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Design Architecture of Automatic Demand Management System for Feeder Tripping

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ABSTRACT: This paper describes the design and development of Feeder Trip Controller (FTC) by Power demand monitoring system using SCADA logic and testing the Functionality of Automatic Demand Management System using Feeder Trip controller. A 32 bit microcontroller is used to design the feeder trip controller. SCADA system mainly monitors two parameters, they are frequency and power demand in the grid. Thus this SCADA system issues a trip signal (with the abnormal change in the power demand or frequency) from Load dispatching center and it is received by this feeder trip controller which is located in the substation. This feeder trip controller is integrated with GPRS module so that it can receive command from load dispatch center. In this system user can configure the feeders for tripping, so that switching (ON/OFF) can be done to those feeders which are configured. Usually this feeder trip controller trips the feeder by enabling corresponding digital output and it is fed to some relays for protection purposes. We propose a modified feeder configuration based on power demand.

KEYWORDS: Power grid, Automatic demand management system (ADMS).Automatic feeder tripping system (AFTS), Feeder trip controller (FTC),Supervisory Control and Data Acquisition(SCADA)

I.INTRODUCTION

The main objective of this paper is to automate the current manual practice of rotational load shedding scheme followed in Electrical Power Distribution sector by the intervention of Load Dispatching Centre (LDC) operator using the Supervisory Control and Data Acquisition (SCADA) system installed in LDC Control Centre. The trip signals are initiated from the SCADA system at LDC Control Centre based on the consumption in the power grid. A Power grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centres, and distribution lines that connect individual customers.

These signals are broadcast to the various substations via GPRS where appropriate feeder tripping is carried out to balance the grid. In this system we can choose the feeders for configuration. The main advantage by this is that there may be some feeders which should not be tripped or that feeders should be ON all the time, that time we can exclude these feeders from tripping off. Generally the trip signals issued are for covering a relief of 150MW to 600MW in steps of 150MW. Currently manual action is taking place in feeder tripping. Here LDC plays an important role. The main functions of LDC are to monitor grid operations, keep accounts of the quantity of electricity transmitted through the State grid, exercise supervision and control over the intra-State transmission system. Also they are responsible for carrying out real time operations for grid control and despatch of electricity within the State through secure and economic operation of the State grid. This system ensures the complete automation in feeder tripping with low cost.

LDC also consist of a system in order to configure the substations. A group of substations will be selected by LDC and the trip signal is send to this group.

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II. PROPOSED METHOD

Automatic Demand Management System's main aim is automate the Feeder Tripping for Energy Demand Management in Electricity Distribution. Feeders connect the substation to the area where power is to be finally distributed to the consumers. Also to automate the current manual practice of rotational load shedding scheme.The scope of the project involves the design, development and implementation of ADMS in 385 Substations and Control Centre at State Load Dispatching Centre (LDC).Currently the feeder tripping is done manually. By introducing this system, we can achieve a precise feeder tripping and respectable power management. Every Substation will occupy with this ADMS system. LDC has a vital role in this system.

LDC will be occupied with Automatic demand management system server PC. This PC is also provided with Graphical user Interface. A Graphical User Interface (GUI) is a type of user interface that allows users to interact with electronic

