10-Bit, 1 MSPS, 8-Channel, Single-Ended, MicroPower, Serial Interface ADC

Check for Samples: ADS7955-Q1

FEATURES

- **Qualified for Automotive Applications**
- **1-MHz Sample Rate Serial Devices**
- **10-Bit Resolution**
- **Zero Latency**
- **20-MHz Serial Interface**
- **Analog Supply Range: 2.7 to 5.25 V**
- **I/O Supply Range: 1.7 to 5.25 V**
- **Two SW Selectable Unipolar, Input Ranges: 0 to 2.5V and 0 to 5V**
- **Auto and Manual Modes for Channel Selection**
- **8-Channel Device can Share 16 Channel Device Footprint**
- **Two Programmable Alarm Levels per Channel**
- **Four Individually Configurable GPIOs for TSSOP Package Devices**
- **Typical Power Dissipation: 14.5 mW (+VA = 5 V, +VBD = 3 V) at 1 MSPS**
- **Power-Down Current (1 µA)**
- **Input Bandwidth (47 MHz at 3 dB)**
- **30-Pin TSSOP Package**

APPLICATIONS

- **PLC / IPC**
- **Battery Powered Systems**
- **Medical Instrumentation**
- **Digital Power Supplies**
- **Touch Screen Controllers**
- **High-Speed Data Acquisition Systems**
- **High-Speed Closed-Loop Systems**

DESCRIPTION

The ADS7955-Q1 is a 10-bit multichannel analog-to-digital converter.

The device includes a capacitor based SAR A/D converter with inherent sample and hold.

The device accepts a wide analog supply range from 2.7V to 5.25V. Very low power consumption makes this device suitable for battery-powered and isolated power supply applications.

A wide 1.7V to 5.25V I/O supply range facilitates a glue-less interface with the most commonly used CMOS digital hosts.

The serial interface is controlled by $\overline{CS}$ and SCLK for easy connection with microprocessors and DSP.

The input signal is sampled with the falling edge of $\overline{CS}$. It uses SCLK for conversion, serial data output, and reading serial data in. The device allows auto sequencing of preselected channels or manual selection of a channel for the next conversion cycle.

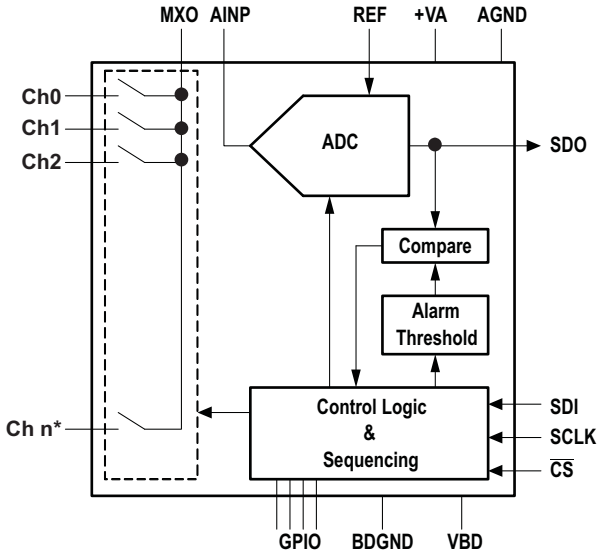
There are two software selectable input ranges (0V - 2.5V and 0V - 5V), four individually configurable GPIOs, and two programmable alarm thresholds per channel. These features make the device suitable for most data acquisition applications.

The device offers an attractive power-down feature. This is extremely useful for power saving when the device is operated at lower conversion speeds.

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ADS7955-Q1 BLOCK DIAGRAM



NOTE: n* is number of channels (16,12,8, or 4) depending on the device from the ADS79XX product family.

NOTE: 4 number of GPIO are available in TSSOP package device.

ORDERING INFORMATION - 10-BIT

T_A	MAXIMUM INTEGRAL LINEARITY (LSB)	MAXIMUM DIFFERENTIAL LINEARITY (LSB)	NO MISSING CODES AT RESOLUTION (BIT)	NUMBER OF CHANNELS	PACKAGE	ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	±0.5	±0.5	10	8	30 pin TSSOP - DBT	ADS7955QDBTRQ1	ADS7955Q1

ABSOLUTE MAXIMUM RATINGS(1)

	VALUE	UNIT
AINP or CHn to AGND	–0.3 to +VA +0.3	V
+VA to AGND, +VBD to BDGND	–0.3 to +7.0	V
Digital input voltage to BDGND	–0.3 to (7.0)	V
Digital output to BDGND	–0.3 to (+VA + 0.3)	V
Operating temperature range	–40 to 125	°C
Storage temperature range	–65 to 150	°C
Junction temperature	150	°C
Power dissipation	$(T_J$ Max–$T_A)/\theta_{JA}$	
DBT packaged versions rated for MSL3 260C per JSTD-020 specifications		
Human Body Model (HBM) ESD, Class H2 per Q100-002	2	kV
Machine Model (MM) ESD, Class M2 per Q100-003	200	V
Charged Device Model (CDM) ESD, Class C3B2 per Q100-011	Maximum withstand voltage > 500 to ≤ to 750 V with corner pins > 750	V
Latch up (per JESD78)	Class I	

(1) Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.

THERMAL INFORMATION

THERMAL METRIC(1)		ADS7955-Q1 DBT 30 PINS	UNITS
θ_{JA}	Junction-to-ambient thermal resistance(2)	89.83	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance(3)	22.94	
θ_{JB}	Junction-to-board thermal resistance(4)	43.13	
ψ_{JT}	Junction-to-top characterization parameter(5)	0.77	
ψ_{JB}	Junction-to-board characterization parameter(6)	42.52	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance(7)	22.94	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.
(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
(3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
(4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
(5) The junction-to-top characterization parameter, ψ_{JT}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA}, using a procedure described in JESD51-2a (sections 6 and 7).
(6) The junction-to-board characterization parameter, ψ_{JB}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA} , using a procedure described in JESD51-2a (sections 6 and 7).
(7) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

ELECTRICAL CHARACTERISTICS

+VA = 2.7 V to 5.25 V, +VBD = 1.7 V to 5.25 V, V_{ref} = 2.5 V ± 0.1 V, T_A = -40°C to 125°C, f_{sample} = 1 MHz (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ANALOG INPUT					
Full-scale input span(1)	Range 1	0		Vref	V
	Range 2 while 2Vref ≤ +VA	0		2*Vref	
Absolute input range	Range 1	–0.20		VREF +0.20	V
	Range 2 while 2Vref ≤ +VA	–0.20		2*VREF +0.20	
Input capacitance			15		ρF
Input leakage current	T_A = 125°C		61		nA
SYSTEM PERFORMANCE					
Resolution			10		Bits
No missing codes		10			Bits
Integral linearity		–0.5	±0.2	0.5	LSB(2)
Differential linearity		–0.5	±0.2	0.5	LSB
Offset error(3)		–1.5	±0.5	1.5	LSB
Gain error	Range 1	–1	±0.1	1	LSB
	Range 2		±0.1		
SAMPLING DYNAMICS					
Conversion time	20 MHz SCLK			800	nSec
Acquisition time		325			nSec
Maximum throughput rate	20 MHz SCLK			1.0	MHz
Aperture delay			5		nsec
Step response			150		nsec
Over voltage recovery			150		nsec

(1) Ideal input span; does not include gain or offset error.
(2) LSB means Least Significant Bit.
(3) Measured relative to an ideal full-scale input

ELECTRICAL CHARACTERISTICS (continued)

+VA = 2.7 V to 5.25 V, +VBD = 1.7 V to 5.25 V, V_{ref} = 2.5 V ± 0.1 V, T_A = -40°C to 125°C, f_{sample} = 1 MHz (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
DYNAMIC CHARACTERISTICS						
Total harmonic distortion (4)		100 kHz		–80		dB
Signal-to-noise ratio		100 kHz	60			dB
Signal-to-noise + distortion		100 kHz	60			
Spurious free dynamic range		100 kHz		82		dB
Full power bandwidth		At –3 dB		47		MHz
Channel-to-channel crosstalk		Any off-channel with 100kHz, Full-scale input to channel being sampled with DC input.		–95		dB
		From previously sampled to channel with 100kHz, Full-scale input to channel being sampled with DC input.		–85		
EXTERNAL REFERENCE INPUT						
V_{ref} reference voltage at REFP			2.0	2.5	3.0	V
Reference resistance				100		kΩ
ALARM SETTING						
Higher threshold range			000		FFC	Hex
Lower threshold range			000		FFC	Hex
DIGITAL INPUT/OUTPUT						
Logic family		CMOS				
Logic level	V_{IH}		0.7*(+VBD)			V
	V_{IL}	+VBD = 5 V			0.8	
	V_{IL}	+VBD = 3 V			0.4	
	V_{OH}	At I_{source} = 200 µA	Vdd-0.2			
	V_{OL}	At I_{sink} = 200 µA	0.4			
Data format MSB first				MSB First		
POWER SUPPLY REQUIREMENTS						
+VA supply voltage			2.7	3.3	5.25	V
+VBD supply voltage			1.7	3.3	5.25	V
Supply current (normal mode)		At +VA = 2.7 to 3.6 V and 1MHz throughput		1.8		mA
		At +VA = 2.7 to 3.6 V static state		1.05	1	mA
		At +VA = 4.7 to 5.25 V and 1 MHz throughput		2.3	3	mA
		At +VA = 4.7 to 5.25 V static state		1.1	1.5	mA
Power-down state supply current				1		µA
+VBD supply current		+VA = 5.25V, f_S = 1MHz		1		mA
Power-up time					1	µSec
Invalid conversions after power up or reset					1	Numbers
TEMPERATURE RANGE						
Specified performance			–40		125	°C

(4) Calculated on the first nine harmonics of the input frequency.

TIMING REQUIREMENTS (see Figure 7 and Figure 8)

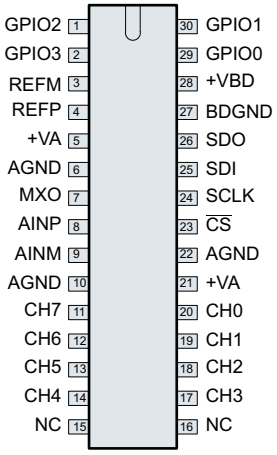
All specifications typical at –40°C to 125°C, +VA = 2.7 V to 5.25 V (unless otherwise specified)

PARAMETER		TEST CONDITIONS (1) (2)	MIN	TYP	MAX	UNIT
t_{conv}	Conversion time	+VBD = 1.8 V			16	SCLK
		+VBD = 3 V			16	
		+VBD = 5 V			16	
t_q	Minimum quiet sampling time needed from bus 3-state to start of next conversion	+VBD = 1.8 V	40			ns
		+VBD = 3 V	40			
		+VBD = 5 V	40			
t_{d1}	Delay time, $\overline{CS}$ low to first data (DO–15) out	+VBD = 1.8 V			38	ns
		+VBD = 3 V			27	
		+VBD = 5 V			17	
t_{su1}	Setup time, $\overline{CS}$ low to first rising edge of SCLK	+VBD = 1.8 V	8			ns
		+VBD = 3 V	6			
		+VBD = 5 V	4			
t_{d2}	Delay time, SCLK falling to SDO next data bit valid	+VBD = 1.8 V			35	ns
		+VBD = 3 V			27	
		+VBD = 5 V			17	
t_{h1}	Hold time, SCLK falling to SDO data bit valid	+VBD = 1.8 V	7			ns
		+VBD = 3 V	5			
		+VBD = 5 V	3			
t_{d3}	Delay time, 16th SCLK falling edge to SDO 3-state	+VBD = 1.8 V			26	ns
		+VBD = 3 V			22	
		+VBD = 5 V			13	
t_{su2}	Setup time, SDI valid to rising edge of SCLK	+VBD = 1.8 V	2			ns
		+VBD = 3 V	3			
		+VBD = 5 V	4			
t_{h2}	Hold time, rising edge of SCLK to SDI valid	+VBD = 1.8 V	12			ns
		+VBD = 3 V	10			
		+VBD = 5 V	6			
t_{w1}	Pulse duration $\overline{CS}$ high	+VBD = 1.8 V	20			ns
		+VBD = 3 V	20			
		+VBD = 5 V	20			
t_{d4}	Delay time $\overline{CS}$ high to SDO 3-state	+VBD = 1.8 V			24	ns
		+VBD = 3 V			21	
		+VBD = 5 V			12	
t_{wh}	Pulse duration SCLK high	+VBD = 1.8 V	20			ns
		+VBD = 3 V	20			
		+VBD = 5 V	20			
t_{wl}	Pulse duration SCLK low	+VBD = 1.8 V	20			ns
		+VBD = 3 V	20			
		+VBD = 5 V	20			
	Frequency SCLK	+VBD = 1.8 V			20	MHz
		+VBD = 3 V			20	
		+VBD = 5 V			20	

