Appendix External Trigger Interface

1. Introduction

The **AT Controller** provides a trigger input interface in order to enable external triggering and synchronization of the tracker measurements.

In general the real-time triggers take measurements triggered by an external clock signal.

The hardware trigger interface of the AT Controller allows a flexible setup. The interface configuration allows the following:

- Balanced RS-422 or single wired input signal (defined by a jumper on the connector).
- Single event or continual clock trigger mode
- Trigger event on negative or positive transition of the clock signal
- Enable measurements using the start/stop signal
- A minimal time delay between measurements

2. Hardware Interface

The trigger input connector can be found on the bottom side of the AT Controller and is designated with the symbol. Currently the trigger connector in the AT Controller supports only a trigger input interface.

The trigger interface contains of the following 3 input signals:

- Clock input
- Start / Stop signal input
- Error input
- An additional configuration line allowing selection of single ended or balanced RS422 interface

To prevent any difficulties with ground loops all inputs are optically isolated to the other parts of the controller electronics.

2.1 Trigger Input Connector

The ***Figure 1*** shows the pins of the 16-way connector type **Lemo** 1B, **EGA.1B.316**

Please note: Only pins 7...16 are used for the external trigger interface and are galvanically isolated (2kV isolation).
The remaining pins 1...6 are reserved for a second T-Probe connection and shall not be used for external trigger interface functions.

Figure 1 Ext. Trigger Connector Pinout

(view from outside into the receptable)

Pin	Name	Description
1	reserved	Do not connect
2	T-PROBE2_P	T-Probe 2 data positive signal
3	reserved	Do not connect
4	T-PROBE2_N	T-Probe 2 data negative signal
5	+15V	T-Probe 2 power supply +15V (1A max)
6	GND	T-Probe ground return
7	EXT_CLK_P	Ext. Clk input positive (for differential configuration) or signal input (for single ended configuration)
8	MEAS_START_OUT_P	reserved
9	EXT_CLK_N	Ext. Clk input negative signal
10	MEAS_START_OUT_N	reserved
11	EXT_START_P	Start/Stop input positive (for differential configuration) or signal input (for single ended configuration)
12	ERROR_INPUT_P	reserved
13	EXT_START_N	Start/Stop input negative signal
14	ERROR_INPUT_N	reserved
15	ISOL_EXT_SELECT	Single ended / differential input configuration. If this pin is tied to +3.3V or left unconnected, the interface is configured for differential inputs. Connecting this pin to GND configures single ended inputs
16	GND'	Ext. Trigger ground return

2.2 Balanced RS-422 Signal Input

The ***Figure 2*** shows the principal interface circuit of the AT Controller trigger interface configured for balanced RS-422 input signals. With INPUT_SELECT (pin no. 15) tied to +3.3V or left unconnected, the interface is configured for differential inputs.

