



# 32/64-Channel Infinite Sample-and-Hold

## Preliminary Technical Data

## AD5532/64

### FEATURES

**Infinite Hold Capability with No Droop**  
**Single Input, 32/64 Output Channels**  
**Input/Output Transfer Function Nonlinearity of  $\pm 0.012\%$  max**  
**Per-Channel Acquisition time of 16  $\mu$ s max**  
**Input Voltage: 0 to +3V**  
**Output Voltage Span: +10V**  
**e.g. -3V to +7V**  
**-2.5V to +7.5V**

### APPLICATIONS

**Level Setting**  
**Instrumentation**  
**Automatic Test Equipment**  
**Control Systems**  
**Data Acquisition**  
**Low Cost I/O**

### GENERAL DESCRIPTION

The AD5532/64 combines a 32/64 channel voltage translation function with an infinite output hold capability. An analog input voltage on the common input pin,  $V_{IN}$ , is sampled and its digital representation transferred

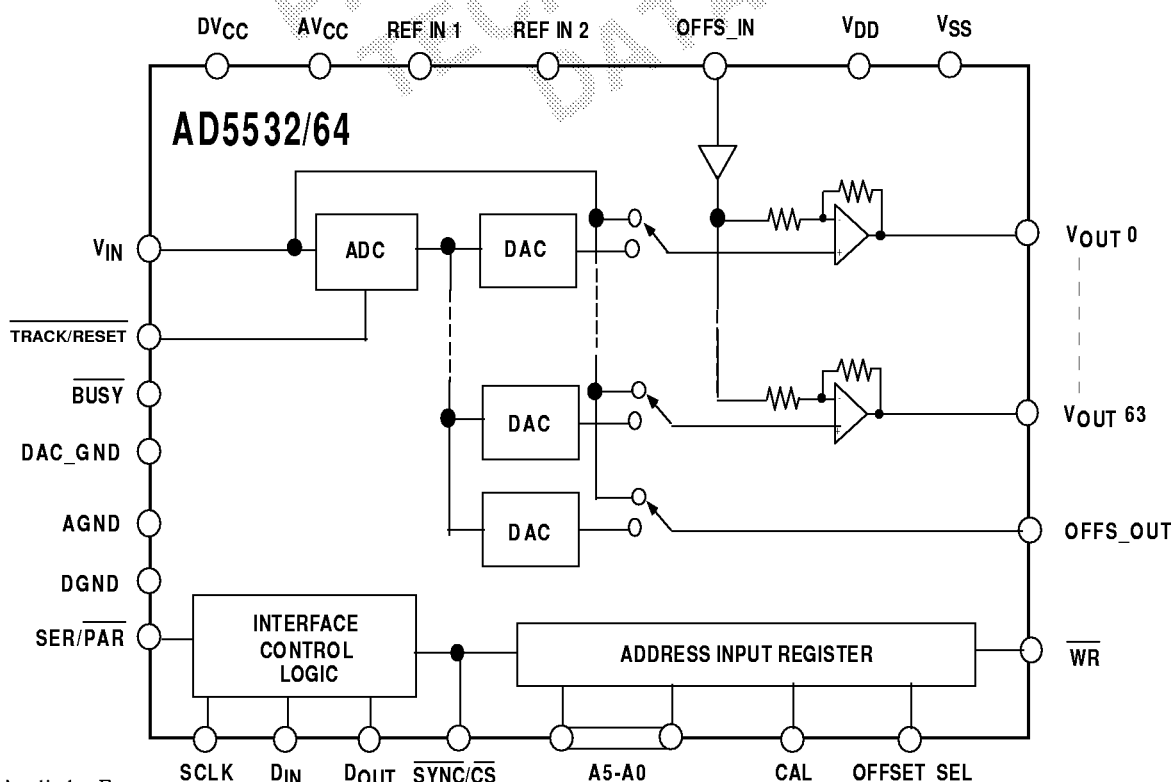
to a chosen DAC register. The output of this DAC is updated to reflect the new contents of the DAC register. Channel selection is accomplished via the parallel address inputs A0-A5 or via the serial input port.

The device is operated with  $AV_{CC} = +5V \pm 5\%$ ,  $DV_{CC} = 2.7V$  to  $5.5V$ ,  $V_{SS} = -4.75V$  to  $-16.5V$  and  $V_{DD} = 8V$  to  $16.5V$  and requires a stable +3V reference on REF IN pins as well as an offset voltage on OFFS\_IN. The output voltage range is determined by the headroom of the output amplifier and is restricted to a range from  $V_{SS} + 2.2V$  to  $V_{DD} - 2V$ . The AD5564 is available in a 119-lead BGA package.

### PRODUCT HIGHLIGHTS

1. No Droop; Infinite Hold Capability
2. Typically  $\pm 0.006\%$  transfer function nonlinearity between Input and Output.
3. 32/64 14-bit DACs in one package, guaranteed monotonic with 9-bit linearity.
4. The AD5564 is available in a 119-lead BGA package with a bump pitch of 1.27mm and a body size of 14mm by 22mm.

### FUNCTIONAL BLOCK DIAGRAM



Patents Applied For

Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices.

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, USA Tel: 781/329-4700 World Wide Web: [www.analog.com](http://www.analog.com) Fax: 781/326-8703

REV. PrE

# AD5532/64-SPECIFICATIONS

## Mode 1 - SHA Mode

$V_{DD} = +8V$  to  $+16.5V$ ,  $V_{SS} = -4.75V$  to  $-16.5V$ ;  $AV_{CC} = +4.75V$  to  $+5.25V$ ;  $DV_{CC} = +2.7V$  to  $+5.25V$ ;  $AGND = DGND = DAC\_GND = 0V$ ; Output Range from  $V_{SS}+2.2V$  to  $V_{DD}-2V$ . All specifications  $T_{MIN}$  to  $T_{MAX}$  unless otherwise noted.

