University of Montenegro
Faculty of Electrical Engineering

The measurement of conductivity using Arduino and Varnier conductivity probe

Course: Industrial Electronics

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Contents

Problem description

In this paper we will explain how Conductivity Probe, Vernier sensor, works and write an Arduino code in order to demonstrate its capabilities on diferent examples.

Firstly, The Conductivity Probe can be used to measure either solution conductivity or total ion concentration of aqueous samples being investigated in the field or in the laboratory. Conductivity is one of the most common environmental tests of aquatic samples. Even though it does not tell you specific ions that are present, it quickly determines the total concentration of ions in a sample.

In addition, all Vernier products, including our Conductivity probe, are designed for educational purposes and its use in medicine or industry is not recommended as results are not 100% reliable.

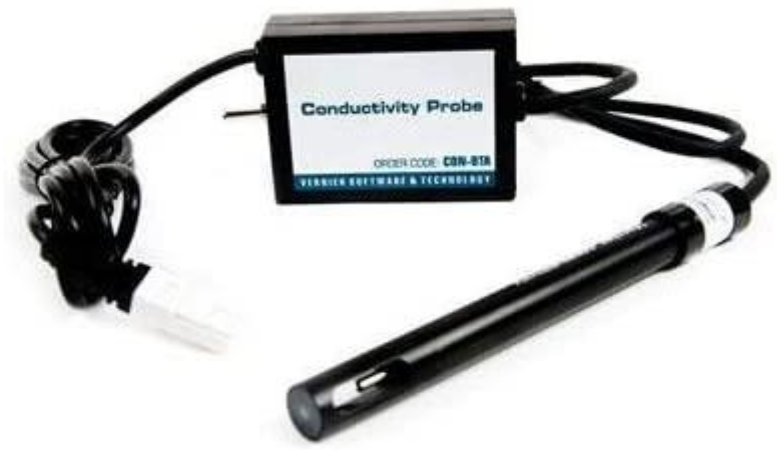


Figure 1. Vernier Conductivity probe

How does Conductivity probe works

The Vernier Conductivity Probe measures the ability of a solution to conduct an electric current between two electrodes. In solution, the current flows by ion transport. Therefore, an increasing concentration of ions in the solution will result in higher conductivity values. The Conductivity Probe is actually measuring *conductance*, defined as the reciprocal of resistance. When resistance is measured in *ohms*, conductance is measured using the SI unit, *siemens*. Even though the Conductivity Probe is measuring conductance, we are often interested in finding conductivity of a solution. Conductivity, C, is found using the following formula:

$$C = G * k_c$$

Un this equation G represents conductance while k_c is a cell constant determined for a probe using the following formula:

$$k_c = d/A$$

Here, d is the distance between the two electrodes, and A is the electrode surface.

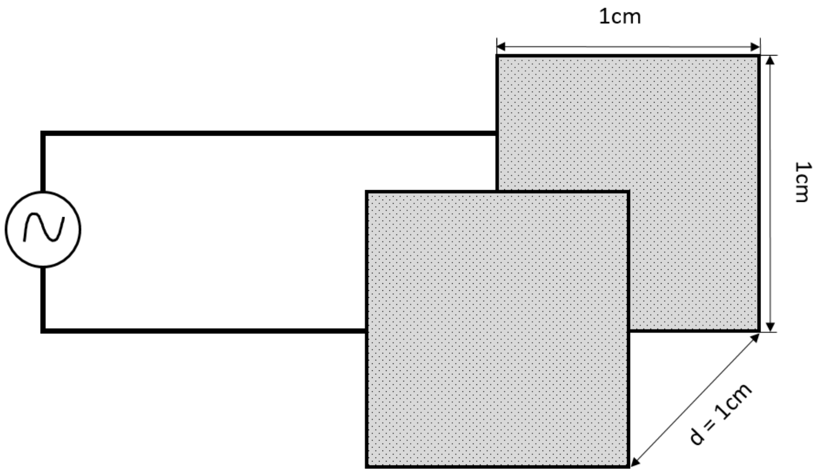


Figure 2.

