RAMP MANAGEMENT in RHIC [*]

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Abstract

In RHIC, magnets and RF cavities are controlled by Wave Form Generators (WFGs), simple real time computers which generate the set points. The WFGs are programmed to change set points from one state to another in a synchronized way. Such transition is called a "Ramp" and consists of a sequence of "stepping stones" which contain the set point of every WFG controlled device at a point in time. An appropriate interpolation defines the set points between these stepping stones. This report describes the implementation of the ramp system. The user interface, tools to create and modify ramps, interaction with modeling tools and measurements and correction programs are discussed.

1 INTRODUCTION

As in all storage rings with energy ramping, magnet currents and RF parameters in RHIC must be ramped in a synchronized way. Because of RHIC's fast emittance growth at injection energies due to intrabeam scattering these ramps must be prepared before the rings are filled and executed as soon as the last bunch is injected. For that reason the control of magnets and RF is performed by WFGs.

Before a ramp can be loaded into the WFGs it must be specified. The input to this process comes from different sources. Initially, the specification comes from the design optics. Later, the operator may modify design parameters like tunes and chromaticities. An orbit correction procedure may supply new set points for the dipole correctors. Other correction procedures adjust the tunes, chromaticity, coupling, etc. All settings are not single values but functions of time and the change rate of the parameters is limited.

It is therefore necessary to provide an environment in which ramps can be created from a variety of sources.

2 ARCHITECTURE

The RHIC ramp system is shown in Figure 1. The central process is the "Ramp Manager" which is implemented as a CDEV[2] Generic Server[3]. The Ramp Manager provides an interface for various correction programs and for the "RAMP Editor". These Client applications are written using the CDEV Application Programming Interface (API) which gives a unified interface to accessing underlying services. The result is a "Ramp File" which is used by the "WFG Manager" to set up the WFGs. For each new ramp a new ramp file is created.

The ramp system allows also knobbing of parameters besides execution of programmed ramps. Similar to the ramp

manager, a "Knob Manager" creates a "Knob File" containing knob assignments and conversion constants.

The "WFG Manager" is used to download ramps and knob assignments into the WFGs. Monitoring and PLC control is performed by two "Magnet Managers", one for the Blue and one for the Yellow ring. Details are given in [1]. The AdoIf API is used to access the hardware.

Another service in this environment is the "Computational Modeling Engine" (CME) which is part of the RHIC/AGS Online Model Environment [4, 5]. The Ramp Manager provides the CME with a consistent set of magnet strength values. The CME provides optics parameters calculated from these values to correction programs and other applications.

3 STRUCTURE OF A RAMP FILE

A Ramp has to provide the set points of all magnets and RF devices as a function of time. This is implemented by defining "Step Stones", snap shots of all set points, and an appropriate interpolation between the Step Stones.

In the RHIC Ramp system a step stone is a data object which is independent of a ramp. It contains for each device a pair of strength parameters ("want" and "trim") which are independent of the beam energy: the deflection angle for dipoles, the inverse focal length for quadrupoles, etc. When the "want" parameter is fed to the CME service, it produces the "wanted" machine behavior. Because of machine imperfections, RHIC will display this behavior only if "trims" are added to the total strength value.

Step stones are referenced in ramps by the Stone name. A step stone can be used in multiple ramps and multiple times in one ramp. For example, the initial acceleration ramp references one step stone twice: at the start end the end of the ramp, since the device strength is independent of the energy. This allows storing the set points only once.

Since the set points of some devices change rarely and others often, step stones are split into six "pebbles": the BlueGlobal and YellowGlobal pebble contain the main diplole, quadrupoles, and multipole set points for the blue and yellow ring. The GreenGlobal pebble contains elements which are common to both rings. The RFGlobal pebble contains RF parameters. A step stone is therefore reduced to a reference to six pebbles. A pebble can be referenced in multiple step stones (Figure 2).

