



Single-Supply, Low-Power, Serial 8-Bit ADCs

MAX1106/MAX1107

General Description

The MAX1106/MAX1107 low-power, 8-bit, single-channel, analog-to-digital converters (ADCs) feature an internal track/hold (T/H), voltage reference, clock, and serial interface. The MAX1106 is specified from +2.7V to +3.6V and consumes only 96 μ A. The MAX1107 is specified from +4.5V to +5.5V and consumes only 107 μ A. The analog inputs are pin-configurable, allowing unipolar and single-ended or differential operation.

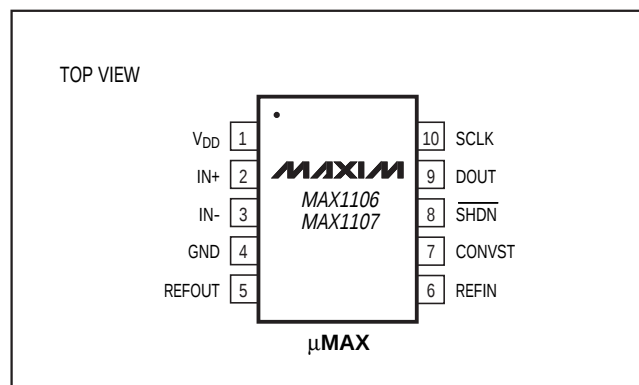
The full-scale analog input range is determined by the internal reference of +2.048V (MAX1106) or +4.096V (MAX1107), or by an externally applied reference ranging from 1V to V_{DD} . The MAX1106/MAX1107 also feature a pin-selectable power-down mode that reduces power consumption to 0.5 μ A when the device is not in use. The 3-wire serial interface directly connects to SPI™, QSPI™, and MICROWIRE™ devices without external logic. Conversions up to 25ksp/s are performed using the internal clock.

The MAX1106/MAX1107 are available in a 10-pin μ MAX package with a footprint that is just 20% of an 8-pin plastic DIP.

Applications

Portable Data Logging
Hand-Held Measurement Devices
Medical Instruments
System Diagnostics
Solar-Powered Remote Systems
4–20mA-Powered Remote Systems
Receive-Signal-Strength Indicators

Pin Configuration



SPI and QSPI are trademarks of Motorola, Inc.

MICROWIRE is a trademark of National Semiconductor Corp.

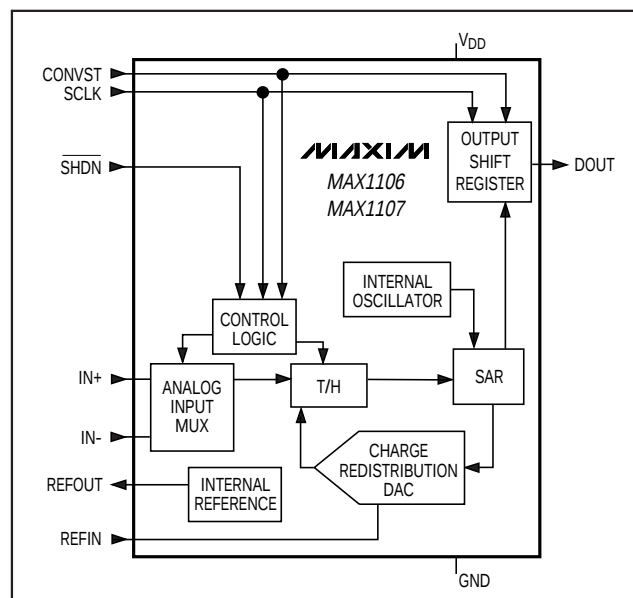
Features

- ♦ **Single Supply:** +2.7V to +3.6V (MAX1106)
+4.5V to +5.5V (MAX1107)
- ♦ **Low Power:** 96 μ A at +3V and 25ksp/s
0.5 μ A in Power-Down Mode
- ♦ **Pin-Programmable Configuration**
- ♦ **0 to V_{DD} Input Voltage Range**
- ♦ **Internal Track/Hold**
- ♦ **Internal Reference:** +2.048V (MAX1106)
+4.096V (MAX1107)
- ♦ **1V to V_{DD} Reference Input Range**
- ♦ **SPI/QSPI/MICROWIRE-Compatible Serial Interface**
- ♦ **Small 10-Pin μ MAX Package**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX1106CUB	0°C to +70°C	10 μ MAX
MAX1106EUB	-40°C to +85°C	10 μ MAX
MAX1107CUB	0°C to +70°C	10 μ MAX
MAX1107EUB	-40°C to +85°C	10 μ MAX

Functional Diagram



Maxim Integrated Products 1

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ABSOLUTE MAXIMUM RATINGS

V_{DD} to GND-0.3V to +6V
 IN+, IN-, REFIN, REFOUT,
 DOUT to GND.....-0.3V to (V_{DD} + 0.3V)
 SHDN, SCLK, CONVST to GND-0.3V to +6V
 Continuous Power Dissipation (T_A = +70°C)
 10-pin μ MAX (derate 5.6mW/°C above +70°C)444mW

Operating Temperature Ranges

MAX110_CUB0°C to +70°C
 MAX110_EUB-40°C to +85°C
 Storage Temperature Range-65°C to +150°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—MAX1106

