On Board Processing Capability for Radiosonde Platforms Using Low Cost Processors Mixed Signal ICs and Semi-conductor Sensors

By: Nuwan Kumarasinghe

Department of Meteorology
Bauddhaloka Mawatha, Colombo 07, Sri Lanka.
Telephone: 94-11-2681039, Fax: 94-11-2698311
e-mail: nuwan1960@yahoo.com

ABSTRACT

Older versions of *Radiosonde* instruments with electromechanical and discrete components are still used by the meteorological community, particularly in developing countries. Within limited costs, the system can be improvised by using a mix of modern semiconductor sensors (for relative humidity and pressure) , mixed signal ICs and micro-controller chips to provide more accurate, easily calibrated and on board processing capability, while reducing the weight to be carried by the balloon.

The new semi-conductor sensor platform consists of modern temperature, pressure and relative humidity sensors , where temperature sensor is in-built on one of the surface mount ICs which also has 4-channel multiplexer and 10-bit A/D converter. Hence the cost and the weight of the platform is considerably reduced. The sensor platform is controlled by 8051 compatible micro-controller provides on board processed data serially feed into an FSK modulator and the transmitter unit. The data received at the ground station can be directly fed to the computer. The computer interface software facilitates all manual calculations and graph plotting of the conventional radiosonde equipment.

1. Introduction

The basic parameters measured in meteorological and environmental monitoring systems are temperature, relative humidity (RH), pressure, wind speed, wind direction and chemical gas particle measurement. The measurement of these parameters are required at upper atmospheric levels in addition to the measurements at the surface level for the successful environmental studies. The present system used in the Department of Meteorology, Sri Lanka for acquiring upper atmospheric information consist of basically two parts, viz;

(a). measurements of wind speed and direction upto a height of approximately 30 Km above the sea level, using a wind finding radar.

(b). measurements of temperature, RH and pressure upto a similar height using *radiosonde* equipment.

Meteorological Department of Sri Lanka is equipped with Indian made radiosonde system. This is entirely a analog system.

In this paper we only consider the measurements of modern I.C. based sensors of relative humidity, temperature and pressure.

The *radiosonde* which is connected to a hydrogen filled balloon and released, converts measurements obtained by the enclosed meteorological sensors (thermistor for temperature, hygristor for RH, both non linear elements) into resistance which control the blocking rate of a blocking oscillator. Consequently, the blocking oscillator modulates *radiosonde* carrier wave either in amplitude or in frequency. The rate of modulation pulses vary from 0-200 Hz, depending upon the meteorological sensor element in circuit and its resistance corresponding to prevalent temperature and RH. Each instrument is provided with a pre-calibrated data sheet in which the contact number for corresponding pressure is indicated. The aneroid capsule used as the pressure sensor performs another function by switching from temperature sensor to RH sensor. In *radiosonde* instrument a 401 MHz transmitter is used. The power required for the operation of the transmitter is obtained through water activated 22.5 V battery which is capable of giving operating voltage for approximately 90 minutes.

The objective of the present exercise confine to design and develop a prototype of a single air borne module capable of replacing the existing system. The system can measure accurately and reliably the upper atmospheric temperature, relative humidity and pressure. Somewhat complex calibration procedure is being used for the present radiosonde system. This newly designed airborne module has pre-calibrated sensors. Therefore it saves the calibration time. I.C. based sensors for the measurements of temperature, atmospheric pressure and relative humidity are being used.

2. Methodology

The existing Radiosonde is used to measure upper air temperature , relative humidity and atmospheric pressure upto 25 km in analog form. The new radiosonde system is designed to measure temperature, relative humidity and pressure in digital mode, which can be directly coupled to a PC. A special I.C. is used for this particular design (AD 7817) , which has a internal temperature sensor in built and 10 –bit ADC and 5 analog channel multiplexer.

