Local Trigger Processor

Philippe Farthouat, Per Gallno, Georges Schuler, Ralf Spiwoks
CERN

Description of a module interfacing a TTC partition to the central trigger processor and containing all the necessary ingredients to run a partition in stand-alone mode.

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Revision 1. July 2002. First draft based on the DCTPI and the liquid argon LTP specs.

Revision 2. September 2002. Add all functionality to be able to run several LTP in a separate partition. Add block diagrams. Rename the module LTP.

Revision 3 & 4. December 2002 and January 2003. Clarifications and including comments.

Revision 5. February 2003. Comments from Guy Perrot.

Revision 6. December 2003. Comments from the DIG included. Version presented at the January 2004 review.

1.0 Introduction

ATLAS is divided in 36 partitions, each of them having its own TTC network, controlled by its own TTCvi. Each partition can run in two modes:

- Global mode, when the TTC signals are coming from the Central Trigger Processor and when the data are part of the main ATLAS run and read-out through the main ATLAS central DAQ system;
- Local mode, when the partition is run stand-alone with “private” TTC signals and when the data are kept separate from the main ATLAS run.

In both cases, the TTCvi must receive all the TTC signals and a way of handling the dead-time has to be foreseen. In addition, some mechanisms allowing special calibration sequences must be allowed.

This note describe a module which will interface the TTCvi with the trigger source which can be either the CTP when running in global mode or some local electronics when running in local mode. The module allows also to combine several TTC partitions in local mode.

2.0 TTC partition root

A TTC partition is driven by a set of 4 modules :

- The LTP;
- The TTCvi;
- The TTCxx (ex, vx or tx);
- The ROD-Busy module.

The LTP interfaces the partition to the Central Trigger Processor when running in Global mode (i.e under control of the CTP) and to the local trigger logic when running in Local mode.

The interface to the CTP is done through a differential link (CTP Link). As the number of TTC partitions in ATLAS is high (a bit less than 40) it is not affordable to have as many CTP Links provided by the CTP. Only 20 of them will be available and there will be one link per sub-detector. It means that one CTP Link connect the CTP to all the LTPs of a given sub-detector and only to these LTPs. The link is daisy chained between the LTPs of a given sub-detector. The connection through the CTP Link of the LTPs of a given sub-detector allows to easily run several partitions of a given sub-detector in local mode (see Section 4.1).

The TTCvi provides the A- and B-Channel signals to the TTCxx module which contains the encoder and the electrical-to-optical converter.

The ROD-Busy module gathers the Busy signals from the RODs attached to this partition to form an overall BUSY signal which will throttle the trigger source (either the CTP or some local trigger logic).

3.0 Partition in a Global run

In normal running an ATLAS partition receives the Timing, Trigger and Control (TTC) signals from the ATLAS Central Trigger Processor (CTP) through a set of interfaces as shown in Figure 1 and detailed in Table 1.

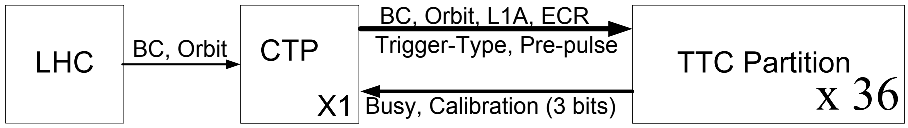

FIGURE 1. Interface between the CTP and a partition

TABLE 1. Signals exchanged between the CTP and a TTC partition when the partition is in the central data acquisition system (global mode)

Name	Function
BC	LHC clock
ORBIT	LHC ORBIT signal used for instance to issue the BCR signal
L1A	L1 Accept signal
Trigger-Type	8-bit trigger-type word issued by the CTP with each L1A
ECR	Event Counter Reset signal. Signal used to reset the 24 low-order bits and to increment the 8 high-order bits of the L1ID
Pre-Pulse	A signal issued by the CTP indicating that in N BC a L1A will be issued. This signal can be used, for instance, to fire a calibration or test electronics at the right time during data taking
BUSY	The BUSY signal generated by the RODs of the sub-detector when their buffers are almost full. Used by the CTP to introduce dead-time
Calibration	3-bit word issued by the sub-detector and used by the CTP to generate calibration triggers

The CTP gets the BC and the ORBIT signals from the LHC machine. These signals should always be available even if the machine is down. For each partition included in the main ATLAS run (global mode) the CTP delivers the BC, ORBIT, L1A, Trigger-Type, ECR and pre-Pulse. It will receive from each sub-detector a BUSY signal and a 3-bit calibration trigger request. It has to be noted that in the case a sub-detector contains more than one partition, the BUSY signals which is transmitted to the CTP on the CTP Link is already the logical "OR" of the BUSY signals of these sub-detector partitions (see Figure 3).

Two ways of having calibration trigger during physics runs are provided by the CTP as defined in Section 3.1. They involve the Pre-Pulse signal provided by the CTP and a 3-bit calibration request sent by a sub-detector to the CTP. It has to be noted that in the case a sub-detector contains more than one partition, several LTPs are sharing the same CTP Link and only one of those LTPs is able to issue the calibration requests. The selection of the LTP in charge is to be done by the sub-detector.

TTC commands (B-Channel of the TTC) are associated to B-Go<0..3> signals of the TTCvi. Due to the internal TTCvi arbitration scheme, it is mandatory that the BCR signal uses the highest priority command (B-Go<0>, but the BCR is derivated from the ORBIT signal in the TTCvi) and the ECR signal to B-Go<1>. The connection of the Pre-Pulse signal to a particular B-Go (B-Go<3> on the figure) is not mandatory.

Figure 2 shows a view of the different modules and their connection when in global mode.

