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Design of DC Servo Motor Control for GMRT FPS at Prime Focus of 45m Dish Antenna.

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Abstract – **In this paper, we propose the design of Feed Positioning System for 45m dish antenna using servomotor control system. Altium software is used for PCB design. For 5volt input with torque of 2.7Nm (Newton meter) obtained speed of 2000rpm & motor stops rotating at 0volt input. Speed and current through motor are controlled by control module. Module is designed o precisely control the FPS (Feed Positioning System) of GMRT (Giant Meterwave Radio Telescope) using DC servomotor, so that the antenna can track the astro objects or satellites in any direction in sky.**

Keywords - **Servomotor, astro-objects, feed positioning system, surge suppressor.**

I. Introduction

I.1. GMRT

Giant Meter wave Radio Telescope is world's largest array of radio telescope at meter wavelength. GMRT is a very versatile instrument for investigating a variety of radio astrophysical problems ranging from nearby Solar system to the edge of observable Universe.

GMRT has 30 fully steerable gigantic parabolic dishes of 45m diameter. Fourteen of the thirty dishes are located more or less randomly in a compact central array in a region of about 1 sq km, which is also known as the central square. The central square also has the main control and observation infrastructure of GMRT. The remaining sixteen dishes are spread out along the 3 arms of an approximately `Y' shaped configuration, the endpoints of which lie on an imaginary circle of 25km diameter [5].

Picture 1: Model showing positions of 30 antennas erected in an imaginary circle of 25km diameter.

I.2. Feed Positioning System

Feed Positioning System is used to precisely position or focus the feeds that are located on the four faces of rotating turret. This precise positioning is achieved by velocity and current control loops. The Telescope is to be operated at 150, 233, 327, 610 and 1420 MHZ. The feed can be positioned for desired frequency by rotating the feed turret. And hence a very accurate control mechanism is required is required for this feed positioning system.

I. Block Schematic:

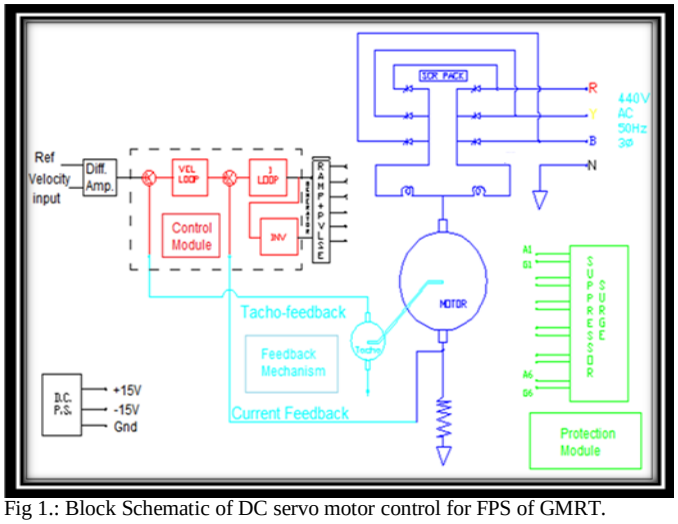

Fig 1.: Block Schematic of DC servo motor control for FPS of GMRT.

The block diagram consists of following main blocks:

- The Power module
- The Control Module
  1) Velocity Loop
  2) Current Loop
  3) Current Limit
  4) Overspeed Detector
- The Protection Module
- The ramp and pulse generator

II.1. Power module

- The SCR packs are the basic power section of the amplifier.
- They are used here as a six pulse thyristor converter.

