DCS Manual

DAMIC-M Safety System

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Inhaltsverzeichnis

DCS Manual

1 System Overview

1.1 Structure

The safety part of the DAMIC-M DCS system includes a PLC and various sensors and actuators. This guarantees the safety of the experiment by shutting down parts of the system in the event of a fault. An extension of the system is possible at any time due to the flexible design.
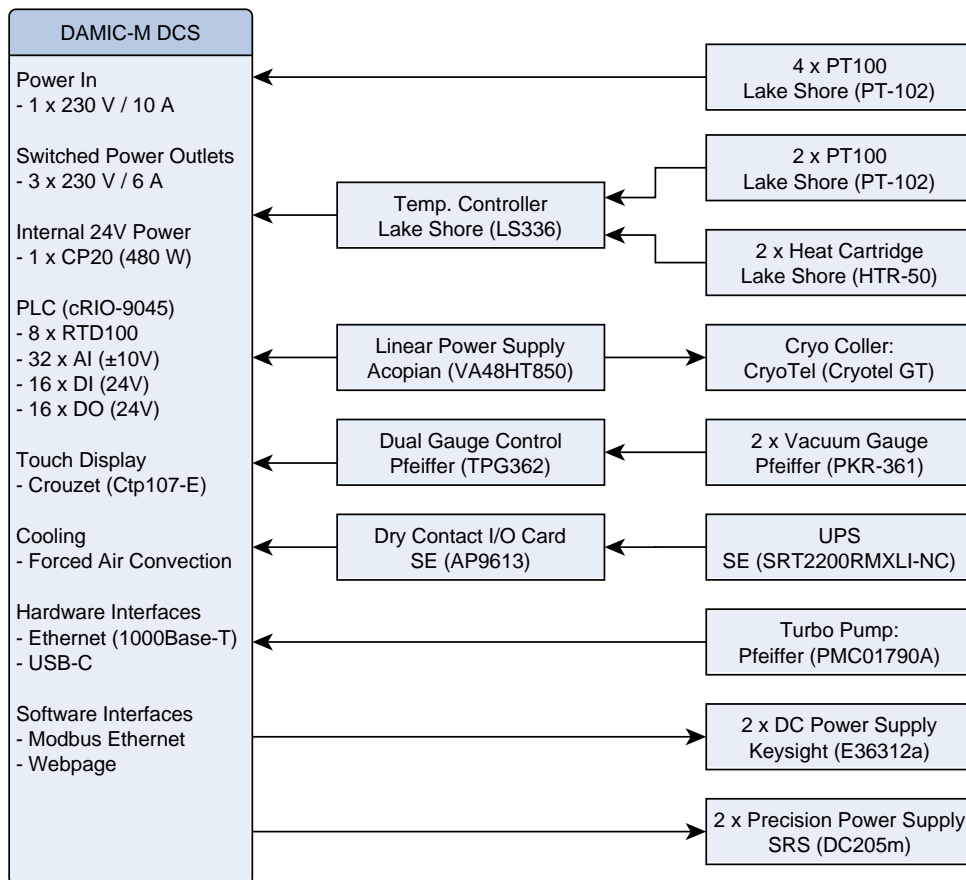
To ensure a reliable operation the DCS system should be buffered by the UPS. This guarantees a proper data logging even when the system is not reachable over Ethernet.

The DCS can be controlled with the touch display and over the Modbus interface.

1.2 DCS Controller

The DCS Controller can be mounted in a 19 in Rack. It is important that there is some free space under the controller, as the air is sucked in from below.
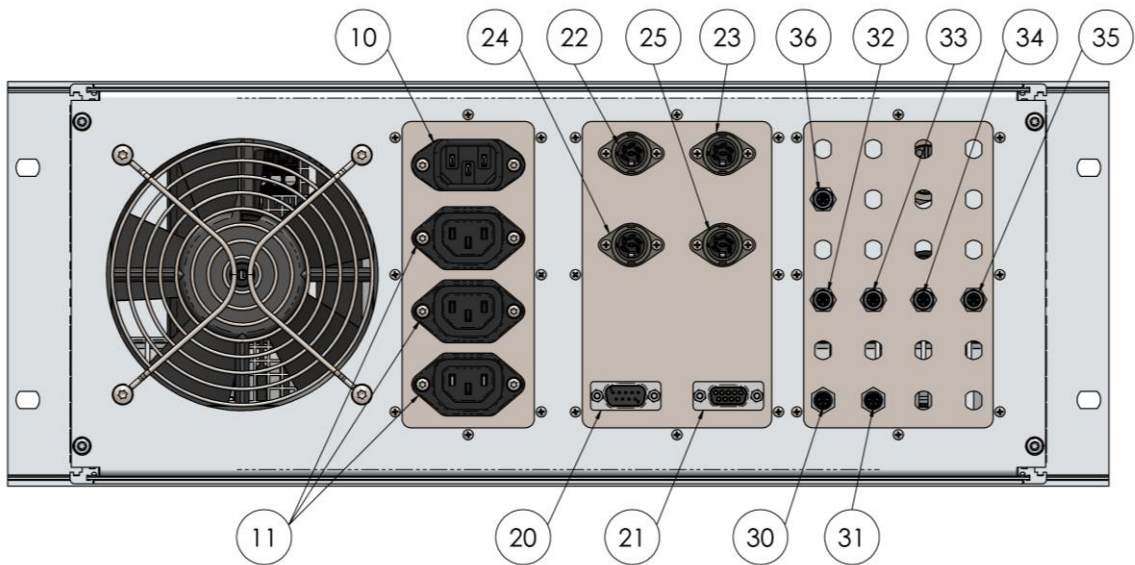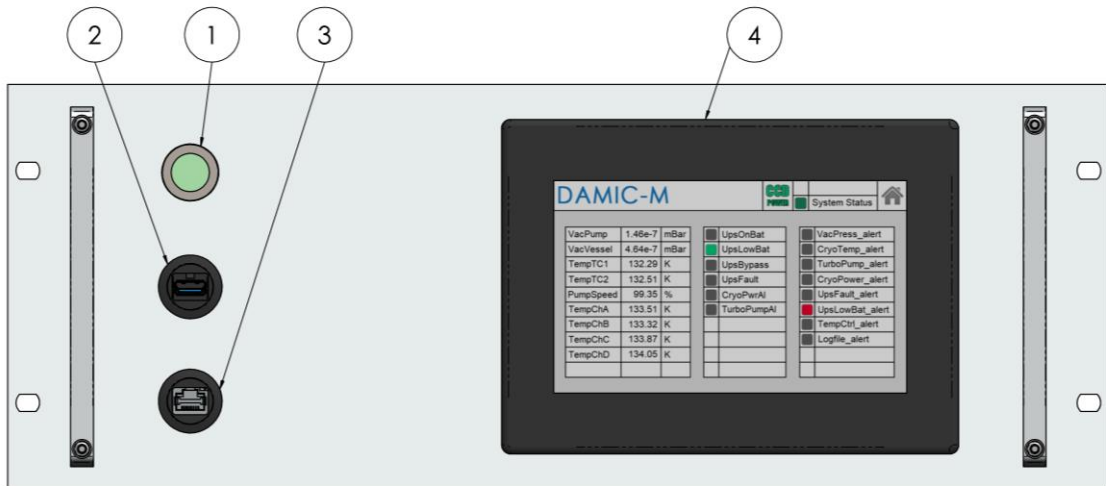
1	Status Lamp	20	Temp. Controller	30	Dual Gauge Controller
2	USB Port (cRIO)	21	UPS Dry Contracts	31	Turbo Pump
3	Ethernet Port (cRIO)	22	PT100 Channel A	32	Interlock PSU 1
4	Touch Display	23	PT100 Channel B	33	Interlock PSU 2
10	Power In (230V / 10A)	24	PT100 Channel C	34	Interlock Vsub 1
11	Power Out (230V / 6A)	25	PT100 Channel D	35	Interlock Vsub 2
				36	Cryo Power Alarm

