Arduino Code for OPC-R1 with air dryer

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Hardware architecture

The sensor system contains an OPC-R1 sensor, a temperature (T) and relative humidity (RH) sensor model HYT221, a thermal low-cost dryer, an OPC Interface board, a data logger shield containing a real-time clock (RTC), a pulse width modulation (PWM) switch, and two Arduino Uno boards, one for the OPC and one for the data logging unit (see Figure 1). This is because an Arduino Uno board provides just one SPI (serial peripheral interface). Since the OPC as well as the SD card use an SPI bus exclusively, two Arduino Uno boards are required.

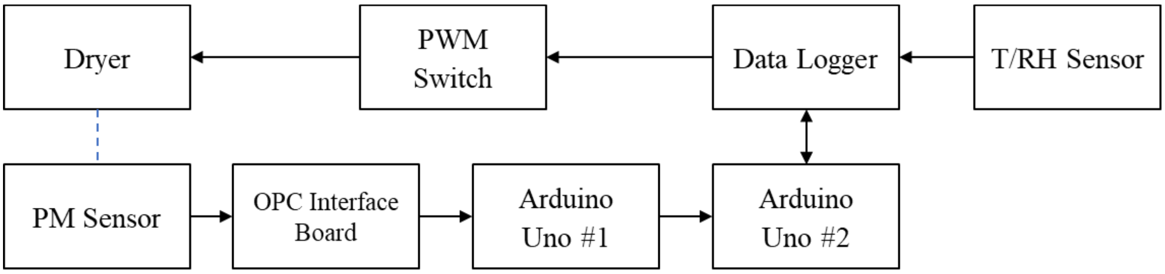

Figure 1. Overall block diagram of the measurement unit showing the main data flow.

The T/RH sensor uses a standardized I2C bus for communication, an addressed bus for which the Arduino provides a dedicated interface. The gate of the MOSFET used as PWM switch is directly controlled by an Arduino digital output pin. Figure 2 illustrates the detailed circuit diagram.

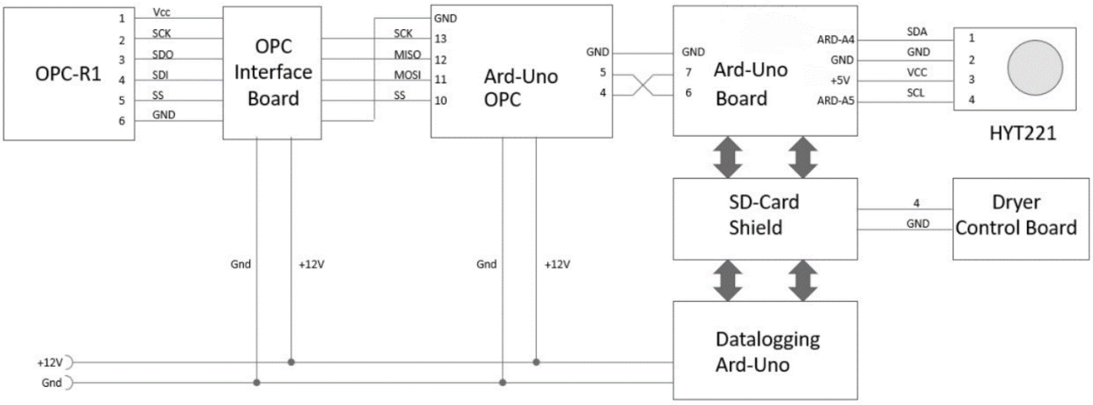

Figure 2. Circuit diagram of the main measurement unit.

The electronics provides a pulse width modulated switched supply. The switch is a NMOS Power-MOSFET of type BUZ11. Source is tied to ground and the resistive wire coil is connected between drain and the 5V power supply. Its gate electrode is controlled by the IO of the Arduino and the PWM is generated by the Arduino software. The thermal energy is controlled by the mean value of the voltage at the resistive coil on the tube.

OPC Interface Board – Arduino Uno

The Arduino that controls the OPC is connected to the OPC interface via the standard SPI using the digital pins 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK), as it is shown in Figure 3. The Arduino pins use 5V levels for this purpose and need to be converted to 3.3V on the OPC interface board for use with the OPC-R1. The serial communication is established through the pins 5(Tx), 4(Rx) and 3 (OPC Cs) which acts as the semaphore control to indicate that the OPC Arduino is allowed to send data.

The OPC-R1 requires a 5V supply, mainly for the fan but internally uses a 3.3V supply for its logic interface and electronics. The Arduino microcontroller that controls the OPC however, has 5V IO’s, therefore, a special OPC interface board was developed to provide power to the OPC and to translate the logic levels. An Arduino Uno is connected via a SPI to send control commands and to continuously receive the data measured by the OPC at a rate of 1 sample per second. The OPC sensor data transmitted to the data logging unit also contains the temperature and humidity of the input gas measured by an OPC internal sensor.

