

SCOPE-EMBEDDED IOC DEVELOPMENT IN SSRF*

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Abstract

The dozen of wide band beam diagnostics sensors such as integration current transformer, faraday cup and wall current monitors were used in Shanghai Synchrotron Radiation Facility (SSRF) Linac and transfer line to measure bunch shape and charge. Few hundreds Mhz bandwidth required very high speed digitizer like digital sampling scope. On the other hand SSRF control system was built on EPICS platform. So Windows PC based Tektronix scope, which equipped with TekVISA interface, was chosen to do this data acquisition. The details of software design and the performance evaluation results will be described in this paper.

INTRODUCTION

SSRF is a third generation light source, consisting of a 150MeV linear accelerator (LINAC), a LINAC to booster transfer line (LTB), a full energy booster (BS), a booster to storage ring transfer line (BTS), and a 3.5GeV storage ring (SR) [1].

In order to measure the precise beam bunch charge an integration current transformers (ICT) manufactured by Bergoz and a copper faraday cup is placed at the end of LINAC. Another ICT is equipped at the end of BTS. The efficiency of booster will be evaluated comparing two ICT readings. Additionally 11 wall current monitors (WCM) manufactured by TOYAMA are placed at LINAC (5), LTB (2), booster (1) and BTS (3), to present the longitudinal distribution of the beam. All these fast pulsed sensors require at least few hundreds MHz bandwidth digitizer. Compared with rare VME and PXI ultra fast digitizers the commercial digital sampling scope becomes the perfect candidate.

On the other hand SSRF control system is built on EPICS platform. The scope data acquisition must be integrated into EPICS frame. The diagram of a typical solution for this requirement is shown in Fig 1.

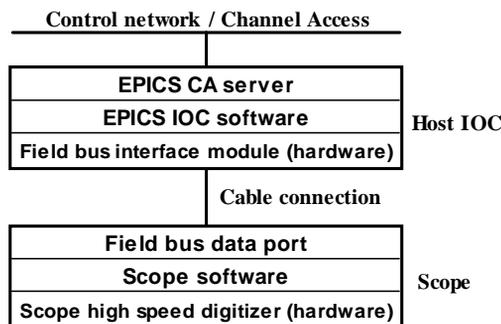


Figure 1: Diagram of a field bus based EPICS scope.

In this architecture scope is attached to a host IOC through field bus (GPIB or LAN). The host IOC could be any kind of industrial computer (VME with VxWorks, IPC with Linux, or IPC with Windows), which is equipped with field bus interface module. A virtual data circuit will be created at the system initialization stage and maintained during the operation by host IOC. So a host IOC has to be assigned before any scope added into the system. They have to always work together.

The modern Windows based scope gives us another option: running IOC software in the same computer as scope routine. The diagram for this solution is shown in Fig. 2.

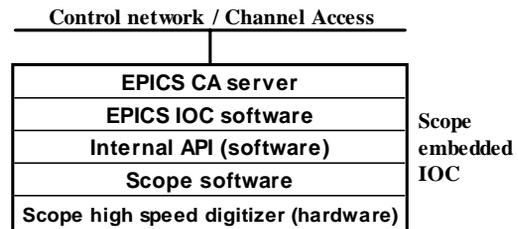


Figure 2: Diagram of embedded scope IOC.

In this way scope IOC will totally stand alone and be plug & play. SSRF will implement all BI scopes in this architecture.

SCOPE SOFTWARE STRUCTURE

Tektronix DPO7054 is chosen as the primary high speed waveform recorder in SSRF BI system, due to friendly application programming interface (TekVISA), powerful trigger function and reasonable cost. TekVISA refers to the Tektronix implementation of the Virtual Instrument Software Architecture (VISA), which provides a common programming interface for all Windows-based instruments such as DPO7000 series scope and RSA8000 series spectrum analyzer [2].

Fig. 3 shows the diagram of the scope software.

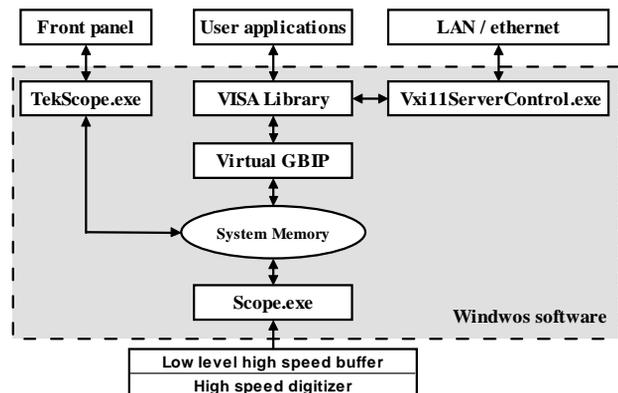


Figure 3: Software diagram of Tektronix scope.

