National Semiconductor

LP2952/LP2952A/LP2953/LP2953A
Adjustable Micropower Low-Dropout Voltage Regulators

General Description

The LP2952 and LP2953 are micropower voltage regulators with very low quiescent current (130 μA typical at 1 mA load) and very low dropout voltage (typ. 60 mV at light load and 470 mV at 250 mA load current). They are ideally suited for battery-powered systems. Furthermore, the quiescent current increases only slightly at dropout, which prolongs battery life.

The LP2952 and LP2953 retain all the desirable characteristics of the LP2951, but offer increased output current, additional features, and an improved shutdown function.

The internal crowbar pulls the output down quickly when the shutdown is activated.

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

Reverse battery protection is provided.

The internal voltage reference is made available for external use, providing a low-T.C. reference with very good line and load regulation.

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

Features

- Output voltage adjusts from 1.23V to 29V
- Guaranteed 250 mA output current
- Extremely low quiescent current
- Low dropout voltage
- Extremely tight line and load regulation
- Very low temperature coefficient
- Current and thermal limiting
- Reverse battery protection
- 50 mA (typical) output pulldown crowbar

LP2953 Versions Only

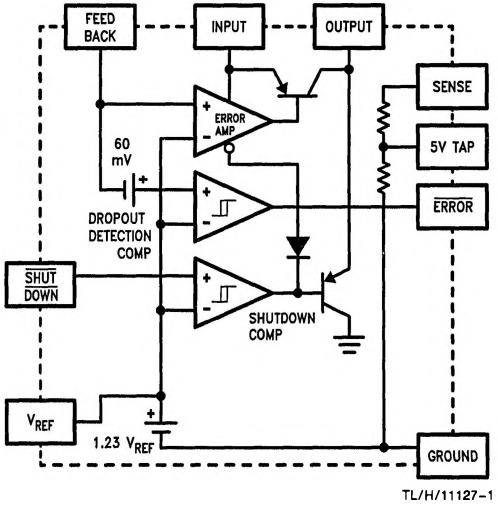
- Auxiliary comparator included with CMOS/TTL compatible output levels. Can be used for fault detection, low input line detection, etc.

Applications

- High-efficiency linear regulator
- Regulator with under-voltage shutdown
- Low dropout battery-powered regulator
- Snap-ON/Snap-OFF regulator

Block Diagrams

LP2952



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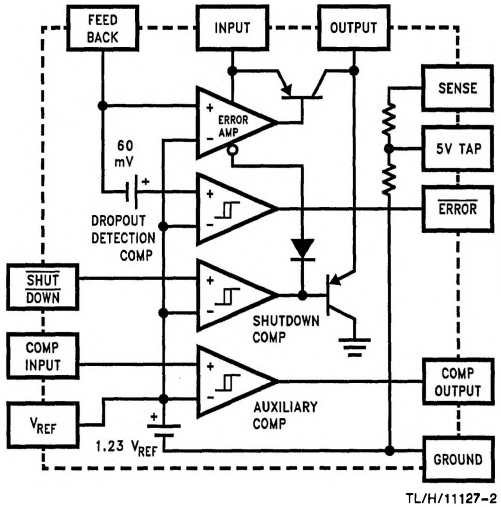
LP2953



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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Storage Temperature Range	−65°C to +150°C
Operating Junction Temperature Range	
LP2952AI/LP2952I	−40°C to +125°C
LP2953AI/LP2953I	−40°C to +125°C
Lead Temp. (Soldering, 5 seconds)	260°C
Power Dissipation (Note 2)	Internally Limited
Input Supply Voltage	−20V to +30V
Feedback Input Voltage (Note 3)	−0.3V to +5V
Comparator Input Voltage (Note 4)	−0.3V to +30V
Shutdown Input Voltage (Note 4)	−0.3V to +30V
Comparator Output Voltage (Note 4)	−0.3V to +30V
ESD Rating (Note 15)	2 kV

Electrical Characteristics

Limits in standard typeface are for T_J = 25°C, **bold typeface** applies over the −40°C to +125°C junction temperature range. Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods. Unless otherwise specified: V_{IN} = 6V, I_L = 1 mA, C_L = 2.2 µF, Feedback pin is tied to 5V Tap pin, Output pin is tied to Output Sense pin, V_{OUT} = 5V.

Symbol	Parameter	Conditions	Typical	2952AI 2953AI		2952I 2953I		Units
				Min	Max	Min	Max	
V_O	Output Voltage		5.0	4.975 **4.940**	5.025 **5.060**	4.950 **4.900**	5.050 **5.100**	V
		1 mA ≤ I_L ≤ 250 mA	5.0	**4.930**	**5.070**	**4.880**	**5.120**	
$\frac{\Delta V_O}{\Delta T}$	Output Voltage Temp. Coefficient	(Note 5)	**20**		**100**		**150**	ppm/°C
$\frac{\Delta V_O}{V_O}$	Output Voltage Line Regulation	V_{IN} = 6V to 30V	0.03		0.1 **0.2**		0.2 **0.4**	%
$\frac{\Delta V_O}{V_O}$	Output Voltage Load Regulation (Note 6)	I_L = 1 mA to 250 mA I_L = 0.1 mA to 1 mA	0.04		0.16 **0.20**		0.20 **0.30**	%
$V_{IN}-V_O$	Dropout Voltage (Note 7)	I_L = 1 mA	60		100 **150**		100 **150**	mV
		I_L = 50 mA	240		300 **420**		300 **420**	
		I_L = 100 mA	310		400 **520**		400 **520**	
		I_L = 250 mA	470		600 **800**		600 **800**	
I_{GND}	Ground Pin Current (Note 8)	I_L = 1 mA	130		170 **200**		170 **200**	µA
		I_L = 50 mA	1.1		2 **2.5**		2 **2.5**	mA
		I_L = 100 mA	4.5		6 **8**		6 **8**	
		I_L = 250 mA	21		28 **33**		28 **33**	
I_{GND}	Ground Pin Current at Dropout (Note 8)	V_{IN} = 4.5V I_L = 100 µA	165		210 **240**		210 **240**	µA
I_{GND}	Ground Pin Current at Shutdown (Note 8)	(Note 9)	105		140		140	µA

