A Low-Cost High-Performance Embedded Platform for Accelerator Controls

Stefano Cleva, Alessio Igor Bogani, Lorenzo Pivetta,
Elettra-Sincrotrone Trieste, Trieste, Italy

Abstract

Over the last years the mobile and hand-held device market has seen a dramatic performance improvement of the microprocessors employed for these systems. As an interesting side effect, this brings the opportunity of adopting these microprocessors to build small low-cost embedded boards, featuring lots of processing power and input/output capabilities. Moreover, being capable of running a full featured operating system such as GNU/Linux, and even a control system toolkit such as Tango, these boards can also be used in control systems as front-end or embedded computers. In order to evaluate the feasibility of this idea, an activity has started at Elettra to select, evaluate and validate a commercial embedded device able to guarantee production grade reliability, competitive costs and an open source platform. The preliminary results of this work are presented.

Accelerator control systems requirements

The capabilities of commercial-off-the-shelf (COTS) hand-held oriented system-on-chip (SOC) devices allow nowadays to fulfil the requirements of modern accelerators control systems:

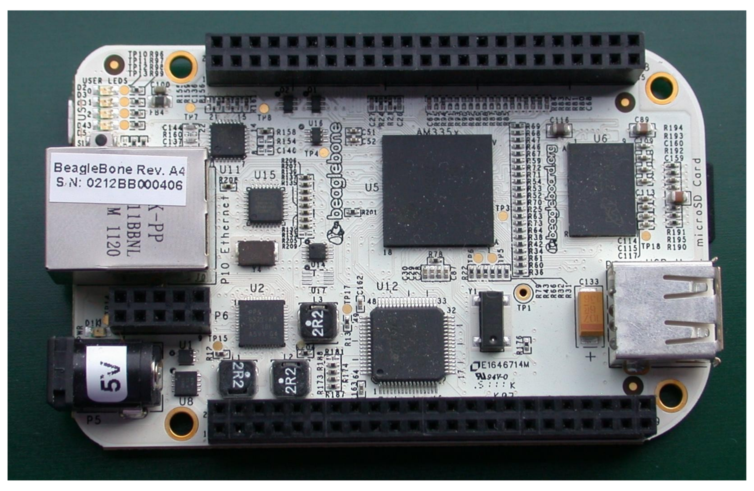
- distributed architecture;
- a large set of Input Output (I/O) subsystems (GPIO, SPI, UART, PWM, …);
- remote control/communication interfaces;
- multiple communication protocols (UDP, TCP/IP, fieldbus based);
- full Operating System (OS) support, with multitasking, multi-user, real-time capabilities;
- hardware, software and documentation support;
- long term commercial availability and support;
- flexibility and modularity to cover a wide range of different fields of application;
- competitive cost-performance ratio;
- competitive development and maintenance costs;
- deterministic (real-time) capabilities.

After a first phase dedicated to market survey and a second phase dedicated to some preliminary tests, the BeagleBone has been chosen.