(1) 1.8V specifications apply from 1.7V to 1.9V, 3V specifications apply from 2.7V to 3.6V, 5V specifications apply from 4.75V to 5.25V.
(2) With 50-pF load

DEVICE INFORMATION

PIN CONFIGURATION (TOP VIEW)



TERMINAL FUNCTIONS - TSSOP PACKAGE

DEVICE NAME ADS7955-Q1 PIN NO.	PIN NAME	I/O	FUNCTION
REFERENCE			
4	REFP	I	Reference input
3	REFM	I	Reference ground
ADC ANALOG INPUT			
8	AINP	I	Signal input to ADC
9	AINM	I	ADC input ground
MULTIPLEXER			
7	MXO	O	Multiplexer output
20	Ch0	I	Analog channels for multiplexer
19	Ch1	I	
18	Ch2	I	
17	Ch3	I	
14	Ch4	I	
13	Ch5	I	
12	Ch6	I	
11	Ch7	I	
-	Ch8	I	
-	Ch9	I	
-	Ch10	I	
-	Ch11	I	
-	Ch12	I	
-	Ch13	I	
-	Ch14	I	
-	Ch15	I	
DIGITAL CONTROL SIGNALS			
23	$\overline{CS}$	I	Chip select input
24	SCLK	I	Serial clock input
25	SDI	I	Serial data input

TERMINAL FUNCTIONS - TSSOP PACKAGE (continued)

DEVICE NAME ADS7955-Q1 PIN NO.	PIN NAME	I/O	FUNCTION
26	SDO	O	Serial data output
GENERAL PURPOSE INPUTS / OUTPUTS: These pins have programmable dual functionality. Refer to Table 8 for functionality programming			
29	GPIO0	I/O	General purpose input or output
	High alarm or High/Low alarm	O	Active high output indicating high alarm or high/low alarm depending on programming
30	GPIO1	I/O	General purpose input or output
	Low alarm	O	Active high output indicating low alarm
1	GPIO2	I/O	General purpose input or output
	Range	I	Selects range: High -> Range 2 / Low -> Range 1
2	GPIO3	I/O	General purpose input or output
	$\overline{PD}$	I	Active low power down input
POWER SUPPLY AND GROUND			
5, 21	+VA	—	Analog power supply
6, 10, 22	AGND	—	Analog ground
28	+VBD	—	Digital I/O supply
27	BDGND	—	Digital ground
NC PINS			
15, 16	—	—	Pins internally not connected, do not float these pins

TYPICAL CHARATERISTICS

SUPPLY CURRENT vs SUPPLY VOLTAGE

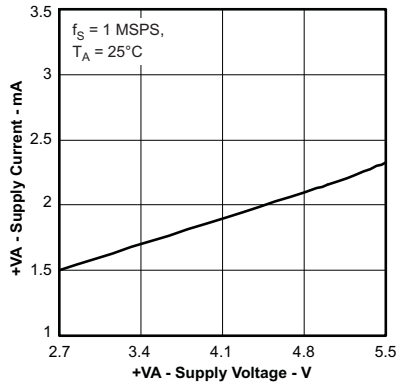


Figure 1.

STATIC SUPPLY CURRENT vs SUPPLY VOLTAGE

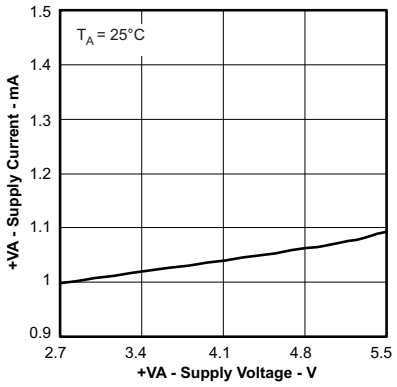


Figure 2.

SUPPLY CURRENT vs FREE-AIR TEMPERATURE

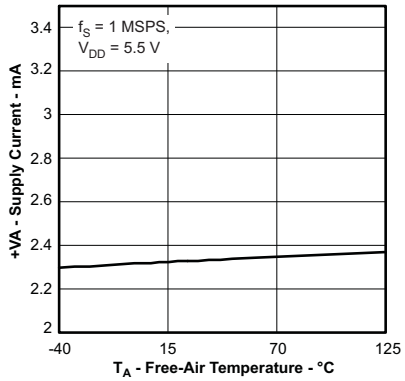


Figure 3.

STATIC SUPPLY CURRENT vs FREE-AIR TEMPERATURE

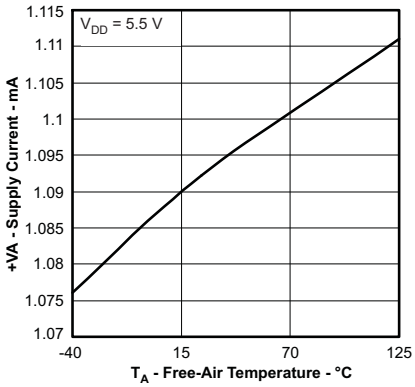


Figure 4.

SUPPLY CURRENT vs SAMPLE RATE

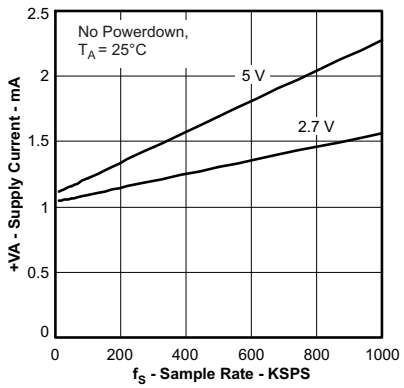


Figure 5.

SUPPLY CURRENT vs SAMPLE RATE

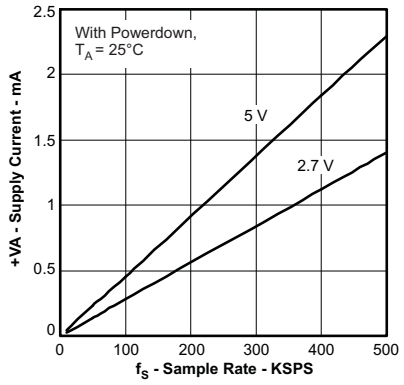


Figure 6.

DETAILED DESCRIPTION

DEVICE OPERATION

The ADS7955-Q1 is a 10-bit 8-channel device. Figure 7 and Figure 8 show device operation timing. Device operation is controlled with $\overline{CS}$, SCLK, and SDI. The device outputs its data on SDO.

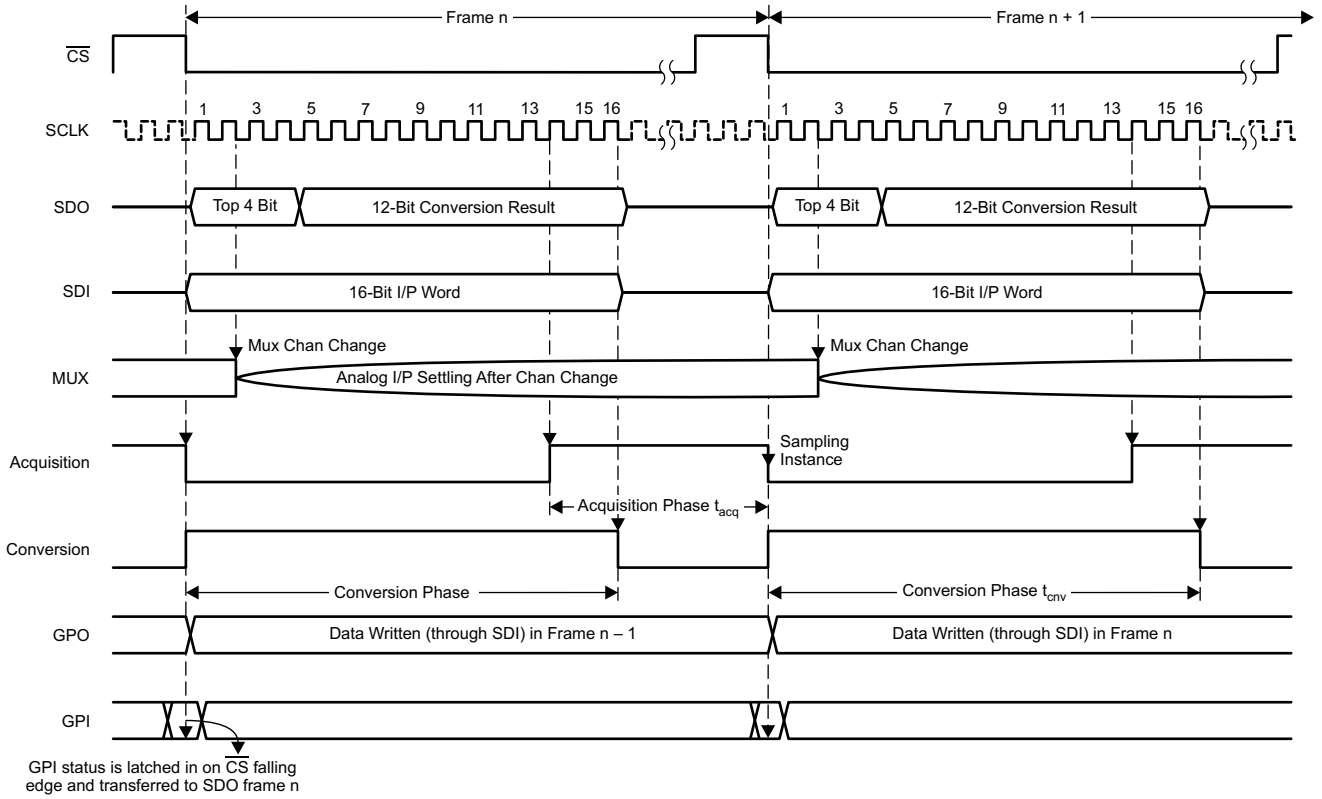


Figure 7. Device Operation Timing Diagram

Each frame begins with the falling edge of $\overline{CS}$. With the falling edge of $\overline{CS}$, the input signal from the selected channel is sampled, and the conversion process is initiated. The device outputs data while the conversion is in progress. The 16-bit data word contains a 4-bit channel address, followed by a 12-bit conversion result in MSB first format. There is an option to read the GPIO status instead of the channel address. (Refer to Table 1, Table 2, and Table 5 for more details.)

The device selects a new multiplexer channel on the second SCLK falling edge. The acquisition phase starts on the fourteenth SCLK rising edge. On the next $\overline{CS}$ falling edge the acquisition phase will end, and the device starts a new frame.

The TSSOP packaged device has four *General Purpose IO* (GPIO) pins, QFN versions have only one GPIO. These four pins can be individually programmed as GPO or GPI. It is also possible to use them for preassigned functions, refer to Table 10. GPO data can be written into the device through the SDI line. The device refreshes the GPO data on the $\overline{CS}$ falling edge as per the SDI data written in previous frame.

Similarly the device latches GPI status on the $\overline{CS}$ falling edge and outputs the GPI data on the SDO line (if GPI read is enabled by writing DI04=1 in the previous frame) in the same frame starting with the $\overline{CS}$ falling edge.

