



150mA Micro-power LDO Regulators

Features

- Supply Current at No-Load is 55 μ A
- Minimum Over-Current Limit: 150mA
- Dropout Voltage is 70mV @ 50mA Load
- Built-in Over-Temperature Protection
- Fixed: 3.3V Output
- Max. Supply Current in Shutdown Mode < 1 μ A
- Output Noise is 210 μ V_{RMS} from 10Hz to 1MHz

Applications

- Notebook Computers
- Cellular Phones
- PDA
- Hand-Held Devices

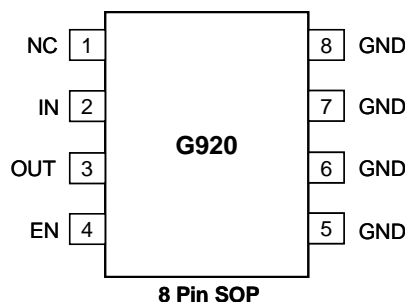
General Description

The G920 is a low supply current, low dropout linear regulator that comes in a space saving SO-8 package. The supply current at no-load is 55 μ A. In the shutdown mode, the maximum supply current is less than 1 μ A. operating voltage range of the G920 is from 3.6V to 6.5V. The over-current protection limit is set at 250mA typical and 150mA minimum. An over-temperature protection circuit is built-in in the G920 to prevent thermal overload. These power saving features make the G920 ideal for use in the battery-powered applications such as notebook computers, cellular phones, and PDA's.

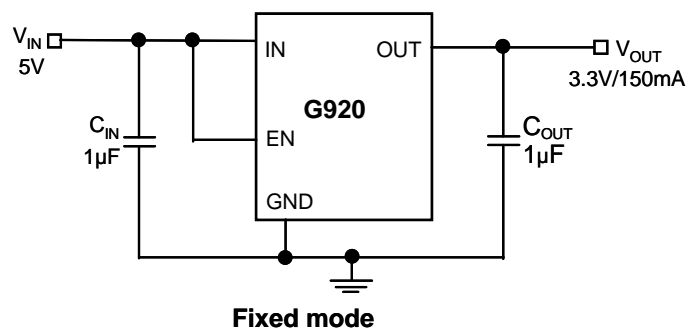
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
G920	-40°C~ +85°C	SOP- 8

Pin Configuration



Typical Operating Circuit



**ABSOLUTE MAXIMUM RATINGS**

V_{IN} to GND.....	-0.3V to +7V
Output Short-Circuit Duration.....	Infinite
ADJ to GND.....	-0.3V to +7V
EN to GND.....	-0.3V to +7V
EN to IN.....	-7V to +0.3V
OUT to GND.....	-0.3V to ($V_{IN} + 0.3V$)
Continuous Power Dissipation ($T_A = +70^\circ\text{C}$)	

SOT23-5 (derate 7.1mW/°C above +70°C).....	571 mW
Operating Temperature Range.....	-40°C to +85°C
Junction Temperature.....	+150°C
θ_{JA}	140°C/Watt
Storage Temperature Range.....	-65°C to +160°C
Lead Temperature (soldering, 10sec).....	+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Electrical Characteristics

($V_{IN} = +3.6V$, $GND = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ\text{C}$.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage (Note 2)	V_{IN}		3.6		6.5	V
Output Voltage	V_{OUT}	$0\text{mA} \leq I_{OUT} \leq 150\text{mA}$, ADJ = GND	3.234	3.300	3.366	V
Adjustable Output Voltage Range (Note 3)	V_{OUT}		V_{SET}		6.5	V
Maximum Output Current			150			mA
Current Limit (Note 4)	I_{LIM}			250		mA
Ground Pin Current	I_Q	ADJ = GND	$I_{LOAD} = 0\text{mA}$	55	120	μA
			$I_{LOAD} = 50\text{mA}$	145		
Dropout Voltage (Note 5)			$I_{OUT} = 1\text{mA}$	2		mV
			$I_{OUT} = 50\text{mA}$	70	120	
			$I_{OUT} = 150\text{mA}$	230		
Line Regulation	ΔV_{LNR}	$V_{IN} = 2.5V$ to $6.5V$, ADJ tied to OUT, $I_{OUT} = 1\text{mA}$		0.1		%/V
Load Regulation	ΔV_{LDR}	$I_{OUT} = 0\text{mA}$ to 150mA	ADJ = GND	0.011		%/mA
			ADJ tied to OUT	0.006		
Output Voltage Noise		10 Hz to 1MHz	$C_{OUT} = 1\mu\text{F}$	210		μV_{RMS}
			$C_{OUT} = 100\mu\text{F}$	190		
SHUTDOWN						
EN Input Threshold	V_{IH}	Regulator enabled	2.8			V
	V_{IL}	Regulator shutdown			0.4	
EN Input Bias Current	I_{IH}	$V_{EN} = V_{IN}$	$T_A = +25^\circ\text{C}$	3	100	nA
			$T_A = T_{MAX}$	5		
Shutdown Supply Current	I_{IL}	$V_{OUT} = 0V$	$T_A = +25^\circ\text{C}$		1	μA
			$T_A = T_{MAX}$	0.2		
THERMAL PROTECTION						
Thermal Shutdown Temperature	T_{SHDN}			170		°C
Thermal Shutdown Hysteresis	ΔT_{SHDN}			20		°C

