

# TMB 2005 Design

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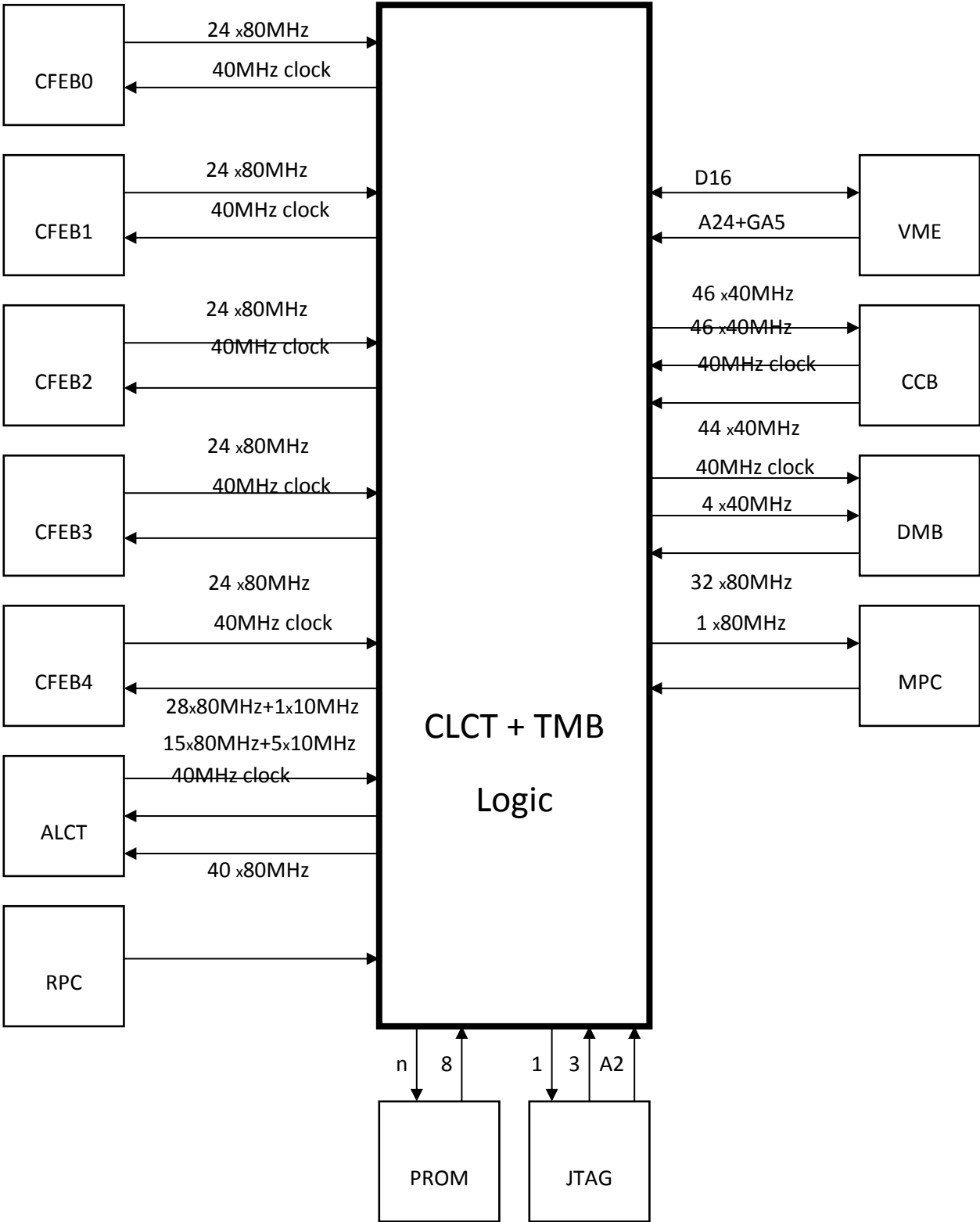
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# TMB Overview

Figure 1 TMB Overview



## CLCT Processing Algorithm

bx -1/2 Latch 1<sup>st</sup>-in-time CFEB transmission  
 bx 0 Latch 2<sup>nd</sup> in-time CFEB transmission  
 Demultiplex 1<sup>st</sup>-in-time and 2<sup>nd</sup>-in-time CFEB Triads  
 Map cable-signal ordering into 5 CFEBs x 8 DiStrip Triads x 6 Layers (240 signals)  
 Store CFEB Triads in Raw-hits RAM  
 Multiplex CFEB Triads with internal pattern-injector RAM  
 AND Triads with Hot Channel Mask to disable errant DiStrips  
 Decode Triad start bits (240 processed in parallel)  
     Triad decoder state machines run continuously to preclude missing any start bits  
     Each 1/2-strip one-shot can fire again on the same clock cycle that the previous 1/2-strip pulse ends  
     If a 2<sup>nd</sup> triad arrives for the same DiStrip while busy, the triad is decoded but the one-shot does not fire  
     In that case, the triad-skipped counter is incremented

bx 1 Decode Triad strip bits

bx 2 Decode Triad 1/2-strip bits

bx 3 Fire 1/2-strip one-shots for 6bx (triad\_persist is programmable, 6bx is the default)

OR 160 1/2-strips on each layer for layer-trigger mode

Stagger correction (if stagger\_hs\_csc =1) shifts alternate layers by -1hs

ly0	-0hs	i.e. hs5 → hs5	
ly1	-1hs	i.e. hs6 → hs5	
ly2	-0hs	i.e. hs5 → hs5	key layer ly2
ly3	-1hs	i.e. hs6 → hs5	
ly4	-0hs	i.e. hs5 → hs5	
ly5	-1hs	i.e. hs6 → hs5	

### Pattern Finding:

For each of 160 key 1/2-strips consider the 42 neighboring 1/2-strips (i.e. on key 5 use the following 1/2-strips)

hs	0123456789A	
ly0[10:0]	xxxxxxxxxxxx	5+1+5 =11
ly1[ 7:3]	xxkxxx	2+1+2 = 5
ly2[ 5:5]	k	0+1+0 = 1
ly3[ 7:3]	xxkxxx	2+1+2 = 5
ly4[ 9:1]	xxxxxxxxxx	4+1+4 = 9
ly5[10:0]	xxxxxxxxxxxx	5+1+5 =11

For each of 160 key 1/2-strips, count layers with hits matching the 9 pattern templates

Pattern ID=1 is a layer-OR trigger, Pattern ID=0 is no-pattern-found

Hit pattern LUTs for 1 layer: - = don't care, xx= one hit or the other or both

Pattern	id=2	id=3	id=4	id=5	id=6	id=7	id=8	id=9	idA
Bend dir	bd=0	bd=1	bd=0	bd=1	bd=0	bd=1	bd=0	bd=1	bd=0
ly0	-----xxx xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----
ly1	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----
ly2 key	-----x-----	-----x-----	-----x-----	-----x-----	-----x-----	-----x-----	-----x-----	-----x-----	-----x-----
ly3	-----xxx-----	-----xxx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----
ly4	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----	-----xx-----
ly5	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----

	0123456789A	0123456789A	0123456789A	0123456789A	0123456789A	0123456789A	0123456789A	0123456789A	0123456789A
// Extent									
// Avg.bend	- 8.0 hs	+ 8.0 hs	-6.0 hs	+6.0 hs	-4.0 hs	+4.0 hs	-2.0 hs	+2.0 hs	0.0 hs
// Min.bend	-10.0 hs	+ 6.0 hs	-8.0 hs	+4.0 hs	-6.0 hs	+2.0 hs	-4.0 hs	0.0 hs	-1.0 hs
// Max.bend	- 6.0 hs	+10.0 hs	-4.0 hs	+8.0 hs	-2.0 hs	+6.0 hs	0.0 hs	+4.0 hs	+1.0 hs

bx 4 Result for each of 160 keys is a list of 9 pattern-ID numbers (pid) [2 to A] and corresponding number of layers [0 to 6] with matching hits (nhits)

Find the best 1-of-9 pattern ID numbers for each key by comparing nhits

Ignore bend direction: left and right bends have equal priority (bit 0 of pid implies bend direction)

If two pattern IDs have the same nhits, take the higher pattern ID

A key with no matching hits, would always return pid=A and nhits=0

- bx 5 Pre-trigger if any 1-of-160 keys have  $\text{nhits} \geq \text{hit\_thresh\_pretrig}$  and  $\text{pid} \geq \text{pid\_thresh\_pretrig}$   
Construct 5-bit active-cfeb list for DMB:  
cfeps with a key that has  $\text{nhits} \geq \text{hit\_thresh\_pretrig}$  and  $\text{pid} \geq \text{pid\_thresh\_pretrig}$   
cfeps with a key that has  $\text{nhits} \geq \text{dmb\_thresh\_pretrig}$   
cfeps adjacent to a cfeb that has  $\text{nhits} \geq \text{hit\_thresh\_pretrig}$  and  $\text{pid} \geq \text{pid\_thresh\_pretrig}$  within  $\text{adjfeb\_dist}$
- bx 6 Finding 1<sup>st</sup> CLCT:  
Construct 7-bit pattern quality for sorting:  $\text{pat}[7:0]$   
 $\text{pat}[7:5] = \text{nhits}[2:0]$   
 $\text{pat}[4:0] = \text{pid}[3:0]$   
Ignore the bend direction bit ( $\text{pid}[0]$ ), left and right bends have equal priority  
Store  $\text{pat}[7:0]$  for 160 keys for use later to find 2<sup>nd</sup> CLCT  
Start finding best 1-of-160 keys by sorting on the 6-bit number  $\text{pat}[7:1]$   
If two keys have the same  $\text{pat}[7:1]$  take the lower key
- bx 7 Find 1<sup>st</sup> CLCT:  
Finish finding best 1-of-160 keys by sorting on the 6-bit number  $\text{pat}[7:1]$   
Store 1<sup>st</sup> CLCT info: key, pattern ID, and number of hits  
For empty events,  $\text{key}=0$ ,  $\text{pid}=A$  and  $\text{nhits}=0$ . If  $\text{clct\_blanking}=1$ , then  $\text{key}=\text{pid}=\text{hits}=0$
- bx 8 Finding 2<sup>nd</sup> CLCT:  
Construct list of busy keys  
Mark keys near 1<sup>st</sup> CLCT as busy from 1<sup>st</sup> key- $\text{nspan}$  to 1<sup>st</sup> key+ $\text{pspan}$   
If  $\text{clct\_sep\_src}=1$ ,  $\text{pspan}$  and  $\text{nspan}$  are set equal to  $\text{clct\_sep\_vme}$ , typically 10hs  
If  $\text{clct\_sep\_src}=0$ ,  $\text{pspan}$  and  $\text{nspan}$  are read from RAM and depend on the pattern ID number  
This allows two non-bending tracks | | to be closer than bending tracks / \  
Start finding best 1-of-160 keys by sorting on the 6-bit number  $\text{pat}[7:1]$   
Skip busy keys  
If two keys have the same  $\text{pat}[7:1]$  take the lower key
- bx 9 Find 2<sup>nd</sup> CLCT:  
Finish finding best 1-of-160 keys by sorting on the 6-bit number  $\text{pat}[7:1]$   
Store 2<sup>nd</sup> CLCT info: key, pattern ID, and number of hits  
For empty events,  $\text{key}=11$ ,  $\text{pid}=A$  and  $\text{nhits}=0$ . If  $\text{clct\_blanking}=1$ , then  $\text{key}=\text{pid}=\text{hits}=0$
- bx 10 Drift Delay 1bx (waits for CSC drifting)
- bx 11 Drift Delay 1bx  
If  $\text{clct0 nhits} < \text{hit\_thresh\_postdrift}$  OR  $\text{pid} < \text{pid\_thresh\_post\_drift}$ , discard event
- bx 12 Match to ALCT window 0  
If  $\text{alct}$  matches, jump to bx15 logic, latency is shortened 2bx
- bx 13 Match to ALCT window 1  
If  $\text{alct}$  matches, jump to bx15 logic, latency is shortened 1bx
- bx 14 Match to ALCT window 2  
If ALCT does not arrive, and  $\text{clct\_only}$  mode is enabled, accept CLCT at window 2  
If ALCT does not arrive, and not in  $\text{clct\_only}$  mode, discard event
- bx 15 Construct two LCTs from CLCT and ALCT data  
If event has 2 CLCTs and 1 ALCT, copy 1<sup>st</sup> ALCT into 2<sup>nd</sup> ALCT position  
If event has 1 CLCT and 2 ALCTs, copy 1<sup>st</sup> CLCT into 2<sup>nd</sup> CLCT position  
Calculate LCT quality  
Multiplex mpc injector ram data
- bx 16 Transmit 1<sup>st</sup>-in-time LCT frame to MPC
- bx 16½ Transmit 2<sup>nd</sup>-in-time LCT frame to MPC

# DDR Signal Synchronization

## CFEB DDR Receiver Sync Stages

CFEB receiver logic is designed to synchronize incoming comparator data to TMBs main clock, while minimizing CLCT trigger-path latency. It has a programmable 0-16bx delay stage to compensate for differing CFEB cable lengths.

The logic is shown schematically (Figure 2) but the actual TMB logic is written in behavioral Verilog.

- U1A Latches incoming CFEB data `din` on the *falling* edge of `clock_job`.  
The user has already tuned the associated `cfeb[n]_rx` digital phase shifter so that `clock_job` always latches stable data.
- U1B Latches incoming `din` on the *rising* edge of `clock_job`.  
U1A and U1B comprise a single Double Data Rate (DDR) I/O-Block flip-flop, and are only shown here separately for clarity.
- U2 Latches data transferred from U1A on the *rising* edge of `clock_job`.  
U2 now holds `din_1st`-in-time data, aligned with the rising edge of `clock_job`, while U1B holds `din_2nd`-in-time data, also aligned with the rising edge of `clock_job`.

In non-muonic firmware, this would be the end stage, because `clock_job` would be the same as TMBs main clock.

In muonic firmware versions, `din_1st` and `din_2nd` still need to be synchronized to TMBs main clock. This is done by latching data on both the posedge and negedge of the main clock, then selecting one latch or the other with the `posneg` bit.

If the posedge flip-flops U11,U12 are out-of-time (creating a dead-spot in the `din` receive window) then the negedge flip-flops U3,U4 must be in-time. One set of latches, either U11,U12 or U3,U4 will always be in-time for a given phase of `clock_job`.

- U3,U4 Latch `din_1st` and `din_2nd` on the falling edge TMBs main `clock_1x`.
- U5,U6 Select either posedge data from U2,U1B or negedge data from U3,U4.
- U7,U8 Delay data by 1-to-16 bx, according to `delay[3:0]` from a VME register.  
Setting `address=0` for U7,U8 gives a 1bx delay, so `delay-1` is used to form the address.
- U14 Subtracts 1 from `delay[3:0]` to form the shift register address for U7,U8.
- U9,U10 Bypass delays U7,U8 if the delay is 0, thus giving a 0-16bx delay span.
- U11,U12 Latch data on the rising edge of TMBs main `clock_1x`, and are the final synchronization stage.

## ALCT DDR Receiver Sync Stages

ALCT receiver logic is designed to synchronize incoming data to TMBs main clock. It uses a small number of flip-flops, and is able to fit in a single FPGA column. It uses a different technique than the CFEB sync section, and does not have a delay stage.

The logic is shown schematically (Figure 3), but the actual TMB logic is written in behavioral Verilog.

- U1A Latches incoming ALCT data *din* on the *falling* edge of *clock\_job*.  
The user has already tuned the associated *alct\_rxd* digital phase shifter so that *clock\_job* always latches stable data.
- U1B Latches incoming *din* on the *rising* edge of *clock\_job*.  
U1A and U1B comprise a single Double Data Rate (DDR) I/O-Block flip-flop, and are only shown here separately for clarity.
- U2 Latches ALCT data transferred from U1A on the *rising* edge of *clock\_job*.  
U2 now holds *din\_1<sup>st</sup>*-in-time data, aligned with the rising edge of *clock\_job*, while U1B holds *din\_2<sup>nd</sup>*-in-time data, also aligned with the rising edge of *clock\_job*.

In non-muonic firmware, this would be the end stage, because *clock\_job* would be the same as TMBs main clock.

- U3,U4 Latch *din\_1<sup>st</sup>* and *din\_2<sup>nd</sup>* on either the *rising* or *falling* edge of TMBs main *clock\_1x*. They are clocked at 2x the main clock frequency, but are enabled for only one edge direction, according to the value of the *posneg* bit. The edges of *clock\_2x* are closely aligned to the edges of *clock\_1x*.
- U7 If *posneg* =1, U7 inverts a logic accessible copy of *clock\_1x*, called *clock\_lac*.  
If *posneg* =0, U7 passes *clock\_lac* un-inverted.

Because *clock\_lac* is delayed by about 2ns after *clock\_1x*, *posneg* =1 enables U3,U4 to latch data on the edge of *clock\_2x* that corresponds to the *rising* edge of *clock\_1x*, and *posneg*=0 enables latching on the *falling* edge.

- U5,U6 Latch data on the rising edge of TMBs main *clock\_1x*, and are the final synchronization stage.



## ALCT DDR Transmitter Sync Stages

The ALCT transmitter logic is designed to synchronize TMBs outgoing data to the ALCT board's clock. It has a programmable 0-16bx delay stage, and a data-path multiplexer for sending test patterns to ALCT.

The logic is shown schematically (Figure 4), but the actual TMB logic is written in behavioral Verilog.

U1,U2 Select the transmitter data source, either ALCT data or the test pattern generator, according to the value of `sync_mode`.

U3,U4 Delay data by 1-to-16 bx, according to the VME-set delay-1 (the subtractor is not shown).

U3,U4 Delay data by 1-to-16 bx, according to `delay[3:0]` from a VME register.  
Setting `address=0` for U3,U4 gives a 1bx delay, so `delay-1` is used to form the address.

U15 Subtracts 1 from `delay[3:0]` to form the shift register address for U3,U4.

U5,U6 Bypass delays U3,U4 if the delay is 0, thus giving a 0-16bx delay span.

U7,U8 Latch data on the rising edge of TMBs main `clock_1x`, and are the final main-clock stage.

In non-muonic firmware, this would be the end stage, because `clock_job` would be the same as TMBs main clock.

U9,U10 Latch data on either the *rising* or *falling* edge of TMBs main `clock_1x`. They are clocked at 2x the main clock frequency, but are enabled for only one edge direction, according to the value of the `posneg` bit. The edges of `clock_2x` are closely aligned to the edges of `clock_1x`.

U14 If `posneg = 1`, U14 inverts a logic accessible copy of `clock_1x`, called `clock_lac`.  
If `posneg = 0`, U14 passes `clock_lac` un-inverted.

Because `clock_lac` is delayed by about 2ns after `clock_1x`, `posneg = 1` enables U9,U10 to latch data on the edge of `clock_2x` that corresponds to the *rising* edge of `clock_1x`, and `posneg = 0` enables latching on the *falling* edge.

U12 Latches 1<sup>st</sup>-in-time data on the *rising* edge of `clock_job`. It is a Double Data Rate I/O Block flip-flop that transmits 1<sup>st</sup>-in-time data on the rising edge of `clock_job`, and 2<sup>nd</sup>-in-time on the falling edge.

U11 Holds 2<sup>nd</sup>-in-time data for ½ cycle while waiting for U12 to transmit 1<sup>st</sup>-in-time data.

Figure 2 CFEB Muonic Receiver

CFEB-to-TMB: 80MHz-to-40MHz Muonic Receiver Sync Stages

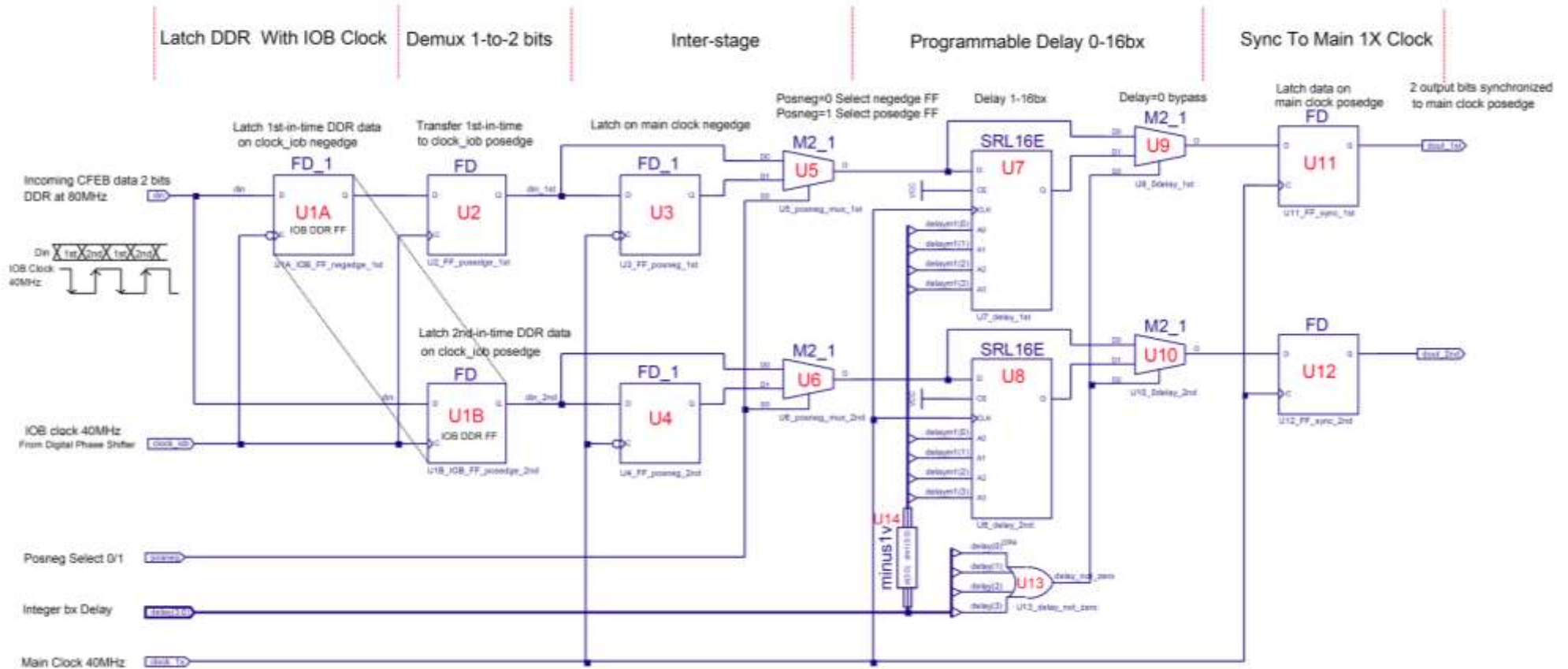


Figure 3 ALCT Muonic Receiver

# ALCT-to-TMB: 80MHz-to-40MHz Muonic Receiver Sync Stages

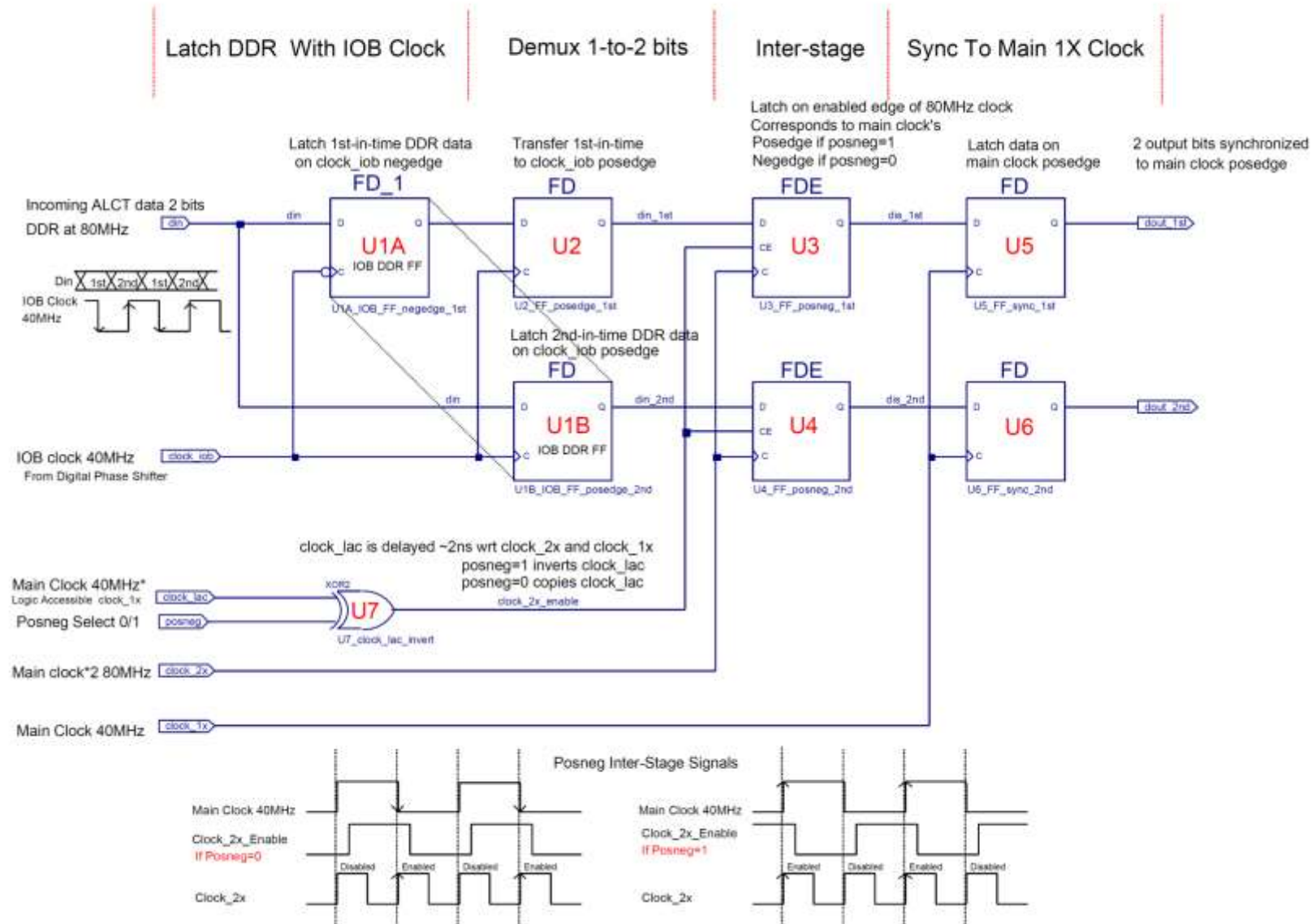
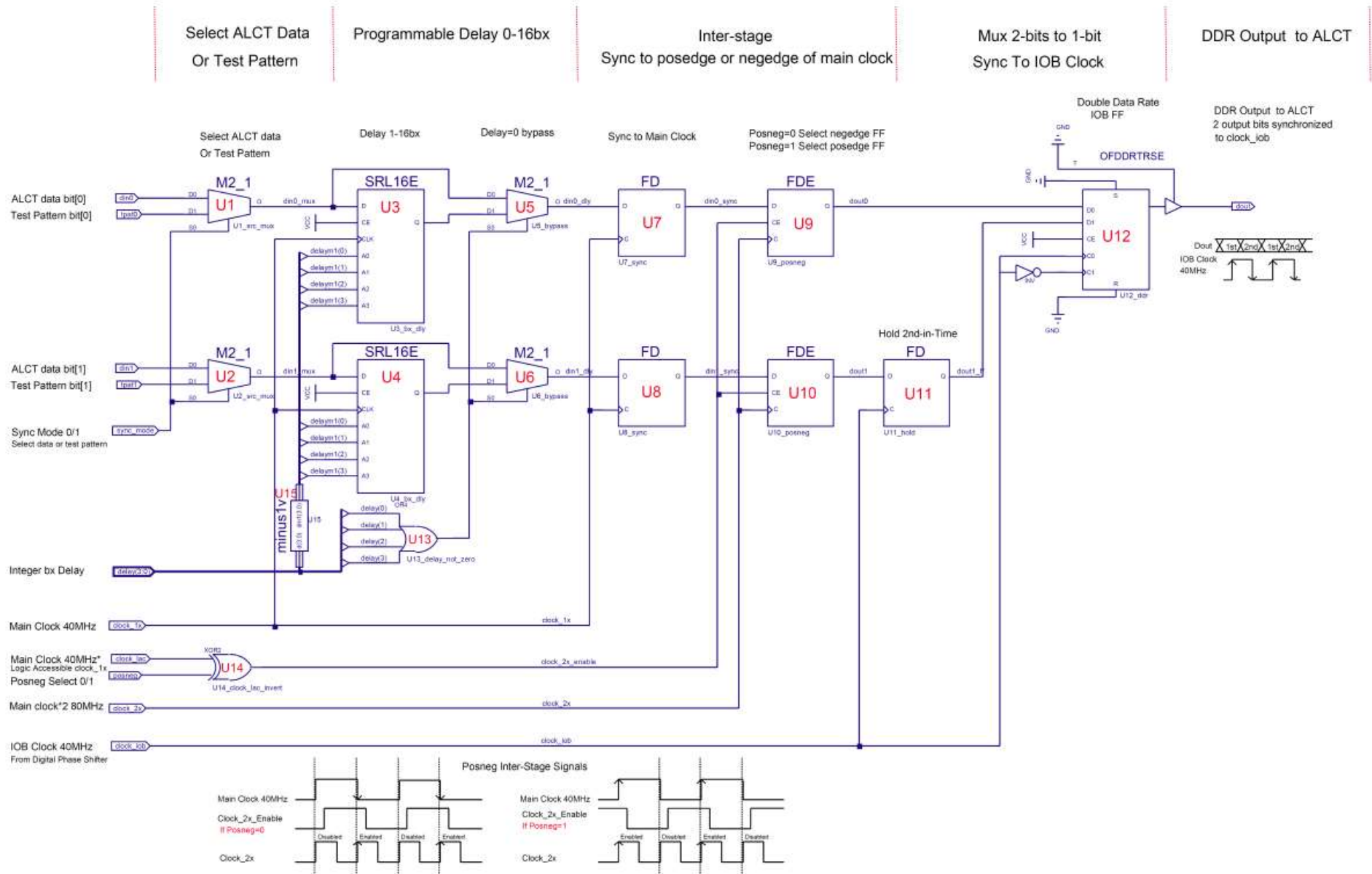


Figure 4 ALCT Muonic Transmitter  
TMB-to-ALCT: Transmitter Sync Stages



## TTC Sequences

### Trigger State

#### Start/Stop Triggering Sequence:

-----

On `hard_reset` go to the StopTrigger state: TMBs CLCT processing machine goes to “idle”.

On `ttc_start_trigger`, wait for the next BX0 (if ttc starts are allowed)

On the next `ttc_bx0`, resume triggering.

On `ttc_stop_trigger` (if ttc stops are allowed) or `ttc_resync` go the StopTrigger state.

### Bunch Crossing Counter

#### Bunch Counter Reset

-----

On `ttc_resync` or `ttc_bxreset`, preset the BXN, and hold the count.

On the next BX0 resume counting bunch crossings.

On subsequent BX0s, check that BXN is again at the preset value, if not, set `sync_error`.

TMB further checks that when BXN is at the preset value, that a BX0 arrived, if not, set `sync_error`.

### Resync

#### L1A Counter Reset

-----

On `ttc_resync` or `ccb_evtntreset`, clear L1A event counters.

#### Buffer Reset

-----

`ttc_resync` clears TMBs buffer-pointers, aborts any readout in progress, and returns various state machines to their idle states.  
(a similar condition to after power-up or hard-reset).

# ALCT+CLCT Matching Algorithm

## Matching Logic

### LCT Duplication

```
// Fill in missing ALCT if CLCT has 2 muons, missing CLCT if ALCT has 2 muons
wire no_alct = !alct0_vpf;
wire no_clct = !clct0_vpf;

wire one_alct = alct0_vpf && !alct1_vpf;
wire one_clct = clct0_vpf && !clct1_vpf;

wire two_alct = alct0_vpf && alct1_vpf;
wire two_clct = clct0_vpf && clct1_vpf;

wire dupe_alct = one_alct && two_clct;
wire dupe_clct = one_clct && two_alct;

wire [MXALCT-1:0] alct_dummy = clct0_real[18:17] << 11; // Inserts clct bxn into
wire [MXCLCT-1:0] clct_dummy = 0; // frame for clct_only events

wire [MXALCT-1:0] alct0 = (no_alct) ? alct_dummy : alct0_real; // Substitute dummy alct
wire [MXALCT-1:0] alct1 = (dupe_alct) ? alct0_real : alct1_real;

wire [MXCLCT-1:0] clct0 = (no_clct) ? clct0_real : clct0_real; // Do not
wire [MXCLCT-1:0] clct1 = (dupe_clct) ? clct0_real : clct1_real;

wire first_vpf = alct0_vpf || clct0_vpf; // First muon exists
wire second_vpf = alct1_vpf || clct1_vpf; // Second muon exists
```

### LCT Quality

```
module lct_quality (ACC,A,C,A4,C4,P,CPAT,Q);

// Ports
input ACC; // ALCT accelerator muon bit
input A; // bit: ALCT was found
input C; // bit: CLCT was found
input A4; // bit (N_A>=4), where N_A=number of ALCT layers
input C4; // bit (N_C>=4), where N_C=number of CLCT layers
input [3:0] P; // 4-bit CLCT pattern number that is presently 1 for n-layer triggers, 2-10 for current
patterns, 11-15 "for future expansion".
input CPAT; // bit for cathode .pattern trigger., i.e. (P>=2 && P<=10) at present
output [3:0] Q; // 4-bit TMB quality output

// Quality-by-quality definition
reg [3:0] Q;

always @* begin

if ( !ACC && A4 && C4 && P==10 ) Q=15; // HQ muon, straight
else if ( !ACC && A4 && C4 && (P==9 || P==8) ) Q=14; // HQ muon, slight bend
else if ( !ACC && A4 && C4 && (P==7 || P==6) ) Q=13; // HQ muon, more
else if ( !ACC && A4 && C4 && (P==5 || P==4) ) Q=12; // HQ muon, more
else if ( !ACC && A4 && C4 && (P==3 || P==2) ) Q=11; // HQ muon, more
// Q=10; // reserved for HQ muons with future patterns
// Q=9; // reserved for HQ muons with future patterns
else if ( ACC && A4 && C4 && CPAT ) Q=8; // HQ muon, but accel ALCT
else if ( A && !A4 && C4 && CPAT ) Q=7; // HQ cathode, but marginal anode
else if ( && A4 && C && !C4 && CPAT ) Q=6; // HQ anode, but marginal cathode
else if ( A && !A4 && C && !C4 && CPAT ) Q=5; // marginal anode and cathode
// Q=4; // reserved for LQ muons with 2D information in
the future
else if ( A && C && P==1 ) Q=3; // any match but layer CLCT
else if ( !A && C ) Q=2; // some CLCT, no ALCT (unmatched)
else if ( A && !C ) Q=1; // some ALCT, no CLCT (unmatched)
else Q=0; // should never be assigned
end
```

## MPC Format

```

assign mpc0_frame0[6:0]    =    alct0_key[6:0];
assign mpc0_frame0[10:7]   =    clct0_pat[3:0];
assign mpc0_frame0[14:11]  =    lct0_quality[3:0] * lct0_vpf;
assign mpc0_frame0[15]    =    lct0_vpf;

assign mpc0_frame1[7:0]    =    {clct0_cfeb[2:0],clct0_key[4:0]};
assign mpc0_frame1[8]     =    clct0_bend;
assign mpc0_frame1[9]     =    clct_sync_err & tmb_sync_err_en[0];
assign mpc0_frame1[10]    =    alct0_bxn[0];
assign mpc0_frame1[11]    =    clct_bx0 * lct0_vpf;
assign mpc0_frame1[15:12]  =    csc_id[3:0]* lct0_vpf;

assign mpc1_frame0[6:0]    =    alct1_key[6:0];
assign mpc1_frame0[10:7]   =    clct1_pat[3:0];
assign mpc1_frame0[14:11]  =    lct1_quality[3:0] * lct1_vpf;
assign mpc1_frame0[15]    =    lct1_vpf;

assign mpc1_frame1[7:0]    =    {clct1_cfeb[2:0],clct1_key[4:0]};
assign mpc1_frame1[8]     =    clct1_bend;
assign mpc1_frame1[9]     =    clct_sync_err & tmb_sync_err_en[1] & lct1_vpf;
assign mpc1_frame1[10]    =    alct1_bxn[0];
assign mpc1_frame1[11]    =    clct_bx0 * lct1_vpf;
assign mpc1_frame1[15:12]  =    csc_id[3:0] * lct1_vpf;

```

Transmission to MPC is

```

1st Frame[31:0] = {mpc1_frame0[15:0],mpc0_frame0[15:0]}
2nd Frame[31:0] = {mpc1_frame1[15:0],mpc0_frame1[15:0]}

```

Signal	1 <sup>st</sup> in Time	2 <sup>nd</sup> in Time	P3Apin	Test Point
mpc_tx[00]	alct_first_key[0]	clct_first_key[0]	A1	TP331-1
mpc_tx[01]	alct_first_key[1]	clct_first_key[1]	B1	TP331-2
mpc_tx[02]	alct_first_key[2]	clct_first_key[2]	D1	TP331-3
mpc_tx[03]	alct_first_key[3]	clct_first_key[3]	E1	TP331-4
mpc_tx[04]	alct_first_key[4]	clct_first_key[4]	A2	TP331-5
mpc_tx[05]	alct_first_key[5]	clct_first_key[5]	B2	TP331-6
mpc_tx[06]	alct_first_key[6]	clct_first_key[6]	D2	TP331-7
mpc_tx[07]	clct_first_pat[0]	clct_first_key[7]	E2	TP331-8
mpc_tx[08]	clct_first_pat[1]	clct_first_bend	A3	TP332-1
mpc_tx[09]	clct_first_pat[2]	clct_first_sync_err	B3	TP332-2
mpc_tx[10]	clct_first_pat[3]	alct_first_bxn[0]	D3	TP332-3
mpc_tx[11]	lct_first_quality[0]	clct_first_bx0_local	E3	TP332-4
mpc_tx[12]	lct_first_quality[1]	csc_id[0]	A4	TP332-5
mpc_tx[13]	lct_first_quality[2]	csc_id[1]	B4	TP332-6
mpc_tx[14]	lct_first_quality[3]	csc_id[2]	D4	TP332-7
mpc_tx[15]	first_vpf	csc_id[3]	E4	TP332-8
mpc_tx[16]	alct_second_key[0]	clct_second_key[0]	A5	TP341-1
mpc_tx[17]	alct_second_key[1]	clct_second_key[1]	B5	TP341-2
mpc_tx[18]	alct_second_key[2]	clct_second_key[2]	D5	TP341-3
mpc_tx[19]	alct_second_key[3]	clct_second_key[3]	E5	TP341-4
mpc_tx[20]	alct_second_key[4]	clct_second_key[4]	A6	TP341-5
mpc_tx[21]	alct_second_key[5]	clct_second_key[5]	B6	TP341-6
mpc_tx[22]	alct_second_key[6]	clct_second_key[6]	D6	TP341-7
mpc_tx[23]	clct_second_pat[0]	clct_second_key[7]	E6	TP341-8
mpc_tx[24]	clct_second_pat[1]	lct_second_bend	A7	TP342-1
mpc_tx[25]	clct_second_pat[2]	clct_second_sync_err	B7	TP342-2
mpc_tx[26]	clct_second_pat[3]	alct_second_bxn[0]	D7	TP342-3
mpc_tx[27]	lct_second_quality[0]	clct_second_bx0_local	E7	TP342-4
mpc_tx[28]	lct_second_quality[1]	csc_id[0]	A8	TP342-5
mpc_tx[29]	lct_second_quality[2]	csc_id[1]	B8	TP342-6
mpc_tx[30]	lct_second_quality[3]	csc_id[2]	D8	TP342-7

mpc_tx[31]	second_vpf	csc_id[3]	E8	TP342-8
------------	------------	-----------	----	---------



# VME Registers

## Addressing Modes

TMB2005 responds to A24D16 VME addressing modes:

Address Modifier  $39_{16}$ , A24 non-privileged mode

Address Modifier  $3D_{16}$ , A24 supervisor mode

It does not respond to byte-addressing modes, so all valid addresses must be even numbers.

## Base Address

TMB2005s "base address" bits A[23:19] select which TMB is being addressed by the VME crate controller. The base address is determined either by the 5 VME-backplane-slot Geographic Address bits or by the Local Address set by two on-board hexadecimal rotary switches. Shunt SH62 selects between Geographic [1-2] and Local [2-3] modes.

A[23:19] = VME Crate Slot Geographic Address, (Slot= 2 to 21)<sub>10</sub> SH62 [1-2]

A[23:19] = Hexadecimal Switch Address SW2x16+SW1 SH62 [2-3]

Multiple TMBs can be addressed simultaneously using a Global Address:

A[23:19] =  $26_{10}$  Addresses all TMBs in parallel

A[23:19] =  $27_{10}$  Address all peripheral crate modules

## Boot Register

When geographic addressing is used, the S2/S1 hexadecimal switches should be set to 1Ah, which allows the hardware Boot Register to respond to the slot  $26_{10}$  global address.

The Boot Register responds to all even VME addresses + base between 70000h and 7FFFEh to allow block-mode VME writes.

## Register Addresses

Address Hexadecimal Add to Base	Register Name	Description
70000	ADR_BOOT	Hardware Bootstrap Register
00	ADR_IDREG0	ID Register 0
02	ADR_IDREG1	ID Register 1
04	ADR_IDREG2	ID Register 2
06	ADR_IDREG3	ID Register 3
08	ADR_VME_STATUS	VME Status Register
0A	ADR_VME_ADR0	VME Address read-back
0C	ADR_VME_ADR1	VME Address read-back
0E	ADR_LOOPBK	Loop-back Register
10	ADR_USR_JTAG	User JTAG
12	ADR_PROM	PROM
14	ADR_DDDSM	3D3444 State Machine Register + Clock DCMs
16	ADR_DDD0	3D3444 Delay Chip 0
18	ADR_DDD1	3D3444 Delay Chip 1
1A	ADR_DDD2	3D3444 Delay Chip 2
1C	ADR_DDDOE	3D3444 Delay Chip Output Enables
1E	ADR_RATCTRL	RAT Module Control
20	ADR_STEP	Step Register
22	ADR_LED	Front Panel +On-Board LEDs
24	ADR_ADC	ADCs
26	ADR_DSN	Digital Serials
28	ADR_MOD_CFG	TMB Configuration
2A	ADR_CCB_CFG	CCB Configuration
2C	ADR_CCB_TRIG	CCB Trigger Control
2E	ADR_CCB_STAT0	CCB Status
30	ADR_ALCT_CFG	ALCT Configuration
32	ADR_ALCT_INJ	ALCT Injector Control
34	ADR_ALCT0_INJ	ALCT Injected ALCT0
36	ADR_ALCT1_INJ	ALCT Injected ALCT1
38	ADR_ALCT_STAT	ALCT Sequencer Control/Status
3A	ADR_ALCT0_RCD	ALCT LCT0 Received by TMB
3C	ADR_ALCT1_RCD	ALCT LCT1 Received by TMB
3E	ADR_ALCT_FIFO	ALCT FIFO RAM Status
40	ADR_DMB_MON	DMB Monitored signals

42	ADR_CFEB_INJ	CFEB Injector Control
44	ADR_CFEB_INJ_ADR	CFEB Injector RAM address
46	ADR_CFEB_INJ_WDATA	CFEB Injector Write Data
48	ADR_CFEB_INJ_RDATA	CFEB Injector Read Data
4A	ADR_HCM001	CFEB0 Ly0,Ly1 Hot Channel Mask
4C	ADR_HCM023	CFEB0 Ly2,Ly3 Hot Channel Mask
4E	ADR_HCM045	CFEB0 Ly4,Ly5 Hot Channel Mask
50	ADR_HCM101	CFEB1 Ly0,Ly1 Hot Channel Mask
52	ADR_HCM123	CFEB1 Ly2,Ly3 Hot Channel Mask
54	ADR_HCM145	CFEB1 Ly4,Ly5 Hot Channel Mask
56	ADR_HCM201	CFEB2 Ly0,Ly1 Hot Channel Mask
58	ADR_HCM223	CFEB2 Ly2,Ly3 Hot Channel Mask
5A	ADR_HCM245	CFEB2 Ly4,Ly5 Hot Channel Mask
5C	ADR_HCM301	CFEB3 Ly0,Ly1 Hot Channel Mask
5E	ADR_HCM323	CFEB3 Ly2,Ly3 Hot Channel Mask
60	ADR_HCM345	CFEB3 Ly4,Ly5 Hot Channel Mask
62	ADR_HCM401	CFEB4 Ly0,Ly1 Hot Channel Mask
64	ADR_HCM423	CFEB4 Ly2,Ly3 Hot Channel Mask
66	ADR_HCM445	CFEB4 Ly4,Ly5 Hot Channel Mask
68	ADR_SEQ_TRIG_EN	Sequencer Trigger Source Enables
6A	ADR_SEQ_TRIG_DLY0	Sequencer Trigger Source Delays
6C	ADR_SEQ_TRIG_DLY1	Sequencer Trigger Source Delays
6E	ADR_SEQ_ID	Sequencer Board + CSC ID
70	ADR_SEQ_CLCT	Sequencer CLCT Configuration
72	ADR_SEQ_FIFO	Sequencer FIFO Configuration
74	ADR_SEQ_L1A	Sequencer L1A Configuration
76	ADR_SEQ_OFFSET0	Sequencer Counter Offsets
78	ADR_SEQ_CLCT0	Sequencer Latched CLCT0
7A	ADR_SEQ_CLCT1	Sequencer Latched CLCT1
7C	ADR_SEQ_TRIG_SRC	Sequencer Trigger Source Read-back
7E	ADR_DMB_RAM_ADR	Sequencer RAM Address
80	ADR_DMB_RAM_WDATA	Sequencer RAM Write Data
82	ADR_DMB_RAM_WDCNT	Sequencer RAM Word Count
84	ADR_DMB_RAM_RDATA	Sequencer RAM Read Data
86	ADR_TMB_TRIG	TMB Trigger Configuration / MPC Accept
88	ADR_MPC0_FRAME0	MPC0 Frame 0 Data sent to MPC
8A	ADR_MPC0_FRAME1	MPC0 Frame 1 Data sent to MPC
8C	ADR_MPC1_FRAME0	MPC1 Frame 0 Data sent to MPC
8E	ADR_MPC1_FRAME1	MPC1 Frame 1 Data sent to MPC

90	ADR_MPC_INJ	MPC Injector Control
92	ADR_MPC_RAM_ADR	MPC Injector RAM address
94	ADR_MPC_RAM_WDATA	MPC Injector RAM Write Data
96	ADR_MPC_RAM_RDATA	MPC Injector RAM Read Data
98	ADR_SCP_CTRL	Scope control
9A	ADR_SCP_RDATA	Scope read data
9C	ADR_CCB_CMD	CCB TTC Command Generator
9E	ADR_BUF_STAT0	Buffer Status
A0	ADR_BUF_STAT1	Buffer Status
A2	ADR_BUF_STAT2	Buffer Status
A4	ADR_BUF_STAT3	Buffer Status
A6	ADR_BUF_STAT4	Buffer Status
A8	ADR_ALCT_FIFO1	ALCT Raw hits RAM Control
AA	ADR_ALCT_FIFO2	ALCT Raw hits RAM data
AC	ADR_SEQMOD	Sequencer Trigger Modifiers
AE	ADR_SEQSM	Sequencer Machine State
B0	ADR_SEQCLCTM	Sequencer CLCT msbs
B2	ADR_TMBTIM	TMB Timing for ALCT*CLCT coincidence
B4	ADR_LHC_CYCLE	LHC Cycle period, Maximum BXN+1
B6	ADR_RPC_CFG	RPC Configuration
B8	ADR_RPC_RDATA	RPC Sync Mode Read Data
BA	ADR_RPC_RAW_DELAY	RPC Raw Hits Delay + RPC BXN Differences
BC	ADR_RPC_INJ	RPC Injector Control
BE	ADR_RPC_INJ_ADR	RPC Injector RAM Addresses
C0	ADR_RPC_INJ_WDATA	RPC Injector Write Data
C2	ADR_RPC_INJ_RDATA	RPC Injector Read Data
C4	ADR_RPC_TBINS	RPC FIFO Time Bins
C6	ADR_RPC0_HCM	RPC0 Hot Channel Mask
C8	ADR_RPC1_HCM	RPC1 Hot Channel Mask
CA	ADR_BX0_DELAY	BX0 to MPC Delays
CC	ADR_NON_TRIG_RO	Non-triggering Event Enables
CE	ADR_SCP_TRIG	Scope Trigger Source Channel
D0	ADR_CNT_CTRL	Status Counter Control
D2	ADR_CNT_RDATA	Status Counter Data
D4	ADR_JTAGSM0	JTAG State Machine Control (reads JTAG PROM)
D6	ADR_JTAGSM1	JTAG State Machine Word Count
D8	ADR_JTAGSM2	JTAG State Machine Checksum

DA	ADR_VMESM0	VME State Machine Control (reads VME PROM)
DC	ADR_VMESM1	VME State Machine Word Count
DE	ADR_VMESM2	VME State Machine Checksum
E0	ADR_VMESM3	Number of VME Addresses Written by VMESM
E2	ADR_VMESM4	VME State Machine Write-Data Check
E4	ADR_DDDRSM	RAT 3D3444 State Machine Control
E6	ADR_DDDR0	RAT 3D3444 RPC Delays
E8	ADR_UPTIME	Uptime Counter
EA	ADR_BDSTATUS	Board Status Summary
EC	ADR_BXN_CLCT	CLCT BXN At CLCT-Pretrigger
EE	ADR_BXN_ALCT	ALCT BXN At ALCT-Valid-Pattern-Flag
F0	ADR_LAYER_TRIG	Layer-Trigger Mode
F2	ADR_ISE_VERSION	ISE Version + Service Pack
F4	ADR_TEMP0	Pattern Finder Pre-Trigger
F6	ADR_TEMP1	CLCT Separation
F8	ADR_TEMP2	CLCT Separation RAM Data
FA	ADR_PARITY	
FC	ADR_CCB_STAT1	
FE	ADR_BXN_L1A	CLCT BXN at last L1A arrival
100	ADR_L1A_LOOKBACK	L1A Lookback distance
102	ADR_SEQ_DEBUG	Sequencer debug signals
104	ADR_ALCT_SYNC_CTRL	ALCT sync mode control
106	ADR_ALCT_SYNC_TXDATA_1 <sup>ST</sup>	ALCT sync mode transmit data 1 <sup>st</sup>
108	ADR_ALCT_SYNC_TXDATA_2 <sup>ND</sup>	ALCT sync mode transmit data 2 <sup>nd</sup>
10A	ADR_SEQ_OFFSET1	Sequencer Counter Offsets Continued
10C	ADR_MINISCOPE	Internal 16 Channel Digital Miniscope
10E	ADR_PHASER0	ALCT rxd delay digital phase shifter
110	ADR_PHASER1	ALCT txd delay digital phase shifter
112	ADR_PHASER2	CFEB0 rxd delay digital phase shifter
114	ADR_PHASER3	CFEB1 rxd delay digital phase shifter
116	ADR_PHASER4	CFEB2 rxd delay digital phase shifter
118	ADR_PHASER5	CFEB3 rxd delay digital phase shifter
11A	ADR_PHASER6	CFEB4 rxd delay digital phase shifter

