Implementation of Computer and Telemetry Subsystems Link, on a Nano-Satellite System

Marlenne Angulo, Marco A. Turrubiartes.

Abstract—**This paper presents a telemetry subsystem of a nano-satellite. It is based on ADF7020 development kit for modulation and AT91SAM3U4-EK as on-board computer. The presented prototype could be used for educational purposes, considering Cubesat standard.**

Index Terms—**Nano-satellites, telemetry subsystem**

I. INTRODUCTION

SATELLITE systems have been widely used; however, development time and cost are significant issues on GEO satellite systems. Nano-satellites are low cost, small payload delivery systems [1].

Currently, Cubesat is a nano-satellite system standard, where a nano-satellite has structure, power, telemetry, payload among other subsystems, however, it fits up to 1.3 kilograms and 10cmx10cmx10cm modules [2].

Tracking, telemetry and command subsystem receives information from satellite sensors and feedbacks satellite's status to earth station [3]. When a satellite is within an earth station's line of sight, it is able to process telemetry information. Satellite communication is based on earth station to satellite link (uplink), and satellite to earth station link (downlink). Earth station is capable to manage up as well as down links, see figure 1.
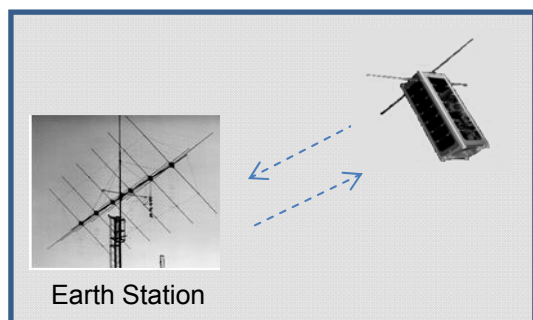

Fig. 1. Satellite communication framework

The Proposed telemetry system used VHF band for downlink and UHF for uplink. This proposal allows tracking and telemetry without much effort even when the satellite is not well stabilized or on-line towards Earth, the advantage is the wide opening angle of the radiation pattern of UHF/VHF antennas.

The telemetry system by its nature, can use various digital modulation schemes, considering that the more complex the scheme it requires more transmission power to maintain the signal to noise ratio required by the receiver subsystem [4].

II. RELATED WORK

Nano-satellites by definition present flexibility in design; in recent years there are several proposals on how to implement the subsystems. About payload applications are as varied as the use of imaging instruments and transmission as in [5] where Panetta et al., propose a nano-satellite constellation whose function (payload) is a remote/ in-situ measurement in space.

Bathi et al [6], proposes FHSS radio transceiver with AX.25 encoding telemetry. In this work several digital modulation schemes are tested in the laboratory, considering that modulation systems with low rate of bps/Hz are sufficient because the speed of transmission of telemetry and command system is set to 200kbps.

III. IMPLEMENTATION

The focus of this paper is the space segment, specifically the link between telemetry & command (TT&C) subsystem and on-board computer subsystem. In this project telemetry subsystem is implemented by transceiver ADF7020-1, in the PCB ADF 702X and the PIC16F87 which is used to program the PCB. Figure 2 shows the TT&C prototype.
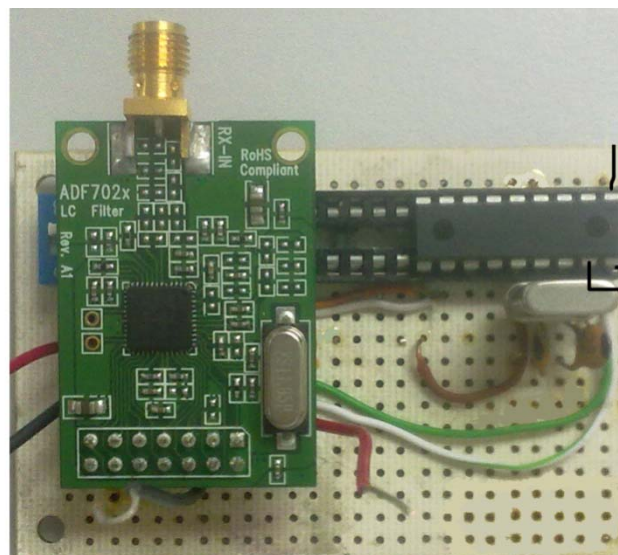

Fig. 2. Telemetry and Tracking subsystem

On-board computer functions are completed by AT91SAM3U4-EK development kit [7], figure 3.
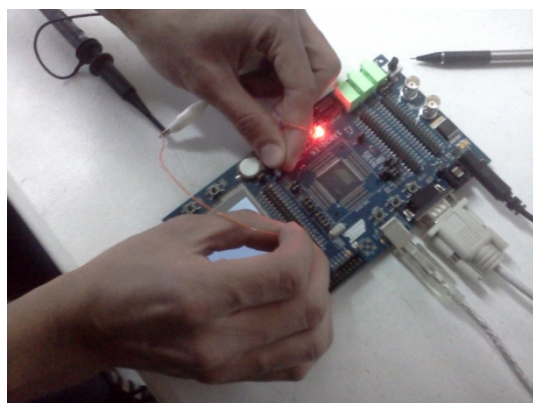

Fig. 3. AT91SAM3U4-EK

PROGRAM UPLOAD

In order to upload the program to the evaluation kit, the PC sends the configuration to AT91SAM3U4-EK through serial connection.