1.3 Structure and wiring

The DCS controller is separated in three parts – the power part, the controller part and the I/O part. The cooling with the fan is made that the controller and the power supply has an optimal cooling. The following picture shows the internals of the DCS controller.
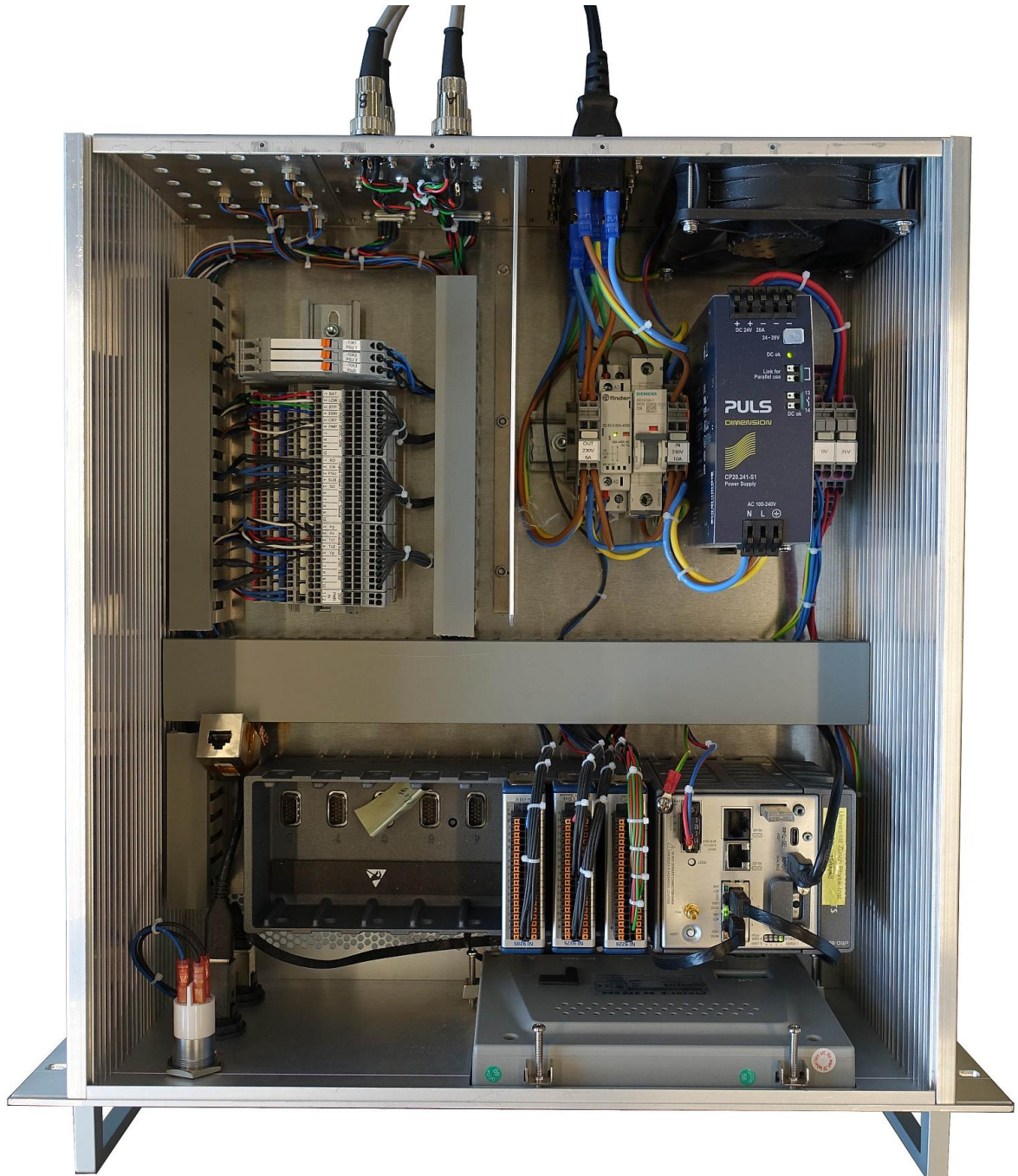
2 Firmware

2.1 Action Matrix

2.1.1 Introduction

The safety system of DAMIC-M monitors and controls all sensors and actuators and publishes the values via Modbus and the Webpage. The safety relevant parts are running in the FPGA of the cRIO. That means that the system safe even when the cRIO controller crashes.

The alerts inform in a first step the user, that there is a problem in the safety system. The user has than a defined time to react and solve the problem if possible. After this time, the alert is locked and reaction is triggered to prevent damages on the CCD sensors.

After an alarm has triggered and the problem is solved, the user can reset the alarm message by set the acknowledge flag over Modbus. The acknowledge flags should only be reset manually to guarantee, that the problem is understood and solved bevor the experiment is switched on again.

All thresholds values and safety mechanisms are programmed in the FPGA of the cRIO. If there is any need to change safety parts, the FPGA program must be adapted and recompiled.

2.1.2 Action List

No	Action Parameter	Parameter	State / Value
1	DisableSys_action	OutletEnable	FALSE
		InterlockPSU	FALSE
		InterlockVSUB	FALSE
	System disable mode: All CCD power supplies and the DCS power outlets are switched off.		