Note 1: Limits is 100% production tested at $T_A = +25^\circ\text{C}$. Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) Methods.

Note 2: Guaranteed by line regulation test.

Note 3: Adjustable mode only.

Note 4: Not tested. For design purposes, the current limit should be considered 150mA minimum to 420mA maximum.

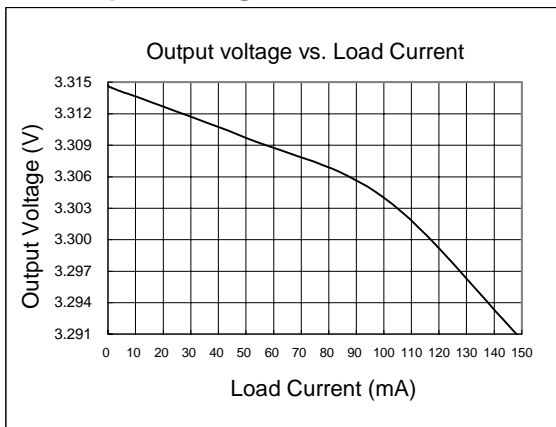
Note 5: The dropout voltage is defined as ($V_{IN} - V_{OUT}$) when V_{OUT} is 100mV below the value of V_{OUT} for $V_{IN} = V_{OUT} + 2V$.



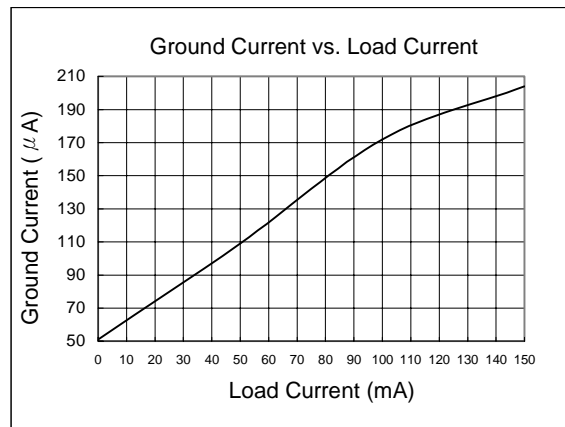
TYPICAL PERFORMANCE CHARACTERISTICS

(VIN=+3.6V, CIN=1μF, COUT=1μF, TA =25 °C, unless otherwise noted.)

