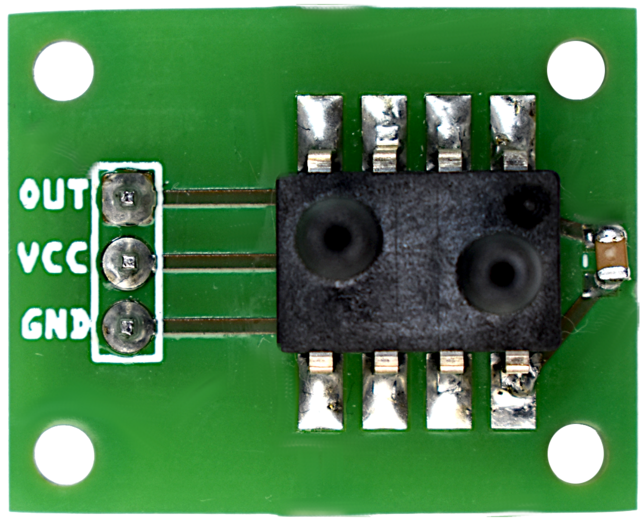
XGMP3v3 Differential Pressure Sensor

Overview

- 3.3V Supply Voltage
- Analog Output 0.2V - 2.7V
- Selectable Pressure Span: 1kPa, 2kPa, 5kPa
- Differential Pressure Sensing
- Selectable Measurement Range: -0.5kPa to +0.5kPa, -1.0kPa to +1.0kPa, -2.5kPa to +2.5kPa
- Compatible with 2.5mm ID Flexible Tubing



Introduction

The XGMP3v3 is a piezoresistive, dual-port differential pressure sensor with temperature compensation, an in-case amplifier, a capacitor for noise reduction, and a three-wire JST connector. The XGMP3v3 is ideal for low-pressure sensing at rapid speeds up to 1000 samples per second. Applications of the differential pressure sensor range from medical respirators and ventilators in the medical field to velocity measurements of drones and aircraft using a pitot tube and pipe flow through a venturi meter [2]. The small profile and mounting holes are also useful for adhering to smaller devices. The ports are designed for connection to 2.5mm internal diameter (ID) flexible tubing and hosing, which makes the XGMP3v3 particularly useful in areas that may be difficult to reach. Overall, the XGMP3v3 is useful for a wide range of low pressure scenarios and is compatible with any microcontroller or analog-to-digital converter (ADC) capable of measuring 0.2V - 2.7V, making it also an ideal choice for Arduino boards and ADCs connected to Raspberry Pi computers.

Technical Specifications*

The XGMP3v3 differential pressure sensor operates at 3.3V and consumes roughly 83mW at an average current consumption of 24mA. The analog output from the XGMP3v3 ranges from 0.2V - 2.7V for each pressure range. Thus, the equation used to convert voltage to pressure in kPa is as follows:

$$P = \left(\frac{P_{max} - P_{min}}{V_{max} - V_{min}}\right) \cdot \left(V_i - \left(\frac{V_{max} + V_{min}}{2}\right)\right) \tag{1}$$

*Prepared by: Joshua Hrisko

Table 1: Average and absolute ratings and operating conditions for the XGMP3v3 differential pressure sensor.

Parameter	Units	Value
Supply Voltage, V_s	V	3.3
Average Current	mA	24
Analog Output, $V_{min} - V_{max}$	V	0.2 - 2.7
Accuracy	%FS*	2.5
Response Time	ms	1
Max Pressure	kPa	2xFS
Pressure Scale Options, $[P_{min}, P_{max}]$	kPa	[-0.5,+0.5], [-1.0,+1.0], [-2.5,+2.5]
Temperature Compensation	°C	0 - 60
Operating Temperature Range	°C	-10 - 80
Long-Term Stability	%FS	0.5

* FS $\equiv$ Full-Scale, for example a full-scale range of 1kPa correlates to a differential range from -0.5kPa to +0.5kPa.

where V_i is an instantaneous voltage reading from the OUT pin on the XGMP3v3 and the rest of the variables relate to parameters prescribed in Table 1 for a given pressure range. The voltage can be calculated from the analog-to-digital converter (ADC) as follows:

$$V_i = \frac{R_i}{N_{ADC} - 1} \cdot V_{ref} \tag{2}$$

where V_{ref} represents the voltage span of the ADC, N_{ADC} is the resolution of the ADC, and R_i is a given ADC reading in bits. For a standard ATmega328P microcontroller (Arduino Uno, Nano, Pro, etc.), $N_{ADC} = 2^{10} = 1024$ (10-bit) and $V_{ref} = 5V$. For a SAMD21-based microcontroller, the standard values are $N_{ADC} = 2^{12} = 4096$ (12-bit) and $V_{ref} = 3.3V$.

