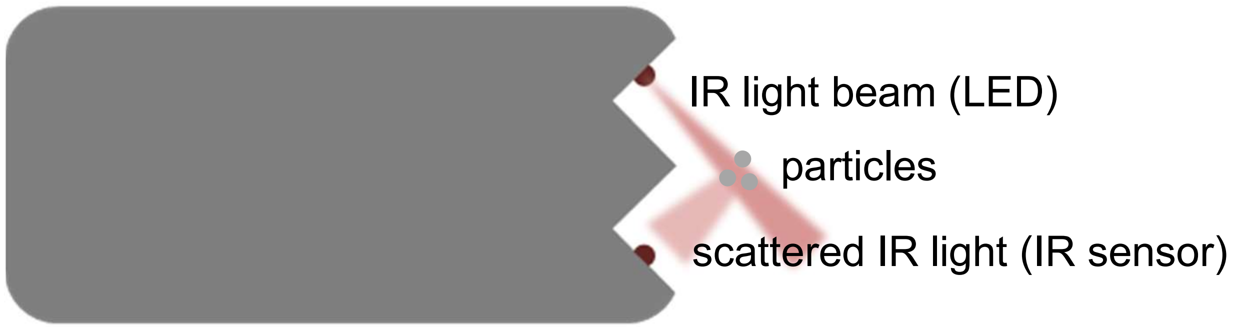
Hydro Hackers Turbidity Sensor

- Turbidity is a traditional and very important quality parameter of water. However, industrial turbidity sensors are very expensive, and thus, the technology is not commonly available. Cheap sensors intended for washing machines are available for everyone, but they are not suitable for practical measurement purposes because their accuracy is very poor.
- We designed a sensor which is decent and affordable. It utilizes the same measurement principle as industrially used sensors, thus it has a good performance.
  – Our turbidity sensor is a multi-purpose water quality sensor for natural water monitoring, irrigation systems, pools, industrial & municipal wastewater etc.
  – It is suitable for professional use , for education purposes and for hobbyists.
  – The analog sensor is simple, robust, affordable and suitable to be used with commercial microcontrollers.

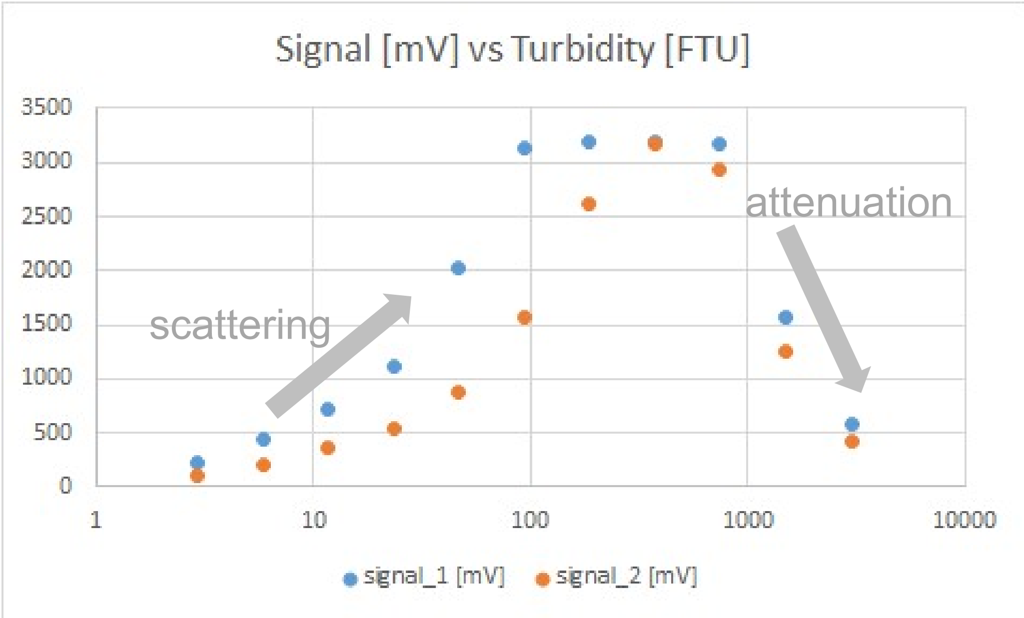
Principle

- IR light scattering effect (low-to-medium turbidities)
  - An IR LED emits IR light. Suspended particles in water scatter (reflect) light in all directions. The intensity of scattering depends on the concentration of particles.
  - An IR sensor detects scattered light at 90^{o} angle. The intensity of scattered light is proportional to turbidity of water.
- IR light attenuation effect (medium-to-high turbidities)
  - At certain turbidity the signal from scattered light reaches its maximum.
  - With increasing turbidity the suspended particles attenuate the IR light, which is seen as decreasing signal level.



