BEAGLEBONE FOR EMBEDDED CONTROL SYSTEM APPLICATIONS* MOPPC015

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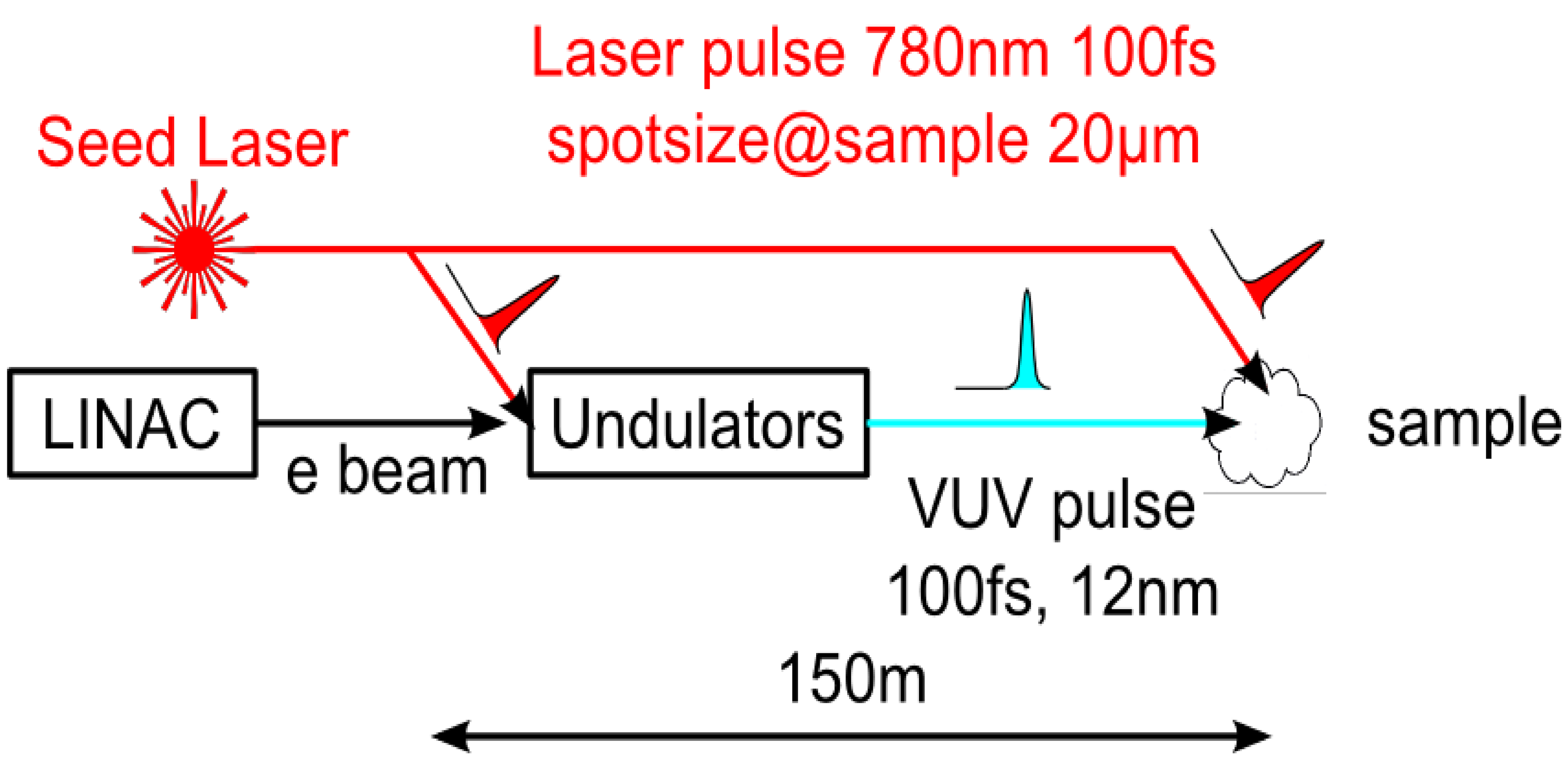
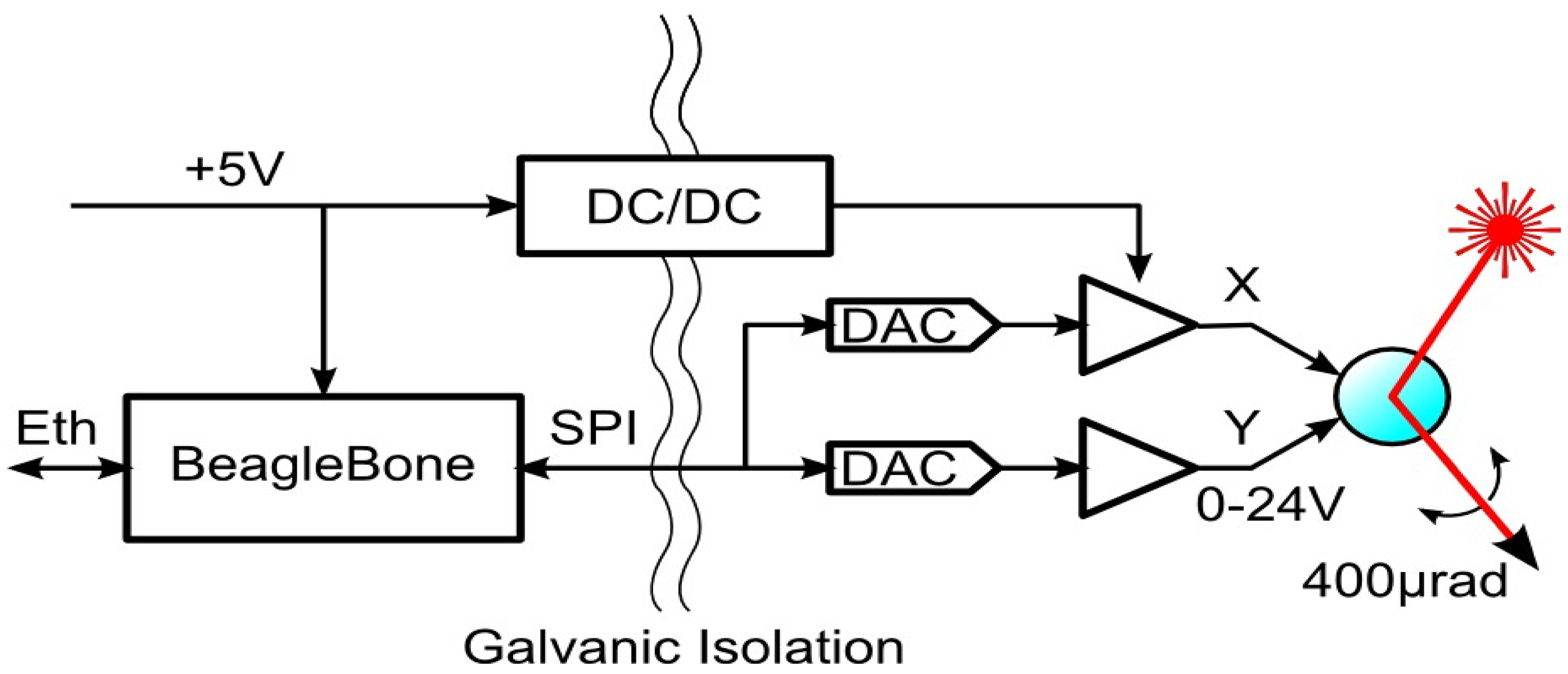
The control system architecture of modern experimental physics facilities needs to meet the requirements of the ever increasing complexity of the controlled devices. Whenever feasible, moving from a distributed architecture based on powerful but complex and expensive computers to an even more pervasive approach based on simple and cheap embedded systems, allows shifting the knowledge close to the devices. The BeagleBone computer, being capable of running a full featured operating system such as GNU/Linux, integrates effectively into the existing control systems and allows executing complex control functions with the required flexibility. The paper discusses the choice of the BeagleBone as embedded platform and reports some examples of control applications recently developed for the Elettra and FERMI light sources.