11C	ADR_DELAY0_INT	CFEB0-3 DDR RxD Interstage delays
11E	ADR_DELAY1_INT	CFEB4 DDR RxD Interstage delays Continued
120	ADR_SYNC_ERR_CTRL	Synchronization Error Control
122	ADR_CFEB_BADBITS_CTRL	CFEB Bad Bit Control/Status
124	ADR_CFEB_BADBITS_TIMER	CFEB Bad Bit Check Interval
126	ADR_CFEB0_BADBITS_LY01	CFEB0 Bad Bits Array
128	ADR_CFEB0_BADBITS_LY23	CFEB0 Bad Bits Array
12A	ADR_CFEB0_BADBITS_LY45	CFEB0 Bad Bits Array
12C	ADR_CFEB1_BADBITS_LY01	CFEB1 Bad Bits Array
12E	ADR_CFEB1_BADBITS_LY23	CFEB1 Bad Bits Array
130	ADR_CFEB1_BADBITS_LY45	CFEB1 Bad Bits Array
132	ADR_CFEB2_BADBITS_LY01	CFEB2 Bad Bits Array
134	ADR_CFEB2_BADBITS_LY23	CFEB2 Bad Bits Array
136	ADR_CFEB2_BADBITS_LY45	CFEB2 Bad Bits Array
138	ADR_CFEB3_BADBITS_LY01	CFEB3 Bad Bits Array
13A	ADR_CFEB3_BADBITS_LY23	CFEB3 Bad Bits Array
13C	ADR_CFEB3_BADBITS_LY45	CFEB3 Bad Bits Array
13E	ADR_CFEB4_BADBITS_LY01	CFEB4 Bad Bits Array
140	ADR_CFEB4_BADBITS_LY23	CFEB4 Bad Bits Array
142	ADR_CFEB4_BADBITS_LY45	CFEB4 Bad Bits Array
144	ADR_ALCT_STARTUP_DELAY	ALCT startup delay milliseconds for Spartan-6
146	ADR_ALCT_STARTUP_STATUS	ALCT startup delay machine status
	Virtex-6 VME Registers	
148	ADR_V6_SNAP12_QPLL	Virtex-6 SNAP12 Serial interface + QPLL status
14A	ADR_V6_GTX_RX_ALL	Virtex-6 GTX common control and status
14C	ADR_V6_GTX_RX0	Virtex-6 GTX0 control and status
14E	ADR_V6_GTX_RX1	Virtex-6 GTX1 control and status
150	ADR_V6_GTX_RX2	Virtex-6 GTX2 control and status
152	ADR_V6_GTX_RX3	Virtex-6 GTX3 control and status
154	ADR_V6_GTX_RX4	Virtex-6 GTX4 control and status
156	ADR_V6_GTX_RX5	Virtex-6 GTX5 control and status
158	ADR_V6_GTX_RX6	Virtex-6 GTX6 control and status
15A	ADR_V6_SYSMON	Virtex-6 Sysmon ADC
15C	ADR_V6_CFEB_BADBITS_CTRL	CFEB Bad Bit Control/Status extends Adr 122
15E	ADR_V6_CFEB5_BADBITS_LY01	CFEB5 Bad Bit Array

160	ADR_V6_CFEb5_BADBITS_LY23	CFEB5 Bad Bit Array
162	ADR_V6_CFEb5_BADBITS_LY45	CFEB5 Bad Bit Array
164	ADR_V6_CFEb6_BADBITS_LY01	CFEB6 Bad Bit Array
166	ADR_V6_CFEb6_BADBITS_LY23	CFEB6 Bad Bit Array
168	ADR_V6_CFEb6_BADBITS_LY45	CFEB6 Bad Bit Array
16A	ADR_V6_PHASER7	Phaser 7 cfeb5_rxd phase
16C	ADR_V6_PHASER8	Phaser 8 cfeb6_rxd phase
16E	ADR_V6_HCM501	CFEB5 Ly0,Ly1 Hot Channel Mask
170	ADR_V6_HCM523	CFEB5 Ly2,Ly3 Hot Channel Mask
172	ADR_V6_HCM545	CFEB5 Ly4,Ly5 Hot Channel Mask
174	ADR_V6_HCM601	CFEB6 Ly0,Ly1 Hot Channel Mask
176	ADR_V6_HCM623	CFEB6 Ly2,Ly3 Hot Channel Mask
178	ADR_V6_HCM645	CFEB6 Ly4,Ly5 Hot Channel Mask
17A	ADR_V6_EXTEND	DCFEB 7-bit extensions to 5 bit fields in 0x42,68

## Register Definitions

Adr 70000<sub>16</sub>

ADR\_BOOT

Hardware Bootstrap Register

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R=tdo	R=ready	hard reset RPC/RAT	/mez clock enable	/fpga vme_en	/en_fpga reset_alct	hard reset TMB	hard reset ALCT	JTAG source vme/fpga	sel3	sel2	sel1	sel0	tck	tms	tdi

Bit	Dir	Signal	Default	Description
[ 0]	RW	jtag_vme1 (tdi)	0	vme tdi
[ 1]	RW	jtag_vme2 (tms)	0	vme tms
[ 2]	RW	jtag_vme3 (tck)	0	vme tck
[ 3]	RW	sel_vme0	0	00XX ALCT JTAG Chain
[ 4]	RW	sel_vme1	0	01XX TMB Mezzanine FPGA + FPGA PROMs Chain
[ 5]	RW	sel_vme2	0	10XX TMB User PROMs JTAG chain
[ 6]	RW	sel_vme3	0	11XX TMB FPGA User JTAG chain
[ 7]	RW	vme/usr_en	0	1=JTAG sourced by Bootstrap Register, 0= from FPGA
[ 8]	RW	hard_reset_alct_vme	0	1=Hard reset to ALCT FPGA
[ 9]	RW	hard_reset_tmb_vme	0	1=Hard reset to TMB FPGA
[10]	RW	/en_fpga_reset_alct	0	0=Allow TMB FPGA to hard reset ALCT
[11]	RW	/fpga_vme_en	0	0=Allow TMB FPGA to issue VME commands
[12]	RW	/mez_clock_en	0	0=Enable TMB FPGA mezzanine clock
[13]	RW	hard_reset_rpc	0	1=Hard reset to RPC (RAT) FPGA
[14]	R	vme_ready	x	1=FPGA vme logic indicates ready
[15]	R	jtag_vme0 (tdo)	0	vme tdo
[14]	W	unassigned	-	No connection on PCB
[15]	W	unassigned	-	No connection on PCB



Adr 00		ADR_IDREG0				ID Register 0									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	ga4	ga3	ga2	ga1	ga0	fvers3	fvers2	fvers1	fvers0	ftype3	ftype2	ftype1	ftype0

Bits	Dir	Typical	Description
[03:00]	R	C	Firmware type, C=Normal CLCT/TMB, D=Debug loopback
[07:04]	R	D	Firmware version code
[12:08]	R	15	Geographic address for this board
[15:13]	R	0	Unassigned

Adr 02		ADR_IDREG1				ID Register 1									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
mont h msd3	mont h msd2	mont h msd1	mont h msd0	mont h lsd3	mont h lsd2	mont h lsd1	mont h lsd0	day msd3	day msd2	day msd1	day msd0	day lsd3	day lsd2	day lsd1	day lsd0

Bits	Dir	Typical	Description
[07:00]	R	09	DD Firmware Version Day (BCD)
[15:08]	R	04	MM Firmware Version Month (BCD)

Adr 04		ADR_IDREG2				ID Register 2									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
year digit3 3	year digit3 2	year digit3 1	year digit3 0	year digit2 3	year digit2 2	year digit2 1	year digit2 0	year digit1 3	year digit1 2	year digit1 1	year digit1 0	year digit0 3	year digit0 2	year digit0 1	year digit0 0

Bits	Dir	Typical	Description
[15:00]	R	2007	YYYY Firmware Version Year (BCD)

Adr 06		ADR_IDREG3				ID Register 3									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
rev code 15	rev code 14	rev code 13	rev code 12	rev code 11	rev code 10	rev code 9	rev code 8	rev code 7	rev code 6	rev code 5	rev code 4	rev code 3	rev code 2	rev code 1	rev code 0

Bits	Dir	Typical	Description
[15:00]	R		Firmware Revcode (as stored in raw hits header)

**Adr 08****ADR\_VME\_STATUS****VME Status Register**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TMB ready	local/geo	iack	acfail	sysreset	sysfail	sysclk	ds1	as	lword	gap	ga4	ga3	ga2	ga1	ga0

Bits	Dir	Typical	Description
[04:00]	R		Crate slot Geographic Address
[05]	R		Crate slot Geographic Address Parity
[06]	R		VME signal lword
[07]	R		VME signal as
[08]	R		VME signal ds1
[09]	R		VME signal sysclk
[10]	R		VME signal sysfail
[11]	R		VME signal sysreset
[12]	R		VME signal acfail
[13]	R		VME signal iack
[14]	R		1=Address mode set to local, 0=Geographic
[15]	R		1=TMB reports ready to boot register

**Adr 0A****ADR\_VME\_ADR0****VME Address Read-Back**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
a15	a14	a13	a12	a11	a10	a9	a8	a7	a6	a5	a4	a3	a2	a1	lword

Bits	Dir	Typical	Description
[15:00]	R	a[15:0]	VME Address captured at last write cycle {a[15:1],lword}

**Adr 0C****ADR\_VME\_ADR1****VME Address Read-Back**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
TMB ready	local/geo	iack	acfail	sysreset	sysfail	sysclk	ds1	as	lword	gap	ga4	ga3	ga2	ga1	ga0

Bits	Dir	Typical	Description
[07:00]	R	a[23:16]	VME Address captured at last write cycle
[13:08]	R	am[5:0]	VME Address modifier
[15:14]	R	0	Unassigned

**Adr 0E                      ADR\_LOOPBK                      Loop-Back Control Register**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	dmb tx res 2	dmb tx res 1	dmb tx res 0	gtl_ oe	gtl_ loop	dmb_ oe	dmb_ loop	rpc loop bdtest	rpc_ loop_ tmb	rpc_ loop_ rat	alct_ txoe	alct_ rxoe	alct_ loop	cfeb_ oe

Bits	Dir	Signal	Default	Description
[00]	R	cfeb_oe	1	1=CFEB output enable
[01]	R	alct_loop	0	0=No ALCT loop-back
[02]	RW	alct_rxoe	1	1=Enable RAT ALCT LVDS receiver, 0=power down
[03]	RW	alct_txoe	1	1=Enable RAT ALCT LVDS transmitter, 0=power down
[04]	R	rpc_loop_rat	0	1=RAT FPGA enters loop-back mode
[05]	R	rpc_loop_bdtest	0	1=En RPC Loop-back (no RAT ), used only in bdtest firmware
[06]	R	rpc_loop_tmb	0	1=TMBs RAT backplane ICs loop-back mode
[07]	R	dmb_loop	0	0=No DMB loop-back
[08]	R	dmb_oe	0	0=DMB driver enable
[09]	R	gtl_loop	0	0=No GTL loop-back
[10]	R	gtl_oe	0	0=Enable GTL outputs
[13:11]	RW	dmb_tx_reserved[2:0]	0	dmb_tx[48:46] unused, set to 0
[15:14]	RW	--		Unassigned

**Adr 10                      ADR\_USR\_JTAG                      User JTAG Register**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
tdo usr	0	0	0	0	0	0	0		sel3 usr	sel2 usr	sel1 usr	sel0 usr	tck usr	tms usr	tdi usr

Bits	Dir	Signal	Description
[00]	RW	tdi_usr	User JTAG Chain TDI (output from FPGA)
[01]	RW	tms_usr	User JTAG Chain TMS
[02]	RW	tck_usr	User JTAG Chain TCK
[06:03]	RW	sel_usr[3:0]	User JTAG Chain Select, 0=ALCT,1=Mez,2=UserPROMs,3=UserChain
[13:07]	RW	--	Unassigned
[14]	RW	wr_usr_jtag_dis	1=disable write access to ADR_USR_JTAG, set in Adr D4[11]
[15]	R	tdo_usr	User JTAG Chain TDO (input to FPGA)

**Adr 12                      ADR\_PROM                      User PROMs Register**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	prom _src	prom 1 ce	prom 1 oe	prom 1 clk	prom 0 ce	prom 0 oe	prom 0 clk	prom _led7	prom _led6	prom _led5	prom _led4	prom _led3	prom _led2	prom _led1	prom _led0

Bits	Dir	Signal	Default	Description
[07:00]	RW	prom_led[7:0]	CD	PROM data bus shared with On-Board LEDs
[08]	RW	prom0_clk	0	PROM 0 clock
[09]	RW	prom0_oe	0	PROM 0 output enable
[10]	RW	prom0_ce	1	PROM 0 /chip_enable
[11]	RW	prom1_clk	0	PROM 1 clock
[12]	RW	prom1_oe	0	PROM 1 output enable
[13]	RW	prom1_ce	1	PROM 1 /chip_enable
[14]	RW	prom_src	0	Data bus 0=on-board LEDs, 1=enabled PROM
[15]	RW	--	0	Unassigned

**Adr 14                      ADR\_DDSDM                      3D3444 State Machine Control + DCM Lock Status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
rpc lock	dcc lock	mpc lock	alctd lock	alct rxclk lock	tmb clock1 lock	tmb0 d lock	tmb clock0 lock	ddd verify	ddds m busy	auto start	serial from	serial to ddd	adr latch	ddd clock	ddd start

Bits	Dir	Signal	Default	Description
[00]	RW	ddd_start_vme	0	Start DDD State Machine
[01]	RW	ddd_clock	0	DDD manual-mode clock
[02]	RW	ddd_adr_latch	1	DDD manual-mode address latch, active low
[03]	RW	ddd_serial_in	0	Serial data to DDD chain
[04]	RW	ddd_serial_out	0	Serial data from DDD chain
[05]	RW	ddd_auto_start	1	DDD State Machine autostart state
[06]	R	ddd_busy	0	DDD State Machine busy
[07]	R	ddd_verify_ok	1	DDD data read back verified OK
[08]	R	lock_tmb_clock0	1	TMB clock 0 DCM locked
[09]	R	lock_tmb_clock0d	1	TMB clock 0d DCM locked
[10]	R	lock_tmb_clock1	1	TMB clock 1 DCM locked
[11]	R	lock_alct_rxclock	1	ALCT rxclock DCM locked
[12]	R	lock_alct_clockd	1	ALCT rxclockd DCM locked
[13]	R	lock_mpc_clock	1	CFEB rxd clock DCM locked (was mpc)
[14]	R	lock_dcc_clock	1	DCC clock DCM locked
[15]	R	lock_rpc_clock	1	RPC clock DCM locked

**Adr 16                      ADR\_DDD0                      3D3444 Chip 0 Delays, 1 step = 2ns**

Bits	Dir	Signal	Default	Description
[03:00]	RW	delay_ch0[3:0]	0	alct_tof_delay, shift entire ALCT in clockspace
[07:04]	RW	delay_ch1[3:0]	1	alct_rxclock delay, not used in muonic firmware
[11:08]	RW	delay_ch2[3:0]	6	DMB tx clock
[15:12]	RW	delay_ch3[3:0]	9	RPC tx clock

**Adr 18                      ADR\_DDD1                      3D3444 Chip 1 Delays, 1 step = 2ns**

Bits	Dir	Signal	Default	Description
[03:00]	RW	delay_ch4[3:0]	0	tmb_clock1, not used
[07:04]	RW	delay_ch5[3:0]	0	mpc_clock not used
[11:08]	RW	delay_ch6[3:0]	0	cfeb_tof_delay, shift all cfebs in clockspace
[15:12]	RW	delay_ch7[3:0]	7	CFEB 0 clock

**Adr 1A                      ADR\_DDD2                      3D3444 Chip 2 Delays, 1 step = 2ns**

Bits	Dir	Signal	Default	Description
[03:00]	RW	delay_ch8[3:0]	7	CFEB 1 clock
[07:04]	RW	delay_ch9[3:0]	7	CFEB 2 clock
[11:08]	RW	delay_ch10[3:0]	7	CFEB 3 clock
[15:12]	RW	delay_ch11[3:0]	7	CFEB 4 clock

**Adr 1C                      ADR\_DDDOE                      3D3444 Chip Output Enables**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	cfeb 4	cfeb 3	cfeb 2	cfeb 1	cfeb 0	dcc	mpc	tmb1	rpc tx	dmb tx	alct rx	alct tx

[11:00]	RW	ddd_oe[11:0]	FFF	Bit(n)=1=Enable DDD output channel n
[15:12]	RW	Unassigned	0	Unassigned

**Adr 1E                      ADR\_RATCTRL                      RAT Module Control**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	rpc dsn en	rpc free	rpc lptm	rpc posneg	rpc sync

Bits	Dir	Signal	Default	Description
[0]	RW	rpc_sync	0	1=RPC 80MHz sync pattern mode
[1]	RW	rpc_posneg	0	1=shift RPC data ½ cycle in RAT FPGA + dsn
[2]	RW	rpc_lptmb	0	Not used (for matching rpc_tx array)
[3]	RW	rpc_free_tx[0]	0	Unassigned
[4]	RW	rat_dsn_en	0	1=Enable RAT dsn readout
[15:5]	RW	--	0	Unassigned

**Adr 20                      ADR\_STEP                      Clock Single-Step + Hard Resets**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	/tmb hard	/alct hard	alct clken	cfeb4 clken	cfeb3 clken	cfeb2 clken	cfeb1 clken	cfeb0 clken	step run	step cfeb	step rpc	step dmb	step alct

Bits	Dir	Signal	Default	Description
[00]	RW	step_alct	0	Step ALCT clock
[01]	RW	step_dmb	0	Step DMB clock
[02]	RW	step_rpc	0	Step RPC clock
[03]	RW	step_cfeb	0	Step CFEB clock
[04]	RW	step_run	0	0=run mode, 1=step clocks
[05]	RW	cfeb_clock_en0	1	1=enable CFEB0 clock
[06]	RW	cfeb_clock_en1	1	1=enable CFEB1 clock
[07]	RW	cfeb_clock_en2	1	1=enable CFEB2 clock
[08]	RW	cfeb_clock_en3	1	1=enable CFEB3 clock
[09]	RW	cfeb_clock_en4	1	1=enable CFEB4 clock
[10]	RW	alct_clock_en	1	1=enable ALCT clock
[11]	RW	/alct_hard_reset_en	1	1=disable ALCT hard reset
[12]	RW	/tmb_hard_reset_en	1	1=disable TMB hard reset
[15:13]	RW	--	0	Unassigned

**Adr 22                      ADR\_LED Front Panel + On-Board LED Register**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
led bd7	led bd6	led bd5	led bd4	led bd3	led bd2	led bd1	led bd0	VME	NL1A	NMAT	INVP	L1A	CLCT	ALCT	LCT

Bits	Dir	Signal	Color	Description
[00]	RW	led_fp_lct	Blue	LCT TMB matched ALCT+CLCT
[01]	RW	led_fp_lct	Green	ALCT found a muon
[02]	RW	led_fp_clct	Green	CLCT found a muon
[03]	RW	led_fp_l1a	Green	L1A level 1 accept
[04]	RW	led_fp_invp	Amber	INVP invalid pattern after CSC drift
[05]	RW	led_fp_nmat	Amber	NMAT no match after ALCT or CLCT triggered
[06]	RW	led_fp_nl1a	Red	NL1A no L1A after trigger
[07]	RW	led_fp_vme	Green	VME power-up = on, off=vme access flash
[08]	RW	led_bd0	Blue	Buffer busy[0]
[09]	RW	led_bd1	Green	Buffer busy[1]
[10]	RW	led_bd2	Green	Buffer busy[2]
[11]	RW	led_bd3	Green	Buffer busy[3]
[12]	RW	led_bd4	Green	Buffer busy[4]
[13]	RW	led_bd5	Green	Buffer busy[5]
[14]	RW	led_bd6	Green	Buffer busy[6]
[15]	RW	led_bd7	Red	Buffer busy[7]

**Adr 24      ADR\_ADC ADC + Power Comparator Register**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	smb data	smb clk	ADC /cs	ADC din	ADC sclock	ADC dout	/tcrit	V1.5	V1.8	V3.3	V5.0

Bits	Dir	Signal	Typical	Description
[00]	R	vstat_5p0v	1	1 = 5.0V power supply OK
[01]	R	vstat_3p3v	1	1 = 3.3V power supply OK
[02]	R	vstat_1p8v	1	1 = 1.8V power supply OK
[03]	R	vstat_1p5v	1	1 = 1.5V power supply OK
[04]	R	/t_crit	1	1 = FPGA and Board Temperature OK
[05]	R	adc_dout	0	Voltage monitor ADC serial data receive
[06]	RW	adc_sclock	0	Voltage monitor ADC serial clock
[07]	RW	adc_din	0	Voltage monitor ADC serial data transmit
[08]	RW	/adc_cs	1	Voltage monitor ADC chip select
[09]	RW	smb_clk	0	Temperature monitor ADC serial clock
[10]	RW	smb_data	1	Temperature monitor ADC serial data, open drain
[15:11]	RW	--	0	Unassigned

**Adr 26      ADR\_DSN Digital Serial Numbers**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	RAT DSN Data	RAT DSN Busy	RAT DSN Init	RAT DSN Write	RAT DSN Start	Mez DSN Data	Mez DSN Busy	Mez DSN Init	Mez DSN Write	Mez DSN Start	TMB DSN Data	TMB DSN Busy	TMB DSN Init	TMB DSN Write	TMB DSN Start

Bits	Dir	Signal	Default	Description
[00]	RW	tmb_sn_start	0	TMB Digital serial SM start
[01]	RW	tmb_sn_write	0	TMB Digital serial write pulse
[02]	RW	tmb_sn_init	0	TMB Digital serial Init pulse
[03]	R	tmb_sn_busy	-	TMB State DSN State Machine busy
[04]	R	tmb_sn_data	-	TMB State DSN read data
[05]	RW	mez_sn_start	0	Mez Digital Serial State Machine start
[06]	RW	mez_sn_write	0	Mez Digital Serial Write pulse
[07]	RW	mez_sn_init	0	Mez Digital Serial Init pulse
[08]	R	mez_sn_busy	-	Mez State DSN State Machine busy
[09]	R	mez_sn_data	-	Mez State DSN read data
[10]	RW	rat_sn_start	0	RAT Digital Serial State Machine start
[11]	RW	rat_sn_write	0	RAT Digital Serial Write pulse
[12]	RW	rat_sn_init	0	RAT Digital Serial Init pulse
[13]	R	rat_sn_busy	-	RAT State DSN State Machine busy
[14]	R	rat_sn_data	-	RAT State DSN read data
[15]	RW	-	0	Unassigned

**Adr 28****ADR\_MOD\_CFG****TMB Module Configuration**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
mez done	ddd auto	power up	global reset enable	cfeb6 exists	cfeb5 exists	cfeb4 exists	cfeb3 exists	cfeb2 exists	cfeb1 exists	cfeb0 exists	bdled cylon	bdled vme	fp led flash	fp led cylon	fp led vme

Bits	Dir	Signal	Default	Description
[00]	RW	led_fp_src_vme	0	1=Front Panel LEDs sourced from VME register
[01]	RW	led_fp_cylon	0	1=FP LED Cylon mode, cool
[02]	RW	led_flash_on_stop	1	1=Flash Front Panel LEDs on TTT stop_trigger
[03]	RW	led_bd_src_vme	0	1=On-Board LEDs sourced from VME register
[04]	RW	led_bd_cylon	0	1=BD LED Cylon mode, cool
[11:5]	R	cfeb_exists[6:0]	7F	CFEB(n) instantiated in this firmware version
[12]	RW	global_reset_en	1	1=fire global reset if main DLL loses lock
[13]	R	power_up		Power-up FF
[14]	R	ddd_autostart		1=3D3444 auto-start enabled, copy of Adr14[05]
[15]	R	mez_done		1=Mezzanine FPGA loaded from PROM

**Adr 2A****ADR\_CCB\_CFG****CCB Configuration**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
adb pulse async	adb pulse sync	alct hard reset	tmb hard reset	tmb resout 2	tmb resout 1	tmb resout 0	tmb res1	tmb res0	l1a vme	clct status en	alct status en	ccb status oe	int l1aen	disabl tx	ignore rx

Bits	Dir	Signal	Default	Description
[00]	RW	ccb_ignore_rx	0	1=Ignore Received CCB backplane inputs
[01]	RW	ccb_disable_tx	0	1=Disble transmitted CCB backplane outputs
[02]	RW	ccb_int_l1a_en	0	1=Enable internal L1A emulator
[03]	RW	ccb_status_oe_vme	0	1=Enable ALCT+CLCT status to CCB front panel
[04]	RW	alct_status_en	0	1=Enable ALCT status GTL outputs (req [03]=1)
[05]	RW	clct_status_en	0	1=Enable CLCT status GTL outputs (req [03]=1)
[06]	RW	l1accept_vme	0	1=fire ccb_l1accept oneshot
[08:07]	R	tmb_reserved[1:0]		Future use
[11:09]	R	tmb_reserved_out[2:0]		Future use
[12]	R	tmb_hard_reset		Reload TMB FPGA
[13]	R	alct_hard_reset		Reload ALCT FPGA
[14]	R	alct_adb_pulse_sync		ALCT synchronous test pulse from CCB
[15]	R	alct_adb_pulse_async		ALCT asynchronous test pulse from CCB
[12]	W	vme_evcntres	0	Event counter reset    ccb_evcntres
[13]	W	vme_bcntres	0	Bunch crossing reset    ccb_bcntres
[14]	W	vme_bx0	0	Bx0 signal    ccb_bx0
[15]	W	vme_bx0_emu_en	0	Bx0 Emulator enable



**Adr 2C                      ADR\_CCB\_TRIG                      CCB Trigger Control**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
l1a delay vme7	l1a delay vme6	l1a delay vme5	l1a delay vme4	l1a delay vme3	l1a delay vme2	l1a delay vme1	l1a delay vme0	ignore start/ stop	ccb exttrig bypas	ext trig both	clct ext trg vme	alct ext trg vme	seq trig l1aen	clct ext trg l1aen	alct ext trg l1aen

Bits	Dir	Signal	Default	Description
[00]	RW	alct_ext_trig_l1aen	0	1=Request ccb l1a on alct_ext_trig
[01]	RW	clct_ext_trig_l1aen	0	1=Request ccb l1a on clct_ext_trig
[02]	RW	seq_trig_l1aen	1	1=Request ccb l1a on sequencer trigger
[03]	RW	alct_ext_trig_vme	0	1=Fire alct_ext_trig oneshot
[04]	RW	clct_ext_trig_vme	0	1=Fire clct_ext_trig oneshot
[05]	RW	ext_trig_both	0	1=clct_ext_trig fires alct + alct fires clct_trig, DC
[06]	RW	ccb_allow_extbypass	0	1=Allow clct_exttrig_ccb when ccb_ignore_rx=1
[07]	RW	ccb_ignore_startstop	0	1=Ignore ttc_trig_start, ttc_trig_stop
[15:08]	RW	l1a_delay_vme	72 <sub>16</sub>	Internal L1A delay (not same as sequencer L1A)

**Adr 2E                      ADR\_CCB\_STAT0                      CCB Status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ccb bx0	ccb bcntres	ccb res4	ccb res3	ccb res2	ccb qpll locked	ccb ttcrx ready	ccb clock en	ccb cmd7	ccb cmd6	ccb cmd5	ccb cmd4	ccb cmd3	ccb cmd2	ccb cmd1	ccb cmd0

Bits	Dir	Signal	Default	Description
[07:00]	R	ccb_cmd[7:0]		CCB Command word from TTC
[08]	R	ccb_clock40_enable	1	1=TMB 40MHz clock from CCB enabled
[09]	R	ccb_reserved[0]	1	ccb_ttcrx_ready TTC ready signal from CCB
[10]	R	ccb_reserved[1]	1	ccb_qpll_locked PLL locked signal from CCB
[13:09]	R	ccb_reserved[4:2]		Future use
[14]	R	ccb_bcntres		Bunch counter reset from CCB (backplane)
[15]	R	ccb_bx0		Bunch crossing 0 from CCB (backplane)

**Adr 30                      ADR\_ALCT\_CFG                      ALCT Configuration**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	cfeb muon ic	alct muon ic	alct clk vme	alct clk ccb	alct seq cmd3	alct seq cmd2	alct seq cmd1	alct seq cmd0	assert alct ext inj	assert alct ext trg	alct ext inj en	alct ext trg en

Bits	Dir	Signal	Default	Description
[00]	RW	cfg_alct_ext_trig_en	1	1=Enable alct_ext_trig from CCB
[01]	RW	cfg_alct_ext_inject_en	0	1=Enable alct_ext_inject from CCB
[02]	RW	cfg_alct_ext_trig	0	1=Assert alct_ext_trig
[03]	RW	cfg_alct_ext_inject	0	1=Assert alct_ext_inject
[07:04]	RW	alct_seq_cmd[3:0]	0	ALCT Sequencer command
[08]	RW	alct_clock_en_use_ccb		1=alct_clock_en_vme = ccb_clock40_enable
[09]	RW	alct_clock_en_use_vme		sets alct_clock_en cable signal if [8]=0
[10]	R	alct_muonic	1	ALCT board has independent time-of-flight delay
[11]	R	cfeb_muonic	0	CFEBs have independent time-of-flight delay
[15:12]	RW	--	0	Unassigned

**Adr 32                      ADR\_ALCT\_INJ                      ALCT Injector Control**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	inject delay 4	inject delay 3	inject delay 2	inject delay 1	inject delay 0	l1a inj ram	alct inj ram	link inject w clct	start inject	clear alct

Bits	Dir	Signal	Default	Description
[00]	RW	alct_clear	0	1=Blank ALCT received data
[01]	RW	alct_inject_mux	0	1=Start ALCT injector State Machine
[02]	RW	alct_sync_clct	0	1=Link ALCT injector with CLCT inject command
[03]	RW	alct_inj_ram_en	0	1=Link ALCT injector to CFEB injector RAM
[04]	RW	l1a_inj_ram_en	0	1=Link L1A injector to CFEB injector RAM
[09:05]	RW	alct_inj_delay[4:0]	13	Injector delay
[15:10]	RW	--	0	Unassigned

**Adr 34                      ADR\_ALCT0\_INJ                      ALCT0 1<sup>st</sup> Muon To Inject**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1 <sup>st</sup> bxn 1	1 <sup>st</sup> bxn 0	1 <sup>st</sup> key 6	1 <sup>st</sup> key 5	1 <sup>st</sup> key 4	1 <sup>st</sup> key 3	1 <sup>st</sup> key 2	1 <sup>st</sup> key 1	1 <sup>st</sup> key 0	1 <sup>st</sup> amu	1 <sup>st</sup> quality 1	1 <sup>st</sup> quality 0	1 <sup>st</sup> vpf

Bits	Dir	Signal	Default	Description
[00]	RW	alct_first_valid	1	Valid pattern flag
[02:01]	RW	alct_first_quality[1:0]	3	Pattern quality
[03]	RW	alct_first_amu	0	Accelerator muon flag
[10:04]	RW	alct_first_key[6:0]	7	Injected ALCT0 key wire-group
[12:11]	RW	alct_first_bxn[1:0]	1	Injected ALCT0 bunch crossing number
[15:13]	RW	--	0	Unassigned

**Adr 36                      ADR\_ALCT1\_INJ                      ALCT1 2<sup>nd</sup> Muon To Inject**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	2 <sup>nd</sup> bxn 1	2 <sup>nd</sup> bxn 0	2 <sup>nd</sup> key 6	2 <sup>nd</sup> key 5	2 <sup>nd</sup> key 4	2 <sup>nd</sup> key 3	2 <sup>nd</sup> key 2	2 <sup>nd</sup> key 1	2 <sup>nd</sup> key 0	2 <sup>nd</sup> amu	2 <sup>nd</sup> quality 1	2 <sup>nd</sup> quality 0	2 <sup>nd</sup> vpf

Bits	Dir	Signal	Default	Description
[00]	RW	alct_second_valid	1	Valid pattern flag
[02:01]	RW	alct_second_quality[1:0]	2	Pattern quality
[03]	RW	alct_second_amu	0	Accelerator muon flag
[10:04]	RW	alct_second_key[6:0]	61 <sub>10</sub>	Injected ALCT1 key wire-group
[12:11]	RW	alct_second_bxn[1:0]	1	Injected ALCT1 bunch crossing number
[15:13]	RW	--	0	Unassigned

**Adr 38                      ADR\_ALCT\_STAT                      ALCT Sequencer Control/Status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
alct txdint delay 3	alct txdint delay 2	alct txdint delay 1	alct txdint delay 0	0	0	0	0	0	0	0	alct sync eccerr 1	alct sync eccerr 0	alct ecc blank	alct ecc en	alct cfg done

Bits	Dir	Signal	Default	Description
[00]	R	alct_cfg_done	1	ALCT FPGA loaded from PROM
[01]	RW	alct_ecc_en	1	ALCT ECC trigger data correction enable
[02]	RW	alct_ecc_err_blank	1	Blank alcts with uncorrected ecc errors
[04:03]	R	alct_sync_ecc_err[1:0]	0	ALCT sync-mode ECC error code
[11:05]	RW	--	0	Unassigned
[15:12]	RW	alct_txd_int_delay[3:0]	0	Delay data transmitted to ALCT by integer bx

**Adr 3A                      ADR\_ALCT0\_RCD                      ALCT 1<sup>st</sup> Muon Received by TMB**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1 <sup>st</sup> bxn 1	1 <sup>st</sup> bxn 0	1 <sup>st</sup> key 6	1 <sup>st</sup> key 5	1 <sup>st</sup> key 4	1 <sup>st</sup> key 3	1 <sup>st</sup> key 2	1 <sup>st</sup> key 1	1 <sup>st</sup> key 0	1 <sup>st</sup> amu	1 <sup>st</sup> quality 1	1 <sup>st</sup> quality 0	1 <sup>st</sup> vpf

Bits	Dir	Signal	Typical	Description
[00]	R	alct_first_valid	1	Valid pattern flag
[02:01]	R	alct_first_quality[1:0]	0-3	Pattern quality
[03]	R	alct_first_amu	0	Accelerator muon flag
[10:04]	R	alct_first_key[6:0]	0-111	ALCT0 key wire-group
[12:11]	R	alct_first_bxn[1:0]	0-3	ALCT0 bunch crossing number
[15:13]	R	--	0	Unassigned

**Adr 3C                      ADR\_ALCT1\_RCD                      ALCT 2<sup>nd</sup> Muon Received by TMB**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	2 <sup>nd</sup> bxn 1	2 <sup>nd</sup> bxn 0	2 <sup>nd</sup> key 6	2 <sup>nd</sup> key 5	2 <sup>nd</sup> key 4	2 <sup>nd</sup> key 3	2 <sup>nd</sup> key 2	2 <sup>nd</sup> key 1	2 <sup>nd</sup> key 0	2 <sup>nd</sup> amu	2 <sup>nd</sup> quality 1	2 <sup>nd</sup> quality 0	2 <sup>nd</sup> vpf

Bits	Dir	Signal	Typical	Description
[00]	R	alct_second_valid	1	Valid pattern flag
[02:01]	R	alct_second_quality[1:0]	0-3	Pattern quality
[03]	R	alct_second_amu	0	Accelerator muon flag
[10:04]	R	alct_second_key[6:0]	0-111	ALCT1 key wire-group
[12:11]	R	alct_second_bxn[1:0]	0-3	ALCT1 bunch crossing number
[15:13]	R	--	0	Unassigned

**Adr 3E                    ADR\_ALCT\_FIFO                    ALCT FIFO RAM Status**  
(Split with Adr A2 ADR\_ALCT\_FIFO1 and A4 ADR\_ALCT\_FIFO2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	alct data1 7	alct data1 6	alct wdcnt 10	alct wdcnt 9	alct wdcnt 8	alct wdcnt 7	alct wdcnt 6	alct wdcnt 5	alct wdcnt 4	alct wdcnt 3	alct wdcnt 2	alct wdcnt 1	alct wdcnt 0	alct RAM done	alct RAM busy

Bits	Dir	Signal		Description
[00]	R	alct_raw_busy		ALCT raw hits FIFO busy writing ALCT data
[01]	R	alct_raw_done		ALCT raw hits ready for VME readout
[12:02]	R	alct_raw_wdcnt[10:0]		ALCT raw hits word count stored in RAM
[14:13]	R	alct_raw_rdata[17:16]		ALCT raw hits data MSBs
[15]	R	--	0	Unassigned

**Adr 40                    ADR\_DMB\_MON                    DMB Monitored Signals**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	2 <sup>nd</sup> bxn 1	2 <sup>nd</sup> bxn 0	2 <sup>nd</sup> key 6	2 <sup>nd</sup> key 5	2 <sup>nd</sup> key 4	2 <sup>nd</sup> key 3	2 <sup>nd</sup> key 2	2 <sup>nd</sup> key 1	2 <sup>nd</sup> key 0	2 <sup>nd</sup> amu	2 <sup>nd</sup> quality 1	2 <sup>nd</sup> quality 0	2 <sup>nd</sup> vpf

Bits	Dir	Signal	Typical	Description
[02:00]	R	dmb_cfeb_calibrate[2:0]	0	DMB calibration
[03]	R	dmb_l1a_release	0	DMB test
[08:04]	R	dmb_reserved_out[4:0]	0	DMB future use
[11:09]	R	dmb_reserved_in[2:0]	0	DMB future use
[15:12]	R	dmb_rx_ff[3:0]	0	DMB received

**Adr 42                    ADR\_CFEB\_INJ                    CFEB Injector Control**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inj start	inj mask 4	inj mask 3	inj mask 2	inj mask 1	inj mask 0	inj febsel 4	inj febsel 3	inj febsel 2	inj febsel 1	inj febsel 0	mask all cfeb4	mask all cfeb3	mask all cfeb2	mask all cfeb1	mask all cfeb0

Bits	Dir	Signal	Default	Description
[04:00]	RW	mask_all[4:0]	11111 <sub>2</sub>	1=Enable, 0=Turn off CFEBn inputs See Adr68 <a href="#">p40</a>
[09:05]	RW	inj_febsel[4:0]	0	1=Select CFEBn for RAM read/write
[14:10]	RW	injector_mask[4:0]	11111 <sub>2</sub>	Enable CFEBn for injector trigger
[15]	RW	inj_trig_vme	0	Start pattern injector

**Adr 44                      ADR\_CFEB\_INJ\_ADR                      CFEB Injector RAM Address**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inj adr 9	inj adr 8	inj adr 7	inj adr 6	inj adr 5	inj adr 4	inj adr 3	inj adr 2	inj adr 1	inj adr 0	inj ren 2	inj ren 1	inj ren 0	inj wen 2	inj wen 1	inj wen 0

Bits	Dir	Signal	Default	Description
[02:00]	RW	inj_wen[2:0]	0	1=Write enable injector RAMn (Ly01,23,45)
[05:03]	RW	inj_ren[2:0]	0	1=Read enable Injector RAMn
[15:06]	RW	inj_rwadr[9:0]	0	Injector RAM read/write address

**Adr 46                      ADR\_CFEB\_INJ\_WDATA                      CFEB Injector Write Data**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inj wdata 15	inj wdata 14	inj wdata 13	inj wdata 12	inj wdata 11	inj wdata 10	inj wdata 9	inj wdata 8	inj wdata 7	inj wdata 6	inj wdata 5	inj wdata 4	inj wdata 3	inj wdata 2	inj wdata 1	inj wdata 0

Bits	Dir	Signal	Default	Description
[07:00]	RW	inj_wdata[7:0]	0	Triad bit for addressed Tbin Ly0 (or 2,4)
[15:08]	RW	inj_wdata[15:8]	0	Triad bit for addressed Tbin Ly1 (or 3,5)

**Adr 48                      ADR\_CFEB\_INJ\_RDATA                      CFEB Injector Read Data**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inj rdata 15	inj rdata 14	inj rdata 13	inj rdata 12	inj rdata 11	inj rdata 10	inj rdata 9	inj rdata 8	inj rdata 7	inj rdata 6	inj rdata 5	inj rdata 4	inj rdata 3	inj rdata 2	inj rdata 1	inj rdata 0

Bits	Dir	Signal	Default	Description
[07:00]	R	inj_rdata[7:0]	0	Triad bit for addressed Tbin Ly0 (or 2,4)
[15:08]	R	inj_rdata[15:8]	0	Triad bit for addressed Tbin Ly1 (or 3,5)

Adr 4A		ADR_HCM001				CFEB0 Ly0,Ly1 Hot Channel Mask									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ly1 distrip 7	ly1 distrip 6	ly1 distrip 5	ly1 distrip 4	ly1 distrip 3	ly1 distrip 2	ly1 distrip 1	ly1 distrip 0	ly0 distrip 7	ly0 distrip 6	ly0 distrip 5	ly0 distrip 4	ly0 distrip 3	ly0 distrip 2	ly0 distrip 1	ly0 distrip 0
Bits		Dir	Signal				Default		Description						
[07:00]		RW	cfeb0_ly0_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 0						
[15:08]		RW	cfeb0_ly1_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 1						
Adr 4C		ADR_HCM023				CFEB0 Ly2,Ly3 Hot Channel Mask									
[07:00]		RW	cfeb0_ly2_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 2						
[15:08]		RW	cfeb0_ly3_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 3						
Adr 4E		ADR_HCM045				CFEB0 Ly4,Ly5 Hot Channel Mask									
[07:00]		RW	cfeb0_ly4_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 4						
[15:08]		RW	cfeb0_ly5_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 5						
Adr 50		ADR_HCM101				CFEB1 Ly0,Ly1 Hot Channel Mask									
[07:00]		RW	cfeb1_ly0_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 0						
[15:08]		RW	cfeb1_ly1_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 1						
Adr 52		ADR_HCM123				CFEB1 Ly2,Ly3 Hot Channel Mask									
[07:00]		RW	cfeb1_ly2_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 2						
[15:08]		RW	cfeb1_ly3_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 3						
Adr 54		ADR_HCM145				CFEB1 Ly4,Ly5 Hot Channel Mask									
[07:00]		RW	cfeb1_ly4_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 4						
[15:08]		RW	cfeb1_ly5_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 5						
Adr 56		ADR_HCM201				CFEB2 Ly0,Ly1 Hot Channel Mask									
[07:00]		RW	cfeb2_ly0_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 0						
[15:08]		RW	cfeb2_ly1_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 1						
Adr 58		ADR_HCM223				CFEB2 Ly2,Ly3 Hot Channel Mask									
[07:00]		RW	cfeb2_ly2_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 2						
[15:08]		RW	cfeb2_ly3_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 3						
Adr 5A		ADR_HCM245				CFEB2 Ly4,Ly5 Hot Channel Mask									
[07:00]		RW	cfeb2_ly4_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 4						
[15:08]		RW	cfeb2_ly5_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 5						

**Adr 5C                      ADR\_HCM301                      CFEB3 Ly0,Ly1 Hot Channel Mask**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ly1 distrip 7	ly1 distrip 6	ly1 distrip 5	ly1 distrip 4	ly1 distrip 3	ly1 distrip 2	ly1 distrip 1	ly1 distrip 0	ly0 distrip 7	ly0 distrip 6	ly0 distrip 5	ly0 distrip 4	ly0 distrip 3	ly0 distrip 2	ly0 distrip 1	ly0 distrip 0

Bits	Dir	Signal	Default	Description
[07:00]	RW	cfeb3_ly0_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 0
[15:08]	RW	cfeb3_ly1_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 1

**Adr 5E                      ADR\_HCM323                      CFEB3 Ly2,Ly3 Hot Channel Mask**

[07:00]	RW	cfeb3_ly2_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 2
[15:08]	RW	cfeb3_ly3_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 3

**Adr 60                      ADR\_HCM345                      CFEB3 Ly4,Ly5 Hot Channel Mask**

[07:00]	RW	cfeb3_ly4_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 4
[15:08]	RW	cfeb3_ly5_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 5

**Adr 62                      ADR\_HCM401                      CFEB4 Ly0,Ly1 Hot Channel Mask**

[07:00]	RW	cfeb4_ly0_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 0
[15:08]	RW	cfeb4_ly1_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 1

**Adr 64                      ADR\_HCM423                      CFEB4 Ly2,Ly3 Hot Channel Mask**

[07:00]	RW	cfeb4_ly2_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 2
[15:08]	RW	cfeb4_ly3_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 3

**Adr 66                      ADR\_HCM445                      CFEB4 Ly4,Ly5 Hot Channel Mask**

[07:00]	RW	cfeb4_ly4_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 4
[15:08]	RW	cfeb4_ly5_hcm[7:0]	11111111 <sub>2</sub>	1=Enable DiStrip[7:0] Layer 5

**Adr 68****ADR\_SEQ\_TRIG\_EN****Sequencer Trigger Source Enables \*\***

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfebe n sourc e	cfebe n 4	cfebe n 3	cfebe n 2	cfebe n 1	cfebe n 0	all cfebs active	ext trig inject	vme trig	alct ext trig en	clct ext trig en	adb ext trig en	adb ext trig en	alct*clct match trig en	alct pat trig en	clct pat trig en

Bits	Dir	Signal	Default	Description
[00]	RW	clct_pat_trig_en	1	1=Allow CLCT pattern triggers (CLCT Active FEB)
[01]	RW	alct_pat_trig_en	0	1=Allow ALCT pattern triggers (ALCT Active FEB)
[02]	RW	alct_match_trig_en	0	1=ALCT*CLCT pattern triggers
[03]	RW	adb_ext_trig_en	0	1=Allow ADB external triggers from CCB
[04]	RW	dmb_ext_trig_en	0	1=Allow DMB external triggers
[05]	RW	clct_ext_trig_en	0	1=Allow CLCT external triggers (scintillator) from CCB
[06]	RW	alct_ext_trig_en	0	1=Allow ALCT external triggers from CCB
[07]	RW	vme_ext_trig	0	1=Initiate Sequencer trigger (write 0 to recover)
[08]	RW	ext_trig_inject	0	1=Change clct_ext_trig to fire pattern injector
[09]	RW	all_cfebs_active	0	1=Make all CFEBs active when triggered
[14:10]	RW*	cfeb_en	1111 <sub>2</sub>	1=Enable CFEB[n] to trigger and send active_feb_flag
[15]	RW	cfeb_en_source	1	1=cfeb_en set by mask_all[4:0] in Adr 42, 0=set by 68

\* normally, cfeb\_en is copied from mask\_all in Adr42 so that masked-off cfebs do not trigger TMB or send active feb to DMB. That prevents the CFEB pattern injector from triggering, so setting\_cfeb\_en\_source=0, allows cfeb\_en to be written independently via Adr68[14:10].

