# Using the FADC250 V3 Module (V6 – 9/14/24)

**1.1 Controlling the Module**

 Communication with the module is by standard VME bus protocols. All registers and memory locations are defined to be 4-byte entities. The VME slave module has three distinct address ranges.

A24 – The base address of this range is set by a 12-element DIP switch on the board. It occupies 4 Kbytes of VME address space, organized in 1 K 32-bit words. Relative to the base address, this space is divided as follows:

 000-0FF – Register space to control and monitor the module (64 long words)

 100-1FF – ADC processing registers (64 long words)

 200-2FF – HITSUM processing registers (64 long words)

 300-3FF – SCALER registers (64 long words)

 400-4FF – SYSTEM TEST registers (64 long words)

 500-5FF – AUXILIARY registers (64 long words)

 600-FFF – Reserved (640 long words)

In addition to registers that are directly mapped to a VME address (Primary Address), the module supports Secondary Addressing in the A24 address space. These registers are accessed through an address mapping register (Secondary Address Register). Each secondary address is associated with a primary address. A Primary Address may have up to 64 K secondary addresses associated with it. A VME cycle loads the mapping register with data which is the internal (secondary) address of the target register. A VME cycle with the associated primary address accesses (read/write) the chosen internal register. Important registers are assigned primary addresses, allowing them to be directly accessible in a single VME cycle. Setup tables are assigned secondary addresses. This allows for a large internal address space, while maintaining a small VME footprint.

A32 - The base address of this range is programmed into register ADR32. It occupies 8 Mbytes of VME address space, organized in 2 M 32-bit words. A read of any address in this range will yield the next FADC data word from the module. Even though the module is logically a FIFO, the expanded address range allows the VME master to increment the address during block transfers. This address range can participate in single cycle, 32-bit block, and 64-bit block reads. The only valid write to this address range is the data value 0x80000000 which re-enables the module to generate interrupts (after one has occurred). The address range must be enabled by setting ADR32[0] = 1.

A32 - The lower and upper limits of this address range are programmed into register ADR\_MB. This common address range for a set of FADC modules in the crate is used to implement the Multiblock protocol. By means of token passing FADC data may be read out from multiple FADC modules using a single logical block read. The board possessing the token will respond to a read cycle in this address range with the next FADC data word from that module. The token is passed along a private daisy chain line to the next module when it has transferred all data from a programmed number of events (register BLOCK SIZE). The address range must be enabled: set ADR\_MB[0] = 1.

**1.3 Module Registers**

VERSION – board/firmware revision (0x0)

 [7…0] – (R) – firmware revision

 [15…8] – (R) – board revision

 [31…16] – (R) – board type (“FADC”)

CSR – Control/Status (0x4)

 0 – (R) – Event Accepted

 1 – (R) – Block of Events Accepted

 2 – (R) – Block of Events ready for readout

 3 – (R) – BERR Status (1 = BERR asserted)

 4 – (R) – Token Status (1 = module has token)

 5 – (R) – Compression Algorithm ERROR

 [6…9] – (reserved)

 10 – (R) – DAC serialization status (1 = active)

 11 – (R) – Data FIFO Empty Flag Asserted

 12 – (R) – Data FIFO Almost Empty Flag Asserted

 13 – (R) – Data FIFO Half Full Flag Asserted

 14 – (R) – Data FIFO Almost Full Flag Asserted

 15 – (R) – Data FIFO Full Flag Asserted

 16 – (R) – ADC Processing FPGA high temperature alarm flag

 17 – (R) – CTRL FPGA high temperature alarm flag

[18…19] – (reserved)

 20 – (W) – Pulse Soft **Trigger 2** (if CTRL[7] = 1 and CTRL[6..4] = 5)

 (delayed **Trigger 1** follows; delay in TRIG21\_DELAY register)

 (R) – Trigger 2 -> Trigger 1 sequence active

 21 – (W) – Pulse Clear Module – soft reset + clear data pipelines

 (R) – Clear Module process active

22 – (W) – ENABLE SCALERS INTO DATA STREAM with FORCED

 BLOCK TRAILER INSERTION (write ‘1’ to bits 22, 23)

 23 – (W) – FORCE BLOCK TRAILER INSERTION – will be successful only

 if there are NO triggers waiting to be processed

 24 – (R) – Last FORCE BLOCK TRAILER INSERTION Successful

 25 – (R) – Last FORCE BLOCK TRAILER INSERTION Failed

 26 – (R) – Local Bus Time Out – target AK or DK timed out (5 us);

 27 – (R/W) – Local Bus Error – target protocol violation;

 (write ‘1’ clears latched bits 26, 27)

 28 – (W) – Pulse Soft **Sync Reset** (if CTRL[11] = 1 and CTRL[10..8] = 6)

 29 – (W) – Pulse Soft **Trigger 1** (if CTRL[7] = 1 and CTRL[6..4] = 6)

 30 – (W) – Pulse Soft Reset – initialize counters, state machines, memory

 31 – (W) – Pulse Hard Reset – initialize module to power-up state

CTRL1 – Control 1 (0x8)

 [1…0] – (R/W) – Sampling Clock Source Select

0 = Internal Clock

1 = Front Panel connector

2 = P0 connector (VXS)

3 = P0 connector (VXS)

 2 – (not used)

 3 – (R/W) – Enable Internal Clock

[6…4] – (R/W) – Trigger Source Select

0 = Front Panel Connector (**Trigger 1**)

1 = Front Panel Connector (**Trigger 1**; synchronized)

2 = P0 Connector (VXS) (**Trigger1**, **Trigger 2**)

3 = P0 Connector (VXS) (**Trigger1**, **Trigger 2**; synchronized)

4 – (not used)

5 – Software Generated (**Trigger 2** + delayed **Trigger 1**)

6 = Software Generated (**Trigger 1**)

7 = Module Internal Logic

7 – (R/W) – Enable Soft Trigger

 [10…8] – (R/W) – Sync Reset Source Select

0 = Front Panel Connector

1 = Front Panel Connector (synchronized)

2 = P0 Connector (VXS)

3 = P0 Connector (VXS) (synchronized)

4 – (not used)

5 – (not used)

6 = Software Generated

7 = no source

11 – (R/W) – Enable Soft Sync Reset

12 – (R/W) – Select Live Internal Trigger to Output (otherwise, Module Trigger).

