



#### DESCRIPTION

The LX8221 family of dual output linear regulators provide for the selection of either fixed or adjustable output voltages, and combine low dropout operation, fast transient performance, tight output voltage accuracy, and ultra-low ground current within a very small package footprint.

The PMOS output transistor allows for an ultra-low dropout characteristic (e.g., typically less than 175mV at 100mA). The individual regulators can be powered from either separate supply voltages or the same supply voltage between 2.8V to 6V allowing for maximum system flexibility.

An optional ceramic or tantalum type capacitor may be connected to each Bypass pin separately to improve performance in critical low-noise applications.

Overall regulator efficiency has been improved with a minimized operating ground current (typical  $< 140\mu\text{A}$  per regulator). Further, this ground current is virtually eliminated in shutdown mode (typical  $< 1\mu\text{A}$ ).

Other safety features include channel independent Thermal and Short Circuit Current protection.

Separate Enable pins allow each regulator to be switched on and off independently by applying a TTL logic level control signal to the Enable pin further enhancing system level power management.

These features combined with a small footprint (i.e., 10-pin MSOP package) make the LX8221 especially useful for battery-operated equipment such as cellular telephones, laptop computers and PDA equipment.

**IMPORTANT:** For the most current data, consult Microsemi's website: <http://www.microsemi.com>

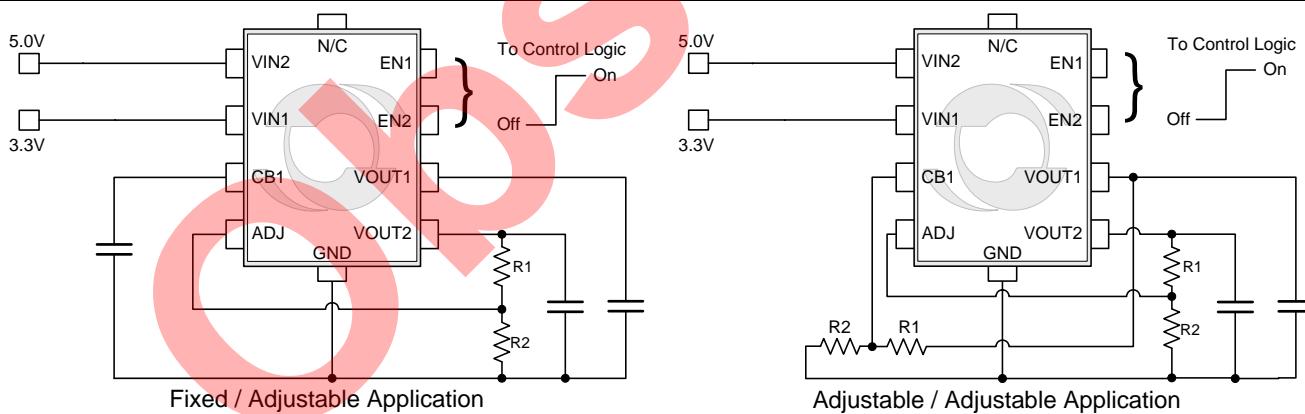
#### KEY FEATURES

- Compact Regulators With Two 150mA Outputs
- Dropout Voltage Typically 175mV @ 100mA
- Ultra Low Shutdown Current Typically Less Than 1 $\mu\text{A}$
- Output Trimmed to 0.5%
- Small MSOP-10 Package
- Over Current & Temperature Protection
- Stable with Ceramic or Tantalum Capacitors

#### APPLICATIONS

- Battery Operated Systems
- Laptop, Notebook and PDA's
- Cellular Telephones/Pagers
- Instrumentation
- Linear Post Regulators for SMPS

#### PRODUCT HIGHLIGHT



#### PACKAGE ORDER INFO

T <sub>A</sub> (°C)	VOUT1	VOUT2	DU	Plastic MSOP 10-Pin RoHS Compliant / Pb-free Transition D/C: 0432	Package Marking
-40 to 85	Adjustable	Adjustable		<b>LX8221AIDU</b>	8221 AIDU LX
-40 to 85	2.5V	Adjustable		<b>LX8221BIDU</b>	8221 BIDU LX
-40 to 85	2.7V	Adjustable		<b>LX8221DIDU</b>	8221 DIDU LX
-40 to 85	3.0V	Adjustable		<b>LX8221GIDU</b>	8221 GIDU LX

