Electronic Setup for the BigBite Timing Hodoscope

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1 High Voltage

High voltage (HV) for the BigBite Timing Hodoscope (hodoscope) is provided by a CAEN SY1527N mainframe equipped with 8 A1932A HV modules. Each module provides 48 channels of high voltage so that only the first 4 are required to power the hodoscope. The remaining four are available for other systems.

After shipment in July 2019 the mainframe has undergone some initial testing and setting up. Basic communication is provided by an attached VGA monitor and keyboard. Primary power to the mainframe is turned on by the switch at the rear followed by the front key switch turned to `local`. `Main, OK, +5, +12` and `-12` leds should light up on the A1531 module and `+48` should show on any attached A1532 power supplies. The internal PC should then boot up and display some status and initialisation information, followed by a SY 1527 screen when complete. Touch any key to initiate a login window. Two accounts have been setup:

1. `admin` (passwd `admin`) to setup system parameters such as IP, accounts, change passwords etc.
2. `BBhodo` (passwd `bbhodo19`) to setup the HV channels.

There is no mouse or touch screen, so navigation around the window, displayed after login is performed, via the <tab> key and the four <arrow> keys. Operation of the HV system is described in the following.

1.1 Check hardware status

From any account, navigate to `Setup` and then down the menu to `Tech Info` and <enter>. Fan speeds should be around 2700 rpm and Primary and Optional

Power Modules 1,2 should be 'Present'. *Optional module 3 has failed and was removed. The mainframe will not operate at maximum power, but there is more than sufficient power for the 4 hodoscope HV modules. However we will try to source a replacement A1532 power module in Glasgow to provide full-power capability.*

To see the attached HV modules, navigate `Main`, `Crate Map`. This should display A1932 HV modules in slots 0, 2, 4, 6, 8, 10, 12, 14. The A1932 is double width so that odd slots show `Board Not Present`.

Hit <tab> to return to the main window.

1.2 Set IP

From the admin account navigate `Setup` then `Communications` and `TCP/IP Settings` and enter the IP Address, Netmask and Gateway, followed by OK. The IP has now been setup so that one can connect to the mainframe via telnet from an xterm or similar:

```
telnet 129.57.37.95 1527
```

The mainframe LAN card, which has a MAC address 00:0B:AB:11:E5:49, has now been entered in the local DNS data base, so that one can use the mainframe's name instead of IP.

```
telnet bbth-hv 1527
```

Note that the `1527`, which specifies the stream-socket port to use, is absolutely necessary and also that ssh will not work. After connection the terminal will display a login window similar to the attached VGA monitor. The same navigation keys are employed.

1.3 User Accounts and Passwords

As admin navigate `Setup`, '`Security`' and then the desired menu option to `Change Admin Password, Create New User, List Users, Exit`

1.4 Setting the HV Channels

After login as BBhodo, navigate `Main`, `Channels` to display the parameters of the HV channels. Note that the A1932 module jumpers have been set, so that in order to turn on HV:

1. The multiway cable must be connected at both the A1932 and the HV distribution box ends. Connecting the multiway cable makes a loop, which if broken, kills the HV immediately.

2. The `Passive Interlock` lemo connector on the rear panel must be terminated with 50 Ω. It is possible to daisy-chain the `Passive Interlock` ports to a single 50 Ω, which if pulled will kill all HV immediately.

If either of these interlocks is not made the channel display will show `Ext-Dis` `Status` and it is not possible to turn on the HV.

The A1932 has a single primary channel and 48 secondary channels. Secondary voltages are derived from the primary via a programable voltage drop in the range of $\sim$ 10 V minimum to 900 V maximum. Thus the secondary voltages, which are applied at the output are always less than the primary. The maximum primary voltage is 3 kV and maximum primary current 30 mA. The maximum secondary current is 0.5 mA. Do not exceed 1350 V on the primary channel.

The channel display table displays a various columns and those relevant to the hodoscope are described in the following.

`Channel Name` Primary channels of the 4 A1932 modules are named `HV_BBhodo_0 - 3.`

Secondary channels are named `hodo_L0 - 86` and `hodo_R0 - 86`.

