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Phase Stability of Analog Components for PEFP LLRF System *

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1. Introduction

The 100MeV, 20mA proton linear accelerator for PEFP (Proton Engineering Frontier project) is being developed [1][2]. As a low energy accelerator, 3MeV RFQ and 20MeV DTL composed of 4 tanks are under operation. The stability of ±1% in amplitude and ±1 ° in phase is required for LLRF control system, which consists of analog components and digital feedback control board. The phase stability of analog components for reference signal, 350MHz RF, 340 LO and 10MHz IF signal has effect on meeting the requirement. Phase measurement and phase stability of analog components are presented.

2. Phase stability of analog components

Digital feedback control board (ICS-572B) is used for cavity amplitude and phase control [3]. This digital board measures and controls 10MHz IF signal converted from 350MHz cavity signal and 340MHz LO signal by using 10MHz reference and 40MHz clock. The phase stability of analog components for 10MHz reference, 40MHz clock, 340MHz LO and 350MHz RF signal is also important to control cavity phase within 1°. As shown in figure 1, cavity phase can be measured by both analog phase comparator and digital feedback board in the feedback control. The phase measured by analog phase comparator is not accordance with phase measured by digital board in open loop and closed loop as shown in figure 2 and 3. This means that there is some possibility of the unstable 40MHz clock or 340MHz LO signal.

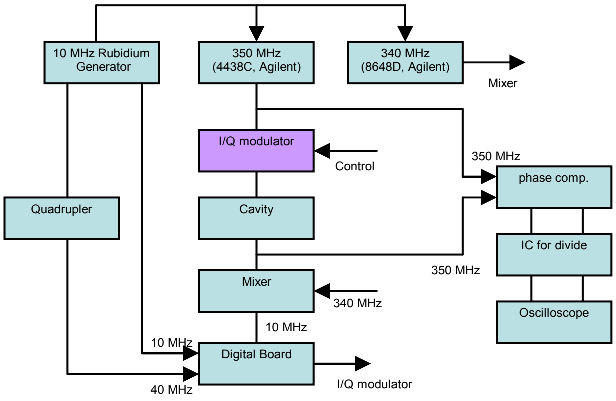

Figure 1. Schematics for the phase measurement

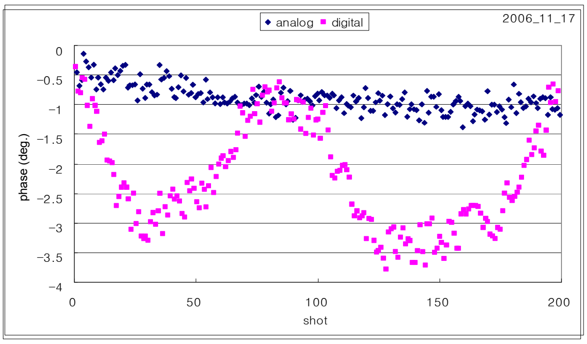

Figure 2. Cavity phase measured by analog phase comparator and digital board in the open loop

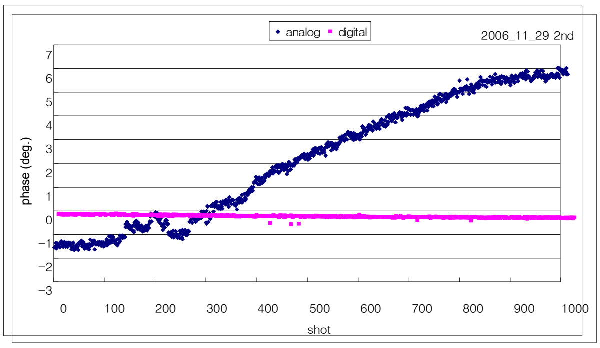

Figure 3. Cavity phase measured by analog phase comparator and digital board in the closed loop

To check the stability of 40MHz clock generated from quadrupler component, The phase for 10MHz IF signal was measured by digital board and Network analyzer (8753ES, Agilent) as shown in Figure 4. ±4° Phase fluctuation measured by Network analyzer is accordance with the phase measured by digital board as shown in Figure 5. Phase fluctuation at a regular interval is caused by temperature change in control room. This test result means that 40MHz clock is stable.

The phase stability for 350MHz RF and 340MHz LO signal was checked as shown in Figure 6. 10MHz OCXO was used for reference signal and phase stability of 4438C for 350MHz RF and 8648D for 340MHz was measured by oscilloscope (TDS7104, Tektronix). ±7° phase fluctuation was measured for 340MHz LO signal (8648D). This means that 8648D signal generator is sensitive to temperature change of control room.

