Implementing IGBT Kicker Pulser and Full-Sine Septum Pulser to Improve the TPS Beam Injection

In 2018, in order to improve the overall beam injection performance in Taiwan Photon Source (TPS), the Linac Group installed two types of the pulsed power supply, an IGBT-switch kicker power supply and a full-sine septum power supply, at the TPS booster ring and the TPS storage ring respectively, where the IGBT stands for the insulated gate bipolar transistor.

IGBT-Switch Kicker Power Supply

An on-axis injection scheme is designed to inject the electron beam from the linac-to-booster (LTB) transfer line to the orbital center of the TPS booster ring by utilizing the injection kicker magnet with the pulsed current. The pulsed current, however, has two essential requirements in the TPS booster ring. The long flat top is to kick the bunch train as long as possible within one revolution time of 1,660 ns; and the sharp falling edge without the following ripple is to avoid twice kicks on the same bunch train after the injected bunch train travels one revolution.

Before implementing the IGBT-switch kicker power supply (IGBT pulser), the TPS booster ring used the pulse-forming-network (PFN) pulser to generate the pulsed current for the beam injection. As illustrated in **Fig. 1(a)**, the PFN pulser has a 300-ns flat top to carry the bunch train,[1] followed by a falling time of 1,360 ns and an extended long-tail ripples. To make a comparison, as shown in **Fig. 1(b)**, the delivering current from the IGBT pulser has a falling time of 460 ns, so that the length of injection bunch train can be set up to 1,200 ns. Also, the flat top provided by the IGBT pulser has the better uniformity to generate the uniform magnet field for kicking.

The information given in **Fig. 2** demonstrates that the available length of the bunch train for the beam injection is significantly enhanced after implementing the IGBT pulser. The longer capability of the bunch train provided by the IGBT pulser can be used as a handy tuning knob to optimize the filling pattern in the top-up operation mode.

Table 1 lists the major operation parameters for easy comparison between the PFN pulser and the IGBT pulser.[2,3] The typical operation voltages for the IGBT pulser and the PFN pulser are 1.5 kV and 15 kV re-

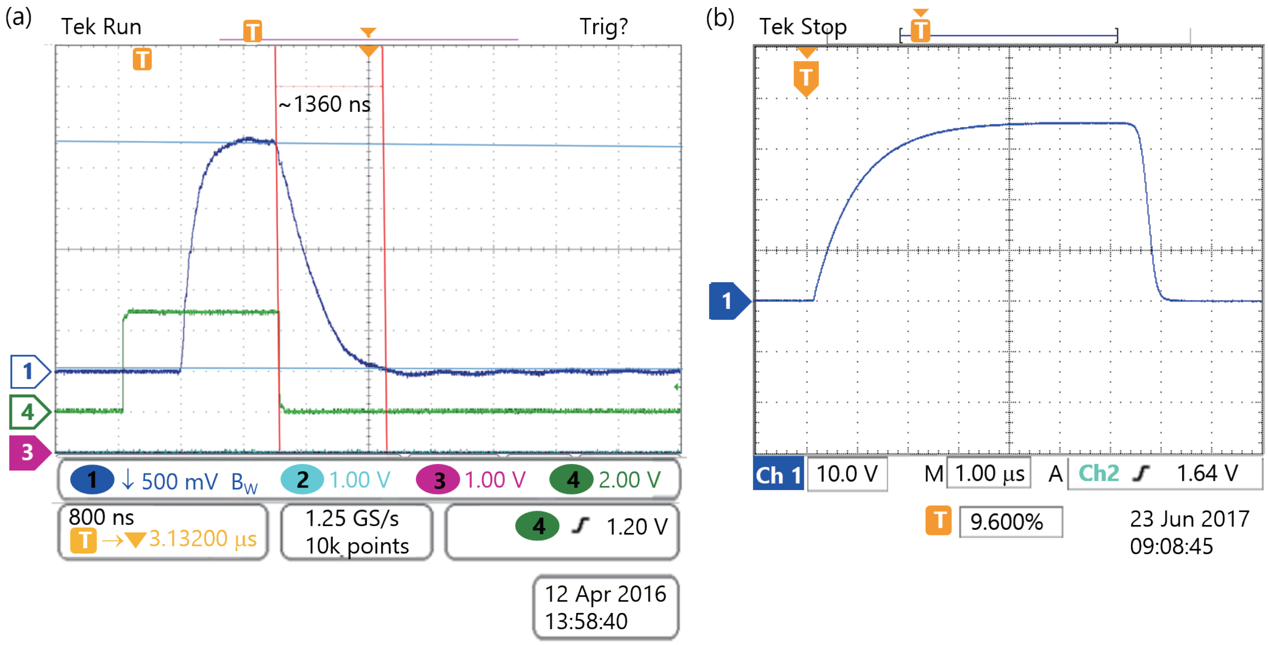

Fig. 1: (a) The long-tail PFN pulser is a compromised solution of an impedance mismatch unit. Only the bunch train of 300 ns is available within one revolution time, 1,660 ns, of the TPS booster ring. (b) The 460-ns falling time of the IGBT pulser provides 1,200-ns bunch train tuning capability.