Elettra Sincrotrone Trieste runs two light sources: Elettra, a 2.4 GeV third generation synchrotron, and FERMI, a 1.5 GeV seeded Free Electron Laser (FEL) based on a linear accelerator.
The large number of subsystems that allow generating and delivering the photon beams to the users, require an up-to-date distributed control system technology.
The increasing capabilities of modern micro-controllers and the cost reduction due to the manufacturers competition, make small, flexible and powerful Systems On Board (SOB) commercially available at low cost.
A survey has been carried out to find the most suitable SOB as core for a general purpose embedded platform: the BeagleBone fulfills most of the desirable characteristics to be used in a particle accelerator control system.
Using a single embedded platform for many applications simplifies the maintenance work, and allows focusing on the development of specific applications. This approach is convenient both where the number of units produced and deployed is quite small, and where the know-how has to be kept in house.



Seed Laser for Users.



TTC block diagram.

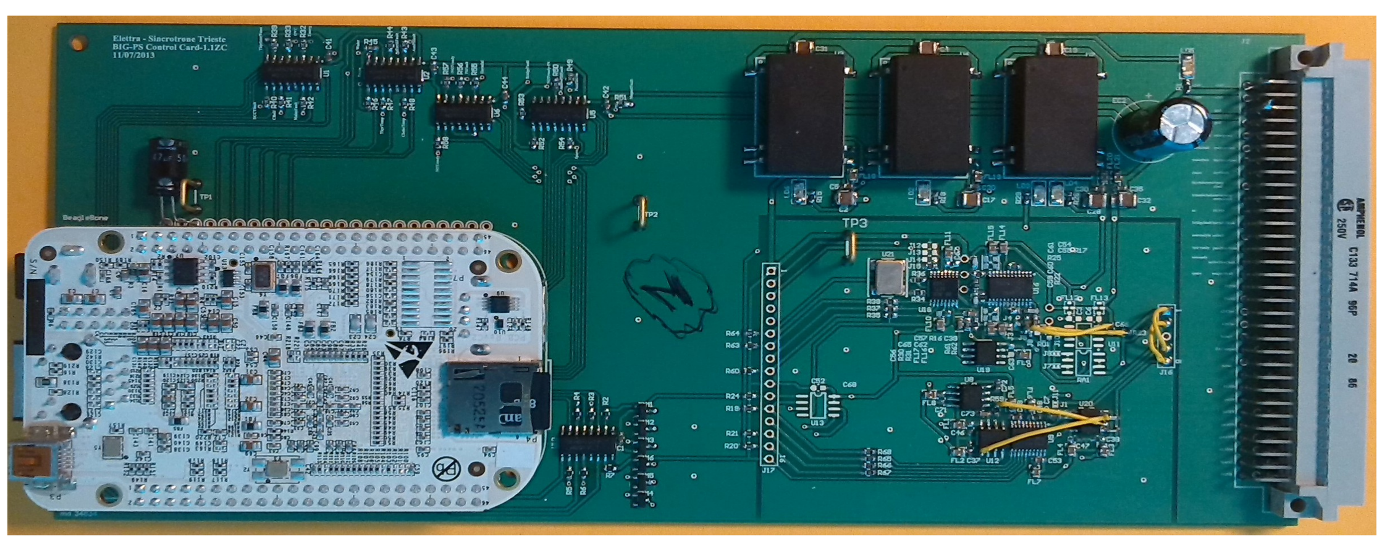
TIP-TILT CONTROLLER

Thanks to a temporal resolution in the order of few fs, FELs are powerful tools to investigate the dynamic behaviour of matter.
FERMI is a seeded machine: the arrival time of the FEL pulse on the sample is determined by the Seed Laser Timing.
To achieve the highest time resolution, in particular for pump-probe experiments, the Seed Laser for Users (SLU) set up has been implemented.
An active feedback loop has been added to keep the optical path of the SLU stable within few micrometers. A central server acquires the images from the SLU CCDs, calculates the errors with respect to the desired optical path, and drives the TTCs.