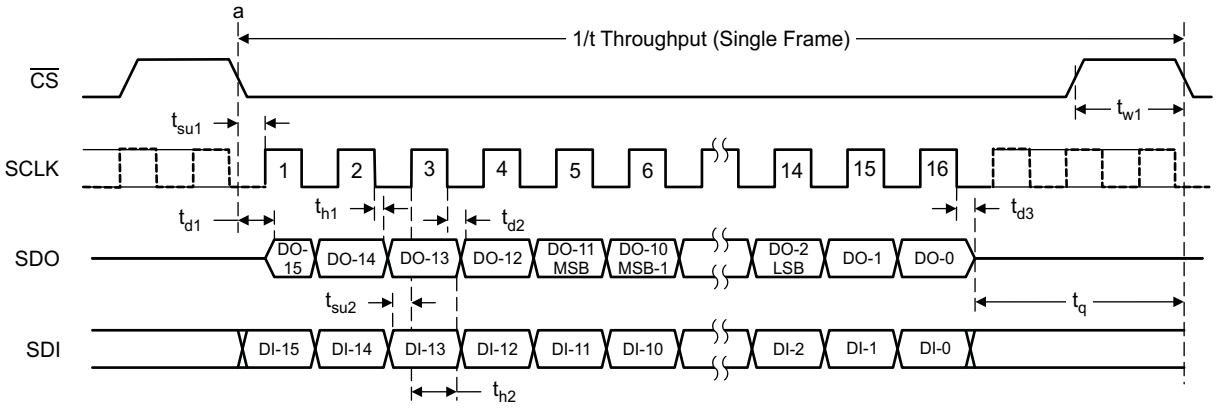


Figure 8. Serial Interface Timing Diagram for 10-Bit Devices

The falling edge of $\overline{CS}$ clocks out DO-15 (first bit of the four bit channel address), and remaining address bits are clocked out on every falling edge of SCLK until the third falling edge. The conversion result MSB is clocked out on the 4th SCLK falling edge and LSB on the 15th/13th/11th falling edge respectively for the 10-bit device. On the 16th falling edge of SCLK, SDO goes to the 3-state condition. The conversion ends on the 16th falling edge of SCLK.

The device reads a sixteen bit word on the SDI pin while it outputs the data on the SDO pin. SDI data is latched on every rising edge of SCLK starting with the 1st clock as shown in Figure 8.

$\overline{CS}$ can be asserted (pulled high) only after 16 clocks have elapsed.

The device has two (high and low) programmable alarm thresholds per channel. If the input crosses these limits; the device flags out an alarm on GPIO0/GPIO1 depending on the GPIO program register settings (refer to Table 10). The alarm is asserted (under the alarm conditions) on the 12th falling edge of SCLK in the same frame when a data conversion is in progress. The alarm output is reset on the 10th falling edge of SCLK in the next frame.

The device offers a power-down feature to save power when not in use. There are two ways to powerdown the device. It can be powered down by writing DI05 = 1 in the mode control register (refer to Table 1, Table 2, and Table 5); in this case the device powers down on the 16th falling edge of SCLK in the next data frame. Another way to powerdown the device is through GPIO in the case of the TSSOP packaged device. GPIO3 can act as the $\overline{PD}$ input (refer to Table 10, to assign this functionality to GPIO3). This is an asynchronous and active low input. The device powers down instantaneously after GPIO3 ($\overline{PD}$) = 0. The device will power up again on the $\overline{CS}$ falling edge with DI05 = 0 in the mode control register and GPIO3 ($\overline{PD}$) = 1.

CHANNEL SEQUENCING MODES

There are three modes for channel sequencing, namely *Manual mode*, *Auto-1 mode*, *Auto-2 mode*. Mode selection is done by writing into the *control register* (refer to Table 1, Table 2, and Table 5). A new multiplexer channel is selected on the second falling edge of SCLK (as shown in Figure 7) in all three modes.

Manual mode: When configured to operate in Manual mode, the next channel to be selected is programmed in each frame and the device selects the programmed channel in the next frame. On powerup or after reset the default channel is 'Channel-0' and the device is in Manual mode.

Auto-1 mode: In this mode the device scans pre-programmed channels in ascending order. A new multiplexer channel is selected every frame on the second falling edge of SCLK. There is a separate ‘program register’ for pre-programming the channel sequence. Table 3 and Table 4 show Auto-1 ‘program register’ settings.

Once programmed the device retains ‘program register’ settings until the device is powered down, reset, or reprogrammed. It is allowed to exit and re-enter the Auto-1 mode any number of times without disturbing ‘program register’ settings.

The Auto-1 program register is reset to FFFF/FFF/FF/F hex for the 8 channel device upon device powerup or reset; implying the device scans all channels in ascending order.

Auto-2 mode: In this mode the user can configure the program register to select the last channel in the scan sequence. The device scans all channels from channel 0 up to and including the last channel in ascending order. The multiplexer channel is selected every frame on the second falling edge of SCLK. There is a separate 'program register' for pre-programming of the last channel in the sequence (multiplexer depth). Table 6 lists the 'Auto-2 prog' register settings for selection of the last channel in the sequence.

Once programmed the device retains program register settings until the device is powered down, reset, or reprogrammed. It is allowed to exit and re-enter Auto-2 mode any number of times, without disturbing the 'program register' settings.

On powerup or reset the bits D9-D6 of the Auto-2 program register are reset to 7 hex for the 8 channel device; implying the device scans all channels in ascending order.

DEVICE PROGRAMMING AND MODE CONTROL

The following section describes device programming and mode control. These devices feature two types of registers to configure and operate the devices in different modes. These registers are referred as 'Configuration Registers'. There are two types of 'Configuration Registers' namely 'Mode control registers' and 'Program registers'.

Mode Control Register

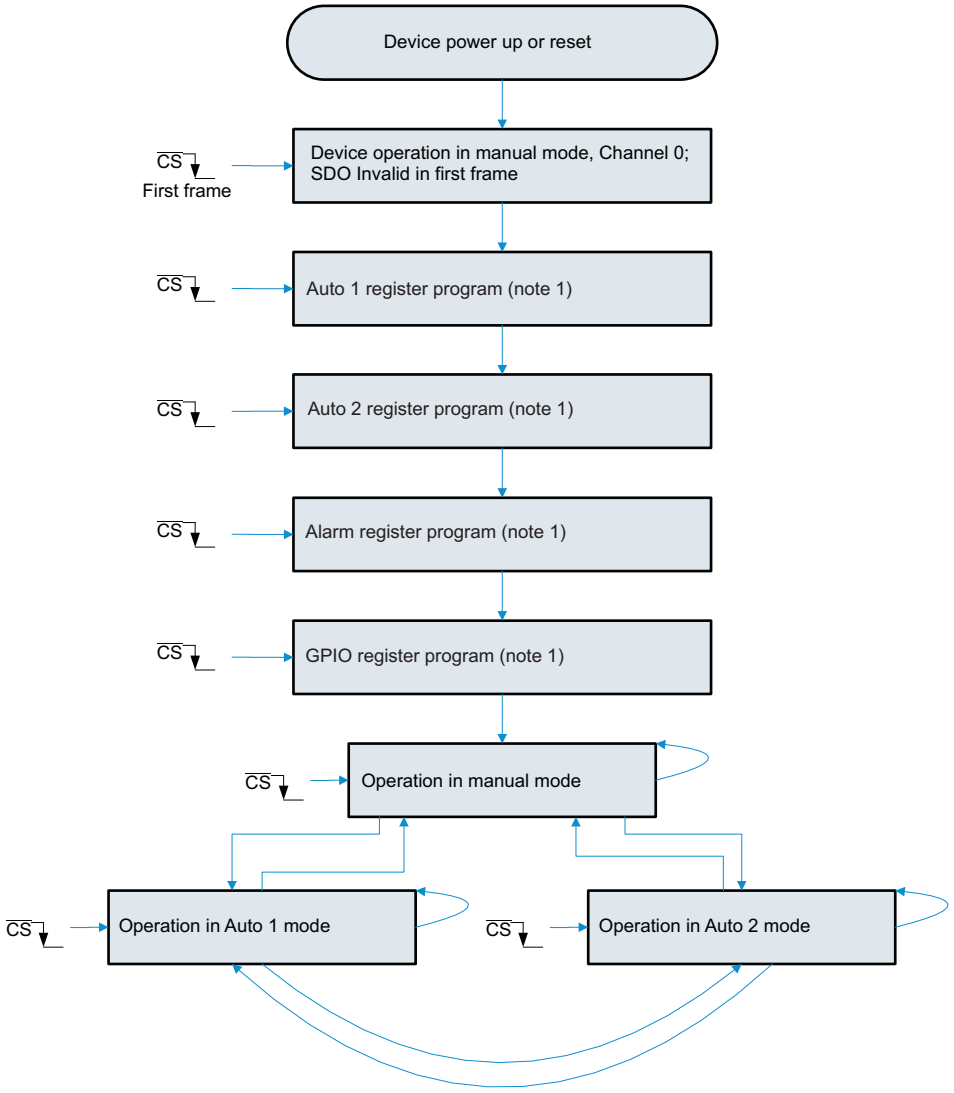
A 'Mode control register' is configured to operate the device in one of three channel sequencing modes, namely Manual mode, Auto-1 Mode, Auto-2 Mode. It is also used to control user programmable features like range selection, device power-down control, GPIO read control, and writing output data into the GPIO.

Program Registers

The 'Program registers' are used for device configuration settings and are typically programmed once on powerup or after device reset. There are different program registers such as 'Auto-1 mode programming' for pre-programming the channel sequence, 'Auto-2 mode programming' for selection of the last channel in the sequence, 'Alarm programming' for all 16 channels (8 channels) and GPIO for individual pin configuration as GPI or GPO or a pre-assigned function.

DEVICE POWER-UP SEQUENCE

The device power-up sequence is shown in Figure 9. Manual mode is the default power-up channel sequencing mode and Channel-0 is the first channel by default. As explained previously, these devices offer Program Registers to configure user programmable features like GPIO, Alarm, and to pre-program the channel sequence for Auto modes. At 'powerup or on reset' these registers are set to the default values listed in Table 1 to Table 10. It is recommended to program these registers on powerup or after reset. Once configured; the device is ready to use in any of the three channel sequencing modes namely Manual, Auto-1, and Auto-2.



(1) The device continues its operation in Manual mode channel 0 through out the programming sequence and outputs valid conversion results. It is possible to change channel, range, GPIO by inserting extra frames in between two programming blocks. It is also possible to bypass any programming block if the user does not intent to use that feature.

(2) It is possible to reprogram the device at any time during operation, regardless of what mode the device is in. During programming the device continues its operation in whatever mode it is in and outputs valid data.

Figure 9. Device Power-Up Sequence

OPERATING IN MANUAL MODE

The details regarding entering and running in Manual channel sequencing mode are illustrated in Figure 10. Table 1 lists the Mode Control Register settings for Manual mode in detail. Note that there are no Program Registers for manual mode.

