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Bench Model of Electrical Control System for Inflatable Hemi-Spherical Structure

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Abstract
The Development of Bench Model of Electrical Control System for Inflatable Hemi Spherical Structure (IHSS) is presented in this paper. Electrical control system is used for controlling the Air Blower System, Air Conditioning System and monitoring of complete IHSS. Electrical Control System also provides the modes of control such as Auto Control, Remote Control and Local Manual Control. A bench model is developed for achieving all these facilities and verifying design concept.
Keywords:-Inflatable, Control System, Bench Model, Simulation.

1. Introduction

Development of such radar and electronics equipments is always required in Defence, which can work in adverse geographical and environment condition. For achieving highest working of Radar and electronic equipments in adverse condition, the control of temperature, humidity and other environmental factors is very important. For these, the controlled environment can be provided by the IHSS. IHSS is a light weight and flexible structure made of coated fabric which provides the controlled environment in limited area for working of Radar. Due to transparent fabric for Micro-waves, it does not affect the working of Radars. IHSS consists of Fabric Structure (without any metallic support), Air Blower System, Air Conditioning System, Electrical Control System and Emergency Power Backup System (EPBS). Electrical Control System is one of critical part of IHSS which controls the other part of IHSS such as Air Blower System and Air Conditioning System. Electrical Control System maintains the shape of structure and temperature inside of IHSS by controlling the Air Blower System and Air Conditioning System with the help of Differential Pressure Sensors, Wind Speed Sensors and Temperature Sensors. The IHSS system is shown in Fig. 1. For developing the technology of Electrical Control System, the bench model is developed.

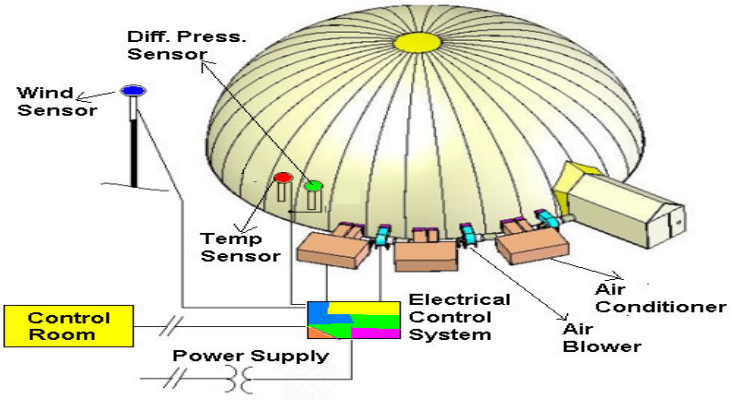

Figure1 Inflatable Hemi Spherical Structure (IHSS) system

2. ELECTRICAL CONTROL SYSTEM

Watermark embedding algorithm –

Electrical Control System is used to control Air Blower System to maintain the Hemi spherical shape of flexible structure of IHSS. It is also used to control the Air Conditioning System for maintaining the temperature inside of IHSS. Block Diagram of Electrical Control System is shown in Fig.2. For controlling the Air Blower System and Air Conditioning System, the signal from Differential Pressure Sensors, Wind Speed Sensors and Temperature Sensors are used in Electrical Control System. Differential Pressure Sensors are used for measuring the differential pressure of IHSS. This differential pressure maintains the Shape of Fabric Structure without any solid metallic support. The differential pressure of IHSS is maintained by pushing the air inside the structure using the Air Blower System. For Controlling the Air Blower System, the deferential pressure and Wind Speed is measured and corresponding signal of sensors are sent as feedback to the Electrical Control System. For example: if wind speed is less than 50Kmph, to maintain a differential pressure of 3mbar, control of one blower

