0	1.0	2.0	V
V_{CM}	Common Mode Voltage	V_{CC} = 5.0V, V_{EE} = −10V, $^*V_{DIFF}$ = 1.0V or 2.0V			−10	±12	+10			V
$R_{130\Omega}$	Terminating Resistance	V_{CC} = 5.5V, V_{EE} = −11V			100	130	175			Ω
I_{CC}	5V Supply Current	S_3, + Inputs = 5.5V, −Inputs = 0V				13.7	22.9			mA
I_{EE}	−10V Supply Current	V_{CC} = 5.5V, V_{EE} = −11V, S_3, + Inputs = 5.5V, − Inputs = 0V				−6.5	−11.1			mA
t_{pd+}	Turn-off Time	V_{CC} = 5.0V, V_{EE} = −10V, V_{IN} 0→3.0V, R_L = 3.9kΩ, C_L = 30pF				38	50			ns
t_{pd-}	Turn-on Time	V_{CC} = 5.0V, V_{EE} = −10V, V_{IN} 0→3.0V, R_L = 0.39kΩ, C_L = 30pF				35	50			ns

$^*V_{DIFF}$ is a differential input voltage referred from A+ to A− and from B+ to B−.

5

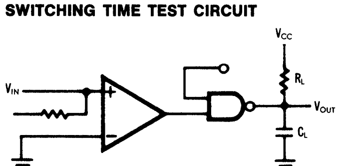
ELECTRICAL CHARACTERISTICS (0°C to +75°C, V_{CC} = 5.0V ±5%, V_{EE} = −10V ±5%)

SYMBOL	CHARACTERISTICS	CONDITIONS & COMMENTS	LIMITS 0°C MIN	0°C MAX	+25°C MIN	+25°C TYP	+25°C MAX	+75°C MIN	+75°C MAX	UNITS
V_{OL}	Output Low Voltage	V_{CC} = 4.75V V_{EE} = −10.5V *V_{DIFF} = 2.0V I_{OL} - 14.1mA		0.45		0.25	0.45		0.45	V
V_{OH}	Output High Voltage	V_{CC} = 4.75V V_{EE} = −9.5V *V_{DIFF} = 1.0V I_{OH} = −0.2mA	2.9		3.0	3.3		2.9		V
I_{CEX}	Output Leakage Current	V_{CC} = 4.75V V_{EE} = −10.5V *V_{DIFF} = 1.0V V_{CEX} = 5.25V		80			100		200	μA
I_{SC}	Output Shorted Current	V_{CC} = 5.0V V_{EE} = −10V *V_{DIFF} = 1.0V V_{SC} = 0V	−1.3	−3.1	−1.4	−2.15	−3.1	−1.3	−3.1	mA
$I_{R(ENABLE)}$	Enable Input Leakage Current	V_{CC} = 4.75V V_{EE} = −10.5V S_3 = 4.75V V_R = 4.0V					5.0		10	μA
$I_{F(ENABLE)}$	Enable Input Forward Current	V_{CC} 5.25V V_{EE} = −9.5V S_3 = 0V V_F = 0V		−1.5		−0.96	−1.5		−1.5	mA
$I_{F(+ INPUT)}$	+ Input Forward Current	V_{CC} = 5.0V V_{EE} = −10V −Input = Gnd V_F = 0V		−2.6		−1.67	−2.4		−2.3	mA
$I_{F(- INPUT)}$	− Input Forward Current	V_{CC}, S_3 = 5.0V V_{EE} = −10V + Input = Gnd V_F = 0V		−2.9		−1.87	−2.7		−2.6	mA
$V_{IL(ENABLE)}$	Input Low Voltage	V_{CC} = 5.0V ±5% V_{EE} = −10V ±5%		1.2		1.4	1.0		0.85	V
V_{th}	Differential Input Threshold Voltage	V_{CC} = 5.0V ±5% V_{EE} = −10V ±5%	1.0	2.0	1.0	1.5	2.0	1.0	2.0	V
V_{CM}	Common Mode Voltage	V_{CC} = 5.0V V_{EE} = −10V *V_{DIFF} = 1.0V or 2.0V			−7.5	±12	+7.5			V
$R_{130\Omega}$	Terminating Resistance	V_{CC} = 5.25V V_{EE} = −10.5V			91	130	185			Ω
I_{CC}	5V Supply Current	S_3, + Inputs = 5.25 V, −Inputs = 0V				13.7	22.9			mA
I_{EE}	−10V Supply Current	V_{CC} = 5.25V V_{EE} = −10.5V S_3, + Inputs = 5.25V, −Inputs = 0V				−6.5	−11.1			mA
t_{pd+}	Turn-off Time	V_{CC} = 5.0V V_{EE} = −10V V_{IN} 0→3.0V, R_L = 3.9kΩ, C_L = 30pF				38	100			ns
t_{pd-}	Turn-on Time	V_{CC} = 5.0V V_{EE} = −10V V_{IN} 0→3.0V, R_L = 0.39kΩ, C_L = 30pF				35	100			ns

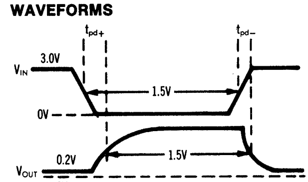
*V_{DIFF} is a differential input voltage referred from A+ to A− and from B+ to B−.

TYPICAL APPLICATIONS

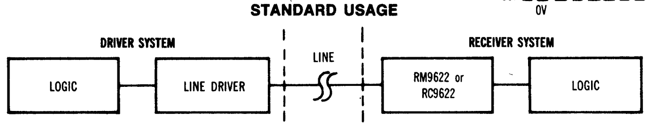
SWITCHING TIME TEST CIRCUIT



WAVEFORMS

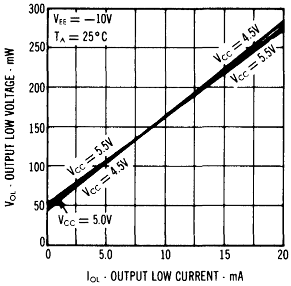


STANDARD USAGE

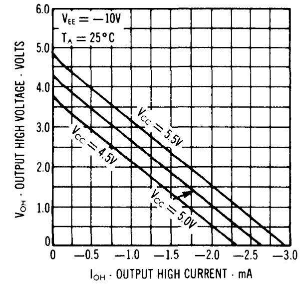


TYPICAL ELECTRICAL DATA

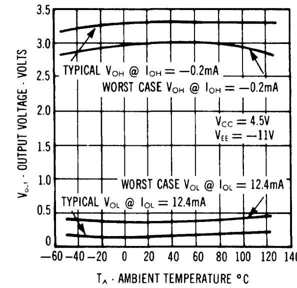
Output Low Voltage versus Output Low Current



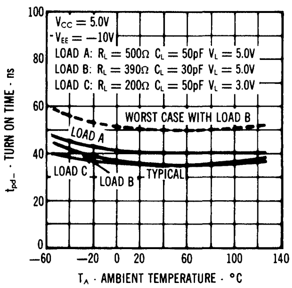
Output High Voltage versus Output High Current



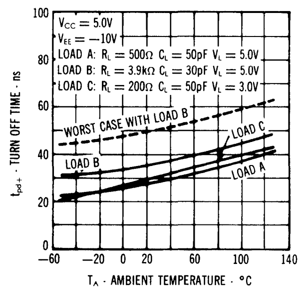
Logic Levels versus Ambient Temperature



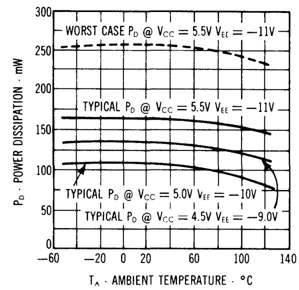
Turn On Time versus Ambient Temperature



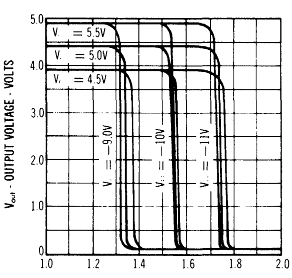
Turn Off Time versus Ambient Temperature



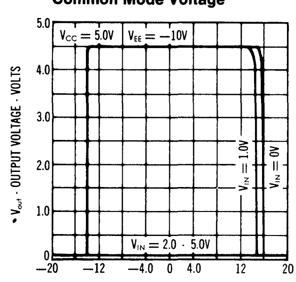
Power Dissipation versus Ambient Temperature



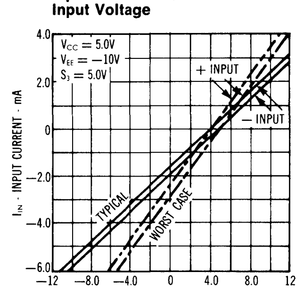
V_{out} - V_{DIFF} Transfer Characteristics



Output Voltage versus Common Mode Voltage



Input Current versus Input Voltage



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GENERAL DESCRIPTION

The RM8T13/RC8T13 is a monolithic dual line driver designed to drive 50-ohm or 75-ohm coaxial transmission lines. TTL multiple emitter inputs allow this line driver to interface with standard TTL or DTL systems. The outputs are designed to drive long lengths of coaxial cable, strip line, or twisted pair transmission lines with impedances of 50 to 500 ohms.

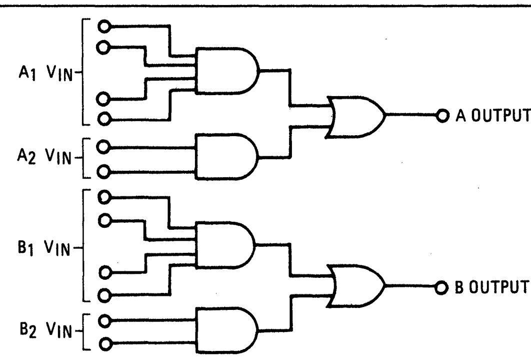
The device incorporates a latch-back short-circuit protection feature which protects the device by limiting the current it may source when operating under conditions of zero load resistance.

The RM8T13 operates over a temperature range of −55°C to +125°C. The RC8T13 operates from 0°C to +75°C.

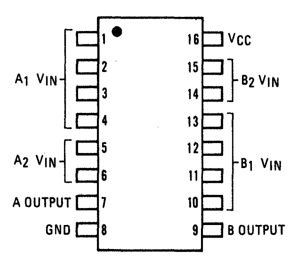
DESIGN FEATURES

- High-Power Drive Specified at −75mA Sink Current Rating at 2.4V (V "1" Out) at 25°C
- Party-Line Operation
- Input Gating Structure Allows Use of "OR" and "AND" Function
- High Speed $t_{ON} = t_{OFF}$ = 20ns Maximum
- Input Clamp Diodes Protect Inputs from Line Ringing
- Single 5V Power Supply

LOGIC DIAGRAM



CONNECTION INFORMATION



DD Dual In-line Packages
(Top View)

Order Part Nos.:
RC8T13DD, RM8T13DD

ABSOLUTE MAXIMUM RATINGS

Input and Output Voltage, V_{CC} . . . . +6.0V
Input Current . . . . ±30mA
Operating Temperature
RM8T13 . . . . −55°C to +125°C
RC8T13 . . . . 0°C to +75°

Storage Temperature
MP Package . . . . −65°C to +150°C
L and DD Package . . . . −65°C to +200°C
Thermal Resistance (θ_{J-A}, Junction to Ambient for Each Package)
MP Package . . . . 0.16°C/mW
L Package . . . . 0.12°C/mW
DD Package . . . . 0.10°C/mW

ELECTRICAL CHARACTERISTICS (Recommended Operating Voltage 5V ±5%. Notes 1-5.)

CHARACTERISTICS	LIMITS MIN	TYP	MAX	UNIT	TEST CONDITIONS TEMP °C S	N	V_{CC} (Volts)	AND GATE #1 INPUT UNDER TEST	OTHER INPUTS	INPUTS OF #2 AND GATE	OUTPUTS	NOTES
"1" Output Voltage	2.4			V	−55		4.75	2.0V	2.0V	0.8V	−75mA	6
	2.8			V	+25	+25	5.0	2.0V	2.0V	0.8V	−75mA	
	2.6			V		+75.0	4.75	2.0V	2.0V	0.8V	−75mA	
	2.5			V	+125		4.75	2.0V	2.0V	0.8V	−75mA	
'1" Output Leakage Current			500	μA	+25	+25	0.0	0V	0V	0V	3.0V	8
"0" Output Leakage Current		−700		μA	+125	+75	5.25	0.8V	4.5V	0V	0V	
			−10	μA	+25	+25	5.25	0.8V	4.5V	0V	0V	
"0" Input Current	−0.1		−1.6	mA	−55,+25, +125	0,+25, +75	5.25	0.4V	4.5V			
"1" Input Current			25	μA	+125	+75	5.0	4.5V	0V			
Turn-On Delay			20	ns	+25	+25	5.0					9, 12
		32		ns	+25	+25	5.0					10, 12
Turn-Off Delay			20	ns	+25	+25	5.0					9, 12
		22		ns	+25	+25	5.0					10, 12
Power/Current Consumption: Output at "0"			315/60	mW/mA	+25	+25	5.25	0.8V	0.8V	0.8V		11
Output at "1"			150/28	mW/mA	+25	+25	5.25	2.0V	2.0V	2.0V		
Input Latch Voltage	5.5			V	+25	+25	5.0	10mA	0V	0V		7
"1" Output Current	−100		−250	mA	+25	+25	5.0	4.5V	4.5V	0V	2.0V	13
Output Short Circuit			−30	mA	+25	+25	5.0	4.5V	4.5V	0V	0V	13
Input Clamp Voltage			−1.5	V	+25	+25	5.0	−12mA				

NOTES:

1. All voltage measurements are referenced to the ground terminal. Terminals not specifically referenced are left electrically open.
2. All measurements are taken with ground pin tied to zero volts.
3. Positive current is defined as into the terminal referenced.
4. Positive logic definition: "UP" Level = "1", "DOWN" Level = "0".
5. Precautionary measures should be taken to ensure current limiting in accordance with Absolute Maximum Ratings should the isolation diodes become forward biased.
6. Output source current is supplied through a resistor to ground.
7. This test guarantees operation free of input latch-up over the specified operating supply voltage range.
8. With forced output voltage of 3 Volts no more than 500μA will enter the driver when output is in "0" state.
9. R_L = 37Ω to ground.
10. Load is 37Ω in parallel with 1000pF.
11. I_{CC} is dependent upon loading. I_{CC} limit specified is for no-load test condition.
12. Reference AC Test Circuit and Pulse Requirements.
13. Reference "Typical Output Current vs. Output Voltage Curve."
14. Output sink current is supplied through a resistor to V_{CC}.
15. One DC fan-out is defined as 0.8mA.
16. Hysteresis is defined as voltage difference between R input level at which output begins to go from "0" to "1" state and level at which output begins to go from "1" to "0".
17. See Hysteresis test circuit.
18. Previous condition is a "1" output state.
19. Previous condition is a "0" output state.
20. One AC fan-out is defined at 50pF.

GENERAL DESCRIPTION

The RM8T14/RC8T14 is a triple line receiver designed for applications requiring digital information to be transmitted over long lengths of coaxial cable, strip line, or twisted pair transmission lines.

The receiver's high impedance input structure presents a minimal load to the driver circuit and allows the transmission line to be terminated in its characteristic impedance to minimize line reflections. The built-in hysteresis characteristic of the RM8T14/RC8T14 also makes it ideal for such applications as Schmitt triggers, one-shots and oscillators.

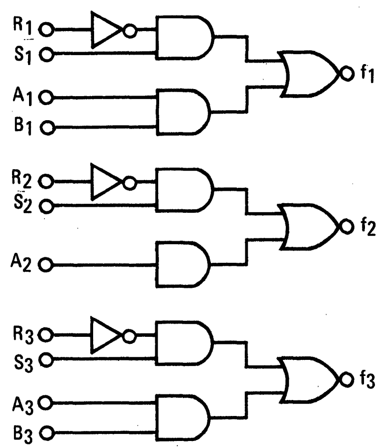
The RM8T14 operates over a temperature range of −55°C to +125°C. The RC8T14 operates from 0°C to +75°C.

DESIGN FEATURES

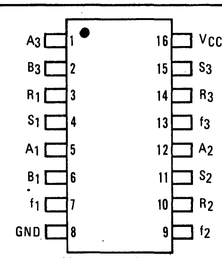
- Built-in Input Threshold Hysteresis*
- High Speed $t_{ON} = t_{OFF}$ = 20ns Typical
- Each Channel Can Be Strobed Independently
- Fanout of 10 With Standard TTL IC
- Input Gating Increases Application Flexibility
- Operates From Single 5V Logic Supply

*Hysteresis is defined as the difference between the input threshold for the "1" and "0" output states. Hysteresis is specified at 0.5V typically and 0.3V minimum over the operating temperature range.

LOGIC DIAGRAM



CONNECTION INFORMATION



DD Dual In-line Packages
(Top View)

Order Part Nos.:
RM8T14DD, RC8T14DD

ABSOLUTE MAXIMUM RATINGS

Input and Output Voltage, V_{CC}	+6.0V
Input Current	±30mA
Output Current	±100mA
Operating Temperature	
RM8T14	-55°C to +125°C
RC8T14	0°C to +75°C
Storage Temperature	
MP Package	-65°C to +150°C
L Package	-65°C to +200°C
Thermal Resistance (θ_{J-A}, Junction to Ambient for Each Package)	
MP Package	0.16°C/mW
L Package	0.12°C/mW

ELECTRICAL CHARACTERISTICS (Recommended Operating Voltage 5V ±5%. Notes 1-6.)

CHARACTERISTICS		LIMITS Min	LIMITS Typ	LIMITS Max	UNIT	TEST CONDITIONS TEMP °C S	TEMP °C N	V_{CC} (Volts)	INPUTS R	INPUTS S	INPUTS A	INPUTS B	OUTPUTS	NOTES
"1" Output Voltage		2.6			V	-55,+125	0,+75	4.75	2.0V	4.5V	0V	0V	-500µA	6
		2.8			V	+25	+25	5.00	2.0V	4.5V	0V	0V	-500µA	6
		2.6			V	-55,+125	0,+75	4.75	0V	0.8V	0V	0V	-500µA	6
		2.8			V	+25	+25	5.00	0V	0.8V	0V	0V	-500µA	6
Receiver "Hold" Test Condition		2.6			V	-55,+125	0,+75	5.00	1.45V	4.5V	0V	0V	-500µA	6, 18
		2.8			V	+25	+25	5.00	1.45V	4.5V	0V	0V	-500µA	6, 18
"0" Output Voltage				0.4	V	-55,+125	0,+75	4.75	0.8V	2.0V	0V	0V	16mA	14
				0.4	V	+25	+25	5.00	0.8V	2.0V	0V	0V	16mA	14
				0.4	V	-55,+125	0,+75	4.75	0V	0V	2.0V	2.0V	16mA	14
				0.4	V	+25	+25	5.00	0V	0V	2.0V	2.0V	16mA	14
Receiver "Hold" Test Condition				0.4	V	-55,+25, +125	0,+25, +75	5.00	1.45V	4.5V	0V	0V	16mA	14,19
"0" Input Current	S_n	-0.1		-1.6	mA	-55,+25, +125	0,+25, +75	5.25	0V	0.4V				
	A_n	-0.1		-1.6	mA	-55,+25, +125	0,+25, +75	5.25	0V		0.4V			
	B_n	-0.1		-1.6	mA	-55,+25, +125	0,+25, +75	5.25				0.4V		
"1" Input Current	R_n			0.17	mA	+125	+75	5.25	3.8V					
	S_n			40	µA	+125	+75	5.25	3.8V	4.5V				
	A_n			40	µA	+125	+75	5.25			4.5V	0V		
	B_n			40	µA	+125	+75	5.25			0V	4.5V		
Turn-on Propagation Dealy			20	30	ns	+25	+25	5.00					DCFO=20	15
Turn-Off Propagation Delay			20	30	ns	+25	+25	5.00					DCFO=20	15
Hysteresis		0.30	0.50		V	-55,+25, +125	0,+25, +75	5.00		4.5V	0V	0V		16,17
Power/Current Consumption			315/60	380/72	mW/mA	+25	+25	5.25						
Input Latch Voltage	S	5.5			V	+25	+25	5.00	3.8V	10mA	0V	0V		7
	A	5.5			V	+25	+25	5.00	0V	0V	10mA	0V		7
	B	5.5			V	+25	+25	5.00	0V	0V	0V	10mA		7
Output ShortCircuit Current		-50		-100	mA	+25	+25	5.00	3.8V	0V	0V	0V		
Input Clamp Voltage S, A, B				-1.5	V	+25	+25	5.00		-12mA	-12mA	-12mA		
Output Fall Time				50	ns	-55	0	4.75					ACFO=6	20

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NOTES:

1. All voltage measurements are referenced to the ground terminal. Terminals not specifically referenced are left electrically open.
2. All measurements are taken with ground pin tied to zero volts.
3. Positive current is defined as into the terminal referenced.
4. Positive logic definition: "UP" Level = "1", "DOWN" Level = "0".
5. Precautionary measures should be taken to ensure current limiting in accordance with Absolute Maximum Ratings should the isolation diodes become forward biased.
6. Output source current is supplied through a resistor to ground.
7. This test guarantees operation free of input latch-up over the specified operating supply voltage range.
8. With forced output voltage of 3 Volts no more than 500μA will enter the driver when output is in "0" state.
9. $R_L = 37\Omega$ to ground.
10. Load is 37Ω in parallel with 1000pF.
11. I_{CC} is dependent upon loading. I_{CC} limit specified is for no-load test condition.
12. Reference AC Test Circuit and Pulse Requirements.
13. Reference "Typical Output Current vs. Output Voltage Curve."
14. Output sink current is supplied through a resistor to V_{CC}.
15. One DC fan-out is defined as 0.8mA.
16. Hysteresis is defined as voltage difference between R input level at which output begins to go from "0" to "1" state and level at which output begins to go from "1" to "0".
17. See Hysteresis test circuit.
18. Previous condition is a "1" output state.
19. Previous condition is a "0" output state.
20. One AC fan-out is defined at 50pF.

