ISIS 2RF PROJECT OUTLINE

31 Mar ‘03

Introduction

The acceleration and bunching of the proton beam in the ISIS synchrotron is currently achieved by the use of six ferrite loaded, co-axial radio frequency cavities. These cavities operate over a swept RF range of 1.3 MHz to 3. 1 MHz, and are called the fundamental RF cavities. They each have two accelerating gaps and operate at twice the beam revolution frequency. The fundamental RF cavities allow us to trap and accelerate a proton beam with a maximum beam current of 200μA. This is delivered to the ISIS Target Station as a 10A proton pulse of duration 0.4 μs at 50 Hz.

Theoretical modelling has indicated that the addition of a second RF system operating at twice the frequency of the fundamental system will allow the maximum beam current of the synchrotron to be increased from 200 μA to 300 μA. This second harmonic RF system (2RF) consists of four ferrite loaded co-axial cavities operating over a frequency range of 2.6 - 6.2 MHz.

Hardware Description

The frequency, phase and amplitude of the ten cavity voltages must be controlled in a precise programmed manner to achieve the beam acceleration. This control is provided by complex Low Power RF (LPRF) electronics. The ferrite-loaded cavities are kept on tune using a bias current to vary the μ-value of the ferrite. This current, which varies from ~200 – 2000 A during the 10 ms acceleration period is provided by large banks of water cooled transistors known as the Bias Supplies. The cavity gap voltages, which vary from 0.1 – 12 kV, are provided by high power (250 kW) tetrode valves, two per cavity for the fundamental system and one per cavity for the 2RF system. These are known as the High Power Drives (HPD).

Schematics of an RF System and cavity are shown in Figure 1 and 2. The cavities and HPDs are situated in the synchrotron room and all other components are outside the shield wall to protect them from radiation damage. Vacuum pressure and radiation resistance requirements are achieved by the use of metal and ceramic, where possible, in the cavity and HPD. The power supplies for the Tetrodes are sited in Hall 2 (R5.4) along with the Bias Supplies (Fig. 3). The Driver Amplifier and some LPRF are sited in the centre of the Synchrotron Room. The rest of the LPRF is in the Beam Diagnostics room next to the ISIS Main Control Room. Many cables carrying signals and power are thus of considerable length.

Programme

The design, build and installation programme has been planned for completion in the ISIS Long Shut Down in 2003/04. However, it has always been stated that ISIS operation takes precedence over the 2RF programme and this results in changes to the available installation periods and to effort availability. The current date for the 2003 Long Shut Down is 11/10/03 to 3/4/04 and installation will be completed in this shut down. Much of the 2RF work can also be carried out during ISIS operation but both types of work are integrated into the required programme for keeping ISIS operating.

The work programme for the 2RF is controlled by four committees.

1. ISIS Management Committee Meeting
   Chairman (A D Taylor)

2. The ISIS Source Group Leaders Meeting
   Chairman (I S K Gardner) (D J S Findlay)

3. The Dual Harmonic RF Meetings.
   Chairman (W A Morris)

4. The ISIS Engineering and Installation Meeting
   Chairman (P E Gear)

5. ISIS Scheduling Meeting
   Chairman (I S K Gardner) (D J S Findlay)

A highly compressed project Gantt Chart is shown in Fig. 4. The detailed Gantt Charts and resource allocations are finalised at the ISIS Engineering and Installation Meetings.

