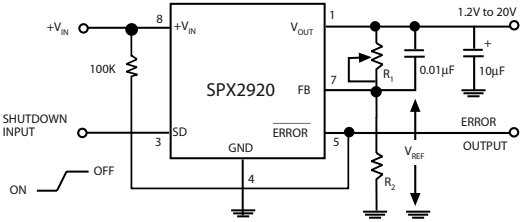
SPX2920

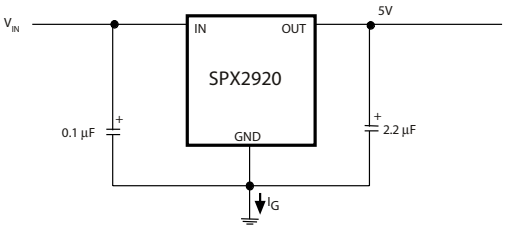
400mA Low Drop Out Voltage Regulator with Shutdown

FEATURES

- Output 3.3V, 5.0V, at 400mA Output
- Very Low Quiescent Current
- Low Dropout Voltage
- Extremely Tight Load and Line Regulation
- Very Low Temperature Coefficient
- Current & Thermal Limiting
- Error Flag Warns of Output Dropout (for SO-8)
- Logic-Controlled Electronic Shutdown (for SO-8)
- Output Programmable from 1.24V to 20V (for SO-8)
- Equivalent Replacement for MIC2920A and MIC2904



Adjustable Regulator



5V Regulator Circuit

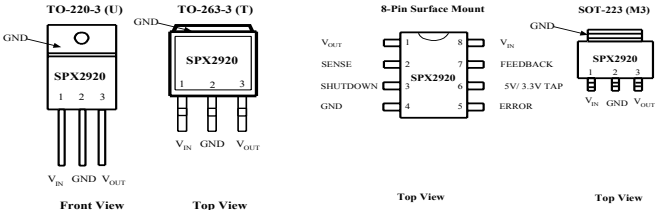
Now Available in Lead Free Packaging

DESCRIPTION

The SPX2920 is a low power voltage regulator. This device is an excellent choice for use in battery-powered applications such as cordless telephones, radio control systems, and portable computers. The SPX2920 features very low quiescent current (140μA Typical) and very low dropout voltage. This includes a tight initial tolerance of 1% maximum and very low output temperature coefficient, making the SPX2920 useful as a low-power voltage reference.

The error flag output feature is used as power-on reset for warning of a low output voltage, due to a falling voltage input from batteries. Another feature is the logic-compatible shutdown input which enables the regulator to be switched on and off. The SPX2920 is offered in 3-pin TO-220 package, surface mount SO-8 (same pin out as SPX2951), SOT-223, and 3-pin TO-263 packages.

The regulator output voltage (of the SO-8) may be pin-strapped for a 3.3V and 5.0V or programmed from 1.24V to 20V with an external pair of resistors.



ABSOLUTE MAXIMUM RATINGS

Power Dissipation ..... Internally Limited
Lead Temp. (Soldering, 5 Seconds) ..... 260°C
Storage Temperature Range ..... -65°C to +150°C
Operating Junction Temperature Range ..... -40°C to +125°C
Input Supply Voltage ..... -20V to +20V

Feedback Input Voltage ..... -1.5V to +20V
Shutdown Input Voltage ..... -0.3V to +20V
Error Comparator Output ..... -0.3V to +20V
ESD Rating 2kV

ELECTRICAL CHARACTERISTICS

Electrical characteristics at V_{IN} =V_O +1V, I_O = 1mA, C_{OUT} = 2.2µF, T_A = 25°C, unless otherwise specified. **Boldface** applies over the full operating temperature range.

