HS-3530RH

Low Power, Radiation Hardened Programmable Operational Amplifier

August 1995

Features

- **Radiation Environment**
  - **Neutron Fluence (Φ) 5 x 10^{12} n/cm^2 (E $\geq$ 10KeV)**
  - **Gamma Rate ($\dot{\gamma}$) 1 x 10^9 RAD (Si)/s**
  - **Gamma Dose (γ) 1 x 10^6 RAD (Si)**
- **Wide Range AC Programming**
  - **Slew Rate 0.06 to 3V/μs**
  - **Gain X Bandwidth 100kHz to 5.0MHz**
- **Wide Range DC Programming**
  - **Power Supply Range $\pm$3.0V to $\pm$15V**
- **Supply Current 10μA to 1.2mA**
- **Dielectrically Isolated Device Islands**
- **Short Circuit Protection**

Description

The HS-3530RH is a Low Power Operational Amplifier which is an internally compensated monolithic device offering a wide range of performance specifications. Parameters such as power dissipation, slew rate, bandwidth, noise and input DC parameters are programmed by selecting an external resistor or current source. Supply voltages as low as $\pm$3V may be used with little degradation of AC performance. The HS-3530RH has been specifically designed to meet exposure to space radiation environments. Operation from -55^{o}C to +125^{o}C is guaranteed.

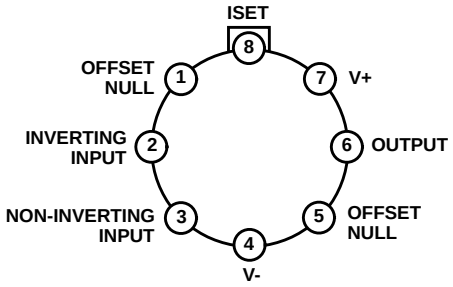
A major advantage of the HS-3530RH is that operating characteristics remain virtually constant over a wide supply range ($\pm$3V to $\pm$15V), allowing the amplifier to offer maximum performance in almost any system, including battery operated equipment. A primary application for this device is in active filtering and conditioning for a wide variety of signals that differ in frequency and amplitude. Also, by modulating the set current, it can be used for designs such as current controlled oscillators/modulators, sample and hold circuits and variable active filters.

Ordering Information

PART NUMBER	TEMPERATURE RANGE	PACKAGE
HS2-3530RH-8	-55^{o}C to +125^{o}C	8 Lead Metal Can
HS2-3530RH-Q	-55^{o}C to +125^{o}C	8 Lead Metal Can
HS2-3530RH/SAMPLE	+25^{o}C	8 Lead Metal Can

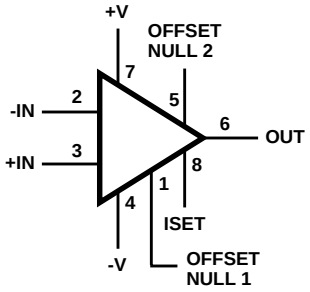
Pinout

8 LEAD METAL CAN PACKAGE (CAN)
MIL-STD-1835 MACY1-X8
TOP VIEW



NOTE:
1. Case tied to V-.

Functional Diagram



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Absolute Maximum Ratings

Voltage Between V+ and V- Terminals 40V
Differential Input Voltage 20V
Voltage at Either Input Terminal . . . . . V+ to V-
ISET (Current at ISET) 500µA
VSET (Voltage to GND at ISET). . . . . (V+ -2.0V) < VSET < V+
Output Short Circuit Duration (Note 1) . . . . . Indefinite
Junction Temperature (TJ) . . . . . +175^{o}C
Storage Temperature Range . . . . . -65^{o}C to +150^{o}C
ESD Rating. . . . . <2000V
Lead Temperature (Soldering 10s) . . . . . 275^{o}C

Reliability Information

Thermal Resistance	θ_{JA}	θ_{JC}
Metal Can Package	160^{o}C/W	70^{o}C/W

Maximum Package Power Dissipation at +125^{o}C Ambient:
Metal Can Package 0.31W
If device power exceeds package dissipation capability, provide heat sinking or derate linearly at the following rate:
Metal Can Package . . . . . 6.3mW/^{o}C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Operating Conditions

Operating Temperature Range . . . . . -55^{o}C to +125^{o}C
Operating Supply Voltage . . . . . ±3V to ±15V

VINcm ≤ $^{1}/_{2}$ (V+ - V-)
RL ≥ 2kV

TABLE 1A. DC ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage = ±15V, RSOURCE = 100Ω, RLOAD = 500kΩ, VOUT = 0V, Unless Otherwise Specified.