Parameter <sup>1</sup>	B Version <sup>2</sup>	Units	Conditions/Comments
ANALOG CHANNEL $V_{IN}$ to $V_{OUT}$ Nonlinearity	$\pm 0.012$	% max	Typically $\pm 0.006\%$ (after gain and offset adjustment)
Offset Error	$\pm 60$	mV max	See Figure 1 (page 8)
Gain Error	$\pm 100$	mV max	See Figure 1 (page 8)
Channel-to-Channel Matching	TBD	% typ	
ANALOG INPUT ( $V_{IN}$ ) Input Voltage Range	0 to +3	V	Nominal Input Range
Input Current	100	nA max	$V_{IN}$ being acquired on one channel
	6.4	$\mu A$ max	$V_{IN}$ being acquired on all 64 channels simultaneously - Cal Mode
Input Capacitance	50	pF typ	
ANALOG INPUT (OFFS_IN) Input Current	100	nA max	
REFERENCE INPUTS Nominal Input Voltage	+3.0	V	
Input Voltage Range	+2.85/+3.15	V min/max	
Input Current	50	nA max	
ANALOG OUTPUTS ( $V_{OUT}$ 0-63) Output Temp Coeff	10	ppm/ $^{\circ}C$ typ	AD780 as reference for the AD5532/64
Output Impedance	1	k $\Omega$ typ	
Output Range	$V_{SS} + 2.2$ / $V_{DD} - 2$	V min/max	100 $\mu A$ load on the output
Maximum Output Current	500	$\mu A$ typ	
Maximum Capacitive Load	15	nF max	
Output Noise	250	$\mu V$ rms	1MHz Bandwidth
Short-Circuit Current	10	mA typ	
Output PSRR	-70	dB	$V_{DD}$ varied $\pm 5\%$ .
	-70	dB	$V_{SS}$ varied $\pm 5\%$
DC Crosstalk	250	$\mu V$ max	
ANALOG OUTPUT (OFFS_OUT) Output Temp Coeff	10	ppm/ $^{\circ}C$ typ	AD780 as reference for the AD5532/64
Output Impedance	1.0	k $\Omega$ typ	
Output Range	0 / +REF IN	V min/max	
Output Noise	100	$\mu V$ rms	1MHz Bandwidth
Maximum Output Current	10	$\mu A$ typ	Source Current
Maximum Capacitive Load	100	pF typ	
Short-Circuit Current	10	mA typ	Sink Current
Output PSRR	-70	dB typ	$AV_{CC}$ varied $\pm 5\%$
DIGITAL INPUTS Input Current	$\pm 10$	$\mu A$ max	
Input Low Voltage	0.8	V max	$DV_{CC} = 5V \pm 5\%$
	0.4	V max	$DV_{CC} = 3V \pm 10\%$
Input High Voltage	2.0	V min	
Input Hysteresis (SCLK only)	200	mV typ	
Input Capacitance	10	pF max	

### NOTES:

<sup>1</sup>See Terminology

<sup>2</sup>B Version: Industrial temperature range  $-40^{\circ}C.$  to  $+85^{\circ}C.$

<sup>3</sup>Guaranteed by design and characterisation, not production tested

# AD5532/64-SPECIFICATIONS

$V_{DD} = +8V$  to  $+16.5V$ ,  $V_{SS} = -4.75V$  to  $-16.5V$ ;  $AV_{CC} = +4.75V$  to  $+5.25V$ ;  $DV_{CC} = +2.7V$  to  $+5.25V$ ;  $AGND = DGND = DAC\_GND = 0V$ ; Output Range from  $V_{SS}+2.2V$  to  $V_{DD} -2V$ . All specifications  $T_{MIN}$  to  $T_{MAX}$  unless otherwise noted.

## Mode 1 - SHA Mode (cont.)

Parameter <sup>1</sup>	B Version <sup>2</sup>	Units	Conditions/Comments
DIGITAL OUTPUTS ( $\overline{BUSY}$ , $D_{OUT}$ )			
Output Low Voltage	0.4	V max	$DV_{CC} = 5V$ . Sinking TBD mA
Output High Voltage	4.0	V min	$DV_{CC} = 5V$ . Sourcing TBD $\mu A$
Output Low Voltage	0.4	V max	$DV_{CC} = 3V$ . Sinking TBD mA
Output High Voltage	2.4	V min	$DV_{CC} = 3V$ . Sourcing TBD $\mu A$
Floating-State Leakage Current <sup>4</sup>	TBD	$\mu A$ max	
Floating-State Input Capacitance <sup>4</sup>	TBD	pF max	
POWER REQUIREMENTS			
Power-Supply Voltages			
$V_{DD}$	+8/+16.5	V min/max	
$V_{SS}$	-4.75/-16.5	V min/max	
$AV_{CC}$	+4.75/+5.25	V min/max	
$DV_{CC}$	+2.7/+5.25	V min/max	
Power-Supply Currents <sup>5</sup>			
$I_{DD}$	22	mA typ	
$I_{SS}$	22	mA typ	
$AI_{CC}$	54	mA typ	
$DI_{CC}$	< 1	mA max	
Power Dissipation <sup>5</sup>	600	mW typ	$V_{DD}=10V$ , $V_{SS}=-5V$
AC CHARACTERISTICS			
AC Crosstalk	2.5	nV-s max	
Output Settling Time	3	$\mu s$ max	100pF Capacitive load
Acquisition Time	16	$\mu s$ max	Acquire $V_{IN}$ to $\pm 0.012\%$ accuracy
Slew Rate	1	V/ $\mu s$ typ	
Digital Feedthrough	2.5	nV-s typ	
Digital Crosstalk	2.5	nV-s typ	
TRACK MODE			
Output PSRR	TBD	dB	$V_{DD}$ varied $\pm 5\%$ .
	TBD	dB	$V_{SS}$ varied $\pm 5\%$
Bandwidth	TBD	kHz typ	

### NOTES:

<sup>1</sup>See Terminology

<sup>2</sup>B Version: Industrial temperature range -40°C. to +85°C.

<sup>3</sup>Guaranteed by design and characterisation, not production tested

<sup>4</sup> $D_{OUT}$  only

<sup>5</sup>Outputs Unloaded. All figures are for the AD5564. The numbers for AD5532 are approx 50% of these.

Specifications subject to change without notice

# AD5532/64-SPECIFICATIONS

$V_{DD} = +8V$  to  $+16.5V$ ,  $V_{SS} = -4.75V$  to  $-16.5V$ ;  $AV_{CC} = +4.75V$  to  $+5.25V$ ;  $DV_{CC} = +2.7V$  to  $+5.25V$ ;  $AGND = DGND = DAC\_GND = 0V$ ; Output Range from  $V_{SS}+2.2V$  to  $V_{DD} -2V$ . All specifications  $T_{MIN}$  to  $T_{MAX}$  unless otherwise noted.

## Mode 2 - DAC Mode

Parameter <sup>1</sup>	B Version <sup>2</sup>	Units	Conditions/Comments
DC PERFORMANCE			
Resolution	14	Bits	Guaranteed Monotonic
Integral Nonlinearity (INL)	TBD	% of FSR typ	
Differential Nonlinearity (DNL)	$\pm 1$	LSB max	
Offset Error	TBD	mV max	
Gain Error	TBD	% max	
Full-Scale Error	TBD	mV max	
Offset Error Temp Coeff	TBD	$\mu V/^{\circ}C$ typ	
Gain Error Temp Coeff	TBD	$\mu V/^{\circ}C$ typ	
Channel-to-Channel Matching	TBD	% max	
AC CHARACTERISTICS			
Output Settling Time	TBD	$\mu s$ typ	
OFFS_IN Settling Time	TBD	$\mu s$ typ	
Digital-to-Analog Glitch Impulse	TBD	nV-s typ	
Digital Crosstalk	TBD	nV-s typ	
Analog Crosstalk	TBD	nV-s typ	
Total Harmonic Distortion (THD)	TBD	dB typ	
Output Noise Spectral Density	TBD	$nV/(Hz)^{1/2}$ typ	

### NOTES:

<sup>1</sup>See Terminology

<sup>2</sup>B version: Industrial temperature range  $-40^{\circ}C$ . to  $+85^{\circ}C$ .

