

EMPLOYING RTEMS AND FPGAS FOR BEAMLINE APPLICATIONS AT THE APS*

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PCaPAC2010

October 5-8, 2010

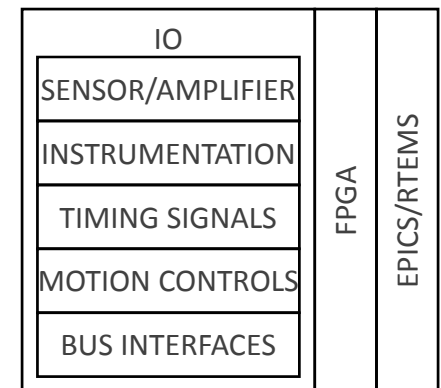
*Use of the Advanced Photon Source at Argonne National Laboratory was supported by the U. S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

Overview

- “Generic Digital” concept
- Hardware
- Software
- Applications
- Conclusions

Generic digital concept

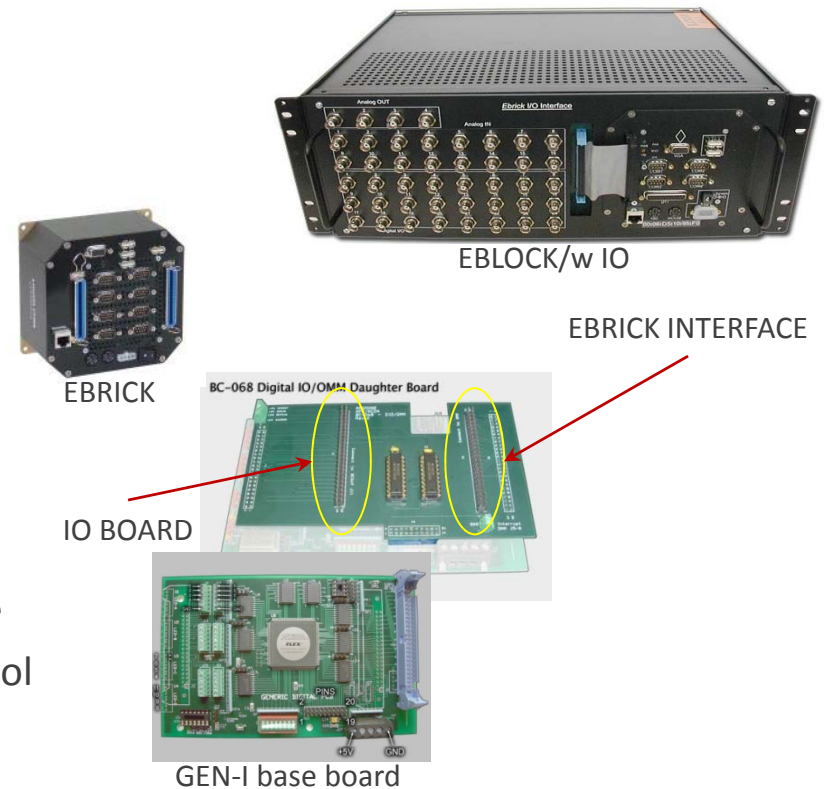
- Generic digital concept (design pattern)
 - Abstract to compartmentalize
 - Model components
 - EPICS component
 - Arcturus uC5282 (uCDIMM), RTEMS (typical)
 - Adapters (optional)
 - FPGA component
 - Generation I, II, development kits
 - IO component
 - Application specific interface
 - APS timing signals
 - Camera Link
 - PC/104 adapter (motion, sensor input)
 - Others...



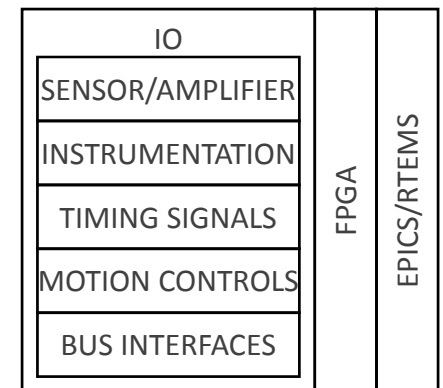
Model diagram

Hardware

- Generation I base board
 - Steve's generic digital
 - Altera FLEX10K FPGA (5V)
 - 64bits buffered TTL IO
 - IO daughter board
 - EPICS Brick (EBRICK) provides EPICS interface
 - Parameterize application/w serial link protocol
 - 1U housing, rack mountable, desktop
 - Applications
 - Simple logic
 - "divide-by" logic
 - Scaler



