Integrated test of the TRD Gas System electronics

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1 Introduction

The test performed in August 2004 [1] at CERN on an integrated gas system apparatus was meant to demonstrate the capability of the control electronics to operate on a gas system in a configuration as close as possible to the final one. For the first time the complete *hot* component of the electronics was succesfully operated simultaneously – tests performed in previous times (december '03 [2], march '04 [3] and may '04 [4] all concerned a subset of the gas system, and consequently a subset of the control electronics.

The WINCAN control software used in the tests consists of a series of graphical user interfaces that allow the communication with the gas system via the control electronics.

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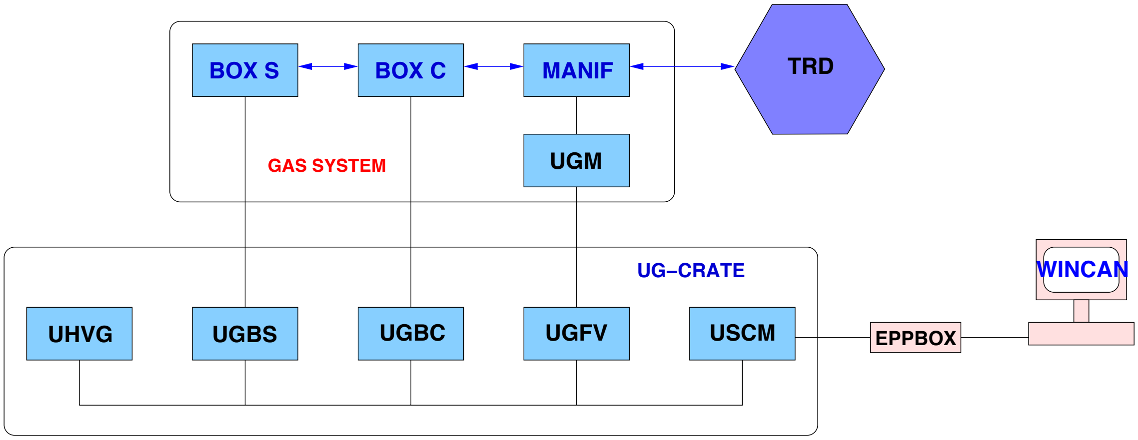

Figure 1: Slow control scheme.

Each button push corresponds to a LeCroy protocol command or a serial port address, issued via the CAN bus through the AMS EPP box (see figure 1).

This document is an update of the status of the TRD gas system slow control electronics. In December 2005 a test on the engineering verision of the gas system, temporarily in Rome, was performed on a set of slow control electronics including both a *hot* and a *cold* USCM. Subsequently in February 2006 the control electronics, equipped with *hot* and *cold* modules, was operated succesfully.

2 The control software

The controllers for box S, box C and for *all* the manifold segments are shown in figures 3, 2 and 4. For a more complete description, see ref. [5].

An example of more complex procedure is given by the gas mixing procedure utility shown in figure 5. For more details on the operations that the software allowed to perform during the CERN tests, see section 3.

3 Reminder: the August '04 tests

3.1 Test setup

The apparatus consisted of box S, box C plus 1 manifold segment. The mechanical components consisted of:

- box S:
  - Marotta MV197 valves V1a, V2a, V3a, V4a, V10a, V20a, V1b, V2b, V3b, V4b, V10a, V20a;
  - GP50 7900 pressure sensors P1a, P1b, P2a, P2b (also temperature sensors);
- box C:
  - Marotta MV100 valves V6a, V18a, V6b, V18b;
  - Bürkert 6124 *flipper* valves V8a and V8b;
  - GP50 7900 pressure sensors P3 and P4 (also temperature sensors);

