Approved (With Feedback Comments)

ORNL WORK PLAN

Operations, Maintenance and Services

Work Plan Name / Rev: WP063253 / 0
Expiration Date: 8/26/2026

63253

WORK SCOPE/DESCRIPTION	
Requester (Name/Badge/Division):	Brand, Kat / 03095854 / X073
Location of work (Bldg/Rm/Other):	7625 / 106 /
Work Plan Title:	Sairem GRP 1000 Transmitters Operations

Description of Service/Work Needed:

System Description:

The Sairem Model GRP1000 13.56 MHz fixed frequency, 100 kW, 50 ohm radiofrequency (RF) transmitters are installed and commissioned in Building 7625. Operation, service and maintenance activities for the RF transmitters are conducted under this work plan. Operation under this work plan consists of RF output through transmission line into one of any target compatible with RF energy input.

The Sairem Transmitters (quantity 3) are primarily installed to support MPEX but may also be reconfigured to support other Fusion R&D projects within 7625. This work plan covers Sairem Transmitters configuration into a dummy load and Sairem #1 transmitter configured to Proto-Lite (Note: operation of the Proto-Lite is conducted under RSS 8797). This work plan is required to be revised for any new configurations.

Activity Based Work Control:

The Activity performed under this Work Plan is operation and maintenance of the Sairem GRP1000 Transmitters. Tasks conducted under this activity include:

- Normal operations of the Transmitters (R&D Staff)
- LTV of the Transmitters (R&D Staff and/or F&O Craft)
- Routine Service and Repair of the Transmitters (R&D Staff and/or F&O Craft)

Configuration Control: This Work Plan covers routine service, maintenance and operations of the Sairem Transmitters. Modifications or alterations to the transmission lines or RF target devices are required to be reviewed and approved under separate work control. Any configuration changes require coordination and approval from MPEX Area Coordinator and MPEX Operations Staff.
Note: This work plan will be revised to include future state MPEX Configuration Control process.

This Work Plan does not cover integrated testing for MPEX.

Work outside of Normal Business Hours:

Follow FFESD After Hours Request and Approval Process. Any after-hours LTV work requires review and approval by line management (Division Director) prior to being performed. At a minimum, the F&O IA, DESO, and/or MPEX Area Coordinator must be informed and engaged in the review of the hazards and scope of the after-hours work.

Additional Information:

NEPA: This project received its own NEPA Categorical Exclusion (4433X). Consult EPO/ECR for additional information.

Facilities Service Center (FSC) Asset ID#: This system is required to be added as an MPEX asset to the FSC Database. This plan will be revised to include the asset ID when available.

System Safety: A HazOps was conducted for the MPEX Device. All HazOps Recommendations applicable to routine operations of the Sairem Transmitters must be completed and closed prior to integrated testing.

Supplemental Documentation:

This plan is to be revised to include the equipment specific operating procedures, LTV procedures, and the MPEX Safety Analysis.

Charge Number, if required:	
Work Plan Grade/Worktype:	3 / 0
Author (Name/Badge):	Brand, Kat / 03095854

File Attachments:

Badge	Name	Attachment Desc	File Name
03095854	Brand, Kat	ORNL-1113, LOTO Pre-Job Brief for Vendors	Attachment 5 - ORNL-1113.pdf
03095854	Brand, Kat	User Manual GRP1000 EN TI1837 Rev B	User Manual GRP1000 EN RI1837 RevB.pdf
03095854	Brand, Kat	Sairem Adjustent Procedure with 480V	Sairem Adjustment Procedure with 480V.pdf
03095854	Brand, Kat	Helicon_RF_CID_R0	Helicon_RF_CID_R0.pdf

INSTRUCTIONS

Prerequisites/Precautions:

MPEX Work Authorization and Release:

1. All tasks conducted under this approved work plan must be approved by the MPEX Area Coordinator
2. The Task Leader and MPEX Area Coordinator verifies Work Control is Authorized, and supplemental procedures/documentation are in place
3. Task Leader and MPEX Area Coordinator verify Conditions are appropriate for work to proceed
4. Planned activities must be posted on the Daily MPEX Stand Up Board and communicated daily by the responsible Task Leader
5. Daily activities conducted under this approved work plan must be logged in the MPEX Logbook. This Work Plan Number must be included in the activity logged. Note: When logging an activity in the MPEX Logbook, include relevant information such as calibration records, measurement results, photos, etc.
6. Any work that impacts other work in 7625/7627 and/or the 7600 Campus, must be communicated in advance at the Plan of the Week meetings
7. Work Control and Supplemental Documentation must be posted in general work area that is readily accessible
8. Pre-job Briefings shall be conducted per recommended controls and/or as deemed necessary by the MPEX Area Coordinator

Note: Operations Support and/or the Division Electrical Safety Officer are present for the Pre-Job Briefing for any work involving a subcontractor or vendor and must be documented.

Prerequisites / Precautions:

1. The Sairem Transmitters have been commissioned and turned over to the MPEX project.
2. Pressure systems are required to be maintained in the FSC Pressure System Database.

3. The Sairem Transmitters have been walked down and visually inspected for damage, anomalies, etc. that may have occurred post-commissioning.
4. System walkdowns are required to verify configuration management and confirm use of administrative control tags/locks as appropriate.
5. Notify MPEX Operations Lead when there are changes in configuration.
6. Identification tags have been attached to the Sairem Transmitters (if applicable)
7. All required PPE has been identified, obtained, and is available for use.
8. Work has been scheduled and is listed on the Building 7625 Plan of the Week.

PPE: The minimum PPE for work covered under this work plan includes safety glasses with side shields. Gloves shall be worn when working with chemicals. Nitrile gloves will be used with all chemicals unless another glove type is specified or designated as acceptable within other RSS hazard questions.

Training:

1. The Task Leader is responsible to ensure staff performing tasks defined in this Work Plan have completed trainings applicable to the activity being performed.
2. All personnel must be on the approved MPEX General Access and Activities Work Plan (MPEX: GENERAL WP).
3. All personnel conducting work under this work plan must sign the Pre-Job Briefing form.
4. Prior to conducting any hands-on work for MPEX, personnel are required to coordinate with the MPEX Area Coordinator.

Directions:

RF Operation

Prior to operation of the transmitters, confirmation of the switch configuration should be performed to verify target device of RF energy. All configurations must be reviewed and approved by the MPEX Area Coordinator. If the transmission configuration is changed and LTV is required to control hazardous energy (e.g., open transmission lines), then RF surveys shall be conducted as the LTV verification step.

The machine shall be operated within the operational limits specified by the Sairem GRP1000 user manual (operational limits may be further constrained by MPEX operations procedures). Any internal faults should be investigated prior to resuming operations.

Only personnel listed below are authorized to operate the GRP1000 RF Transmitters:

- Michael Kaufman
- John Caughman
- Josh Larson
- Tim Bigelow
- Rick Goulding
- Other personnel explicitly authorized by Task Leader.

Perform Repairs on Sairem

NOTE: Personnel performing hands-on work on the Sairem GRP 1000 RF generator during the preparation phase must have completed LTV training. Personnel needing to cross the lockout/tagout boundary must apply a red personal lock to the lockbox. If Personnel are not ORNL employees, an Issuing Authority (IA) must oversee LTV.

NOTE: LTV of the Sairem GRP 1000 will be performed per SMBS procedures either under complex permit using ORNL-213 and a lock box or under an equipment specific procedure (ESP) with a lock box.

NOTE: Calculations of arc flash energy for the capacitors require Category A PPE and Class 2 voltage-rated gloves.

Prior to any repairs or re-work being performed, personnel pause and verify the controls in this work plan are adequate for each of the necessary repairs:

a. If the controls in this work plan are considered adequate, proceed with the repairs using the steps below.

b. If the controls are not considered adequate, a new work plan will be developed to cover these repairs.

To perform repairs under this work plan:

a. Issuing Authority places equipment under LTV.

b. Authorized employees apply personal locks to lockbox.

c. Authorized employees perform repairs.

d. Issuing Authority verifies tools, parts, debris, and any other undesirable materials have been removed from the equipment and equipment is ready to be reenergized (if water valves have not yet been adjusted, then do NOT open valves).

e. Authorized employee removes lockout devices and grounding straps from the equipment without operating the devices.

f. Authorized employee removes the LTV boundaries and postings.

g. Validate repairs by reentering RF Operation sections of work plan as necessary.

Validate Lockout/Tagout Procedure

If the system is in a compatible configuration and an equipment-specific LTV procedure was not used prior, perform a lockout/tagout/verification and subsequent lockout/tagout release of the Sairem in accordance with it at this time. This will complete validation of the equipment-specific LTV procedure for the Sairem.

Post Work Testing:

1.Task Leader is responsible to ensure completed activities are logged into the MPEX Logbook.

Closeout:

1. Upon completion of daily activities conduct under this work plan, log the activity in the MPEX Logbook and include this Work Plan number.
2. Any equipment issues shall be logged into the MPEX Logbook. Task Leader is responsible to ensure equipment issues are resolved.

JOB HAZARD EVALUATION	
HAZARDS	PERMITS / CONTROLS
Deenergized Hazardous Energy Sources (LTV): 480VAC 3-phase power is provided from PP-14; The Sairem GRP1000 contains large capacitors that must be safed during LTV.	ı Perform Complex Lock/Tag/Verify - PERMIT - OR Equipment-Specific Hazardous Energy Control Procedure: Stored energy will generally necessitate complex LTV of Sairem GRP 1000 transmitter; safeing the capacitors inside the cabinet requires ORNL Cat A PPE and Class 2 Voltage-rated gloves. ı Manage Lock/Tag/Verify for Subcontract/Vendor Work (ORNL-1113 Subcontractor/Vendor LTV Job-Briefing Checklist) ı ORNL-1022 Hazard Analysis for Electrical Work Form ı Confirm LOTO boundary has been established around deenergized equipment, and delineate using red chain and postings. ı Personnel needing to cross the LTV boundary must have current LTV training and place a personal LTV lock on the facility breaker locking device. ı For operation of Sairem #1 transmitter and open ports on the RF transmission lines on the combiner farm, work performed on the transmission lines must be conducted under LTV. Verification of the configuration requires an RF survey. An admisntrative lock may be used to maintain Sairem#1 configuration to Proto-lite. Yellow barricades and signage will be posted around Sairem#1 indicating R&D operation to Proto-lite
Elevated Work: Ladders and ladder stands may be required to gain access to top of transmitter enclosure.	ı Personnel using ladders or ladder stands shall have completed ORNL ladder safety training.
Non Ionizing Radiation (Please identify the type	ı Exposure Assessment: Enter or attach justification to

(s) of NIR hazard in text box below: Optical Radiation, RF and Microwave, Static Magnetic Fields, Sub-Radiofrequency (30 kHz and below) Magnetic Fields, Sub-Radiofrequency (30 kHz and below) Static Electric Fields): The Sairem GRP 1000 transmitter generates RF at 13.56 MHz at power levels up to 100 kW.	classify exposure scenario as low risk, qualitative exposure assessment (QEA), or requirement to conduct quantitative exposure monitoring (QEM): This is the first operation oRF Surveys will be conducted for leakage from the unit or the output coax transmission line upon change of configuration. - Confirm Sairem output transmission lines, fittings, and flanges are securely attached and are undamaged. - Upon change of configuration, operate the Sairem at low power and use RF Survey instrument to check for leakage. Progressively increase power and repeat checks for electromagnetic radiation leakage, ensuring that electromagnetic radiation is less than 135 V/m.
Obstructed Access/Egress: Sairem work area (Room 106) will extend into the pedestrian corridor, limiting personnel access.	- Keep work area as clear of equipment, tools, as possible. Maintain good housekeeping. - Maintain clear access to facility exterior door in Room 101A. - Keep electrical cords clear of walkways and properly managed.
Breaker and Disconnect Switch Operation: Operation of facility and equipment disconnect switches and breakers up to 480 V is required as part of this work scope.	- Personnel operating disconnect switches and/or breakers (up to 600 V) must have completed circuit breaker operation training. - Wear arc flash PPE as appropriate for the disconnect or breaker to be operated. Use NFPA 70E Tables 130.7(C)(15)(b) and 130.7(C)(16) to determine PPE requirements.

DOCUMENTATION REVIEW AUTHORIZATION (Approvals are certification of hazards assessment)		
Reviewer/Approver Roles	Signature	Date
Accountable Management (Service Provider, Line, Equipment Owner, or Facility Management)	Duckworth, Robert	8/20/2025
Area Manager	Dessel, Matt	8/26/2025
Area Manager	Morrow III, Michael C	8/20/2025
Division Electrical Safety Officer (DESO)	Barth, Gerald	8/26/2025
IS/IH	Penn, Timothy	8/25/2025
Operations Manager	Brand, Kat	8/20/2025
QA	Keys, Milena	8/20/2025
Task Leader	Caughman, John	8/20/2025
Task Leader	Kaufman, Michael	8/21/2025
Work Package Concurrence		
Facility Manager		
Operations Supervisor		
Facility Manager Approval To Start Work		
Facility Manager		
Work Start Authorization		
Task Leader		
Work Acknowledged Complete		
Task Leader		
Worker Feedback:		
Work Plan Feedback:		

The ACGIH TLV for Electric Field Strength (E) at 13.56MHz is 135.84 V/m.
The ACGIH TLV for Magnetic Field Strength (H) at 13.56MHz is 1.20 A/m.

MPEX Assembly and Install LTV Controls:

Lock/Tag/Verify (LTV): All MPEX
Assembly and Installation activities will adhere to SBMS Procedure: Verify Absence of Hazardous Electrical Energy for Lock/Tag/Verify (LTV). All LTV must be conducted under an approved work control.

Complex
LTV: Shall be coordinated through an F&O Issuing Authority (IA) with a permit and pre-job briefing conducted. If an Equipment Specific Procedure (ESP) has been developed and verified, the ESP may be used but work must be reflected on the MPEX plan of Day board coordinated through the F&O IA and pre-job briefing conducted and documented.

Non-ORNL
Staff Performing Work Under LTV: The F&O Issuing Authority (IA) must be involved with LTV, permit and pre-job briefing conducted. Anyone working on equipment under LTV must have and be current in their company's LTV/LOTO program/training, be on the pre-job briefing and overlocked on the LTV. If lock is removed, they may not return lock until discussed with and approved by IA. If an Equipment Specific Procedure (ESP) has been developed and verified, the ESP may be used but work must be coordinated through the F&O IA and pre-job briefing conducted. Operations Support is required to be present at Pre-Job Briefings for subcontractor/vendor activities.

Electrical
LTV and Zero Energy Verifications: Shall be performed by F&O staff for all MPEX installation activities.

Barth- question- was the call out for Class 2 voltage rated gloves for the capacitors the min needed? - under work instructions tab for Sairem repairs: Calculations of arc flash energy for the capacitors require Category A PPE and Class 2 voltage-rated gloves.

Penn- Currently only two Sairem GRP1000 Transmitters installed.

Would including current configuration and configuration to Proto Lite be helpful?

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PRE-JOB SAFETY REVIEW GUIDE

ID: 63253

Scope of Work: Review work package/plan to ensure all participants understand the work activity.

Hazards: Review the hazards identified in Job Hazard Evaluation (JHE) / work plan (IOP).

- Since the work package / plan was written: 1) Have conditions changed? 2) Are there new hazards? Refer to Field Notes and Focus Areas.

Hazard Controls / Permits: Review:

- Written permits for the work activity.
- Precautions, step warnings, Hold Points ...
- Personal Protective Equipment (PPE)
- Work instructions for information - e.g., steps where hazards are introduced.
- ORNL subject area requirements - e.g., non-permit hazard controls.

Performing Work:

- Discuss group/individual responsibilities for safe & effective work.
- Follow work instructions & safety procedures.
- Availability/location of materials, tools, etc.
- Any previous experiences / lessons learned?
- Response if work cannot be performed as planned.
- What is the worst thing that could happen?
- Are there *Potential error traps* with the job? → →
- Take a minute before: work start & leaving work area.
- Work Hand-off / Turnover - workers & Task Leader

→ Potential Error Traps:

- Time pressures
- Distractive environment
- High workload
- First time evolution
- First day back
- Vague guidance
- Over confidence
- Imprecise communications
- Work stress

Abnormal Situation Response:

- *Stop Work*: Observe an unsafe act, activity or condition that creates an imminent danger.
- *Emergency Response*: Discuss egress paths or other responses if problems are encountered.

Field Notes and Focus Areas: (Use this area as a work space to record notes related to new hazards identified in the field or changed conditions. Record feedback in work package/plan information systems.)

By signing below, I am indicating that I have been briefed on the potential hazards associated with completing this job.

Signature / Badge	Date	Signature / Badge	Date

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INSTRUCTION MANUAL

MODEL :	**GRP1000K**
MODEL DESCRIPTION **:**	**50Ω 100KW TRANSMITTER**
REVISION :	**B**

THIS MANUAL PROVIDES OPERATING INSTRUCTIONS & TROUBLESHOOTING ADVICE
KEEP FOR FUTURE REFERENCE

CE

(THE EQUIPMENT IS NOT UL LISTED BUT HAS BEEN INSPECTED BY A NRTL AND NO ADVERSE FINDINGS IN FINAL REPORT, AS PER CONTRACTUAL REQUIREMENTS)

PRODUCT SPECIFICATION

TECHNOLOGY:	**RF**
MAINS VOLTAGE:	**480V 3 PH + EARTH**
MAINS POWER:	**220 kVA**
OPERATING FREQUENCY:	**13.56 MHz**
OUTPUT POWER :	**100 kW**
BASIC DIMENSIONS:	**LENGTH 270 CM X HEIGHT 260 ± 4 CM X DEPTH/WIDTH 164 CM**
TOTAL FOOTPRINT (including maintenance zones):	**LENGTH 348 CM X HEIGHT 290 ± 4CM X DEPTH/WIDTH 350 CM**
COOLING METHOD:	**WATER**

REVISION INDEX

Issue	Author	Checker	Issue date	Revision comments
A	VGU	JTH	12/23	Creation
B	VGU	JTH	12/24	Revision

ATTENTION!

THIS IS HIGH VOLTAGE RF EQUIPMENT

BEFORE USING THIS EQUIPMENT READ CAREFULLY THE INSTRUCTION MANUAL, PAYING SPECIAL ATTENTION TO THE SAFETY SECTION

TAKE ALL NECESSARY PRECAUTIONS CONCERNING THE EMPLOYMENT OF ELECTROMAGNETIC RADIATION AND HIGH VOLTAGE

DO NOT USE THIS EQUIPMENT WITH EXPLOSIVE OR CORROSIVE SUBSTANCES

ENSURE THAT ALL SPECIFICATIONS REGARDING THE COOLING WATER ARE SATISFIED, IN ORDER TO PROLONG THE LIFE OF THE COMPONENTS THAT GENERATE AND TRANSMIT RF ENERGY

WARRANTY

Sairem's equipment is warranted for the period of twelve (12) months from the date of commissioning* against defective materials and workmanship.

Travelling expenses, shipment of parts and triodes (manufacturer's warranty for 1 year or 2,000 running hours on a pro-rata time basis) are excluded from this warranty.

** Commissioning must be no later than 1 month after delivery.*

In the event that warranty service is requested, Sairem or their authorized service centres must be contacted. They will inform about process to be observed.

New faulty products to be exchanged/repaired must be absolutely returned in their original packaging. Prior to any return, Sairem or their authorized service centres must be contacted. They will provide RMA number and associated return procedure.
In the event of a returned product in a different packaging, possible degradations due to transportation can't be taken under warranty, and will be charged to the client.

In case of difficulty, details of Authorised Service Centres are available from:

SAIREM SAS
82 rue Elisée Reclus, Décines-Charpieu, 69150, FRANCE
Tel. + 33 (0)4 72 01 81 60
Support hotline: +33 4 81 65 13 88
Support email: support@sairem.freshdesk.com
Web: www.sairem.com

The warranty is void if:

- The defective material or design is attributable to the Buyer;
- The defective working of the goods is due to an unauthorized intervention on the said goods, attributable to the Buyer;
- The defective working of the goods sold is due to normal wear and tear or a negligence or a wrong keeping attributable to the Buyer;
- Misuse, including the failure to use this equipment for its contractual purposes or incorrect installation;
- For the goods integrated as such by SAIREM, these goods remaining with warranties of their manufacturers (electronic components, sub-assemblies,…).

This warranty covers none of the following:

- Periodic check-ups and maintenance;
- Cost relating to the transport, removal of installation of the equipment;
- Damage caused by Lighting, Water, Fire, War, public disturbances, incorrect mains voltage, improper ventilation or any other cause beyond the control of Sairem.

TABLE OF CONTENTS

1. SAFETY PRECAUTIONS & INSTALLATION

Notes: *The content of this manual may change from time to time without notice. SAIREM accepts no liability for any errors that may appear in this manual nor does it make any expressed or implied warranties regarding the content. So far, as is reasonably practicable, SAIREM has ensured that its products have been designed and constructed so as to be safe and without risks when properly installed and used in accordance with SAIREM operating instructions.*

SAIREM accepts no liability for loss of profit, loss of market or any other indirect or consequential loss whatsoever.

Product warranty and limit of liability are dealt with in SAIREM standard terms and conditions of sale or negotiated contract under which this document is supplied.

This manual provides operation instructions for the SAIREM ***GRP1000K,*** a 100kW Radio-Frequency Transmitter, referred to TRANSMITTER in the remainder of this manual.

You must use the TRANSMITTER as described in this manual.

Read this manual before you install, operate and maintain the TRANSMITTER.

Important safety information is highlighted as WARNING and CAUTION instructions; you must obey these instructions.
The use of WARNINGS and CAUTIONS is defined below.

WARNING

Warnings are given where failure to observe the instruction could result in injury or death to people.

CAUTION

Cautions are given where failure to observe the instruction could result in damage to the equipment, associated equipment or process.

Throughout this manual:
The units used conform to the SI international system of units of measurement.

Note: *Where pressures are quoted in Pascal (Pa) in this manual, the values are absolute; that is, they include one atmosphere (1.013 x 10^5 Pa). For example, a supply pressure of 4 x 10^5 Pa will have the equivalent value of 3 bar gauge.*

Two main dangers arise from the use of a radio frequency transmitter:

- High voltage – to supply the triodes,

- Electromagnetic radiation.

1.1 HIGH VOLTAGE POWER SUPPLY

WARNING

Any accidental contact with high voltage can be fatal.

The triodes are supplied with up to 15.5 kV.

Before any operation on HV or filament devices, RF cavity and power supply:

- ensure that metallic parts are earthed,
- turn off the mains electricity supply and lock the mains circuit breaker in the open position,
- short-circuit the HV with an earth wire.

The power supply must be correctly earthed during operation.

Never disable safety devices.

Never start the TRANSMITTER with any of the covers removed, unless a SAIREM engineer or authorized to perform maintenance on SAIREM products

Never try to introduce metallic objects inside the power supply or RF cavity.

Work on the HV network may ONLY be done by qualified persons.

Protect the TRANSMITTER from water spray and conductive or corrosive substances

In case of accidental introduction of water, or a cooling water leak or failure, dry out the TRANSMITTER before trying to re-start the unit.

In case a maintenance intervention should be applied to the TRANSMITTER, make sure to follow the corresponding LOTO procedure indicated on the Maintenance Manual.

1.2 ELECTROMAGNETIC RADIATION

WARNING

HIGH LEVEL ELECTROMAGNETIC RADIATION

Output circuit: use efficient screening to contain electromagnetic field. Never touch HF parts: cold burning hazard. No iron or conductive material between electrodes.

13.56 MHz frequency, amplifier circuits keep harmonics at very low levels and allow the use of electronic control circuits without problem.

On commissioning, start the TRANSMITTER at low power. Check for possible leakage. If necessary, modify the RF Applicator. When satisfactory, progressively increase the power whilst ensuring that the electromagnetic radiation is less than limits given by standards.

Avoid using the TRANSMITTER without a matched load. Limit power for low loads.

The TRANSMITTER is protected against excessive reflected power(RP), but **care must be taken that reflected power does not exceed 11% of forward power(FP) in CW (25 ohm) and average forward power does not exceed 100kW** . Please contact SAIREM in case of excessive RP Max Faults. Where necessary, modify the RF Applicator or use a tuning system between the TRANSMITTER and RF Applicator. *In the case of excessive reflected power, the life of the triode decreases very quickly.*

Whilst assembling and operating the system, take care not to introduce conductive or corrosive material into the RF connection between the TRANSMITTER and the matching system.

1.3 INSTALLATION OF THE GRP1000K

Install the TRANSMITTER on a flat base, with enough space to carry out maintenance operations. All parts must be in line: use adjustable feet to level the cabinet and reduce mechanical stress. You must protect the TRANSMITTER against corrosive and flammable products and vibrations (that may break the filament). The RF line between TRANSMITTER and RF Applicator, the mains power supply, water cooling circuit and maintenance facilities are parameters which can affect position of TRANSMITTER. Base must be stable and vibration free.

Follow the Installation Manual instructions if provided by SAIREM.

CAUTION

With respect to European Electromagnetic Compatibility (EMC) requirements for harmonics and flicker, the TRANSMITTER should be treated as Class A (industrial) as defined by EN 61326. In this context the TRANSMITTER is not intended for use in domestic buildings, or in properties directly connected to an electrical supply network which also supplies domestic buildings.

