National Semiconductor

MICROCIRCUIT DATA SHEET

MNLP2956A-X REV 0A0

Original Creation Date: 08/09/94
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Last Major Revision Date: 08/09/94

DUAL MICROPOWER LOW-DROPOUT VOLTAGE REGULATORS

General Description

The LP2956 is a micropower voltage regulator with very low quiescent current(170uA typical at light loads) and very low dropout voltage (typically 60mV at 1mA load current and 470mV at 250mA load current on the main output).

The LP2956 retains all the desirable characteristics of the LP2951, but offers increased output current (main output), an auxiliary LDO adjustable regulated output (75mA), and additional features.

The auxiliary output is always on (regardless of main output status), so it can be used to power memory circuits.

Quiescent current increases only slightly at dropout, which prolongs battery life.

The error flag goes low if the main output voltage drops out of regulation.

An open-collector auxiliary comparator is included, whose inverting input is tied to the 1.23V reference.

Reverse battery protection is provided.

The parts are available in plastic DIP and surface mount packages.

Industry Part Number

LP2956A

NS Part Numbers

LP2956AMJ-QML

Prime Die

LP2956A

Controlling Document

5962-9554701QEA

Processing

MIL-STD-883, Method 5004

Quality Conformance Inspection

MIL-STD-883, Method 5005

Subgrp	Description	Temp (^{O}C)
1	Static tests at	+25
2	Static tests at	+125
3	Static tests at	-55
4	Dynamic tests at	+25
5	Dynamic tests at	+125
6	Dynamic tests at	-55
7	Functional tests at	+25
8A	Functional tests at	+125
8B	Functional tests at	-55
9	Switching tests at	+25
10	Switching tests at	+125
11	Switching tests at	-55

Features

- Output voltage adjusts from 1.23V to 29V.
- Guaranteed 250 mA current (main output).
- Auxiliary LDO (75 mA) adjustable output.
- Auxiliary comparator with open-collector output.
- Shutdown pin for main output.
- Extremely low quiescent current.
- Low dropout voltage.
- Extremely tight line and load regulation.
- Very low temperature coefficient.
- Current and thermal limiting.
- Reverse battery protection.

Applications

- High-efficiency linear regulator.
- Low dropout battery-powered regulator.
- uP system regulator with switchable high-current Vcc.

(Absolute Maximum Ratings)

(Note 1)

Storage Temperature Range	-65 C to +150 C
Operating Junction Temperature Range	-55 C to +125 C
Lead Temperature (Soldering, 5 Seconds)	260 C
Power Dissipation (Note 2, 3)	Internally Limited
Input Supply Voltage	-20V to +30V
Maximum Junction Temperature	150 C
Feedback Input Voltage (Note 4)	-0.3V to +5V
Aux. Feedback Input Voltage (Note 4)	-0.3V to +5V
Shutdown Input Voltage (Note 4)	-0.3V to +30V
Comparator Input Voltage (Note 4, 5)	-0.3V to +30V
Comparator Output Voltage (Note 4, 5)	-0.3V to +30V
Thermal Resistance	
ThetaJA	
CERDIP (Still Air)	72 C/W
(500LF/Min Air flow)	36 C/W
ThetaJC (Note 3)	
CERDIP	2 C/W
ESD Rating (Note 6)	2kV

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 2: The maximum power dissipation must be derated at elevated temperatures and is dictated by Tjmax (maximum junction temperature), ThetaJA (package junction to ambient thermal resistance), and TA (ambient temperature). The maximum allowable power dissipation at any temperature is Pdmax = (Tjmax - TA)/ThetaJA or the number given in the Absolute Maximum Ratings, whichever is lower. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. See Application Hints for additional information on heat sinking and thermal resistance.

