THE DESIGN AND FABRICATION OF THE KICKER POWER SUPPLY FOR TPS PROJECT

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Abstract

The preliminary test results of the kicker power supply for TPS (Taiwan Photon Source) project will be presented in this report. The achieved capability of this test unit demonstrates that it fulfills the design requirement of providing half-sine pulsed current of 2.5 kA (peak), 5.2 µs (base-width), with jitter < 1 ns (peak-to-peak). Both units of using thyratron and IGBT switches are built with the same requirements. The technical considerations of both units for this particular application will be discussed.

INTRODUCTION

The Taiwan Photon Source (TPS) under construction consists of a 150 MeV electron linac, a 3 GeV full energy booster, and a 3 GeV storage ring. The storage ring is planned to operate top-up at 400 mA.

The top-up filling process will take place periodically within about every 100 seconds. In order to fulfill this requirement, the injection kickers will be triggered repeatedly at the same repetition rate. This proposed top-up operation mode requires stringent performance of the 4 injection kickers for good stability on pulse amplitude and jitter, and in particular, pulse-shape matching among these 4 kickers.

Test units of the kicker pulser have been built to examine their feasibility. Pulsers using both thyratron and IGBT switches have been tested. The results show that both units fulfill the pulser requirements on amplitude and jitter stability. The system configuration and the test results are briefly described in this report.

PERFORMANCE REQUIREMENTS

The circumference of the TPS storage ring is 518.4 m [1]. Beam injection will be taken place at a 10 m long straight section. The proposed injection scheme demand a 5.2 µs (base-width) half-sine pulse for the injection kickers in order to perform four-turn injection process [2]. The estimated parameters had been applied to examine and evaluate the feasibility of building pulse power supply for kicker in house. The design of the prototype kicker magnet requires the driving peak current to be 2.5 kA. The suggested stability goals of both pulse amplitude and jitter for the test unit are given as 0.5% and 2 ns, respectively. Since top-up mode will be implemented in the future for routine user operation, performance on high reliability and small long term drift of the test unit are required. The stability will be examined and analyzed for this purpose.

The estimated parameters for evaluating kicker pulser test unit are given in Table 1.

Table 1: Parameters for evaluating kicker pulser test unit

straight section (m)	10
magnet length (m)	0.6
magnet gap (mm)	34
field strength (T)	0.1
bend angle (mrad)	5.5
Width (half-sine base；us)	5.2
pulse current (peak；kA)	2.5
amplitude stability (%)	0.5
timing jitter (ns)	2

SYSTEM CONFIGURATION

The test unit configurations for both using thyratron and IGBT switches are briefly described in this section.

Thyratron Switch

Different models of thyratron tube have been tested for evaluation purpose based on the performance requirement and economics consideration. They are CX-1536AX and CX-1174 both equipping with double trigger capability. Typical functional block diagram of the thyratron test unit is shown in Fig. 1. A photo showing layout of the test unit is given in Fig. 2.

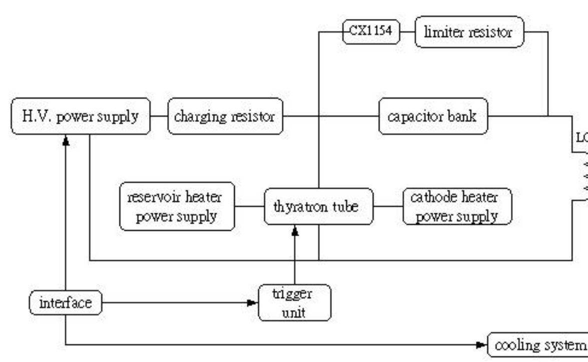

Figure 1: Functional block diagram of the thyratron pulser.

IGBT Switch

The IGBT test unit utilizes eupec switches in parallel on the primary side of the output transformer [3]. The corresponding output currents are configured adding up on the secondary side to fulfill the specification

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requirement. The IGBT chosen in this study uses optical trigger to turn-on the switching process. With this equipping property and appropriate isolation arrangement, these IGBT modules can be configured to operate at high voltage application [4]. Typical functional block diagram of the IGBT test unit is shown in Fig. 3. A photo of the IGBT arrangement and its trigger element is shown in Fig. 4 [5].

Figure 2: Photo of the pulser test unit using thyratron tube.

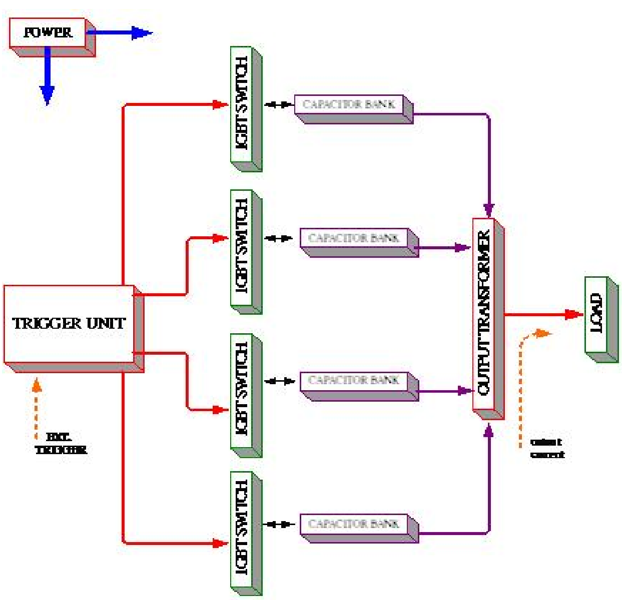

Figure 3: Functional block diagram of the IGBT pulser.

