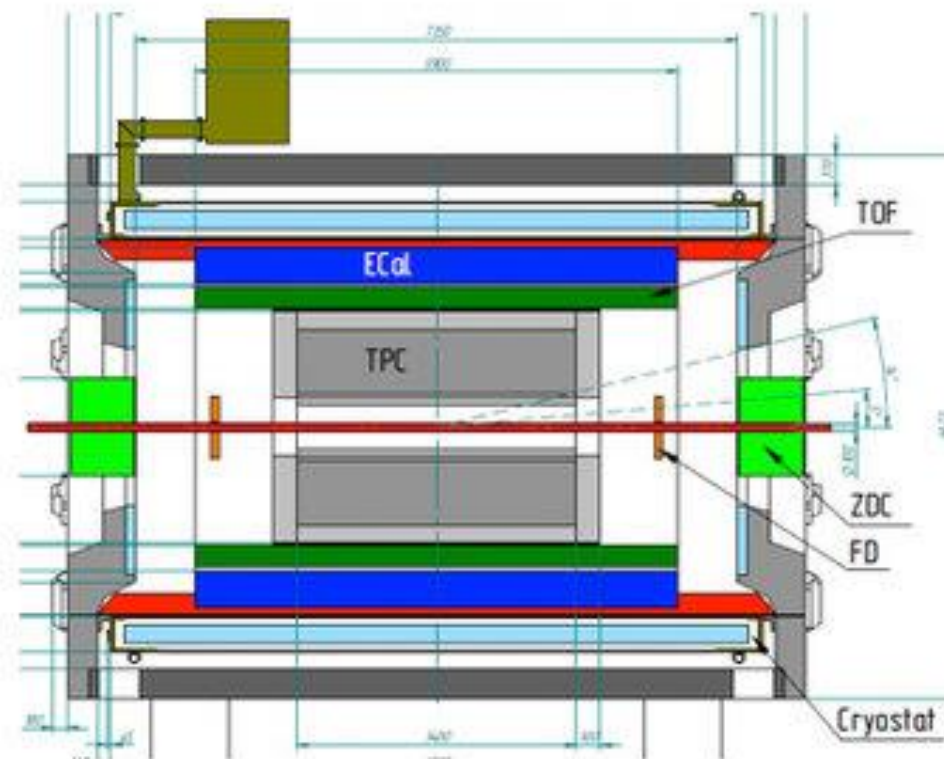
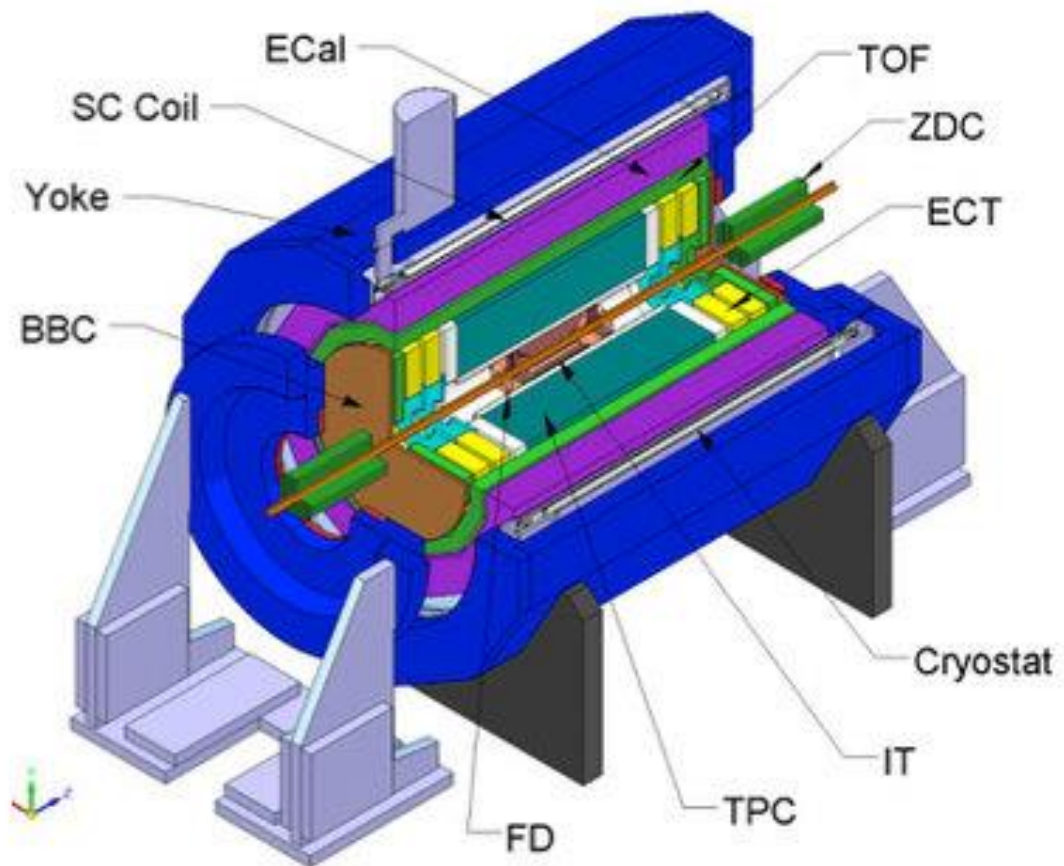




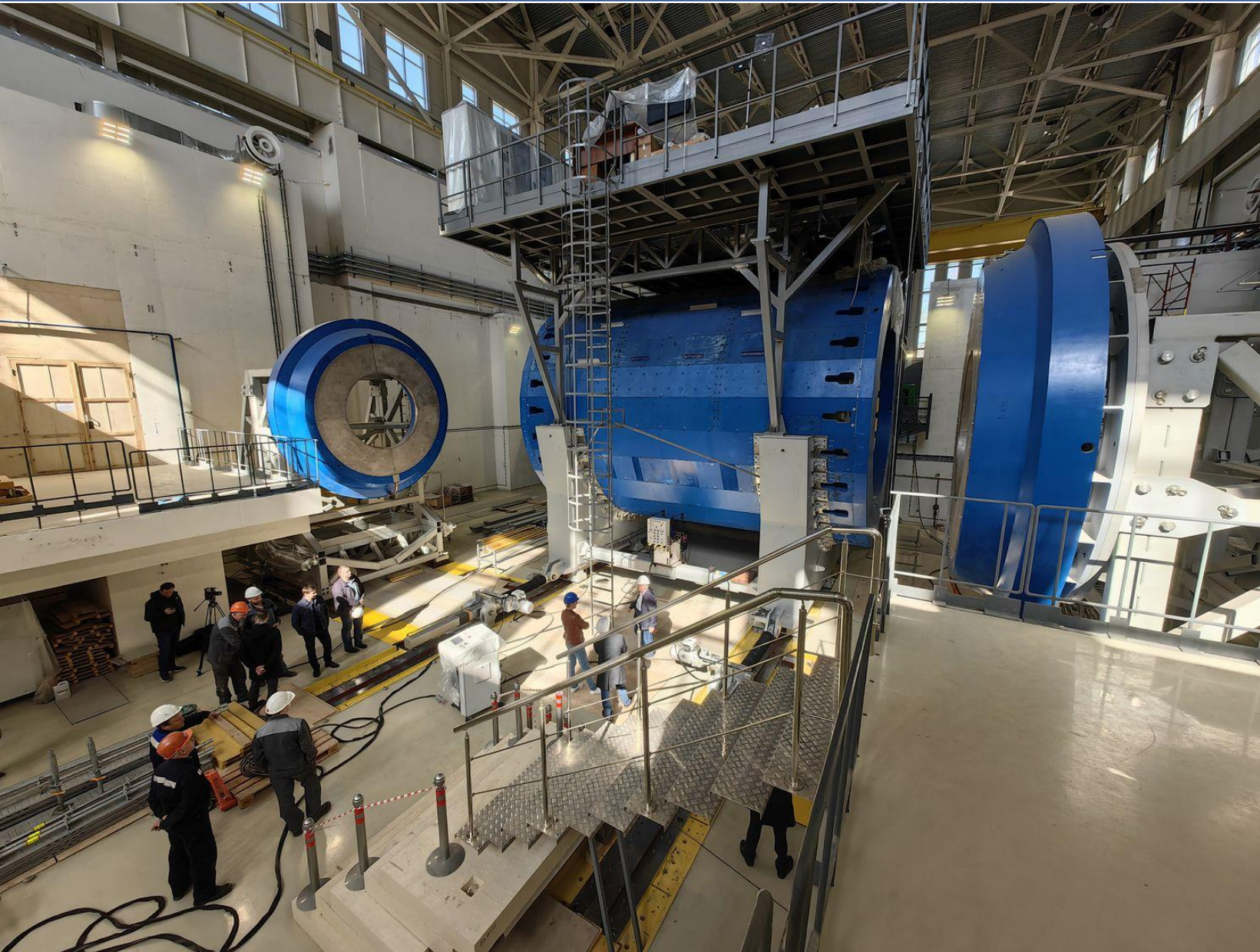
Monitoring and Control system of MPD solenoid satellite refrigerator

(or how to run facility without docs by reverse engineering)

MPD



Superconducting solenoid MPD



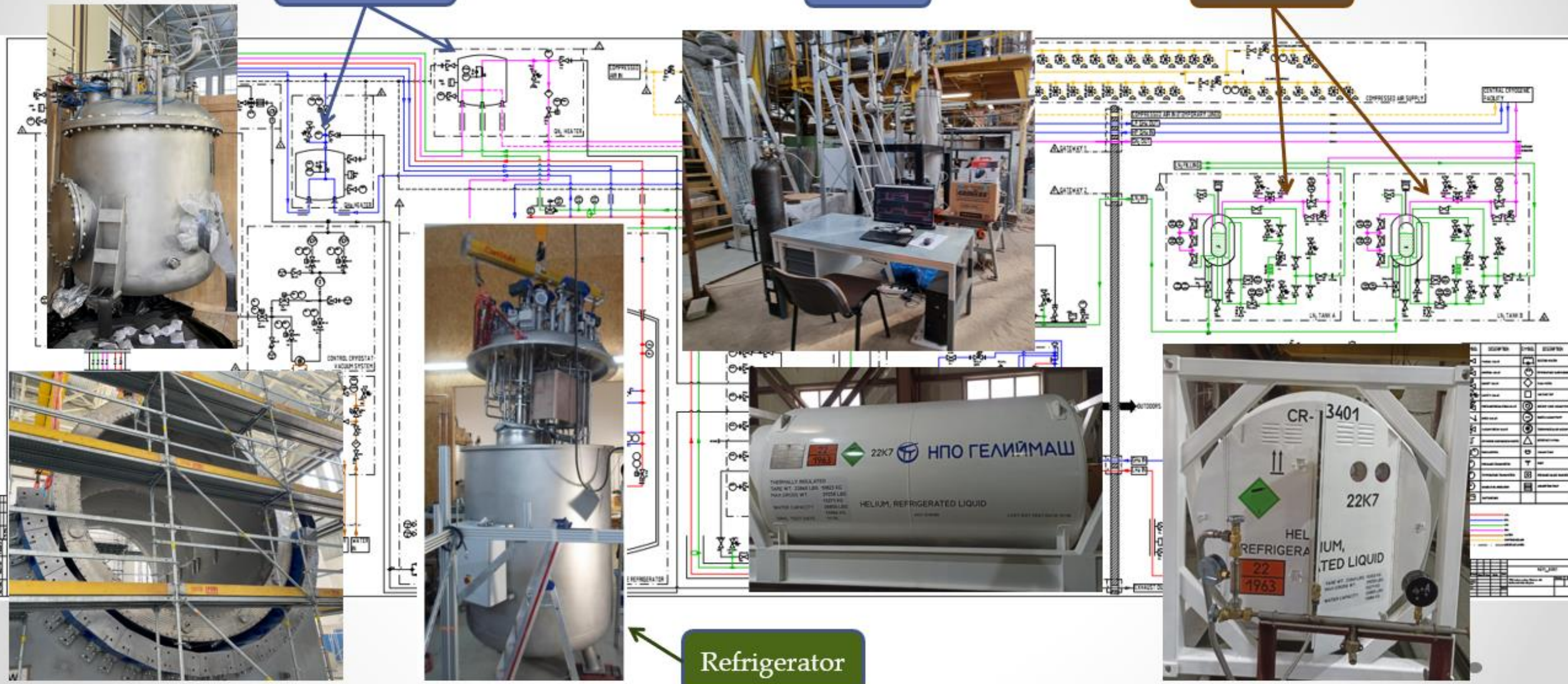
- The superconducting solenoid is a backbone of multipurpose detector
- The superconducting solenoid must provide a homogeneous magnetic field of 0.5 Tesla

