Changes to the PTC

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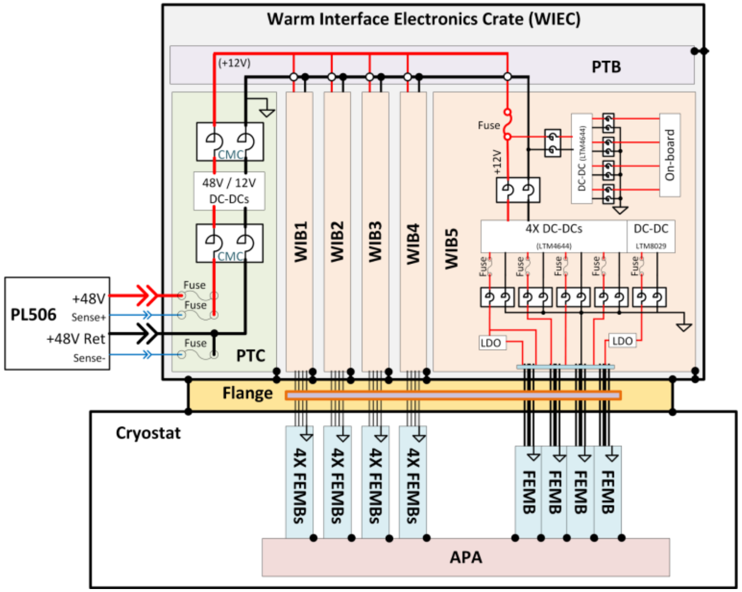
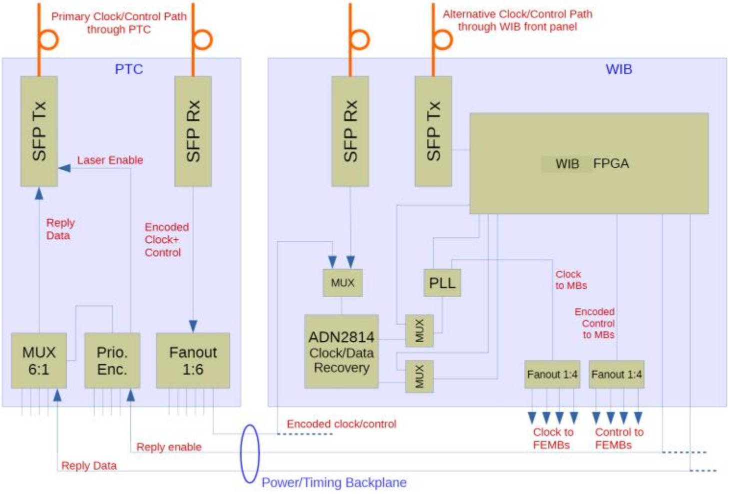
Outline

- The ProtoDUNE PTC (reminder)
- Why do we need changes to the PTC ?
- What needs to change in the PTC ?
- Requirements

The current PTC

- The current PTC is a brainless object
- Receives 48V from the LV power supply (WIENER PL506)
- Uses buck voltage regulators to generate 12V passed to the WIBs via the PTB
- Receives clock signal from timing system and passes it to the WIBs via the PTB, receives clock feedback signals from the WIBs, multiplexes them and sends them to the timing system
- Can power up to 6 WIBs, selected via dip switches (6 bits, very slow brain)



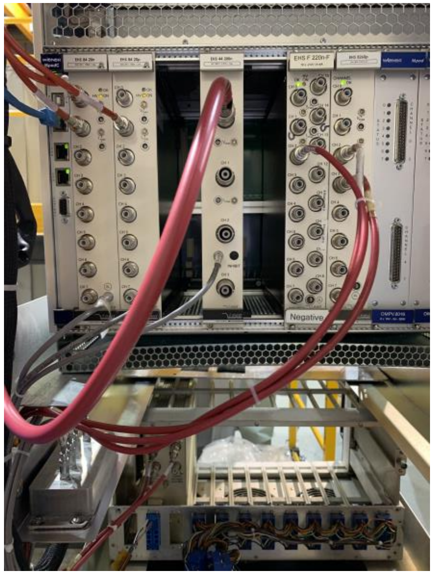


Does the PTC need a brain ? (i)

