ACCT technical note on:

Requirements on the MRF external trigger for the ESS BCM system

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Acronyms:

ACCT:	AC Current Transformer
AMC:	Advanced Mezzanine Card
BCM:	Beam Current Monitor
BIS:	Beam Interlock System
MPS:	Machine Protection System
MRF:	Micro Research Finland

1. Background

It is planned to use a digitizer/FPGA AMC with 8/10 input channels for the ESS BCM system[1]. An MRF timing receiver board sitting in the same crate as the digitizer/FPGA AMC will be needed to provide clock/trigger as well as beam/machine mode information to the ACCT readout electronics.

The width of the external trigger needs to be equal to the one of the beam pulse. Moreover, the rising/falling edges of the external trigger need to be received by the ACCT electronics at fixed intervals before the rising/falling edges of the beam pulse. The time windows for the ACCT signal processing including the MPS-related checks will then be generated in firmware based on the external trigger.

The ESS linac will run under different beam modes with a pulse width range of 5 us – 2.86 ms, and pulse frequency range of 1/30 Hz – 14 Hz. This requires the external trigger be configured based on the beam mode so that the rising/falling trigger edges always arrive at a fixed time before those of the beam pulse.

This technical note summarizes the requirements on the ACCT external trigger from the ESS MRF timing system.

[1] - The two main candidates are the Struck and the IOxOS platforms that can receive signals from up to 10 and 8 ACCTs per AMC respectively.

2. ACCT digital signal processing and MPS checks

The FPGA signal processing on the ACCT signal includes baseline level correction, per-pulse charge measurement as well as beam current checks against the MPS thresholds.

The baseline level correction requires a precise measurement of the ACCT signal during the whole time window without beam. The per-pulse charge measurement needs to be performed within a time window that starts before the rising edge, and ends after the falling edge. The MPS-related checks include several thresholds that need to be activated at well-defined time intervals with respect to the external trigger.

Figure 1 shows three prohibited zones that are defined by the MPS thresholds. The ACCT firmware needs to initiate a beam-abort-request if the beam current enters any of these zones.

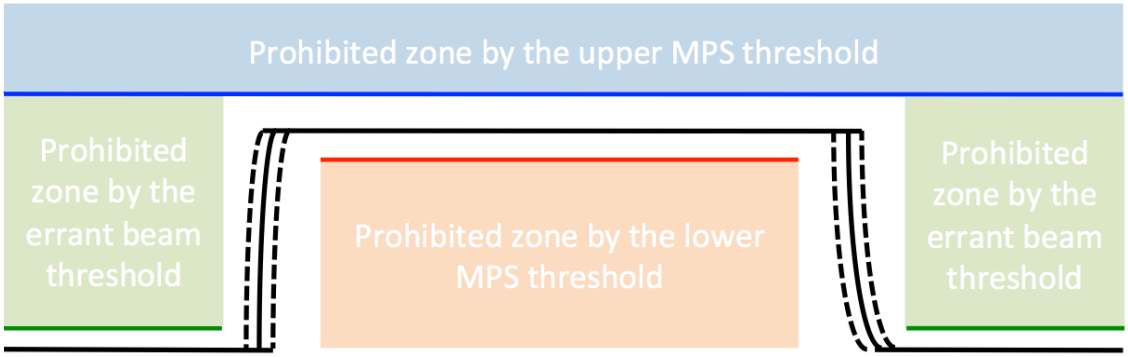

Fig 1: Prohibited zones defined by the lower/upper and the errant beam thresholds. The threshold levels will be configurable from the user screen.

2. ACCT trigger requirements

Figure 2 summarizes the ACCT timing requirements including those relevant to machine protection.

The rising/falling edge of the external trigger needs to be received by the AMC at a fixed time interval of 100 ± 1 us before the rising/falling edge of the beam pulse, with 100 us being the ideal time, and ± 1 us the acceptable error [1]. The MPS-relevant time windows will then be generated in firmware as shown in Fig. 2.