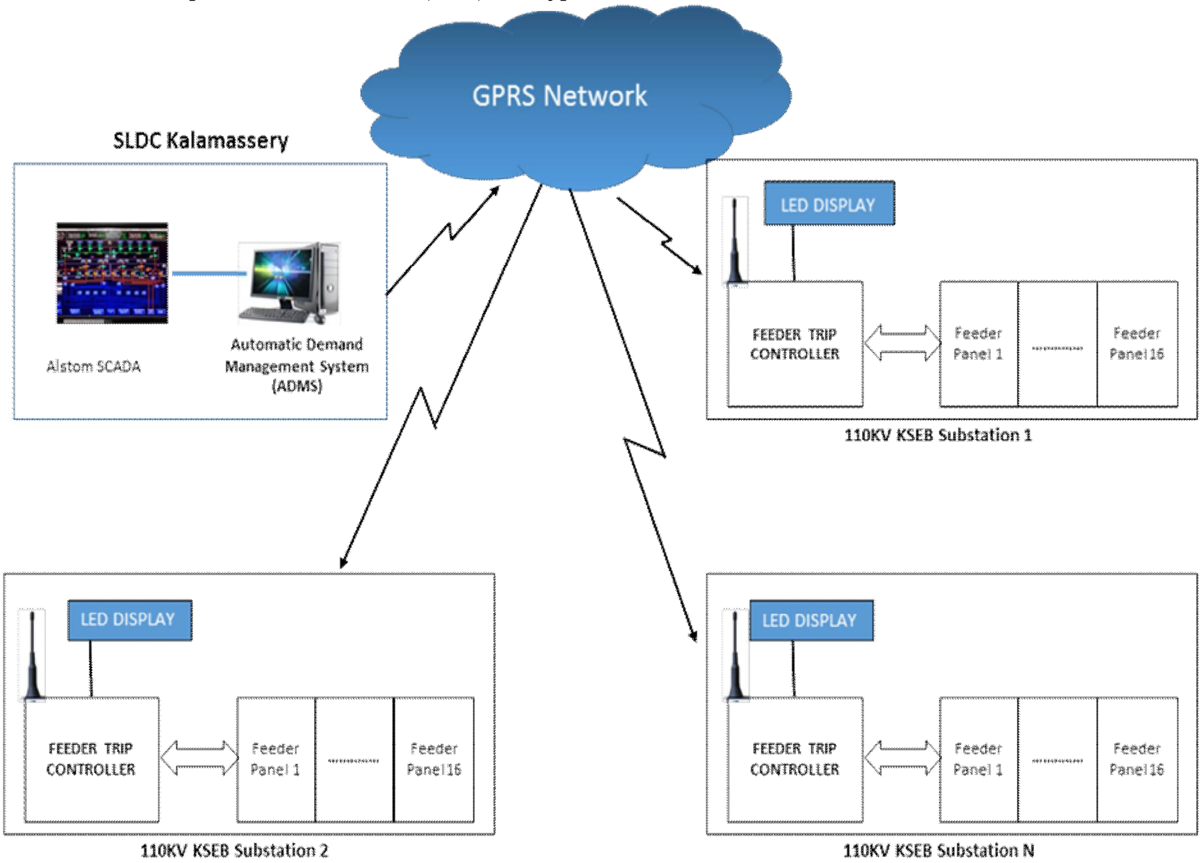

Fig.1. Automatic Demand Management System Architecture

devices through graphical icons and visual indicators such as secondary notation, instead of text-based user interfaces, typed command labels or text navigation. This is used to group several substations so that only selected substation group will receive a trip command from the server. Each substation is connected with the LDC using GPRS connection. SCADA system is used to initialise the trip signal in the LDC. Feeder tripping is done effectively using microcontroller. ADMS is intended for safe and efficient automation of feeders.

The ADMS has mainly two components

- ADMS server PC at the LDC Control Centre which issues the trip commands based on the signals received from SCADA
- Automatic Feeder Tripping System (AFTS) at the Substations to intelligently carry out the feeder tripping instructions from the Control Centre.

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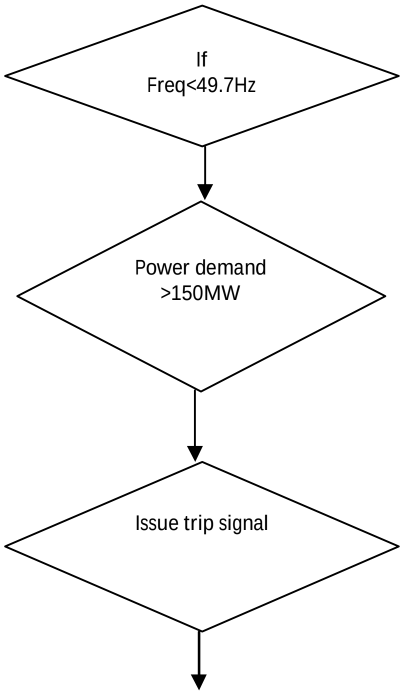

Fig.2. SCADA logic

The SCADA system will carry out the logic check and issue the trip command in IEC 60870 – 5-104 standards. The command will be received by the ADMS server PC, the payload is extracted and broadcast via GPRS to the Substations using a proprietary protocol. The ADMS server PC is provided with a GUI to configure the Substations into groups. When Server PC receives trip signal from SCADA, it checks for the relief to be provided and routes the trip command to the appropriate group based on round robin method and the amount of relief to be achieved. The trip command will be encrypted to ensure security.The important parameters for issuing trip signals are Power demand and Frequency.

