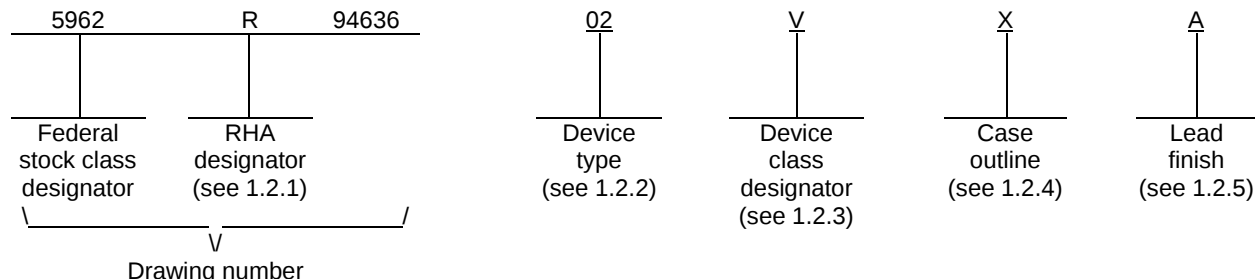


REVISIONS																				
LTR	DESCRIPTION										DATE (YR-MO-DA)					APPROVED				
A	Replace reference to MIL-STD-973 with reference to MIL-PRF-38535. - ro										07-06-12					R. HEBER				
B	Add device type 02. Add paragraphs 1.5, 4.4.4.1 and table IIB. Add footnote <u>6</u> / under Table I. - ro										14-07-14					C. SAFFLE				
REV																				
SHEET																				
REV	B																			
SHEET	15																			
REV STATUS		REV		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
OF SHEETS		SHEET		1	2	3	4	5	6	7	8	9	10	11	12	13	14			
PMIC N/A				PREPARED BY RAJESH PITHADIA							DLA LAND AND MARITIME COLUMBUS, OHIO 43218-3990 http://www.landandmaritime.dla.mil									
STANDARD MICROCIRCUIT DRAWING THIS DRAWING IS AVAILABLE FOR USE BY ALL DEPARTMENTS AND AGENCIES OF THE DEPARTMENT OF DEFENSE AMSC N/A				CHECKED BY RAJESH PITHADIA																
				APPROVED BY MICHAEL FRYE							MICROCIRCUIT, LINEAR, PRECISION VOLTAGE REFERENCE, MONOLITHIC SILICON									
				DRAWING APPROVAL DATE 94-05-31																
								REVISION LEVEL B							SIZE A	CAGE CODE 67268	5962-94636			
SHEET 1 OF 15																				

1. SCOPE

1.1 Scope. This drawing documents two product assurance class levels consisting of high reliability (device class Q and M) and space application (device class V). A choice of case outlines and lead finishes are available and are reflected in the Part or Identifying Number (PIN). When available, a choice of Radiation Hardness Assurance (RHA) levels is reflected in the PIN.

1.2 PIN. The PIN is as shown in the following example:



1.2.1 RHA designator. Device classes Q and V RHA marked devices meet the MIL-PRF-38535 specified RHA levels and are marked with the appropriate RHA designator. Device class M RHA marked devices meet the MIL-PRF-38535, appendix A specified RHA levels and are marked with the appropriate RHA designator. A dash (-) indicates a non-RHA device.

1.2.2 Device type(s). The device type(s) identify the circuit function as follows:

Device type	Generic number	Circuit function
01	780	2.5 V / 3.0 V high precision reference
02	780	2.5 V high precision reference

1.2.3 Device class designator. The device class designator is a single letter identifying the product assurance level as follows:

Device class	Device requirements documentation
M	Vendor self-certification to the requirements for MIL-STD-883 compliant, non-JAN class level B microcircuits in accordance with MIL-PRF-38535, appendix A
Q or V	Certification and qualification to MIL-PRF-38535

1.2.4 Case outline(s). The case outline(s) are as designated in MIL-STD-1835 and as follows:

Outline letter	Descriptive designator	Terminals	Package style
P	GDIP1-T8 or CDIP2-T8	8	Dual-in-line
X	CDFP3-F10	10	Bottom brazed flat pack

1.2.5 Lead finish. The lead finish is as specified in MIL-PRF-38535 for device classes Q and V or MIL-PRF-38535, appendix A for device class M.

