THE MODULATOR STABILITY SYSTEM FOR THE BEPCII KLYSTRON

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Abstract

The stability of the modulator high voltage output pulse is very important for a klystron. The voltage stability of the BEPCII modulator demanded is less than ±0.15%. To achieve this target, we use a thyristor voltage regulator having a feedback function to stabilize the DC high voltage of the modulator and a De-Qing circuit to stabilize the PFN charging voltage. This paper describes the modulator stability system and the stabilization measurement.

INTRODUCTION

One of the upgrading goals of the injector Linac for the Beijing Electron Positron Collider(BEPCII-Linac) is to control the beam energy spread within the acceptance of the storage ring. The energy spread required is within ±0.5%[1]. The klystron output power stability affects the energy spread, and the modulator high voltage pulse stability is one of the factors affecting the klystron output stability. To meet the energy spread target, the stability of the BEPCII modulator demanded must be less than ±0.15%. There are 16 modulators that drive 16 klystrons in BEPCII Linac. Each modulator output peak power is 110MW, DC high voltage is 21.5KV, and the pulse voltage is 320KV, whilst the repetition frequency is 50Hz. The klystron RF output is 50MW with a 4μs RF pulse width. Table 1 shows the basic parameters of E3730A klystron and modulator.

Table1: the parameters of klystron and modulator

Klystron	E3730A
frequency	2856MHz
output RF power	50MW, 4μs
cathode voltage	312KV
pulse current	365A
Modulator	
PFN & pulse trans	12stage, 2 para., 4.0Ω, 1:15
PFN charged voltage	43KV with D-Q
repetition frequency	50Hz
pulse width	4.5μs
stability(pulse to pulse)	±0.15%

THE FACTORS OF AFFECTING THE MODULATOR STABILITY

There are three factors causing the pulse high voltage instability in the line-type modulator. The first factor is the voltage fluctuation of power network making the modulator DC high voltage unstable. it causes instability of the modulator output pulse high voltage. The second factor is the ripple of DC high voltage after the high voltage rectifier transformer filter, also making the modulator output pulse high voltage unstable. The third factor is the variation of Q in the modulator resonant charging circuit causing modulator output pulse high voltage instability.

These three instability factors above are always present near the Q of the resonant charging voltage. By reducing this voltage instability, we can get a stable PFN charging voltage. Once the charging voltage is stable, the modulator output pulse high voltage is stable. The De-Qing circuit is used to reduce instability of the PFN voltage by saturating the charging transformer and so reducing the Q of the circuit when charging voltage achieves the desired voltage value. The De-Qing circuit is a fast acting voltage stabilizer and is triggered into operation for each modulator charging cycle. During the De-Qing operation, the resonant charging from a large storage capacitor via the charging transformer into the parallel connected PFN capacitors. The triggering of the De-Qing circuit just before the peak of the PFN voltage, which makes the charging transformer stop the resonant charging cycle due to the under damped or resonant conditions. This case can make the modulator charging voltage stable[3].

The modulator DC high voltage is obtained from the AC line passing via the thyristor voltage regulator, the high voltage rectifier transformer, a semiconductor rectifier assembly and the LC filter. We stabilize the modulator DC high voltage using a Thyristor Voltage Regulator which has a feedback control function to prevent any fluctuation of the AC line making the modulator DC voltage unstable. Then we use the De-Qing circuit to stabilize the modulator PFN charging voltage. The Thyristor Voltage Regulator adjusts the voltage by a proportional and integral controller (PI), so it is a slow feedback stabilizing voltage system needing some time to correct gradually the error voltage and obtain the required operating voltage.

Figure 1 shows the BEPCII modulator stability system. There are two feedback loops to stabilize the modulator charging voltage in the Figure1. One is slow feedback loop which stabilizes the modulator DC voltage by the thyristor voltage regulation. The other is the fast loop which stabilizes the modulator charging voltage by the De-Qing circuit.

We use a high precision AC stabilizer to stabilize the klystron filament voltage, the thyratron cathode heater voltage and the thyratron reservoir voltage to prevent any voltage variations affecting the modulator output pulse high voltage stability. The output phase voltage stability of the high precision stabilizer is less than ±0.1%. It is important to stabilize the klystron filament voltage.

