GX7190: 4.8kSPS, 24-bit Sigma-Delta ADC with PGA

FEATURES

Programmable Gain: 1/2/4/8/16/32/64/128
Data Rates: 4.7SPS to 4.8kSPS
RMS Noise: 15nV at 10SPS (Gain=128)
22.4 noise-free bits at 10SPS (Gain=1)
Offset Drift: 3nV/°C (Gain=128)
Gain Drift: 0.5ppm/°C
Integral Non-Linearity: 2ppm
Internal or External Clock
Simultaneous 50Hz/60Hz Rejection
2 Differential/4 Pseudo Differential Inputs
Automatic Channel Sequencer
Burnout Current Sources
4 General Purpose Digital Outputs
Parity Check
Power Supply
   AVDD: 2.7V to 5.25V or ±2.5V
   DVDD: 2.7V to 5.25V
Current: 2.7mA Package:
24-lead TSSOP

APPLICATIONS

Weigh Scales
Strain Gauges
Temperature Measurement
Industrial Process Control
Pressure Sensors

DESCRIPTION

The GX7190 is a low noise, low drift, and high-resolution 24-bit analog-to-digital converter (ADC) with integrated programmable gain amplifier (PGA) that offers high-accuracy measurement solutions for bridge sensors, thermocouples, and resistance temperature devices (RTD).

The device contains a low noise PGA with gains selected from 1, 2, 4, 8 16, 32, 64, and 128, a delta-sigma (Δ-Σ) modulator, and a programmable digital SINC4/SINC3/fast settling filter. 50Hz/60Hz simultaneous rejection option is also provided. The output data rate from the device can be configured from 4.7SPS up to 4800SPS. This device provides channel sequencer feature to measure two differential inputs or four pseudo differential inputs automatically. Burnout current sources are provided at the analog inputs for sensor connection diagnosis.
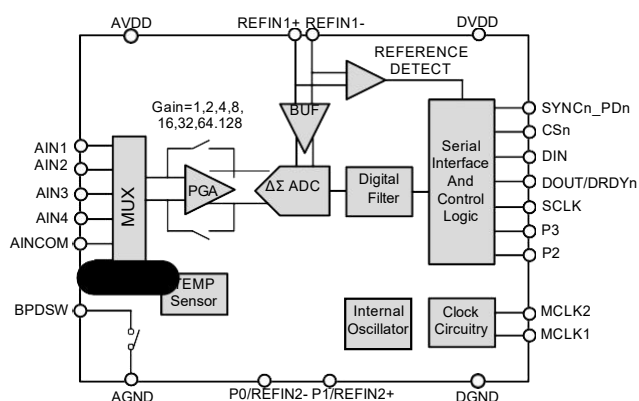
Offset and gain calibration registers are provided with calibration command or direct register write to calibrate the ADC errors or overall system errors. SPI-compatible interface is used for device configuration and parity check is provided for data integrity.

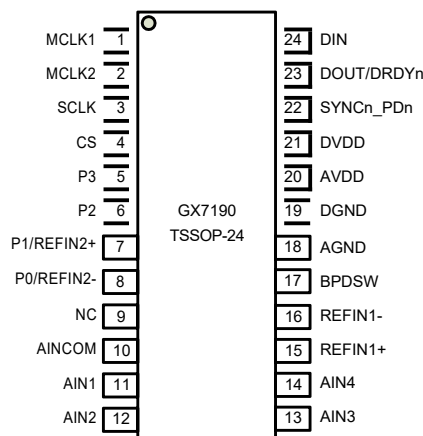The on-chip oscillator, an external clock, or an external crystal can be used as the clock source to the device.

The device can operate with bipolar ±1.35V to ±2.625V analog power supplies, or with a single 2.7V to 5.25V analog power supply.

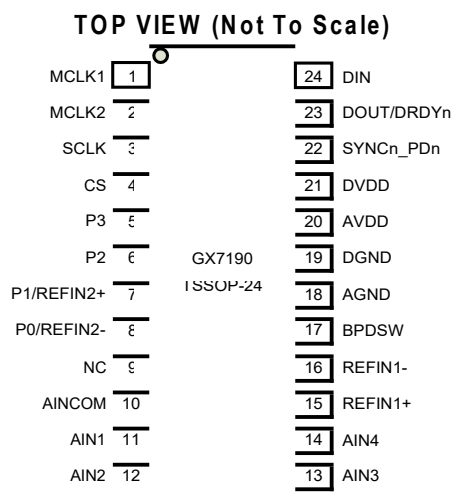The GX7190 is available in 24-lead TSSOP package and is fully specified over the -40°C to +125°C temperature range.

Function Block Diagram

TSSOP-24

PIN CONFIGURATION and DESCRIPTIONS

TOP VIEW (Not To Scale)

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MCLK1        1    ┌──────────┐   24   DIN
MCLK2        2                    23   DOUT/DRDYn
SCLK         3                    22   SYNCn_PDn
CS           4                    21   DVDD
P3           5                    20   AVDD
P2           6       GX7190       19   DGND
P1/REFIN2+   7      TSSOP-24      18   AGND
P0/REFIN2-   8                    17   BPDSW
NC           9                    16   REFIN1-
AINCOM       10                   15   REFIN1+
AIN1         11                   14   AIN4
AIN2         12   └──────────┘   13   AIN3
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		FUNCTION	DESCRIPTION
1	MCLK1	Digital Input	Crystal Connection.
2	MCLK2	Digital Input/Output	Master clock input or internal clock output depending on MODE Register bits CLK[1:0].
3	SCLK	Digital Input	Serial data clock.
4	CSn	Digital Input	Serial chip select. Active low.
5	P3	Analog Output	General purpose output bit between AVDD and AGND.
6	P2	Analog Output	General purpose output bit between AVDD and AGND.
7	P1/REFIN2+	Analog Input/Output	General purpose output bit between AVDD and AGND or second positive reference input.
8	P0/REFIN2-	Analog Input/Output	General purpose output bit between AVDD and AGND or second negative reference input.
9	NC	Analog	No connection (float) or connect to AVDD/AGND.
10	AINCOM	Analog Input	Negative analog input for pseudo differential operation.
11	AIN1	Analog Input	Analog input channel 1.
12	AIN2	Analog Input	Analog input channel 2.
13	AIN3	Analog Input	Analog input channel 3.
14	AIN4	Analog Input	Analog input channel 4.
15	REFIN1+	Analog Input	Positive reference input.
16	REFIN1-	Analog Input	Negative reference input.
17	BPDSW	Analog Input	Bridge Power-down switch to AGND.
18	AGND	Analog	Negative analog power supply. AGND can be taken below DVSS to provide bipolar power supplies. For example, AGND can be tied to –2.5V and AVDD can be tied to +2.5V, providing a ±2.5V dual supplies to the ADC.
19	DGND	Digital	Digital ground reference point.
20	AVDD	Analog	Positive analog power supply. 2.7V to 5.25V relative to AGND. AVDD is independent of DVDD.
21	DVDD	Digital	Digital power supply, 2.7V to 5.25V. DVDD is independent of AVDD.
22	SYNCn_PDn	Digital Input	Synchronization control signal. While this pin is low, the digital filter is reset and DOUT pin is forced to high. The device starts a new conversion after this pin goes back to high. The device enters power-down if holding this pin low for longer than 0.83ms.
23	DOUT/DRDYn	Digital Output	Serial data output and data ready indicator.
24	DIN	Digital Input	Serial data input.

