

INCH-POUND
MIL-M-38510/114B
20 August 2003
SUPERSEDING
MIL-M-38510/114A
09 November 1979

MILITARY SPECIFICATION

MICROCIRCUITS, LINEAR, BI-FET OPERATIONAL AMPLIFIERS, MONOLITHIC SILICON

Reactivated after 20 August 2003 and may be used for either new or existing design acquisitions.
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This specification is approved for use by all Departments and Agencies of the Department of Defense.

The requirements for acquiring the product herein shall consist of this specification sheet and MIL-PRF-38535.

1. SCOPE

1.1 Scope. This specification covers the detail requirements for monolithic silicon, BI-FET operational amplifier microcircuit. Two product assurance classes and a choice of case outlines and lead finishes are provided and are reflected in the complete part number. For this product, the requirements of MIL-M-38510 have been superseded by MIL-PRF-38535, (see 6.3)

1.2 Part number. The part number should be in accordance with MIL-PRF-38535, and as specified herein.

1.2.1 Device types. The device types are internally compensated and should be as follows:

<u>Device type</u>	<u>Circuit</u>
01	Operational amplifier, JFET input, low power
02	Operational amplifier, JFET input, wide band
03	Operational amplifier, JFET input, wide band, undercompensated
04	Operational amplifier, JFET input, low power, low offset
05	Operational amplifier, JFET input, wide band, low offset
06	Operational amplifier, JFET input, wide band, under compensated, low offset

1.2.2 Device class. The device class should be the product assurance level as defined in MIL-PRF-38535.

1.2.3 Case outline. The case outline should be as designated in MIL-STD-1835 and as follows:

<u>Outline letter</u>	<u>Descriptive designator</u>	<u>Terminals</u>	<u>Package style</u>
G	MACY1-X8	8	Can
H	GDFP1-F10 or CDFP2-F10	10	Flat pack
P	GDIP1-T8 or CDIP2-T8	8	Dual-in-line

<p>Comments, suggestions, or questions on this document should be addressed to: Commander, Defense Supply Center Columbus, ATTN: DSCC-VAS, 3990 East Broad St., Columbus, OH 43216-5000, or emailed to linear@dsccl.dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at www.dodssp.daps.mil.</p>

1.3 Absolute maximum ratings.

Supply voltage range	±22 V
Input voltage range	±20 V <u>1/</u>
Differential input voltage range	±40 V
Storage temperature range	-65°C to +150°C
Output short-circuit duration	Unlimited <u>2/</u>
Lead temperature (soldering, 60 seconds)	+300°C.
Junction temperature (T _J)	+175°C <u>3/</u>

1.4 Recommended operating conditions.

Supply voltage range	±5 V dc to ±20 V dc
Ambient operating temperature range (T _A)	-55°C to +125°C

1.5 Power and thermal characteristics.

Case outlines	Maximum allowable power dissipation	Maximum θ_{JC}	Maximum θ_{JA}
G	330 mW at T _A = +125°C	40°C/W	150°C/W
H	330 mW at T _A = +125°C	60°C/W	150°C/W
P	400 mW at T _A = +125°C	35°C/W	120°C/W

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Departments of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-38535 - Integrated Circuits (Microcircuits) Manufacturing, General Specification for.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-883 - Test Method Standard for Microelectronics.
 MIL-STD-1835 - Interface Standard Electronic Component Case Outlines.

(Copies of these documents are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.

2.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein the text of this document shall takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

1/ The absolute maximum negative input voltage is equal to the negative power supply voltage.
2/ Short circuit may be to ground or either supply. Rating applies to +125°C case temperature or +75°C ambient temperature.
3/ For short term test (in the specific burn-in and life test configuration when required and up to 168 hours maximum), T_J = 275°C.

3. REQUIREMENTS

3.1 Qualification. Microcircuits furnished under this specification shall be products that are manufactured by a manufacturer authorized by the qualifying activity for listing on the applicable qualified manufacturers list before contract award (see 4.3 and 6.4).

3.2 Item requirements. The individual item requirements shall be in accordance with MIL-PRF-38535 and as specified herein or as modified in the device manufacturer's Quality Management (QM) plan. The modification in the QM plan shall not affect the form, fit, or function as described herein.

3.3 Design, construction, and physical dimensions. The design, construction, and physical dimensions shall be as specified in MIL-PRF-38535 and herein.

3.3.1 Terminal connections. The terminal connections shall be as specified on figure 1.

3.3.2 Schematic circuits. The schematic circuits shall be maintained by the manufacturer and made available to the qualifying activity and the preparing activity (DSCC-VA) upon request.

3.3.3 Case outlines. The case outlines shall be as specified in 1.2.3.

3.4 Lead material and finish. The lead material and finish shall be in accordance with MIL-PRF-38535 (see 6.6).

3.5 Electrical performance characteristics. The electrical performance characteristics are as specified in table I, and apply over the full recommended ambient operating temperature range, unless otherwise specified.

3.5.1 Offset null circuits. The nulling inputs shall be capable of being nulled 1 mV beyond the specified offset voltage limits for $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$ using the circuit of figure 2.

3.5.2 Instability oscillations. The devices shall be free of oscillations when operated in the test circuits of this specification.

3.6 Rebonding. Rebonding shall be in accordance with MIL-PRF-38535.

3.7 Electrical test requirements. Electrical test requirements for each device class shall be the subgroups specified in table II. The electrical tests for each subgroup are described in table III.

3.8 Marking. Marking shall be in accordance with MIL-PRF-38535.

3.9 Microcircuit group assignment. The devices covered by this specification shall be in microcircuit group number 49 (see MIL-PRF-38535, appendix A).

TABLE I. Electrical performance characteristics.

Test	Symbol	Conditions -55°C ≤ T _A ≤ +125°C unless otherwise specified See figure 3	Group A subgroups	Device type	Limits		Unit
					Min	Max	
Input offset voltage	V _{IO}	±V _{CC} = ±5 V, V _{CM} = 0 V	1	01,02, 03	-5	5	mV
				04,05, 06	-2	2	
		±V _{CC} = ±20 V, V _{CM} = ±15 V, 0 V	2,3	01,02, 03	-7	7	
				04,05, 06	-2.5	2.5	
Input offset voltage temperature sensitivity	ΔV _{IO} / ΔT	±V _{CC} = ±20 V, V _{CM} = 0 V	1,2,3	01,02, 03	-30	30	μV/°C
				04,05, 06	-10	10	
Input offset current	I _{IO}	±V _{CC} = ±20 V, V _{CM} = 0 V	T _J = +25°C	All	-20	20	pA
			T _J = +125°C		-20	20	nA
Input bias current <u>1/ 2/</u>	+I _{IB}	±V _{CC} = ±20 V, V _{CM} = +15 V, t ≤ 25 ms	T _J = +25°C	All	-100	3500	pA
			T _J = +125°C		-10	60	nA
	<u>3/</u> -I _{IB}	±V _{CC} = ±15 V, V _{CM} = +10 V, t ≤ 25 ms	T _J = +25°C	All	-100	300	pA
			T _J = +125°C		-10	50	nA
		±V _{CC} = ±20 V, -15 V ≤ V _{CM} ≤ 0 V, t ≤ 25 ms	T _J = +25°C	All	-100	100	pA
			T _J = +125°C		-10	50	nA
Power supply rejection ratio	+PSRR	+V _{CC} = 10 V, -V _{CC} = -20 V	1,2,3	All	85		dB
	-PSRR	+V _{CC} = 20 V, -V _{CC} = -10 V			85		
Input voltage common mode rejection <u>4/</u>	CMR	±V _{CC} = ±20 V, V _{IN} = ±15 V	1,2,3	All	85		dB
Adjustment for input offset voltage	V _{IO} ADJ(+)	±V _{CC} = ±20 V	1,2,3	All	+8		mV
	V _{IO} ADJ(-)					-8	
Output short circuit current (for positive output) <u>5/</u>	I _{OS} (+)	±V _{CC} = ±15 V, t ≤ 25 ms, (short circuit to ground)	1,2,3	All	-50		mA

See footnotes at end of table.

