FEBEX4A CFD

Summary:

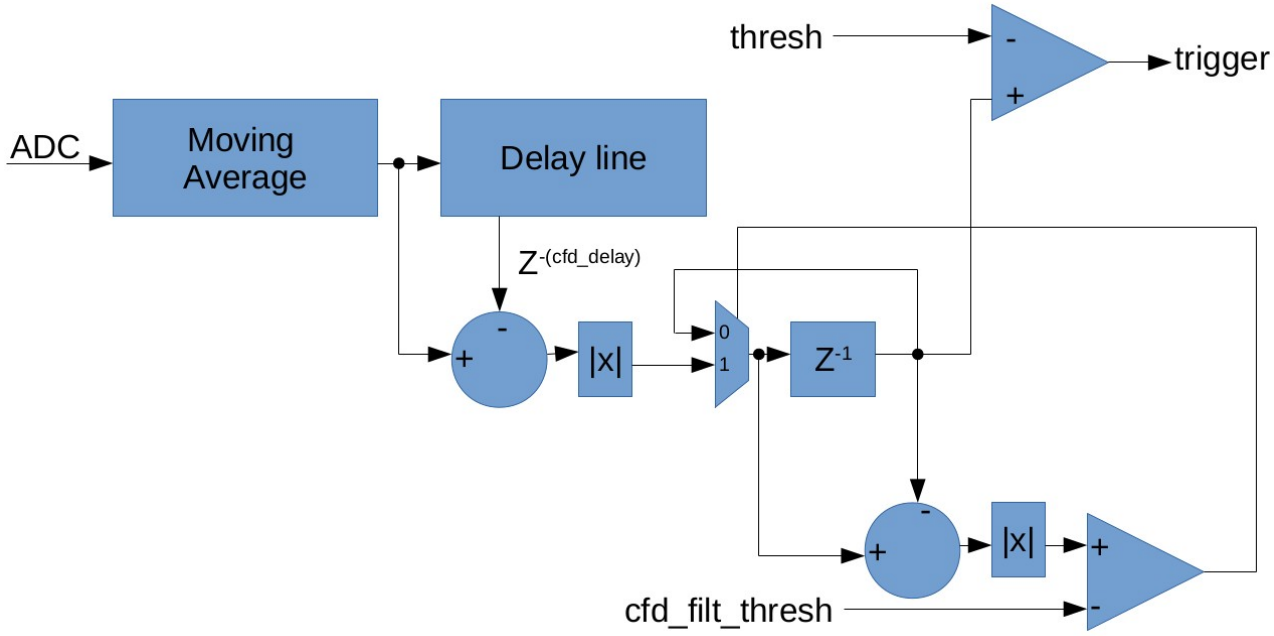
This document describes the functionality and interface of the CFD (constant fraction discriminator) that has been implemented on the FEBEX4A. The CFD generates independent channel triggers from the incoming ADC samples. The ADC is assumed to be sampling the output of an RC preamp.

Features:

- Two operating modes ‘CFD’ and threshold based triggering
- CFD is triggered on negative and positive going pulses (no need to select polarity)
- Threshold can be negative edge or positive edge triggered (similar to an oscilloscope)
- Selectable length moving average filters can be applied to the incoming sample stream to reduce noise
- Hysteresis filter for trigger waveform noise reduction (helps prevent multiple triggering events when operating with low threshold)
- CFD delay for slope calculation can be set between 1 sample and 255 samples (10nS to 2.55uS)
- Delay output that can be used to select optimal sample point in MWD (moving window deconvolution algorithm.
- Parameters adjustable on a per-channel basis (useful for mixed detectors or if channels are noisy)

Block Diagram (CFD mode):

Note this diagram does not accurately show the delay through the CFD



Addressing:

Only one register is used to communicate with the trigger peripheral with the GOSIP address 0x200020. The writes to this register are 32 bits with the most significant byte used to distinguish which sub register the write is for and the nibble below this used to select the channel. The least significant bits are used for the data payload.

If settings are needed to be read back the same address is written to but with the most significant bit set (E.G Ena most significant byte becomes 1000 0001). To read a write should be undertaken and then a subsequent read of the register 0x200020 will have the correct data payload. (similar to how the SPI read/write is performed (see memory map)).

The channel is selected using the 3rd most significant nibble. Channels are numbered 0 through to 15 (16 total).

