

# **Diagnostics Use Case for ATCA Based Fast Controller**

**Factory Acceptance Test (FAT) at DMCS (Poland)  
February 23-24, 2011**

# Outline

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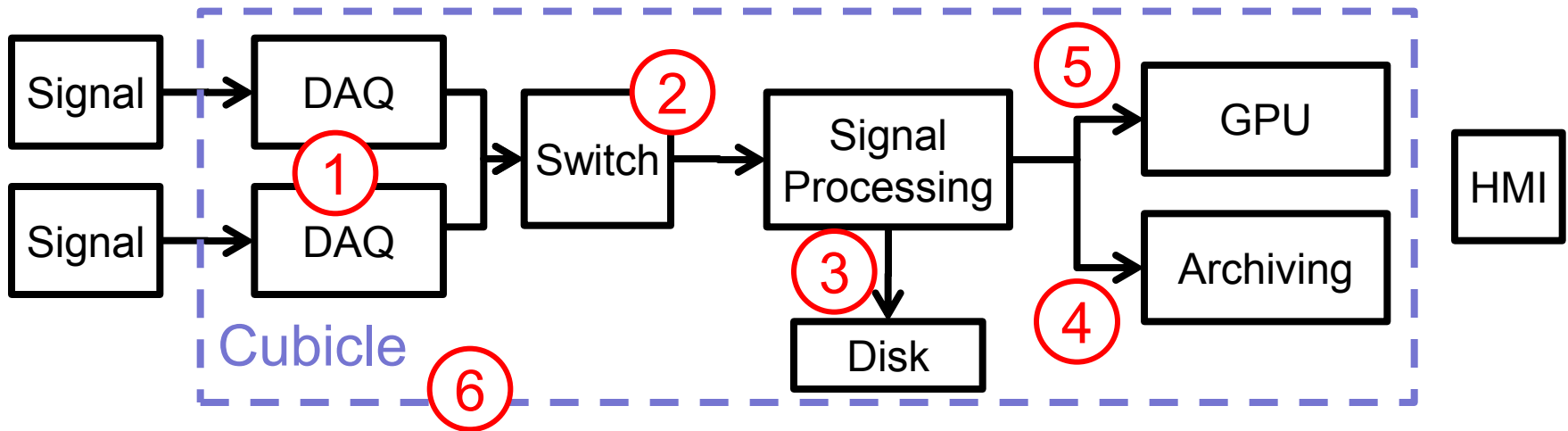
- **Diagnostics Use Case**
- **Factory Acceptance**
- **Products**
- **System Experience and Areas for Improvement**
- **Future Plans**

# Basic Diagnostic Needs for I&C

- Data Acquisition
  - 1 MS/s ADCs (16+ bit resolution, 10 ch.)
  - 100 MS/s ADCs (14+ bit resolution, 10 ch.)
  - 1 GS/s (12 bit resolution, 4 ch.)
  - (Digital) Frame Grabber for Cameras (full CameraLink)
- Signal Processing
  - FPGA
  - DSP
  - CPU
  - GPU
- Communication Links
  - PCI express (PCIe)
  - Gigabit Ethernet (GbE)

**Note: Covers most diagnostics fast controller needs**

# Simplified Diagnostics Use Case and Tasks



**Subtask 0** – Assembly of test stand (performed by ITER IO)

**Subtask 1** – Data acquisition with TAMC900 and GbE link to CPU on ATCA-7301

**Subtask 2** – 10 GbE communication link to ATCA CPU Blade (7360)

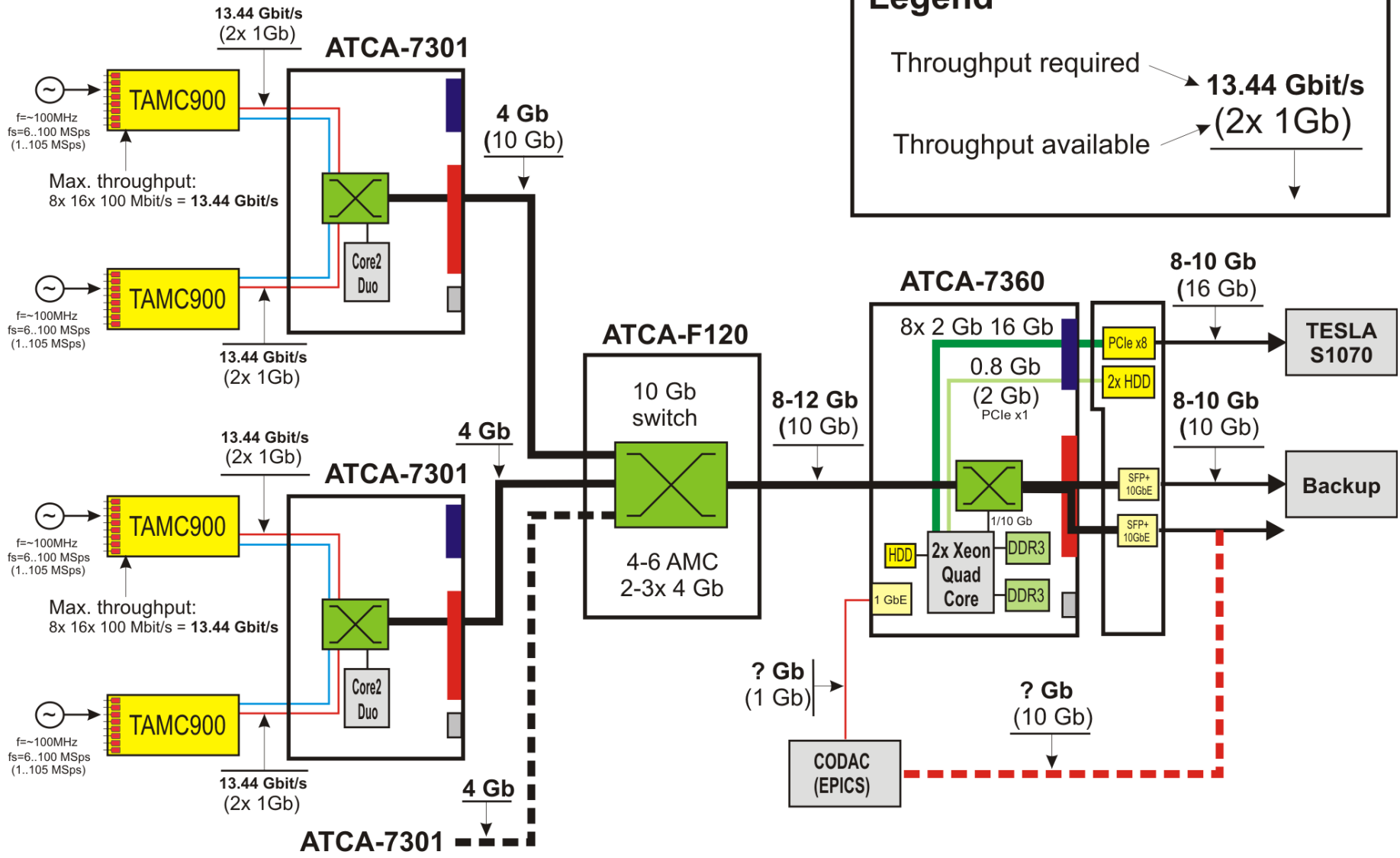
**Subtask 3** – Store data on RAID 0 on ATCA RTM

**Subtask 4** – 10 GbE uplink through ATCA-RTM

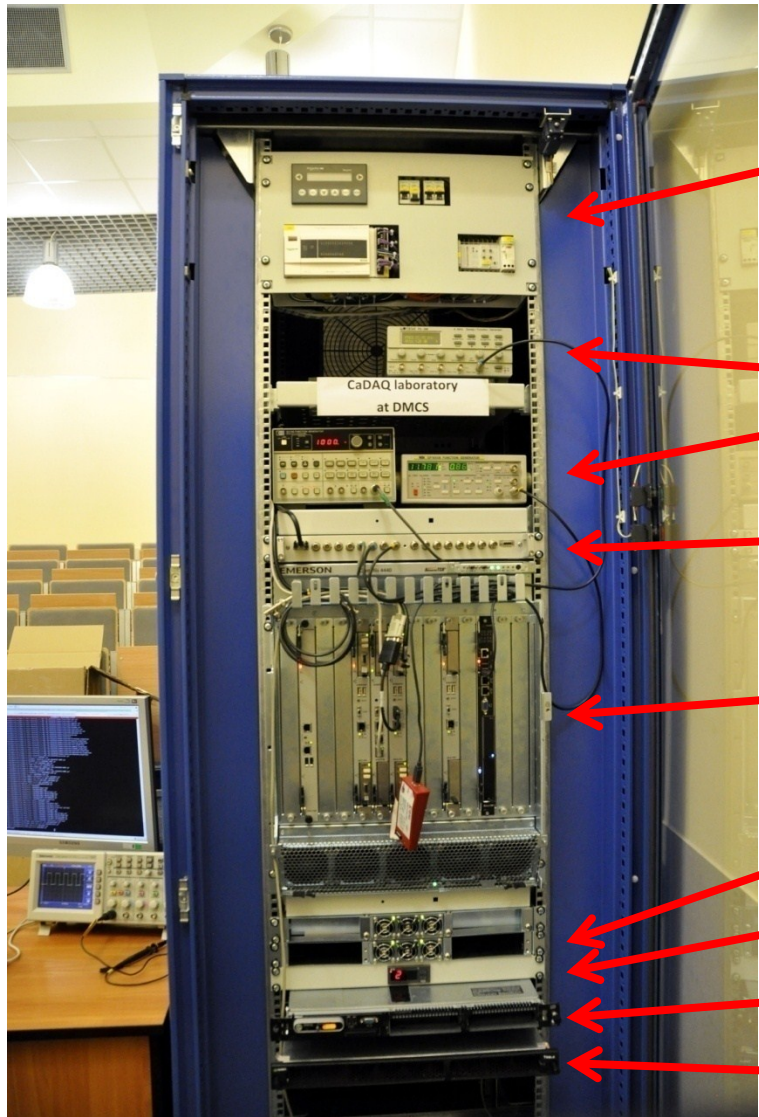
**Subtask 5** – PCI e (x8/x16) link to GPU

