DCS User Requirements Document for TRD

Version 0 (12 July 2002)

1. INTRODUCTION

Here goes a short general introduction to My-Detector, maybe with a picture (< 1 page).

The TRD consist of 540 readout chambers organised in 18 Φ sectors (super-modules), each consisting of 6 layers in radial direction. Each layer is formed by 5 chambers. Each chamber is read out by 8 readout boards, each containing 16 multi-chip readout modules (MCM). Each module reads data from 18 pads. In total the TRD readout consist of 65k MCM reading 1.15M channels.

2. DESCRIPTION OF TRD

Here goes a more detailed description of My-Detector focussing of the equipment or elements to be controlled by the DCS, maybe with schematic drawings (< 2 pages).

- Each chamber has a DCS controller connected to MCMs via 4 DCS fast serial links running custom made communication protocol.
- On each readout board are 3 groups of voltage regulators. Two of them deliver the power for groups of 8 MCM, the third is used for data merger MCM and optical link.
- Each group has 3 regulators for analog 3.3V , digital 3.3V and digital 1.8V . Each group can be switched on/off by DCS.
- DCS controller on dedicated chambers will read also voltages on main power lines before the regulators and relative humidity.
- DCS controller will be connected to higher level of control system by Ethernet.
- In the top control layer will be used PVSS supervisory system.

3. THE CONTROL SYSTEM

Here goes a description of the control system clearly identifying the various sub-systems in the DCS of My-Detector (e.g. High Voltage, Low Voltage, Cooling System, etc.).
A schematic drawing of the hierarchy should be present (see below), also a more physical representation would be useful (indication of the location of equipment).

The control system TRD control system will consist of 5 subsystems:

- High Voltage control for drift HV and chamber readout HV.
- Low Voltage control with 3 main branches - LV main power supplies, DCS power supplies and LV regulation on chambers.
- Front End Electronics control monitoring and configuration of MCM modules.
- Gas system
- Cooling system

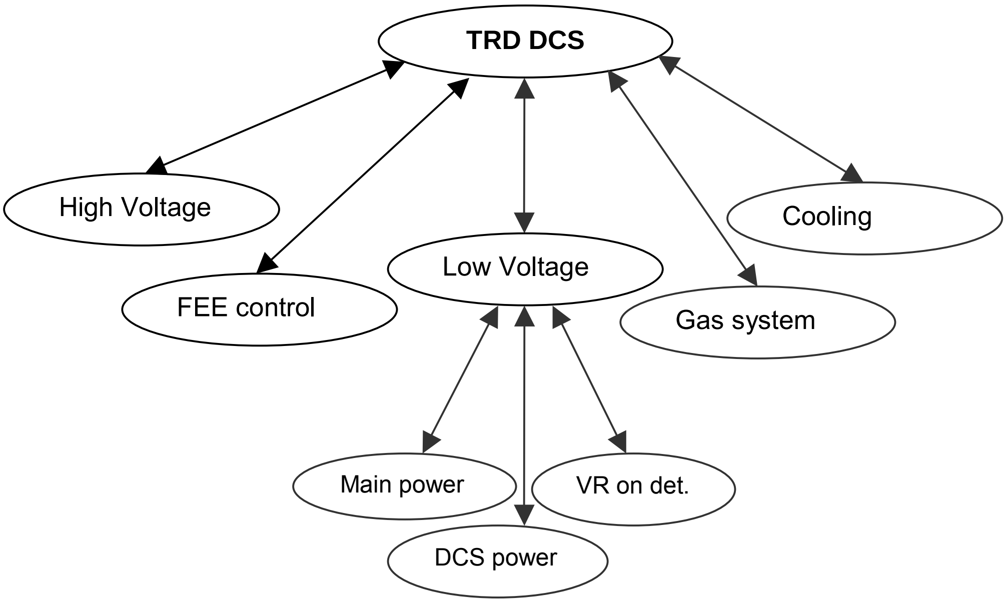


Figure 1: Global structure of TRD DCS

The first part (I) should hold all the information and requirements per sub-system.
The second part (II) should cover the information and requirements on the control system as a whole: interaction between the sub-systems, operational aspects of the control system. Typical sub systems are:
High Voltage (HV), Low Voltage (LV), DCS access to Front End Electronics (FEE), Cooling, Remote controlled equipment (e.g VME crates or other equipment, especially in the cavern), Alignment or calibration systems (Lasers, pulsers, motors etc.). Also the gas system should be covered; not so much the controls of the gas system (that will be handled by the Gas Working Group) but rather the interaction with the gas system controls.

I. DESCRIPTION AND REQUIREMENTS OF THE SUB-SYSTEMS

1) HIGH VOLTAGE

a) Functionality

The high voltage system delivers required voltages to the readout chambers. The required voltages and number of channels involved is listed below:

HV for drift field:	-3.5kV	40μA/chan.	540channels
HV for readout chamber:	+2.5Kv	40μA/chan.	540channels

b) Device or Equipment

Here goes a description of the device(s) or equipment to be controlled that make up the sub-system. It should at least list the following items:

Location:
HV power supplies will be located in UX25 and PX24.

