ZEBRA: a Flexible Solution for Controlling Scanning Experiments

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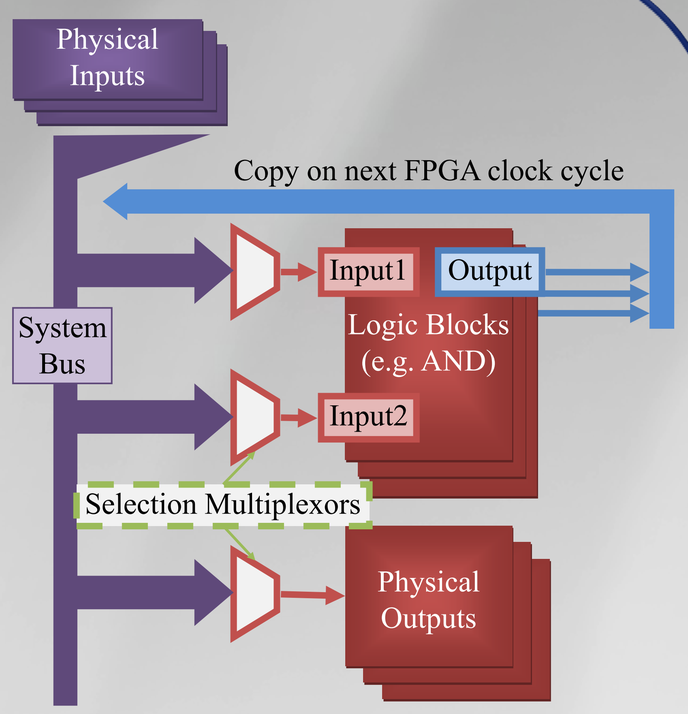
ZEBRA is a stand-alone event handling system with interfaces to multi-standard digital I/O signals (TTL, LVDS, PECL, NIM and Open Collector) and RS422 differential quadrature incremental encoder signals. Input events can be triggered by input signals, encoder position signals or repetitive time signals, and can be combined using logic gates in an FPGA to generate and output other events. The positions of all 4 encoders can be captured at the time of a given event and made available to the controlling system. All control and status is available through a serial protocol, so there is no dependency on a specific higher level control system. We have found it has applications on virtually all Diamond beamlines, from applications as simple as signal level shifting to, for example, using it for all continuous scanning experiments. The internal functionality is reconfigurable on the fly through the user interface and can be saved to static memory. It provides a flexible solution to interface different third party hardware (detectors and motion controllers) and to configure the required functionality as part of the experiment.

Logic Blocks

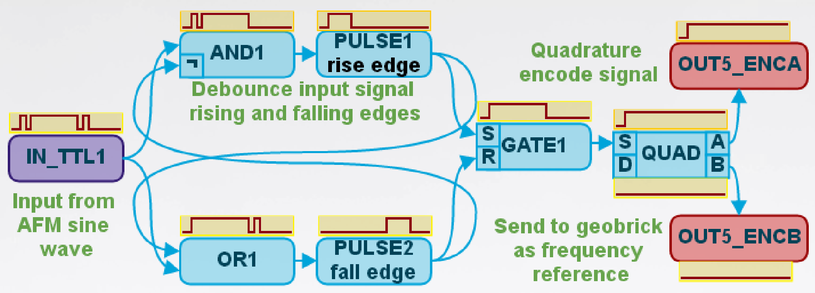
Inside the FPGA, there are a number of logic blocks, connected by the system bus. This allows the input of any logic block to be taken from a physical input or the output from any other logic block. Each physical output is also taken from the system bus in the same way. The following blocks are available:



- Logical AND of up to 4 signals, with the option to invert individual input signals
- Logical OR of up to 4 signals, with the option to invert individual input signals
- Set-reset gate, options to trigger each input on rising/falling edges
- Pulse divider with programmable divisor
- Pulse generator with delay and pulse width options
- Quadrature generator taking step and direction signals as input

