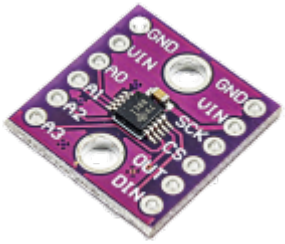
LamaPLC: Texas Instruments ADCs: Delta-sigma multi-channel Analog Converters with SPI communication

Texas Instruments' ADCs are all delta-sigma converters that primarily differ in resolution, interface type, sample rate, and integrated features such as input channels and programmable gain amplifiers (PGAs). The ADS111x series is a 16-bit, I2C-compatible device, while the ADS12xx series is typically a 24-bit, SPI-compatible device with more advanced features for high-precision applications such as weighing scales and industrial process control.

ADS111x Series (16-bit, I²C)

The Texas Instruments ADS111x series is a set of 16-bit-precision ADCs designed for low-power, space-constrained sensor measurement tasks. Key features include a broad supply-voltage range (2.0V to 5.5V), low current consumption (about 150µA in continuous operation), and built-in components such as a low-drift voltage reference and an oscillator.



ADS111x General Specifications

- **Resolution:** 16 bits
- **Supply Voltage Range:** 2.0 V to 5.5 V
- **Low Current Consumption:** Typically 150 µA in continuous-conversion mode
- **Internal Components:** All devices include a low-drift voltage reference and an internal oscillator.
- **Operating Temperature Range:** -40°C to +125°C

Model	nterface	Channels (SE/Diff)	PGA	Comparator	Max Data Rate (SPS)	Unique Features
ADS1110	I²C	1 Diff	Yes (Gains up to 8)	No	240	Continuously self-calibrating
ADS1112	I²C	1 SE or Diff	Yes	No	240	(Similar to ADS1113/4/5 in core, but specific variant details are sparse)
ADS1113	I²C	1 SE or Diff	No	No	86	Basic model, minimal features
ADS1114	I²C	1 SE or Diff	Yes	Yes	860	Includes PGA and comparator
ADS1115	I²C	4 SE or 2 Diff	Yes	Ye	860	Input MUX for multiple channels
ADS1118	SPI	4 SE or 2 Diff	Yes	No	860	Integrated temperature sensor

Model	nterface	Channels (SE/Diff)	PGA	Comparator	Max Data Rate (SPS)	Unique Features
ADS1119	I²C	4 SE or 2 Diff	Yes (Gains 1 or 4)	No	1000	Single-cycle settling filter at 20 SPS (for 50/60Hz rej.)

ADS1118 Pinout

Pin	Name	Type	Description
1	SCLK	Digital Input	SPI serial clock
2	CS	Digital Input	Chip select; active low
3	GND	Supply	Ground
4	AIN0	Analog Input	Analog input channel 0
5	AIN1	Analog Input	Analog input channel 1
6	AIN2	Analog Input	Analog input channel 2
7	AIN3	Analog Input	Analog input channel 3
8	VDD	Supply	Power supply (2V to 5.5V)
9	DIN	Digital Input	SPI serial data input (MOSI)
10	DOUT/DRDY	Digital Output	SPI serial data output / Data-ready (MISO)

Key Pin Notes

- **DOUT/DRDY:** This pin serves a dual purpose. It provides serial data output and serves as a data-ready indicator, pulling low when a new conversion result is ready. An internal pull-up resistor can be enabled on this pin via software.
- **Analog Inputs (AIN0-AIN3):** These pins can be configured as four single-ended inputs (measured against GND) or two differential pairs (AIN0-AIN1 and AIN2-AIN3).
- **Input Limits:** Voltages on any analog input pin must remain between GND - 0.3V and VDD + 0.3V to prevent damage to the internal ESD diodes.

Arduino & ADS1118

To interface the ADS1118 16-bit ADC with an Arduino, the most common approach is to use the **ADS1118 library** by denkitronik.

Wiring Diagram

The ADS1118 communicates via SPI. Connect it to your Arduino as follows:

ADS1118 Pin	Arduino Pin (Uno/Nano)
VCC	3.3V or 5V
GND	GND
DIN (MOSI)	Pin 11
DOUT (MISO)	Pin 12
SCLK	Pin 13
CS	Pin 10 (or any digital pin)

