

## FEATURES

- Programmable frequency profile—no external components necessary
- Output frequency up to 25 Mhz
- Predefined frequency profile minimizes number of DSP/μcontroller writes
- Sinusoidal/triangular/square wave outputs
- Powerdown mode (20 μA)
- +2.3 V to +5.5 V power supply
- Extended temperature range –40°C to +105°C
- 16-pin TSSOP

## APPLICATIONS

- Frequency Scan
- Network/Impedance Measurements
- Incremental Frequency stimulus
- Sensory Applications—Proximity and Motion
- BFSK

## GENERAL DESCRIPTION

The AD5932 is a waveform generator providing a programmable frequency scan. Utilizing embedded digital processing allowing enhanced frequency control the device generates synthesized analog or digital frequency-stepped waveforms. Because frequency profiles are preprogrammed continuous write cycles are eliminated, thereby freeing up valuable DSP/μController resources. Waveforms start from a known phase and are incremented phase continuously allowing phase shifts to be easily determined. Consuming only 8mA the AD5932 provides a convenient low power solution to waveform generation.

To program the device, the user enters the start frequency, the increment step size, the number of increments to be made and the time interval the part stays at each frequency. The frequency profile can be initiated by toggling the CTRL pin.

*(continued on Page 3)*

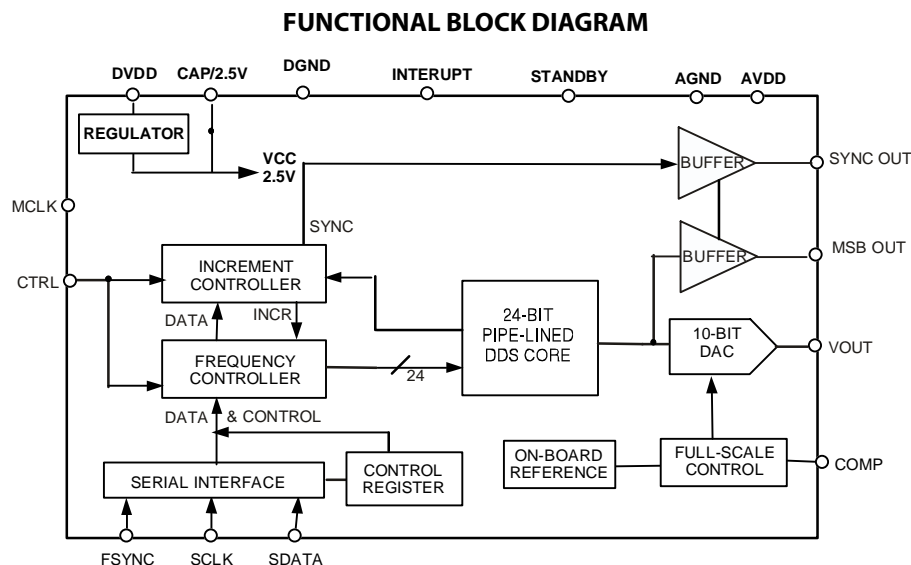


Figure 1.

\*Protected by US Patent Number 6747583, other patents pending

Rev. PrA 02/05

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**REVISION HISTORY**

Revision PrA: Preliminary Version

## GENERAL DESCRIPTION

*(continued from Page 1)*

A number of different scan profiles are offered. The user can choose to output the last frequency in the scan continuously, or can choose to return to midscale.

The AD5932 is written to via a 3-wire serial interface, which operates at clock rates up to 40 MHz. The device operates with a

power supply from 2.3 V to 5.5 V and has a standby function which allows sections of the device that are not being used to be powered down.

The AD5932 is available in a 16-pin TSSOP package.

## SPECIFICATIONS

$A_{VDD} = D_{VDD} = +2.3 \text{ V to } +5.5 \text{ V}$ ;  $AGND = DGND = 0 \text{ V}$ ;  $T_A = T_{MIN} \text{ to } T_{MAX}$ ; unless otherwise noted.

Table 1.

