

FEATURES:

- RAD-PAK® radiation-hardened against natural space radiation
- Total dose hardness:
 - > 100 krad (Si), depending upon space mission
- Latch-up Protection Technology (LPT™)
- SEL converted into a reset
 - Rate based on cross section and mission
- Package: 24 pin RAD-PAK flat package
- 100 kHz min sampling rate
- ±10 V and 0 V to 5 V input range
- DNL: 15-bits "No Missing Codes"
- 83 dB min SINAD with 20 kHz input
- Single +5 V supply operation
- Utilizes internal or external reference
- Serial output
- Power dissipation: 132 mW max

DESCRIPTION:

Maxwell Technologies' 7809ALP high-speed 16-bit analog to digital converter features a greater than 100 kilorad (Si) total dose tolerance depending upon space mission. Using Maxwell's radiation-hardened RAD-PAK® packaging technology is latchup protected by Maxwell Technologies' Latchup Protection Technology (LPT™). It is a 24 pin, 16-bit sampling analog-to-digital converter using state-of-the-art CMOS structures. The 7809ALP contains a 16-bit capacitor based SAR A/D with S/H, reference, clock, interface for microprocessor use, and serial output drivers. The 7809ALP is specified at a 100kHz sampling rate, and guaranteed over the full temperature range. Laser-trimmed scaling resistors provide various input ranges include ±10 V and 0 to 5 V, while the innovative design allows operation from a single +5 V supply, with power dissipation of under 132 mW.

Maxwell Technologies' patented RAD-PAK® packaging technology incorporates radiation shielding in the microcircuit package. It eliminates the need for box shielding while providing the required radiation shielding for a lifetime in orbit or space mission. In a GEO orbit, RAD-PAK® provides greater than 50 krad (Si) radiation dose tolerance. This product is available with screening up to Maxwell Technologies' self-defined Class K.

16-Bit Latchup Protected Analog to Digital Converter 7809ALP

TABLE 1. 7809ALP PIN DESCRIPTION

PIN	SYMBOL	LPT PROTECTION	DESCRIPTION
1	R1IN	Not Protected	Analog Input.
2	AGND1	N/A	Analog Ground. Used internally as ground reference point.
3	R2IN	Not Protected	Analog Input.
4	R3IN	Not Protected	Analog Input.
5	CAP	Not Protected	Reference Buffer Capacitor. 2.2 μ F tantalum to ground.
6	REF	Not Protected	Reference Input/Output. 2.2 μ F tantalum capacitor to ground.
7	AGND2	N/A	Analog Ground.
8	SB/BTC	Not Protected	Select Straight Binary or Binary Two's Complement data output format. If HIGH, data will be output in a Straight Binary format. If LOW, data will be output in a Binary Two's Complement format.
9	EXT/INT	Not Protected	Select External or Internal Clock for transmitting data. If HIGH, data will be output synchronized to the clock input on DATACLK. If LOW, a convert command will initiate the transmission of the data from the previous conversion, along with 16 clock pulses output on DATACLK.
10	DGND	N/A	Digital Ground.
11	LPBIT	Not Protected	Built In test function of the latchup protection. Drive LOW during normal operation.
12	LPSTATUS	Not Protected	Latchup Protection Status Output. LPSTATUS when HIGH indicates latchup protection is active and output data is invalid.
13	VDIG	Protected	Digital Supply Input. Nominally 5V.
14	VANA	Protected	Analog Supply Input. Nominally 5V.
15	SYNC	Not Protected	Sync Output. If EXT/INT is HIGH, either a rising edge on $\overline{R/C}$ with \overline{CS} LOW or a falling edge on \overline{CS} with R/C HIGH will output a pulse on SYNC synchronized to the external DATACLK.
16	DATACLK	Protected	Either an input or an output depending on the EXT/INT level. Output data will be synchronized to this clock. If EXT/INT is LOW, DATACLK will transmit 16 pulses after each conversion, and then remain LOW between conversions.
17	DATA	Not Protected	Serial Data Output. Data will be synchronized to DATACLK, with the format determined by the level of SB/BTC. In the external clock mode, after 16-bits of data, the 7809LOPO will output the level input of TAG as long as \overline{CS} is LOW and R/\overline{C} is HIGH. If EXT/INT is LOW, data will be valid on both the rising and falling edges of DATACLK, and between conversions DATA will stay at the level of the TAG input when the conversion was started.
18	TAG	Protected	Tag input for use in external clock mode. If EXT/INT is HIGH, the digital data input on TAG will be output on DATA with a delay of 16 DATACLK pulses as long as \overline{CS} is LOW and R/\overline{C} is HIGH.

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TABLE 1. 7809ALP PIN DESCRIPTION

PIN	SYMBOL	LPT PROTECTION	DESCRIPTION
19	$\overline{R/C}$	Protected	Read/Convert Input. With \overline{CS} LOW, a falling edge on $\overline{R/C}$ puts the internal sample/hold into the hold state and starts a conversion. When EXT/INT is LOW, this also initiates the transmission of the data results from the previous conversion. If EXT/INT is HIGH, a rising edge on $\overline{R/C}$ with \overline{CS} LOW, or a falling edge on \overline{CS} with $\overline{R/C}$ HIGH, transmits a pulse on SYNC and initiates the transmission of data from the previous conversion.
20	\overline{CS}	Protected	Chip Select. Internally OR'ed with $\overline{R/C}$.
21	\overline{BUSY}		Busy Output. Falls when a conversion is started, and remains LOW until the conversion is completed and the data is latched into the output shift register. \overline{CS} or $\overline{R/C}$ must be HIGH when \overline{BUSY} rises, or another conversion will start without time for signal acquisition.
22	PWRD	Protected	Power Down Input. If HIGH, conversions are inhibited and power consumption is significantly reduced. Results from the previous conversions are maintained in the output shift register.
23	LPVANA	Protected	Latchup Protected Analog Supply.
24	LPVDIG	Protected	Latchup Protected Digital Supply.