(V_{DD} = +2.7V to +3.6V; IN- to GND; f_{SCLK} = 2MHz; 25ksps conversion rate; 1 μ F capacitor at REFOUT; external +2.048V reference at REFIN; 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
DC ACCURACY						
Resolution			8			Bits
Relative Accuracy (Note 1)	INL	V _{DD} = 2.7V to 3.6V	±0.15		±0.5	LSB
		V _{DD} = 5.5V (Note 2)	±0.2			
Differential Nonlinearity	DNL	No missing codes over temperature			±1	LSB
Offset Error		V _{DD} = 2.7V to 3.6V	±0.2		±1	LSB
		V _{DD} = 5.5V (Note 2)	±0.5			
Gain Error (Note 3)					±1	LSB
Gain Temperature Coefficient			±0.8			ppm/°C
Total Unadjusted Error	TUE	T _A = +25°C			±1	LSB
		T _A = T _{MIN} to T _{MAX}	±0.5			
DYNAMIC PERFORMANCE (10kHz sine-wave input, 2.048Vp-p, 25ksps conversion rate)						
Signal-to-Noise Plus Distortion	SINAD		49			dB
Total Harmonic Distortion (up to the 5th harmonic)	THD		-70			dB
Spurious-Free Dynamic Range	SFDR		68			dB
Small-Signal Bandwidth	BW-3dB	-3dB rolloff	1.5			MHz
Full-Power Bandwidth			0.8			MHz
ANALOG INPUTS						
Input Voltage Range (Note 4)	V _{IN_}	V _{IN+} to V _{IN-}	0		V _{REFIN}	V
Input Leakage Current		On/off-leakage current, V _{IN+} or V _{IN-} = 0 or V _{DD}	±0.01		±1	µA
Input Capacitance	C _{IN}		18			pF

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ELECTRICAL CHARACTERISTICS—MAX1106 (continued)

(V_{DD} = +2.7V to +3.6V; I_{IN-} to GND; f_{SCLK} = 2MHz; 25ksps conversion rate; 1 μ F capacitor at REFOUT; external +2.048V reference at REFIN; 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
TRACK/HOLD						
Conversion Time	t_{CONV}	Figure 7			35	μ s
Track/Hold Acquisition Time	t_{ACQ}		1			μ s
Aperture Delay				10		ns
Aperture Jitter				<50		ps
Internal Clock Frequency				400		kHz
External Clock Frequency Range		For data transfer only			2	MHz
INTERNAL REFERENCE						
Output Voltage	V_{REFOUT}		1.968	2.048	2.128	V
REF Short-Circuit Current	I_{REFSC}	(Note 5)		150		μ A
REF Tempco				± 50		ppm/°C
Load Regulation		0 to 0.5mA (Note 6)		4		mV
Capacitive Bypass at REFOUT			1			μ F
EXTERNAL REFERENCE						
Input Voltage Range	V_{REFIN}		1.0	$V_{DD} + 0.05$		V
Input Current		+2.048V at REFIN, full scale		1	20	μ A
POWER REQUIREMENTS						
Supply Voltage	V_{DD}		2.7	3	5.5	V
Supply Current (Notes 2, 7)	I_{DD}	$V_{DD} = 3.6V, C_L = 10pF$		96	250	μ A
		$V_{DD} = 5.5V, C_L = 10pF$		115		
		Power down, $V_{DD} = 3.6V$		0.5	2.5	
Power-Supply Rejection (Note 8)	PSR	Full-scale input, $V_{DD} = 2.7V$ to 3.6V		± 0.4	± 4	mV
DIGITAL INPUTS ($\overline{SHDN}$, SCLK, and CONVST)						
Threshold Voltage High	V_{IH}	$V_{DD} \leq 3.6V$			2	V
		$V_{DD} > 3.6V$			3	
Threshold Voltage Low	V_{IL}		0.8			V
Input Hysteresis	V_{HYST}			0.2		V
Input Current High	I_{IH}				± 1	μ A
Input Current Low	I_{IL}				± 1	μ A
Input Capacitance	C_{IN}			15		pF

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ELECTRICAL CHARACTERISTICS—MAX1106 (continued)

(V_{DD} = +2.7V to +3.6V; I_{N-} to GND; f_{SCLK} = 2MHz; 25ksps conversion rate; 1μF capacitor at REFOUT; external +2.048V reference at REFIN; 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 OUTPUT (DOUT)						
Output High Voltage	V _{OH}	I _{SOURCE} = 0.5mA	V _{DD} - 0.5			V
Output Low Voltage	V _{OL}	I _{SINK} = 5mA			0.4	V
		I _{SINK} = 16mA		0.8		
Three-State Leakage Current	I _L	Figure 6, DOUT High-Z		±0.01	±10	μA
Three-State Output Capacitance	C _{OUT}	Figure 6, DOUT High-Z		15		pF
TIMING CHARACTERISTICS (Figures 6 and 7)						
Acquisition Time	t _{ACQ}		1			μs
CONVST Pulse Width High	t _{CSPW}		1			μs
CONVST Fall to Output Data Valid	t _{CONV}				35	μs
CONVST Rise to Output Enable	t _{DV}	Figure 1, C _{LOAD} = 100pF			240	ns
SCLK Fall to Output Data Valid	t _{DO}	Figure 1, C _{LOAD} = 100pF	20		200	ns
SCLK Pulse Width High	t _{CH}		200			ns
SCLK Pulse Width Low	t _{CL}		200			ns
SCLK Low to Output Disable	t _{TR}	Figure 2, C _{LOAD} = 100pF			240	ns
SCLK Low to CONVST Rise	t _{SCC}		100			ns
SHDN Fall to Output Disable	t _{SHDN}	Figure 2, C _{LOAD} = 100pF			240	ns
Wake-Up Time	t _{WAKE}	External reference		20		μs
		Internal reference (Note 9)		12		ms

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ELECTRICAL CHARACTERISTICS—MAX1107

