Welcome to the Texas Instruments New Product Update

We will begin promptly at 1 min past the hour- thank you for your patience
Phone lines will be muted during the presentation.

We are now using web-ex VOIP audio. There is no telephone dial in.

Please post questions on the chat Web-Ex Chat
or contact your sales person or field applications engineer

Precision ADC Update

November 2019

Introduction to Precision ADC

What we do

- **SAR and delta-sigma ADCs (up to 10 MSPS)**
- **Isolated amplifiers and isolated delta-sigma modulators**
- **Audio ADCs and codecs**
- **Automotive**

What we will cover

Important collateral

- Fundamental knowledge
- Device-specific

How to find ADCs

Factory automation products

Collateral Update

Fundamental knowledge

Precision Labs

- Comprehensive online “classroom” – 180 videos and counting
- Ties fundamental knowledge to practical applications
- Many modules include hands-on training

Example Video

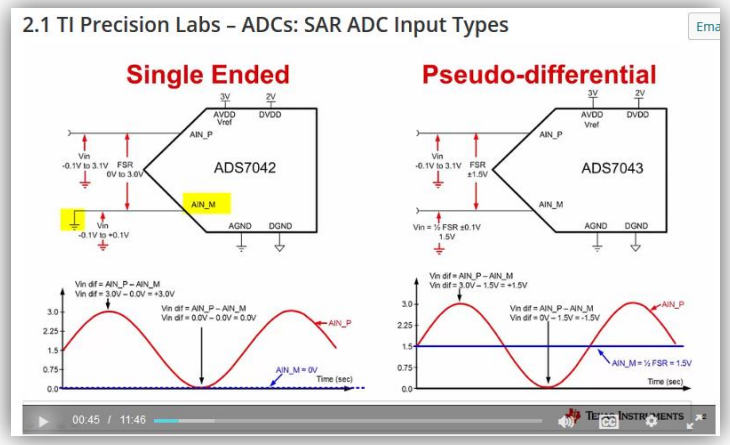
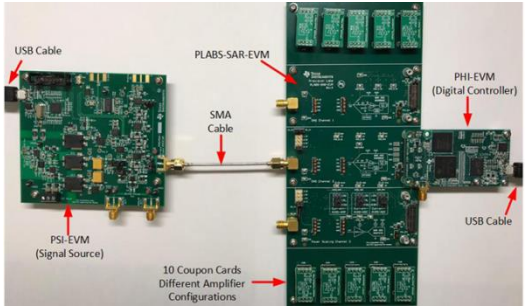


Table of Contents

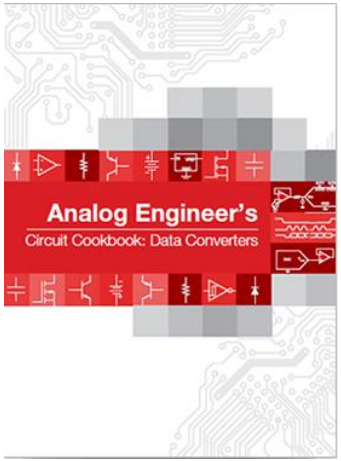
Hardware for hands-on training



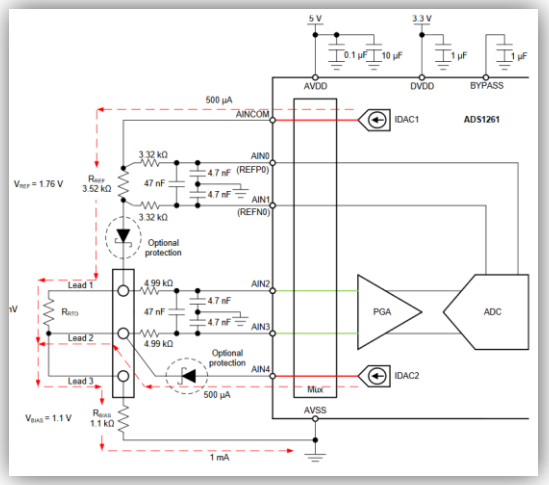
Circuit Cookbooks

- Simulated circuits for common applications
- System / Component tradeoffs make circuits adaptable
- # of circuits: amplifiers (64), ADCs (34), DACs (15)

ADC Table of Contents



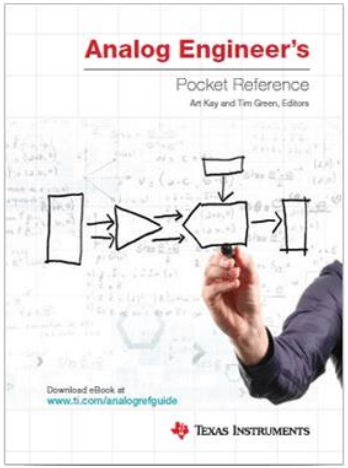
Example: High-side 3-wire RTD



Analog Engineer's Pocket Reference

- Easy reference guide for everyday analog design challenges
- Media options: hard copy via TI.com store, PDF, smart phone app