Example Arduino Code

This basic example initializes the ADC and reads the voltage from input AIN0 and the internal temperature sensor.

```
#include <SPI.h>
#include <ADS1118.h>

// Define the Chip Select (CS) pin
#define CS_PIN 10

ADS1118 ads1118(CS_PIN);

void setup() {
  Serial.begin(115200);

  // Initialize ADS1118 with default settings
  ads1118.begin();

  // Optional: Set sampling rate (e.g., 128 SPS)
  ads1118.setSamplingRate(ads1118.RATE_128SPS);
}

void loop() {
  // Read voltage from Single-Ended Input 0 (AIN0)
  // Returns value in millivolts (double)
  double voltage = ads1118.getMilliVolts(ads1118.AIN_0);

  // Read internal chip temperature
  double temp = ads1118.getTemperature();

  Serial.print("Voltage AIN0: ");
  Serial.print(voltage);
  Serial.print(" mV | ");

  Serial.print("Internal Temp: ");
  Serial.print(temp);
  Serial.println(" C");

  delay(1000);
}
```

Key Library Methods

- *ads1118.begin():* Initializes the SPI communication.
- *getMilliVolts(input):* Takes the ADC reading and converts it directly to mV. Inputs can be single-ended (AIN_0 to AIN_3) or differential (DIFF_0_1, DIFF_2_3, etc.).
- *getTemperature():* Retrieves the temperature from the ADS1118's internal sensor.
- *setSamplingRate():* Adjusts speed from 8 SPS up to 860 SPS.

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ADS12xx Series (Generally 24-bit, SPI)

The Texas Instruments **ADS12xx series** includes high-resolution, 24-bit delta-sigma ADCs designed mainly for precise measurement tasks such as weigh scales, strain gauges, and industrial process control. They come with built-in features such as onboard PGAs, internal references, and temperature sensors.

ADS12xx Series Specifications

Model	Resolution (bits)	Interface	Max Data Rate (SPS)	Channels (SE/Diff)	PGA	Key Applications/Features
ADS1220	24	SPI	2k	4 SE or 2 Diff	Yes (up to G=128)	RTDs, thermocouples, integrated temp sensor, IDACs
ADS1232	24	Pin-driven Serial	80	2 Diff	Yes (up to G=128)	Weigh scales, strain gauges, simple control (no registers)
ADS1234	24	Pin-driven Serial	80	4 Diff	Yes (up to G=128)	Weigh scales, strain gauges, simple control (no registers)
ADS1256	24 (23 noise-free)	SPI	30k	8 SE or 4 Diff	Yes (up to G=64)	High speed, chopper-stabilized buffer, self/system calibration
ADS1261	24	SPI	38.4k	Multiple	Yes (up to G=32)	Low-noise, low-drift, IDACs for sensor excitation
ADS1263	24	SPI	38.4k	Multiple	Yes (up to G=32)	Same as ADS1261, but with an auxiliary 24-bit ADC

Key Takeaways

- **The ADS1232 and ADS1234** are unique in that they are controlled via simple pin-driven commands, eliminating the need for complex register programming. They are specifically designed as a complete front-end solution for bridge sensors, such as weigh scales.
- **The ADS1256** offers a significantly higher maximum data rate of 30 kSPS compared to the 80 SPS of the ADS123x family, making it suitable for faster data acquisition while still maintaining high resolution.
- **The ADS1220, ADS1261, and ADS1263** include highly integrated features such as internal temperature sensors and programmable current sources (IDACs), simplifying designs for applications such as RTD measurements.
- **The ADS1263** is the most feature-rich, integrating a main 24-bit ADC and an additional auxiliary 24-bit ADC channel for background measurements.

ADS1220 Pinout

The ADS1220 is a 24-bit precision ADC. It uses an SPI-compatible interface and includes specific pins for dual-matched current sources (IDACs) and a low-side power switch.

Key pins include:

- **SPI interface pins** such as SCLK, CS (active low), DOUT/DRDY, and DIN.
- **Analog inputs** like AIN0 through AIN3.
- **Reference inputs** REFP0, REFN0, and the dual-function pins AIN0/REFP1 and AIN3/REFN1.
- **Supply pins** DVDD, DGND, AVDD, and AVSS.
- **The DRDY pin** indicates when new data is available.
- An **external clock input CLK** is also available.

For a detailed pinout, please refer to the Olimex ADS1220 datasheet.

Critical hardware notes include

- AIN0 and AIN3 serve as the external reference inputs REFP1/REFN1.
- The DRDY pin or DOUT can signal data readiness.
- The AIN3/REFN1 pin connects to an internal low-side switch.
- Decoupling capacitors are advised between AVDD/AVSS and DVDD/DGND

Arduino & ADS1220

To use the ADS1220 with an Arduino, the **ADS1220_WE** library by Wollewald or the **Protocentral ADS1220** library is the most common option. Both are available via the Arduino Library Manager.