PARAMETER	CONDITIONS (Note 2)	TYP	MIN	MAX	UNITS
3.3V Version					
Output Voltage		3.3	3.267	3.333	V
	1mA ≤ I_L ≤ 400mA	**3.3**	**3.217**	**3.382**	
5.0V Version					
Output Voltage		5.0	4.950	5.050	V
	1mA ≤ I_L ≤ 400mA	**5.0**	**4.880**	**5.120**	
All Voltage Options					
Output Voltage Temperature Coefficient	(Note1)	20		**100**	ppm/°C
Line Regulation (Note 4)	6V ≤ V_{IN} ≤ 20V	1.5		**20**	mV
Load Regulation (Note 3)	I_L=1 to 400mA	5		20 **30**	mV
Dropout Voltage (Note5)	I_L=1mA	60		100 **150**	mV
	I_L=400mA	370		400 **500**	
Ground Current	I_L=1mA	140		200 **300**	µA
	I_L=100mA	1.3		2 **2.5**	mA
	I_L=250mA	3.4		9 **12**	mA
	I_L=400mA	6		15 **25**	mA
Current Limit	V_{OUT}=0			**800**	mA
Thermal Regulation		0.05		0.2	%/W
Output Noise, 10Hz to 100kHz I_L=100mA	C_L=10µF C_L=100µF	400 260			µV Vrms
Adjustable 8-Pin Version only					
Reference Voltage		1.235	1.210	1.260	V
Reference Voltage	Over Temperature		1.185	1.285	V
Feedback Pin Bias Current		20		40 **60**	nA
Reference Voltage Temperature Coefficient		20			ppm/°C

ELECTRICAL CHARACTERISTICS

Electrical characteristics at $V_{IN} = V_O+1V$, I_O = 1mA, C_{OUT} = 2.2µF, T_A = 25°C, unless otherwise specified. **Boldface** applies over the full operating temperature range.

PARAMETER	CONDITIONS (Note 2)	TYP	MIN	MAX	UNITS
Feedback Pin Bias Current Temperature Coefficient		0.1			nA/°C
Error Comparator					
Output Leakage Current	V_{0UT}=20V	0.01		1 **2**	µA
Output Low Voltage	V_{IN}=4.5V I_{OUT}=400µA	150		250 **400**	mV
Upper Threshold Voltage	(Note 6)	60	40 **25**		mV
Lower Threshold Voltage	(Note 6)	75		95 **140**	mV
Hysteresis	(Note 6)	15			mV
Shutdown Input					
Input Logic Voltage	 Low (Regulator ON) High (Regulator OFF)	1.3	 **2.0**	 **0.7**	 V
Shutdown Pin Input Current	V_S=2.4V V_S=20V	30 450		50 **100** 600 **750**	µA
Regulator Output Current in Shutdown	(Note 7)	3	10 **20**		µA
Thermal Resistance Theta JA	TO-220-3 TO-263-3 NSOIC-8 SOT-223		29.4 31.4 128.4 62.3		ºC/W

Note 1: Output or reference voltage temperature coefficients defined as the worst case voltage change divided by the total temperature range.

Note 2: Additional conditions for the 8-pin versions are feedback tied to 5V/3.3V tap and output tied to output sense (V_{OUT} = 5V) and $V_{SHUTDOWN} \leq 0.8V$.

Note 3: Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation.

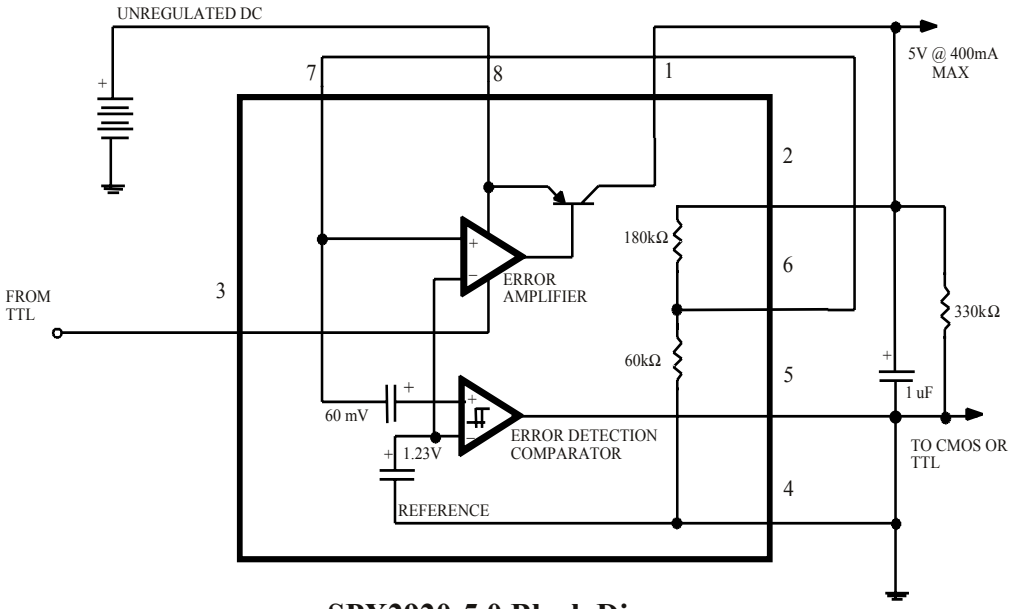
Note 4: Line regulation for the SPX2920 is tested at 150°C for I_L = 1 mA. For T_J = 125°C, line regulation is guaranteed by design.

