APS 350MHz RF SWITCHING SYSTEM

Sequence of Operations

The Advanced Photon Source utilizes five one-megawatt, 352-MHz klystron rf systems, RF1 through RF5, to produce rf power for the Booster-Synchrotron and Storage Ring rf cavities. RF1 through RF4 are dedicated to the Storage Ring, and RF5 is dedicated to the Booster-Synchrotron. The 350Mhz RF Switching System provides the flexibility to operate the Storage Ring with two, three, or four rf stations, depending on the rf power required. The system utilizes 3dB waveguide hybrid combiner/splitters to combine and split the rf power generated by the rf stations and delivers it to the accelerator cavities. The RF Switching System also provides the capability for one of the Storage Ring rf stations (RF3) to provide rf power to the Booster-Synchrotron in the event RF5 fails, and to allow RF1 to provide rf power for the 350MHz Test Stand.

The possible combinations of rf stations comprise twelve distinct modes of operation. These different modes require changes in the waveguide circuit configuration; interlock delegation, and low-level rf signal distribution to permit proper operation of the rf systems. The RF switching systems controls execute and verify the required circuit changes for each mode automatically in response to a manual operator command, and also provide continuous system monitoring functions. Motor-driven WR2300 waveguide switches are used to route the RF output of specific rf stations to the intended accelerator rf cavity, and take an rf system off-line in the event of a failure or maintenance. (See Fig.2) The motorize WR2300 waveguide shutters provide rf isolation in the waveguide system to prevent the flow of rf power through the waveguide when it is not desired. Motor-driven WR2300 phase shifters are utilized to correct for output port phase differences when the 3-dB hybrids are used as combiners/splitters with RF stations in parallel, or when a single RF system is used. (See Fig. 4) The cavity and klystron interlock signals for each RF system are routed and delegated respectively by the switching control system to insure that all interlock circuits required by the accelerator hardware are routed to the RF system supplying power to the accelerator cavities.

The heart of the RF system switching control is an Allen-Bradley programmable logic controller (PLC), which is interfaced to the existing RF system hardware by eight intermediate relay interface panels. (See Fig.1) The PLC accepts manual mode inputs from an operator via a key-switch panel, executes all necessary system changes required by the selected mode, and monitors overall system status.

1.0 Making A Mode Selection

Mode zero is automatically selected when no key is present. In this mode, the logic disables the RF power supplies, inhibiting all RF power. When selecting a different Mode, all RF power supplies must be off and no RF present in the waveguide before the PLC (Programmable Logic Controller) will switch modes. These conditions are indicated on the Allen-Bradley Panelview's General and Detailed System Status screens. The waveguide RF detectors are located in the rack labeled RF6- Rack 2. A red lamp lit on

any of the RF Detectors indicates RF is present in that port, and the RF detector indications are also located on the Detailed System Status screen. Before a mode selection can be made, the waveguide switched 120V and phase shifter switched 120V must be enabled. Keys for enabling a waveguide switch can be allocated through the MCR.

MODE SELECTION TABLE

Mode	Storage Ring Supplies	Booster Supply	Test Stand	Offline
1	RF1, RF2, RF3, RF4	RF5		
2	RF2, RF3, RF4	RF5	RF1	RF1
3	RF1, RF3, RF4	RF5		RF2
4	RF1, RF2, RF4	RF5		RF3
5	RF1, RF2, RF4	RF5		RF4
6	RF1, RF2, RF4	RF3		RF5
7	RF2, RF4	RF3	RF1	RF5, RF1
8	RF1, RF2	RF3		RF4, RF5
9	RF1, RF2	RF5		RF3, RF4
10	RF3, RF4	RF5	RF1	RF2, RF1
11	RF2, RF4	RF5	RF1	RF3, RF1
12	RF1, RF3	RF5		RF2, RF4

2.0 Confirmation of Subsystem Status

One second after a mode selection key is turned; the General and System Status screens will indicate the configuration for the Mode selected. Equipment will be set to the desired position and configured for the selected mode. Within the Detailed Status screen, a white box with an upper case M (Mode requirement) will appear next to each component position that requires a true condition for the interlock delegation. Next to each Mode requirement indicator a green status indicator must reside to satisfy the truth table. (See Fig.6) After all Truth Table = Output and Movement Timed Out indicators turn green, an enable is sent to the RF high voltage power supplies (shown on the General screen as External 5). Operations personnel can turn on the RF HVPS units manually at this point. (See Fig.5)