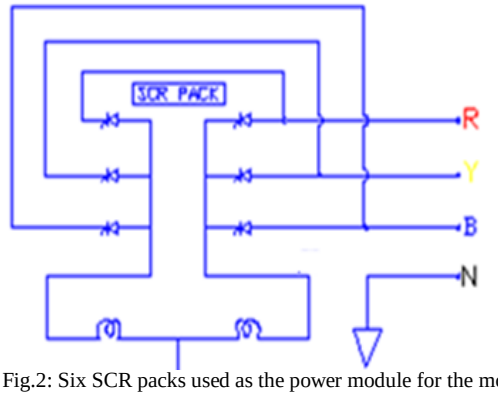

Fig.2: Six SCR packs used as the power module for the motor.

II.2. Control Module

It consists of two main blocks:

1) Velocity Loop
2) Current Loop

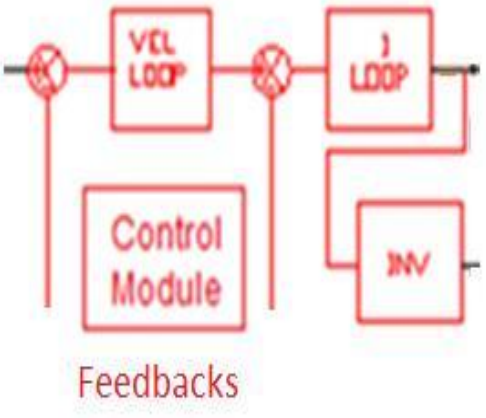

Fig. 3: Control Module showing velocity and current loops.

a. Velocity Loop:

The velocity loop senses both the speeds and control averages of both the speeds. Speed feedback is derived from tachometers provided with servo motors. The tachos produce a DC voltage proportional to the motor speed. The velocity loop controller uses a lead lag compensator. The lead network is included in the tacho feed back path, boosts the low frequency forward gain necessary for good steady state accuracy[3].

b. Current Loop:

The current loop consists of the current loop compensator, thyristor four quadrant convertor and DC servomotors. The current loop compensator consists of a PI controller giving good steady state accuracy. The thyristor convertor consists of a fully controlled, three phase half wave, four quadrant, and fully regenerative thyristor bridge. Four quadrant operation enables a motor to act as a generator thereby exerting an opposing torque in the counter torquing arrangement. Regenerative braking ensures quick reversal of motor[2].

c. Current Limit:

Current Limit is used to maintain the current flowing through motor below the maximum current rating of the motor.

d. Over speed Controller:

Over speed Controller is used to keep the speed of motor below its maximum rpm ratings. The over speed will switch on red LED and also stops further increase in motor speed.

II.3. Protection Module:

This circuit is connected in between the anode and gate of SCRs to protect them from RF interference. Surge

currents from nearby industries cause falls triggering of SCR packs and he motor rotates automatically.

Due to this false triggering the antenna will rotate and the racking path will be changed. This is undesirable for the observations. Hence Surge suppressor card is used.

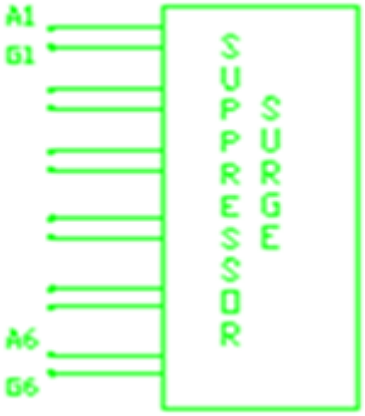

Fig.4: Surge Suppressor working as the protection module.

The surge currents and spikes of currents are suppressed by this module making these spikes smoother to avoid any triggering.

III. Designs and Circuit Diagrams:

III.1. Power Supply:

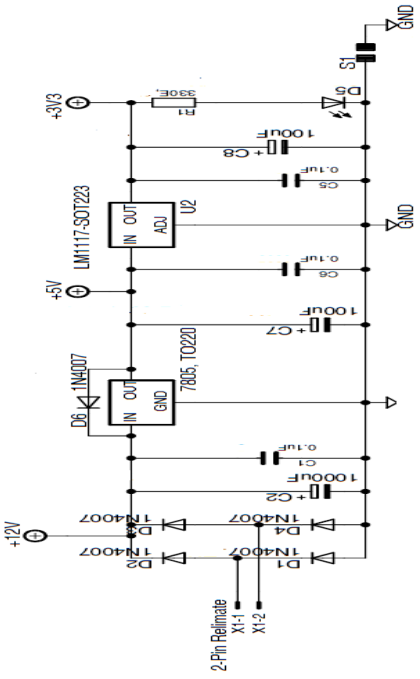

Fig 5: DC Power Supply circuit.