Electrical Characteristics Limits in standard typeface are for T_J = 25°C, **bold typeface** applies over the −40°C to +125°C junction temperature range. Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods. Unless otherwise specified: V_{IN} = 6V, I_L = 1 mA, C_L = 2.2 µF, Feedback pin is tied to 5V Tap pin, Output pin is tied to Output Sense pin, V_{OUT} = 5V. (Continued)

Symbol	Parameter	Conditions	Typical	2952AI 2953AI		2952I 2953I		Units
				Min	Max	Min	Max	
I_{LIMIT}	Current Limit	V_{OUT} = 0	380		500 **530**		500 **530**	mA
$\frac{\Delta V_O}{\Delta Pd}$	Thermal Regulation	(Note 10)	0.05		0.2		0.2	%/W
e_n	Output Noise Voltage (10 Hz to 100 kHz) I_L = 100 mA	C_L = 2.2 µF	400					µV RMS
		C_L = 33 µF	260					
		C_L = 33 µF (Note 11)	80					
V_{REF}	Reference Voltage	(Note 12)	1.230	1.215 **1.205**	1.245 **1.255**	1.205 **1.190**	1.255 **1.270**	V
$\frac{\Delta V_{REF}}{V_{REF}}$	Reference Voltage Line Regulation	V_{IN} = 2.5V to 6V V_{IN} = 6V to 30V (Note 13)	0.03		0.1 **0.2**		0.2 **0.4**	%
$\frac{\Delta V_{REF}}{V_{REF}}$	Reference Voltage Load Regulation	I_{REF} = 0 to 200 µA	0.25		0.4 **0.6**		0.8 **1.0**	%
$\frac{\Delta V_{REF}}{\Delta T}$	Reference Voltage Temp. Coefficient	(Note 5)	**20**					ppm/°C
I_B(FB)	Feedback Pin Bias Current		20		40 **60**		40 **60**	nA
I_O (SINK)	Output "OFF" Pulldown Current	(Note 9)	50	30 **20**		30 **20**		mA
DROPOUT DETECTION COMPARATOR								
I_{OH}	Output "HIGH" Leakage	V_{OH} = 30V	0.01		1 **2**		1 **2**	µA
V_{OL}	Output "LOW" Voltage	V_{IN} = 4V I_O(COMP) = 400 µA	150		250 **400**		250 **400**	mV
V_{THR} (MAX)	Upper Threshold Voltage	(Note 14)	−240	−320 **−380**	−150 **−100**	−320 **−380**	−150 **−100**	mV
V_{THR} (MIN)	Lower Threshold Voltage	(Note 14)	−350	−450 **−640**	−230 **−160**	−450 **−640**	−230 **−160**	mV
HYST	Hysteresis	(Note 14)	60					mV
SHUTDOWN INPUT (Note 16)								
V_{OS}	Input Offset Voltage	(Referred to V_{REF})	±3	−7.5 **−10**	7.5 **10**	−7.5 **−10**	7.5 **10**	mV
HYST	Hysteresis		6					mV
I_B	Input Bias Current	V_{IN}(S/D) = 0 to 5V	10	−30 **−50**	30 **50**	−30 **−50**	30 **50**	nA

Electrical Characteristics Limits in standard typeface are for T_J = 25°C, **bold typeface** applies over the −40°C to +125°C junction temperature range. Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods. Unless otherwise specified: V_{IN} = 6V, I_L = 1 mA, C_L = 2.2 µF, Feedback pin is tied to 5V Tap pin, Output pin is tied to Output Sense pin, V_{OUT} = 5V. (Continued)

Symbol	Parameter	Conditions	Typical	2952AI 2953AI		2952I 2953I		Units
				Min	Max	Min	Max	
AUXILIARY COMPARATOR (LP2953 Only)								
V_{OS}	Input Offset Voltage	(Referred to V_{REF})	±3	−7.5 **−10**	7.5 **10**	−7.5 **−10**	7.5 **10**	mV
HYST	Hysteresis		6					mV
I_B	Input Bias Current	V_{IN}(COMP) = 0 to 5V	10	−30 **−50**	30 **50**	−30 **−50**	30 **50**	nA
I_{OH}	Output "HIGH" Leakage	V_{OH} = 30V V_{IN}(COMP) = 1.3V	0.01		1 **2**		1 **2**	µA
V_{OL}	Output "LOW" Voltage	V_{IN}(COMP) = 1.1V I_O(COMP) = 400 µA	150		250 **400**		250 **400**	mV

Note 1: Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.

Note 2: The maximum allowable power dissipation is a function of the maximum junction temperature, T_J(MAX), the junction-to-ambient thermal resistance, θ_{J-A}, and the ambient temperature, T_A. The maximum allowable power dissipation at any ambient temperature is calculated using: $P(MAX) = \frac{T_J(MAX) - T_A}{\theta_{J-A}}$.

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 heatsinking and thermal resistance.

Note 3: 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 4: May exceed the input supply voltage.

Note 5: Output or reference voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

Note 6: Load regulation is measured at constant junction temperature using low duty cycle pulse testing. Two separate tests are performed, one for the range of 100 µA to 1 mA and one for the 1 mA to 250 mA range. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

Note 7: Dropout voltage is defined as the input to output differential at which the output voltage drops 100 mV below the value measured with a 1 volt differential. At very low values of programmed output voltage, the input voltage minimum of 2V **(2.3V over temperature)** must be observed.

Note 8: 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 divider (if used).

Note 9: $V_{SHUTDOWN} \leq 1.1V$, V_{OUT} = 5V.

Note 10: 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 200 mA load pulse at V_{IN} = 20V (3W pulse) for T = 10 ms.

Note 11: Connect a 0.1 µF capacitor from the output to the feedback pin.

