

User manual K100

GD000018 Scandinoa K100 Modulator User Manual

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Safety Information

The following warnings and precautions are for your safety and prevention of injury. Read them carefully and observe at all times when installing or operating the ScandiNova Solid State Modulator. Hazard warning signs, as defined in ISO 3864 (Safety Signs and Colours), are used on the equipment to highlight any possible hazards.

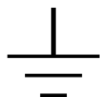
The K100 Modulator must only be operated by qualified personnel who have read this manual and are familiar with the operation, hazards and application of the K100 Modulator.

The K100 Modulator should only be serviced by factory qualified personnel.



Protective ground

Ensure all the correct required grounding has been connected before applying any AC power. Proper grounding for the Modulator is required to reduce the risk of electric shock and to comply with relevant safety requirements. Grounding requirements are contained within this manual.



Functional ground

Ensure all the correct required grounding has been connected before applying any AC power. Proper grounding for the Modulator is required to reduce the risk of electric shock and to comply with relevant safety requirements. Grounding requirements are contained within this manual.



Dangerous voltage

Equipment must be installed so that personnel cannot come into contact with high voltage terminals.

After disconnecting the single phase and 3-phase it is impossible for the modulator to generate any high voltage on any terminals. All left stored energy is internally and requires disassembly of the unit in order to gain access.

The modulator has internal bleeders removing all high voltage (>60V) inside the units within 2 minutes after removal of single and 3-phase.

A ground hook is not needed since there are no high voltage parts accessible on the outside of the modulator once turned off.

Ensure all covers are in place and securely fastened before applying any AC power.

Power Supplies To The System

External overload protection on the 3-phase supply must be provided by the user. Always replace fuses with the same type and voltage/current rating.

Use extreme caution when connecting input AC power, and apply only the input voltages specified on the rating labels.

**Heavy Equipment**

The supplied equipment is heavy. The modulator is marked with the unit weight. Observe your local health and safety regulations when lifting.

**Toxic Material**

The modulator contains hydrocarbon mineral oil (Nynäs Nitro 10X). The user must not loosen or remove any of the unit's fixings or seals as leakage could occur and performance affected. Consult ScandiNova for details regarding the disposal of old or damaged modulators.

**Risk of X-Ray Radiation**

All high voltage devices can produce X-rays during operation and may require shielding. The X-ray radiation is usually reduced to a safe level by enclosing the equipment within steel or lead panels.

Users and equipment manufacturers must check the radiation level under their maximum operating conditions.

High voltage klystrons emit a significant intensity of X-rays not only from the klystron, but also from the output waveguide. These rays can constitute a health hazard unless adequate shielding for X-ray radiation is provided.

**RF Radiation**

Personnel must not be exposed to excessive RF radiation. All RF connectors must be correctly fitted before operation so that no leakage of RF energy can occur and the RF output must be coupled efficiently to the load. It is particularly dangerous to look into open waveguide or coaxial feeders while the device is energized.

**Electrostatic Sensitive Devices**

Damage to components may occur if static handling procedures are not carried out.

**Hot surfaces**

Some surfaces may get hot during normal use. The oil pump located on the tank unit will during normal use get hot. A total of 10 minutes must be allowed before any work is done on the pump or surrounding components

**Disposal of modulator or components**

ScandiNova works according to the **WEEE-directives** WEEE 2012/19/EU (Waste from Electrical and Electronic Equipment)

All used components and the modulator itself should when it reaches end of life, be shipped to ScandiNova or to ScandiNova assigned company for disposal and recycling.

Contact Information

Sweden

ScandiNova Systems AB

Ultunaallen 2A

756 51 Uppsala

Telephone: +46 (0)18 480 59 00

Fax: +46 (0)18 480 59 99

www.scandinovasystems.com

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3 Introduction

Thank you for purchasing a ScandiNova K100 modulator.

Before installing or using the modulator system, or any component, ScandiNova recommend that you familiarize yourself with the unit, its operation and features, by reading this manual.

The K100 modulator series is a range of fully integrated, compact, solid-state modulator systems. It is designed to drive a broad range of klystrons, and utilize Scandinavia's patented solid-state modulator technology.

3.1 Manual Scope

This manual will provide all necessary information to allow you to:

- Unpacking/lifting
- Solenoid/klystron installation
- Make all necessary interconnections.
- Maintenance

3.2 Location of Serial Numbers/nameplate

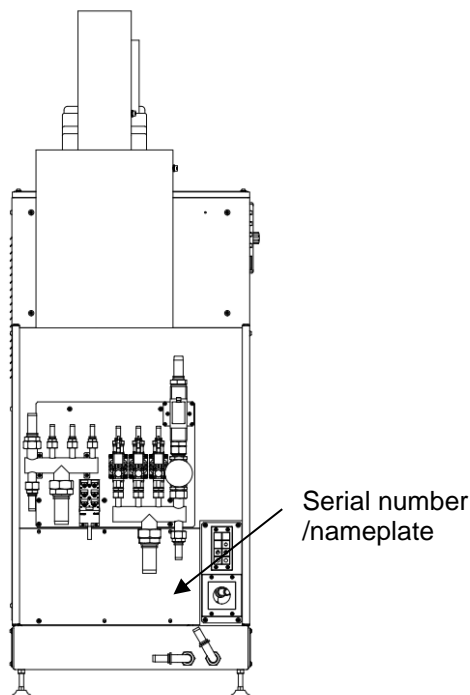


Figure 1: Modulator, serial number/nameplate

3.3 Abbreviations

CCPS	Capacitor Charging Power Supply
MCU	Main Control Unit
ESD	Electrostatic Discharge
FPS	Filament Power Supply
IPC	Ion Pump Controller
PCB	Printed circuit board
PDU	Power Distribution Unit
PRF	Pulse Repetition Frequency
SPS	Solenoid Power Supply
SU	Switch Unit
TANK	Transformer Tank Assembly

4 Intended use

The modulator is intended to drive klystron. All other use is not allowed without a written approval from ScandiNova.