The circuit uses standard power supply comprising of a step-down transformer from 230V to 12V and 4 diodes forming a Bridge Rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 470µF to 1000µF. The filtered dc being unregulated, IC LM7805 is used to get 5V DC constant at its pin no 3 irrespective of input DC varying from 9V to 14V. The input dc shall be varying in the event of input ac at 230volts section varies in the ratio of V1/V2=N1/N2.

The regulated 5V DC is further filtered by a small electrolytic capacitor of 10µF for any noise so generated by the circuit. One LED is connected of this 5V point in series with a resistor of 330Ω to the ground i.e., negative voltage to indicate 5V power supply availability. The 12V point is used for other applications as on when required.

III.2. Control Module

a. Velocity Loop:

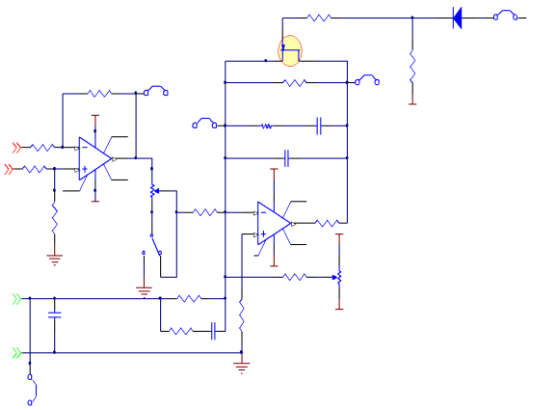

Fig.: Circuit Diagram of Velocity Loop

VR+ and VR- are Voltage Reference inputs that can be given manually by the users. TF+ and TF- are Tacho-Feedback inputs which gives negative feedback from the motor. These two inputs are compared and the error between these two is minimized to obtain the desired speed of revolution.

b. Current Loop:

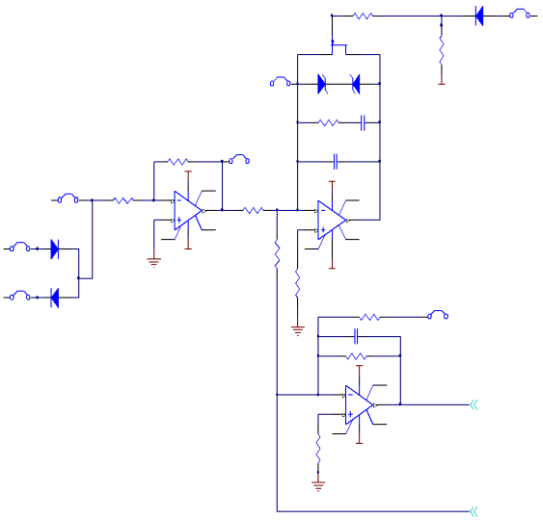

Fig.: Circuit Diagram for Current Loop.

The output of velocity loop is given to the current loop. It compensates for the gravitational force and wind effect acting on the antenna. It ensures smooth and steady changes in motor speed.