13 – (R/W) – Enable Front Panel Trigger Output

14 – (R/W) – Enable P0 (VXS) Trigger Output

15 – (R/W) – Insert ADC parameter word into data stream. The data word appears as a block header continuation word and has the following format:

[31…29] – 0

[28…18] – PL (see ADC processing FPGA address map below)

[17…9] – NSB

[8…0] – NSA

16 – (R/W) – Suppress both trigger time words from data stream

17 – (R/W) – Suppress trigger time word 2 from data stream

 (most significant bytes)

 18 – (R/W) – Enable Event Level Interrupt

 19 – (reserved)

 20 – (R/W) – Enable BERR response

 21 – (R/W) – Enable Multiblock protocol

 22 – (R/W) – FIRST board in Multiblock system

 23 – (R/W) – LAST board in Multiblock system

 24 – (reserved)

 25 – (R/W) – Enable Debug Mode

 [27…26] – (R/W) – Readout Data Format (see **Appendix 1**)

0 = Standard format (default)

1 = Intermediate compression format

2 = Full compression format

3 = Full compression format

 28 – (R/W) – Multiblock Token passed on P0

 29 – (R/W) – Multiblock Token passed on P2

 30 – (reserved)

31 – (R/W) – System Test Mode (0 = normal, 1 = test mode enabled)

CTRL2 – Control 2 (0xC)

 0 – (R/W) – GO (allow data transfer from external FIFOs to input FIFOs)

 1 – (R/W) – Enable **Trigger** (**1** & **2**) to Module (source = CTRL1[6…4])

 2 – (R/W) – Enable **Sync Reset** to Module (source = CTRL1[10…8])

 3 – (R/W) – Enable Internal Trigger Logic

 4 – (R/W) – Enable Streaming mode (NO event build)

5 – (R/W) – Use pulse derived from leading edge of **Sync Reset** signal as module

 Sync Reset

 [7…6] – Hall B data compression mode

 0 = NO compression

 1 = Verify (raw + compressed)

 2 = Compression ON

8 – (R/W) – Enable Test Event Generation (for debug)

9 – (R/W) – HALL B user (for data compression)

10 – (R/W) – data output mode select

 0 = VME (default)

 1 = VXS

[14…11] – VXS data output control bits

15 – (reserved)

 Bits 16 – 31 are functional only in Debug Mode (CTRL1[25] = 1)

 16 – (reserved)

 17 – (R/W) – Transfer data: build FIFO 🡪 output FIFO

 [18…31] – (reserved)

BLOCK SIZE (0x10)

[15…0] – (R/W) – number of events in a BLOCK.

 Stored Event Count ≥ BLOCK SIZE → CSR[3] = 1.

 [31…16] – (reserved)

INTERRUPT (0x14)

 [7…0] – (R/W) – Interrupt ID (vector)

 [10…8] – (R/W) – Interrupt Level [2..0]. Valid values = 1,..,7.

 11 - 15 – (reserved)

 [20…16] – (R) – Geographic Address (slot number) in VME64x chassis.

 21 – 22 – (reserved)

 23 – (R) – Parity Error in Geographic Address.

 24 – 31 – (reserved)

ADR32 – Address for data access (0x18)

 0 – (R/W) – Enable 32-bit address decoding

 1 – 6 – (reserved – read as 0)

 [15…7] – (R/W) – Base Address for 32-bit addressing mode (8 Mbyte total)

ADR\_MB – Multiblock Address for data access (0x1C)

 0 – (R/W) – Enable Multiblock address decoding

 1 – 6 – (reserved – read as 0)

 [15…7] – (R/W) – Lower Limit address (ADR\_MIN) for Multiblock access

 16 – 22 – (reserved – read as 0)

 [31…23] – (R/W) – Upper Limit address (ADR\_MAX) for Multiblock access

The board that has the TOKEN will respond with data when the VME address satisfies the following condition:

 ADR\_MIN ≤ Address < ADR\_MAX.

SEC\_ADR – Secondary Address (0x20)

 [15…0] – (R/W) – Secondary Address for 24-bit addressing mode

16 – (R/W) – Enable auto-increment mode (secondary address increments by 1 after each access of the associated primary address)

DELAY – Trigger/Sync\_Reset Delay (0x24) (NOT USED)

 [21…16] – (R/W) – Sync reset delay

 [5…0] – (R/W) – Trigger delay

INTERNAL TRIGGER CONTROL (0x28)

 [23…16] – (R/W) – trigger width (4 ns per count; max = 1024 ns)

 [11…0] – (R/W) – trigger hold off delay (4 ns per count; max = 16,384 ns)

RESET CONTROL (0x2C)

 0 – (W) – Hard reset – Control FPGA

 1 – (W) – Hard reset – ADC processing FPGA

[2…3] – (reserved)

 4 – (W) – Soft reset – Control FPGA

 5 – (W) – Soft reset – ADC processing FPGA

[6…7] – (reserved)

 8 – (W) – Reset – ADC data FIFO

 [9…10] – (reserved)

 10 – (W) – Reset – HITSUM FIFO

 11 – (W) – Reset – DAC (all channels)

 12 – (W) – Reset – EXTERNAL RAM Read & Write Address Pointers

 [13…15] – (reserved)

 16 – (W) – Take Token – return token to 1st board of multiboard set

 [17…31] – (reserved)

TRIGGER COUNT (0x30)

 [31…0] – (R) – total trigger count

 31 – (W) – reset count

EVENT COUNT (0x34)

 [23…0] – (R) – number of events on board (non-zero → CSR[0] = 1).

 [31…24] – (reserved)

BLOCK COUNT – (0x38)

 [31…20] – reserved

 [19…0] – (R) - number of event BLOCKS on board (non-zero → CSR[2] = 1).

BLOCK FIFO COUNT – (0x3C)

 [31…6] – reserved

 [5…0] – (R) - number of entries in BLOCK WORD COUNT FIFO

BLOCK WORD COUNT FIFO – (64 deep FIFO) (0x40)

 [31…25] – reserved (read as ‘0’)

 24 – (R) – count not valid (word count FIFO empty)

 [23…20] – reserved (read as ‘0’)

 [19…0] – (R) - number of words in next event BLOCK

INTERNAL TRIGGER COUNT (0x44)

 [31…0] – (R) – internal live trigger count

 31 – (W) – reset count

EXTERNAL RAM WORD COUNT (0x48)

 [31…22] – reserved (read as ‘0’)

 21 – (R) – RAM empty

 20 – (R) – RAM full (1,048,576 eight byte words)

 [19…0] – (R) – data word count (eight byte words)

DATA FLOW STATUS (0x4C) (for debug)

DAC CSR (Control/Status) (0x50)

 31 – (W) – DAC initialize

 30 – (R) – DAC initialization complete

 29 – (W) – Clear latched status bits for DAC (bits 18-19)

 [28...20] – (reserved – read as 0)

 19 – (R) – DAC timeout on access since last status Clear (bit 29)

 18 – (R) – DAC not ready on access since last status Clear (bit 29)

 17 – (R) – Last DAC access successful

 16 – (R) – DAC ready – current state

 [15…4] – (reserved – read as 0)

 [3...0] – (R/W) – DAC channel (0-15) to access with DAC DATA register

DAC DATA (0x54)

 [31…22] – (reserved – read as 0)

 21 – (R) – register A,B select (valid for DAC read only)

 20 – (R) – 1 (valid for DAC read only)

 19 – (R) – 0 (valid for DAC read only)

 18 – (R) – 0 (valid for DAC read only)

 [17…14] – (R) – channel accessed (valid for DAC read only)

 [13…12] – (R) – DAC register select [REG1,REG0] (valid for DAC read only)

 [11...0] – (R/W) – DAC data to write or read (channel selected in DAC CSR)

[To write or read DAC:

 1 – Set channel to access by writing DAC\_CSR register

 2 – DAC write: write 12-bit value to DAC\_DATA register

 3 – DAC read: read 12-bit value from DAC\_DATA register ]

CONFIG ROM CONTROL 0 (0x58)

 [7…0] – (R/W) – Configuration CMD

 8 – (R/W) – Configuration HostEndOfCmd

9 – (R/W) – Configuration Host\_Exec

 10 – (R/W) – Configuration ThreBytesAdr

 11– (R/W) – Reboot FPGA from Config ROM. Write 1 to Reboot.