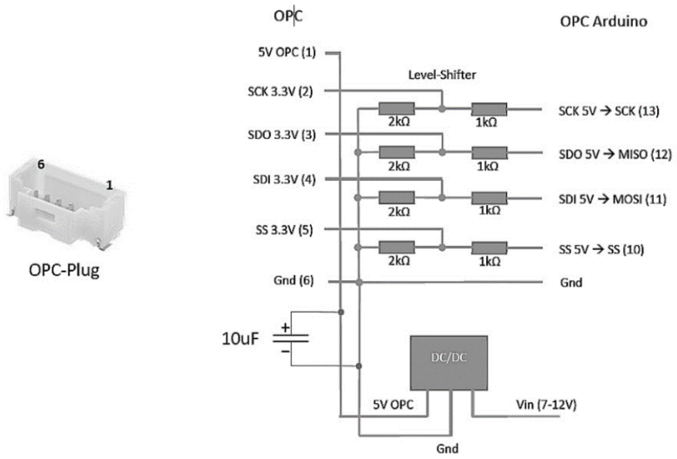

Figure 3. Circuit diagram of the OPC interface board.

The dryer

A schematic diagram of the low-cost thermal dryer can be seen in Figure 4. In Table 1 the technical specifications for the dryer are summarized.

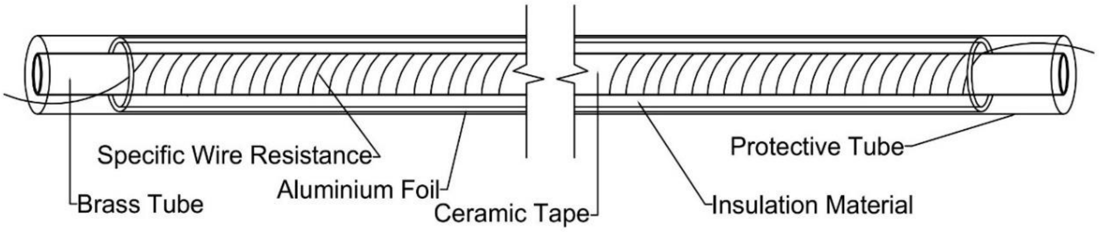

Figure 4. Schematic diagram of the low-cost thermal dryer.

Table 1. Technical specifications for the dryers designed for OPC-R1 and OPC-N3

Total length (cm)	50
Free space (cm)	2.5
Outer diameter (mm)	10
Inner diameter (mm)	9
Tube material	brass
Foil material	ceramic
Insulation material	100% Polyester
Winding material	Constantan
Resistance of wire (Ω m^{-1})	0.975
Voltage (V)	12
Power (W)	10

The dryer is controlled digitally using pulse width modulation (PWM) via a high current MOSFET switch (BUZ11A, ON Semiconductor, USA) by the Arduino board used for data logging. The Arduino Uno microcontroller uses RH data of an ambient temperature and RH sensor model HYT221 from iST (Switzerland) and the temperature sensor inside the OPC-R1 (T_{OPC}) to control the dryer executing the following loop: if RH > 65 %, electrical current will be passed through the wire resistance so that the dryer will be heated. In a second step, the temperature inside the OPC-R1 is used to control the heater. If $T_{\mathrm{OPC}} > 35$ °C the dryer will be switched off and start cooling down to avoid overheating. Once $T_{\mathrm{OPC}} < 34$ °C and RH is still > 65 % the dryer will be switched on again. Figure 5 depicts the circuit diagram of the dryer control board with PWM switch.

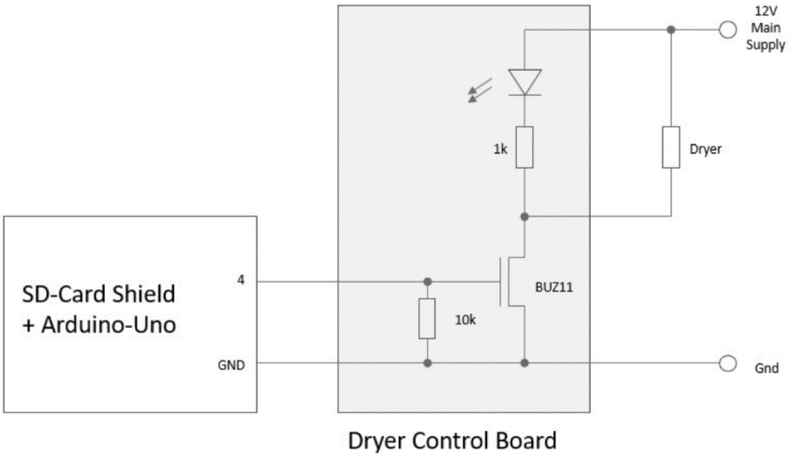

Figure 4. Circuit diagram of the dryer control board with PWM switch.

Software architecture

Two Arduino files (.ino) are attached to this document:

- For the Arduino Uno #1: OPC-R1_BL4.ino
- For the Arduino Uno #2: Logger_HYT_and_OPC-R1_dryer.ino

Note

The sensor OPC-R1 is as date of 10 April 2022 out of the market. It has been replaced to the OPC-R2. According to the manufacture, the R1 and R2 have identical power requirements, communication protocols and data formats. More information in https://www.alphasense.com/products/optical-particle-counter/

Sources and Links

Arduino Home: https://www.arduino.cc/
External Libraries: http://www.billporter.info/2011/05/30/easytransfer-arduino-library/
Adafruit Datalogging Shield: https://www.adafruit.com/product/1141
Temperature & humidity sensor: https://www.ist-ag.com/sites/default/files/DHHYT221_D.pdf

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