\*\* See adr F0 [p67](#) for layer-trigger mode

**Adr 6A****ADR\_SEQ\_TRIG\_DLY0****Sequencer Trigger Source Delays**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
adb delay 3	adb delay 2	adb delay 1	adb delay 0	alct aff delay 3	alct aff delay 2	alct aff delay 1	alct aff delay 0	alct pretri g delay	alct pretri g delay 2	alct pretri g delay 1	alct pretri g delay 0	alct width 3	alct width 2	alct width 1	alct width 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	alct_trig_width[3:0]	3	ALCTCLCT Pre-trigger window width
[07:04]	RW	alct_pre_trig_dly	0 (2)	ALCT Pre-trigger delay for ALCT*CLCT
[11:08]	RW	alct_pat_trig_dly[3:0]	0	Delay alct_pat_trig (active feb flag from ALCT)
[15:12]	RW	adb_ext_trig_dly[3:0]	1	Delay adb_ext_trig from CCB



**Adr 6C                      ADR\_SEQ\_TRIG\_DLY1                      Sequencer Trigger Source Delays**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	alct ext delay 3	alct ext delay 2	alct ext delay 1	alct ext delay 0	clct ext delay 3	clct ext delay 2	clct ext delay 1	clct ext delay 0	dmb ext delay 3	dmb ext delay 2	dmb ext delay 1	dmb ext delay 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	dmb_ext_trig_dly[3:0]	1	Delay dmb_ext_trig from DMB
[07:04]	RW	clct_ext_trig_dly[3:0]	7	Delay clct_ext_trig (scintillator) from CCB
[11:08]	RW	alct_ext_trig_dly[3:0]	7	Delay alct_ext_trig from CCB
[15:12]	RW	-	0	Unused

**Adr 6E                      ADR\_SEQ\_ID                      Sequencer Board + CSC Ids**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	run id 3	run id 2	run id 1	run id 0	csd id 3	csd id 2	csd id 1	csd id 0	board id 4	board id 3	board id 2	board id 1	board id 0

Bits	Dir	Signal	Default	Description
[04:00]	RW	board_id[4:0]	21	Board ID = VME Slot Geographic Adr
[08:05]	RW	csc_id[3:0]	5	CSC Chamber ID number
[12:09]	RW	run_id[3:0]	0	Run ID number
[15:13]	RW	--	0	Unassigned

**Adr 70                      ADR\_SEQ\_CLCT                      Sequencer CLCT Configuration**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
pretri g halt	drft delay 0	drft delay 0	hit thresh post 2	hit thresh post 1	hit thresh post 0	dmb thresh 2	dmb thresh 1	dmb thresh 0	hs thresh 2	hs thresh 1	hs thresh 0	triad persis t 3	triad persis t 2	triad persis t 1	triad persis t 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	triad_persist	6	Triad One-Shot Persistence (6=150ns)
[06:04]	RW	hit_thresh_pretrig[2:0]	4	Pattern hits pre-trigger threshold
[09:07]	RW	dmb_thresh_pretrig[2:0]	4	Minimum pattern hits 0-6 for DMB active-febs
[12:10]	RW	hit_thresh_postdrift[2:0]	4	Minimum pattern hits allowed after drift
[14:13]	RW	drift_delay[1:0]	2	CSC Drift delay, number 25ns clock periods
[15]	RW	pretrig_halt	0	Pretrigger and halt until unhalt arrives

**Adr 72                      ADR\_SEQ\_FIFO                      Sequencer FIFO Configuration**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
bcb read enable	0	fifo no raw hits	fifo pretrig 4	fifo pretrig 3	fifo pretrig 2	fifo pretrig 1	fifo pretrig 0	fifo tbins 4	fifo tbins 3	fifo tbins 2	fifo tbins 1	fifo tbins 0	fifo mode 2	fifo mode 1	fifo mode 0

Bits	Dir	Signal	Default	Description
[02:00]	RW	fifo_mode[2:0]	1	FIFO Mode: 0=no CFEB raw hits full header 1=all CFEB raw hits full header 2=local CFEB raw hits full header 3=no CFEB raw hits short header 4=no CFEB raw hits no header
[07:03]	RW	fifo_tbins[4:0]	7	Number FIFO time bins to read out
[12:08]	RW	fifo_pretrig[4:0]	2	Number FIFO time bins before pretrigger
[13]	RW	fifo_no_raw_hits	0	1=do not wait to store raw hits [a no_daq mode]
[14]	RW	--	0	Unassigned
[15]	RW	bcb_read_enable	0	1=enable cfep blocked distrip bits in dmb readout

**Adr 74                      ADR\_SEQ\_L1A                      Sequencer L1A Configuration**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
l1a internally 2	l1a internally 1	l1a internally 0	l1a intern	l1a window 3	l1a window 2	l1a window 1	l1a window 0	l1a delay 7	l1a delay 6	l1a delay 5	l1a delay 4	l1a delay 3	l1a delay 2	l1a delay 1	l1a delay 0

Bits	Dir	Signal	Default	Description
[07:00]	RW	l1a_delay[7:0]	128 <sub>10</sub>	Level1 Accept delay from pretrig status output
[11:08]	RW	l1a_window[3:0]	3	Level1 Accept window width after delay
[12]	RW	l1a_internal	0	Generate internal Level 1, overrides external
[15:13]	RW	l1a_internal_dly[2:0]	0	Window position for internal L1A

**Adr 76                      ADR\_SEQ\_OFFSET0                      Sequencer Counter Offsets** [see Adr10A p70 for L1A bxn offset]

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
bxn offset 11	bxn offset 10	bxn offset 9	bxn offset 8	bxn offset 7	bxn offset 6	bxn offset 5	bxn offset 4	bxn offset 3	bxn offset 2	bxn offset 1	bxn offset 0	l1a offset 3	l1a offset 2	l1a offset 1	l1a offset 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	l1a_offset[3:0]	0	L1A counter preset value
[15:04]	RW	bxn_offset_pretrig[11:0]	0	BXN offset at reset for pretrigger bxn

**Adr 78      ADR\_SEQ\_CLCT0      Sequencer Latched CLCT0 (LSBs)**  
(Split with Adr B0 ADR\_SEQCLCTM)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
hs key 7	hs key 6	hs key 5	hs key 4	hs <sup>t</sup> key 3	hs key 2	hs key 1	hs key 0	hs pid 3	hs pid 2	hs pid 1	hs pid 0	hs hits 2	hs hits 1	hs hits 0	vpf

Bits	Dir	Signal	Typical	Description
[00]	R	clct0[0]    clct_1 <sup>st</sup> _valid	1	Valid pattern flag
[03:01]	R	clct0[3:1]    hs_hit_1 <sup>st</sup> [2:0]	4-6	Hits on pattern: 0 to 6
[07:04]	R	clct0[7:4]    hs_pid_1 <sup>st</sup> [3:0]	0-10	Pattern shape 0 to 10
[15:08]	R	clct0[15:8]    hs_key_1 <sup>st</sup> [7:0]	0-159 <sub>10</sub>	Key ½-strip

**Adr 7A      ADR\_SEQ\_CLCT1      Sequencer Latched CLCT1 (LSBs)**  
(Split with Adr B0 ADR\_SEQCLCTM)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
hs key 7	hs key 6	hs key 5	hs key 4	hs <sup>t</sup> key 3	hs key 2	hs key 1	hs key 0	hs pid 3	hs pid 2	hs pid 1	hs pid 0	hs hits 2	hs hits 1	hs hits 0	vpf

Bits	Dir	Signal	Typical	Description
[00]	R	clct1[0]    clct_2 <sup>nd</sup> _valid	1	Valid pattern flag
[03:01]	R	clct1[3:1]    hs_hit_2 <sup>nd</sup> [2:0]	4-6	Hits on pattern: 0 to 6
[07:04]	R	clct1[7:4]    hs_pid_2 <sup>nd</sup> [3:0]	0-10	Pattern shape 0 to 10
[15:08]	R	clct1[15:8]    hs_key_2 <sup>nd</sup> [7:0]	0-159 <sub>10</sub>	Key ½-strip

**Adr 7C      ADR\_SEQ\_TRIG\_SRC      Sequencer Trigger Source Read-back**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	me1b pretri g	me1a pre trig	layer trig	vme trig	alct ext trig en	clct ext trig en	adb ext trig en	adb ext trig en	alct*clct pat trig en	alct pat trig en	clct pat trig en

Bits	Dir	Signal	Typical	Description
[00]	R	clct_pat_trig_en	1	CLCT pattern triggered sequencer
[01]	R	alct_pat_trig_en	0	ALCT pattern triggered sequencer
[02]	R	alct_match_trig_en	0	ALCT*CLCT pattern triggered sequencer
[03]	R	adb_ext_trig_en	0	ADB external triggered sequencer
[04]	R	dmb_ext_trig_en	0	DMB external triggered sequencer
[05]	R	clct_ext_trig_en	0	CLCT (CCB scintillator) external triggered sequencer
[06]	R	alct_ext_trig_en	0	ALCT (CCB) external triggered sequencer
[07]	R	vme_ext_trig	0	VME triggered sequencer
[08]	R	layer_trig	0	Layer trigger
[09]	R	me1a_only_pretrig	0	CLCT pattern trigger was on ME1A only
[10]	R	me1b_only_pretrig	0	CLCT pattern trigger was on ME1B only
[13:11]	R	--	0	Unassigned

Adr 7E		ADR_DMB_RAM_ADR				Sequencer RAM Address									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dmb wdata 17	dmb wdata 16	dmb reset	dmb wr	dmb adr 11	dmb adr 10	dmb adr 9	dmb adr 8	dmb adr 7	dmb adr 6	dmb adr 5	dmb adr 4	dmb adr 3	dmb adr 2	dmb adr 1	dmb adr 0

Bits	Dir	Signal	Default	Description
[11:00]	RW	dmb_adr[11:0]	0	Raw hits RAM VME read/write address
[12]	RW	dmb_wr	0	Raw hits RAM VME write enable
[13]	RW	dmb_reset	0	Raw hits RAM VME address reset
[15:14]	RW	dmb_wdata[17:16]	0	Raw hits RAM VME write data MSBs

Adr 80		ADR_DMB_RAM_WDATA				Sequencer RAM Write Data									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dmb wdata 15	dmb wdata 14	dmb wdata 13	dmb wdata 12	dmb wdata 11	dmb wdata 10	dmb wdata 9	dmb wdata 8	dmb wdata 7	dmb wdata 6	dmb wdata 5	dmb wdata 4	dmb wdata 3	dmb wdata 2	dmb wdata 1	dmb wdata 16

Bits	Dir	Signal	Default	Description
[15:00]	RW	dmb_wdata[15:0]	0	Raw hits RAM VME write data (msb in adr 76)

Adr 82		ADR_DMB_RAM_WDCNT				Sequencer RAM Word Count									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	dmb busy	dmb rdata 17	dmb wdata 16	dmb wdcnt 11	dmb wdcnt 10	dmb wdcnt 9	dmb wdcnt 8	dmb wdcnt 7	dmb wdcnt 6	dmb wdcnt 5	dmb wdcnt 4	dmb wdcnt 3	dmb wdcnt 2	dmb wdcnt 1	dmb wdcnt 0

Bits	Dir	Signal	Default	Description
[11:00]	R	dmb_wdcnt[11:0]	0	Raw hits RAM VME word count
[13:12]	R	dmb_rdata[17:16];	0	Raw hits RAM VME read data MSBs
[14]	R	dmb_busy	0	Raw hits RAM VME
[15]	R	--	0	Unassigned

Adr 84		ADR_DMB_RAM_RDATA				Sequencer RAM Read Data									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
dmb rdata 15	dmb rdata 14	dmb rdata 13	dmb rdata 12	dmb rdata 11	dmb rdata 10	dmb rdata 9	dmb rdata 8	dmb rdata 7	dmb rdata 6	dmb rdata 5	dmb rdata 4	dmb rdata 3	dmb rdata 2	dmb rdata 1	dmb rdata 16

Bits	Dir	Signal	Default	Description
[15:00]	R	dmb_rdata[15:0]	0	Raw hits RAM VME read data (msb in adr 7A)

**Adr 86****ADR\_TMB\_TRIG****TMB Trigger Configuration / MPC Accept**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
mpc oe	mpc idle blank	mpc sel_ttc bx0	mpc reserved 1	mpc reserved 0	mpc accept 1	mpc accept 0	mpc delay 3	mpc delay 2	mpc delay 1	mpc delay 0	allow clct+alct match	allow clct only	allow alct only	sync err en 1	sync err en 0

Bits	Dir	Signal	Default	Description
[01:00]	RW	tmb_sync_err_en[1:0]	11 <sub>2</sub>	Allow sync_err to MPC for either muon
[02]	RW	tmb_allow_alct	0	Allow ALCT-only L1A (not used in current version)
[03]	RW	tmb_allow_clct	1	Allow CLCT0-only L1A
[04]	RW	tmb_allow_match	1	Allow ALCT+CLCT match pre-trigger
[08:05]	RW	mpc_rx_delay[3:0]	7	MPC accept response delay
[10:09]	R	mpc_accept[1:0]	-	MPC accept latched after delay
[12:11]	R	mpc_reserved[1:0]	-	MPC reserved latched after delay
[13]	RW	mpc_sel_ttc_bx0	1	1=MPC gets ttc_bx0, 0=bx0_local
[14]	RW	mpc_idle_blank	0	1=blank mpc data & bx0 except when triggered
[15]	RW	mpc_oe	1	1=enable outputs to MPC, 0=aset FFs to 1s

**Adr 88****ADR\_MPC0\_FRAME0****MPC0 Frame0 Data Sent to MPC**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1 <sup>st</sup> vpf	lct 1 <sup>st</sup> q 3	lct 1 <sup>st</sup> q 2	lct 1 <sup>st</sup> q 1	lct 1 <sup>st</sup> q 0	clct 1 <sup>st</sup> pat 3	clct 1 <sup>st</sup> pat 2	clct 1 <sup>st</sup> pat 1	clct 1 <sup>st</sup> pat 0	alct 1 <sup>st</sup> wg 6	alct 1 <sup>st</sup> wg 5	alct 1 <sup>st</sup> wg 4	alct 1 <sup>st</sup> wg 3	alct 1 <sup>st</sup> wg 2	alct 1 <sup>st</sup> wg 1	alct 1 <sup>st</sup> wg 0

Bits	Dir	Signal	Typical	Description
[06:00]	R	alct_first_key[6:0]	0-111 <sub>10</sub>	ALCT first key wire-group
[10:07]	R	clct_first_pat[3:0]	0-10	CLCT first pattern number
[14:11]	R	lct_first_quality[3:0]	8	LCT first muon quality
[15]	R	first_vpf	1	First valid pattern flag

**Adr 8A****ADR\_MPC0\_FRAME1****MPC0 Frame1 Data Sent to MPC**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
csc id 3	csc id 2	csc id 1	csc id 0	tmb bx0 local	alct 1 <sup>st</sup> bxn 0	sync err	clct 1 <sup>st</sup> bend	clct 1 <sup>st</sup> key 7	clct 1 <sup>st</sup> key 6	clct 1 <sup>st</sup> key 5	clct 1 <sup>st</sup> key 4	clct 1 <sup>st</sup> key 3	clct 1 <sup>st</sup> key 2	clct 1 <sup>st</sup> key 1	clct 1 <sup>st</sup> key 0

Bits	Dir	Signal	Typical	Description
[07:00]	R	clct_first_key[7:0]	0-159 <sub>10</sub>	CLCT first muon key ½-strip
[08]	R	clct_first_bend	0	CLCT first muon bend direction
[09]	R	sync_err	0	BXN does not match at BX0
[10]	R	alct_first_bxn[0]	0-1	ALCT first muon bunch crossing number
[11]	R	clct_first_bx0_local	0-1	1=TMBs bxn[11:0]==0
[15:12]	R	csc_id[3:0]	1-9	CSC chamber ID

**Adr 8C                      ADR\_MPC1\_FRAME0                      MPC1 Frame0 Data Sent to MPC**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2 <sup>nd</sup> vpf	lct 2 <sup>nd</sup> q 3	lct 2 <sup>nd</sup> q 2	lct 2 <sup>nd</sup> q 1	lct 2 <sup>nd</sup> q 0	clct 2 <sup>nd</sup> pat 3	clct 2 <sup>nd</sup> pat 2	clct 2 <sup>nd</sup> pat 1	clct 2 <sup>nd</sup> pat 0	alct 2 <sup>nd</sup> wg 6	alct 2 <sup>nd</sup> wg 5	alct 2 <sup>nd</sup> wg 4	alct 2 <sup>nd</sup> wg 3	alct 2 <sup>nd</sup> wg 2	alct 2 <sup>nd</sup> wg 1	alct 2 <sup>nd</sup> wg 0

Bits	Dir	Signal	Typical	Description
[06:00]	R	alct_second_key[6:0]	0-111 <sub>10</sub>	ALCT second key wire-group
[10:07]	R	clct_second_pat[3:0]	0-10	CLCT second pattern number
[14:11]	R	lct_second_quality[3:0]	8	LCT second muon quality
[15]	R	second_vpf	1	Second valid pattern flag

**Adr 8E                      ADR\_MPC1\_FRAME1                      MPC1 Frame1 Data Sent to MPC**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
csc id 3	csc id 2	csc id 1	csc id 0	tmb bx0 local	alct 2 <sup>nd</sup> bxn 0	sync err	clct 2 <sup>nd</sup> bend	clct 2 <sup>nd</sup> key 7	clct 2 <sup>nd</sup> key 6	clct 2 <sup>nd</sup> key 5	clct 2 <sup>nd</sup> key 4	clct 2 <sup>nd</sup> key 3	clct 2 <sup>nd</sup> key 2	clct 2 <sup>nd</sup> key 1	clct 2 <sup>nd</sup> key 0

Bits	Dir	Signal	Typical	Description
[07:00]	R	clct_second_key[7:0]	0-159 <sub>10</sub>	CLCT second muon key ½-strip
[08]	R	clct_second_bend	0	CLCT second muon bend direction
[09]	R	sync_err	0	BXN does not match at BX0
[10]	R	alct_second_bxn[0]	0-1	ALCT second muon bunch crossing number
[11]	R	clct_second_bx0_local	0-1	1=TMBs bxn[11:0]==0
[15:12]	R	csc_id[3:0]	1-9	CSC chamber ID

**Adr 90                      ADR\_MPC\_INJ                      MPC Injector Control**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
mpc inj clct bx0	mpc inj alct bx0	mpc reserv 1	mpc reserv 0	mpc accep t 1	mpc accep t 0	ttc inj enabl e	mpc inject	mpc nfram 7	mpc nfram 6	mpc nfram 5	mpc nfram 4	mpc nfram 3	mpc nfram 2	mpc nfram 1	mpc nfram 0

Bits	Dir	Signal	Default	Description
[07:00]	RW	mpc_nframes[7:0]	5	Number frames to inject
[08]	RW	mpc_inject	0	1=Start MPC test pattern injector
[09]	RW	ttc_mpc_inj_en	1	1=Enable injector start by TTC command
[11:10]	R	mpc_accept[1:0]	-	MPC accept stored at injector RAM address
[13:12]	R	mpc_reserved[1:0]	-	MPC reserved stored at injector RAM address
[14]	RW	mpc_inj_alct_bx0	0	1=Fire alct_bx0 one-shot
[15]	RW	mpc_inj_clct_bx0	0	1=Fire clct_bx0 one-shot

**Adr 92                      ADR\_MPC\_RAM\_ADR                      MPC Injector RAM Address**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
mpc adr 7	mpc adr 6	mpc adr 5	mpc adr 4	mpc adr 3	mpc adr 2	mpc adr 1	mpc adr 0	mpc ren 3	mpc ren 2	mpc ren 1	mpc ren 0	mpc wen 3	mpc wen 2	mpc wen 1	mpc wen 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	mpc_wen[3:0]	0	Select RAM to write
[07:04]	RW	mpc_ren[3:0]	0	Select RAM to read
[15:08]	RW	mpc_adr[7:0]	0	Injector RAM read/write address

**Adr 94                      ADR\_MPC\_RAM\_WDATA                      MPC Injector RAM Write Data**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
mpc wdata 7	mpc wdata 6	mpc wdata 5	mpc wdata 4	mpc wdata 3	mpc wdata 2	mpc wdata 1	mpc wdata 0	mpc wdata 3	mpc wdata 2	mpc wdata 1	mpc wdata 0	mpc wdata 3	mpc wdata 2	mpc wdata 1	mpc wdata 0

Bits	Dir	Signal	Default	Description
[15:00]	RW	mpc_wdata[15:0]	0	MPC Injector RAM write data

**Adr 96                      ADR\_MPC\_RAM\_RDATA                      MPC Injector RAM Read Data**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
mpc rdata 7	mpc rdata 6	mpc rdata 5	mpc rdata 4	mpc rdata 3	mpc rdata 2	mpc rdata 1	mpc rdata 0	mpc rdata 3	mpc rdata 2	mpc rdata 1	mpc rdata 0	mpc rdata 3	mpc rdata 2	mpc rdata 1	mpc rdata 0

Bits	Dir	Signal	Default	Description
[15:00]	R	mpc_rdata[15:0]	0	MPC Injector RAM read data

**Adr 98****ADR\_SCP\_CTRL****Scope Control** [see Adr9A p48 SCP\_RDATA and adr CE p59 SCP\_TRIG]

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0		trig done	waitin for trigger	ram sel 3	ram sel 2	ram sel 1	ram sel 0	tbins 2	tbins 1	tbins 0	no write	auto	force trig	run stop	trig en

Bits	Dir	Signal	Default	Description
[00]	RW	scp_ch_trig_en	1	1=Enable channel triggers, see AdrCE p59 for ch
[01]	RW	scp_runstop	0	1=Run, 0=Stop
[02]	RW	scp_force_trig	0	1=Force a trigger (to trig: set 0,1,0 in 3 writes)
[03]	RW	scp_auto	0	Sequencer readout mode 1=insert in DMB data
[04]	RW	scp_nowrite	0	1=Preserve initial RAM test pattern for debug
[07:05]	RW	scp_tbins[2:0]	4	Auto mode tbins per channel code, actual tbins/ch=(scp_tbins+1)*64, spans 64-512
[11:08]	RW	scp_ram_sel[3:0]	0	RAM bank address 0-9 for VME readout
[12]	R	scp_waiting	-	Scope waiting for trigger
[13]	R	scp_trig_done	-	Scope triggered, ready for readout
[15:14]	RW	-		Unassigned

**Adr 9A****ADR\_SCP\_RDATA****Scope Read data**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
rdata 15	rdata 14	rdata 13	rdata 12	rdata 11	rdata 10	rdata 9	radr8 rdata 8	radr7 rdata 7	radr6 rdata 6	radr5 rdata 5	radr4 rdata 4	radr3 rdata 3	radr2 rdata 2	radr1 rdata 1	radr0 rdata 0

Bits	Dir	Signal		Description
[08:00]	W	scp_radr[8:0]		Scope data read address=tbin for selected RAM
[15:00]	R	scp_rdata[15:0]		See channel assignments below

**Scope Channel Assignments**

// Pre-trigger to DMB

```

assign scp_ch[0]      = (clct_sm == pretrig);    // Trigger alignment marker, scope triggers on this ch usually
assign scp_ch[1]      = triad_tp[0];            // Triad test point at input to raw hits RAM
assign scp_ch[2]      = any_cfeb_hit;           // Any CFEB over threshold
assign scp_ch[3]      = active_feb_flag;        // Active feb flag to DMB
assign scp_ch[8:4]    = active_feb_list[4:0];   // Active feb list to DMB

```

// Pre-trigger CLCT\*ALCT matching

```

assign scp_ch[9]      = alct_active_feb;        // ALCT active feb flag, should precede alct0_vpf
assign scp_ch[10]     = alct_pretrig_window;    // ALCT*CLCT pretrigger matching window

```

// Pre-trigger Processing

```

assign scp_ch[13:11]  = clct_sm_vec[2:0];       // Pre-trigger state machine
assign scp_ch[14]     = wr_buf_ready;           // Write buffer ready
assign scp_ch[15]     = (clct_sm == pretrig);   // Skip channels 15,31,47,63,79,95,111,127,143,159
assign scp_ch[27:16]  = bxn_counter[11:0];     // BXN counter
assign scp_ch[28]     = discard_nowrbuf;       // Event discard, no write buffer

```

// CLCT Pattern Finder Output

```

assign scp_ch[29]     = 0;

```



```

assign scp_ch[30]      = 0;
assign scp_ch[31]      = (clct_sm == pretrig);    // Skip channels 15,31,47,63,79,95,111,127,143,159

assign scp_ch[34:32]   = hs_hit_1st[2:0];        // CLCT0 number hits after drift
assign scp_ch[38:35]   = hs_pid_1st[3:0];        // CLCT0 Pattern number
assign scp_ch[46:39]   = hs_key_1st[7:0];        // CLCT0 ½-strip ID number

assign scp_ch[47]      = (clct_sm == pretrig);    // Skip channels 15,31,47,63,79,95,111,127,143,159

assign scp_ch[50:48]   = hs_hit_2nd[2:0];        // CLCT1 number hits after drift
assign scp_ch[54:51]   = hs_pid_2nd[3:0];        // CLCT1 Pattern number
assign scp_ch[62:55]   = hs_key_2nd[7:0];        // CLCT1 ½-strip ID number

assign scp_ch[63]      = (clct_sm == pretrig);    // Skip channels 15,31,47,63,79,95,111,127,143,159

// CLCT Builder
assign scp_ch[64]      = clct0_really_valid;      // CLCT0 is over threshold, not forced by an external trigger
assign scp_ch[65]      = clct0_vpf;              // CLCT0 vpf
assign scp_ch[66]      = clct1_vpf;              // CLCT1 vpf
assign scp_ch[67]      = clct_push_xtmb;         // CLCT sent to TMB matching
assign scp_ch[68]      = discard_invp;           // CLCT discarded, below threshold after drift

// TMB Matching
assign scp_ch[69]      = alct0_valid;             // ALCT0 vpf direct from 80MHz receiver, before alct_delay
assign scp_ch[70]      = alct1_valid;             // ALCT1 vpf direct from 80MHz receiver, before alct_delay

assign scp_ch[71]      = alct_vpf_tprt;          // ALCT vpf in TMB after pipe delay, unbuffered real time
assign scp_ch[72]      = clct_vpf_tprt;          // CLCT vpf in TMB
assign scp_ch[73]      = clct_window_tprt;       // CLCT matching window in TMB
assign scp_ch[77:74]   = tmb_match_win[3:0];     // Location of alct in clct window
assign scp_ch[78]      = tmb_alct_discard;       // ALCT pair was not used for LCT

assign scp_ch[79]      = (clct_sm == pretrig);    // Skip channels 15,31,47,63,79,95,111,127,143,15

assign scp_ch[80]      = tmb_clct_discard;       // CLCT pair was not used for LCT

// TMB Match Results
assign scp_ch[81]      = tmb_trig_pulse;         // TMB Triggered on ALCT or CLCT or both
assign scp_ch[82]      = tmb_trig_keep;         // ALCT or CLCT or both triggered, and trigger is allowed
assign scp_ch[83]      = tmb_match;              // ALCT and CLCT matched in time
assign scp_ch[84]      = tmb_alct_only;          // Only ALCT triggered
assign scp_ch[85]      = tmb_clct_only;          // Only CLCT triggered
assign scp_ch[86]      = discard_tmbreject;      // TMB discarded event

// MPC
assign scp_ch[87]      = mpc_xmit_lct0;          // MPC LCT0 sent
assign scp_ch[88]      = mpc_xmit_lct1;          // MPC LCT1 sent
assign scp_ch[89]      = mpc_response_ff;        // MPC accept is ready
assign scp_ch[91:90]   = mpc_accept_ff[1:0];     // MPC muon accept response

// L1A
assign scp_ch[92]      = l1a_pulse;              // L1A strobe from ccb or internal
assign scp_ch[93]      = l1a_window_open;        // L1A window open duh
assign scp_ch[94]      = l1a_match;              // L1A strobe match in window

assign scp_ch[95]      = (clct_sm == pretrig);    // Skip channels 15,31,47,63,79,95,111,127,143,159

```

```

// Buffer push at L1A
    assign scp_ch[96]      = buf_push;           // Allocate write buffer space for this event
    assign scp_ch[103:97]  = buf_push_adr[6:0];  // Address of write buffer to allocate

// DMB Readout
    assign scp_ch[104]     = dmb_dav;           // DAV to DMB
    assign scp_ch[105]     = dmb_busy;          // Readout in progress
    assign scp_ch[110:106] = read_sm_vec[4:0];  // Readout state machine

    assign scp_ch[111]     = (clct_sm == pretrig); // Skip channels 15,31,47,63,79,95,111,127,143,159

    assign scp_ch[126:112] = seq_wdata[14:0];   // DMB dump image, very cool
    assign scp_ch[127]     = (clct_sm == pretrig); // Skip channels 15,31,47,63,79,95,111,127,143,159
    assign scp_ch[128]     = seq_wdata[15];     // DMB dump image, very cool

// CLCT+TMB Pipelines
    assign scp_ch[132:129] = wr_buf_adr[3:0];   // Event address counter

    assign scp_ch[133]     = wr_push_xtmb;      // Buffer write strobe after drift time
    assign scp_ch[137:134] = wr_adr_xtmb[3:0];  // Buffer write address after drift time

    assign scp_ch[138]     = wr_push_rtmb;      // Buffer write strobe at TMB matching time
    assign scp_ch[142:139] = wr_adr_rtmb[3:0];  // Buffer write address at TMB matching time

    assign scp_ch[143]     = (clct_sm == pretrig); // Skip channels 15,31,47,63,79,95,111,127,143,159

    assign scp_ch[144]     = wr_push_xmpc;      // Buffer write strobe at MPC xmit to sequencer
    assign scp_ch[148:145] = wr_adr_xmpc[3:0];  // Buffer write address at MPC xmit to sequencer

    assign scp_ch[149]     = wr_push_rmpc;      // Buffer write strobe at MPC received
    assign scp_ch[153:150] = wr_adr_rmpc[3:0];  // Buffer write address at MPC received

// Buffer pop at readout completion
    assign scp_ch[154]     = buf_pop;           // Specified buffer is to be released
    assign scp_ch[158:155] = buf_pop_adr[3:0];  // Address of read buffer to release

    assign scp_ch[159]     = (clct_sm == pretrig); // Skip channels 15,31,47,63,79,95,111,127,143,159

```

**Adr 9C****ADR\_CCB\_CMD****CCB TTC Command Generator (Internal)**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ccb cmd 7	ccb cmd 6	ccb cmd 5	ccb cmd 4	ccb cmd 3	ccb cmd 2	ccb cmd 1	ccb cmd 0	0	fmm state 2	fmm state 1	fmm state 0	subaddr strobe	data strobe	brdst strobe	disconnect ccb

Bits	Dir	Signal	Default	Description
[00]	RW	vme_ccb_cmd_enable	0	1=Disconnect CCB backplane ccb_cmd[7:0]
[01]	RW	vme_ccb_cmd_strobe	0	1=Assert internal ccb_cmd brdst strobe
[02]	RW	vme_ccb_data_strobe	0	1=Assert internal ccb_cmd data strobe
[03]	RW	vme_ccb_subaddr_strobe	0	1=Assert internal ccb_cmd sub-adr strobe
[06:04]	R	fmm_state[2:0]	-	FMM machine states: 0: fmm_startup 1: fmm_resync 2: fmm_stop 3: fmm_wait_bx0 4: fmm_run
[07]	RW	-		Unassigned
[15:08]	RW	vme_ccb_cmd[7:0]	0	TTC command to generate

**Adr 9E****ADR\_BUF\_STAT0****Buffer Status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
buffer disp 7	buffer disp 6	buffer disp 5	buffer disp 4	buffer disp 3	buffer disp 2	buffer disp 1	buffer disp 0	buf stalled once	buf q adrerr	buf q udferr	buf q ovferr	buf q empty	buf q full	buf stalled	wr buf ready

Bits	Dir	Signal	Typical	Description
[00]	R	wr_buf_ready	1	Write buffer is ready
[01]	R	buf_stalled	0	Buffer write pointer hit a fence and stalled
[02]	R	buf_q_full	0	All raw hits ram in use, ram writing must stop
[03]	R	buf_q_empty	0	No fences remain in buffer queue
[04]	R	buf_q_ovf_err	0	Tried to push new event when queue full
[05]	R	buf_q_udf_err	0	Tried to pop event when queue empty
[06]	R	buf_q_adr_err	0	Fence adr popped from queue doesn't match expected adr
[07]	R	buf_stalled_once	0	Buffer stalled at least once since last resync
[15:08]	R	buf_display[7:0]	0	Buffer fraction in use, for in-board LED display

**Adr A0****ADR\_BUF\_STAT1****Buffer Status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	buf adr 10	buf adr 9	buf adr 8	buf adr 7	buf adr 6	buf adr 5	buf adr 4	buf adr 3	buf adr 2	buf adr 1	buf adr 0

Bits	Dir	Signal	Typical	Description
[10:00]	R	wr_buf_adr[10:0]	-	Current address of event & header write buffer
[15:11]	R	-	0	Unassigned

Adr A2		ADR_BUF_STAT2				Buffer Status									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	buf fence dist 10	buf fence dist 9	buf fence dist 8	buf fence dist 7	buf fence dist 6	buf fence dist 5	buf fence dist 4	buf fence dist 3	buf fence dist 2	buf fence dist 1	buf fence dist 0
Bits		Dir	Signal				Typical		Description						
[10:00]		R	buf_fence_dist[10:0]				-		Distance to 1 <sup>st</sup> fence address						
[15:11]		R	-				0		Unassigned						

Adr A4		ADR_BUF_STAT3				Buffer Status									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	buf fence cntr 11	buf fence cnt 10	buf fence cnt 9	buf fence cnt 8	buf fence cnt 7	buf fence cnt 6	buf fence cnt 5	buf fence cnt 4	buf fence cnt 3	buf fence cnt 2	buf fence cnt 1	buf fence cnt 0
Bits		Dir	Signal				Typical		Description						
[11:00]		R	buf_fence_cnt[11:0]				-		Number of fences in fence RAM currently						
[15:12]		R	-				0		Unassigned						

Adr A6		ADR_BUF_STAT4				Buffer Status									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	buf fence peak 11	buf fence peak 10	buf fence peak 9	buf fence peak 8	buf fence peak 7	buf fence peak 6	buf fence peak 5	buf fence peak 4	buf fence peak 3	buf fence peak 2	buf fence peak 1	buf fence peak 0
Bits		Dir	Signal				Typical		Description						
[11:00]		R	buf_fence_cnt_peak [11:0]				-		Peak number of fences in fence RAM						
[15:12]		R	-				0		Unassigned						

**Adr A8****ADR\_ALCTFIFO1****ALCT Raw Hits RAM Control**

(Split with Adr 3E ADR\_ALCT\_FIFO0 and Adr A4 ADR\_ALCT\_FIFO2)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	alct demux mode	0	alct radr 10	alct radr 9	alct radr 8	alct radr 7	alct radr 6	alct radr 5	alct radr 4	alct radr 3	alct radr 2	alct radr 1	alct radr 0	alct raw reset

Bits	Dir	Signal	Default	Description
[00]	RW	alct_raw_reset	0	Reset ALCT raw hits FIFO controller
[11:01]	RW	alct_raw_radr[10:0]	0	ALCT raw hits RAM read address or demux wd
[12]	RW	--	0	Unassigned
[13]	RW	alct_demux_mode	0	0=alctfifo2 has RAM data, 1=fifo2=demux data
[15:14]	RW	--	0	Unassigned

**Adr AA****ADR\_ALCTFIFO2****ALCT Raw Hits RAM data (LSBs)**

(Split with Adr 3E ADR\_ALCT\_FIFO0 and Adr A2 ADR\_ALCT\_FIFO1)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
alct fifo 15	alct fifo 14	alct fifo 13	alct fifo 12	alct fifo 11	alct fifo 10	alct fifo 9	alct fifo 8	alct fifo 7	alct fifo 6	alct fifo 5	alct fifo 4	alct fifo 3	alct fifo 2	alct fifo 1	alct fifo 0

Bits	Dir	Signal	Default	Description
[15:00]	R	alct_raw_rdata[15:0] OR alct_1 <sup>st</sup> _vme[14:1] alct_1 <sup>st</sup> _vme[28:15] alct_2 <sup>nd</sup> _vme[14:1] alct_2 <sup>nd</sup> _vme[28:15]		ALCT FIFO data (msbs in adr_alct_fifo) alct_raw_radr=0 and alct_demux_mode=1 alct_raw_radr=1 alct_raw_radr=2 alct_raw_radr=3

**Adr AC****ADR\_SEQMOD****Sequencer Trigger Modifiers**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
event clear vme	active feb src	Scint veto state	Clear scint veto	L1A alct only	L1A tmb nol1a	L1A no tmb	L1A tmb trig	valid clct requir	wr buf requir	hdr wr cont	wrbuf auto clr	flush timer 3	flush timer 2	flush timer 1	flush timer 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	clct_flush_delay[3:0]	1	Trigger sequencer flush state timer
[04]	RW	wr_buf_autoclr_en	1	1=Enable frozen buffer auto clear
[05]	RW	hdr_wr_continuous	0	1=allow continuous header buffer writing for invalid triggers
[06]	RW	wr_buf_required	1	Require wr_buffer available to pre-trigger
[07]	RW	valid_clct_required	1	Require valid CLCT after drift delay
[08]	RW	l1a_allow_match	1	Readout allows tmb trig pulse in L1A window
[09]	RW	l1a_allow_notmb	0	Readout allows notmb trig pulse in L1A window
[10]	RW	l1a_allow_nol1a	0	Readout allows tmb trig pulse outside L1A wind
[11]	RW	l1a_allow_alct_only	0	Allow ALCT-only events to readout at L1A
[12]	RW	scint_veto_clr	0	Clear scintillator veto FF
[13]	R	scint_veto_vme	0	Scintillator veto FF state
[14]	RW	active_feb_src	0	Active feb flag source, 0=pretrig, 1=tmb match
[15]	RW	event_clear_vme	0	Event clear for aff,clct,mpc VME diagnostic registers

Adr AE		ADR_SEQSM				Sequencer Machine State									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	buf_q adr err	buf_q ovf	buf_q empty	buf_q full	read sm 2	read sm 4	read sm 3	read sm 2	read sm 1	read sm 0	clct sm 2	clct sm 1	clct sm 0
Bits		Dir	Signal					Description							
[02:00]		R	clct_sm[2:0]					CLCT Trigger machine state							
[07:03]		R	read_sm[4:0]					Readout machine state							
[08]		R	buf_q_full					All raw hits ram in use, ram writing must stop							
[09]		R	buf_q_empty					No fences remain in buffer queue							
[10]		R	buf_q_ovf_err					Tried to push new event when queue full							
[11]		R	buf_q_adr_err					Tried to pop event when queue empty							
[15:12]		R	--		0			Unassigned							

Adr B0

ADR\_SEQCLCTM

Sequencer CLCT (MSBs)

(Split with Adr 78 ADR\_SEQCLCT0 and Adr 7A ADR\_SEQCLCT1)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sync err	clock lock lost	0	0	0	0	active cfcb 6	active cfcb 5	active cfcb 4	active cfcb 3	active cfcb 2	active cfcb 1	active cfcb 0	sync err	clct bxn 1	clct bxn 0

Bits	Dir	Signal	Typ	Description
[01:00]	R	clctc[1:0] bxn_counter	-	Bunch crossing number at pretrigger, common to clct0/1
[02]	R	clctc[2] sync_err	0	BX0 disagrees with BXN counter, common to clct0/1
[9:3]	R	clctf[6:0]	-	Active feb list latched at TMB alct*clct matching time
[13:10]	R	--	0	Unassigned
[14]	R	clock_lock_lost FF	0	40MHz main clock lost lock, global_reset asserted
[15]	R	sync_err (direct)	0	Sync error: bxn counter==0 does not match bx0

Adr B2		ADR_TMBTIM				TMB Timing for ALCT*CLCT Coincidence									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	mpctx delay 3	mpctx delay 2	mpctx delay 1	mpctx delay 0	clct wind 3	clct wind 2	clct wind 1	clct wind 0	alct delay 3	alct delay 2	alct delay 1	alct delay 0
Bits		Dir	Signal		Default			Description							
[03:00]		RW	alct_delay[3:0]		1			Delay ALCT for CLCT match window							
[07:04]		RW	clct_window[3:0]		3			CLCT match window width							
[11:08]		RW	mpc_tx_delay[3:0]		0			MPC transmit delay							
[15:12]		RW	--		0			Unassigned							

Adr B4		ADR_LHC_CYCLE				LHC Cycle Period, Maximum BXN Count									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	lhc cycle 11	lhc cycle 10	lhc cycle 9	lhc cycle 8	lhc cycle 7	lhc cycle 6	lhc cycle 5	lhc cycle 4	lhc cycle 3	lhc cycle 2	lhc cycle 1	lhc cycle 0

Bits	Dir	Signal	Default	Description
[11:00]	RW	lhc_cycle[11:0]	3564	Maximum bxn+1 3564(hDEC) for LHC 924(h39C) for beam test
[15:12]	RW	--	0	Unassigned

Adr B6		ADR_RPC_CFG				RPC Configuration									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	rpc done	read bxn 2	read bxn 1	read bxn 0	read bank 1	read bank 0	bxn offset 3	bxn offset 2	bxn offset 1	bxn offset 0	read enable	0	0	rpc1 exists	rpc0 exists

Bits	Dir	Signal	Default	Description
[01:00]	RW	rpc_exists[1:0]	3	Bit (n) = 1 = RPC(n) Exists
[03:02]	RW	--	0	Unused
[04]	RW	rpc_read_enable	1	1=Include Existing RPCs in DMB Readout
[08:05]	RW	rpc_bxn_offset[3:0]	0	RPC BXN offset
[10:09]	RW	rpc_bank[1:0]	0	RPC bank address, for reading rdata sync mode
[13:11]	R	rpc_rbxn[2:0]	-	RPC rdata[18:16] msbs for sync mode, adr 1E
[14]	R	rpc_done	1	RPC FPGA reports configuration done
[15]	RW	--	0	Unassigned

Adr B8		ADR_RPC_RDATA				RPC Raw Hits Sync Mode Read Data, See Adr 1E <a href="#">p29</a>									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
rdata 15	rdata 14	rdata 13	rdata 12	rdata 11	rdata 10	rdata 9	rdata 8	rdata 7	rdata 6	rdata 5	rdata 4	rdata 3	rdata 2	rdata 1	rdata 0

Bits	Dir	Signal	Default	Description
[15:00]	R	rpc_rdata[15:0]	-	RPC RAM read data for sync mode

Adr BA		ADR_RPC_RAW_DELAY				RPC Raw Hits Data Delay + RPC BXN Differences									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
rpc1 bxn diff3	rpc1 bxn diff2	rpc1 bxn diff1	rpc1 bxn diff0	rpc0 bxn diff3	rpc0 bxn diff2	rpc0 bxn diff1	rpc0 bxn diff0	rpc1 delay 3	rpc1 delay 2	rpc1 delay 1	rpc1 delay 0	rpc0 delay 3	rpc0 delay 2	rpc0 delay 1	rpc0 delay 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	rpc0_delay[3:0]	1	RPC0 Raw hits data delay
[07:04]	RW	rpc1_delay[3:0]	1	RPC1 Raw hits data delay
[11:08]	R	rpc0_bxn_diff[3:0];	-	RPC bxn – Offset (in adr B6)
[15:12]	R	rpc1_bxn_diff[3:0];	-	RPC bxn – Offset (in adr B6)

Adr BC		ADR_RPC_INJ				RPC Injector Control									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	rpc tbins test	inj rdata 18	inj rdata 17	inj rdata 16	inj wdata 18	inj wdata 17	inj wdata 16	inj sel	delay rat 3	delay rat 2	delay rat 1	delay rat 0	mask rpc	mask rat	mask all

Bits	Dir	Signal	Default	Description
[00]	RW	rpc_mask_all	1	1=Enable RPC Inputs from RAT, 0=disable all
[01]	RW	injector_mask_rat	0	1=Enable RAT for injector fire
[02]	RW	injector_mask_rpc	1	1=Enable RPC injector RAM for injector fire
[06:03]	RW	inj_delay_rat[3:0]	0	CFEB/RPC injectors wait for RAT
[07]	RW	rpc_inj_sel	0	1=Enable injector RAM write
[10:08]	RW	rpc_inj_wdata[18:16]	0	RPC injector write data MSBs, see adr C0 <a href="#">p56</a>
[13:11]	R	rpc_inj_rdata[18:16]	-	RPC injector read data MSBs, see adr C0 <a href="#">p56</a>
[14]	RW	rpc_tbins_test	0	Set write_data=address test mode
[15]	RW	--	0	Unassigned

Adr BE		ADR_RPC_INJ_ADR				RPC Injector RAM Addresses									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inj adr 7	inj adr 6	inj adr 5	inj adr 4	inj adr 3	inj adr 2	inj adr 1	inj adr 0	0	0	inj ren 1	inj ren 0	0	0	inj wen 1	inj wen 0

Bits	Dir	Signal	Default	Description
[01:00]	RW	rpc_inj_wen[1:0]	0	1=Write enable injector RAMn
[03:02]	RW	--	0	Unused
[05:04]	RW	rpc_inj_ren[1:0]	0	1=Read enable Injector RAMn
[15:06]	RW	inj_rwadr[9:0]	0	Injector RAM read/write address

Adr C0		ADR_RPC_INJ_WDATA				RPC Injector Write Data									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inj wdata 15	inj wdata 14	inj wdata 13	inj wdata 12	inj wdata 11	inj wdata 10	inj wdata 9	inj wdata 8	inj wdata 7	inj wdata 6	inj wdata 5	inj wdata 4	inj wdata 3	inj wdata 2	inj wdata 1	inj wdata 0

Bits	Dir	Signal	Default	Description
[15:00]	RW	rpc_inj_wdata[15:0]	0	RPC RAM write data LSBs (see Adr BC msbs <a href="#">p56</a> )

Adr C2		ADR_RPC_INJ_RDATA				RPC Injector Read Data									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
inj rdata 15	inj rdata 14	inj rdata 13	inj rdata 12	inj rdata 11	inj rdata 10	inj rdata 9	inj rdata 8	inj rdata 7	inj rdata 6	inj rdata 5	inj rdata 4	inj rdata 3	inj rdata 2	inj rdata 1	inj rdata 0

Bits	Dir	Signal	Default	Description
[15:00]	R	rpc_inj_rdata[15:0]	-	RPC RAM read data LSBs (see Adr BC msbs <a href="#">p56</a> )



Adr C4		ADR_RPC_TBINS				RPC FIFO Time Bins									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	rpc de coupl e	rpc pre 4	rpc pre 3	rpc pre 2	rpc pre 1	rpc pre 0	rpc tbins 4	rpc tbins 3	rpc tbins 2	rpc tbins 1	rpc tbins 0

Bits	Dir	Signal	Default	Description
[04:00]	RW	fifo_tbins_rpc[4:0]	7	Number RPC FIFO time bins to read out
[09:05]	RW	fifo_pretrig_rpc[4:0]	2	Number RPC FIFO time bins before pretrigger
[10]	RW	rpc_decouple	0	1=Independent rpc tbins, 0=copy cfeb tbins
[15:11]	RW	--	0	Unused

Adr C6		ADR_RPC0_HCM				RPC0 Hot Channel Mask									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
enabl e pad15	enabl e pad14	enabl e pad13	enabl e pad12	enabl e pad11	enabl e pad10	enabl e pad9	enabl e pad8	enabl e pad7	enabl e pad6	enabl e pad5	enabl e pad4	enabl e pad3	enabl e pad2	enabl e pad1	enabl e pad0

Bits	Dir	Signal	Default	Description
[15:00]	RW	rpc0_hcm[15:0]	FFFF	Bit(n)=1=Enable RPC Pad(n), FFFF=enable all

Adr C8		ADR_RPC1_HCM		RPC1 Hot Channel Mask	
Bits	Dir	Signal	Default	Description	
[15:00]	RW	rpc1_hcm[15:0]	FFFF	Bit(n)=1=Enable RPC Pad(n), FFFF=enable all	

Adr CA		ADR_BX0_DELAY				BX0 to MPC Delays									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	bx0 match	bx0 vpf test	alct bx0 enabl e	clct bx dly 3	clct bx dly 2	clct bx dly 1	clct bx dly 0	alct bx dly 3	alct bx dly 2	alct bx dly 1	alct bx dly 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	alct_bx0_delay[3:0]	0	ALCT bx0 delay to mpc transmitter
[07:04]	RW	clct_bx0_delay[3:0]	0	CLCT bx0 delay to mpc transmitter
[08]	RW	alct_bx0_enable	1	1=Enable using alct bx0, else copy clct bx0
[09]	RW	bx0_vpf_test	0	Sets clct_bx0=lct0_vpf for bx0 alignment tests
[10]	R	bx0_match	1	1=alct_bx0==clct_bx0, latched at clct_bx0
[15:11]	RW	--	-	Unused

Adr CC		ADR_NON_TRIG_RO				Non-Triggering Event Enables + ME1A/B Reversal									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
csc type 3	csc type 2	csc type 1	csc type 0	0	0	reverse me1b	reverse me1a	reverse csc	stagger csc	csc me1a b	cnt non me1a b	mpc me1a block	allow match ro	allow clct ro	allow alct ro

Bits	Dir	Signal	Default Type A	Description
[00]	RW	tmb_allow_alct_ro	0	1=Allow ALCT-only non-triggering readout
[01]	RW	tmb_allow_clct_ro	0	1=Allow CLCT-only non-triggering readout
[02]	RW	tmb_allow_match_ro	1	1=Allow ALCT*CLCT non-triggering readout
[03]	RW	mpc_me1a_block	1	Block ME1A LCTs from MPC, still queue for readout
[04]	RW	cnt_non_me1ab_en	1	Allow clct pretrig counters count non me1ab
[05]	R	csc_me1ab	0	1= CSC is ME1A or ME1B. 0=normal CSC
[06]	R	stagger_hs_csc	1	1=Staggered CSC, 0=non-staggered
[07]	R	reverse_hs_csc	0	1=Reversed staggered CSC, non-me1
[08]	R	reverse_hs_me1a	0	1=reversed me1a hstrips
[09]	R	reverse_hs_me1b	0	1=reversed me1b hstrips
[11:10]	RW	--	0	Free 2
[15:12]	R	csc_type[3:0]	A	Firmware compile type A=Normal CSC B=Reversed CSC C=Normal ME1B, Reversed ME1A D=Reversed ME1B, Normal ME1A

Firmware Compile Type Codes A,B,C,D:

CSC_type	stagger_hs_csc	reverse_hs_csc	reverse_hs_me1a	reverse_hs_me1b	csc_me1ab
A	1	0	0	0	0
B	0	1	0	0	0
C	0	0	1	0	1
D	0	0	0	1	1

Adr CE		ADR_SCP_TRIG				Scope Trigger Source Channel									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	ch6	ch5	ch4	ch3	ch2	ch1	ch0

Bits	Dir	Signal	Default	Description
[06:00]	RW	trigger_ch[6:0]	0	ch0=trigger on sequencer→ pretrig
[14:07]	RW	--	0	Unassigned
[15]	RW	scp_ch_overlay	0	0=normal ch assignments, 1=debug assignments

Adr D0		ADR_CNT_CTRL				Status Counter Control [See Adr D2 p62]									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cnt select 6	cnt select 5	cnt select 4	cnt select 3	cnt select 2	cnt select 1	cnt select 0	cnt adr lsb	hdr clr resync	cnt clr resync	en alct debug	seq cnt ovf	alct cnt ovf	stop on ovf	snap shot	clear all

Bits	Dir	Signal	Default	Description
[00]	RW	cnt_all_clear	-	Clear VME counters (also clr on ccb_evntres)
[01]	RW	cnt_snapshot	-	Take snapshot of current counter state
[02]	RW	cnt_stop_on_ovf	0	Stop all counters if any overflows
[03]	R	cnt_any_ovf_alct	-	At least 1 alct counter overflowed
[04]	R	cnt_any_ovf_seq	-	At least 1 sequencer counter overflowed
[05]	RW	cnt_alct_debug	1	1=enable alct_lct_err counter
[06]	RW	cnt_clear_on_resync	0	1=Clear VME counters on ttc_resync
[07]	RW	hdr_clear_on_resync	1	1=Clear header counters on ttc_resync
[08]	RW	cnt_adr_lsb	-	Counter half select, 0=bits[15:0], 1=bits[29:16]
[15:09]	RW	cnt_select[6:0]	-	Counter select address

### Counter Select Addresses (even cnt\_ad\_lsb=LSBs, odd cnt\_adr\_lsb=MSBs)

Address <sub>10</sub>	Counter Description	Bits	VME Clears
00	ALCT: alct0 vpf received	30	Y
01	ALCT: alct1 vpf received	30	Y
02	ALCT: alct data structure error	30	Y
03	ALCT: trigger path ECC 1-bit error corrected	30	Y
04	ALCT: trigger path ECC 2-bit error not corrected	30	Y
05	ALCT: trigger path ECC >2-bit error not corrected	30	Y
06	ALCT: trigger path ECC ≥2-bit error not corrected, ALCT data blanked	30	Y
07	ALCT: alct replied ECC 1-bit error corrected	30	Y
08	ALCT: alct replied ECC 2-bit error not corrected	30	Y
09	ALCT: alct replied ECC >2-bit error not corrected	30	Y
10	ALCT: raw hits readout	30	Y
11	ALCT: raw hits readout CRC error	30	Y
12		30	Y
13	CLCT: Pre-trigger was on any CFEB	30	Y
14	CLCT: Pre-trigger includes a CLCT on CFEB0	30	Y
15	CLCT: Pre-trigger includes a CLCT on CFEB1	30	Y
16	CLCT: Pre-trigger includes a CLCT on CFEB2	30	Y

17	CLCT: Pre-trigger includes a CLCT on CFEB3	30	Y
18	CLCT: Pre-trigger includes a CLCT on CFEB4	30	Y
19	CLCT: Pre-trigger includes a CLCT on CFEB5	30	Y
20	CLCT: Pre-trigger includes a CLCT on CFEB6	30	Y
21	CLCT: Pre-trigger was on ME1A cfeb4 only	30	Y
22	CLCT: Pre-trigger was on ME1B cfebs0-3 only	30	Y
23	CLCT: Pretrig discarded, no wrbuf available, buffer stalled	30	Y
24	CLCT: Pretrig discarded, no alct in window	30	
25	CLCT: CLCT discarded, clct0 had invalid pattern after drift	30	Y
26	CLCT: CLCT0 passed hit thresh but failed pid thresh after drift	30	Y
27	CLCT: CLCT1 passed hit thresh but failed pid thresh after drift	30	Y
28	CLCT: Bx pre-trigger machine waited for triads to dissipate before rearm	30	Y
29	CLCT: clct0 sent to TMB matching section	30	Y
30	CLCT: clct1 sent to TMB matching section	30	Y
31	TMB: TMB matching accepted a match, alct-only, or clct-only event	30	Y
32	TMB: CLCT*ALCT matched trigger	30	Y
33	TMB: ALCT-only trigger	30	Y
34	TMB: CLCT-only trigger	30	Y
35	TMB: TMB matching rejected event	30	Y
36	TMB: TMB matching rejected event, but queued for non-trigger readout	30	Y
37	TMB: TMB matching discarded an ALCT pair	30	Y
38	TMB: TMB matching discarded a CLCT pair	30	Y
39	TMB: TMB matching discarded CLCT0 from ME1A	30	Y
40	TMB: TMB matching discarded CLCT1 from ME1A	30	Y
41	TMB: Matching found no ALCT	30	Y
42	TMB: Matching found no CLCT	30	Y
43	TMB: Matching found One ALCT	30	Y
44	TMB: Matching found One CLCT	30	Y
45	TMB: Matching found Two ALCTs	30	Y
46	TMB: Matching found Two CLCTs	30	Y
47	TMB: ALCT0 copied into ALCT1 to make 2 <sup>nd</sup> LCT	30	Y
48	TMB: CLCT0 copied into CLCT1 to make 2 <sup>nd</sup> LCT	30	Y
49	TMB: LCT1 has higher quality than LCT0, error	30	Y
50	TMB: Transmitted LCT0 to MPC	30	Y
51	TMB: Transmitted LCT1 to MPC	30	Y
52	TMB: MPC accepted LCT0	30	Y
53	TMB: MPC accepted LCT1	30	Y
54	TMB: MPC rejected both LCT0 & LCT1	30	Y
55	L1A: L1A received	30	Y
56	L1A: L1A received, TMB in L1A window	30	Y
57	L1A: L1A received, no TMB in window	30	Y
58	L1A: TMB triggered, no L1A in window	30	Y

59	L1A: TMB readouts completed	30	Y
60	L1A: TMB readouts lost by 1-event-per-L1A limit	30	Y
61	STAT: CLCT Triads skipped	30	Y
62	STAT: Raw hits buffer had to be reset due to ovf, error	30	Y
63	STAT: TTC Resyncs received	30	Y
64	STAT: Sync error, bxn!=offset at bx0 arrival or no bx0 at bxn==offset	30	Y
65	STAT: Parity error in CFEB or RPC raw hits RAM, possible SEU	30	Y
	Event counters that follow are in the TMB header: They are cleared via TTC commands, such as event counter reset, and are not via direct VME command to Adr D0.		
66	HDR: Pre-trigger counter	30	N
67	HDR: CLCT counter	30	N
68	HDR: TMB trigger counter	30	N
69	HDR: ALCTs received counter	30	N
70	HDR: L1As received from ccb counter, 12 bits	12	N
71	HDR: Readout counter, 12 bits	12	N
72	HDR: Orbit counter	30	N
73	ALCT: Structure error, Expected alct0[10:1]=0 when alct0_vpf=0	8	Y
74	ALCT: Structure error, Expected alct1[10:1]=0 when alct1_vpf=0	8	Y
75	ALCT: Structure error, Expected alct0_vpf=1 when alct1_vpf=1	8	Y
76	ALCT: Structure error, Expected alct0[10:1]>0 when alct0_vpf=1	8	Y
77	ALCT: Structure error, Expected alct1[10:1]>0 when alct1_vpf=1	8	Y
78	ALCT: Structure error, Expected alct1!=alct0 when alct0_vpf=1	8	Y
79	CCB: TTCrx lock lost	8	Y
80	CCB: qPLL lock lost	8	Y
81	GTX: Optical receiver error gtx_rx_err_count0	16	N
82	GTX: Optical receiver error gtx_rx_err_count1	16	N
83	GTX: Optical receiver error gtx_rx_err_count2	16	N
84	GTX: Optical receiver error gtx_rx_err_count3	16	N
85	GTX: Optical receiver error gtx_rx_err_count4	16	N
86	GTX: Optical receiver error gtx_rx_err_count5	16	N
87	GTX: Optical receiver error gtx_rx_err_count6	16	N

**Adr D2                      ADR\_CNT\_RDATA                      Status Counter Data [See Adr D0 [p59](#)]**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata	rdata
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bits	Dir	Signal	Default	Description
[15:00]	R	cnt_rdata[15:0]	-	Data for selected counter (see adr D0 <a href="#">p59</a> )

**Adr D4                      ADR\_JTAGSM0                      JTAG State Machine Control (reads JTAG PROM)**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
throt	throt	throt	throt	dis	jsm	jsm	vme	jsm	jsm	jsm	jsm	jsm	jsmsel	jsm	jsm
3	2	1	0		jtag	ok	ready	tck	wdcnt	cksum	abort	busy	/	reset	start
					oe			ok	ok	ok			vsm		
													jtag		
													auto		

Bits	Dir	Signal	Typical	Description
[00]	RW	jsm_start	0	Manual cycle start command
[01]	RW	jsm_sreset	0	Status signal reset
[02]	RW	jsm_sel	0	1=select new JTAG format, 0=select old format
[03]	R	jsm_busy	0	State machine busy writing
[04]	R	jsm_aborted	0	State machine aborted reading PROM
[05]	R	jsm_cksum_ok	1	Check-sum matches PROM contents
[06]	R	jsm_wdcnt_ok	1	Word count matches PROM contents
[07]	R	jsm_tck_fpga_ok	1	FPGA jtag tck detected
[08]	R	vme_ready	1	TMB VME registers done loading from PROM
[09]	R	jsm_ok	1	JTAG state machine completed without errors
[10]	R	jsm_jtag_oe	0	Enable jtag drivers else tri-state
[11]	RW	wr_usr_jtag_dis	0	1=disable write access to ADR_USR_JTAG adr10
[15:12]	RW	jsm_throttle[3:0]	0	JTAGspeed, 0=fastest,20MHz read,10MHz TCK

**Adr D6                      ADR\_JTAGSM1                      JTAG State Machine Word Count**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt	wdcnt
15	14	13	12	11	10	9	98	7	6	5	4	3	2	1	0

Bits	Dir	Signal	Typical	Description
[15:00]	R	jsm_wdcnt[15:0];	-	JTAG PROM word-count bits [15:0]

Adr D8		ADR_JTAGSM2				JTAG State Machine Checksum									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
chain ok	header ok	end ok	tck cnt OK	tck cnt 3	tck cnt 2	tck cnt 1	tck cnt 0	cksum 7	cksum 6	cksum 5	cksum 4	cksum 3	cksum 2	cksum 1	cksum 0

Bits	Dir	Signal	Typical	Description
[07:00]	R	jsm_cksum[7:0];	-	jtag state machine checksum
[11:08]	R	tck_fpga_cnt[3:0]	-	fpga jtag chain tck counter
[12]	R	jsm_tckcnt_ok	1	Total TCKs sent matches PROM trailer tck_cnt
[13]	R	jsm_end_ok	1	jtag PROM end marker detected
[14]	R	jsm_header_ok	1	jtag PROM header marker detected
[15]	R	jsm_chain_ok	1	jtag PROM chain marker detected

Adr DA		ADR_VMEM0				VME State Machine Control (reads VME PROM)									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
throt 3	throt 2	throt 1	throt 0	vsm phaser auto	vsm path ok	vsm ok	vme ready	vsm jtag auto	vsm wdcnt ok	vsm cksum ok	vsm abort	vsm busy	vsm auto start	vsm sreset	vsm start

Bits	Dir	Signal	Typical	Description
[00]	RW	vsm_start	0	Manual cycle start command
[01]	RW	vsm_sreset	0	Status signal reset
[02]	R	vsm_autostart	1	Auto-start after hard-reset
[03]	R	vsm_busy	0	State machine busy writing
[04]	R	vsm_aborted	0	State machine aborted reading PROM
[05]	R	vsm_cksum_ok	1	Check-sum matches PROM contents
[06]	R	vsm_wdcnt_ok	1	Word count matches PROM contents
[07]	RW*	vsm_jtag_auto	1	JTAG SM autostart after vmesm completes
[08]	R	vme_ready	1	TMB VME registers done loading from PROM
[09]	R	vsm_ok	1	State machine completed without errors
[10]	R	vsm_path_ok	1	State machine wrote 55AAh to ADR_VMESM4
[11]	RW	vsm_phaser_auto	1	Digital phase shifter autostart after vmesm done
[15:12]	RW	vsm_throttle[3:0]	0	VME PROM-read speed control, 0=fastest

\* vsm\_jtag\_auto should be set to 0 to enable U76 testing, otherwise jtagism will run, and erase U76 data.