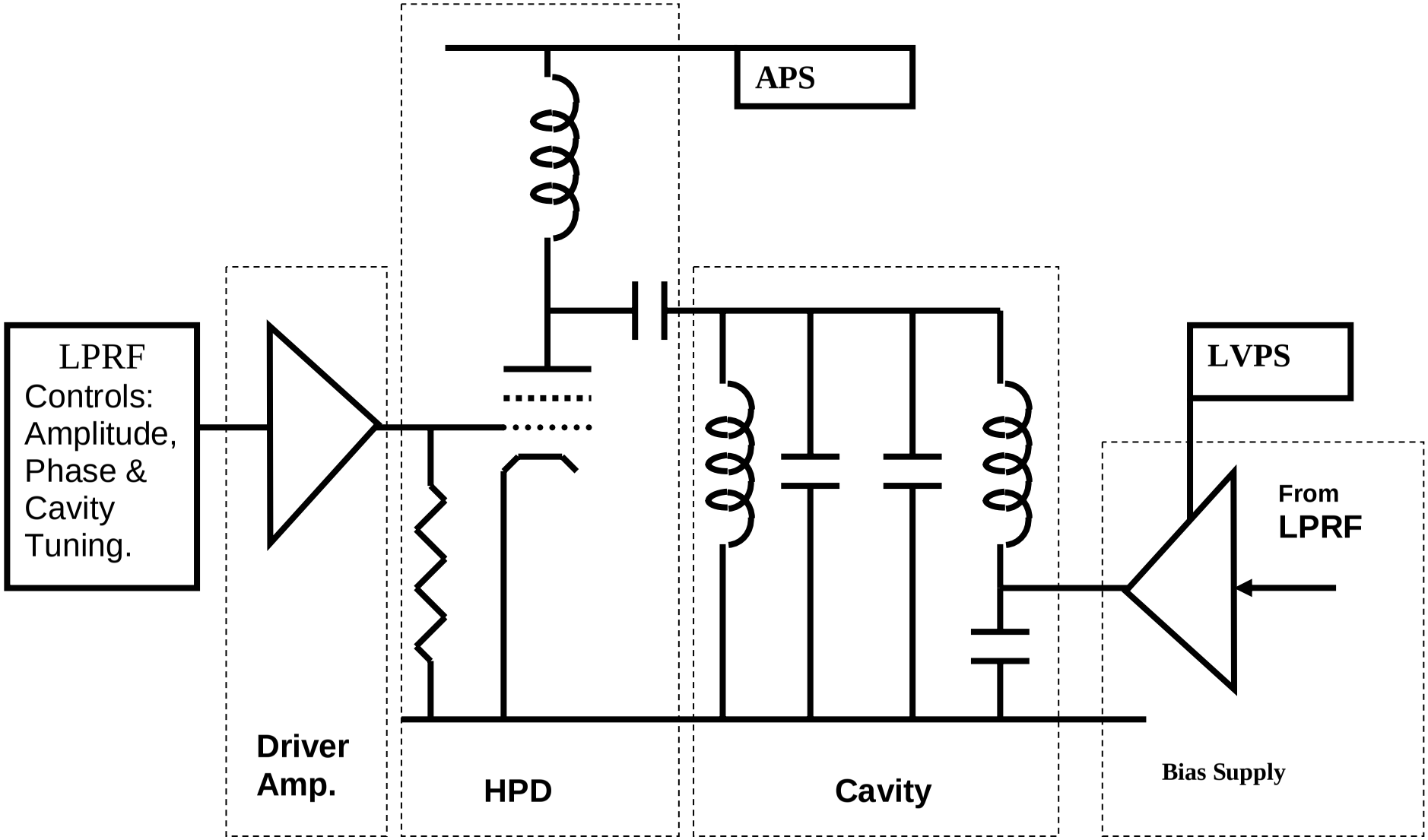

Fig.1: ISIS 2RF Schematic.