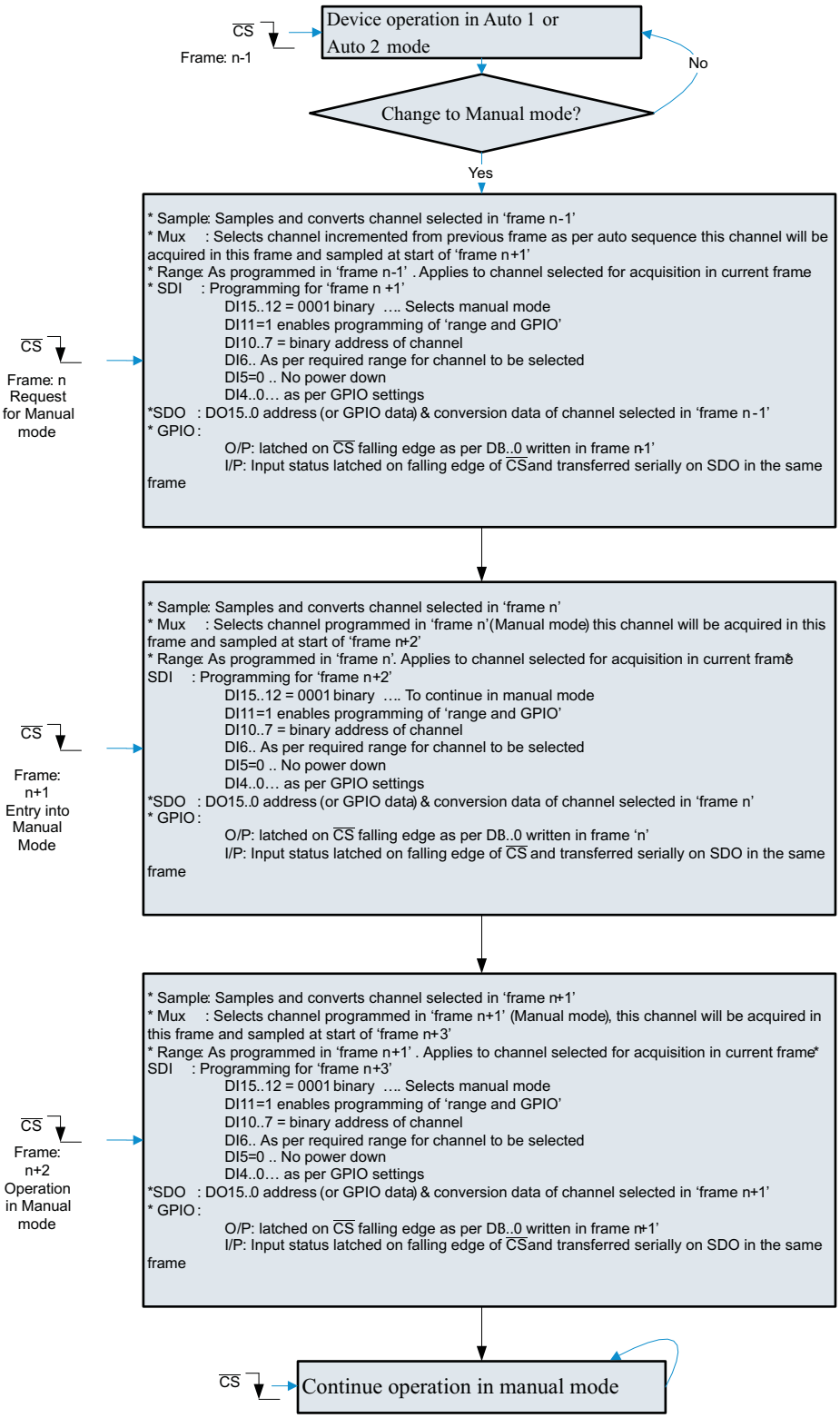


Figure 10. Entering and Running in Manual Channel Sequencing Mode

Table 1. Mode Control Register Settings for Manual Mode

BITS	RESET STATE	DESCRIPTION				
		LOGIC STATE	FUNCTION			
DI15-12	0001	0001	Selects Manual Mode			
DI11	0	1	Enables programming of bits DI06-00.			
		0	Device retains values of DI06-00 from the previous frame.			
DI10-07	0000	This four bit data represents the address of the next channel to be selected in the next frame. DI10: MSB and DI07: LSB. e.g. 0000 represents channel- 0, 0001 represents channel-1 etc.				
DI06	0	0	Selects 2.5V i/p range (Range 1)			
		1	Selects 5V i/p range (Range 2)			
DI05	0	0	Device normal operation (no powerdown)			
		1	Device powers down on 16th SCLK falling edge			
DI04	0	0	SDO outputs current channel address of the channel on DO15..12 followed by 12 bit conversion result on DO11..00.			
		1	GPIO3-GPIO0 data (both input and output) is mapped onto DO15-DO12 in the order shown below. Lower data bits DO11-DO00 represent 12-bit conversion result of the current channel.			
			DOI5	DOI4	DOI3	DOI2
			GPIO3(1)	GPIO2(1)	GPIO1(1)	GPIO0(1)
DI03-00	0000	GPIO data for the channels configured as output. Device will ignore the data for the channel which is configured as input. SDI bit and corresponding GPIO information is given below				
			DI03	DI02	DI01	DI00
			GPIO3(2)	GPIO2(2)	GPIO1(2)	GPIO0(2)

(1) GPIO 1 to 3 are available only in TSSOP packaged devices. QFN device offers GPIO 0 only.
(2) GPIO 1 to 3 are available only in TSSOP packaged devices. QFN device offers GPIO 0 only.

OPERATING IN AUTO-1 MODE

The details regarding entering and running in Auto-1 channel sequencing mode are illustrated in the flowchart in Figure 11. Table 2 lists the Mode Control Register settings for Auto-1 mode in detail.

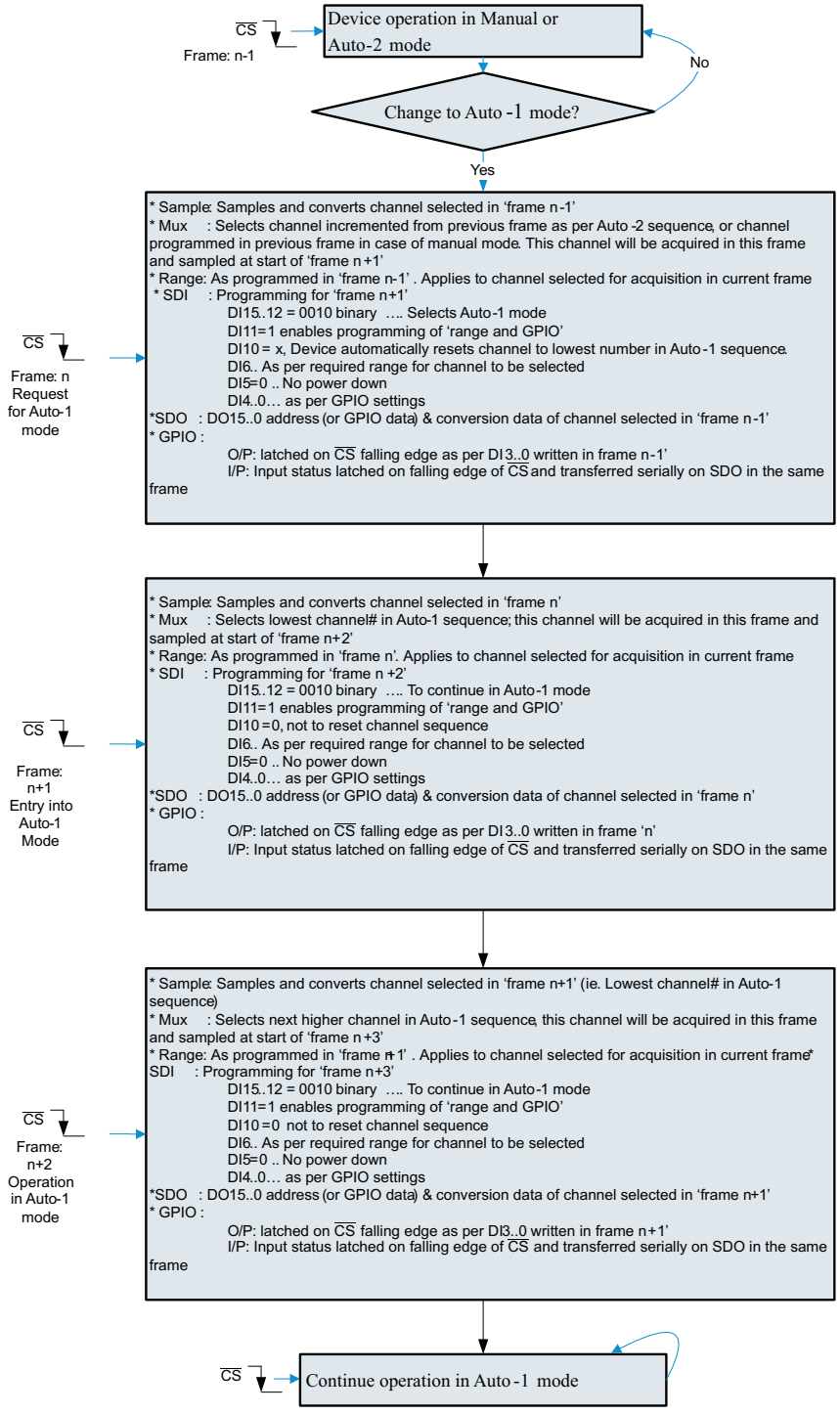


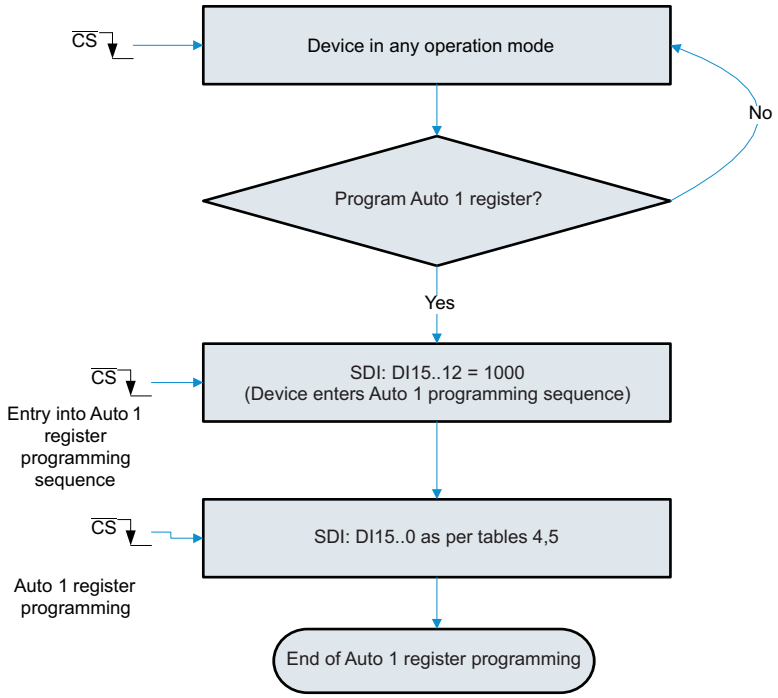
Figure 11. Entering and Running in Auto-1 Channel Sequencing Mode

Table 2. Mode Control Register Settings for Auto-1 Mode

BITS	RESET STATE	DESCRIPTION				
		LOGIC STATE	FUNCTION			
DI15-12	0001	0010	Selects Auto-1 Mode			
DI11	0	1	Enables programming of bits DI10-00.			
		0	Device retains values of DI10-00 from previous frame.			
DI10	0	1	The channel counter is reset to the lowest programmed channel in the Auto-1 Program Register			
		0	The channel counter increments every conversion (No reset)			
DI09-07	000	xxx	Do not care			
DI06	0	0	Selects 2.5V i/p range (Range 1)			
		1	Selects 5V i/p range (Range 2)			
DI05	0	0	Device normal operation (no powerdown)			
		1	Device powers down on the 16th SCLK falling edge			
DI04	0	0	SDO outputs current channel address of the channel on DO15..12 followed by 12-bit conversion result on DO11..00.			
		1	GPIO3-GPIO0 data (both input and output) is mapped onto DO15-DO12 in the order shown below. Lower data bits DO11-DO00 represent 12-bit conversion result of the current channel.			
			DO15	DO14	DO13	DO12
			GPIO3(1)	GPIO2(1)	GPIO1(1)	GPIO0(1)
DI03-00	0000	GPIO data for the channels configured as output. Device will ignore the data for the channel which is configured as input. SDI bit and corresponding GPIO information is given below				
			DI03	DI02	DI01	DI00
			GPIO3(2)	GPIO2(2)	GPIO1(2)	GPIO0(2)

(1) GPIO 1 to 3 are available only in TSSOP packaged devices. QFN device offers GPIO 0 only.
(2) GPIO 1 to 3 are available only in TSSOP packaged devices. QFN device offers GPIO 0 only.