Note 5: Dropout voltage is defined as the input to output differential at which the output voltage drops 100 mV below its nominal value measured at 1V differential at very low values of programmed output voltage, the minimum input supply voltage of 2V (2.3V over temperature) must be taken into account.

Note 6: Comparator thresholds are expressed in terms of a voltage differential at the feedback terminal below the nominal reference voltage measured at 6V input. To express these thresholds in terms of output voltage change, multiply by the error amplifier gain = V_{OUT}/V_{REF} = (R1 + R2)/R2. For example, at a programmed output voltage of 5V, the Error output is guaranteed to go low when the output drops by 95 mV x 5V/1.235 = 384 mV. Thresholds remain constant as a percent of V_{OUT} as V_{OUT} is varied, with the dropout warning occurring at typically 5% below nominal, 7.5% guaranteed.

Note 7: $V_{SHUTDOWN} \geq 2V$, $V_{IN} \leq 20V$, V_{OUT} = 0, Feedback pin tied to 5V/3.3V Tap.

BLOCK DIAGRAM



SPX2920-5.0 Block Diagram

APPLICATION HINTS

External Capacitors

The stability of the SPX2920 requires a 2.2µF or greater capacitor between output and ground. Oscillation could occur without this capacitor. Most types of tantalum or aluminum electrolytic capacitors work fine here. For operations of below -25°C, solid tantalum is recommended since many of the aluminum types have electrolytes that freeze at about -30°C. The ESR of about 5Ω or less and resonant frequency above 500kHz are the most important parameters in the value of the capacitor. The capacitor value can be increased without limit.

At lower values of output current, less output capacitance is required for stability. For the currents below 10mA the value of the capacitor can be reduced to 0.5µF and 0.15µF for 1mA. More output capacitance is needed for the 8-pin version at voltages below 5V since it runs the error amplifier at lower gain. At worst case, 4.7µF or greater must be used for the condition of 250mA load at 1.23V output.

The SPX2920, unlike other low dropout regulators, will remain stable and in regulation with no load in addition to the internal voltage divider. This feature is especially important in applications like CMOS RAM keep-alive.

If there is more than 10 inches of wire between the input and the AC filter capacitor, or if a battery is used as the input, then a 0.1µF tantalum or aluminum electrolytic capacitor should be placed from the input to the ground.

Instability can occur if there is stray capacitance to the SPX2920 feedback terminal (pin 7). This could cause more problems when using a higher value of external resistors to set the output voltage.

This problem can be fixed by adding a 100pF capacitor between output and feedback and increasing the output capacitor to at least 3.3µF.

Error Detection Comparator Output

The Comparator produces a logic low output whenever the SPX2920 output falls out of regulation by more than about 5%. This is around 60mV offset divided by the 1.235 reference voltage. This trip level remains 5% below normal regardless of the programmed output voltage of the regulator. Figure 1 shows the timing diagram depicting the ERROR signal and the regulator output voltage as the SPX2920 input is ramped up and down. The ERROR signal becomes low at around 1.3V input, and goes high around 5V input (input voltage at which V_{OUT} = 4.75V). Since the SPX2920's dropout voltage is load dependent, the input voltage trip point (around 5V) will vary with the load current. The output voltage trip point (approximately 4.75V) does not vary with load.