 [12-31] – reserved

See VME\_Program\_FADCV3\_Config\_ROM.docx and FADC250V3\_Firmware\_ver\_4100\_Description\_Instructions.docx located at M:\FE\fADC-250V3\document

CONFIG ROM CONTROL 1 (0x5C)

 [31…0] – (R/W) – Configuration Rom\_Address

CONFIG ROM CONTROL 2 (0x60)

 [31…0] – (R/W) – Configuration DataToROM

CONFIG ROM STATUS 0 (0x64)

 [31…0] – (R) – Configuration DataReadFromROM

CONFIG ROM STATUS 1 (0x68)

 0 – (R) – Configuration NotValidOpCode

 1 – (R) – Configuration ReadyForCmd

 [2…31] – reserved

RESERVED (0x6C)

STATUS 1 – Input Buffer Status (0x70)

 31 – (R) – data buffer ready for input

 30 – (R) – data buffer input paused

 29 – (R) – reserved (read as ‘0’)

 28 – (R) – data buffer empty

 27 – (R) – data buffer full

 [26…16] – (R) – data buffer word count

[15…11] – (reserved)

[10…2] – latched compression buffer full flags (should always be ZERO)

1 – (R) – compression buffer full

0 – (R) – compression buffer empty

STATUS 2 – Build Buffer Status (0x74)

 [31…29] – reserved (read as ‘0’)

 28 – (R) – data buffer ‘A’ empty

 27 – (R) – data buffer ‘A’ full

 [26…16] – (R) – data buffer ‘A’ word count

 [15…13] – reserved (read as ‘0’)

 12 – (R) – data buffer ‘B’ empty

 11 – (R) – data buffer ‘B’ full

 [10…0] – (R) – data buffer ‘B’ word count

STATUS 3 – Output Buffer Status (0x78)

 [31…30] – reserved (read as ‘0’)

 29 – (R) – data buffer ‘A’ empty

 28 – (R) – data buffer ‘A’ full

 [27…16] – (R) – data buffer ‘A’ word count

 [15…14] – reserved (read as ‘0’)

 13 – (R) – data buffer ‘B’ empty

 12 – (R) – data buffer ‘B’ full

 [11…0] – (R) – data buffer ‘B’ word count

STATUS 4 – (spare) (0x7C)

 [31…0] – reserved

AUXILIARY 1 – (spare) (0x80)

 [31…0] – reserved

TRIGGER CONTROL (0x84) – Under normal conditions, a trigger received by the module is counted and sent to the ADC Processing FPGA. A trigger is considered acknowledged when data associated with it has been transferred to the Control FPGA. To ensure that data buffers in the ADC Processing FPGA are not overrun, the number of unacknowledged triggers is continuously compared to levels (MAX1, MAX2) set by the user. These levels are based on the parameters (processing mode, # samples in window) loaded into the ADC Processing FPGA. Two module based methods to avert buffer overflow and the resulting data corruption are available to the user.

In the first method, module BUSY is asserted when the number of unacknowledged triggers ≥ MAX1. BUSY propagates back to the Trigger Supervisor. The Trigger Supervisor does not deliver triggers to the system while BUSY is asserted. Level MAX1 is based on the BUSY propagation delay, ADC Processing parameters, and the minimum trigger interval parameter of the Trigger Supervisor.

In the second method, triggers received by the module are not sent to the ADC Processing FPGA when the number of unacknowledged triggers ≥ MAX2. Level MAX2 is based on the ADC Processing parameters. Not sending triggers to the FPGA Processing FPGA can cause a loss of synchronization among system components, but will prevent data corruption within the module. (See Auxiliary Scaler 2 for a count of lost triggers.)

Both methods can be applied together, with MAX2 ≥ MAX1.

31 – (R/W) – enable trigger stop when number of unacknowledged triggers ≥ MAX2

 [23...16] – (R/W) – level MAX2

15 – (R/W) – enable module busy assertion when number of unacknowledged triggers ≥ MAX1

 [7...0] – (R/W) – level MAX1

TRIG21 DELAY (0x88)

 [31…12] – reserved

 [11…0] – (R/W) – Delay from soft TRIG2 to generated TRIG1 (4 ns/count)

RAM Address Register (0x8C) – The RAM is organized as two 36-bit words with a common address. Auxiliary VME access (R/W) to the RAM is provided through a pair of 32 bit data registers (RAM 1, RAM 2). Note that bits 35 – 32 of each RAM word are not accessible through VME. During data flow operations, these bits carry event marker tags (header, trailer).

 31 – increment address after access (R/W) of RAM 1 Data Register

 30 – increment address after access (R/W) of RAM 2 Data Register

 [29…21] – reserved (read as 0)

[19…0] – RAM address

RAM 1 Data Register (0x90)

 [31…0] – RAM data word bits 67 – 36 (32 bits)

RAM 2 Data Register (0x94)

 [31…0] – RAM data word bits 31 – 0 (32 bits)

(PROM Registers 1 and 2 are used for FPGA configuration over VME.)

PROM Register 1 (0x98)

31 – READY – (R) – configuration state machine is available to accept command

 (i.e. no configuration process is currently executing).

 [30…8] – reserved (read as 0)

 [7…0] – configuration OPCODE

PROM Register 2 (0x9C)

 [31…0] – PROM ID – (R) response to specific OPCODE write to PROM reg 1.

BERR Module Count (0xA0)

 [31…0] – BERR count (driven by module to terminate data transmission)

BERR Total Count (0xA4)

 [31…0] – BERR count (as detected on bus)

Auxiliary Scaler 1 (0xA8)

 [31…0] – Total word count from ADC Processing FPGA

Auxiliary Scaler 2 (0xAC)

[31…0] – Count of triggers lost because number of unacknowledged triggers ≥ MAX2. (See TRIGGER CONTROL register.)

Auxiliary Scaler 3 (0xB0)

 [31…0] – Event header word count from ADC Processing FPGA

TRIGGER 2 SCALER (0xB4)

 [31…0] – (R) – **Trigger 2** count

 31 – (W) – write ‘1’ to reset count

Auxiliary Scaler 5 (0xB8)

 [31…0] – Event trailer word count from ADC Processing FPGA

SYNC RESET SCALER (0xBC)

 [31…0] – (R) – **Sync Reset** count

 31 – (W) – write ‘1’ to reset count

Module Busy Level (0xC0)

 [31] – Force module busy

 [30…20] – reserved

 [19…0] – Busy Level (eight-byte words)

 (External RAM word count > Busy Level 🡪 module busy = 1)

NOTE: At the system level, an asserted module busy signal should be used to prevent further triggers from being sent to the modules. By setting the Busy Level well below the memory capacity (1,048,576 eight-byte words), triggers already in the distribution pipeline can still be accepted by the module.