For example, the cell in Figure 2. has a cell constant: kc = d / A = 1.0 cm / 1.0 cm2= 1.0 cm-1 The conductivity value is found by multiplying conductance and the cell constant. Since the Vernier Conductivity Probe also has a cell constant of 1.0 cm-1, its conductivity and conductance have the same numerical value. For a solution with a conductance value of 1000 µS, the conductivity, C, would be:

$$C = G * k_c = (1000\mu S) * (1.0cm^{-1}) = 1000\mu S/cm$$

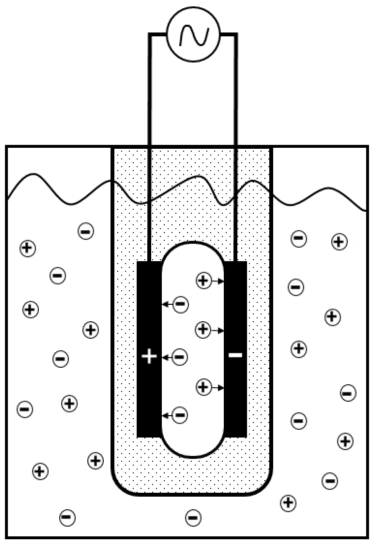


Figure 3.

As shown in Figure 3. potential difference is applied to the two probe electrodes in the Conductivity Probe. The resulting current is proportional to the conductivity of the solution. This current is converted into a voltage. We managed to convert current into voltage in our Arduino code which will be discussed further below.

The Vernier Conductivity Probe is automatically temperature compensated between temperatures of 5 and 35°C. Note that the temperature of a solution is being read by a thermistor that extends into the space between the graphite electrodes. Readings are automatically referenced to a conductivity value at 25°C; therefore, the Conductivity Probe will give the same conductivity reading in a solution that is at 15°C as it would if the same solution were warmed to 25°C. This means you can calibrate your probe in the lab, and then use these stored calibrations to take readings in colder (or warmer) water in a lake or stream. If the probe was not temperature compensated, you would notice a change in the conductivity reading as temperature changed, even though the actual ion concentration did not change.

Connection scheme

Vernier Conductivity probe and an Arduino UNO board are connected through Analog protoboard adapter as shown in Figure 4.

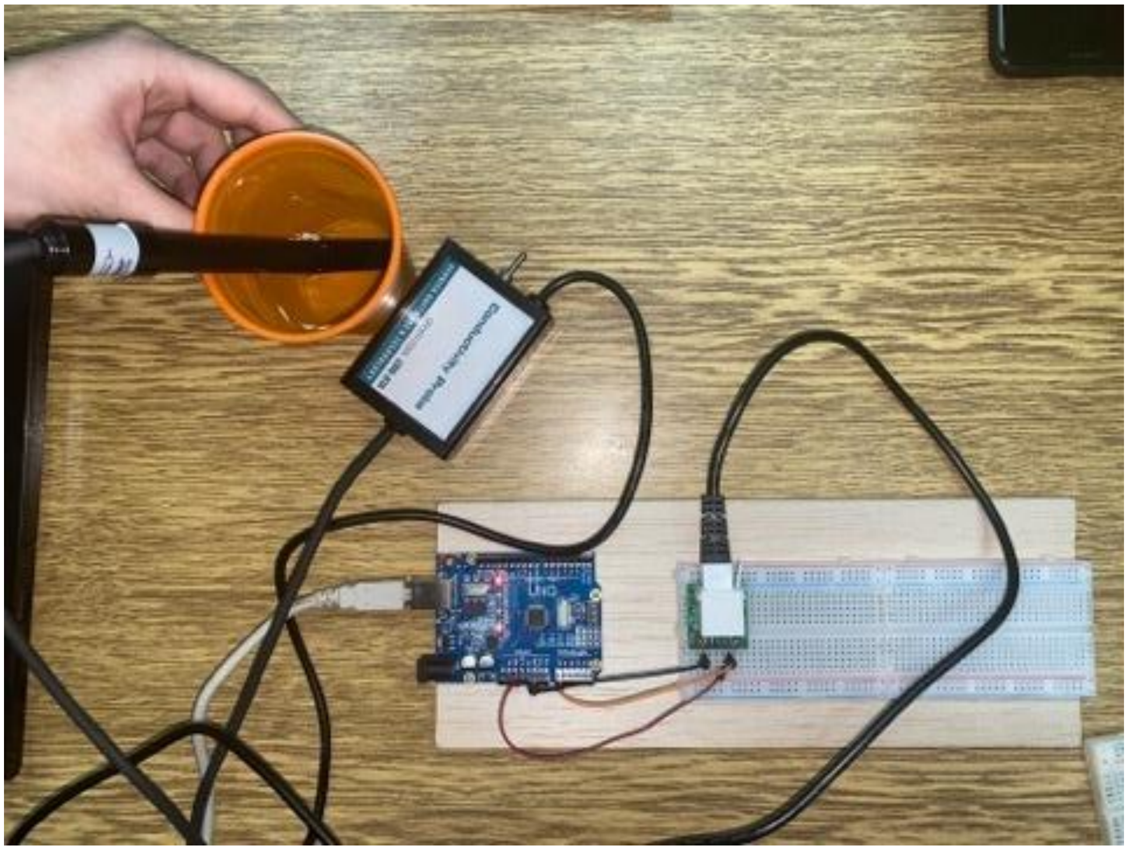


Figure 4. Wiring

Analog protoboard adapter values and corresponding Arduino UNO board pins:

- SIG1 on Arduino PIN A0
- GND on Arduino PIN GND
- 5V on Arduino PIN 5V

Program

```
char inChar='A'  // blank Serial monitor at the beggining

unsigned int Nt=53036;  // initial speed of printing values

boolean procitao=false;

int pinSignal=A0;

int sensorValue=0;

float Siemens=0;

char prethodni=0;

void setup() {

  Serial.begin(57600);

  noInterrupts();           // disable all interrupts

  TCCR1A = 0;

  TCCR1B = 0;

  TCNT1 = Nt;             // preload timer 65536-16MHz/256/100Hz

  TCCR1B |= (1 << CS12);    // 256 prescaler 64us

  TIMSK1 |= (1 << TOIE1);   // enable timer overflow interrupt

  interrupts();             // enable all interrupts

}

void loop() {

   if (procitao==true && inChar=='a')   //If A/D read

 {
```

```
prethodni='a';
 sensorValue=analogRead(pinSignal);
 Siemens=float(sensorValue)*5/1024;  //
 Siemens=Siemens*31462/3.82;  // 0-200
 Serial.println(Siemens);  //Print value
 procitao=false;  //enable A/D read again
 }
  if(procitao==true && inChar=='b') //If A/D read
 {
 prethodni='b';
 sensorValue=analogRead(pinSignal);
 Siemens=float(sensorValue)*5/1024; //
 Siemens=Siemens*2871/0.35; //0-2000
 Serial.println(Siemens); //Print value
 procitao=false; //enable A/D read again
 }
 if(procitao==true && inChar=='c') //If A/D read
 {
   prethodni='c';
 sensorValue=analogRead(pinSignal);
 Siemens=float(sensorValue)*5/1024; //
 Siemens=Siemens*370/0.04; //0-20000
 Serial.println(Siemens); //Print value
 procitao=false; //enable A/D read again
 }
 if(procitao==true && inChar<='9' && inChar>='1') //If A/D read
 {
   Nt=65536-16000000/256/(inChar-48);
   inChar=prethodni;
  procitao=false; //enable A/D read again
  }
  if(procitao=false && inChar=='d') //If A/D read
  {
  Serial.println(sensorValue); //Print value
  procitao=true; //enable A/D read again
  }
}
void serialEvent(){
while(Serial.available()){
inChar = (char)Serial.read();
    }
    }
  ISR(TIMER1_OVF_vect){
 TCNT1 = Nt;            // preload timer
sensorValue= analogRead(A0); //read A/D
 procitao=true;                //A/D read
}
```

Our task was to measure conductivity of water using Vernier Conductivity probe that has three ranges:

- 0-200
- 200-2000
- 2000-20000

We have written our code so that click on the character ‘a’, in Serial monitor on Arduino, initiates display of values measured by sensor in 0-200 range. Similar, click on the character ‘b’ initiates display of values in 200-2000 range and click on the character ‘c’ displays values in 2000-20000 range. Finally, when we click ‘d’, program stops showing values.

In addition, our code allows us to display values in different speed. Therefore, any number from 1-9 represents certain frequency that lead to slower or faster display of values.

