DESIGN AND STATUS OF THE BPM RF REFERENCE DISTRIBUTION IN THE SNS*

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Abstract

The Spallation Neutron Source (SNS) is an accelerator-based neutron source being built at Oak Ridge National Laboratory. The BPMs (Beam Position Monitors) requires RF reference signals to measure the phase of the beam with respect to the RF. In the MEBT (Medium Energy Beam Transport) Line and in the DTLs (Drift Tube Linac Cavities) are cavities that accelerate and bunch the beam at 402.5 MHz. In the CCLs (Coupled Cavity Linac) and SCLs (Superconducting Linac) accelerate the beam at 805 MHz. To mitigate effects of RF leakage into the BPM electrodes it is required to measure the phase in the MEBT and DTLs at 805 MHz and in the CCL and SCL at 402.5 MHz. We are directly connected to the RF group MO (master oscillator) and send these signals along the entire linac using fiber optic technology. Schematics, measurements, and installation update are discussed.

SYSTEM HEADER LAYOUT

A schematic for the RF header is depicted in Fig. 1. The signals are brought in from the LLRF MO (master oscillator) and distributed to DTL Row 7 LLRF box. The signals are then split and amplified to be transmitted to the MEBT and DTL BPMs.

The RF to Fiber transmitter was chosen for its temperature stability and bandwidth. A separate transmitter was chosen for each frequency, and therefore four transmitters were installed. The model number of transmitter is the Miteq LBT-HP-10M3G-25-15-M14. This particular transmitter has a bandwidth of about 5 GHz and is temperature stabilized. The transmitters that were implemented were a new variety of transmitters by Miteq and the part numbers of the transmitters are not typical of temperature stabilized transmitters. [1]

The fiber from the transmitter was fusion spliced to the fiber splitters using a Fujikura FSM-40s Kit. This particular model measures the loss of the splice after the fusion process and success was declared when the splice had a loss of 0.04 dB or better. The fiber was cleaved using a CT-04b cleaver, which can be phase matched to about 40 picoseconds.

The installed fiber splitter is the JDS Uniphase DWBW3F4S12370, which is a standard 13 dB coupler of