Contact Microsemi for additional / available options

Note: Available in Tape & Reel. Append the letters "TR" to the part number. (i.e. LX8221AIDU-TR)



#### ABSOLUTE MAXIMUM RATINGS

Input Voltage (VIN1, VIN2).....	-0.3V to +7V
Output Current (I <sub>OUT1</sub> , I <sub>OUT2</sub> ).....	150mA
Operating Temperature Range .....	-40 to +125 °C
Maximum Junction Temperature (T <sub>J</sub> ) .....	150 °C
Storage Temperature (T <sub>J</sub> ) .....	-65 to +150 °C
Peak Package Solder Reflow Temp. (40 second max. exposure).....	260°C (+0, -5)

Note: Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of specified terminal.

#### PACKAGE PIN OUT

VOUT1	1	10	VIN1
CB1	2	9	EN1
NC	3	8	GND
EN2	4	7	ADJ
VIN2	5	6	VOUT2

**DU PACKAGE**  
(Top View)  
"NC" = No Internal Connection  
RoHS / Pb-free 100% Matte Tin Lead Finish

#### THERMAL DATA

##### DU Plastic MSOP 8-Pin

###### THERMAL RESISTANCE-JUNCTION TO AMBIENT, $\theta_{JA}$

206°C/W

Junction Temperature Calculation:  $T_J = T_A + (P_D \times \theta_{JC})$ .

The  $\theta_{JA}$  numbers are guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.

#### FRONT MARKING

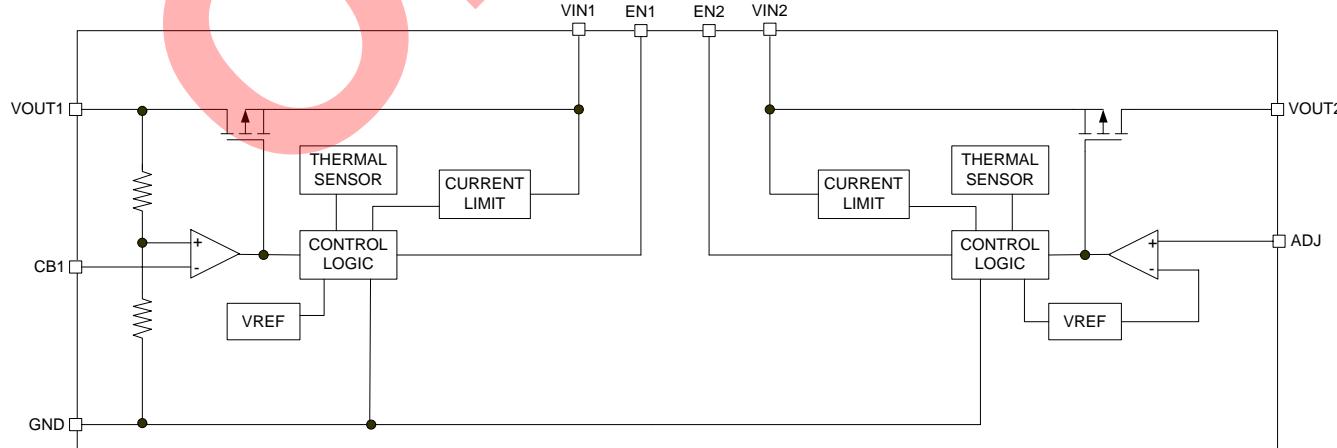
8221  
xIDU  
LX

x = Voltage Combination  
i.e. A = Adj/Adj

#### FUNCTIONAL PIN DESCRIPTION

PIN NAME	DESCRIPTION
VIN1/VIN2	Unregulated input supply voltage
GND	Ground Pin
EN1/EN2	Enable control input: Logic high = Enable; logic low or open = Shutdown
CB1	Reference bypass input. Adding an additional external capacitor reduces output noise.
VOUT1/VOUT2	Regulated output voltage. Regulator stability is achieved with external capacitor of 1μF
ADJ (1, 2)	Adjust pin. Connect a resistor divider to this pin to establish preferred output voltage.