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKING OPTION
GX7190	TSSOP-24	-40°C to +125°C	GX7190-ITSP24-RL	Reel, 3000

SPECIFICATIONS

Absolute Maximum Ratings

Over operating free-air temperature range, unless otherwise noted.[1]

		MIN	MAX	UNIT
Voltage	AVDD to AGND	−0.3	6.5	V
	AGND to DGND	−3	0.3	V
	DVDD to DGND	−0.3	6.5	V
	Analog input	$V_{AGND} - 0.3$	$V_{AVDD} + 0.3$	V
	Digital input	$V_{DGND} - 0.3$	$V_{DVDD} + 0.3$	V
Current	Input current	−10	10	mA
Temperature	Junction (T_J)	−50	150	°C
	Storage (T_{stg})	-60	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD Ratings

SYMBOL	PARAMTER	CONDITION	VALUE	UNIT
HBM	Human-body model	ANSI/ESDA/JEDEC JS-001	±8000	V
CDM	Charged-device model	JEDEC EIA/JESD22-C101F	±2000	V
MM	Machine model	JEDEC EIA/JESD22-A115C	±600	V

This integrated circuit can be damaged by ESD. GXSC 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.

Electrical Characteristics

Minimum/Maximum specifications apply from -40˚C to +125˚C. Typical specifications are at +25˚C. All specification are at V_{AVDD}=5V, V_{AGND}=0V, V_{DVDD}=3.3V, V_{REF}=2.5V, f_{CLK}=4.9152MHz, data rate=10SPS, and PGA Gain=1, unless otherwise noted.

PARAMETER	TEST CONDITION OR NOTES	MIN[1]	TYP	MAX[1]	UNITS
ANALOG INPUTS					
Differential Input Voltage	$V_{IN} = V_{INP} - V_{INN}$	$-V_{REF}$/Gain		$+V_{REF}$/Gain	V
Absolute Input Voltage	Buffer Off, Gain=1	$V_{AGND} - 0.05$		$V_{AVDD} + 0.05$	V
	Buffer On	$V_{AGND} + 0.5$		$V_{AVDD} - 0.5$	
Common Mode Input Range	Buffer On	$V_{AGND} + 0.5 +$ $\lvert V_{INMAX} \rvert \cdot$Gain/2		$V_{AVDD} - 0.5 -$ $\lvert V_{INMAX} \rvert \cdot$Gain/2	V
Absolute Input Current	Buffer off, Gain=1		±100		nA
	Buffer On		±2		nA
SYSTEM PERFORMANCE					
PGA Gain			1/2/4/8/16/32/64/128		V/V
Resolution			24		Bits
Data Rate		4.7		4800	SPS
Noise			See Noise Table		
Integral Nonlinearity (INL)	Buffer Off, Gain=1		±10		ppm
	Buffer On		±2		ppm
Offset Error	All PGA gains		±150/Gain		µV
Offset Drift vs. Temperature	All PGA gains		±150/Gain ± 2		nV/°C
Gain Error[2]	Gain = 1, 2, and 4	-0.0025	±0.001	-0.0025	%
	Gain = 8, 16, and 32	-0.01	±0.004	-0.01	
	Gain = 64 and 128	-0.025	±0.01	-0.025	
Gain Drift vs. Temperature	All PGA gains	-3	±0.5	+3	ppm/°C
Normal Mode Rejection (NMRR)	f_{IN} = 50/60Hz, ±2%, data rate=10SPS		See Table 20		dB
Common Mode Rejection (CMRR)	f_{IN} = 50Hz, data rate = 1200SPS	100	120		dB
Power Supply Rejection[2] (PSRR)	AVDD, AGND	85	105		dB
	DVDD	90	110		dB
REFERENCE INPUT					
Differential Reference Voltage (V_{REF})	$V_{REF} = V_{REFP} - V_{REFN}$	0.5		$V_{AVDD} - V_{AGND} + 0.1$	V
Absolute Negative Reference Voltage (V_{REFN})		$V_{AGND} - 0.05$		$V_{REFP} - 0.5$	V
Absolute Positive Reference Voltage (V_{REFP})		$V_{REFN} + 0.5$		$V_{AVDD} + 0.05$	V
Average Voltage Input Current			±500		nA
Burnout Current Sources					
Current Setting			500		nA
ADC CLOCK					
External Clock	Frequency Range	1	4.9152	5.0	MHz
	Duty Cycle	40%		60%	
Internal Oscillator	Nominal Frequency		4.9152		MHz
	Accuracy	−3%	±0.5%	3%	
Crystal Oscillation	Frequency Range	1	4.9152	2.5	MHz
	Start-up time		20		ms
DIGITAL INPUT/OUTPUT					
High-level Output Voltage (V_{OH})	I_{OH} = 4mA	$0.8 \cdot V_{DVDD}$			V
Low-level Output Voltage (V_{OL})	I_{OL} = −4mA			$0.2 \cdot V_{DVDD}$	V
High-level Input Voltage (V_{IH})		$0.7 \cdot V_{DVDD}$		V_{DVDD}	V
Low-level Input Voltage (V_{IL})		V_{DGND}		$0.3 \cdot V_{DVDD}$	V

