

**EVALUATION KIT MANUAL
FOLLOWS DATA SHEET**



Low-Cost, 2-Channel, ± 14 -Bit Serial ADCs

General Description

The MAX110/MAX111 analog-to-digital converters (ADCs) use an on-chip auto-calibration technique to achieve 15-bit resolution plus overrange, with no external components. Operating supply current is only 550 μ A, and reduces to 1 μ A in power-down mode, making these ADCs ideal for high-resolution battery-powered or remote sensing applications. A fast serial interface simplifies signal routing and opto-isolation, saves microcontroller pins, and offers compatibility with SPI™, QSPI™, and Microwire™. The MAX110 operates with ± 5 V supplies and converts single-ended or differential analog signals in the -2.5V to +2.5V range, while the MAX111 operates with a single +5V supply and converts differential signals in the ± 2 V range, or single-ended signals in the 0V to 2V range.

On-chip calibration allows for both offset and gain-error correction under microprocessor (μ P) control. Both devices are available in space-saving 16-pin DIP and SO packages, as well as an even smaller 20-pin SSOP package.

Applications

- Process Control
- Weigh Scales
- Panel Meters
- Data-Acquisition Systems
- Temperature Measurement

Features

- ◆ 14-Bit Resolution + Sign + Overrange
- ◆ 12-Bit Accuracy
- ◆ Low Power Consumption:
400 μ A Operating Current
1 μ A Shutdown Current
- ◆ High Input Impedance
- ◆ 50Hz/60Hz Rejection
- ◆ Calibration μ P Control
- ◆ No External Components Required
- ◆ 16-Pin DIP/SO, 20-Pin SSOP

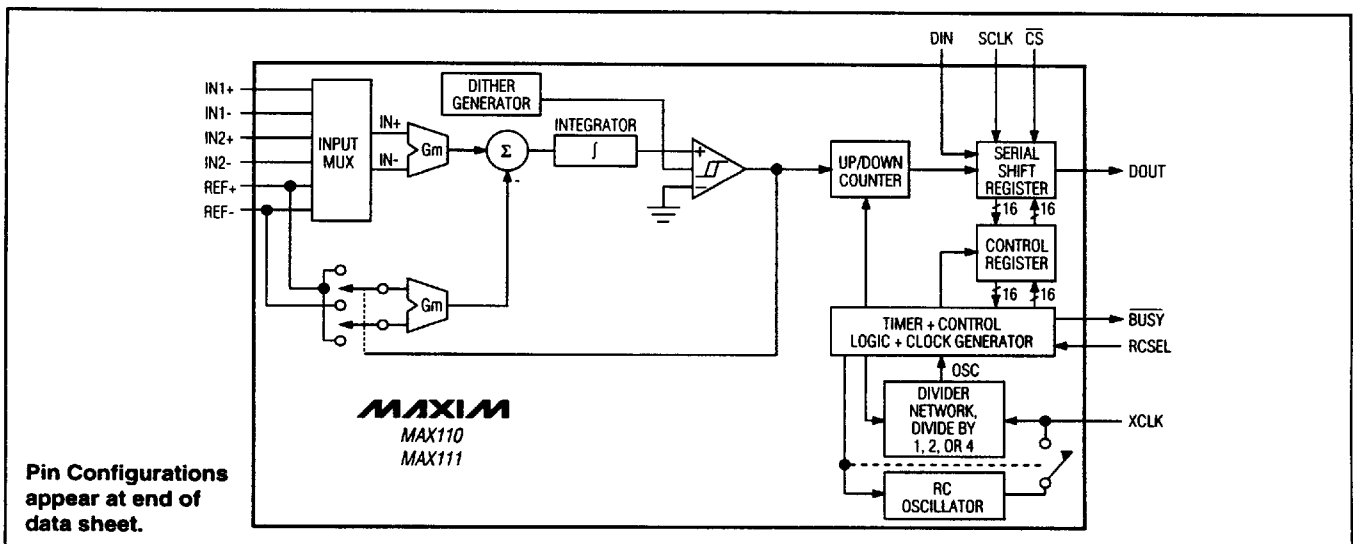
Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX110CPE	0°C to +70°C	16 Plastic DIP
MAX110CWE	0°C to +70°C	16 Wide SO
MAX110CAP	0°C to +70°C	20 SSOP
MAX110C/D	0°C to +70°C	Dice*
MAX110EPE	-40°C to +85°C	16 Plastic DIP
MAX110EWE	-40°C to +85°C	16 Wide SO
MAX110EAP	-40°C to +85°C	20 SSOP
MAX110MJE	-55°C to +125°C	16 CERDIP

Ordering Information continued at end of data sheet.

* Contact factory for dice specifications.

