A NEW TV BEAM OBSERVATION SYSTEM FOR CERN

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Abstract

Beam observation, emittance measurements and initial beam steering, are often achieved using scintillating or OTR (optical transition radiation) screens. In the CERN accelerators complex, this system is known as the BTV or MTV system. It consists of an observation camera, an illumination device and a vacuum tank provided of a view port containing the radiator.

More than 100 such equipments, in several different flavours, are installed in the CPS complex, another 50 in the SPS complex and another 50 will be installed in the upcoming LHC.

The newly developed electronics hardware consists of a single VME 64x card. This card is capable of controlling: all the different types of positioning mechanism for the screens, the adjustment of the illumination intensity, the different types of cameras (i.e. CCD or Vidicon tube) and the positioning of optical filters in front of the camera. Apart from the analogue video signal the card provides as output also the digitized image.

A preserie of this new electronics has been installed and tested during the tests of the LHC beam transfer line TI8 last autumn. The production of 300 cards is now underway. These cards will be used for the complete renovation of the MTV system of the CPS complex[1] and for the installations in LHC and its transfer lines.

In this contribution the new system is described with particular emphasis on the new VME card. The performances and limitations are also presented.

SYSTEM OVERVIEW

Figure 1 shows the principle of a TV beam observation system (BTV or MTV), where a radiator screen, attached to an insertion device, an illuminator and a camera represent the basic of the system. The type of radiator depends on the type of beam (sensitivity, dynamic range, linearity and temperature issues) and on the type of measurement to be done. To cope with the problem of the dynamic range of the beam, filters can be used in front of the camera.

The complexity of this system arises mainly from the variety of equipments that were installed over the past 25 years. Now, thanks to the recent unification of different accelerator departments of CERN and to the development of new devices for LHC, all new installations of BTV and MTV systems are made following a standard design, which simplified layout is shown in figure 2. For the new mechanical designs too, as many parts as possible are reused, in particular, all the 50 new BTVs in LHC will share the same type of mechanism. The problem of the many existing different devices is however much reduced now with the installation of the new control hardware.

Figure 2: Layout of the new BTV/MTV hardware control system.

Figure 1: Principle of a BTV or MTV system.
NEW HARDWARE CONTROL

A new VME card for the control of the beam observation system of CERN has been designed. The objective was to redesign completely the system for all new installations, like LEIR and LHC, and taking advantage of this new design to renovate the park of MTVs on the Proton Synchrotron complex.

Specifications

The electronics has to be able to:

- Control CCDs or Vidicon tube cameras
- Transmit the video signals over long distances (up to 1200m)
- Control the intensity of filament light bulbs (24V/5W)
- Control all the existing different types of insertion devices (electric with 2, 3 or 4 positions, Pneumatic with 2 or 3 positions)
- Control the new insertion and filter devices.
- Provide digitalization of the video signal

Moreover, all these features had to be implemented in a single VME64X 6U card (2 or 3 different crates were needed with the old system).

Card insight

The card is based on a 240 pins FPGA from ALTERA. The 175 I/O are used to interface with the VME bus and in general for all the digital circuits of the system (control of power drivers, timings, digitalisation, video processing, etc...). The use of FPGAs allows much more design freedom and reduces space requirements on the PCB, so that all the features can fit on a standard size card.

Two light bulbs are driven independently by a fast switching circuit, synchronised with the horizontal synch. The light intensity is controlled using a DAC (0 to 1V).

The type of insertion device to be controlled is selected via a rotary switch. This indicates to the FPGA which control logic to use. The configuration of the power drivers is made by the mean of straps on the card.

The video receiver includes an amplifier of 26dB that is used only with the Vidicon camera where the signal is small. A set of bits, this time programmable from the VME bus, selects one of 4 different amplification levels for the video signal before being digitized.

The digitalisation is made using a 12 bits ADC clocked at 8MHz. The acquisition RAM size is 512x512x16, which allows the storage of 1 image at a time (the useful image area is 500x320).

Some input and output signals have been added directly in the front panel, (veto and ext-TRIG as inputs and screen-OUT as output). The composite video signal is also available on the front panel. A picture of the card is given in figure 3 with its main features highlighted.

Video performances and limitations

The video signal from the camera is transmitted over twisted pair cables to the receiver on the VME card up to 1200m away. After the signal is received on the VME card it is completely reconstructed and the video level adapted.

The video signal is then amplified to 5Vpp and sent to the ADC. For 5V signal, the comparable noise is 50mV, which leads to a S/N ratio equal to 1%.

The signal attenuation over 1200m cables is 20%. Figure 4 shows a video signal sent over 1200m. The S/N ratio is not influenced by the cable length; in fact the main source of noise is the VME crate itself. A typical measurement of a laser beam can be observed in figure 5.

![Figure 3: Overview of the VME64x BTV/MTV control card.](image)

![Figure 4: Video image and relative projection showing the linearity of the system (cable length of 1200m).](image)
THE CONTROL CRATE

The VME64x crate is the new standard for the whole accelerator control system. A new hardware environment has been developed around it in order to make the complete BTV/MTV system compact and easy to handle.

The system is composed of the following components:

- VME-64x crate
- Additional specific power supply (lamps, motors, HV) distributed over the P0 connector
- Transition modules to bring the specific power lines to the P0 connector (back and front of crate)
- Transition modules to bring the signals from the BTV/MTV cards to the back of the crate

Up to 8 BTVs can be installed in the same crate. The number of devices per crate is limited by the available space for the connections on the back and by the maximum power of the power supplies and VME bus lines. Figure 6 shows a complete system.

SOFTWARE ENVIRONMENT

The front-end software runs on the VME controller (Power PC). It consists of one real-time task per device and a communication server built using the FESA framework [2], the current AB standard. The FESA framework provides the controls infrastructure (task handling, beam synchronization, middleware…) on top of which the real time behavior and user interface of the equipment is modeled. A graphical user interface (figure 7) accesses remotely the front-end software to display the acquired images and profiles and to provide the status and control registers of the BTVI device.

STATUS / CONCLUSION

A new VME electronics card for the control and acquisition of the beam observation system (BTV/MTV) has been designed. In September 2004, 13 new BTVs have been installed in one of the transfer lines to LHC (T18) using this new system. The results have been very positive, achieving all the required specifications. The series production of 300 cards has already been launched. LEIR, the Low Energy Ion Ring, will be the next machine at CERN to benefit from this new electronics, followed by CNGS, the remaining of the LHC transfer lines and the LHC itself.

An executive plan has already been prepared for the renovation of all existing MTV systems of the PS accelerators complex and the Clic Test Facility (CTF3).

REFERENCES