#### BLOCK DIAGRAM





#### RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	LX8221			Units
		Min	Typ	Max	
Input Operating Voltage Range (Note 1)	V <sub>IN1</sub> , V <sub>IN2</sub>	2.5		6	V
Enable Input Voltage Range	EN1/2			V <sub>IN</sub> + 0.3V	V
Continuous Output Current Range	I <sub>OUT1</sub> , I <sub>OUT2</sub>		150		mA
Input Capacitor (V <sub>IN</sub> to GND)	C <sub>IN</sub>	1.0*			μF
Output Capacitor (V <sub>OUT</sub> to GND)	C <sub>OUT</sub>	1.0*	2.2		μF

Note 1: The minimum V<sub>IN</sub> has to meet two conditions V<sub>IN</sub> ≥ 2.5V and V<sub>IN</sub> ≥ V<sub>OUT</sub> + V<sub>DROPOUT</sub>, at high line voltage conditions output current may be limited to less than 150mA due to the power dissipation.

\* Size your output capacitor to meet the transient loading requirement. If you have a very dynamic load, a lower ESR and larger value capacitor will improve the response to these load steps.

#### ELECTRICAL CHARACTERISTICS

Unless otherwise specified, the following specifications apply over the operating ambient temperature -40°C ≤ T<sub>A</sub> ≤ 85°C except where otherwise noted. Test conditions: V<sub>IN</sub> = V<sub>OUT</sub> + 0.5V; I<sub>OUT</sub> = 10mA; C<sub>IN</sub> = 1μF; C<sub>OUT</sub> = 1μF; T<sub>J</sub> = T<sub>A</sub> using low duty cycle pulse testing methods.

Parameter	Symbol	Test Conditions	LX8221			Units
			Min	Typ	Max	
Output Voltage (2.5, 2.7, 3.0, ADJ)	V <sub>OUT1/2</sub>	T <sub>J</sub> = 25°C 0mA ≤ I <sub>OUT1/2</sub> ≤ 100mA, (V <sub>OUT1/2</sub> + 0.5V) ≤ V <sub>IN</sub> ≤ 6V	-1		1	%
			-2.5		2.5	
Adjust Reference Voltage	V <sub>ADJ</sub>	T <sub>J</sub> = 25°C 0mA ≤ I <sub>OUT1/2</sub> ≤ 100mA, 2.85V ≤ V <sub>IN</sub> ≤ 6V	1.163	1.175	1.187	V
			1.140		1.210	
Line Regulation $\left(\frac{\Delta V_O}{\Delta V_{IN}}\right)$	V <sub>RV</sub>	(V <sub>OUT1/2</sub> + 0.5V) ≤ V <sub>IN</sub> ≤ 5V, I <sub>OUT1/2</sub> = 0.1mA		0.04	0.15	%/V
Load Regulation $\left(\frac{\Delta V_O}{\Delta I_O}\right)$	V <sub>RI</sub>	T <sub>J</sub> = 25°C, 0.5mA ≤ I <sub>OUT1/2</sub> ≤ 150mA 0.5mA ≤ I <sub>OUT1/2</sub> ≤ 100mA		0.5		%V <sub>NOM</sub>
Dropout Voltage (V <sub>IN</sub> - V <sub>O</sub> ) (Note 2)	V <sub>DO</sub>	I <sub>LOAD1/2</sub> = 1mA, Δ <sub>VO</sub> = -1% I <sub>LOAD1/2</sub> = 50mA, Δ <sub>VO</sub> = -1% I <sub>LOAD1/2</sub> = 100mA, Δ <sub>VO</sub> = -1% I <sub>LOAD1/2</sub> = 150mA, Δ <sub>VO</sub> = -1%			0.050	
					0.175	
				0.175	0.3	V
				0.25	0.4	
Ground Pin Current	I <sub>GND</sub>	EN1 = High, EN2 = High		280	440	
	I <sub>STBY</sub>	EN1 = Low, EN2 = Low			1	μA
Adjust Input Bias Current	I <sub>ADJ</sub>	V <sub>ADJ</sub> = 1.25V			100	nA
Enable Pin Current	I <sub>EN</sub>	V <sub>EN1/2</sub> = V <sub>IN</sub>			100	nA
Enable Threshold	V <sub>EN(IH)</sub>			2.0		V
	V <sub>EN(IL)</sub>				0.4	
Short Circuit Current Limit	I <sub>OUT(SC)</sub>	V <sub>OUT1</sub> = 0V, V <sub>OUT2</sub> = 0V		400		mA
Power Supply Rejection Ratio	PSRR	T <sub>J</sub> = 25°C, f = 120Hz		50		dB
Output Noise	e <sub>N</sub>	T <sub>J</sub> = 25°C, C <sub>OUT</sub> = 10μF, C <sub>BYPASS</sub> = 470pF		50		μV
Thermal Shutdown Temperature	T <sub>SD</sub>			170		°C