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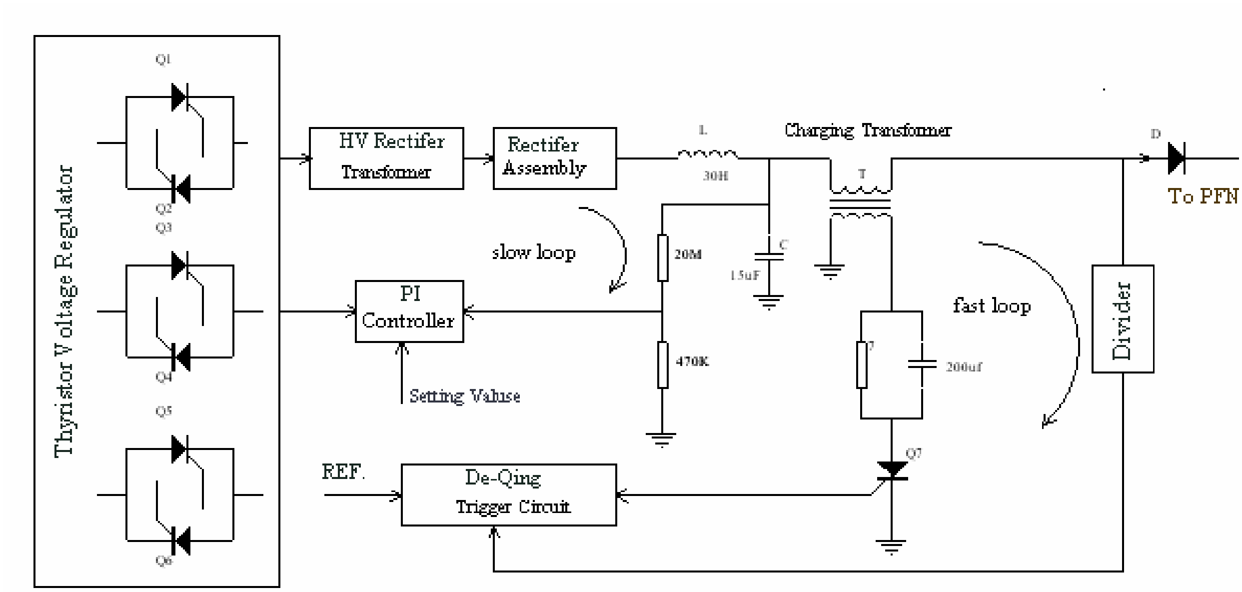

Figure1 modulator stability system

THE BEPCII MODULATOR STABILITY MEASURMENT

The measurement of the modulator stability has been done using two of the BEPCII modulators (the seventh and the tenth modulators) with a repetition frequency of 50Hz. We measured the modulator stability (pulse to pulse) using a digital oscilloscope, industry computer, GBIP interface and LabView software. Figure 2 shows the measurement system.

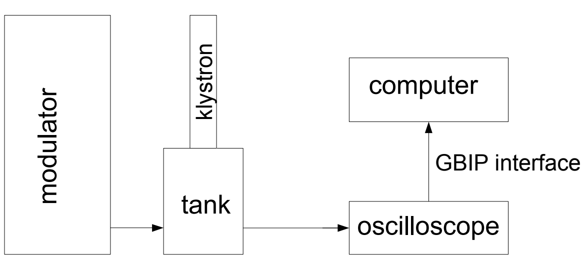

Figure2 the measurement system

The digital oscilloscope is a Tektronics TDS3034 with an offset function in order to remove high frequency noise coming from the thyratrons, The 16 sequential sampling points were averaged[2]. The high speed interface GBIP interface is made by NI.

We have measured the seventh and tenth modulators stability using this arrangement. Figure3 shows the seventh modulator stability measuring chart and Figure 4 shows the tenth modulator stability measuring chart.

Table 2 is the measuring data of the seventh and the tenth modulators stability.

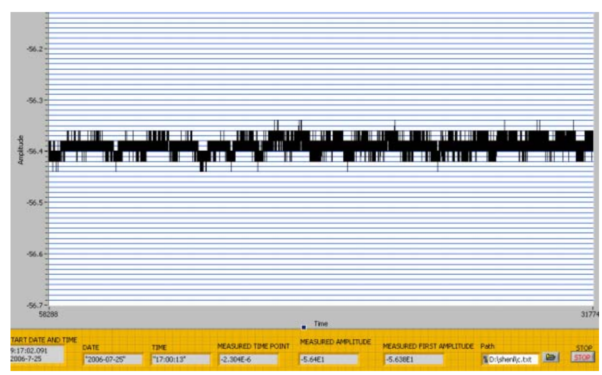

Figure 3 the seventh modulator stability measuring chart

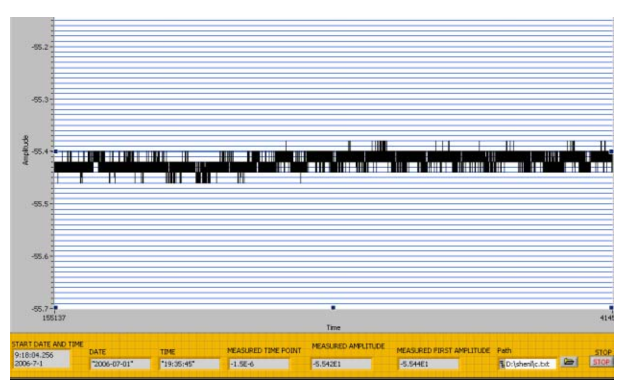

Figure 4 the tenth modulator stability measuring chart

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Table 2 the measuring data of the modulators stability.

Modulator	7#	10#
Stability	±0.09%	±0.075%

The modulator stability is less than ±0.15% from table 2. It achieves the target.

SUMMARY

This paper describes the BEPCII linac modulator stability system. The measuring results of two modulators stability satisfy the stability target. We will measure other modulators stability after October this year.

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