Operating and storage conditions

Operating environment	Suitable for indoor use only.
Operating/storage ambient temperature range	5 / 40 ^{0}C operation, 0 / 60 °C storage.

Operating/storage ambient humidity range	85 % RH & 40 °C maximum external conditions of the transmitter. An air conditioning system reduces humidity inside cabinet.
Maximum operating altitude	2000 m
ATEX Classification	Not applicable

1.3.1 COOLING WATER

You must supply cooling-water for the different components in the TRANSMITTER.

Note: *Use demineralized water for your cooling-water supply, which meets the following criteria.*

Cooling-water supply data

Minimum supply pressure	4 bar gauge, 5 x 10^5 Pa,
Maximum supply pressure	**5 bar gauge, 6 x 10^5 Pa,**
Minimum differential pressure	3.2 bar gauge, 3.2 x 10^5 Pa, @ 80l/min
Minimum flow rate	**70 L/min including 40l/min at Final triode. For long CW operations and when Final triode plate efficiency is below 70%, it is recommended to have more than 61l/min at Final triode**
Supply temperature	**min. 18 ^{0}C, max. 30 ^{0}C**
RSI (Ryznar Stability Index) *	6.5 – 7
Maximum particle size	30 µm
Acidity	6.5 to 8.0 pH
Hardness	< 100 ppm
Water conductivity	5 µS/cm < σ< 150 µS/cm
Solids (turbidity)	< 100 ppm
TH	< 5°.

*The Ryznar Stability Index (RSI) provides a means of calculating the suitability of the cooling-water supply for use in systems. High water temperature and low flow can cause corrosion with soft water, or cause dissolved salts to be precipitated with hard water.
You must calculate the RSI for your cooling- water supply and check whether the supply is suitable for use. You should contact your local water authority for details of the water quality and, if required, for advice on suitable in-line water treatment.
For calculation of the RSI you may use http://www.lenntech.com/calculators/ryznar/index/ryznar.htm

SAIREM recommend that your cooling-water supply has an RSI of 6.5 to 7.0.
If the RSI of your cooling-water supply is outside this range, you should incorporate suitable in-line water treatment methods, to ensure that the RSI of the cooling-water supply into your system is in this recommended range.

The following list indicates the amount of deposit or corrosion that can be expected according to the RSI of your cooling-water supply.

- 4.0 to 5.0 Heavy scale
- 5.0 to 6.0 Light scale
- 6.0 to 7.0 Little scale or corrosion
- 7.0 to 7.5 Significant corrosion
- 7.5 to 9.0 Heavy corrosion
- > 9.0 Unacceptable corrosion

Do not use water circuit with carbon steel pipe. Valve or pump: use stainless steel, copper or plastic tube.

To cool the TRANSMITTER, use water with a temperature above the dew point, to avoid condensation inside the TRANSMITTER.

Do not store or operate the TRANSMITTER in a room where the temperature is close to or below 0° C. If unavoidable, drain the water cooling system.

CAUTION
In case that another cooling fluid is used, increase the flow to match the thermal characteristics of water. Other fluids may have lower heat capacities and higher conductivity.

The TRANSMITTER should be installed in a clean, dry place, protected against water or moisture. Never operate the transmitter in a dusty environment.
Do not hesitate to consult SAIREM or the local distributor if there is the slightest doubt about the operating environment (dust, cooling water...).

If the TRANSMITTER is to be transported, drain the water circuits and pack the equipment to protect against shock during transport.

1.3.2 VENTILATION AND FIRE SUPPRESSION

Ensure that there is sufficient circulation of cooling air around the TRANSMITTER and that no air vents are blocked.
In case of fire:

- Power off the transmitter,

- Use equipment provided for use against fires of electrical origin:
  - chemical extinguishers,
  - dry ice extinguishers.

- Keep a distance of at least 1 meter between the extinguisher and the parties involved.

1.4 INSTALLING THE TRIODES

WARNING

Before any intervention on HV parts, open mains breaker and secure it in the open position. Check that external parts are well grounded. Earth all HV parts.

Follow the Triode Installation Guide in the Installation manual if provided by SAIREM. If not, contact SAIREM to organize an intervention.

1.5 ELECTRICAL AND WATER CONNECTIONS

Please consult wiring and mechanical diagrams provided by SAIREM. Follow the steps provided in the Installation Manual if provided by SAIREM. If not, contact SAIREM to organize an intervention.

1.5.1 RF LINE

Link the TRANSMITTER to the RF Applicator with 50 Ω 4”1/2 coaxial line; check continuity. Use mechanical supports to eliminate mechanical stress. Protect RF line against mechanical shock

In case of long operation at high powers, it is advised to install a small air flow (1 or 2 liters / min) inside RF line to protect the coaxial line from dust and humidity.

CAUTION

Never use the RF line as a mechanical support!

During installation, be sure that the RF line is either supported from above or below at sufficient intervals according to the total distance covered.

1.5.2 ELECTRICAL WIRING

Connect to the mains with electric cables: power and controls as indicated in the Installation Manual provided by SAIREM. If not, contact SAIREM to organize an intervention.

Mains power 480V - 60 Hz three phases 220 kVA max Until 240 kVA could be needed on a 25 ohm load at 0 m in pulsed operations The cable gland for the mains cable is situated on top of the TRANSMITTER cabinet. Check the Installation Manual or the electric schematics to understand the different connections involved.

1.5.3 WATER COOLING CIRCUIT

Connect the TRANSMITTER cooling circuit to water circuit with enough flow capacity and pressure:
70 l/min minimum (or 91 l/min with at least 61l/min on Final triode in long CW operations) and 6 bars maximum absolute pressure.
It is advised to install a stop valve on input and output circuit to isolate TRANSMITTER cooling circuit during maintenance operations.

CAUTION:

Use cooling water with temperature up to dew point. Check water connections. Ensure both the minimum pressure and flow rate.

2. PRODUCT OVERVIEW

2.1 PRINCIPLE OF OPERATION OF THE GRP1000K

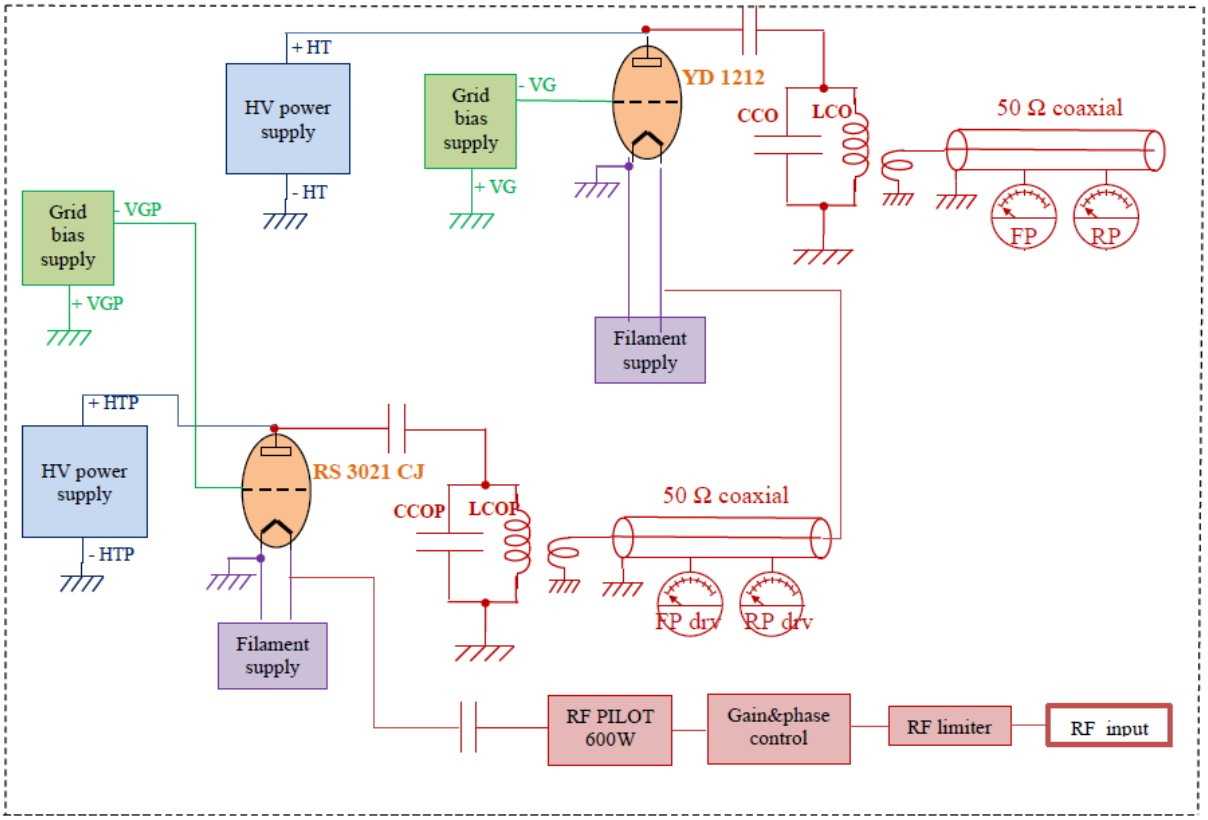


FIG. 1 100 KW RF TRANSMITTER PRINCIPLE

The transmitter uses three successive amplifiers: a first SSPA called RF PILOT 600W which supplies RF (0 to 600 W) to the driver based on a 0 to 10 kW triode pre-amplifier, which one drives the grid of the final triode, to get RF power at output between 0 and 100 kW. The filament supplies heat up the cathodes, the DC high voltages power supplies at anodes and the grid supplies bias the triodes for C-class operation.

Example for a 100 kW output power transmitter: Driver triode = 10 kW, HV = 14.0 kV and 11 A, filament = 380 A at 12.6 VAC and grid = 1.5 A at - 440 VDC.

The output circuit consists of a band-pass circuit (inductance OCL & capacitor OCC), and an inductive coupling system to match output impedance to 50 Ω.

In the 50 Ω transmitter design, the role of the band-pass circuit is not to produce a fixed frequency signal as in the self-oscillator transmitter, but to match at 50 Ω and to eliminate harmonics.

The product to heat into the RF Applicator is totally independent of the 50 Ω transmitter. Calculation shows a maximum power transfer when the output impedance of the transmitter (50 Ω) is equal to the impedance of the line and equal to the input impedance of

the applicator (containing the load). Differences in these values result in increased reflected power; however, if this is the case, the level of reflected power can be read and tune.

The main characteristics of the 50 Ω amplifier are as follows:

- The 50 Ω amplifier is a component of the installation, interchangeable with another transmitter; maintenance, power supply substitutions are straightforward. **The LLRF needed ahead of the Transmitter is specific to each model : relations of gain and phase in function to RF input power is specific to each transmitter**

- HMI displays information on the forward and reflected power measurements. Additional parameters are available : electrical, cooling and air measurements, RP and Ig1 limitations, status of faults, past duration of filaments's use, communication control

-

- The 50 Ω coaxial line is standardized, e.g. EIA 4"1/2 at 13.56 MHz and 100 kW. In consequence, all usual coaxial components* for building the RF installation can be chosen without any importance of the transmitter's model. For example, it is simple to test or repair a transmitter with a 50 Ω water load or calibrate the output RF power with a standard 50 Ω coupler;
  * Standard coaxial components developed for telecommunication applications

- The transmitter can be positioned far from Applicator, e.g. in a different room or on a different floor;

- The global efficiency of the transmitter is nominally around 45-50 % on a 50 ohm load. It can be increased to 60% approximately if needed.

2.2 CHARACTERISTICS

TRANSMITTER 's output power can be continuously adjusted from 0.1 kW to 100 kW. The RF power is amplifier at a frequency of 13.56 MHz.

The TRANSMITTER is fully cooled by water, and its cabinet is dust-proof.

The TRANSMITTER is equipped with a PLC with touch screen. All control parameters are displayed on this element. Parameters are set on each different screen of the PLC.

The TRANSMITTER can be controlled locally via the PLC touch screen or remotely via Ethernet-Modbus or Analog signals.

Power control, safety circuits and parameter display are made with the PLC and one compact electronic control unit. Check the block diagrams for more information on the TRANSMITTER control elements.

A two level safety circuit controls the operation of the emergency stop, doors, and other safety signals connected to user interlock devices.

Protection of the triode is ensured by different independent circuits. Please check the fault description guide

2.3 DESCRIPTION

2.3.1 SPECIFICATIONS

Specification	Value
Electric supply	480 VAC Three phase + GND 60 Hz
Power consumption	Max 220 kVA with matched load
Frequency of operation	13.56 MHz
Nominal power	100 kW ± 4 % max (with feedback loop activated)
Maximum operation mismatch	**VSWR = 2 all phases**
External arc stop time, stop time in case of excessive RP	<= 100 µs
Power rise time	**<10 ms (Transmitter has been validated in pulsed conditions with rise time of RF_input of 6 ms)**
Power falling time when LLRF power being removed	< 100 us

Triode type: YJ1212 for final stage, RS3021CJ for driver stage
Triode cooling: water cooled (anode) and air cooling (cathode)
Triode life: 10,000 hours typical of filament heating
Preheating time: 3 min minimum before HV, 1 hour in case of new triode replacement (until 8h in case of new triode manufactured since a long time ago)

2.3.2 BLOCK DIAGRAM

In order to explain the internal operation of the transmitter, a block diagram is shown. The description of the individual elements will be done afterwards.

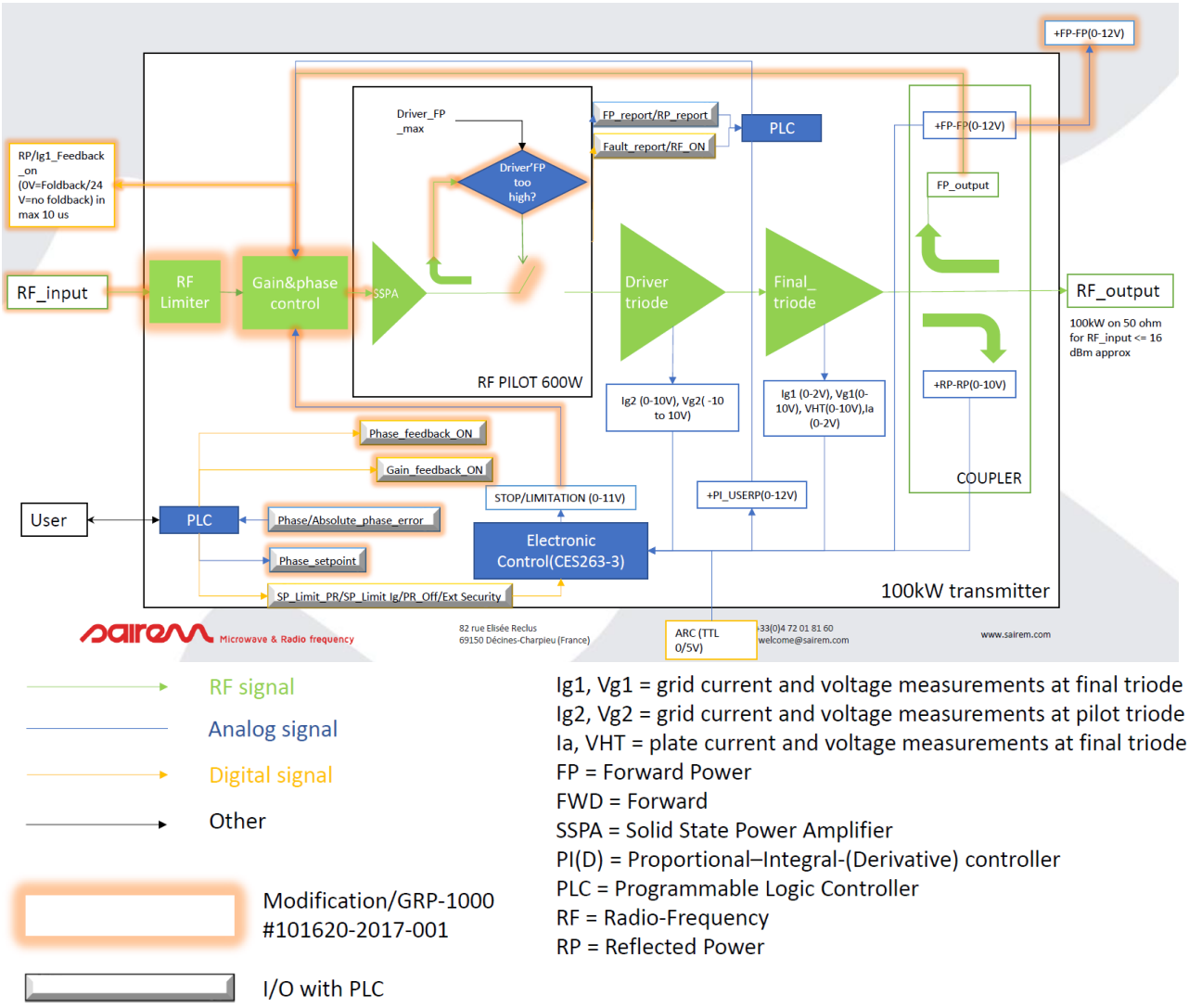


FIG. 2 TRANSMITTER BLOCK DIAGRAM

The TRANSMITTER amplifies the power delivered by the external LLRF source RF_input with three amplifier stages:

- First one is a SSPA, called RF PILOT 600W, delivering until approx.200W on 50 ohm load
- Second one is a grounded-grid triode amplifier called Driver Triode, delivering until 10 kW on 50 ohm load
- Third one is a grounded-grid triode amplifier called Final Triode delivering until 100kW on 50 ohm load

Between RF_input and SSPA, a RF_limiter saturates RF level when RF_input is above 15-18 dBm and a Gain&phase control block filters and controls overall FP and phase of TRANSMITTER.This latter control is on the electronic board CES419 described below.

NB : The RF_limiter can accept max. 2W of RF input power in CW.

Each triode amplifier has individual power supplies for the filament, grid and anode. These supplies are transformer based.

A combined PLC+HMI controls the TRANSMITTER. It interacts with two secondary control boards :

- Gain&phase Control (CES419-1) : This board handles FP and phase adjustment of the transmitter. The phase can be feedback controlled in closed loop, with a setpoint transmitted by the PLC+HMI. The FP is per default feedback controlled in closed loop, without any setpoint needed from the PLC+HMI. The setpoint for FP is automatically generated in function of RF_input power and STOP/LIMITATION. The open loop of FP is possible, and is only effective after intervention of SAIREM. The activation of open loop on HMI alone prevents from getting any FP.
  This board contains an RF switch for on-or-off protections. It outputs measurements of phase, and phase error to PLC+HMI, and digital information of FP foldback in case of RP or Ig1 limitation (0 or 24V)
- Electronic Control (CES263-3) called also EC board. This board handles on-or-off protections based on current and voltage levels, presence of external ARC, level of RP, and other conditions set and transmitted by the PLC+HMI. It handles also FP foldback based on RP and Ig1 measurements whose thresholds are set and transmitted by the PLC+HMI. It outputs an analog signal, STOP/LIMITATION, activating or not a RF switch on Gain&phase control board, depending on the state of on-or-off protections. In case of FP foldback, STOP/LIMITATION reduces the FP setpoint on Gain&phase control board. This board condition some measurements to PLC input requirements.

Measurements and commands are available on HMI, it is the LOCAL mode.
Some of them are available with I/O analog signals or Ethernet Modbus.

2.3.3 BLOCK DESCRIPTION

PLC+HMI

FIG. 3 PLC BLOCK

The PLC+HMI that concentrates the information of the state of the TRANSMITTER has two main elements.

- Touchscreen HMI
- Programmable Logic Controller

The programming language of the PLC is traditional LADDER. This device allows to monitor online the states of the process being performed in its logic. The modification of the PLC software is strongly not recommended but the monitor functionality can be useful for maintenance purposes.
The PLC communicates with other electronic peripherals such as the I/O modules, the EC board via CANOPEN fieldbus.
The external communication with the remote controller is typically done via Ethernet Modbus.

Gain&phase Control

This block contains mainly a band-pass filter centered on 13.56Mhz and the board CES419-1.
As described before, this board enables to adjust phase and gain of the TRANSMIT-TER. By default, phase and gain are adjusted in closed loop. Setpoint of phase is chosen during FAT and confirmed at SAT. It is transmitted to CES419 by the HMI+PLC. A setpoint of FP is used to adjust the gain. It is automatically generated from the RF_input power and STOP/LIMITATION. User can activate or not the feed-back controls. The activation of open loop for FP is only effective after intervention of SAIREM, so activation on HMI alone is not sufficient. NB : phase measurements and setpoint are not the values of overall phase of the TRANSMITTER. The latters differ from overall phase by a constant at a given FP.

EC Board

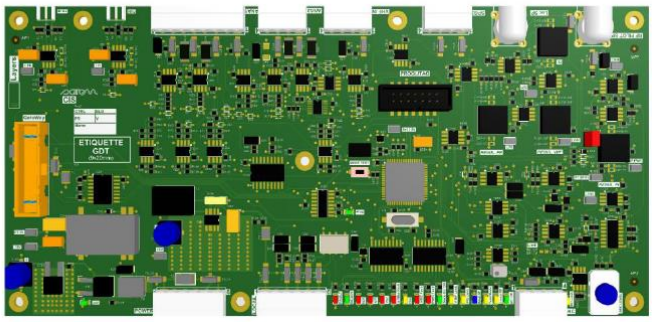


FIG. 4 EC BOARD BLOCK

The EC board has the main task to protect TRANSMITTER by reducing the nominal FP setpoint, in case of abnormal operating conditions. The protections that this board integrates are listed below.
Protections handled entirely by hardware on board :

- RP limitation by FP foldback.
- Too high RP by FP shutdown
- Ig1 limitation by FP foldback
- Final Triode grid (Ig1) overcurrent by FP shutdown
- (external over RF voltage limitation by FP foldback, not used here)
- Final Triode anode (Ia) overcurrent.
- Final Triode grid (Vg1) overvoltage
- Driver Triode grid (Ig2) overcurrent
- External Arc

Protections handled by software on board :

- Too high variation of RP
- Too high FP

In both cases listed above, thresholds are transmitted by the PLC, related measurements are analogically read and post conditioned directly on board.

The board also activates FP shutdown in case of all other on-or-off protections managed by the PLC : anode under voltages, fault on RF PILOT 600W, too high RP on Driver triode, abnormal anode and grid current on Driver triode, abnormal air/water parameters…Thresholds are also transmitted by the PLC, related measurements are either analogically read and conditioned directly on board or numerically transmitted from the PLC.

RF PILOT 600W

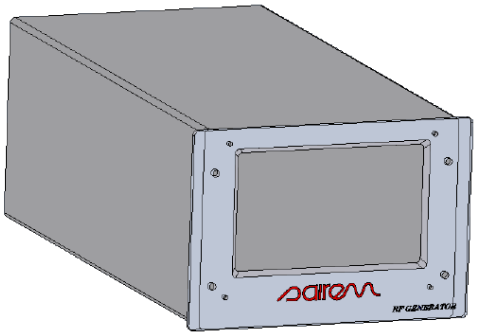


FIG. 5 RF PILOT 600W BLOCK

This amplifier has several successive cascaded solid state amplifier stages. Its maximum output power ranges theoretically until 600 W, however, the power needed to drive the TRANSMITTER to the nominal power is typically between 200 to 300 W, function of the load.
This transmitter provides a very fast reaction time, ideal for PR or Ig1 limitations and on-or-off protections.
It has its own protections (overcurrent, excessive RP..)

Power Couplers

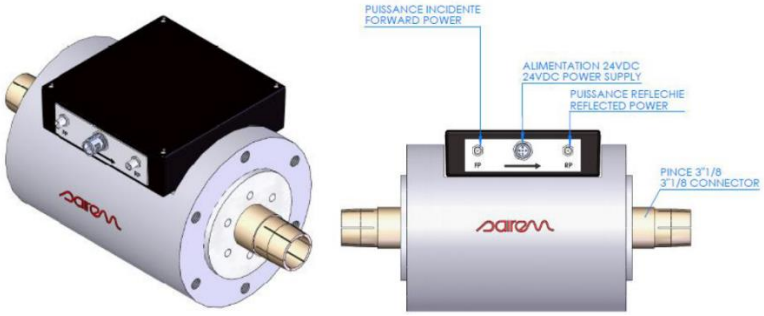


FIG. 6 POWER COUPLERS BLOCK

The power couplers allow the measurement of FP and RP of each one of the amplifier stages. For triode amplifiers, they are mounted directly at the output of their cavities. Two versions exist, 3’1/8 and 4’1/2, for the Driver triode and Final triode amplifiers respectively.
The RF PILOT 600W has also its own integrated bidirectional power coupler.

Triode amplifiers

FIG. 7 AMPLIFIER BLOCK

The tube amplifiers are class C providing high efficiency (up to 70%). Both cavities are similar, with an output LC filter recovering the sinusoidal oscillation.
The amplifiers are polarized with an anode supply, a grid supply and have a filament supply. The RF drive power is applied to the cathode, and power gains are over 10 dB.