The Auto-1 Program Register is programmed (once on powerup or reset) to pre-select the channels for the Auto-1 sequence. Auto-1 Program Register programming requires two $\overline{CS}$ frames for complete programming. In the first $\overline{CS}$ frame the device enters the Auto-1 register programming sequence and in the second frame it programs the Auto-1 Program Register. Refer to Table 2, Table 3, and Table 4 for complete details.



NOTE: The device continues its operation in selected mode during programming. SDO is valid, however it is not possible to change the range or write GPIO data into the device during programming.

Figure 12. Auto-1 Register Programming Flowchart

Table 3. Program Register Settings for Auto-1 Mode

BITS	RESET STATE	DESCRIPTION	
		LOGIC STATE	FUNCTION
FRAME 1			
DI15-12	NA	1000	Device enters Auto-1 program sequence. Device programming is done in the next frame.
DI11-00	NA	Do not care	
FRAME 2			
DI15-00	All 1s	1 (individual bit)	A particular channel is programmed to be selected in the channel scanning sequence. The channel numbers are mapped one-to-one with respect to the SDI bits; e.g. DI15 → Ch15, DI14 → Ch14 … DI00 → Ch00
		0 (individual bit)	A particular channel is programmed to be skipped in the channel scanning sequence. The channel numbers are mapped one-to-one with respect to the SDI bits; e.g. DI15 → Ch15, DI14 → Ch14 … DI00 → Ch00

Table 4. Mapping of Channels to SDI Bits

Device(1)	SDI BITS															
	DI15	DI14	DI13	DI12	DI11	DI10	DI09	DI08	DI07	DI06	DI05	DI04	DI03	DI02	DI01	DI00
8 Chan	X	X	X	X	X	X	X	X	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0

(1) When operating in Auto-1 mode, the device only scans the channels programmed to be selected.

OPERATING IN AUTO-2 MODE

The details regarding entering and running in Auto-2 channel sequencing mode are illustrated in Figure 13. Table 5 lists the Mode Control Register settings for Auto-2 mode in detail.

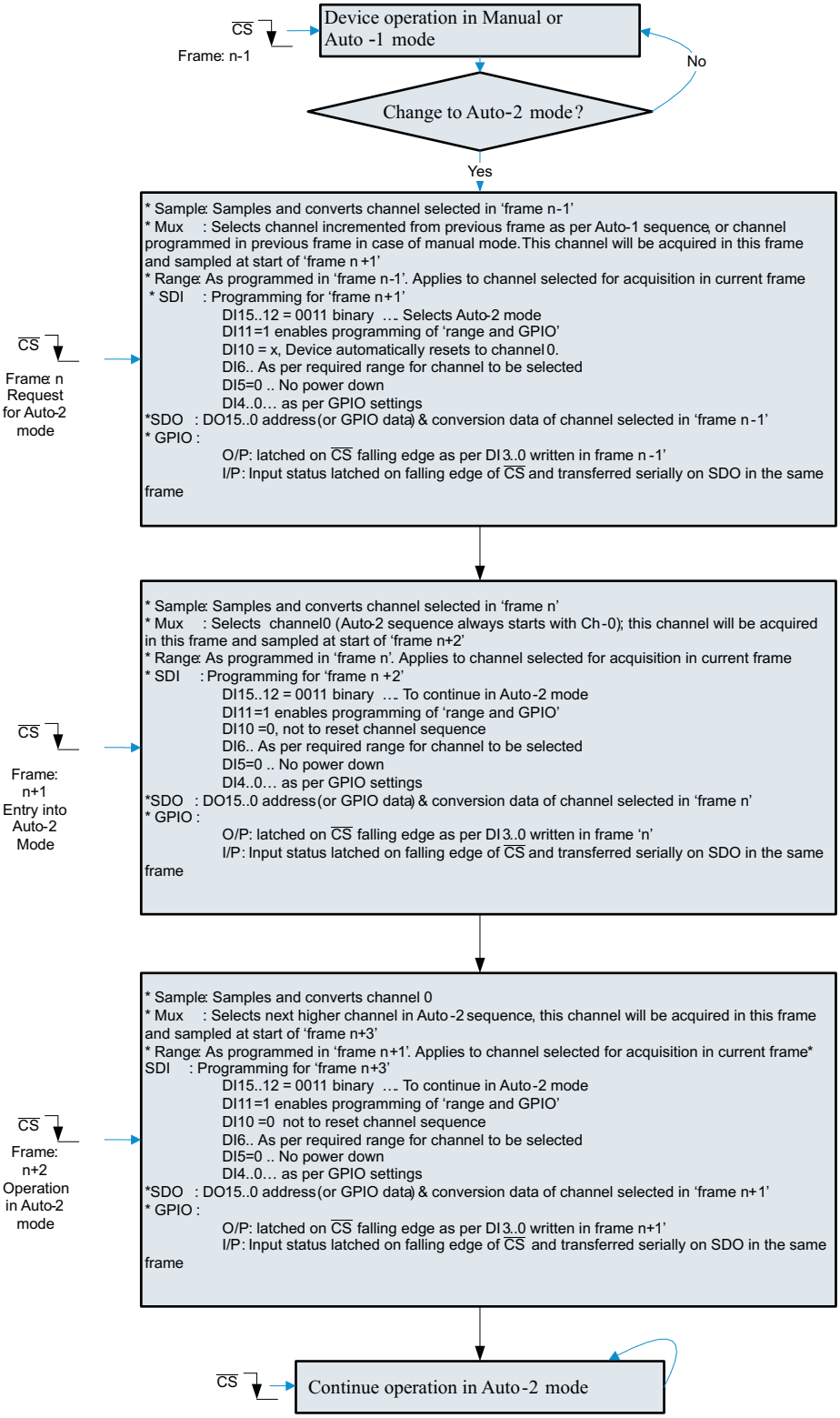


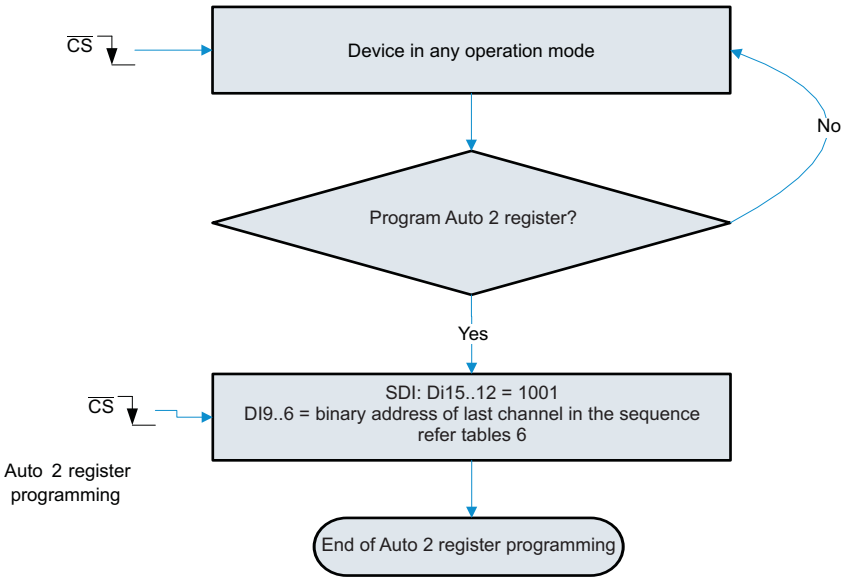
Figure 13. Entering and Running in Auto-2 Channel Sequencing Mode

Table 5. Mode Control Register Settings for Auto-2 Mode

BITS	RESET STATE	DESCRIPTION				
		LOGIC STATE	FUNCTION			
DI15-12	0001	0011	Selects Auto-2 Mode			
DI11	0	1	Enables programming of bits DI10-00.			
		0	Device retains values of DI10-00 from the previous frame.			
DI10	0	1	Channel number is reset to Ch-00.			
		0	Channel counter increments every conversion.(No reset).			
DI09-07	000	xxx	Do not care			
DI06	0	0	Selects 2.5V i/p range (Range 1)			
		1	Selects 5V i/p range (Range 2)			
DI05	0	0	Device normal operation (no powerdown)			
		1	Device powers down on the 16th SCLK falling edge			
DI04	0	0	SDO outputs the current channel address of the channel on DO15..12 followed by the 12-bit conversion result on DO11..00.			
		1	GPIO3-GPIO0 data (both input and output) is mapped onto DO15-DO12 in the order shown below. Lower data bits DO11-DO00 represent the 12-bit conversion result of the current channel.			
			DO15	DO14	DO13	DO12
			GPIO3(1)	GPIO2(1)	GPIO1(1)	GPIO0(1)
DI03-00	0000	GPIO data for the channels configured as output. Device ignores data for the channel which is configured as input. SDI bit and corresponding GPIO information is given below				
			DI03	DI02	DI01	DI00
			GPIO3(1)	GPIO2(1)	GPIO1(1)	GPIO0(1)

(1) GPIO 1 to 3 are available only in TSSOP packaged devices. QFN device offers GPIO 0 only.

The Auto-2 Program Register is programmed (once on powerup or reset) to pre-select the last channel (or sequence depth) in the Auto-2 sequence. Unlike Auto-1 Program Register programming, Auto-2 Program Register programming requires only 1 $\overline{CS}$ frame for complete programming. See Figure 14 and Table 6 for complete details.



NOTE: The device continues its operation in the selected mode during programming. SDO is valid, however it is not possible to change the range or write GPIO data into the device during programming.

Figure 14. Auto-2 Register Programming Flowchart

Table 6. Program Register Settings for Auto-2 Mode

BITS	RESET STATE	DESCRIPTION	
		LOGIC STATE	FUNCTION
DI15-12	NA	1001	Auto-2 program register is selected for programming
DI11-10	NA	Do not care	
DI09-06	NA	aaaa	This 4-bit data represents the address of the last channel in the scanning sequence. During device operation in Auto-2 mode, the channel counter starts at CH-00 and increments every frame until it equals “aaaa”. The channel counter roles over to CH-00 in the next frame.
DI05-00	NA	Do not care	

CONTINUED OPERATION IN A SELECTED MODE

Once a device is programmed to operate in one of the modes, the user may want to continue operating in the same mode. Mode Control Register settings to continue operating in a selected mode are detailed in Table 7.