PARAMETER	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	ISET = 1.5µA		ISET = 15µA		UNITS
					MIN	MAX	MIN	MAX	
Input Offset Voltage	VIO	VCM = 0V	1	+25^{o}C	-3	3	-3	3	mV
			2, 3	+125^{o}C, -55^{o}C	-5	5	-5	5	mV
Input Bias Current	+IB	VCM = 0V, +RS = 10kΩ -RS = 100Ω Note 2	1	+25^{o}C	-	-	-40	40	nA
			2, 3	+125^{o}C, 0^{o}C	-	-	-50	+50	nA
			3	-55^{o}C	-	-	-60	60	nA
	-IB	VCM = 0V, +RS = 100Ω -RS = 10kΩ Note 2	1	+25^{o}C	-	-	-40	40	nA
			2, 3	+125^{o}C, 0^{o}C	-	-	-50	+50	nA
			3	-55^{o}C	-	-	-60	60	nA
Input Offset Current	IIO	VCM = 0V, +RS = 10kΩ -RS = 10kΩ Note 2	1	+25^{o}C	-	-	-15	15	nA
			2, 3	+125^{o}C, 0^{o}C	-	-	-20	+20	nA
			3	-55^{o}C	-	-	-30	30	nA
Large Signal Voltage Gain	+AVOL	VOUT = 0V and +10V Note 1	4	+25^{o}C	65	-	80	-	kV/V
			5, 6	+125^{o}C, -55^{o}C	25	-	50	-	kV/V
	-AVOL	VOUT = 0V and -10V Note 1	4	+25^{o}C	65	-	80	-	kV/V
			5, 6	+125^{o}C, -55^{o}C	25	-	50	-	kV/V
Common Mode Rejection Ratio	+CMRR	ΔVCM = +5V, +V = +10V -V = -20V, VOUT = -5V	1	+25^{o}C	80	-	80	-	dB
			2, 3	+125^{o}C, -55^{o}C	80	-	80	-	dB
	-CMRR	ΔVCM = -5V, +V = +20V -V = -10V, VOUT = +5V	1	+25^{o}C	80	-	80	-	dB
			2, 3	+125^{o}C, -55^{o}C	80	-	80	-	dB
Output Voltage Swing	+VOUT	Note 1	1	+25^{o}C	12.5	-	12.5	-	V
			2, 3	+125^{o}C, -55^{o}C	10.5	-	10.5	-	V
	-VOUT	Note 1	1	+25^{o}C	-	-12.5	-	-12.5	V
			2, 3	+125^{o}C, -55^{o}C	-	-10.5	-	-10.5	V
Output Current	+IOUT	RL = 2kΩ	1	+25^{o}C	0.25	-	2.5	-	mA
	-IOUT	RL = 2kΩ	1	+25^{o}C	-	-0.25	-	-2.5	mA

TABLE 1A. DC ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)

Device Tested at: Supply Voltage = ±15V, RSOURCE = 100Ω, RLOAD = 500kΩ, VOUT = 0V, Unless Otherwise Specified.

PARAMETER	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	ISET = 1.5µA		ISET = 15µA		UNITS
					MIN	MAX	MIN	MAX	
Quiescent Power Supply Current	+ICC	IOUT = 0mA	1	+25°C	-	15	-	150	µA
			2, 3	+125°C, -55°C	-	15	-	160	µA
	-ICC	IOUT = 0mA	1	+25°C	-15	-	-150	-	µA
			2, 3	+125°C, -55°C	-15	-	-160	-	µA
Power Supply Rejection Ratio	+PSRR	ΔVSUP = 10V +V = +10V, -V = -15V +V = +20V, -V = -15V	1	+25°C	80	-	80	-	dB
			2, 3	+125°C, -55°C	80	-	80	-	dB
	-PSRR	ΔVSUP = 10V +V = +15V, -V = -10V +V = +15V, -V = -20V	1	+25°C	80	-	80	-	dB
			2, 3	+125°C, -55°C	80	-	80	-	dB

NOTES:

1. RL = 75kΩ at ISET = 1.5µA, RL = 5kΩ at ISET = 15µA.
2. Temperature 0°C performed for Intersil -8 product flow only.

TABLE 1B. DC ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage = ±3V, RSOURCE = 100Ω, RLOAD = 500kΩ, VOUT = 0V, Unless Otherwise Specified.

PARAMETER	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	ISET = 1.5µA		ISET = 15µA		UNITS
					MIN	MAX	MIN	MAX	
Input Offset Voltage	VIO	VCM = 0V	1	+25°C	-3	3	-3	3	mV
			2, 3	+125°C, -55°C	-5	5	-5	5	mV
Large Signal Voltage Gain	+AVOL	VOUT = 0V and +1V Note 1	4	+25°C	25	-	25	-	kV/V
			5, 6	+125°C, -55°C	15	-	25	-	kV/V
	-AVOL	VOUT = 0V and -1V Note 1	4	+25°C	25	-	25	-	kV/V
			5, 6	+125°C, -55°C	15	-	25	-	kV/V
Common Mode Rejection Ratio	+CMRR	ΔVCM = +1.5V +V = +1.5V, -V = -4.5V VOUT = -1.5V	1	+25°C	80	-	80	-	dB
			2, 3	+125°C, -55°C	80	-	80	-	dB
	-CMRR	ΔVCM = -1.5V +V = +4.5V, -V = -1.5V VOUT = +1.5V	1	+25°C	80	-	80	-	dB
			2, 3	+125°C, -55°C	80	-	80	-	dB
Output Voltage Swing	+VOUT	Note 1	1	+25°C	2.0	-	2.0	-	V
			2, 3	+125°C, -55°C	2.0	-	2.0	-	V
	-VOUT	Note 1	1	+25°C	-	-2.0	-	-2.0	V
			2, 3	+125°C, -55°C	-	-2.0	-	-2.0	V
Quiescent Power Supply Current	+ICC	IOUT = 0mA	1	+25°C	-	15	-	150	µA
			2, 3	+125°C, -55°C	-	15	-	160	µA
	-ICC	IOUT = 0mA	1	+25°C	-15	-	-150	-	µA
			2, 3	+125°C, -55°C	-15	-	-160	-	µA
Power Supply Rejection Ratio	+PSRR	ΔVSUP = 1.5V +V = +3V, -V = -3V +V = +4.5V, -V = -3V	1	+25°C	80	-	80	-	dB
			2, 3	+125°C, -55°C	80	-	80	-	dB
	-PSRR	ΔVSUP = 1.5V +V = +3V, -V = -3V +V = +3V, -V = -4.5V	1	+25°C	80	-	80	-	dB
			2, 3	+125°C, -55°C	80	-	80	-	dB

NOTE:

1. RL = 75kΩ at ISET = 1.5µA, RL = 5kΩ at ISET = 15µA.

TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: CL = 100pF, AVCL = +1, RL = 75kΩ, Unless Otherwise Specified.

