HINS 325 MHz RF Component Test Cage Commissioning Procedure

Bob Webber
April 24, 2007,

Introduction

"RF Component Test Cage (RF Cage) commissioning is the activity of establishing RF power through the waveguide system, the waveguide shutter, and the waveguide-to-coaxial transition into the RF Cage. The commissioning includes verifying the performance and safety of these RF power distribution and control elements and of the Cage itself."[1]
This document details the steps to be performed for this commissioning task. This document is not intended to be a RF Cage operating manual nor does it describe procedures for testing particular RF components in the RF Cage.

Prerequisites

The Run Plan requires the following documentation prior to starting RF Cage commissioning. Check that these documents are available.

_____ Approved RF Cage interlock and search/secure procedures (by AD ES&H)
_____ Approved RF Cage LOTO procedure (use 325 MHz RF Power Distribution System LOTO Procedure ADDP-RF-7902, Beams-doc #2701)
_____ Approved klystron/modulator operating procedure (HINS White Binder in MDB)
_____ RF and Klystron Equipment Interlock Test Procedure/ Checklists for RF Cage commissioning (this document and klystron/modulator operating procedure)
_____ RF Cage commissioning procedure (this document)

Required Configuration for RF Cage Commissioning

The RF distribution system shall be configured such that RF power may be applied to all parts of the waveguide sections of the distribution system and to the 3" coaxial section of the system up to and including the coaxial switch and its immediately attached RF load.

____ 1. The waveguide switch shall be positioned (not necessarily locked) to direct RF energy toward the Cage.[2] (Note: subsequent to completion of klystron commissioning, operation into the RF load at the other position of the waveguide switch is acceptable, although it is not the position for RF Cage commissioning.)

[1] "HINS RF Commissioning Run Plan", Beams-doc #2616
[2] Waveguide switch shall be positioned to RF load for klystron warm-up prior to start of Cage commissioning

____ 2. The coaxial switch in the 3” coaxial line shall be locked in position to direct RF energy to the immediately attached RF load.

____ 3. Any section of the 3” coaxial RF distribution system attached to the remaining coaxial switch port shall be terminated in a suitable RF load or shall be blanked off at the end(s) with a conducting plate.

____ 4. The waveguide shutter shall be positioned open or closed as required by steps in this RF Cage commissioning procedure.

____ 5. The coax side of waveguide-to-coax transition inside the RF Cage shall be blanked off with suitable components to prevent electromagnetic radiation and to tolerate full reflection of > 600 kW 325 MHz RF power.

____ 6. The RF cage, an enclosure secured by an AD ES&H Dept. interlock system, shall be secured according to the interlock procedures.

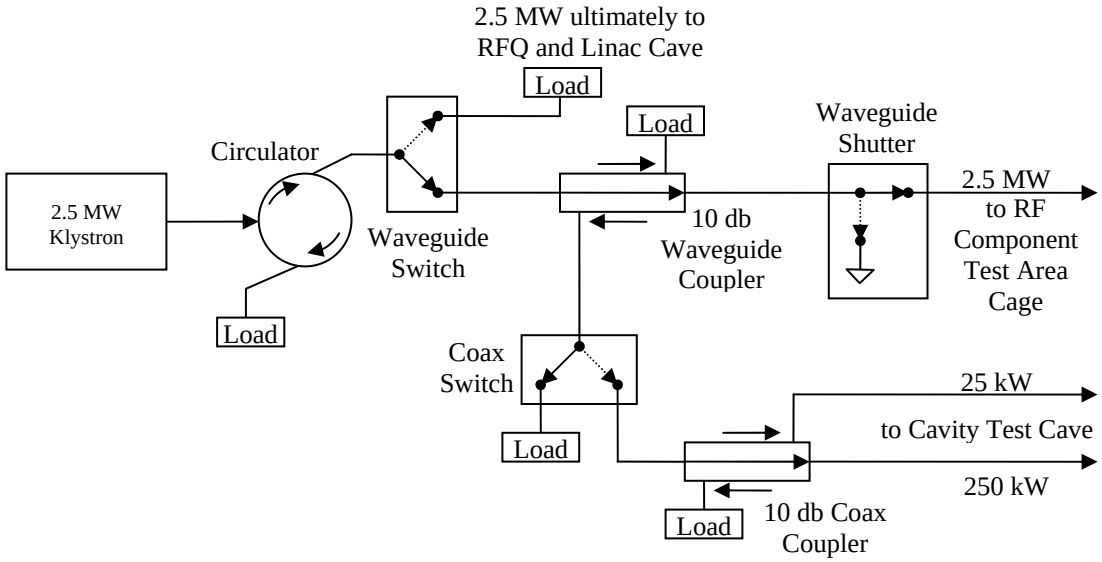

Figure 1. RF Power Distribution System

Power Limits for RF Cage Commissioning

Klystron output power shall not exceed 650kW at any time unless the waveguide shutter is closed. This limitation is set by coaxial components connected to waveguide-to-coax transition in the Cage. Note that this is also the maximum power anticipated for any future Cage operation.