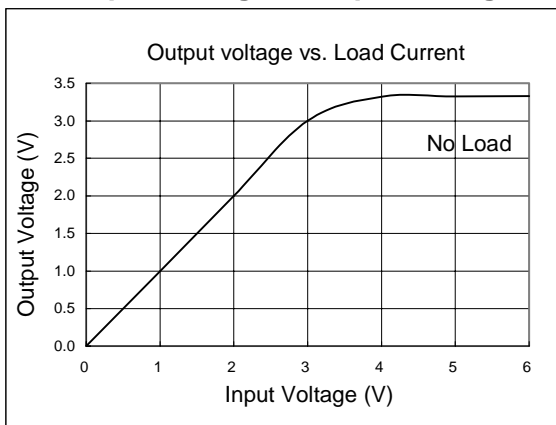
Output Voltage vs. Load Current



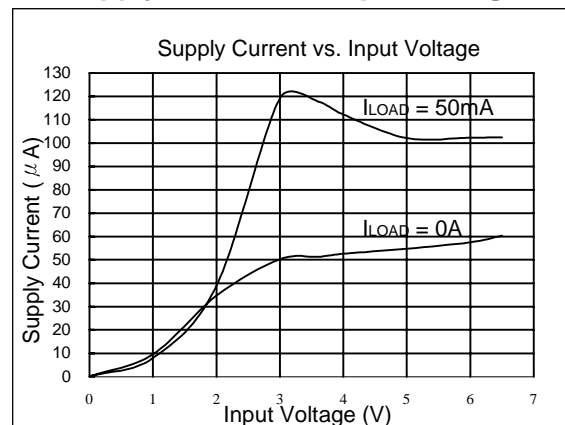
Ground Current vs. Load Current



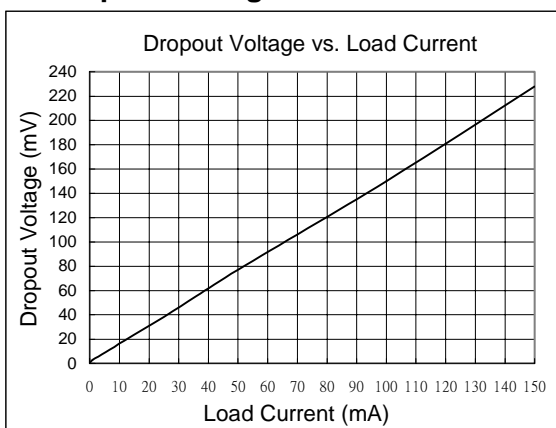
Output Voltage vs. Input Voltage



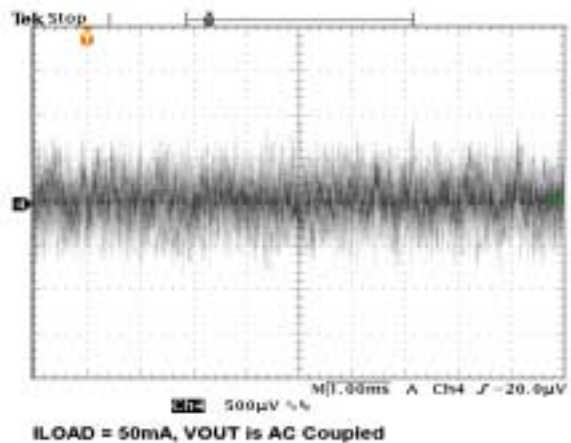
Supply Current vs. Input Voltage



Dropout Voltage vs. Load Current



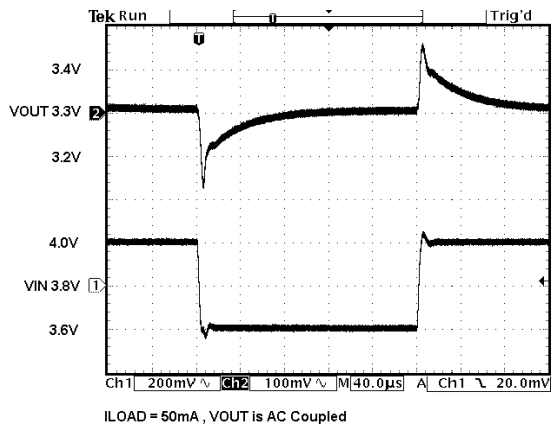
Output Noise 10HZ to 1MHZ



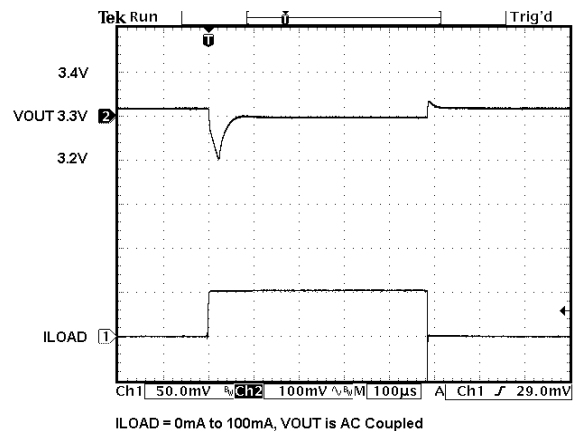


TYPICAL PERFORMANCE CHARACTERISTICS (continue)