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1.3 Absolute maximum ratings. 1/ 2/

Input voltage to ground (V_{IN})	+36 V
Trim pin to ground	+36 V
Temp pin to ground	+36 V
Power dissipation (P_D)	500 mW
Storage temperature range	-65°C to +150°C
Lead temperature (soldering, 10 seconds)	+300°C
Junction temperature (T_J)	+155°C
Thermal resistance, junction-to-case (θ_{JC}) :	
Case outline P	28°C/W
Case outline X	28°C/W
Thermal resistance, junction-to-ambient (θ_{JA}) :	
Case outline P	110°C/W
Case outline X	78°C/W

1.4 Recommended operating conditions. 2/

Operating voltage range (2.5 V output)	4.0 V to 36 V
Operating voltage range (3.0 V output) :	
Device type 01	4.5 V to 36 V
Ambient operating temperature range (T_A)	-55°C to +125°C

1.4.1 Operating performance characteristics.

Input / output characteristics: ($T_A = +25^\circ\text{C}$, $+V_{IN} = 5\text{ V}$)

Load regulation series sinking mode ($-10\text{ mA} < I_{OUT} < 0\text{ mA}$)	75 μV / mA
Load regulations shunt mode ($1\text{ mA} < I_{SHUNT} < 10\text{ mA}$)	75 μV / mA
Minimum shunt current	0.7 mA
Temperature pin output resistance	3 k Ω
Temperature pin temperature sensitivity	1.9 mV / °C
Wideband output noise at $T_A = +25^\circ\text{C}$ ($f = 0.1\text{ Hz to } 1\text{ kHz}$)	3 μVRMS
Wideband output noise at $T_A = +125^\circ\text{C}$ ($f = 0.1\text{ Hz to } 1\text{ kHz}$)	3.8 μVRMS
Wideband output noise at $T_A = -55^\circ\text{C}$ ($f = 0.1\text{ Hz to } 1\text{ kHz}$)	2.4 μVRMS
Voltage noise (special density, $f = 100\text{ Hz}$)	100 nV / $\sqrt{\text{Hz}}$

1.5 Radiation features.

Maximum total dose available (dose rate = 50 – 300 rads(Si)/s):

Device type 02	100 krad(Si) <u>3/</u>
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1/ Stresses above the absolute maximum rating may cause permanent damage to the device. Extended operation at the maximum levels may degrade performance and affect reliability.

2/ V_{IN} and V_{OUT} are differential relative to GND.

3/ Device type 02 may be dose rate sensitive in a space environment and may demonstrate enhanced low dose rate effects. Radiation end point limits for the noted parameter are guaranteed only for the conditions specified in MIL-STD-883, method 1019, condition A.

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2. APPLICABLE DOCUMENTS

2.1 Government specification, standards, and handbooks. The following specification, standards, and handbooks form a part of this drawing to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATION

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

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-883 - Test Method Standard Microcircuits.

MIL-STD-1835 - Interface Standard Electronic Component Case Outlines.

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-103 - List of Standard Microcircuit Drawings.

MIL-HDBK-780 - Standard Microcircuit Drawings.

(Copies of these documents are available online at <http://quicksearch.dla.mil> or 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 drawing and the references cited herein, the text of this drawing takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Item requirements. The individual item requirements for device classes Q and V shall be in accordance with MIL-PRF-38535 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. The individual item requirements for device class M shall be in accordance with MIL-PRF-38535, appendix A for non-JAN class level B devices and as specified herein.

3.2 Design, construction, and physical dimensions. The design, construction, and physical dimensions shall be as specified in MIL-PRF-38535 and herein for device classes Q and V or MIL-PRF-38535, appendix A and herein for device class M.

3.2.1 Case outlines. The case outlines shall be in accordance with 1.2.4 herein.

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

3.2.3 Block diagram. The block diagram shall be as specified on figure 2.

3.2.4 Radiation exposure circuit. The radiation exposure circuit shall be maintained by the manufacturer under document revision level control and shall be made available to the preparing and acquiring activity upon request.

3.3 Electrical performance characteristics and postirradiation parameter limits. Unless otherwise specified herein, the electrical performance characteristics and postirradiation parameter limits are as specified in table I and shall apply over the full ambient operating temperature range.

3.4 Electrical test requirements. The electrical test requirements shall be the subgroups specified in table IIA. The electrical tests for each subgroup are defined in table I.

3.5 Marking. The part shall be marked with the PIN listed in 1.2 herein. In addition, the manufacturer's PIN may also be marked. For packages where marking of the entire SMD PIN number is not feasible due to space limitations, the manufacturer has the option of not marking the "5962-" on the device. For RHA product using this option, the RHA designator shall still be marked. Marking for device classes Q and V shall be in accordance with MIL-PRF-38535. Marking for device class M shall be in accordance with MIL-PRF-38535, appendix A.

