



Embedded Environment with EPICS Support for Control Applications

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Abstract

System on a chip (SoC) is widely used in embedded environment. Current generation SoC commercial products with small footprint and low-cost have powerful in CPU performance and rich interface solution to support many control applications. To deal with some embedded control applications, the "Banana Pi" which is a card-size single-board computer and runs Linux-based operation system has been adopted as the EPICS IOC to implement several applications. The efforts for implementing are summarized in this paper.

Introduction

- The applications of single-board computer (SBC) cover in industrial control, telecommunications, blade and high density servers, and lately laptops and mini-PCs, etc.
- The Banana Pi (BPI) is the latest product of such category with powerful CPU, low power consumption SBC indeed, and the area of circuit board is only as credit card size.
- The Banana Pi which design idea is similar to the RPi-style SBC, and it is a fork of the Raspberry project using different components.
- TPS (Taiwan Photon Source) control system of 3 GeV synchrotron light source is also based on the EPICS framework.
- EPICS framework which has various functionalities is employed to monitor and to control on embedded applications of accelerator system.

Table 1: hardware specification of the Banana Pi

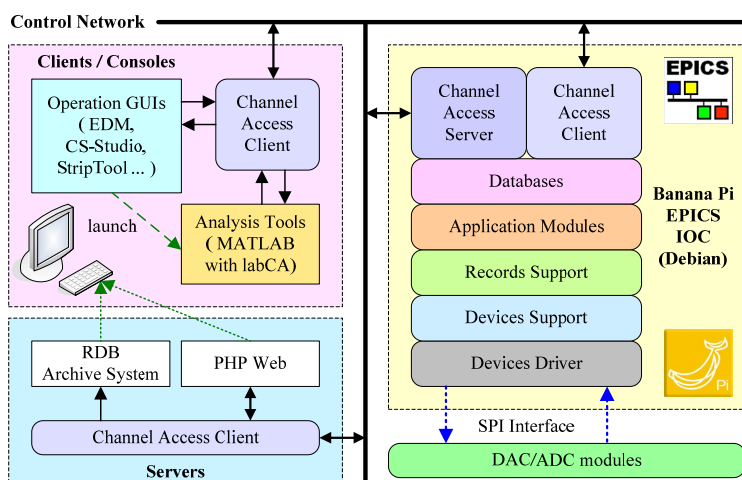
Banana Pi M1/M1+/M2	
CPU	A20 ARM Cortex-A7 1GHz Dual-Core A31S ARM Cortex-A7 1GHz Quad-Core
Memory	1GB DDR3 DRAM
Network	1Gbps Ethernet RJ45, Wi-Fi
Storage	SD card slot (up to 64GB), Extensible with SATA interface
I/O	GPIO, UART, I2C bus, SPI bus with two chip selects, CAN bus, ADC, PWM, +3.3V, +5V, GND
OS	Debian, Bananian, Lubuntu, Android ...

Banana Pi as EPICS IOC

- At the TPS project, some control functions, such as frequency divider, direct digital synthesizer, radiation-sensing reader, alarm announcer, etc., are implemented by use of the Banana Pi platforms with EPICS support.

Software Architecture

- To implement the Banana Pi as the EPICS IOC for specific control applications, the EPICS base and modules are necessary to be set up on the Banana Pi platform which operation system can be the Debian or Ubuntu Linux.
- The device driver of SPI (Serial Peripheral Interface) bus is built for communicating with DAC/ADC modules, and the device support interface is also developed as the glue between the EPICS records and device drivers.
- The EPICS records support with databases are created according to the specific functions.
- The application module, such as "autosave" function, is installed for logging setting parameters values and recovering last setting parameters values automatically when the IOC is start-up.

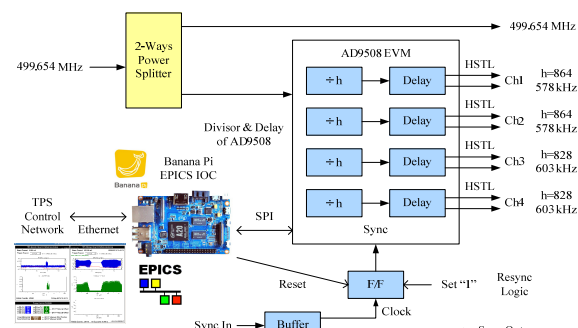


Software architecture of the Banana Pi with EPICS support.

