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著者(和文)	由元崇
Author(English)	Takashi Yoshimoto
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	由元　崇	指導教員（主）： Academic Advisor(main)	高山　健
		指導教員（副）： Academic Advisor(sub)	堀岡　一彦

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

In the case of desiring maximum beam intensity for synchrotrons, RF cavities with a lower quality factor are adapted. Modern hadron machines are just the case. This comes from a fact that low *Q* cavities can generate a larger beam bucket to accommodate a beam in the phase space of time and energy. From this reason, frequency band widening of RF cavity or development of a low *Q* cavity have been a big concern the accelerator society since 1983. Under the current trend of pursuing low *Q* RF cavity, the induction synchrotron (IS) has been invented in 2000, which is regarded as a synchrotron operated with extremely wider RF frequency. In order to study wide-band acceleration technologies for synchrotrons, the KEK Digital Accelerator (KEK-DA) has been constructed as a small fast-cycling IS in 2007.

The IS provides three notable acceleration capabilities. The first is the "wide-band acceleration", in which a low energy beam can be accelerated up to energy allowed by the maximum magnetic flux density of the guiding magnet in a single synchrotron. It does not require an expensive and large-scale injector such as Radio-Frequency Quadrupole (RFQ) and drift-tube linac. The beam revolution frequency is allowed to change in two orders in one acceleration cycle. This technology has another aspect of all ion acceleration as mentioned above. Various ion species with different mass to charge ratio including cluster ions can be accelerated by this method. The second is "novel beam handling" by the state of art use of the barrier buckets. The longitudinal beam compression, expansion, splitting, and merging are among them. The third is the "super-bunch acceleration" with asymmetric rectangular acceleration pulses. Although this induction acceleration technology in a circular ring has still unsolved problems such as beam loading compensation for a high intensity beam, the super-bunch operation even in the KEK digital accelerator is possible when the beam intensity there is reduced to low level.

Although the induction synchrotron has been considered to have above unique and useful aspects, they have not been comprehensively, especially experimentally explored. For the purpose to fully manifest its capability, this thesis work has been conducted. The results should be beneficial for future ideal induction synchrotrons. In this dissertation, wide-band acceleration technologies and their possibilities in the KEK-DA have been studied by means of experimental and numerical tools.

This construction of the thesis is as follows.

Chapter 2 gives general properties of induction synchrotron. It establishes voltage separation of confinement and acceleration functions. Three super-wide-band technologies are derived from the impedance characteristic. Preceding studies for various induction acceleration systems for arbitrary pulse generation by Linear Transformer Driver (LTD) and asymmetric pulse generation are also described.

Chapter 3 provides the overview of the KEK-DA which is a small prototype of induction synchrotron. This machine specifications and limitations are introduced in detail. As the author contrived, several methods about typical beam information such as transverse beam sizes and initial momentum spread using acceleration voltages are explained.

Chapter 4 explains the wide-band acceleration technology of induction synchrotron which can accelerate heavy ion beams within some wide-band frequency with experiments. This is an intermittent-turn acceleration scheme called the pulse density control because of the combination of fixed heights of induction accelerate voltage and fast cycling characteristic of the KEK-DA. This experiment has demonstrated successfully and also compared to simulation results, which has well reproduced it and revealed the mechanism of longitudinal emittance blow-up at the initial acceleration stage.

In Chapter 5, super-bunch acceleration technology is discussed for the upgraded KEK-DA. It can not only accelerate long beams with asymmetric induction pulses but also resolve the problems about initial longitudinal emittance blow-up and synchro-beta coupling caused by the combination of the present KEK-DA optics and setups. The key technology is a time-variable induction system which can always provide required acceleration voltage. The result of its SPICE model shows such a system is acceptable and can stably produce asymmetric pulses for super bunches under the condition of ignoring beam loading effects.

In Chapter 6, typical beam handling technologies are introduced with barrier buckets with experimental results. In the first section, several barrier buckets schemes which have been carried out for other facilities in the world are introduced. The author has proposed new beam handling method, fast beam compression scheme which saves its manipulating time without large emittance blow-up. The second is about fast beam rotation method for beam splitting and merging in longitudinal phase space. Both of them have been demonstrated experimentally and shown their capabilities.

Chapter 7 summarizes and concludes and the studies in this thesis. A brief discussion about the future possibilities is discussed.