Parameter	Y Grade <sup>1</sup>			Unit	Test Conditions/Comments
	Min	Typ	Max		
<b>SIGNAL DAC SPECIFICATIONS</b>					
Resolution		10		Bits	From 0V to the trough of the waveform
Update Rate			50	MSPS	
Vout peak-to-peak		0.6		V	
Vout offset		30		mV	
Vout TC		200		ppm/°C	
DC Accuracy:					
Integral Nonlinearity (INL)		±1		LSB	
Differential nonlinearity (DNL)		±0.5		LSB	
<b>DDS SPECIFICATIONS</b>					
Dynamic Specifications:					
Signal to Noise Ratio	55	60		dB	$f_{MCLK} = 50 \text{ MHz}$ , $f_{OUT} = f_{MCLK}/4096$
Total Harmonic Distortion		-66	-56	dBc	$f_{MCLK} = 50 \text{ MHz}$ , $f_{OUT} = f_{MCLK}/4096$
Spurious Free Dynamic Range (SFDR):					
Wideband (0 to Nyquist)		-60	-56	dBc	$f_{MCLK} = 50 \text{ MHz}$ , $f_{OUT} = f_{MCLK}/50$
NarrowBand (± 200 kHz)		-78	-67	dBc	$f_{MCLK} = 50 \text{ MHz}$ , $f_{OUT} = f_{MCLK}/50$
Clock Feedthrough		-50		dBc	
Wake Up Time		1		ms	
<b>OUTPUT BUFFER</b>					
Vout peak-to-peak		$D_{VDD}$		V	Squarewave on MSB OUT
Output Rise/Fall Time		12		ns	When DAC data MSB is output
Output Jitter		120		ps rms	
<b>VOLTAGE REFERENCE</b>					
Internal Reference	1.12	1.18	1.24	V	
Reference TC		100		ppm/°C	
<b>LOGIC INPUTS</b>					
Input current			10	μA	$V_{DD} = 2.3 \text{ V to } 2.7 \text{ V}$ $V_{DD} = 2.7 \text{ V to } 5.5 \text{ V}$ $V_{DD} = 2.3 \text{ V to } 2.7 \text{ V}$ $V_{DD} = 2.7 \text{ V to } 5.5 \text{ V}$
$V_{INH}$ , input high voltage	1.7			V	
	2.0			V	
$V_{INL}$ , input low voltage			0.7	V	
			0.8	V	
$C_{IN}$ , input capacitance <small>Error! Bookmark not defined.</small>		3		pF	
<b>LOGIC OUTPUTS</b>					
$V_{OHL}$ , output high voltage	$D_{VDD} - 0.8 \text{ V}$			V	$I_{SINK} = 1 \text{ mA}$
$V_{OL}$ , output low voltage			0.4	V	$I_{SINK} = 1 \text{ mA}$
Floating-state O/P capacitance		8		pF	
<b>POWER REQUIREMENTS</b>					
$A_{VDD}/D_{VDD}$	2.3		5.5	V	$f_{MCLK} = 50 \text{ MHz}$ , $f_{OUT} = f_{MCLK}/7$
$I_{AA}$		3.8	5	mA	All outputs powered down, MCLK = 0MHz, Serial interface active
$I_{DD}$		2.0	3	mA	
$I_{AA} + I_{DD}$		5.8	8	mA	
Low Power Sleep Mode		20		μA	

<sup>1</sup> Operating temperature range is as follows: Y Version: -40°C to +105°C; typical specifications are at 25°C.



## ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 2.

Parameter	Rating
AVDD to AGND	-0.3 V to +6 V
DVDD to DGND	-0.3 V to +6 V
AGND to DGND.	-0.3 V to +0.3 V
CAP/2.5V to DGND	2.75 V
Digital I/O Voltage to DGND	-0.3 V to DVDD + 0.3 V
Analog I/O Voltage to AGND	-0.3 V to AVDD + 0.3 V
Operating Temperature Range	
Extended (Y Version)	-40°C to +105°C
Storage Temperature Range	-65°C to +150°C
Maximum Junction Temperature	+150°C
TSSOP Package	
$\theta_{JA}$ Thermal Impedance	143°C/W
$\theta_{JC}$ Thermal Impedance	45°C/W
Lead Temperature, Soldering (10 sec)	300°C
IR Reflow, Peak Temperature	220°C

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.