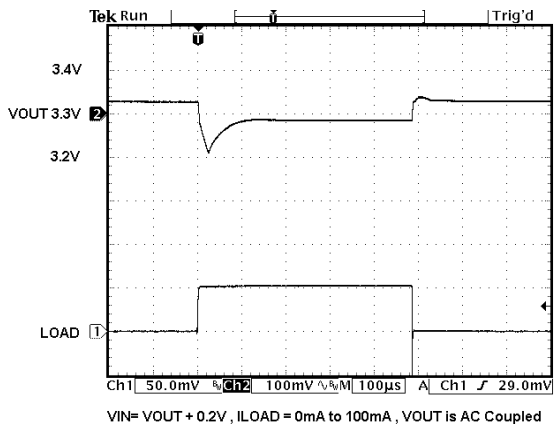
Line Transient



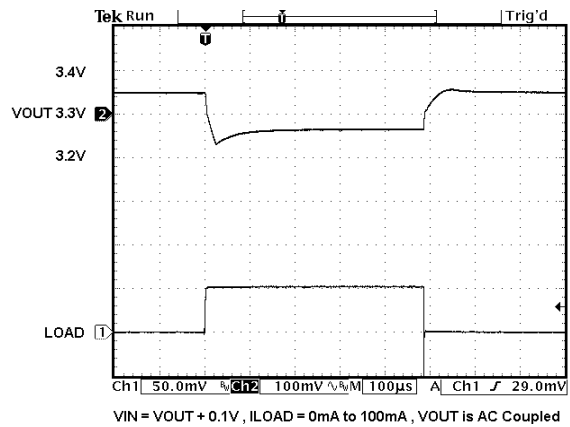
Load Transient



Load Transient



Load Transient



Pin Description

PIN	NAME	FUNCTION
1	NC	This is a NC pin, should be left unconnected.
2	IN	Regulator Input. Supply voltage can range from +2.5V to +6.5V. Bypass with 1μF to GND.
3	OUT	Regulator Output. Sources up to 150mA. Bypass with a 1μF, <0.2Ω typical ESR capacitor to GND.
4	EN	Active-High Enable Input. A logic low reduces the supply current to less than 1μA. Connect to IN for normal operation.
5,6,7,8	GND	Ground. This pin also functions as a heatsink. Solder to large pads or the circuit board ground plane to maximize thermal dissipation.

Detailed Description

The block diagram of the G920 is shown in Figure 1. It consists of an error amplifier, 1.25V bandgap reference, PMOS output transistor, internal feedback voltage divider, shutdown logic, over current protection circuit, and over temperature protection circuit.

The internal feedback voltage divider's central tap is connected to the non-inverting input of the error amplifier. The error amplifier compares non-inverting input with the 1.25V bandgap reference. If the feedback voltage is higher than 1.25V, the error amplifier's output becomes higher so that the PMOS output transistor has a smaller gate-to-source voltage (V_{GS}). This reduces the current carrying capability of the PMOS

output transistor, as a result the output voltage decreases until the feedback voltage is equal to 1.25V. Similarly, when the feedback voltage is less than 1.25V, the error amplifier causes the output PMOS to conductor more current to pull the feedback voltage up to 1.25V. Thus, through this feedback action, the error amplifier, output PMOS, and the voltage divider effectively form a unity-gain amplifier with the feedback voltage force to be the same as the 1.25V bandgap reference. The output voltage, V_{OUT} , is then given by the following equation:

$$V_{OUT} = 1.25 (1 + R1/R2). \tag{1}$$

For the G920, the pre-set output voltage is 3.3V.