PARAMETER	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	ISET = 1.5µA		ISET = 15µA		UNITS
					MIN	MAX	MIN	MAX	
VSUPPLY = ±15V									
Slew Rate Note 1	+SR	VOUT = -10V to +10V	9	+25°C	0.025	-	0.25	-	V/µs
	-SR	VOUT = +10V to -10V	9	+25°C	0.025	-	0.25	-	V/µs
Rise & Fall Time	TR	VOUT = 0 to +400mV 10% < TR < 90%	9	+25°C	-	8.0	-	0.8	µs
	TF	VOUT = 0 to -400mV 10% < TF < 90%	9	+25°C	-	8.0	-	0.8	µs
Overshoot	+OS	VOUT = 0 to +400mV	9	+25°C	-	35	-	35	%
	-OS	VOUT = 0 to -400mV	9	+25°C	-	35	-	35	%
VSUPPLY = ±3V									
Slew Rate Note 1	+SR	VOUT = -2V to +2V	9	+25°C	0.01	-	0.1	-	V/µs
	-SR	VOUT = +2V to -2V	9	+25°C	0.01	-	0.1	-	V/µs

TABLE 3. AC ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: RSOURCE = 50Ω, CL = 100pF, AVCL = +1, Unless Otherwise Specified.

PARAMETER	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	ISET = 1.5µA		ISET = 15µA		UNITS
					MIN	MAX	MIN	MAX	
VSUPPLY = ±15V									
Differential Input Resistance	RIN	VCM = 0V	1	+25°C	50	-	50	-	MΩ
Full Power Bandwidth	FPBW	VPEAK = 10V	1, 2	+25°C	0.4	-	4	-	kHz
Minimum Closed Loop Stable Gain	CLSG	RL = 2kΩ, CL = 50pF	1	-55°C to +125°C	+1	-	+1	-	V/V
Output Resistance	ROUT	Open Loop	1	+25°C	-	10	-	10	Ω
Quiescent Power Consumption	PC	VOUT = 0V, IOUT = 0mA	1, 3	-55°C to +125°C	-	4.8	-	4.8	mW
Output Short-Circuit Current	IOSC	VOUT = 0V	1, 4	+25°C	-14	38	-27	42	mA
Gain Bandwidth Product	GBWP	AVCL = 10V/V VO = 200mV, fO = 10kHz	1	+25°C	45	-	750	-	kHz
VSUPPLY = ±3V									
Gain Bandwidth Product	GBWP	AVCL = 10V/V VO = 200mV, fO = 10kHz	1	+25°C	30	-	600	-	kHz

NOTES:

1. Parameters listed in Table 3 are controlled via design or process parameters and are not directly tested at final production. These parameters are lab characterized upon initial design release, or upon design changes. These parameters are guaranteed by characterization based upon data from multiple production runs which reflect lot to lot and within lot variation.
2. Full Power Bandwidth guarantee based on Slew Rate measurement using FPBW = Slew Rate/(2πVPEAK).
3. Quiescent Power Consumption based upon Quiescent Supply Current test maximum. (No load on outputs).
4. Caution: Continuous long-duration short-circuit operation may degrade the operating life of the device.

TABLE 4. POST RAD DC ELECTRICAL PERFORMANCE CHARACTERISTICS

PARAMETER	SYMBOL	CONDITIONS	TEMPERATURE	MIN	MAX	UNITS
Open Loop Voltage Gain	AVOL	VSUPPLY = ±15V ISET = 15µA	+25°C	15	-	kV/V
Input Offset Voltage	VIO	VSUPPLY = ±15V ISET = 15µA	+25°C	-	5.0	mV

TABLE 5. BURN-IN DELTA PARAMETERS GROUP B, SUBGROUPS 5 (T_A = +25°C)

PARAMETER	DELTA LIMIT
VIO	±0.5mV
IBIAS	±30nA

TABLE 6. APPLICABLE SUBGROUPS

CONFORMANCE GROUP	MIL-STD-883 METHOD	GROUP A SUBGROUPS			
		TESTED FOR -Q	RECORDED FOR -Q	TESTED FOR -8	RECORDED FOR -8
Initial Test	100% 5004	1, 4, 9	1 (Note 2)	1, 4, 9	
Interim Test	100% 5004	1, 4, 9, Δ	1, Δ (Note 2)	1, 4, 9	
PDA	100% 5004	1, Δ	-	1	
Final Test	100% 5004	2, 3, 5, 6	-	2, 3, 5, 6	
Group A (Note 1)	Sample 5005	1, 2, 3, 4, 5, 6, 9	-	1, 2, 3, 4, 5, 6, 9	
Subgroup B5	Sample 5005	1, 2, 3, 4, 5, 6, 9, Δ	1, 2, 3, Δ (Note 2)	-	
Subgroup B6	Sample 5005	1, 4, 9	-	-	
Group C	Sample 5005	-	-	1, 2, 3, 4, 5, 6, 9	
Group D	Sample 5005	1, 4, 9	-	1, 4, 9	
Group E, Subgroup 2	Sample 5005	1	-	1	

NOTES:

1. Alternate Group A testing in accordance with MIL-STD-883 method 5005 may be exercised.
2. Table 5 parameters only

Intersil Space Level Product Flow -Q

Wafer Lot Acceptance (All Lots) Method 5007 (Includes SEM)

GAMMA Radiation Verification (Each Wafer) Method 1019, 4 Samples/Wafer, 0 Rejects

100% Nondestructive Bond Pull, Method 2023

Sample - Wire Bond Pull Monitor, Method 2011

Sample - Die Shear Monitor, Method 2019 or 2027

100% Internal Visual Inspection, Method 2010, Condition A

100% Temperature Cycle, Method 1010, Condition C, 10 Cycles

100% Constant Acceleration, Method 2001, Condition per Method 5004

100% PIND, Method 2020, Condition A

100% External Visual

100% Serialization

100% Initial Electrical Test (T0)

100% Static Burn-In, Condition A or B, 240 Hours, +125^{o}C or Equivalent, Method 1015

100% Interim Electrical Test 1 (T1)

100% Delta Calculation (T0-T1)

100% PDA, Method 5004 (Note 1)

100% Final Electrical Test

100% Fine/Gross Leak, Method 1014

100% Radiographic (X-Ray), Method 2012 (Note 2)

100% External Visual, Method 2009

Sample - Group A, Method 5005 (Note 3)

Sample - Group B, Method 5005 (Note 4)

Sample - Group D, Method 5005 (Notes 4 and 5)

100% Data Package Generation (Note 6)

NOTES:

1. Failures from subgroup 1 and deltas are used for calculating PDA. The maximum allowable PDA = 5%.
2. Radiographic (X-Ray) inspection may be performed at any point after serialization as allowed by Method 5004.
3. Alternate Group A testing may be performed as allowed by MIL-STD-883, Method 5005.
4. Group B and D inspections are optional and will not be performed unless required by the P.O. When required, the P.O. should include separate line items for Group B test, Group B samples, Group D test and Group D samples.
5. Group D Generic Data, as defined by MIL-I-38535, is optional and will not be supplied unless required by the P.O. When required, the P.O. should include a separate line item for Group D generic data. Generic data is not guaranteed to be available and is therefore not available in all cases.
6. Data Package Contents:
   - Cover Sheet (Intersil Name and/or Logo, P.O. Number, Customer Part Number, Lot Date Code, Intersil Part Number, Lot Number, Quantity).
   - Wafer Lot Acceptance Report (Method 5007). Includes reproductions of SEM photos with percent of step coverage.
   - GAMMA Radiation Report. Contains Cover page, disposition, RAD Dose, Lot Number, Test Package used, Specification Numbers, Test equipment, etc. Radiation Read and Record data on file at Intersil.
   - X-Ray report and film. Includes penetrometer measurements.
   - Screening, Electrical, and Group A attributes (Screening attributes begin after package seal).
   - Lot Serial Number Sheet (Good units serial number and lot number).
   - Variables Data (All Delta operations). Data is identified by serial number. Data header includes lot number and date of test.
   - Group B and D attributes and/or Generic data is included when required by the P.O.
   - The Certificate of Conformance is a part of the shipping invoice and is not part of the Data Book. The Certificate of Conformance is signed by an authorized Quality Representative.

Intersil Space Level Product Flow -8

GAMMA Radiation Verification (Each Wafer) Method 1019, 4 Samples/Wafer, 0 Rejects

Periodic- Wire Bond Pull Monitor, Method 2011

Periodic- Die Shear Monitor, Method 2019 or 2027

100% Internal Visual Inspection, Method 2010, Condition B

100% Temperature Cycle, Method 1010, Condition C, 10 Cycles

100% Constant Acceleration, Method 2001, Condition per Method 5004

100% External Visual

100% Initial Electrical Test

100% Static Burn-In, Condition A or B, 160 Hours, +125^{o}C or Equivalent, Method 1015

100% Interim Electrical Test

100% PDA, Method 5004 (Note 1)

100% Final Electrical Test

100% Fine/Gross Leak, Method 1014

100% External Visual, Method 2009

Sample - Group A, Method 5005 (Note 2)

Sample - Group B, Method 5005 (Note 3)

Sample - Group C, Method 5005 (Notes 3 and 4)