Triode power Supplies

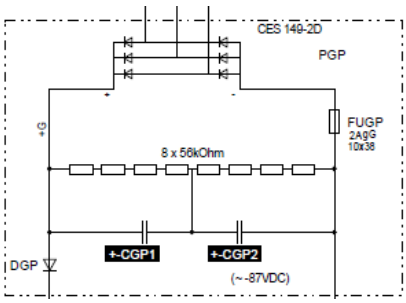


FIG. 8 POWER SUPPLY OF VGP

The triode power supplies are transformer based. Three different supplies exist for each tube, filament, grid and anode. This polarization is needed for the correct operation of the tubes. Otherwise faults will appear.
Depending on the type (filament, anode or grid), the output signal can be DC or AC.

2.4 GRP1000K IN PICTURES

A set of images and diagrams is provided to illustrate the different functional blocks of the TRANSMITTER.

2.4.1 TRANSMITTER BLOCK VIEWS

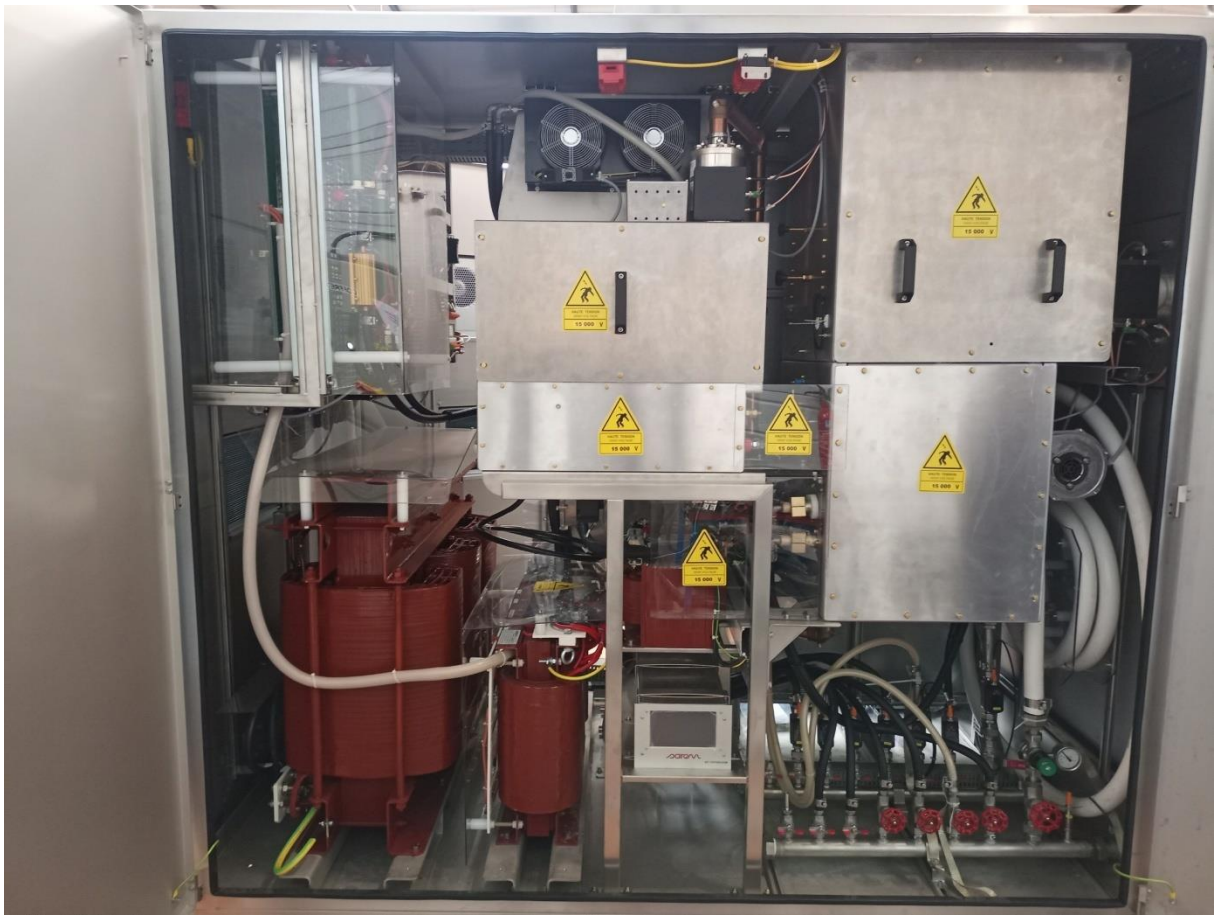


FIG. 9 REAR VIEW OF THE TRANSMITTER

FIG. 10 SIDE VIEW OF TRANSMITTER: HV RECTIFIERS

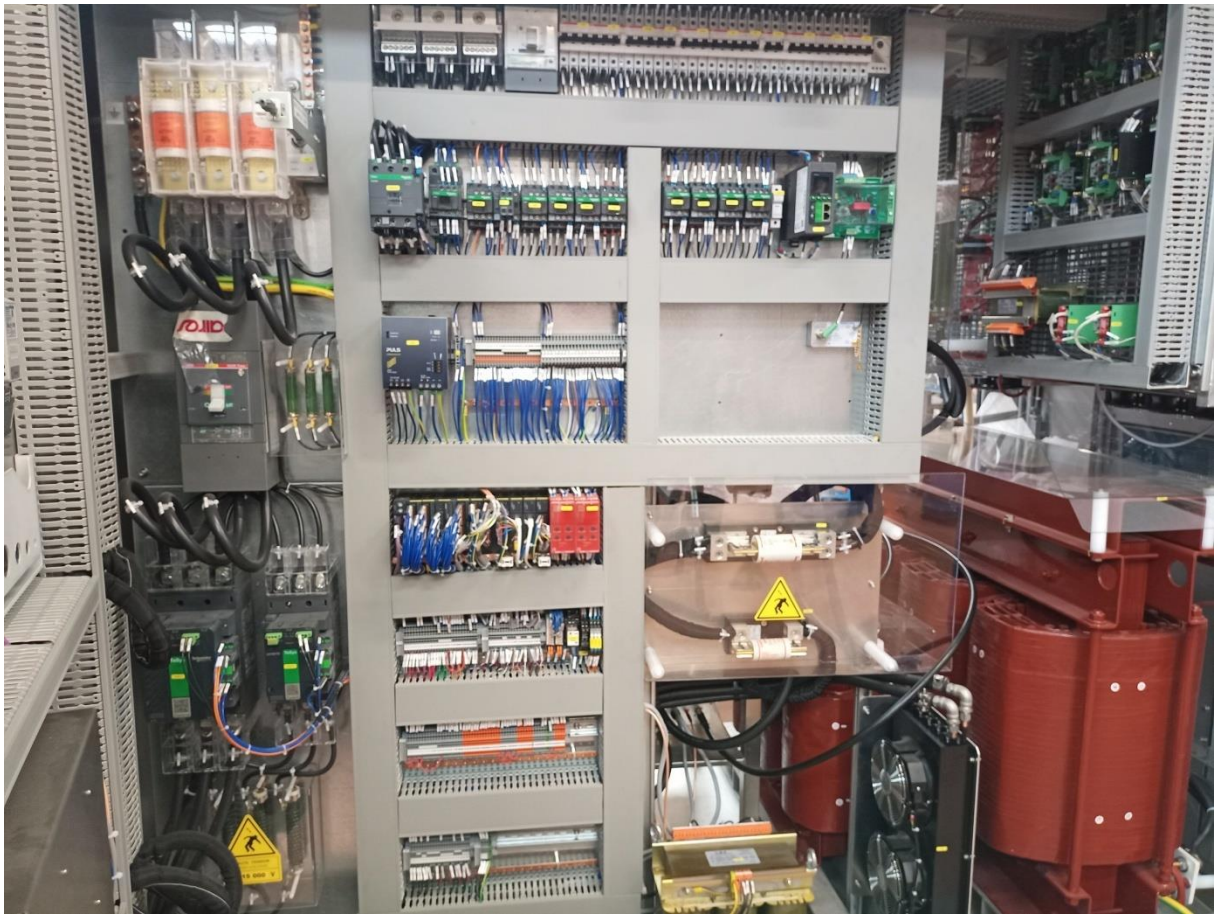
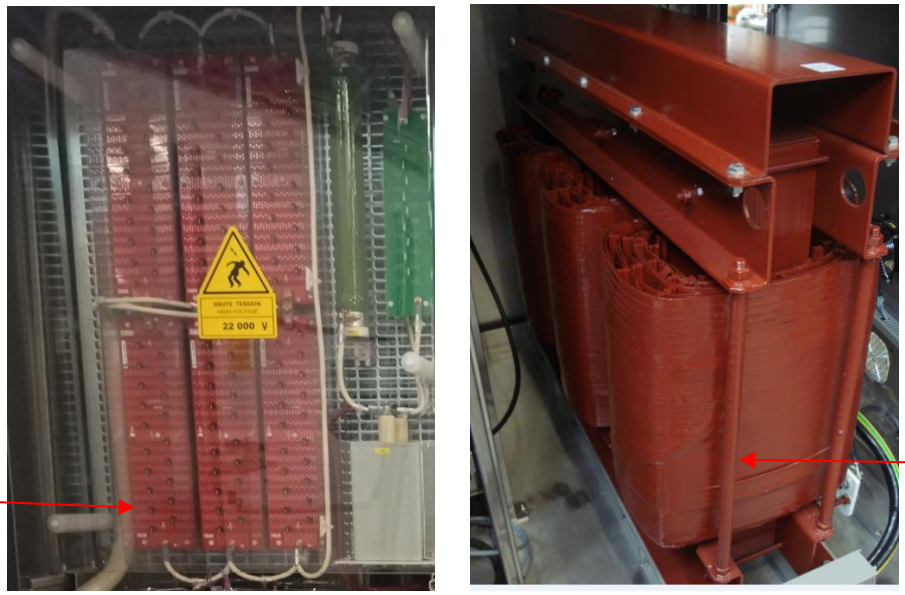


FIG. 11 FRONT VIEW OF TRANSMITTER

FIG. 12 MEASUREMENT PANEL VIEW

Resistor/rectifier bridge – transforms the transformer's AC output into a direct current to supply the triode



TRHT - High voltage transformer – Mains voltage to approximately 9.5 kV AC peak

FIG. 13 HV TRANSFORMER + DIODE BRIDGE FOR +HT

2.4.2 CONTROL PANEL

FIG. 14 CONTROL PANEL VIEW

2.4.3 CONNECTOR PLATE

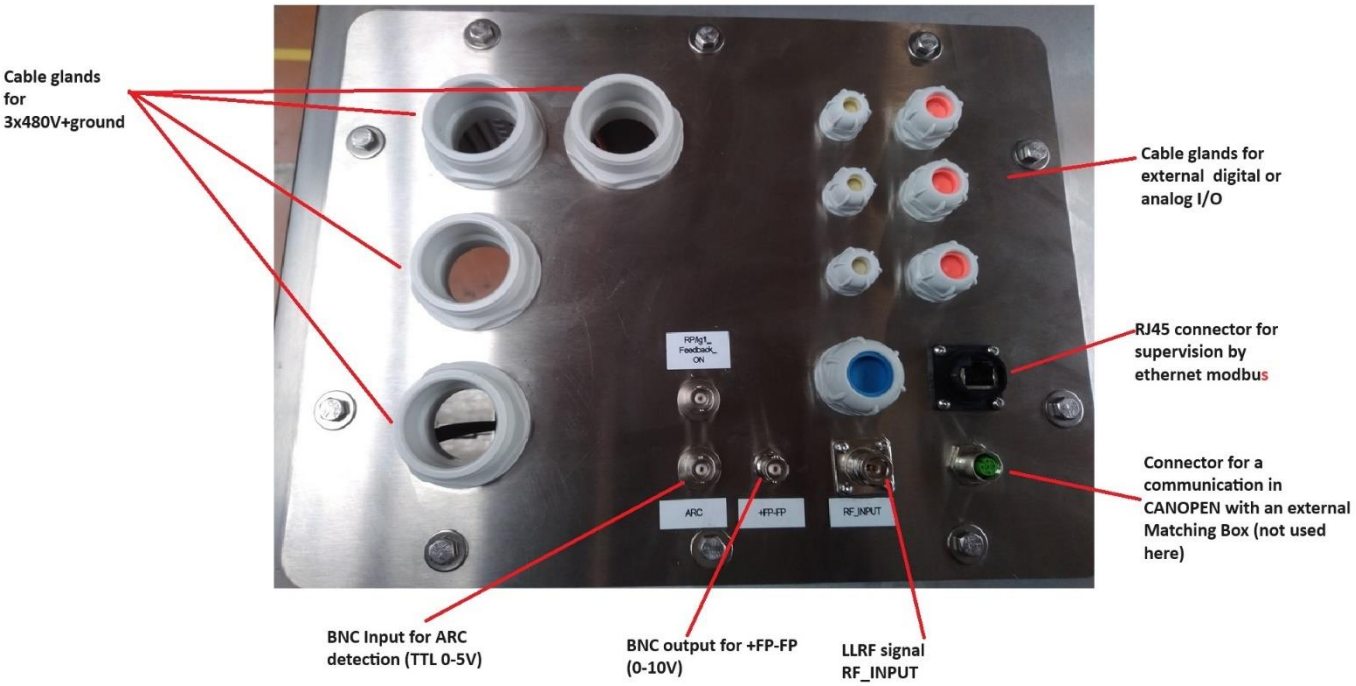


FIG. 15 CONTROL PANEL VIEW

2.5 PLC CONFIGURATION

The PLC control system is connected to different slaves through CANOPEN Fieldbus. The devices are the following.

- HTB I/O module: The analog and digital I/O of the PLC
- EC Board: The control board for protections.

The PLC can be connected to an external control device via Ethernet MODBUS.

2.6 WATER CIRCUIT

The water circuit of the TRANSMITTER can be described as follows.
The water inlet of the TRANSMITTER is connected to an adjustable pressure regulator in 1’1/4 diameter. A water temperature sensor is connected directly at this node, providing the input water temperature of the circuit.
Immediately afterwards, the circuit is split into several parallel branches that will cool dedicated circuits. Each one of these circuits possess isolation valves on the inlet and outlet. The circuits are described as follows.

- Circuit 1. Cooling of RF PILOT 600W in series with the output resonant inductance of the Driver triode. This branch is monitored by the flow switch SQ14 that has a fault threshold of 5.5 L/min.
- Circuit 2. Cooling of the Driver triode anode. This branch is monitored by the flow switch SQ12 that has a fault threshold of 8.5 L/min.
- Circuit 3. Available for future use. Keep the isolation valves closed.
- Circuit 4. Cooling of the Final triode filament choke inductance and the output resonant inductance of the Final triode. This branch is monitored by the flow switch SQ15 that has a fault threshold of 2 L/min.
- Circuit 5. Cooling of the Final triode anode. The pressure of this branch is independently controlled by a ¾’ pressure regulator. This branch is monitored by the flow switch SQ13 that has a fault threshold of 40 L/min. In case of plate efficiency below 70%, it is recommended to have at least 61l/min for long CW operations until 100kW
- Circuit 6. Cooling provided for the air/water heat exchanger 1 of the TRANSMITTER. This branch is monitored by the flow switch SQ19 that has a fault threshold of 2 L/min.
- Circuit 7. Cooling provided for the second air/water heat exchanger 2 of the TRANSMITTER. This branch is monitored by the flow switch SQ20 that has a fault threshold of 2 L/min.
- Circuit 8. Cooling provided for grid supply resistors. This branch is monitored by the flow switch SQ16 that has a fault threshold of 10 L/min.

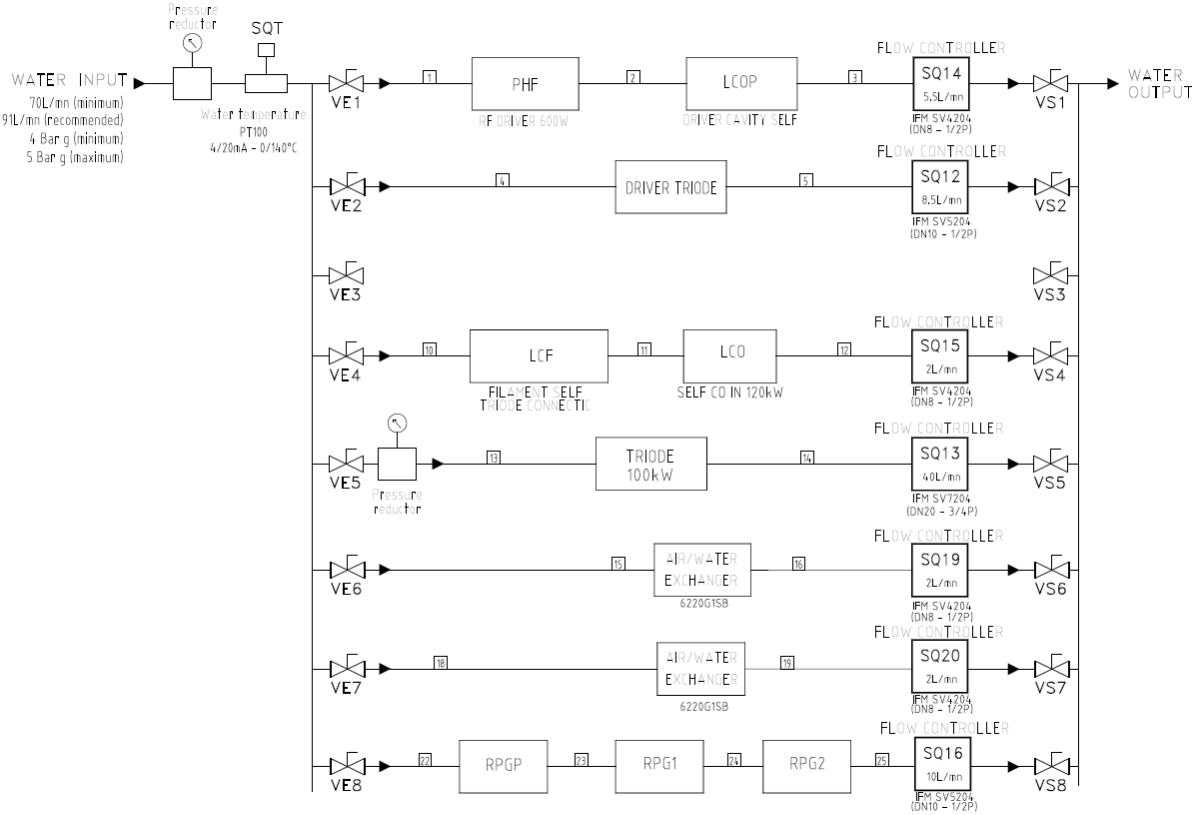


FIG. 16 WATER CIRCUIT SCHEMATIC

3. OPERATION

The control system in the GRP1000K enclosure has a PLC (Programmable Logic Controller) which is the master controller in the system. It is integrated directly into the HMI (Human Machine Interface), a Pro-Face Touchscreen display, where commands can be made and set-points entered directly by touching the screen with the fingers.

The PLC controls the overall operation of the system and:

- Monitors the system safety and process interlocks;
- Controls the TRANSMITTER in the system enclosure;
- Displays status and fault messages on the status display;
- Provides system warnings and alarms through the Interface Module.

Fault conditions and interlocks

The GRP1000K uses two sets of interlocks:

- System safety interlocks
- Process interlocks

System safety interlocks ensure the safe operation of the GRP1000K for all personnel. The operation of the system safety interlocks have to be verified by a service engineer during scheduled maintenance operations, as defined by the maintenance schedule applicable to your installation.

Process interlocks help to prevent damage to the GRP1000K.

WARNING

WEAR THE CORRECT PERSONAL PROTECTIVE EQUIPMENT WHEN USING THE GRP1000K.

WARNING

YOU MUST COMPLETE A FULL SAFETY ASSESSMENT AND ENSURE THAT ALL SYSTEMS CONNECTED TO THE GRP1000K ARE CORRECTLY CONFIGURED.

It is your responsibility to:

- Complete a full safety assessment of the installation (that is, the GRP1000K together with all interconnected systems such as the pumping systems, the water supplies and so on).
- Ensure that all systems connected to the GRP1000K are configured to correctly generate the control interface signals (if required) for the GRP1000K.

- Ensure that all systems connected to the GRP1000K are configured to correctly respond to the GRP1000K status output signals (if required).

3.1 STARTING TRANSMITTER

Before energizing the unit, check water circuits for possible leakage.

CAUTION
Be careful: do not operate without load.

CAUTION
Always use TRANSMITTER with full load to reduce reflected power level

3.1.1 FIRST START IN LOCAL MODE

- Open TRANSMITTER cooling circuit's valves to activate water flow if they have been closed previously.
- Close all panels and rear doors. Connect RF output connector to RF Applicator with enough power capability. The RF applicator can be a load.
- Connect connector "RF_input" fo an external LLRF source.
- Feed the TRANSMITTER with sufficient cooling
- Switch on Mains isolating switch.

3.1.2 SELECT CONTROL MODE AND SETTINGS

- Switch the control key of the TRANSMITTER into LOCAL or REMOTE depending on the required setting.
- Access the Control Screen on the HMI. Select the control types (Local, REMOTE ANA, REMOTE ETH, ETH) on the page "TRANSMITTER COMMAND SELECTION" (see figure below)
  Select the required control settings on the screen for each function's block : Logic Control, Functions of gain&phase control, RP Limitation...**Refer to the Source inspection sheet filled at SAT for each setting (except the setting in page "TRANSMITTER COMMAND SELECTION") and for each TRANSMITTER**

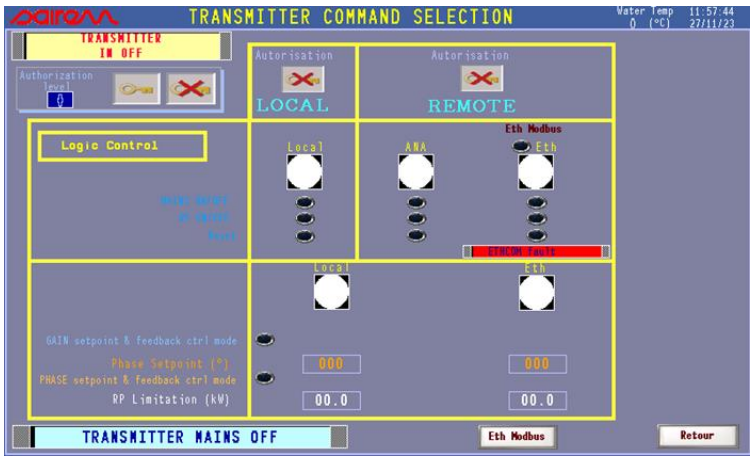


FIG. 17 PLC CONTROL SELECTION

3.1.3 MAINS ON STATE

- **Check the absence of default, especially regarding water cooling and ARC fault**. The latter fault appears if there is no 5V on the dedicated BNC connector.
- **Switch the TRANSMITTER into MAINS ON condition** by sending the corresponding signal via the control interface.
  For LOCAL mode, press the Mains ON button twice in a quick succession.
  For REMOTE ETHERNET MODBUS, press the Mains Button once and send the Mains ON command.
  For REMOTE ANALOG, close the EXTERNAL MAINS ON First Contact switch (latched) and next close the EXTERNAL MAINS ON Second Contact switch (momentary).
  MAINS ON = filament heating, grid biasing, air cooling and no defaults
  If necessary remove fault with Reset button on HMI in order to activate grid biasing.
- TRANSMITTER is energized and preheating. FILAMENT ON, DRIVER FIL ON, TRANSMITTER MAINS ON are indicated in green on SERVICE page of HMI. If necessary, clear fault with Reset signal.
  For LOCAL mode, the Reset signal is available on the touch panel.
  For REMOTE ETHERNET MODBUS mode, the signal is sent through the fieldbus.
  For REMOTE ANALOG mode, the signal is sent by closing the EXTERNAL RESET switch.

2.

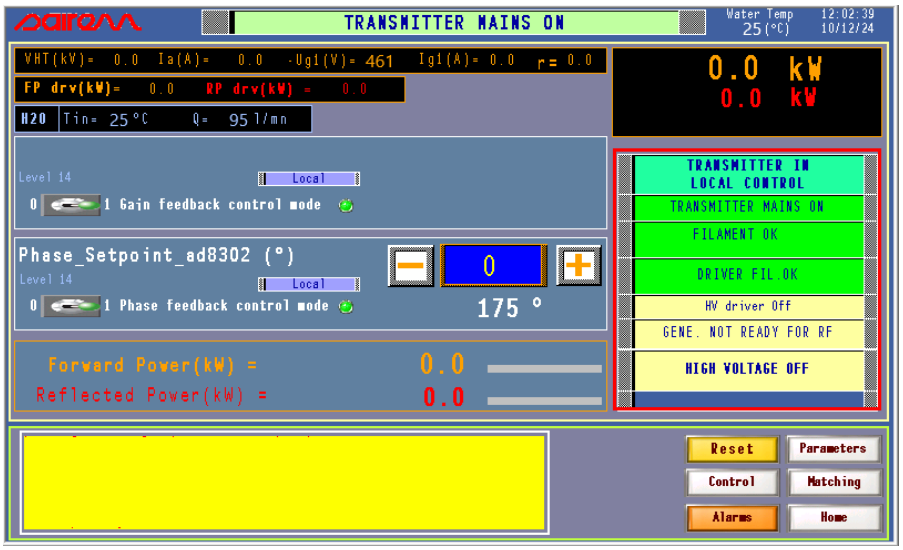


FIG. 18 PAGE SERVICE OF PLC IN MAINS ON STATE

- If the triodes are new, make sure to heat the filament for at least 1 hour (more if the triode is manufactured more than 2-3 months ago), if not, 3 minutes time preheating is sufficient.