Note 12: $V_{REF} \leq V_{OUT} \leq (V_{IN} - 1V)$, $2.3V \leq V_{IN} \leq 30V$, $100\ \mu A \leq I_L \leq 250$ mA.

Note 13: Two separate tests are performed, one covering $2.5V \leq V_{IN} \leq 6V$ and the other test for $6V \leq V_{IN} \leq 30V$.

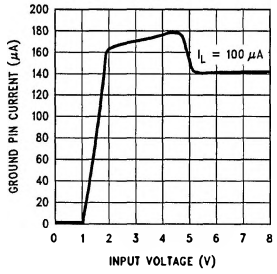
Note 14: Comparator thresholds are referred to a 5V output. To express the threshold voltages in terms of a differential at the Feedback terminal, divide by the error amplifier gain = V_{OUT}/V_{REF}.

Note 15: Human body model, 200 pF discharged through 1.5 kΩ.

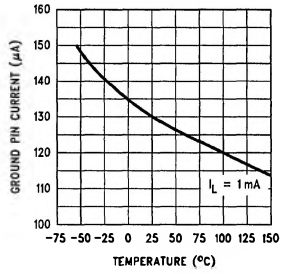
Note 16: Drive $\overline{\text{Shutdown}}$ pin with TTL or CMOS-low level to shut regulator OFF, high level to turn regulator ON.

Typical Performance Characteristics

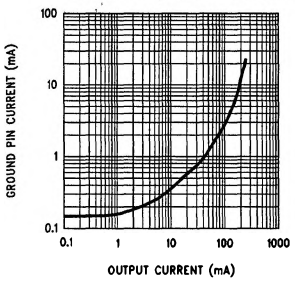
Quiescent Current



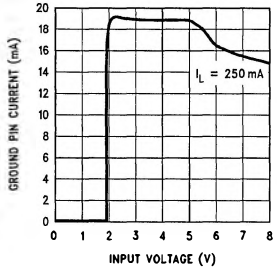
Quiescent Current



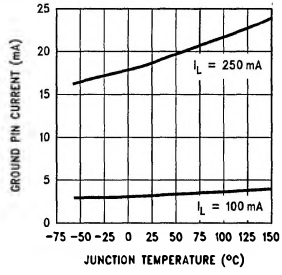
Ground Pin Current vs Load



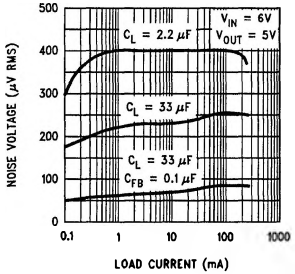
Ground Pin Current



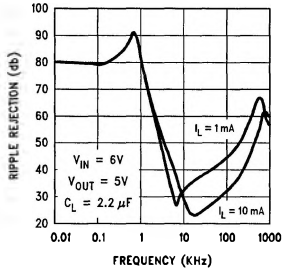
Ground Pin Current



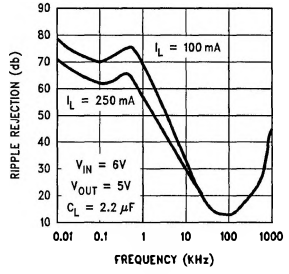
Output Noise Voltage



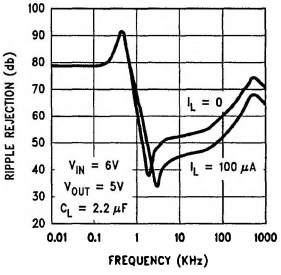
Ripple Rejection



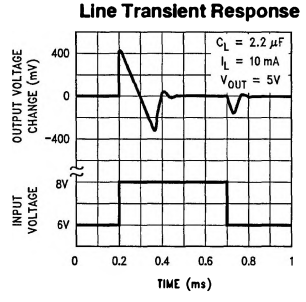
Ripple Rejection



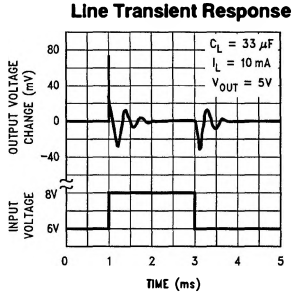
Ripple Rejection



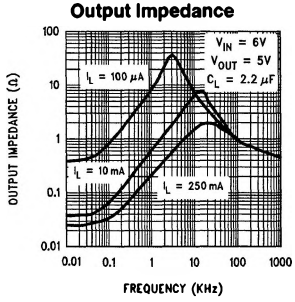
Line Transient Response



Line Transient Response



Output Impedance



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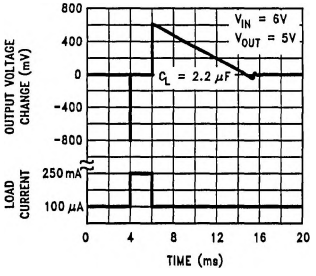
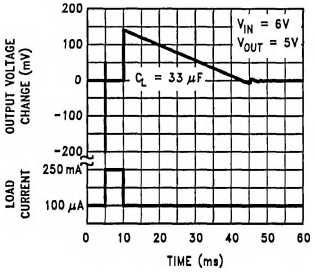
Typical Performance Characteristics (Continued)