GENERAL DESCRIPTION

The RM8T23/RC8T23 is a dual line driver designed to meet all the requirements of the IBM System 360 interface specification for interface drivers.

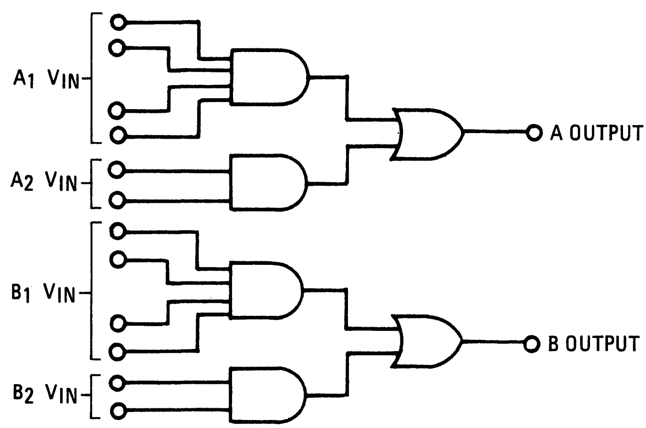
The low impedance emitter follower output will drive terminated lines such as coaxial cable or twisted pair. The output is protected against accidental shorting by an internal clamping network which turns on once the output voltage drops below approximately 1.5V. The uncommitted emitter output structure allows "Dot-OR" logic to be performed as in "party-line" operations.

The RM8T23 operates from −55°C to +125°C; the RC8T23 from 0°C to +70°C.

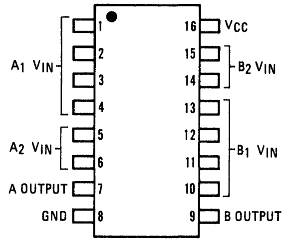
DESIGN FEATURES

- Output Current 59.3mA at 3.11V
- Uncommitted Emitter Output Structure for Party-Line Operation
- Short-Circuit Protection
- Single 5V Power Supply
- AND-OR Logic Configuration

LOGIC DIAGRAM



CONNECTION INFORMATION



DD Dual In-line Packages
(Top View)

Order Part Nos.:
RM8T23DD, RC8T23DD

ABSOLUTE MAXIMUM RATINGS

Input Voltage	+5.5V	Operating Temperature	
Output Voltage	+7.0V	RM8T23	−55°C to +125°
V_{CC}	+7.0V	RC8T23	0°C to +75°C
Input Current	±30mA	Storage Temperature	−65°C to +150°C

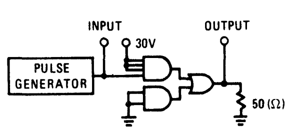
ELECTRICAL CHARACTERISTICS (Over Full Operating Temperature and Voltage Ranges)

CHARACTERISTICS	LIMITS MIN	TYP	MAX	UNITS	TEST CONDITIONS: AND GATE #1 INPUT UNDER TEST	AND GATE #1 OTHER INPUT	INPUTS OF #2 AND GATE	OUTPUT	NOTES
"0" Output Voltage			+0.15	V				−240μA	7
"1" Output Leakage Current			40	μA	0V	0V	0V	3.0V	1, 14
"0" Input Current	−0.1		−1.6	mA	0.4V	4.5V			
"1" Input Current			40	μA	4.5V	0V			
V_{CC} = 5.0V, T_A = 25°C									
"1" Output Voltage	3.11			V	2.0V	2.0V	0.8V	59.3mA	
Turn-on Delay		12	20	ns					8, 12
		30	50	ns					9. 12
Turn-off Delay		12	20	ns					8, 12
		20	35	ns					9, 12
Power/Current Consumption									
Output at "0"			315/60	mW/mA	0.8V	0.8V	0.8V		11, 15
Output at "1"			150/28	mW/mA	2.0V	2.0V	2.0V		11, 15
Input Latch Voltage	5.5			V	10mA	0V	0V		10
"1" Output Current	−100		−250	mA	4.5V	4.5V	0V	2.0V	13
Input Clamp Voltage			−1.5	V	−12mA				13

NOTES:
1. All voltage measurements are referenced to the ground terminal. Terminals not specifically referenced are left electrically open.
2. All measurements are taken with ground pin tied to zero volts.
3. Positive current is defined as into the terminal referenced.
4. Positive logic definition: "UP" Level="1", "DOWN" Level="0".
5. Precautionary measures should be taken to ensure current limiting in accordance with Absolute Maximum Ratings should the isolation diodes become forward biased.
6. Output source current is supplied through a resistor to ground.
7. With forced output current of 240μA the output voltage must not exceed 0.15V.
8. R_L = 50 ohms to ground.
9. Load is 50 ohms in parallel with 1000pF.
10. This test guarantees operation free of input latch-up over the specified operating supply voltage range.
11. I_{CC} is dependent upon loading. I_{CC} limit specified is for no-load test condition for both drivers.
12. Reference AC Test Circuit and Pulse Requirements.
13. Reference "Typical Output Current vs. Output Voltage Curve."
14. V_{CC} = 0.00V.
15. V_{CC} = 5.25V.
16. Output sink current is supplied through a resistor to V_{CC}.
17. Hysteresis is defined as voltage difference between R input level at which output begins to go from "0" to "1" state and level at which output begins to go from "1" to "0".
18. See Hysteresis test circuit.

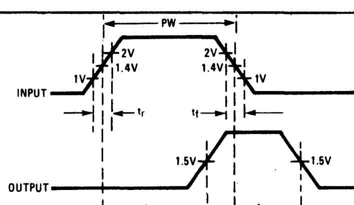
AC TEST CIRCUIT AND WAVEFORMS

AC Test Diagram



Pulse Requirements

INPUT PULSE:
Amplitude = 3.0V
PW = 40ns (50% Duty Cycle)
$t_r = t_f \leq$ 5ns (10% and 90% measurement points)



GENERAL DESCRIPTION

The RM8T24/RC8T24 are triple line receivers designed specifically to meet the IBM System 360 interface specification. Each receiver incorporates hysteresis to provide high noise immunity and high input impedance to minimize loading on the driver circuit.

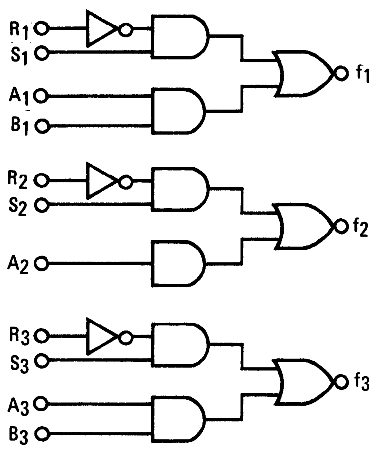
The RM8T24/RC8T24 is fully compatible with TTL and DTL systems and operates from a single 5V power supply.

The RM8T24 operates over a temperature range of −55°C to +125°C. The RC8T24 operates from 0°C to +70°C.

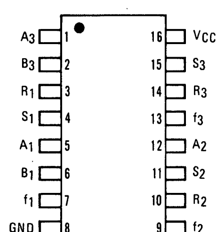
DESIGN FEATURES

- Built-in Input Threshold Hysteresis*
- High Speed $t_{ON} = t_{OFF} = 20$ ns Typical
- Each Channel Can Be Strobed Independently
- Fanout of 10 With Standard TTL IC
- Input Gating Increases Application Flexibility
- Operates From Single 5V Logic Supply

LOGIC DIAGRAM



CONNECTION INFORMATION



DD Dual In-line Packages
(Top View)

Order Part Nos.:
RM8T24DD, RC8T24DD

*Hysteresis is defined as the difference between the input threshold for the "1" and "0" output states. Hysteresis is specified at 0.4V typically and 0.2V minimum over the operating temperature range.

ABSOLUTE MAXIMUM RATINGS

Input and Output Voltage, V_{CC}	+7.0V
Input Current	±30mA
Output Current	±100mA
Operating Temperature	
RM8T24	−55°C to +125°C
RC8T24	0°C to +75°C
Storage Temperature	−65°C to +150°C

ELECTRICAL CHARACTERISTICS (Over Recommended Temperature and Voltage Ranges)

CHARACTERISTIC		LIMITS				TEST CONDITIONS					NOTES
		MIN	TYP	MAX	UNITS	R	S	A	B	OUTPUTS	
"1" Output Voltage		2.6	3.4		V	1.7V	4.5V	0V	0V	−800µA	6
		2.6	3.4		V	0V	0.8V	0V	0V	−800µA	
"0" Output Voltage			0.2	0.4	V	0.7V	2.0V	0V	0V	16mA	16
			0.2	0.4	V	0V	0V	2.0V	2.0V	16mA	
"0" Input Current	S_n	−0.1		−1.6	mA	0V	0.4V				
	A_n	−0.1		−1.6	mA	0V		0.4V			
	B_n	−0.1		−1.6	mA				0.4V		
"1" Input Current	R_n			0.17	mA	3.8V					14
	R_n			5.0	mA	7.0V					
	R_n			5.0	mA	6.0V					
	S_n			40	µA	3.8V	4.5V				
	A_n			40	µA			4.5V	0V		
	B_n			40	µA			0V	4.5V		
V_{CC} = 5.0V, T_A = 25°C											
Turn-on Propagation Delay			20	30	ns						12
Turn-off Propagation Delay			20	30	ns						12
Hysteresis		0.2	0.4		V		4.5V	0V	0V		17, 18
Power/Current Consumption			315 60	380 72	mW/mA						15
Input Latch Voltage	S	5.5			V	3.8V	10mA	0V	0V		10
	A	5.5			V	0V	0V	0V	10mA		
	B	5.5			V	0V	0V	0V	10mA		
Output Short-Circuit Current		−50		−100	mA	3.8V	0V	0V	0V		
Input Clamp Voltage	S			−1.5	V		−12mA				
	A			−1.5	V			−12mA			
	B			−1.5	V				−12mA		

NOTES:

1. All voltage measurements are referenced to the ground terminal. Terminals not specifically referenced are left electrically open.
2. All measurements are taken with ground pin tied to zero volts.
3. Positive current is defined as into the terminal referenced.
4. Positive logic definition: "UP" Level = "1", "DOWN" Level = "0".
5. Precautionary measures should be taken to ensure current limiting in accordance with Absolute Maximum Ratings should the isolation diodes become forward biased.
6. Output source current is supplied through a resistor to ground.
7. With forced output current of 240µA the output voltage must not exceed 0.15V.
8. R_L = 50 ohms to ground.
9. Load is 50 ohms in parallel with 1000pF.
10. This test guarantees operation free on input latch-up over the specified operating supply voltage range.
11. I_{CC} is dependent upon loading. I_{CC} limit specified is for no-load test condition for both drivers.
12. Reference AC Test Circuit and Pulse Requirements.
13. Reference "Typical Output Current vs. Output Voltage Curve."
14. V_{CC} = 0.00V.
15. V_{CC} = 5.25V.
16. Output sink current is supplied through a resistor to V_{CC}.
17. Hysteresis is defined as voltage difference between R input level at which output begins to go from "0" to "1" state and level at which output begins to go from "1" to "0".
18. See Hysteresis test circuit.

GENERAL DESCRIPTION

The RM55325/RC75325 are monolithic integrated circuit memory drivers with logic inputs designed for use with magnetic memories.

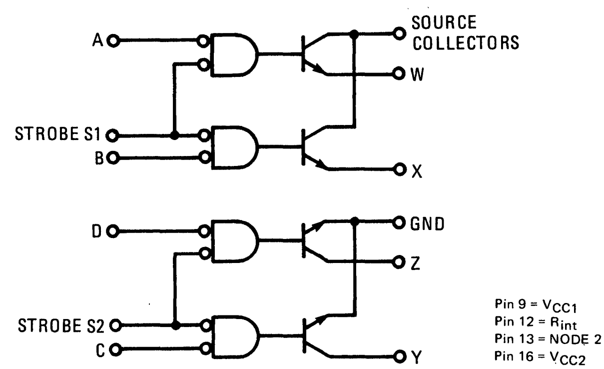
The devices contain two 600mA source switch pairs and two 600mA sink-switch pairs. Source selection is determined by one of two logic inputs, and source turn-on is determined by the source strobe. Likewise, sink selection is determined by one of two logic inputs, and sink turn-on is determined by the sink strobe. This arrangement allows selection of one of the four switches and its subsequent turn-on with minimum time skew of the output current rise.

The RM55325 will operate over a temperature range of −55°C to +125°C. The RC75325 operates from 0°C to +70°C.

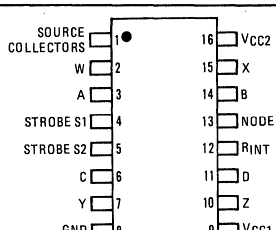
DESIGN FEATURES

- 600mA Output Capability
- Fast Switching Times
- Output Short-Circuit Protection
- Dual Sink and Dual Source Outputs
- Minimum Time Skew Between Address and Output Current Rise
- 24V Output Capability
- Source Base Drive Externally Adjustable
- TTL or DTL Compatibility
- Input Clamping Diodes
- Transformer Coupling Eliminated
- Reliability Increased
- Drive Line Lengths Reduced
- Use of External Components Minimized

LOGIC DIAGRAM



CONNECTION INFORMATION



DD Dual In-line Packages
(Top View)

Order Part Nos.:
RM55325DD, RC75325DD

TRUTH TABLE

Address Inputs				Strobe Inputs		Outputs			
Source		Sink		Source	Sink	Source		Sink	
A	B	C	D	S1	S2	W	X	Y	Z
L	H	X	X	L	H	ON	OFF	OFF	OFF
H	L	X	X	L	H	OFF	ON	OFF	OFF
X	X	L	H	H	L	OFF	OFF	ON	OFF
X	X	H	L	H	L	OFF	OFF	OFF	ON
X	X	X	X	H	H	OFF	OFF	OFF	OFF
H	H	H	H	X	X	OFF	OFF	OFF	OFF

H = high level, L = low level, X = irrelevant
NOTE: Not more than one output is to be on at any one time.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage
- V_{CC1} (Note 1) 7.0V
- V_{CC2} (Note 1) 25V

Input Voltage (any address or strobe input) 5.5V
Continuous Total Dissipation (at or below +70°C) 800mW

Operating Temperature
- RM55325 . . . . −55°C to +125°C
- RC75325 . . . . 0°C to +70°C

Storage Temperature . . . . −65°C to +150°C
Lead Temperature (Soldering, 10s) . . . . +300°C

ELECTRICAL CHARACTERISTICS

SYMBOL	PARAMETER		CONDITIONS		55325 MIN	55325 TYP (Note 3)	55325 MAX	75325 MIN	75325 TYP (Note 3)	75325 MAX	UNITS
V_{IH}	High Level Input Voltage				2.0			2.0			V
V_{IL}	Low Level Input Voltage						0.8			0.8	V
V_I	Input Clamp Voltage		V_{CC1}=4.5V, V_{CC2}=24V, I_I=−10mA, T_A = 25°C			−1.3	−1.7		−1.3	−1.7	V
$I_{(off)}$	Source-collectors Terminal Off-state Current		V_{CC1}=4.5V, V_{CC2}=24V	Full range			500			200	µA
				T_A = 25°C		3.0	150		3.0	200	
V_{OH}	High Level Sink Output Voltage		V_{CC1}=4.5V, V_{CC2}=24V, I_O = 0		19	23		19	23		V
$V_{(sat)}$	Saturation Voltage (Note 5)	source outputs	V_{CC1}=4.5V, V_{CC2}=15V, R_L=24Ω, $I_{(source)}$≈−600mA (Note 2)	Full range			0.9			0.9	V
				T_A = 25°C		0.43	0.7		0.43	0.75	
		sink outputs	V_{CC1}=4.5V, V_{CC2}=15V, R_L=24Ω, $I_{(sink)}$≈600mA (Note 2)	Full range			0.9			0.9	
				T_A=25°C		0.43	0.7		0.43	0.75	
I_I	Input Current at maximum Input Voltage	address inputs	V_{CC1}=5.5V, V_{CC2}=24V, V_I=5.5V				1.0			1.0	mA
		strobe inputs					2.0			2.0	
I_{IH}	High Level Input Current	address inputs	V_{CC1}=5.5V, V_{CC2}=24V, V_I=2.4V			3.0	40		3.0	40	µA
		strobe inputs				6.0	80		6.0	80	
I_{IL}	Low Level Input Current	address inputs	V_{CC1}=5.5V, V_{CC2}=24V, V_I=0.4V			−1.0	−1.6		−1.0	−1.6	mA
		strobe inputs				−2.0	−3.2		−2.0	−3.2	
$I_{CC(off)}$	Supply Current, All Sources and Sinks Off	from V_{CC1}	V_{CC1}=5.5V, V_{CC2}=24V, T_A = 25°C			14	22		14	22	mA
		from V_{CC2}				7.5	20		7.5	20	
I_{CC1}	Supply Current from V_{CC1}, Either Sink On		V_{CC1}=5.5V, V_{CC2}=24V, $I_{(sink)}$=50mA, T_A = 25°C			55	70		55	70	mA
I_{CC2}	Supply Current from V_{CC2}, Either Source On		V_{CC1}=5.5V, V_{CC2}=24V, $I_{(source)}$=−50mA, T_A = 25°C			32	50		32	50	mA

SWITCHING CHARACTERISTICS (V_{CC1} = 5V, T_A = 25°C)

PARAMETER	TO (OUTPUT)	CONDITIONS	MIN	TYP	MAX	UNITS
t_{PLH}	Source Collectors	V_{CC2} = 15V, R_L = 24Ω, C_L = 25pF		25	50	ns
t_{PHL}				25	50	
t_{TLH}	Source Outputs	V_{CC2} = 20V, R_L = 1kΩ, C_L = 25pF		55		ns
t_{THL}				7.0		
t_{PLH}	Sink Outputs	V_{CC2} = 15V, R_L = 24Ω, C_L = 25pF		20	45	ns
t_{PHL}				20	45	
t_{TLH}	Sink Outputs	V_{CC2} = 15V, R_L = 24Ω, C_L = 25pF		7.0	15	ns
t_{THL}				9.0	20	
t_S	Sink Outputs	V_{CC2} = 15V, R_L = 24Ω, C_L = 25pF		15	30	ns

NOTES:
1. Voltage values are with respect to network ground terminal.
2. These parameters must be measured using pulse techniques tw = 200µs, duty cycle ≤ 2%.
3. All typical values are at T_A = 25°C.
4. Not more than one output is to be on at any one time.