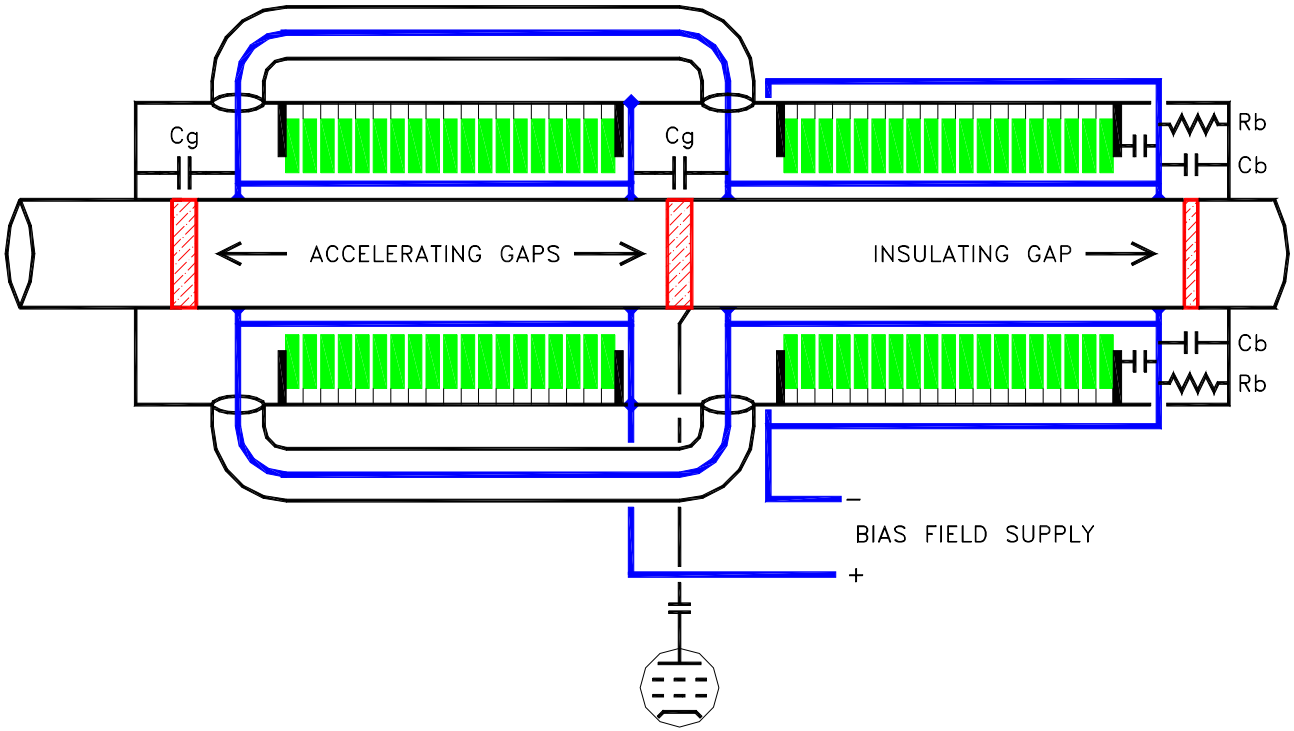

Fig.2: ISIS 2RF Cavity Schematic.