It monitors the error signal and the actual current flowing through motor. It then increase/ decrease the current flowing through motor to achieve the desired rpm.

b. Current Limit:

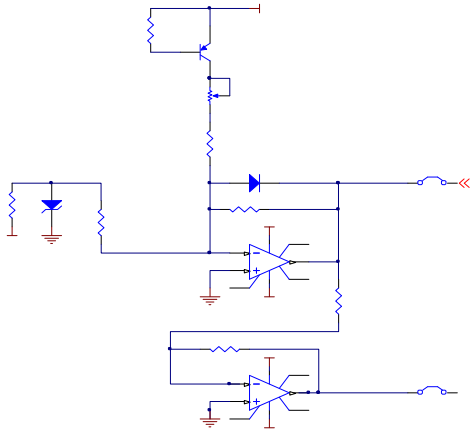

Fig.: Circuit for Current Limit module.

Current limit ensures that, current flowing through motor is maintained below the maximum rating of motor.

c. Over Speed Detector

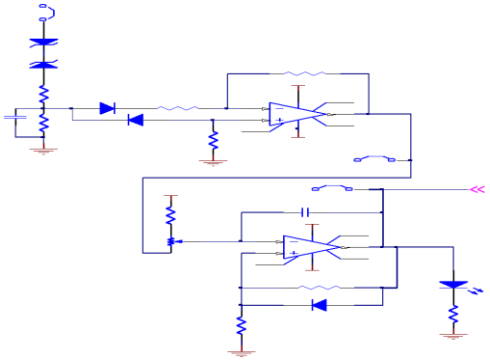

Fig.: Over Speed Detector Circuit Diagram.

This protection circuit keeps the rpm below its maximum ratings preventing the motor from over speeding. Over speeding may occur if motor draws more current due to sudden variations in the load.

II. Result:

Potmeter Front Panel Control(v)	Motor Speed(rpm)	Vtacho(v)	Itacho Front Panel Meter(A)
0	0	0	1.4
1	160	2.56	1.9
2	350	5.69	2.2
3	554	8.96	2.4
4	751.5	12.04	2.4
5	940.1	15.02	2.7
6	1140	18.20	2.9
6.73	1276	20.44	2.9

Table 1: Readings of Motor Speed, reference input, and tacho feedback.

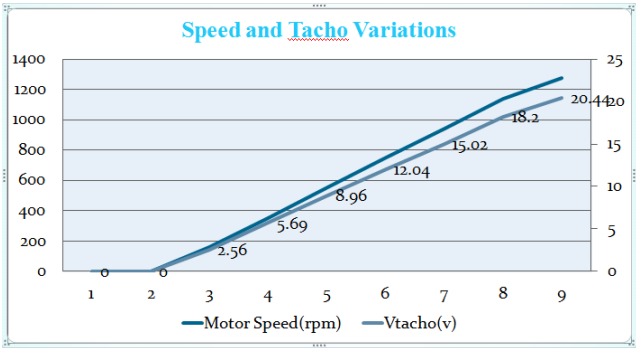

Fig: Speed and Tacho variations with respect to time.

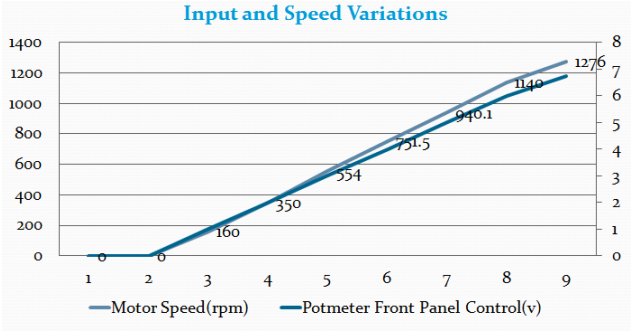

Fig: Reference input and speed variations with respect to time

III. Conclusion

Precise controls of a 3 phase DC servomotor for GMRT antenna feed position system have been obtained. The current FPS used at GMRT is bulky. So in order to miniaturized & make it more handy and compact. We removed some of the current blocks that are not much needed in our new system. The system is working as desired giving speed range between 0 to 2000 rpm as per the requirements.

The protection circuits are working perfectly keeping the current and speed of motor below its maximum ratings. Surge suppressor protects the motor from the RF noise generated in the industry.

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