SECTION 6

Special Functions

CONTENTS

6

GENERAL DESCRIPTION

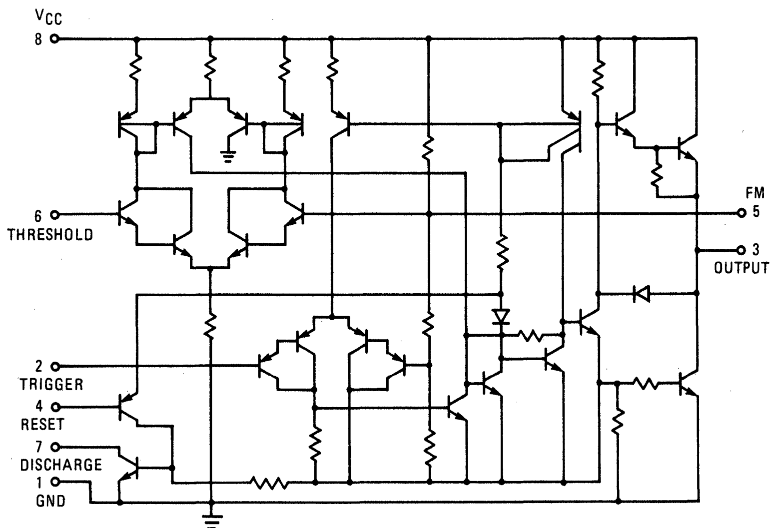
The RC555 and RM555 monolithic timing circuits are highly stable controllers capable of producing accurate time delays or oscillation. In the time delay mode, delay time is precisely controlled by only two external parts: a resistor and a capacitor. For operation as an oscillator, both the free running frequency and the duty cycle are accurately controlled by two external resistors and a capacitor.

Terminals are provided for triggering and resetting. The circuit will trigger and reset on falling waveforms. The output can source or sink up to 200mA or drive TTL circuits.

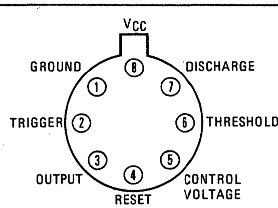
DESIGN FEATURES

- Timing From Microseconds Through Hours
- Operates in Both Astable and Monostable Modes
- Adjustable Duty Cycle
- Output Drives TTL
- High Current Output Can Source or Sink 200mA
- Temperature Stability of 0.005%/°C
- Normally On and Normally Off Output

SCHEMATIC DIAGRAM

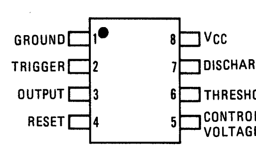


CONNECTION INFORMATION



TE Metal Can Package
(Top View)

Order Part Nos.:
RC555T, RM555T



NB Dual In-line
(Top View)

Order Part Nos.
RC555NB, RV555NB

ABSOLUTE MAXIMUM RATINGS

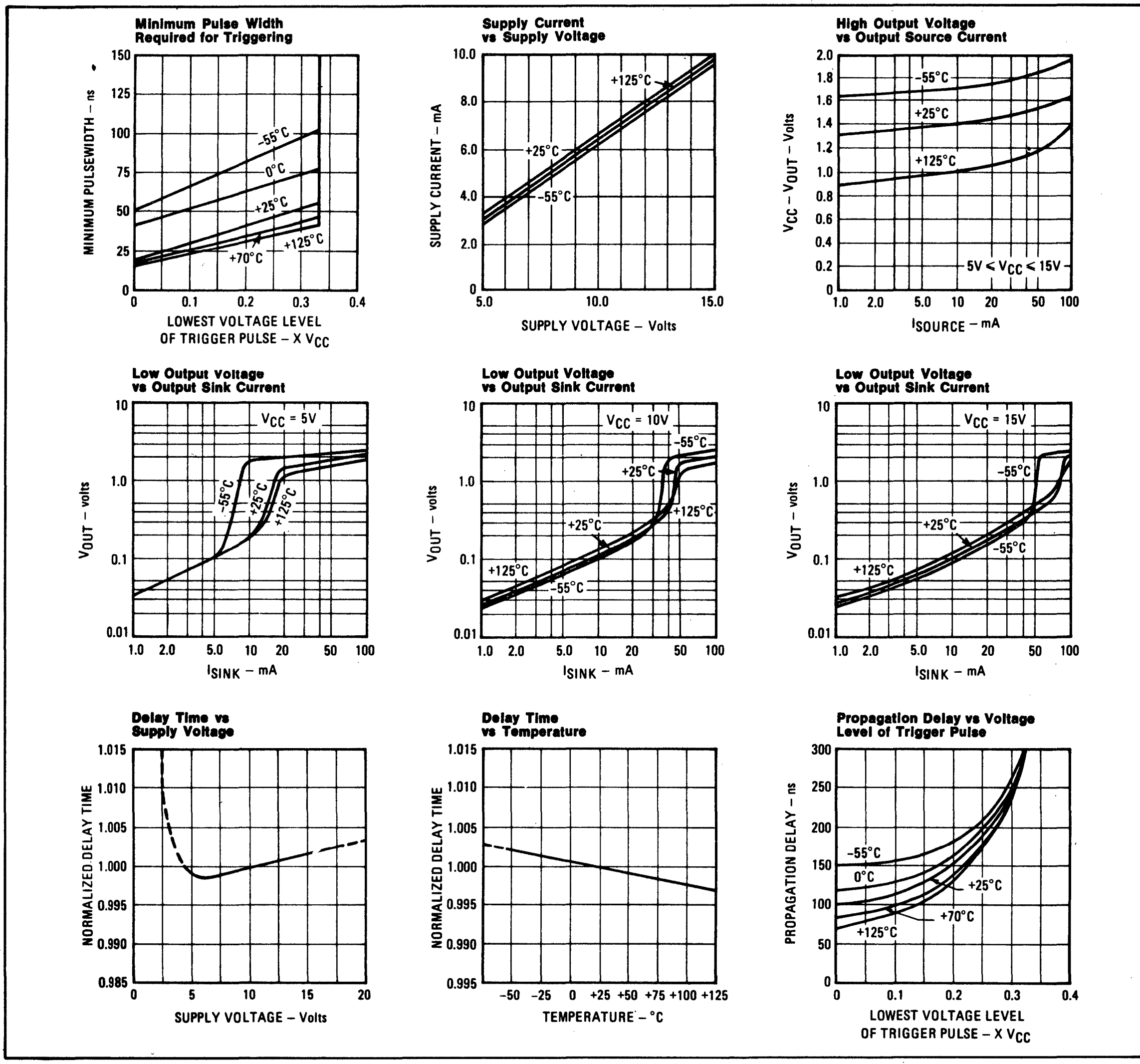
Supply Voltage	+18V
Power Dissipation	600mW
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60s)	+300°C
Operating Temperature Range	
RC555	0°C to +70°C
RM555	−55°C to +125°C

ELECTRICAL CHARACTERISTICS (V_{CC} = +5V to +15V, T_A = 25°C unless otherwise specified)

PARAMETER	CONDITIONS	RM555			RC555			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Supply Voltage		4.5		18	4.5		16	V
Supply Current	V_{CC} = 5V, $R_L = \infty$		3	5		3	6	mA
	V_{CC} = 15V, $R_L = \infty$		10	12		10	15	mA
	Low State, (Note 1)							
Timing Error	R_A, R_B = 1kΩ to 100kΩ							
	C = 0.1μF (Note 2)							
Initial Accuracy			0.5	2		1		%
Drift with Temperature			30	100		50		ppm/°C
Drift with Supply Voltage			0.005	0.02		0.01		%/Volt
Threshold Voltage			2/3			2/3		x V_{CC}
Trigger Voltage	V_{CC} = 15V	4.8	5	5.2		5		V
	V_{CC} = 5V	1.45	1.67	1.9		1.67		V
Trigger Current			0.5			0.5		μA
Reset Voltage		0.4	0.7	1.0	0.4	0.7	1.0	V
Reset Current			0.1			0.1		mA
Threshold Current	(Note 3)		0.1	0.25		0.1	0.25	μA
Control Voltage Level	V_{CC} = 15V	9.6	10	10.4	9.0	10	11	V
	V_{CC} = 5V	2.9	3.33	3.8	2.6	3.33	4	V
Output Voltage Drop (low)	V_{CC} = 15V							
	I_{SINK} = 10mA		0.1	0.15		0.1	0.25	V
	I_{SINK} = 50mA		0.4	0.5		0.4	0.75	V
	I_{SINK} = 100mA		2	2.2		2	2.5	V
	I_{SINK} = 200mA		2.5			2.5		
	V_{CC} = 5V							
	I_{SINK} = 8mA		0.1	0.25				V
	I_{SINK} = 5mA					0.25	0.35	
Output Voltage Drop (high)	I_{SOURCE} = 200mA							
	V_{CC} = 15V		12.5			12.5		V
	I_{SOURCE} = 100mA							
	V_{CC} = 15V	13	13.3		12.75	13.3		V
	V_{CC} = 5V	3	3.3		2.75	3.3		V
Rise Time of Output			100			100		ns
Fall Time of Output			100			100		ns

NOTES:
1. Supply current when output high typically 1mA less.
2. Tested at V_{CC} = 5V and V_{CC} = 15V.
3. This will determine the maximum value of $R_A + R_B$. For 15V operation, the max total R = 20 megohm.

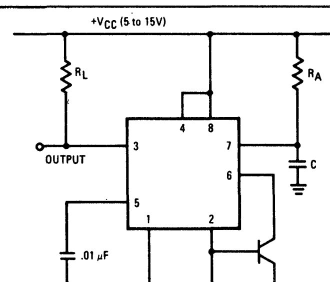
TYPICAL ELECTRICAL DATA



TYPICAL APPLICATIONS

Missing Pulse Detector

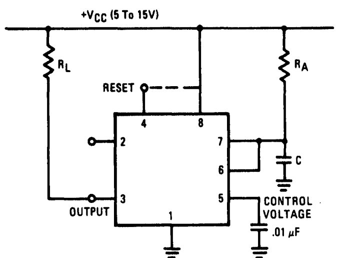
With the RC555/RM555 connected as shown, the timing cycle will be continuously reset by the input pulse train. A change in frequency, or a missing pulse, allows the timing cycle to go to completion and change the output level. For proper operation the time delay should be set slightly longer than the normal time between pulses.



TYPICAL APPLICATIONS (Cont.)

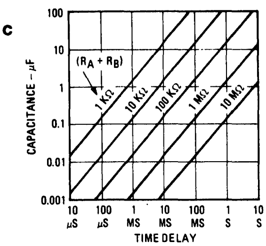
Monostable Operation

In this mode, the timer functions as a one-shot. The external capacitor is initially held discharged by a transistor internal to the timer. Applying a negative trigger pulse to Pin 2 sets the flip-flop, driving the output high and releasing the short-circuit across the external capacitor. The voltage across the capacitor increases with time constant $r = R_AC$ to 2/3 V_{CC}, where the comparator resets the flip-flop and discharges the external capacitor. The output is now in the low state.



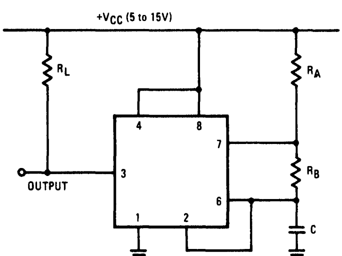
Circuit triggering takes place when the negative-going trigger pulse reaches $1/3V_{CC}$ and the circuit stays in the output high state until the set time elapses. The time the output remains in the high state is $1.1R_AC$ and can be determined by the graph. A negative pulse applied to Pin 4 (reset) during the timing cycle will discharge the external capacitor and start the cycle over again beginning on the positive-going edge of the reset pulse. If reset function is not used, Pin 4 should be connected to V_{CC} to avoid false resetting.

Time Delay vs R_A, R_B and C

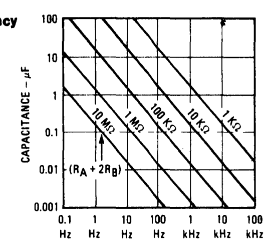


Free Running Operation

With the circuit connected as shown, it will trigger itself and free run as a multivibrator. The external capacitor charges through R_A and R_B and discharges through R_B only. Thus the duty cycle is set by the ratio of these two resistors, and the capacitor charges and discharges between $1/3V_{CC}$ and $2/3V_{CC}$. Charge and discharge times, and therefore frequency, are independent of supply voltage. The free running frequency versus R_A, R_B, and C is shown in the graph.



Free Running Frequency vs R_A, R_B and C



GENERAL DESCRIPTION

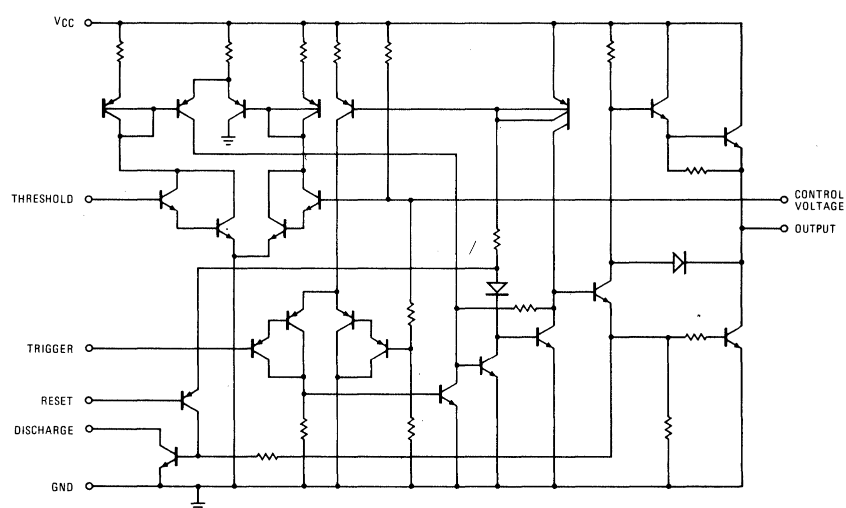
The RC556 and RM556 monolithic timing circuits are highly stable controllers capable of producing accurate time delays or oscillation. In the time delay mode, delay time is precisely controlled by only two external parts: a resistor and a capacitor. For operation as an oscillator, both the free running frequency and the duty cycle are accurately controlled by two external resistors and a capacitor.

Terminals are provided for triggering and resetting. The circuit will trigger and reset on falling waveforms. The output can source or sink up to 200mA or drive TTL circuits.

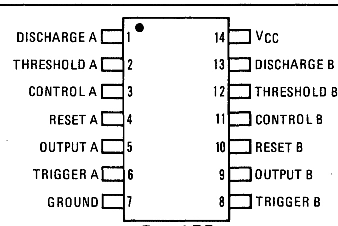
DESIGN FEATURES

- Timing From Microseconds Through Hours
- Operates in Both Astable and Monostable Modes
- Adjustable Duty Cycle
- Output Drives TTL
- High Current Output Can Source or Sink 200mA
- Temperature Stability of 0.005%/°C
- Normally On and Normally Off Output

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



D and DP
Dual In-line Package
(Top View)

Order Part Nos.;
RC556DB, RC556DC,
RM556DC

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	+18V
Power Dissipation	600mW
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60s)	+300°C
Operating Temperature Range	
RC556	0°C to +70°C
RM556	−55°C to +125°C
RV556	−40°C to +85°C

ELECTRICAL CHARACTERISTICS (V_{CC} = +5V to +15V, T_A = 25°C unless otherwise specified)

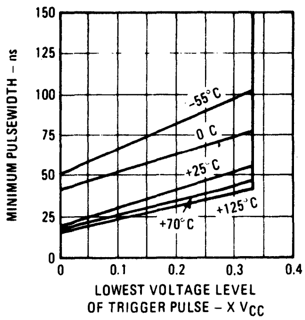
PARAMETER	CONDITIONS	RM556			RC556, RV556			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Supply Voltage		4.5		18	4.5		16	V
Supply Current (Each Side)	V_{CC} = 5V, R_L = ∞		3	5		3	6	mA
	V_{CC} = 15V, R_L = ∞		10	11		10	14	mA
	Low State, (Note 1)							
Timing Error (Free Running)	R_A, R_B=2kΩ to 100kΩ							
	C = 0.1µF (Note 2)							
Initial Accuracy			1.5			2.25		%
Drift with Temperature			90			150		ppm/°C
Drift with Supply Voltage			0.15			0.3		%/Volt
Timing Error (Monostable)	R_A, R_B=2kΩ to 100kΩ							
	C = 0.1µF (Note 2)							
Initial Accuracy			0.5	1.5		0.75		%
Drift with Temperature			30	100		50		ppm/°C
Drift with Supply Voltage			0.05	0.2		0.1		%/Volt
Threshold Voltage			2/3			2/3		x V_{CC}
Trigger Voltage	V_{CC} = 15V	4.8	5	5.2		5		V
	V_{CC} = 5V	1.45	1.67	1.9		1.67		V
Trigger Current			0.5			0.5		µA
Reset Voltage		0.4	0.7	1.0	0.4	0.7	1.0	V
Reset Current			0.1			0.1		mA
Threshold Current	(Note 3)		0.03	0.1		0.03	0.1	µA
Control Voltage Level	V_{CC} = 15V	9.6	10	10.4	9.0	10	11	V
	V_{CC} = 5V	2.9	3.33	3.8	2.6	3.33	4	V
Output Voltage Drop (low)	V_{CC} = 15V							
	I_{SINK} = 10mA		0.1	0.15		0.1	0.25	V
	I_{SINK} = 50mA		0.4	0.5		0.4	0.75	V
	I_{SINK} = 100mA		2	2.25		2	2.75	V
	I_{SINK} = 200mA		2.5			2.5		
	V_{CC} = 5V							
	I_{SINK} = 8mA		0.1	0.25				V
	I_{SINK} = 5mA					0.25	0.35	
Output Voltage Drop (high)	I_{SOURCE} = 200mA							
	V_{CC} = 15V		12.5			12.5		V
	I_{SOURCE} = 100mA							
	V_{CC} = 15V	13	13.3		12.75	13.3		V
	V_{CC} = 5V	3	3.3		2.75	3.3		V
Rise Time of Output			100			100		ns
Fall Time of Output			100			100		ns
Matching Characteristics Between Each Section								
Initial Timing Accuracy			.05	0.1		0.1	0.2	%
Timing Drift with Temperature			±10			±10		ppm/°C
Drift with Supply Voltage			0.1	0.2		0.2	0.5	%/Volt

Notes on following page.

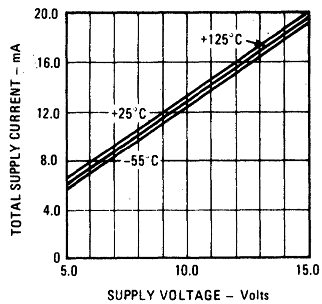
6

TYPICAL ELECTRICAL DATA

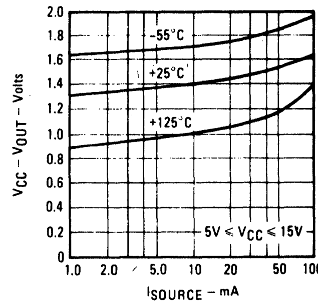
Minimum Pulse Width Required for Triggering



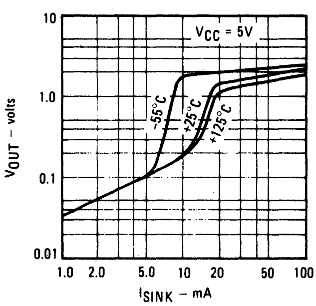
Supply Current vs Supply Voltage



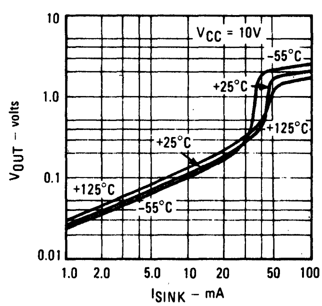
High Output Voltage vs Output Source Current



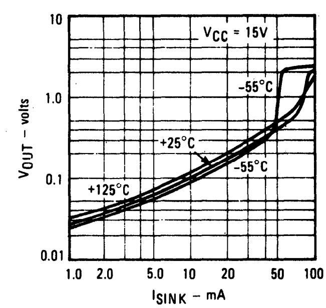
Low Output Voltage vs Output Sink Current



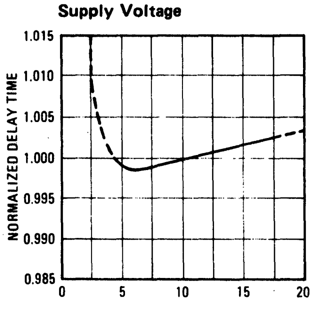
Low Output Voltage vs Output Sink Current



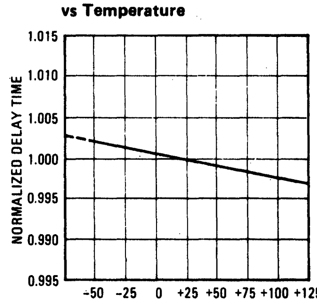
Low Output Voltage vs Output Sink Current



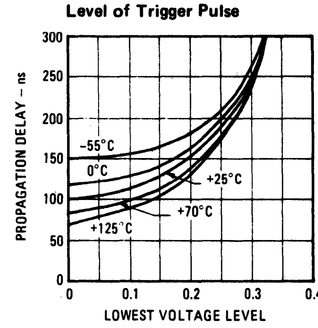
Delay Time vs Supply Voltage



Delay Time vs Temperature



Propagation Delay vs Voltage Level of Trigger Pulse



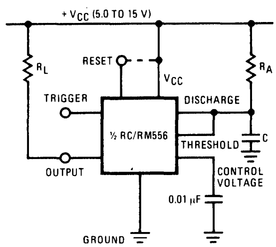
NOTES

1. Supply current when output high typically 2mA less.
2. Tested at V_{CC} = 5V and V_{CC} = 15V.
3. This will determine the maximum value of $R_A + R_B$. For 15V operation, the maximum total R = 20MΩ.