3.1.4 RF ON STATE

- Once the preheating has been finished, enable RF power amplification by sending the corresponding signal.
  For LOCAL mode, press the RF ON button.
  For REMOTE ETHERNET MODBUS mode, send the RF ON command through the fieldbus.
  For REMOTE ANALOG mode, the signal is sent by closing the EXTERNAL RF ON switch.
  Power amplification enabled = RF ON = Plate biasing (HV on triodes), activation of EC board , activation of RF PILOT 600W, no default

  The SERVICE page of HMI indicates HV driver ON, HIGH VOLTAGE ON in orange, GENE READY FOR RF in green.
- **Send the LLRF signal @ 13.56Mhz on the connector RF_input. Its level should not exceed 2W in CW.** Each TRANSMITTER is tuned for a level ranging up to 16dBm approximately.
- **After use of the TRANSMITTER, remove LLRF signal. Then remove High Voltages** by sending the corresponding signal.
  For LOCAL mode, press the RF OFF button.
  For REMOTE ETHERNET MODBUS mode, send the RF OFF command through the fieldbus.
  For REMOTE ANALOG mode, the signal is sent by opening the EXTERNAL RF ON switch.

3.2 SHUT DOWN TRANSMITTER

- Enter the Mains OFF condition by sending the corresponding signal to the TRANSMITTER. This will start the shutdown sequence (filament heating decreases slowly with air cooling still activated). This shutdown sequence lasts typically 3 minutes.
  Press Mains OFF on the TRANSMITTER if in LOCAL mode.
  Send the Mains OFF signal via the fieldbus if operating in REMOTE ETHERNET MODBUS
  Open the EXTERNAL MAINS ON switch if in EXTERNAL ANALOG mode.

- The Mains ON button will flash until the shutdown sequence is complete and the button will then switch off.
- The external chiller can be shut down
- At this moment it is safe isolate the TRANSMITTER at the Mains isolating switch. Do not use the emergency circuit to stop TRANSMITTER, except in case of emergency: this can shorten triode life by inducing thermal stress.

It is important that this procedure is respected to avoid a reduction of the triode lifetime.

3.3 OPERATING SCREENS (HMI)

This section will provide information on the different PLC Screens that are used to navigate and set up the different operating parameters.

Note: The values indicated on the pictures shown are not necessarily the normal operation values. They are presented for illustrational purposes.

3.3.1 HOME PAGE

When the Mains isolator is switched on, the PLC is energized and starts up in the Home Page.

FIG. 19 PLC HMI HOME PAGE

The language selection is performed by pressing the “flag” button.

On this screen the information about the IP address of the TRANSMITTER is shown, as well as the software version.

The PARAMETERS 1/3 screen as well as the SERVICE screens can be accessed using their corresponding buttons.

3.3.2 SERVICE PAGE

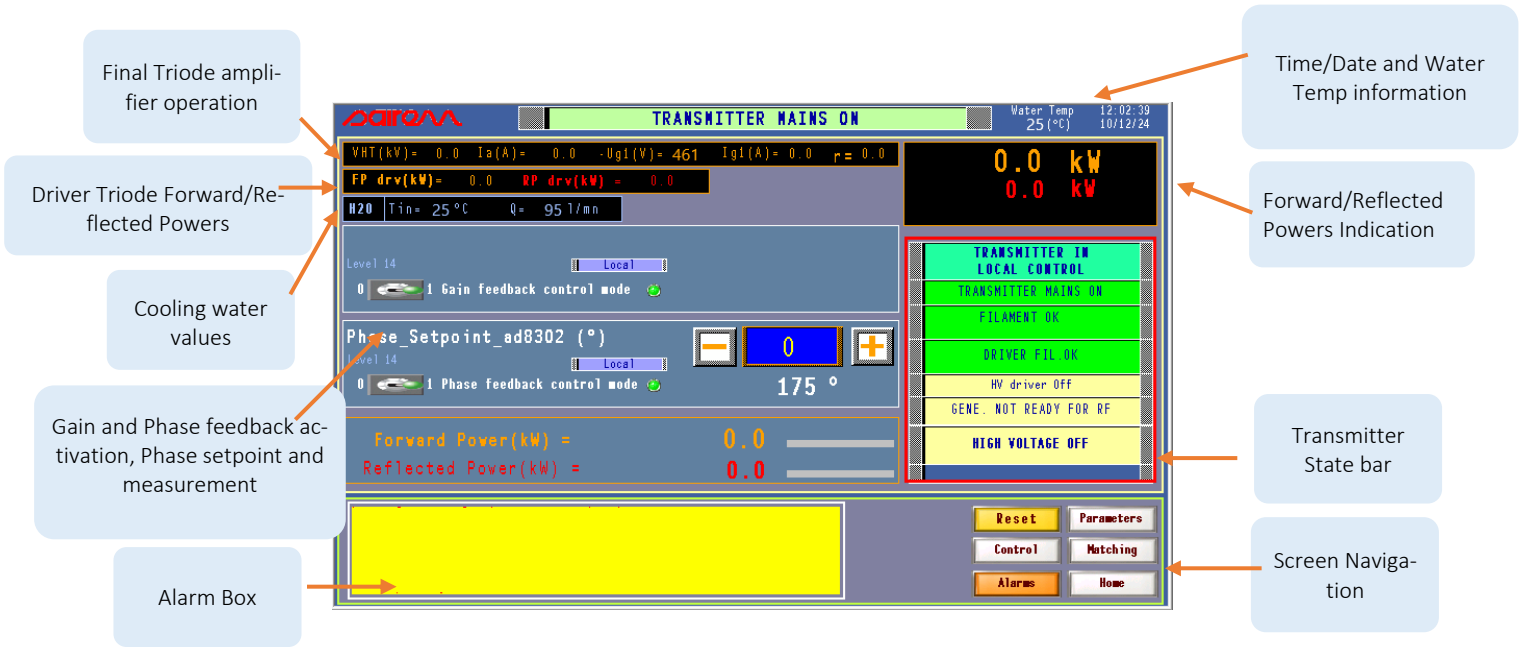


FIG. 20 PLC HMI SERVICE PAGE

The Service Page is used for general monitoring of the operation of the TRANSMITTER.

The final triode amplifier's parameters are shown on the top black banner, showing anode voltage, anode current, grid voltage, grid current and plate efficiency.

The driver triode amplifier's forward and reflected power values are shown on the banner directly below.

The water inlet temperature as well as the overall water flow are shown on the third banner.

The center block allows visualization of : the current FP and RP levels, the Phase setpoint and measurement, the activation or not of Gain and Phase feedbacks.

NB : the phase setpoint and measurement are related to an internal circuit, they differ from the total phase of the TRANSMITTER by a constant;

To show the various stages of readiness of the TRANSMITTER, there is a status bar on the right. As each start-up stage is completed, the color of the bar changes to green or orange and the status changes as follows:

TRANSMITTER IN – can be either LOCAL, ANALOG OR ETHERNET.
TRANSMITTER MAINS OFF – turns green and displays TRANSMITTER MAINS ON in MAINS ON state
FILAMENT OFF – shows FILAMENT PRE-HEATING and finally FILAMENT OK, with green background.
DRIVER FIL OFF – shows DRIVER PREHEATING FIL and finally DRIVER FIL. OK, with green background.

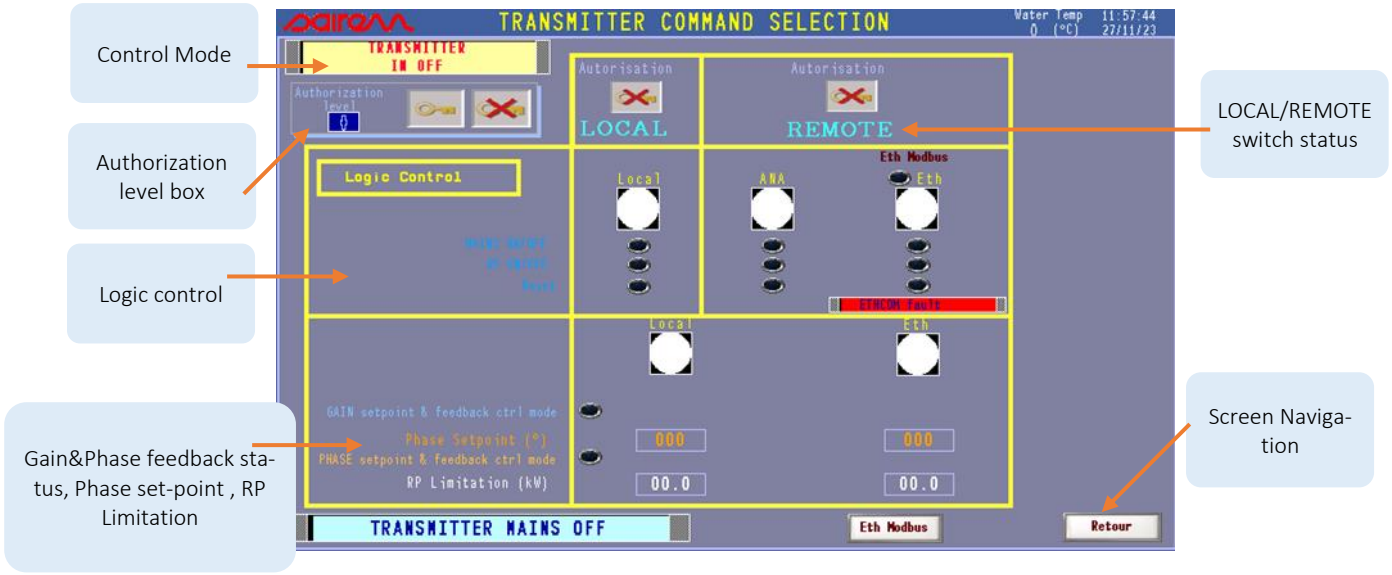
GENE. NOT READY FOR HF – displays GENE. READY FOR HF on green background
HIGH VOLTAGE OFF – displays HIGH VOLTAGE ON, when RF on.

The fault display box at the bottom of the screen serves as a hyperlink. By touching the fault on the screen, the operator is taken directly to a screen registering past defaults (see ALARM HISTORY PAGE)

The navigation buttons are used to access the other screens.

3.3.3 CONTROL PAGE

FIG. 21 PLC HMI CONTROL PAGE



The Control Page is used to configure the types of control of the TRANSMITTER. Intern functions are separated into two boxes. Control type is set for each box.

Logic control box :
Three independent settings can be made for the control : Local, ANA (=Analog), Eth(=Ethernet). Each can be activated by pressing on the related button. Only one can be activated simultaneously.
For each type of control, LED indicate the status of MAINS OFF/ON, RF OFF/ON and RESET FAULT signals.

Box for Gain&Phase feedbacks, RF limitation:
The control of these status and variables is either in Local or Eth (=Ethernet).Pressing on button Local in Logic Control box activates automatically the Local control mode.
Feedback status, Phase setpoint and RP Limitation are indicated.

The current REM/LOCAL switch status is shown on top left of the page.

3.3.4 ALARM HISTORY PAGE

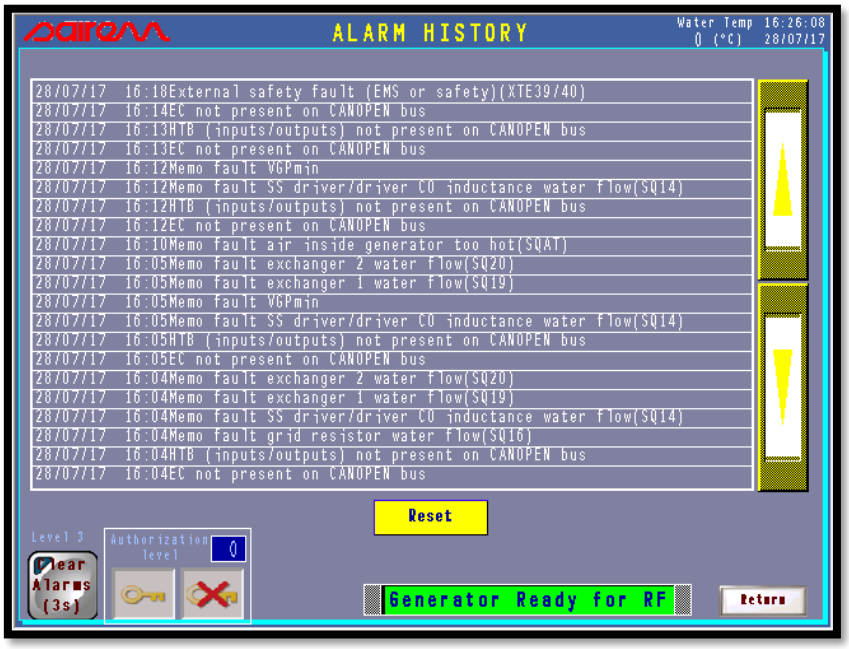
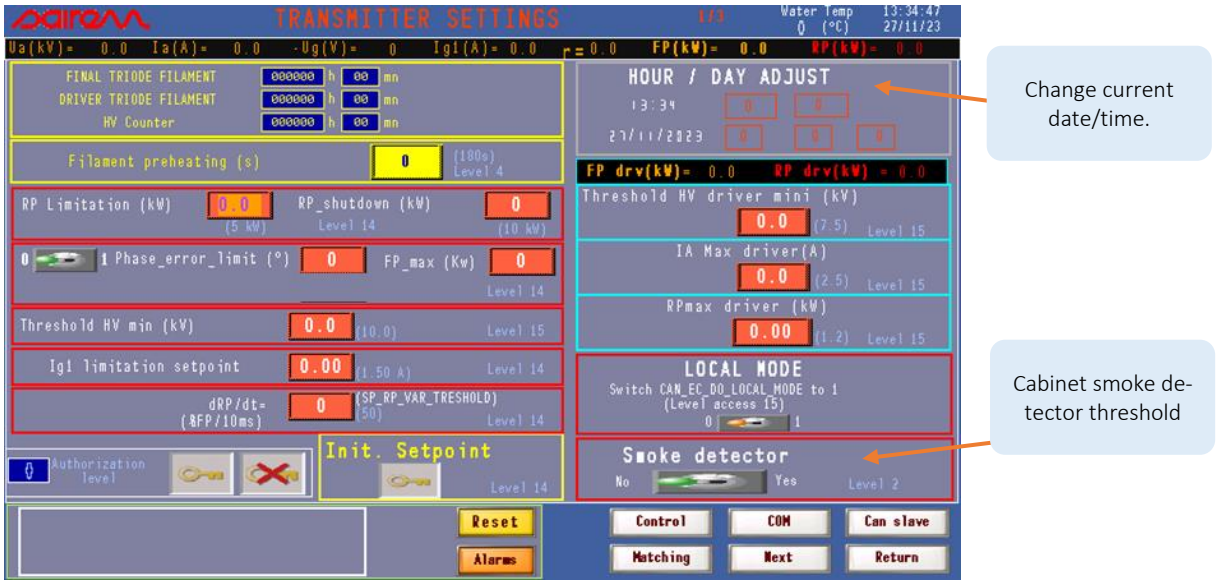


FIG. 22 PLC ALARM HISTORY PAGE

The occurred alarms is registered in the Alarm History, for consultation and troubleshooting.

3.3.5 PARAMETERS 1/3 PAGE

FIG. 23 PLC HMI PARAMETERS 1/3 PAGE



The parameter pages show a range of dynamic settings (can be changed in process) that are factory adjusted to protect the TRANSMITTER operation.

The Filaments and HV life counters measure respectively the filaments heating duration and the HV activation's duration since the first start-up of TRANSMITTER, in hours and minutes. Filaments begin heating when the Mains ON is activated, whereas HV is activated when RF ON is activated. Note: The Filament life counter is not reset during a Triode change, so the operator must record this data to know when the next Triode change is due.

Other parameters of this screen are accessible only with high authorization levels (14 or above). They allow the change of critical operation parameters such as:

- RP Limitation (kW) : The maximum value of reflected power without reduction of FP. Over this value, the gain will be reduced to keep the RP under this set-point value.
- RP_shutdown (kW): The reflected power value that will trigger an alarm and stop RF operation.
- Threshold HV min (kV): The maximum HT supply value that will trigger a fault with RF stop.
- Ig1 limitation set-point: The maximum value of grid current at Final triode without reduction of the forward power. Over this value, the FP will be reduced to keep the IG under this set-point value.
- dRP/dt (%FP/10ms): The value that will trigger an alarm in case of excess of RP variation.
- Threshold HV driver min (kV): The maximum HTP supply value at Driver Triode that will trigger a fault with RF stop.
- IA Max driver (A): The value of the driver anode current that will trigger an alarm.
- RPmax driver (kW): The driver reflected power value that will trigger an alarm and stop RF operation.

- Phase_error_limit(°): the value of absolute phase error that will stop RF operation.This protection can be activated or not.
- FP_max-(kW) : the value of FP that will stop RF operation
- Smoke detector : activates or not the internal smoke detector
- LOCAL MODE : should be let activated
- Filament preheating (s) : set to 180 s per default

3.3.6 PARAMETERS 2/3 PAGE

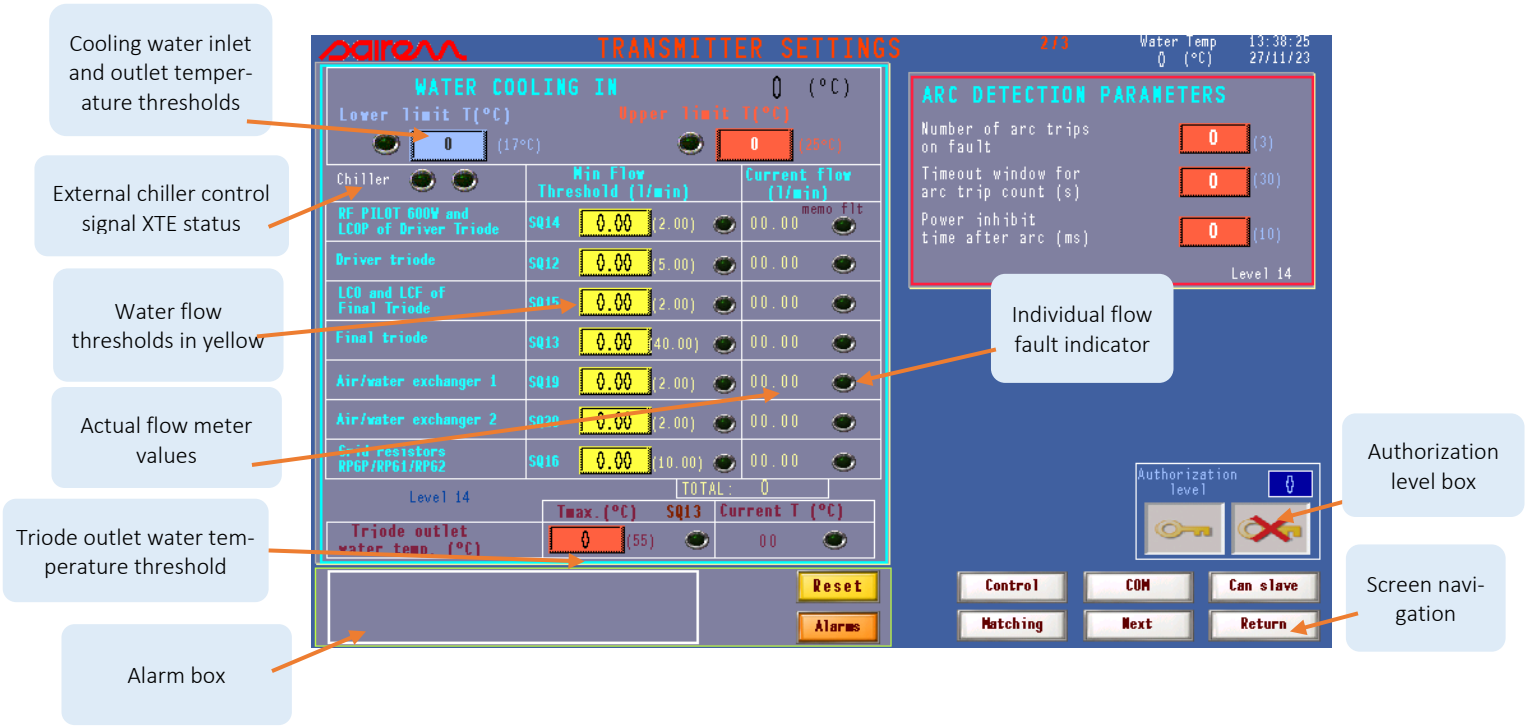


FIG. 24 PLC PARAMETERS 2/3 PAGE

This page monitors the water cooling status. For example, the flow fault thresholds can be set and the current flow values are shown. In case an insufficient flow fault is triggered, the individual flow fault indicator is lit. The water inlet temperature threshold is shown as well its current value and fault status. The outlet water temperature is monitored for the Final triode and the TRANSMITTER.

The value in brackets is either the minimum or maximum value accepted for a fault threshold.

The External chiller control signal status shows by means of two LEDs the current status of the chiller (XTE contact pad 7/14) and the memorized fault of the chiller.

The page has also set the settings for ARC detection (ARC detection comes from connector called ARC on electrical schematics) :
Number of arc trips on fault = number of successive arc trips before RF is stopped,
Timeout window for arc trip count (s) = time period considered to count successive arc trips before RF is stopped. Used when Number of arc trips on fault equals 2 or 3.
Power inhibit time after arc (ms) = duration of time during which Restart of RF is not allowed after fault due to arc trip(s), …

3.3.7 PARAMETERS 3/3 PAGE

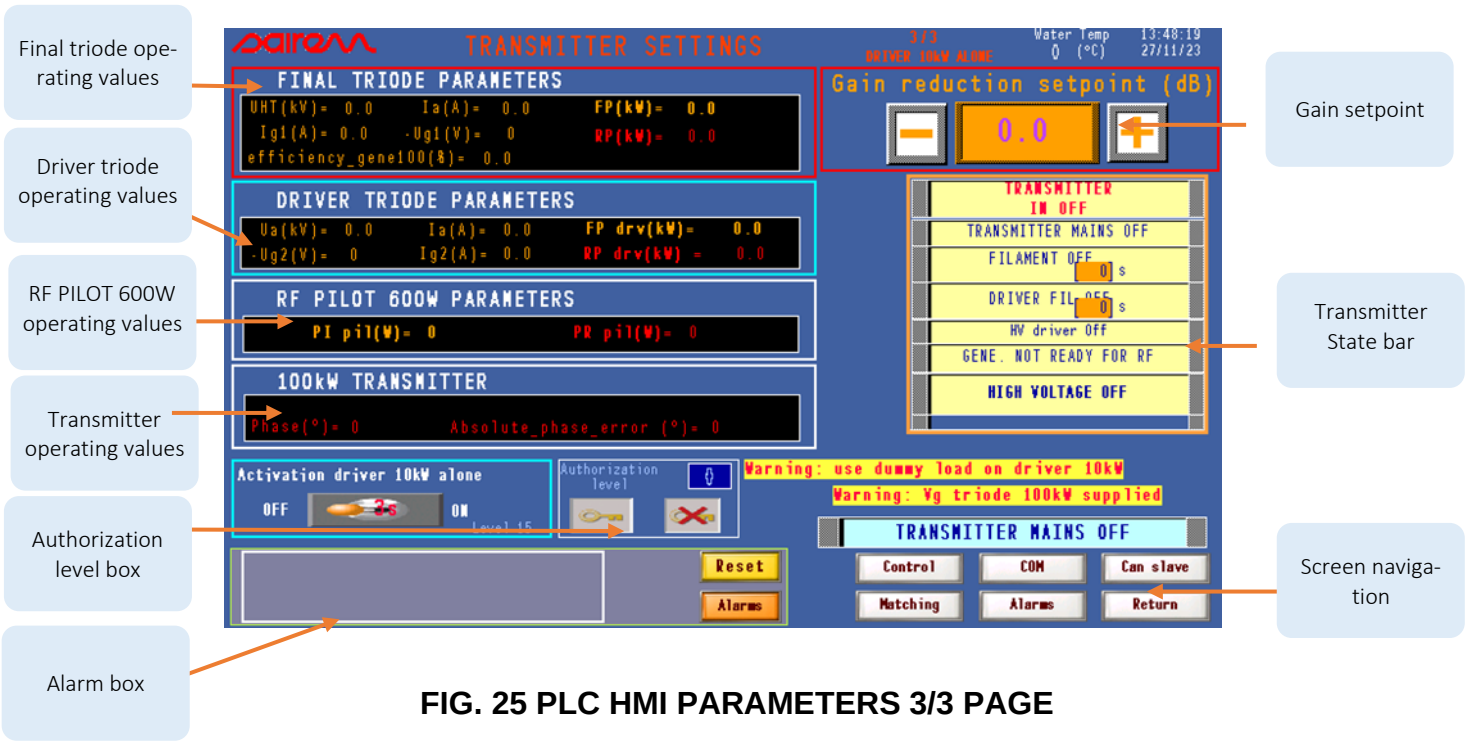


FIG. 25 PLC HMI PARAMETERS 3/3 PAGE

This page is for visualization of the operating point of the transmitter. It is used for diagnostic purposes.