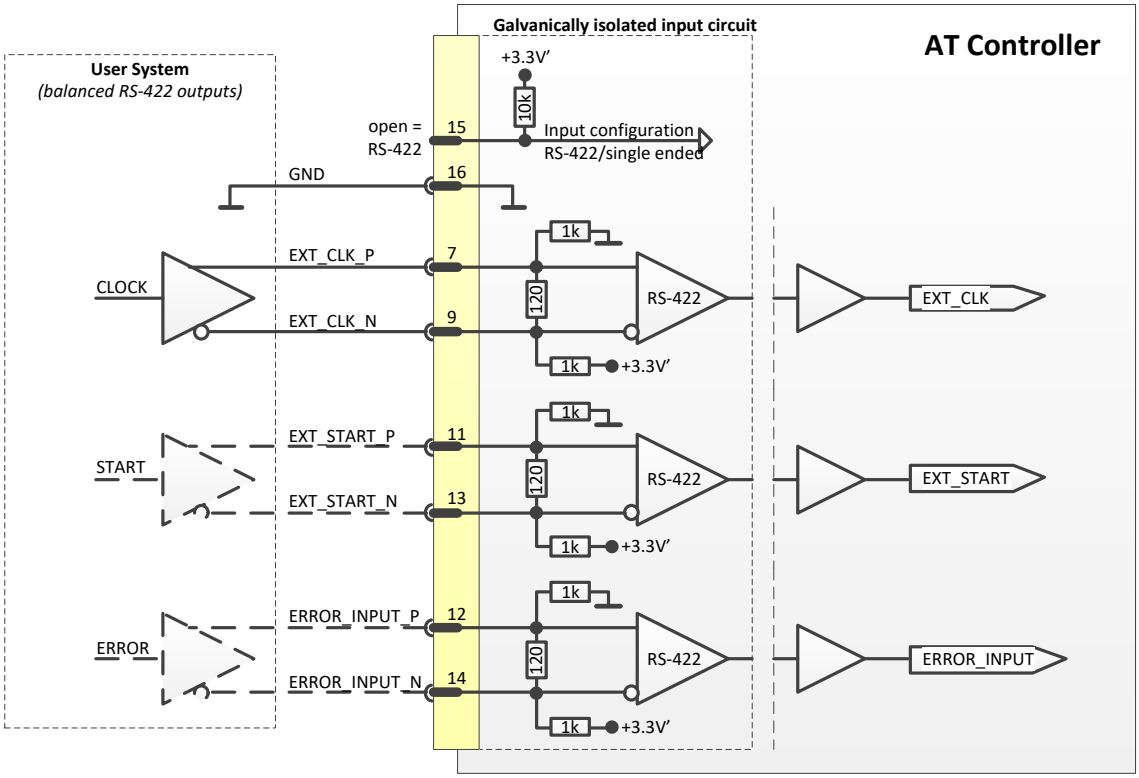


Figure 2 Ext. Trigger configured for differential interface

The Start/Stop inputs can be left unconnected in cases where only the clock signal is used for event triggering.

Please note: For improved noise immunity in an industrial environment the use of balanced RS-422 signals is strongly recommended.

2.3 Single wired Signal Input

The ***Figure 3*** illustrates the principal interface circuit of the AT Controller trigger interface using unbalanced signals. With pin 15 tied to GND the interface is configured for single ended inputs referenced to GND.

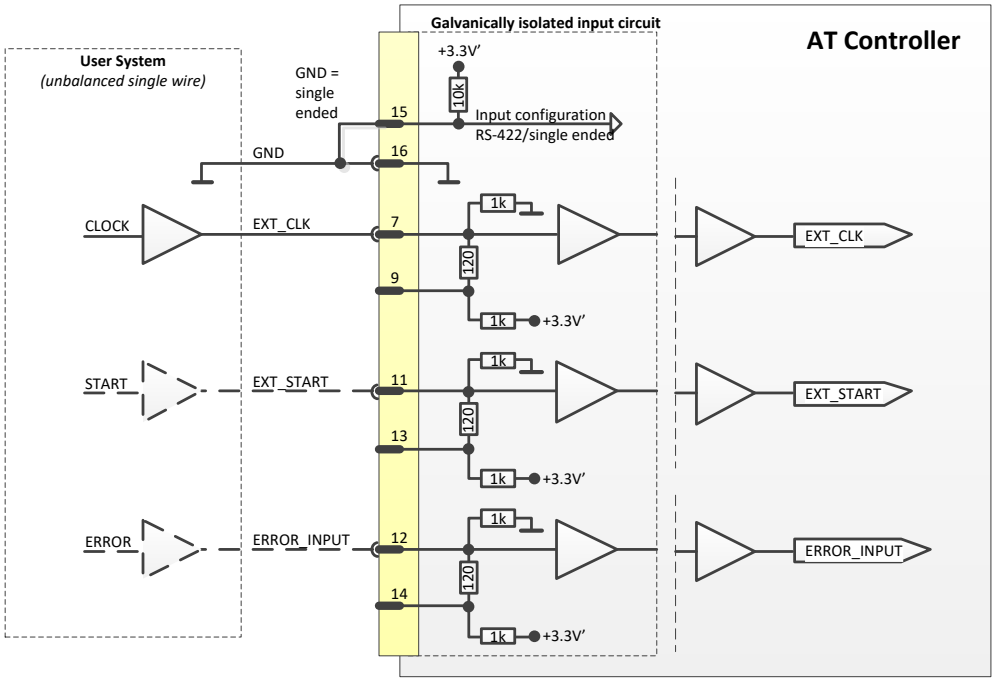


Figure 3 Ext. Trigger configured for single ended interface

The Start/Stop input can be left unconnected in cases where only the clock signal is used for event triggering.