Documentation:
List (links to) documentation of the device or equipment to be controlled.

c) Parameters

Control parameters apply for one channel, for HV module or for the whole HV crate.

Parameters of the individual channel:

Output:

1. set state on/off
2. set voltage
3. set software voltage limit
4. set software current limit
5. set ramp-up rate

6. set ramp-down rate
7. set action on trip (kill, enable ,disable)
8. add channel to group
9. remove channel from group
10. save configuration

Input:
1. read channel status
2. read voltage
3. read current
4. read software voltage limit
5. read software current limit
6. read ramp-up rate
7. read ramp-down rate
8. read channel group number

Parameters of the HV crate:
Output:
1. set state on/off for all channels in crate
2. emergency cutoff
3. reset communication

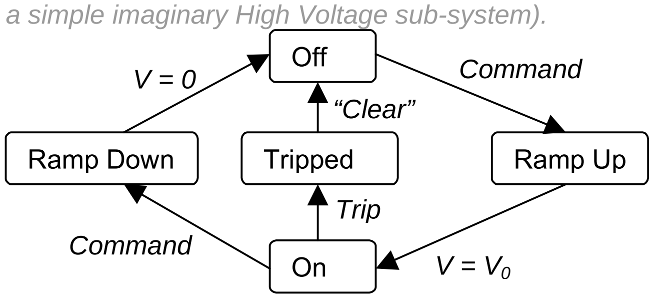
Input:
1. read crate identifier
2. read bit rate
3. read CAN message configuration
4. read list of HV modules currently installed
5. read status of HV modules currently installed

Parameters of the HV module:
Output:
1. set state on/off
2. emergency cutoff
3. voltage fine adjust on/off
4. save configuration

Input:
1. read voltages and temperature
2. read general module status (ramping state, safety loop on/off, fine adjustment on/off, voltage supplies in/out of range)
3. HV current limit exceeded
4. voltage limit exceeded

d) Interlocks and Safety aspects
If an over-current is detected, the corresponding voltage will be ramped down at a pre-set rate. Operation of the HV system will be interlocked in case of cooling water leak.

e) Operational and Supervisory aspects
Here goes a description of all aspects related to operation of the sub-system, its behaviour, constraints, etc. It should also describe the errors and alarms that can be generated in the sub-system. A state diagram would be helpful (see below an example for a simple imaginary High Voltage sub-system).



Here should also go the requirements of the supervisory layer of the sub-system. This could cover: a list of parameters to be archived (with archiving rate or deadband), ideas on user interfaces, ideas on what events should be logged (commands, errors etc.).

2) LOW VOLTAGE

a) Functionality

The low voltage system delivers required voltages to readout modules (MCM). Power is delivered from main power supply to readout boards, where is regulated by 3 groups of low-drop regulators. Each group of regulators serving 8 regular MCM of 1 data merging MCM can be switched on/off. Each MCM measures all internal voltages and currents, MCM row closest to voltage regulators measures output voltage of regulators. Required voltages on main power supply and on readout board and number of involved channels are listed below:

Analog	4.3V	3.3V	(preamplifier)	108 channels	38A/channel
Digital1	3V	1.8V	(ADC,core)	108 channels	?
Digital2	4.3V	3.3V	(I/O)	108 channels	?
DCS	7V	6V	(DCS)	108 channels	10A/channel

b) Device or Equipment

Following signal description is based on assumption, that the Wiener PL500 series power supplies will be used.

Location:

Main power supplies will be located in UX25, local voltage regulators on readout boards.

Documentation:

List (links to) documentation of the device or equipment to be controlled.

c) Parameters

Parameters apply for:

- Single LV channel
- LV crate
- Chamber
- MCM

Parameters for single channel (of main power supply):

Output:

1. set module name
2. set current limit
3. monitoring U_{min}
4. monitoring U_{max}
5. monitoring I_{max}
6. OVP (?)
7. set output voltage
8. save configuration

Input:

1. read module name
2. read module status
3. read operating time
4. read temperature
5. read current limit
6. read max. current
7. monitoring U_{min}
8. monitoring U_{max}
9. monitoring I_{max}
10. OVP
11. read output voltage
12. read max. voltage read channel status

Parameters for LV crate:
Output:
1. switch on/off
2. trip off on error on/off

Input:
1. read crate status (power on/off, external inhibit, power fail, any error, fans broken, trip off if fans are broken, trip off if err. is disabled)
2. read fan speed
3. read temperatures

Parameters for chamber:
Output:
1. switch voltage regulator group (0..23) on/off – emergency
2. power for MCM on/off - regular startup

Input:
1. status of voltage regulator groups (0..23)
2. read voltages before regulators (dedicated chambers)
3. read voltages after regulators for group (0..23)
4. read internal voltages on all MCM
5. read internal currents in all MCM
6. read temperature of all MCM
7. read relative humidity (selected chambers)
8. read V_{DCS}

Parameters for MCM:
Output:
1. switch to standby mode on/off

Input:
1. read V_{analog}
2. read $V_{digital1}$
3. read $V_{digital2}$
4. read I_{analog}
5. read $I_{digital1}$
6. read $I_{digital2}$
7. read temperature
8. read standby mode on/off

d) Interlocks and Safety aspects

LV power supplies will be interlocked in case of cooling water leak or failure of the cooling system.

e) Operational and Supervisory aspects

Here goes a description of all aspects related to operation of the sub-system, its behaviour, constraints, etc. It should also describe the errors and alarms that can be generated in the sub-system.
Here should also go the requirements of the supervisory layer of the sub-system. This could cover: a list of parameters to be archived (with archiving rate or deadband), ideas on user interfaces, ideas on what events should be logged (commands, errors etc.).