Infrastructure for cooling

Two heaters

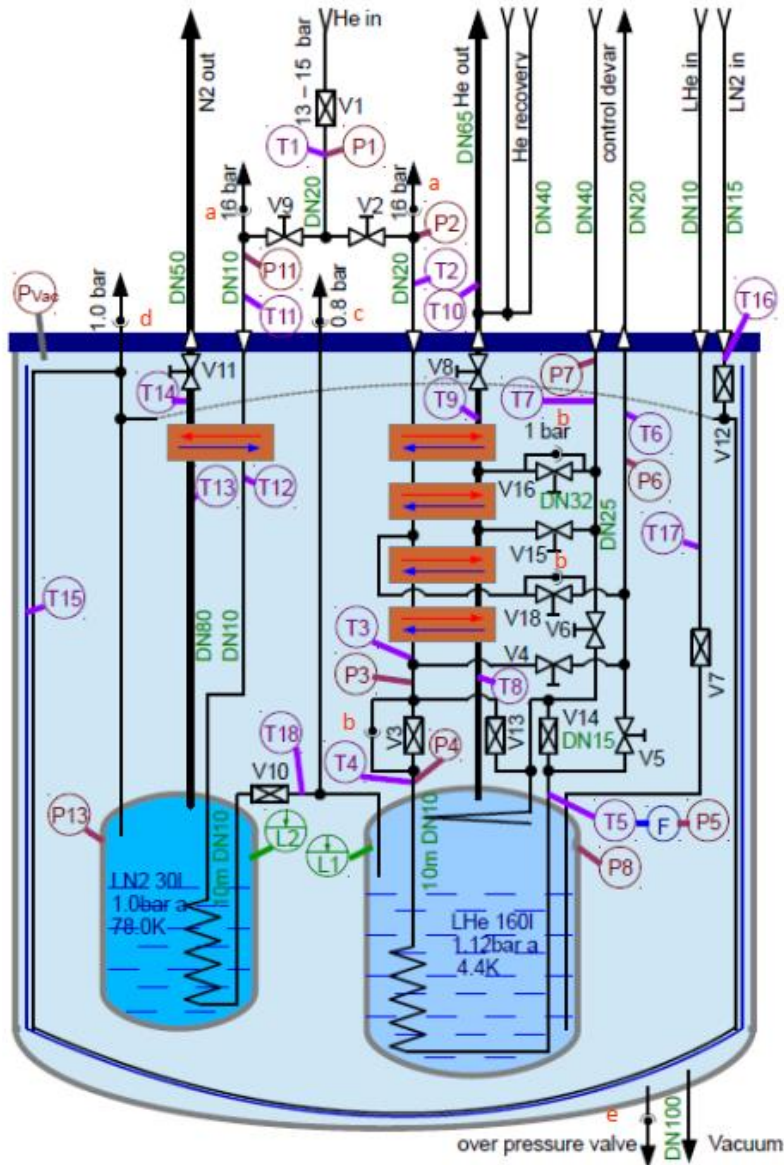
MFS

LN2 Tanks



Refrigerator

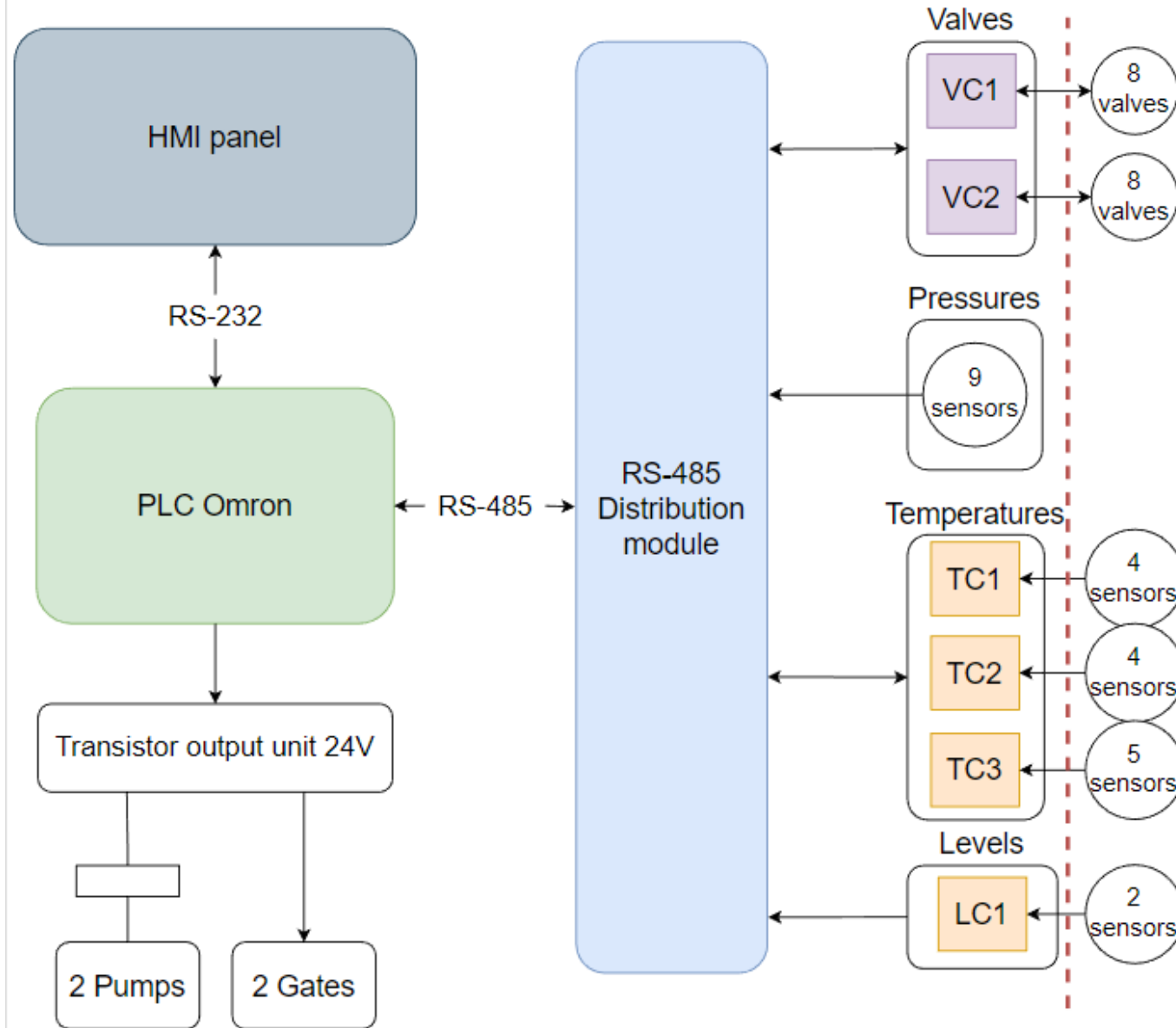
Refrigerator



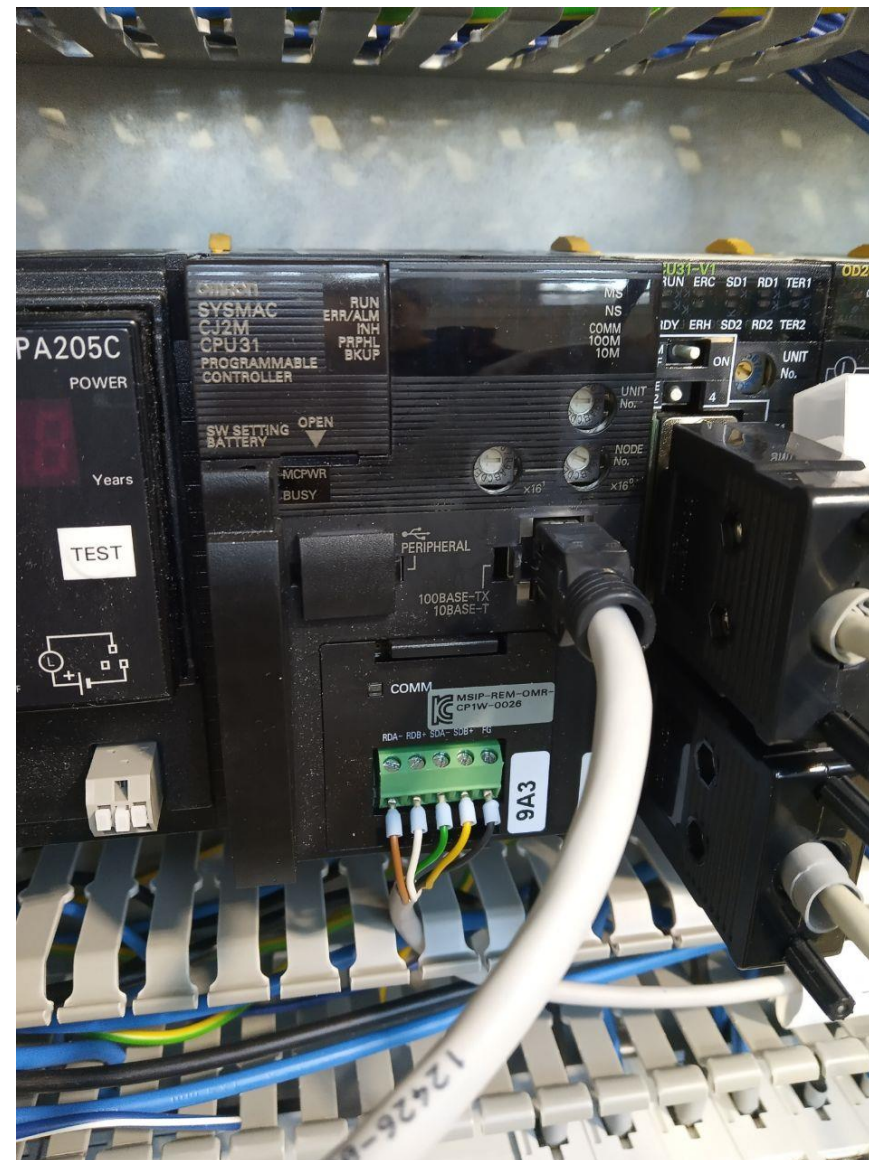
ILK braked a contract of refrigerator assembling and integration in to solenoid system!

