



# 6.5MSPS/5.5MSPS, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

## General Description

The MAX1336/MAX1337 2-channel, serial-output, 8-bit, analog-to-digital converters (ADCs) feature two true-differential analog inputs and offer outstanding noise immunity and dynamic performance. Both devices easily interface with SPI™/QSPI™/MICROWIRE™ and standard digital signal processors (DSPs).

The MAX1336 operates from a single supply of +4.75V to +5.25V with sampling rates up to 6.5MSPS. The MAX1337 operates from a single supply of +2.7V to +3.6V with sampling rates up to 5.5MSPS. These devices feature a partial power-down mode and a full power-down mode that reduce the supply current to 3.3mA and 0.2µA, respectively. Also featured is a separate power supply input (DVDD) that allows direct interfacing to +2.7V to +3.6V digital logic. The fast conversion speed, low power dissipation, excellent AC performance, and DC accuracy ( $\pm 0.1$  LSB INL) make the MAX1336/MAX1337 ideal for industrial process control, motor control, and base-station applications.

The MAX1336/MAX1337 are available in a space-saving (3mm x 3mm), 16-pin, TQFN package and operate over the extended (-40°C to +85°C) temperature range.

## Applications

- Data Acquisition
- Bill Validation
- Motor Control
- Base Stations
- High-Speed Modems
- Optical Sensors
- Industrial Process Control

## Features

- ◆ 6.5MSPS Sampling Rate (+5V, MAX1336)
- ◆ 5.5MSPS Sampling Rate (+3V, MAX1337)
- ◆ Separate Logic Supply: +2.7V to +3.6V
- ◆ Two True-Differential Analog Input Channels
- ◆ Bipolar/Unipolar Selection Input
- ◆ Only 40mW (typ) Power Consumption
- ◆ Only 2µA (max) Shutdown Current
- ◆ High-Speed, SPI-Compatible, 3-Wire Serial Interface
- ◆ 6.6MHz Full-Linear Bandwidth
- ◆ 49.5dB SINAD at 525kHz Input Frequency
- ◆ No Pipeline Delays
- ◆ Space-Saving (3mm x 3mm), 16-Pin, TQFN Package

## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	PKG CODE
MAX1336ETE**	-40°C to +85°C	16 TQFN-EP* (3mm x 3mm)	T1633F-3
MAX1337ETE	-40°C to +85°C	16 TQFN-EP* (3mm x 3mm)	T1633F-3

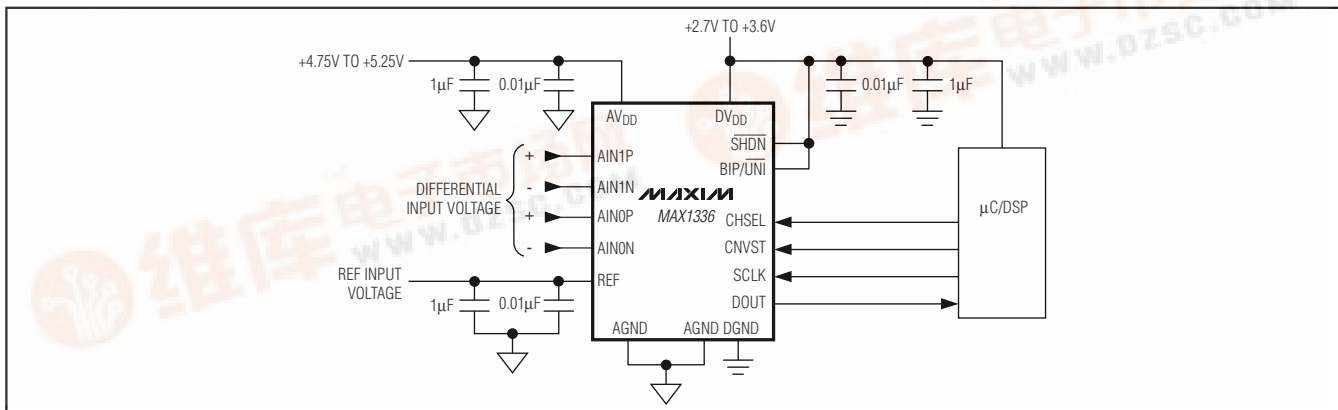
\*EP = Exposed paddle.

\*\*Future product—contact factory for availability.

Selector Guide appears at end of data sheet.

Pin Configuration appears at end of data sheet.

## Typical Operating Circuit



SPI/QSPI are trademarks of Motorola, Inc.

MICROWIRE is a trademark of National Semiconductor Corp.

MAXIM

Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at

1-800-368-4646

or visit Maxim's website at

www.maxim-ic.com

MAX1336/MAX1337



## 6.5Msps/5.5Msps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

### ABSOLUTE MAXIMUM RATINGS

AV <sub>DD</sub> to AGND (MAX1336)	-0.3V to +6V
AV <sub>DD</sub> to AGND (MAX1337)	-0.3V to +4V
DV <sub>DD</sub> to DGND	-0.3V to +4V
AGND to DGND	-0.3V to +0.3V
SCLK, CNVST, $\overline{\text{SHDN}}$ , CHSEL, BIP/UNI, DOUT to DGND	-0.3V to (DV <sub>DD</sub> + 0.3V)
AIN0P, AIN0N, AIN1P, AIN1N, REF to AGND	-0.3V to (AV <sub>DD</sub> + 0.3V)
Maximum Current into Any Pin	±50mA

Continuous Power Dissipation (T <sub>A</sub> = +70°C) 16-Pin TQFN (derate 17.5mW/°C above +70°C)	1398.6mW
Operating Temperature Range MAX133_ETE	-40°C to +85°C
Junction Temperature	+150°C
Storage Temperature Range	-60°C to +150°C
Lead Temperature (soldering, 10s)	+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 (MAX1336)

(AV<sub>DD</sub> = +4.75V to +5.25V, DV<sub>DD</sub> = +2.7V to +3.6V, f<sub>SCLK</sub> = 78MHz, V<sub>REF</sub> = 4.096V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>DC ACCURACY (Note 1) (BIP/UNI = DGND)</b>						
Resolution	N		8			Bits
Integral Nonlinearity	INL			±0.1	±1.0	LSB
Differential Nonlinearity	DNL			±0.1	±1.0	LSB
Offset Error				±0.2	±0.5	LSB
Gain Error				±0.9	±2.0	LSB
Offset-Error Temperature Coefficient				±1.1		ppm/°C
Gain-Error Temperature Coefficient				±5.2		ppm/°C
<b>DYNAMIC SPECIFICATIONS (A<sub>IN</sub> = -0.2dBFS, f<sub>IN</sub> = 525kHz, BIP/UNI = DV<sub>DD</sub>, unless otherwise noted) (Note 1)</b>						
Signal-to-Noise Ratio	SNR		48	49.5		dB
Signal-to-Noise Plus Distortion	SINAD		48	49.5		dB
Total Harmonic Distortion	THD			-72	-62	dBc
Spurious-Free Dynamic Range	SFDR		63	68		dBc
Channel-to-Channel Isolation				76		dB
Full-Linear Bandwidth		SINAD > 47dB		6.6		MHz
Full-Power Bandwidth				5.4		MHz
Small-Signal Bandwidth				5		MHz
<b>CONVERSION RATE</b>						
Minimum Conversion Time	t <sub>CONV</sub>	DV <sub>DD</sub> = 2.7V to 3.6V, Figure 5			115	ns
Maximum Throughput Rate		DV <sub>DD</sub> = 2.7V to 3.6V	6.5			Msps
Minimum Track-and-Hold Acquisition Time	t <sub>ACQ</sub>	Figure 5			32	ns

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MAX1336/MAX1337

## ELECTRICAL CHARACTERISTICS (MAX1336) (continued)

(AVDD = +4.75V to +5.25V, DVDD = +2.7V to +3.6V, fSCLK = 78MHz, VREF = 4.096V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Aperture Delay	tAD	Figure 21		< 10		ns
Aperture Jitter	tAJ	Figure 21		< 10		ps
<b>DIFFERENTIAL ANALOG INPUTS (AIN0P, AIN0N, AIN1P, AIN1N)</b>						
Differential Input Voltage Range (VAIN_P - VAIN_N)	VIN	BIP/UNI = DGND	0		VREF	V
		BIP/UNI = DVDD	-VREF / 2		+VREF / 2	
Absolute Input Voltage Range			AGND - 50mV		AVDD + 50mV	V
DC Leakage Current	ILKG				±10	µA
Input Capacitance	CIN			14		pF
<b>REFERENCE INPUT (REF)</b>						
REF Input Voltage Range	VREF		1.0		AVDD + 50mV	V
REF Input Capacitance	CREF			14		pF
REF DC Leakage Current	IREF				±10	µA
<b>DIGITAL INPUTS (SCLK, CNVST, SHDN, CHSEL, BIP/UNI)</b>						
Input Voltage Low	VIL				0.3 x DVDD	V
Input Voltage High	VIH		0.7 x DVDD			V
Input Hysteresis				100		mV
Input Leakage Current	ILKG			±0.2	±5	µA
Input Capacitance	CIN			15		pF
<b>DIGITAL OUTPUT (DOUT)</b>						
Output Voltage Low	VOL	ISINK = 5mA			0.4	V
Output Voltage High	VOH	ISOURCE = 1mA	DVDD - 0.5			V
Tri-State Leakage Current	ILKGT	Between conversions, CNVST = DVDD			±1	µA
Tri-State Output Capacitance	COUT	Between conversions, CNVST = DVDD		15		pF
<b>POWER REQUIREMENTS</b>						
Analog Supply Voltage	AVDD		4.75		5.25	V
Digital Supply Voltage	DVDD		2.7		3.6	V
Analog Supply Current	IAVDD	Normal mode; average unloaded current (fSAMPLE = 4.0MHz, fSCLK = 64MHz)		11	12	mA
		Partial power-down mode		3.3	4.0	
		Full power-down mode		0.1	2	µA

## 6.5MSPS/5.5MSPS, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

### ELECTRICAL CHARACTERISTICS (MAX1336) (continued)

(AVDD = +4.75V to +5.25V, DVDD = +2.7V to +3.6V, fSCLK = 78MHz, VREF = 4.096V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Digital Supply Current	IDVDD	Average unloaded current (fSAMPLE = 4.0MHz, fSCLK = 64MHz, zero-scale input)		5	8	mA
		Power-down (fSCLK = 64MHz)		18	45	μA
		Static or power-down; all digital inputs are connected to DVDD or DGND		0.2	2	
Power Supply Rejection	PSR	AVDD = 4.75V to 5.25V, full-scale input			±5	mV

### TIMING CHARACTERISTICS (MAX1336) (Figure 4)

(AVDD = +4.75V to +5.25V, DVDD = +2.7V to +3.6V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SCLK Clock Period	tCP		12.8			ns
SCLK Pulse Width	tSPW		6			ns
CNVST Rise to DOUT Disable	tCRDD		15			ns
CNVST Fall to DOUT Enable	tCFDE		15			ns
CHSEL to CNVST Fall Setup	tCHCF		32			ns
BIP/UN $\bar{I}$ to CNVST Fall Setup	tBUCF		32			ns
CNVST Fall to CHSEL Hold	tCFCH		0			ns
CNVST Fall to BIP/UN $\bar{I}$ Hold	tCFBU		0			ns
DOUT Remains Valid After SCLK	tDHOLD	CLOAD = 0pF (Note 2)	1	2		ns
SCLK Rise to DOUT Transition	tDOT				6	ns
CNVST to SCLK Rise	tSETUP		6			ns
SCLK Rise to CNVST	tHOLD		0			ns
CNVST Pulse Width	tCSW		6			ns
Minimum Recovery Time (Full Power-Down)	tFPD	From CNVST fall or $\overline{\text{SHDN}}$ rise			4	μs
Minimum Recovery Time (Partial Power-Down)	tPPD	From CNVST fall			500	ns

