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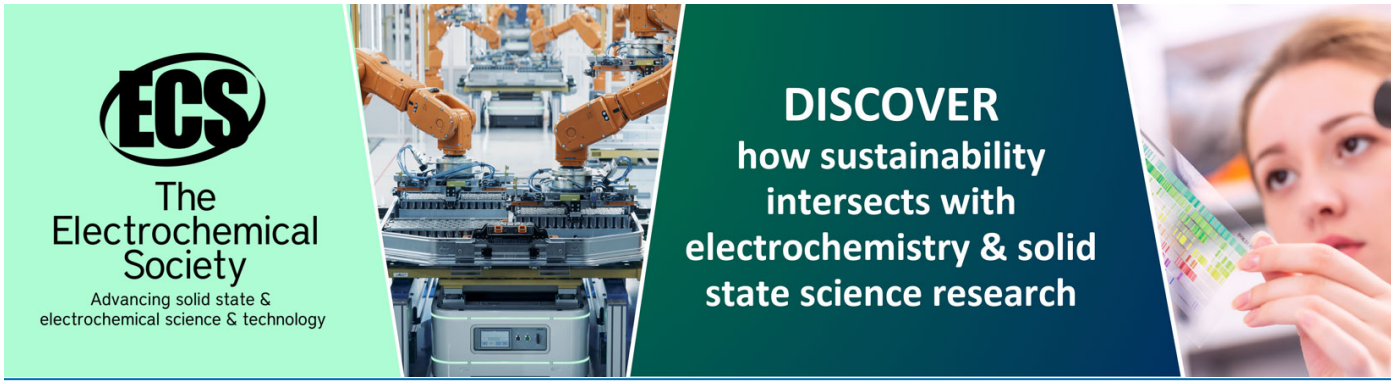

IOP Conf. Series: Journal of Physics: Conf. Series **853** (2017) 012006 doi:10.1088/1742-6596/853/1/012006

Development of TGS2611 methane sensor and SHT11 humidity and temperature sensor for measuring greenhouse gas on peatlands in south kalimantan, indonesia

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Abstract. The research was focused on development of data acquisition system to monitor the content of methane, relative humidity and temperature on peatlands in South Kalimantan, Indonesia. Methane is one of greenhouse gases that emitted from peatlands; while humidity and temperature are important parameters of microclimate on peatlands. The content of methane, humidity and temperature are three parameters were monitored digitally, real time, continuously and automatically record by data acquisition systems that interfaced to the personal computer. The hardware of data acquisition system consists of power supply unit, TGS2611 methane gas sensor, SHT11 humidity and temperature sensors, voltage follower, ATMega8535 microcontroller, 16 x 2 LCD character and personal computer. ATMega8535 module is a device to manage all part in measuring instrument. The software which is responsible to take sensor data, calculate characteristic equation and send data to 16 x 2 LCD character are Basic Compiler. To interface between measuring instrument and personal computer is maintained by Delphi 7. The result of data acquisition showed on 16 x 2 LCD characters, PC monitor and database with developed by XAMPP. Methane, humidity, and temperature which release from peatlands are trapped by Closed-Chamber Measurement with dimension 60 x 50 x 40 cm^3. TGS2611 methane gas sensor and SHT11 humidity and temperature sensor are calibrated to determine transfer function used to data communication between sensors and microcontroller and integrated into ATMega8535 Microcontroller. Calculation of RS and RL of TGS2611 methane gas sensor refer to data sheet and obtained respectively 1360 ohm and 905 ohm. The characteristic equation of TGS2611 satisfies equation V*RL* = 0.561 ln n – 2.2641 volt, with n is a various concentrations and V*RL* in volt. The microcontroller maintained the voltage signal than interfaced it to liquid crystal displays and personal computer (laptop) to display result of the measurement. The result of data acquisition saved on excels and database format.

1. Introduction

Peatlands are a specific type wetland formed by the accumulation of incompletely decayed plant material by forming layers of peat. They are middling between terrestrial area and wetland where only found handful of standing water. The depth of peatlands is more than 30 cm to 40 cm with organic content more than 50% by weight [1].