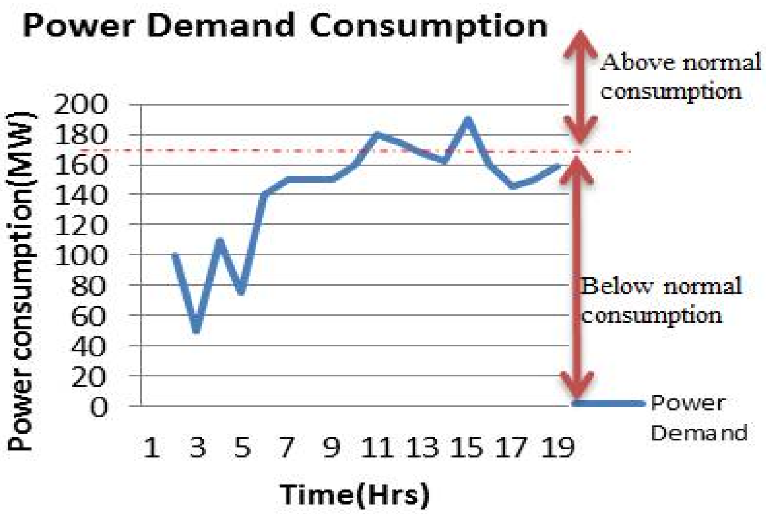

Fig.3. Power consumption

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Case 1

As the graph shown above, if the power consumption is above 150 MW a power demand will be there. That time the SCADA system will check that and issues a trip command.

Case 2

As the graph shown below if frequency of the grid is above 49.7Hz, the SCADA system will issue a trip signal.

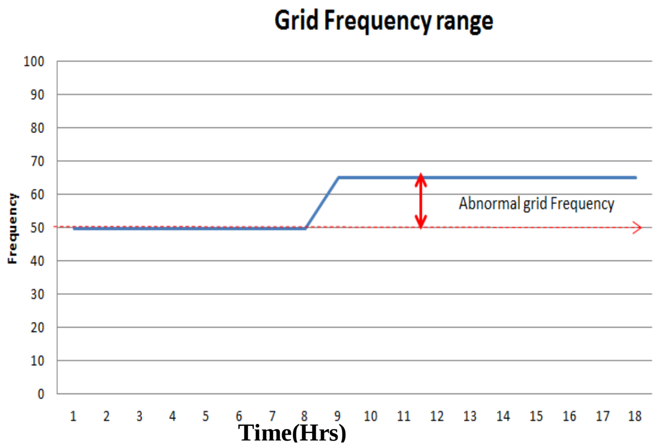

Fig.4. Grid Frequency range

III. AUTOMATIC FEEDER TRIPPING SYSTEM ARCHITECTURE

Automatic feeder tripping system (AFTS) is the essential part of this Automatic demand management system. AFTS consists of

- Feeder Trip Controller (FTC)
- LCD Display Panel
- Power Supplies
- Interposing Relays

A maximum of 16 feeders can thus be wired to Feeder Trip Controller. One interposing relay each is wired for tripping each feeder. This Interposing relays act as barrier between the controller and the feeders. It normally allows a low voltage level circuit to control or send signal to another circuit. Two over current relays and an Earth fault relay are currently wired in the feeder panel in order to carry out feeder tripping in case of fault. The main working principle of over current relay is based on a current coil. When current flows through this coil, a magnetic field is generated in the coil, but that should be not sufficient to displace the moving element of the relay, that indicates that the limiting force is greater than deflecting force. When the current through the coil is increased, magnetic field increases and thus the deflecting force will overcome the limiting force and the moving element starts moving to change the contact position in the relay.These relays derive supply from 110 V DC provided from the battery supply available in the Substations. The interposing relay as part of ADMS will be connected parallel to the existing fault detecting relays.

