A VERSATILE VHF TELEMETRY SYSTEM FOR TETHERSONDE

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ABSTRACT

The design of a low power VHF digital telemetry system for data transmission from multiple sensors, validated for tethersonde measurements is presented. It is designed around a miniature two stage crystal controlled narrowband frequency modulation (NBFM) transmitter module operating at 173 MHz. The sensor-data are digitized and transmitted as a serial bit-stream using FSK modulation. The telemetry receiver uses a narrowband single conversion superhetrodyne receiver module with a PC for data logging. The acquisition software does automatic channel identification and sequencing using a sync word that is transmitted along with the data and stores the data in a worksheet format for offline processing and analysis.

INTRODUCTION

Tethersondes are used very extensively for boundary layer measurements. Measurement parameters include the standard meteorological quantities of temperature, relative humidity, pressure, wind speed as well as wind direction and any other additional parameters of interest according to specific needs of particular soundings. For example, the Vaisala tethersode **TTS111** includes an ozone sensor to collect ozone data also in addition to the meteorological parameters, in the standard unit. It is normal for tethersondes to have provisions for making measurements at multiple height levels similar to a tower by keeping the balloon at a fixed height and attaching sensors at desired heights along the tetherline. Obviously, tethersondes need multi-channel data handling telemetry systems for real time transfer of the data from balloon to the ground receiver. These telemetries usually operate in the VHF or UHF bands with line of sight range of up to a few kilometers. Here we present the design of a multi-channel data telemetry system developed in house at the National Physical Laboratory (NPL) for tethered balloon experiments. This system operates at 173 MHz and features a simple low-cost design using readily available components.

SYSTEM DESIGN

A functional block diagram of the system is shown in Fig. 1. The data transmitter is designed to deal with signals that are in the range of 0 to 5V and from up to 14 different sensors by time multiplexing. The analog voltage outputs of the sensors are digitized using a 12 – bit serial out analog-to-digital converter (ADC, AD7893-5). The 16×1

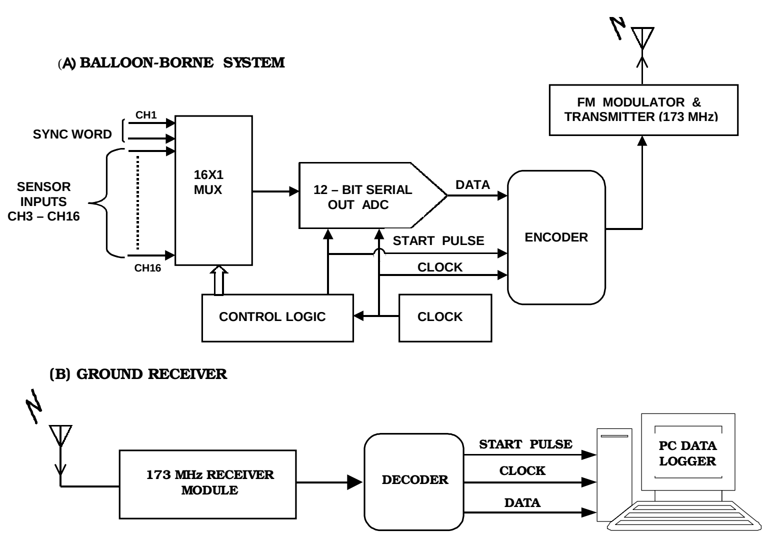

Fig.1. Functional block diagram of tethersonde telemetry system

multiplexer connects, one at a time, each of the signals to the ADC. Two channels of the multiplexer are reserved for transmitting a known signal (SYNC WORD), which will be used as a sort of control word for monitoring as well as channel identification purpose at the receiver end of the telemetry. The analog to digital conversion is initiated by a start pulse. The logic required to control and synchronize the multiplexing and ADC operation is generated by the Logic Control circuit. The clock period decides the data rate. Timing diagram of analog to digital conversion is depicted in Fig. 2. The ADC output for one conversion consists of 16 bits made up of four leading zeros followed by 12 bits of data corresponding to analog input voltage. The telemetry uses a low power frequency modulation (FM) transmitter, operating at 173 MHz (TX1-173), which works with digital signals using FSK modulation. It is an IC module from Radiometrix company UK, and consists of a two stage crystal controlled narrow-band FM transmitter. With 3V supply, it delivers nominally +10dBm rf output. The encoder converts the digitized serial data into two discrete frequencies, f_1 and f_2 determined by the 1's and 0's in the data and these frequencies then modulate the FM transmitter. The start pulse is also transmitted with the data (frequency f_3). The start pulse will be used in delimiting the data channels at the receiver end. Fig.3. depicts of the encoding process. This encoding of the data is done in synchronization with the clock and this arrangement enables easy recovery of the clock from the received data.