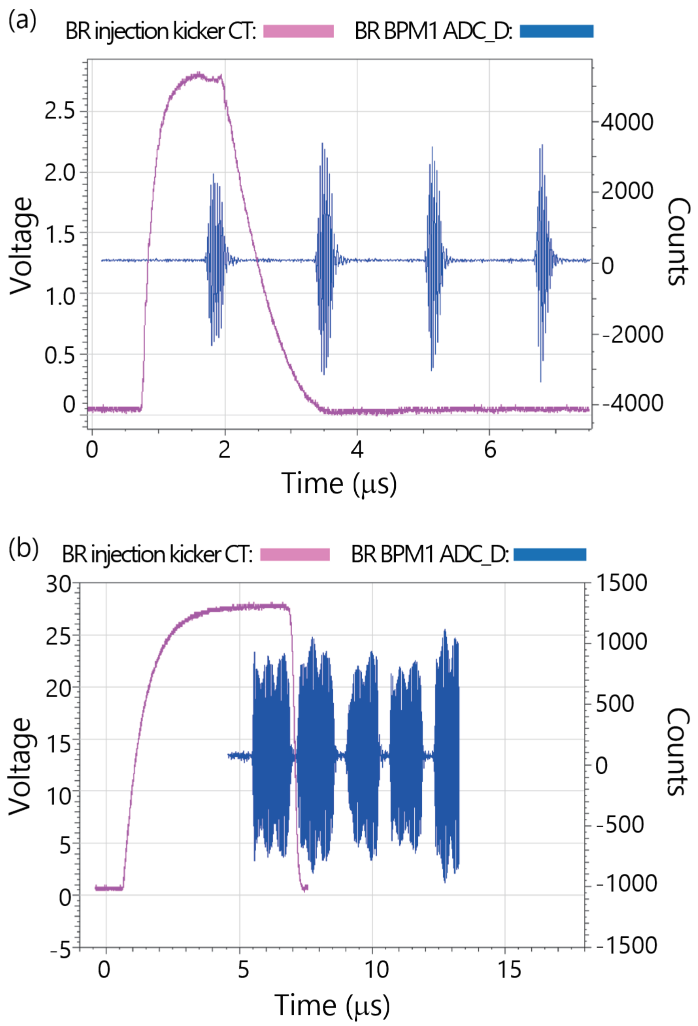

Fig. 2: The comparison of the capability of the bunch train carrying between (a) the PFN pulser and (b) the IGBT pulser. The tuning capability of the bunch train carrying is greatly enhanced by utilizing the IGBT pulser.

Table 1: The major operation parameters of the PFN pulser and the IGBT pulser

Parameter \ Pulser	PFN	IGBT
Pulse shape	Flat-top	Flat-top
Pulse length (s) used for bunch train*	0.3	1.2
Nominal current (A)	280	280
Inductance (μH)	3	3
Falling time (μs)	1.36	0.46
Pulse-to-pulse stability (%)	0.1	0.02
Flatness (%)	±0.2	±0.1
Postpulse ripple (%)	±0.2	±0.1
Repetition rate (Hz)	3	3

* The available pulse length for bunch-train tuning is limited by the TPS booster revolution time and the pulser falling time.

spectively. The low operation voltage of the IGBT pulser still provides a comparable environment to that of the PFN pulser. The IGBT pulser also requires drastically less space in the TPS tunnel, as shown in **Fig. 3**.

Full-Sine Septum Power Supply

An orbit disturbance of 13 μs was observed while the beam was excited by the injection septum in the TPS storage ring.[4] This un-negligible orbit disturbance results from the effect of the eddy current induced by the leakage field of the injection septum, and could not be suppressed effectively by the orbit feedback system. In order to diminish the effect of the eddy current, therefore, a full-sine septum power supply replaced the existing half-sine septum power supply for the beam injection in the TPS storage ring,[5] as shown in **Fig. 4**.

As illustrated in **Fig. 5**, the effect of the eddy current caused by the leakage field of the injection septum with the half-sine power supply gives a prolonged orbit disturbance of about 13 ms, whereas the disturbance duration is reduced to 0.7 ms after implementing the full-sine septum pulser. Notice that the 0.7 ms orbit disturbance duration matches with the full-sine period. On the other hand, this improvement also provides an opportunity to re-examine a more stringent criterion concerning the pulse-shape matching among four kicker pulses.[5]

In 2018, with the installation of the IGBT-switch kicker power supply and the full-sine septum power supply in the TPS booster ring and the TPS storage ring respectively, the overall beam

Fig. 3: The comparison of the space occupation between the IGBT pulser (green rectangle) and the PFN pulser (red rectangle) in the TPS tunnel.