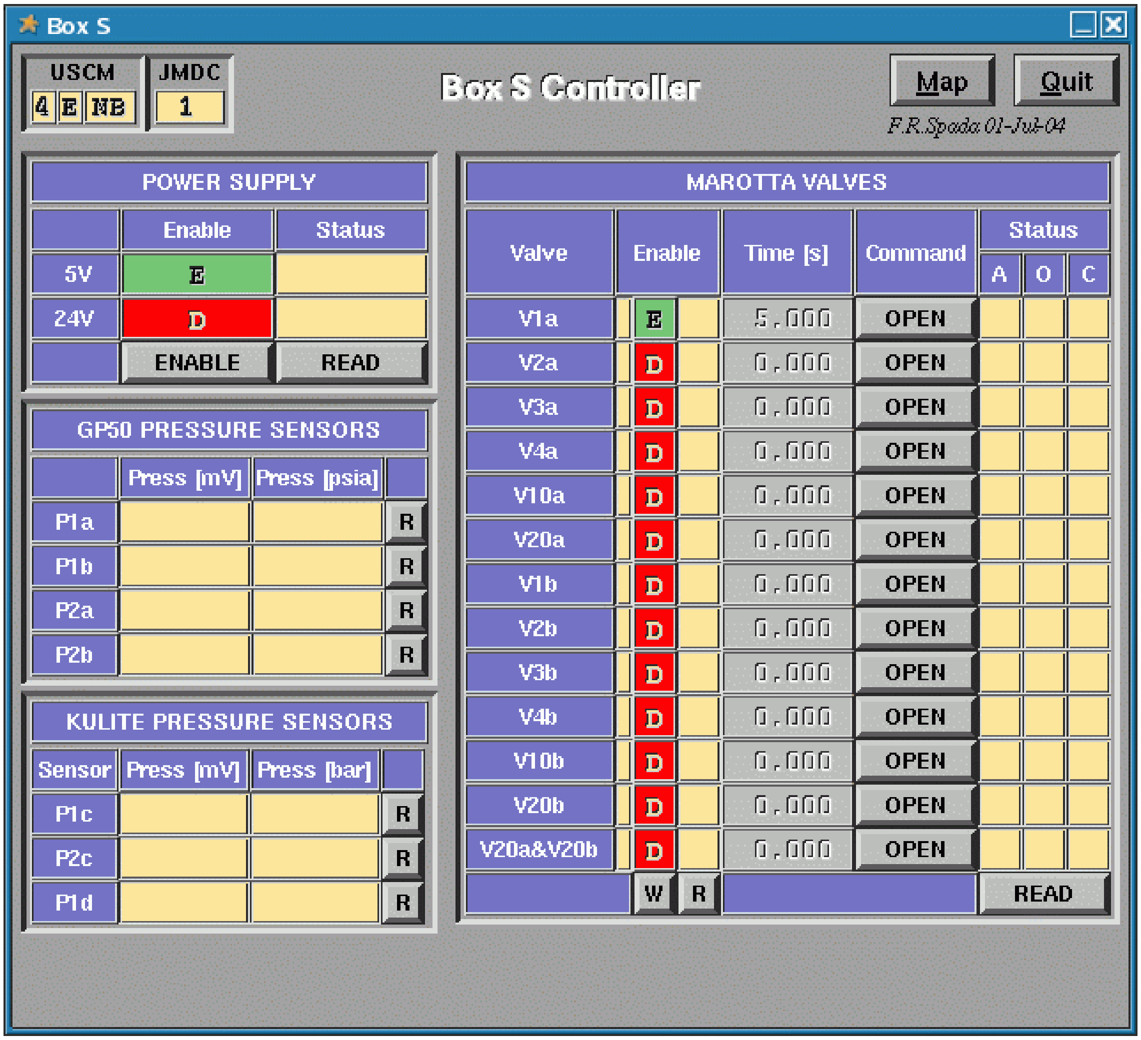

Figure 2: The WINCAN box S control interface.