Note 2: Dropout voltage is defined as the input to output differential at which the output voltage drops 1% below the nominal value. Dropout voltage specification applies only to output voltages greater than 2.8V. For output voltages below 2.8V, the dropout voltage is nothing but the input to output differential, since the minimum input voltage is 2.8V.



## APPLICATIONS

### Description

The LX8221 family of LDO linear regulators is available in a 10-pin MSOP Package and provides a cost effective power management solution for battery driven applications. The regulator family includes both fixed/adjustable and adjustable/adjustable output voltage versions. The internal PMOS power device provides low dropout regulation with a fast line and load transient response. It also includes internal current limiting and thermal shutdown circuitry. In this section you will find information about capacitor, thermal, and layout design considerations.

### Input Capacitor

To improve load transient response and noise rejection a bypass capacitor is recommended (but it is not required for stability). There are no requirements for the ESR (Equivalent Series Resistor) on the input capacitor, but tolerance and temperature coefficient must be considered when selecting this capacitor to ensure that the capacitor's value will be around  $1\mu\text{F}$  over the entire operating temperature range. For the LX8221, a  $1\mu\text{F}$  ceramic type capacitor may be connected between both  $\text{VIN1/2}$  and ground.

### Output Capacitor

The LX8221 uses an internal feedback loop to maintain a constant output voltage. This feedback loop induces a natural phase shift and the amount of phase shift determines the loop's stability. Therefore, like any low-dropout regulator, an output capacitor with low ESR (Equivalent Series Resistance) is required between  $\text{VOUT}$  and  $\text{GND}$  to stabilize the internal control loop. A ceramic, tantalum or electrolytic capacitor with a minimum recommended capacitance value of  $1.0\mu\text{F}$  and ESR between  $5\text{m}\Omega$  and  $1\Omega$  will satisfy the stability for the entire operating range.

### Optional Bypass Capacitor

The fixed/adjustable voltage version of the LX8221 includes a separate Bypass pin (CB1) for the fixed regulator that allows for further reduction of output noise. If the regulator's output noise performance meets system design specifications without the capacitor, omit it. The bypass capacitor impacts the start up time, which is inversely proportional to the size of bypass capacitor. Further, the bypass capacitor reduces the regulator phase margin. Hence, implementing the bypass capacitor will require the use of a larger output capacitor to maintain the

LDO's stability. The LX8221-x adjustable regulator's output voltage can be externally set by connecting the  $\text{ADJ}$  pin/s to an external resistor divider (See Figure 1 and 2). The output voltage can be calculated using the formula:

$$V_{\text{OUT}} = V_{\text{ADJ}} \left( 1 + \frac{R_1}{R_2} \right)$$

### Enable

The Enable pin allows the LX8221 to be independently turned on and off. The Enable pins are compatible with standard TTL-CMOS levels. A logic zero (0.4V) on the  $\text{En}_1/\text{En}_2$  pins shuts the LX8221 off and reduces the supply current to less than  $1\mu\text{A}$  (typical). Pulling the Enable inputs high (2.0V) causes normal operation to resume. If the Enable feature is not used, this pin can be connected to  $\text{V}_{\text{IN}}$ .

