Requirements for SCAM for three beam operation

Rev.1 11/4/97
Rev 2. 11/20/97
Rev. 3 12/10/97
Rev. 4 5/22/98

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Introduction

The SCAM (Service Building Catch All Module) is an interface between a programmable pulser and the drive circuitry that generates electron beam. We will revise the SCAM to provide three independently controllable wave forms to the polarized source and at the same time, keep the present thermionic gun capabilities unaffected. We will limit the wave forms to the lasers to a subset of the thermionic gun's capabilities, because we rarely use our present wave form generation capabilities. The system design will still allow us to generate arbitrary wave forms on those rare occasions.

Functional Description of SCAM for Thermionic Source Operation

The present way of operation of the thermionic source remains unchanged.

Functional Description of SCAM for Polarized Source Operation

We will partition the machine into four parts: accelerator, Hall A transport line, Hall B transport line and Hall C transport line. We will define and describe five pulse structures.

1. Beam off
2. Viewer Limited
3. Tune
4. CW (DC) and
5. User Mode for the accelerator/ Pass for transport lines

These pulse structures are user programmable via VME accessible registers (Control and Status Registers - CSR). Each one of the four partitions has a pair of registers associated with it.

The modes set in the accelerator CSR limit the modes set in the transport line CSRs. No transport line beam structure can be at a higher order than that set in the accelerator. User mode is the highest order, followed by CW, Tune, Viewer Limited and Off. See section titled 'More on accelerator and hall modes'.

We will now define the various modes.

1. *Off Mode*
   In this mode, the user can turn the beam off to any hall individually. The user can turn off beam to all Halls and the accelerator by turning the beam off in the accelerator CSR..
2. *Viewer Limited Mode*
   In this mode, the user can set any hall to Viewer Limited Mode, as long as the accelerator CSR is at an equal or higher order. The SCAM will generate a default 250 ns pulse. (AC line synchronized). A programmable register allows the user to increase the pulse duration to 10 μs. Since there is only one register, all halls will get pulses of the same duration. The user can set Viewer Limited beam to all Halls and the accelerator by setting Viewer Limited bit in the accelerator CSR. The Transport lines with Beam Off mode in their CSRs will stay in Beam Off Mode.

3. *Tune Mode*
   In this mode, the user can set any hall to 'standard' Pulsed Mod Mode, as long as the accelerator CSR is at an equal or higher order. The SCAM will generate a 354 μs beam pulse and a default 99.5 μs mod pulse. The user can change the duration of the mod pulse from 98.5 μs to 100.4 μs by writing to Mod Adjust Register. The mod pulse will occur 250 μs after the leading edge of the beam pulse. The pulses are synchronous to the AC line frequency.
4. *CW (DC) Mode*
   In this mode, the user can set any hall to CW/DC Mode, as long as the accelerator CSR is at an equal or higher order.
5. *User Mode/Pass Mode*
   User Mode in the accelerator CSR allows the user to set any type of pulse structure in the accelerator. Pass Mode in any transport line (Hall) CSR will pass any pulse structure set in the accelerator without modifications. User Mode in the accelerator is a special mode and we expect its use to be rare.

Interfaces

In order to provide the above functionality and the CEBAF required safety features, the SCAM will have the following interfaces.

1. Interface to Mizar 8310 Pulser
2. Interface to the gun control electronics
3. Interface to Fast Shutdown System (Machine Protection System)
4. Interface to the Personnel Safety System,
5. Interface to the VME bus,
6. RS232 Interface and
7. Valve Interface for Gun Switching

1. Interface to the Mizar 8310 Pulser
This interface remains unchanged from the present SCAM. This will be a 50 pin ribbon cable with mass termination.

2. Interface to the gun control electronics
The gun control electronics (the Control Electrode Driver, in the case of thermionic gun, or pulse amplifiers in the case of polarized source) will receive Beam and Modulation signals over fiber optic cables.