TABLE I. Electrical performance characteristics – Continued.

Test	Symbol	Conditions -55°C ≤ T _A ≤ +125°C unless otherwise specified See figure 3	Group A subgroups	Device type	Limits		Unit
					Min	Max	
Output short circuit current (for negative output) <u>5/</u>	I _{OS(-)}	±V _{CC} = ±15 V, t ≤ 25 ms, (short circuit to ground)	1,2,3	All		50	mA
Supply current	I _{CC}	±V _{CC} = ±15 V	1,2	01,04		4	mA
				02,03, 05,06		7	
			3	01,04		6	
				02,03, 05,06		11	
Output voltage swing (maximum)	V _{OP}	±V _{CC} = ±20 V, R _L = 10 kΩ	1,2,3	All	±16		V
		±V _{CC} = ±20 V, R _L = 2 kΩ			±15		
Open loop voltage gain (single ended) <u>6/</u>	A _{VS(+)}	±V _{CC} = ±20 V, R _L = 2 kΩ,	1	All	50		V/mV
	A _{VS(-)}	V _{OUT} = ±15 V	2,3		25		
Open loop voltage gain (single ended) <u>6/</u>	A _{VS}	±V _{CC} = ±5 V, R _L = 2 kΩ, V _{OUT} = ±2 V	1	All	10		V/mV
Transient response, rise time	T _{R(tr)}	±V _{CC} = ±15 V, R _L = 2 kΩ, C _L = 100 pF, V _{IN} = 50 mV, AV = 1, see figure 4	4,5,6	01,04		150	ns
				02,05		100	
		±V _{CC} = ±15 V, R _L = 2 kΩ, C _L = 100 pF, V _{IN} = 50 mV, AV = 5, see figure 4		03,06		450	
Transient response, overshoot	T _{R(os)}	±V _{CC} = ±15 V, R _L = 2 kΩ, C _L = 100 pF, V _{IN} = 50 mV, AV = 1, see figure 4		01,02, 04,05		40	%
		±V _{CC} = ±15 V, R _L = 2 kΩ, C _L = 100 pF, V _{IN} = 50 mV, AV = 5, see figure 4		03,06		25	

See footnotes at end of table.

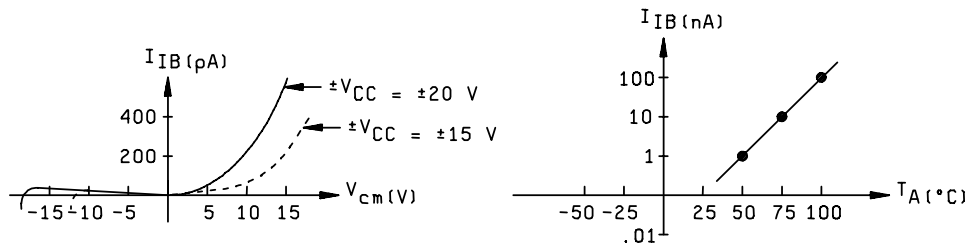
TABLE I. Electrical performance characteristics – Continued.

Test	Symbol	Conditions -55°C ≤ T _A ≤ +125°C unless otherwise specified See figure 3	Group A subgroups	Device type	Limits		Unit	
					Min	Max		
Slew rate	SR(+) and SR(-)	V _{IN} = ±5 V, ±V _{CC} = ±15 V, AV = 1, see figure 4	1	01	2		V/μs	
				02	7.5			
				04	3			
				05	10			
			2,3	01	1			
				02	5			
				04	1.5			
				05	7			
			1	V _{IN} = ±5 V, ±V _{CC} = ±15 V, AV = 5, see figure 4	03	30		
					06	40		
2,3	03	20						
	06	25						
Settling time	ts(+) and ts(-)	±V _{CC} = ±15 V, (0.1% error) T _A = +25°C, AV = -1, see figure 5	9	01,04		4000	ns	
				02,05		1500		
				03,06		800		
Noise (referred to input) broadband	N _I (BB)	±V _{CC} = ±20 V, bandwidth = 5 kHz	9	All		10	μVrms	
Noise (referred to input) popcorn	N _I (PC)	±V _{CC} = ±20 V, bandwidth = 5 kHz	9	All		80	μVpk	

See footnotes at end of table.

TABLE I. Electrical performance characteristics – Continued.

- 1/ Bias currents are actually junction leakage currents which double (approximately) for each 10°C increase in junction temperature (T_J). Measurement of bias current is specified at T_J rather than T_A , since normal warm up thermal transients will affect the bias currents. The measurements for bias currents must be made within 25 ms or 5 loop time constants, whichever is greater after power is first applied to the device for test. Measurement at $T_A = -55^\circ\text{C}$ is not necessary since expected values are too small for typical test systems.
- 2/ Bias current is sensitive to power supply voltage, common mode voltage and temperature as shown by the following typical curves:



- 3/ Negative I_{IB} minimum limits reflect the characteristics of device with bias current compensation.
- 4/ CMR is calculated from V_{IO} measurements at $V_{CM} = +15$ V and -15 V.
- 5/ Continuous limits shall be considerably lower. Protection for shorts to either supply exists providing that $T_J(\text{max}) \leq 175^\circ\text{C}$.
- 6/ Because of thermal feedback effects from output to input, open loop gain is not guaranteed to be linear or positive over the operating range. These requirements, if needed, should be specified by the user in additional procurement documents.

TABLE II. Electrical test requirements.

MIL-PRF-38535 test requirements	Subgroups (see table III)	
	Class S devices	Class B devices
Interim electrical parameters	1	1
Final electrical test parameters	1*, 2, 3, 4	1*, 2, 3, 4
Group A test requirements	1, 2, 3, 4, 5, 6, 7, 8, 12	1, 2, 3, 4, 5, 6, 7
Group B electrical test parameters when using the method 5005 QCI option	1, 2, 3 and table IV delta limits	N/A
Group C end-point electrical parameters	1, 2, 3 and table IV delta limits	1 and table IV delta limits
Additional electrical subgroups for Group C periodic inspections	N/A	8, 12
Group D end-point electrical parameters	1, 2, 3	1

*PDA applies to subgroup 1.