### Minimum Load Requirement

Although line regulation is improved with a minimum load of  $100\mu\text{A}$ , the LX8221 does not have a minimum load current in order to maintain stability. This is an especially important feature in certain applications.

### Temperature Protection

The thermal protection shuts the LX8221 down when the junction temperature exceeds approximately  $150^{\circ}\text{C}$ ; there is no appreciable thermal hysteresis.

### Short Circuit Current Protection

The LX8221 includes over-current protection, when the output load current exceeds about 400mA. When this occurs, the protection circuit forces the regulator to decrease its output current.

### Thermal Consideration

Thermal shutdown protects the integrated circuit from thermal overload caused from a rise in junction temperature during power dissipation. This type of protection is intended for fault protection only and not as a means of current (or, power) limiting during normal application usage. Proper thermal evaluation should be done to ensure that the junction temperature dose not exceed it's maximum rating. Operating at the maximum  $T_j$  of  $150^{\circ}\text{C}$  can impact reliability. Due to variation in individual device electrical characteristics and thermal resistance, the built in thermal overload protection may be activated at power levels slightly above or below the rated dissipation. Power dissipation for each regulator can



## APPLICATIONS

be calculated using the following equation:

$$P_D = (V_{IN(MAX)} - V_{OUT(MIN)}) \times I_{OUT(MAX)}$$

(Note: power dissipation resulting from quiescent current is negligible)

For the MSOP package, thermal resistance,  $\theta_{JA}$  is  $206^\circ\text{C}/\text{W}$  when mounted on a FR4 copper clad PCB. Junction temperature of the integrated circuit can be calculated using:

$$T_J = T_A + T_{RISE}$$

Where:

$$T_{RISE} = (P_D \times \theta_{JA})$$

**Example:** Given the following conditions:

- $T_A = 60^\circ\text{C}$
- $V_{IN} = 4.2\text{V}$
- $V_{OUT} = 2.7\text{V}$
- $I_{OUT} = 100\text{mA}$

calculate the *total power dissipation* and *junction temperature*:

Total Power Dissipation:

$$P_D = (4.2\text{V} - 2.7\text{V}) \times 0.1\text{A} = 0.15\text{W}$$

Junction Temperature:

$$T_J = 60^\circ\text{C} + (0.15\text{W} \times 206^\circ\text{C}/\text{W}) = 91^\circ\text{C}$$

### Layout Consideration:

The layout must be implemented with low impedance paths for  $V_{IN}$ ,  $V_{OUT}$  and Ground by creating sufficiently wide traces to avoid voltage drops and pick up noise. Adding an area of PCB copper to the GND pin (pin 8) will reduce the overall  $\theta_{JA}$  since it is thermally connected to the device substrate. This will lower the device junction temperature improving overall output voltage accuracy. The input/output capacitors must be placed as close as possible to each voltage regulator output pin.



