GLAST Large Area Telescope:

GASU Modifications to enable GARC fix

Presented by G. Haller

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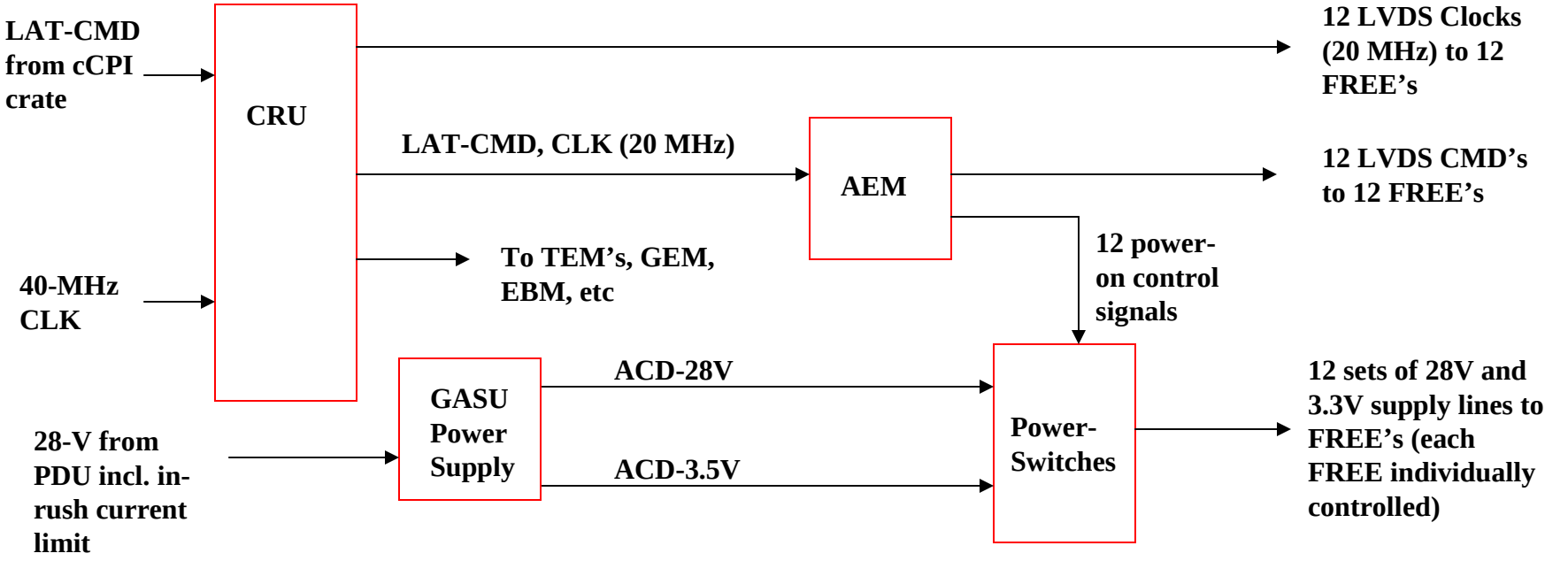
Baseline Flight Design of DAQ-GASU