Diagrams

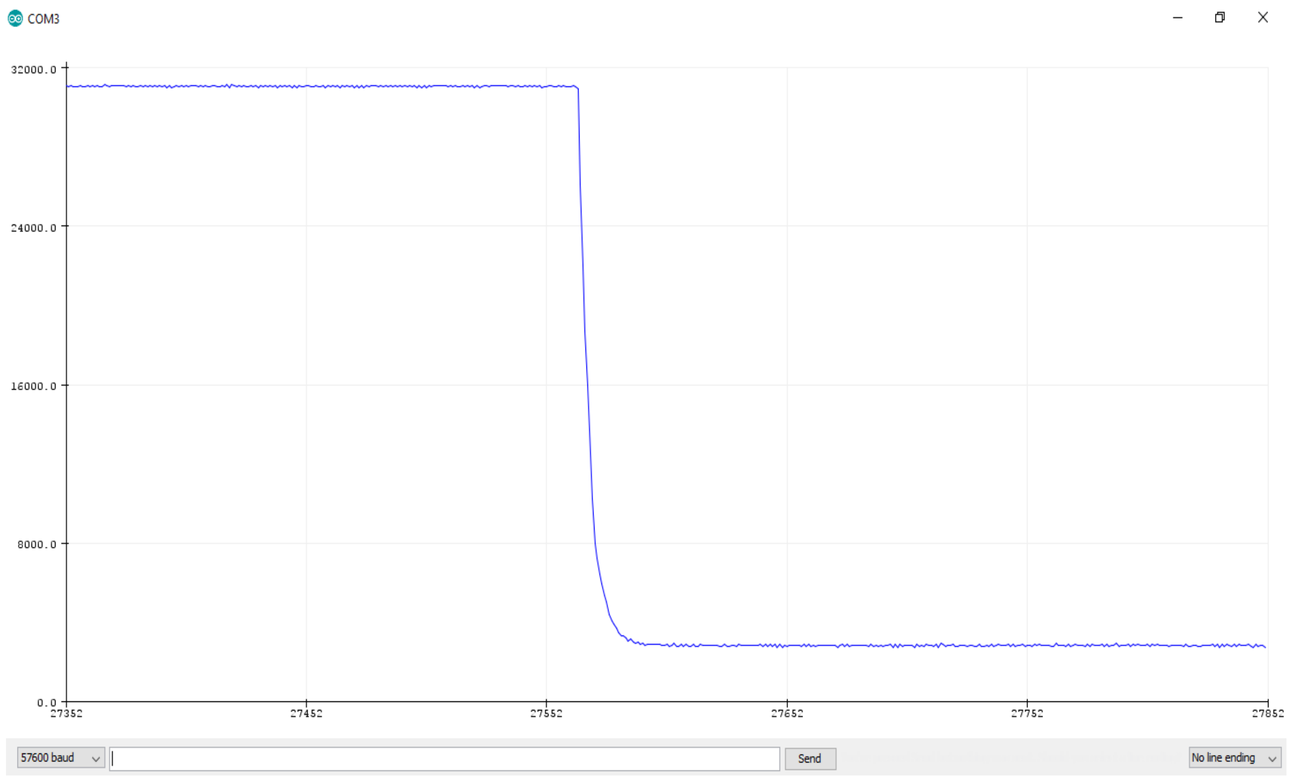


Figure 5. values graph of 200 - 2000 range

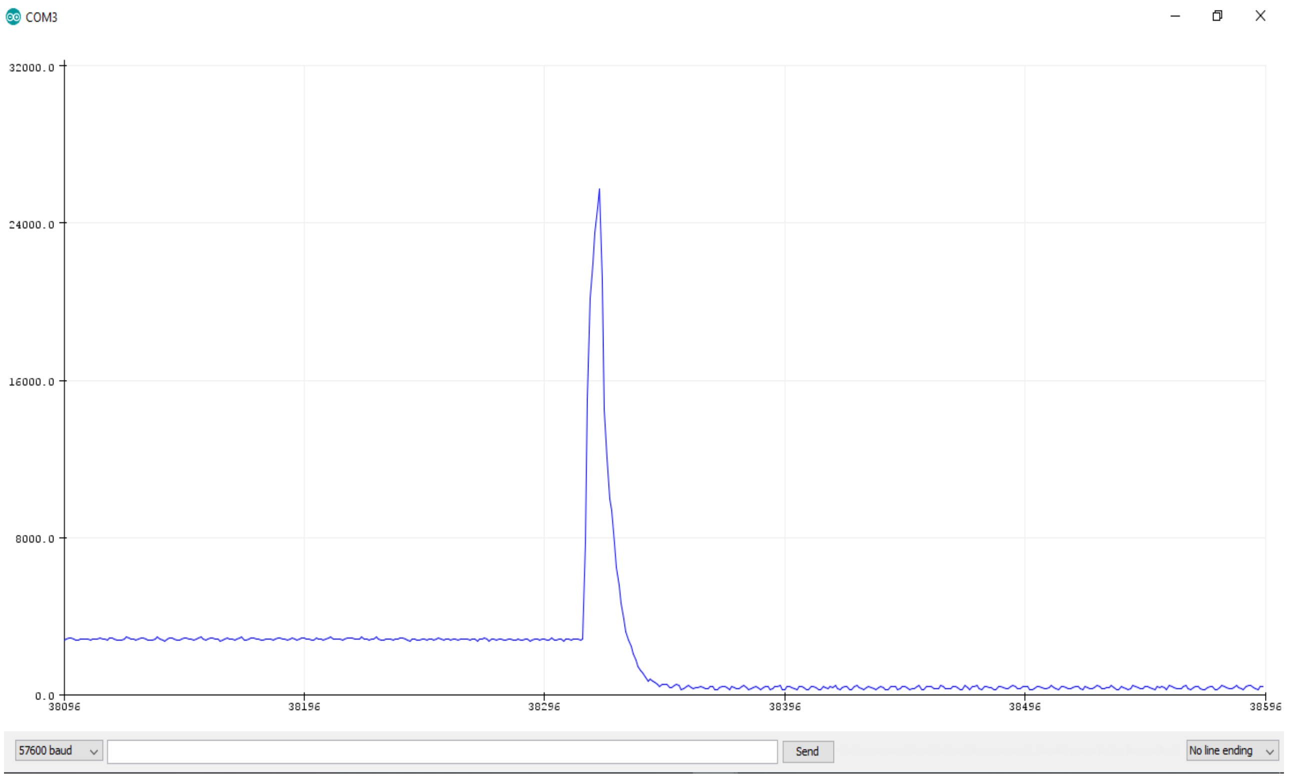
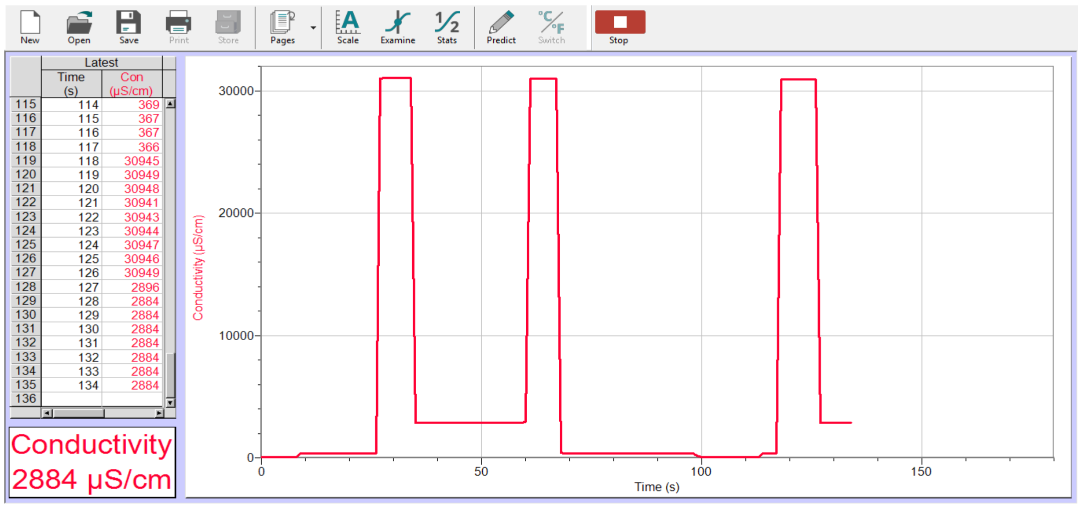


Figure 6. values graph of 2000 - 20000 range

Conclusion

At the beginning, we used program named Logger Lite to get conductivity values for every range of our Vernier Conductivity probe. Values are graphically displayed in Figure 7.



	Latest	
	Time (s)	Con (µS/cm)
115	114	369
116	115	367
117	116	367
118	117	366
119	118	30945
120	119	30949
121	120	30948
122	121	30941
123	122	30943
124	123	30944
125	124	30947
126	125	30946
127	126	30949
128	127	2896
129	128	2884
130	129	2884
131	130	2884
132	131	2884
133	132	2884
134	133	2884
135	134	2884
136		

Conductivity
2884 µS/cm

Figure 8. Conductivity values obtained in Logger Lite program

Then, after running our Arduino code we compared gotten values with those obtained using Logger Lite. Values are presented in the Table 1. and as you can see they are almost matching.

Range	Conductivity values obtained using Logger Lite	Conductivity values obtained using Arduino
0 - 200	≈ 30949	30948.82
200 - 2000	≈ 2884	2886.06
2000 - 20000	≈ 367	365.3

Table 1.

To conclude, Arduino code is valid but can only be used to measure conductivity in educational purposes.

Literature

1. Vjezba provodnost; http://apeg.ac.me/nastava/
2. https://www.vernier.com/product/conductivity-probe/
3. https://www.vernier.com/manuals/con-bta/