**Note 1:** Tested with AVDD = 4.75V and DVDD = +2.7V.

**Note 2:** Guaranteed by design, not production tested.

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MAX1336/MAX1337

## ELECTRICAL CHARACTERISTICS (MAX1337)

(AVDD = +2.7V to +3.6V, DVDD = +2.7V to +3.6V, fSCLK = 66MHz, VREF = 2.5V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>DC ACCURACY (Note 3) (BIP/UNI = DGND)</b>						
Resolution	N		8			Bits
Relative Accuracy	INL			±0.1	±1.0	LSB
Differential Nonlinearity	DNL			±0.1	±1.0	LSB
Offset Error				±0.2	±0.5	LSB
Gain Error				±0.9	±2.0	LSB
Offset-Error Temperature Coefficient				±1.1		ppm/°C
Gain-Error Temperature Coefficient				±5.2		ppm/°C
<b>DYNAMIC SPECIFICATIONS (AIN = -0.2dBFS, fIN = 525kHz, BIP/UNI = DVDD, unless otherwise noted) (Note 3)</b>						
Signal-to-Noise Ratio	SNR		48	49.5		dB
Signal-to-Noise Plus Distortion	SINAD		48	49.5		dB
Total Harmonic Distortion	THD			-72	-62	dBc
Spurious-Free Dynamic Range	SFDR		63	68		dBc
Channel-to-Channel Isolation				76		dB
Full-Linear Bandwidth		SINAD > 44dB		6.6		MHz
Full-Power Bandwidth				5.4		MHz
Small-Signal Bandwidth				5		MHz
<b>CONVERSION RATE</b>						
Minimum Conversion Time	tCONV	Figure 5			136	ns
Maximum Throughput Rate			5.5			Msps
Minimum Track-and-Hold Acquisition Time	tACQ	Figure 5			38	ns
Aperture Delay	tAD	Figure 21		< 10		ns
Aperture Jitter	tAJ	Figure 21		< 10		ps
<b>DIFFERENTIAL ANALOG INPUTS (AIN0P, AIN0N, AIN1P, AIN1N)</b>						
Differential Input Voltage Range (VAIN_P - VAIN_N)	VIN	BIP/UNI = DGND	0		VREF	V
		BIP/UNI = DVDD	-VREF / 2		+VREF / 2	
Absolute Input Voltage Range			AGND - 50mV		AVDD + 50mV	V
DC Leakage Current	ILKG				±1	µA

## 6.5Msps/5.5Msps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

### ELECTRICAL CHARACTERISTICS (MAX1337) (continued)

(AVDD = +2.7V to +3.6V, DVDD = +2.7V to +3.6V, fSCLK = 66MHz, VREF = 2.5V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Capacitance	CIN			14		pF
<b>REFERENCE INPUT (REF)</b>						
REF Input Voltage	VREF		1.0		AVDD + 50mV	V
REF Input Capacitance	CREF			14		pF
REF DC Leakage Current	IREF				±10	µA
<b>DIGITAL INPUTS (SCLK, CNVST, SHDN, CHSEL, BIP/UNI)</b>						
Input-Voltage Low	VIL				0.3 x DVDD	V
Input-Voltage High	VIH		0.7 x DVDD			V
Input Hysteresis				100		mV
Input Leakage Current	IILKG			±0.2	±5	µA
Input Capacitance	CIN			15		pF
<b>DIGITAL OUTPUT (DOUT)</b>						
Output-Voltage Low	VOL	ISINK = 5mA			0.4	V
Output-Voltage High	VOH	ISOURCE = 1mA	DVDD - 0.5			V
Tri-State Leakage Current	ILKGT	Between conversions, CNVST = DVDD			±1	µA
Tri-State Output Capacitance	COUT	Between conversions, CNVST = DVDD		15		pF
<b>POWER REQUIREMENTS</b>						
Analog Supply Voltage	AVDD		2.7		3.6	V
Digital Supply Voltage	DVDD		2.7		AVDD	V
Analog Supply Current	IAVDD	Normal mode; average unloaded current (fSAMPLE = 5.5MHz, fSCLK = 66MHz)		9.7	12	mA
		Partial power-down mode		3.3	4	
		Full power-down mode		0.1	2	µA
Digital Supply Current	IDVDD	Average unloaded current (fSAMPLE = 5.5MHz, fSCLK = 66MHz, zero-scale input)		5	8.0	mA
		Power-down (fSCLK = 66MHz)		18	45	
		Static or power-down; all digital inputs are connected to DVDD or DGND		0.2	2	µA
Positive Supply Rejection	PSR	AVDD = 2.7V to 3.6V, full-scale input			±8	mV

# 6.5MSPS/5.5MSPS, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

MAX1336/MAX1337

## TIMING CHARACTERISTICS (MAX1337) (Figure 4)

(AVDD = +2.7V to +3.6V, DVDD = +2.7V to +3.6V, TA = TMIN to TMAX, unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SCLK Clock Period	tCP		15.1			ns
SCLK Pulse Width	tCPW		6			ns
CNVST Rise to DOUT Disable	tCRDD		15			ns
CNVST Fall to DOUT Enable	tCFDE		15			ns
CHSEL to CNVST Fall Setup	tCHCF		36			ns
BIP/ $\overline{\text{UNI}}$ to CNVST Fall Setup	tBU CF		36			ns
CNVST Fall to CHSEL Hold	tCFCH		0			ns
CNVST Fall to BIP/ $\overline{\text{UNI}}$ Hold	tCFBU		0			ns
DOUT Remains Valid After SCLK	tDHOLD	CLOAD = 0pF (Note 4)	1	2		ns
SCLK Rise to DOUT Transition	tDOT	CLOAD = 30pF			6	ns
CNVST to SCLK Rise	tSETUP		6			ns
SCLK Rise to CNVST	tHOLD		0			ns
CNVST Pulse Width	tCSW		6			ns
Minimum Recovery Time (Full Power-Down)	tFPD	From CNVST fall or $\overline{\text{SHDN}}$ rise			4	$\mu\text{s}$
Minimum Recovery Time (Partial Power-Down)	tPPD	From CNVST fall			500	ns

**Note 3:** Tested with AVDD = DVDD = +2.7V.

**Note 4:** Guaranteed by design, not production tested.

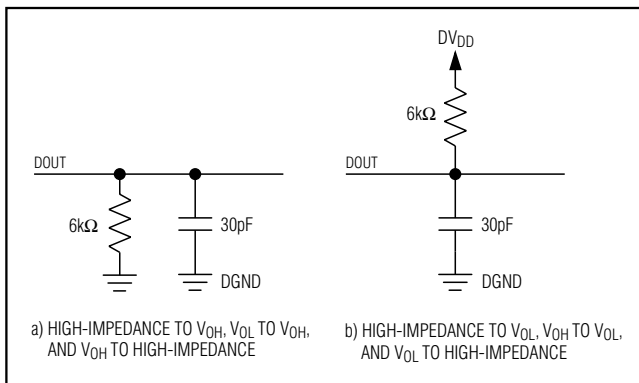


Figure 1. Load Circuits for Enable/Disable Times

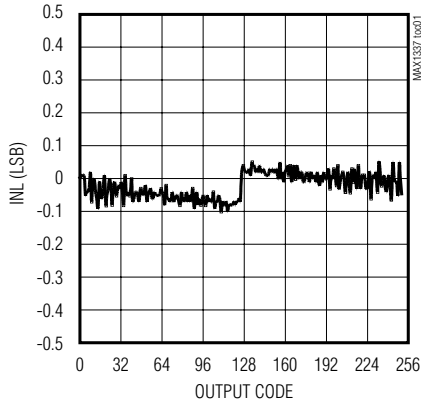
# 6.5Mps/5.5Mps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

## Typical Operating Characteristics

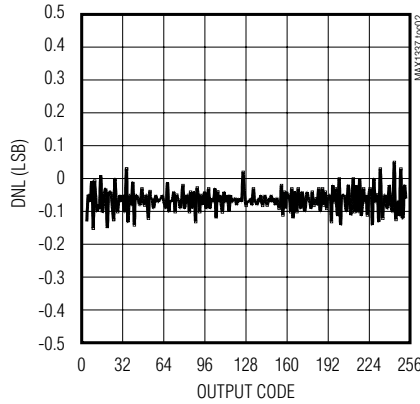
(AVDD = +5V, DVDD = +3V, VREF = 4.096V, fSCLK = 66MHz. TA = +25°C unless otherwise noted.)

### MAX1337

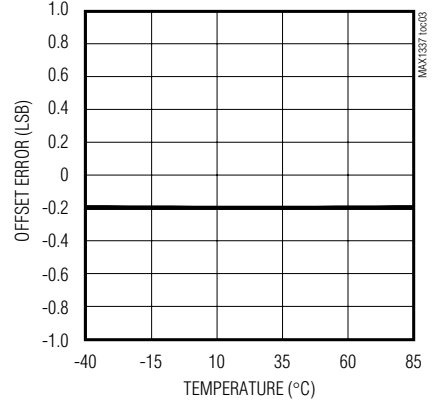
**INTEGRAL NONLINEARITY vs. OUTPUT CODE**



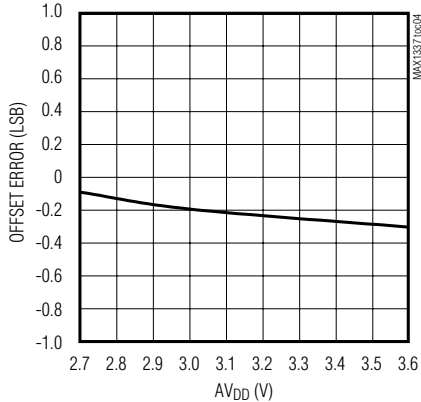
**DIFFERENTIAL NONLINEARITY vs. OUTPUT CODE**