2.1.3 Alert List

No	Sensor Reference	Persistency Threshold	Trigger	Condition		Alarm Reference	Delay	Action Reference
1	VacPump_mBar	1E-5 mBar	TOO HIGH	AND		VacPress_alert	10 s	-
	CcdPwrEn	1 s	TRUE					
	If the isolation vacuum gets bad the power of the CCD sensors will be switched off. Cause the vacuum gauge on the chamber will be disabled during the operation only the gauge near the turbo pump will be used for this alert.							
2	TempTC1_K	80 K – 170 K	OUT OF RANGE	≥ 2	AND	CryoTemp_alert	10 s	-
	TempTC2_K	80 K – 170 K	OUT OF RANGE					
	TempChA_K	80 K – 170 K	OUT OF RANGE	≥ 1				
	TempChB_K	80 K – 170 K	OUT OF RANGE					
	TempChC_K	80 K – 170 K	OUT OF RANGE					
	TempChD_K	80 K – 170 K	OUT OF RANGE					
	CcdPwrEn	1 s	TRUE	-				
	If the cold head is to warm or a temperature sensor is disconnected, the system will be shut down in case the CCD sensors are powered. For not to be too sensitive the alert will only be triggered when both 'temperature controlled' and one direct connected sensor is out of range.							

No	Sensor Reference	Persistency Threshold	Trigger	Condition		Alarm Reference	Delay	Action Reference
3	PumpSpeed_%	80 %	TOO LOW	OR	AND	TurboPump_alert	10 s	DisableSys_action
	TurboPumpAl	-	TRUE					
	CcdPwrEn	1 s	TRUE	-				
	If the speed of the turbo pump sinks too low or if the pump controller detects any fault an alert will be activated.							
4	CryoPwrAl	-	TRUE	AND		CryoPower_alert	10 s	-
	CcdPwrEn	1 s	TRUE					
	If the power supply for the cryo cooler returns an error message, an alert is generated.							
5	UpsFault	-	TRUE	-		UpsFault_alert	10 s	-
	If any UPS fault, self test failure, or overload occurs, an alert is generated.							
6	UpsLowBat	-	*TRUE*	-		UpsLowBat_alert	10 s	-
	If the battery of the UPS reached a low level (configuration parameter in the UPS), an alert is generated.							
7	TempTC1_K	Max - Min > 2 K	TOO HIGH	-		TempCtrl_alert	10 s	-
	TempTC2_K							
	If the temperature difference between the two sensors is too large, there is a fault at the cold head and an alert is generated.							
9	LogfileAl	0 s	TRUE	-		Logfile_alert	70 s	-
	If the logfile could not be written							

2.2 Modbus Interface

2.2.1 Introduction

The communication to the DAMIC-M DCS system is made by the Modbus TCP protocol. The internal touch panel connects to this interface but also the slow control server and other devices can communicate over the same interface.

The analog values can only be represented as an INT16 value on the Modbus interface. For this reason, the analog values are scaled with different factors.
The Modbus registers can be changed over different Modbus masters an also directly over LabView. This means that the output registers must be read back because the state can change.

2.2.2 Modbus Setup

The Modbus interface has only a few parameters. The default settings for the interface are used:

Protocoll: TCP, Port: 502
Mode: Slave

2.2.3 Analog Inputs (10)

ID	Code	Addr	r/w	Variable	Scale	Type	Description
01	03	0000	r	VacPump_mBar	10^(x/3000)	int16	HOLDING
01	03	0001	r	VacVessel_mBar	10^(x/3000)	int16	HOLDING
01	03	0002	r	TempTC1_K	1:100	uint16	HOLDING
01	03	0003	r	TempTC2_K	1:100	uint16	HOLDING
01	03	0004	r	PumpSpeed_%	1:100	uint16	HOLDING
01	03	0040	r	TempChA_K	1:100	uint16	HOLDING
01	03	0041	r	TempChB_K	1:100	uint16	HOLDING
01	03	0042	r	TempChC_K	1:100	uint16	HOLDING
01	03	0043	r	TempChD_K	1:100	uint16	HOLDING
01	03	0060	r	TempRIO_C	1:100	uint16	HOLDING
01	03	0061	r	CpuLoadTotal_%	1:100	uint16	HOLDING
01	03	0062	r	CpuLoadMain_%	1:100	uint16	HOLDING

2.2.4 Digital Inputs (6)

ID	Code	Addr	r/w	Variable	Description
01	01	0200	r	UpsOnBat	COIL
01	01	0201	r	UpsLowBat	COIL
01	01	0202	r	UpsBypass	COIL
01	01	0203	r	UpsFault	COIL
01	01	0204	r	CryoPwrAl	COIL
01	01	0205	r	TurboPumpAl	COIL

2.3 Digital Outputs (1)

ID	Code	Addr	r/w	Variable	Description
01	01/05	0300	r/w	CcdPwrEn	COIL

2.4 Alert Flags (8)

ID	Code	Addr	r/w	Variable	Description
01	01	0800	r	VacPress_alert	COIL
01	01	0801	r	CryoTemp_alert	COIL
01	01	0802	r	TurboPump_alert	COIL
01	01	0803	r	CryoPower_alert	COIL
01	01	0804	r	UpsFault_alert	COIL
01	01	0805	r	UpsLowBat_alert	COIL
01	01	0806	r	ColdHead_alert	COIL
01	01	0807	r	ColdBlock_alert	COIL

2.4.1 Alert Acknowledge Flags (8)

ID	Code	Addr	r/w	Variable	Description
01	05	0850	w	VacPress_alert_ack	COIL
01	05	0851	w	CryoTemp_alert_ack	COIL
01	05	0852	w	TurboPump_alert_ack	COIL
01	05	0853	w	CryoPower_alert_ack	COIL
01	05	0854	w	UpsFault_alert	COIL
01	05	0855	w	UpsLowBat_alert	COIL

ID	Code	Addr	r/w	Variable	Description
01	05	0856	w	ColdHead_alert	COIL
01	05	0857	w	ColdBlock_alert	COIL

2.4.2 Actions (2)

ID	Code	Addr	r/w	Variable	Description
01	01	0840	r	DisableCCD_action	COIL
01	01	0841	r	DisableSys_action	COIL

2.4.3 Firmware Version (10)

ID	Code	Addr	r/w	Variable	Description
01	03	0910	r	FirmwareFPGA_high	HOLDING
01	03	0911	r	FirmwareFPGA_low	HOLDING
01	03	0912	r	FirmwareFPGA_day	HOLDING
01	03	0913	r	FirmwareFPGA_month	HOLDING
01	03	0914	r	FirmwareFPGA_year	HOLDING
01	03	0915	r	FirmwareRIO_high	HOLDING
01	03	0916	r	FirmwareRIO_low	HOLDING
01	03	0917	r	FirmwareRIO_day	HOLDING
01	03	0918	r	FirmwareRIO_month	HOLDING
01	03	0919	r	FirmwareRIO_year	HOLDING