is required. If wind speed is more than 50Kmph, a differential pressure of 9mbar is required to be maintained. For controlling the Air Conditioning System, Temperature sensors are used for temperature measurement and feedback signal is sent to Electrical Control System. On failure of Power Supply from Grid, Electrical Control System operates the emergency Air Blower of Air Blower System through EPBS and keeps off all other Air blower and Air Conditioners. All information of IHSS is send to Remote Operating Station for monitoring purpose. Same information is also displayed at panel of Electrical Control System. Electrical Control System also schedule the operation of Air Blowers of Air Blower System and Air Conditioners of Air Conditioning System, i.e. after a certain time period, the duties of Air Blowers or Air Conditioners are changed. First Air Blower will work as second Air Blower and Second Air Blower will work as First Air Bower. Electrical Control System provides the Auto Control mode, Remote Control mode and Local Manual Control mode for controlling the Air Blower System and Air Conditioning System.

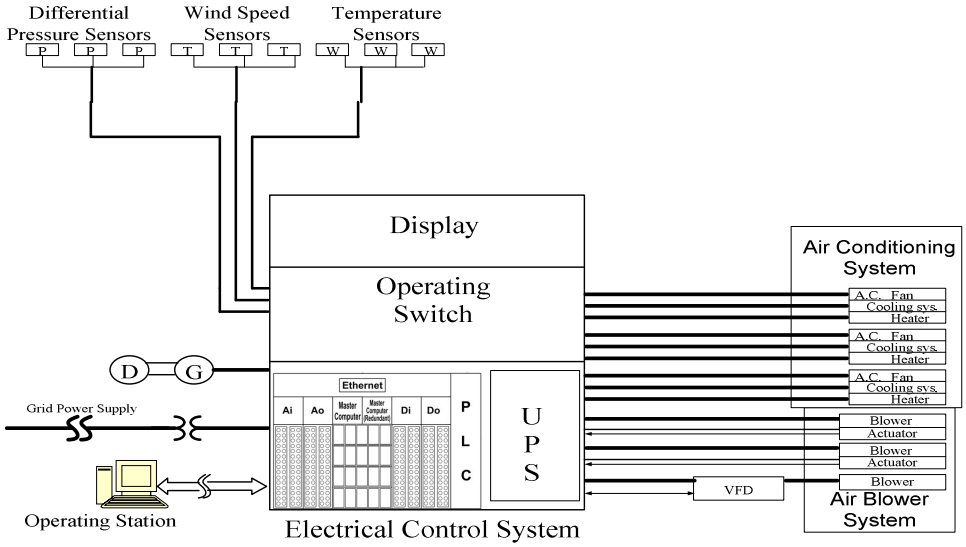

Fig.2 Configuration of Electrical Control System

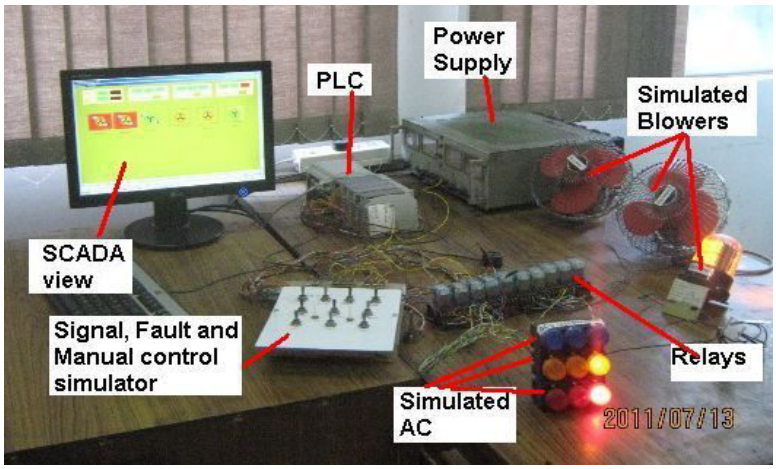

Fig.3 Bench Model of Electrical control System

3. NEED OF ELECTRICAL CONTROL SYSTEM

Inflatable Structure is a hemispherical structure of coated fabric without any solid metallic structure and provides a controlled environment in limited area. For maintaining the shape of IHSS and temperature in it, Air Blower System and Air Conditioning System are used. Electrical Control System is required for controlling the Air Blower System and Air Conditioning System. Electrical Control System is required for following purpose:-

For maintaining the hemi spherical shape of Inflatable Structure.
For controlling of Air Blower System and Air Conditioning System as per requirement.
For Auto control of Air Blower System & Air Conditioning System.
For Remote control of Air Blower System & Air Conditioning System.

