

CDF TRIGGER INTERFACE BOARD 'FRED'

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Abstract

We describe FASTBUS boards which interface sixteen different trigger interrupts to the Collider Detector Facility (CDF) data acquisition system. The boards are known to CDF by the acronym 'FRED'.

The data acquisition scheme for CDF allows for up to 16 different parts of the detector, called 'Partitions', to run independently. Four partitions are reserved for physics runs and sophisticated calibration and debugging: they use the common Level 1 and Level 2 trigger logic and have access to information from all the components of the CDF detector. These four partitions are called "CDF Partitions". The remaining twelve partitions have no access to the common trigger logic and provide their own Level 1 and Level 2 signals: they are called "Autonomous Partitions".

Fred collects and interprets signals from independent parts of the CDF trigger system and delivers Level 1 and Level 2 responses to the Trigger Supervisors (FASTBUS masters which control the data acquisition process in each partition).

Introduction

The data acquisition scheme for CDF allows for up to 16 different parts of the detector, called 'Partitions', to run independently.

The Data Acquisition process, in each partition, is controlled by a Trigger Supervisor (a microprogrammed FASTBUS Master).

Each partition may have its own independent trigger made from signals coming from various sources, including a number of special purpose processors. These trigger signals must be combined and interfaced to the Trigger Supervisor, according to an appropriate protocol. This function is performed by a number of FASTBUS slave modules, globally known to CDF by the acronym "FRED". It is within FRED that the Physics signature of an event is determined by the correlation of signals from different processors and different parts of the detector.

The block diagram in fig.1 shows FRED and the other components of the CDF data acquisition system to which it is directly connected: the Trigger System on one side and Trigger Supervisors on the other side. The main signals entering and leaving FRED are also shown: their meaning is discussed in the course of this paper.

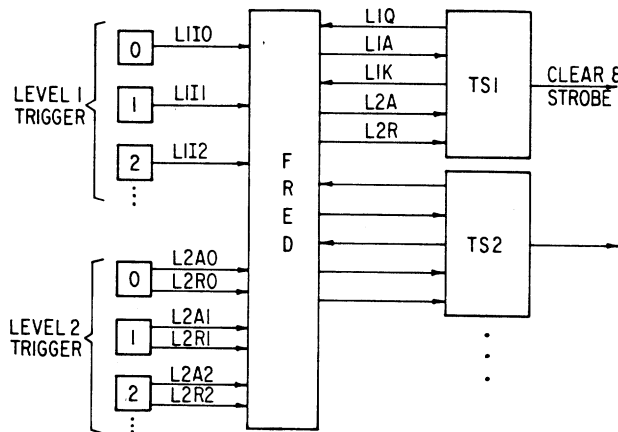


Fig. 1 : FRED

Partitions

The concept of "Partitions" is one of the fundamental ideas underlying the design of the CDF Data Acquisition System. A Partition is a subset of the detector that is being run with its own trigger and possibly its own Data Acquisition Computer as if it were an independent experiment.

Partitions can be defined dynamically and are intended to be used mainly during setting up, calibration or debugging. In general they are a powerful tool whenever different groups of people are

working simultaneously on different parts of the detector.

During data taking, when all the detector is functional, there will be only one partition - the "Global Partition" - that will include all the detector components.

Triggers

In the CDF data acquisition system, two levels of triggering are required before data are digitized and stored in temporary buffers. They are called Level 1 and Level 2 triggers. An event passing both levels of triggers will then be assembled and submitted to an array of processors for further selection (Level 3).

At the Fermilab Collider bunch crossings can occur every 3.5 microseconds. In coincidence with each bunch crossing, all front end electronics are strobed and signals from the detector are stored into analog sample and holds. A decision on whether to consider the event for further analysis must be made before the next bunch crossing. This task is performed by the Level 1 trigger. If no Level 1 trigger is generated all front end electronics are cleared and readied for the next bunch crossing. Since no beam-beam collision occur between bunch crossings the Level 1 trigger logic introduces no dead time.

If a Level 1 trigger is generated the front end is not cleared and analog values are held until the Level 2 trigger logic has reached a decision. This may take a time equivalent to many bunch crossings. All the events occurring in the meanwhile are lost, consequently the Level 2 trigger logic is a source of dead time. We require that Level 2 does not generate more than 10% dead-time.

CDF and Autonomous Partitions

Every partition in CDF needs trigger signals. This applies both to Level 1 and Level 2 (Level 3 will be available only to the Global Partition).

The trigger signals to the Global Partition will be provided by special hardware designed to look for special physics processes. Some partitions will be able to share the response of the same trigger processors for their own purposes. These partitions are called "CDF Partitions". The synchronization required for the sharing of the same trigger logic is provided by FRED through the generation and use of the "Trigger Busy" signal.

Partitions that provide their own trigger logic, are called "Autonomous Partitions". They are independent and do not share dead-time with CDF Partitions.

FRED has been designed to allow for a maximum of 4 CDF Partitions and 12 Autonomous Partitions.

Level 1 Trigger Protocol

The Data Acquisition Process is controlled in every partition, CDF or Autonomous, by a microprogrammed FASTBUS master called "Trigger Supervisor" (TS).

Level 1 Accept (L1A) must be delivered to the TS before the next bunch crossing so that the clearing of the front end can be inhibited.

After each bunch crossing the TS raises Level 1 Query (L1Q) to signify it is ready to accept a Level 1 trigger from FRED. Level 1 Query is lowered shortly before the next crossing. The Level 1 trigger must come while L1Q is high in order to be valid. After a valid Level 1 trigger has been received the TS asserts Level 1 Acknowledge (L1K).

