A NEW RF POWER DISTRIBUTION SYSTEM FOR X-BAND LINAC EQUIVALENT TO AN RF PULSE COMPRESSION SCHEME OF FACTOR 2^n

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ABSTRACT

As an RF power source system for a future X-band linear colliders, some RF pulse compression system is necessary. A new simple scheme which can provide the better efficiency than the present scheme such as SLED or SLED-2, is proposed. This scheme consist of 2-Klystrons, a 3-dB coupler and a TE01 mode delay line that is one half of the linac RF pulse. The output RF pulse of 2-klystrons are combined through 3-dB coupler and the first half of the pulse is transported to the upstream of a linac through the TE01 mode wave guide. Then, by reversing the phase of the one of 2-klystrons, the last half of the RF pulse is directly fed to the linac structure located close to the klystrons. The RF power loss in this system is determined by the loss in the transporting waveguide. In the case of 400nsec pulse. ie 200nsec pulses at the input of 2-different accelerating structures, the estimated efficiency could reach more than 98%.

INTRODUCTION

As described in several papers, in the RF power feeding system in the future X-band linacs of the linear colliders, an RF pulse compression system is required to achieve short RF pulses such as 200ns or even shorter. In the present state of arts in the high voltage pulse technology, such short pulse operation of the high power pulse klystron is still impossible from the view point of high energy efficiency in the mudulator. Therefore, in the design of linear colliders, several RF pulse compression scheme has been considered. In SLAC SLC, the RF pulse compression system named SLED(SLAC Energy Doubler) wasn developed and successfully under operation for years of SLC experiments(REF-1). Recently, at X-band this scheme was tested in KEK(REF-2). These schemes including SLED-2(REF-3) and VPM(REF-4) have the moderate efficiency around 70% due to the reflection of the RF power while transient and wall losses on the cavity surface during the energy storage period of it's operation. As long as the RF compression ratio of factor 4 or more than that is considered, these schemes are the best solution for the compromise between fairly long operation time of the klystron driven by the modulator and the shorter RF pulse which is required for the X-band liner collider. But, recent design of the linear collider has been shifted to use fairly long bunch train and consequently the duration of the RF pulse necessary for covering the filling time and successive bunch train has became longer to 200ns or even more. Due to this change in the design of the linear colliders, and the recent progress in the short pulse modulator(REF-6), the new RF power distribution system consist of the delay line and the power distribution system is considered.

PRINCIPLE

Fig-1) shows the principle of this RF distribution system, which is equivalent to the factor 2 RF pulse compression scheme. The factor 2^n equivalent system can be constructed by the use of 2^n klystrons, but in practical purpose factor 2 equivalent scheme is preferable. The output power from the two independent klystrons are combined through the 3-dB hybrid. and the combined power are fed into the two different part of the accelerating section. One part of the accelerator section is located at the upstream of the RF power station and the other part of the section is located close to the klystrons. If the output phase of the two klystron can be controlled independently, the RF output pulse can be steered to the either port of the 3-dB coupler by reversing the phase of the one klystron while keeping the other klystron at the constant phase. Thus the first half of the RF out put pulse is sent to the upstream acceleration unit and the latter half of the output is fed into the acceleration unit located close to the klystron system. The timing chart of this scheme is shown in the Fig-2), as the form of "RAILLOAD DIAGRAM". As shown in this Figure, the necessary delay time for the first half pulse widt of RF power is about one half of the linac operating pulse, and this may change slightly due to the fact that the group velocity of the RF in the waveguide is slower than the light velocity which is the speed of the electron bunches.

SYSTEM EFFICIENCY

The energy loss in this scheme is the wall loss in the waveguide. The losses in the several waveguide are shown in Table-1). Table-1)a) and b) are TE01 mode and TE11 mode respectively. As shown in these tables, practically the loss in the waveguide is small enough in all cases. The latter half of the RF pulse is directly fed to the second acceleration structure which is located close to the RF power source, therefore, the RF power loss of this system is only in the first half of the RF pulse. Thus, the total loss of this power distribution system is one half of the values shown in the Table1). Practical;y this energy loss is negligible small if they are compared to the energy loss of ~25% or more in the ordinary RF pulse compression system od factor 4~6. As shown in Table-1), even TE11 mode in the D=51mm waveguide has sufficiently small loss, such as ~4% as this RF power distribution system. Therefore, either TE11 or TE01 mode is applicable for the RF power source system for the future linear colliders.