(Continued)

Note 3: The package material for these devices allows much improved heat transfer over our standard ceramic packages. In order to take full advantage of this improved heat transfer, heat sinking must be provided between the package base (directly beneath the die), and either metal traces on, or thermal vias through, the printed circuit board. Without this additional heat sinking, device power dissipation must be calculated using junction-to-ambient, rather than junction-to-case, thermal resistance. It must not be assumed that the device leads will provide substantial heat transfer out of the package, since the thermal resistance of the leadframe material is very poor, relative to the material of the package base. The stated junction-to-case thermal resistance is for the package material only, and does not account for the additional thermal resistance between the package base and the printed circuit board. The user must determine the value of the additional thermal resistance and must combine this with the stated value for the package, to calculate the total allowed power dissipation for the device.

Note 4: When used in dual-supply systems where the regulator load is returned to a negative supply, the output voltage must be diode-clamped to ground.

Note 5: May exceed the input supply voltage.

Note 6: All pins are rated for 2kV, except for the auxiliary feedback pin which is rated for 1.2kV (human body model, 100pF discharged through 1.5kOhms).

Electrical Characteristics

MAIN OUTPUT

(The following conditions apply to all the following parameters, unless otherwise specified.)
DC: Vin=6V,Cl=2.2uF(Main Out.) and 10uF(Aux. Out.), Feedback pin is tied to 5V Tap pin,Cin=1uF,Vsd=0V,Main Out. pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load
AC: SAME AS DC CONDITION

SYMBOL	PARAMETER	CONDITIONS	NOTES	PIN-NAME	MIN	MAX	UNIT	SUB-GROUPS
Vo	Output Voltage				4.975	5.025	V	1
					4.940	5.060	V	2, 3
		1mA ≤ Il ≤ 250mA			4.930	5.070	V	1, 2, 3
Delta Vo / Delta t	Temperature Coefficient		1			100	ppm/C	1, 2, 3
Delta Vo / Vo	Line Regulation	Vin = 6V to 30V				0.1	%	1
						0.2	%	2, 3
Delta Vo / Vo	Load Regulation	Il = 1mA to 250mA				0.16	%	1
		Il = 0.1mA to 1mA	2			0.20	%	2, 3
Vin - Vo	Dropout Voltage	Il = 1mA	3			100	mV	1
			3			150	mV	2, 3
		Il = 50mA	3			300	mV	1
			3			420	mV	2, 3
		Il = 100mA	3			400	mV	1
			3			520	mV	2, 3
		Il = 250mA	3			600	mV	1
			3			800	mV	2, 3
Ilimit	Current Limit	Rl = 1 Ohm				500	mA	1
						530	mA	2, 3
Delta Vo / Delta Pd	Thermal Regulation		4			0.2	%/W	1
Vfb	Feedback Pin Voltage				1.215	1.245	V	1
Ifb	Feedback Pin Bias Current					40	nA	1
						60	nA	2, 3
Io(OFF)	Output Leakage In Shutdown	I(SD IN) ≥ 1uA, Vin = 30V, Vout = 0V				10	uA	1
		I(SD IN) ≥ 1uA, Vin = 30V, Vout = 0V				20	uA	2, 3

Electrical Characteristics

AUXILIARY OUTPUT

(The following conditions apply to all the following parameters, unless otherwise specified.)
DC: Vin=6V,Cl=2.2uF(Main Out.) and 10uF(Aux. Out.), Feedback pin is tied to 5V Tap pin,Cin=1uF,Vsd=0V,Main Out. pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load
AC: SAME AS DC CONDITION

SYMBOL	PARAMETER	CONDITIONS	NOTES	PIN-NAME	MIN	MAX	UNIT	SUB-GROUPS
Vfb	Feedback Pin Voltage				1.22	1.25	V	1
					1.21	1.26	V	2, 3
Ifb	Feedback Pin Bias Current					20	nA	1
						30	nA	2, 3
Delta Vo / Vo	Line Regulation	6V ≤ Vin ≤ 30V				0.3	%	1
		6V ≤ Vin ≤ 30V				0.5	%	2, 3
Delta Vo / Vo	Load Regulation	Il = 0.1mA to 1mA				0.3	%	1
		Il = 1mA to 75mA	5			0.6	%	2, 3
Vin - Vo	Dropout Voltage	Il = 1mA				200	mV	1
						300	mV	2, 3
		Il = 50mA				600	mV	1
						700	mV	2, 3
		Il = 75mA				700	mV	1
						850	mV	2, 3
Ilim	Current Limit	Vout = 0V	6			200	mA	1
			6			250	mA	2, 3
Delta Vo/Delta Pd	Thermal Regulation		4			0.5	%/W	1, 2, 3