- We have operated ProtoDUNE without any problems in the WIECs
  - PTC turns on when the corresponding low voltage power supply channel is enabled by slow control, automatically turn on the power also on the WIBs that are enabled
  - Use the speed of the fans in hardware interlocks (if the fans are not spinning cannot power up WIBs, RTDs on the WIBs are read out via software)
  - FEMBs are powered on, enabled, and configured by slow control via direct communication via Ethernet
  - Could implement more software interlocks based on status of FEMBs, bias voltage, cryostat’s environment
- Why change ?
  - In ICEBERG we have realized that we need an hardware interlock system (presentation tomorrow)
  - Increase monitoring and control of status of WIBs

Does the PTC need a brain ? (ii)

- Hardware interlocks for DUNE
  - Low voltage power to front-end ASIC used to bias diodes that clamp the input in the range ~-0.4 to ~2.2 V
  - When the FEMBs don't receive the 1.8 V used to power the FE ASIC, the preamp is less protected against discharges taking place in the TPC
  - In ICEBERG this turned out to be a problem, and we've implemented a simple hardware interlock between the PTC and the bias voltage supplies
    - We could do this because ICEBERG has 1 LV channel and 3 bias channels
    - Hardware solution does not scale with number of channels
  - Temperature on the boards (instead of using the fans' speed as a proxy)



Implementing (hardware) interlocks

- Build interlocks in software (slow control)
  - Pro: cheap, already available
  - Cons: depends on SC software running
- Build interlocks in hardware
  - Constraints: optical communication from the WIB to the DUNE Detector Safety System (grounding rules)
  - 750 WIBs, require 1 duplex fiber connection for each WIB, require 1 optical receiver interfaced to PLC system (expensive, ~$350 per connection)
  - Pros: feed into industry standard
  - Cons: expensive

Concentrate information

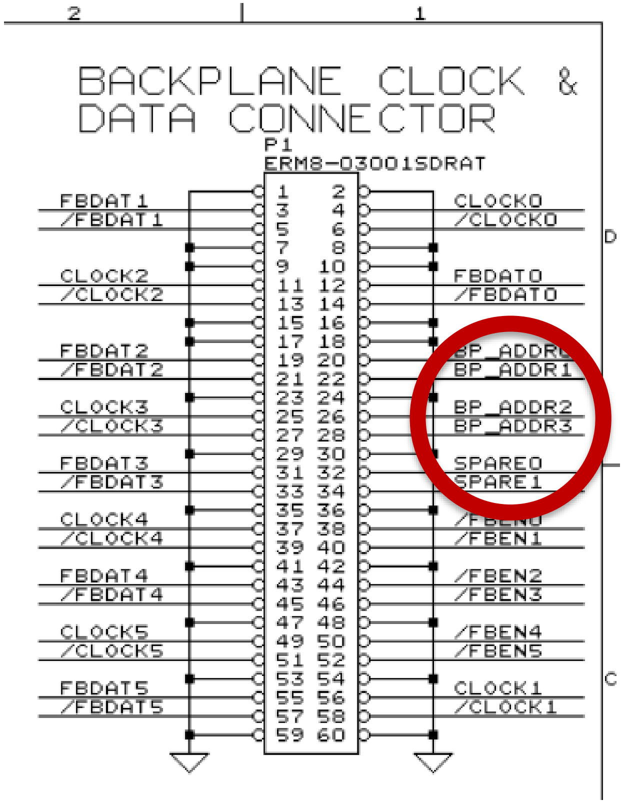
- We don't need to transmit data at 1-10 Gb/s for interlocks
- We can concentrate the information on the Warm Interface Electronics Crate
  - Requires infra-crate communication
    - 1 Master WIB plus 4 slaves ?
    - Use the PTC as master and the WIBs as slaves
  - Pros: reduce number of connections (and cost) between WIECs and DDSS by factor 5
  - Cons: need infra-crate communication
- Concentrating information requires a brain with more than 6 bits of a dip-switch, make that brain communicate not just with DDSS, but also with SC

