Real-Time Communication between Aero Gas Turbine Engine Controller and Pilot Online Monitoring System

Anupa.K, Channabasappa Baligar

Abstract – The application presented, is developed based on real-time systems which is built for a very small set of mission-critical applications like space craft's , avionics and other distributed control systems. The modern software deals with external interfaces and has to consider various timing implications The platform is based on the VxWorks 5.4.2 and developed using Tornodo IDE 2.0.2 tool with the targeted deadline of 30 milliseconds at the baud rate of 9.6kbps. RS232 interface executes the role of Transportation and Communication, an interface cable used for serial communication between Digital Electronic Control Unit (DECU) and the host to transfer data to the pilot Online Monitoring System and that is based on Laboratory Virtual Instrument Engineering Workbench (LabVIEW)7.1.

Index Terms - Aero gas turbine engine, Digital Electronic Control Unit (DECU), Online Monitoring display, RS232 serial communication.

I. INTRODUCTION

Defence aircraft is a high-performance avionics mission computer which is the central computing resource. It evaluates, coordinates, controls large amount of data like rig, ground, altitude, temperature, fuel intake, power dissipated, pressure, amount of air taken, speed etc .It must also respond quickly to the changing conditions within the aircraft and in its own operating environment. An avionics mission computer has very strict "hard" Real Time requirements. Very low latency and exceedingly predictable behaviors are crucial nod only to mission success, but also to the safety of the pilots. Any computer hardware or software designed for this environment, receives intense scrutiny for its performance and reliability [1]. In embedded system it's important that the behavior of the application has to be same on development environment (host PC) as well as deployed environment (target). Due to unavailability of target there is a need to check for application functionality, timing performance etc. The simulator development environment and operating system is different from target board where actual application is residing.

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In embedded system executable application has to be deployed on the limited available size of the flash. Execution of application from FLASH creates unforeseen timing dependencies as well as other behaviors, which are tolerable in RAM but not in FLASH [1].

Presently, MIL-STD-1553B interface cable is used for real-time communication between Aero gas turbine engine controller and Pilot online monitoring system. Due to redundancy, there is a need for similitude component to provide alternative in case of any component failure. In order to achieve this, RS232 serial communication is used in this application.

The presented work is organized in six categories. Section II describes with architecture of VxWorks RTOS platform and features of Tornado 2.0 IDE tool. It also gives a brief overview of LabVIEW and serial communication. Section III deals with Aero gas turbine engine controller and the Pilot online monitoring system. Section IV is emphasized on the hardware system of the application. Section V shows flow chart of the presented application. Section VI presents the tested results of the application.

II. VXWORKS AND TORNADO FEATURES

VxWorks is a powerful Real-Time Operating System (RTOS) designed by WindRiver Systems of USA. It is a telescopic, scalable, highly reliable and efficient real-time multi-tasking scheduling, interrupt management, real-time system resource and real-time communication. It is widely used in communication, military, aviation, aerospace and other sophisticated technology, it is also a highly demanding real-time field because of good reliability and excellent real-time [2] [3]. The VxWorks operating system supports full range of real time features including fast multitasking, hardware interrupts, both priority-preemptive and round-robin scheduling. Due to scalability of kernel, it has minimizes system overhead and enables fast, deterministic response to the external events. The run-time environment also provides efficient intertask communication mechanisms, permitting independent tasks to coordinate their actions within a real-time system. For controlling and synchronizing critical system resources, several types of semaphores are provided – binary, counting, and mutual exclusion with priority inheritance. Tornado integrated development environment is available for a variety of hardware platforms and widely used by industry. [4].

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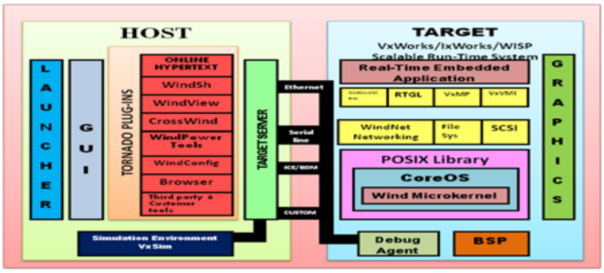

Fig I: Tornado Architecture from Wind River

Fig I illustrates the Tornado Architecture. The basic components of Tornado architecture include:

Kernel (VxWorks) – It provides task scheduling and configurable real-time operating systems utilities on the target.

Boot ROM – It supports target initialization and boot procedure.

Network Facilities with Target Server – It provides target connection with development environment.

Module Loader and Symbol Table – It incrementally loads object modules into a target system, keeps the operating system and application software information visible to the development environment

Project Facility (Configuration) – It provides graphical interface automating configuration of the operating system and building VxWorks applications,

Shell (WindSh) – It interprets and executes C language expressions giving an easy-to-use interface to the target environment.

Graphic debugger (CrossWind) – It debugs the programs graphically with GNU gdb debugging engine

Browser – It presents graphical information and monitors the state of the target operating-system objects.

Integrated Simulator (VxSim) – It begins developing and debugging code even if target hardware is unavailable.

Logic Analyzer (WindView) – It provides graphical representation of the application's dynamic behavior by displaying the timing diagrams.

The developmental environment is an integrated suite of host tools with Editor, Shell, Debugger, Browser, and Configuration. The Target Server component is responsible for the connection to the target. On the target side, in addition to the Core OS with microkernel and the Board Support Package (BSP), the minimal Debug Agent is responsible for the communication as illustrated in Fig I. The VxWorks kernel and the application, runs on the target with only minimal interference of the Debug Agent tasks [4].

A. *LabVIEW*

LabVIEW is a development environment based on graphical programming. It includes terminology, icons and ideas recognizable to technicians, scientists and engineers.

