Development of PLC controlled Motorized Tuning System for 3 MW Tunable Pulse Magnetron

N, Kanagarj[1], RK Verma[1, 2], S. Maurya[1,2], Prateek Chaudhary[1]
[1]CSIR-Central Electronics Engineering Research Institute, Pilani-333 031
[2]Academy of Scientific and Innovative Research (AcSIR), New Delhi
Email: nkraj86@gmail.com

Abstract – This paper presents precise frequency tuning of a 3.0 MW S-band (2.856 GHz) pulse magnetron using the developed PLC controlled motorized frequency tuning circuit. Any vacuum electronic device poses risks of harmful radiation emission (like X-rays) while in operation, and magnetron is also not an exception. Hence the dynamic tuning of such magnetrons has to be done remotely. The manuscript highlights the design and development of a remote tuning system using PLC control circuit and feedback network. Total Tuning of 12 MHz has been obtained with 2.5MHz per turns by the developed tuning system during magnetron operation. In addition 0.5V set potentiometer value equivalents to 1MHz frequency tuning. The tuning mechanism has been implemented by sets of pulley connected via belts and DC motors, a driver circuit, a 12 V DC power circuit and a PLC controller. The reference potentiometer is used to set the analog input voltage (corresponding to specific tuner position) to the PLC, the PLC controller then execute the program and sets the digital output by comparing the reference value and the tuner feedback value. This in turn makes the tuner move to a specific direction (forward or reverse) and thereby controlling the magnetron frequency within its tuning range[1].

I. INTRODUCTION

A Magnetron is a highly efficient, portable and cost effective crossed field vacuum tube microwave oscillator[2]. These are used in Radars, Microwave Ovens, Cargo Screening Machines, Medical Linear Accelerators, Industrial Drying systems, microwave based autoclave systems, etc. Magnetron being an oscillator is susceptible to small change of frequency during its operation. In addition an operational magnetron can emit harmful radiations and hence should be operated remotely. Precise remote tuning of the frequency is an added advantage and is a must for such devices. A motorized frequency tuning control mechanism is explained in this paper.

II. FREQUENCY TUNING CONTROL DESIGN

The major components of the frequency tuning control system are (a) PLC controller (b) Feedback mechanism (c) Power supplies and driver circuit. Each unit has its own specific tasks and the combined effect results in the dynamic frequency tuning control of the magnetron, while in operation.

(a) PLC Controller section

PLC is a microprocessor based controller. It has programmable memory for internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic through digital or analogue input and output modules [3]. The PLC receives input data, processes the logical sequence based on the user program and then finally drives the motor for frequency tuning of magnetron. The schematic of the PLC controller is shown in the Fig.1 [3].

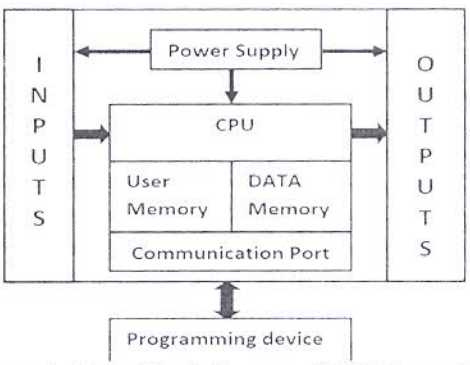

Figure 1: Basic Block diagram of PLC Controller

(b) Feedback Mechanism

This section of the tuning mechanism (Fig.2) consists of a set of pulleys connected via belt, a set of variable potentiometers, a 12 V DC motor and its driver circuit. One of the pulley is connected to the tuner of the magnetron (pulley 1) and the other is

connected to the 12V DC motor (pulley 2). One of the potentiometer is used as a 'set pot' which sets the reference voltage for the PLC controller, while the other is the 'feedback pot' connected to the pulley 1 [4]. The DC motor is controlled by the motor driver circuit getting its input from PLC controller in the form of digital pulse outputs. To control motor speed we can use pulse width modulation (PWM), applied to the enable pins of L293 driver. PWM is the scheme in which duty cycle of a square wave output from PLC is varied to provide a varying average DC output. By applying a PWM pulse the motor is switched ON and OFF at a given frequency Here IC L293D used as motor driver. It has two H-bridge drivers. So it can drive two dc motors. Direction of the motor controlled by asserting one of the inputs to motor to be high (logic1 or +5V) and the other to be low (logic 0 or gnd). To run the motor in the opposite direction just interchange the logic applied to the inputs of the driver. Asserting both inputs to logic high or logic low will stop the motor.