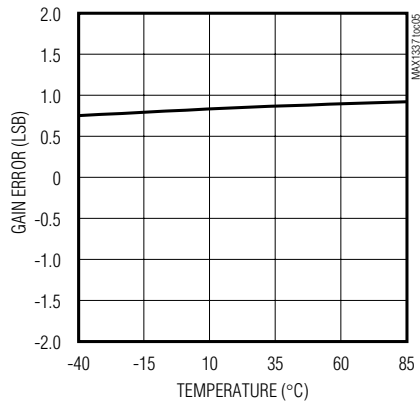
**OFFSET ERROR vs. TEMPERATURE**



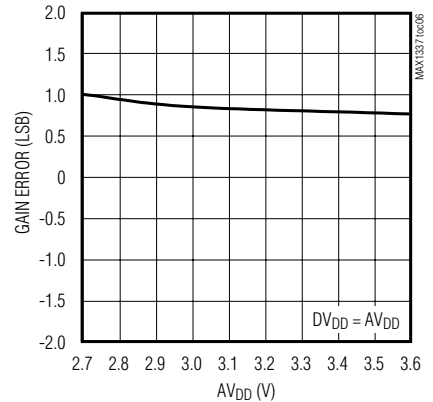
**OFFSET ERROR vs. AVDD**



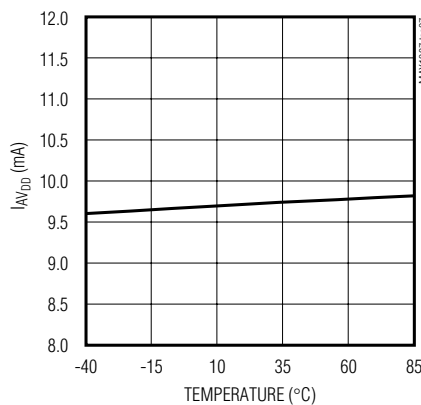
**GAIN ERROR vs. TEMPERATURE**



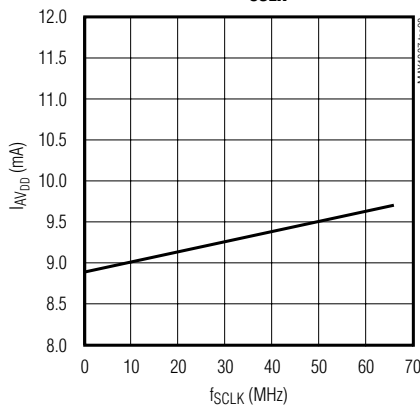
**GAIN ERROR vs. AVDD**



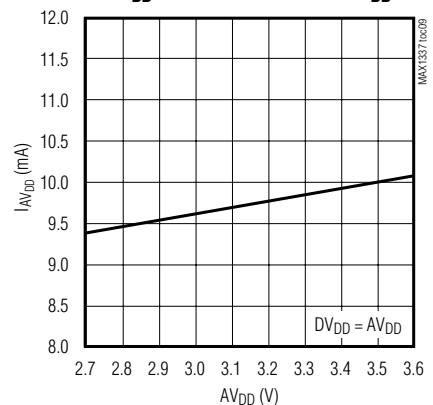
**AVDD SUPPLY CURRENT vs. TEMPERATURE**



**AVDD SUPPLY CURRENT vs. fSCLK**



**AVDD SUPPLY CURRENT vs. AVDD**





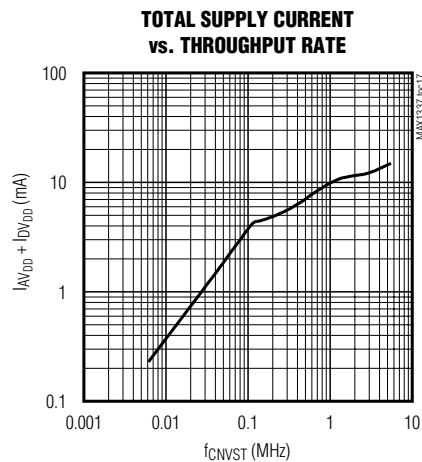
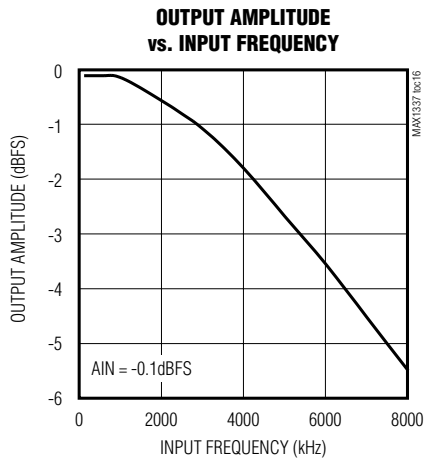
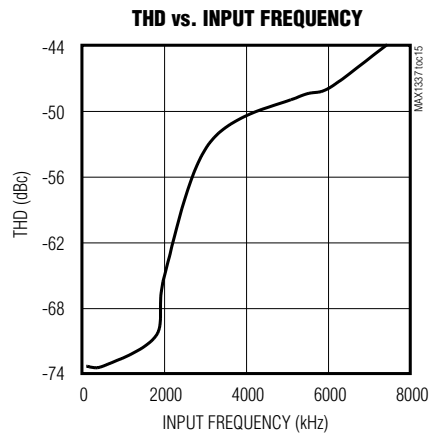
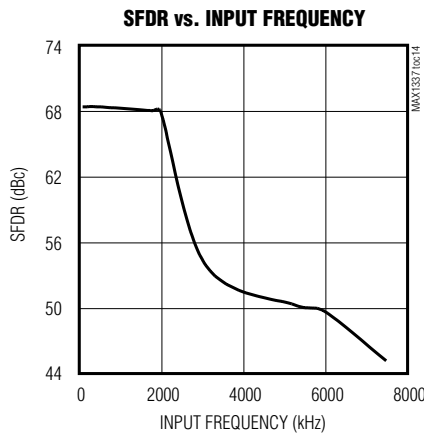
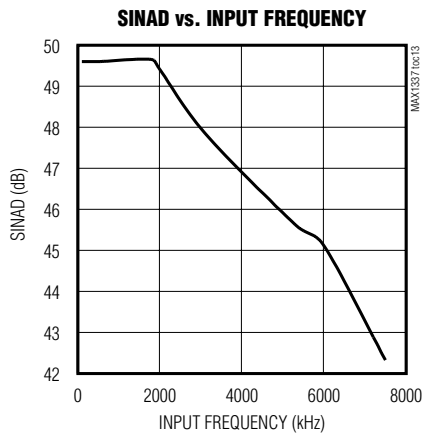
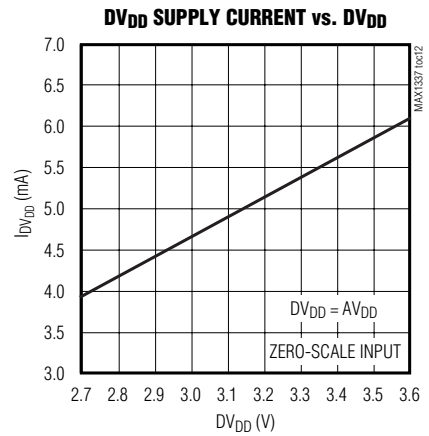
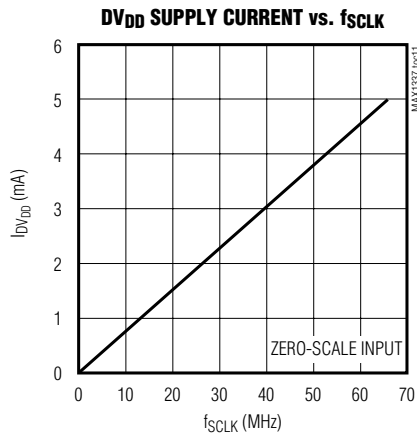
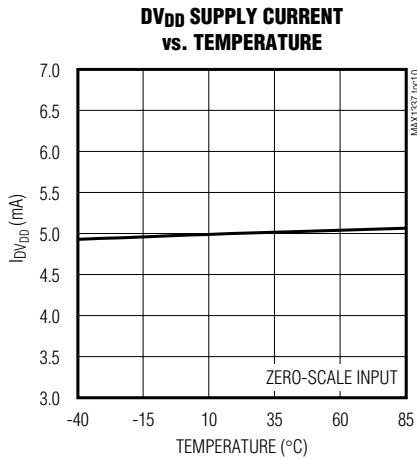
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## Typical Operating Characteristics (continued)

( $V_{DD} = +5V$ ,  $DV_{DD} = +3V$ ,  $V_{REF} = 4.096V$ ,  $f_{SCLK} = 66MHz$ .  $T_A = +25^\circ C$  unless otherwise noted.)

### MAX1337

MAX1336/MAX1337



## 6.5Msps/5.5Msps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

### Pin Description

PIN	NAME	FUNCTION
1	AIN0P	Positive Analog-Input Channel 0
2	AIN0N	Negative Analog-Input Channel 0
3	AIN1P	Positive Analog-Input Channel 1
4	AIN1N	Negative Analog-Input Channel 1
5	REF	External Reference Voltage Input. $V_{REF} = 1V$ to $(AV_{DD} + 50mV)$ . Bypass REF to AGND with a $0.1\mu F$ and a $1\mu F$ .
6	$\overline{SHDN}$	Shutdown Input. Pull $\overline{SHDN}$ low to enter full power-down mode. Drive $\overline{SHDN}$ high to resume normal operation regardless of previous software entered into power-down mode.
7	BIP/ $\overline{UNI}$	Analog-Input-Mode Select. Drive BIP/ $\overline{UNI}$ high to select bipolar-input mode. Pull BIP/ $\overline{UNI}$ low to select unipolar-input mode.
8	AGND	Analog Ground. Connect all AGNDs and EP to the same potential.
9	CHSEL	Channel-Select Input. Drive CHSEL high to select channel 1. Pull CHSEL low to select channel 0.
10	CNVST	Conversion-Start Input. The first rising edge of CNVST powers up the MAX1336/MAX1337 and begins acquiring the analog input. A falling edge samples the analog input and starts a conversion. CNVST also controls the power-down mode of the device (see the <i>Partial Power-Down (PPD) and Full Power-Down (FPD) Mode</i> section).
11	SCLK	Serial-Clock Input. Clocks data out of the serial interface. SCLK also sets the conversion speed.
12	DOUT	Serial-Data Output. Data is clocked out on the rising edge of SCLK (see the <i>Starting a Conversion</i> section).
13	DVDD	Positive-Digital-Supply Input. $DV_{DD}$ is the positive supply input for the digital section of the MAX1336/MAX1337. Connect $DV_{DD}$ to a 2.7V to 3.6V power supply. Bypass $DV_{DD}$ to DGND with a $0.1\mu F$ capacitor in parallel with a $1\mu F$ capacitor. Place the bypass capacitors as close to the device as possible.
14	DGND	Digital Ground. Ensure that the potential difference between AGND and DGND is less than $\pm 0.3V$ .
15	AVDD	Positive-Analog-Supply Input. $AV_{DD}$ is the positive supply input for the analog section of the MAX1336/MAX1337. Connect $AV_{DD}$ to a 4.75V to 5.25V power supply for the MAX1336. Connect $AV_{DD}$ to a 2.7V to 3.6V power supply for the MAX1337. Bypass $AV_{DD}$ to AGND with a $0.1\mu F$ capacitor in parallel with a $1\mu F$ capacitor. Place the bypass capacitors as close to the device as possible.
16	AGND	Analog Ground. Connect all AGNDs and EP to the same potential.
—	EP	Exposed Paddle. Internally connected to AGND. Connect the exposed paddle to the analog ground plane.

## 6.5MSPS/5.5MSPS, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

### Detailed Description

The MAX1336/MAX1337 use an input track and hold (T/H) circuit along with a successive-approximation register (SAR) to convert a differential analog input signal to a digital 8-bit output. The serial interface requires only three digital lines (SCLK, CNVST, and DOUT) and provides easy interfacing to microcontrollers ( $\mu$ Cs) and DSPs. Figure 2 shows the simplified functional diagram for the MAX1336/MAX1337.

### Power Supplies

The MAX1336/MAX1337 accept two power supplies that allow the digital noise to be isolated from sensitive analog circuitry. For both the MAX1336 and MAX1337, the digital power-supply input accepts a supply voltage of +2.7V to +3.6V. However, the supply voltage range for the analog power supply is different for each device. The MAX1336 accepts a +4.75V to +5.25V analog power supply, and the MAX1337 accepts a +2.7V to +3.6V analog power supply. See the *Layout, Grounding, and Bypassing* section for information on how to isolate digital noise from the analog power input.

The MAX1336/MAX1337s' analog power supply consists of one AV<sub>DD</sub> pin, two AGND pins, and the exposed paddle (EP). The digital power input consists of one DV<sub>DD</sub> pin and one DGND pin. Ensure that the potential on both AGND inputs and EP is the same. Furthermore, ensure that the potential between AGND and DGND is limited to  $\pm 0.3$ V. Ideally, there should be no potential difference between AGND and DGND. There are no power-sequencing issues between AV<sub>DD</sub> and DV<sub>DD</sub>.

### True-Differential Analog Input T/H

The equivalent input circuit of Figure 3 shows the MAX1336/MAX1337s' input architecture, which is composed of a T/H, a comparator, and a switched-capacitor DAC. On power-up, the MAX1336/MAX1337 enter full power-down mode. Drive CNVST high to exit full power-down mode and to start acquiring the input. The positive input capacitor is connected to AIN<sub>P</sub>, and the negative input capacitor is connected to AIN<sub>N</sub>. The T/H enters its hold mode on the falling edge of CNVST, and the ADC starts converting the sampled difference between the analog inputs. Once a conversion has been initiated, the T/H enters acquisition mode for the next conversion on the 9th falling edge of SCLK after CNVST has been transitioned from high to low.