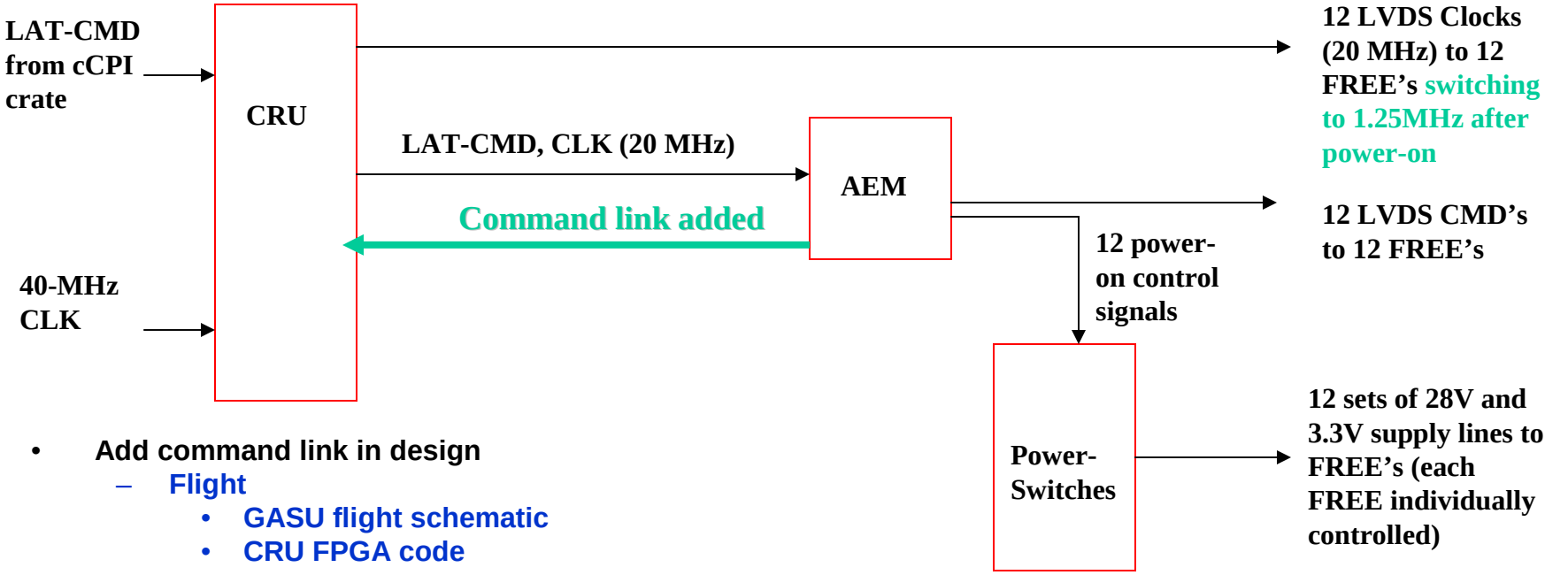


- GASU contains
  - Event-Builder Module (EBM)
  - Global Trigger Module (GEM)
  - Command-Response Unit (CRU)
  - ACD Electronics Module (AEM)
  - Figure shows simplified GASU
- AEM contains all ACD registers/control/read-out decoded from LAT-AEM command line
  - Includes ACD power-on registers -> controls power to 12 FREE cards individually
- CRU
  - Origin of 20 MHZ clock to FREE's (due to clock-skew requirements)

New Requirements

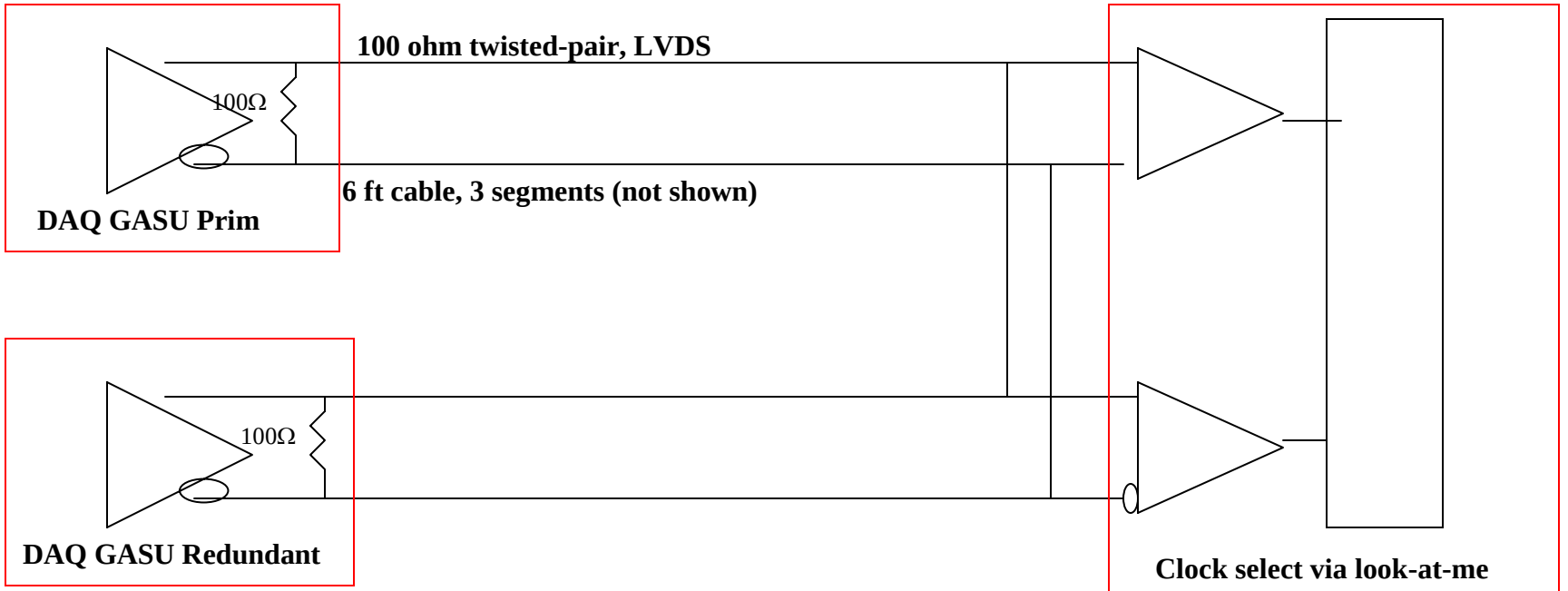
- Switch FREE clock frequency from nominal 20-MHz to 1.25 MHz for about 1-sec following power-on to FREE
- Problem
  - Clock comes from CRU
  - Only AEM knows when FREE's are powered
- Preferred Solution
  - Add path from AEM to CRU to communicate power-on transition
    - Can't use already available 12-FREE power-on signals on board (digital contamination of signals to base of power-on pnp-transistors resulting in cross-talk into AEM 3.3V voltage), plus need 12 additional pins on CRU
  - Implement as serial command connection from AEM to CRU