Unused channels are named `spare.`

`VOSet` Primary voltages have an initial setting of 1100 V. To change the value, navigate with the <arrow> keys to the desired position in the display table (the current position is highlighted) and type the desired new value, followed by <enter>. Secondary voltages have a preliminary setting of 1000 V and are changed as for the primary. Note that the primary voltage has to be greater than any of the secondaries on a given module.

`IOSet` The maximum current output of the primary channel has been set to 12 mA which is sufficient to power the 48 secondaries at $\sim$ 0.25 mA each. Changing this value is accomplished as for `VOSet`. There is no provision to set the maximum current on the secondaries.

`VMon` This is the sensed voltage when HV is `On` and cannot be changed by the user. It should be within $\sim$ 1 V of the `VOSet` value.

`IMon` This is the sensed current for the primary supply and must be less than `IOSet`, otherwise the module will be current limited, which will then stop `VMon` from reaching the desired value. `IMon` is not available for secondary channels.

`Pw` Power is either `Off` or `On` and pressing the <space> bar while `Pw` is selected and highlighted will toggle between the two states. The secondary channels have been left `On` and turning HV `On/Off` is accomplished using the primary module only. Note that the secondary channels only turn `On/Off` in groups of 8. When a secondary group of 8 is turned on, a corresponding orange led will light on the rear of the A1932 module.

`Status` If `Ext-Dis` displays then one or both interlocks are broken and the module will not turn `On`. The interlock requires the 50Ω terminator on the rear panel of the A1932 module and the multiway HV cable must be connected at both ends. When the interlock is made a green led will light on the rear of the A1932 and `Ext-Dis` will be removed from the `Status` column.

`SVMax` This is the software maximum voltage setting, which is the upper limit for `VOSet` on the primary channel. It is set to 1350 V. Please do not change this limit. If it seems unsuitable consult Rachel Montgomery.

`V1Set, I1Set` For the present setting of the SY1527 these parameters are not used

`RDWn` Voltage ramp down speed, set to 150 V/s

`RUp` Voltage ramp up speed, set to 150 V/s

1.5 Groups of Channels

Channel grouping can be used to display and operate on selected subsets of channels. By default, channel display shows `Group00` which is all channels connected to the mainframe. To change the displayed group, navigate to `Groups` and then to the desired `Group01 - Group15`. Some groups have been setup:

`Group01` The 4 primary power channels of the A1932 modules attached to the hodoscope.

`Group02, Group03, Group04, Group05` Active HV channels attached to hodoscope A1932 boards 0, 2, 4, 6 respectivelyAdditional groups may be setup by selecting a group to view and then running the `Add Channels` or `Rem. Channel` utilities. If `Group Mode` is selected then operations such as `VOSet` or `Pw On/Off` will act simultaneously on all channels of the group.

`Group6` All secondary HV channels attached to the hodoscope

1.6 Status

The SY1527 mainframe has been located in the weldment and is currently running with 2 (out of 3) 48 V power modules, so that its current power capability is 2/3 of the maximum. 4 (out of a maximum 8) A1932 HV modules are connected and the 1st has been tested under load. After a fault in the wiring of the multiway HV distributer boxes as found and corrected, the 44 connected HV

channels, each set to 1 kV, draw 9.84 mA on the primary supply, set to 1.1 kV. Thus each hodoscope PMT base is drawing around 0.22 mA.

At present the A1932 boards seem to trip off randomly. The module HV_BBhodo_0 was replaced with one of the spares, which has reduced the trip frequency, but not eliminated tripping. Before any further debugging the mains power source should be changed to that which supplies the rest of the weldment (this needs a change of power connector). The A1932 cards are operating at about 1/3 of their maximum current, so in principle should run smoothly.

Note that programable HV parameters are stored on the A1932 modulDrafte, so that if a module is changed, the new module will require programing.

1.7 HV EPICS Controls

EPICS controls have been implemented for the SY1527 mainframe (Steve Wood). EPICS controls will provide more flexibility and allow for backup and restoring of HV settings. The EPICS driver for the SYS1527 controls is based on Hall B's driver (from `https://github.com/JeffersonLab/clas12-epics`) and the GUI is based on Hall C's HV screens.

