XX-XXXX, Rev 0; 7/94

EVALUATION KIT MANUAL FOLLOWS DATA SHEET

MAXIM

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 550µA, and reduces to 1µA 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 ±5V 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 ±2V range, or single-ended signals in the 0V to 2V range.

On-chip calibration allows for both offset and gain-error correction under microprocessor (µP) 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:**
  400µA Operating Current
  1µA Shutdown Current
- ♦ **High Input Impedance**
- ♦ **50Hz/60Hz Rejection**
- ♦ **Calibration µP Control**
- ♦ **No External Components Required**
- ♦ **16-Pin DIP/SO, 20-Pin SSOP**

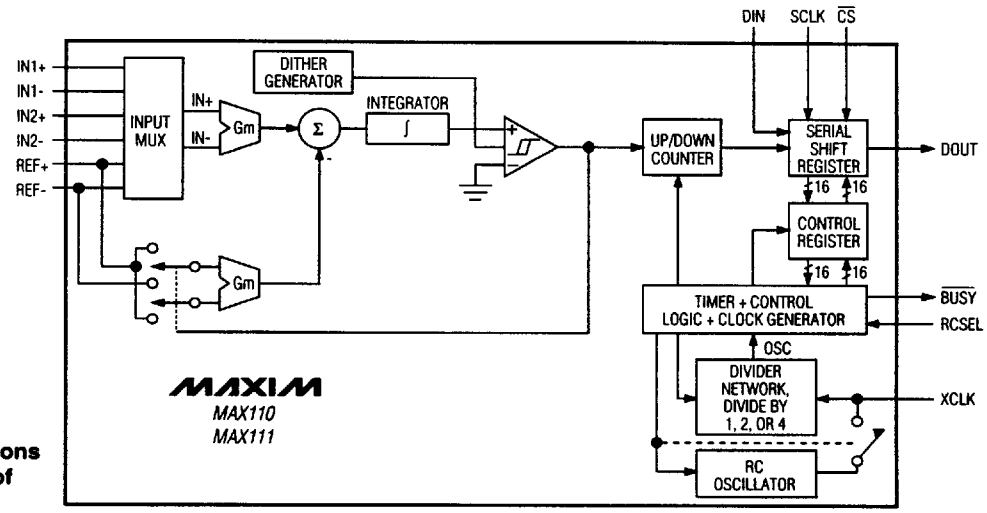
Ordering Information

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



Pin Configurations appear at end of data sheet.

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

ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND ..... +6V
V_{SS} to GND..... +0 3V to -6V
IN1+, IN1- to GND .....(V_{DD} + 0.3V) to (V_{SS} - 0.3V)
IN2+, IN2- to GND .....(V_{DD} + 0.3V) to (V_{SS} - 0.3V)
REF+, REF- to GND .....(V_{DD} + 0.3V) to (V_{SS} - 0.3V)
Digital Inputs and Outputs to GND .....-0.3V
Continuous Power Dissipation
16-Pin Plastic DIP (derate 10.53mW/°C above +70°C).... 842mW
16-Pin Wide SO (derate 9.52mW/°C above +70°C) 762mW
20-Pin SSOP (derate 8.00mW/°C above +70°C) 640mW
16-Pin CERDIP (derate 10.00mW/°C above +70°C).....800mW
Operating Temperature Ranges
MAX110C_ _/MAX111C_ _ .....0°C to +70°C
MAX110E_ _/MAX111E_ _.....-40°C to +85°C
MAX110MJE/MAX111MJE..... .....-55°C to +125°C
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—MAX110

(V_{DD} = 5V ±5%, V_{SS} = -5V ±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	$-V_{REF} \le V_{IN} \le V_{REF}$			±8	LSB
			$-0.8 \times V_{REF} \le V_{IN} \le 0.8 \times V_{REF}$			±4	
		MAX110E/M	$-V_{REF} \le V_{IN} \le V_{REF}$			±12	
			$-0.8 \times V_{REF} \le V_{IN} \le 0.8 \times V_{REF}$			±8	
Offset Error		IN+ = IN- = 0V				±12	LSB
Common-Mode Rejection Ratio	CMRR	-2.5V ≤ (IN+ = IN-) ≤ 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

ELECTRICAL CHARACTERISTICS—MAX110 (continued)

(V_{DD} = 5V ±5%, V_{SS} = -5V ±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
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 (DOUT, $\overline{BUSY}$)							
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 ±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°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	$-V_{REF} \le V_{IN} \le V_{REF}$			±8	LSB
			$-0.8 \times V_{REF} \le V_{IN} \le 0.8 \times V_{REF}$			±4	
		MAX111E/M	$-V_{REF} \le V_{IN} \le V_{REF}$			±12	
			$-0.8 \times V_{REF} \le V_{IN} \le 0.8 \times V_{REF}$			±8	
Relative Accuracy Single-Ended Input (IN- = GND) (Notes 3, 4)	INL	MAX111C	$V_{IN} \le V_{REF}$			±8	LSB
			$V_{IN} \le 0.8 \times V_{REF}$			±4	
		MAX111E/M	$V_{IN} \le V_{REF}$			±16	
			$V_{IN} \le 0.8 \times V_{REF}$			±8	
Offset Error		IN+ = IN- = 0V				±20	LSB
Common-Mode Rejection Ratio	CMRR	10mV ≤ (IN+ = IN-) ≤ 2.0V			0.25		LSB/V
Full-Scale Error						±0.1	%
Full-Scale-Error Temperature Drift		(Note 5)				0.0008	%/°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_{XCLK}			0.25		1.25	MHz

ELECTRICAL CHARACTERISTICS—MAX111 (continued)

(V_{DD} = 5V ±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°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} = 200µA				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} = 200µA		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.