<sup>3</sup>Guaranteed by design and characterisation, not production tested  
Specifications subject to change without notice

## Timing Characteristics

### Serial Interface

Parameter <sup>1</sup>	Limit at $T_{MIN}$ , $T_{MAX}$ (B Version)	Units	Conditions/Comments
$t_1$	25	ns min	SCLK High Pulse Width
$t_2$	25	ns min	SCLK Low Pulse Width
$t_3$	5	ns min	SYNC Falling Edge to SCLK Falling Edge Setup Time
$t_4$	TBD	ns min	SYNC Low Time
$t_5$	10	ns min	$D_{IN}$ Setup Time
$t_6$	5	ns min	$D_{IN}$ Hold Time
$t_7$	5	ns min	SYNC Falling Edge to SCLK Rising Edge Setup Time
$t_8^2$	10	ns max	SCLK Rising Edge to $D_{OUT}$ Valid
$t_9^2$	20	ns max	SCLK Falling Edge to $D_{OUT}$ High Impedance

### NOTES:

<sup>1</sup>See Interface Timing Diagrams on following pages

<sup>2</sup>These numbers are measured with the load circuit of Figure x

# AD5532/64 Prelim Technical Information

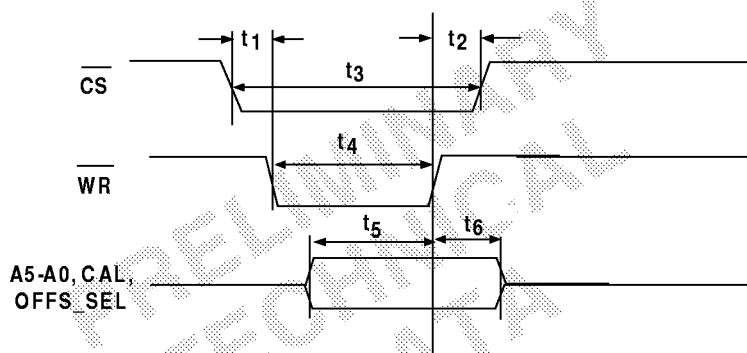
## Parallel Interface

Parameter <sup>1</sup>	Limit at T <sub>MIN</sub> , T <sub>MAX</sub> (B Version)	Units	Conditions/Comments
t <sub>1</sub>	0	ns min	$\overline{\text{CS}}$ to $\overline{\text{WR}}$ Setup Time
t <sub>2</sub>	0	ns min	$\overline{\text{CS}}$ to $\overline{\text{WR}}$ Hold Time
t <sub>3</sub>	50	ns min	$\overline{\text{CS}}$ Pulse Width Low
t <sub>4</sub>	50	ns min	$\overline{\text{WR}}$ Pulse Width Low
t <sub>5</sub>	20	ns min	A5-A0, CAL, OFFS_SEL to $\overline{\text{WR}}$ Setup Time
t <sub>6</sub>	0	ns min	A5-A0, CAL, OFFS_SEL to $\overline{\text{WR}}$ Hold Time

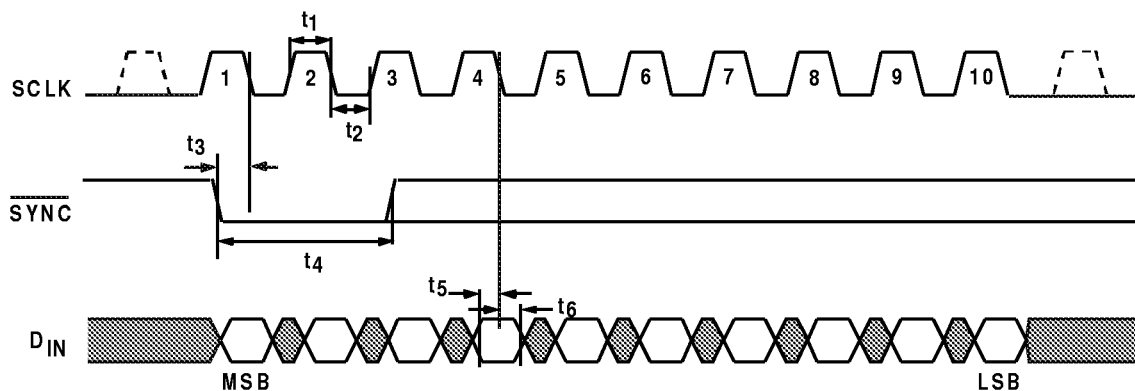
NOTES:

<sup>1</sup>See Interface Timing Diagrams below

## Parallel Interface Timing Diagram



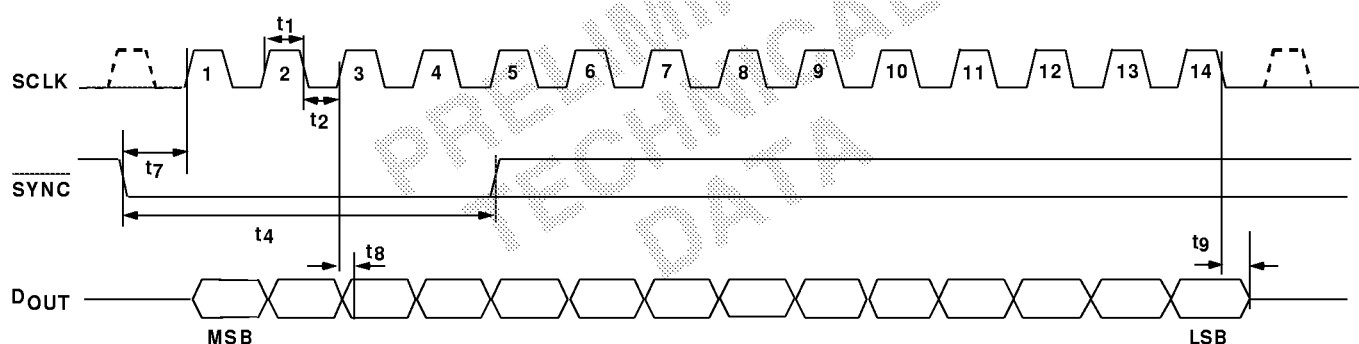
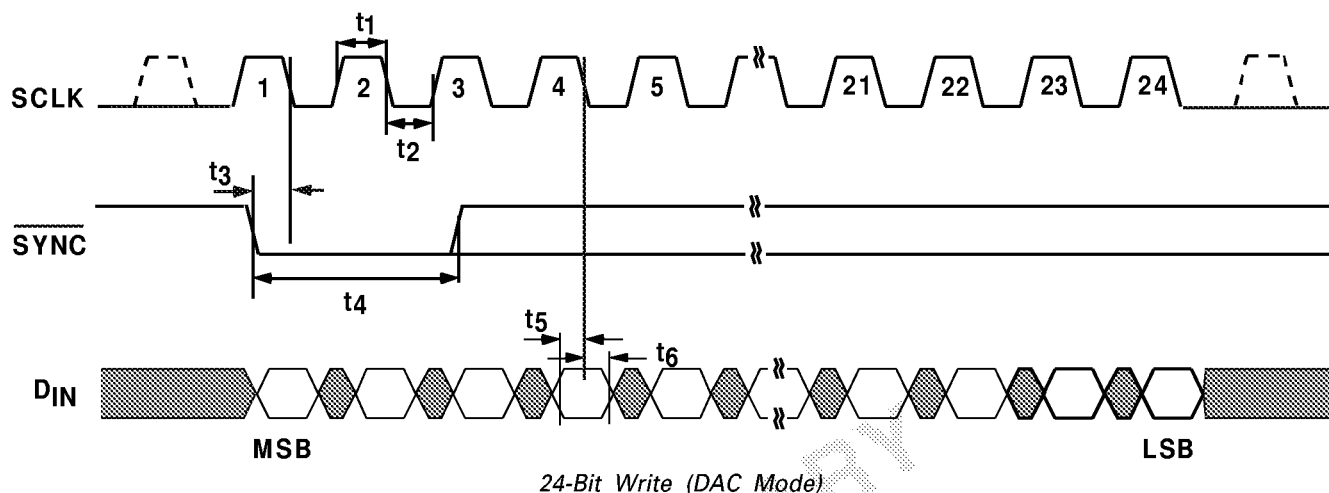
## Serial Interface Timing Diagrams



10-Bit Write (SHA Mode and Both Readback Modes)

# AD5532/64 Prelim Technical Information

## Serial Interface Timing Diagrams



### ABSOLUTE MAXIMUM RATINGS\*

( $T_A = +25^\circ\text{C}$  unless otherwise noted)

$V_{DD}$ to AGND.....	-0.3V to +17V
$V_{SS}$ to AGND.....	+0.3V to -17V
$AV_{CC}$ to AGND, DAC_GND.....	-0.3V to +7V
$DV_{CC}$ to DGND.....	-0.3V to +7V
Digital Inputs to DGND.....	-0.3V to $DV_{CC}+0.3V$
Digital Outputs to DGND.....	-0.3V to $DV_{CC}+0.3V$
REF IN to AGND, DAC_GND.....	-0.3V to +7V
$V_{IN}$ to AGND, DAC_GND.....	-0.3V to +7V
$V_{OUT0-63}$ to AGND.....	$V_{SS}-0.3V$ to $V_{DD}+0.3V$
OFFS_OUT to AGND.....	$V_{SS}-0.3V$ to $V_{DD}+0.3V$

AGND to DGND.....	TBD
Short-Circuit Current.....	TBD mA
Operating Temperature Range	
Industrial (B Version).....	$-40^\circ\text{C}$ to $+85^\circ\text{C}$
Storage Temperature Range.....	$-65^\circ\text{C}$ to $+150^\circ\text{C}$
Junction Temperature ( $T_J$ max).....	$+150^\circ\text{C}$
BGA Package,	
Power Dissipation.....	$(T_J \text{ max} - T_A)/\theta_{JA}$ mW
$\theta_{JA}$ Thermal Impedance.....	$28^\circ\text{C} / \text{W}$
Solder Ball Temperature, Soldering.....	TBD $^\circ\text{C}$ .

#### NOTES:

<sup>1</sup>Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

<sup>2</sup>Transient currents of up to 100mA will not cause SCR latch-up

### CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the AD5532/64 devices feature proprietary ESD protection circuitry, permanent damage may still occur on these devices if they are subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

## Terminology

### SHA Mode

#### $V_{IN}$ to $V_{OUT}$ Nonlinearity

This is a measure of the maximum deviation from a straight line passing through the endpoints of the  $V_{IN}$  vs.  $V_{OUT}$  transfer function. It is expressed as a percentage of the full-scale span.

#### Offset Error

This is a measure of the output error when  $V_{IN} = 100\text{mV}$ . Ideally, with  $V_{IN}=100\text{mV}$ :

$$V_{OUT} = 350\text{mV} - 2.5 \cdot V_{\text{OFFSET}}$$

Offset error is a measure of the difference between  $V_{OUT}$  (actual) and  $V_{OUT}$  (ideal). It is expressed in mV.

#### Full-Scale Error

This is a measure of the output error when  $V_{IN} = V_{\text{REF}}$ . Ideally, with  $V_{IN}=V_{\text{REF}}$ :

$$V_{OUT} = 3.5 \cdot V_{\text{REF}} - 2.5 \cdot V_{\text{OFFSET}}$$

Full-scale error is a measure of the difference between  $V_{OUT}$  (actual) and  $V_{OUT}$  (ideal). It is expressed in mV.

#### Gain Error

This is a measure of the span error of the analog channel. It is the deviation in slope of the transfer function expressed in mV. It is calculated as:

$$\text{Gain Error} = \text{Full-Scale error} - \text{Offset Error}$$

#### Channel-to-Channel Matching

This is a measure of the difference between  $V_{OUT}$  on any two channels if they acquire the same  $V_{IN}$ . It is expressed as a percentage of the Full-Scale span.

#### Output Temp Coefficient

This is a measure of the change in analog output with changes in temperature. It is expressed in ppm/°C.

#### Output PSRR

Power-Supply Rejection Ratio (PSRR) is a measure of the change in analog output for a change in supply voltage ( $V_{DD}$  and  $V_{SS}$ ). It is expressed in dBs.  $V_{DD}$  and  $V_{SS}$  are varied  $\pm 5\%$ . For the PSRR measurement of  $\text{OFFS\_OUT}$ , the  $\text{AV}_{CC}$  supply is varied  $\pm 5\%$ .

#### DC Crosstalk

This the DC change in the output level of one channel in response to a full-scale change in the output of all other channels. It is expressed in  $\mu\text{V}$ .

#### AC Crosstalk

This is the area of the glitch that occurs on the output of one channel while another channel is acquiring. It is expressed in nV-secs.