2.4.4 IP-Address (12)

ID	Code	Addr	r/w	Variable	Description
01	03	0920	r	IpAddressA-1	HOLDING
01	03	0921	r	IpAddressA-2	HOLDING
01	03	0922	r	IpAddressA-3	HOLDING
01	03	0923	r	IpAddressA-4	HOLDING
01	03	0924	r	IpAddressB-1	HOLDING
01	03	0925	r	IpAddressB-2	HOLDING
01	03	0926	r	IpAddressB-3	HOLDING

ID	Code	Addr	r/w	Variable	Description
01	03	0927	r	IpAddressB-4	HOLDING
01	03	0928	r	IpAddressC-1	HOLDING
01	03	0929	r	IpAddressC-2	HOLDING
01	03	0930	r	IpAddressC-3	HOLDING
01	03	0931	r	IpAddressC-4	HOLDING

2.4.5 Miscellaneous

ID	Code	Addr	r/w	Variable	Description
01	03	0900	r	OperatingDays	HOLDING
01	03	0901	r	CheckByte (0x55AA)	HOLDING
01	03	0902	r	ModbusCon	HOLDING

2.5 cRIO Firmware Compilation & Download

2.6 Basics

The Firmware is programmed with LabView20 and runs on a cRIO-9045 controller. All safety relevant parts are running in the FPGA and the rest on the RT-controller part of the cRIO. For that reason, the firmware is also split in two different parts.

To compile and download the cRIO firmware, following LabVIEW parts must be installed in minimum:
1. LabVIEW 2020 (32-bit)
2. LabVIEW 2020 FPGA Module
3. NI System Configuration
4. NI-RIO Driver

2.6.2 Configuration

1. Open the LabVIEW Project file "DCS.lvproj"

2. Open the '**Properties**' menu of the cRIO device

3. Set the IP-address of the cRIO under the category 'General'.
   The IP-address is shown on the touch panel in front of the DCS. Please be aware that the computer and the DCS must be in the same Ethernet network.
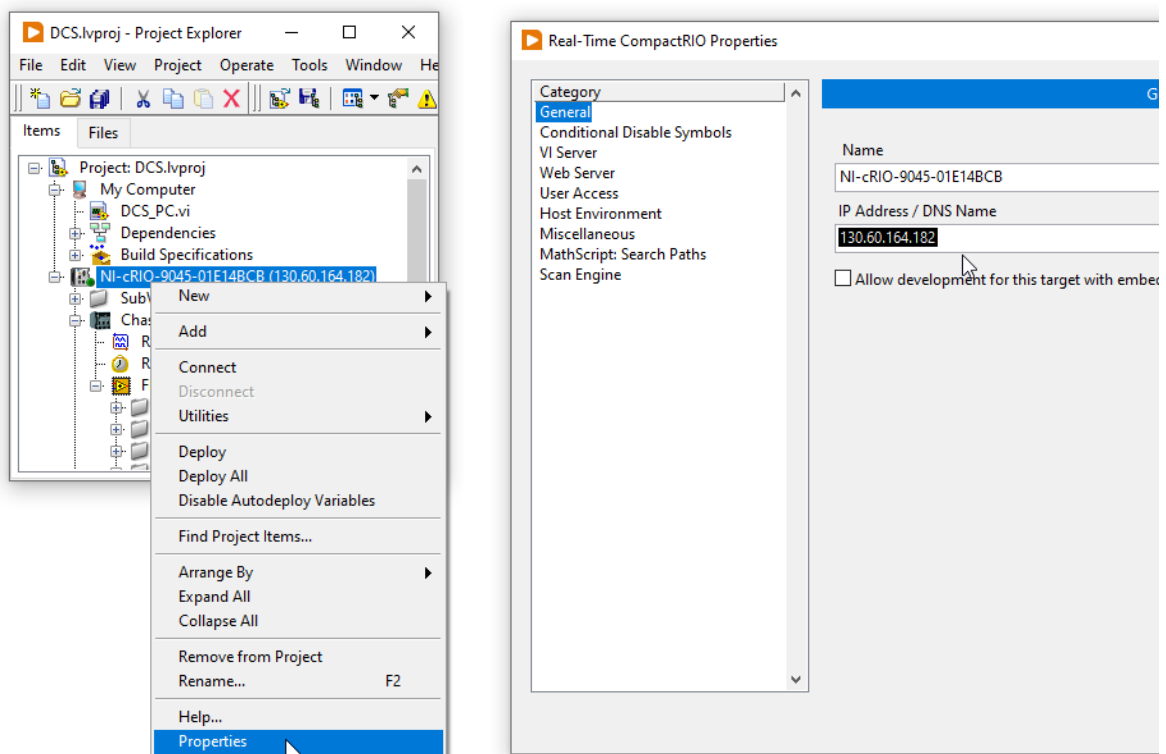
4.   Connect LabVIEW to the cRIO to check the configuration. If successful, the green dot from the NI-cRIO-9045 symbol is lighting up.