Table 7. Continued Operation in a Selected Mode

BITS	RESET STATE	DESCRIPTION	
		LOGIC STATE	FUNCTION
DI15-12	0001	0000	The device continues to operate in the selected mode. In Auto-1 and Auto-2 modes the channel counter increments normally, whereas in the Manual mode it continues with the last selected channel. The device ignores data on DI11-DI00 and continues operating as per the previous settings. This feature is provided so that SDI can be held low when no changes are required in the Mode Control Register settings.
DI11-00	All '0'	Device ignores these bits when DI15-12 is set to 0000 logic state	

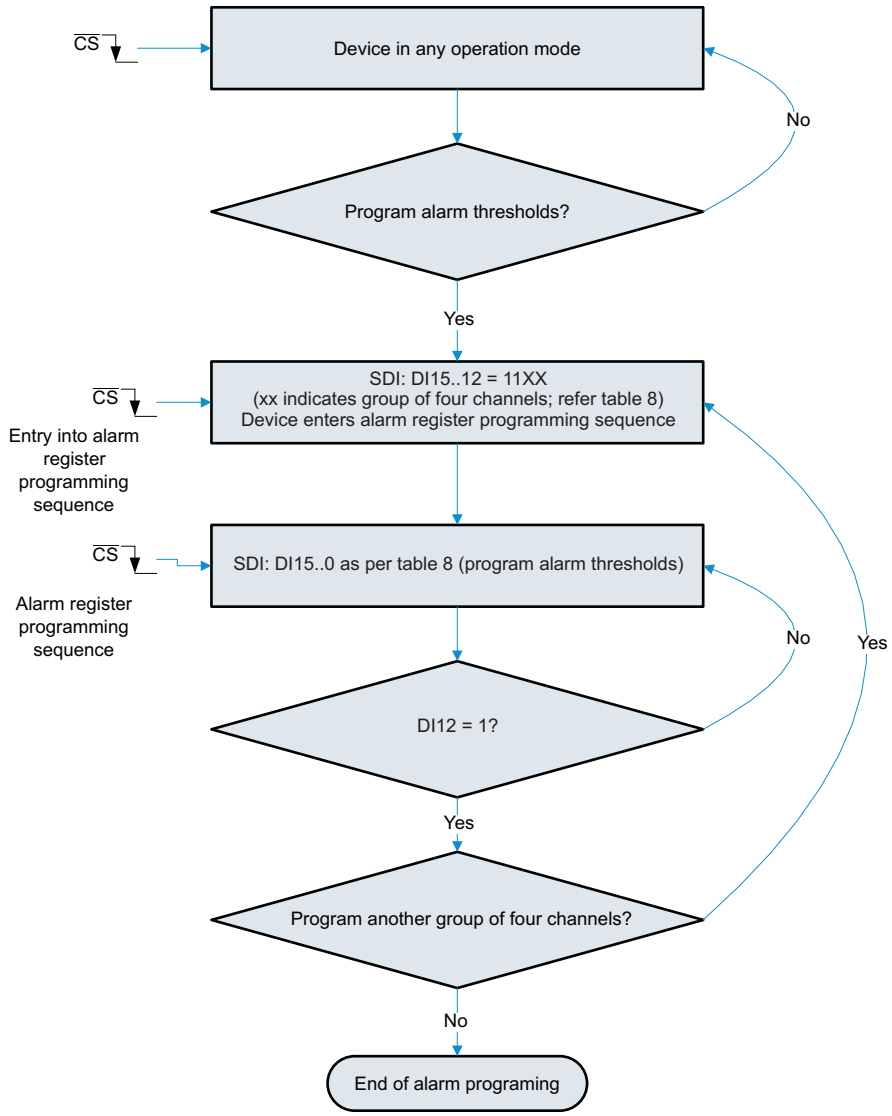
PROGRAMMING ALARM THRESHOLDS

There are two Alarm Program Registers per channel, one for setting the high alarm threshold and the other for setting the low alarm threshold. For ease of programming, two alarm programming registers per channel, corresponding to four consecutive channels, are assembled into one group (a total eight registers). There are four such groups for 16 channel devices and 3/2/1 such groups for 12/8/4 channel devices respectively. The grouping of the various channels for each device in the ADS7955-Q1 is listed in Table 8. The details regarding programming the alarm thresholds are illustrated in the flowchart in Figure 15. Table 9 lists the details regarding the Alarm Program Register settings.

Table 8. Grouping of Alarm Program Registers

GROUP NO.	REGISTERS
0	High and low alarm for channel 0, 1, 2, and 3
1	High and low alarm for channel 4, 5, 6, and 7

Each alarm group requires 9 $\overline{CS}$ frames for programming their respective alarm thresholds. In the first frame the device enters the programming sequence and in each subsequent frame it programs one of the registers from the group. The device offers a feature to program less than eight registers in one programming sequence. The device exits the alarm threshold programming sequence in the next frame after it encounters the first ‘Exit Alarm Program’ bit high.



NOTE: The device continues its operation in selected mode during programming. SDO is valid, however it is not possible to change the range or write GPIO data into the device during programming.

Figure 15. Alarm Program Register Programming Flowchart

Table 9. Alarm Program Register Settings

BITS	RESET STATE	DESCRIPTION	
		LOGIC STATE	FUNCTION
FRAME 1			
DI15-12	NA	1100	Device enters ‘alarm programming sequence’ for group 0
		1101	Device enters ‘alarm programming sequence’ for group 1
		1110	Device enters ‘alarm programming sequence’ for group 2
		1111	Device enters ‘alarm programming sequence’ for group 3
Note: DI15-12 = 11bb is the alarm programming request for group bb. Here ‘bb’ represents the alarm programming group number in binary format.			
DI11-14	NA	Do not care	
FRAME 2 AND ONWARDS			

Table 9. Alarm Program Register Settings (continued)

BITS	RESET STATE	DESCRIPTION	
		LOGIC STATE	FUNCTION
DI15-14	NA	cc	Where “cc” represents the lower two bits of the channel number in binary format. The device programs the alarm for the channel represented by the binary number “bbcc”. Note that “bb” is programmed in the first frame.
DI13	NA	1	High alarm register selection
		0	Low alarm register selection
DI12	NA	0	Continue alarm programming sequence in next frame
		1	Exit Alarm Programming in the next frame. Note: If the alarm programming sequence is not terminated using this feature then the device will remain in the alarm programming sequence state and all SDI data will be treated as alarm thresholds.
DI11-10	NA	xx	Do not care
DI09-00	All ones for high alarm register and all zeros for low alarm register	This 10-bit data represents the alarm threshold. The 10-bit alarm threshold is compared with the upper 10-bit word of the 12-bit conversion result. The device sets off an alarm when the conversion result is higher (High Alarm) or lower (Low Alarm) than this number. For 10-bit devices, all 10 bits of the conversion result are compared with the set threshold. For 8-bit devices, all 8 bits of the conversion result are compared with DI09 to DI02 and DI00, 01 are 'do not care'.	

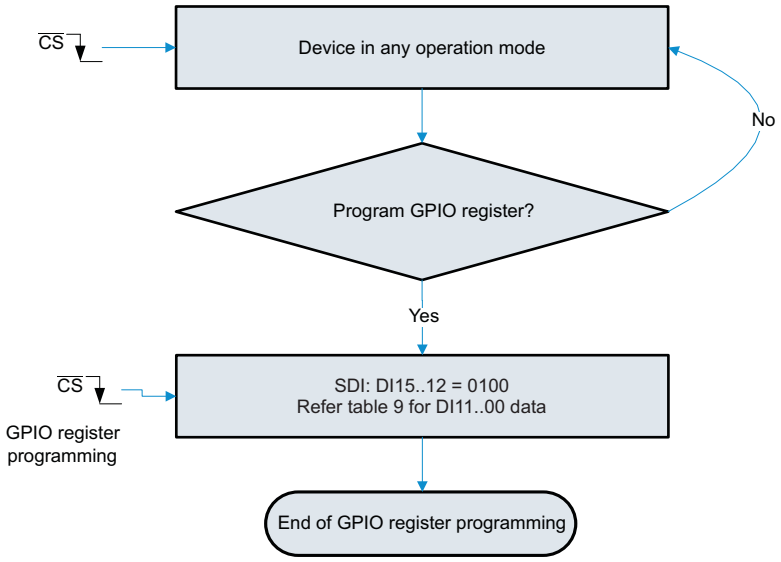
PROGRAMMING GPIO REGISTERS

NOTE

GPIO 1 to 3 are available only in TSSOP packaged devices. The QFN device offers 'GPIO 0' only. As a result, all references related to 'GPIO 0' only are valid in the case of QFN package devices.

The device has four General Purpose Input and Output (GPIO) pins. Each of the four pins can be independently programmed as General Purpose Output (GPO) or General Purpose Input (GPI). It is also possible to use the GPIOs for some pre-assigned functions (refer to Table 10 for details). GPO data can be written into the device through the SDI line. The device refreshes the GPO data on every $\overline{CS}$ falling edge as per the SDI data written in the previous frame. Similarly, the device latches GPI status on the $\overline{CS}$ falling edge and outputs it on SDO (if GPI is read enabled by writing DI04 = 1 during the previous frame) in the same frame starting on the $\overline{CS}$ falling edge.

The details regarding programming the GPIO registers are illustrated in the flowchart in Figure 16. Table 10 lists the details regarding GPIO Register programming settings.



NOTE: The device continues its operation in selected mode during programming. SDO is valid, however it is not possible to change the range or write GPIO data into the device during programming.

Figure 16. GPIO Program Register Programming Flowchart

Table 10. GPIO Program Register Settings

BITS	RESET STATE	DESCRIPTION	
		LOGIC STATE	FUNCTION
DI15-12	NA	0100	Device selects GPIO Program Registers for programming.
DI11-10	00	00	Do not program these bits to any logic state other than '00'
DI09	0	1	Device resets all registers in the next $\overline{CS}$ frame to the reset state shown in the corresponding tables (it also resets itself).
		0	Device normal operation
DI08	0	1	Device configures GPIO3 as the device power-down input.
		0	GPIO3 remains general purpose I or O. Program 0 for QFN packaged devices.
DI07	0	1	Device configures GPIO2 as device range input.
		0	GPIO2 remains general purpose I or O. Program 0 for QFN packaged devices.
DI06-04	000	000	GPIO1 and GPIO0 remain general purpose I or O. Valid setting for QFN packaged devices.
		xx1	Device configures GPIO0 as 'high or low' alarm output. This is an active high output. GPIO1 remains general purpose I or O. Valid setting for QFN packaged devices.
		010	Device configures GPIO0 as high alarm output. This is an active high output. GPIO1 remains general purpose I or O. Valid setting for QFN packaged devices.
		100	Device configures GPIO1 as low alarm output. This is an active high output. GPIO0 remains general purpose I or O. Setting not allowed for QFN packaged devices.
		110	Device configures GPIO1 as low alarm output and GPIO0 as a high alarm output. These are active high outputs. Setting not allowed for QFN packaged devices.
Note: The following settings are valid for GPIO which are not assigned a specific function through bits DI08..04			
DI03	0	1	GPIO3 pin is configured as general purpose output. Program 1 for QFN packaged devices.
		0	GPIO3 pin is configured as general purpose input. Setting not allowed for QFN packaged devices.
DI02	0	1	GPIO2 pin is configured as general purpose output. Program 1 for QFN packaged devices.
		0	GPIO2 pin is configured as general purpose input. Setting not allowed for QFN packaged devices.
DI01	0	1	GPIO1 pin is configured as general purpose output. Program 1 for QFN packaged devices.
		0	GPIO1 pin is configured as general purpose input. Setting not allowed for QFN packaged devices.
DI00	0	1	GPIO0 pin is configured as general purpose output. Valid setting for QFN packaged devices.

Table 10. GPIO Program Register Settings (continued)

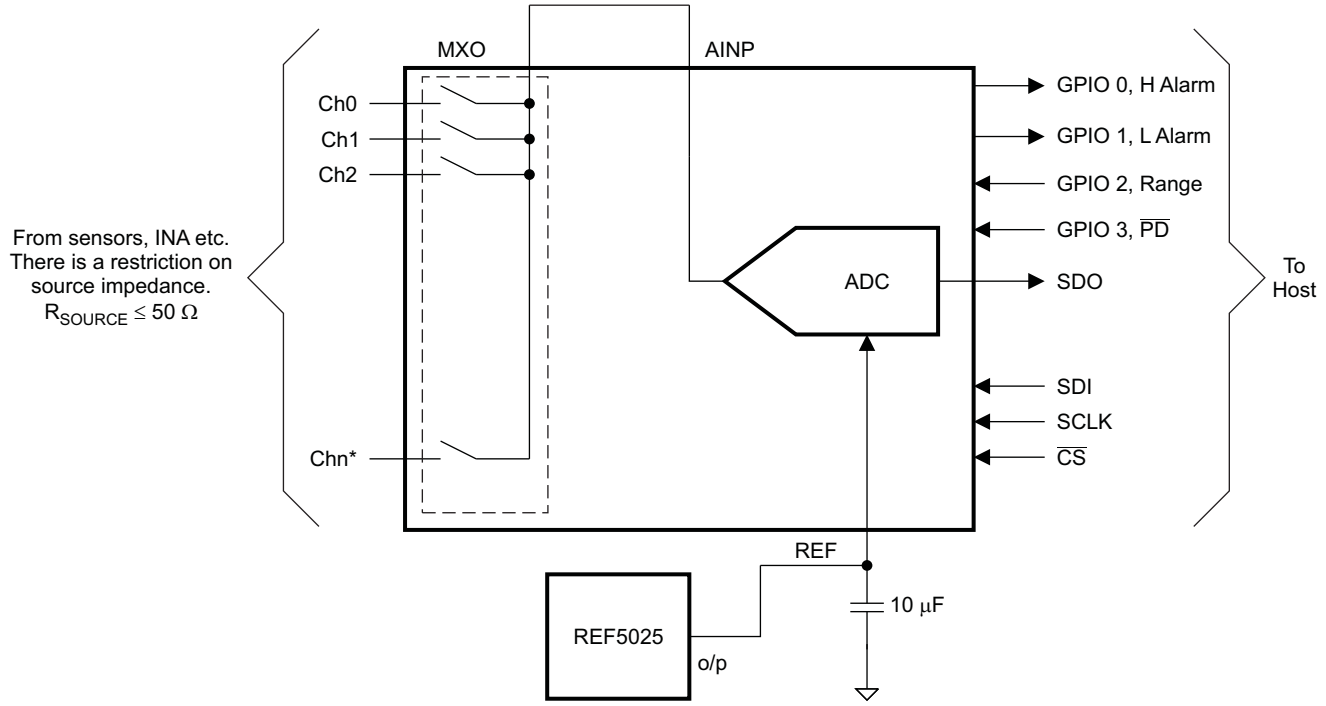
BITS	RESET STATE	DESCRIPTION	
		LOGIC STATE	FUNCTION
		0	GPIO0 pin is configured as general purpose input. Valid setting for QFN packaged devices.