- No drawings and instruction for assembly
- No correct software (not signals from gauges, valves can't regulation...) for operation
- No electrical scheme
- No calibration data for cernox temperature gauges

Refrigerator CS block scheme



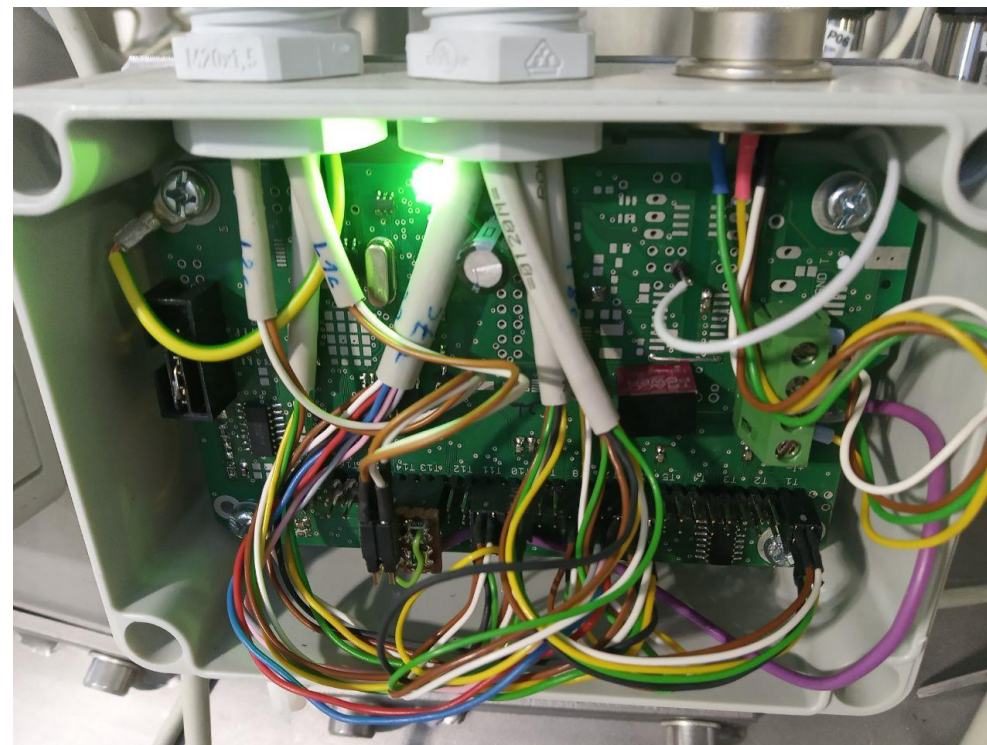
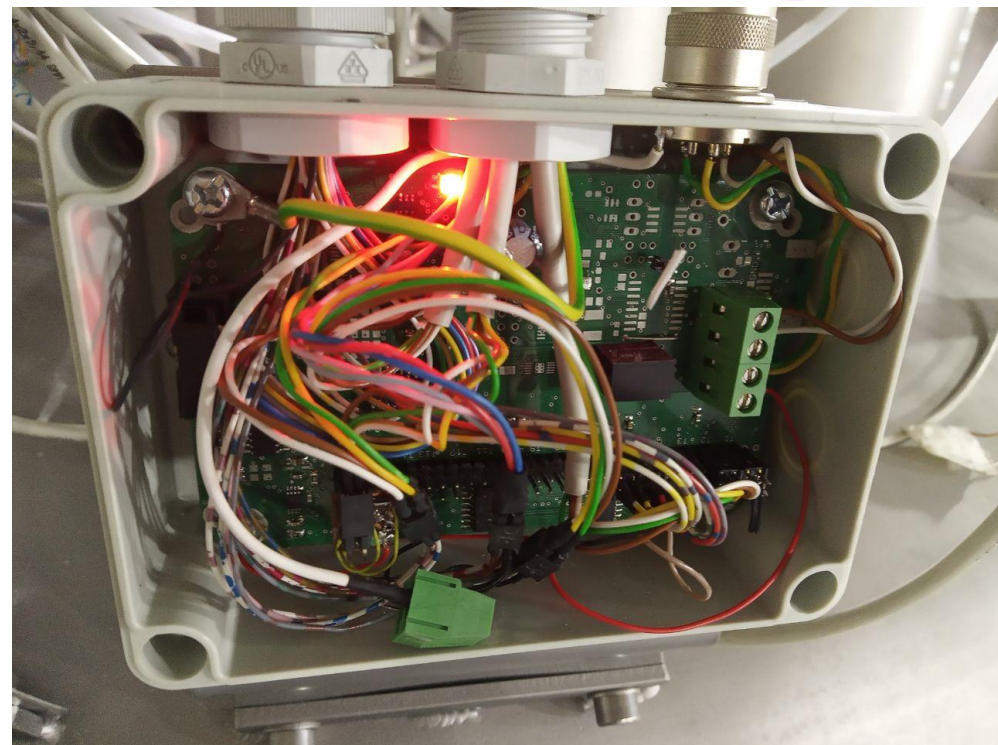
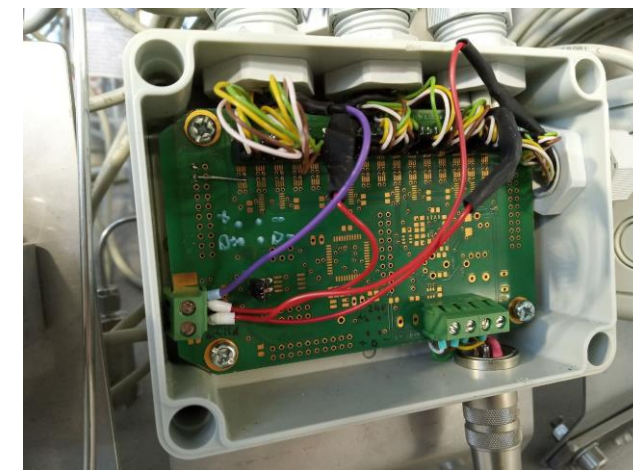
PLC



