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Upgrading the Performance Features of the CBSS Indigenous Weather Station

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Abstract

This work presents an upgrade on the legacy version of the Centre for Basic Space Science (CBSS) indigenous Weather Station. The station is a microcontroller-based system that employed the use of sensor modules to acquire atmospheric, environmental and soil parameters values for scientific purpose. These data variables, station's coordinate and owner's informations are logged into an on-board Random Access Memory (RAM) in a Comma-Separated Value (CSV) format. The information is transmittable via radio telemetry setup to a handheld user-interactive communication console sub-system. In the event of components' failure, the system offers precise identification of these failed components for ease of troubleshooting and maintenance.

Keywords: Data, Indigenous, Legacy, Microcontroller, Weather station

1. Introduction

Weather station involves the gathering of instruments, such as thermometer, barometer, anemometer and others that could be used to acquire weather information, in the same equipment [1]. Weather stations have wide application areas in various fields of human endeavor [2, 3]. The Instrument is an indigenous weather station that was developed at the Instrumentation Division of Centre for Basic Space Science and Astronomy (CBSS) Nsukka, Enugu State [4]. CBSS is one of the space research facilities that are under National Space Research and Development Agency (NASRDA) of Nigeria. The station is a microcontroller-based system that reads physical quantities from array of sensors peripherals, processes the information, and writes the result to a Secured Data (SD) card for storage and future analysis. The station is a scalable project that was structured to go through variant phases of design. Each variant design presents improvement upgrade on the pre-existed version in accordance to the state-of-art interests and specifications.

This work, the second version presents key improvement features that addressed some of the design shortfalls that were recorded in the legacy version. The improved station bears close resemblance in functionality and operation with the legacy model except with few modifications to accommodate users' interests. The improvements are seen in the development of the station's schematic, payload structure, communication protocol, user interaction, packaging and installation among others. The CBSS indigenous station like most weather stations as stated in [5, 6], offers real-time measurement of environmental, atmospheric and soil parameter of the location of its deployment. Such parameters include ambient temperature and pressure, relative humidity, soil temperature and moisture condition, ultraviolet index and solar irradiance. These informations are stored in the on-board Random Access Memory (RAM) chip in a Comma-Separated Value (.CSV) format for future purposes. The station has an integrated clock chip and Global Positioning System (GPS) module that respectively stamp both the time of data collation and the coordinates of the station on the same data file. The station is designed with Radio Frequency (RF) telemetry feature for remote data transmission to a hand console. This feature is in-line with current trend in weather station designs [7]. Again, it was designed with cost effectiveness as also seen in some related works [8, 9, 10].

This work presents details of the improvement features that were built into the improved version of the CBSS indigenous weather station project.

2. Implementation

2.1 Design structure

The structure of station comprises of two design sub-systems: Mother station and Hand console. This is shown in Fig 1.

The Mother station comprised of three ATMEG328P-PU microcontrollers. This is a 28-pin microcontroller that handles arithmetic and logical functions for the station [11]. These microcontrollers are connected together in a bus line via I2C communication protocol [12, 13]. Array of sensors is interfaced with one of the microcontrollers. These sensors collate the physical parameters information from the field and output their respective readings to the microcontroller in the form of electrical signal. This microcontroller makes this information available to other microcontrollers through the bus line. The second microcontroller is charged with the storage of these sensor readings with the time stamp into an on-board memory location in a .CSV format for future purposes. The third microcontroller is responsible for the information transmission via an RF communication link to the Hand console for user interaction. The mother station is powered by 18V 10W solar panel with 6V duty cycle rechargeable battery energy backup.

The Hand console comprised of two ATMEG328p-PU microcontrollers that are also connected together via the I2C bus line. Again, one of the controllers handles the RF link communication with the mother station. The RF link communication between the Mother station and the Hand console was achieved with NRF2401 wireless transceiver modules [14]. The second microcontroller writes the data to a 20*4 LCD screen and also handles user interaction via pushbuttons. A rechargeable 3.85V 5000mAh LiPo battery powers the hand console. This energy was processed to provide the required 5V for the Hand console sub-part.

The coordination of these microcontrollers with the peripherals was written in Arduino programming language.

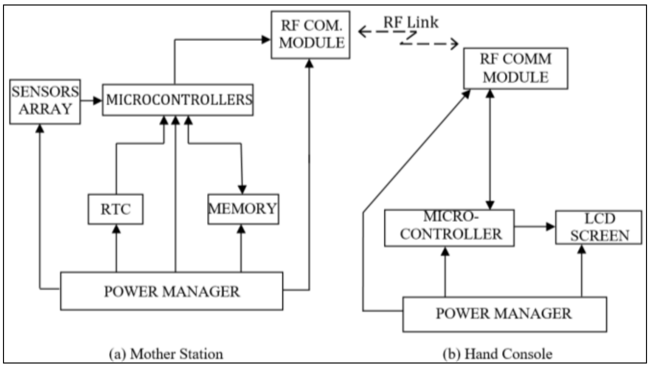

Fig 1: Operational Block diagram of improved weather station

2.2 Design model

Fig 2 shows the schematic model of the mother station with some of the peripheral modules and sensors in a Computer - Aided Design (CAD) application software environment. Fig 3 shows the pictorial view of the station, which is currently deployed and operational at the Centre for Basic Space Science and Astronomy (CBSS), Nsukka in Enugu State Nigeria.