Other benefits of infra-crate communications

- If we choose the PTC as master configuration
  - Turn on / off and monitor the power to each WIB individually
  - Program (dip-switch ? Non-volatile memory ?) address on the PTC, all WIBs can automatically get a defined address (PTC_x, where PTC=001-150, x=1-5)
  - All WIBs are treated equally (instead of having a master WIB)
  - Can perform initial processing of monitoring informations from the WIBs (and the PTC itself) prior to transmitting the data to the DDSS
- In addition (to be investigated) we could reduce the number of connections between the SC and the WIBs by using the PTC as a gateway
  - Have to understand how well the SC scales with the number of objects that are connected

How do you implement infra-crate communications ?

- The PTB has 4 lines originally meant for assigning the address to each WIB, plus 2 spare lines
- Use these lines to establish I2C communication between the PTC (master) and the WIBs (slaves)
  - Transmit to the PTC from the WIBs:
    - Status of FEMBs LV supplies (on/off, voltage, current)
    - Temperature from RTD on board
  - Transmit from the PTC to the WIBs:
    - Enable/disable command for the FEMB LV supplies
  - Could in principle channel all SC commands to the FEMBs via the PTC



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Requirements for infra-crate communications ?

- This requires the addition of a small FPGA on the PTC
  - Will handle I2C communications with the WIBs
  - Will enable/disable 12V power to the WIBs
  - Will form interlock signals to be sent to DDSS based on status of WIBs/FEMBs (in the FPGA fabric)
- PTC will also require two SFP transceivers
  - One for communication with SC (PTC becomes one additional element in the system)
  - One for communication with the DDSS
- Cost increase of PTC: $50 for smallest Zynq FPGA, plus 2*$50 for 2 transceivers, not a major perturbation of the PTC cost

Hardware requirements for the PTC

- Receive power from the LV power supply (48V) and use converters to provide power at 12V to the 5 WIBs in the crate
- Monitor the 12V power to each WIB (no need for regulation)
- Be able to turn on/off the 12V to each WIB independently from remote
- Have a low cost FPGA (with Zynq) for communications with SC, DDSS, and I2C communication with the WIBs via PTB
- Optical connection to the timing system (as in current PTC), fanout of the clock to the WIBs and multiplexing of the return information from the WIBs
- Optical Gbit/s Ethernet connection for SC
- Optical Gbit/s Ethernet connection for DDSS

Firmware requirements for the PTC

- Turn on/off voltage lines to WIBs
- Monitor voltage lines to WIBs
- Communication with other WIBs via I2C bus
- Communication with DDSS (need to understand whether protocol will be in firmware or in the Zynq, first would be preferable)
- Sufficient FPGA fabric to implement simple interlock decisions based on the status of inputs received from WIBs (not clear this will be exploited, but may be necessary depending on the communication protocol with DDSS)

Software requirements for the PTC

- Transmit configuration from SC to the PTC (i.e. power on/off individual WIBs)
- Transmit monitoring information from the PTC to SC (status of each 12 V line, interlock values from each individual WIB)
- Implement OPC Unified Architecture server for communication with SC
- Firmware download (via SC or via CCM ?)

PTC Status

- Clearly we are at very early stages
- Decision to modify the PTC is very recent, but this is also not going to be a very complicated object
- Defining completely the requirements for the PTC involves having a better definition of the DUNE Detector Safety System
- That will drive the requirements for firmware / software