Functional Diagram



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MAX110/MAX111

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ABSOLUTE MAXIMUM RATINGS

V _{DD} to GND	+6V	20-Pin SSOP (derate 8.00mW/°C above +70°C)	640mW
V _{SS} to GND	+0.3V to -6V	16-Pin CERDIP (derate 10.00mW/°C above +70°C)	800mW
IN1+, IN1- to GND	(V _{DD} + 0.3V) to (V _{SS} - 0.3V)	Operating Temperature Ranges	
IN2+, IN2- to GND	(V _{DD} + 0.3V) to (V _{SS} - 0.3V)	MAX110C_/MAX111C_	0°C to +70°C
REF+, REF- to GND	(V _{DD} + 0.3V) to (V _{SS} - 0.3V)	MAX110E_/MAX111E_	-40°C to +85°C
Digital Inputs and Outputs to GND	-0.3V	MAX110MJE/MAX111MJE	-55°C to +125°C
Continuous Power Dissipation		Storage Temperature Range	-65°C to +160°C
16-Pin Plastic DIP (derate 10.53mW/°C above +70°C)	842mW	Lead Temperature (soldering, 10sec)	+300°C
16-Pin Wide SO (derate 9.52mW/°C above +70°C)	762mW		

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—MAX110

(V_{DD} = 5V \pm 5%, V_{SS} = -5V \pm 5%, f_{XCLK} = 500kHz, REF+ = 1.5V, REF- = -1.5V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
ACCURACY (Note 1)						
Resolution (Note 2)	RES	± 13 bits, no missing codes guaranteed	± 14			Bits
Relative Accuracy (Notes 3, 4)	INL	MAX110C	$-V_{REF} \leq V_{IN} \leq V_{REF}$		± 8	LSB
			$-0.8 \times V_{REF} \leq V_{IN} \leq 0.8 \times V_{REF}$		± 4	
		MAX110E/M	$-V_{REF} \leq V_{IN} \leq V_{REF}$		± 12	
			$-0.8 \times V_{REF} \leq V_{IN} \leq 0.8 \times V_{REF}$		± 8	
Offset Error		IN+ = IN- = 0V			± 12	LSB
Common-Mode Rejection Ratio	CMRR	$-2.5V \leq (IN+ = IN-) \leq 2.5V$		0.1		LSB/V
Full-Scale Error					± 0.1	%
Full-Scale Error Temperature Drift		(Note 5)			0.0008	%/°C
Power-Supply Rejection		V _{SS} = -5V, V _{DD} = 4.75V to 5.25V		0.25		LSB
		V _{DD} = 5V, V _{SS} = -4.75V to -5.25V		0.5		
ANALOG INPUTS						
Differential Input Voltage Range	V _{IN}	(Note 3)	-V _{REF}		+V _{REF}	V
Absolute Input Voltage Range	IN+		V _{SS} + 2.25		V _{DD} - 2.25	V
Input Bias Current	I _{IN+} , I _{IN-}				200	nA
Input Capacitance		(Note 5)			10	pF
REFERENCE INPUTS						
Differential-Reference Input Voltage Range	V _{REF}		0		3.0	V
Absolute-Reference Input Voltage Range	REF+, REF-		V _{SS} + 2.25		V _{DD} - 2.25	V
Reference Input Current	I _{REF+} , I _{REF-}	REF+ = 2.5V, REF- = 0V			200	nA
Reference Input Capacitance		(Note 5)			10	pF

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ELECTRICAL CHARACTERISTICS—MAX110 (continued)

($V_{DD} = 5V \pm 5\%$, $V_{SS} = -5V \pm 5\%$, $f_{XCLK} = 500kHz$, $REF+ = 1.5V$, $REF- = -1.5V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CONVERSION TIME						
Synchronous Conversion Time (Note 6)	t_{CONV}	10,240 clock-cycles/conversion	20.48		ms	
		102,400 clock-cycles/conversion	204.80			
Oversampling Clock Frequency	f_{XCLK}		0.25		1.25	MHz
DIGITAL INPUTS (\overline{CS} , $SCLK$, DIN , $XCLK$)						
Input High Voltage	V_{IH}		2.4			V
Input Low Voltage	V_{IL}			0.8		V
Input Capacitance		(Note 5)		10		pF
Input Leakage Current	I_{LKG}	Digital inputs at 0V or 5V		± 1		μA
DIGITAL OUTPUTS (DO_{OUT} , $BUSY$)						
Output Low Voltage	V_{OL}	$V_{DD} = 4.75V$, $I_{SINK} = 1.6mA$		0.4		V
Output High Voltage	V_{OH}	$V_{DD} = 4.75V$, $I_{SOURCE} = 1.0mA$	$V_{DD} - 0.5$			V
Leakage Current	I_{LKG}	$V_{OUT} = 5V$ or $0V$		± 10		μA
Output Capacitance		(Note 5)		10		pF
POWER REQUIREMENTS (all digital inputs at 0V or 5V)						
Positive Supply Voltage	V_{DD}	Performance guaranteed by supply rejection test	4.75		5.25	V
Negative Supply Voltage	V_{SS}	Performance guaranteed by supply rejection test	-4.75		-5.25	V
Positive Supply Current	I_{DD}	$V_{DD} = 5.25V$, $V_{SS} = -5.25V$	$V_{XCLK} = 0V$	325	650	μA
			$f_{XCLK} = 500kHz$, continuous-conversion mode	550		
			$XCLK$ unloaded, continuous-conversion mode, RC oscillator operational	780	1200	
Negative Supply Current	I_{SS}	$V_{DD} = 5.25V$, $V_{SS} = -5.25V$	$V_{XCLK} = 0V$	225	500	μA
			$f_{XCLK} = 500kHz$, continuous-conversion mode	320		
Power-Down Current	I_{DD}	$V_{DD} = 5.25V$, $V_{SS} = -5.25V$, $V_{XCLK} = 0V$, $PD = 1$		1	4	μA
	I_{SS}			0	2	