Front Cover



Example: Resistor coding

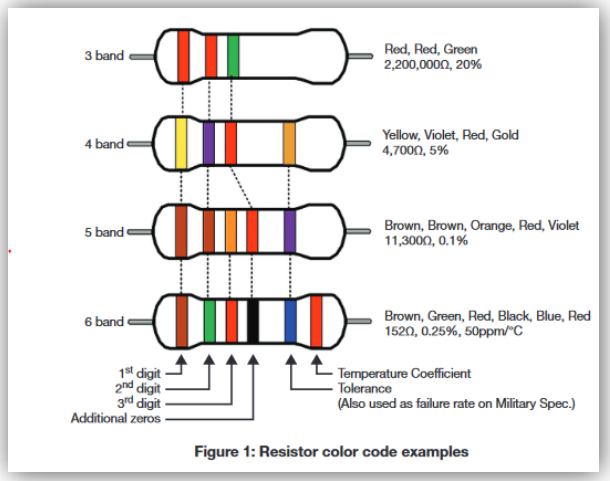


Figure 1: Resistor color code examples

Example: Settling time & accuracy

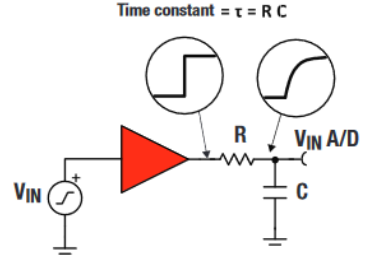


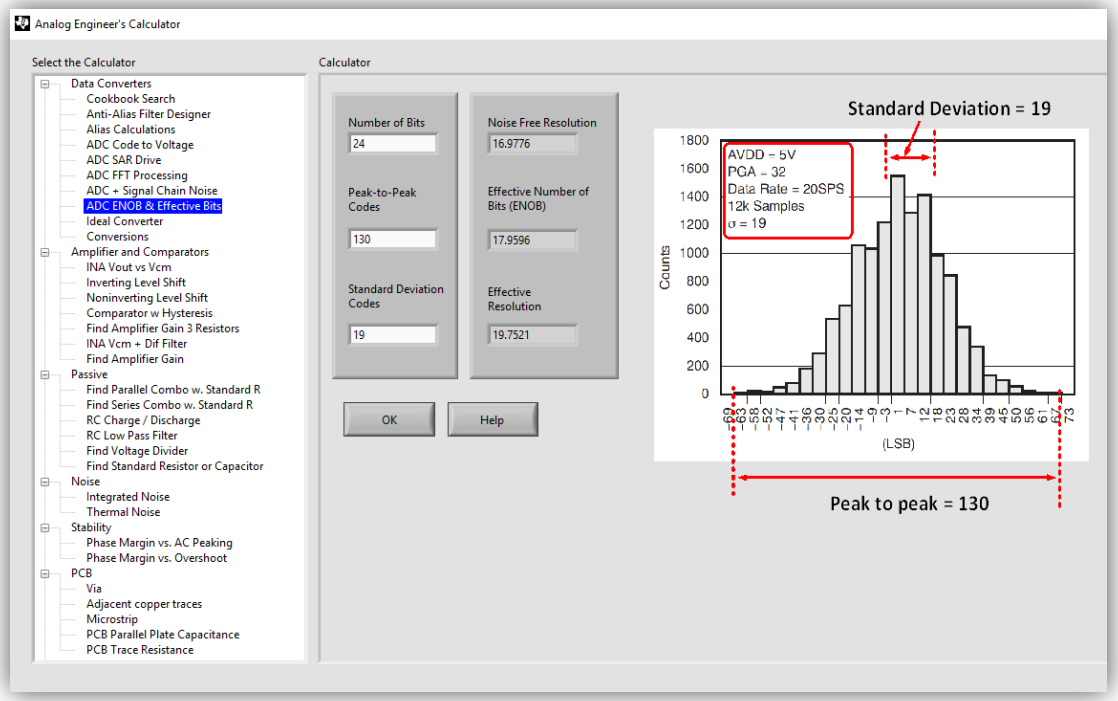
Figure 86: Settling time for RC circuit-related to ADC converters

Table 37: Conversion accuracy achieved after a specified time

Settling time in time constants (N_{TC})	Accuracy in bits (N)	Settling time in time constants (N_{TC})	Accuracy in bits
1	1.44	10	14.43
2	2.89	11	15.87
3	4.33	12	17.31
4	5.77	13	18.76
5	7.21	14	20.20
6	8.66	15	21.64
7	10.10	16	23.08
8	11.54	17	24.53
9	12.98	18	25.97

Analog Engineer’s Calculator

- Calculator featuring many helpful ADC, Op Amp, and passive tools
- Extension of the pocket reference
- Includes cookbook links
- Downloadable, Labview-based offline tool

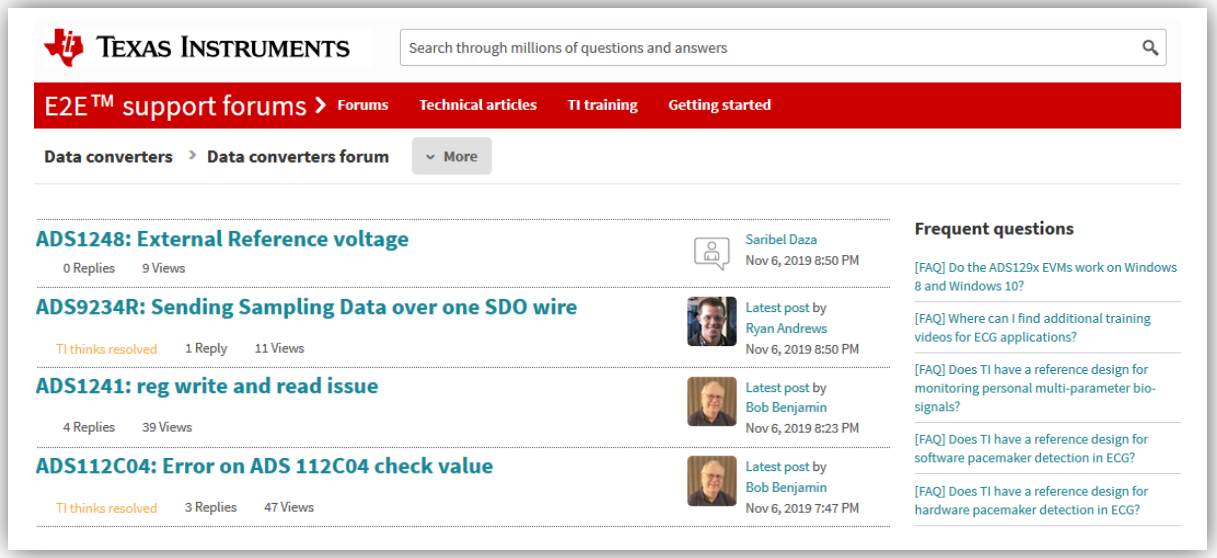


Collateral Update

Device-specific

E2E forum

- Direct support from TI's applications team for all device-related questions
- Replies within 24 hours
- Growing list of answers to frequently asked questions (FAQs)