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3.5.1 Certification/compliance mark. The certification mark for device classes Q and V shall be a "QML" or "Q" as required in MIL-PRF-38535. The compliance mark for device class M shall be a "C" as required in MIL-PRF-38535, appendix A.

3.6 Certificate of compliance. For device classes Q and V, a certificate of compliance shall be required from a QML-38535 listed manufacturer in order to supply to the requirements of this drawing (see 6.6.1 herein). For device class M, a certificate of compliance shall be required from a manufacturer in order to be listed as an approved source of supply in MIL-HDBK-103 (see 6.6.2 herein). The certificate of compliance submitted to DLA Land and Maritime-VA prior to listing as an approved source of supply for this drawing shall affirm that the manufacturer's product meets, for device classes Q and V, the requirements of MIL-PRF-38535 and herein or for device class M, the requirements of MIL-PRF-38535, appendix A and herein.

3.7 Certificate of conformance. A certificate of conformance as required for device classes Q and V in MIL-PRF-38535 or for device class M in MIL-PRF-38535, appendix A shall be provided with each lot of microcircuits delivered to this drawing.

3.8 Notification of change for device class M. For device class M, notification to DLA Land and Maritime-VA of change of product (see 6.2 herein) involving devices acquired to this drawing is required for any change that affects this drawing.

3.9 Verification and review for device class M. For device class M, DLA Land and Maritime, DLA Land and Maritime's agent, and the acquiring activity retain the option to review the manufacturer's facility and applicable required documentation. Offshore documentation shall be made available onshore at the option of the reviewer.

3.10 Microcircuit group assignment for device class M. Device class M devices covered by this drawing shall be in microcircuit group number 59 (see MIL-PRF-38535, appendix A).

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TABLE I. Electrical performance characteristics.

Test	Symbol	Conditions <u>1/ 2/ 3/ 4/</u> -55°C ≤ T _A ≤ +125°C unless otherwise specified	Group A subgroups	Device type	Limits		Unit
					Min	Max	
Quiescent current	I _{CC}	2.5 V / 3.0 V	1,2,3	01		1.3	mA
		V _{OUT} = 2.5 V	1	02		940	μA
			2			890	
			3			990	
		P, L, R	1			940	
Output voltage error	V _{OUTERR}	2.5 V / 3.0 V, T _A = 25°C	1	01	-5	5	mV
		V _{OUT} = 2.5 V	1,2,3	02	-5	5	
		P, L, R	1		-5	8	
Line regulation	V _{RLINE}	2.5 V output, 4 V < +V _{IN} < 36 V	1,2,3	01		10	μV/V
		3.0 V output, 4.5 V < +V _{IN} < 36 V				10	
		V _{OUT} = 2.5 V, 4 V < +V _{IN} < 36 V	1	02		5	
			2,3			7.5	
		P, L, R	1			5	
Load regulation, sourcing	V _{RLOADSO}	I _L = 0 mA to 10 mA, series mode	1	01		50	μV/mA
			2,3			75	
			1,3	02		100	
			2			125	
		P, L, R	1			125	
Output short circuit current	I _{SC}	V _O = 0 V	1,2,3	02		45	mA
		P, L, R	1			45	
Load regulation, sinking	V _{RLOADSI}	I _L = -10 mA to 0 mA, series mode	1	01		75	μV/mA
			2,3			150	
Minimum shunt current	I _{shunt}	T _A = +25°C	1	01		1	mA
Load regulation, shunt	V _{RLOADREGSH}	1 mA < I _{shunt} < 10 mA	1	01		75	μV/mA
			2,3			150	

See footnotes at end of table.

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TABLE I. Electrical performance characteristics - Continued.

Test	Symbol	Conditions <u>1/ 2/ 3/ 4/</u> $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ unless otherwise specified	Group A subgroups	Device type	Limits		Unit
					Min	Max	
Output voltage temperature coefficient	DV_{OUT}/dt <u>5/</u>		2,3	01	-20	20	ppm/ $^{\circ}\text{C}$
		$T_A = +125^{\circ}\text{C}$ to -55°C	2,3	02	-15	15	
		$T_A = +125^{\circ}\text{C}$ to $+25^{\circ}\text{C}$			-15	15	
		$T_A = +25^{\circ}\text{C}$ to -55°C			-20	20	
Voltage output- temperature pin	V_{TEMP}		1	01	500	620	mV
			1	02	500	620	
			2,		680	850	
			3		350	480	
			P, L, R	1	500	620	
Trim range	T_{RANGE}		1,2,3	01,02	± 4		%
			P, L, R	1	02	± 4	
Wideband output noise	en_{RMS} <u>6/</u>	$f = 0.1 \text{ Hz to } 1 \text{ kHz}$	4	02		8	μVRMS

1/ $V_{CC} = +5 \text{ V}$, $I_L = 0 \text{ mA}$. See section 6.7 for application notes.