If this fails, check if the IP-address on the DCS touch panel under INFO matches the configuration in LabVIEW. You can also try to open the cRIO configuration page. The link is shown on the DCS touch panel under INFO.
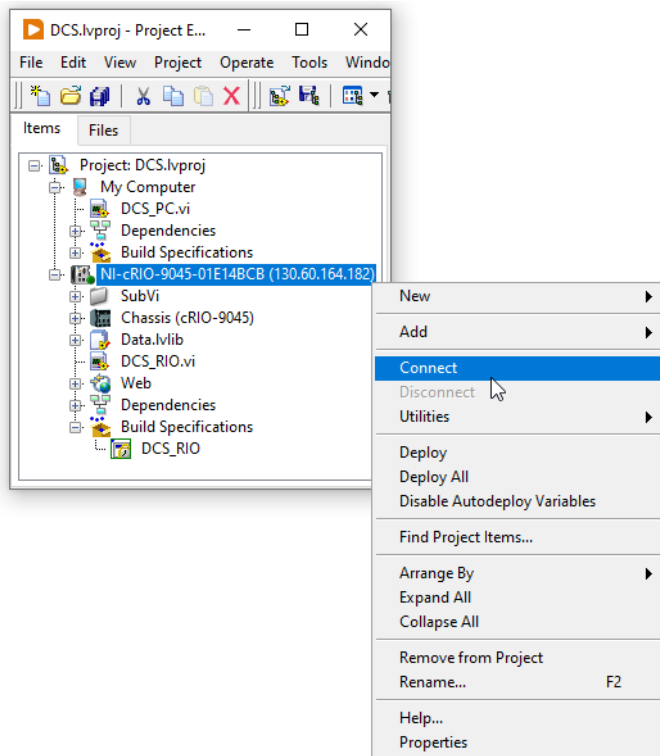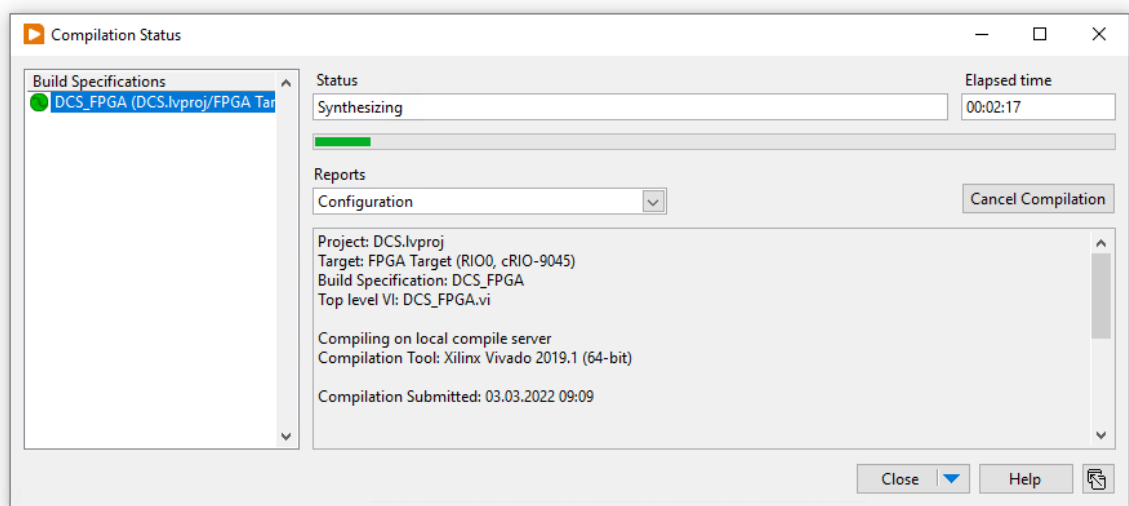
2.6.3 Compilation

1. Open the "DCS_FPGA.vi" file

2. Select "**Build**" under "Chassis -> FPGA Target -> Build Specifications -> DCS_FPGA"
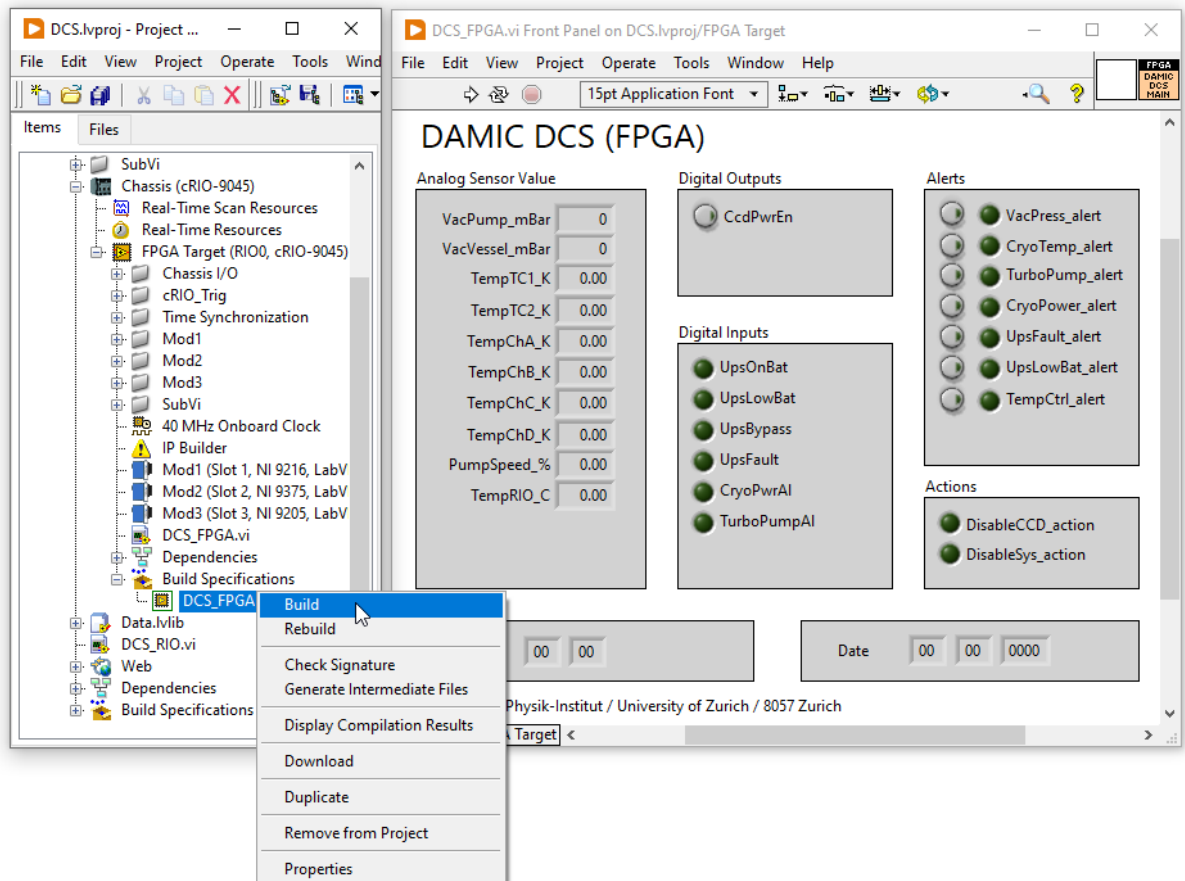
3. A window with the compilation status opens. The time for the compilation is around 30 min.