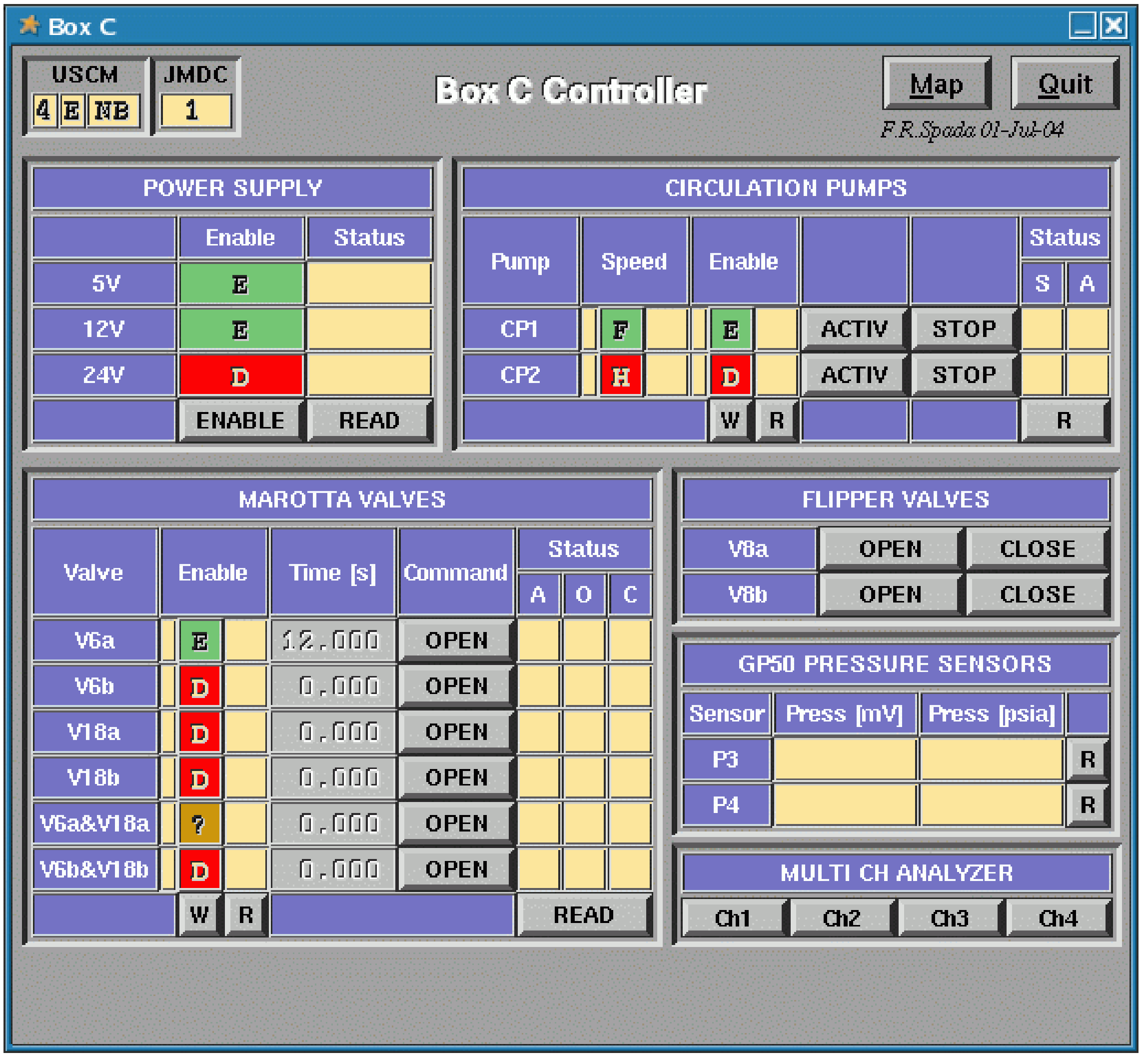

Figure 3: The WINCAN box C control interface.