**Subtask 6** – Installation of ATCA fast controller in SAREL cubicle

# Diagnostics Use Case Details



# DAQ System Installed in SAREL Cubicle



Monitoring PLC

Signal Generators

Signal Converter

ATCA shelf

Redundant Power Supply

Thermometer

DB server

TESLA Blade

# Factory Acceptance : Agenda

## Thursday, 24 January

9:45 Introduction, A. Napieralski

**10:00 Overview (Hardware components), D. Makowski**

**10:15 Data Acquisition Communication Protocol, G. Jablonski**

**10:30 Firmware for TAMC900 DAQ Module, T. Kozak**

10:45 Coffee Break

**11:15 DAQ Server, A. Piotrowski**

**11:30 DAQ Database, M. Orlikowski**

**11:45 EPICS - Panels and Server, P. Predki**

12:00 Lunch

**14:00 DAQ System - Demonstration**

16:15 Coffee Break

16:45 Conclusions

17:30 End of Meeting

18:30 Dinner

## Friday, 25 January

9:30 System Performance Improvements

10:00 xTCA at DMCS - Hardware and Software Development

10:30 Plans for the Future, S. Simrock/P. Makijarvi

11:00 End of Meeting

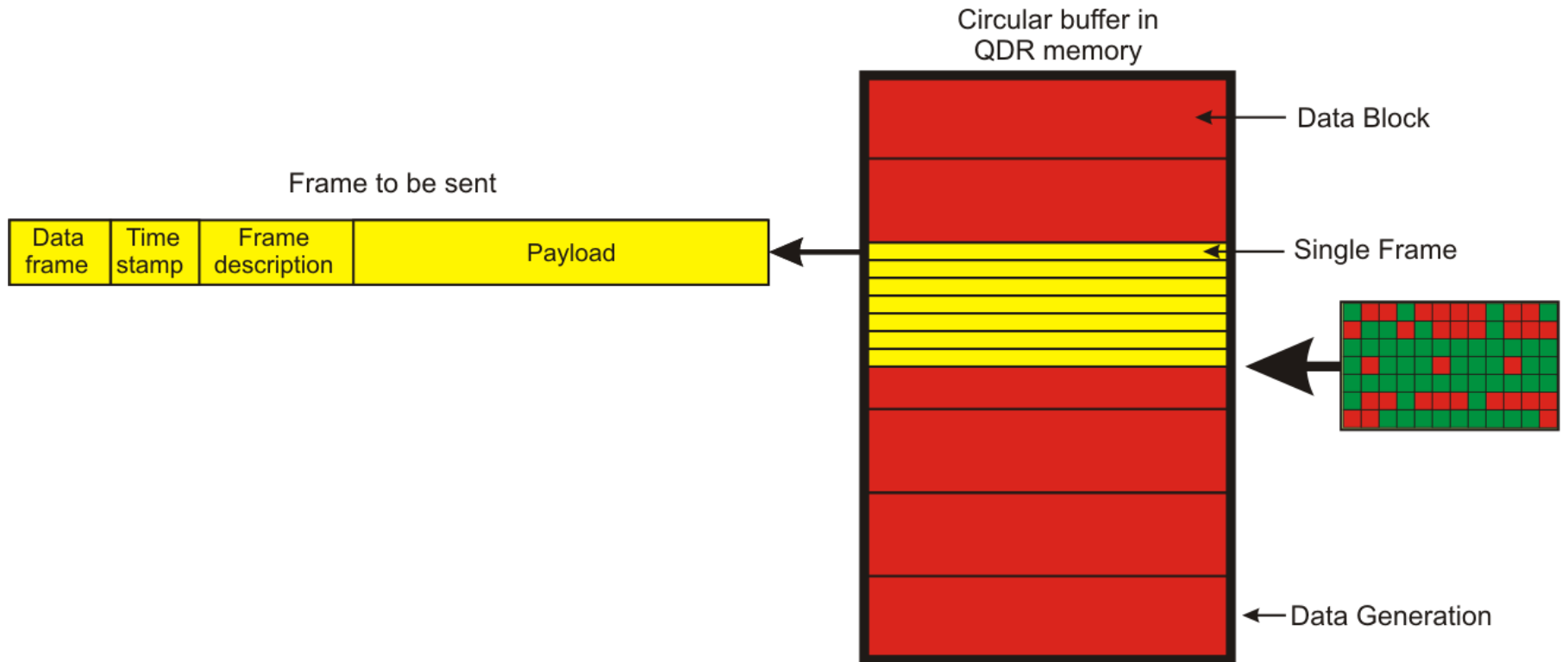
# Factory Acceptance : Lectures



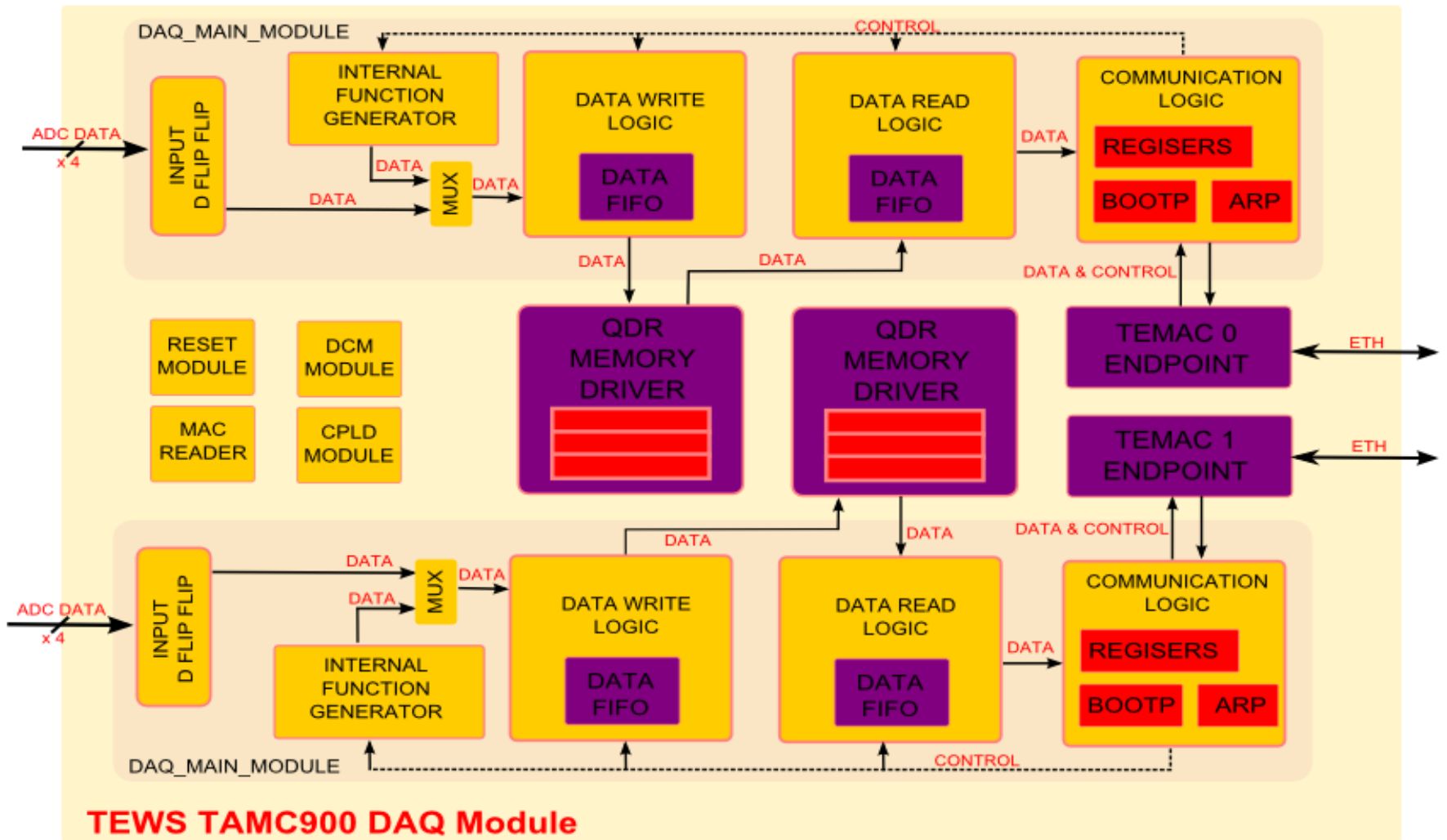


# Data Acquisition Communication Protocol

- Circular buffer divided into blocks
- Blocks divided into frames
- Data frame fits in a single UDP frame



# VHDL Code for Data Acquisition

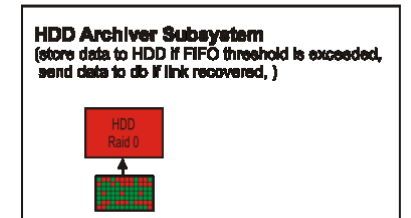
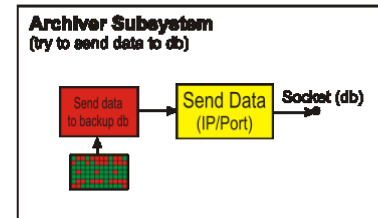
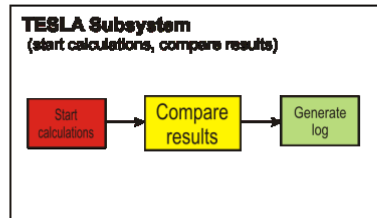
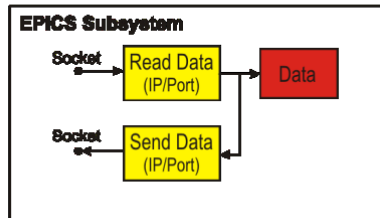
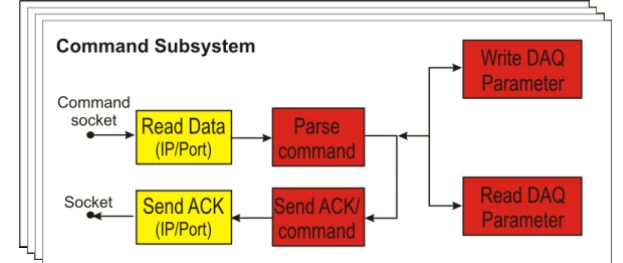
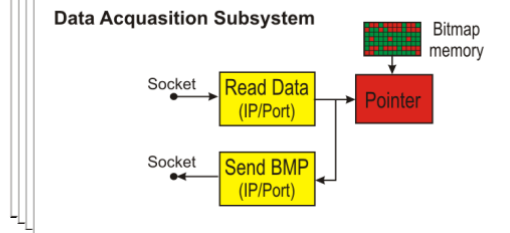
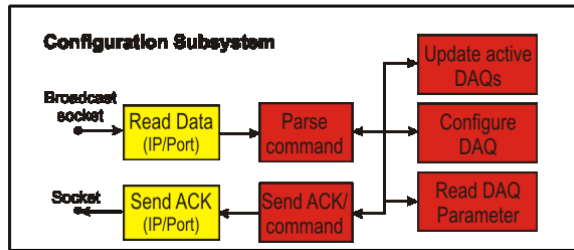


