THE PULSED POWER SUPPLY SYSTEMS FOR TPS PROJECT

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Abstract

The performance of the pulsed power supply system for TPS project is summarized in this report. It consists of three types of pulser for booster injection/extraction and storage ring injection needs. Categorizing by their capability of delivered peak current, pulse shape base-width, they are for: 1) booster kicker: 500 A, flat-top, 1 μs; 2) storage ring kicker: 5 kA, half-sine, 5 μs; 3) transfer line septum: 10 kA, half-sine, 300 μs; respectively. All together, there are 10 units constructed for the associated pulsed magnets. The measurement results of the pulsed power supplies are presented.

INTRODUCTION

The accelerator complex of Taiwan Photon Source (TPS) project consists of a 150 MeV linac, 3 GeV booster, and a 3 GeV storage ring [1]. Pulsed magnets are used for beam injection into and extraction out of the booster and storage ring. The requirements of these magnets are given by the designed injection scheme, and the associated power supply specifications are derived as fabrication guideline [2-4]. A two-year project of constructing the pulsed power supply system for TPS project was initiated in 2010 for the fiscal year of 2011-2012 [5]. There are various types of 10 units pulsed power supplies to be fabricated for their associated pulsed magnets. They are: 3 units of PFN (pulse-forming-network) kickers for booster injection (1 unit) and extraction (2 units); 3 units of half-sine septum for booster injection, extraction, and storage ring injection; 4 units of half-sine kicker for storage ring injection. The power supply components were purchased, fabricated, assembled and bench tested covering the range as specifications required. While arranging the bench test, since the magnets are not available yet the corresponding inductive dummy loads are installed individually for testing each category power supply. The system construction was completed in 2012. They are ready to be delivered for injection system integration. In the following sections, the performance of these three types of pulsed power supply will be presented.

LAYOUT AND PROJECT TARGETS

The schematic layout of the pulsed power supplies involving in the beam injection and extraction processes is illustrated in Figure 1. The 150 MeV electron beam from the linac is injected on-axis into the booster in which the beam energy is raised up to 3 GeV. Then, the electron beam is extracted out of the booster by using two consecutive kickers. The storage ring multi-turn injection is accomplished with 4 units of well-matched half-sine kickers. There are also individual septa located at upstream of injection kicker and at downstream of extraction kickers for beam trajectory guiding purpose. The major required parameters of nominal current for these pulsed power supplies are summarized in Table 1.

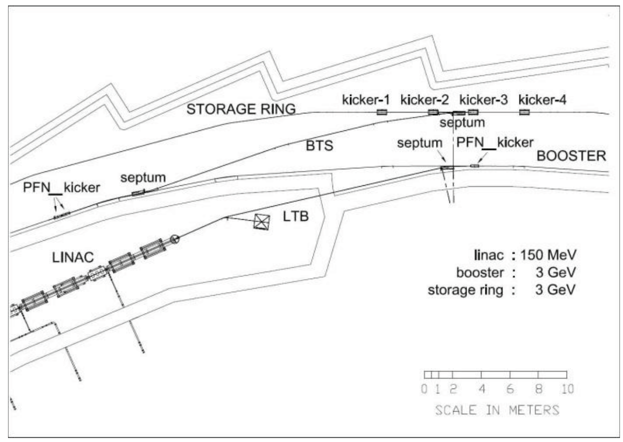

Figure 1: Schematic layout of pulsed power supplies.

Table 1: Designed Nominal Currents of the Pulsed-PS

PS - pulse_shape and design capability			
beam energy		150 MeV	3 GeV
booster	half-sine_septum	2.3 kA	8.5 kA
injection / extraction	PFN_kicker	270 A	370 A
storage ring	half-sine_septum	-	8.5 kA
injection	half-sine_kicker	-	2.5 kA

POWER SUPPLY TEST RESULTS

PFN Kicker Power Supply

The revolution time of the TPS booster ring is about 1.6 μs. The magnetic field shape of the injection and extraction kickers is of flat-top type. They are accomplished by using PFN power supplies. The design of the on-axis injection requests an available bunch train length of at least 1 μs [1]. This particular demand implies that the fall-time of injection and rise-time of extraction PFNs should be less that 0.6 μs. All together, three PFN power supplies are built with the same assembly for the easy of fabrication and future maintenance purpose. Typical bench tested result of the delivered pulsed current of PFN power supply is shown in Figure 2. The overall performance of the PFN-PS is summarized in Table 2 for specification list-checking purpose. It fulfils the beam injection (at 150 MeV) and extraction (at 3 GeV) needs

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with moderate output at nominal operation condition. It provides the flexibility of tuning with extended range in case selected approaches of injection test are to be explored in the early phase of beam commissioning.