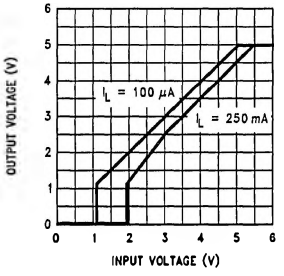
Load Transient Response



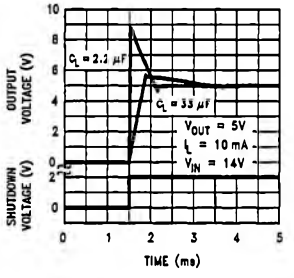
Load Transient Response



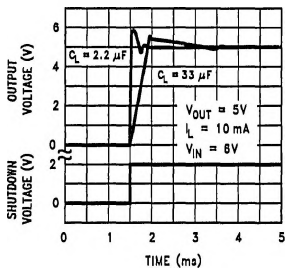
Dropout Characteristics



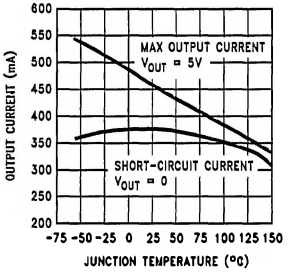
Enable Transient



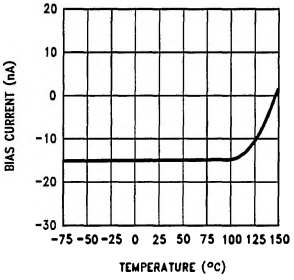
Enable Transient



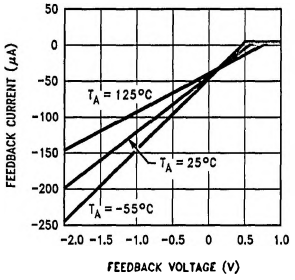
Short-Circuit Output Current and Maximum Output Current



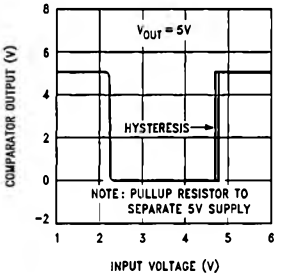
Feedback Bias Current



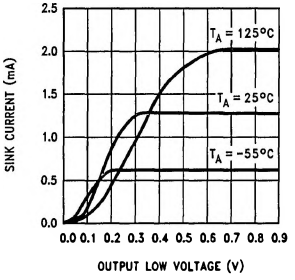
Feedback Pin Current



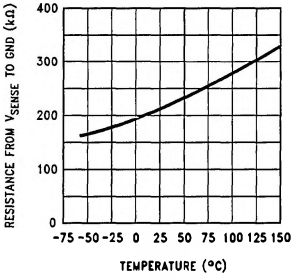
Error Output



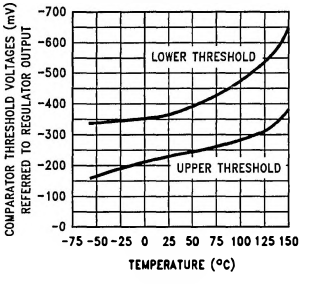
Comparator Sink Current



Divider Resistance



Dropout Detection Comparator Threshold Voltages



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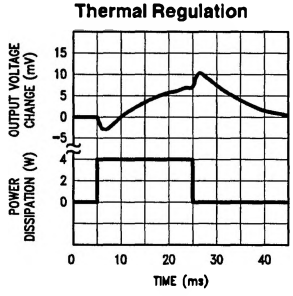
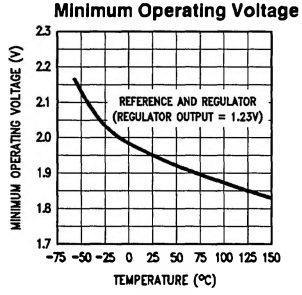
Typical Performance Characteristics (Continued)





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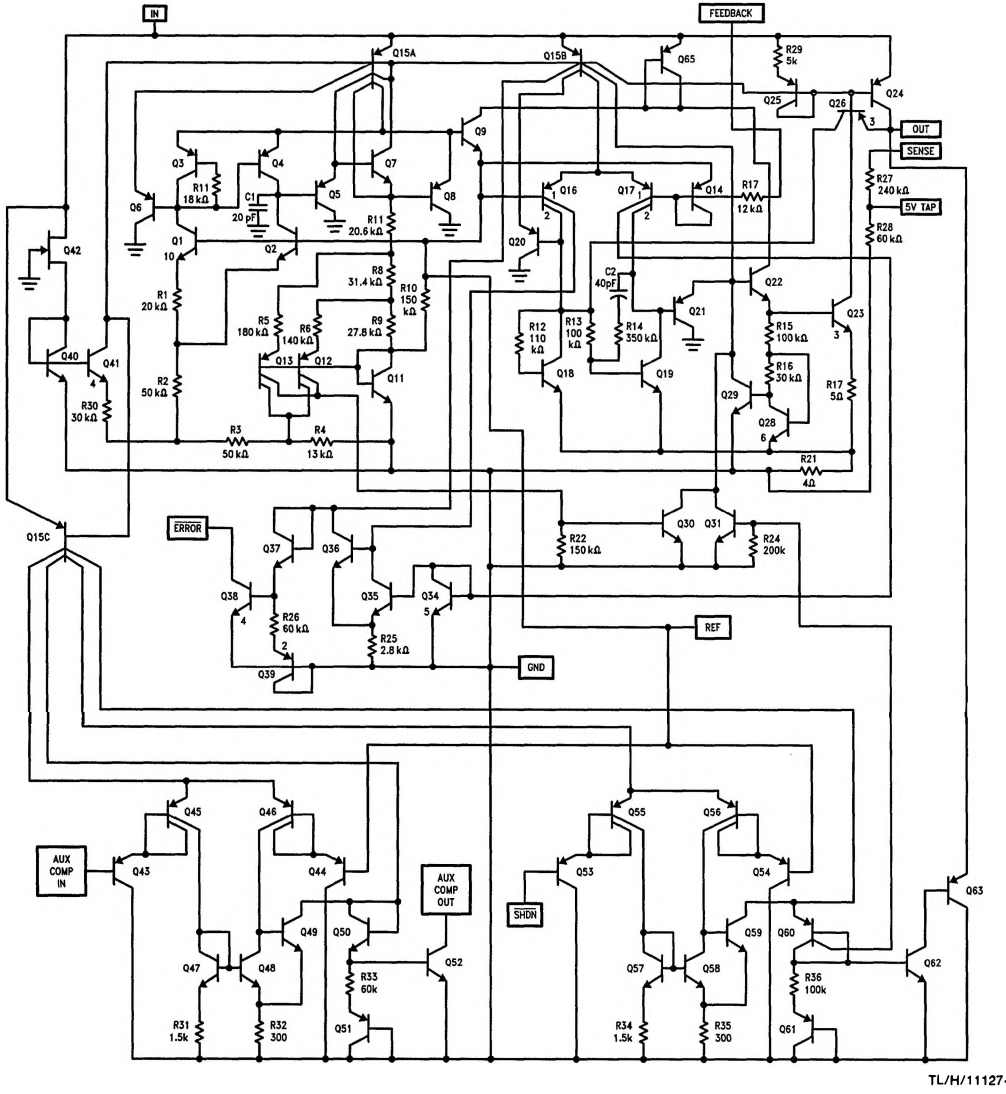
Schematic Diagram