Input Hysteresis			0.5		V
Input Leakage				±10	µA
POWER SUPPLY					
AGND Voltage (V$_{AGND}$)		−2.625		0	V
AVDD Voltage (V$_{AVDD}$)		V$_{AGND}$ + 2.7		V$_{AGND}$ + 5.25	V
DVDD Voltage (V$_{DVDD}$)		2.7		5.25	V
AVDD, AGND Current (I$_{AVDD}$)	Buffer Off		0.9	1.3	mA
	Buffer On		2.5	3.2	mA
	Sleep Mode		1		µA
	Power-down Mode		1		µA
DVDD Current (I$_{DVDD}$)	Active Mode		260	360	µA
	Sleep Mode		50		µA
	Power-down Mode		1		µA
Total Power Dissipation	Buffer Off		5.5		mW
	Buffer On		13.5		mW
	Sleep Mode		0.16		mW
	Power-down Mode		0.01		mW
TEMPERATURE RANGE					
Specified temperature range		−40		125	°C
Operating temperature range		−50		125	°C
Storage temperature range		−60		150	°C

(1) Compliance to datasheet limits is assured by one or more methods: production test, characterization and/or design.
(2) MIN and MAX values listed for gain error are for +25˚C room temperature only.

Timing Requirements: Serial Interface

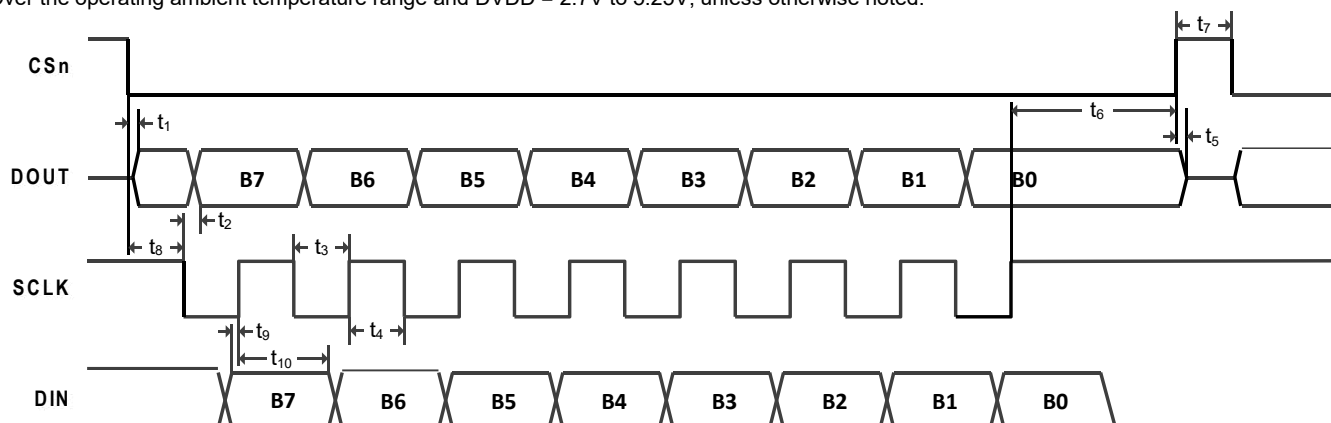Over the operating ambient temperature range and DVDD = 2.7V to 5.25V, unless otherwise noted.

Figure 1. Serial Interface Timing Requirements

SYMBOL	DESCRIPTION	MIN	MAX	UNIT
t_1	CSn falling edge to DOUT/DRDYn driven: propagation delay[1]		50	ns
t_2	SCLK falling edge to valid DOUT/DRDYn: propagation delay[1]		50	ns
t_3	SCLK low pulse width	100		ns
t_4	SCLK high pulse width	100		ns
	SCLK period	200	10^6	ns
t_5	CSn rising edge to DOUT high impedance: propagation delay		40	ns
t_6	Last SCLK rising edge to CSn rising edge: delay time	50		ns
t_7	CSn high pulse width	50		ns
t_8	CSn falling edge to first SCLK falling edge: setup time[2]	50		ns
t_9	Valid DIN to SCLK rising edge: setup time	50		ns
t_{10}	Valid DIN to SCLK rising edge: hold time	25		ns

(1) DOUT load = 20pF || 100k Ω to DGND.
(2) CSn can be tied low.

NOISE PERFORMANCE

The noise performance of the ADC is affected by PGA gain, data rate, and digital filter setting. The following tables show the rms noise and peak-to-peak noise for SINC4 and SINC3 filters and fast settling mode with chop disabled. The effective number of bits (ENOB) and noise-free bits are also listed according to Equation (1) and Equation (2):

$$ENOB = \log_2(2 \times V_{REF}/Gain/V_{RMS}) \tag{1}$$

$$Noise\,Free\,Bits = \log_2\left(2 \times V_{REF}/Gain/V_{p\text{-}p}\right) \tag{2}$$

The noise data listed in the table are typical and are generated from continuous ADC readings with differential input voltage of 0 V. With chop enabled, the resolution improves by 0.5 bits.

SINC4 and Chop Disabled

Table 1. ADC Noise in µVRMS (µVPP) at T_A = 25°C, V_{AVDD} = 5 V, V_{REF} = 5 V, SINC4 Filter, Chop Disabled