TABLE 2. 7809ALP ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	MIN	MAX	UNIT
Analog Inputs	$R1_{IN}$ $R2_{IN}$ $R3_{IN}$ CAP REF ¹	-25 -25 -25 $V_{ANA} + 0.3$	25 25 25 AGND2 - 0.3	V V V V
Ground Voltage Differences: DGND, AGND2		-0.3	0.3	V
V_{ANA}		--	7	V
V_{DIG}			7	V
V_{DIG} to V_{ANA}		--	0.3	V
Digital Inputs		-0.3	$V_{DIG} + 0.3$	V
Weight		--	7.8	Grams
Thermal Resistance	T_{JC}	--	7.3	°C/W
Operating Temperature ²	T_{OPE}	-35	+85	°C
Storage Temperature	T_{STG}	-65	150	°C

1. Indefinite short to AGND2, momentarily short to V_{ANA} .
2. Minimum Temperature is -40°C when using with an external reference.

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TABLE 3. 7809ALP DC ACCURACY SPECIFICATIONS

(SPECIFIED PERFORMANCE: -40 TO +85°C USING EXTERNAL REFERENCE; -35 TO +85°C USING INTERNAL REFERENCE)

PARAMETER	SUBGROUPS	MIN	TYP	MAX	UNIT
Integral Linearity Error	1, 2, 3	--	--	±7	LSB ¹
Differential Linearity Error	1	--	--	-2, 3	LSB
-35 to 85°C (Internal Reference); -40 to 85°C (External Reference)	2, 3	--	--	-1, 6	LSB
No Missing Codes ²		15	--	--	Bits
Transition Noise ³		--	1.3	--	LSB
Full Scale Error ^{4,5}	1, 2, 3	--	--	±0.8	%
Full Scale Error ^{4,5} (using ext. 2.5000 V _{ref})	1, 2, 3	--	--	±0.8	%
Full Scale Error Drift	--	--	±7	--	ppm/°C
Full Scale Error Drift (using ext. 2.5000 V _{ref})	1, 2, 3	--	±2	--	ppm/°C
Bipolar Zero Error ⁴	1, 2, 3	--	--	±12	mV
Bipolar Zero Error Drift		--	±2	--	ppm/°C
Unipolar Zero Error ⁴	1	--	--	±3	mV
-35 to 85°C (Internal Reference); -40 to 85°C (External Reference)	2, 3	--	--	±16	mV
Unipolar Zero Error Drift		--	±2	--	ppm/°C
Recovery to Rated Accuracy after Power Down (1 uF Capacitor to CAP)		--	1	--	ms
Power Supply Sensitivity (V _{DIG} = V _{ANA} = V _D) 4.75 V ≤ V _D ≤ 5.2 V	1	--	--	±8	LSB
-35 to 85°C (Internal Reference); -40 to 85°C (External Reference)	2, 3	--	--	±32	LSB

1. LSB stands for Least Significant Bit. One LSB is equal to 305 μV.
2. Not tested.
3. Typical rms noise at worst case transitions and temperatures.
4. Measured with various fixed resistors.
5. For bipolar input ranges, full scale error is the worst case of -Full Scale or +Full Scale untrimmed deviation from ideal first and last scale code transitions, divided by the transition voltage (not divided by the full-scale range) and includes the effect of offset error. For unipolar input ranges, full scale error is the deviation of the last code transition divided by the transition voltage. It also includes the effect of offset error.

TABLE 4. DELTA LIMITS¹

PARAMETER	VARIATION
I _{CC}	+/- 10%

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TABLE 5. 7809ALP ANALOG INPUT AND THROUGHPUT SPEED

(SPECIFIED PERFORMANCE: -40 TO +85°C USING EXTERNAL REFERENCE; -35 TO +85°C USING INTERNAL REFERENCE)

PARAMETER	SUBGROUPS	MIN	TYP	MAX	UNIT
Voltage Ranges	1, 2, 3	10 V, 0 V to 5 V, etc. See Table 12.			
Impedance	1, 2, 3				
Capacitance ¹		--	35	--	pF
Conversion Time	9, 10, 11	--	7.6	8	μs
Complete Cycle (Acquire and Convert)	9, 10, 11	--	--	10	μs
Throughput Rate ²	9, 10, 11	--	--	100	kHz

1. Guaranteed by design.

2. Tested by application of signal.

TABLE 6. 7809ALP AC ACCURACY SPECIFICATIONS

(SPECIFIED PERFORMANCE: -40 TO +85°C USING EXTERNAL REFERENCE; -35 TO +85°C USING INTERNAL REFERENCE)

PARAMETER	SUBGROUPS	MIN	TYP	MAX	UNIT
Spurious-Free Dynamic Range, $f_{IN} = 20 \text{ kHz}$ ¹	4, 5, 6	90	100	--	dB ²
Total Harmonic Distortion, $f_{IN} = 20 \text{ kHz}$ ¹	4, 5, 6	--	-100	-90	dB
Signal-to-Noise (Noise + Distortion) ¹	4, 5, 6				dB
$f_{IN} = 20 \text{ kHz}$		83	88	--	
-60 dB Input		--	30	--	
Signal-to-Noise ¹ , $f_{IN} = 20 \text{ kHz}$		83	88	--	dB
Full-Power Bandwidth ^{1,3}		--	250	--	kHz

1. Guaranteed by design.

2. All specifications in dB are referred to a full-scale $\pm 10 \text{ V}$ input.

3. Full-Power Bandwidth defined as Full-Scale input frequency at which Signal-to-Noise (Noise + Distortion) degrades to 60 dB.

