Design of Adaptive Weather Station with Reduced Power Consumption

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Abstract – **This paper describes the initial design of an adaptive weather station. The device relays on an ultra-low power micro architecture, adaptive power distribution mechanism, small form factor, and GPS receiver for time synchronization. The device is dynamically reconfigurable for working in high performance, real time transfer mode with direct operator control; and ultra-low power, fully autonomous, self-monitoring, long-term measurement mode. For convenience the collected data of the environment parameters will be initially analyzed and visualized by specialized software.**

Keywords – **Weather Station, Ultra-Low Power Management, Self-Monitoring, Dynamically Reconfigurable, GPS synchronized, Global Warming**

I. INTRODUCTION

Weather stations are facilities, with instruments and equipment for measuring atmospheric conditions to provide information for weather forecasts and to study the weather and climate.

For studying the climate changes is necessary to analyze the data from long-term measurements of the environment parameters (like temperature, barometric pressure, humidity, etc.). In correspondence with the requirements of the World Meteorological Organization [1], those measurements are done three times a day, with respect of the Sun position per each whether station. The data from the daily measurements are then logged in sets of different time frames (3 months, 6 months, year, etc.) and analyzed to define the tendencies in the climate changes.

The weather stations are often conveniently located in easily accessible locations, and the data could be collected daily. But sometimes scientific interests are remote regions without sustainable access (unattended areas). In this case, it is necessary to use a sophisticated apparatus capable of self-configuring, data logging and performance control, taking into account their power distribution and working conditions of the respective area.

For a number of activities (aviation, shipping, scientific

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research, etc.) measurements are focused on current weather conditions. In this case is used equipment allowing monitoring of environmental parameters in real time - measurements are done continuously, as a suitable interface is provided for communication with the user. Data from these measurements can be used as reference in order to take into account possible errors in the further processing of data from other measurements taken in parallel or used as input for other systems.

With records since latest 50s of last century showing rise in average temperature of the atmosphere and ocean on Earth, and the predictions for the possible consequences if these trends in climate change preserve, more attention is paid to strict measurement of environment parameters, globally and continuously. But the ground control stations designed for this purpose are often too expensive and highly power consuming to be installed permanently in remote areas. Therefore reporting of climate change on these sites often rely on satellite measurements - primary temperature. However this measurements are not directly comparable to the quoted above, since it is a skin temperature deduced from satellite-measured upwelling radiance, rather than a thermometer-measured temperature of the air 1.5 m above the ground surface.

In order to support a research of Bulgarian Antarctic Expedition was requested to provide systems for environment control in two different bases - measuring environmental parameters in real time as an aid to perform parallel measurements; and securing long term environment measurements in order to log statistical information on climate change during the winter season. These conditions make two contradictory system requirements - first, ensure monitoring of a wide range of parameters, where the high performance of the system is priority; and second - long-term measurements, where the total power consumption should be as low as possible. Last one requires great reduction of the parameter count and data logging rate, which are a priority for the first one. The optimal solution is to create an adaptive compact system, that ensures all the necessary measurements to support experiments performed in real-time and able to autonomously provide series long-term measurements, by dynamically reconfiguring its working rate.