Electrical Characteristics

DROPOUT DETECTION COMPARATOR

(The following conditions apply to all the following parameters, unless otherwise specified.)
DC: Vin=6V,Cl=2.2uF(Main Out.) and 10uF(Aux. Out.), Feedback pin is tied to 5V Tap pin,Cin=1uF,Vsd=0V,Main Out. pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load
AC: SAME AS DC CONDITION

SYMBOL	PARAMETER	CONDITIONS	NOTES	PIN-NAME	MIN	MAX	UNIT	SUB-GROUPS
Ioh	Output "High" Leakage	Voh = 30V				1	uA	1
						2	uA	2, 3
Vol	Output "Low" Voltage	Vin = 4V				250	mV	1
		Io (COMP) = 400uA				400	mV	2, 3
VThr (max)	Upper Threshold Voltage		7		-320	-150	mV	1
			7		-380	-100	mV	2, 3
VThr (min)	Lower Threshold Voltage		7		-450	-230	mV	1
			7		-640	-160	mV	2, 3

SHUTDOWN INPUT

(The following conditions apply to all the following parameters, unless otherwise specified.)
DC: Vin=6V,Cl=2.2uF(Main Out.) and 10uF(Aux. Out.), Feedback pin is tied to 5V Tap pin,Cin=1uF,Vsd=0V,Main Out. pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load
AC: SAME AS DC CONDITION

Iin	Input Current to Disable Output		8			0.5	uA	1, 2, 3
Vih	Shutdown Input High Threshold	I(sd in) $\geq$ 1uA			900		mV	1
		I(sd in) $\geq$ 1uA			1200		mV	2, 3
Vil	Shutdown Input Low Threshold	Vo $\geq$ 4.5V				400	mV	1
		Vo $\geq$ 4.5V				200	mV	2, 3

Electrical Characteristics

AUXILIARY COMPARATOR

(The following conditions apply to all the following parameters, unless otherwise specified.)
DC: Vin=6V,Cl=2.2uF(Main Out.) and 10uF(Aux. Out.), Feedback pin is tied to 5V Tap pin,Cin=1uF,Vsd=0V,Main Out. pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load
AC: SAME AS DC CONDITION

SYMBOL	PARAMETER	CONDITIONS	NOTES	PIN-NAME	MIN	MAX	UNIT	SUB-GROUPS
Vt(High)	Upper Trip Point		9		1.20	1.28	V	1
			9		1.19	1.29	V	2, 3
Vt(Low)	Lower Trip Point		9		1.19	1.27	V	1
			9		1.18	1.28	V	2, 3
Ioh	Output "HIGH" Leakage	Voh = 30V				1	uA	1
		Vin(COMP) = 1.3V				2	uA	2, 3
Vol	Output "LOW" Leakage	Vin(COMP) = 1.1V				250	mV	1
		Io(COMP) = 400uA				400	mV	2, 3
Ib	Input Bias Current	0 ≤ Vin(COMP) ≤ 5V			-30	30	nA	1
		0 ≤ Vin(COMP) ≤ 5V			-50	50	nA	2, 3

Electrical Characteristics

GROUND PIN CURRENT

(The following conditions apply to all the following parameters, unless otherwise specified.)
DC: Vin=6V,Cl=2.2uF(Main Out.) and 10uF(Aux. Out.), Feedback pin is tied to 5V Tap pin,Cin=1uF,Vsd=0V,Main Out. pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load
AC: SAME AS DC CONDITION