(V_{DD} = +4.5V to +5.5V; I_{IN-} = GND; f_{SCLK} = 2MHz; 25ksps conversion rate; 1 μ F capacitor at REFOUT; external +4.096V reference at REFIN; 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
DC ACCURACY						
Resolution			8			Bits
Relative Accuracy (Note 1)	INL		±0.15		±0.5	LSB
Differential Nonlinearity	DNL	No missing codes over temperature			±1	LSB
Offset Error			±0.2		±1	LSB
Gain Error (Note 3)					±1	LSB
Gain Temperature Coefficient			±0.8			ppm/°C
Total Unadjusted Error	TUE	T _A = +25°C			±1	LSB
		T _A = T _{MIN} to T _{MAX}	±0.5			
DYNAMIC PERFORMANCE (10kHz sine-wave input, 4.096Vp-p, 25ksps conversion rate)						
Signal-to-Noise Plus Distortion	SINAD		49			dB
Total Harmonic Distortion (up to the 5th harmonic)	THD		-70			dB
Spurious-Free Dynamic Range	SFDR		68			dB
Small-Signal Bandwidth	BW-3dB	-3dB rolloff	1.5			MHz
Full-Power Bandwidth			0.8			MHz
ANALOG INPUTS						
Input Voltage Range (Note 4)	V _{IN_}	V _{IN+} to V _{IN-}	0	V _{REFIN}		V
Input Leakage Current		On/off-leakage current, V _{IN+} or V _{IN-} = 0 or V _{DD}	±0.01		±1	µA
Input Capacitance	C _{IN}		18			pF
TRACK/HOLD						
Conversion Time	t _{CONV}	Figure 7	35			µs
Track/Hold Acquisition Time	t _{ACQ}		1			µs
Aperture Delay			10			ns
Aperture Jitter			<50			ps
Internal Clock Frequency			400			kHz
External Clock Frequency Range		For data transfer only	2			MHz
INTERNAL REFERENCE						
Output Voltage	V _{REFOUT}		3.936	4.096	4.256	V
REF Short-Circuit Current	I _{REFSC}		5			mA
REF Tempco			±50			ppm/°C
Load Regulation		0 to 0.5mA (Note 6)	4			mV
Capacitive Bypass at REFOUT			1			µF

Single-Supply, Low-Power, Serial 8-Bit ADCs

ELECTRICAL CHARACTERISTICS—MAX1107 (continued)

(V_{DD} = +4.5V to +5.5V; I_{IN-} = GND; f_{SCLK} = 2MHz; 25ksps conversion rate; 1 μ F capacitor at REFOUT; external +4.096V reference at REFIN; 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

Supply Voltage	V_{DD}		4.5	5	5.5	V
		V_{DD} = 5.5V, C_L = 10pF, full-scale input		115	250	
		Power down, V_{DD} = 4.5V to 5.5V				

Output Low Voltage	VOL	ISINK = 5mA	0.4		V
		ISINK = 16mA	0.8		
Three-State Leakage Current	IL	Figure 6, DOUT High-Z	±0.01	±10	μA
Three-State Output Capacitance	COUT	Figure 6, DOUT High-Z	15		pF
Acquisition Time	tACQ		1		μs
CONVST Pulse Width High	tCSPW		1		μs
CONVST Fall to Output Data Valid	tCONV		35		μs
CONVST Rise to Output Enable	tdv	Figure 1, CLOAD = 100pF	240		ns
SCLK Fall to Output Data Valid	tDO	Figure 1, CLOAD = 100pF	20	200	ns
SCLK Pulse Width High	tCH		200		ns

Single-Supply, Low-Power, Serial 8-Bit ADCs

MAX1106/MAX1107

ELECTRICAL CHARACTERISTICS—MAX1107 (continued)

($V_{DD} = +4.5V$ to $+5.5V$; $IN^- = GND$; $f_{SCLK} = 2MHz$; 25ksps conversion rate; $1\mu F$ capacitor at $REFOUT$; external $+4.096V$ reference at $REFIN$; $T_A = T_{MIN}$ to T_{MAX} ; unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SCLK Pulse Width Low	t_{CL}		200			ns
SCLK Low to Output Disable	t_{TR}	Figure 2, $C_{LOAD} = 100pF$			240	ns
SCLK Low to CONVST Rise	t_{SCC}		100			ns
$\overline{SHDN}$ Fall to Output Disable	t_{SHDN}	Figure 2, $C_{LOAD} = 100pF$			240	ns
Wake-Up Time	t_{WAKE}	External reference		20		μs
		Internal reference (Note 9)		12		ms

Note 1: Relative accuracy is the deviation of the analog value at any code from its theoretical value after the full-scale range has been calibrated.

Note 2: See *Typical Operating Characteristics*.

Note 3: $V_{REFOUT} = +2.048V$ (MAX1106), $V_{REFOUT} = +4.096V$ (MAX1107), offset nulled.

Note 4: Common-mode range (IN^+ , IN^-) GND to V_{DD} .

Note 5: $REFOUT$ supplies typically 2.5mA under normal operating conditions.

Note 6: External load should not change during the conversion for specified accuracy.

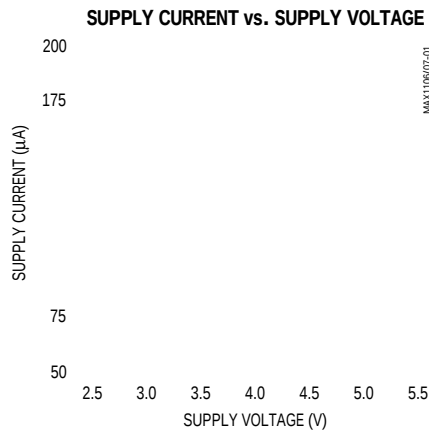
Note 7: Power consumption with CMOS levels.

Note 8: Measured as $|V_{FS}(2.7V) - V_{FS}(3.6V)|$ for MAX1106, and measured as $|V_{FS}(4.5V) - V_{FS}(5.5V)|$ for MAX1107.

Note 9: $1\mu F$ at $REFOUT$, internal reference settling to 0.5LSB.