BASIC OPERATIONAL MODES

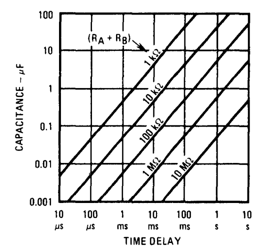
Monostable Operation

In this mode, the timer functions as a one-shot. The external capacitor is initially held discharged by a transistor internal to the timer. Applying a negative trigger pulse to Pin 2 sets the flip-flop, driving the output high and releasing the short-circuit across the external capacitor. The voltage across the capacitor increases with time constant r = R_AC to 2/3 V_{CC}, where the comparator resets the flip-flop and discharges the external capacitor. The output is now in the low state.



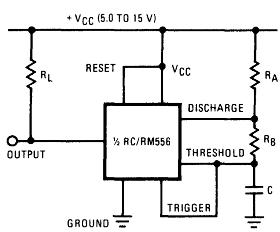
Circuit triggering takes place when the negative-going trigger pulse reaches 1/3V_{CC} and the circuit stays in the output high state until the set time elapses. The time the output remains in the high state is 1.1R_AC and can be determined by the graph. A negative pulse applied to Pin 4 (reset) during the timing cycle will discharge the external capacitor and start the cycle over again beginning on the positive-going edge of the reset pulse. If reset function is not used, Pin 4 should be connected to V_{CC} to avoid false resetting.

Time Delay vs R_A, R_B and C

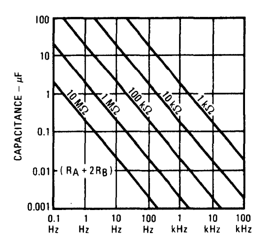


Free Running Operation (Astable)

With the circuit connected as shown, it will trigger itself and free run as a multivibrator. The external capacitor charges through R_A and R_B and discharges through R_B only. Thus the duty cycle is set by the ratio of these two resistors, and the capacitor charges and discharges between 1/3V_{CC} and 2/3V_{CC}. Charge and discharge times, and therefore frequency, are independent of supply voltage. The free running frequency versus R_A, R_B, and C is shown in the graph.



Free Running Frequency vs R_A, R_B and C



6

GENERAL DESCRIPTION

The RC4151 and RM4151 provide a simple low-cost method of A/D conversion. They have all the inherent advantages of the voltage-to-frequency conversion technique. The output of RC4151/RM4151 is a series of pulses of constant duration. The frequency of the pulses is proportional to the applied input voltage. These converters are designed for use in a wide range of data conversion and remote sensing applications.

DESIGN FEATURES

- Single Supply Operation (+8V to +22V)
- Pulse Output Compatible With All Logic Forms
- Programmable Scale Factor (K)
- Linearity ±0.05% typical—precision mode
- Temperature stability ±100% ppm/°C typical
- High Noise Rejection
- Inherent Monotonicity
- Easily Transmittable Output
- Simple Full Scale Trim
- Single-Ended Input, Referenced to Ground
- Also Provides Frequency-to-Voltage Conversion

SCHEMATIC DIAGRAM

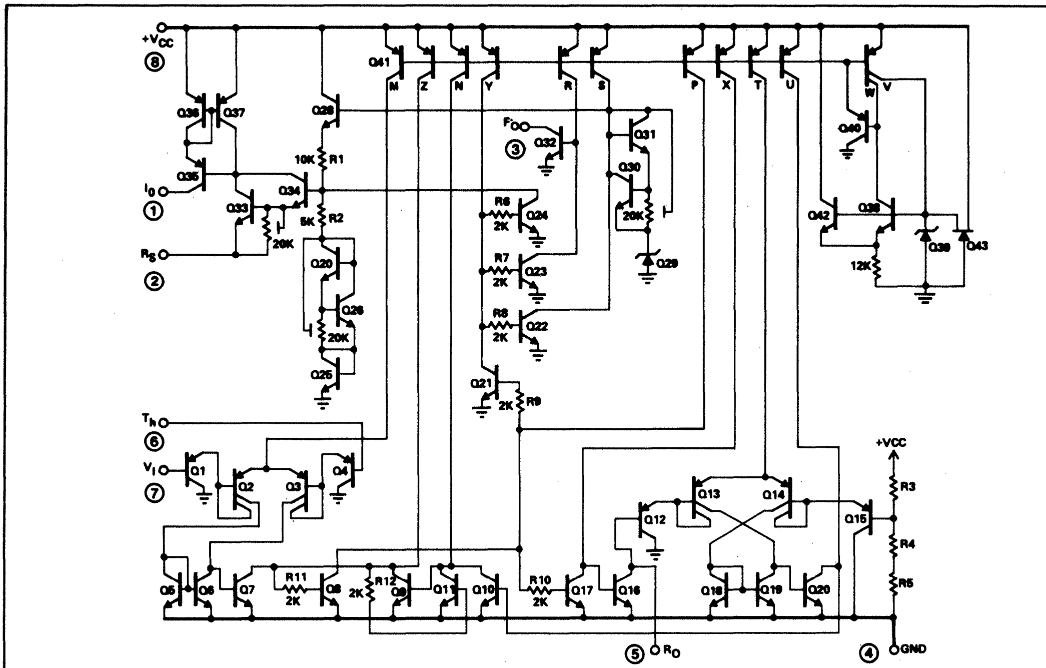
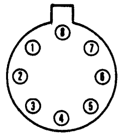


Figure 1

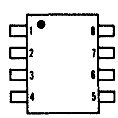
CONNECTION INFORMATION

TE (TO-99) METAL CAN
(Top View)



Order Part Nos.: RC4151T, RM4151T
NOTE: PIN 4 CONNECTED TO CASE

NB MINIATURE DUAL-IN-LINE
(Top View)



Order Part Nos.: RC4151NB, RV4151NB

PIN	FUNCTION
1	CURRENT SOURCE
2	SCALE FACTOR
3	LOGIC OUTPUT
4	GROUND
5	ONE-SHOT R, C
6	THRESHOLD
7	INPUT VOLTAGE
8	V_{CC}

ABSOLUTE MAXIMUM RATINGS

Supply Voltages	+8.0 to +22V
Output Sink Current	20mA
Internal Power Dissipation	500mW
Input Voltage	−0.2V to $+V_{CC}$
Output Short Circuit to Ground	Continuous
Storage Temperature Range	
RM4151	−65°C to +150°C
RV4151	−55°C to +125°C
RC4151	−55°C to +125°C
Operating Temperature Range	
RM4151	−55°C to +125°C
RV4151	−40°C to +85°C
RC4151	0°C to +70°C

ELECTRICAL CHARACTERISTICS (V_{CC} = +15V, T_A = +25°C, unless otherwise specified)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	8V < V_{CC} < 15V	2.0	3.5	6.0	mA
	15V < V_{CC} < 22V	2.0	4.5	7.5	mA
Conversion Accuracy Scale Factor	Circuit Figure 3, V_I = 10V R_S = 14.0k	0.90	1.00	1.10	kHz/V
Drift with Temperature	Circuit Figure 3, V_I = 10V	–	±100	–	ppm/°C
Drift with V_{CC}	Circuit Figure 3, V_I = 1.0V 8V < V_{CC} < 18V	–	0.2	1.0	%/V
Input Comparator Offset Voltage		–	5	10	mV
Offset Current		–	±50	±100	nA
Input Bias Current		–	-100	-300	nA
Common Mode Range (Note 1)		0	0 to V_{CC} -2	V_{CC} -3.0	V
One-Shot Threshold Voltage, Pin 5		0.63	.667	0.70	x V_{CC}
Input Bias Current, Pin 5		–	-100	-500	nA
Reset V_{SAT}	Pin 5, I = 2.2mA	–	0.15	0.50	V
Current Source Output Current (R_S = 14.0kΩ)	Pin 1, Figure 2, V = 0	–	138.7	–	μA
Change with Voltage	Pin 1, V = 0V to V = 10V	–	1.0	2.5	μA
Off Leakage	Pin 1, V = 0V	–	1	50.0	nA
Reference Voltage	Pin 2, Figure 2	1.70	1.9	2.08	V
Logic Output V_{SAT}	Pin 3, I = 3.0mA	–	0.15	0.50	V
V_{SAT}	Pin 3, I = 2.0mA	–	0.10	0.30	V
Off Leakage		–	.1	1.0	μA

Note 1: Input Common Mode Range includes ground.

6

PRINCIPLE OF OPERATION

Single Supply Mode Voltage-to-Frequency Conversion

In this application the RC4151/RM4151 functions as a stand-alone voltage to frequency converter operating on a single positive power supply. Refer to Figure 2, the simplified block diagram. The RC/RM4151 contains a voltage comparator, a one-shot, and a precision switched current source. The voltage comparator compares a positive input voltage applied at pin 7 to the voltage at pin 6. If the input voltage is higher, the comparator will fire the one-shot. The output of the one-shot is connected to both the logic output and the precision switched current source. During the one-shot period, T, the logic output will go low and the current source will turn on with current I. At the end of the one-shot period the logic output will go high and the current source will shut off. At this time the current source has injected an amount of charge $Q = I_O T$ into the network R_B–C_B. If this charge has not increased the voltage V_B such that $V_B > V_I$, the comparator again fires the one-shot and the current source injects another lump of charge, Q, into the R_B–C_B network. This process continues until $V_B > V_I$. When this condition is achieved the current source remains off and the voltage V_B decays until V_B is again equal to V_I. This completes one cycle. The VFC will now run in a steady state mode. The current source dumps lumps of charge into the capacitor C_B at a rate fast enough to keep $V_B \geqslant V_I$. Since the discharge rate of capacitor C_B is proportional to V_B/R_B, the frequency at which the system runs will be proportional to the input voltage.

The 4151 VFC is easy to use and apply if you understand the operation of it through the block diagram, Figure 2. Many users, though, have expressed the desire to understand the workings of the internal circuitry. Figure 1 shows the schematic of the 4151. The circuit can be divided into five sections: the internal biasing network, input comparator, one-shot, voltage reference, and the output current source.

The internal biasing network is composed of Q39-Q43. The N-channel FET Q43 supplies the initial current for zener diode Q39. The NPN transistor Q38 senses the zener voltage to derive the current reference for the multiple collector current source Q41. This special PNP transistor provides active pull-up for all of the other sections of the 4151.

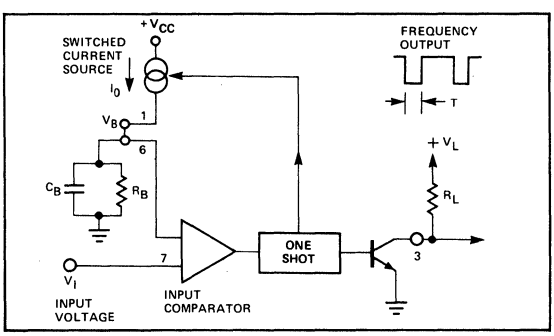


Figure 2. Simplified Block Diagram, Single Supply Mode

The input comparator section is composed of Q1-Q7. Lateral PNP transistors Q1-Q4 form the special ground-sensing input which is necessary for VFC operation at low input voltages. NPN transistors Q5 and Q6 convert the differential signal to drive the second gain stage Q7. If the voltage on input pin 7 is less than that on threshold pin 6, the comparator will be off and the collector of Q7 will be in the high state. As soon as the voltage on pin 7 exceeds the voltage on pin 6, the collector of Q7 will go low and trigger the one-shot.

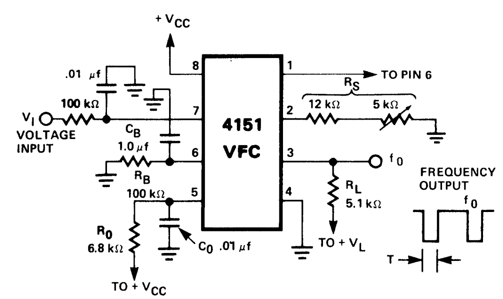
The one-shot is made from a voltage comparator and an R-S latch. Transistors Q12-Q15 and Q18-Q20 form the comparator, while Q8-Q11 and Q16-Q17 make up the R-S latch. One latch output, open-collector reset transistor Q16, is connected to a comparator input and to the terminal, pin 5. Timing resistor R_O is tied externally from pin 5 to $+V_{CC}$ and timing capacitor C_O is tied from pin 5 to ground. The other comparator input is tied to a voltage divider R_3-R_5 which sets the comparator threshold voltage at 0.667 V_{CC}. One-shot operation is initiated when the collector of Q7 goes low and sets the latch. This causes Q16 to turn off, releasing the voltage at pin 5 to charge exponentially towards $+V_{CC}$ through R_O. As soon as this voltage reaches 0.667 V_{CC}, comparator output Q20 will go high causing Q10 to reset the latch. When the latch is reset, Q16 will discharge C_O to ground. The one-shot has now completed its function of creating a pulse of period $T = 1.1\ R_O C_O$ at the latch output, Q21. This pulse is buffered through Q23 to drive the open-collector logic circuit transistor Q32. During the one-shot period the logic output will be in the low state. The one-shot output is also used to switch the reference voltage by Q22 and Q24. The low T.C. reference voltage is derived from the combination of a 5.5V zener diode with resistor and diode level shift networks. A stable 1.89 volts is developed at pin 2, the emitter of Q33.

Connecting the external current-setting resistor $R_S = 14.0\Omega$ from pin 2 to ground gives 135μA from the collectors of Q33 and Q34. This current is reflected in the precision current mirror Q35-Q37 and produces the output current I_O at pin 1. When the R-S latch is reset, Q22 and Q24 will hold the reference voltage off, pin 2 will be at 0V, and the current will be off. During the one-shot period T, the latch will be set, the voltage of pin 2 will go to 1.89V, and the output current will be switched on.

TYPICAL APPLICATIONS

Single Supply Voltage-to-Frequency Converter

Figure 3 shows the simplest type of VFC that can be made with the 4151. Input voltage range is from 0 to +10V, and output frequency is from 0 to 10kHz. Full scale frequency can be tuned by adjusting R_S, the output current set resistor. This circuit has the advantage of being simple and low in cost, but it suffers from inaccuracy due to a number of error sources. Linearity error is typically 1%. A frequency offset will also be introduced by the input comparator offset voltage. Also, response time for this circuit is limited by the passive integration network R_B C_B. For the component values shown in Figure 3, response time for a step change input from 0 to +10V will be 135msec. For applications which require fast response time and high accuracy, use the circuits of Figure 4 and 5.



DESIGN EQUATIONS

$f_0 = KV_I$ Where $K = 0.486 \dfrac{R_S}{R_B R_0 C_0} \dfrac{kHz}{V}$

$T = 1.1\, R_0 C_0$

Figure 3. Single Supply Voltage-to-Frequency Converter

Precision VFC with Single Supply Voltage

For applications which requrie a VFC which will operate from a single positive supply with positive input voltage, the circuit of Figure 4 will give greatly improved linearity, frequency offset, and response time. Here, an active integrator using one section of the RC3403A quad ground-sensing op-amp has replaced the R_B-C_B network in Figure 3. Linearity error for this circuit is due only to the 4151 current source output conductance. Frequency offset is due only to the op-amp input offset and can be nulled to zero by adjusting R_B. This technique uses the op-amp bias current to develop the null voltage, so an op-amp with stable bias current, like the RC3403A, is required.

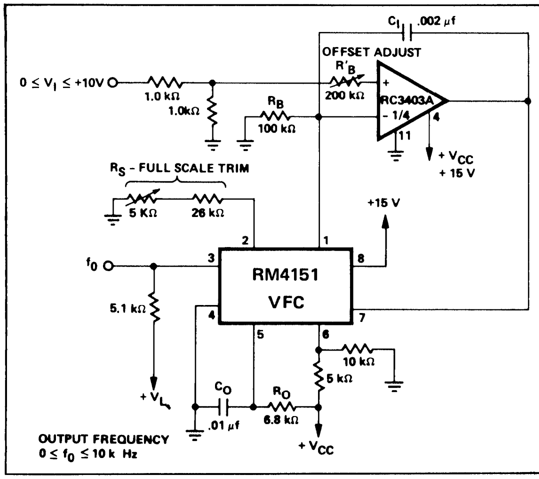


Figure 4. Precision Voltage-to-Frequency Converter Single Supply

Precision Voltage-to-Frequency Converter

In this application (Figure 5) the 4151 VFC is used with an operational amplifier integrator to provide typical linearity of 0.05% over the range of 0 to −10V. Offset is adjustable to zero. Unlike many VFC designs which lose linearity below 10mV, this circuit retains linearity over the full range of input voltage, all the way to 0V.

Trim the full scale adjust pot at V_I = −10V for an output frequency of 10kHz. The offset adjust pot should be set for 10Hz with an input voltage of −10mV.

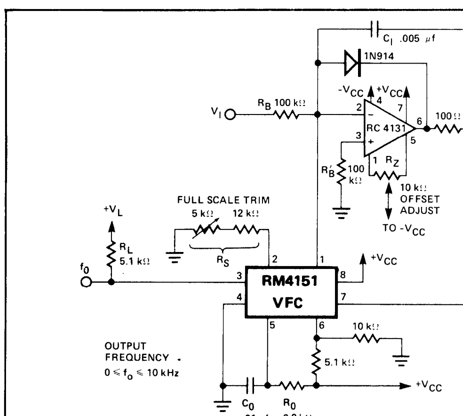


Figure 5. Precision Voltage-to-Frequency Converter

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The 4131 operational amplifier integrator improves linearity of this circuit over that of Figure 3 by holding the output of the source, Pin 1, at a constant 0V. Therefore linearity error due to the current source output conductance is eliminated. The diode connected around the op-amp prevents the voltage at 4151 pin 7 from going below 0. Use a low-leakage diode here, since any leakage will degrade the accuracy. This circuit can be operated from a single positive supply if an RC3403A ground-sensing op-amp is used for the integrator. In this case, the diode can be left out. Note that even though the circuit itself will operate from a single supply, the input voltage is necessarily negative. For operation above 10kHz, bypass 4151 pin 6 with 0.01μf.

Comparison of Voltage-to-Frequency Applications Circuits

Table 1 compares the VFC applications circuits for typical linearity, frequency offset, response time for a step input from 0 to 10 volts, sign of input voltage, and whether the circuit will operate from a single positive supply or split supplies.

Table 1

	Figure 3	Figure 4	Figure 5
Linearity	1%	0.2%	0.05%
Frequency Offset	+10Hz	0	0
Response Time	135msec	10μsec	10μsec
Input Voltage	+	+	–
Single Supply	yes	yes	yes
Split Supply	–	–	yes

Frequency-to-Voltage Conversion

The 4151 can be used as a frequency-to-voltage converter. Figure 6 shows the single-supply FVC configuration. With no signal applied, the resistor bias networks tied to pins 6 and 7 hold the input comparator in the off state. A negative going pulse applied to pin 6 (or positive pulse to pin 7) will cause the comparator to fire the one-shot. For proper operation, pulse width must be less than the period of the one-shot, $T = 1.1\ R_O\ C_O$. For a 5V p-p square-wave input the differentiator network formed by the input coupling capacitor and the resistor bias network will provide pulses which correctly trigger the one-shot. An external voltage comparator such as the 311 or 339 can be used to "square-up" sinusoidal input signals before they are applied to the 4151. Also, the component values for the input signal differentiator and bias network can be altered to accommodate square waves with different amplitudes and frequencies. The passive integrator network $R_B\ C_B$ filters the current pulses from the pin 1 output. For less output ripple, increase the value of C_B.