SYMBOL	PARAMETER	CONDITIONS	NOTES	PIN-NAME	MIN	MAX	UNIT	SUB-GROUPS
Ignd	Ground Pin Current	Il (Main Out) = 1mA	10			250	uA	1
		Il (Aux. Out) = 0.1mA	10			280	uA	2, 3
		Il (Main Out) = 50mA	10			2	mA	1
		Il (Aux. Out) = 1mA	10			2.5	mA	2, 3
		Il (Main Out) = 100mA	10			6	mA	1
		Il (Aux. Out) = 1 mA	10			8	mA	2, 3
		Il (Main Out) = 250mA	10			28	mA	1
		Il (Aux. Out) = 1mA	10			33	mA	2, 3
		Il (Main Out) = 1 mA	10			6	mA	1
		Il (Aux. Out) = 50mA	10			8	mA	2, 3
		Il (Main Out) = 1mA	10			8	mA	1
		Il (Aux. Out) = 75mA	10			10	mA	2, 3
Ignd	Ground Pin Current at Dropout	Vin = 4.5V	10			325	uA	1
		Il (Main Out) = 0.1mA	10			350	uA	2, 3
		Il (Aux. Out) = 0.1mA	10					
Ignd	Ground Pin Current at Shutdown	No Load on Either Output	10			180	uA	1
		I(sd in) $\geq$ 1uA	10			200	uA	2, 3

Note 1: Output or reference voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
Note 2: Load regulation is measured at constant junction temperature using low duty cycle pulse testing. Two separate tests are performed, one for the range of 100uA to 1mA and one for the 1mA to 250mA range. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
Note 3: Dropout voltage is defined as the input to output differential at which the output voltage drops 100mV below the value measured with a 1V differential. At very low values of programmed output voltage, the input voltage minimum of 2V (2.3V over temperature) must be observed.
Note 4: Thermal regulation is the change in output voltage at a time T after a change in power dissipation, excluding load or line regulation effects. Specifications are for a 200mA load pulse at Vin = 20V (3W pulse) for T = 10ms on the Main regulator output. For the Auxiliary regulator output, specifications are for a 66mA load pulse at Vin = 20V (1W pulse) for T = 10ms.
Note 5: Load regulation is measured at constant junction temperature using low duty cycle pulse testing. Two separate tests are performed, one for the range of 100uA to 1mA and one for the 1mA to 75mA range. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
Note 6: The auxiliary regulator output has foldback limiting, which means the output current reduces with output voltage. The tested limit is for Vout = 0V, so the output current will be higher at higher output voltage.

(Continued)

Note 7: Dropout dectection comparator thresholds are expressed as changes in a 5V output. To express the threshold voltages in terms of a differential at the Feedback terminal, divide by the error amplifier gain = Vout/Vref.

Note 8: The shutdown input equivalent circuit is the base of a grounded-emitter NPN transistor in series with a current-limiting resistor. Pulling the shutdown input high turns off the main regulator. For more details, see Application Hints.

Note 9: This test is performed with the auxiliary comparator output sinking 400uA of current. At the upper trip point, the comparator output must be $\geq$2.4V. At the low trip point, the comparator output must be $\leq$0.4V.

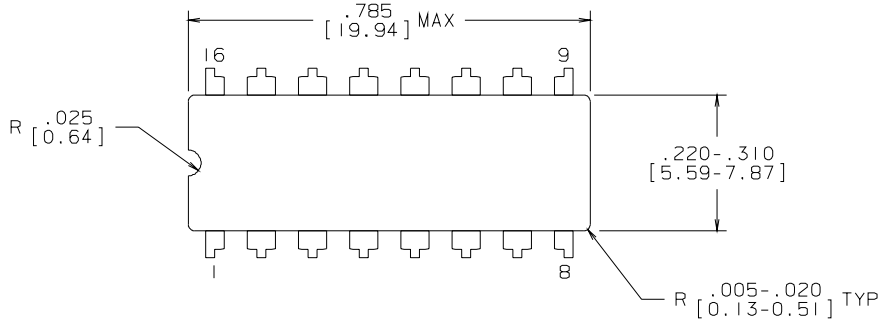
Note 10: Ground pin current is the regulator quiescent current. The total current drawn from the source is the sum of the ground pin current, output load current, and current through the external resistive dividers (if used).