To prevent data corruption in the module if this global trigger control is NOT in place, the module itself will BLOCK input triggers when the number of 8-byte words in memory is within 12K (1.2%) of memory capacity (i.e. 1,036,288).

When global trigger control IS in place, it is important to set Busy Level significantly LESS than 1,036,288 so that local trigger blocking will NEVER occur. (Local trigger blocking will result in a loss of system synchronization.) The safe maximum Busy Level depends on data size per trigger (i.e. mode of ADC processing), but a Busy Level equal to ~87.5% of memory capacity (i.e. 917,504 = 0xE0000) should be adequate for all circumstances.

Generate Event Header Word (0xC4) (for debug)

 [31…0] – (W) – Event Header Word

Generate Event Data Word (0xC8) (for debug)

 [31...0] – (W) – Event Data Word

Generate Event Trailer Word (0xCC) (for debug)

 [31...0] – (W) – Event Trailer Word

MGT STATUS (0xD0)

 0 – (R) – lane 1 up (GTX1)

 1 – (R) – lane 2 up (GTX1)

 2 – (R) – channel up (GTX1)

 3 – (R) – hard error (GTX1)

 4 – (R) – soft error (GTX1)

 5 – (R) – lane 1 up (GTX2)

 6 – (R) – lane 2 up (GTX2)

 7 – (R) – channel up (GTX2)

 8 – (R) – hard error (GTX2)

 9 – (R) – soft error (GTX2)

 10 – (R) – SUM DATA VALID

 11 – (R) – MGT RESET ASSERTED

[31...12] – (R) - Reserved

MGT CONTROL (0xD4)

0 – **RELEASE MGT RESET** (0 = reset MGT, 1 = release reset)

1 – Data Type to CTP(0 = counting sequence, 1 = front-end data)

2 – Enable Data Alignment on Sync Reset occurrence

 [31...3] – Reserved

RESERVED (2 registers) (0xD8 – 0xDC)

SCALER CONTROL (0xE0) – See SCALERS (0x300 – 0x340)

 0 – (R/W) – Enable all scalers to count (1 = enable, 0 = disable)

1 – (W) – Latch all scalers. Write ‘1’ to simultaneously transfer all 17 scaler counts to registers for readout.

2 – (W) – Reset all scalers. Write ‘1’ to simultaneously reset all 17 scaler counts to zero.

[3 – 31] – (reserved)

BOARD SERIAL NUMBER 0 (0xE4)

 [31…24] – (R) – board serial number byte 0

 [23…16] – (R) – board serial number byte 1

 [15…8] – (R) – board serial number byte 2

 [7…0] – (R) – board serial number byte 3

BOARD SERIAL NUMBER 1 (0xE8)

 [31…24] – (R) – board serial number byte 4

 [23…16] – (R) – board serial number byte 5

 [15…8] – (R) – board serial number byte 6

 [7…0] – (R) – board serial number byte 7

BOARD SERIAL NUMBER 2 (0xEC)

 [31…24] – (R) – board serial number byte 8

 [23…16] – (R) – board serial number byte 9

 [15…8] – (R) – board serial number byte 10

 [7…0] – (R) – board serial number byte 11

SCALER INSERTION INTERVAL (0xF0) - Data from the SCALERS defined below (0x300 – 0x340) may be inserted into the readout data stream at regular event count intervals. The interval is specified in multiples of the event BLOCK SIZE. When the interval is ZERO (the default condition), there is NO insertion of scaler data into the data stream. When programmed for a non-zero interval, the current scaler values are appended to the last event of the appropriate BLOCK of events. The current Trigger 1 count is also inserted as the 18th scaler. Note that the scalers are **NOT** reset after their values are captured.

Example: Interval = 10 means that every 10th block of events will have the integrated scaler data appended to it.

(See the document FADC V2 Data Format for information on identifying scaler data words in an event.)

The scalers may ALSO be inserted into the data stream when a FORCE BLOCK TRAILER is done by the user. A simultaneous write of ‘1’ to bit 22 and bit 23 of the CSR (0x4) accomplishes this. The scaler values are those at the time of the last trigger’s occurrence.

[15…0] - (R/W) – N (in BLOCKS of events); every Nth block of events has integrated scaler data appended to the last event in the block.

 [31…16] – (reserved)

SUM THRESHOLD (History buffer) (0xF4)

 31 – (R) – sum data READY for readout if value = ‘1’

 [30…16] – (R/W) – reserved (read as ‘0’)

 [15…0] – (R/W) – sum threshold value for data capture

SUM DATA (History buffer) (0xF8)

 31 – (W) – writing a ‘1’ARMs History buffer for data capture

 [30…16] – (R) – reserved (read as ‘0’)

 [15…0] – (R) – sum data sample

SYSTEM MONITOR (0xFC)

 [31…22] – (R) – FPGA auxiliary voltage (2.5V) (common)

 vaux = (((float)((reg\_value >> 22) & 0x3FF))/1024.0) \* 3.0;

 21 – (R) – reserved (read as ‘0’)

 [20…11] – (R) – FPGA core voltage (1.0V) (common)

 vint = (((float)((reg\_value >> 11) & 0x3FF))/1024.0) \* 3.0;

 10 – (R) – reserved (read as ‘0’)

 [9…0] – (R) – CTRL\_FPGA temperature (oC)

 temp\_ctrl = (((float)(reg\_value & 0x3FF)) \* 503.975/1024.0) - 273.15;

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SCALER Registers (0x300 – 0x340) (R)

 SCALER[0] – (0x300) - input channel 0 count

 SCALER[1] – (0x304) - input channel 1 count

 SCALER[2] – (0x308) - input channel 2 count

 SCALER[3] – (0x30C) - input channel 3 count

 SCALER[4] – (0x310) - input channel 4 count

 SCALER[5] – (0x314) - input channel 5 count

 SCALER[6] – (0x318) - input channel 6 count

 SCALER[7] – (0x31C) - input channel 7 count

 SCALER[8] – (0x320) - input channel 8 count

 SCALER[9] – (0x324) - input channel 9 count

 SCALER[10] – (0x328) - input channel 10 count

 SCALER[11] – (0x32C) - input channel 11 count

 SCALER[12] – (0x330) - input channel 12 count

 SCALER[13] – (0x334) - input channel 13 count

 SCALER[14] – (0x338) - input channel 14 count

 SCALER[15] – (0x33C) - input channel 15 count

 TIME COUNT – (0x340) - timer (each count represents 2048 ns)

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SYSTEM TEST Registers (0x400 – 0x410)

TEST BIT REGISTER (0x400)

 0 – (R/W) – trigger\_out\_p0 (1 = asserted, 0 = not asserted)

 1 – (R/W) – busy\_out\_p0 (1 = asserted, 0 = not asserted)

 2 – (R/W) – sdlink\_out\_p0 (1 = asserted, 0 = not asserted)

 3 – (R/W) – token\_out\_p0 (1 = asserted, 0 = not asserted)

 [4 – 7] – (R/W) – spare out test bits

 8 – (R) – status\_b\_in\_p0 state (1 = asserted, 0 = not asserted)

 9 – (R) – token\_in\_p0 state (1 = asserted, 0 = not asserted)

[10 - 14] – (R) – reserved (read as ‘0’)

15 – (R) – clock\_250 counter status (1 = counting, 0 = not counting)

[16 - 31] – (R) – reserved (read as ‘0’)

CLOCK\_250 COUNT REGISTER (0x404)

 0 – (W) – Write ‘0’ resets the counter. Write ‘1’ initiates 20us counting interval.