Developed by  
DMCS

Xilinx Core  
Generator

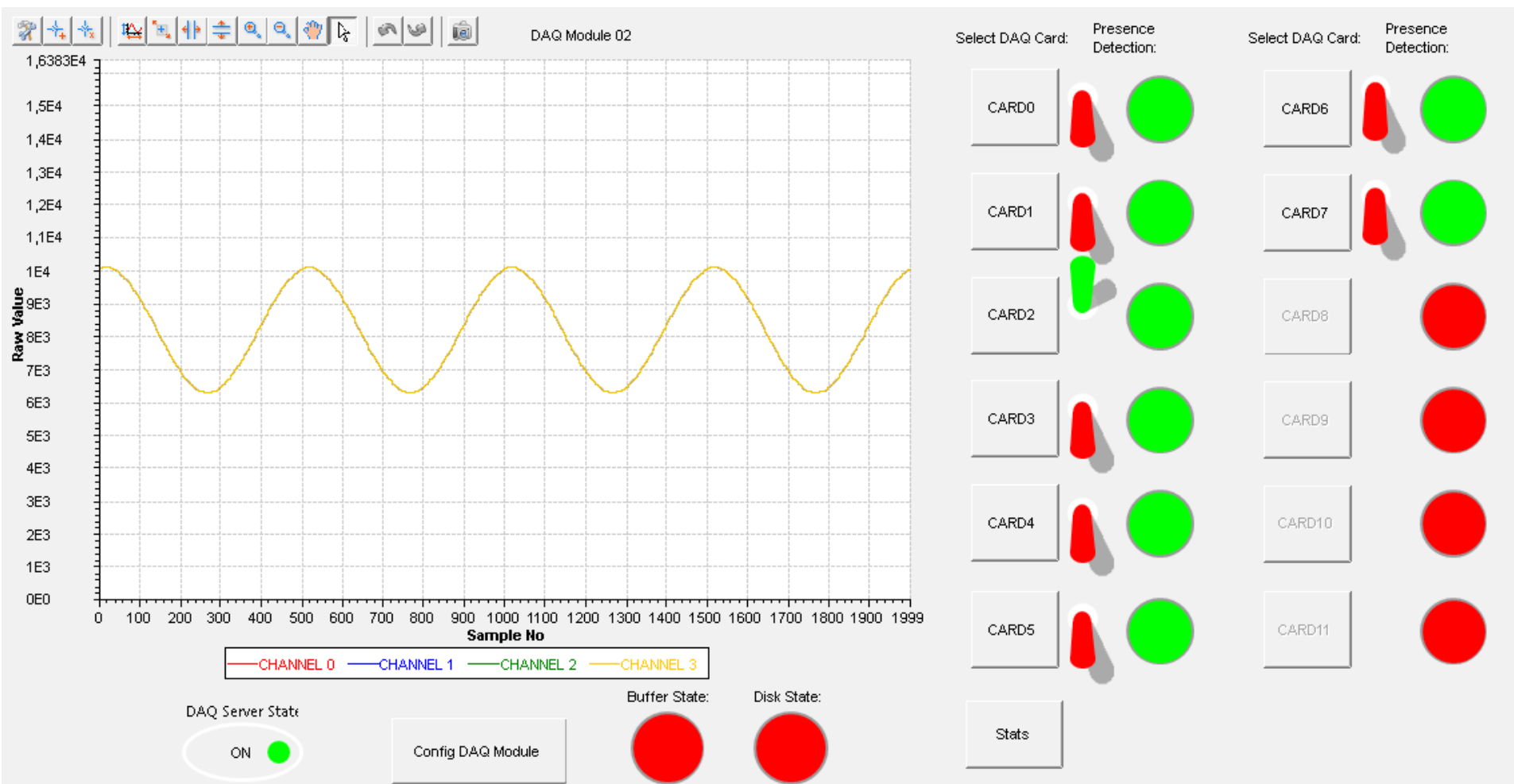
# Data Acquisition Server

## Separate for each client



# CODAC Core System Integration (1)

## CSS BOY Panels: Main Screen



# CODAC Core System Integration (2)

## BOY Screen: DAQ Setup

Viewing settings for Card 02.

DAQ Module IP Address 192.168.11.103

DAQ Module Port Number 24810

Number of Active Channels

4 Channels

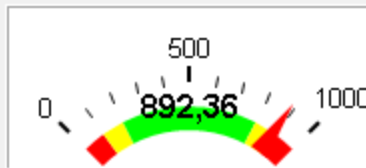
Sampling Freq

12.5 MHz

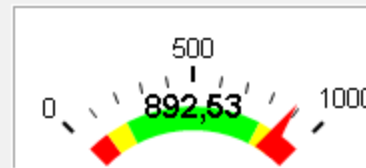
CRC CUDA Errors

0

Received Throughput Mbps



Avg Received Throughput Mbps



Sendto Throughput Mbps



Avg Sendto Throughput Mbps



Input signal for channel 0:

Sine wave

Input signal for channel 1:

Sine wave

Input signal for channel 2:

Sine wave

Input signal for channel 3:

Sine wave

Trigger Value

0 0 0 0 0



Trigger Value

0 0 0 0 0



Trigger Value

0 0 0 0 0



Trigger Value

0 0 0 0 0



Signal Amp Multiplier

15

Signal Amp Multiplier

15

Signal Amp Multiplier

15

Signal Amp Multiplier

15

Signal Phase Shift

0

Signal Phase Shift

0

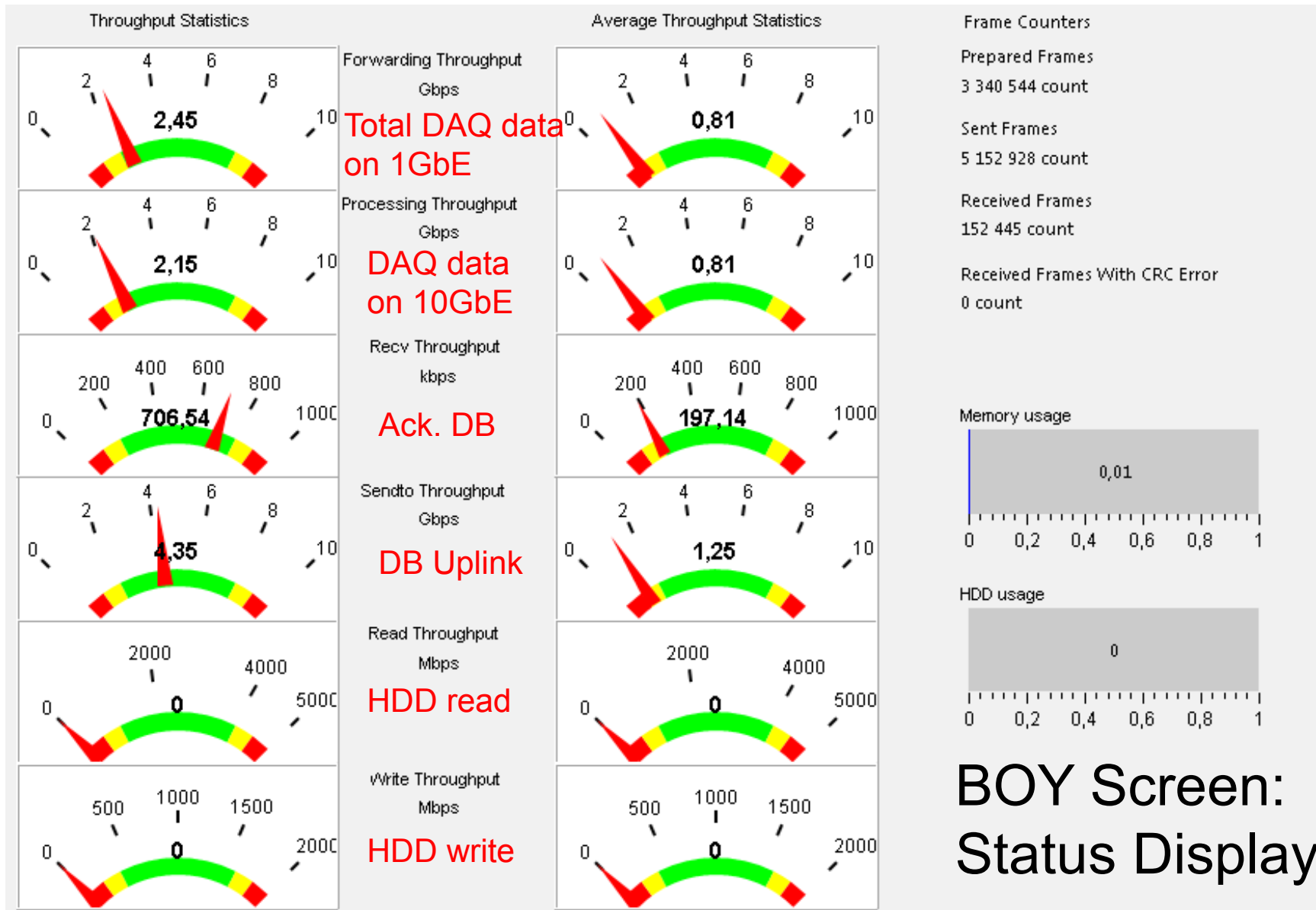
Signal Phase Shift

0

Signal Phase Shift

0

# CODAC Core System Integration (3)



## BOY Screen: Status Display

# Factory Acceptance: System Set-up



# Factory Acceptance : Testplan (1)

## DIAGNOSTICS USE CASE CHECKLIST FOR FAT

### SUBTASK 0. TEST STAND

|   |   |                          |
|---|---|--------------------------|
| <b>ATCA hardware</b>                          | <p>Check completeness of installed components:</p> <ul style="list-style-type: none"> <li>• ATCA 14-slot shelf: Emerson Network Power Centellis 4440 AdvancedTCA (1pc)</li> <li>• 10 Gb Ethernet switch blade: Emerson ATCA-F120 (1 pc)</li> <li>• DAQ module: TEWS TAMC 900 modules (2 pcs)</li> <li>• Carrier blade: Emerson ATCA-7301 (2 pcs)</li> <li>• CPU blade: Emerson ATCA-7360 (1 pc)</li> <li>• Computation blade: NVIDIA Tesla S1070 (1 pc)</li> <li>• External database server: DELL PowerEdge 1950 (1 pc, DMCS property)</li> <li>• Differential to single ended signal convertor (16 channels): developed by DMCS (1 pc)</li> <li>• ATCA power supply: Schroff 11098-282 (1 pc, DMCS property)</li> <li>• Function generator: f = 0..20MHz (2 pcs, DMCS property)</li> </ul> | <input type="checkbox"/> |
| <b>DAQ software</b>                           | <p>Check installed software and firmware:</p> <ul style="list-style-type: none"> <li>• DAQ firmware installed on TEWS TAMC modules (DAQ-firmware)</li> <li>• DAQ software installed on ATCA-7360 (DAQ-server)</li> <li>• Database software installed on DELL PowerEdge 1950 (DAQ-database)</li> </ul>   | <input type="checkbox"/> |
| <b>SUBTASK 1 DATA ACQUISITION (ATCA-7301)</b> |   |                          |
| <b>SUBTASK 2 DATA ACQUISITION (ATCA-7360)</b> |   |                          |
| <b>Hot-plug functionality</b>                 | <p>Verify hot-plug support for selected AMC-DAQ module. Deactivate/activate DAQ module and observe behaviour of EPICS panels. DAQ module should be recognised and activated. Start data acquisition and observe EPICS panels.</p>   | <input type="checkbox"/> |
| <b>Hot-plug functionality</b>                 | <p>Verify hot-plug support for selected AMC-DAQ module. Change location of selected DAQ module and observe behaviour of EPICS panels. DAQ module should be recognised and activated. Start data acquisition and observe EPICS panels.</p>   | <input type="checkbox"/> |