Typical Operating Characteristics

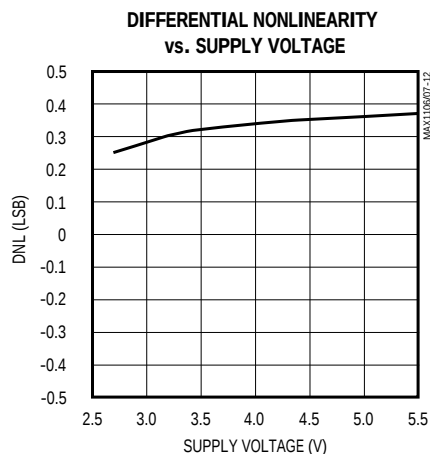
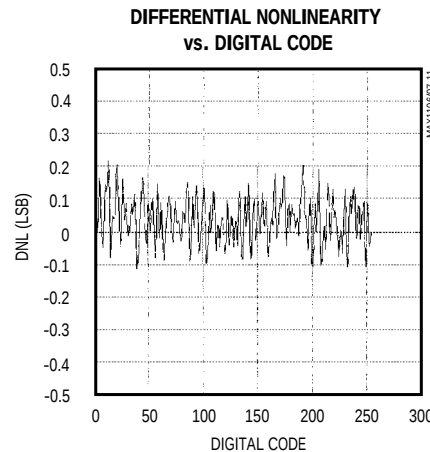
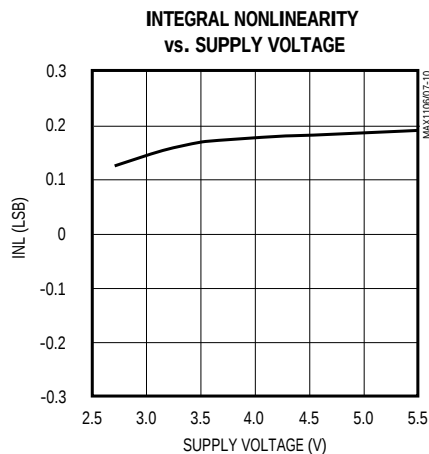
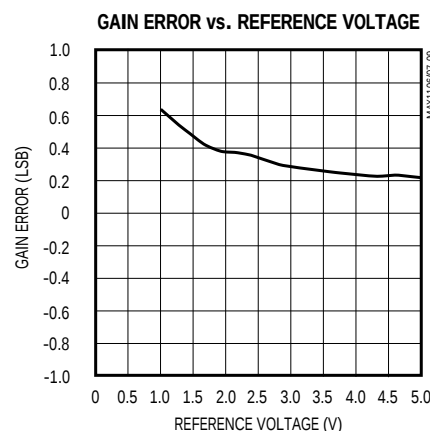
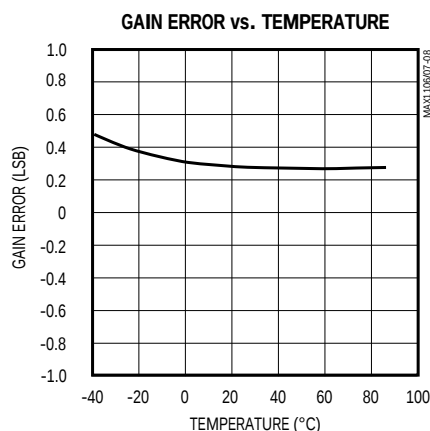
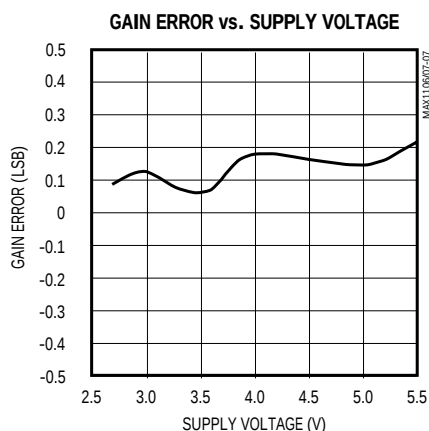
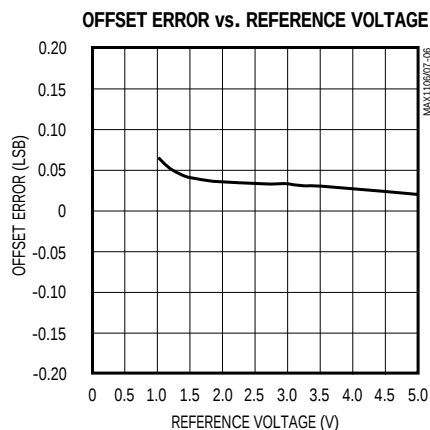
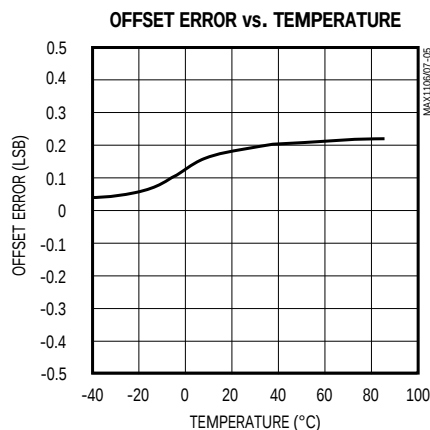
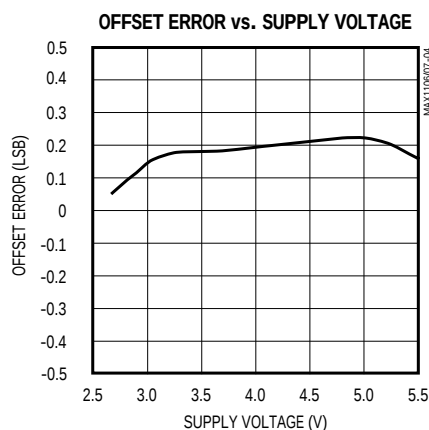
($V_{DD} = +3.0V$ (MAX1106), $V_{DD} = +5.0V$ (MAX1107); $f_{SCLK} = 2MHz$; 25ksps conversion rate; external reference; $1\mu F$ at $REFOUT$; $T_A = +25^\circ C$; unless otherwise noted.)



