Design and Implementation of a Ground Based Microwave Radiometer

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Abstract

We have built a low-cost microwave radiometer operating at Ka band (18~22GHz) at the ESSIC/CISESS Remote Sensing Lab for the purpose of student education and training. It can also be used as a ground observation instrument for in-situ experiments to support the JPSS program. The instrument can be operated under two different detection modes: total power and Dicke-type detection. All key components, such as the low noise amplifier, Low Noise Downconverting Block (LNB), band pass filter, antenna feed are purchased from the domestic commercial market. The components are then tested and assembled in our Lab. The cumulative cost to produce the instrument is under five thousand dollars.

The instrument is built based on the self-designed digital back-end processing module. A microcontroller is used to generate a PWM signal to control the Dicky switch, the signals then are processed with AC coupling, AC/DC amplification, demodulation, and finally being digitized through ADC processing available to the ATMEL ATMEGA 328p microcontroller through the on-board ADC register. The RF module of the instrument is very sensitive to the variation of temperature, and a temperature control system consisting of a temperature sensor and cooling fan is needed to keep the instrument in the required ambient temperature range. Another important function of the back-end processing module is data collection and transfer.

In order to process the multiple tasks required by this microprocessor, the on-board timer registers are used to control the timing and priority of each task, higher priority tasks include reading and storing data coming across the ADC line, and will interrupt lower priority tasks during the running of the main loop of the code. Lower priority tasks include the sampling of the temperature sensor, as well as updating the device's built-in liquid crystal display. Testing results during the field campaign show that the system works well and the design can be applied to future prototypes.

In our next steps of development, we will compress our existing electronics module to a single PCB, in order to save enclosure space and take further steps to optimize internal heat flow. Additionally, we have designed support for autonomous data acquisition, in the form of the feed horn being driven by a stepper motor to automatically perform sky sweeps and collect brightness temperature data. Early tests on the motor system have been successful, and we have decided to move forward with this design. In terms of range of use, we would also like to extend the device's capability by adding polarizations for lower frequencies.