2/ Device type 02 supplied to this drawing has been characterized through all levels P, L and R of irradiation. Device type 02 is only tested at the "R" level. Pre and post irradiation values are identical unless otherwise specified in Table I. When performing post-irradiation electrical measurement for any RHA level, $T_A = +25^{\circ}\text{C}$.

3/ Device type 02 may be dose rate sensitive in a space environment and may demonstrate enhanced low dose rate effects. Radiation end point limits for the noted parameters are guaranteed only for the conditions specified in MIL-STD-883, method 1019 condition A.

4/ V_{IN} and V_{OUT} are differential relative to GND.

5/ Parameter not tested post irradiation. Output voltage temperature coefficient is measured by the box method. The temperature coefficient is defined as the slope of the diagonal of a box drawn around the output voltage plotted against temperature. V_{OUT} measured at -55°C , $+25^{\circ}\text{C}$, and $+125^{\circ}\text{C}$. For each temperature range, the lower temperature V_{OUT} reading is subtracted from the higher temperature V_{OUT} reading and the resulting difference is divided by the reference voltage (ppm full scale) and then divided by ($T_{max} - T_{min}$) for the temperature range calculated.

6/ Parameter not tested post irradiation.

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Device types	01	02
Case outlines	P	X
Terminal number	Terminal symbol	
1	NC	DNC
2	+V _{IN}	+V _{IN}
3	TEMP	TEMP
4	GND	NC
5	TRIM	GND
6	V _{OUT}	TRIM
7	NC	NC
8	O/P SELECT 2.5 V – NC 3.0 V - GND	V _{OUT}
9	---	NC
10	---	DNC

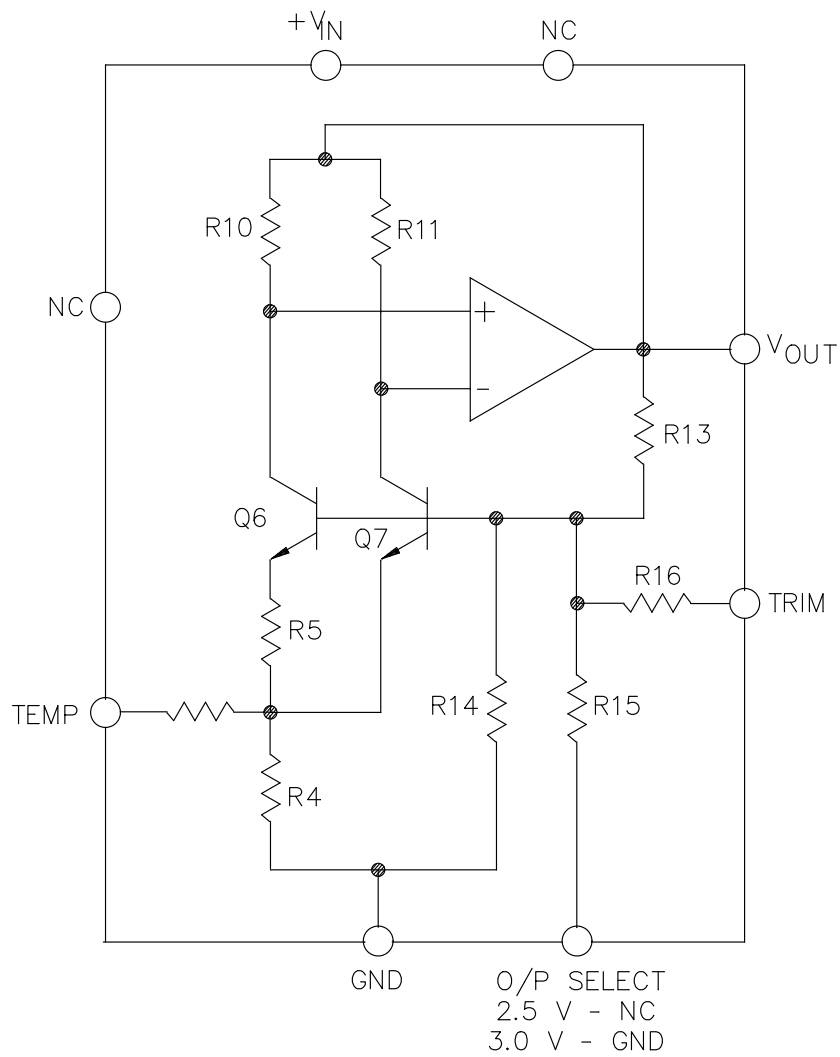
NC = No connected internally. Can be externally connected to ground or other DC bias greater than or equal to ground but, less than +V_{IN}.