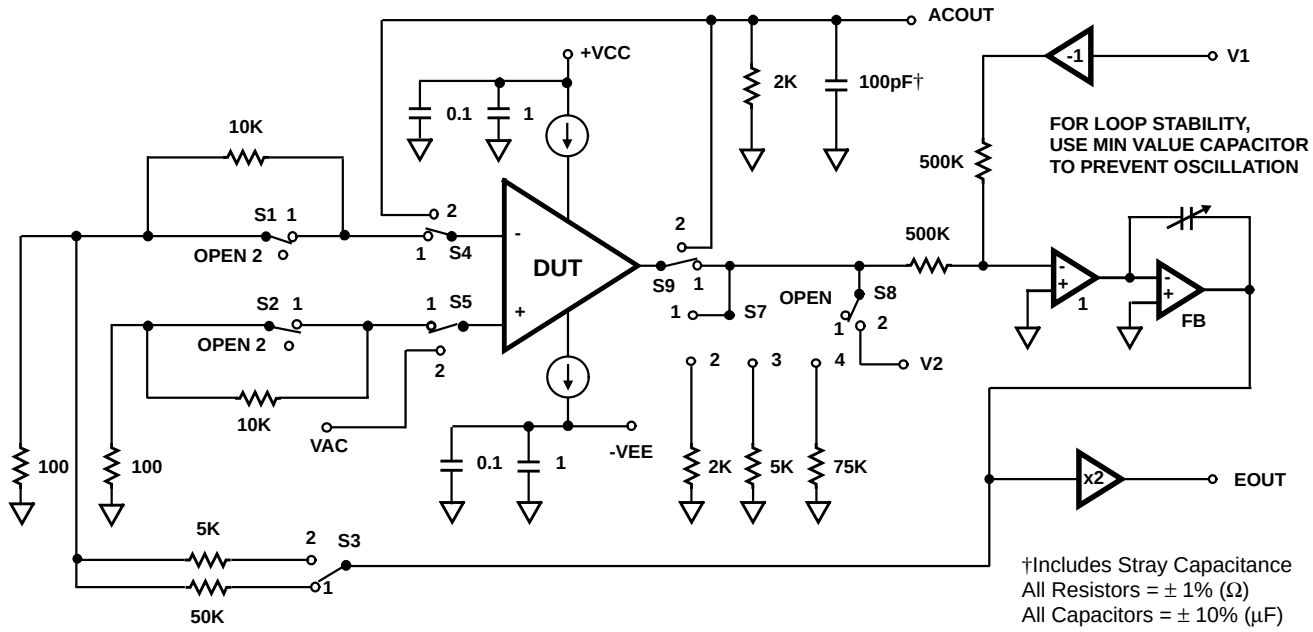
Sample - Group D, Method 5005 (Notes 3 and 4)

100% Data Package Generation (Note 4)

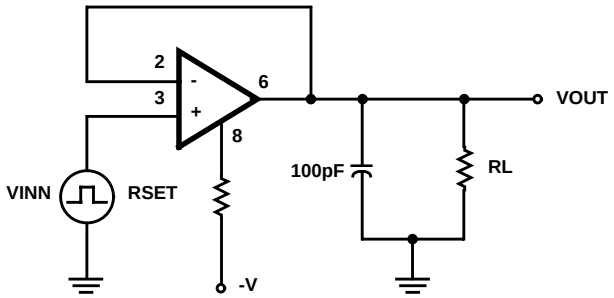
NOTES:

1. Failures from subgroup 1 are used for calculating PDA. The maximum allowable PDA = 5%.
2. Alternate Group A testing may be performed as allowed by MIL-STD-883, Method 5005.
3. Group B, C and D inspections are optional and will not be performed unless required by the P.O. When required, the P.O. should include separate line items for Group B test, Group B samples, Group C test and Group C samples and Group D test and Group D samples.
4. Group C and/or D Generic Data, as defined by MIL-I-38535, is optional and will not be supplied unless required by the P.O. When required, the P.O. should include a separate line item for Group C generic data and/or D generic data. Generic data is not guaranteed to be available and is therefore not available in all cases.
5. Data Package Contents:
   - Cover Sheet (Intersil Name and/or Logo, P.O. Number, Customer Part Number, Lot Date Code, Intersil Part Number, Lot Number, Quantity).
   - GAMMA Radiation Report. Contains Cover page, disposition, RAD Dose, Lot Number, Test Package used, Specification Numbers, Test equipment, etc. Radiation Read and Record data on file at Intersil.
   - Screening, Electrical, and Group A attributes (Screening attributes begin after package seal).
   - Group B, C and D attributes and/or Generic data is included when required by the P.O.
   - The Certificate of Conformance is a part of the shipping invoice and is not part of the Data Book. The Certificate of Conformance is signed by an authorized Quality Representative.

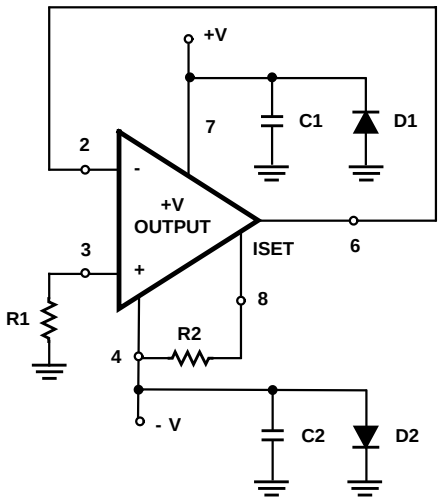
Test Circuit



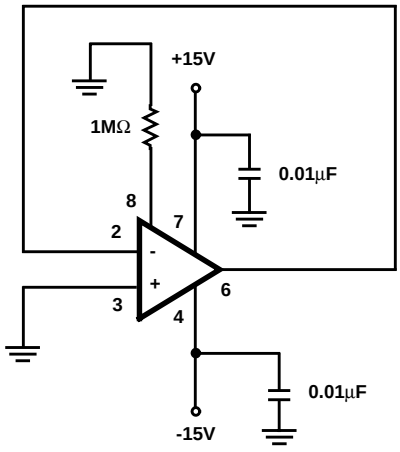
Simplified Transient Response/Slew Rate Circuit