# Factory Acceptance : Testplan (2)

... parameters are configured using ...

| SUBTASK 3 DATA BUFFERING (SSD ON ATCA-7360-RTM) |   |                          |
|---|---|--------------------------|
| Data transmission                               | Verify transfer buffering with active 10 GbE uplink connection. Activate connection to external database. Check status of memory and hard disk buffers. | <input type="checkbox"/> |
| Data  | Verify transfer buffering with inactive 10 GbE uplink connection. Deactivate connection to external   | <input type="checkbox"/> |

| SUBTASK 4 DATA TRANSFER TO EXTERNAL DATABASE (VIA 10 GBE UPLINK) |  |                          |
|--|--|--------------------------|
| Data transmission  | Check connectivity between ATCA-7360 CPU blade and external data base (ping 10.1.3.137). | <input type="checkbox"/> |

| SUBTASK 5 DATA TRANSFER TO TESLA GPU (VIA PCIE) |   |                          |
|---|---|--------------------------|
| Data transmission                               | Check PCIe connectivity between ATCA-7360 CPU blade and TESLA GPU (e.g. <code>lspci   grep Tesla</code> ).    | <input type="checkbox"/> |
| Data  | Verify data transfer to GPU. Check data consistency, control sum correctness (CRC calculated on TESLA blade). | <input type="checkbox"/> |

| SUBTASK 6 INSTALLATION AT ITER CUBICLE |   |                          |
|--|---|--------------------------|
| Hardware installation                  | Verify correctness of hardware installation in ITER cubicle.  | <input type="checkbox"/> |
| Hardware                               | Verify correctness of cable installation. Verify cross-section of power cables for ATCA power supply. | <input type="checkbox"/> |

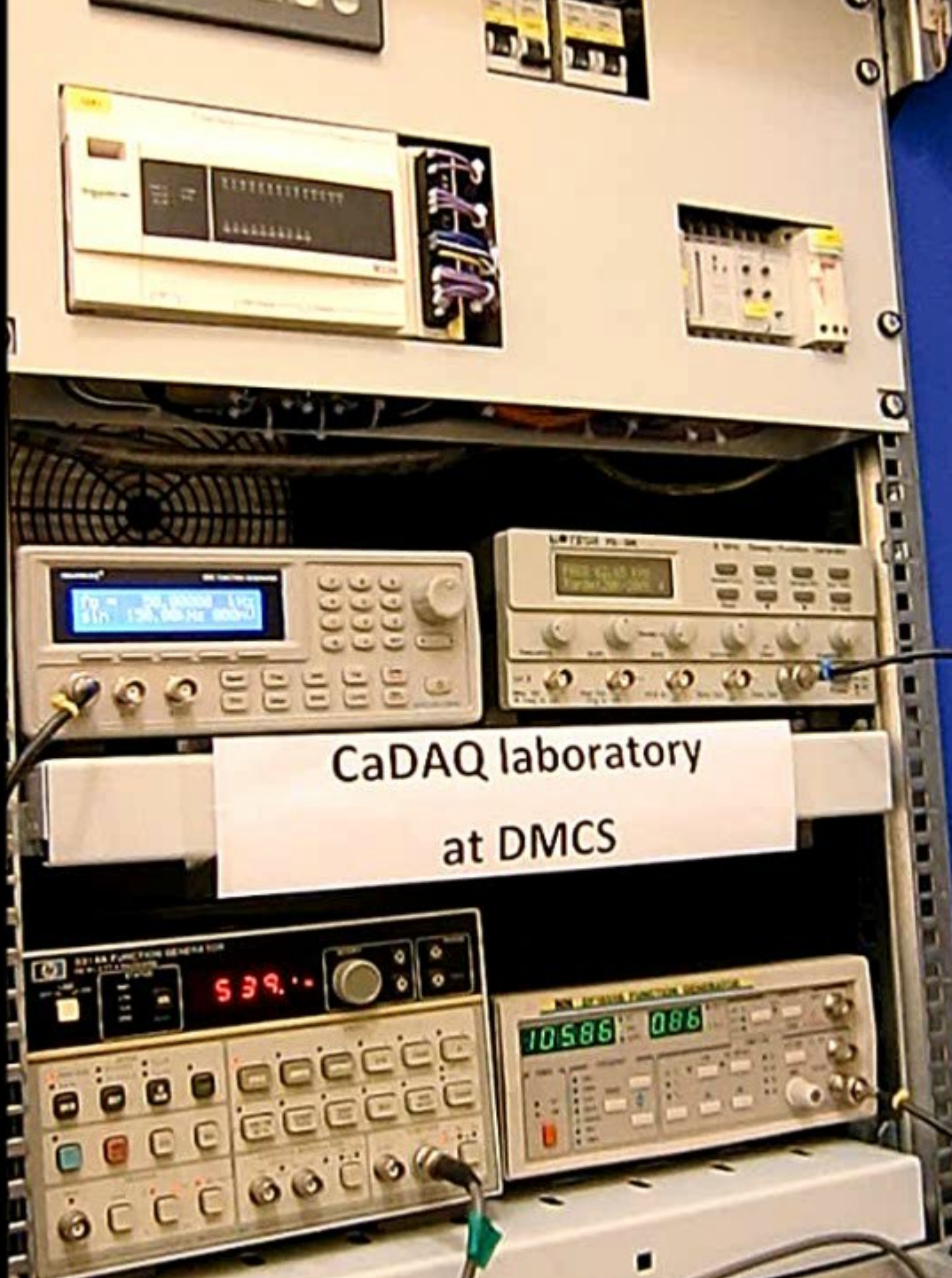
# Videos Clips

**01\_cubicle\_front.avi**  
**02\_cubicle\_front\_detail.avi**  
**03\_cubicle\_rear.avi**  
**04\_cubicle\_healt\_monitoring.avi**  
**11\_hot\_swap\_01.avi**  
**12\_hot\_swap\_02.avi**  
**21\_data\_capture\_setup\_multi\_channel.avi**  
**22\_data\_acquisition-4\_channel.avi**  
**23\_changing\_input\_signal.avi**  
**24\_trigger\_on\_input\_signal.avi**  
**25\_verify\_measured\_waveform.avi**  
**31\_disconnect\_archiving.avi**  
**32\_reconnection\_archiving.avi**  
**33\_buffering\_data\_01.avi**  
**34\_buffering\_dat\_02.avi**  
**41\_data\_rates.avi**  
**42\_dropped\_frames.avi**