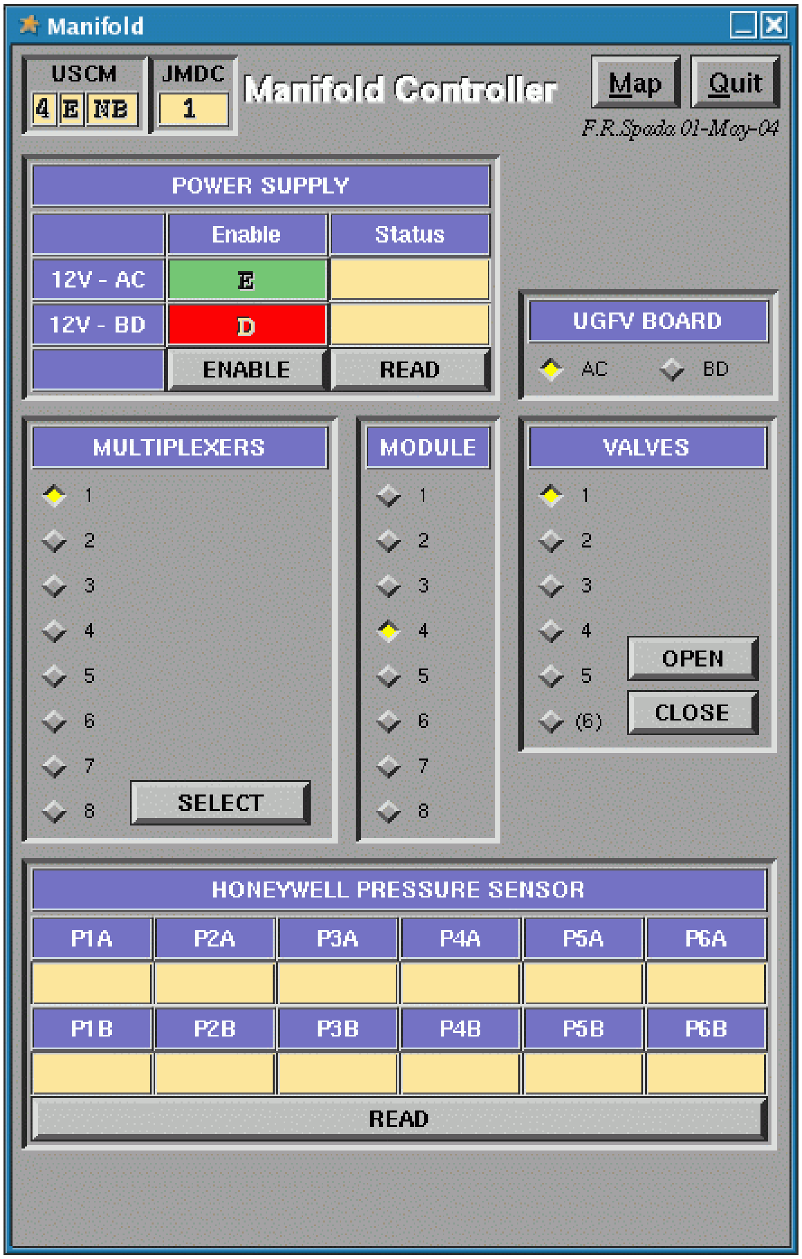

Figure 4: The WINCAN control interface for manifold segments.

Figure 5: The WINCAN interface to control the mixing procedure.

- KNF UMNP830 circulation pumps CP1 and CP2;
- ndd ASIC spirometer;

- one manifold segment:
  - Bürkert 6124 *flipper* valves Va, Vb, Vc and Vd;
  - Honeywell 26PCCFA6D pressure sensors Pa and Pb.

See also table 1 for a list of the full test equipment.

Electronic components under test consisted of the hot USCM, UGBS, UGBC, and the two UGFV boards connected through the UG-crate backplane and controlled by a computer interface. The electronics was totally controlled via a software user interface (called *WINCAN* [5]) including a box S controller, a box C controller, a manifold controller and few other programs where sequences of higher level commands, e.g. the mixing procedure, were hard-coded. The computer control was operated by an ACER laptop with Linux Red Hat 9b and the WINCAN software (see section 2) installed, that was connected to the CAN bus via the AMS EPPBOX (see figure 1).

3.2 Low level tests

This part of the test was meant to confirm that the electronics can successfully control all the electromechanical components individually.

- All the valves were succesfully operated;
- A command to simultaneously open valves V6a and V18a, as well as V6b and V18b is forseen in the electronics and was succesfully issued and executed. In addition, it was confirmed that it is possible to keep two valves open simultaneously – e.g. V1a and V2a – using sequential CAN bus commands to open them;
- The GP50 pressure sensors were successfully read out, as well as the temperature sensors;
- While the pump CP2 were turned on to half speed, CP1 could not. It was discovered that CP1 drew more current than was anticipated, and because of this the electronics did not provide adequate voltage for the pump to turn on at half speed. Both pumps were turned on to full speed.
- The spirometer was read out correctly. However attempts to change the sampling rate would corrupt the data and required the spirometer to be power cycled in order to be read again.

3.3 Higher level tests

The electronics was capable of performing all the required higher level actions (see below). However, due to leaks in the system, the behaviour of the system as a whole could only be observed in a qualitative way.

3.3.1 Mixing procedure

This sequence of operations was meant to fill up the mixing vessel with the Argon/CO_2 gas mixture and consisted of the following steps (these step names correspond to the operations on mechanical components described in table 2):

Power supply	24 V 12 V 5 V
Electronics	UG-crate USCM UGBC UGBS UGFV x2
Marotta MV197	V1a V2a V3a V4a V10a V20a V1b V2b V3b V4b V10b V20b
Marotta MV100	V6a V18a V6b V18b
Bürkert 6124	V8a V8b Vma Vmb VmC VmD
gp50 7900	P1a P1b P2a P2b P3 P4
Honeywell 26PCCFA6D	Pma Pmb
KNF UMNP830	CP1 CP2
ndd ASIC spirometer	

Table 1: The gas system components tested in the August '04 test at CERN.