The time required for the T/H to acquire an input signal is determined by how quickly its input capacitance is charged. If the input signal's source impedance is high, the acquisition time lengthens. The acquisition time,

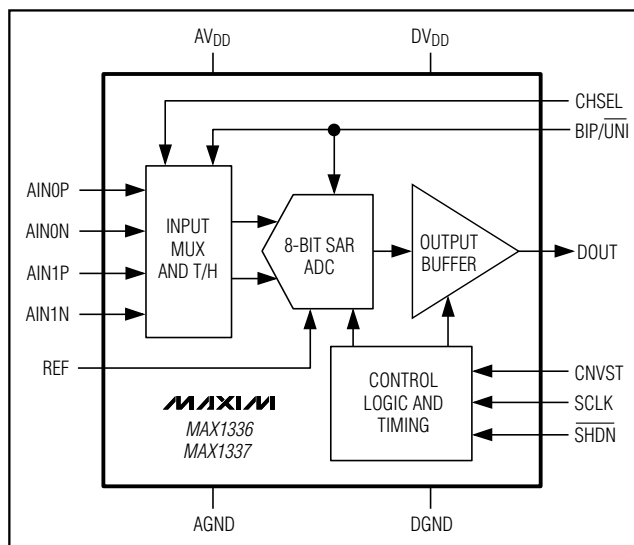


Figure 2. Simplified Functional Diagram

$t_{ACQ}$ , is the minimum time needed for the signal to be acquired. It is calculated by the following equation:

$$t_{ACQ} \geq k \times (R_{SOURCE} + R_{IN}) \times C_{IN}$$

where:

$$k = 6 \approx \ln(2 \times 2^N)$$

The constant  $k$  is the number of RC time constants required so that the voltage on the internal sampling capacitor reaches  $N$ -bit accuracy, i.e., so that the difference between the input voltage and the sampling capacitor voltage is equal to 0.5 LSB.  $N = 8$  for the MAX1336/MAX1337.  $R_{IN} = 250\Omega$  is the equivalent differential analog input resistance,  $C_{IN} = 14\text{pF}$  is the equivalent differential analog input capacitance, and  $R_{SOURCE}$  is the source impedance of the input signal. Note that  $t_{ACQ}$  is never less than 38ns and any source impedance below  $200\Omega$  does not significantly affect the ADC's AC performance.

### Input Bandwidth

The ADC's input-tracking circuitry has a 5MHz small-signal bandwidth, making it possible to digitize high-speed transient events and measure periodic signals with bandwidths exceeding the ADC's sampling rate by using undersampling techniques. To avoid high-frequency signals being aliased into the frequency band of interest, lowpass or bandpass filtering is recommended to limit the bandwidth of the input signal.

## 6.5Msps/5.5Msps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

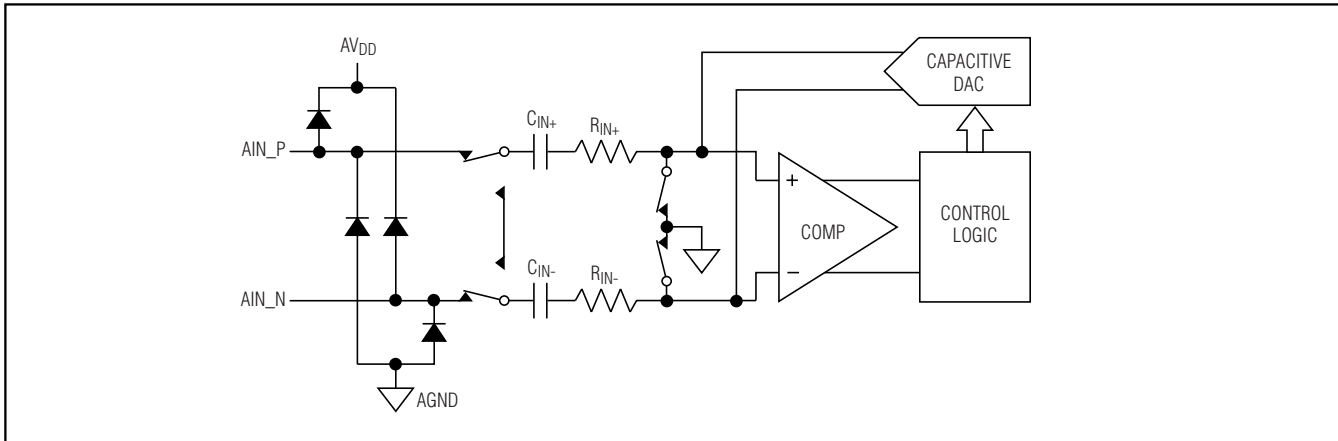


Figure 3a. Equivalent Input Circuit (Acquisition Mode)

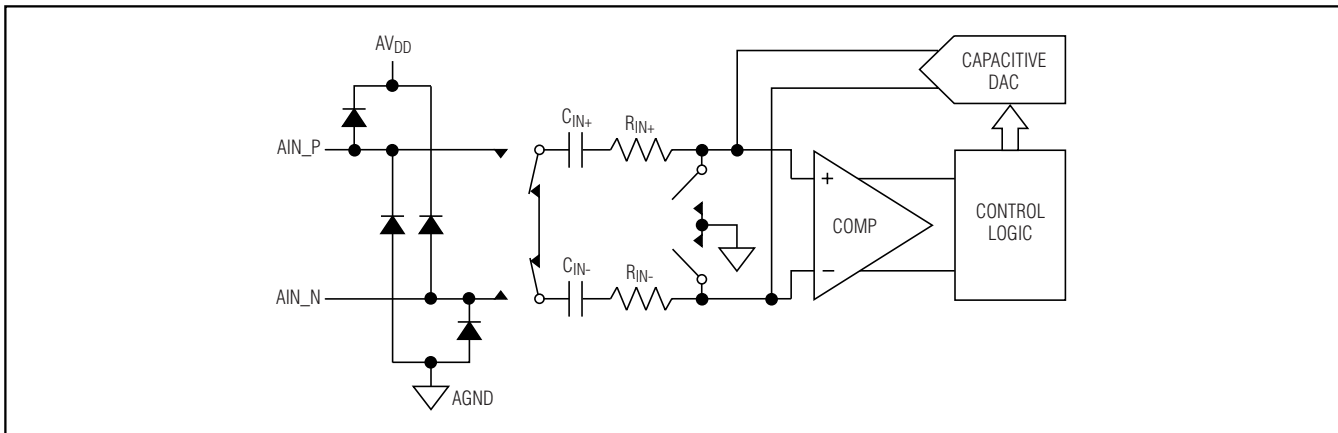


Figure 3b. Equivalent Input Circuit (Hold/Conversion Mode)

### Input Buffer

To improve the input signal bandwidth under AC conditions, drive the input with a wideband buffer (> 50MHz) that can drive the ADC's input capacitance (14pF) and settle quickly. Most applications require an input buffer to achieve 8-bit accuracy. Although slew rate and bandwidth are important, the most critical input buffer specification is settling time. The sampling requires an acquisition time of 32ns (MAX1336) and 38ns (MAX1337). At the beginning of the acquisition, the ADC internal sampling capacitors connect to the analog inputs, causing some disturbance. Ensure the amplifier is capable of settling to at least 8-bit accuracy during this interval. Use a low-noise, low-distortion, wideband amplifier that settles quickly and is stable with the ADC's 14pF input capacitance.

Refer to the Maxim website ([www.maxim-ic.com](http://www.maxim-ic.com)) for application notes on how to choose the optimum buffer amplifier for an ADC application. The MAX4430 is one of the devices that are ideal for this application.

### Differential Analog Input Range and Protection

The MAX1336/MAX1337 produce a digital output that corresponds to the differential analog input voltage as long as the differential analog inputs are within the specified range. When operating in unipolar mode ( $BIP/UNI = 0$ ), the usable differential analog input range is from 0 to  $V_{REF}$ . When operating in bipolar mode ( $BIP/UNI = 1$ ), the differential analog input range is from  $-V_{REF} / 2$  to  $+V_{REF} / 2$ . In both unipolar and bipolar modes, the input common-mode voltage can vary as long as the voltage at any single analog input ( $V_{AIN\_P}$ ,

## 6.5Mps/5.5Mps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

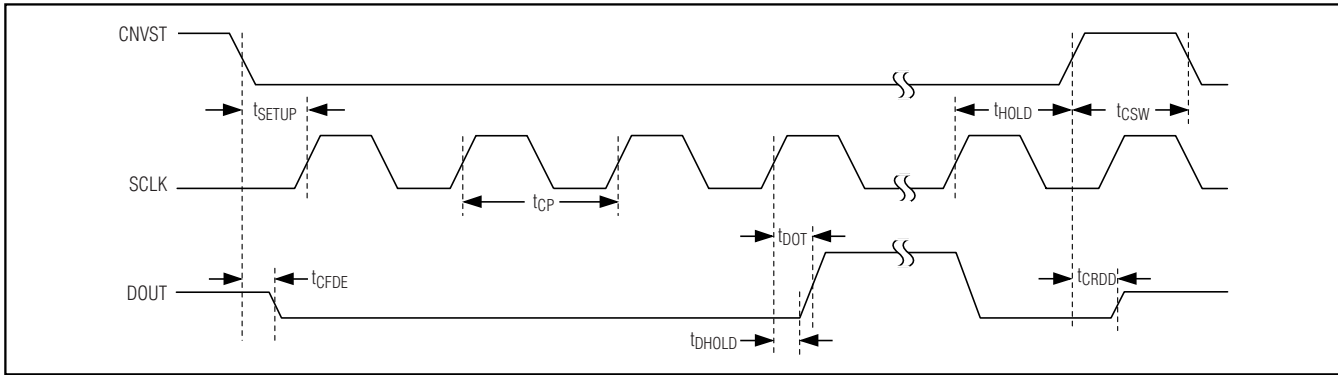


Figure 4. Detailed Serial-Interface Timing

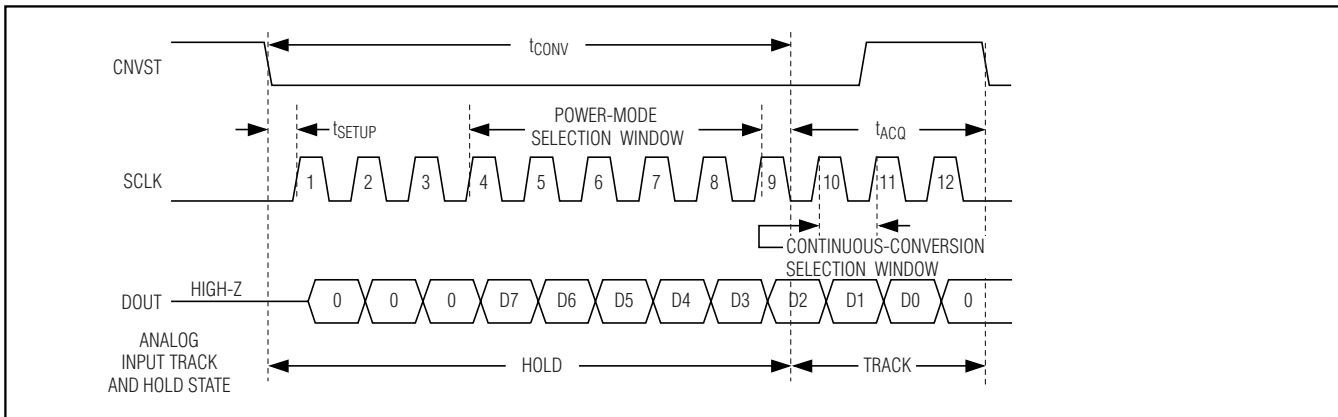


Figure 5. Interface Timing Sequence

$V_{AIN\_N}$ ) remains within 50mV of the analog power-supply rails ( $AV_{DD}$ , AGND).

As shown in Figures 3a and 3b, internal protection diodes confine the analog input voltage within the region of the analog power-supply rails ( $AV_{DD}$ , AGND) and allow the analog input voltage to swing from AGND - 0.3V to  $AV_{DD}$  + 0.3V without damage. Input voltages beyond AGND - 0.3V and  $AV_{DD}$  + 0.3V forward bias the internal protection diodes. In this situation, limit the forward diode current to 50mA to avoid damaging the MAX1336/MAX1337.