If connected and/or used outside of intended use the protective functions within the modulator could be impaired.

5 System Contents

5.1 Packaging/What Is Supplied

Depending on what has been ordered, the modulator could be delivered in separate containers or cases.

Before starting, check you have been supplied with all the necessary items.

Components	Options	Note
K100 modulator	115/208V 115/480V 230/400V	Voltage depending on configuration, check name plate for details
Software Kit		
User manual		

Table 1: Packing/What is supplied

5.2 Storage conditions

The modulator and its high voltage power supply must be stored in the horizontal position, in its supplied packing case.

The storage temperature range for all components is -25 °C to +70 °C.

The storage humidity range for all components is 20% to 95% (condensing). Each item must be left at room temperature for at least 24 hours prior to use.

5.3 Unpacking and Lifting the Modulator

Besides the information contained in this document, local safety regulations must also be compiled.

To safely unpack the modulator, follow the instructions below.

1. Check that there are no damages to the shipping crate or that the shock and tilt indicator have not been activated. If damages or activated indicators are found please contact the shipping company and Scandinoa AB as soon as possible.



Figure 2: Shockwatch



Figure 3: Tiltwatch

2. Open the top and sides of the box by unscrewing the screws with a Torx T25 screwdriver.

- The modulator is bolted to the pallet with four M12 screws. Undo these screws and lift the modulator up.

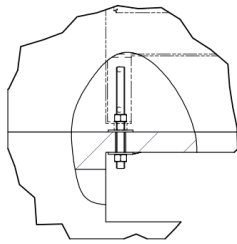


Figure 4: Modulator on Pallet

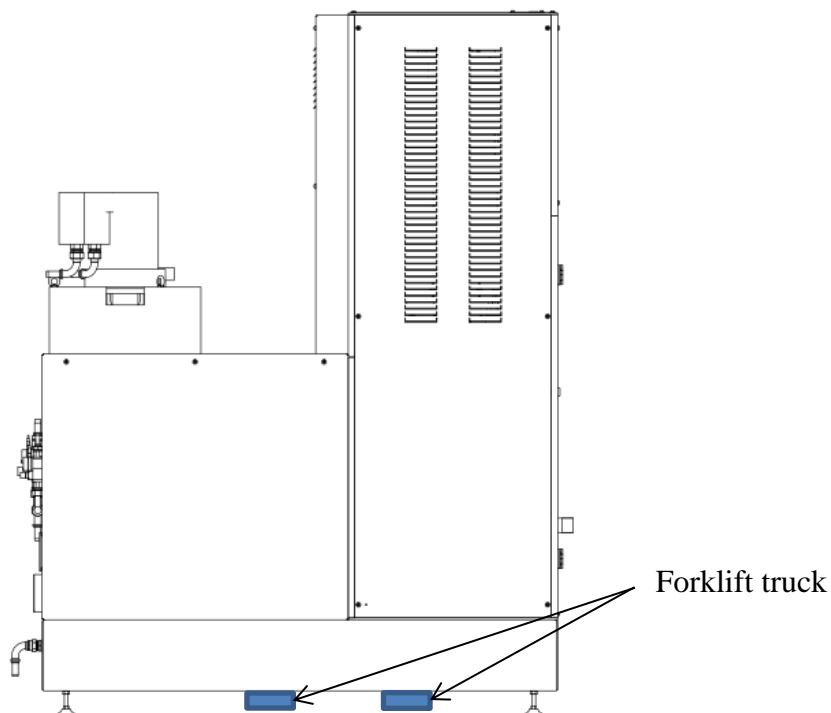


Figure 5: Lifting the modulator

While the modulator is lifted mount the 4 machine feet, included in the shipment, on the bottom socket.


	WARNING: The klystron modulator weighs up to 1500kg. Weight of your specific configuration is printed on the machine sign. Make sure suitable lifting equipment is used during lifting, positioning and installation of the pulse unit
	WARNING: Make sure the klystron modulator is installed on a flat even surface otherwise the unit may fall over during installation/service/maintenance

During all type of movement/adjustment suitable lifting equipment has to be used due to the high weight of the unit.

6 Installation

6.1 Typical installation procedure

For more details regarding the different steps, check the corresponding following sections.

	WARNING: The modulator/solenoid/klystron is heavy equipment. Make sure suitable lifting equipment is used during lifting, positioning and installation of these parts
	WARNING: Installing klystron and solenoid on the modulator tank will cause risk for crushing. Never work under the solenoid or the klystron.