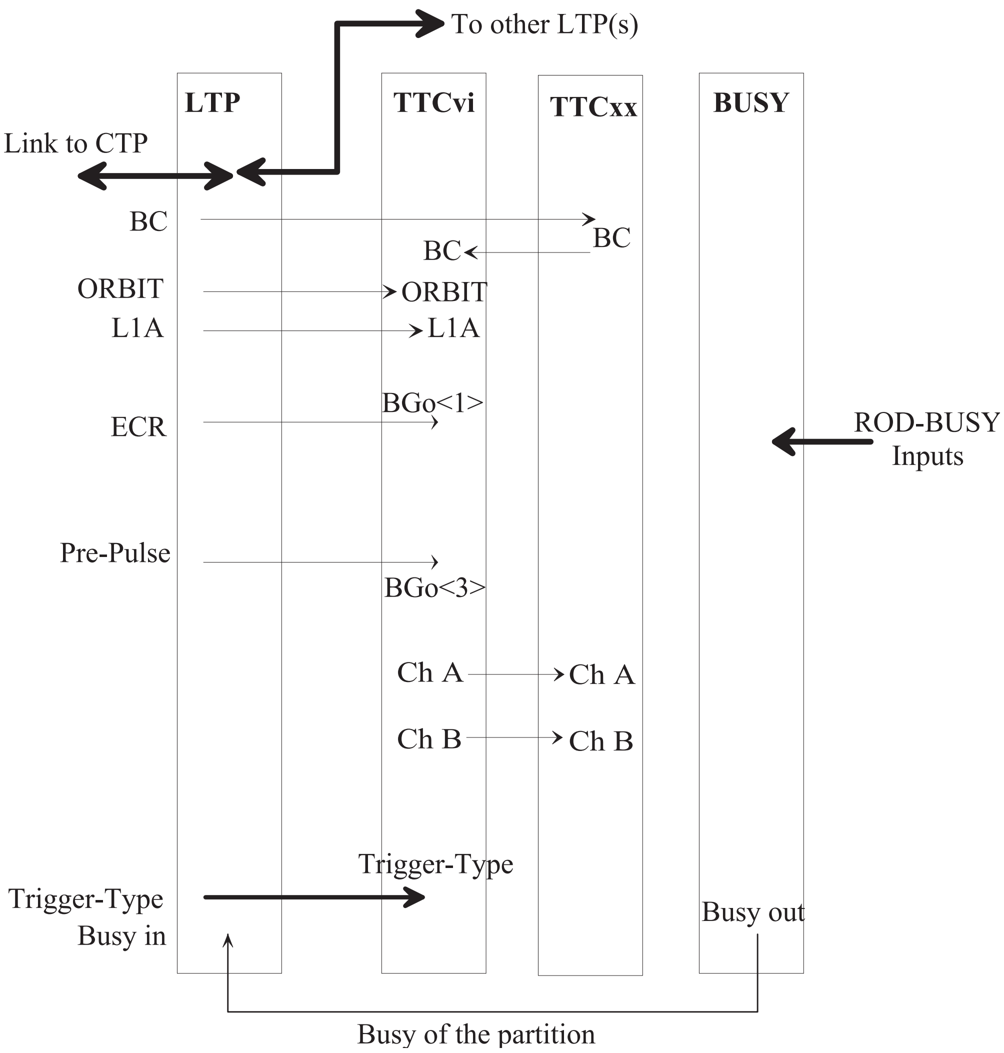

FIGURE 2. View of the TTC root modules in global mode

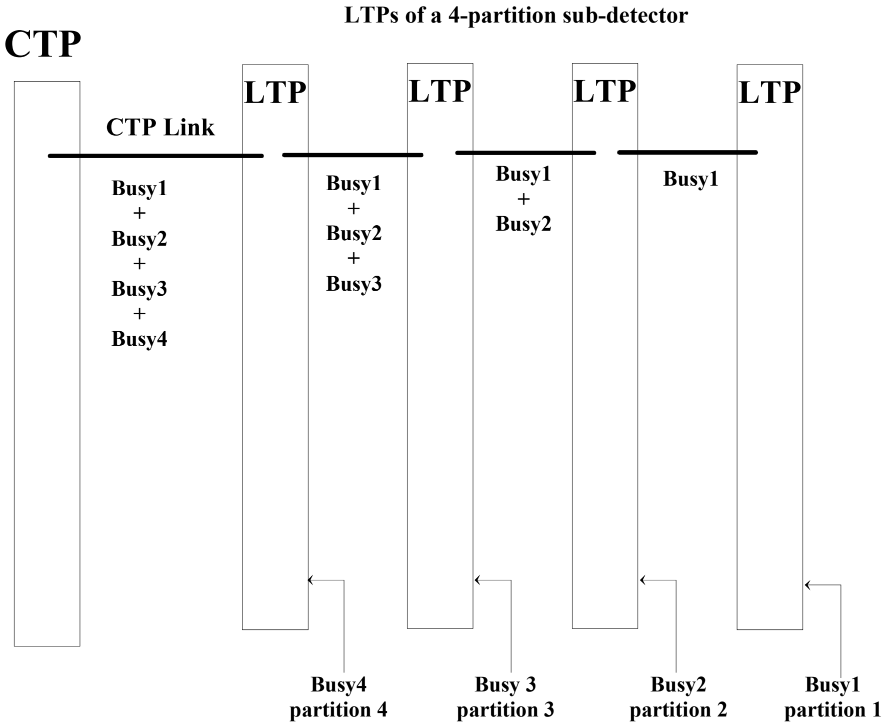

FIGURE 3. Daisy chain of the BUSY signals of the different partitions of a sub-detector

3.1 Calibration during a physics run

During a physics run all L1A must be centrally issued by the CTP to avoid synchronisation problems. This means that even the calibration triggers have to be handled by the CTP. Two mechanisms are implemented for such triggers:

1. The CTP issues trigger at a known BCID during the LHC turn. In order for a subdetector to make efficient use of such a trigger the CTP issues a Pre-Pulse signal a fixed number of BCs before the trigger will be issued. When receiving this signal a sub-detector can decide to perform a calibration sequence (e.g firing a generator) with a timing such that the L1A associated to this Pre-Pulse will be in phase with calibration data. It has to be noted that despite the fact that the CTP implements the necessary logic to make sure that a L1A will be issued a fixed time after the Pre-Pulse, it may happen that external dead-time (BUSY signal) masks this trigger.
2. The long gap at the end of the LHC turn can be used by sub-detectors to perform calibration sequences on request. In order to avoid problems (e.g a calibration trigger for one sub-detector being masked by the dead-time introduced by a calibration trigger from another sub-detector), the gaps are uniquely assigned to subdetectors. A 4-bit counter incremented by ORBIT and reset by ECR counts the LHC cycle modulo-16 (turn number). Each sub-system will be assigned a turn number during which any operation can be performed. The use of ECR and BCR to maintain the turn numbering allows a very easy implementation across the experiment. The calibration requests from one sub-detector will be taken into account by the CTP only if the gap is allocated to this sub-detector.

The timing (i.e the BCID at which the L1A will be issued) can be done in two ways:

- The L1A is issued at a given BCID (programmable) as soon as the 3-bit calibration request word transmitted on the CTP Link is equal to predefined values (the value of the calibration request word are used as input in the CTP and hence enters in the trigger menu);
- The L1A is issued when a transition on the calibration request word occurs.

As already mentionned, in the case a sub-detector contains more than one partition, several LTPs are sharing the same CTP Link and only one of those LTPs is able to issue the calibration requests. The selection of the LTP in charge is to be done by the sub-detector.

In both case the value of the calibration word is used by the CTP to form the Trigger-Type word.

In both cases the sub-detectors are in charge of the timing adjustment; the CTP team is in charge of programming the CTP accordingly to the sub-detectors requirements in terms of trigger.

The LTP keeps track of the turn number and is capable to provide a signal when the turn number is equal to a progamable value; this allows a sub-detector to know when his calibration request is taken into account.

4.0 Partition in local mode

In the ATLAS pit, the BC and ORBIT signals are always available. Still, for debug purpose (outside of the ATLAS pit) an internal crystal oscillator (40.08 MHz) can provide the BC clock. Similarly, the ORBIT signal can be internally generated.

In local mode, all other signals are locally generated and handled. Test trigger inputs are made available and output towards the test trigger inputs of the TTCvi after having been vetoed by the BUSY signal which is now locally handled (i.e it is not transmitted to the CTP). Similarly, the Trigger-Type has to be locally generated.

The test triggers and the local commands can either be issued externally (with a generator for instance) or internally.

Figure 4 shows a view of the TTC root modules when in local mode.

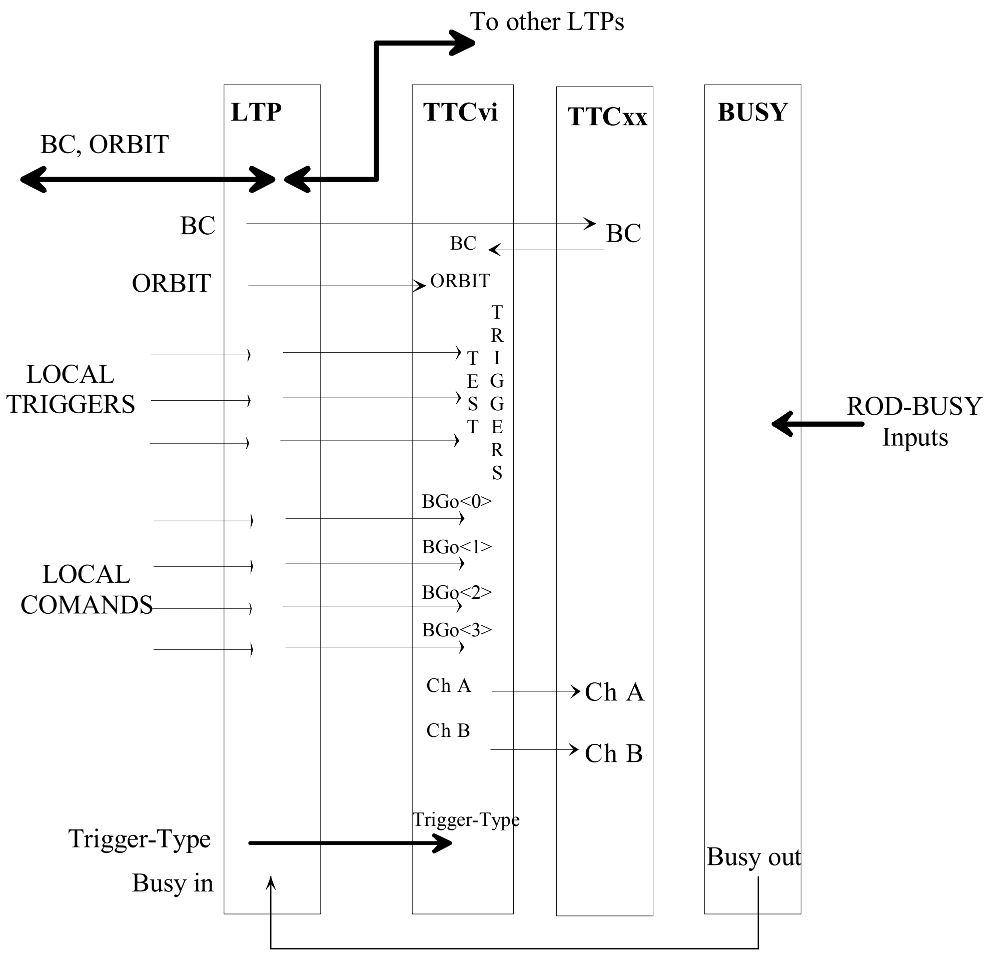

FIGURE 4. View of the TTC root modules when in local mode

It must be possible to have several LTPs connected together when running in local mode. For instance it is necessary to be able to run the calorimeter level-1 trigger partition together with the calorimeters partitions. The LTP provides all the functionality required to do so and different cases must be considered.