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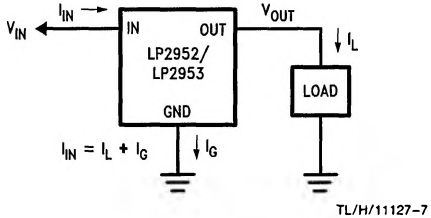
Application Hints

HEATSINK REQUIREMENTS

A heatsink may be required with the LP2952/LP2953 depending on the maximum power dissipation and maximum ambient temperature of the application. Under all possible operating conditions, the junction temperature must be within the range specified under Absolute Maximum Ratings.

To determine if a heatsink is required, the maximum power dissipated by the regulator, P(max), must be calculated. It is important to remember that if the regulator is powered from a transformer connected to the AC line, the **maximum specified AC input voltage** must be used (since this produces the maximum DC input voltage to the regulator). *Figure 1* shows the voltages and currents which are present in the circuit. The formula for calculating the power dissipated in the regulator is also shown in *Figure 1*:



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$$P_{TOTAL} = (V_{IN} - V_{OUT})\, I_L + (V_{IN})\, I_G$$

FIGURE 1. Current/Voltage Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, $T_R(max)$. This is calculated by using the formula:

$$T_R(max) = T_J(max) - T_A(max)$$

where: $T_J(max)$ is the maximum allowable junction temperature

$T_A(max)$ is the maximum ambient temperature

Using the calculated values for $T_R(max)$ and P(max), the required value for junction-to-ambient thermal resistance, $\theta_{(J-A)}$, can now be found:

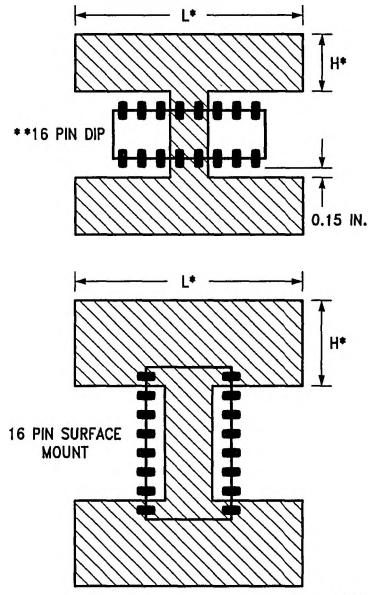
$$\theta_{(J-A)} = T_R(max)/P(max)$$

The heatsink for the LP2952 and LP2953 is made using the PC board copper. The heat is conducted from the die, through the lead frame (inside the part), and out the pins which are soldered to the PC board. The pins used for heat conduction are:

TABLE I

Part	Package	Pins
LP2952N	14-Pin DIP	3, 4, 5, 10, 11, 12
LP2953N	16-Pin DIP	4, 5, 12, 13
LP2952M	16-Pin Surface Mt.	1, 8, 9, 16
LP2953M	16-Pin Surface Mt.	1, 8, 9, 16

Figure 2 shows copper patterns which may be used to dissipate heat from the LP2952 and LP2953:



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*For best results, use L ≈ 2H

**14-Pin DIP is similar, refer to Table I for pins designated for heatsinking.

FIGURE 2. Copper Heatsink Patterns

Table II shows some values of junction-to-ambient thermal resistance (θ_{J-A}) for values of L and W for 1 oz. copper:

TABLE II

Package	L (in.)	H (in.)	θ_{J-A} (°C/W)
16-Pin DIP	1	0.5	70
	2	1	60
	3	1.5	58
	4	0.19	66
	6	0.19	66
14-Pin DIP	1	0.5	65
	2	1	51
	3	1.5	49
Surface Mount	1	0.5	83
	2	1	70
	3	1.5	67
	6	0.19	69
	4	0.19	71
	2	0.19	73

Application Hints (Continued)

EXTERNAL CAPACITORS

A 2.2 μF (or greater) capacitor is required between the output pin and ground to assure stability. Without this capacitor, the part may oscillate. Most type of tantalum or aluminum electrolytics will work here. Film types will work, but are more expensive. Many aluminum electrolytics contain electrolytes which freeze at −30°C, which requires the use of solid tantalums below −25°C. The important parameters of the capacitor are an ESR of about 5Ω or less and a resonant frequency above 500 kHz (the ESR may increase by a factor of **20** or **30** as the temperature is reduced from 25°C to −30°C). The value of this capacitor may be increased without limit.

At lower values of output current, less output capacitance is required for stability. The capacitor can be reduced to 0.68 μF for currents below 10 mA or 0.22 μF for currents below 1 mA.

Programming the output for voltages below 5V runs the error amplifier at lower gains requiring *more* output capacitance for stability. For the worst-case condition of 1.23V output and 250 mA of load current, a 6.8 μF (or larger) capacitor should be used.

A 1 μF capacitor should be placed from the input pin to ground if there is more than 10 inches of wire between the input and the AC filter capacitor or if a battery input is used.

Stray capacitance to the Feedback terminal can cause instability. This problem is most likely to appear when using high value external resistors to set the output voltage. Adding a 100 pF capacitor between the Output and Feedback pins and increasing the output capacitance to 6.8 μF (or greater) will cure the problem.