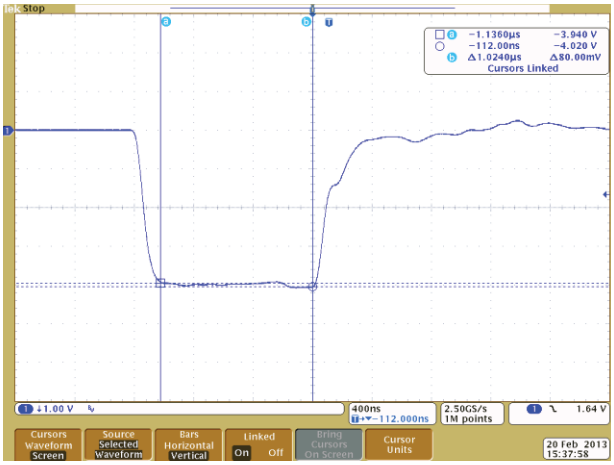

Figure 2: The pulsed current of the PFN-PS; scale: 100 A/V.

Table 2: The Performance of PFN Kicker-PS

PFN_kicker-PS			
parameter		specification	measured
pulse shape		flat-top	√
pulse length (µs)		> 1	1.1
nominal current (A) / max	inj	270 / 500	570
	ext	370 / 570	570
load inductance (µH)	inj	1.6	-
	ext	1.9	-
fall-time (ns; 5-95%)	inj	380	350
rise-time (ns; 5-95%)	ext	380	200
pulse-to-pulse stability (%)		± 0.1	± 0.1
flatness (%)		± 1	± 1
repetition rate (Hz)		3	3

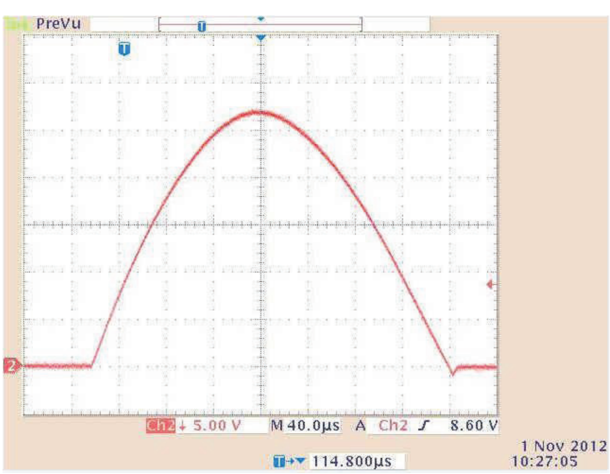

Figure 3: The pulsed current of the half-sine septum-PS; scale: 2 kA/5V.

Half-sine Septum Power Supply

There are three units of half-sine septum power supplies fabricated for this project with the same configuration. The septum are arranged in the beam transfer lines (LTB: linac to booster; BTS: booster to storage ring) at upstream of injection kicker so as to guide the electron beam aiming toward the designated phase space coordinates at injection scheme. Or, it sits at downstream of extraction kicker to guide the electron beam arriving at the proper entrance of the transfer line. The delivered current pulse specifications and build-up components are similar to what was adopted in previous TLS project with higher capability. Typical bench tested result of the delivered pulsed current of septum power supply is shown in Figure 3. The overall performance of the septum-PS is summarized in Table 3.

Table 3: The Performance of Half-sine Septum-PS

septum-PS			
parameter		specification	measured
pulse shape		half-sine	√
base-width (µs)		300	300
nominal current (kA) / max	inj	2.3 / 3.5	5
	ext	8.5 / 10	11
load inductance (µH)	inj	2	-
	ext	3	-
pulse-to-pulse stability (%)		± 0.1	± 0.1
repetition rate (Hz)		3	3

Half-sine Kicker Power Supply

Four identical units of half-sine kicker power supplies are fabricated for storage ring multi-turn injection purpose.

