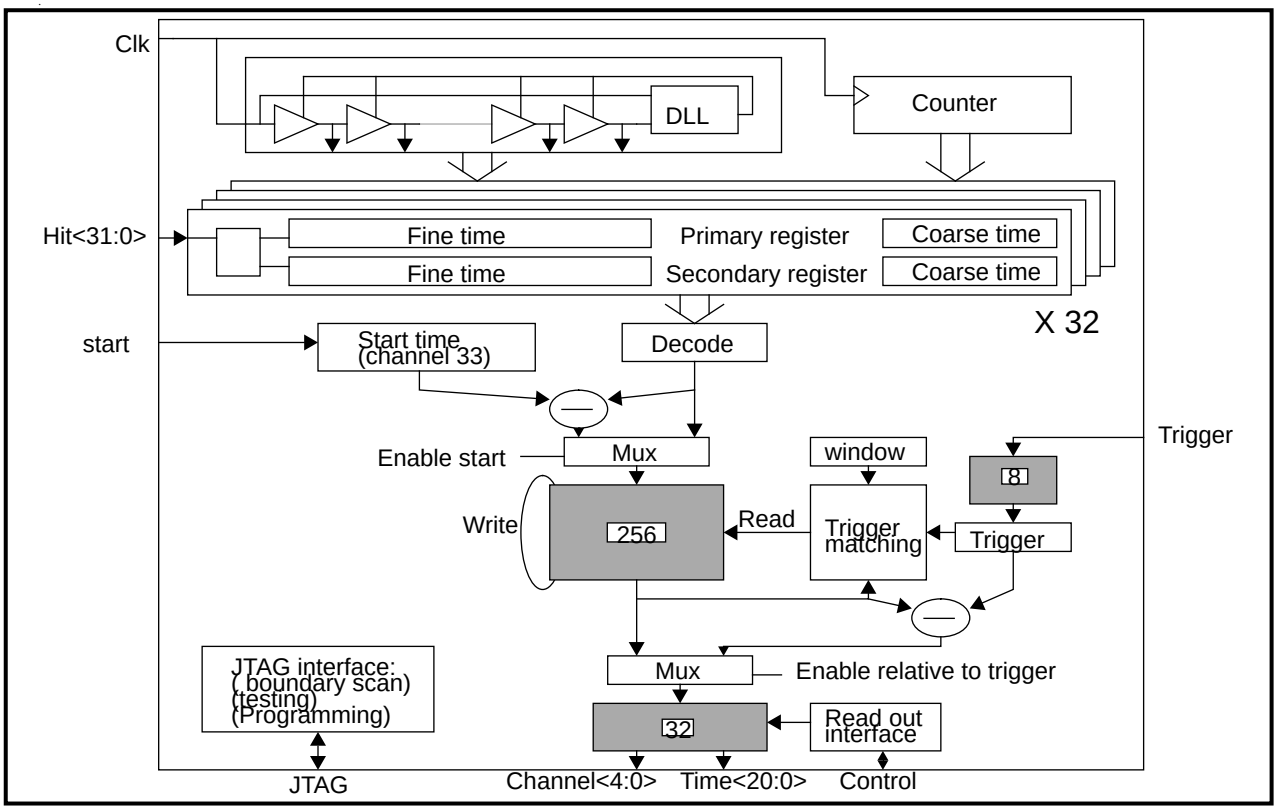
32 Channel, 21 bit, 0.5 ns bin size TDC with on-chip buffering and trigger matching.

High precision time measurements are required in many future high energy physics experiments to perform time of flight measurements or to measure the drift time in wire- or drift-chambers. The required number of channels in these experiments is of the order of many thousands and a highly integrated Time to Digital Converter (TDC) system is required. To circumvent the need of developing many different TDC circuits optimized for specific applications a highly programmable 32 channel TDC has been developed in the micro electronics group at CERN. This development is based on the successful 16 channel TDC previously developed for the NA48 experiment.

A time bin size of 0.5 ns (at 62.5 MHz, 0.8 ns at 40 MHz) can be obtained in a low cost modern standard CMOS process when the gate delay is used as the base for the time measurement. This scheme prevents the use of very high speed clocks in the circuit and results in a low power device (10 mW/channel with 40 MHz clock). The gate delay of CMOS devices normally have very large variations as function of process, voltage, and temperature. In this TDC a self calibrating scheme is implemented by using voltage controlled delay elements as a part of a Delay Locked Loop (DLL). The fine time measurement from the DLL is extended to a 21 bit dynamic range by a coarse time counter counting clock cycles.

Each channel consists of two time registers where measurements are stored until they can be written into a common on-chip 256 words deep circular buffer. The dual register scheme enables a double pulse resolution of 10 ns to be obtained. Start / Stop timing measurements are support by optionally subtracting a common start timing measured by an additional dedicated start timing channel (channel 33).

The measurements stored in the circular buffer can be passed directly to a 32 words read-out fifo or a trigger matching function may select events related to a trigger. The trigger information consists of a time tag locating in time where measurements of interest should be extracted from the circular buffer. A time window of programmable size is available for the trigger matching to accommodate the time spread of hits related to the same event. A special scheme is used for the matching of events and the trigger such that the matching can be performed independently of the 21 bit counting range of the TDC.



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