Adr DC		ADR_VMESM1				VME State Machine Word Count									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
wdcnt 15	wdcnt 14	wdcnt 13	wdcnt 12	wdcnt 11	wdcnt 10	wdcnt 9	wdcnt 98	wdcnt 7	wdcnt 6	wdcnt 5	wdcnt 4	wdcnt 3	wdcnt 2	wdcnt 1	wdcnt 0

Bits	Dir	Signal	Typical	Description
[15:00]	R	vsm_wdcnt[15:0];	-	VME PROM word-count bits [15:0]

Adr DE		ADR_VMESM2				VME State Machine Checksum									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	jtag vec 1	jtag vec 0	fmt err 4	fmt err 3	fmt err 2	fmt err 1	fmt err 0	cksum 7	cksum 6	cksum 5	cksum 4	cksum 3	cksum 2	cksum 1	cksum 0

Bits	Dir	Signal	Typical	Description
[07:00]	R	vsm_cksum[7:0];	-	VME state machine checksum
[08]	R	vsm_fmt_err[0]	0	Missing BC header-begin marker
[09]	R	vsm_fmt_err[1]	0	Missing EC header-end marker
[10]	R	vsm_fmt_err[2]	0	Missing FC data-end marker
[11]	R	vsm_fmt_err[3]	0	Missing FF prom-end marker
[12]	R	vsm_fmt_err[4]	0	Word counter overflow
[14:13]	R	jtag_sm_vec[1:0]	0	JSM JTAG signal State Machine vector
[15]	R	--	-	unassigned

Adr E0		ADR_VMESM3				Number of VME Addresses Written by VMESM									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	forma t sm 2	forma t sm 1	forma t sm 0	prom sm 3	prom sm 2	prom sm 1	prom sm 0	nvme writes 7	nvme writes 6	nvme writes 5	nvme writes 4	nvme writes 3	nvme writes 2	nvme writes 1	nvme writes 0

Bits	Dir	Signal	Typical	Description
[07:00]	R	vsm_nvme_writes[7:0]	-	Number of vme addresses written
[11:8]	R	jsm_prom_sm_vec[3:0]	-	JSM PROM State Machine state vector
[14:12]	R	jsm_format_sm_vec[2:0]	-	JSM Data Format Machine state vector
[15]	R	--	0	unassigned

Adr E2		ADR_VMESM4				VME State Machine Write-Data Check									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
data 15	data 14	data 13	data 12	data 11	data 10	data 9	data 8	data 7	data 6	data 5	data 4	data 3	data 2	data 1	data 0

Bits	Dir	Signal	Typical	Description
[15:00]	R	vmes4_rd[15:0]	55AAh	vsm_path_ok=1 if vsm writes 55aa to this adr



**Adr E4                      ADR\_DDDSM                      RAT 3D3444 State Machine Control**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
verify dly1	verify dly0	rx phase	link tmb	oe 3	oe 2	oe 1	oe 0	verify ok	sm busy	auto start	serial from	serial to	adr latch	dddr clock	dddr start

Bits	Dir	Signal	Default	Description
[00]	RW	dddr_start_vme	0	Start DDDR State Machine
[01]	RW	dddr_clock	0	DDDR manual-mode clock
[02]	RW	dddr_adr_latch	1	DDDR manual-mode address latch, active low
[03]	RW	dddr_serial_in	0	Serial data to DDDR chip
[04]	R	dddr_serial_out	0	Serial data from DDDR chip
[05]	RW	dddr_auto_start	1	DDDR State Machine autostart state
[06]	R	dddr_busy	0	DDDR State Machine busy
[07]	R	dddr_verify_ok	1	DDDR data read back verified OK
[11:08]	RW	dddr_oe[3:0]	0011 <sub>2</sub>	3D3444 output enables, 1=enable
[12]	RW	dddr_linktmb	1	1=start RAT machine when starting TMB machine
[13]	RW	dddr_rxphase	1	1=use negative clock edge to latch verify data, 0=posedge
[15:14]	RW	dddr_verify_dly[1:0]	3	Delay before latching verify data

**Adr E6                      ADR\_DDDR0                      RAT 3D3444 RPC Delays, 1 step = 2ns**

Bits	Dir	Signal	Default	Description
[03:00]	RW	delay_ch0[3:0]	3	RPC0 rx clock
[07:04]	RW	delay_ch1[3:0]	3	RPC1 rx clock
[11:08]	RW	delay_ch2[3:0]	0	RAT2 rx clock, not used
[15:12]	RW	delay_ch3[3:0]	0	RAT2 rx clock, not used

**Adr E8                      ADR\_UPTIME                      Uptime Counter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	up time 14	up time 13	up time 12	up time 11	up time 10	up time 9	up time 8	up time 7	up time 6	up time 5	up time 4	up time 3	up time 2	up time 1	up time 0

Bits	Dir	Signal	Typical	Description
[04:00]	R	uptime[14:0]	-	Seconds since last hard-reset
[15]	R	--	0	unassigned

Adr EA		ADR_BDSTATUS				Board Status Summary (copy of raw-hits header)									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
status 15	status 14	status 13	status 12	status 11	status 10	status 9	status 8	status 7	status 6	status 5	status 4	status 3	status 2	status 1	status 0

Bits	Dir	Signal	Typical	Description
[00]	R	bdstatus_ok	1	Voltages OK, temperature OK, prom-load OK
[01]	R	vstat_5p0V	1	Voltage Comparator +5.0V, 1=OK
[02]	R	vstat_3p3v	1	Voltage Comparator +3.3V, 1=OK
[03]	R	vstat_1p8v	1	Voltage Comparator +1.8V, 1=OK
[04]	R	vstat_1p5v	1	Voltage Comparator +1.5V, 1=OK
[05]	R	/t_crit	1	Temperature ADC Tcritical, 1=OK
[06]	R	vsm_ok	1	VME Machine ran without errors
[07]	R	vsm_aborted	0	VME State machine aborted reading PROM
[08]	R	vsm_cksum_ok	1	VME Check-sum matches PROM contents
[09]	R	vsm_wdcnt_ok	1	VME Word count matches PROM contents
[10]	R	jsm_ok	1	JTAG State machine completed without errors
[11]	R	jsm_aborted	0	JTAG State machine aborted reading PROM
[12]	R	jsm_cksum_ok	1	JTAG Check-sum matches PROM contents
[13]	R	jsm_wdcnt_ok	1	JTAG Word count matches PROM contents
[14]	R	jsm_tck_fpga_ok	1	JTAG tck loopback detected on chain adr C
[15]	R	jsm_tckcnt_ok	1	JTAG state machine TCK count matches PROM

Adr EC		ADR_BXN_CLCT				CLCT BXN At CLCT-Pretrigger									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	clct bxn 11	clct bxn 10	clct bxn 9	clct bxn 8	clct bxn 7	clct bxn 6	clct bxn 5	clct bxn 4	clct bxn 3	clct bxn 2	clct bxn 1	clct bxn 0

Bits	Dir	Signal	Typical	Description
[11:00]	R	bxn_clct_vme[11:0]	-	CLCT BXN latched at last CLCT pretrigger
[15:12]	R	--	0	unassigned

Adr EE		ADR_BXN_ALCT				ALCT BXN At ALCT-Valid-Pattern-Flag									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	alct bxn 4	alct bxn 3	alct bxn 2	alct bxn 1	alct bxn 0

Bits	Dir	Signal	Typical	Description
[4:00]	R	bxn_alct_vme[4:0]	-	ALCT BXN latched at last ALCT vpfi
[15:5]	R	--	0	unassigned

Adr F0		ADR_LAYER_TRIG				Layer-Trigger Mode									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
clct throt 7	clct throt 6	clct throt 5	clct throt 4	clct throt 3	clct throt 2	clct throt 1	clct throt 0	0	nlayrs hit 2	nlayrs hit 1	nlayrs hit 0	layer thresh 2	layer thresh 1	layer thresh 0	layer trig en

Bits	Dir	Signal	Typical	Description
[00]	RW	layer_trigger_en	0	1=Enable layer trigger mode(see adr 68 <a href="#">p40</a> )
[03:01]	RW	lyr_thresh_pretrig[2:0]	4	layer-trigger threshold
[06:04]	R	nlayers_hit_vme[2:0]	--	number layers hit on last layer-trigger
[07]	RW	--	--	Unassigned
[15:08]	RW	clct_throttle[7:0]	0	CLCT Pre-trigger rate throttle

Adr F2		ADR_ISE_VERSION				ISE Version									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ver 7	ver 6	ver 5	ver 4	ver 3	ver 2	ver 1	ver 0	minor 3	minor 2	minor 1	minor 0	spack 3	spack 2	spack 1	spack 0

Bits	Dir	Signal	Typical	Description
[03:00]	R	ise_version[3:0]	03h	ISE Service Pack
[07:04]	R	ise_version[7:4]	01h	ISE Minor Version
[15:08]	R	ise_version[15:8]	10h	ISE Major Version

Adr F4		ADR_TEMPO				Pattern Finder Pre-Trigger									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
adj cfcb dist 5	adj cfcb dist 4	adj cfcb dist 3	adj cfcb dist 2	adj cfcb dist 1	adj cfcb dist 0	pid thresh post 3	pid thresh post 2	pid thresh post 1	pid thresh post 0	pid thresh pretri g 3	pid thresh pretri g 2	pid thresh pretri g 1	pid thresh pretri g 0	0	clct blank

Bits	Dir	Signal	Typical	Description
[00]	RW	clct_blanking	1	1=blank non-vpf clct output [requires alct-only or l1a-notmb mode enabled to change this to 0]
[01]	RW	--	0	Unassigned
[05:02]	RW	pid_thresh_pretrig[3:0]	0	Minimum pattern ID 0x0-0xA for pre-trigger
[09:06]	RW	pid_thresh_postdrift[3:0]	0	Minimum pattern ID 0x0-0xA after drift delay
[15:10]	RW	adjcfcb_dist[5:0]	5	Distance from key on CFEBn to CFEBn+1 to set active feb flag on CFEBn+1 for DMB Setting to 5 enables hs0,1,2,3,4 and hs31,30,29,28,27.

Adr F6		ADR_TEMP1				CLCT Separation									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
clct sep 7	clct sep 6	clct sep 5	clct sep 4	clct sep 3	clct sep 2	clct sep 1	clct sep 0	0	clct sep ram sel_ab	clct sep ram adr 3	clct sep ram adr 2	clct sep ram adr 1	clct sep ram adr 0	clct sep ram we	clct sep src

Bits	Dir	Signal	Typical	Description
[00]	RW	clct_sep_src	1	CLCT separation source 1=vme, 0=ram
[01]	RW	clct_sep_ram_we	0	1=enable CLCT separation ram for writing
[05:02]	RW	clct_sep_ram_adr[3:0]	0	CLCT separation RAM rw address 0-F
[06]	RW	clct_sep_ram_sel_ab	0	1=read me1a RAM, 0=me1b RAM or std RAM
[07]	RW	--	--	Unassigned
[15:08]	RW	clct_sep_vme[7:0]	10	Minimum CLCT separation in key ½-strips

Adr F8		ADR_TEMP2				CLCT Separation RAM Data									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
pspan 7	pspan 6	pspan 5	pspan 4	pspan 3	pspan 2	pspan 1	pspan 0	nspan 7	nspan 6	nspan 5	nspan 4	nspan 3	nspan 2	nspan 1	nspan 0

Bits	Dir	Signal	Typical	Description
[07:00]	RW/R	clct_sep_ram_wr[7:0]	10	nspan CLCT separation RAM data, blanks keys from 1 <sup>st</sup> key to keys>=key-nspan
[15:08]	RW/R	clct_sep_ram_wr[15:8]	10	pspan CLCT separation RAM data, blanks keys from 1 <sup>st</sup> key to keys<=key+pspan

Adr FA		ADR_PARITY				SEU Parity Errors									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
perr mux 5	perr mux 4	perr mux 3	perr mux 2	perr mux 1	perr mux 0	0	0	perr reset	perr ff	perr	perr en	perr adr 3	perr adr 2	perr adr 1	perr adr 0

Bits	Dir	Signal	Typical	Description
[03:00]	RW	perr_adr[3:0]	0	Parity data bank select address
[4]	R	perr_en	1	Parity error latch enabled
[5]	R	perr	0	Parity error summary
[6]	R	perr_ff	0	Parity error summary, latched
[7]	RW	perr_reset	0	Parity error reset
[9:8]	RW	--	0	Unassigned
[15:10]	R	parity_rd_mux[5:0]	0	Parity data multiplexer, selected by perr_adr[]

```

adr 0: parity_rd_mux <= perr_ram_ff[ 5: 0]; // R cfeb0 rams
adr 1: parity_rd_mux <= perr_ram_ff[11: 6]; // R cfeb1 rams
adr 2: parity_rd_mux <= perr_ram_ff[17:12]; // R cfeb2 rams
adr 3: parity_rd_mux <= perr_ram_ff[23:18]; // R cfeb3 rams
adr 4: parity_rd_mux <= perr_ram_ff[29:24]; // R cfeb4 rams
adr 5: parity_rd_mux <= perr_ram_ff[35:30]; // R cfeb5 rams
adr 6: parity_rd_mux <= perr_ram_ff[41:36]; // R cfeb6 rams
adr 7: parity_rd_mux <= {1'b0,perr_ram_ff[46:42]}; // R rpc rams
adr 8: parity_rd_mux <= {4'h0,perr_ram_ff[48:47]}; // R mini rams
adr 9: parity_rd_mux <= {1'b0,perr_cfeb[6:0]}; // R cfeb parity errors
adr 10: parity_rd_mux <= {1'b0,perr_cfeb_ff[6:0]}; // R cfeb parity errors,latched
adr 11: parity_rd_mux <= {4'h0,perr_rpc_ff,perr_rpc}; // R rpc parity errors,latched
adr12: parity_rd_mux <= {4'h0,perr_mini_ff, perr_mini}; // R mini parity errors,latched

```

Adr FC    **ADR\_CCB\_STAT1**                      CCB Status Register Continued from Adr 2E

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bits	Dir	Signal	Typical	Description
[00]	R	ccb_ttcx_lock_never	0	TTCrx lock never achieved
[01]	R	ccb_ttcx_lost_ever	0	TTCrx lock was lost at least once
[02]	R	ccb_qpll_lock_never	0	QPLL lock never achieved
[03]	R	ccb_qpll_lost_ever	0	QPLL lock was lost at least once
[15:04]	R	--	0	Unassigned

**Adr FE                      ADR\_BXN\_L1A                      CLCT BXN at L1A Arrival**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	l1a bxn 11	l1a bxn 10	l1a bxn 9	l1a bxn 8	l1a bxn 7	l1a bxn 6	l1a bxn 5	l1a bxn 4	l1a bxn 3	l1a bxn 2	l1a bxn 1	l1a bxn 0

Bits	Dir	Signal	Typical	Description
[11:00]	R	bxn_l1a_vme[11:0]	-	CLCT BXN latched at last L1A arrival
[15:12]	R	--	0	unassigned

**Adr 100                      ADR\_L1A\_LOOKBACK                      L1A Lookback Distance**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
l1a win pri en	inj rdata 17	inj rdata 16	inj wdata 17	inj wdata 16	l1a look back 10	l1a look back 9	l1a look back 8	l1a look back 7	l1a look back 6	l1a look back 5	l1a look back 4	l1a look back 3	l1a look back 2	l1a look back 1	l1a look back 0

Bits	Dir	Signal	Typical	Description
[10:00]	RW	l1a_lookback[10:0]	128	bx to look back from L1As wr_buf_adr for L1A-only readouts
[12:11]	RW	inj_wdata[17:16]	0	Injector RAM write data MSBs
[14:13]	R	inj_rdata[17:16]	0	Injector RAM read data MSBs
[15]	RW	l1a_win_pri_en	1	1=Limit TMB to 1 event readout per L1A

**Adr 102                      ADR\_SEQ\_DEBUG                      Sequencer Debug Signals**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	l1a bxn 11	l1a bxn 10	l1a bxn 9	l1a bxn 8	l1a bxn 7	l1a bxn 6	l1a bxn 5	l1a bxn 4	l1a bxn 3	l1a bxn 2	l1a bxn 1	l1a bxn 0

Bits	Dir	Signal	Typical	Description
[03:00]	RW	seqdeb_adr[3:0]	-	Sequencer signal address 0-15
[15:04]	R	seqdeb_rd_mux[11:0]	-	Multiplexed sequencer data for debugging

adr 0: deb_wr_buf_adr[10:0]	Buffer write address at last pretrig
adr 1: deb_buf_push_adr[10:0]	Queue push address at last push
adr 2: deb_buf_pop_adr[10:0]	Queue pop address at last pop
adr 3: deb_buf_push_data[11:0]	Queue push data at last push
adr 4: deb_buf_push_data[23:12]	+Queue push data at last push
adr 5: deb_buf_push_data[31:24]	+Queue push data at last push
adr 6: deb_buf_pop_data[11:0]	Queue pop data at last pop
adr 7: deb_buf_pop_data[23:12]	+Queue pop data at last pop
adr 8: deb_buf_pop_data[31:24]	+Queue pop data at last pop

Adr 104		ADR_ALCT_SYNC_CTRL				ALCT Sync Mode Control									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sync pre 3	sync pre 2	sync pre 1	sync pre 0	0	0	sync 2 <sup>nd</sup> err ff	sync 1 <sup>st</sup> err ff	sync 2 <sup>nd</sup> err	sync 1 <sup>st</sup> err	sync clr	sync rand	sync dly 3	sync dly 2	sync dly 1	sync dly 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	alct_sync_rxdata_dly [3:0]	0	Sync mode delay pointer to valid data
[04]	RW	alct_sync_tx_random	0	Sync mode tmb transmits random data to alct
[05]	RW	alct_sync_clr_err	0	ALCT sync mode clear rng error FFs
[06]	R	alct_sync_1 <sup>st</sup> _err	0	1 <sup>st</sup> -in-time match ok, alct-to-tmb
[07]	R	alct_sync_2 <sup>nd</sup> _err	0	2 <sup>nd</sup> -in-time match ok, alct-to-tmb
[08]	R	alct_sync_1 <sup>st</sup> _err_ff	0	1 <sup>st</sup> -in-time match ok, alct-to-tmb, latched
[09]	R	alct_sync_2 <sup>nd</sup> _err_ff	0	2 <sup>nd</sup> -in-time match ok, alct-to-tmb, latched
[11:10]	RW	--	0	Unassigned
[15:12]	RW	alct_sync_rxdata_pre[3:0]	9	Sync mode pre-delay pointer to valid data

Adr 106		ADR_ALCT_SYNC_TXDATA_1 <sup>ST</sup>				ALCT Sync Mode Transmit Data 1 <sup>st</sup>									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	sync 1 <sup>st</sup> 9	sync 1 <sup>st</sup> 8	sync 1 <sup>st</sup> 7	sync 1 <sup>st</sup> 6	sync 1 <sup>st</sup> 5	sync 1 <sup>st</sup> 4	sync 1 <sup>st</sup> 3	sync 1 <sup>st</sup> 2	sync 1 <sup>st</sup> 1	sync 1 <sup>st</sup> 0

Bits	Dir	Signal	Typical	Description
[09:00]	RW	alct_sync_txdata_1 <sup>st</sup> [9:0]	-	Sync mode data to send for loopback 1 <sup>st</sup> in time
[15:10]	RW	--	0	Unassigned

Adr 108		ADR_ALCT_SYNC_TXDATA_2 <sup>ND</sup>				ALCT Sync Mode Transmit Data 2 <sup>nd</sup>									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	sync 2 <sup>nd</sup> 9	sync 2 <sup>nd</sup> 8	sync 2 <sup>nd</sup> 7	sync 2 <sup>nd</sup> 6	sync 2 <sup>nd</sup> 5	sync 2 <sup>nd</sup> 4	sync 2 <sup>nd</sup> 3	sync 2 <sup>nd</sup> 2	sync 2 <sup>nd</sup> 1	sync 2 <sup>nd</sup> 0

Bits	Dir	Signal	Typical	Description
[09:00]	RW	alct_sync_txdata_1 <sup>st</sup> [9:0]	-	Sync mode data to send for loopback 1 <sup>st</sup> in time
[15:10]	RW	--	0	Unassigned

Adr 10A		ADR_SEQ_OFFSET1				Sequencer Counter Offsets Continued [from Adr076]									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	bxn offset 11	bxn offset 10	bxn offset 9	bxn offset 8	bxn offset 7	bxn offset 6	bxn offset 5	bxn offset 4	bxn offset 3	bxn offset 2	bxn offset 1	bxn offset 0

Bits	Dir	Signal	Typical	Description
[11:00]	RW	bxn_offset_l1a[11:0]	-	L1A bxn offset preset value
[15:12]	RW	--	0	Unassigned

**Adr 10C                      ADR\_MINISCOPE                      Internal 16 Channel Digital Miniscope**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	tbins pretri g 4	tbins pretri g 3	tbins pretri g 2	tbins pretri g 1	tbins pretri g 0	tbins 4	tbins 3	tbins 2	tbins 1	tbins 0	tbins word ninsert	tbins test mode	read enabl e

Bits	Dir	Signal	Default	Description
[00]	RW	mini_read_enable	1	Enable Miniscope readout to DMB
[01]	RW	mini_tbins_test	0	Miniscope data=write_address, for testing
[02]	RW	mini_tbins_word	1	Insert tbins and pretrig tbins in 1 <sup>st</sup> word
[07:03]	RW	fifo_tbins_mini[4:0]	22	Number Mini FIFO time bins to read out, must multiple of 2 but not of 4
[12:08]	RW	fifo_pretrig_mini[4:0]	4	Number Mini FIFO time bins before pre-trigger
[15:13]	RW	--	0	Unassigned

**Adr 10E                      ADR\_PHASER0                      ALCT rxd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
alct rxd delay 7	alct rxd delay 6	alct rxd delay 5	alct rxd delay 4	alct rxd delay 3	alct rxd delay 2	alct rxd delay 1	alct rxd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_alct_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_alct_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_alct_rxd	0	Phase shifter busy
[03]	R	lock_alct_rxd	1	DCM lock status
[06:04]	R	phaser_sm_alct_rxd[2:0]	0	Phase shifter machine state vector
[07]	RW	alct_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	alct_rxd_delay[7:0]	32	Phase delay to latch data received from ALCT approximately 0.1ns steps (clock period/256)

**Adr 110                      ADR\_PHASER1                      ALCT txd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
alct txd delay 7	alct txd delay 6	alct txd delay 5	alct txd delay 4	alct txd delay 3	alct txd delay 2	alct txd delay 1	alct txd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_alct_txd	0	Set new phase, software sets then unsets
[01]	RW	reset_alct_txd	0	Reset current phase to 32
[02]	R	phaser_busy_alct_txd	0	Phase shifter busy
[03]	R	lock_alct_txd	1	DCM lock status
[06:04]	R	phaser_sm_alct_txd[2:0]	0	Phase shifter machine state vector
[07]	RW	alct_txd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	alct_txd_delay[7:0]	32	Phase delay for data transmitted to ALCT approximately 0.1ns steps (clock period/256)

**Adr 112      ADR\_PHASER2      CFEB0 rxd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfeb rxd delay 7	cfeb rxd delay 6	cfeb rxd delay 5	cfeb rxd delay 4	cfeb rxd delay 3	cfeb rxd delay 2	cfeb rxd delay 1	cfeb rxd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_cfeb0_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_cfeb0_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_cfeb0_rxd	0	Phase shifter busy
[03]	R	lock_cfeb0_rxd	1	DCM lock status
[06:04]	R	phaser_sm_cfeb0_rxd[2:0]	0	Phase shifter machine state vector
[07]	RW	cfeb0_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfeb0_rxd_delay[7:0]	32	Phase delay to latch data received from CFEB approximately 0.1ns steps (clock period/256)

**Adr 114      ADR\_PHASER3      CFEB1 rxd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfeb rxd delay 7	cfeb rxd delay 6	cfeb rxd delay 5	cfeb rxd delay 4	cfeb rxd delay 3	cfeb rxd delay 2	cfeb rxd delay 1	cfeb rxd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_cfeb1_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_cfeb1_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_cfeb1_rxd	0	Phase shifter busy
[03]	R	lock_cfeb1_rxd	1	DCM lock status
[06:04]	R	phaser_sm_cfeb1_rxd[2:0]	0	Phase shifter machine state vector
[07]	RW	cfeb1_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfeb1_rxd_delay[7:0]	32	Phase delay to latch data received from CFEB approximately 0.1ns steps (clock period/256)



**Adr 116      ADR\_PHASER4      CFEB2 rxd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfeb rxd delay 7	cfeb rxd delay 6	cfeb rxd delay 5	cfeb rxd delay 4	cfeb rxd delay 3	cfeb rxd delay 2	cfeb rxd delay 1	cfeb rxd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_cfeb2_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_cfeb2_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_cfeb2_rxd	0	Phase shifter busy
[03]	R	lock_cfeb2_rxd	1	DCM lock status
[06:04]	R	phaser_sm_cfeb2_rxd[2:0]	0	Phase shifter machine state vector
[07]	RW	cfeb2_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfeb2_rxd_delay[7:0]	32	Phase delay to latch data received from CFEB approximately 0.1ns steps (clock period/256)

**Adr 118      ADR\_PHASER5      CFEB3 rxd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfeb rxd delay 7	cfeb rxd delay 6	cfeb rxd delay 5	cfeb rxd delay 4	cfeb rxd delay 3	cfeb rxd delay 2	cfeb rxd delay 1	cfeb rxd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_cfeb3_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_cfeb3_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_cfeb3_rxd	0	Phase shifter busy
[03]	R	lock_cfeb3_rxd	1	DCM lock status
[06:04]	R	phaser_sm_cfeb3_rxd[2:0]	0	Phase shifter machine state
[07]	RW	cfeb3_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfeb3_rxd_delay[7:0]	32	Phase delay to latch data received from CFEB approximately 0.1ns steps (clock period/256)

**Adr 11A      ADR\_PHASER6      CFEB4 rxd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfb4 rxd delay 7	cfb4 rxd delay 6	cfb4 rxd delay 5	cfb4 rxd delay 4	cfb4 rxd delay 3	cfb4 rxd delay 2	cfb4 rxd delay 1	cfb4 rxd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_cfeb4_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_cfeb4_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_cfeb4_rxd	0	Phase shifter busy
[03]	R	lock_cfeb4_rxd	1	DCM lock status
[06:04]	R	phaser_sm_cfeb4_rxd[2:0]	0	Phase shifter machine state vector
[07]	RW	cfb4_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfb4_rxd_delay[7:0]	32	Phase delay to latch data received from CFEB approximately 0.1ns steps (clock period/256)

**Adr 11C      ADR\_DELAY0\_INT      CFEB DDR RxD Interstage Delays**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfb3 delay 3	cfb3 delay 2	cfb3 delay 1	cfb3 delay 0	cfb2 delay 3	cfb2 delay 2	cfb2 delay 1	cfb2 delay 0	cfb1 delay 3	cfb1 delay 2	cfb1 delay 1	cfb1 delay 0	cfb0 delay 3	cfb0 delay 2	cfb0 delay 1	cfb0 delay 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	cfb0_rxd_int_delay[3:0]	0	Delay data received from CFEB0 by integer bx
[07:04]	RW	cfb1_rxd_int_delay [3:0]	0	Delay data received from CFEB1 by integer bx
[11:08]	RW	cfb2_rxd_int_delay [3:0]	0	Delay data received from CFEB2 by integer bx
[15:12]	RW	cfb3_rxd_int_delay [3:0]	0	Delay data received from CFEB3 by integer bx

**Adr 11E      ADR\_DELAY1\_INT      CFEB DDR RxD Interstage Delays Continued**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	cfb6 delay 3	cfb6 delay 2	cfb6 delay 1	cfb6 delay 0	cfb5 delay 3	cfb5 delay 2	cfb5 delay 1	cfb5 delay 0	cfb4 delay 3	cfb4 delay 2	cfb4 delay 1	cfb4 delay 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	cfb4_rxd_int_delay 3:0]	0	Delay data received from CFEB4 by integer bx
[07:04]	RW	cfb5_rxd_int_delay 3:0]	0	Delay data received from CFEB5 by integer bx
[11:08]	RW	cfb6_rxd_int_delay 3:0]	0	Delay data received from CFEB6 by integer bx
[15:12]	RW	--	0	Unassigned

**Adr 120****ADR\_SYNC\_ERR\_CTRL****Synchronization Error Control**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
sync err forced	clock lock err	bx0 match err	alct ecc tx err	alct ecc rx err	clct bx0 err	sync err	err stops L1As	err stops pretri g	err blanks LCTs	clock lock lost en	bx0 match en	alct tx ecc en	alct rx ecc en	clct bx0 en	sync err reset

Bits	Dir	Signal	Default	Description
[00]	RW	sync_err_reset	0	VME sync error reset
Sync error source enables:				
[01]	RW	clct_bx0_sync_err_en	1	TMB clock pulse count err: bxn!=0+offset at ttc_bx0 arrival
[02]	RW	alct_ecc_rx_err_en	0	ALCT uncorrected ECC error in data ALCT received from TMB
[03]	RW	alct_ecc_tx_err_en	0	ALCT uncorrected ECC error in data ALCT transmitted to TMB
[04]	RW	bx0_match_err_en	0	ALCT alct_bx0 != clct_bx0 in LCT to MPC
[05]	RW	clock_lock_lost_err_en	0	40MHz main clock lost lock
Sync error action enables:				
[06]	RW	sync_err_blanks_mpc_en	0	Sync error blanks LCTs to MPC
[07]	RW	sync_err_stops_pretrig_en	0	Sync error stops CLCT pre-triggers
[08]	RW	sync_err_stops_readout_e n	0	Sync error stops L1A readouts
Sync error types latched for VME readout:				
[09]	R	sync_err	0	Sync error OR of enabled types of error
[10]	R	clct_bx0_sync_err_ff	0	TMB clock pulse count err: bxn!=0+offset at ttc_bx0 arrival
[11]	R	alct_ecc_rx_err_ff	0	ALCT uncorrected ECC error in data ALCT received from TMB
[12]	R	alct_ecc_tx_err_ff	0	ALCT uncorrected ECC error in data ALCT transmitted to TMB
[13]	R	bx0_match_err_ff	0	ALCT alct_bx0 != clct_bx0 in LCT to MPC
[14]		clock_lock_lost_err_ff	0	40MHz main clock lost lock
[15]	RW	sync_err_forced	0	Force sync_err=1

See [p45](#) Adr86[1:0] for tmb\_sync\_err\_en[1:0]

Allow sync\_err to MPC for either muon

See [p35](#) Adr38[2] for alct\_ecc\_err\_blank

Blank alct muons having uncorrected ecc errors

**Adr 122      ADR\_CFEF\_BADBITS\_CTRL      CFEB Bad Bits Control/Status (see 0x15C for V6)**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfeb blocked	found cfeb4	found cfeb3	found cfeb2	found cfeb1	found cfeb0	block cfeb4	block cfeb3	block cfeb2	block cfeb1	block cfeb0	reset cfeb4	reset cfeb3	reset cfeb2	reset cfeb1	reset cfeb0

Bits	Dir	Signal	Default	Description
[04:00]	RW	cfeb_badbits_reset[4:0]	0	0x1F=Reset bad cfeb bits FFs for cfeb[n]
[09:05]	RW	cfeb_badbits_block[4:0]	0	0x1F=Block bad cfeb bits in cfeb[n]
[14:10]	R	cfeb_badbits_found[4:0]	0	CFEB[n] has at least 1 bad bit
[15]	R	cfeb_badbits_blocked	0	At least one CFEB has a bad bit that was blocked

**Adr 124      ADR\_CFEF\_BADBITS\_TIMER      CFEB Bad Bits Check Interval**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
nbx 15	nbx 14	nbx 13	nbx 12	nbx 11	nbx 10	nbx 9	nbx 8	nbx 7	nbx 6	nbx 5	nbx 4	nbx 3	nbx 2	nbx 1	nbx 0

Bits	Dir	Signal	Default	Description
[15:00]	RW	cfeb_badbits_nbx [15:0]	3564	Check Interval for CFEB bad bits, bx units

**Adr 126      ADR\_CFEBO\_BADBITS\_LY01      CFEB0 Ly0,Ly1 Bad Bits List**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ly1 distrip 7	ly1 distrip 6	ly1 distrip 5	ly1 distrip 4	ly1 distrip 3	ly1 distrip 2	ly1 distrip 1	ly1 distrip 0	ly0 distrip 7	ly0 distrip 6	ly0 distrip 5	ly0 distrip 4	ly0 distrip 3	ly0 distrip 2	ly0 distrip 1	ly0 distrip 0

Bits	Dir	Signal	Default	Description
[07:00]	R	cfeb0_ly0_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb0_ly1_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 128      ADR\_CFEBO\_BADBITS\_LY23      CFEB0 Ly2,Ly3 Bad Bits List**

[07:00]	R	cfeb0_ly2_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb0_ly3_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 12A      ADR\_CFEBO\_BADBITS\_LY45      CFEB0 Ly4,Ly5 Bad Bits List**

[07:00]	R	cfeb0_ly4_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb0_ly5_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 12C      ADR\_CFEB1\_BADBITS\_LY01      CFEB1 Ly0,Ly1 Bad Bits List**

[07:00]	R	cfeb1_ly0_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb1_ly1_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 12E      ADR\_CFEB1\_BADBITS\_LY23      CFEB1 Ly2,Ly3 Bad Bits List**

[07:00]	R	cfeb1_ly2_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb1_ly3_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 130          ADR\_CFEb1\_BADBITS\_LY45          CFEB1 Ly4,Ly5 Bad Bits List**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ly1 distrip 7	ly1 distrip 6	ly1 distrip 5	ly1 distrip 4	ly1 distrip 3	ly1 distrip 2	ly1 distrip 1	ly1 distrip 0	ly0 distrip 7	ly0 distrip 6	ly0 distrip 5	ly0 distrip 4	ly0 distrip 3	ly0 distrip 2	ly0 distrip 1	ly0 distrip 0

Bits	Dir	Signal	Default	Description
[07:00]	R	cfeb1_ly4_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb1_ly5_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 132          ADR\_CFEb2\_BADBITS\_LY01          CFEB2 Ly0,Ly1 Bad Bits List**

[07:00]	R	cfeb2_ly0_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb2_ly1_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 134          ADR\_CFEb2\_BADBITS\_LY23          CFEB2 Ly2,Ly3 Bad Bits List**

[07:00]	R	cfeb2_ly2_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb2_ly3_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 136          ADR\_CFEb2\_BADBITS\_LY45          CFEB2 Ly4,Ly5 Bad Bits List**

[07:00]	R	cfeb2_ly4_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb2_ly5_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 138          ADR\_CFEb3\_BADBITS\_LY01          CFEB3 Ly0,Ly1 Bad Bits List**

[07:00]	R	cfeb3_ly0_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb3_ly1_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 13A          ADR\_CFEb3\_BADBITS\_LY23          CFEB3 Ly2,Ly3 Bad Bits List**

[07:00]	R	cfeb3_ly2_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb3_ly3_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 13C          ADR\_CFEb3\_BADBITS\_LY45          CFEB3 Ly4,Ly5 Bad Bits List**

[07:00]	R	cfeb3_ly4_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb3_ly5_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 13E          ADR\_CFEb4\_BADBITS\_LY01          CFEB4 Ly0,Ly1 Bad Bits List**

[07:00]	R	cfeb4_ly0_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb4_ly1_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 140          ADR\_CFEb4\_BADBITS\_LY23          CFEB4 Ly2,Ly3 Bad Bits List**

[07:00]	R	cfeb4_ly2_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb4_ly3_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 142          ADR\_CFEb4\_BADBITS\_LY45          CFEB4 Ly4,Ly5 Bad Bits List**

[07:00]	R	cfeb4_ly4_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb4_ly5_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

Adr 144		ADR_ALCT_STARTUP_DELAY						ALCT startup delay milliseconds for Spartan-6							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
d[15]	d[14]	d[13]	d[12]	d[11]	d[10]	d[9]	d[8]	d[7]	d[6]	d[5]	d[4]	d[3]	d[2]	d[1]	d[0]

Bits	Dir	Signal	Default	Description
[15:00]	RW	alct_startup_delay [15:0]	116	<p>Msec to wait after TMB powers up before Initializing DDD delays and ALCT JTAG.</p> <p>This setting is only used after TMB first powers up or has a hard reset, so changes need to be stored in VME PROM.</p> <p>ALCT Spartan-6 takes 212msec to configure. TMB Virtex-2 takes 100msec.</p> <p>This register holds the number of msec to wait after TMB configures, so a value of 116 corresponds to 100ms + 116ms =216ms after a TMB hard reset.</p>

Adr 146		ADR_ALCT_STARTUP_STATUS						ALCT startup delay machine status							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	alct start done	alct wait cfg	alct wait vme	alct wait dll	alct start msec	vsm ready	power up	global reset

Bits	Dir	Signal	Typical	Description
[00]	R	global_reset	0	Global reset
[01]	R	power_up	1	DLL clock locked, we wait for it
[02]	R	vsm_ready	1	Injector RAM read data MSBs
[03]	R	alct_startup_msec	0	Startup machine millisecond pulse, width=25ns
[04]	R	alct_wait_dll	0	Startup machine waiting for TMB DLL lock
[05]	R	alct_wait_vme	0	Startup machine waiting for TMB VME user PROM
[06]	R	alct_wait_cfg	0	Startup machine waiting for ALCT FPGA to config
[07]	R	alct_startup_done	1	Startup machine done ALCT FPGA assumed configured
[15:08]	R	--	0	Unassigned

**Adr 148      ADR\_V6\_SNAP12\_QPLL      Virtex-6 SNAP12 Serial interface + QPLL status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	r12 fok	r12 sdat	r12 sclk	0	qpll err	qpll lock	qpll nrst

Bits	Dir	Signal	Typical	Description
[00]	RW	qpll_nrst	1	nReset QPLL, 0=reset
[01]	R	qpll_lock	0	QPLL locked status
[02]	R	qpll_err	0	QPLL error status
[03]	RW	--	0	Unassigned
[04]	R	r12_sclk	1	SNAP12 Serial interface clock, drive high
[05]	R	r12_sdat	0	SNAP12 Serial interface data
[06]	R	r12_fok	0	SNAP12 Serial interface status
[15:07]	R	--	0	Unassigned

**Adr 14A      ADR\_V6\_GTX\_RX\_ALL      Virtex-6 GTX common control and status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	gtx err	gtx pol swal	gtx sync done	gtx match	gtx valid	gtx fc	gtx start	gtx en prbs	gtx reset err cnt	gtx reset	gtx en

Bits	Dir	Signal	Typical	Description
[00]	RW	gtx_rx_enable_all	1	Enable all GTX optical inputs, disables copper CFEBs
[01]	RW	gtx_rx_reset_all	0	Reset all GTX
[02]	RW	gtx_rx_reset_err_cnt_all	0	Reset all PRBS test error counters
[03]	RW	gtx_rx_en_prbs_test_all	0	Select all random input test data mode
[04]	R	gtx_rx_start[6:0]	0	Set when the DCFEb Start Pattern is present
[05]	R	gtx_rx_fc[6:0]	0	Rx sees "FC" code (sent by Tx) for latency measurement
[06]	R	gtx_rx_valid[6:0]	0	Valid data detected on link
[07]	R	gtx_rx_match[6:0]	0	PRBS test data match detected
[08]	R	gtx_rx_sync_done[6:0]	1	GTX ready
[09]	R	gtx_rx_pol_swap[6:0]	1	GTX 5,6 [ie dcfcb 4,5] have swapped rx board routes
[10]	R	gtx_rx_err[6:0]	0	PRBS test detects an error
[15:11]	R	--	0	Unassigned

**Adr 14C-158      ADR\_V6\_GTX\_RX0-6      Virtex-6 GTX idcfcb[6:0] control and status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	gtx err	gtx pol swal	gtx sync done	gtx match	gtx valid	gtx fc	gtx start	gtx en prbs	gtx reset err cnt	gtx reset	gtx en

Bits	Dir	Signal	Typical	Description
[00]	RW	gtx_rx_enable[idcfcb]	1	Enable all GTX optical inputs, disables copper CFEBs
[01]	RW	gtx_rx_reset[idcfcb]	0	Reset all GTX
[02]	RW	gtx_rx_reset_err_cnt[idcfcb]	0	Reset all PRBS test error counters
[03]	RW	gtx_rx_en_prbs_test[idcfcb]	0	Select all random input test data mode
[04]	R	gtx_rx_start[idcfcb]	0	Set when the DCFEb Start Pattern is present
[05]	R	gtx_rx_fc[idcfcb]	0	Rx sees "FC" code (sent by Tx) for latency measurement
[06]	R	gtx_rx_valid[idcfcb]	0	Valid data detected on link
[07]	R	gtx_rx_match[idcfcb]	0	PRBS test data match detected
[08]	R	gtx_rx_sync_done[idcfcb]	1	GTX ready
[09]	R	gtx_rx_pol_swap[idcfcb]	0	GTX 5,6 [ie dcfeb 4,5] have swapped rx board routes
[10]	R	gtx_rx_err[idcfcb]	0	PRBS test detects an error
[15:11]	R	--	0	Unassigned

**Adr 15A      ADR\_V6\_SYSMON      Virtex-6 Sysmon ADC**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	gtx err	gtx pol swal	gtx sync done	gtx match	gtx valid	gtx fc	gtx start	gtx en prbs	gtx reset err cnt	gtx reset	gtx en

Bits	Dir	Signal	Typical	Description
[04:00]	RW	adc_adr[4:0]	0	ADC channel
[05]	R	adc_valid	0	ADC RAM has valid data for this adc_adr, readonly
[05]	W	adc_reset	0	Reset Sysmon module, writeonly
[15:6]	R	adc_data[15:6]	0	ADC counts for this adc_adr

**Virtex-6 Sysmon ADC Channel Assignments**

adr	Source	Units	Conversion Factor
0	Temperature	Degrees C	= (ADC code × 503.975) / 1024 - 273.15
1	VccINT	Volts	= (ADC Code / 1024) × 3V
2	VccAUX	Volts	= (ADC Code / 1024) × 3V
4	Vref 1.25V	Volts	= (ADC Code / 1024) × 3V
5	Vzero 0.00V	Volts	= (ADC Code / 1024) × 3V



**Adr 15C      ADR\_V6\_CFEb\_BADBITS\_CTRL      CFEB Bad Bits Control/Status (See Adr 0x122)**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	found cféb6	found cféb5	block cféb6	block cféb5	reset cféb6	reset cféb5

Bits	Dir	Signal	Default	Description
[01:00]	RW	cféb_badbits_reset[6:5]	0	0x1F=Reset bad cféb bits FFs for cféb[n]
[03:02]	RW	cféb_badbits_block[6:5]	0	0x1F=Block bad cféb bits in cféb[n]
[05:04]	R	cféb_badbits_found[6:5]	0	CFEB[n] has at least 1 bad bit
[15:06]	RW	--	0	Unassigned

**Adr 15E      ADR\_V6\_CFEb5\_BADBITS\_LY01 CFEB5 Ly0,Ly1 Bad Bits List**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ly1 dstrip 7	ly1 dstrip 6	ly1 dstrip 5	ly1 dstrip 4	ly1 dstrip 3	ly1 dstrip 2	ly1 dstrip 1	ly1 dstrip 0	ly0 dstrip 7	ly0 dstrip 6	ly0 dstrip 5	ly0 dstrip 4	ly0 dstrip 3	ly0 dstrip 2	ly0 dstrip 1	ly0 dstrip 0

Bits	Dir	Signal	Default	Description
[07:00]	R	cféb5_ly0_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cféb5_ly1_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 160      ADR\_V6\_CFEb5\_BADBITS\_LY23 CFEB5 Ly2,Ly3 Bad Bits List**

[07:00]	R	cféb5_ly2_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cféb5_ly3_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 162      ADR\_V6\_CFEb5\_BADBITS\_LY45 CFEB5 Ly4,Ly5 Bad Bits List**

[07:00]	R	cféb5_ly4_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cféb5_ly5_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 164      ADR\_V6\_CFEb6\_BADBITS\_LY01 CFEB6 Ly0,Ly1 Bad Bits List**

[07:00]	R	cféb6_ly0_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cféb6_ly1_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 166      ADR\_V6\_CFEb6\_BADBITS\_LY23 CFEB6 Ly2,Ly3 Bad Bits List**

[07:00]	R	cféb6_ly2_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cféb6_ly3_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 168      ADR\_V6\_CFEb6\_BADBITS\_LY45 CFEB6 Ly4,Ly5 Bad Bits List**

[07:00]	R	cféb6_ly4_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cféb6_ly5_badbits [7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 16A      ADR\_V6\_PHASER7      CFEB5 rxd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfb rxd delay 7	cfb rxd delay 6	cfb rxd delay 5	cfb rxd delay 4	cfb rxd delay 3	cfb rxd delay 2	cfb rxd delay 1	cfb rxd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_cfeb0_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_cfeb0_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_cfeb0_rxd	0	Phase shifter busy
[03]	R	lock_cfeb0_rxd	1	DCM lock status
[06:04]	R	phaser_sm_cfeb0_rxd[2:0]	0	Phase shifter machine state vector
[07]	RW	cfb0_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfb0_rxd_delay[7:0]	32	Phase delay to latch data received from CFEB approximately 0.1ns steps (clock period/256)

**Adr 16C      ADR\_V6\_PHASER8      CFEB6 rxd Digital Phase Shifter**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cfb rxd delay 7	cfb rxd delay 6	cfb rxd delay 5	cfb rxd delay 4	cfb rxd delay 3	cfb rxd delay 2	cfb rxd delay 1	cfb rxd delay 0	pos neg	sm 2	sm 1	sm 0	lock	busy	reset	fire

Bits	Dir	Signal	Default	Description
[00]	RW	fire_cfeb0_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_cfeb0_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_cfeb0_rxd	0	Phase shifter busy
[03]	R	lock_cfeb0_rxd	1	DCM lock status
[06:04]	R	phaser_sm_cfeb0_rxd[2:0]	0	Phase shifter machine state vector
[07]	RW	cfb0_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfb0_rxd_delay[7:0]	32	Phase delay to latch data received from CFEB approximately 0.1ns steps (clock period/256)

Adr 16E		ADR_V6_HCM501				CFEB5 Ly0,Ly1 Hot Channel Mask									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ly1 distrip 7	ly1 distrip 6	ly1 distrip 5	ly1 distrip 4	ly1 distrip 3	ly1 distrip 2	ly1 distrip 1	ly1 distrip 0	ly0 distrip 7	ly0 distrip 6	ly0 distrip 5	ly0 distrip 4	ly0 distrip 3	ly0 distrip 2	ly0 distrip 1	ly0 distrip 0
Bits		Dir	Signal				Default		Description						
[07:00]		RW	cfeb5_ly0_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 0						
[15:08]		RW	cfeb5_ly1_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 1						

Adr 170		ADR_V6_HCM523				CFEB5 Ly2,Ly3 Hot Channel Mask									
[07:00]		RW	cfeb5_ly2_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 2						
[15:08]		RW	cfeb5_ly3_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 3						

Adr 172		ADR_V6_HCM545				CFEB5 Ly4,Ly5 Hot Channel Mask									
[07:00]		RW	cfeb5_ly4_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 4						
[15:08]		RW	cfeb5_ly5_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 5						

Adr 174		ADR_V6_HCM601				CFEB6 Ly0,Ly1 Hot Channel Mask									
[07:00]		RW	cfeb6_ly0_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 0						
[15:08]		RW	cfeb6_ly1_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 1						

Adr 176		ADR_V6_HCM623				CFEB6 Ly2,Ly3 Hot Channel Mask									
[07:00]		RW	cfeb6_ly2_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 2						
[15:08]		RW	cfeb6_ly3_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 3						

Adr 178		ADR_V6_HCM645				CFEB6 Ly4,Ly5 Hot Channel Mask									
[07:00]		RW	cfeb6_ly4_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 4						
[15:08]		RW	cfeb6_ly5_hcm[7:0]				11111111 <sub>2</sub>		1=Enable DiStrip[7:0] Layer 5						

Adr 17A		ADR_V6_EXTEND				DCFE7 7-bit extensions to 5 bit fields in 0x42, 0x68									
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	cfeben 6 read	cfeben 5 read	cfeben 6 vme	cfeben 5 vme	inj mask 6	inj mask 5	inj febsel 6	inj febsel 5	mask all cfeb6	mask all cfeb5
Bits		Dir	Signal				Default		Description						
[01:00]		RW	mask_all[6:5]				11 <sub>2</sub>		Extend 0x42[4:0] = mask_all[4:0]						
[03:02]		RW	inj_febsel[6:5]				0		Extend 0x42[9:5] = inj_febsel[4:0]						
[05:04]		RW	injector_mask[6:5]				11 <sub>2</sub>		Extend 0x42[14:10] = injector_mask_cfeb[4:0]						
[07:06]		RW	cfeb_en_vme[6:5]				11 <sub>2</sub>		Extend 0x68[14:10] = cfeb_en_vme[4:0]						
[09:08]		R	cfeb_en[6:5]				11 <sub>2</sub>		Extend 0x68[14:10] = cfeb_en[4:0] readback						
[15:10]		RW	--				0		Unassigned						

## TTC Commands:

### Fast Control Bus ccb\_cmd[5..0] Decoding Scheme

Signal	Code (hex)	Decoded by TMB	Description
BX0 (*)	01	Y	Bunch Crossing Zero
L1 Reset (*)	03	Y	Reset L1 readout buffers and resynchronize optical links
Hard_reset (*)	04		Reload all FPGAs from EPROMs
Start Trigger	06	Y	Go to trigger run , wait for bx0, may be disabled by Adr 2C[7]
Stop Trigger	07	Y	Go to stop state, wait for bx0, may be disabled by Adr 2C[7]
Test Enable	08		
Private Gap	09		
Private Orbit	0A		
Tmb_hard_reset (*)	10		Reload TMB FPGAs from EPROM
Alct_hard_reset (*)	11		Reload ALCT FPGAs from EPROM
Dmb_hard_reset (*)	12		Reload DMB FPGAs from EPROM
Mpc_hard_reset (*)	13		Reload MPC FPGAs from EPROM
Dmb_cfeb_calibrate0 (*)	14		CFEB Calibrate Pre-Amp Gain
Dmb_cfeb_calibrate1 (*)	15		CFEB Trigger Pattern Calibration
Dmb_cfeb_calibrate2 (*)	16		CFEB Pedestal Calibration
Dmb_cfeb_initiate (*)	17		Initiate CFEB calibration (Hold next L1ACC and Pretriggers)
Alct_adb_pulse_sync (*)	18		Pulse Anode Discriminator, synchronous
Alct_adb_pulse_async (*)	19		Pulse Anode Discriminator, asynchronous
Clct_external_trigger (*)	1A		External Trigger All CLCTs
Alct_external_trigger (*)	1B		External Trigger All ALCTs
Soft_reset (*)	1C		Initializes the FPGA on DMB, TMB and MPC boards
DMB_soft_reset (*)	1D		Initializes the FPGA on a DMB
TMB_soft_reset (*)	1E		Initializes the FPGA on a TMB
MPC_soft_reset (*)	1F		Initializes the FPGA on a MPC
Send_bcnc[7..0] (*)	20		Send Bunch_Counter[7..0] to ccb_data[7..0] bus
Send_evnc[7..0] (*)	21		Send Event_Counter[7..0] to ccb_data[7..0] bus
Send_evnc[15..8] (*)	22		Send Event_Counter[15..8] to ccb_data[7..0] bus
Send_evnc[23..16] (*)	23		Send Event_Counter[23..16] to ccb_data[7..0] bus
Inject patterns from TMBs	24	Y	Injects patterns from TMB's internal RAM to MPC
Alct_adb_pulse (*)	25		Generate sync and async anode discriminator pulses
Inject patterns from MPCs	30		Injects patterns from MPC's input FIFO to SP
Inject patterns from MS	31		Injects patterns from MS input FIFO to Global Muon Trigger
tmb_bxreset	32	Y	Reset TMB/ALCT BXN, do not reset L1A counters

(\*) – decoded by CCB

## TMB Board Status Operations

()

### ID Registers

id_slot=15	VME Slot
id_rev =D	Firmware version
id_type=C	Firmware Type
id_date=06/08/2004	Firmware Compile Date
id_rev =38CA=06/10/04 xc2v3000	Firmware Revcode

### Digital Serial Numbers

Digital Serial for TMB CRC=DC DSN=000000A237E7F MFG=01 OK  
Digital Serial for Mez CRC=BF DSN=000007E06194 MFG=01 OK  
Digital Serial for RAT CRC=52 DSN=000000AB39AAD MFG=01 OK

### Power Supply ADC

TMB2005E Comparators  
5.0V status=OK  
3.3V status=OK  
1.8V status=OK  
1.5V status=OK  
Tcrit status=OK

#### TMB2005E ADC

+5.0 TMB	5.004 V	0.305 A
+3.3 TMB	3.221 V	1.160 A
+1.5 TMBcore	1.488 V	0.795 A
+1.5 GTLtt	1.492 V	0.230 A
+1.0 GTLref	1.004 V	0.000 A
+3.3 RAT	3.221 V	0.250 A
+1.8 RATcore	1.797 V	8.985 A
+vref/2	2.047 V	0.000 A
+vzero	0.000 V	0.000 A
+vref	4.095 V	0.000 A

#### TMB2005E Temperature IC

T tmb pcb	73.4	F	23.	C	Tcrit=261./127.
T tmb fpga	95.0	F	35.	C	Tcrit=261./127.