(c) Power Supplies

There are primarily two power supply used in this tuning system a 5V DC and a 12V DC. The 5V Dc supply is used for driver IC L293D operation and its inputs and the 12 V DC supply drives the motor [5].

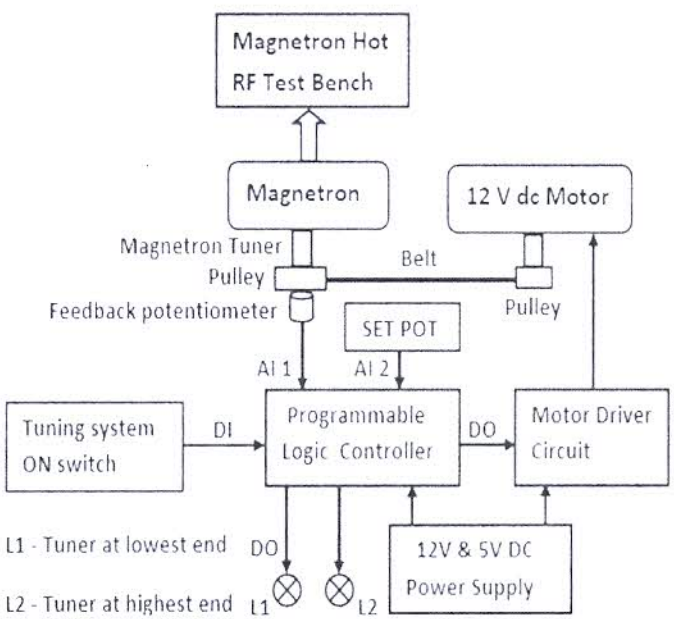

Figure 2: Basic Block diagram of Motorized frequency tuning system

The frequency tuning mechanism happens as follows: when the tuning system is switched on a digital input DI goes to the PLC controller and this initiates the program. At this moment the magnetron's tuner and the feedback potentiometer are kept at the lowest tuner position (corresponding voltage equivalent is 0V). Now the PLC compares the 'set pot' value and the 'feedback pot' value for deciding the motor direction. If the set pot value > feedback pot value then the forward command gets ON else the backward command is ON. The motor is at rest if the set pot value is equal to feedback pot value.

III. HARDWARE MODULES AND TUNING RESULTS

The hardware modules of major components of the motorized frequency tuning mechanism is shown in Fig.3. The PLC controller module and the Driver module is shown in Fig.3. The set pot can be seen on the front panel of the PLC controller module. The PLC module is also provided with the highest end and the lowest end interlocks. These interlocks prevents the motor from rotating once the tuner reaches its highest or the lowest end. The highest digital count value of the set pot for highest end corresponds to 600 and for the lowest digital count value is 0. Fig.4a shows the placement of the motor, pulley1, pulley 2, feedback potentiometer and the belt mounting. The entire setup is mounted on the electromagnet pole-piece using supporting plates. The magnetron is placed in between the poles of the electromagnet and is hidden in the present view. Fig.4b. shows the complete tuning control system with the 3MW magnetron test bench.