Some of the details below such as location of files and instructions for starting EPICS and GUI controls will change when the detector is moved to the hall.

1.7.1 Starting EPICS

In order to activate EPICS controls for the high voltage, the EPICS server must be running. The EPICS server may either be started manually, or it can be configured to start automatically using cron and the procServMgr package.

To start the server manually, use these commands on the `bbhodo` account:

```
cd ~/EPICS/sbs-epics/apps/iocBoot/ioccaenhv
./st.cmd
```

If the IP address of the SY1527 crate is changed, edit the line

```
Start_CAEN(0, "129.57.37.95")
```

in `st.cmd`.

To configure the EPICS server to start automatically, use this command to configure cron:

```
crontab ~/EPICS/sbs-epics/tools/procServMgr/tedbbdaq.crontab
```

Then after 5 minutes, check that the server is running with

```
ps -aux | grep procServ
```

which should show a line that include `ioccaen`.

To disable automatic starting of the server, remove the crontab entry with

```
crontab -d
```

and stop the server with

```
killall procServ
```

When the EPICS controls are relocated to the counting house computers, the locations of files will likely change.

1.7.2 HV GUI

To run the HV GUI, use these commands:

```
cd ~/EPICS/HV
./starthvgui
```

This will bring up a GUI with bar charts showing the voltage readback and current draw of every primary and distrubted channel. The current draw is meaningless for all but the four primary channels.

To view or change individual channels select one of the five groups from the "Group" menu. These groups are detectors 0-44 for the right and left bars, and detectors 45-89 for the two sides. The fifth group is the primary channels for each of the slots. The primary channels do not necessarily correspond to the detector groups.

Not all properties are available for the distributed channels. Namely current monitoring and current limits for tripping are only availble for the primary channels. A "-1" is shown for these fields on the distributed channels.

1.7.3 Reconfiguring EPICS and GUI

If the mapping of HV supply channels to PMTs changes, both the EPICS software and the GUI screens must be rebuilt. To do this rebuilding, first edit the spreadsheet (e.g. `HodoMapping_Mar2021.csv`) that defines the HV cable mapping and save it to a CSV file. Then run

```
cd ~/EPICS/sbs-epics/apps/caenHvApp/Db/subs
./BBHODOsubs.py -csvfile CSVFILENAME
```

This will create `HVBBHODO.substitutions`. If python3 is not installed, you may need to run the script on a different computer and copy the substitution files back to the subs directory.

After updating substitutions files, rebuild the EPICS system with:

```
cd ~/EPICS/sbs-epics/apps
make
```

Then stop the EPICS server and restart it as described in section 1.7.1. If the server is configured to run automatically, do `killall procServ` and wait 5 minutes for the server to restart. (Or do `telnet localhost 20000` and type `exit`.

When HV channel mappings are changed, the GUI must also rebuilt. When `BBHODOsubs.py` is run it also creates `HV.hvc` and `HV.group`. Copy these files into `~/EPICS/HV/bb_hodo` type `make` in that directory.

2 Low Voltage for NINO Cards

2.1 Main Power Supply

Low voltage is provided by an Agilent N5761A DC supply which can produce 0 - 6 V up to a current of 180 A. It now sits in the weldment directly above the SY1527 HV system. Remote control via a LAN interface is possible, but this has not been setup yet.

A LV panel has been installed to distribute to the 12 NINO cards attached to the hodoscope. Each NINO-card line is fused at 1.5 A. Due to voltage drop along the supply lines the supply has been set to +5.97 V in order to deliver +5.0 V at the NINO card. The total current drawn is 15.8 A. At this current the ripple on the DC voltage was measured as 5.4 mV peak-to-peak. Noise at the analogue output of the NINO card was measured as ~ 0.5 mV.

The NINO cards have also been connected individually and each found to draw the expected 1.3 A.

2.2 Threshold Power Supply

The NINO cards have been jumpered to use the onboard threshold voltage. This has been adjusted to +1.5 V using the onboard potentiometers.

3 NINO Cards

12 NINO cards, 6 on each side of the detector stack, have been installed for the hodoscope.