4. Open the "DCS_RIO.vi" file. Probably LabView ask during the opening process for a specific file and give some option. In this case, the suggested file should be selected. If everything is imported correctly the 'run' button is white and the code is runnable.
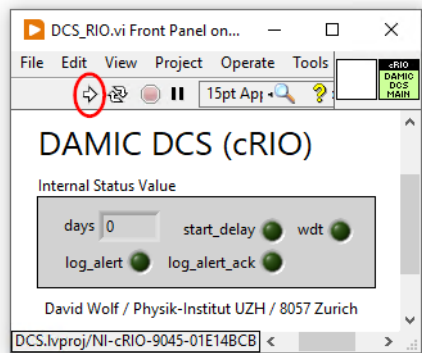
5. Select '**build**' under "NI-cRIO-9045 -> Build Specifications -> DCS_RIO"
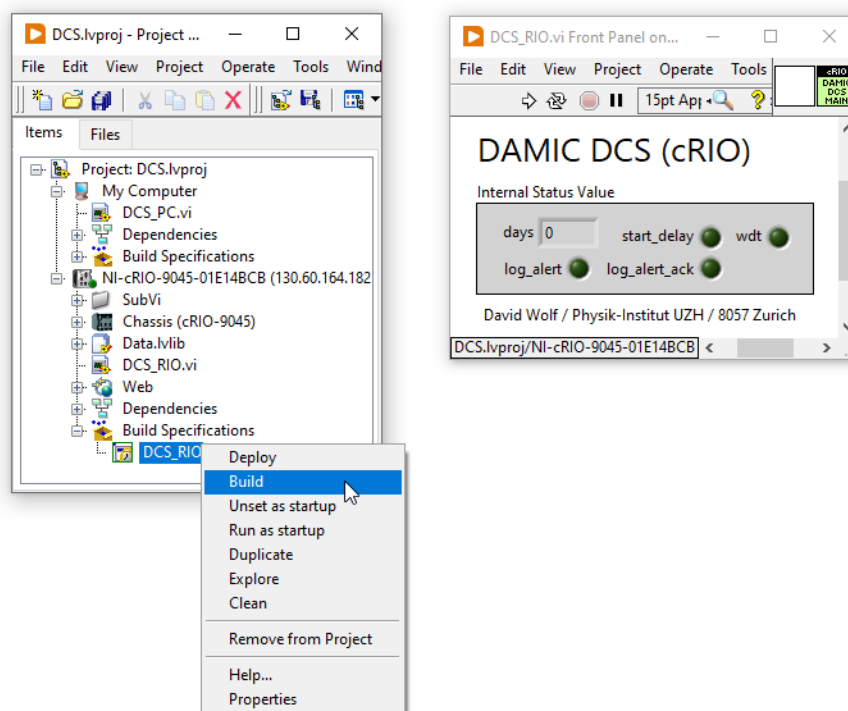
6. Go to the same menu as in the last step and select '**Deploy'**. Please retry if this step fails.

7. Go again to the same menu and select "**Run as startup**". Before downloading the firmware LabVIEW ask for a password. The default user is 'admin' and the password is 'admin'. The password can also be found on the DCS touch panel under 'INFO'. Please retry if this step fails.

    After rebooting the new cRIO firmware is now installed and running.

2.7 cRIO Firmware Deployment

2.8 Basics

A firmware image of the DAMIC-M DCS system can only be created with a fully programmed cRIO device. For this reason, it is necessary to download the code with via a licensed LabVIEW version. If the firmware is tested on the experimental setup, an image can be created from it with the "RAD Utility"[1] from National Instruments.

2.8.1 PC Software Installation

LabView has the best support on Windows operating system, so it is strongly recommended to have a (virtual) Windows PC with a fully functional LabView installed. The minimum requirements for the LabView installation are the following:
1.   LabVIEW 2020 (32-bit)
2.   LabVIEW 2020 FPGA Module
3.   LabVIEW Run-time Engine 2020 (32-bit)
4.   NI System Configuration
5.   NI-RIO Driver
6.   Replication and Deployment (RAD) Utility

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[1] Replication and Deployment Utility: http://www.ni.com/example/30986/en/
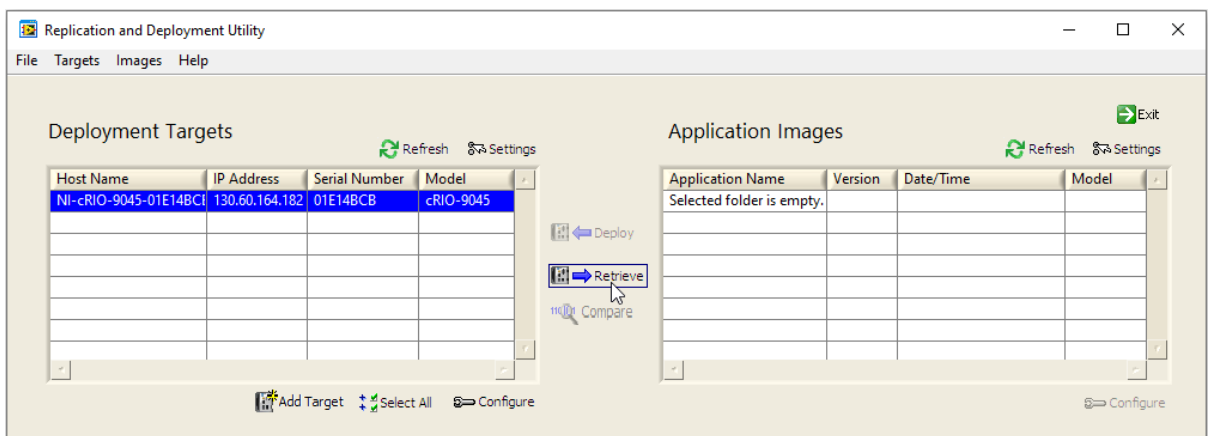
2.8.2 cRIO Image Generation

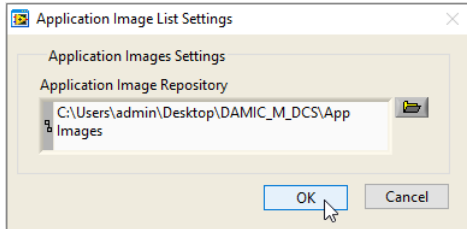Please note the following steps:

1.   Build the RT-Application in the LabView project

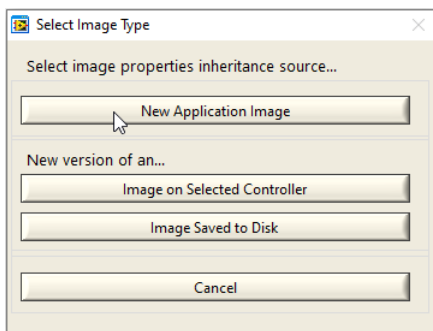2.   Download the cRIO firmware to a fully functional DCS system.
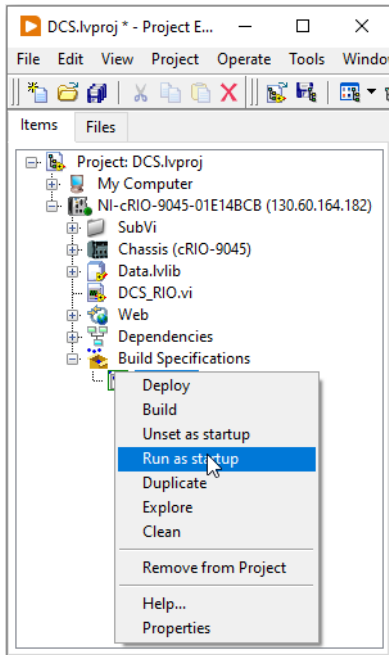
3.   Test the new firmware to get sure, so that the whole firmware is functioning properly.

