6 - 30 Electric Field Measurement Results and Analysis of PLIA

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An oil dielectric helical pulse line to demonstrate the principle of pulse line ion accelerator (PLIA) has been fabricated and measured[1]. In order to make a reference for the subsequent ion acceleration experiment, it is necessary to measure the electric field of PLIA.

Because of the limited interior space of accelerator, strong directional and high value of electric field, the electric field measurement of accelerator is rarely to be seen at home and abroad. The optical electric integrated electric field measurement system, which was developed by department of electrical engineering, Tsinghua University, has a very small size (7 cm×1 cm×1 cm), intensive electric field measurement range (10^6 V/m), wide pass band (1 GHz), and it can measure the electric field in one direction only[2]. Besides, this optical electric integrated electric field measurement system is passive, which will have no effect on the measured electric field. So it is suitable to measure the electric field of PLIA.

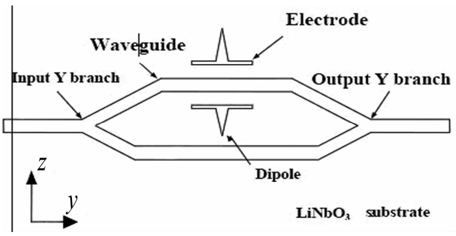

Fig. 1 The structure of the sensor.

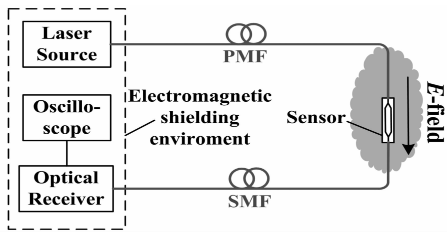

Fig. 2 The configuration of the measurement system.

The structure of the sensor is illustrated in Fig. 1. There is a path difference of one-quarter of the wavelength of light between these two arms in order to form an optical bias of $\pi/2$, which is desirable for the output of the sensor to be linear with the input electric field. The refracting index of some electro-optic crystals will change when an electric field is put on it, which will cause the phase shift of the light wave. According to the fundamental principle of Mach-Zehnder modulator, the modulator output of optical power can be expressed as $P_o = (\mathrm{Pi}/2)(1\text{-}\sin\varphi)$, so the value of electric field can be acquired by measuring the output laser power[3]. Fig. 2 is the configuration of the measurement system.

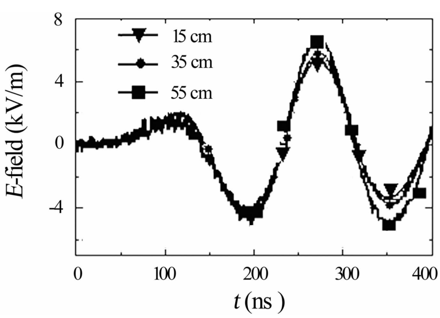

Fig. 3 The axis electric field at different locations along the helix.

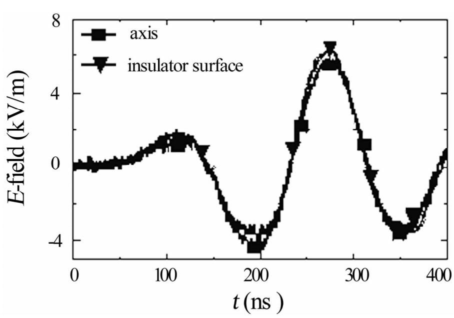

Fig. 4 The comparison of electric field on axis and on insulator surface for low frequency.

The axis electric field at different locations along the helix is shown in Fig. 3. The electric field at different locations is almost the same, which shows that the electric field is almost loss-free during the propagation. But the amplitude is smaller than the calculated value. The possible reason is described as follows. The helix inductance decreased at both ends because mutual coupling from the neighboring turns was lower at both ends of the helix. To approximate the mutual inductance from later turns, a string of resisters in a spiral with a pitch similar to the helix was used on the oil dielectric helix[4]. Due to the space limitation of both ends of the helix and the volume limitation of resister, the actual pitch of resister column is much less than that of helix. So the electric field will be decreased in this situation.

Fig. 4 is the comparison of electric field on axis and on insulator surface for low frequency. The amplitude of electric field on axis is similar to that on insulator surface, which is close to the theoretical analysis.

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6 - 31 RF Power Supplies for RFQ Cooler and Buncher RFQ1L

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For the purpose of matching directly the beams from the gas-filled recoil separator, the RFQ cooler and buncher RFQ1L[1] has been designed to have a large radius ($r_0 = 60$ mm), thus the RF power supply becomes not a trivial problem. We have successfully solved this problem by two different methods, and the RF power supplies specific to the RFQ1L have been developed and tested.

The first solution is a so-called wide-band RF power supply. The RF signal is generated by a generator, and its frequency and amplitude can be easily adjusted as our need. The RF amplitude is then amplified by a power amplifier and a home-made air-core transformer. To give two outputs with a phase difference of 180°, the transformer has been grounded at the center point and the turn ratio of the two parts has been controlled very carefully.

Although the wide-band RF power supply has advantages such as easy adjustment of RF amplitude and frequency, the rapid decrease of the RF amplitude for frequencies higher than 250 kHz becomes a real problem for the normal operation of the RFQ1L. We solve this problem by using series resonance circuits. A sinusoidal wave is generated by a signal source and sent to a power amplifier. A home-made phase splitter is used to produce two outputs with the same amplitude and frequencies, and with 180° phase difference. Each channel can make a resonance with a home-made inductance L, and capacitance C. The resonant state can be obtained by adjusting L and the RF frequency. While for high RF voltages at frequencies of more than 250 kHz, the RF power supply with series resonant circuits will be used at the RFQ1L although the change in RF frequency is not as flexible.

This work has been published in Ref. [2, 3].

References

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