The Analogue State Analyzer and It's Application to the Control System for Superconducting Cavities

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ABSTRACT

A Microcomputer based data acquisition and analysing system called "Analogue State Analyzer" (ASA for short) has been developed. This system is applied to the control system for superconducting cavities in HERA ring of DESY. The purpose of this system is: (a) Monitoring and real-time displaying the working state of the cavity; (b) Recording the information of any unusual process, such as the quench, an abnormal control signal, etc; (c) Analysing the information by some assistant functions. The main system structure of ASA and the principle for event detecting method are described in this paper. In addition, some application results are also included.

1. INTRODUCTION

In many scientific research projects and application areas, there is such a comon requirement: catching all informations when an unusual situation happens, and then analysing what the cause is. For the superconducting cavities, to find the initial reasons of any unsual phenomenon, or any abnormal interrupt of interlock system, and to know how the related signals behave before and after such event are very important for the proper operation of those cavities in accalerator.

The ASA is developed for above purpose. Based on the microcomputer and a dedicated program, the ASA has stongth intelligence to detect many possible events predefined by the condition patterns. It can acquire the information arround the events in different trigger modes, and record them in variable duration length.

The main characteristics of the ASA (version 1.1x) are as following:

Computer:	IBM PC/AT (286 or 386)
Input Channels:	16 analog differential channels
Resolution:	12Bits
Input Range:	+/- 10V
Sampling Speed:	10mS to 1S per sample, 16 channels

Record Length:	250 - 1000 Points/channel (Base memory)
	500 - 8000 Points/channel (Expanded memory)
Test Condition:	A<=, A>=, |Rate|>=
Logical Relation:	OR/AND
Trig Mode:	Begin/End/Middle/Auto
External Trig:	1xTTL, raise edge
Display:	8 traces real time (VGA)
Zoom:	10% - 100%
Output:	HPGL plotter for hardcopy.

2. SYSTEM DESCRIPTION

The ASA hardware consists of a microcomputer, a data acquisition card, 16-channel head box and a pen plotter. Fig.1. shows its structure.

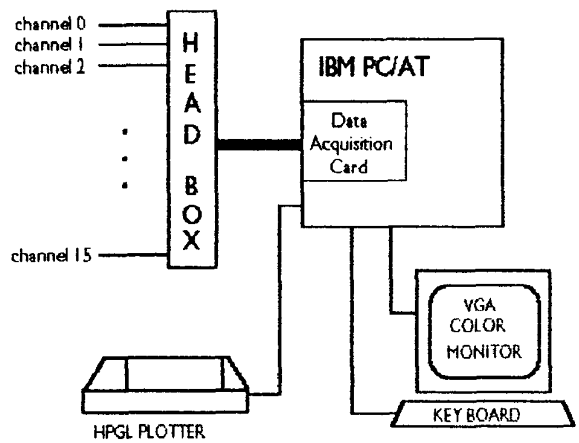


Fig.1 The hardware structure of ASA

The Data Acquisition Card has the interface to the computer, the ADC module, one timer chip and the control circuit. The timer can be programmed to generate hardware interrupt which actives the interrupt service subroutine of the program.

Inside the Head Box, there is a multiplexer which conbines the 16 input channels to a variable-gain preamplifier. Then the singal is fed into the ADC module in Data Acquisition Card. The multiplxer is controlled by the digital output of the Data Acquisition Card. So every input channel can be selected by the program.

The ASA has real-time display ability. It can display up to 8 traces on the VGA display. Thus the operators can have a overview about current situation of the taget object under testing, even without any event.

The multi-color pen plotter is needed for hardcopy, while the program is doing the off-line analysing.

The program, also called "ASA", written in C language, runs under DOS 3.0 or later. It has a friendly menu-driven user interface which lets operator spend little efferts to become familiar with all the functions.

3. EVENT DETECTING AND TRIGGER MODES

The most important feture of ASA is being able to "grab" the "events". In pinciple, the ASA is much different from normal data logging system or rolling-paper recorder, which continuously record the signals disregarding the meaning of the them. By contrast, while there is nothing happening, the ASA is working like a signal displayer, showing the current information on its screen. When an event is detected, the ASA will catch the event, and store the information about the event to a permanent disk data file.

The "events" are predefined by the operator. Events are the combination of some conditions. The ASA is designed to allow any one of the 16 input signals to contribute to the events. Every signal can be given up to three independent conditions, i.e. "too high" (the amplitude is greater than a certain threshold level), "too low" (less than a level), and "changing too fast" (the changing rate is greater than a threshold value). If a signal meets any of those conditions, it is a event. Whether or not this event can trigger the system depends on the attribute assignment for this signal channel and the logical relation with theevents from other channels. ASA has two trigger logical operations for events to form the trigger, i.e. OR and AND. For OR logical, any event from any signal channel can generate trigger. But in AND logical state, all events from attribute enabled channel should come together to form the trigger. Fig.2 gives a simple show of the process to detect the events and form the trigger.