For Manual control of Air Blower System & Air Conditioning System.
For maintaining required Differential Pressure, if wind speed is less then 50Kmph.
For maintaining required Differential Pressure, if wind speed is more then 50Kmph.
For maintaining temperature comfortable range inside of IHSS.
For transferring the requirement on other Air Blower, on occurrence of failure of one Air Blower in Air Blower System.
For transferring the requirement on other Air Conditioner, on occurrence of failure of one Air Conditioner in Air Conditioning System.
For maintenance of Air Blower and Air conditioner without shut down of IHSS.
For monitoring of various parameters for complete IHSS.
For controlling of emergency blower with EPBS on failure of redundant main power.
Sending alarm to panel/remote location in case of failure of any Air Blower or Air Conditioner.

4. BENCH MODEL OF ELECTRICAL CONTROL SYSTEM

For development of Bench Model of Electrical Control System, the Air Blower System and Air Conditioning System have to be simulated. The Bench model of Electrical Control System is shown in Fig.3. The main components of Bench Model are marked in Fig.3. Programmable Logic Controller (PLC), Supervisory Control and Data Acquisition (SCADA) view, Relay and Power Supply are the main components of Bench Model of Electrical Control System which control the simulated Air Blower System and Air Conditioning System. For simulating the different operating conditions for Electrical Control System. Signal, Fault and Manual Control (SFMC) simulator is used. Auto Control, Remote Control and Manual control mode of Electrical Control System is developed in Bench Model.

4.1 Simulated Air Blower

To maintain the differential pressure of IHSS, three Air Blowers are used as Air Blower System for pressurization of Air. In Bench model of Electrical Control System, this Air Blowers System is simulated. For simulating this, two Blower fan (Blower Fan1 as Air Blower-1, Blower fan-2 as Air Blower-2) and one LED (as Air Blower -3) is used as Air Blower of Air Blower System. Simulated Air Blower system is shown in Fig.4.

4.2 Simulated Air Conditioner

Three Air conditioners are used as Air Conditioning System in IHSS. These are simulated by indicator in Bench Model of Electrical Control System. Each Air Conditioner is simulated by three indicators - Blue indicator as cooling system of Air Conditioner, yellow indicator as fan of Air Conditioner and third red is heating system of Air conditioner. Simulated Air Conditioner System is shown in Fig.5.

4.3 Programmable Logic Controller (PLC)

The decision for operation of Air Blower system and Air Conditioning System is made by Programmable Logic Controller (PLC). The simulated feedback signals of sensors are used in PLC and low power control signal are generated for controlling the Air Blower System and Air Conditioning System by PLC. For making the decision for operation, PLC is programmed for automatic control of system and also provides the remote control of the system. PLC is also programmed for SCADA view. Pictorial View of PLC is shown in Fig. 6.

4.4 Relay

Relay are used for isolating the low power control signal generated from PLC and amplify these for operation of Air Blower System and Air Conditioning System.

4.5 SCADA View

SCADA View is used for displaying the information regarding differential pressure and inside temperature of IHSS, wind speed in external environment and information of faults. It is also used for monitoring the operation of Air Blower System and Air Conditioning System of IHSS in remotely located Operating Room. It is developed with the bench model and can give the information about IHSS operation at remote. SCADA View is shown in Fig.7. SCADA View is also used for remote control of the Air Blower System and Air Conditioning System. For remote control of Air Blower System and Air Conditioning System, the switch on SCADA View is provided. SCADA view is programmed with PLC for the Remote Control Mode.