4. VERIFICATION.

4.1 Sampling and inspection. Sampling and inspection procedures shall be in accordance with MIL-PRF-38535 or as modified in the device manufacturer's Quality Management (QM) plan. The modification in the QM plan shall not effect the form, fit, or function as function as described herein.

4.2 Screening. Screening shall be in accordance with MIL-PRF-38535, and shall be conducted on all devices prior to qualification and quality conformance inspection. The following additional criteria shall apply:

- a. The burn-in test duration, test condition, and test temperature, or approved alternatives shall be as specified in the device manufacturer's QM plan in accordance with MIL-PRF-38535. The burn-in test circuit shall be maintained under document control by the device manufacturer's Technology Review Board (TRB) in accordance with MIL-PRF-38535 and shall be made available to the acquiring or preparing activity upon request. The test circuit shall specify the inputs, outputs, biases, and power dissipation, as applicable, in accordance with the intent specified in test method 1015 of MIL-STD-883.
- b. Interim and final electrical test parameters shall be as specified in table II, except interim electrical parameters test prior to burn-in is optional at the discretion of the manufacturer.
- c. Additional screening for space level product shall be as specified in MIL-PRF-38535.

NOTE: If accelerated high-temperature test conditions are used, the device manufacturer shall ensure that at least 85 percent of the applied voltage is dropped across the device at temperature. The device is not considered functional under accelerated test conditions.

4.3 Qualification inspection. Qualification inspection shall be in accordance with MIL-PRF-38535.

4.4 Technology Conformance inspection (TCI). Technology conformance inspection shall be in accordance with MIL-PRF-38535 and herein for groups A, B, C, and D inspections (see 4.4.1 through 4.4.4).

4.4.1 Group A inspection. Group A inspection shall be in accordance with table III of MIL-PRF-38535 and as follows:

- a. Tests shall be as specified in table II herein.
- b. Subgroups 9, 10, and 11 shall be omitted.
- c. Subgroup 12 shall be added to group A inspection for class S devices only as shown in table III herein. The sample size series number for subgroup 12 shall be 5.

4.4.2 Group B inspection. Group B inspection shall be in accordance with table II of MIL-PRF-38535.

4.4.3 Group C inspection. Group C inspection shall be in accordance with table III of MIL-PRF-38535 and as follows:

- a. End point electrical parameters shall be as specified in table II herein. Delta limits shall apply only to subgroup 1 of group C inspection for class B devices.
- b. The steady-state life test duration, test condition, and test temperature, or approved alternatives shall be as specified in the device manufacturer's QM plan in accordance with MIL-PRF-38535. The burn-in test circuit shall be maintained under document control by the device manufacturer's Technology Review Board (TRB) in accordance with MIL-PRF-38535 and shall be made available to the acquiring or preparing activity upon request. The test circuit shall specify the inputs, outputs, biases, and power dissipation, as applicable, in accordance with the intent specified in test method 1005 of MIL-STD-883.
- c. Subgroup 3 and 4 shall be added to group C inspection and shall consist of group A, subgroup 8 and 12, as specified in table III herein. The sample size series number for subgroup 3 shall be 10 for class B; the sample size series number for subgroup 4 shall be 5 for class B.

4.4.4 Group D inspection. Group D inspection shall be in accordance with table IV of MIL-PRF-38535. End point electrical parameters shall be as specified in table II herein.

4.5 Methods of inspection. Methods of inspection shall be specified and as follows.

4.5.1 Voltage and current. All voltage values given, except the input offset voltage (or differential voltage) are referenced to the external zero reference level of the supply voltage. Currents given are conventional current and positive when flowing into the referenced terminal.

4.5.2 Life test cooldown procedure. When devices are measured at +25°C following application of the operating life or burn-in test condition, they shall be cooled to room temperature prior to removal of the bias.

DEVICE TYPES 01,02,03,04,05, AND 06

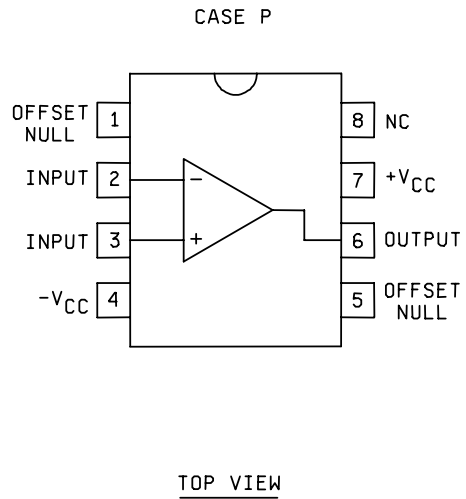
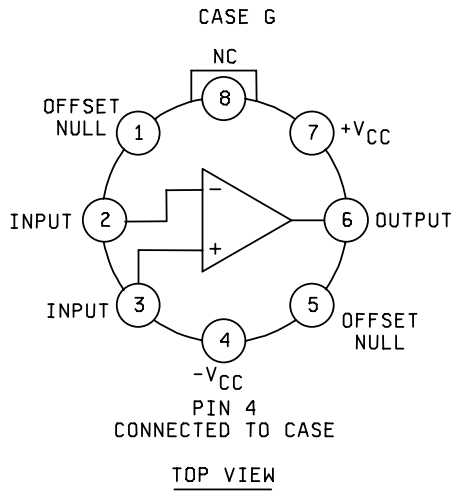


Figure 1. Terminal connections.

DEVICE TYPES 01,02,03,04,05, AND 06

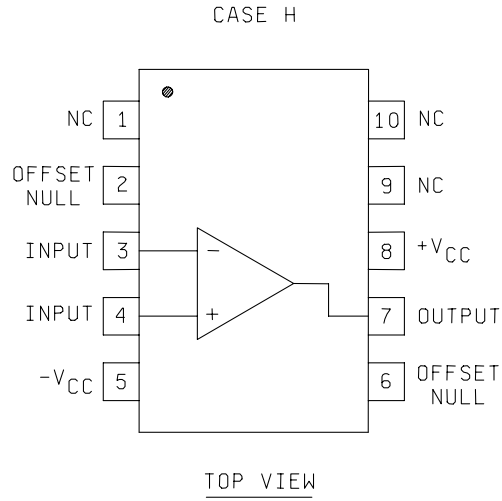


Figure 1. Terminal connections – Continued.

