11/15/01
B.Baldin
S.Hansen

Procedure for timing adjustments in PDT Electronics

The PDT Electronics consist of two types of boards: the Front-End Board (FEB) and the Control Board (CB). Both boards require proper adjustment of their timing delays and data pipelines. In the Front-End Board, there are two adjustable pipelines: the TMC pipeline and ADC pipeline. The TMC pipeline runs at RF/2 clock frequency (RF = 53.1047 MHz). The ADC pipeline runs at RF/4 clock frequency. The ADC and TMC pipelines have to be set to approximately the same total delay time. That means that the setting for the ADC pipeline has to be about twice smaller than that of the TMC due to the difference in their respective clock frequencies. In the Control Board there is at least one pipeline that has to approximately match settings in the FEB. It is shown as a Pipeline Delay in Fig. 1 and is controlled by the "Pipeline delay of First Crossing" parameter. This pipeline determines an offset in crossing counter values relative to the beam interaction. The Tevatron beam is synchronized to the RF with an accuracy of a few nanoseconds. The Tevatron beam structure has a period of 7 RF clock cycles. The interval between two adjacent beam bunches is called the beam crossing interval. There are 159 beam crossing intervals along one beam orbit in the Tevatron. By definition, the time measurements are related to the beginning of the first RF clock cycle within the current beam crossing interval. A Beam Delay shown in Fig. 1 is implemented to adjust PDT Electronics timing relative to the actual beam structure and is controlled by the “Beam delay of First Crossing” parameter in the CB. This delay along with FEB one-shot duration width settings is used to adjust the timing of the L1 data transmission.

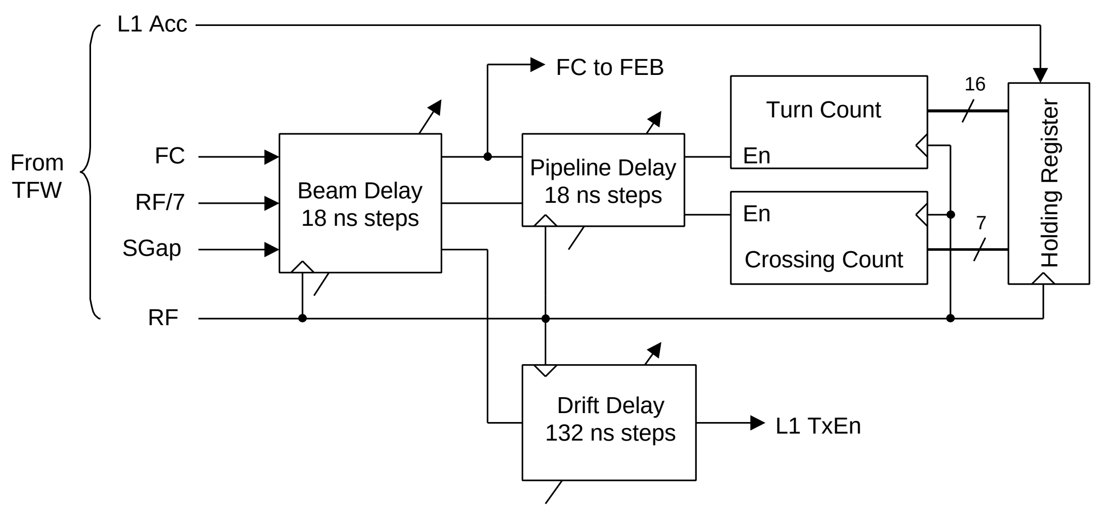

Fig. 1 Simplified block-diagram of the PDT timing circuitry

Due to the mismatch between the RF/2 clock used in the TMC for time measurements and the RF/7 beam period, there is a dynamic offset of 18.9 ns (1/2 of RF/2 period) in the TMC data for every other beam crossing interval. This offset is a function of the current turn and crossing number. This means that the arrival time of the hit as measured by the TMC depends on the current crossing and turn number. This problem is resolved by applying an “Even/Odd” correction to the data before it is send to the D0 DAQ (see Fig. 2). The DSP code uses the current crossing number obtained from the crossing counter delayed by the Pipeline Delay ("Pipeline delay of First Crossing"). The crossing counter value has to correspond to the actual TMC data coming out of the TMC pipeline in order for the correction procedure to work properly. This can be achieved by adjusting the “Beam Delay of First Crossing” parameter. A change of the beam delay by one count will invert the phase of the TMC clock and, thus, the sense of the correction. Changes in the beam delay also affect the event synchronization. This means that every increase of the beam delay has to be compensated by an equivalent decrease of the crossing counter pipeline delay and vice versa. In this way, the value for the Beam Delay can be selected to satisfy the L1 trigger system requirements, but it has to be set to the nearest even or odd number in order to preserve “Even/Odd” correction.