MINIMUM LOAD

When setting the output voltage using an external resistive divider, a minimum current of 1 μA is recommended through the resistors to provide a minimum load.

It should be noted that a minimum load current is specified in several of the electrical characteristic test conditions, so this value must be used to obtain correlation on these tested limits.

PROGRAMMING THE OUTPUT VOLTAGE

The regulator may be pin-strapped for 5V operation using its internal resistive divider by tying the Output and Sense pins together and also tying the Feedback and 5V Tap pins together.

Alternatively, it may be programmed for any voltage between the 1.23V reference and the 30V maximum rating using an external pair of resistors (see *Figure 3*). The complete equation for the output voltage is:

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R1}{R2}\right) + (I_{FB} \times R1)$$

where V_{REF} is the 1.23V reference and I_{FB} is the Feedback pin bias current (−20 nA typical). The minimum recommended load current of 1 μA sets an upper limit of 1.2 MΩ on the value of R2 in cases where the regulator must work with no load (see **MINIMUM LOAD**). I_{FB} will produce a typical 2% error in V_{OUT} which can be eliminated at room temperature by trimming R1. For better accuracy, choosing R2 = 100 kΩ will reduce this error to 0.17% while increasing the resistor program current to 12 μA. Since the typical quiescent current is 120 μA, this added current is negligible.

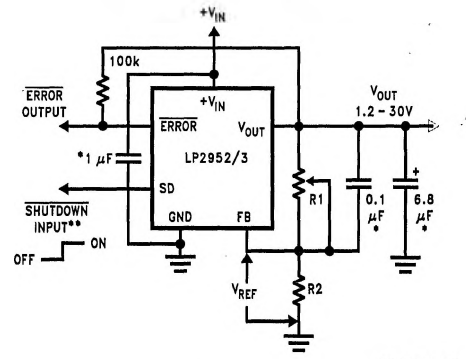

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FIGURE 3. Adjustable Regulator

*See Application Hints

**Drive with TTL-low to shut down

DROPOUT VOLTAGE

The dropout voltage of the regulator is defined as the minimum input-to-output voltage differential required for the output voltage to stay within 100 mV of the output voltage measured with a 1V differential. The dropout voltage is independent of the programmed output voltage.

DROPOUT DETECTION COMPARATOR

This comparator produces a logic "LOW" whenever the output falls out of regulation by more than about 5%. This figure results from the comparator's built-in offset of 60 mV divided by the 1.23V reference (refer to block diagrams on page 1). The 5% low trip level remains constant regardless of the programmed output voltage. An out-of-regulation condition can result from low input voltage, current limiting, or thermal limiting.

Figure 4 gives a timing diagram showing the relationship between the output voltage, the $\overline{\text{ERROR}}$ output, and input voltage as the input voltage is ramped up and down to a regulator programmed for 5V output. The $\overline{\text{ERROR}}$ signal becomes low at about 1.3V input. It goes high at about 5V input, where the output equals 4.75V. Since the dropout voltage is load dependent, the **input** voltage trip points will vary with load current. The **output** voltage trip point does not vary.

The comparator has an open-collector output which requires an external pull-up resistor. This resistor may be connected to the regulator output or some other supply voltage. Using the regulator output prevents an invalid "HIGH" on the comparator output which occurs if it is pulled up to an external voltage while the regulator input voltage is reduced below 1.3V. In selecting a value for the pull-up resistor, note that while the output can sink 400 μA, this current adds to battery drain. Suggested values range from 100 kΩ to 1 MΩ. This resistor is not required if the output is unused.

When $V_{IN} \leq 1.3V$, the error flag pin becomes a high impedance, allowing the error flag voltage to rise to its pull-up voltage. Using V_{OUT} as the pull-up voltage (rather than an external 5V source) will keep the error flag voltage below 1.2V (typical) in this condition. The user may wish to divide down the error flag voltage using equal-value resistors (10 kΩ suggested) to ensure a low-level logic signal during any fault condition, while still allowing a valid high logic level during normal operation.

Application Hints (Continued)

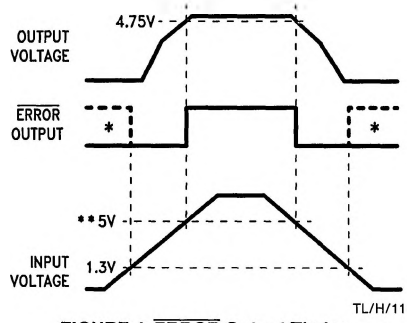


FIGURE 4. ERROR Output Timing

*In shutdown mode, ERROR will go high if it has been pulled up to an external supply. To avoid this invalid response, pull up to regulator output.

**Exact value depends on dropout voltage. (See Application Hints)

OUTPUT ISOLATION

The regulator output can be left connected to an active voltage source (such as a battery) with the regulator input power shut off, **as long as the regulator ground pin is connected to ground.** If the ground pin is left floating, **damage to the regulator can occur** if the output is pulled up by an external voltage source.

REDUCING OUTPUT NOISE

In reference applications it may be advantageous to reduce the AC noise present on the output. One method is to reduce regulator bandwidth by increasing output capacitance. This is relatively inefficient, since large increases in capacitance are required to get significant improvement.

Noise can be reduced more effectively by a bypass capacitor placed across R1 (refer to *Figure 3*). The formula for selecting the capacitor to be used is:

$$C_B = \frac{1}{2\pi\ R1 \times 20\ Hz}$$

This gives a value of about 0.1 μF. When this is used, the output capacitor must be 6.8 μF (or greater) to maintain stability. The 0.1 μF capacitor reduces the high frequency gain of the circuit to unity, lowering the output noise from 260 μV to 80 μV using a 10 Hz to 100 kHz bandwidth. Also, noise is no longer proportional to the output voltage, so improvements are more pronounced at high output voltages.