TABLE 7. 7809ALP SAMPLING DYNAMICS

(SPECIFIED PERFORMANCE: -40 TO +85°C USING EXTERNAL REFERENCE; -35 TO +85°C USING INTERNAL REFERENCE)

PARAMETER	SUBGROUPS	MIN	TYP	MAX	UNIT
Aperture Delay		--	40	--	ns
Aperture Jitter	9, 10, 11	Sufficient to meet AC specification			
Transient Response FS Step		--	2	--	us
Overvoltage Recovery ¹		--	150	--	ns

1. Recovers to specified performance after 2 X FS input overvoltage.

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TABLE 8. 7809ALP REFERENCE

(SPECIFIED PERFORMANCE: -40 TO +85°C USING EXTERNAL REFERENCE; -35 TO +85°C USING INTERNAL REFERENCE)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Internal Reference Voltage ¹	No Load	2.48	2.5	2.52	V
Internal Reference Source Current (Must be ext. buffer)		--	1	--	μA
External Reference Voltage Range for Specified Linearity ²		2.3	2.5	2.7	V
External Reference Current Drain	Ext. 2.5000V Ref	--	--	175	μA

1. Tested from -35°C to +85°C

2. Tested by application of signal.

TABLE 9. 7809ALP DIGITAL OUTPUTS

(SPECIFIED PERFORMANCE: -40 TO +85°C USING EXTERNAL REFERENCE; -35 TO +85°C USING INTERNAL REFERENCE)

PARAMETER	SUBGROUPS	CONDITIONS	MIN	TYP	MAX	UNIT
Data Format Data Coding Pipeline Delay		Serial 16-bits Binary Two's Complement or Straight Binary Conversion results only available after completed conversion				
Data Clock	Selectable for internal or external data clock					
Internal (Output Only When Transmitting Data) External (Can Run Continually)	9, 10, 11	EXT/INT Low EXT/INT High	-- 0.1	2.3 --	-- 10	MHz
V _{OL} V _{OH}	1, 2, 3	I _{SINK} = 1.6 mA I _{SOURCE} = 500 μA	-- 4	-- --	0.4 --	V
Leakage Current ¹		High-Z State, V _{OUT} = 0V to V _{DIG}	--	--	±16	μA
Output Capacitance ¹		High-Z State	--	15	--	pF

1. Not tested.

TABLE 10. 7809ALP DIGITAL INPUTS

PARAMETER	SUBGROUPS	MIN	TYP	MAX	UNIT
V _{IL}	1, 2, 3	-0.3	--	0.8	V
V _{IH}		2.0	--	V+0.3	V
I _{IL} - I _{HL}		--	--	+/- 10	μA

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TABLE 11. 7809ALP POWER SUPPLIES

(SPECIFIED PERFORMANCE: -40 TO +85°C USING EXTERNAL REFERENCE; -35 TO +85°C USING INTERNAL REFERENCE)

PARAMETER	SUBGROUPS	CONDITIONS	MIN	TYP	MAX	UNIT
V_{DIG}	1, 2, 3	Must be $< V_{ANA}$	4.75	5	5.25	V
V_{ANA}	1, 2, 3		4.75	5	5.25	V
I_{DIG}			--	0.3	--	mA
I_{ANA}			--	16	--	mA
I_{CC}	1, 2, 3	$I_{DIG} + I_{ANA}$ @ 100KHz			26.4	mA
Power Dissipation PWRD LOW PWRD HIGH ¹	1, 2, 3	$V_{ANA} = V_{DIG} = 5V$ $f_s = 100\text{ kHz}$	-- --	-- --	132 100	mW

1) Not Tested

TABLE 12. 7809ALP CONTROL LINE FUNCTIONS FOR READ AND CONVERT

SPECIFIC FUNCTION	\overline{CS}	R/\overline{C}	\overline{BUSY}	EXT/\overline{INT}	DATA CLK	PWRD	SB/\overline{BTC}	OPERATION
Initiate Conversion and Output Data using Internal Clock	1 > 0	0	1	0	Output	0	x	Initiates conversion "n". Data from conversion "n-1" clocked out on DATA synchronized to 16 clock pulses output on DATA-CLK
	0	1 > 0	1	0	Output	0	x	Initiates conversion "n". Data from conversion "n-1" clocked out on DATA synchronized to 16 clock pulses output on DATA-CLK

