MULTIPOINT WIND SPEED AND DIRECTION MEASUREMENT AND DATA LOGGING BY USING 8051–BASED MICROCONTROLLER

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ABSTRACT

A 8051-based data logger has been developed to measure wind speed and wind direction to store these data into an eeprom with the date and time. The data is then transferred to the computer through RS232 serial port. The instantaneous data –wind speed, wind direction, date, time are shown on a 16x2 lcd with the help of an 4x4 keypad. The keypad is also used to set the date and time , and also to define the sampling interval. Three anemometers and one wind vane are used in this study. The anemometer which will be read is selected by a 3-state selector switch. The transferred data to the computer is read by a user-interface program.

I. INTRODUCTION

Since natural resources are running out and the use of electricity is being increased in the casual life, mankind is forced to find new sources to produce electrical energy. Although, the wind power, which is one of the most attractive way to produce electrical energy, has been used for many years in developed countries, using of this energy has been accelerated recently in Turkey [1]. One of the most important factor of installing a wind power system is to choose the site where system will be installed. It will be waste of time and money to build wind power system without investigating wind potential of the site [2]. The period of return on investment is another important factor also, even if the wind power potential is satisfactory. For these reasons, if a wind power system is decided to install, it is necessary to carry out the feasibility study of wind power using accurate devices as first step.

In this study, NRG maximum #40 anemometers and NRG #200P wind vane are used as wind sensors. The analogue sine wave output of the anemometer is converted to square wave with a zero cross detector circuit to measure the wind speed and the output of wind vane is read by an eight bit a analogue-to-digital converter to define the wind direction.

Wind speed and wind direction data are stored into an EEPROM with the calendar and time which are read from a real time clock (RTC) integrated circuit. All data are shown on the LCD after each sample. When the EEPROM has reached its maximum address, the data are transferred to the computer via RS232.

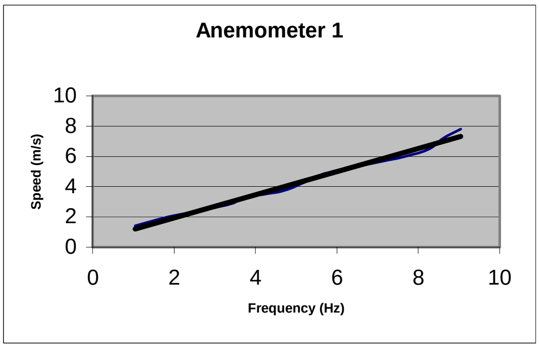
II. CALIBRATION OF SENSORS

An anemometer is an instrument which measures the speed of the apparent wind. A common type of anemometer measures the wind speed by means of a set of three cups which rotate on a vertical axis. The force of the wind on the cups causes them to rotate at a speed which is proportional to the speed of the apparent wind. Thus the greater the wind the faster the cups will rotate. By rotating it produces a sine wave which its frequency is proportionally changing with the wind speed.

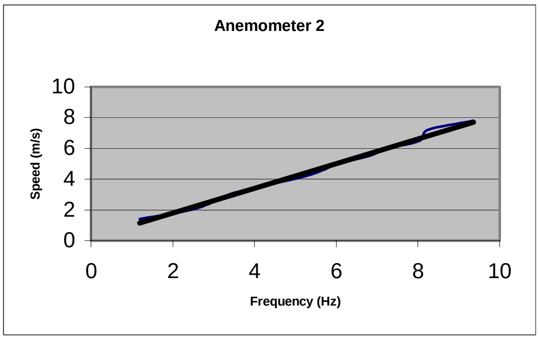
Wind direction is measured by wind vanes. The vane is directly connected to a potentiometer located in the main body. An analogue voltage output directly proportional to the wind direction is produced when a constant DC excitation voltage is applied to the potentiometer.

Because of production differences, a calibration process has to be taken in order to obtain transfer functions of anemometer and vane. The calibration-processes of the anemometers are realized in the wind tunnel on the mechanical engineering department. The anemometers' outputs were measured by a digital Fluke 123 Scope Meter for a number of wind speeds which is generated by an inverter controlled motor.

The speed and frequency curves for anemometers are shown in Figure 1.