Wiring Diagram (Typical)

The ADS1220 uses the SPI protocol. Connect it to your Arduino (e.g., Uno) as follows:

ADS1220 Pin	Arduino Uno Pin	Description
VDD	5V or 3.3V	Power Supply
GND	GND	Ground
SCLK	D13	Serial Clock
DOUT/DRDY	D12	MISO (Data Out)
DIN	D11	MOSI (Data In)
CS	D7 (selectable)	Chip Select
DRDY	D6 (selectable)	Data Ready Indicator

Basic Example Code

This example uses the **ADS1220_WE** library to perform a simple differential measurement between AIN0 and AIN1.

```
#include <ADS1220_WE.h>
#include <SPI.h>

#define ADS1220_CS_PIN 7
#define ADS1220_DRDY_PIN 6

ADS1220_WE ads = ADS1220_WE(ADS1220_CS_PIN, ADS1220_DRDY_PIN);

void setup() {
  Serial.begin(9600);

  if (!ads.init()) {
    Serial.println("ADS1220 not connected!");
    while (1);
  }

  // Set to differential mode: AIN0 vs AIN1
  ads.setCompareChannels(ADS1220_MUX_0_1);

  // Set Gain (1, 2, 4, 8, 16, 32, 64, 128)
  ads.setGain(ADS1220_GAIN_1);

  // Optional: Set Data Rate (e.g., 20, 45, 90, 175, 330, 600, 1000 SPS)
  ads.setDataRate(ADS1220_DR_LVL_0); // 20 SPS (normal mode)
}

void loop() {
  // Read voltage in millivolts
  float voltage = ads.getVoltage_mV();

  Serial.print("Voltage AIN0-AIN1 (mV): ");
  Serial.println(voltage, 4);

  // Read internal temperature sensor
  float temp = ads.getTemperature();
  Serial.print("Internal Temp (°C): ");
  Serial.println(temp);

  delay(1000);
}
```

Advanced Usage Notes

- **Temperature Compensation:** For thermocouples, you can use *ads.enableTemperatureSensor(true)* to read the ambient temperature for cold-junction compensation.

- **Data Ready:** The library handles the DRDY pin internally to ensure the ADC has finished its conversion before the Arduino attempts to read data.
- **High Resolution:** For raw 24-bit data (useful for weigh scales), use *ads.getRawData()* instead of voltage methods.

I²C topics on lamaPLC

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• lamaPLC Communication: 1-Wire	2026/04/23 21:51	1-wire, communication, bus, microlan, i2c, uart, usart, ds18b20
• lamaPLC Communication: I²C	2025/09/23 21:25	i2c, i c, smbus, philips, bus, communication, arduino
• lamaPLC project: Sension SCD CO² measurement module	2026/04/15 19:34	scd30, scd40, scd41, iaq, ndir, sensor, i2c, arduino code
• LamaPLC: AHT10 Modul	2026/03/22 03:14	communication, i2c, temperature, humidity, sensor, aht, aht 10, modul
• LamaPLC: AHT20 / BMP280 Modul	2026/04/23 21:52	bmp280, aht20, adafruit, temperature, humidity, pressure, sensor, arduino, code, i2c
• LamaPLC: APDS - Avago ALS and proximity detection sensors with I²C communication	2026/04/23 21:52	avago, apds-9900, apds-9930, apds-9960, als, proximity, detection, gesture recognition, gesture, i2c, communication, sensor, arduino, code
• lamaPLC: Arduino Modul: BME680	2026/05/12 18:40	code, c, 2026, arduino, bme680, sensor, i2c, comunication
• lamaPLC: AS5600 Magnetic Induction Angle Measurement Sensor Module	2026/04/23 21:52	communication, i2c, as5600, as-5600, magnetic, induction, angle, sensor
• lamaPLC: Bi-Directional Logic Level Converter 3.3V ↔ 5V	2026/04/12 00:34	bi-directional, logic level converter, i2c, uart, spi
• LamaPLC: BMP/BME Bosch Temperature/Humidity/Pressure sensors with I²C communication	2026/04/23 21:52	bme280, bme680, bme688, bmp180, bmp280, hw-611, hw611, bosch, temperature, humidity, pressure, sensor, arduino, i2c, communication, ai, cjmcu, volatile organic compounds, vocs, volatile sulfur compounds, vscs, iaq
• LamaPLC: CJMCU-219/INA-219 breakout board/IC with I²C communication	2026/04/23 21:52	cjmcu-219, ina-219, ina219, breakout board, i2c, communication, sensor, voltage, current, arduino, code, cjmcu
• LamaPLC: CJMCU-3216 / AP-3216 integrated digital ambient light and proximity sensor module/IC with I²C communication	2026/04/23 21:52	cjmcu-3216, cjmcu, ap-3216, ap3216, ambient light, proximity, sensor, arduino, code, i2c, communication
• lamaPLC: CJMCU-811 CCS811 Gas Sensor (VOCs TVOC CO2)	2026/04/23 21:52	cjmcu-811, ccs811, gas, sensor, vocs, tvoc, eco2, co2, arduino, air quality metal oxide, mox, i2c, micropython, rp2040-eth
• LamaPLC: D6T Omron Non-Contact Thermal Sensors with I²C communication	2026/04/23 21:52	d6t, d6t-32l, d6t-44l, d6t-8l, d6t-1a, omron, non-contact, thermal, sensor, i2c, arduino, code