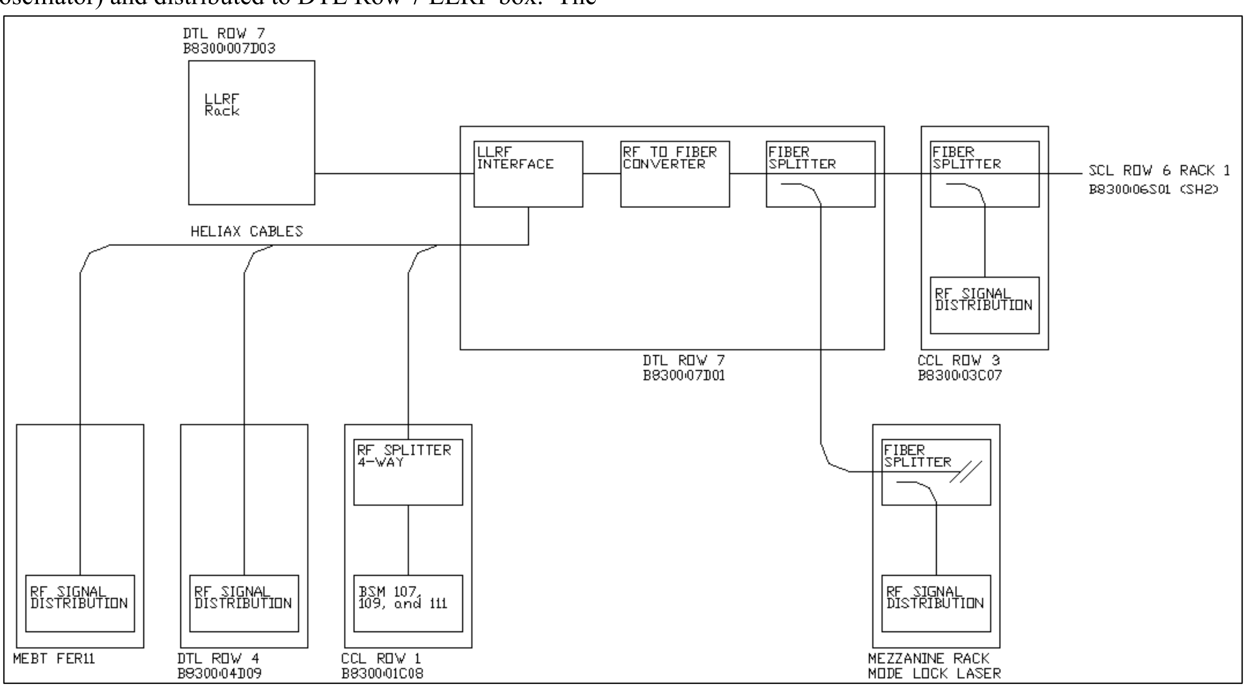

Figure 1: Diagnostics RF header distribution

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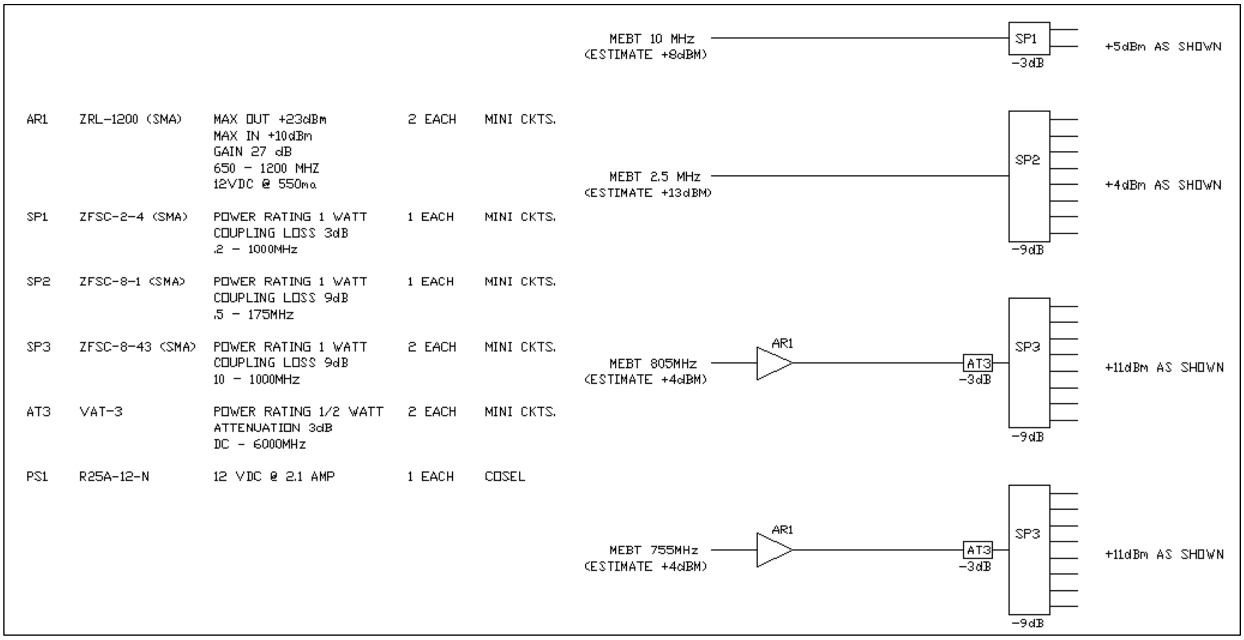

Figure 2: MEBT and DTL RF distribution schematic

95% thru transmission, 5% tapped. The output of the splitters is fusion spliced to the Single Mode, 24 Count Plenum fiber OCC part number- DX24-085D-SLS/900-OFNR. This fiber has a negative coefficient of expansion for phase stability over temperature fluctuations in the RF gallery.

MEBT AND DTL DISTRIBUTION

A schematic for the MEBT distribution is shown in Fig. 2, and the DTL distribution is topologically similar.

To meet schedule and commissioning milestones, it was chosen to install these systems using a standard copper transmission media. The losses of each cable was measured so that the final signal level delivered to each BPM chassis is between 0 and 11 dBm.

Since the BPM system has strict requirements for phase stability and relative/absolute accuracy, all the cables were absolutely phase matched going into each BPM chassis.