1. Empty mix volume (open D vessel to external atmosphere)
2. Set to ground state Xe (open intermediate buffers on Xenon line to external atmosphere)
3. Set to ground state CO_2 (open intermediate buffers on CO_2 line to external atmosphere)
4. Empty mix volume
5. CO_2 fill step
6. Xenon fill step
7. Xenon fill step
8. Xenon fill step
9. Empty mix volume
10. Empty mix volume
11. Empty mix volume
12. Empty mix volume
13. Empty mix volume

Empty mix volume	Open V4a, V6a, and V18a for 60 s, wait 10 s
Set to ground state Xe	Open V2a for 1 s, wait 5 s, open V3a for 1 s, wait 5 s, open V4a and V18a for 60 s, wait 10 s
Set to ground state CO_2	Open V2b for 1 s, wait 5 s, open V3b for 1 s, wait 5 s, open V4a and V18a for 60 s, wait 10 s
CO_2 fill step	Open V1b for 1 s, wait 5 s, open V2b for 1 s, wait 5 s, open V3b for 40, wait 10 s
Xenon fill step	Open V1a for 1 s, wait 5 s, open V2a for 1 s, wait 5 s, open V3a for 40, wait 10 s

Table 2: Definition of the mixing procedure steps.

3.3.2 Filling procedure

The following sequence filled the manifold segment including the volume that was simulating one fourth of the TRD volume (see table 3 for the action definitions):

1. Close valves of Box C
2. Stop pumps
3. Open manifold segment
4. Connect Box S to Box C
5. Check pressure

Close valves of Box C	Close V8a, V8b, V6a, V6b, V18a, V18b
Stop pumps	Turn off CP1 and CP2
Open manifold segment	Open Va, Vb, Vc and Vd
Connect Box S to Box C	Open V4a and V6a for 5 s
Check pressure	Check if P4 is in nominal range of 17-25 psi. If not, repeat 4-5

Table 3: Definition of the filling procedure steps.

3.3.3 Circulation

This procedure circulates the gas mitxure in the manifold segment (see table 4 for action definitions):

1. Choose circuit
2. Turn pump to High Speed
3. Turn pump to Low Speed

Choose circuit	Open V8a or V8b according to the chosen pump
Turn pump to High Speed	Turn CP1(CP2) to high speed and wait for a given P4
Turn pump to Low Speed	Turn CP1(CP2) to low speed, keep recording P4

Table 4: Definition of the circulation procedure steps.

Even though the electronic and the control software were succesfully operated on the system and the correct actions were executed, a leakage in the gas pipes prevented the TRD volume to be filled, so that the regime situation was never reached and the fill time could not be measured.

4 Update: the Hot/Cold electronics tests

A slow control electronic set composed of two USCMs, one UGBS (hot) and one UGBC (hot) was tested in december 2005 on an engineering model of the gas system box S and box C currently available in the Rome INFN clean room. The scheme of the gas cyrcuit is shown in figure 6. The aim of the test was to exclude that some conflict could arise in the joint use of two USCM modules. One UGSCM (identification number 0xA0 newborn) was used as *hot* and a second USCM (0x4E newborn) as *cold*. The 0xA0 is of new type with Dallas patch panel, while the 0x4E is of old type (no Dallas patch panel, no Dallas connectors). A third USCM (the 0x97 newborn, new type but no Dallas patch panel) has also been tested alternatively with the other two.

No conflict in the electronics was observed. All the components responded correctly, no matter which USCM (*hot* or *cold*) was addressed. The success of the communication with the serial ports was confirmed by the fact that the two devices connected answered correctly, and the data was transmitted in the format expected.

In February 2006 further tests were carried out, on a set of hot and cold USCM, UGBS and UGBC. These tests are described in detail in the following sections.

