



Cryomodule Test Facility/Coupler Probe Test Stand

**Personnel Safety System
Users Guide**

Revision 1.2
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Prepared by the JLab Safety Systems Group

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1 Things to Know

All PSS devices, including the PSS display computer, are under personnel safety configuration control. Only safety system group personnel may access, modify, or alter these devices.

Activating ANY crash switch will shut off ALL RF sources, regardless of the waveguide configuration.

When the 1MW source is configured to run to the CPTS, mezzanine RF monitor or any CARM fault will *not* shut it off.

When any RF source trips, the PSS control key (either CMTF or CPTS) must be cycled down then back up before RF can be re-enabled.

2 Reference Documents

JLab CMTF/CPTS PLC Logic Specification

JLAB CMTF Standard Operating Procedure

JLab Coupler Probe Test Stand Standard Operating Procedure

JLab 1MegaWatt Test Stand Standard Operating Procedure

3 Introduction

The CMTF/CPTS personnel safety system is an engineered interlock system to help protect personnel from exposure to prompt ionizing radiation (PIR) and radio frequency non-ionizing (microwave) radiation that results from operation of the CMTF test cave and the 1 Megawatt RF test areas in the JLab SRF test lab building (building 58).

The CMTF is composed of a completely enclosed concrete bunker, called the 'test cave' and a control room outside the test cave. Fully assembled super-conducting RF cryomodules are rolled into the facility through a drop down concrete equipment door for final test and characterization. A personnel door, shielded from the test area by a concrete labyrinth, is located at the other end of the facility. It is through this door that personnel enter and exit the CMTF during a sweep.

The coupler probe test stand (CPTS) area is used to test and process super-conducting RF cavity coupling systems before assembly into a cryomodule. The couplers are tested using a high power pulsed RF source. The CPTS area is fully open and accessible with no RF or radiation shielding.

There are presently three high power RF sources. The 1 Megawatt, 805 MHz pulsed source is located in the CPTS area. The 20-kilowatt CW, 805 MHz , and the 32kW (16kWx2), 1497 MHz sources are located in the mezzanine area directly above the CMTF test cave. The 1 MW source can be routed to either the coupler test stand or the CMTF. The other two sources may only be operated into the test cave.

The Personnel Safety System must be able to ensure that high power RF is only allowed to operate when the RF systems are configured to safely do so. It is the job of the PSS logic to unambiguously determine the status of the test cave, coupler test stand, and the RF waveguide that routes the high power RF to the various destinations and then permit

or inhibit operation of the RF sources. As a back up to this logic, ionizing and non-ionizing (RF) radiation monitors are located near areas that would be most likely affected by improper or unanticipated configurations of the RF systems or the test cave. If a fault is detected on one of these systems, all RF sources configured for the cave are shut off.

3.1 Assumptions

The configuration of the RF systems is highly dependent on administrative procedures and configuration control. There are several assumptions concerning high power RF system configuration that form part of this logic.

- The 20 kW 805MHz RF system is composed of two 10kW RF sources, the two 10 kW sources cannot be configured to operate to any area other than the CMTF cave.
- The 32 kW 1497MHz RF system is composed of four 8kW RF sources; the sources cannot be configured to operate to any area other than the CMTF cave.
- 1MW 805MHz RF source cannot be configured to operate to any areas other than the CMTF cave or the CPTS.
- Although the PSS can open the equipment door, the equipment door is not considered an emergency exit.
- The PSS cannot determine that all waveguide sections are in place between the RF sources and their appropriate destinations. Administrative controls shall be used to ensure that this waveguide is in place.

3.2 Differences between the CMTF/CPTS Personnel Safety System and the CEBAF Personnel Safety Systems.

The CMTF is designed as a production and R&D test facility. It does not utilize a dedicated safety system operator.

- The CMTF/CPTS safety systems do not utilize a safety system operator to oversee sweeps and PSS operation. Therefore, a sweep timer is used to ensure that the sweep is performed in a timely manner.
- The CMTF test cave does not have a controlled access mode.
- There is no electron gun. Prompt radiation is an undesired result produced by field emission in the test cavities.
- The CMTF safety interlock system supports multiple quasi-independent test areas.
- The CMTF utilizes a 1MW pulsed RF source. This source is an order of magnitude more powerful than other sources at JLab. The 1MW klystron itself can produce significant amounts of prompt radiation, although this is not interlocked through the PSS.

- The CMTF test systems use re-configurable waveguide transmission lines. Waveguide can be uncoupled and reconnected in alternate routing plans. The PSS is required to monitor waveguide switches and shutters in order to determine the desired destination of the RF source. The waveguide reconfiguration is a mixture of administrative procedures and automated switching systems.
- Because the waveguide systems are re-configurable, a pressure interlock is not used to ensure that the waveguides are connected. Interlock switches similar to the ones used to sense door position are used to detect that the waveguide is properly connected.
- RF monitors are used in areas where the waveguide is routinely disconnected to detect high RF fields from open or leaky waveguide joints.
- There is no Beam Permit mode. RUN mode is the equivalent of Power Permit.
- The PSS display software is a limited version of that used in the CEBAF system. One limitation is the number of signals that can be displayed. For this reason, “first faults” are not displayed on the CMTF PSS display screens.