The Parameter Page 3/3 shows the voltages, currents, powers, phase of the different stages that compose the TRANSMITTER.
Phase_ad8302 differs from the total phase of the TRANSMITTER by a constant, at a given FP.

3.3.8 MATCHING BOX CONTROL PAGE (NOT USED HERE)

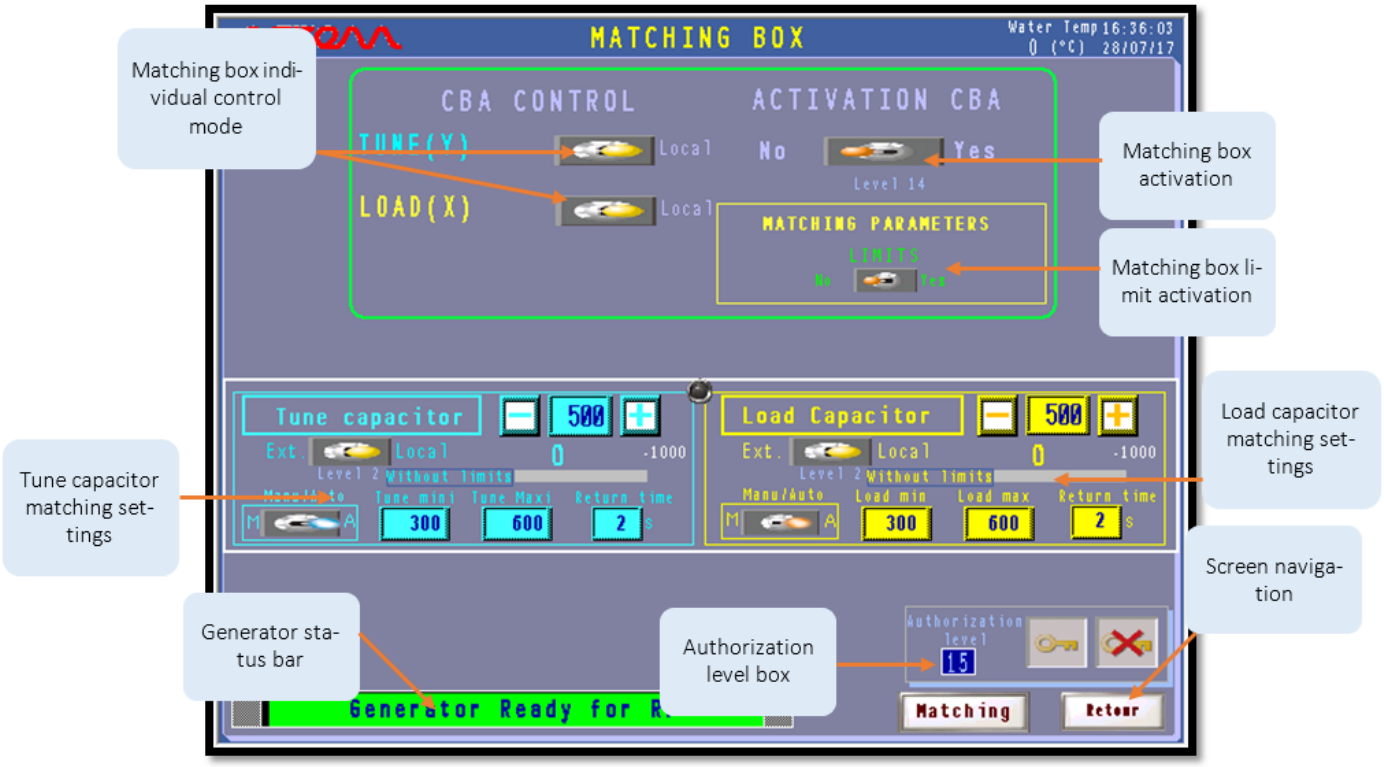


FIG. 26 PLC HMI MATCHING BOX CONTROL PAGE

This screen is used to set up the operation of the matching box associated with the TRANSMITTER.

It can be switched OFF if the TRANSMITTER is not equipped with a matching box by using the activation switch.

The individual variable elements (load capacitor and tune capacitor) can be controlled in LOCAL or REMOTE ETHERNET via the individual control mode switches.

The matching settings of each variable element include:

- Variable set-point (for MANUAL operation only).
- MANUAL operation (via variable set-point) or AUTO operation (via discriminator signal) switch.
- Minimum and maximum operation thresholds for AUTO operation. Active only if the Matching box limit activation switch is activated.
- Return time to the valid interval when the current value goes outside the valid operation interval defined by the minimum and maximum thresholds (only in AUTO operation).
- Current value of the variable element (represented as 0 in the image). There is bar that shows graphically the current value of the element.

3.3.9 MATCHING BOX PARAMETERS PAGE (NOT USED HERE)

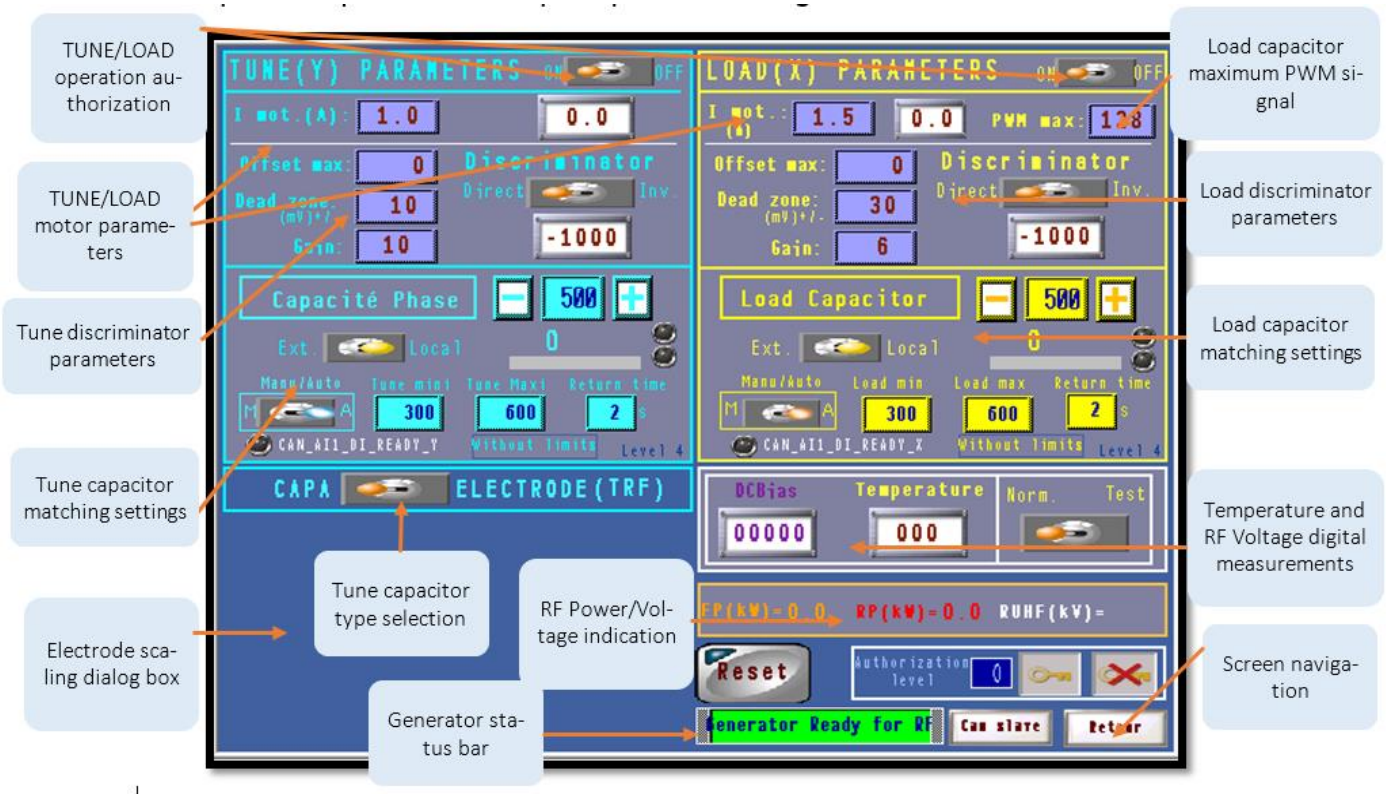


FIG. 27 PLC HMI MATCHING BOX PARAMETERS PAGE

This page controls the matching system. Tune refers to the tune capacitor and phase to the phase capacitor. Check principle in matching box/ tunnel.

The most important settings of this page includes:

- TUNE/LOAD operation authorization: allows to stop the operation of the TUNE or LOAD capacitors.
- Maximum motor current limit and current value: Allows to protect the motors from malfunctioning mechanics. The current motor value in Ampers is shown. For the LOAD capacitor, an additional setting allows to limit the speed of the motorization by limiting the duty cycle of the driving PWM signal.
- TUNE/LOAD discriminator parameters: Possible to set up the parameters associated to the discriminator signal. The discriminator signal can be switched to invert its polarity. The current discriminator value is shown.
- TUNE/LOAD capacitor matching settings: Same as previous page parameters. Additional LEDs shown the activation of the hard limit switches.
- TUNE capacitor type selection: Depending the application, this capacitor can be implemented with vacuum device or with variable distance parallel plate electrode. If the electrode is selected, a new set of parameters will be shown, allowing the scaling of the electrode in order to correctly show the distance of the hot electrode to the cold electrode.

3.3.10 ETHERNET/MODBUS COMMUNICATION PAGES

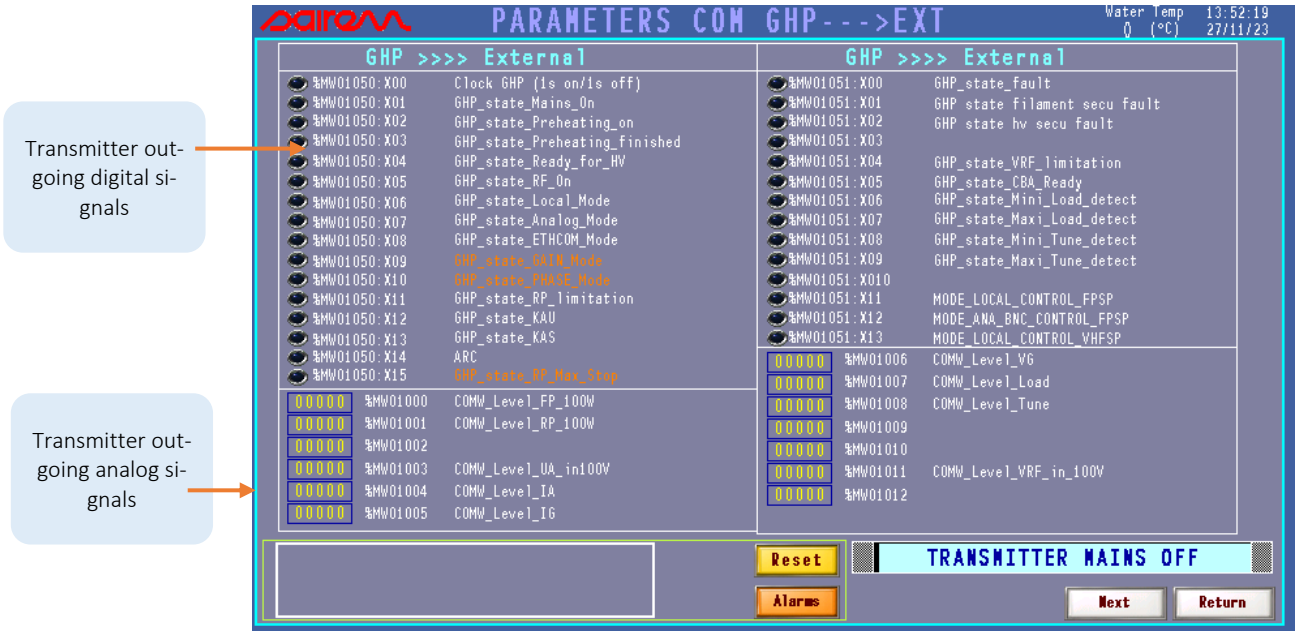
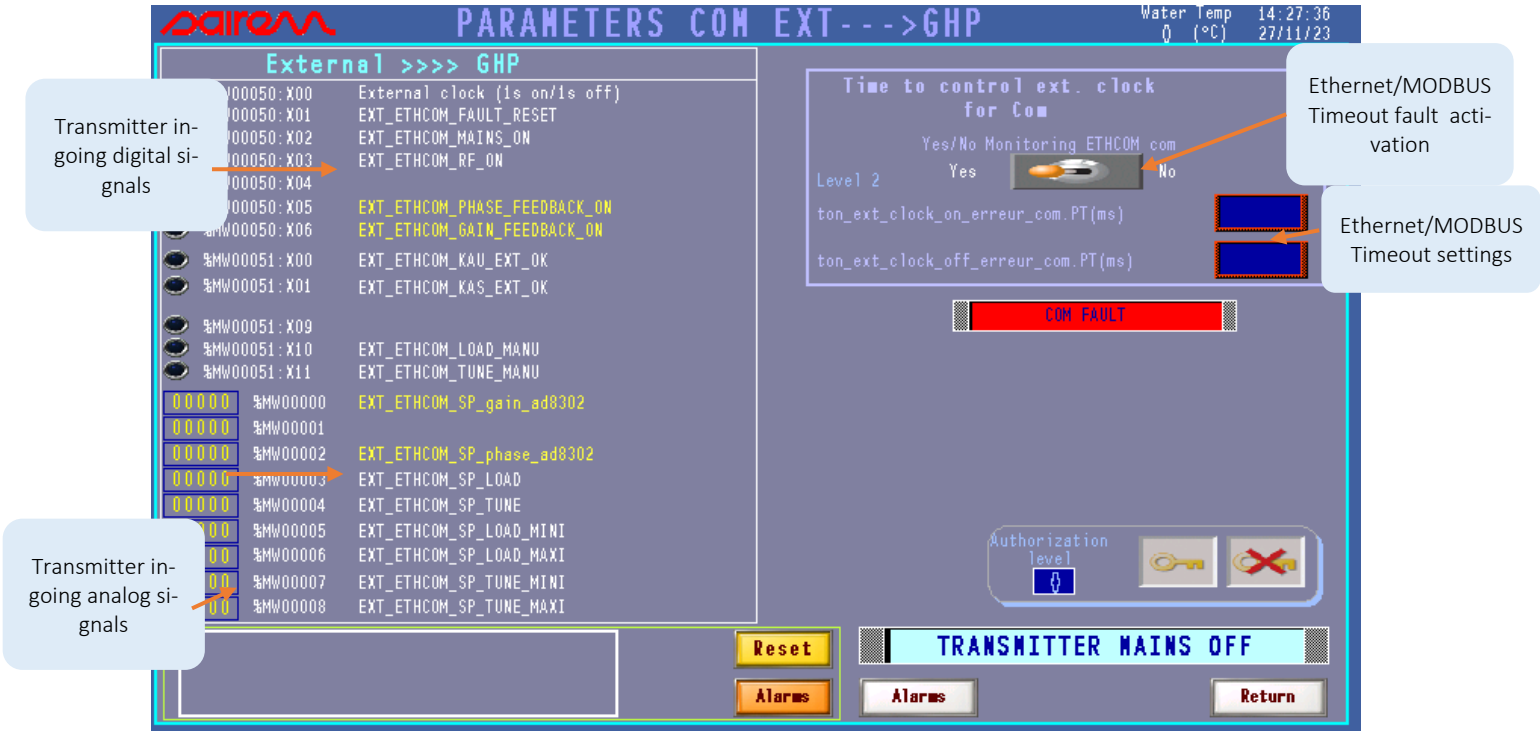


FIG. 28 PLC HMI ETHERNET/MODBUS PAGE

This set of pages allow the monitoring of the EXTERNAL ETHERNET/MODBUS communication between the TRANSMITTER and the connected external device.

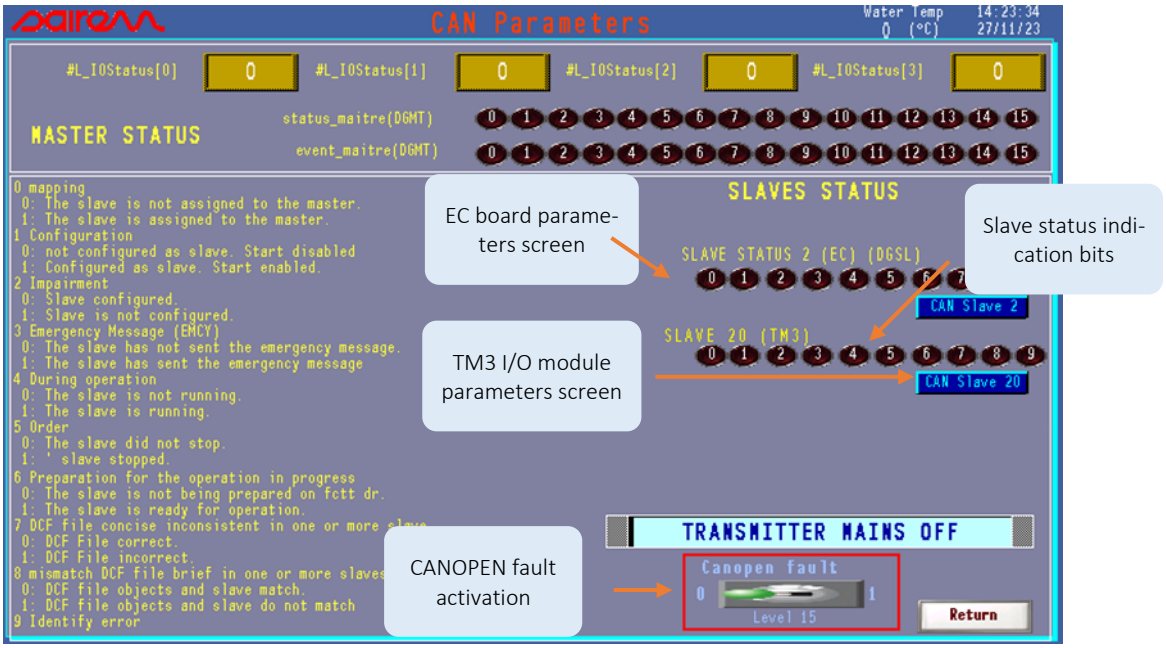
3.3.11 CANOPEN BUS PAGES



The following set of pages are used for troubleshooting purposes. They allow to visualize the current status of digital and analog sensors of the TRANSMITTER as well as fault states.

General CANOPEN bus screen

FIG. 29 PLC HMI GENERAL CANOPEN PAGE



On this page the status of the CANOPEN slaves is shown. The status bits allow monitoring of the different slaves. For example, it is possible by observing the status bit 4 that the slave is running.
Each slave has its own CANOPEN status page that can be accessed by using the corresponding button.
The CANOPEN fault activation switch allows the emission of an alarm in the case at least one of the slaves is not present on the bus.

TM3 I/O module screen

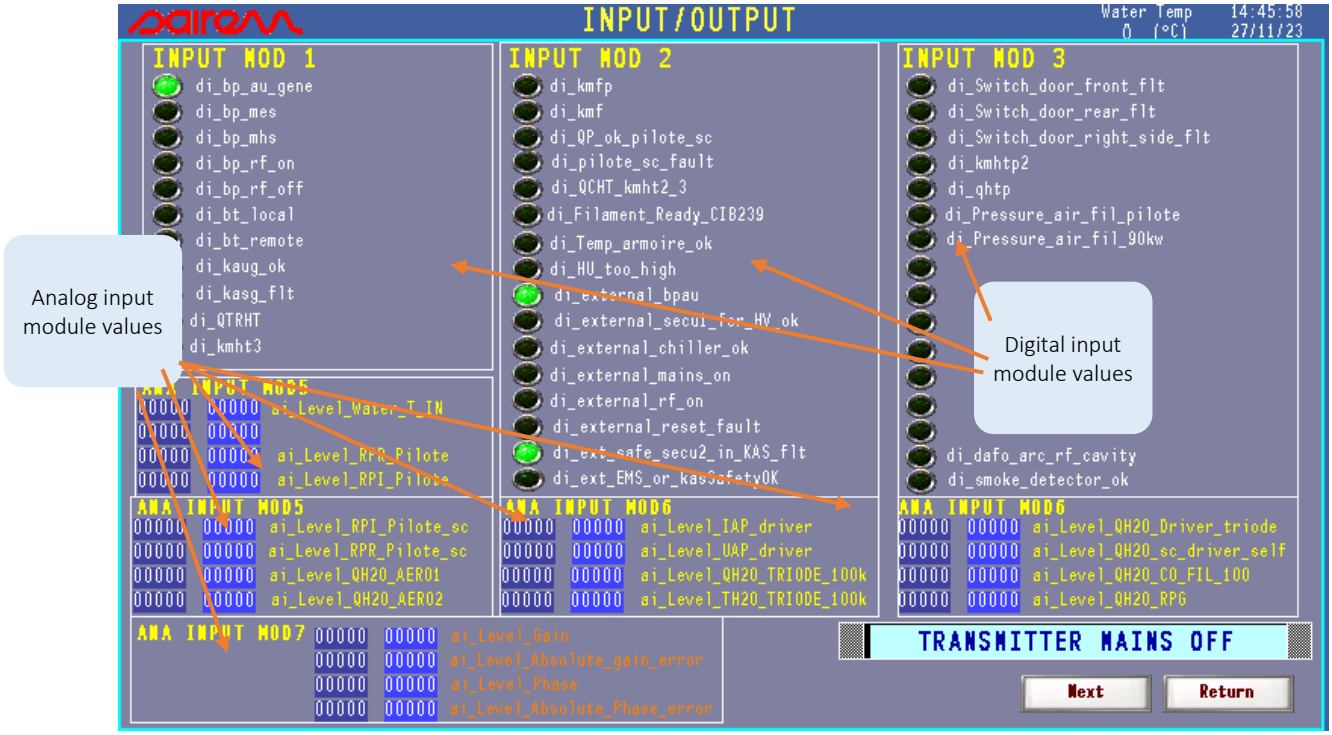


FIG. 30 PLC HMI HTB Input MODULEs CANOPEN PAGE

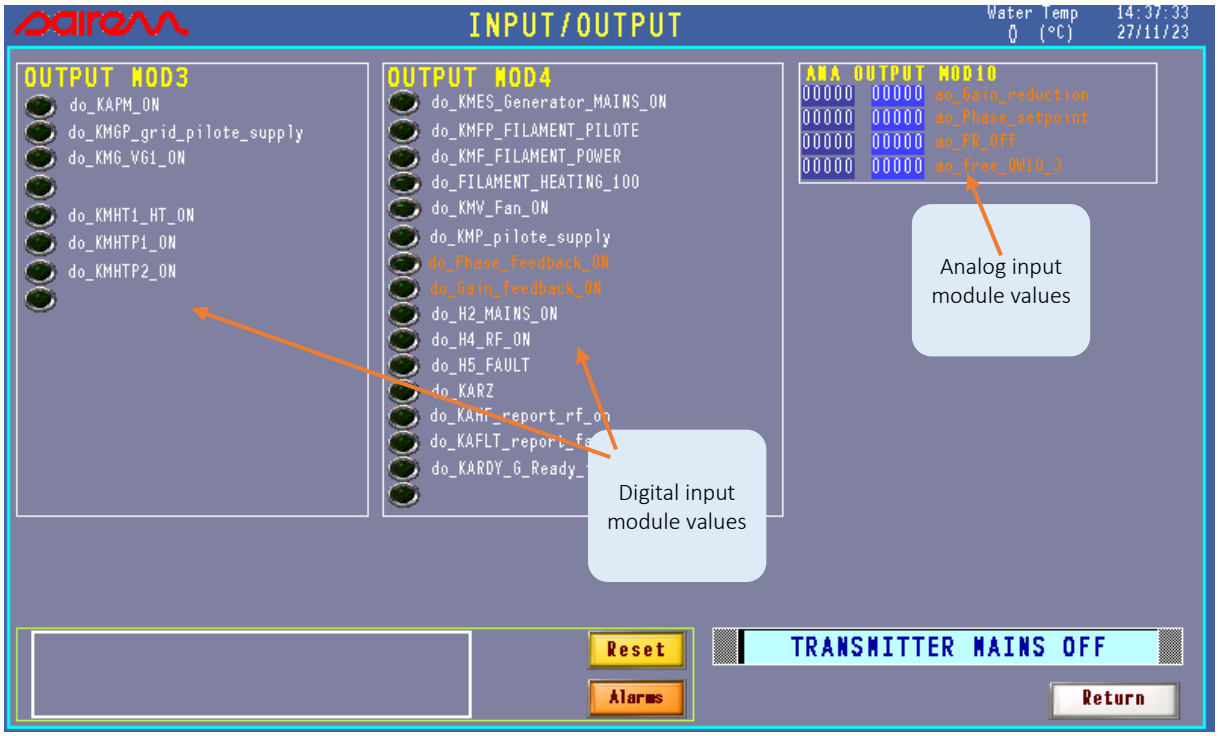


FIG. 31 PLC HMI HTB Output MODULEs CANOPEN PAGE

EC board screen

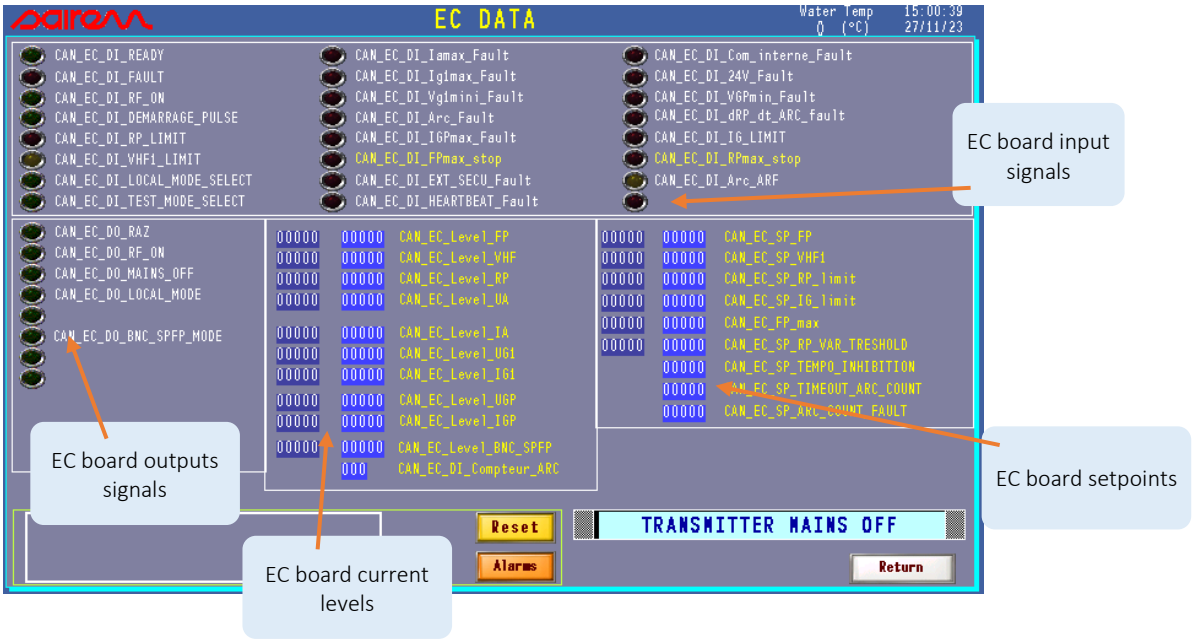


FIG. 32 PLC HMI EC BOARD CANOPEN PAGE

Matching box screen (not used here)