#### RAT2005E Temperature IC

T rat pcb	68.0	F	20.	C	Tcrit=261./127.
T rat xstr	69.8	F	21.	C	Tcrit=261./127.

### Clock Delays

Current 3D3444 Delay Settings 02/27/2006

Ch0	8steps	16ns	ALCT	tx clock	alct_tof_delay in muonic firmware versions
Ch1	1steps	2ns	ALCT	rx clock	not used in muonic firmware versions
Ch2	2steps	4ns	DMB	tx clock	
Ch3	9steps	20ns	RPC	tx clock	
Ch4	0steps	0ns	TMB1	rx clock	not used in muonic firmware versions
Ch5	0steps	0ns	MPC	rx clock	
Ch6	0steps	0ns	DCC	tx clock	cfeb_tof_delay in muonic firmware versions
Ch7	7steps	14ns	CFEB0	tx clock	
Ch8	7steps	14ns	CFEB1	tx clock	
Ch9	7steps	14ns	CFEB2	tx clock	
ChA	7steps	14ns	CFEB3	tx clock	
ChB	7steps	14ns	CFEB4	tx clock	

## JTAG Chains

Chain Select Address (X=don't care)

3210	Base	Function
00SS	0	ALCT: SS=00 (Slow user) SS=01 (Slow prom) SS=10 (Mez user) SS=11 (Mez prom)
01XX	4	TMB Mezzanine FPGA+PROMs
10XX	8	TMB User PROMs
1100	C	FPGA Monitor (for TMB self-test)
1101	D	RAT Module FPGA+PROM

## RAT Module Status Register USER1

```
RAT FPGA device 0 Idcode= 20A10093
RAT PROM device 1 Idcode= 05024093
RAT FPGA device 0 USERcode=02232006
RAT PROM device 1 USERcode=02232006
RAT USER1=E00000007FFFFFFFE02300336205650565E400CCC989C20060223EB
rs_begin B
rs_version E
rs_monthday 0223
rs_year 2006
rs_syncmode 0
rs_posneg 0
rs_loop 1
rs_rpc_en 3
rs_clk_active 0
rs_locked_tmb 1
rs_locked_rpc0 0
rs_locked_rpc1 0
rs_locklost_tmb 0
rs_locklost_rpc0 1
rs_locklost_rpc1 1
rs_txok 0
rs_rxok 0
rs_ntcrit 1
rs_rpc_free 0
rs_dsn 0
rs_ddd_wr 3
rs_ddd_wr 0033
rs_ddd_auto 1
rs_ddd_start 0
rs_ddd_busy 0
rs_ddd_verify_ok 1
rs_rpc0_parity_ok 1
rs_rpc1_parity_ok 1
rs_rpc0_cnt_perr 0565
rs_rpc1_cnt_perr 0565
rs_last_opcode 02
rw_rpc_en 3
rw_ddd_start 0
rw_ddd_wr 0033
rw_ddd_wr 3
rw_perr_reset 0
rw_parity_odd 1
rw_perr_ignore 0
rw_rpc_future 00
rs_rpc0_pdata 7FFFF
rs_rpc1_pdata 7FFFF
rs_unused 00000000
rs_end E
```

## RAT Module Control Register USER2

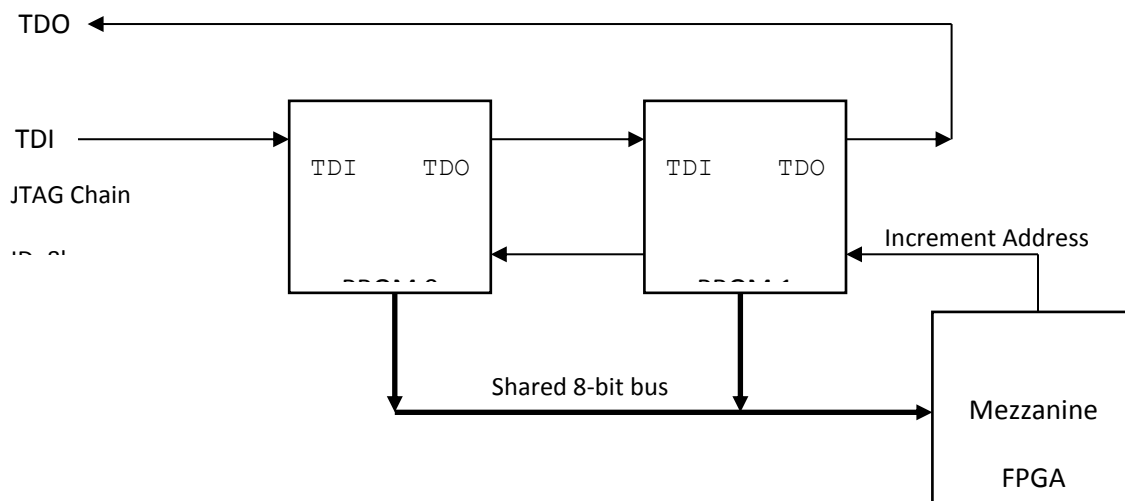
```
RAT USER2=0118019B
ws_rpc_en      3
ws_ddd_start   0
ws_ddd_wr      0033
ws_dddoe_wr    3
ws_perr_reset  0
ws_parity_odd  1
ws_perr_ignore 0
ws_rpc_future  00
```

## User PROM Programming

TMB has two on-board erasable PROMs that contain non-volatile data for modifying VME registers and for initializing JTAG chains. The PROMs are read automatically by firmware state machines after power-up or hard-reset.

Both PROMs are Xilinx XC18V256 devices, which have a capacity of 256K bits stored 1-byte wide in 32K addresses. Some late-production TMBs may have one or two XC18V512 devices, because the 256K product was discontinued by the manufacturer.

PROM contents are programmed and verified either via the front-panel JTAG connector or from the VME backplane using TMBs boot register. The data may be read out 8-wide through TMBs PROM-port register ADR\_PROM (12h) or it may be read 1-bit serial via JTAG.



## Register Initialization

Initialization after power-up or hard reset proceeds as follows:

- 1) FPGA loads its firmware from mezzanine PROMs (100msec)
- 2) Delay Locked Loops (DLLs) acquire lock on the 40MHz TTC clock (lock time not yet tested)
- 3) VME registers load their default values (100ns)
- 4) The VMEsm state machine reads PROM 0 and writes any new data to the specified VME registers.
- 5) JTAGsm state machine reads PROM 1 and write JTAG data to the specified chains.



## VME PROM-0

After TMB loads default values into its VME registers, the VMESm state machine reads PROM 0 and updates the specified VME registers with PROM data. The PROM contains a 16-word header, followed by an arbitrary number of 24-bit VME-addresses and their associated 16-bit data word, then followed by a 3-byte trailer sequence that contains the checksum and end-of-PROM marker.

The VMESm state machine expects PROM-0 data to be organized in a specific format and it may either terminate the read-process or indicate an error condition if the format is incorrect. If the BCh header-begin marker is missing, the state machine terminates reading immediately.

The 16-byte header consists of the BC “begin CLCT data” marker, a 2-byte word count, and the EC end marker. There are no restrictions on the values of the other 12 header bytes. VMESm assembles the two word-count bytes into a 16-bit number that it uses to recognize when to stop reading the PROM.

The word-count includes every PROM address between the BC and FF markers, inclusive. If there are n VME addresses to be written, the word count would be  $16 \text{ header} + 5n \text{ vme data} + 3 \text{ trailer} = 19_{10} + 5n$ . A counter in `ADR_VMESM3` records the number of VME addresses what were actually written. A value of 55Aah should be written to VME address `ADR_VMESM4` to test the PROM-to-FPGA data path.

### VME PROM-0 data format:

Adr	7654 3210	Hex	Description
---	----	--	-----
0	1011 1100	BC	Begin CLCT Header Marker, if missing state machine stops
1	tttt oooo	LL	Word count [7:0] kkkk hhhh tttt oooo from BC to FF
2	kkkk hhhh	HH	Word count [15:8]
3	tttt oooo	12	Month (month/day in “hex-ascii” December 31, 2006)
4	tttt oooo	31	Day
5	tttt oooo	06	Year 2006 = kkkk hhhh tttt oooo
6	kkkk hhhh	20	Year
7	vvvv vvvv	XX	Version number = vvvv vvvv
8	xxxx xxxx	AA	Option (suggest AA to test even bits)
9	xxxx xxxx	55	Option (suggest 55 to test odd bits)
A	xxxx xxxx	XX	Option
B	xxxx xxxx	XX	Option
C	xxxx xxxx	XX	Option
D	xxxx xxxx	XX	Option
E	xxxx xxxx	XX	Option
F	1110 1100	EC	End Header Marker
10	aaaa aaaa	LL	VME adr[7:0]
11	aaaa aaaa	MM	VME adr[15:8]
12	aaaa aaaa	HH	VME adr[23:16]
13	dddd dddd	LL	VME data[7:0]
14	dddd dddd	HH	VME data[15:8]
L-2	1111 1100	FC	End of CLCT VME data Marker
L-1	cccc cccc	cc	Check sum [7:0] includes addresses 0 to L-2
L	1111 1111	FF	End of PROM data Marker

If VMESm detects an error condition, status information can be read from VME address `ADR_VMESM2 (0xDE)`:

`fmt_err[0]` = Missing BC header-begin marker  
`fmt_err[1]` = Missing EC header-end marker  
`fmt_err[2]` = Missing FC data-end marker  
`fmt_err[3]` = Missing FF prom-end marker  
`fmt_err[4]` = Word counter overflow

## JTAG PROM-1

After the VMesm state machine completes successful, the JTAGsm machine is started. It reads PROM-1 and writes to the JTAG chains specified by the PROM data. The PROM contains a 16-word header, followed by an arbitrary number of 3-byte Chain Blocks, then followed by a 8-byte trailer sequence that contains the tck-count, word-count, checksum and end-of-PROM marker.

### Header

The JTAGsm state machine expects PROM-1 data to be organized in a specific format and it may either terminate the read-process or indicate an error condition if the format is incorrect. If the Bah header-begin marker is missing, the state machine terminates reading immediately.

The 16-byte header consists of the BA “begin ALCT data” marker and the EA end marker. The state machine skips over the next 15 bytes, so are no restrictions on the header contents.

Adr	7654 3210	Hex	Description
---	-----	--	-----
0	10111010	BA	Begin ALCT Marker, if “BA” missing state machine stops
1	0000aaaa	03	ALCT MSD 3 Type (288,384,672)
2	0000aaaa	08	ALCT 8
3	0000aaaa	04	ALCT LSD 4
4	0000mmmm	00	Month MSD 0 in “hex-ascii” June 9, 2008
5	0000mmmm	06	Month LSD 6
6	0000dddd	00	Day MSD 0
7	0000dddd	09	Day LSD 9
8	0000yyyy	02	Year MSD 2
9	0000yyyy	00	Year 0
A	0000yyyy	00	Year 0
B	0000yyyy	08	Year LSD 8
C	0000vvvv	01	Version number [3:0]
D	0000xxxx	00	Future use
E	0000xxxx	00	Future use
F	00101010	EA	End ALCT Header Marker

### Chain Block

A Chain Block marker “Cs” signals the start of a new sequence to generate TCK,TMS, and TDI for a JTAG chain. The “s” in the “Cs” marker is the chain address SEL[3:0]. Normally, TCK will be held high after the last TMS/TDI pair is sent, unless the “C” marker is replaced by a “D” maker. After Cs, there are two more bytes specifying the number of TCK clock pulses to send to the chain.

Following the TCK count are JTAG data bytes that contain packed TMS and TDI bits for up to 4 TCKs. The number of data bytes is tck\_count/4+1.

### Chain Block Format [7:0]:

76543210		
1100ssss	Cs	Chain Block begin marker chain address ssss =SEL[3:0]. Cs=hold tck high, Ds= do not
tttttttt	ww	TCK count [15:8]
tttttttt	ww	TCK count [7:0]
lsisisisi	si	JTAG data [7:0], I=TDI bit, s=TMS bit, defined below

### 4 TCKs packed per byte format, data[7:0]:

Bit	Signal
[0]	TDI[0]
[1]	TMS[0]
[2]	TDI[1]
[3]	TMS[1]
[4]	TDI[2]
[5]	TMS[2]
[6]	TDI[3]
[7]	TMS[3]

### SEL[3:0] Selects the active JTAG chain:

SEL[3:0]		
Hex	3210	Function
0	0000	ALCT Slow Control FPGA user registers
1	0001	ALCT Slow Control FPGA PROM)
2	0010	ALCT Mezzanine FPGA user registers
3	0011	ALCT Mezzanine FPGA PROMs
4	01XX	TMB Mezzanine FPGA+PROMs
8	10XX	TMB User PROMs
C	1100	TMB FPGA Monitor (for TMB self-test)
D	1101	RAT Module FPGA+PROM

### Chain Block, Continued

The state machine copies the signals TMS, and TDI to the JTAG chain selected by SEL[3:0]. It automatically generates the JTAG clock TCK and also arranges for asserting the next TMS and TDI values while TCK is low.

TMB hardware pulls TCK, TMS, and TDI high for chains that are not currently selected. When changing to a new chain ID, it is recommend that the last PROM word for that chain sets the signals to a logic high.

The number of Chain Blocks is limited only by the memory capacity of the PROM. Each block begins with a Cs marker, and the last block is indicated by an "FA" marker.

### Trailer

An 8-byte trailer sequence contains the total-tck-count, PROM word count, data checksum and end-of-PROM marker. The tck-count is the number of TCKs the state machine sent to all chains. The word-count includes every PROM address between the BA and FA markers, inclusive, as well as the 3 TCK-count bytes. Checksum includes every PROM address from the BA marker to the last word-count byte.

Adr	7654 3210	Hex	Description	
---	----	--	-----	
T-1	11111010	FC	End of JTAG data Marker	Also set chain address to C
T+0	tttttttt	tt	TCK Count Total [17:16]	Includes tcks sent for all chain blocks
T+1	tttttttt	tt	TCK Count Total [15:8]	
T+2	tttttttt	tt	TCK Count Total [7:0]	
T+3	wwwwwww	ww	Word Count [15:8]	Includes Adr 0 and end JTAG marker at T+2
T+4	wwwwwww	ww	Word Count [7:0]	
T+5	cccccccc	cc	Check sum [7:0]	Includes addresses 0 and T+5
T+6	11111111	FF	End of PROM data Marker	

If the tck-count, word-count or checksum are incorrect, or if the last-word marker is missing, the state machine indicates the an error by setting `jsm_tck_fpga_ok=0`.

### TCK Throttle

The JTAGsm state machine reads header and trailer bytes from the PROM at 20MHz, then slows to 2.5MHz for processing JTAG data bytes. This results in TCK being pulsed at 10MHz (because there are 4 TCKs per byte, each 50ns high + 50ns low).

If this rate is too high for ALCT JTAG chains, the state machine can be throttled to a lower speed by setting `jsm_throttle[3:0]` in `ADR_VMESM0` (D4h). A `jsm_throttle` value of 0 corresponds firing TCK at 10MHz full speed. Increasing `jsm_throttle` by 'n' increases the TCK period by 25ns\*n, and maintains a 50% duty cycle.

### State Machine Status

Automatic operation of the state machine can be verified by including TCK writes to chain address C. That chain effectively loops-back TCK, TMS and TDI to the FPGA. If at least 1 TCK transition is seen on chain C, then signal `jsm_tck_fpga_ok` will be a logic 1 in VME register `ADR_JTAGSM0`, and `tck_fpga_cnt[3:0]` in `ADR_JTAGSM2` counts

the number of TCKs. Demo software exists that converts old PROM data files to this new format and automatically inserts a C-chain Block if there is not one already.

#### JTAG PROM-1 data format Example:

Adr	7654 3210	Hex	Description
----	-----	--	-----
0	10111010	BA	Begin ALCT Marker, if "BA" missing state machine stops
1	0000aaaa	03	ALCT MSD 3 Type (288,384,672)
2	0000aaaa	08	ALCT 8
3	0000aaaa	04	ALCT LSD 4
4	0000mmmm	00	Month MSD 0 in "hex-ascii" June 9, 2008
5	0000mmmm	06	Month LSD 6
6	0000dddd	00	Day MSD 0
7	0000dddd	09	Day LSD 9
8	0000yyyy	02	Year MSD 2
9	0000yyyy	00	Year 0
A	0000yyyy	00	Year 0
B	0000yyyy	08	Year LSD 8
C	0000vvvv	01	Version number [3:0]
D	0000xxxx	00	Future use
E	0000xxxx	00	Future use
F	00101010	EA	End ALCT Header Marker
10	1100ssss	C3	Chain Block Markder for chain adr 3 (or Ds to set TCK low)
11	ttttttttt	ww	TCK count [15:8]
12	ttttttttt	ww	TCK count [7:0]
13	sisisisi	si	JTAG data
14	sisisisi	si	JTAG data
15	sisisisi	si	JTAG data
T-1	11111010	FC	End of JTAG data Marker
T+0	ttttttttt	tt	TCK Count Total [17:16] Includes tcks sent for all chain blocks
T+1	ttttttttt	tt	TCK Count Total [15:8]
T+2	ttttttttt	tt	TCK Count Total [7:0]
T+3	wwwwwww	ww	Word Count [15:8] Includes Adr 0 and end JTAG marker at T+2
T+4	wwwwwww	ww	Word Count [7:0]
T+5	cccccccc	cc	Check sum [7:0] Includes addresses 0 and T+5
T+6	11111111	FF	End of PROM data Marker

## DMB Readout

### Full-Readout and Local-Readout Format (Long Header):

1	DBOC	header	Beginning Of Cathode Data	
7	event	header	Non-buffered event data	
e	clct	header	Cathode LCTs	
e	tmb	header	TMB match result	
e	mpc	header	MPC frames	
e	rpc	header	RPC status	
e	buf	header	Buffer status	
e	6EOB	header	End of header block	
n	hits		CFEB0 raw hits	
n	hits		CFEB1 raw hits	
n	hits		CFEB2 raw hits	
n	hits		CFEB3 raw hits	
n	hits		CFEB4 raw hits	
1	6B04		Start of RPC raw hits marker	(optional)
m	hits		RPC0 raw hits	(optional)
m	hits		RPC1 raw hits	(optional)
1	6E04		End of RPC raw hits marker	(optional)
1	6B05		Beginning scope data	(optional)
s	scope data		Scope data	(optional)
1	6E05		End of scope data	(optional)
1	6B07		Beginning miniscope data	(optional)
22	miniscope data		Miniscope data 22 words	(optional)
1	6E07		End of miniscope data	(optional)
1	6BCB		Beginning blocked CFEB list	(optional)
20	blocked cfebs list		Blocked CFEBs list 20 words	(optional)
1	6ECB		End blocked CFEB list	(optional)
1	6EOC		End of raw hits	
1	2AAA		Make word count x4	(inserted only if needed)
1	5555		Make word count x4	(inserted only if needed)
1	DE0F		End of Frame	
1	Dcrc0		CRC22[10:0]	
1	Dcrc1		CRC22[21:11]	
1	Dwordcount		Total words in transmission	(inclusive)

-----  
Word Count =     42(nheaders)  
                  + 1(E0B)  
                  + ncfefs\*(6\*ntbins)  
                  + 1(B04)                   (if RPC readout enabled)  
                  + nrpcs\*(2\*ntbins)       (if RPC readout enabled)  
                  + 1(E04)                   (if RPC readout enabled)  
                  + 1(B05)                   (if Scope readout enabled)  
                  + nch(128)/16\*256       (if Scope readout enabled)  
                  + 1(E05)                   (if Scope readout enabled)  
                  + 1(B07)                   (if miniscope readout enabled)  
                  + 22                       (if miniscope readout enabled)  
                  + 1(E07)                   (if miniscope readout enabled)  
                  + 1(BCB)                  (if blocked cfebs list readout enabled)  
                  + ncfefs\*4                (if blocked cfebs list readout enabled)  
                  + 1(ECB)                  (if blocked cfebs list readout enabled)  
                  + 1(EOC)  
                  + 2(2AAA 5555)           (if needed to make word count multiple of 4)  
                  + 1(E0F)  
                  + 2(crc)

+1(wordcount)

### Long Header-only Format:

1	DB0C	header	Beginning of Cathode Data
7	event	header	Non-buffered event data
e	clct	header	Cathode LCTs
e	tmb	header	TMB match result
e	mpc	header	MPC frames
e	buf	header	Buffer status
e	rpc	header	RPC status
1	6E0B		End of header block
1	6E0C		End of raw hits
1	DE0F		End of Frame
1	Dcrc0		CRC22
1	Dcrc1		CRC22
1	Dwordcount		Total words in transmission (inclusive)

-----  
40 words = nheaders(34)+E0B+E0C+2crc+E0F+wdcnt

### Short Header-only Format:

1	DB0C	header	Beginning of Cathode Data
7	event	header	Non-buffered event data
1	DEEF		End of Frame
1	Dcrc0		CRC22
1	Dcrc1		CRC22
1	Dframe wordcount		Total words in transmission (inclusive)

-----  
12 words = 8headers+2crc+EEF+wdcnt

## Miniscope:

TMB contains a smaller version of the main digital scope that is intended to be included in the DMB readout stream by default. The miniscope displays a time history of ALCTs, CLCTs, and L1As that helps reproduce TMB behavior offline.

Miniscope data is written continuously to Block RAM, in the same fashion as CFEB raw hits are stored.

When there is a CLCT pre-trigger, miniscope data starts at `fifo_pretrig_mini` time bins before the pre-trigger occurred. If there is no CLCT pre-trigger, miniscope data can still be read out in an L1A-only event, using the L1A look-back mode.

The miniscope is enabled by setting:

```
0x10C [00]    mini_read_enable = 1    Turn miniscope on
0x10C [01]    mini_tbins_test  = 1    Turn debug mode off
0x10C [02]    mini_tbins_word  = 1    Insert tbins and pre-trig tbins settings in 1st word
0x10C [07:03] fifo_tbins_mini  = 22   Number of time bins to read out, must be a multiple of 2, but not of 4
0x10C [12:08] fifo_pretrig_mini = 4   Number of time bins before pre-trigger
```

Once enabled, miniscope data is included in every event readout that contains a full header.

Events that contain miniscope data will have

- 1) header19[14] `mini_read_enable` = 1 to indicate the event includes miniscope data.
- 2) 06B07 begin miniscope marker in the data stream, located after RPC and main-scope data
- 3) Typically 22 miniscope time-bin data words
- 4) 06E07 end miniscope marker

The number of miniscope time-bin data words depends on the VME register 0x10C[7:3].

Because the total number of words in the DMB readout is required to be a multiple of 4, and 2 words are used for 06E07|06E07 markers, the number of miniscope time-bin words must be a multiple of 2, but not a multiple of 4.

The first word after the 06B07 marker contains the number of miniscope time-bins, which along with the `mini_read_enable` bit in header19[14] allows event-unpacking software to locate the miniscope data markers and predict the total event word count.

Miniscope data is inserted between RPC and Blocked-bits list

```
Adr= 282 Data= 06E04
Adr= 283 Data= 06B07    ← begin miniscope marker
Adr= 284 Data= 00416    ← tbin count 0x16 and tbins before pre-trigger 0x04
Adr= 285 Data= 00002    ← 14 miniscope channels at tbin=1
Adr= 286 Data= 00002
Adr= 287 Data= 00002
Adr= 288 Data= 00403
Adr= 289 Data= 01805
Adr= 290 Data= 01009
Adr= 291 Data= 01009
Adr= 292 Data= 02009
Adr= 293 Data= 00009
Adr= 294 Data= 00158
Adr= 295 Data= 00302
Adr= 296 Data= 00102
Adr= 297 Data= 00002
Adr= 298 Data= 00002
Adr= 299 Data= 00002
Adr= 300 Data= 00002
Adr= 301 Data= 00002
Adr= 302 Data= 00002
```



```

Adr= 303 Data= 00002
Adr= 304 Data= 00002
Adr= 305 Data= 00002
Adr= 306 Data= 06E07 ← end miniscope marker
Adr= 307 Data= 06BCB ← blocked bits marker, if blocked bits are in the readout

```

### Miniscope Channel Assignments:

ch[00]	any_cfeb_hit	At least 1 CFEB meets pre-trigger layer-hit threshold
ch[03:01]	clct_sm_vec[2:0]	CLCT pre-trigger state machine vector
ch[04]	clct0_vpf	Valid pattern flag for 1 <sup>st</sup> best CLCT
ch[05]	clct1_vpf	Valid pattern flag for 2 <sup>nd</sup> best CLCT
ch[06]	alct0_vpf_tprt	Valid pattern flag for 1 <sup>st</sup> best ALCT, after pipe delay
ch[07]	alct1_vpf_tprt	Valid pattern flag for 2 <sup>nd</sup> best ALCT, after pipe delay
ch[08]	clct_window	CLCT match window
ch[09]	wr_push_rtmb	ALCT*CLCT match signal
ch[10]	tmb_push_dly	L1A signals are l1a_delay+2bx later
ch[11]	l1a_pulse	L1A from CCB
ch[12]	l1a_window_open	L1A window
ch[13]	l1a_push_me	L1A queued for readout signal
ch[14]	tmb_special	Always 0 in DMB readout, required by unpacker
ch[15]	ddu_special	Always 0 in DMB readout, required by DDU

### CLCT Pre-trigger State Machine Vector:

```

0 s: Startup wait after hard-reset
1 I: Idle, waiting for pre-trigger
2 p: Pre-triggered
3 f: Flushing triad one-shots [checks any_cfeb_hit, waits n-bx, returns to idle, n may be 0, n=1 here]
4 t: Trigger-rate throttle [ optional fixed delay before returning to idle]
5 h: Halted

```

### Decoded Readout Example:

	0000000000000000111111	← Time bins	
	123456789ABCDEF012345		
ch 00	any_cfeb_hit	-----	← CLCT signals are in pre-trigger time domain
ch 03	clct_state_machine	1111244444111111111111	
ch 03	clct_state_machine	iiiiipffffiiiiiiiiiiii	← CLCT Pre-trigger machine state
ch 04	clct0_vpf	-----	
ch 05	clct1_vpf	-----	
ch 06	alct0_vpf	-----	← ALCT arrival is needed to check TMB offline
ch 07	alct1_vpf	-----	
ch 08	clct_window	-----	
ch 09	wr_push_rtmb	-----	← ALCT*CLCT match signal
ch 10	tmb_push_dly	-----	← L1A signals are l1a_delay+2bx later
ch 11	l1a_pulse	-----	← L1A from CCB merged with other L1A
ch 12	l1a_window_open	-----	
ch 13	l1a_push_me	-----	← L1A queued for readout signal
ch 14	tmb_special	-----	← Unpacker prevents TMB from using 15 <sup>th</sup> bit
ch 15	ddu_special	-----	← DDU prevents TMB from using 16 <sup>th</sup> bit

## Blocked CFEB DiStrips List Format:

1	6BCB	marker	Beginning of blocked cfeb distrip list
1	CFEB0	word 0	[14:12]=cfebid[2:0]=0 [11:0]=cfeb0 distrips[11:0]
1	CFEB0	word 1	[14:12]=cfebid[2:0]=0 [11:0]=cfeb0 distrips[23:12]
1	CFEB0	word 2	[14:12]=cfebid[2:0]=0 [11:0]=cfeb0 distrips[35:24]
1	CFEB0	word 3	[14:12]=cfebid[2:0]=0 [11:0]=cfeb0 distrips[47:36]
1	CFEB1	word 0	[14:12]=cfebid[2:0]=1 [11:0]=cfeb1 distrips[11:0]
1	CFEB1	word 1	[14:12]=cfebid[2:0]=1 [11:0]=cfeb1 distrips[23:12]
1	CFEB1	word 2	[14:12]=cfebid[2:0]=1 [11:0]=cfeb1 distrips[35:24]
1	CFEB1	word 3	[14:12]=cfebid[2:0]=1 [11:0]=cfeb1 distrips[47:36]
1	CFEB2	word 0	[14:12]=cfebid[2:0]=2 [11:0]=cfeb2 distrips[11:0]
1	CFEB2	word 1	[14:12]=cfebid[2:0]=2 [11:0]=cfeb2 distrips[23:12]
1	CFEB2	word 2	[14:12]=cfebid[2:0]=2 [11:0]=cfeb2 distrips[35:24]
1	CFEB2	word 3	[14:12]=cfebid[2:0]=2 [11:0]=cfeb2 distrips[47:36]
1	CFEB3	word 0	[14:12]=cfebid[2:0]=3 [11:0]=cfeb3 distrips[11:0]
1	CFEB3	word 1	[14:12]=cfebid[2:0]=3 [11:0]=cfeb3 distrips[23:12]
1	CFEB3	word 2	[14:12]=cfebid[2:0]=3 [11:0]=cfeb3 distrips[35:24]
1	CFEB3	word 3	[14:12]=cfebid[2:0]=3 [11:0]=cfeb3 distrips[47:36]
1	CFEB4	word 0	[14:12]=cfebid[2:0]=4 [11:0]=cfeb4 distrips[11:0]
1	CFEB4	word 1	[14:12]=cfebid[2:0]=4 [11:0]=cfeb4 distrips[23:12]
1	CFEB4	word 2	[14:12]=cfebid[2:0]=4 [11:0]=cfeb4 distrips[35:24]
1	CFEB4	word 3	[14:12]=cfebid[2:0]=4 [11:0]=cfeb4 distrips[47:36]
1	6ECB	marker	End of blocked cfeb distrip list

-----  
22 words

Blocked DiStrips list includes:

DiStrips turned off via VME Hot Channel Mask

DiStrips turned off via mask\_all applied to the entire CFEB

DiStrips marked as bad by automatic bad-bits detection

CFEB DiStrip Bit Packing:

Each CFEB has 6 layers of 8 DiStrips = 48 bits

```
block_distrip_list[ 7: 0] = Layer0 Ds[7:0]
block_distrip_list[15: 8] = Layer1 Ds[7:0]
block_distrip_list[23:16] = Layer2 Ds[7:0]
block_distrip_list[31:24] = Layer3 Ds[7:0]
block_distrip_list[39:32] = Layer4 Ds[7:0]
block_distrip_list[47:40] = Layer5 Ds[7:0]
```

Which are packed into 4 readout words, 12 bits per word = 48 bits

```
CFEBn word 0 = block_distrip_list[11: 0]
CFEBn word 1 = block_distrip_list[23:12]
CFEBn word 2 = block_distrip_list[35:24]
CFEBn word 3 = block_distrip_list[47:36]
```

## Header Word Descriptions:

### First 4 header words must conform to DDU format specification:

header00_[11:0]	12'hB0C	Beginning of Cathode record marker
header00_[14:12]	3'b101	DDU code for TMB/ALCT
header00_[15]	1	DDU special-word flag
header01_[11:0]	pop_bxn_counter[11:0]	BXN pushed into L1A queue at L1A arrival
header01_[14:12]	3'b101	DDU code for TMB/ALCT
header01_[15]	1	DDU special-word flag

#### *header01 notes:*

- (4) bxn\_counter contains the value of the 12-bit BXN counter at the time L1A arrives, and is typically 128bx later than the pre-trigger BXN (see header08). Readouts will always have bxn\_counter, but may or may not have pre-trigger data.

header02_[11:0]	pop_l1a_rx_counter[11:0]	L1As received by TMB
header02_[14:12]	3'b101	DDU code for TMB/ALCT
header02_[15]	1	DDU special-word flag
header03_[11:0]	readout_counter[11:0]	Counts L1A readouts
header03_[14:12]	3'b101	DDU code for TMB/ALCT
header03_[15]	1	DDU special-word flag

### Next 4 words for short-header mode or full-header:

header04_[4:0]	board_id[4:0]	TMB module ID number = VME slot number 1-20
header04_[8:5]	csc_id[3:0]	Chamber ID number, set by VME register
header04_[12:9]	run_id[3:0]	Run info, set by VME register
header04_[13] =	buf_q_ovf_err	Tried to push new event when queue full
header04_[14] =	r_sync_err	BXN sync error

#### *header04 notes:*

- (4) board\_id defaults to the VME crate slot number, unless overridden via VME.
- (2) csc\_id is a user-set value to identify the CSC connected to this TMB
- (3) run\_id is a user-set value to identify the current data run.
- (4) buf\_q\_ovf indicates that more L1As arrived than TMB was able to push into its readout processing queue. In this case the average trigger rate is probably higher than the readout data path can tolerate.
- (5) sync\_err indicates that bx0 did not arrive when the BXN counter turned over to the bxn-preset value. Either bx0 is not functioning, or the 40 MHz clock gained or lost counts. A sync\_err is latched-on until ttc\_resync or ttc\_bxreset.

header05_[5:0]	r_nheaders[5:0]	Number of header words
header05_[8:6]	fifo_mode[2:0]	Raw hits fifo readout mode set via VME
header05_[10:9]	r_type[1:0]	Record type: dump, nodump, full header, short header
header05_[12:11]	l1a_type[1:0]	L1A Pop type code: buffers, no buffers, clct/alct_only
header05_[13]	r_has_buf	Event has clct and rpc buffer data
header05_[14]	r_buf_stalled	Buffer write pointer hit a fence and stalled

*header05 notes:*

- (4) nheaders indicates the length of the current header block, including the BOC marker to 1 frame before the EOB marker.  
In current firmware it will be 8 for short headers and 42 for full.

(2) FIFO Modes:

<u>mode</u>	<u>raw hits</u>	<u>header</u>	
0	no	full	(if buffer was available at pre-trigger)
1	all 5 CFEBs	full	(if buffer was available at pre-trigger)
2	local	full	(if buffer was available at pre-trigger), local=sparsified cfebs
3	no	short	
4	no	no	

(3) Record Type Codes:

<u>r-type</u>	<u>raw hits</u>	<u>header</u>	
0	no	full	
1	full	full	
2	local	full	
3	no	short	(no buffer was available at pre-trigger)

(4) L1A Type Codes:

<u>l1a-type</u>		
0	Normal CLCT trigger with buffer data and L1A window match	
1	ALCT-only trigger, no data buffers	(not usually read out)
2	L1A-only, no matching TMB trigger, no buffer data	(not usually read out)
3	TMB triggered, no L1A-window match, event has buffer data	(not usually read out)

header06_[14:0]	bd_status[14:0]	Board status summary
-----------------	-----------------	----------------------

*header06 notes:*

(1)	bd_status[ 0]	bd_status_ok	Board all-OK: voltages OK, temperature OK, prom-load OK
	bd_status[ 1]	vstat_5p0v	Voltage Comparator +5.0V, 1=OK
	bd_status[ 2]	vstat_3p3v	Voltage Comparator +3.3V, 1=OK
	bd_status[ 3]	vstat_1p8v	Voltage Comparator +1.8V, 1=OK
	bd_status[ 4]	vstat_1p5v	Voltage Comparator +1.5V, 1=OK
	bd_status[ 5]	*t_crit	Temperature ADC Tcritical 1=OK
	bd_status[ 6]	vsm_ok	VME Machine ran without errors
	bd_status[ 7]	vsm_aborted	VME State machine aborted reading PROM
	bd_status[ 8]	vsm_cksum_ok	VME Check-sum matches PROM contents
	bd_status[ 9]	vsm_wdcnt_ok	VME Word count matches PROM contents
	bd_status[10]	jsm_ok	JTAG state machine completed without errors
	bd_status[11]	jsm_aborted	JTAG State machine aborted reading PROM
	bd_status[12]	jsm_cksum_ok	JTAG Check-sum matches PROM contents
	bd_status[13]	jsm_wdcnt_ok	JTAG Word count matches PROM contents
	bd_status[14]	jsm_tck_fpga_ok	FPGA jtag tck detected correctly

header07_[14:0]	revcode[14:0]	Firmware version date code
-----------------	---------------	----------------------------

*header07 notes:*

(1)	revcode[04:00]	day 1-31
	revcode[08:05]	month 1-12
	revcode[12:09]	years after 2000
	revcode[14:13]	fpga type, 1 for xc2v3000, 2 for xc2v4000

## Full Header-mode words 8-EOB: Event Counters

header08_[11:0]	r_bxn_counter_ff[11:0]	CLCT Bunch Crossing number at pre-trigger, 0-3563
header08_[12]	r_tmb_clct0_discard;	TMB discarded clct0 from ME1A
header08_[13]	r_tmb_clct1_discard;	TMB discarded clct1 from ME1A
header08_[14]	clock_lock_lost	Main DLL clock lost lock
header09_[14:0]	r_pretrig_counter[14:0]	Counts CLCT pre-triggers [stops on ovf]
header10_[14:0]	r_pretrig_counter[29:15]	
header11_[14:0]	r_clct_counter[14:0]	Counts CLCTs post-drift [stops on ovf]
header12_[14:0]	r_clct_counter[29:15]	
header13_[14:0]	r_trig_counter[14:0]	Counts TMB triggers to MPC, L1A request to CCB,
header14_[14:0]	r_trig_counter[29:15]	[stops on ovf]
header15_[14:0]	r_alct_counter[14:0]	Counts ALCTs received from ALCT board [stops on ovf]
header16_[14:0]	r_alct_counter[29:15]	
header17_[14:0]	r_orbit_counter[14:0]	BXOs since last hard reset [stops on ovf]
header18_[14:0]	r_orbit_counter[29:15]	

## CLCT Raw Hits Size:

header19_[2:0]	r_ncfeps[2:0]	Number of CFEBs read out
header19_[7:3]	r_fifo_tbins[4:0]	Number of time bins per CFEB in dump
header19_[12:8]	fifo_pretrig[4:0]	Number of time bins before pre-trigger
header19_[13]	scope_data_exists	Readout includes logic analyzer scope data
header19_[14]	mini_read_enable	Readout includes miniscope data, 22wds+2markers

## CLCT Configuration:

header20_[2:0]	hit_thresh_pretrig[2:0]	Hits on pattern template pre-trigger threshold
header20_[6:3]	pid_thresh_pretrig[3:0]	Pattern shape ID pre-trigger threshold
header20_[9:7]	hit_thresh_postdrift[2:0]	Hits on pattern post-drift threshold
header20_[13:10]	pid_thresh_postdrift[3:0]	Pattern shape ID post-drift threshold
header20_[14]	stagger_hs_csc	CSC Staggering ON
header21_[3:0]	triad_persist[3:0]	CLCT Triad persistence
header21_[6:4]	dmb_thresh_pretrig[2:0]	DMB pre-trigger threshold for active-cfeb list
header21_[10:7]	alct_delay[3:0]	Delay ALCT for CLCT match window
header21_[14:11]	clct_window[3:0]	CLCT match window width

## CLCT Trigger Status:

header22\_[8:0] r\_trig\_source\_vec[8:0] Pre-trigger source vector  
header22\_[14:9] r\_layers\_hit\_vec[5:0] CSC layers hit on layer trigger

*header22 notes:*

- (1) trig\_source [ 0] CLCT pattern triggered sequencer
- trig\_source [ 1] ALCT pattern triggered sequencer
- trig\_source [ 2] ALCT\*CLCT pattern triggered sequencer
- trig\_source [ 3] ADB external triggered sequencer
- trig\_source [ 4] DMB external triggered sequencer
- trig\_source [ 5] CLCT (CCB scintillator) external triggered sequencer
- trig\_source [ 6] ALCT (CCB) external triggered sequencer
- trig\_source [ 7] VME triggered sequencer
- trig\_source [ 8] Layer-mode trigger

header23\_[4:0] r\_active\_feb\_mux[4:0] Active CFEB list sent to DMB  
header23\_[9:5] r\_cfefs\_read[4:0] CFEBs read out for this event  
header23\_[13:10] pop\_l1a\_match\_win[3:0] Position of l1a in window  
header23\_[14] active\_feb\_src Active CFEB list source, 0=pretrig, 1=at TMB match

**CLCT+ALCT Match Status:**

header24\_[0] r\_tmb\_match ALCT and CLCT matched in time, pushed into L1A queue  
header24\_[1] r\_tmb\_alct\_only Only ALCT triggered, pushed into L1A queue  
header24\_[2] r\_tmb\_clct\_only Only CLCT triggered, pushed into L1A queue  
header24\_[6:3] r\_tmb\_match\_win[3:0] Location of alct in clct window, pushed into L1A queue  
header24\_[7] r\_no\_alct\_tmb; No ALCT  
header24\_[8] r\_one\_alct\_tmb; One ALCT  
header24\_[9] r\_one\_clct\_tmb; One CLCT  
header24\_[10] r\_two\_alct\_tmb; Two ALCTs  
header24\_[11] r\_two\_clct\_tmb; Two CLCTs  
header24\_[12] r\_dupe\_alct\_tmb; ALCT0 copied into ALCT1 to make 2<sup>nd</sup> LCT  
header24\_[13] r\_dupe\_clct\_tmb; CLCT0 copied into CLCT1 to make 2<sup>nd</sup> LCT  
header24\_[14] r\_rank\_err\_tmb; LCT1 has higher quality than LCT0, error

## CLCT Trigger Data:

header25_[14:0]	r_clct0_tmb[14:0]	CLCT0 after drift lsbs
header26_[14:0]	r_clct1_tmb[14:0]	CLCT1 after drift lsbs
header27_[0]	r_clct0_tmb[15]	CLCT0 after drift msbs
header27_[1]	r_clct1_tmb[15]	CLCT1 after drift msbs
header27_[4:2]	r_clctc_tmb[2:0]	CLCT0/1 common after drift msbs
header27_[5]	r_clct0_invp	CLCT0 had invalid pattern after drift delay
header27_[6]	r_clct1_invp	CLCT1 had invalid pattern after drift delay
header27_[7]	r_clct1_busy	2 <sup>nd</sup> CLCT busy, logic error indicator
header27_[12:8]	perr_cfeb_ff[4:0]	CFEB raw hits RAM parity error, latched, SEU detection
header27_[13] 0	perr_rpc_ff   perr_mini_ff	RPC raw hits RAM parity error, latched, SEU detection
header27_[14] 0	perr_ff	Raw hits RAM parity error summary, latched, SEU

*header25-27 notes:*

(4) clct0, clct1, clctc packing format:

clct0[0]	clct_1 <sup>st</sup> _valid	Valid pattern flag
clct0[3:1]	hs_hit_1 <sup>st</sup> [2:0]	Hits on pattern 0-6
clct0[7:4]	hs_pid_1 <sup>st</sup> [3:0]	Pattern shape 0-A
clct0[15:8]	hs_key_1 <sup>st</sup> [7:0]	½-strip ID number
clct1[0]	clct_2 <sup>nd</sup> _valid	Valid pattern flag
clct1[3:1]	hs_hit_2 <sup>nd</sup> [2:0]	Hits on pattern 0-6
clct1[7:4]	hs_pid_2 <sup>nd</sup> [3:0]	Pattern shape 0-A
clct1[15:8]	hs_key_2 <sup>nd</sup> [7:0]	½-strip ID number
clctc[1:0]	bxn_counter_ff[1:0]	Bunch crossing number at pretrigger, common to clct0/1
clctc[2]	sync_err	BX0 disagrees with BXN count, common to clct0/1

## ALCT Trigger Data:

header28_[0]	alct_1 <sup>st</sup> _valid	ALCT0 valid pattern flag
header28_[2:1]	alct_1 <sup>st</sup> _quality[1:0]	ALCT0 quality
header28_[3]	alct_1 <sup>st</sup> _amu	ALCT0 accelerator muon flag
header28_[10:4]	alct_1 <sup>st</sup> _key[6:0]	ALCT0 key wire group
header28_[14:11]	alct_pretrig_win[3:0]	ALCT active_feb_flag position in pretrig window
header29_[0]	alct_2 <sup>nd</sup> _valid	ALCT1 valid pattern flag
header29_[2:1]	alct_2 <sup>nd</sup> _quality[1:0]	ALCT1 quality
header29_[3]	alct_2 <sup>nd</sup> _amu	ALCT1 accelerator muon flag
header29_[10:4]	alct_2 <sup>nd</sup> _key[6:0]	ALCT1 key wire group
header29_[12:11]	drift_delay[1:0]	CLCT drift delay
header29_[13]	bcb_read_enable	CFEB blocked DiStrip bits list included in readout
header29_[14]	hs_layer_trig	Layer-mode trigger
header30_[4:0]	alct_bxn[4:0]	ALCT0/1 bxn
header30_[6:5]	alct_ecc_err[1:0]	ALCT trigger path ECC error code
header30_[11:7]	cfeb_badbits_found[4:0]	Bad distrip bits detected in cfeb[n]
header30_[12]	cfeb_badbits_blocked	At least one CFEB has a bad bit that was blocked
header30_[13]	alct_cfg_done	ALCT FPGA configuration done
header30_[14]	bx0_match	alct_bx0==clct_bx0, latched at clct_bx0 time

## MPC Frames:

header31_[14:0]	r_mpc0_frame0_ff[14:0]	MPC muon 0 frame 0 LSBs
header32_[14:0]	r_mpc0_frame1_ff[14:0]	MPC muon 0 frame 1 LSBs
header33_[14:0]	r_mpc1_frame0_ff[14:0]	MPC muon 1 frame 0 LSBs
header34_[14:0]	r_mpc1_frame1_ff[14:0]	MPC muon 1 frame 1 LSBs
header35_[0]	= r_mpc0_frame0_ff[15]	MPC muon 0 frame 0 MSB
header35_[1]	= r_mpc0_frame1_ff[15]	MPC muon 0 frame 1 MSB
header35_[2]	= r_mpc1_frame0_ff[15]	MPC muon 1 frame 0 MSB
header35_[3]	= r_mpc1_frame1_ff[15]	MPC muon 1 frame 1 MSB
header35_[7:4]	mpc_tx_delay[3:0]	MPC transmit delay
header35_[9:8]	r_mpc_accept[1:0]	MPC muon accept response
header35_[14:10]	cfeb_en[4:0]	CFEBs enabled for triggering (didn't fit elsewhere)