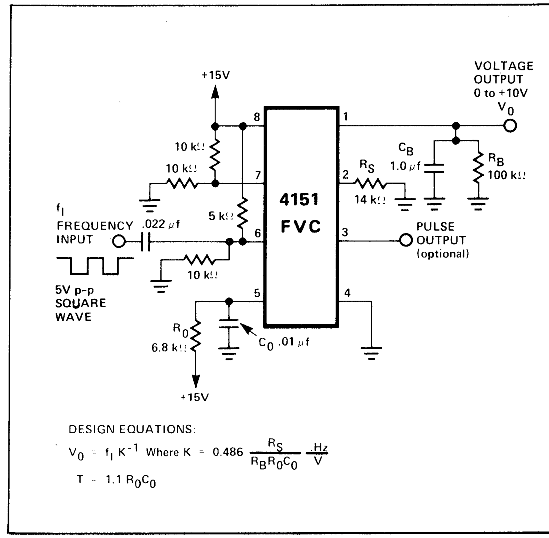


Figure 6. Single Supply Frequency-to-Voltage Converter

For increased accuracy and linearity, use an operational amplifier integrator as shown in Figure 7, the precision FVC configuration. Trim the offset to give –10mV out with 10Hz in and trim the full scale adjust for –10V out with 10kHz in. Input signal conditioning for this circuit is necessary just as for the single supply mode, and scale factor can be programmed by the choice of component values. A tradeoff exists between output ripple and response time, through the choice of integration capacitor C_I. If $C_I = 0.1\mu f$ the ripple will be about 100mV. Response time constant $\tau_R = R_B\ C_I$. For $R_B = 100k\Omega$ and $C_I = 0.1\mu f$, $\tau_R = 10msec$.

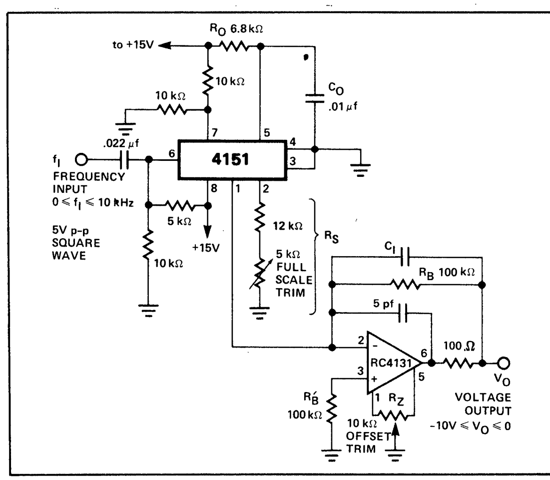


Figure 7. Precision Frequency-to-Voltage Converter

PRECAUTIONS

1. The voltage applied to comparator input pins 6 and 7 should not be allowed to go below ground by more than 0.3 volt.
2. Pins 3 and 5 are open-collector outputs. Shorts between these pins and $+V_{CC}$ can cause overheating and eventual destruction.
3. Reference voltage terminal pin 2 is connected to the emitter of an NPN transistor and is held at approximately 1.9 volts. This terminal should be protected from accidental shorts to ground or supply voltages. Permanent damage may occur if current in pin 2 exceeds 5mA.
4. Avoid stray coupling between 4151 pins 5 and 7, which could cause false triggering. For the circuit of Figure 3, bypass pin 7 to ground with at least 0.01µf. If false triggering is experienced with the precision mode circuits, bypass pin 6 to ground with at least 0.01µf. This is necessary for operation above 10kHz.

PROGRAMMING THE 4151

The 4151 can be programmed to operate with a full scale frequency anywhere from 1.0Hz to 100kHz. In the case of the VFC configuration, nearly any full scale input voltage from 1.0V and up can be tolerated if proper scaling is employed. Here is how to determine component values for any desired full scale frequency.

1. Set $R_S = 14k\Omega$ or use a 12k resistor and 5k pot as shown in the figures. (The only exception to this is Figure 5.)
2. Set $T = 1.1\ R_O C_O = 0.75\left[\frac{1}{fo}\right]$ where fo is the desired full scale frequency. For optimum performance make $6.8k\Omega < R_O < 680k\Omega$ and $0.001\mu f < C_O < 1.0\mu f$.
3. a) For the circuit of Figure 3 make $C_B = 10^{-2}\left[\frac{1}{fo}\right]$ Farads.

   Smaller values of C_B will give faster response time, but will also increase frequency offset and nonlinearity.

   b) For the active integrator circuits make

   $$C_I = 5 \times 10^{-5}\left[\frac{1}{fo}\right] \text{ Farads.}$$

   The op-amp integrator must have a slew rate of at least $135 \times 10^{-6}\left[\frac{1}{C_I}\right]$ volts per second where the value of C_I is again give in Farads.
4. a) For the circuits of Figure 3 and 4 keep the values of R_B and R_B' as shown and use an input attenuator to give the desired full scale input voltage.

   b) For the precision mode circuit of Figure 5, set $R_B = \frac{V_{IO}}{100\mu A}$ where V_{IO} is the full scale input voltage. Alternately the op-amp inverting input (summing node) can be used as a current input with full scale input current $I_{IO} = -100\mu A$.
5. For the FVCs, pick the value of C_B or C_I to give the optimum tradeoff between response time and output ripple for the particular application.

DESIGN EXAMPLE

I. Design a precision VFC (from Figure 5) with fo = 100kHz and $V_{IO} = -10V$.

1. Set $R_S = 14.0k\Omega$.
2. $T = 0.75\left[\frac{1}{10^{-5}}\right] = 7.5\mu sec$

   Let $R_O = 6.8k\Omega$ and $C_O = 0.001\mu f$.
3. $C_I = 5 \times 10^{-5}\left[\frac{1}{10^{-5}}\right] = 500pf.$

   Op-amp slew rate must be at least

   $$SR = 135 \times 10^{-6}\left[\frac{1}{500pf}\right] = 0.27\mu sec$$
4. $R_B = \frac{10V}{100\mu A} = 100k\Omega.$

II. Design a precision VFC with fo = 1Hz and $V_{IO} = -10V$.

1. Let $R_S = 14.0k\Omega$.
2. $T = 0.75\left[\frac{1}{1}\right] = 0.75$ sec.

   Let $R_O = 680k\Omega$ and $C_O = 1.0\mu f$.
3. $C_I = 5 \times 10^{-5}\left[\frac{1}{1}\right] F = 50\mu f.$
4. $R_B = 100k\Omega.$

III. Design a single supply FVC to operate with a supply voltage of 9V and full scale input frequency fo = 83.3Hz. The output voltage must reach at least 0.63 of its final value in 200msec. Determine the output ripple.

1. Set $R_S = 14.0k\Omega$.
2. $T = 0.75\left[\frac{1}{83.3}\right] = 9msec$

   Let $R_O = 82k\Omega$ and $C_O = 0.1\mu f$.
3. Since this FVC must operate from 8.0V, we shall make the full scale output voltage at pin 6 equal to 5.0V.
4. $R_B = \frac{5V}{100\mu A} = 50k\Omega.$
5. Output response time constant is $\tau_R \leqslant 200msec$

   Therefore $C_B \leqslant \frac{\tau_R}{R_B} = \frac{200 \times 10^{-3}}{50 \times 10^{3}} = 4\mu f.$

   Worst case ripple voltage is:

   $$V_R = \frac{9mS \times 135\mu A}{4\mu f} = 304mV.$$

6

RAYTHEON

IV. Design an opto-isolated VFC with high linearity which accepts a full scale input voltage of +10V. See Figure 8 for the final design. This circuit uses the precision mode VFC configuration for maximum linearity. The RC3403A quad op-amp provides the functions of inverter, integrator, regulator, and LED driver.

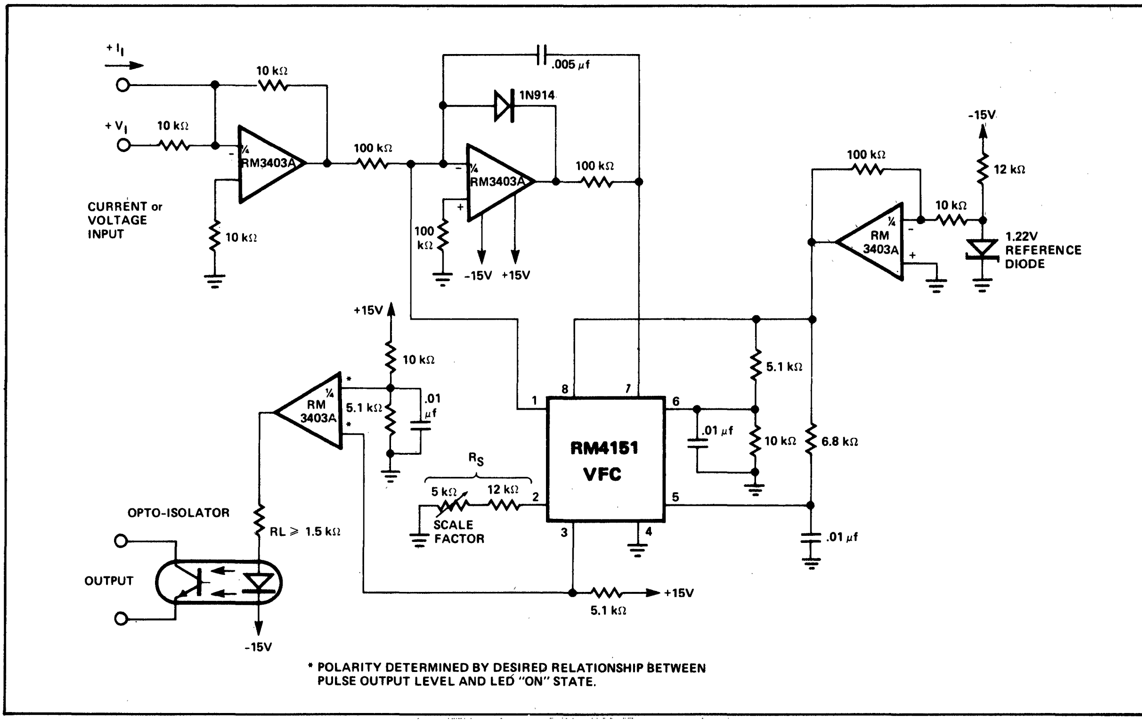


Figure 8. Opto-Isolated VFC

4 x 4 x 2 Balanced Switching Crosspoint Array 4444

GENERAL DESCRIPTION

The RC4444 is a monolithic dielectrically isolated crosspoint array arranged into a 4x4x2 matrix. The primary applications are for balanced switching of 600 ohm transmission lines. The ring and tip are selected by selective biasing of the P+ and P− gate.

Designed to replace reed-relays in telephone switchboards, it does not require a constant gate drive to keep the SCR in the "on" condition. It is several orders faster, with no bouncing, and has a much longer operating life than its mechanical counterpart.

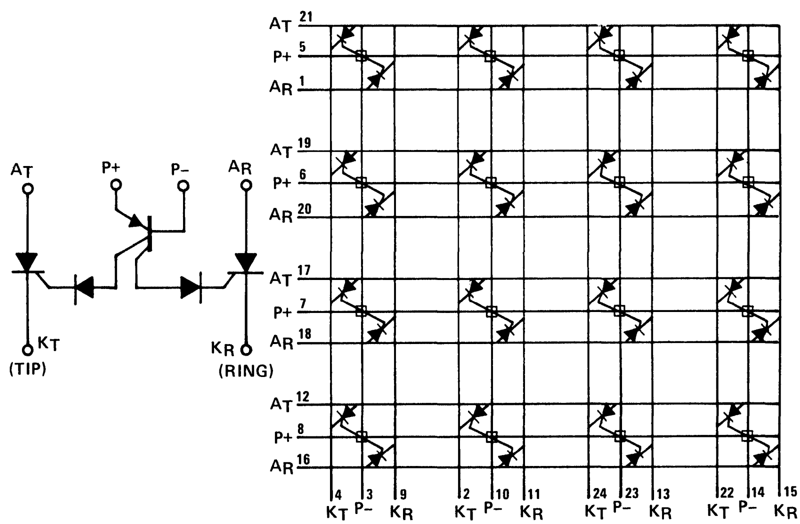
The 16 SCR pairs with the gating system are packaged in a 24 pin dual-in-line package.

The RC4444 is a monolithic pin-for-pin replacement for the MC3416 and MCBH7601.

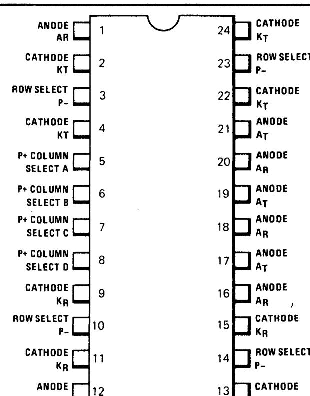
DESIGN FEATURES

- Low Bi-Directional R_{on}
- High R_{off}
- Excellent Matching of Gates
- Low Capacitance
- High Rate Firing
- Predictable Holding Current

SCHEMATIC DIAGRAM



CONNECTION INFORMATION



Order Part No.:
RC4444R

ABSOLUTE MAXIMUM RATINGS

Operating Voltage (Note 1) 25V	Storage Temperature Range . . . . −65°C to +150°C
Internal Power Dissipation (Note 2) 900mW	Operating Temperautre Range . . . . 0°C to +70°C
Operating Current per Crosspoint (Note 2) 100mA	Lead Temperature (Soldering, 60s) . . . . 300°C

ELECTRICAL CHARACTERISTICS (0°C ⩽ T_A ⩽ 70°C unless otherwise noted)

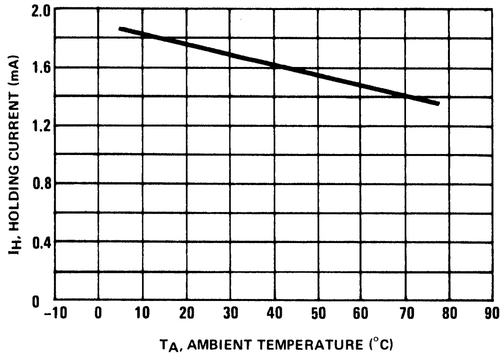
CHARACTERISTIC	SYMBOL	MIN	MAX	UNIT
Anode-Cathode Breakdown Voltage (I_{AK} = 25μA)	BV_{AK}	25	–	Vdc
Cathode-Anode Breakdown Voltage (I_{KA} = 25μA)	BV_{KA}	25	–	Vdc
Base-Cathode Breakdown Voltage (I_{BK} = 25μA)	BV_{BK}	25	–	Vdc
Cathode-Base Breakdown Voltage (I_{KB} = 25μA)	BV_{KB}	25	–	Vdc
Base-Emitter Breakdown Voltage (I_{BE} = 25μA)	BV_{BE}	25	–	Vdc
Emitter-Cathode Breakdown Voltage (I_{EK} = 25μA)	BV_{EK}	25	–	Vdc
OFF State Resistance (V_{AK} = 10V)	r_{off}	100	–	MΩ
Dynamic ON Resistance	r_{on}			Ω
(Center Current = 10mA)		4.0	12	
(Center Current = 20mA)		2.0	10	
Holding Current (See Figure 10)	I_H	0.9	3.8	mA
Enable Current (V_{BE} = 1.5V)	I_{En}	4.0	–	mA
Anode-Cathode ON Voltage	V_{AK}			V
(I_{AK} = 10mA)		–	1.0	
(I_{AK} = 20mA)		–	1.1	
Gate Sharing Current Ratio @ Cathodes (Under Select Conditions with Anodes Open)	G_{Sh}	0.8	1.25	mA/mA
Inhibit Voltage (V_B = 3.0V)	V_{inh}	–	0.3	V
Inhibit Current (V_B = 3.0V)	I_{inh}	–	0.1	mA
OFF State Capacitance (V_{AK} = 0V)	C_{off}	–	2.0	pF
Turn-ON Time	t_{on}	–	1.0	μs
Minimum Voltage Ramp (Which Could Fire the SCR Under Transient Conditions)	dv/dt	800	–	V/μs

NOTES:

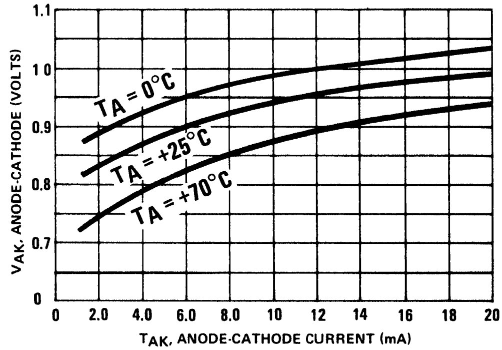
1. Maximum voltage from anode to cathode.
2. Package thermal resistance θ_{JA} typically .055°C/mW. Package power dissipation limited to 900mW.

TYPICAL APPLICATIONS

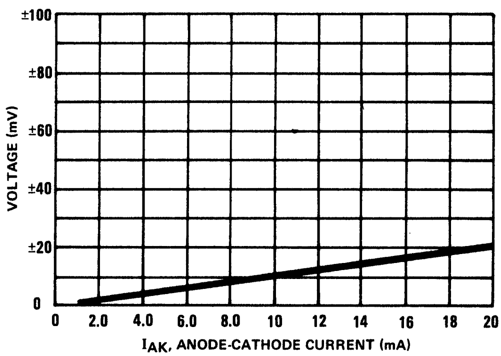
HOLDING CURRENT VERSUS AMBIENT TEMPERAUTRE



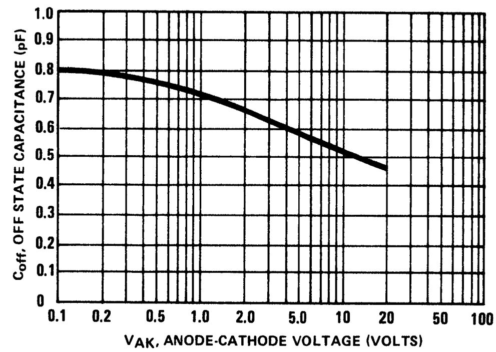
ANODE-CATHODE ON VOLTAGE VERSUS CURRENT AND TEMPERATURE



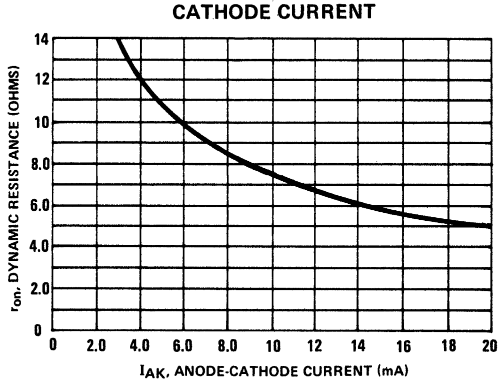
DIFFERENCE IN ANODE-CATHODE ON VOLTAGE (Between Associate Pairs of SCR's) VERSUS ANODE-CATHODE CURRENT



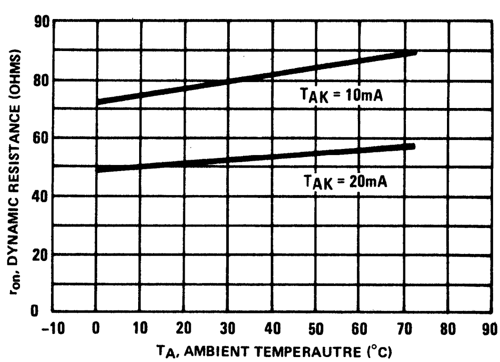
OFF-STATE CAPACITANCE VERSUS ANODE CATHODE VOLTAGE



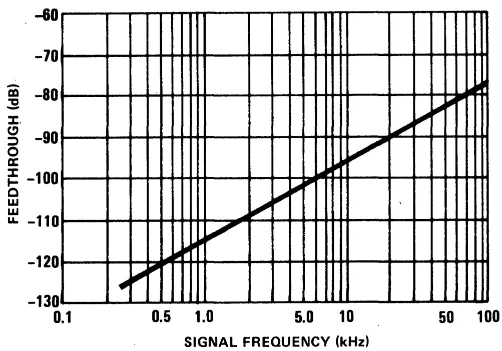
DYNAMIC ON RESISTANCE VERSUS ANODE-CATHODE CURRENT

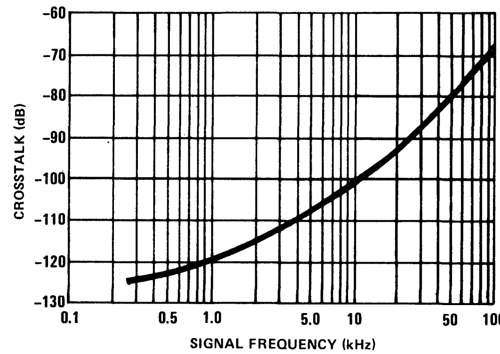


DYNAMIC ON RESISTANCE VERSUS AMBIENT TEMPERATURE

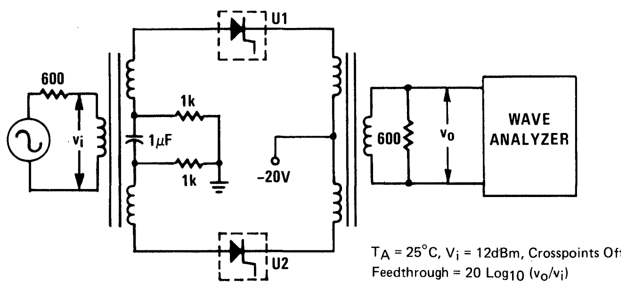


TYPICAL APPLICATIONS



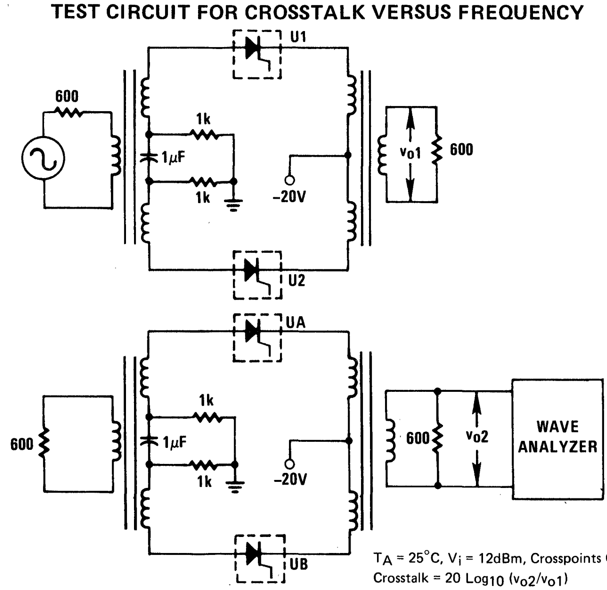


TEST CIRCUIT FOR FEEDTHROUGH VERSUS FREQUENCY



$T_A = 25°C$, V_i = 12dBm, Crosspoints Off
Feedthrough = 20 Log_{10} (v_o/v_i)

TEST CIRCUIT FOR CROSSTALK VERSUS FREQUENCY



$T_A = 25°C$, V_i = 12dBm, Crosspoints On
Crosstalk = 20 Log_{10} (v_{o2}/v_{o1})

SECTION 7

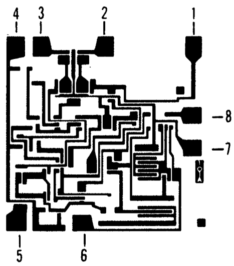
Chips and Beam Lead Products

CONTENTS

7

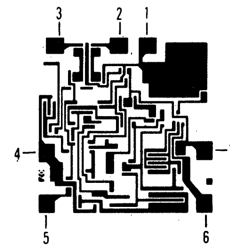
Linear IC Chips

101A GENERAL PURPOSE OPERATIONAL AMPLIFIER
Die Size: 55 x 55 mils.