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Three major Windows routines involve into the scope normal operation:

- Scope.exe, the kernel task for scope, which maps digitized real-time data to Windows environment.
- TekScope.exe, the associated human interface task for scope, which implements hardware front panel functionality and data presentation functionality on screen.
- Vxi11ServerControl.exe, the LAN connection server task, which implements remote connectivity.

The Tektronix Windows based scope provides an internal data channel so called “Virtual GPIB”. User application running in the scope Windows environment could control and access scope data through this channel.

LABVIEW SOLUTION

In order to minimize the development period and man power cost, SSRF BI group chose LabVIEW graphic programming language to complete scope data acquisition routine in the first stage. The Shared Memory IOCcore interface and associated LabVIEW library, which is developed and maintained by SNS/ORNL, is adopted to integrate user application into EPICS [3].

Fig. 4 shows the software architecture of this solution.

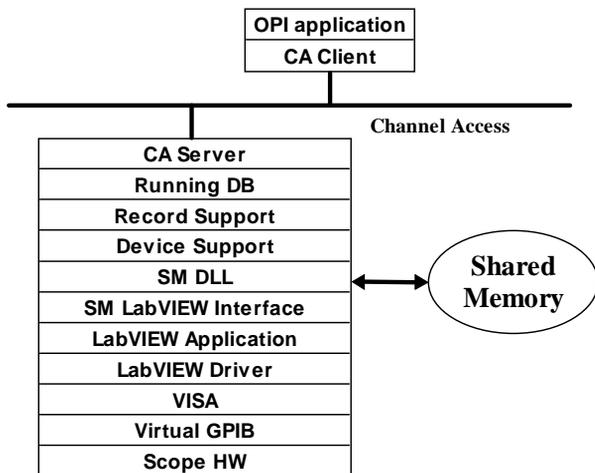


Figure 4: Shared Memory IOCcore interface.

In this solution “memory” is treated as a kind of special devices. On the local low level LabVIEW side, user application keeps doing data acquisition, processing, and calling SM.DLL functions to write data into “Shared Memory” devices or read data from them. On the high level EPICS IOC side, the dedicated “Shared Memory” device support modules are implemented to access these memories. In this way user specified LabVIEW routines are easily connected to EPICS based control system.

LabVIEW based embedded scope IOC software was completed in two weeks. Fig. 5 shows the local panel and remote EDM panel used in LINAC BCM application.

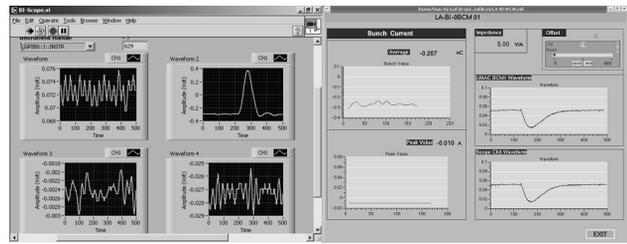


Figure 5: Local LabVIEW panel & remote EDM panel.

The operation during the SSRF LINAC commissioning proves that the software has satisfied the basic data acquisition and processing requirements of LINAC. But the poor updating rate and huge CPU loading makes it useless during daily operation.

Table 1 shows the bench test results of CPU usage of key scope tasks for different configurations.

Table 1: Scope IOC CPU usage for 4 CHs & 1k samples

Update rate \ Task name	0.1Hz	0.2Hz	0.5Hz
Scope.exe	49%	44%	<1%
LabVIEW.exe	28%	37%	99%
epicsSM.exe	1%	1%	1%
TekScope.exe	<1%	<1%	<1%
TekVisaRM.exe	<1%	<1%	<1%

The upper limit of updating rate is about 0.2Hz. When updating rate goes up the “LabVIEW” task takes more CPU time from other tasks especially “Scope” task. It finally kills real-time data acquisition and makes scope stop responding any data requests.

Because “LabVIEW” task is the biggest consumer in the system, it looks like there is no much more space to optimize the embedded scope IOC performance with this solution.