3.0 Equipment Photographs

Figure 1. WGSW Interlock Racks

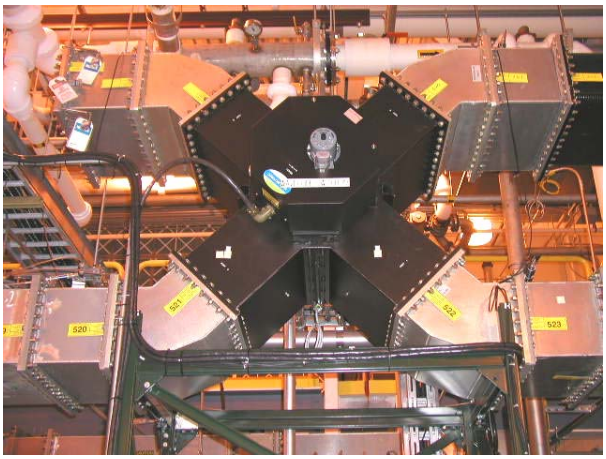
Figure 2. WR2300 WG Switch


Figure 3. WR2300 WG Shutters


Figure 4. WR2300 Phase Shifter

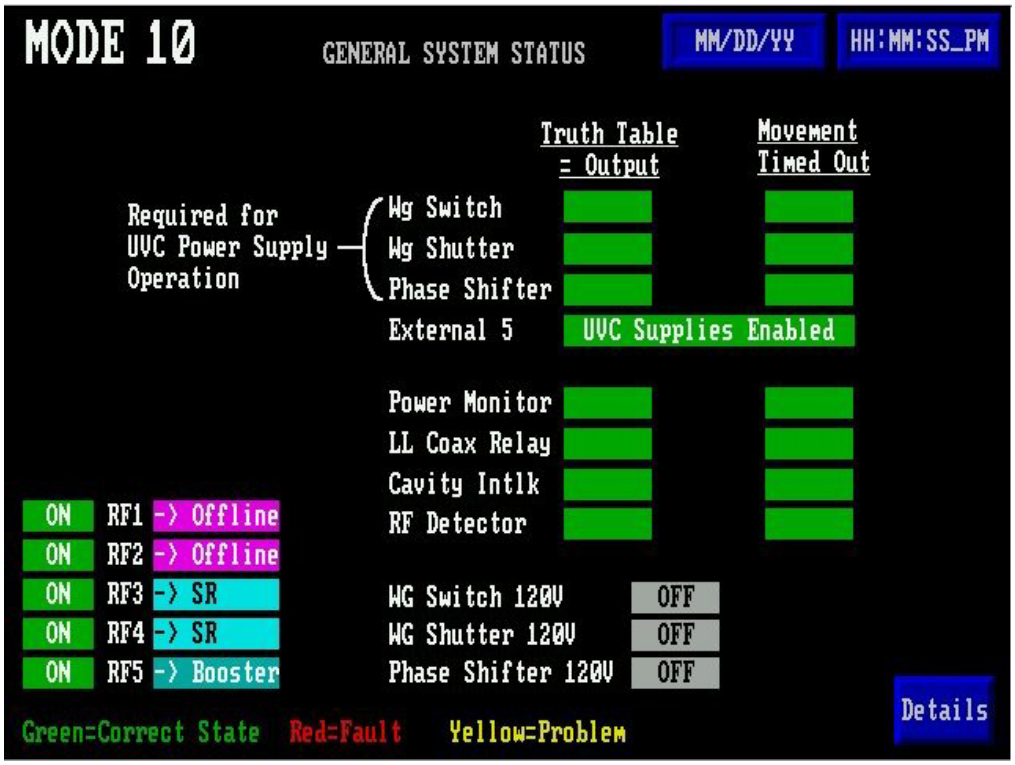

Figure 5. General System Status Screen – Normal Operations for Mode 10

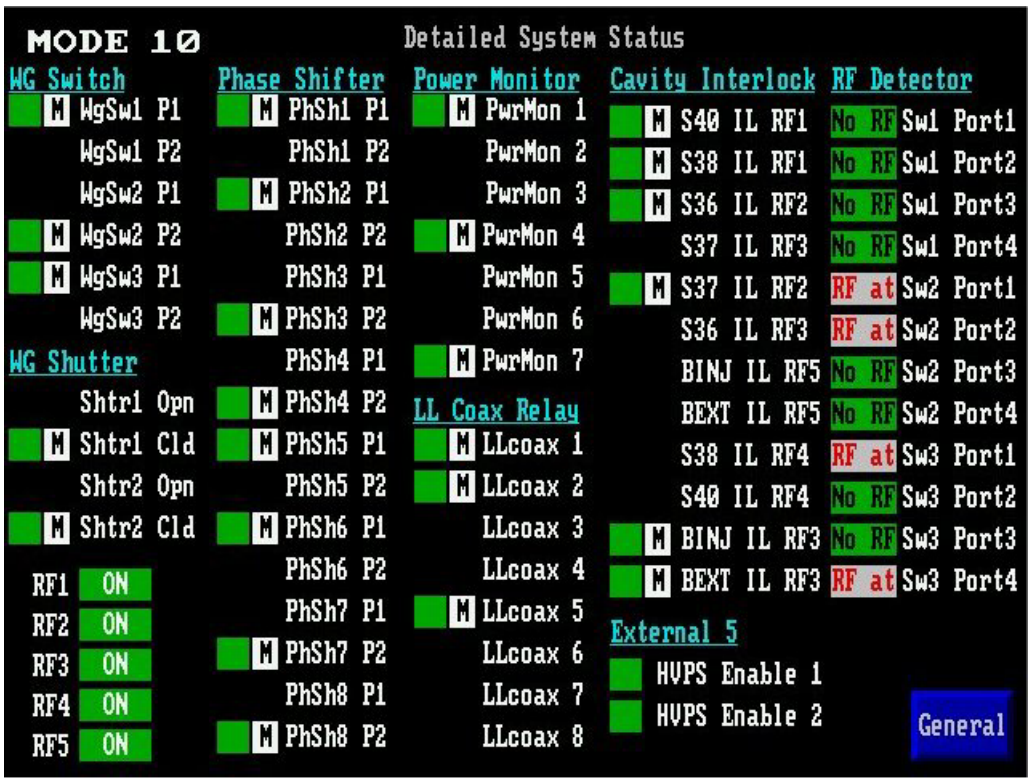

Figure 6. Detailed System Status Screen – Normal Operations for Mode 10

4.0 System Troubleshooting

Faults During Normal RF Operation:

If Mode 0 confirmation is achieved from the General Status Screen, a device may have faulted, and the RF HVPS enable will be removed. Check the General and Detailed System Status displays to make sure the power supplies are off and that no RF is present. The only conditions that disable the HVPS are faults within the WG Switches, WG Shutters or Phase Shifters. The General Status Screen will display a red fault indicator in the specific faulted device row and Truth Table= Output column. (See Fig.7)
In the Detailed System Status screen, the trip data is latched as a yellow indicator to help in identifying intermittent and true failure conditions. (See Fig.9)

Faults During Mode Changes:

A Mode 0 and selected Mode confirmation is achieved but the HVPS enable is not sent. This means that the cavity interlocks, power monitor, and low-level RF delegation relays are properly configured, and the controller is now waiting for the WG switches, shutters or phase shifters to complete their moves to the new Mode configuration. The General Status Screen will display a red fault indicator in the specific faulted device row and Truth Table= Output column plus a red fault indicator will appear in the corresponding Movement Timed Out column. (See Fig. 8) The trip data is latched as a yellow indicator in the Detailed System Status screen to help in identify the faulty condition. (See Fig.9)

The cavity interlocks, power monitor, and low-level RF delegation relays are switched automatically when the Mode keys turn and should complete their change in ~2 seconds. These motor-operated devices are switch in the following sequence: WG switches, WG shutters then phase shifters. The WG switches, shutters and phase shifters are allotted 6 seconds, 30 seconds and 240 seconds, respectfully to move into proper position.
The RF power supply enable is sent when all equipment on the general status screen turns green.