3) FEE CONTROL

a) Functionality

Control of the FEE consist of setting up MCM, configuration, checking the status of MCM, temperature measurement, setting/reading of user defined I/O on MCM and reading of the user (DCS) ADC. DCS ADC of MCMs closest to the voltage regulators will read output voltage of regulators. Configuration consist of code down-loading to 4 LTU processors on the MCM, configuration of MCM registers, loading the pedestals and zero suppression thresholds. As additional option the event data can be loaded or read via the DCS link for debugging purposes. The preamplifier input can be pulsed.

b) Device or Equipment

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Location:
MCM modules are placed on the detector.
Documentation:
List (links to) documentation of the device or equipment to be controlled.

c) Parameters

Signals for each MCM:
Output:

1. switch to standby mode on/off
2. configure MCM
3. load pulser pattern
4. load memory content
5. start code in LTU processor
6. write to user I/O
7. start pulsing
8. load pedestals
9. load zero supression thresholds

Input:

1. read MCM temperature
2. read user ADC
3. read pulsing pattern
4. read pedestals
5. read zero suppression thresholds
6. read memory
7. read user I/O
8. read MCM status
9. read exceptions

Signals for controller:
Output:

1. reset
2. configure via JTAG
3. compress data on/off

Input:

1. controller status

d) Interlocks and Safety aspects

MCM operation will be interlocked in case of overheating or power malfunction. Interlocks in LV power system will also terminate the activity of MCM.

e) Operational and Supervisory aspects

Here goes a description of all aspects related to operation of the sub-system, its behaviour, constraints, etc. It should also describe the errors and alarms that can be generated in the sub-system.
Here should also go the requirements of the supervisory layer of the sub-system. This could cover: a list of parameters to be archived (with archiving rate or deadband), ideas on user interfaces, ideas on what events should be logged (commands, errors etc.).

4) GAS SYSTEM

a) Functionality

Gas system is using close loop circulation. It will be built using the standard LHC gas system units. System delivers Xe - CO_2(85%, 15%) mixture necessary for operation of TRD chambers with overpressure 1mbar and circulation flow 5m^3/h. To reduce influence of hydrostatic pressure is the system segmented to 18 individually pressure regulated sections. DCS will interact with regulation units by setting the parameters and reading the status and alarms.

b) Device or Equipment

.

Location:
Gas supplies, mixer, purifier and recovery system will be placed in SGX2, re-circulation unit in PX24 on plug and temperature, flow and pressure gauges on the detector.
Documentation:
List (links to) documentation of the device or equipment to be controlled.

c) Parameters

Parameters for each section:
Output:
1. set flow Xe
2. set flow CO_2
   (or set composition, set total flow)
3. compressor on/off
4. set compressor speed
5. Xe tank heating on/off
6. Xe tank temperature set
7. vacuum pump on/off
8. set overpressure
9. set gas temperature in detector

Input:
1. get Xe flow
2. get CO_2 flow
3. get composition
4. get compressor status (on/off, speed)
5. get Xe tank status (heating on/off, pre-set temperature, temperature)
6. get vacuum pump status on/off
7. get gas flow in detector
8. get gas temperature in detector (inlet, outlet)

d) Interlocks and Safety aspects

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e) Operational and Supervisory aspects

Here goes a description of all aspects related to operation of the sub-system, its behaviour, constraints, etc. It should also describe the errors and alarms that can be generated in the sub-system.
Here should also go the requirements of the supervisory layer of the sub-system. This could cover: a list of parameters to be archived (with archiving rate or deadband), ideas on user interfaces, ideas on what events should be logged (commands, errors etc.).

5) COOLING

a) Functionality

TRD cooling system needs to remove large amount of heat (75kW during Pb-Pb operation and 105kW during p-p operation). Large part of the heat is generated inside the super-modules. Cooling system uses under-pressure leak-less system LCS2 developed by CERN/ST/CV.

b) Device or Equipment

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Location:
System will be placed in UX 25, RB 26, each of the 18 sectors will be supplied and controlled independently. Pressure (flow) regulators will be kept outside the L3 magnet to avoid use of special equipment. Cooling liquid is kept in tank at the lowest point of the system 30 m from L3 magnet.
Documentation:
List (links to) documentation of the device or equipment to be controlled.

c) **Parameters**
Parameters for each section:
Output:
1. cooling on/off
2. set temperature on which should be kept electronics
3. set max flow

Input:
1. get water temperature at detector input
2. get water temperature at detector output
3. get water flow
4. get max flow
5. get under-pressure
6. get system status

input from services:

7. get temperature of primary cooling water
8. get status of primary cooling

d) **Interlocks and Safety aspects**
LV power will be interlocked in case of cooling failure. Interlock will be implemented on 3 levels: soft interlock via PVSS and hard interlock via DCS controller (reacting on sudden increase of MCM temperature).Ultimate power interlock will be implemented in voltage regulators having the overheat shutdown feature.

e) **Operational and Supervisory aspects**
Here goes a description of all aspects related to operation of the sub-system, its behaviour, constraints, etc. It should also describe the errors and alarms that can be generated in the sub-system.
Here should also go the requirements of the supervisory layer of the sub-system. This could cover: a list of parameters to be archived (with archiving rate or deadband), ideas on user interfaces, ideas on what events should be logged (commands, errors etc.).