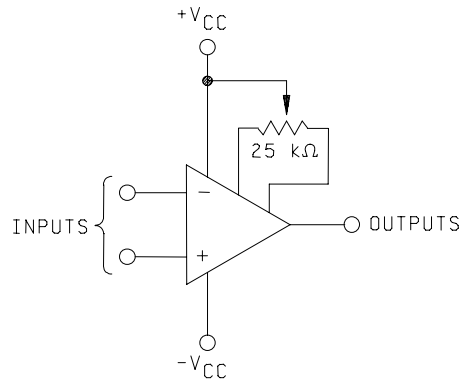
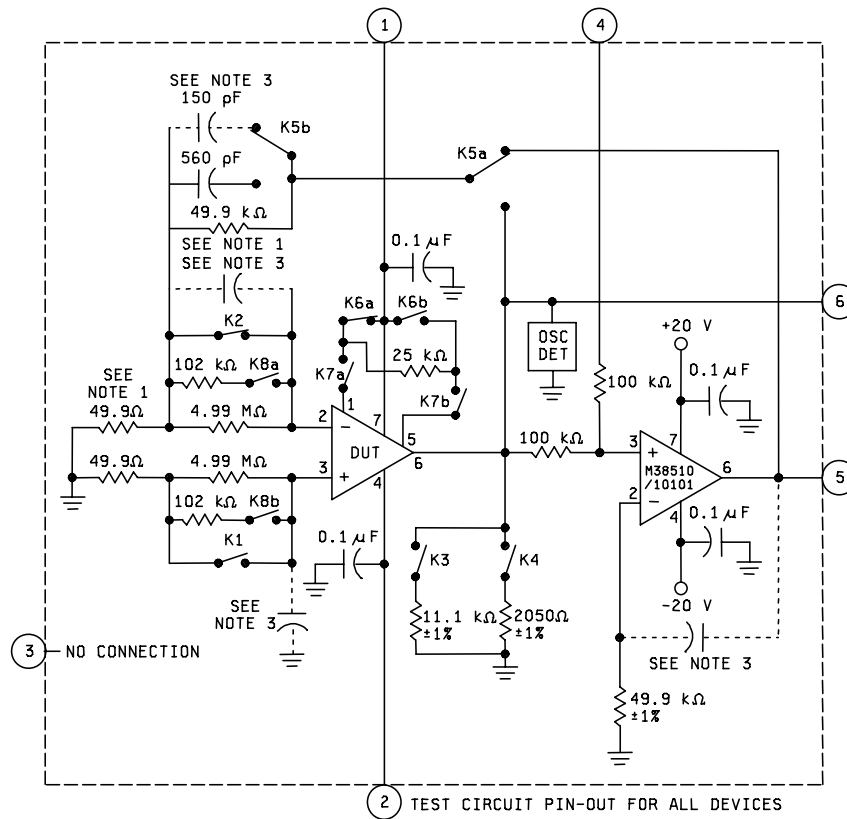


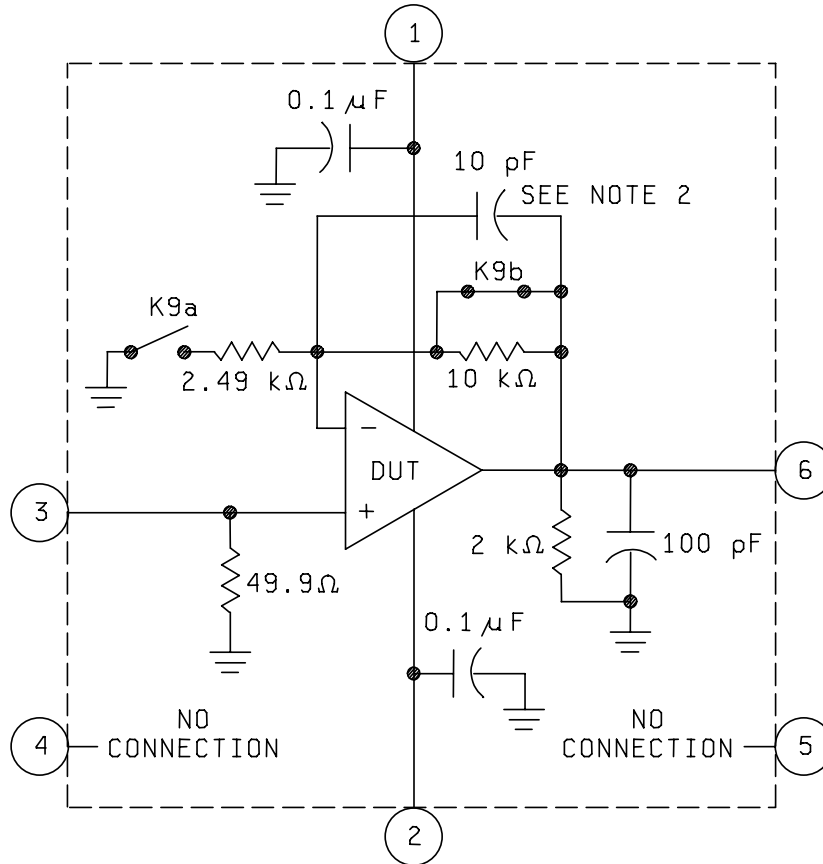
Figure 2. Offset null circuit.



NOTES:

1. All resistors are $\pm 0.1\%$ tolerance and all capacitors are $\pm 10\%$ tolerance unless otherwise specified.
2. Precautions shall be taken to prevent damage to the device under test during insertion into socket and change of state of relays (i.e. disable voltage supplies, current limit $\pm V_{CC}$, etc).
3. Compensation capacitors should be added as required for test circuit stability. Two general methods for stability compensation exist. One method is with a capacitor for nulling amp feedback. The other method is with a capacitor in parallel with the 49.9 kΩ closed loop feedback resistor. Both methods should not be used simultaneously. Proper wiring procedures shall be followed to prevent unwanted coupling and oscillations, etc. Loop response and settling time shall be consistent with the test rate such that any value has settled for at least 5 loop time constants before the value is measured.
4. Adequate settling time should be allowed such that each parameter has settled to within 5% of its final value.
5. All relays are shown in the normal de-energized state.
6. The nulling amplifier shall be a M38510/10101XXX. Saturation of the nulling amplifier is not allowed on tests where E (pin 5) value is measured.
7. The load resistors 2050 Ω and 11.1 kΩ yield effective load resistances of 2 kΩ and 10 kΩ respectively.
8. Any oscillation greater than 300 mV in amplitude (peak-to-peak) shall be cause for device failure.

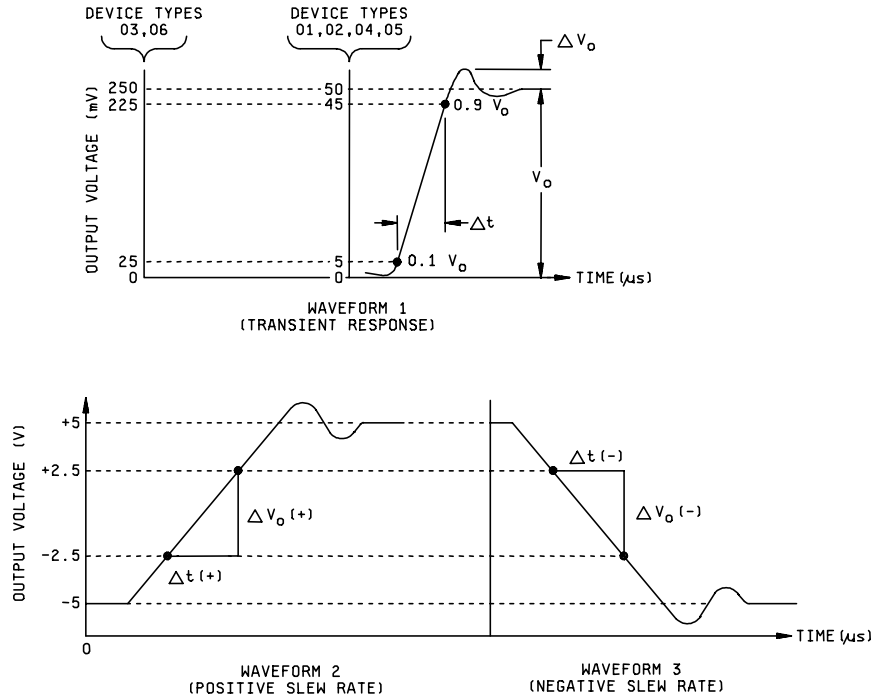
FIGURE 3. Test circuit for static tests.