Filter Word	Data Rate (SPS)	PGA GAIN							
		1	2	4	8	16	32	64	128
1023	4.7	0.211(1.27)	0.126(0.686)	0.069(0.368)	0.044(0.264)	0.028(0.138)	0.018(0.099)	0.013(0.073)	0.010(0.054)
640	7.5	0.267(1.60)	0.159(0.866)	0.087(0.465)	0.055(0.333)	0.035(0.175)	0.023(0.125)	0.017(0.092)	0.013(0.069)
480	10	0.308(1.85)	0.183(1.00)	0.101(0.537)	0.064(0.385)	0.041(0.202)	0.027(0.144)	0.019(0.106)	0.015(0.079)
96	50	0.689(4.13)	0.410(2.24)	0.225(1.20)	0.143(0.860)	0.091(0.451)	0.059(0.323)	0.043(0.237)	0.033(0.177)
80	60	0.755(4.52)	0.449(2.45)	0.247(1.32)	0.157(0.942)	0.099(0.495)	0.065(0.354)	0.047(0.259)	0.036(0.194)
32	150	1.19(7.15)	0.710(3.87)	0.390(2.08)	0.248(1.49)	0.157(0.782)	0.103(0.559)	0.075(0.410)	0.057(0.307)
16	300	1.64(8.94)	0.940(5.36)	0.574(3.13)	0.353(1.79)	0.213(1.19)	0.143(0.708)	0.109(0.671)	0.086(0.494)
5	960	2.69(17.9)	1.80(11.9)	1.10(6.86)	0.652(4.02)	0.391(2.31)	0.269(1.68)	0.191(1.24)	0.148(0.955)
2	2400	6.91(55.4)	3.89(30.7)	2.17(15.6)	1.20(9.16)	0.691(4.99)	0.434(3.07)	0.310(2.30)	0.242(1.63)
1	4800	57.8(427)	29.1(229)	14.4(153)	7.36(61.5)	3.60(30.6)	1.86(15.4)	0.969(7.14)	0.557(4.00)

Table 2. ADC ENOB (Noise Free Bits) at T_A = 25°C, V_{AVDD} = 5 V, V_{REF} = 5 V, SINC4 Filter, Chop Disabled

Filter Word	Data Rate (SPS)	PGA GAIN							
		1	2	4	8	16	32	64	128
1023	4.7	25.5(22.9)	25.2(22.8)	25.1(22.7)	24.8(22.2)	24.4(22.1)	24.0(21.6)	23.5(21.0)	22.9(20.5)
640	7.5	25.2(22.6)	24.9(22.5)	24.8(22.4)	24.4(21.8)	24.1(21.8)	23.7(21.3)	23.2(20.7)	22.5(20.1)
480	10	25.0(22.4)	24.7(22.3)	24.6(22.1)	24.2(21.6)	23.9(21.6)	23.5(21.0)	22.9(20.5)	22.3(19.9)
96	50	23.8(21.2)	23.5(21.1)	23.4(21.0)	23.1(20.5)	22.7(20.4)	22.3(19.9)	21.8(19.3)	21.2(18.7)
80	60	23.7(21.1)	23.4(21.0)	23.3(20.9)	22.9(20.3)	22.6(20.3)	22.2(19.8)	21.7(19.2)	21.0(18.6)
32	150	23.0(20.4)	22.7(20.3)	22.6(20.2)	22.3(19.7)	21.9(19.6)	21.5(19.1)	21.0(18.5)	20.4(18.0)
16	300	22.5(20.1)	22.3(19.8)	22.1(19.6)	21.8(19.4)	21.5(19.0)	21.1(18.8)	20.5(17.8)	19.8(17.3)
5	960	21.8(19.1)	21.4(18.7)	21.1(18.5)	20.9(18.2)	20.6(18.0)	20.1(17.5)	19.6(16.9)	19.0(16.3)
2	2400	20.5(17.5)	20.3(17.3)	20.1(17.3)	20.0(17.1)	19.8(16.9)	19.5(16.6)	18.9(16.1)	18.3(15.6)
1	4800	17.4(14.5)	17.4(14.4)	17.4(14.0)	17.4(14.3)	17.4(14.3)	17.4(14.3)	17.3(14.4)	17.1(14.3)

SINC3 and Chop Disabled

Table 3. ADC Noise in µVRMS (µVPP) at T_A = 25°C, V_{AVDD} = 5 V, V_{REF} = 5 V, SINC3 Filter, Chop Disabled

Filter Word	Data Rate (SPS)	PGA GAIN							
		1	2	4	8	16	32	64	128
1023	4.7	0.229(1.37)	0.139(0.844)	0.080(0.447)	0.047(0.303)	0.032(0.158)	0.019(0.122)	0.014(0.087)	0.011(0.064)
640	7.5	0.289(1.73)	0.175(1.07)	0.101(0.565)	0.060(0.382)	0.041(0.200)	0.023(0.154)	0.018(0.110)	0.014(0.081)
480	10	0.334(2.00)	0.202(1.23)	0.117(0.652)	0.069(0.441)	0.047(0.231)	0.027(0.178)	0.021(0.127)	0.017(0.093)
96	50	0.747(4.46)	0.453(2.75)	0.262(1.46)	0.154(0.987)	0.105(0.516)	0.061(0.398)	0.047(0.284)	0.037(0.209)
80	60	0.818(4.89)	0.496(3.02)	0.287(1.60)	0.169(1.08)	0.115(0.565)	0.066(0.436)	0.051(0.311)	0.040(0.229)
32	150	1.29(7.73)	0.784(4.77)	0.453(2.53)	0.267(1.71)	0.182(0.894)	0.105(0.689)	0.081(0.492)	0.064(0.362)
16	300	1.70(10.1)	1.08(6.56)	0.666(3.87)	0.372(2.38)	0.226(1.34)	0.153(0.931)	0.117(0.687)	0.097(0.540)
5	960	5.26(32.8)	3.01(19.1)	1.67(10.6)	0.889(5.51)	0.516(3.95)	0.310(1.86)	0.207(1.44)	0.165(1.03)
2	2400	67.0(351)	35.5(184)	17.3(96.7)	8.81(51.3)	4.30(24.2)	2.18(13.6)	1.10(6.42)	0.592(3.72)
1	4800	558(3050)	277(1530)	138(787)	68.8(393)	34.7(185)	17.8(98.3)	8.65(48.4)	4.37(25.0)

Table 4. ADC ENOB (Noise Free Bits) at T_A = 25°C, V_{AVDD} = 5 V, V_{REF} = 5 V, SINC3 Filter, Chop Disabled