II. REQUIREMENTS ON THE CONTROL SYSTEM

The following aspects should be covered, related to the control system as a whole.

a) **Interlocks and Safety aspects**
Here goes a description of the interlocks that can be received or generated. Describe their nature (hardwired, software). Describe also interaction with equipment outside of My-Detectors responsibility.

b) **Operational and Supervisory aspects**
Here goes a description of all aspects related to operation of (the control system of) My-Detector, its behaviour, constraints, etc. It should also describe the errors and alarms that can be generated in My-Detectors control system. A state diagram would be helpful.
Here should also go the requirements of the supervisory layer of the control system as a whole. This could cover: ideas on user interfaces, ideas on what events should be logged (commands, errors etc.).

4. SYSTEM SCHEMATICS

On following figures is schematically illustrated how will be implemented four DCS rings on the chamber (see Figure 2), distribution of clock, trigger and voltage regulator control signals (see Figure 3), detailed architecture of the DCS communication (see Figure 4) and preliminary component layout of the DCS TTC board on which will be implemented DCS controller (see Figure 5).

DCS COMMUNICATION RINGS

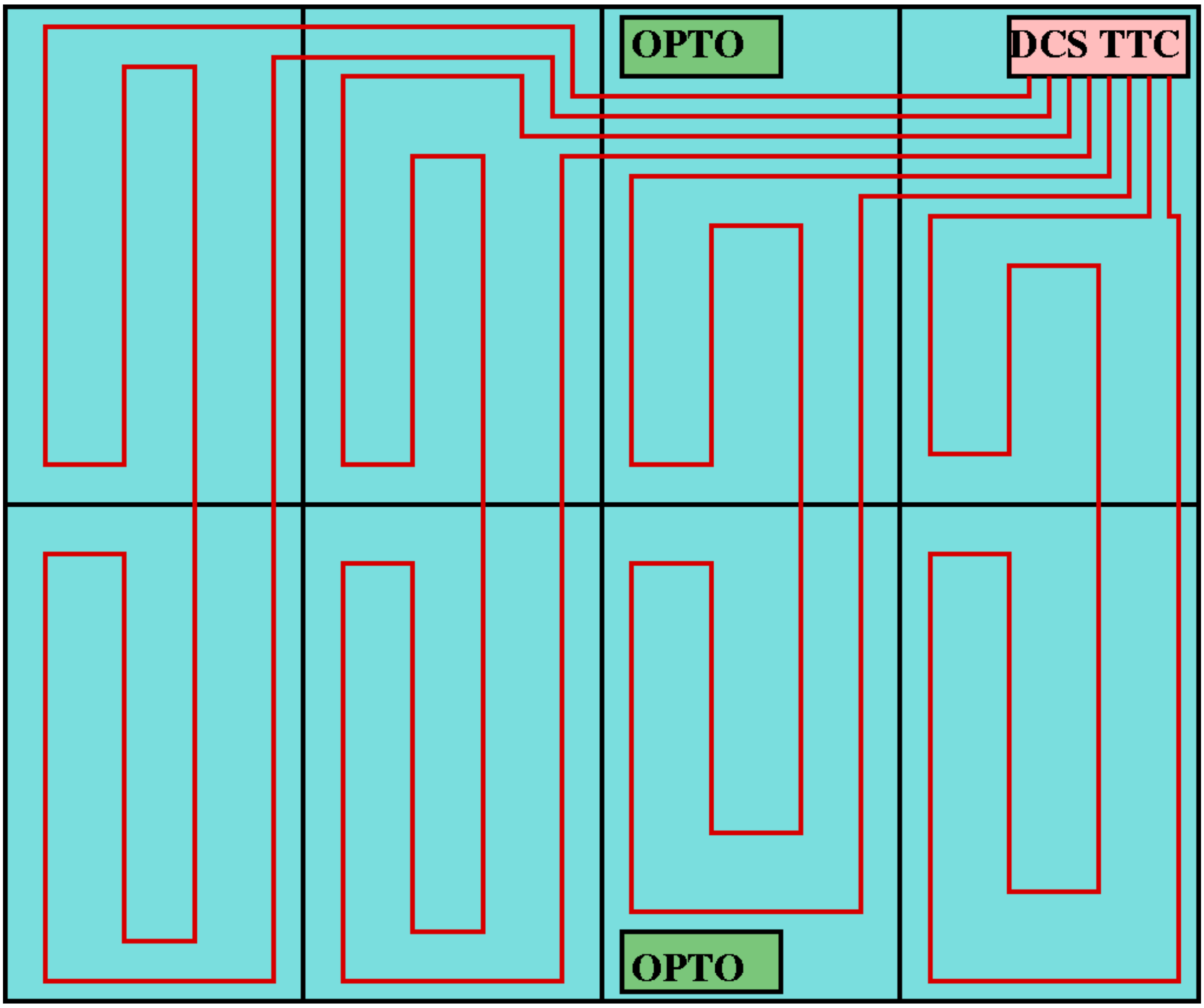


Figure 2: Schematic DCS communication on the chamber

VOLTAGE REGULATOR CONTROL & CLOCK AND TRIGGER DISTRIBUTION

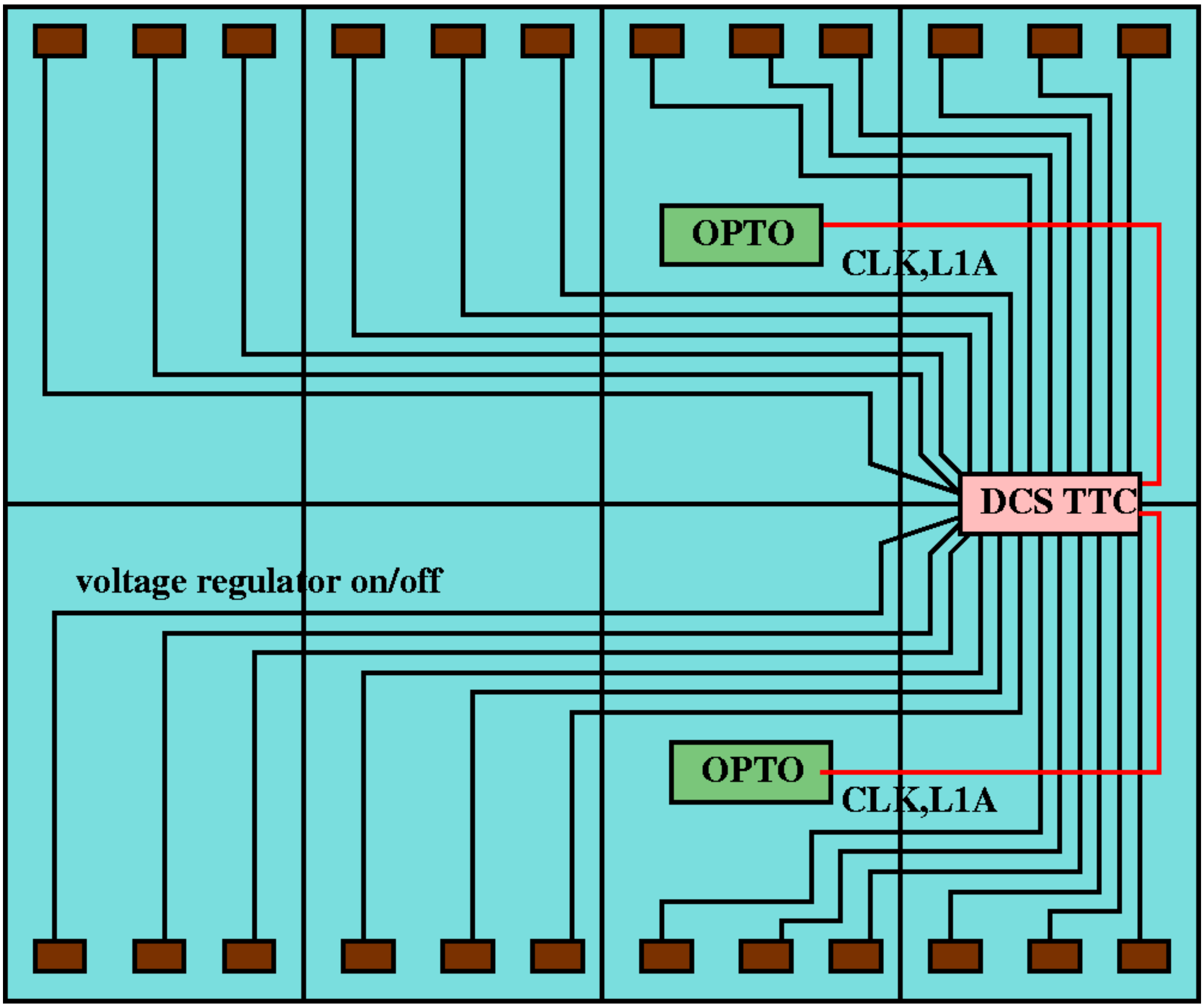


Figure 3: Schematic voltage regulator control on the chamber

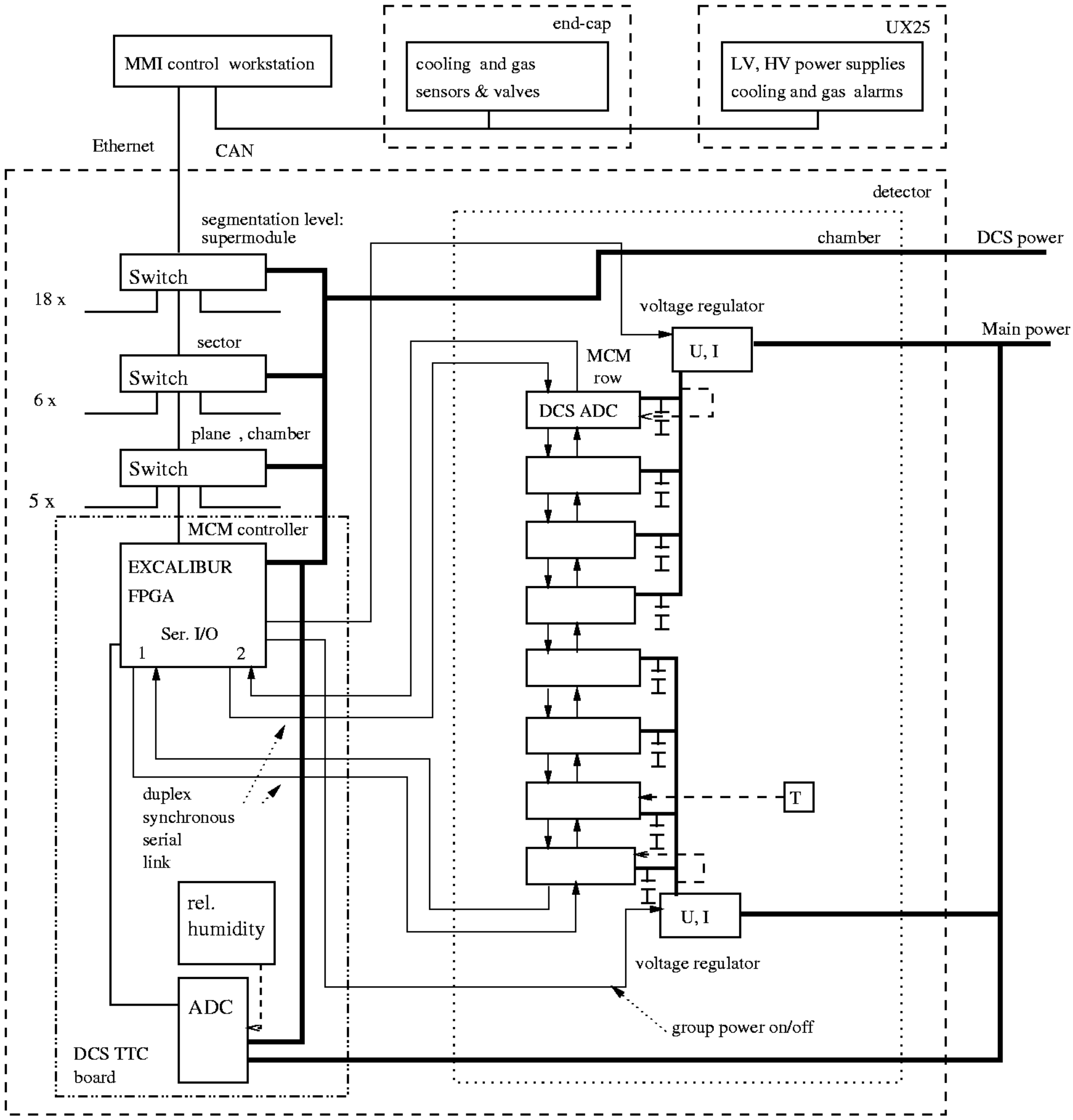
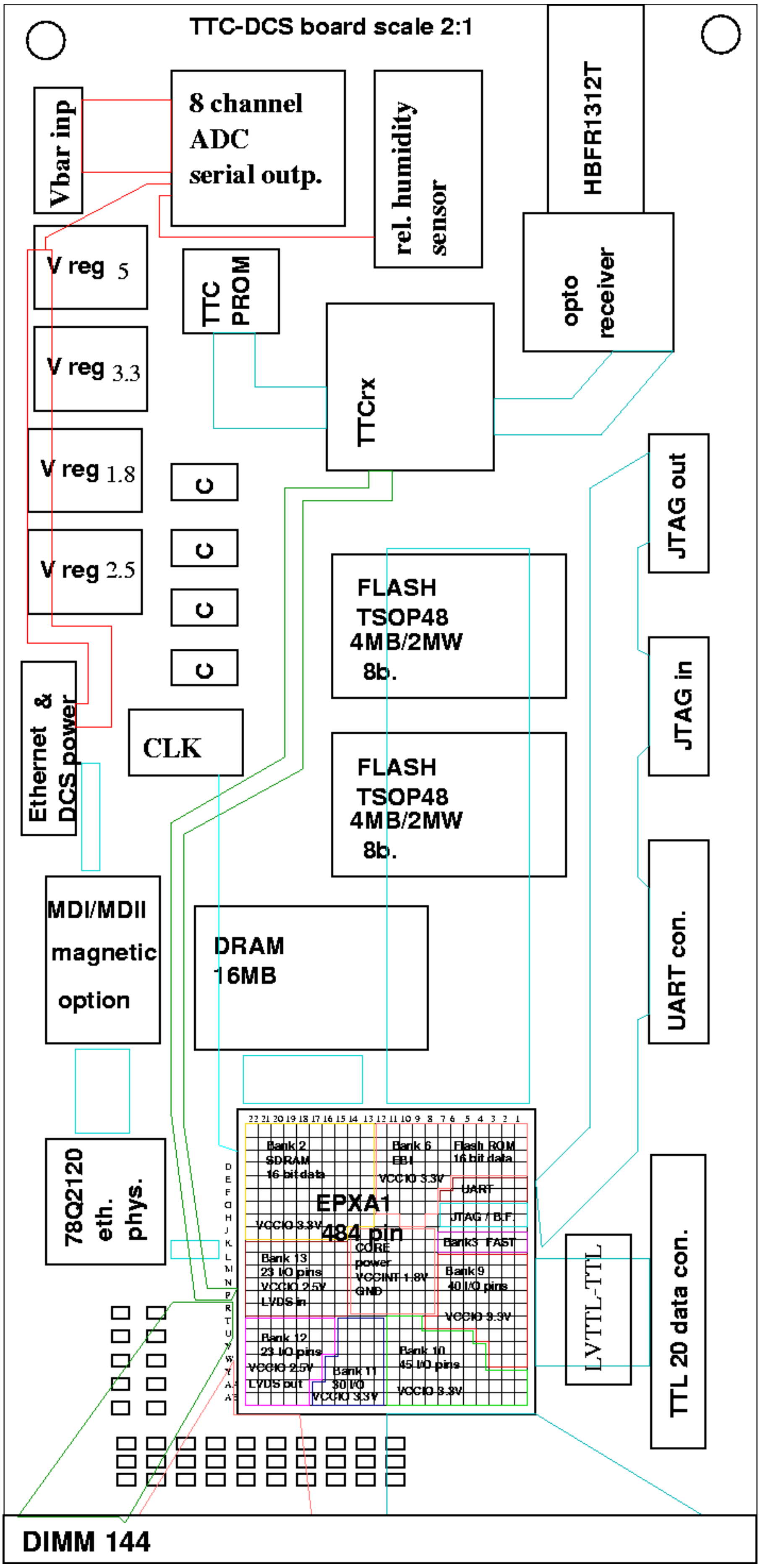