GEN-I generic digital/w EBRICK-II

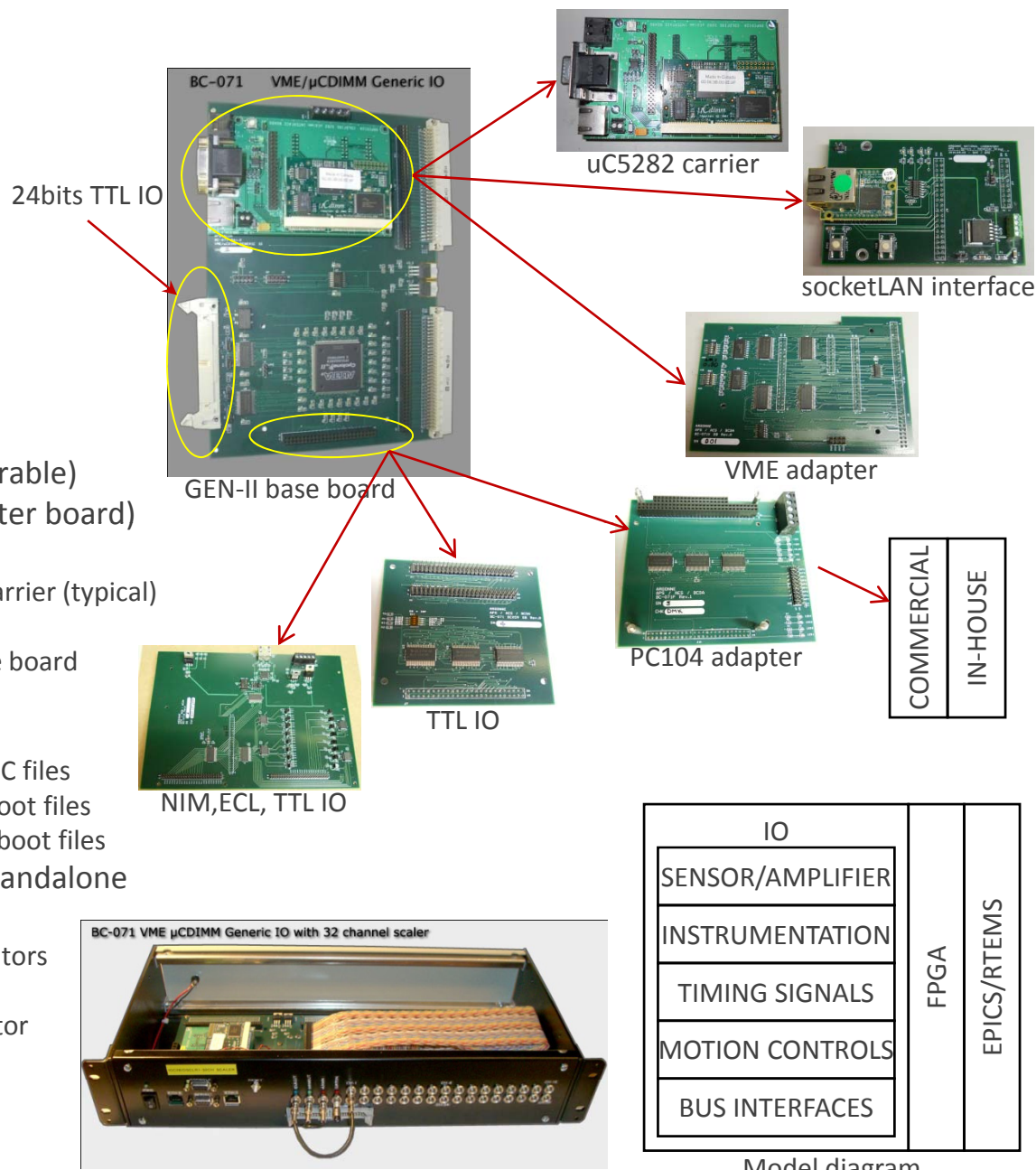


Model diagram

Hardware, cont...