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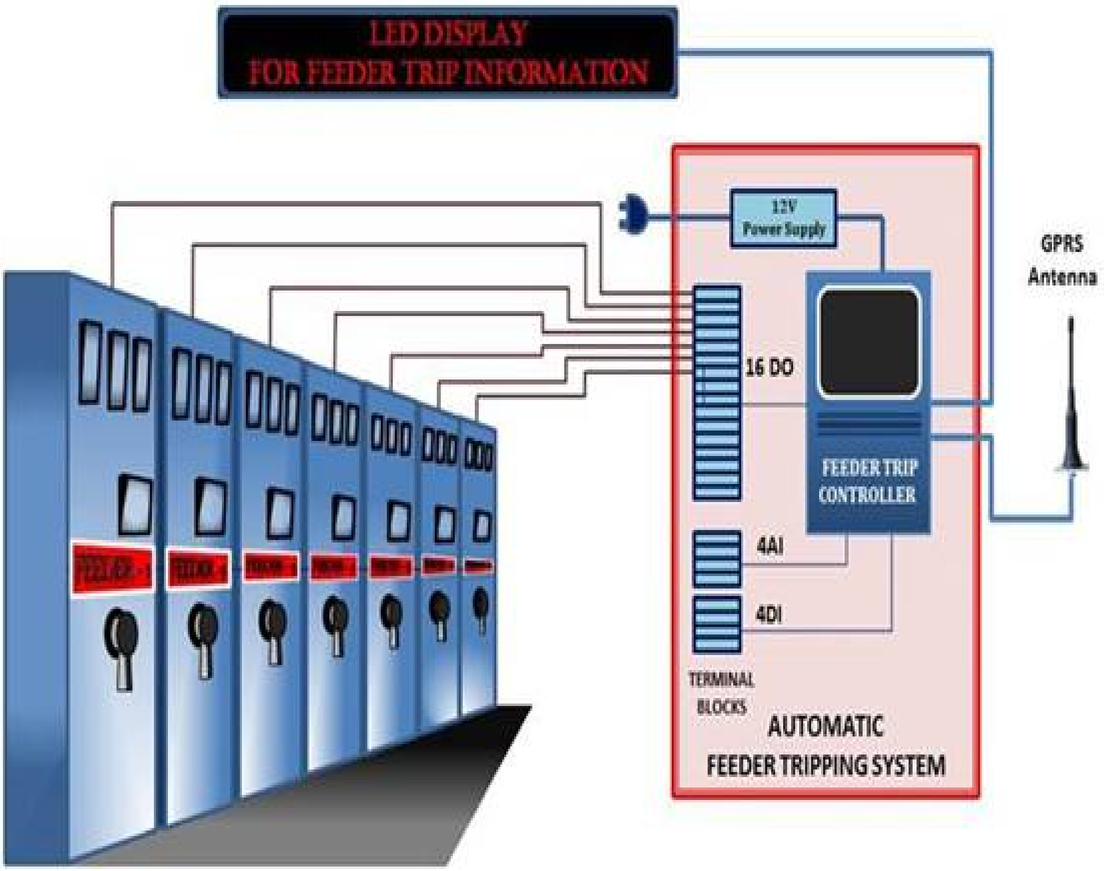

Fig.5. Automatic Feeder Tripping System architecture

A 16 character, single line LCD display panel is provided to show the feeder trip information. The LCD display panel is tripping will be displayed in the LCD display panel as provided by the FTC. The FTC has a touch screen display and a GUI module to enable configuration of feeders in active / inactive mode to avoid load shedding in important feeders. The AFTS will receive the trip command via GPRS.The Feeder Trip Controller selects feeder for tripping in a round robin fashion and outputs a high in the corresponding digital channel. The same information will be displayed in the LCD display panel. The Feeder Trip Controller selects feeder for tripping in a round robin fashion and outputs a high in the corresponding digital channel. The same information will be displayed in the LCD display panel.

IV FEEDER TRIP CONTROLLER (FTC)

AT91SAM3X8E is the controller used as Feeder Tripping.Essential features of this controller are 512 Kbytes embedded Flash memory, Crystal oscillators of 3 to 20 MHz main and optional low power 32.768 kHz for RTC or device clock. Controller operates from 1.62V to 3.6V and is available in 100- and 144-pin QFP and LFBGA packages. The SAM3X/A devices are particularly well suited for networking applications: industrial and home/building automation.