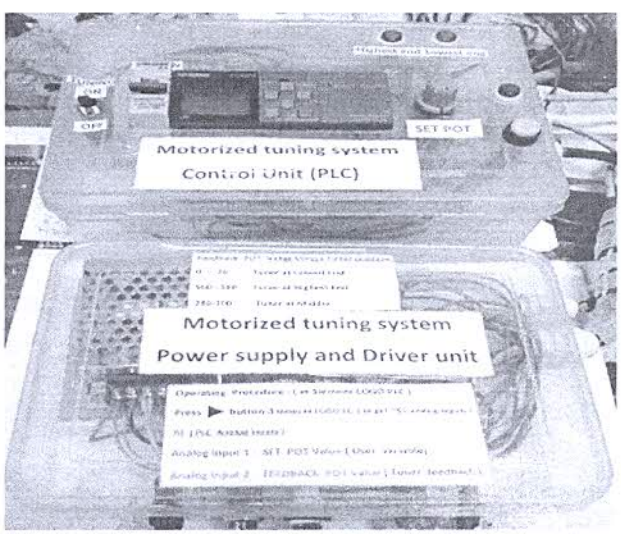

Figure 3: PLC Controller and Driver Circuit Modules of tuning system

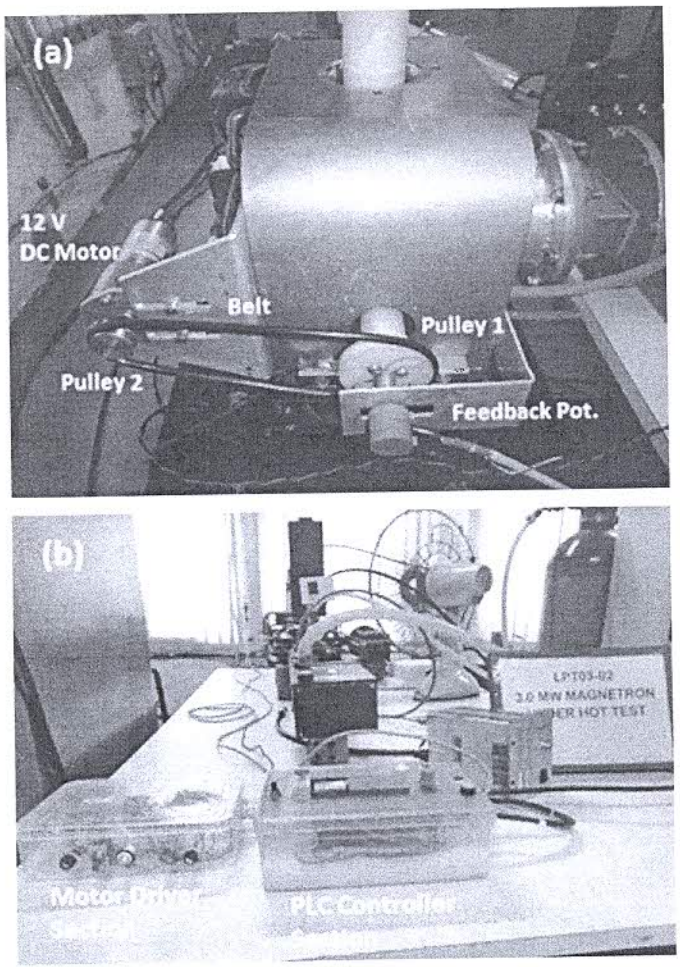

Figure 4: (a) Basic mounting and placement of components of Motorized frequency tuning system (b) Complete experimental setup

IV. CONCLUSION

Remote frequency tuning of a 3 MW tunable pulsed magnetron operating at 2.856 GHz with a tuning range of 12 MHz has been successfully implemented with PLC controller based motorized tuning control system. Total Tuning of 12 MHz has been obtained with 2.5MHz per turns by the developed motorized tuning system during the magnetron operation.

ACKNOWLEDGMENT

Authors are thankful to the Director, CSIR-CEERI for granting permission to present this paper. They are also thankful to their colleagues of Project team for their supports.

REFERENCES

[1] F. Rosebury, "Handbook of electron tubes & vacuum techniques", Page No. 80-81, Addison Wesley, 1965.
[2] G. B. Collins, "Microwave Magnetrons", Chapter 12, McGraw-Hill, New York, 1948.
[3] www.siemens.com
[4] www.bourns.com
[5] www.circuittoday.com