9mA study plan – DESY, Sept. 2009

Gradient and energy stability / control optimization with beam

Goals for the study:

Demonstrate optimal LLRF regulation of VS gradients and beam energy atILC-like operating conditions. (NOTE: We are aware that the ILC design may have slightly different knobs compared to the ones at FLASH.)

- Use existing cavity model including the experience gained by the cavity model study (see J. Branlard). Compare model against experimental data (understand discrepancies + improve model) .
- Analyze disturbances.
- Calculate, model, simulate and verify control strategies such as FF, FB, AFF.
- Understand the roll of calibration in the stability of the control.

Preparation:

1. compare model with results from previous study.
2. understand the influence of tuning parameters on stability. For instance, gradient stability is a function of cavity detuning, initial detuning, Q_L, beam phase, etc.
3. a priori modeling and simulation. Modeling and simulation can be done in the frequency domain (transfer function) and the time domain (state equations). The analysis in the frequency domain is simpler but limited because the LLRF control is time variant.
4. understand calibration errors and their influence on stability. For instance, VS calibration errors.
5. correlate energy stability with gradient stability.

Low gradient, beam OFF/ON study (on-site):

1. The purpose of this study is to validate the control strategies. Hopefully, most parameters will be already measured during the cavity model studies (i.e. Q_L, $\Delta\omega$, ω_{12}, R_L, group delay).
2. At low gradients we can neglect LFD and minimize other detuning using knobs. This is the simplest case for the control because there is no mix between I and Q. There is quite a lot we can learn using different control strategies at low gradients with beam OFF and beam ON.
3. Take data while running the following experiments:
   3.1 FF only
   3.2 FB only
   3.3 FF + FB
   3.4 AFF + FB.
      For instance, turn AFF ON, make it learn, freeze AFF, etc.
   3.5 FB with variable group delay.
4. Observe cavity passband modes and correlate then to gradient stability.
4.1 Measure optimal FB gain and compare to numbers predicted in the models. Understand differences, correct models, suggest improvements if appropriate.
5. Observe long term stability, energy stability. Correlate energy stability to gradient stability.

High gradient, beam OFF/ON study (on-site):

1. LFD disturbance study: Repeat the above experiment at higher gradients where we observe substantial LFD but no substantial klystron saturation. Use klystron linearization ON to keep a linear klystron model for the control.
2. Klystron saturation study: Turn klystron linearization OFF and repeat control studies at high gradients. Observe an increase in control instabilities due to klystron saturation.

study wrap-up:

1. documentation of results.
2. hopefully the studies will provide a better understanding on achievements and limitations of control strategies based on typical machine parameters, calibrations and measurement errors.