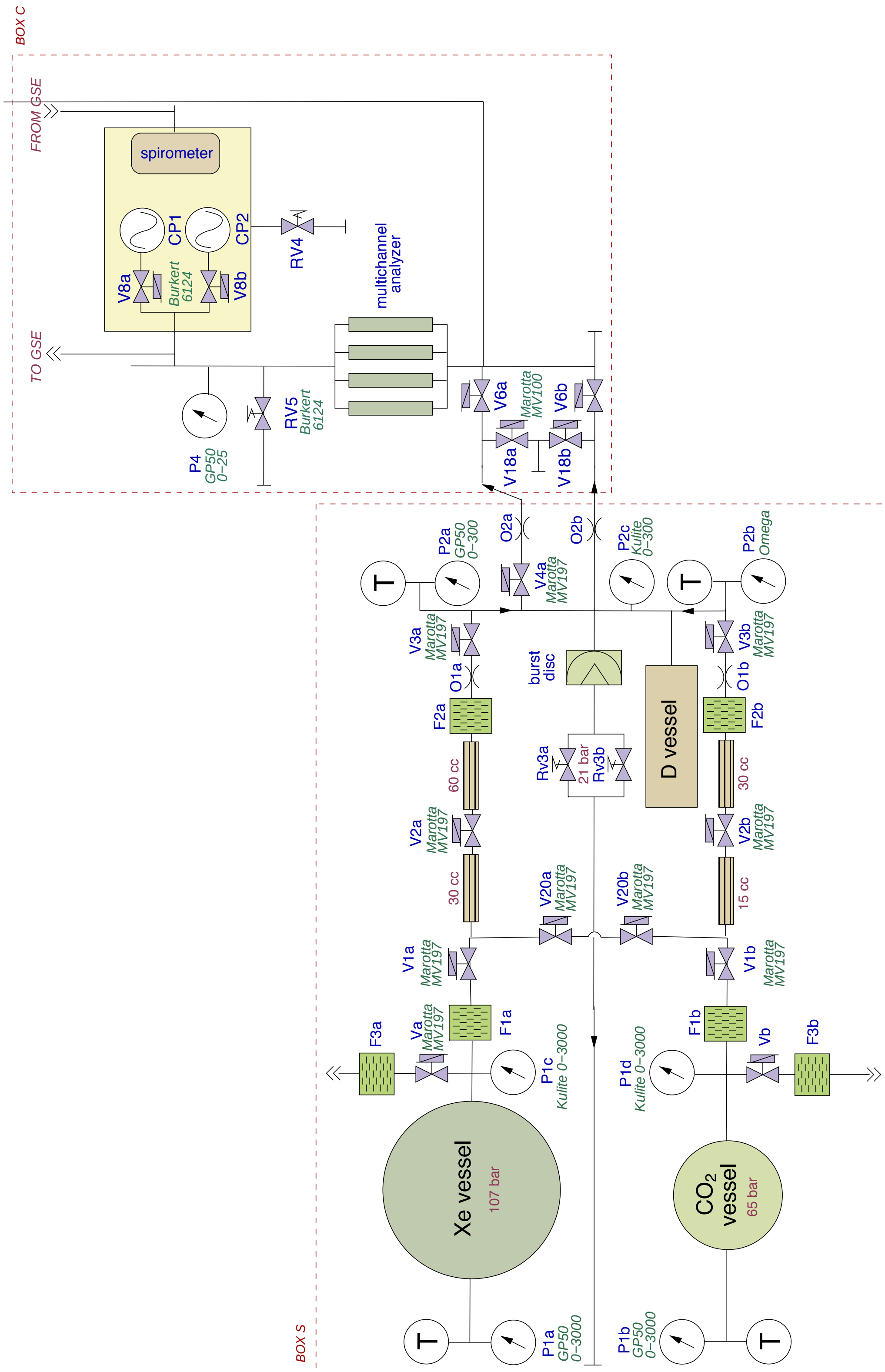

Figure 6: Layout of the gas system used in the test.

4.1 Test setup

The mechanical components available in the engineering model of the gas system box S and box C are listed in table 5. The V10a and V10b valves were substituted by leds, and the corresponding open command addressed the two tanks heaters instead. The valve V4b was not present, and was substitued by a led. The CO_2 analyzer and the MCa were connected to the USCM RS232 serial ports through the UGBC serial ports, so that they could be addressed from both the USCMs.

4.2 Hot/Cold USCM interaction test

The following operations were succesfully executed with the control software described in section 2.

- UGBS-controlled operations:
  - open valves V1a, V2a, V3a, V4a, V20a, V1b, V2b, V3b, V4b, V20b
  - read pressure sensors P1a, P1b, P2a, P2b
  - activate CO_2 and Xenon tanks heaters
- UGBC-controlled operations:
  - open valves V6a, V6b, V18a, V18b
  - read pressure sensor P4
  - open and close V8a and V8b
  - activate pumps CP1 and CP2 at half and full speed
  - communicate with the RS232 serial port

All the above operations were repeated four times, in all the possbile hot/cold combinations: addressing the *hot* USCM and alternatively the *hot* UGBS/UGBC and the *cold* UGBS/UGBC, then again through the *cold* USCM.