Indonesia has tropical peatlands that spread out in the islands of Sumatera, Kalimantan, and Papua. Tropical peatlands are involved 10% of the coastal, sub-coastal and low altitude areas with estimates reach 16.8 to 27.0 million ha [2]. Peatlands in Kalimantan spans nearly 5.9 million ha, approach 11% of total terrestrial land area in Kalimantan [3]. Tropical Peatlands in South Kalimantan, Indonesia, could emission of three main greenhouse gases especially carbon dioxide, methane and nitrous oxide [4].

Methane, emitted by peatlands to the atmosphere, plays a major role in determining the climate of the atmosphere. The dominant sources of methane are single-celled archeae by manner inhibit anaerobic micro sites in the soil and water. Methane is produced by archeae via a group of methanogens. Environment parameters like humidity and temperature also take effect on production on methane [5].

Closed-chamber is a media that used to trap greenhouse gases that emitted by peatlands to atmosphere. The method of closed-chamber measurement is the most used to determine CH4 fluxes in peatlands and to measure rates of gas exchange between soil, vegetation and the atmosphere in terrestrial [6]. Mostly, in measuring the concentration of methane emitted from peatlands, gas chromatography such as gas chromatography (GC-8A) which consisted of a flame ionization detector maintained at 130 ^{0}C and a 2-m long activated carbon column (80/100 mesh) at 70 ^{0}C with pure nitrogen gas used as a carrier [7].

In this research, we develop microcontroller-based methane measurement with TGS2611 and humidity and temperature with SHT11. The system of hardware of data acquisition consists of powersupply unit, TGS2611 methane gas sensor, SHT11 humidity and temperature sensors, voltage follower, ATMega8535 microcontroller, 16 x 2 LCD character and personal computer. ATMega8535 module is a device to manage all part in measuring instrument. The software which is responsible to take sensor data, calculating characteristic equation and sending data to 16 x 2 LCD character are Basic Compiler. To interface between measuring instrument and personal computer is maintained by Delphi 7. The result of data acquisition which shown on 16 x 2 LCD characters, PC monitor and database with developed by XAMPP.

2. Material and methods

The data acquisition system for monitoring methane, humidity, and temperature in closed-chamber measurement on peatlands was conducted by pursuing block diagram presented in Figure 1. Two sensors, TGS2611 and SHT11, were connected with signal conditioning. TGS2611 was formed with the voltage divider, Figure 2, and then output voltage signals were taken from RL, whereas SHT11 configured with two wire interfaces. Output voltage signals connected with ATMega8535 microcontroller subsequently connected with LCD, personal computer, and database.

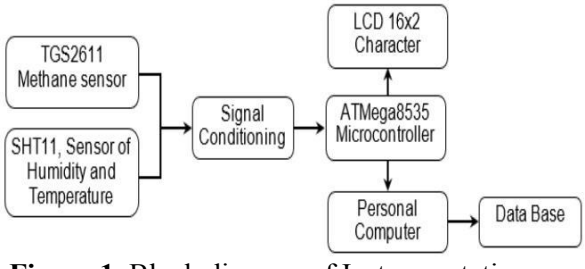


Figure 1. Block diagram of Instrumentations

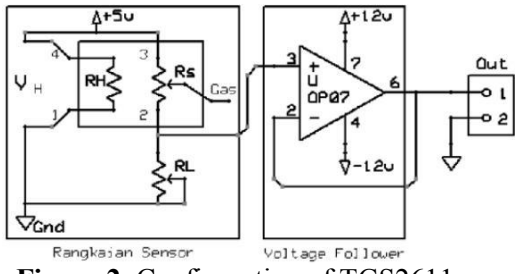


Figure 2. Configuration of TGS2611

TGS2611 is a methane gas sensor in the form semiconductor type which has low power consumption, very high sensitivity and long life. TGS2611 requires only 56 mA for heater current due to small size chip and housed in a standard TO-5 package [8]. The various concentration of methane displayed by TGS2611 has changes value of sensor resistance (RS). The sensor requires two voltage inputs that are the voltage of heater (VH) and voltage of the circuit (VC), shown in Figure 2. Power

supply circuit of TGS2611 was commonly applied +5 volt for both VH and VC. Pin 1 connected with +5 volt and pin 4 with the ground, similarly for pin 3 and pin 2. The load resistor (RL) which is assembled between pin 2 and ground and voltage signal (VRL) was accepted from RL whose value proportional to the concentration of methane were detected by TGS2611. The sensor resistance (RS), RL, VC, and VRL was calculated by using equation 1 and the power of dissipation using equation 2 in the following formula.