### ESD 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 this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



## PIN CONFIGURATIONS AND FUNCTIONAL DESCRIPTIONS

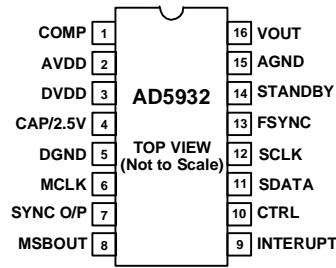


Figure 2.

Table 3. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	COMP	DAC Bias Pin. This pin is used for de-coupling the DAC bias voltage to AVDD.
2	AVDD	Positive power supply for the analog section. AVDD can have a value from +2.3 V to +5.5 V. A 0.1 $\mu$ F decoupling capacitor should be connected between AVDD and AGND.
3	DVDD	Positive power supply for the digital section. DVDD can have a value from +2.3 V to +5.5 V. A 0.1 $\mu$ F decoupling capacitor should be connected between DVDD and DGND.
4	CAP/2.5V	The digital circuitry operates from a +2.5 V power supply. This +2.5 V is generated from DVDD using an on board regulator. The regulator requires a decoupling capacitor of typically 100 nF which is connected from CAP/2.5 V to DGND. If DVDD is equal to or less than +2.7 V, CAP/2.5 V can be shorted to DVDD.
5	DGND	Ground for all Digital Circuitry.
6	MCLK	Digital Clock Input. DDS output frequencies are expressed as a binary fraction of the frequency of MCLK. The output frequency accuracy and phase noise are determined by this clock.
7	SYNC O/P	Digital Output for Scan Status information. User selectable for “End of Scan” (EOS), or Frequency Increments through the control register (SYNCOP bit). This pin must be enabled through setting control register bit SYNCOPEN to 1.
8	MSB OUT	Digital Output. The inverted MSB of the DAC data is available at this pin. This output pin must be enabled by setting bit OPBITEN in the control register to 1.
9	INTERUPT	Digital Input. This pins acts as an interrupt during a frequency scan. A Low to High transition is sampled by the internal MCLK, which resets internal state machines. This results in the DAC output going to midscale.
10	CTRL	Digital Input. Triple Function pin for Initalisation, Start and External frequency Increments. A low-to-high transition, sampled by the internal MCLK, is used to initialise and start internal state machines, which then execute the pre-programmed frequency scan sequence. When in Auto-Increment mode, a single pulse executes the entire scan sequence, while in External – Increment mode, each frequency increment is triggered by low-to-high transitions.
11	SDATA	Serial Data Input. The 16-bit serial data word is applied to this input, with the register address first followed by the MSB to LSBs of the data.
12	SCLK	Serial Clock Input. Data is clocked into the AD5932 on each falling SCLK edge.
13	FSYNC	Active Low Control Input. This is the frame synchronisation signal for the serial data. When FSYNC is taken low, the internal logic is informed that a new word is being loaded into the device.
14	STANDBY	Active high digital input. When this pin is high, the internal MCLK is disabled, and the reference, DAC and regulator are powered down. This resultsin a shutdown current of typically 20 $\mu$ A.
15	AGND	Ground for all Analog Circuitry.
16	VOUT	Voltage Output. The analog outputs from the AD5932 are available here. An external resistive load is not required as the device has a 200 $\Omega$ resistor on board. A 20 pF capacitor to AGND is recommended to act as a low-pass filter and to reduce clock feedthrough.

## TERMINOLOGY

### Integral Nonlinearity

This is the maximum deviation of any code from a straight line passing through the endpoints of the transfer function. The endpoints of the transfer function are zero scale, a point 0.5 LSB below the first code transition (000 . . . 00 to 000 . . . 01) and full scale, a point 0.5 LSB above the last code transition (111 . . . 10 to 111 . . . 11). The error is expressed in LSBs.

### Differential Nonlinearity

This is the difference between the measured and ideal 1 LSB change between two adjacent codes in the DAC. A specified differential nonlinearity of  $\pm 1$  LSB maximum ensures monotonicity.