Filter Word	Data Rate (SPS)	PGA GAIN							
		1	2	4	8	16	32	64	128
1023	4.7	25.4(22.8)	25.1(22.5)	24.9(22.4)	24.7(22.0)	24.2(21.9)	24.0(21.3)	23.4(20.8)	22.7(20.2)
640	7.5	25.0(22.5)	24.8(22.2)	24.6(22.1)	24.3(21.6)	23.9(21.6)	23.7(21.0)	23.0(20.4)	22.4(19.9)
480	10	24.8(22.3)	24.6(22.0)	24.3(21.9)	24.1(21.4)	23.7(21.4)	23.5(20.7)	22.8(20.2)	22.2(19.7)
96	50	23.7(21.1)	23.4(20.8)	23.2(20.7)	23.0(20.3)	22.5(20.2)	22.3(19.6)	21.7(19.1)	21.0(18.5)
80	60	23.5(21.0)	23.3(20.7)	23.1(20.6)	22.8(20.1)	22.4(20.1)	22.2(19.5)	21.5(18.9)	20.9(18.4)
32	150	22.9(20.3)	22.6(20.0)	22.4(19.9)	22.2(19.5)	21.7(19.4)	21.5(18.8)	20.9(18.3)	20.2(17.7)
16	300	22.5(19.9)	22.1(19.5)	21.8(19.3)	21.7(19.0)	21.4(18.8)	21.0(18.4)	20.3(17.8)	19.6(17.1)
5	960	20.9(18.2)	20.7(18.0)	20.5(17.9)	20.4(17.8)	20.2(17.3)	19.9(17.4)	19.5(16.7)	18.9(16.2)
2	2400	17.2(14.8)	17.1(14.7)	17.1(14.7)	17.1(14.6)	17.1(14.7)	17.1(14.5)	17.1(14.6)	17.0(14.4)
1	4800	14.1(11.7)	14.1(11.7)	14.1(11.6)	14.1(11.6)	14.1(11.7)	14.1(11.6)	14.1(11.7)	14.1(11.6)

Fast Settling, Average=16, SINC4 and Chop Disabled

Table 5. ADC Noise in µVRMS (µVPP) at T_A = 25°C, V_{AVDD} = 5 V, V_{REF} = 5 V, SINC4 Filter, Chop Disabled

Filter Word	Data Rate (SPS)	PGA GAIN							
		1	2	4	8	16	32	64	128
96	3.125	0.286(1.36)	0.144(0.816)	0.080(0.442)	0.042(0.221)	0.030(0.144)	0.020(0.098)	0.015(0.076)	0.012(0.062)
30	10	0.511(2.43)	0.258(1.46)	0.143(0.791)	0.076(0.396)	0.053(0.258)	0.036(0.175)	0.027(0.137)	0.021(0.110)
6	50	1.14(5.44)	0.578(3.26)	0.320(1.77)	0.170(0.885)	0.120(0.578)	0.081(0.391)	0.061(0.306)	0.047(0.246)
5	60	1.25(5.96)	0.633(3.58)	0.351(1.94)	0.186(0.969)	0.131(0.633)	0.089(0.428)	0.067(0.335)	0.051(0.270)
2	150	1.61(7.75)	0.927(5.36)	0.595(3.73)	0.359(1.86)	0.218(1.04)	0.135(0.689)	0.107(0.596)	0.089(0.442)
1	300	3.73(22.7)	2.05(11.6)	1.18(7.60)	0.587(3.28)	0.340(1.94)	0.228(1.34)	0.155(0.903)	0.113(0.666)

Table 6. ADC ENOB (Noise Free Bits) at T_A = 25°C, V_{AVDD} = 5 V, V_{REF} = 5 V, SINC4 Filter, Chop Disabled

Filter Word	Data Rate (SPS)	PGA GAIN							
		1	2	4	8	16	32	64	128
96	3.125	25.1(22.8)	25.0(22.5)	24.9(22.4)	24.8(22.4)	24.3(22.0)	23.9(21.6)	23.3(21.0)	22.7(20.3)
30	10	24.2(22.0)	24.2(21.7)	24.1(21.6)	24.0(21.6)	23.5(21.2)	23.0(20.8)	22.4(20.1)	21.8(19.4)
6	50	23.1(20.8)	23.0(20.5)	22.9(20.4)	22.8(20.4)	22.3(20.0)	21.9(19.6)	21.3(19.0)	20.7(18.3)
5	60	22.9(20.7)	22.9(20.4)	22.8(20.3)	22.7(20.3)	22.2(19.9)	21.7(19.5)	21.2(18.8)	20.5(18.1)
2	150	22.6(20.3)	22.4(19.8)	22.0(19.4)	21.7(19.4)	21.5(19.2)	21.1(18.8)	20.5(18.0)	19.7(17.4)
1	300	21.4(18.8)	21.2(18.7)	21.0(18.3)	21.0(18.5)	20.8(18.3)	20.4(17.8)	19.9(17.4)	19.4(16.8)

ON-CHIP REGISTER MAPS

There are total eight registers inside the device which is 8-bit or 24-bit wide. These registers are used to configure and control the ADC to the desired mode of operation. These registers can be accessed through the SPI-compatible serial interface by using register read and write commands. At power-on or reset, the registers default to their initial settings, as shown in the *Reset Value* column of Table 7.

Table 7. Register map

ADDR.	NAME	DIR.	RESET VALUE	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
3'b000	STATUS	R	80	DRDYn	ERR	NOREF	PARITY	CHD[3:0]			
3'b001	MODE	R/W	080060	MD[2:0]			DATUS	CLK[1:0]		AVG[1:0]	
				SINC3	0	ENPAR	0	SINGLE	REJ60	FS[9:8]	
				FS[7:0]							
3'b010	CONFIG	R/W	000117	CHOP	0	0	REFSEL	0	0	0	0
				CH[7:0]							
				BCS	REFDET	0	BUF	FORMAT	PGA[2:0]		
3'b011	DATA	R	000000	DATA[23:16]							
				DATA[15:8]							
				DATA[7:0]							
3'b100	ID	R	X0	x	x	x	x	0	0	0	0
3'b101	GPOCON	R/W	00	0	BPDSW	GP32EN	GP10EN	P3DAT	P2DAT	P1DAT	P0DAT
3'b110	OFFSET	R/W	800000	OFFSET[23:16]							
				OFFSET[15:8]							
				OFFSET[7:0]							
3'b111	GAIN	R/W	555555	GAIN[23:16]							
				GAIN[15:8]							
				GAIN[7:0]							