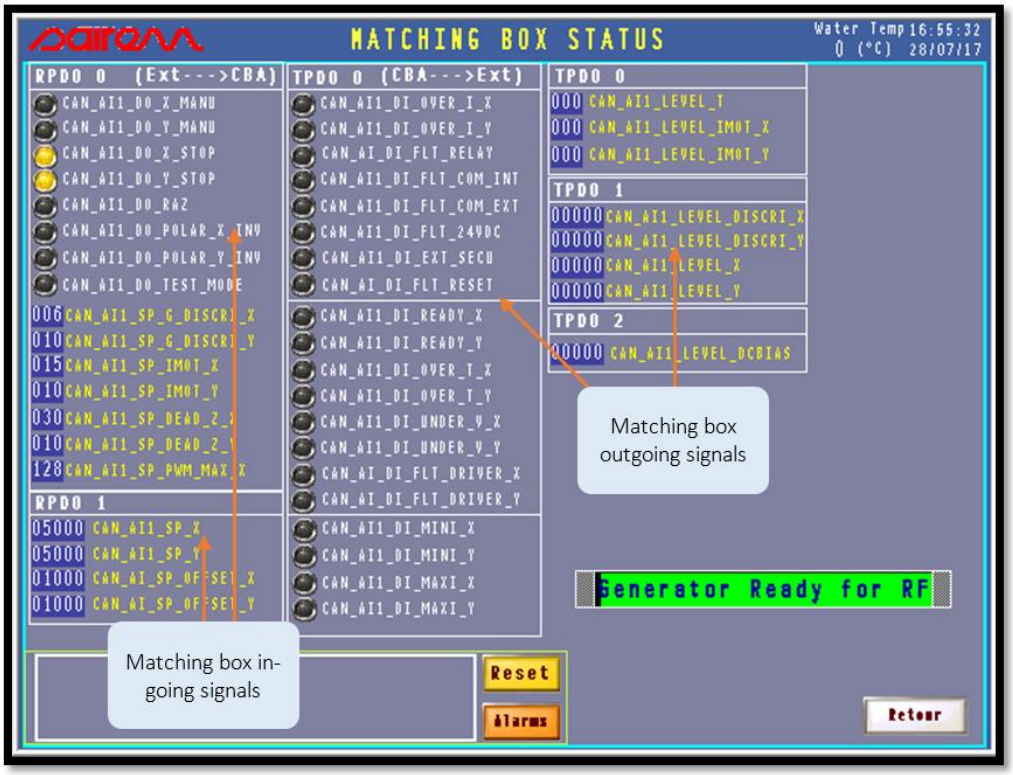


FIG. 33 PLC HMI MATCHING BOX CANOPEN PAGE

3.3.12 ACCESS LEVELS

The passwords for the authorization levels within the control system are to be held by the system owner and will be communicated to that person by SAIREM on delivery of the system. The system owner will have the discretion to delegate levels of authority within his organization.

Authorization levels exist within the control system to ensure that certain functions can only be accessed or modified by experienced and trained operators and by qualified maintenance engineers.

The following list shows the difference in function access between these authorization levels.

Level 0: No password Change language. Time and date. Control mode of TRANSMITTER. TUNE/LOAD capacitor matching box settings. Matching box stop.

Level 2: ‘2222’ Smoke detector activation. ETHERNET/MODBUS timeout fault. Threshold for communication

Level 3: 3333’ Clear alarm history.

Level 4: 4444’ Filament pre-heating time. Water cooling temperature thresholds. Matching parameters change.

Level 14: ‘XXXX’ Accessible only by SAIREM

Level 15: ‘YYYY’ Accessible only by SAIREM

3.4 EXTERNAL Control Signals.

3.4.1 ETHERNET/MODBUS Fieldbus

The ETHERNET/MODBUS Fieldbus allows the control of the TRANSMITTER by exchanging several data frames with the external master unit.
Check the appendix for the different variables that are exchanged between the Master controller and the GRP slave.

3.4.2 ANALOG interface

Logic control: The control signals are connected to the dry contact XTE interface according to the following table.

Name	Schematic page	Function	Position on XTE	Logic
External Mains ON (first contact)	21	INPUT	XTE 19/20	Activation on ON/OFF transition
External Mains ON/OFF (second contact)	29	INPUT	XTE 8/15	Closed: ON Open: OFF
External RF ON	29	INPUT	XTE 9/16	Closed: ON Open: OFF
External Reset	29	INPUT	XTE 10/17	Closed: Reset Open: No action

The External Mains (first contact) must be activated once after the mains power has been cycled OFF/ON or if the External Emergency Stops signals are used.

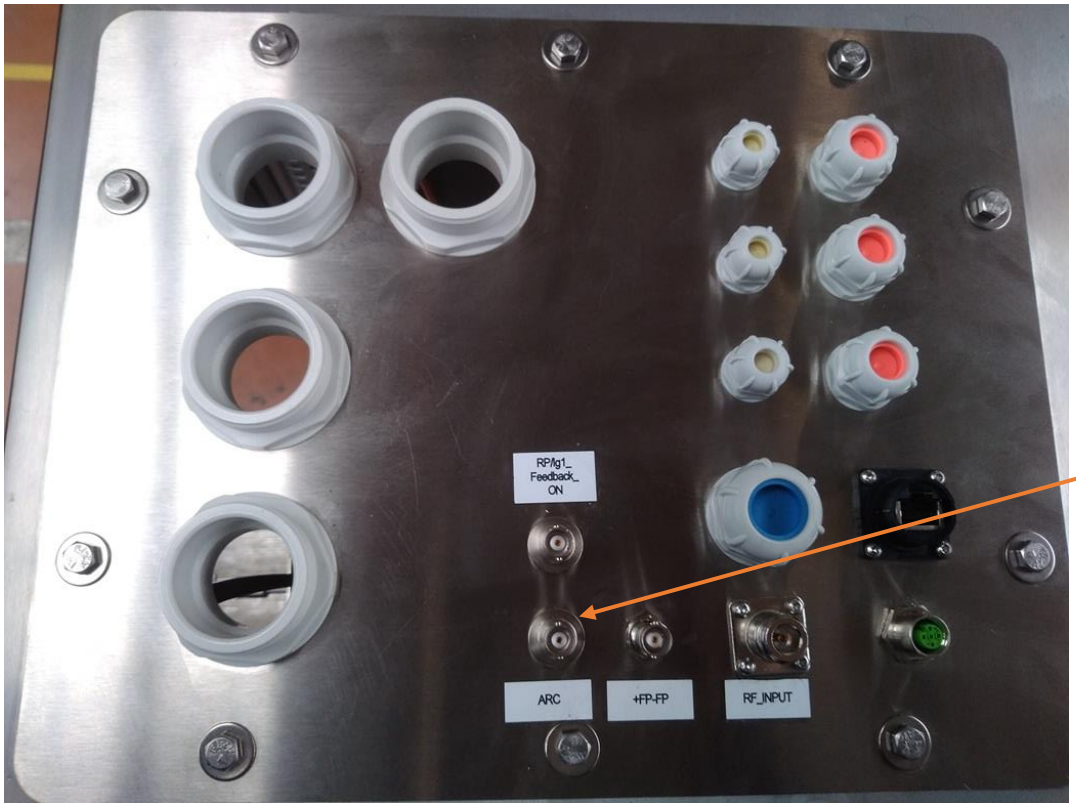
3.4.3 RF voltage

The RF Voltage probe is connected to the XTE contact pad as well. It delivers a proportional signal of 0/10VDC for 0/20 kV RF.

Name	Schematic page	Function	Position on XTE	Logic
RF Voltage probe	20	INPUT	XTE 50/51	Analog 0/10V

3.4.4 Arc detection signals

The TRANSMITTER is equipped with an arc detection safety that stops RF operation.



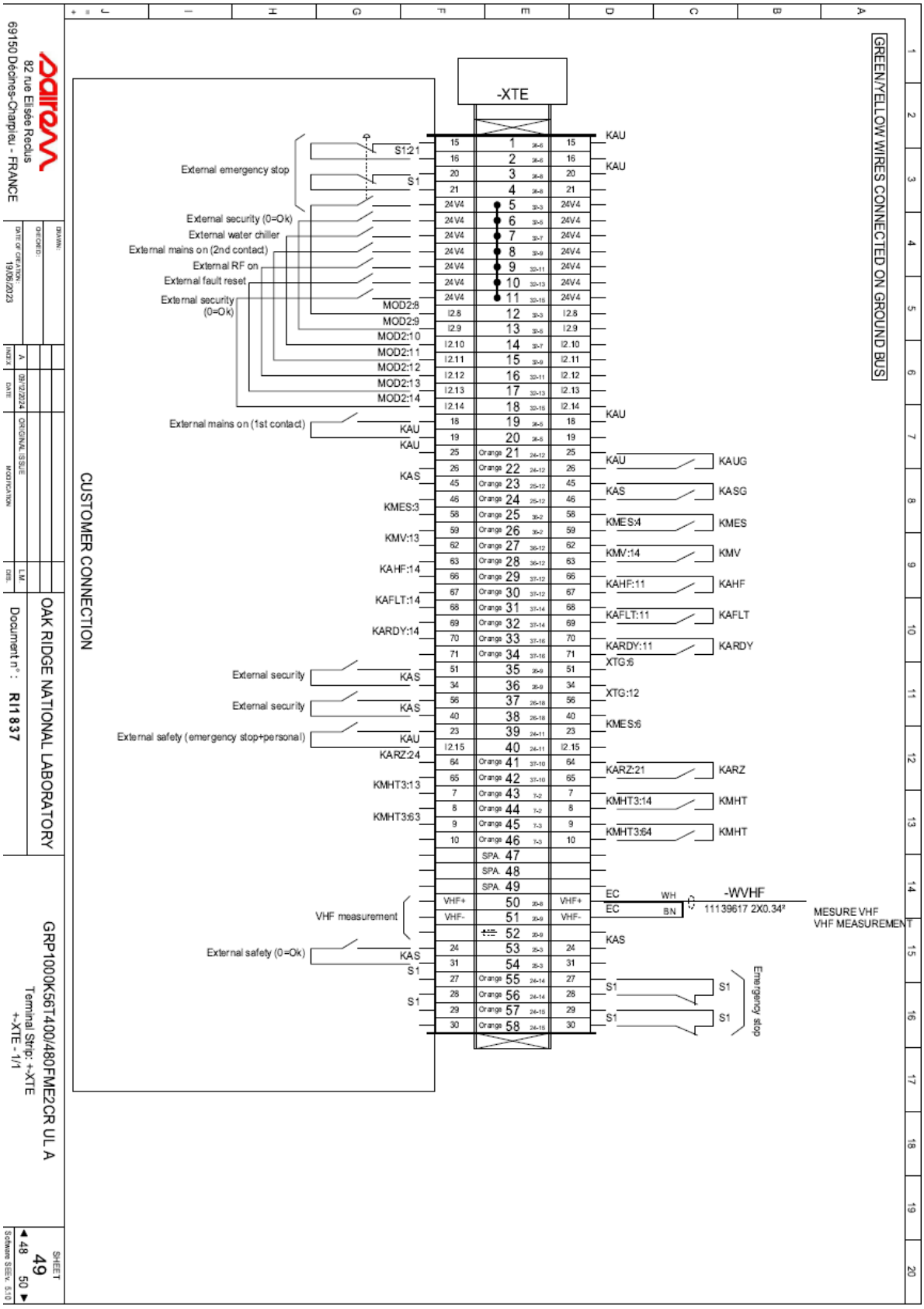
This protection is accessible from the top connector plate of the TRANSMITTER in form of a BNC coaxial signal. The input signal connected to this port must be formatted to 0 - 5 V inverted logic. An arc is detected when there is a negative edge from 5 V to 0 V. No arc condition corresponds to 5 V. When an Arc is detected, the TRANSMITTER will stop RF power giving a fault condition. The power reduction is performed in under 100 µs.
Input impedance of this port is of 300 kΩ.

3.4.5 Other dry contact signals

The TRANSMITTER offers a wide variety of other control signals that can be connected to the XTE contact pad.
The safety signals indicated in red must be shorted if not used.

Name	Schematic page	Function	Position on XTE	Logic
External Emergency Stop	24	INPUT	XTE 1/2 and XTE 3/4	Closed: OK Open: Stop **If not used, strap**
External Safety ES+PERSONAL	24	INPUT	XTE 39/40	Closed: OK Open: Stop **If not used, strap**
External Safety	25	INPUT	XTE 53/54	Closed: OK Open: Stop **If not used, strap**
External Safety Security 1	26	INPUT	XTE 35/36 and XTE 37/38	Closed: OK Open: Fault **If not used, strap**

External Emergency Stop state	32	INPUT	XTE 5/12	Closed: Stop Open: OK
External security state	32	INPUT	XTE 6/13	Closed: OK Open: Fault **If not used, strap**
External Water Chiller Unit	32	INPUT	XTE 7/14	Closed: OK Open: Fault **If not used, strap**
External Mains on (2nd contact)	32	INPUT	XTE 8/15	Pulse : mains on Open: Fault
External Mains on (1st contact)	24	INPUT	XTE 19/20	Pulse : mains on Open: Fault
External RF on	32	INPUT	XTE 9/16	Pulse: RF on Open: -
External Fault reset	32	INPUT	XTE 10/17	Pulse: Fault reset Open: -
External Safety Se-curity state	32	INPUT	XTE 11/18	Closed: OK Open: Fault **If not used, strap**
S1 Emergency Stop state	24	OUTPUT	XTE 55/56 and XTE 57/58	Closed: OK Open: Stop
KAUG STATE	24	OUTPUT	XTE 21/22	Closed: Armed Open: Unarmed
KASG STATE	25	OUTPUT	XTE 23/24	Closed: Armed Open: Unarmed
KMES STATE	36	OUTPUT	XTE 25/26	Closed: Mains on state Open: Mains off state
KMV STATE	36	OUTPUT	XTE 27/28	Closed: Ventilation ON Open: Ventilation OFF
KAHF STATE	34	OUTPUT	XTE 29/30	Closed: RF ON Open: RF OFF
KAFLT STATE	34	OUTPUT	XTE 31/32	Closed: Fault present Open: Fault not present
KARDY STATE	34	OUTPUT	XTE 33/34	Closed: Transmitter ready for RF Open: Transmitter not ready for RF
KARZ Relay	37	OUTPUT	XTE 41/42	Closed: Reset signal ON Open: Reset signal OFF
KMHT3 state	7	OUTPUT	XTE 43/44 and XTE 45/46	Closed: Contactor ON Open: Contactor OFF
SPARE			XTE 47/48/49	
VHF MEASURE-MENT	20		XTE 50/51/52	Analog 0/10V


-XTE
GREEN/YELLOW WIRES CONNECTED ON GROUND BUS
CUSTOMER CONNECTION
External emergency stop
S1:21
S1
External security (0=Ok)
External water chiller
External mains on (2nd contact)
External RF on
External fault reset
External security (0=Ok)
MOD2:8
MOD2:9
MOD2:10
MOD2:11
MOD2:12
MOD2:13
MOD2:14
External mains on (1st contact)
KAU
KAS
KMES:3
KMV:13
KAHF:14
KAFLT:14
KARDY:14
External security
External security
External safety (emergency stop+personal)
KARZ:24
KMHT3:13
KMHT3:63
VHF measurement
External safety (0=Ok)
KAU
KAUG
KASG
KMES:4
KMES
KMV:14
KMV
KAHF:11
KAHF
KAFLT:11
KAFLT
KARDY:11
KARDY
XTG:6
XTG:12
KMES:6
KARZ:21
KARZ
KMHT3:14
KMHT
KMHT3:64
KMHT
-WVHF
11139617 2X0.34²
MESURE VHF
VHF MEASUREMENT
Emergency stop
OAK RIDGE NATIONAL LABORATORY
GRP1000K56T400/480FME2CR UL A
Terminal Strip: +-XTE
+-XTE - 1/1
Document n°: RI1837
SHEET 49
48
50

4. TROUBLESHOOTING

If the TRANSMITTER encounters fault conditions, it will inform it through the Alarm Box.

The following table shows the description of all the alarm messages and the recommended action. Some of these actions must be performed by qualified personnel only.

CAUTION

Only qualified and protected personnel may open the cabinet doors after following the corresponding Lock-Out Tag-Out procedure.

Fault Code	Corrective action
600W SS TRANSMITTER breaker fault(QP)	Check QP breaker for tripping.
CAN_EC_DI_24V_Fault	Check 24 V supply of the EC Board.
CAN_EC_DI_Arc_Fault	Not yet implemented
CAN_EC_DI_Com_interne_Fault	Contact SAIREM
CAN_EC_DI_EXT_SECU_Fault	Not used. Verify presence of EXT SEC connector on EC Board.
CAN_EC_DI_FAULT	Appears simultaneously with other faults. Check CANOPEN EC screen for more information.
CAN_EC_DI_HEARTBEAT_Fault	Contact SAIREM
CAN_EC_DI_Iamax_Fault	Triode anode overcurrent. Check for non-detected arcs or RF short circuits if systematic fault.
CAN_EC_DI_IG1_MAX_Pilote_Fault	Driver grid current too high. Possible mismatch between triode stages. Check driver cavity and internal coaxial line.
CAN_EC_DI_Ig1max_Fault	Triode grid overcurrent. Related to matching adjustment. Reduce RP limit, or increase load on chamber. Control the correct operation of the matching box.
CAN_EC_DI_LOCAL_MODE_SELECT	Used for factory tests.
CAN_EC_DI_PWR_Fault	Used for factory tests. Verify the operation of the solid state TRANSMITTER (pilot).
CAN_EC_DI_TEST_MODE_SELECT	Used for factory tests.
CAN_EC_DI_Vg1mini_Fault	Grid voltage too low. Check Grid Supply Board (CES 149) for FUG fuse condition. Measure the condition of the diode bridge. Can also be related to KAS false contacts or XTE 39/40.
CBA not present on can	Check CBA for 24V supply presence. Verify the CANOPEN wire condition and bus settings. Verify fuses.
EC not present on can	Check EC board for 24V supply presence. Verify the CANOPEN wire condition and bus settings. Verify fuses.
memo_fault_DI_dRP_dt_ARC	There is an important temporal variation on the value of RP. Check the RP level and the driving signal. Check for problems in coaxial line.
Emergency stop relay unarmed	Check TRANSMITTER emergency stop button and XTE 1/2 and 3/4 condition.

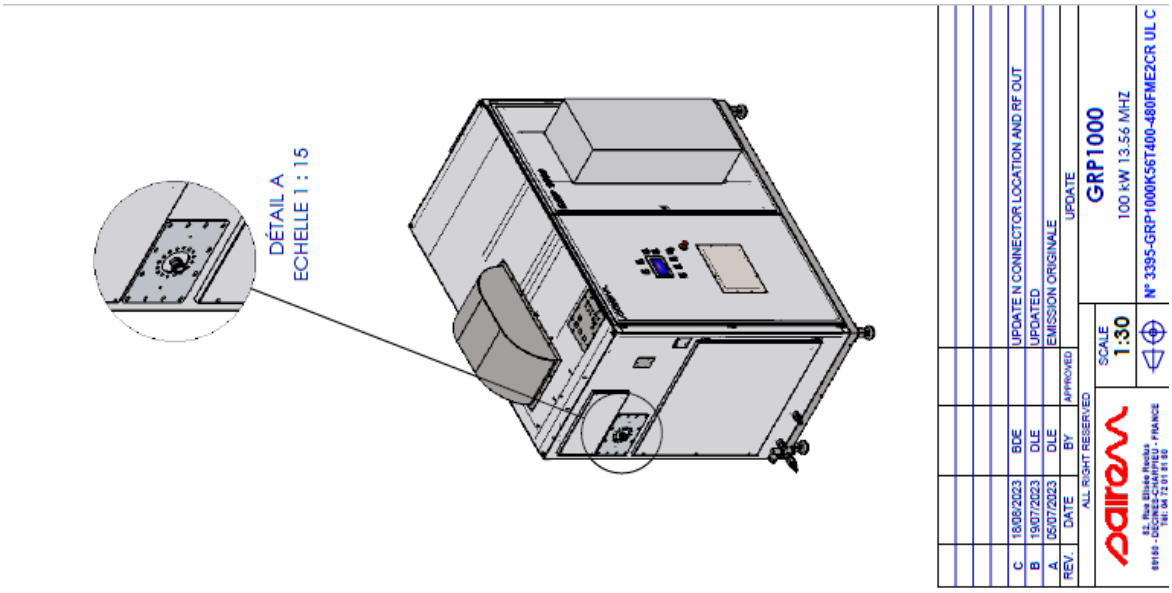
External emergency relay unarmed(applicator)	Check applicator emergency relay (emergency stop buttons).
External emergency relay unarmed(applicator's doors)	Check applicator safety relay (applicator doors).
External Emergency stop button ON	Check external emergency stop contact XTE 5/12
External safety fault (EMS or safety)(XTE39/40)	Check external safety button on XTE 39/40
External safety security (XTE11/18)	Check external safety state condition on XTE 11/18
External security 1(XTE6/13)	Check external security contact (1 OK)
External water cooling not ready(XTE7/14)	Check external water cooling state condition on XTE 7/14
Fault moding	Check matching box position before applying RF power. Increase load in cavity.
Fault on HV power supply of 10KW driver	Appears when another fault on the driver supply is generated
Fault primary TRHT contactors KMHT2/3	Check the QCHT breaker for tripping.
TRANSMITTER emergency stop button ON	Check TRANSMITTER emergency stop button
TRANSMITTER front doors open	Check door closure. Verify security contacts position.
TRANSMITTER front doors open	Check door closure. Verify security contacts position.
TRANSMITTER rear doors open	Check door closure. Verify security contacts position.
TRANSMITTER rear doors open	Check door closure. Verify security contacts position.
TRANSMITTER right side door open	Check door closure. Verify security contacts position.
TRANSMITTER right side door open	Check door closure. Verify security contacts position.
HTB (in/out) not present on can	Check the API module connections. Verify the CANOPEN wire condition and the bus settings. Verify fuses.
HV driver breaker fault QHTP	Check QHTP for tripping. Inspect the driver HV circuit for arcs if high apparition rate.
HV min fault	Check the mains voltage. Verify condition of DHT diode bridges. Observe UA value during RF ON.
HV min fault on driver	Check the mains voltage. Verify condition of the DHTP diodes. Observe UAP value during RF ON.
IA max driver fault	Driver anode overcurrent fault. Check for arcs in coaxial line if fault appears systematically
KASG unarmed	Push reset to rearm. Check the door closure. Check external XTE39/40 contacts condition.
Loss of external ethernet communication	Check the connection of the RJ45 connectors. Activate the control mode. Check the Ethernet cable. Verify not in LOCAL mode.
Loss of external profibus communication	Check the Profibus connector/cable. Activate the control mode on the Profibus screen of the PLC. Verify not in LOCAL mode.
Matching box fault	Observe CBA alarm list on CANOPEN slave screen
Memo external emergency stop button	Check external emergency stop contact XTE 5/12
Memo External safety security (XTE11/18)	Check external safety state condition on XTE 11/18
Memo fault 600W SS TRANSMITTER	Fault on 600 W TRANSMITTER (pilot). Take safety measures needed and control the screen of the 600 W TRANSMITTER.