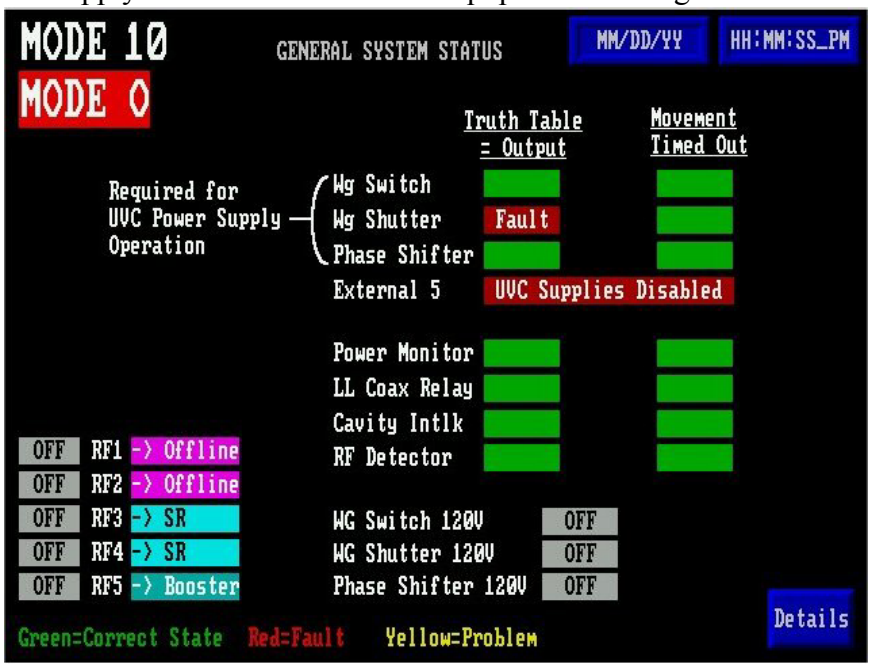

Figure 7. Mode 10 Operation Fault

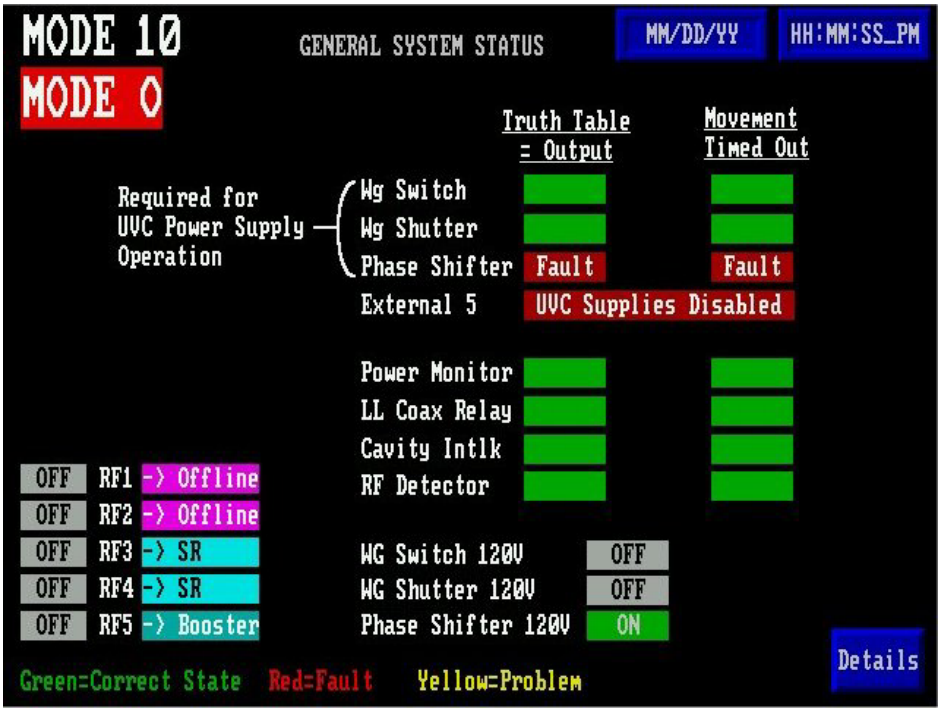

Figure 8. Movement Fault into Mode 10

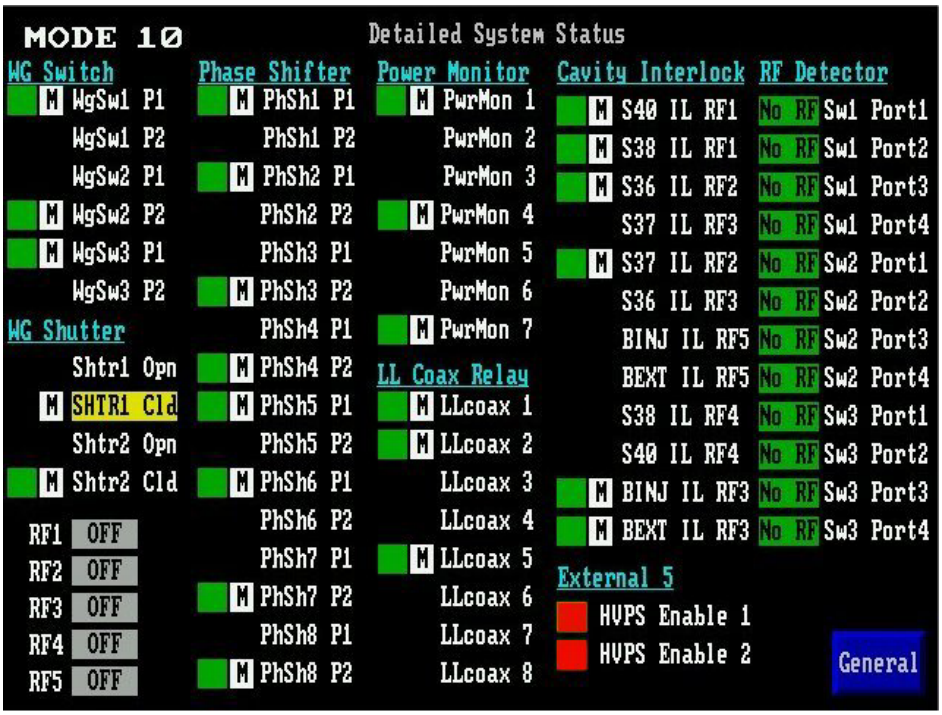

Figure 9. First Trip – Latched Fault Indicator