Figure 4: Architecture of the TRD DCS communication



TTC-DCS board scale 2:1
Vbar inp
8 channel ADC serial outp.
rel. humidity sensor
HBFR1312T
opto receiver
V reg 5
V reg 3.3
V reg 1.8
V reg 2.5
TTC PROM
TTCrx
C
C
C
C
CLK
Ethernet & DCS power
JTAG out
JTAG in
FLASH TSOP48 4MB/2MW 8b.
FLASH TSOP48 4MB/2MW 8b.
MDI/MDII magnetic option
DRAM 16MB
UART con.
78Q2120 eth. phys.
EPXA1 484 pin
Bank 2 SDRAM 16 bit data
Bank 6 EBI
Flash ROM 16 bit data
VCCIO 3.3V
UART
JTAG / BLF
Bank5 FAST
CORE power
VCCINT 1.8V
GND
Bank 13 23 I/O pins VCCIO 2.5V LVDS in
Bank 9 40 I/O pins
VCCIO 3.3V
Bank 12 23 I/O pins VCCIO 2.5V LVDS out
Bank 11 30 I/O VCCIO 3.3V
Bank 10 45 I/O pins
VCCIO 3.3V
LVTTL-TTL
TTL 20 data con.
DIMM 144

Figure 5: TTC-DCS board

5. TIMESCALES AND PLANNING

Here goes the timescale of the project, including milestones (e.g. prototype tests, test beams etc.).

1) Design

Based on this URD a detailed solution should be projected for each sub-system and the prototyping can start. Once the prototype solution is working on the process and field level it will be linked up to PVSS and integrated into the supervisory layer environment. Indicate the latest date for these stages to be completed.

	HV [mm/yy]	LV [mm/yy]	Cooling [mm/yy]	Gas [mm/yy]	FEE [mm/yy]	[mm/yy]	[mm/yy]
Process control solution projected							
Process control solution prototyped							
Process control linked to PVSS							

2) Production and Purchasing

The controls components (PLC's I/O units, field buses and interfaces, etc) can only be purchased in quantities once the devices to be controlled (HV and LV power supplies, cooling and FE electronics equipment, etc.) have been fixed and a final prototype controls solution exists. Please indicate for each sub-system the latest date at which the purchasing and test of devices and controls components must be completed.

	HV [mm/yy]	LV [mm/yy]	Cooling [mm/yy]	Gas [mm/yy]	FEE [mm/yy]	[mm/yy]	[mm/yy]
P/P of devices to be controlled							
P/P of controls components							
P/P tests							

3) Installation

Some detectors will be pre-assembled and tested on the surface before they are installed in the pit. Indicate where this will take place (SXL2?). Give the pre-assembly and tests period and indicate if and which controls sub-system should be available. Indicate as well the period of the final installation of the detector in the pit. Preliminary dates for pre- and final installation as they appear in the overall ALICE planning, are given below:

	Pre-installation		**Final installation**	
Project	**Start**	**Finished**	**Start**	**Finish**
TPC	Dec-01	Oct-04	May-05	Nov-05
HMPID	Sep-03	Feb-05	May-05	Jul-05
MUON	Sep-03	Jan-05	Apr-04	Jul-05
ITS	Nov-03	Feb-05	Jun-05	Oct-05
ZDC	Apr-04	Jul-04	Oct-04	Mar-05
PMD	Apr-04	Sep-04	Sep-04	Mar-05
PHOS	Apr-04	Sep-04	Dec-04	Jun-05
CASTOR	Apr-04	Sep-04	May-05	Jun-05
FMD/T0/V0	Apr-04	Sep-04	Aug-05	Aug-05
TOF	May-04	Nov-04	Jan-05	Jun-05
TRD	May-04	Aug-04	Feb-05	Jun-05

Pre-assembly in: SLX2	HV [mm/yy]	LV [mm/yy]	Cooling [mm/yy]	Gas [mm/yy]	FEE [mm/yy]	[mm/yy]	[mm/yy]
Pre-assembly and test - start							
Pre-assembly and test - end							
Is a control system needed (yes/no)?							
Final installation in the pit - start							
Final installation in the pit - end							

4) Commissioning

Commissioning will normally start once the detectors are installed in the pit; individual sub-systems first, then full detector and finally full experiment.

	HV [mm/yy]	LV [mm/yy]	Cooling [mm/yy]	Gas [mm/yy]	FEE [mm/yy]	[mm/yy]	[mm/yy]
Individual sub-systems - start							
Individual sub-systems - end							

	start [mm/yy]	end [mm/yy]
Full detector		
Full experiment		31/12/2005

5) Operation with beam

For completeness, these are the LHC milestones.

1st test with beam	01 / 02 / 2006
Pilot run (1 month)	01 / 04 / 2006
PP physics run	01 / 08 / 2006
Pb-ion physics run	01 / 03 / 2007

6) Tests and Test beam

Please indicate if and when you plan to perform tests (with or without test-beam) and if you wish to test prototype control solutions at this occasion. In this case please indicate which sub-systems you wish to test.

	start [mm/yy]	end [mm/yy]	List of sub-system control prototypes to test
1st test period			
2nd test period			
3rd test period			

APPENDIX

------------- This is to help you to fill the description of the parameters -------------
Below are templates of various types of parameters that should be used in the list of parameters above.

The following applies to parameters that are controlled ‘directly’: via ADC or DAC and digital inputs or outputs.
For parameters that are acquired from or written to ‘intelligent’ devices or equipment via software (e.g. OPC), not all of the fields above are relevant since in most cases the physical value will be available directly. In that case describe the mechanism how to access the parameter.

Note that the entries in the tables are explained below.

- **An analog input parameter**

An analog input parameter is an input to the control system from the device or equipment to be controlled (e.g. a voltage from a device read by an ADC). Describe where the signal for this parameter is read.

Parameter type	AI
Parameter name	
Physical input range	
Control signal range	
Required physical resolution	
Corresp. control signal resol.	
Time resolution	

- **An analog output parameter**

An analog output parameter is an output from the control system to the device or equipment to be controlled (e.g. a voltage generated by a DAC to a device). Describe where the signal for this parameter is to be set.

Parameter type	AO
Parameter name	
Physical output range	
Control signal range	
Required physical resolution	
Corresp. control signal resol.	
Impedance	

- **A digital input parameter**

A digital input parameter is an input to the control system from the device or equipment to be controlled (e.g. a 24V signal or a closed contact). Describe where the signal for this parameter is read.

Parameter type	DI
Parameter name	
Physical input signal	
Logical 0 (signal definition)	
Logical 1 (signal definition)	
Logical 0 (meaning)	
Logical 1 (meaning)	
Time resolution	

- **A digital output parameter**

A digital output parameter is an output from the control system to the device or equipment to be controlled (e.g. a 24V signal or a closed contact). Describe where the signal for this parameter is to be set.

Parameter type	DO
Parameter name	
Physical output signal	
Logical 0 (signal definition)	
Logical 1 (signal definition)	
Logical 0 (meaning)	
Logical 1 (meaning)	
Impedance	

<u>Explanation of the table entries:</u>

Parameter type: AI (analog input), AO (analog output), DI (digital input), DO (digital output).
Parameter name: a symbolic name of this parameter that could be used e.g. as (part of) a variable name etc.
Physical input/output range: the range of the physical parameter to be controlled.
Control signal range: the range of the control signal corresponding to the physical range above. Give the conversion if not linear.
Required physical resolution: the resolution of the controlled physical parameter.
Corresp. control signal resol.: the resolution of the control signal corresponding to the given resolution of the physical signal (calculation).
Time resolution: the resolution in time of the input signal, defines the lowest sampling rate for that parameter.
Impedance: impedance as seen by the analog or digital output, defines the power/current to be delivered by a DAC or digital output.
Physical input/output signal: the type of digital input or output (e.g. voltage level, open or closed contact).
Logical 0/1 (signal definition): definition of the level logical 0 and 1 in terms of physical signal (e.g. 0 ≡ Voltage < 1.2V, or 1 ≡ closed contact).
Logical 0/1 (meaning): definition of the meaning of the logical 0 and 1 in terms of state of or action to the device or equipment (e.g. 0 ≡ valve is closed (for DI), 1 ≡ open a valve (for DO)).
------------- *End* -------------

- `This is an example on how to use a different typestyle for a comment or question.`