4 Staffing

When the CMTF is in sweep mode or higher, there must be a cognizant¹ person in the test lab responsible for CMTF PSS operation. That is, someone who is aware of, and responsible for, the CMTF status. Typically this is the Principle Investigator. Additional staffing requirements are given in the CMTF operating procedures.

The coupler probe test stand (CPTS) does not require full time staffing for PSS operation purposes. However, having a cognizant staff member responsible for PSS operation in the area is recommended. Other requirements for CPTS staffing are contained in the CPTS operating procedures.

4.1 CMTF shift change over

At the end of a shift, the Principle Investigator must either return the CMTF to Open Access, or formally turn over SSO duties to another CMTF qualified crew. The incoming Principle Investigator must sign in the PSS logbook, indicating that they are now responsible for CMTF PSS operations.

The outgoing Principle Investigator should brief the incoming CMTF operations staff on the following items:

- PSS Status
- PSS faults or alarms during shift
- RF configuration and status

5 PSS Logbook

All PSS operations and changes of state shall be recorded in the PSS logbook, located on the PSS console in the CMTF control room. This log is a legal record of PSS operation.

¹ Cognizant is defined as a person or persons trained in the operation and operational hazards of the CMTF/CPTS and associated systems, including the Personnel Safety System.

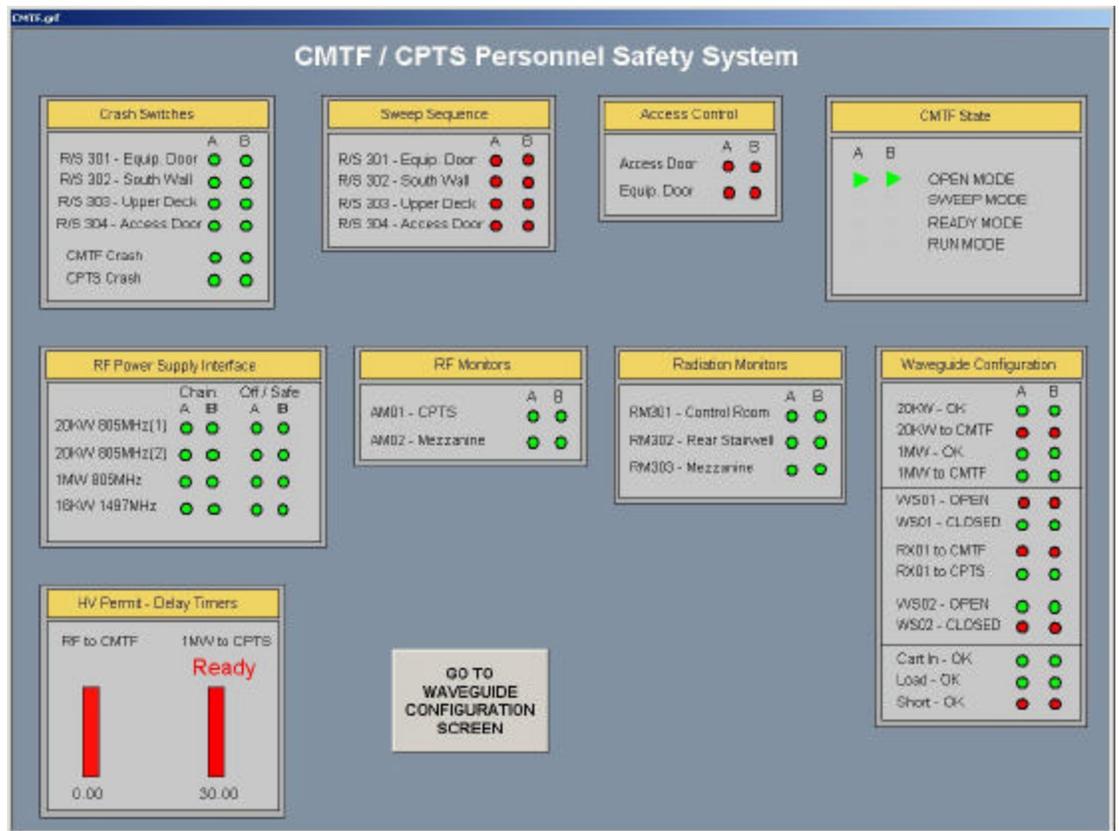
6 PSS Operator Screens

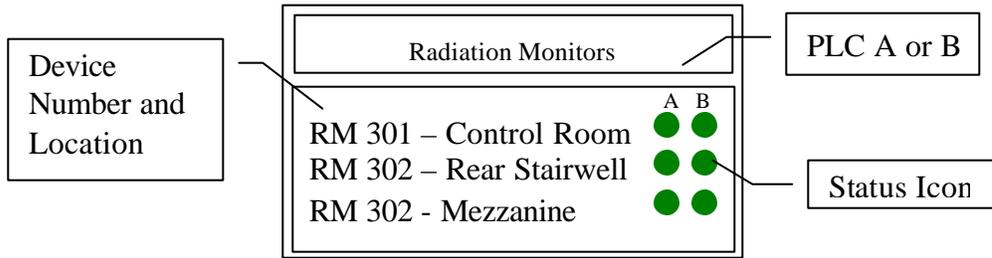
The PSS operator screens are used to view the status of the PSS system. A Scanning and Alarm Control Application (SCADA) package from Intellution is used to query the PSS programmable logic controllers (PLCs) and display real time status on the PSS PC.

6.1 PLC Screen

The status of each PSS input is shown on the CMTF PLC screen. Inputs are grouped by function. The PSS system A and System B inputs are shown separately as a circular icon.

The color-coded icons are grouped into topical boxes in to ease location of similar functions. Table 1 gives a description of each icon and the meaning of red vs. green status.





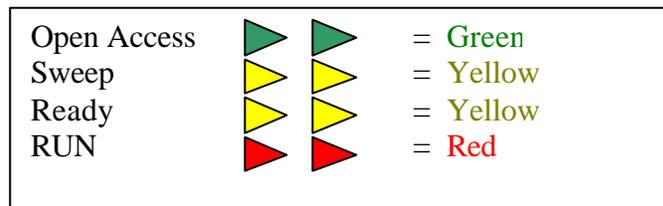
A **GREEN** icon means the device is in the OK or safe condition. ●

A **RED** icon means the device is in the fault or unsafe condition. ●

During normal operation of the PSS system most of the icons should be **GREEN**. The “Off/Safe” icons should be **RED** only when the PSS is in “RUN” mode and a high voltage power supply is turned on.

The CMTF delay timers show the current status of the gun high voltage delay timers. Each timer is 30 seconds. The device cannot be turned ON until the timeout period is complete.

The “CMTF State” window shows the current state of the system A and B PLCs. Figure 1 shows both systems in the “Open Mode” state. Notice that these icons are also color-coded.