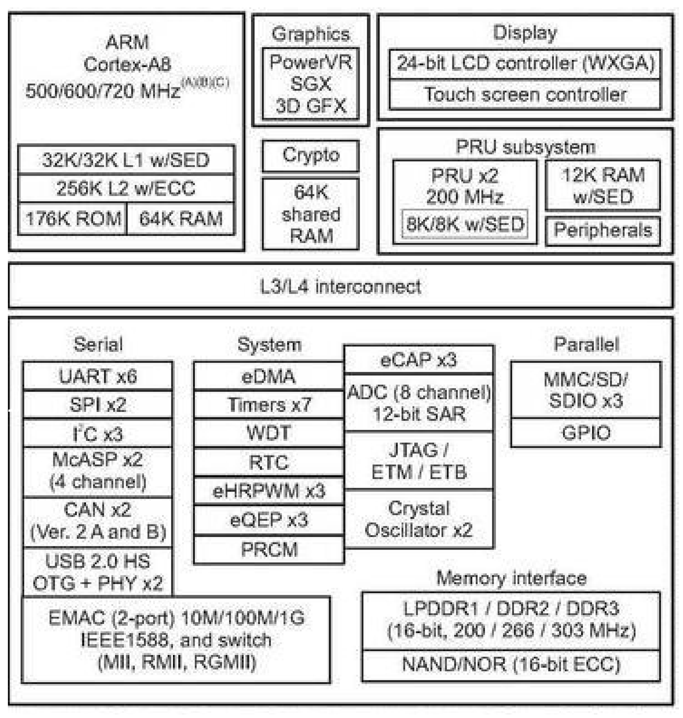
The BeagleBone board

Based on the Texas Instrument AM3359 SOC, the board's key features are:

- compact form factor;
- robust, accessible expansion connectors;
- large number of I/O pins;
- enough computational power (ARM Cortex-A8 main core up to 720 MHz);
- deterministic execution hardware support by means of a dedicated processing unit (PRUSS);
- 256 MB RAM and microSD card slot:
- native Ethernet interface;
- open source approach;
- board support packages (BSP) for Linux and Android;
- large community of developers and users.



BeagleBone board

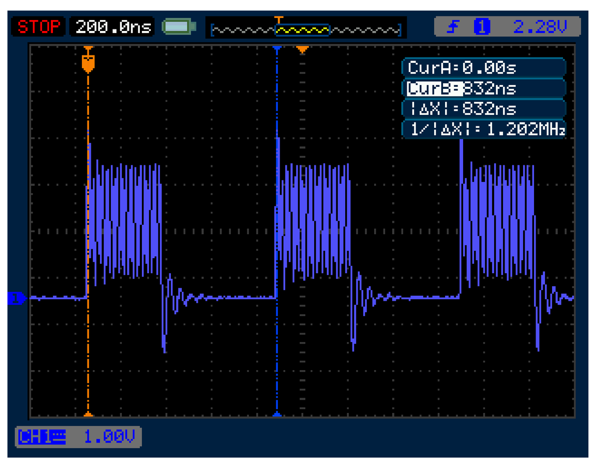


AM3359 architecture

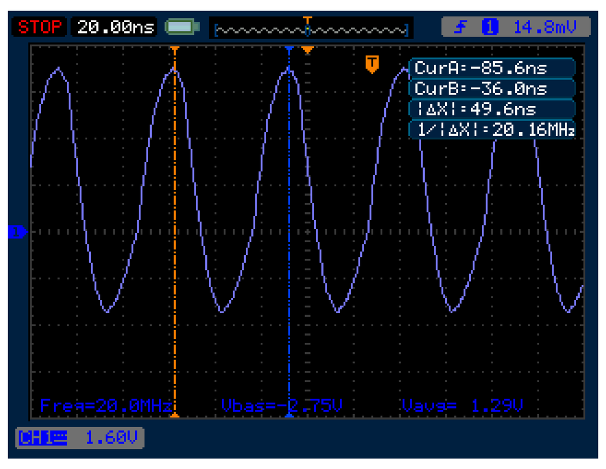
The BeagleBone evaluation

The board evaluation has been split in phases:

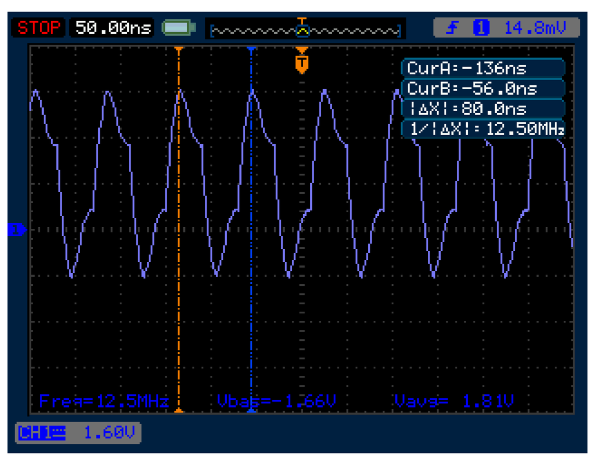
- development environment tests (native and cross toolchain) on a Ubuntu demo;
- porting of OmniORB, Tango and Tango based device servers;
- Linux kernel and platform BSP patching;
- PRUSS code development and performances evaluation;
- long term test of the SPI driven by UDP packets.