Procedure

Warm Up Klystron

1. With waveguide switch positioned to direct the power into the immediately attached RF load, follow the klystron/modulator operating procedure to turn on and warm up klystron to full power with 3.5 msec RF pulse width..
2. Reduce klystron output level to <200 kW.
3. Turn off klystron/modulator.
    a. Set the waveguide switch to direct power toward the RF Cage.
    b. Make sure that the waveguide shutter is CLOSED.
    c. Make sure that 3 1/8" coax switch is in LOAD position.

Commission Waveguide Up to Shutter and 3 1/8" Coax Up to Coax Switch

1. Turn on klystron/modulator to <200 kW with power directed toward RF Cage.
2. Measure and record forward and reverse signal levels and computed forward and reverse power levels at the klystron output coupler. The klystron reverse power should be low, at least 20db lower than the forward power. If this is not the case, this must be resolved before proceeding.
3. Measure and record forward and reverse signal levels and computed forward and reverse power levels at the circulator coupler. The circulator forward power should agree closely with the klystron forward power measured in step #2. The circulator reverse power should be about 20% lower than the forward power. If this is not the case, this must be resolved before proceeding.
4. Measure and record forward and reverse signal levels and computed forward and reverse power levels at the waveguide coupler upstream of the waveguide shutter. The forward and reverse power levels should be nearly equal and should agree with the measured klystron output power to within ~10%. If this is not the case, this must be resolved before proceeding.
5. Measure and record forward and reverse signal levels and computed forward and reverse power levels at the waveguide coupler downstream of the waveguide shutter. The forward and reverse power levels should both be small, at least 40db lower than those observed upstream of the shutter. If this is not the case, this must be resolved before proceeding.
6. Measure and record forward and reverse signal levels and computed forward and reverse power levels at the 3 1/8" coax coupler immediately upstream of the 3 1/8" coax switch. The reverse power should be low, at least 10db lower than the forward power. If this is not the case, this must be resolved before proceeding.
7. Measure and record forward and reverse signal levels and computed forward and reverse power levels at the 3 1/8" coax coupler immediately downstream of the 3 1/8" coax switch. The forward and reverse power levels should both be small, at least 40db lower than those observed upstream of the coax switch. If this is not the case, this must be resolved before proceeding.

8. Using loop antenna, snoop around waveguide section joints looking for RF leaks. (This need be done only when running at 0.2, 1.0 and 2.5 MW power levels). If any particular joint is 20 db worse than typical of other joints commissioning should be halted until the problem is resolved or that it is determined safe to proceed.
9. Repeat steps 2-8 at klystron output power levels of 0.5, 1.0, 1.5, 2.0, and 2.5 MW while being watchful of possible sparking in waveguide and/or coax transmission line system. Any sparking must be resolved before proceeding further.
10. At klystron output power ~2.5 MW, measure the waveguide switch attenuation when in this position "Cage/Cave" position. Measure and record forward signal level and computed forward power level for the circulator output coupler. Measure and record forward signal level and computed forward power level for the coupler between the waveguide switch and the immediately adjacent load. The switch should provide >40 db isolation. If this is not the case, this must be resolved before proceeding.

Commission Shutter and Cage

1. Reduce klystron output level to <200 kW.
2. Verify power level at coupler immediately upstream of the waveguide shutter.
3. Turn off klystron modulator and open the waveguide shutter.
4. Turn on klystron modulator at same <200 kW power level.
5. Measure and record forward and reverse signal levels and computed forward and reverse power levels at the waveguide coupler upstream of the waveguide shutter. The forward and reverse power levels should be nearly equal and should agree with the measured klystron output power to within ~10%. If this is not the case, this must be resolved before proceeding.
6. Measure and record forward and reverse signal levels and computed forward and reverse power levels at the waveguide coupler downstream of the waveguide shutter. The forward and reverse power levels should be nearly equal and should agree with the measured klystron output power and with the coupler immediately upstream of the waveguide shutter to within ~10%. If this is not the case, this must be resolved before proceeding.
7. Repeat steps 5 and 6 at klystron output power levels of 400 and 600 kW while being watchful of possible sparking in waveguide and/or coax transmission line system. Any sparking must be resolved before proceeding further.
8. The RF interlock trip setting for the forward power coupler signal downstream of the waveguide shutter shall be adjusted to limit peak power at this point to <650 kW.

Definition of Completion of RF Cage Commissioning

With the waveguide shutter closed and the coaxial switch in the "Load" position, RF power shall have been successfully applied to the RF distribution system at 2.5 MW peak pulse klystron output power at 3.5 millisecond RF pulse length and with maximum duty cycle supported by the presently installed modulator charging power supply. RF power shall have been successfully delivered through the waveguide shutter into the RF Cage at 600 kW peak pulse power at > 1 millisecond RF pulse length and with maximum duty cycle supported by the presently installed modulator charging power supply.
AND under those conditions:

____ 1. Power level and timing controls have been demonstrated to operate as designed.
____ 2. RF equipment interlocks have been demonstrated to function satisfactorily.
____ 3. RF leakage from relevant sections of the RF power distribution system has been verified as acceptable within guidelines of Fermilab ES&H and Radiological Control Manuals and IEEE Standard C95.1.
____ 4. Waveguide shutter attenuation has been measured at klystron power of >2 MW.
____ 5. Power coupler calibrations shall have been established.
____ 6. Any sparking issues shall have been resolved.

AND an approved RF Cage operating procedure is available.