4.6 Power Supply

Power Supply provides the power for bench model of Electrical Control System and for operation of Air Blower System and Air Conditioning System.

4.7 Signals, Fault and Manual Control (SFMC) Simulator

SFMC Simulator is used to simulate the sensors output signals, Faults in Air Blower System and Air Conditioning System. In Bench Model of Electrical control System, the Local Manual Control is also simulated on this same simulator. With SFMC simulator, the sensors output signals according to Differential Pressure and Temperature of IHSS, and Wind Speed in external environment are simulated and various operation condition for IHSS are created for operation of the Electrical Control System. Fault in Air Blower system and Air

Conditioning System, power failure is also simulated with SFMC. The manual control for operation of Air Blower system and Air Conditioning System can be done with SFMC simulator. SFMC Simulator is shown in Fig. 8.

5. WORKING

In Bench Model of Electrical Control System, Simulated Air Blower System and Air Conditioning System are controlled. The Effect of differential pressure of IHSS due to air pressurization by Air Blower System is simulated by SFMC simulator. Similarly the effect temperature variation due to Air conditioner and wind speed in external environment is simulated by SFMC simulator. SFMC simulator generates simulated signals of sensors of IHSS and faults according to different situation. These signals are used in PLC and according to program, PLC generate control signal for operation of Air Blower System and Air Conditioning System with these simulated signals. These signals are isolated and amplified by relays and simulated Air Blower System and Air Conditioning System is operated by relay. Auto control mode, Remote control mode and Local Manual control mode is developed in bench model of Electrical Control System.

5.1 Auto-Control Mode

In this mode, Electrical Control System is controlled automatically by the PLC. When signal of differential pressure, temperature and wind speed correspond to 3mbar, less 19˚C or more than 25˚C and 50KmpH respectively are generated by SFMC simulator, PLC generates the control signals for one Air Blower of Air Blower system and one Air conditioner of Air Conditioning System according to programming and if differential pressure is less than 2mbar, PLC generates the control signals for two Air Blowers. If any Air Blower or Air conditioner is faulted in Bench Model, the corresponding fault signal is generated by SFMC and gives it to PLC and PLC stops the operation of that Air Blower or Air Conditioner and starts the operation of another one. When all the Air Blower or Air Conditioner are in healthy condition, PLC changes the duty of first and second Air blower or Air Conditioner after a certain time period. If SFMC simulator generates the signal of wind speed which corresponds to more than 50KmpH, PLC generates the control signal for Air Blower to maintain 8mbar differential pressure and if differential pressure is less than 5mbar, it operates two Air Blowers. If temperature signal for less than 16˚C or more than 29˚C and less then 13˚C or more than 32˚C are generated from SFMC simulator, PLC generate two and three Air conditioners respectively.

Fig.4 Simulated Air Blower System

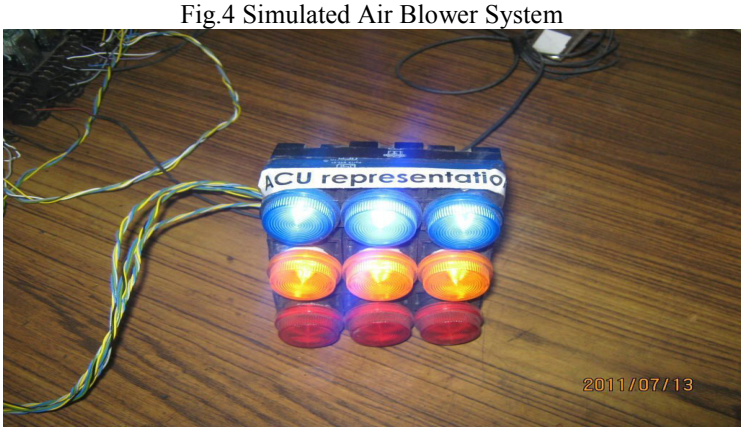

Fig.5 Simulated Air Conditioning System

5.2 Remote Control Mode

In this mode of control, Electrical Control System is controlled from SCADA View on Computer. The program of PLC is interrupted from the SCADA. SCADA is used as user interface for generate the control signal of PLC which controls Air Blower System and Air Conditioning System. For controlling the Air Blower System and Air Conditioning System from SCADA, there are separate switches on SCADA for each Air Blower and Air Conditioner.