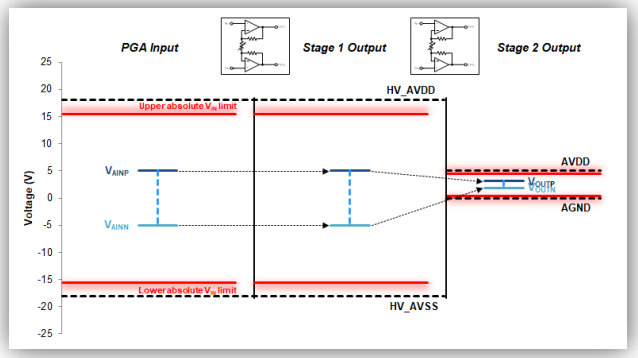


Device calculators

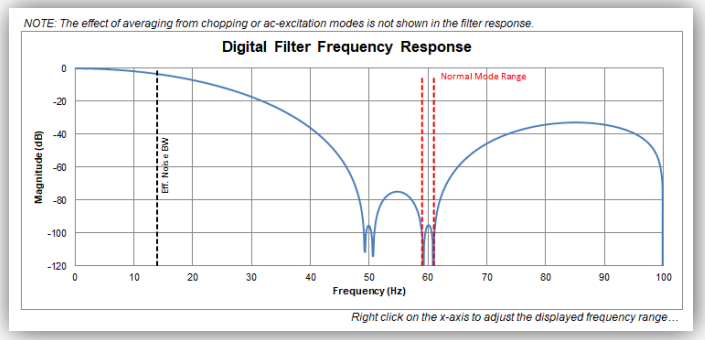
- Product-specific design calculators for integrated ADCs
- Tools and calculations to complement datasheet information
- Reduce design challenges and time to market

ADS125H02 product folder

Example: CM range calculator



Example: Digital filter response



Software code examples

- Releasing C Code Examples for popular products
- Designed to be part of the EVM GUI creation process
- Next: LINUX, FPGA

ADS125H02 product folder

Example: register read

```
/**
 * \fn uint8_t readSingleRegister(uint8_t addr)
 * \brief Reads contents of a single register at the specified address
 * \param addr address of the register to read
 * \return 8-bit register read result
 */
uint8_t readSingleRegister(uint8_t addr)
{
        /* Check that the register address is in range */
        assert(addr < NUM_REGISTERS);

        uint8_t DataTx[6];
        uint8_t DataRx[6] = { 0 };
        uint8_t byteLength = 6;
        uint8_t dataPosition = 4;

        /* Build TX array */
        DataTx[0] = OPCODE_RREG + (addr & 0x1F);
        DataTx[1] = ADC_DontCare;
    DataTx[2] = calculateCRC(&DataTx[0], 2);    /* Compute CRC-2 */
    DataTx[3] = 0;
    DataTx[4] = 0;
    DataTx[5] = 0;

        /* Select which /CSx pin to set low */
        bool nCS1 = !(addr <= 0x0Fu);
        bool nCS2 = !(addr >= 0x10u);

        /* SPI send & receive */
    setCS(nCS1, nCS2);
        SPI_SendReceive(DataTx, DataRx, byteLength);
        setCS(HIGH, HIGH);

        /* Validate command response */
        if (validateSPI(DataTx, DataRx, OPCODE_RREG))
        {
                /* Handle SPI error */
                handleSPIerror(DataTx, DataRx, byteLength, "RREG");
        }
        else
        {
                /* Update register array */
                ADC_RegisterMap[addr] = DataRx[dataPosition];
        }

        return DataRx[dataPosition];
```

Circuit cookbooks → circuit design hub

Texas Instruments

Analog Engineer's Circuit: Data Converters
SBAA310–December 2018

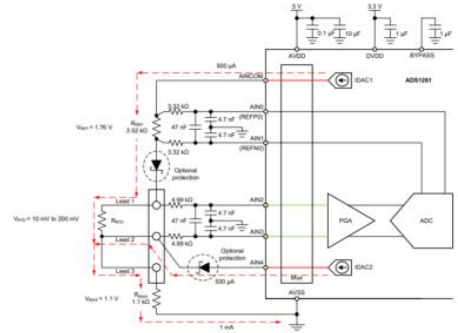
Three-wire PT100 RTD measurement circuit with high-side reference and two IDAC current sources

Joseph Wu, Chris Hall

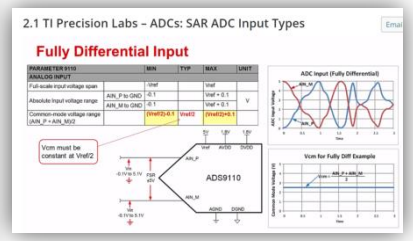
Power Supplies		
AVDD	AVSS, DGND	DVDD
5V	0V	3.3V

Design Description

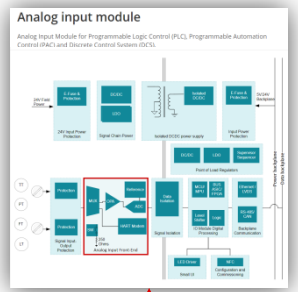
This cookbook design describes a temperature measurement for a three-wire RTD using the ADS1261. This design uses a ratiometric measurement with a high-side reference using two matched excitation current sources for a PT100 type RTD with a temperature measurement range from –200°C to 850°C. Included in this design are ADC configuration register settings and pseudo code to configure and read from the device. This circuit can be used in applications such as *analog input modules* for PLCs, *lab instrumentation*, and *factory automation*. For more information about making precision ADC measurements with a variety of RTD wiring configurations, see *A Basic Guide to RTD Measurements*.