Устройства сопряжения с объектом



Устройства сопряжения с объектом

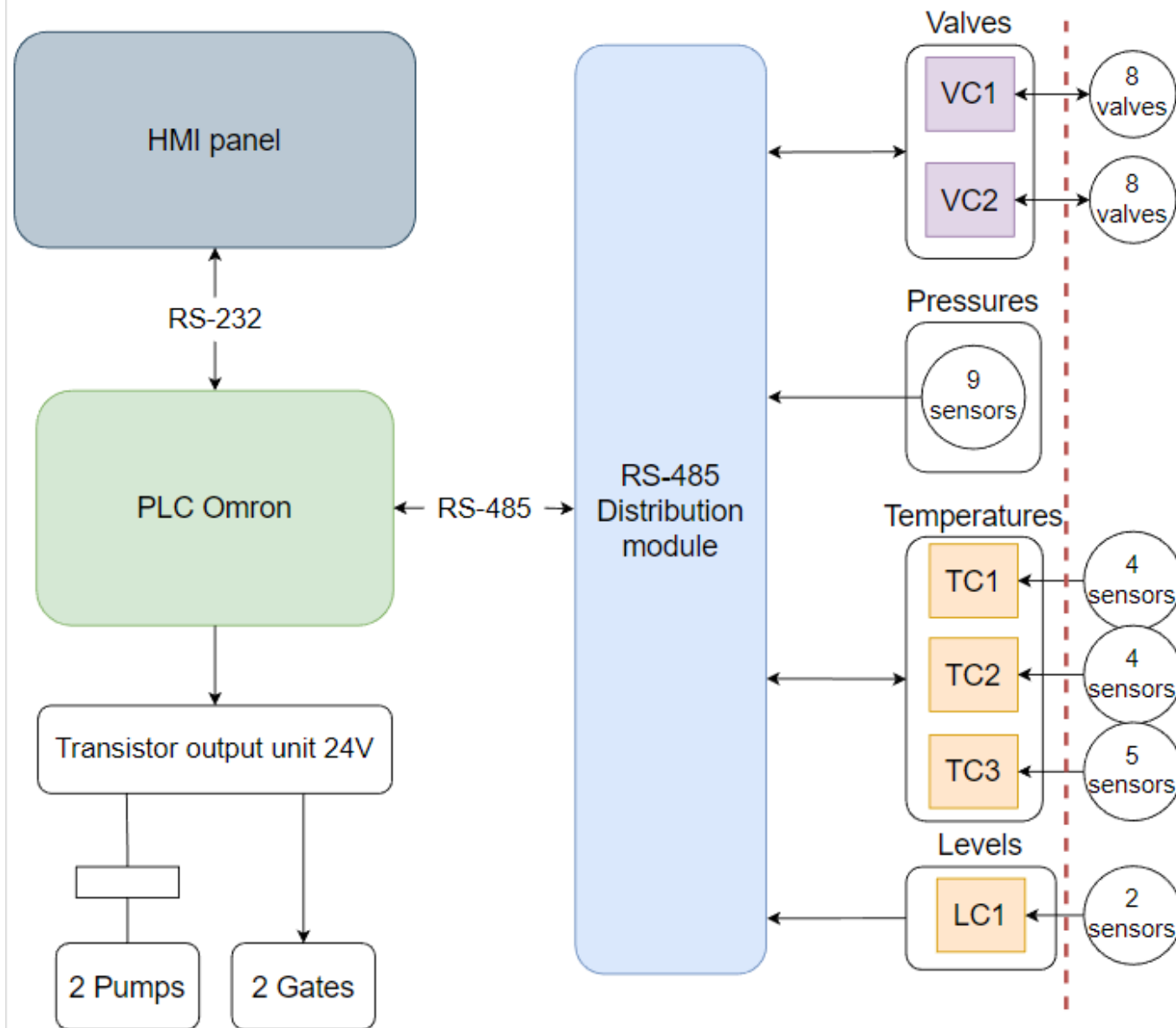




HMI

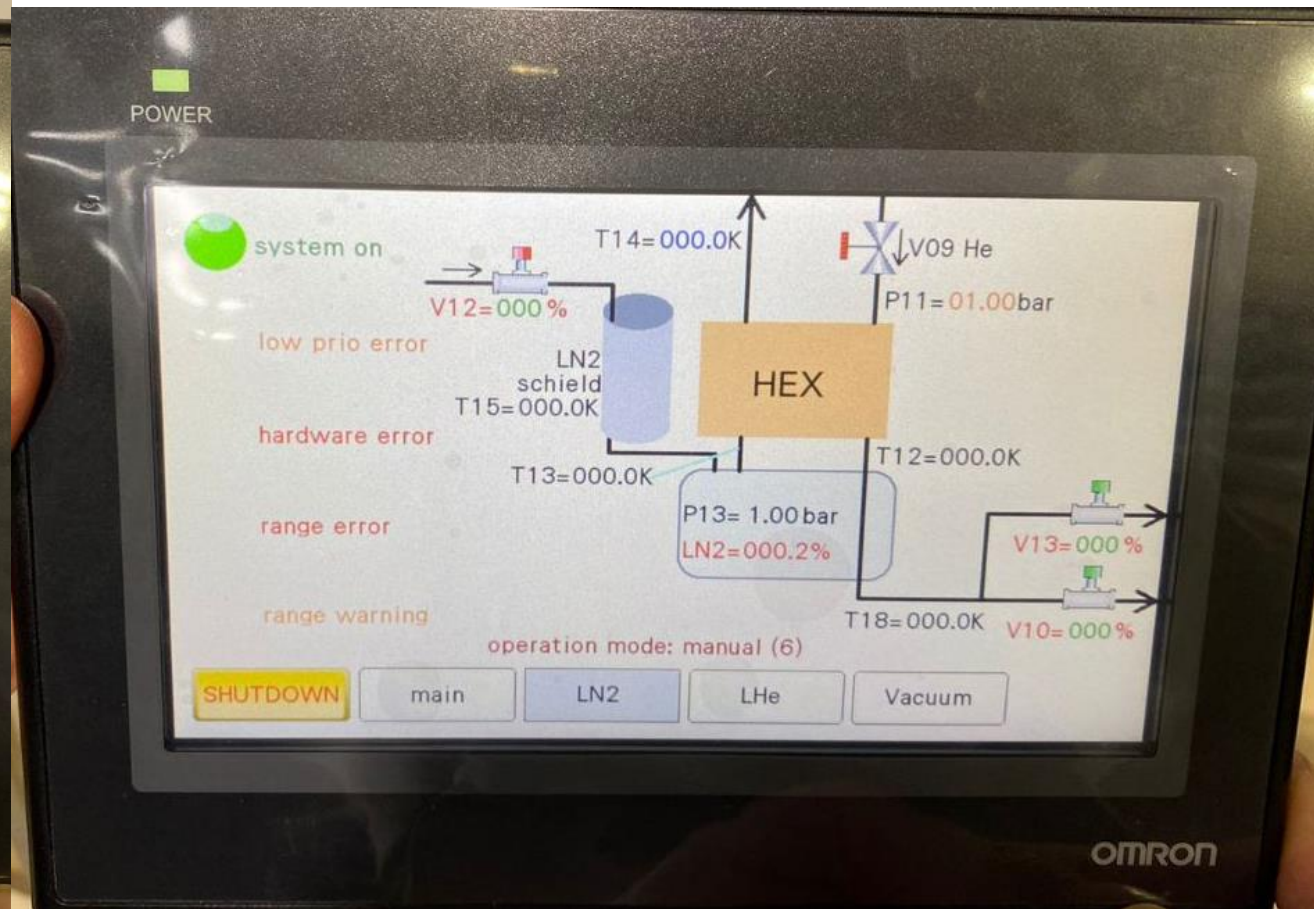
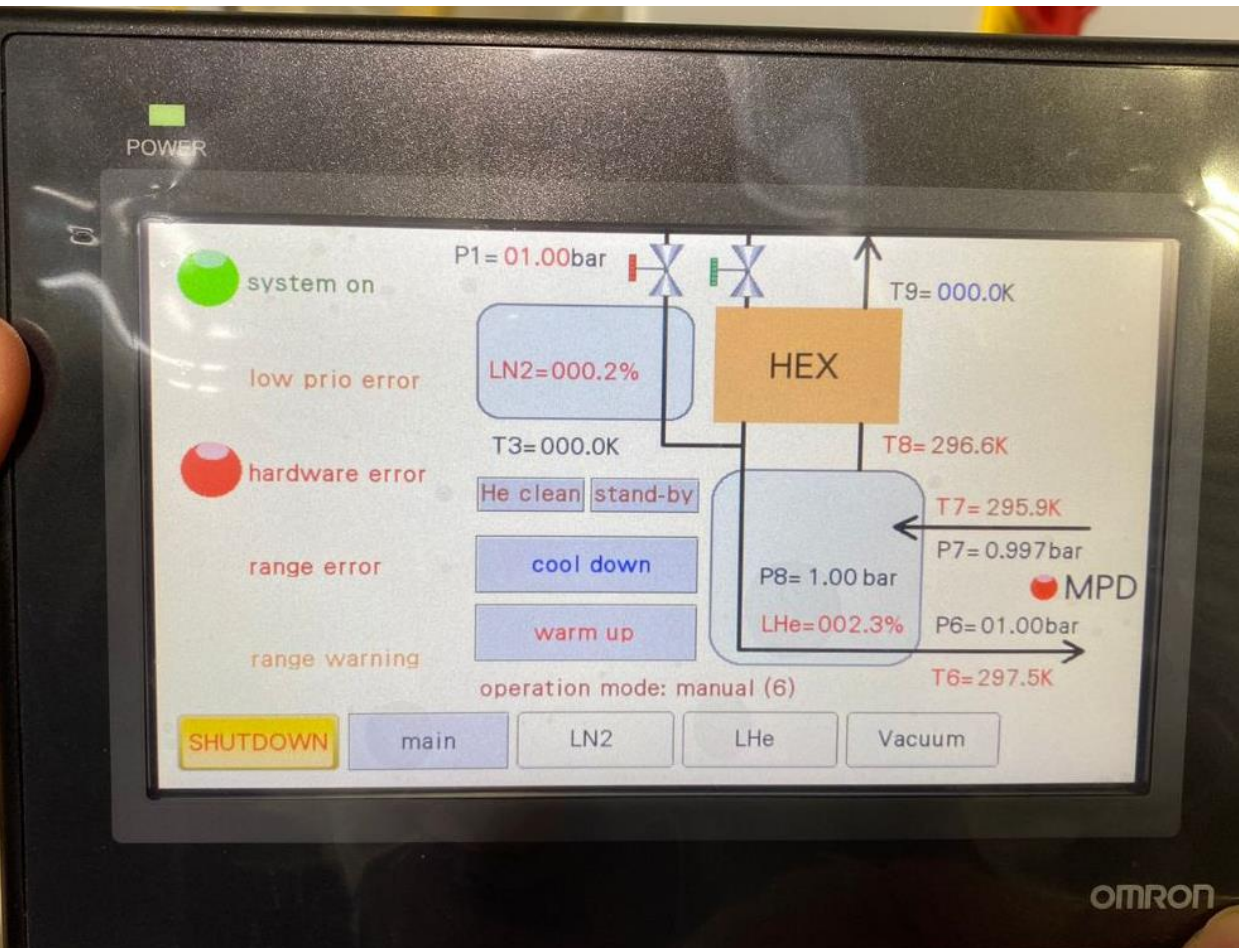


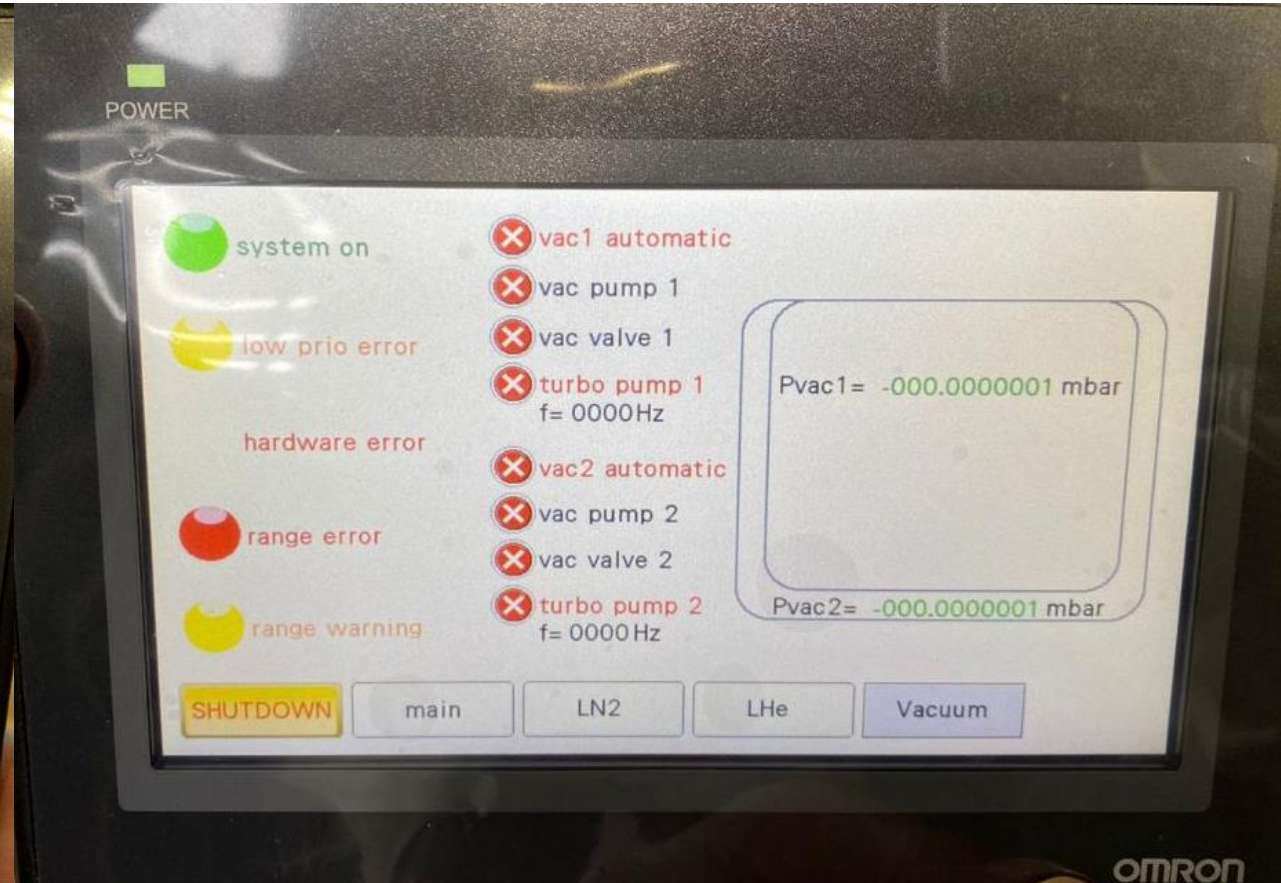
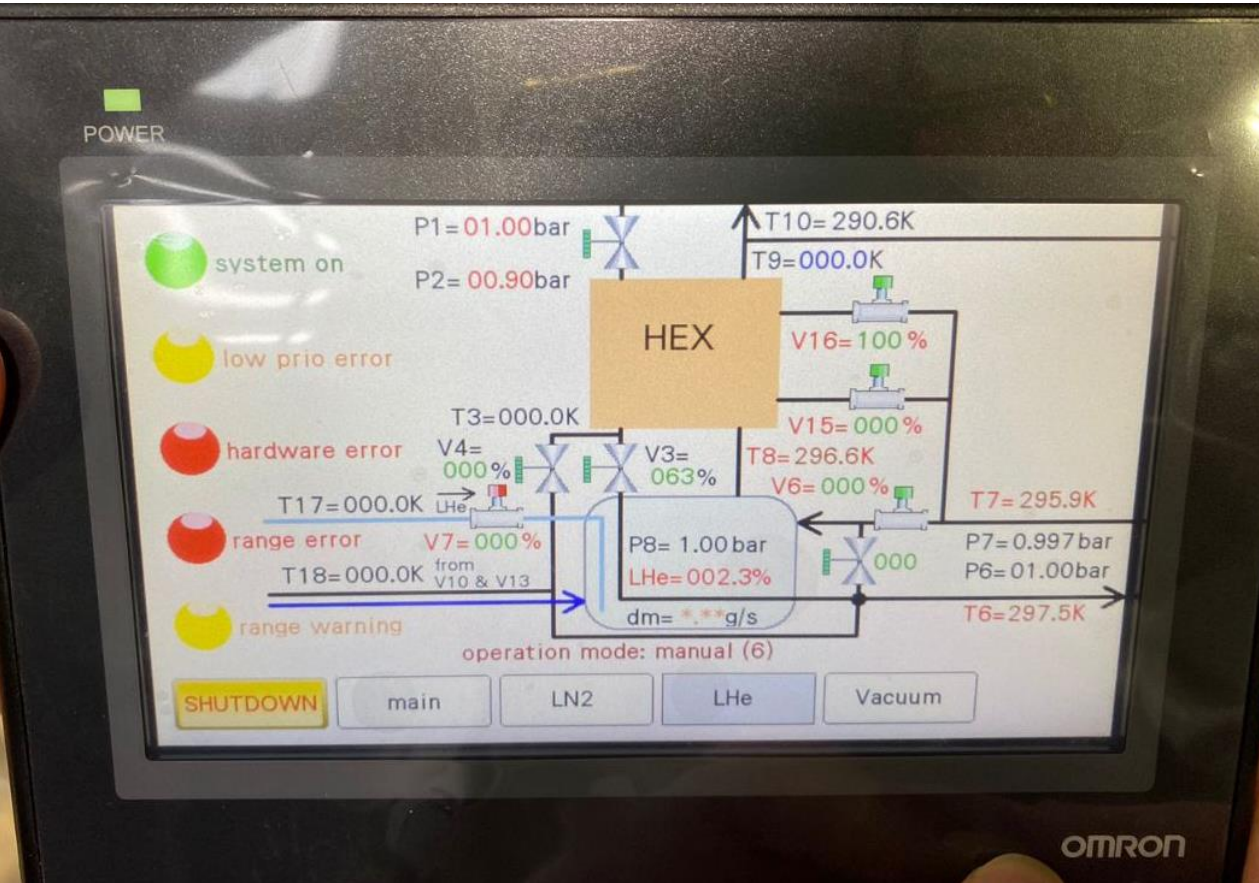
Refrigerator CS block scheme



