Optimizing reliability and identifying current limitations of the MTV system for 5 Hz CTF3 operation

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Abstract

Given the large number of MTV's installed at CTF3 (24), the system should be operated in its most reliable state. The most reliable method to operate the system given its current hardware will be described. In addition, the hardware limitations to the system will be identified for two modes of operation, the first being operating simultaneously at the current frequency which is 0.833 Hz (1.2 s cycle) more than one MTV, connected to the same VME crate and secondly the mode of operation when the CTF3 machine would be running at about 5 Hz.

Contents

1 Description of the Current System

1.1 Choice of Camera

For most systems in CTF3, the camera used is B/W CCD Camera. made by Sanyo, Model number VCB-3385P. It has a CCIR standard analog video signal output with 582 interlacing lines at

15625Hz, with a filed rate of 50 Hz. The total number of physical pixels 795(H) $\times$ 596(V).

The analog signal is digitized by the BTV card. Normally, the analog signal of $52\mu s$, is sampled at a frequency of 8 MHz, given by the clock on the card. With these settings,

$$\frac{\text{Sampling Time Window}}{\text{SamplingRate}}; \tag{1}$$

$\frac{52\times10^{-6}\text{s}}{\frac{1}{8\times10^{6}}\text{s}} = 414$ vertical samples and the array is then typically 414(V) $\times$ 290(H). Of these "pixels", one can configure the readout only a subset of these pixels, in order to optimize the image size and the time it takes to read out an image. For example, at CTF3, an array of typically 378×274 pixels is read.

1.2 MTV control card

The BTV card is triggered by the timing system of CTF3, which has a repetition frequency of 0.833 Hz (1.2 s CTF3 Period). As shown in Figure 1, the readout of the camera is then triggered at the first vertical sync after this CTF3 trigger. The image read has a 20 ms integration time, which is the time until the next vertical sync.

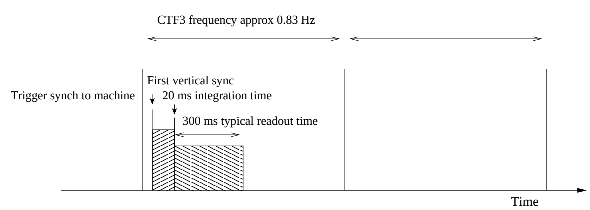

Figure 1: Trigger of camera and readout time

1.3 VME crates and CPU modules

Four VME64x crates and 4 CPU modules are installed in CTF3. These are manufactured by CES Model RIO-3 8064 Operating system is Lynx-OS version 4, and are named:

1. DCTFMTV1
2. DCTFMTV2
3. CTF-2010-BTVCLEX1
4. CTF-2010-BTVCLEX2

Currently, 8 BTV cards are installed on each of the first 3 BTV crates, making those crates full. There is at the moment only 1 card installed on CTF-2010-BTVCLEX2.

The BTV cards were designed primarily for the large scale project of the LHC and the CPS-renovation and then for the SPS , where the trigger rate is lower than for CTF3, and that costs and performance of this system was optimized for that purpose and to standardize the system. Hence a choice was made to address the cards is done with only 16 of the available 32 bits, which was not needed for the LHC system. The data bus width used is 16 bits.

1.4 Data acquisition and controls

Once a camera is switched in, requests are sent and the image is read. Hence, it is important to only switch on cameras that are being used for a particular measurement. To read an average size image through the VME the CPU takes approximately 300 ms, see Table 1.

case	time (ms)	array size	CPU load (with only one user)
A	343	385×285	$27\% - 32\%$
B	210	256×256	$24\% - 27\%$
C	55	120×120	$21\% - 23\%$

Table 1: The time it takes to read an image with the current CPU. This excludes transmission over CMW or any treatment of the image, for example fitting etc.