DNC = Do not connect. Internally connected for factory use only. Cannot be connected externally.

Metal package lid on case outline X can be grounded.

FIGURE 1. Terminal connections.

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NOTE: O/P SELECT only applies to device type 01.

FIGURE 2. Block diagram.

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4. VERIFICATION

4.1 Sampling and inspection. For device classes Q and V, 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 affect the form, fit, or function as described herein. For device class M, sampling and inspection procedures shall be in accordance with MIL-PRF-38535, appendix A.

4.2 Screening. For device classes Q and V, screening shall be in accordance with MIL-PRF-38535, and shall be conducted on all devices prior to qualification and technology conformance inspection. For device class M, screening shall be in accordance with method 5004 of MIL-STD-883, and shall be conducted on all devices prior to quality conformance inspection.

4.2.1 Additional criteria for device class M.

- a. Burn-in test, method 1015 of MIL-STD-883.
 - (1) Test condition A, B, C, or D. The test circuit shall be maintained by the manufacturer under document revision level control and shall be made available to the preparing or acquiring activity upon request. The test circuit shall specify the inputs, outputs, biases, and power dissipation, as applicable, in accordance with the intent specified in method 1015 of MIL-STD-883.
 - (2) $T_A = +125^{\circ}\text{C}$, minimum.
- b. Interim and final electrical test parameters shall be as specified in table IIA herein.

4.2.2 Additional criteria for device classes Q and V.

- 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 revision level control of 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 method 1015 of MIL-STD-883.
- b. Interim and final electrical test parameters shall be as specified in table IIA herein.
- c. Additional screening for device class V beyond the requirements of device class Q shall be as specified in MIL-PRF-38535, appendix B.

4.3 Qualification inspection for device classes Q and V. Qualification inspection for device classes Q and V shall be in accordance with MIL-PRF-38535. Inspections to be performed shall be those specified in MIL-PRF-38535 and herein for groups A, B, C, D, and E inspections (see 4.4.1 through 4.4.4).

4.4 Conformance inspection. Technology conformance inspection for classes Q and V shall be in accordance with MIL-PRF-38535 including groups A, B, C, D, and E inspections, and as specified herein. Quality conformance inspection for device class M shall be in accordance with MIL-PRF-38535, appendix A and as specified herein. Inspections to be performed for device class M shall be those specified in method 5005 of MIL-STD-883 and herein for groups A, B, C, D, and E inspections (see 4.4.1 through 4.4.4).

4.4.1 Group A inspection.

- a. Tests shall be as specified in table IIA herein.
- b. Subgroups 5, 6, 7, 8, 9, 10, and 11 in table I, method 5005 of MIL-STD-883 shall be omitted.

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TABLE IIA. Electrical test requirements.

Test requirements	Subgroups (in accordance with MIL-STD-883, method 5005, table I)	Subgroups (in accordance with MIL-PRF-38535, table III)	
	Device class M	Device class Q	Device class V
Interim electrical parameters (see 4.2)	1	1	1
Final electrical parameters (see 4.2)	1,2,3 <u>1/</u>	1,2,3 <u>1/</u>	1,2,3 <u>1/ 2/ 3/</u>
Group A test requirements (see 4.4)	1,2,3	1,2,3	1,2,3,4
Group C end-point electrical parameters (see 4.4)	1	1	1,2,3 <u>2/ 3/</u>
Group D end-point electrical parameters (see 4.4)	1	1	1,2,3
Group E end-point electrical parameters (see 4.4)	---	---	1

1/ PDA applies to subgroup 1.

2/ See Table IIB for delta parameters. Delta limits are included in the PDA.

3/ Delta limits as specified in table IIB shall be required where specified, and the delta limit shall be computed with reference to the zero hour electrical parameters (see table I).

TABLE IIB. Burn-in and operating life test delta parameters. 1/

Parameters	Symbol	Device type	Limits		Units
			Min	Max	
Quiescent current	I _{CC}	02	-30	30	μA
Output voltage error	V _{OUT}	02	-2.5	2.5	mV

1/ 240 hour burn in and Group C end point electrical parameters.

Deltas are performed at T_A = +25°C.

4.4.2 Group C inspection. The group C inspection end-point electrical parameters shall be as specified in table IIA herein.