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TABLE 12. 7809ALP CONTROL LINE FUNCTIONS FOR READ AND CONVERT

SPECIFIC FUNCTION	\overline{CS}	R/\overline{C}	\overline{BUSY}	$\overline{EXT}/\overline{INT}$	DATACLK	PWRD	$\overline{SB}/\overline{BTC}$	OPERATION
Initiate Conversion and Output Data using External Clock	1 > 0	0	1	1	Input	0	x	Initiates conversion "n"
	0	1 > 0	1	1	Input	0	x	Initiates conversion "n"
	1 > 0	1	1	1	Input	x	x	Outputs a pulse on SYNC followed by data from conversion "n" clocked out synchronized to external DATACLK.
	1 > 0	1	0	1	Input	0	x	Outputs a pulse on SYNC followed by data from conversion "n-1" clocked out synchronized to external DATACLK ¹ . Conversion "n" in process.
	0	0 > 1	0	1	Input	0	x	Outputs a pulse on SYNC followed by data from conversion "n-1" clocked out synchronized to external DATACLK ¹ . Conversion "n" in process.
Incorrect Conversions	0	0	0 > 1	x	x	0	x	CS or R/C must be HIGH or a new conversion will be initiated without time for acquisition
Power Down	x	x	x	x	x	0	x	Analog circuitry powered. Conversion will be initiated without time for acquisition
	x	x	x	x	x	1	x	Analog circuitry disabled. Data from previous conversion maintained in output registers
1) Not Tested								
Selecting Output Format	x	x	x	x	x	x	0	Serial data is output in Binary Two's Complement format.
	x	x	x	x	x	x	1	Serial data is output in Straight Binary format.

1. See Figure 4 for constraints on previous data valid during conversion.

TABLE 13. 7809ALP INPUT RANGE CONNECTION

ANALOG INPUT RANGE	CONNECT R1 _{IN} VIA 200Ω TO	CONNECT R2 _{IN} VIA 100Ω TO	CONNECT R3 _{IN} TO	IMPEDANCE
±10V	V _{IN}	AGND	CAP	22.9 kΩ

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TABLE 13. 7809ALP INPUT RANGE CONNECTION

ANALOG INPUT RANGE	CONNECT R1 _{IN} VIA 200Ω TO	CONNECT R2 _{IN} VIA 100Ω TO	CONNECT R3 _{IN} TO	IMPEDANCE
±5V ¹	AGND	V _{IN}	CAP	13.3 kΩ
±3.3V ¹	V _{IN}	V _{IN}	CAP	10.7 kΩ
0V to 10V ¹	AGND	V _{IN}	AGND	13.3kΩ
0V to 5V ¹	AGND	AGND	V _{IN}	10.0 kΩ
0V to 4V	V _{IN}	AGND	V _{IN}	10.7 kΩ

TABLE 14. 7809ALP CONVERSION AND DATA TIMING

(SPECIFIED PERFORMANCE: -40 TO +85°C USING EXTERNAL REFERENCE; -35 TO +85°C USING INTERNAL REFERENCE)

SYMBOL	DESCRIPTION	SUBGROUPS	MIN	TYP	MAX	UNIT
t1	Convert Pulse Width	9, 10, 11	40	--	6000	ns
t2	BUSY Delay	9, 10, 11	--	--	80	ns
t3	BUSY LOW	9, 10, 11	--	--	8	μs
t4	BUSY Delay after End of Conversion	9, 10, 11	--	220	--	ns
t5	Aperture Delay	9, 10, 11	--	40	--	ns
t6	Conversion Time	9, 10, 11	--	7.6	8	μs
t7	Acquisition Time	9, 10, 11	--	--	2	μs
t6 + t7	Throughput Time	9, 10, 11	--	9	10	μs
t8	R/C Low to DATACLK Delay	9, 10, 11	--	450	--	ns
t9	DATACLK Period	9, 10, 11	--	440	--	ns
t10	Data Valid to DATACLK HIGH Delay	9, 10, 11	20	75	--	ns
t11	Data Valid after DATACLK LOW Delay	9, 10, 11	100	125	--	ns
t12	External DATACLK	9, 10, 11	100	--	--	ns
t13	External DATACLK HIGH	9, 10, 11	20	--	--	ns
t14	External DATACLK LOW	9, 10, 11	30	--	--	ns
t15	DATACLK HIGH Setup Time	9, 10, 11	20	--	t12 + 5	ns
t16	R/C to CS Setup Time	9, 10, 11	10	--	--	ns
t17	SYNC Delay After DATACLK High	9, 10, 11	15	--	45	ns
t18	Data Valid Delay	9, 10, 11	25	--	70	ns
t19	CS to Rising Edge Delay	9, 10, 11	25	--	--	ns
t20	Data Available after CS LOW	9, 10, 11	6	--	--	μs

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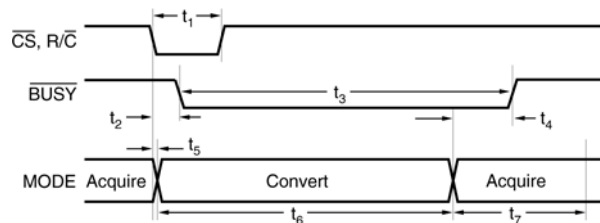
TABLE 15. 7809ALP OUTPUT CODES AND IDEAL INPUT VOLTAGES