#### Output Settling Time

This is the time taken from when  $\overline{\text{BUSY}}$  goes high to when the output has settled to  $\pm 0.012\%$  ( $\pm 0.5$  LSB at 12 bits).

#### Acquisition Time

This is the time taken for the  $V_{IN}$  input to be acquired. It is the length of time that  $\overline{\text{BUSY}}$  stays low.

#### Digital Feedthrough

This is a measure of the impulse injected into the analog outputs from the digital control inputs when the part is not being written to, i.e.  $\text{CS/SYNC}$  is high. The digital inputs are toggled between all 0s and all 1s. The area of the glitch is expressed in nV-secs.

#### Digital Crosstalk

This is the area of the glitch transferred to the analog output while a digital word is being written to the part. The area of the glitch is expressed in nV-secs.

#### TRACK Mode Bandwidth

When  $\text{TRACK}$  input is brought low, the input voltage on  $V_{IN}$  is not acquired. It is connected directly to the output buffer stage and the output voltage is:

$$V_{OUT} = 3.5 \cdot V_{IN} - 2.5 \cdot V_{\text{OFFSET}}$$

$V_{IN}$  can, of course, be an AC waveform in which case the  $\text{TRACK}$  mode has a finite bandwidth. The bandwidth is the frequency at which the sine wave at the output falls to 3dB below the sine wave at the input (ignoring the gain factor).

## DAC Mode

#### Integral Nonlinearity (INL)

This is a measure of the maximum deviation from a straight line passing through the endpoints of the DAC transfer function. It is expressed as a percentage of Full-Scale span.

#### Differential Nonlinearity (DNL)

Differential Nonlinearity (DNL) is the difference between the measured change and the ideal 1 LSB change between any two adjacent codes. A specified DNL of  $\pm 1$  LSB maximum ensures monotonicity.

#### Offset Error

This is a measure of the output error with all zeroes loaded to the DAC. Ideally the output should be:

$$V_{OUT} = 350\text{mV} - 2.5 \cdot V_{\text{OFFSET}}$$

Offset error is a measure of the difference between  $V_{OUT}$  (actual) and  $V_{OUT}$  (ideal). It is expressed in mV.

#### Full-Scale Error

This is a measure of the output error with all ones loaded to the DAC. Ideally, the output should be:

$$V_{OUT} = 3.5 \cdot V_{\text{REF}} - 2.5 \cdot V_{\text{OFFSET}}$$

Full-scale error is a measure of the difference between  $V_{OUT}$  (actual) and  $V_{OUT}$  (ideal). It is expressed in mV.

#### Gain Error

This is a measure of the span error of the DAC. It is the deviation in slope of the transfer function expressed in mV. It is calculated as:

$$\text{Gain Error} = \text{Full-Scale error} - \text{Offset Error}$$

## AD5532/64 Prelim Technical Information

### Channel-to-Channel Matching

This is a measure of the difference between  $V_{OUT}$  on any two DACs if they have the same digital code loaded to them. It is expressed as a percentage of the Full-scale span.

### Output Settling Time

This is the time taken from when the last data bit is clocked into the DAC until the output has settled to within  $\pm 0.012\%$  ( $\pm 0.5$  LSB at 12 bits).

### OFFS\_IN Settling Time

This is the time taken from a step change in input voltage on OFFS\_IN until the output has settled to within  $\pm 0.012\%$  ( $\pm 0.5$  LSB at 12 bits).

### Digital-to-Analog Glitch Impulse

This is the area of the glitch injected into the analog output when the code in the DAC register changes state. It is specified as the area of the glitch in nV-secs when the digital code is changed by 1 LSB at the major carry transition (011...11 to 100...00).

### Digital Crosstalk

This is the area of the glitch transferred to the analog output while a DAC code is being written to the part. The area of the glitch is expressed in nV-secs.

### Analog Crosstalk

This is the area of the glitch transferred to the output of one DAC due to a full-scale change in the output of another DAC. The area of the glitch is expressed in nV-secs.

### Total Harmonic Distortion

This is the difference between an ideal sine-wave and a digitally constructed one using the DAC. The THD is a measure of the harmonics and noise present on the DAC output. It is measured in dBs.