(a)



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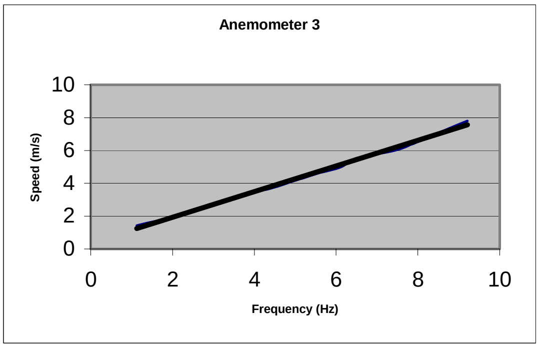


(c)

Figure 1. Speed – frequency curves

The relation between speed and frequency found to be as;

$$V_1 = 0,765 f_1 + 0,409 \quad [1]$$

$$V_2 = 0,803 f_2 + 0,184 \quad [2]$$

$$V_3 = 0,781 f_3 + 0,358 \quad [3]$$

where V is wind speed, and f is output frequency of an anemometer.

The wind vane's output was measured by an ohmmeter for each 10° before installation to help us calculating wind direction when it is read by an ADC. There are 16 predetermined directions as shown in Figure 2.

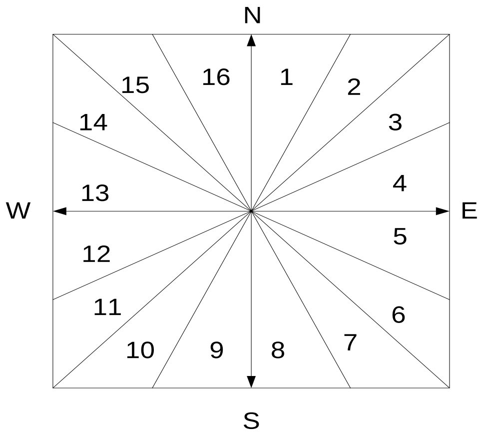
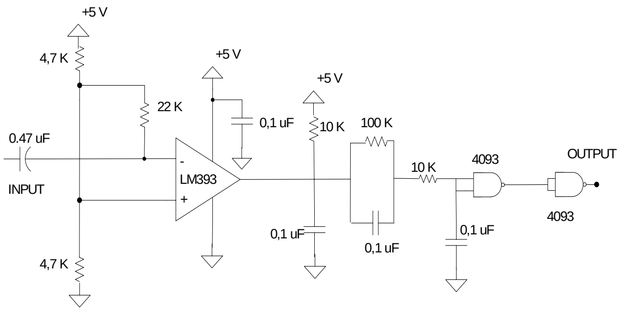


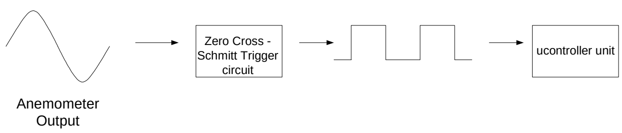
Figure 2. Wind Directions

III. MEASURING WIND SPEED

The sine wave coming from anemometers are passed through a zero cross detector and converted square wave to reduce noise effects on signal and to make counting easier in order to measure wind speed. The output signal of zero cross detector is sharpened by a Schmitt trigger circuit before applying to the microcontroller.



(a) Circuit



(b) Operational logic

Figure 3. Anemometer wave-shaping circuit.
(a) Circuit diagram (b) Operational logic diagram.

Microcontroller's 16-bit timer is programmed to start count when an external interrupt occurred on the falling edge of the pulse and to stop when the next interrupt received. On the other hand timer overflows are counted by a special function register [3,4].

Since a single machine cycle consists of 12 crystal pulses and crystal frequency was chosen 18432000 Hz. A running timer will be incremented:

18432000 / 12 = 1,536,000 times per second

Thus the frequency of an anemometer can be calculated as

$$f = \frac{1536000}{overflows + timervalue} \quad [4]$$

And the speed is calculated by using eq. 1,2,3.

IV. MEASURING WIND DIRECTION

+5 V power supply applied to the potentiometer of wind vane and the voltage on potentiometer is read by using a 8-bit serial analogue-to-digital converter.