The error comparator has an open-collector output, which requires an external pull-up resistor. Depending on the system requirements the resistor may be returned to 5V output or other supply voltage. In determining the value of this resistor, note that the output is rated to sink 400µA; this value adds to battery drain in a low battery condition. Suggested values range from 100K to 1MΩ. If the output is unused this resistor is not required.

Programming the Output Voltage of SPX2920

The SPX2920 may be pin-strapped for 5V or 3.3V using its internal voltage divider by tying Pin 1 (output) to Pin 2 (sense) and Pin 7 (feedback) to Pin 6 (5V/3.3V Tap).

Also, it may be programmed for any output voltage between its 1.235V reference and its 20V maximum rating. As seen on the front page, an external pair of resistors is required.

Refer to the equation below for the programming of the output voltage:

$$V_{OUT} = V_{REF} \times (1 + R_1 / R_2) + I_{FB} R_1$$

The V_{REF} is 1.235 and I_{FB} is the feedback bias current, nominally -20nA. The minimum recommended load current of 1µA forces an upper limit of 1.2MΩ on the value of R_2. If no load is presented, the I_{FB} produces an error of typically 2% in V_{OUT}, which may be eliminated at room temperature by trimming R_1. To improve the accuracy choose the value of R_2 = 100kΩ; this reduces the error by 0.17% and increases the resistor program current by 12µA. Since the SPX2920 typically draws 60µA at no load with Pin 2 open-circuited, this is a small price to pay.

Reducing Output Noise

It may be an advantage to reduce the AC noise present at the output. One way is to reduce the regulator bandwidth by increasing the size of the output capacitor. This is the only way that noise can be reduced on the 3 lead SPX2920 but it is relatively inefficient; as increasing the capacitor from 1µF to 220µF only decreases the noise from 430µV to 160µV Vrms for a 100kHz bandwidth at 5V output.

Noise could also be reduced fourfold by a bypass capacitor across R_1, since it reduces the high frequency gain from 4 to unity. Pick

$$C_{BYPASS} \cong 1 / 2\pi R_1 \times 200 \text{ Hz}$$

or choose 0.01µF. When doing this, the output capacitor must be increased to 3.3µF to maintain stability. These changes reduce the output noise from 430µV to 100µV Vrms for a 100kHz bandwidth at 5V output. With the bypass capacitor added, noise no longer scales with output voltage so that improvements are more dramatic at higher output

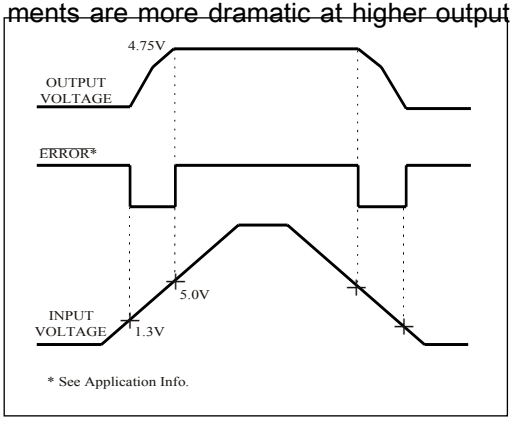
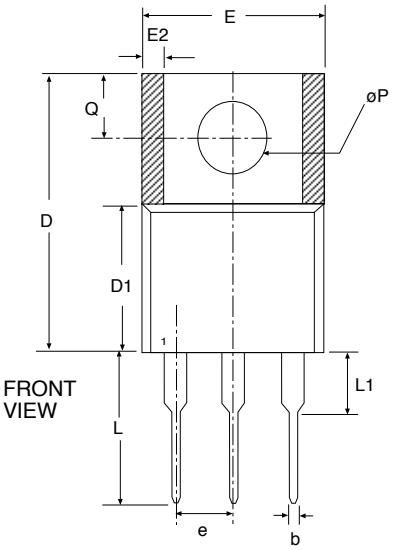
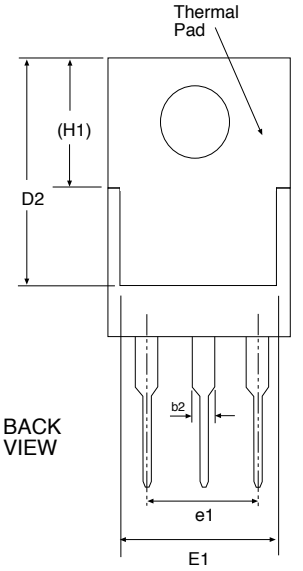
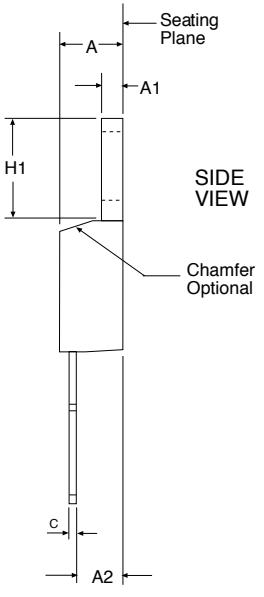