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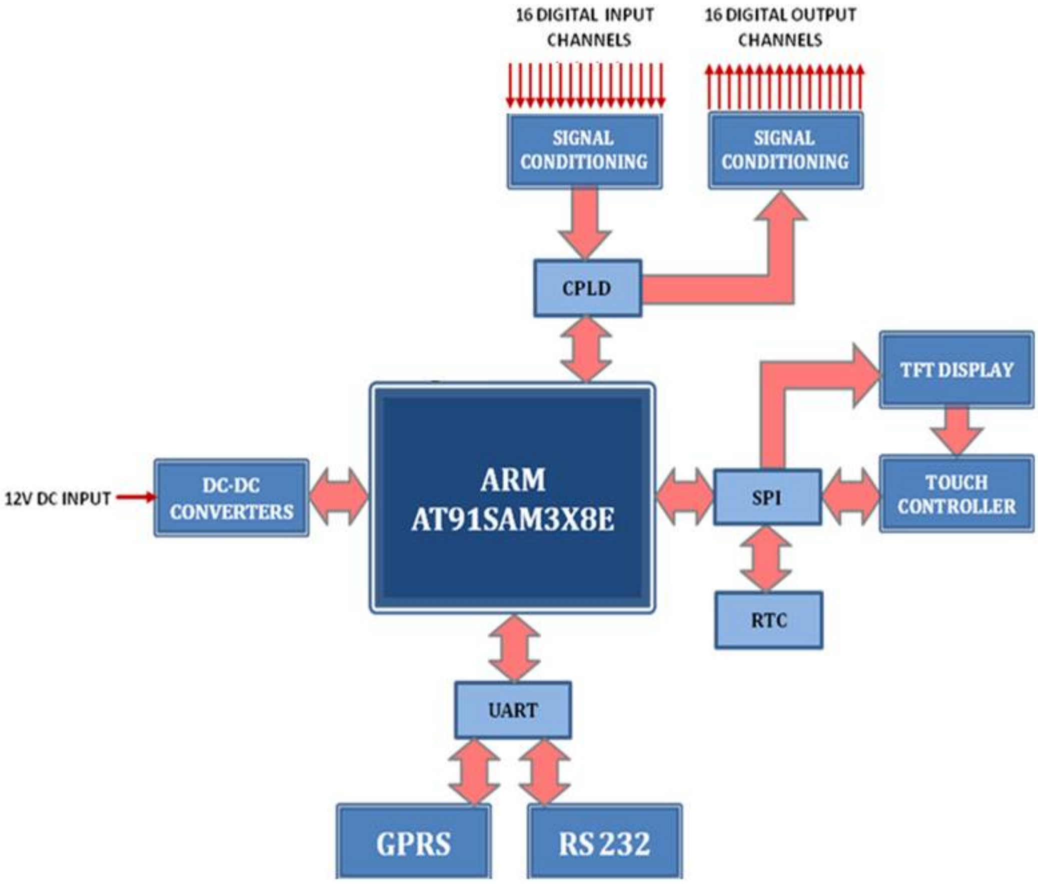

Fig.6. Feeder trip controller architecture

A. Controller AT91SAM3X8E

The ARM Cortex M3 based AT91SAM3X8E is the main processor. Atmel's SAM3X/A series is a member of a family of Flash microcontrollers based on the high performance 32-bit ARM Cortex-M3 RISC processor. It operates at a maximum speed of 84 MHz and features up to 512 Kbytes of Flash and up to 100 Kbytes of SRAM.The SAM3X/A devices have three software-selectable low-power modes: Sleep, Wait and Backup. In Sleep mode, the processor is stopped while all other functions can be kept running. In Wait mode, all clocks and functions are stopped but some peripherals can be configured to wake up the system based on predefined conditions. In Backup mode, only the RTC, RTT, and wake-up logic are running.

B. COMPLEX PROGRAMMABLE LOGICAL DEVICE

A collection of PLDs on a single chip can be termed as Complex Programmable Logic Device (CPLD). CPLD has a complexity less than FPGAs. Can perform a lot of logic functions. Advantages of using CPLD are

- Processor pins for Input Output operations can be reduced
- IC's that are used for logical applications can be minimized
- Logic can be changed according to the field requirements using software environment

C. Digital Output:

16 channel digital outputs is obtain from the CPLD. Digital output portion consist of TCMT4100 optocoupler and ULN2803A transistor array. TCMT4100 consist of one photo diode and a photo transistor. Total of 4 TCMT4100 are used here. ULN2803A is a transistor array which is used to drive the voltage and current. Total of 2 ULN2803A is used here.