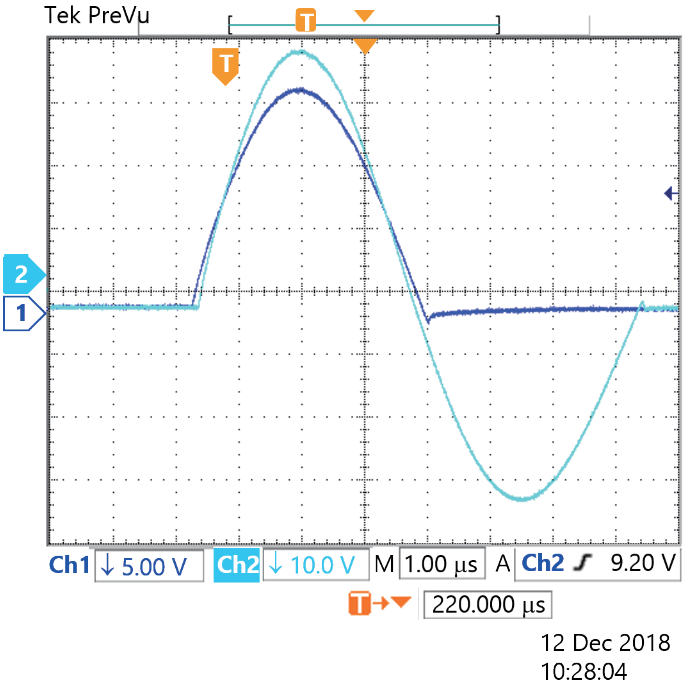

Fig. 4: The current durations of the TPS injection septum driven by the half-sine power supply (blue) and full-sine power supply (light-blue) are 350 µs and 700 µs respectively.

injection performance in TPS is significantly improved by carrying longer bunch train and having a smaller orbit disturbance. (Reported by Chyi-Shyan Fann and Kuang-Kung Tsai)

This report features the performance improvement of the TPS beam injection led by Chyi-Shyan Fann and Kuang-Lung Tsai.

References

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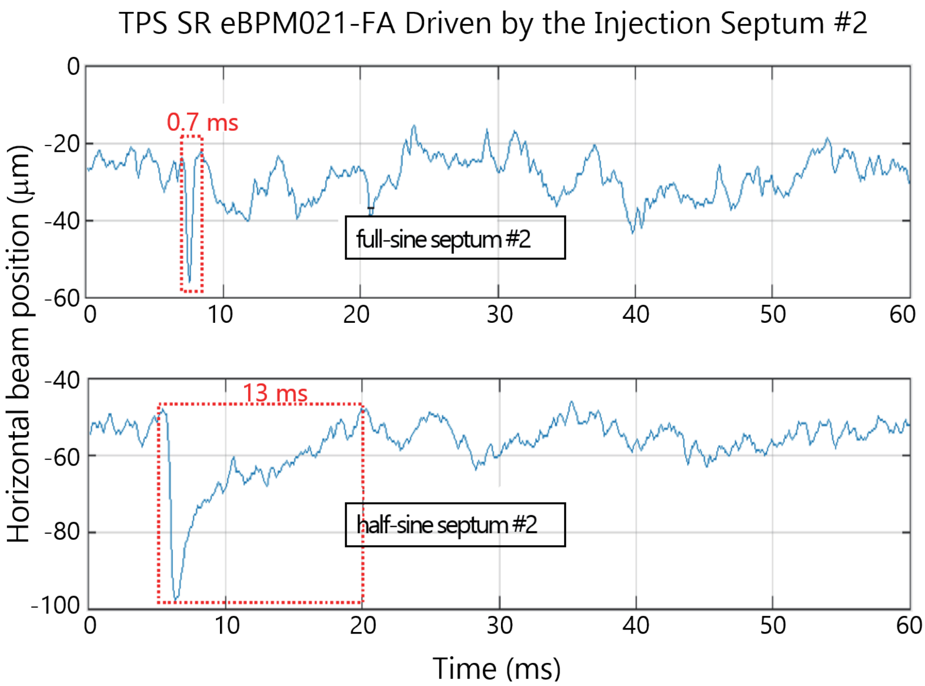

Fig. 5: The comparison of the orbit disturbance during the beam injection between the full-sine septum (top plot) and the half-sine septum (bottom plot). After implementing the full-sine power supply for the injection septum, the disturbance amplitude was reduced from 50 µm to 25 µm on the horizontal beam position, and the disturbance duration was drastically decreased from 13 ms to 0.7 ms