Connecting end devices





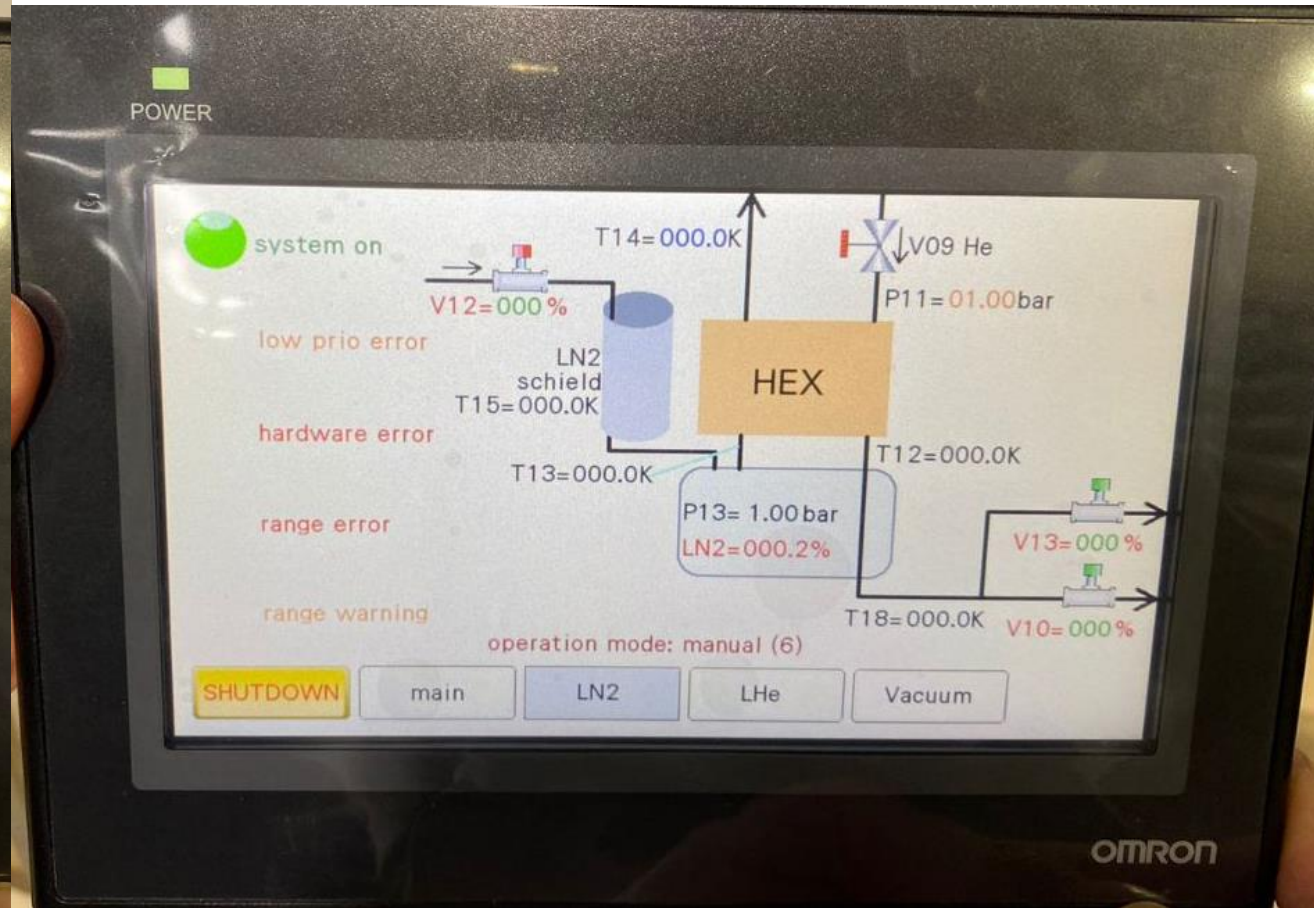
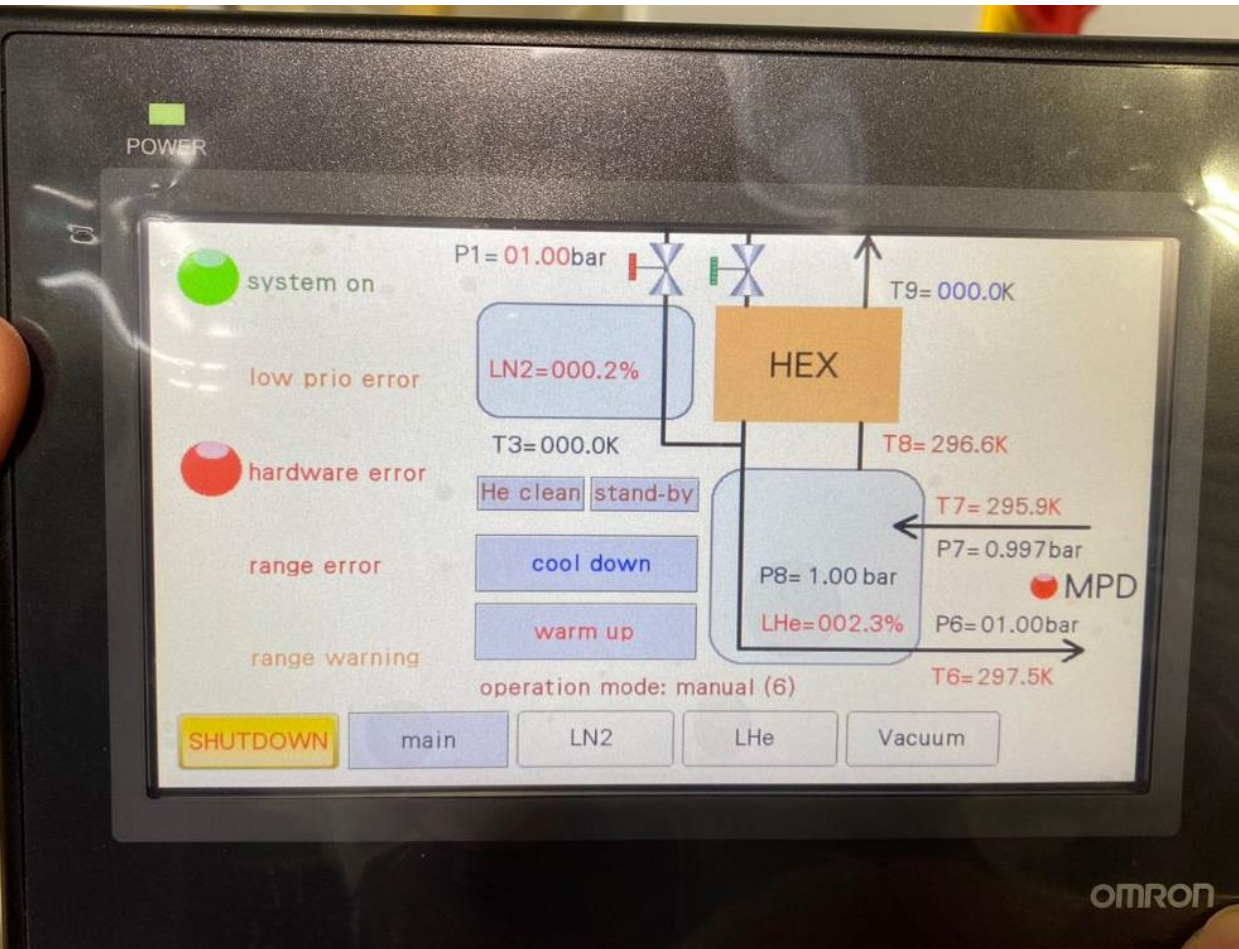


Ready to run...