■ Generation II base board

- Dave's generic digital
- Altera Cyclone-II (240 Quad)
- VME footprint
- 24bits buffered TTL IO (configurable)
- 40bits LVTTTL expansion (daughter board)
- 58bits external interface
 - Option 1: uC5282 (Coldfire) carrier (typical)
 - Option 2: VME interface
 - Option 3: socketLAN interface board
- Boot methods
 - NFS synApps autosave
 - Completely standalone, all IOC files
 - Standalone, IOC image, NFS boot files
 - Standalone, TFTP image, NFS boot files
- 2U housing, rack mountable, standalone
- Applications
 - Timing modules, delay generators
 - Scalers
 - P0 bunch intensity compensator
 - Bunch photon counting



Hardware, cont...

■ Development kits

- High-end applications (detectors)
- On-board LVDS, LVTTTL IO, memory
- EPICS interface (uC5282 carrier)
- Applications
 - Fuel spray experiment
 - DOE SBIR (Small Business Innovative Research)
 - Voxel, Inc. multi-pixel array ASIC/Sensor
 - Radiation Monitoring Devices, Inc. APD arrays



HSMC uC5282
carrier



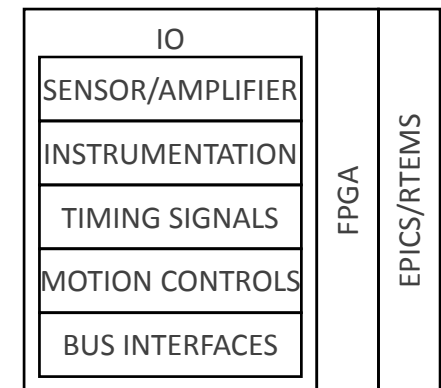
HSMC Camera-link



Development kit



Voxel
ASIC/Sensor



Model diagram

Software

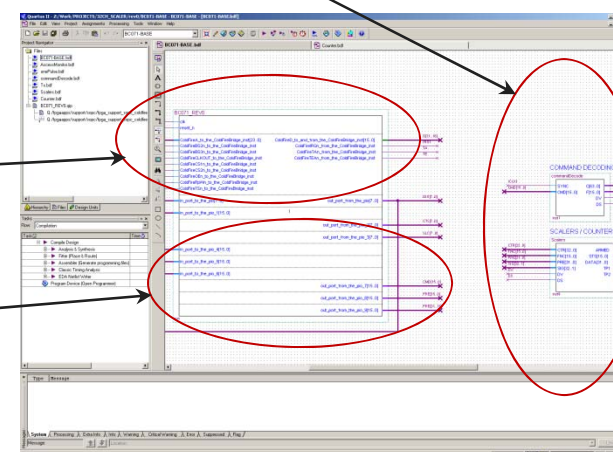
- Development
 - Linux and Windows environment
 - Linux: EPICS development
 - Windows: FPGA development
- EPICS
 - Central repository for base, synApps (support, nonsupport)
 - Central location for IOC app, boot files, autosave
 - synApps EBRICK supports uC5282/RTEMS
- FPGA
 - Altera's Quartus-II design software
 - uC5282 bridge (AES-controls)
 - SOPC configuration
 - FPGA application logic



FPGA application, etc...

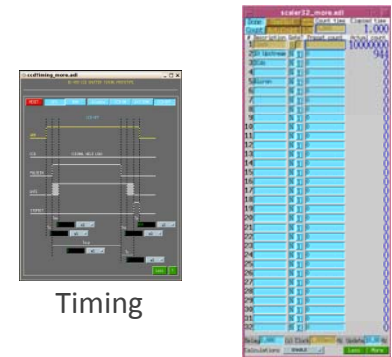
uC5282 bridge

SOPC PIOs



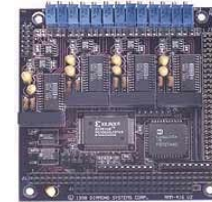
Applications

- 32-channel scaler
- Flexible CCD shutter timing module
- Configurable delay generator
- P0 bunch intensity compensator
- Time-resolved photon counter (bunch scaler)
- *FlexLogic* prototype
- PC104: ADCs, Motion control, sensor input
- Fast ADC (detector development)
 - Radiation Monitoring Devices, Inc. APD arrays for x-ray timing (~100ps), counting
 - Fuel spray experiment
 - Voxel, Inc. multi-pixel array detector