Note 1: These specifications apply after auto-null and gain calibration. Tests are performed at $V_{DD} = 5V$, $V_{SS} = -5V$ (MAX110) or $V_{SS} = 0V$ (MAX111), and performance at power-supply tolerance limits is guaranteed by power-supply rejection tests

Note 2: $1LSB = (REF+ - REF-)/16384$

Note 3: $V_{REF} = (REF+ - REF-)$, $V_{IN} = (IN1+ - IN1-)$ or $(IN2+ - IN2-)$

Note 4: Tested at $V_{REF} = 3V$ for MAX110, $V_{REF} = 2V$ for MAX111.

Note 5: Guaranteed by design. Not subject to production testing.

Note 6: Conversion time is set by control bits CONV1-CONV4.

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ELECTRICAL CHARACTERISTICS—MAX111

($V_{DD} = 5V \pm 5\%$, $V_{SS} = 0V$, $f_{CLK} = 500kHz$, $REF+ = 2V$, $REF- = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
ACCURACY (Note 1)						
Resolution (Note 2)	RES	± 13 bits, no missing codes guaranteed	± 14			Bits
Relative Accuracy, Differential Input (Notes 3, 4)	INL	MAX111C	$-V_{REF} \leq V_{IN} \leq V_{REF}$		± 8	LSB
			$-0.8 \times V_{REF} \leq V_{IN} \leq 0.8 \times V_{REF}$		± 4	
		MAX111E/M	$-V_{REF} \leq V_{IN} \leq V_{REF}$		± 12	
			$-0.8 \times V_{REF} \leq V_{IN} \leq 0.8 \times V_{REF}$		± 8	
Relative Accuracy Single-Ended Input ($IN- = GND$) (Notes 3, 4)	INL	MAX111C	$V_{IN} \leq V_{REF}$		± 8	LSB
			$V_{IN} \leq 0.8 \times V_{REF}$		± 4	
		MAX111E/M	$V_{IN} \leq V_{REF}$		± 16	
			$V_{IN} \leq 0.8 \times V_{REF}$		± 8	
Offset Error		$IN+ = IN- = 0V$			± 20	LSB
Common-Mode Rejection Ratio	CMRR	$10mV \leq (IN+ = IN-) \leq 2.0V$		0.25		LSB/V
Full-Scale Error					± 0.1	%
Full-Scale-Error Temperature Drift		(Note 5)			0.0008	%/ $^\circ C$
Power-Supply Rejection		$V_{SS} = 0V$, $V_{DD} = 4.75V$ to $5.25V$		0.5		LSB
ANALOG INPUTS						
Differential Input Voltage Range	V_{IN}	(Note 3)	$-V_{REF}$		$+V_{REF}$	V
Absolute Input Voltage Range	$IN+$, $IN-$		0		$V_{DD} - 3.0$	V
Input Bias Current	I_{IN+} , I_{IN-}				200	nA
Input Capacitance		(Note 5)			10	pF
REFERENCE INPUTS						
Differential-Reference Input Voltage Range	V_{REF}		0		2.0	V
Absolute-Reference Input Voltage Range	$REF+$, $REF-$		0		$V_{DD} - 3.0$	V
Reference Input Current	I_{REF+} , I_{REF-}	$REF+ = 2.5V$, $REF- = 0V$			200	nA
Reference Input Capacitance		(Note 5)			10	pF
CONVERSION TIME						
Synchronous Conversion Time (Note 6)	t_{CONV}	10,240 clock-cycles/conversion	20.48			ms
		102,400 clock-cycles/conversion	204.80			
Oversampling Clock Frequency	f_{CLK}		0.25		1.25	MHz