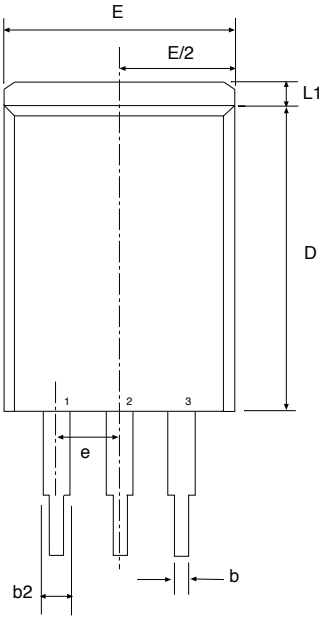
Figure 1. ERROR Output Timing



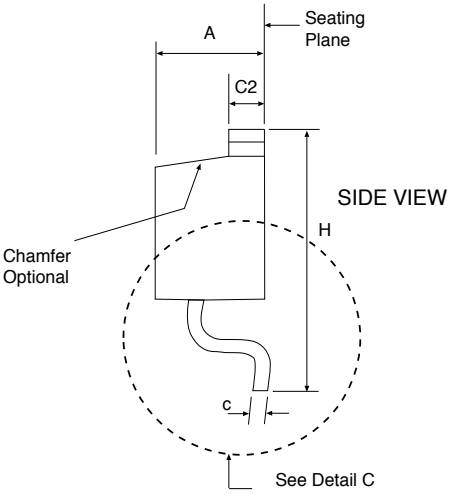


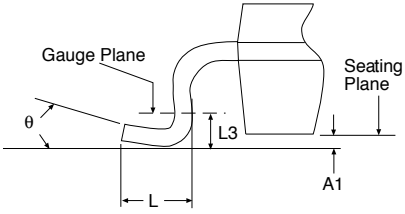


3 Pin TO-220 JEDEC TO-220 Variation AB						
SYMBOL	Dimensions in Inches: Controlling Dimension			Dimensions in Millimeters: Conversion Factor: 1 Inch = 25.40 mm		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.140	-	0.190	3.56	-	4.83
A1	0.020	-	0.055	0.51	-	1.27
A2	0.080	-	0.115	2.03	-	2.79
b	0.015	0.027	0.040	0.25	0.51	1.02
b2	0.045	0.057	0.070	1.14	1.45	1.78
c	0.014	-	0.024	0.25	-	0.51
D	0.560	-	0.650	14.22	-	16.51
D1	0.330	-	0.355	8.38	-	8.89
D2	0.480	-	0.507	12.19	-	12.70
E	0.380	-	0.420	9.65	-	10.67
E1	0.270	-	0.350	6.86	-	8.89
E2	-	-	0.030	-	-	0.76
e	.100 BSC			2.54 BSC		
e1	.200 BSC			5.08 BSC		
H1	0.230	-	0.270	5.84	-	6.86
L	0.500	-	0.580	12.70	-	14.73
L1	-	-	0.250	-	-	6.35
ΦP	0.139	-	0.161	3.30	-	4.06
Q	0.100	-	0.135	2.54	-	3.30
SIPEX Pkg Signoff Date/Rev:				JL Aug4-05 / Rev A		