STATUS Register

Table 8. STATUS Register (Address = 3'b000)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
DRDYn	ERR	NOREF	PARITY	CHD[3:0]			

Power-On/Reset Value = 0x80

Bits	Bit Name	Access	Reset	Description
7	DRDYn	R	1'b1	**ADC Ready Bit:** This bit is cleared when new data is written to the ADC data register. It is set automatically after the ADC data register is read. In addition to this bit, DOUT/DRDYn pin can also be used as an alternative to monitor the update of new ADC data.
6	ERR	R	1'b0	**ADC Error Bit.** This bit is written at the same time as new data update. Error sources include input overrange, input underrange, or lower than expected reference voltage.
5	NOREF	R	1'b0	**No External Reference Bit:** The function of this bit is only enabled by setting the REFDET bit in the CONFIG Register to 1. While the REFDET bit is 1 and the selected reference voltage is below a specified threshold, which is about 0.4V, this bit is set and conversion results are clamped to all 1s.
4	PARITY	R	1'b0	**Parity Check Bit:** The function of this bit is only enabled by setting the ENPAR bit in MODE Register to 1. While the ENPAR bit is 1 and there is odd number of 1s in the data register, this bit is set. Otherwise it is always 0.
3:0	CHD[3:0]	R	4'b0000	**Data Channel Number:** These bits indicate the corresponding channel to the ADC data in data register (see Table 11).

MODE Register

Table 9. MODE Register (Address = 3'b001)

BIT 23	BIT 22	BIT 21	BIT 20	BIT 19	BIT18	BIT 17	BIT 16
BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT10	BIT 9	BIT 8
BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
MD[2:0]			DATUS	CLK[1:0]		AVG[1:0]	
SINC3	0	ENPAR	0	SINGLE	REJ60	FS[9:8]	
FS[7:0]							

Power-On/Reset Value = 0x080060

Bits	Bit Name	Access	Reset	Description
23:21	MD[2:0]	R/W	3'b000	**Mode Select Bits:** These bits select the operating mode of the device. 000: Continuous conversion mode. (default) 001: Single conversion mode. ADC first wakeup if in idle or sleep mode; resets the filter to perform one conversion; and enters sleep mode. The conversion result remains in the data register with DOUT/DRDYn as low. 010: Idle mode. The digital filter is in reset state with ADC free running. 011: Sleep mode. Most of circuitry is turned off to save the power. BPDSW remains active in sleep mode. 100: Internal zero-scale calibration. 101: Internal full-scale calibration. 110: System zero-scale calibration. 111: System full-scale calibration. For each above calibration mode, DOUT/DRDYn goes high when the calibration is initiated and returns low when the calibration is complete. The ADC is automatically placed in idle mode after the calibration. The measured offset/full-scale coefficient is placed in the offset/full-scale register of the selected channel.
20	DATUS	R/W	1'b0	**Status Enable Bit:** When DATUS is set, the contents of the status register are transmitted along with each data register read.
19:18	CLK[1:0]	R/W	2'b10	**Clock Select Bits:** This bits select the clock source for SYSCLK. 00: External crystal applied between MCLK1 and MCLK2. 01: External clock applied to the MCLK2 pin. 10: Internal 4.9152MHz clock with MCLK2 tristated. (default) 11: Internal 4.9152MHz clock with its output on MCLK2 pin.
17:16	AVG[1:0]	R/W	2'b00	**Fast Settling Filter Setting:** In fast settling mode, a first-order average is added after the SINC filter to further improve the rms noise. It can work for any data rate select bits FS[9:0]. 00: Not averaging (default) 01: Average by 2 10: Average by 8 11: Average by 16
15	SINC3	R/W	1'b0	**SINC3 Enable Bit:** 0: SINC4 filter (default) 1: SINC3 filter
14	RESERVED	R/W	1'b0	**Reserved** Always write 1'b0
13	ENPAR	R/W	1'b0	**Enable Parity Bit:** This bit enables the parity check on the data register.
12	RESERVED	R/W	1'b0	**Reserved** Always write 1'b0

Bits	Bit Name	Access	Reset	Description
11	SINGLE	R/W	1'b0	**Single Cycle Conversion Bit:** When this bit is set, the ADC settles in one conversion cycle so that it functions as a zero latency ADC. When chop is disabled, fast settling mode is disabled, continuous conversion mode is selected, and SINGLE bit is set, the output data rate is $$\text{Output Data Rate} = \text{SYSCLK}/1024/\text{FS[9:0]}/N$$ Where N is 3 for SINC3 filter and 4 for SINC4 filter. With a nominal SYSCLK of 4.9152MHz, default Data Rate bits 0x060=96, and SINC3 bit set to 0, output data rate is 4915200/1024/96/4=12.5SPS.
10	REJ60	R/W	1'b0	**50/60Hz Notch Bit:** This bit can only be effective while FS[9:0]=0x060. A filter notch is placed at 60Hz to allow simultaneous 50Hz/60Hz rejection.
9:0	FS[9:0]	R/W	0x060	**Data Rate Select Bits:** The 10 bits are used to configure the ADC data rate. When chop is disabled, fast settling mode is disabled, and continuous conversion mode is selected, the output data rate is $$\text{Output Data Rate} = \text{SYSCLK}/1024/\text{FS[9:0]}$$ With a nominal SYSCLK of 4.9152MHz and default Data Rate bits 0x060=96, output data rate is 4915200/1024/96=50SPS.