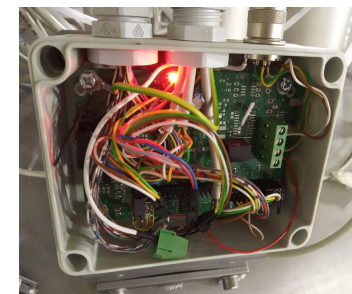
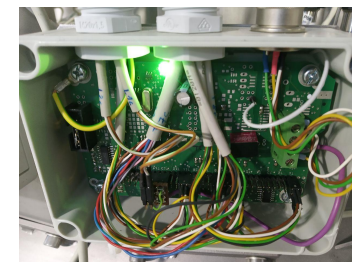
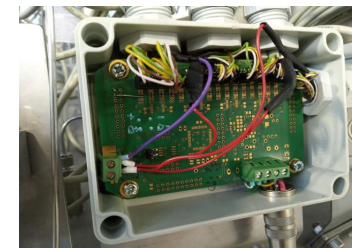
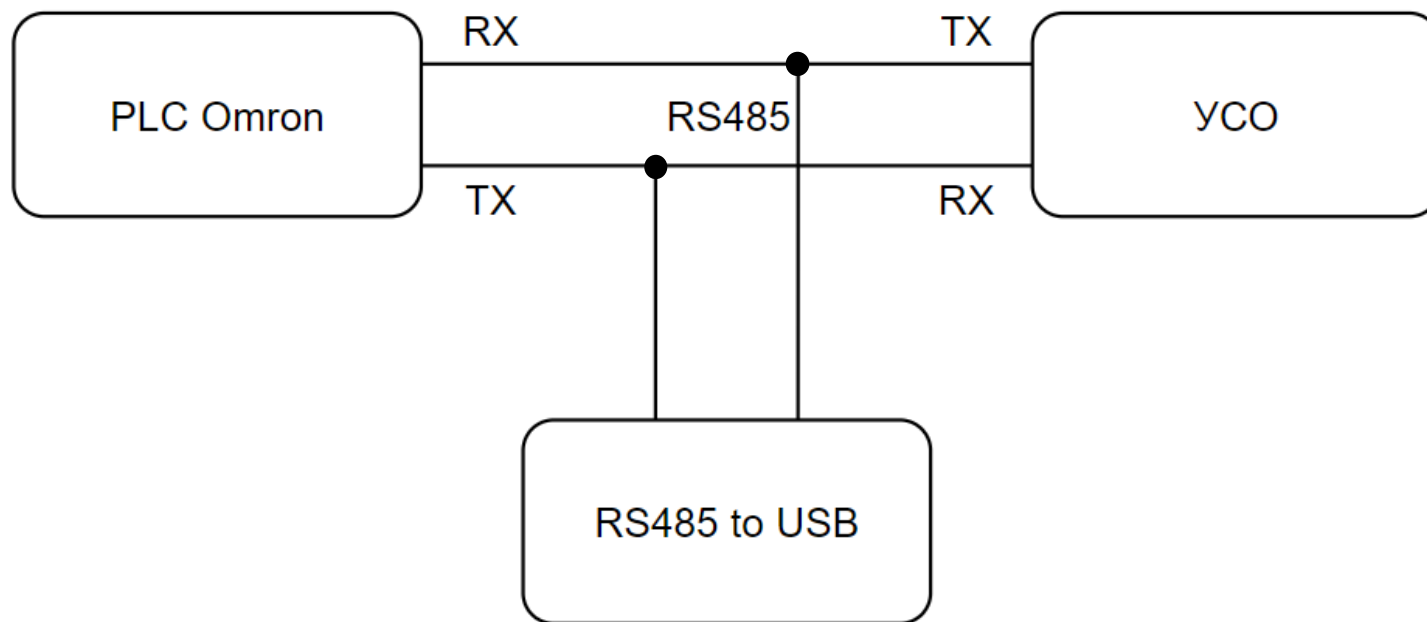


The run failed...

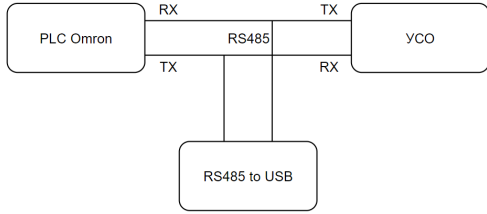




Sniffer



Serial Port Monitor



rtu with responses (master) - Serial Port Monitor

Session Edit View Monitoring Window Help

Modbus view

Checksum: 50637 (OK)

[30/01/2017 18:04:11]

Modbus Response (COM2)

Address: 1

Function: 3 (0x03) - Read Holding Registers

Byte Count: 20

Values: 00 2c 00 00 00 00 37 00 00 00 42 00 00 00 00 00 00 00 00 00

Register0: 44

Register1: 0

Register2: 55

Register3: 0

Register4: 66

Register5: 0

Register6: 0

Dump view

```

00 00 00 00 00 00 00 12 9e          .....h
[30/01/2017 18:04:07] Written data (COM2)
01 03 00 00 00 0a c5 cd          .....EH
[30/01/2017 18:04:07] Read data (COM2)
01 03 14 00 2c 00 00 00 00 00 37 00 00 00 42 00 00 00  .....7...B...
00 00 00 00 00 00 00 12 9e          .....h
[30/01/2017 18:04:08] Written data (COM2)
01 03 00 00 00 0a c5 cd          .....EH
[30/01/2017 18:04:08] Read data (COM2)
01 03 14 00 2c 00 00 00 00 00 37 00 00 00 42 00 00 00  .....7...B...
00 00 00 00 00 00 00 12 9e          .....h
[30/01/2017 18:04:09] Written data (COM2)
01 03 00 00 00 0a c5 cd          .....EH
[30/01/2017 18:04:09] Read data (COM2)
01 03 14 00 2c 00 00 00 00 00 37 00 00 00 42 00 00 00  .....7...B...
    
```

Terminal view

```

.EH.....Jg.....
.EH.....Jg.....
.EH.....Jg.....
.EH.....Jg.....
.EH.....Jg.....
.EH.....Jg.....
.EH.....Jg.....
.EH.....Jg.....
.EH.....;c.....
.EH.....;c.....
.EH.....;c.....
.EH.....7.....Ls.....
.EH.....7.....Ls.....
.EH.....7.....Ls.....
.EH.....7...B.....h.....
.EH.....7...B.....h.....
    
```

Table view

#	Time	Function	Direct...	Status	Data
311	30/01/2017 18:04:09	IRP_MJ_DEVICE_CONTROL (IOCTL_SERIAL_PURGE)	UP	STATUS_SUCCESS	
312	30/01/2017 18:04:09	IRP_MJ_WRITE	DOWN		
313	30/01/2017 18:04:09	IRP_MJ_WRITE	UP	STATUS_SUCCESS	01 03 00 00 00 ...
314	30/01/2017 18:04:09	IRP_MJ_READ	DOWN		
315	30/01/2017 18:04:09	IRP_MJ_READ	UP	STATUS_TIMEOUT	
316	30/01/2017 18:04:09	IRP_MJ_READ	DOWN		
317	30/01/2017 18:04:09	IRP_MJ_READ	UP	STATUS_SUCCESS	01 03 14 00 2c
318	30/01/2017 18:04:09	IRP_MJ_READ	DOWN		
319	30/01/2017 18:04:09	IRP_MJ_READ	UP	STATUS_SUCCESS	00 00 00 37 00 ...
320	30/01/2017 18:04:10	IRP_MJ_DEVICE_CONTROL (IOCTL_SERIAL_PURGE)	DOWN		0c 00 00 00
321	30/01/2017 18:04:10	IRP_MJ_DEVICE_CONTROL (IOCTL_SERIAL_PURGE)	UP	STATUS_SUCCESS	
322	30/01/2017 18:04:10	IRP_MJ_WRITE	DOWN		
323	30/01/2017 18:04:10	IRP_MJ_WRITE	UP	STATUS_SUCCESS	01 03 00 00 00 ...

Send dialog (available in Professional version only)

Port: COM2 Baudrate: 9600 Databits: 8 Stopbits: 1 stop bit Parity: No parity Flow control: None

String Hex Dec Oct Bin

Send file

Loop this command sending every 1000 ms Start loop

Open Send

For help press F1

IRP: 0 Read: 0 Written: 0 U-U-U-U

RTS CTS DSR DCD DTR RI

Data stream example

```
[22/12/2022 15:09:25]
Modbus Response (COM4)
Address: 61
Function: 3 (0x03) - Read Holding Registers
  Byte Count: 16
  Values: 00 00 10 45 fa 3d 03 20 3b 93 05 43 60 06 fc 42
    Register0: 0
    Register1: 4165
    Register2: 64061
    Register3: 800
    Register4: 15251
    Register5: 1347
    Register6: 24582
    Register7: 64578
Checksum: 24030(BAD)
```

```
[22/12/2022 15:09:25]
Modbus Response (COM4)
Address: 62
Function: 3 (0x03) - Read Holding Registers
  Byte Count: 16
  Values: 00 00 10 45 c9 3e 03 20 82 e8 00 43 3b 5e e6 c1
    Register0: 0
    Register1: 4165
    Register2: 51518
    Register3: 800
    Register4: 33512
    Register5: 67
    Register6: 15198
    Register7: 59073
Checksum: 16969(BAD)
```

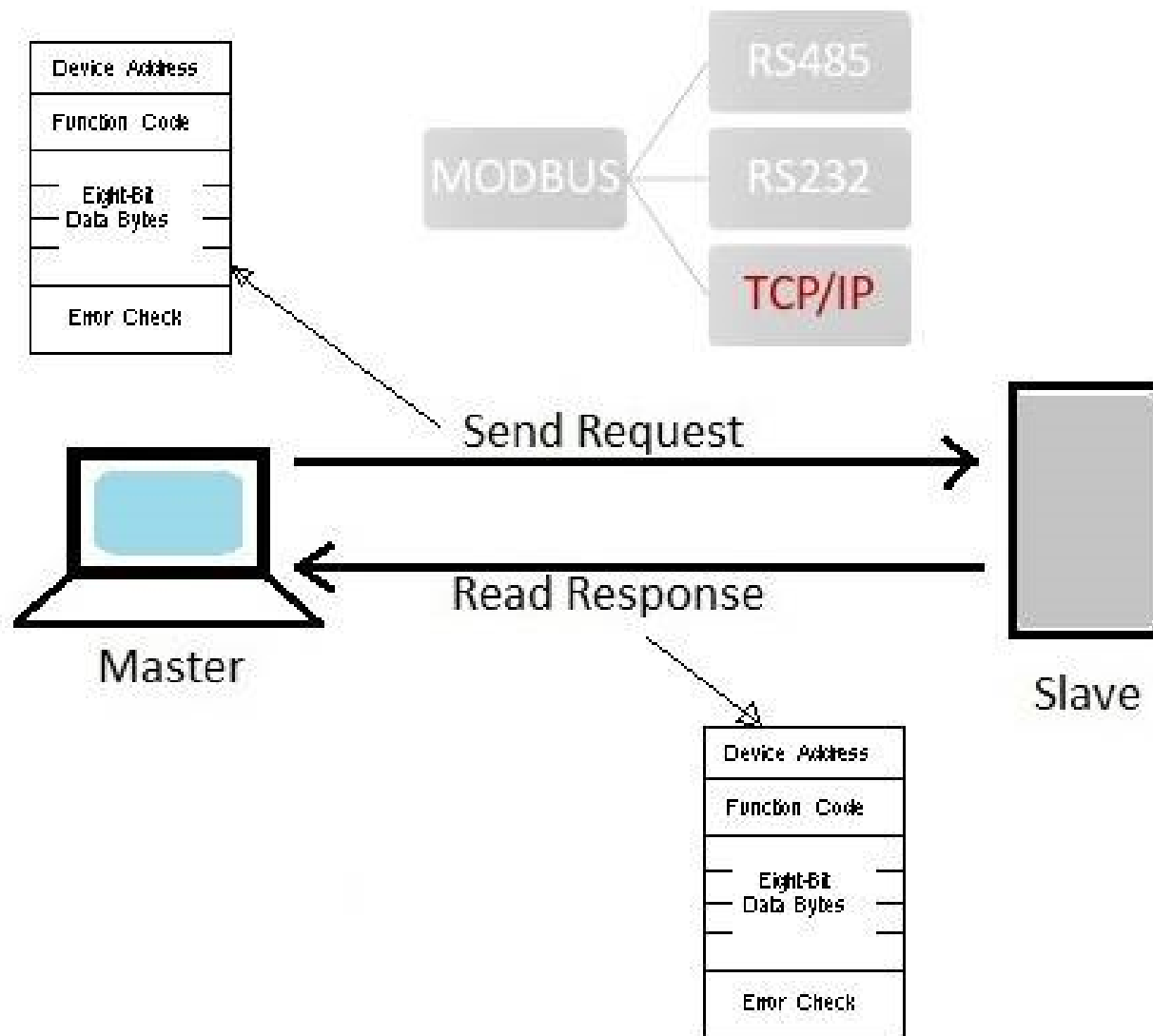
```
[22/12/2022 15:09:25]
Modbus Response (COM4)
Address: 18
Function: 3 (0x03) - Read Holding Registers
  Byte Count: 0
  Values:
Checksum: 39670(BAD)
```

```
[22/12/2022 15:09:25]
Modbus Response (COM4)
Address: 19
Function: 3 (0x03) - Read Holding Registers
  Byte Count: 16
  Values: 00 00 04 43 bb 13 03 08 00 00 80 3f 00 00 00 00
    Register0: 0
    Register1: 1091
    Register2: 47891
    Register3: 776
    Register4: 0
    Register5: 32831
    Register6: 0
    Register7: 0
Checksum: 49514(BAD)
```

```
[22/12/2022 15:09:25]
Modbus Response (COM4)
Address: 20
Function: 3 (0x03) - Read Holding Registers
  Byte Count: 48
  Values: 00 00 40
    Register0: 0
Checksum: 18943(OK)
```

```
[22/12/2022 15:09:25]
Modbus Response (COM4)
Address: 20
Function: 3 (0x03) - Read Holding Registers
  Byte Count: 128
  Values: 19 da 8f 43 d3 7b 8f 43 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
    Register0: 6618
    Register1: 36675
```