4.4.2.1 Additional criteria for device class M. Steady-state life test conditions, method 1005 of MIL-STD-883:

- a. Test condition A, B, C, or D. The test circuit shall be maintained by the manufacturer under document revision level control and shall be made available to the preparing or acquiring activity upon request. The test circuit shall specify the inputs, outputs, biases, and power dissipation, as applicable, in accordance with the intent specified in method 1005 of MIL-STD-883.
- b. T_A = +125°C, minimum.
- c. Test duration: 1,000 hours, except as permitted by method 1005 of MIL-STD-883.

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4.4.2.2 Additional criteria for device classes Q and V. 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 test circuit shall be maintained under document revision level control by the device manufacturer's 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 method 1005 of MIL-STD-883.

4.4.3 Group D inspection. The group D inspection end-point electrical parameters shall be as specified in table IIA herein.

4.4.4 Group E inspection. Group E inspection is required only for parts intended to be marked as radiation hardness assured (see 3.5 herein).

a. End-point electrical parameters shall be as specified in table IIA herein.

b. For device classes Q and V, the devices or test vehicle shall be subjected to radiation hardness assured tests as specified in MIL-PRF-38535 for the RHA level being tested. For device class M, the devices shall be subjected to radiation hardness assured tests as specified in MIL-PRF-38535, appendix A for the RHA level being tested. All device classes must meet the postirradiation end-point electrical parameter limits as defined in table I at $T_A = +25^{\circ}\text{C} \pm 5^{\circ}\text{C}$, after exposure, to the subgroups specified in table IIA herein.

4.4.4.1 Total dose irradiation testing. Total dose irradiation testing shall be performed in accordance with MIL-STD-883 method 1019, condition A for device type 02 and as specified herein.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-PRF-38535 for device classes Q and V or MIL-PRF-38535, appendix A for device class M.

6. NOTES

6.1 Intended use. Microcircuits conforming to this drawing are intended for use for Government microcircuit applications (original equipment), design applications, and logistics purposes.

6.1.1 Replaceability. Microcircuits covered by this drawing will replace the same generic device covered by a contractor prepared specification or drawing.

6.1.2 Substitutability. Device class Q devices will replace device class M devices.

6.2 Configuration control of SMD's. All proposed changes to existing SMD's will be coordinated with the users of record for the individual documents. This coordination will be accomplished using DD Form 1692, Engineering Change Proposal.

6.3 Record of users. Military and industrial users should inform DLA Land and Maritime when a system application requires configuration control and which SMD's are applicable to that system. DLA Land and Maritime will maintain a record of users and this list will be used for coordination and distribution of changes to the drawings. Users of drawings covering microelectronic devices (FSC 5962) should contact DLA Land and Maritime-VA, telephone (614) 692-8108.

6.4 Comments. Comments on this drawing should be directed to DLA Land and Maritime-VA, Columbus, Ohio 43218-3990, or telephone (614) 692-0540.

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

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6.6 Sources of supply.

6.6.1 Sources of supply for device classes Q and V. Sources of supply for device classes Q and V are listed in MIL-HDBK-103 and QML-38535. The vendors listed in MIL-HDBK-103 and QML-38535 have submitted a certificate of compliance (see 3.6 herein) to DLA Land and Maritime-VA and have agreed to this drawing.

6.6.2 Approved sources of supply for device class M. Approved sources of supply for class M are listed in MIL-HDBK-103. The vendors listed in MIL-HDBK-103 have agreed to this drawing and a certificate of compliance (see 3.6 herein) has been submitted to and accepted by DLA Land and Maritime-VA.

6.7 Application notes.

6.7.1 Product description.

The device is an ultrahigh precision band gap reference voltage that provides a 2.5 V output. Low initial error and temperature drift combined with low output noise and the ability to drive any value of capacitance make the device the ideal choice for enhancing the performance of high resolution analog to digital converters (ADCs) and digital to analog converters (DACs), and for any general-purpose precision reference application.

The device can be used to source or sink up to 10 mA, and can be used in series or shunt mode, thus allowing positive or negative output voltages without external components. This makes it suitable for virtually any high performance reference application. The device has no region of possible instability. The part is stable under all load conditions when a 1 μ F bypass capacitor is used on the supply.

A temperature output pin on the device provides an output voltage that varies linearly with temperature, allowing the part to be configured as a temperature transducer while providing a stable 2.5 V output.

Laser trimming of both initial accuracy and temperature coefficients results in low errors over temperature without the use of external components. For applications that require even higher accuracy, an optional external fine-trim connection is provided.

6.7.2 Theory of operation.

Band gap references are the high performance solution for low supply voltage and low power voltage reference applications. In this technique, a voltage with a positive temperature coefficient is combined with the negative coefficient of a transistor's base emitter voltage (V_{be}) to produce a constant band gap voltage.