### Spurious Free Dynamic Range

Along with the frequency of interest, harmonics of the fundamental frequency and images of these frequencies are present at the output of a DDS device. The spurious free dynamic range (SFDR) refers to the largest spur or harmonic which is present in the band of interest. The wide band SFDR gives the magnitude of the largest harmonic or spur relative to the magnitude of the fundamental frequency in the 0 to Nyquist bandwidth. The narrow band SFDR gives the attenuation of the largest spur or harmonic in a bandwidth of  $\pm 200$  kHz about the fundamental frequency.

### Total Harmonic Distortion

Total Harmonic Distortion (THD) is the ratio of the rms sum of harmonics to the rms value of the fundamental. For the AD5932, THD is defined as:

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

where  $V_1$  is the rms amplitude of the fundamental and  $V_2, V_3, V_4, V_5$  and  $V_6$  are the rms amplitudes of the second through sixth harmonic.

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

S/N is the ratio of the rms value of the measured output signal to the rms sum of all other spectral components below the Nyquist frequency. The value for SNR is expressed in decibels.

### Clock Feedthrough

There will be feedthrough from the MCLK input to the analog output. Clock feedthrough refers to the magnitude of the MCLK signal relative to the fundamental frequency in the AD5932's output spectrum.



## DETAILED OPERATION

The AD5932 is a General Purpose Synthesized Waveform Generator capable of providing digitally programmable Waveform Sequences in both the frequency and time domain. The device contains embedded digital processing to provide a scan of a user-programmable frequency profile allowing enhanced frequency control. Because the device is pre-programmable, it eliminates continuous write cycles from a DSP/microcontroller in generating a particular waveform.

The frequency profile is defined by a Start Frequency ( $F_{START}$ ), a Frequency Increment ( $\Delta f$ ) and the number of increments per Scan ( $N_{INCR}$ ). The Increment interval between frequency increments, ( $t_{INT}$ ), is either user-programmable and frequency automatically incremented by the device or externally controlled via a hardware pin. For automatic update the interval profile can either be for a fixed number of clock periods or for a fixed number of output waveform cycles. An example of a 3-step frequency scan is shown in Figure 3. Note the frequency swept output signal is continuously available, and is therefore phase continuous at all frequency increments.

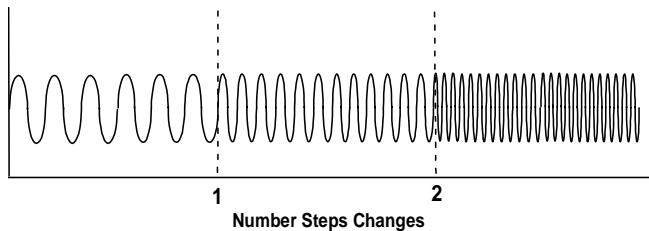


Figure 3. Operation of the AD5932

In the auto-increment mode, a single pulse at the CTRL pin starts and executes the frequency scan. In the external-increment mode the CTRL pin also starts the scan but the frequency increment interval is determined by the time interval between sequential 0 / 1 transitions on the CTRL pin.

The user has the option of two outputs once the frequency scan is complete:

- Output the last frequency in the scan or reset and output midscale.

For the first option, the AD5932 completes the frequency scan from frequency-start to frequency-end, i.e. from  $F_{START}$  incrementally to  $(F_{START} + N_{INCR} \times \Delta f)$ , and then continues to output the last frequency in the scan. This is shown in Figure 4. This gives a frequency scan time of  $(N_{INCR} + 1) \times T_{INT}$ .

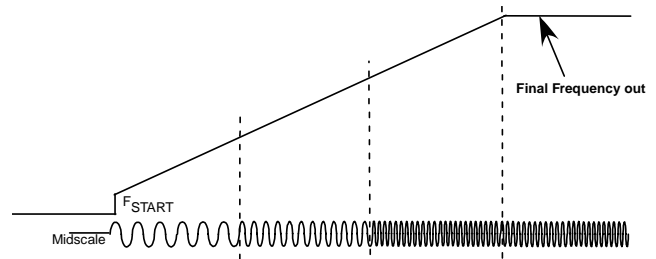


Figure 4. Frequency scan, Final frequency out

For the second option, the A5932 completes the scan as before, but in this case it outputs Midscale at the end of the scan. As before, the frequency scan time is  $(N_{INCR} + 1) \times T_{INT}$ . This is shown in Figure 5.