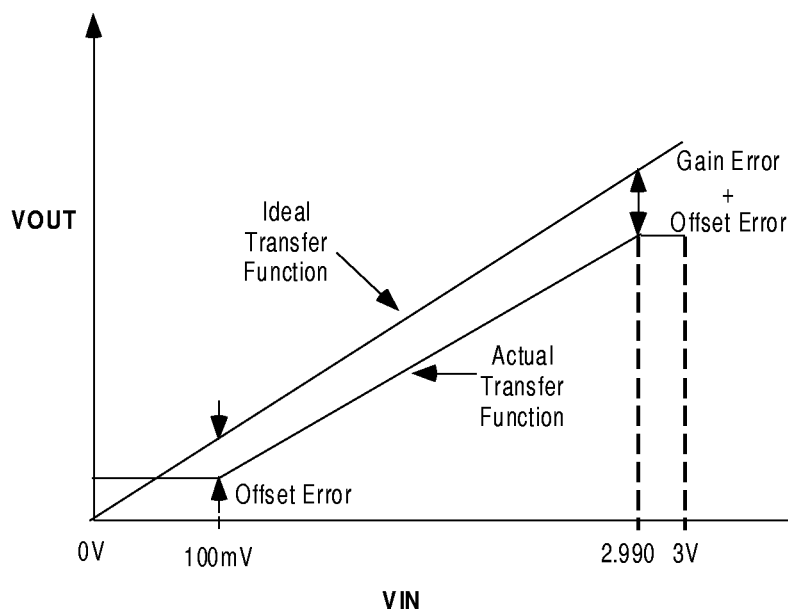


Figure 1. SHA Transfer Function



# AD5532/64 Prelim Technical Information

## PIN FUNCTION DESCRIPTION

### PIN NUMBERS

Pin No.	Mnemonic	Function
	AGND (1-4)	4 Analog GND pins.
	AV <sub>CC</sub> (1-4)	4 Analog supply pins. Voltage range from +4.75V to +5.25V.
	V <sub>DD</sub> (1-8)	8 V <sub>DD</sub> supply pins. Voltage range from +8V to +16.5V.
	V <sub>SS</sub> (1-8)	8 V <sub>SS</sub> supply pins. Voltage range from -4.75V to -16.5V.
	DGND (1-2)	2 Digital GND pins
	DV <sub>CC</sub> (1-2)	2 Digital supply pins. Voltage range from +2.7V to +5.25V.
	DAC_GND (1-4)	Reference GND supply for all the DACs.
	REF IN 1	Reference voltage for channels 0-31
	REF IN 2	Reference voltage for channels 32-63
	V <sub>OUT</sub> (0-63)	Analog output voltages from the 64 channels.
	V <sub>IN</sub>	Analog input voltage
	A5-A1 <sup>1</sup> , A0 <sup>2</sup>	Parallel Interface: 6 address pins for the 64 channels. A5=MSB of channel address, A0=LSB.
	CAL <sup>1</sup>	Parallel Interface: Control input which allows all 64 channels to acquire V <sub>IN</sub> simultaneously
	$\overline{\text{CS}}$ / $\overline{\text{SYNC}}$ <sup>2</sup>	This pin is both the active low Chip Select pin for the parallel interface and the Frame Synchronisation pin for the serial interface.
	$\overline{\text{WR}}$ <sup>1</sup>	Parallel Interface. Write pin. Active low. This is used in conjunction with the $\overline{\text{CS}}$ pin to address the device using the parallel interface.
	OFFSET_SEL <sup>1</sup>	Offset Select pin. This is activated when writing to the DAC which provides its output at the OFFS_OUT pin.
	SCLK <sup>2</sup>	Serial Clock input for serial interface. This can operate up at clock speeds up to 20MHz.
	D <sub>IN</sub> <sup>2</sup>	Data input for serial interface. Data must be valid on the falling edge of SCLK
	D <sub>OUT</sub>	Output from the DAC registers for readback. Data is clocked out on the rising edge of SCLK and is valid on the falling edge of SCLK.
	SER/ $\overline{\text{PAR}}$ <sup>1</sup>	This pin allows the user to select whether the serial or parallel interface will be used. If the pin is tied low, the parallel interface will be used. If it is tied high, the serial interface will be used.
	OFFS_IN	Offset input. The user can supply a voltage here to offset the output span. OFFS_OUT can also be tied to this pin if the user wants to drive this pin with the Offset Channel.
	OFFS_OUT	Offset output. This is the acquired offset voltage which can be tied to OFFS_IN to offset the span.
	$\overline{\text{BUSY}}$	This output tells the user when the input voltage is being acquired. It goes low during acquisition and returns high when the acquisition operation is complete.
	$\overline{\text{TRACK/RESET}}$ <sup>2</sup>	If this input is held high, V <sub>IN</sub> is acquired once the channel is addressed. While it is held low, the input to the gain/offset stage is switched directly to V <sub>IN</sub> . The addressed channel begins to acquire V <sub>IN</sub> on the rising edge of $\overline{\text{TRACK}}$ . See $\overline{\text{TRACK}}$ Input section for further information. This input can also be used as a means of resetting the complete device to its power-on-reset conditions. This is achieved by applying a low going pulse of between 50ns and 150ns to this pin. See section on RESET Function for further details.

#### NOTES:

<sup>1</sup>Internal Pull-down devices on these logic inputs. Therefore, they can be left floating and will default to a logic low condition.

<sup>2</sup>Internal Pull-up devices on these logic inputs. Therefore, they can be left floating and will default to a logic high condition.

# AD5532/64 Prelim Technical Information

## Circuit Description

The AD5532/64 can be thought of as consisting of an ADC and 32/64 DACs in a single package. The input voltage  $V_{IN}$  is sampled and converted into a digital word. The digital result is loaded into one of the DAC registers and is converted (after the gain and offset in the output buffer) into an analog output voltage ( $V_{OUT0}$  -  $V_{OUT63}$ ). Since the channel output voltage is effectively the output of a DAC there is no droop associated with it. As long as power is maintained to the device the output voltage will remain constant until this channel is addressed again.

To update a single channel's output voltage the required new voltage level is set up on the common input pin,  $V_{IN}$ . The desired channel is then addressed via the parallel port or the serial port. When the channel address has been loaded, provided  $\overline{TRACK}$  is high, the circuit begins to acquire the correct code to load to the DAC in order that the DAC output matches the voltage on  $V_{IN}$ . At this stage the  $\overline{BUSY}$  pin goes low and remains so until the acquisition is complete. The non-inverting input to the output buffer (gain and offset stage) is tied to  $V_{IN}$  during the acquisition period to avoid spurious outputs while the DAC acquires the correct code. This is completed in 16  $\mu$ s max. The  $\overline{BUSY}$  pin goes high at this stage. Also at this time the updated DAC output assumes control of the output voltage. The output voltage of the DAC is connected to the non-inverting input of the output buffer. The held voltage will remain on the output pin indefinitely, without drooping, as long as power is maintained to the device.

On power-on, all the DACs, including the offset channel, are loaded with zeroes. The outputs of the DACs are at 100mV and the outputs of the output buffers are at negative full-scale. If the OFFS\_IN pin is driven by the on-board offset channel, the outputs  $V_{OUT0}$  to  $V_{OUT63}$  are also at 100mV on power-on since  $OFFS\_IN = 100mV$  ( $V_{OUT} = 3.5 * V_{DAC} - 2.5 * V_{OFFSET} = 350mV - 250mV = 100mV$ ).

## TRACK Input

In normal mode of operation,  $\overline{TRACK}$  is held high and the channel begins to acquire when it is addressed. However, if  $\overline{TRACK}$  is low when the channel is addressed then  $V_{IN}$  is switched to the output buffer and an acquisition on the channel will not occur until a rising edge of  $\overline{TRACK}$ . At this stage the  $\overline{BUSY}$  pin will go low

until the acquisition is complete at which point the DAC assumes control of the voltage to the output buffer and  $V_{IN}$  is free to change again without affecting this output value.

This is useful in an application where the user wants to ramp up  $V_{IN}$  until  $V_{OUT}$  reaches a particular level (Figure 2).  $V_{IN}$  doesn't need to be acquired continuously while it is ramping up.  $\overline{TRACK}$  can be kept low and only when  $V_{OUT}$  has reached its desired voltage is  $\overline{TRACK}$  brought high. At this stage, the acquisition of  $V_{IN}$  begins.

In the example shown, a desired voltage is required on the output of the pin driver. This voltage is represented by one input to a comparator. The microcontroller/microprocessor ramps up the input voltage on  $V_{IN}$  through a DAC.  $\overline{TRACK}$  is kept low while the voltage on  $V_{IN}$  ramps up so that  $V_{IN}$  is not continually acquired. When the desired voltage is reached on the output of the pin driver, the comparator output switches. The  $\mu C/\mu P$  then knows what code is required to be input in order to get the desired voltage at the DUT. The  $\overline{TRACK}$  input is now brought high and the part begins to acquire  $V_{IN}$ . At this stage  $\overline{BUSY}$  goes low until  $V_{IN}$  has been acquired. Then the output buffer is switched from  $V_{IN}$  to the output of the DAC.