1. Unpack modulator and place on flat horizontal floor.
2. Level modulator using the adjustable feet. This is important to do before 14).
3. Dismount covers plates around klystron and solenoid opening on modulator.
4. Mount solenoid on top of modulator tank lid using instruction provided by the supplier.
5. Connect electric connections and cooling hoses to solenoid according to instructions provided by the supplier, or in documentation provided by Scandionova:
 - a. Solenoid current connections
 - b. Water cooling hoses
 - c. Temperature switch
6. Mount klystron in solenoid, using instruction provided by the supplier.
Do not touch klystron ceramic ring with hands. Keep clean. Carefully check that klystron connection gets connected to modulator socket inside tank when lowering klystron into solenoid. Use inspection windows on tank to check this. If necessary dismount inspection windows for better view.
Don't forget to put back inspection windows before filling oil.
Align klystron with waveguide opening in desired direction. If klystron is equipped with clamps, fasten the clamps to solenoid.
7. Connect electric connections and cooling water to klystron according to instructions provided by the supplier, or in documentation provided by Scandionova:
 - a. Ion pump HV cable
 - b. RF input cable
 - c. Grounding wire or braid connected to modulator tank lid.
 - d. Cooling water hoses

8. Connect external cooling water to the modulators cooling circuits 1 and 2. Turn on external cooling water. See Mechanical drawings provided by Scandinoa.
Check all water connections on klystron and solenoid for any leakage.
9. Connect three phase mains power to terminal block in modulator PDU (Power Distribution Unit). See Installation Data provided by Scandinoa.
10. Connect single phase mains power to terminal block in modulator PDU. See Installation Data provided by Scandinoa.
11. Connect appropriate signals to the hardwired connector. See Installation Data provided by Scandinoa.
12. Connect external trig (optional). See Installation Data provided by Scandinoa.
13. Connect external RF trig and LowLevel RF signal (optional). See installation Data provided by Scandinoa.
14. Connect communication cable RJ45 (optional). See Installation Data provided by Scandinoa.
15. Add transformer oil to modulator transformer tank by opening tank fill cap on top of tank lid. Fill oil to the marked line on oil level indicator.
16. Use transformer oil, type Nynas Nytro, Shell Diala or oil recommended by Scandinoa.

6.2 Connection Overview – Block Diagram

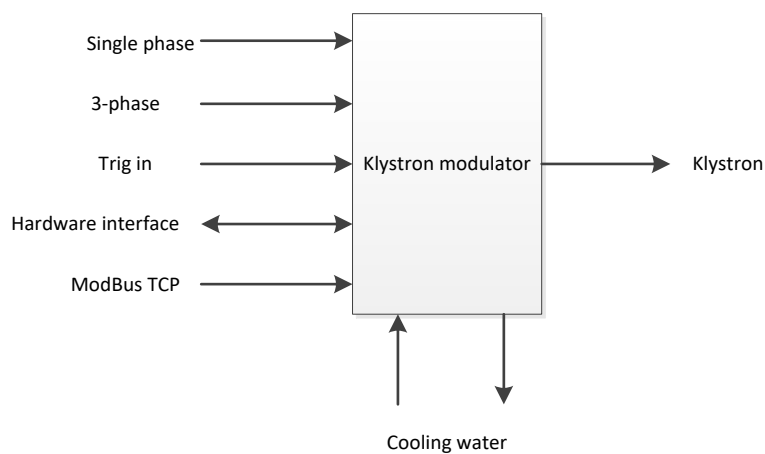


Figure 6: Connection overview

Environmental service

		Note
Ambient temp	+5°C - +40°C	
Altitude	Max: 2000m above sea level	
Humidity	<90 % non-condensing	

Table 2: Environmental services

Electrical services

		Note
Single phase	115V +/-10% 230V +/-10% ~50/60Hz	Depending on configuration Line, neutral and earth on screw terminals
3-phase	208V +/-10% 400V +/-10% 480V +/-10% ~50/60Hz	Depending on configuration 3 phases and ground on screw terminals

Table 3: Electrical services

For details on required voltage/current, check nameplate located on modulator

Cooling services

Note		
Klystron modulator	Max 8 bar Water temp: 20-45degC (non condensing)	

Table 4: Cooling water services

External signal services

Note		
External trig	BNC	
Hardwired interface	Socket in MCU	
Modbus TCP	RJ45 connector	

Table 5: External signal services

6.3 Protective/Functional ground

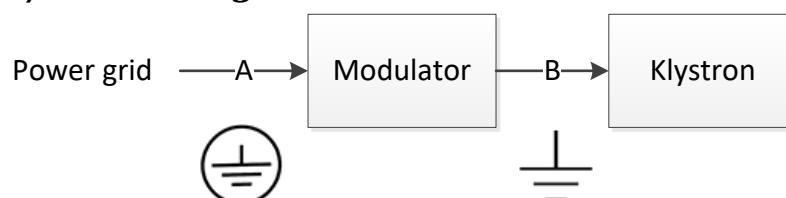


Figure 7: Protective/Functional ground

- A. Protective ground from the power grid is connected to the power terminal inside the PDU (Power Distribution Unit).
- B. Connect a ground braid between the tank lid and klystron body.

Cable type	Cable type	Rating	Standard	Note
A				
B	Cable braid	250V, 80A		

Table 6: Protective/Functional ground

6.4 Water and Cooling

Inside the klystron modulator there are flow switches handling the interlock/monitoring of internal cooling circuits


The flow rates specified on the nameplate is for operation at max power conditions.

There is no need to maintain water cooling when modulator is switched off.

6.5 Cooling Fans

There are internal fans cooling different internal units. On the modulator there are a few ventilation holes. Any installation arrangement close to the unit has to be designed not to interfere nor block the airflow of these ventilation holes.

6.6 Power – Single/3-Phase

	WARNING: All electrical installation should be done by trained personnel
	WARNING: Always follow local electrical safety regulation for permanently connected equipment

The modulator requires both single and 3-phase to operate.