Timing

Scaler



ADC module



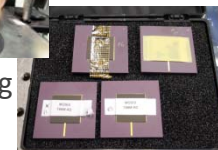
Motion controller



Sensor input



Sensor testing



Voxel ASIC/Sensor

Applications

- 32-channel scaler
 - Motivation
 - Lower hardware costs
 - VME-less beamlines
 - Mobility
 - GEN-II generic digital
 - IO board (LVTTTL<->TTL)
 - TTL inputs (scalers,ARMIN,GATEIN)
 - TTL outputs (CLKOUT,ARMOUT)
 - LED indicators (EPICS,ARMOUT,ARMIN,GATEIN)
 - Standalone / mobile enclosure
 - Software development
 - Scaler record support (synApps STD)
 - Standard support (record,MEDM)
 - Framework
 - ASYN driver
 - Device support (framework methods)
 - Interface to access scalers, status
 - MEDM screens



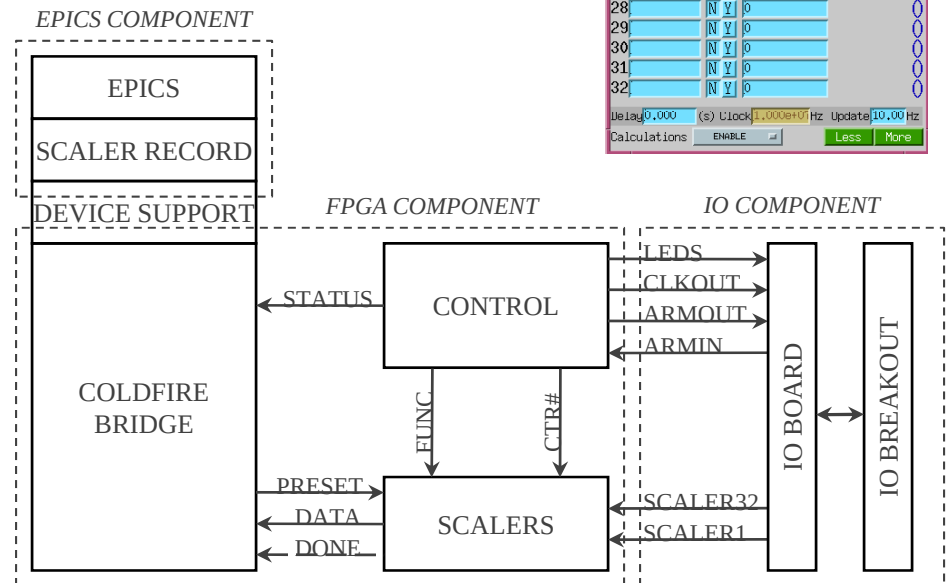
IO board



scaler32_more.adl