SAM3U also sends information to the PC that can be detected through a terminal, for example, in Microsoft Windows this terminal is called "HyperTerminal" which is included among the accessories of communication. The required configuration is as follows:

- 115200 bauds.
- 8 data bits.
- No parity.
- 1 stop bit.
- No flow control.

Start the terminal, and then reset the micro controller and waits until the terminal displays the following message:
-- Basic Touchscreen Project xxx --
-- AT91xxxxxx-xx
-- Compiled: xxx xx xxxx xx:xx:xx --
-- Calibration successful!

TOUCH SCREEN INTERFACE

On the touch screen the user has access to three buttons, every button contains a code to respond to human touch and each one is assigned a different function: transmit, receive and end the program, figure 4.

We used a project called "basic-touchscreen-project" found in the microcontroller's software to make a user interface for the microcontroller. This project was modified to create a screen with the three buttons referenced above.
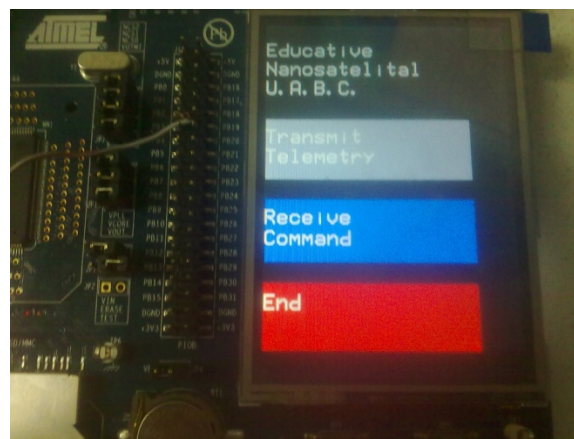

Fig. 4. Main Interface of Touch Screen

The touch screen presents some buttons to select the required operations by the user. The touch screen program follows the flow chart depicted by figure 5.
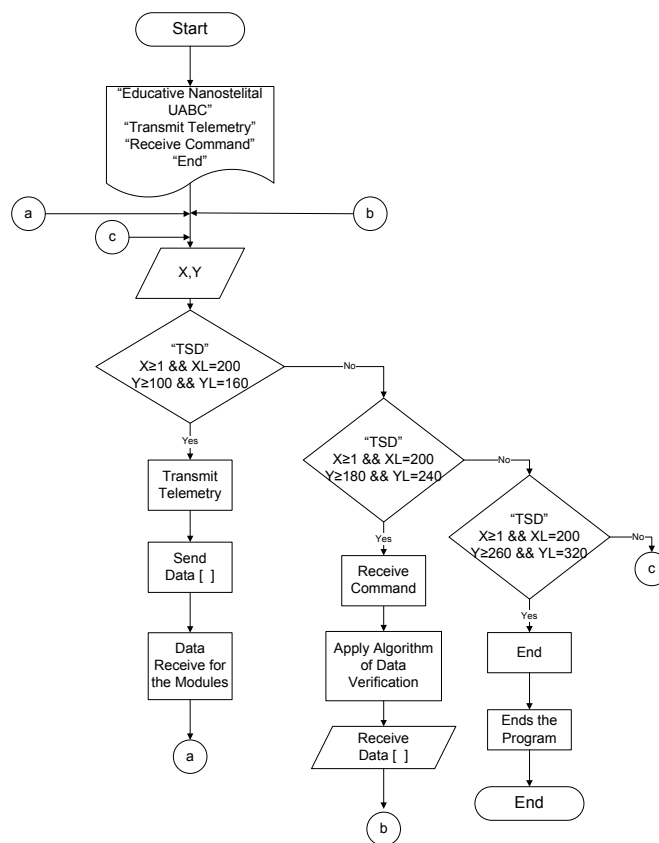

Fig. 5. Flow Chart of the Touch Screen program

Integrating analog to digital converter and user interface

In this work it is used the IAR software Workbench development environment to generate the microcontroller code. The software developed in this work includes the library of the analog to digital converter and the code related to the touch screen. Interface has been modified for proper operation and full integration with the converter.

The analog to digital converter and the touch screen algorithm originally are separated programs. Finally this work presents one program to handle both peripherals. So, when you start the program in the microcontroller AT91SAM3U4-EK, the touch screen displays a menu configuration of the analog to digital converter. Simultaneously Windows HyperTerminal program presents the configuration of the menu, figure .

IV. RESULTS AND CONCLUSIONS

In order to run the above mentioned program it must be calibrated the touch screen by clicking arbitrary points. The hyper-terminal displays messages such as the following:

- Pen moved at   (106, 222)
- Pen released at (106, 222)
- Pen pressed at (123, 249)
- Pen moved at   (113, 247)

Analog to Digital Converter

The test bed of analog to digital converter uses a 1.7 volts connected to the main board PB3 pin. Then the microcontroller converts the analog to digital signal, process it and sends the information to Windows HyperTerminal.