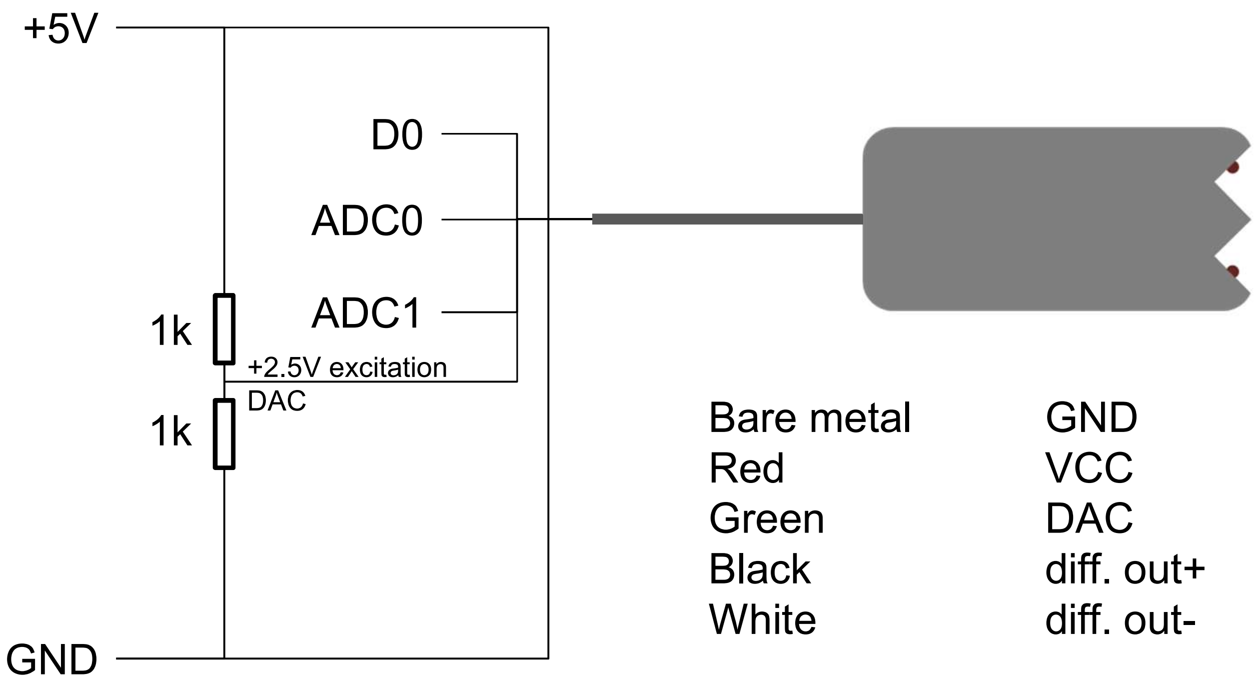
Performance

- Figure shows typical measurement curves, i.e. output signal as a function of turbidity. Please note that the signal level rises until it peaks, and then the signal decreases with increasing turbidity. This kind of measurement response is typical for side-scattering turbidity sensors; the rising part of the curve indicates light scattering, while decreasing of the signal level is due to signal attenuation.
- Both parts of the curve are useful, i.e the rising part of the curve is for low-to-medium turbidities, and the falling part for medium-to-high turbidities. As can be seen, the signal saturates quickly if the excitation voltage is too high.



measurements with 3.3V excitation (blue) and 2.5V excitation

Connections



Bare metal	GND
Red	VCC
Green	DAC
Black	diff. out+
White	diff. out-

Technical data

- **Absolute Maximum Ratings**
  - Supply voltage 5.5V
  - Excitation voltage 3.5V
  - Operating medium temperature -20°C to +60°C
  - Duration of short circuit to ground unlimited
- **ESD Ratings**
  - Electrostatic discharge Human-body model ±2000V
  - Electrostatic discharge Charged-device model ±1000V
- **Recommended Operating Conditions**
  - Supply voltage 5V ±10%
  - Excitation voltage 0-3.3V
  - Operating medium temperature -20°C to +40°C
- **Materials**
  - Housing and insulation of wire: PVC
  - Electronics is cast into epoxy resin
  - The product is lead-free