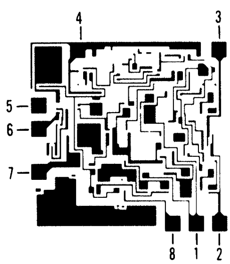
1. COMP/BAL
2. − INPUT
3. + INPUT
4. V⁻
5. BAL
6. OUTPUT
7. V⁺
8. COMP

107 GENERAL PURPOSE OPERATIONAL AMPLIFIER
Die Size: 55 x 55 mils.



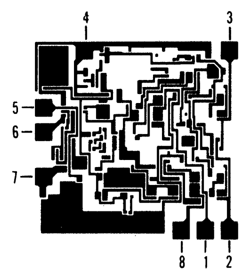
1. NC
2. − INPUT
3. + INPUT
4. V⁻
5. NC
6. OUTPUT
7. V⁺

108 SUPER BETA OPERATIONAL AMPLIFIER
Die Size: 63 x 65 mils.



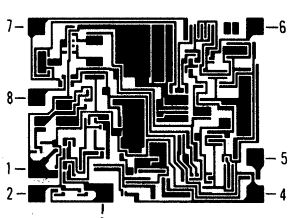
1. COMP
2. − INPUT
3. + INPUT
4. V⁻
5. NC
6. OUTPUT
7. V⁺
8. COMP

112 SUPER BETA OPERATIONAL AMPLIFIER
Die Size: 63 x 65 mils.



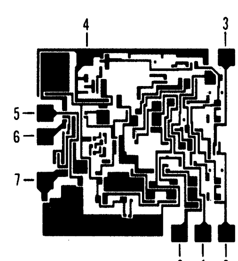
1. BAL
2. − INPUT
3. + INPUT
4. V⁻
5. COMP
6. OUTPUT
7. V⁺
8. BAL

118 HIGH SLEW RATE OPERATIONAL AMPLIFIER
Die Size: 59 x 74 mils.



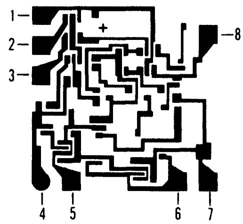
1. BAL/COMP 1
2. − INPUT
3. + INPUT
4. V⁻
5. BAL/COMP 3
6. OUTPUT
7. V⁺
8. COMP 2

216 HIGH INPUT IMPEDANCE OPERATIONAL AMPLIFIER
Die Size: 63 x 65 mils.



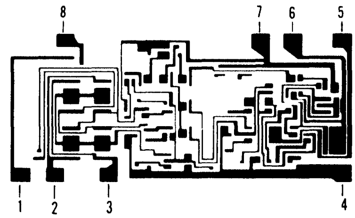
1. BAL
2. − INPUT
3. + INPUT
4. V⁻
5. COMP
6. COMP
7. V⁺
8. BAL

709 GENERAL PURPOSE OPERATIONAL AMPLIFIER
Die Size: 55 x 55 mils.



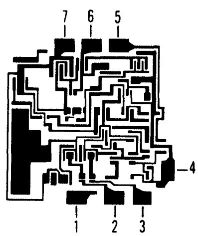
1. INPUT COMP (A)	5. OUTPUT COMP
2. −INPUT	6. OUTPUT
3. +INPUT	7. V^+
4. V^-	**8. INPUT COMP (B)**

725 INSTRUMENTATION OPERATIONAL AMPLIFIER
Die Size: 46 x 98 mils.



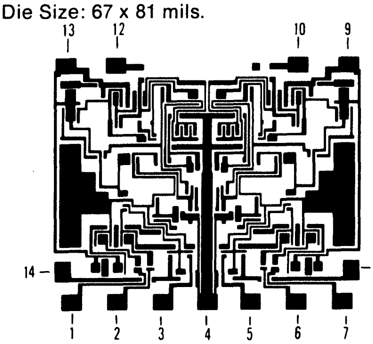
1. BAL	5. COMP
2. −INPUT	6. OUTPUT
3. +INPUT	7. V^+
4. V^-	8. BAL

741 GENERAL PURPOSE OPERATIONAL AMPLIFIER
Die Size: 55 x 55 mils.



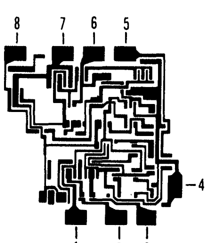
1. BAL	5. BAL
2. −INPUT	6. OUTPUT
3. +INPUT	7. V^+
4. V^-	

747 DUAL 741 OPERATIONAL AMPLIFIER
Die Size: 67 x 81 mils.



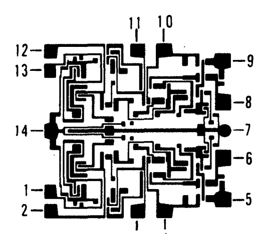
1. -INPUT (A)	**6. +INPUT (B)**	**11. NC**
2. +INPUT (A)	**7. -INPUT (B)**	**12. OUTPUT (A)**
3. BAL (A)	**8. BAL (B)**	**13. V^+ (A)**
4. V^-	**9. V^+ (B)**	**14. BAL (A)**
5. BAL (B)	**10. OUTPUT (B)**	

748 GENERAL PURPOSE OPERATIONAL AMPLIFIER
Die Size: 55 x 55 mils



1. BAL	5. BAL
2. −INPUT	6. OUTPUT
3. +INPUT	7. V^+
4. V	8. COMP

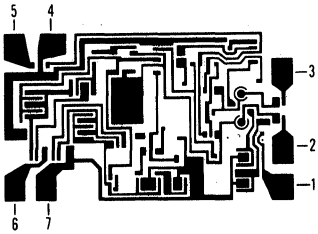
1437/1537 (4709) DUAL 709 OPERATIONAL AMPLIFIERS
Die Size: 75 x 80 mils.



1. OUTPUT LAG 2	6. +INPUT 2	11. INPUT LAG 1
2. OUTPUT 2	7. V^-	12. OUTPUT 1
3. INPUT LAG 2	8. +INPUT 1	13. OUTPUT LAG 2
4. INPUT LAG 2	9. −INPUT 1	14. V^+
5. −INPUT 2	10. INPUT LAG 1	

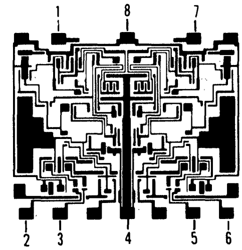
Linear IC Chips

1556A SUPER BETA OPERATIONAL AMPLIFIER
Die Size: 38 x 61 mils.



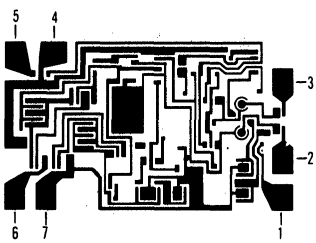
1. BAL
2. – INPUT
3. + INPUT
4. V⁻
5. BAL
6. OUTPUT
7. V⁺

1458/1558 DUAL 741 OPERATIONAL AMPLIFIER
Die Size: 68 x 81 mils.



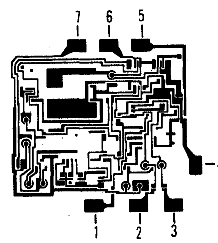
1. OUTPUT (A)
2. -INPUT (A)
3. +INPUT (A)
4. V⁻
5. +INPUT (B)
6. -INPUT (B)
7. OUTPUT (B)
8. V⁺

4131 HIGH-GAIN OPERATIONAL AMPLIFIER
Die Size: 38 x 61 mils.



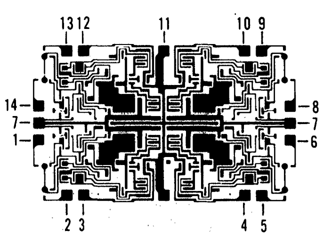
1. BAL
2. – INPUT
3. + INPUT
4. V⁻
5. BAL
6. OUTPUT
7. V⁺

4132 MICROPOWER OPERATIONAL AMPLIFIER
Die Size: 60 x 70 mils.



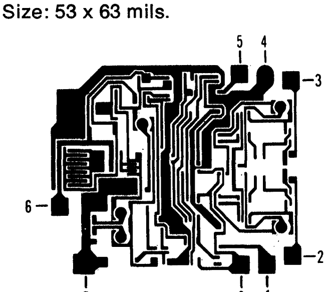
1. BAL
2. – INPUT
3. + INPUT
4. V⁻
5. BAL
6. OUTPUT
7. V⁺

4136 QUAD 741 OPERATIONAL AMPLIFIER
Die Size: 61 x 99 mils.



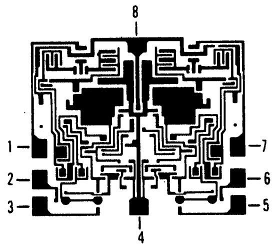
1. – INPUT (A)
2. + INPUT (A)
3. OUTPUT (A)
4. OUTPUT (B)
5. + INPUT (B)
6. – INPUT (B)
7. – V
8. – INPUT (C)
9. + INPUT (C)
10. OUTPUT (C)
11. + V
12. OUTPUT (D)
13. + INPUT (D)
14. – INPUT (D)

4531 HIGH SLEW RATE OPERATIONAL AMPLIFIER
Die Size: 53 x 63 mils.



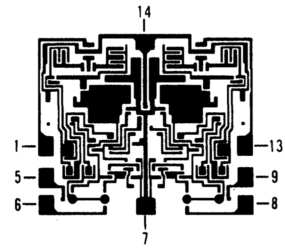
1. BAL
2. – INPUT
3. + INPUT
4. V⁻
5. BAL
6. OUTPUT
7. V⁺
8. COMP

4558 DUAL 741 OPERATIONAL AMPLIFIER
Die Size: 52 x 61 mils.



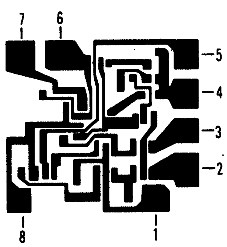
1. OUTPUT (A)
2. -INPUT (A)
3. +INPUT (A)
4. V−
5. +INPUT (B)
6. -INPUT (B)
7. OUTPUT (B)
8. V+

4739 LOW NOISE DUAL OPERATIONAL AMPLIFIER
Die Size: 52 x 61 mils.



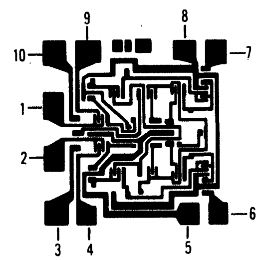
1. OUTPUT (A)
2. NC
3. NC
4. NC
5. +INPUT (A)
6. -INPUT (A)
7. V−
8. -INPUT (B)
9. +INPUT (B)
10. NC
11. NC
12. NC
13. B OUTPUT
14. V+

702 WIDEBAND AMPLIFIER
Die Size: 40 x 44 mils.



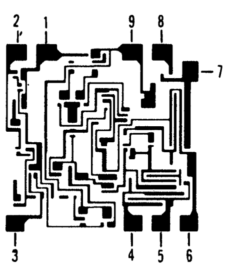
1. GROUND
2. − INPUT
3. + INPUT
4. V−
5. LEAD/COMP
6. LAG/COMP
7. OUTPUT
8. V+

733 VIDEO WIDEBAND AMPLIFIER
Die Size: 47 x 47 mils.



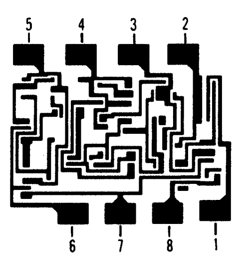
1. INPUT 1
2. INPUT 2
3. G_{2B} GAIN SELECT
4. G_{1B} GAIN SELECT
5. V−
6. OUTPUT 2
7. OUTPUT 1
8. V+
9. G_{1A} GAIN SELECT
10. G_{2A} GAIN SELECT

104 NEGATIVE VOLTAGE REGULATOR
Die Size: 50 x 51 mils.



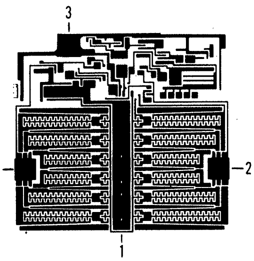
1. ADJ
2. REF
3. REF SUPPLY
4. COMP
5. UNREG INPUT
6. CURRENT LIMIT
7. BOOSTER
8. REG OUTPUT
9. GROUND

105 POSITIVE VOLTAGE REGULATOR
Die Size: 40 x 48 mils.



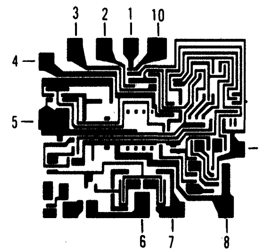
1. CURRENT LIMIT
2. BOOSTER OUTPUT
3. UNREGULATED INPUT
4. GROUND (CASE)
5. REFERENCE BYPASS
6. FEEDBACK
7. COMP SHUTDOWN
8. REGULATED OUTPUT

109 +5 VOLT VOLTAGE REGULATOR
Die Size: 82 x 88 mils.



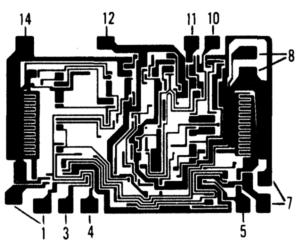
1. INPUT
2. OUTPUT
3. GND

723 PRECISION VOLTAGE REGULATOR
Die Size: 53 x 60 mils.



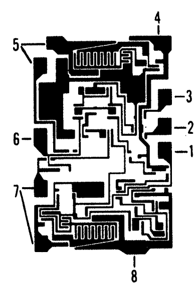
1. CURRENT SENSE
2. −INPUT
3. +INPUT
4. V_{REF}
5. V^-
6. V_{OUT}
7. V_C
8. V^+
9. COMP
10. CURRENT LIMIT

4194 ADJUSTABLE DUAL TRACKING VOLTAGE REGULATOR
Die Size: 66 x 96 mils.



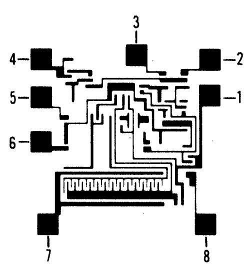
1. V_O^+
2. NC
3. COMP+
4. BAL
5. COMP−
6. NC
7. V^-
8. V_O^-
9. NC
10. R_O
11. R_{SET}
12. GND
13. NC
14. V^+

4195 ±5 VOLT FIXED DUAL TRACKING VOLTAGE REGULATOR
Die Size: 49 x 74 mils.



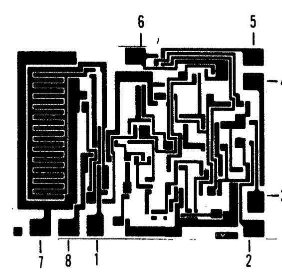
1. COMP+
2. GND
3. COMP−
4. $-V_{IN}$
5. $-15V_{OUT}$
6. BAL
7. $+15V_{OUT}$
8. $+V_{IN}$

106 HIGH SPEED COMPARATOR
Die Size: 49 x 49 mils.



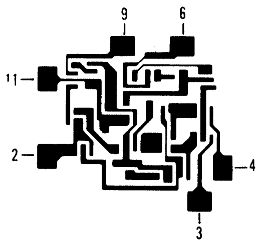
1. GND
2. +INPUT
3. −INPUT
4. V^-
5. STROBE
6. STROBE
7. OUTPUT
8. V^+

111 PRECISION COMPARATOR
Die Size: 52 x 68 mils.



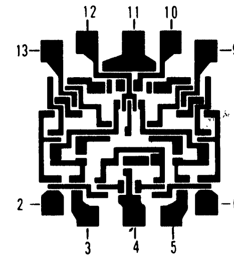
1. GND
2. +INPUT
3. −INPUT
4. V^-
5. BAL
6. BAL/STROBE
7. OUTPUT
8. V^+

710 GENERAL PURPOSE COMPARATOR
Die Size: 39 x 43 mils.



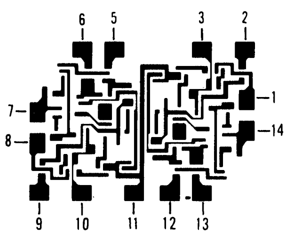
1. NC
2. GND
3. + INPUT
4. − INPUT
5. NC
6. V⁻
7. NC
8. NC
9. V_O
10. NC
11. V⁺

711 DUAL 710 COMPARATOR
Die Size: 46 x 50 mils.



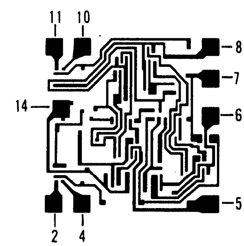
1. NC
2. $-INPUT_1$
3. $+INPUT_1$
4. V⁻
5. $+INPUT_2$
6. $-INPUT_2$
7. NC
8. NC
9. $STROBE_2$
10. OUTPUT
11. V⁺
12. GROUND
13. STROBE 1
14. NC

1514 DUAL 710 COMPARATOR
Die Size: 44 x 60 mils.



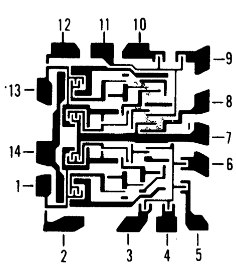
1. OUTPUT (A)
2. STROBE (A)
3. V⁺
4. NC
5. +INPUT (B)
6. -INPUT (B)
7. V⁻
8. OUTPUT (B)
9. STROBE (B)
10. V⁺
11. GND
12. +INPUT (B)
13. -INPUT (A)
14. V⁻

1150 DUAL LINE DRIVER
Die Size: 45 x 45 mils.



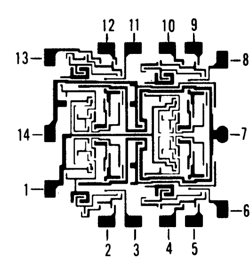
1. NC
2. INPUT (A)
3. NC
4. INPUT (A_1)
5. OUTPUT (A_2)
6. OUTPUT (B)
7. GND
8. -12V
9. NC
10. INPUT (B_1)
11. INPUT (B_2)
12. NC
13. NC
14. +12V

9621 DUAL LINE DRIVER
Die Size: 49 x 53 mils.



1. OUTPUT (A)
2. 105Ω OUTPUT (A)
3. INPUT (A)
4. INPUT (A)
5. INPUT (A)
6. INPUT (A)
7. GND
8. V_{CC2}
9. INPUT (B)
10. INPUT (B)
11. EXTENDER
12. 105Ω OUTPUT (B)
13. OUTPUT (B)
14. V_{CC1}

1488 QUAD LINE DRIVER
Die Size: 68 x 68 mils.

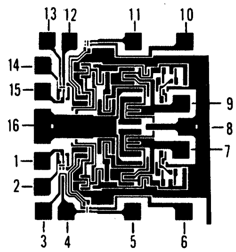


1. V⁻
2. INPUT (A)
3. OUTPUT (A)
4. INPUT (B)
5. INPUT (B)
6. OUTPUT (B)
7. GND
8. OUTPUT (C)
9. INPUT (C)
10. INPUT (C)
11. OUTPUT (D)
12. INPUT (D)
13. INPUT (D)
14. V⁺

7

8T13 DUAL LINE DRIVER

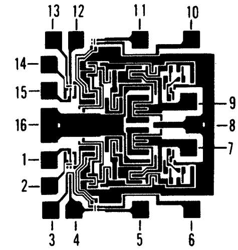
Die Size: 64 x 71 mils.