Notes:

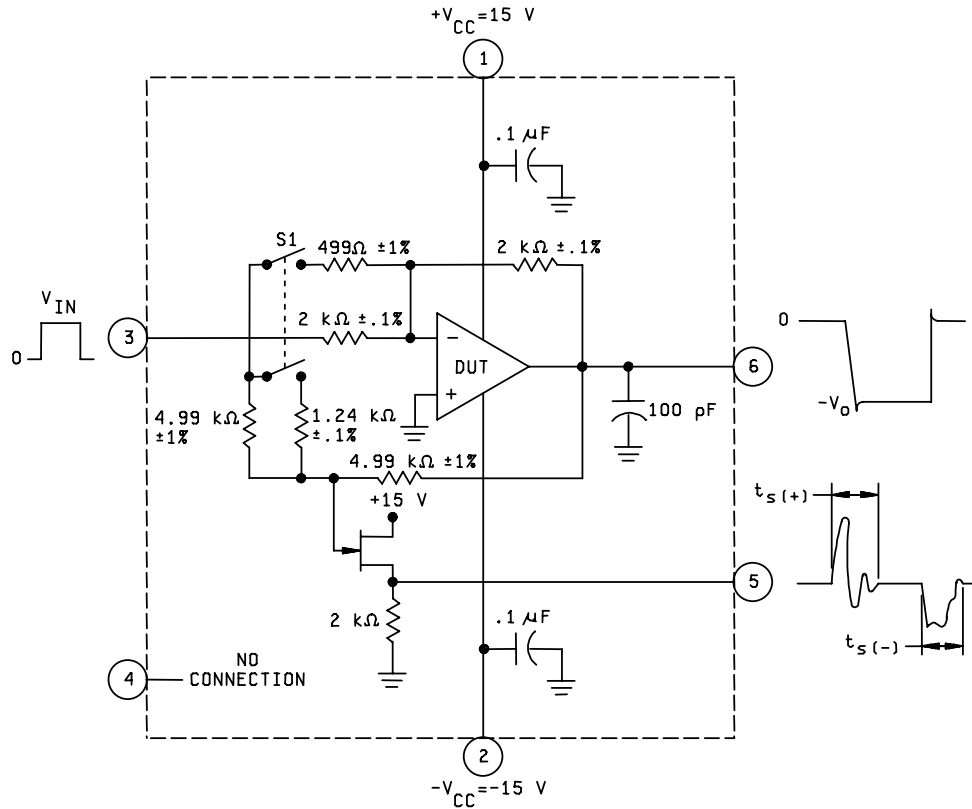
1. Resistors are $\pm 1.0\%$ tolerance and capacitors are $\pm 10\%$ tolerance.
2. This capacitance includes the actual measured value with stray and wire capacitance.
3. Precaution shall be taken to prevent damage to the device under test during insertion into socket and in applying power.
4. Pulse input and output characteristics are shown on the next page.

FIGURE 4. Test circuit for transient response and slew rate.



Parameter symbol	Device type	Input pulse signal at $t_r \leq 50$ ns	Output pulse signal	Equation
TR (t_r)	All	+50 mV	Waveform 1	TR (t_r) = Δt
TR (o_s)	All	+50 mV	Waveform 1	TR (o_s) = $100 (\Delta V_o / V_o) \%$
SR (+)	01,02,04,05	-5 V to +5 V step	Waveform 2	SR(+) = $\Delta V_o (+) / \Delta t (+)$
	03,06	-1 V to +1 V step	Waveform 2	
SR (-)	01,02,04,05	+5 V to -5 V step	Waveform 3	SR(-) = $\Delta V_o (-) / \Delta t (-)$
	03,06	-1 V to +1 V step	Waveform 3	

FIGURE 4. Test circuit for transient response and slew rate – Continued.



Notes:

1. Resistors are $\pm 1.0\%$ and capacitors are $\pm 10\%$ unless otherwise specified.
2. Precaution shall be taken to prevent damage to the device under test during insertion into socket and in applying power.
3. For device types 01, 02, 04 and 05, S1 is open, $AV = -1$ and $V_{IN} = 10$ V.
4. For device types 03 and 06, S1 is closed, $AV = -5$ and $V_{IN} = 2$ V.
5. Settling time, t_s , measured on pin 5, is the interval during which the summing node is not nulled relative to the specified percentage of the final output value. (See table I settling time test conditions).

FIGURE 5. Test circuit for settling time.

TABLE III. Group A inspection for all device types.