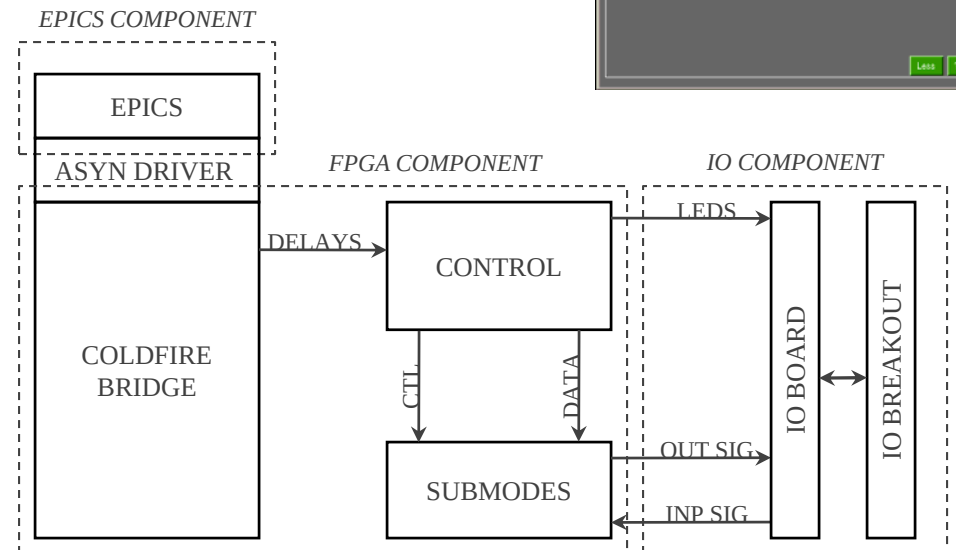
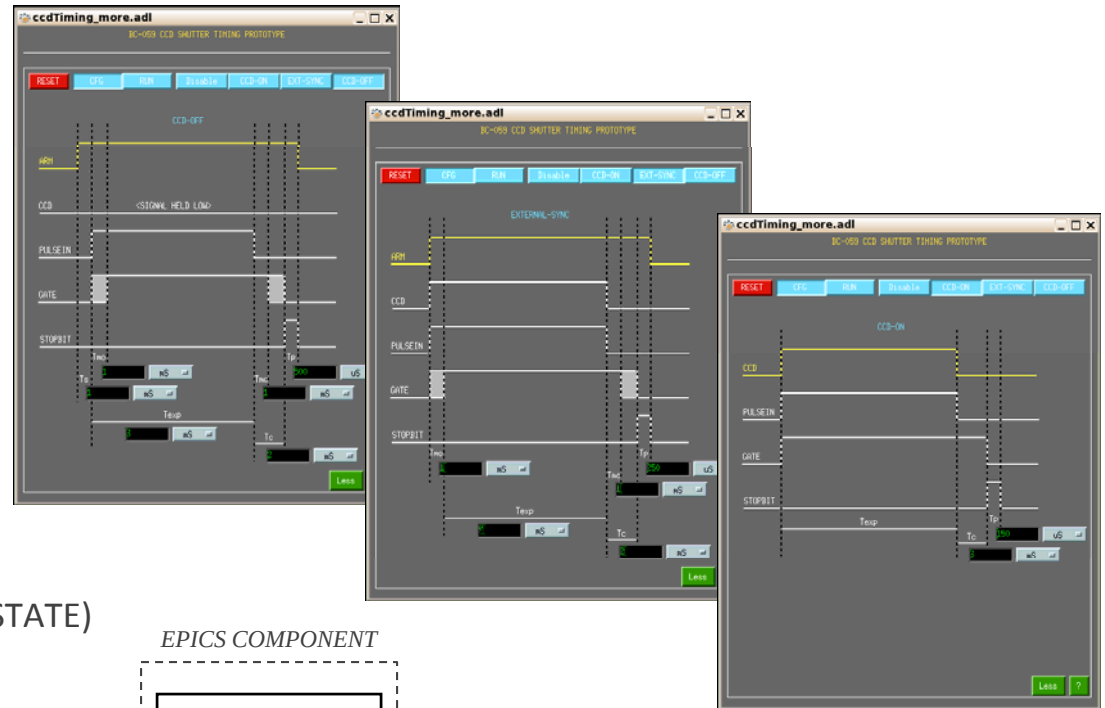
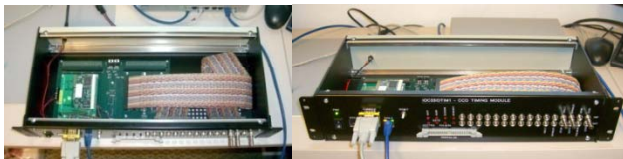
Done	OneShot	AutoCount	Count time	Elapsed time
Count	AutoCount	1.00	0.000	1.000
# Description	Gate?	Preset count		Actual count
1 Clock	N Y	0		10000000
2 IO Upstream	N Y	0		944
3 ICds	N Y	0		0
4	N Y	0		0
5 Bicorn	N Y	0		0
6	N Y	0		0
7	N Y	0		0
8	N Y	0		0
9	N Y	0		0
10	N Y	0		0
11	N Y	0		0
12	N Y	0		0
13	N Y	0		0
14	N Y	0		0
15	N Y	0		0
16	N Y	0		0
17	N Y	0		0
18	N Y	0		0
19	N Y	0		0
20	N Y	0		0
21	N Y	0		0
22	N Y	0		0
23	N Y	0		0
24	N Y	0		0
25	N Y	0		0
26	N Y	0		0
27	N Y	0		0
28	N Y	0		0
29	N Y	0		0
30	N Y	0		0
31	N Y	0		0
32	N Y	0		0

Waiting 0.000 (s) Clock 1.000e+07 Hz Update 10.00 Hz
Calculations ENABLE Less More