### *header31-35 notes:*

#### (4) MPCframe packing format:

	mpc0_frame0[6:0]	=	alct0_key[6:0];	
	mpc0_frame0[10:7]	=	clct0_pat[3:0];	
	mpc0_frame0[14:11]	=	lct0_quality[3:0];	
	mpc0_frame0[15]	=	lct0_vpf;	
	mpc0_frame1[7:0]	=	{clct0_cfeb[2:0],clct0_key[4:0]};	
	mpc0_frame1[8]	=	clct0_bend;	
	mpc0_frame1[9]	=	clct_sync_err & tmb_sync_err_en[0];	
	mpc0_frame1[10]	=	alct0_bxn[0];	
	mpc0_frame1[11]	=	clct_bx0;	// bx0 gets replaced after mpc_tx_delay, keep here to mollify
xst	mpc0_frame1[15:12]	=	csc_id[3:0];	
	mpc1_frame0[6:0]	=	alct1_key[6:0];	
	mpc1_frame0[10:7]	=	clct1_pat[3:0];	
	mpc1_frame0[14:11]	=	lct1_quality[3:0];	
	mpc1_frame0[15]	=	lct1_vpf;	
	mpc1_frame1[7:0]	=	{clct1_cfeb[2:0],clct1_key[4:0]};	
	mpc1_frame1[8]	=	clct1_bend;	
	mpc1_frame1[9]	=	clct_sync_err & tmb_sync_err_en[1];	
	mpc1_frame1[10]	=	alct1_bxn[0];	
	mpc1_frame1[11]	=	alct_bx0;	// bx0 gets replaced after mpc_tx_delay, keep here to mollify
xst	mpc1_frame1[15:12]	=	csc_id[3:0];	



## RPC Configuration:

header36_[1:0]	rd_list_rpc[1:0]	RPCs included in read out
header36_[3:2]	r_nrpcs_read[1:0]	Number of RPCs in readout, 0,1,2, 0 if header-only
header36_[4]	= rpc_read_enable	RPC readout enabled
header36_[9:5]	fifo_tbins_rpc[4:0]	Number RPC FIFO time bins to read out
header36_[14:10]	fifo_pretrig_rpc[4:0]	Number RPC FIFO time bins before pretrigger

## Buffer Status:

header37_[10:0]	r_wr_buf_adr[10:0]	Buffer RAM write address at pretrigger
header37_[11]	r_wr_buf_ready	Write buffer was ready at pretrig
header37_[12]	wr_buf_ready	Write buffer ready now
header37_[13]	buf_q_full	All raw hits ram in use, ram writing must stop
header37_[14]	buf_q_empty	No fences remain on buffer stack
header38_[10:0]	r_buf_fence_dist[10:0]	Distance to 1 <sup>st</sup> fence address at pretrigger
header38_[11]	buf_q_ovf_err	Tried to push when stack full
header38_[12]	buf_q_udf_err	Tried to pop when stack empty
header38_[13]	buf_q_adr_err	Fence adr popped from stack doesn't match rls adr
header38_[14]	buf_stalled_once	Buffer stalled at least once since last resync
header39_[11:0]	buf_fence_cnt[11:0]	Number of fences in fence RAM currently
header39_[12]	reverse_hs_csc	1=Reverse staggered CSC, non-me1
header39_[13]	reverse_hs_me1a	1=ME1A hstrip order reversed
header39_[14]	reverse_hs_me1b	1=ME1B hstrip order reversed
header40_[1:0]	active_feb_mux[6:5];	Extend Hdr23[4:0] Active CFEB list sent to DMB
header40_[3:2]	r_cfefs_read[6:5];	Extend Hdr23[9:5] CFEBs read out for this event
header40_[5:4]	perr_cfef_ff[6:5];	Extend Hdr27[12:8] CFEB RAM parity error, latched
header40_[7:6]	cfeb_badbits_found[6:5];	Extend Hdr30[11:7] CFEB[n] has at least 1 bad bit
header40_[9:8]	cfeb_en[6:5];	Extend Hdr35[14:10] CFEBs enabled for triggering
header40_[10]	buf_fence_cnt_is_peak;	Current fence is peak number of fences in RAM
header40_[11]	(MXCFEB==7);	TMB has 7 DCFEBs so hdr40_[10:0] are active
header40_[13:12]	r_trig_source_vec[10:9]	Pre-trigger source vector for ME1A/B
header40_[14]	r_tmb_trig_pulse	TMB trig_pulse signal matched rtmb_push

## Spare Frame:

header41_[0]	tmb_allow_alct	Allow ALCT-only tmb-matching
header41_[1]	tmb_allow_clct	Allow CLCT-only tmb-matching
header41_[2]	tmb_allow_match	Allow Match-only tmb-matching
header41_[3]	tmb_allow_alct_ro	Allow ALCT-only tmb-matching, non-trigger readout
header41_[4]	tmb_allow_clct_ro	Allow CLCT-only tmb-matching, non-trigger readout
header41_[5]	tmb_allow_match_ro	Allow Match-only tmb-matching, non-trigger readout
header41_[6]	r_tmb_alct_only_ro	Only ALCT trig, pushed into L1A queue, non-triggering
header41_[7]	r_tmb_clct_only_ro	Only CLCT trig, pushed into L1A queue, non-triggering
header41_[8]	r_tmb_match_ro	ALCT*CLCT match, pushed into L1A queue, non-triggering
header41_[9]	r_tmb_trig_keep	This is a triggering readout event
header41_[10]	r_tmb_non_trig_keep	This is a non-triggering readout event
header41_[13:11]	lyr_thresh_pretrig[2:0]	Layer pre-trigger threshold
header41_[14]	layer_trig_en	Layer-trigger mode enabled

# TMB Data Format: Short Header Mode

FIFO Control				DDU	TMB Data [14:0]														
Frame #	/write fifo	DAV Data Available	last word	d15 DDU special	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1	d0
No Write	1	1	0	0															
0	0	0	0	1	DDU Code 101 <sub>2</sub>			BOC <sub>16</sub>											
1	0	0	0	1	DDU Code 101 <sub>2</sub>			BXN Counter at L1A arrival [11:0]											
2	0	0	0	1	DDU Code 101 <sub>2</sub>			L1A Rx Counter [11:0]											
3	0	0	0	1	DDU Code 101 <sub>2</sub>			Readout Counter[11:0]											
4	0	0	0	0	sync err	buf_q ovf	run_id[3:0]				csc_id[3:0]				board_id[4:0]				
5	0	0	0	0	buf stalled	has buf	l1a_type[1:0]		rec_type[1:0]		fifo_mode[2:0]			nheader_words[5:0]					
6	0	0	0	0	board_status[14:0]														
7	0	0	0	0	firmware_revcode[14:0]														
8	0	0	0	1	DDU Code 101 <sub>2</sub>			EEF <sub>16</sub> [11:0] (=EOF for full header events, EEF for short header)											
9	0	0	0	1	DDU Code 101 <sub>2</sub>			1 TMB	CRC22[10:0]										
10	0	0	0	1	DDU Code 101 <sub>2</sub>			1 TMB	CRC22[21:11]										
11	0	0	1	1	DDU Code 101 <sub>2</sub>			1 TMB	Word Count [10:0]										
No Write	1	0	0	0															
Frame #	/write fifo	DAV Data Available	last word	d15	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1	d0

### ALCT Header/Trailer Format:

FIFO Control				DDU	ALCT Data [14:0]														
Frame #	/write fifo	DAV Data Available	last word	d15 DDU special	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1	d0
No Write	1	1	0	0															
0	0	0	0	1	DDU Code 101 <sub>2</sub>			B0A <sub>16</sub>											
1	0	0	0	1	DDU Code 101 <sub>2</sub>			BXN Counter at L1A arrival [11:0]											
2	0	0	0	1	DDU Code 101 <sub>2</sub>			L1A Rx Counter [11:0]											
3	0	0	0	1	DDU Code 101 <sub>2</sub>			Readout Counter[11:0]											

n-3	0	0	0	1	DDU Code 101 <sub>2</sub>			E0D <sub>16</sub> [11:0]											
n-2	0	0	0	1	DDU Code 101 <sub>2</sub>			0 ALCT	CRC22[10:0]										
n-1	0	0	0	1	DDU Code 101 <sub>2</sub>			0 ALCT	CRC22[21:11]										
n	0	0	1	1	DDU Code 101 <sub>2</sub>			0 CRC OK=1	Word Count [10:0]										
No Write	1	0	0	0															
Frame #	/write fifo	DAV Data Available	last word	d15	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1	d0

**Notes:**

[1] CRC OK=1 is inserted by TMB after it calculates the CRC for data received from ALCT, and compares it to the CRC words sent by ALCT

# TMB Data Format: Long Header-Only Mode

FIFO Control				DDU	TMB Data [14:0]														
Frame #	/write fifo	DAV Data Available	last word	d15 DDU special	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1	d0
No Write	1	1	0	0															
0	0	0	0	1	DDU Code 101 <sub>2</sub>			B0C <sub>16</sub>											
1	0	0	0	1	DDU Code 101 <sub>2</sub>			BXN Counter at L1A arrival [11:0]											
2	0	0	0	1	DDU Code 101 <sub>2</sub>			L1A Rx Counter [11:0]											
3	0	0	0	1	DDU Code 101 <sub>2</sub>			Readout Counter[11:0]											
4	0	0	0	0	sync err	buf_q ovf	run_id[3:0]			csc_id[3:0]			board_id[4:0]						
5	0	0	0	0	buf stalled	has buf	l1a_type[1:0]		rec_type[1:0]		fifo_mode[2:0]			nheader_words[5:0]					
6	0	0	0	0	board_status[14:0]														
7	0	0	0	0	firmware_revcode[14:0]														
8	0	0	0	0	lock lost	clct1 discard	clct0 discard	bxn_counter_ff[11:0]											
9	0	0	0	0	pretrig_counter[14:0]														
10	0	0	0	0	pretrig_counter[29:15]														
11	0	0	0	0	clct_counter[14:0]														
12	0	0	0	0	clct_counter[29:15]														
13	0	0	0	0	trig_counter[14:0]														
14	0	0	0	0	trig_counter[29:15]														
15	0	0	0	0	alct_counter[14:0]														
16	0	0	0	0	alct_counter[29:15]														
17	0	0	0	0	uptime_counter[14:0]														
18	0	0	0	0	uptime_counter[29:15]														
19	0	0	0	0	miniscope read ena	scope esixts	fifo_pretrig[4:0]				fifo_tbins[4:0]				ncfebs[2:0]				
20	0	0	0	0	stagger csc	pid_thresh_postdrift[3:0]				hit_thresh_postdrift[2:0]			pid_thresh_pretrig[3:0]			hit_thresh_pretrig[2:0]			
21	0	0	0	0	clct_window[3:0]				alct_delay[3:0]				dmb_thresh_pretrig[2:0]			triad_persist[3:0]			
22	0	0	0	0	layers_hit_vec[5:0]						trig_source_vec[8:0]								
23	0	0	0	0	aff source	l1a_match_win[3:0]				cfebs_read[4:0]					active_cfeb[4:0]				
24	0	0	0	0	lct rank err	dupe clct	dupe alct	two clct	two alct	one clct	one alct	no alct	match_win[3:0]				clct only	alct only	tmb match
25	0	0	0	0	clct0[14:0]														
26	0	0	0	0	clct1[14:0]														

27	0	0	0	0	perr summary	perr rpc+mini	parity error cfeb ram[4:0] SEU				clct1 busy	clct1 invp	clct0 invp	clctc[2:0]			clct1[15]	clct0[15]		
28	0	0	0	0	alct_pretrig_win[3:0]			alct0_key[6:0]					alct0 amu		alct0 quality[1:0]		alct0 valid			
29	0	0	0	0	layer triggerd	bcfb readout	drift_delay[1:0]		alct1_key[6:0]					alct1 amu		alct1 quality[1:0]		alct1 valid		
30	0	0	0	0	bx0 match	alct cfg done	cfeb bits blocked	cfeb_badbits_found[4:0]				alct_ecc_err[1:0]		alct_bxn[4:0]						
31	0	0	0	0	mpc0_frame0[14:0]															
32	0	0	0	0	mpc0_frame1[14:0]															
33	0	0	0	0	mpc1_frame0[14:0]															
34	0	0	0	0	mpc1_frame1[14:0]															
35	0	0	0	0	cfeb_en[4:0]				mpc_accept[1:0]		mpc_tx_delay[3:0]			mpc1fr1 [15]	mpc1fr0 [15]	mpc0fr1 [15]	mpc0fr0 [15]			
36	0	0	0	0	fifo_pretrig_rpc[4:0]				fifo_tbins_rpc[4:0]				rpc read en	nrpcs[1:0]		rpc_list[1:0]				
37	0	0	0	0	buf_q empty	buf_q full	wr_buf ready	r_wr_buf ready	r_wr_buf_adr[10:0]											
38	0	0	0	0	buf stalled ff	buf_q adr err	buf_q udf err	buf_q ovf err	r_buf_fence_dist[10:0]											
39	0	0	0	0	reverse me1b	reverse me1a	reverse csc	buf_fence_cnt[11:0]												
40	0	0	0	0	tmb trig pulse	trig_src_vec[10:9]		mxcfeb=7	peak fence	cfeb_en[6:5]		perr_cfeb[6:5 ]		cfeb_badbits_found[6:5]		cfebs_read[6:5]		active_cfeb[6:5]		
41	0	0	0	0	layer trig enabled	lyr_thresh_pretrig[2:0]			non-trig readout	triggered readout	non-trig match ro	non-trig clct ro	non-trig alct o	allow match ro	allow clct ro	allow alct ro	allow match	allow clct	allow alct	
42	0	0	0	0	6				EOB End Header Block											
43	0	0	0	0	6				EOC End Cathode Block											
44	0	0	0	1	DDU Code 101 <sub>2</sub>				EOF <sub>16</sub> [11:0]											
45	0	0	0	1	DDU Code 101 <sub>2</sub>				1 TMB	CRC22[10:0]										
46	0	0	0	1	DDU Code 101 <sub>2</sub>				1 TMB	CRC22[21:11]										
47	0	0	1	1	DDU Code 101 <sub>2</sub>				1 TMB	Word Count [10:0]										
No Write	1	0	0	0																
Frame #	/write fifo	DAV Data Available	last word	d15	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1	d0	

# TMB Data Format: Full-Readout Mode

FIFO Control				DDU	TMB Data [14:0]														
Frame #	/write fifo	DAV Data Available	last word	d15 DDU special	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1	d0
No Write	1	1	0	0															
0	0	0	0	1	DDU Code 101 <sub>2</sub>			BOC <sub>16</sub>											
1	0	0	0	1	DDU Code 101 <sub>2</sub>			BXN Counter at L1A arrival [11:0]											
2	0	0	0	1	DDU Code 101 <sub>2</sub>			L1A Rx Counter [11:0]											
3	0	0	0	1	DDU Code 101 <sub>2</sub>			Readout Counter[11:0]											
4	0	0	0	0	sync err	buf_q ovf	run_id[3:0]			csc_id[3:0]			board_id[4:0]						
5	0	0	0	0	buf stalled	has buf	l1a_type[1:0]		rec_type[1:0]		fifo_mode[2:0]			nheader_words[5:0]					
6	0	0	0	0	board_status[14:0]														
7	0	0	0	0	firmware_revcode[14:0]														
8	0	0	0	0	lock lost	clct1 discard	clct0 discard	bxn_counter_ff[11:0]											
9	0	0	0	0	pretrig_counter[14:0]														
10	0	0	0	0	pretrig_counter[29:15]														
11	0	0	0	0	clct_counter[14:0]														
12	0	0	0	0	clct_counter[29:15]														
13	0	0	0	0	trig_counter[14:0]														
14	0	0	0	0	trig_counter[29:15]														
15	0	0	0	0	alct_counter[14:0]														
16	0	0	0	0	alct_counter[29:15]														
17	0	0	0	0	uptime_counter[14:0]														
18	0	0	0	0	uptime_counter[29:15]														
19	0	0	0	0	miniscopere ad ena	scope esixts	fifo_pretrig[4:0]				fifo_tbins[4:0]				ncfebs[2:0]				
20	0	0	0	0	stagger csc	pid_thresh_postdrift[3:0]				hit_thresh_postdrift[2:0]			pid_thresh_pretrig[3:0]			hit_thresh_pretrig[2:0]			
21	0	0	0	0	clct_window[3:0]				alct_delay[3:0]			dmb_thresh_pretrig[2:0]			triad_persist[3:0]				
22	0	0	0	0	layers_hit_vec[5:0]						trig_source_vec[8:0]								
23	0	0	0	0	aff source	l1a_match_win[3:0]				febs_read[4:0]				active_feb[4:0]					
24	0	0	0	0	lct rank err	dupe clct	dupe alct	two clct	two alct	one clct	one alct	no alct	match_win[3:0]				clct only	alct only	tmb match
25	0	0	0	0	clct0[14:0]														
26	0	0	0	0	clct1[14:0]														

27	0	0	0	0	perr summary	perr rpc+mini	parity error cfeb ram[4:0] SEU				clct1 busy	clct1 invp	clct0 invp	clctc[2:0]				clct1[15]	clct0[15]
28	0	0	0	0	alct_pretrig_win[3:0]				alct0_key[6:0]					alct0 amu		alct0 quality[1:0]		alct0 valid	
29	0	0	0	0	layer triggerd	bcfb readout	drift_delay[1:0]		alct1_key[6:0]					alct1 amu		alct1 quality[1:0]		alct1 valid	
30	0	0	0	0	bx0 match	alct cfg done	cfcb bits blocked	cfcb_badbits_found[4:0]				alct_ecc_err[1:0]		alct_bxn[4:0]					
31	0	0	0	0	mpc0_frame0[14:0]														
32	0	0	0	0	mpc0_frame1[14:0]														
33	0	0	0	0	mpc1_frame0[14:0]														
34	0	0	0	0	mpc1_frame1[14:0]														
35	0	0	0	0	cfcb_en[4:0]				mpc_accept[1:0]		mpc_tx_delay[3:0]			mpc1fr1 [15]	mpc1fr0 [15]	mpc0fr1 [15]	mpc0fr0 [15]		
36	0	0	0	0	fifo_pretrig_rpc[4:0]				fifo_tbins_rpc[4:0]				rpc read en	nrpcs[1:0]		rpc_list[1:0]			
37	0	0	0	0	buf_q empty	buf_q full	wr_buf ready	r_wr_buf ready	r_wr_buf_adr[10:0]										
38	0	0	0	0	buf stalled ff	buf_q adr err	buf_q udf err	buf_q ovf err	r_buf_fence_dist[10:0]										
39	0	0	0	0	reverse me1b	reverse me1a	reverse csc	buf_fence_cnt[11:0]											
40	0	0	0	0	tmb trig pulse	trig_src_vec[10:9]		mxcfcb=7	peak fence	cfcb_en[6:5]		perr_cfeb[6:5]		cfcb_badbits_found[6:5]		cfcb_read[6:5 ]	active_cfeb[6:5]		
41	0	0	0	0	layer trig enabled	lyr_thresh_pretrig[2:0]		non-trig readout	triggered readout	non-trig match ro	non-trig clct ro	non-trig alct o	allow match ro	allow clct ro	allow alct ro	allow match	allow clct	allow alct	
42	0	0	0	0	6			EOB End Header Block											
43					CFEB 0			Tbin 0			Ly0[7:0] Triad bits								
44					CFEB 0			Tbin 0			Ly1[7:0]								
45					CFEB 0			Tbin 0			Ly2[7:0]								
46					CFEB 0			Tbin 0			Ly3[7:0]								
47					CFEB 0			Tbin 0			Ly4[7:0]								
48					CFEB 0			Tbin 0			Ly5[7:0]								
49					CFEB 0			Tbin 1			Ly0[7:0]								
50					CFEB 0			Tbin 1			Ly1[7:0]								
51					CFEB 0			Tbin 1			Ly2[7:0]								
52					CFEB 0			Tbin 1			Ly3[7:0]								
53					CFEB 0			Tbin 1			Ly4[7:0]								
54					CFEB 0			Tbin 1			Ly5[7:0]								
55-246					---			---			---								
247					CFEB 4			Tbin 6			Ly0[7:0]								
248					CFEB 4			Tbin 6			Ly1[7:0]								

249					CFEB 4	Tbin 6			Ly2[7:0]											
250					CFEB 4	Tbin 6			Ly3[7:0]											
251					CFEB 4	Tbin 6			Ly4[7:0]											
252					CFEB 4	Tbin 6			Ly5[7:0]											
253					6	B04 <sub>16</sub> Begin RPC Raw Hits (if RPC readout enabled)														
254					RPC 0	Tbin 0			Pads[7:0] RPC0 Pads											
255					RPC 0	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
256					RPC 0	Tbin 1			Pads[7:0]											
257					RPC 0	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
258					RPC 0	Tbin 2			Pads[7:0]											
259					RPC 0	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
260					RPC 0	Tbin 3			Pads[7:0]											
261					RPC 0	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
262					RPC 0	Tbin 4			Pads[7:0]											
263					RPC 0	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
264					RPC 0	Tbin 5			Pads[7:0]											
265					RPC 0	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
266					RPC 0	Tbin 6			Pads[7:0]											
267					RPC 0	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
268					RPC 1	Tbin 0			Pads[7:0] RPC1 Pads											
269					RPC 1	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
270-279					--	--			--											
280					RPC 1	Tbin 6			Pads[7:0]											
281					RPC 1	clct pretrigger	rpc_bxn[2:0]			Pads[15:8]										
282					6	E04 <sub>16</sub> End RPC Raw Hits														
283					6	E0C <sub>16</sub> End Cathode Data														
opt					2AAA <sub>16</sub> [14:0] (Optional to make word count multiple of 4)															
opt					5555 <sub>16</sub> [14:0] (Optional to make word count multiple of 4)															
284	0	0	0	1	DDU Code 101 <sub>2</sub>			E0F <sub>16</sub> [11:0]												
285	0	0	0	1	DDU Code 101 <sub>2</sub>			1 TMB	CRC22[10:0]											
286	0	0	0	1	DDU Code 101 <sub>2</sub>			1 TMB	CRC22[21:11]											
287	0	0	1	1	DDU Code 101 <sub>2</sub>			1 TMB	Word Count [10:0]											
No Write	1	0	0	0																
Frame #	/write fifo	DAV Data Available	last word	d15	d14	d13	d12	d11	d1	d9	d8	d7	d6	d5	d4	d3	d2	d1	d0	



									0										
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## Sample TMB Raw Hits Dump

TMB internal pattern injector + RPC internal pattern injector

7-Time bins, full 5 CLCTs+ 2 RPCs raw hits readout (Blocked CFEB DiStrips list turned off)

Adr= 0 Data=2DB0C	Adr= 68 Data=00400	Adr= 136 Data=02100	Adr= 204 Data=03500
Adr= 1 Data=0DCC8	Adr= 69 Data=00402	Adr= 137 Data=02100	Adr= 205 Data=03600
Adr= 2 Data=0D001	Adr= 70 Data=00400	Adr= 138 Data=02100	Adr= 206 Data=03600
Adr= 3 Data=0D001	Adr= 71 Data=00402	Adr= 139 Data=02200	Adr= 207 Data=03600
Adr= 4 Data=04045	Adr= 72 Data=00400	Adr= 140 Data=02200	Adr= 208 Data=03600
Adr= 5 Data=0226A	Adr= 73 Data=00500	Adr= 141 Data=02200	Adr= 209 Data=03600
Adr= 6 Data=0777F	Adr= 74 Data=00500	Adr= 142 Data=02200	Adr= 210 Data=03600
Adr= 7 Data=0512C	Adr= 75 Data=00500	Adr= 143 Data=02200	Adr= 211 Data=04000
Adr= 8 Data=00C47	Adr= 76 Data=00500	Adr= 144 Data=02200	Adr= 212 Data=04000
Adr= 9 Data=00001	Adr= 77 Data=00500	Adr= 145 Data=02300	Adr= 213 Data=04000
Adr= 10 Data=00000	Adr= 78 Data=00500	Adr= 146 Data=02300	Adr= 214 Data=04000
Adr= 11 Data=00001	Adr= 79 Data=00600	Adr= 147 Data=02300	Adr= 215 Data=04000
Adr= 12 Data=00000	Adr= 80 Data=00600	Adr= 148 Data=02300	Adr= 216 Data=04000
Adr= 13 Data=00001	Adr= 81 Data=00600	Adr= 149 Data=02300	Adr= 217 Data=04100
Adr= 14 Data=00000	Adr= 82 Data=00600	Adr= 150 Data=02300	Adr= 218 Data=04100
Adr= 15 Data=00001	Adr= 83 Data=00600	Adr= 151 Data=02400	Adr= 219 Data=04100
Adr= 16 Data=00000	Adr= 84 Data=00600	Adr= 152 Data=02400	Adr= 220 Data=04100
Adr= 17 Data=002DD	Adr= 85 Data=01000	Adr= 153 Data=02400	Adr= 221 Data=04100
Adr= 18 Data=00000	Adr= 86 Data=01000	Adr= 154 Data=02400	Adr= 222 Data=04100
Adr= 19 Data=0023D	Adr= 87 Data=01000	Adr= 155 Data=02400	Adr= 223 Data=04200
Adr= 20 Data=04204	Adr= 88 Data=01000	Adr= 156 Data=02400	Adr= 224 Data=04200
Adr= 21 Data=01A46	Adr= 89 Data=01000	Adr= 157 Data=02500	Adr= 225 Data=04200
Adr= 22 Data=07E01	Adr= 90 Data=01000	Adr= 158 Data=02500	Adr= 226 Data=04200
Adr= 23 Data=003E1	Adr= 91 Data=01100	Adr= 159 Data=02500	Adr= 227 Data=04200
Adr= 24 Data=00301	Adr= 92 Data=01100	Adr= 160 Data=02500	Adr= 228 Data=04200
Adr= 25 Data=005AD	Adr= 93 Data=01100	Adr= 161 Data=02500	Adr= 229 Data=04300
Adr= 26 Data=00000	Adr= 94 Data=01100	Adr= 162 Data=02500	Adr= 230 Data=04300
Adr= 27 Data=0531C	Adr= 95 Data=01100	Adr= 163 Data=02600	Adr= 231 Data=04300
Adr= 28 Data=010A7	Adr= 96 Data=01100	Adr= 164 Data=02600	Adr= 232 Data=04300
Adr= 29 Data=01000	Adr= 97 Data=01200	Adr= 165 Data=02600	Adr= 233 Data=04300
Adr= 30 Data=00001	Adr= 98 Data=01200	Adr= 166 Data=02600	Adr= 234 Data=04300
Adr= 31 Data=07D0A	Adr= 99 Data=01200	Adr= 167 Data=02600	Adr= 235 Data=04400
Adr= 32 Data=02605	Adr= 100 Data=01200	Adr= 168 Data=02600	Adr= 236 Data=04400
Adr= 33 Data=00000	Adr= 101 Data=01200	Adr= 169 Data=03000	Adr= 237 Data=04400
Adr= 34 Data=00000	Adr= 102 Data=01200	Adr= 170 Data=03000	Adr= 238 Data=04400
Adr= 35 Data=07C01	Adr= 103 Data=01300	Adr= 171 Data=03000	Adr= 239 Data=04400
Adr= 36 Data=008FB	Adr= 104 Data=01300	Adr= 172 Data=03000	Adr= 240 Data=04400
Adr= 37 Data=01E25	Adr= 105 Data=01300	Adr= 173 Data=03000	Adr= 241 Data=04500
Adr= 38 Data=007FF	Adr= 106 Data=01300	Adr= 174 Data=03000	Adr= 242 Data=04500
Adr= 39 Data=00001	Adr= 107 Data=01300	Adr= 175 Data=03100	Adr= 243 Data=04500
Adr= 40 Data=06001	Adr= 108 Data=01300	Adr= 176 Data=03100	Adr= 244 Data=04500
Adr= 41 Data=02326	Adr= 109 Data=01400	Adr= 177 Data=03100	Adr= 245 Data=04500
Adr= 42 Data=06E0B	Adr= 110 Data=01400	Adr= 178 Data=03100	Adr= 246 Data=04500
Adr= 43 Data=00000	Adr= 111 Data=01400	Adr= 179 Data=03100	Adr= 247 Data=04600
Adr= 44 Data=00000	Adr= 112 Data=01400	Adr= 180 Data=03100	Adr= 248 Data=04600
Adr= 45 Data=00000	Adr= 113 Data=01400	Adr= 181 Data=03200	Adr= 249 Data=04600
Adr= 46 Data=00000	Adr= 114 Data=01400	Adr= 182 Data=03200	Adr= 250 Data=04600
Adr= 47 Data=00000	Adr= 115 Data=01500	Adr= 183 Data=03200	Adr= 251 Data=04600
Adr= 48 Data=00000	Adr= 116 Data=01500	Adr= 184 Data=03200	Adr= 252 Data=04600
Adr= 49 Data=00100	Adr= 117 Data=01500	Adr= 185 Data=03200	Adr= 253 Data=06B04
Adr= 50 Data=00100	Adr= 118 Data=01500	Adr= 186 Data=03200	Adr= 254 Data=00000
Adr= 51 Data=00100	Adr= 119 Data=01500	Adr= 187 Data=03300	Adr= 255 Data=00000
Adr= 52 Data=00100	Adr= 120 Data=01500	Adr= 188 Data=03300	Adr= 256 Data=00100
Adr= 53 Data=00100	Adr= 121 Data=01600	Adr= 189 Data=03300	Adr= 257 Data=00000
Adr= 54 Data=00100	Adr= 122 Data=01600	Adr= 190 Data=03300	Adr= 258 Data=00200
Adr= 55 Data=00202	Adr= 123 Data=01600	Adr= 191 Data=03300	Adr= 259 Data=007AB
Adr= 56 Data=00202	Adr= 124 Data=01600	Adr= 192 Data=03300	Adr= 260 Data=00301
Adr= 57 Data=00202	Adr= 125 Data=01600	Adr= 193 Data=03400	Adr= 261 Data=006AB
Adr= 58 Data=00202	Adr= 126 Data=01600	Adr= 194 Data=03400	Adr= 262 Data=00402
Adr= 59 Data=00202	Adr= 127 Data=02000	Adr= 195 Data=03400	Adr= 263 Data=005AB
Adr= 60 Data=00202	Adr= 128 Data=02000	Adr= 196 Data=03400	Adr= 264 Data=00503
Adr= 61 Data=00300	Adr= 129 Data=02000	Adr= 197 Data=03400	Adr= 265 Data=004AB
Adr= 62 Data=00302	Adr= 130 Data=02000	Adr= 198 Data=03400	Adr= 266 Data=00604
Adr= 63 Data=00300	Adr= 131 Data=02000	Adr= 199 Data=03500	Adr= 267 Data=003AB
Adr= 64 Data=00302	Adr= 132 Data=02000	Adr= 200 Data=03500	Adr= 268 Data=01000
Adr= 65 Data=00300	Adr= 133 Data=02100	Adr= 201 Data=03500	Adr= 269 Data=01000
Adr= 66 Data=00302	Adr= 134 Data=02100	Adr= 202 Data=03500	Adr= 270 Data=01100
Adr= 67 Data=00402	Adr= 135 Data=02100	Adr= 203 Data=03500	Adr= 271 Data=01000

Addr= 272 Data=01200  
 Addr= 273 Data=017CD  
 Addr= 274 Data=01301  
 Addr= 275 Data=016CD  
 Addr= 276 Data=01402

Addr= 277 Data=015CD  
 Addr= 278 Data=01503  
 Addr= 279 Data=014CD  
 Addr= 280 Data=01604  
 Addr= 281 Data=013CD

Addr= 282 Data=06E04  
 Addr= 283 Data=06E0C  
 Addr= 284 Data=0DE0F  
 Addr= 285 Data=0D94F  
 Addr= 286 Data=0DDF2

Addr= 287 Data=1D920

## Configuration

### Shunt Settings

Table 1: Shunts

#	Shunt	Default	Function
1	SH501 [CLK SRC]	1-2 [CCB]	1-2 [CCB] CCB sources TMB s 40MHz Main clock 2-3 [XTAL] Onboard crystal sources TMBs 40MHz Main clock
2	SH502 [CFEB CLK]	2-3 [DCC]	1-2 [NRM] CFEB clocks sourced by 3D3444 64/36 duty-cycle 2-3 [DCC] CFEB clocks duty-cycle corrected
3	SH55 [GBL]	1-2 [ENA]	1-2 [ENA] Boot Register responds to TMB VME Global Address 2-3 [DIS] Boot Register ignores TMB VME Global Address
4	SH56 [GEO]	1-2 [ENA]	1-2 [ENA] Boot Register responds to VME Geographic Address 2-3 [DIS] Boot Register ignores VME Geographic Address
5	SH57 [ADM]	1-2 [REQ]	1-2 [REQ] Boot Register requires VME Address Mode 39h or 3Dh 2-3 [PAS] Boot Register accepts any VME Address Mode
6	SH97 [FPGA]	1-2 [ENA]	1-2 [ENA] Cleared Boot Register enables FPGA VME access 2-3 [DIS] Cleared Boot Register disables FPGA VME access
7	SH69-1 [REG IN]	2-3 [REG]	1-2 [BPL] Disconnect +3.3V from U69 1.5V regulator input 2-3 [REG] Connect +3.3V to U69 1.5V regulator input
8	SH69-2 [REG OUT]	2-3 [REG]	1-2 [BPL] Backplane sources +1.5Vtt 2-3 [REG] Onboard regulator U69 sources +1.5Vtt
9	SH95 [BOOT]	1-2 [EN]	1-2 [EN] CCB hard-reset clears Boot Register 2-3 [DIS] CCB hard-reset does not clear Boot Register
10	SH104 [VME]	1-2 [EN]	1-2 [EN] VME write to Boot Register can hard-reset TMB or ALCT 2-3 [DIS] Boot Register can not hard-reset TMB or ALCT
11	SH105 [CCB]	1-2 [EN]	1-2 [EN] CCB can hard-reset TMB or ALCT 2-3 [DIS] CCB can not hard-reset TMB or ALCT
12	SH106 [ALCT]	1-2 [EN]	1-2 [EN] TMB FPGA can hard-reset ALCT board if enabled by Boot 2-3 [DIS] TMB FPGA firmware can not hard-reset ALCT board
13	SH107 [SELF]	2-3 [DIS]	1-2 [EN] TMB FPGA firmware can hard-reset TMB 2-3 [DIS] TMB FPGA firmware can not hard-reset TMB
14	SH1081 [ALCT]	1-2 [EN]	1-2 [EN] TMB can send hard-reset to ALCT board 2-3 [DIS] TMB can not send hard-reset to ALCT board
15	SH1082 [TMB]	1-2 [EN]	1-2 [EN] TMB can send hard-reset to TMB 2-3 [DIS] TMB can not send hard-reset to TMB
16	SH1083 [RPC]	1-2 [EN]	1-2 [EN] TMB can send hard-reset to RAT/RPC board 2-3 [DIS] TMB can not send hard-reset to RAT/RPC board
17	SH1084 [PUP]	1-2 [EN]	1-2 [EN] Issue hard-reset to TMB on power-up 2-3 [DIS] Do not issue hard-reset to TMB on power-up
18	SH62 [VMEADR]	1-2 [GEO]	1-2 [GEO] Slot Address derived from VME backplane GEO pins 2-3 [LCL] Slot Address derived from SW2/SW1 hex switches

19	SH74 [JTAG SRC]	2-3 [SW3]	1-2 [XBL] 2-3 [SW3]	X-blaster board sources JTAG chain address Onboard SW3 hex switch sources JTAG chain address
20	SH921 [RAT ADC]	1-2 [ACORE]	1-2 [ACORE] 2-3 [+3.3VR]	ADC Ch9 measures RAT core current ADC Ch9 measures RAT main +3.3V supply

## Switch Settings

Table 2: Switch Settings

Switch	Module	Default	Function
SW1	VME	A	SW2/SW1 Form the VME slot address for Local Mode addressing and for the Boot Register Global Address.  Normally, SH62 [VMEADR] will be set to 1-2 [GEO] and the VME Slot-Address is determined by the Slot-ID signals from the VME P1 backplane connector. SW2/SW1 should be set to 1A [26 decimal] to specify the Boot Register Global Address. SW2 is the most-significant hex digit.  If SH62 [VMEADR] is set 2-3 [LCL], hex rotary switches SW2/SW1 determine the VME slot address for the module, and the P1 Geographic Address signals are ignored.
SW2	VME	1	
SW3	JTAG	4	Selects the JTAG Chain Address for the Xblaster when SH74 [JTAG ADR SRC] is set to 2-3 [SW3]. If SH74 is set 1-2 [XBL], the JTAG Chain Address is determined by the Xblaster.  0000 0 ALCT SLOW USER 0001 1 ALCT SLOW PROM 0010 2 ALCT FPGA USER 0011 3 ALCT FPGA PROMs 01XX 4 TMB FPGA PROMs 10XX 8 TMB User PROMs 1100 C TMB FPGA Loop (for TMB self-test) 1101 D RAT FPGA PROM

## Fuses

Table 3: Fuses

Fuse	Circuit	Amps	LED	Function	Littelfuse Part #
F1	+5.0V	5A	D_F1 Red	VME-bus I/O	154005.DR
F2	+3.3V	10A	D_F2 Red	Main board logic, FPGA IOBs	154010.DR
F3	+1.5V	5A	None	GTLP termination	154005.DR
F4	+3.3VXB	1A	D_F4 Grn	Xblaster power	154001.DR

# Signal Summary

## CCB

1 Input            LVDS 40MHz clock  
 46 Inputs        GTLP at 40MHz  
 46 Outputs       GTLP at 40MHz

Table 4: CCB Signal Summary

Signal	Bits	Dir	Logic	Function
Clock Bus				
ccb_clock40	1	In	LVDS	
Total	1			
Fast Control Bus				
ccb_clock40_enable	1	In	GTLP	
ccb_cmd[5..0]	6	In	GTLP	
ccb_evntres	1	In	GTLP	
ccb_bcntres	1	In	GTLP	
ccb_cmd_strobe	1	In	GTLP	
ccb_bx0	1	In	GTLP	
ccb_l1accept	1	In	GTLP	
ccb_data[7..0]	8	In	GTLP	
ccb_data_strobe	1	In	GTLP	
ccb_reserved[4..0]	5	In	GTLP	
Total	26			
TMB Reload Bus: ALCT+CLCT+TMB FPGA Reload				
tmb_hard_reset	1	In	GTLP	
tmb_cfg_done[8..0]	9	Out	GTLP	
alct_hard_reset	1	In	GTLP	
alct_cfg_done[8..0]	9	Out	GTLP	
tmb_reserved[1..0]	2	In	GTLP	
Total	22			
DAQ Special Purpose Bus [Used by DMB and TMB]				
dmb_cfeb_calibrate[2..0]	3	In	GTLP	
dmb_l1a_release	1	(In)	GTLP	
dmb_reserved_out[4..0]	5	In	GTLP	
dmb_reserved_in[2..0]	3	(In)	GTLP	
Total	12			
Trigger Special Purpose Bus [Used by TMB only]				
alct_adb_pulse_sync	1	In	GTLP	
alct_adb_pulse_async	1	In	GTLP	
clct_external_trigger	1	In	GTLP	
alct_external_trigger	1	In	GTLP	
clct_status[8..0]	9	Out	GTLP	
alct_status[8..0]	9	Out	GTLP	
tmb_l1a_request	1	Out	GTLP	
tmb_l1a_release	1	Out	GTLP	

tmb_reserved_in[4..0]	5	Out	GTLP	
tmb_reserved_out[2..0]	3	In	GTLP	
Total	32			

## ALCT

29 Inputs      LVDS Multiplexed at 80 MHz  
 20 Outputs    LVDS Multiplexed at 80 MHz  
 1 Output       LVDS 40MHz clock

Table 5: ALCT Signal Summary

Signal	Bits	Pins	Mux	Dir	Logic	Function
first_valid	1	0.5	Yes	In	LVDS	Valid Pattern Flag, best muon
first_quality[1..0]	2	1	Yes	In	LVDS	Pattern Quality, best muon
first_amu	1	0.5	Yes	In	LVDS	Accelerator Muon Flag, best muon
first_key[6..0]	7	3.5	Yes	In	LVDS	Key Wire Group, best muon
second_valid	1	0.5	Yes	In	LVDS	Valid Pattern Flag, 2 <sup>nd</sup> best muon
second_quality[1..0]	2	1	Yes	In	LVDS	Pattern Quality, 2 <sup>nd</sup> best muon
second_amu	1	0.5	Yes	In	LVDS	Accelerator Muon Flag, 2 <sup>nd</sup> best muon
second_key[6..0]	7	3.5	Yes	In	LVDS	Key Wire Group, 2 <sup>nd</sup> best muon
bxn[4..0]	5	2.5	Yes	In	LVDS	Bunch Crossing Number
daq_data[13..0]	14	7	Yes	In	LVDS	DAQ data
/wr_fifo	1	0.5	Yes	In	LVDS	/Write_enable DAQ FIFO
lct_special	1	0.5	Yes	In	LVDS	LCT Special Word Flag
ddu_special	1	0.5	Yes	In	LVDS	DAQ Special Word Flag
first_frame	1	0.5	Yes	In	LVDS	First DAQ Frame
last_frame	1	0.5	Yes	In	LVDS	Last DAQ Frame
seq_status[1..0]	2	1	Yes	In	LVDS	Sequencer Status
seu_status[1..0]	2	1	Yes	In	LVDS	Radiation SEU Status
active_feb_flag	1	0.5	Yes	In	LVDS	Active FEB Flag (ALCT pre-triggered)
cfg_done	1	0.5	Yes	In	LVDS	FPGA configuration done
reserved_out[3..0]	4	2	Yes	In	LVDS	Future use
tdo	1	1	No	In	LVDS	JTAG tdo from ALCT
Total Inputs	57	29				

Signal	Bits	Pins	Mux	Dir	Logic	Function
ccb_brcst[7..0]	8	4	Yes	Out	LVDS	CCB broadcast command
brcst_str	1	0.5	Yes	Out	LVDS	ccb_brcst strobe
dout_str	1	0.5	Yes	Out	LVDS	ccb_dout strobe
subadr_str	1	0.5	Yes	Out	LVDS	ccb_subaddr strobe
bx0	1	0.5	Yes	Out	LVDS	Bunch Crossing Zero
ext_inject	1	0.5	Yes	Out	LVDS	External Test Pattern Inject Command
ext_trig	1	0.5	Yes	Out	LVDS	External Trigger Command
level1_accept	1	0.5	Yes	Out	LVDS	Level 1 Accept
sync_adb_pulse	1	0.5	Yes	Out	LVDS	Synchronous ADB Test Pulse
seq_cmd[2..0]	3	1.5	Yes	Out	LVDS	Sequencer Command
reserved_in[4..0]	5	2.5	Yes	Out	LVDS	Future use
clock	1	1	No	Out	LVDS	40MHz clock
clock_en	1	1	No	Out	LVDS	Clock enable
hard_reset	1	1	No	Out	LVDS	FPGA Reload Command
async_adb_pulse	1	1	No	Out	LVDS	Asynchronous ADB Test Pulse
jtag_select[1..0]	2	2	No	Out	LVDS	JTAG Chain Select
tck	1	1	No	Out	LVDS	JTAG tck to ALCT
tms	1	1	No	Out	LVDS	JTAG tms to ALCT

tdi	1	1	No	Out	LVDS	JTAG tdi to ALCT
Total Outputs	33	21				



## DMB

3 Inputs      LVTTTL at 40 MHz  
45 Outputs    LVTTTL at 40 MHz

Table 6: DMB Signal Summary

Signal	Bits	Dir	Logic	Function
tmb_data[14:0]	15	Out	LVTTTL	TMB data[14:0] to DMB FIFO
alct_data[14:0]	15	Out	LVTTTL	ALCT data [14:0] to DMB FIFO
tmb_ddu_special	1	Out	LVTTTL	TMB DDU Special Word Flag
tmb_last_frame	1	Out	LVTTTL	TMB Last FIFO frame
tmb_data_available	1	Out	LVTTTL	TMB Data Available
/tmb_write_enable_fifo	1	Out	LVTTTL	TMB FIFO /write_enable
tmb_active_feb_flag	1	Out	LVTTTL	TMB Active Front-End-Board Flag
tmb_active_feb[4..0]	5	Out	LVTTTL	TMB Active FEB indicators[4..0]
fifo_clock	1	Out	LVTTTL	40MHz FIFO storage clock [= tmb_clock]
alct_ddu_special	1	Out	LVTTTL	ALCT DDU Special Word Flag
alct_last_frame	1	Out	LVTTTL	ALCT Last FIFO frame
alct_first_frame(dav)	1	Out	LVTTTL	ALCT First FIFO frame, data available
/alct_write_enable_fifo	1	Out	LVTTTL	ALCT FIFO /write_enable
reserved_to_dmb	5	Out	LVTTTL	Unassigned
Total Outputs	50			
dmb_request_lct	1	In	LVTTTL	DMB requests active_feb_flag from TMB
dmb_ext_trig	1	In	LVTTTL	DMB external trigger to TMB
dmb_fpga_pgm_done	1	In	LVTTTL	DMB FPGA Program Done
reserved_from_dmb	3	In	LVTTTL	Unassigned
Total Inputs	6			

## CFEB

120 Inputs      LVDS data multiplexed at 80 MHz  
5 Outputs      LVDS 40MHz clock

Table 7: CFEB Signal Summary

Signal	Bits	Pins	Dir	Logic	Function
cfeb0_ly[5..0]_tr[7..0]	48	24	In	LVDS	CFEB0 6 layers x 8 triads, 80MHz
cfeb1_ly[5..0]_tr[7..0]	48	24	In	LVDS	CFEB1 6 layers x 8 triads, 80MHz
cfeb2_ly[5..0]_tr[7..0]	48	24	In	LVDS	CFEB2 6 layers x 8 triads, 80MHz
cfeb3_ly[5..0]_tr[7..0]	48	24	In	LVDS	CFEB3 6 layers x 8 triads, 80MHz
cfeb4_ly[5..0]_tr[7..0]	48	24	In	LVDS	CFEB4 6 layers x 8 triads, 80MHz
Total Inputs	240	120			
Signal	Bits	Pins	Dir	Logic	Function
cfeb0_lct_clock	1	1	Out	LVDS	CFEB 1 40MHz clock
cfeb1_lct_clock	1	1	Out	LVDS	CFEB 2 40MHz clock
cfeb2_lct_clock	1	1	Out	LVDS	CFEB 3 40MHz clock
cfeb3_lct_clock	1	1	Out	LVDS	CFEB 4 40MHz clock
cfeb4_lct_clock	1	1	Out	LVDS	CFEB 5 40MHz clock
Total Outputs	5	5			



## MPC

1 Input GTLP at 80MHz  
32 Outputs GTLP at 80MHz

Table 8: MPC Signal Summary

	Signal	Bits	Pins	Dir	Logic	Function
First In Time	alct_first_key[6:0]	7	3.5	Out	GTLP	LCT 0 ALCT key wire-group
	clct_first_pat[3:0]	4	2	Out	GTLP	LCT 0 CLCT pattern number
	lct_first_quality[3:0]	4	2	Out	GTLP	LCT 0 Muon quality
	first_vpf	1	0.5	Out	GTLP	LCT 0 Valid pattern flag
	alct_second_key[6:0]	7	3.5	Out	GTLP	LCT 1 ALCT key wire-group
	clct_second_pat[3:0]	4	2	Out	GTLP	LCT 1 CLCT pattern number
	lct_second_quality[3:0]	4	2	Out	GTLP	LCT 1 Muon quality
	second_vpf	1	0.5	Out	GTLP	LCT 1 Valid pattern flag
Second In Time						
	clct_first_key[7:0]	8	4	Out	GTLP	LCT 0 CLCT key ½-strip
	clct_first_bend	1	0.5	Out	GTLP	LCT 0 CLCT bend direction
	lct 0 sync_err	1	0.5	Out	GTLP	LCT 0 BXN does not match at BX0
	alct_first_bxn[0]	1	0.5	Out	GTLP	LCT 0 ALCT bunch crossing number
	clct_first_bx0_local	1	0.5	Out	GTLP	LCT 0 local BXN from CLCT
	csc_id[3:0]	4	2	Out	GTLP	CSC chamber ID
	clct_second_key[7:0]	8	4	Out	GTLP	LCT 1 CLCT key ½-strip
	clct_second_bend	1	0.5	Out	GTLP	LCT 1 CLCT bend direction
	lct 1 sync_err	1	0.5	Out	GTLP	LCT 1 BXN does not match at BX0
	alct_second_bxn[0]	1	0.5	Out	GTLP	LCT 1 ALCT bunch crossing number
	clct_second_bx0_local	1	0.5	Out	GTLP	LCT 1 local BXN from CLCT
	csc_id[3:0]	4	2	Out	GTLP	CSC chamber ID
	Total Output Signals	37	18.5			2:1 Multiplexing at 80 MHz

Time	Signal	Bits	Pins	Dir	Logic	Function
1 <sup>st</sup>	lct0_accept	1	0.5	In	GTLP	LCT 0 Accepted by MPC best 3 of 18 sort
2 <sup>nd</sup>	lct1_accept	1	0.5	In	GTLP	LCT 1 Accepted by MPC best 3 of 18 sort
	Total Input Signals	2	1			2:1 Multiplexing at 80 MHz

## RPC

80 Inputs      40MHz LVTTTL [from receivers on transition module]  
0 Outputs

Table 9: RPC Signal Summary

Signal	Bits	Dir	Logic	Function
rpc0_seg[15..0]	16	In	LVTTTL	RPC Segment[15..0]
rpc0_bxn[2..0]	3	In	LVTTTL	Bunch Crossing Number [2..0]
rpc0_clock	1	In	LVTTTL	Clock from RPC Link Board
rpc1_seg[15..0]	16	In	LVTTTL	RPC Segment[15..0]
rpc1_bxn[2..0]	3	In	LVTTTL	Bunch Crossing Number [2..0]
rpc1_clock	1	In	LVTTTL	Clock from RPC Link Board
Total data bits	40			

## VME

24 Inputs TTL Address  
16 BiDir TTL Data

Table 10: VME Signal Summary

Signal	Bits	Dir	Logic	Function
address	24	In	TTL	VME Address[23..0]
data	16	BiDir	TTL	VME Data[15..0]
control in		In	TTL	VME Control Inputs
control out		Out	TTL	VME Control Outputs

## JTAG

5 Inputs      LVDS  
1 Outputs      LVDS

Table 11: JTAG Signal Summary

Signal	Bits	Dir	Logic	Function
tck	1	In	LVDS	JTAG TCK
tms	1	In	LVDS	JTAG TMS
tdi	1	In	LVDS	JTAG TDI
chain_select	2	In	LVDS	Chain Select Address
tdo	1	Out	LVDS	JTAG TDO

## LEDs

Table 12: TMB Front Panel LEDs

LED	Color	Function
LCT	Blue	ALCT vpf and CLCT vpf match within the 75ns ALCT window (see note <sup>1</sup> below)
ALCT	Green	ALCT active FEB flag (may not always be the same as ALCT valid pattern flag)
CLCT	Green	CLCT active FEB flag Or any external trigger except ALCT
L1A	Green	Level 1 Accept arrived in L1A window
INVP	Amber	Invalid CLCT pattern after drift delay Pattern dropped below threshold, probably triggered on noise
NMAT	Amber	ALCT vpf or CLCT vpf arrived but did not match in ALCT window
NL1A	Red	No Level 1 Accept arrived in L1A window after TMB triggered Constant flash rate = buffers full
VME	Green	ON = TMB FPGA loaded successfully from PROM Flashes OFF when module addressed by VME

---

<sup>1</sup> NB: All external triggers (including scintillator and ALCT active FEB) create a dummy CLCT to force the TMB to read out raw hits. ALCT triggers can produce an LCT match if the ALCT active FEB is followed by an ALCT valid pattern flag.