$$R_S = \frac{V_C - V_{RL}}{V_{RL}} \, x \, R_L \quad (1)$$

$$P_S = \frac{(V_C - V_{RL})^2}{R_S} \quad (2)$$

SHT11 has a fully calibrated, digital output, low power consumption, and long terms stability sensor of humidity and temperature. Internally, band gap sensor was applied to measure temperature while a unique capacitive element sensor was used to measure relative humidity. SHT11 pin assignment consisted eight pins; namely ground (GND), serial data (DATA), serial clock (CLK) and the source voltage (VDD) for pin 1 – 4, while pin 5 – 8 had no connection (NC) [9]. VDD and GND were connected to 5 volts and 0 volts (ground) from power supply unit. Output data signals from SHT11 were in form digital serial and then were interfaced with microcontroller by two wire serial interface which applies DATA and SCK respectively connected with port B.1 and port B.0 microcontroller.

Operational amplifier (op-amp) is a device with two input signals and one output signal which used to amplification output voltage signal from sensor device. Op-amp could be configured in five sharp: non-inverting amplifier, inverting amplifier, the differential amplifier, voltage follower and instrumentation amplifier. OP07 was a small scale integrated circuit to accommodate the op-amp [10]. In this research, OP07 are configured as voltage follower where inverting input (pin 2) directly connected to the output voltage (pin 6) of OP07 and non-inverting input receive the voltage signal from TGS2611. Output voltage signal was connected to the microcontroller, presented in Figure 3.

Figure 3. Component sides of TGS2611 and OP07

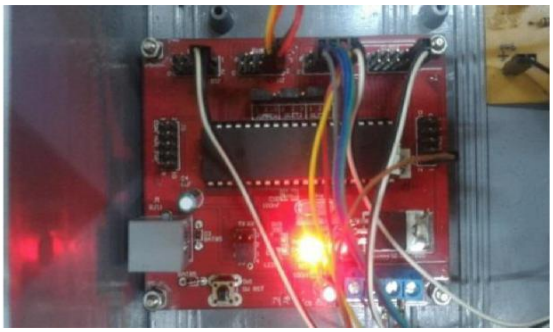


Figure 4. Connection ATMega8535 with OP07, LCD, and SHT11

The ATMega8535 is a heart of instrumentation systems. ATMega8535 is an 8-bit microcontroller with low power complementary metal oxide semiconductor (CMOS) by RISC architecture and part of Alf and Vegard RISC Processor (AVR) family [11]. Figure 4 showed the connection signal conditioning, SHT11, and LCD to ATMega8535. There were four input/output ports with each port have 8 bits, port A, port B, port C and port D. Port A.0 to A.7 are analog input port where internally include with analog to digital conversion (ADC) and the multiplexer. Port A.0 received the analog voltage from TGS2611 and port B.0 and B.1 received digital serial data from SHT11.

LCD is a thin film and flat screen device consisting amount of color pixel which composed in the front of light source. Each pixel consists of liquid crystal column that hangs up with two transparent electrodes and two filters polarization [12].

Basic Compiler (Bascom) is a software to write a program to the microcontroller that produced by MCS Electronics. Program language is based on the structure of basic language program. Bascom can

execute the arithmetic command, logic, and special command to configure LCD pins [13]. Bascom was used to managing output data signal of TGS2611 which entered from port A.0 ATMega8535, to maintain two wire interface from SHT11 via port B.0 and B.1 ATMega8535, and interfaced between ATMega8535 and LCD.