CONFIG Register

Table 10. CONFIG Register (Address = 3'b010)

BIT 23	BIT 22	BIT 21	BIT 20	BIT 19	BIT18	BIT 17	BIT 16
BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT10	BIT 9	BIT 8
BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
CHOP	0	0	REFSEL	0	0	0	0
CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0
BURN	REFDET	0	BUF	FORMAT	PGA[2:0]		

Power-On/Reset Value = 0x000117

Bits	Bit Name	Access	Reset	Description
23	CHOP	R/W	1'b0	**Chop Enable Bit:** When this bit is enabled, the offset and offset drift of the ADC are dramatically improved with longer conversion time and settling time. For default data rate settling of 50SPS with SINC4 filter, the conversion time is 20ms and the settling time is 80ms with chop disabled. If chop is enabled, the conversion time is 80ms and the settling time is 160ms.
22, 21	RESERVED	R/W	2'b00	**Reserved** Always write 2'b00
20	REFSEL	R/W	1'b0	**Reference Select Bit:** Select the reference source for the ADC. 0: REFIN1+, REFIN1- (default) 1: REFIN2+, REFIN2-
19, 18, 17, 16	RESERVED	R/W	4'b0000	**Reserved** Always write 4'b0000
15:8	CH7 to CH0	R/W	0x01	**Channel Select Bits:** This bits select which channels are enabled for ADC conversion (see Table 11). When more than one channel are enabled, ADC automatically sequences them and places the data into data register with corresponding channel information in STATUS register and append them during data register read if DAT_STA bit in MODE RegisterMODE Register is enabled. For calibrations, only one channel can be selected and the lowest bit channel is selected if more than one channels are enabled.
7	BURN	R/W	1'b0	**Burnout Enable Bit:** When this bit is enabled, a pair of 500nA current sources are applied to analog inputs to source positive input and sink negative input.
6	REFDET	R/W	1'b0	**Reference Detection Enable Bit:** When this bit is enabled, the

NOREF bit in the STATUS register indicates when the reference input voltage is less than specified threshold, which is about 0.4V.

5	RESERVED	R/W	1'b0	**Reserved** Always write 1'b0
4	BUF	R/W	1'b0	**Buffer Enable Bit:** When this bit is set, analog input is buffered. Otherwise the input buffer is bypassed.
3	FORMAT	R/W	1'b0	**Data Format Bit:** This bit sets the ADC data format. 0: Bipolar mode (default) 1: Unipolar mode
2:0	PGA[2:0]	R/W	3'b111	**PGA Gain Configuration:** Selects the PGA gain. If PGA gain is set to other than 1, the BUF bit setting is ignored with buffer always enabled. 000: Gain=1 001: Gain=2 010: Gain=4 011: Gain=8 100: Gain=16 101: Gain=32 110: Gain=64 111: Gain=128 (default)

Table 11. Channel Selection

Channel	Channel Enabled		Status Register Bits CHD[3:0]	Calibration Register Pair
	Positive Input AIN+	Negative Input AIN-		
CH0=1	AIN1	AIN2	0000	0
CH1=1	AIN3	AIN4	0001	1
CH2=1	Temperature Sensor		0010	None
CH3=1	AIN2	AIN2	0011	0
CH4=1	AIN1	AINCOM	0100	0
CH5=1	AIN2	AINCOM	0101	1
CH6=1	AIN3	AINCOM	0110	2
CH7=1	AIN4	AINCOM	0111	3

DATA Register

Table 12. DATA Register (Address = 3'b011)

BIT 23	BIT 22	BIT 21	BIT 20	BIT 19	BIT18	BIT 17	BIT 16
BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT10	BIT 9	BIT 8
BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
DATA{23]	DATA{22]	DATA{21]	DATA{20]	DATA{19]	DATA{18]	DATA{17]	DATA{16]
DATA{15]	DATA{14]	DATA{13]	DATA{12]	DATA{11]	DATA{10]	DATA{9]	DATA{8]
DATA{7]	DATA{6]	DATA{5]	DATA{4]	DATA{3]	DATA{2]	DATA{1]	DATA{0]

Power-On/Reset Value = 0x000000

Bits	Bit Name	Access	Reset	Description
23:0	DATA{23:0]	R	0x000000	**Data Bits:** The 24-bit word is signed number in 2's complement format. See Data Format section for more information.

ID Register

Table 13. ID Register (Address = 3'b100)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
x	x	x	x	0	0	0	0

Power-On/Reset Value = 0xX0

Bits	Bit Name	Access	Reset	Description
7:0	ID	R	8'bxxxx0000	**ID Bits:** Read only.

GPOCON Register

Table 14. GPO Register (Address = 3'b101)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
0	BPDSW	GP32EN	GP10EN	P3DAT	P2DAT	P1DAT	P1DAT

Power-On/Reset Value = 0x00

Bits	Bit Name	Access	Reset	Description
7	RESERVED	R/W	1'b0	**Reserved** Always write 1'b0
6	BPDSW	R/W	1'b0	**Bridge Power-down Switch Control Bit:** When this bit is set to 1, the switch is closed to short BPDSW to AGND with low on-resistor of typical 3 Ohms. The switch is open if the bit is cleared. The switch remains active in idle and sleep modes.
5	GP32EN	R/W	1'b0	**P3 and P2 Output Enable Bit:** When this bit is set to 1, the P3 and P2 pins are configured as outputs. When this bit is set to 0, the P3 and P2 pins are tri-state.
4	GP10EN	R/W	1'b0	**P1 and P0 Output Enable Bit:** When this bit is set to 1, the P1 and P0 pins are configured as outputs. When this bit is set to 0, the P1 and P0 pins are tri-state.
3	P3DAT	R/W	1'b0	**Data Output P3 Bit:** This bit sets the value of the P3 output pin if GP32EN bit is set to 1. During GPO register read, the P3DAT reflects the status of the P3 pin if GP32EN bit is set to 1.
2	P2DAT	R/W	1'b0	**Data Output P2 Bit:** This bit sets the value of the P2 output pin if GP32EN bit is set to 1. During GPO register read, the P2DAT reflects the status of the P2 pin if GP32EN bit is set to 1.
1	P1DAT	R/W	1'b0	**Data Output P1 Bit:** This bit sets the value of the P1 output pin if GP10EN bit is set to 1. During GPO register read, the P1DAT reflects the status of the P1 pin if GP10EN bit is set to 1.
0	P0DAT	R/W	1'b0	**Data Output P0 Bit:** This bit sets the value of the P0 output pin if GP10EN bit is set to 1. During GPO register read, the P1DAT reflects the status of the P0 pin if GP10EN bit is set to 1.

OFFSET Register

The device has four OFFSET registers, each channel has a dedicated OFFSET register (see Table 11). OFFSET register read is allowed anytime, but writing to OFFSET register is only allowed while the device is in idle or sleep mode.