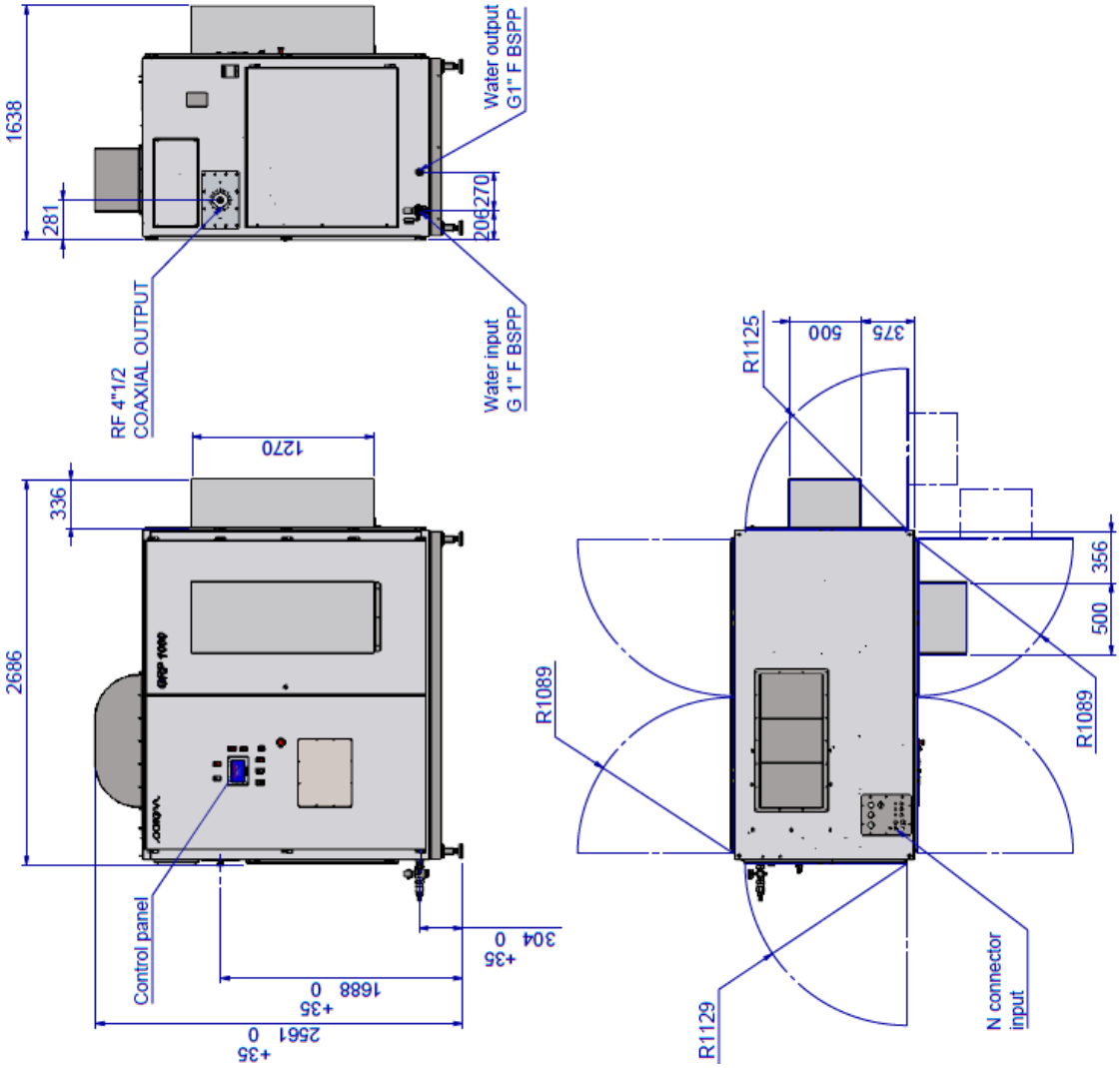
Memo fault air inside TRANSMITTER too hot(SQAT)	Cabinet air temperature too high. Check dust filters and air exhaust for blocking.
Memo fault canopen	Check CANOPEN bus for absent slaves.
Memo fault chiller	Check external water cooling state condition on XTE 7/14
Memo fault driver triode filament air pressure(SQ9)	Check the operation of the driver filament cooling fan. Check fuses.
Memo fault driver triode water cooling(SQ12)	Check the chiller operation. Check the flow switch operation. Look for obstructions
Memo fault external security 1(XTE6/13)	Check external security contact (1 OK)
Memo fault filament air pressure(SQ10)	Check the operation of the filament cooling fans. Check fuses.
Memo fault filament not ready on CIB239	Filament preheating time not enough. Set filament preheating time to 180 s. Contact SAIREM.
Memo fault HV breaker(QTRHT)	Check the QTRHT breaker for tripping.
Memo fault input water temp too cold	Check water temperature of chiller
Memo fault input water temp too high	Check water temperature of chiller
Memo fault no RF (SS TRANSMITTER check)	Contact SAIREM
Memo fault on high voltage contactors	Check the HV contactors coils for the activation sequence.
Memo fault on kaug	Check emergency stop relay for false contacts. Check condition of XTE 1/2 and XTE 3/4
Memo fault on kmf	Check KMF auxiliary contacts. Verify QF for tripping. Check MOD3 connection. Check fuses.
Memo fault on kmfp	Check KMFP auxiliary contacts. Verify QFP for tripping. Check MOD3 connection. Check fuses.
Memo fault ON/OFF on KMHTP driver	Check the driver HV contactor coils for the activation sequence.
Memo fault ON/OFF RF on Electronic control	Not yet implemented
Memo fault SS driver/driver CO inductance water flow(SQ14)	Check the chiller operation. Check the flow switch operation. Look for obstructions
Memo fault 100 kW triode inductances water flow(SQ15)	Check the chiller operation. Check the flow switch operation. Look for obstructions
Memo fault exchanger 1 water flow(SQ19)	Check the chiller operation. Check the flow switch operation. Look for obstructions
Memo fault exchanger 2 water flow(SQ20)	Check the chiller operation. Check the flow switch operation. Look for obstructions
Memo fault triode water cooling(SQ13)	Check the chiller operation. Check the flow switch operation. Look for obstructions
Memo fault grid resistor water flow(SQ16)	Check the chiller operation. Check the flow switch operation. Look for obstructions.
Memo fault VGPmin	Driver grid voltage too low. Check the Driver Grid Supply Board (CES 149-2) for FUGP fuse.
Memo TRANSMITTER emergency stop button	Check TRANSMITTER emergency stop button
memo_fault_hv_contactors(contacts collés)	Turn off TRANSMITTER and control KMHT1 and KMHT3 contactors

memo_fault_sensor_air_water(Reset 5s)	Not a fault. Water cooling is present before TRANSMITTER mains ON.
RPmax fault on 10kW driver	Possible matching problem. Possible arcing in small coaxial line on input triode stage. Contact SAIREM.
Smoke detected in cabinet	Turn main switch off and inspect inside of the panel.
Memo fault arc detection in RF cavity	An arc (or light intensity variation) has been detected on the triode cavity or on the external arc input. Check the triode cavity for arcs, and clean if arc traces are present. Improve TRANSMITTER output matching.
Memo fault overheat water triode	The TRANSMITTER outlet water temperature is too high. Control the value of the TRANSMITTER efficiency. Reduce the RP level. Increase the water flow.
Triode anode overheat(SQ11)	Not yet implemented
Memo fault Humidity too high	Check the air conditioning unit activation. Verify the closure of the doors. Measure the TRANSMITTER relative humidity and compare it to HU1 setpoint.

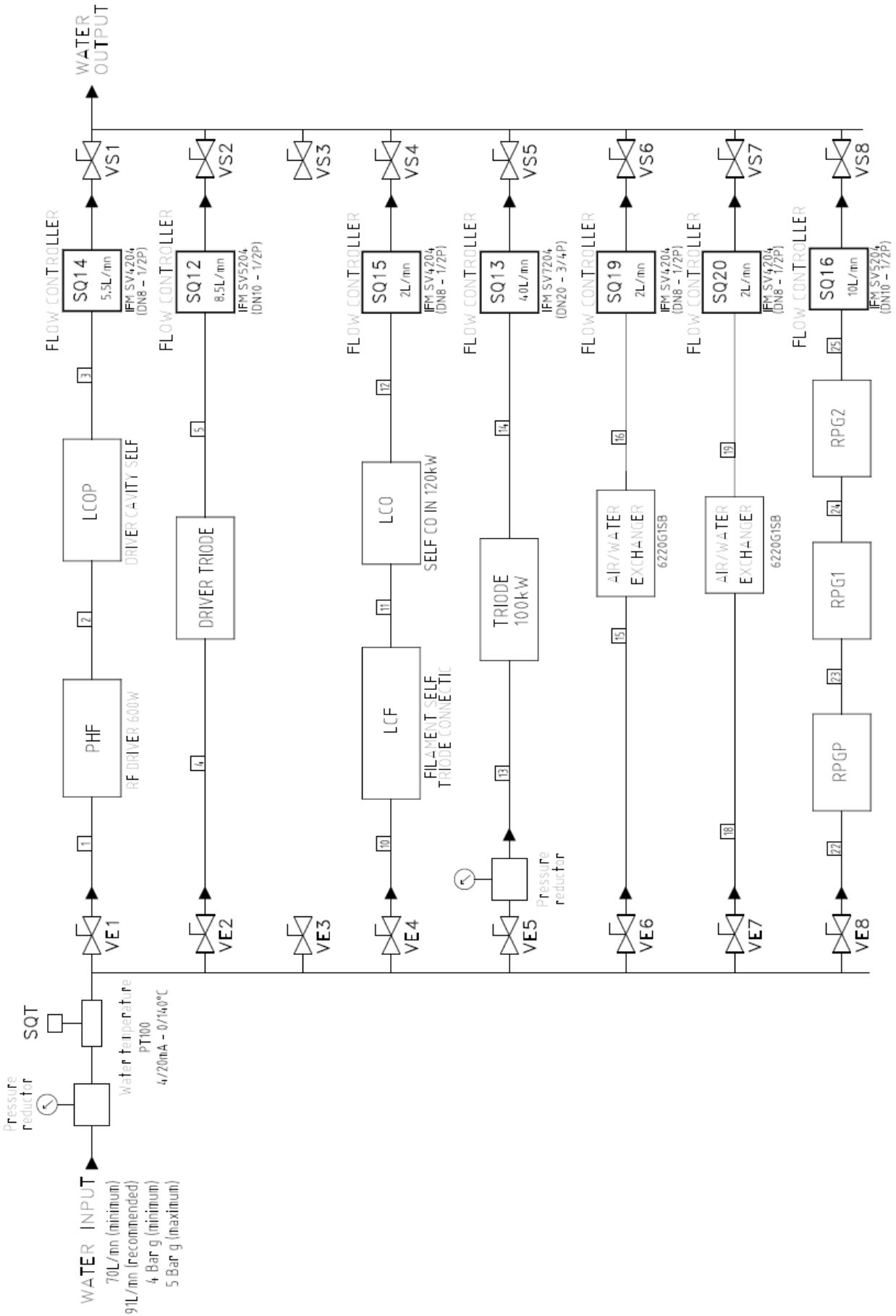
APPENDICES

A.DIMENSIONED DRAWINGS





B.WATER CIRCUIT



C. ETHERNET/MODBUS VARIABLES

Inputs from External to GRP

Inputs from External to GHP				
			Ethernet Modbus	
Exchanges	**Range**	**Type**	**Address Modbus**	**Variable (Proface)**
EXT_Gain_ad8302	0 / 600 (-30,0 à 30,0dB)	Word	[PLC1]%MW00000	COM_CDE_MOT_00000
Reflected power limit setpoint	0 to 100 (0/10,0KW)	Word	[PLC1]%MW00001	COM_CDE_MOT_00001
EXT_Phase_ad8302	5 / 175 (5 à 175°)	Word	[PLC1]%MW00002	COM_CDE_MOT_00002
Load setpoint	0 / 1000 (capa min to capa max)	Word	[PLC1]%MW00003	COM_CDE_MOT_00003
Tune setpoint	0 / 1000 (capa min to capa max)	Word	[PLC1]%MW00004	COM_CDE_MOT_00004
Mini Load setpoint	0 / 1000 (capa min to capa max)	Word	[PLC1]%MW00005	COM_CDE_MOT_00005
Maxi load setpoint	0 / 1000 (capa min to capa max)	Word	[PLC1]%MW00006	COM_CDE_MOT_00006
Mini tune setpoint	0 / 1000 (capa min to capa max)	Word	[PLC1]%MW00007	COM_CDE_MOT_00007
Maxi tune setpoint	0 / 1000 (capa min to capa max)	Word	[PLC1]%MW00008	COM_CDE_MOT_00008
External clock for control communication (1 s On / 1 s Off)	0/1 (1 s On / 1 s Off)	Bit	[PLC1]%MW00050:X00	COM_CDE_MOT_00050.X[0
Reset fault	1=Reset	Bit	[PLC1]%MW00050:X01	COM_CDE_MOT_00050.X[1
Order Mains ON/Mains OFF (front montant+etat1)	0=OFF / 1=ON	Bit	[PLC1]%MW00050:X02	COM_CDE_MOT_00050.X[2
Order RF ON/OFF (front montant + etat1)	0=OFF / 1=ON	Bit	[PLC1]%MW00050:X03	COM_CDE_MOT_00050.X[3
		Bit	[PLC1]%MW00050:X04	COM_CDE_MOT_00050.X[4
Phase_feedback_ON_u (not functional)	0=OFF / 1=ON	Bit	[PLC1]%MW00050:X05	COM_CDE_MOT_00050.X[5
Gain_feedback_ON_u (not functional)	0=OFF / 1=ON	Bit	[PLC1]%MW00050:X06	COM_CDE_MOT_00050.X[6

		Bit	[PLC1]%MW00050:X07	COM_CDE_MOT_00050.X[7
		Bit	[PLC1]%MW00050:X08	COM_CDE_MOT_00050.X[8
		Bit	[PLC1]%MW00050:X09	COM_CDE_MOT_00050.X[9
		Bit	[PLC1]%MW00050:X10	COM_CDE_MOT_00050.X[10
		Bit	[PLC1]%MW00050:X11	COM_CDE_MOT_00050.X[11
		Bit	[PLC1]%MW00050:X12	COM_CDE_MOT_00050.X[12
		Bit	[PLC1]%MW00050:X13	COM_CDE_MOT_00050.X[13
		Bit	[PLC1]%MW00050:X14	COM_CDE_MOT_00050.X[14
		Bit	[PLC1]%MW00050:X15	COM_CDE_MOT_00050.X[15
External emergency stop safety relay OK (KAU)	1=OK	Bit	[PLC1]%MW00051:X00	COM_CDE_MOT_00051.X[0
External interlock safety relay OK(applicator doors)(KAS)	1=OK	Bit	[PLC1]%MW00051:X01	COM_CDE_MOT_00051.X[1
		Bit	[PLC1]%MW00051:X02	COM_CDE_MOT_00051.X[2
		Bit	[PLC1]%MW00051:X03	COM_CDE_MOT_00051.X[3
		Bit	[PLC1]%MW00051:X04	COM_CDE_MOT_00051.X[4
		Bit	[PLC1]%MW00051:X05	COM_CDE_MOT_00051.X[5
		Bit	[PLC1]%MW00051:X06	COM_CDE_MOT_00051.X[6
		Bit	[PLC1]%MW00051:X07	COM_CDE_MOT_00051.X[7
		Bit	[PLC1]%MW00051:X08	COM_CDE_MOT_00051.X[8
		Bit	[PLC1]%MW00051:X09	COM_CDE_MOT_00051.X[9
Load Auto/Manu	1=Manu/0=Auto	Bit	[PLC1]%MW00051:X10	COM_CDE_MOT_00051.X[10
Tune Auto/Manu	1=Manu/0=Auto	Bit	[PLC1]%MW00051:X11	COM_CDE_MOT_00051.X[11
		Bit	[PLC1]%MW00051:X12	COM_CDE_MOT_00051.X[12
		Bit	[PLC1]%MW00051:X13	COM_CDE_MOT_00051.X[13
		Bit	[PLC1]%MW00051:X14	COM_CDE_MOT_00051.X[14
		Bit	[PLC1]%MW00051:X15	COM_CDE_MOT_00051.X[15

Outputs from GHP to External

			Ethernet Modbus	
Exchanges	**Range**	**Type**	**Address Modbus**	**Variable (Proface)**
Level Forward power generator	0 /1000 (0/100,0KW)	Word	[PLC1]%MW01000	COM_STATE_MOT_01000
Level Reflected power generator	0 /100 (0/10,0KW)	Word	[PLC1]%MW01001	COM_STATE_MOT_01001
Level High voltage	0 / 200 (0/20,0kV)	Word	[PLC1]%MW01003	COM_STATE_MOT_01003
Level Anodic current	0 / 1000 (0/10,00A)	Word	[PLC1]%MW01004	COM_STATE_MOT_01004
Level Grid current	1 /1000 (0/10,00A)	Word	[PLC1]%MW01005	COM_STATE_MOT_01005
Level Grid voltage	0/200 (0/200V)	Word	[PLC1]%MW01006	COM_STATE_MOT_01006
Level Load	0 / 1000 (capa min to capa max)	Word	[PLC1]%MW01007	COM_STATE_MOT_01007
Level Tune	0 / 1000 (capa min to capa max)	Word	[PLC1]%MW01008	COM_STATE_MOT_01008
Level VRF	0 / 200 (0/20,0kV)	Word	[PLC1]%MW01011	COM_STATE_MOT_01011
GHP clock for control communication (1 s On / 1 s Off)	0/1 (1 s On / 1 s Off)	Bit	[PLC1]%MW01050:X00	COM_STATE_MOT_01050.X[0
GHP state Mains on	0=off/1=on	Bit	[PLC1]%MW01050:X01	COM_STATE_MOT_01050.X[1
GHP state Preheating	1=Fil preheating	Bit	[PLC1]%MW01050:X02	COM_STATE_MOT_01050.X[2
GHP state Filament ready	1=Fil ready	Bit	[PLC1]%MW01050:X03	COM_STATE_MOT_01050.X[3
GHP state ready for RF	1=Ready for RF	Bit	[PLC1]%MW01050:X04	COM_STATE_MOT_01050.X[4
GHP state RF on	1=RF on	Bit	[PLC1]%MW01050:X05	COM_STATE_MOT_01050.X[5
GHP state in local control	1=Local mode	Bit	[PLC1]%MW01050:X06	COM_STATE_MOT_01050.X[6
GHP state in analog control	1=Analog mode	Bit	[PLC1]%MW01050:X07	COM_STATE_MOT_01050.X[7

GHP state in Ethernet control	1=Ethernet mode	Bit	[PLC1]%MW01050:X08	COM_STATE_MOT_01050.X[8
GHP state Param mode control	0=Local mode 1=Ethernet mode	Bit	[PLC1]%MW01050:X09	COM_STATE_MOT_01050.X[9
		Bit	[PLC1]%MW01050:X10	COM_STATE_MOT_01050.X[10
GHP state RP limitation	1=RP limit	Bit	[PLC1]%MW01050:X11	COM_STATE_MOT_01050.X[11
GHP state KAU (EMS security relay)	1=kau ok	Bit	[PLC1]%MW01050:X12	COM_STATE_MOT_01050.X[12
GHP state KAS (GLPl door security relay)	1=kas ok	Bit	[PLC1]%MW01050:X13	COM_STATE_MOT_01050.X[13
GHP state arc detection	1=arc	Bit	[PLC1]%MW01050:X14	COM_STATE_MOT_01050.X[14
GHP RP Max stop state	1=fault	Bit	[PLC1]%MW01050:X15	COM_STATE_MOT_01050.X[15
GHP state fault	1=fault	Bit	[PLC1]%MW01051:X00	COM_STATE_MOT_01051.X[0
GHP state filament securities fault	1=fault	Bit	[PLC1]%MW01051:X01	COM_STATE_MOT_01051.X[1
GHP state hv securities fault	1=fault	Bit	[PLC1]%MW01051:X02	COM_STATE_MOT_01051.X[2
GHP FP Max Stop state	1=fault	Bit	[PLC1]%MW01051:X03	COM_STATE_MOT_01051.X[3
GHP state VRF limitation	1=VRF limit	Bit	[PLC1]%MW01051:X04	COM_STATE_MOT_01051.X[4
Matching box ready	1=ready (0 = défaut)	Bit	[PLC1]%MW01051:X05	COM_STATE_MOT_01051.X[5
Matching box -Mini_load_position_detected	0=ok	Bit	[PLC1]%MW01051:X06	COM_STATE_MOT_01051.X[6
Matching box -Maxi_load_position_detected	0=ok	Bit	[PLC1]%MW01051:X07	COM_STATE_MOT_01051.X[7
Matching box -Mini_tune_position_detected	0=ok	Bit	[PLC1]%MW01051:X08	COM_STATE_MOT_01051.X[8
Matching box -Maxi_tune_position_detected	0=ok	Bit	[PLC1]%MW01051:X09	COM_STATE_MOT_01051.X[9
		Bit		
MODE_LOCAL_CONTROL_FPSP	1=local FPSP	Bit	[PLC1]%MW01051:X11	COM_STATE_MOT_01051.X[11
MODE_ANA_BNC_CONTROL_FPSP	1=BNC FPSP	Bit	[PLC1]%MW01051:X12	COM_STATE_MOT_01051.X[12
MODE_LOCAL_CONTROL_VHFSP	1=local VHFSP	Bit	[PLC1]%MW01051:X13	COM_STATE_MOT_01051.X[13
		Bit		
Fault_0	1=fault	Bit	[PLC1]%MW01052:X00	COM_STATE_MOT_01052.X[0
Fault_1	1=fault	Bit	[PLC1]%MW01052:X01	COM_STATE_MOT_01052.X[1
Fault_2	1=fault	Bit	[PLC1]%MW01052:X02	COM_STATE_MOT_01052.X[2
Fault_3	1=fault	Bit	[PLC1]%MW01052:X03	COM_STATE_MOT_01052.X[3

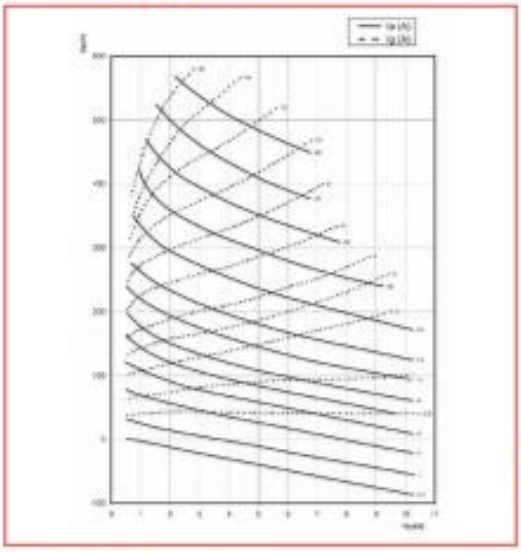
Fault_4	1=fault	Bit	[PLC1]%MW01052:X04	COM_STATE_MOT_01052.X[4
Fault_5	1=fault	Bit	[PLC1]%MW01052:X05	COM_STATE_MOT_01052.X[5
Fault_6	1=fault	Bit	[PLC1]%MW01052:X06	COM_STATE_MOT_01052.X[6
Fault_7	1=fault	Bit	[PLC1]%MW01052:X07	COM_STATE_MOT_01052.X[7
Fault_8	1=fault	Bit	[PLC1]%MW01052:X08	COM_STATE_MOT_01052.X[8
Fault_9	1=fault	Bit	[PLC1]%MW01052:X09	COM_STATE_MOT_01052.X[9
Fault_10	1=fault	Bit	[PLC1]%MW01052:X10	COM_STATE_MOT_01052.X[10
Fault_11	1=fault	Bit	[PLC1]%MW01052:X11	COM_STATE_MOT_01052.X[11
Fault_12	1=fault	Bit	[PLC1]%MW01052:X12	COM_STATE_MOT_01052.X[12
Fault_13	1=fault	Bit	[PLC1]%MW01052:X13	COM_STATE_MOT_01052.X[13
Fault_14	1=fault	Bit	[PLC1]%MW01052:X14	COM_STATE_MOT_01052.X[14
Fault_15	1=fault	Bit	[PLC1]%MW01052:X15	COM_STATE_MOT_01052.X[15

D. TRIODE DATA SHEET

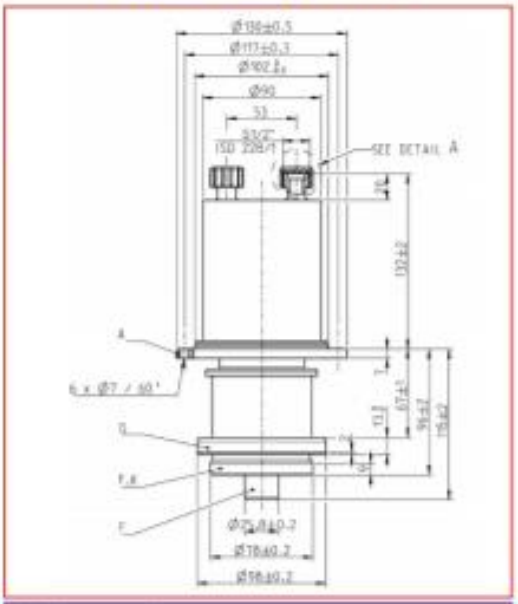
RS 3021 CJ

Industrial RF Heating

Constant current characteristics



Outline drawing (in mm)



Technical specifications

Cathode	thoriated tungsten	
Filament voltage	5.7	V
Filament current	137	A
Max. heater surge current	550	A
Amplification factor	120	
Capacitances		
• grid-anode	23	pF
• grid-cathode	56	pF
• cathode-anode	0.3	pF

Mechanical characteristics

Operating position	vertical	
Weight	4.1	kg
Dimensions	130 x 247	mm

Cooling characteristics (industrial water)

Max. water temperature at tube outlet	65	°C
Min. water pressure at tube inlet	6	bar
Max. T° at any point on the tube envelope	220	°C
Min. air flow on filament connections	0.7	m³/min

Maximum ratings

Frequency	120	MHz
Anode voltage		
• up to 40 MHz	14	kV
• from 40 to 80 MHz	12	kV
• from 80 to 120 MHz	10	kV
Grid voltage	-800	V
Grid current, at full load up to 40 MHz	1.7	A
Grid current, off load up to 40 MHz	2.1	A
DC cathode current	5	A
Peak cathode current	25	A
Anode dissipation	20	kW
Grid dissipation		
• up to 40 MHz	500	W
• from 40 to 80 MHz	420	W
• from 80 to 120 MHz	330	W

RF amplifier B or C class operation, common grid circuit

Frequency	<120	<120	MHz
Output power	22.7+1.28	12.3+0.32	kW
Anode voltage	9.5	9	kV
Anode DC idle current	0	0.3	
Anode DC current	3.2	2.0	A
Anode dissipation	6.6	5.6	kW
Grid DC voltage	-220	-65	V
Grid DC current	920	450	mA
Grid dissipation	191	55	W
Peak RF cathode voltage	462	205	V
Drive power	0.39+1.28	0.08+0.32	kW

Thales propose R0EKG 321G socket which is convenient, fast and secure for the installation and deinstallation of the tube on any type of generator.