Delphi is a visual program package in windows environment which using pascal compiler. Although Delphi uses pascal logic in programming, Delphi appearance is more interesting, less time consuming to write a long and complicated syntax for drawing, laying and adjusting of the image. Delphi also provides more choice interface component such as menu, drop down, pop up menu, text box, radio button, check box, TComPort and others. TComPort is a component on delphi to organize communication between peripheral devices and the personal computer via serial port [14]. Delphi is responsible for displaying the result data measurement from TGS2611 and SHT11 in the form of data array, graphs and excel. In addition, Delphi does not only display the result of data measurement, but also interface with the database.

Xampp is a database software package that includes with apache as a web server, MySql as a database server, and PHPMyAdmin. Xampp is used to storage the result data monitoring to the database [15]. The Xampp and MySql-ODBC-connect were installed to the personal computer to communication between Delphi and database systems. Recording data on MySql database can be displayed by online where MySql combined with web language program like HTML.

3. Discussion

3.1. Determination of characteristics equation of TGS2611

Data sheet of TGS2611 showed that the value of sensor resistance ranges from 0.68 to 6.8 kilo ohm and the span of methane concentration from 500 to 10000ppm. In other words, the value of RS was 0.68 kilo ohm equal to 500ppm of methane concentration as same as 6.8 kilo ohm equal to 10000ppm. The value of VRL was 2 volts when the concentration of methane is 2000ppm, so the value of RS was obtained by comparison with following formula:

$$R_S = \frac{2000\ ppm}{10000\ ppm} x6800\ ohm \tag{3}$$
$$R_S = 1360\ ohm$$

The value of RS = 1360 ohm used to compute the value of RL, which referred to equation 1 obtained that RL = 905 ohm. Typical sensitivity characteristics of TGS2611 could be determined by graph approximation on data sheets. For n was a various concentration of methane in ppm, VRL satisfies the equation:

$$V_{RL} = 0.561 \ln n - 2.2641 \tag{4}$$

3.2. Realizations of instrument systems

The instrumentation systems were realized to supporting measurement concentration of methane, humidity, and temperature on peatlands, presented in Figure 5. Two probes of sensors were embedded in closed-chamber measurement; the probe of TGS2611 was shown in Figure 1SHT11 in Figure 6. Closed-chamber was placed on peatland and methane emission accommodated in the chamber. Methane that released on peatlands was sensed by TGS2611 and SHT11 measure humidity and temperature in the chamber.

Figure 5. System of Instrument are implementes on Peatlands

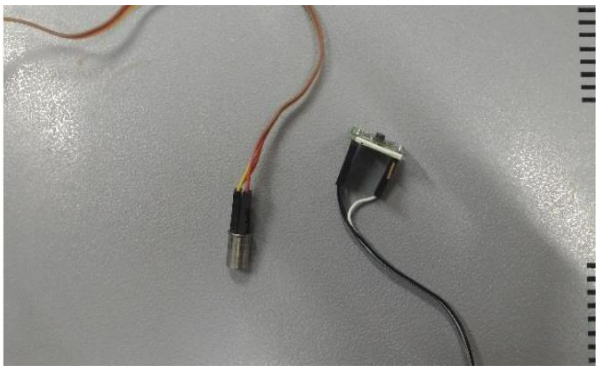


Figure 6. Probe of sensor SHT11 and TGS2611

Figure 7. Realization of instrument system

Figure 8. Displaying of LCD

All component in data acquisition system which consisted of TGS2611, SHT11, voltage follower with OP07, microcontroller ATMega8535 and LCD 16x2 character generated by the regulated power supply, shown in Figure 7. The power supply was designed with three output voltage signal, which were split supply ±12 volt for generates voltage follower and +5 volt for all microcontrollers ATMega8535, TGS2611 and SHT11. The voltage signal from TGS2611 was connected by voltage follower with OP07 then connected with port A0 microcontroller ATMega8535 to conversion by 10 bits ADC in ATMega8535. Microcontroller ATMega8535 realized to manage output voltage signal from TGS2611 and SHT11, to convert analog to digital conversion, to interface with LCD and personal computer. Figure 8 presented LCD which displaying three parameters which were CH4, T, and H.

