AD/RHIC/RD–63

RHIC PROJECT

Brookhaven National Laboratory

RHIC Real Time Data Link System

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Introduction

Many magnet excitation currents will be related to the beam energy or similarly to the the main magnet current. In order to avoid adjustment of hundreds of excitation currents to track the main magnet dipole current, the control system shall provide for the distribution of real time data on the main dipole current and other parameters in a form that can be used directly by equipment control hardware. The Rhic Real Time Data Link (RTDL) broadcasts to all locations around the RHIC ring certain machine parameters of general interest to users and equipment. The information is broadcast on a serial link from a central facility located in the four O'clock equipment house. Each parameter is transmitted as a separate data frame with the following format:

*1 start bit
*8 bit parameter ID field
*24 bit parameter field
*1 parity bit
*1 stop bit

All data frames are transmitted every 1.39 ms (720 Hz.) on a 10 MHz self clocking serial link. The 8 bit parameter ID field permits up to 255 different frames to be defined. Each frame requires 3.5 us to transmit. The system transmits a continuous bi-phase mark "one" (10MHz carrier) during idle periods.

Hardware

The RTDL central hardware consists of a VME chassis, one encoder module; input modules and a front end computer (FEC) interface to the accelerator controls system. The Encoder and Input Modules are built using a 6U high by 4HP wide by 160 mm deep form factor. A standard 84 HP VME chassis provides sufficient space to support thirty RTDL frames. Additional frames can be added with extension chassis.

Data to be transmitted on the link can be input to the RTDL system from two sources:

1) directly to the individual input channels on separate serial fiber optic links from the various system sources or
2) written to the individual input channels via the VME interface

Separate registers are provided on each input channel for storing both the serial input and VME supplied data. The source of the data to be transmitted, either serial or VME, is selected by command to each input channel. A strobe, derived from the 720 Hz timeline event, simultaneously transfers the content of the selected data register for each input channel to its respective output register. The content of both the VME and serial registers may be read through the VME interface. The parameter ID for each input channel is jumper selected on the input module, and may be read by the FEC via the status register.

The serial output of the RHIC power supply waveform generator is format and data rate compatible with the serial input on the RTDL input module. Waveform generators used in

combination with the RTDL should be configured to operated at the 720 Hz rate. Data values calculated by the WFG at time "T" will be broadcast on the RTDL at time "T" + 2.8 ms.

The Encoder module contains a RHIC event/clock line interface and initiates the transmission cycle synchronous with the 720 Hz event. The module contains a list of all defined parameter ID codes. When the 720 Hz event is sensed by the Encoder circuitry, the RTDL parameter transmission sequence is activated and frames are output based on the list order on the encoder module. There is no system limitation that frames be transmitted in numerical sequence.

Distribution

The RTDL central facility drives a fanout/repeater module which provides multiple buffered TTL differential outputs. Some of these outputs will be used locally within the 4 o'clock equipment house, and others will drive fiber optic transmitters for transmission to other RHIC equipment locations.

At each RHIC equipment location, the optical transmission is converted to single ended TTL, regenerated (restoring wave shape and timing), and buffered as differential TTL. A fanout/repeater is utilized to generate multiple outputs. The RTDL system interconnections are point-to-point differential TTL. The RTDL repeater module is isolated from the receiving module by transformer coupling at the receiving modules input.

A Utility module with provision for the RTDL serial input will be included in each FEC chassis. The VME utility module will store in on board RAM memory the most recent values for all RTDL data frames received. Any VME process or program requiring RTDL data will be able to access individual frame data via a memory access to the appropriate address in the utility modules memory.

The RTDL decoder is implemented in a single gate array which can be incorporated on any custom module requiring RTDL data such as the RHIC waveform generator.

Utilization

The current plan for handling accelerator ramps in RHIC associates "primary" and "secondary" level waveform generator modules with input channels into the RTDL, on a one to one basis. Primary level values output from WFG's are put onto the RTDL to represent "pseudo-time" variables parameterizing a ramp, such as B (the dipole field in tesla) for the energy ramp, or Ts (the time after the ramp began) for the low beta squeeze. Secondary level values correspond to accelerator variables, such as GF (gradient in the F family of arc quadrupoles), or Vacc (voltage on RF accelerator cavities).*

The following table lists a preliminary set of pseudo-time and accelerator variables that will be broadcast over the RTDL. There will be one such variable for the blue ring, and one for the yellow (except, arguably for some of the pseudo-time variables). There are undoubtedly items missing from this list, such as RF variables, but it gives a feel for the scope of the problem.

Variable Name	Symbol	Units	Min	Max	LSB
Programmed Main Dipole Current	Ip	A	0	5500	3.27e-4
Programmed MDC rate of change	Ipdot	A/s	- 775	775	9.23e-5
Measured MDC	Im	A	0	5500	3.27e-4
Measured MDC rate of change	Imdot	A/s	- 775	775	9.23e-5
Main Dipole Field	B	T	0	3.5	9.08e-7
Main Dipole rate of change	Bdot	T/s	- 0.5	0.5	5.96e-8
Injection ramp time	Ti	s	0	10	5.96e-8
Transition jump ramp time	Tj	s	0	1	5.96e-8
Re-bucketing ramp time	Tr	s	0	1	5.96e-8
Low beta squeeze ramp time	ts	s	0	1000	5.96e-5
Reset Ramp time	T0	s	0	1000	5.96e-5
Arc F quad gradient	Gf	T/m	0	100	5.96e-6
Arc D quad gradient	Gd	T/m	0	100	5.96e-6
Gamma-T quad gradient 1	GGT1	T/m	- 5.0	5.0	5.96e-7
CQS skew quad gradient 2	GS02	T/m	- 5.0	5.0	5.96e-7
CQS skew quad gradient 3	GS03	T/m	- 5.0	5.0	5.96e-7
Triplet skew quad gradient 1	GTC1	T/m	- 5.0	5.0	5.96e-7
Triplet skew quad gradient 2	GTC2	T/m	- 5.0	5.0	5.96e-7
Triplet skew quad gradient 3	GTC3	T/m	- 5.0	5.0	5.96e-7
Triplet skew quad gradient 4	GTC4	T/m	- 5.0	5.0	5.96e-7
Arc F sextupole strength	Sf	T/(m^2)	0	1500	8.94e-5
Arc D sextupole strength	Sd	T/(m^2)	0	1500	8.94e-5
CQS F octupole strength	Of	T/(m^3)	- 1500	1500	1.78e-4
CQS D octupole strength	Od	T/(m^3)	- 1500	1500	1.78e-4
CQS F decapole strength	Df	T/(m^3)	-50000	50000	1.78e-4
CQS D decapole strength	Dd	T/(m^3)	-50000	50000	1.78e-4

*When using the WFG's in a hiearchical arrangement to generate RTDL data, care should be taken to evaluate the time delays that results from pipeline effects.