Table 15. OFFSET Register (Address = 3'b110)

BIT 23	BIT 22	BIT 21	BIT 20	BIT 19	BIT18	BIT 17	BIT 16
BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT10	BIT 9	BIT 8
BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
OFFSET[23]	OFFSET[22]	OFFSET[21]	OFFSET[20]	OFFSET[19]	OFFSET[18]	OFFSET[17]	OFFSET[16]
OFFSET[15]	OFFSET[14]	OFFSET[13]	OFFSET[12]	OFFSET[11]	OFFSET[10]	OFFSET[9]	OFFSET[8]
OFFSET[7]	OFFSET[6]	OFFSET[5]	OFFSET[4]	OFFSET[3]	OFFSET[2]	OFFSET[1]	OFFSET[0]

Power-On/Reset Value = 0x800000

Bits	Bit Name	Access	Reset	Description
23:0	OFFSET[23:0]	R/W	0x800000	**Offset Calibration Bits:** The 24-bit word is signed number in 2's complement format. See Calibration section for more information.

GAIN Register

The device has four GAIN registers, each channel has a dedicated GAIN register (see Table 11). GAIN register read is allowed anytime, but writing to GAIN register is only allowed while the device is in idle or sleep mode.

Table 16. GAIN Register (Address = 3'b111)

BIT 23	BIT 22	BIT 21	BIT 20	BIT 19	BIT18	BIT 17	BIT 16
BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT10	BIT 9	BIT 8
BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
GAIN[23]	GAIN[22]	GAIN[21]	GAIN[20]	GAIN[19]	GAIN[18]	GAIN[17]	GAIN[16]
GAIN[15]	GAIN[14]	GAIN[13]	GAIN[12]	GAIN[11]	GAIN[10]	GAIN[9]	GAIN[8]
GAIN[7]	GAIN[6]	GAIN[5]	GAIN[4]	GAIN[3]	GAIN[2]	GAIN[1]	GAIN[0]

Power-On/Reset Value = 0x555555

Bits	Bit Name	Access	Reset	Description
23:0	GAIN[23:0]	R/W	0x555555	**Gain Calibration Bits:** The 24-bit word is unsigned positive number in binary format. See Calibration section for more information.

REVISION HISTORY

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to web to make sure you have the latest revision.

DATE	REVISION	CHANGE
Sept. 20, 2021		Initial release.

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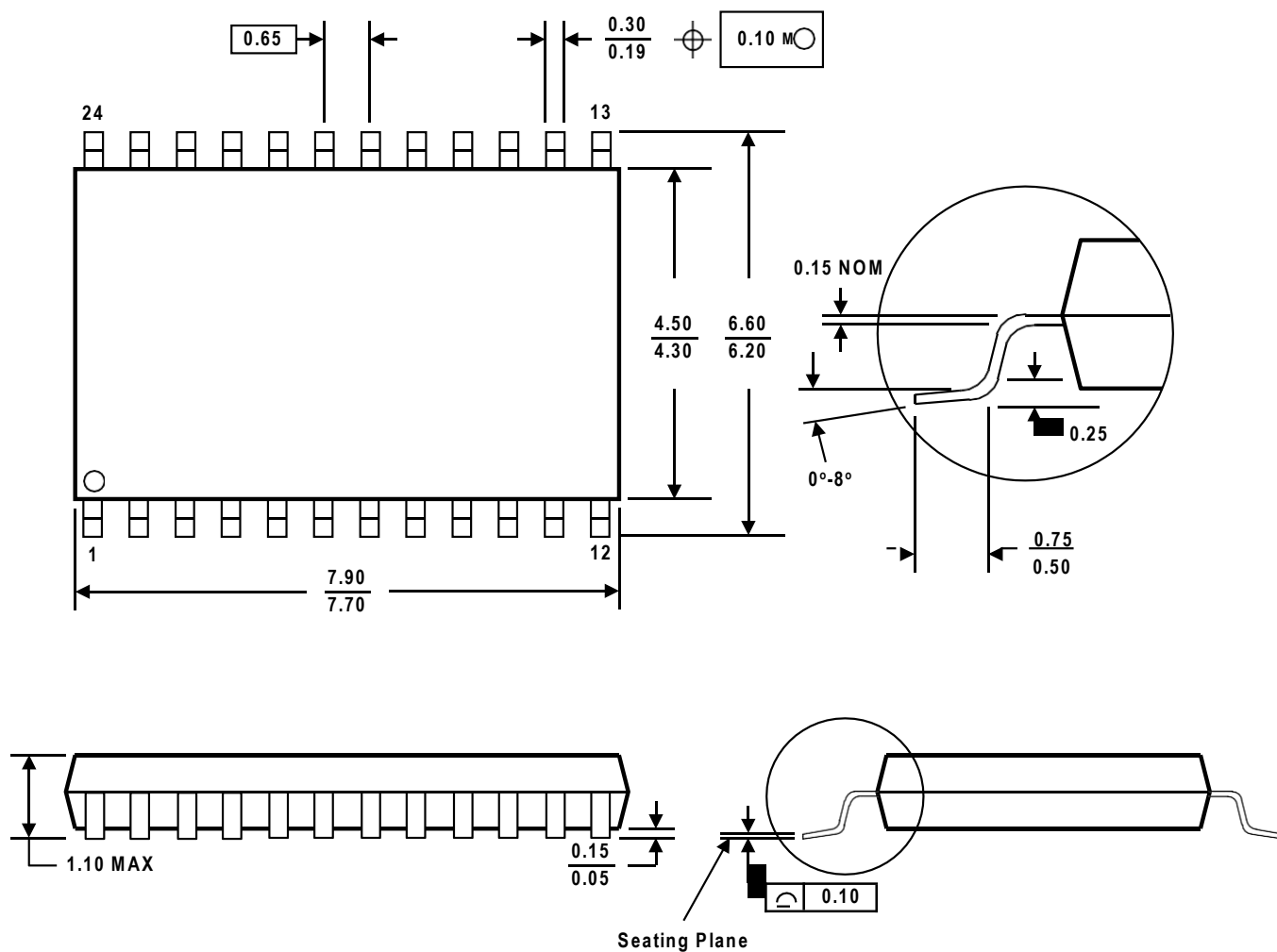

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PACKAGE OUTLINE DIMENSIONS

A. Compliant to JEDEC STARDARDS MO-153-AD.
B. All linear dimensions are in millimeters.
C. This drawing is subject to change without notice.