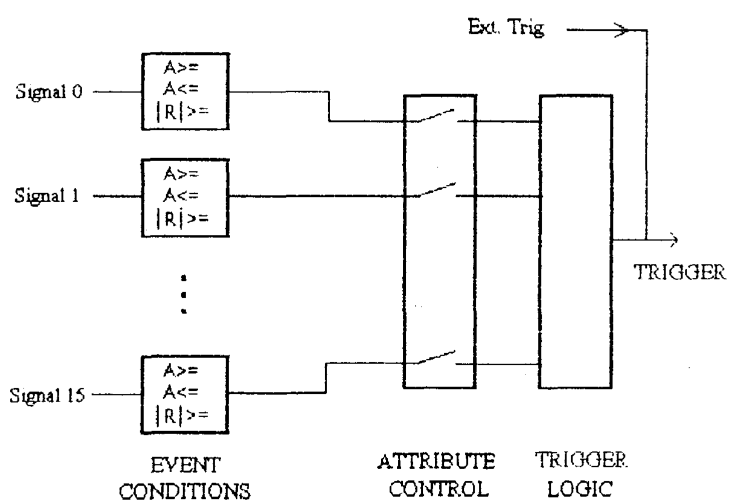


Fig.2. The process to detect events and form trigger

ASA has basically three different trigger modes, i.e. "Begin", "End", "Middle", and "Auto". The trigger mode controls how the data acquisition subroutine record the information. Fig.3. shows the time relation between the data recording and the trigger position.

In "Begin" mode, system will record a duration of data just after the trigger time. The data recording contains the information after the event. By contrast, the "End" mode records the information before the event.

The "Middle" mode, different from above two modes, records the information "arround" the event, that is, a half before the trigger, and another half after the trigger. In most case, the "Middle" mode is more convenient than others.

Sometime, we want this system to record the signals continously, like normal signal recorders. This can be done by setting the ASA to the "Auto" mode. In "Auto" mode, ASA automatically records the data one period after another with no relation to any event. See Fig.3. (d).

Any time, during the running of the program, operator can stop it and store the current information to the data file.

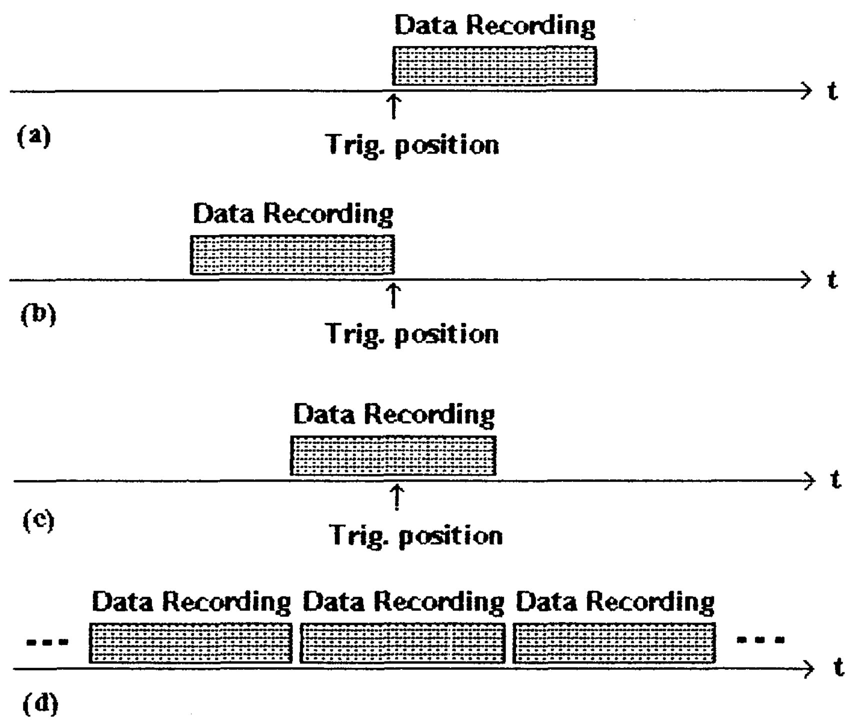


Fig.3. The relation betwee the data recording
and the trigger position
(a)."Begin", (b)."End", (c)."Middle", (d)."Auto"

4. OTHER FUNCTIONS

(a). Run-time trace selection and display range modification.