Subgroup	Symbol	MIL-STD-883 method	Test no.	Notes	Adapter pin numbers				Energized relays	Measured pin		Equation	Device type	Test limits		Unit				
					1	2	3	4		No.	Value			Units	Min		Max			
1 T _A = +25°C	V _{IO}	4001	1	2/	35 V	-5 V	Open	-15 V	None	5	E1	V	01,02,03 04,05,06	-5	5	mV				
			2	"	5 V	-35 V	"	15 V	"	"	E2	"								
			3	"	20 V	-20 V	"	0 V	"	"	E3	"								
			4	"	5 V	-5 V	"	0 V	"	"	E4	"								
	+I _{IB}	4001	5	"	5 V	-35 V	"	15 V	K1, K8	"	E5	"	All	-100	3500	pA				
			6	"	5 V	-25 V	"	10 V	None	"	E6	"								
			7	"	5 V	-25 V	"	10 V	K1	"	E7	"								
			8	"	20 V	-20 V	"	0 V	K1	"	E8	"								
			9	"	35 V	-5 V	"	-15 V	K1	"	E9	"								
			10	"	5 V	-35 V	"	15 V	K2, K8	"	E10	"								
			11	"	5 V	-25 V	"	10 V	None	"	E11	"								
			12	"	5 V	-25 V	"	10 V	K2	"	E12	"								
			13	"	20 V	-20 V	"	0 V	K2	"	E13	"								
2 T _A = +125°C	-I _{IB}	4001	14	"	35 V	-5 V	"	-15 V	K2	"	E14	"	All	-100	3500	pA				
			15	"	Calculate value using data from tests 3, 7, and 11															
			16	"	10 V	-20 V	Open	0 V	None	5	E15	V								
			+PSRR	4003	17	3/	20 V	-10 V	Open	0 V	None	5		E16	V		"	85	85	dB
					18	"	Calculate value using data from tests 1 and 2													
			-PSRR	4003	19	"	20 V	-20 V	Open	0 V	K7	5		E17	V		"	8	8	mV
					20	"	20 V	-20 V	"	0 V	K6, K7	5		E18	V					
			CMR	4003	21	"	15 V	-15 V	"	-10 V	None	6		I1	mA		"	-50	50	mA
					22	"	15 V	-15 V	"	10 V	None	6		I2	mA					
			V _{IO}	4001	23	5/	15 V	-15 V	"	0 V	None	2		I3	mA		"	4	4	mA
					24	5/	15 V	-15 V	"	0 V	None	2		I3	mA					
			I _{OS(+)}	3011	25	"	35 V	-5 V	Open	-15 V	None	5		E19	V		01,04 02,03, 05,06	-7	7	mV
					26	"	5 V	-35 V	"	15 V	"	"		E20	"					
I _{OS(-)}	3005	27	"	20 V	-20 V	"	0 V	None	"	E21	"	01,02,03	-2.5	2.5	mV					
		28	"	5 V	-5 V	"	0 V	"	"	E22	"									
I _{CC}	3005	29	6/	ΔV _{IO} / ΔT = [V _{IO} (Test 24) - V _{IO} (Test 3)] / 100°C								04,05,06	-30	30	μV/°C					
		30	"	5 V	-5 V	"	0 V	"	"	E23	V									
+I _{IB}	4001	31	2/	5 V	-35 V	Open	15 V	K1, K8	5	E24	"	All	-10	10	°C					
		32	"	5 V	-25 V	"	10 V	None	"	E25	"									
-I _{IB}	4001	33	"	5 V	-25 V	"	10 V	K1, K8	"	E26	"	"	-10	50	nA					
		34	"	20 V	-20 V	"	0 V	K1, K8	"	E27	"									
+I _{IB}	4001	35	"	20 V	-20 V	"	0 V	K1, K8	"	E28	"	"	-10	50	nA					
		36	"	35 V	-5 V	"	-15 V	K1, K8	"	E29	"									
-I _{IB}	4001	37	"	5 V	-35 V	"	15 V	K2, K8	"	E30	"	All	-10	60	nA					
		38	"	5 V	-25 V	"	10 V	None	"	E31	"									
+I _{IB}	4001	39	"	5 V	-25 V	"	10 V	K2, K8	"	E32	"	"	-10	50	nA					
		40	"	5 V	-25 V	"	10 V	K2, K8	"	E33	"									
-I _{IB}	4001	41	"	20 V	-20 V	"	0 V	K2, K8	"	E34	"	"	-10	50	nA					
		42	"	35 V	-5 V	"	-15 V	K2, K8	"	E35	"									

TABLE III. Group A inspection for all device types – Continued.

Subgroup	Symbol	MIL-STD-883 method	Test no.	Notes	Adapter pin numbers				Energized relays	Measured pin			Equation	Device type	Test limits		Unit		
					1	2	3	4		No.	Value	Units			Min	Max			
2 T _A = +125°C	I _{IO}	4001	35	2/	20 V	-20 V	Open	0 V	K1, K2, K8	5	E33	V	I _{IO} = 10(E21 - E33)	All	-20	20	nA		
	+PSRR	4003	36		10 V	-20 V	Open	0 V	None	5	E34	V	+PSRR = 20 log 10 ⁴ / (E21 - E34)	"	85		dB		
	-PSRR	4003	37		20 V	-10 V	Open	0 V	None	5	E35	V	-PSRR = 20 log 10 ⁴ / (E21 - E35)	"	85		dB		
	CMR	4003	38	3/	Calculate value using data from tests 22 and 23.									"	85		dB		
	V _{IO}		39		20 V	-20 V	Open	0 V	K7	5	E36	V	V _{IO} ADJ(+) = (E21 - E36)	"	8		mV		
	V _{IO}		40		20 V	-20 V	"	0 V	K6, K7	5	E37	V	V _{IO} ADJ(-) = (E21 - E37)	"		-8		mV	
	I _{OS} (+)	3011	41	5/	15 V	-15 V	"	-10 V	None	6	I4	mA	I _{OS} (+) = I4	"	-50		mA		
	I _{OS} (-)		42	5/	15 V	-15 V	"	10 V	None	6	I5	mA	I _{OS} (-) = I5	"		50		mA	
3 T _A = -55°C	I _{CC}	3005	43		15 V	-15 V	"	0 V	None	2	I6	mA	I _{CC} = I6	01,04		4		mA	
														02,03,05,06		7		"	
	V _{IO}	4001	44	2/	35 V	-5 V	Open	-15 V	None	5	E38	V	V _{IO} = E38	01,02,03	-7	7		mV	
			45	"	5 V	-35 V	"	15 V	"	"	E39	"	V _{IO} = E39	"				"	
			46	"	20 V	-20 V	"	0 V	"	"	E40	"	V _{IO} = E40	04,05,06	-2.5	2.5		"	
			47	"	5 V	-5 V	"	0 V	"	"	E41	"	V _{IO} = E41	"				"	
			48	6/	ΔV _{IO} / ΔT = [V _{IO} (Test 46) - V _{IO} (Test 3)] / 80°C										01,02,03	-30	30		μV/°C
			49		10 V	-20 V	Open	0 V	None	5	E42	V	+PSRR = 20 log 10 ⁴ / (E40 - E42)	All	85			dB	
4 T _A = +25°C	-PSRR	4003	50		20 V	-10 V	Open	0 V	None	5	E43	V	-PSRR = 20 log 10 ⁴ / (E40 - E43)	"	85			dB	
	CMR	4003	51	3/	Calculate value using data from tests 44 and 45.									"	85			dB	
	V _{IO}		52		20 V	-20 V	Open	0 V	K7	5	E44	V	V _{IO} ADJ(+) = (E40 - E44)	"	8			mV	
	V _{IO}		53		20 V	-20 V	"	0 V	K6, K7	5	E45	V	V _{IO} ADJ(-) = (E40 - E45)	"		-8		mV	
	I _{OS} (+)	3011	54	5/	15 V	-15 V	"	-10 V	None	6	I7	mA	I _{OS} (+) = I7	"	-50			mA	
	I _{OS} (-)		55	5/	15 V	-15 V	"	10 V	None	6	I8	mA	I _{OS} (-) = I8	"		50		mA	
	I _{CC}	3005	56		15 V	-15 V	"	0 V	None	6	I9	mA	I _{CC} = I9	"		11		mA	
	+V _{OP}	4004	57		20 V	-20 V	Open	-20 V	K3	6	(E0)1	V	+V _{OP} = (E0)1	All	16			V	
	-V _{OP}		58		"	"	"	20 V	K3	"	(E0)2	"	-V _{OP} = (E0)2	"		-16		"	
	+V _{OP}		59		"	"	"	-20 V	K4	"	(E0)3	"	+V _{OP} = (E0)3	"	15			"	
	-V _{OP}		60		"	"	"	20 V	"	"	(E0)4	"	-V _{OP} = (E0)4	"		-15		"	
	A _V S(+)		61	4/	"	"	"	-15 V	"	"	5	E46	"	A _V S(+) = 15 / (E3 - E46)	"	50			V/mV
	A _V S(-)		62	4/	"	"	"	15 V	"	"	"	E47	"	A _V S(-) = 15 / (E47 - E3)	"	50			"
	A _V S		63		5 V	-5 V	"	-2 V	"	"	"	E48	"	A _V S = 4 / (E48 - E48)	"	10			"
					5 V	-5 V	"	2 V	"	"	E49	"		"				"	

TABLE III. Group A inspection for all device types – Continued.