## TMB Total I/O Count

Table 13: TMB Total I/O Count

Bits	Pins	Dir	Logic	Connect To	Function
1	2	In	LVDS	CCB	Clock Bus
26	26	In	GTLP	CCB	Fast Control Bus
4	4	In	GTLP	CCB	TMB Reload Bus
12	12	In	GTLP	CCB + 9 DMB + 9 TMB	DAQ Special Purpose Bus
7	7	In	GTLP	CCB + 9 TMB	Trigger Special Purpose Bus
240	120	In	LVDS	5 CFEBs	CFEB Comparators
57	29	In	LVDS	ALCT	ALCT Module
6	6	In	LVTTTL	1 DMB	DMB commands
2	1	In	GTLP	MPC	MPC winner
80	40	In	LVTTTL	RPC	RPC Inputs
24	24	In	TTL	VME	VME Address
16	16	BiDir	TTL	VME	VME Data
5	5	In	LVTTTL	JTAG	JTAG
480	292				Totals

Bits	Pins	Dir	Logic	Connect To	Function
0	0	Out	LVDS	CCB	Clock Bus
0	0	Out	GTLP	CCB	Fast Control Bus
18	18	Out	GTLP	CCB	TMB Reload Bus
0	0	Out	GTLP	CCB + 9 DMB + 9 TMB	DAQ Special Purpose Bus
25	25	Out	GTLP	CCB + 9 TMB	Trigger Special Purpose Bus
5	5	Out	LVDS	5 CFEBs	CFEB Comparators
33	21	Out	LVDS	ALCT	ALCT Module
50	50	Out	LVTTTL	1 DMB	DMB data
64	32	Out	GTLP	MPC	MPC winner
0	0	Out	LVTTTL	RPC	RPC Inputs
0	0	Out	TTL	VME	VME data is BiDir
1	1	Out	LVTTTL	JTAG	JTAG
196	152				Totals

FPGA I/O Estimate: 392 in – 7 clock + 152 out = 537

## Connectors

### TMB Connector Summary

Table 14: TMB2005 Connector Summary

ID	Pins	Type	Function
J0	50	SCSI-II	CFEB0 Inputs + Clock Out
J1	50	SCSI-II	CFEB1 Inputs + Clock Out
J2	50	SCSI-II	CFEB2 Inputs + Clock Out
J3	50	SCSI-II	CFEB3 Inputs + Clock Out
J4	50	SCSI-II	CFEB4 Inputs + Clock Out
J5	50	SCSI-II	ALCT Cable 1 Inputs
J6	50	SCSI-II	ALCT Cable 2 I/O
J7	10	Header	Xilinx LVDS X-Blaster I/O
P1	160	VME64x	VME J1/P1 Bus I/O
P2A	125	Z-Pack 25x5	CCB + DMB I/O
P2B	55	Z-Pack 11x5	DMB I/O
P3A	55	Z-Pack 11x5	MPC I/O
P3B	125	Z-Pack 25x5	RPC Inputs + ALCT alternate I/O

## J0-J4 CFEB0-CFEB4 Connectors

Function: Receives 80MHz data from CFEBs. Transmits 40MHz clock.

Connector Type: PCB: AMP 787190-5  
 Cable: AMP 749111-4  
 Shell: AMP 749889-3 [with latches]

**Table 15: J0-J4 CFEB0/4-to-TMB Connectors**  
 (This table uses Layer numbers Ly0-to-Ly5, Triad numbers Tr0-to-Tr7)

Pair	Pin		Dir	Logic	Multiplexed Signals	
1	1+	2-	In	LVDS	Ly0Tr0	Ly3Tr0
2	3+	4-	In	LVDS	Ly0Tr2	Ly3Tr2
3	5+	6-	In	LVDS	Ly5Tr0	Ly4Tr0
4	7+	8-	In	LVDS	Ly5Tr2	Ly4Tr2
5	9+	10-	In	LVDS	Ly1Tr0	Ly2Tr0
6	11+	12-	In	LVDS	Ly1Tr2	Ly2Tr2
7	13+	14-	In	LVDS	Ly0Tr4	Ly3Tr4
8	15+	16-	In	LVDS	Ly0Tr6	Ly3Tr6
9	17+	18-	In	LVDS	Ly5Tr4	Ly4Tr4
10	19+	20-	In	LVDS	Ly5Tr6	Ly4Tr6
11	21+	22-	In	LVDS	Ly1Tr4	Ly2Tr4
12	23+	24-	In	LVDS	Ly1Tr6	Ly2Tr6
13	25+	26-	Out	LVDS	LCT_Clock	
14	27+	28-	In	LVDS	Ly1Tr7	Ly2Tr7
15	29+	30-	In	LVDS	Ly1Tr5	Ly2Tr5
16	31+	32-	In	LVDS	Ly5Tr7	Ly4Tr7
17	33+	34-	In	LVDS	Ly5Tr5	Ly4Tr5
18	35+	36-	In	LVDS	Ly0Tr7	Ly3Tr7
19	37+	38-	In	LVDS	Ly0Tr5	Ly3Tr5
20	39+	40-	In	LVDS	Ly1Tr3	Ly2Tr3
21	41+	42-	In	LVDS	Ly1Tr1	Ly2Tr1
22	43+	44-	In	LVDS	Ly5Tr3	Ly4Tr3
23	45+	46-	In	LVDS	Ly5Tr1	Ly4Tr1
24	47+	48-	In	LVDS	Ly0Tr3	Ly3Tr3
25	49+	50-	In	LVDS	Ly0Tr1	Ly3Tr1



## J5 ALCT Cable1 Connector (Receiver)

Function: Receives 80MHz data from ALCT.

Connector Type: PCB: AMP 787190-5  
Cable: AMP 749111-4  
Shell: AMP 749889-3 [with latches]

**Table 16: J5 ALCT Cable1 Connector [J10 on ALCT board]**  
Modified 4/12/01 to match ALCT2001 PCB. Stinking bad signal inversion = ☹

Pair	Inverted	Pin		Dir	Logic	Multiplexed Signals	
		+	-			First in Time	Second in Time
1	☹	1+	2-	In	LVDS	first_valid	second_valid
2		49+	50-	In	LVDS	first_amu	second_amu
3	☹	3+	4-	In	LVDS	first_quality0	second_quality0
4		47+	48-	In	LVDS	first_quality1	second_quality1
5	☹	5+	6-	In	LVDS	first_key0	second_key0
6		45+	46-	In	LVDS	first_key1	second_key1
7	☹	7+	8-	In	LVDS	first_key2	second_key2
8		43+	44-	In	LVDS	first_key3	second_key3
9	☹	9+	10-	In	LVDS	first_key4	second_key4
10		41+	42-	In	LVDS	first_key5	second_key5
11	☹	11+	12-	In	LVDS	first_key6	second_key6
12		39+	40-	In	LVDS	bxn0	bxn3
13	☹	13+	14-	In	LVDS	bxn1	bxn4
14		37+	38-	In	LVDS	bxn2	/wr_fifo
15	☹	15+	16-	In	LVDS	daq_data0	daq_data7
16		35+	36-	In	LVDS	daq_data1	daq_data8
17	☹	17+	18-	In	LVDS	daq_data2	daq_data9
18		33+	34-	In	LVDS	daq_data3	daq_data10
19	☹	19+	20-	In	LVDS	daq_data4	daq_data11
20		31+	32-	In	LVDS	daq_data5	daq_data12
21	☹	21+	22-	In	LVDS	daq_data6	daq_data13
22		29+	30-	In	LVDS	lct_special	first_frame
23	☹	23+	24-	In	LVDS	parity_out0 seq_status0	parity_out2 seu_status0
24		27+	28-	In	LVDS	parity_out1 seq_status1	parity_out3 seu_status1
25	☹	25+	26-	In	LVDS	ddu_special	last_frame

## J6 ALCT Cable2 Connector (Transmitter)

Function: Sends/Receives 80MHz data to/from ALCT.

Connector Type: PCB: AMP 787190-5  
Cable: AMP 749111-4  
Shell: AMP 749889-3 [with latches]

**Table 17: J6 ALCT Cable2 Connector [J11 on ALCT board]**  
Modified 4/12/01 to match ALCT2001 PCB. Stinking bad signal inversion ☹

Pair	Inverted	Pin		Dir	Logic	Multiplexed Signals	
		+	-			First in Time	Second in Time
1		1+	2-	Out	LVDS	tdi	
2	☹	49+	50-	Out	LVDS	tms	
3		3+	4-	Out	LVDS	tck	
4	☹	47+	48-	Out	LVDS	jtag_select0	
5		5+	6-	Out	LVDS	jtag_select1	
6	☹	45+	46-	Out	LVDS	ccb_brcst0	ccb_brcst4
7		7+	8-	Out	LVDS	ccb_brcst1	ccb_brcst5
8	☹	43+	44-	Out	LVDS	ccb_brcst2	ccb_brcst6
9		9+	10-	Out	LVDS	ccb_brcst3	ccb_brcst7
10	☹	41+	42-	Out	LVDS	brcst_str1	subaddr_str
11		11+	12-	Out	LVDS	dout_str	bx0
12	☹	39+	40-	Out	LVDS	ext_inject	ext_trig
13		13+	14-	Out	LVDS	level1_accept	sync_adb_pulse
14	☹	37+	38-	Out	LVDS	seq_cmd0	seq_cmd2
15		15+	16-	Out	LVDS	seq_cmd1	seq_cmd3 reserved_in4
16	☹	35+	36-	Out	LVDS	parity_in0 reserved_in0 <sup>2</sup>	parity_in2 reserved_in2
17		17+	18-	Out	LVDS	parity_in1 reserved_in1	parity_in3 reserved_in3
18	☹	33+	34-	Out	LVDS	async_adb_pulse	
19		19+	20-	Out	LVDS	/hard_reset	
20	☹	31+	32-	Out	LVDS	clock_en	
21		21+	22-	Out	LVDS	clock	
22		29+	30-	In	LVDS	tdo	
23	☹	23+	24-	In	LVDS	parity_out4 reserved_out0	parity_out6 reserved_out2
24		27+	28-	In	LVDS	parity_out5 reserved_out1	alct_bx0 reserved_out3
25	☹	25+	26-	In	LVDS	active_feb_flag	cfg_done

<sup>2</sup> Reserved cable input signals connect to ALCT FPGA user input pins

**J1-J6 SCSI-II 50-Pin Connector Pin Convention**

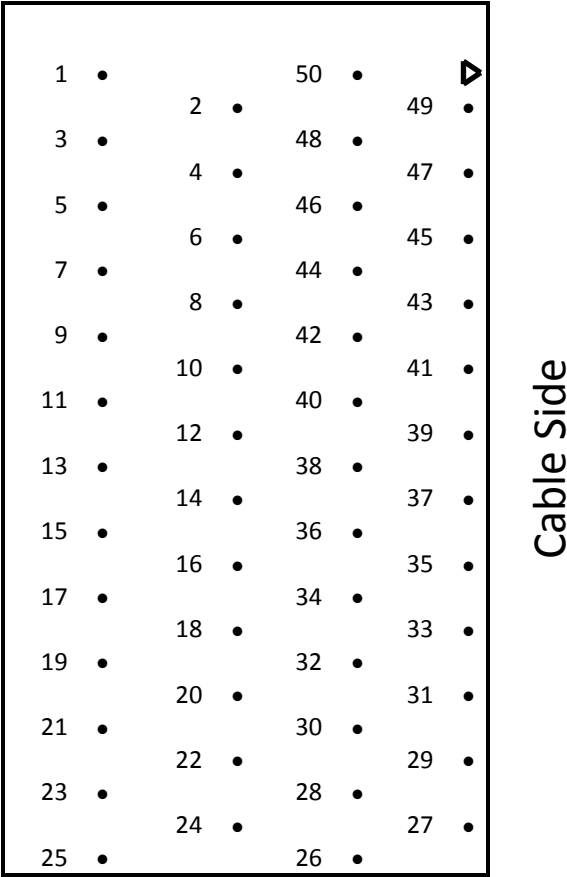
**Figure 5: 50-Pin PCB Connector (Female)<sup>3</sup>**  
(Looking into PCB Connector)



**Figure 6: 50 Pin Cable Connector (Male)**  
(Looking into Cable Connector)



**Figure 7: 50 Pin PCB Connector Pin Convention**  
(Looking At Top of PCB)




<sup>3</sup> Copied from CFEB design: <http://www.physics.ohio-state.edu/~gujh/works/cmpdata.html>

# J7 Xilinx LVDS Xilinx X-Blaster Connector

Function: Connects TMB2005 to LVDS x-Blaster for programming FPGAs and PROMs.  
The LVDS signals and voltage sources on this connector are not directly compatible with the standard Xilinx programming cable.  
JTAG chain select signals SEL[3:0] are TTL ☹.

Connector Type: PCB: 3M 3316-5002 16-pin right angle center key  
Cable: 3M 3452-6600 16-pin center bump

Table 18: J8 Xilinx LVDS X-Blaster Connector

+TCK	In	1		2	In	-TCK
+TDO	Out	3		4	Out	-TDO
+TMS	In	5		6	In	-TMS
+3.3V	Out	7		8	-	GND
+TDI	In	9		10	In	-TDI
+3.3V	In	11		12	In	JTAG_EN(TTL)
SEL0 (TTL)	Out	13		14	In	SEL1 (TTL)
SEL2 (TTL)	In	15		16	In	SEL3 (TTL)

## P1 Backplane VME64x J1/P1 Connector

Function: VME interface.

Connector Type: PCB: Harting 02-02-160-2101 Male Right-Angle  
Backplane: Harting 02-01-160-2201 Female

Address bits: 24

Data bits: 16

Geographic Address bits: 5

Table 19: P1 VME64x Connector

Pin	Row z	Row a	Row b	Row c	Row d
1	MPR	D00	BBSY*	D08	VPC
2	GND	D01	BCLR*	D09	GND
3	MCLK	D02	ACFAIL*	D10	+V1
4	GND	D03	BG0IN*	D11	+V2
5	MSD	D04	BG0OUT*	D12	RsvU
6	GND	D05	BG1IN*	D13	-V1
7	MMD	D06	BG1OUT*	D14	-V2
8	GND	D07	BG2IN*	D15	RsvU
9	MCTL	GND	BG2OUT*	GND	GAP*
10	GND	SYSCLK	BG3IN*	SYSFAIL*	GA0*
11	RESP*	GND	BG3OUT*	BERR*	GA1*
12	GND	DS1*	BR0*	SYSRESET*	+3.3V
13	RsvBus1	DS0*	BR1*	LWORD*	GA2*
14	GND	WRITE*	BR2*	AM5	+3.3V
15	RsvBus2	GND	BR3*	A23	GA3*
16	GND	DTACK*	AM0	A22	+3.3V
17	RsvBus3	GND	AM1	A21	GA4*
18	GND	AS*	AM2	A20	+3.3V
19	RsvBus4	GND	AM3	A19	RsvBus11
20	GND	IACK*	GND	A18	+3.3V
21	RsvBus5	IACKIN*	SERCLK	A17	RsvBus12
22	GND	IACKOUT*	SERDAT	A16	+3.3V
23	RsvBus6	AM4	GND	A15	RsvBus13
24	GND	A07	IRQ7*	A14	+3.3V
25	RsvBus7	A06	IRQ6*	A13	RsvBus14
26	GND	A05	IRQ5*	A12	+3.3V
27	RsvBus8	A04	IRQ4*	A11	LI/I*
28	GND	A03	IRQ3*	A10	+3.3V
29	RsvBus9	A02	IRQ2*	A09	LI/O*
30	GND	A01	IRQ1*	A08	+3.3V
31	RsvBus10	-12V	+5VSTDBY	+12V	GND
32	GND	+5V	+5V	+5V	VPC

## P2A Backplane CCB+DMB Connector

Function: Sends and receives data to/from CCB, and carries some DMB signals.

Connector Type: PCB: AMP Z-Pack 125 (25 rows of 5 pins) female      AMP 100145-1  
Backplane: AMP Z-Pack 125 (25 rows of 5 pins) male      AMP ?

Table 20: P2A Backplane CCB+DMB Connector

Pin	Dir	Logic	Signal
A1	In	LVDS	ccb_clock40+
A2	In	GTLP	ccb_clock40_enable
A3	In	GTLP	ccb_cmd0
A4	In	GTLP	ccb_cmb4
A5	In	GTLP	ccb_cmd_strobe
A6	In	GTLP	ccb_data0
A7	In	GTLP	ccb_data4
A8	In	GTLP	ccb_reserved0
A9	In	GTLP	tmb_hard_reset
A10	In	GTLP	alct_adb_pulse_sync
A11	Out	GTLP	clct_status0
A12	Out	GTLP	clct_status4
A13	Out	GTLP	clct_status6
A14	Out	GTLP	alct_status3
A15	Out	GTLP	alct_status7
A16	Out	GTLP	tmb_reserved_in0
A17	Out	GTLP	tmb_reserved_in4
A18			
A19	In	GTLP	dmb_cfeb_calibrate0
A20	In	GTLP	dmb_reserved_out0
A21	In	GTLP	dmb_reserved_out4
A22			
A23	Out	LVTTL	tmb_data0
A24	Out	LVTTL	tmb_data4
A25	Out	LVTTL	tmb_data8

Pin	Dir	Logic	Signal
B1	In	LVDS	ccb_clock40-
B2	In	GTLP	ccb_reserved4
B3	In	GTLP	ccb_cmd1
B4	In	GTLP	ccb_cmb5
B5	In	GTLP	ccb_bx0
B6	In	GTLP	ccb_data1
B7	In	GTLP	ccb_data5
B8	In	GTLP	ccb_reserved1
B9	In	GTLP	alct_hard_reset
B10	In	GTLP	alct_adb_pulse_async
B11	Out	GTLP	clct_status1
B12	Out	GTLP	clct_status5
B13	Out	GTLP	alct_status0
B14	Out	GTLP	alct_status4
B15	Out	GTLP	alct_status8
B16	Out	GTLP	tmb_reserved_in1
B17	In	GTLP	tmb_reserved_out0
B18			
B19	In	GTLP	dmb_cfeb_calibrate1
B20	In	GTLP	dmb_reserved_out1
B21	(In) <sup>1</sup>	GTLP	dmb_reserved_in0
B22			
B23	Out	LVTTL	tmb_data1
B24	Out	LVTTL	tmb_data5
B25	Out	LVTTL	tmb_data9

Pins C1 through C25 are connected to Backplane Ground

Notes:

- 4) TMB can monitor signals to/from DMB, but can not assert them.

## P2A Backplane CCB+DMB Connector Continued

Table 20: P2A Backplane CCB Connector Continued

Pin	Dir	Logic	Signal
D1	Out	GTLP	tmb_config_done
D2			
D3	In	GTLP	ccb_cmd2
D4	In	GTLP	ccb_evtntres
D5	In	GTLP	ccb_l1accept
D6	In	GTLP	ccb_data2
D7	In	GTLP	ccb_data6
D8	In	GTLP	ccb_reserved2
D9	In	GTLP	tmb_reserved0
D10	In	GTLP	clct_external_trigger
D11	Out	GTLP	clct_status2
D12	Out	GTLP	clct_status6
D13	Out	GTLP	clct_status1
D14	Out	GTLP	alct_status5
D15	Out	GTLP	tmb_l1a_request
D16	Out	GTLP	tmb_reserved_in2
D17	In	GTLP	tmb_reserved_out1
D18			
D19	In	GTLP	dmb_cfeb_calibrate2
D20	In	GTLP	dmb_reserved_out2
D21	(In) <sup>1</sup>	GTLP	dmb_reserved_in1
D22			
D23	Out	LVTTL	tmb_data2
D24	Out	LVTTL	tmb_data7
D25	Out	LVTTL	tmb_data11

Pin	Dir	Logic	Signal
E1	Out	GTLP	alct_config_done
E2			
E3	In	GTLP	ccb_cmd3
E4	In	GTLP	ccb_bcntres
E5	In	GTLP	ccb_data_strobe
E6	In	GTLP	ccb_data3
E7	In	GTLP	ccb_data7
E8	In	GTLP	ccb_reserved3
E9	In	GTLP	tmb_reserved1
E10	In	GTLP	alct_external_trigger
E11	Out	GTLP	clct_status3
E12	Out	GTLP	clct_status7
E13	Out	GTLP	alct_status2
E14	Out	GTLP	alct_status6
E15	Out	GTLP	tmb_l1a_release
E16	Out	GTLP	tmb_reserved_in3
E17	In	GTLP	tmb_reserved_out2
E18			
E19	(In) <sup>1</sup>	GTLP	dmb_l1a_release
E20	In	GTLP	dmb_reserved_out3
E21	(In) <sup>1</sup>	GTLP	dmb_reserved_in2
E22			
E23	Out	LVTTL	tmb_data3
E24	Out	LVTTL	tmb_data7
E25	Out	LVTTL	tmb_data11

Notes:

1) TMB can monitor signals to/from DMB, but can not assert them.

## P2B Backplane DMB Connector

Function: Sends and receives data to/from DMB.

Connector Type: PCB: AMP Z-Pack 55 (11 rows of 5 pins) female AMP 100161-1  
Backplane: AMP Z-Pack 55 (11 rows of 5 pins) male AMP ?

Table 21: P2B Backplane DMB Connector

Pin	Dir	Logic	Signal
A1	Out	LVTTL	tmb_data12
A2	Out	LVTTL	alct_data1
A3	Out	LVTTL	alct_data5
A4	Out	LVTTL	alct_data9
A5	Out	LVTTL	alct_data13
A6	Out	LVTTL	tmb_data_available
A7	Out	LVTTL	tmb_active_feb1
A8	Out	LVTTL	fifo_clock
A9	Out	LVTTL	alct_last_frame
A10	In	LVTTL	res_from_dmb2
A11	Out	LVTTL	tmb_active_feb6 (v6)

Pin	Dir	Logic	Signal
B1	Out	LVTTL	tmb_data13
B2	Out	LVTTL	alct_data2
B3	Out	LVTTL	alct_data6
B4	Out	LVTTL	alct_data10
B5	Out	LVTTL	alct_data14
B6	Out	LVTTL	/tmb_write_enable_fifo
B7	Out	LVTTL	tmb_active_feb2
B8	In	LVTTL	dmb_request_lct
B9	In	LVTTL	dmb_ext_trig
B10	In	LVTTL	res_from_dmb3
B11	Out	LVTTL	res_to_dmb3

Pin	Dir	Logic	Signal
D1	Out	LVTTL	tmb_data14
D2	Out	LVTTL	alct_data3
D3	Out	LVTTL	alct_data7
D4	Out	LVTTL	alct_data11
D5	Out	LVTTL	tmb_ddu_special
D6	Out	LVTTL	tmb_active_feb_flag
D7	Out	LVTTL	tmb_active_feb3
D8	Out	LVTTL	/alct_write_enable_fifo
D9	In	LVTTL	res_from_dmb1
D10	Out	LVTTL	res_to_dmb5
D11	Out	LVTTL	res_to_dmb4

Pin	Dir	Logic	Signal
E1	Out	LVTTL	alct_data0
E2	Out	LVTTL	alct_data4
E3	Out	LVTTL	alct_data8
E4	Out	LVTTL	alct_data12
E5	Out	LVTTL	tmb_last_frame
E6	Out	LVTTL	tmb_active_feb0
E7	Out	LVTTL	tmb_active_feb4
E8	Out	LVTTL	alct_ddu_special
E9	Out	LVTTL	alct_data_available
E10	Out	LVTTL	tmb_active_feb5 (v6)
E11	In	LVTTL	dmb_fpga_pgm_done

Pin	Dir	Logic	Signal
C1	In	Pwr	Gnd
C2	In	Pwr	V <sub>TT</sub> (+1.5V)
C3	In	Pwr	Gnd
C4	In	Pwr	V <sub>TT</sub>
C5	In	Pwr	Gnd
C6	In	Pwr	V <sub>TT</sub>
C7	In	Pwr	Gnd
C8	In	Pwr	V <sub>TT</sub>
C9	In	Pwr	Gnd
C10	In	Pwr	V <sub>TT</sub>



C11	In	Pwr	Gnd
-----	----	-----	-----

## P3A Backplane MPC Connector

Function: Sends and receives data to/from MPC.

Connector Type: PCB: AMP Z-Pack 55 (11 rows of 5 pins) female AMP 100161-1  
Backplane: AMP Z-Pack 55 (11 rows of 5 pins) male AMP ?

**Table 22: P3A Backplane MPC Connector**  
See ADR\_MPCx\_FRAMEx on [p45](#) for signal assignments

Pin	Dir	Logic	Signal
A1	Out	GTLP	/mpc_out0
A2	Out	GTLP	/mpc_out4
A3	Out	GTLP	/mpc_out8
A4	Out	GTLP	/mpc_out12
A5	Out	GTLP	/mpc_out16
A6	Out	GTLP	/mpc_out20
A7	Out	GTLP	/mpc_out24
A8	Out	GTLP	/mpc_out28
A9	In	GTLP	lct_winner
A10			
A11			

Pin	Dir	Logic	Signal
B1	Out	GTLP	/mpc_out1
B2	Out	GTLP	/mpc_out5
B3	Out	GTLP	/mpc_out9
B4	Out	GTLP	/mpc_out13
B5	Out	GTLP	/mpc_out17
B6	Out	GTLP	/mpc_out21
B7	Out	GTLP	/mpc_out25
B8	Out	GTLP	/mpc_out29
B9			
B10			
B11			

Pin	Dir	Logic	Signal
D1	Out	GTLP	/mpc_out2
D2	Out	GTLP	/mpc_out6
D3	Out	GTLP	/mpc_out10
D4	Out	GTLP	/mpc_out14
D5	Out	GTLP	/mpc_out18
D6	Out	GTLP	/mpc_out22
D7	Out	GTLP	/mpc_out26
D8	Out	GTLP	/mpc_out30
D9			
D10			
D11			

Pin	Dir	Logic	Signal
E1	Out	GTLP	/mpc_out3
E2	Out	GTLP	/mpc_out7
E3	Out	GTLP	/mpc_out11
E4	Out	GTLP	/mpc_out15
E5	Out	GTLP	/mpc_out19
E6	Out	GTLP	/mpc_out23
E7	Out	GTLP	/mpc_out27
E8	Out	GTLP	/mpc_out31
E9			
E10			
E11			

Pins C1 through C11 are connected to Backplane Ground

## P3B Backplane RPC+ALCT Connector

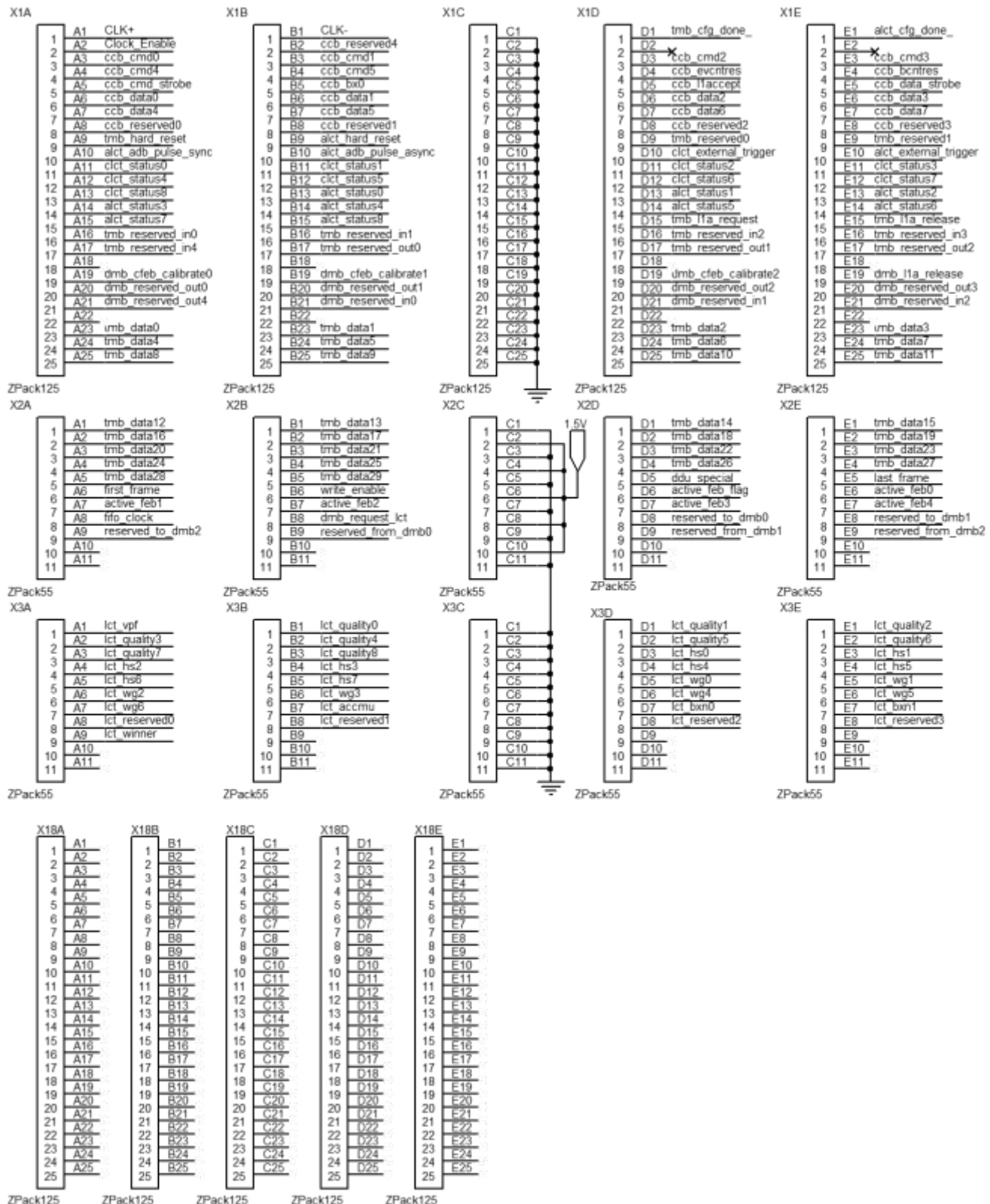
Function: Sends and receives data to/from ALCT, and receives from RPC.

Connector Type: PCB: AMP Z-Pack 125 (25 rows of 5 pins) female AMP 100145-1  
Backplane: AMP Z-Pack 125 (25 rows of 5 pins) male AMP ?

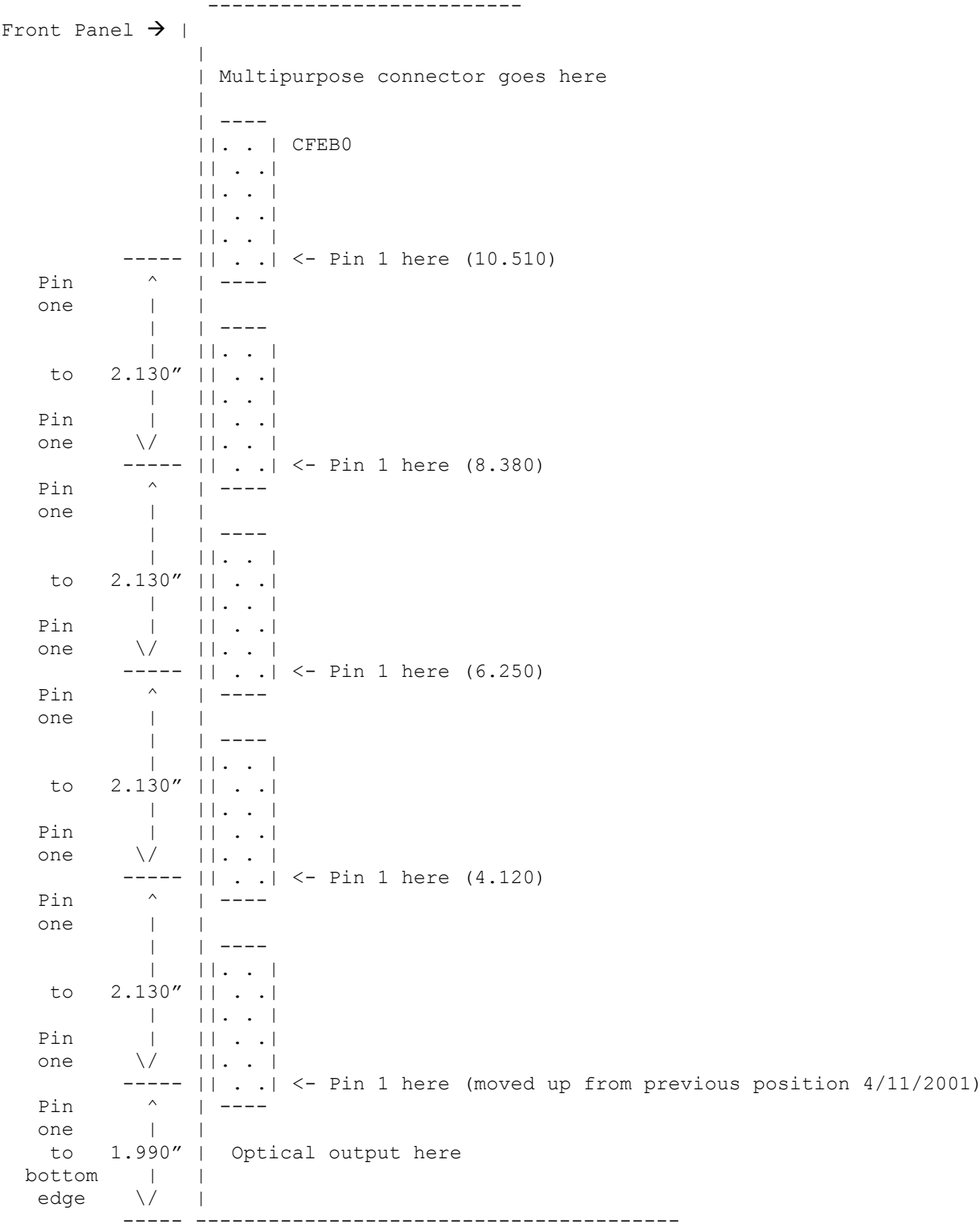
Table 23: P3B Backplane RPC+ALCT Connector

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
A1	rpc_rx31	B1	rpc_rx30	C1	rpc_rx29	D1	rpc_rx28	E1	rpc_rx27
A2	rpc_rx26	B2	rpc_rx25	C2	rpc_rx24	D2	rpc_rx23	E2	rpc_rx22
A3	rpc_rx21	B3	rpc_rx20	C3	rpc_rx19	D3	rpc_rx18	E3	rpc_rx17
A4	rpc_rx16	B4	rpc_rx15	C4	rpc_rx14	D4	rpc_rx13	E4	rpc_rx12
A5	rpc_rx11	B5	rpc_rx10	C5	rpc_rx9	D5	rpc_rx8	E5	rpc_rx7
A6	rpc_rx6	B6	rpc_rx5	C6	rpc_rx4	D6	rpc_rx3	E6	rpc_rx2
A7	rpc_rx1	B7	rpc_rx0	C7	rpc_clock	D7	smb_clk	E7	tck
A8	tms	B8	tdi	C8	rpc_loop	D8	posneg	E8	sync
A9	tdo	B9	smbrx	C9	rpc_in37	D9	rpc_in36	E9	rpc_in35
A10	rpc_in34	B10	rpc_in33	C10	rpc_in32	D10		E10	+3.3V
A11	+3.3V	B11	+3.3V	C11	GND	D11	GND	E11	GND
A12	alct_rx31	B12	alct_rx30	C12	alct_rx29	D12	alct_rx28	E12	alct_rx27
A13	alct_rx26	B13	alct_rx25	C13	alct_rx24	D13	alct_rx23	E13	alct_rx22
A14	alct_rx21	B14	alct_rx20	C14	alct_rx19	D14	alct_rx18	E14	alct_rx17
A15	alct_rx16	B15	alct_rx15	C15	alct_rx14	D15	alct_rx13	E15	alct_rx12
A16	alct_rx11	B16	alct_rx10	C16	alct_rx9	D16	alct_rx8	E16	alct_rx7
A17	alct_rx6	B17	alct_rx5	C17	alct_rx4	D17	alct_rx3	E17	alct_rx2
A18	alct_rx1	B18	alct_rx0	C18	smbtx	D18	hrst_rpc	E18	free_tx0
A19	alct_oe	B19	alct_clock	C19	alct_clk_en	D19	txoe	E19	alct_loop
A20	alct_tx23	B20	alct_tx22	C20	alct_tx21	D20	alct_tx20	E20	alct_tx19
A21	alct_tx18	B21	alct_tx17	C21	alct_tx16	D21	alct_tx15	E21	alct_tx14
A22	alct_tx13	B22	alct_tx12	C22	alct_tx11	D22	alct_tx10	E22	alct_tx9
A23	alct_tx8	B23	alct_tx7	C23	alct_tx6	D23	alct_tx5	E23	alct_tx4
A24	alct_tx3	B24	alct_tx2	C24	alct_tx1	D24	alct_tx0	E24	+1.8V
A25	+1.8V	B25	+1.8V	C25	GND	D25	GND	E25	GND

## Backplane Pin Diagram



Front Panel Connector Locations



## CCB Front Panel

### CCB Input connector P10

Pin (+)	Pin (-)	Signal
1	2	external_clock40
3	4	external_clock40_enable
5	6	external_l1accept
7	8	dmb_cfeb_calibrate[0]
9	10	dmb_cfeb_calibrate[1]
11	12	dmb_cfeb_calibrate[2]
13	14	alct_adb_pulse_sync
15	16	alct_adb_pulse_async
17	18	clct_external_trigger
19	20	alct_external_trigger
21	22	tmb_l1a_request
23	24	ccb_fp_reserved_in[0]
25	26	ccb_fp_reserved_in[1]
27	28	
29	30	
31	32	
33	34	

### CCB Output connector P11

Pin (+)	Pin (-)	Signal	Test Point	TMB Assignment	Description
1	2	clct_status[0]	391-1	pretrig	Sequencer pre-triggered
3	4	clct_status[1]	391-2	seq_busy	Sequencer busy
5	6	clct_status[2]	391-3	invpat	Invalid pattern after drift delay
7	8	clct_status[3]	391-4	daqmb	Dump to DMB in progress
9	10	clct_status[4]	391-5	l1a_window	L1A window
11	12	clct_status[5]	391-6	l1a	L1A (should be in L1A window)
13	14	clct_status[6]	391-7	tmb	CLCT sent for TMB match
15	16	clct_status[7]	391-8	tmb_flush	TMB found no match or rejected trigger
17	18	clct_status[8]	391-9	no1a_flush	No L1A, Sequencer flushing event
19	20	ccb_clock40			
21	22	ccb_bx0			
23	24	ccb_l1accept			
25	26	ccb_cmdstr			
27	28	ccb_fp_reserved_out[0]			
29	30				
31	32				
33	34				

## CCB Output connector P12

Pin (+)	Pin (-)	Signal	Test Point	TMB Assignment	Description
1	2	alct_status[0]	392-1	alct_active_feb	ALCT fast active AFEB
3	4	alct_status[1]	392-2	first_valid	First muon valid pattern flag
5	6	alct_status[2]	392-3	second_valid	Second muon valid pattern flag
7	8	alct_status[3]	392-4	first_amu	First accelerator muon flag
9	10	alct_status[4]	392-5	second_amu	Second accelerator muon flag
11	12	alct_status[5]	392-6	/wr_fifo(alct)	ALCT /write enable raw-hit FIFO
13	14	alct_status[6]	392-7	alct_vpf	ALCT 1 <sup>st</sup> Valid Pattern (TMB pipe)
15	16	alct_status[7]	392-8	clct_vpf	CLCT 1 <sup>st</sup> Valid Pattern (TMB pipe)
17	18	alct_status[8]	392-9	scint_veto	Scintillator Veto (clears via VME)
19	20				
21	22				
23	24				
25	26				
27	28				
29	30				
31	32				
33	34				

## Documentation Revision History

Version	Date	Action
1.00	07/12/2003	Initial, copied from TMB2001
1.01	10/29/2003	Replaced PHOS4 registers with DDD, update shunts table, rat signals updated
1.02	03/15/2004	Update 3D3444 registers, add RAT/RPC registers
1.03	03/16/2004	Move RAT register addy to match bdtest.v
1.04	04/15/2004	Copy from TMB2003
2.01	05/19/2004	Add RPC Readout
2.01	06/09/2004	New registers B6-CC, 4 new header words, new raw hits format, started logic docs
2.02	06/10/2004	Add mpc_tx_delay, modify header 21,22
2.03	06/18/2004	Add register CE for new scope trigger source, add mpc data format
2.04	07/23/2004	Add nph_pattern to header word 21
2.05	08/03/2004	Add counter registers
2.06	10/01/2004	Add scp bit to header
2.07	10/04/2004	Add mpc_bx0 to reg ADR_TMB_TRIG
2.08	10/07/2004	Typos fixed
2.09	12/15/2004	Typos fixed
3.00	06/02/2005	Ported from TMB2004 v2.09 dated 12/15/04
3.00	06/09/2005	Add rpc_hard_reset to boot reg, update ADR_LOOPBK for RAT signals
3.01	06/28/2005	alct_rxoe, alct_txoe in 0E are now readonly to foil errant software
3.02	08/01/2005	Change default alct_status_en, tmb_status_en=0 for multi-crate use
3.03	08/08/2005	Change c_status_oe to ccb_status_oe
3.04	02/27/2006	Add configuration section
3.05	05/24/2006	Add jtag state machine registers, add alct scope channels
3.06	07/28/2006	Add vme state machine registers, update raw hits header, add prom info
3.07	08/08/2006	Add layer-or trigger mode
3.08	09/05/2006	Add rat delay registers
3.09	09/15/2006	Add CLCT processing steps
3.10	10/16/2006	Add ISE Version register, triad persistence default now 6 for 6 clocks
3.11	04/09/2007	Reduce RPCs from 4 to 2, add mpc_oe, affects 86,B6,BA,BE,C4,CA,CC,header22
3.12	04/11/2007	Remove duplicate header22 description, update header tables
3.13	04/27/2007	Add ignore ttc_start/stop to ADR 2C, expand fmm_state in ADR 9C
3.14	05/16/2007	New pattern finder registers
4.01	05/24/2007	New clct pattern finder algorithm
4.02	06/21/2007	New pattern ID numbers, new layer triggermods to Adrs 10,D4, and A0,A6,A8,AA,CA,CC,header16
4.03	07/05/2007	Key layer shifted from ly3 to ly2, adjcfcb_dist expanded to 6 bits, activefeb bugfix
4.04	07/10/2007	Firmware update, no change to doc
4.05	07/24/2007	Update ADR 78,88,8C descriptions to match current CLCT0/1 4-bit pattern IDs
4.06	07/26/2007	Fix text for adr 68, 6C, A6
4.07	08/06/2007	Increase injector read-write adr to 10 bins in ADR 44, ADR BE
4.08	08/30/2007	New header/trailer format
4.09	09/04/2007	Mods to header format, expand VME counters to 30 bits
4.10	09/10/2007	New fields in header 24, new VME counters
4.11	09/14/2007	Header bug fixes, new no-alct counter
4.12	09/21/2007	Push hsd bit into pat[3] in documentation
4.13	12/17/2007	Switch to big-buffer logic
4.14	01/28/2008	Replace entire L1A logic, replace lct_quality



4.15	02/05/2008	Add raw hits RAM parity errors to header27
4.16	04/29/2008	Major update for new flow-through triggering
4.17	05/01/2008	All scope channels reassigned, header frame bug fixes
4.18	05/12/2008	Add clct + alct bx0 heartbeat to mpc_tx[11], mpc_tx[27]
4.19	05/23/2008	Adr B0[15:14] Add clock_lock_lost and sync_er
4.20	06/03/2008	Add counter clears on ttc_resync, add alct debug to scope, new active_feb_flag
4.21	07/09/2008	Replace jtag state machine, rename thresh signals, add pid_thresh_postdrift
4.22	07/15/2008	non-trigger readout mods
4.23	08/12/2008	Add bx0_match, add me1a/b separation ram mux, add alct data tx delay
4.24	08/28/2008	Programmable stagger removed, csc firmware types created, new counters
4.25	09/12/2008	Add tmb logic signals to header40,41
4.26	09/16/2008	Update tables for header words 36(rpc),40,41. Updated sample raw hits dump
4.27	10/01/2008	Mod header08,36,40,41, replaced scope module and vme register, jtag sel
4.28	11/18/2008	Add reg FE, L1A and parity logic mods, add sync err and parity err counters
4.29	11/19/2008	Remove stagger_csc from Adr F4[1], staggering info is in Adr CC
4.30	12/10/2008	Add l1a_lookback mode, l1a_lookback reg + sequencer debug reg; add parity ram
4.31	02/05/2009	Add alct-loopback logic in alct.v module
4.32	03/16/2009	Add ecc to alct data, add ecc counters, add cfeb counters
4.33	04/15/2009	Updates for alct 80MHz output stages
4.34	05/15/2009	Miniscope added, RPC readout mods, bx0 test mode
4.35	05/29/2009	Add alct muonic timing
4.36	06/22/2009	More alct muonic mods
4.37	06/29/2009	Replace alct_txd, alct_rxd DDD delays with digital phase shifters
4.38	07/13/2009	Add cfeb muonic timing, 5 digital phase shifters, 2 vme delay registers
4.39	08/14/2009	CFEB muonic version, removed cfeb and alct_rx posnegs, still has alct_tx posneg
4.40	08/25/2009	ALCT+CFEB muonic with posneg sync stages, ISE 8.2sp3
4.41	09/02/2009	Correct adr 16
4.42	09/08/2009	Add digital phase shifter autostart
4.43	09/21/2009	Add sync register 0x120, limit bxn offsets to be < lhc_cycle
4.44	10/15/2009	Add alct0==alct1 error counter, change D0[5] default to 1, enables alct err counter
4.45	11/23/2009	Text corrections
4.46	12/09/2009	Add alct and cfeb muonic figures
4.47	12/16/2009	Add cfeb bad bit detection and registers
4.48	01/14/2010	Add cfeb bad bit list to header30, mod bad bit ctrl reg
4.49	02/10/2010	Add event clear for aff, clct, mpc VME diagnostic registers
4.50	03/12/2010	Add blocked bits readout, clct-only mode bug fix
4.51	04/09/2010	Fix header30 typo, add firmware log for 3/19/2010 version
4.52	05/14/2010	Mod Adr 0x2A and Adr 0x120, add firmware log for 5/14/10 version
4.53	07/02/2010	Mod Adr 0x32, 0x42, 0x9E, 0x100, and hdr38[14]
4.54	07/08/2010	Move injector ram msbs to lookback reg, revert injector wen,ren
4.55	07/15/2010	Add miniscope section to header chapter
4.56	09/03/2010	Convert to MS Word 2010
4.57	08/17/2012	Add startup delay for ALCT Spartan-6 mezzanine
4.58	09/16/2012	Add Virtex-6 GTX optical receivers
4.59	09/23/2012	Add Virtex-6 Sysmon
4.60	10/15/2012	Change pid_thresh descriptions in adr 0xF4
4.61	03/07/2013	Convert doc to docx, mod header + add registers for 7 DCFEB Virtex-6

4.62	2013/10/24	Change order of keys in LCT quality module, documentation updated accordingly
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# Firmware Change Log

Version 03/08/2013

## Adds support for 7 DCFEBs with Virtex-6

- 1) Modified ADR\_SEQCLCTM=0xB0 Sequencer CLCT msbs Register, Readonly  
Added seq\_clctmsb\_rd[9:8] = clctf\_vme[6:5], bits were formerly unused  
Now seq\_clctmsb\_rd[9:3] = clctf\_vme[6:0] Active cfeb list at TMB match
- 2) ADR\_PARITY=0xFA Parity errors  
Changed sub-address assignments to accommodate DCFEB[6:5]
- 3) Modified ADR\_CNT\_CTRL=0xD0 Status Counter Control  
Inserted 2 new counters after cnt[18], shifts subsequent counter addresses by 2  
cnt\_en[19] <= cfeb\_hit\_at\_pretrig[5] CLCT pretrigger is on CFEB5  
cnt\_en[20] <= cfeb\_hit\_at\_pretrig[6] CLCT pretrigger is on CFEB6
- 4) Modified ADR\_DELAY1\_INT=0x11E DDR Interstage delays for DCFEB[6:5]  
Added:  
cfeb5\_rxd\_int\_delay[3:0] = delay1\_int\_wr[7:4];  
cfeb6\_rxd\_int\_delay[3:0] = delay1\_int\_wr[11:8];
- 5) Added ADR\_V6\_CFE5\_BADBITS\_CTRL=0x15C CFEB Bad Bits Control/Status  
For DCFEB[6:5] badbits, extends 5 bit fields from ADR\_CFE5\_BADBITS\_CTRL
- 6) Added 6 new bad bit VME registers  
ADR\_V6\_CFE5\_BADBITS\_LY01 = 0x15E CFEB5 Bad Bit Array  
ADR\_V6\_CFE5\_BADBITS\_LY23 = 0x160 CFEB5 Bad Bit Array  
ADR\_V6\_CFE5\_BADBITS\_LY45 = 0x162 CFEB5 Bad Bit Array  
  
ADR\_V6\_CFE6\_BADBITS\_LY01 = 0x164 CFEB6 Bad Bit Array  
ADR\_V6\_CFE6\_BADBITS\_LY23 = 0x166 CFEB6 Bad Bit Array  
ADR\_V6\_CFE6\_BADBITS\_LY45 = 0x168 CFEB6 Bad Bit Array
- 7) Added 2 new Digital Phase Shifter VME registers  
ADR\_V6\_PHASER7=0x16A DCM Phase Shifter Register: CFEB5 rxd  
ADR\_V6\_PHASER8=0x16C DCM Phase Shifter Register: CFEB6 rxd

8) Added 6 New hot channel mask registers

ADR\_V6\_HCM501 = 0x16E      CFEB5 Ly0,Ly1 Hot Channel Mask  
ADR\_V6\_HCM523 = 0x170      CFEB5 Ly2,Ly3 Hot Channel Mask  
ADR\_V6\_HCM545 = 0x172      CFEB5 Ly4,Ly5 Hot Channel Mask

ADR\_V6\_HCM601 = 0x174      CFEB6 Ly0,Ly1 Hot Channel Mask  
ADR\_V6\_HCM623      = 0x176 CFEB6 Ly2,Ly3 Hot Channel Mask  
ADR\_V6\_HCM645      = 0x178 CFEB6 Ly4,Ly5 Hot Channel Mask

9) Modified ADR\_MOD\_CFG 0x28 TMB Module Configuration Register

Replaced led\_flash\_rate from mod\_cfg\_wr[11:10] with cfeb\_exists[6:5]  
Now: mod\_cfg\_rd[11:5] = cfeb\_exists[6:0] = CFEBs instantiated in this firmware

10) Added new VME register ADR\_V6\_EXTEND = 0x17A: DCFEB 7-bit extensions

Extends 5-bit cfeb fields in ADR 0x42 and 0x68 to 7 bits

mask\_all[6:5]                      = [1:0] Extend 0x42[4:0]      = mask\_all[4:0] 1=Enable, 0=Turn off all CFEB inputs  
inj\_febsel[6:5]                    = [3:2] Extend 0x42[9:5]      = inj\_febsel[4:0] 1=Select CFEBn for RAM read/write  
injector\_mask\_cfeb[6:5] = [5:4] Extend 0x42[14:10] = injector\_mask\_cfeb[4:0] 1=Enable CFEB(n) for injector  
cfeb\_en\_vme[6:5]                  = [7:6] Extend 0x68[14:10] = cfeb\_en\_vme[4:0] 1=Enable CFEBs for triggering

11) Modified ADR\_LOOPBK 0x0E      Loop-Back Control Register 2 remove 2 spare DMB signals

Reassigned dmb\_tx\_reserved to remove the 2 new active feb bits from the unused list  
Updated bits [10:5] to match current firmware

12) TMB-to-DMB Active CFEB List backplane signals extended 5 bits to 7

Assigned 2 new bits to the next available spare DMB signals.

dmb\_tx[45:44] <= active\_feb\_list[6:5]

TMB schematic signals:

Signal res\_to\_dmb1 is now active\_feb\_list[5] on backplane pin E10

Signal res\_to\_dmb2 is now active\_feb\_list[6] on backplane pin A11

13) Modified header40\_[11:0] for 7-bit extensions to various 5-bit header fields

Header40\_[11:0] used to contain the peak RAM fence counter for raw hits storage debugging.  
The peak count has been removed, but can still be read out with VME, and its dynamic status is indicated by header40\_[10].