### Serial Digital Interface

#### Timing and Control

Conversion-start and data-read operations are controlled by the CNVST and SCLK digital inputs. CNVST controls the state of the T/H as well as when a conversion is initiated. CNVST also controls the power-down mode of the device (see the *Partial Power-Down (PPD) and Full Power-Down (FPD) Mode* section). SCLK

clocks data out of the serial interface and sets the conversion speed. Figures 4 and 5 show timing diagrams that outline the serial-interface operation.

#### Starting a Conversion

On power-up, the MAX1336/MAX1337 enter full power-down mode. The first rising edge of CNVST exits the full power-down mode, and the MAX1336/MAX1337 begin acquiring the analog input. A CNVST falling edge initiates a conversion sequence. The T/H stage holds the input voltage, DOUT changes from high impedance to logic-low, and the ADC begins to convert at the first SCLK rising edge. SCLK is used to drive the conversion process, and it shifts data out of DOUT. SCLK begins shifting out the data after the 4th rising edge of SCLK. DOUT transitions  $t_{DOT}$  after each SCLK's rising edge and remains valid for  $t_{DHOLD}$  after the next rising edge. The 4th rising clock edge produces the MSB of the conversion result at DOUT, and the MSB remains valid  $t_{DHOLD}$  after the 5th rising edge of SCLK. Twelve rising SCLK edges are needed to clock out the three

## 6.5Mps/5.5Mps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

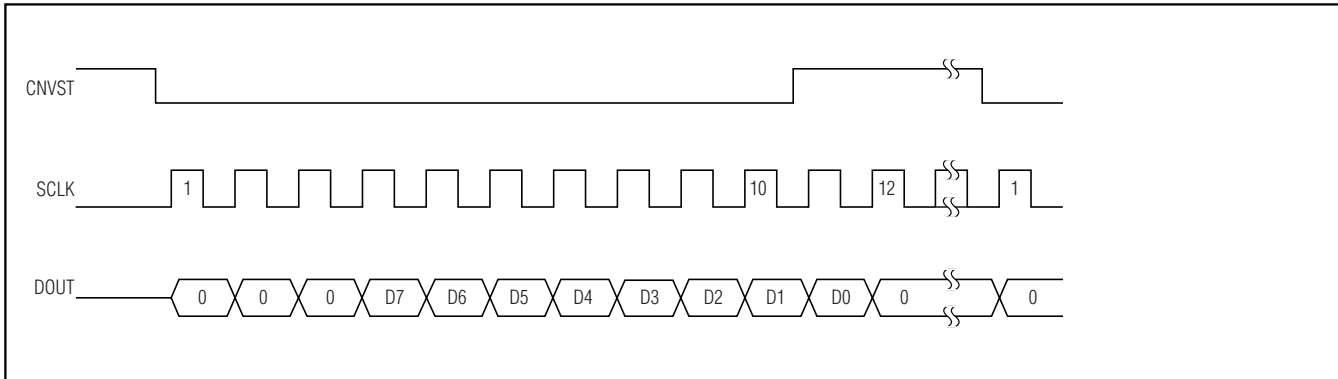


Figure 6. Continuous Conversion with Burst or Continuous Clock

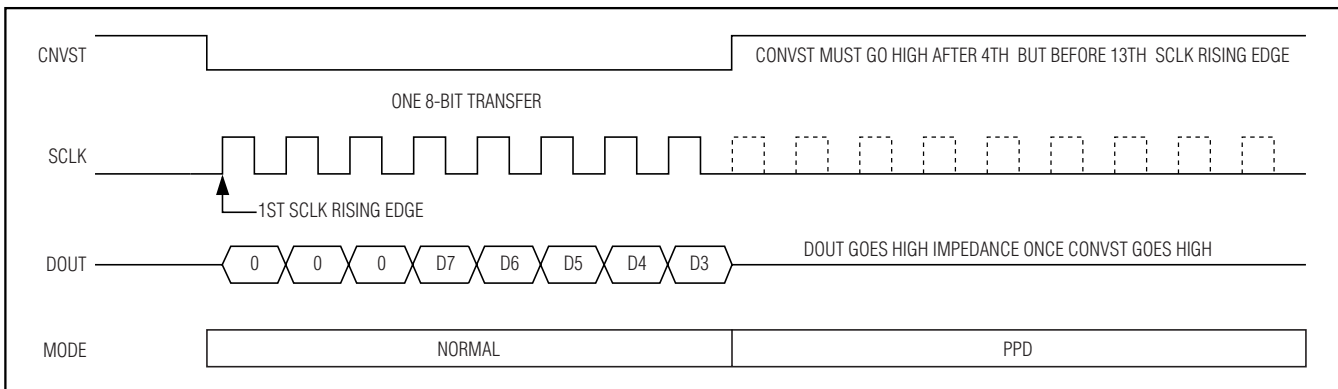


Figure 7. SPI Interface—Partial Power-Down

leading zeros, 8 data bits, and a trailing zero. For continuous operation, pull CNVST high between the 10th and the 11th rising edges of SCLK. The highest throughput is achieved when performing continuous conversions. If CNVST is low during the rising edge of the 12th SCLK, the DOUT line goes to a high-impedance state on either CNVST's rising edge or the next SCLK's rising edge, enabling the serial interface to be shared by multiple devices. Figure 6 illustrates a conversion using a typical serial interface.

### Partial Power-Down (PPD) and Full Power-Down (FPD) Mode

Power consumption is reduced significantly by placing the MAX1336/MAX1337 in either partial power-down mode or full power-down mode. Partial power-down mode is ideal for infrequent data sampling and fast wake-up time applications. Once CNVST is transitioned from high to low, pull CNVST high any time after the 4th rising edge of the SCLK but before the 9th rising edge of the SCLK to enter partial power-down mode (see Figure

7). Drive CNVST low and then drive high before the 4th SCLK to remain in partial power-down mode. This reduces the supply current to 3.3mA. Drive CNVST low and allow at least nine SCLK cycles to elapse before driving CNVST high to exit partial power-down mode.

Full power-down mode reduces the supply current to 0.2 $\mu$ A and is ideal for infrequent data sampling. To enter full power-down mode, the MAX1336/MAX1337 must first be in partial power-down mode. While in partial power-down mode, repeat the sequence used to enter partial power-down mode to enter full power-down mode (see Figure 8). Drive CNVST low and allow at least nine SCLK cycles to elapse before driving CNVST high to exit full power-down mode.

Maintain a logic-low or a logic-high on SCLK and all digital inputs at DV<sub>DD</sub> or DGND while in either partial power-down or full power-down mode to minimize power consumption.

Another way of entering the full power-down mode is using the  $\overline{\text{SHDN}}$  input. Drive  $\overline{\text{SHDN}}$  to a logic-low to put

# 6.5Mps/5.5Mps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

MAX1336/MAX1337

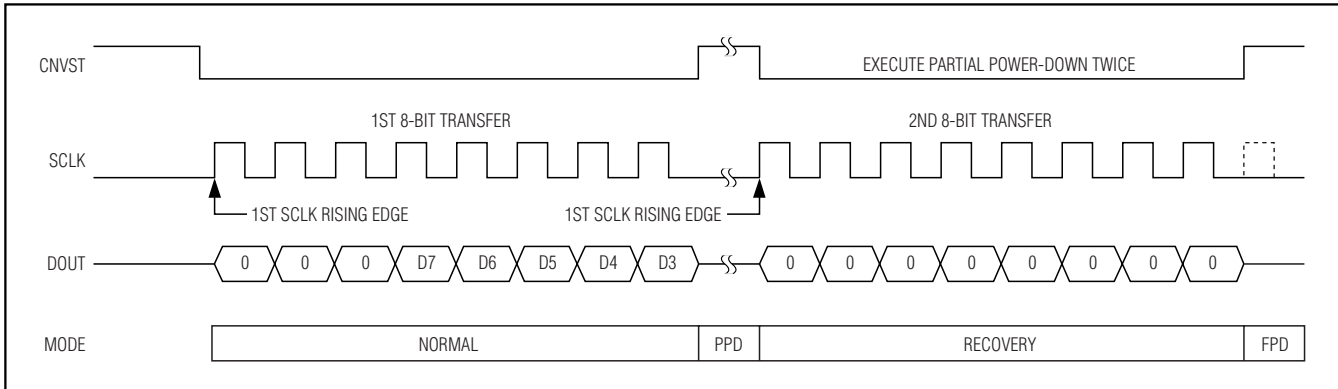


Figure 8. SPI Interface—Full Power-Down

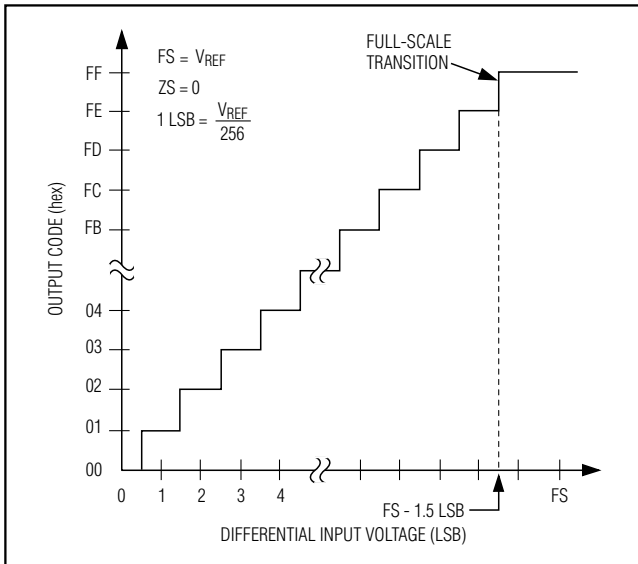


Figure 9. Unipolar Transfer Function

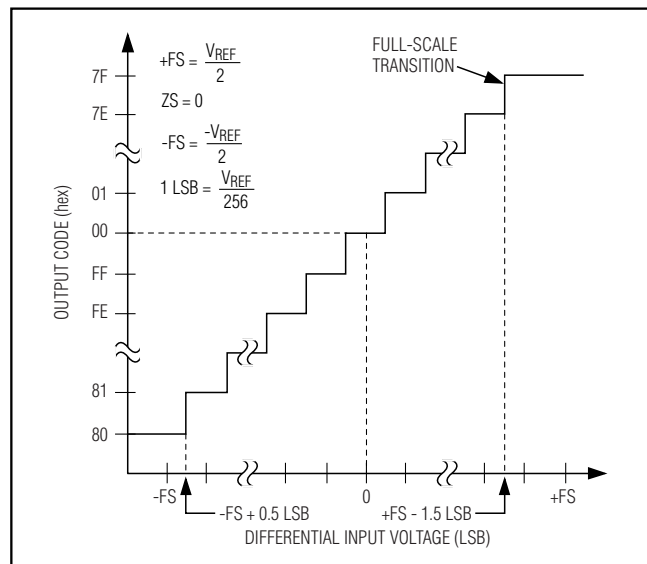


Figure 10. Bipolar Transfer Function

the device into the full power-down mode. Drive  $\overline{\text{SHDN}}$  high to exit full power-down mode, and return to normal operating mode.  $\overline{\text{SHDN}}$  overrides any software-controlled power-down mode and every time it is deasserted, it places the MAX1336/MAX1337 in its normal mode of operation regardless of its previous state.

### Transfer Function

The MAX1336/MAX1337 output is straight binary in unipolar mode and is two's complement in bipolar mode. Figure 9 shows the unipolar transfer function for the MAX1336/MAX1337. Table 1 shows the unipolar relationship between the differential analog input voltage and the digital output code. Figure 10 shows the bipolar transfer function for the MAX1336/MAX1337. Table 2

shows the bipolar relationship between the differential analog input voltage and the digital output code.