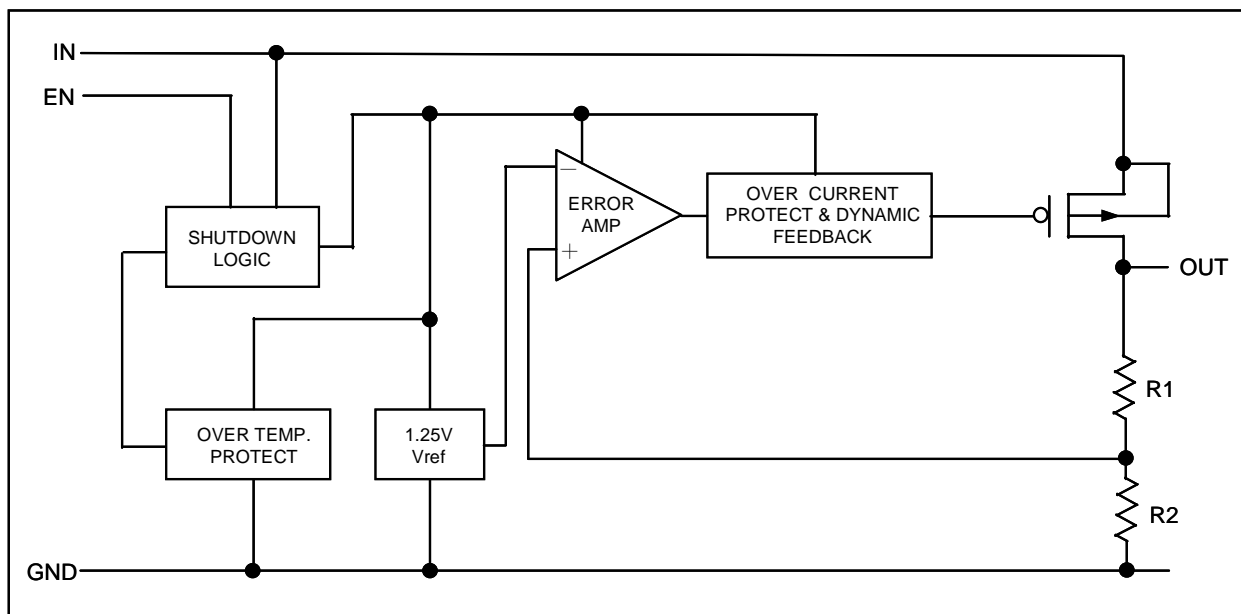


Figure 1. Functional Diagram



Over Current Protection

The G920 use a current mirror to monitor the output current. A small portion of the PMOS output transistor's current is mirrored onto a resistor such that the voltage across this resistor is proportional to the output current. This voltage is compared against the 1.25V reference. Once the output current exceeds the limit, the PMOS output transistor is turned off. Once the output transistor is turned off, the current monitoring voltage decreases to zero, and the output PMOS is turned on again. If the over current condition persist, the over current protection circuit will be triggered again. Thus, when the output is shorted to ground, the output current will be alternating between 0 and the over current limit. The typical over current limit of the G920 is set to 250mA. Note that the input bypass capacitor of 1 μ F must be used in this case to filter out the input voltage spike caused by the surge current due to the inductive effect of the package pin and the printed circuit board's routing wire. Otherwise, the actual voltage at the IN pin may exceed the absolute maximum rating.

Dynamic Current Feedback

The G920 is designed to work with both low and high ESR output capacitors. Since a PMOS transistor is used as the output transistor, an output capacitor greater than 1 μ F is needed to stabilize the feedback loop of the regulator. Due to the large value of the output capacitor, the dominant pole is the pole caused by the output node. The pole cause by the error amplifier's output node is the second pole. With a high ESR output capacitor, the zero caused by the ESR is typically near the second pole so that the second pole is cancelled by the zero, and the loop is stable. However, when the output capacitor has a low ESR, the zero will be much larger than the second pole. When the zero is near or larger than the unity-gain frequency, it can no longer cancel the phase shift caused by the second pole, and the loop becomes unstable. The G920 uses dynamic current feedback to stabilize the loop. The output impedance of the error amplifier is reduced when the output current increases. Thus, the second pole is pushed outward in accordance with the output current so that the second pole can be cancelled by the ESR's zero to maintain regulator stability.

Over Temperature Protection

To prevent abnormal temperature from occurring, the G920 has a built-in temperature monitoring circuit. When it detects the temperature is above 170°C, the output transistor is turned off. When the IC is cooled down to below 150°C, the output is turned on again. In this way, the G920 will be protected against abnormal junction temperature during operation.

Shutdown Mode

When the EN pin is connected a logic low voltage, the G920 enters shutdown mode. All the analog circuits are turned off completely, which reduces the current

consumption to only the leakage current. The output is disconnected from the input. When the output has no load at all, the output voltage will be discharged to ground through the internal resistor voltage divider.

Operating Region and Power Dissipation

Since the G920 is a linear regulator, its power dissipation is always given by $P = I_{OUT} (V_{IN} - V_{OUT})$. The maximum power dissipation is given by:

$$P_{MAX} = (T_J - T_A) / \theta_{JA}$$

Where $(T_J - T_A)$ is the temperature difference the G920 die and the ambient air, θ_{JA} , is the thermal resistance of the chosen package to the ambient air. In the case of a SOT23-5 package, the thermal resistance is typically 140°C/Watt.