4.1 Combining several partitions of one sub-detector in local mode

In this case the LTPs of the different partitions are connected to the same CTP Link as shown in Figure 5. The first LTP of the chain will act as a master of the others (referred as local master), i.e it will transmit on the link all the trigger and timing signals used locally and will receive the BUSY from the others LTP. The BUSY signal used by the master LTP is the OR of the BUSY signals of the partition (see Section 5.2.9). As already mentioned, the calibration request signals are not handled in this mode.

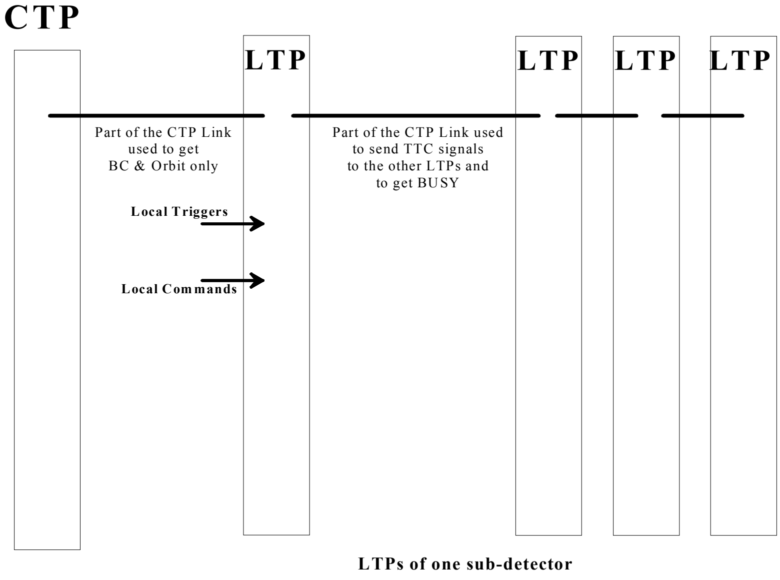

FIGURE 5. Combining partitions from the same sub-detector

4.2 Combining two partitions from 2 different sub-detectors

In this case one of the LTPs of one of the sub-detectors has to act as a master and a few extra cables transmitting the trigger and timing signals (from the master to the slaves) and the BUSY signal (from the slaves to the master) have to be provided as shown in Figure 6. The BUSY used by the master LTP is the OR of all the BUSY signals of the partition. This OR is done in the LTP (the local master LTP of sub-system 2 delivers the OR of all the BUSY of sub-system 2; the local master LTP from sub-system 1 makes the OR of the sub-system 1 BUSY signals and of the BUSY delivered by the local master LTP of sub-system 2). Here also the calibration request signals are not handled.

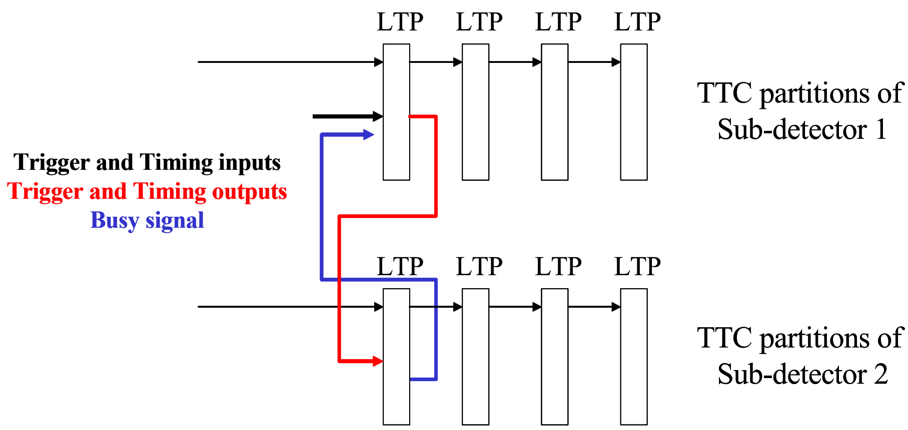

FIGURE 6. Combining partitions from two sub-detectors

4.3 Combining several partitions from several different sub-detectors

Similarly to the previous mode, one LTP has to act as a master, but there is now a need for transmitting timing and trigger signals to several places and to receive BUSY signals from several places. This can be done using standard NIM-ECL converters as shown in Figure 7. As in the previous case, the local master LTPs of sub-detectors 2 and 3 deliver the global BUSY signal of each sub-system. The OR of BUSY signals from sub-systems 2 and 3 can either be done as wired OR on the link between the NIM-ECL converters or in the BUSY module of sub-detector 1; this last possibility has the advantage of providing all the tools for monitoring the BUSY signals. The final OR of all the BUSY signals is done by the local master LTP of sub-system 1.

The extra cabling necessary to connect partitions from several sub-detectors can stay in place; the selection of the operating mode (global, local with one sub-detector only, local with several sub-detectors) is programmable. However the limited number of Local commands and Test trigger inputs may be a problem. For instance, we need to have local mode runs with the level-1 calorimeter trigger electronics alone, with the Larg calorimeter, with the Tile calorimeter or with both of them; the calorimeters themselves must be able to run in local mode also. If in all cases all the test trigger inputs and local commands input are needed, then a recabling or an extra multiplexer module will be required.

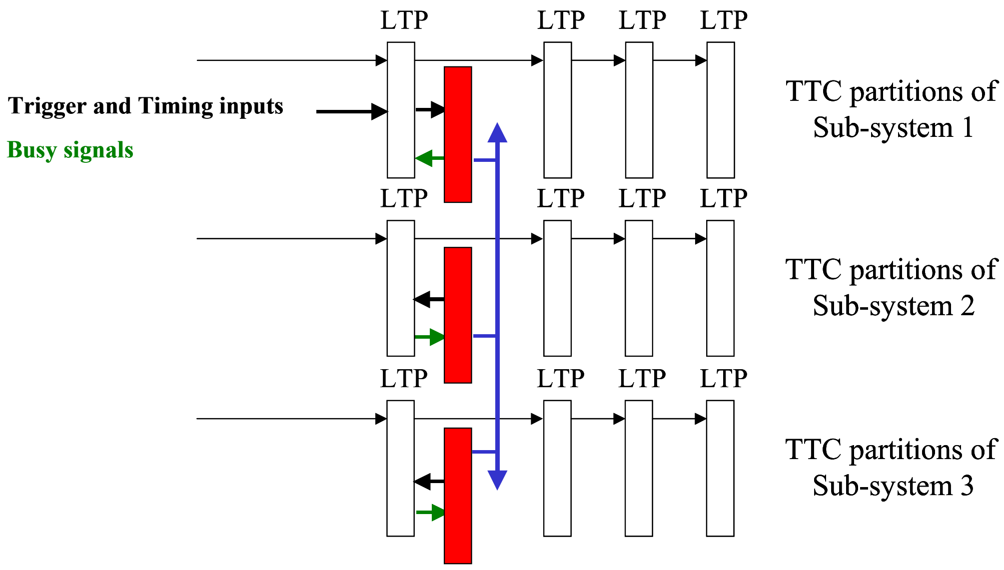

FIGURE 7. Combining partitions from several sub-detectors

5.0 LTP module description

As a first approximation the LTP consists of a programmable switch allowing to interconnect any Input to any Output and a pattern generator, as shown in Figure 8.