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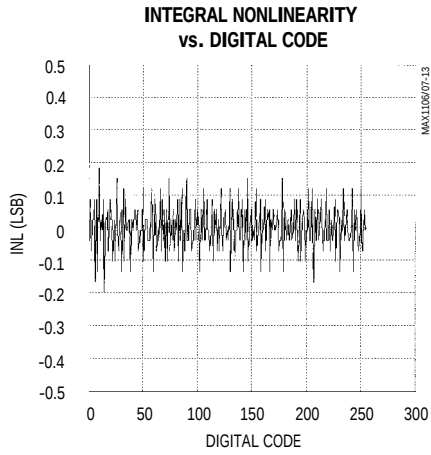
Typical Operating Characteristics (continued)

($V_{DD} = +3.0V$ (MAX1106), $V_{DD} = +5.0V$ (MAX1107); $f_{SCLK} = 2MHz$; 25kps conversion rate; external reference; $1\mu F$ at REFOUT; $T_A = +25^\circ C$; unless otherwise noted.)



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MAX1106/MAX1107



Single-Supply, Low-Power, Serial 8-Bit ADCs

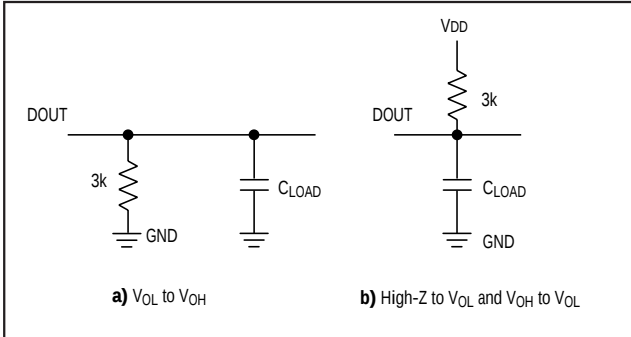


Figure 1. Load Circuits for Enable Time

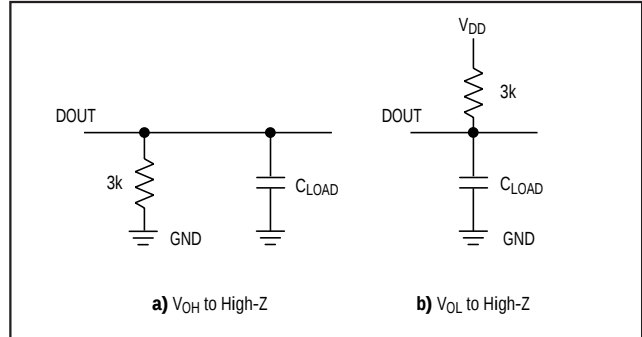


Figure 2. Load Circuits for Disable Time

Detailed Description

The MAX1106/MAX1107 analog-to-digital converters (ADCs) use a successive-approximation conversion technique and input track/hold (T/H) circuitry to convert an analog signal to an 8-bit digital output. A simple serial interface provides easy interface to microprocessors (μ Ps). No external hold capacitors are required. All of the MAX1106/MAX1107 operating modes are pin configurable: internal or external reference, single-ended or pseudo-differential unipolar conversion, and power down. Figure 3 shows the typical operating circuit.

Analog Inputs

Track/Hold

The input architecture of the ADCs is illustrated in Figure 4's equivalent-input circuit of and is composed of the T/H, the input multiplexer, the input comparator, the switched capacitor DAC, and the auto-zero rail.

The device is in acquisition mode most of the time. During the acquisition interval, the positive input (IN+) is tracked and is connected to the holding capacitor (CHOLD). The acquisition interval ends with the falling edge of CONVST. At this point the T/H switch opens and CHOLD is connected to the negative input (IN-), retaining charge on CHOLD as a sample of the signal at IN+. Once conversion is complete the T/H returns immediately to its tracking mode.

The time required for the T/H to acquire an input signal is a function of how quickly its input capacitance is charged. If the input signal's source impedance is high, the acquisition time lengthens, and more time must be allowed between conversions. The acquisition time, t_{ACQ} , is the minimum time needed for the signal to be acquired. It is calculated by:

$$t_{ACQ} = 6(R_S + R_{IN})18pF$$

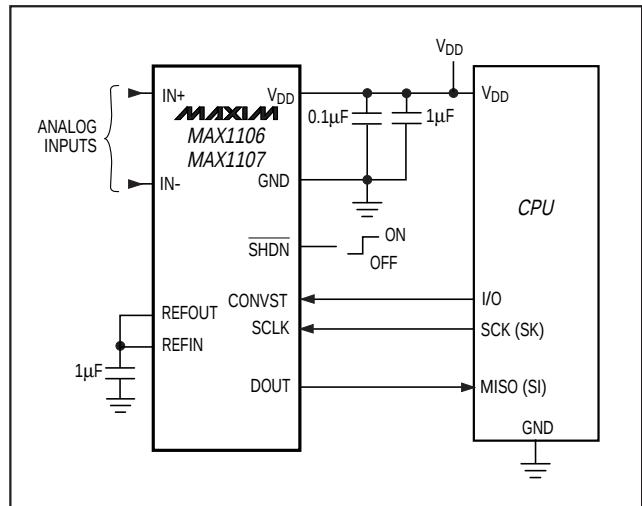


Figure 3. Typical Operating Circuit

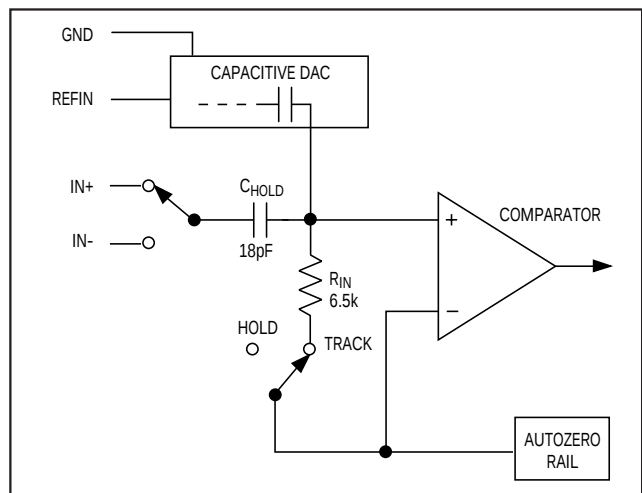


Figure 4. Equivalent Input Circuit

*Single-Supply, Low-Power,
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MAX1106/MAX1107