Please note: Due to the combined RS-422/Single ended input circuit open input pins remain at about 2.5V, which represents a logical '1'. Applying to any input a voltage lower than +1.5V corresponds to a logical '0'.

The simplest trigger interface is just using a mechanical switch or relay, as shown on ***Figure 4.***

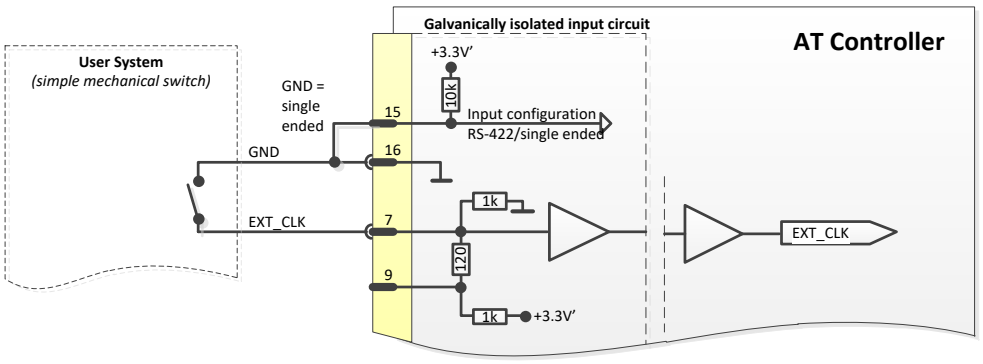


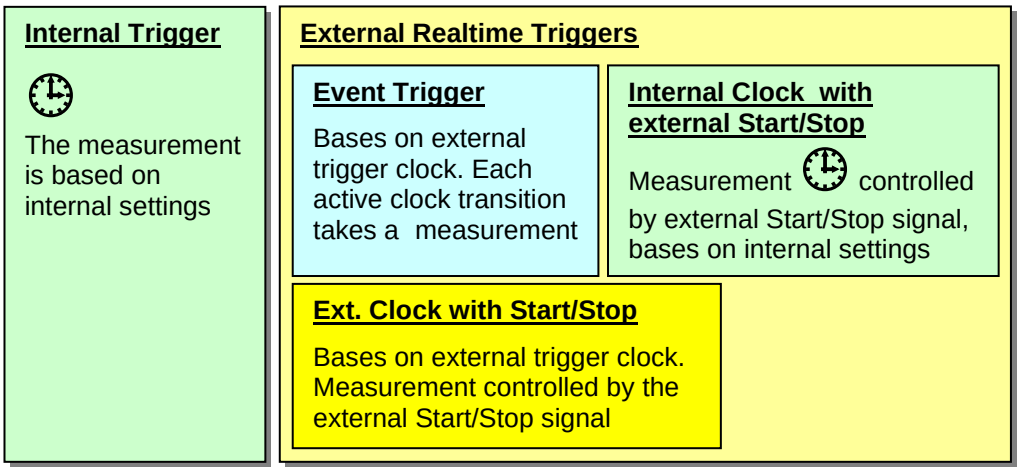
Figure 4 Simple Ext. Trigger Interface (mechanical switch)

*Please note that mechanical switches or relays tend to bounce for some milliseconds before they finally close or open. That might end up in multiple trigger events causing a time violation warning (as explained in **3.2 Configuration of the Trigger Input Signals**) or even in triggering multiple measurements.*

3. Trigger Modes

There are two major categories of trigger modes:

- Internal - takes measurements based on internal settings - occurrence of any external conditions is not required
- Realtime Triggers - take measurements triggered by external signals.



3.1 Realtime Trigger Modes:

- **External Clock with Start/Stop signal**
  The measurement will be controlled by a start/stop signal on the trigger board. One transition of the clock signal (positive or negative depends on the configuration) triggers a measurement if the start/stop signal is active (refer to ***Figure 5***)

- **Event Trigger**
  In the event trigger mode each positive or negative transition (depending on the configuration) of the clock signal will take a measurement. In this mode the start/stop signal will be ignored.

- **Internal clock with external start/stop signal**
  Measurements will be controlled by the external start/stop signal on the trigger board. The continuous measurement will be taken based on internal settings and is not synchronized to an external signal.