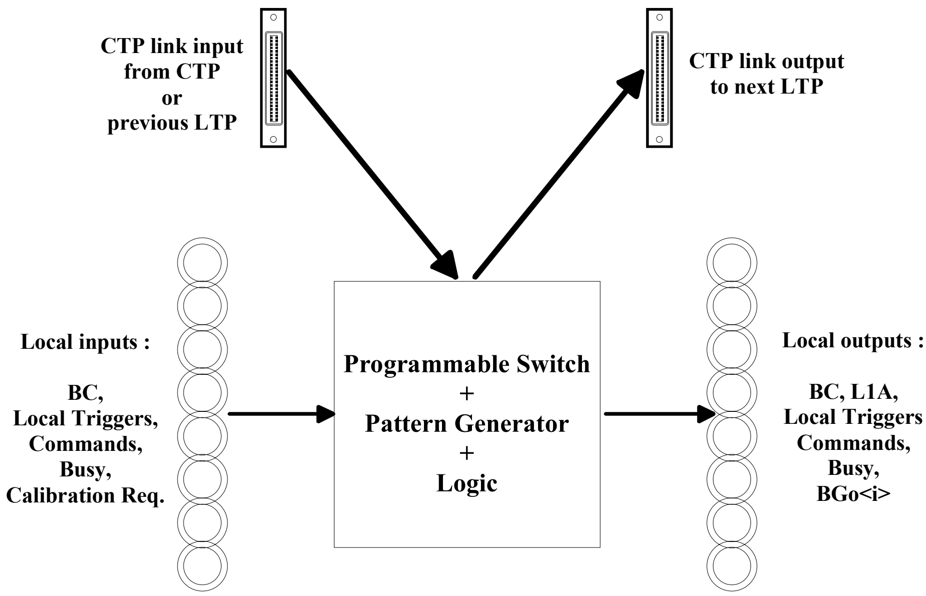

FIGURE 8. Simplified block diagram of the LTP

5.1 Inputs - Outputs

The inputs and outputs are:

- The input CTP Link;
- The output CTP Link;
- The outputs to the TTCvi;
- The local inputs;
- The Busy input-output;
- The calibration request inputs.

Several electrical standards are used by the LTP (NIM, ECL, LVDS). Special colored rings will be added to the LEMO connectors in order to identify the level used on each connector.

5.1.1 The input CTP Link

This input is either connected to the CTPDI of the CTP or to the output CTP Link of another LTP. It is using LVDS standard and carries the following signals:

- Inputs
  - BC
  - ORBIT

    - L1A
    - Trigger-Type<7..0>
    - ECR
    - Local Command<1..0> (see Section 5.2.7)
    - Test Trigger<2..0> (see Section 5.2.5)
    - Pre-Pulse
- Outputs
    - BUSY
    - Calibration<2..0>

5.1.2 The output CTP Link

This output can be connected to another LTP input CTP Link and carries the following LVDS signals:

- Outputs
    - BC
    - ORBIT
    - L1A
    - Trigger-Type
    - ECR
    - Local Command<1..0> (see Section 5.2.7)
    - Test Trigger<2..0> (see Section 5.2.5)
    - Pre-Pulse
- Inputs
    - BUSY
    - Calibration<2..0>

5.1.3 The outputs to the TTCvi

The LTP delivers to the TTCvi (Lemo00 connectors):

- L1A, ECL
- Test-Trigger <2..0>, NIM
- BC, ECL
- ORBIT, ECL
- BGo<3..0>, NIM

and the 8-bit Trigger-Type word through a 16-pin 3M connector (differential ECL level).

5.1.4 The local inputs

The LTP accepts the following local inputs (Lemo00 connectors):

- L1A, NIM
- Test-Trigger <2..0>, NIM
- BC, NIM

- ORBIT, NIM
- BGo<3..0>, NIM

5.1.5 The Busy input-output

The LTP accepts two external BUSY input and delivers a local BUSY output (Lemo00 connectors):

- BUSY-in1, Open Collector TTL
- BUSY-in2, NIM
- Local BUSY-out or Dead Time Monitoring, NIM

5.1.6 The calibration request input

The 3-bit calibration request (Calibration<2..0>) can be input through a 10-pin 3M connector. LVDS or ECL or PECL levels are used.

5.1.7 The monitoring outputs

A copy of the signals sent to the TTCvi are available (Lemo00 connectors):

- L1A, NIM
- Test-Trigger<2..0>, NIM
- BC, NIM
- ORBIT or TURN (meaning the current turn number is equal to a programmable value; when active, the current LHC turn is allocated to the sub-detector associated to this LTP), NIM
- B-Go<3..0>, NIM
- Dead Time Monitoring, NIM

5.2 Description of the different logical blocks

This section gives some details of all the different logical blocks:

- Pattern generator
- BC block
- ORBIT block
- L1A block
- Test-trigger block
- Trigger-Type block
- B-Go block
- Calibration request block
- BUSY block

5.2.1 Pattern Generator

The pattern generator allows to generate internal signals at a given time with respect to the LHC cycle. It is realised with a 1 MWord RAM which can be written (and read for control) through VME and which is then read-out at the BC frequency. The content of the RAM (data-out bits) is then used internally to generate signals.

The size of the RAM allows to cover a time window of 26.2 ms. The sequencer can either continuously loops or just stops after a first read path.

The sequence can be started when the ORBIT signal occurs or when the Pre-Pulse signal occurs or upon a VME access.

A block diagram of the pattern generator is given in Figure 9.

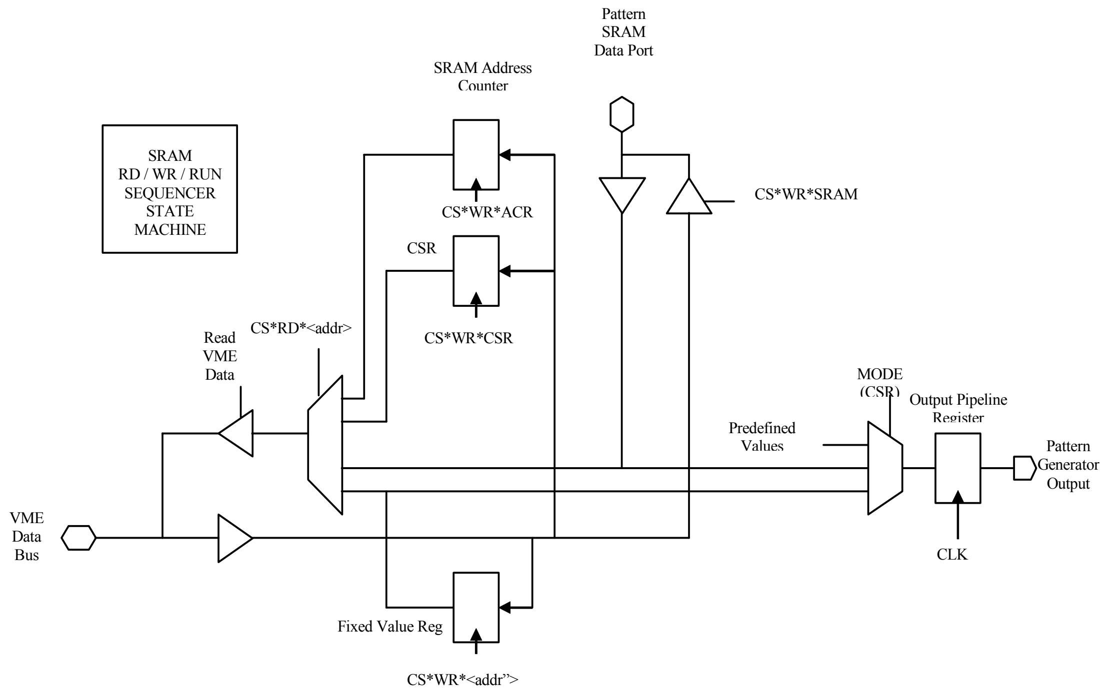

FIGURE 9. Pattern Generator Block diagram

There are four modes of operation:

- Outputs are disabled and in non-active states. Used to write and read-back the memory through VME. The address counter points at the address to be accessed.
- Outputs are driven by the memory in single shot (triggered by External signal or VME access) or in continuous mode.
- Outputs are levels which are controlled by a VME register, with read-back facility. Sequencer is idle.

All the signals can be generated from the pattern generator except the trigger-type word.