DESCRIPTION	ANALOG INPUT						DIGITAL OUTPUT			
							BINARY TWO'S COMPLEMENT (SB/BTC LOW)		STRAIGHT BINARY (SB/BTC HIGH)	
							BINARY CODE	HEX CODE	BINARY CODE	HEX CODE
Full Scale Range	±10	±5	±3.33V	0V to 10V	0V to 5V	0V to 4V				
Least Significant Bit (LSB)	305 μV	153 μV	102 μV	153 μV	76 μV	61 μV				
+ Full Scale (FS - 1 LSB)	9.99969 5V	4.99984 7V	3.33323 1V	9.99984 7V	4.99992 4V	3.99993 8V	0111 1111 1111 1111	7FFF	1111 1111 1111 1111	FFFF
Midscale	0V	0V	0V	5V	2.5V	2V	0000 0000 0000 0000	0000	1000 0000 0000 0000	8000
One LSB Below Mid-scale	-305 μV	-153 μV	-102 μV	4.99984 7V	2.49992 4V	1.99993 9V	1111 1111 1111 1111	FFFF	0111 1111 1111 1111	7FFF
-Full Scale	-10V	-5V	3.33333 3V	0V	0V	0V	1000 0000 0000 0000	8000	0000 0000 0000 0000	0000

TABLE 16. LPT™ OPERATING CHARACTERISTICS

PARAMETER	SYMBOL	TYPICAL	UNIT
Supply Threshold	ITHR	75	ma
Protection Time	TPT	10	us
Supply Recovery Time	TSR	50	us
Functional Recovery Time	TFR	75	us
8-Bit Accuracy Recovery Time	T8R	80	us
Full Scale Recovery Time	TFAR	5	ms

FIGURE 1. CONVERSION TIMING



16-Bit Latchup Protected Analog to Digital Converter 7809ALP

FIGURE 2. SERIAL DATA TIMING USING INTERNAL CLOCK (\overline{CS} , $\overline{EXT/INT}$ AND TAG TIED LOW)

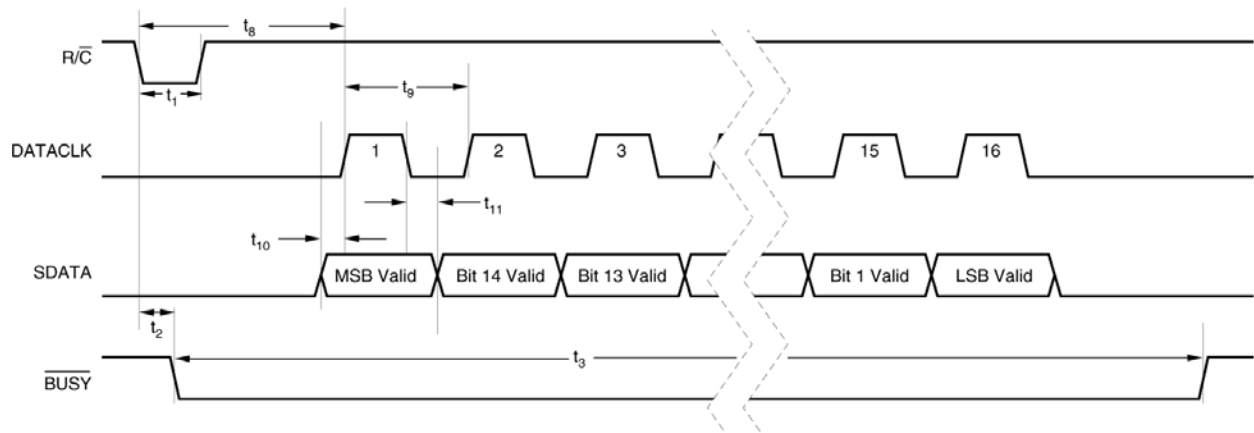
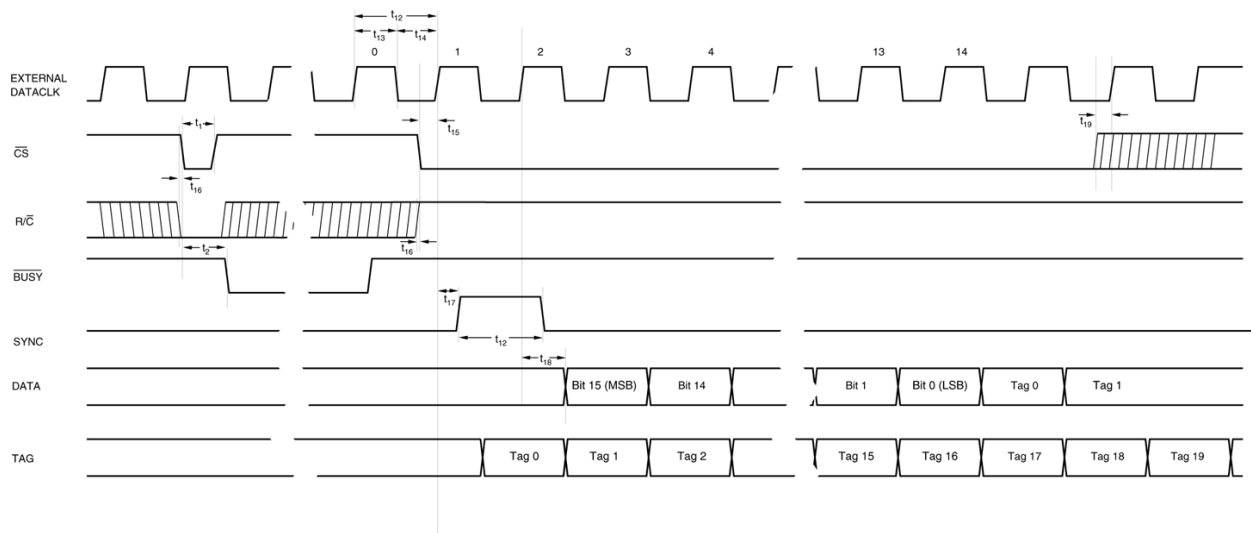
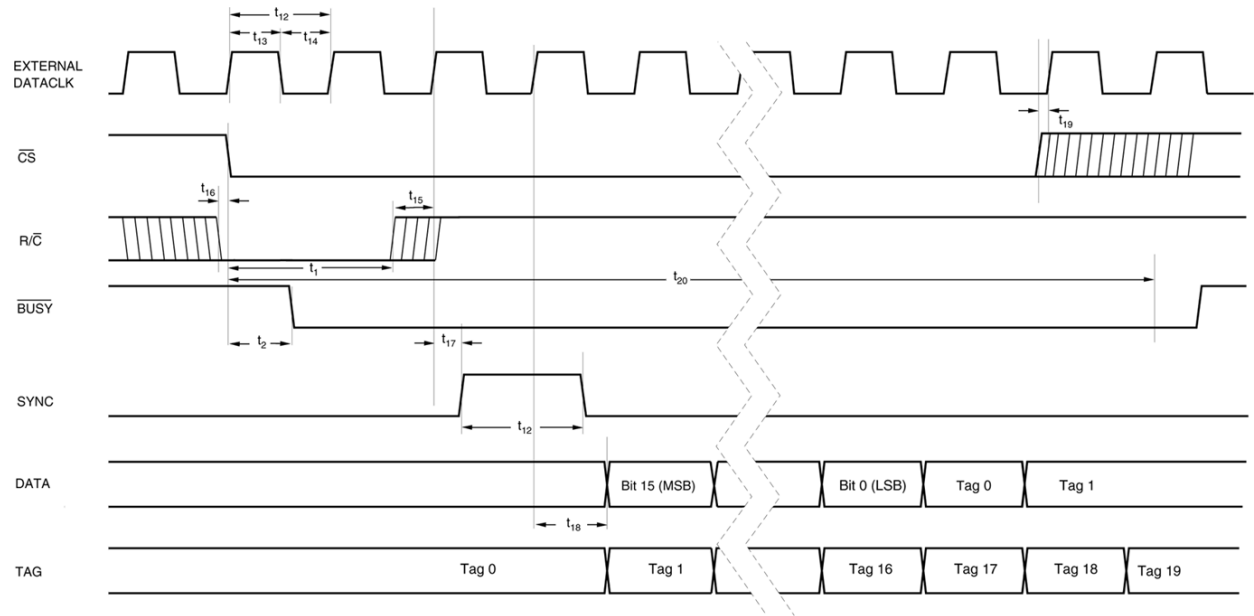