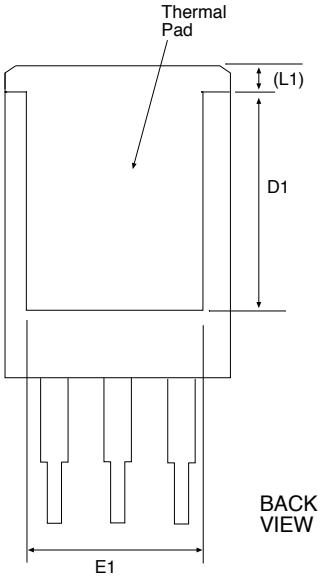


FRONT VIEW

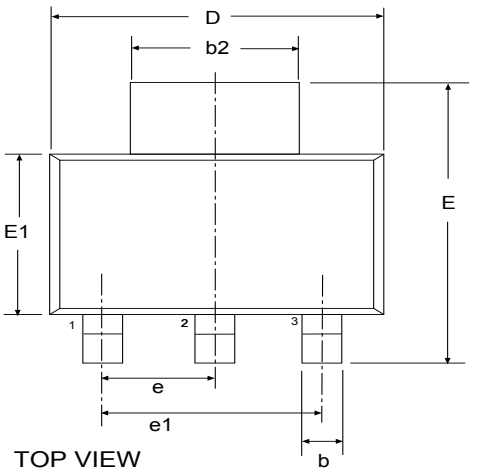




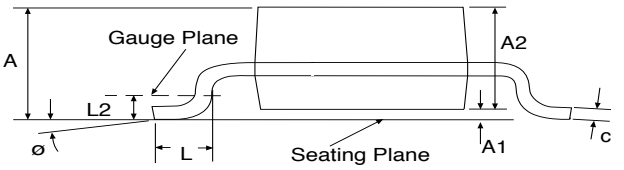
DETAIL C



3 Pin TO-263 JEDEC TO-263 Variation AA						
SYMBOL	Inches Controlling Dimension			Millimeters Conversion Factor: 1 Inch = 25.40 mm		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.160	-	0.190	4.06	-	4.83
A1	0.000	-	0.010	0.00	-	0.25
b	0.020	-	0.039	0.51	-	0.99
b2	0.045	-	0.070	1.14	-	1.78
c	0.015	-	0.029	0.38	-	0.74
c2	0.045	-	0.065	1.14	-	1.65
D	0.330	-	0.380	8.38	-	9.65
D1	0.270	-	-	6.86	-	-
E	0.380	-	0.420	9.65	-	10.67
E1	0.245	-	-	6.22	-	-
e	.100 BSC			2.54 BSC		
H	0.575	-	0.625	14.61	-	15.88
L	0.070	-	0.110	1.78	-	2.79
L1	-	-	0.066	-	-	1.68
L3	.010 BSC			0.25 BSC		
Θ	0°	-	8°	0°	-	8°
SIPEX Pkg Signoff Date/Rev:				JL Aug5-05 / Rev A		