Arduino code

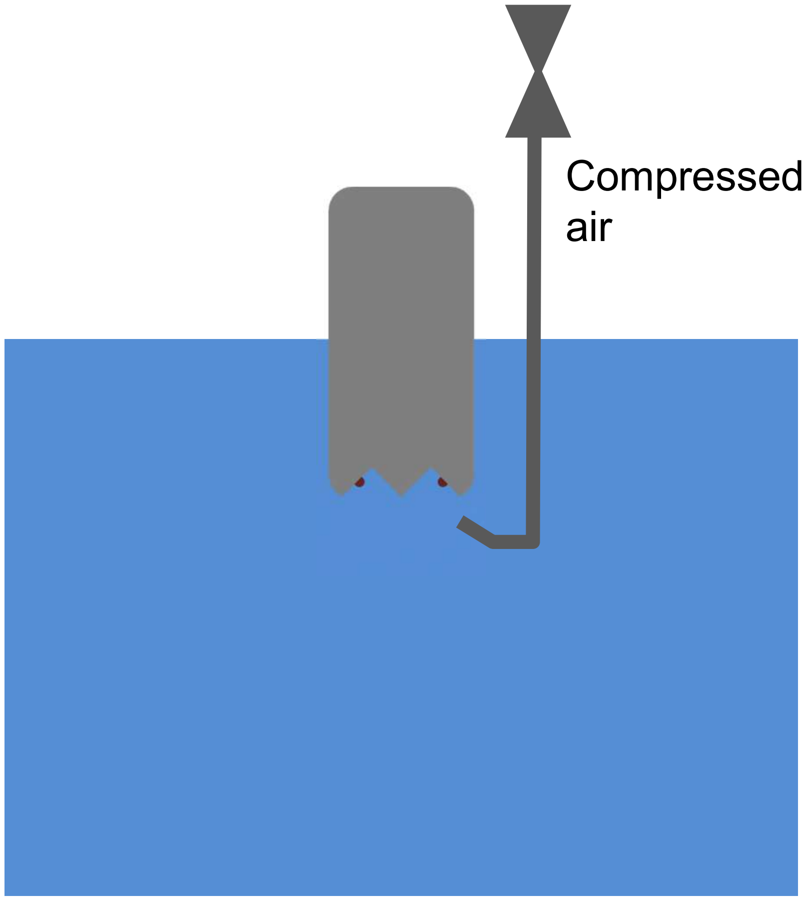
```
void setup() {

  pinMode(2, OUTPUT);  //Set excitation pin
  digitalWrite(2, LOW); //Set Excitation pin LOW
  Serial.begin(9600);

}

void loop() {

// Start measurement cycle
  digitalWrite(2, HIGH); //Set excitation voltage HIGH
  delay(50); //delay before measurements
  double out_neg = analogRead(A0); //measure diff.input 1
  delay(50);
  double out_pos = analogRead(A1); //measure diff.input 2
  double diff = out_pos - out_neg; //signal is the difference of measured signals

//print output
  Serial.print(diff);
  Serial.print(" ");
  Serial.print(out_pos);
  Serial.print(" ");
  Serial.println(out_neg);
  digitalWrite(2, LOW); //set excitation voltage LOW
  delay(1000);
//end measurement cycle

}
```

Arduino pins:

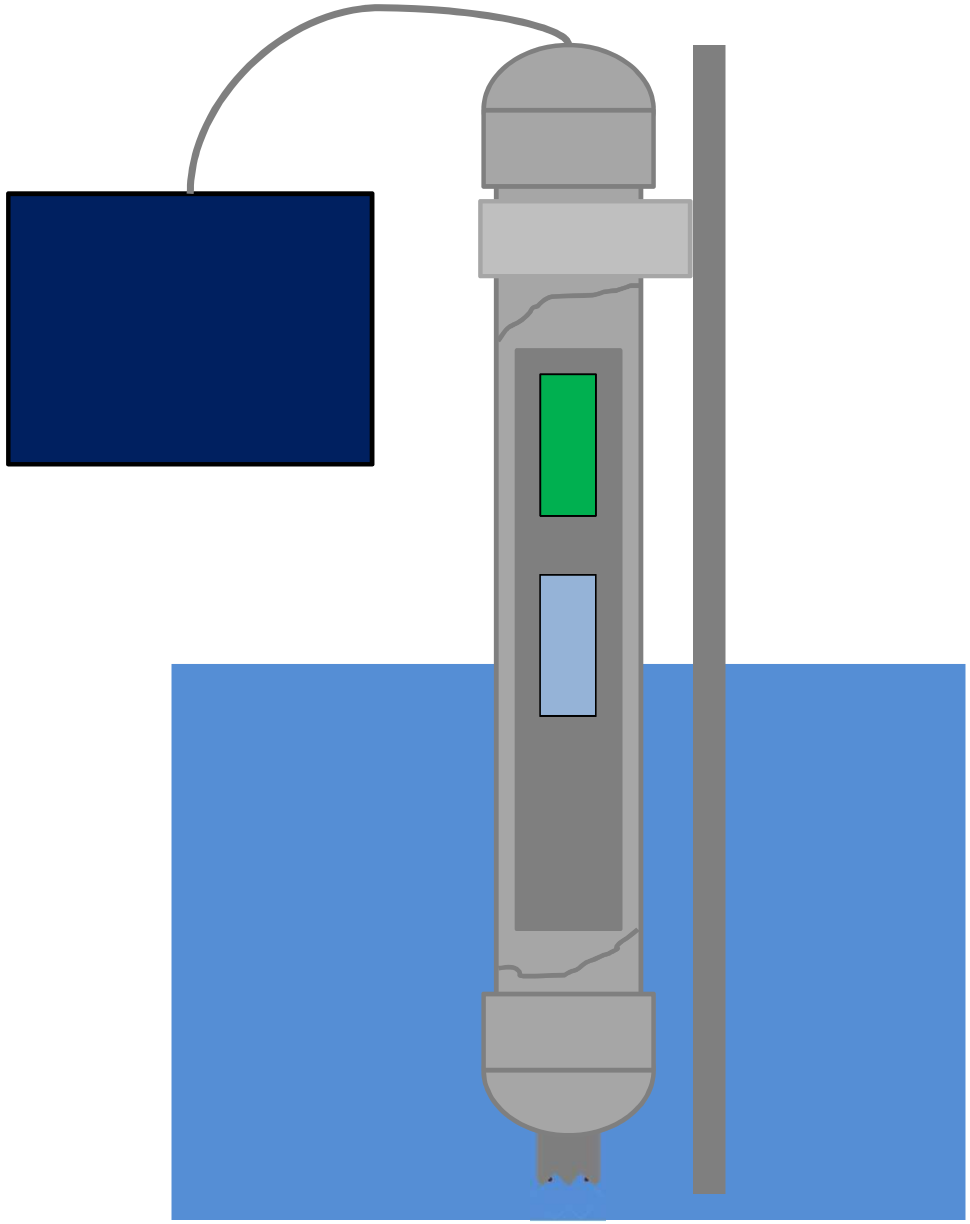
- D2 is for excitation (DAC) via voltage divider circuit
- A0 is differential input (-)
- A1 is differential input (+)

Measurement

- Immerse sensor to water so that the sensor head is well under water surface. The sensor is waterproof and can be immersed entirely under water.
- Keep the sensor far from any surfaces that can reflect IR light (at least 30 cm)
- Protect the sensor from sunlight or other light sources that can emit IR light.
- The sensor must be cleaned frequently. Automated cleaning by compressed air jet is recommended if the sensor is installed permanently.



Simple Water Quality Measurement System



BOM:
- 75 mm PVC tube, 50 - 100 cm long
  - two end caps
  - tube wall support
- 4 mm PVC sheet (support plate for MCU and LiPo)
- Support pole
- Microcontroller with cellular modem and LiPo cell connection (e.g. Particle Electron, www.particle.io)
- Solar panel with USB charger (10 – 30 W)
- Water-tight bushing for charging lead
- Hydro Hacker Turbidity Sensor

How-to:
- Make a hole to other end cap to fit the sensor.
- Glue the sensor to the cap using PVC welding glue or 2-component polyurethane glue. Check that the joint is water-tight
- Attach the end cap to the tube and seal the joint using elastic glue.
- Drill a hole to the other cap for the bushing
- Attach the MCU and LiPo to the support plate
- Connect the sensor to the programmed MCU
- Connect the LiPo and the solar charger
- Attach the cap to the tube and seal it using elastic glue
- Support the system and the solar panel well