New Design of DAQ-GASU



- Add command link in design
  - Flight
    - GASU flight schematic
    - CRU FPGA code
    - AEM FPGA code
  - G3 test-stand
    - Add wires on G3-GASU board
    - Modify CRU and AEM FPGA code
    - Modify software for AEM register control
- Need to see how to test since 1.25MHz clock is only temporary and effect on FREE can not be "read-back"
- Question of
  - "hard-wire" 1-sec 1.25Mhz duration only at power-up
  - Add register in AEM to select frequency independent of power-up

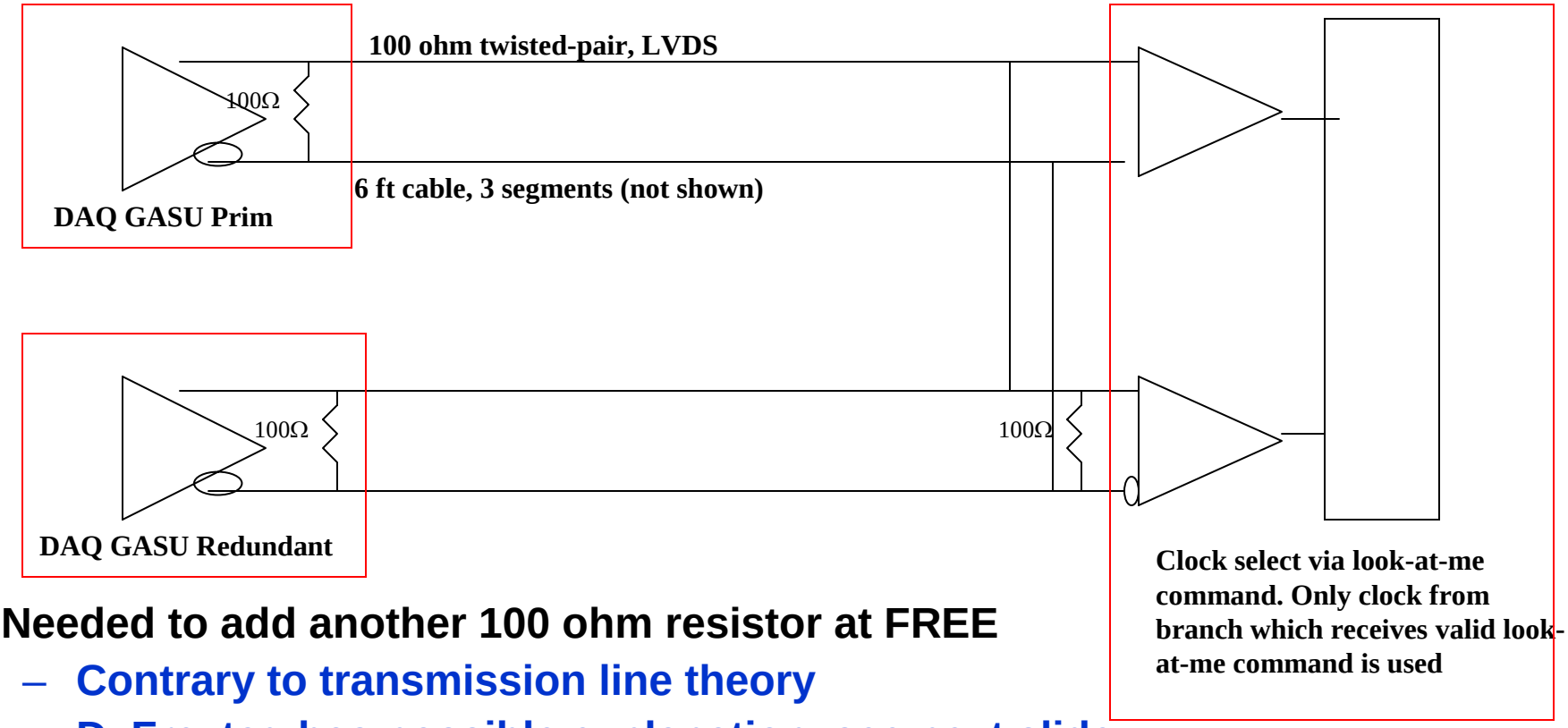
First solution



- Short out prim and redundant inputs to GARC on FREE
- Must terminate 100 ohm at both, prim and redundant GASU ends
  - Otherwise system does not work due to reflections
- Disadvantage:
  - Requires prim and redundant cable
  - Loose FREE if prim or redundant wire fails!
  - Loose FREE if prim or redundant driver shorts
  - Signal is cut in half
    - Concern about noise margin, pick-up
    - ACD cables are only cable outside LAT shield, and the longest.
- However this does not seem to work according to tests done at GSFC
  - Why?

GARC on FREE (only clock circuit is shown)

First solution (con't)



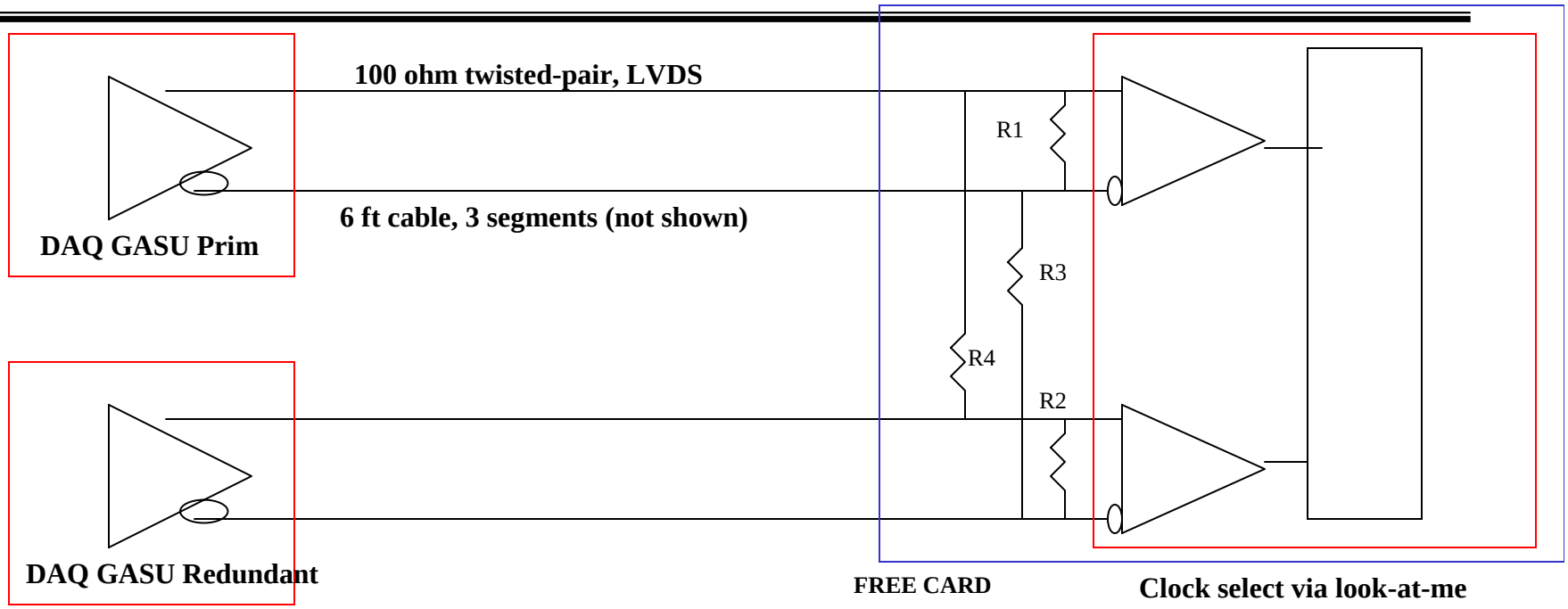
- **Needed to add another 100 ohm resistor at FREE**
  - **Contrary to transmission line theory**
  - **D. Freytag has possible explanation, see next slide**
  - **Consequences:**
    - **Only get 1/3 of the nominal LVDS signal!**
    - **Plus still need both cross-strapped cables to work**