• LamaPLC: DPS Infineon Temperature/Pressure sensors with I2C communication	2026/04/23 21:52	dps310, infineon, temperature, pressure, sensor, arduino, i2c, communication, code
• lamaPLC: Energy, power, current, and voltage	2025/05/31 23:32	i2c, i c, communication, arduino, energy, power, current, sensor, ina226
• LamaPLC: ENS ScioSense Multi-gas sensors with I²C communication	2026/04/23 21:52	ens160, sciosense, gas-quality, i2c, communication, sensor, arduino, code, eco₂, tvoc, aqi, indoor air quality, iaq, co₂, voc
• lamaPLC: ESP32 / ESP8266	2025/11/22 00:07	esp8266, esp32, esp32-c2, esp32-c3, esp32-c5, esp32-c6, esp32-c61, esp32-h2, esp32-s2, esp32-s3, esp32-p4, espressif systems, communication, ethernet, ip, wi-fi, thread, zigbee, matter, homekit, bluetooth, mqtt, adc, spi, uart, i2c, i2s, rmt, pwm, usb, usb otg, twai
• LamaPLC: Gas sensors	2023/07/01 17:29	gas, sensor, i2c, onewire, communication, mq-3, mq-4, mq-5, mq-6, mq-7, mq-8, mq-9, mq-135, gm-102b, gm-302b, gm-502b, gm-702b, alcohol, ch4, natural gas, smoke, lng, co, co2, lpg, h2, iso-butane, nox, nh3, benzene, town gas, formaldehyde, propane, humidity, temperature, voc, grv gas sens v2
• lamaPLC: GY-511 6DOF sensor module	2026/03/22 01:44	stmicroelectronics, lsm303dlhc, i2c, lsm303, sensor, gy-511, 6dof, pololu, module, arduino
• LamaPLC: GY-9250 MPU-9250/6500 9-axis Attitude Sensor Board	2026/04/23 21:52	ak8963, gy-9250, mpu-9250, 9-axis, motion detection, magnetometer, communication, i c, i2c, spi
• LamaPLC: HDC Texas Instruments Temperature/humidity sensors with I²C communication	2026/04/23 21:52	sht21, htu21, si7021, gy-21, gy-213v, hdc1080, gy-213v-hdc1080, cjmcu, cjmcu-1080, texas instruments, temperature, humidity, sensor, i2c, communication, arduino, code
• lamaPLC: HT16K33 display controller	2026/04/23 21:51	i2c, 7-segment display, display, ht16k33, arduino
• LamaPLC: HTU TE Connectivity temperature/humidity sensors with I²C communication	2026/04/23 21:52	htu, htu31d, htu21d, htu20d, sht20, htu20, sht21, htu21, si7021, gy-21, gy-213v, hdc1080, si702, gy-20, sht31, htu31, si7031, gy-31, te connectivity, temperature, humidity, i2c, communication, sensor, arduino, code
• lamaPLC: INA modules with Arduino libraries	2026/04/11 19:54	i2c, i c, communication, arduino, energy, power, current, monitor, sensor, ina219, gy-219, ina226, gy-216, ina228, gy-228, ina237, ina238, ina260, ina3221, ina
• lamaPLC: INA226 - current/voltage/power monitor with I²C communication	2026/04/23 21:52	i2c, i c, communication, arduino, energy, power, current, monitor, sensor, ina226, ina219, ina