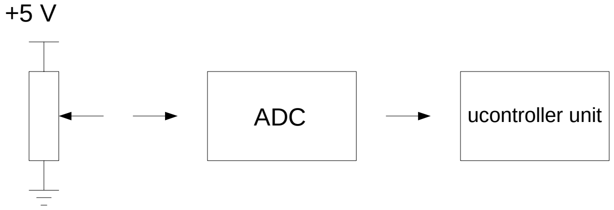


Figure 4. Reading wind vane

We divided directions into 16 parts, thus the voltage difference between two directions will be 5V/16=0,3125V and the following table shows the relation between direction and ADC values.

Table 1.

Voltage range on Potentiometer (V)	ADC value (Hexadecimal)	Direction
0,0000 – 0,3125	00	1
0,3125 – 0,6250	01	2
0,6250 – 0,9335	02	3
0,9335 – 1,2500	03	4
1,2500 – 1,5625	04	5
1,5625 – 1,8750	05	6
1,8750 – 2,1875	06	7
2,1875 – 2,5000	07	8
2,5000 – 2,8125	08	9
2,8125 – 3,1250	09	10
3,1250 – 3,4375	0A	11
3,4375 – 3,7500	0B	12
3,7500 – 4,0625	0C	13
4,0625 – 4,3750	0D	14
4,3750 – 4,6875	0E	15
4,6875 – 5,0000	F	16

Each ADC value has a correspondent direction shown on Figure 2.

V. Overall system and Data-Logging

A 4x4 keypad is used to set date and time variables of RTC, to input sampling interval of measurement, and to choose desired functions of the program. Block diagram of the overall system is shown in Figure 5.

An 16x2 LCD was used to display real time, wind speeds and direction. 4 of 8 pins used for data bus, and 6 pins for selecting LCD, activating LCD, read/write, adjusting contrast, +5 V supply, and ground respectively. The former 7 pins of LCD connected to Port1 of microcontroller. R/W pin is connected to ground directly because LCD will be used only for output.

DS1307 Real time clock was used to get calendar and time information. DS1307 counts seconds, minutes, hours, day of the month, month, day of the week, and year with leap year compensation valid up to 2100. i2c protocol [5] was used to establish communication between microcontroller and RTC [6,7] while microcontroller is master and RTC is slave. Address and data are transferred serially via 2-wire bidirectional bus.

ADC0832 8-bit successive approximation analog to digital converter was used to convert the voltage of internal potentiometer of Wind vane to binary data. The ADC has 2 channel named as CH0 and CH1. The desired channel is selected by a multiplexer which is controlled by software. ADC0832 has 2 multiplexer mode, single-ended and differential mode. Since the input configuration is under software control, it can be modified, as required, at each conversion mode. A channel can be treated as single ended ground referenced input or differential mode can be selected by selecting a channel as + input terminal and other channel as – input terminal. Single-ended mode has been chosen in this study and channel 1 is connected to potentiometer while channel 0 is connected to ground. The voltage on potentiometer is divided into 256 and the converted ADC value ranges from 00h to FFh.

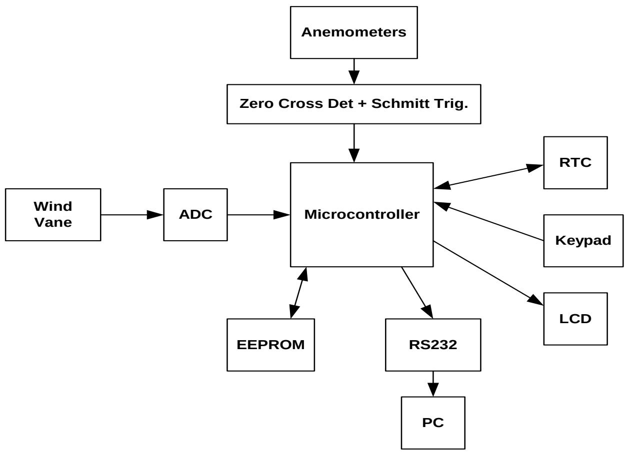


Figure 5. Block diagram of hardware

The data taken from RTC, anemometers, and wind vane are stored into EEPROM in 5 or 10 minutes intervals. Two I/O pins are assigned for the communication, and microcontroller uses RS232 to send data to computer when EEPROM is full. So the data-logging is performed either by an EEPROM or by a computer.

