

# **TMB 2022+2013+2005 Design**

---

TAMU & UCLA High Energy Physics

Version 6.0

19 April 2022

# TMB 2022+2013+2005 DESIGN

TAMU & UCLA High Energy Physics

Version 6.0

19 April 2022

## TABLE OF CONTENTS

<b>TMB OVERVIEW .....</b>	<b>5</b>
.....	5
<b>CLCT PROCESSING ALGORITHM: RUN2 .....</b>	<b>6</b>
<b>CLCT PROCESSING ALGORITHM: RUN3 WITH GEMCSC MATCH .....</b>	<b>8</b>
<b>SIGNAL SYNCHRONIZATION.....</b>	<b>12</b>
CFEB MUONIC RECEIVER SYNCHRONIZATION STAGES.....	12
ALCT MUONIC RECEIVER SYNCHRONIZATION STAGES .....	13
ALCT MUONIC TRANSMITTER SYNCHRONIZATION STAGES.....	14
<b>TTC SEQUENCES.....</b>	<b>18</b>
TRIGGER STATE.....	18
BUNCH CROSSING COUNTER .....	18
RESYNC .....	18
<b>ALCT+CLCT MATCHING ALGORITHM.....</b>	<b>19</b>
RUN2 MATCHING LOGIC .....	19
RUN3 MATCHING LOGIC .....	22
<b>VME REGISTERS.....</b>	<b>24</b>
ADDRESSING MODES .....	24
BASE ADDRESS.....	24
BOOT REGISTER .....	24
LIST OF REGISTER ADDRESSES .....	25
DEFINITIONS OF REGISTER ADDRESSES.....	33
Counter Select Addresses, CSC .....	67
NEW REGISTERS FOR RUN3 .....	96
Counter Select Addresses, GEM.....	102
TTC COMMANDS.....	111
<b>TMB BOARD STATUS OPERATIONS.....</b>	<b>113</b>
ID REGISTERS .....	113
DIGITAL SERIAL NUMBERS .....	113
POWER SUPPLY ADC .....	113
CLOCK DELAYS .....	113
JTAG CHAINS .....	113
RAT MODULE STATUS REGISTER USER1 .....	114
RAT MODULE CONTROL REGISTER USER2 .....	114
<b>USER PROM PROGRAMMING.....</b>	<b>115</b>
INTRODUCTION .....	115
REGISTER INITIALIZATION.....	115
VME PROM-0 .....	115
JTAG PROM-1 .....	116
<b>DMB READOUT: RUN2.....</b>	<b>119</b>
FULL-READOUT AND LOCAL-READOUT FORMAT (LONG HEADER) .....	119
LONG HEADER-ONLY FORMAT .....	119
SHORT HEADER-ONLY FORMAT .....	120
MINISCOPE .....	120
BLOCKED CFEB DiSTRIPS LIST FORMAT.....	121
HEADER WORD DESCRIPTIONS .....	122
SAMPLE TMB RAW HITS DUMP .....	135
<b>DMB READOUT: RUN3.....</b>	<b>137</b>

RUN3 HEADER WORD DESCRIPTIONS .....	137
<b>RUN2 UPDATES SUMMARY .....</b>	<b>150</b>
LOCALIZED DEAD TIME ZONE.....	150
<b>RUN3 UPDATES SUMMARY .....</b>	<b>150</b>
FIRMWARE REVISION CODE CONVENTION.....	150
SCAN OTMB LINK PHASERS: NEW TOOL FOR CFEB RX SCAN.....	150
GEM TIMING SCAN .....	150
HIGH MULTIPLICITY TRIGGER.....	150
TRIGGER MODE SUMMARY .....	151
<b>CONFIGURATION .....</b>	<b>152</b>
SHUNT SETTINGS.....	152
SWITCH SETTINGS .....	153
FUSES .....	154
<b>SIGNAL SUMMARY .....</b>	<b>155</b>
CCB .....	155
ALCT .....	156
DMB .....	157
CFEB .....	158
MPC.....	159
RPC.....	160
VME .....	160
JTAG.....	160
LEDs & TESTPOINTS.....	161
TMB TOTAL I/O COUNT .....	162
<b>CONNECTORS.....</b>	<b>163</b>
TMB CONNECTOR SUMMARY .....	163
J0-J4 CFEBO-CFEB4 CONNECTORS .....	164
J5 ALCT CABLE1 CONNECTOR (RECEIVER) .....	165
J6 ALCT CABLE2 CONNECTOR (TRANSMITTER) .....	166
J1-J6 SCSI-II 50-PIN CONNECTOR PIN CONVENTION .....	167
J7 XILINX LVDS XILINX X-BLASTER CONNECTOR .....	167
P1 BACKPLANE VME64x J1/P1 CONNECTOR .....	169
P2A BACKPLANE CCB+DMB CONNECTOR.....	170
P2A BACKPLANE CCB+DMB CONNECTOR CONTINUED.....	171
P2B BACKPLANE DMB CONNECTOR .....	172
P3A BACKPLANE MPC+RPC CONNECTOR .....	174
P3B BACKPLANE RPC+ALCT CONNECTOR .....	176
BACKPLANE PIN DIAGRAM.....	178
FRONT PANEL CONNECTOR LOCATIONS.....	179
CCB FRONT PANEL .....	180
<b>DOCUMENTATION REVISION HISTORY .....</b>	<b>182</b>
<b>FIRMWARE CHANGE LOG.....</b>	<b>186</b>

## LIST OF FIGURES

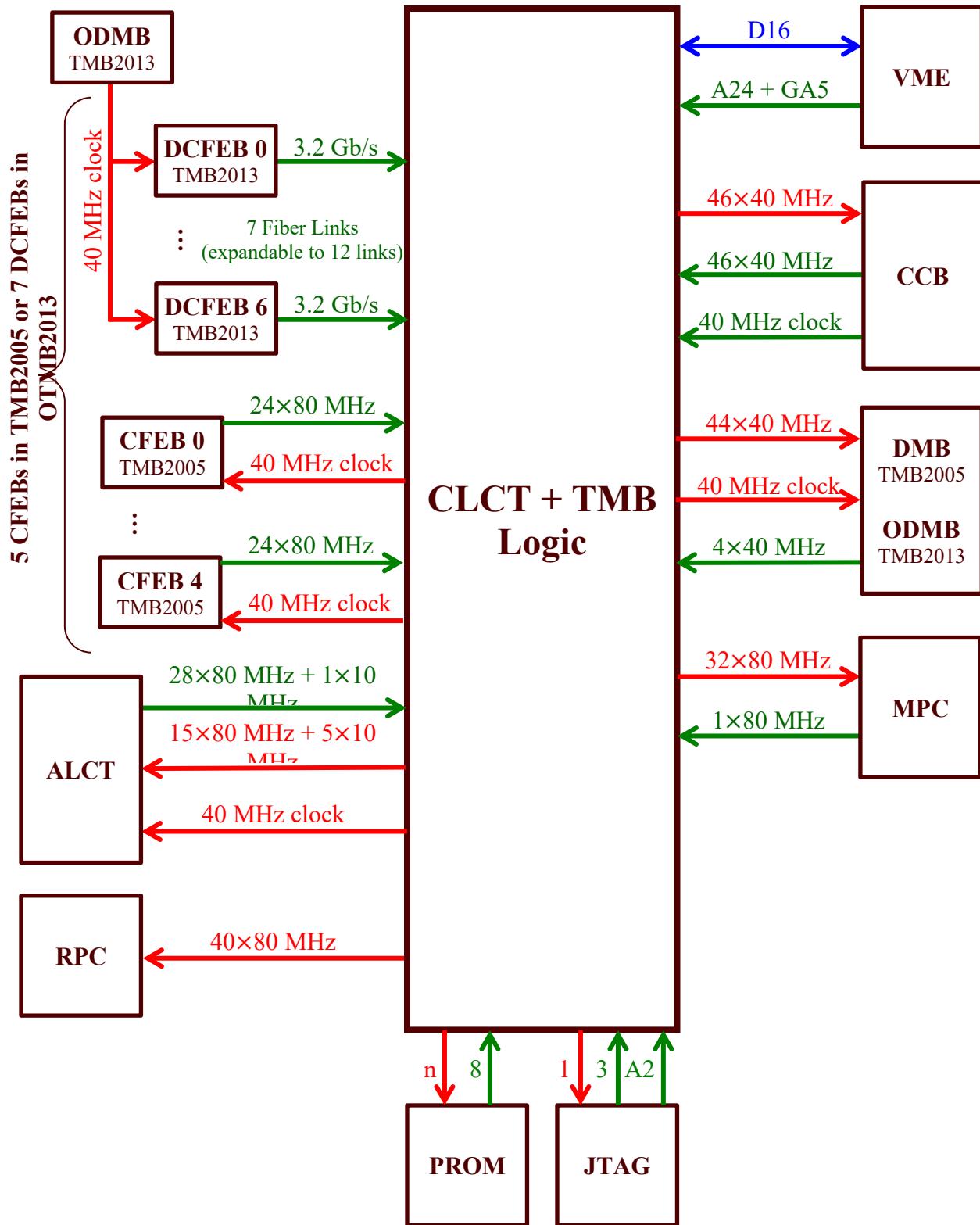
<b>Figure 1: TMB Overview.....</b>	<b>5</b>
<b>Figure 2: CFEB Muonic Receiver .....</b>	<b>15</b>
<b>Figure 3: ALCT Muonic Receiver .....</b>	<b>16</b>
<b>Figure 4: ALCT Muonic Transmitter .....</b>	<b>17</b>
<b>Figure 5: 50-Pin PCB Connector (Female) .....</b>	<b>167</b>
<b>Figure 6: 50 Pin Cable Connector (Male) .....</b>	<b>167</b>
<b>Figure 7: 50 Pin PCB Connector Pin Convention .....</b>	<b>167</b>

## LIST OF TABLES

<b>Table 1: List of VME Register Addresses .....</b>	<b>25</b>
<b>Table 2: Fast Control Bus ccb_cmd[5..0] Decoding Scheme .....</b>	<b>111</b>

<b>Table 3: Shunts .....</b>	<b>152</b>
<b>Table 4: Switch Settings.....</b>	<b>153</b>
<b>Table 5: Fuses for TMB2005 .....</b>	<b>154</b>
<b>Table 6A: Fuses for TMB2013 .....</b>	<b>154</b>
<b>Table 7: CCB Signal Summary .....</b>	<b>155</b>
<b>Table 8: ALCT Signal Summary .....</b>	<b>156</b>
<b>Table 9: DMB Signal Summary .....</b>	<b>157</b>
<b>Table 10: CFEB Signal Summary.....</b>	<b>158</b>
<b>Table 11: MPC Signal Summary .....</b>	<b>159</b>
<b>Table 12: RPC Signal Summary .....</b>	<b>160</b>
<b>Table 13: VME Signal Summary .....</b>	<b>160</b>
<b>Table 14: JTAG Signal Summary.....</b>	<b>160</b>
<b>Table 15: TMB Front Panel LEDs.....</b>	<b>161</b>
<b>Table 16: TMB Total I/O Count .....</b>	<b>162</b>
<b>Table 17: TMB2005 Connector Summary .....</b>	<b>163</b>
<b>Table 18: J0-J4 CFEB0/4-to-TMB Connectors .....</b>	<b>164</b>
<b>Table 19: J5 ALCT Cable1 Connector [J10 on ALCT board].....</b>	<b>165</b>
<b>Table 20: J6 ALCT Cable2 Connector [J11 on ALCT board].....</b>	<b>166</b>
<b>Table 21: J8 Xilinx LVDS X-Blaster Connector .....</b>	<b>168</b>
<b>Table 22: P1 VME64x Connector .....</b>	<b>169</b>
<b>Table 23: P2A Backplane CCB+DMB Connector.....</b>	<b>170</b>
<b>Table 24: P2B Backplane DMB Connector.....</b>	<b>172</b>
<b>Table 25: P3A Backplane MPC Connector.....</b>	<b>174</b>
<b>Table 26: P3B Backplane RPC+ALCT Connector .....</b>	<b>176</b>
<b>Table 27: Connector CCB Input connector P10.....</b>	<b>180</b>
<b>Table 28: CCB Output connector P11 .....</b>	<b>180</b>
<b>Table 29: CCB Output connector P12.....</b>	<b>181</b>

# TMB OVERVIEW



*Figure 1: TMB Overview.*

# CLCT PROCESSING ALGORITHM: RUN2

**bx -½:** 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(7 for ME11) 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 ½-strip one-shot can fire again on the same clock cycle that the previous ½-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 ½-strip bits

**bx 3:** Fire ½-strip one-shots for 6bx (triad\_persist is programmable, 6bx is the default) OR 160 ½-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
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 ½-strips consider the 42 neighboring ½-strips (i.e. on key 5 use the following ½-strips)

hs	0123456789A
ly0[10:0]	xxxxxxkxxxxxx
ly1[ 7:3]	xxkxxx
ly2[ 5:5]	k
ly3[ 7:3]	xxkxxx
ly4[ 9:1]	xxxxkxxxxx
ly5[10:0]	xxxxxxkxxxxxx

- For each of 160 key ½-strips, count layers with hits matching the 9 pattern templates. For Run3 pattern finder, 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						
ly1	-----xx-	--xx-----	---xx---	---xx---	---xx---	---xx---	---xx-	---xx-	---xx-
ly2 key	-----x-								
ly3	-----xx-								
ly4	-----xxx-								
ly5	xxx-----	-----xxx							
// Extent	0123456789A								
// 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 nhits ≥ hit\_thresh\_pretrig and pid ≥ pid\_thresh\_pretrig

- Construct 5-bit active-cfeb list for DMB:

- cfebs with a key that has  $\text{nhits} \geq \text{hit\_thresh\_pretrig}$  and  $\text{pid} \geq \text{pid\_thresh\_pretrig}$
- cfebs with a key that has  $\text{nhits} \geq \text{dmb\_thresh\_pretrig}$
- cfebs 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 1st 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 2nd 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 1st CLCT:

- Finish finding best 1-of-160 keys by sorting on the 6-bit number  $\text{pat}[7:1]$
- Store 1st CLCT info: key, pattern ID, and number of hits
- For empty events, key=0, pid=A and nhits=0. If  $\text{clct\_blanking}=1$ , then key=pid=hits=0

**bx 8:** Finding 2nd CLCT:

- Construct list of busy keys
- Mark keys near 1st CLCT as busy from 1st key-nspan to 1st key+pspan
- If  $\text{clct\_sep\_src}=1$ , pspan and nspan are set equal to  $\text{clct\_sep\_vme}$ , typically 10hs
- If  $\text{clct\_sep\_src}=0$ , pspan and 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 2nd CLCT:

- Finish finding best 1-of-160 keys by sorting on the 6-bit number  $\text{pat}[7:1]$
- Store 2nd CLCT info: key, pattern ID, and number of hits
- For empty events, key=11, pid=A and nhits=0. If  $\text{clct\_blanking}=1$ , then key=pid=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 alct matches, jump to bx15 logic, latency is shortened 2bx

**bx 13:** Match to ALCT window 1

- If 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 1st ALCT into 2nd ALCT position
- If event has 1 CLCT and 2 ALCTs, copy 1st CLCT into 2nd CLCT position
- Calculate LCT quality
- Multiplex mpc injector ram data

**bx 16:** Transmit 1st-in-time LCT frame to MPC

**bx 16½:** Transmit 2nd-in-time LCT frame to MPC

# CLCT PROCESSING ALGORITHM: RUN3 WITH GEMCSC MATCH

**bx -½:** 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(7 for ME11) 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 ½-strip one-shot can fire again on the same clock cycle that the previous ½-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 ½-strip bits

**bx 3:** Fire ½-strip one-shots for 6bx (triad\_persist is programmable, 6bx is the default) OR 160 ½-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
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 ½-strips consider the 42 neighboring ½-strips (i.e. on key 5 use the following ½-strips)

hs	0123456789ABC	
ly0[10:0]	xxxxxxkxxxx	5+1+5 = 11
ly1[ 9:1]	xxxxkxxxx	4+1+4 = 9
ly2[ 7:3]	xxkxx	2+1+2 = 5
ly3[ 7:3]	xxkxx	2+1+2 = 5
ly4[ 9:1]	xxxxkxxxxxxxx	4+1+4 = 9
ly5[10:0]	xxxxxxxxxxxxxx	5+1+5 = 11

- For each of 160 key ½-strips, count layers with hits matching the 5 pattern templates. It also computes the 12-bit comparator code for Comparator Code LUT (CCLUT) algorithm with 2-bit comparator for each layer.

Pattern	id=0	id=1	id=2	id=3	id=4
Bend dir	bd=0	bd=1	bd=0	bd=1	bd=0
ly0	-----xxx	xxx-----	-----xxx	-----xxx-----	-----xxx-----
ly1	-----xxx-----	xxx-----	-----xxx-----	xxx-----	-----xxx-----
ly2 key	-----kxxx-----	xxx-----	-----xkx-----	-----xkx-----	-----xkx-----
ly3	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----
ly4	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----
ly5	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----	-----xxx-----
// Extent	0123456789A	0123456789A	0123456789A	0123456789A	0123456789A
// Avg.bend	- 7.0 hs	+ 7.0 hs	-3.0 hs	+3.0 hs	0.0 hs
// Min.bend	-10.0 hs	+ 4.0 hs	-6.0 hs	+0.0 hs	-2.0 hs
// Max.bend	- 4.0 hs	+10.0 hs	-0.0 hs	+6.0 hs	+2.0 hs

```
=====
Comparator code for each layer:
Hit pattern      2-bit comparator code
000              2'b00
x00              2'b01
0x0              2'b10
0x0              2'b11
```

**bx 4:** Result for each of 160 keys is a list of 5 pattern-ID numbers (pid) [0 to 4] and corresponding number of layers [0 to 6] with matching hits (nhits)

- Find the best 0-of-4 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 nhits  $\geq$  hit\_thresh\_pretrig and pid  $\geq$  pid\_thresh\_pretrig

- Construct 5-bit active-cfeb list for DMB:
- cfebs with a key that has nhits  $\geq$  hit\_thresh\_pretrig and pid  $\geq$  pid\_thresh\_pretrig
- cfebs with a key that has nhits  $\geq$  dmb\_thresh\_pretrig
- cfebs adjacent to a cfeb that has nhits  $\geq$  hit\_thresh\_pretrig and pid  $\geq$  pid\_thresh\_pretrig within adjfeb\_dist

**bx 6:** Finding 1st CLCT:

- Construct 7-bit pattern quality for sorting: pat[7:0]
- pat[7:5]=nhits[2:0]
- pat[4:0]=pid[3:0]
- Ignore the bend direction bit (pid[0]), left and right bends have equal priority
- Store pat[7:0] for 160 keys for use later to find 2nd CLCT
- Start finding best 1-of-160 keys by sorting on the 6-bit number pat[7:1]
- If two keys have the same pat[7:1] take the lower key

**bx 7:** Find 1st CLCT:

- CCLUT algorithm: map comparator code to find the  $\frac{1}{4}$  and 1/8 strip bits and bnd[4:0] for best CLCTs found from each CFEB, where bending uses 4bits for absolute value and 1bit for bending direction
- Finish finding best 1-of-160 keys by sorting on the 6-bit number pat[7:1]
- Store 1st CLCT info: key, pattern ID, and number of hits
- For empty events, key=0, pid=A and nhits=0. If clct\_blank=1, then key=pid=hits=0

**bx 8:** Finding 2nd CLCT:

- Construct list of busy keys
- Mark keys near 1st CLCT as busy from 1st key-nspan to 1st key+pspan
- If clct\_sep\_src=1, pspan and nspan are set equal to clct\_sep\_vme, typically 10hs
- If clct\_sep\_src=0, pspan and 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 pat[7:1]
- Skip busy keys
- If two keys have the same pat[7:1] take the lower key

**bx 9:** Find 2nd CLCT:

- CCLUT algorithm: map comparator code to find the  $\frac{1}{4}$  and 1/8 strip bits and bnd[4:0] for 2<sup>nd</sup> best CLCTs found from each CFEB, where bending uses 4bits for absolute value and 1bit for bending direction
- Finish finding best 1-of-160 keys by sorting on the 6-bit number pat[7:1]
- Store 2nd CLCT info: key, pattern ID, and number of hits
- For empty events, key=11, pid=A and nhits=0. If clct\_blank=1, then key=pid=hits=0

**bx 10:** Drift Delay 1bx (waits for CSC drifting)

**bx 11:** Drift Delay 1bx

- If clct0 nhits < hit\_thresh\_postdrift OR pid < pid\_thresh\_post\_drift, discard event

**bx 11:** Delay GEM and window 0 for GEM-ALCT match

- If alct-GEM matches. Move this GEM to ALCT-CLCT window 2 for GEM-CLCT-ALCT match

**bx 12:** Match to CLCT-ALCT window 0. Meanwhile window1 for GEM-ALCT match

- If alct matches, jump to bx15 logic, latency is shortened 2bx
- If alct-GEM matches. Move this GEM to ALCT-CLCT window 2 for GEM-CLCT-ALCT match

**Bx 13:** Match to CLCT-ALCT window 1. Meanwhile window2 for GEM-ALCT match

- If alct matches, jump to bx15 logic, latency is shortened 1bx
- If alct-GEM matches. Move this GEM to ALCT-CLCT window 2 for GEM-CLCT-ALCT match
- If alct-GEM matches is not found and GEM two layer coincidence is found, then do CLCT-Copad match in next BX

**Bx 14:** Match to CLCT-ALCT window 2. GEM-ALCT-CLCT

- If ALCT and GEM are available, do GEM-ALCT-CLCT position match
  - GEM pad and roll number are converted into strip position with 1/8 precision and wiregroup respectively after GEM is received by OTMB
  - Extrapolate the CLCT position to GEM chamber using CLCT bending + LUT when best two CLCTs are found
  - Check wiregroup from converted GEM position with ALCT wiregroup and strip position from converted GEM position with extrapolated CLCT position. Once both differences are within their respective window, then good GEM-ALCT-CLCT match is found
  - Sort GEM-ALCT-CLCT match by quality and bending angle
- If ALCT does not arrive and GEM copad is found, do GEM copad-CLCT match
- If ALCT and GEM copad are available but CLCT is not found, do GEM copad-ALCT match
- If ALCT does not arrive and GEM copad is not found, and clct\_only mode is enabled, accept CLCT at window 2
- If ALCT does not arrive and GEM copad is not found, and not in clct\_only mode, discard event

**Bx 15:** Construct two LCTs from CLCT and ALCT data

- If event has 2 CLCTs and 1 ALCT, copy 1st ALCT into 2nd ALCT position if GEM copad is not found
- If event has 1 CLCT and 2 ALCTs, copy 1st CLCT into 2nd CLCT position if GEM copad is not found
- Calculate LCT quality
- Calculate the bending using GEMCSC bending angle if configuration enables gemcsc\_bend\_enable
- Meanwhile add HMT bits to LCT data format
- Multiplex mpc injector ram data

**Bx 16:** Transmit 1st-in-time LCT frame to MPC

- only when LCT is valid or HMT bits is non-zero

**Bx 16½:** Transmit 2nd-in-time LCT frame to MPC

### LCT quality for GEMCSC match

Match Type	Matching Results				
	Timing	Anode Position	Cathode Position	bending	Quality
ALCT-CLCT-Copad	ALCT	ALCT WG	CLCT HS	GEM-CSC	111
				CSC-only	110
ALCT-CLCT-1GEM	ALCT	ALCT WG	CLCT HS	GEM-CSC	101
				CSC-only	100
ALCT-CLCT	ALCT	ALCT WG	CLCT HS	CSC only	011
CLCT-Copad	GEM	GEM roll	CLCT HS	GEM-CSC	001
ALCT-Copad	ALCT	ALCT WG	GEM pad	GEM only	010

# SIGNAL SYNCHRONIZATION

## CFEB Muonic Receiver Synchronization Stages

CFEB Double Data Rate (DDR) receiver logic is designed to synchronize incoming comparator data to TMB's 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_iob`.

- The user has already tuned the associated `cfeb[n].rxd` digital phase shifter so that `clock_iob` always latches stable data.

**U1B:** Latches incoming `din` on the *rising* edge of `clock_iob`.

- U1A and U1B comprise a single 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_iob`.

- U2 now holds `din_1st-in-time` data, aligned with the *rising* edge of `clock_iob`, while
- U1B holds `din_2nd-in-time` data, also aligned with the *rising* edge of `clock_iob`.
- In non-muonic firmware, this would be the end stage, because `clock_iob` would be the same as TMB's main clock.
- In muonic firmware versions, `din_1st` and `din_2nd` still need to be synchronized to TMB's main clock. This is done by latching data on both the *rising* (positive) edge and *falling* (negative) edge of the main clock, then selecting one latch or the other with the `posneg` bit.
- If the positive edge 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_iob`.

**U3, U4:** Latch `din_1st` and `din_2nd` on the *falling* edge TMB's main `clock_1x`.

**U5, U6:** Select either positive edge data from U2, U1B or negative edge 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-to-16bx delay span.

**U11, U12:** Latch data on the *rising* edge of TMBs main `clock_1x`, and are the final synchronization stage.

## ALCT Muonic Receiver Synchronization Stages

ALCT Double Data Rate (DDR) receiver logic is designed to synchronize incoming data to TMB's 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* (negative) edge of `clock_iob`.

- The user has already tuned the associated `alct_rxrd` digital phase shifter so that `clock_iob` always latches stable data.

**U1B:** Latches incoming `din` on the *rising* (positive) edge of `clock_iob`.

- U1A and U1B comprise a single DDR I/O-Block flip-flop, and are only shown here separately for clarity.

**U2:** Latches ALCT data transferred from U1A on the *rising* (positive) edge of `clock_iob`.

- U2 now holds `din_1st-in-time` data, aligned with the *rising* (positive) edge of `clock_iob`, while
- U1B holds `din_2nd-in-time` data, also aligned with the *rising* (positive) edge of `clock_iob`.
- In non-muonic firmware, this would be the end stage, because `clock_iob` would be the same as TMB's main clock.

**U3, U4:** Latch `din_1st` and `din_2nd` on either the *rising* (positive) or *falling* (negative) edge of TMB's 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 TMB's main `clock_1x`, and are the final synchronization stage.

