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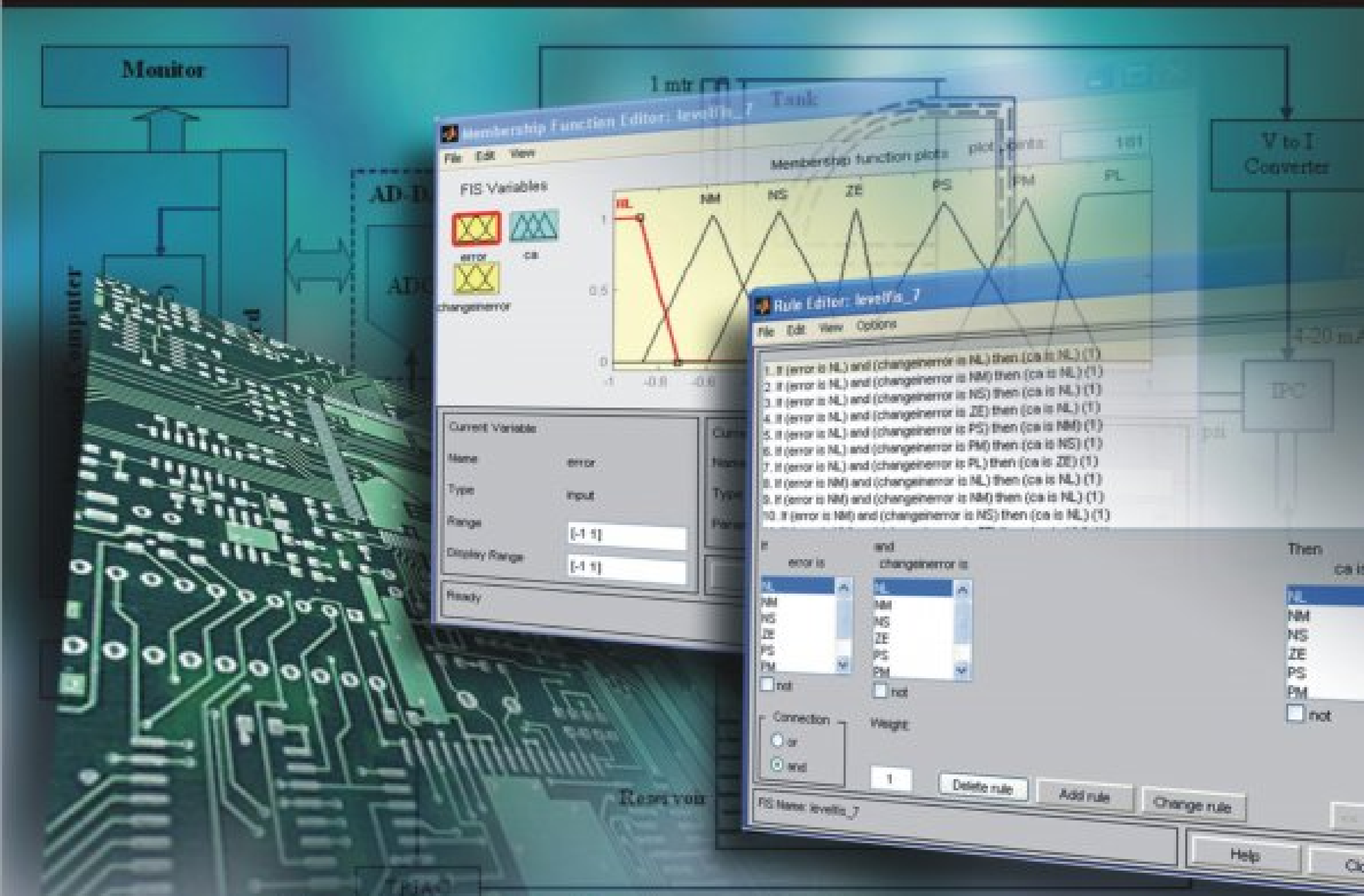

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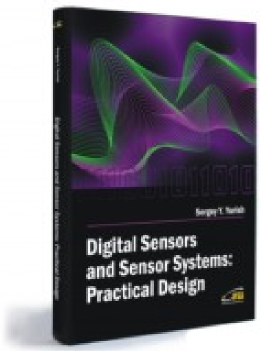


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Development of Ethernet Based Remote Monitoring and Controlling of MST Radar Transmitters using ARM Cortex Microcontroller