5.2.2 BC block

Figure 10 shows the block diagram of the BC block. The local BC used can be one of the following sources:

- Internal oscillator
- Local Input
- BC from the CTP Link input

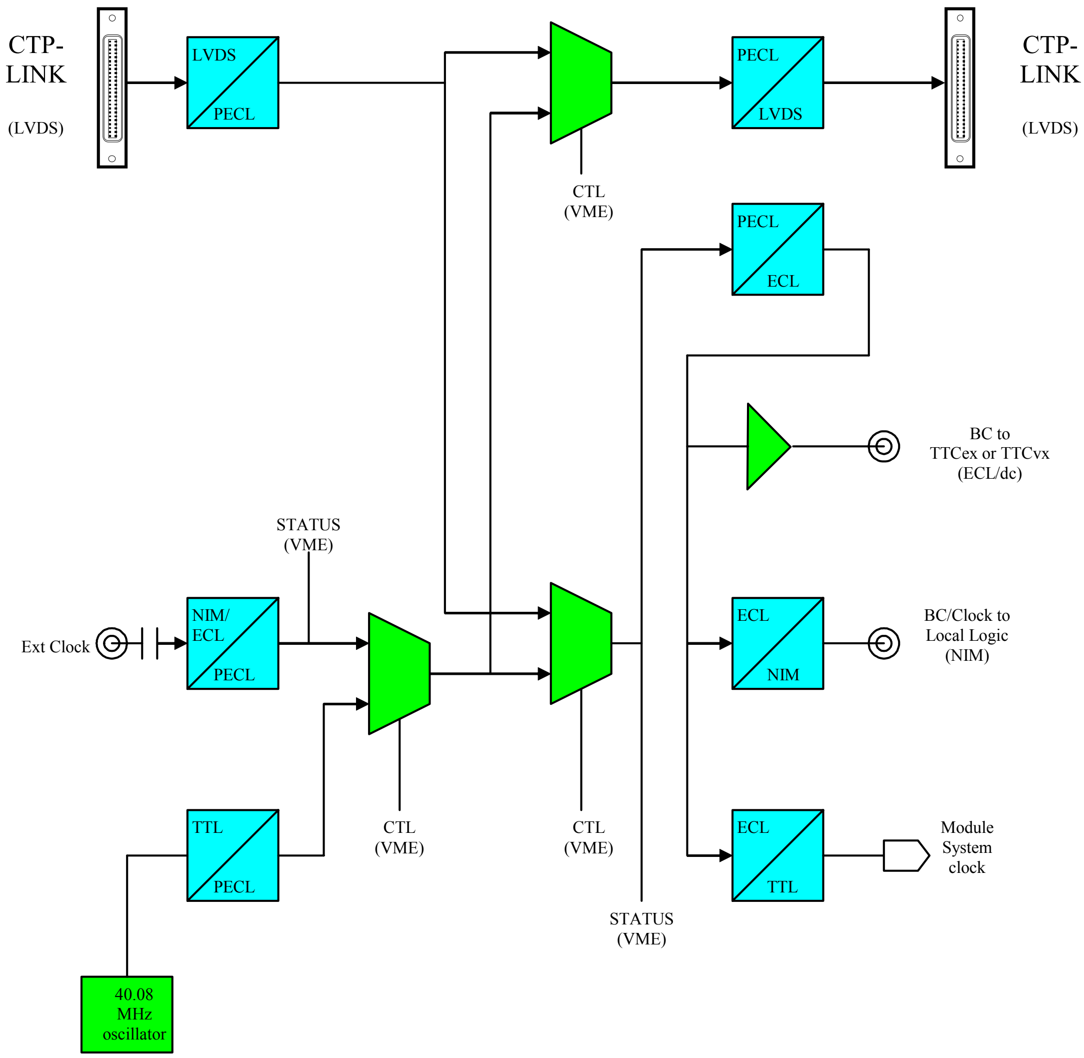

FIGURE 10. Block diagram of the BC block

The BC transmitted on the CTP Link output can either be the local BC or the one coming from the CTP Link input.

5.2.3 ORBIT block

Figure 11 shows the block diagram of the Orbit path.The Orbit signal can either comes from the CTP or be locally generated.

The Orbit transmitted on the CTP Link output is either coming from the CTP Link input or the local one.

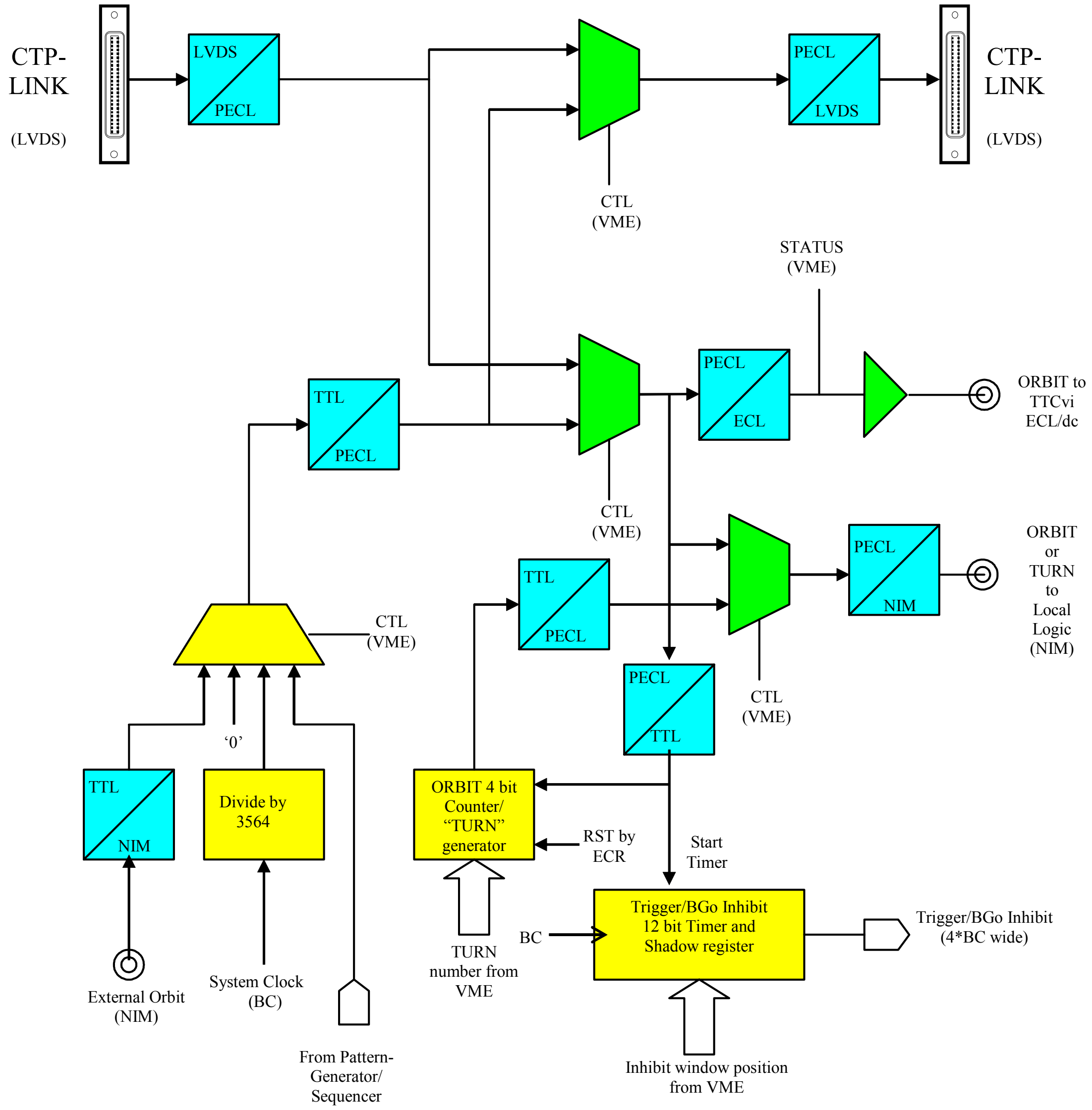

FIGURE 11. Block diagram of the Orbit block

One ORBIT output is connected to the TTCvi ORBIT input while the other can be used by the local logic. This output can also be programmed in order to deliver a signal when the Turn counter is equal to a programmable value; in this case the signal tells when the current LHC turn is allocated to the associated sub-detector.

A timer allows also to generate an Inhibit signal which can be used to inhibit local commands and/or test triggers during certain phases of the LHC turn.