To quantify reliability issues, a test was performed using a camera from the PSB. This consisted of one by one switch ON the cameras, thus, starting the FE-server acquisition. An typical array size of about 380×280 was read. When one camera is ON the process takes around the 30% of the CPU, as listed on Table 1, two cameras ON goes to almost 60% CPU, three cameras over 85% and 4 cameras ON overload totally the CPU. When the CPU is overloaded, it is still possible to "ping" the PC but the acquisition of the images no longer takes the normal reading time, and this can sometimes lead to a complete overload of the crate and the crate will crash and need to be rebooted. This means that acquiring at each user with the current image size more than 3 cameras is just not possible with the current CPU. In order to read more than 3 cameras, the size of the array should be reduced.

2 Operation and reliability

2.1 Reliability tips to run 1 camera at 0.833 Hz

From the above test of CPU load and acquisition time, it should be possible to operate reliably one camera at 0.833 Hz operation. In this configuration, all other cameras should be switched off.

The acquisition time can be reduced if the image array size if reduced. With an array size in the range of case A and B in Table 1, the speed of the CPU would be the main limitation in making the system faster, the transmission over the CMW, which is estimated to be of the order of 20 ms will be minimal. When the array size is reduced to the order of case C, then the transmission over the CMW will take significant fraction of the time, and should be studied in more detail by the control group. It should be also possible to have more than application requesting the image from over the CMW, as long as the application is fast enough. In principle the speed of the internet should not be a limiting factor.

2.2 Acquiring data from more than 1 camera on the same crate at 0.833 Hz

As mentioned in the previous section, running 2 camera simultaneously is achievable given the CPU load (60% with the current array size). Recommendations would be to reduce the array size for more reliability. Running 3 camera is near the CPU limit (80%) and should be avoided. Running more than 3 cameras is impossible in the current configuration and with the current array size . The crate will crash and in most cases need to be rebooted.

2.3 Limitations to running the system at about 5 Hz

Given that a single image takes 300 ms to read out, it is not feasible to run a system consisting of 1 camera faster than 3 Hz. Running at 3 Hz would be the absolute limit because 300 ms $\times$ 3 is needed to read the images, and the camera integration time would be 20 ms $\times$ 3 plus latency. In order to run at 5 Hz a single acquisition needs to take less than 180 ms.

A simple solution to reduce the readout time is to digitize a smaller time window, as described in Equation 1, and hence read a smaller array size. It is estimated, that it will be possible to work with the current system at 5 Hz if a digitizing sample is selected that results in an array size of about 150×150, see Table 1.

2.4 Modifications to system to acquire data at about 5 Hz

In order to read out the the full image, one would need to increase the CPU by a factor of 2. Modifications to BTV card should be avoided, since this card also controls the movement of the screens and control of the lights and hence it would be a large amount of work. As mentioned before, to work with the current system at about 5 Hz a smaller digitizing sample can be selected, for example less than a 150×150 size array. To change the configuration from 0.833 Hz to another acquisition frequency will require a change in the configuration code, running on the crate. After a recompilation, the acquisition will happen at the new frequency.

3 Recommendation for control system independent operation at 5 Hz

3.1 Dedicated PC and frame grabber for specific experiment at 5 Hz

If the requirements to operate simultaneously 2 cameras at 5 Hz is restricted to the Two Beam Test Stand (TBTs) area in the CLIC Experimental Area (CLEX), then a solution might be to equip only those two cameras with a dedicated commercial frame grabber connected directly to a dedicated PC, and by–pass the control system and regular BI/SW installation. These frame grabbers with the corresponding control software can be bought from industry and incorporated to software like LabView of Matlab.

3.2 Digital camera technology for specific experiment at 5 Hz

Alternately, what would be the technology for the future, would be to have the CCD signals directly digital converted at the camera head and transferred using Firewire IEE139xx protocol. Compared to an analog video link, no degradation of the signal due to long cables occurs. The Firewire bus standard allows at data rate of about 800 Mb/s over an ethernet cable and in the future to xGbit/s over single mode fiber cables [1]. An investment would need to be made in new camera hardware and corresponding readout and data transfer equipment. The BTV card would still be used to control the screen and the lights.

4 Support from BI for system at 5 Hz

There is currently no planning foreseen for an upgrade of the BTV card or a change in the hardware of the camera, however the front end code can be recompiled for an acquisition at another frequency.

References

[1] The latest technology should be checked.