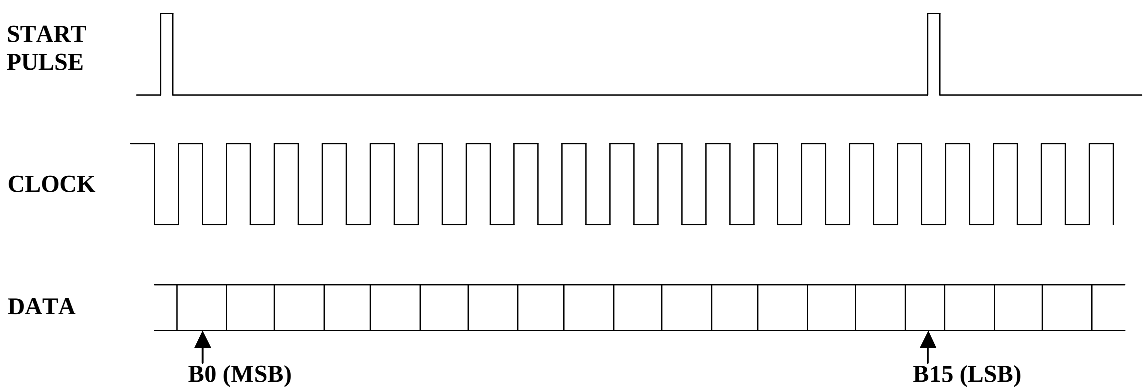

Fig.2. Timing diagram of analog to digital conversion

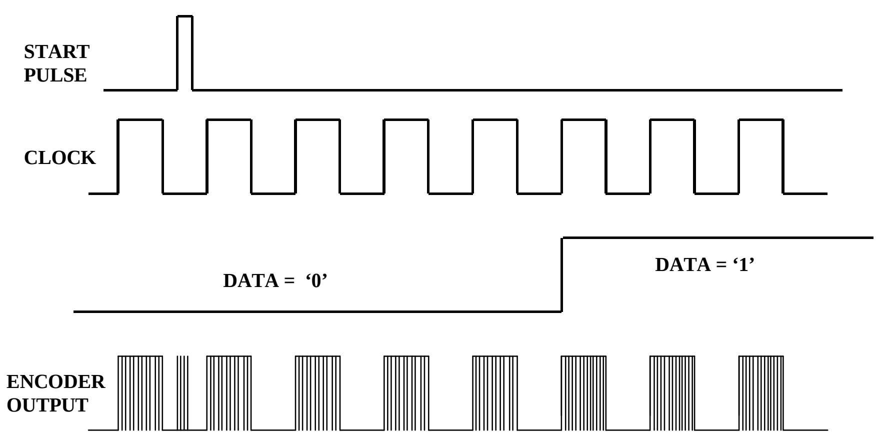

Fig.3. Schematic representation of encoding process

The data receiver in the ground setup is also an IC module, RX1-173, from Radiometrix corporation and, is the matching pair for the transmitter module. It consists of a single conversion narrowband FM superheterodyne receiver. The decoding of the receiver output to recover the data in its original form is carried out with tone decoders and logic circuits.

DATA ACQUISITION AND LOGGING

Data acquisition and logging is done on a PC through the printer port connection with out the need for add-on card. As mentioned above, the start pulse is used for channel delimiting. The acquisition software first detects the occurrence of the start pulse. Once the start pulse is asserted, program acquires the data of one channel after which it again looks for the start pulse and the process repeats. The timing of the data bits is determined by the clock signal. One data cycle consists of 16 channels of data. The basic data format is shown in Fig.4. At the beginning of a data cycle, the program will search for the two control words (the SYNC WORD) and only when these words are received properly the data of the next 14 channels will be written into a file on the computer hard disk.

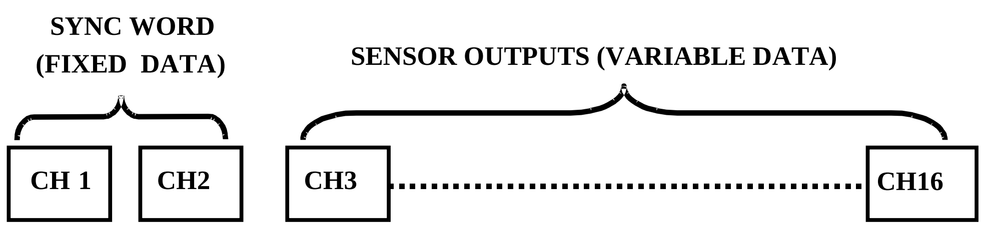

Fig.4. Sixteen channel data format

CONCLUDING REMARKS

The system described above has been used for tethersonde measurements quite successfully in NPL [1]. The air-borne unit operates from 9V battery. Line of sight range of a few kilometers is possible by using a quarter-wave whip antenna on the transmitter and a yagi antenna on the receiver. A metal ground plane extending all round the base of the whip is a good idea for increasing the transmitter range. Data rate can also be suitably adjusted to obtain maximum range.

REFERENCES

[1] Thomas John, S.C.Garg, H.K.Maini, D.S.Chaunal and V.S.Yadav, "Design of a simple low cost tethersonde data acquisition system for meteorological measurements," *Review of Scientific Instruments,* Vol.76, 084501, August 2005.