## Output Buffer Stage - Gain and Offset

The function of the output buffer stage is to translate the 0-3V output of the DAC to a useful range for ATE applications. This is done by gaining up the DAC output by 3.5 and offsetting the voltage by the voltage on  $OFFS\_IN$  pin. The following table shows how the output range relates to the Offset voltage supplied by the user.

$$V_{OUT} = 3.5 * V_{DAC} - 2.5 * V_{OFFSET}$$

$V_{DAC}$  is the output of the DAC and its range is 0- $V_{REF}$ .

$V_{OFFSET}$  is the voltage at the  $OFFS\_IN$  pin.

## SAMPLE OUTPUT RANGES

$V_{OFFSET}$ (V)	$V_{DAC}$ (V)	$V_{OUT}$ (V)
1	0 to 3	-2.5 to 8
0.5	0 to 3	-1.25 to 9.25

$V_{OUT}$  is limited only by the headroom of the output amplifiers.

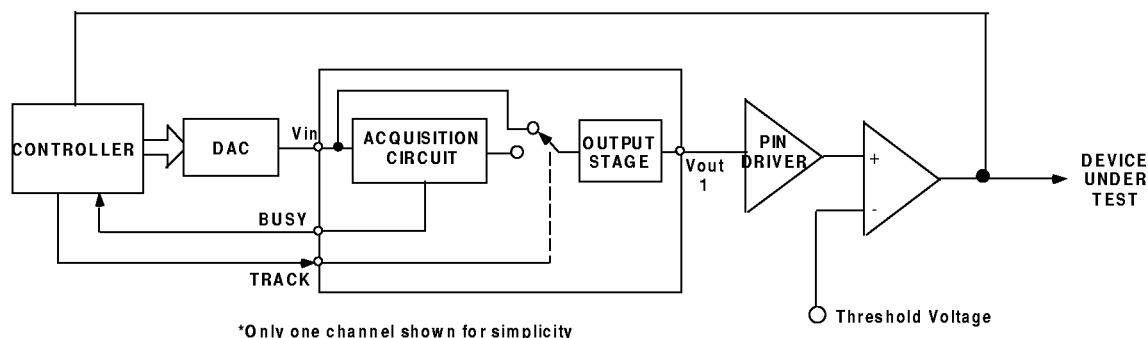


Figure 2. Typical ATE circuit using TRACK Input

# AD5532/64 Prelim Technical Information

## Offset Voltage Channel

The offset voltage can be supplied externally by the user or it can be supplied by an additional DAC on the device itself. The offset voltage channel is used just like any other channel. The required offset voltage is set up on  $V_{IN}$  and it is acquired by the DAC. The DAC output is connected directly to  $OFFS\_OUT$ . This offset voltage is used as the offset voltage for the 64 output amplifiers.

## Reset Function

The reset function on the AD5532/64 can be used to reset all nodes on this device to their power-on-reset condition. This is implemented by applying a low going pulse of between 50ns and 150ns to the  $\overline{TRACK/RESET}$  pin on the device. If the applied pulse is less than 50ns it is taken as being a glitch and no operation takes place. If the applied pulse is wider than 150ns this pin adopts its track function on the selected channel,  $V_{IN}$  is switched to the output buffer and an acquisition on the channel will not occur until a rising edge of  $\overline{TRACK}$ .

## INTERFACE

### Serial Interface

The serial interface is controlled by 4 pins.

$\overline{SYNC}$ ,  $D_{IN}$ ,  $SCLK$ : Standard 3-wire SPI interface pins.

The  $\overline{SYNC}$  pin is shared with the  $\overline{CS}$  function of the parallel interface.

$D_{OUT}$ : Data Out pin for reading back the contents of the DAC registers. The data is clocked out on the rising edge of  $SCLK$  and is valid on the falling edge of  $SCLK$ .

The  $\overline{SER/PAR}$  pin must also be tied high to enable the serial interface and to disable the parallel interface.

Mode bits: There are 4 different modes of operation. See below for descriptions.

Cal bit: This is used as a calibration instruction. When this is active, all 64 channels acquire  $V_{IN}$  simultaneously.

Offset\_Sel bit: Used to address the offset voltage control channel.

A5-A0: Used to address any one of the 64 channels (A5 = MSB of address, A0=LSB).

DB13-DB0: These are used to write a 14-bit word into the addressed DAC register. Clearly, this is only valid when in DAC mode.

The AD5532/64 can be used in 4 different modes of operation. These modes are set by two Mode bits, the first 2 bits in the serial word.

### MODES OF OPERATION

Mode Bit 1	Mode Bit 2	Operating Mode
0	0	SHA Mode
0	1	DAC Mode
1	0	Acquire and Readback
1	1	Readback

#### 1) SHA Mode:

Standard mode where a channel is addressed and that

channel acquires the voltage on  $V_{IN}$ . This mode requires a 10-bit write (see figure below) to address the relevant channel ( $V_{OUT0}$ - $V_{OUT63}$ , Offset Channel or all channels).

#### 2) DAC Mode:

In this mode, a particular DAC register can be written to directly. This mode requires the 10-bit write from the SHA mode plus an extra 14 bits to write to the 14-bit register of the DAC. Any one of the 64 DAC registers may be written to individually or they can all be loaded simultaneously.

#### 3)Acquire and Readback Mode:

This mode allows the user to read back the data in a particular DAC register. The relevant DAC is addressed (10-bit write as with SHA mode) and  $V_{IN}$  is acquired in typically 16 $\mu$ s. Following the acquisition the next falling edge of  $\overline{SYNC}$  clocks the data in the relevant DAC register out onto the  $D_{OUT}$  line in a 14-bit serial format. The full acquisition time must elapse before the DAC register data can be clocked out.

#### 4) Readback

Again, this is a readback mode but no acquisition is performed. The relevant DAC is addressed (10-bit write) and on the next falling edge of  $\overline{SYNC}$ , the data in the relevant DAC register is clocked out onto the  $D_{OUT}$  line in a 14-bit serial format.

The serial write and read words can be seen in the figures below.

#### Digital Readback

This feature allows the user to readback the DAC register code of any of the DACs. This is useful if the system has been calibrated and the user wants to know what code in the DAC corresponds to a desired voltage on  $V_{OUT}$ . If the user requires this voltage again, all he needs to do is to input the code directly to the DAC register without going through the acquisition sequence. The user can readback the DAC register contents through the serial interface and can write directly to the DAC, again through the serial interface.

#### Parallel Interface

The parallel interface is controlled by 10 pins.

$\overline{CS}$ : Active low package select pin. This pin is shared with the  $\overline{SYNC}$  function for the serial interface.

$\overline{WR}$ : Active low Write pin. The values on the address pins are latched on a rising edge of  $\overline{WR}$ .

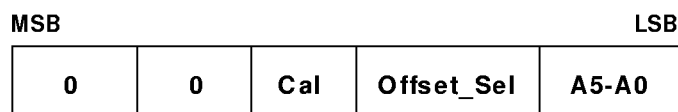
A5-A0: 6 Address pins (A5=MSB of address, A0=LSB). These are used to address the relevant channel (out of a possible 64).

