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SLAC ATCA SCOPE - UPGRADING THE EPICS SUPPORT PACKAGE*

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Abstract

The SLAC ATCA Scope, a 4-channel dual oscilloscope, has an EPICS support package that runs on top of SLAC's Common Platform software and firmware and communicates with several high-performance systems in LCLS running on the 7-slot Advanced Telecommunications Computing Architecture (ATCA) crate. The software was completely refactored to improve the usability for EPICS IOC engineers. Once linked with an EPICS IOC, it initializes the oscilloscope hardware and instantiates the upper software stack providing a set of PVs to control the hardware and to operate the oscilloscope. The exported PVs provide a seamless means to configure triggers and obtain data acquisitions similar to a real oscilloscope. The ATCA scope probes are configured dynamically by the user to probe up to four inputs of the ATCA ADC daughter cards. The EPICS support package automatically manages available ATCA carrier board DRAM resources based on the number of samples requested by the user, allowing acquisitions of up to 8 GBytes per trigger. The user can also specify a desired sampling rate, and the ATCA Scope will estimate the nearest possible sampling rate using the current sampling frequency, and perform downsampling to try to match that rate. Adding the EPICS module to an IOC is simple and straightforward. The ATCA Scope support package works for all high-performance systems that have the oscilloscope common hardware implemented in its FPGAs. Generic interfaces developed in PyDM are also provided to the user to control the oscilloscope and enrich the user's seamless overall experience.

INTRODUCTION

The 7-slot Advanced Telecommunications Computing Architecture (ATCA) crate is used for numerous high-performance systems (HPS) at SLAC, such as the bunch charge monitor [1], bunch length monitor [1], beam position monitor [2], low-level radio frequency [3], machine protection system [4], timing system, and a few others. Each slot takes an advanced mezzanine card (AMC) generic carrier board equipped with an FPGA and two double-wide, full-height AMC bays. A variety of AMC cards (commercial and custom) can be plugged into the carrier. Some are application-specific and others are generic [5]. The most common is called the General Purpose ADC/DAC AMC Card, which contains DACs and ADCs. Other examples of AMCs designed at SLAC can be found in [4].

Having FPGA-level visibility in most of the stream-based applications mentioned earlier is always practical for obtaining raw data, debugging, and analysis. For this purpose, a standard FPGA firmware component to receive streams, encapsulate them, and send them upstream was developed and integrated into all high-performance systems. This standard firmware component requires accompanying easy-to-use software resembling an oscilloscope as much as possible. With that in mind, the SLAC ATCA Scope EPICS [6] support package was completely refactored to improve the usability for SLAC's EPICS IOC engineers. In this paper, we will discuss the upgraded EPICS support package.

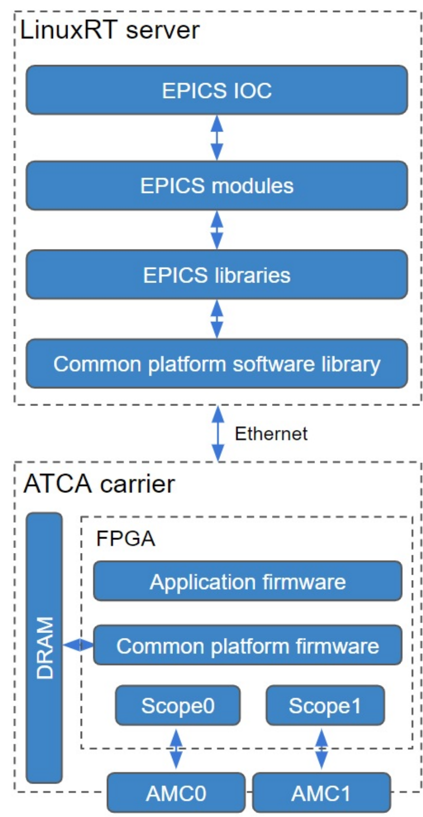

Figure 1: High-performance system SW/HW overview.

HPS OVERVIEW

A general overview of the high-performance systems is shown in Fig. 1. Each AMC card is linked to a Scope component in the firmware, where most streams passing in and out of the AMC are fed into the Scope module, and data is stored in the DRAM. Communication between the server and the ATCA is established through the common platform firmware and software [7]. The common platform firmware and software also provide means to read data from the DRAM and send it upstream. The Scopes can be triggered using multiple trigger sources and rates. The Scope software is linked as

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an EPICS support package to all high-performance systems as an EPICS Asyn Driver.

SCOPE EPICS ASYN DRIVER

Adding the EPICS module to an IOC is simple and straightforward. The ATCA Scope support package works for all high-performance systems with the Scope common hardware implemented in its FPGAs. The scope Asyn [8] Driver and package initializes the Scope firmware and instantiates the upper software stack providing a set of PVs (EPICS process variables) that access the API to control the hardware and to operate the oscilloscope. That includes trigger-based acquisition, configurable data depth, acquired stream visualization, and down-sampling with or without averaging.