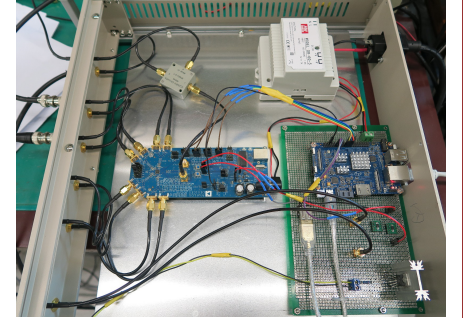
Control Applications with Banana Pi EPICS IOC

Programmable Frequency Divider

- Machine clock of the accelerator system generated discrete fast logic chip (ECL/PECL) or combined of fast logic and field programmable logic array (FPGA) usually.



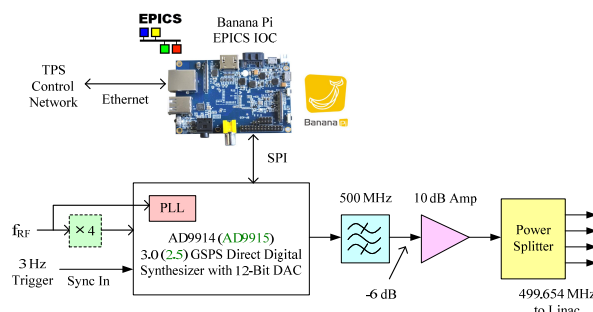
(a) Block diagram of programmable clock generator.



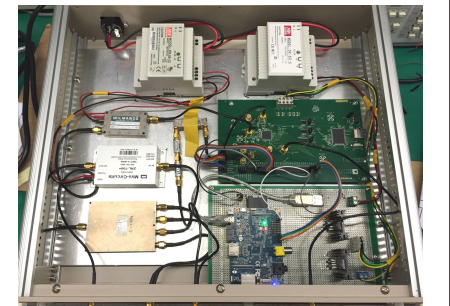
(b) Photo of frequency divider unit for the TPS filling pattern measurement timing.

Direct Digital Synthesizer Control

- To make possibility of different RF frequency for linear accelerator (Linac) and booster synchrotron, a RF signal generator direct digital synthesizer (DDS) which can synchronize at injection instance have been implemented.



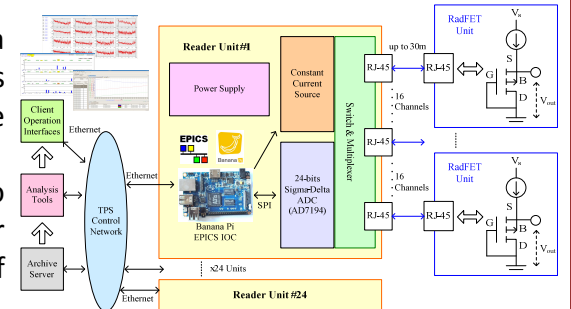
(a) Block diagram of direct digital synthesizer control.



(b) Photo of prototype DDS signal generator.

RadFET Reader

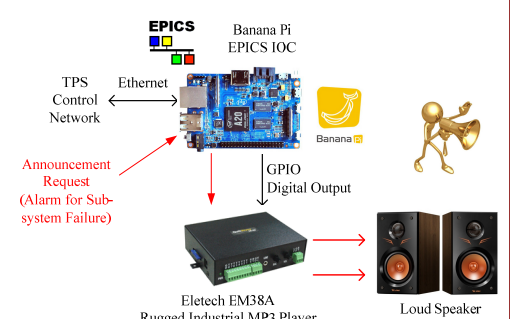
- To investigate the beam loss, a sixteen-channel readout box was initially designed to read the threshold voltage of the RadFETs.
- The Banana Pi will be also adopted as the EPICS IOC for collecting the threshold voltage of the sixteen-channel RadFETs.



Block diagram of the RadFET readers system.

Alarm Announcer

- During the TPS commissioning and operation phases, abnormal status may occur from one of sub-systems, and operators need to find out.
- According to the sum signals of alarm in each sub-system, the Banana Pi which uses the EPICS IOC will receive the request and send alarm announcement sound to loud speaker for noticing.



Block diagram of alarm announcer.

BeagleBone Black (BBB) Application

- Vibration monitoring and voltage signal monitoring play an important role in the accelerators system for beam stability characterization.
- Support of Linux-based OS and software development kit includes numerous components help the development.
- Synchronization interface is easy to integrate with accelerator timing system. Coherent data acquisition is under implementation.

Current Status

- Low cost credit-card size SBC is widely adopted for educational purpose and also suitable for small scale embedded applications.
- The BPI and BBB are chosen for several applications at the TPS control environment as auxiliary supports.
- More applications will be explored and implemented in near future.