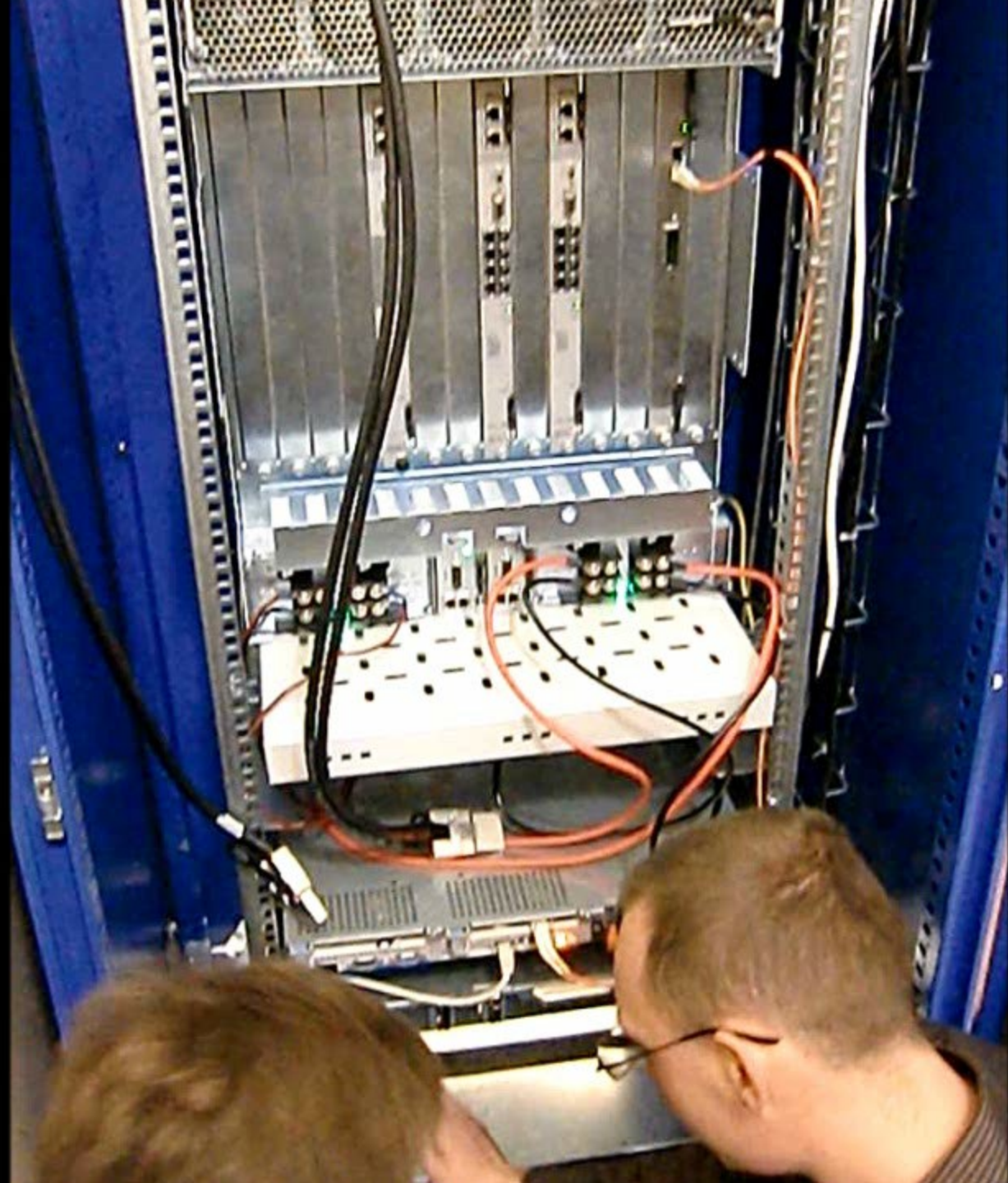


CaDAQ laboratory  
at DMCS

EMERSON



CaDAQ laboratory  
at DMCS



Schneider Electric

Magelis

← Temperature  
Current

0 0  
0 MA

ESC

DEL

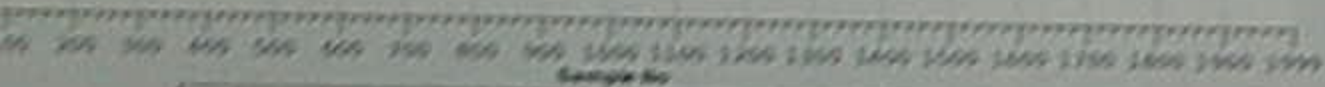


MOD

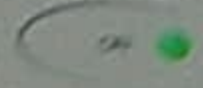
ENT

LEAD I  
 LEAD II  
 LEAD III  
 LEAD aVR  
 LEAD aVL  
 LEAD aVF  
 None

LEAD I  
 LEAD II  
 LEAD III  
 LEAD aVR  
 LEAD aVL  
 LEAD aVF  
 None



ECG Signal State



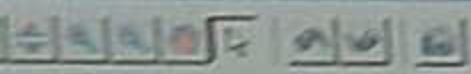
ECG Module

Buffer State

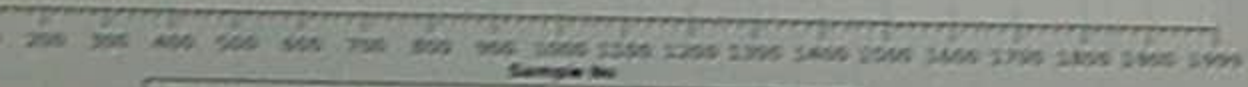


Gate State





DAQ Module 10



DAQ Server State  
 OK

Config DAQ Module

Buffer State

Disk State

Select DAQ Card

Proximal Detection

Select DAQ

CARD0



CARD1



CARD2



CARD3



CARD4



CARD5



None

CARD0

CARD1

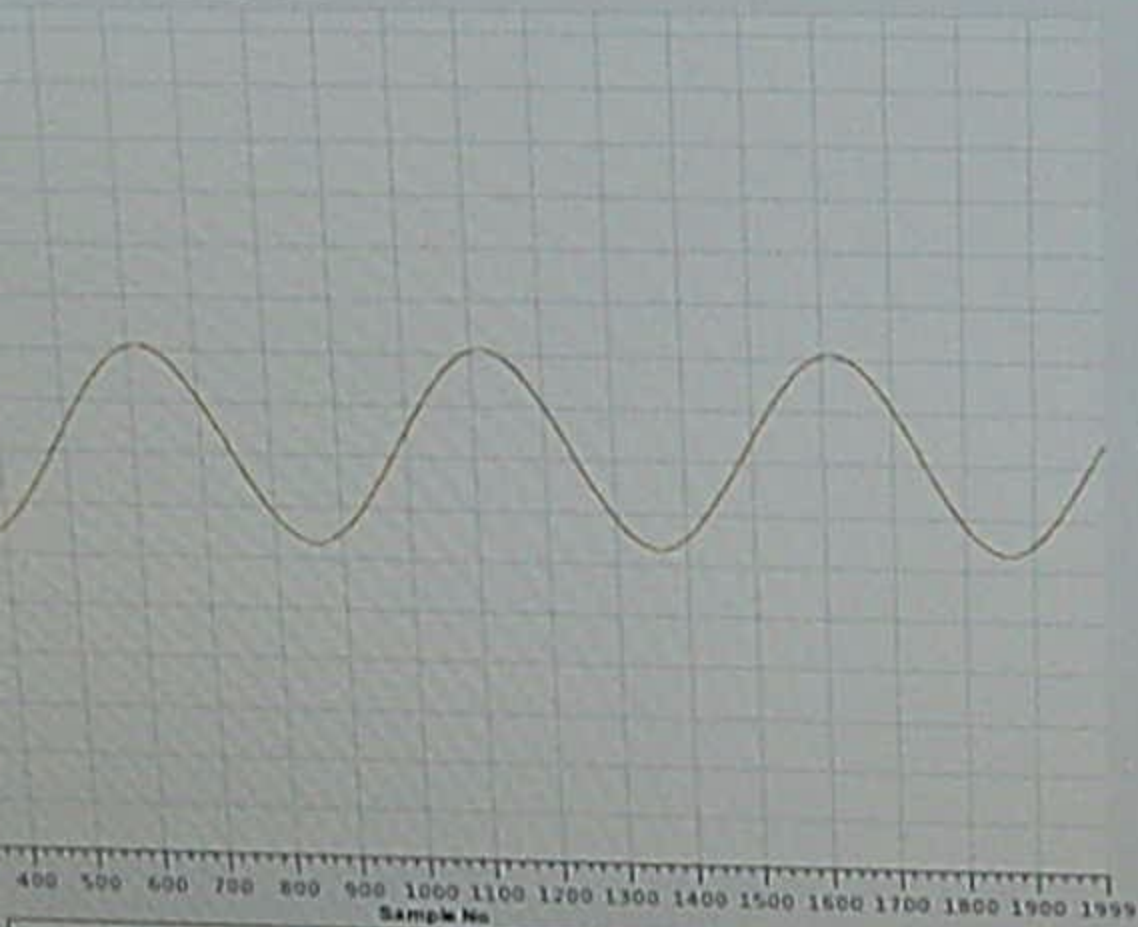
CARD2

CARD3

CARD4

CARD5





Power State

ON 

Config DAQ Module

Buffer State



Disk State



Select DAQ Card

Presence Detection

Select DAQ Card

CARD0



CARD6

CARD1



CARD7

CARD2



CARD8

CARD3



CARD9

CARD4



CARD10

CARD5

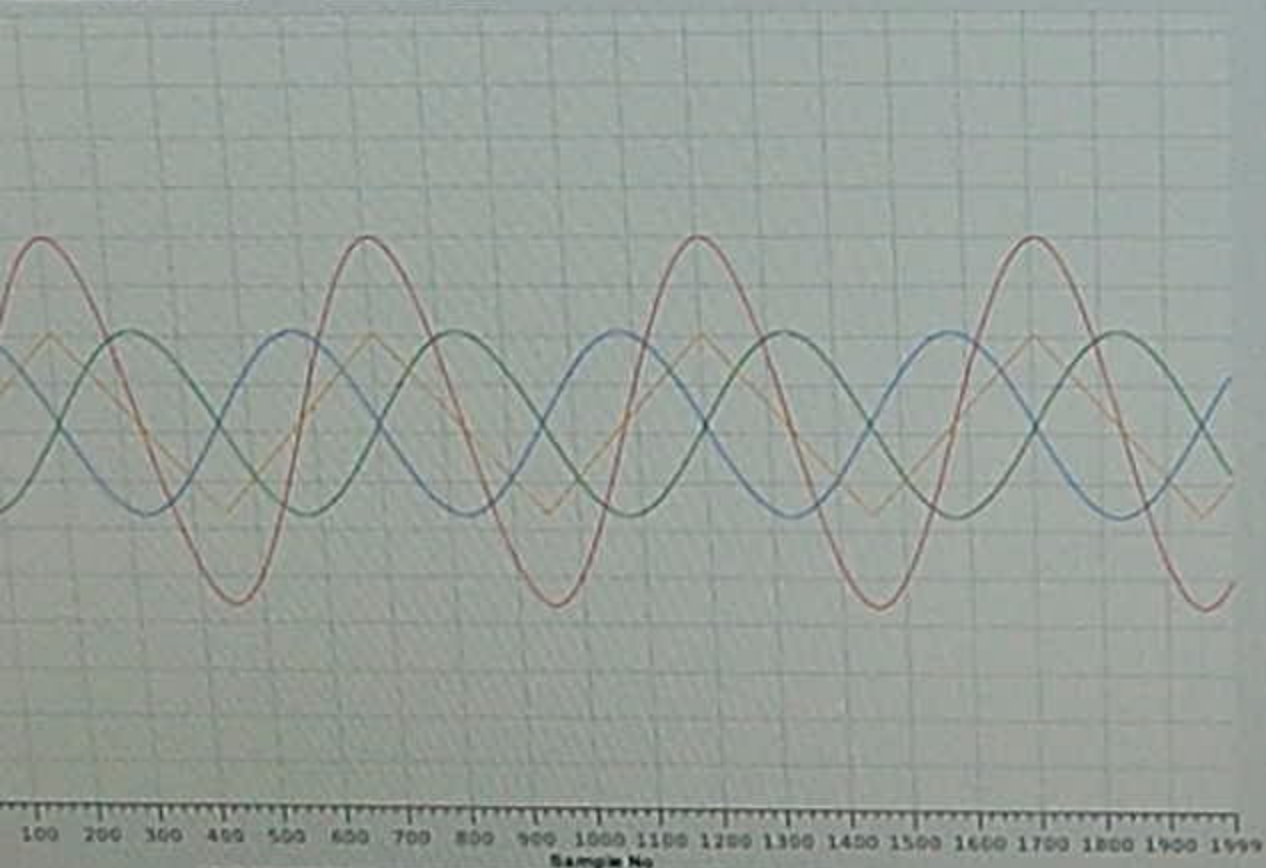


CARD11

State



\$(pv\_value)



| Select DAQ Card: | Presence Detection: | Select DAQ |       |
|------------------|---------------------|------------|-------|
| CARD0            |                     |            | CARD0 |
| CARD1            |                     |            | CARD1 |
| CARD2            |                     |            | CARD2 |
| CARD3            |                     |            | CARD3 |
| CARD4            |                     |            | CARD4 |
| CARD5            |                     |            | CARD5 |
| Stats            |                     |            |       |

DAQ Server State:

ON

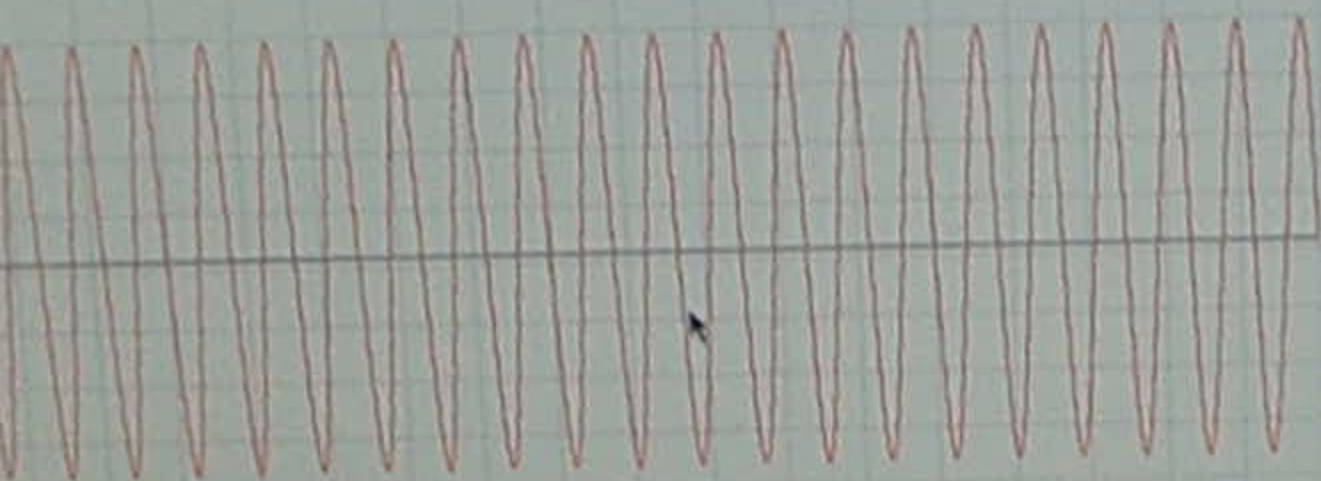
Config DAQ Module

Buffer State



Disk State





0 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 1999  
Sample No

— CHANNEL 0 — CHANNEL 1 — CHANNEL 2 — CHANNEL 3

DAQ Server State

OK



Config DAQ Module

Buffer State



Data State



CARD0



CARD1



CARD2



CARD3



CARD4



CARD5



State

192.168.11.102

24810

4 Channels

Sampling Freq

12.5 MHz

CRC/CUDA Errors

0

Mbps



Avg Sendto Throughput

Mbps



Received Throughput

Mbps



Avg Received Throughput

Mbps



channel 0

None

Input signal for channel 1:

None

Input signal for channel 2:

None

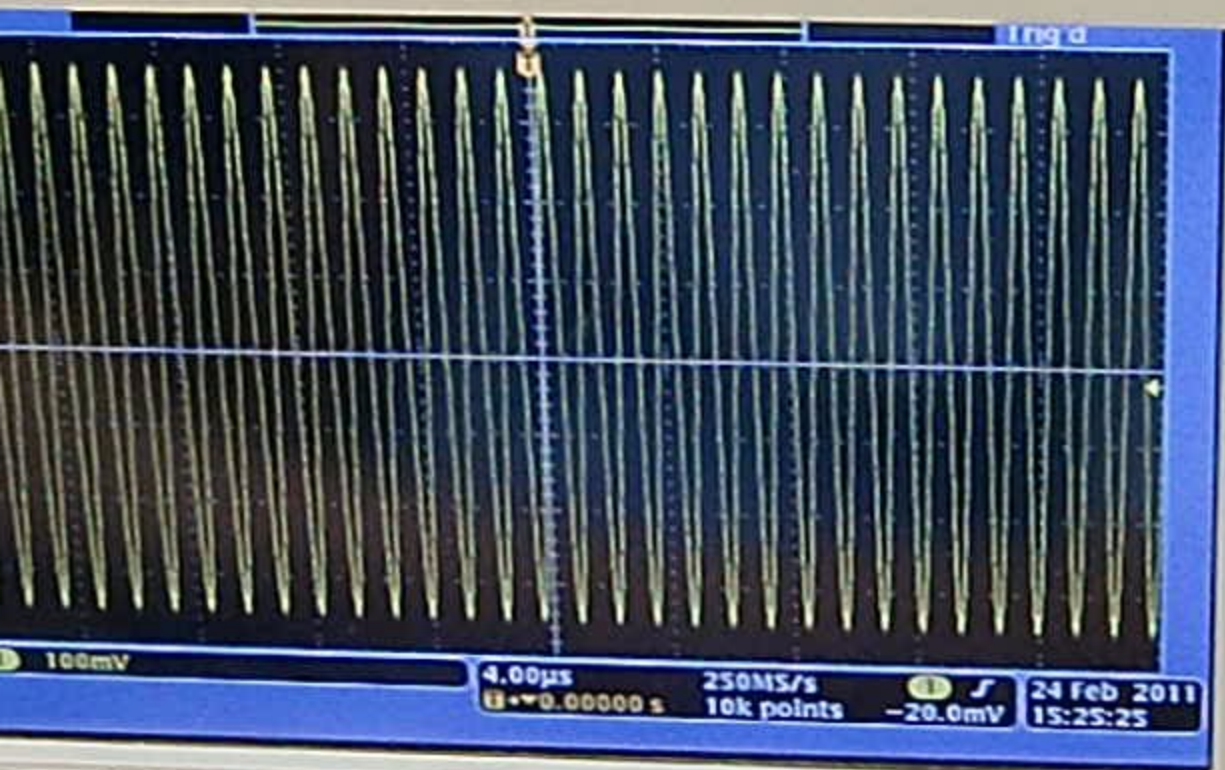
Input signal for channel 3:

Hardware input  
Sine wave  
Triangular wave  
Rectangular wave  
None



onix DPO 3034 Digital Phosphor Oscilloscope

300 MHz  
2.5 GS/s



Multipurpose



Cursors



Select

Fine

Intensity



Mult

Measure

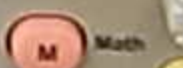
Search



Mark

Set Clear

Vertical Position



M Math



R Ref



B1 Bus



B2 Bus



1

2

Menu



Scale

1 MO, 11.5pF (300 Vmax CAT II, 50

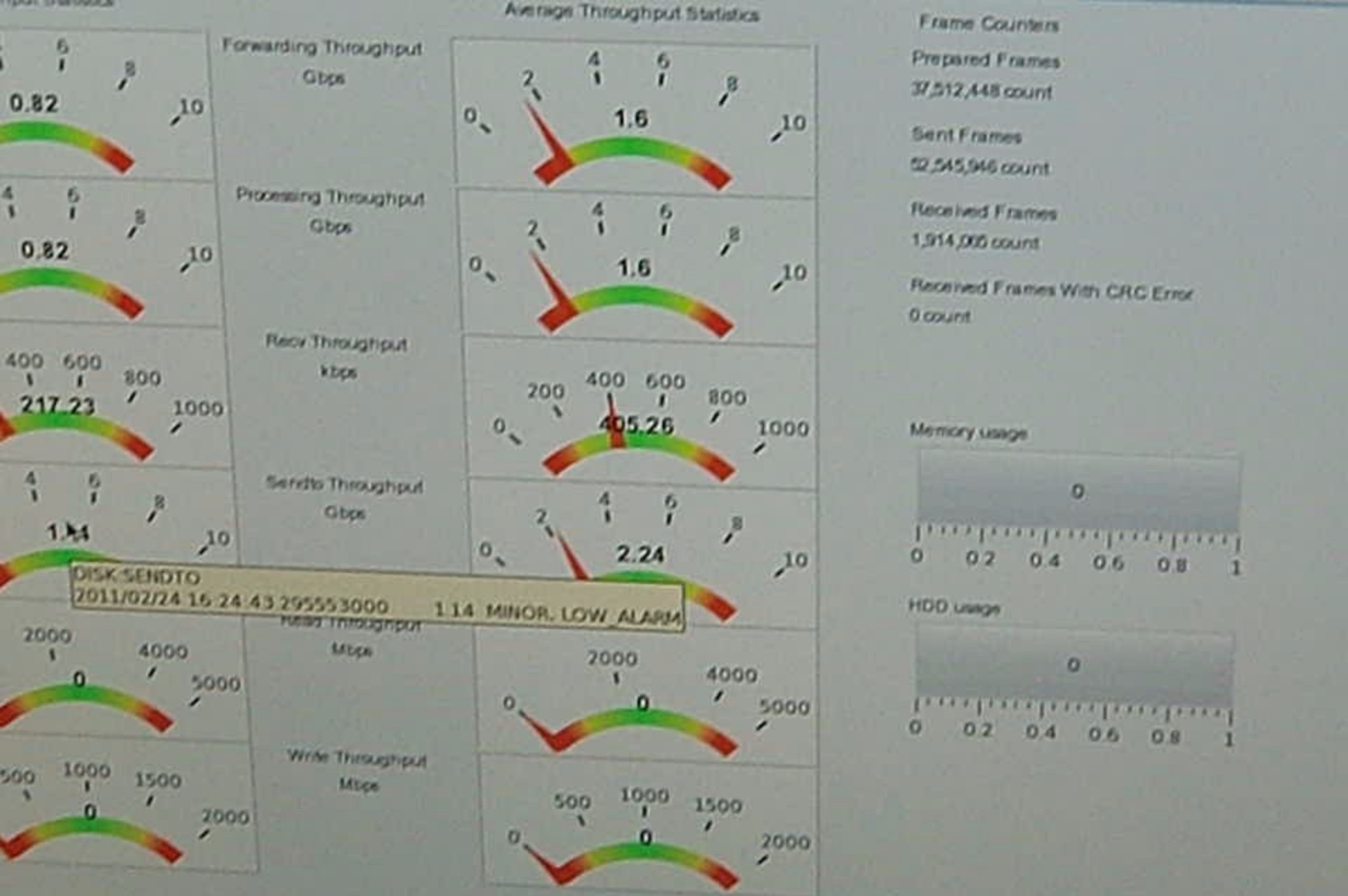


Save

Menu

Default Setup

Utility



## Average Throughput Statistics



Forwarding Throughput

Gbps

Processing Throughput

Gbps

Rx Throughput

Kbps

Tx Throughput

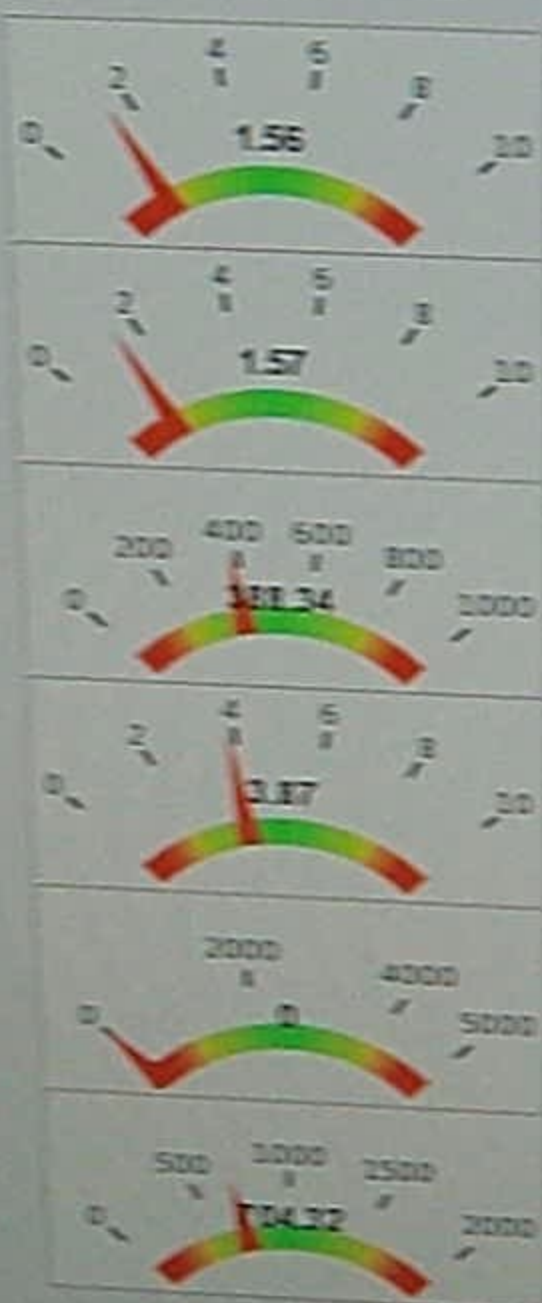
Gbps

Rx Throughput

Mbps

Tx Throughput

Mbps



Frame Counts

Prepared Frames

37,547,022 count

Sent Frames

94,814,289 count

Received Frames

1,312,775 count

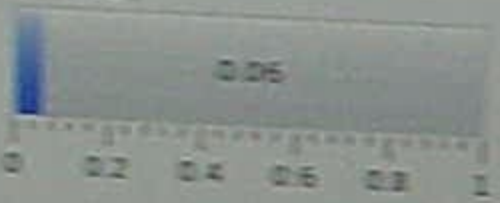
Received Frames With CRC Error

0 count

Memory usage



CPU usage





Prepared Panel  
 45 (45.00) count  
 Sent Panel  
 10 (10.00) count  
 Received Panel  
 2 (2.00) count  
 Received Panel With CRC Error  
 0 count





### Average Throughput Statistics



### Frame Counters

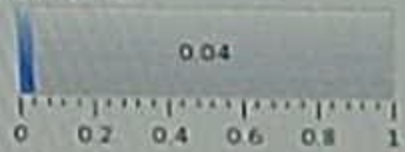
Prepared Frames  
200,998 count

Sent Frames  
2,660,816 count

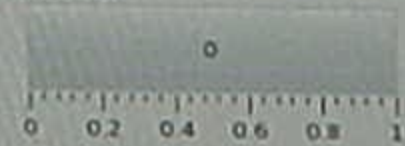
Received Frames  
9,832 count

Received Frames With CRC Error  
0 count

### Memory usage



### HDD usage



192.168.11.101

24810

4 Channels

Sampling Freq

12.5 MHz

CRC/CUDA Errors

0

Mbps

Avg Send Throughput

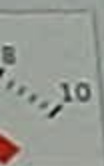
Mbps

Received Throughput

Mbps

Avg Received Throughput

Mbps



Input signal for channel 1

Sine wave

Trigger Value

|   |   |   |   |   |
|---|---|---|---|---|
| ▲ | ▲ | ▲ | ▲ | ▲ |
| 0 | 0 | 0 | 0 | 0 |
| ▼ | ▼ | ▼ | ▼ | ▼ |

Signal Amp Multiplier

15

Signal Phase Shift

0

Input signal for channel 2

Sine wave

Trigger Value

|   |   |   |   |   |
|---|---|---|---|---|
| ▲ | ▲ | ▲ | ▲ | ▲ |
| 0 | 0 | 0 | 0 | 0 |
| ▼ | ▼ | ▼ | ▼ | ▼ |

Signal Amp Multiplier

15

Signal Phase Shift

0

Input signal for channel 3

Sine wave

Trigger Value

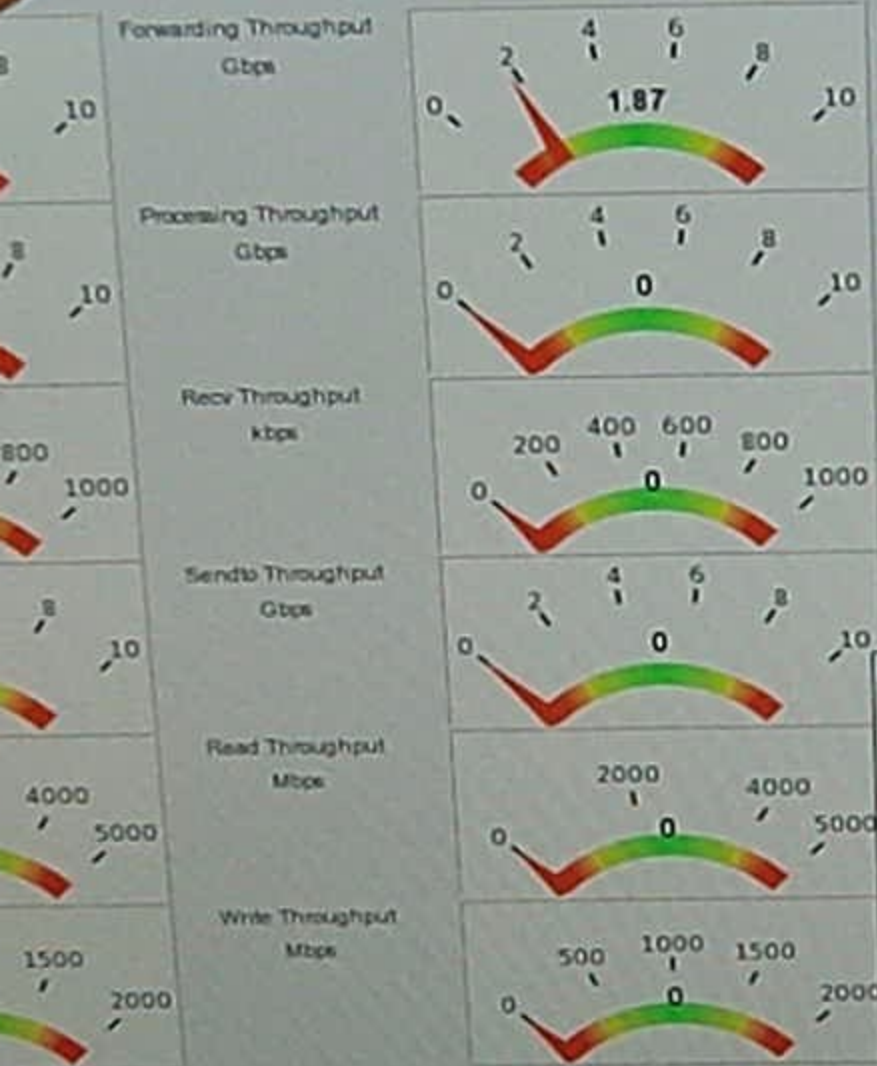
|   |   |   |   |   |
|---|---|---|---|---|
| ▲ | ▲ | ▲ | ▲ | ▲ |
| 0 | 0 | 0 | 0 | 0 |
| ▼ | ▼ | ▼ | ▼ | ▼ |

Signal Amp Multiplier

15

Signal Phase Shift

0



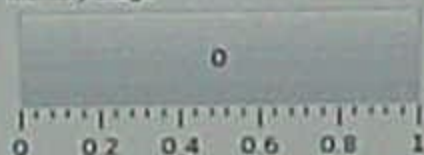
Prepared Frames  
0 count

Sent Frames  
0 count

Received Frames  
0 count

Received Frames With CRC Error  
0 count

Memory usage



codac-dev@7360:~/jmc-server/trunk

File Edit View Terminal Help

```
LOG_WARNING 2011-02-24 18:14:04 - Block dropped
LOG_WARNING 2011-02-24 18:14:05 - Block dropped
LOG_WARNING 2011-02-24 18:14:06 - Block dropped
LOG_WARNING 2011-02-24 18:14:07 - Block dropped
LOG_WARNING 2011-02-24 18:14:09 - Block dropped
LOG_WARNING 2011-02-24 18:14:10 - Block dropped
LOG_WARNING 2011-02-24 18:14:12 - Block dropped
LOG_WARNING 2011-02-24 18:14:13 - Block dropped
LOG_WARNING 2011-02-24 18:14:14 - Block dropped
LOG_WARNING 2011-02-24 18:14:15 - Block dropped
LOG_WARNING 2011-02-24 18:14:17 - Block dropped
LOG_WARNING 2011-02-24 18:14:18 - Block dropped
LOG_WARNING 2011-02-24 18:14:20 - Block dropped
LOG_WARNING 2011-02-24 18:14:21 - Block dropped
LOG_WARNING 2011-02-24 18:14:22 - Block dropped
LOG_WARNING 2011-02-24 18:14:23 - Block dropped
LOG_WARNING 2011-02-24 18:14:24 - Block dropped
LOG_WARNING 2011-02-24 18:14:25 - Block dropped
LOG_WARNING 2011-02-24 18:14:26 - Block dropped
LOG_WARNING 2011-02-24 18:14:27 - Block dropped
LOG_WARNING 2011-02-24 18:14:28 - Block dropped
LOG_WARNING 2011-02-24 18:14:29 - Block dropped
```

# Products

- **TAMC900 (8-channel ADC, 125 MHz, 16-bit)**
  - **Linux driver, EPICS device support**
  - **FPGA configuration, DAQ Server**
- **Data Flow Configuration**
  - **Configuration data**
- **Complete example system**
  - **All CODAC Core System Sources incl. HMI (to be packaged)**
  - **Hardware and software installation Instructions (for SAT)**
- **Understanding of potential and limitations of ATCA based DAQ system (FAT and SAT Reports)**
- **Ability to support deployment of products**

**NOTE: All software and configuration data in SVN**

**Installation/ Operation Manual and Performance data in IDM**

([https://svn.iter.org/codac/iter/codac/contracts/2011/DMCS\\_DAQ](https://svn.iter.org/codac/iter/codac/contracts/2011/DMCS_DAQ)).