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D. USART communication

UniversalSynchronous Asynchronous Receiver Transmitter in synchronous mode transmits data in frames. In synchronous operation, characters must be provided on time until a frame is complete.The receiver time-out enables handling variable-length frames and the transmitter time guard facilitates communications with slow remote devices. Here USART isused for GPRS and RS232 purposes. Controller consist of 4 USARTs and 1 UART. For GPRS connection we make use of USART with a buadrate of 9600. For RS232 interface, USART is used to communicate with the PC with a buadrate of 115200. The RS-232 standard is commonly used in computer serial ports.

E. Serial Peripheral Interface

The Serial Peripheral Interface (SPI) circuit is a synchronous serial data link that provides communication with external devices in Master or Slave Mode. It also enables communication between processors if an external processor is connected to the system.

The SPI system consists of two data lines and two control lines:

- Master Out Slave In (MOSI): This data line supplies the output data from the master shifted into the input(s) of the slave(s).
- Master In Slave Out (MISO): This data line supplies the output data from a slave to the input of the master. There may be no more than one slave transmitting data during any particular transfer.

Here SPI is used to interface TFT display, Touch and Touch controller with the microcontroller SAM3x8e.The controller act as a Master and display touch interfaces with act as slaves.

V.RESULT

The figure below shows the overall test setup for Automatic demand Management System. The program was downloaded into the controller using JTAG. Atmel studio 6.1 is used for debugging. ADMS consist of a Power supply of 12v and from this it derives 3.3v for all DVCC. A separate connector headers are used to connect the JTAG, LCD and GSM with the controller board. LCD used here is K350QVG-V2-F**.**

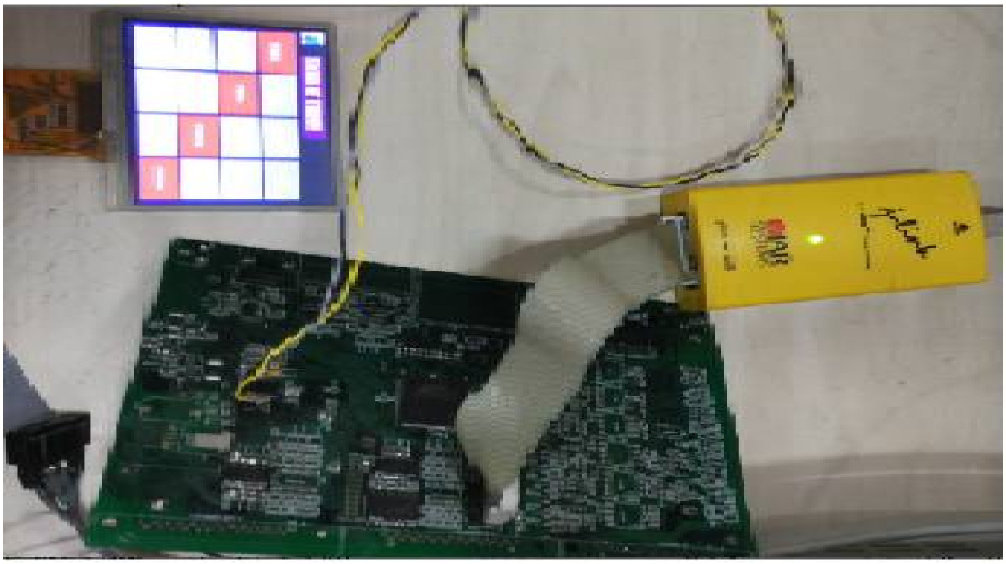

Fig.7. Overall Test setup

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F. LCD display Configuration