• lamaPLC: LCD 1602/2004 with I²C communication	2026/02/14 18:27	communication, i2c, display, lcd, 1602, 2004, hd44780, pcf8574, pcf8574t, pcf8574at, arduino
• LamaPLC: MAX30100/MAX30102 Heart Rate Click Sensor Module	2026/04/23 21:52	max30102, max30100, heart rate click, sensor, communication, i2c, arduino, code
• lamaPLC: MCP23017 / MCP23S17 16-Bit I/O Expander with Serial Interface I²C / SPI	2026/04/23 21:52	communication, i2c, mcp23017, mcp23s17, spi, i o expander, serial, cjmcu-2317, cjmcu
• lamaPLC: MLX90614 (GY-906) infrared non-contact thermometer	2026/05/08 00:03	communication, i2c, temperature, mlx90614, gy-906, modul, infrared, non-contact thermometer, dsp, pwm, smbus, hailege
• LamaPLC: Pixart PAJ7620U2 Gesture recognition sensors/module with I²C communication	2026/04/23 21:52	paj7620u2, gy-paj7620, pixart, gesture recognition, i2c, communication, sensor, arduino, code
• lamaPLC: RP2040_ETH_Modul: I²C scanner	2026/05/12 16:20	code, micropython, 2026, rp2040 eth, i2c, comunication
• lamaPLC: RP2040_ETH_Modul: MLX90614 simple	2026/05/12 17:06	code, micropython, 2026, rp2040 eth, i2c, communication, mlx90614
• lamaPLC: RP2040_ETH_Modul: Read BME 680/688 sensor data	2026/05/12 21:06	code, micropython, 2026, rp2040 eth, bme680, i2c, sensor, communication
• lamaPLC: RP2040_ETH_Modul: Read BME 680/688 sensor data and store in Modbus input registers	2026/05/12 18:58	code, micropython, 2026, rp2040 eth, bme680, i2c, sensor, communication
• LamaPLC: SC16IS750 / SC16IS752: One or two serial (UART) ports from microcontroller via I²C or SPI communication	2026/04/23 21:52	cjmcu-750, cjmcu-752, cjmcu, nxp, sc16is750, sc16is752, uart, serial, i2c, spi, modul, converter, arduino, code
• LamaPLC: SGP Sensirion TVOC/VOC sensors with I²C communication	2026/04/15 19:41	sgp30, sgp40, sgp41, sensirion, gas-sensor, i2c, communication, sensor, arduino, code, eco₂, voc, tvoc, indoor air quality, iaq, nox, hydrogen
• LamaPLC: SHT Sensirion Temperature/humidity sensor with I²C communication	2026/04/23 21:52	sht20, sht21, sht25, sht30, sht31, sht35, sht40, gy21, temperature, humidity, i2c, communication, sensor, arduino, code
• lamaPLC: Signal level converters	2026/02/14 23:47	pca9306, i2c, voltage, level, converter
• lamaPLC: TCA9548A (HW617); Low-Voltage 8-Channel I²C Switch Module	2026/02/14 23:51	tca9548a, hw617, i2c, switch, communication, expansion board, arduino
• lamaPLC: TM1637 7-segment display	2026/02/14 18:26	i2c, 7-segment display, display, tm1637, arduino
• LamaPLC: TOFnnnC STMicroelectronics Time-of-Flight (ToF) sensors with I²C communication	2026/04/23 21:52	tof050c, vl6180, tof200c, vl53l0x, tof400c, vl53l1x, stmicroelectronics, time-of-flight, tof, i2c, communication, sensor, arduino, code
• LamaPLC: VL53Lnn STMicroelectronics time-of-flight (ToF) laser-ranging sensors with I²C communication	2026/04/23 21:52	vl53l0x, vl53l1x, vl53l0 1xv2, gy-530, time-of-flight, tof, laser-ranging, i2c, communication, sensor, arduino, code

• LamaPLC: VL6180X STMicroelectronics Time-of-Flight (ToF) sensor with I²C communication	2026/04/23 21:52	vl6180x, stmicroelectronics, time-of-flight, tof, i2c, communication, sensor, arduino, code
• Magnetic angle sensors	2026/03/05 21:19	magnetic angle sensor, magnetic flux, sensor, spi, i2c, pwm, communication, modul, as5047p, as5600, mt6701, mt6816, mt6835, tle5012b, amr, gmr, tmr, anisotropic magnetoresistive
• SSH1106/SSD1306 OLED Display with I²C communication	2026/02/14 18:27	i2c, oled, display, ssd1306, sh1106, ssh1106, arduino, cmos

ADS111x, ADS12xx, Delta-sigma, Converter, Texas Instruments, ADC, SPI, communication, sensor, arduino, code, ADS1110, ADS1112, ADS1113, ADS1114, ADS1115, ADS1118, ADS1119, ADS1220, ADS1232, ADS1234, ADS1256, ADS1261, ADS1263, multi channel