[31 - 0] – (R) – CLK\_250 counter value. (Should be 5000 after count interval.)

SYNC\_IN\_P0 COUNT REGISTER (0x408)

 0 – (W) – Write ‘0’ resets the counter.

[31 - 0] – (R) – SYNC\_IN\_P0 counter value.

TRIG1\_IN\_P0 COUNT REGISTER (0x40C)

 0 – (W) – Write ‘0’ resets the counter.

[31 - 0] – (R) – TRIG1\_IN\_P0 counter value.

TRIG2\_IN\_P0 COUNT REGISTER (0x410)

 0 – (W) – Write ‘0’ resets the counter.

[31 - 0] – (R) – TRIG2\_IN\_P0 counter value.

------------------------------------------------------------------------------------------------------

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AUXILIARY Registers (0x500 – 0x5FF)

DEBUG (0x500 – 0x518) – for VME transfers

Three registers enable the tracking of the state machine used for 2eSST VME data transmission from the module. State values are saved in a FIFO buffer when recording is enabled and a change in the state value occurs. While enabled the buffer is continuously updated so that the last ‘N’ state values are present in the buffer; ‘N’ is programed by the user. Recording must be disabled before user readout of the state value buffer (FIFO) can begin. The actual number of valid saved state values is available to the user.

STATE LEVEL (0x500) (AUX 0)

 [31…16] – (R) – reserved (read as ‘0’)

 [15…9] – (R/W) – reserved

[8…0] – (R/W) – number of state values to capture (up to 511). Default value is

 500 (loaded on power up or hard reset of module).

STATE CSR (0x504) (AUX 1)

 31 – (R/W) – ‘1’ - buffer armed for state value capture; ‘0’ – buffer not armed

 [30…28] – (R) – reserved (read as ‘0’)

 [27] – (R) – state buffer full

 [26] – (R) – state buffer empty

 [25…9] – (R) – reserved (read as ‘0’)

 [8…0] – (R) – number of valid state values stored in buffer

STATE VALUE (0x508) (AUX 2)

 [31…17] – (R) – reserved (read as ‘0’)

 [16…0] – (R) – next 2eSST state value

SPARE DEBUG REGISTER 1 (0x50C) (AUX 3)

 [31…17] – (R/W) – reserved

BERR DRIVEN COUNT (0x510) (AUX 4)

 [31…0] – (R) – count of BERR driven by the module

RETRY DRIVEN COUNT (0x514) (AUX 5)

 [31…0] – (R) – count of RETRY driven by the module

SPARE DEBUG REGISTER 2 (0x518) (AUX 6)

 [31…17] – (R/W) – reserved

----------------------------------------------------------------------------

VXS OUTPUT STATUS REGISTER (0x51C) (AUX 7)

 [31…0] – (R) – status of VXS data output

----------------------------------------------------------------------------

SPARSIFY CONTROL REGISTER (0x520) (AUX 8)

0 – (R/W) – Bypass sparsification (1 = no sparsification (default on hard reset))

 [3 – 1] – (R/W) – sparsification mode (000 on hard reset)

 [31…4] – (R/W) – reserved

SPARSIFY STATUS REGISTER (0x524) (AUX 9)

0 – (R) – wait channel mask

1 – (R) – sparsification active

 [30 – 2] – (R) – reserved (read as 0)

31 – (W) – clear sparsification status (pulse)

FIRST TRIGGER NUMBER MISMATCH REGISTER (0x528) (AUX 10)

 [31…0] – (R) – trigger number at mismatch

MISMATCH TRIGGER NUMBER COUNTER (0x52C) (AUX 11)

 [31…0] – (R) – mismatched trigger count

NUMBER OF TRIGGERS PROCESSED COUNTER (0x530) (AUX 12)

 [31…0] – (R) – processed trigger count

SPARE DEBUG REGISTER 3 (0x534) (AUX 13)

 [31…17] – (R/W) – reserved

SPARE DEBUG REGISTER 4 (0x538) (AUX 14)

 [31…17] – (R/W) – reserved

SPARE DEBUG REGISTER 5 (0x53C) (AUX 15)

 [31…17] – (R/W) – reserved

IDELAY CONTROL 1 (0x540) (AUX 16)

 [31…0] – (R/W) – idelay1

 [8…0] – (R/W) – Idelay Count Value to be loaded into Idelay array

 [12…9] – (R/W) – Select ADC channel to load Idelay Count Value

[15..13] – (R/W) – Select ADC channel Idelay Count Value to be at idelay\_status1[28..11]

[16] – (R/W) – Rising edge load all values in Idelay array into Idelay

[17] – (R/W) – 1 allows changing Idelay Count Value. ) enable VTC

[18] -- (R/W) – Rising edge reset IDELAY Control.

\*\*\* See Appendix C for description of bit 16

IDELAY CONTROL 2 (0x544) (AUX 17)

 [31…0] – (R/W) – idelay2

 [3…0] – (R/W) – Select ADC Channel Idelay Value in pico Second stored in ROM to be at idelay\_status1[10..0]

IDELAY STATUS 1 (0x548) (AUX 18)

 [31…0] – (R) – current idelay1

[10..0] – (R) – Idelay Value in picosecond from ADC chanel select by IDELAYCONTROL2 [ 3..0]

 [19..11] – (R) – Idelay Count Value from ADC channel 0-8 select from IDELAYCONTROL1[15..13]

[28..20] - Idelay Count Value from ADC channel 0-8 select from IDELAYCONTROL1[15..13]

[29] – Done Loading Idelay Count Value (Success)

[30] – Failed to Load Idelay Count Value

[31] – Done Load Idelay Count Value

 \*\*\* See Appendix C for description of bit 29,30,31

IDELAY STATUS 2 (0x54C) (AUX 19)

 [31…0] – (R) – current idelay2

**Appendix A - Hall D FADC250 Data Format (9/16)**

**Data Type List**

0 – block header

1 – block trailer

2 – event header\*

3 – trigger time

4 – window raw data

5 – 8 – (reserved)

9 – pulse parameters\*\*

10 – 11 – (reserved)

12 – scaler data

13 – (reserved)

14 – data not valid (empty module)

15 – filler (non-data) word

 \* reformatted data type

 \*\* new data type – information from previous data types 7, 8, 10

 (data types not marked with \* or \*\* remain unchanged)

**Data Word Categories**

Data words from the module are divided into two categories: Data Type Defining (bit 31 = 1) and Data Type Continuation (bit 31 = 0). Data Type Defining words contain a 4-bit data type tag (bits 30 - 27) along with a type dependent data payload (bits 26 - 0). Data Type Continuation words provide additional data payload (bits 30 – 0) for the *last defined data type*. Continuation words permit data payloads to span multiple words and allow for efficient packing of raw ADC samples and pulse parameters. Any number of Data Type Continuation words may follow a Data Type Defining word. The scaler data type is an exception. It specifies the number of 32-bit data words that follow.

