

Lecture 5: Homework Problems

Q1: The rf systems (1300 MHz) of the main linacs of the ILC must provide rf power for 7280 cavities. Each rf station at the ILC consists of 1 klystron driving 26 cavities. With a linac energy gain of 245 GeV, and a beam current of 9 mA calculate:

- the average gradient of the cavities (cavity length 1.038 m).
- the rf klystron power required for each rf station if the complete power is transferred to the beam
- The loaded Q required to achieve the matched condition in (b).
Note 1: matched conditions are achieved when the beam induced voltage is equal to the operating voltage.

Note 2: It is assumed that the Lorentz force detuning is compensated with the piezo tuners.

Q2: The 10 MW multibeam klystron is replaced by a single beam klystron with an efficiency of 65%.

- What is the perveance of the klystron and what the operating voltage.

Q3: The microphonics noise level is 10 Hz rms at a loaded Q of 3×10^7 . The linac is operated with single bunches with a bunch charge of 8 nC (i.e. practically no beam loading).

- What feedback gain is needed to achieve a field stability of 0.1 deg.

Q4: An rf controller for 1300 MHz employs a digital field detection scheme with an IF frequency of 50 MHz which is sampled at 75 MHz. The ADC clock at 75 MHz has a timing jitter of 5 ps (rms).

- What is the noise on a single cavity phase measurement if the clock jitter is the dominating noise source ?
- What clock jitter is required if the phase must be measured with an accuracy of 0.1 deg. for a single measurement and when averaging over 100 measurements ?

Q5: How does the latency in the feedback loop effect performance ? Estimate the latency in the rf control loop for ILC ?. Take into account cables, waveguides, klystrons, data conversion/processing etc. .

Q6: Describe the differences between correlated and uncorrelated field errors in the main linac with 7280 cavities ?

Q7: The cavities in the bunch compressor are operated 20 degrees off crest at a gradient of 31.5 MV/m.

- a) What is the energy gain of an rf station with 26 cavities ?
- b) What is the necessary klystron power for (i) a tuned ($\Delta\omega=0$ Hz) cavity and (ii) for cavities at optimum detuning angle ?

Q8: The local reference distribution uses a coaxial cable with a temperature coefficient of 1 ppm/deg.C.

- a) What is the phase change over 100m cable length for a 1 deg. temperature change at the frequency of 1300 MHz.