For reference, an example calibration plot implementing Eqns. 1 and 2 against a U-tube manometer for the -2.5kPa to +2.5kPa range sensor over an approximate pressure range of -1.25kPa to +1.0kPa is shown in Fig. 1.

Diagrams

A diagram of the XGMP3v3 is shown in Fig. 2 depicting the dimensions of the ported pressure sensor, PCB, and mounting holes. 2.5mm ID flexible tubing is the best for connecting the pressure sensor to a port or pitot tube, as it fits snugly over the 3.2mm pressure port. The sensor board can be mounted using four M2 screws in order to affix the sensor to a surface. Additionally, the JST-XH connector allows for easy wiring via the 3-pin output to any microcontroller or ADC. Table 2 shows the function of each of the three pins. The OUT pin connects to an analog input of a microcontroller or ADC, while the VCC is connected to 3.3V, and GND is connected to ground. Figure 3 also contains a wiring diagram between the XGMP3v3 and an Arduino Uno board. The OUT pin can be wired to any analog input of the Arduino board.

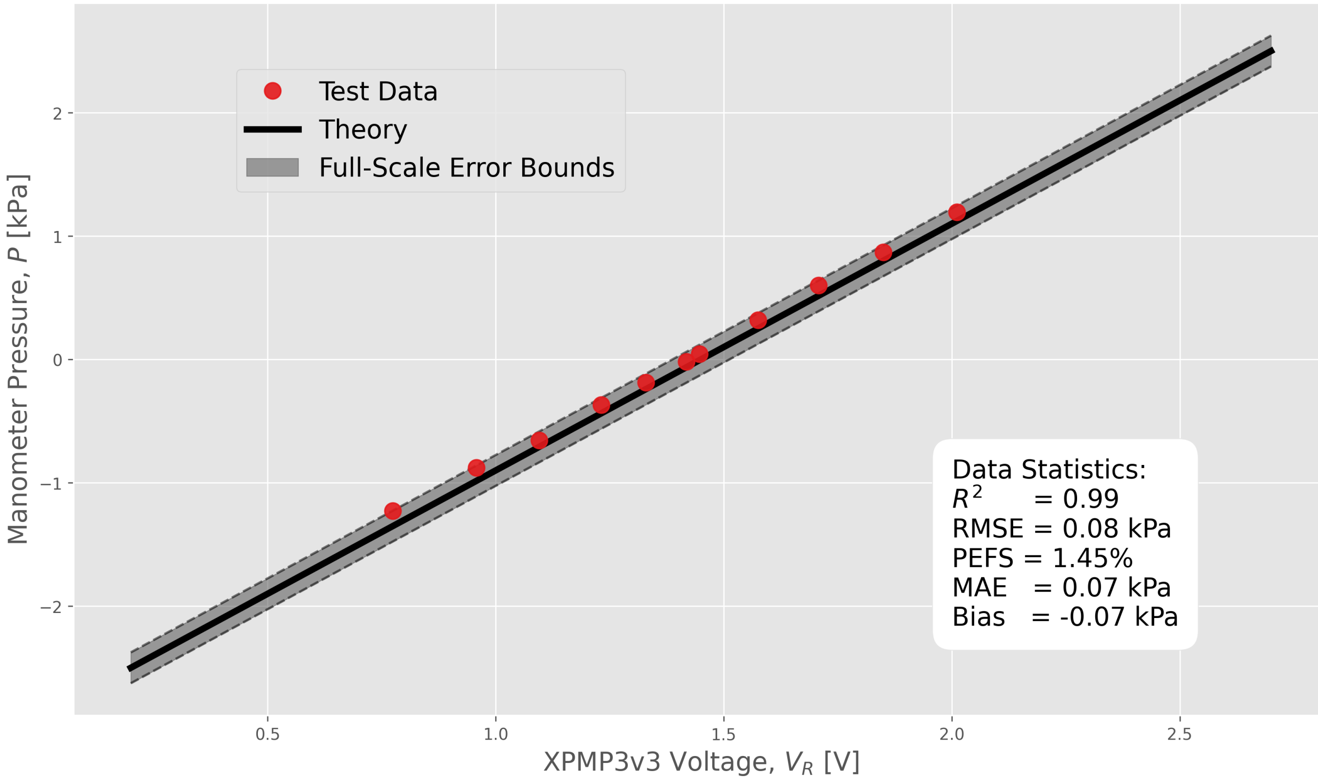


Figure 1: Typical calibration curve for the XGMP3v3 for a -2.5kPa to +2.5kPa pressure range.

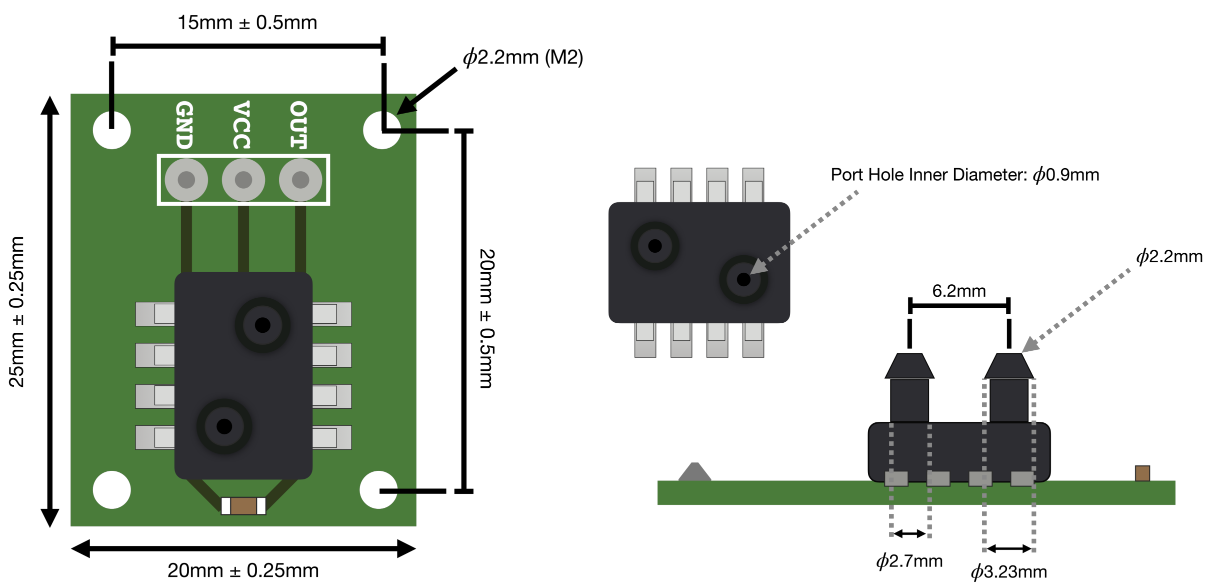


Figure 2: Dimensions of the XGMP3v3 differential pressure sensor module.

Table 2: Pinout configuration on the XGMP3v3 for wiring to a microcontroller or ADC.