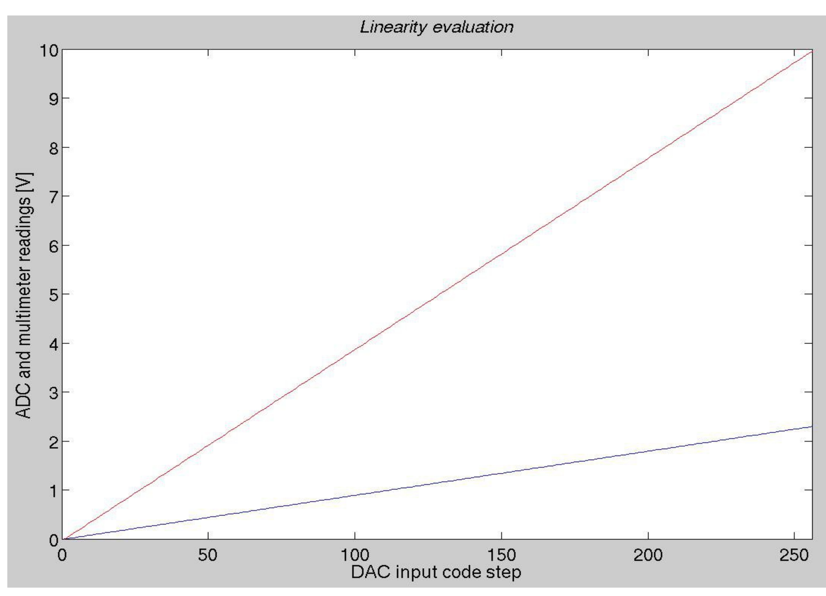
Main characteristics of the TTC:
- **two channel 18-bit DAC;**
- **full galvanic isolation;**
- **low parasitic capacity to ground;**
- **high output amplifier peak current;**
- **ability to drive high capacitive loads;**
- **0 to 24 V output voltage;**
- **UDP controlled over ethernet.**

TTC exploded view.

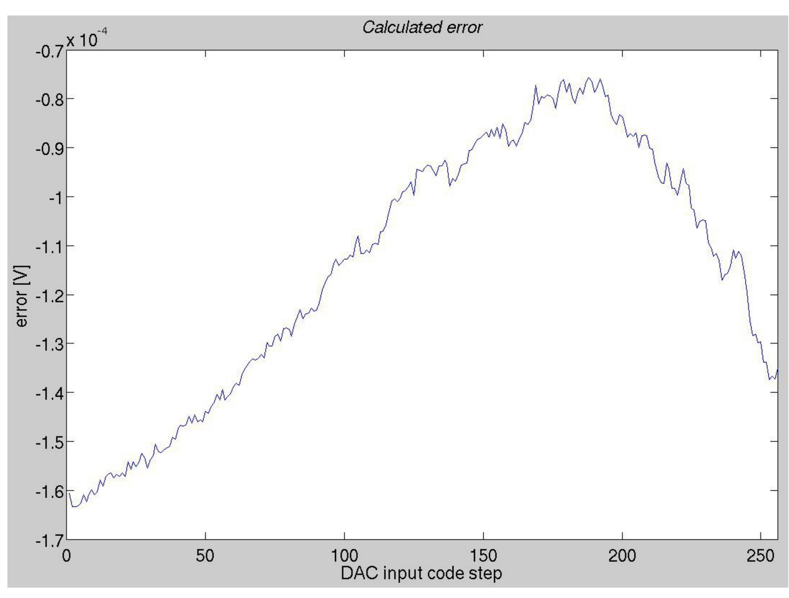
POWER SUPPLY CONTROLLER



NewPSC board assembly.



Linearity measurement of ADC (blue) and DAC (red).



Calculated DAC vs ADC error.

The quality of the photon beams produced by the Elettra storage ring strongly depends on the magnet power supplies. They directly affect the overall up-time of the machine and the beam orbit stability: reliability, precision and stability are mandatory.
Aging considerations, obsolescence of the components and the impossibility to service old boards, have led to an upgrade program which aims at replacing the old VME controllers maintaining the original power supply power circuits and control interface.
The new power supply controller houses:
- **the BeagleBone dedicated strip connectors;**
- **a 24-bit ΣΔ SPI A/D converter (ADS1271) capable of 52 kSample/s;**
- **the ADC voltage reference;**
- **a 20-bit SPI D/A converter (AD5791);**
- **two DAC voltage references;**
- **22 digital inputs;**
- **6 digital outputs;**
- **a DIN 41612 connector for power supply interfacing.**

The analog section of the board has been tested to measure accuracy, noise, linearity, repeatability and short term stability, using a 7½ digit Keithley 2010 DMM. The linearity and the reading error between the DMM and the ADC chain (gain = 0.2306) are shown.

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