TI Precision Labs

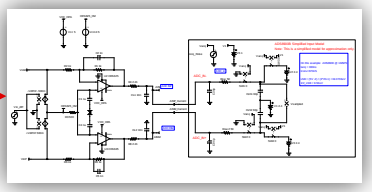


EERDs, EE Pages

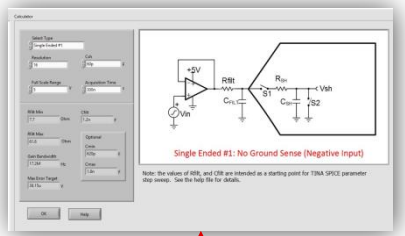


Product Folders

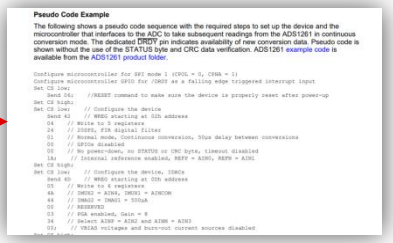
SPICE Models



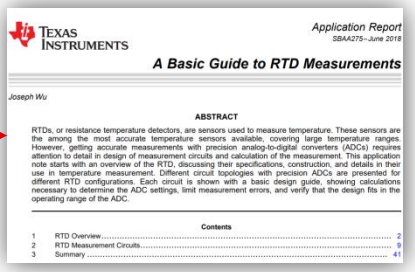
Design Calculators



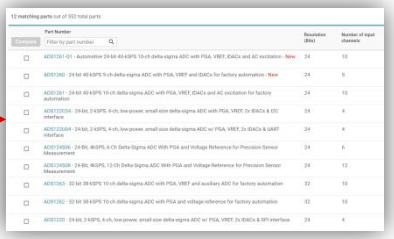
Code Examples



Related Content



Pre-Filtered Search

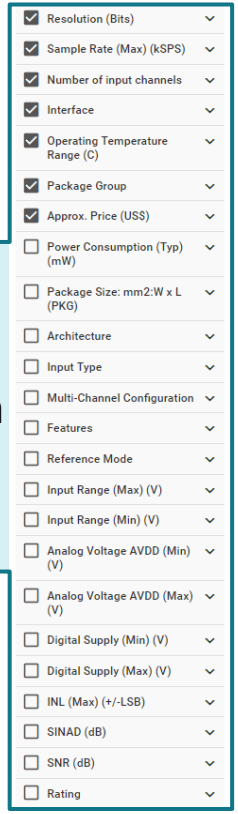


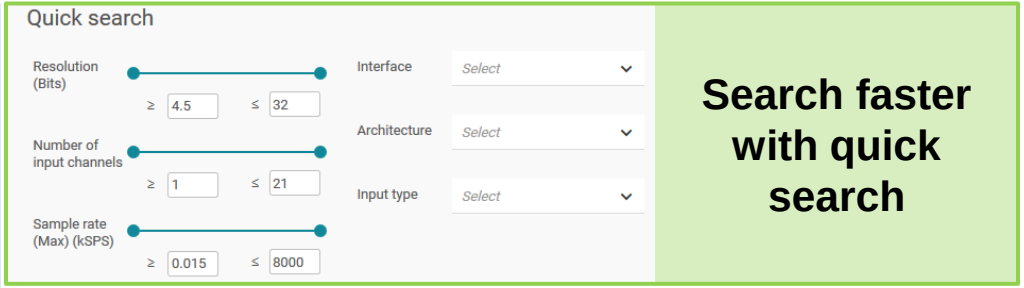
How to Find Precision ADCs

Finding TI's Precision ADCs

"Products → Data Converters → Precision ADCs (<=10MSPS)"
Or
http://www.ti.com/data-converters/adc-circuit/precision-adcs/products.html

Find the best device for your application with 17 additional parameters





Search faster with quick search

Part Number (Filter by part number)	Resolution (Bits)	Number of input channels	Sample rate (Max) (kSPS)	Interface
TLA2518 - Small 8-channel 12-bit analog-to-digital converter (ADC) with SPI interface and GPIOs - New	12	8	1000	Enhanced SPI
ADS131M04 - 24-bit 32-kSPS 4-channel simultaneous-sampling delta-sigma ADC - New	24	4	32	SPI
ADS9234R - 14-bit, 3.5-MSPS, dual, simultaneous-sampling SAR ADC with internal reference and enhanced SPI - New	14	2	3500	Enhanced SPI, SPI
ADS7038 - Small 8-channel 1-MSPS 12-bit analog-to-digital converter (ADC) with SPI interface, GPIOs and CRC - New	12	8	1000	Enhanced SPI
ADS7028 - Small 8-channel 12-bit analog-to-digital converter (ADC) with SPI interface, GPIOs and CRC - New	12	8	1000	Enhanced SPI
ADS7128 - Small 8-channel 12-bit analog-to-digital converter (ADC) with I2C interface, GPIOs, CRC and RMS m - New	12	8	140	I2C
TLA2528 - Small 8-channel 12-bit analog-to-digital converter (ADC) with I2C interface and GPIOs - New	12	8	140	I2C
ADS9224R - 16-bit, 3-MSPS, dual-channel, simultaneous-sampling SAR ADC with internal reference and enhanced SPI - New	16	2	3000	Enhanced SPI, SPI

Easily search through TI's 558 Precision ADCs

Precision ADC Hero Products

ADC types covered in this presentation

Factory Automation

- Low noise, 24-bit delta-sigma ADCs
- Excellent DC precision
- Features for process level (4-20mA / ±10V) and sensor (temp / pressure) inputs

Grid Infrastructure

- 24-bit delta-sigmas / 12-18-bit SAR
- Simultaneous sampling
- Metrology features
- ±10 V input option w/ 5 V supply

General Purpose

- <16-bit ADCs
- SAR and delta-sigma
- Low power, small size, low cost
- Ideal for monitoring functions (V / I / temp)

Factory Automation ADCs

ADS124S06 / ADS124S08

24-bit, 4 kSPS, 6/12-Ch ΔΣ ADC for Precision Sensor Measurement

Features

Resolution	24
# of Ch	6 / 12
Sample Rate	4 kSPS
Interface	SPI
AVDD	2.7 V to 5.25 V ±2.5 V
DVDD	2.7 V to 3.6 V
Input Type	Single-Ended Differential
Temperature Range	-50°C to +125°C
Package	5 mm x 5 mm (QFN-32 / TQFP-32)

Low-Noise PGA
(19 nV @ G=128)

Low-Drift Reference
(10 ppm/°C max)

2x Current Sources
(IDACs)

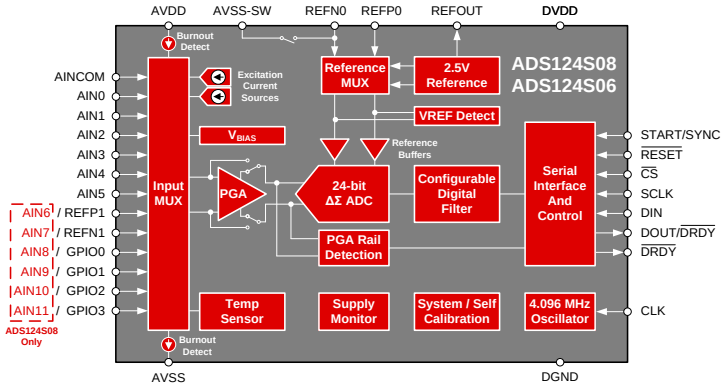
High Accuracy
Oscillator (1.5%)