**Data Types**

**Block Header** (0) – Word 1 indicates the beginning of a block of events. Optional continuation Word 2 contains ADC processing parameters.

Word 1:

 (31) = 1

 (30 – 27) = 0

 (26 – 22) = slot number (set by VME64x backplane)

 (21 – 18) = module ID (‘1’ for FADC250)

 (17 – 8) = event block number

 (7 – 0) = number of events in block

Word 2:

(31) = 0

(30 – 29) = 0

(28 – 18) = PL (# samples before trigger point for processing to begin)

(17 – 9) = NSB (# samples before threshold crossing to include in processing)

 (pulse modes)

(8 – 0) = NSA (# samples after threshold crossing to include in processing)

 (pulse modes)

**Block Trailer** (1) – indicates the end of a block of events.

 (31) = 1

 (30 – 27) = 1

 (26 – 22) = slot number (set by VME64x backplane)

 (21 – 0) = total number of words in block of events

**Event Header** (2) – indicates the start an event.

 (31) = 1

 (30 – 27) = 2

(26 – 22) = slot number (set by VME64x backplane)

 (21 – 12) = trigger time (bits 9 – 0 (see below))

 (11 – 0) = trigger number

**Trigger Time** (3) – time of trigger occurrence relative to the most recent global reset. Time in the ADC data processing chip is measured by a 48-bit counter that is clocked by the 250 MHz system clock. The six bytes of the trigger time

 Time = TA TB TC TD TE TF

are reported in two words (Type Defining + Type Continuation). (Both Words or Word 2 alone may be suppressed from readout by the user.)

Word 1:

 (31) = 1

 (30 – 27) = 3

 (26 – 24) = TC bits 2 – 0 (duplicated in Word 2)

 (23 – 16) = TD

 (15 – 8) = TE

 (7 – 0) = TF

Word 2:

 (31) = 0

 (30 – 24) = reserved (read as 0)

 (23 – 16) = TA

 (15 – 8) = TB

 (7 – 0) = TC

**Window Raw Data** (4) – raw ADC data samples for the trigger window. The first word identifies the channel number and window width. Multiple continuation words contain two samples each. The earlier sample is stored in the most significant half of the continuation word. Strict time ordering of the samples is maintained in the order of the continuation words. A *sample not valid* flag may be set for any sample; e.g. the last reported sample is not valid when the window consists of an odd number of samples.

Word 1:

 (31) = 1

 (30 – 27) = 4

 (26 – 23) = channel number (0 – 15)

 (22 – 12) = reserved (read as 0)

 (11 – 0) = window width (in number of samples)

Words 2 - N:

 (31) = 0

 (30) = reserved (read as 0)

 (29) = sample x not valid

 (28 – 16) = ADC sample x (includes overflow bit)

 (15 – 14) = reserved (read as 0)

 (13) = sample x + 1 not valid

 (12 – 0) = ADC sample x + 1 (includes overflow bit)

**Pulse Parameters** (9) – computed pulse parameters for detected pulses in a channel. The first word identifies the channel number, event number within the block, and pedestal information for the window. Multiple continuation word *pairs* contain information about the pulses detected. For a channel with hits detected:

Word 1: Channel ID and Pedestal information (reported *once* for a channel with hits)

 (31) = 1

 (30 – 27) = 9

 (26 – 19) = event number within block (1 – 255)

 (18 – 15) = channel number (0 – 15)

 (14) = pedestal quality

 (13 – 0) = pedestal sum

Word 2 : Integral of first pulse in window

 (31) = 0

 (30) = 1

 (29 – 12) = 18-bit sum of raw samples that constitute the pulse data set

 (11 – 9) = integral quality

 (8 – 0) = number of samples within NSA that the pulse is above threshold

Word 3 : Time of first pulse in window

 (31) = 0

 (30) = 0

 (29 – 21) = coarse time (4 ns/count)

 (20 – 15) = fine time (0.0625 ns/count)

 (14 – 3) = pulse peak

 (2 – 0) = time quality

Words 2 and 3 are repeated for *each additional pulse* found in the window for the channel.

**Scaler Header** (12) – indicates the beginning of a block of scaler data words. The number of scaler data words that will immediately follow it is provided in the header. The scaler data words are 32 bits wide and so have no bits available to identify them. Currently there are 18 scaler words reported: 16 from individual channels, a timer, and a trigger count. The scalers and time represent values recorded at the indicated trigger count. Scaler data must be enabled into the data stream by the user.

 (31) = 1

 (30 – 27) = 12

 (26 – 6) = reserved (read as 0)

 (5 – 0) = number of scaler data words to follow (18 = current)

**Data Not Valid** (14) – module has no valid data available for read out.

 (31) = 1

 (30 – 27) = 14

 (26 – 22) = slot number (set by VME64x backplane)

 (21 – 0) = undefined

**Filler Word** (15) – non-data word appended to the block of events. Forces the total number of 32-bit words read out of a module to be a multiple of 2 or 4 when 64-bit VME transfers are used. **This word should be ignored**.

 (31) = 1

 (30 – 27) = 15

 (26 – 22) = slot number (set by VME64x backplane)

 (21 – 0) = undefined

**Processing Modes**

Two processing modes are supported.

Mode 9: reports pulse parameters (type 9) for hits

Mode 10: reports raw window samples (type 4) and pulse parameters (type 9) for hits

**Readout Format**

Standard: For a block of *N* events

 Block Header

 Event 1 Header

 Trigger Time 1

 Trigger Time 2

 Data words (event 1)

 Event 2 Header

 Trigger Time 1

 Trigger Time 2

 Data words (event 2)

 ------------------

 ------------------

 Event *N* Header

 Trigger Time 1

 Trigger Time 2

 Data words (event *N*)

 Block Trailer

Intermediate compression: For a block of *N* events and data in events *I, J, K*

 Block Header

 Event 1 Header (always)

 Event *I* Header

 Data words (event *I*)

 Event *J* Header

 Data words (event *J*)

 Event *K* Header

 Data words (event *K*)

 Block Trailer

Full compression: For a block of *N* events and data in events *I, J, K*

 Block Header

 Event 1 Header

 Data words (event *I*)

 Data words (event *J*)

 Data words (event *K*)

 Block Trailer

**Notes about the Readout Format**

For the *Full compression* readout format the trigger time in the Event 1 Header enables the detection of synchronization loss among modules. If synchronization is lost (e.g. module misses a trigger), it will likely not be discovered until the next *Sync Event* (TS pauses triggers and test for synchronization). Synchronization loss thus requires that multiple blocks of events be discarded. Since the *Standard* and *Intermediate compression* readout formats have the trigger time available for each event (within the Event Header for *Intermediate compression* format), the exact point of synchronization loss can be discovered in off-line analysis. Events can be re-aligned, with a loss of only one event for each trigger missed by a module.