- 1., 2., 3., 4. — A_1 V_{IN}
- 5., 6. — A_2 V_{IN}
- 7. OUTPUT (A)
- 8. GND
- 9. OUTPUT (B)
- 10., 11., 12., 13. — B_1 V_{IN}
- 14., 15. — B_2 V_{IN}
- 16. V_{CC}

8T23 DUAL LINE DRIVER

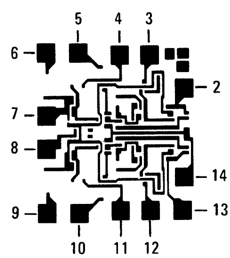
Die Size: 64 x 71 mils.



- 1., 2., 3., 4. — A_1 V_{IN}
- 5., 6. — A_2 V_{IN}
- 7. OUTPUT (A)
- 8. GND
- 9. OUTPUT (B)
- 10., 11., 12., 13. — B_1 V_{IN}
- 14., 15. — B_2 V_{IN}
- 16. V_{CC}

1160 DUAL LINE RECEIVER

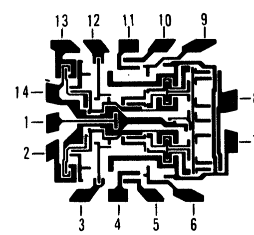
Die Size: 44 x 45 mils.



1. NC
2. OUTPUT (A_1)
3. STROBE (A_2)
4. HYS (A)
5. INPUT (A_1)
6. INPUT (A_2)
7. GND
8. -12V
9. INPUT (B_1)
10. INPUT (B_2)
11. HYS (B)
12. STROBE (B)
13. OUTPUT (B)
14. +5V

9622 DUAL LINE RECEIVER

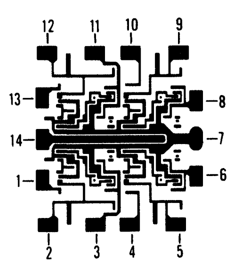
Die Size: 55 x 64 mils.



1. OUTPUT STATES
2. OUTPUT (A)
3. INPUT (A)
4. A^+
5. A^+ 130Ω
6. A^-
7. V^+
8. V^-
9. B^-
10. B^+ 130Ω
11. B^+
12. INPUT (B)
13. OUTPUT (B)
14. GND

1489/1489A QUAD LINE RECEIVERS

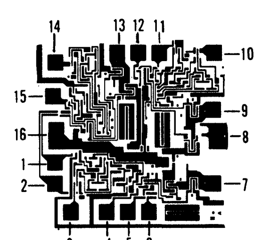
Die Size: 55 x 66 mils.



1. INPUT (A)
2. CONTROL (A)
3. OUTPUT (A)
4. INPUT (B)
5. CONTROL (B)
6. OUTPUT (B)
7. GND
8. OUTPUT (C)
9. CONTROL (C)
10. INPUT (C)
11. OUTPUT (D)
12. CONTROL (D)
13. INPUT (D)
14. OUTPUT (D)

8T14 TRIPLE LINE RECEIVER

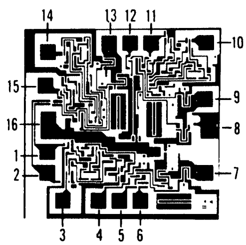
Die Size: 78 x 78 mils.



1. A_3
2. B_3
3. R_1
4. S_1
5. A_1
6. B_1
7. f_1
8. GND
9. f_2
10. R_2
11. S_2
12. A_2
13. f_3
14. R_3
15. S_3
16. V_{CC}

8T24 TRIPLE LINE RECEIVER

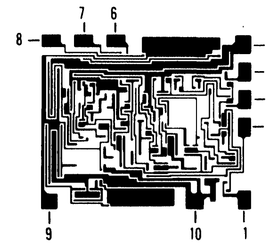
Die Size: 78 x 78 mils.



1. A_3	5. A_1	9. f_2	13. f_3
2. B_3	6. B_1	10. R_2	14. R_3
3. R_1	7. f_1	11. S_2	15. S_3
4. S_1	8. GND	12. A_2	16. V_{CC}

8341 LOW POWER AUDIO AMPLIFIER

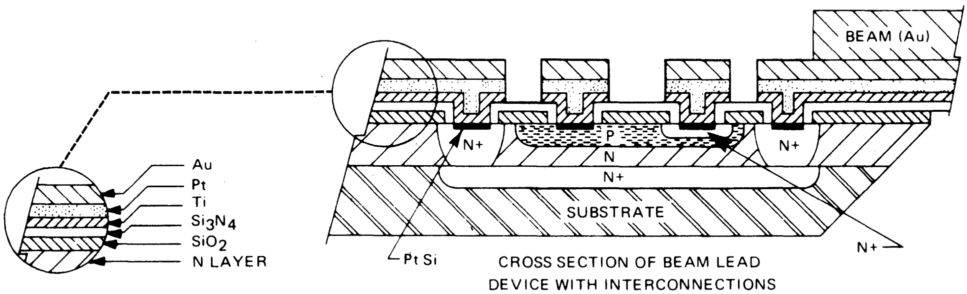
Die Size: 60 x 71 mils.



1. VOL CONTROL	6. AGC LEVEL SELECT
2. MIC BYPASS	7. AGC CONTROL
3. +INPUT	8. GAIN SELECT
4. -INPUT	9. OUTPUT
5. GND	10. V_{CC}

7

Typical Beam Lead Cross Section with Interconnections



CROSS SECTION OF BEAM LEAD DEVICE WITH INTERCONNECTIONS

Ordering Information

Beam Lead Linear IC's may be ordered either as military or commercial grade devices:

RM = $-55°C$ to $+125°C$ operating temperature range, B-level visual.

RC = $0°C$ to $+70°C$, C-level visual.

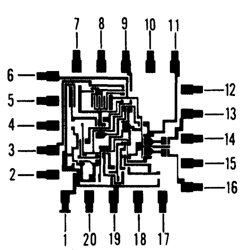
Examples

RM101ABL
- RM: Military Specifications
- 101A: Product Type No.
- BL: Beam Lead Device

RC104BL
- RC: Commercial Specifications
- 104: Product Type No.
- BL: Beam Lead Device

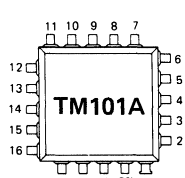
101A GENERAL PURPOSE OPERATIONAL AMPLIFIER
Die Size: 58 x 60 mils.

Order Part Nos.: RM101ABL, RC101ABL



ACTIVE SIDE

Mechanical Outline 16

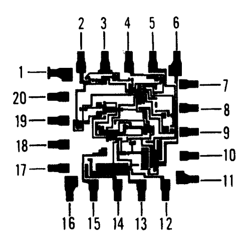


AS BONDED

1. BAL
2. NC
3. OUTPUT
4. NC
5. NC
6. $+V_{CC}$
7. NC
8. NC
9. COMP
10. NC
11. COMP/BAL
12. NC
13. –INPUT
14. NC
15. NC
16. +INPUT
17. NC
18. NC
19. $-V_{CC}$
20. NC

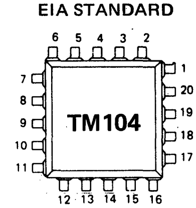
104 NEGATIVE VOLTAGE REGULATOR
Die Size: 55 x 55 mils.

Order Part Nos.: RM104BL, RC104BL



ACTIVE SIDE

Mechanical Outline 15
EIA STANDARD



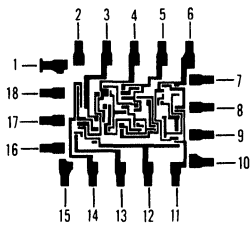
AS BONDED

1. NC
2. OUTPUT VOLTAGE ADJUST
3. REF
4. REF SUPPLY
5. COMP
6. UNREG INPUT
7. NC
8. NC
9. NC
10. NC
11. NC
12. CURRENT LIMIT
13. BOOSTER OUTPUT
14. REG OUTPUT
15. GND
16. NC
17. NC
18. NC
19. NC
20. NC

105 POSITIVE VOLTAGE REGULATOR

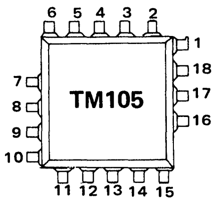
Die Size: 53 x 63 mils.

Order Part Nos.: RM105BL, RC105BL



ACTIVE SIDE

Mechanical Outline 22
EIA STANDARD



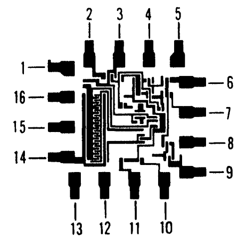
AS BONDED

1. NC
2. NC
3. BOOSTER OUTPUT
4. UNREG INPUT
5. GND
6. BYPASS
7. NC
8. NC
9. NC
10. NC
11. FEEDBACK
12. COMP
13. REG OUTPUT
14. CURRENT LIMIT
15. NC
16. NC
17. NC
18. NC

106 HIGH SPEED COMPARATOR

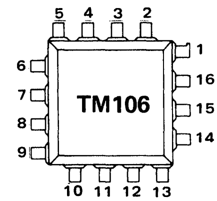
Die Size: 45 x 45 mils.

Order Part Nos.: RM106BL, RC106BL



ACTIVE SIDE

Mechanical Outline 10
EIA STANDARD



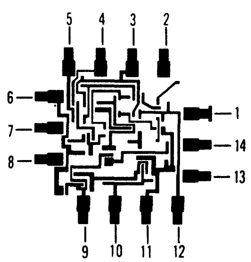
AS BONDED

1. NC
2. $+V_{CC}$
3. GND
4. NC
5. NC
6. +INPUT
7. –INPUT
8. NC
9. $-V_{CC}$
10. STROBE 1
11. STROBE 2
12. NC
13. NC
14. OUTPUT
15. NC
16. NC

709 GENERAL PURPOSE 709A OPERATIONAL AMPLIFIER

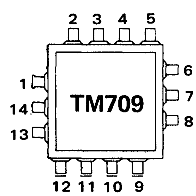
Die Size: 48 x 48

Order Part Nos.: RM709BL, RM709ABL, RC709BL



ACTIVE SIDE

Mechanical Outline 8



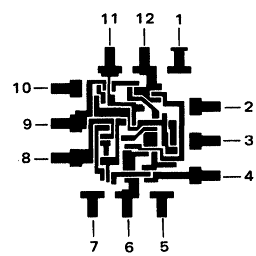
AS BONDED

1. NC
2. NC
3. INPUT COMP
4. –INPUT
5. +INPUT
6. $-V_{CC}$
7. NC
8. NC
9. OUTPUT COMP
10. OUTPUT
11. $+V_{CC}$
12. INPUT COMP
13. NC
14. NC

710 GENERAL PURPOSE COMPARATOR

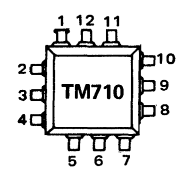
Die Size: 41 x 41 mils.

Order Part Nos.: RM710BL, RM710ABL, RC710BL



ACTIVE SIDE

Mechanical Outline 5



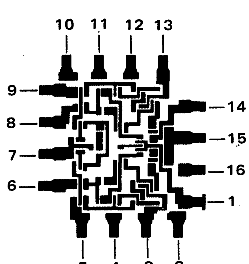
AS BONDED

1. NC
2. NC
3. NC
4. +INPUT
5. NC
6. –INPUT
7. NC
8. $-V_{CC}$
9. OUTPUT
10. NC
11. $+V_{CC}$
12. GND

711 DUAL COMPARATOR

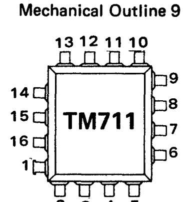
Die Size: 44 x 49 mils.

Order Part Nos.: RM711BL, RC711BL



ACTIVE SIDE

Mechanical Outline 9



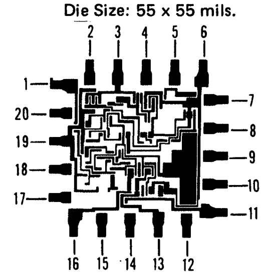
AS BONDED

1. GND
2. NC
3. STROBE 1
4. NC
5. –INPUT (A)
6. +INPUT (A)
7. $-V_{CC}$
8. +INPUT (B)
9. –INPUT (B)
10. NC
11. NC
12. NC
13. STROBE 2
14. OUTPUT
15. $+V_{CC}$
16. NC

1741 GENERAL PURPOSE OPERATIONAL AMPLIFIER

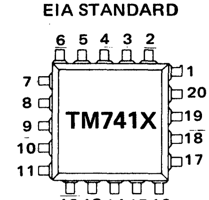
Die Size: 55 x 55 mils.

Order Part Nos.: RM1741BL, RC1741BL



ACTIVE SIDE

Mechanical Outline 15
EIA STANDARD



AS BONDED

1. BALANCE
2. NC
3. OUTPUT
4. NC
5. NC
6. $+V_{CC}$
7. NC
8. NC
9. NC
10. NC
11. BALANCE
12. NC
13. –INPUT
14. NC
15. NC
16. +INPUT
17. NC
18. NC
19. $-V_{CC}$
20. NC

7

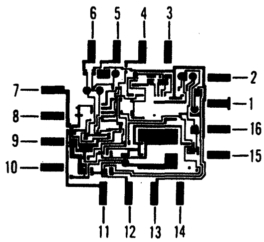
Beam Lead Linear IC's

4132 MICRO POWER OPERATIONAL AMPLIFIER

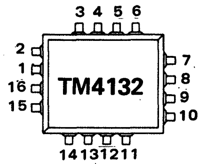
Die Size: 64 x 74 mils.

Order Part Nos.: RM4132BL, RC4132BL

Mechanical Outline 14



ACTIVE SIDE



AS BONDED

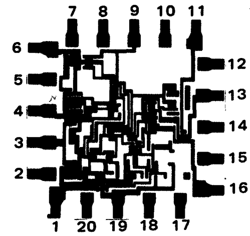
1. NC	5. −INPUT	9. NC	13. V+
2. NC	6. +INPUT	10. NC	14. NC
3. NC	7. $-V_{CC}$	11. BAL	15. NC
4. BAL	8. NC	12. OUTPUT	16. NC

748 OPERATIONAL AMPLIFIER

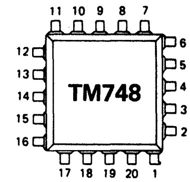
Die Size: 55 x 55

Order Part Nos.: RM748BL, RC748BL

Mechanical Outline 15
EIA STANDARD

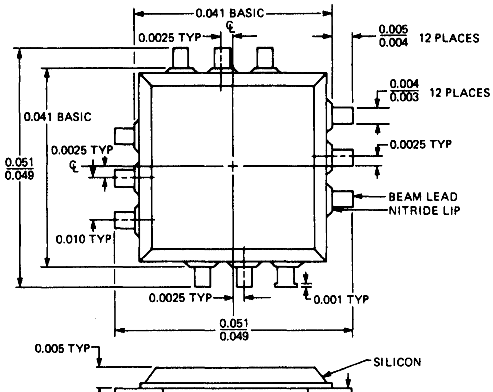


ACTIVE SIDE



AS BONDED

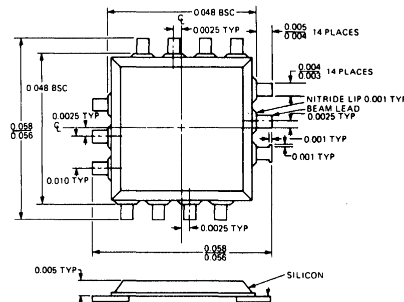
1. BAL	6. $+V_{CC}$	11. BAL	16. +INPUT
2. NC	7. NC	12. NC	17. NC
3. OUTPUT	8. NC	13. −INPUT	18. NC
4. COMP	9. COMP	14. NC	19. $-V_{CC}$
5. NC	10. NC	15. NC	20. NC



12 BEAM CHIP
RAYTHEON STANDARD

NOTE 1 METALIZATION DOWN
2 COUNTER CLOCKWISE BEAM ORDER

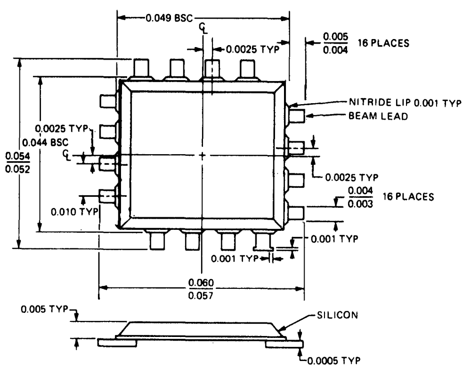
MECHANICAL OUTLINE 5



NOTE 1. METALLIZATION DOWN
2 CLOCKWISE BEAM ORDER

14 BEAM CHIP
RAYTHEON STANDARD

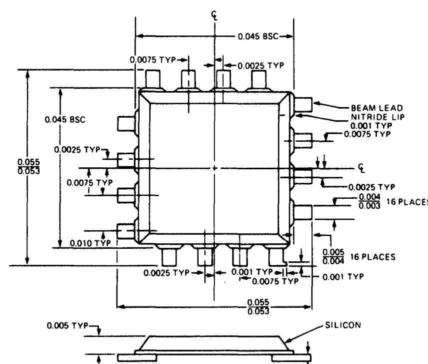
MECHANICAL OUTLINE 8



16 BEAM CHIP
RAYTHEON STANDARD

NOTE: 1. METALIZATION DOWN
2. COUNTER CLOCKWISE BEAM ORDER

MECHANICAL OUTLINE 9



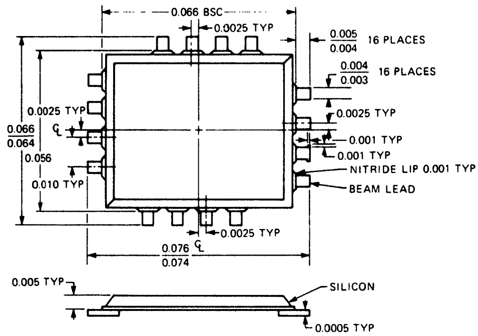
NOTE: 1. METALLIZATION DOWN
2. COUNTER-CLOCKWISE BEAM ORDER

16 BEAM CHIP

EIA STANDARD

MECHANICAL OUTLINE 10

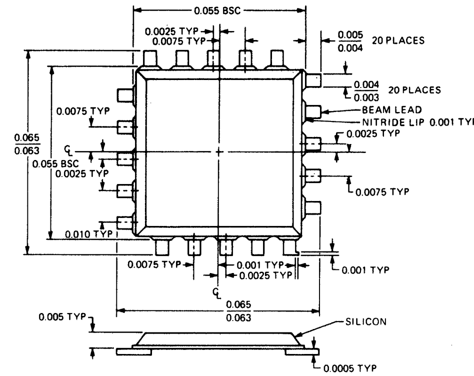
Mechanical Outline Information



16 BEAM CHIP
RAYTHEON STANDARD

NOTE: 1. METALIZATION DOWN
2. CLOCKWISE BEAM ORDER

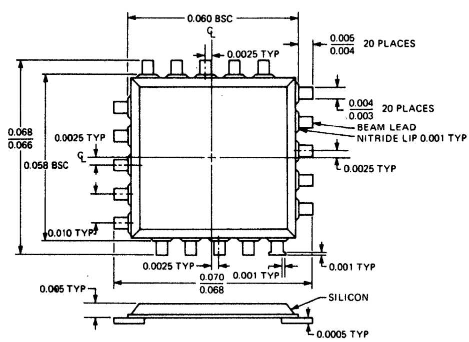
MECHANICAL OUTLINE 14



20 BEAM CHIP
EIA STANDARD

NOTE 1. METALIZATION DOWN
2. COUNTER CLOCKWISE BEAM ORDER

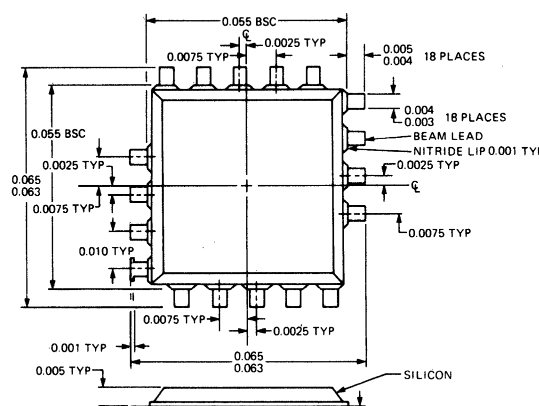
MECHANICAL OUTLINE 15



20 BEAM CHIP
RAYTHEON STANDARD

NOTE: 1. METALIZATION DOWN
2. COUNTER CLOCKWISE BEAM ORDER

MECHANICAL OUTLINE 16



18 BEAM CHIP
EIA STANDARD

NOTE 1 METALIZATION DOWN
2 COUNTER CLOCKWISE BEAM ORDER

MECHANICAL OUTLINE 22

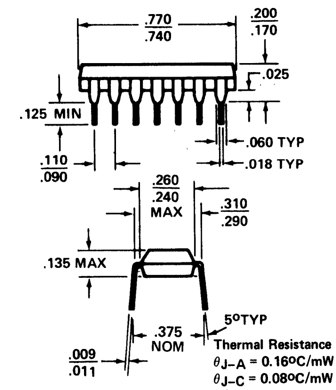
SECTION 8

Appendices

CONTENTS

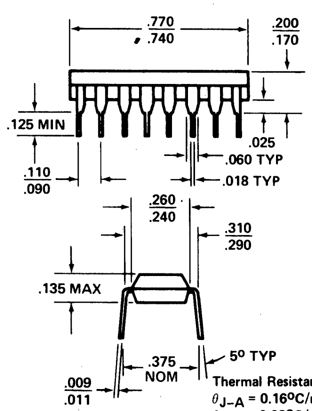
DUAL IN-LINE CERAMIC PACKAGES

14-Pin DB Package



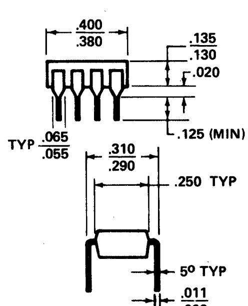
Thermal Resistance
θ_{J-A} = 0.16°C/mW
θ_{J-C} = 0.08°C/mW