The single phase is used for control electronics, fans, filament PS and have to be enabled at all time when using the modulator.

The 3-phase is used for the CCPS (Capacitor Charging Power Supply) and oil pump and has to be enabled before changing the modulator state to HV.

Verify the input voltage configuration (115V or 230V single phase, 208V, 400V or 480V 3-phase) on the nameplate before applying any voltage to the system. Applying incorrect voltage will immediately cause major damage and void the warranty.

Cable type	Cable type	Rating	Standard	Note
Single phase NA	SOOW alt SOW-A/SOW alt STOW	115V Current depending on configuration, see nameplate	UL62	For NA UL-listed
Single phase EU	H07VV-F alt H07RN-F alt H07BQ-F	250V Current depending on configuration, see nameplate	HAR	<HAR>
3-phase NA	SOOW alt SOW-A/SOW alt STOW	600V, WV-1 208V/480V Current depending on configuration, see nameplate	UL62	For NA UL-listed
3-phase EU	H07VV-F alt H07RN-F alt H07BQ-F	450/750 Vac, F2 Current depending on configuration, see nameplate	HAR	<HAR>

Table 7: Power – Pulse unit Single/3-Phase

External cables have to be properly secured using a cord anchorage/cord entry/cord bushing making sure no external forces are applied on the connector. If the attachment fails the protective earth conductor should be the last one to take the strain

6.7 Trig input

TRIG Input	
Input impedance:	50 Ohm.
Input voltage:	5 – 15 Volt.
Pulse width:	1 – 100 us.

Table 8: Trig Input

Note. External trig input via SC fiber will not work if the modulator is configured to use internal trig generation.

Trig through BNC Trig In can be made externally or by looping from internal BNC Trig Out.

6.8 Control Interface

Control Interface	Type	Description
Connector	Shielded RJ45	
Matting connector/cable	RJ45, CAT 5e/6, FTP or STP	
Protocol	ModBus/TCP	See separate ModBus protocol document for details.

Table 9: Control Interface

7 System Operation

These procedures assume that the modulator is fully installed and able to operate in a normal manner.

Startup procedure

Make sure that the cooling water is circulating in a sufficient high flow. The minimum allowed flow is stated on the nameplate.

Open the PDU door and turn on breaker for 1-phase, located to the right of the Main breaker.
Close the door.

Turn on the Main breaker, located on the PDU door.

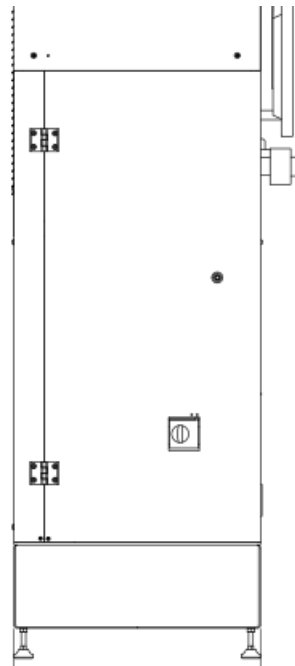


Figure 8: Main breaker

Wait a few minutes for the built-in computer to start.



Figure 9: Touchscreen for the built-in computer.

Press and hold the “HV-ON/OFF” button for a few seconds. The power supply will now start up and generate an OK signal to the MCU.

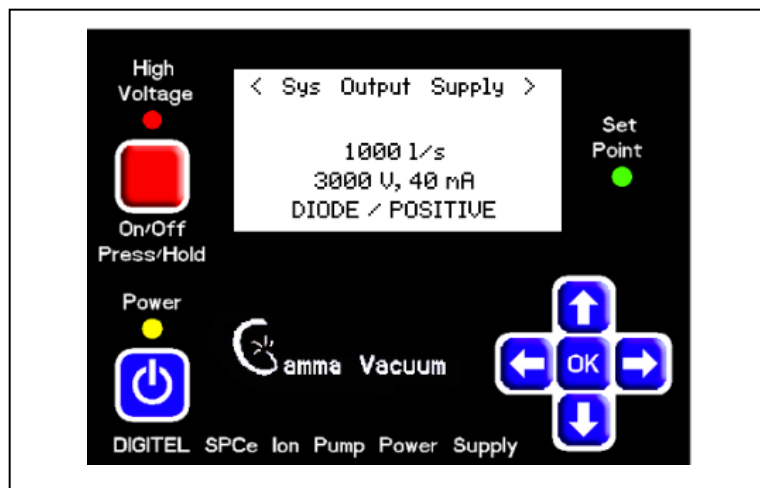


Figure 10: Ion pump front panel

The picture on the touch screen will look similar to the figure on the right.

The modulator may have indicated warnings on external circuits at this point. Make sure that emergency switches, door switches, etc. are giving an ok signal to the modulator.