In between step stones cubic interpolation is used to calculate set points. However, the time is not used as independent variable, but a "pseudo time" P, which is a function of time. These power supplies are current regulated: a feedback system adjusts the voltage so that the requested current is maintained. By chosing a appropriate pseudo time
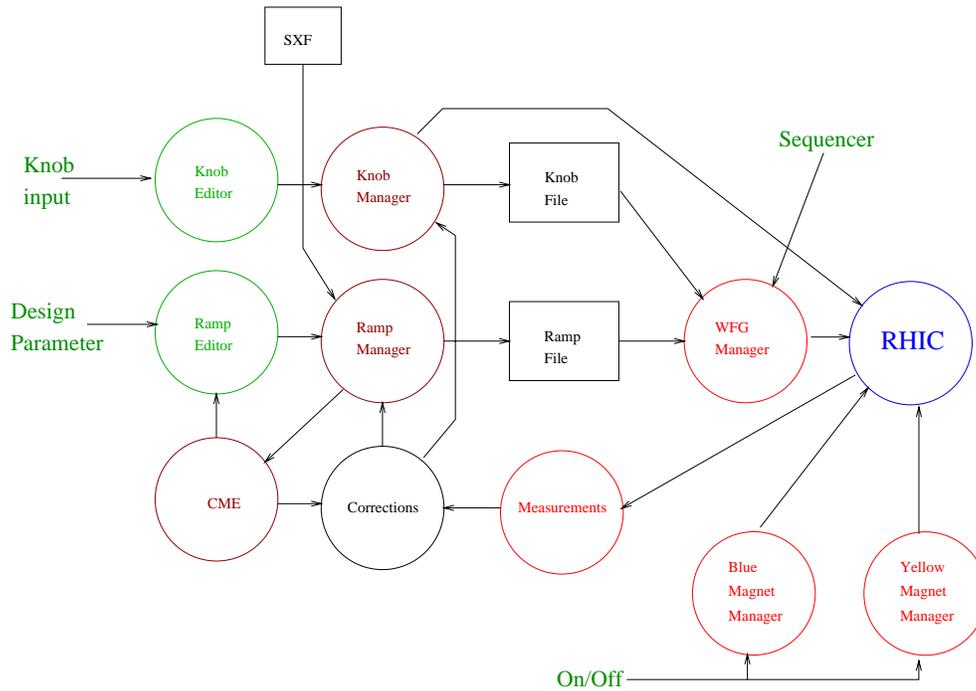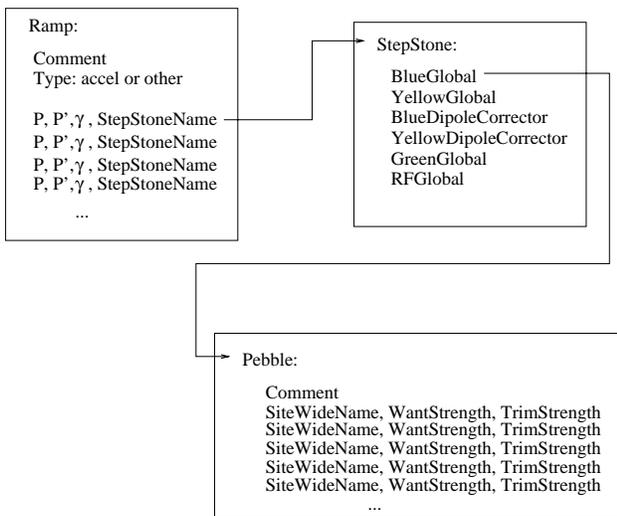
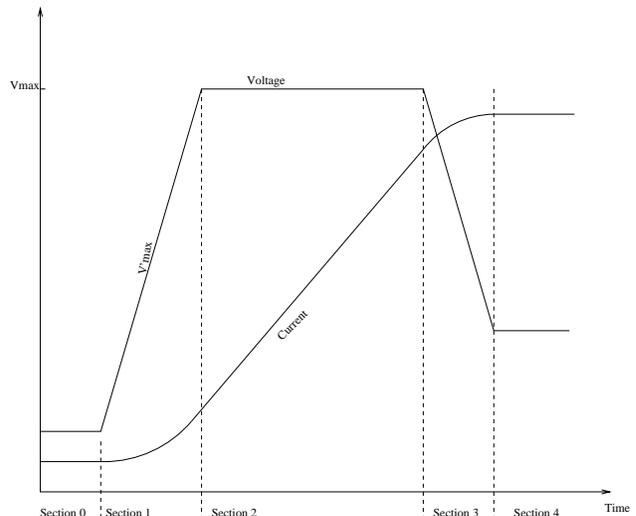Figure 1: Software Configuration.

Figure 2: Ramp File structure.