II. BASIC DESIGN

A. Requirements and Block Diagram

Key factors affecting the development of the system, with the specified requirements, are the working conditions
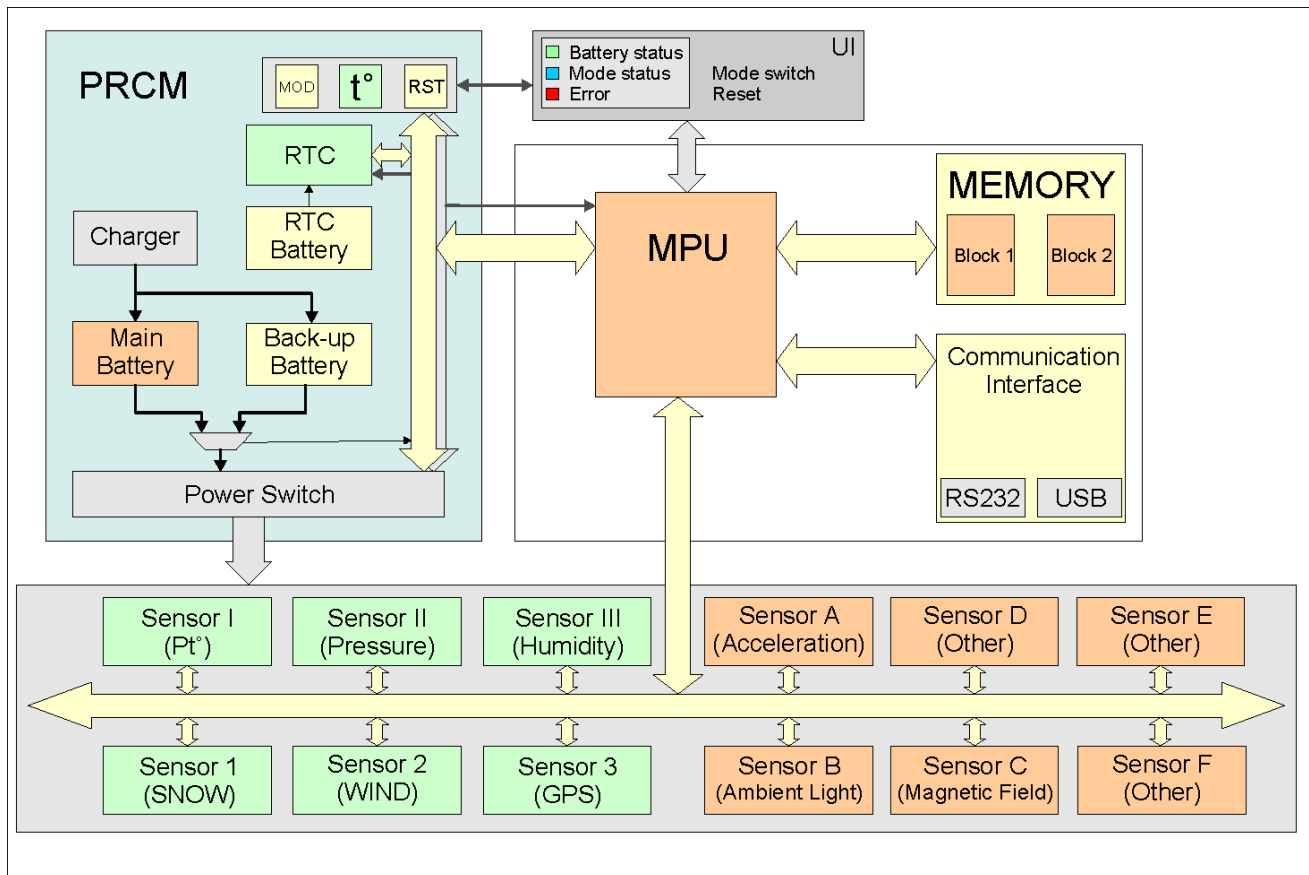
Fig. 1. Block diagram

under which the system operates, power consumption, autonomy and cooperativeness.

The weather station is developed on the base of three main subsystems:

- *Power, Reset, and Clock Manager (PRCM)*
- *Control Subsystem*
- *Sensor Subsystem*

Figure 1 is the conceptual block diagram of the weather station.

A special feature is the combination of high power consumption real-time monitoring system of environmental parameters and minimum power consumption requirements for long-term measurements. For this purpose was developed a specialized power control system (PRCM) that could isolate from the power source all unnecessary subsystems, for the duration of their passive states, and switch them on again when necessary. Management is fully electronic, as the specifics of the working conditions do not allow use of mechanical switches or moving parts.

B. Power, Reset, and Clock Manager

Power, Reset, and Clock Manager includes main and reserve batteries, interface insulator, as well as specialized charger.

Most weather stations for long-term measurements in unattended areas are equipped with various independent power sources - solar panels, wind or water turbines. These sources, however, are practically irrelevant in terms of the

polar winter, so the system is designed to use only battery power.

The role of the charger is to provide power to the system in real-time modes and recharging batteries in serviceable stage of the device operation.

It also provides data for battery status to the control system on the base of which the latter may decide to limit the consumption during the period of unattended operation. This can be achieved by the exclusion of certain low-priority sensors.

C. Control Subsystem

The control subsystem is based on a microcontroller and includes a user interface for direct work with the system, interfaces for data transfer with other systems, real-time clock, an additional external watch-dog subsystem, and a data memory.

System management is executed by embedded software, including algorithms for determining the operating modes of the system (autonomous control or subordinate work), powering the sensors, synchronization, error detection, analysis and reconfiguration of the operating modes, the data logging and transmission.

The Device has two command interfaces - RS232 and USB.

RS232 is the system service interface designed for setup and connection with other autonomous systems. This allows the station to be integrated as a module in a larger system, and actively exchange data with it.

USB interface is designed for direct transmission of data to the computer systems, so the operator can monitor real-time measurements.

Real time clock and the additional watch-dog subsystem, though defined as control devices, in fact belong to the PRCM, as they ensure the continuous operation of the station. RTC also provides time stamp required for the synchronization of the measured parameters with a global database.