## ALCT Muonic Transmitter Synchronization Stages

ALCT Double Data Rate (DDR) transmitter logic is designed to synchronize TMB's 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-to-16 bx delay span.

**U7, U8:** Latch data on the *rising* edge of TMB's main `clock_1x`, and are the final main-clock stage.

- In non-muonic firmware, this would be the end stage, because `clock_iob` would be the same as TMB's 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`.

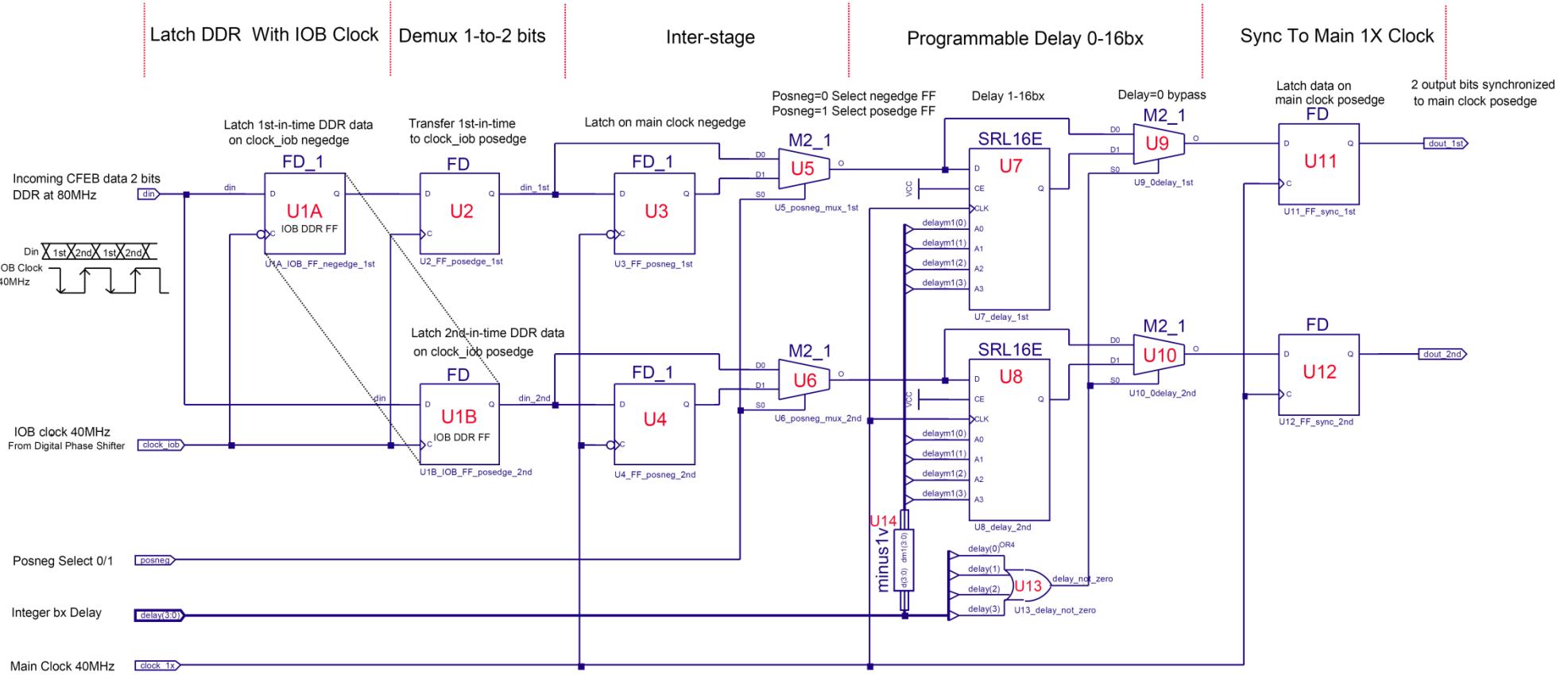
**U14:**

- 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 1st-in-time data on the *rising* edge of `clock_iob`. It is a DDR I/O Block flip-flop that transmits 1st-in-time data on the *rising* edge of `clock_iob`, and 2nd-in-time on the *falling* edge.

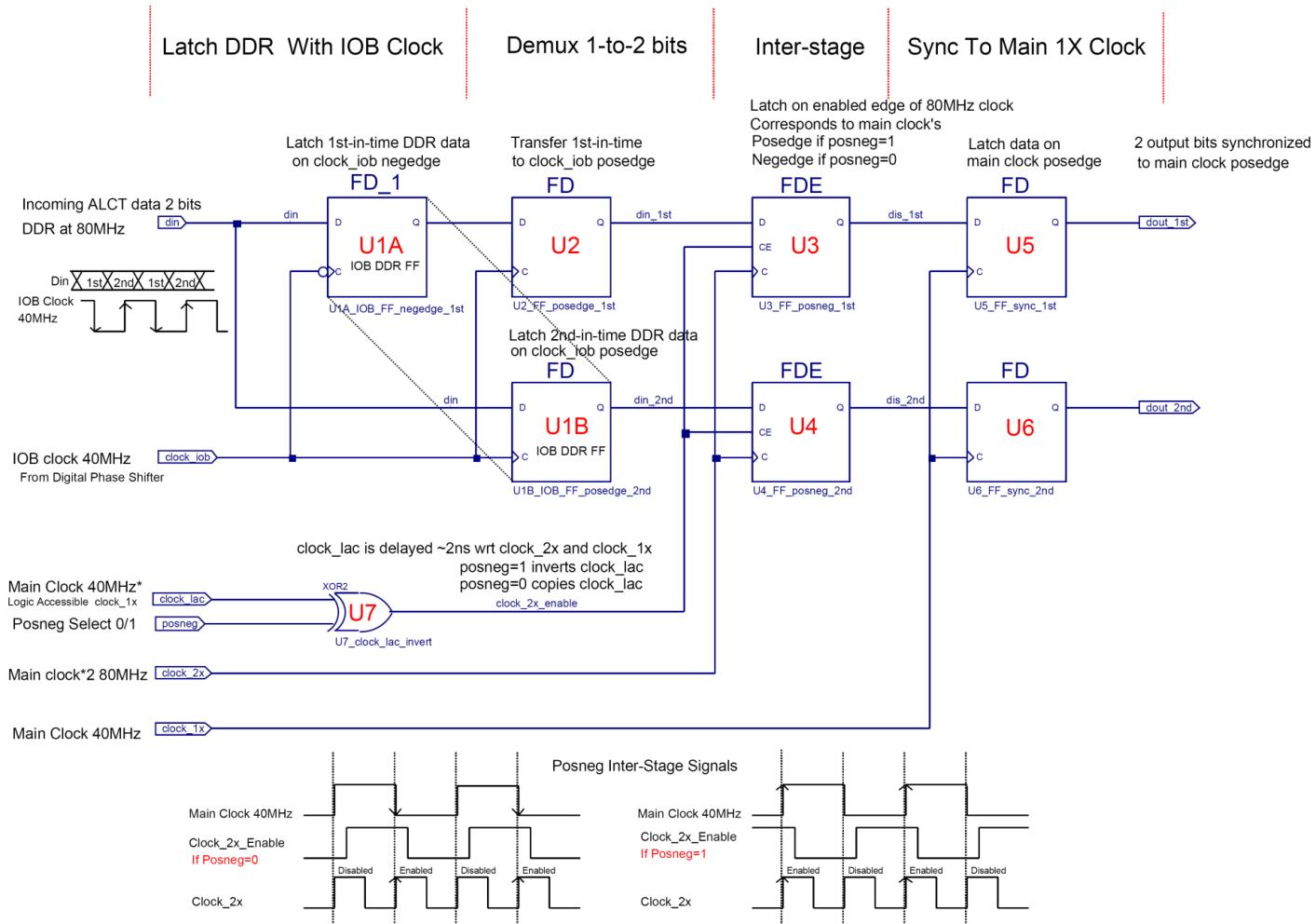
**U11:** Holds 2nd-in-time data for  $\frac{1}{2}$  cycle while waiting for U12 to transmit 1st-in-time data.

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



**Figure 2: CFEB Muonic Receiver**

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



**Figure 3: ALCT Muonic Receiver**

### TMB-to-ALCT: Transmitter Sync Stages

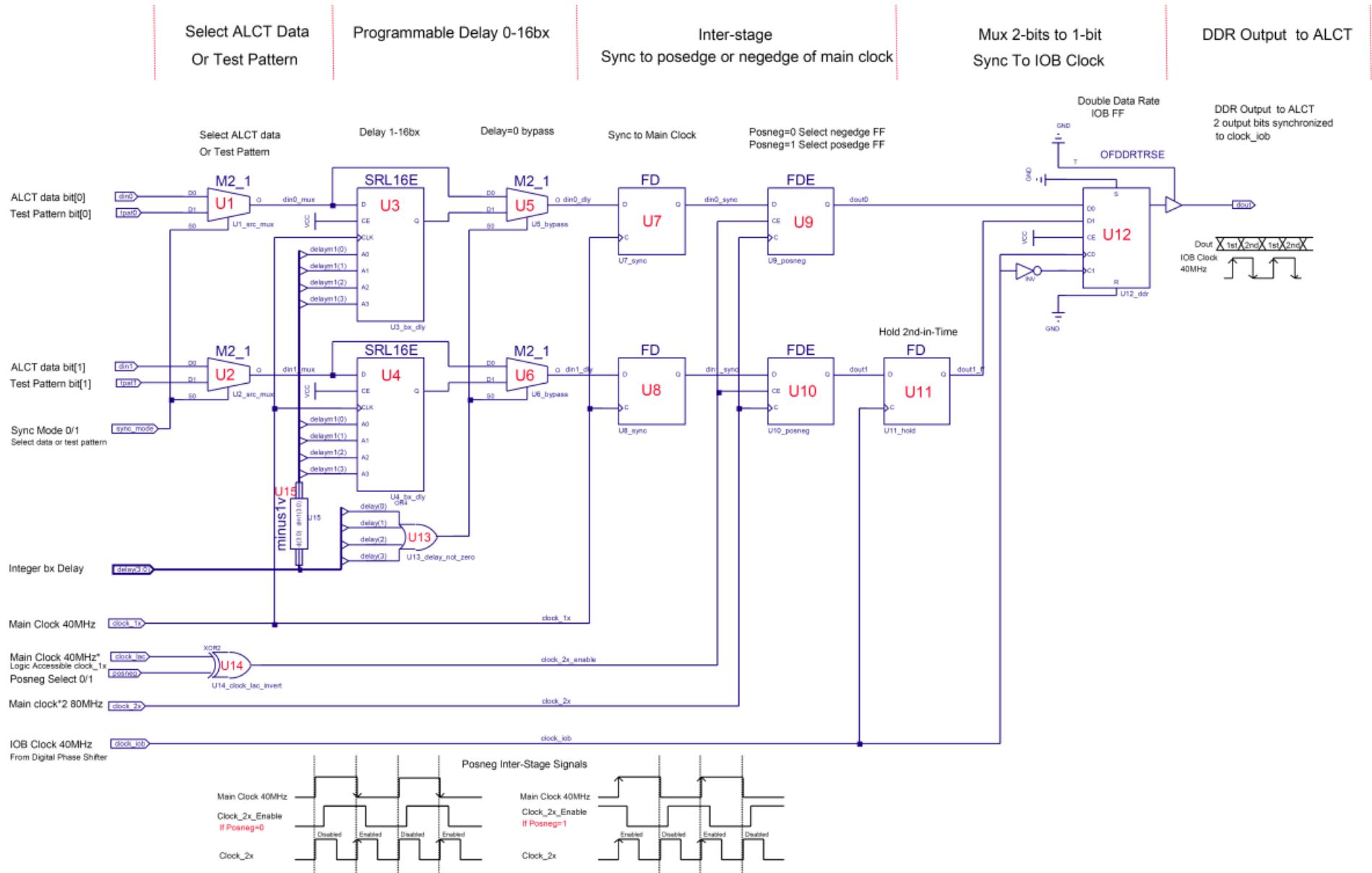


Figure 4: ALCT Muonic Transmitter

# 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\_evcntreset, 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

## Run2 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
endmodule
```

## 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

<b>Signal</b>	<b>1<sup>st</sup> in Time</b>	<b>2<sup>nd</sup> in Time</b>	<b>P3Apin</b>	<b>Test Point</b>
mpc_tx[30]	lct_second_quality[3]	csc_id[2]	D8	TP342-7
mpc_tx[31]	second_vpf	csc_id[3]	E8	TP342-8

## Run3 Matching Logic

### LCT Duplication for Run3, GEMCSC case

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

wire tmb_one_alct = alct0_vpf && !alct1_vpf;
wire tmb_one_clct = clct0_vpf && !clct1_vpf;

wire tmb_two_alct = alct0_vpf && alct1_vpf;
wire tmb_two_clct = clct0_vpf && clct1_vpf;

wire tmb_dupe_alct = tmb_one_alct && tmb_two_clct; // Duplicate alct if there are 2 clcts
wire tmb_dupe_clct = tmb_one_clct && tmb_two_alct; // Duplicate clct if there are 2 alcts

wire tmb_dupe_alct_run3 = tmb_dupe_alct && copyalct0_foralct1_pos; // Duplicate alct if there are 2 clcts
wire tmb_dupe_clct_run3 = tmb_dupe_clct && copyclct0_forclct1_pos; // Duplicate clct if there are 2 alcts

always @* begin
if (tmb_no_clct) begin
    clct0 <= clct_dummy;
    clct1 <= clct_dummy;
    clctc <= clctc_dummy;
    clct0_cclut <= clct_cclut_dummy;
    clct1_cclut <= clct_cclut_dummy;
end // clct0 and clct1 do not exist, use dummy clct
//else if (tmb_dupe_clct) begin
else if (tmb_dupe_clct_run3) begin
    clct0 <= clct0_real;
    clct1 <= clct0_real;
    clctc <= clctc_real;
    clct0_cclut <= clct0_cclut_real;
    clct1_cclut <= clct0_cclut_real;
end // clct0 exists, but clct1 does not exist, copy clct0 into clct1
else begin
    clct0 <= clct0_real;
    clct1 <= clct1_real;
    clctc <= clctc_real;
    clct0_cclut <= clct0_cclut_real;
    clct1_cclut <= clct1_cclut_real;
end // clct0 and clct1 exist, so use them
end

always @* begin
if (tmb_no_alct) begin alct0 <= alct_dummy; alct1 <= alct_dummy; end // alct0 and alct1 do not exist, use dummy alct
//else if (tmb_dupe_alct) begin alct0 <= alct0_real; alct1 <= alct0_real; end // alct0 exists, but alct1 does not exist, copy alct0 into alct1
else if (tmb_dupe_alct_run3) begin alct0 <= alct0_real; alct1 <= alct0_real; end // alct0 exists, but alct1 does not exist, copy alct0 into alct1
else begin alct0 <= alct0_real; alct1 <= alct1_real; end // alct0 and alct1 exist, so use them
end
```

### LCT Quality for Run3, GEMCSC case

```
always @* begin
if (alct_clct_copad_match && gemcsc_bend_enable) Q=3'b111;
else if (alct_clct_copad_match && !gemcsc_bend_enable) Q=3'b110;
else if (alct_clct_gem_match && gemcsc_bend_enable) Q=3'b101;
else if (alct_clct_gem_match && !gemcsc_bend_enable) Q=3'b100;
else if (alct_clct_match) Q=3'b011;
else if (clct_copad_match) Q=3'b001;
else if (alct_copad_match) Q=3'b010;
else Q=3'b000;
end
```

### LCT Quality for Run3, CSC only case

```
always @* begin
```

```

if (A && C) begin
    if (alct_nhit == 3'd6 || clct_nhit == 3'd6 )      Q=2'b11;
    else if (alct_nhit == 3'd5 || clct_nhit == 3'd5 )      Q=2'b10;
    else if (alct_nhit == 3'd4 || clct_nhit == 3'd4 )      Q=2'b01;
    else                                              Q=2'b0;
end
else
end

```

Q=2'b0; // should never be assigned

## LCT Bend for Run3, GEMCSC case: use GEM-CSC strip difference + LUT to find final bend value for LCT

### MPC Format for Run3

```

//real LCT for Run3
assign mpc0_frame0_run3[6:0] = alct0_key_run3[6:0];
assign mpc0_frame0_run3[10:7] = lct_pid_run3[3:0]; //new bending from CCLUT
assign mpc0_frame0_run3[13:11] = lct0_qlt_run3[2:0];
assign mpc0_frame0_run3[14] = clct0_xky_run3[1]; // CLCT0 1/4 strip bit
assign mpc0_frame0_run3[15] = lct0_vpf_run3; //LCT run3 vpf

assign mpc0_frame1_run3[7:0] = clct0_xky_run3[9:2];
assign mpc0_frame1_run3[8] = clct0_bnd_run3[4]; // left or right from CCLUT
assign mpc0_frame1_run3[9] = clct0_xky_run3[0];// CLCT0 1/8 strip bit
assign mpc0_frame1_run3[10] = alct0_bxn[0];
assign mpc0_frame1_run3[11] = clct_bx0; // bx0 gets replaced after mpc_tx_delay, keep here to
mollify xst
assign mpc0_frame1_run3[15:12] = clct0_bnd_run3[3:0];

assign mpc1_frame0_run3[6:0] = alct1_key_run3[6:0];
assign mpc1_frame0_run3[7] = lct_pid_run3[4]; // new bending from CCLUT
assign mpc1_frame0_run3[10:8] = hmt_trigger_run3[3:1];// 
assign mpc1_frame0_run3[13:11] = lct1_qlt_run3[2:0];
assign mpc1_frame0_run3[14] = clct1_xky_run3[1]; // CLCT1 1/4 strip bit
assign mpc1_frame0_run3[15] = lct1_vpf_run3; //LCT run3 vpf

assign mpc1_frame1_run3[7:0] = clct1_xky_run3[9:2];
assign mpc1_frame1_run3[8] = clct1_bnd_run3[4];
assign mpc1_frame1_run3[9] = clct1_xky_run3[0];// CLCT1 1/8 strip bit
assign mpc1_frame1_run3[10] = hmt_trigger_run3[0];
assign mpc1_frame1_run3[11] = alct_bx0; // bx0 gets replaced after mpc_tx_delay, keep here to
mollify xst
assign mpc1_frame1_run3[15:12] = clct1_bnd_run3[3:0];

```

# VME REGISTERS

## Addressing Modes

TMB2005 responds to A24D16 VME addressing modes:

- Address Modifier 39<sub>16</sub>, A24 non-privileged mode
- Address Modifier 3D<sub>16</sub>, 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<sub>10</sub> Addresses all TMBs in parallel
- A[23:19] = 27<sub>10</sub> 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<sub>10</sub> global address.

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

## List of Register Addresses

The addresses are hexadecimal and should be added to base.

*Table 1: List of VME Register Addresses*

Address	Register Name	Page	Description
70000	ADR_BOOT	<a href="#">33</a>	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

<b>Address</b>	<b>Register Name</b>	<b>Page</b>	<b>Description</b>
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

<b>Address</b>	<b>Register Name</b>	<b>Page</b>	<b>Description</b>
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	<a href="#">61</a>	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	<a href="#">67</a>	Status Counter Control
D2	ADR CNT RDATA	<a href="#">70</a>	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

<b>Address</b>	<b>Register Name</b>	<b>Page</b>	<b>Description</b>
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

<b>Address</b>	<b>Register Name</b>	<b>Page</b>	<b>Description</b>
136	ADR_CFE2_BADBITS_LY45		CFEB2 Bad Bits Array
138	ADR_CFE3_BADBITS_LY01		CFEB3 Bad Bits Array
13A	ADR_CFE3_BADBITS_LY23		CFEB3 Bad Bits Array
13C	ADR_CFE3_BADBITS_LY45		CFEB3 Bad Bits Array
13E	ADR_CFE4_BADBITS_LY01		CFEB4 Bad Bits Array
140	ADR_CFE4_BADBITS_LY23		CFEB4 Bad Bits Array
142	ADR_CFE4_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
<b>Virtex-6 VME Registers:</b>			
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_CFE2_BADBITS_CTRL		CFEB Bad Bit Control/Status extends Adr 122
15E	ADR_V6_CFE2_BADBITS_LY01		CFEB5 Bad Bit Array
160	ADR_V6_CFE2_BADBITS_LY23		CFEB5 Bad Bit Array
162	ADR_V6_CFE2_BADBITS_LY45		CFEB5 Bad Bit Array
164	ADR_V6_CFE2_BADBITS_LY01		CFEB6 Bad Bit Array
166	ADR_V6_CFE2_BADBITS_LY23		CFEB6 Bad Bit Array
168	ADR_V6_CFE2_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
<b>VME Registers to access and control FIFOs with last trigger decisions sent to MPCs</b>			
17C	ADR_MPC0_FRAME0_FIFO		MPC0 Frame0 Data Sent to MPC stored in FIFO
17E	ADR_MPC0_FRAME1_FIFO		MPC0 Frame1 Data Sent to MPC stored in FIFO

Address	Register Name	Page	Description
180	ADR MPC1 FRAME0 FIFO		MPC1 Frame0 Data Sent to MPC stored in FIFO
182	ADR MPC1 FRAME1 FIFO		MPC1 Frame1 Data Sent to MPC stored in FIFO
184	ADR MPC FRAMES FIFO CTRL		Control of FIFO Storage for Data Sent to MPC
<b>VME Registers to access startup timers</b>			
186	ADR TMB MMCM LOCK TIME		TMB Clock Startup Timer
188	ADR TMB POWER UP TIME		TMB Power-up Timer
18A	ADR TMB LOAD CFG TIME		TMB Load Config Timer
18C	ADR ALCT PHASER LOCK TIME		ALCT Phaser MMCM Lock Timer
18E	ADR ALCT LOAD CFG TIME		ALCT Load Config Timer
190	ADR GTX RST DONE TIME		GTX Reset Done Timer
192	ADR GTX SYNC DONE TIME		GTX Sync Done Timer
198	ADR ALGO2016 CTRL		Control for 2016 SLHC Algorithm
19A	ADR CLCT0 CC		Comparator code for 1 <sup>st</sup> CLCT
19C	ADR CLCT1 CC		Comparator code for 2 <sup>nd</sup> CLCT
19E	ADR CLCT0 BNDXKY		New bend and XKY for 1 <sup>st</sup> CLCT
1A0	ADR CLCT1 BNDXKY		New bend and XKY for 2nd CLCT
1AA	ADR RUN3 FORMAT CTRL		Run3 data format control
1AC	ADR HMT CTRL		HMT control
1AE	ADR HMT THRESH1		Cathode HMT thresh1, loose thresh
1B0	ADR HMT THRESH2		Cathode HMT thresh2, nominal thresh
1B2	ADR HMT THRESH3		Cathode HMT thresh3, tight thresh
1B4	ADR HMT NHITS SIG		Cathode HMT in-time hits
1B6	ADR HMT NHITS BKG		Cathode HMT out-of-time hits
1BA	ADR V6 GTX0 NOTINTABLE		Virtex6 gtx0 not in table counter
1BC	ADR V6 GTX1 NOTINTABLE		Virtex6 gtx1 not in table counter
1BE	ADR V6 GTX2 NOTINTABLE		Virtex6 gtx2 not in table counter
1C0	ADR V6 GTX3 NOTINTABLE		Virtex6 gtx3 not in table counter
1C2	ADR V6 GTX4 NOTINTABLE		Virtex6 gtx4 not in table counter
1C4	ADR V6 GTX5 NOTINTABLE		Virtex6 gtx5 not in table counter
1C6	ADR V6 GTX6 NOTINTABLE		Virtex6 gtx6 not in table counter
1C8	ADR V6 GTX0 DISPERR		Virtex6 gtx0 disperr counter
1CA	ADR V6 GTX1 DISPERR		Virtex6 gtx1 disperr counter
1CC	ADR V6 GTX2 DISPERR		Virtex6 gtx2 disperr counter
1CE	ADR V6 GTX3 DISPERR		Virtex6 gtx3 disperr counter
1D0	ADR V6 GTX4 DISPERR		Virtex6 gtx4 disperr counter
1D2	ADR V6 GTX5 DISPERR		Virtex6 gtx5 disperr counter
1D4	ADR V6 GTX6 DISPERR		Virtex6 gtx6 disperr counter

### VME register for GEM section

300	ADR GEM GTX RX0		GEM GTX0 control and status
302	ADR GEM GTX RX1		GEM GTX1 control and status
304	ADR GEM GTX RX2		GEM GTX2 control and status
306	ADR GEM GTX RX3		GEM GTX3 control and status
308	ADR V6 PHASER9		Phase9 for GEMA
30A	ADR V6 PHASER10		Phase10 for GEMB

Address	Register Name	Page	Description
30C	ADR GEM DEBUG FIFO CTRL		Gem debug fifo control
30E	ADR GEM DEBUG FIFO DATA		Gem debug fifo data
310	ADR GEM TBINS		GEM readout time bin
312	ADR GEM CFG		GEM delay and readout mask
314	ADR GEM CNT CTRL		GEM counter control
316	ADR GEM CNT DATA		GEM counter value
318	ADR GEM CSC MATCH WINDOW		
320	ADR GEM INJ CTRL		GEM injector control
322	ADR GEM INJ DATA		GEM injector data
324	ADR GEM COPAD CTRL		GEM copad match control
326	ADR GEM BX0 DELAY		GEM BX0 delay control
328	ADR GEMA TRG CTRL		GEMA trigger control
32A	ADR GEMB TRG CTRL		GEMB trigger control
32C	ADR GEM CSC MATCH CTRL		GEMCSC match control
32E	ADR GEM CSC MATCH CLUSTER00		1st part of Cluster0 for gem-csc match
330	ADR GEM CSC MATCH CLUSTER01		2 <sup>nd</sup> part of Cluster0 for gem-csc match
332	ADR GEM CSC MATCH CLUSTER10		1st part of Cluster1 for gem-csc match
334	ADR GEM CSC MATCH CLUSTER10		2nd part of Cluster1 for gem-csc match
336	ADR GEMA BXN COUNTER		GEMA BXN counter
338	ADR GEMB BXN COUNTER		GEMB BXN counter
33A	ADR GEM VFAT HCM0		Hot channel for GEM, 1 <sup>st</sup> part
33C	ADR GEM VFAT HCM1		Hot channel for GEM, 2nd part
33E	ADR GEM VFAT HCM2		Hot channel for GEM, 3rd part
340	ADR GEMA CLUSTER0		Cluster0 from gmeA
342	ADR GEMA CLUSTER0		Cluster0 from gmeA
344	ADR GEMA CLUSTER0		Cluster0 from gmeA
346	ADR GEMA CLUSTER0		Cluster0 from gmeA
348	ADR GEMA CLUSTER0		Cluster0 from gmeA
34A	ADR GEMA CLUSTER0		Cluster0 from gmeA
34C	ADR GEMA CLUSTER0		Cluster0 from gmeA
34E	ADR GEMA CLUSTER0		Cluster0 from gmeA
350	ADR GEMB CLUSTER0		Cluster0 from gmeB
352	ADR GEMB CLUSTER0		Cluster0 from gmeB
354	ADR GEMB CLUSTER0		Cluster0 from gmeB
356	ADR GEMB CLUSTER0		Cluster0 from gmeB
358	ADR GEMB CLUSTER0		Cluster0 from gmeB
35A	ADR GEMB CLUSTER0		Cluster0 from gmeB
35C	ADR GEMB CLUSTER0		Cluster0 from gmeB
35E	ADR GEMB CLUSTER0		Cluster0 from gmeB
360	ADR GEM COPAD0		GEM copad0
362	ADR GEM COPAD1		GEM copad1
364	ADR GEM COPAD2		GEM copad2
366	ADR GEM COPAD3		GEM copad3