One can tell the correct functioning of the Marotta valves either by the valve click, or looking at the leds connected to the valves, and finally from the increase in the absorbed current (about 700 mA). For the flipper valves only the click shows the execution of the command. The pumps can be checked both by their humming and by the current absorption (about 400 mA at half speed, 550 mA at full speed).

No conflict in the electronics was observed. Except sensor P4 (broken) and valve V8b (no click), featuring known hardware problems, all the components responded correctly, no matter which boards was addressed. The results of the tests are summarized in table 6.

5 Conclusions

The tests carried out from 2003 to 2006 showed that the engineering model of the gas system slow control electronics works correctly and can perform the required operations.

References

[1] A. Bartoloni, B. Borgia, H.B. Broker, J. Burger, M. Kamenetska, A. Lebedev, G. Rybka, F.R. Spada, A. Werner, *"August 2004 AMS-02 TRD Electronics Test"* (internal note, 2005)

Power supply:	24 V 12 V 5 V
Electronics:	UG-crate USCM *hot* USCM *cold* UGBC UGBS

	Box S	Box C
Marotta MV197:	V1a V2a V3a V4a V20a V1b V2b V3b V4b (led) V20b	
Marotta MV100:		V6a V18a V6b V18b
Bürkert 6124:		V8a V8b
gp50 7900:	P1a P1b P2a	P4
Omega:	P2b	
KNF UMNP830:		CP1 CP2
	CO_2 heater Xe heater	
		ndd ASIC spirometer Amptek MCA8000A

Table 5: The gas system components tested in the Hot/Cold test in Rome.

	USCM HOT		USCM COLD	
	UGBS HOT	UGBS COLD	UGBS HOT	UGBS COLD
enable 5 V	ok	ok	ok	ok
enable 24 V	ok	ok	ok	ok
open V1a	click	click	click	click
open V2a	click	click	click	click
open V3a	click	click	click	click
open V4a	click	click	click	click
open V10a	led on	led on	led on	led on
open V20a	click	click	click	click
open V1b	click	click	click	click
open V2b	click	click	click	click
open V3b	click	click	click	click
open V4b	led on	led on	led on	led on
open V10b	led on	led on	led on	led on
open V20b	click	click	click	click
open V20a & V20b	click	click	click	click
read P1a	ok	ok	ok	ok
read P1b	ok	ok	ok	ok
read P2a	ok	ok	ok	ok
read P2b	ok	ok	ok	ok
	UGBC HOT	UGBC COLD	UGBC HOT	UGBC COLD
enable 5 V	ok	ok	ok	ok
enable 12 V	ok	ok	ok	ok
enable 24 V	ok	ok	ok	ok
open V6a	click	click	click	click
open V18a	click	click	click	click
open V6b	click	click	click	click
open V18b	click	click	click	click
open V6a & V18a	click	click	click	click
open V6b & V18b	click	click	click	click
open V8a	click	click	click	click
close V8a	click	click	click	click
open V8b	?	?	?	?
close V8b	?	?	?	?
read P4	?	?	?	?
run CP1 half speed	ok	ok	ok	ok
run CP1 full speed	ok	ok	ok	ok
run CP2 half speed	ok	ok	ok	ok
run CP2 full speed	ok	ok	ok	ok

Table 6: Summary of the Hot/Cold test done in Rome (february '06).

[2] A. Bartoloni, C. Bosio, J. Burger, S. Gentile, *"AMS-02 TRD gas system manifold electronics test"* (internal note, 2004)

[3] A. Bartoloni, C. Bosio, J. Burger, S. Gentile, F.R. Spada, *"AMS-02 TRD UGBS electronics test on engineering Box S"* (internal note, 2004)

[4] A. Bartoloni, C. Bosio, J. Burger, S. Gentile, F.R. Spada, A. Werner, *"AMS-02 TRD UGBC electronics eest on engineering Box C"* (internal note, 2004)

[5] F. Bucci, S. Gentile, A. Lebedev, F.R. Spada, *"WINCAN v.2.2 – Slow Control commands and operations for the TRD gas system of AMS-02"* (internal note, 2006)