Applications

- Temperature Measurement: **RTDs | Thermocouples | Thermistors**
- Pressure Sensors
- Electro-Magnetic Flow Meters
- Universal PLC / DCS Analog Input Modules
- Weigh Scales

Benefits

- **Low-noise PGA** enables precision measurements for the smallest input signals
- **Low-drift integrated voltage reference** reduces system cost and size while still offering high precision and accuracy
- **Dual, matched IDACs** can used for RTD biasing, reducing BOM size and solution cost
- **High-accuracy oscillator** enables better 50/60 Hz rejection than competitors for noisy industrial environments



Device	# of Ch	Resolution	Device	# of Ch	Resolution
ADS124S08	12	24	ADS114S08	12	16
ADS124S06	6		ADS114S06	6	

ADS1260 / ADS1261

24-bit, 40 kSPS, 5/10-Ch ΔΣ ADC w/ Low Noise in 5 mm x 5 mm QFN

Features

Resolution	24
# of Ch	5 / 10
Sample Rate	40 kSPS
Interface	SPI
AVDD	4.75 V to 5.25 V ±2.5 V
DVDD	2.7 V to 5.25 V
Input Type	Single-Ended Differential
Temperature Range	-40°C to +125°C
Package	5 mm x 5 mm (QFN-32)

Low-Noise PGA
(6 nV_{RMS} @ G=128, 2.5 SPS)

Small 5 mm x 5 mm QFN Package

AC Excitation (ADS1261 only)

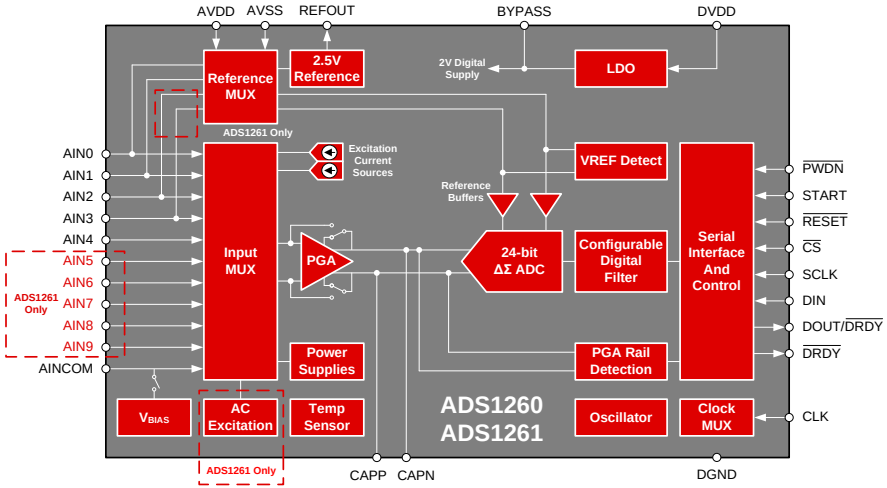
Monitoring & Diagnostics

Applications

- PLC Analog Input Modules:
  - 4-20 mA | 10 V | RTD | Thermocouple
- DAQ and Dynamic Strain Analyzers
- Gas Chromatographs / Flow Meters
- Weigh Scale / Resistive Bridge Measurements

Benefits

- **Low-noise PGA** enables precision measurements for the smallest input signals
- **Small 5x5 mm QFN package** reduces system footprint while still providing a highly-integrated, high-performance solution
- **AC-excitation** drive for H-bridge chopping helps remove offset and offset drift errors to improve system accuracy
- **Monitoring & diagnostic** features help improve system reliability



ADS125H01** / ADS125H02

Samples: NOW
RTM: 4Q19**

Industry's First ±20 V Input, 24-bit, 40kSPS, 1-/2-Ch ΔΣ ADC with High Input Impedance

Features

Resolution	24
# of Ch	1 / 2
Sample Rate	40 kSPS
Interface	SPI
CM Range	±15.5 V
HV AVDD	±18 V / 0 V to 36 V
AVDD	4.75 V to 5.25 V
DVDD	2.7 V to 5.25 V
PGA Gains	0.125 to 128 (binary)
Input Type	Single-Ended Differential
Temp Range	-40°C to +125°C
Package	5 mm x 5 mm (QFN-32)

Wide FS Input Signal Range:
±20 mV to ±20 V

Ultra-Low Noise:
45 nV_{RMS} (20 SPS)

Small Solution Size:
5 mm x 5 mm QFN

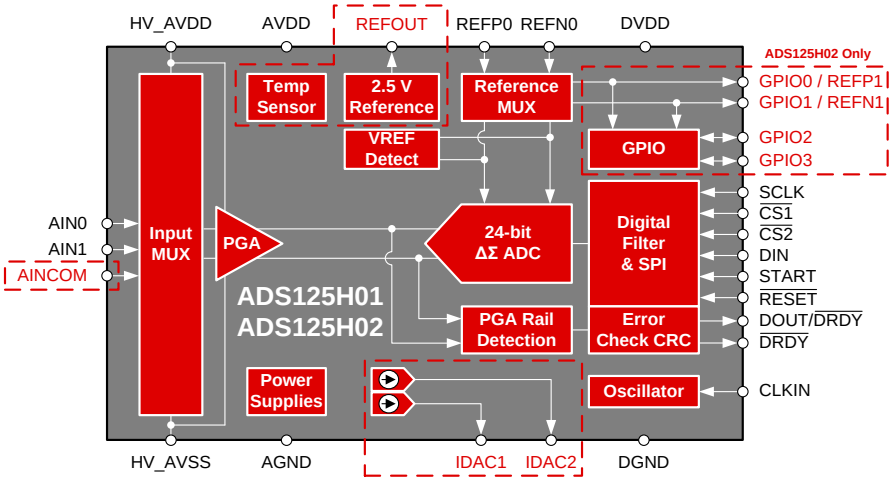
High Input Impedance:
1 GΩ

Applications

- PLC Analog Input Modules:
  - ±10 V / 4-20 mA
  - Thermocouple / RTD
  - Universal Input
- High-Voltage, Precision T&M
  - Battery Test Equipment

Benefits

- **Programmable input signal range** accepts high-voltage inputs **and** low-voltage inputs
- **Low noise PGA + high-resolution 24-bit ADC** suitable for direct connection to bridge / RTD / thermocouple sensors
- **Small form factor, single-chip solution** is >50% smaller than discrete devices, reducing PCB area and simplifying design
- **1-GΩ input impedance** eliminates measurement errors caused by sensor loading