3. Interface to the Fast Shutdown System
The SCAM will receive four Fast Shutdown (FSD) signals. These are FSDA from Hall A, FSDB from Hall B, FSDC from Hall C and FSD from the accelerator. Any FSD fault will turn off beam pulses to the thermionic gun. For the polarized source, FSD fault from the accelerator will turn off ***all*** Beam and Modulation signals for all three halls; FSDA will turn off Beam and Modulation signals to Hall A, FSDB will turn off Beam and Modulation signals to Hall B and FSDC will turn off Beam and Modulation signals to Hall C.

4. Interface to the Personnel Safety System (PSS)
PSSA and PSSB courtesy signals are presently available at the SCAM to turn off the beam. This function will remain the same. A PSS fault will turn off the Beam and Modulation signals to ***all*** three halls.

5. VME bus interface

The SCAM will have a VME bus A16/D8(O), short privileged and non-privileged access interface. The user accesses control and status registers through this interface in order to change the modes of the SCAM. Since this is the major change, we will describe the programming and operating aspects in detail.

The SCAM contains a pair of CSRs for the accelerator and a pair of CSRs for each of the three transport lines. These CSRs are for the use of polarized source control. It also contains three additional registers to provide limited flexibility in pulse duration and for generating line frequency harmonics.

Description of CSRs for the accelerator

Figure 1 shows the bit assignments for the accelerator CSR0 and CSR1.

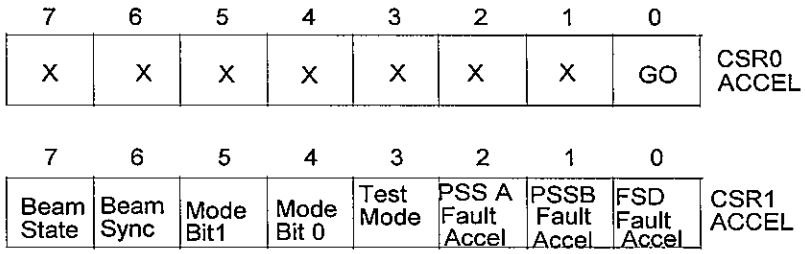

Figure 1

CSR0, Bits 7:1 - Unused

CSR0, Bit 0 - The user sets this bit to 1 for beam delivery to the accelerator and the halls. When the user sets this bit to 0, there will be no beam pulses to any hall..

CSR1, Bit 7 - Read Only. A value of 1 enables beam pulses to the halls.

CSR1, Bit 6 - Read Only. If reads back as 1, beam sync signal is present. If reads back as 0, no beam sync signals are present.

CSR1, Bit 5:4 Mode bits - Read/Write. A table and explanation of the modes follow.

Mode Bit 1 (CSR bit 5)	Mode bit 0 (CSR bit 4)	Beam Mode
0	0	Viewer Limited
0	1	Tune
1	0	CW (DC)
1	1	User

Viewer Limited Mode - Provides default 250 ns of line synchronized pulses to the gun. User changes the pulse duration using the Viewer Limited Length Register.

Tune Mode - Provides the 'standard pulsed mod mode' (354 μs beam, and 250 μs later, 99.5 μs modulation) pulses. The halls that are in CW mode will drop to Tune. The halls that are in Tune, Viewer Limited Mode or Beam Off Mode stay as they were.. User changes the mod pulse duration using the Mod Adjust Register.

CW Mode - Allows CW(DC) beam in the accelerator and to any hall provided the relevant Halls' CSR 1 is also in CW(DC) mode.

User Mode - User mode does not automatically affect other halls. This feature allows one Hall to request a custom beam structure while the other halls are in Viewer Limited, Tune or CW mode. The user sets Pass Mode in the relevant Hall's CSR1 to pass this beam structure to the requesting hall.

CSR1, Bit 3 - Test Mode bit, when set to 1 allows one source to be in test mode while the other delivers beam to the accelerator. Default mode on power up is 0.