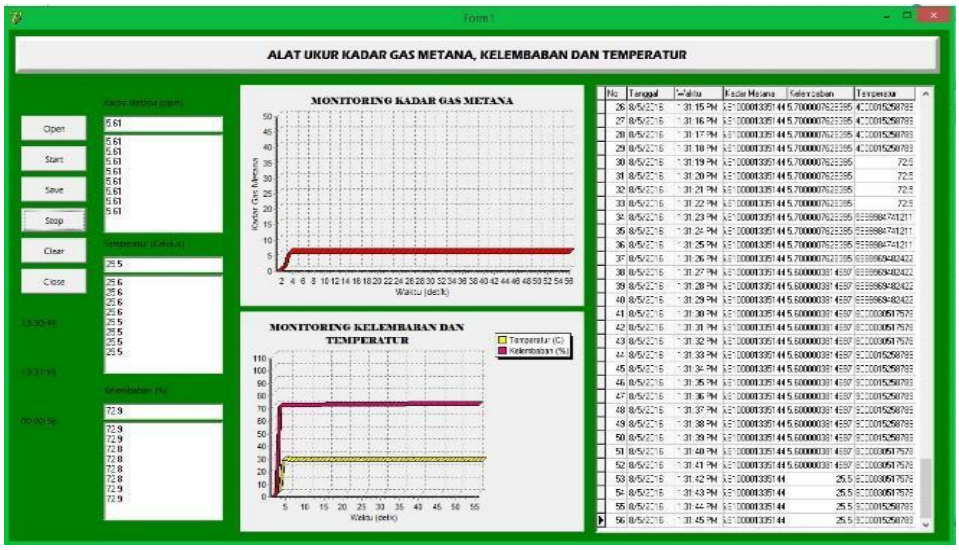
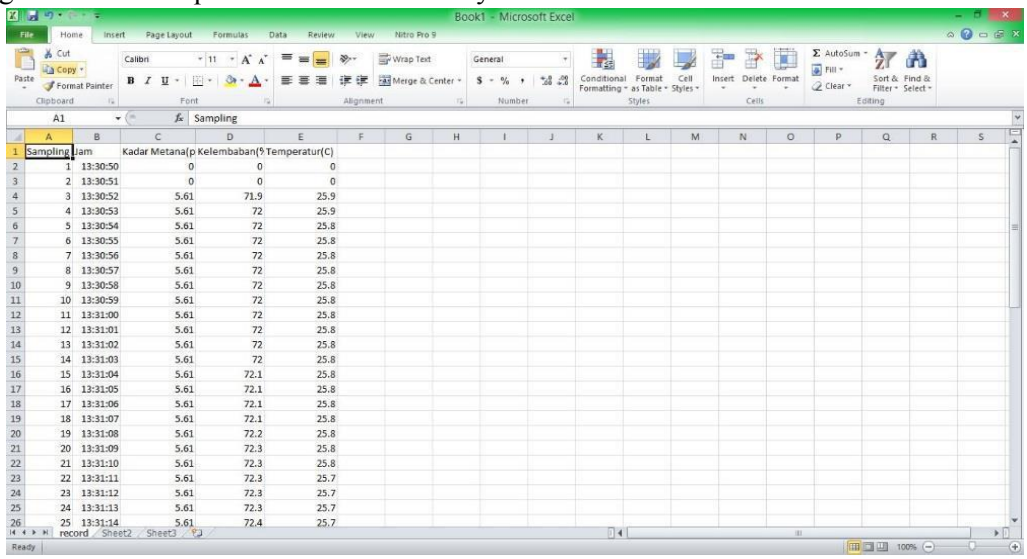


Figure 9. Display of data acquisition on PC/laptop

The result of data acquisition shown on the monitor screen of personal computer or laptop in Figure 9 is an application program to create the application developed by Delphi. On the left side on the form in Figure 9, monitoring windows were equipped with six buttons namely open, start, save, stops, clear and close. Each button running used to configure protocol interface, to start measurement of methane, temperature, and humidity, to storage the result data monitoring in excel form shown in Figure 10, to stop application program operation, to erase all value in text box and to close the window. Three textboxes showed respectively the content of methane, value of temperature and humidity. The value of physical parameters corresponded to two graphs that figured in the middle of windows. The upper one was graph referred to the content of methane were detected in closed-chamber measurement, the other one presentation of temperature and humidity. On the right side, the form of application program presenting all value of acquisition that is treated by the database.