5.3 Local Manual Control Mode

In this mode, Electrical control System is controlled manually. PLC is by passed by manual control signal from SFMC simulator and Air Blower and Air Conditioners are controlled manually by generating the control signal from switch given in SFMC simulator for manual control.

In all control modes, the information regarding operation of Air Blower, Air Conditioner and Sensors and their fault is displayed on SCADA View.

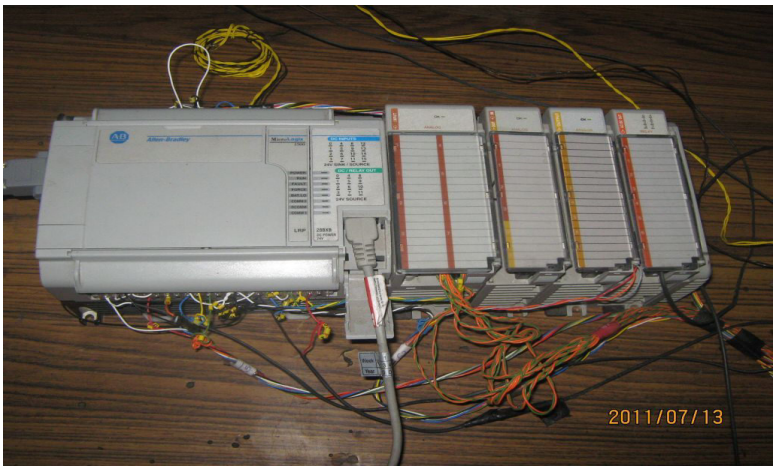

Fig.6 Programmable Logic Controller (PLC)

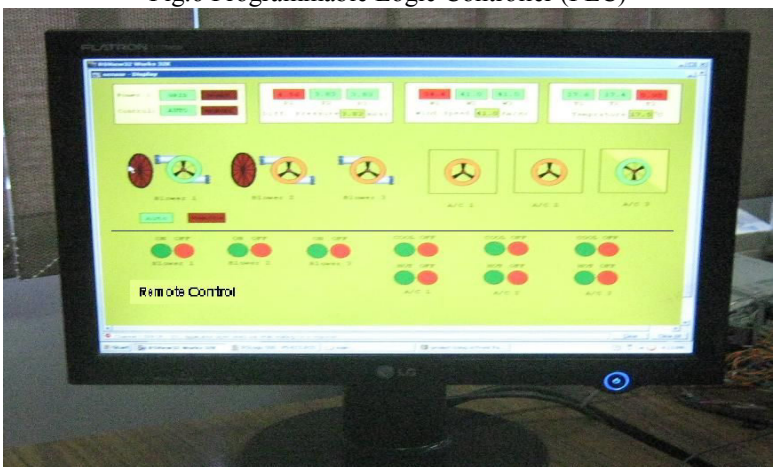

Fig. 7 SCADA View

Fig. 8 Signal, Fault and Manual Control (SFMC) Simulator

6. CONCLUSION

The Bench Model of Electrical Control System is very helpful for understanding the functionality of the actual Electrical Control System. Auto Control mode, Remote Control mode and Local Manual Control mode is developed for Electrical Control System in Bench Model. This Bench Model is base for testing the Programming of PLC for Electrical Control System and modification in programming of PLC can be tested. The bench model of Electrical Control System can be used for training of operator for Actual System. On the basis of bench model, prototype model of Electrical Control System is also being developed, which will be used for testing of functioning of other subsystems of IHSS.

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7. REFERENCE

[1] Balraj Gupta, Aerial Delivery Systems and Technologies, Defence Science Journal, Vol. 60, No. 2, March 2010, pp. 124-136.