## APPLICATION CIRCUITS

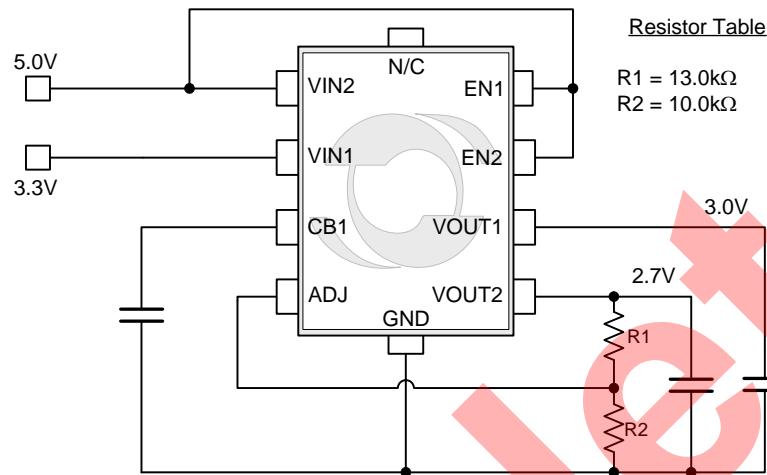


Figure 1 – Fixed / Adjustable Output Application

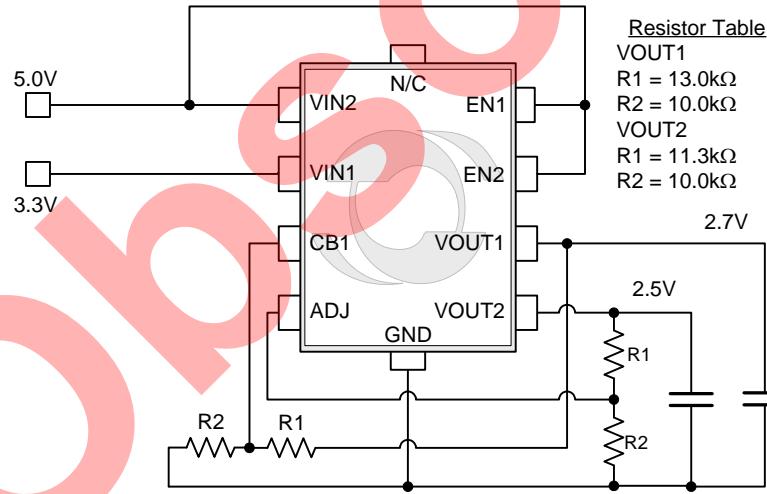
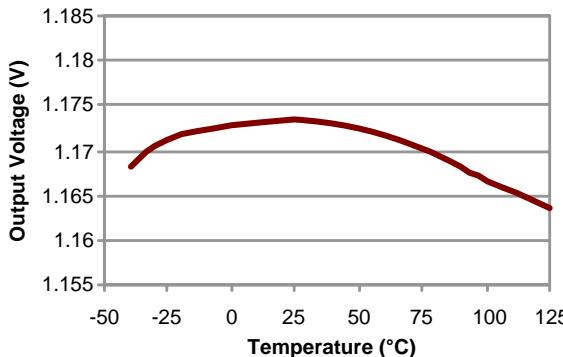


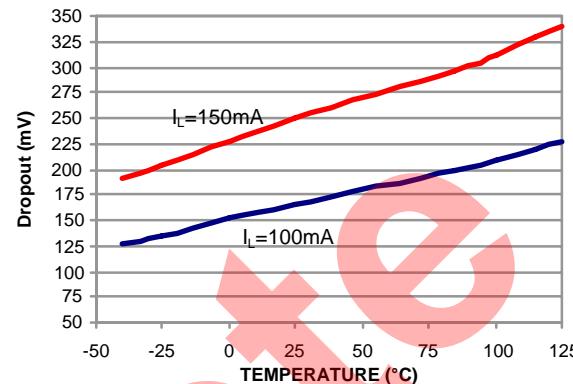
Figure 2 – Adjustable / Adjustable Output Application