<b>Address</b>	<b>Register Name</b>	<b>Page</b>	<b>Description</b>
368	ADR GEM COPAD4		GEM copad4
36A	ADR GEM COPAD5		GEM copad5
36C	ADR GEM COPAD6		GEM copad6
36E	ADR GEM COPAD7		GEM copad7
370	ADR GEM GTX0 NOTINTABLE		GEM gtx0 not in table counter
372	ADR GEM GTX1 NOTINTABLE		GEM gtx1 not in table counter
374	ADR GEM GTX2 NOTINTABLE		GEM gtx2 not in table counter
376	ADR GEM GTX3 NOTINTABLE		GEM gtx3 not in table counter
378	ADR GEM GTX0 DISPERR		GEM gtx0 disperr counter
37A	ADR GEM GTX1 DISPERR		GEM gtx1 disperr counter
37C	ADR GEM GTX2 DISPERR		GEM gtx2 disperr counter
37E	ADR GEM GTX3 DISPERR		GEM gtx3 disperr counter

## Definitions of Register Addresses

**Adr  $70000_{16}$**

**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
month msd3	month msd2	month msd1	month msd0	month lsd3	month lsd2	month lsd1	month 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	dmr_tx_res_2	dmr_tx_res_1	dmr_tx_res_0	gtl_oe	gtl_loop	dmr_oe	dmr_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	dmr_loop	0	0>No DMB loop-back
[08]	R	dmr_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	dmr_tx_reserved[2:0]	0	dmr_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	prom1_ce	prom1_oe	prom1_clk	prom0_ce	prom0_oe	prom0_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\_DDDSM      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	tmb0d lock	tmb clock0 lock	ddd verify	dddsdm 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**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
delay_ch3	delay_ch3	delay_ch3	delay_ch3	delay_ch2	delay_ch2	delay_ch2	delay_ch2	delay_ch1	delay_ch1	delay_ch1	delay_ch1	delay_ch0	delay_ch0	delay_ch0	delay_ch0

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**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
delay_ch7	delay_ch7	delay_ch7	delay_ch7	delay_ch6	delay_ch6	delay_ch6	delay_ch6	delay_ch5	delay_ch5	delay_ch5	delay_ch5	delay_ch4	delay_ch4	delay_ch4	delay_ch4

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**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
delay_ch11	delay_ch11	delay_ch11	delay_ch11	delay_ch10	delay_ch10	delay_ch10	delay_ch10	delay_ch9	delay_ch9	delay_ch9	delay_ch9	delay_ch8	delay_ch8	delay_ch8	delay_ch8

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	cfeb4	cfeb3	cfeb2	cfeb1	cfeb0	dec	mpc	tmb1	rpc_tx	dmb_tx	alct_rx	alct_tx

Bits	Dir	Signal	Default	Description
[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	/terit	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	fpled flash	fpled cylon	fpled 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 resout 2	tmb hard resout 1	tmb hard resout 0	tmb resl	tmb res0	ll1a vme	clct status en	alct status en	ccb status oe	int ll1aen	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=Disable transmitted CCB backplane outputs
[02]	RW	ccb_int_ll1a_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	ll1accept_vme	0	1=fire ccb_ll1accept 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
ll1a delay vme7	ll1a delay vme6	ll1a delay vme5	ll1a delay vme4	ll1a delay vme3	ll1a delay vme2	ll1a delay vme1	ll1a delay vme0	Ignore start/ stop	ccb exttrig bypass	ext trig both	clct ext trig vme	alct ext trig vme	seq trig ll1aen	clct ext trig ll1aen	alct ext trig ll1aen

Bits	Dir	Signal	Default	Description
[00]	RW	alct_ext_trig_ll1aen	0	1=Request ccb_ll1a on alct_ext_trig
[01]	RW	clct_ext_trig_ll1aen	0	1=Request ccb_ll1a on clct_ext_trig
[02]	RW	seq_trig_ll1aen	1	1=Request ccb_ll1a 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	ll1a_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_bcntrs	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_data17	alct_data16	alct_wdcnt10	alct_wdcnt9	alct_wdcnt8	alct_wdcnt7	alct_wdcnt6	alct_wdcnt5	alct_wdcnt4	alct_wdcnt3	alct_wdcnt2	alct_wdcnt1	alct_wdcnt0	alct_RAMdone	alct_RAMbusy

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_11a_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 p49
[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**

[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
cfeben source	cfeben 4	cfeben 3	cfeben 2	cfeben 1	cfeben 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	dmЬ_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	11111 <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 p75 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_ext_trig_dly[3:0]	alct_pat_trig_dly[3:0]				alct_preClct_dly[3:0]	alct_preClct_width[3:0]				alct_preClct_width[3:0]	alct_preClct_width[3:0]				
3	2	1	0	3	2	1	0	3	2	1	0	3	2	2	0

Bits	Dir	Signal	Default	Description
[03:00]	RW	alct_preClct_width[3:0]	4	Window width for ALCT*preCLCT overlap (opens with alct_active_feb flag from ALCT)
[07:04]	RW	alct_preClct_dly[3:0]	2 (0)	Delay for ALCT*preCLCT overlap (applied to alct_active_feb flag from ALCT)
[11:08]	RW	alct_pat_trig_dly[3:0]	0	Delay alct0 valid 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	dmЬ_ext_delay_3	dmЬ_ext_delay_2	dmb_ext_delay_1	dmb_ext_delay_0

Bits	Dir	Signal	Default	Description
[03:00]	RW	dmЬ_ext_trig_dly[3:0]	1	Delay dmЬ_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
pretrig 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 persist 3	triad persist 2	triad persist 1	triad persist 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
[09:071]	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 cfeb 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
ll a intern dly 2	ll a intern dly 1	ll a intern dly 0	ll a intern	ll a windo 3	ll a windo 2	ll a windo 1	ll a windo 0	ll a delay 7	ll a delay 6	ll a delay 5	ll a delay 4	ll a delay 3	ll a delay 2	ll a delay 1	ll a delay 0

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

**Adr 76 ADR\_SEQ\_OFFSET0**

(see Adr10A p79 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	ll a offset 3	ll a offset 2	ll a offset 1	ll a offset 0

Bits	Dir	Signal	Defau lt	Description
[03:00]	RW	ll a_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' 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' 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 pretrig	mela 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	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	dmЬ_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	mela_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 0

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 alct only	allow clct 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=reset 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
lct 1 <sup>st</sup> vpf 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 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
lct 2 <sup>nd</sup> vpf 3	lct 2 <sup>nd</sup> q 2	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 accept 1	mpc accept 0	ttc inj enable	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_inj	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 p56 SCP\_RDATA and adr CE p66 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 p66 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 rdata8	radr7 rdata7	radr6 rdata6	radr5 rdata5	radr4 rdata4	radr3 rdata3	radr2 rdata2	radr1 rdata1	radr0 rdata0

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 %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 %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_tp; // ALCT vpf in TMB after pipe delay, unbuffered real time
assign scp_ch[72] = clct_vpf_tp; // CLCT vpf in TMB
assign scp_ch[73] = clct_window_tp; // 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_addr[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_addr[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_addr[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	subadr strobe	data strobe	brcst strobe	dis con 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 brcst 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 raddr 10	alct raddr 9	alct raddr 8	alct raddr 7	alct raddr 6	alct raddr 5	alct raddr 4	alct raddr 3	alct raddr 2	alct raddr 1	alct raddr 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 raddr[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 noll1a	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 noll1a	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 cfeb 6	active cfeb 5	active cfeb 4	active cfeb 3	active cfeb 2	active cfeb 1	active cfeb 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 p39

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 p64
[13:11]	R	rpc_inj_rdata[18:16]	-	RPC injector read data MSBs, see adr C0 p64
[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_rwaddr[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 p64)

**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 p64)

**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 couple	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
enable pad15	enable pad14	enable pad13	enable pad12	enable pad11	enable pad10	enable pad9	enable pad8	enable pad7	enable pad6	enable pad5	enable pad4	enable pad3	enable pad2	enable pad1	enable 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 enable	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 melb	reverse mela	reverse csc	stagger csc	csc melab	cnt non melab	mpc mela 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_mela_block	1	Block ME1A LCTs from MPC, still queue for readout
[04]	RW	cnt_non_melab_en	1	Allow clct pretrig counters count non melab
[05]	R	csc_melab	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-mel
[08]	R	reverse_hs_mela	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_mela	reverse_hs_me1b	csc_melab
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 also ADR\_CNT\_RDATA=D2 on page [70](#))

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_evcentres)
[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, CSC

(even cnt adr 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	ALCT: bx0 sent to TMB	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 ( <i>non-zero in OTMB2013 only</i> )	30	Y
20	CLCT: Pre-trigger includes a CLCT on CFEB6 ( <i>non-zero in OTMB2013 only</i> )	30	Y

<b>Address<sub>10</sub></b>	<b>Counter Description</b>	<b>Bits</b>	<b>VME Clears</b>
21	CLCT: Pre-trigger was on ME1A CFEB4-6 only ( <i>non-zero in OTMB2013 only</i> )	30	Y
22	CLCT: Pre-trigger was on ME1B CFEB0-3 only ( <i>non-zero in OTMB2013 only</i> )	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

<b>Address<sub>10</sub></b>	<b>Counter Description</b>	<b>Bits</b>	<b>VME Clears</b>
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 alc0[10:1]=0 when alc0_vpf=0	8	Y
74	ALCT: Structure error, Expected alc1[10:1]=0 when alc1_vpf=0	8	Y
75	ALCT: Structure error, Expected alc0_vpf=1 when alc1_vpf=1	8	Y
76	ALCT: Structure error, Expected alc0[10:1]>0 when alc0_vpf=1	8	Y
77	ALCT: Structure error, Expected alc1[10:1]>0 when alc1_vpf=1	8	Y
78	ALCT: Structure error, Expected alc1!=alc0 when alc0_vpf=1	8	Y
79	CCB: TTCrx lock lost	8	Y
80	CCB: qPLL lock lost	8	Y
81	TMB: CLCT pre-trigger and L1A coincidence counter	30	Y
82	TMB: CLCT pre-trigger and ALCT coincidence counter	30	Y
83	CLCT: CFEB0 active flag sent to DMB for readout	30	Y
84	CLCT: CFEB1 active flag sent to DMB for readout	30	Y
85	CLCT: CFEB2 active flag sent to DMB for readout	30	Y
86	CLCT: CFEB3 active flag sent to DMB for readout	30	Y
87	CLCT: CFEB4 active flag sent to DMB for readout	30	Y
88	CLCT: CFEB5 active flag sent to DMB for readout ( <i>non-zero in OTMB2013 only</i> )	30	Y
89	CLCT: CFEB6 active flag sent to DMB for readout ( <i>non-zero in OTMB2013 only</i> )	30	Y
90	CLCT: CFEB active flag sent to DMB was on ME1A CFEB4-6 only ( <i>non-zero in OTMB2013 only</i> )	30	Y
91	CLCT: CFEB active flag sent to DMB was on ME1B CFEB0-3 only ( <i>non-zero in OTMB2013 only</i> )	30	Y
92	CLCT: CFEB active flag sent to DMB was on <b>any</b> CFEB	30	Y

<b>Address<sup>10</sup></b>	<b>Counter Description</b>	<b>Bits</b>	<b>VME Clears</b>
93	CLCT: sequential trigger counter	30	
94	CLCT: checking pretrigger in last 4BX	30	
95	TMB: ALCT-CLCT BX0 match	30	
96	TMB: fired anode HMT in-time region	30	Y
97	TMB: fired anode HMT in in and out-of time region	30	Y
98	TMB: fired cathode HMT in in time region	30	Y
99	TMB: fired cathode HMT in in and out- time region	30	Y
100	TMB: cathode hmt over threshold1(loose)	30	Y
101	TMB: cathode hmt over threshold2(median)	30	Y
102	TMB: cathode hmt over threshold2(tight)	30	Y
103	TMB: anode hmt+ALCT coincidence	30	Y
104	TMB: cathode hmt+preCLCT coincidence	30	Y
105	TMB: cathode hmt+CLCT coincidence	30	Y
106	TMB: cathode hmt+ALCT coincidence	30	Y
107	TMB: cathode hmt+LCT coincidence	30	Y
108	anode hmt fired only for trigger or readout	30	Y
109	cathode hmt fired only for trigger or readout	30	Y
110	anode or cathode hmt fired for trigger or readout	30	Y
111	anode and cathode hmt fired for trigger or readout	30	Y
112	anode and cathode hmt fired, with valid LCT	30	Y
113	anode and cathode hmt fired, without valid ALCT	30	Y
114	trigger pulse source from HMT only (non-muon trig)	30	Y
115	trigger keep source from HMT only (non-muon trig)	30	Y
116	HMT trigger counter	30	N
117	HMT reaout counter	30	N
118	HMT active cfeb flag counter	30	N
119	buffer stall counter since last resync/hardset	30	Y
120	ME1B Links Sync Error	30	Y
121	ME1A Links Sync Error	30	Y

#### Adr D2 ADR\_CNT\_RDATA

Status Counter Data (See ADR\_CNT\_CTRL=D0 on page [67](#))

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	cnt_rdata[15:0]	-	Data for selected counter (See ADR_CNT_CTRL=D0 on page <a href="#">67</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 3	throt 2	throt 1	throt 0	dis	jsm jtag oe	jsm ok	vme ready	jsm tck ok	jsm wdcnt ok	jsm cksum ok	jsm abort	jsm busy	jsmsel / vsm jtag auto	jsm reset	jsm start

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 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	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\_VMESM0****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 jtagsm 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	format sm 2	format sm 1	format 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	vmesm4_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_tckent_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	clet bxn 11	clet bxn 10	clet bxn 9	clet bxn 8	clet bxn 7	clet bxn 6	clet bxn 5	clet bxn 4	clet bxn 3	clet bxn 2	clet bxn 1	clet bxn 0

Bits	Dir	Signal	Typical	Description
[11:00]	R	bxn_clet_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 4	alct 3	alct 2	alct 1	alct 0

Bits	Dir	Signal	Typical	Description
[4:00]	R	bxn_alct_vme[4:0]	-	ALCT BXN latched at last ALCT vpf
[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 7	clct 6	clct 5	clct 4	clct 3	clct 2	clct 1	clct 0	0	nlaysrs hit 2	nlaysrs hit 1	nlaysrs 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 p49)
[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\_TEMP0**
**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 pretrig 3	pid thresh pretrig 2	pid thresh pretrig 1	pid thresh pretrig 0	0	clet blank

Bits	Dir	Signal	Typical	Description
[00]	RW	clct_blank	1	1=blank non-vpf clct output [requires alct-only or lla-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 hs31,30,29,29,28,27.

**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_addr[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_ttcrx_lock_never	0	TTCrx lock never achieved
[01]	R	ccb_ttcrx_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	11a bxn 11	11a bxn 10	11a bxn 9	11a bxn 8	11a bxn 7	11a bxn 6	11a bxn 5	11a bxn 4	11a bxn 3	11a bxn 2	11a bxn 1	11a 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
11a win pri en	inj rdata 17	inj rdata 16	inj wdata 17	inj wdata 16	11a look back 10	11a look back 9	11a look back 8	11a look back 7	11a look back 6	11a look back 5	11a look back 4	11a look back 3	11a look back 2	11a look back 1	11a 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	11a bxn 11	11a bxn 10	11a bxn 9	11a bxn 8	11a bxn 7	11a bxn 6	11a bxn 5	11a bxn 4	11a bxn 3	11a bxn 2	11a bxn 1	11a 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 pretrig 4	tbins pretrig 3	tbins pretrig 2	tbins pretrig 1	tbins pretrig 0	tbins 4	tbins 3	tbins 2	tbins 1	tbins 0	tbins word nsert	tbins test mode	read enable

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 rx <sub>d</sub> delay 7	alct rx <sub>d</sub> delay 6	alct rx <sub>d</sub> delay 5	alct rx <sub>d</sub> delay 4	alct rx <sub>d</sub> delay 3	alct rx <sub>d</sub> delay 2	alct rx <sub>d</sub> delay 1	alct rx <sub>d</sub> 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 tx <sub>d</sub> delay 7	alct tx <sub>d</sub> delay 6	alct tx <sub>d</sub> delay 5	alct tx <sub>d</sub> delay 4	alct tx <sub>d</sub> delay 3	alct tx <sub>d</sub> delay 2	alct tx <sub>d</sub> delay 1	alct tx <sub>d</sub> 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 rx <sub>d</sub> delay 7	cfeb rx <sub>d</sub> delay 6	cfeb rx <sub>d</sub> delay 5	cfeb rx <sub>d</sub> delay 4	cfeb rx <sub>d</sub> delay 3	cfeb rx <sub>d</sub> delay 2	cfeb rx <sub>d</sub> delay 1	cfeb rx <sub>d</sub> 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 rx <sub>d</sub> delay 7	cfeb rx <sub>d</sub> delay 6	cfeb rx <sub>d</sub> delay 5	cfeb rx <sub>d</sub> delay 4	cfeb rx <sub>d</sub> delay 3	cfeb rx <sub>d</sub> delay 2	cfeb rx <sub>d</sub> delay 1	cfeb rx <sub>d</sub> 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
cfeb rx <sub>d</sub> delay 7	cfeb rx <sub>d</sub> delay 6	cfeb rx <sub>d</sub> delay 5	cfeb rx <sub>d</sub> delay 4	cfeb rx <sub>d</sub> delay 3	cfeb rx <sub>d</sub> delay 2	cfeb rx <sub>d</sub> delay 1	cfeb rx <sub>d</sub> 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	cfeb4_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfeb4_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
cfeb3 delay 3	cfeb3 delay 2	cfeb3 delay 1	cfeb3 delay 0	cfeb2 delay 3	cfeb2 delay 2	cfeb2 delay 1	cfeb2 delay 0	cfeb1 delay 3	cfeb1 delay 2	cfeb1 delay 1	cfeb1 delay 0	cfeb0 delay 3	cfeb0 delay 2	cfeb0 delay 1	cfeb0 delay 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	cfeb0_rxd_int_delay[3:0]	0	Delay data received from CFEB0 by integer bx
[07:04]	RW	cfeb1_rxd_int_delay[3:0]	0	Delay data received from CFEB1 by integer bx
[11:08]	RW	cfeb2_rxd_int_delay[3:0]	0	Delay data received from CFEB2 by integer bx
[15:12]	RW	cfeb3_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	cfeb6 delay 3	cfeb6 delay 2	cfeb6 delay 1	cfeb6 delay 0	cfeb5 delay 3	cfeb5 delay 2	cfeb5 delay 1	cfeb5 delay 0	cfeb4 delay 3	cfeb4 delay 2	cfeb4 delay 1	cfeb4 delay 0

Bits	Dir	Signal	Default	Description
[03:00]	RW	cfeb4_rxd_int_delay[3:0]	0	Delay data received from CFEB4 by integer bx
[07:04]	RW	cfeba_rxd_int_delay[3:0]	0	Delay data received from A-side CFEBS by int bx
[11:08]	RW	cfebb_rxd_int_delay[3:0]	0	Delay data received from B-side CFEBS by int 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 pretrig	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_en	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 p53 Adr86[1:0] for tmb\_sync\_err\_en[1:0] Allow sync\_err to MPC for either muon

See p44 Adr38[2] for alct\_ecc\_err\_blank Blank alct muons having uncorrected ecc errors

**Adr 122 ADR\_CFEB\_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\_CFEB\_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\_CFEBO1\_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\_CFEBO1\_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
mmcm_lostlock_count								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	mmcm lostlock count	0	FPGA MMCM lost-lock count (full scale is hex FC)

**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
qpll_lostlock_count								tmbm mem_ locklo st	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]	R	qpll_locklost	0	QPLL lost its lock at least once since the last reset
[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
[07]	R	tmbmmcm_locklost	0	FPGA MMCM lost its lock since the last reset
[15:08]	R	qpll_lostlock_count	0	QPLL lost-lock count (full scale is hex FC)

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

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gtx err sum bit 7	gtx err sum bit 6	gtx err sum bit 5	gtx err sum bit 4	gtx err sum bit 3	gtx err sum bit 2	gtx err sum bit 1	gtx err sum bit 0	gtx pol swap	gtx link bad	gtx linkha d err	gtx link good	gtx sync done	gtx en prbs	gtx reset	gtx en

Bits	Dir	Signal	Typical	Description
[00]	RW	gtx_rx_enable_all	1	Enable all GTX optical inputs (0 puts GTX in reset state)
[01]	RW	gtx_rx_reset_all	0	Reset the sync stage of all GTX
[02]	RW	gtx_rx_en_prbs_test_all	0	Select all GTX for PRBS test input mode
[03]	R	&gtx_rx_sync_done[6:0]	1	All GTX are ready
[04]	R	&gtx_link_good[6:0]	1	All GTX links are locked (over 15 BX with clean structure)
[05]	R	gtx_link_had_err[6:0]	0	At least one GTX link had an error since last reset
[06]	R	gtx_link_bad[6:0]	0	At least one GTX link had over 100 errors
[07]	R	gtx_rx_pol_swap[6:0]	0	GTX 5,6 [ie dcfeb 4,5] have swapped rx board routes
[15:8]	R	gtx_rx_err_count_sum_all	0	Sum of GTX link error counts (full scale count is hex FE)

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

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gtx err count bit 7	gtx err count bit 6	gtx err count bit 5	gtx err count bit 4	gtx err count bit 3	gtx err count bit 2	gtx err count bit 1	gtx err count bit 0	gtx pol swap	gtx link bad	gtx linkhad err	gtx link good	gtx sync done	gtx en prbs	gtx reset	gtx en

Bits	Dir	Signal	Typical	Description
[00]	RW	gtx_rx_enable[idcfeb]	1	Enable this GTX optical input (0 puts GTX in reset state)
[01]	RW	gtx_rx_reset[idcfeb]	0	Reset the sync stage of this GTX
[02]	RW	gtx_rx_en_prbs_test[idcfeb]	0	Select this GTX for PRBS test input mode
[03]	R	gtx_rx_sync_done[idcfeb]	1	GTX ready
[04]	R	gtx_link_good	1	GTX link is locked (over 15 BX with clean data frames)
[05]	R	gtx_link_had_err	0	GTX link had an error (bad data frame) since last reset
[06]	R	gtx_link_bad	0	GTX link had over 100 errors since last reset
[07]	R	gtx_rx_pol_swap[idcfeb]	0	GTX 5,6 [ie dcfeb 4,5] have swapped rx board routes
[15:8]	R	gtx_rx_err_count[idcfeb]	0	GTX link error count (full scale count is hex E0)

**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
adc_d ata bit 9	adc_d ata bit 8	adc_d ata bit 7	adc_d ata bit 6	adc_d ata bit 5	adc_d ata bit 4	adc_d ata bit 3	adc_d ata bit 2	adc_d ata bit 1	adc_d ata bit 0	adc_v alid or adc_re set	adc_a dr bit 4	adc_a dr bit 3	adc_a dr bit 2	adc_a dr bit 1	adc_a dr bit 0

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 x 503.975)/1024 - 273.15
1	VccINT	Volts	= (ADC Code / 1024) x 3V
2	VccAUX	Volts	= (ADC Code / 1024) x 3V
4	Vref 1.25V	Volts	= (ADC Code / 1024) x 3V
5	Vzero 0.00V	Volts	= (ADC Code / 1024) x 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 cfeb6	found cfeb5	block cfeb6	block cfeb5	reset cfeb6	reset cfeb5

Bits	Dir	Signal	Default	Description
[01:00]	RW	cfeb_badbits_reset[6:5]	0	0x1F=Reset bad cfеб bits FFs for cfеб[n]
[03:02]	RW	cfeb_badbits_block[6:5]	0	0x1F=Block bad cfеб bits in cfеб[n]
[05:04]	R	cfeb_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 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	cfeb5_ly0_badbits[7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb5_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	cfeb5_ly2_badbits[7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb5_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	cfeb5_ly4_badbits[7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb5_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	cfeb6_ly0_badbits[7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb6_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	cfeb6_ly2_badbits[7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb6_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	cfeb6_ly4_badbits[7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad
[15:08]	R	cfeb6_ly5_badbits[7:0]	00000000 <sub>2</sub>	1=CFEB rx bit[n] went bad

**Adr 16A ADR\_V6\_PHASER7ME1/1 A-Side CFEBs rxd Digital Phase Shifter**

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

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

**Adr 16C ADR\_V6\_PHASER8ME1/1 B-Side CFEBs rxd Digital Phase Shifter**

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

Bits	Dir	Signal	Default	Description
[00]	RW	fire_cfebb_rxd	0	Set new phase, software sets then unsets
[01]	RW	reset_cfebb_rxd	0	Reset current phase to 32
[02]	R	phaser_busy_cfebb_rxd	0	Phase shifter busy
[03]	R	lock_cfebb_rxd	1	DCM lock status
[06:04]	R	phaser_sm_cfebb_rxd[2:0]	0	Phase shifter machine state vector
[07]	RW	cfebb_rxd_posneg	0	0=latch inter-stage on falling main clock edge 1=latch inter-stage on rising main clock edge
[15:08]	RW	cfebb_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 DCFEB 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