Single-Supply, Low-Power, Serial 8-Bit ADCs

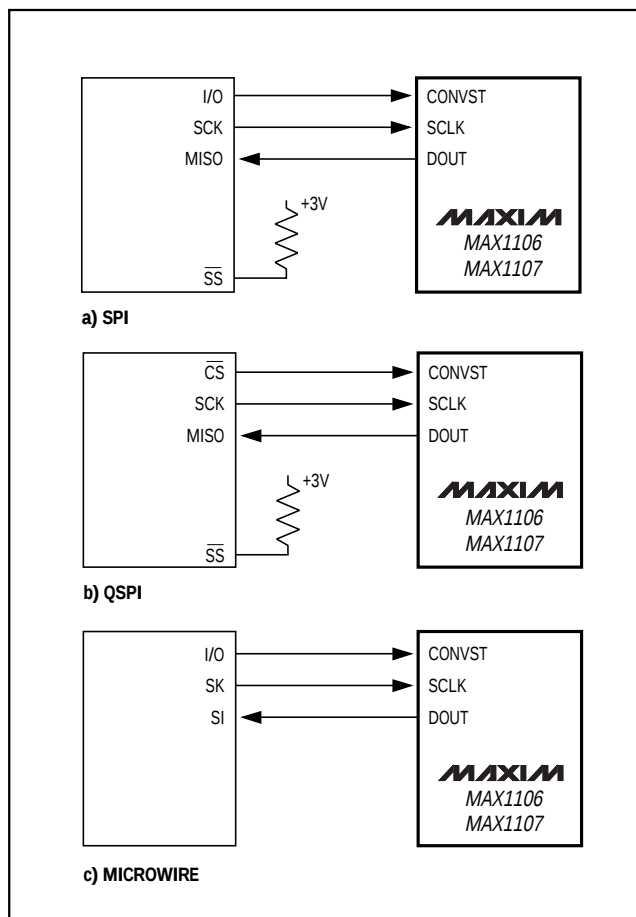


Figure 5. Common Serial-Interface Connections

Starting SCLK before conversion is complete corrupts the conversion in progress, and the data clocked out at DOUT does not represent the input signal. Bringing CONVST high at anytime during a conversion or while the data is clocked out will result in an incorrect conversion. A new conversion can be restarted only if all eight data bits of conversion have been clocked out. Toggle CONVST after all data is clocked out to restart a new conversion.

$\overline{\text{SHDN}}$ is used to place the MAX1106/MAX1107 in low-power mode (see *Power-Down* section). In this mode DOUT is high impedance and any conversion in progress is stopped immediately. If a conversion is stopped by $\overline{\text{SHDN}}$ going low, the device must be reset by waiting 35 μs and clearing the output register with eight SCLKs before the next conversion.

How to Perform a Conversion

The MAX1106/MAX1107 converts an input signal using the internal clock. This frees the μP from the burden of running the SAR conversion clock, and allows the conversion results to be read back at the μP 's convenience at any clock rate up to 2MHz.

Figures 6 and 7 show the serial interface timing characteristics. CONVST idles low. Toggle CONVST high for at least 1 μs to perform the autozero adjustment. After CONVST goes low, conversion starts immediately. Allow 35 μs for the internal conversion to complete and issue the MSB of the conversion at DOUT. CONVST needs to be held low once a conversion is started, while SCLK should remain low during conversion for best noise performance. An internal register stores data when the conversion is in progress. SCLK clocks the