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Abstract: **T**he recently emerging Web Services technology has provided a new and excellent solution to Industrial Automation in online control and remote monitoring. In this paper, a Web Service Based Remote Monitoring & Controlling of Radar Transmitters for safety management (WMCT) developed for MST Radar is described. It achieved the MST radar transmitters' remote supervisory, data logging and controlling activities. The system is developed using an ARM Cortex M3 processor to monitor and control the 32 triode-based transmitters of the 53-MHz Radar. The system controls transmitters via the internet using an Ethernet client server and store health status in the Database for radar performance analysis. The system enables scientists to operate and control the radar transmitters from a remote client machine Webpage. *Copyright © 2013 IFSA.*

Keywords: ARM cortex-M3 Processor, MST radar, ASP, Net C#.

1. Introduction

MST Radar located near Gadanki (13.5°N, 79.2°E) India is a prime instrument for atmospheric science research, the fig. 1 is the bird's eye view of the radar antenna array and transmitter control rooms. Scientific research is being performed with Indian MST Radar for the past two decades, by constantly upgrading the Radar with state of the art technological features. It is a very powerful remote sensing tool for studying the Earth's atmosphere from 3.6 km up to ionized F layer regions. During two decades of its operations from 1991, more than 300 publications of international repute were published and it is being extensively operated round the clock for scientific research in the Ionosphere, Mesosphere, lower Stratosphere and Troposphere regions.

Fig. 1. Photograph of MST radar antenna array, transmitters rooms bird's eye view.

The MST Radar consists of 32 transmitters powering 1024-element phased antenna array. Each transmitter provides an RF gain of 81 dB with four stages of amplifiers; solid-state amplifier followed by triode based amplifiers namely pre-driver, driver, and high power amplifiers. Remote supervisory control and comprehensive safety interlock is built-in the system to protect expensive devices. The remote system senses TX critical parameters like anode voltages, heater currents, temperature and airflow etc for all 32 transmitters. This system receives input from the sensors placed in the amplifier cavities and monitors a total of 12 safety parameters. This unit logic circuit process sensor data for abnormal voltage, temperature and current deviations, and switches-off the Transmitter subsystems incase of any mall functions, with the help of Control unit. The Fig. 2 is the hardware interface of radar transmitters and interlock control.

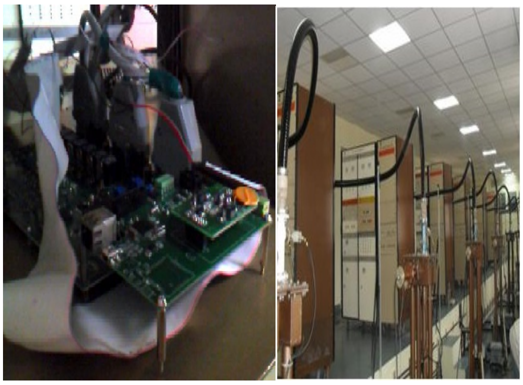

Fig. 2. Photograph of hardware interface and radar transmitters.

This interlock control unit ensures the protection of the expensive devices from any failure in the system. The transmitters can be operated in auto mode (remotely) as well as in the manual mode (by using front panel switches). In the auto mode, each transmitter is made to operate in a predefined mode.

The original TTL ICs based 15 board system was replaced by low-cost Xilinx XC9572C10pc84 CPLD and later is upgraded with ARM Cortex-M3 LM3S9B96 microcontroller to control the radar transmitters through remote Embedded Web based Real Time Application. The microcontroller, Ethernet MAC, and PHY are incorporated on a single chip, thereby eliminating more external components. This enables the MAC and PHY to be matched and reduces the overall pin count and chip footprint. It can also lower power consumption, especially if power-down modes are implemented. Real-time performance of radar is improved with this activity utilizing industrial Ethernet technology and fast 10 bit ADC.

2. Experimental Setup

Fig. 3 presents total Setup of transmitter's remote monitoring and control ported into ARM Cortex-M3 processor with Ethernet connectivity to remote computer. The conventional hardware functioning logic is incorporated in the Texas Instruments device LM3S9B96. This ARM Cortex-M3 processor is programmed to interface with the remote console computer WEB page, to monitor the health condition of the transmitters, and to produce control actions to ensure transmitter safety. The user selection buttons and TX sensor parameters have been interfaced to the ARM Cortex-M3 processor through digital I/O lines to control the transmitter parameters. The analog to digital converters (ADC) read the sensors outputs in the transmitters; the digital data are framed in packets and sent to a web server. The remote webpage communicates to a client transmitter in the network with IP to monitor, log data and control through internet.