**Adr 17C ADR\_MPC0\_FRAME0\_FIFO**

**MPC0 Frame0 Data Sent to MPC stored in FIFO**

(see also Adr 88)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1 <sup>st</sup> vpf 3	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 17E ADR\_MPC0\_FRAME1\_FIFO**

**MPC0 Frame1 Data Sent to MPC stored in FIFO**

(see also Adr 8A)

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 180 ADR\_MPC1\_FRAME0\_FIFO**

**MPC1 Frame0 Data Sent to MPC stored in FIFO**

(see also Adr 8C)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2 <sup>nd</sup> vpf 3	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 182 ADR\_MPC1\_FRAME1\_FIFO**

**MPC1 Frame1 Data Sent to MPC stored in FIFO**

(see also Adr 8E)

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 184 ADR\_MPC\_FRAMES\_FIFO\_CTRL**

**Control of FIFO Storage for Data Sent to MPC**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	dbiterr	sbiterr	prog full	empty	overfl ow	write ack	full	read enable	write enable						

Bits	Dir	Signal	Typical	Description
[00]	RW	mpc_frames_fifo_ctrl_wr[0]	0	FIFO write enable
[01]	RW	mpc_frames_fifo_ctrl_wr[1]	0	FIFO read enable
[02]	R	mpc_frames_fifo_ctrl_full	0	FIFO full flag
[03]	R	mpc_frames_fifo_ctrl_wr_ack	0	FIFO write acknowledge
[04]	R	mpc_frames_fifo_ctrl_overflow	0	FIFO overflow
[05]	R	mpc_frames_fifo_ctrl_empty	0	FIFO empty flag
[06]	R	mpc_frames_fifo_ctrl_prog_full	0	FIFO programmable full
[07]	R	mpc_frames_fifo_ctrl_sbiterr	0	FIFO Single Bit Error
[08]	R	mpc_frames_fifo_ctrl_dbiterr	0	FIFO Double Bit Error

**Adr 186 ADR\_TMB\_MMCM\_LOCK\_TIME TMB Clock Startup Timer**

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

Bits	Dir	Signal	Default	Description
[15:00]	R	mmcm_lock_time[15:0]	0	Time to lock MMCM, with special test counter

**Adr 188 ADR\_TMB\_POWER\_UP\_TIME TMB Power-up Timer**

Bits	Dir	Signal	Default	Description
[15:00]	R	power_up_time[15:0]	0	Time to lock MMCM after Hard Reset, in 100 ns units

**Adr 18A ADR\_TMB\_LOAD\_CFG\_TIME TMB Load Config Timer**

Bits	Dir	Signal	Default	Description
[15:00]	R	tmb_load_cfg_time[15:0]	0	Time to read config from flash after Hard Reset, in 100 ns units

**Adr 18C ADR\_ALCT\_PHASER\_LOCK\_TIME ALCT Phaser MMCM Lock Timer**

Bits	Dir	Signal	Default	Description
[15:00]	R	phaser_lock_time[15:0]	0	Time to lock Phaser after Hard Reset, in 100 ns units

**Adr 18E ADR\_ALCT\_LOAD\_CFG\_TIME ALCT Load Config Timer**

Bits	Dir	Signal	Default	Description
[15:00]	R	alct_load_cfg_time[15:0]	0	Time to complete ALCT config after alct wait period, in 100 ns units

**Adr 190 ADR\_GTX\_RST\_DONE\_TIME GTX Reset Done Timer**

Bits	Dir	Signal	Default	Description
[15:00]	R	gtx_RST_DONE_time[15:0]	0	Time to finish GTX reset after Hard Reset, in 100 ns units

**Adr 192 ADR\_GTX\_SYNC\_DONE\_TIME GTX Sync Done Timer**

Bits	Dir	Signal	Default	Description
[15:00]	R	gtx_SYNC_DONE_time[15:0]	0	Time to finish GTX sync after Hard Reset, in 100 ns units

**Adr 198****ADR\_ALGO2016\_CTRL****Control of 2016 SLHC algorithm**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	not used	not used	chamber number parity	no deadtime for seq trigger	correct lctbx	cross bx algorithm	drop used clct	alct centric match	use dynamic dead time zone	dead time zone4	dead time zone3	dead time zone2	dead time zone1	dead time zone0	used dead_time_zone
Bits		Dir	Signal						Typical		Description				
[00]		RW	algo2016_use_dead_time_zone						1		Toggle dead time zone				
[05:01]		RW	algo2016_dead_time_zone_size						15		Dead time zone size(0-31 HS), NOT USED				
[06]		RW	algo2016_use_dynamic_dead_time_zone						0		Toggle dead time zone depending on pattern, NOT USED				
[07]		RW	algo2016_clct_to_alct						0		ALCT centric match, NOT USED				
[08]		RW	algo2016_drop_used_clcts						0		Drop the CLCTs used for match. 0 means to enable CLCT reuse				
[09]		RW	algo2016_cross_bx_algorithm						0		LCT sorting with cross bx algorithm, NOT USED				
[10]		RW	algo2016_lct_use_corrected_bx						0		Correct LCT BX, NOT USED				
[11]		RW	seq_trigger_nodeadtime						0		Allow two triggers in a row				
[12]		RW	evenchamber						0		Chamber number parity, 1=odd and 0=even				
[15:13]		-	-						0		NOT USED				

**NEW REGISTERS FOR RUN3****Adr 19A****ADR\_CLCT0\_CC****CLCT0 Comparator Code**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	not used	not used	not used	clct0_cc11	clct0_cc10	clct0_cc9	clct0_cc8	clct0_cc7	clct0_cc6	clct0_cc5	clct0_cc4	clct0_cc3	clct0_cc2	clct0_cc1	clct0_cc0
Bits		Dir	Signal						Typical		Description				
[11:00]		R	clct0_vme_carry						0		12-bit comparator code for 1 <sup>st</sup> CLCT				
[15:12]		-	-						-		NOT USED				

**Adr 19C****ADR\_CLCT1\_CC****CLCT1 Comparator Code**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	not used	not used	not used	clct1_cc11	clct1_cc10	clct1_cc9	clct1_cc8	clct1_cc7	clct1_cc6	clct1_cc5	clct1_cc4	clct1_cc3	clct1_cc2	clct1_cc1	clct1_cc0
Bits		Dir	Signal						Typical		Description				
[11:00]		R	clct1_vme_carry						0		12-bit comparator code for 2 <sup>nd</sup> CLCT				
[15:12]		-	-						-		NOT USED				

**Adr 19E****ADR\_CLCT0\_BNDXKY****CLCT0 BEND and XKY**

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

not used	clet0_xky9	clet0_xky8	clet0_xky7	clet0_xky6	clet0_xky5	clet0_xky4	clet0_xky3	clet0_xky2	clet0_xky1	clet0_xky0	clet0_bnd4	clet0_bnd3	clet0_bnd2	clet0_bnd1	clet0_bnd0
----------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------	------------

Bits	Dir	Signal	Typical	Description
[04:00]	R	clct0_bnd	0-31	bend value for 1 <sup>st</sup> CLCT. [4] means direction of bending and 1 for left. [3:0] for bend value
[14:05]	R	clct0_xky	-	1 <sup>st</sup> CLCT position, unit is 1/8 strip

### Adr 1A0

### ADR\_CLCT1\_BNDXKY

### CLCT1 BEND and XKY

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	clct1_xky9	clct1_xky8	clct1_xky7	clct1_xky6	clct1_xky5	clct1_xky4	clct1_xky3	clct1_xky2	clct1_xky1	clct1_xky0	clct1_bnd4	clct1_bnd3	clct1_bnd2	clct1_bnd1	clct1_bnd0

Bits	Dir	Signal	Typical	Description
[04:00]	R	clct1_bnd	0-31	bend value for 2 <sup>nd</sup> CLCT. [4] means direction of bending and 1 for left. [3:0] for bend value
[14:05]	R	clct1_xky	-	2 <sup>nd</sup> CLCT position, unit is 1/8 strip

### Adr 1AA

### ADR\_RUN3\_FORAMT\_CTRL

### Control of Run3 Data Format

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	run2_r_evcde_o	run3_alct_d_f	run3_daq_d_f	run3_t_rig_df	cclut_enable										

Bits	Dir	Signal	Typical	Description
[00]	R	cclut_enable	1	CCLUT enabled or not. 1=enabled
[01]	RW	run3_trig_df	0	Enable Run3 trigger data format or not. 1=enable
[02]	RW	run3_daq_df	0	Enable Run3 DAQ data format or not. 1=enable
[03]	RW	run3_alct_df	0	Enable Run3 ALCT data format or not. 1=enable
[04]	RW	run2_revcode	0	Enable Run2 revcode or not. 1=enable

### Adr 1AC

### ADR\_HMT\_CTRL

### Control of HMT Algorithm

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
hmt_c_athode_3	hmt_c_athode_2	hmt_c_athode_1	hmt_c_athode_0	hmt_n_hits9	hmt_n_hits8	hmt_n_hits7	hmt_n_hits6	hmt_n_hits5	hmt_n_hits4	hmt_n_hits3	hmt_n_hits2	hmt_n_hits1	hmt_n_hits0	hmt_me1a_enable	hmt_enable

Bits	Dir	Signal	Typical	Description
[00]	RW	hmt_enable	0	Enable HMT or not. 1=enable
[01]	RW	hmt_me1a_enable	0	Enable HMT in ME1a. 1=enable
[11:02]	RW	hmt_nhits_bx7_vme	0	Number comparator hits in center of HMT
[15:12]	RW	hmt_cathdoe_vme	0	Cathode HMT bits

### Adr 1AE

### ADR\_HMT\_THRESH1

### HMT Loose Threshold and Control

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
hmt_a ff_thr esh 6	hmt_a ff_thr esh 5	hmt_a ff_thr esh 4	hmt_a ff_thr esh 3	hmt_a ff_thr esh 2	hmt_a ff_thr esh 1	hmt_a ff_thr esh 0	hmt_c feb_ro	hmt_t hresh1 7	hmt_t hresh1 6	hmt_t hresh1 5	hmt_t hresh1 4	hmt_t hresh1 3	hmt_t hresh1 2	hmt_t hresh1 1	hmt_t hresh1 0

Bits	Dir	Signal	Typical	Description
[07:00]	RW	hmt_thresh1	90	Loose threshold for cathode HMT
[08]	RW	cfeb_allow_hmt_ro	0	Enable cfeb readout for cathode HMT
[15:09]	RW	hmt_aff_thresh	6	HMT threshold for active cfeb flag

### Adr 1B0      ADR\_HMT\_THRESH2

### HMT Nominal Threshold and Control

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
hmt_a lct_wi n3	hmt_a lct_wi n2	hmt_a lct_wi n1	hmt_a lct_wi n0	hmt_d elay3	hmt_d elay2	hmt_d elay1	hmt_d elay0	hmt_t hresh2 _7	hmt_t hresh2 _6	hmt_t hresh2 _5	hmt_t hresh2 _4	hmt_t hresh2 _3	hmt_t hresh2 _2	hmt_t hresh2 _1	hmt_t hresh2 _0

Bits	Dir	Signal	Typical	Description
[00]	RW	hmt_thresh2	95	Nominal threshold for cathode HMT
[05:01]	RW	hmt_delay	5	Delay for cathode HMT.
[06]	RW	hmt_alct_win_size	7	Cathode HMT and ALCT(also anode HMT) window size. Should be the same as ALCT-CLCT window size

### Adr 1B2      ADR\_HMT\_THRESH3

### HMT Tight Threshold and Control

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	hmt_o uttime _chec k	hmt_a llow match _ro	hmt_a llow cathod e _ro	hmt_a llow anode _ro	hmt_a llow match	hmt_a llow cathod e	hmt_a llow anode	hmt_t hresh3 _7	hmt_t hresh3 _6	hmt_t hresh3 _5	hmt_t hresh3 _4	hmt_t hresh3 _3	hmt_t hresh3 _2	hmt_t hresh3 _1	hmt_t hresh3 _0

Bits	Dir	Signal	Typical	Description
[07:00]	RW	hmt_thresh3	100	Tight threshold for cathode HMT
[08]	RW	hmt_allow_anode	0	Allow to trigger on anode HMT
[09]	RW	hmt_allow_cathode	0	Allow to trigger on cathode HMT
[10]	RW	hmt_allow_match	1	Allow to trigger on matched HMT
[11]	RW	hmt_allow_anode_ro	0	Allow to readout on anode HMT
[12]	RW	hmt_allow_cathode_ro	0	Allow to readout on cathode HMT
[13]	RW	hmt_allow_match_ro	1	Allow to readout on matched HMT
[14]	RW	hmt_outtime_check	0	Check out-of-time HMT or not

### Adr 1B4      ADR\_HMT\_NHITS\_SIG

### In-time NHITS FOR HMT

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	hmt_s ig_nhi t9	hmt_s ig_nhi t8	hmt_s ig_nhi t7	hmt_s ig_nhi t6	hmt_s ig_nhi t5	hmt_s ig_nhi t4	hmt_s ig_nhi t3	hmt_s ig_nhi t2	hmt_s ig_nhi t1	hmt_s ig_nhi t0					

Bits	Dir	Signal	Typical	Description
[09:00]	RW	hmt_nhites_sig_vme	-	Number of comparator in-time (BX678) hits

### Adr 1B6      ADR\_HMT\_NHITS\_BKG

### Out-of-time NHITS FOR HMT

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	hmt_b_kg_nh_it9	hmt_b_kg_nh_it8	hmt_b_kg_nh_it7	hmt_b_kg_nh_it6	hmt_b_kg_nh_it5	hmt_b_kg_nh_it4	hmt_b_kg_nh_it3	hmt_b_kg_nh_it2	hmt_b_kg_nh_it1	hmt_b_kg_nh_it0					

Bits	Dir	Signal	Typical	Description
[09:00]	RW	hmt_nhits_bkg_vme	-	Number of comparator out-of-time (BX345) hits

**Adr 1BA,1BC,1BE,1C0,1C2,1C4,1C6      ADR\_V6\_GTX[0-3]\_NOTINTABLE      CFEB  
GTX0-6 notintable coutner**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt	Notint table_cnt
Bits	Dir	Signal				Typical		Description							
[15:00]	R	gtx[0-6]_rx_notintable_count				0		Counter for CFEB GTX0-6 not in table error							

**Adr 1C8,1CA,1CC,1CE,1D0,1D2,1D4      ADR\_V6\_GTX[0-3]\_DISPERR      CFEB GTX0-6  
disperr coutner**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt	disper_r_cnt
Bits	Dir	Signal				Typical		Description							
[15:00]	R	gtx[0-6]_rx_disperr_count				0		Counter for GEM GTX0-6 disperr error							

**Adr 300,302,304,306 ADR\_GEM\_GTX\_RX0-4      GEM GTX (0-3) control and status**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gtx err count bit 7	gtx err count bit 6	gtx err count bit 5	gtx err count bit 4	gtx err count bit 3	gtx err count bit 2	gtx err count bit 1	gtx err count bit 0	gtx pol swap	gtx link bad	gtx linkhad err	gtx link good	gtx sync done	gtx en prbs	gtx reset	gtx en
Bits	Dir	Signal				Typical		Description							
[00]	RW	gem_gtx_rx_enable[igem]				1		Enable this GTX optical input (0 puts GTX in reset state)							
[01]	RW	gem_gtx_rx_reset[igem]				0		Reset the sync stage of this GTX							
[02]	RW	gem_gtx_rx_en_prbs_test [igem]				0		Select this GTX for PRBS test input mode							
[03]	R	gem_gtx_rx_sync_done[i gem]				1		GTX ready							
[04]	R	gem_gtx_link_good				1		GTX link is locked (over 15 BX with clean data frames)							
[05]	R	gem_gtx_link_had_err				0		GTX link had an error (bad data frame) since last reset							
[06]	R	gem_gtx_link_bad				0		GTX link had over 100 errors since last reset							
[07]	R	gem_gtx_rx_pol_swap[ig em]				0		GTX 5,6 [ie dcfeb 4,5] have swapped rx board routes							
[15:8]	R	gem_gtx_rx_err_count[ig em]				0		GTX link error count (full scale count is hex E0)							

**Adr 308****ADR\_V6\_PHASER9****GEMA rxd Digital Phase Shifter**

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

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

**Adr 30A****ADR\_V6\_PHASER10****GEMA rxd Digital Phase Shifter**

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

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

**Adr 30C****ADR\_GEM\_DEBUG\_FIFO\_CTRL****Control of GEM FIFO for Debug**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	fifo_cl uster_adr9	fifo_cl uster_adr8	fifo_cl uster_adr7	fifo_cl uster_adr6	fifo_cl uster_adr5	fifo_cl uster_adr4	fifo_cl uster_adr3	fifo_cl uster_adr2	fifo_cl uster_1	fifo_cl uster_0	fifo_i gem1	fifo_i gem0	fifo_s el1	fifo_s el0	fifo_r eset

Bits	Dir	Signal	Typical	Description
[00]	RW	gem_debug_fifo_reset	0	Reset GEM debug fifo
[02:01]	RW	gem_debug_fifo_sel	0	Select GEM cluster 0-3 for debug fifo
[04:03]	RW	gem_debug_fifo_igem	0	Select GEM fiber 0-3 for debug fifo
[07]	RW	gem_debug_fifo_adr	0	GEM cluster address for debug fifo

**Adr 30E****ADR\_GEM\_DEBUG\_FIFO\_DATA****GEM DEBUG FIFO DATA**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	gem_data	
Bits	Dir	Signal						Typical	Description							
[15:00]	R	gem_debug_fifo_data						-	GEM data for debug fifo							

**Adr 310 ADR\_GEM\_TBINS Control of GEM READOUT**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
not used	not used	not used	gem_zero_su ppress	gem_read_e nable	gem_decou ple	gem_fifo_pr etrig4	gem_fifo_pr etrig3	gem_fifo_pr etrig2	gem_fifo_pr etrig1	gem_fifo_pr etrig0	gem_fifo_tb in4	gem_fifo_tb in3	gem_fifo_tb in2	gem_fifo_tb in1	gem_fifo_tb in0	
Bits	Dir	Signal						Typical	Description							
[04:00]	RW	fifo_tbins_gem_wr						10	Number of fifo time bin for GEM readout							
[09:05]	RW	fifo_pretrig_gem_wr						2	Number of fifo time bin before pretrigger for GEM readout							
[10]	RW	gem_decouple						0	Decouple GEM and CSC time bin control in readout							
[11]	RW	gem_read_enable						1	Enable GEM readout							
[12]	RW	gem_zero_suppress						0	Zero suppress GEM readout							

**Adr 312 ADR\_GEM\_CFG Control of GEM Configuration**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
not used	not used	not used	gemB_read_mask_1	gemB_read_mask_0	gemA_read_mask_1	gemA_read_mask_0	gemA_B_decouple	gemB_rxd_delay3	gemB_rxd_delay2	gemB_rxd_delay1	gemB_rxd_delay0	gemA_rxd_delay3	gemA_rxd_delay2	gemA_rxd_delay1	gemA_rxd_delay0	
Bits	Dir	Signal						Typical	Description							
[03:00]	RW	gemA_rxd_int_delay						0	gemA Rxd integer BX delay							
[07:04]	RW	gemB_rxd_int_delay						0	gemB Rxd integer BX delay							
[08]	RW	gem_rxd_int_delay_decouple						0	Decouple gemA/B for integer delay							
[10:09]	RW	gemA_read_mask						3	read out mask for two fibers in gemA							
[12:11]	RW	gemB_read_mask						3	read out mask for two fibers in gemB							

**Adr 314 ADR\_GEM\_CNT\_CTRL GEM Counter Control (See also ADR\_CNT\_RDATA=D2 on page 70)**

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_debug	seq_ovf	alct_ovf	stop_ovf	snap_shot	clear_all

Bits	Dir	Signal	Default	Description
[00]	RW	gem_cnt_all_reset_vme	0	Clear VME counters (also clr on ccb_evcntres)
[01]	RW	gem_cnt_snapshot	0	Take snapshot of current counter state
[02]	RW	gem_cnt_stop_on_ovf	0	Stop all counters if any overflows
[03]	R	unganged_counter_control	1	Ungang GEM and CSC counter control. 1=unganged
[04]	R	gem_cnt_any_ovf_seq	-	At least 1 sequencer counter overflowed
[05]	RW	-	1	-
[06]	RW	gem_cnt_clear_on_resync	0	1=Clear VME counters on ttc_resync
[07]	RW	-	-	-
[08]	RW	gem_cnt_adr_lsb	-	Counter half select, 0=bits[15:0], 1=bits[29:16]
[15:09]	RW	gem_cnt_select[6:0]	-	Counter select address

### Counter Select Addresses, GEM

(even cnt\_adr\_lsb=LSBs, odd cnt\_adr\_lsb=MSBs)

Address <sub>10</sub>	Counter Description	Bits	VME Clears
00	GEM: GEM A Sync Error	30	Y
01	GEM: GEM B Sync Error	30	Y
02	GEM: Superchamber Sync Error	30	Y
03	GEM: GEM A Overflow	30	Y
04	GEM: GEM B Overflow	30	Y
05	GEM: GEM A BC0marker	30	Y
06	GEM: GEM B BC0marker	30	Y
07	GEM: GEM A resyncmarker	30	Y
08	GEM: GEM B resyncmarker	30	Y
09	GEM: GEM A cluster counts	30	Y
10	GEM: GEM B cluster counts	30	Y
11	GEM copad counts	30	Y
12	gem A Vfat0	30	Y
13	gem A Vfat1	30	Y
14	gem A Vfat2	30	Y
15	gem A Vfat3	30	Y
16	gem A Vfat4	30	Y
17	gem A Vfat5	30	Y
18	gem A Vfat6	30	Y
19	gem A Vfat7	30	Y
20	gem A Vfat8	30	Y
21	gem A Vfat9	30	Y
22	gem A Vfat10	30	Y
23	gem A Vfat11	30	Y
24	gem A Vfat12	30	Y
25	gem A Vfat13	30	Y
26	gem A Vfat14	30	Y

<b>Address<sub>10</sub></b>	<b>Counter Description</b>	<b>Bits</b>	<b>VME Clears</b>
27	gem A Vfat15	30	Y
28	gem A Vfat16	30	Y
29	gem A Vfat17	30	Y
30	gem A Vfat18	30	Y
31	gem A Vfat19	30	Y
32	gem A Vfat20	30	Y
33	gem A Vfat21	30	Y
34	gem A Vfat22	30	Y
35	gem A Vfat23	30	Y
36	gem B Vfat0	30	Y
37	gem B Vfat1	30	Y
38	gem B Vfat2	30	Y
39	gem B Vfat3	30	Y
40	gem B Vfat4	30	Y
41	gem B Vfat5	30	Y
42	gem B Vfat6	30	Y
43	gem B Vfat7	30	Y
44	gem B Vfat8	30	Y
45	gem B Vfat9	30	Y
46	gem B Vfat10	30	Y
47	gem B Vfat11	30	Y
48	gem B Vfat12	30	Y
49	gem B Vfat13	30	Y
50	gem B Vfat14	30	Y
51	gem B Vfat15	30	Y
52	gem B Vfat16	30	Y
53	gem B Vfat17	30	Y
54	gem B Vfat18	30	Y
55	gem B Vfat19	30	Y
56	gem B Vfat20	30	Y
57	gem B Vfat21	30	Y
58	gem B Vfat22	30	Y
59	gem B Vfat23	30	Y
60	Copad Match in Vfat0	30	Y
61	Copad Match in Vfat1	30	Y
62	Copad Match in Vfat2	30	Y
63	Copad Match in Vfat3	30	Y
64	Copad Match in Vfat4	30	Y
65	Copad Match in Vfat5	30	Y
66	Copad Match in Vfat6	30	Y
67	Copad Match in Vfat7	30	Y
68	Copad Match in Vfat8	30	Y
69	Copad Match in Vfat9	30	Y
70	Copad Match in Vfat10	30	Y
71	Copad Match in Vfat11	30	Y
72	Copad Match in Vfat12	30	Y

<b>Address<sub>10</sub></b>	<b>Counter Description</b>	<b>Bits</b>	<b>VME Clears</b>
73	Copad Match in Vfat13	30	Y
74	Copad Match in Vfat14	30	Y
75	Copad Match in Vfat15	30	Y
76	Copad Match in Vfat16	30	Y
77	Copad Match in Vfat17	30	Y
78	Copad Match in Vfat18	30	Y
79	Copad Match in Vfat19	30	Y
80	Copad Match in Vfat20	30	Y
81	Copad Match in Vfat21	30	Y
82	Copad Match in Vfat22	30	Y
83	Copad Match in Vfat23	30	Y
84	GEM: gem A clusters in ME1a counter	30	Y
85	GEM: gem A clusters in ME1b counter	30	Y
86	GEM: gem B clusters in ME1a counter	30	Y
87	GEM: gem B clusters in ME1b counter	30	Y
88	GEM: gemA-CLCT BX0 match	30	Y
89	GEM: gemB-CLCT BX0 match	30	Y
90	GEM: gemA*ALCT Match,timing only	30	Y
91	GEM: gemB*ALCT Match,timing only	30	Y
92	GEM: gemA*CLCT Match,timing only	30	Y
93	GEM: gemB*CLCT Match,timing only	30	Y
94	GEM: gemA*ALCT*CLCT Match,timing only	30	Y
95	GEM: gemB*ALCT*CLCT Match,timing only	30	Y
96	GEM: CLCT*CoGEM (no ALCT),timing only	30	Y
97	GEM: ALCT*CoGEM (no CLCT),timing only	30	Y
98	GEM: ALCT*GEMA,timing+position	30	Y
99	GEM: ALCT*GEMB,timing+position	30	Y
100	GEM: CLCT*GEMA,timing+position	30	Y
101	GEM: CLCT*GEMB,timing+position	30	Y
102	GEM: ALCT*COGEM,timing+position	30	Y
103	GEM: CLCT*COGEM,timing+position	30	Y
104	GEM: ALCT*CLCT*COGEM,timing+position	30	Y
105	GEM: ALCT*CLCT*GEMA,timing+position	30	Y
106	GEM: ALCT*CLCT*GEMB,timing+position	30	Y
107	GEM: Run3 copy ALCT0 into ALCT1	30	Y
108	GEM: Run3 copy CLCT0 into CLCT1	30	Y
109	GEM: Build ALCT0 from CoGEM	30	Y
110	GEM: Build ALCT1 from CoGEM	30	Y
111	GEM: Build CLCT0 from CoGEM	30	Y
112	GEM: Build CLCT1 from CoGEM	30	Y
113	GEM: swap ALCT/CLCT from ALCTxCLCTxCoapd match	30	Y
114	GEM: swap ALCT/CLCT from ALCTxCLCTxGEM match	30	Y
115	GEM: swap ALCT/CLCT from ALCT/CLCT xCoapd match	30	Y
Following counters used only for special test tool in Emulib and usually their values are 0 in normal run			
116	GEM: Special test: delay alct, dlyalct_gemA_match	30	Y