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ELECTRICAL CHARACTERISTICS—MAX111 (continued)

($V_{DD} = 5V \pm 5\%$, $V_{SS} = 0V$, $f_{XCLK} = 500kHz$, $REF+ = 2V$, $REF- = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DIGITAL INPUTS (\overline{CS} , SCLK, DIN, XCLK)						
Input High Voltage	V_{IH}		2.4			V
Input Low Voltage	V_{IL}				0.8	V
Input Capacitance		(Note 5)			10	pF
Input Leakage Current	I_{LKG}	Digital inputs at 0V or 5V			± 1	μA
DIGITAL OUTPUTS (DOUT, \overline{BUSY} , XCLK)						
Output Low Voltage	V_{OL}	DOUT, \overline{BUSY} , $I_{SINK} = 1.6mA$			0.4	V
		XCLK, RCSEL = 1, $I_{SINK} = 200\mu A$			0.4	
Output High Voltage	V_{OH}	DOUT, \overline{BUSY} , $V_{DD} = 4.75V$, $I_{SOURCE} = 1.0mA$	$V_{DD} - 0.5$			V
		XCLK, $V_{DD} = 4.75V$, $I_{SOURCE} = 200\mu A$	$V_{DD} - 0.5$			
Leakage Current	I_{LKG}	$V_{OUT} = 5V$ or $0V$			± 10	μA
Output Capacitance		(Note 5)			10	pF
POWER REQUIREMENTS (all digital inputs at 0V or 5V)						
Positive Supply Voltage	V_{DD}	Performance guaranteed by supply rejection test	4.75		5.25	V
Supply Current	I_{DD}	$V_{DD} = 5.25V$	$V_{XCLK} = 0V$	400	800	μA
			$f_{XCLK} = 500kHz$, continuous-conversion mode	640		
			XCLK unloaded, continuous-conversion mode, RC oscillator operational	960	1500	
Power-Down Current	I_{DD}	$V_{DD} = 5.25V$, $V_{XCLK} = 0V$, PD = 1		1	4	μA

Note 1: These specifications apply after auto-null and gain calibration. Tests are performed at $V_{DD} = 5V$, $V_{SS} = -5V$ (MAX110) or $V_{SS} = 0V$ (MAX111), and performance at power-supply tolerance limits is guaranteed by power-supply rejection tests.

Note 2: $1LSB = (REF+ - REF-)/16384$

Note 3: $V_{REF} = (REF+ - REF-)$, $V_{IN} = (IN1+ - IN1-)$ or $(IN2+ - IN2-)$

Note 4: Tested at $V_{REF} = 3V$ for MAX110, $V_{REF} = 2V$ for MAX111.

Note 5: Guaranteed by design. Not subject to production testing.

Note 6: Conversion time is set by control bits CONV1–CONV4.

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TIMING CHARACTERISTICS—MAX110/MAX111 (see Figure 5)

(V_{DD} = 5V, V_{SS} = -5V, guaranteed by design, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
\overline{CS} to SCLK Setup Time (Note 7)	t _{css}	T _A = +25°C		60			ns
		MAX11_C/E		80			
		MAX11_M		100			
\overline{CS} to SCLK Hold Time (Note 7)	t _{CSH}			0			ns
DIN to SCLK Setup Time (Note 7)	t _{DS}	T _A = +25°C		60			ns
		MAX11_C/E		80			
		MAX11_M		100			
DIN to SCLK Hold Time (Note 7)	t _{DH}			0			ns
SCLK, XCLK Pulse Width (Note 7)	t _{CK}	T _A = +25°C		100			ns
		MAX11_C/E		120			
		MAX11_M		160			
Data Access Time (Note 7)	t _{DA}	C _{LOAD} = 50pF	T _A = +25°C	0	35	80	ns
			MAX11_C/E	0		100	
			MAX11_M	0		120	
SCLK to DOUT Valid Delay (Note 7)	t _{DO}	C _{LOAD} = 50pF	T _A = +25°C	0	TBD	85	ns
			MAX11_C/E	0		TBD	
			MAX11_M	0		TBD	
Bus Relinquish Time (Note 7)	t _{DH}	T _A = +25°C			25	60	ns
		MAX11_C/E/M				80	
XCLK to \overline{BUSY} (Notes 7, 8)	t _{B1}	C _{LOAD} = 50pF	T _A = +25°C		45	100	ns
			MAX11_C/E			120	
			MAX11_M			160	
RC Oscillator Frequency		T _A = +25°C		1.6	2.0	2.5	MHz
		MAX11_C/E		1.45		2.75	
		MAX11_M		1.4		2.8	

Note 7: QA sample tested

Note 8: XCLK is asynchronous to SCLK and \overline{BUSY} may be delayed by one clock cycle.