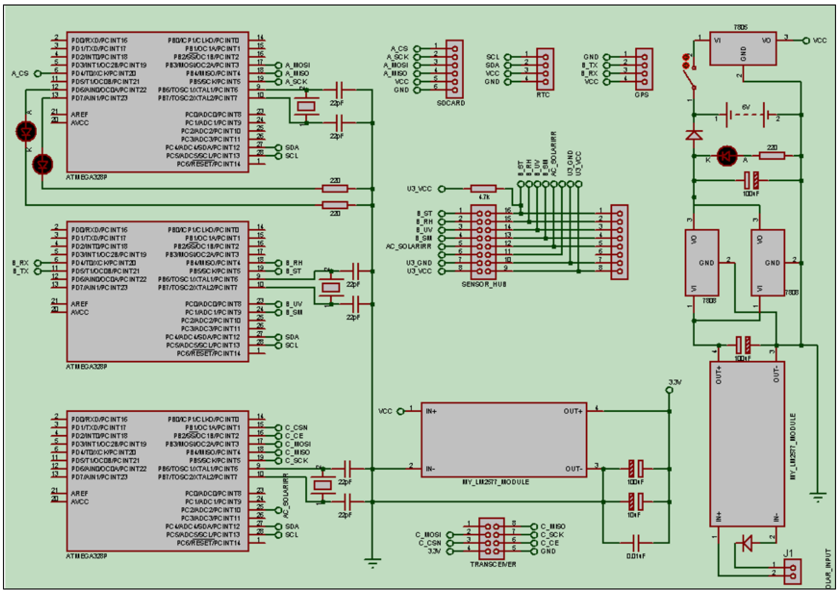

Fig 2: Improved Station Schematic Design model

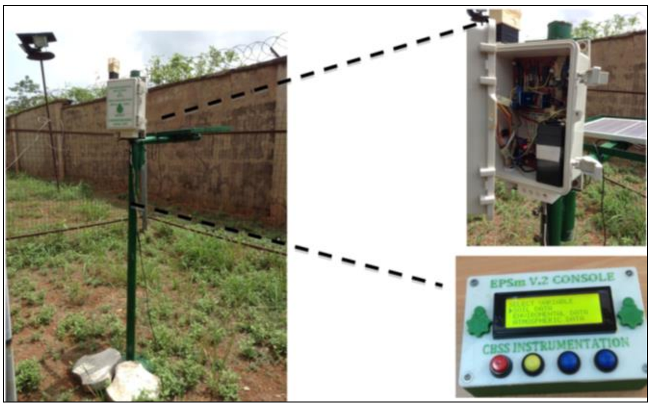

Fig 3: The Improved Weather Station

3. Performance result

This variant, like the legacy version, was again validated using data from Campbell Scientific Automatic Meteorological instrument, the Nigeria Environmental Climatic and Observing Program (NECOP) Station at the CBSS [15]. Fig 4 presents one-day performance result of few of the featured parameters.

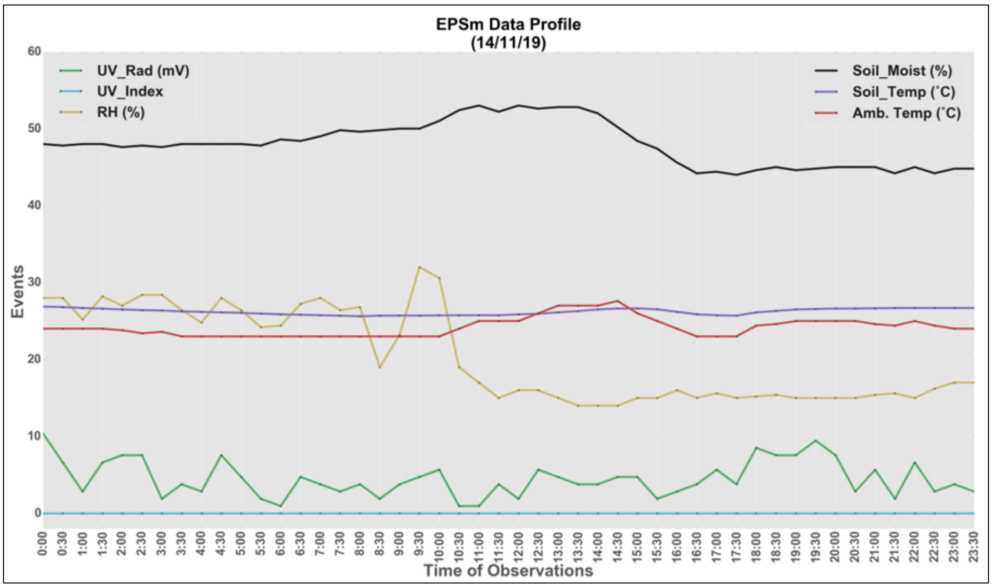

Fig 4: Performance plot

Observation shows that this variant presents better optimization response in terms of data reliability and performance monitoring. In the event of component failure, the integrated telemetry feature avails an administrator to quickly spot aberration in the information data. This anomaly could simply be shown on the interactive hand console. Such information could be of great guide for maintenance and troubleshooting.

Again, this variant presents better design outlook and simple outdoor mount structure than the previous version.

4. Conclusion

The CBSS Indigenous Weather Station is a scalable project that was designed to go through variants of improvement developmental stages. This work presented the second variant of this project that meets its design improvement specifications. The integrated improvement features that were built into this variant offered not just better outlook, user interaction, added payload and RF communication; it also opened new possibility of integrating Application Programming Interface (API) that would allow users to login to the station and access real-time data seamlessly for their scientific purposes. Again, subsequent versions would likely feature cloud-based data storage that would further promote data availability to wider research community.

5. Acknowledgements

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6. Data Availability

Data used could be shared upon request.

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