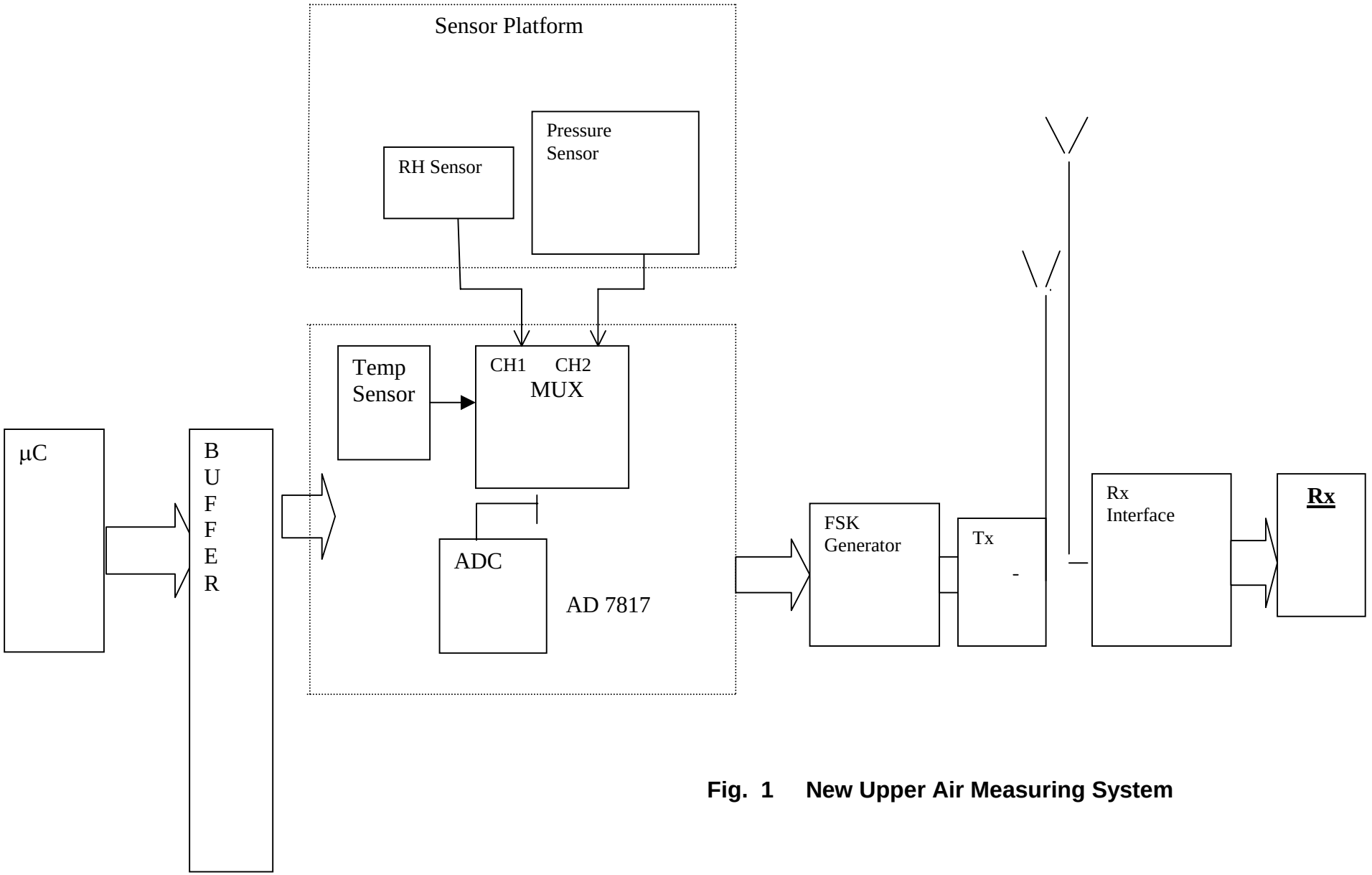

Fig. 1 New Upper Air Measuring System

The measurable temperature range is –55 C^0 to +125 C^0. The temperature value is appeared as 10 – bit data at the output of ADC AD 7817 . On-chip temperature can be accessed via multiplexer channel 0 . The result of the 10 – bit conversion on channel 0 can be converted to a temperature value by using the following equation. AD 7817 contains two on-chip register. The address register and the over temperature register. These registers can be accessed by carrying out 8-bit serial write operation to the device.

$$T_{AMB} = - 103\ C^0 + (\text{ADC Code}) / 4$$

In this design we have used Honeywell, IH 3602 L sensor for relative humidity measurements. IH 3602L is a high accuracy, fast response and stable sensor. It's output voltage is directly proportionate to the RH % value.