Example

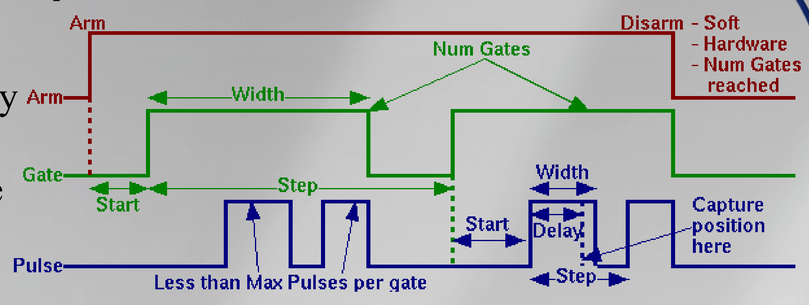
Synchronizing an Atomic Force Microscope (AFM) with a fast beam chopper.



The AFM outputs a 0 - 5 V sine wave that corresponds to its scanning frequency (IN_TTL1). ZEBRA uses two pulse generators, two logic gates, and a set-reset gate to debounce the signal, before quadrature encoding it. It is output as a differential quadrature signal to a motion controller (OUT5_ENCA and ENCB) to use as a speed reference.

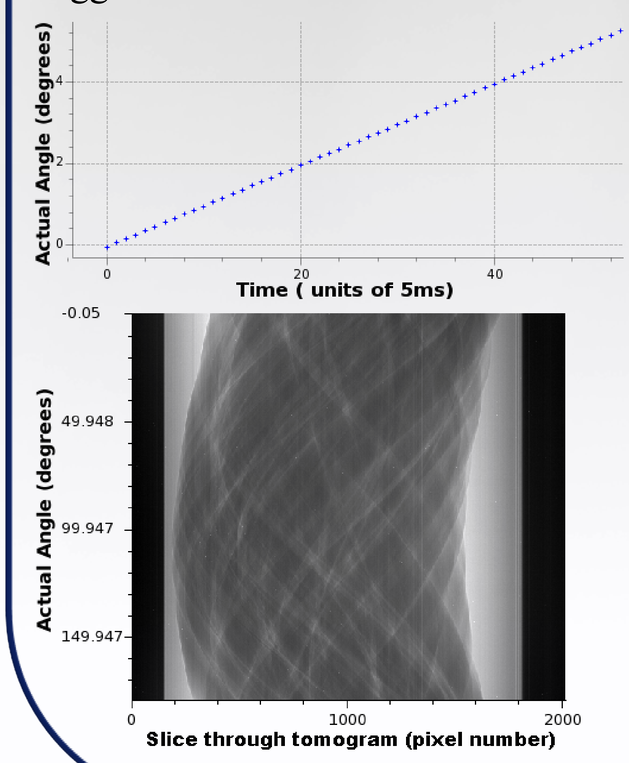
Position Capture

A range of position capture functionality is required on beamlines, with use cases falling into 3 main categories:



- Position based capture – where the motion controller outputs pulses when the encoder position reaches a certain value, or regularly spaced series of values
- Time based capture – where the motion controller outputs pulses at regular time intervals, storing the encoder position when this happens
- External trigger capture – where the motion controller stores the encoder position on an external trigger signal

The position capture block in ZEBRA was designed to meet all these needs, having an Arm signal, repeating Gates, and a stream of Pulses, each of which could be position based, time based, or externally triggered.



Example

Doing tomography with a PCO Dimax camera and fast rotation stage. The camera takes a trigger signal and exposes for a fixed amount of time on each trigger signal. To maximise the time the camera is exposing, ZEBRA sends out time based pulses within a position based gate of 0 - 180°. On the left is a cropped plot of the position of the stage against the time the trigger pulse was sent to the camera, along with a sinogram generated from the captured data. This data took 9 seconds to capture.

ZEBRA is available commercially from Quantum Detectors:

http://www.quantumdetectors.com