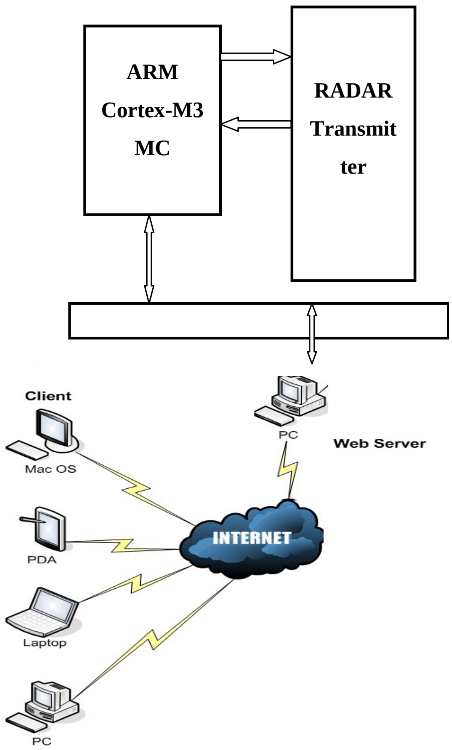

Fig. 3. WMCT system setup.

Keil-4 (IDE) software targeted onto ARM Cortex-M3 based LM3S9B96 device programs the monitoring and controlling functionalities. This system connects the Triode based transmitters through internet to control and monitor the health of four RF amplifier stages. Thus 'Design and Development of a web-based Real-Time Radar Transmitter remote control system for safety management' allow scientists to operate and control the transmitters from remote client with the help of web servers using a web page.

3. Hardware Description

The Hardware included radar transmitter is microcontroller LM3S9B96 pin diagram is shown in Fig. 4, ADC, DAC, RTC, 5 V and 3.3 V power supply, RJ45, relays circuit to control the transmitter. The microcontroller is the brain of the web based remote supervisory and control system. J1 connector is a JTAG port in Fig. 5 is used to dump program and helps in debugging the software functionality.

The GPIO module is composed of nine physical GPIO blocks, each corresponding to an individual GPIO port (Port A, Port B, Port C, Port D, Port E, Port F, Port G, Port H, Port J). The GPIO module supports up to 65 programmable input/output pins; we are using 8 GPIOs to control the transmitter relays. The Fig. 6 is the hardware connectivity of relays with GPIOs. The IC ULN 2803 is used to relay controlling with sufficient current drive. Two 10-bit Analog-to-Digital Converters (ADC) with 16 analog input channels and sample rate of one million samples/second are used to digitize 14 sensor parameters for reading the sensor outputs (transmitter parameters). In the Fig. 7 Max-232 is a serial line driver to establish the communication between microcontroller and PC. In Fig. 8 the SST's 25 series Serial Flash family is a four-wire, SPI-compatible interface that allows for a low pin-count package which occupies less board space and ultimately lowers total system costs.