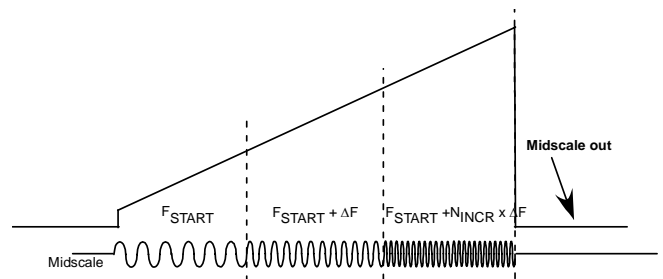


Figure 5. Frequency scan, Midscale out

The AD5932 offers two digital outputs, available from the MSB OUT pin and the SYNC O/P pin. The inverted MSB of the DAC data is available at the MSB OUT pin. The SYNC O/P can be used to give the status of the scan. It is user selectable for the End of the Scan, or to output a  $4 \times T_{CLOCK}$  pulse at frequency increments.

## FUNCTIONAL DESCRIPTION

### Serial Interface

The AD5932 has a standard 3-wire serial interface, which is compatible with SPI, QSPI, MICROWIRE and DSP interface standards.

Data is loaded into the device as a 16-bit word under the control of a serial clock input, SCLK. The timing diagram for this operation is given in Figure .

The FSYNC input is a level triggered input that acts as a frame synchronization and chip enable. Data can only be transferred into the device when FSYNC is low. To start the serial data transfer, FSYNC should be taken low, observing the minimum FSYNC to SCLK falling edge setup time,  $t_s$ . After FSYNC goes low, serial data will be shifted into the device's input shift register on the falling edges of SCLK for 16 clock pulses. FSYNC may be taken high after the sixteenth falling edge of SCLK, observing the minimum SCLK falling edge to FSYNC rising edge time,  $t_r$ . Alternatively, FSYNC can be kept low for a multiple of 16 SCLK pulses, and then brought high at the end of

the data transfer. In this way, a continuous stream of 16 bit words can be loaded while FSYNC is held low, FSYNC only going high after the 16th SCLK falling edge of the last word loaded.

The SCLK can be continuous or, alternatively, the SCLK can idle high or low between write operations.

### Powering Up the AD5932

When the AD5932 is powered up, the part is in an un-defined state, and therefore must be reset before use. The 7 registers (control and frequency) will contain invalid data and, therefore, should all be set to a known value by the user. The control register should be the first register to be programmed, as this sets up the part. Note that a write to the control register will automatically reset the internal state machines, and will provide an analog output of midscale as it provides the same function as the INTERRUPT pin. Typically, this is followed by a serial loading of all the required scan parameters. The DAC output remains at midscale until a scan is started using the CTRL pin.

### OUTPUTS FROM THE AD5932

The AD5932 offers a variety of outputs from the chip. The analog outputs are available from the  $V_{OUT}$  pin, and include a sinewave and a triangle output. The square-wave output is available from the MSB OUT pin.

**Sinusoidal Output:** The SIN ROM is used to convert the phase information from the frequency and phase registers into amplitude information, which results in a sinusoidal signal at the output. To have a sinusoidal output from the  $V_{OUT}$  pin, set the bit SINE/TRI (D9) in the control register to 1.

**Triangle Output:** The SIN ROM can be bypassed so that the truncated digital output from the NCO is sent to the DAC. In this case, the output is no longer sinusoidal. The DAC produces 10-bit linear triangular function. To have a triangle output from the  $V_{OUT}$  pin, set the bit SINE/TRI (D9) = 0.

Note that the DAC ENABLE bit (D10) must be "1" (i.e. the DAC is enabled) when using these pins.

**Digital Outputs:** The digital outputs are available from the MSB OUT pin and the SYNCOP pin. The inverse of the MSB of the DAC data is available at the MSB OUT pin. The MSB OUT pin must be enabled before use. The enabling/disabling of this pin is controlled by the bit MSBOUTEN (D8) in the control

register. When MSBOUTEN = 1, this pin is enabled. This is useful as a synthesised clock source.