<b>Address<sub>10</sub></b>	<b>Counter Description</b>	<b>Bits</b>	<b>VME Clears</b>
117	GEM: Special test: delay alct, dlyalct_gemB_match	30	Y
118	GEM: Special test: delay gemA, alct_dlygemA_match	30	Y
119	GEM: Special test: delay gemB, alct_dlygemB_match	30	Y

**Adr 318      ADR\_GEM\_CSC\_MATCH\_WINDOW      GEM-CSC Position Match**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
deltaw ire_ev en1	deltaw ire_ev en1	deltaw ire_ev en0	deltah s_eve n4	deltah s_eve n3	deltah s_eve n2	deltah s_eve n1	deltah s_eve n0	deltaw ire_od d1	deltaw ire_od d1	deltaw ire_od d0	deltah s_odd 4	deltah s_odd 3	deltah s_odd 2	deltah s_odd 1	deltah s_odd 0

Bits	Dir	Signal	Typical	Description
[04:00]	RW	gem_clct_deltahs_odd	10	GEMCSC match window in strip direction for odd chamber pair, unit=CLCT halfstrip
[07:05]	RW	gem_alct_deltawire_odd	15	GEMCSC match window in wire direction for odd chamber pair, unit=ALCT wiregroup
[12:08]	RW	gem_clct_deltahs_even	7	GEMCSC match window in strip direction for even chamber pair, unit=CLCT halfstrip
[15:13]	RW	gem_alct_deltawire_even	7	GEMCSC match window in wire direction for even chamber pair, unit=ALCT wiregroup

**Adr 320      ADR\_GEM\_INJ\_CTRL      Control of GEM Raw Hits Readout RAM**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gem_i nj_ma sk	gem_i nj_adr 9	gem_i nj_adr 8	gem_i nj_adr 7	gem_i nj_adr 6	gem_i nj_adr 5	gem_i nj_adr 4	gem_i nj_adr 3	gem_i nj_adr 2	gem_i nj_adr 1	gem_i nj_adr 0	gem_i nj_ige m1	gem_i nj_ige m0	gem_i nj_sel 1	gem_i nj_sel 0	gem_i nj_we n

Bits	Dir	Signal	Typical	Description
[00]	RW	gem_inj_wen	0	RAM write enable
[02:01]	RW	gem_inj_sel	0	Selector of gem cluster0-3
[04:03]	RW	gem_inj_igem	0	Selector of gem fiber0-3
[14:05]	RW	gem_inj_addr	0	Fifo address
[15]	RW	gem_inj_mask	0	Mask of RAM

**Adr 322      ADR\_GEM\_INJ\_DATA      GEM Data for GEM Raw Hits Readout RAM**

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

Bits	Dir	Signal	Typical	Description
[15:00]	RW	gem_inj_data	-	GEM data for GEM injection RAM

**Adr 324      ADR\_GEM\_COPAD\_CTRL      Control of GEM Copad Matching**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	copad_delta	copad_delta	copad_delta	copad_delta	copad_pad	not used	not used	copad_roll							

								pad3	pad2	pad1	pad0	en			en
Bits	Dir	Signal						Typical	Description						
[00]	RW	gem_match_neighborroll						1	Enable GEM hits from neighbor rolls for GEM copad match						
[02:01]	RW	-						-	Not used						
[03]	RW	gem_match_neighborpad						1	Enable GEM pad window for GEM copad match						
[07:04]	RW	gem_match_deltapad						7	GEM pad window size for GEM copad match						

### Adr 326

### ADR\_GEM\_BX0\_DELAY

### GEM BX0 Delay

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gemB_bx0_match	gemB_bx0_enabel	gemB_bx0	gemB_bx0	gemB_bx0	gemB_bx0	gemB_bx0	gemB_bx0	gemA_bx0_match	gemA_bx0_enabel	gemA_bx0	gemA_bx0	gemA_bx0	gemA_bx0	gemA_bx0	gemA_bx0

Bits	Dir	Signal						Typical	Description						
[05:00]	RW	gemA_bx0_delay						16	Delay for gemA BX0, unit=bx						
[06]	RW	gemA_bx0_enable						1	Enable gemA BX0 match with CLCT						
[07]	R	gemA_bx0_match						0	gemA and CLCT BX0 match, 1=matched						
[13:08]	RW	gemB_bx0_delay						16	Delay for gemB BX0, unit=bx						
[14]	RW	gemB_bx0_enable						1	Enable gemB BX0 match with CLCT						
[15]	R	gemB_bx0_match						0	gemB and CLCT BX0 match, 1=matched						

### Adr 328

### ADR\_GEMA\_TRG\_CTRL

### Control of GEMA-CSC MATCH

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	not used	not used	gemA_fiber_enabl_e1	gemA_fiber_enabl_e0	not used	not used	not used	gem_c_lct_wi_n3	gem_c_lct_wi_n2	gem_c_lct_wi_n1	gem_c_lct_wi_n0	gem_a_lct_wi_n3	gem_a_lct_wi_n2	gem_a_lct_wi_n1	gem_a_lct_wi_n0

Bits	Dir	Signal						Typical	Description						
[03:00]	RW	match_gem_alct_window						3	GEM-ALCT match in timing window, unit=BX						
[05:01]	RW	match_gem_clct_window						7	GEM-CLCT match in timing window, unit=BX. NOT USED. Used ALCT-CLCT window fro GEM-CLCT						
[12:11]	RW	gemA_fiber_enable						0	Enable gemA fibers for GEMCSC match. 2'b11 means to enable both						

### Adr 32A

### ADR\_GEMB\_TRG\_CTRL

### Control of GEMB-CSC MATCH

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
not used	not used	not used	gemB_fiber_enabl_e1	gemB_fiber_enabl_e0	not used	not used	not used	gem_delay_7	gem_delay_6	gem_delay_5	gem_delay_4	gem_delay_3	gem_delay_2	gem_delay_1	gem_delay_0

Bits	Dir	Signal	Typical	Description
[07:00]	RW	match_gem_alct_delay	1	GEM delay for GEM-ALCT match. Usually only least significant 4 bits used
[12:11]	RW	gemB_fiber_enable	0	Enable gemB fibers for GEMCSC match. 2'b11 means to enable both

### **Adr 32C      ADR\_GEM\_CSC\_MATCH\_CTRL      Control of GEM-CSC match**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Gemc_sc_ignore_bend_end_check	Gemc_sc_be_nd_enable	gemB_ignor_e_posi_tion	gemA_ignor_e_posi_tion	Copad_clect	Copad_alct	Copad_clect_ro	Copad_alct_ro	Me1b_drop_lowqclct	Me1a_drop_lowqclct	Drop_lowqa_lct	Gemc_sc_ma_tch_tightwin	Gemc_sc_ma_tch_be_nd_coor	Gemc_sc_ma_tch_extrapola_tion	Gem_me1b_enabl_e	Gem_me1a_enable
Bits	Dir	Signal				Typical		Description							
[00]	RW	gem_me1a_match_enable				1		Enable GEMCSC match in ME1a							
[01]	RW	gem_me1b_match_enable				1		Enable GEMCSC match in ME1b							
[02]	R	gemcsc_match_extrapolate				1		READ only. Firmware always used GEMCSC match with extrapolating CLCT location back to GEM							
[03]	RW	gemcsc_match_bend_correctio_n				0		NOT USED							
[04]	RW	gemcsc_match_tight_window				0		NOT USED							
[05]	RW	match_drop_lowqalct				1		Drop low quality ALCT (nhits<=3) for GEMCSC match							
[06]	RW	me1a_match_drop_lowqcclct				1		Drop low quality CLCT(nhits<=3) for GEMCSC match in ME1a							
[07]	RW	me1b_match_drop_lowqcclct				1		Drop low quality CLCT (nhits<=3) for GEMCSC match in ME1b							
[08]	RW	tmb_copad_alct_allow_ro				1		Allow Copad+ALCT match for readout							
[09]	RW	tmb_copad_clct_allow_ro				0		Allow Copad+CLCT match for readout							
[10]	RW	tmb_copad_alct_allow				1		Allow Copad+ALCT match for trigger							
[11]	RW	tmb_copad_clct_allow				0		Allow Copad+CLCT match for trigger							
[12]	RW	gema_match_ignore_position				0		Ignore position match for GEMA-CSC match							
[13]	RW	gemb_match_ignore_position				0		Ignore position match for GEMB-CSC match							
[14]	RW	gemcsc_bend_enable				1		Use the bending from GEMCSC bendign agnle correction for LCT							
[15]	RW	gemcsc_ignore_bend_check				0		Ignore bending direction check for GEMCSC match							

### **Adr 32E      ADR\_GEM\_CSC\_MATCH\_CLUSTER00 1<sup>st</sup> part of Cluster0 matched to CSC**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cluster_00															

Bits	Dir	Signal	Typical	Description
[02:00]	R	gem_csc_match_cluster00[2:0]	0	Cluster index of 1 <sup>st</sup> GEM cluster matched to CSC
[05:03]	R	gem_csc_match_cluster00[5:3]	0	Cluster roll of 1 <sup>st</sup> GEM cluster matched to CSC
[15:06]	R	gem_csc_match_cluster00[15:0] 6]	0	Converted cluster strip position of 1 <sup>st</sup> GEM cluster matched to CSC, unit=1/8 CLCT strip

**Adr 330      ADR\_GEM\_CSC\_MATCH\_CLUSTER01 2<sup>nd</sup> part of Cluster0 matched to CSC**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
cluster 01															

Bits	Dir	Signal	Typical	Description
[07:00]	R	gem_csc_match_cluster01[7:0]	0	Cluster pad number of 1 <sup>st</sup> GEM cluster matched to CSC
[14:07]	R	gem_csc_match_cluster01[14:8] ]	0	Bending angle between 1 <sup>st</sup> GEM cluster and CSC, unit is 1/8 CLCT strip
[15]	R	gem_csc_match_cluster01[15]	0	Bending direction of GEMCSC, 1=left and also means GEM_xky < CLCT_xky

**Adr 332      ADR\_GEM\_CSC\_MATCH\_CLUSTER10 1<sup>st</sup> part of Cluster1 matched to CSC**

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

Bits	Dir	Signal	Typical	Description
[02:00]	R	gem_csc_match_cluster10[2:0]	0	Cluster index of 2 <sup>nd</sup> GEM cluster matched to CSC
[05:03]	R	gem_csc_match_cluster10[5:3]	0	Cluster roll of 2 <sup>nd</sup> GEM cluster matched to CSC
[15:06]	R	gem_csc_match_cluster10[15:0] 6]	0	Converted cluster strip position of 2 <sup>nd</sup> GEM cluster matched to CSC, unit=1/8 CLCT strip

**Adr 334      ADR\_GEM\_CSC\_MATCH\_CLUSTER11 2<sup>nd</sup> part of Cluster1 matched to CSC**

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

Bits	Dir	Signal	Typical	Description
[07:00]	R	gem_csc_match_cluster11[7:0]	0	Cluster pad number of 2 <sup>nd</sup> GEM cluster matched to CSC
[14:07]	R	gem_csc_match_cluster11[14:8] ]	0	Bending angle between 2 <sup>nd</sup> GEM cluster and CSC, unit is 1/8 CLCT

					strip
[15]	R	gem_csc_match_cluster11[15]	0		Bending direction of GEMCSC, 1=left and also means GEM_xky < CLCT_xky

Adr 336 ADR_GEMA_BXN_COUNTER GEMA BXN Counter															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	gemA_bxn_c_nt	
Bits	Dir	Signal								Typical	Description				
[14:00]	R	gemA_bxn_counter[14:0]								-	gemA BXN number since gemA BX0				
[15]	R	gemA_bxn_counter[15]								15	gemA BXN number stays the same or not. 1=same				

Adr 338 ADR_GEMB_BXN_COUNTER GEMB BXN Counter															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	gemB_bxn_c_nt	
Bits	Dir	Signal								Typical	Description				
[14:00]	R	gemB_bxn_counter[14:0]								-	gemB BXN number since gemB BX0				
[15]	R	gemB_bxn_counter[15]								15	gemB BXN number stays the same or not. 1=same				

Adr 33A ADR_GEM_VFAT_HCM0 GEM HOT CHANNLE CTRL0															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	gem_hcm0	
Bits	Dir	Signal								Typical	Description				
[15:00]	RW	gem_vfat_hcm0_wr								0	GEMA VFAT 15-0 hot channel, one bit for one VFAT and 0 means enable VFAT				

Adr 33C ADR_GEM_VFAT_HCM1 GEM HOT CHANNLE CTRL1															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	gem_hcm1	
Bits	Dir	Signal								Typical	Description				
[07:00]	RW	gem_vfat_hcm1_wr[7:0]								0	GEMA VFAT 23-16 hot channel, one bit for one VFAT and 0 means enable				
[15:08]	RW	gem_vfat_hcm1_wr[15:8]								0	GEMB VFAT 7-0 hot channel. one bit for one VFAT and 0 means enable				

Adr 33E ADR_GEM_VFAT_HCM2 GEM HOT CHANNLE CTRL2															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

gem_hcm2															
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------

Bits	Dir	Signal	Typical	Description
[15:00]	RW	gem_vfat_hcm2_wr	0	GEMB VFAT 23-8 hot channel. one bit for one VFAT and 0 means enable

**Adr 340,342,344,346,348,34A,34C,34E      ADR\_GEMA\_CLUSTER0-7      GEMA Cluster0-7**

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

Bits	Dir	Signal	Typical	Description
[07:00]	R	gemA_cluster0-7_vme[7:0]	0	GEMA cluster0-7 pad number
[10:08]	R	gemA_cluster0-7_vme[10:8]	0	GEMA cluster0-7 roll number
[13:11]	R	gemA_cluster0-7_vme[13:11]	0	GEMA cluster0-7 size
[14]	R	gemA_cluster0_vme[14]	0	gemA overflow mark
[15]	R	gemA_cluster0_vme[15]	0	Two fibers of gemA synced or not. 1=synced

**Adr 350,352,354,356,358,35A,35C,35E      ADR\_GEMB\_CLUSTER0-7      GEMB Cluster0-7**

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

Bits	Dir	Signal	Typical	Description
[07:00]	R	gemB_cluster0-7_vme[7:0]	0	GEMB cluster0-7 pad number
[10:08]	R	gemB_cluster0-7_vme[10:8]	0	GEMB cluster0-7 roll number
[13:11]	R	gemB_cluster0-7_vme[13:11]	0	GEMB cluster0-7 size
[14]	R	gemB_cluster0_vme[14]	0	gemB overflow mark
[15]	R	gemB_cluster0_vme[15]	0	Two fibers of gemB synced or not. 1=synced

**Adr 360,362,364,366,368,36A,36C,36E      ADR\_GEM\_COPAD0-7      GEM COPAD0-7**

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

Bits	Dir	Signal	Typical	Description
[07:00]	R	gem_copad0-7_vme[7:0]	0	GEM copad0-7 pad number
[10:08]	R	gem_copad0-7_vme[10:8]	0	GEM copad0-7 roll number
[13:11]	R	gem_copad0-7_vme[13:11]	0	GEM copad0-7 size
[14]	R	gem_copad0_vme[14]	0	four fibers of gemA and gmeB synced or not. 1=synced

**Adr 370,372,374,376 ADR\_GEM\_GTX[0-3]\_NOTINTABLE      GEM GTX0-3 notintable coutner**

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

Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt	Notint table_ cnt
Bits	Dir	Signal										Typical	Description			
[15:00]	R	gem_gtx[0-3]_rx_notintable										0	Counter for GEM GTX0-3 not in table error			

**Adr 378,37A,37C,37E      ADR\_GEM\_GTX[0-3]\_DISPERR      GEM GTX0-3 disperr coutner**

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

Bits	Dir	Signal										Typical	Description			
[15:00]	R	gem_gtx[0-3]_rx_disperr										0	Counter for GEM GTX0-3 disperr error			

## TTC Commands

**Table 2: 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_bcnt[7..0] (*)	20		Send Bunch Counter[7..0] to ccb_data[7..0] bus
Send_evcnt[7..0] (*)	21		Send Event Counter[7..0] to ccb_data[7..0] bus
Send_evcnt[15..8] (*)	22		Send Event Counter[15..8] to ccb_data[7..0] bus
Send_evcnt[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=00000A237E7F MFG=01 OK
Digital Serial for Mez CRC=BF DSN=000007E06194 MFG=01 OK
Digital Serial for RAT CRC=52 DSN=00000AB39AAD 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)

## 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=E00000007FFFFFFE02300336205650565E400CCC989C20060223EB
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_dddoe_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_dddoe_wr   3
rw_perr_reset 0
rw_parity_odd 1
rw_perr_ignore 0
rw_rpc_future 00
rs_rpc0_pdata 7FFF
rs_rpc1_pdata 7FFF
rs_unused     0000000
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

```

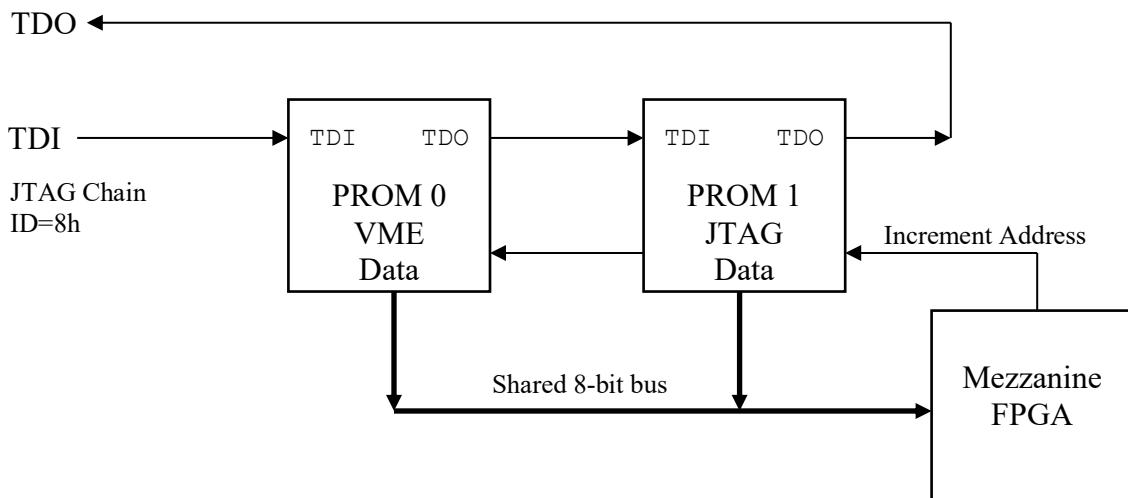
# USER PROM PROGRAMMING

## Introduction

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 header + 5n vme data + 3 trailer = 19<sub>10</sub> + 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] This 5-byte structure is repeated
11	aaaa aaaa	MM	VME adr[15:8] for every VME address that is
12	aaaa aaaa	HH	VME adr[23:16] to be modified
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 BA 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” marker. 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]	
1sisisisi	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	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 recommended 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	ccccccc	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  $25\text{ns} \times n$ , 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 Marker for chain adr 3 (or Ds to set TCK low)
11	tttttttt	ww	TCK count [15:8]
12	tttttttt	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	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	wwwwwwww ww	Word Count [15:8]	Includes Adr 0 and end JTAG marker at T+2
T+4	wwwwwwww 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: RUN2

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

```

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      rpc  header     RPC status
e      buf   header    Buffer status
e      6E0B header     End of header block
n      hits          CFEBO 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 CFEBs list (optional)
20     blocked cfebs list Blocked CFEBs list 20 words (optional)
1      6ECB          End blocked CFEB list (optional)
1      6E0C          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(EOB)
+ ncfeps*(6*ntbins)
+1(B04)          (if RPC readout enabled)
+ nrpc*(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)
+ncfebs*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(EOF)
+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

```

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 1 <sup>st</sup> 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 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	← tbins count 0x16 and tbins before pre-trigger 0x04
Adr= 285	Data= 00002	← 14 miniscope channels at tbins=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_tpri	Valid pattern flag for 1 <sup>st</sup> best ALCT, after pipe delay
ch[07]	alct1_vpf_tpri	Valid pattern flag for 2 <sup>nd</sup> best ALCT, after pipe delay
ch[08]	clct_window	CLCT match window
ch[09]	wr_push_rtm	ALCT*CLCT match signal
ch[10]	tmb_push_dly	L1A signals are lla_delay+2bx later
ch[11]	lla_pulse	L1A from CCB
ch[12]	lla_window_open	L1A window
ch[13]	lla_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:

	00000000000000000000111111	← Time bins
	123456789ABCDEF012345	
ch 00	any_cfeb_hit	-----
ch 03	clct_state_machine	1111244444111111111111
ch 03	clct_state_machine	iiiiipfffffiiiiiiiiii
ch 04	clct0_vpf	----- - -----
ch 05	clct1_vpf	----- - -----
ch 06	alct0_vpf	----- - -----
ch 07	alct1_vpf	-----
ch 08	clct_window	----- --- -----
ch 09	wr_push_rtm	----- - -----
ch 10	tmb_push_dly	- -----
ch 11	lla_pulse	----- - -----
ch 12	lla_window_open	----- --- -----
ch 13	lla_push_me	----- - -----
ch 14	tmb_special	-----
ch 15	ddu_special	-----

← CLCT signals are in pre-trigger time domain  
 ← CLCT Pre-trigger machine state  
 ← ALCT arrival is needed to check TMB offline  
 ← ALCT\*CLCT match signal  
 ← L1A signals are lla\_delay+2bx later  
 ← L1A from CCB merged with other L1A  
 ← L1A queued for readout signal  
 ← Unpacker prevents TMB from using 15<sup>th</sup> bit  
 ← 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]=cfебid[2:0]=0 [11:0]=cfеб0 distrips[11:0]
1	CFEB0	word 1	[14:12]=cfебid[2:0]=0 [11:0]=cfеб0 distrips[23:12]
1	CFEB0	word 2	[14:12]=cfебid[2:0]=0 [11:0]=cfеб0 distrips[35:24]
1	CFEB0	word 3	[14:12]=cfебid[2:0]=0 [11:0]=cfеб0 distrips[47:36]
1	CFEB1	word 0	[14:12]=cfебid[2:0]=1 [11:0]=cfеб1 distrips[11:0]
1	CFEB1	word 1	[14:12]=cfебid[2:0]=1 [11:0]=cfеб1 distrips[23:12]
1	CFEB1	word 2	[14:12]=cfебid[2:0]=1 [11:0]=cfеб1 distrips[35:24]
1	CFEB1	word 3	[14:12]=cfебid[2:0]=1 [11:0]=cfеб1 distrips[47:36]
1	CFEB2	word 0	[14:12]=cfебid[2:0]=2 [11:0]=cfеб2 distrips[11:0]
1	CFEB2	word 1	[14:12]=cfебid[2:0]=2 [11:0]=cfеб2 distrips[23:12]
1	CFEB2	word 2	[14:12]=cfебid[2:0]=2 [11:0]=cfеб2 distrips[35:24]
1	CFEB2	word 3	[14:12]=cfебid[2:0]=2 [11:0]=cfеб2 distrips[47:36]
1	CFEB3	word 0	[14:12]=cfебid[2:0]=3 [11:0]=cfеб3 distrips[11:0]
1	CFEB3	word 1	[14:12]=cfебid[2:0]=3 [11:0]=cfеб3 distrips[23:12]
1	CFEB3	word 2	[14:12]=cfебid[2:0]=3 [11:0]=cfеб3 distrips[35:24]
1	CFEB3	word 3	[14:12]=cfебid[2:0]=3 [11:0]=cfеб3 distrips[47:36]
1	CFEB4	word 0	[14:12]=cfебid[2:0]=4 [11:0]=cfеб4 distrips[11:0]
1	CFEB4	word 1	[14:12]=cfебid[2:0]=4 [11:0]=cfеб4 distrips[23:12]
1	CFEB4	word 2	[14:12]=cfебid[2:0]=4 [11:0]=cfеб4 distrips[35:24]
1	CFEB4	word 3	[14:12]=cfебid[2:0]=4 [11:0]=cfеб4 distrips[47:36]
1	6ECB	marker	End of blocked cfeb distrip list

## Blocked DiStrips list includes:

- DiStrips turned off via VME Hot Channel Mask
- DiStrips turned off via mask\_all applied to the entire CFEB
- DisStrips marked as bad by automatic bad-bits detection

## CFEB DiStrip Bit Packing

Each CFEB has 6 layers of 8 DiStrips = 48 bits

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

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

```
CFEBn word 0 = block_distrrip_list[11: 0]
CFEBn word 1 = block_distrrip_list[23:12]
CFEBn word 2 = block_distrrip_list[35:24]
CFEBn word 3 = block_distrrip_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:

- 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:

- board\_id defaults to the VME crate slot number, unless overridden via VME
- csc\_id is a user-set value to identify the CSC connected to this TMB
- run\_id is a user-set value to identify the current data run
- 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
- 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:

- 1) 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:

mode	raw hits	header
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:

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

### 4) L1A Type Codes:

l1a-type		
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:

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:

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]	BX0s since last hard reset [stops on ovf]
header18_[14:0]	r_orbit_counter[29:15]	

### CLCT Raw Hits Size:

header19_[2:0]	r_ncfebs[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]	dmr_thresh_pretrig[2:0]	DMR 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:

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_cfebs_read[4:0]	CFEBs read out for this event
header23_[13:10]	pop_ll1a_match_win[3:0]	Position of ll1a 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:

clct0, clct1, clctc packing format:	
clct0[0]	clct_1 <sup>st</sup> _valid
clct0[3:1]	hs_hit_1 <sup>st</sup> [2:0]
clct0[7:4]	hs_pid_1 <sup>st</sup> [3:0]
clct0[15:8]	hs_key_1 <sup>st</sup> [7:0]
clct1[0]	clct_2 <sup>nd</sup> _valid
clct1[3:1]	hs_hit_2 <sup>nd</sup> [2:0]
clct1[7:4]	hs_pid_2 <sup>nd</sup> [3:0]
clct1[15:8]	hs_key_2 <sup>nd</sup> [7:0]
clctc[1:0]	bxn_counter_ff[1:0]
clct0/1	
clctc[2]	sync_err
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:

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] = alctl_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] = alctl_bxn[0];
mpc1_frame1[11] = clct_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_nrpc_s_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-mei
header39_[13]	reverse_hs_mela	1=ME1A hstrip order reversed
header39_[14]	reverse_hs_melb	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_cfeps_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]	cfep_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

Run2 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	<b>1</b>	<b>1</b>	0	0																									
0	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			B0C <sub>16</sub>																					
1	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			BXN Counter at L1A arrival [11:0]																					
2	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			L1A Rx Counter [11:0]																					
3	0	0	0	<b>1</b>	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	<b>1</b>	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	<b>1</b>	DDU Code 101 <sub>2</sub>			1 <sub>TMB</sub>	CRC22[10:0]																				
10	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			1 <sub>TMB</sub>	CRC22[21:11]																				
11	0	0	<b>1</b>	<b>1</b>	DDU Code 101 <sub>2</sub>			1 <sub>TMB</sub>	Word Count [10:0]																				
No Write	<b>1</b>	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										

Run2 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	<b>1</b>	<b>1</b>	0	0															
0	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>				B0A <sub>16</sub>										
1	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>				BXN Counter at L1A arrival [11:0]										
2	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>				L1A Rx Counter [11:0]										
3	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>				Readout Counter[11:0]										

n-3	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>				E0D <sub>16</sub> [11:0]										
n-2	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>				0 <sub>ALCT</sub>	CRC22[10:0]									
n-1	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>				0 <sub>ALCT</sub>	CRC22[21:11]									
n	0	0	<b>1</b>	<b>1</b>	DDU Code 101 <sub>2</sub>				0 <sub>CRC OK=1</sub>	Word Count [10:0]									
No Write	<b>1</b>	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]				cfubs_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 cfеб ram[4:0] SEU				clet1 busy	clet1 invp	clet0 invp	clctc[2:0]		clet1[15]	clet0[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	bcb 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	cfеб_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	cfеб_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	nrpc[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 udff 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	tnb trig pulse	trig_src_vec[10:9]		mxcfеб=7	peak fence	cfеб_en[6:5]		perr_cfеб[6:5]		cfеб_badbits_found[6:5]		cfебs_read[6:5]		active_cfеб[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 elct ro	non-trig alct o	allow match ro	allow elct ro	allow alct ro	allow match	allow elct	allow alct		
42	0	0	0	0	6				EOB End Header Block												
43	0	0	0	0	6				E0C End Cathode Block												
44	0	0	0	1	DDU Code 101 <sub>2</sub>				E0F <sub>16</sub> [11:0]												
45	0	0	0	1	DDU Code 101 <sub>2</sub>				1 <sub>TMB</sub>	CRC22[10:0]											
46	0	0	0	1	DDU Code 101 <sub>2</sub>				1 <sub>TMB</sub>	CRC22[21:11]											
47	0	0	1	1	DDU Code 101 <sub>2</sub>				1 <sub>TMB</sub>	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		

## Run2 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>			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]			<td data-cs="3" data-kind="parent">board_id[4:0]</td> <td data-kind="ghost"></td> <td data-kind="ghost"></td> <td data-cs="6" data-kind="parent"></td> <td data-kind="ghost"></td> <td data-kind="ghost"></td> <td data-kind="ghost"></td> <td data-kind="ghost"></td> <td data-kind="ghost"></td>	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	clet1 discard	clet0 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	miniscoperead_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]																									
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 clet	dupe alct	two clet	two alct	one clet	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]			clet1[15]	clet0[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_triggered	bcb_readout	drift_delay[1:0]		alct1_key[6:0]			
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_melb	reverse_mela	reverse_esc	buf_fence_cnt[11:0]				
40	0	0	0	0	tnb_trig_pulse	trig_src_vec[10:9]	mxcfeb=7	peak_fence	cfeb_en[6:5]	perr_cfeb[6:5]	cfeb_badbits_found[6:5]	cfubs_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_alet_o	allow_match_ro allow_clet_ro allow_alet_ro allow_match allow_alet
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									
255					RPC 0	clet pretrigger	rpc_bxn[2:0]	Pads[15:8]							
256					RPC 0	Tbin 1									
257					RPC 0	clet pretrigger	rpc_bxn[2:0]	Pads[15:8]							
258					RPC 0	Tbin 2									
259					RPC 0	clet pretrigger	rpc_bxn[2:0]	Pads[15:8]							
260					RPC 0	Tbin 3									
261					RPC 0	clet pretrigger	rpc_bxn[2:0]	Pads[15:8]							
262					RPC 0	Tbin 4									
263					RPC 0	clet pretrigger	rpc_bxn[2:0]	Pads[15:8]							
264					RPC 0	Tbin 5									
265					RPC 0	clet pretrigger	rpc_bxn[2:0]	Pads[15:8]							
266					RPC 0	Tbin 6									
267					RPC 0	clet pretrigger	rpc_bxn[2:0]	Pads[15:8]							
268					RPC 1	Tbin 0									
269					RPC 1	clet pretrigger	rpc_bxn[2:0]	Pads[15:8]							
270-279					--	--									
280					RPC 1	Tbin 6									
281					RPC 1	clet 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	<b>1</b>	DDU Code 101 <sub>2</sub>			E0F <sub>16</sub> [11:0]							
285	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>	<sup>1</sup> <sub>TMB</sub>	CRC22[10:0]								
286	0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>	<sup>1</sup> <sub>TMB</sub>	CRC22[21:11]								
287	0	0	<b>1</b>	<b>1</b>	DDU Code 101 <sub>2</sub>	<sup>1</sup> <sub>TMB</sub>	Word Count [10:0]								
No Write	<b>1</b>	0	0	0											

## 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= 69 Data=00402	Adr= 138 Data=02100	Adr= 207 Data=03600
Adr= 1 Data=0DCC8	Adr= 70 Data=00400	Adr= 139 Data=02200	Adr= 208 Data=03600
Adr= 2 Data=0D001	Adr= 71 Data=00402	Adr= 140 Data=02200	Adr= 209 Data=03600
Adr= 3 Data=0D001	Adr= 72 Data=00400	Adr= 141 Data=02200	Adr= 210 Data=03600
Adr= 4 Data=04045	Adr= 73 Data=00500	Adr= 142 Data=02200	Adr= 211 Data=04000
Adr= 5 Data=0226A	Adr= 74 Data=00500	Adr= 143 Data=02200	Adr= 212 Data=04000
Adr= 6 Data=0777F	Adr= 75 Data=00500	Adr= 144 Data=02200	Adr= 213 Data=04000
Adr= 7 Data=0512C	Adr= 76 Data=00500	Adr= 145 Data=02300	Adr= 214 Data=04000
Adr= 8 Data=00C47	Adr= 77 Data=00500	Adr= 146 Data=02300	Adr= 215 Data=04000
Adr= 9 Data=00001	Adr= 78 Data=00500	Adr= 147 Data=02300	Adr= 216 Data=04000
Adr= 10 Data=00000	Adr= 79 Data=00600	Adr= 148 Data=02300	Adr= 217 Data=04100
Adr= 11 Data=00001	Adr= 80 Data=00600	Adr= 149 Data=02300	Adr= 218 Data=04100
Adr= 12 Data=00000	Adr= 81 Data=00600	Adr= 150 Data=02300	Adr= 219 Data=04100
Adr= 13 Data=00001	Adr= 82 Data=00600	Adr= 151 Data=02400	Adr= 220 Data=04100
Adr= 14 Data=00000	Adr= 83 Data=00600	Adr= 152 Data=02400	Adr= 221 Data=04100
Adr= 15 Data=00001	Adr= 84 Data=00600	Adr= 153 Data=02400	Adr= 222 Data=04100
Adr= 16 Data=00000	Adr= 85 Data=01000	Adr= 154 Data=02400	Adr= 223 Data=04200
Adr= 17 Data=002DD	Adr= 86 Data=01000	Adr= 155 Data=02400	Adr= 224 Data=04200
Adr= 18 Data=00000	Adr= 87 Data=01000	Adr= 156 Data=02400	Adr= 225 Data=04200
Adr= 19 Data=0023D	Adr= 88 Data=01000	Adr= 157 Data=02500	Adr= 226 Data=04200
Adr= 20 Data=04204	Adr= 89 Data=01000	Adr= 158 Data=02500	Adr= 227 Data=04200
Adr= 21 Data=01A46	Adr= 90 Data=01000	Adr= 159 Data=02500	Adr= 228 Data=04200
Adr= 22 Data=07E01	Adr= 91 Data=01100	Adr= 160 Data=02500	Adr= 229 Data=04300
Adr= 23 Data=003E1	Adr= 92 Data=01100	Adr= 161 Data=02500	Adr= 230 Data=04300
Adr= 24 Data=00301	Adr= 93 Data=01100	Adr= 162 Data=02500	Adr= 231 Data=04300
Adr= 25 Data=005AD	Adr= 94 Data=01100	Adr= 163 Data=02600	Adr= 232 Data=04300
Adr= 26 Data=00000	Adr= 95 Data=01100	Adr= 164 Data=02600	Adr= 233 Data=04300
Adr= 27 Data=0531C	Adr= 96 Data=01100	Adr= 165 Data=02600	Adr= 234 Data=04300
Adr= 28 Data=010A7	Adr= 97 Data=01200	Adr= 166 Data=02600	Adr= 235 Data=04400
Adr= 29 Data=01000	Adr= 98 Data=01200	Adr= 167 Data=02600	Adr= 236 Data=04400
Adr= 30 Data=00001	Adr= 99 Data=01200	Adr= 168 Data=02600	Adr= 237 Data=04400
Adr= 31 Data=07D0A	Adr= 100 Data=01200	Adr= 169 Data=03000	Adr= 238 Data=04400
Adr= 32 Data=02605	Adr= 101 Data=01200	Adr= 170 Data=03000	Adr= 239 Data=04400
Adr= 33 Data=00000	Adr= 102 Data=01200	Adr= 171 Data=03000	Adr= 240 Data=04400
Adr= 34 Data=00000	Adr= 103 Data=01300	Adr= 172 Data=03000	Adr= 241 Data=04500
Adr= 35 Data=07C01	Adr= 104 Data=01300	Adr= 173 Data=03000	Adr= 242 Data=04500
Adr= 36 Data=008FB	Adr= 105 Data=01300	Adr= 174 Data=03000	Adr= 243 Data=04500
Adr= 37 Data=01E25	Adr= 106 Data=01300	Adr= 175 Data=03100	Adr= 244 Data=04500
Adr= 38 Data=007FF	Adr= 107 Data=01300	Adr= 176 Data=03100	Adr= 245 Data=04500
Adr= 39 Data=00001	Adr= 108 Data=01300	Adr= 177 Data=03100	Adr= 246 Data=04500
Adr= 40 Data=06001	Adr= 109 Data=01400	Adr= 178 Data=03100	Adr= 247 Data=04600
Adr= 41 Data=02326	Adr= 110 Data=01400	Adr= 179 Data=03100	Adr= 248 Data=04600
Adr= 42 Data=06EBB	Adr= 111 Data=01400	Adr= 180 Data=03100	Adr= 249 Data=04600
Adr= 43 Data=00000	Adr= 112 Data=01400	Adr= 181 Data=03200	Adr= 250 Data=04600
Adr= 44 Data=00000	Adr= 113 Data=01400	Adr= 182 Data=03200	Adr= 251 Data=04600
Adr= 45 Data=00000	Adr= 114 Data=01400	Adr= 183 Data=03200	Adr= 252 Data=04600
Adr= 46 Data=00000	Adr= 115 Data=01500	Adr= 184 Data=03200	Adr= 253 Data=06B04
Adr= 47 Data=00000	Adr= 116 Data=01500	Adr= 185 Data=03200	Adr= 254 Data=00000
Adr= 48 Data=00000	Adr= 117 Data=01500	Adr= 186 Data=03200	Adr= 255 Data=00000
Adr= 49 Data=00100	Adr= 118 Data=01500	Adr= 187 Data=03300	Adr= 256 Data=00100
Adr= 50 Data=00100	Adr= 119 Data=01500	Adr= 188 Data=03300	Adr= 257 Data=00000
Adr= 51 Data=00100	Adr= 120 Data=01500	Adr= 189 Data=03300	Adr= 258 Data=00200
Adr= 52 Data=00100	Adr= 121 Data=01600	Adr= 190 Data=03300	Adr= 259 Data=007AB
Adr= 53 Data=00100	Adr= 122 Data=01600	Adr= 191 Data=03300	Adr= 260 Data=00301
Adr= 54 Data=00100	Adr= 123 Data=01600	Adr= 192 Data=03300	Adr= 261 Data=006AB
Adr= 55 Data=00202	Adr= 124 Data=01600	Adr= 193 Data=03400	Adr= 262 Data=00402
Adr= 56 Data=00202	Adr= 125 Data=01600	Adr= 194 Data=03400	Adr= 263 Data=005AB
Adr= 57 Data=00202	Adr= 126 Data=01600	Adr= 195 Data=03400	Adr= 264 Data=00503
Adr= 58 Data=00202	Adr= 127 Data=02000	Adr= 196 Data=03400	Adr= 265 Data=004AB
Adr= 59 Data=00202	Adr= 128 Data=02000	Adr= 197 Data=03400	Adr= 266 Data=00604
Adr= 60 Data=00202	Adr= 129 Data=02000	Adr= 198 Data=03400	Adr= 267 Data=003AB
Adr= 61 Data=00300	Adr= 130 Data=02000	Adr= 199 Data=03500	Adr= 268 Data=01000
Adr= 62 Data=00302	Adr= 131 Data=02000	Adr= 200 Data=03500	Adr= 269 Data=01000
Adr= 63 Data=00300	Adr= 132 Data=02000	Adr= 201 Data=03500	Adr= 270 Data=01100
Adr= 64 Data=00302	Adr= 133 Data=02100	Adr= 202 Data=03500	Adr= 271 Data=01000
Adr= 65 Data=00300	Adr= 134 Data=02100	Adr= 203 Data=03500	Adr= 272 Data=01200
Adr= 66 Data=00302	Adr= 135 Data=02100	Adr= 204 Data=03500	Adr= 273 Data=017CD
Adr= 67 Data=00402	Adr= 136 Data=02100	Adr= 205 Data=03600	Adr= 274 Data=01301
Adr= 68 Data=00400	Adr= 137 Data=02100	Adr= 206 Data=03600	Adr= 275 Data=016CD

Adr= 276 Data=01402
Adr= 277 Data=015CD
Adr= 278 Data=01503
Adr= 279 Data=014CD

Adr= 280 Data=01604
Adr= 281 Data=013CD
Adr= 282 Data=06E04
Adr= 283 Data=06E0C

Adr= 284 Data=0DE0F
Adr= 285 Data=0D94F
Adr= 286 Data=0DDF2

Adr= 287 Data=1D920
---------------------

# DMB READOUT: RUN3

## Run3 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:

- 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:

- board\_id defaults to the VME crate slot number, unless overridden via VME
- csc\_id is a user-set value to identify the CSC connected to this TMB
- run\_id is a user-set value to identify the current data run
- 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
- 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:

- 5) 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.
- 6) FIFO Modes:

mode	raw hits	header
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
---	----	----

## 7) Record Type Codes:

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

## 8) L1A Type Codes:

l1a-type	
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:

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, Run3 convention
-----------------	---------------	-----------------------------------

## header07 notes:

revcode[04:00]	minor version code
revcode[08:05]	major version code
revcode[12:09]	Data format type code, 0=TMB standard, 1=OTMB Standard, 2=CCLUT, 3=GEM+CCLUT, 4=Run3 TMB
revcode[14:13]	2'b00

## 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_run3_[11: 0]	= r_clct0_carry_xtmb[MXPATC-1:0];
header10_run3_[13:12]	= r_clct0_xky_xtmb[1:0];
header10_run3_[14]	= r_hmt_nhits_sig_header[0];
header10_[14:0]	= run3_daq_df ? header10_run3_[14:0] : r_pretrig_counter[29:15]; // CLCT pre-trigger counter

header11_[14:0]	r_clct_counter[14:0]	Counts CLCTs post-drift [stops on ovf]
-----------------	----------------------	--

header12_run3_[ 0]	= r_lct0_nogem;
header12_run3_[ 1]	= r_lct0_with_gemA;
header12_run3_[ 2]	= r_lct0_with_gemB;
header12_run3_[ 3]	= r_lct0_with_copad;
header12_run3_[ 4]	= r_lct1_nogem;
header12_run3_[ 5]	= r_lct1_with_gemA;
header12_run3_[ 6]	= r_lct1_with_gemB;
header12_run3_[ 7]	= r_lct1_with_copad;
header12_run3_[ 8]	= !r_gemA_forclct_real;
header12_run3_[ 9]	= !r_gemB_forclct_real;
header12_run3_[ 10]	= r_gemA_overflow_real;

```

header12_run3_[ 11] = r_gemB_overflow_real;
header12_run3_[ 12] = r_gemA_sync_err_real;
header12_run3_[ 13] = r_gemB_sync_err_real;
header12_run3_[ 14] = r_gems_sync_err_real;
header12_[14:0]      = run3_daq_df ? header12_run3_[14:0] : r_clct_counter[29:15]; // CLCT post-drift
counter

header13_[14:0]      r_trig_counter[14:0]          Counts TMB triggers to MPC, L1A request to CCB,
header14_run3_[11: 0] = r_clct1_carry_xtmb[MXPATC-1:0];
header14_run3_[13:12] = r_clct1_xky_xtmb[1:0];
header14_run3_[14]    = r_hmt_nhits_sig_header[1];
header14_[14:0]      = run3_daq_df ? header14_run3_[14:0] : r_trig_counter[29:15]; // TMB trigger
counter

header15_[14:0]      r_alct_counter[14:0]          Counts ALCTs received from ALCT board [stops on ovf]

header16_run3_[3 : 0] = r_num_copad[3:0];
header16_run3_[7 : 4] = match_gem_alct_delay[3:0]; //at the BX with LCT construction
header16_run3_[11: 8] = r_gem_clct_win[3:0];
header16_run3_[14:12] = r_alct_gem_win[2:0];
header16_[14:0]      = run3_daq_df ? header16_run3_[14:0] : r_alct_counter[29:15]; // Counts ALCTs
received from ALCT board, stop on ovf

header17_[14:0]      r_orbit_counter[14:0]         BX0s since last hard reset [stops on ovf]
header18_[14:0]      r_orbit_counter[29:15]

```

### CLCT Raw Hits Size:

header19_[2:0]	r_ncfebs[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]	dmr_thresh_pretrig[2:0]	DMR 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]	= run3_daq_df ? {r_clct1_bnd_xtmb[4], r_clct0_bnd_xtmb[4:0]} : r_layers_hit[5:0];	

### header22 notes:

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]	DMR 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 DMR
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:

clct0, clct1, clctc packing format:		
clct0[0]	clct_1st_valid	Valid pattern flag
clct0[3:1]	hs_hit_1st[2:0]	Hits on pattern 0-6
clct0[7:4]	hs_pid_1st[3:0]	Pattern shape 0-4, Run3 pattern id
clct0[15:8]	hs_key_1st[7:0]	½-strip ID number
clct1[0]	clct_2nd_valid	Valid pattern flag
clct1[3:1]	hs_hit_2nd[2:0]	Hits on pattern 0-4, Run3 pattern id
clct1[7:4]	hs_pid_2nd[3:0]	Pattern shape 0-A
clct1[15:8]	hs_key_2nd[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_1st_valid	ALCT0 valid pattern flag
header28_[2:1] alct_1st_quality[1:0]		ALCT0 quality
header28_[3]	alct_1st_amu	ALCT0 accelerator muon flag
header28_[10:4]	alct_1st_key[6:0]	ALCT0 key wire group
header28_[14:11] = run3_daq_df ? r_clct1_bnd_xtmb[3:0] : r_alct_preClct_win[3:0];		
header29_[0]	alct_2nd_valid	ALCT1 valid pattern flag
header29_[2:1] alct_2nd_quality[1:0]		ALCT1 quality
header29_[3]	alct_2nd_amu	ALCT1 accelerator muon flag
header29_[10:4]	alct_2nd_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] = run3_daq_df ? r_hmt_nhits_sig_header[6:2] : r_alct_bxn[4:0];		
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 with Run2/3 Trigger Data Format:

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: Run2 trigger data format

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];

```

## header31-35 notes: Run3 trigger data format

MPCframe packing format:

```

mpc0_frame0_run3[6:0]  = alct0_key_run3[6:0];
mpc0_frame0_run3[10:7] = lct_pid_run3[3:0]; //new bending from CCLUT
mpc0_frame0_run3[13:11] = lct0_qlt_run3[2:0];
mpc0_frame0_run3[14]   = clct0_xky_run3[1]; // CLCT0 1/4 strip bit
mpc0_frame0_run3[15]   = lct0_vpf_run3; //LCT0 run3 vpf

mpc0_frame1_run3[7:0]  = clct0_xky_run3[9:2];
mpc0_frame1_run3[8]    = clct0_bnd_run3[4]; // left or right from CCLUT. 1=left
mpc0_frame1_run3[9]    = clct0_xky_run3[0];// CLCT0 1/8 strip bit
mpc0_frame1_run3[10]   = alct0_bxn[0];
mpc0_frame1_run3[11]   = clct_bx0; // bx0 gets replaced after mpc_tx_delay, keep here to mollify xst
mpc0_frame1_run3[15:12] = clct0_bnd_run3[3:0];

mpc1_frame0_run3[6:0]  = alct1_key_run3[6:0];
mpc1_frame0_run3[7]    = lct_pid_run3[4]; // new bending from CCLUT
mpc1_frame0_run3[10:8] = hmt_trigger_run3[3:1];// 
mpc1_frame0_run3[13:11] = lct1_qlt_run3[2:0];
mpc1_frame0_run3[14]   = clct1_xky_run3[1]; // CLCT1 1/4 strip bit
mpc1_frame0_run3[15]   = lct1_vpf_run3; //LCT1 run3 vpf

mpc1_frame1_run3[7:0]  = clct1_xky_run3[9:2];
mpc1_frame1_run3[8]    = clct1_bnd_run3[4];
mpc1_frame1_run3[9]    = clct1_xky_run3[0];// CLCT1 1/8 strip bit
mpc1_frame1_run3[10]   = hmt_trigger_run3[0];
mpc1_frame1_run3[11]   = alct_bx0; // bx0 gets replaced after mpc_tx_delay, keep here to mollify xst
mpc1_frame1_run3[15:12] = clct1_bnd_run3[3:0];

```

## GEM Configuration:

```

header36_gem_[3:0] = gem_read_mask[3:0]; // GEM Fiber Enabled for readout
header36_gem_[4:4] = gem_zero_suppress; // GEM zero-suppression enabled
header36_gem_[9:5] = fifo_tbins_gem[4:0]; // Number GEM FIFO time bins to read out
header36_gem_[14:10] = fifo_pretrig_gem[4:0]; // Number GEM 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_mela	1=ME1A hstrip order reversed
header39_[14]	reverse_hs_melb	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_cfcb_ff[6:5];	Extend Hdr27[12:8] CFEB RAM parity error, latched
header40_[7:6]	cfcb_badbits_found[6:5];	Extend Hdr30[11:7] CFEB[n] has at least 1 bad bit
header40_[9:8]	cfcb_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]	= run3_daq_df ? gemcsc_bend_enable : (MXCFEB==7);	
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_[12:11]	= run3_daq_df ? r_tmb_cathode_hmt[1:0] : lyr_thresh_pretrig[1:0]; // Layer pre-trigger threshold	
header41_[13]	= run3_daq_df ? (r_alct_bxn[1] & run3_alct_df) : lyr_thresh_pretrig[2];	
header41_[14]	= run3_daq_df ? (r_alct_bxn[2] & run3_alct_df) : layer_trig_en; // Layer trigger mode enabled	

## TMB Data Format: Short Header Mode

Control			DDU	TMB Data [14:0]																															
/write fifo	DAV Data Available	last word	d15 DDU special	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1																		
1	1	0	0																																
0	0	0	1	DDU Code 101 <sub>2</sub>				B0C <sub>16</sub>																											
0	0	0	1	DDU Code 101 <sub>2</sub>				BXN Counter at L1A arrival [11:0]																											
0	0	0	1	DDU Code 101 <sub>2</sub>				L1A Rx Counter [11:0]																											
0	0	0	1	DDU Code 101 <sub>2</sub>				Readout Counter[11:0]																											
0	0	0	0	sync err	buf_q ovf	run_id[3:0]			csc_id[3:0]			board_id[4:0]																							
0	0	0	0	buf stalled	has buf	l1a_type[1:0]	rec_type[1:0]	fifo_mode[2:0]			nheader_words[5:0]																								
0	0	0	0	board_status[14:0]																															
0	0	0	0	firmware_revcode[14:0]																															
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)																											
0	0	0	1	DDU Code 101 <sub>2</sub>				1 TMB	CRC22[10:0]																										
0	0	0	1	DDU Code 101 <sub>2</sub>				1 TMB	CRC22[21:11]																										
0	0	1	1	DDU Code 101 <sub>2</sub>				1 TMB	Word Count [10:0]																										
1	0	0	0																																
/write fifo	DAV Data Available	last word	d15	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1																		

ALCT Header/Trailer Format:

Control			DDU	ALCT Data [14:0]															
/write fifo	DAV Data Available	last word	d15 DDU special	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1		
<b>1</b>	<b>1</b>	0	0																
0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			B0A <sub>16</sub>												
0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			BXN Counter at L1A arrival [11:0]												
0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			L1A Rx Counter [11:0]												
0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			Readout Counter[11:0]												
0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			E0D <sub>16</sub> [11:0]												
0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			0 ALCT	CRC22[10:0]											
0	0	0	<b>1</b>	DDU Code 101 <sub>2</sub>			0 ALCT	CRC22[21:11]											
0	0	<b>1</b>	<b>1</b>	DDU Code 101 <sub>2</sub>			0 CRC OK=1	Word Count [10:0]											
<b>1</b>	0	0	0																
/write fifo	DAV Data Available	last word	d15	d14	d13	d12	d11	d10	d9	d8	d7	d6	d5	d4	d3	d2	d1		

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 Mode For Run3. Red for all OTMB and Blue for GEMCSCOTMB

FIFO Control		DD U	TMB Data [14:0]																																												
Frame #	/ write if f o	D A V data available	I a s t A v a i l a b l e	d1 5 DD U spec	d1 4	d1 3	d1 2	d11	d1 0	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	11a_ty pe[1:0]	rec_TYP e[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	eclt1 discard	eclt0 discar d	bxn_counter_ff[11:0]																																										
9	0 0 0 0	pretrig_counter[14:0]																																													
10	0 0 0 0	hmt_n hits[0]	clet0_key[1:0]	clct0_comparatorcode[11:0]																																											
11	0 0 0 0	clet counter[14:0]																																													
12	0 0 0 0	gems_s yn c	gemb_sy nc	gema_s ync	gemb_overflo w	gema_overfl ow	gemb_v pf	gema_vp f	lct1_with_copad	lct1_with_g ema	lct1_no ge m	lct0_with_c opad	lct0_wi th_g emb	lct0_wi th_g ema	lct0_no geom	lct0_no geom	lct0_no geom	lct0_no geom																													
13	0 0 0 0	trig_counter[14:0]																																													
14	0 0 0 0	hmt_nh its[1]	clet1_key[1:0]	clct1_comparatorcode[11:0]																																											
15	0 0 0 0	alct counter[14:0]																																													
16	0 0 0 0	alct_gem_wi n[2:0]	gem_clct_wi n[3:0]			gem_delay[3:0]				num_copad[3:0]																																					
17	0 0 0 0	uptime_counter[14:0]																																													
18	0 0 0 0	uptime_counter[29:15]																																													
19	0 0 0 0	minisco pe	scope esixts	fifo_pretrig[4:0]					fifo_tbins[4:0]					ncfebs[2:0]																																	
20	0 0 0 0	stagger csc	pid_thresh_po stdrift[3:0]			hit_thresh_postdrift[2:0]				pid_thresh_pret rig[3:0]				hit_thresh_pret rig[2:0]																																	
21	0 0 0 0	clct_window[3:0]				alct_delay[3:0]				dmb_thres h_pretrig[2:0]		triad_persist[3:0]																																			
22	0 0 0 0	clet1_b nd[4:0]	clct0_bnd[4:0]				trig_source_vec[8:0]																																								
23	0 0 0 0	aff source	11a_match wi n[3:0]			cfebs_read[4:0]				active_cfeb[4:0]																																					
24	0 0 0 0	lct rank err	dupe elct	dupe alct	two clct	two alct	one	one alct	no alct	match_wi n[3:0]				elct only	alct only	tm b																															

								clc t							m atc h			
25	0	0	0	0	clc0[14:0]													
26	0	0	0	0	clc1[14:0]													
27	0	0	0	0	perr summar y	perr rpc+mini	parity error cfeb ram[4:0] SEU	clet1 busy	clet 1 inv p	clc t0 in vp	clctc[2:0]	clet1[15]	clc0 [15]					
28	0	0	0	0	clc1_bnd [3:0]		alct0_key[6:0]				alct0 amu	alct0 quality[1:0]		alct0 valid				
29	0	0	0	0	layer triggerd	bcb readout	drift _del ay[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 blocke d	cfeb_badbits_found[4:0]	alct_ecc_err[1:0]		hmt_nhits[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]	mpc1f0[15]	mpc0fr1[15]	mpc0f0[15]						
36	0	0	0	0	fifo_pretrig_gem[4:0]		fifo_tbins_gem[4:0]		gem_ze ro_supr ess		gem_readout_mask[3:0]							
37	0	0	0	0	buf_q empty	buf_q full	wr_bu f ready	r_wr_buf_ready	r_wr_buf_addr[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	revers e csc		buf_fence_cnt[11:0]									
40	0	0	0	0	tmb trig pulse	trig_src_vec[10:9]	gemcsc_bend_e nable	peak fence	cfeb_e n[6:5]	perr_cfeb[6:5]	cfeb_badbits_found[6:5]	cfefs_read[6:5]	acti ve_cfeb [6:5]					
41	0	0	0	0	anod e_hm t[1:0]	cathode_hmt [1:0]	non-trig read out	triggered read out	non-trig match ro	non-trig elct ro	non-trig alet o	hmt_match_win [3:0]	gem_enabl e	run3_trig _df				
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>								E0F <sub>16</sub> [11:0]					
45	0	0	0	1	DDU Code 101 <sub>2</sub>	1 <sub>TMB</sub>							CRC22[10:0]					
46	0	0	0	1	DDU Code 101 <sub>2</sub>	1 <sub>TMB</sub>							CRC22[21:11]					
47	0	0	1	1	DDU Code 101 <sub>2</sub>	1 <sub>TMB</sub>							Word Count [10:0]					
No Writ e	1	0	0	0														
Fram e#	/w r e f f o	D A V D a A v i a b l e	I a s t a w o r d	d1 5	d1 4	d1 3	d1 2	d11	d 1 0	d9	d8	d7	d6	d5	d4 3	d2	d1	d 0

TMB Data Format: Full-Readout Mode For Run3. Red for all OTMB and Blue for GEMCSCOTMB

FIFO Control		DD U	TMB Data [14:0]																														
Frame #	/writetime	D A V data available	I a s t	5 DD U spec	d1	d1 4	d1 3	d1 2	d11	d1 0	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	11a_t ype[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	elet1 discard	elet0 discard	bxn_counter_ff[11:0]																									
9	0	0	0	0	pretrig_counter[14:0]																												
10	0	0	0	0	hmt_n hits[0]	clct0_key[1:0]	clct0_comparatorcode[11:0]																										
11	0	0	0	0	clct counter[14:0]																												
12	0	0	0	0	gmc_syn_c	gemb_sy_nc	gema_sync	gemb_overflow	gema_overflow	gemb_vpff	gema_vpff	lct1_with_copad	lct1_with_gemb	lct1_with_gema	lct0_with_copad	lct0_with_gemb	lct0_with_gema	lct0_no_gem															
13	0	0	0	0	trig_counter[14:0]																												
14	0	0	0	0	hmt_nhits[1]	clct1_key[1:0]	clct1_comparatorcode[11:0]																										
15	0	0	0	0	alct counter[14:0]																												
16	0	0	0	0	alct_gem_win[2:0]	gem_clct_win[3:0]			gem_delay[3:0]			num_copad[3:0]																					
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_po_stdrift[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]				dmbs_thresh_pretrig[2:0]	triad_persist[3:0]																			
22	0	0	0	0	clet1_bnd[4]	clct0_bnd[4:0]			trig_source_vec[8:0]																								
23	0	0	0	0	aff source	11a_match_wi_n[3:0]		cfubs_read[4:0]				active_cfeb[4:0]																					
24	0	0	0	0	lct rank err	dupe_clet	dupe_alct	two_clct		two_alct	one_clet	one_alct	no_alct	match_win[3:0]				clet_only	alct_only	tm_bm_atc_h													

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+mi ni	parity error cfeb ram[4:0] SEU				clet1 busy	clet 1 invp	clc i0 in vp	clctc[2:0]		clct1[15]	clct0 [15]			
28	0	0	0	0	clct1_bnd [3:0]			alct0_key[6:0]				alct0 amu		alct0 quality[1:0]	alct0 valid					
29	0	0	0	0	layer triggered	bcb reado ut	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_erro r[1:0]	hmt_nhbits[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_gem[4:0]			fifo_tbins_gem[4:0]				gem_ze ro_supr ess	gem_readout_mask[3:0]							
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	revers e me1a	reverse csc	buf_fence_cnt[11:0]												
40	0	0	0	0	tmb trig pulse	trig_src_vec[10: 9]		gemsc_bend_e nable	peak fence	cfcb_e n[6:5]	perr_cfeb[6:5]		cfcb_badbits_found[6:5]		cfbebs read[6 :5]	acti ve_cfeb [6:5]				
41	0	0	0	0	anod e_hm tf[1:0]	cathode_hmt [1:0]		non-trig read out	trigg ered read out	non-trig match ro	non-trig clet ro		non-trig alct o	hmt_match_win [3:0]		gem_enabl e	run3 _trig _df			
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 GEM Raw Hits (if GEM readout enabled)																										
254				GME Tbin0	Layer 1D, 0 or 1						GEM cluster0[13:0]																				
255				GME Tbin0	Layer 1D, 0 or 1						GEM cluster1[13:0]																				
256				GME Tbin0	Layer 1D, 0 or 1						GEM cluster2[13:0]																				
257				GME Tbin0	Layer 1D, 0 or 1						GEM cluster3[13:0]																				
258				GME Tbin0	Layer 1D, 0 or 1						GEM cluster4[13:0]																				
259				GME Tbin0	Layer 1D, 0 or 1						GEM cluster5[13:0]																				
260				GME Tbin0	Layer 1D, 0 or 1						GEM cluster6[13:0]																				
261				GME Tbin0	Layer 1D, 0 or 1						GEM cluster7[13:0]																				
262				GME Tbin0	Layer 1D, 0 or 1						GEM cluster0[13:0]																				
263				GME Tbin0	Layer 1D, 0 or 1						GEM cluster1[13:0]																				
264				GME Tbin0	Layer 1D, 0 or 1						GEM cluster2[13:0]																				
265				GME Tbin0	Layer 1D, 0 or 1						GEM cluster3[13:0]																				
266				GME Tbin0	Layer 1D, 0 or 1						GEM cluster4[13:0]																				
267				GME Tbin0	Layer 1D, 0 or 1						GEM cluster5[13:0]																				
268				GME Tbin0	Layer 1D, 0 or 1						GEM cluster6[13:0]																				
269				GME Tbin0	Layer 1D, 0 or 1						GEM cluster7[13:0]																				
270	--			--	--						--																				
279																															
280				GEM Tbin6	Layer 1D, 0 or 1						GEM cluster6[13:0]																				
281				GEM Tbin6	Layer 1D, 0 or 1						GEM cluster7[13:0]																				
282				6	D04 <sub>16</sub> End GEM Raw Hits																										
283	0	0	0	0	6											E0C End Cathode Block															
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>			<sup>1</sup> <sub>TMB</sub>	CRC22[10:0]																						
286	0	0	0	1	DDU Code 101 <sub>2</sub>			<sup>1</sup> <sub>TMB</sub>	CRC22[21:11]																						
287	0	0	1	1	DDU Code 101 <sub>2</sub>			<sup>1</sup> <sub>TMB</sub>	Word Count [10:0]																						
No Write	1	0	0	0																											
Fr a m e #	/ w r i t e f i f o	D A V D a t a A v i a b l e	I a s t t w 5	d1 d1 d1 d1 d1 d11	d 1 4 3 2 d11	d 1 0	d 9	d 8	d 7	d 6	d 5	d 4	d 3	d 2	d 1	d 0															

## **RUN2 UPDATES SUMMARY**

### **Localized Dead Time Zone**

## **RUN3 UPDATES SUMMARY**

Comparator Code LUT (CCLUT) algorithm and GEMCSC match are also described in previous sections and here description of these two features are skipped.

### **Firmware revision code convention**

Revcode[14:0] is used to represent the (O)TMB firmware revision code. The run2 convention used the year-month-day of firmware to define the revision code

```
assign revcode_vme[8:0] = (MONTHDAY[15:12]*10 + MONTHDAY[11:8])*32+ (MONTHDAY[7:4]*10 +
MONTHDAY[3:0]);
assign revcode_vme[12:9] = YEAR[3:0]+4'hA; // Need to reformat this in year 2018
assign revcode_vme[15:13] = FPGAID[15:13]; // Virtex 2,4,6 etc
```

New convention of revision code is proposed to follow the below definition:

- revcode[15:13] = 3'b000
- Data format type version: revcode[12:9]: 0=TMB standard, 1=OTMB Standard, 2=CCLUT, 3=GEM+CCLUT, 4=Run3 TMB (Hybrid, Run2 pattern finder+Partial Run3 data format)
- Major version: revcode[8:5]
- Minor version: revcode[4:0]

### **Scan OTMB Link Phasers: new tool for CFEB RX scan**

### **GEM Timing Scan**

### **High Multiplicity Trigger**

#### **Anode HMT:**

- Implemented in ALCT board
- Count number of anode hits over whole chamber for single BX
- Requires at least 5 layers with hits
- Compare number of anode hits with loose/nominal/tight thresholds, and calculate the 2-bit anode HMT results from number of anode hits and threshold comparison
- Encode 2-bit anode HMT bits in ALCT trigger data and send to (O)TMB. Usually anode HMT is aligned with ALCT in timing if one event has both valid anode HMT bits and ALCT

#### **Cathode HMT:**

- Implemented in OTMB board
- Count number of comparator hits over whole chamber for three BXs
- Requires at least 5 layers with hits in the middle of three BX
- Cathode HMT is 5BX earlier than CLCT and hmt\_delay by default should be 5BX

- Compare number of comparator hits with loose/nominal/tight thresholds, and calculate the 2-bit cathode HMT results from number of comparator hits and threshold comparison

### **Matched HMT:**

- Implemented in OTMB board
- OTMB receives anode HMT bits from ALCT trigger data and builds cathode HMT
- Cathode HMT opens a window for anode HMT and the match in timing is anode HMT centric. The window size is same of ALCT-CLCT match window

### **Trigger mode summary**

	<b>Trigger mode</b>	<b>Configuration</b>
<b>Legacy Run2 muon trigger</b>	<b>ALCT+CLCT</b>	
	<b>CLCT-alone</b>	
	<b>ALCT-alone</b>	
	<b>ALCT or CLCT</b>	
<b>GEM+CSC muon trigger New for Run3</b>	<b>ALCT+CLCT+2GEM</b>	
	<b>ALCT+CLCT+1GEM</b>	
	<b>CLCT+2GEM</b>	
	<b>ALCT+2GEM</b>	
<b>Showering trigger New For Run3</b>	<b>Anode+Cathode HMT</b>	
	<b>Cathode HMT alone</b>	
	<b>Anode HMT alone</b>	
	<b>Anode or Cathode HMT</b>	

# CONFIGURATION

## Shunt Settings

*Table 3: Shunts*

#	Shunt	Default	Function	
1	SH501 [CLK SRC]	1-2 [CCB] 2-3 [XTAL]	1-2 [CCB] 2-3 [XTAL]	CCB sources TMB s 40MHz Main clock Onboard crystal sources TMBs 40MHz Main clock
2	SH502 [CFEB CLK]	<b>2-3</b> [DCC]	1-2 [NRM] 2-3 [DCC]	CFEB clocks sourced by 3D3444 64/36 duty-cycle CFEB clocks duty-cycle corrected
3	SH55 [GBL]	1-2 [ENA]	1-2 [ENA] 2-3 [DIS]	Boot Register responds to TMB VME Global Address Boot Register ignores TMB VME Global Address
4	SH56 [GEO]	1-2 [ENA]	1-2 [ENA] 2-3 [DIS]	Boot Register responds to VME Geographic Address Boot Register ignores VME Geographic Address
5	SH57 [ADM]	1-2 [REQ]	1-2 [REQ] 2-3 [PAS]	Boot Register requires VME Address Mode 39h or 3Dh Boot Register accepts any VME Address Mode
6	SH97 [FPGA]	1-2 [ENA]	1-2 [ENA] 2-3 [DIS]	Cleared Boot Register enables FPGA VME access Cleared Boot Register disables FPGA VME access
7	SH69-1 [REG IN]	<b>2-3</b> [REG]	1-2 [BPL] 2-3 [REG]	Disconnect +3.3V from U69 1.5V regulator input Connect +3.3V to U69 1.5V regulator input
8	SH69-2 [REG OUT]	<b>2-3</b> [REG]	1-2 [BPL] 2-3 [REG]	Backplane sources +1.5Vtt Onboard regulator U69 sources +1.5Vtt
9	SH95 [BOOT]	1-2 [EN]	1-2 [EN] 2-3 [DIS]	CCB hard-reset clears Boot Register CCB hard-reset does not clear Boot Register
10	SH104 [VME]	1-2 [EN]	1-2 [EN] 2-3 [DIS]	VME write to Boot Register can hard-reset TMB or ALCT Boot Register can not hard-reset TMB or ALCT
11	SH105 [CCB]	1-2 [EN]	1-2 [EN] 2-3 [DIS]	CCB can hard-reset TMB or ALCT CCB can not hard-reset TMB or ALCT
12	SH106 [ALCT]	1-2 [EN]	1-2 [EN] 2-3 [DIS]	TMB FPGA can hard-reset ALCT board if enabled by Boot TMB FPGA firmware can not hard-reset ALCT board
13	SH107 [SELF]	<b>2-3</b> [DIS]	1-2 [EN] 2-3 [DIS]	TMB FPGA firmware can hard-reset TMB TMB FPGA firmware can not hard-reset TMB
14	SH1081 [ALCT]	1-2 [EN]	1-2 [EN] 2-3 [DIS]	TMB can send hard-reset to ALCT board TMB can not send hard-reset to ALCT board
15	SH1082 [TMB]	1-2 [EN]	1-2 [EN] 2-3 [DIS]	TMB can send hard-reset to TMB TMB can not send hard-reset to TMB
16	SH1083 [RPC]	1-2 [EN]	1-2 [EN] 2-3 [DIS]	TMB can send hard-reset to RAT/RPC board TMB can not send hard-reset to RAT/RPC board
17	SH1084 [PUP]	1-2 [EN]	1-2 [EN] 2-3 [DIS]	Issue hard-reset to TMB on power-up Do not issue hard-reset to TMB on power-up
18	SH62 [VMEADR]	1-2 [GEO]	1-2 [GEO] 2-3 [LCL]	Slot Address derived from VME backplane GEO pins Slot Address derived from SW2/SW1 hex switches
19	SH74 [JTAG SRC]	<b>2-3</b> [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 4: 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.																								
SW2	VME	1	<p>Normally, SH62 [VMEADDR] 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.</p> <p>SW2/SW1 should be set to 1A [26 decimal] to specify the Boot Register Global Address. SW2 is the most-significant hex digit.</p> <p>If SH62 [VMEADDR] 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.</p>																								
SW3	JTAG	4	<p>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.</p> <table> <tbody> <tr><td>0000</td><td>0</td><td>ALCT SLOW USER</td></tr> <tr><td>0001</td><td>1</td><td>ALCT SLOW PROM</td></tr> <tr><td>0010</td><td>2</td><td>ALCT FPGA USER</td></tr> <tr><td>0011</td><td>3</td><td>ALCT FPGA PROMs</td></tr> <tr><td>01XX</td><td>4</td><td>TMB FPGA PROMs</td></tr> <tr><td>10XX</td><td>8</td><td>TMB User PROMs</td></tr> <tr><td>1100</td><td>C</td><td>TMB FPGA Loop (for TMB self-test)</td></tr> <tr><td>1101</td><td>D</td><td>RAT FPGA PROM</td></tr> </tbody> </table>	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
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 5: Fuses for TMB2005*

<b>Fuse</b>	<b>Circuit</b>	<b>Amps</b>	<b>LED</b>	<b>Function</b>	<b>Littelfuse Part #</b>
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

*Table 6A: Fuses for TMB2013*

<b>Fuse</b>	<b>Circuit</b>	<b>Amps</b>	<b>LED</b>	<b>Function</b>	<b>Littelfuse Part #</b>
F1	+5.0V	10A	D_F1 Red	VME-bus I/O	0451010.MRL
F2	+3.3V	15A	D_F2 Red	Main board logic, FPGA IOBs	0451015.MRL
F3	+1.5V	10A	None	GTLP termination	0451010.MRL
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 7: CCB Signal Summary*

Signal	Bits	Dir	Logic	Function
<b>Clock Bus</b>				
ccb_clock40	1	In	LVDS	
Total	1			
<b>Fast Control Bus</b>				
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_llaccept	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			
<b>TMB Reload Bus: ALCT+CLCT+TMB FPGA Reload</b>				
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			
<b>DAQ Special Purpose Bus [Used by DMB and TMB]</b>				
dmbs_cfeb_calibrate[2..0]	3	In	GTLP	
dmbs_ll1a_release	1	(In)	GTLP	
dmbs_reserved_out[4..0]	5	In	GTLP	
dmbs_reserved_in[2..0]	3	(In)	GTLP	
Total	12			
<b>Trigger Special Purpose Bus [Used by TMB only]</b>				
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_ll1a_request	1	Out	GTLP	
tmb_ll1a_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 8: ALCT Signal Summary**

Signal	Bits	Pins	Mux	Dir	Logic	Function
<b>Inputs</b>						
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				
<b>Outputs</b>						
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 LVTTL at 40 MHz
- 45 Outputs<sup>1</sup> LVTTL at 40 MHz (see note<sup>1</sup> below)
- 47 Outputs<sup>2</sup> LVTTL at 40 MHz (see note<sup>2</sup> below)

**Table 9: DMB Signal Summary**

Signal	Bits	Dir	Logic	Function
<b>Outputs</b>				
tmb_data[14:0]	15	Out	LVTTL	TMB data[14:0] to DMB FIFO
alct_data[14:0]	15	Out	LVTTL	ALCT data [14:0] to DMB FIFO
tmb_ddu_special	1	Out	LVTTL	TMB DDU Special Word Flag
tmb_last_frame	1	Out	LVTTL	TMB Last FIFO frame
tmb_data_available	1	Out	LVTTL	TMB Data Available
/tmb_write_enable_fifo	1	Out	LVTTL	TMB FIFO /write_enable
tmb_active_feb_flag	1	Out	LVTTL	TMB Active Front-End-Board Flag
tmb_active_feb[4...0] <sup>1</sup>	5	Out	LVTTL	TMB Active FEB indicators[4...0] <sup>1</sup>
tmb_active_feb[6...0] <sup>2</sup>	7	Out	LVTTL	TMB Active FEB indicators[6...0] <sup>2</sup>
fifo_clock	1	Out	LVTTL	40MHz FIFO storage clock [= tmb_clock]
alct_ddu_special	1	Out	LVTTL	ALCT DDU Special Word Flag
alct_last_frame	1	Out	LVTTL	ALCT Last FIFO frame
alct_first_frame(dav)	1	Out	LVTTL	ALCT First FIFO frame, data available
/alct_write_enable_fifo	1	Out	LVTTL	ALCT FIFO /write_enable
reserved_to_dmb	5	Out	LVTTL	Unassigned
Total Outputs	57			
<b>Inputs</b>				
dmb_request_lct	1	In	LVTTL	DMB requests active_feb_flag from TMB
dmb_ext_trig	1	In	LVTTL	DMB external trigger to TMB
dmb_fpga_pgm_done	1	In	LVTTL	DMB FPGA Program Done
reserved_from_dmb	3	In	LVTTL	Unassigned
Total Inputs	6			

<sup>1</sup> For TMB 2005 operation with up to 5 CFEBs.

<sup>2</sup> For TMB 2013 operation with 7 DCFEBs.