Although the cavity phase is not changed in the open loop, the cavity phase measured by digital board is shifted due to the unstable 340MHz LO phase as shown in figure 2. In the closed loop, although the cavity phase is not shifted, incorrect cavity phase is controlled by digital board. This is caused by phase shift of 10MHz IF signal due to the unstable 340MHz LO signal.

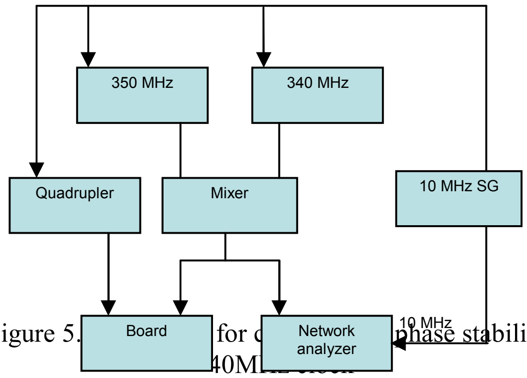

Figure 5. for c phase stability of 40M

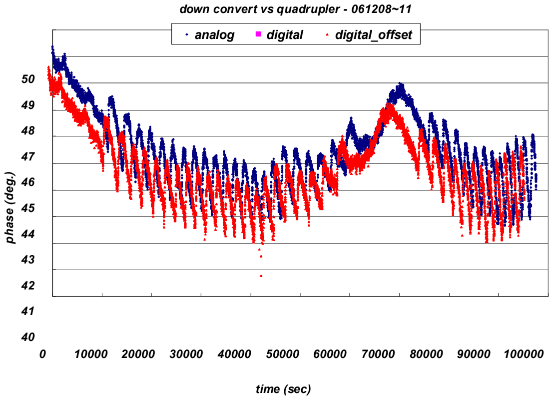

Figure 5. Measured result for the phase stability of 40MHz clock (quadrupler)

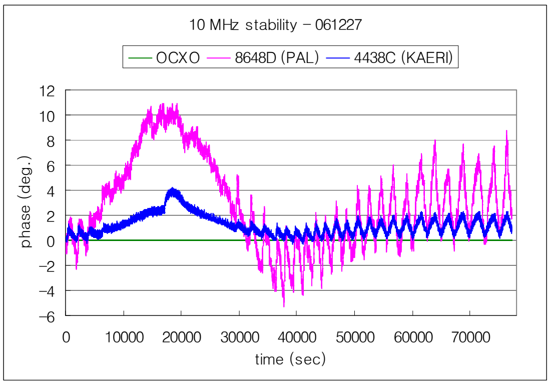

Figure 6. Measured result for phase stability of 340MHz LO and 350MHz RF signal

In the feedback control for PEFP 20MeV accelerator, it is important that the relative phase between the RFQ and DTL should be maintained. Although the phase of 340MHz LO signal is shifted in the feedback control, the relative phase between two cavities should be maintained by the same effect of the 340MHz LO signal.

To check the relative phase, cavity pickup signal instead of forward signal is used for reference signal in analog phase comparator. After the reference position of analog phase comparator was changed, relative phase between two dummy cavities was measured by analog phase comparator and digital board as shown in figure 7. In the relative phase measurement, the phase shift affected by 340MHz LO signal disappeared.

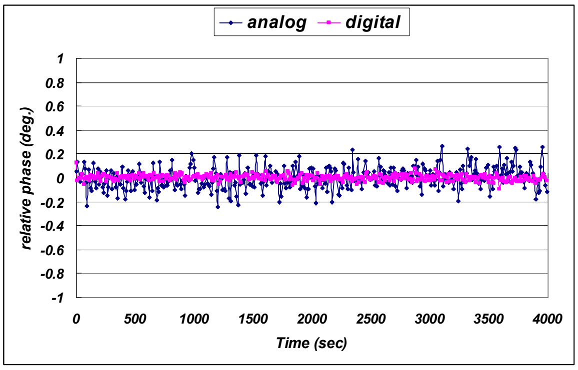

Figure 5. Relative phase between two dummy cavities

3. Summary

In the phase stability of analog components, the phase of 340MHz LO signal is unstable and sensitive to temperature change of control room. In the feedback control of 20MeV accelerator, it is important that the relative phase between two cavities should be maintained. To measure the relative phase, cavity pickup signal instead of forward signal is used for reference signal in analog phase comparator. With this configuration, we can confirm the relative phase stability between the RFQ and DTL with in desired level in spite of the fluctuation of 340MHz LO signal.

4. Acknowledgements

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