For simplicity of design the ADC Processing FPGA always transmits data to the Control FPGA in *Standard* format (less Block Header or Trailer words). Based on the readout format selected by the user, the Control FPGA suppresses data words that are not required to be read out.

When using processing mode 10, raw window samples (type 4 words) will precede pulse parameters (type 9 words) for a given channel. This is done for performance reasons. Because type 4 words do not have an event number in their definition, it is recommended that the *Standard or Intermediate compression* readout formats be used for this mode.

**Appendix B: Example of Data Format for Production Mode 9**

1st Trigger Occurred at Time 0x123456

Channel 1 and 15 has 1 good pulse each

**Event Header** (2) – indicates the start an event.

Word 1:

 (35 – 32) = 0001

 (31) = 1

 (30 – 27) = 2

(26 – 22) = 00000

 (21 – 12) = “00” & x”56” ( trigger time (bits 9 –))

 (11 – 0) = x”0001”

**Trigger Time**

Word 2:

 (35 – 32) = 0000

 (31) = 1

 (30 – 27) = 3

 (26 – 24) = “011” TC bits 2 – 0 (duplicated in Word 2)

 (23 – 16) = x”4”

 (15 – 8) = x”5”

 (7 – 0) = x”6”

Word 3:

 (35 – 32) = 0000

 (31) = 0

 (30 – 24) = 0

 (23 – 16) = x”1”

 (15 – 8) = x”2”

 (7 – 0) = x”3”

**Pulse Parameters**

**Channel 1 data**

Word 4: Channel ID and Pedestal information (reported *once* for a channel with hits)

 (35 – 32) = 0000

 (31) = 1

 (30 – 27) = 9

 (26 – 19) = 00000000 event number within block (0 – 255)

 (18 – 15) = 0001

 (14) = 0

 (13 – 0) = pedestal sum

0xC800----

Word 5 : Integral of first pulse in window

 (35 – 32) = 0000

 (35 – 32) = 0000

 (31) = 0

 (30) = 1

 (29 – 12) = 18-bit sum of raw samples that constitute the pulse data set

 (11 – 9) = 000

 (8 – 0) = number of samples within NSA that the pulse is above threshold

Word 6 : Time of first pulse in window

 (35 – 32) = 0000

 (35 – 32) = 0000

 (31) = 0

 (30) = 0

 (29 – 21) = coarse time (4 ns/count)

 (20 – 15) = fine time (0.0625 ns/count)

 (14 – 3) = pulse peak

 (2 – 0) = time quality

**Channel 15 data**

Word 7: Channel ID and Pedestal information (reported *once* for a channel with hits)

 (35 – 32) = 0000

 (31) = 1

 (30 – 27) = 9

 (26 – 19) = 00000000 event number within block (0 – 255)

 (18 – 15) = 1111

 (14) = 0

 (13 – 0) = pedestal sum

Word 8 : Integral of first pulse in window

 (35 – 32) = 0000

 (31) = 0

 (30) = 1

 (29 – 12) = 18-bit sum of raw samples that constitute the pulse data set

 (11 – 9) = 000

 (8 – 0) = number of samples within NSA that the pulse is above threshold

Word 9 Time of first pulse in window

 (35 – 32) = 0000

 (31) = 0

 (30) = 0

 (29 – 21) = coarse time (4 ns/count)

 (20 – 15) = fine time (0.0625 ns/count)

 (14 – 3) = pulse peak

 (2 – 0) = time quality

**Event Trailer:** Indicate the end of an event.

Word 10

 EVENT\_TRAILER = "0010" & X"E8000000";