Open vacuum valve implies that polarized source can provide electrons to the halls. Closed vacuum valve implies that the thermion gun can source electrons to the halls. Open vacuum valve inhibits pulses to the

thermionic gun. By writing 1 to this bit, the user can send pulses to the thermionic gun. Closed vacuum valve inhibits pulses to the polarized source. By setting this bit to 1, the user can send pulses to the polarized source.
CSR1,Bit 2 - Read Only. Latched PSS A fault. Stays latched as long as the PSS A fault in the accelerator exists. Pulse delivery to all guns stops. Clears when the fault clears and the user turns on one of the beam modes.
CSR1,Bit 1 - Read Only. Latched PSS B fault. Stays latched as long as the PSS B fault in the accelerator exists. Clears when the fault clears and the user turns on one of the beam modes.
CSR1,Bit 0 - Read Only. Latched FSD fault. Stays latched as long as the FSD fault in the accelerator exists. Clears when the fault clears and the user turns on one of the beam modes.

Description of CSR for the halls

Figure 2 shows the bit assignments in CSR0 and CSR 1 for Hall A. The registers for the other halls are identical - substitute Hall B or Hall C where Hall A appears in the bit assignments.

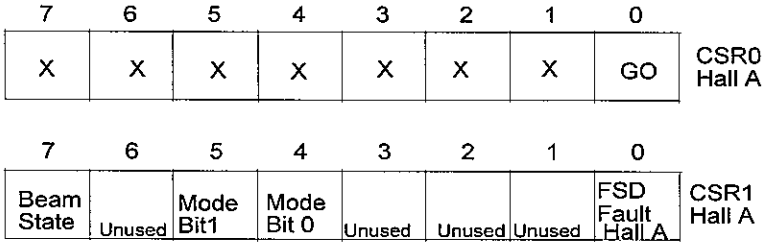

Figure 2

CSR0, Bits 7:1 - Unused.
CSR0, Bit 0 - Write Only. Writing a 1 to this bit enables pulse delivery to Hall A's gun. Writing a 0 removes the pulses at the Hall A's gun. (Go bit in the accelerator CSR0 must be set to 1 for any beam pulses to occur).
CSR1, Bit 7 - Read Only. Read back of 1 indicates that the pulses for Hall A gun are active. Read back of 0 indicates that there are no pulses to Hall A gun. For example, when we are running beam to Hall A and an FSD trip occurs, the read back will be 0. If the user turns off the beam, the read back will be 0
CSR1, Bit 6 - Unused.
CSR1, Bit 5:4 Mode bits - Read/Write. A table and explanation of the modes follow.

Mode Bit 1 (CSR bit 5)	Mode bit 0 (CSR bit 4)	Beam Mode
0	0	Viewer Limited
0	1	Tune
1	0	CW (DC)
1	1	Pass Mode

Viewer Limited Mode - Provides short (250 ns - 10 μs) line synchronized pulses to the hall.
Tune Mode - Provides the 'standard pulsed mod mode' (354 μs beam, and 250 μs later, 99.5 μs modulation) pulses. The accelerator mode must NOT be in Viewer Limited mode.
CW Mode - Allows CW(DC) beam to the hall. The accelerator mode must be in CW or User mode..
Pass Mode - The user sets Pass Mode in the relevant Hall's CSR1 to pass the beam structure from the Mizar 8310.
CSR1, Bit 3:1 - Unused.
CSR1,Bit 0 - Read Only. Latched FSD fault. Stays latched as long as the FSD fault in the hall exists. Clears when the fault clears and the user turns on one of the beam modes.

More on the accelerator and hall modes

This table explains the dependence of Hall beam modes on the mode settings in the accelerator.