### PROGRAMMING THE AD5932

The AD5932 is designed to provide automatic frequency scans when the CTRL pin is triggered. The automatic scan is controlled by a set of registers, the addresses of which are given in the table below. The function of each register is described in the subsequent pages.

Table 4. Register Addresses

Register Address				Mnemonic	Name
D15	D14	D13	D12		
0	0	0	0	C <sub>REG</sub>	Control Bits
0	0	0	1	N <sub>INCR</sub>	Number of Increments
0	0	1	0	$\Delta f$	Lower 12 bits of Delta Frequency
0	0	1	1	$\Delta f$	Higher 12 bits of Delta Frequency
0	1			T <sub>INT</sub>	Increment Interval
1	0	x	x		Reserved
1	1	0	0	F <sub>START</sub>	Lower 12 bits of Start Frequency
1	1	0	1	F <sub>START</sub>	Higher 12 bits of Start Frequency
1	1	1	0		Reserved
1	1	1	1		Reserved

### The Control Register

The AD5932 contains a 12-bit control register which sets up the operating modes of the AD5932. The different functions and the various output options from the AD5932 are controlled by this register. Table 5 below describes the individual bits of the control register.

To address the control register, D15 to D12 of the 16-bit serial word must be set to '0'.

Table 5. Control Register

D15	D14	D13	D12	D11	D0
0	0	0	0	CONTROL BITS	

Table 6. Description of bits in the Control Register

Bit	Name	Function
D15– D12	ADDR	Register Address bits.
D11	B24	Two write operations are required to load a complete word into the $F_{START}$ register and the $\Delta f$ register. B24 = '1' allows a complete word to be loaded into a frequency register in two consecutive writes. The first write contains the 12 LSBs of the frequency word and the next write will contain the 12 MSBs. Refer to Table 4 for the appropriate addresses. The write to the destination register occurs after both words have been loaded, so the register never holds an intermediate value. When B24 = '0' the 24-bit $F_{START} / \Delta f$ register operates as 2 12-bit registers, one containing the 12 MSBs and the other containing the 12 LSBs. This means that the 12 MSBs of the frequency word can be altered independent of the 12 LSBs and vice versa. This is useful if the complete 24 bit update is not required. To alter the 12 MSBs or the 12 LSBs, a single write is made to the appropriate register address. Refer to Table 4 for the appropriate addresses.
D10	DAC ENABLE	When DAC ENABLE = '1', the DAC is enabled. When DAC ENABLE = '0', the DAC is powered down. This is useful if a user is just using the MSB of the DAC data (available at the MSBOUT pin), and wants to save power.
D9	SINE/TRI	The function of this bit is to control what is available at the $V_{OUT}$ pin. When SINE/TRI = '1' the SIN ROM is used to convert the phase information into amplitude information which results in a sinusoidal signal at the output (See Table 4). When SINE/TRI = '0', the SIN ROM is bypassed, resulting in a triangular (up-down) output from the DAC.
D8	MSBOUTEN	When MSBOUTEN = '1', the MSBOUT pin is enabled. When MSBOUTEN = '0', the MSBOUT is disabled (tri-state).
D7	Reserved	This bit must always be set to 1.
D6	Reserved	This bit must always be set to 1.
D5	INT/EX INCR	When INT/EX INCR = '1' the frequency increments are triggered externally through the CTRL pin. When INT/EX INCR = '0', the frequency increments are triggered automatically.
D4	MODE	The function of this bit is to control what the AD5932 will output at the end of the frequency scan. When MODE = '1', the devcie outputs the last frequency in the scan. When MODE = '0', the AD5932 resets and outputs miscale.
D3	SYNCSEL	User selectable for "End of Scan" (EOS), or Frequency Increments When SYNCSEL = '1', the SYNCOP pin outputs a high level the End of the scan and returns to zero at the start of a new frequency scan. When SYNCSEL = '0', the SYNCOP outputs a pulse of $4 \times T_{CLOCK}$ only at each frequency increment.
D2	SYNCOUTEN	When SYNCOUTEN = '1', the SYNC output is available at the pin SYNCOP. When SYNCOUTEN = '0', the SYNCOP pin is disabled (tri-state).
D1	Reserved	This bit must always be set to 1.
D0	Reserved	This bit must always be set to 1.