APPLICATION INFORMATION

ANALOG INPUT

The ADS7955-Q1 device offers a 10-bit ADC with 8-channel multiplexers for analog input. The multiplexer output is available on the MXO pin. AINP is the ADC input pin. The devices offers flexibility for a system designer as both signals are accessible esternally.

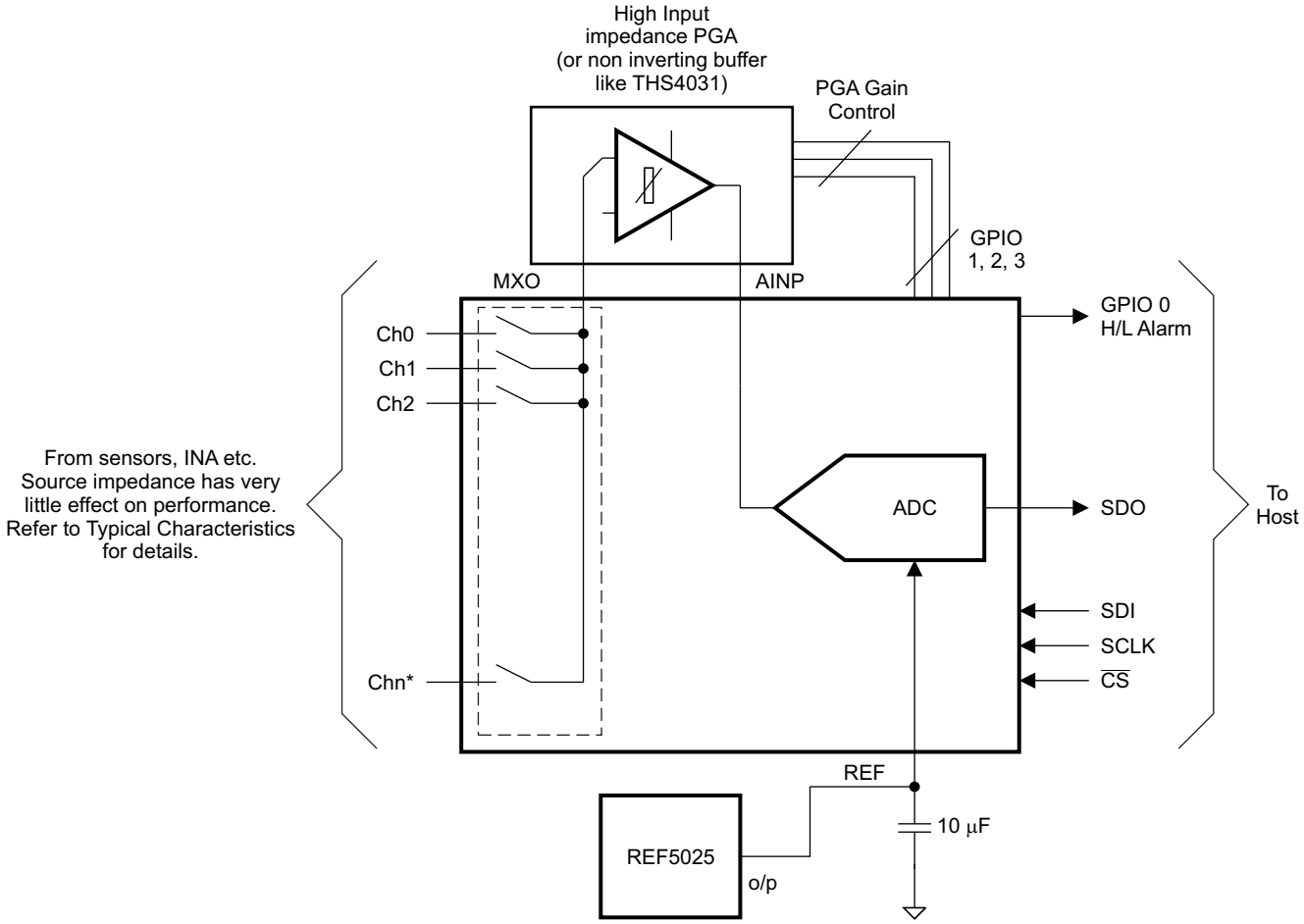
Typically it is convenient to short MXO to the AINP pin so that signal input to each multiplexer channel can be processed independently. In this condition it is recommended to limit source impedance to 50Ω or less. Higher source impedance may affect the signal settling time after a multiplexer channel change. This condition can affect linearity and total harmonic distortion.



GPIO 1 to 3 are available only in TSSOP packaged devices. QFN device offers 'GPIO 0' only. As a result all references related to 'GPIO 0' only are valid in case of QFN package devices.

Figure 17. Typical Application Diagram Showing MXO Shorted to AINP

Another option is to add a common ADC driver buffer between the MXO and AINP pins. This relaxes the restriction on source impedance to a large extent. Refer to the typical characteristics section for the effect of source impedance on device performance. The typical characteristics show that the device has respectable performance with up to 1kΩ source impedance. This topology (including a common ADC driver) is useful when all channel signals are within the acceptable range of the ADC. In this case the user can save on signal conditioning circuit for each channel.



GPIO 1 to 3 are available only in TSSOP packaged devices. QFN device offers 'GPIO 0' only. As a result all references related to 'GPIO 0' only are valid in case of QFN package devices.

Figure 18. Typical Application Diagram Showing Common Buffer/PGA for all Channels

When the converter samples an input, the voltage difference between AINP and AGND is captured on the internal capacitor array. The (peak) input current through the analog inputs depends upon a number of factors: sample rate, input voltage, and source impedance. The current into the ADS7955-Q1 charges the internal capacitor array during the sample period. After this capacitance has been fully charged, there is no further input current. When the converter goes into hold mode, the input impedance is greater than 1 GΩ.

Care must be taken regarding the absolute analog input voltage. To maintain linearity of the converter, the Ch0 .. Chn and AINP inputs should be within the limits specified. Outside of these ranges, converter linearity may not meet specifications.

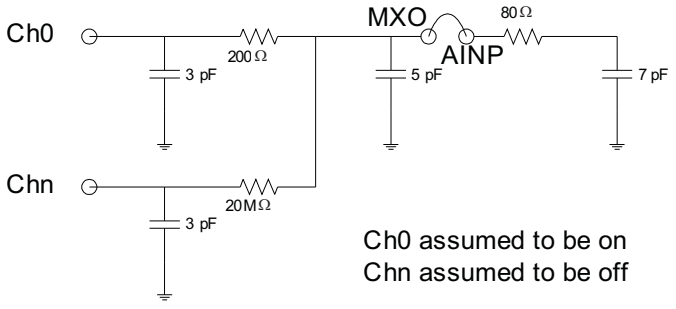


Figure 19. ADC and Mux Equivalent Circuit

REFERENCE

The ADS7955-Q1 can operate with an external 2.5V ± 10mV reference. A clean, low noise, well-decoupled reference voltage on the REF pin is required to ensure good performance of the converter. A low noise band-gap reference like the REF5025 can be used to drive this pin. A 10-µF ceramic decoupling capacitor is required between the REF and GND pins of the converter. The capacitor should be placed as close as possible to the pins of the device.

POWER SAVING

The ADS7955-Q1 device offers a power-down feature to save power when not in use. There are two ways to powerdown the device. It can be powered down by writing DI05 = 1 in the Mode Control register (refer to Table 1, Table 2 and Table 5); in this case the device powers down on the 16th falling edge of SCLK in the next data frame. Another way to powerdown the device is through GPIO. GPIO3 can act as a $\overline{PD}$ input (refer to Table 10, for assigning this functionality to GPIO3). This is an asynchronous and active low input. The device powers down instantaneously after GPIO3 ($\overline{PD}$) = 0. The device will powerup again on the $\overline{CS}$ falling edge while DI05 = 0 in the Mode Control register and GPIO3 ($\overline{PD}$) = 1.

DIGITAL OUTPUT

As discussed previously in the Device Operation section, the digital output of the ADS7955-Q1 device is SPI compatible. The following table lists the output codes corresponding to various analog input voltages.

Table 11. Ideal Input Voltages and Output Codes

DESCRIPTION		ANALOG VALUE	DIGITAL OUTPUT	
Full scale range	Range 1 → V_{ref}	Range 2 → 2×V_{ref}	STRAIGHT BINARY	
Least significant bit (LSB)	V_{ref}/1024	2V_{ref}/1024	BINARY CODE	HEX CODE
Full scale	V_{ref} – 1 LSB	2V_{ref} – 1 LSB	11 1111 1111	3FF
Midscale	V_{ref}/2	V_{ref}	10 0000 0000	200
Midscale – 1 LSB	V_{ref}/2 – 1 LSB	V_{ref} – 1 LSB	01 1111 1111	1FF
Zero	0 V	0 V	00 0000 0000	000

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
ADS7955QDBTRQ1	ACTIVE	TSSOP	DBT	30	2000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	ADS7955Q1	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

OTHER QUALIFIED VERSIONS OF ADS7955-Q1 :

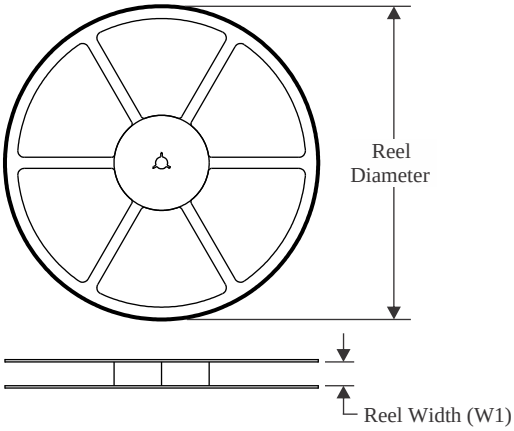
- Catalog: ADS7955

NOTE: Qualified Version Definitions:

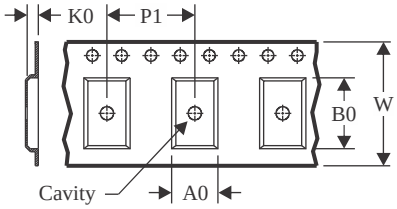
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