Sampling	Jam	Kadar Metana(p	Kelembaban(%	Temperatur(C)
1	13:30:50	0	0	0
2	13:30:51	0	0	0
3	13:30:52	5.61	71.9	25.9
4	13:30:53	5.61	72	25.9
5	13:30:54	5.61	72	25.8
6	13:30:55	5.61	72	25.8
7	13:30:56	5.61	72	25.8
8	13:30:57	5.61	72	25.8
9	13:30:58	5.61	72	25.8
10	13:30:59	5.61	72	25.8
11	13:31:00	5.61	72	25.8
12	13:31:01	5.61	72	25.8
13	13:31:02	5.61	72	25.8
14	13:31:03	5.61	72	25.8
15	13:31:04	5.61	72.1	25.8
16	13:31:05	5.61	72.1	25.8
17	13:31:06	5.61	72.1	25.8
18	13:31:07	5.61	72.1	25.8
19	13:31:08	5.61	72.2	25.8
20	13:31:09	5.61	72.3	25.8
21	13:31:10	5.61	72.3	25.8
22	13:31:11	5.61	72.3	25.7
23	13:31:12	5.61	72.3	25.7
24	13:31:13	5.61	72.3	25.7
25	13:31:14	5.61	72.4	25.7

Figure 10. Recording data and saved on excel form

The display of data acquisition was shown on the database which developed by xampp. Database has contents six column that named *nomor* (number), *tanggal* (date), *waktu* (time), *kadarmetana* (concentration of methane), *kelembaban* (humidity) and *temperatur* (temperature). Each column presented real time data monitoring. The advantages in using a database in the measurement system are monitoring data can directly record, without the person to write the result of data acquisition, and data obtained can be processed and relocated to other media.

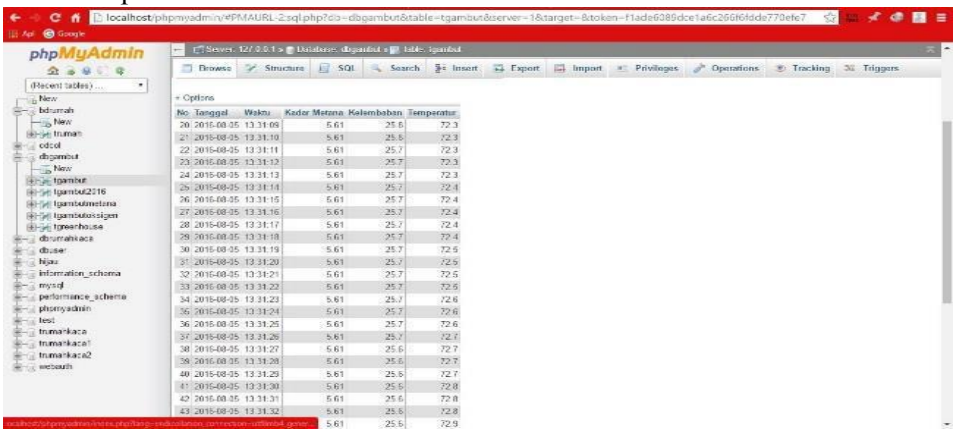


Figure 11. Display on Xampp database

4. Conclusion

Development of TGS2611 methane sensor and SHT11 humidity and temperature sensor gave a stable performance in monitoring methane, humidity, and temperature in peatlands. By monitoring system of methane, humidity and temperature on peatlands, methane production which emitted as greenhouse gas and change of humidity and temperature in closed-chamber measurement would be recorded always in real time and continuously. Portable dimension of the equipment gives another advantage which is easier to install in closed-chamber on peatlands.

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