## SETTING UP THE FREQUENCY SCAN

As stated previously, the AD5932 requires certain registers to be programmed to enable a frequency scan. The frequency profile is described by data for the Start Frequency ( $F_{START}$ ), the Frequency Increment ( $\Delta f$ ) and for the number of increments per Scan ( $N_{INCR}$ ). The Increment interval ( $T_{INT}$ ) between frequency increments during the scan is user-programmable, and can either be for a fixed number of clock periods or for a fixed number of output waveform cycles. The following section discusses these registers in more detail.

### Start Frequency ( $F_{START}$ )

To start a frequency scan, the user needs to tell the AD5932 what frequency to start scanning from. This frequency is stored in a 24-bit register called  $F_{START}$ . If the user wishes to alter the entire contents of the  $F_{START}$  register, two consecutive writes must be preformed, one to the LSBs and the other to the MSBs. Note that for an entire write to this register, the control bit B24 (D11) should be set to '1'. With the LSBs programmed first.

Table 7.  $F_{START}$  Register Bits

D15	D14	D13	D12	D11	D0
1	1	0	0	12 LSBs of $F_{START}$ <11...0>	
1	1	0	1	12 MSBs of $F_{START}$ <23...12>	

In some applications, the user does not need to alter all 24 bits of the  $F_{START}$  register. By setting the control bit B24 (D11) to '0', the 24-bit register operates as two 12-bit registers, one containing the 12 MSBs and the other containing the 12 LSBs. This means that the 12MSBs of the  $F_{START}$  word can be altered independently of the 12 LSBs, and vice versa. The addresses of both the LSBs and the MSBs of this register is given in Table 7.

### Frequency Increments ( $\Delta f$ )

The value in the  $\Delta f$  register sets the Increment frequency for the scan and is added incrementally to the current frequency being output. Note that the increment frequency can be positive or negative, thereby giving an increasing or decreasing frequency scan.

At the start of a scan, the frequency contained in the  $F_{START}$  register will be output. Next, the frequency ( $F_{START} + \Delta f$ ) will be output. This will be followed by ( $F_{START} + \Delta f + \Delta f$ ) and so on. Multiplying the  $\Delta f$  value by the number of Increments ( $N_{INCR}$ ), and adding it to the start frequency ( $F_{START}$ ), will give the final frequency in the scan. Mathematically this final frequency/stop frequency is represented by  $F_{START} + (N_{INCR} \times \Delta f)$ . The  $\Delta f$  register is a 23-bit register, and requires two 16-bit writes to be programmed. Table 8 gives the addresses associated with both the MSB and LSB registers of the  $\Delta f$  word.

Table 8.  $\Delta f$  Register Bits

D15	D14	D13	D12	D11	D10	D0	Scan Direction
0	0	1	0	12 LSBs of $\Delta f$			n/a
				<11...0>			
0	0	1	1	0	11 MSBs of $\Delta f$		Positive $\Delta f$
					<22...12>		( $F_{START} + \Delta f$ )
0	0	1	1	1	11 MSBs of $\Delta f$		Negative $\Delta f$
					<22...12>		( $F_{START} - \Delta f$ )

### Number of Increments ( $N_{INCR}$ )

An End frequency is not required on the AD5932. Instead, this End frequency is calculated by multiplying the frequency Increment value ( $\Delta f$ ) value by the number of Frequency Steps ( $N_{INCR}$ ), and adding it to/subtracting it from the start frequency ( $F_{START}$ ), i.e.  $F_{START} + (N_{INCR} \times \Delta f)$ .

The  $N_{INCR}$  register is a 12 bit register, with the address shown in the table below.

Table 9.  $N_{INCR}$  Register Bits

D15	D14	D13	D12	D11	D0
0	0	0	1	12 bits of $N_{INCR}$	
				<11...0>	

The number of increments is programmed in binary fashion, with 00000000010 representing the minimum number of frequency increments (2 increments), and 11111111111 representing the maximum number of increments (4095).

Table 10.  $N_{INCR}$  Data Bits

D11	D0	No. of Increments	
0000	0000	0010	2 frequency increments. This is a minimum number of Frequency Increments
0000	0000	0011	3 frequency increments.
0000	0000	0100	4 frequency increments.
...		...	
1111	1111	1110	4094 frequency increments.
1111	1111	1111	4095 frequency increments.