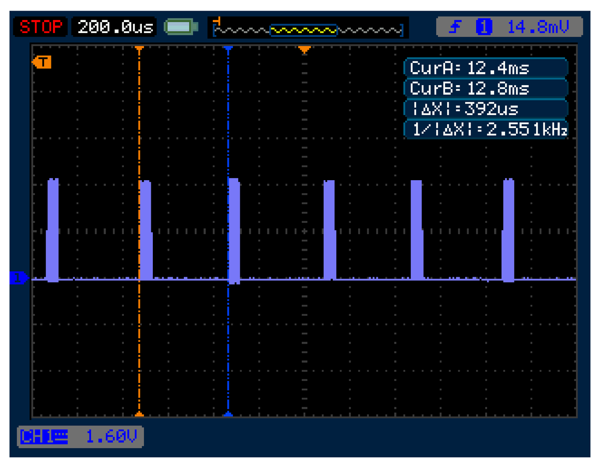
PRUSS driven SPI burst



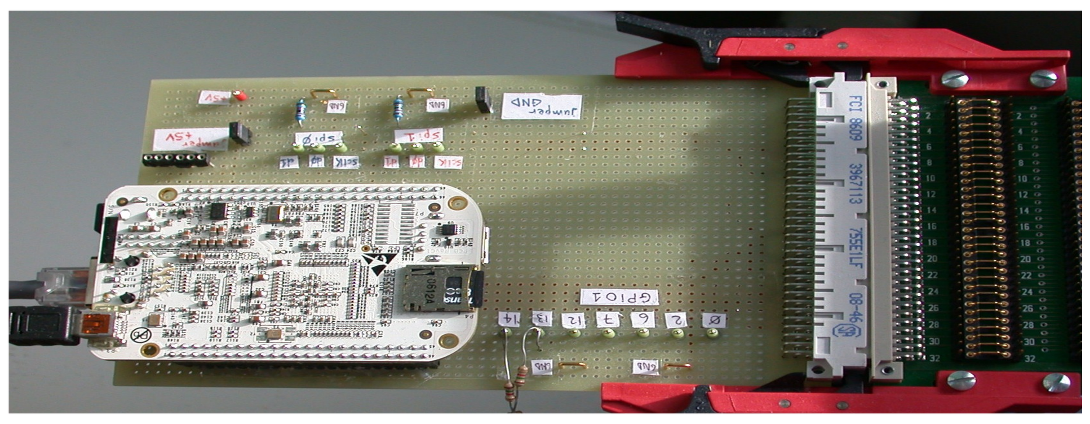
PRUSS driven GPIO toggle



Indirect PRUSS driven GPIO toggle



Userland driven SPI burst

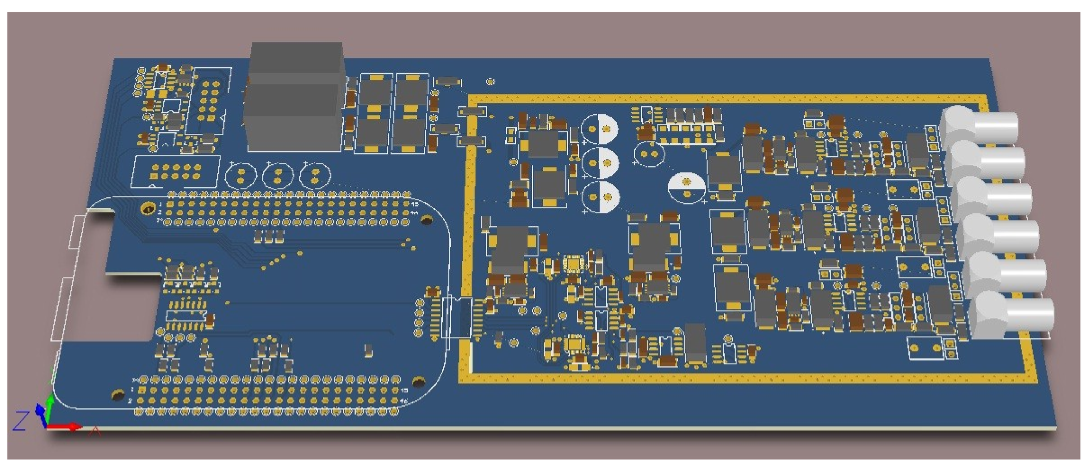


SPI, UART , GPIO long term test evaluation board

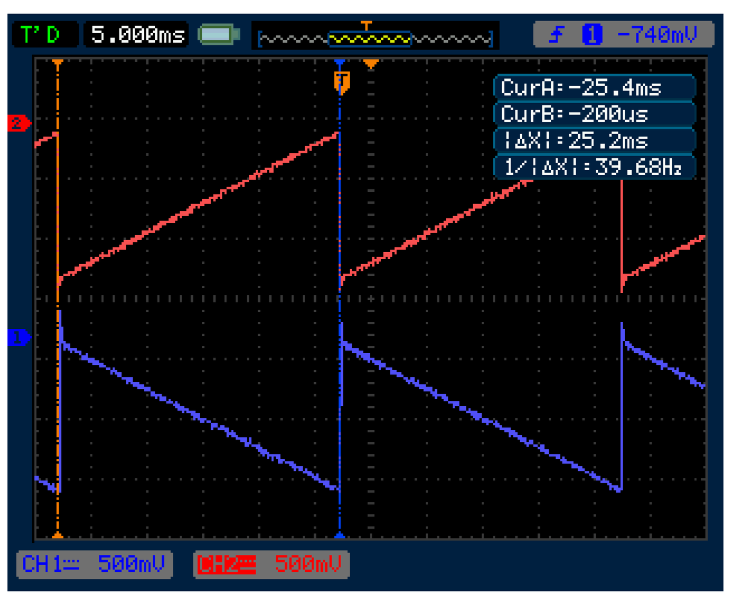
The TipTilt controller

A number of TipTilt controllers will be used in the stabilization system of the optical path of the laser used in pump&probe experiments at the FERMI@Elettra Free Electron Laser. The main requirements are:

- the optical path must be kept stable within few μrad acting on mirror positions;
- the TipTilt subsystem must be synchronized with the rest of the accelerator control system in real-time;
- the mirror position (x,y) must be adjusted generating a ramp between FEL shots.

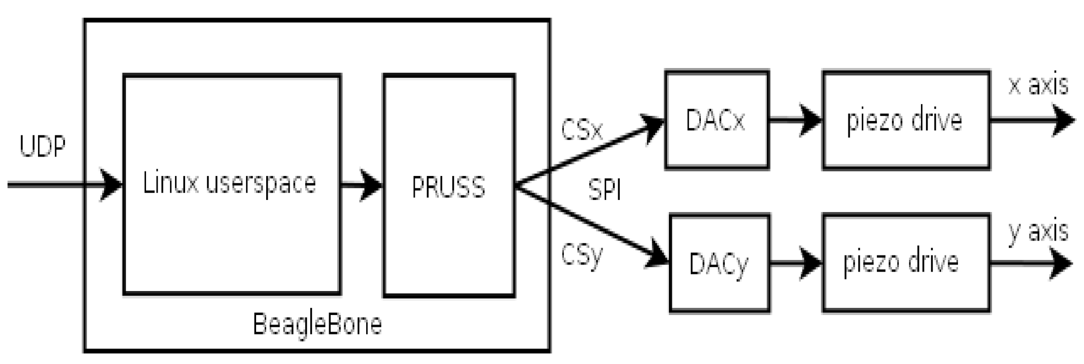


Tip Tilt Controller board assembly



PRUSS driven (x,y) voltage ramp

2kHz driving signal



Tip Tilt Controller block diagram

for additional information, please contact:
stefano.cleva@elettra.trieste.it, lorenzo.pivetta@elettra.trieste.it

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