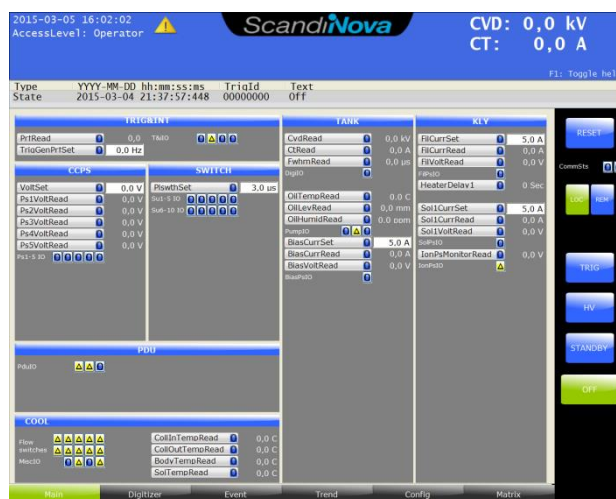


Figure 11: GUI overview

Set the desired filament current according to klystron manufacturer test protocol

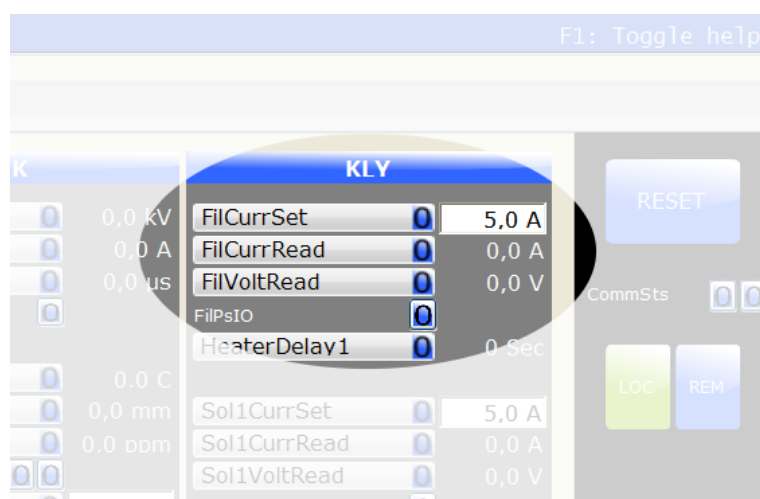


Figure 12: Filament settings

Press the “STANDBY” button located at the right side of the screen.

If there are warnings, may the system inhibit the modulator from enter a higher state. If this is the case, use the information given in the GUI to locate the problem, solve it and continue.

The modulator will now start a smooth ramp-up of the filament current and the Standby button will start to flash.

The flashing will continue during the filament warm up time, typically 1 hour.



Figure 13: GUI in Standby state

When the filament ‘warm up time’ has completed, the standby button becomes constant green and the modulator is ready for HV-state.

Set the desired HV voltage.

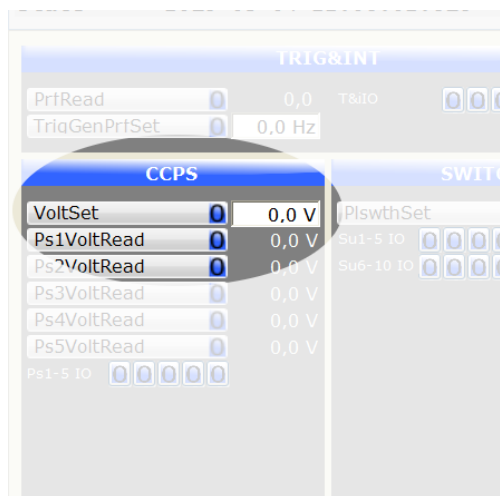


Figure 14: CCPS voltage setting

Press HV.

The HV-button will now become green after a few seconds and the SUs will charge up to the given voltage.

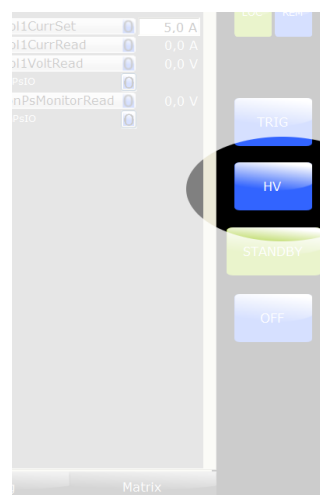


Figure 15: HV button

Set the desired pulse length.

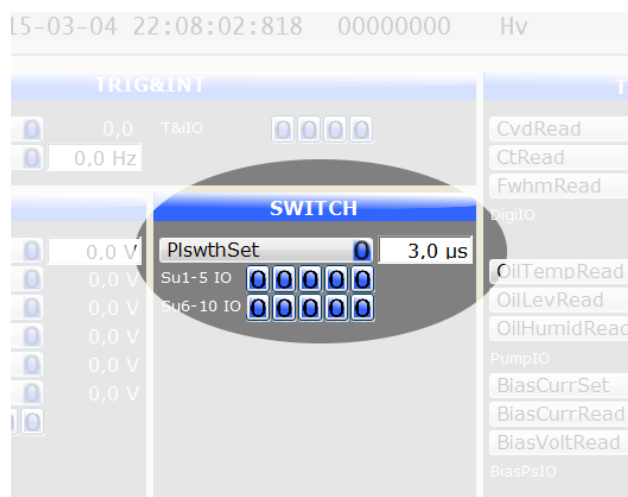


Figure 16: SU pulse width setting

Make sure the trig source is generating the expected pulse repetition frequency.