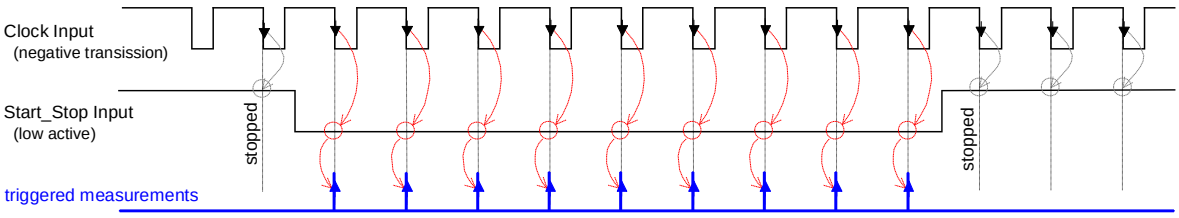


Figure 5 External clock with start/stop signal

3.2 Configuration of the Trigger Input Signals

- **Clock Signal**
  The clock signal can be configured to work either with the positive or the negative clock transition. Default is negative transition.

- **Start/Stop Signal**
  The start/stop signal can be, depending on configuration, either low or high active (low active means that clock events are being generated as long as the start/stop signal remains low). Default is low active.

- **Error Signal**
  The error signal can be used to indicate an error condition to the tracker

- **Minimal Delay Time**
  When using a real-time trigger mode based on an external clock, the maximal rate, at which measurements are taken (minimal delay between two consecutive measurements), can be defined.

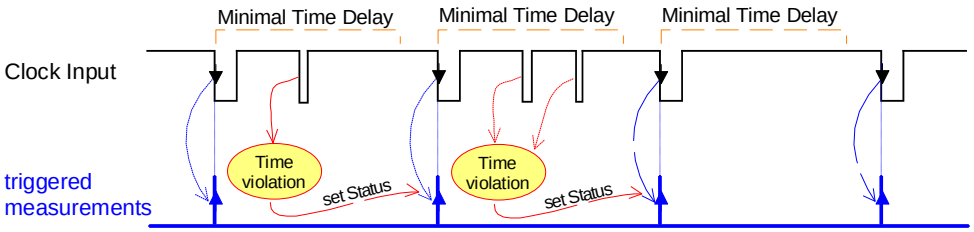


Figure 6 Filtering spurious events with minimal delay time

Trigger events, which violate the minimal time delay are ignored and do not trigger a measurement. The time violation flag will be set in the status of the next delivered measurement point.
Please note: the minimal pulse width that can be recognised on any input is 10 µs.

4. Time Information

4.1 Timestamp and Clock Drift

A timestamp is supplied with each measurement from the tracker. The time reference bases on the internal clock of the tracker controller with a **0.1 µs** resolution.

As it lies in the nature of subject, internal clocks having the same nominal value but coming from different clock domains may slightly differ. Even when initially set accurately, real clocks will differ after some amount of time due to drift, caused by clocks counting time at slightly different rates.

The tracker controller captures the trigger event (point of interest) in its own time system. Then two closest internal measurements (on prior and one past) are interpolated to deliver measurement output exactly at the required point in time. The timestamp captured with the trigger event will be sent together with the measurement.

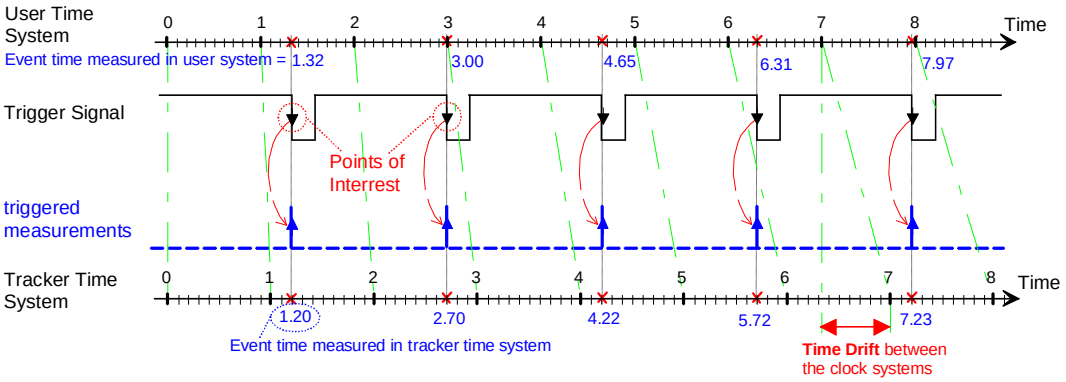


Figure 7 Clock drift between two time systems (clock domains)

The ***Figure 7*** illustrates the effect of the drift between the two time systems. The measurement is taken in the exact point of interest but the time measured in the tracker may differ from a reference time taken externally.