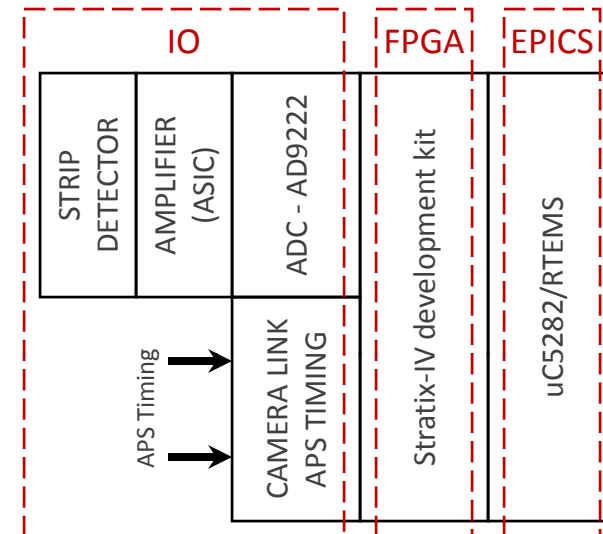
Applications, cont...

- Flexible CCD shutter control
 - Delay, stretch signals
 - GEN-II generic digital
 - IO board (same as scaler)
 - TTL IO
 - LED indicators (EPICS,MODE,STATE)
 - Standalone / mobile enclosure
 - Software development
 - ASYN driver
 - MEDM screens
 - User configures
 - Main modes (CFG,RUN)
 - Sub-modes (CCD ON/OFF,EXT SYNC)
 - Signal delay, duration



Applications, cont...

- Fast ADC – Fuel spray experiment (current)
 - Altera Stratix-IV development kit
 - IO boards
 - 8chan ADC (AD9222 480Mbps/chan)
 - Amplifier, sensor
 - Camera-link, APS timing
 - Sensor development
 - Silvaco tools (Schematic,simulation,layout,TSMC)
 - University clean room
 - Standalone / mobile enclosure
 - Software development
 - ASYN driver
 - MEDM screens



Conclusions

- Serves as “design pattern” applicable to many applications
- Flexible and adaptive, varying configurations and complexities
- uC5282/FPGA combination proven reliable
- EPICS, synApps modules, RTEMS reduces development time
- Focus more on application
- APS users benefit

Thank You
Comments, questions, reactions?



TEAM MEMBER GROUP PHOTO



!!!REAL TEAM MEMBERS!!!

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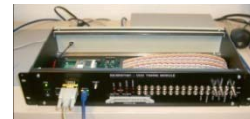
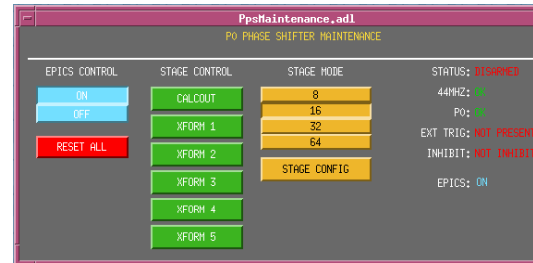
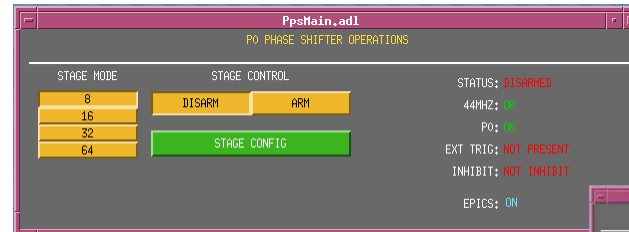


Supplemental material follows

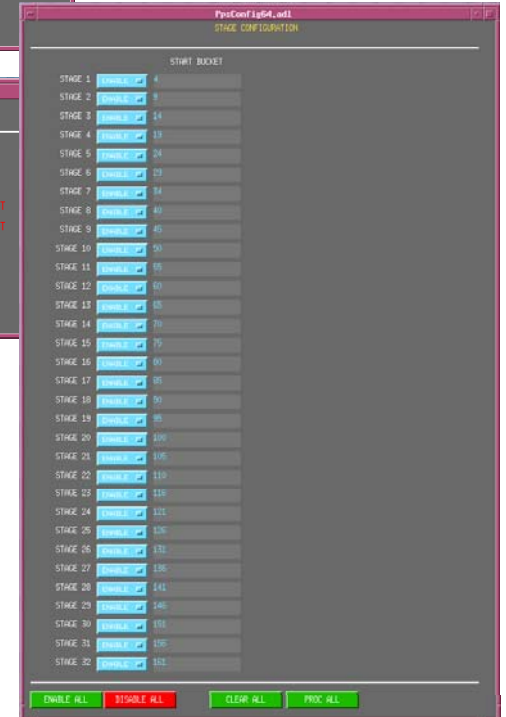


Applications, cont...