We have used Motorola MPX 5500 silicon based pressure sensor for atmospheric pressure measurements. It is a on-chip signal conditioned temperature compensated pressure sensor. It has a measuring range of 0 – 1200 millibar.

DS 87C520 high-speed micro-controller was used as the main processor. This micro-controller is an 8051 compatible processor. It has four 8-bit I/O ports, three 16-bit timer/counters and 256 bytes scratchpad RAM. It features 16 KB of EPROM with an extra 1 KB of data RAM. Besides greater speed , the micro includes a second full hardware serial port. Port 2 is used to create the control word for AD 7817 chip. Output data of AD 7817 is accessed through LSB of the Port 0.

If the five MSB's of the control byte are all logic '0' then the three LSB's are transferred to the analog input channel on which to carry out a conversion. It is also used to select the temperature sensor, which has the address of 000.

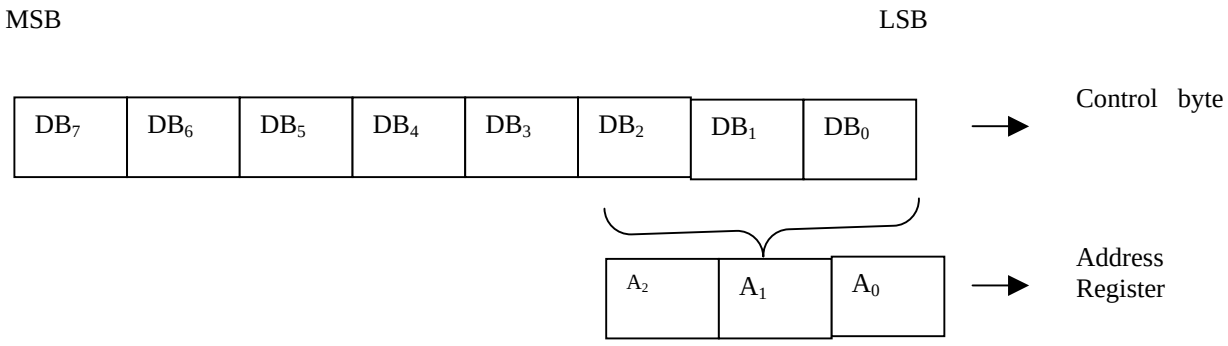

Fig. 2 Control Byte

The processed data is generated via Port 3 at 300 baud speed which is a compatible speed for the existing Radiosonde receiving unit. Assembly language is used to program the micro-controller DS 87C520. The corresponding flow chart is shown in Fig. 3.