**Appendix C: Control Bus Memory Map for Registers**

Unused Bits are read back as zeroes

**Failure to adhere to Min values can result in unpredictable results**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Name **[VME ADDRESS]** | Width (Bits) | Quantity | Access | Primary Address(SecondaryAddress) | Power Up Values (hex) | Function  |
| STATUS0**[0x100]** | 16 | 1 | R | 0x0000(---) |  | Bits 14 to 0: Code VersionBit 15: 1= Command can be sent to AD4229 |
| STATUS1**[0x104]** | 16 | 1 | R | 0x0001(---) |  | 15 : 1 Done all Trig received11-0 : TRIGGER NUMBER  |
| STATUS2**[0x108]** | 16 | 1 | R | 0x0002(---) |  | Monitored Pedestal 15 🡪 Sum is valid14 🡪 0 Sum OK. 1 One or more is out of bound13-0 🡪 Sum |
| CONFIG1**[0x10C]** | 16 | 1 | R/W | 0x0003(---) | 0040 | Bit 0-2 (old code process mode): Bit 3: 1:RunBit 5-4 : Max Number of Pulses in Mode 10 and 9Bit 6: 1 Inverts ADC data outputBit 7: Test Mode (play Back). Bit 9-8: 00 🡪 mode 9 (pulse parameters) 01 🡪 mode 10 (pulse parameters & raw) 11 🡪 mode 11 (raw)11-10 NSAT13-12 TNSAT15🡪 Request Sum of Pedestal for monitoring purpose  |
| CONFIG2**[0x110]** |  |  | R/W | 0x0004(---) | 0040 | When 1 ADC values = 0Bit 0 🡪 ADC 0 Bit 1 🡪 ADC 1 Bit 2 🡪 ADC 2 Bit 3 🡪 ADC 3 Bit 4 🡪 ADC 4 Bit 5 🡪 ADC 5 Bit 6 🡪 ADC 6 Bit 7 🡪 ADC 7 Bit 8 🡪 ADC 8 Bit 9 🡪 ADC 9 Bit 10🡪 ADC 10 Bit 11🡪 ADC 11Bit 12🡪 ADC 12Bit 13🡪 ADC 13Bit 14🡪 ADC 14Bit 15🡪 ADC 15 |
| CONFIG 4**[0x114]** | 16 | 1 | R/W | 0x0005 | 0040 | ~~15..12=>~~ ~~Select which ADC receive IDELAY control bits and read back IDELAY comparator error~~15..12 => Select which ADC Idelay Error Bits to monitor~~11=>~~ ~~Idelay comparator reset~~~~10=>~~ ~~Increment IDELAY N delay value~~~~9 =>~~ ~~Decrement IDELAY P delay value~~~~8 =>~~ ~~Reset IDELAY~~11 => IDELAYE3\_EN\_VTC\_D10 => LdNextIdlyCh~~9 => ConfigIdelay~~~~8 => IDELAYCTRL\_RST~~7 => rising edge execute ADC command6 => 1 write to all ADC 5 => 0 write to ADC 1 read from ADC. Data is at Stat 44 => ~~1 Reset ADC~~3..0 => Select ADC to write to or read from |
| CONFIG5**[0x118]** | 16 | 1 |  | 0x0006 | 0040 | 15..8 => Register inside ADC7..0 => Data to write to register. |
| PTW**[0x11C]** | 9 | 1 | R/W | 0x0007(---) | 0010 | **PTW + 1** number of ADC sample to include in trigger window.PTW = Trigger Window (ns) \* 250 MHz.**Minimum is 6**. |
| PL**[0x120]** | 11 | 1 | R/W | 0x0008(---) | 0000 | Number of sample back from trigger point.PL = Trigger Window(ns) \* 250MHz |
| NSB**[0x124]** | 4 | 1 | R/W | 0x0009(---) | 0000 | 3..0: Read Back Path NSBNumber of sample before trigger point to include in data processing. This include the trigger Point. When NSB bit 3 is 1:**NSA has to be > NSB bits 1,0 by at least 4 => NSA – (NSB bits 1,0) ≥ 3** |
| NSA**[0x128]** | 15 | 1 | R/W | 0x000A(---) | 0005 | 8..0: Read Back Path NSANumber of sample after trigger point to include in data processing. **Minimum is 2**14..9: Trigger Path NSA |
| TET**[0x12C-148]** | 12 | 16 | R/W | 0x000B -0x001A | 0000 | ~~Trigger~~ Read Out Energy Thredhold. |
| CONFIG6 (Monitored Pedestal Sum)**[0x14C]** | 16 | 1 | R/W | 0x001B | 0000 | 13-10 MNPED : The number of ADC sample to sum up is MNPED + 1. **Min is 4**9-0 PMaxPed : When an ADC Samples is greater than this, bit 14 of the 14 bits (13-0) Sum will be set. |
| CONFIG7(Read Back Pedestal Sum) **[0x150]** | 16 | 1 | R/W | 0x001C | 0000 | 13-10 NPED : The number of ADC sample is NPED + 19-0 MaxPed |
| Test Wave Form**[0x154]** | 16 | 1 | R/W | 0x001D | 0000 | Write to PPG. Read should immediately follow write. |
| ADCPedestal Subtract**[0x158-194]** | 12 | 16 | R/W | 0x001E-0x002D | 0000 | Subtract from ADC(0-15) Count before Summing  |
|  |  |  |  |  |  |  |
| Config 3**[0x198]** | 16 | 1 | R/W | 0x002E | 0000 | 15 : Sync Disable (11..0) Trigger Path Processing Threshold |
| STATUS 3**[0x19C]** | 16 | 1 | R | 0x002F |  | ~~FPGA core temp (DieTemp)~~5 - DoneReadSeriallRomAt250404 - DoneLdIdelayCntVal 3 - Detect\_ERROR\_IDDR\_P\_CH8\_15 2 - Detect\_ERROR\_IDDR\_N\_CH8\_15 1 - Detect\_ERROR\_IDDR\_P\_CH0\_7 0 - Detect\_ERROR\_IDDR\_N\_CH0\_7 |
| STATUS 4**[0x1A0]** | 16 | 1 | R | 0x0030 |  | 14 – Vcc Aux is out of range13 – Vcc Int is out of range12 – FPGA over 85 degree C11 – FPGA over 125 degree C9-0 Result of ADC AD4229 register read back |
| Roque\_PTW\_Fall\_Back**[0x1A4]** | 16 | 1 | R/W | 0x0032 |  | When 1 enable send raw data when any of the first 4 samples is above threshold.When 0 proceed to calculate SUM and TDC Bit 0 🡪 ADC 0 Bit 1 🡪 ADC 1 Bit 2 🡪 ADC 2 Bit 3 🡪 ADC 3 Bit 4 🡪 ADC 4 Bit 5 🡪 ADC 5 Bit 6 🡪 ADC 6 Bit 7 🡪 ADC 7 Bit 8 🡪 ADC 8 Bit 9 🡪 ADC 9 Bit 10🡪 ADC 10 Bit 11🡪 ADC 11Bit 12🡪 ADC 12Bit 13🡪 ADC 13Bit 14🡪 ADC 14Bit 15🡪 ADC 15 |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

**Appendix B**

 **Bias DAC Count ADC Count With No Input (in hex)**

|  |  |  |  |
| --- | --- | --- | --- |
| 4096 |  |  | 1000 |
| 4000 |  |  | 1000 |
| 3500 |  |  | 1000 |
| 3300 |  |  | 66 |
| 3100 |  |  | 173 |
| 3000 |  |  | 1FB |
| 2900 |  |  | 281 |
| 2800 |  |  | 30A |
| 2700 |  |  | 393 |
| 2600 |  |  | 419 |
| 2500 |  |  | 49E |
| 2400 |  |  | 526 |
| 2300 |  |  | 5ae |
| 2200 |  |  | 632 |
| 2100 |  |  | 6BA |
| 2000 |  |  | 741 |
| 1900 |  |  | 7C6 |
| 1800 |  |  | 850 |
| 1700 |  |  | 8D5 |
| 1600 |  |  | 95B |
| 1500 |  |  | 9E1 |
| 1400 |  |  | A6B |
| 1300 |  |  | AF0 |
| 1200 |  |  | B7B |
| 1100 |  |  | C00 |
| 1000 |  |  | C86 |
| 900 |  |  | D0E |
| 800 |  |  | D91 |
| 700 |  |  | E19 |
| 600 |  |  | EA1 |
| 500 |  |  | F29 |
| 400 |  |  | FAC |
| 300 |  |  | 1FFF |

**Appendix D:**

**Idelay Values for FPGA ADC Input Pins:**

**Description:**

 ADC output data is Double Data Rate (data bits change on rising edge and falling edge of clock) at 250MHz. The FPGA clock has to be (approximately) at the center of the data bits. Due to a difference delay (when data and clock arrived at the FPGA) between the data and clock, the data have to be delayed. FPGA’s delay circuit has 512 tap with each tap provided approximately 17.857 pS of delay. The tap’s delay is varying with temperature and voltage. To accommodate this variation, the desired delay for each ADC is found at the current temperature and voltage and stored in on board serial ROM. The FPGA is compiled with a delay of 1000pS for all ADC channels. The tap values that provided this 1000pS at the current temperature and voltage are then load when FPGA is booting. These tap values are read by user to determine “tap per ps”. The “tap per ps” is multiplied by the desired delay stored in ROM. The tap count is then loaded into the Idelay in the FPGA. The FPGA changes these count based on temperature and voltage to keep the desired delay (stored in ROM).

**Loading Idelay values for FPGA’s input citcuit:**

1. Run the Calc\_Load\_IdelayCntVal routine AT POWER UP in For\_Coda\_1.cpp file . The file is located at M:\FE\fADC-250V3\C\_test\_code\_CPP2022\For\_Coda. This routine does the following:
	1. Read the deisre delays (in pSec from serial ROM on the FADCV3 board => IdelayValInRom
	2. Read the present Idely Count Values (position of 512 taps) => InitIdelyCountValue
	3. Tap delay resoultion; TapRes = 500 pS/InitIdelyCountValue
	4. NewTapVal = TapRes \* IdelayValInRom
	5. Program NewTapVal into Idelay
2. Read IDELAY STATUS 1 (0x548) (AUX 18)
	1. If bit 29 is a 1 then the count values are successfully loaded
	2. If bit 30 is a 1 then the count values are not loaded. Something is wrong with the IDELAY circuit in the FPGA

**Appendix F:**

**Rebooting the FPGA**

The host can reboot the FPGA from configuration ROM by setting bit 11 of CONFIG ROM CONTROL 0 (0x58)