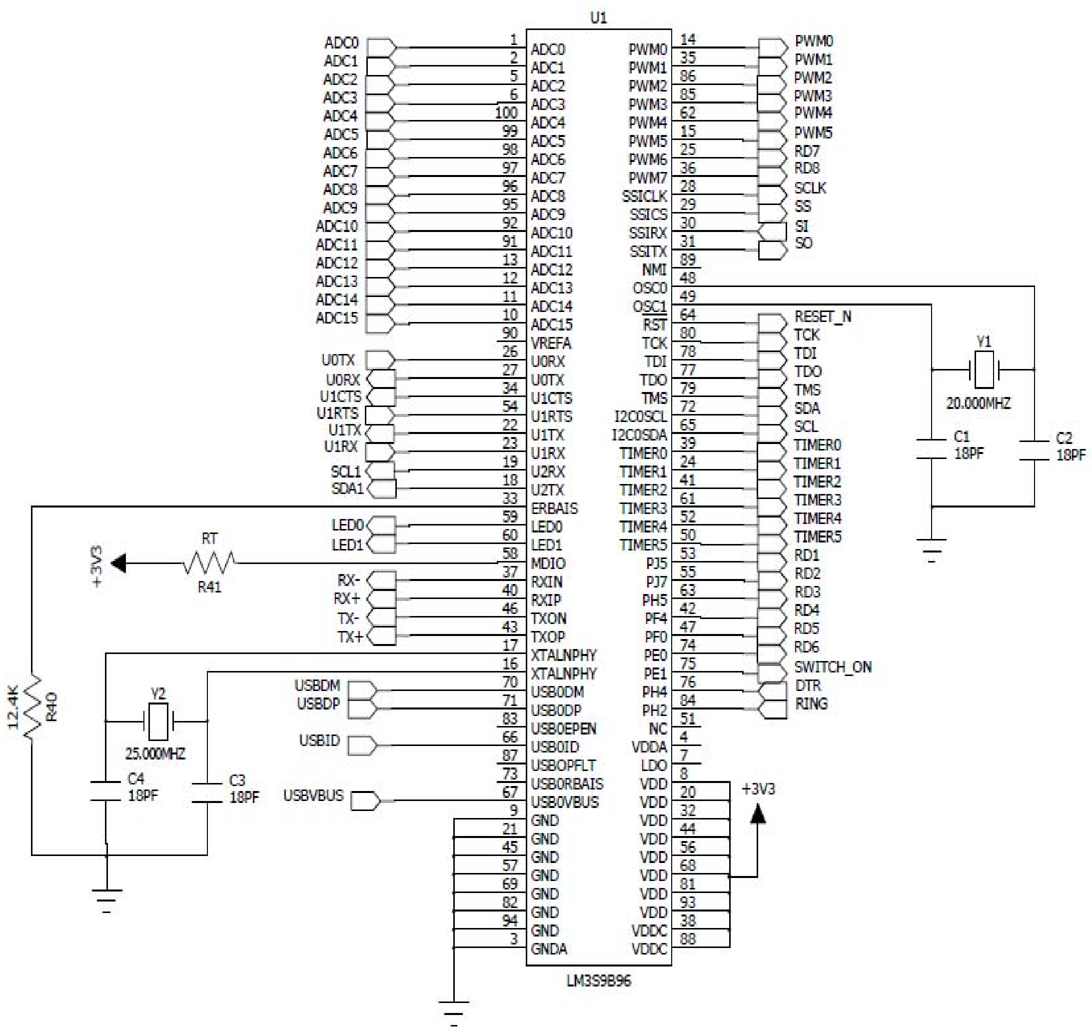

Fig. 4. LM3S9B96 MCU schematic diagram.

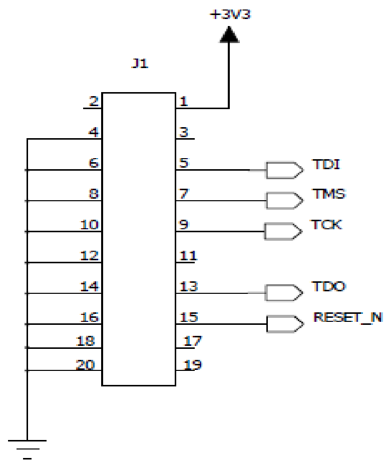

Fig. 5. Jtag interface schematic diagram.

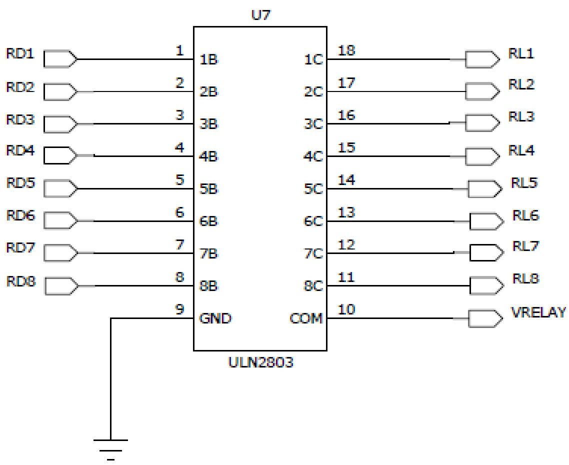

Fig. 6. Relay driver schematic diagram.

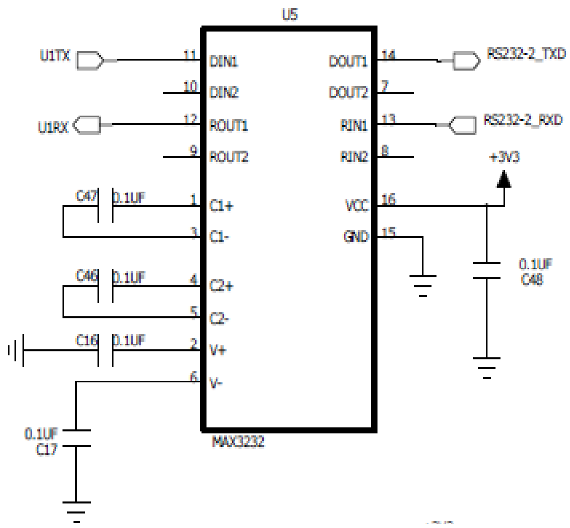

Fig. 7. Max-232 Line driver schematic diagram.