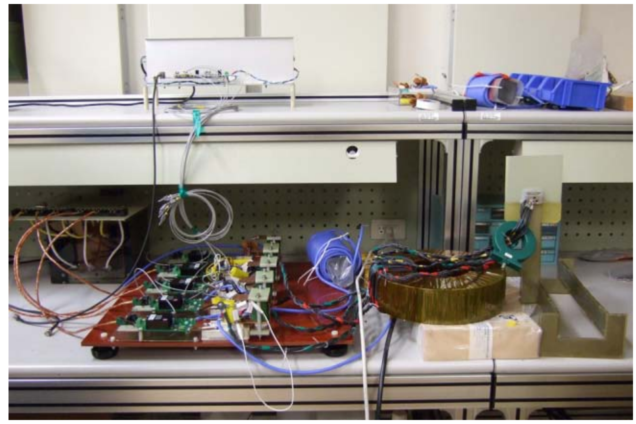

Figure 4: Photo of the pulser test unit using IGBT.

MEASUREMENT RESULTS

The measurement results of the pulser test units are presented and discussed in this section.

Thyratron Switch

Both CX1536AX and CX1174 thyratron tubes have been installed in the test unit for evaluation purpose. The test unit have been operating continuously 8 hours for long term stability and heat dissipation (cooling capability) monitoring purpose. The test results indicate that both cases fulfill the requirements indicated in Table 1 with long term drift <1%. The delivered pulsed current peak value has been tested up to 150% of that specified in Table 1. It is most probably that CX1174 switch will be selected for subsequent production for economy reason. A typical measured pulse current is given in Fig. 5.

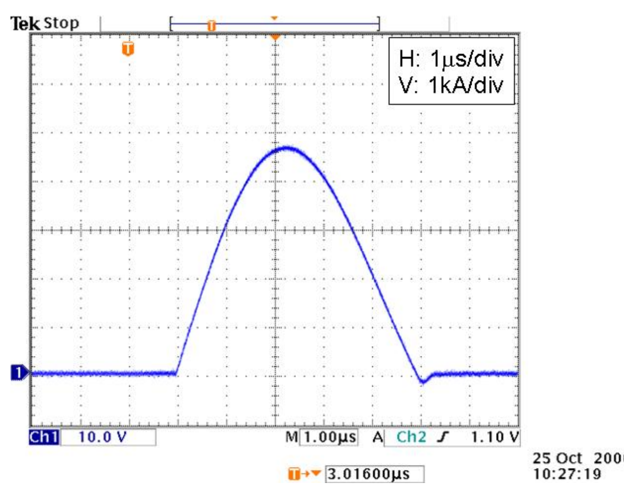

Figure 5: Typical pulse current delivered by the test unit using CX1174 thyratron switch.

IGBT Switch

As shown in Fig. 4, the simulating trigger signal is generated using DG-535 with precision < 0.1 ns. After converting into photon signals, they are transmitted in parallel to the high-voltage deck where these IGBT are installed. A single trigger source is used to initiate the transmitter for each IGBT simultaneously. These IGBT are considered acting independently such that the delivered pulsed currents are configured at the output transformer. Typical result of the IGBT delivered pulse current is shown in Fig. 6. It indicates that the IGBT arrangement and the associating configuration at the output transformer, a steady half-sine pulse current of 2.5 kA peak and 5.2 μs basewidth is achieved.

It is worth of noting that the response of the IGBT used in this study is relatively slow (~ 0.2 us) comparing with the thyratron used in previous cases (~ 20 ns). Yet, it is fast enough for the required 5.2 μs half-sine pulse. The various configurations applied at the output transformer and their effect in pulse shape matching among four kickers requires further examination.

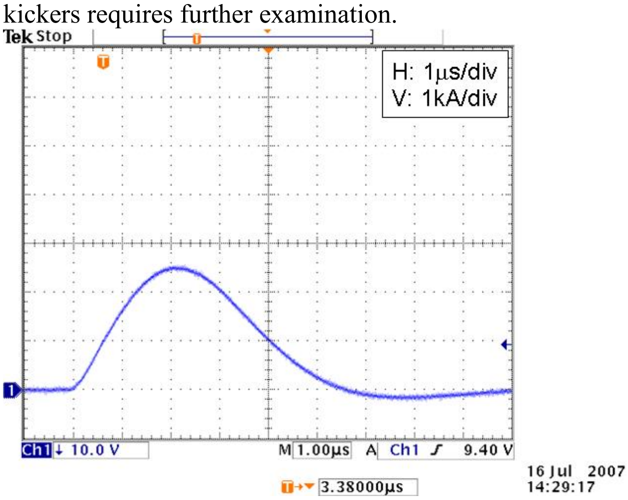

Figure 6: Typical pulse current delivered by the test unit using eupec-IGBT switch.

SUMMARY

Both test units of kicker pulser using thyratron and IGBT switches have been constructed and tested in this work. The measurement results show that both units fulfill the examining target. The thyratron unit has been driven with full loading for long term stability observation and the result is satisfactory. The IGBT unit demonstrates its advantage in operating at low voltage with comfortable operation margin. Considering the practical application in a four kickers system for TPS storage ring injection, the firing moment of each kicker pulser will need to be adjusted independently. The IGBT configuration employed in this study requires timing adjustment of individual IGBT involving in the subsequent synchronization process. It appears that the benefit of applying IGBTs and output transformer configuration in achieving the requirement of kicker pulser requires further study.

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