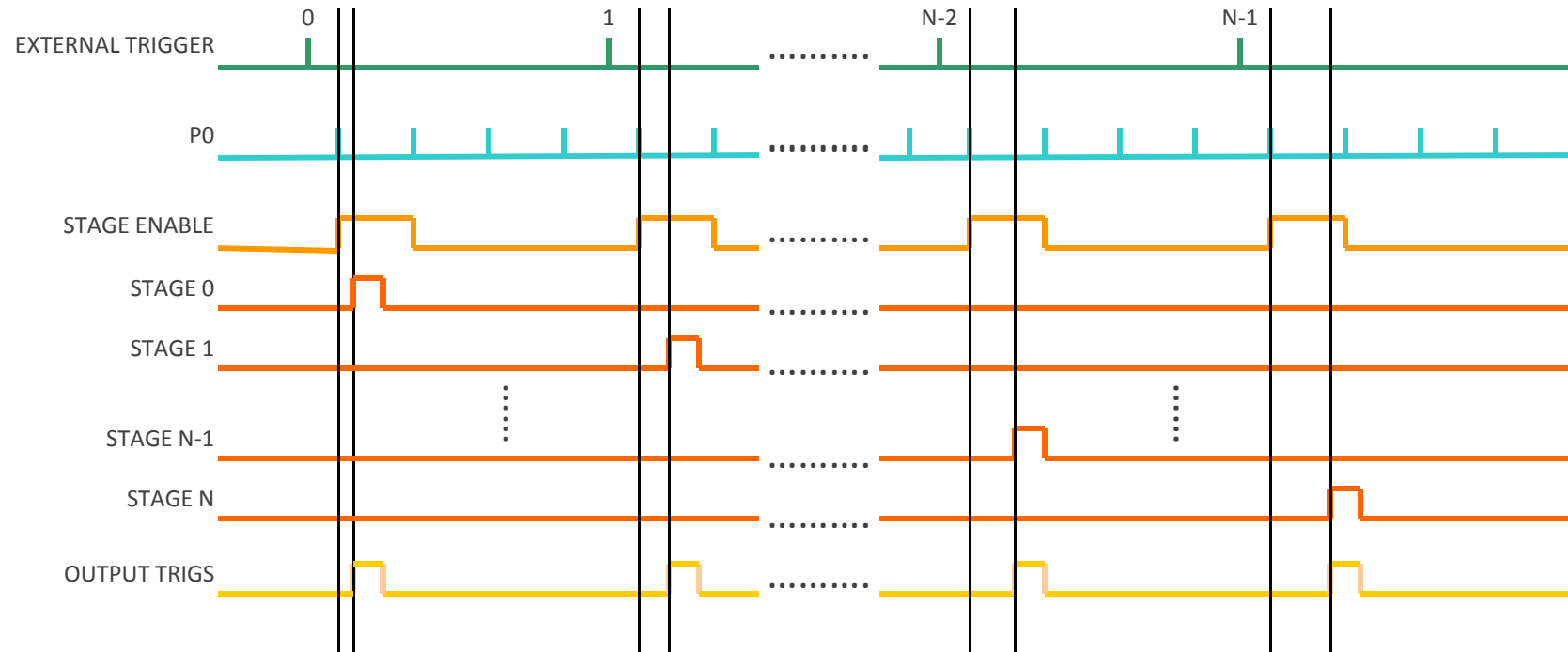
- P0 bunch intensity compensator
 - Trigger external DAQ for averaging
 - GEN-II generic digital
 - IO board (same as bunch scaler)
 - Standalone / mobile enclosure
 - ASYN driver
 - User configuration
 - Bunch window
 - # of stages
 - Trigger at bunch # for 1uS



P0 bunch intensity compensator



Applications, cont...



TIMING DIAGRAM FOR N=16