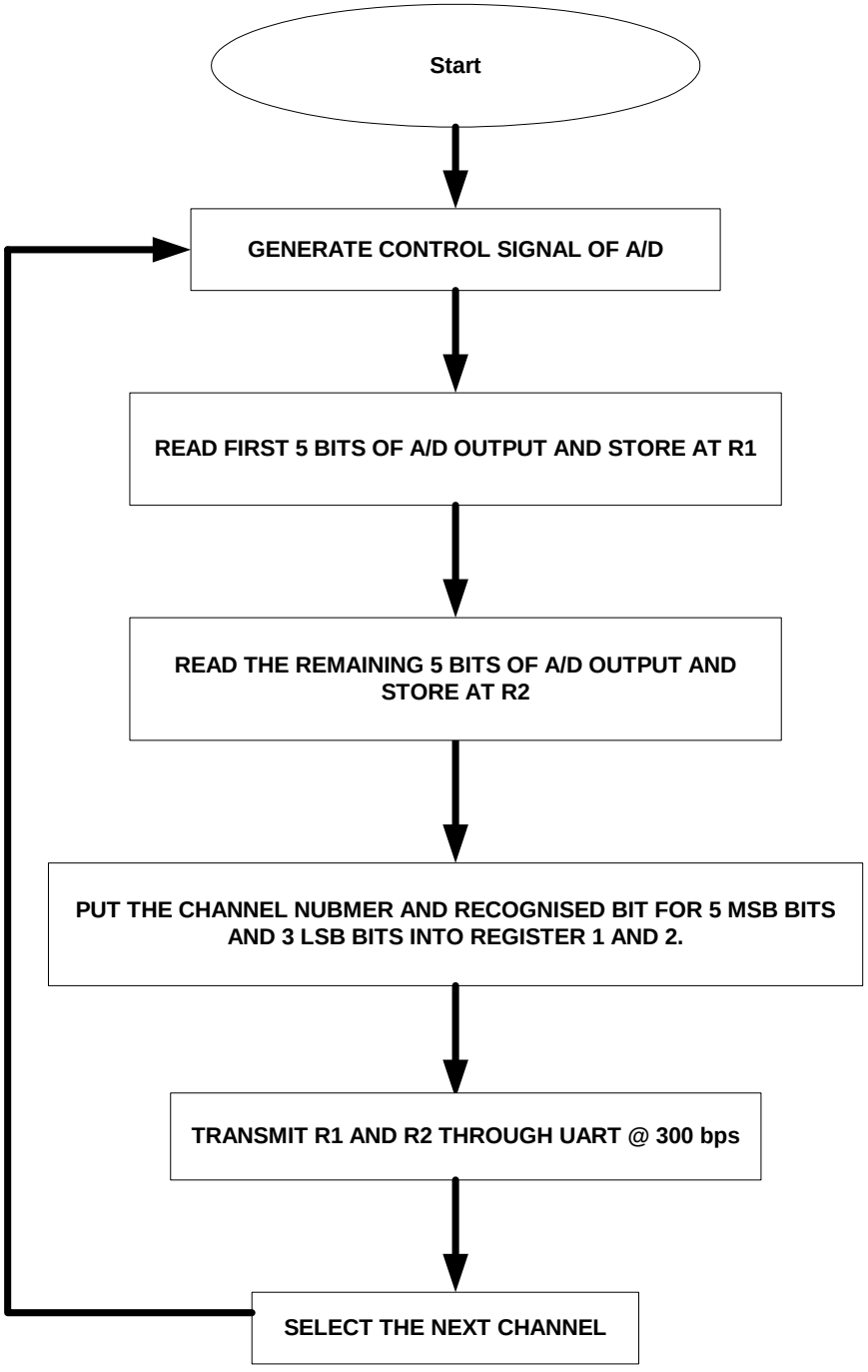

Fig. 3 Flow Chart

Output data steam of DS 87C520 micro-controller is then fed to a FSK(frequency shift keying) modulator. In this particular design, two frequencies of 1250 Hz and 625 Hz are being used for logic'1' and logic '0' respectively. The output of the FSK modulator is fed to the transmitter unit which has a center frequency of 401 MHz.

Finally the UHF receiver is used to receive the FM radiosonde signals. The frequency modulated carriers are demodulated to produce audio frequency signals.

3. Results and discussion

Ground level tests were conducted and the following results were obtained.

Parameter	Sensor Reading	Actual Value
Temperature (C^0)	26.2	26.7
Relative Humidity (%)	73	76
Pressure (mb)	1011	1009

Similar results were obtained in various tests. It clearly shows that the values obtained were acceptable in the ground level. Due to time limitation upper air test cold not carryout.

4. Conclusions

Radiosonde devices normally use analog type sensors, therefore their calibration procedure is bit complex. It is somewhat troublesome to get a PC graphical output because of its analog nature. This project fulfills that need. Modern I.C. based sensors are being used for the air born module. All on board processing is done by a 8051 compatible micro-controller. PC compatible data outputs are available for any graphical outputs.

5. References

1. Hood and Linsely J. : " The Art of Linear Electronics"; Butterworth Heinemann; 1993.
2. James M.R. : " Microcontroller Cookbook"; Mike James 1997.
3. Andrews M.: " Programming Microprocessor Interfaces for Control and Instrumentation; Prentice- Hall. Inc; Englewood Cliffs 1982.