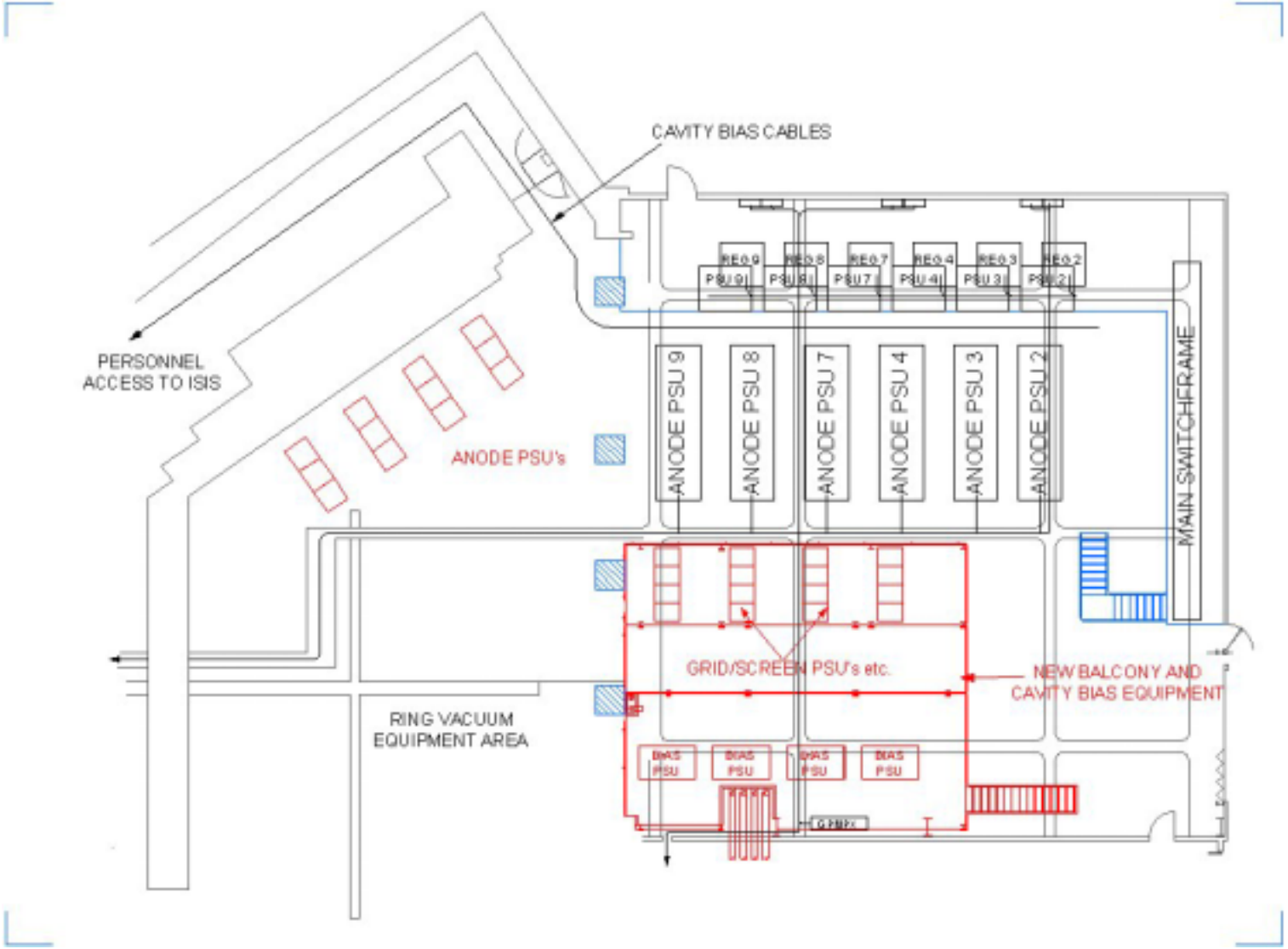

Fig. 3: Hall 2 (R5.4) Showing new Power Supplies and Bias Supplies.

ISIS 2RF PROJECT PROGRESS REPORT

31 March 2003
WA Morris

Introduction

Considerable progress has been made with the 2RF project since its start in 2000. Completion of the full four-cavity installation is expected at the end of the 2003/04 ISIS Long Shut Down.

1. Low Power RF

1.6 km of cable has been installed between the synchrotron and control room for the Low Power RF. Due to restricted access from R5.2 to R5.3, a 30cm diameter hole had to be drilled through 11 metres of concrete for the cable route.

The LPRF rack layout adjacent to the main control room

A large percentage of the LPRF modules have been manufactured and installed in the diagnostic room ready for commissioning. Two systems will be complete for early in 2003 and the remainder will be ready for the end of the Long Shut Down in 2004.

2. High Power RF System

2.1 High Power Drives (HPD)

	Ops	Spares
Number required	4	1
Built	2	
Installed	0	
Services completed	2	
Commissioned	0	

Each cavity is supplied with RF power from a 250 kW tetrode amplifier. The amplifier requires a high voltage supply from the APS (up to 20kV) and is housed with all the necessary support equipment. Five of the amplifier housings have now been manufactured and the installation of components is proceeding.

Assembling the first HPD

2.2 Low Power Driver

	Ops	Spares
Number required	4	2
Built	4	2
Installed	0	
Services completed	4	
Commissioned	0	

The Low Power Driver is a 500 W wide band commercial amplifier. Six have been purchased and tested. Cabling and racks are prepared for their installation in the centre of the synchrotron room.