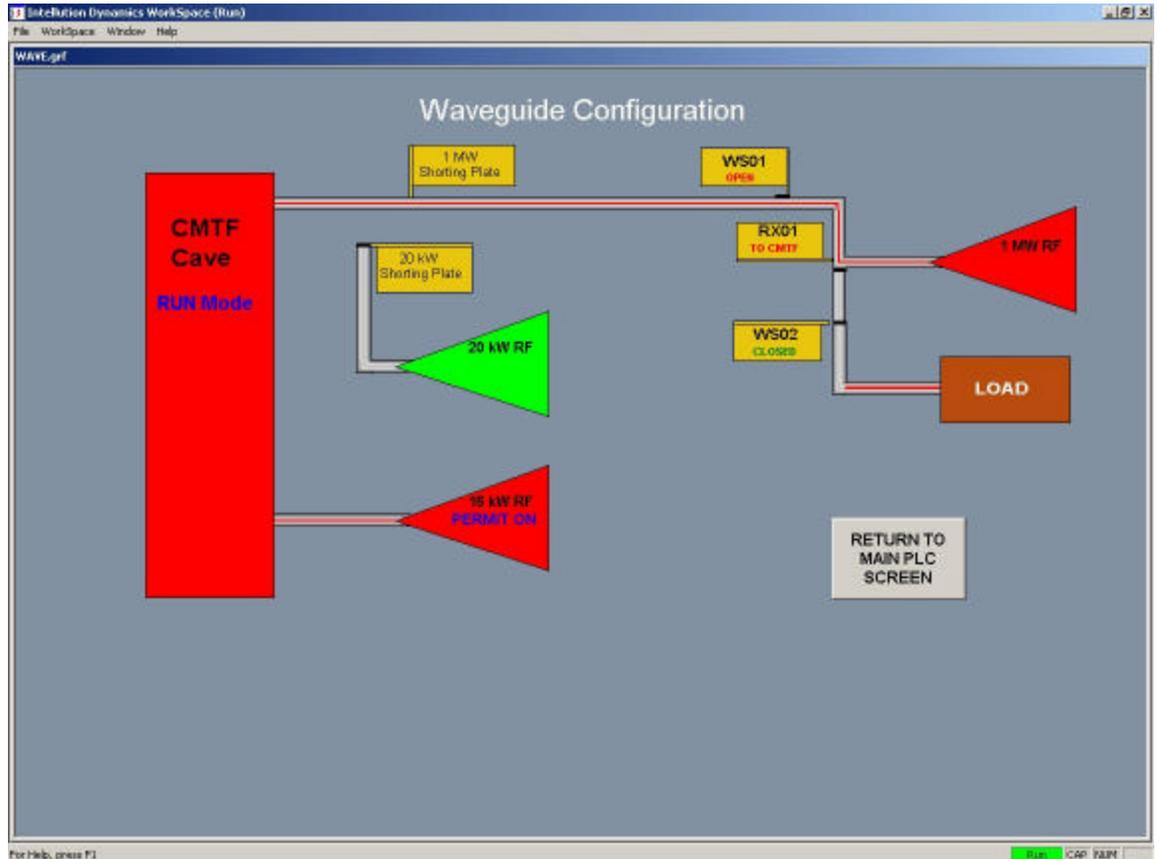
Description of PLC screen Icons

<i>Type of Signal</i>	<i>Description</i>	<i>What Green Means</i> 	<i>What Red Means</i> 
Sweep Sequence	Shows “operational” status of each Run/safe box in the order of the sweep pattern.	Box is armed	Box is not armed. Sweep Required.
Crash Switches	Shows the status of each crash switch. Includes CMTF control room and CPTS crash switches.	Switch is not crashed.	Switch is crashed. CMTF should be in “Open” mode. All RF should be OFF.
Radiation Monitors	Shows fault status of each CARM.	CARM is OK.	CARM is in alarm state.
OFF/Safe	Shows on/off status of device that gets a permissive from PSS.	Device is OFF.	Device is ON.
Chain (Intact)	Shows status of connection between PLC and field interface chassis.	Connection OK	Chassis disconnected.
Doors	Shows Open/Closed status of doors	Door Closed	Door Open
Waveguide Switches RX	Indicates position of waveguide switch that directs 1MW to either the CMTF or CPTS.	Switch in position indicated.	Switch not in position indicated.
Waveguide Shutters WS	Indicates position of waveguide shutters in 1MW system path. Either to the CMTF or the CPTS.	Switch in position indicated	Switch not in position indicated