Applications Information

Capacitor Selection and Regulator Stability

Normally, use a 1 μ F capacitor on the input and a 1 μ F capacitor on the output of the G920. Larger input capacitor values and lower ESR provide better supply-noise rejection and transient response. A higher-value input capacitor (10 μ F) may be necessary if large, fast transients are anticipated and the device is located several inches from the power source. For stable operation over the full temperature range, with load currents up to 120mA, a minimum of 1 μ F is recommended.

Power-Supply Rejection and Operation from Sources Other than Batteries

The G920 is designed to deliver low dropout voltages and low quiescent currents in battery powered systems. Power-supply rejection is 53dB at low frequencies as the frequency increases above 20kHz, the output capacitor is the major contributor to the rejection of power-supply noise.

When operating from sources other than batteries, improve supply-noise rejection and transient response by increasing the values of the input and output capacitors, and using passive filtering techniques.

Load Transient Considerations

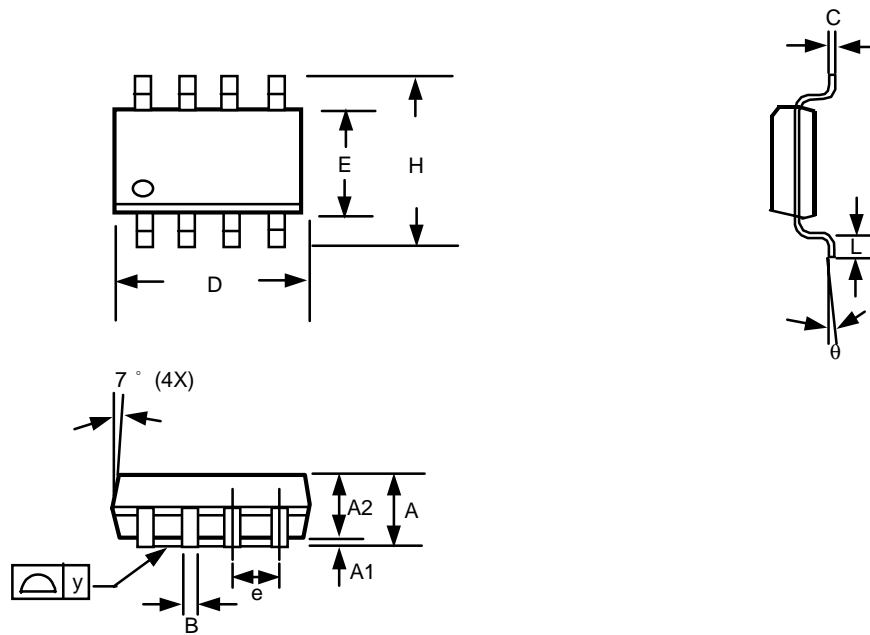
The G920 load-transient response graphs show two components of the output response: a DC shift of the output voltage due to the different load currents, and the transient response. Typical overshoot for step changes in the load current from 0mA to 100mA is 12mV. Increasing the output capacitor's value and decreasing its ESR attenuates transient spikes.

Input-Output (Dropout) Voltage

A regulator's minimum input-output voltage differential (or dropout voltage) determines the lowest usable supply voltage. In battery-powered systems, this will determine the useful end-of-life battery voltage. Because the G920 use a P-channel MOSFET pass transistor, their dropout voltage is a function of $R_{DS(ON)}$ multiplied by the load current.



Package Information



Note:

1. Package body sizes exclude mold flash and gate burrs
2. Dimension L is measured in gage plane
3. Tolerance 0.10mm unless otherwise specified
4. Controlling dimension is millimeter converted inch dimensions are not necessarily exact.

SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.35	1.60	1.75	0.053	0.063	0.069
A1	0.10	-----	0.25	0.004	-----	0.010
A2	-----	1.45	-----	-----	0.057	-----
B	0.33	-----	0.51	0.013	-----	0.020
C	0.19	-----	0.25	0.007	-----	0.010
D	4.80	-----	5.00	0.189	-----	0.197
E	3.80	-----	4.00	0.150	-----	0.157
e	-----	1.27	-----	-----	0.050	-----
H	5.80	-----	6.20	0.228	-----	0.244
L	0.40	-----	1.27	0.016	-----	0.050
y	-----	-----	0.10	-----	-----	0.004
θ	0°	-----	8°	0°	-----	8°