The SVN includes three directories for the source files:

1.) ITER\_FCI\_AMC/

2.) amc-server/

3.) m-iterdaq/

# Issues Identified

1. TEWS MMC not compatible with ATCA/uTCA standard - problem with activation/deactivation, "communication lost" after longer time
2. Problem with ShM - connection via Ethernet cable not possible
3. Weak throughput of RAID SSD (max 160 MB/s for 64k block and 35 MB/s for 10k blocks, measured using `dd if=/dev/zero of=/dev/md0 bs=xx`). 8-channel ADC card provides 2 x 1 Gbit/s (i.e supports 125 MS/s for 16 bit data words).
4. Problem with activation/deactivation ATCA7301
5. Centellis 4440 shelf has problems with cooling when fan speed too low (<30 %)
6. Difficult debugging because of heavy load system
7. Lack of processing power on db server
8. No support for IPMI-shut down for OS on ATCA-7301/7360
9. Problem with low quality hot-swap latches and switches, not always are latched correctly and then the board is not activated
10. Difficult to make a professional installation inside Sarel cubicle, not cable rulers available
11. Problem with grounding in CaDAQ laboratory, suitable grounding point not available
12. Poor quality of hot-plug switches of ATCA carrier blades.

# Power Consumption

| SUB#   | QTY | SYMBOL                 | DESCRIPTION                              | NORMAL POWER [W] | MAXIMUM POWER [W] |
|--|-----|------------------------|--|------------------|-------------------|
| 1  | 1   | Sarel PLC              | Cubicle diagnostics                      | 28               | 38                |
| 2  | 2   | f=0-40 MHz             | Function generator                       | 2x25             | 2x25              |
| 3  | 2   | f=0-40 MHz             | Function generator                       | 2x25             | 2x25              |
| 4  | 1   | DMCS Convert 28        | Single ended-to-diff. signal converter   | 0                | 0                 |
| 5  | 1   | EMERSON Centellis 4441 | ATCA shelf                               | 120              | 275               |
| 5.1  | 1   | EMERSON ATCA-F120      | ATCA 10 GbE switch blade                 | 75               | 200               |
| 5.2  | 1   | EMERSON ATCA-7360      | ATCA computation blade                   | 180              | 260               |
| 5.3  | 2   | EMERSON ATCA-7301      | ATCA carrier blade                       | 2x 80            | 2x 150            |
| 5.4  | 4   | TEWS TAMC900           | 8 channel DAQ module                     | 4x 40            | 4x 40             |
| 5.5  | 1   | 004091-RTM7360-ITER1   | RTM with SDD, PCIe and 10 GbE uplink     | 35               | 50                |
| 6  | 1   | ASTECH HPS35-700       | Power supply unit (2x 1200 W/ 4x 1200 W) | 240              | 480               |
| 7  | 1   | Sarel NSYASTCRMT1UVTD  | Panel with digital thermostat            | 5                | 5                 |
| 8  | 1   | DELL PowerEdge 1950    | Computation blade                        | 665              | 800               |
| 9  | 1   | NVidia TESLA S1070     | Computation blade                        | 350              | 700               |
| 10   | 1   | Cubicle Fan (slow)     | Fan on rear doors                        | 42               | 42                |
| <b>Case 1+ (2) calc. : Power dissipation</b> |     |                        |  | <b>2160</b>      | <b>3410</b>       |
| <b>Total power</b>                           |     |                        |  | <b>2160</b>      | <b>3410</b>       |

Case 1+ (2) calc. : Power dissipation 2160 (3410) W Heating = 12 (19) °C

DMCS lab meas. : Operation temp. :30 C Ambient temp.: 23.5 C, Pd =1200 W

# Future Steps

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- Site acceptance test in May 2011
- Package software products with CODAC Core System
- Include hardware product in fast controller guidelines/catalog
- Add Camera Interface to DAQ System with full CameraLink
- Implement and evaluate Real Time on the DAQ System
- Add timing to DAQ System

# Documentation (in IDM)

<https://user.iter.org/?uid=46K92P>

## FAT - Reports

1. Functional Specification
2. System Installation
3. User Manual
4. Developers Manual
5. Final Report

## Presentations for FAT

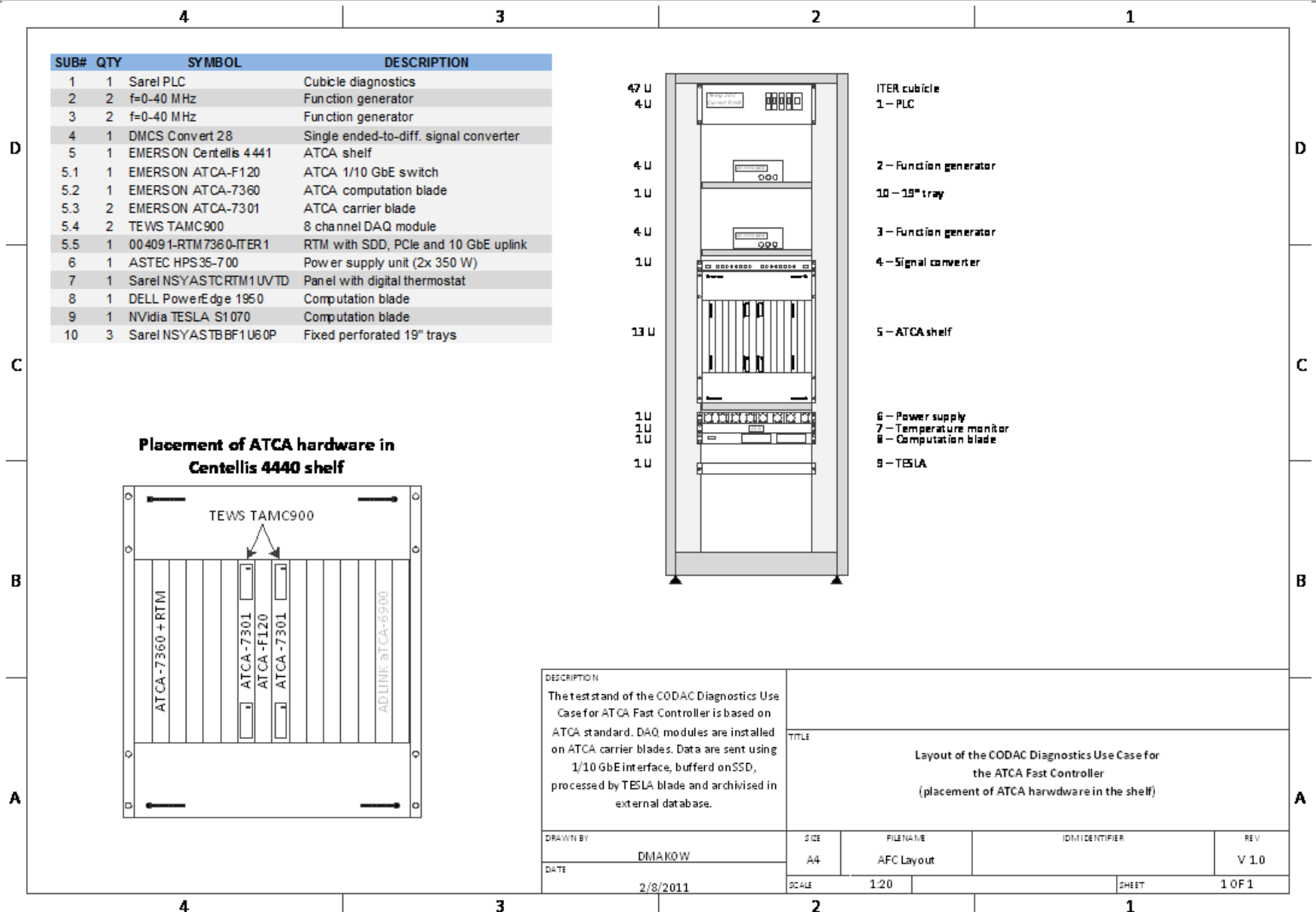
1. Data Acquisition Communication Protocol
2. Firmware for TAMC900 DAQ Module
3. DAQ Server
4. DAQ Database
5. EPICS - Panels and Server



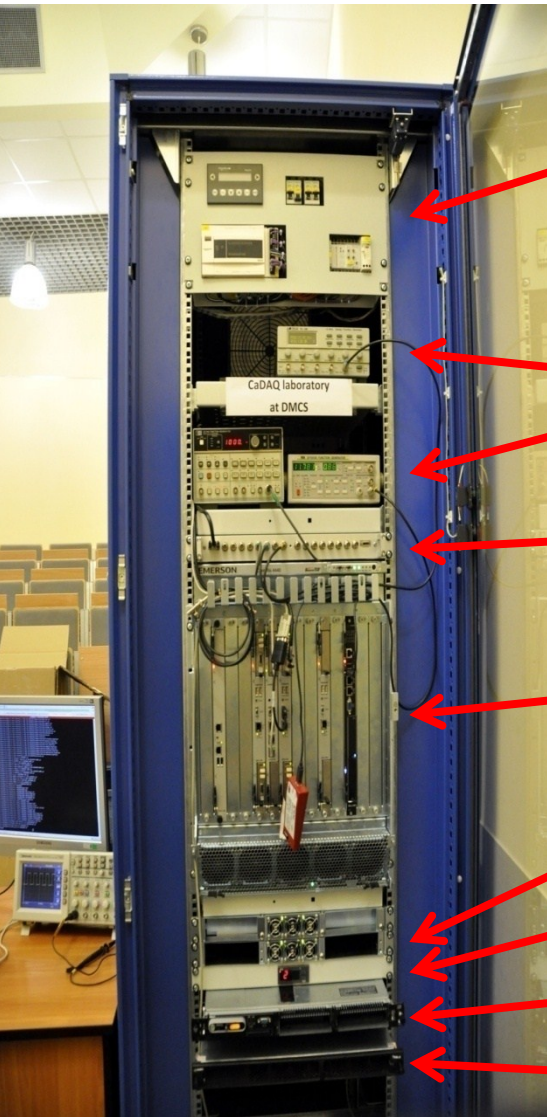
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# Back-up Slides

# Cubicle Layout



# DAQ System Installed in SAREL Cubicle



- Monitoring PLC
- Signal Generators
- Signal Converter
- ATCA shelf
- Redundant Power Supply
- Thermometer
- DB server
- TESLA Blade