Summarizing, the following requirements have to be met for proper PDT time measurements:

- Crossing counter pipeline delay ("Pipeline Delay of First Crossing" parameter) has to be adjusted to match the TFW crossing number to satisfy the event synchronization requirement; out of seven possible settings of this parameter, middle values are preferable
- ADC and TMC pipeline delays have to be set at about 1/4 and 1/2 of the pipeline delay above for proper extraction of the hit information; otherwise there is no actual limitation to these settings
- Beam delay (“Beam Delay of First Crossing” parameter) has to be set to satisfy “Even/Odd” TMC time correction procedure and L1 trigger system requirement; the actual value will depend on the cable delays.

The simplest way to determine if the beam delay is properly set, is to take test pulser data with the TFW set to generate a trigger at a fixed crossing. One has to make sure that the TFW decisions have even and odd turn numbers. One possible way to guarantee this is to issue INIT several times. The resulting data will be consistent if the beam delay is correct, otherwise the pulser data will vary by one RF/2 period.

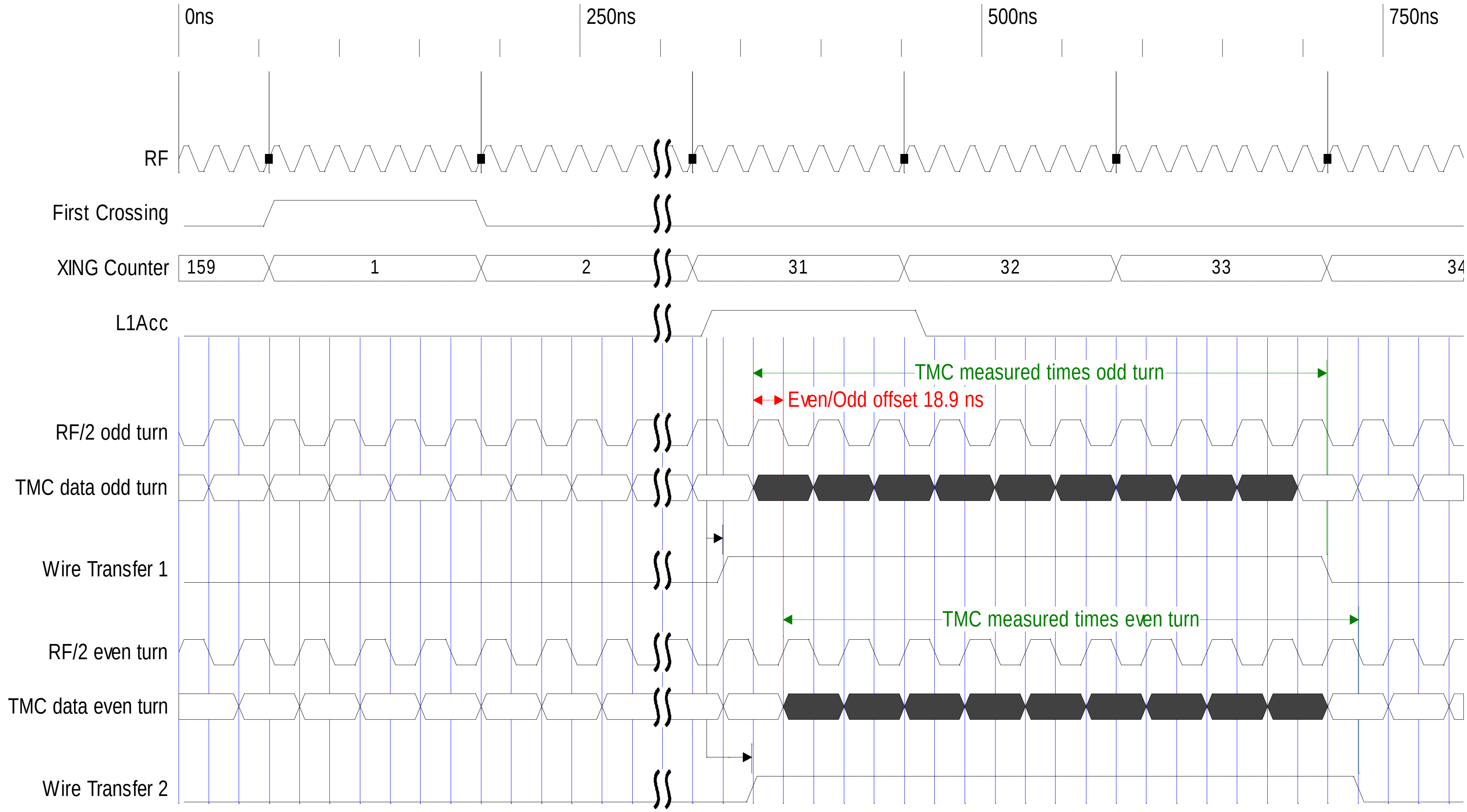

Fig. 2 Even/Odd timing offset