VI. SOFTWARE

The software can be divided into two parts, the first is programming microcontroller which is developed in 8051 assembly and the second is a windows based PC program developed in Delphi programming language. The flowcharts of the microcontroller and PC programs are illustrated in Figure 6 and 7 respectively.

There are 6 main functions in microcontroller program which are

1- Adjusting RTC
2- Showing the real time and calendar on LCD
3- Showing the real time wind speeds on LCD
4- Showing the real time wind direction on LCD
5- Selecting sampling intervals and storing the values into EEPROM.
6- Sending all data in the EEPROM to PC via RS232

PC program checks the RS232 port in a loop and stores the values in a file if microcontroller sends data. PC program shows also wind speed and direction for a desired date and time by opening the saved file and finding the desired values.

VI. CONCLUSION

A wind speed and wind vane measurement instrument with real time clock and data logger has been developed. The device has a satisfied accuracy, large memory, and can be configured easily. The software functions and the ability of downloading data from PC directly makes easier to use of this instrument, and it can be adapted almost every condition. The instrument can also be used at any site as a stand alone meter and data logger.

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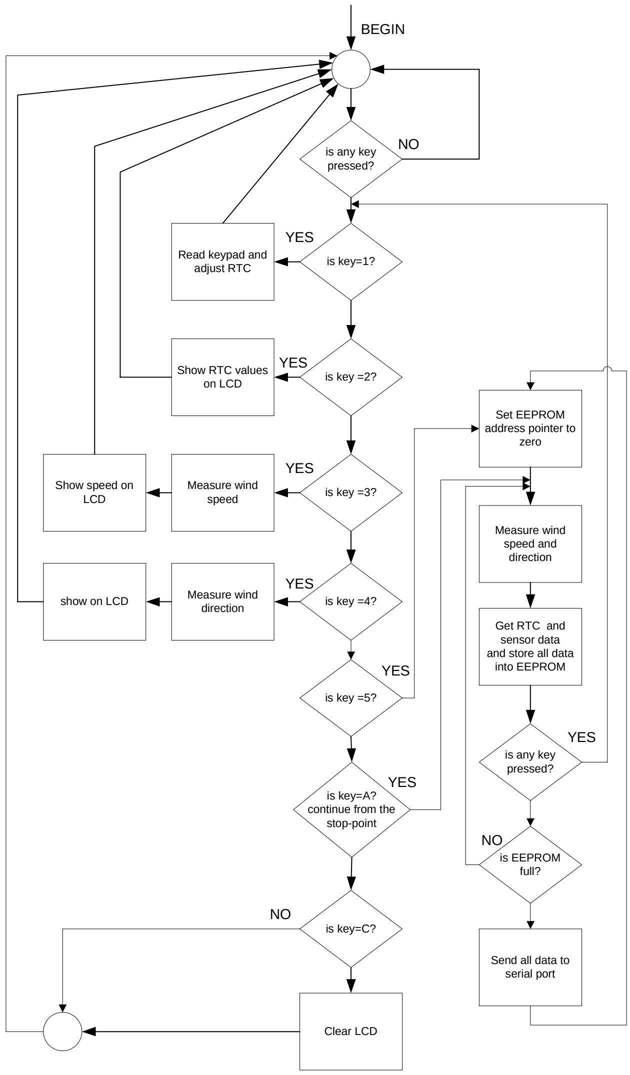

Figure 6. Flowchart of microcontroller program.

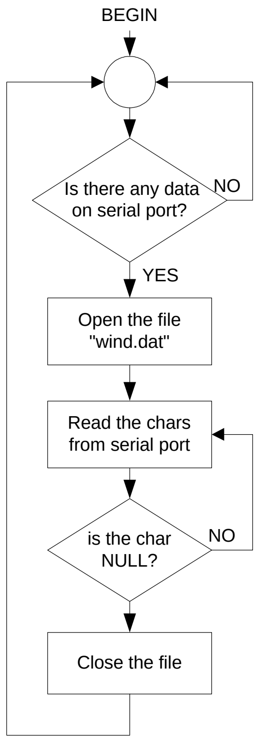

Figure 7. Flowchart of PC program.