Accelerator Mode	Hall Mode allowed
User	CW, Tune, Viewer Limited, Pass
CW	CW, Tune, Viewer Limited
Tune	Tune, Viewer Limited
Viewer Limited	Viewer Limited

Assuming that all halls have active beam signals,
If the user sets the accelerator mode to Viewer Limited, all Halls go to Viewer Limited. The user will not be able to set Pass, CW or Tune to any hall.
If the user sets the accelerator mode to Tune, Halls that are in Tune and Viewer Limited modes stay unaffected. Halls in CW or Pass mode drop to Tune mode. The user will not be able to set Pass or CW mode to any hall.
If the user sets the accelerator mode to CW, Halls that are in CW, Tune or Viewer Limited modes stay unaffected. Halls in Pass mode drop to CW. The user will not be able to set pass mode for any hall.
If the user sets the accelerator mode to Pass, Hall modes stay unaffected. The user may choose any mode for any hall.

Description of the Modulation Adjustment Register

For the thermionic gun in Tune Mode, the pulse structure is beam On for 250 μs, beam Off for 100 μs and beam on for 4 μs. During operations of the two guns, due to slight differences in the beam drive circuitry, the Off time for the polarized source had to be 99.5 μs instead of 100 μs in order for the SEE BPMs to record the signals. The 4-bit modulation adjustment register accommodates slight changes in the drive circuitry's timing and allows the off time to be between 98.5 μs to 100.5 μs. The default value on power up is 99.5 μs. When the value in this register is 0, the off time is 98.5 μs. Unit increment in the register value increases the off time by 125 ns.

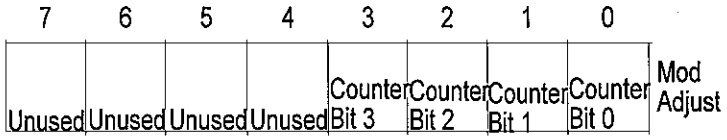

Figure 3

Description of the Viewer Limited Length Register

In Viewer Limited Mode, the hardware generates 250 ns pulse (power on default). User can program the Viewer Limited Length Register to set the pulse width to a maximum of 10 μs.
Unit increment in the register value increases the pulse duration by 250 ns.

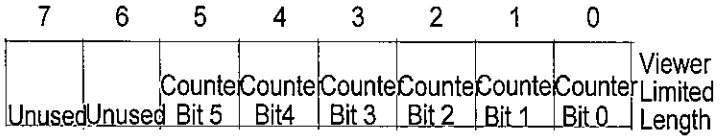

Figure 4

Description of the Harmonic Generator Register

The SCAM contains an AC phase locked oscillator to generate harmonics of the line frequency. Figure 5 shows the settings in the VME accessible register and the table below shows the SCAM's output frequency The primary oscillator has a frequency of 4320 Hz.

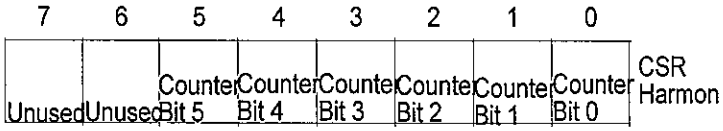

Figure 5

Bit 7:6 - Unused
Bits 5:0 - Read/Write. The table shows the allowed values.

Value in the Register(decimal)	Output Frequency (Hz)
0 (Default)	60
36	120
24	180
18	240
12	360
9	480
8	540
6	720

Register Summary

Accelerator CSR0 - VME Base Address + 1
Accelerator CSR0 - VME Base Address + 3
Hall A CSR0 - VME Base address + 5
Hall A CSR1 - VME Base address + 7
Hall B CSR0 - VME Base address + 9
Hall B CSR1 - VME Base address + b
Hall C CSR0 - VME Base address + d
Hall C CSR0 - VME Base address + f
Harmonic Generator Register - VME Base address + 11
Modulation Adjustment Register - VME Base Address + 13
Viewer Limited Length Register - VME Base Address + 15

6. RS232 Interface

The present SCAM has an electric to fiber optic interface to the Analog Devices 6B backplane in the HV deck. In the new system, we will use a commercial device at the RS232 port of the ioc to do the electrical to optical signal conversion.