CONCLUSION

1) A factor 2^n-RF pulse compression equivalent system can be constructed without any RF power storage device, such as a cavity or cavities.
2) In case of the X-band multi-bunch linear colliders, this system has very high efficiency. The energy loss in the delay line is less than 2%. While an ordinary RF pulse compression system of the factor 4-6 may suffer energy loss of ~25%.
3) A narrow band component such as an energy storage cavity is not necessary. Therefore this system can be as flexible as a conventional electron linac RF system.
5) The number of klystrons must be doubled, compared to the case of factor 4 RF pulse compression scheme.
6) In case of the change in RFpulse width of the linac, the delay line length and the configuration of the distribution system must be rearranged

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Table-1)
Transfer losses in the waveguides

a) TE01 mode

Waveguide	Loss (dB/m)	Vg/C	Total loss (200ns)
51mm	1.3e-2	0.8733	8.02%
69mm	4.5e-3	0.886	2.82%
118.1mm	8.3e-4	0.9625	0.56%

b)TE11 mode

Waveguide	Loss (dB/m)	Vg/C	Total loss (200ns)
51mm	1.22e-2	0.9626	7.93%
69mm	8.44e-3	0.9748	5.60%
118.1mm	4.7e-3	0.9915	3.18%

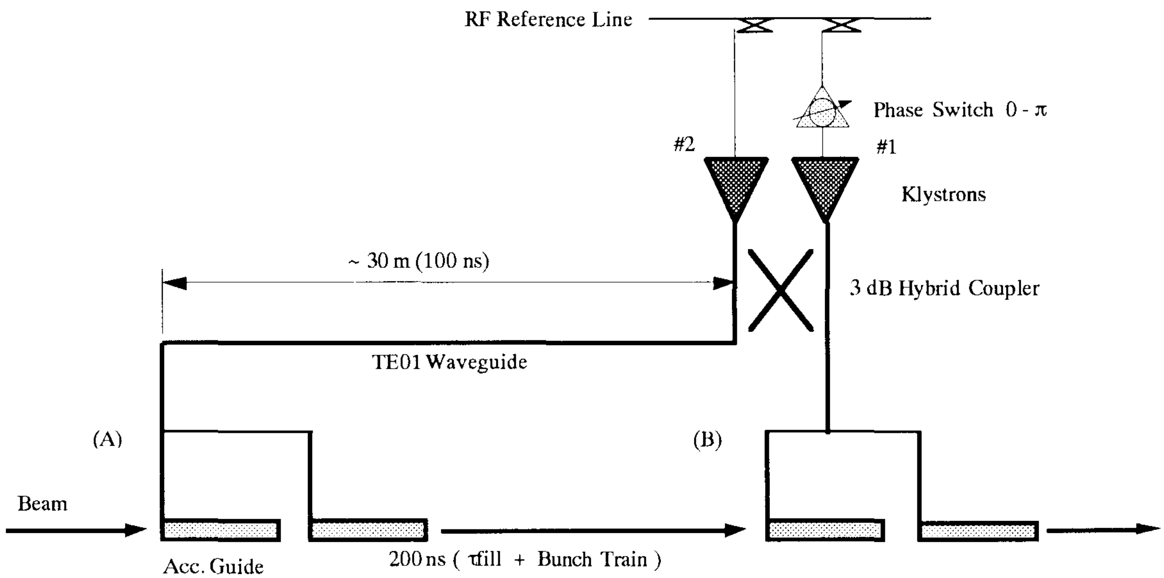

Fig-1)A schematic diagram of the delay line distribution system

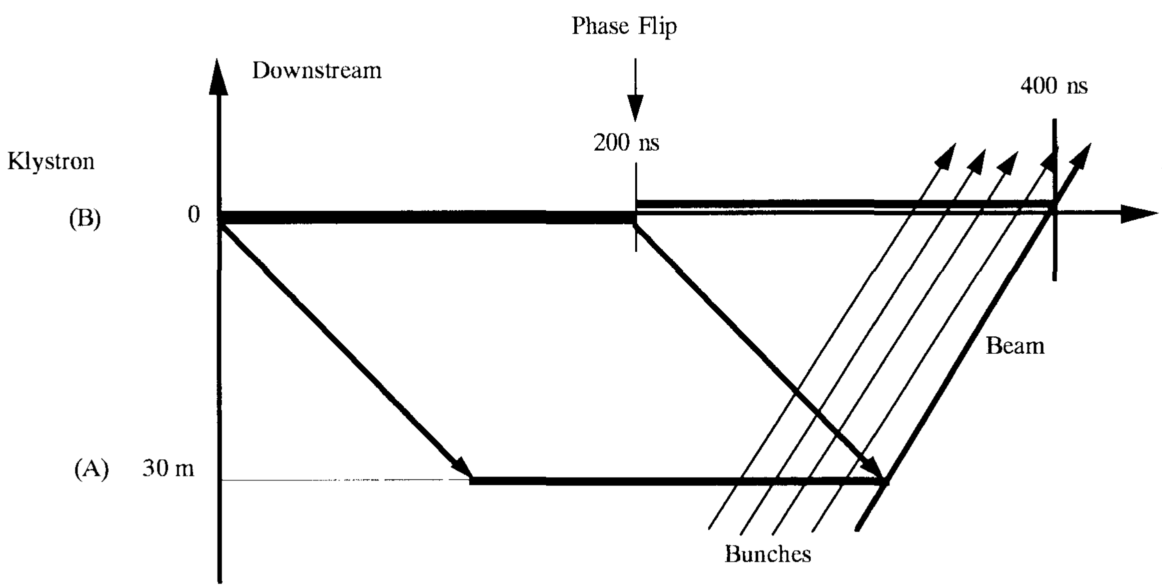

Fig-2)A railload diagram of the delayed line distribution system