Modbus protocol



CX-Programmer



The screenshot shows the CX-Programmer software interface. The title bar reads 'TRIAL - CX-Programmer - [NewPLC1.NewProgram1.Section1 [Diagram]]'. The menu bar includes File, Edit, View, Insert, PLC, Program, Simulation, Tools, Window, and Help. The toolbar contains various icons for file operations, editing, and simulation. The left sidebar shows a project tree with 'NewProject' containing 'NewPLC1[CP1E] Offline' and 'NewProgram1 (00)'. The main workspace displays a ladder logic diagram for 'Section 1' with the following rungs:

- Rung 0: [Program Name : NewProgram1] [Section Name : Section 1]
- Rung 1: Ladder logic with inputs 'EMERGENCY ...' (W0.00) and 'LIGHT SENSOR' (t: 0.03), leading to output 'RELAY' (W0.00).
- Rung 2: Ladder logic with inputs 'RELAY' (W0.00), 'LIMIT SWITCH' (t: 0.02), 'RELAY 1' (W0.01), and 'NIGHT TIMER' (T000), leading to output 'ROOF OPEN' (Q: 100.00).
- Rung 3: Ladder logic with input 'RAIN SENSOR' (t: 0.04), leading to output 'RELAY 1' (W0.01).
- Rung 4: Ladder logic with inputs 'RELAY 1' (W0.01) and 'LIMIT SWITCH 1' (t: 0.05), leading to output 'ROOF CLOSE' (Q: 100.01).
- Rung 5: Ladder logic with input 'LIMIT SWITCH 1' (t: 0.05) and 'NIGHT TIMER' (T000), leading to output 'RELAY 2' (W0.02).
- Rung 6: Ladder logic with input 'RELAY 2' (W0.02), leading to output 'ROOF CLOSE AT NIGHT' (Q: 100.02).
- Rung 7: Ladder logic with input 'RELAY' (W0.00), leading to a timer block.

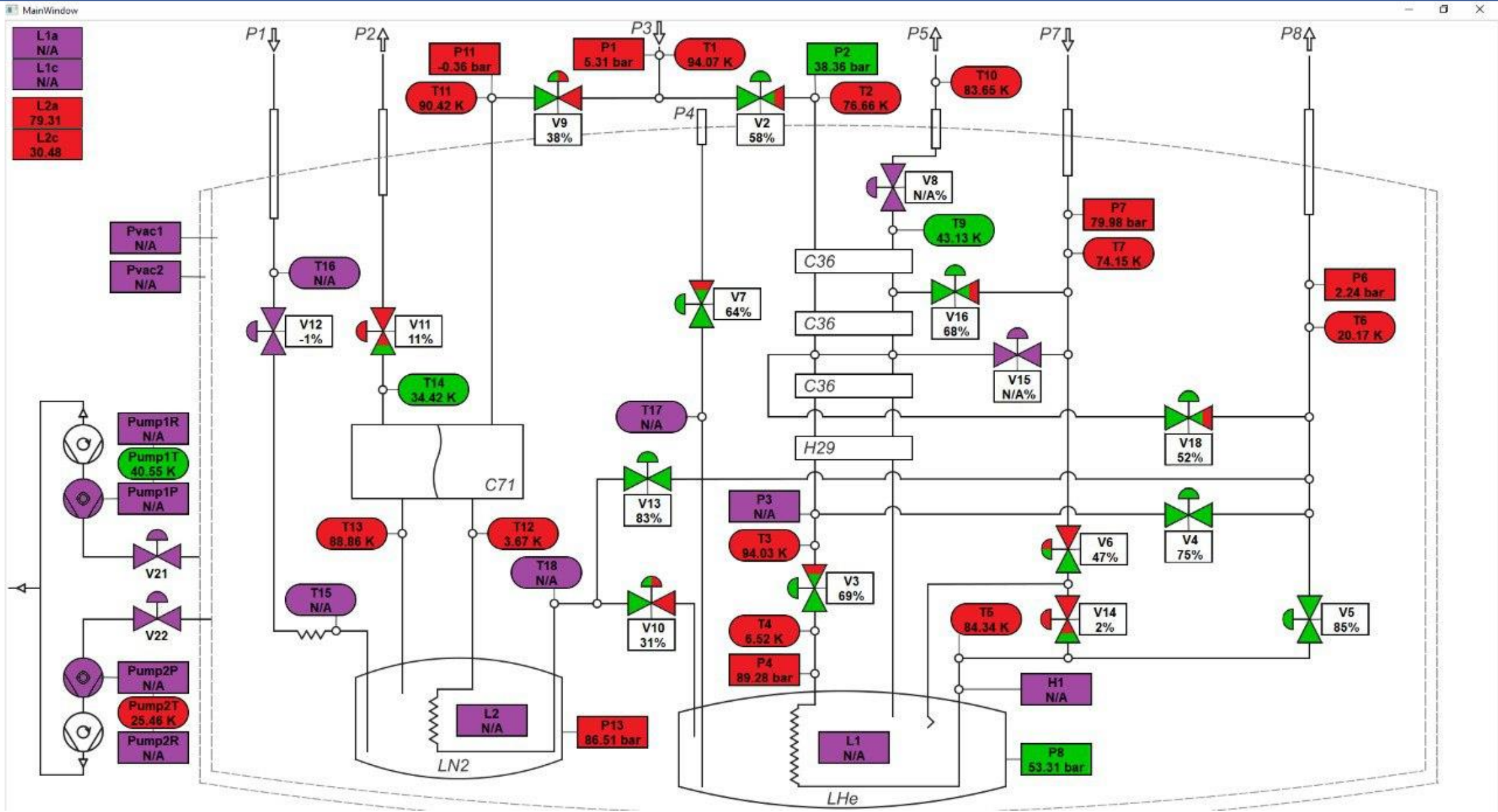
The timer block is a '100ms Timer (Timer) [BCD Type]' with 'NIGHT TIMER' as the timer number and a 'Set value' of '#030'.

Modbus register map

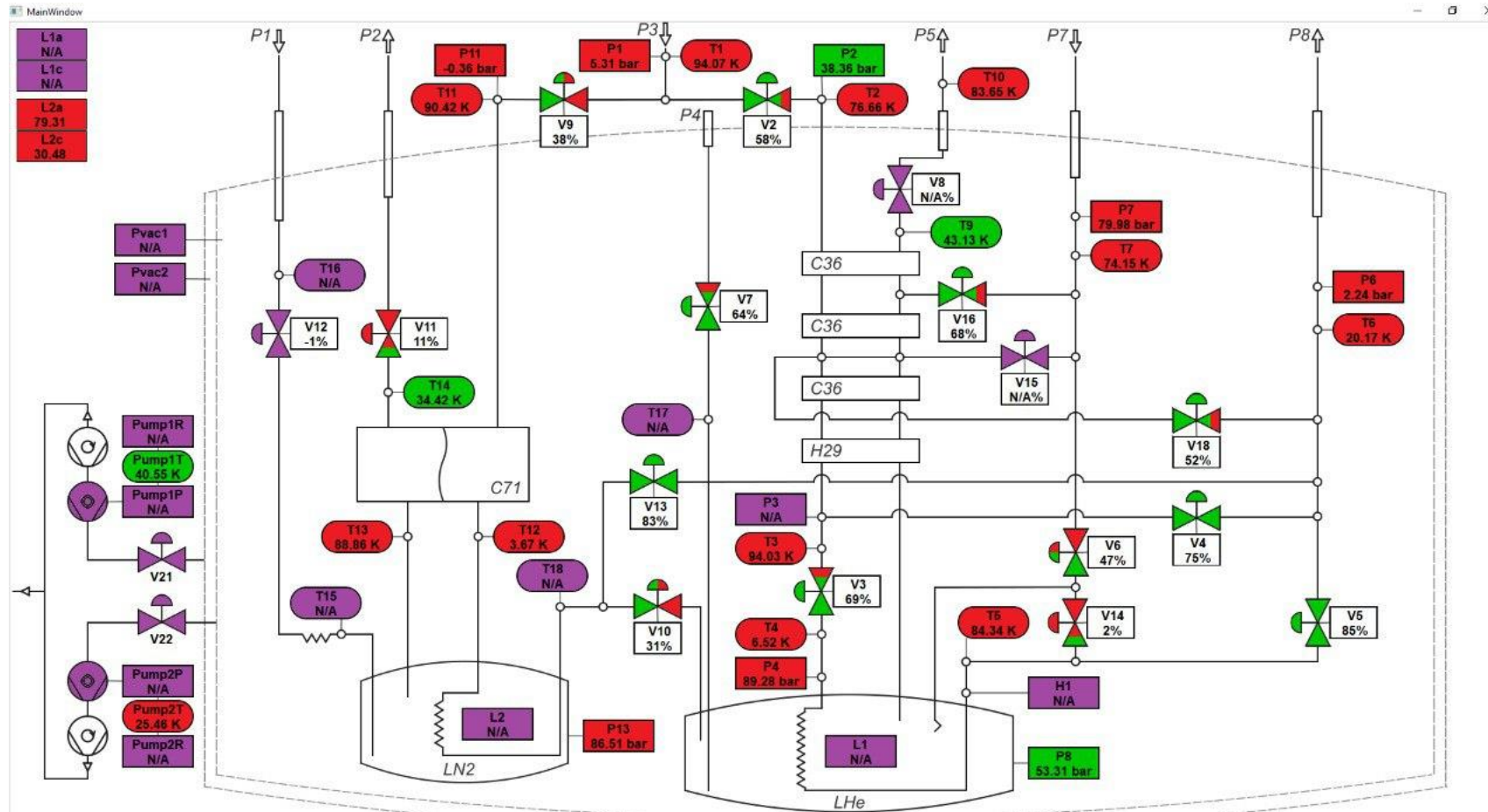
```
13
14
15 control_devices:
16   V9:
17     modbus_id: 01
18     start_register: 16399
19     num_registers: 2
20   V8:
21     modbus_id: 01
22     start_register: 16397
23     num_registers: 2
24   V7:
25     modbus_id: 01
26     start_register: 16395
27     num_registers: 2
28   V6:
29     modbus_id: 01
30     start_register: 16393
31     num_registers: 2
32   V5:
33     modbus_id: 01
34     start_register: 16391
35     num_registers: 2
36   V4:
37     modbus_id: 01
38     start_register: 16389
39     num_registers: 2
40   V3:
41     modbus_id: 01
42     start_register: 16387
43     num_registers: 2
44   V2:
45     modbus_id: 01
46     start_register: 16385
47     num_registers: 2
```

```
81 sensor_devices:
82   V2_fb:
83     modbus_id: 01
84     start_register: 4096
85     num_registers: 2
86   V3_fb:
87     modbus_id: 01
88     start_register: 4098
89     num_registers: 2
90   V4_fb:
91     modbus_id: 01
92     start_register: 4100
93     num_registers: 2
94   V5_fb:
95     modbus_id: 01
96     start_register: 4102
97     num_registers: 2
98   V6_fb:
99     modbus_id: 01
100    start_register: 4104
101    num_registers: 2
102   V7_fb:
103     modbus_id: 01
104     start_register: 4106
105     num_registers: 2
106   V8_fb:
107     modbus_id: 01
108     start_register: 4108
109     num_registers: 2
110   V9_fb:
111     modbus_id: 01
112     start_register: 4110
113     num_registers: 2
114   V10_fb:
115     modbus_id: 02
116     start_register: 4096
117     num_registers: 2
```