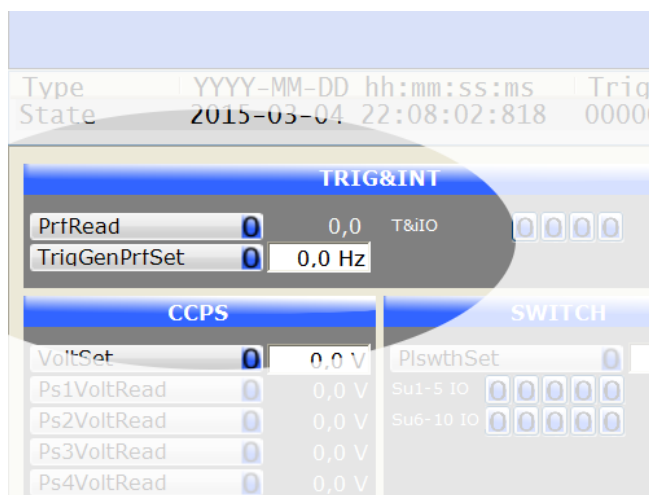


Figure 17:PRF setting

Press trig

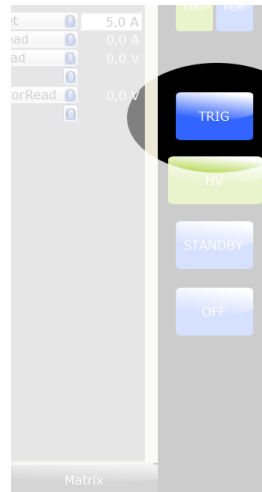


Figure 18: Trig button

The modulator is now generating high voltage pulses to the klystron.
The pulse voltage and current can be read out in the GUI.

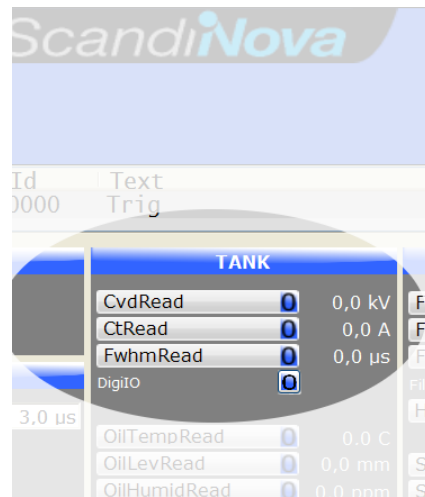


Figure 19: Tank mode reading

Shutdown to OFF state

The OFF button can be pressed at any time.

When pressing the OFF button, the modulator will turn off each unit in a controlled manner.

Do not cut the main voltage before the OFF button is constant green.

The modulator does not require circulating cooling water in OFF state.

Turn off the main breaker (figure 11) if the modulator is not going to be used in a long time.

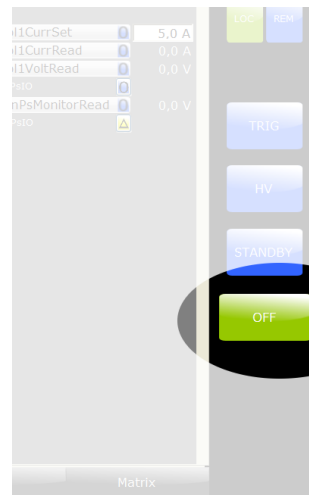


Figure 20: OFF button

Standby

If the modulator is just temporary stopped the “Standby mode” is preferred.

The filament heating power supply is on in Standby mode and no filament heating time is required enter trig state.

Note that this mode requires that the cooling water is circulating.

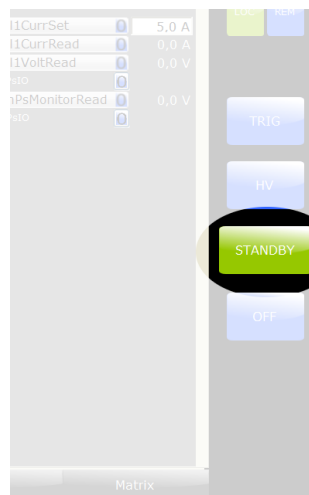


Figure 21: Standby button




A brief description of each state is as follow:

State (Code)	Note
Off (1):	All units except the IPC (Ion Pump Controller) is off
Standby interlock (2):	As above but some units will indicate interlock
Standby Off Req. (3):	FPS is ramped down, oil pump & fans are stopped.
Standby On Req. (4):	FPS is ramped up, oil pump & fans are started.
Standby (5):	FPS is at set point, oil pump & fans are running and interlocks circuits are monitored
HV interlock (6):	As above but some units will indicate interlock
HV Off Req. (7):	All CCPS and SPS are ramped down and more interlocks circuits are monitored
HV On Req. (8):	All CCPS and SPS are ramped up and more interlocks circuits are monitored
HV (9):	All CCPS and SPS are at set point and more interlocks circuits are monitored
Trig interlock (10):	As above but some units will indicate interlock
Trig Off Req. (11):	Trigger is blocked, all SU's are disabled and all interlocks circuits are monitored
Trig On Req. (12):	Trigger is un-blocked, all SU's are enabled and all interlocks circuits are monitored
Trig (13):	Pulsing & collecting pulse data and all interlocks circuits are monitored

Table 10: State description

8 Maintenance

8.1 Safety precautions

	Warning – High Voltage: If the 3-phase is disconnected there will still be live parts within the unit from the single phase.
	A total of 2 minutes must be allowed after removing the power, before removing any covers to allow all voltages to discharge.
	Only ScandiNova personnel or by ScandiNova trained personnel may open up the unit for service or maintenance
	All spare parts must be supplied by ScandiNova
	All internal PCB:s should be handled as ESD sensitive components
	Some internal parts may get hot during normal use and in the case of malfunction/interlock

8.2 Periodic maintenance

Cleaning

To clean, disconnect the unit from the AC supply and allow 5min. for discharging internal voltages. The front panel and the metal surfaces should be cleaned using a mild solution of detergent and water. The solution should be applied onto a soft cloth, and not directly to the surface of the unit. Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. Use low pressure compressed air to blow dust from the unit.