FIGURE 3. CONVERSION AND READ TIMING WITH EXTERNAL CLOCK ($\overline{EXT/INT}$ TIED HIGH). READ AFTER CONVERSION



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FIGURE 4. CONVERSION AND READ TIMING WITH EXTERNAL CLOCK (EXT/INT TIED HIGH). READ DURING CONVERSION



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FIGURE 5. OFFSET/GAIN CIRCUITS FOR UNIPOLAR INPUT RANGES

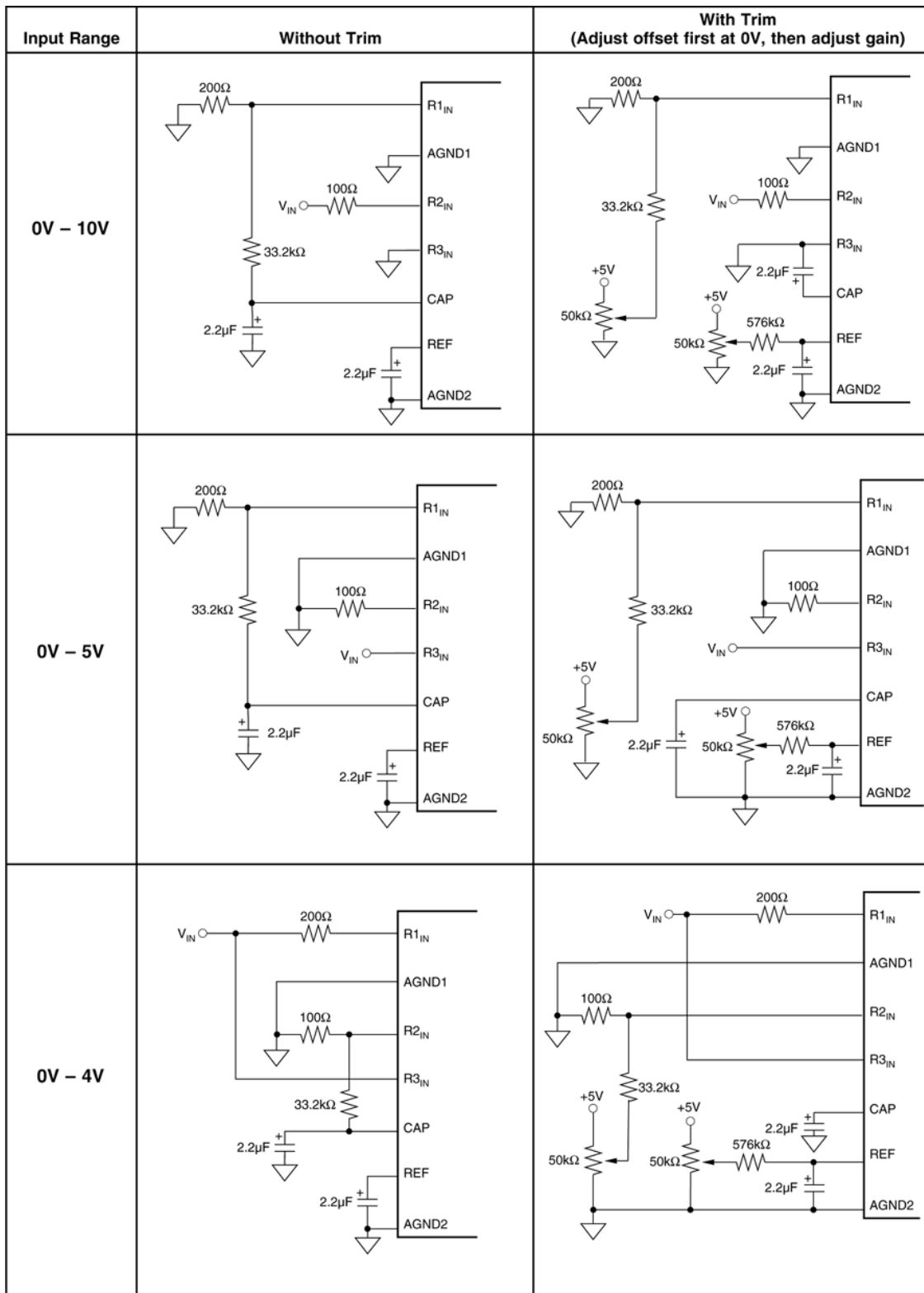
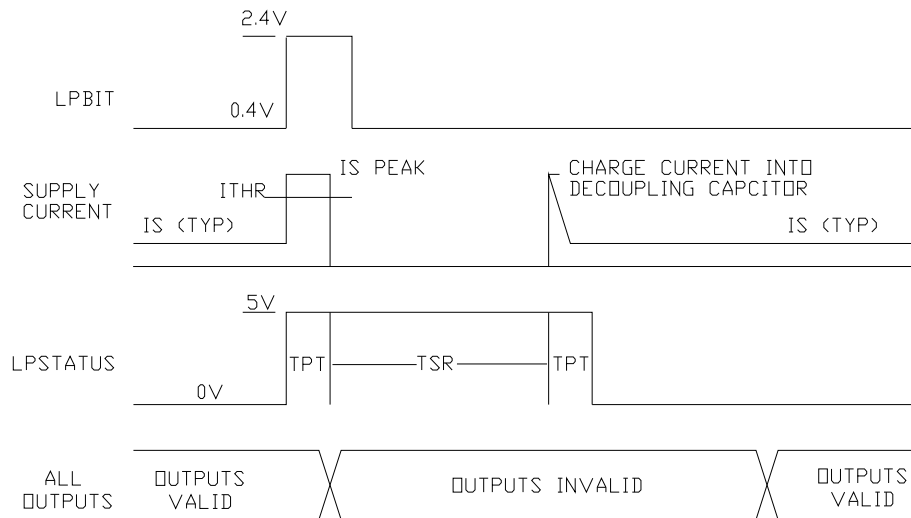


Figure 7. LPT™ Timing Diagram

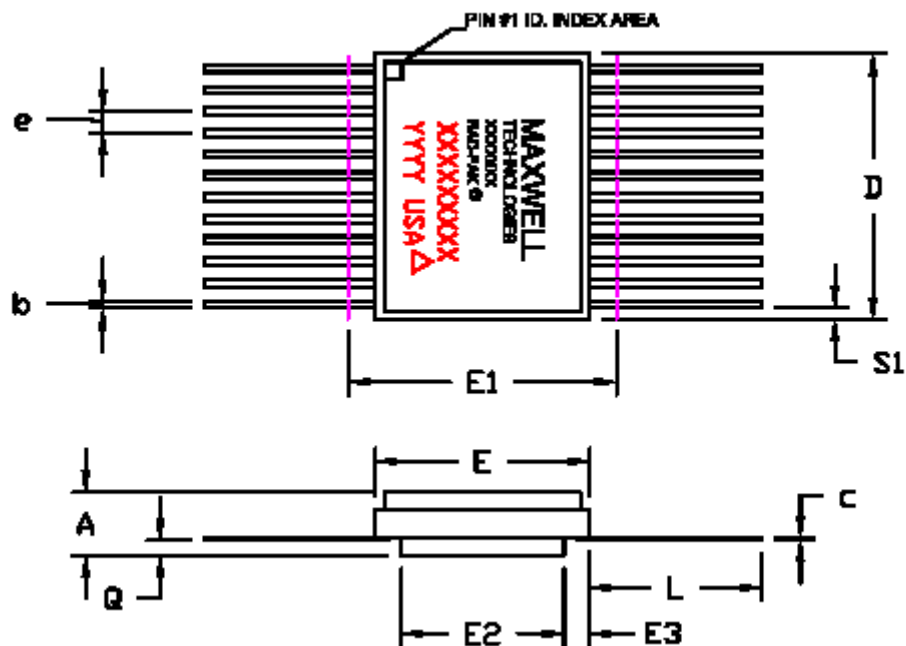


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FIGURE 6. OFFSET/GAIN CIRCUITS FOR BIPOLAR INPUT RANGES

Input Range	Without Trim	With Trim (Adjust offset first at 0V, then adjust gain)
±10V		
±5V		
±3.33V		

