Design Study of Pulsed Multipole Injection for Aichi SR

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Introduction

Since March of 2013 the user operation has been started with the top-up injection mode of the storage ring at Aich SR. The accelerators of Aichi SR consisted of a 50 MeV linac, an 1.2 GeV full energy booster and the storage ring. The operation current of the storage ring is 300 mA and the injection rate is up to 1 Hz. The single bunch injection scheme is employed and the electron beam can be injected into the arbitrary bucket of the storage ring. Up to now, the stability of 0.2 % for the stored beam current was achieved, however, the coherent oscillation of stored beams due to injection kikers is also observed.

Pulsed Multipole Injection

The injection beam is captured into the ring acceptance as a result of pulsed multipole kicks, and the stored beam passes through the center of the multipole magnet, where the field strength is almost zero.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Field type} & \textbf{Bump Inj.} & \textbf{Pulsed Multipole Inj.} \\
\hline
\textbf{Number of magnets} & 4 & 1 \\
\hline
\end{tabular}
\caption{Comparison with the bump injection}
\end{table}

Installation Location

Numerical simulations indicate that several locations exist where the pulsed multipole injection scheme can be applied with adequate kick angle. We select the position that located an existing pulsed dipole magnet because it required the smallest kick angle for beam injection.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure1.png}
\caption{Phase advance from injection point (deg)}
\end{figure}

Injection Calculation

• Single kick injection

In the ideal case, an injection beam experiences only one kick. In this situation, the required kick is about 1 mrad (180G).

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure2.png}
\caption{Injection efficiencies as functions of injection timings and operation currents. (designed tune, chromaticity = 0)}
\end{figure}

Summary

To introduce pulsed multipole injection into the AichiSR storage ring, we designed a pulsed multipole magnet and a power supply. As a result of beam-tracking simulation, it is confirmed that the injection method works at Aichi SR.

Magnet Design

The designed magnet consists of a rectangular shaped yolk and a one-turn coil to realize sufficient field strength and small electromagnetic inductance.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
\textbf{Parameter} & \textbf{Value} \\
\hline
Core length & 200 mm \\
Vertical Gap & 50 mm \\
Horizontal Gap & 105 mm \\
Inductance & 1.8 \, \mu H \\
\hline
\end{tabular}
\caption{Parameters for the multipole magnet}
\end{table}

Power Supply

The power supply has a maximum charging voltage of 23 kV and produces a 2.0 kA output current in a half-sine pulse shape with a full width of 960 ns. A reflection current is assumed with an amplitude that is 30 % the main peak. When the injection timing is tuned at 720ns, the beam experiences single kick.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure3.png}
\caption{Calculated temporal response}
\end{figure}

Multi-kick Injection

In actual, an injection beam experiences several kicks due to the reflection current. In the calculation, we assumed “UVSOR-type scaling” (see above figure) as a temporal response of power supply.

When the injection timing is tuned at 720ns, the 2nd kick angle can be reduced around zero and the third kick works effectively. Then higher injection efficiency could be expected.