16-Pin MP Package



Thermal Resistance
θ_{J-A} = 0.16°C/mW
θ_{J-C} = 0.08°C/mW

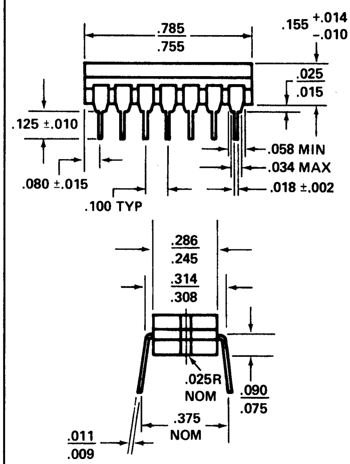
8-Pin DN Package



Thermal Resistance
θ_{J-A} = 0.21°C/mW
θ_{J-C} = 0.08°C/mW

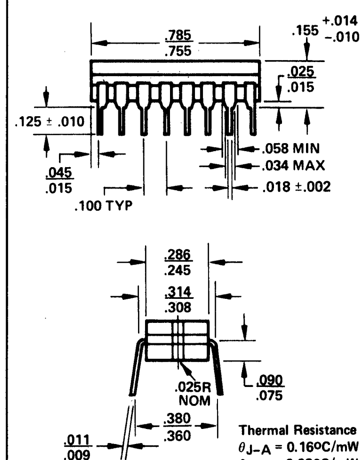
DUAL IN-LINE PLASTIC PACKAGES

14-Pin DC Package



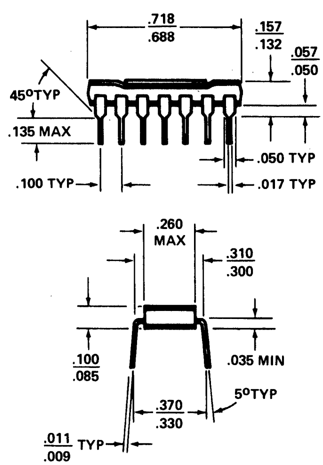
Thermal Resistance
θ_{J-A} = 0.120°C/mW
θ_{J-C} = 0.06°C/mW

16-Pin DD Package



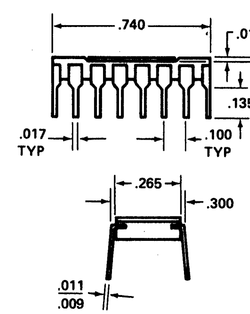
Thermal Resistance
θ_{J-A} = 0.16°C/mW
θ_{J-C} = 0.08°C/mW

14-Pin D Package



Thermal Resistance
θ_{J-A} = 0.128°C/mW
θ_{J-C} = 0.055°C/mW

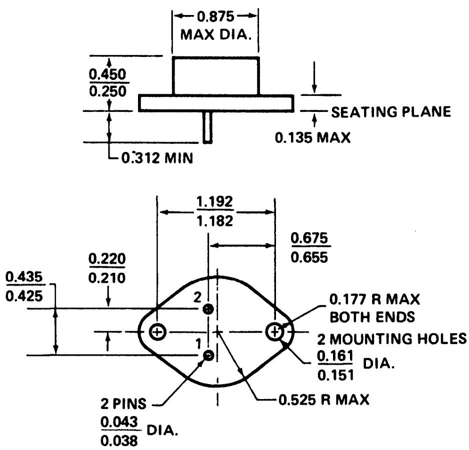
16-Pin M Package



Thermal Resistance
θ_{J-A} = 0.128°C/mW
θ_{J-C} = 0.055°C/mW

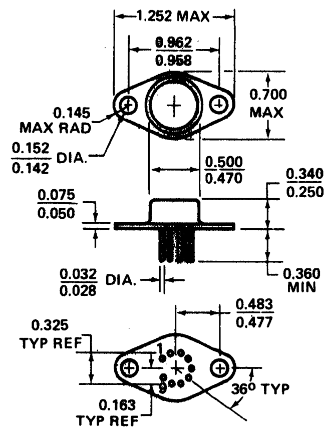
METAL CAN PACKAGES

2-pin LK(TO-3) Package



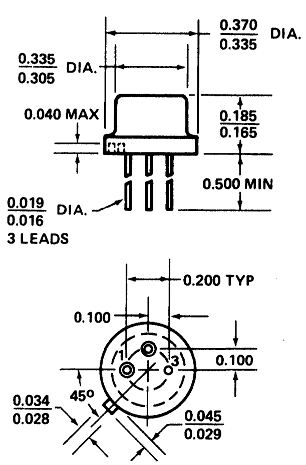
Thermal Resistance
θ_{J-A} = 35°C/W
θ_{J-C} = 3°C/W

10-pin TK(TO-66) Package



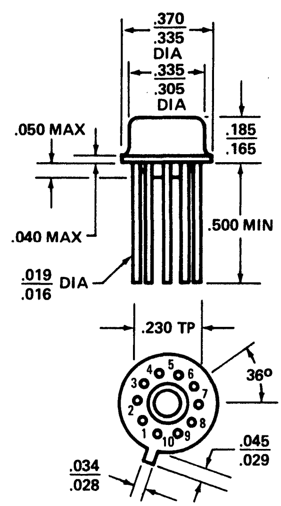
Thermal Resistance
θ_{J-A} = 41.6°C/W
θ_{J-C} = 7.15°C/W

3-pin TH(TO-5) Package



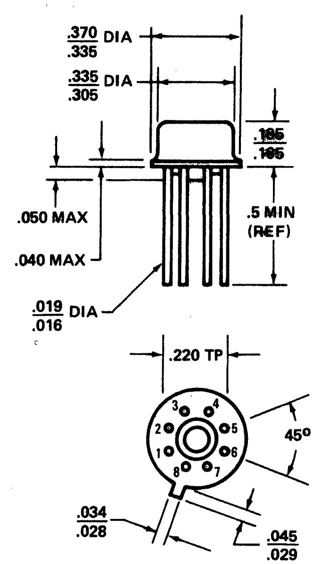
Thermal Resistance
θ_{J-A} = 0.15°C/mW
θ_{J-C} = 0.015°C/mW

10-pin TF(TO-100) Package



Thermal Resistance
θ_{J-A} = 0.150°C/mW
θ_{J-C} = 0.045°C/mW

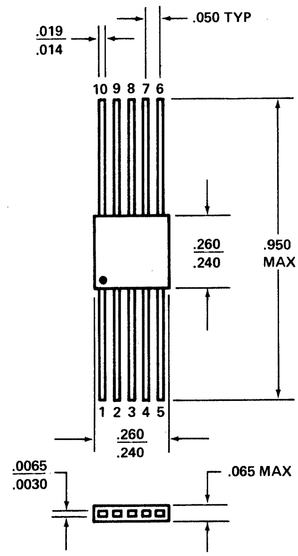
8-pin TE(TO-99) Package



Thermal Resistance
θ_{J-A} = 0.015°C/mW
θ_{J-C} = 0.045°C/mW

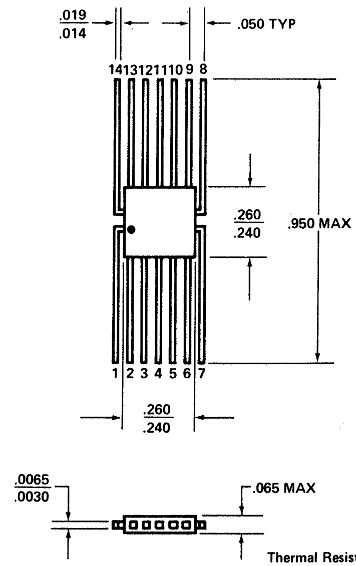
FLAT PACKAGES

10-pin Q(TO-91) Package



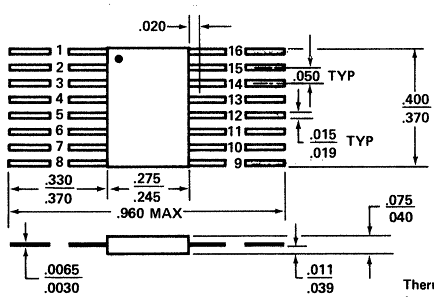
Thermal Resistance
θ_{J-A} = 0.17°C/mW
θ_{J-C} = 0.06°C/mW

14-pin J(TO-86) Package



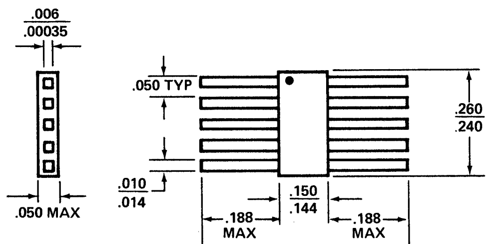
Thermal Resistance
θ_{J-A} = 0.15°C/mW
θ_{J-C} = 0.05°C/mW

16-pin L Package



Thermal Resistance
θ_{J-A} = 0.15°C/mW
θ_{J-C} = 0.05°C/mW

10-pin G Package



OP AMPS

Average Input Offset Current t° Coefficient—Change in input offset current divided by change in ambient temperature producing it.

Average Input Offset Voltage t° Coefficient—Change in input offset voltage divided by change in ambient temperature producing it.

Common-Mode Input Resistance—Resistance looking into both inputs tied together.

Common-Mode Rejection Ratio (CMRR)—Ratio of change of input offset voltage to input common-mode voltage change producing it.

Full Power Bandwidth—Maximum frequency at which full sinewave output might be obtained.

Input Bias Current—Average of the two input currents at zero output voltage. In some cases, input current for either input independently.

Input Capacitance—Capacitance looking into either input terminal with other grounded.

Input Current—Current into an input terminal.

Input Noise Voltage—Square root of mean square narrow-band noise voltage referred to input.

Input Offset Current—Difference in currents into two input terminals with output at zero volts.

Input Offset Voltage—Voltage which must be applied between input terminals to obtain zero output voltage. Input offset voltage may also be defined for case where two equal resistances are inserted in series with input leads.

Input Resistance—Resistance looking into either input terminal with other grounded.

Input Voltage Range—Range of voltages on input terminals for which amplifier operates within specifications. In some cases, input offset specifications apply over input voltage range.

Large-Signal Voltage Gain—Ratio of maximum output voltage swing to change in input voltage required to drive output to this voltage.

Output Resistance—Resistance seen looking into output terminal with output at null. This parameter is defined only under small signal conditions at frequencies above a few hundred cycles to eliminate influence of drift and thermal feedback.

Settling Time—Time between initiation of input step function and time when output voltage has settled to within specified error band of final output voltage.

Output Short-Circuit Current—Maximum output current available from amplifier with output shorted to ground or to either supply.

Output Voltage Swing—Peak output swing, referred to zero, that can be obtained.

Power Consumption—DC power required to operate amplifier with output at zero and with no load current.

Power Supply Rejection Ratio—Ratio of change in input offset voltage to change in supply voltages producing it.

Rise Time—Time required for an output voltage step to change from 10% to 90% of its final value.

Slew Rate—Maximum rate of change of output voltage under large signal condition.

Supply Current—Current required from power supply to operate amplifier with no load and output at zero.

Temperature Stability Of Voltage Gain—Maximum variation of voltage gain over specified temperature range.

Harmonic Distortion—Percentage of harmonic distortion being defined as 100 times ratio of RMS sum of harmonics to fundamental.

% harmonic distortion =

$$\frac{(V_2{}^2 + V_3{}^3 + V_4{}^2 + \ldots)^{1/2}\ (100\%)}{V_I}$$

where V_I is RMS amplitude of fundamental and V_2, V_3, V_4, . . . are RMS amplitudes of individual harmonics.

Transient Response—Closed-loop step-function response of amplifier under small-signal conditions.

Unity Gain Bandwidth—Frequency range from DC to frequency where amplifier open-loop gain rolls off to one.

Voltage Gain—Ratio of output voltage to input voltage under stated conditions for source resistance (R_S) and load resistance (R_L).

Bandwidth—Frequency at which voltage gain is reduced to $1/\sqrt{2}$ times the low frequency value.

Output Impedance—Ratio of output voltage to output current under stated conditions for source resistance (R_S) and load resistance (R_L).

Input Impedance—Ratio of input voltage to input current under stated conditions for source resistance (R_S) and load resistance (R_L).

REGULATORS

Dropout Voltage—Input-output voltage differential at which circuit ceases to regulate against further reductions in input voltage.

Input-Output Voltage Differential—Range of voltage difference between supply voltage and regulated output voltage over which regulator will operate.

Line Regulator—Percentage change in output voltage for a specified change in input voltage.

Load Regulator—Percentage change in output voltage for specified change in load current.

Maximum Power Dissipation—Maximum total device dissipation for which regulator will operate within specifications.

Output Noise Voltage—RMS output noise voltage with constant load and no input ripple.

Glossary of Terms

Output Voltage Range—Range of output voltage over which regulator will operate.

Quiescent Current—Part of input current to regulator that is not delivered to load.

Reference Voltage—Output of reference amplifier measured with respect to negative supply.

Ripple Rejection—Ratio of peak-to-peak input ripple voltage to peak-to-peak output ripple voltage.

Sense Voltage—Voltage between current sense and current limit terminals necessary to cause current limiting.

Short-Circuit Current Limit—Output current of regulator with output shorted to negative supply.

Standby Current Drain—Supply current drawn by regulator with no output load and no reference voltage load.

Temperature Stability—Percentage change in output voltage for thermal variation from room temperature to either temperature extreme.

Long Term Stability—Output voltage stability under accelerated life-test conditions at 125°C with maximum rated voltages and power dissipation for 1000 hours.

Output Voltage Scale Factor—Output voltage obtained for unit value of resistance between adjustment terminal and ground.

Input Voltage Range—Range of DC input voltages over which regulator will operate within specifications.

Current-Limit Sense Voltage—Voltage across current limit terminals required to cause regulator to current-limit with short-circuited output. This voltage is used to determine value of external current-limit resistor when external booster transistors are used.

COMPARATORS/SENSE AMPLIFIERS

Common-Mode Firing Voltage—CM input voltage that exceeds dynamic range of inputs with strobe enabled resulting in output switching states.

Common-Mode Recovery Time—Time from turn off of CM signal to analog input threshold of earliest sense line pulse signal that can be processed normally. Processed normally refers to bi-polar signals greater than or less than input threshold with corresponding proper output.

Equivalent Input Common-Mode Noise Voltage—Change in input offset voltage due to common-mode input noise.

Logic Input High Voltage—Minimum voltage allowed at bit control gate to hold bit off.

Logic Input Low Voltage—Maximum voltage allowed at bit control gate to hold bit on.

Output Sink Current—Maximum negative current that can be delivered by comparator.

Peak Output Current—Maximum current that may flow into output load without causing damage to comparator.

Propagation Delay—Interval between application of an input voltage step and its arrival at either output, measured at 50% of final value.

Response Time—Interval between application of input step function and time when output crosses logic threshold voltage. Input step drives comparator from some initial, saturated input voltage to input level just barely in excess of that required to bring output from saturation to logic threshold voltage overdrive.

Strobe Current—Maximum current drawn by strobe terminals when it is at zero logic level.

Strobe Delay—Time delay measured from strobe to output threshold with signal present exceeding input threshold.

Strobe Release Time—Time required for output to rise to logic threshold voltage after strobe terminal has been driven from zero to one logic level. Appropriate input conditions are assumed.

Strobed Output Level—DC output voltage, independent of input voltage, with voltage on strobe terminal equal to or less than minimum specified amount.

Switching Speed—Time required to turn on least significant bit.

Threshold Uncertainty—With all sense amps sharing same input threshold less uncertainty as "0." This includes unit to unit, power supply and temperature variations.

Threshold Voltage—Typical referred to input voltage which determines whether input is "1" or "0." Signal whose magnitude is greater than threshold level is sensed as logic "1" and signal whose magnitude is less as "0."

Zero Scale Output Current—Output current for all bits turned off.

Supply Current—Current required from positive or negative supply to operate comparator with no output load. Power will vary with input voltage, but is specified as maximum for entire range of input voltage conditions.

Voltage Gain—Ratio of change in output voltage to change in voltage between input terminals producing it.

Differential Input Offset Current—Absolute difference in two input bias currents of one differential input.

Differential Input Overload Recovery Time—Time necessary for device to recover from 2V differential pulse ($t_f = t_r$ = 20ns) prior to strobe enable signal.

Offset Voltage—Difference between absolute values of threshold voltage in positive- and negative-going directions.

Input Bias Current—Average of two input currents.

Input Offset Current—Absolute value of difference between two input currents for which output will be driven higher or lower than specified voltages.

Input Offset Voltage—Absolute value of voltage between input terminals required to make output voltage greater or less than specified voltages.

Input Voltage Range—Range of voltage on input terminals (common-mode) over which offset specifications apply.

Positive Output Level—High output voltage level with given load and input drive equal to or greater than specified value.

Power Consumption—Power required to operate comparator with no output load. Power will vary with signal level, but is specified as maximum for entire range of input signal conditions.

Output Leakage Current—Current into output terminal with output voltage within given range and input drive equal to or greater than given value.

Output Resistance—Resistance seen looking into output terminal with DC output level at logic threshold voltage.

Strobed Output Level—DC output voltage, independent of input conditions, with voltage on strobe terminal equal to or less than specified low state.

Strobe ON Voltage—Maximum voltage on either strobe terminal required to force output to specified high state independent of input voltage.

Differential Input Threshold Voltage—DC input voltage which forces logic output to logic threshold voltage (~1.5V) level.

Input Bias Current—DC current which flows into each input pin with differential input of 0V.

Negative Output Level—Negative DC output voltage with comparator saturated by differential input equal to or greater than specified voltage.

Strobe OFF Voltage—Minimum voltage on strobe terminal that will guarantee that it does not interfere with operation of comparator.

NOTES

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