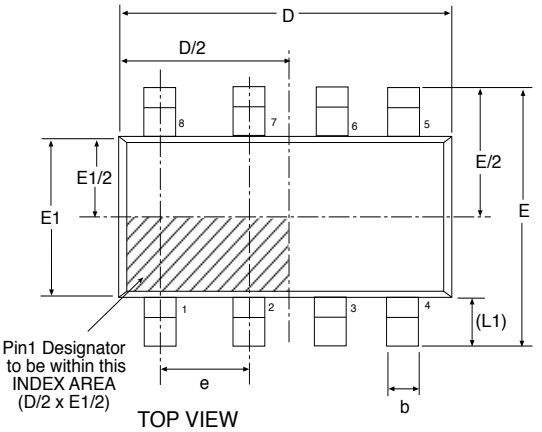


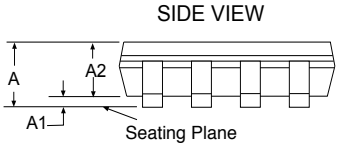
TOP VIEW

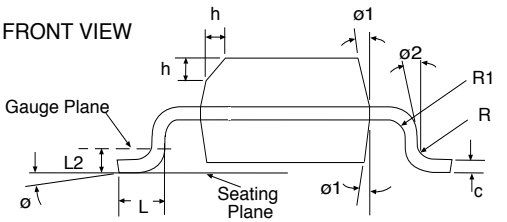


FRONT VIEW

3 Pin SOT-223 JEDEC TO-261 Variation AA						
	Millimeters Controlling Dimension			Inches Conversion Factor: 1 Inch = 25.40 mm		
SYMBOL	MIN	NOM	MAX	MIN	NOM	MAX
A	-	-	1.80	-	-	0.071
A1	0.02	-	0.10	0.001	-	0.004
A2	1.50	1.60	1.70	0.060	0.063	0.067
b	0.66	0.76	0.84	0.026	0.030	0.033
b2	2.90	3.00	3.10	0.114	0.118	0.122
c	0.23	0.30	0.35	0.010	0.012	0.014
D	6.30	6.50	6.70	0.248	0.256	0.264
E	6.70	7.00	7.30	0.264	0.276	0.287
E1	3.30	3.50	3.70	0.130	0.138	0.146
e	2.30 BASIC			0.091 BASIC		
e1	4.60 BASIC			0.182 BASIC		
L	0.75	-	-	0.030	-	-
L2	0.25 BASIC			0.010 BASIC		
ø	0º	-	10º	0º	-	10º
SIPEX Pkg Signoff Date/Rev:				JL Aug8-05/Rev A		







8 Pin NSOIC		JEDEC MS-012		Variation AA		
SYMBOL	Dimensions in Millimeters: Controlling Dimension			Dimensions in Inches Conversion Factor: 1 Inch = 25.40 mm		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.35	-	1.75	0.053	-	0.069
A1	0.10	-	0.25	0.004	-	0.010
A2	1.25	-	1.65	0.049	-	0.065
b	0.31	-	0.51	0.012	-	0.020
c	0.17	-	0.25	0.007	-	0.010
E	6.00 BSC			0.236 BSC		
E1	3.90 BSC			0.154 BSC		
e	1.27 BSC			0.050 BSC		
h	0.25		0.50	0.010	-	0.020
L	0.40	-	1.27	0.016	-	0.050
L1	1.04 REF			0.041 REF		
L2	0.25 BSC			0.010 BSC		
R	0.07	-	-	0.003	-	-
R1	0.07	-	-	0.003	-	-
ø	0º	-	8º	0º	-	8º
ø1	5º	-	15º	5º	-	15º
ø2	0º	-	-	0º	-	-
D	4.90 BSC			0.193 BSC		
SIPEX Pkg Signoff Date/Rev:				JL Aug16-05 / Rev A		

Ordering No.	Accuracy	Output Voltage	Packages
SPX2920M3-3-3	1%	3.3V	3-Pin SOT-223
SPX2920M3-3-3/TR	1%	3.3V	3-Pin SOT-223
SPX2920M3-5-0	1%	5.0V	3-Pin SOT-223
SPX2920M3-5-0/TR	1%	5.0V	3-Pin SOT-223
SPX2920S-3-3	1%	3.3V	8-Pin NSOIC
SPX2920S-3-3/TR	1%	3.3V	8-Pin NSOIC
SPX2920S-5-0	1%	5.0V	8-Pin NSOIC
SPX2920S-5-0/TR	1%	5.0V	8-Pin NSOIC
SPX2920T-3-3	1%	3.3V	3-Pin TO-263
SPX2920T-3-3/TR	1%	3.3V	3-Pin TO-263
SPX2920T-5-0	1%	5.0V	3-Pin TO-263
SPX2920T-5-0/TR	1%	5.0V	3-Pin TO-263
SPX2920U-3-3	1%	3.3V	3-Pin TO-220
SPX2920U-5-0	1%	5.0V	3-Pin TO-220

Available in lead free packaging. To order add "-L" suffix to part number.
Example: SPX2920T-3-3/TR = standard; SPX2920T-L-3-3/TR = lead free

/TR = Tape and Reel
Pack quantity is 500 for TO-263 and 2,500 for SOT-223 and NSOIC.

Solved by Sipex™

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