Grid Infrastructure ADCs

ADS85xxx (ADS8588S family)

14/16/18-bit, 4/6/8-Ch Sim-Sam SAR ADC w/ High Input Impedance Front End & Single Supply Operation

Features

Resolution	14 / 16 / 18
# of Ch	4 / 6 / 8 (simultaneous)
Sample Rate	200 kSPS / 250 kSPS / 330 kSPS / 500 kSPS
Interface	SPI / Parallel
AVDD	4.75 V to 5.25 V
DVDD	2.3 V to AVDD
Input Type	Single-Ended
Temperature Range	-40°C to +125°C
Package	10 mm x 10 mm (LQFP-64)

High Input Impedance:
1 MΩ

Exceptional AC & DC Performance:
- SNR: 101.8 dB
- THD: -114 dB

Pin-Programmable Bipolar Inputs: ±10 V and ±5 V

5 V Single Supply Operation

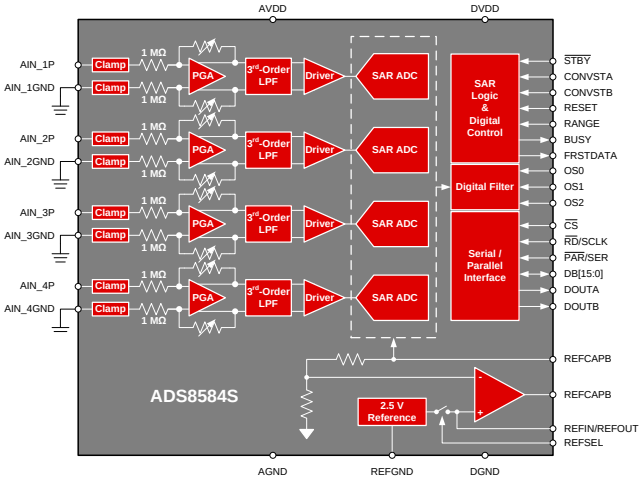
Applications

- Protection Relays
- Test & Measurement
- Battery Test
- Industrial Automation
- Power Monitoring

Benefits

- A **high input impedance** front end with programmable input range (unipolar/bipolar) enables direct sensor interface & simplifies design
- **3 dB** better SNR than AD7606
- 5 V single supply operation **simplifies design**
- The high speed (200 kSPS / 500 kSPS) simultaneous sampling enables **fast data acquisition** across multiple signals with **no channel-to-channel latency**

Device	Resolution	Sample Rate	# of Ch
ADS8578S	14	200 kSPS	8
ADS8584S	16	330 kSPS	4
ADS8586S	16	250 kSPS	6
ADS8588S	16	200 kSPS	8
ADS8588H	16	500 kSPS	8
ADS8598S	18	200 kSPS	8
ADS8598H	18	500 kSPS	8



ADS131A02 / ADS131A04

24-bit, 128 kSPS, 2/4-Ch ΔΣ ADC for Energy Applications with High Dynamic Range

Features

Resolution	24
# of Ch	2 / 4
Sample Rate	128 kSPS
Interface	SPI
AVDD	3.3 V to 5.5 V
DVDD	1.65 V to 3.6 V
Input Type	Single-Ended Differential
Temperature Range	-40°C to +125°C
Package	5 mm x 5 mm (TQFP-32)

High Dynamic Range:
115 dB

Flexible Interface:
Daisy-Chain Capability

Extended Input Range:
AVSS-1.5 V to AVDD with Unipolar Supply

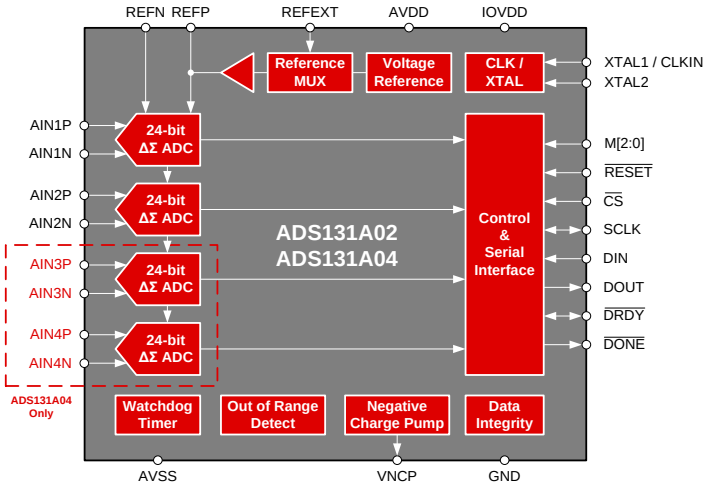
High Data Rate:
128 kSPS

Applications

- Relay Protection & Circuit Breakers
- Power Metrology
- Portable Instrumentation/IEDs
- Battery Test

Benefits

- **High Performance** allows solutions with high dynamic range
- Serial interface provides sync options for multiple devices
- **Extended Input Range** enables low cost solution by simplifying the front end design
- Wide bandwidth allows for harmonic analysis



ADS131M02* / ADS131M03* / ADS131M04

*RTM soon

Industry's lowest power, low cost and small size 2/3/4-Ch, 24-bit, 32 kSPS, Simultaneous Sampling ADC

Features

Resolution	24-bit
# of Ch	2 / 3 / 4
Sample Rate	32 kSPS
Gain	Up to 128
Input Impedance	240 kΩ (G = 1,2,4) 1 MΩ (G = 8,16,32,64)
AVDD	2.7 V to 3.6 V
DVDD	2.7 V to 3.6 V
Input Type	Single-Ended Differential
Temperature Range	-40°C to +125°C
Package	See table

Low Power:
- ADS131M02: 2.3 mW
- ADS131M03: 3.0 mW
- ADS131M04: 3.3 mW

High Input Impedance

High Dynamic Range: 100 dB

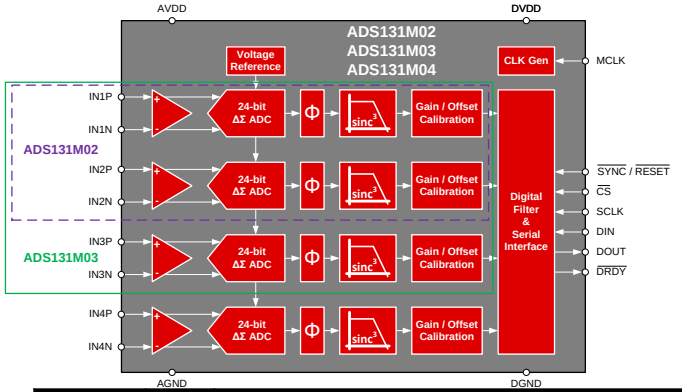
Small Size

Applications

- Energy measurement: V/I/T
  - Electricity meters: residential & commercial
  - Circuit breakers
  - Battery management