Periodic maintenance schedule

Description	6 months	12 months
CCPS		
Check DC voltage, from GUI, calibrate if >1% deviation	X	X
Visually inspect DC bus cables for damages on insulation and connectors	X	X
SU		
Visually inspect Primary Pulse cables for damages on insulation and connectors	X	
Check primary pulses at driver board		X
TANK		
Visually inspect primary pulse cables for damages on insulation and connectors	X	
Check dehumidifier and replace if necessary		X
Change oil filter	X	
Check humidity in oil		X
COOLING		
Visually inspect water cooling hoses for leakage or degradation	X	
Visually inspect oil hoses for leakage	X	

Description	6 months	12 months
Check function of oil circulation pumps		X
CONTROL SYSTEM		
Remote check of read value trends	X	X
Verification of klystron current	X	X
Verification of klystron voltage	X	X
Verification of pulse length	X	X
Verification of filament current	X	X
Verification of bias current	X	X
PDU		
Check screw terminal connections and tighten if necessary		X

Table 11: Periodic maintenance

8.3 Basic Troubleshooting

General

This system has a self-diagnostics feature that will indicate potential failures in sub-units. Most parts of this system is active at all-time, but some parts can be activated from the control system as a “built-in self-test”.

The all-time activated system is designed as an “interlock system”. An interlock inactivates a state (or a set of states) that is not available under the current conditions. Note that an interlock is not the same as an error, an interlock is a protection for the operator, the modulator or its load. Interlocks are designed to prevent faults to occur.

The interlocks can be divided into three groups:

- **Warning**, will not stop the system but can prevent the system to go to higher state.
- **Non-latched interlock**, will not require a “reset action” from the operator after the condition has changed into a allowed state.
- **Latched interlock**, will require a “reset action” from the operator when the condition that have caused the interlock has change into a allowed **condition**.

A recommended troubleshooting approach is to:

1. Get information about active interlocks in the control system.
2. Find information about how these interlocks work in this manual, in ScandiCAT Control System manual (000364), the F1 Toggle Help, wiring diagrams or by contact with ScandiNova.

Finding active interlocks

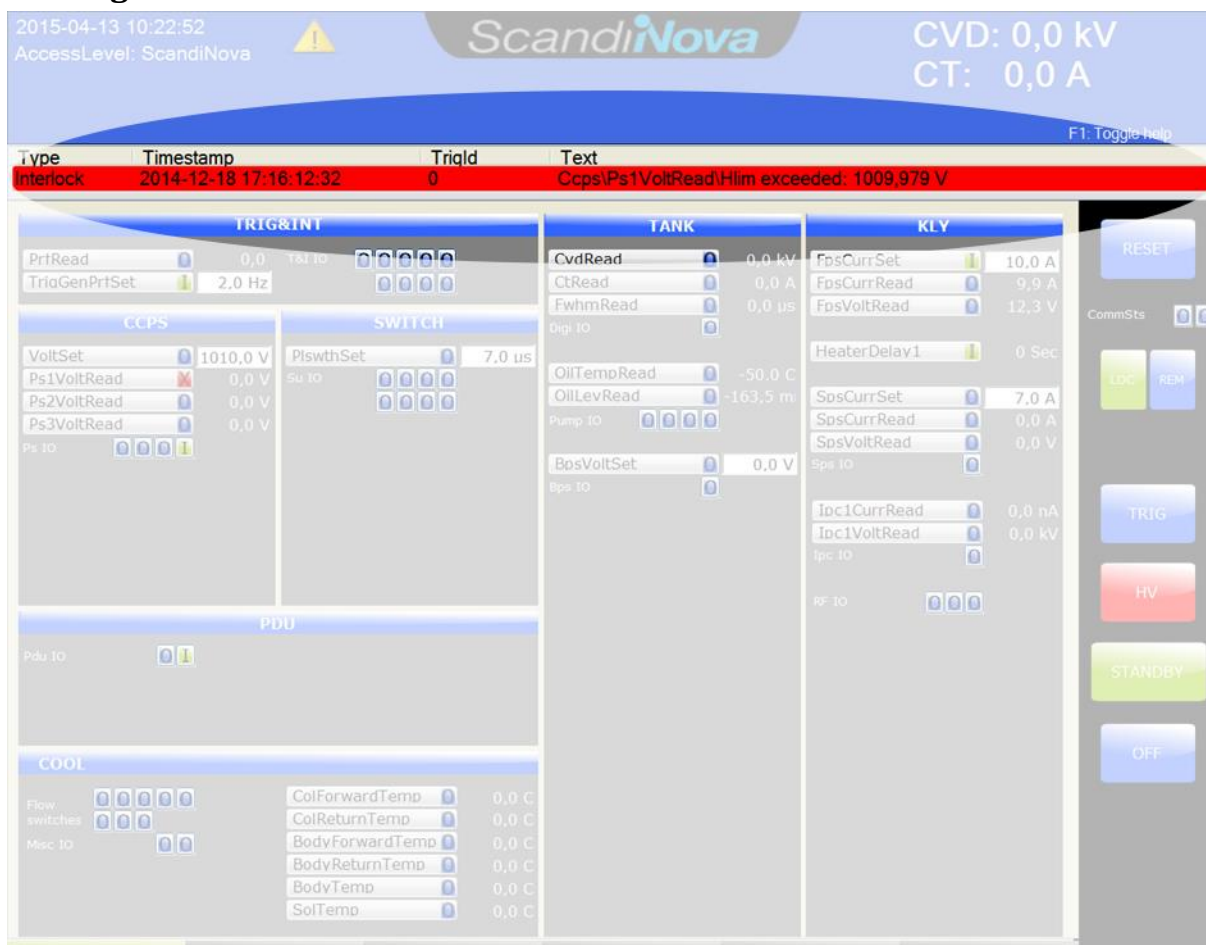


Figure 22: Active interlock a few seconds after it appeared.