5.2.4 L1A block

Figure 12 shows the block diagram of the L1A block. This block includes the dead-time handling when L1A is locally generated. It has to be noted that no complex dead-time algorithm is implemented when using an external L1A input. However fixed dead-time (a programmable number of BC from 0 to 8) can be introduced after a L1A has been issued (see BUSY block in Section 5.2.9).

When using the pattern generator as L1A source, complex dead-time algorithm can be implemented in programming properly the pattern generator.

A dead-time is introduced when BCR is issued.

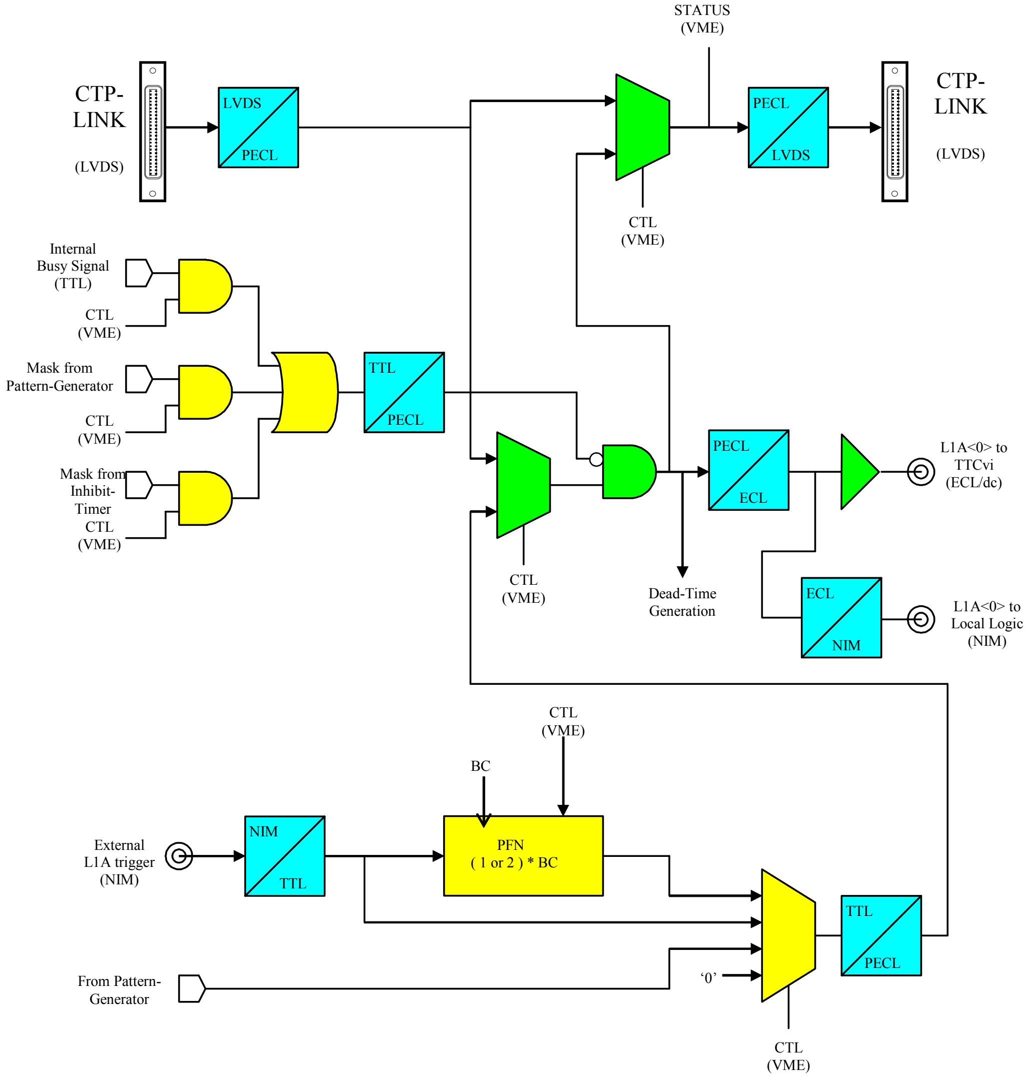

FIGURE 12. Block diagram of the L1A block

L1A source is either the CTP Link input, or a local NIM input or the pattern generator. The local NIM input,can either be passed without resynchronisation with the local BC, or resynchronised and reshaped with a 1- or 2-BC length.

The L1A can be locally masked by the internal BUSY signals (when in local mode), and/or an internal Inhibit signal and/or one signal of the pattern generator.

5.2.5 Test Triggers block

The test triggers are the triggers locally generated by each sub-systems. Figure 13 shows the block diagram of the test triggers block. The selected test triggers are available as front-panel outputs (to be connected to the TTCvi) and can also be transmitted on the CTP Link output to allow several LTPs running with the same test triggers.

As for the L1A, no complex dead-time is implemented when using external inputs but dead-time (a programmable number of BC from 0 to 8) can be introduced after a test trigger has been issued (see BUSY block in Section 5.2.9).

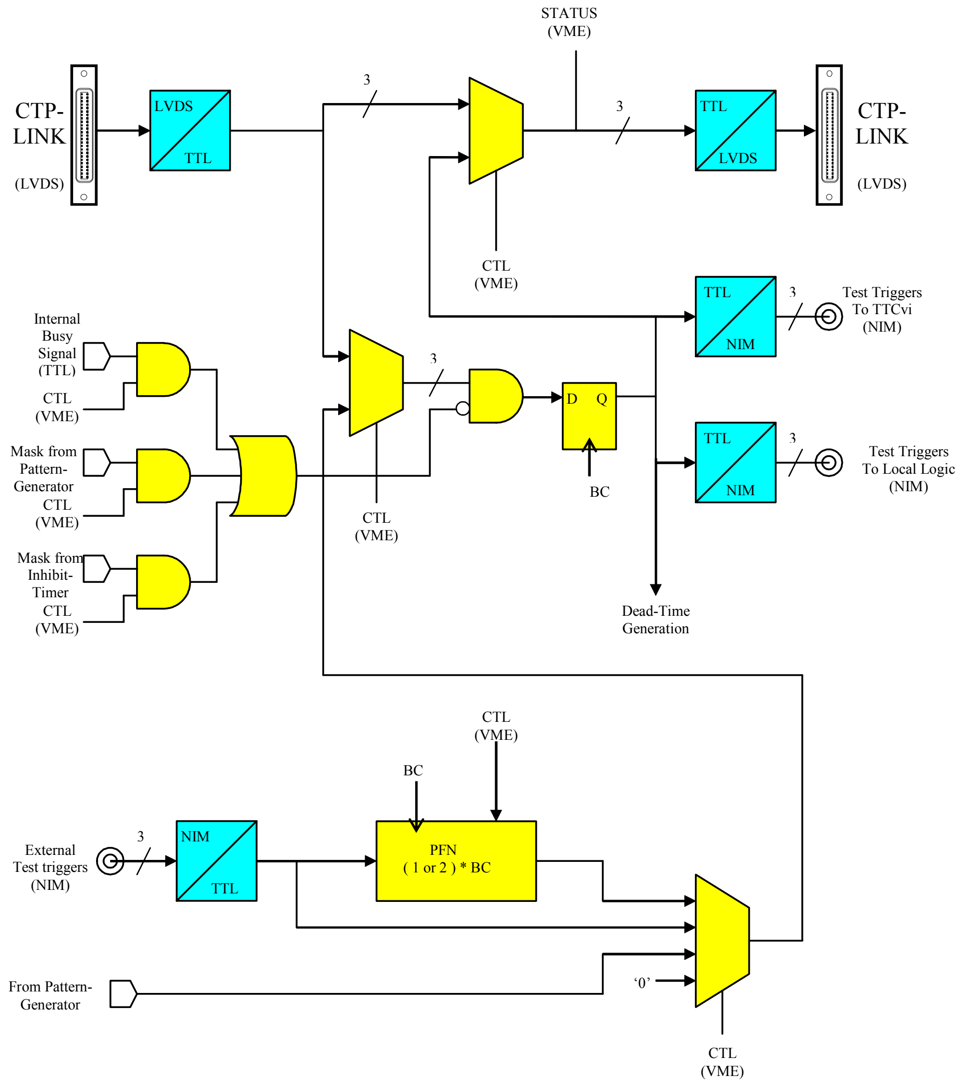

FIGURE 13. Block diagram of the Test Triggers block

The Test trigger inputs can either be passed without resynchronisation with the local BC, or resynchronised and reshaped with a 1- or 2-BC length.