AUXILIARY COMPARATOR (LP2953 only)

The LP2953 contains an auxiliary comparator whose inverting input is connected to the 1.23V reference. The auxiliary comparator has an open-collector output whose electrical characteristics are similar to the dropout detection comparator. The non-inverting input and output are brought out for external connections.

SHUTDOWN INPUT

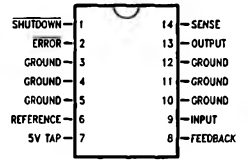
When the operating junction temperature is between −40°C and +125°C, the shutdown input may be left open (floating) for normal regulator operation (regulator output ON).

Operation at junction temperatures above the 125°C maximum (which is **not recommended)** has shown that leaving the shutdown pin open may cause the part to turn ON and OFF. This occurs when internal leakage current activates the shutdown pin, causing the output to go OFF. This reduces power dissipation, which results in die cooling. This allows the part to turn back ON, and the cycle starts over.

If the part is operated above 125°C, the shutdown pin must be connected to the regulator input voltage through a pull-up resistor to assure that the regulator remains ON. This resistor is not required for operation between −40°C and +125°C, but can be used without affecting performance.

Pinout Drawings

LP2952 14-Pin DIP



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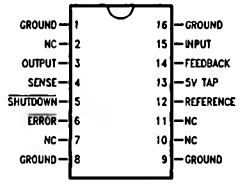
LP2952 16-Pin SO



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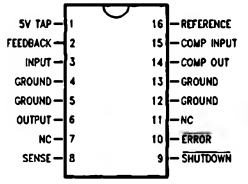
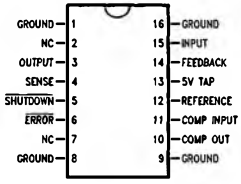
LP2953 16-Pin DIP



TL/H/11127–13

LP2953 16-Pin SO



TL/H/11127–14

Ordering Information

LP2952

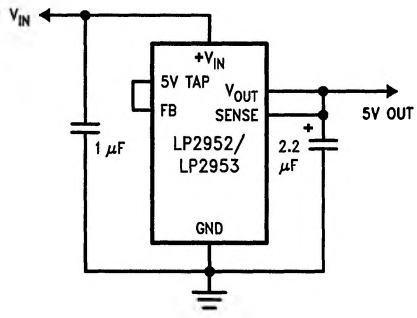
Order Number	Temp. Range (T_J) °C	Package	NSC Drawing Number
LP2952IN	−40 to +125	14-Pin Molded DIP	N14A
LP2952AIN			
LP2952IM	−40 to +125	16-Pin Surface Mt.	M16A
LP2952AIM			

LP2953

Order Number	Temp. Range (T_J) °C	Package	NSC Drawing Number
LP2953IN	−40 to +125	16-Pin Molded DIP	N16A
LP2953AIN			
LP2953IM	−40 to +125	16-Pin Surface Mt.	M16A
LP2953AIM			

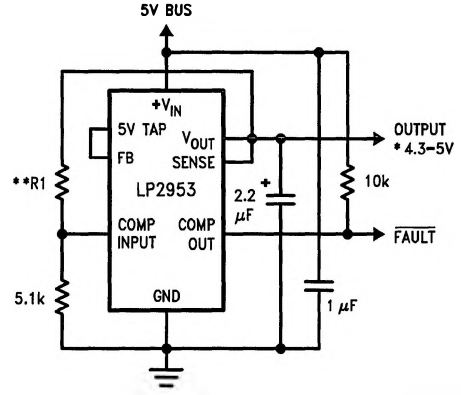
Typical Applications

Basic 5V Regulator



TL/H/11127–15

5V Current Limiter with Load Fault Indicator

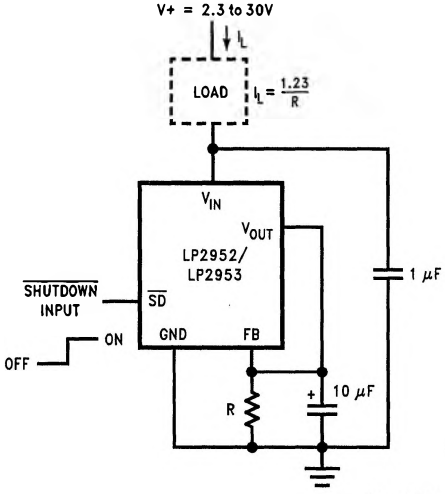


TL/H/11127–16

*Output voltage equals +V_{IN} minum dropout voltage, which varies with output current. Current limits at a maximum of 380 mA (typical).

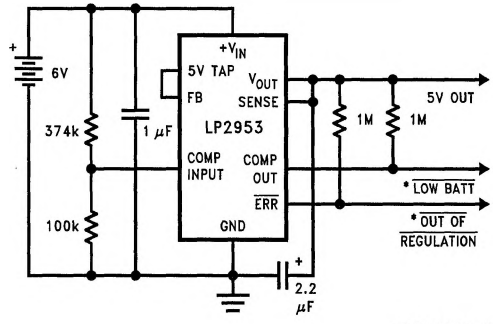
**Select R1 so that the comparator input voltage is 1.23V at the output voltage which corresponds to the desired fault current value.