During the data acquisition, any one of the 16 channels can be assigned to a displayable trace, without interrupting the data acquisition process. This is different from most data logging systems, like NOTEBOOK, which must stop current running data acquisition to change the screen display parameters.

(b). Multi-run function

Ths ASA was designed to acquire upto 1000 events in "multi-run" mode. In multi-run mode, the system will restart the data acquisition after last event has been recorded. It is helpful for the long time running system. By contract, the "single-run" will stop the data acquisition if one event is detected.

(c). Zooming in analysing state

In off-line data analysing, zoom function help the operator to see the detail of acquired information. The zoom is as a window to display a part of time duration on the full screen. The window length can be 10% to 100% of full record length.

(d). Cursor with reference mark

By moving the cursor, the values of selected signals at the cursor position can be seen. If the reference mark is turned on, then the signal difference and the time difference between the reference mark position and the cursor position are calculated and displayed on the screen.

(e). Normal data logging function

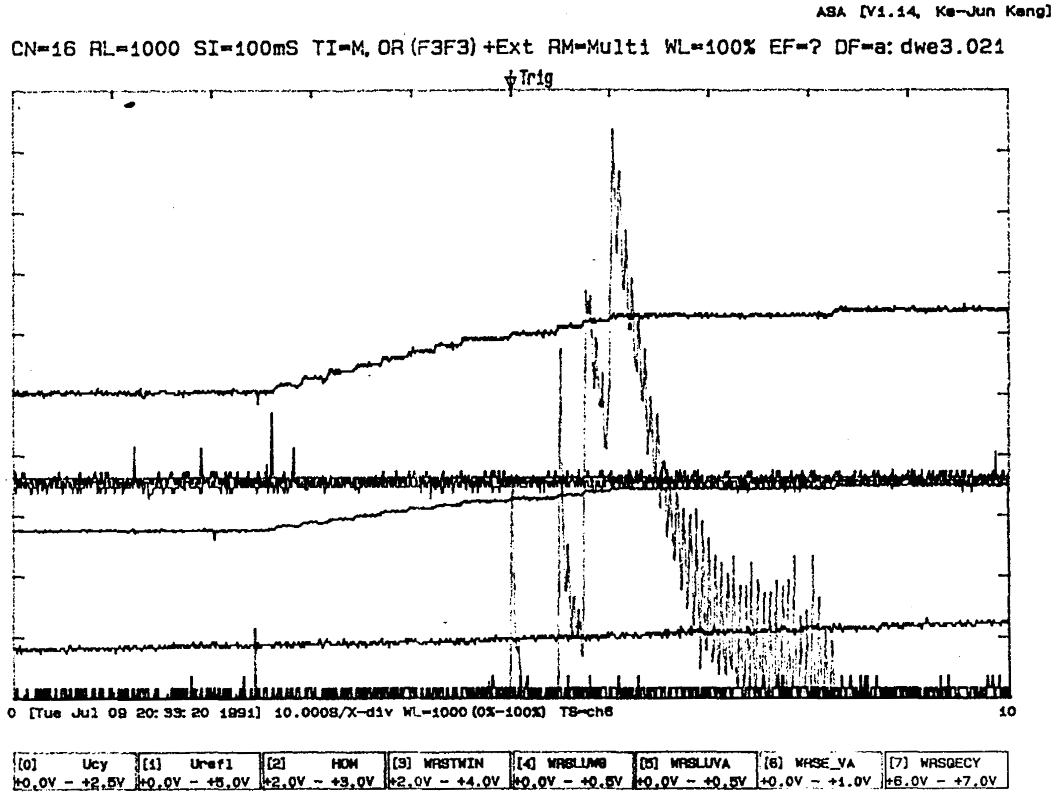
In addition to its event detecting and the smart trigger abilities, the ASA can also be used as a normal data logging system (trigger mode is "auto" as shown in Fig. 3 (d)). It records one segment after another segment. One segment length can be up to 1000 points (8000 points by using EMS) for every channel; The sampling interval can be selected from 10mS to 1S; And the maximum segment number is 1000.