Subgroup	Symbol	MIL-STD-883 method	Test no.	Notes	Adapter pin numbers				Energized relays	Measured pin			Equation	Device type	Test limits		Unit
					1	2	3	4		No.	Value	Units			Min	Max	
5 T _A = +125°C	+V _{OP}	4004	64		20 V	-20 V	Open	-20 V	K3	6	(E0)5	V	1/	All	16	-16	V
	-V _{OP}	"	65		"	"	"	K3	"	(E0)6	"	+V _{OP} = (E0)5 -V _{OP} = (E0)6			"	"	"
	+V _{OP}	"	66		"	"	"	"	K4	"	(E0)7	"	+V _{OP} = (E0)7	"	15	-15	"
	-V _{OP}	"	67		"	"	"	"	"	"	(E0)8	"	-V _{OP} = (E0)8	"	"	"	"
	A _V S(+)	"	68	4/	"	"	"	-15 V	"	5	E50	"	A _V S(+) = 15/(E21 - E50)	"	25		V/mV
	A _V S(-)	"	69	4/	"	"	"	15 V	"	"	E51	"	A _V S(-) = 15/(E51 - E21)	"	25		"
	A _V S	"	70		"	-5 V	5 V	-2 V	"	"	E52	"	A _V S = 4/(E53 - E52)	"	10		"
6 T _A = -55°C	+V _{OP}	4004	71		20 V	-20 V	Open	-20 V	K3	6	(E0)9	V	1/	All	16	-16	V
	-V _{OP}	"	72		"	"	"	K3	"	(E0)10	"	+V _{OP} = (E0)9 -V _{OP} = (E0)10			"	"	"
	+V _{OP}	"	73		"	"	"	"	K4	"	(E0)11	"	+V _{OP} = (E0)11	"	15	-15	"
	-V _{OP}	"	74		"	"	"	20 V	"	"	(E0)12	"	-V _{OP} = (E0)12	"	"	"	"
	A _V S(+)	"	75	4/	"	"	"	-15 V	"	5	E54	"	A _V S(+) = 15/(E40 - E54)	"	25		V/mV
	A _V S(-)	"	76	4/	"	"	"	15 V	"	"	E55	"	A _V S(-) = 15/(E55 - E40)	"	25		"
	A _V S	"	77		"	5 V	-5 V	-2 V	"	"	E56	"	A _V S = 4/(E57 - E56)	"	10		"
7 T _A = +25°C	TR(tr)	"	78		5 V	-5 V	2 V	"	"	"	E57	"	TR(tr) = Δt ₁ (see figure 4)	01,04	150	ns	
	TR(os)	"	79		15 V	-15 V	+50 mV	Open	None	6	Δtr	ns		02,05	100		
	SR(+)	"	80	8/	"	"	"	"	K9	"	Δtr	"		03,06	450		
	SR(-)	"	80	9/	"	"	"	"	None	"	V01	mV	TR(os) = 100 (ΔV ₀₁ /V ₀₁) (see figure 4)	01,02, 04,05	40	%	
	SR(+)	"	80	8/	15 V	-15 V	See notes	Open	None	6	ΔV ₀₁ (+)	V	SR(+)= ΔV ₀₁ (+) / Δt ₁ (+)	01	2	V/μs	
	SR(-)	"	80	9/	"	"	"	"	K9	"	ΔV ₀₁ (-)	mV	(see figure 4)	02	7.5	"	
	SR(-)	"	80	9/	"	"	"	"	None	"	Δt ₁ (+)	μs		04	3	"	
8 T _A = +25°C	NI(BB)	"	82	Z/	20 V	-20 V	Open	0 V	K5	6	(E0)13	mVrms	SR(-) = ΔV ₀₁ (-) / Δt ₁ (-)	01	2	V/μs	
	NI(PC)	"	83	Z/	20 V	-20 V	Open	0 V	K1, K2, K5, K8	"	(E0)14	mVpk	(see figure 4)	02	7.5	"	
		"			"	"	"	"	"	"	"	"		04	3	"	
		"			"	"	"	"	"	"	"	"		05	10	"	
		"			"	"	"	"	K9	"	Δt ₁ (-)	μs		03	30	"	
		"			"	"	"	"	"	"	"	"		06	40	"	
		"			"	"	"	"	"	"	"	"		06	40	"	

TABLE III. Group A inspection for all device types – Continued.

Subgroup	Symbol	MIL-STD-883 method	Test no.	Notes	Adapter pin numbers				Energized relays	Measured pin			Equation	Device type	Test limits		Unit	
					1	2	3	4		No.	Value	Units			Min	Max		
8 T _A = +125°C	TR(tr)		84		15 V	-15 V	+50 mV	Open	None	6	Δt ₂	ns	TR(tr) = Δt ₂ (see figure 4)	01,04	150	ns		
					"	"	"	"	K9	"	"	100						
	TR(os)			85		"	"	"	"	None	"	V ₀₂	mV	TR(os) = 100 (ΔV ₀₂ / V ₀₂) (see figure 4)	01,02,04,05	40	%	
						"	"	"	"	K9	"	ΔV ₀₂	mV			25		
						15 V	-15 V	See notes	Open	None	6	ΔV ₀₂ (+)	V ₁			1		V/μs
						"	"	"	"	K9	"	Δt ₂ (+)	μs			5		
8 T _A = -55°C	SR(+)		86		"	"	"	"	None	"	"	"	SR(+) = ΔV ₀₂ (+) / Δt ₂ (+) (see figure 4)	02	"	"		
					"	"	"	"	K9	"	"	"			1.5			
	SR(-)			87		"	"	"	"	None	"	V ₁	V ₁	SR(-) = ΔV ₀₂ (-) / Δt ₂ (-) (see figure 4)	01,04	1	V/μs	
						"	"	"	"	K9	"	Δt ₂ (+)	μs			5		
						15 V	-15 V	See notes	Open	None	6	ΔV ₀₂ (+)	V ₁			1		V/μs
						"	"	"	"	K9	"	Δt ₂ (+)	μs			5		
TR(tr)			88		15 V	-15 V	+50 mV	Open	None	6	Δt ₃	ns	TR(tr) = Δt ₃ (see figure 4)	01,04	150	ns		
					"	"	"	"	K9	"	"	"			100			
TR(os)			89		"	"	"	"	None	"	V ₀₃	mV	TR(os) = 100 (ΔV ₀₃ / V ₀₃) (see figure 4)	01,02,04,05	40	%		
					"	"	"	"	K9	"	ΔV ₀₃	mV			25			
8 T _A = -55°C	SR(+)		90		-15 V	-15 V	See notes	Open	None	6	ΔV ₀₃ (+)	V ₁	SR(+) = ΔV ₀₃ (+) / Δt ₃ (+) (see figure 4)	01	1	V/μs		
					"	"	"	"	K9	"	Δt ₃ (+)	μs			5			
	SR(-)			91		"	"	"	"	None	"	"	"	SR(-) = ΔV ₀₃ (-) / Δt ₃ (-) (see figure 4)	02	"	"	
						"	"	"	"	K9	"	"	"			1.5		
						15 V	-15 V	See notes	Open	None	6	ΔV ₀₃ (-)	V ₁			1		V/μs
						"	"	"	"	K9	"	Δt ₃ (-)	μs			5		
t _s (+)			92		15 V	-15 V	See notes	Open	None	5	t _s (+)	ns	(See figure 5)	01,04	4000	ns		
					"	"	"	"	"	"	"	"			1500			
t _s (-)			93		15 V	-15 V	See notes	Open	None	5	t _s (-)	ns	(See figure 5)	01,04	4000	"		
					"	"	"	"	"	"	"	"			1500			
12 T _A = +25°C					15 V	-15 V	See notes	Open	None	5	t _s (+)	ns	(See figure 5)	01,04	4000	"		
					"	"	"	"	"	"	"	"			800			