### Increment Interval ( $T_{INT}$ )

The increment interval dictates the duration for which the DAC output signal for each individual frequency of the Frequency scan will be available. The AD5932 offers the user two choices:

- To have the duration as a multiple of cycles of the output frequency.
- To have the duration as a multiple of MCLK periods.

This is selected by Bit D13 in the  $T_{INT}$  register as shown in Table 11.

**Table 11.  $t_{INT}$  Register Bits**

D15	D14	D13	D12	D11	D10	D0
0	1	0	x	x	11 bits <10 .....0> Fixed number of output waveform cycles	
0	1	1	x	x	11 bits <10 ....0> Fixed number of clock periods	

Programming of this register is in binary form with the minimum number being decimal 2. Note from the table above that there are 11 bits, <D10 to D0>, of the register available to program the time interval. As an example, for MCLK = 50 MHz, each clock period/base interval is  $(1/50 \text{ MHz}) = 20 \text{ ns}$ . If, for example, each frequency needs to be output for 100ns, then <00000000101> or decimal 5 needs to be programmed to this register. Note that the AD5932 can output each frequency for a maximum duration of  $2^{11} - 1$  (or 2047) times the increment interval. So for the MCLK = 50MHz example, a time interval of  $20 \text{ ns} \times 2047 = 40 \mu\text{s}$  is maximum, with the minimum being 40 ns.

In the example above, the maximum time that an individual frequency can be output is 40  $\mu\text{s}$ . For some applications, this may be insufficient. Therefore to cater for scans that need a longer Increment Interval, Time-base Multipliers are provided. In

Table 11, D12 and D11 are dedicated to the Time-base Multipliers. A more detailed table of the Multiplier options is given in Table 12 below.

To explain this via an example, and again assuming an MCLK of 50 MHz. If a multiplier of 500 is used, then the base interval is now  $(1/(50 \text{ MHz}) \times 500) = 10\mu\text{s}$ . Therefore, using a multiplier of 500, the maximum Increment Interval is  $10 \mu\text{s} \times 2^{11} - 1 = 20.5 \text{ ms}$ . Therefore, as can be seen from the example above, the option of Time-base Multipliers gives the user great flexibility when programming the length of the frequency window as any frequency can be output for a minimum of 40 ns up to a maximum of 20.5 ms.

**Table 12. Time-base Multiplier Values**

D12	D11	Multiplier value
0	0	Multiply (1/MCLK) by 1
0	1	Multiply (1/MCLK) by 5
1	0	Multiply (1/MCLK) by 100
1	1	Multiply (1/MCLK) by 500

**Length of Scan Time**

The length of time to complete a user-programmed frequency scan is given by the following equation:

$$T_{SCAN} = (1 + N_{INCR}) \times T_{INT}$$

OUTLINE DIMENSIONS

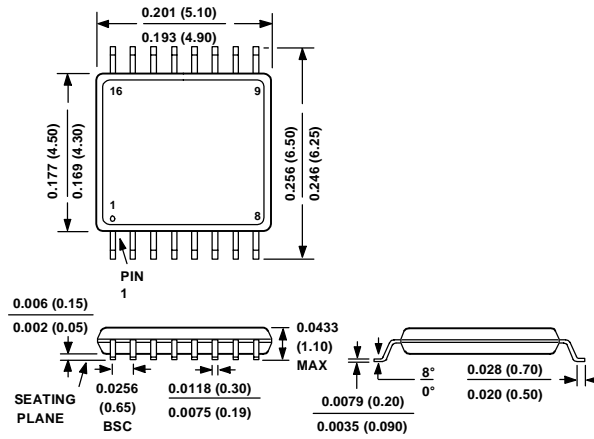


Figure 3. 16-Lead Small Outline Package (TSSOP)  
(RU-16)  
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
AD5932YRUZ	-40 °C to +105 °C	16-lead TSSOP (Thin Shrink Small Outline Package)	RU-16
AD5932YRUZ-REEL	-40 °C to +105 °C	16-lead TSSOP (Thin Shrink Small Outline Package)	RU-16

