AUTOMATING POWER SUPPLY CHECKOUT*

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Abstract

Power Supply checkout is a necessary, pre-beam, time-critical function. At odds are the desire to decrease the amount of time to perform the checkout while at the same time maximizing the number and types of checks that can be performed and analyzing the results quickly (in case any problems exist that must be addressed). Controls and Power Supply Group personnel have worked together to develop tools to accomplish these goals. Power Supply checkouts are now accomplished in a time-frame of hours rather than days, reducing the number of person-hours needed to accomplish the checkout and making the system available more quickly for beam development.

INTRODUCTION

The goal of the Collider-Accelerator Department (C-AD) at Brookhaven National Laboratory is to provide experimenters with collisions of heavy-ions and polarized protons. The Relativistic Heavy-Ion Collider (RHIC) magnets are controlled by 100's of varying types of power supplies. There is a concentrated effort to perform routine maintenance on the supplies during shutdown periods. There is an effort at RHIC to streamline the time needed for system checkout in order to quickly arrive at a period of beam operations for RHIC. This time-critical period is when the checkout of the power supplies is performed as the RHIC ring becomes cold and the supplies are connected to their physical magnets. The checkout process is used to identify problems in voltage and current regulation by examining data signals related to each for problems in settling and regulation (ripple).

DESIGN PROCESS

Personnel in the Power Supply group provided the C-AD Controls Group with a description of the power supply pre-beam checkout process. Each power supply undergoes the same type of analysis. The power supply is first brought to nominal current. Then the technician watches the output of the power supply (digitized waveform on a workstation using a custom 'VirtualScope' process – which had been setup to acquire data at a desired rate of 10 kHz) for a few seconds to get an idea of how much ripple is seen in the signal, as well as the variation in the current. The technician then uses these results to make a determination if the supply has passed or failed its checkout. A failure would require more intensive testing.

Time estimates to manually perform the checkout process were on the order of four days. Two crews of two technicians worked full days (8-hour shifts) on the effort, or a total of 128 person-hours. The ultimate goal was to reduce the time needed to perform this checkout, allowing the hand-over of the power supplies to operations for the beginning of beam operations. This would also reduce personnel involvement in this repetitive task, thereby freeing up technicians for other tasks.

Meetings were held between Operations, Power Supply Group, and Controls personnel to determine the best way to pursue solving the requirements. From the start, it was clear that many tools that already existed could be used with minor adjustments to accomplish the goal.

The repetitive procedure performed on each power supply was a match for our custom sequencer application ('tape', tool for automated procedure execution [1]). A sequence could be developed to execute the following procedure for each supply to be checked: turn the supply on, set it to a nominal current, wait for it to stabilize, execute a process for data to be saved (the same data the technician saw on the 'VirtualScope' process) and analyze how it performed. Upon completion of sequence execution, a spreadsheet would be filled in with a summary of results of the checkout for the Power Supply Group.

All agreed at the initial meeting that the data to be saved and analyzed should be available for later review by the Power Supply Group. This would be necessary for confidence in the system. A system was already in place to save power supply data based on error states during operations. This data was available for viewing through a graphical interface. One thought was to use this system to save data based on a user request for a checkout. The checkout would store the current data collection rate, set the desired data collection rate, acquire and save the data, then restore the initial data collection rate as found. The checkout process would then analyze the data and store the results in a file for the sequence process to use in its pass/fail designation and summary.

IMPLEMENTATION

Clear requirements specified by the Power Supply Group made the sequence creation quite simple for our Operations Group sequence developer (Fig. 1).

The infrastructure already in place in the 'psSnapshot' System (which consists of a server, saving process, and viewer) was able to be enhanced to satisfy the requirements of the project: support for setting the desired data collection rate, collecting and saving the data, making it available for later review, and performing the

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analysis on the collected data (Fig. 2).

The result summary of the data is produced at the end of the checkout by the sequence process (Fig. 3).

SUMMARY

Multiple groups, working together, were able to produce an automated system for checkout of the RHIC power supplies. The total time required for the first automated checkout, with no experience by the Power Supply Group users, was two hours per RHIC ring (technicians monitored the progress simultaneous with the automated tools), or a total of four hours. The second time the checkout was performed, the time was reduced in half to one hour per ring, a total checkout time of two hours. The initial four days of delay to RHIC operations with beam was reduced to less than half a day, not taking into account power supplies that failed the analysis and required further investigation (which would be the same whether the checkout were performed manually or was automated). The Power Supply Group quickly gained confidence in the system delivered and recognized that it is more reliable than personnel performing this type of manual, repetitive checkout.