Benefits

- **Low power** enables efficient energy measurements
- **High input impedance** at all gain settings enables direct sensor interface
- **ADC accuracy** exceeds requirements for Class 0.2 metering
- **Ideal features for metrology:**
  - Channel phase delay for CT or Rogowski Coil compensation
  - Fast startup ideal for circuit breakers
  - Third channel for monitoring neutral for tamper protection



Device	# of Ch	Package Options	
ADS131M02	2	3 mm x 3 mm (VQFN-16)	5 mm x 4.4 mm (TSSOP-16)
ADS131M03	3	3 mm x 3 mm (WQFN-20)	6.5 mm x 4.4 mm (TSSOP-20)
ADS131M04	4	3 mm x 3 mm (WQFN-20)	6.5 mm x 4.4 mm (TSSOP-20)

General Purpose ADCs (<16-bit)

General Purpose ADCs

Low Cost, Small Size, High Ch Density and Highly flexible ADCs

Low Cost

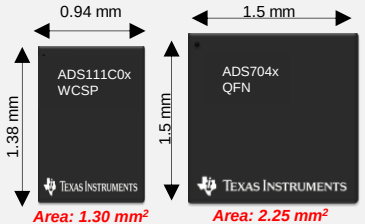
Industry's Lowest Priced ADCs

ADS7040:	8-bit, 1 channel SPI	*$0.40 @ 1ku*
TLA2021:	12-bit, 1 channel, I2C	*$0.55 @ 1ku*
TLA2022:	12-bit, 1 channel, PGA, I2C	*$0.60 @ 1ku*
ADS7041:	10-bit, 1 channel SPI	*$0.60 @ 1ku*
TLA2024:	12-bit, 4 channels, PGA, I2C	*$0.65 @ 1ku*

Small Size

Industry's Smallest Sized ADCs

ADS111C04: 16-bit, 4 channel, I^2C
ADS7066: 16-bit, 8 channel, SPI
ADS7042: 12-bit, 1 channel, 1 MSPS, SPI
ADS7046: 12-bit, 1 channel, 3 MSPS, SPI
ADS7056: 14-bit, 1 channel, 3 MSPS, SPI



High Ch Density

2 Channels		4 Channels	
ADS7142	*(2 mm X 1.5 mm)*	**ADS111C04*** **TLA2024**	***(1.38 mm X 0.94 mm)*** *(1.5 mm X 1.5 mm)*
8 Channels		**16 Channels**	
TLA2528* **ADS7066***	***(3 mm X 3 mm)*** ***(1.66 mm X 1.66 mm)***	**ADS7953**	*(5 mm X 5 mm)*

Diversified Features

GPIOs		Autonomous Monitoring	
ADS7953 **TLA7128**	*4 GPIOs* *8 GPIOs*	**ADS7142** **ADS7138**	
Integrated PGA		**P2P compatible devices**	
TLA2022 **TLA2024**	*Input ranges from ±256 mV to ±6.144 V*	**ADS795x / ADS794x :** *8,10,12 bit with 4, 8, 12, 16 channels* **ADCxxxSxxx :** *8,10,12 bit with 1, 2, 4, 8 channels and 200, 500, 1000 kSPS*	

ADS7128 – Device Family

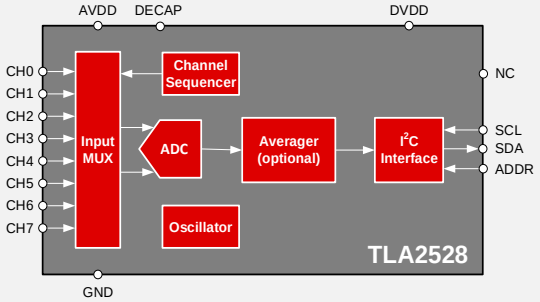
12-bit, 140 kSPS, 8-Ch SAR ADC w/ GPIOs

Samples: NOW
RTM: 4Q19

TLA2528

Lowest Cost

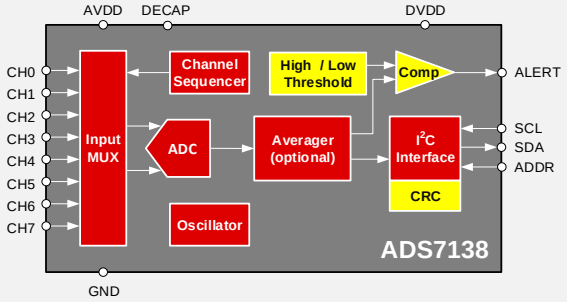
- **Smallest** 8 Channel ADC
- Programmable **GPIOs**
- **Averaging** (16 bit mode)



ADS7138 & ADS7138-Q1

TLA2528 +

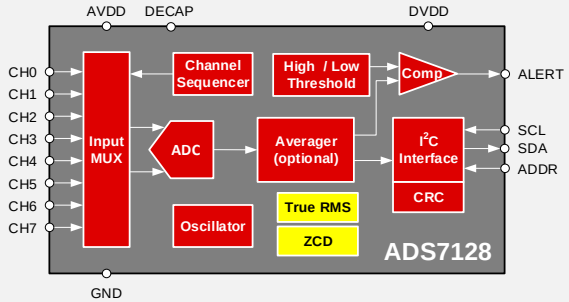
- **Autonomous** Monitoring
- **CRC** on Data Interface
- -40°C to +125°C



ADS7128

ADS7138 +

- **True RMS** module
- **ZCD** module
- -40°C to +85°C



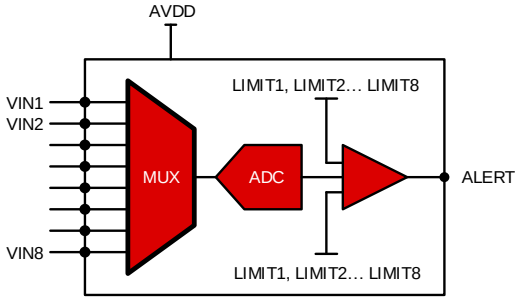
ADS7128/38 are p2p and backward compatible with TLA2528