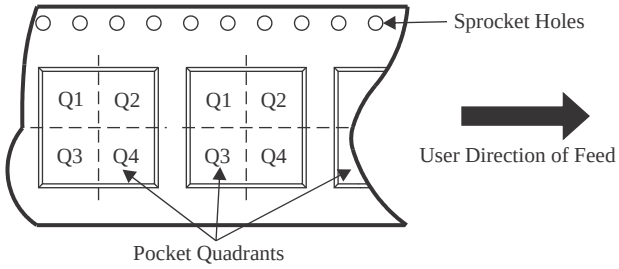


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

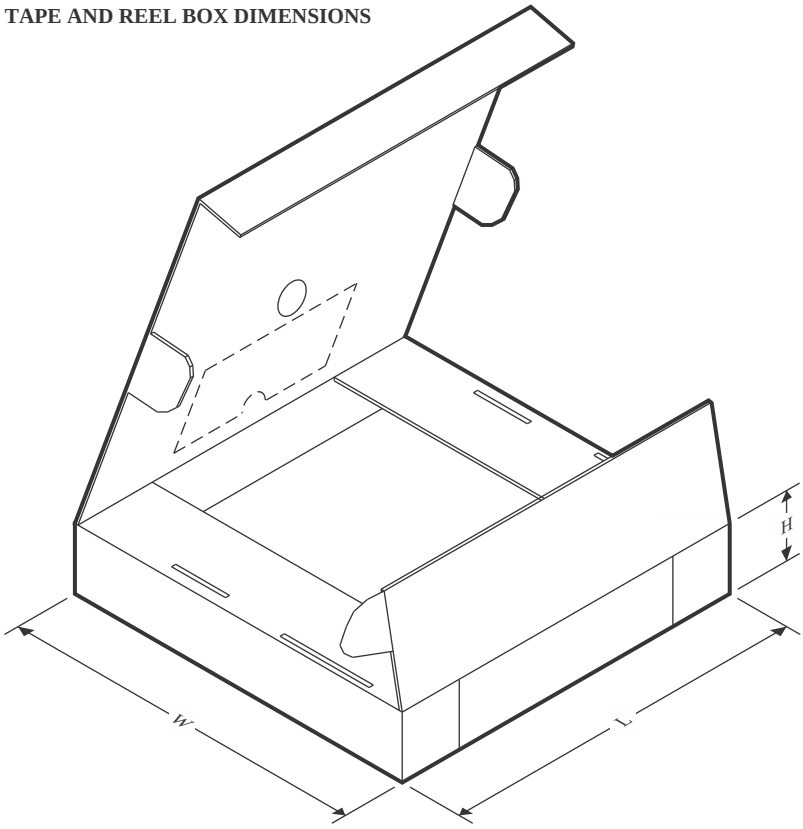
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
ADS7955QDBTRQ1	TSSOP	DBT	30	2000	330.0	16.4	6.95	8.3	1.6	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

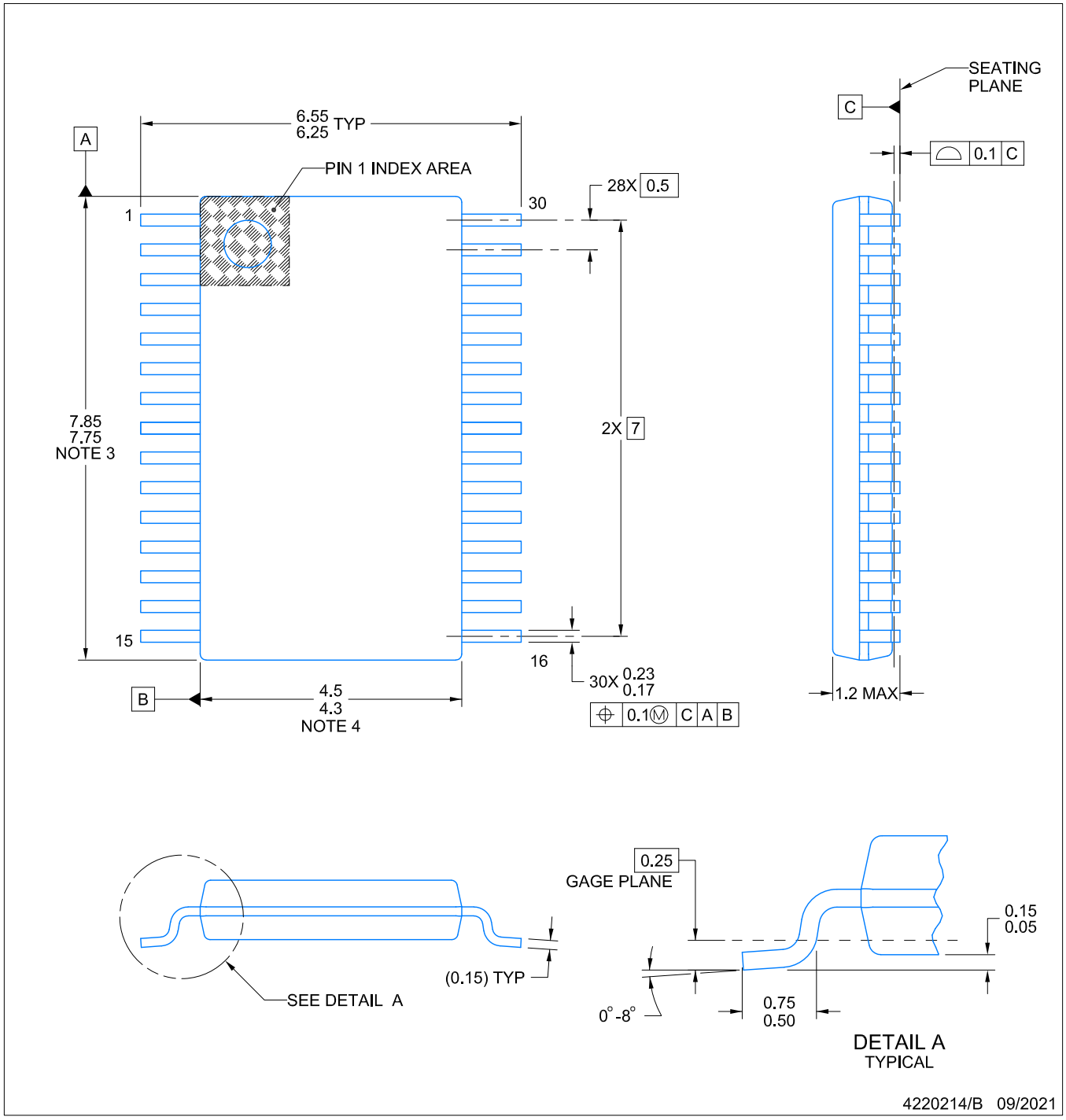
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ADS7955QDBTRQ1	TSSOP	DBT	30	2000	356.0	356.0	35.0

PACKAGE OUTLINE

DBT0030A

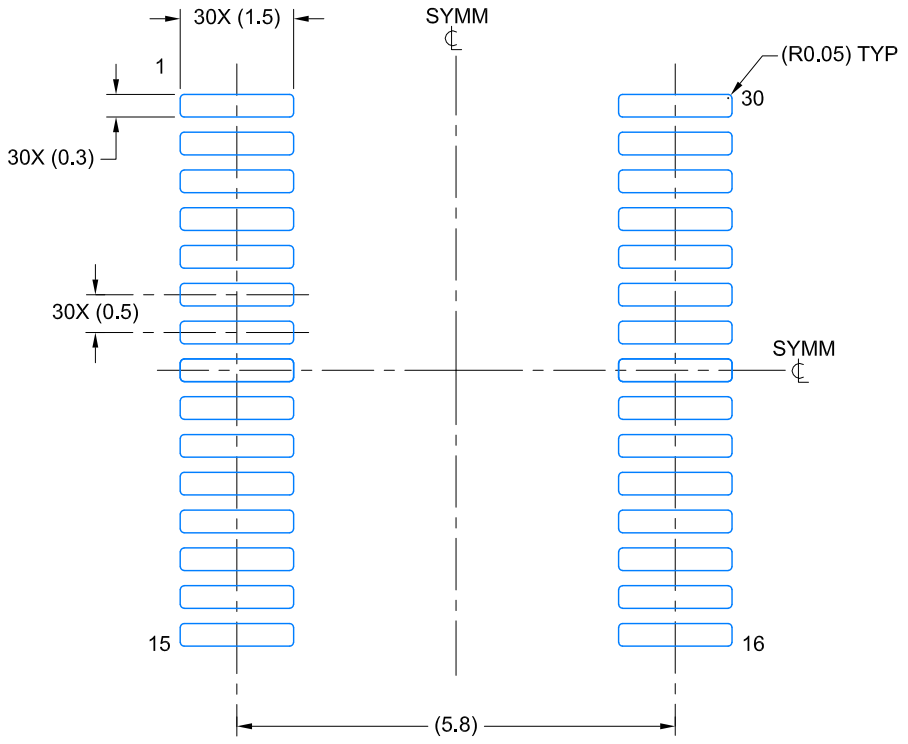
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

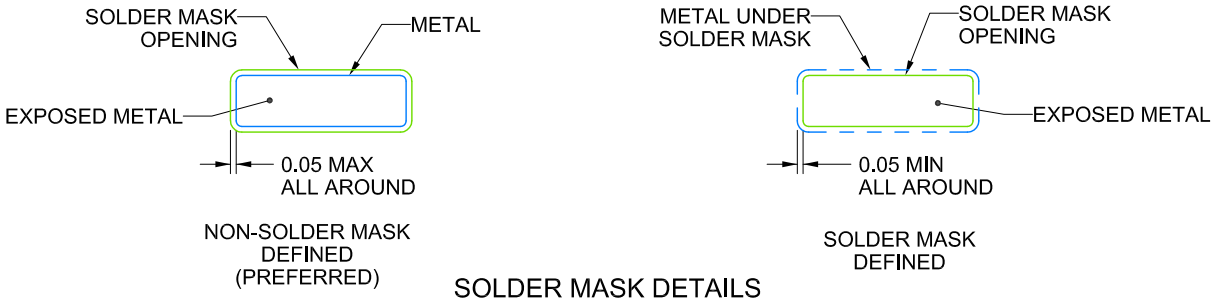


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

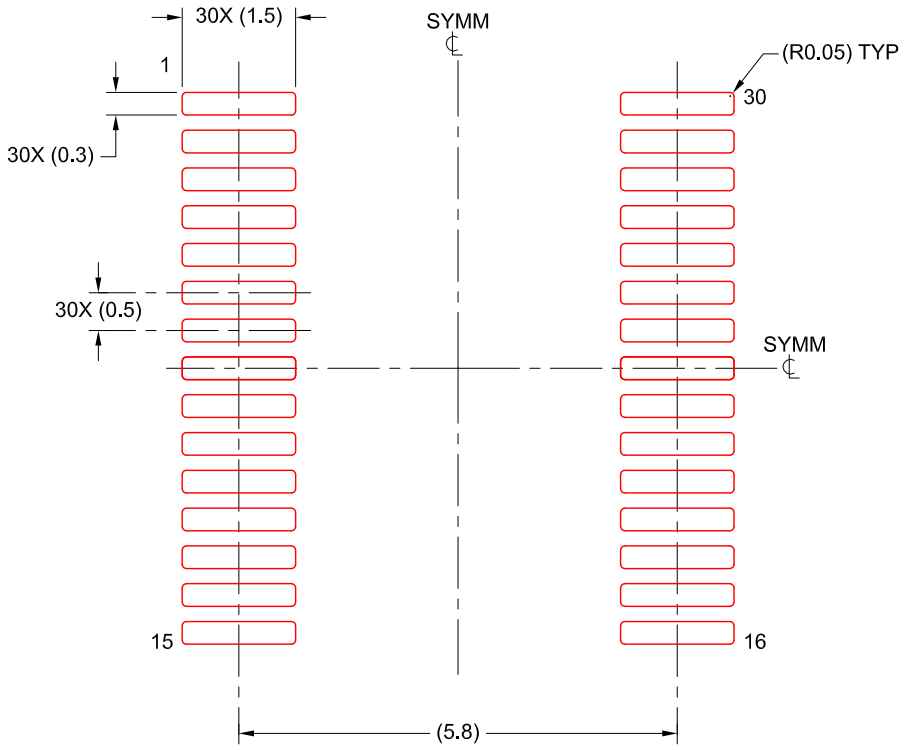


SOLDER MASK DETAILS

4220214/B 09/2021

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220214/B 09/2021

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265