16-Bit Latchup Protected Analog to Digital Converter 7809ALP



24-PIN RAD-PAK[®] FLAT PACKAGE

SYMBOL	DIMENSION		
	MIN	NOM	MAX
A	0.255	0.278	0.302
b	0.015	0.017	0.022
c	0.006	0.008	0.010
D	--	0.596	0.606
E	0.390	0.400	0.410
E1	--	--	0.440
E2	0.268	0.270	0.272
E3	0.055	0.065	--
e	0.050 BSC		
L	0.420	0.430	0.450
Q	0.040	0.045	0.050
S1	0.006	0.014	--
N	24		

Note: All dimensions in inches
Top and Bottom of package internally connected to ground.

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Important Notice:

These data sheets are created using the chip manufacturers published specifications. Maxwell Technologies verifies functionality by testing key parameters either by 100% testing, sample testing or characterization.

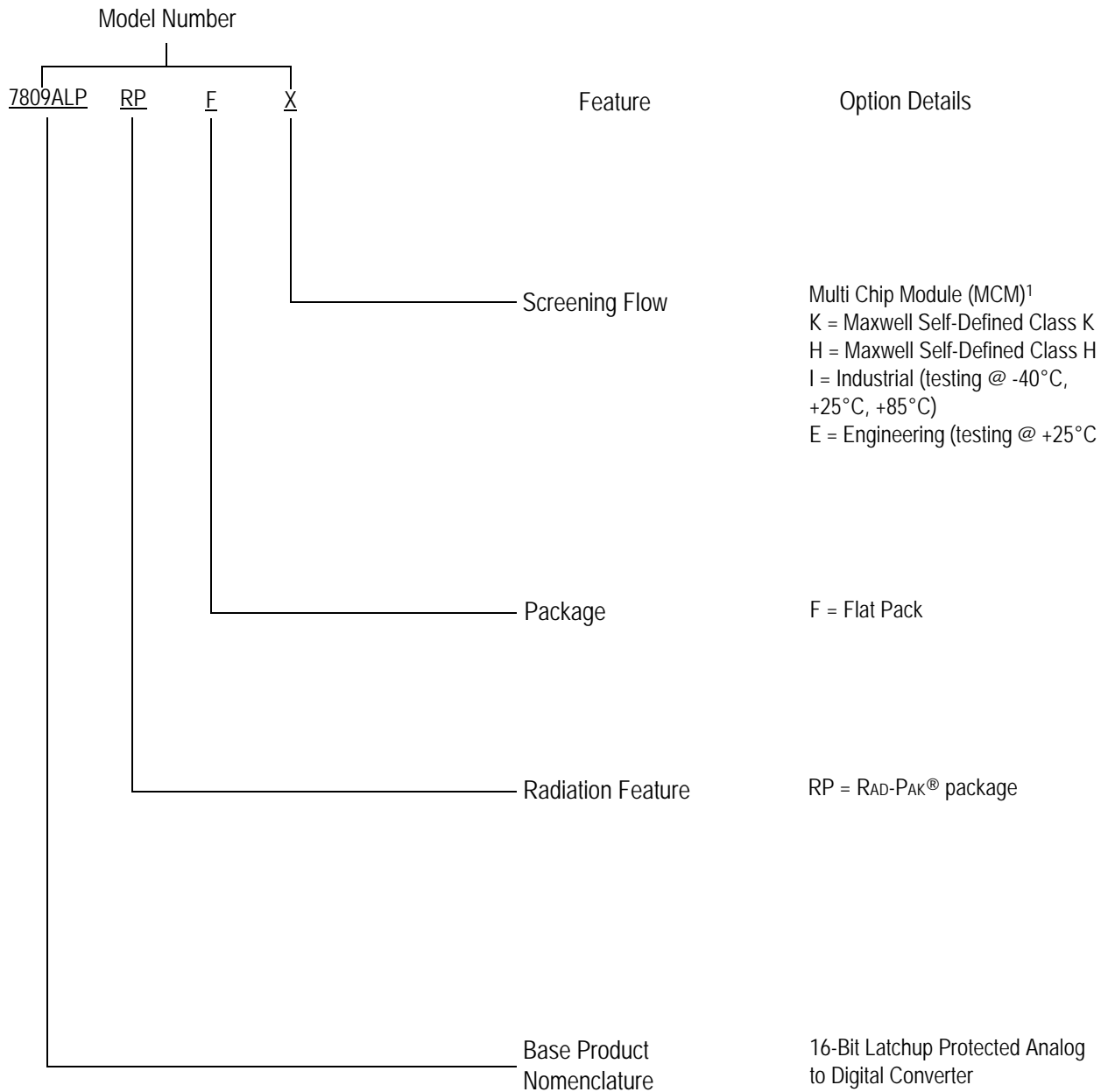
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Any claim against Maxwell Technologies must be made within 90 days from the date of shipment from Maxwell Technologies. Maxwell Technologies' liability shall be limited to replacement of defective parts.

16-Bit Latchup Protected Analog to Digital Converter 7809ALP

Product Ordering Options



1) Products are manufactured and screened to Maxwell Technologies self-defined Class H and Class K flows.