7. Valve Interface for Gun Switching

The present SCAM has an input from valve VBV1I07, to indicate the source (polarized or thermionic) supplying the electrons to the machine. We use this interface to allow test modes for the two guns as well as selecting the Beam Sync, whether it comes from the SCAM itself (when polarized source is the supplier of electrons to the experiments) or from the Mizat 8310 (when thermionic gun is the supplier of electrons to the experiments).

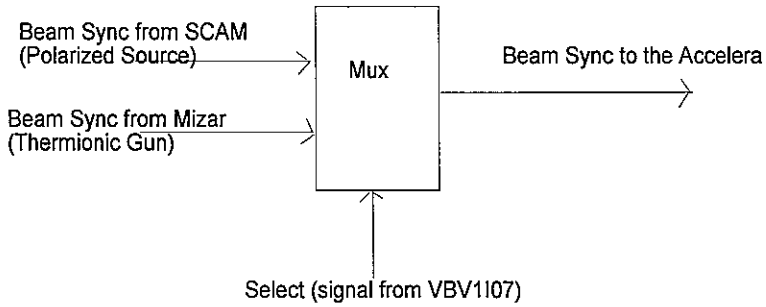

Figure 6

Test Mode during Restricted and Controlled Accesses

An HV interlock input, supplied by the Safety Systems Group, to the SCAM allows generation of beam pulses during restricted and controlled accesses. When the High Voltage to the guns is off, as indicated by the HV interlock input, the SCAM will ignore FSD and PSS faults. The user can generated pulses from the SCAM for test purposes.

Polarized Source in Test Mode during Thermionic Gun operations

The system allows beam from polarized source for test purposes, while the thermionic gun is providing electrons to the accelerator. In this mode, FSD faults from the transport lines do not turn off pulses from SCAM to the polarized source. PSS faults and FSD fault in the accelerator will turn off pulses from the SCAM. Note that any FSD or PSS faults will always turn of pulses to the thermionic source regardless of its mode (test or operations).