GUI application for refrigerator



GUI application for refrigerator



Conclusion

Was:

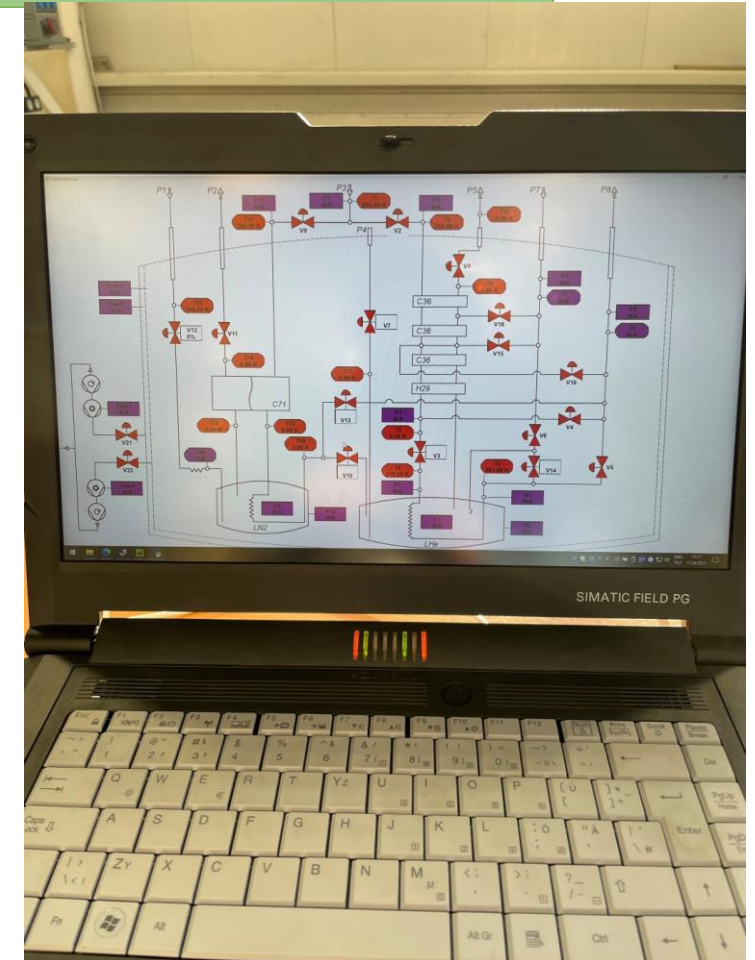
- ILK braked a contract of refrigerator assembling and integration in to solenoid system!;
- No drawings and instruction for assembly;
- No correct software (not signals from gauges, valves can't regulation...) for operation;
- No electrical scheme;
- No calibration data for cernox temperature gauges;

Became:

- Mechanically assembling refrigerator;
- Developed software and got signals for gauges and valves;
- Provide leak tests;
- Pumping started;

Will:

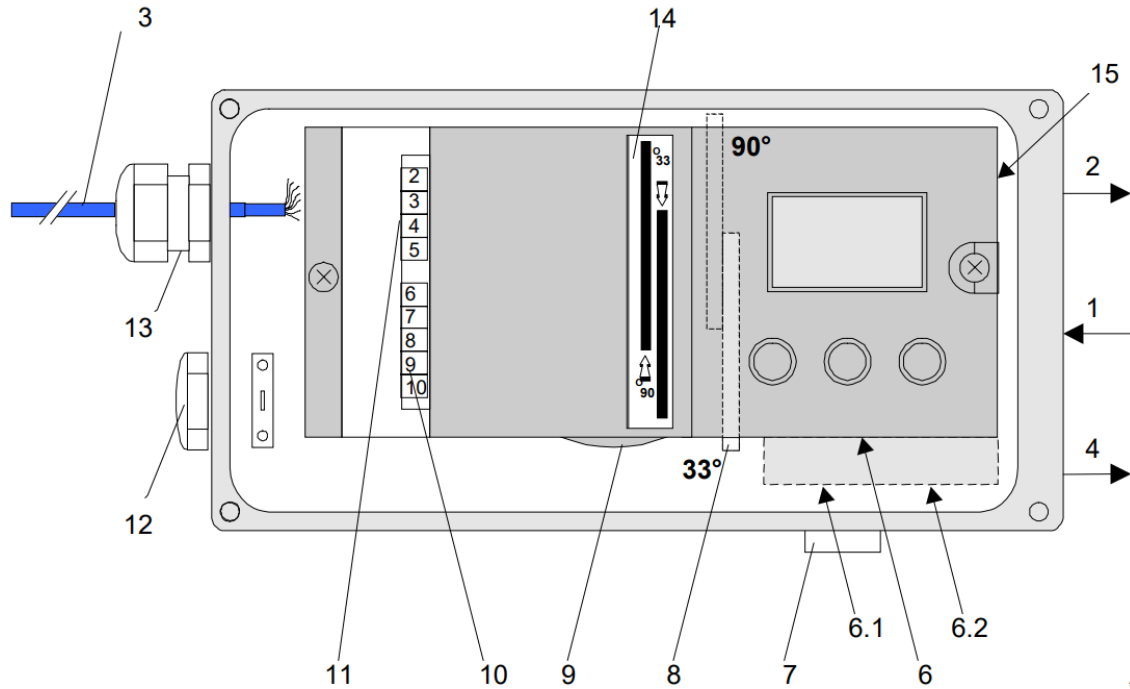
- Electronics units will be replaced;
- Implement Tango Controls.



Conclusion



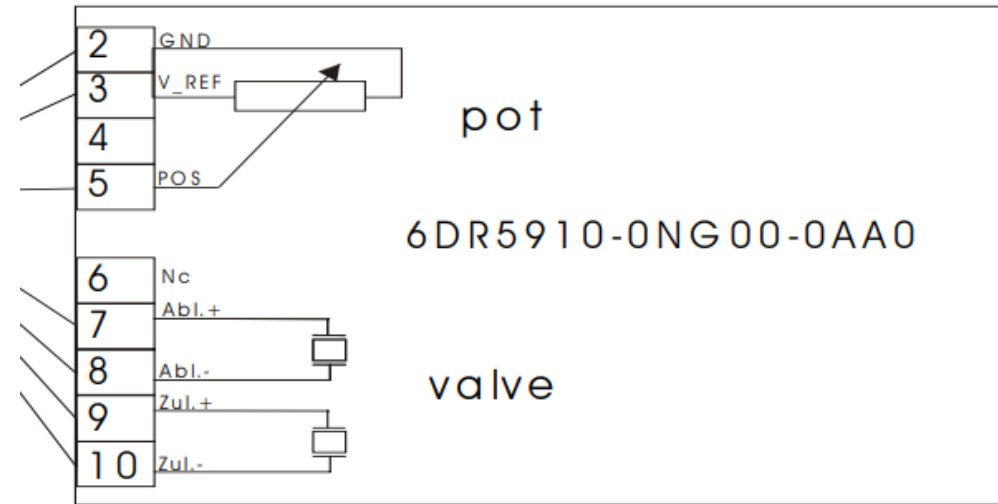
Connecting end devices. Valves



- 1 Input: air
- 2 Output: Set press. Y1
- 3 Shielded cable
- 4 Output: Set press.Y2 **'
- 6 Choke Y1
- 6.1 Choke Y1 **'
- 6.2 Choke Y2 **'
- 7 Silencer
- 8 Gear trans-Mission switch
- 9 Adjusting wheel slip clutch
- 10 Terminals Valve
- 11 Terminals Pot
- 12 Dummy plug
- 13 Screw cable gland
- 14 Switch plate on cover
- 15 Purge air switch

**') in double action drives

Valve control



При отсутствии тока в катушке пружина 13, опирающаяся на заглушку 14, прижимает нижний клапан 12 к втулке 11, перекрывая доступ сжатого воздуха из канала А к пневмоприводу (канал Б). Поскольку при этом верхний клапан 3 отжат вверх (открыт), воздушная полость пневмопривода через каналы Б и В соединена с атмосферой. Когда на катушку подается напряжение, возникающая электромагнитная сила втягивает якорь внутрь катушки. Под действием якоря перемещаются вниз клапаны 3 и 12. Верхнее отверстие во втулке 11 закрывается, а нижнее — открывается. Сжатый воздух из канала А поступает в канал Б к пневмоприводу, а связь канала Б с атмосферой прерывается.

При отключении катушки вентиля клапаны под действием пружины 13 возвращаются в исходное положение. Доступ сжатого воздуха к пневмоприводу прекращается, а имеющийся в нем воздух по каналу Б, через верхнее отверстие втулки 11 и канал В выходит наружу (пневмопривод отключается). Ход клапанов — 1 мм. Зазор между якорем и сердечником в притянутом состоянии — 0,8 мм; в отпущенном — 1,8 мм.