5.2.6 Trigger-Type block

Figure 14 shows the block diagram of the Trigger-Type block.The Trigger-Type can either come from the CTP or be generated locally. In this latter case the trigger-type words are stored in local registers (up to four) and 2 bits from the pattern generator are used to select which trigger-type is to be transmitted.

The trigger-type words are also loaded in a VME accessible FIFO so that a VME master can read-back the trigger-type words sent for test purpose.

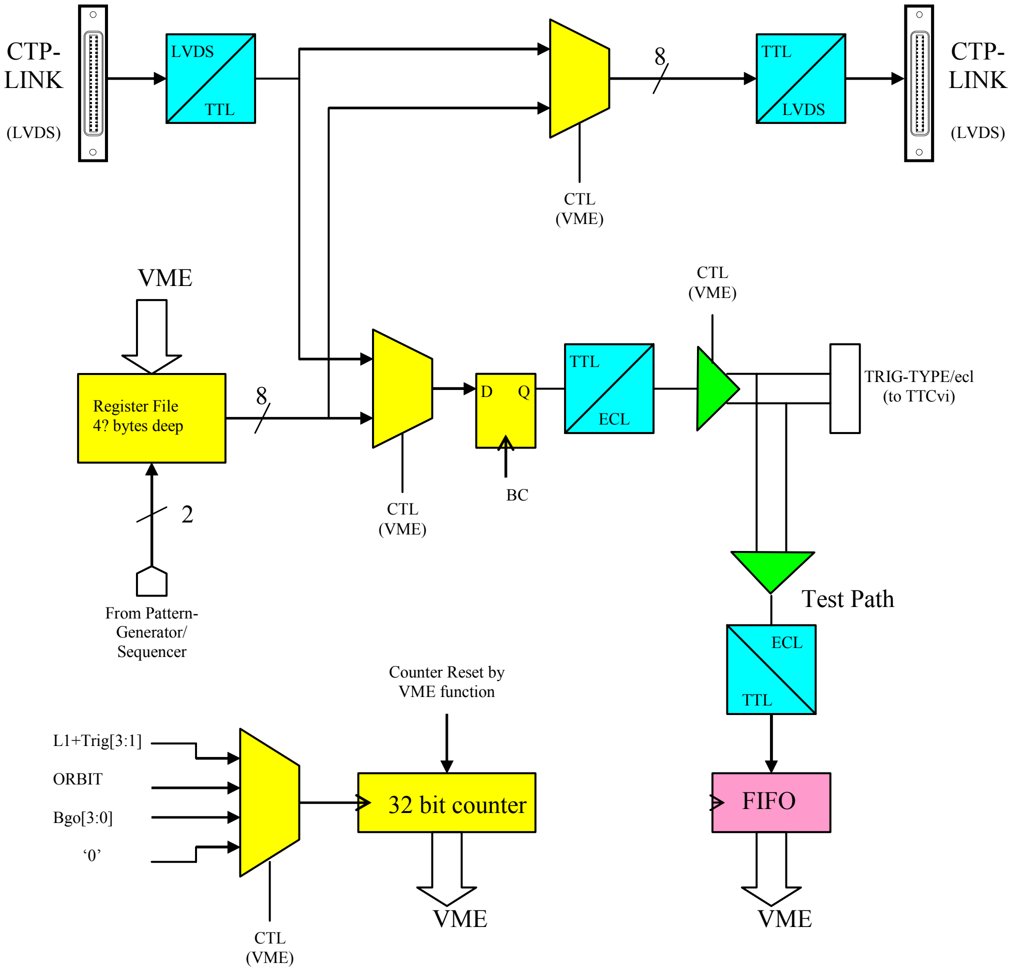

FIGURE 14. Block diagram of the Trigger-Type block

A general purpose VME accessible 32-bit counter has also been implemented. It can count any of the following signals: L1A, test triggers, B-Go signals, Orbit. The selection of the signal to be counted is done through a VME register.

5.2.7 Local commands block

Figure 15 shows the block diagram of the local commands (connected to the TTCvi B-Go inputs) block. Two of them are used for the global commands BCR (derivated from ORBIT in the TTCvi) and ECR. The other ones are left to the sub-systems for special purpose uses (e.g test pulse generation, calibration signals, ...). The local commands sources can be external signals or VME registers or pattern generator. It has to be noted that both BCR and ECR can be generated by the pattern generator.

The CTP is delivering only ORBIT and ECR but the four commands signals are available on the CTP Link out; this could be useful for test or calibration purpose when in local mode (e.g a single source of command for a complete detector).

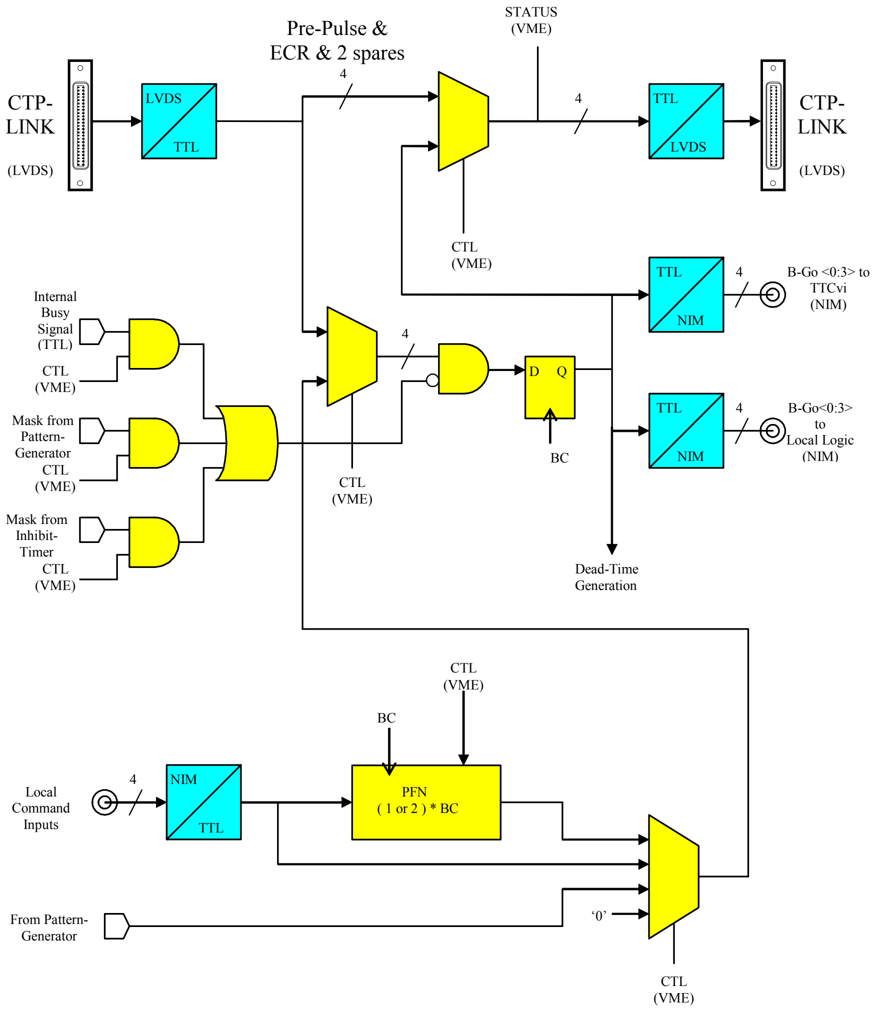

FIGURE 15. Block diagram of the Local Commands block

As for the test triggers, the local commands can either be passed without resynchronisation with the local BC, or resynchronised and reshaped with a 1- or 2-BC length.

5.2.8 Calibration request block

Figure 16 shows the block diagram of the calibration request block. The 3-bit calibration request can come from the internal sequencer or from external signals or from a VME register. When several LTPs are connected on a CTP Link only one is allowed to send the calibration request signals. This is deemed not being a limitation as only one sub-detector can be connected to a specific CTP Link (the CTP has 20 CTP Links allowing to have one link per sub-system). Anyone of the LTPs on the CTP Link can be selected to send the calibration request (i.e it is not necessarily the closest one to the CTP).

