Appendix I: Evaluation of the Present System

The evaluation of the present RF system consists of an overview of the present system limitations, and an estimate of the needed modifications for the control of the new c7−cell cavities**.**

1.0 Present System Limitations

1.1 Lorentz Detuning

The 7−cell cavities will have bandwidths of ≈70 Hz. The Lorentz force on the cavity at 15 MV/m detunes the cavity up to 6 bandwidths away from resonance. The present RF systems cannot operate beyond 1 cavity bandwidth (hardware limitation). This is a problem when going quickly from zero gradient to full gradient in the cavity. Should the need arise for RF pulsed operation, this problem worsens (Low Level RF Control System Requirements 3.x.x).

Refer to section on Low Level RF Controls (Low Level RF Control System Requirements 3.x.x)for tuning.

1.2 Gradient Dynamic Range

The present system, designed for gradients of 10 MV/m may saturate when operating the 7−cell cavities, with a design gradient of 12.5 MV/m. (Low Level RF Control System Requirements 3.x.x. The 7−cell cavities are likely to sustain gradients well above the design specification of 12.5 MV/m).

At present, adding attenuation to the cavity probe cables has allowed operations above 10 MV/m. Unfortunately this solution has the drawback of not having constant gain over the gradient range. This results in poorly regulated cavity fields at lower gradient, which becomes a problem for low energy operations. (Physics User Requirements 2.x.x).

1.3 Piezo Tuner

The present system only supports a mechanical stepper motor tuner. The new cavities will have both a mechanical and Piezo tuner (Low Level RF Control System Requirements 3.x.x). This necessitates the development of an add−on subsystem.

1.4 System Flexibility

A major drawback of the present system is its inability to allow changes to some basic system concepts concerning feedback (e.g. self−excited loop), which will make it easier to operate the high gradient cavities.

1.5 HPA/CPS Control Interface

In the present system, the HPA/CPS interfaces to EPICS through the RF interface. This dependency hinders the stand alone commissioning and maintenance of the HPA/CPS Controls. (HPA/CPS Control Requirements 4.x.x).

1.6 Control System Interface

The present system's interface to the control system satisfies Low Level RF Control System Requirement 3.x.x through a CAMAC interface. This interface is neither direct nor robust and definitely needs a redesign for a system whose lifetime should be longer than 10 years.

1.7 Maintenance

The present system uses custom in−house designed processor. The software maintenance of such a non−commercial component requires specialized talent and is not easily shareable among the general software population. (General Requirements 5.x.x Use commercial processors). The use of non−commercial components also requires specialization in hardware maintenance and demands talented labor.

The present system does not allow online maintenance. It is possible to bypass a cavity, but it is not possible to debug or repair the RF controls without removing the modules from the chassis (General Requirements 5.x.x).

1.7 System Life Span and Parts Availability

The present system is 10 years old and is rapidly approaching the middle of its useful design life span of 20 years. Parts for the system are becoming harder to find and consequently becoming expensive. This fact prompted a redesign of one sub−system, the RF Converter module, which reduced the component cost. It is possible to take a similar redesign of other sub−systems. Section 2 describes the costs associated with such an effort in detail.

2.0 Upgrading the Present RF Control Module for >12 MV/m Operation

There are eight hardware subsystems in the present RF control:

1. CAMAC crate controller and peripheral cards for tuners, ADC, DAC and digital input and ouputt,
2. Interface chassis containing arc/ir detectors,
3. MOPS, multiple output power supply, which powers the RF control module,
4. CPU (i186 microprocessor) board,
5. I/O board containing ADC, DAC and digital in/out,
6. Analog board, controls feedback gains for phase and amplitude,
7. IF board provides signal processing for phase and amplitude and
8. RF Converter board

Each subsystem will reach its planned lifetime in the next five to ten years. Some of the sub−systems are complex, or obsolete and require modifications. Included in each modification assessment are estimated labor costs to upgrade a subsystem. Material costs for the upgrade will eqaul the manpower costs.

2.1 CAMAC and Peripheral Boards

a. Eliminate the indirect CAMAC interface to the control system,
b. Replace CAMAC peripheral boards (DAC, ADC, digital in/out) with VME substitutes
c. Design and implement Peizo controller (hardware and software).

Costs
NRE: 1 man−year

2.2 Multiple Output Power Supply

This is a simple but important system, which supplies dc to the RF control modules. It also powers the cryomodule heater resistors. This may need a minor redesign with more efficient switching power supplies.

Costs
NRE: 1/4 man−year

2.3 CPU board

There are two basic limitations in this module; 1. The communication interface is convoluted and 2. It has very limited memory(256Kb?). Since the module resides in a custom back plane, it is not possible to buy a commercial unit. This is a major design task. (Low Level RF Control System Requirements 3.x.x, development environment)

Costs
NRE: 4 man−years

2.4 I/O Board

This board is the digital link to the rest of the control system. While redesigning the CPU board, it would be wise to upgrade this unit with more modern parts.

Costs
NRE: 3/4 man−year

2.5 Analog Board

The analog board is a tribute to what you can do with discrete analog IC's. It is an extremely complex system and is difficult to maintain. The module also contains a number of obsolete parts. The present module does not support feed−forward and RF pulsing (Low Level RF Control System Requirements 3.x.x and 3.x.x).

Costs
NRE: 1 man−year

2.6 IF Board

The IF board uses one multiplier (AD834) for most of the signal processing. It is still readily available and appears to be a mainstay for similar work for the next ten years. Since the time of the design of this board, (over 10 years ago), many IC vendors have designed signal−processing IC's that integrate into one IC the functionality that required multiple Ics on this board. A redesign with modern components will simplify the board and provide amplitude and gain control (Low Level RF Control System Requirements 3.x.x).

Costs
NRE: ½ man year

2.7 RF Converter Board

There is a new design of thos sub−system using more modern and inexpensive components. One item that still needs upgrade is the RF detector/oven assembly.

Costs
NRE: was ~ 1/3 man year
New design reduced the cost by ~ $2000/board (It used to cost $3000, now it costs $1000 per board).

3.0 Conclusion

From the above sections, it is clear that the present system shall not meet the requirements for energy upgraded RF system without significant changes. We believe that it is better to invest the effort and expense in a new design that will meet the requirements set forth in this document than to modify the present system.