Modular Pulse Sequencing in a Tokamak System.

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Abstract

Pulse technique applied in the timing and sequencing of the various part of the MUT tokamak system are discussed. The modular architecture of the pulse generating device highlights the versatile application of the simple physical concepts in precise and complicated research experiment.

I. Introduction

In experimental studies of pulse plasma devices, timing and sequencing of the various events are an important part of the experiment and requires careful considerations. This is achieved in the MUT (University of Malaya Tokamak) tokamak system [1] by employing modular architecture involving various modules of pulse generating devices [2].

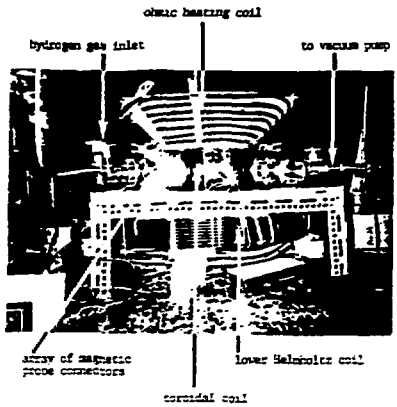

Fig. 1 The MUT system.

II. The MUT System

The MUT system consists of the stainless steel toroidal chamber, the toroidal field coil system and the ohmic heating coil system incorporating the vertical field generating design is assembled as shown in Fig. 1. The major radius of the chamber is 25 cm while the minor radius is 5.4 cm. The torus is divided into two halves separated by insulating flanges. The diagram of the top view of the torus is shown in Fig. 2. The vacuum system uses a 300 litres s^{-1} diffusion pump backed by a rotary pump. The system provides a base pressure of 10^{-5} torr. The toroidal field coil consists of 99 turns of insulated copper wire of total cross-sectional area of 0.3 cm^2. coil resistance of 0.02 Ω and inductance of 95 μH, giving a time constant for the toroidal field of 4.7 ms. It is powered by a 4.5 mF, 1.3 kV capacitor bank system while the ohmic heating system are powered by a 5 μF, 20 kV capacitor bank. The block diagram in Fig. 3 shows the sequence of operation of the various stages.

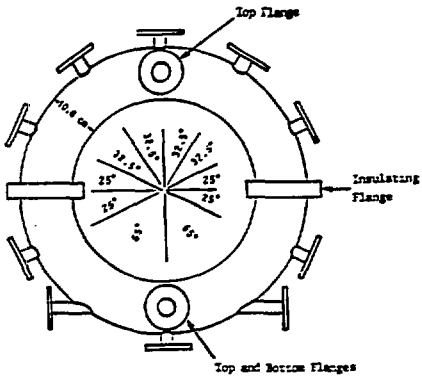

Fig. 2 The tokamak vessel.

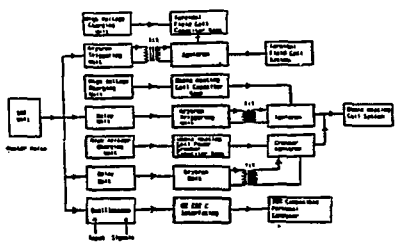

Fig. 3. Block diagram for the operational sequence of the tokamak system.

III. Modular Electronics and Control System.

The electronic system for the MUT tokamak system are specially designed in modular form. The four modules are as described below.

A. Module 1

Module 1 generates the 50 ns master trigger pulse which is produced by a SCR circuit activated manually by a 22.5 V pulse circuit shown in Fig. 4. The 0.1 μF capacitor of the SCR unit generates a pulse when fired across a 50 Ω load resistor. This pulse is sufficient to provide accurate triggering of the units shown in Fig. 3.

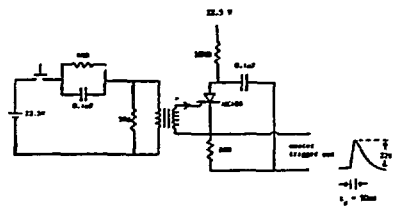

Fig. 4. Module 1 - SCR circuit.

B. Module 2

Module 2 consists of a SCR trigger unit. In this module the SCR switches a 400 V, 0.1 μF capacitor upon the introduction of a 20 V, 50 ns pulse from module 1 to the gate via a decoupling trigger transformer . The circuit is shown in Fig. 5(a).

C. Module 3

Module 3 is a krytron triggering unit. It uses a KN-6B krytron to switch a 0.47 μF capacitor charged to 2.5 kV. The pulse circuit is as shown in Fig. 5(b). The krytron is "kept-alive" by a 50 μA current to the KA electrode via a 50 MΩ tapping resistor. The krytron is triggered by the introduction of a pulse from module 2 to the gate of the krytron via a decoupling trigger transformer as before.

D. Module 4

Module 4 generates the ignitor pulse used to switch the ignitron and hence discharge the capacitor energy into the tokamak system. The circuit is shown in Fig.5(c). It consists of a 1:1 decoupling trigger transformer. The secondary of the transformer is connected via

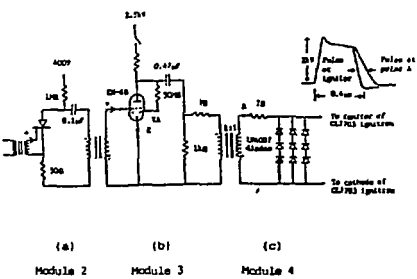

Fig. 5 Modules 2, 3 and 4.

a 7 Ω protective series resistor to the ignitor of the GL 7703 ignitron. The ignitron is protected from pulse reversal (not to exceed 25 V) by a bank of 1N4007 diodes. The 1:1 pulse transformer serves to isolate the trigger circuits from the high power capacitors that the ignitron is switching. The krytron circuit in module 4 provides a 2 kV pulse at the ignitor with a current flow of 200 A to create the required hot spot in the ignitron mercury pool necessary for switching on the ignitron. The ionization time (turn-on time) of the GL 7703 ignitron is 0.4 μs.

IV. CONCLUSION

A modular architecture consisting of the pulse generating devices used in the timing and time sequencing of the tokamak system is described. Its compactness and versatility have allowed its applications in other pulse plasma devices such as the focus [3], pinch [4] and electromagnetic shock tube [5] with minimal modifications.

V. REFERENCES

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