Waveguide Sections 20kW 1MW	Configurable 805MHz waveguide transmission lines have PSS switches to indicated presence of waveguide section.	Waveguide installed in position indicated	Waveguide not installed in position indicated
Cart IN	Coupler probe test stand movable cart is connected to CPTS waveguide.	Cart connected	Cart not connected
CPTS Load	Coupler probe test stand Load status. Either load or short must be installed for CPTS operation.	Load connected	Load not connected
CPTS Short	Coupler probe test stand Load status. Either load or short must be installed for CPTS operation.	Short connected	Short not connected

6.2 RF Waveguide Configuration Screen

The Waveguide configuration screen shows the status of the 1495 MHz and 805 MHz RF and waveguide systems. Dynamic icons show the status of the current routing of the 805MHz

Waveguide and the associated waveguide switches and shutters. Shutters (WS0x) will indicate "Open" or "Closed". The waveguide switch (RX01) will show the switch position. Shorting plates, when installed, will show



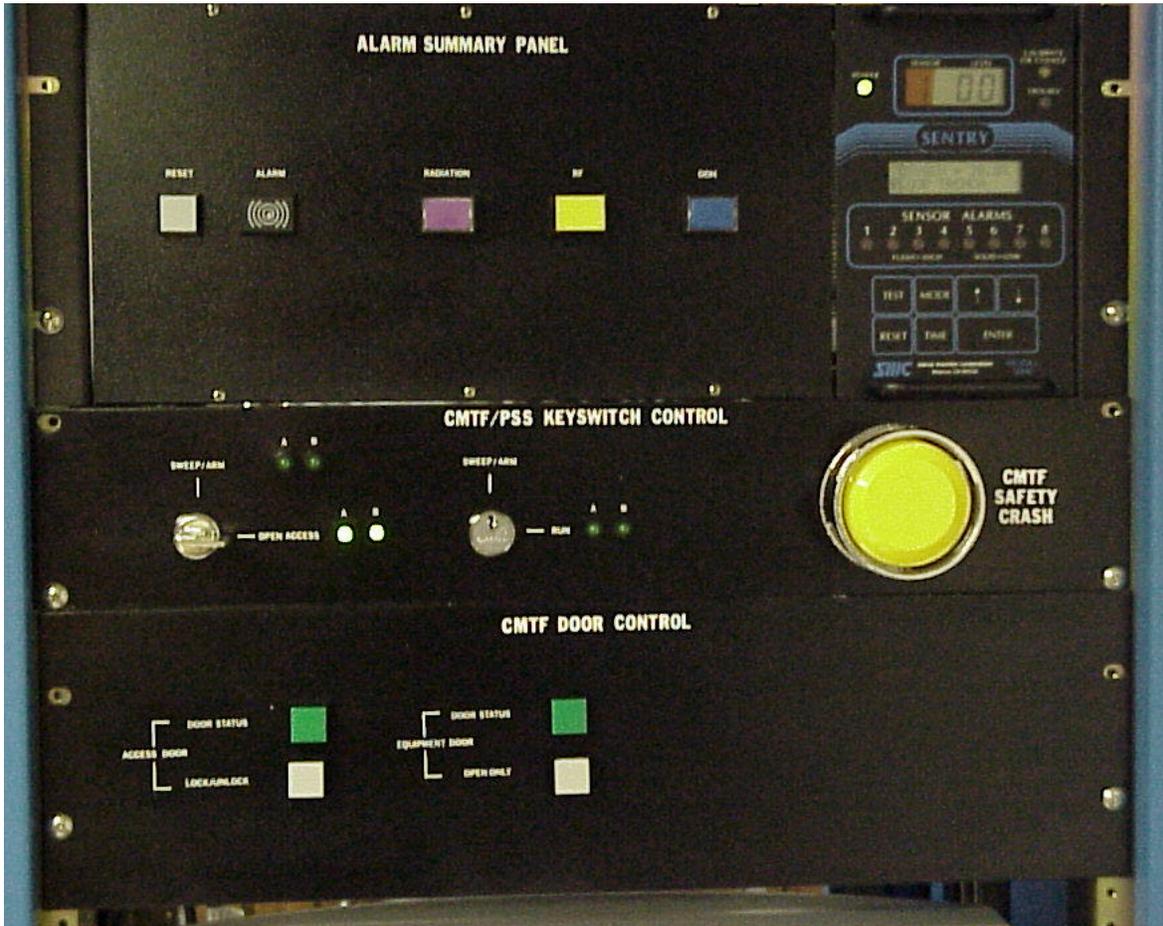
up as black rectangles at the end of a waveguide transmission line. If a predefined section of waveguide is removed, it will not be shown on the screen.