## CFEB

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

*Table 10: 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 11: MPC Signal Summary**

	<b>Signal</b>	<b>Bits</b>	<b>Pins</b>	<b>Dir</b>	<b>Logic</b>	<b>Function</b>
First In Time	alct_first_key[6:0]	7	3.5	Out	GTLP	LCT 0 ALCT key wire-group
	clet_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
	clet_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		0	0			
	clet_first_key[7:0]	8	4	Out	GTLP	LCT 0 CLCT key ½-strip
	clet_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
	clet_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
	clet_second_key[7:0]	8	4	Out	GTLP	LCT 1 CLCT key ½-strip
	clet_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
	clet_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
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	76	38			2:1 Multiplexing at 80 MHz

## RPC

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

*Table 12: RPC Signal Summary*

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

## VME

24 Inputs TTL Address  
 16 BiDir TTL Data

*Table 13: 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 14: 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 & Testpoints

**Table 15: TMB Front Panel LEDs**

LED Label	Color	Function
LCT	Blue	ALCT vpf and CLCT vpf match within the 75ns ALCT window (see note <sup>3</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	Yellow	Invalid CLCT pattern after drift delay Pattern dropped below threshold, probably triggered on noise
NMAT	Yellow	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

**Table 12A: Mez-2013 SMT LEDs**

LED Label	Color	Function
D1	Blue	When lit, indicates at least one fiber link had an error since last reset
D2	Green	When lit, indicates TMB clock0 MMCM has locked since the last reset
D3	Yellow	When lit, indicates TMB clock0 MMCM is not currently locked
D4	Red	When lit, indicates TMB clock0 MMCM lost lock at least once since the last reset
D5	Green	When lit, indicates the QPLL has locked since the last reset
D6	Yellow	When lit, indicates the QPLL is not currently locked
D7	Red	When lit, indicates the QPLL lost lock at least once since the last reset
D8	Green	When lit, indicates at least one fiber link has a stable input
D0	Yellow	When lit, indicated the FPGA is Not Programmed (i.e. DONE is False)

**Table 12B: Mez-2013 Testpoints**

Testpoint Label	Function
9	TRUE indicates at least one fiber link had over 100 errors since the last reset
8	TRUE indicates all fiber links have a stable input
7:1	TRUE signs indicate that links 7:1 have a stable input, respectively

<sup>3</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 16: 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	LVTTL	1 DMB	DMB commands
2	1	In	GTLP	MPC	MPC winner
80	40	In	LVTTL	RPC	RPC Inputs
24	24	In	TTL	VME	VME Address
16	16	BiDir	TTL	VME	VME Data
5	5	In	LVTTL	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	LVTTL	1 DMB	DMB data
64	32	Out	GTLP	MPC	MPC winner
0	0	Out	LVTTL	RPC	RPC Inputs
0	0	Out	TTL	VME	VME data is BiDir
1	1	Out	LVTTL	JTAG	JTAG
196	152				Totals

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

# CONNECTORS

## TMB Connector Summary

*Table 17: TMB2005 Connector Summary*

<b>ID</b>	<b>Pins</b>	<b>Type</b>	<b>Function</b>
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
MTP Rx	-	aqua MTP with reduced flange & SC footprint	10 Gbps panel-mount adapter to receive up to 12 fiber links carrying DCFEB comparator data to Mez-2013 boards

## 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 18: 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 19: J5 ALCT Cable1 Connector [J10 on ALCT board]**

Modified 4/12/01 to match ALCT2001 PCB. Stinking bad signal inversion = ⊗

Pair	Inverte d	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 20: J6 ALCT Cable2 Connector [J11 on ALCT board]**

Modified 4/12/01 to match ALCT2001 PCB. Stinking bad signal inversion ☺

Pair	Inverte d	Pin		Dir	Logic	Multiplexed Signals	
		+	-			First 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>4</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>4</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>5</sup>**

(Looking into PCB Connector)

\ 25	1/
\ 26	50/

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

(Looking into Cable Connector)

\ 1	25/
\ 50	26/

**Figure 7: 50 Pin PCB Connector Pin Convention**

(Looking At Top of PCB)

1	•	50	•	►
2	•	48	•	•
3	•	46	•	•
4	•	44	•	•
5	•	42	•	•
6	•	40	•	•
7	•	38	•	•
8	•	36	•	•
9	•	34	•	•
10	•	32	•	•
11	•	30	•	•
12	•	28	•	•
13	•	26	•	•
14	•			
15	•			
16	•			
17	•			
18	•			
19	•			
20	•			
21	•			
22	•			
23	•			
24	•			
25	•			

Cable Side

## 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 ⊕.

<sup>5</sup> Copied from CFEB design: <http://www.physics.ohio-state.edu/~gujh/works/cmpdata.html>

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

**Table 21: 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 22: 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 23: 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	dmr_cfeb_calibrate0
A20	In	GTLP	dmr_reserved_out0
A21	In	GTLP	dmr_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	dmr_cfeb_calibrate1
B20	In	GTLP	dmr_reserved_out1
B21	(In) <sup>1</sup>	GTLP	dmr_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:

- 1) 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	GTLPI	tmb_config_done
D2			
D3	In	GTLPI	ccb_cmd2
D4	In	GTLPI	ccb_evntrses
D5	In	GTLPI	ccb_llaccept
D6	In	GTLPI	ccb_data2
D7	In	GTLPI	ccb_data6
D8	In	GTLPI	ccb_reserved2
D9	In	GTLPI	tmb_reserved0
D10	In	GTLPI	clct_external_trigger
D11	Out	GTLPI	clct_status2
D12	Out	GTLPI	clct_status6
D13	Out	GTLPI	clct_status1
D14	Out	GTLPI	alct_status5
D15	Out	GTLPI	tmb_ll1a_request
D16	Out	GTLPI	tmb_reserved_in2
D17	In	GTLPI	tmb_reserved_out1
D18			
D19	In	GTLPI	dmr_cfeb_calibrate2
D20	In	GTLPI	dmr_reserved_out2
D21	(In) <sup>1</sup>	GTLPI	dmr_reserved_in1
D22			
D23	Out	LVTTL	tmb_data2
D24	Out	LVTTL	tmb_data7
D25	Out	LVTTL	tmb_data11

Pin	Dir	Logic	Signal
E1	Out	GTLPI	alct_config_done
E2			
E3	In	GTLPI	ccb_cmd3
E4	In	GTLPI	ccb_bcntrses
E5	In	GTLPI	ccb_data_strobe
E6	In	GTLPI	ccb_data3
E7	In	GTLPI	ccb_data7
E8	In	GTLPI	ccb_reserved3
E9	In	GTLPI	tmb_reserved1
E10	In	GTLPI	alct_external_trigger
E11	Out	GTLPI	clct_status3
E12	Out	GTLPI	clct_status7
E13	Out	GTLPI	alct_status2
E14	Out	GTLPI	alct_status6
E15	Out	GTLPI	tmb_ll1a_release
E16	Out	GTLPI	tmb_reserved_in3
E17	In	GTLPI	tmb_reserved_out2
E18			
E19	(In) <sup>1</sup>	GTLPI	dmr_ll1a_release
E20	In	GTLPI	dmr_reserved_out3
E21	(In) <sup>1</sup>	GTLPI	dmr_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 24: 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
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

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

## P3A Backplane MPC+RPC Connector

Function: Sends and receives data to/from MPC.

Sends and receives data to/from RPC.

Connector Type: PCB: AMP Z-Pack 110 (25 rows of 5 pins) Female AMP  
5352068-1 Backplane: AMP Z-Pack 110 (25 rows of 5 pins) Male

Column C is connected to Ground

**Table 25: P3A Backplane MPC Connector**

See ADR MPCx FRAMEx on p54 for signal assignments

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
A1	/mpc_out0	B1	/mpc_out1	D1	/mpc_out2	E1	/mpc_out3
A2	/mpc_out4	B2	/mpc_out5	D2	/mpc_out6	E2	/mpc_out7
A3	/mpc_out8	B3	/mpc_out9	D3	/mpc_out10	E3	/mpc_out11
A4	/mpc_out12	B4	/mpc_out13	D4	/mpc_out14	E4	/mpc_out15
A5	/mpc_out16	B5	/mpc_out17	D5	/mpc_out18	E5	/mpc_out19
A6	/mpc_out20	B6	/mpc_out21	D6	/mpc_out22	E6	/mpc_out23
A7	/mpc_out24	B7	/mpc_out25	D7	/mpc_out26	E7	/mpc_out27
A8	/mpc_out28	B8	/mpc_out29	D8	/mpc_out30	E8	/mpc_out31
A9	/mpc_in0	B9	/mpc_in1	D9	NC	E9	NC
A10	NC	B10	NC	D10	NC	E10	NC
A11	NC	B11	NC	D11	NC	E11	NC
A12	NC	B12	NC	D12	NC	E12	NC
A13	NC	B13	GND	D13	NC	E13	GND
A14	NC	B14	NC	D14	NC	E14	NC
A15	rpc_txa0	B15	+VcoreRAT	D15	+AcoreRAT	E15	+V3.3RAT
A16	+3.3V	B16	rpc_txa3	D16	rpc_txa2	E16	rpc_txa1
A17	rpc_txa7	B17	rpc_txa6	D17	rpc_txa5	E17	rpc_txa4
A18	+3.3V	B18	rpc_rxa31	D18	rpc_rxa38	E18	rpc_rxa30
A19	rpc_rxa27	B19	rpc_rxa28	D19	rpc_rxa29	E19	rpc_rxa39
A20	+3.3V	B20	rpc_rxa24	D20	rpc_rxa25	E20	rpc_rxa26
A21	rpc_rxa20	B21	rpc_rxa21	D21	rpc_rxa22	E21	rpc_rxa23
A22	+3.3V	B22	rpc_rxa17	D22	rpc_rxa18	E22	rpc_rxa19
A23	rpc_rxa13	B23	rpc_rxa14	D23	rpc_rxa15	E23	rpc_rxa16
	+3.3V		rpc_rxa10		rpc_rxa11	E24	rpc_rxa12

A24		B24		D24			
A25	rpc_rx6	B25	rpc_rx7	D25	rpc_rx8	E25	rpc_rx9

## P3B Backplane RPC+ALCT Connector

Function: Sends and receives data to/from ALCT.

Sends and receives data to/from RPC.

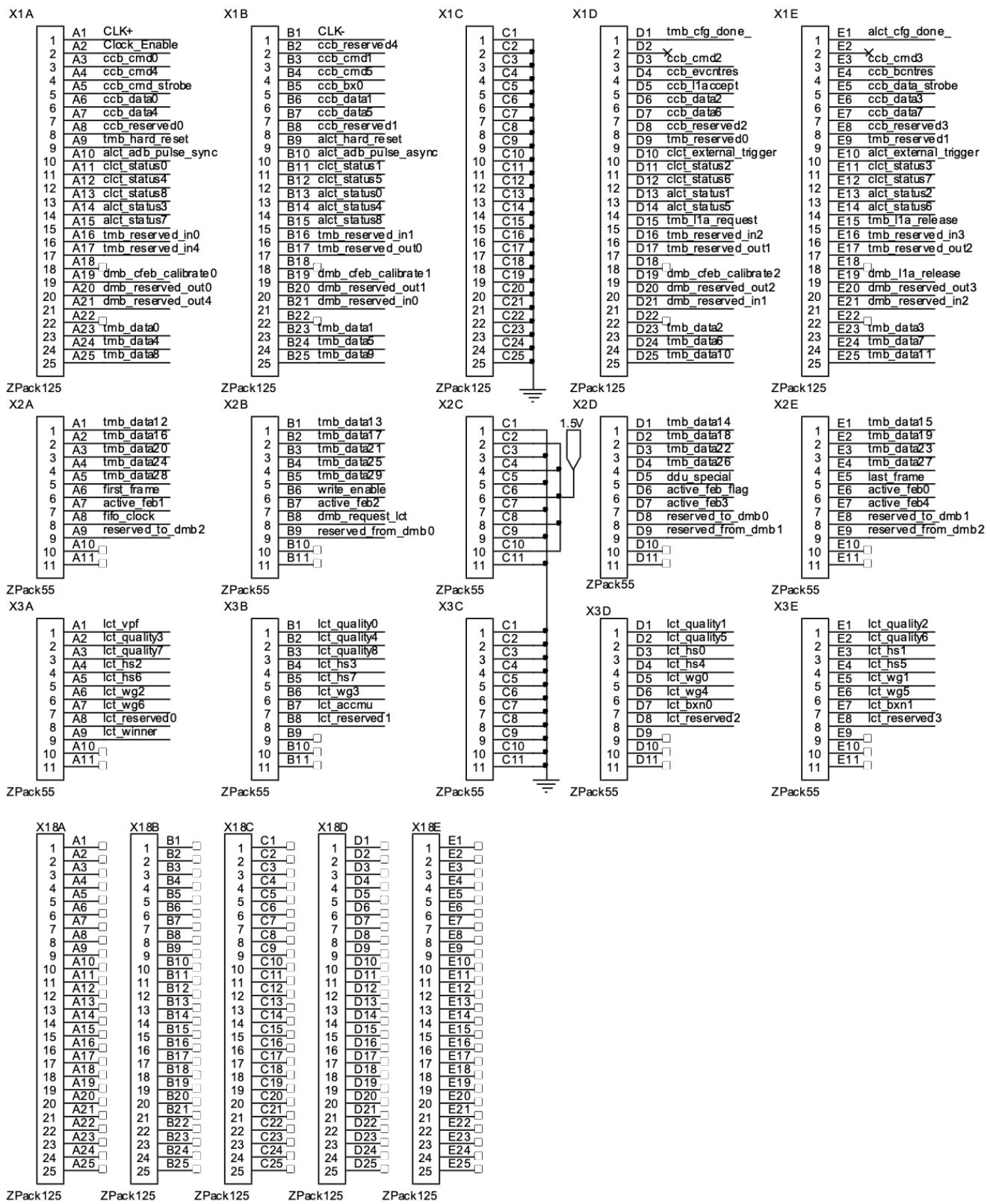
Connector Type: PCB: AMP Z-Pack 110 (25 rows of 5 pins) Female  
5352068-1 Backplane: AMP Z-Pack 110 (25 rows of 5 pins) Male

*Table 26: P3B Backplane RPC+ALCT Connector*

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
A1	+3.3V	B1	rpc_rxa3	C1	GND	D1	rpc_rxa4	E1	rpc_rxa5
A2	rpc_rxa35	B2	rpc_rxa0	C2	GND	D2	rpc_rxa1	E2	rpc_rxa2
A3	+3.3V	B3	rpc_rxa32	C3	GND	D3	rpc_rxa33	E3	rpc_rx34
A4	alct_txa1	B4	alct_txa0	C4	GND	D4	rpc_rxa36	E4	rpc_rxa37
A5	+3.3V	B5	alct_txa4	C5	GND	D5	alct_txa3	E5	rpc_txa2
A6	alct_txa8	B6	alct_txa7	C6	GND	D6	alct_txa6	E6	rpc_txa5
A7	+3.3V	B7	alct_txa11	C7	GND	D7	alct_txa10	E7	rpc_txa9
A8	alct_txa15	B8	alct_txa14	C8	GND	D8	alct_txa13	E8	rpc_txa12
A9	+3.3V	B9	alct_txa18	C9	GND	D9	alct_txa17	E9	rpc_txa16
A10	alct_txa25	B10	alct_txa27	C10	GND	D10	alct_txa26	E10	rpc_txa19
A11	+3.3V	B11	alct_txa22	C11	GND	D11	alct_txa21	E11	rpc_txa20
A12	NC	B12	NC	C12	NC	D12	NC	E12	NC
A13	+3.3V	B13	NC	C13	NC	D13	NC	E13	NC
A14	NC	B14	NC	C14	NC	D14	NC	E14	NC
A15	+3.3V	B15	alct_rear_rxoe_out	C15	GND	D15	alct_txa24	E15	rpc_txa23
A16	alct_rxa0	B16	rpc_smbtx_out	C16	GND	D16	/hard_reset_rpc_out	E16	rpc_free0_out
A17	+3.3V	B17	alct_rxa3	C17	GND	D17	alct_rxa2	E17	rpc_rxa1
A18	alct_rxa7	B18	alct_rxa6	C18	GND	D18	alct_rxa5	E18	rpc_rxa4
A19	+3.3V	B19	alct_rxa10	C19	GND	D19	alct_rxa9	E19	rpc_rxa8
A20	alct_rxa14	B20	alct_rxa13	C20	GND	D20	alct_rxa12	E20	rpc_rxa11
A21	+3.3V	B21	alct_rxa17	C21	GND	D21	alct_rxa16	E21	rpc_rxa15
A22	alct_rxa21	B22	alct_rxa20	C22	GND	D22	alct_rxa19	E22	rpc_rxa18
A23	+3.3V	B23	alct_rxa24	C23	GND	D23	alct_rxa23	E23	rpc_rxa22
A24	alct_rxa28	B24	alct_rxa27	C24	GND	D24	alct_rxa26	E24	rpc_rxa25

A25	+3.3V	B25	alct_rxa31	C25	GND	D25	alct_rxa30	E25	rpc_rxa29
-----	-------	-----	------------	-----	-----	-----	------------	-----	-----------

# Backplane Pin Diagram



## Front Panel Connector Locations

```
-----  
Front Panel → |  
               | Multipurpose connector goes here  
               | ----  
               ||. . | CFEBO  
               || . . |  
               ||. . |  
               || . . |  
               ||. . |  
               | . . | <- Pin 1 here (10.510)  
Pin   ^ | ----  
one  | |  
     | |----  
     | | . . |  
to   2.130" | | . . |  
Pin   | | . . |  
one  \ / | | . . |  
     | | . . | <- Pin 1 here (8.380)  
Pin   ^ | ----  
one  | |  
     | |----  
     | | . . |  
to   2.130" | | . . |  
Pin   | | . . |  
one  \ / | | . . |  
     | | . . | <- Pin 1 here (6.250)  
Pin   ^ | ----  
one  | |  
     | |----  
     | | . . |  
to   2.130" | | . . |  
Pin   | | . . |  
one  \ / | | . . |  
     | | . . | <- Pin 1 here (4.120)  
Pin   ^ | ----  
one  | |  
     | |----  
     | | . . |  
to   2.130" | | . . |  
Pin   | | . . |  
one  \ / | | . . |  
     | | . . | <- Pin 1 here (moved up from previous position 4/11/2001)  
Pin   ^ | ----  
one  | |  
     | |----  
     | | . . |  
to   1.990" | Optical output here  
bottom | |  
edge  \ / |  
-----
```

## CCB Front Panel

**Table 27: Connector CCB Input connector P10**

Pin (+)	Pin (-)	Signal
1	2	external_clock40
3	4	external_clock40_enable
5	6	external_l1accept
7	8	dmbs_cfeb_calibrate[0]
9	10	dmbs_cfeb_calibrate[1]
11	12	dmbs_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	

**Table 28: 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	nol1a_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				

**Table 29: CCB Output connector P12**

<b>Pin (+)</b>	<b>Pin (-)</b>	<b>Signal</b>	<b>Test Point</b>	<b>TMB Assignment</b>	<b>Description</b>
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	clect_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**

<b>Version</b>	<b>Date</b>	<b>Action</b>
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, adjcfab_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

<b>Version</b>	<b>Date</b>	<b>Action</b>
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 hsds 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 stager 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 stager_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 cfcb 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 cfcb muonic timing, 5 digital phase shifters, 2 vme delay registers
4.39	08/14/2009	CFEB muonic version, removed cfcb 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 cfcb muonic figures
4.47	12/16/2009	Add cfcb bad bit detection and registers
4.48	01/14/2010	Add cfcb 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

<b>Version</b>	<b>Date</b>	<b>Action</b>
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 DCFCB Virtex-6
4.62	2013/10/24	Change order of keys in LCT quality module, documentation updated accordingly
5.01	2013/12/19	Created assignments for Mez-2013 TPs & SMT LEDs: qpll & mmcm lock monitoring. Also minor corrections for VME GTX register table (Adr 14C-158)
5.02	2014/01/06	Changes to Reset for CFEB badbits, fiber link monitor logic & GTX VME registers 14A-158
5.03	2014/01/08	Add optical links to Fig. 1 and made some minor format changes for some tables
5.04	2014/04/24	Format cleaning. The following styles applied consistently throughout the text: section title – “My Heading 1” subsection title – “My Heading 2” normal text – “Normal” code excerpt – “Code in fixed font” paragraph title – “Paragraph heading” tables – “No spacing” text on figures – “Text box in plot” The styles are stored within document and accessible in Home -> Styles tab in Word
5.05	2014/04/28	Andrew Peck updated tables with the correct TMB2005 backplane pin assignments and connector (now 24,25). Some other minor formatting changes in that general section
5.06	2014/05/15	Add description of 5 new VME registers 17C – 188 to access data sent to MPC stored in FIFO (up to 512 last trigger events)
5.07	2014/06/26	Edited signal synchronization section. Start to edit list of VME addresses
5.08	2014/07/31 2014/08/04	Fix table with bits for Adr 15A ADR_V6_SYSMON Virtex-6 Sysmon ADC Fix table for Adr 16A and 16C changing cfeb0 to cfeb5 and cfeb6
5.09	2015/02/12	Edit VME register details for Adr 146 - 158, also 16A, 16C and 11E Added startup timers in VME Adr 186 - 192
5.10	2015/09/28	Edit counters 81 and 82 controlled by register D0 and read from register D2. GTX errors in these counters are obsolete. Counters of CLCT pre-triggers and L1A (counter 81) and ALCT (counter 82) are added.
5.11	2016/02/04 2016/02/26	Edit names of variables and description in VME register 6A for ALCT window width and delay to overlap with CLCT pre-trigger. Add counters 83-92 controlled by register D0 and read from register D2. These counters are for CFEBs active flags sent to DMB.
5.12	2016/04/14	Edit Figure 1

<b>Version</b>	<b>Date</b>	<b>Action</b>
		Edit names of counters 83-92, they are synchronized for OTMB2013 and TMB2005

# FIRMWARE CHANGE LOG

## **Version 1/20/2015**

Has redefined **enable** and **reset** control for Virtex-6 SNAP12 GTX fiber optic receivers (Adr 14A-158), and these now control GTX reset and GTX resync respectively

Added registers to monitor startup timing for several modules after a Hard Reset, with 100 ns units (Adr 186-192)

No longer uses the GTX internal RX Delay Align module for DCFEB fibers (which never worked well), but now uses just 2 phasers with one to control A-side DCFEB links (Adr 16A, used to be cfeb5\_rxd) and the other for B-side links (Adr 16C, used to be cfeb6\_rxd), and Adr 11E is also changed (rx<sub>d</sub>\_int\_delay control)

## **Version 12/26/2014**

Improved enable and reset control for Virtex-6 SNAP12 GTX fiber optic receivers (Adr 14A-158)

Added registers to count “lock lost” conditions for MMCM and QPLL (Adr 146 and 148)

Now using the GTX internal RX Delay Align module for DCFEB fibers instead of the phaser clocks

## **Version 01/06/2014**

Improved control & monitoring for Virtex-6 SNAP12 GTX fiber optic receivers

First applied in firmware version 12302013

TTC\_Resync now included in reset logic for CFEB badbits

cfeb\_badbits\_reset[4:0] = (cfeb\_badbits\_ctrl\_wr[4:0] | {5{ttc\_resync}});

cfeb\_badbits\_reset[6:5] = (cfeb\_v6\_badbits\_ctrl\_wr[1:0] | {2{ttc\_resync}});

GTX VME registers 14A-158 changed significantly to reflect improved fiber link monitor & control logic

Removed functions that were not useful (previously accessed in bits 10, 7:4, 2)

Reassigned some other functions to different bits (previous bit 9 → bit 7, bit 3 → bit 2)

Added new functions to bits 6:3 (gtx\_link\_bad, gtx\_link\_had\_err, gtx\_link\_good, gtx\_rx\_sync\_done)

Changed the readout response for bits 2:0 in registers 14C – 158 when master GTX control is asserted

When the master GTX control bits are set in register 14A (bits 2:0) they are now accurately reflected in the respective readout bits for the individual GTX links (bitwise OR in each GTX)

The error count now counts link sync failures when the PRBS function is not enabled

An occasional loss of sync for a link is expected due to SEUs, but large numbers of them or repeated occurrences may indicate a problem in the system

Increased the error count size to 8 bits and assigned this to bits 15:8

For registers 14C – 158 the maximum error count is hex E0 (n.b. a count larger than 1 is severe)

Register 14A is the sum of the other 7 counters, with maximum allowed value of hex FE

## **Version 12/19/2013**

Adds diagnostic features for Mez-2013

Applied in firmware versions 12162013 – 12172013

Assign Mez-2013 SMT LEDs to indicate qpll & mmcm lock conditions and status changes

See Table 12A

Assign additional diagnostic signals to the Mez-2013 test points and SMT LEDs

See Tables 12A and 12B

Minor corrections to the table for VME GTX registers (Adr 14C-158)  
Removed references to “all”

### 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\_CFEBS\_BADBITS\_CTRL=0x15C CFEB Bad Bits Control/Status

For DCFEB[6:5] badbits, extends 5 bit fields from ADR\_CFEBS\_BADBITS\_CTRL

6) Added 6 new bad bit VME registers

ADR\_V6\_CFEBS\_BADBITS\_LY01=0x15E CFEB5 Bad Bit Array

ADR\_V6\_CFEBS\_BADBITS\_LY23=0x160 CFEB5 Bad Bit Array

ADR\_V6\_CFEBS\_BADBITS\_LY45=0x162 CFEB5 Bad Bit Array

ADR\_V6\_CFEBS\_BADBITS\_LY01=0x164 CFEB6 Bad Bit Array

ADR\_V6\_CFEBS\_BADBITS\_LY23=0x166 CFEB6 Bad Bit Array

ADR\_V6\_CFEBS\_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-dcfb firmware versions.

header40_[1:0] = active_feb_mux[6:5];	Extend Hdr23[4:0]	Active CFEB list sent to DMB
header40_[3:2] = r_cfesbs_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 cfesbs\_read[6:0]. The 7-bit CFFEB list cfesbs\_read[6:0] is constructed from cfesbs\_read[4:0] in header23\_[9:5] and cfesbs\_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 (cfesbs\_read for instance).

15) Blocked bits readout

Readout can now include blocked hits from 0 to 7 CFEBs, as

indicated by cfesbs\_read[6:0].

## **Version 09/23/2012**

Add VME register 0x15A: ADR\_VIRTEX6\_SYSMON

## **Version 09/16/2012**

Adds support for Virtex-6 SNAP12 GTX fiber optic receivers

Add VME register 0x148: ADR\_VIRTEX6\_SNAP12\_QPLL

Virtex-6 mezzanine QPLL reset and status

Virtex-6 mezzanine SNAP12 receiver serial interface

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**

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 at 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] [p50](#) 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, [p120](#)
- 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 regisers 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 cfеб bits FFs for cfеб[n]  
[09:05]      RW    cfeb\_badbits\_block[4:0]    Block bad cfеб bits in cfеб[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\_CFEBO\_BADBITS\_LY01 CFEB0 Ly0,Ly1 Bad Bits List  
Adr 128    ADR\_CFEBO\_BADBITS\_LY23 CFEB0 Ly2,Ly3 Bad Bits List  
Adr 12A    ADR\_CFEBO\_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\_11a  
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 qcycles 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]_rxn_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]_rxn_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 tmbo-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 tmbo-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 cfeps

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

Adr14[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=9bx

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 18: J5 ALCT Cable1 Connector [J10 on ALCT board]  
Table 19: 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  $\frac{1}{2}$ -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,  $50\Omega$ )

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 [p67](#) 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 elcts 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:

Firmware compile type codes introduced, replaces programmable stagger and reversal

Added hs reversal for ME1A and ME1B and full hs reversal for non-ME1A/B CSCs

Added blocking for ME1A to MPC, but is not yet functional in this release

Added 2 state machines to detect and count TTC lock loss signals from CCB

Adr 2E[9]: Add `ccb_ttcrx_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 cfefs0-3 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_ttcrx_lock_never`    TTCrx lock never achieved

AdrFC[01]    `ccb_ttcrx_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 $\frac{1}{2}$ -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\_me1a1=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 $\frac{1}{2}$ -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\_nrpcss\_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 [p116](#)

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 adjcfb\_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 pid ≥ pid\_thresh\_postdrift

#### Version 06/03/2008

Modifies global\_reset and ttc\_resync behavior

Adds ability to send active feb flag to DMB at tmbo 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 tmbo matching  
 (13) AdrB0[7:3]=clctf[4:0] active cfcb list at tmbo matching  
 (14) Header23[4:0] active feb list is stored either at pretrig time or tmbo 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 bxn 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 [p56](#)
- (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] adjcfb\_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 DE0F marker due to DDUs failure to include the marker.
- (2) ALCT raw hits CRC check stops at the frame before the DE0D 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 adjcfb\_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 adjcfb[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] hsds 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\_blankng=1 is the new default value