Please note: A drift of 10-20 microseconds per second is not unusual. (As an example: 10µs/s is equal to a drift of about 1 second in a day).

4.2 Time and Trigger Accuracy

The internal clock bases on a crystal oscillator with an overall stability of **±100ppm**, including temperature changes within operating range, shock and vibration, aging, etc.

Catching a measurement with an external trigger signal has an accuracy of **±5µs**, including acquisition of the trigger signal and several components of a measurement.

5. Calculation of triggered Measurement Results

The external trigger signal does not directly influence the raw measure data flow in the tracker. While the angle and distance reading runs at a fix rate of 1kHz the 6Dof camera and probe devices capture rotation measurements with 100Hz. Each measurement component is captured together with a timestamp based on the internal tracker clock with a resolution of 0.1µs.

In the same way the timestamps of events from external trigger are captured. With the knowledge of the time of all occurrences it is possible to interpolate a measurement to the exact point of interest without a time lag.

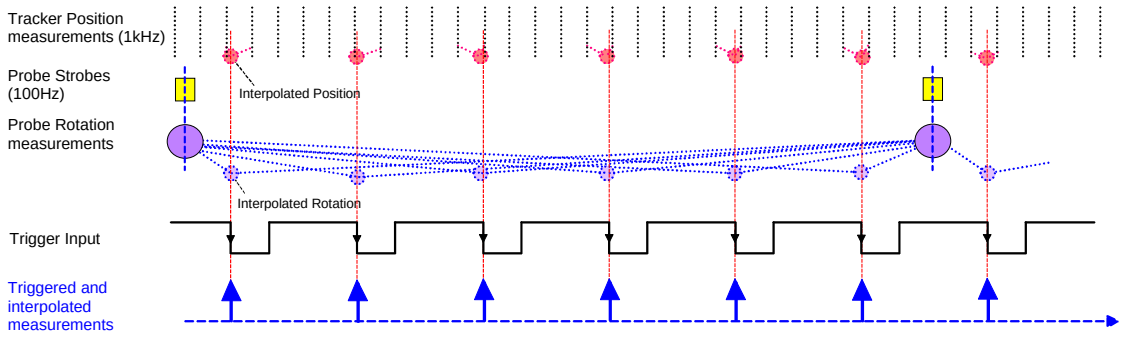


Figure 8 Generation of triggered measurements

The ***Figure 8*** illustrates how tracker and probe measurements are captured and interpolated. In case of a reflector it works the same way but using only the tracker position measurement.

6. Trigger Status on the Tracker Controller Display

The “System Information Details” support page on the AT Controller LCD Display shows some information about the configuration and the status of the trigger interface.

Line 9 starting with **Trg:** displays the information about the trigger.

Trg: *<Start/Stop signal level>, <config,status>, <event>*

e.g **Trg: LO, Started, edge_n**

whereas:

<Start/Stop signal level>
the current level of the Start/Stop signal

<config,status>
the configured trigger mode

- **Internal** using internal clock source
- **Ignored** event trigger mode, ignoring start/stop
- **Stopped, Started** status of start/stop realtime trigger

<event>
incomming trigger events, either **edge_p** or **edge_n** depending on the configured clock transition, positive or negative.

LMF implementation

As of the triggered data arriving in LMF, the following has to be considered:

- The CustomTriggerProfile has to be selected, adapted and the measurement started, from then on, **every trigger pulse generates a measurement** (this is different compared to the AT901), the info flag informs on the state of the measurement, it is recommended to just use ALLOK measurements.

- Triggered measurements arrive in the Trigger Profile

- Measurements in the trigger event **do always follow the same convention** "HVD, and quaternions", they are not following the settings object