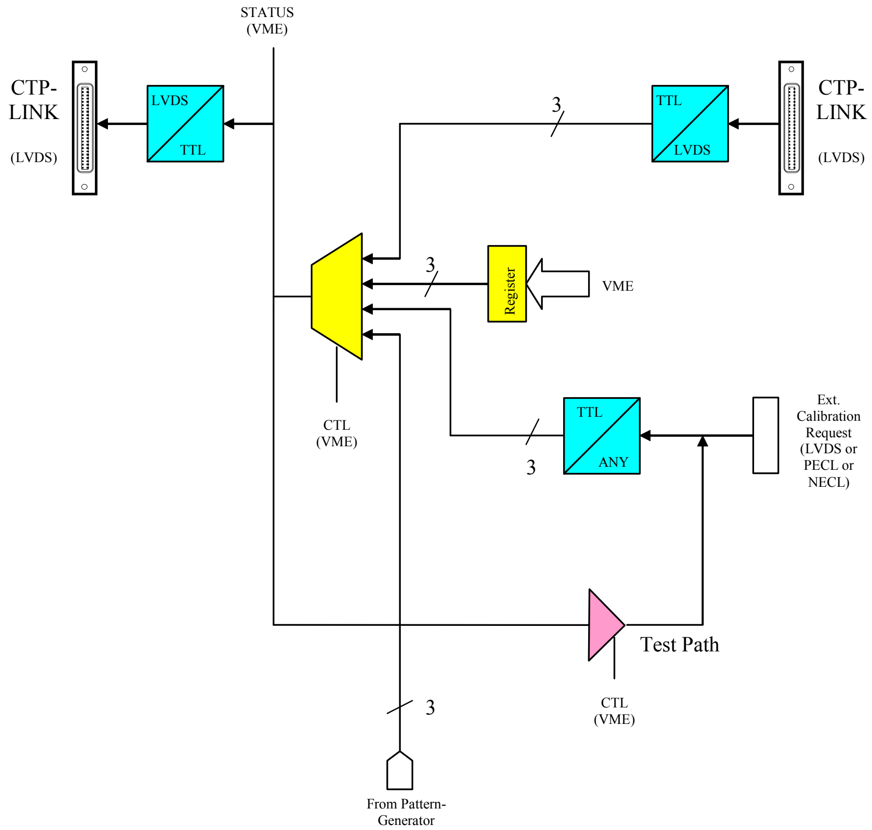

FIGURE 16. Block diagram of the calibration request block

The calibration request can either be levels or pulses (as described in Section 3.1). In the later case, there is a need for resynchronisation in the CTP.

5.2.9 BUSY block

Figure 17 shows the block diagram of the BUSY block. Several sources of BUSY signal can be selected. When in global mode, the BUSY signal is sent back to the CTP. When in local mode it is used to generate a local dead-time.

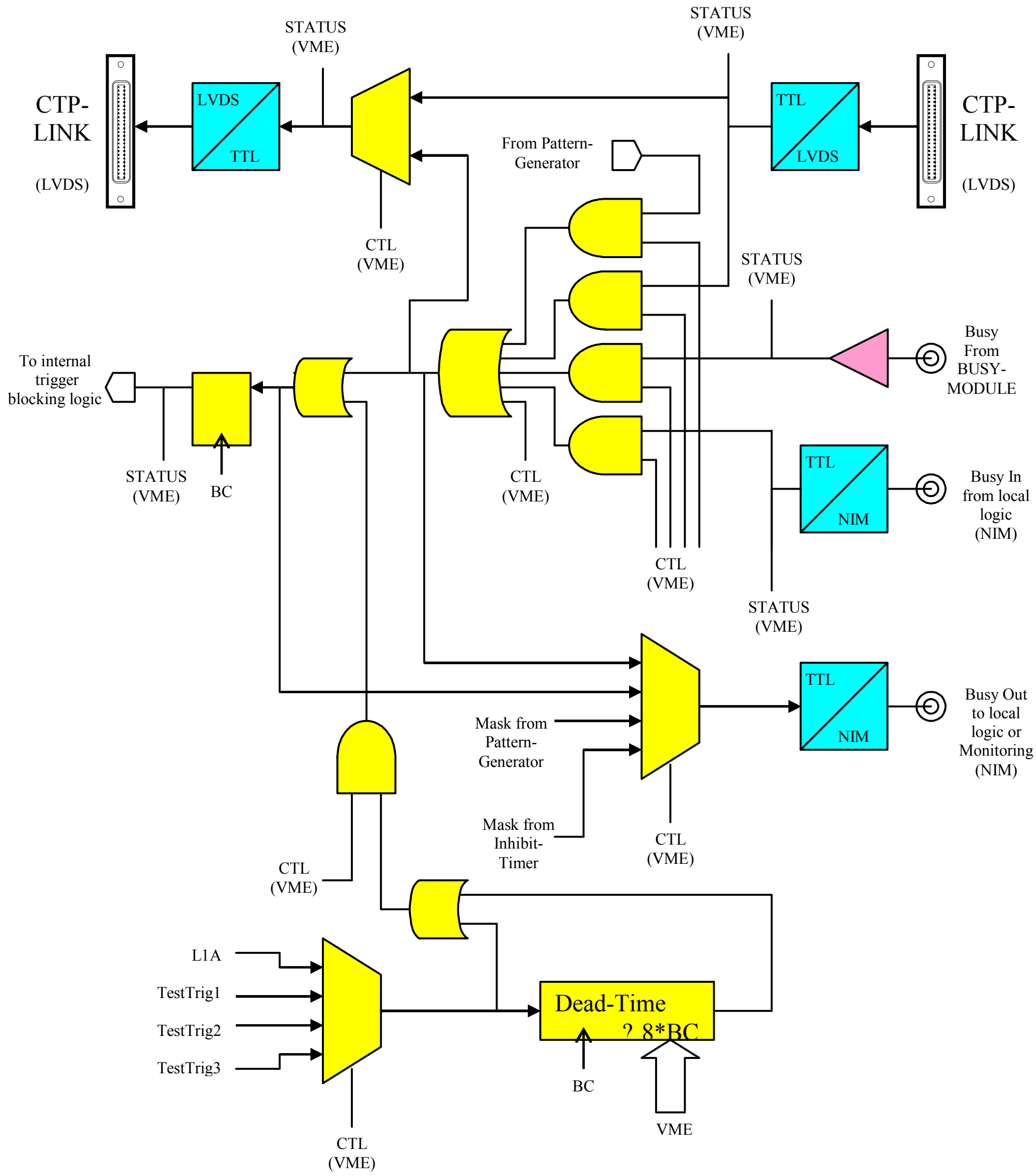

FIGURE 17. Block diagram of the BUSY block

When in global mode, the last LTP directly connected to the CTP makes the OR of the local BUSY input with the BUSY signal coming from the other LTP connected to this link.

When in local mode the BUSY signal is not sent to the CTP.

It is also possible to have some of the LTPs of a particular CTP Link in local modes with others in global mode as there is a full control of what is transmitted on the CTP Link.

5.3 Reset conditions

After a RESET signal (VME SYSRESET) the module is set in local mode and does not transmit anything to the CTP.

5.4 Mechanics

The LTP is a 6U VME module with a double front panel width.

A view of the front panel of the LTP is shown in Figure 18. As mentioned earlier the electrical standard used on the Lemo 00 connectors will be identified with different colored rings.

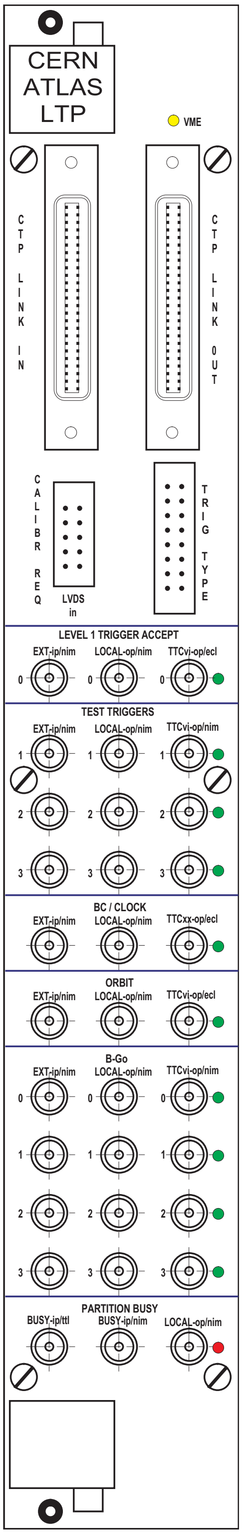

FIGURE 18. LTP front panel