Determine the differential analog input voltage as a function of  $V_{\text{REF}}$  and the digital output code with the following equation:

$$\Delta V_{\text{AIN}} = \text{LSB} \times \text{CODE}_{10} \pm 0.5 \times \text{LSB}$$

where:

$$\Delta V_{\text{AIN}} = V_{\text{AIN\_P}} - V_{\text{AIN\_N}}$$

$$\text{LSB} = \frac{V_{\text{REF}}}{2^8} = \frac{V_{\text{REF}}}{256}$$

## 6.5MSPS/5.5MSPS, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

Table 1. Unipolar Code Table (MAX1336)

BINARY DIGITAL OUTPUT CODE D7–D0	HEXADECIMAL EQUIVALENT OF D7–D0	DECIMAL EQUIVALENT OF D7–D0 (CODE <sub>10</sub> )	DIFFERENTIAL INPUT VOLTAGE (V) (V <sub>REF</sub> = 4.096V)
1111 1111	0xFF	255	+4.080 ±0.5 LSB
1111 1110	0xFE	254	+4.064 ±0.5 LSB
1000 0001	0x81	129	+2.064 ±0.5 LSB
1000 0000	0x80	128	+2.048 ±0.5 LSB
0111 1111	0x7F	127	+2.032 ±0.5 LSB
0000 0001	0x01	1	+0.016 ±0.5 LSB
0000 0000	0x00	0	+0.000 ±0.5 LSB

Table 2. Bipolar Code Table (MAX1336)

TWO'S COMPLEMENT DIGITAL OUTPUT CODE D7–D0	HEXADECIMAL EQUIVALENT OF D7–D0	DECIMAL EQUIVALENT OF D7–D0 (CODE <sub>10</sub> )	DIFFERENTIAL INPUT VOLTAGE (V) (V <sub>REF</sub> = 4.096V)
0111 1111	0x7F	+127	+2.032 ±0.5 LSB
0111 1110	0x7E	+126	+2.016 ±0.5 LSB
0000 0001	0x01	+1	+0.016 ±0.5 LSB
0000 0000	0x00	0	0.000 ±0.5 LSB
1111 1111	0xFF	-1	-0.001 ±0.5 LSB
1000 0001	0x81	-127	-2.032 ±0.5 LSB
1000 0000	0x80	-128	-2.048 ±0.5 LSB

CODE<sub>10</sub> = the decimal equivalent of the digital output code (see Tables 1 and 2).

±0.5 x LSB represents the quantization error that is inherent to any ADC.

When using a 4.096V reference, 1 LSB equals 16mV. When using a 2.5V reference, 1 LSB equals 9.77mV.

### Applications Information

#### External Reference

The MAX1336/MAX1337 use an external reference between 1V and (AV<sub>DD</sub> + 50mV). Bypass REF with a 1μF capacitor in parallel with a 0.1μF capacitor to AGND for best performance (see the *Typical Operating Circuit*).

#### Connection to Standard Interfaces

The MAX1336/MAX1337 serial interface is fully compatible with SPI, QSPI, and MICROWIRE (see Figure 11). If a serial interface is available, set the μC's serial interface in master mode so the μC generates the serial clock. Choose a clock frequency based on the AV<sub>DD</sub> and DV<sub>DD</sub> amplitudes.

#### SPI and MICROWIRE

When using SPI or MICROWIRE, the MAX1336/MAX1337 are compatible with all four modes programmed with the CPHA and CPOL bits in the SPI or MICROWIRE control register. (This control register is in the bus master, not the MAX1336/MAX1337.) Conversion begins with a CNVST falling edge. DOUT goes low, indicating a conversion is in progress. Two consecutive 1-byte reads are required to get the full 8 bits from the ADC. DOUT transitions on SCLK rising edges and is guaranteed to be valid t<sub>DOUT</sub> later and remain valid until t<sub>DHOLD</sub> after the following SCLK rising edge. When using CPOL = 0 and CPHA = 0 or CPOL = 1 and CPHA = 1, the data is clocked into the μC on the following or next SCLK rising edge. When using CPOL = 0 and CPHA = 1 or CPOL = 1 and CPHA = 0, the data is clocked into the μC on the next falling edge. See Figure 11 for connections and Figures 12 and 13 for timing. See the *Timing Characteristics* table to determine the best mode to use.



## 6.5MSPS/5.5MSPS, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

### QSPI

Unlike SPI, which requires two 1-byte reads to acquire the 8 bits of data from the ADC, QSPI allows acquiring the conversion data with a single 12-bit transfer. The MAX1336/MAX1337 require 12 clock cycles from the  $\mu$ C to clock out the 8 bits of data. Figure 14 shows a transfer using CPOL = 1 and CPHA = 1. The conversion result contains three zeros, followed by the 8 data bits and a trailing zero with the data in MSB-first format.

### DSP Interface to the TMS320C54\_

The MAX1336/MAX1337 can be directly connected to the TMS320C54\_ family of DSPs from Texas Instruments. Set the DSP to generate its own clocks or use external clock signals. Use either the standard or buffered serial port. Figure 15 shows the simplest interface between the MAX1336/MAX1337 and the TMS320C54\_, where the transmit serial clock (CLKX) drives the receive serial clock (CLKR) and SCLK, and the transmit frame sync (FSX) drives the receive frame sync (FSR) and CNVST.

For continuous conversion, set the serial port to transmit a clock and pulse the frame sync signal for a clock period before data transmission. Use the serial-port-configuration (SPC) register to set up with internal frame sync (TXM = 1), CLKX driven by an on-chip clock source (MCM = 1), burst mode (FSM = 1), and 12-bit word length (FO = 0, FE = 1). The FE bit is located in the serial-port-configuration extension register (SPCE).

This setup allows continuous conversions provided that the data transmit register (DXR) and the data-receive register (DRR) are serviced before the next conversion. Alternately, autobuffering can be enabled when using the buffered serial port to execute conversions and read the data without  $\mu$ C intervention. Connect DV<sub>DD</sub> to the TMS320C54\_ supply voltage. The word length can be set to 8 bits with FO = 1 and FE = 0, to implement the power-down modes. The CNVST pin must idle high to remain in either power-down state.

Another method of connecting the MAX1336/MAX1337 to the TMS320C54\_ is to generate the clock signals external to either device. This connection is shown in Figure 16 where the serial clock (CLOCK) drives the receive serial clock (CLKR) and SCLK, and the convert signal (CONVERT) drives the receive frame sync (FSR) and CNVST.

The serial port must be set up to accept an external receive clock and external receive frame sync. Write the serial-port-configuration (SPC) register as follows:

TXM = 0, external frame sync

MCM = 0, CLKX is taken from the CLKX pin

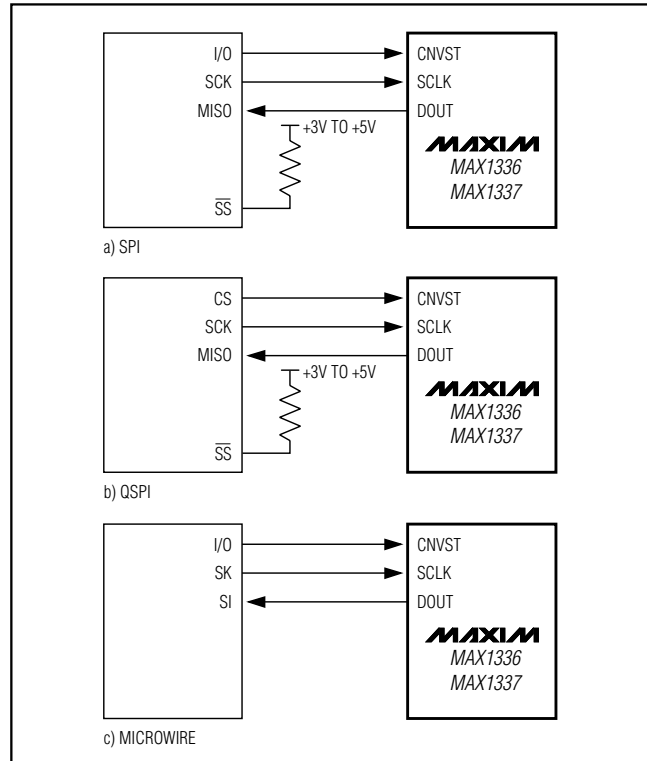


Figure 11. Common Serial-Interface Connections to the MAX1336/MAX1337

FSM = 1, burst mode

FO = 0, FE = 1, data transmitted/received as 12-bit words

This setup allows continuous conversion provided that the DRR is serviced before the next conversion. Alternately, autobuffering can be enabled when using the buffered serial port to read the data without  $\mu$ C intervention. Connect DV<sub>DD</sub> to the TMS320C54\_ supply voltage.

The MAX1336/MAX1337 can also be connected to the TMS320C54\_ by using the data-transmit (DX) pin to drive CNVST and the transmit clock (CLKX) generated internally to drive SCLK. A pullup resistor is required on the CNVST signal to keep it high when DX goes high impedance and write (0001)h to the data-transmit register (DXR) continuously for continuous conversions. The power-down modes may be entered by writing (00FF)h to the DXR (see Figures 17 and 18).

### DSP Interface to the ADSP21\_ \_ \_

The MAX1336/MAX1337 can be directly connected to the ADSP21\_ \_ \_ family of DSPs from Analog Devices. Figure 19 shows the direct connection of the MAX1336/MAX1337 to the ADSP21\_ \_ \_. There are two

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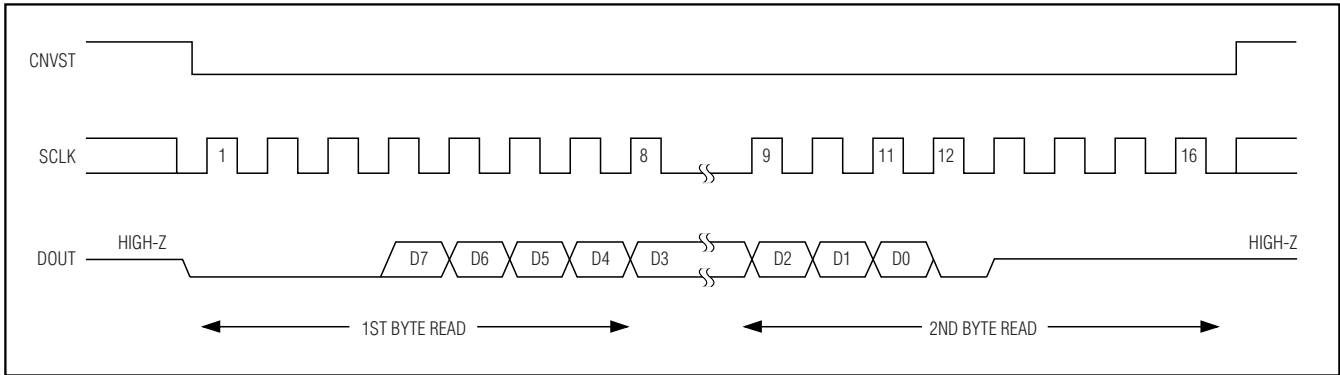


