Home Work (problems)

Room temperature RF

Part 2: *Strong beam-cavity coupling*

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Problem 1

In a linac build from standing wave accelerating structures and operating in CW at 10 MV/m accelerating gradient and 1 GHz rf frequency, what shunt impedance per meter length is necessary to reach rf-to-beam efficiency of 50% for beam current of 1A?

In the same linac which has unloaded Q-factor: Q_0=25000, going to pulsed mode of operation at 20 MV/m accelerating gradient and 5 μs, what total pulse duration is necessary to maintain the rf-to-beam efficiency above 10%? What will be the average beam current in this case assuming pulse repetition frequency of 50 Hz?

Assume that structure coupling can be adjusted to operate always in matched condition.

Problem 2

Constant impedance travelling wave structure with following parameters: f = 12 GHz, L_s = 0.25m, v_g = 3000000m/s, Q_0 = 10000, R'=100MΩ/m, is fed with 100MW input power.

1. What is the gradient at the input of the structure?
2. What beam current correspond to maximum rf-to-beam efficiency in steady-state?
3. What is the maximum rf-to-beam efficiency?
4. What is the gradient at the output of the structure at this beam current?
5. What is the rf-to-beam efficiency at full beam loading condition?
6. Why is it different from the maximum?

Problem 3

Constant gradient travelling wave structure with following parameters:

f = 12 GHz, L_s = 0.25m, $v_g(z)=v_{g0}\,(1+az)$; v_{g0} = 6000000m/s, Q_0 = 10000, R'=100MΩ/m, is used to accelerate train of 1 nC bunches spaced by 1 ns at 100 MV/m gradient.

1. What is the rf-to-beam efficiency if the bunch train is 200 ns long?
2. Find an analytical expression for the input gradient ramping during structure filling to compensate transient beam loading effect.