Hardware Block Diagram

Figure 4 is the hardware block diagram of the SCAM

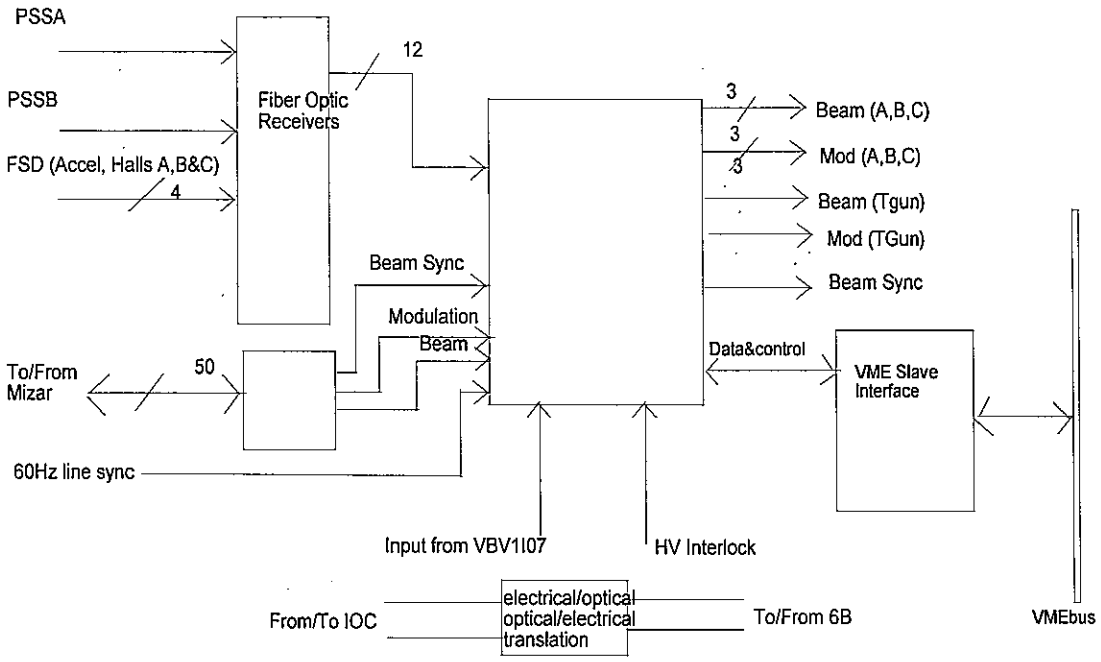

Figure 7

Programming Information

Assuming that the VME base address of the SCAM is 0xFFFF7130

```
/* Control and Status Register for accelerator */
volatile character  *accelerator_csr0 = (character *)0xffff7130;
volatile character  *accelerator_csr1 = (character *)0xffff7131;
/* Control and Status Register for gun 1 */
volatile character *halla_csr0 = (character *)0xffff7132;
volatile character *halla_csr1 = (character *)0xffff7133;
/* Control and Status Register for gun 2 */
volatile character *hallb_csr0 = (character *)0xffff7134;
volatile character *hallb_csr1 = (character *)0xffff7135;
/* Control and Status Register for gun 3 */
volatile character *hallc_csr0 = (character *)0xffff7136;
volatile character *hallc_csr1 = (character *)0xffff7137;
/* Harmonic Generator Register */
volatile character *harmonic_r = (character *)0xffff7138;

volatile character accelerator_mode, halla_mode,hallb_mode,hallc_mode,harmonic_mode;

/* set pulsed mod mode for Hall A
First - Set tune Mode in the accelerator CSR1. Then set tune mode in Hall A CSR1.*/

*accelerator_csr1 = 0x0;  /* For Pol.source only operation, this will be 0x40 */
/* verify that the correct mode is set */
```

```
accelerator_mode = *accelerator_csr1 && 0xff;
if (accelerator_mode !=0x) {code to report error}
*halla_csr1 = 0;
/*verify that the correct mode is set */
halla_mode = *halla_csr1 && 0xff;
If (halla_mode != 0; {  code to report error - It may be that the switch on SCAM was left in test mode }

/* set viewer limited mode for Hall B
This is allowed, since the accelerator is in Tune mode */

*hallb_csr1 = 0x10;
/*verify that the correct mode is set */
hallb_mode = *hallb_csr1 && 0xff;
If (hallb_mode != 0x10) {  code to report error }

/*set pass mode for Hall C */

*hallc_csr1 = 0;
/*verify that the correct mode is set */
hallc_mode = *hallc_csr1 && 0xff;
If (hallc_mode != 0) {  code to report error }

/* Now turn beam on to all halls - nothing happens until the accelerator CSR0 is set to 1 */
*halla_csr0 = 1;
*hallb_csr0 = 1;
*hallc_csr0 = 1;
*accelerator_csr0 = 1;

/* turn off beam to Hall B only*/
*hallb_csr0 = 0x0;

/* Display safety system status for Hall C */
hallc_mode = *hallc_csr1;

if (hallc_mode && 1 == 1) { report FSD fault Hall C}
if (hallc_mode >>1 && 1 == 1) {report PSS B fault for Hall C}
if (hallc_mode >> 2 && 1 == 1) {report PSS A fault for Hall C}

/* Choose 540 Hz as the beam sync frequency. First turn beam off in the accelerator */
accel_csr0 = 0;
*harmonic_r = 8;
/*read back and verify */
harmonic_mode = *harmonic_r;
if (harmonic_mode != 8) {report hardware error}
else
accel_csr0 = 1;  /*turn beam on */;
```