For more technical information regarding this tube, feel free to ask our distributor Richardson Electronics - www.rell.com

THALES MICROWAVE & IMAGING SUB-SYSTEMS
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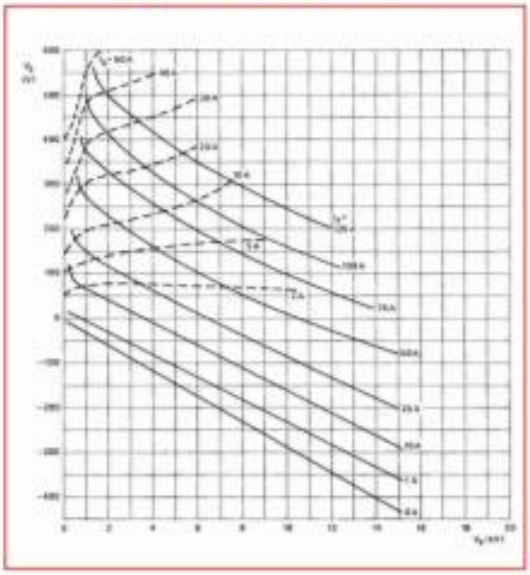
THALES

Richardson Electronics

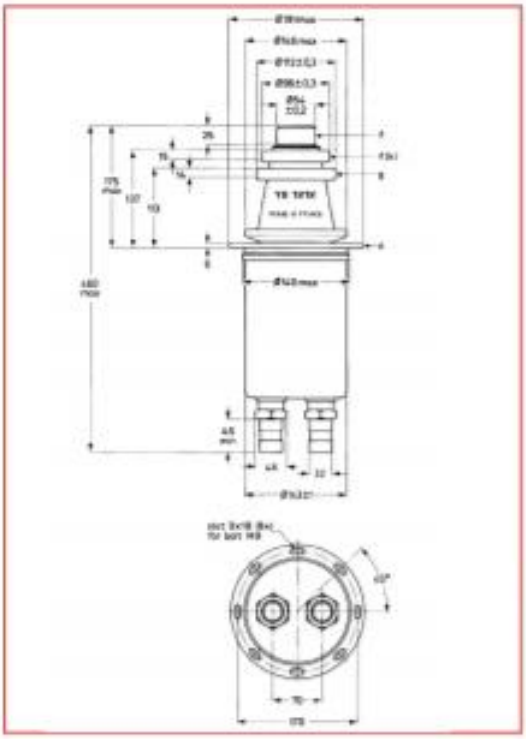
YD 1212

Industrial RF Heating

Constant current characteristics



Outline drawing (in mm)



Technical specifications

Cathode	thoriated tungsten	
Filament voltage	12.6	V
Filament current	380	A
Max. heater surge current	2000	A
Amplification factor	40	
Capacitance		
• grid-anode	60	pF
• grid-cathode	185	pF
• cathode-anode	3	pF

Mechanical characteristics

Operating position	vertical	
Weight	15	kg
Dimensions	191 x 460	mm

Cooling characteristics (industrial water)

Max. water temperature at tube inlet	40	°C
Max. water temperature at tube outlet	60	°C
Min. water pressure at tube inlet	600	kPa
Max. T° at any point on the tube envelop	240	°C
Min. water flow in the filament of water cooled	0.5	l/min
Min. air flow on filament connections	2	m^3/min

Maximum ratings

Frequency	30	MHz
Anode voltage	16.8	kV
Grid voltage	-2000	V
Anode current, CW	25	A
Grid current, at full load	7	A
Grid current, off load	8.5	A
Peak cathode current	175	A
Anode dissipation	120	kW
Grid dissipation up to 30 MHz	3	kW
Grid resistance	10	kΩ

Class C, RF oscillator for industrial applications

Frequency	30	MHz
Anode voltage	14	kV
Anode current	23.5	A
Anode input power	329	kW
Anode output power	240	kW
Anode dissipation	81.5	kW
Grid current, on load	6	A
Grid dissipation	2.6	kW
Grid resistance	135	Ω
Feedback ratio	10.4	%
Oscillator efficiency	73	%

Operations at higher frequencies available on request.

For more technical information regarding this tube, feel free to ask our distributor Richardson Electronics - www.rell.com

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THALES

Richardson Electronics

E.FUSE REPLACEMENT RATINGS

FUSE REPLACEMENT VALUES – GRP1000K				
Component pro-tected	**Schematic reference**	**Type of fuse**	**Current rating**	**Size**
Filament supply	FUTY	URB	25 A	10x38
PLC	XF24	T	2.5 A	5x20
HTB head module	XF25	F	1.6 A	5x20
HTB I/O module	XF26	F	0.5 A	5x20
HTB I/O module	XF27	F	0.63 A	5x20
HTB I/O module	XF28	T	0.63 A	5x20
HTB I/O module	XF29	T	0.63 A	5x20
Safety relay supply and HTB I/O module	XF30	T	1.0 A	5x20
Isolator circuit for driver IA	XF31	T	4.0 A	5x20
EC board	XF32	T	1.0 A	5x20
RF driver power coupler	XF33	F	0.63 A	5x20
Temperature sensor	XF34	F	0.16 A	5x20
RF driver cooling fan	XF35	T	3.15 A	5x20
RF final triode cooling fan	XF36	T	6.3 A	5x20
Diode bridge cooling fans	XF37	T	10 A	5x20
Air/water heat exchanger fans	XF38	T	4.0 A	5x20
Fire detector	XF39	T	1.6 A	5x20
Air conditioning control	XF40	F	0.2 A	5x20
Arc detection DAFO	XF41	F	0.16 A	5x20
Water flow meters SQ12/SQ15	XF42	F	0.16 A	5x20
Water flow meters SQ16/SQ17	XF43	F	0.16 A	5x20
Filament power regulator	XF44	F	0.16 A	5x20
Water flow meter SQ13	XF45	F	0.16 A	5x20
Water flow meters SQ17/SQ18	XF46	F	0.16 A	5x20
CES419	XF48	F	0.4 A	5x20
FILAMENT	F2	J	400A	Blade Amp-Trap

F. ELECTRICAL DRAWINGS

The Electrical drawings of the TRANSMITTER : see document RI1837.

CAUTION
Ensure that all electrical connections are made as specified in the following sections. If they are not, you can damage the GRP1000K.


WARNING
Ensure that the electrical installation of the GRP1000K conforms with your local and national safety requirements. It must be connected to a suitably fused and protected isolator and a suitable earth (ground) point, and incorporate an over-current circuit protection device, suitable for the full load current rating.


WARNING
Isolate your electrical supply before you make the connections to the GRP1000K. If you do not, there will be a risk of injury or death by electric shock.

CAUTION
Ensure that all electrical connections are made as specified in the following sections. If they are not, you can damage the GRP1000K.

Have the installation inspected and commissioned

CAUTION
The warranty on your GRP1000K will be invalid unless the GRP1000K has been installed and commissioned in accordance with SAIREM requirements and you have signed the commissioning form.

Procedure description for work requiring open cabinet doors with 480 V.

Date	Version	Changes	Modified by
04/07/2017	A	Creation of the document	AME
19/02/2025	B	Updates for 2025 new transmitters	VGUH

The following constitutes a list of the procedures needed to be performed on the GENERATOR during commissioning.

Procedure: Check 24 V sensor operation.

Condition: Mains isolator ON and all the circuit breakers off except Q24 (24 V circuit breaker).

Description: Check the correct operation of the 24 V sensors:

1. Open and close GENERATOR doors and validate the correct signal change.
   - Front door closure
   - Rear door closure
   - Right side door closure

If necessary, mechanical adjustment will be performed on these sensors.

2. Verify the trip condition is detected for
   - QTRHT
   - QHTP
   - QP
   - QCHT
3. Verify emergency stop is detected when activated.

Check both the PLC and the safety relay detect the activation of the emergency stop.

4. Verify front door buttons/switches operate correctly
   - S6 switch change is detected correctly
   - Mains ON button is detected correctly

- RF ON button is detected correctly
- RF OFF button is detected correctly

5. Verify 24 V fans start correctly when in Mains ON mode.

Press Mains ON button and verify that the fans are operating. Forcing KMV ON with the PLC might be necessary.

6. Verify air pressure sensors operate correctly.

In Mains ON with KMV closed, disconnect a fan connector and control that the corresponding pressure sensor triggers a fault.

- Driver air pressure sensor SQ9.
- Triode air pressure sensor SQ10

7. Trigger the fire detection sensor

Apply the test spray and check the corresponding alarm is triggered on the screen.

8. Arc detection test

Apply a light change on the optic fibres to check the signal is recognized by the PLC.

9. Hot air / humidity sensor check

Apply hot air or disconnect the SQAT sensor to trigger a hot air fault.

Apply humid spray on HU1 sensor to trigger the high humidity fault.

Procedure: Adjusting water flow valves

Switch mains isolator OFF. Open doors and switch off all circuit breakers except Q24.

Switch the mains isolator ON Adjust the water flow valves while checking the flow level on the PLC screen. Once finished, switch mains isolator OFF, activate all the breakers and close doors.

Procedure: Calibration of the Current (MIA/MIG/MIAP/MIGP) measurement system.

Switch mains isolator OFF. Open doors and switch off all circuit breakers except Q24.

Connect a DC regulated supply in parallel with the measurement resistor. Switch the mains isolator ON. While observing the PLC screen, adjust the potentiometer on each board (MIA/MIG/MIAP/MIGP) to equalize the indicated value on the PLC and the current supplied by the DC supply.

~~Procedure: Program electronic board~~

~~Switch mains isolator OFF. Open doors and switch off all circuit breakers except Q24. Connect the RS232 cable to the interface of the board and update firmware by switching ON Q24.~~

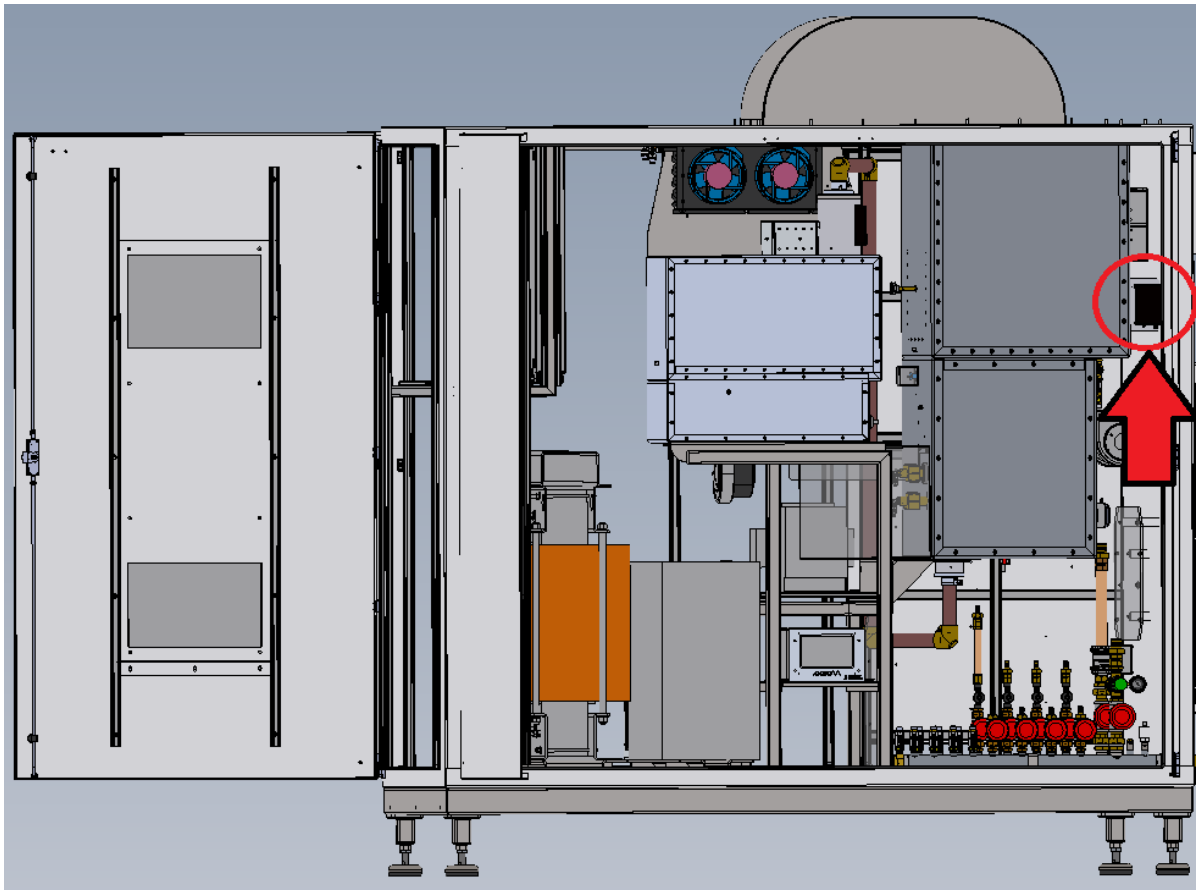
~~Once finished, switch mains isolator OFF, activate all the breakers and close doors.~~

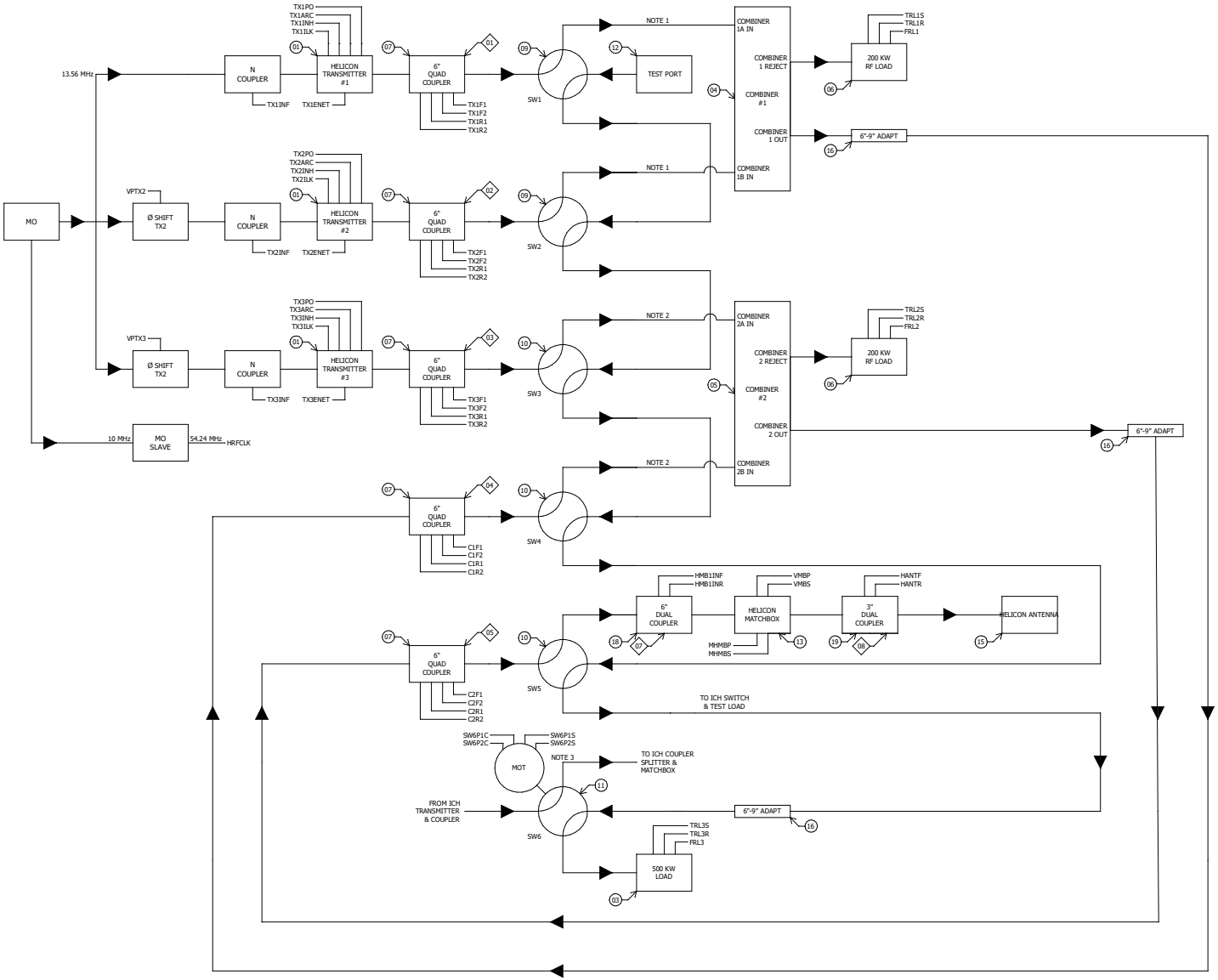
Procedure: Optimization of Gain or Phase regulation.

If requested by client, an oscilloscope must be connected to the electronic board on specific test ports. Ideally this connection is performed while the mains isolator is turned OFF. It can also be done without turning OFF mains isolator (no safety issues) however the operator shall be very careful not to create any short circuits while connecting the probes.

Procedure: Adjustment of FP coupler

If the client needs to increase the forward power of the GENERATOR, the coupler can be adjusted dynamically. For this procedure, the GENERATOR must be operating in HV while an operator changes the value of a potentiometer on the output coupler. The estimated clearance from HV components is 2 meters.





REV.	DATE	NAME	CHANGES
			1/19/2021
0	10/15/2020	C. Mauer	Initial

APPROVALS		
DESIGNER	--	DATE --
DETAILER	--	DATE --
CHECKER	--	DATE --
ENGINEER	--	DATE --
TEAM LEAD	--	DATE --
VERIFIER	--	DATE --
RELEASE	--	DATE --
CAM	M. Kaufman	

OAK RIDGE National Laboratory

FISSION AND FUSION ENERGY AND SCIENCE DIRECTORATE

Helicon RF C&ID (Sheet 1 of 2)

DRAWING: Helicon C&ID (1 of 2)

REVISION: 0

BOOK: 1.03.03 FLDR: 1.03.03.02 DRAWING: 01

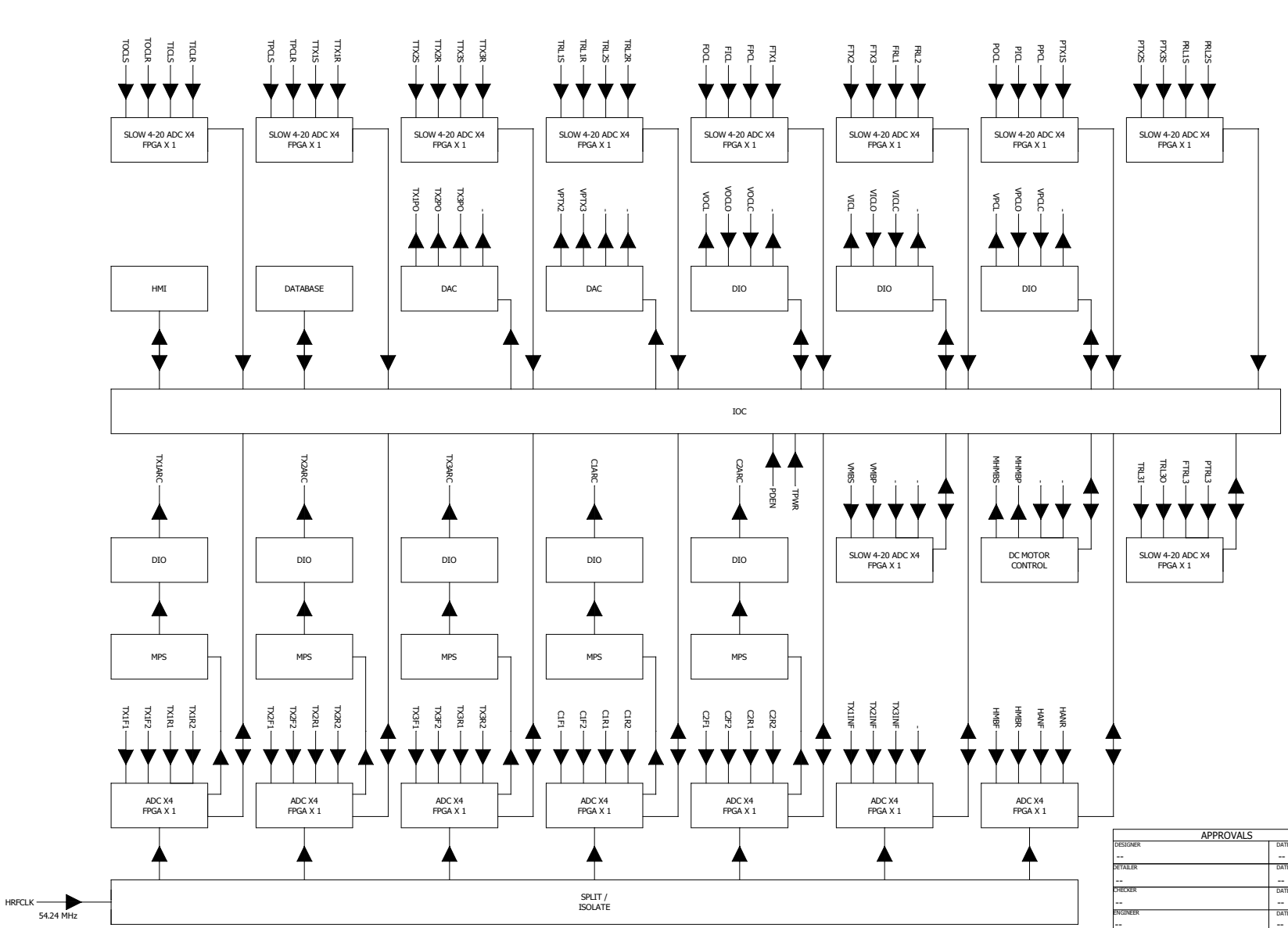
1.03.03 Plasma Source and Heating

PROJECT: Material Plasma Exposure eXperiment

LOCATION: BLDG 7625

SCALE: DO NOT SCALE

Document realized with version :



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Helicon RF I&C (Sheet 2 of 2)

DRAWING: Helicon C&ID (2 of 2)
REVISION: 0
BOOK: 1.03.03 FLDR: 1.03.03.02 DRAWING: 02

1.03.03 Plasma Source and Heating
PROJECT: Material Plasma Exposure eXperiment
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