Triangles represent the high power RF amplifiers. A "Green" status means the amplifier does not have a "Permit" from the PSS. A "RED" status means the amplifier has a "Permit" from the PSS.

The waveguide configuration screen will also show the status of the couple probe test stand and the devices (load or short) connect to the test stand.

7 CMTF PSS Operator Control Panel

The CMTF Operator Control Panel is composed of the Alarm Summary Panel, the CMTF/PSS Keyswitch Control Panel, and the CMTF Door Control Panel. In addition, the CMTF Oxygen monitor front-end electronics is located on the right hand side of the alarm summary panel.



7.1 Alarm Panel

Alarms are group by major function – Radiation, RF, and ODH. When an alarm occurs the corresponding light will flash and an audible alert will sound. The audible alert may be acknowledged by pushing the “Reset” button.

The status of the radiation and RF alarms may be viewed on the PSS PLC screen. The status of an ODH alarm may be viewed directly on the front panel of the oxygen monitor electronics.

7.2 CMTF Keyswitch Control Panel

The Keyswitch control panel is used to change the state of the CMTF PSS operating mode, reset non-access control faults, and crash the CMTF and RF systems in an emergency. Green LED lights indicate the status of the CMTF PSS operating mode.

There are two keyswitches and one key used in the operation of the CMTF. The left hand keyswitch is used to switch between OPEN mode and SWEEP mode. The key can only be removed when in the “sweep” position. The same key is used for the sweep so that the CMTF cannot be accidentally switched to RUN while a sweep team is in the test cave.

When a sweep is completed the key is returned to the right hand key switch and used to set the operating mode to RUN.

If a non-access control fault occurs, such as a radiation monitor trip, the key must be cycled from RUN to SWEEP then back to RUN in order to reset the PSS system.

Note: Switching the keyswitch from Sweep to RUN starts a 30 second timer. RF may not be operated until the timer has reached 30 seconds.

7.3 CMTF Door Control Panel

The CMTF Door Control Panel is used to control the access status of the test cave doors and to indicate the status of the doors.

Personnel Door

The Personnel Door control switch toggles the personnel door magnetic lock on and off.

Note: the door is automatically locked during a sweep and when the CMTF is switched to RUN mode.

The Equipment Door control switch is used to open the door remotely from the control room. The door must be enabled in order to close the door before a sweep.

8 CMTF Operation

Operation of the CMTF and the CPTS involves setting up the proper RF waveguide configuration and securing of the CMTF test cave.

8.1 CMTF Operator Requirements

(Note these requirements are part of the CMTF SOP)

Be familiar with the safety aspects of CMTF and CPTS operation

Be familiar enough with the basic operation of the PSS to recognize unusual or hazardous states.

Be familiar with the sweep sequence

Be familiar enough with this manual to do basic troubleshooting of PSS problems

Be familiar with the waveguide switching arrangements and the administrative requirements for the various waveguide configurations.