Figure 12. SPI/MICROWIRE Serial-Interface Timing—Single Conversion

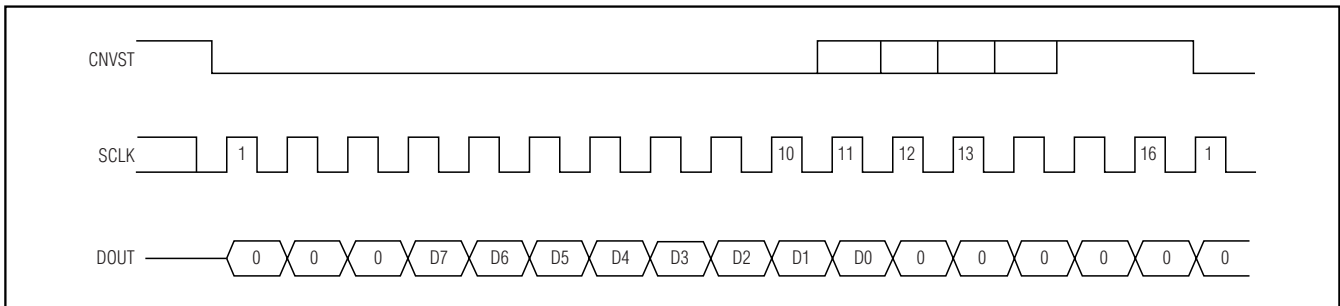


Figure 13. SPI/MICROWIRE Serial-Interface Timing—Continuous Conversion

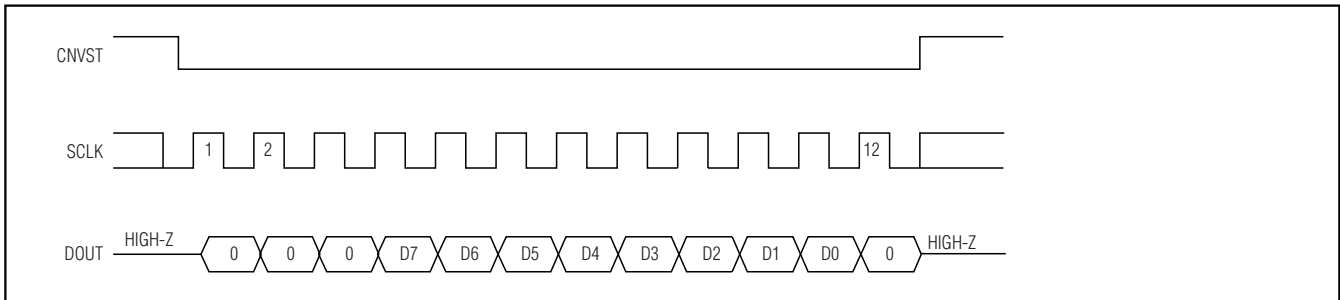


Figure 14. QSPI Serial-Interface Timing

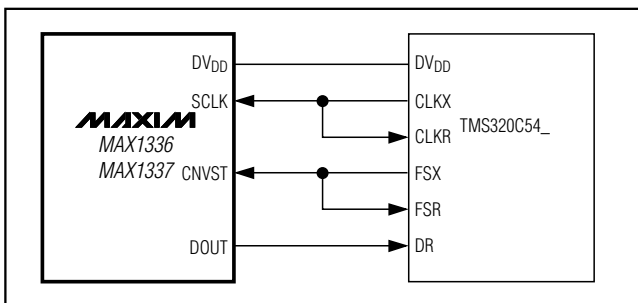


Figure 15. Interfacing to the TMS320C54\_ Internal Clocks

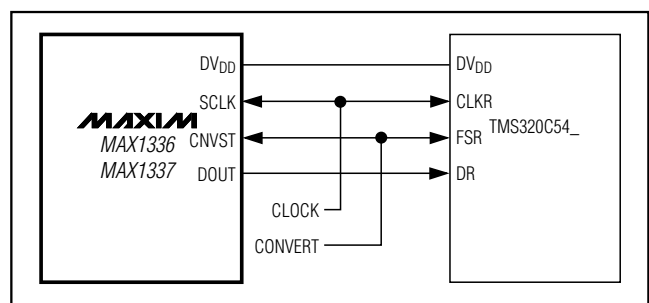


Figure 16. Interfacing to the TMS320C54\_ External Clocks

## 6.5Mps/5.5Mps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

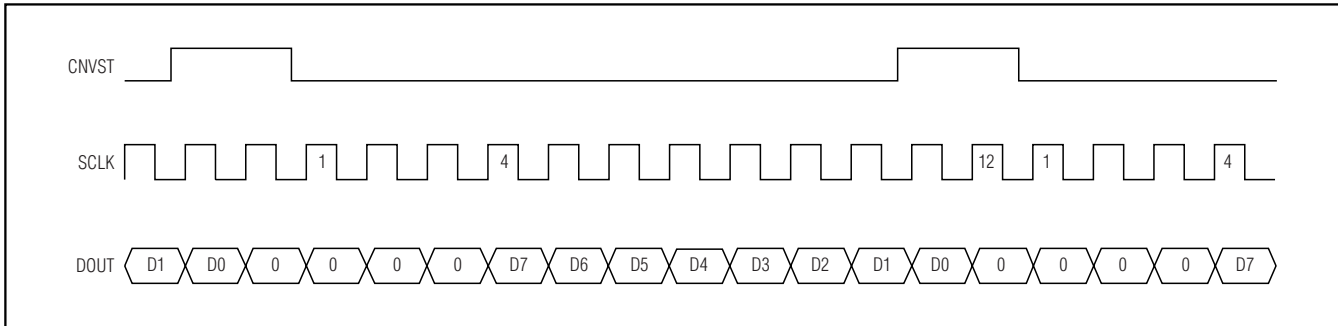


Figure 17. DSP Interface—Continuous Conversion

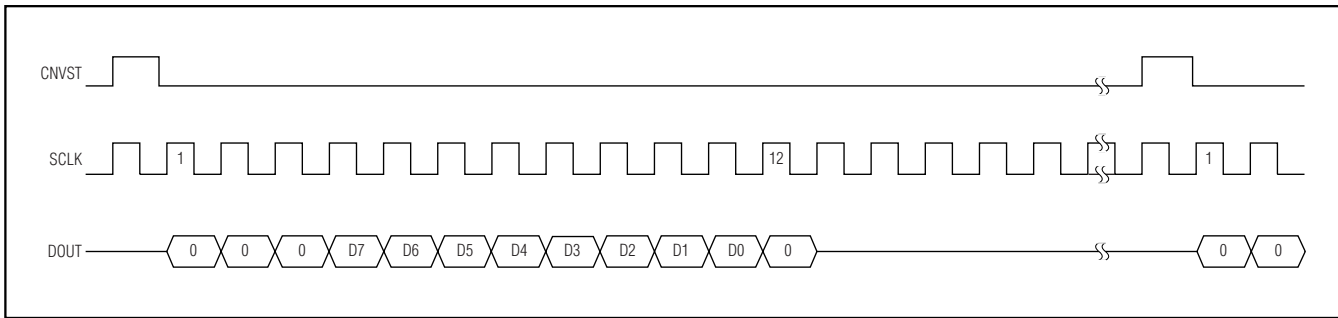


Figure 18. DSP Interface—Single Conversion—Continuous/Burst Clock

modes of operation that can be programmed to interface with the MAX1336/MAX1337. For continuous conversions, idle CNVST low and pulse it high for one clock cycle during the LSB of the previous transmitted word. Configure the ADSP21\_ \_ \_ STCTL and SRCTL registers for early framing (LAFR = 0) and for an active-high frame (LTFS = 0, LRFS = 0) signal. In this mode, the data-independent frame-sync bit (DITFS = 1) can be selected to eliminate the need for writing to the transmit data register more than once. For single conversions, idle CNVST high and pulse it low for the entire conversion. Configure the ADSP21\_ \_ \_ STCTL and SRCTL registers for late framing (LAFR = 1) and for an active-low frame (LTFS = 1, LRFS = 1) signal. This is also the best way to enter the power-down modes by setting the word length to 8 bits (SLEN = 0111). Connect the DVDD pin to the ADSP21\_ \_ \_ supply voltage (see Figures 17 and 18).

### Layout, Grounding, and Bypassing

For best performance, use PC boards. Wire-wrap boards must not be used. Board layout must 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 digital lines underneath the ADC package.

Figure 20 shows the recommended system ground connections. Establish an analog ground point at AGND and a digital ground point at DGND. Connect all other analog grounds to the analog ground point. Connect all digital grounds to the digital ground point. For lowest noise operation, make the power-supply returns as low impedance and as short as possible. Connect the analog ground point to the digital ground point together at the IC.

High-frequency noise in the power supplies degrades the ADC's performance. Bypass AVDD to AGND with 0.1µF and 1µF bypass capacitors. Likewise, bypass DVDD to DGND with 0.1µF and 1µF bypass capacitors. Minimize capacitor lead lengths for best supply noise rejection. To reduce the effects of supply noise, a 10Ω resistor can be connected as a lowpass filter to attenuate supply noise (see Figure 20).

### Exposed Paddle

The MAX1336/MAX1337 TQFN package has an exposed paddle on the bottom of the package, providing a very low thermal resistance path for heat removal from the IC,

## 6.5Mps/5.5Mps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

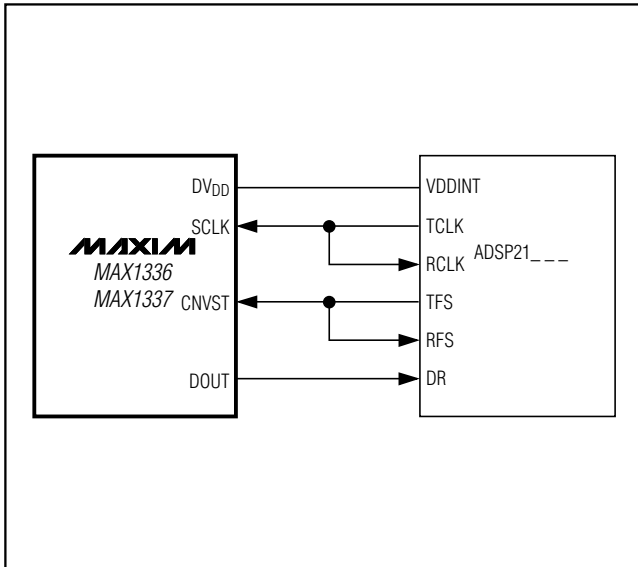


Figure 19. Interfacing to the ADSP21\_...

as well as a low inductance path to ground. The pad is electrically connected to AGND on the MAX1336/MAX1337 and must be soldered to the circuit board analog ground plane for proper thermal and electrical performance. Refer to Maxim Application Note HFAN-08.1: *Thermal Considerations of OFN and Other Exposed-Paddle Package* for additional information.

### Definitions

#### Integral Nonlinearity (INL)

INL is the deviation of the values on an actual transfer function from a straight line. For the MAX1336/MAX1337, this straight line is between the end points of the transfer function once offset and gain errors have been nullified. INL deviations are measured at every step and the worst-case deviation is reported in the *Electrical Characteristics* table.

#### Differential Nonlinearity (DNL)

DNL is the difference between an actual step width and the ideal value of 1 LSB. A DNL error specification of less than 1 LSB guarantees no missing codes and a monotonic transfer function. For the MAX1336/MAX1337, DNL deviations are measured at every step and the worst-case deviation is reported in the *Electrical Characteristics* table.

#### Offset Error

Offset error is a figure of merit that indicates how well the actual transfer function matches the ideal transfer function at a single point. Typically, the point at which

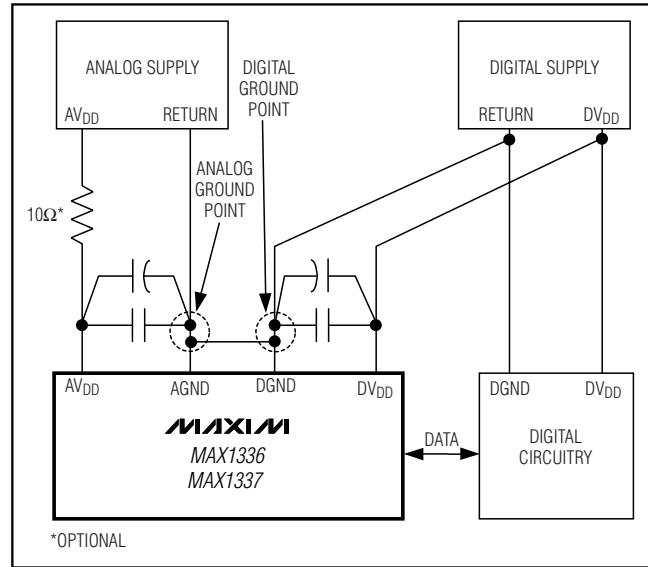


Figure 20. Power-Supply Grounding Condition

the offset error is specified is at or near the zero-scale of the transfer function or at or near the midscale of the transfer function.

For the MAX1336/MAX1337, operating with a unipolar transfer function, the ideal zero-scale digital output transition from 0x00 to 0x01 occurs at 0.5 LSB above AGND. Unipolar offset error is the amount of deviation between the measured zero-scale transition point and the ideal zero-scale transition point.