TABLE III. Group A inspection – Continued.

- 1/ The equations take into account both the closed loop gain of 1,000 and the scale factor multiplier so that the calculated value is in table I units. The measured value units should, therefore, be used in the equation.
(For example: If $E_1 = 2 \text{ V}$ and $V_{IO} = E_1$, then $V_{IO} = 2 \text{ mV}$).
- 2/ Each device shall be tested over the common mode range as specified in table III. V_{CM} conditions are achieved by grounding the inputs and algebraically subtracting V_{CM} from each supply.
(For example: If $V_{CM} = -15 \text{ V}$, then $+V_{CC} = +20 \text{ V} - (-15 \text{ V}) = +35 \text{ V}$ and $-V_{CC} = -20 \text{ V} - (-15 \text{ V}) = -5 \text{ V}$).
- 3/ Common mode rejection is calculated using the offset voltage values measured at the common mode range and end points.
- 4/ To minimize thermal drift the reference voltage for the gain measurement (E_3 , E_{21} and E_{40}) shall be taken immediately prior to or after the reading corresponding to device gain (E_{46} , E_{47} , E_{50} , E_{51} , E_{54} , and E_{55}).
- 5/ The output shall be shorted to ground for 25 ms or less.
- 6/ Tests 26 and 48 which require a read and record measurement plus a calculation may be omitted except when subgroups 2 and 3 are being accomplished for group A sampling inspection and groups C and D end point measurements.
- 7/ Broadband noise NI(BB) shall be measured using a true RMS voltmeter with a minimum bandwidth of 10 Hz to 20 kHz. "Popcorn" noise NI(PC) shall be measured for 15 seconds.
- 8/ Device types 01, 02, 04, and 05 are tested with a -5 V to $+5 \text{ V}$ step input as shown in figure 4. The circuit gain is 1 V/V.
- 9/ Device types 03 and 06 are tested with a -1 V to $+1 \text{ V}$ step input as shown in figure 4. The circuit gain is 5 V/V.

5. PACKAGING

5.1 Packaging requirements. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department of Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

TABLE IV. Group C end point electrical parameters.(T_A = 25°C, ±V_{CC} = ±20 V for all device types)

Table III test no.	Symbol	Device types	Delta limits		Limits		Units
			Min	Max	Min	Max	
3	V _{IO}	01, 02, 03	-1	+1	-5	+5	mV
		04, 05, 06	-0.5	0.5	-2	2	
7	+I _B	01, 02, 03	-50	+50	-100	+100	pA
		04, 05, 06	-50	+50	-100	+100	
11	-I _B	01, 02, 03	-50	+50	-100	+100	pA
		04, 05, 06	-50	+50	-100	+100	

6. NOTES

6.1 Intended use. Microcircuits conforming to this specification are intended for original equipment design applications and logistic support of existing equipment.

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of the specification.
- b. Complete part number (see 1.2).
- c. Requirements for delivery of one copy of the quality conformance inspection data pertinent to the device inspection lot to be supplied with each shipment by the device manufacturer, if applicable.
- d. Requirements for certificate of compliance, if applicable.
- e. Requirements for notification of change of product or process to acquiring activity in addition to notification of the qualifying activity, if applicable.
- f. Requirements for failure analysis (including required test condition of MIL-STD-883, method 5003), corrective action and reporting of results, if applicable.
- g. Requirements for product assurance options.
- h. Requirements for special carriers, lead lengths, or lead forming, if applicable. These requirements should not affect the part number. Unless otherwise specified, these requirements will not apply to direct purchase by or direct shipment to the Government.
- i. Requirements for "JAN" marking.
- j. Packaging requirements (see 5.1).

6.3 Superseding information. The requirements of MIL-M-38510 have been superseded to take advantage of the available Qualified Manufacturer Listing (QML) system provided by MIL-PRF-38535. Previous references to MIL-M-38510 in this document have been replaced by appropriate references to MIL-PRF-38535. All technical requirements now consist of this specification and MIL-PRF-38535. The MIL-M-38510 specification sheet number and PIN have been retained to avoid adversely impacting existing government logistics systems and contractor's parts lists.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Manufacturers List QML-38535 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from DSCC-VQ, 3990 E. Broad Street, Columbus, Ohio 43123-1199.

6.5 Abbreviations, symbols, and definitions. The abbreviations, symbols, and definitions used herein are defined in MIL-PRF-38535 and MIL-STD-1331.

6.6 Logistic support. Lead materials and finishes (see 3.3) are interchangeable. Unless otherwise specified, microcircuits acquired for Government logistic support will be acquired to device class B (see 1.2.2), lead material and finish A (see 3.4). Longer length leads and lead forming should not affect the part number.

6.7 Substitutability. The cross-reference information below is presented for the convenience of users. Microcircuits covered by this specification will functionally replace the listed generic-industry type. Generic-industry microcircuit types may not have equivalent operational performance characteristics across military temperature ranges or reliability factors equivalent to MIL-M-38510 device types and may have slight physical variations in relation to case size. The presence of this information should not be deemed as permitting substitution of generic-industry types for MIL-M-38510 types or as a waiver of any of the provisions of MIL-PRF-38535.

<u>Military device type</u>	<u>Generic-industry type</u>
01	LF 155
02	LF 156
03	LF 157
04	LF 155A
05	LF 156A
06	LF 157A

6.8 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Custodians: Army – CR Navy - EC Air Force - 11 NASA - NA DLA – CC	Preparing activity: DLA - CC Project 5962-1980
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Review activities:
Army - MI, SM
Navy - AS, CG, MC, SH, TD
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2. DOCUMENT DATE (YYYYMMDD)
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4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

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Columbus, Ohio 43216-5000

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