Burn-In Circuit



Irradiation Circuit



Typical Performance Curves

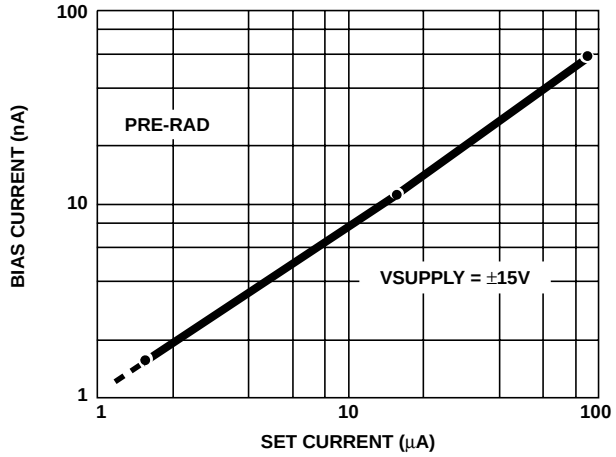


FIGURE 1. INPUT BIAS CURRENT vs SET CURRENT

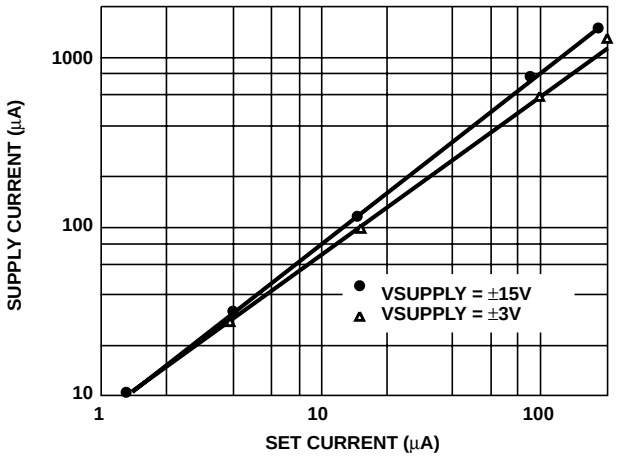


FIGURE 2. PRERAD POSITIVE SUPPLY CURRENT

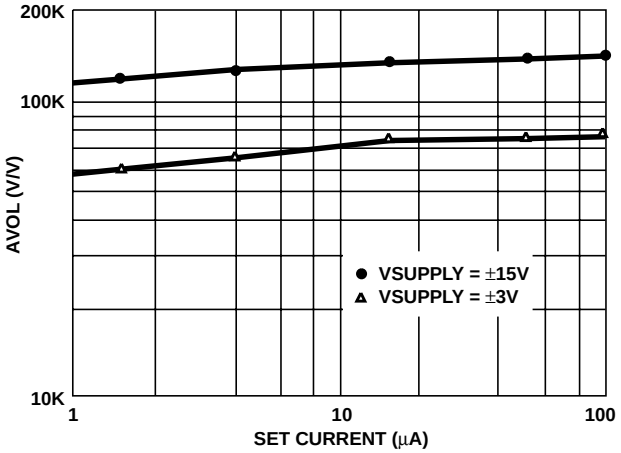


FIGURE 3. PRERAD LARGE SIGNAL VOLTAGE GAIN vs ISET

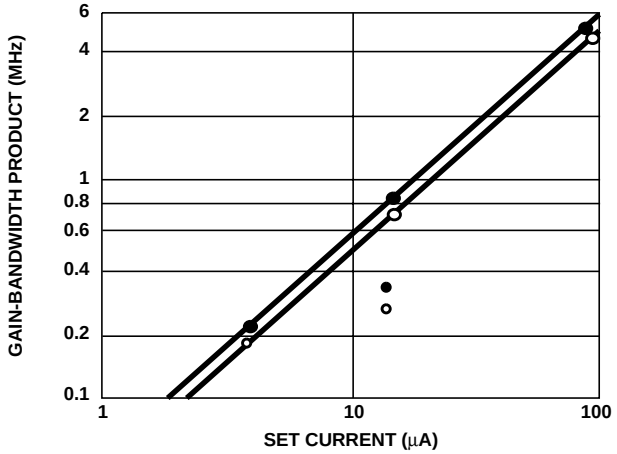


FIGURE 4. GAIN BANDWIDTH PRODUCT vs SET CURRENT

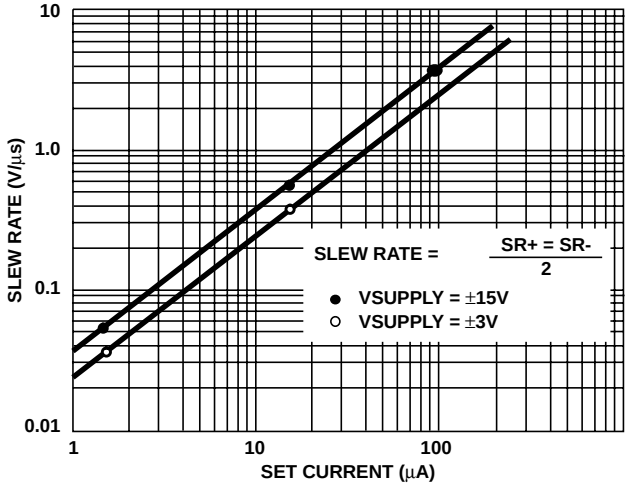


FIGURE 5. SLEW RATE vs SET CURRENT

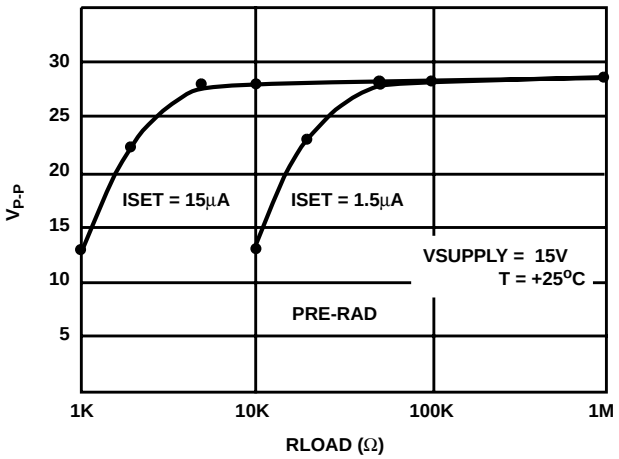


FIGURE 6. OUTPUT VOLTAGE SWING vs LOAD RESISTANCE

Typical Performance Curves (Continued)