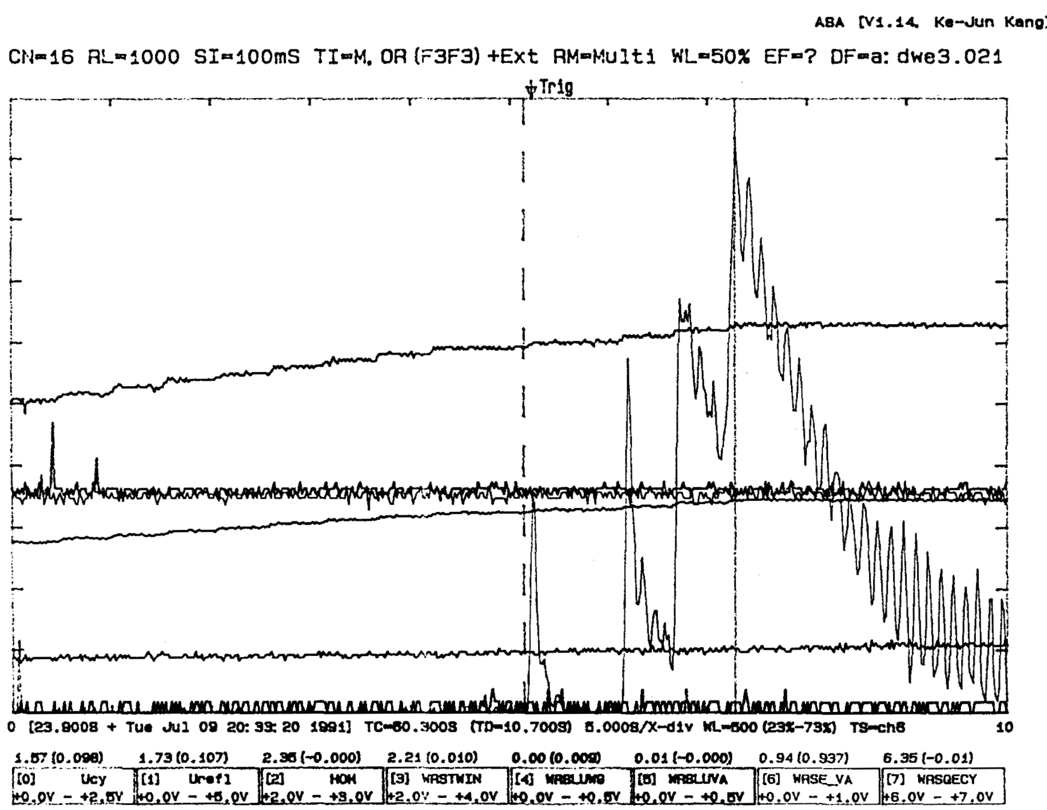
5. ACKNOWLEDGMENT

I would like to thank Mr. B. Dwersteg (DESY) for his helpful suggestions, and Dr. D. Proch (DESY) and Mr. B. L. Norris (Fermi Lab.) for their helpful discussion.

6. PRACTICAL RESULTS AND CONCLUTION

Some samples shown here are from the practical application of ASA in superconducting cavities running in HERA. Although the ASA is initially designed to meet the requirement of the superconducting cavity, it is by no means limited on in this area. According to its ability of real-time displying, event detecting, information recording and off-line analysing, the ASA can be used in any research project or running system, as a inteligent trouble-shooter, to help the researchers to find the problem easily.


ASA [V1.14, Ke-Jun Kang]
CN=16 RL=1000 SI=100mS TI=M, OR(F3F3)+Ext RM=Multi WL=100% EF=? DF=a: dwe3.021
Trig
0 [Tue Jul 09 20:33:20 1991] 10.000S/X-div WL=1000 (0%-100%) TS=ch6
10
[0] Ucy +0.0V - +2.5V
[1] Urefl +0.0V - +5.0V
[2] HOM +2.0V - +3.0V
[3] WRSTWIN +2.0V - +4.0V
[4] WRSLUWS +0.0V - +0.5V
[5] WRSLUVA +0.0V - +0.5V
[6] WRSE_VA +0.0V - +1.0V
[7] WRSQECY +6.0V - +7.0V


ASA [V1.14, Ke-Jun Kang]
CN=16 RL=1000 SI=100mS TI=M, OR(F3F3)+Ext RM=Multi WL=50% EF=? DF=a: dwe3.021
Trig
0 [23.900S + Tue Jul 09 20:33:20 1991] TC=60.300S (TD=10.700S) 5.000S/X-div WL=500 (23%-73%) TS=ch6
10
1.57 (0.098)
1.73 (0.107)
2.36 (-0.000)
2.21 (0.010)
0.00 (0.009)
0.01 (-0.000)
0.94 (0.937)
6.35 (-0.01)
[0] Ucy +0.0V - +2.5V
[1] Urefl +0.0V - +5.0V
[2] HOM +2.0V - +3.0V
[3] WRSTWIN +2.0V - +4.0V
[4] WRSLUWS +0.0V - +0.5V
[5] WRSLUVA +0.0V - +0.5V
[6] WRSE_VA +0.0V - +1.0V
[7] WRSQECY +6.0V - +7.0V