Pin	Function
OUT	Analog Output (0.2V - 2.7V)
VCC	3.3V Power Supply
GND	Ground

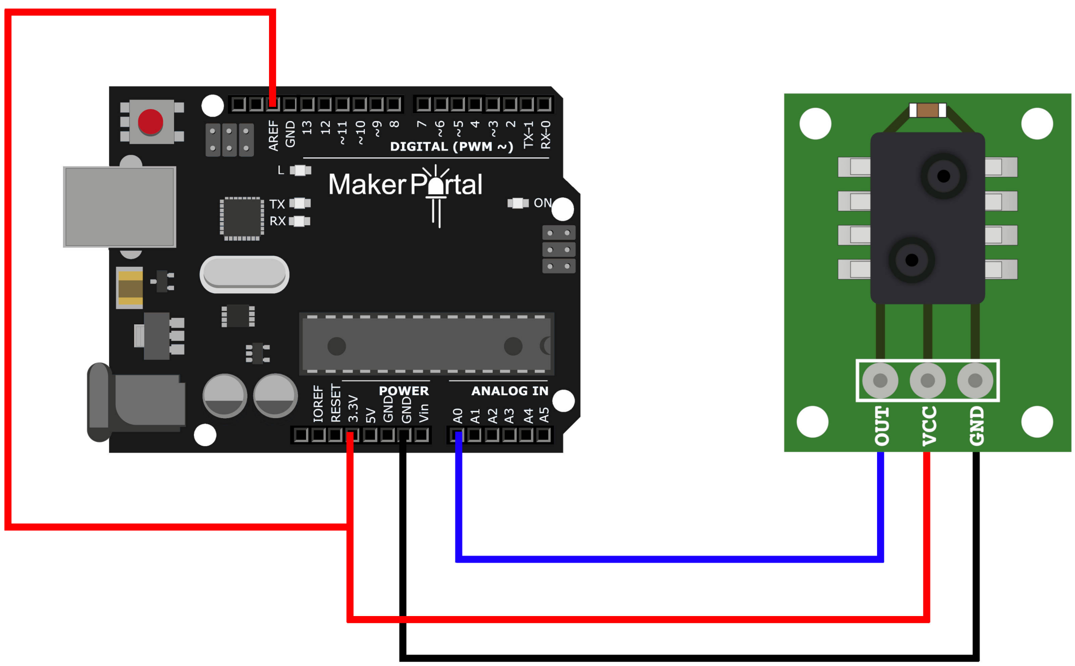


Figure 3: Wiring diagram between the XGMP3v3 differential pressure sensor and an Arduino Uno microcontroller with the 3.3V supply being used as an external voltage reference [1].

Sample Arduino Code

A sample Arduino code is given in Code 1 for an XGMP3v3 sensor wired to pin A0 on an Arduino Uno. The same code can be found on the sensor's GitHub page as well, for easier copy and paste:

- https://github.com/makerportal/xgmp3v3

MakerPortal

Code 1: Arduino code to read analog voltage from capacitive soil moisture sensor.

```
//
// Arduino code Used to read analog data from XGMP3v3 Differential Pressure
// Sensor and approximate pressure in [kPa]
//
// by Joshua Hrisko, Maker Portal LLC (c) 2021
//
//
int input_pin = A0;    // analog input pin
float V_ref = 3.3; // reference voltage
float ADC_res = pow(2.0,10); // ADC resolution (ATmega = 10-bit, SAMD21 = 12-bit)
float P_max =  0.5; // pressure max in [kPa] for specific XGMP3v3 sensor
float P_min = -0.5; // pressure min in [kPa] for specific XGMP3v3 sensor
float V_max = 2.7; // max analog voltage output
float V_min = 0.2; // min analog voltage output

void setup() {
  analogReference(EXTERNAL); // set 3.3V as V_ref | not needed for SAMD21 boards
  Serial.begin(9600); // start serial
  while (!Serial){}; // wait for serial to start (required for some boards)
}

void loop() {
  int adc_val; float volt_calc;  // sensor read variables
  float pres_approx;
  adc_val    = analogRead(input_pin); // read ADC data
  volt_calc  = (adc_val/(ADC_res-1.0))*V_ref; // convert ADC to voltage
  String prnt_str, str_buf; // string buffers for printing to serial port
  str_buf = "ADC val: ";
  prnt_str = str_buf+String(adc_val)+", Voltage: "; // adc value string
  str_buf = prnt_str + String(volt_calc,2)+" V, Pressure: "; // add voltage
  pres_approx = ((P_max-P_min)/(V_max-V_min))*(volt_calc-((V_max+V_min)/2.0));
  prnt_str = str_buf+String(pres_approx,2)+" kPa"; // add pressure approx [kPa]
  Serial.println(prnt_str); // print values to serial port
  delay(1); // wait between readings for valid sensor reading [1ms]
}
```

References

[1] Arduino. Arduino Uno. [Online]. *https://store. arduino. cc/usa/arduino-uno-rev3, diakses 4* (2019).

[2] Singh, R., Ngo, L. L., Seng, H. S., and Mok, F. N. C. A silicon piezoresistive pressure sensor. In *Proceedings First IEEE International Workshop on Electronic Design, Test and Applications' 2002* (2002), IEEE, pp. 181--184.

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