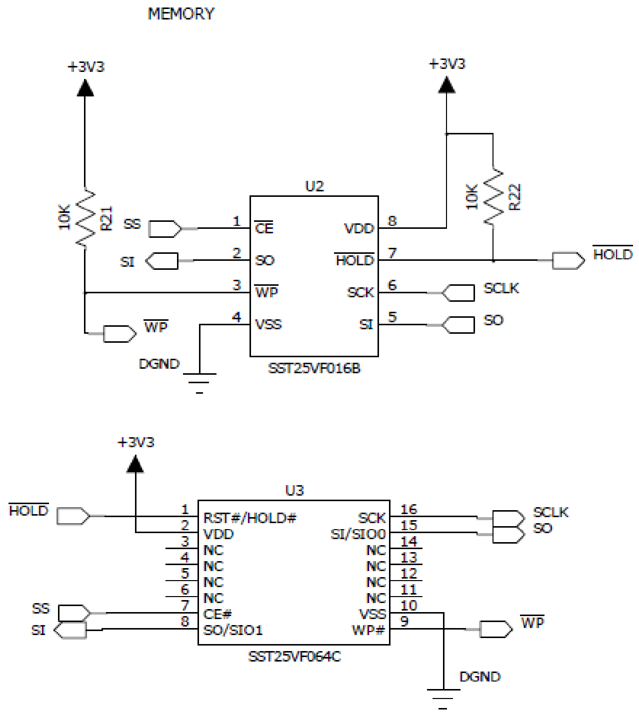

Fig. 8. Memory interface schematic diagram.

The Stellaris® Ethernet Controller consists of a fully integrated media access controller (MAC) and network physical (PHY) interface. The Ethernet Controller conforms to IEEE 802.3 specifications and fully supports 10BASE-T and 100BASE-TX standards. In Fig. 9 the schematic of RJ45 Ethernet connectivity is shown. This Ethernet feature is used to communicate computer through the network.

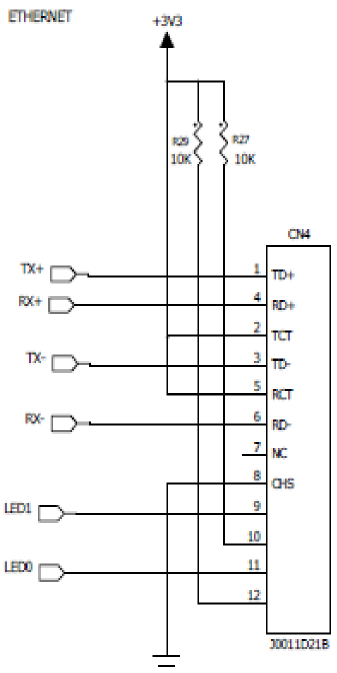

Fig. 9. Ethernet schematic diagram.

4. Software Implementation

To provide the flexibility and to reduce complexity, modularization programming method has been implemented. Modularizing the whole software resulted in flexibility of designing, testing, debugging and maintenance. The following two points are considered in program, first one is to distribute system resources by functionality i.e. ROM, RAM, interrupt sources and so on, second point is enhancing its universality and anti-jamming ability. Keil cross compiler and embedded C language combination are used for application program writing. It has a real-time multitasked kernel and offers TCP/IP programming of SOCKET grade and support various kinds of network protocols (such as HTTP, FTP, SMTP, PPP). With the development of network technology TCP/IP protocol has been written into the embedded system. As a result, embedded system became an embedded web system. The controller of embedded system turns into a miniature network server. By this, the seamless link of bottom equipment with internet becomes true and the remote monitoring is indeed realized. Installation of TCP/IP protocol in LM3S9B96 controller realizes Internet connectivity to the equipment.

