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Technical Note for adjusting Power and Cavity Sum Phase Loops

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This adjustment is probably the least understood and most difficult to explain of any LL adjustments to be made. It doesn't help that it cannot be measured, varies with klystron cathode voltage and current and is sensitive to any changes in cabling that are made in the loop. It also requires a subjective assessment of loop operation, and testing to insure that it re-starts. Lastly, the two loops interact with each other, compounding the difficulties. Anyone making this adjustment should refer to the system block diagram, because it will help with intuition.

Each RF station has two phase control loops; one around the klystron (power phase) and one around the entire sector pair (cavity sum). Both are referenced to the RF source signal feeding each station from A014.Both loops are attempting to minimize phase shift presented to the cavities and therefore the beam. Some phase shifts are cyclic(60Hz power supply ripple, etc)and some are static(equipment changes and temperature changes affecting physical dimensions).The phase changes are read by phase detectors and continually adjusted to match a set point by analog PID controllers at each klystron LL rack. The adjustment to be made is to ensure that the controller is not operating near its limits (so it doesn't lose regulation for normal operating conditions) and to be sure that it will re-start itself after RF is interrupted.

On the block diagram, you see that each station has a section of cable just before the Kalmus driver amplifier labeled "system phasing cable" and also a section near phase shifter 1-3 labeled the same. The first is a BNC cable and the second and SMA cable; a variety of which are kept in the low-level spares cabinet in six inch (90 degree) increments. They install directly on the front of the Kalmus and on the rear of the interface chassis (#57) and are easy to locate. An offset phase shifter exists for each loop (PHS1-3 and PHS1-2) providing 200 degrees of phase shift to adjust the PID controllers' output voltage for each loop. Correct tuning is accomplished by installing a 90,180,270,or 360 degree cable adjusting the offset phase shifter for the correct PID out put voltage(with the phase shifter control not at its' extremes and switching the polarity if needed),and then shutting off the RF and re-starting it to verify that it is automatic re-starting. The PID output voltages are -5 volts DC ± 1 volt for the cavity sum loop and –0.5 volts DC +0/-1 volt for the power phase loop. These voltages are with the system running at injection levels. They will vary with more or less klystron forward power and cathode voltage.

The difficulty generally is either getting the offset phase shifter near the middle of its' range or getting the control loop to re-start without jolting the loop (forcing the controller output from limit to limit so it can at some point be in its lock range). Both of these can occur at the same time and are both remedied by changing the "system phasing cable" to a different length then repeating the offset phase shifter and PID DC volts tests. It can be seen in the block diagram that the power phase loop resides inside the cavity sum phase loop. The implication is that any changes made to the power phase loop will affect the cavity sum loop. This interaction means that any time one of them is adjusted the other must be verified to be still operating properly.

The offset phase shifter controls are available in EPICS under Rfpanel,RF1-5,LLRF,phase shifter 1.The PID output voltages are available locally at each RF station on an analog scope in the center LL rack or in EPICS under Rfpanel:RF1-5: instruments:xy566 klystron. The PID controls are available under Rfpanel RF1-5: LLRF: RFkly: feedback.

Problems with tuning can also mean that PID control parameters have been altered or that some hardware has failed. There is always a printout inside the low-level rack next to the VXI crate at each station which contains all relevant PID and other low- level information from the last time that station was used to store beam. The block diagram for the system you are working on should help with troubleshooting.