Figure 3: Current and voltage of a power supply during a ramp.

function regulation errors are avoided. We require that the voltage $V = R \cdot I + L \cdot \dot{I}$ is a continuous function with a maximum value V_{max} and a maximum slope $\dot{V}_{max}$. The shortest ramp of a magnet current is shown in Figure 3. The pseudo time function is calculated so that for each magnet the maximum $\dot{I}$ and $\ddot{I}$ is not exceeded.

Ramps and step stones are addressed by unique names, under which they are available as "devices" in the CDEV interface, and multiple ramps and step stones are available simultaneously.

4 RAMP MANAGER INTERFACE

Messages are available to create, clone, and modify ramps and step stones. On demandi, notification of changes are transmitted to interested clients by using the Generic Server callback mechanism. Applications using this interface include the RHIC Orbit Correction system, the RHIC injection system[6], and the ramping system editor GUI.

5 RAMP EDITOR

The user interface is implemented with the Tcl/Tk toolbox[7] which provides a flexible language for creating GUI applications. Windows for editing ramps and step stones are provided (see Fig. 4,5). the Ramp Editor allows changing high level parameters like tunes and chromaticities as well as set points. Step stones and pebbles can be copied from one ramp to another.
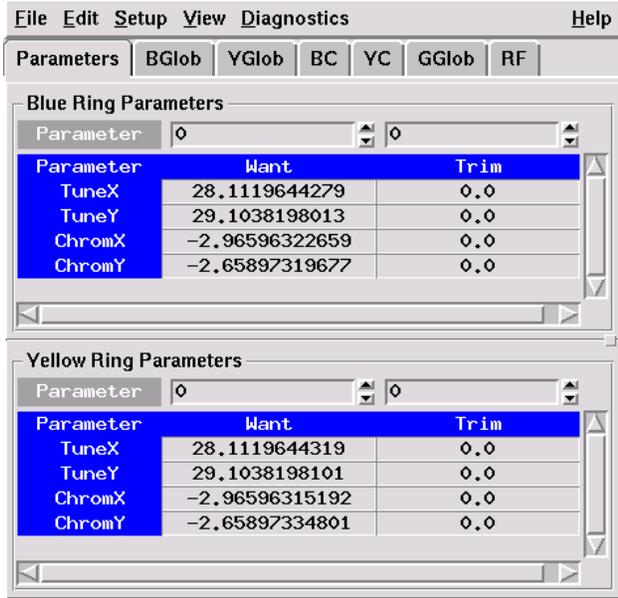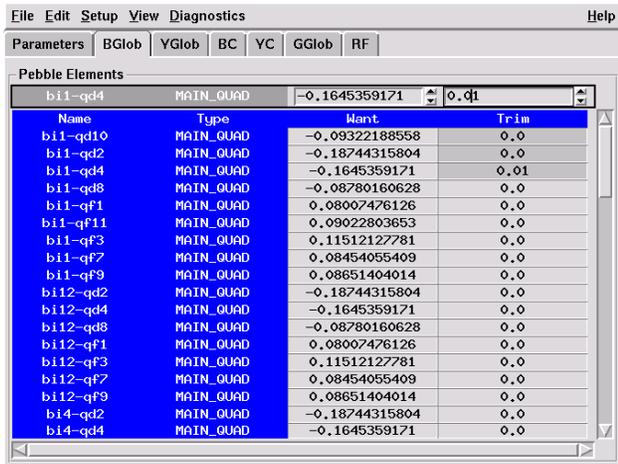

Figure 4: Step Stone parameter editing window.

Figure 5: Pebble Magnet parameter editing window.

6 MODELING INTERFACE

A on-line model server can be synchronized with a given step stone; conversely a step stone can be created from the magnet values in the model. Model parameters such as tunes, γ_t and chromaticity are retrieved from the model

and presented in the GUI. The editor allows small changes to these parameters, which are performed by retrieving a sensitivity matrix from the model.

7 KNOB MANAGER

During the time a ramp is playing, magnet strength can be modified dynamically using the Real Time Data Link system. The WFG's can listen to a maximum of 2 different frames changing at a maximum rate of 720Hz. The frames available for this system are managed by the "Knob Manager" which allows creation, modification, and activation of knobs. They are described in high level terms like "tune x", etc. and the required coefficients relating a change in a set of magnets to these parameters are retrieved from the modeling server.

8 CONCLUSION

The RHIC ramp system provides an environment for creating ramps from multiple sources. Ramps are described using high level parameters. Besides programmed ramping the system allows knobbing of parameters during and after ramps.

9 REFERENCES

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