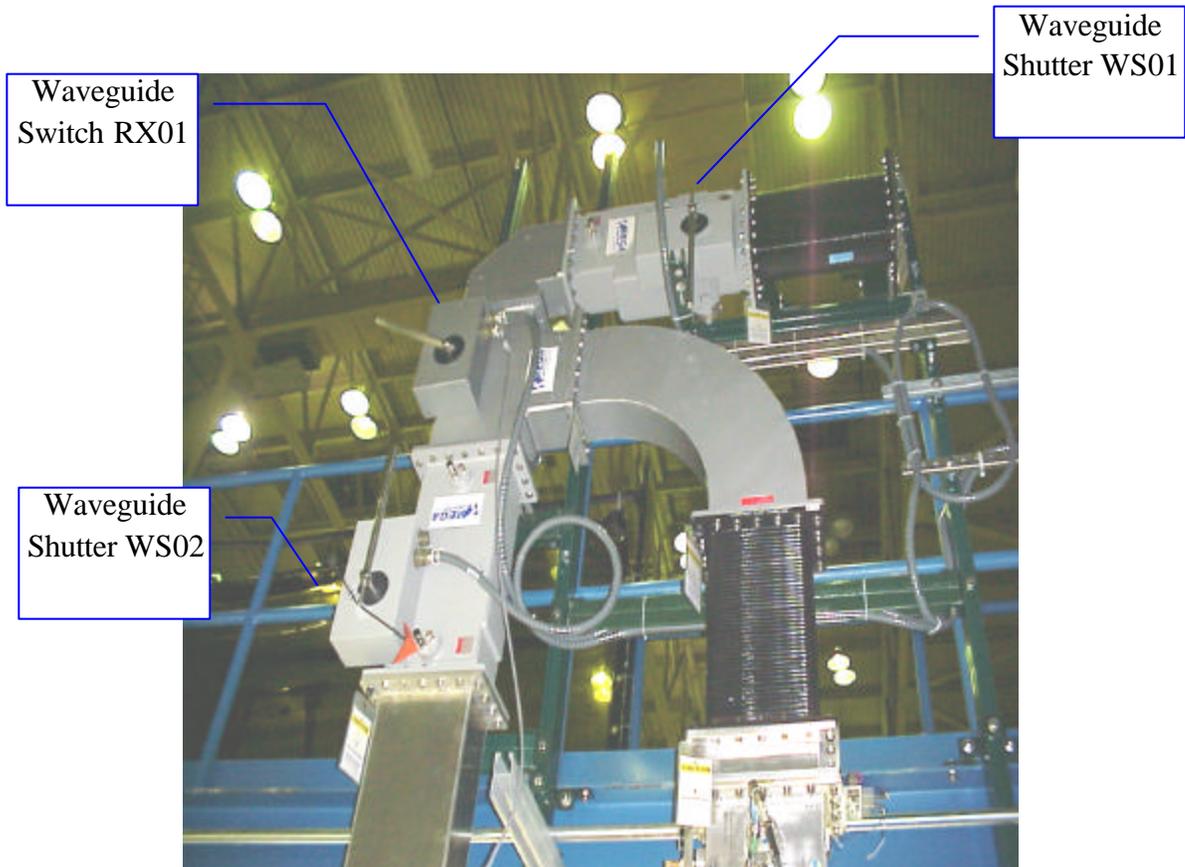
8.2 Waveguide Configurations

8.2.1 20kW/805MHz to CMTF

In this mode, RF will be operated from the 20 kW 805 MHz source. Waveguide in the mezzanine area must be configured to disconnect the 1MW source and connect the 20kW source to the CMTF. The waveguide switch RX01 and waveguide shutters WS01 and WS02 must be configured to block 1MW RF to the CMTF cave.

8.2.1.1 Switched Waveguide

The waveguide shutters and the waveguide switch have a Kirk-key locking mechanism.



