VLBI-F-REP-4101-890 Cryogenic and Vacuum Control Unit Report for Matera VGOS receiver

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Contents

Index of Figures

Introduction

In this report, the VGOS Matera Cryogenic and Vacuum Control Unit (CVCU) is described. The integration and programming were performed in the facilities of Yebes Observatory with the instrumentation available in it.

Hardware description

The CVCU is built within a 19-inch 2U Schroff rack unit. Figures 1 and 2 show the module opened and the back panel interfaces.
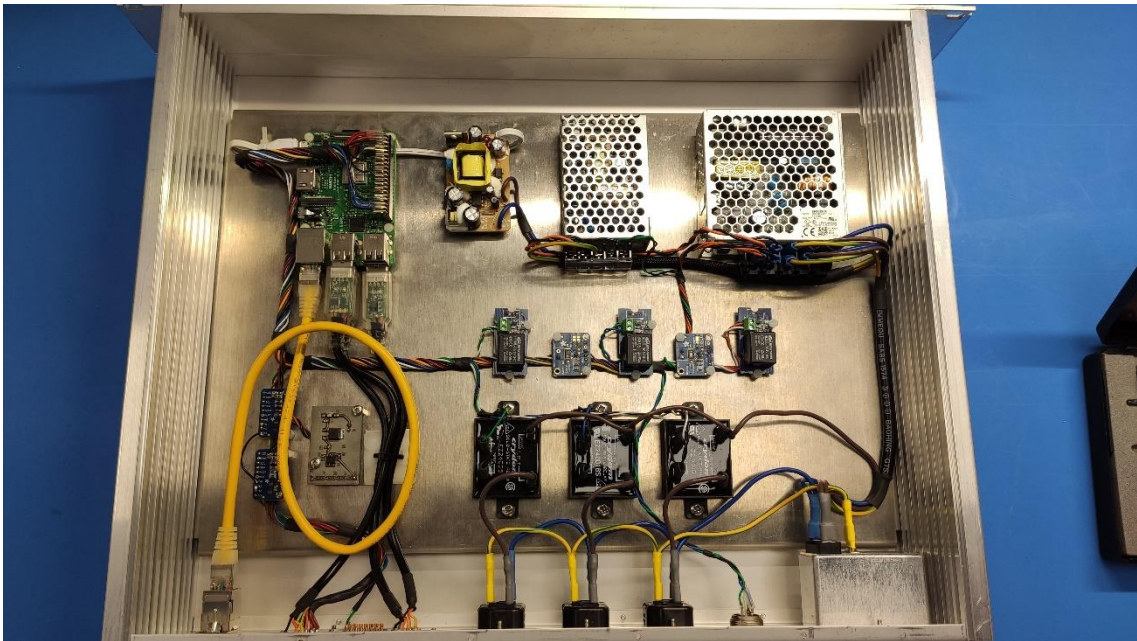

Figure 1: CVCU module

Figure 2: CVCU Interfaces

The module integrates the following hardware:

- A Raspberry Pi 3B+ with Raspbian OS used to control the rest of the hardware.
- A power supply for the Raspberry Pi 3B+
- A 5V power supply for the Cryostat regenerators.
- A 24V power supply for the Cryostat heaters.

- Three 230V solid state relays to power the electro valve the turbo molecular pump power supply and the backing pump power supply.
- Three relay to operate the compressor, the regenerators, and the heaters.
- Three RS485/RS232 transceivers for the control of the turbo molecular pump and the backing pump, and to read the pressure from the pressure sensor control module (MKS PDR900).
- Electronic circuit to power and read the cryogenic temperature inside the cryostat.

Software description

The module is programmed with Python3 code, and it uses two *systemd* services (vgosmonitor.service and vgoscontrol.service) that open two TCP sockets: one to read the temperature and the pressure inside the cryostat and the other to control the vacuum system, compressor, electro valve, and heaters and regenerators.

The TCP socket listening on port 10001 (vgosmonitor.service) is used to read pressure and temperature. An example of use is shown below (commands in bold black and responses in bold red):

```
terminal:~$ telnet vgosmatera 10001
Trying 172.16.15.19...
Connected to vgosmatera.
Escape character is '^]'.
get_temp()
38.53834876543203 7.913678571428568 7.437206491712705 12.437613122171946
get_pressure()
9.06e-07
```

The TCP socket listening on port 10000 (vgoscontrol.service) is used to control the vacuum system, compressor, electro valve, heaters and regenerators. An example of use is shown below (commands in bold black and responses in bold red):

```
terminal:~$ telnet vgosmatera 10000
Trying 172.16.15.19...
Connected to vgosmatera.
Escape character is '^]'.
get_comp_status()
1
get_ev()
0
```

Operation

The list of monitoring commands **(vgosmonitor service, TCP port 10001)** available for the operation is shown in Figure 3:

Command	Response	Operation
get_temp()	Tint Tcold Tlna Tfeed	Read cryostat temperatures (K)
get_pressure()	Pressure	Read cryostat pressure (mbar)

Figure 3: Monitor commands table

The list of monitoring commands **(vgoscontrol service, TCP port 10000)** available for the operation is shown in Figure 4:

Command	Response	Operation
set_ev(open)	OK	Open electro valve
set_ev(close)	OK	Close electro valve
get_ev()	1/0	Get electro valve status (1=open, 0=closed)
set_comp(on)	OK	Turn compressor on
set_comp(off)	OK	Turn compressor off
get_comp_status()	1/0	Get compressor status (1=on, 0=off)
set_regen(on)	OK	Turn regenerators on
set_regen(off)	OK	Turn regenerators off
get_regen_current()	Current	Regenerators current (mA)
set_heaters(on)	OK	Turn heaters on
set_heaters(off)	OK	Turn heaters off
get_heaters_current()	Current	Heaters current (mA)
acp15(on)	OK	Turn Backing Pump on
acp15(off)	OK	Turn Backing Pump off
get_acp15()	1/0	Get Backing Pump status (1=on, 0=off)
hipace80(on)	Waiting 10 seconds. OK	Turn Turbo molecular pump power supply on
hipace80(off)	OK	Turn Turbo molecular pump power supply off
get_hipace80()	1/0	Get Turbo molecular pump power supply status (1=on, 0=off)
set_010(on)	OK	Turn pumping station on
set_010(off)	OK	Turn pumping station off
get_010()	1/0	Get pumping station status (1=on, 0=off)
set_023(on)	OK	Turn motor pump on
set_023(off)	OK	Turn motor pump off
get_023()	1/0	Get motor pump status (1=on, 0=off)
set_venting_valve(on)	OK	Set on turbo molecular pump venting valve
set_venting_valve(off)	OK	Set off turbo molecular pump venting valve
get_venting_valve()	1/0	Get turbo molecular pump venting valve status (1=on, 0=off)
get_speed()	speed	Get turbo molecular motor pump speed (Hz)
get_pump_hours()	hours	Get turbo molecular pump time of use (hours)
get_pump_voltage()	voltage	Get turbo molecular pump supply power (mV)
get_pump_current()	current	Get turbo molecular pump consuming current (mA)

get_pump_power()	power	Get turbo molecular pump consuming power (W)
get_error()	error code	Get turbo molecular pump error codes.

Figure 4: Control commands table

Procedure to operate the backing pump (Pfeiffer ACP 15):

```
terminal:~$ telnet vgosmatera 10000
Trying 172.16.15.19...
Connected to vgosmatera.
Escape character is '^]'.
acp15(on) #Turn on the backing pump to start rough vacuum.
OK
get_acp15()
1
```

[Comments in blue, commands in black, responses in red]

Procedure to operate the turbo molecular pump (Pfeiffer Hipace80):

```
terminal:~$ telnet vgosmatera 10000
Trying 172.16.15.19...
Connected to vgosmatera.
Escape character is '^]'.
#STARTING THE TURBOMOLECULAR PUMP:
hipace80(on) #Turn on the turbo molecular pump power supply. Wait 10 seconds
to allow electronics to boot up.
Waiting 10 seconds. OK
get_hipace80()
1
set_010(on) #Turn on the pumping station (turn the fan on and closes the venting
valve in case it was open from a previous use)
OK
get_010()
1
set_023(on) #Turn on the motor pump. The pump starts spinning. Do this once
the pressure inside the dewar is below 5mbar and with the backing pump always
ON!!!
OK
get_023()
1
get_speed()
234
get_speed()
467
get_speed()
978
get_speed()
1500
#STOPPING THE TURBOMOLECULAR PUMP:
set_venting_valve(on) #Set on venting valve. The valve is configured to open
at 750Hz (This is possible to configure with the DCU 002 control display
integrated within the pumping system)
OK
```

```
get_venting_valve()
1
set_023(off) #Turn off the motor pump. The pump starts to slow down.
OK
get_023()
0
get_speed()
1435
set_010(off) #Turn on the pumping station (turn the fan on and let the venting
valve open once the pump speed reaches 750Hz)
OK
get_010()
0
get_speed()
132
set_venting_valve(off) #Set off venting valve.
OK
get_venting_valve()
0
hipace80(off) #Turn off the turbo molecular pump power supply
OK
get_hipace80()
0
```

[Comments in blue, commands in black, responses in red]

The lines above depict a simplified operation of the turbo molecular pump. For a more detailed information about the operation, refer to the turbo molecular pump manufacturer operation manual.

Conclusions

The CVCU is together with the pumping system, the compressor, the temperature and pressure sensors, and the heaters and regenerators are the core for the receiver's cryogenic operation and maintenance. Therefore, special attention must be kept when using it to ensure proper operation. It is important only qualified and trained personnel uses it.

A detailed operation and maintenance manual will be provided, for the full operation of the cryogenic receiver.