Low T.C. Current Sink



TL/H/11127–17

5V Regulator with Error Flags for LOW BATTERY and OUT OF REGULATION



TL/H/11127–18

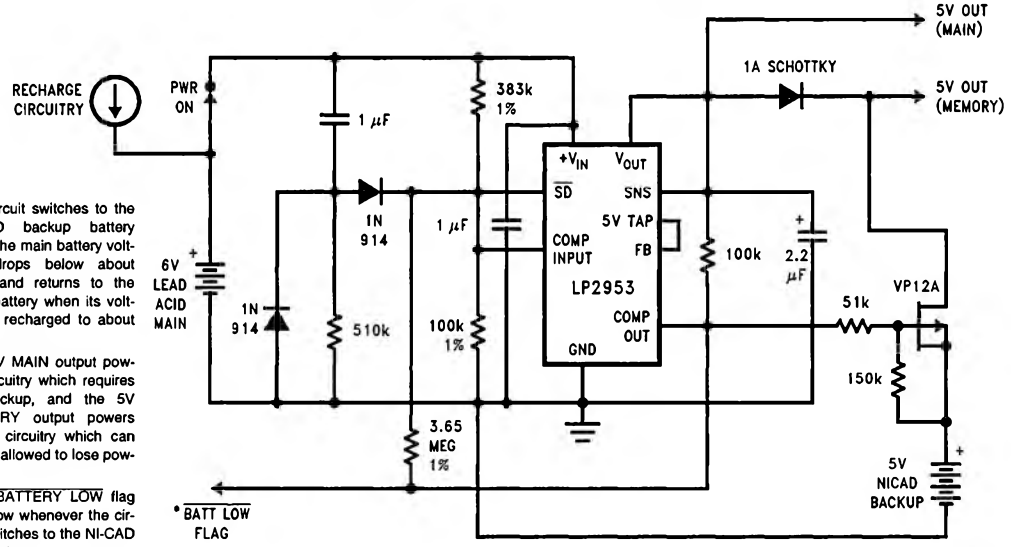
*Connect to Logic or μP control inputs.

LOW BATT flag warns the user that the battery has discharged down to about 5.8V, giving the user time to recharge the battery or power down some hardware with high power requirements. The output is still in regulation at this time.

OUT OF REGULATION flag indicates when the battery is almost completely discharged, and can be used to initiate a power-down sequence.

Typical Applications (Continued)

5V Battery Powered Supply with Backup and Low Battery Flag



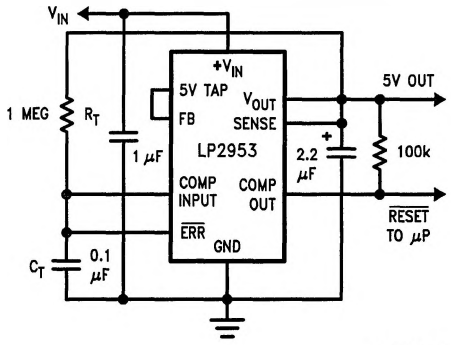
The circuit switches to the NI-CAD backup battery when the main battery voltage drops below about 5.6V, and returns to the main battery when its voltage is recharged to about 6V.

The 5V MAIN output powers circuitry which requires no backup, and the 5V MEMORY output powers critical circuitry which can not be allowed to lose power.

*The $\overline{\text{BATTERY LOW}}$ flag goes low whenever the circuit switches to the NI-CAD backup battery.

TL/H/11127–19

5V Regulator with Timed Power-On Reset



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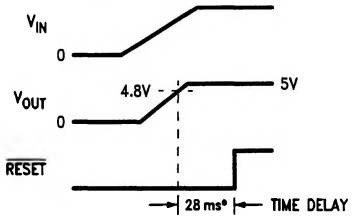
Timing Diagram for Timed Power-On Reset

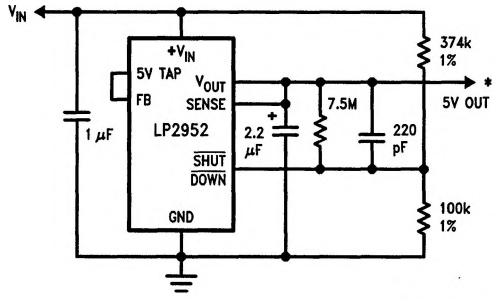


TL/H/11127–21

*R_T = 1 MEG, C_T = 0.1 μF

Typical Applications (Continued)

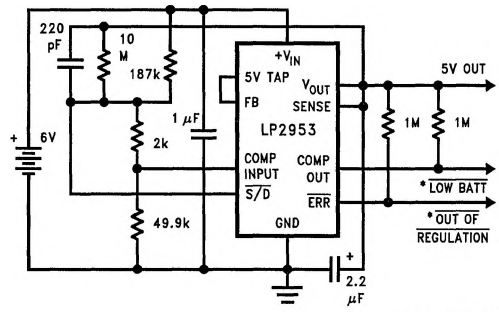
5V Regulator with Snap-On/Snap-Off Feature and Hysteresis



TL/H/11127–22

*Turns ON at V_{IN} = 5.87V
Turns OFF at V_{IN} = 5.64V
(for component values shown)

5V Regulator with Error Flags for LOW BATTERY and OUT OF REGULATION with SNAP-ON/SNAP-OFF Output



TL/H/11127–23

*Connect to Logic or µP control inputs.

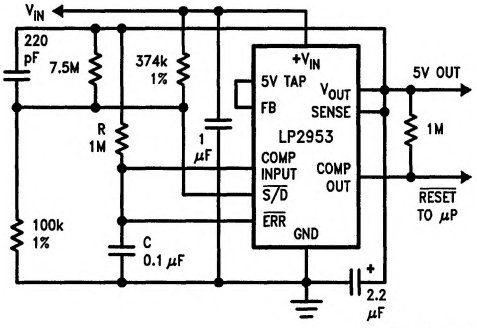
OUTPUT has SNAP-ON/SNAP-OFF feature.

LOW BATT flag warns the user that the battery has discharged down to about 5.8V, giving the user time to recharge the battery or shut down hardware with high power requirements. The output is still in regulation at this time.

OUT OF REGULATION flag goes low if the output goes below about 4.7V, which could occur from a load fault.

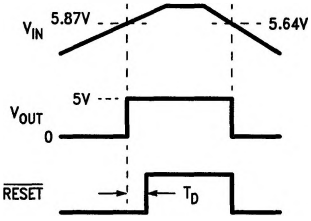
OUTPUT has SNAP-ON/SNAP-OFF feature. Regulator snaps ON at about 5.7V input, and OFF at about 5.6V.

5V Regulator with Timed Power-On Reset, Snap-On/Snap-Off Feature and Hysteresis



TL/H/11127–24

Timing Diagram



TL/H/11127–25

Td = (0.28) RC = 28 ms for components shown.