ADS7128 – Applications

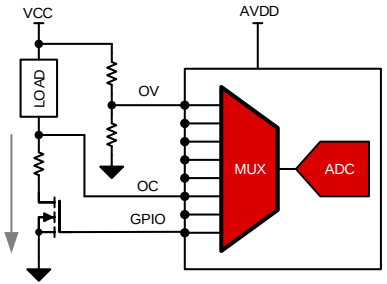
Samples: NOW
RTM: 4Q19

12-bit, 140 kSPS, 8-Ch SAR ADC w/ GPIOs

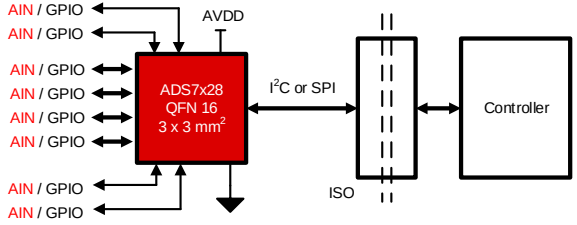
Voltage Supervisor w/ Fast ALERT



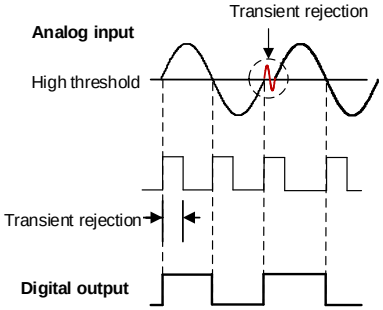
Over Current / Over Voltage Protection w/ Fast Shutdown



ADC + IO Expander

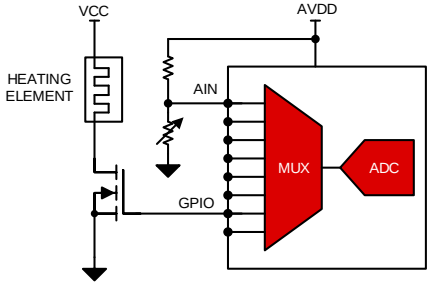


Zero-Crossing-Detection for Appliances



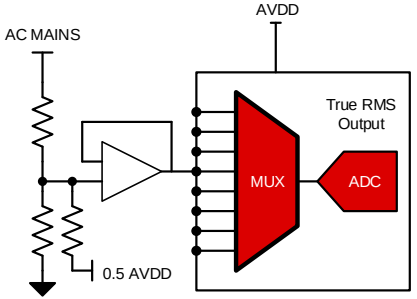
ADS7128 eliminates transients in the ZCD output caused by switching noise in the line voltage.

Temperature Control



Temperature control loop using analog inputs and GPIO.

True Root-Mean-Square Measurement



RMS to digital conversion with lowest power. Competes with ADI's RMS-DC converter.

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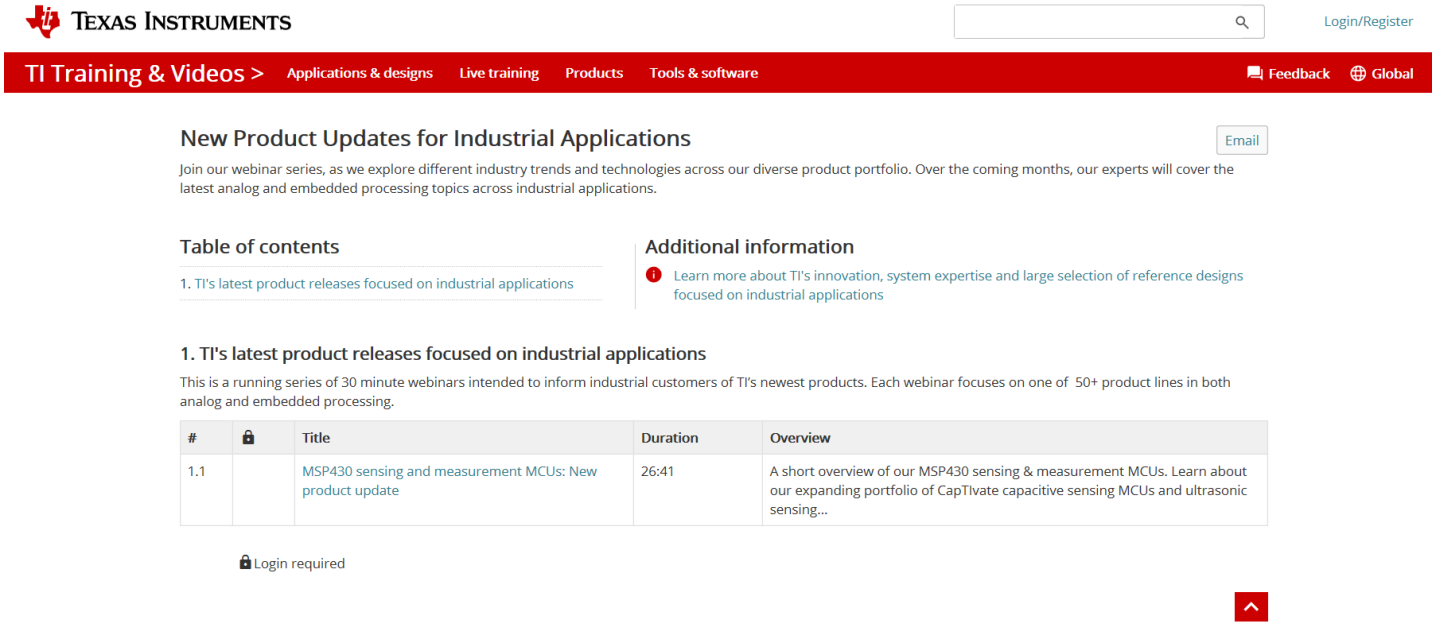
https://training.ti.com/npu



Upcoming Broadcasts

Date	Topic
12/5/2019	Boost Converters and Controllers
12/12/2019	Power over Ethernet
12/19/2019	Break
12/26/2019	Break
1/2/2020	Break
1/9/2020	SimpleLink™ wired and wireless Arm® MCUs