Lookup Table

As shown in fig.2, 12 independent triggers inputs (Level 1 Inputs) contribute to the Level 1 formation in each CDF Partition. They come from different parts of the detector and are input into a lookup table to provide 4 possible Level 1 triggers that are filtered through "Rate Limiters" before being ORed to provide the Level 1 Accept (L1A) to the TS. The lookup table provides a powerful and flexible tool to define triggers based on correlations between different parts of the detector.

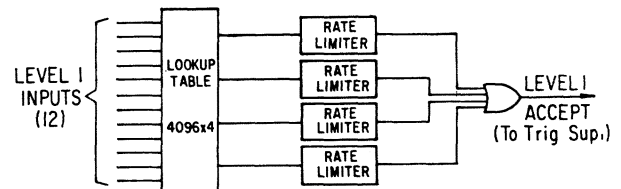


Fig. 2 : Level 1 Logic

Rate Limiter

Up to 4 independent Level 1 triggers can be defined for each CDF partition. The rate of each trigger can be scaled down, if wanted, through appropriate programming of the Rate Limiter section. In this way the dead time caused by each trigger can be controlled and a sample of high rate events can be taken without losing interesting physics often characterized by very low rates.

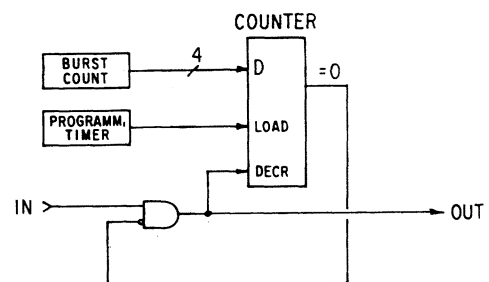


Fig. 3 : Rate Limiter

A block diagram of the Rate Limiter as implemented in FRED is shown in fig.3. A 4-bit counter is loaded at regular time intervals with a number from 1 to 15 ("Burst Count"). Every time a

trigger is accepted the counter is decremented. If the counter reaches 0 further triggering is inhibited until the counter is loaded again. The time interval between consecutive loads, and the number loaded, are both programmable through FASTBUS registers. The rate limit may be set anywhere between 0.16 Hz and 10 kHz.

One advantage of this scheme over the "divide by N" approach is that, whatever the input rate, the output rate cannot exceed the set limit. This approach gives direct control over the maximum dead-time introduced by each trigger independent of the input rate which may vary if the luminosity of the machine or the background conditions change.

Level 2 Trigger Protocol

If the Level 1 decision has been affirmative the Level 2 logic is started.

While the Level 1 logic has a limited amount of time to give an answer (before the next bunch crossing) no time limit is set a-priori for the Level 2 decision. A limit is imposed by dead time considerations and by the volatile nature of analog memories in the front end which tend to drift with time. A reasonable limit for the Level 2 decision is of the order of 100 microseconds. The goal is to generate most Level 2 decisions in less time.

The Level 2 decision is made for each partition, by one or more "Level 2 Processors". Each one of them is expected to output either a "Level 2 Reject" (L2R) or a "Level 2 Accept" (L2A). If more than one processor is involved, the standard option is to accept the event whenever at least one processor accepts it. As an alternate solution, one or more processors may be allowed to "veto" the event. If one processor generates a veto the event is rejected no matter what the response of other processors.

The logic to implement the Level 2 protocol for CDF partitions is shown in fig. 4: each processor assigned to any of the four CDF partitions can be defined as "Standard" or "Veto". Note that if no processor is assigned to a partition, a Level 2 accept will be automatically delivered to the TS for every event passing Level 1.

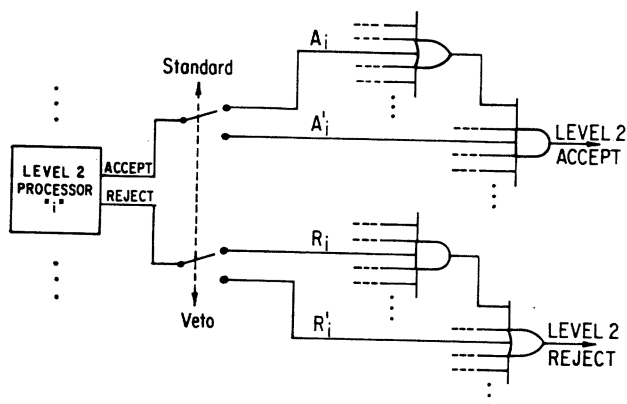


Fig. 4 : Level 2 Logic

Trigger Busy

CDF partitions share part of the trigger logic. This implies that dead time introduced by the Level 2 trigger must also be shared. In other words while the trigger logic is busy working for one partitions it is not available for other partitions.

A "Trigger Busy" (TB) signal is fanned out to all CDF partitions and prevents them from generating a Level 1 Accept. TB is asserted to all partitions whenever at least one partition has passed Level 1 and lasts until a Level 2 decision has been made and the trigger logic is available again. All the time that TB is on is dead-time for all CDF partitions. The amount of dead-time that is induced by one partition over another through this mechanism can be controlled by proper programming of the Rate Limiters.

FASTBUS Implementation

FRED is implemented as a number of FASTBUS slaves. Autonomous partitions are handled by two identical boards. Each board is an independent FASTBUS slave and handles six partitions. Connection to the Trigger Supervisors is via the auxiliary connector. Connection to the trigger logic goes through front panel connectors.

CDF partitions are handled by a FASTBUS slave implemented on five boards: one board ("Control Board") implements the FASTBUS protocol, four identical boards ("Partition Boards") implement the Level 1 and 2 protocols (1 partition/board). The Control Board and Partition Boards communicate through the auxiliary connectors. Connection to the Trigger Supervisor goes through front panel connectors on Partition Boards. Connection to the trigger logic is made via front panel connectors on the Control Board.