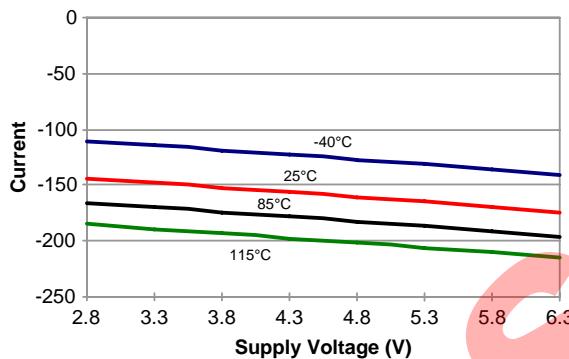
OUTPUT VOLTAGE VS TEMPERATURE



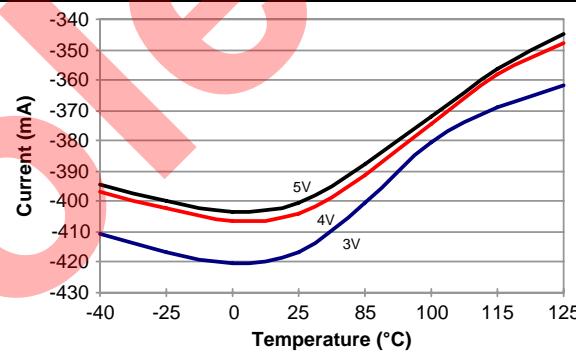
DROPOUT VOLTAGE VS TEMPERATURE



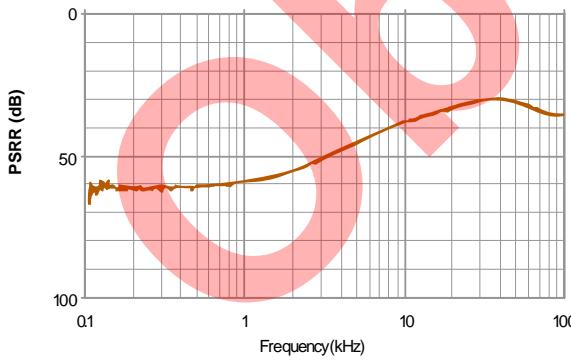
OUTPUT CURRENT VS SUPPLY VOLTAGE



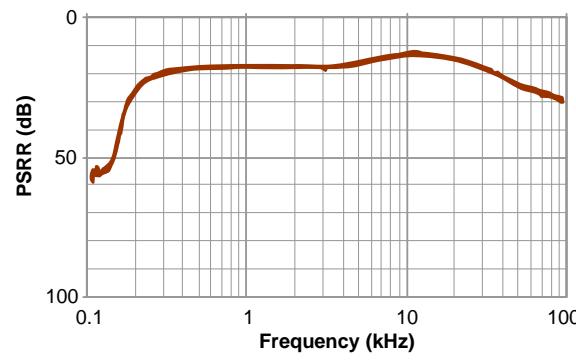
SHORT CIRCUIT CURRENT VS TEMPERATURE



PSRR VS FREQUENCY



PSRR VS FREQUENCY IN DROPOUT

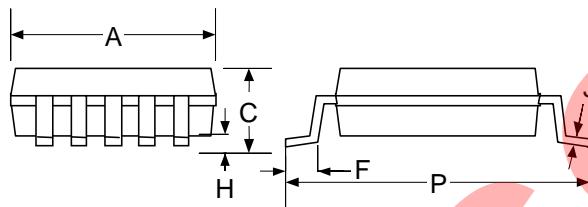
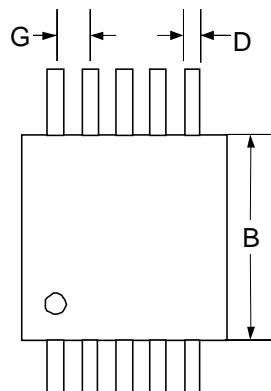


Typical performance characteristics, unless otherwise specified are:  $C_{IN} = C_{OUT} = 1\mu F$ ,  $C_{BY} = 470pF$ ,  $V_{IN} = V_{OUT} = 2.5V$ ,  $T_A = 25^{\circ}C$ , ENABLE is tied to  $V_{IN}$ .



## PACKAGE DIMENSIONS

### DU 10-Pin Plastic MSOP



Dim	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.85	3.05	0.112	0.120
B	2.90	3.10	0.114	0.122
C	-	1.10	-	0.043
D	0.16	0.31	0.006	0.0124
F	0.40	0.60	0.015	0.023
G	0.50 BSC		0.019 BSC	
H	0.050	0.150	0.002	0.006
J	0.10	-	0.004	-
P	4.75	5.05	0.187	0.198
*LC	-	0.10	-	0.004

\*Lead Coplanarity

**Note:** Dimensions do not include mold flash or protrusions; these shall not exceed 0.155mm(.006") on any side. Lead dimension shall not include solder coverage.



**Microsemi**<sup>®</sup>

**LX8221**

**Dual 150mA CMOS Low Dropout Regulator**

**PRODUCTION DATA SHEET**

**NOTES**

**Obsolete**

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