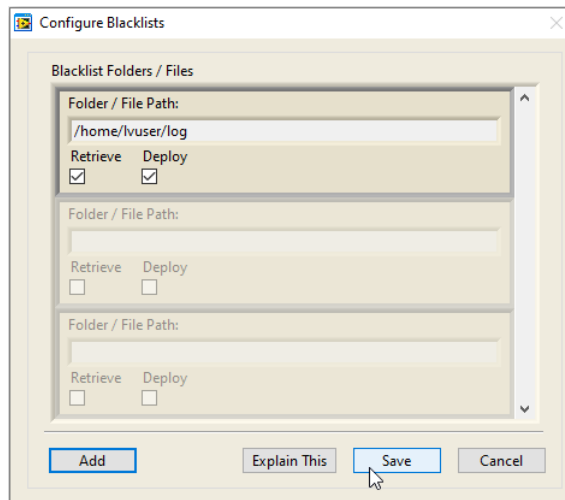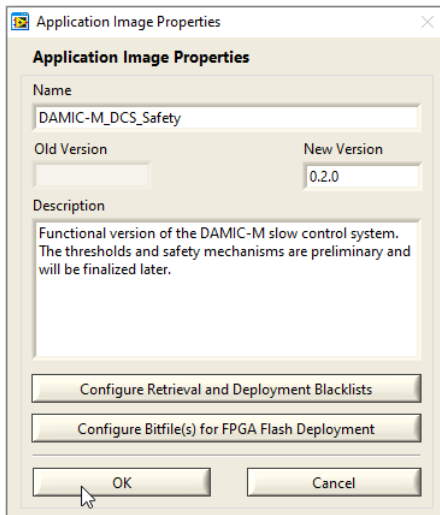4.   Select the cRIO with the new and tested firmware and press "retrieve".

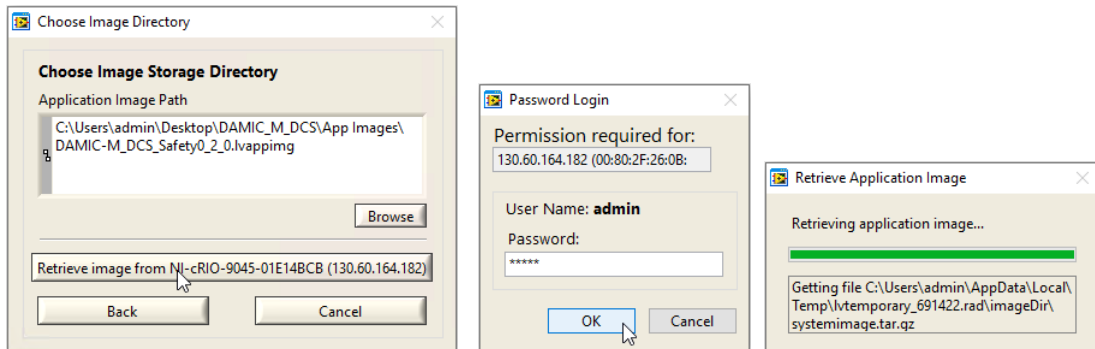5.   Configure the path for the image file.

6.