3. Synchrotron RF Cavities

Number required	4
Built	3
Installed	2
Services completed	2
Commissioned	0

Ferrite and cooling pancakes have been manufactured for all cavities along with a supply of spares. These components are identical to those in the fundamental system. Two of the four cavities are now installed in synchrotron superperiod 5 (SP5) and 6 (SP6). The vacuum systems were completed to programme and the services are nearing completion.

SP6 with components removed and new base supports being installed

SP6 cavity installed and vacuum restored.

4. High Power RF Supplies

4.1 Hall 2

Most of the power supply equipment is located in Hall 2 (R5.4). To enable the siting of the power equipment a mezzanine platform was built. The platform houses the four LVPS bias power supplies and 16 racks for screen and grid power supplies for the Tetrodes in the High Power Drive (HPD) units. 10 km of power cables, control and interlock cables have been installed.

Hall 2 platform with racks for the HPD power supplies and controls

4.2 Cavity Bias Regulator LVPS

	Ops	Spare
Number required	4	1
Built	4	1
Installed	4	
Services completed	4	
Commissioned	0	

Hall 2 platform with two of the LVPS for the Bias systems.

4.3 Cavity Bias Regulators and Cables

	Ops	Spares
Number required	4	1
Built	5	1
Installed	4	
Services completed	3	
Commissioned	0	

The series regulators control the current to the variable bias field by altering the ferrite μ value. Four regulators are now in place and support services are being installed. Currents as low as a few amps and as high as several thousand amps will flow in this circuit. 4-core aluminium cables run from the Bias Systems to the cavities. The four cores are configured to keep the cable inductance value low.

The Cavity Bias regulators

The sixteen, 4-core aluminium cables that run from the Bias Systems to the cavities.

4.4 Anode Power Supplies

	Ops	Spares
Number required	4	1
Built	4	0
Installed	3	
Services completed	3	
Commissioned	0	

Four 20kV, 10Amp power supplies have been delivered and three are being installed in Hall 2. Small amounts of fitting are necessary to enable the HV cable to be connected to a dummy load where tests will continue to verify the power supply specification.

Two of the high voltage anode power supplies in Hall 2.

5. Power Transformers and Electrical Distribution

Number required	4
Built	4
Installed	4
Services completed	4
Commissioned	4

New power transformers (11kV/415V) and a 415V distribution switchboard were installed to meet the power demand for the fundamental RF and 2nd harmonic RF load. Work started in early January 02 and was completed during April 02.

The new outdoor transformer bay showing two of the four 1.5MVA transformers

New power cables have been installed to supply fundamental RF and 2nd harmonic RF equipment from the 415V switchboard. The power system is now energised and is supplying the fundamental RF systems.


New 415V distribution board in Hall 2 (R5.4)

6. Civil Engineering

The civil engineering has been completed for superperiods 5 and 6 in the synchrotron room. Superperiods 4 and 8 will be completed in 2003/4. The mezzanine floor in Hall 2 is completed along with the drilling of the cable duct from R5.2 into the synchrotron room. The remaining civil work is associated with cooling water supplies. This is a combined project with ISIS operations.

7. Target Station

The new section of Target Station reflector is now designed and out to manufacture. The delivery will be at the end of the financial year or possibly into next financial year.

Conclusion

No risk is currently seen to completion of the 2RF installation programme by the end of the Long Shut Down in 2003/04. However, the exact timing of the shut down may still be adjusted to optimise ISIS operation and the 2RF programme would then need to be adjusted to fit with this.

Summary of ISIS 2RF Project Progress

Major Components	Status
• Low Power RF	4 Systems manufactured 2 Systems installed 4 Service systems complete
• High Power Drives	2 Built and in test area 2 Service systems complete
• Low Power Drivers	4 Built ready for installation 4 Service systems complete
• RF Cavities	3 Built 2 Installed 1 Service Systems complete 1-- 90% complete.
• RF Power Supplies	4 Systems built and installed Services complete
• Bias Regulator LVPS	4 Built and installed All services complete
• Bias Regulators	4 Built 3 Installed 3 Service Systems complete
• Anode Power Supplies	4 Built 3 Installed 3 Service Systems complete
• Power Transformer and Switchgear	4 Systems installed and operational