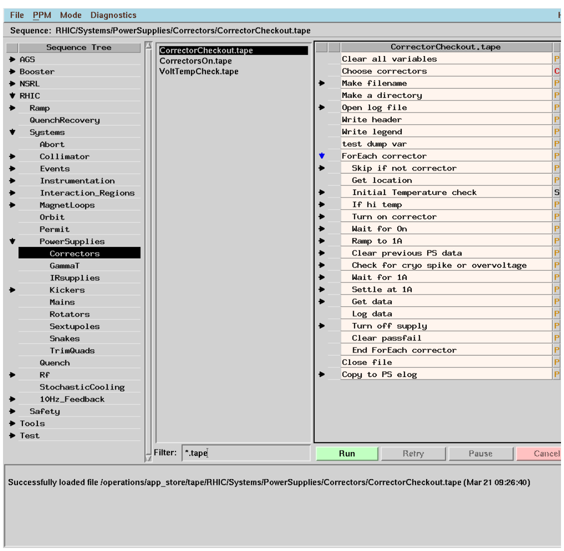

Figure 1: Corrector Checkout Sequence

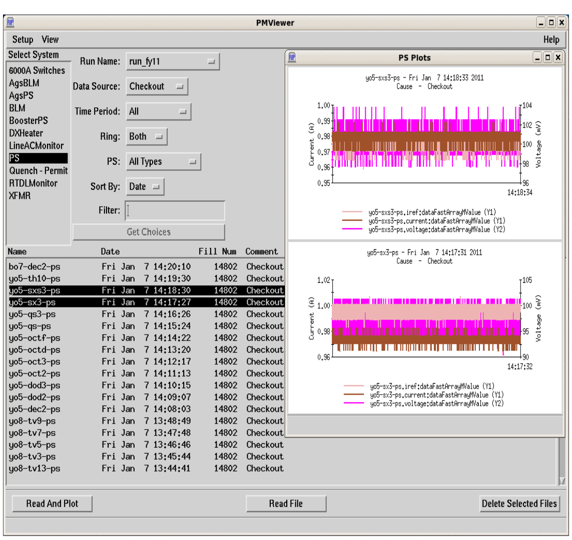

Figure 2: Checkout Stored Data

ADDITIONAL USE

The system delivered met the Power Supply Groups needs very well. The checkout system, developed for reducing pre-beam checkout time for RHIC startup, is now in use after each maintenance day (typically held one day every two weeks during operations). This provides the Power Supply Group with a basic level of confidence that the power supplies are ready for operations with a minimum level of checkout before handing over the system to Operations personnel.

REFERENCES

[1] T. D'Ottavio, J. Niedziela, "Using Sequencing to Improve Operational Efficiency and Reliability," ICALEPCS 2007.

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PSname	WFG-loopback(A)	Iref(A)	Current(A)	Voltage(mV)	AvgVolts(mV)	VoltsPeak-Peak(mV)	Oscillation	Grade
yo5-dec2-ps	1	0.87	0.86	86.79	86.17	14.65	na	[iref current]
yo5-dod2-ps	1	1	1.01	99.86	99.85	9.77	na	pass
yo5-dod3-ps	1	0.98	0.97	99.49	99.39	6.1	na	pass
yo5-oct2-ps	1	0.94	0.95	102.72	101.96	9.77	na	pass
yo5-oct3-ps	1	0.98	0.98	101.02	101.22	4.88	na	pass
yo5-octd-ps	1	0.97	0.94	151.64	151.18	6.1	na	voltage
yo5-octf-ps	1	0.89	0.85	155.82	155.37	7.32	na	[iref current volt
yo5-qs-ps	1	0.95	0.96	102.56	101.88	4.88	na	pass
yo5-qs3-ps	1	0.84	0.81	83.19	82.54	7.32	na	[iref current]
yo5-sx3-ps	1	0.99	0.97	96.91	97.08	10.99	na	pass
yo5-sxs3-ps	1	0.97	0.98	100.78	100.44	6.1	na	pass
yo5-th10-ps	1	0.93	0.93	36.27	35.86	7.32	na	pass
yo5-th12-ps	1	0.96	0.95	10.65	10.16	7.32	na	voltage
yo5-th14-ps	1	0.92	0.95	14.76	14.16	10.99	na	voltage
yo5-th2-ps	1	0.92	0.91	90.73	89.79	7.32	na	pass
yo5-th4-ps	1	0.91	0.92	66.63	66.18	8.55	na	pass
yo5-th6-ps	1	0.97	0.96	90.51	90.06	9.77	na	pass
yo5-th8-ps	1	0.93	0.99	66.99	66.73	7.32	na	pass
yo5-tv11-ps	1	0.91	0.95	21.64	21.22	9.77	na	pass
yo5-tv13-ps	1	0.91	0.96	15.09	14.72	7.32	na	voltage
yo5-tv3-ps	1	0.92	0.91	87.2	86.37	4.88	na	pass
yo5-tv5-ps	1	0.93	0.93	75	74.52	6.1	na	pass
yo5-tv7-ps	1	0.99	1.02	82.72	82.91	9.77	na	pass
yo5-tv9-ps	1	0.96	0.93	49.2	48.57	23.19	na	ripple

Figure 3: PSCheckout Summary