WINDOWS IOC SOLUTION

Based above test results, the only way to improve scope IOC performance is removing LabVIEW from the system. We chose to remove both LabVIEW and Shared Memory interface and connect EPICS device support module to VISA layer directly, as shown in Fig.6.

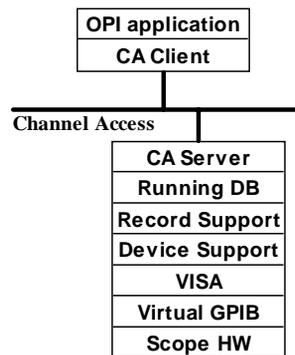


Figure 6: Diagram of Windows scope IOC.

The beta version of new software has been finished in the middle of Sep, 2007. In order to evaluate the performance of new scope IOC, a series of bench tests were performed. Basically the scope IOC performance depends on sampling rate, sample numbers per channel and waveform updating rate.

Table 2 shows the CPU loading test results with fixed updating rate (1Hz) and varied sampling rate and sample numbers.

Table 2: CPU loading (%) with 1Hz updating rate

Sample #/ch Sampling rate	1k	5k	10k	20k	50k
2.5GHz samples / s	69	70	75	86	87
1GHz samples / s	68	60	60	60	63
500MHz samples / s	67	59	60	62	63
200MHz samples / s	67	60	60	60	63
100MHz samples / s	67	60	58	59	62
50MHz samples / s	69	61	60	60	60

Table 3 shows the CPU loading test results with fixed sampling rate (2.5GHz) and varied updating rate and sample numbers.

Table 3: CPU loading (%) with 2.5GHz sampling rate

Sample #/ch Updating rate	1k	5k	10k	20k	50k
10Hz	86	87	92	87	90
5Hz	75	78	83	88	90
2Hz	71	72	77	87	87
1Hz	69	70	75	86	87
0.5Hz	67	68	74	85	87

Table 4 shows the major consumers of CPU loading and memories during a typical scope IOC operation (2.5G sampling rate, 5000 samples per channel, 2Hz updating rate).

Table 4: Major resource consumer

	CPU usage	Memory usage
Scope.exe	69%	562MBytes
ScopeIOC.exe	1%	3.2MBytes
TekScope.exe	<1%	3.7MBytes
TekVisaRM.exe	<1%	37MBytes

Obviously “scope.exe” routine is the bottleneck of the system. It contributes more than 90% of total CPU loading in any situations. So there is no way to run IOC software under 50% CPU loading condition.

IOC software still works well up 10Hz updating rate, 2.5GHz sampling rate and 50k samples per channel. But

CPU loading goes to very high level (90%) in this situation. To ensure system daily operation stability, less than 20k sample number and lower than 2Hz updating rate is recommended.

The new scope-embedded IOC has been used in SSRF booster commissioning. Fig.7 shows the sampled timing signal and beam signal from stripline pickup, which has been transfer into EPICS enviroment.

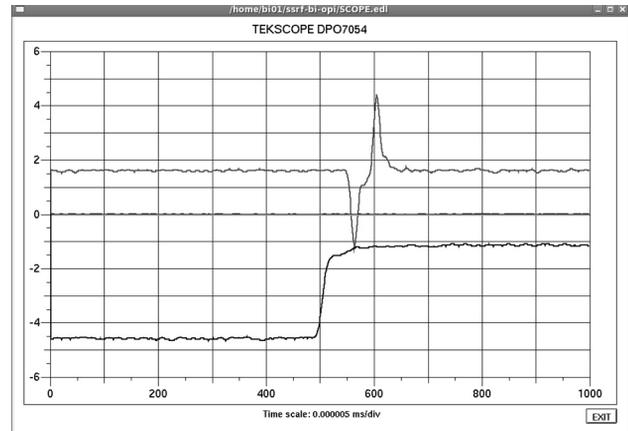


Figure 7: Scope-embedded IOC EDM panel.

CONCLUSION

Digital sampling scope is very powerful tool for machine commissioning and daily operation. Windows based instrument and portable EPICS server technology provides a possibility to embed IOC software into scope computer. Shared Memory IOCore package and LabVIEW platform is an easy way to complete this job. But huge consumption of resource and poor updating rate makes this solution useless in the field. SSRF completes a set of new Windows based scope IOC software associated with Tektronix DPO7000 series scope. The prototype has been used in the booster commissioning.

ACKNOWLEDGMENTS

The authors would like to thank everyone who contributed to this work through discussions and suggestions.

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