The flag bit in header40\_[11] indicates when bits [10:0] are valid for 7-dcfcb firmware versions.

header40\_[1:0] = active\_feb\_mux[6:5]; Extend Hdr23[4:0] Active CFEB list sent to DMB  
header40\_[3:2] = r\_cfefs\_read[6:5];                      Extend Hdr23[9:5] CFEBs read out for this event  
header40\_[5:4] = perr\_cfeb\_ff[6:5];                      Extend Hdr27[12:8] CFEB RAM parity error, latched  
header40\_[7:6] = cfeb\_badbits\_found[6:5];              Extend Hdr30[11:7] CFEB[n] has at least 1 bad bit  
header40\_[9:8] = cfeb\_en[6:5];                          Extend Hdr35[14:10] CFEBs enabled for triggering  
header40\_[10] = buf\_fence\_cnt\_is\_peak;                  Current fence is peak number of fences in RAM  
header40\_[11] = (MXCFEB==7);                          TMB has 7 DCFEBs so hdr40\_[10:0] are active

14) Modified raw hits readout

Readout can now include raw hits from 0 to 7 CFEBs, as indicated by cfefs\_read[6:0]. The 7-bit CFEB list cfefs\_read[6:0] is constructed from cfefs\_read[4:0] in header23\_[9:5] and cfefs\_read[6:5] in header40\_[3:2].

In 5-CFEB firmware versions, header40[11] is zero (unless there is a fault in the readout logic).

A zero in header40\_[11] indicates a 5-CFEB TMB, and the bits in header40\_[10:0] should not be used to extend 5-bit fields (cfebs\_read for instance).

15) Blocked bits readout

Readout can now include blocked hits from 0 to 7 CFEBs, as indicated by cfebs\_read[6:0].

## Version 09/23/2012

- 1) Add VME register 0x15A: ADR\_VIRTEX6\_SYSMON

## Version 09/16/2012

### Adds support for Virtex-6 SNAP12 GTX fiber optic receivers

- 2) Add VME register 0x148: ADR\_VIRTEX6\_SNAP12\_QPLL  
Virtex-6 mezzanine QPLL reset and status  
Virtex-6 mezzanine SNAP12 receiver serial interface
- 3) Add VME register 0x14A: ADR\_VIRTEX6\_GTX\_RX\_ALL  
GTX control and status common to all 7 receivers
- 3) Add 7 VME registers 0x14C-0x158: ADR\_VIRTEX6\_GTX\_RX0 - ADR\_VIRTEX6\_GTX\_RX6  
GTX control and status for individual receivers
- 4) Add event counters 79-85:  
GTX receiver counters for fibers 0-6  
Clears on gtx\_rx\_reset\_err\_cnt
- 5) Add mezzanine test points for GTX receiver [0]

```
`ifdef VIRTEX6
    assign meztp20 = gtx_rx_start[0];
    assign meztp21 = gtx_rx_valid[0];
    assign meztp22 = gtx_rx_match[0];
    assign meztp23 = gtx_rx_fc[0];
    assign meztp24 = alct_wait_cfg;
    assign meztp25 = lock_tmb_clock0;
    assign meztp26 = 0;
    assign meztp27 = sump;
`else
    assign meztp20 = alct_startup_msec;
    assign meztp21 = alct_wait_dll;
    assign meztp22 = alct_startup_done;
    assign meztp23 = alct_wait_vme;
    assign meztp24 = alct_wait_cfg;
    assign meztp25 = lock_tmb_clock0;
    assign meztp26 = 0;
    assign meztp27 = sump;
`endif
```

## Version 08/17/2012

- 1) Delay JTAG PROM data stream to ALCT by 116msec to allow Spartan-6 mezzanine to finish configuration.

Spartan-6 takes 212msec to configure and TMB takes 100msec.

TMB sends JTAG data to ALCT 100+116=216msec, after a simultaneous hard reset.

The 4msec pad allows ALCTs DLL/PLL time to lock.

- 2) Add VME register Adr 0x144 ALCT Spartan-6 startup delay
- 3) Add VME register Adr 0x146 ALCT Spartan-6 startup state machine status
- 4) Change Adr 0xD4[2]=jsm\_sel, was Write-only, is now Read/Write

## Version 07/07/2010

- 1) Injector RAM mods:

Move injector RAM data msbs [17:16] from 0x44 to 0x100

Revert 0x44 wen and ren to independent RAM enables

## Version 07/04/2010

- 1) Changed default Adr 0x100[15] l1a\_win\_pri\_en = 1  
Enables window prioritizing mode to limit TMB to 1 readout per L1A

## Version 07/01/2010

- 1) Bug fix in alct\*clct matching for a rare case when 2 CLCTs are exactly clct\_window bx apart in time.  
Caused 1<sup>st</sup> CLCT to be replaced by 2<sup>nd</sup> CLCT, sending 2 identical events to L1A pipeline.
- 2) New algorithm for L1A matching prevents multiple events from reading out for 1 L1A.  
Original algorithm allowed multiple events to read out if they were within the L1A window.  
A system downstream of TMB apparently fails to tolerate multiple readouts per L1A.  
Adr 0x100[15] l1a\_win\_pri\_en = 0 enables original multiple event readouts per L1A mode  
l1a\_win\_pri\_en = 1 enables a prioritizing mode that limits TMB to 1 readout per L1A  
Current default l1a\_win\_pri\_en = 0 to allow checking alct\*clct matching logic.  
Next firmware release will set the default to 1.
- 3) New counter 58 is inserted after counter 57, all subsequent counters shift up 1 channel number.  
Counter 58 counts events lost from readout queue due to L1A window prioritizing that limits TMB to 1 event readout per L1A.
- 4) A buffer stalled-at-least-once bit has been added to Adr 0x9E[7] and Header38[14].  
Indicates there was a least one buffer stall since the last resync.
- 5) Adr 0x44 rebuilt to expand CFEB pattern injectors to also assert L1A and ALCTs at an arbitrary time.  
The 3 individual injector RAM select bits ren and wen have been replaced by 2-bit RAM addresses.  
Injector RAM data width expanded from 16 to 18 bits to provide storage for 2 ALCTs and L1A.
- 6) Adr 0x32[3] alct\_inj\_ram\_en = 1 enables ALCT pattern injector RAM  
Adr 0x32[4] l1a\_inj\_ram\_en = 1 enables L1A pattern injector RAM
- 7) Miniscope is now turned on by default: Adr 0x10C[0] mini\_read\_enable = 1.  
Miniscope word count automatically inserted in readout stream by default Adr 0x10C[2]=1  
New channel assignments, see Adr 0x10C section.



## Version 05/14/2010

- 1) Add bx0 emulator enable to Adr 0x2A[15]. Power-up default is 0.  
Generates bx0 that is ORed with ttc\_bx0. For use in systems lacking a CCB.
- 2) Add clock\_lock\_lost\_err\_en to Adr 0x120[5] (shifts other bits left by 1).  
Add clock\_lock\_lost\_err\_ff to Adr 0x120[14].  
Add force\_sync\_err to Adr 0x120[15].
- 3) Redesign vme.v to use initial blocks to specify power-up state for VME registers instead of load pulse  
Add explicit integer widths to VME address decoder case statement.  
Replace constants passed as signals from top level module with defparam mechanism.
- 4) Remove clock\_lock\_lost from OR with bx0\_sync\_err in sequencer.v  
Add clock\_lock\_lost term to sync\_err\_ff in sync\_err\_ctrl.v  
Remove bx0\_sync\_err from sync\_err\_ff, add it as an independent OR with sync\_err signal.  
Fixes sync\_err fails-to-clear bug:  
Sync\_err\_ff clears on ttc\_resync but bx0\_sync\_err takes n bx to clear.  
TMB was synchronizing correctly on ttc\_resync, but incorrectly latched sync\_err=1.
- 5) Modify bx0 sync error counter[61] to count only when TMB is in trigger-run state.  
Was counting sync errors before ttc\_resync arrived, now only counts errors that occur after a resync.  
A non-zero value in this counter indicates incorrect bxns in TMB readouts and LCTs.
- 6) Modify FMM state machine fmm\_trig\_stop signal to power up as a 1.  
Was powering up as 0, then set to 1 after the 1<sup>st</sup> clock cycle.  
Entered trigger-run state for 1bx but was ignored since pre-trigger logic is held off 5bx after power up
- 7) Fix tmb.v kill\_clct logic for type C|D for 1 clct + 2 alct case where clct is on ME1A

## Version 03/19/2010

- 1) Mod cfeb.v module busy hs delimiters for me1a me1b cscs to separate cfeb4 from cfebs0-3.  
Prevents pattern finder from discarding 2<sup>nd</sup> CLCT at the me1a|me1b boundary.

## Version 03/07/2010

- 1) Added requested mod that blocks bad cfeb distrips from both trigger path and data path.
- 2) Add bcb\_read\_enable to Adr72[15] [p42](#) to include blocked CFEB DiStrip list in the DMB readout stream:  
Blocked bits include:  
CFEB DiStrip bits turned off in the Hot Channel Mask,  
CFEB DiStrip bits turned off by automatic bad-bits detection  
Entire CFEBs turned off via mask\_all  
Set Adr72[[15]=1 to enable blocked bits readout.  
Power up default is 0, which is backwards compatible with older versions of the readout stream.
- 3) Add bcb\_read\_enable to Header29[13]
- 4) Document CFEB blocked DiStrip readout format, [p96](#)
- 5) Bug fix for CLCT-only trigger mode  
The 2<sup>nd</sup> CLCT in previous firmware versions had bxn=0 in the LCT sent to MPC when using the clct-only mode, and there was also no ALCT coincidence.

## Version 02/10/2010

- 1) Add event\_clear\_vme to AdrAC[15] to clear aff, clct, and mpc VME read-back registers
- 2) Add active\_feb list reversal for TypeB CSCs

## Version 01/14/2010 CFEB bad di-strip bit detection

1) Header30[11:7] = cfeb\_badbits\_found[4:0]    Bad distrip bits detected in cfebn[n]  
Header30[12] = 0

2) New VME registers Adr 0x122 to 0x142

Adr 122 ADR\_CFEB\_BADBITS\_CTRL, CFEB Bad Bits Control/Status

[04:00]	RW	cfeb_badbits_reset[4:0]	Reset bad cfeb bits FFs for cfeb[n]
[09:05]	RW	cfeb_badbits_block[4:0]	Block bad cfeb bits in cfeb[n]
[14:10]	R	cfeb_badbits_found[4:0]	CFEB[n] has at least 1 bad bit
[15]	R	cfeb_badbits_blocked	At least one CFEB has a bad bit that was blocked

Adr 124 ADR\_CFEB\_BADBITS\_TIMER            CFEB Bad Bits Check Interval

Sets number of bx a bit must be continuously high before being marked as bad.

Adr 126	ADR_CFEB0_BADBITS_LY01	CFEB0 Ly0,Ly1 Bad Bits List
Adr 128	ADR_CFEB0_BADBITS_LY23	CFEB0 Ly2,Ly3 Bad Bits List
Adr 12A	ADR_CFEB0_BADBITS_LY45	CFEB0 Ly4,Ly5 Bad Bits List
Adr 12C	ADR_CFEB1_BADBITS_LY01	CFEB1 Ly0,Ly1 Bad Bits List
Adr 12E	ADR_CFEB1_BADBITS_LY23	CFEB1 Ly2,Ly3 Bad Bits List
Adr 130	ADR_CFEB1_BADBITS_LY45	CFEB1 Ly4,Ly5 Bad Bits List
Adr 132	ADR_CFEB2_BADBITS_LY01	CFEB2 Ly0,Ly1 Bad Bits List
Adr 134	ADR_CFEB2_BADBITS_LY23	CFEB2 Ly2,Ly3 Bad Bits List
Adr 136	ADR_CFEB2_BADBITS_LY45	CFEB2 Ly4,Ly5 Bad Bits List
Adr 138	ADR_CFEB3_BADBITS_LY01	CFEB3 Ly0,Ly1 Bad Bits List
Adr 13A	ADR_CFEB3_BADBITS_LY23	CFEB3 Ly2,Ly3 Bad Bits List
Adr 13C	ADR_CFEB3_BADBITS_LY45	CFEB3 Ly4,Ly5 Bad Bits List
Adr 13E	ADR_CFEB4_BADBITS_LY01	CFEB4 Ly0,Ly1 Bad Bits List
Adr 140	ADR_CFEB4_BADBITS_LY23	CFEB4 Ly2,Ly3 Bad Bits List
Adr 142	ADR_CFEB4_BADBITS_LY45	CFEB4 Ly4,Ly5 Bad Bits List

### Usage Notes:

1) Dead channel detection:

Detects CFEB channels that never fire

Set Adr122[09:5]=0x00 to turn off badbit blocking

Set Adr124[15:0]=0x0001 to set high-time threshold to 1 bx

Read dead channel list from Adrs126-142

2) Noisy channel detection:

Detects CFEB channels that have after-pulsing or frequent firing,  
for instance, 3 consecutive triad starts)

Set Adr122[09:5]=0x00 to turn off badbit blocking

Set Adr124[15:0]=0x0007 to set high-time threshold to 7 bx

Read noisy channel list from Adrs126-142

3) Bad bit detection or blocking

Detects CFEB channels that are always high or high for an unreasonable length of time

Set Adr122[09:5]=0x1F to turn on badbit blocking (or set 0x00 for just monitoring)

Set Adr124[15:0]=0x0DEC to set high-time threshold to 3564 bx or something similar

Read bad channel list from Adrs126-142

## Version 10/15/09 ALCT duplicate alct detection + Header r-type

- 1) Header05[10:9] r\_type always == 1 on previous versions.  
It should equal fifo\_mode unless the event buffer is full.
- 2) Added ALCT structure error counter cnt[75] to count events where alct0==alct1.
- 3) ADRD0[5] Changed default to cnt\_alct\_debug=1 to enable ALCT data structure error counters.  
N.B. The ALCT structure error counters are only 8 bits, and could reach full scale quickly.  
So, ADRD0[02] cnt\_stop\_on\_ovf should be 0, when setting cnt\_alct\_debug=1, otherwise all event counters will stop counting if there are excessive ALCT errors.

## Version 09/21/09 Synchronization Error Control Register + bxn offset limit

Add limits for bxn\_offset\_pretrig and bxn\_offset\_l1a  
bxn\_offset > lhc\_cycle is converted to lhc\_cycle-1

Add sync\_err\_ctrl register ADR 0x120

## Version 09/08/09 Digital Phase Shifter Autostart

Add vsm\_phaser\_auto to ADRDA[11].  
Default = 1, starts digital phase shifters after VME user PROM is read

## Version 08/25/09 PosNeg sync FFs for ALCT and CFEBs

Same as 8/14/09 version but has ALCT and CFEB posneg sync stages enabled.  
Switched to ISE 8.2sp3 because ISE 10.1sp3 could not complete PAR.

Documentation updates to conform firmware to c++ demo code:

Phaser register signal names now absorb hcycle and qcycle bits into 1 8-bit phase delay:

ADR10E:        alct\_rxd\_delay[7:0]                Delays latching data received from ALCT in 0.1ns steps  
ADR110:alct\_txd\_delay[7:0]                Delays data transmitted to ALCT in 0.1ns steps  
ADR112-11A:    cfeb[n]\_rxd\_delay[7:0] Delays latching data received from CFEB[n] in 0.1ns steps

Modify interstage delay signals to make it clear they are integer bx delays:

ADR38:        alct\_txd\_int\_delay[3:0] Delay data transmitted to ALCT by integer bx  
ADR11C-11E:   cfeb[n]\_rxd\_int\_delay[3:0]        Delay data received from CFEB[n] by integer bx

## Version 08/14/09 Digital Phase shifters for CFEBs

Has both ALCT and CFEB muonic timing.

Disabled cfeb posnegs and alct\_rxd\_posneg else compile fails. Alct\_txd\_posneg is OK.

Notes on ALCT and CFEB timing adjustments:

ALCT:

- 1) Select a Time of Flight delay:
  - Using DDD 2ns steps, ranging from 0 to 12, spanning 0 to 24ns
  - Based on distance from IP to "some point" on the CSC
  - Also compensate for tmb-to-alct cable propagation delay differences between CSCs
  - Write alct\_tof\_delay to DDD chip in ADR16[3:0]
- 2) Tune alct\_rxd\_delay to the good-data window center
  - Using Digital Phase Shifter 0.1ns steps, ranging from 0 to 255, spanning 0 to 25ns
  - Put ALCT into loopback mode to send a test pattern to TMB
  - Scan alct\_rxd\_delay 0-255 using Phaser0 ADR10E[15:8]
  - Scan alct\_rxd\_posneg 0-1 using Phaser0 ADR10E[15:8] (disabled in 8/14/09 firmware)
- 3) Tune alct\_txd\_delay to the good-data window center
  - Using Digital Phase Shifter 0.1ns steps, ranging from 0 to 255, spanning 0 to 25ns
  - Put ALCT into loopback mode to send a test pattern to TMB
  - Scan alct\_txd\_delay 0-255 using Phaser1 ADR110[15:8]
  - Scan alct\_rxd\_posneg 0-1 using Phaser1 ADR110[15:8] (not disabled in 8/14/09 firmware)

CFEBs:

- 1) Select a Time of Flight delay:
  - Using DDD 2ns steps, ranging from 0 to 12, spanning 0 to 24ns
  - Based on distance from IP to "some point" on the CSC
  - Also compensate for tmb-to-cfeb cable propagation delay differences between CSCs
  - Write cfeb\_tof\_delay to DDD chip in ADR18[11:8]
- 2) Tune cfeb[n] clock delays for simultaneous arrival at all 5 cfebs
  - Using DDD 2ns steps, ranging from 0 to 12, spanning 0 to 24ns
  - Delays might be set according to known cable propagation delays
  - Delays might be determined empirically by setting high comparator thresholds to make the analog signal time-over-threshold less than 25ns, then scanning DDD delay vs 6-hit efficiency.
  - Write cfeb[n] clock delays to DDD channels in ADR18[15:12] and ADR1A[15:0]
- 3) Tune cfeb\_rxd\_delay for cfeb[n] to the good-data window center
  - Using Digital Phase Shifter 0.1ns steps, ranging from 0 to 255, spanning 0 to 25ns
  - Generate CFEB test pulses or use muon tracks
  - Scan cfeb\_rxd\_delay 0-255 using Phaser2-6 ADR112-ADR11A bits[15:8]
  - Scan cfeb\_rxd\_posneg 0-1 using Phaser2-6 ADR112-ADR11A
- 4) Tune cfeb inter-stage integer delay for cfeb[n]
  - Set a delay 0-15bx so that triad bits from all 5 CFEBs arrive at TMB on the same bxn
  - Might be done by pulsing all 5 CFEBs simultaneously, then checking the CFEB raw hits readout to see that triad start bits all appear in the same bxn.

Set cfeb[n] inter-stage delays in Adr11C-Adr11E

### Version 07/13/09 Digital Phase shifters for CFEBs

Added 5 digital phase shifters for cfeb rxd delays: Adr112-Adr11A

Add 2 VME registers: Adr11C-Adr11E for CFEB interstage delays

### Version 06/29/09 Digital Phase shifters for ALCT

Two digital phase shifters replace DDD delays for alct\_txd\_delay and alct\_rxd\_delay

Add VME registers Adr10E and Adr110 for digital phase shifters

Adr14[13,11,10] reverted to old format, removed phase shifter DCM locks

Adr30[15:13] removed posnegs, they now reside in Adr10E and Adr110, cfeb posneg is gone for now

## Version 06/22/09 Muonic Timing for ALCT

Added muonic timing to float ALCT board in clock-space independently of good-data rxd|txd windows.

Changes to DLL lock register:

Adr14[10] lock\_alct\_rxd [these get undone in 6/29/09 version]  
Adr14[11] lock\_alct\_txd  
Adr 14[13] lock\_cfeb\_rxd

Changes to DDD delay and posneg registers:

Adr16[3:0] alct\_tof\_delay Shift entire ALCT in clock-space to compensate for muon time of flight  
Adr16[7:4] alct\_txd\_delay Latches TMB-to-ALCT data in middle of transmit data window  
Adr16[11:8] dmb\_tx\_delay Change default to 6

Adr18[3:0] alct\_rxd\_delay Latches ALCT-to-TMB data in middle of receive data window  
Adr18[7:4] cfeb\_rxd\_delay Latches CFEB-to-TMB data in middle of receive data window  
Adr18[11:8] cfeb\_tof\_delay Shift all CFEBs in clock-space to compensate for muon time of flight.

Adr30[8] alct\_clock\_en\_use\_ccb moved from [11]  
Adr30[9] alct\_clock\_en\_use\_vme moved from [12]  
Adr30[10] alct\_muonic 1=ALCT muonic version instantiated, readonly  
Adr30[11] cfeb\_muonic 1=CFEB muonic version instantiated, readonly  
Adr30[12] unassigned

[These changes get undone in 6/29/09 version:]

Adr30[13] cfeb\_rxd\_posneg Sets receive data posneg clock polarity (new signal)  
Adr30[14] alct\_txd\_posneg Sets transmit data posneg clock polarity, (was alct\_posneg)  
Adr30[15] alct\_rxd\_posneg Sets receive data posneg clock polarity (new signal)

Changed 8bx constant delay in alct random number pipeline to be VME programmable

Added 2bx to compensate for muonic sync stages.

Default delay is now  $8+2-1=9$ bx

Good spots for reference TMB+ALCT384 occur at pipedepth 4 when alct\_sync\_rxdata\_pre=9

Adr104[15:12] = alct\_sync\_rxdata\_pre[3:0], default=9

Changed Adr 0E[15:11] to connect dmb\_tx\_reserved[4:0] to dmb\_tx[48:44]

Adr 0E[15:11] = dmb\_tx\_reserved[4:0], just set to 0 for now

## Version 06/05/09

Re-structure dmb\_tx[48:0] flip-flops to force IOB instantiation

No other changes

## Version 05/15/09

Added miniscope to monitor clct pretrigger processing and alct\*clct matching.

Added miniscope VME register Adr 0x10C.

Rebuilt parity register Adr 0xFA to accept miniscope RAM parity.

Restructured DMB image RAM from 5 BRAMs down to 4 BRAMs to free up 1 RAM

Reduced ALCT raw hits storage RAM from 2048bx down to 1024bx to free up 1 RAM

Replaced Virtex-E era RPC de-mux and pipeline stages to minimize latency.

Added clct pre-trigger signal to RPC readout to DMB in a former always-zero bit.

Added data=address test mode to RPC storage RAM

Added 8bx constant delay in alct random number pipeline. Good spots at depth 12 before are now at 4.

Removed legacy alct signals from Adr 0x38,0x30 and Hdr 30[12:7] that are now used for ECC parity.

Added alct\_ecc\_err\_blank to Adr 038[2] to blank alct data that has uncorrected ecc errors.

Added counter[6] to count alct data blanked due to uncorrected ecc errors

Adr 0x30: Removed Adr30[11:8] alct\_reserved\_out[3:0], as these bits now carry ecc parity.

Adr 0x38: Adr38 has been reorganized to make room for the new alct\_ecc\_err\_blank signal

**Moved alct\_ecc\_en to Adr38[1] n.b. this affects loop-back test software**

Added alct\_ecc\_err\_blank to Adr38[2] blanks alcts with uncorrected ecc errors.

**Moved alct\_sync\_ecc\_err to Adr38[4:3] n.b. this affects loop-back test software**

Removed Adr38[2:1] seq\_status[1:0]

Removed Adr38[4:3] seu\_status[1:0]

Removed Adr38[8:5] reserved\_out[3:0]

```
alct_stat_rd[0]    = alct_cfg_done;           // R   ALCT FPGA loaded
alct_stat_rd[1]    = alct_ecc_en;            // RW  Enable ALCT ECC decoder, else do no ECC correction
alct_stat_rd[2]    = alct_ecc_err_blank;      // RW  Blank alcts with uncorrected ecc errors
alct_stat_rd[4:3]  = alct_sync_ecc_err[1:0]; // R   ALCT sync mode ecc error syndrome
alct_stat_rd[11:5] = alct_stat_wr[11:5];     // RW  Free
alct_stat_rd[15:12] = alct_txd_delay[3:0];    // RW  ALCT data transmit delay, integer bx
```

Adr 0xFA: AdrFA has been reorganized to make room for the new miniscope RAM parity  
perr\_adr[] expanded from 3 to 4 bits.

Adr 0x10C: New Miniscope control register.

Adr 0xBC[14] Added rpc\_tbins\_test for RPC RAM data=address test mode

Adr 0xCA[9] Moved bx0\_match to [10]  
Added bx0\_vpf\_test to [9]

Hdr27[13] now ORs miniscope RAM parity errors with RPC RAM parity errors

Hdr19[14] vme\_exists replaced by mini\_read\_enable

RPC readout format: unused tbin bit[11] was always 0, now has clct-pretrigger flag

Counter[06]: Inserted scnt[06]="ALCT: trigger path ECC>=2-bit error, ALCT discarded"  
Shifts subsequent counters up by 1 address.

TMB readout format changed to include miniscope data and markers when mini\_read\_enable=1.



By default, inserts B07 marker, 22 scope words, then E07 marker after RPC data.

ALCT legacy cable signals that are now ecc parity updated in

Table 24: J5 ALCT Cable1 Connector [J10 on ALCT board]

Table 17: J6 ALCT Cable2 Connector [J11 on ALCT board]

### Versions 04/07/2009 - 04/14/09

Added TMB-to-ALCT sync-stage and inter-stage in alct.v module.

Improves alct\_rx\_clock windows, and allows a ½-cycle shift  
in alct\_rx\_clock at inter-stage, but adds 2bx to output signals.

Add Adr 30[14] alct\_posneg

Modified UCF to constrain ALCT inter-stage flip-flops to FPGA slice locations near ALCT IOBs

Compiled 1 version with ALCT 80 MHz IOBs set to Slew=Fast | Drive=12

Another version has ALCT 80 MHz IOBs set to LVDCI\_33 (Digitally Controlled Impedance, 50Ω)

Added TMB-to-ALCT 80MHz diagram to this doc

## Version 03/16/2009

### New Features:

- Error Correcting Code to ALCT-to-TMB trigger data path, using reserved rx signals
- Error Correcting Code to TMB-to-ALCT TTC command path, using reserved tx signals
- Separate bxn counter and offset for L1A

New event counters + re-numbered ALCT-counter-group 0-11 [see counter register adr 0x000]  
(see AdrD0 [p59](#) for details)

- 3 for ECC rx data
- 3 for ECC tx data
- 5 for individual CFEB pre-triggers
- 1 for alct\_bx0

### Register Changes:

Adr 016 change delay\_ch0[3:0] alct\_tx\_clock default to 11 for use with reference ALCT

Adr 076 rename from adr\_seq\_offset to adr\_seq\_offset0

Adr 076 rename bxn\_offset[11:0] to bxn\_offset\_pretrig[11:0]

Adr 0D0 increase cnt\_select[6:0] by 1 bit to address more event counters

Adr 0D0 move perr\_reset from AdrD0[15] to AdrFA[6]

Adr 10A new register adr\_seq\_offset1

Adr 10A add bxn\_offset\_pretrig[11:0], which is a separate bxn offset for the new L1A bxn counter

Adr038[10:9] new signal: alct\_sync\_ecc\_err[1:0] is ALCT sync-mode ECC error code, readonly

Adr038[11] new signal: alct\_ecc\_en is ALCT ECC trigger data correction enable with default=1

N.B. setting alct\_ecc\_en =0 stops ALCT trigger data correction, but does not affect ECC counters

### Header Changes:

Header30[6:5] now contains alct\_ecc\_err[1:0]

### ALCT Cable Signal Changes for ECC

Old	New	Comment
reserved_in[0]	parity_in[0]	ECC parity [5:0] for TMB-to-ALCT
reserved_in[1]	parity_in[1]	""
reserved_in[2]	parity_in[2]	""
reserved_in[3]	parity_in[3]	""
seq_cmd[0]	seq_cmd[0]	Activates ALCT sync mode
seq_cmd[1]	parity_in[4] seq_cmd[1]	Parity sent unless in sync mode
seq_cmd[2]	seq_cmd[2]	Activates ALCT sync mode
seq_cmd[3]	seq_cmd[3]   parity_in[5]	Parity sent unless in sync mode
seq_status[0]	parity_out[0]	ECC parity [6:0] for ALCT-to-TMB
seq_status[1]	parity_out[1]	""
seu_status[0]	parity_out[2]	""
seu_status[1]	parity_out[3]	""
reserved_out[0]	parity_out[4]	""
reserved_out[1]	parity_out[5]	""
reserved_out[02]	parity_out[6]	""

## Version 02/05/2009

Added ALCT-TMB sync mode loop-back test logic to alct.v module.

Mod Adr F2: Change compiler ID field to accommodate extra digit for ISE 10.1I  
Add Adr104, Adr106, Adr108 for ALCT sync-mode data

### Version 01/13/2009

Rename ALCT cable 2 pair 15 from reserved\_in4 to seq\_cmd3  
Adr 30: alct\_cfg: rename Adr30[7] to seq\_cmd3, replaces reserved\_in4

### Version 12/10/2008

Add L1A-only readout mode with full header and raw hits  
Add L1A lookback offset in new VME register     Adr 0x100  
Add sequencer debug signals to new VME register     Adr 0x102

Replaced parity errors Adr 0x0FA with sub-adr multiplexing  
Add 35-bit RAM parity error array to Adr 0x0FA

## Version 11/18/2008

Replaced L1A data storage logic:

Moved L1A data from header RAM to fence queue RAM

Allows L1A-only TMB readout mode to have valid data in short-header (i.e. bxn at L1A arrival)

To enable L1A-only TMB readout

[1] fifo\_mode=3                      sets short header

[2] l1a\_allow\_notmb=1 allows readout when tmb didn't trigger for that L1A

[3] turn off TMB pre-triggers (set mask\_all=0 or halt pre-trigger machine)

[4] send L1A via TTC....all ~500 TMBs should send short header to DDU

Inverted raw hits RAM parity.

Now parity bit=1 if RAM data[7:0]=8'b00000000

Modified CFEB and RPC raw hits RAMB16s to be read-first instead of write-first.

Guarantees parity data on port B is valid before writing new data to port A.

AdrFE[2] BXN latched at last L1A

New Event Counters

Inserted 2 new counters after counter[47]

counter[48]= Sync error, bxn!=offset at bx0 arrival or bx0 did not arrive at bxn==offset

counter[49]= Raw hits RAM parity error, possible radiation SEU

Note on enabling internal scope readout to DMB/DDU

Adr98 = 0x108B

Adr9A = 0x0000

AdrCE = 0x0000

## Version 09/30/2008

AdrD4[2] add jsm\_sel to select old/new alct user prom format.

This is a write-only bit, it reads back the value of vsm\_jtag\_auto

New Internal Scope Logic:

Allows scope channel data to be inserted in DMB readout stream

All scope channel signal assignments have been replaced

Adr98 Replaced with new internal scope signals

Adr9A Replaced with new internal scope signals

To enable scope data in DMB readout, set

scp\_ch\_trig\_en =1

scp\_runstop=1

scp\_force\_trig=0

scp\_auto=1 (also appears in Header19[13])

scp\_tbins=4 (may be 0 to 7, number of scope tbins =  $64 * (scp\_tbins + 1)$ , thus spanning 64 to 512)

scp\_nowrite=0

Rename Event Counters to better describe their functions

counter[22]= TMB matching discarded an ALCT pair (all alcts in the pair were discarded)

counter[23]= TMB matching discarded a CLCT pair (all clcts in the pair were discarded)

New Event Counters

Inserted 2 new counters after counter[23]

counter[24]= TMB matching discarded CLCT0 from ME1A

counter[25]= TMB matching discarded CLCT1 from ME1A

Shifts all subsequent counter addresses up by 2

Header Updates:

header08\_[12]                      r\_tmb\_clct0\_discard;

TMB discarded clct0 from ME1A

header08\_[13]                      r\_tmb\_clct1\_discard;

TMB discarded clct1 from ME1A

## Version 09/12/2008

Added tmb\_trig\_pulse to header40[14]

Added tmb\_trig\_keep to header41[9]

Added tmb\_non\_trig\_keep to header41[10]

## Version 09/05/2008

Add blocking of LCTs to MPC for ME1A

## Version 08/28/2008

Logic modifications:

- 1) Firmware compile type codes introduced, replaces programmable stagger and reversal
- 2) Added hs reversal for ME1A and ME1B and full hs reversal for non-ME1A/B CSCs
- 3) Added blocking for ME1A to MPC, but is not yet functional in this release
- 4) Added 2 state machines to detect and count TTC lock loss signals from CCB

Adr 2E[9]: Add ccb\_ttcx\_ready TTC ready signal from CCB

Adr 2E[10]: Add ccb\_qpll\_locked Lock signal from CCB

Adr 2E changed register symbolic name from ADR\_CCB\_STAT to ADR\_CCB\_STAT0

Adr FA[15:0] Add new register ADR\_PARITY contains parity SEU error status

Adr FC[15:0] Add new register ADR\_CCB\_STAT1 contains TTC lock status from lock state machines

Rename event counter [5] "Pre-trigger was on any cfeb"

Inserted 2 new event counters after counter[5], shifts all other counter addresses up 2

[6] Pre-trigger was on ME1A cfeb4 only

[7] Pre-trigger was on ME1B cfebs0-3 only

Add 2 new event counters after counter[57],

[58] CCB: TTCrx lock lost

[59] CCB: qPLL lock lost

Add new register AdrFC for CCB lock detection

AdrFC[00] ccb\_ttcx\_lock\_never TTCrx lock never achieved

AdrFC [01] ccb\_ttcx\_lost\_ever TTCrx lock was lost at least once

AdrFC [02] ccb\_qpll\_lock\_never QPLL lock never achieved

AdrFC [03] ccb\_qpll\_lost\_ever QPLL lock was lost at least once

Extended trigger source vector in VME and Header:

Adr7C[9] me1a\_only\_pretrig

Adr7C[10] me1b\_only\_pretrig

Hdr40[12]=r\_trig\_source\_vec[9]

Hdr40[13]=r\_trig\_source\_vec[10]

Introduced Firmware Compile Type Codes

A=Normal CSC

B=Reversed CSC

C=Normal ME1B, Reversed ME1A

D=Reversed ME1B, Normal ME1A

Extended ½-strip reversal and ME1A/B signals to Adr CC

Adr CC[05] csc\_me1ab 1= CSC is ME1A or ME1B. 0=normal CSC

Adr CC[06] stagger\_hs\_csc 1=Staggered Adr CSC, 0=non-staggered

Adr CC[07] reverse\_hs\_csc 1=Reversed staggered CSC, non-me1

Adr CC[08] reverse\_hs\_me1a 1=reversed me1a hstrips

Adr CC[09] reverse\_hs\_me1b 1=reversed me1b hstrips

Adr CC[15:12] csc\_type[3:0] Firmware compile type A, B,C or D

Added ½-strip reversal signals to Header

Header does not contain csc\_type explicitly, but csc\_type can be inferred from reversal signals in Hdr39[14:12] and Hdr20[14]

Hdr20[14]	stagger_hs_csc	CSC Staggering ON
Hdr39[12]	reverse_hs_csc	1=Reverse staggered CSC, non-me1
Hdr39[13]	reverse_hs_me1a	1=ME1A hstrip order reversed
Hdr39[14]	reverse_hs_me1b	1=ME1B hstrip order reversed

Added ME1A LCT blocking to MPC [not yet functional in this release]

Adr CC[03] mpc_me1a_block	Block ME1A LCTs from MPC, still queue for readout
Adr CC[04] cnt_non_me1ab_en	Allow clct pretrig counters count non me1ab events

End of 8/28/2008 mods

### Version 08/12/2008

Adr38[15:12] add alct\_txd\_delay[3:0] to delay alct tx data, delay=0 by default has same timing as previous firmware versions.

Adr CA[9]: add bx0\_match

Hdr30[14]: add bx0\_match

### Version 08/04/2008

Adr F6[6]: add clct\_sep\_ram\_sel\_ab to select A or B separation RAM data readback

### Version 08/01/2008

Adr F4[1]: stagger\_csc is now read-only, set at firmware compile time

Header36: r\_nrpcs\_read in header now gated with rpc\_read\_enable.  
now indicates 0 rpcs when rpc readout is disabled

### Version 07/15/2008

Added ability to readout non-triggering events

Header41[0] = VME settings for tmb\_allow\_alct, for trigger and readout

Header41[1] = VME settings for tmb\_allow\_clct, for trigger and readout

Header41[2] = VME settings for tmb\_allow\_match, for trigger and readout

Header41[3] = VME settings for tmb\_allow\_alct\_ro, for non-triggering readout

Header41[4] = VME settings for tmb\_allow\_clct\_ro, for non-triggering readout

Header41[5] = VME settings for tmb\_allow\_match\_ro, for non-triggering readout

Header41[6] = alct-only non-triggering event

Header41[7] = clct-only non-triggering event

Header41[8] = alct\*clct match non-triggering event

Header41[9] = This event is a non-triggering readout

New Event counter at subadr[19] counts non-triggering events queued for readout

Shifts all subsequent counter addresses up 1

New VME register adrCC:

AdrCC[0] = tmb\_allow\_alct\_ro allow alct-only non-triggering event readout

AdrCC[1] = tmb\_allow\_clct\_ro allow clct-only non-triggering event readout

AdrCC[2] = tmb\_allow\_match\_ro allow alct\*clct-match non-triggering event readout



## Version 07/09/2008

Replaced entire ALCT UserPROM JTAG State Machine

New compressed data format: see JTAG PROM-1 section [p90](#)

Adr 70: Move dmb\_thresh[2:0] from adr F4[8:6] to adr70[9:7]

Adr 70: Rename dmb\_thresh to dmb\_thresh\_pretrig

Adr 70: Rename hit\_thresh to hit\_thresh\_pretrig

Adr 70: Rename nph\_thresh to hit\_thresh\_postdrift

Adr F0: Rename lyr\_thresh[2:0] to lyr\_thresh\_pretrig[2:0]

Adr F4: Remove dmb\_thresh from F4[8:6]

Adr F4: Add new signal pid\_thresh\_postdrift[3:0] to F4[9:6]

Adr F4: Move adjcfeb\_dist from F4[14:9] to F4[15:10]

Adr F4: Rename pid\_thresh to pid\_thresh\_pretrig

Add adr D8[12] jsm_tckcnt_ok	JTAG PROM TCKs sent matches TCKs in trailer frame
Add adr D8[13] jsm_end_ok	JTAG PROM FF end marker found where expected
Add adr D8[14] jsm_header_ok	JTAG PROM BA begin marker found where expected
Add adr D8[15] jsm_chain_ok	JTAG PROM Chain Block marker found where expected

Add adr DE[14:13] jtag\_sm\_vec[1:0] JSM JTAG signal state machine vector

Add adr E0[11:8] jsm\_prom\_sm\_vec[3:0] JSM PROM state machine vector

Add adr E0[14:12] jsm\_format\_sm\_vec[3:0] JSM Data format state machine vector

Add adr EA[15] jsm\_tckcnt\_ok JSM tckcnt added to board status

Header20:	remove header20_[12:10]	lyr_thresh[2:0]
Header20	remove header20_[13]	layer_trig_en
Header20	add header20_[13:10]	pid_thresh_postdrift[3:0]

Header41:	add header41_[13:11]	lyr_thresh_pretrig[2:0]
Header41	add header41_[14]	layer_trig_en

New Counters:

Inserted 2 counters after counter at SubAdr[8]

SubAdr[9]CLCT: CLCT0 passed hit thresh but failed pid thresh after drift

SubAdr[10]CLCT: CLCT0 passed hit thresh but failed pid thresh after drift

Shifts all other counter addresses up by 2, i.e. old counter at SubAdr[9] moved to [11]

Change CLCT Processing Algorithm at bx11 to also require  $\text{pid} \geq \text{pid\_thresh\_postdrift}$

## Version 06/03/2008

Modifies global\_reset and ttc\_resync behavior

Adds ability to send active feb flag to DMB at tmb alct\*clct matching, retains ability to send at pre-trig

Overlays ALCT rx data with normal scope channels to aid alct debugging

- (1) Remove Adr A8[12] alct\_raw\_sync, wasn't being used
- (2) Add temporary alct structure error counters [48]-[52]
- (3) Add Adr D0[6] cnt\_clear\_on\_resync clears VME counters [0]-[40] on ttc\_resync, default=0
- (4) Add Adr D0[7] hdr\_clear\_on\_resync clears header counters [41]-[47] on ttc\_resync, default=1
- (5) Update MPC frame format doc (reflects changes to 5/12/08 firmware)
- (6) Added a startup state to the readout state machine to wait 1bx for buf\_q\_empty to update after a reset (prevents machine from resuming a readout that was in progress at the time of a ttc\_resync)
- (7) Add perr\_reset (one-shot) to Adr D0[15], removed ttc\_resync perr reset logic
- (8) Block ttc\_resync from clearing resync event counter, requires vme-clear
- (9) Adr2A[3] change ccb\_status\_oe default from 1 to 0, turns off backplane drivers to ccb  
Added write-only bits to parallel non-decoded ccb commands:  
Adr2A [12]            vme\_evntres            Event counter reset || ccb\_evntres  
Adr2A[13]            vme\_bcntres           Bunch crossing reset || ccb\_bcntres  
Adr2A14]vme\_bx0            Bx0 signal            || ccb\_bx0
- (10) Adr28[12] now contains global\_reset\_en=1 to enable resets on DLL lock-lost
- (11) Header08[14] now contains clock\_lock\_lost
- (12) AdrAC[14]=active\_feb\_src, 0=pretrig, 1=at tmb matching
- (13) AdrB0[7:3]=clctf[4:0] active cfeb list at tmb matching
- (14) Header23[4:0] active feb list is stored either at pretrig time or tmb match, depending active\_feb\_src
- (15) Header23[14] now contains active\_feb\_src bit
- (16) Header29[14] now contains hs\_layer\_trig (moved from header23[14])
- (17) AdrCE[15]=scp\_ch\_overlay, 0=normal scope channels, 1=use debugging channel overlay

Current overlay assignments:

scp\_ch[71:0] = normal

scp\_ch[128:72] = scp\_alct\_rx[55:0]

assign	scp_alct_rx[0]	= alct_active_feb_flag;
assign	scp_alct_rx[1]	= alct_first_valid;
assign	scp_alct_rx[2]	= alct_first_amu;
assign	scp_alct_rx[4:3]	= alct_first_quality[1:0];
assign	scp_alct_rx[11:5]	= alct_first_key[6:0];
assign	scp_alct_rx[12]	= alct_second_valid;
assign	scp_alct_rx[13]	= alct_second_amu;
assign	scp_alct_rx[15:14]	= alct_second_quality[1:0];
assign	scp_alct_rx[22:16]	= alct_second_key[6:0];
assign	scp_alct_rx[27:23]	= alct_bxn[4:0];
assign	scp_alct_rx[28]	= #alct_wr_fifo;
assign	scp_alct_rx[29]	= alct_first_frame;
assign	scp_alct_rx[43:30]	= alct_daq_data[13:0];
assign	scp_alct_rx[44]	= alct_lct_special;
assign	scp_alct_rx[45]	= alct_ddu_special;
assign	scp_alct_rx[46]	= alct_last_frame;
assign	scp_alct_rx[48:47]	= alct_seq_status[1:0];
assign	scp_alct_rx[50:49]	= alct_seu_status[1:0];
assign	scp_alct_rx[54:51]	= alct_reserved_out[3:0];
assign	scp_alct_rx[55]	= alct_cfg_done;

### Version 05/23/2008

- (1) Adr B0[15:14] Add clock\_lock\_lost and sync\_er

### Version 05/12/2008

- (1) mpc alct\_bx0 and clct\_bx0 signals now bypass mpc\_tx\_delay
- (2) Note: Adr86[13] default=0 uses ttc\_bx0, set it to 1 to use local bx0 counter instead  
Adr86[14] default=0 enables bx0 to mpc continuously, 1 blanks mpc frames unless triggering
- (3) Adr CA[8] default changed to 1 to enable using reserved[3] signal from alct as alct\_bx0
- (4) Adr90[15:14] now contains bx0 injector one-shots

### Version 05/01/2008

- (1) All scope channels replaced, see Scope Channel Assignments [p48](#)
- (2) Header11 CLCT counter was behind by 1 event, fixed.
- (3) Header22 Trigger source for alct\*clct matching is set even if match mode is off, fixed.
- (4) Header28/29/30 ALCT data was latched n-bx early, leaving empty frames, fixed.

## Version 04/29/2008

- (1) ALCT signal reserved\_out[3] (alct-to-tmb) is now alct\_bx0
- (2) Adr 68[02] renamed match\_pat\_trig\_en to alct\_match\_trig\_en
- (3) Adr AC[5] hdr\_wr\_continuous should be set to 0 unless using l1a\_allow\_notmb=1 mode
- (4) Adr AC[14] removed allow\_pretrig\_noflush bit
- (5) Adr AE[11:0] sequencer state shortened from [14:0]
- (6) Adr B2[7:4] Renamed clct\_width to clct\_window
- (7) Adr BA[15:8] Now contains rpc\_bxn differences moved from Adr C4
- (8) Adr C4 renamed to ADR\_RPC\_TBINS  
Adr C4 added rpc\_tbins, tbins before pre-trigger, and rpc\_decouple [=0 to copy cfeb tbins]
- (9) Adr CA[] new name ADR\_BX0\_DELAY, all new signals for bx0\_delay and bx0 source
- (10) Adr D0[8] now contains counter lower-half / upper-half mux bit cnt\_adr\_lsb  
Adr D0[14:9] now contains counter sub-address cnt\_adr[5:0]  
Adr D0 Event counters replaced with new names and new sub-address channel numbers
- (11) Adr F0[15:8] = clct\_throttle[7:0], default=0
- (12) Adr F4[0]=clct\_blanking=1 (new default), prevented from setting to 0 unless l1a\_allow\_notmb=1 or tmb\_alct\_only=1
- (13) Header21[14:11] Renamed clct\_width to clct\_window
- (14) Header36 replaced to display rpc\_tbins and rpc\_pretrig, affects event-size calculation software, rpc\_exists[1:0] deleted.
- (15) Header41 now contains the enabled TMB matching modes

## Version 02/5/2008

Added parity checking to cfeb and rpc raw hits RAMs for SEU detection  
Added parity error bits to header27  
Add drift\_delay to header29  
Add alct\_pretrig window position to header28

## Version 01/24/2008

Replaced entire L1A logic.

Replaced 8-buffer system with 2048 buffers.

Replaced readout stack with event queue.

Replaced lct\_quality.

Several VME addresses have changed:

(1) Adr AC[4] is now wr\_buf\_autoclr (formerly clct\_turbo).

Adr AC[5] 1=allow continuous header buffer writing for invalid triggers

Previously an unused bit. Default remains 0 until new trigger logic is ready.

(2) New buffer status signals now occupy Adrs 9E,A0,A2,A4,A6.

ADR\_BUF\_STAT0=9E

ADR\_BUF\_STAT1=A0

ADR\_BUF\_STAT2=A2

ADR\_BUF\_STAT3=A4

ADR\_BUF\_STAT4=A6

Old Adr A2 (alctfifo1) moved to A8 (old A8 was empty)

Old Adr A4 (alctfifo2) moved to AA (old AA was empty)

Old Adr A6[5:0] adjcfeb\_dist[5:0] moved to F4[14:9]

(3) Adr 72[13] is now fifo\_no\_raw\_hits [1=do not wait to store raw hits. A no\_daq mode.]

(4) Adr 74[15:13] is now l1a\_internal\_dly[2:0] (mostly for use by the simulator)

(5) Adr AE[14:11] signal names changed for buffer status

(6) Adrs B0, 78, 7A contain new CLCT internal format

(7) Header04[13] is now buf\_q\_ovf\_err, formerly stack\_ovf\_latch

Header05[14] is now buf\_stalled, formerly buf\_full

Header37,38,39, 40 changed for buffer status [some assignments are probably temporary]

Header25,26,27 contain new CLCT internal format

(8) Scope channels replaced

(9) Counters 1A, 1C, 1E changed, now count debug signal presence instead of time-outs

## Version 10/11/2007

(1) CLCT raw hits CRC now stops at the frame before the DEOF marker due to DDUs failure to include the marker.

(2) ALCT raw hits CRC check stops at the frame before the DEOD marker, same reason.

### Version 9/14/2007

- (1) Header bug fixes in readout counter and lct-duplication flags
- (2) New no-alct VME counter, channel 32/33, shifts subsequent channel numbers up 2
- (3) ALCT DDR transmitter constraints minimize routing delays between alct\_rx\_clock and main clock.

### Version 9/10/2007

- (1) New raw hits readout header+trailer format replaces all previous header field assignments.
- (2) New VME counters, channels 32 to 4C.

### Version 7/10/2007

- (1) Increase tmb.v-sequencer.v handshake time-out from 8bx to 15bx to prevent late alct\*clct matches from being counted as discarded events when using higher than normal clct\_width values.
- (2) Modify pre-trigger state machine to wait for alct\*clct matching (or clct-only) before re-arming for the next pre-trigger event to prevent writing current event to wrong header buffer when using higher than normal clct\_width values.
- (3) Modify pre-trigger state machine to wait for active\_feb signal to return to 0 before the next pre-trigger event to avoid re-triggering on same event when using longer than normal triad\_persistence.

### Version 7/05/2007

- (1) Pattern-finder key layer shifted from ly3 back to ly2.  
Ly3 pattern templates were flipped top-to-bottom to shift key layer to ly2, and flipped left-to-right to preserve bend direction.
- (2) Adr A6 adjcfeb\_dist[5:0] is now 6-bits instead of 5 to allow dist=32 to span a full cfeb, default value remains 5hs.
- (3) Adr F4 dmb\_thresh[3:0] default is now 4 to reduce spurious active feb signals to DMB
- (4) CLCT Processing Algorithm description updated for current patterns

## Version 6/21/2007

(1) Adr D4 bit 11 now contains wr\_usr\_jtag\_dis.

When wr\_usr\_jtag\_dis=1, write access to register adr\_usr\_jtag is blocked.

This allows parallel writes to jtag chains for selected alcts.

Adr 10 bit 14 indicates the state of wr\_usr\_jtag\_dis.

(2) Adrs A0, A8, AA, CA, CC are now obsolete.

Their FFs have been removed, and they read back 0000h.

(3) Adr A6 now contains adjcfeb[4:0] with a default value of 5 hstrips.

This replaces the function of mask registers A6, A8, and AA.

If there is n hstrip key on hs 0,1,2,3,4 on CFEBn, with hits  $\geq$  hit\_thresh\_pretrig, then CFEBn-1 will be marked in the active\_feb list for DMB readout.

If there is a hstrip key on hs 31,30,29,28,27 on CFEBn, with hits  $\geq$  hit\_thresh\_pretrig, then CFEBn+1 will be marked in the active\_feb list for DMB readout.

(4) Adr 6C, layer\_trig\_dly has been removed.

(5) Header05[12] now contains trigger source vector bit [8] (layer trigger)

Header05[13] hds bit removed.

(6) Header16[14:11] now contains pid\_thresh[3:0] instead of ds\_thresh[2:0].

(7) References to hs\_thresh[2:0] have been changed to hit\_thresh\_pretrig[2:0].

References to ds\_thresh[2:0] have been removed.

(8) Adr 70, ds\_thresh[2:0] has been removed.

(9) Pattern ID numbers have been shifted from 0-to-8 to 2-to-10.

Pattern ID=1 now indicates a layer-trigger event.

Pattern ID=0 now indicates no pattern matches found.

(10) Adr F4, clct\_blanking=1 is the new default value