The user selects on HyperTerminal menu the channel associated to the used ADC pin. In this case a 1.7volt on pin PB3 is related to channel, figure 6. Then the user exits the menu of the analog to digital converter and linked with the touch screen, figure 7.
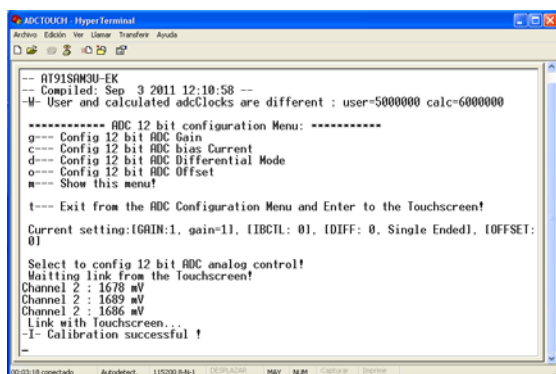

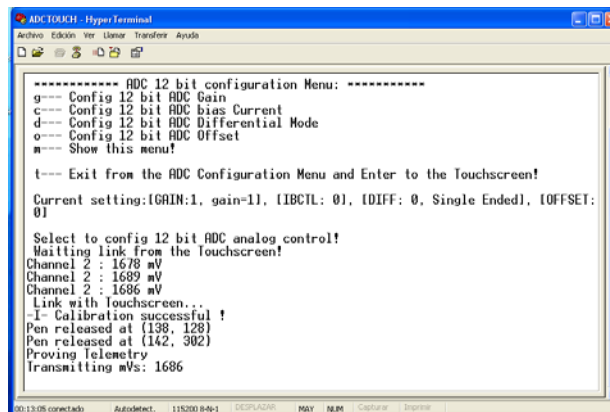Fig. 6. Windows HyperTerminal receiving data of channel two

Fig. 7. Windows HyperTerminal receiving telemetry data from the Transmit command to touch screen

In order to probe the noise induced by other subsystems the test bed is set up into a *Faraday cage* were the results from analog to digital converter are 8mV as shows figure 8.
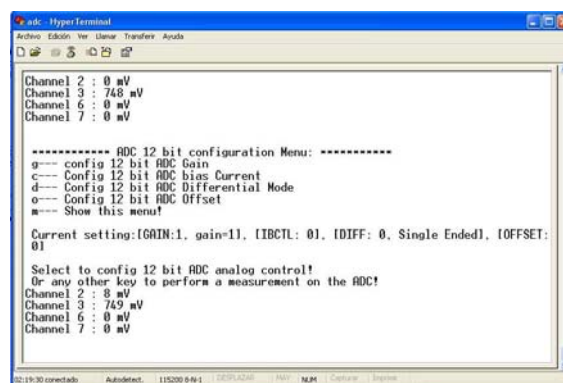

Fig. 8. Windows HyperTerminal register 8mV noise

Telemetry Transmit button activates transmitting the information to the HyperTerminal program, where the last conversion is continuously displayed by the touch screen, figure 9.

Fig. 9. Displaying measured voltage on touch screen

V. CONCLUDING REMARKS

This paper analyzes the link between on board-computer and telemetry tracking and command (TTC) subsystems.

We conclude that the use of AT91SAM3U4-EK and ADF7020 as on board computer and TTC respectively, fulfills the requirements of nanosatellite specification concerning to power consumption and mass dimensions. The evaluation focuses on QAM and less complex digital modulation schemes. Further work is to analyze the behavior of this link for higher bps/Hz rates modulations schemes.

REFERENCES

[1] NASA, Early stage innovation. Available: http://www.nasa.gov/offices/oct/early_stage_innovation/centennial_challenges/nano_satellite/index.html

[2] Cubesat Design Specification, Rev 12. California State Polytechnic University. Available: http://www.cubesat.org/images/developers/cds_rev12.pdf

[3] G. Maral, M. Bousquet, "Satellite communications systems: Systems, Techniques and Technology", Ed. John Wiley &Sons, 2002.

[4] B. P. Lathi, "Modern Digital and Analog Communication systems", Ed. Oxford University press, 1998.

[5] Panetta et. al., "NASA/GSFC Nano-satellite technology development", NASA-GSFC, Geenbelt, Maryland.

[6] B.S. RANI, "On board communication subsystem for Sathyabama University nano-satellite", proceedings of Recent Advances in Space Technology Services and Climate Change (RSTSCC), 2010

[7] AT91SAM3U4-EK development kit. Available: http://atmel.com/dyn/resources/prod_documents/doc11020.pdf

[8] ADF 7020 development board, EVALADF7020-XDBX, http://www.analog.com/Analog_Root/static/techSupport/designTools/evaluationBoards/downloads/ADF7020-XDBX_Tech_Note_PrC.pdf