The API also handles intelligently all other complex configurations that should be hidden from users, including the DRAM layout for both Scopes depending on the configured data depth size without user intervention or knowledge, allowing acquisitions of up to 8 GBytes per trigger. Before the upgrade, users needed to set the DRAM layout manually while avoiding conflicting regions of the memory. One example of a conflict is related to the BSA [9] reserved space, as shown in Fig. 2. The figure shows the default memory space for Scope if no customizations are made. The new version of the Scope takes care of configuring the right amount of memory in the right regions avoiding overwriting BSA with data from the waveforms.

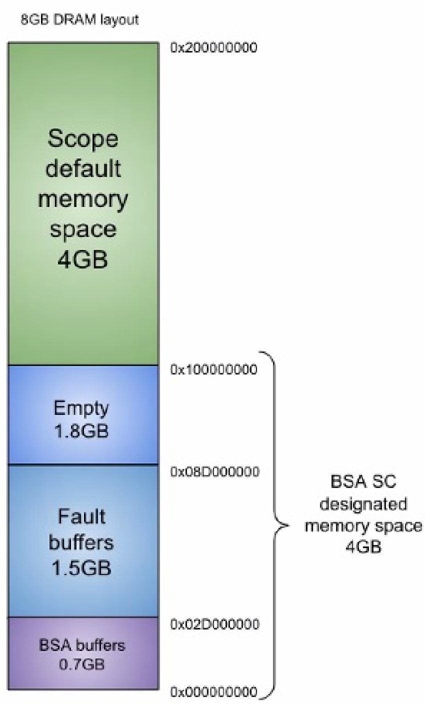

Figure 2: DRAM layout showing BSA reserved space.

The Scope Asyn Driver is instantiated in the IOC through a simple configuration command specifying the port name, Scope number, and channel data type. For advanced users, a more elaborate command was created to finely tune their Scope data types and optionally buffer sizes. If the buffer size is not specified, the default size is 4000 elements. In both cases, the associated database file needs to be loaded consequently.

For each Scope, a configuration command needs to be executed. The code snippet below shows the difference between the simplified and the advanced commands:

```
# 10000 samples of int32
scopeAsynDriverConfigure("atca_str0", 1, "
    int32", "10000")

# 10000 samples of int16, no matter the
# types of individual waveforms
scopeAdvancedAsynDriverConfigure("
    atca_str1", 1, "int32", "int32", "
    int32", "int16", "10000")
```

This is the only EPICS database loading that is required per Scope:

```
dbLoadRecords("db/Stream.db","DEV=${P}:
    STR0, PORT=atca_str0, TSE=-2")
```

The configuration command and the database loading are the only requirements to have the Scope working at its default specification. The previous version forced the user to configure a few dozen variables before any waveform could be seen.

GENERIC USER INTERFACES

Generic user interfaces developed in PyDM [10] are also provided to the user to control the oscilloscope and enrich the user's seamless overall experience. The Scope standard interface using PyDM is depicted in Fig. 3. As observed, the ATCA Scope probes are configured dynamically by the user to probe up to four inputs of the ATCA ADC/DAC daughter cards. The stream data type interpretation is also configured dynamically as well.

Figure 4 (left) shows the trigger and down-sampling configurations for Scope 1. The user can also specify a desired sampling rate and the ATCA Scope will estimate the nearest possible sampling rate using the current sampling frequency, and perform down-sampling to try to match that rate. If the user requires averaging to be applied when the channel is down-sampled, then he would need to enable the averaging button for the corresponding channel. The averaging is done over the number of samples that were dropped.

Figure 4 (right), shows the Scope trigger configurations and information:

- *Trigger Count*: the number of triggers that the Scope received up to that point.
- Button *Clear*: clears *Trigger Count*.
- Button *Trigger*: induces a manual trigger event by clicking the trigger button. This is the same button as shown in Fig. 3.