For the MAX1336/MAX1337, operating with a bipolar transfer function, the ideal midscale digital output transition from 0xFF to 0x00 occurs at 0.5 LSB below AGND. Bipolar offset error is the amount of deviation between the measured midscale transition point and the ideal midscale transition point.

#### Gain Error

Gain error is a figure of merit that indicates how well the slope of the actual transfer function matches the slope of the ideal transfer function. For the MAX1336/MAX1337, the gain error is the difference of the measured full-scale and zero-scale transition points minus the difference of the ideal full-scale and zero-scale transition points.

For the unipolar input, the full-scale transition point is from 0xFE to 0xFF and the zero-scale transition point is from 0x00 to 0x01.

For the bipolar input, the full-scale transition point is from 0x7E to 0x7F and the zero-scale transition point is from 0x80 to 0x81.

# 6.5MSPS/5.5MSPS, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

MAX1336/MAX1337

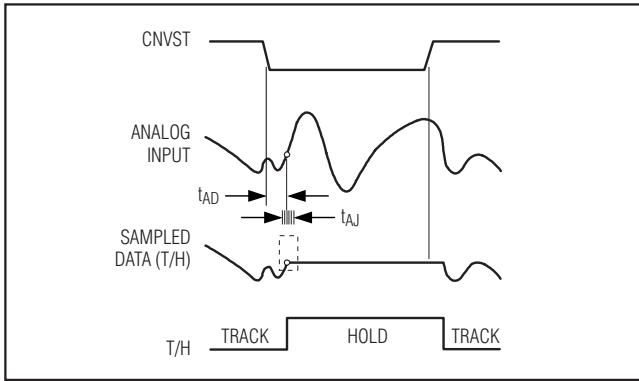


Figure 21. T/H Aperture Timing

### Aperture Jitter

Aperture jitter ( $t_{AJ}$ ) is the sample-to-sample variation in the aperture delay.

### Aperture Delay

Aperture delay ( $t_{AD}$ ) is the time defined between the falling edge of the CNVST and the instant when an actual sample is taken (Figure 21).

### Signal-to-Noise Ratio (SNR)

SNR is a dynamic figure of merit that indicates the converter's noise performance.

For a waveform perfectly reconstructed from digital samples, the theoretical maximum SNR is the ratio of the full-scale analog input (RMS value) to the RMS quantization error (residual error). The ideal, theoretical minimum analog-to-digital noise is caused by quantization error only and results directly from the ADC's resolution (N bits):

$$\text{SNR}_{\text{dB}[\text{max}]} = 6.02\text{dB} \times N + 1.76\text{dB}$$

In reality, there are other noise sources such as thermal noise, reference noise, and clock jitter that also degrade SNR.

For the MAX1336/MAX1337, SNR is computed by taking the ratio of the RMS signal to the RMS noise. RMS noise includes all spectral components to the Nyquist frequency excluding the fundamental, the first five harmonics, and the DC offset:

### Signal-to-Noise Plus Distortion (SINAD)

SINAD is a dynamic figure of merit that indicates the converter's noise and distortion performance.

SINAD is computed by taking the ratio of the RMS signal to the RMS noise plus distortion. RMS noise plus distortion includes all spectral components to the Nyquist frequency excluding the fundamental and the DC offset.

$$\text{SINAD}(\text{dB}) = 20 \times \log \left[ \frac{\text{SIGNAL}_{\text{RMS}}}{(\text{NOISE} + \text{DISTORTION})_{\text{RMS}}} \right]$$

### Effective Number of Bits (ENOB)

ENOB specifies the global accuracy of an ADC at a specific input frequency and sampling rate. An ideal ADC's error consists of quantization noise only. ENOB for a full-scale sinusoidal input waveform is computed from:

$$\text{ENOB} = \frac{\text{SINAD} - 1.76}{6.02}$$

### Total Harmonic Distortion (THD)

THD is a dynamic figure of merit that indicates how much harmonic distortion the converter adds to the signal.

THD is the ratio of the RMS sum of the first five harmonics of the fundamental signal to the fundamental itself. This is expressed as:

$$\text{THD} = 20 \times \log \left( \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + V_5^2 + V_6^2}}{V_1} \right)$$

where  $V_1$  is the fundamental amplitude, and  $V_2$  through  $V_6$  are the amplitudes of the 2nd- through 6th-order harmonics.

### Spurious-Free Dynamic Range (SFDR)

SFDR is a dynamic figure of merit that indicates the lowest usable input signal amplitude. SFDR is the ratio of the RMS amplitude of the fundamental (maximum signal component) to the RMS value of the next-largest spurious component, excluding DC offset. SFDR is specified in decibels relative to the carrier (dBc).

### Intermodulation Distortion (IMD)

IMD is the total power of the IM2 to IM5 intermodulation products to the Nyquist frequency relative to the total input power of the two input tones  $f_{IN1}$  and  $f_{IN2}$ . The individual input tone levels are at -7dBFS. The intermodulation products are as follows:

2nd-order intermodulation products (IM2):  $f_{IN1} + f_{IN2}$ ,  $f_{IN2} - f_{IN1}$

3rd-order intermodulation products (IM3):  $2f_{IN1} - f_{IN2}$ ,  $2f_{IN2} - f_{IN1}$ ,  $2f_{IN1} + f_{IN2}$ ,  $2f_{IN2} + f_{IN1}$

4th-order intermodulation products (IM4):  $3f_{IN1} - f_{IN2}$ ,  $3f_{IN2} - f_{IN1}$ ,  $3f_{IN1} + f_{IN2}$ ,  $3f_{IN2} + f_{IN1}$

5th-order intermodulation products (IM5):  $3f_{IN1} - 2f_{IN2}$ ,  $3f_{IN2} - 2f_{IN1}$ ,  $3f_{IN1} + 2f_{IN2}$ ,  $3f_{IN2} + 2f_{IN1}$

## 6.5Mps/5.5Mps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

### Channel-to-Channel Isolation

Channel-to-channel isolation is a figure of merit that indicates how well each analog input is isolated from the others. The channel-to-channel isolation for the MAX1336/MAX1337 is measured by applying a low-frequency 500kHz -0.5dBFS sine wave to the “on” channel while a high-frequency 900kHz -0.5dBFS sine wave is applied to the “off” channel. An FFT is taken for the “on” channel. From the FFT data, channel-to-channel crosstalk is expressed in dB as the power ratio of the 500kHz low-frequency signal applied to the “on” channel and the 900kHz high-frequency crosstalk signal from the “off” channel.

### Full-Power Bandwidth

A large -0.5dBFS analog input signal is applied to an ADC, and the input frequency is swept up to the point where the amplitude of the digitized conversion result has decreased by -3dB. This point is defined as full-power input bandwidth frequency.

### Full-Linear Bandwidth

Full-linear bandwidth is the frequency at which the signal-to-noise plus distortion (SINAD) is equal to 44dB. The amplitude of the analog input signal -0.2dBFS.

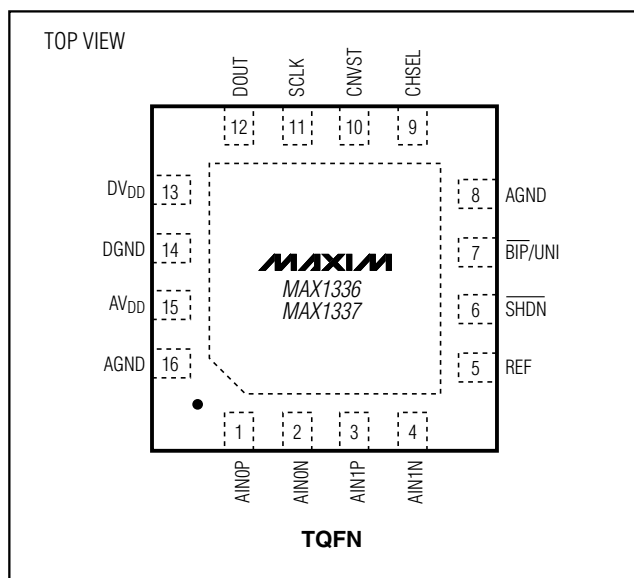
### Small-Signal Bandwidth

A small -20dBFS analog input signal is applied to an ADC in such a way that the signal's slew rate does not limit the ADC's performance. The input frequency is then swept up to the point where the amplitude of the digitized conversion result has decreased by -3dB.

### Power-Supply Rejection (PSR)

PSR is defined as the shift in offset and gain error when the analog power supply is moved from 2.7V to 3.6V.

### Pin Configuration



### Selector Guide

PART	AVDD	MAX SAMPLING RATE (Mps)
MAX1336ETE	+5V	6.5
MAX1337ETE	+3V	5.5

### Chip Information

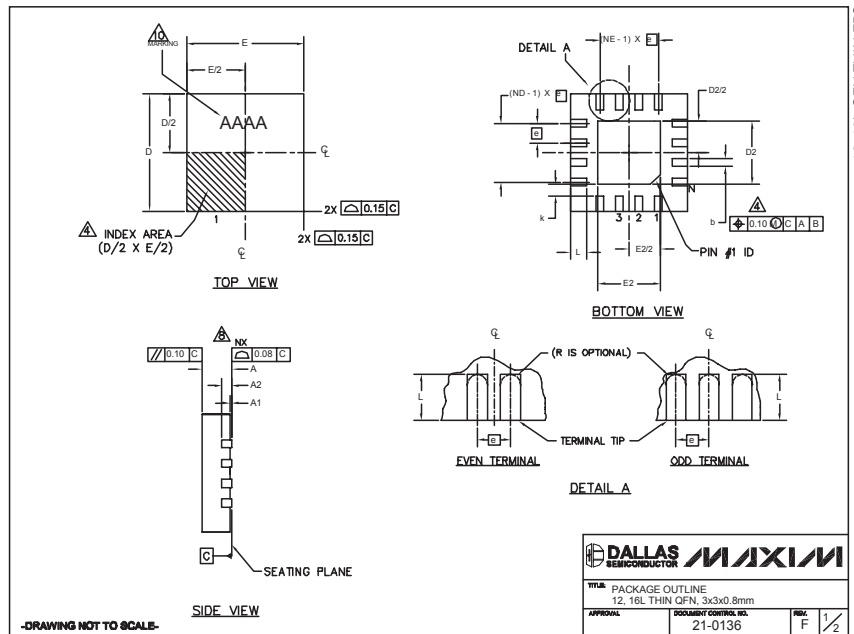
PROCESS: BICMOS

# 6.5Mps/5.5Mps, 2-Channel, 5V/3V, True-Differential, 8-Bit ADCs

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

MAX1336/MAX1337



PKG	12L 3x3			16L 3x3		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80
b	0.20	0.25	0.30	0.20	0.25	0.30
D	2.90	3.00	3.10	2.90	3.00	3.10
E	2.90	3.00	3.10	2.90	3.00	3.10
e	0.50 BSC.			0.50 BSC.		
L	0.45	0.55	0.65	0.30	0.40	0.50
N	12			16		
ND	3			4		
NE	3			4		
A1	0	0.02	0.05	0	0.02	0.05
A2	0.20 REF			0.20 REF		
k	0.25	-	-	0.25	-	-

PKG. CODES	D2			E2			PIN ID	JEDEC	DOWN BONDS ALLOWED
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.			
T1233-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	NO
T1233-3	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	YES
T1233-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-1	YES
T1633-1	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	NO
T1633-2	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	YES
T1633F-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45°	WEED-2	N/A
T1633FH-3	0.65	0.80	0.95	0.65	0.80	0.95	0.225 x 45°	WEED-2	N/A
T1633-4	0.95	1.10	1.25	0.95	1.10	1.25	0.35 x 45°	WEED-2	NO

NOTES:

- DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
- ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
- N IS THE TOTAL NUMBER OF TERMINALS.
- THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JEDEC 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
- DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.20 mm AND 0.25 mm FROM TERMINAL TIP.
- ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
- DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
- COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
- DRAWING CONFORMS TO JEDEC MO220 REVISION C.
- MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY
- NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY

-DRAWING NOT TO SCALE-

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