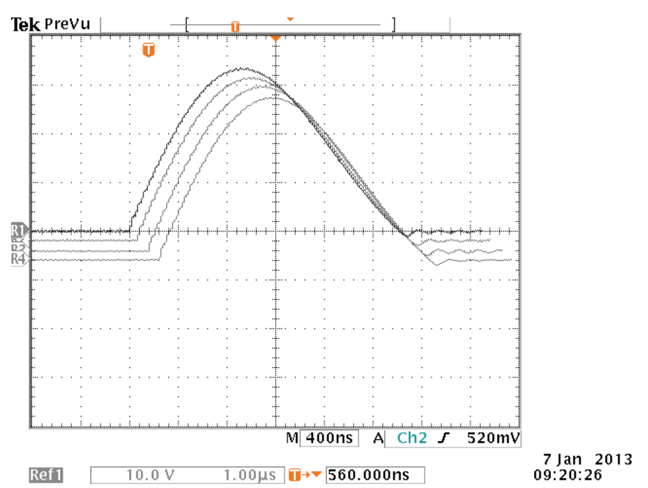

Figure 4: The aligned pulses of four units of kicker-PS; scale: 1 kA/10V.

The shape-matching of these four kicker pulses are crucial for top-up operation and inhibiting selection for user data acquisition application as well. Typical bench tested result of the delivered four current pulses is shown in Figure 4. Example of shape-matching examination using a commonly available lab-scope is given in Figure 5. The overall performance of the half-sine kicker-PS is summarized in Table 4 for specification list-checking.

Detailed observation of the measurement results concerning the shape-matching of the kicker pulses illustrated in Figure 5 indicates that the overall difference between any two sets of power supply is about 0.2%. This 0.2% kicker strength difference corresponds to a 0.1 mrad disturbance to the electron beam and is well acceptable to the injection need.

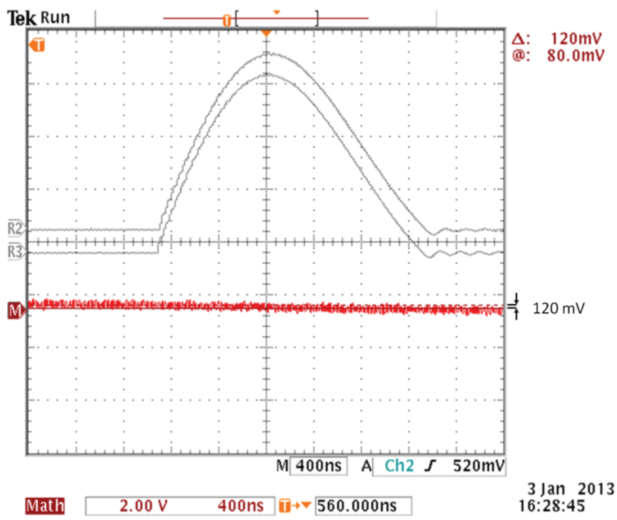

Figure 5: Shape-match checking of half-sine kicker-PS; scale: 1 kA/10V.

Table 4: The performance of half-sine kicker-PS

half-sine_kicker-PS		
parameter	specification	measured
pulse shape	half-sine	√
base-width (μs)	5.2	5.2
nominal current (kA) / max	2.3 / 5.0	5
load inductance (μH)	2.5	-
pulse-to-pulse stability (%)	± 0.1	± 0.1
shape-matching	< 5%	0.2%
jitter, p-p (ns)	± 2	√
repetition rate (Hz)	3	3

Half-sine Pinger for Beam Instrumentation Application

For beam instrumentation consideration, a pair of pingers is requested at a later phase of this pulsed-PS project. The horizontal and vertical planes pingers are a miniature version of the storage ring half-sine kicker with a base-width of 3 μs for single turn beam excitation purpose [6]. Some major parameters are listed in Table 5 for comparison purpose.

Table 5: The Performance of Half-sine Pinger-PS

half-sine_pinger-PS		
parameter	specification	measured
pulse shape	half-sine	√
base-width (μs)	3	3
nominal current (kA) H / V	2.5	2.5
load inductance (μH) H / V	0.8 / 0.35	-

SUMMARY

There are 10 units of the pulsed-PS constructed for TPS beam injection and extraction consideration. They are bench tested and reliability verified in fulfilling their corresponding specifications. The pulsed-PS system is ready to be integrated with the associated magnets, vacuum system and control interface. Two units of pinger for beam excitation purpose are also built and tested. The pulsed-PS system are designed and constructed with moderate margin if the TPS is operating at 3.3 GeV in the future phase.

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