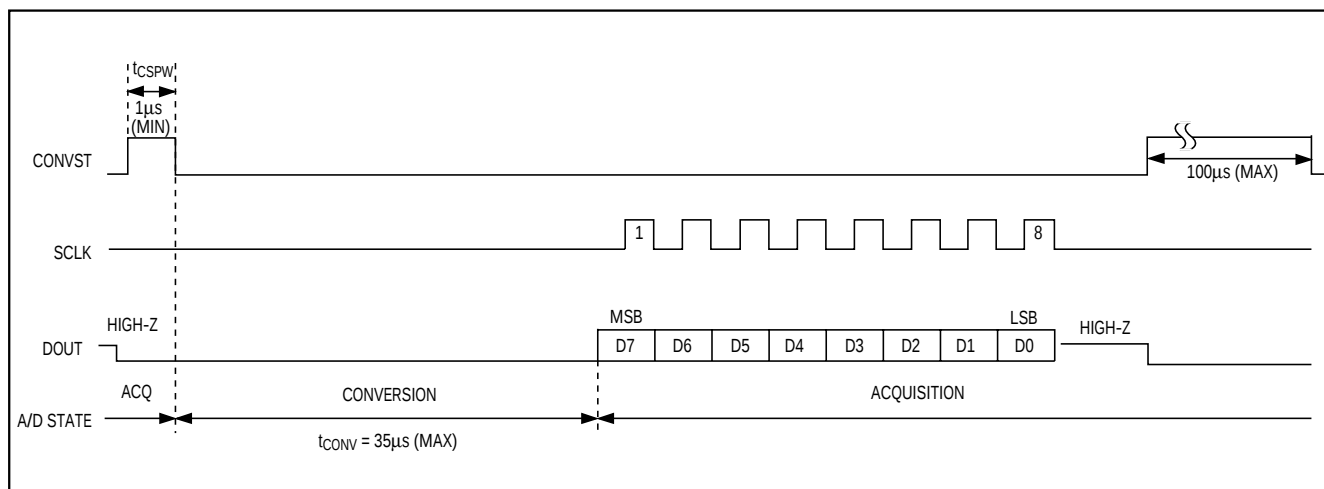


Figure 6. Conversion Timing Diagram

Single-Supply, Low-Power, Serial 8-Bit ADCs

MAX1106/MAX1107

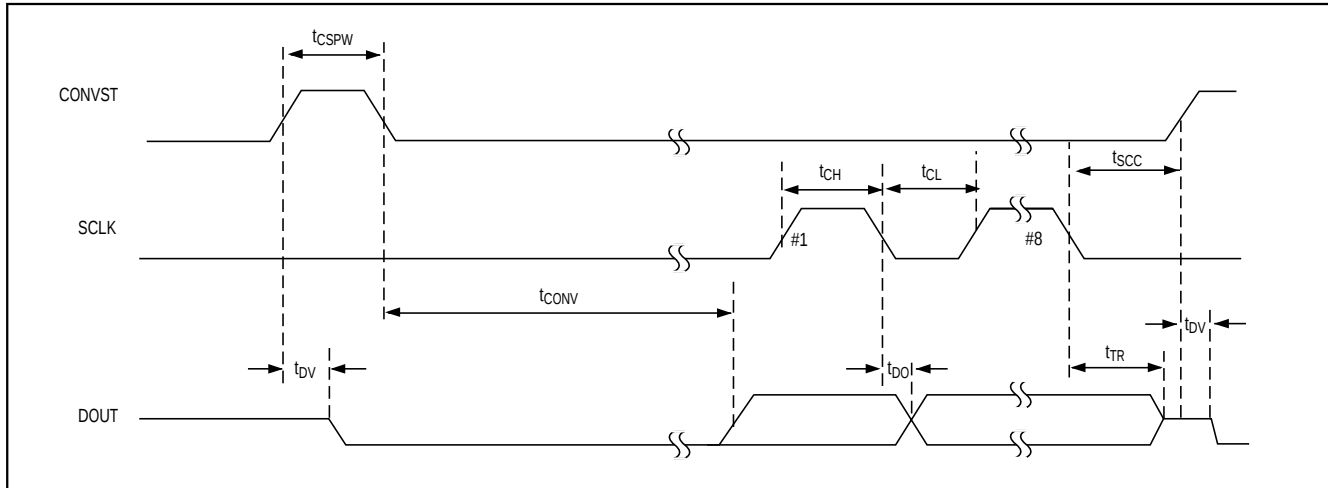


Figure 7. Detailed Serial Interface Timing

data out of this register at any time after the conversion is complete. After the eighth data-bit has clocked out, DOUT goes high impedance and remains so with additional SCLKs.

Normally leave CONVST low until a new conversion needs to be started. CONVST should be high for a maximum of 100 μ s to maintain the 8-bit accuracy of the Autozero Circuit.

The acquisition time, t_{ACQ} , starts immediately after the end of conversion and a new conversion can be started immediately after all data has been clocked out by toggling CONVST high. Figure 8 shows a timing diagram for a conversion at the data rate of 40ksps. Typically 20 μ s are necessary for the conversion to complete, 4 μ s for reading the eight bits of data with a serial clock of 2MHz, and 1 μ s to complete the zero rail adjustment and acquisition. The conversion time is guaranteed to be less than 35 μ s, therefore the data rate should be limited to 25ksps unless the conversion time for the specific condition is known. Conversion time can be determined by measuring the time between CONVST falling edge and DOUT rising edge with a full-scale input voltage.

Applications Information

Power-On Reset

When power is first applied with $\overline{SHDN}$ high or connected to V_{DD} , the MAX1106/MAX1107 is in track mode. Conversion can be started by toggling CONVST high to low as soon as the reference is settled when using the internal reference, or after 20 μ s when an external reference is used. Powering up the MAX1106/MAX1107 with

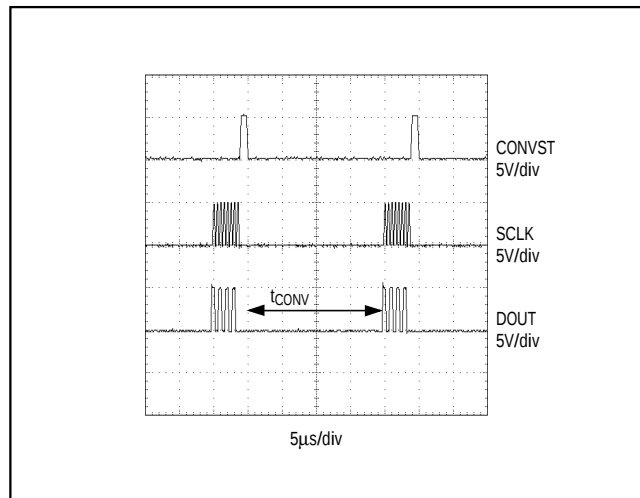


Figure 8. 40ksps Timing Diagram

CONVST low will not start a conversion. No conversions should be performed until the reference voltage (internal or external) has stabilized.

Shutdown Operation

Pulling $\overline{SHDN}$ low places the converter in low-current power-down mode. In this state the converter draws typically 0.5 μ A. In shutdown the analog biasing circuit and the internal bandgap reference are powered down, and DOUT goes high impedance.

The conversion stops coincidentally with $\overline{SHDN}$ going low. If shutdown occurs during a conversion, power up, wait 35 μ s, and clock SCLK eight times.

Single-Supply, Low-Power, Serial 8-Bit ADCs

When operating at speeds below the maximum sampling rate, the MAX1106/MAX1107's power-down mode

Single-Supply, Low-Power, Serial 8-Bit ADCs

Layout, Grounding, and Bypassing

For best performance, use printed circuit boards. Wire-wrap boards are not recommended. Board layout should ensure that digital and analog signal lines are separated from each other. Do not run analog and digital (especially clock) lines parallel to one another or run digital lines underneath the ADC package.