The web server software has been developed by Microsoft ASP.NET and C# tools. The Web page GUI (Graphical User Interface) which runs on a web server is implemented in hypertext markup language (HTML). The background controls and sockets have been implemented using C# programming in ASP.NET framework. This server software allows communicating remote clients from any web browsing compatible operating system to interact with our experimental test-bed. The transmitters' sensor values for every 10 minutes are logged in a database designed using SQL Server2008. The web server stores the transmitter health status in database continuously. This recorded data can be viewed in the grid view format for analysis.

5. Results and Discussions

The design and implementation of ARM Cortex-M3 processor based Interlock and fault monitoring plug–in is thus carried out due to its advantages over high density code size, cost and power requirements. The combination of complexity and speed is finding ready applications for ARM Cortex-M3 systems in digital processing and particularly in those application areas requiring sophisticated high speed digital processing. The following are the measurements of parameters in radar Transmitter.

Check the Transmitter radiation to measure TX power output by giving RF input.

Transmitter output power at

60 dB coupler = $V_{(pk\text{-}pk)} = 3$ V

$Power = V_{rms}^2/R$

$Power = (V_{(pk\text{-}pk)}^2/8\times R) = [V_{(pk\text{-}pk)}^2/800]\times 10^6 =$

= 22.5 kWatt

$Power = 10\times\log(power)/10^{-3} = 73.5$ dBm

In Fig. 10 the web page contains an RF ON/OFF button used for switching on the RF power circuitry on the transmitter. The health status of each parameter and voltage levels are mentioned in Tables 1, 2 and 3. Health status is good or bad is indicated as a colorful bubble. The RED is indicated as fault/bad condition of the corresponding parameter and GREEN indicates good condition. When click on the RF ON/OFF and control ON/OFF button the respective command/data is sent by the client browser to the server through the protocol layer of the TCP/IP stack. Then the server logically handles the data and sends to the microcontroller. The web server load transmitter current status automatically in few seconds refresh rate of a web page. ARM Cortex-M3 microcontroller will take the appropriate actions.

Table 1. Fan sense signals.

Amplifier	OFF	ON
PDR	4.67	0
DR	4.82	0
HPA	4.82	0

Table 2. Heater current Sense Voltages.

Amplifier	OFF	HALF HEATER POWER (1st 3min)	FULL HEATER POWER (after 3min)
PDR	0	2.4	3.4
DR	0.3	2.5	3.6
HPA	0	2.6	3.13

Table 3. Anode supply sense Monitor Voltages.

Amplifier	Anode supply OFF	Anode supply ON
PDR	2.7	3.1
DR	1.5	2.4
HPA	1.7	3.06

Fig. 10. Screen shot of webpage Transmitter parameters health status and controls.

6. Conclusion

A WMCT is proposed in this paper. It is intended to support the capabilities of the remote supervisory and controlling system based on web services technology for embedded devices is designed and implemented. The system adopts Browser/Server mode and realizes the interconnection of the embedded devices like ARM Cortex-M3 Processor target board. Therefore, remote users can access, control and manage the embedded devices [ARM Cortex-M3 processor through the MST radar transmitter] using a standard web browser over the internet. It has advantages of small size, data logger, system maintenance, longer work time and stable performance. It is applicable to a variety of fields like industrial control, industrial automation, medical, instrument etc.

Acknowledgement

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References

[1]. User's Manual, Control and Interlock Units, *National Atmospheric Research Laboratory*, 1996.
[3]. Design of Control and Interlocking System for a Typical Radar Transmitter, Nagabhushan Raju KONDURU, Department of Instrumentation, *Sri Krishnadevaraya University, Anantapur* – 515 003. India, Accepted: 24 July 2010 /Published: 31 July 2010.
[4]. Nagabhushan Raju K, Lakshmi Narayana R, Rajendra Prasad T, Chandrasekhar Reddy D, An Embedded Web based Real Time Application for Remote Monitoring & Controlling of MST RADAR Transmitters, *Sensors & Transducers*, Vol. 136, Issue 1, January 2012, pp. 96-104.
[5]. Texas Instruments Microcontrollers (TI-MCU) datasheet, [Online]: http://www.ti.com/ds/symlink/lm3s9b96.pdf
[6]. The website of the Keil compiler and IDE [online]. http://www.keil.com/arm/mdk.asp/
[7]. Microsoft website [Online], http://www.microsoft.com
[8]. Murach's ASP.NET 4 Web Programming with C# 2010 by Joel Murach and Anne Boehm.
[9]. Programming Microsoft SQL Server 2008 (PRO-Developer), Leonard Lobel, Andrew J. Brust and Stephen Forte.

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