An active interlock will appear a few seconds in the top row of the GUI. The information provided is:

Type	Warning Interlock
Timestamp	YYYY-MM-DD HH:mm:ss:hh Where: YYYY = Year MM = Month DD = Day in month HH = Hour mm = Minute SS = Second hh = hundreds of second

If MultDi (multiple digital inputs) interlocks appear, the triggering bit can be found in View Bits

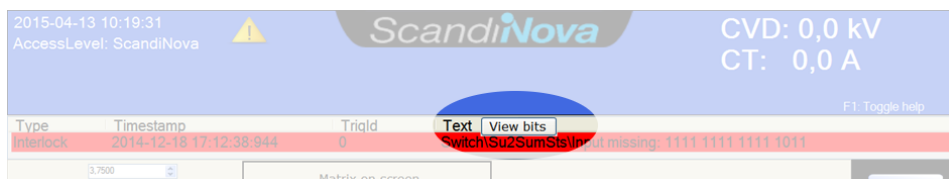


Figure 23: View bits button

Event log will keep track of warnings, interlocks, state changes, parameter changes, etc.

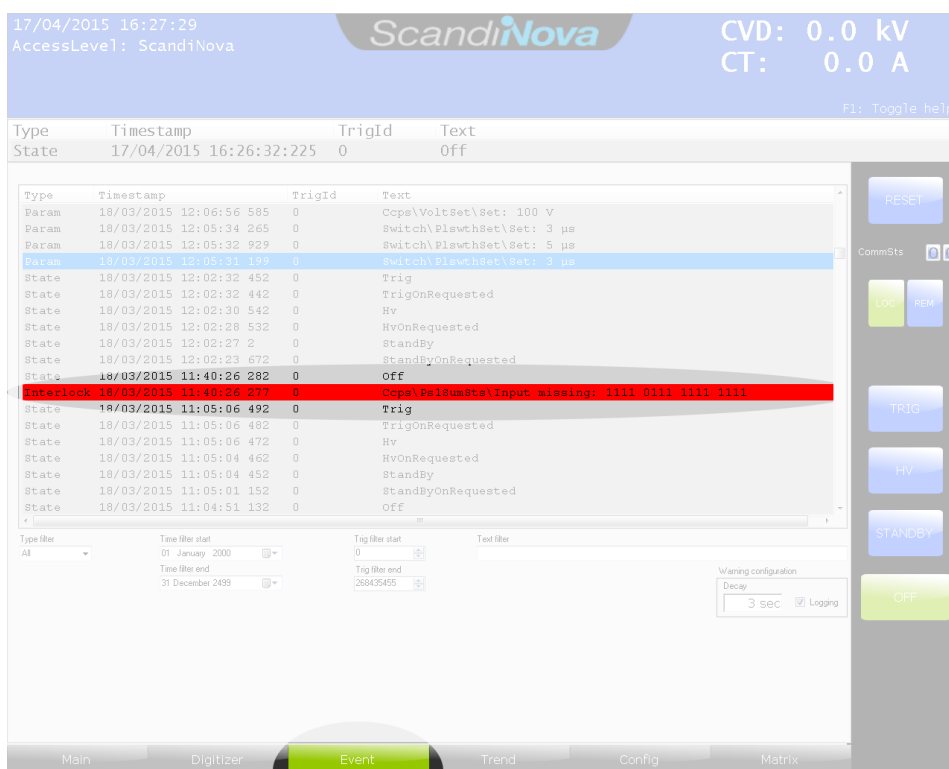


Figure 24: Interlock displayed in 'Eventlog'-tab

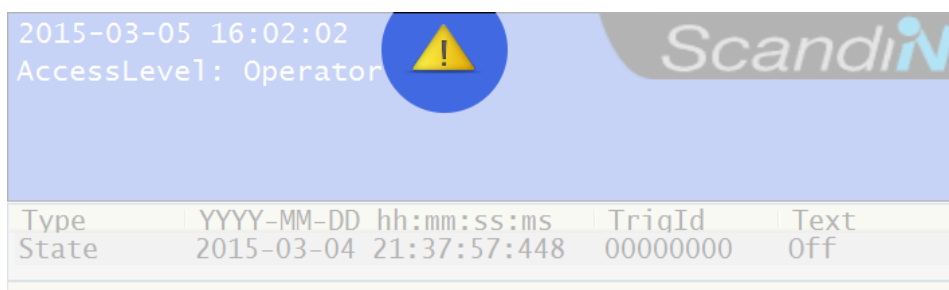


Figure 25: The modulator indicates active warnings.

Appendix A Product Compliance (EMC and Safety)

The system is designed according to:

LVD

- EN/(IEC) 61010-1:2010 “Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements”

EMC

- EN/(IEC) 61000-6-2:2005 “Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments”
- EN/(IEC) 61000-6-4:2007+A1 “Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments”
- EN/(IEC) 61326-1:2006 “Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements”

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