Referring to figure 2, the band gap cell contains two NPN transistors (Q6 and Q7) that differ in emitter area by 12x. The difference in their V_{be} voltages produces a proportional to absolute temperature (PTAT) current in R5. This, in turn, produces a PTAT voltage across R4 that, when combined with the V_{be} of Q7, produces a voltage (V_{bg}) that does not vary with temperature. Precision laser trimming of the resistors and other patented circuit techniques are used to further enhance the drift performance. The output voltage of the device is determined by the configuration of resistors R13 and R14 (and R15 for device type 01) in the amplifiers feedback loop. This sets the output to 2.5 V (or 3.0 V for device type 01 if R15 is grounded).

A unique feature of the device is the low headroom design of the high gain amplifier, which produces a precision 2.5 V output from as low as 4.0 V input.

The PTAT voltage is also used to provide the user with a thermometer output voltage on the TEMP pin that increases at a rate of approximately +1.9 mV/ $^{\circ}$ C.

6.7.3 Applying the device.

The device can be used without any external components to achieve specified performance. If power is supplied to $+V_{IN}$ and GND is grounded, V_{OUT} provides a 2.5 V output. A bypass capacitor of 1 μ F ($+V_{IN}$ and GND) should be used if the load capacitance in the application is expected to be greater than 1 nF.

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6.7.4 Increased accuracy with external trim.

Initial error can be nulled using a single 25 k Ω potentiometer connected between V_{OUT} , TRIM and GND ($R_{NULL} = 0 \Omega$ in figure 3). This is a coarse trim with an adjustment range of 4% included here for compatibility with other references. A fine trim can be implemented by inserting a large value resistor in series with the wiper of the potentiometer (for example, $1 \text{ M}\Omega < R_{NULL} < 5 \text{ M}\Omega$). The trim range, expressed as a fraction of the output, is greater than or equal to $2.1 \text{ k}\Omega / R_{NULL}$.

The external null resistor affects the overall temperature coefficient by a factor equal to the percentage of V_{OUT} nulled. For example, a 1 mV (0.04 %) shift in the output caused by the trim circuit, with a 100 ppm/ $^{\circ}\text{C}$ null resistor, adds less than 0.08 ppm/ $^{\circ}\text{C}$ to the output drift (0.04 % $\times$ 200 ppm/ $^{\circ}\text{C}$, since the resistors internal to the device also have temperature coefficients of less than 100 ppm/ $^{\circ}\text{C}$).

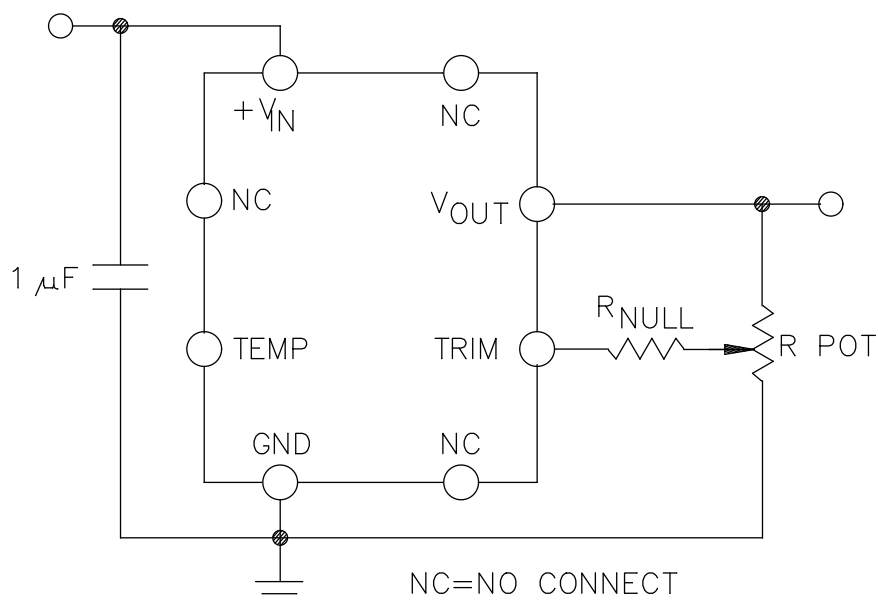


FIGURE 3. Optional Fine-Trim Circuit

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6.7.5. Noise performance

The impressive noise performance of the device can be further improved, if desired, by adding two capacitors: a load capacitor (C1) between the output and ground, and a compensation capacitor (C2) between the TEMP pin and ground. Suitable values are shown in figure 4. C1 and C2 also improve the settling performance of the device when subjected to load transients.