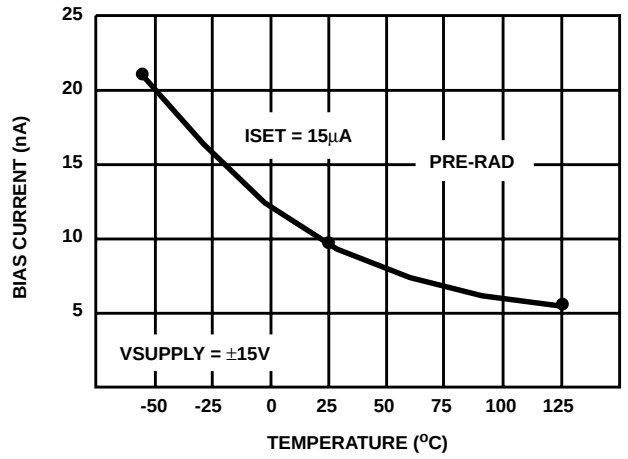


FIGURE 7. INPUT BIAS CURRENT vs TEMPERATURE

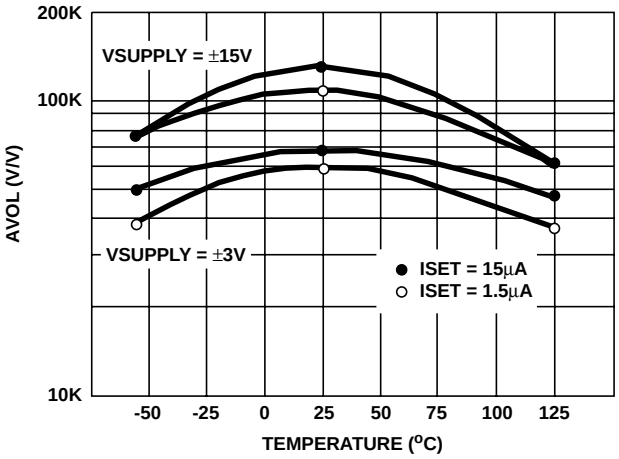
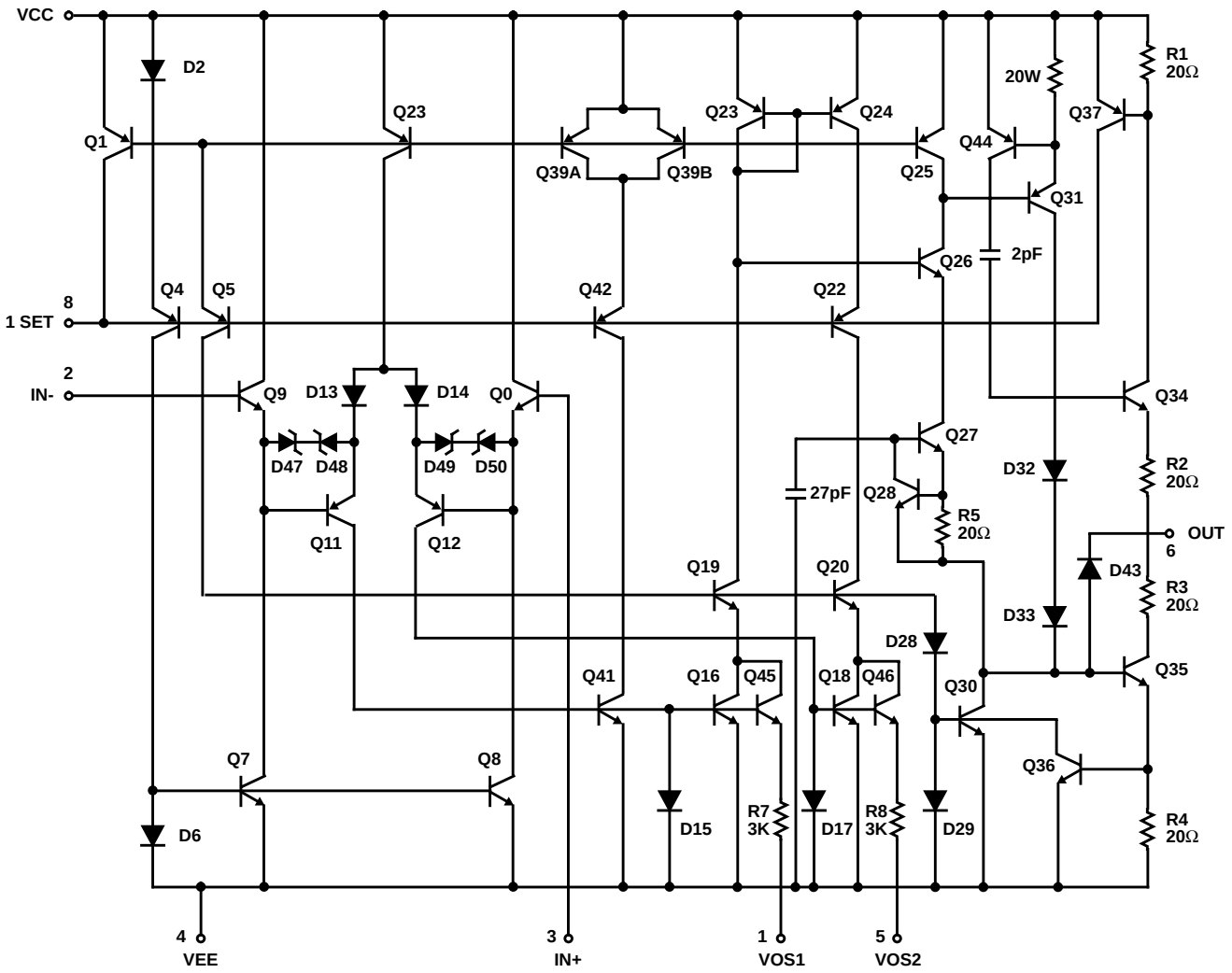