7.   Generate a "New Application Image".

8.   Configure the name and the version of the application image file. After this, add one entry in the blacklist as described below.
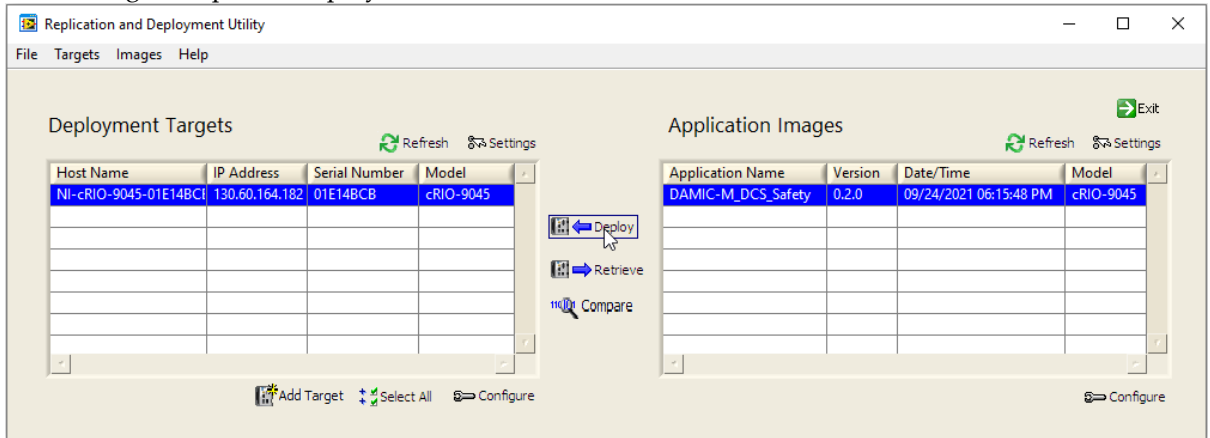
9.   Define the application image file. The press "Retrieve image from…". The image of the cRIO will then be generated.
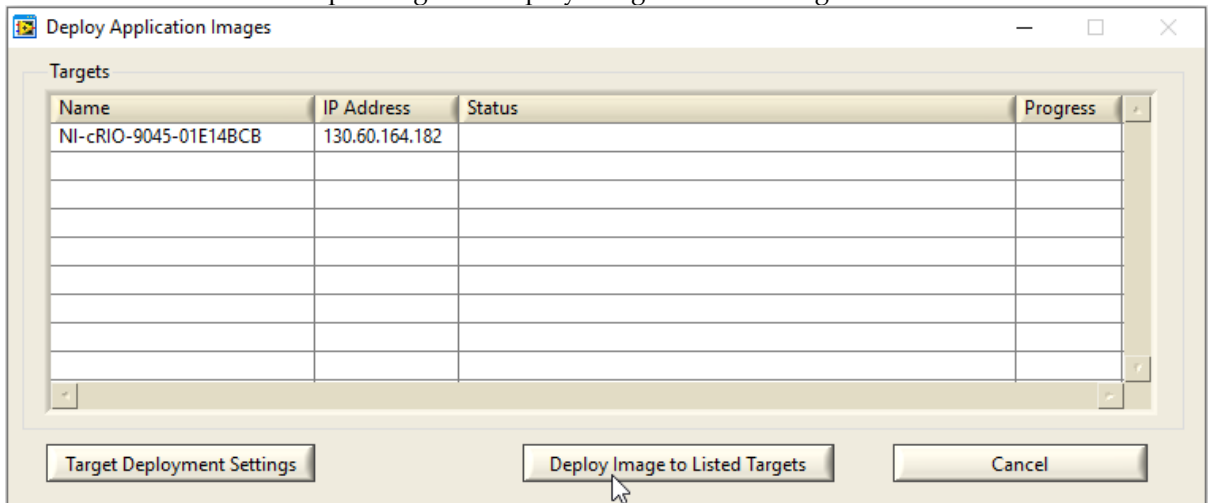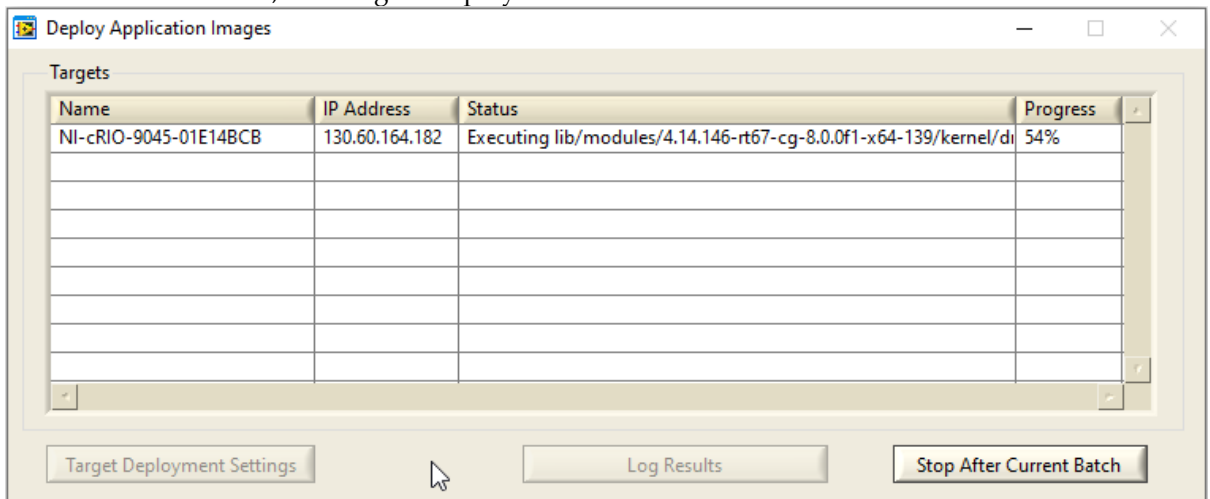
2.8.3 cRIO Image Download

1. Start the RAD Utility and select all cRIO devices to be programmed. Then select the application image and press "Deploy".

2. An overview window will be opened with the selected cRIO devices. The deployment process will be started when pressing the "Deploy Image to Listed Targets".

3. After a few time, the image is deployed to all selected devices.

2.9 Terminal Assignment

2.9.1 RTD Input (Slot 1)

IO	Clamp	Variable	Description
RTD0	-	TempChA	Channel A / 4-Wire / RTD100 / Cold block Temperature
RTD1	-	TempChB	Channel B / 4-Wire / RTD100 / Cold block Temperature
RTD2	-	TempChC	Channel C / 4-Wire / RTD100 / Cold block Temperature
RTD3	-	TempChD	Channel D / 4-Wire / RTD100 / Cold block Temperature

2.9.2 Digital I/O (Slot 2)

IO	Clamp	Variable	Description
DI0	BAT	UpsOnBat	UPS runs on battery
DI1	LOW	UpsLowBat	UPS battery level is low
DI2	BYP	UpsBypass	UPS is bypassed
DI3	ERR	UpsFault	UPS any fault
DI4	CRY	CryoPwrAl	Alert from the cryo cooler power supply
DI5	PMP	TurboPumpOk	No fault signal from the turbo pump
DO0	RD	StatusLampRd	Red light for indicating an error
DO1	GN	StatusLampGn	Green light for indication no error
DO2	PSU	InterlockPSU	Interlock for the two DC power supplies
DO3	SUB	InterlockVsub	Interlock for the Vsub power supply
DO4	SO	OutletEnable	230 V socket outlet enable

2.10 Analog Input (Slot 3)

IO	Clamp	Variable	Range	Description
AI0	Pp	VacPump_mBar	1.82 – 9.50 V 1E-9 – 1E3 mBar	Vacuum gauge near turbo pump
AI1	Pv	VacVessel_mBar		Vacuum gauge near the vessel
AI2	Tc1	TempTC1_K	0 – 400 K	Temperature 1 of the controller
AI3	Tc2	TempTC2_K	0 – 400 K	Temperature 2 of the controller
AI4	Cp	PumpSpeed	0 – 100 %	Speed of the turbo pump

2.11 Touch Panel

The menu is displayed in the home screen. The overview screen displays all parameters of the DCS system.

The cockpit view shows the analog parameters in pointer diagrams. This diagrams can be selected to have a larger view.

All information about the cRIO controller and the touch display are shown in the info view.

1/2 Info cRIO

Firmware FPGA	V0.8 / 19.10.2021
Firmware cRIO	V0.9 / 19.10.2021
cRIO Temp.	28.16 °C
Operating Time	53 d
CPU Total	32.1 %
CPU Main	1.82 %
Login Admin	User: "admin" / Password: "admin"
Login User	User: "DCS" / Password: "DCS"

2/2 Info External Connections

Web Panel	http://103.60.164.120:8002/Web/
cRIO Config	http://103.60.164.120/#home
Logfiles	http://103.60.164.120/files/u/Logfiles
Modbus Int.	192.168.0.10:502
Modbus Ext. 1	103.60.164.120:502
Modbus Ext. 2	127.0.0.1:502
ModBUS Con.	2
PW Touchpanel	Password: "111111"

2.12 Webpage

All parameters from the DCS system can be read via the webpage (exact link can be found on the touch panel). Because the web server in the cRIO has limited resources, the number of open web pages should be kept low.