8.2.2 16kW/1497MHz to CMTF

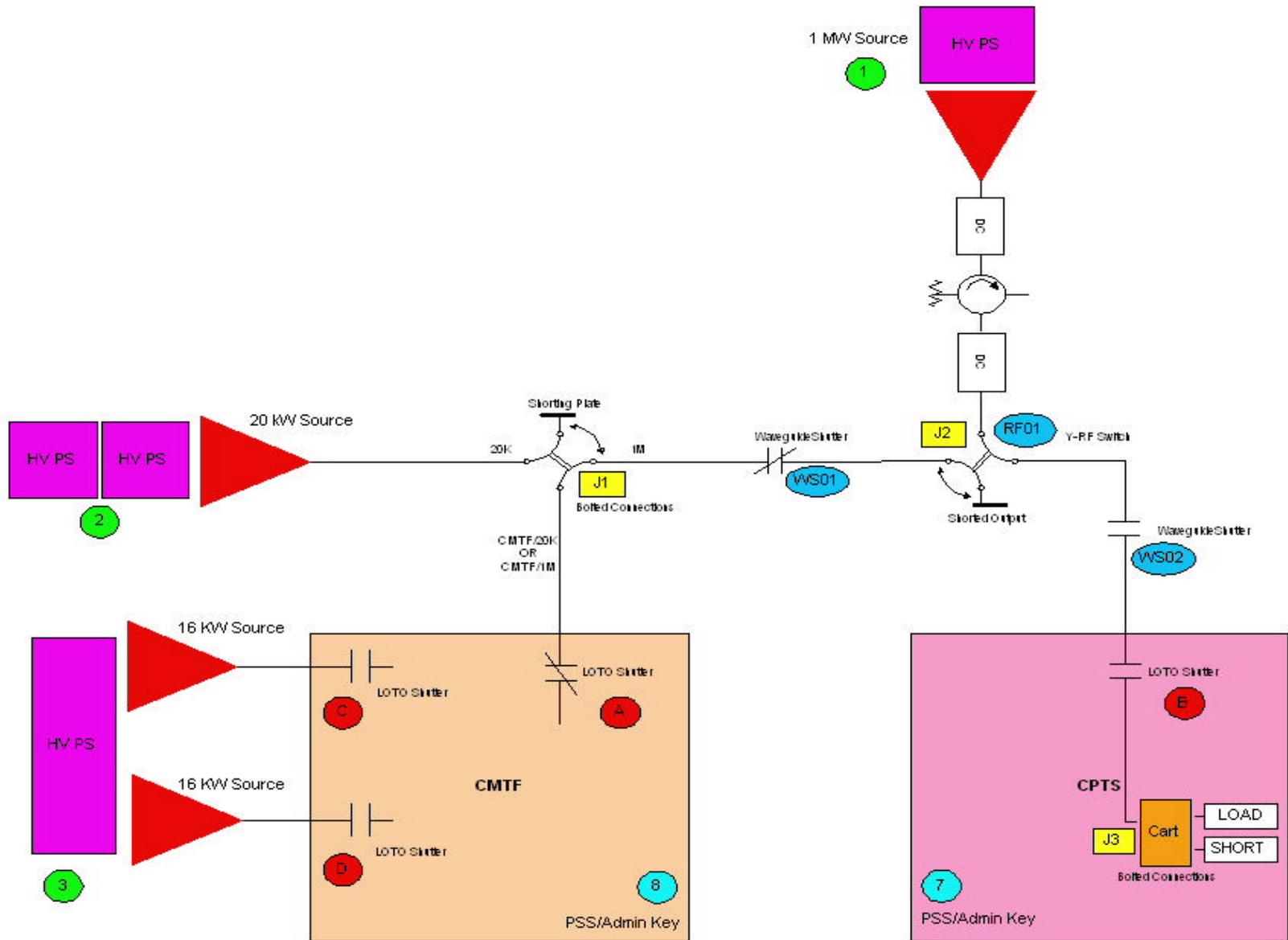
To be incorporated at a later date.

8.2.3 1MW to CMTF

In this mode the waveguide shutter system and the manually configurable waveguide are set up to block 1MW 805MHz RF to the coupler probe test stand and direct it to the CMTF cave. Waveguide switch RX01 and waveguide shutter WS01 must be in the “to CMTF” position, and waveguide shutter WS02 must be closed.

8.2.4 1MW to CPTS

This configuration directs the 1MW RF to the Coupler Test Stand and is discussed in section 10 of this document.



Waveguide Configuration Schematic

9 Operational Modes

9.1 Open Mode

Open mode is the default state for the PSS. In this mode all run/safe boxes are not armed and all RF source permits are OFF.

9.1.1 Preoperational Checks

In order to avoid having to resweep, the following preoperational checks should be made:

- Waveguide configuration
 - Check that waveguide is routed to desired destination. Failure to properly configure the waveguide may prevent the PSS from going to Sweep mode.
- Concrete door operation
 - Check that the door is enabled and can be closed
- ODH 2 classified area personal protective equipment
 - Check that escape packs are OK and the personal oxygen monitors work properly.

9.2 Sweep Mode

Notice: CMTF Sweepers **MUST** be ODH 2 qualified (see ref. CMTF operating procedures).

Prior to operation of the CMTF the beam enclosure is searched by 2 personnel. These “sweepers” ensure that no one is in the enclosure. One of the sweepers must have experience in sweeping the CMTF and must be familiar with the CMTF sweep pattern. The PSS users manual contains a map and directions that the sweep team may take with them to confirm the proper sweep procedure and pattern.

9.2.1 Duties of the Sweep Team:

The sweepers should ensure that the concrete equipment door at the west end of the test cave is closed. Confirm that the PSS screen indicates that the doors are closed and the PSS display and control panel LEDs read “Sweep Mode” for both systems A and B.

It is the duty of the sweep team to thoroughly search an area for personnel. During the sweep, the team members must assume that there may be personnel who did not hear announcements or are incapacitated.

The sweepers should not perform any other tasks when doing a tunnel Sweep. Once the sweep starts, a 10 minute timer also starts. If the sweep is not completed within 10 minutes, the sweep will drop and will have to be reswept.