The choice of C1 and C2 was primarily dictated by the need for a relatively flat response that rolled off early in the high frequency noise at the output. However, there is considerable margin in the choice of these capacitors. For example, the user can actually put a huge C2 on the TEMP pin with none on the output pin. However, one must either use very little or a lot of capacitance at the TEMP pin. Intermediate values of capacitance can sometimes cause oscillation. In any case, the user should follow the recommendations in figure 4.

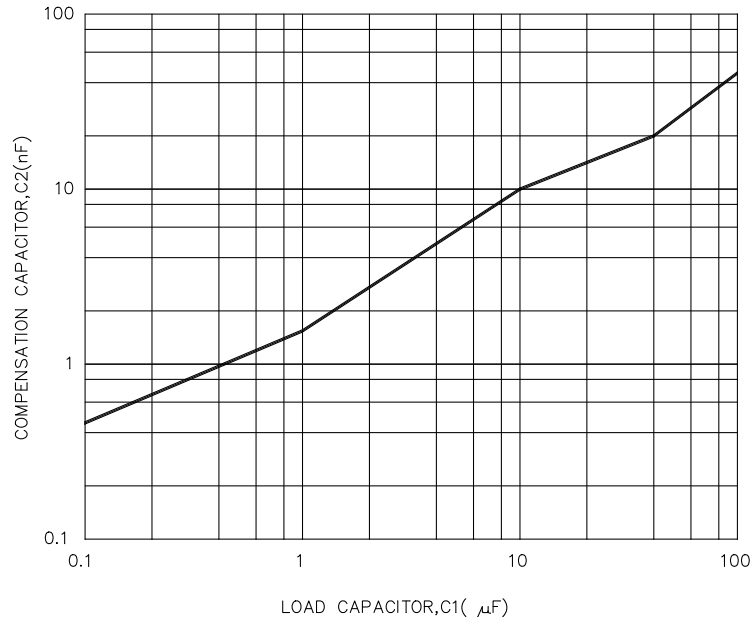


FIGURE 4. Compensation and load capacitor combinations

6.7.6. Temperature output pin

The device provides a TEMP output pin that varies linearly with temperature. This output can be used to monitor changes in system ambient temperature, and to initiate calibration of the system if desired. The voltage V_{TEMP} is nominally 565 mV at 25°C, and the temperature coefficient is approximately 1.9 mV/°C.

Since the TEMP voltage is acquired from the band gap core circuit, current pulled from this pin has a significant effect on V_{OUT} . Care must be taken to buffer the TEMP output with a low enough bias current amplifier. The relationship between I_{TEMP} and V_{OUT} is: $\Delta V_{OUT} = 5.8 \text{ mV} / \mu\text{A} \times I_{TEMP}$ (2.5 V range)

6.7.7. Turn-on time

The time required for the output voltage to reach its final value within a specified error band is defined as the turn-on settling time. The two major factors that affect this are the active circuit settling time and the time for the thermal gradients on the chip to stabilize. The device normally settles to within 0.1 % of its final value within 10 μs.

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STANDARD MICROCIRCUIT DRAWING BULLETIN

DATE: 14-07-14

Approved sources of supply for SMD 5962-94636 are listed below for immediate acquisition information only and shall be added to MIL-HDBK-103 and QML-38535 during the next revision. MIL-HDBK-103 and QML-38535 will be revised to include the addition or deletion of sources. The vendors listed below have agreed to this drawing and a certificate of compliance has been submitted to and accepted by DLA Land and Maritime-VA. This information bulletin is superseded by the next dated revision of MIL-HDBK-103 and QML-38535. DLA Land and Maritime maintains an online database of all current sources of supply at <http://www.landandmaritime.dla.mil/Programs/Smcr/>.

Standard microcircuit drawing PIN <u>1</u> /	Vendor CAGE number	Vendor similar PIN <u>2</u> /
5962-9463601MPA	<u>3</u> /	AD780SQ/883B
5962R9463602VXA	24355	AD780AF/QMLR

- 1/ The lead finish shown for each PIN representing a hermetic package is the most readily available from the manufacturer listed for that part. If the desired lead finish is not listed contact the vendor to determine its availability.
- 2/ Caution. Do not use this number for item acquisition. Items acquired to this number may not satisfy the performance requirements of this drawing.
- 3/ Not available from an approved source of supply.

Vendor CAGE
number

24355

Vendor name
and address

Analog Devices
Route 1 Industrial Park
P.O. Box 9106
Norwood, MA 02062
Point of contact: 7910 Triad Center Drive
Greensboro, NC 27409-9605

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