Paraneter	**Data word (32bit, x = don't care)**
Ena	0000 0001 [chan] xxxx xxxx xxxx xxxx xxx[DATA]
thresh	0000 0010 [chan] xxxx [DATA] [DATA] [DATA] [DATA]
Direction	0000 0011 [chan] xxxx xxxx xxxx xxxx xxx[DATA]
cfd_mode	0000 0100 [chan] xxxx xxxx xxxx xxxx xxx[DATA]
cfd_delay	0000 0101 [chan] xxxx xxxx xxxx [DATA] [DATA]
cfd_filt_threshold	0000 0110 [chan] xxxx [DATA] [DATA] [DATA] [DATA]
cfd_mavg	0000 0111 [chan] xxxx xxxx xxxx [DATA] [DATA]

Write example:

In this example the CFD filter threshold of channel 4 is set to 75 using the program GOC to card 0 on SFP1:

goc -w -x 1 0 0x200020 0x0640004B

Read example:

In this example the enable bit is read from channel 15

goc -w -x 1 0 0x200020 0x81F00000
goc -r -x 1 0 0x200020
0x00000001 (Enabled)

Detailed description of input parameters:

Ena:

Enable ‘1’ or disable ‘0’ trigger output in both CFD and threshold mode.

thresh:

Unsigned 16bit value for for threshold in both CFD mode and threshold mode. The ADC data is also unsigned 16 bit (left shifted two times 14 bit data) with the zero input point at mid-scale. When using threshold mode the mid-scale offset must be taken into account. Threshold values in CFD mode are not effected by the midscale offset and are typically much lower values.

Direction:

Sets positive edge ‘1’ or negative ‘0’ edge triggering in threshold mode, has no effect in CFD mode.

cfd_mode:

CFD mode ‘1’, threshold mode ‘0’

cfd_delay:

8 bit unsigned value controlling which delay line tap is used for the slope calculation in the CFD, has no effect on threshold mode. This should be set shorter than the detector+preamp rise time. With fs=100MHz the delay granularity is 10nS.

cfd_filt_thresh:

Unsigned 16 bit threshold value for the hysteresis filter. If the hysteresis filter is to not be used this can be set to 0 to disable the filter. This filter is useful for avoiding multiple trigger events at low threshold. It should be set by looking at the detector waveforms, computing the trigger waveform

(input to trigger comparator in CFD diagram) off-line and setting the threshold to ~4x the RMS value of the trigger waveform.

cfd_mavg:

Unsigned 8 bit value that sets the stages of the moving average input filter in powers of two. E.G setting of 1 results in a two stage filter, setting of 4 a 16 stage filter. An input of 0 disables filtering effects. This filter is before the trigger and active for both CFD and threshold mode.

Summary of testing:

All features have been verified in HDL test benches. A hardware test of triggering has also been performed with negative and positive going pulses to channel 0 with the following parameters:

- Amplitude 1 Vpp
- Sample rate 100 MHz
- Rise time (0 – 100%) 200 nS
- Decay time constant 50 µS
- Repatition rate 1 kHz

The following script is run to set up the channel for triggering:

```
#!/bin/bash
#Set up trigger for input waveform of -0.5V to 0.5V, Tr = 400nS,
#RC time constant = 50uS on channel 0
#James Lawson 2020
BA=0x200020 #Address of CFD register
echo $BA
gosipcmd -w -x 1 0 $BA 0x020005DC #threshold = 1500 CH0
gosipcmd -w -x 1 0 $BA 0x03000001 #Direction set to positive edge (should have no effect)
gosipcmd -w -x 1 0 $BA 0x04000001 #CFD Mode CH0
gosipcmd -w -x 1 0 $BA 0x05000010 #CFD delay = 16
gosipcmd -w -x 1 0 $BA 0x06000190 #CFD filter threshold = 400
gosipcmd -w -x 1 0 $BA 0x07000000 #CFD MAVG disable
gosipcmd -w -x 1 0 $BA 0x01000001 #Enable CH0

#Readback settings
gosipcmd -w -x 1 0 $BA 0x820005DC
gosipcmd -r -x 1 0 $BA
gosipcmd -w -x 1 0 $BA 0x83000000
gosipcmd -r -x 1 0 $BA
gosipcmd -w -x 1 0 $BA 0x84000000
gosipcmd -r -x 1 0 $BA
gosipcmd -w -x 1 0 $BA 0x85000000
gosipcmd -r -x 1 0 $BA
gosipcmd -w -x 1 0 $BA 0x86000000
gosipcmd -r -x 1 0 $BA
gosipcmd -w -x 1 0 $BA 0x87000000
gosipcmd -r -x 1 0 $BA
```

```
gosipcmd -w -x 1 0 $BA 0x81000000
gosipcmd -r -x 1 0 $BA
```

Trigger signals are then observed on trigger output 6 of exploder, duration 250nS, -500mV, repetition rate 1kHz.