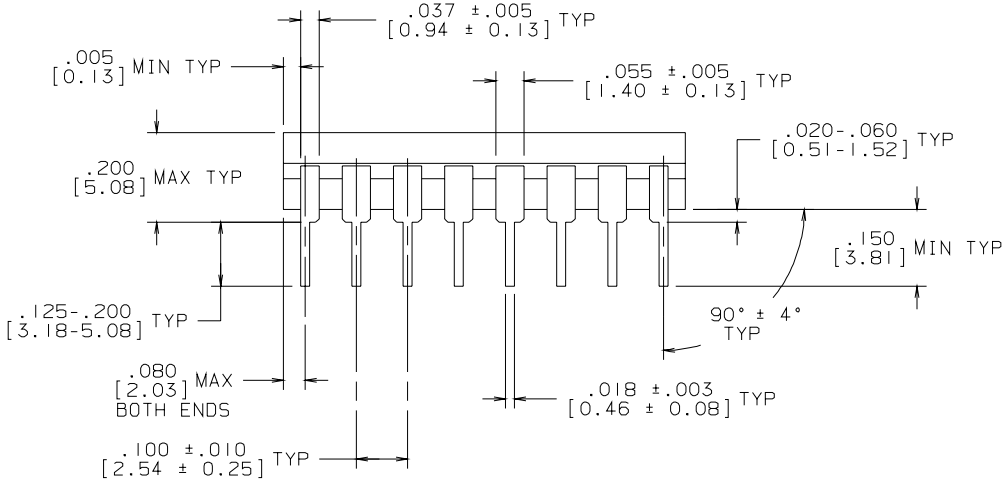
Graphics and Diagrams

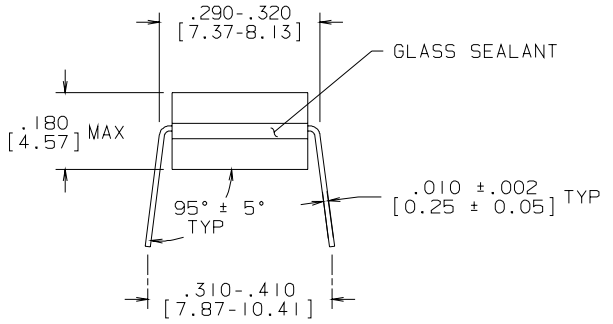
GRAPHICS#	DESCRIPTION
6270HRA2	CERDIP (J), 16 LEAD (B/I CKT)
J16ARL	CERDIP (J), 16 LEAD (P/P DWG)

See attached graphics following this page.

REVISIONS				
LTR	DESCRIPTION	E.C.N.	DATE	BY/APP'D
L	REVISE PER CURRENT STD; REDRAW	09996	09/15/93	TL/







MIL/AERO CONFIGURATION CONTROL

MIL-M-38510 CONFIGURATION CONTROL

CONTROLLING DIMENSION: INCH

APPROVALS	DATE
DRAWN T. LEQUANG	09/15/93
DFTG. CHK.	
ENGR. CHK.	
APPROVAL	

NATIONAL SEMICONDUCTOR CORPORATION
2900 Semiconductor Drive, Santa Clara, CA 95052-8090

CERDIP (J), 16 LEAD

PROJECTION

INCH [MM]

SCALE	SIZE	DRAWING NUMBER	REV
N/A	B	MKT-J16A	L

DO NOT SCALE DRAWING | SHEET 1 OF 1

NOTES: UNLESS OTHERWISE SPECIFIED

1. LEAD FINISH TO BE 200 MICROINCHES / 5.08 MICROMETERS MINIMUM SOLDER MEASURED AT THE CREST OF THE MAJOR FLATS.
2. JEDEC REGISTRATION MO-036, VARIATION AD, DATED 04/1981.

Revision History

Rev	ECN #	Rel Date	Originator	Changes
0A0	M0000610	07/08/97	Barbara Lopez	Initial Release of: MNLP2956A-X Rev. 0A0. Added note for power dissipation and reference to thermal resistance for Aluminum Nitride package.