At least one of the sweepers shall be a qualified lead sweeper. This is someone who is familiar with the sweep procedures for the CMTF and has swept the area at least once. A list of qualified lead sweepers is kept in the "sweep" section of the safety system user's handbook or on the safety system group's web site under User Documentation.

If anyone is found in the enclosure during a sweep, the person(s) must accompany the sweep team back to the CMTF control room. The lead sweeper or the principle investigator shall record the names of the personnel found during the sweep in the PSS logbook. The Principle Investigator shall then inform the safety systems group leader within one business day.

What happens if someone is in the test cave when it is switched to RUN Mode?

- In all areas the Run/Safe box lamps switch to “Unsafe”
- An alarm klaxon sounds for 30 seconds before any RF is enabled.

Personnel should immediately exit the tunnel, hitting the nearest crash switch on the way out.

If someone is present in the cave after a sweep is complete, it may be a DOE reportable incident. All operations must cease at once and assistance given to any injured personnel, if required. The Principle Investigator must write down the names of all personnel on shift and that of the person(s) that were in the cave. The Principle Investigator must then contact the accelerator division safety officer and the radiation control group leader for further instructions.

9.2.2 Sweep Procedure

Identify two ODH 2 qualified personnel as the sweep team

Equip the team with personal oxygen monitors and 5 minute escape packs

Walk through the test cave

- Ask any personnel in the cave to leave immediately
- Close the personnel access door (Do not lock it.)
- Close the concrete equipment door (Push the PSS door control button first. It should flash until the door is closed.)

Return to the control room

- Look at the PSS PLC screen.
 - Verify that the doors indicate they are closed
 - Verify that the 805 MHz waveguide is properly routed
 - Verify that the RF systems are OFF/Safe

Switch the PSS to Sweep and remove the sweep key

- Verify that the PSS changes to Sweep mode
- Take a copy of the sweep map if desired

Two sweepers exit the control room and enter the test cave through the personnel access door.

- Arm the first run/safe box at the equipment door
 - Verify that the Yellow “Operational” indicator is lit.
- Arm the second run/safe box on the south wall
- Both sweepers go up to the second level.
- Arm the third run/safe box on the north wall
- Descend the stairs and return to the personnel access door
- Arm the last box at the door
- Exit the test cave and return to the control room
- Place the sweep key in the right hand keyswitch

Once the sweep is complete and the sweepers have exited the test cave, the PSS will automatically go to “Ready” mode. Verify this on the PSS PLC screen.

9.3 Ready Mode

“Ready Mode” serves two functions. One – it is an indication that the CMTF sweep is complete. Two it serves as a mode that the PSS will drop to when there is a non-access control fault, such as a radiation monitor or a RF sniffer alarm.

9.4 Run Mode

In order to enter and remain in RUN mode, all interlocks must be OK.

To enter RUN mode

- Sweep the test cave
- Place the control key in the right hand key switch
- Turn the key to the “RUN” position
- The RF to CMTF timer will start
- After the timer has reached 30 seconds, RF may be turned on

If a RF or CARM trips the PSS, turn the key from RUN back to Sweep, then back to RUN in order to reset the fault.

9.4.1 Returning to Open Mode

- Turn off RF
- Switch cave to “Sweep”
- Remove key and insert in left hand key switch
- Switch cave to “OPEN” mode
- Press the Concrete Door “Open” button
- Press the Access Door maglock button to unlock the personnel door.

10 CPTS Operation

Coupler test stand operation consists of configuring the waveguide for operation to the test cart and enabling the 1MW source.



10.1 CPTS/PSS Keyswitch Control Panel

The CPTS keyswitch control panel serves two purposes. One it provides a convenient means to disable the 1MW source when not in use. Two, it provides a means for the operator to crash all RF sources if a problem is discovered.

In CPTS mode, the enable switch is used to reset a CPTS PSS trip. The 20-second delay timer also restarts.

10.1.1 CPTS Safety Crash

Hitting the CPTS crash switch will immediately shut off ALL RF sources, including the 20kW/805MHz and the 16kW-32kW/1497MHz systems.

10.1.2 CPTS Keyswitch

Note: The CPTS Enable Key Switch is NOT a substitute for personal lock out tag out.

The CPTS keyswitch is used to enable or disable operation of the 1MW source to the CPTS. It is also used to reset the CPTS PSS if a PSS fault has dropped the CPTS permit chain.

Switching the CPTS Keyswitch to "OFF" will disable the 1MW source ONLY IF it is configured to run to the CPTS. If the 1MW source is configured to run to the CMTF, the CPTS keyswitch will have no affect.

Once the CPTS keyswitch is set to "ENABLE" a 30 second timer starts. Once the time reaches 30 seconds, the 1MW source may be turned on.

10.2 Waveguide Configuration

To enable RF to the test cart WS02 is opened, WS01 is closed, and RX01 is in the "to CPTS" position. The test stand waveguide can be physically configured to drive RF into a Load or a Short. Either is acceptable to the PSS, and each is monitored with magnetic waveguide switches.

Revision History

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