FIGURE 8. OPEN LOOP VOLTAGE GAIN vs TEMPERATURE

Schematic



Metallization Topology

DIE DIMENSIONS:
54 x 67 x 11.5mils
(1370 x 1700 x 290µm)

METALLIZATION:
Type: Al
Thickness: 12.5kÅ ± 2kÅ

GLASSIVATION:
Type: SiO_2
Thickness: 8kÅ ± 1kÅ

DIE ATTACH:
Temperature: Metal Can - 420°C (Max)

WORST CASE CURRENT DENSITY:
0.544 x 10^5 A/cm^2 at 2.5mA

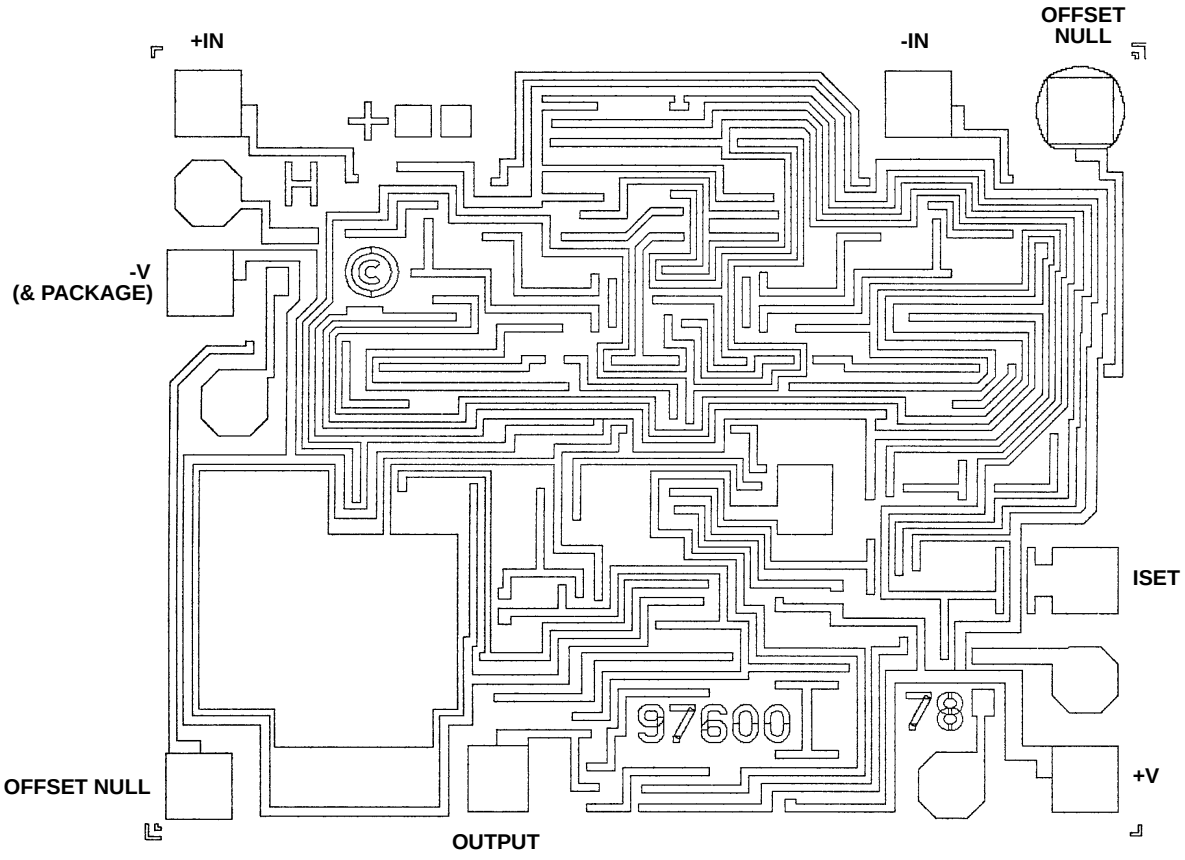
SUBSTRATE POTENTIAL (POWERED UP): -V

TRANSISTOR COUNT: 49

PROCESS: Complimentary Bipolar

Metallization Mask Layout

HS-3530RH



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Sales Office Headquarters

NORTH AMERICA
Intersil Corporation
P. O. Box 883, Mail Stop 53-204
Melbourne, FL 32902
TEL: (407) 724-7000
FAX: (407) 724-7240

EUROPE
Intersil SA
Mercure Center
100, Rue de la Fusee
1130 Brussels, Belgium
TEL: (32) 2.724.2111
FAX: (32) 2.724.22.05

ASIA
Intersil (Taiwan) Ltd.
Taiwan Limited
7F-6, No. 101 Fu Hsing North Road
Taipei, Taiwan
Republic of China
TEL: (886) 2 2716 9310
FAX: (886) 2 2715 3029