CCL AND SCL LINAC DISTRIBUTION

The CCL and SCL linac distribution is fundamentally identical as shown in Fig. 2 except that the RF timing signals are distributed via fiber, and the distribution frequencies are different.

The fiber is routed into a Telinks-RAC24X-24SCAPC-PL-2T-MOD-REV1, which has 24 fiber ports pre terminated and has the optical splitters pre-mounted. This permits a quick installation as this is an industry standard.

The signals are detected using a fiber receiver, the Miteq LBR-10M3G-10-20-10. This receiver uses the APC connector and therefore the panel on the distribution chassis is an SC/APC.

SYSTEM PERFORMANCE

The performance of the Diagnostics RF distribution was measured to understand the implications of jitter or phase noise that is induced into the beam phase measurements.

The specification of the BPM system is to measure the phase of the beam to +/- 2 degrees. Concerns therefore about phase noise injected into the RF timing system as a result of using long heliax cables or fiber optic transmitters/receivers have a real implication on system performance.

The phase noise and jitter of the RF distribution was measured using an Agilent E4440A spectrum analyzer with a phase noise option and with a Tektronix TDS8000B digital sampling oscilloscope. The measurements between each of these instruments showed similar results to within a few percent, though the results could not compare to the data supplied by the manufacturer of the oscillator, Wenzel Associates. [2]

The measurements of the phase noise did, however, show that the measured phase noise of the signals supplied by the master oscillator from the low level rf rack were not appreciably increased, to the accuracy of the measurement system, by going through a series of low level amplifiers or the fiber optic system.

A table of the measured jitter versus position is shown in Table 1. The measurement of the jitter of the master oscillator is shown in the first column. One assumes that the jitter should increase as one measures the jitter in the MEBT or in the CCL racks. Note, however, that the MEBT does not contain the 402.5 and 352.5 MHz signals, and the CCL does not have 755 and 805 MHz signals, ,so these measurements are not applicable.

Table 1: Jitter Measurement Comparison

Frequency	LLRF MO	MEBT Heliax	CCL Fiber
2.5 MHz	37.9 ps	41.7 ps	40.8 ps
10 MHz	11.4 ps	10.5 ps	11.2 ps
352.5 MHz	313 fs	n/a	317 fs
402.5 MHz	274 ps	n/a	196 fs
755 MHz	163 fs	195 fs	n/a
805 MHz	163 fs	179 fs	n/a

SYSTEM ISSUES

The system was initially installed without any thermal insulation or active thermal ovens. It was observed that the fiber transmitter and receiver pair, though thermally compensated, has a time constant of about two minutes and the phase of the measurement would change by about 1.2 degrees. This was not observed, however, using the copper distribution at an even higher frequency and over a longer distribution length where the phase would change the most.

Studies are taking place to help mitigate this phase oscillation. Two different paths to solution involve a) placing a small piece of thermal insulation placed over both the fiber transmitter and receiver in order to help maintain temperature stability or b) placing a bigger heat sink on the fiber transmitter. Discussions with the manufacturer Miteq are also taking place so that the phase jitter in the optical transmitter/receiver pair are minimized.

Since phase stability is desired, it may be required to implement a temperature controlled oven for both the fiber transmitter and receiver. While the BPM system is within specification of +/- 1 degree at present, an upgrade is a simple and cost effective way of improving system performance.

CONCLUSION

The Diagnostics RF timing system is being installed and has shown that it is possible and feasible to use fiber optic technology to transmit timing signals for phase measurement along the SNS linac. The measured BPM phase remained phase locked to the LLRF master oscillator and no appreciable drift was observed during beam commissioning. Measurements of the jitter from the master oscillator compared to be similar to the jitter of the RF timing at racks along the linac,to within the accuracy of the measurement device. The fiber transmitter and receiver may need temperature compensation to reduce phase fluctuations.

REFERENCES

[1] See Miteq's webpage about different fiber transmitters and receivers. The SCM variety is the new standard temperature controlled pair. http://www.miteq.com/micro/fiberoptics/index.html.

[2] C. Deibele, "Jitter and Phase Noise Analysis,", SNS-NOTE-DIAG-104, http://it.sns.ornl.gov/asd/public/pdf/sns0104/sns0104.pdf.