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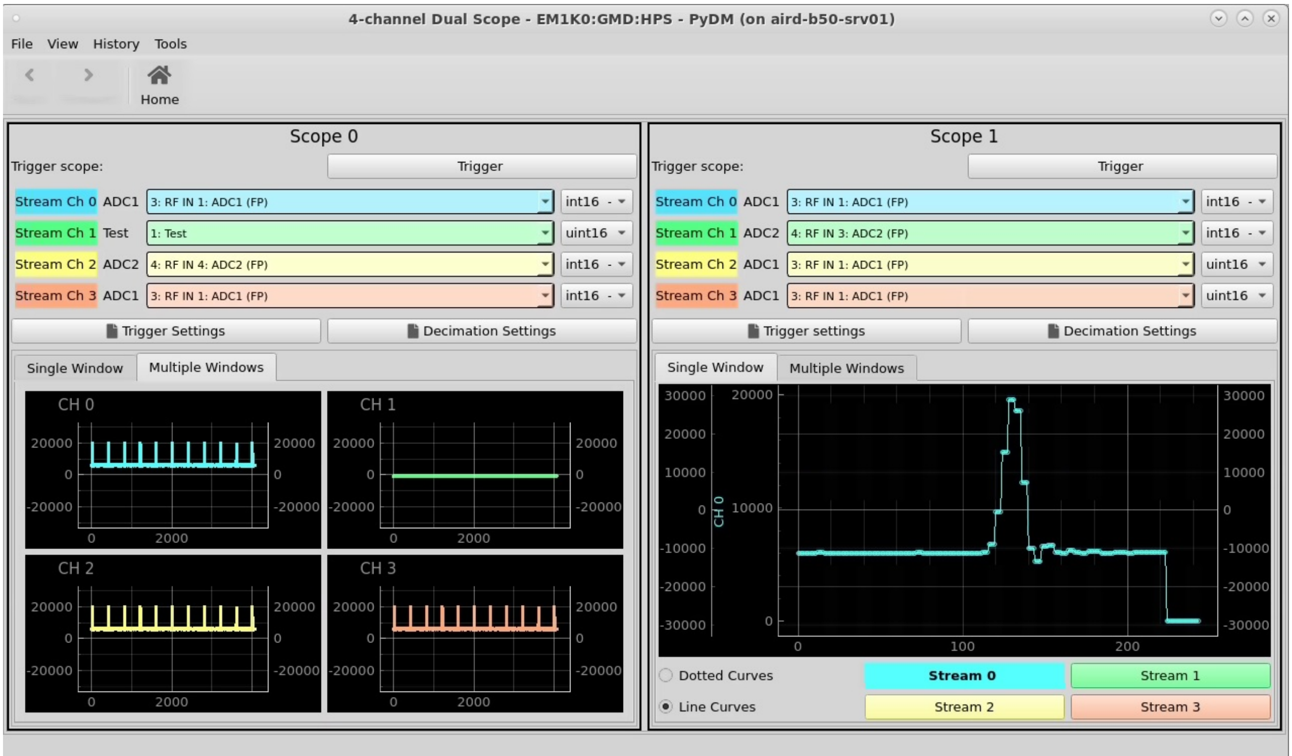

Figure 3: Dual-scope 4 channel graphical user interface.

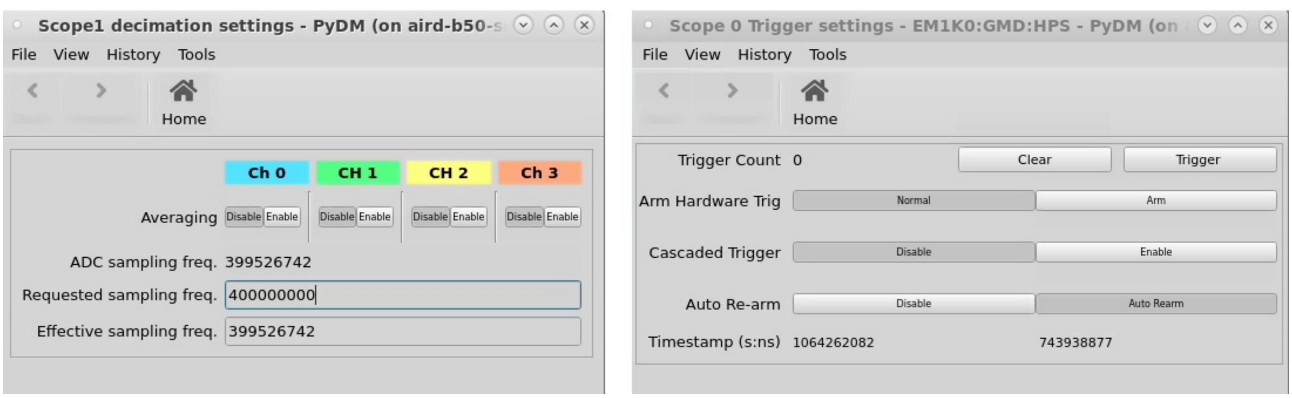

Figure 4: Dual-scope 4 channel trigger and downsampling UI.

- Buttons *Auto-Re-arm* and *Arm Hardware Trig*: if *Auto Rearm* is selected, every time the trigger event occurs, the next trigger will automatically be armed. If *Disable* is selected, the user needs to arm the trigger by clicking on the *Arm* trigger button and, after the trigger happens, select the *Normal* position of the button again.
- Button *Cascaded Trigger*: if *Cascaded Trigger* is enabled for Scope 1, it will trigger together with Scope 0 and vice-versa.
- *Timestamp (s:ns)*: shows seconds and nanoseconds for the last trigger.

CONCLUSION

The 4-channel dual scope and its support package were presented. The software was completely refactored to improve the usability for EPICS IOC engineers and users. Very few essential configurations are required to operate the scope and are similar to those of a real oscilloscope. Scope operation via user interfaces enriches the user's seamless overall experience.

The Scope upgrade has been successfully running since the end of August 2023 in the Gas Monitor Detector (GMD) system.

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