D. Sensor Subsystem

The sensor subsystem contains all the necessary sensors and peripherals required for the operation of the station. Sensors are prioritized and divided into 3 main groups.

The first group contains the basic sensors for the station - temperature sensors, sensor for pressure and temperature compensated humidity sensor.

The sensors for measuring the temperature of the system are two. The main sensor is built from platinum RTD (Pt100) type B. It is connected by a three-wire circuit to the instrumental amplifier INA827 [2] with offset correction. Analog to Digital conversation is performed by 12-bit ADC ADS7828 [3]. Figure 2 shows connection schematic.
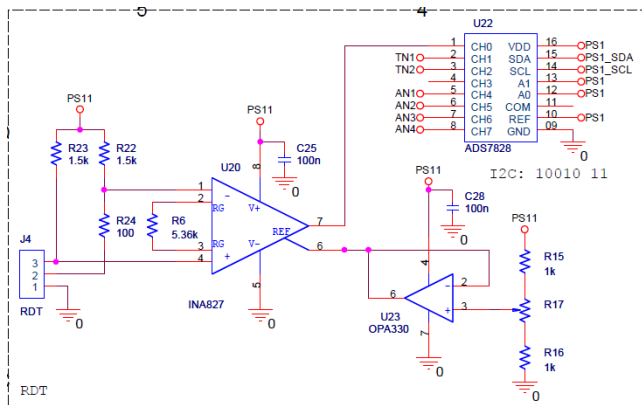

Fig. 2. Primary temperature sensor

In compliance with the requirements of the World Meteorological Organization temperature measurements are made at 1.5 meters above the ground [1].

There is an additional temperature sensor of semiconductor type (TMP112 [4]), whose role is to monitor the internal temperature of the system in the quartz resonator of real-time clock.

The humidity measurement is based on intelligent sensor with internal temperature compensation and a full range relative humidity - HDC1008 [5].

Measurement of barometric pressure is provided by other intelligent sensor - BMP085 [6].

The second group of sensors are used for the purposes of the research. It includes an accelerometer, a light sensor, and a magnetic field sensor.

The third group of sensors are low-priority and high consuming additional and synchronizing systems - GPS, wind sensor and sensor for thickness of the snow cover.

The GPS subsystem is provided as synchronization module for time adjustment. GPS as well as Anemometric module are intended to operate primary in serviceable period with available power supply, as their power consumption is very high.

Sensor module for reporting the snow cover thickness is designed to work during unattended period of the system. Therefore, it is planned to provide data once a day and to work in very short interval of time. If a shortage of energy resources appears - use can be further reduced by the system.

The sensor subsystem includes three expansion interface for adding additional sensor modules. The interfaces are equipped with controllable power supply, two analog inputs, a digital interface for transmission of data and two digital ports with general purpose.

III. PC Application

A specialized computer application is designed to provide easy control over the station during the real-time operation, and easily retrieve data collected during long-term measurements.

Figure 3 presents the summary diagram of computer application for working with the station.
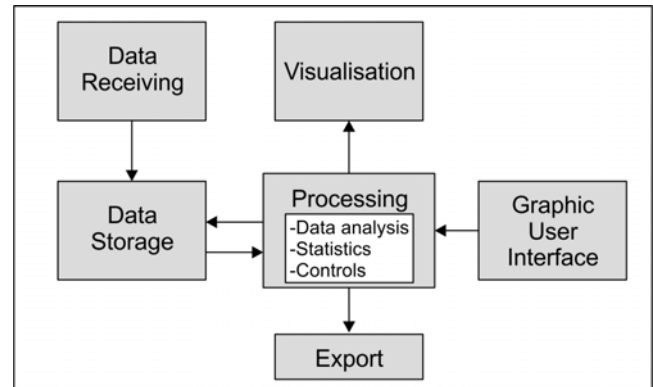

Fig. 3. Block diagram of the PC application

The application enables direct recording and storing data obtained during real-time operation of the station. It can be processed immediately and visualized on the display for direct monitoring and / or exported as a file for further analysis.

The user interface allows to set various parameters – configuring the work of the station and the application itself.

IV. Conclusion

Ground-based weather stations are among the most important tools for monitoring climate change and the impact that these changes have on the environment. Of great importance is the collection of as larger amounts of data from all over the world. The main problems in the construction of such a network of ground-based instruments is the size and cost of the stations, and their use is additionally limited by the specific function they are initially designed for.

Building a cheap and adaptive compact stations could significantly ease the process of collecting data in remote areas, and at the same time offers the possibility to use them as reference tools in other studies.

ACKNOWLEDGEMENT

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