Figure 10 shows the recommended system-ground connections. A single-point analog ground (star-ground point) should be established at the A/D ground. Connect all analog grounds to the star ground. No digital-system ground should be connected to this point. The ground return to the power supply for the star ground should be low impedance and as short as possible for noise-free operation.

High-frequency noise in the V_{DD} power supply may affect the comparator in the ADC. Bypass the supply to the star ground with $0.1\mu\text{F}$ and $1\mu\text{F}$ capacitors close to the V_{DD} pin of the MAX1106/MAX1107. Minimize capacitor lead lengths for best supply-noise rejection. If the power supply is very noisy, a 10Ω resistor can be connected to form a lowpass filter.

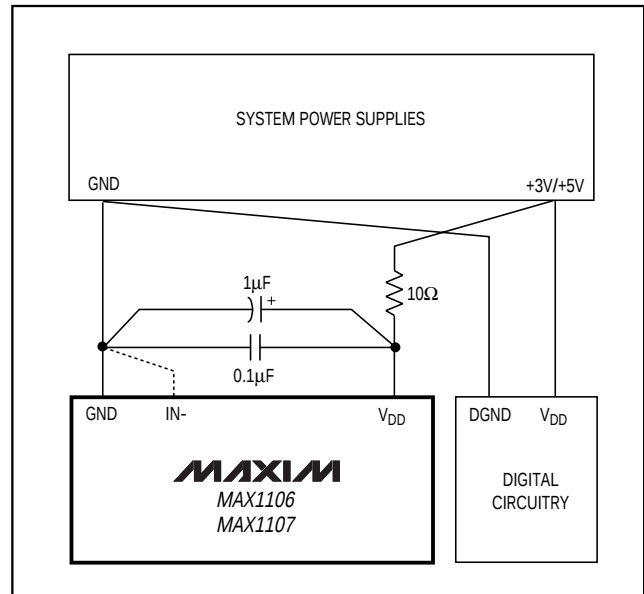


Figure 10. Power-Supply Connections

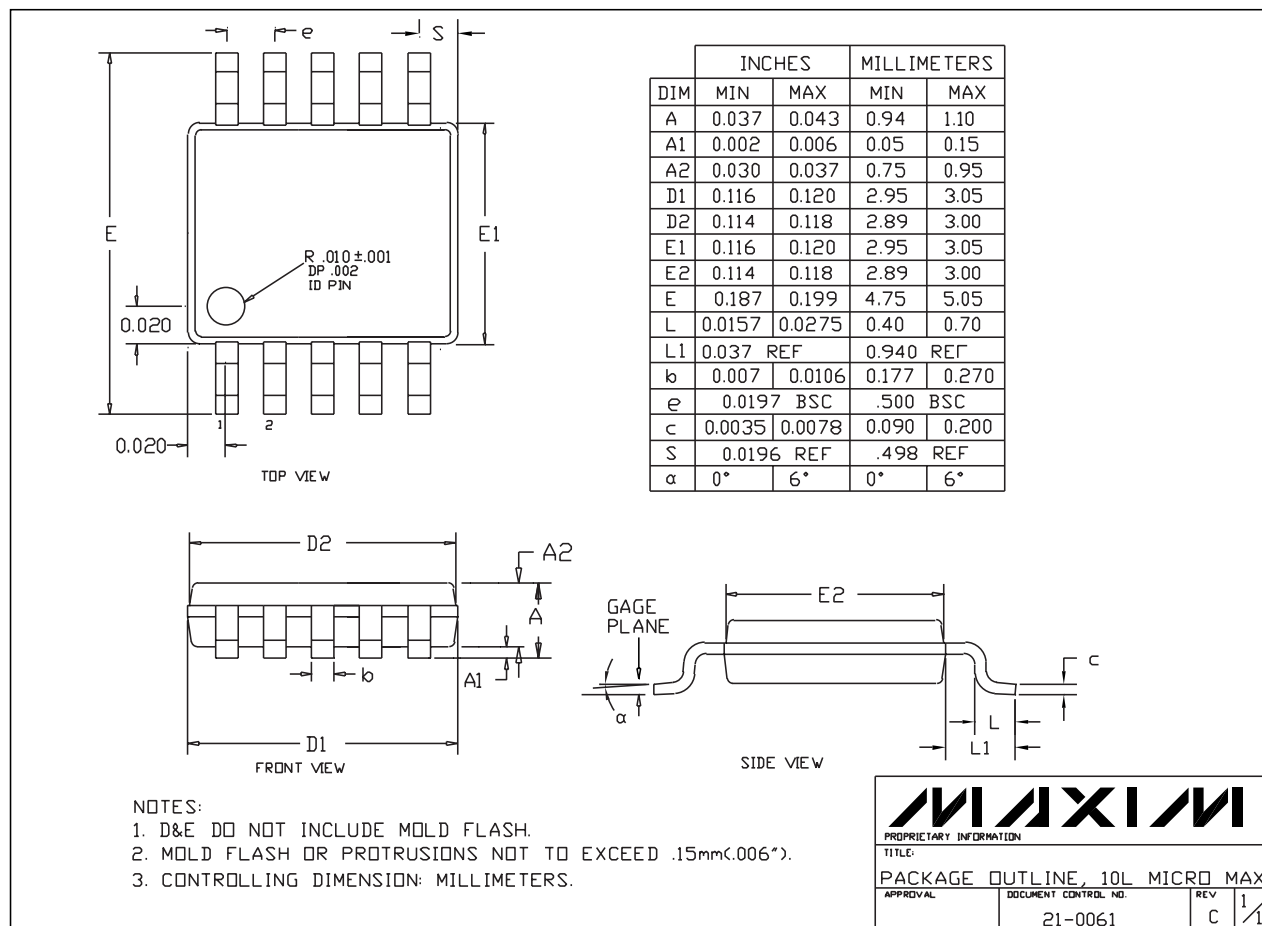
MAX1106/MAX1107

Chip Information

TRANSISTOR COUNT: 2373

Single-Supply, Low-Power, Serial 8-Bit ADCs

Package Information



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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