LCD display of Automatic Demand Management System is shown below

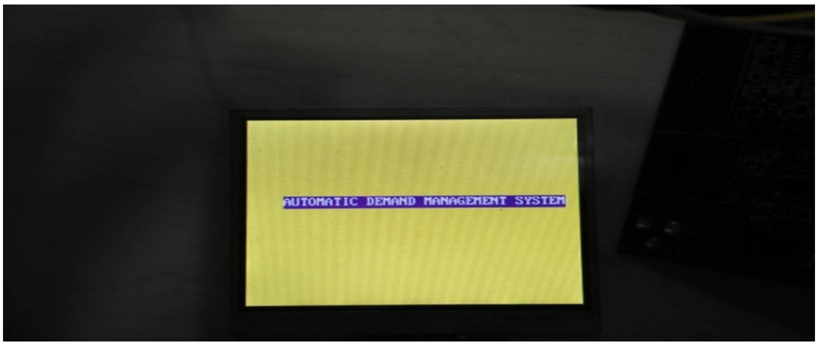

Fig.8. LCD display home page

This is the home page of Automatic Demand Management System. From home page we can go to main menu page. Main menu page consist of

- Configuration Page
- Status Page
- Home Page

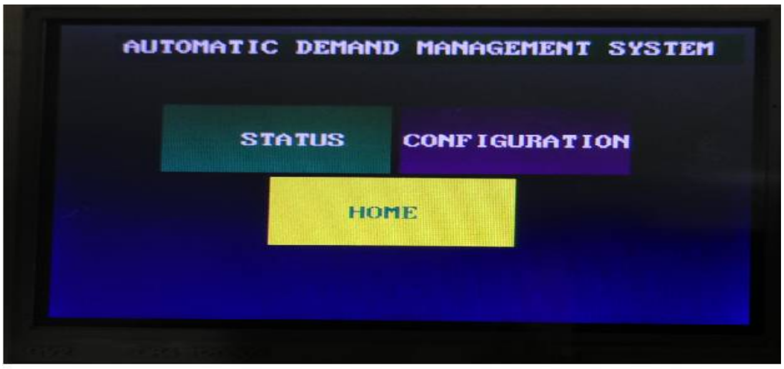

Fig.9. LCD display main menu

G. Configuration page

Fig.10. Configuration page

The figure 10 shows the Configuration page. In this page we can select which feeders should be ON or OFF when the trip command is received. Total of 16 feeders can be connected to the system. We can select the feeders randomly. By default all the feeders are in OFF condition which is indicated by red colour. Feeders which are selected are indicated by green colour. We can see a “save” button on the display screen. Whenever the feeders are selected, the save button should be pressed, otherwise the configuration will not be done. Whenever we press the “save” button, the current

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configuration will be stored/written in flash memory so that the configuration information won't be lost even if the power is lost

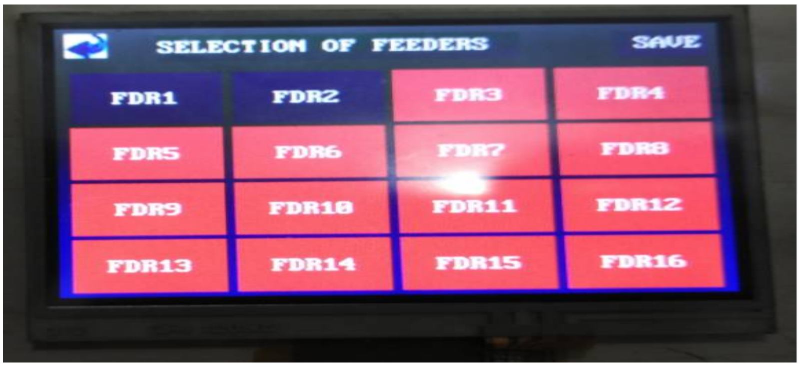

Fig.11. Selection of Feeders for tripping

We can see in the figure 11, 2 feeders are configured for tripping and saved so that display will go back to the main menu.

Status page

Fig.12. Status page

In this page we can see the current status of the feeders which are configured for tripping. The which are in OFF/ disabled condition is indicated by grey colour and the feeders which are configured is shown in green colour

As soon as the trip command is received by the system the controller will trip one feeder correspondingly which is shown in the figure below.

Fig.13. Tripping of feeders

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VI. CONCLUSION

As part of this work, the AFTS module for ADMS has been successfully designed and tested. The AFTS was tested by establishing GPRS connection with a Test Server from where the trip commands are issued. ADMS is capable of monitoring and controlling (switching on/off) different feeders appropriately in various substations in accordance with the power demand. Thus a systematic way of power sharing can be achieved. Load shedding can be done more effectively during power shortage.

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