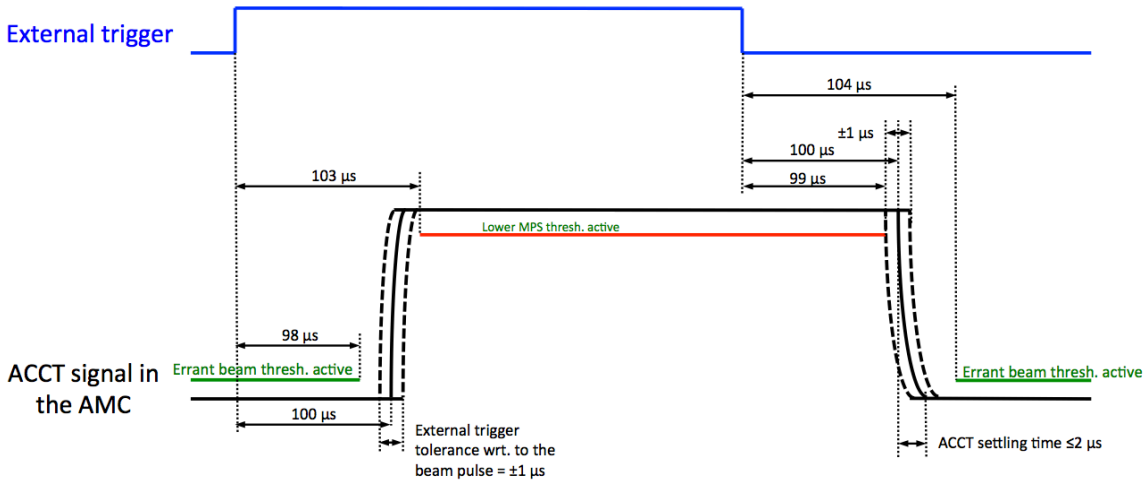

Fig 2: ACCT external trigger requirements

It is planned to measure the pulse width using a fixed threshold of 3 mA in all beam modes (see Fig. 3). The total time that the beam current will be above 3 mA within one cycle will then indicate the pulse width. The ACCT electronics will send out a beam abort request to the BIS if the measured width is not consistent with the active beam mode.

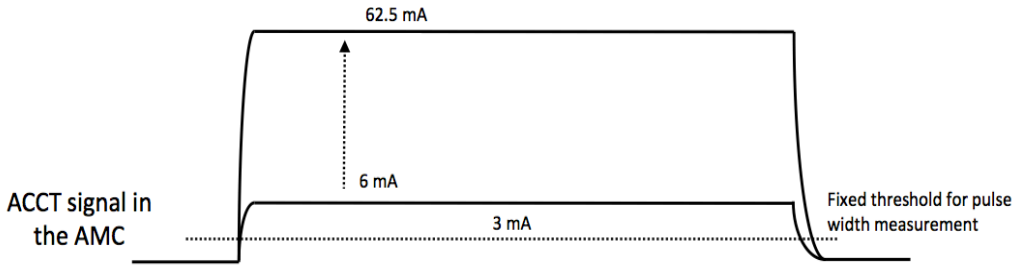

Fig 3: Threshold for pulse width measurement

3. Summary of requirements on the external trigger from the MRF timing system

The ESS MRF timing system is configured for an event rate of 88.0525 MHz corresponding to a time resolution of ~11 ns. One MRF receiver board needs to provide a single external trigger for up to 10 ACCTs that will be all connected to one digitizer/FPGA AMC. The MRF receiver should be configured so that the delay from the external trigger to the ACCT with largest delay (due to cable length and beam travel time) is 100 us when these signals are received by the AMC. The signals from the other ACCTs will then arrive in the AMC up to a few hundred ns earlier depending on their

location[1]. These delay differences will then be individually compensated in the firmware for each ACCT as well as for each differential ACCT pair [2].

If the pulse width/frequency changes as a result of using a different beam mode, the external trigger should change accordingly so that its width remain equal to the beam pulse, and the rising/falling edges continue to arrives 100 us before those of the beam pulse. Moreover, the new beam mode information should be communicated to the AMC to reconfigure it before the new pulse arrives.

4. References

[1] H. Hassanzadegan et al., "LEBT ACCT "Pre-version" firmware and software requirements version 2.4"
[2] M. Werner, "A concept for BCM trigger and data alignment", BCM tech. note sent to ESS for the ESS BCM project, April 25th 2016

[1] - The maximum distance between the ACCT sensors that will be connected to one AMC is assumed to be about 50 m.