GARC on FREE (only clock circuit is shown)

Reason for unexpected need of additional termination at FREE end

- **Analysis from Dieter Freytag (SLAC):**
  - **GSFC reports that for the case of interconnected clock lines (A,B), there is a need for a 100 Ohm termination at the GARC, in addition to the terminations at the drivers. That at first seemed strange. The resistor at the cable junction destroys the natural impedance match in the transition from cables A to B. (A=prim, B=redund.)**
  - **On inspection of the actual assembly, a likely explanation for the need for the termination at the GARC becomes apparent.**
  - **In the region near the GARC, the routing of the differential lines is on the FREE card including flex circuit is not clean.**
  - **The differential signals are not routed as well-defined pairs, picking up equally from neighbouring signal lines. There seem to be ample possibilities for the two wires randomly picking up signals of different magnitude.**
  - **The function of the termination resistor near the GARC then seems to be to short out such differential pick-up with a short time constant (<1 ns, 100 Ohm and a few pF of cross coupling), thus making it invisible to the receiver.**
  - **The terminator at the sending end cannot perform this function because the round trip delay to the terminator and back is too long.**

Original Plan with O. Milgrome suggestion



Clock select via look-at-me command. Only clock from branch which receives valid look-at-me command is used

- Oren Milgrome (SLAC): Add 2 resistors to get some signal from one branch into other
- If resistors are properly chosen (see next page)
  - Each, prim and redundant GASU driver see effective 100 ohm termination at receiver, just like in original plan
  - No back-termination at driver
    - If cable/wire fails, no problem, can use other path
  - GARC input used has still full nominal LVDS levels (350 mV each way or 700 mV diff) to get clean clock with margin

O. Milgrome solution (con't)

- How to choose resistors:
  - For discussion prim GASU is active, redundant GASU is not active, but works either way
  - Function of R3 and R4:
    - 1) Inject percentage of full prim lvds signal to feed into GARC input which is not used
      - Just enough to make sure that there are some clocks to get out of likely RESET state, no need for "clean" clock
      - Let's use 15% of signal for discussion purposes (105 mV, need much less)
      - Key is that clock shape or timing is not important into non-active input. In fact pick-up on redundant line helps in this case, is bad in prim path
    - 2) Attenuate reflection error signal from far end cable
      - Note that reflection is twice attenuated
        - » First, signal injected into redundant path is attenuated, and second, reflected signal is again attenuated before injected back into prim
      - In other words: if 15% of active receiver signal is fed into redundant receiver, then only 2.2% of original amplitude is injected by reflection

O. Milgrome solution (con't)

- **Selection of R1 and R2:**
  - **Both incoming clock lines in are terminated at the GARC, where the termination is most efficient in shorting out differential pick-up in the flex coupler near the GARC**
  - **The (voltage) amplitude does not drop due to the cross coupling if the resistors are sized to maintain the 100 Ohm termination.**
  - **For example, for two 200 Ohm coupling resistors the termination R will change to 124 Ohm to maintain 100 Ohm impedance matching for both clock lines.**
  - **Generally, the termination resistor R1 (R2) can be calculated for two coupling resistors R3 (R4) and a desired impedance Z from:**
  - **R1 = Z – R3 + sqrt(Z**2 + R3**2)**

Conclusion

- If delay and cost of fixing FREE card is not viable
  - Suggest Oren's solution
    - No impact to cross-strapping in respect to failures. This is important
    - Maintains 100 ohm terminated transmission line system
    - Full nominal LVDS signal in active driver/receiver system
    - Reflections are substantially attenuated
    - Easy fix on FREE (wire in two resistors)
    - Need to determine how much signal to leak into non-active FREE input. Due to pick up really only need a few 10's of mV. Don't make too large since then reflected signal from un-used cable is also larger reducing the noise margin of the prim signal
- Oren did a couple of tests (write-up in progress). Without coupling resistors FREE was locking up a few times out of 10 power-ups.
  - With as little as 30 mV coupled into secondary, no lock-up was observed in 30 power-ups.
- Comments:
  - differential lines on FREE are not quite routed as pairs
    - Potential of cross-talk from veto and other signals on board reduces effective noise margin
    - Mitigation: do tests what the noise margin is with all lines and board active, not just write/read commands.
  - Need to do more measurements to better come up with cross-coupling attenuation.
    - Maybe 105 mV which results in only 4% effect from reflection.
  - Recheck this all, since Oren just had idea and should be a bit more analysed, and possibly simulated.