Offset\_Sel: Offset select pin. This has the same function as the Offset\_Sel bit in the serial interface. When it is activated, the offset voltage control channel is addressed. The address on A5-A0 is ignored in this case.

Cal: Same functionality as the Cal bit in the serial interface (calibration instruction). When this pin is active, all 64 channels acquire  $V_{IN}$  simultaneously.

The  $\overline{SER/PAR}$  bit must be tied low to enable the parallel interface and disable the serial interface.

# AD5532/64 Prelim Technical Information



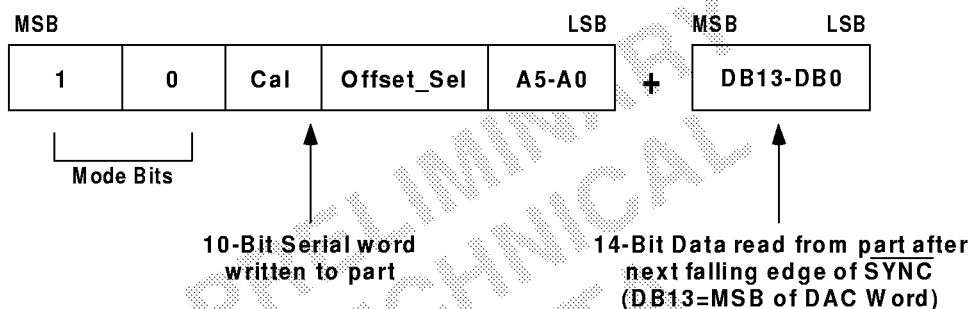
Mode Bits

10-Bit Input Serial Write Word (SHA Mode)

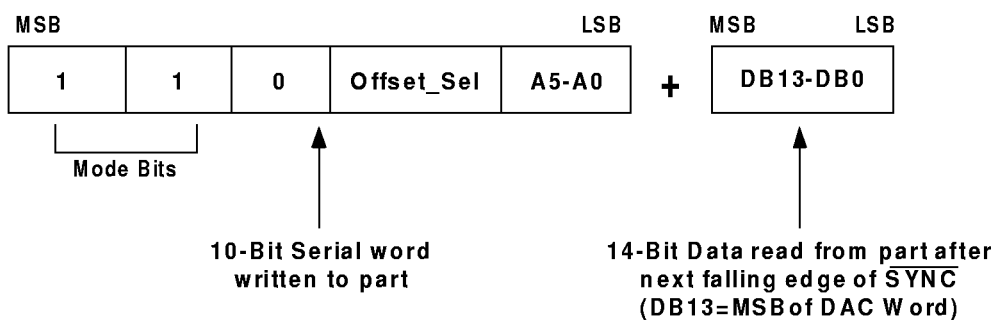


Mode Bits

24-Bit Input Serial Write Word (DAC Mode)

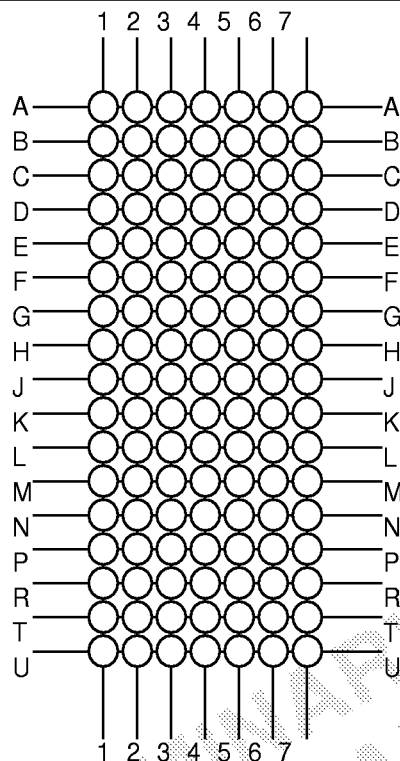


Input Serial Interface (Acquire and Readback Mode)



Input Serial Interface (Readback Mode)

# AD5532/64 Prelim Technical Information



**PBGA BALL CONFIGURATIONS**

PBGA Number	Ball Name	PBGA Number	Ball Name	PBGA Number	Ball Name	PBGA Number	Ball Name
A1	VO26	E3	AVSS8	J5	AGND3	N7	VO59
A2	$\overline{\text{CS}}/\text{SYNC}$	E4	AVSS7	J6	AGND4	P1	VO34
A3	A2	E5	N/C	J7	VO3	P2	VO41
A4	A1	E6	VO10	K1	VO31	P3	AVDD4
A5	A0	E7	VO5	K2	DACGND1	P4	AVDD7
A6	$\overline{\text{BUSY}}$	F1	VO14	K3	DACGND2	P5	REF_IN1
A7	VO9	F2	VO12	K4	DACGND3	P6	VO55
B1	VO25	F3	AVSS6	K5	DACGND4	P7	VO62
B2	$\overline{\text{WR}}$	F4	AVSS5	K6	AIN	R1	VO35
B3	SCLK	F5	DVCC1	K7	VO2	R2	VO40
B4	SDIN	F6	DVCC2	L1	VO32	R3	VO43
B5	SDOUT	F7	VO4	L2	AVCC1	R4	VO46
B6	OFFSEL	G1	VO16	L3	AVCC2	R5	VO63
B7	VO8	G2	OFFS_IN	L4	AVCC3	R6	VO54
C1	VO24	G3	OFFS_OUT	L5	AVCC4	R7	VO58
C2	VO22	G4	AVSS4	L6	VO0	T1	VO37
C3	A5	G5	$\text{SER}/\overline{\text{PAR}}$	L7	VO1	T2	VO39
C4	A4	G6	VO15	M1	VO27	T3	VO49
C5	A3	G7	VO17	M2	AVDD1	T4	VO48
C6	VO13	H1	VO18	M3	AVDD2	T5	VO45
C7	VO7	H2	AVSS1	M4	AVDD5	T6	VO53
D1	VO23	H3	AVSS2	M5	AVDD8	T7	VO57
D2	VO21	H4	AVSS3	M6	VO60	U1	VO36
D3	CAL	H5	$\overline{\text{TRACK}}/\overline{\text{RESET}}$	M7	VO61	U2	VO38
D4	DGND1	H6	VO19	N1	VO33	U3	VO50
D5	DGND2	H7	VO51	N2	VO42	U4	VO47
D6	VO11	J1	VO30	N3	AVDD3	U5	VO44
D7	VO6	J2	VO28	N4	AVDD6	U6	VO52
E1	VO29	J3	AGND1	N5	REF_OUT	U7	VO56
E2	VO20	J4	AGND2	N6	REF_IN2		