LabVIEW relies on graphical symbols rather than text-based language to describe programming actions. It is integrated fully for communication with hardware such as GPIB, VXI, RS232, RS-485, TCP/IP networking, ActiveX and plug-in data acquisition boards [5].

B. *Serial Communication*

Asynchronous serial communication technology plays an important role in automatic testing field for embedded system, because of its flexibility, facility and reliability.RS-232 is a standard interface for the transferring information between the devices and debugging of application. Serial communication requires mainly four parameters: the baud rate of the transmission, the number of data bits encoding a character, the sense of the optional parity bit and the number of stop bits [6].

Baud rate is the rate of data being transmitted through RS-232 it uses only two voltage status called MARK and SPACE. In such a two state coding scheme, the baud rate is identical to the maximum number of bits of information including "control" bits, which are transmitted per second. It is a full duplex communication protocol which can transmit and receive data, at the same time adopt the three-line link mode of the RS-232, three pins of RXD, TXD and GND to implement the serial communication between engine controller and pilot online monitoring display system [6].

III. Aero Gas Turbine Engine Controller and Pilot Online Monitoring Display

Aero gas turbine engine controller performs engine control functions as per the control laws apart from providing the monitoring display system with details of various engine parameters. Since engine needs to be monitored and controlled periodically, the presence of engine controller is inevitable. Aero gas turbine engine controller is a critical component of the aircraft. This criticality demands a high reliability of the engine and its control unit. The Aero gas turbine engine controller is controlled by a full authority digital engine control system consisting of hydro mechanical components, actuators, sensors and digital electronic control unit (DECU). DECU is a rugged and robust industrial computer, which acts as a black box, and runs infinitely and gets data periodically for every 30 milliseconds from aero gas turbine engine.

The online monitoring system functionality is to monitor, store and analyze engine parameters. This is done through serial communication. As engine controller is critical, expensive and sophisticated component, so the online monitoring system may not be always available for testing. Hence, a simulator is required for testing of online monitoring system in its absence.

The various hardware interfaces of the online monitoring system and their interaction with one another are illustrated in Fig II. Aero engine comprises of ADC, DAC, MIL-STD-1553B interface, timer, Pentium III processor, VME backplane, power cards etc which is used in embedded controller display. There is a requisite for real time communication between aero gas turbine engine controller and pilot online monitoring system. This is accomplished by using RS232 serial communication. The application software which is designed and developed will be real time and it takes care of serial communication protocol.

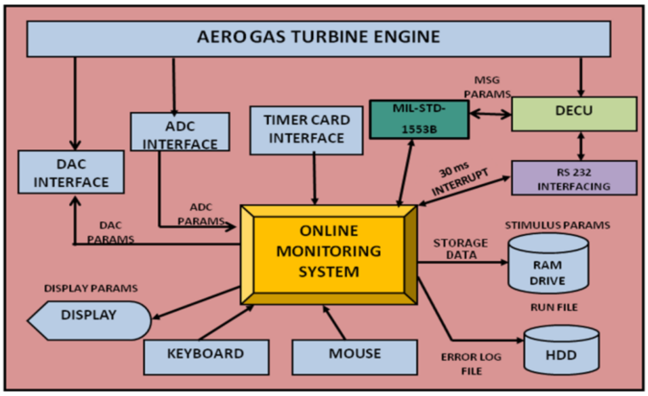

Fig II: Hardware Interface Diagram of the Monitoring System

IV. HARDWARE SYSTEM

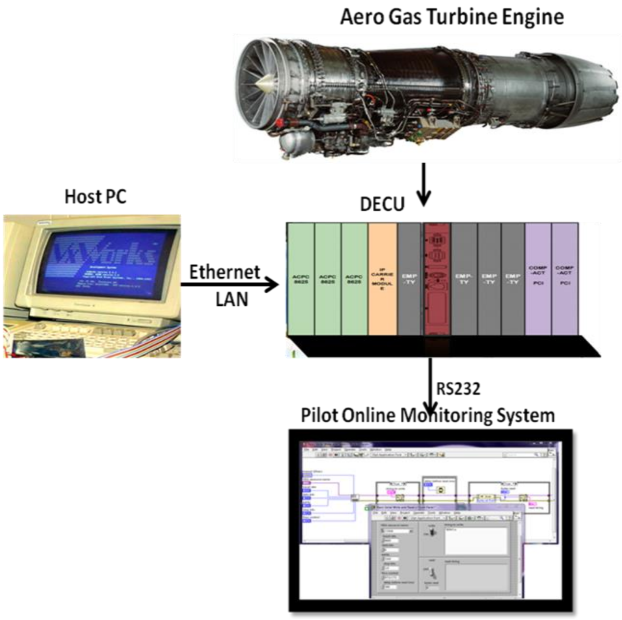

Fig III: Block Diagram of hardware system

The Figure III shows block diagram of hardware system. Hardware system comprises of following.

Host PC: Host PC consists of host operating system i.e. windows 2000. This host operating system has a target operating system i.e. VxWorks 5.4.2. VxWorks can be configured and scaled based on the application.

Ethernet LAN: Ethernet LAN acts as a media for communication between host PC and DECU.

Engine controller: Engine controller is Commercial Off The Shelf component (COTS) which controls the engine.

RS232: RS232 acts as a serial communicator between engine controller and pilot critical display.

Pilot critical display: Pilot critical display is a standalone application which gets the information from engine controller periodically for every 30milisecond which is needed to be displayed. This is developed by using LabVIEW.

The hierarchy of the design carried is as follows.

Initially, the configuration of RS-232 serial communication port COM-1 is done. The data taken from aero gas turbine engine to the Digital Electronic Control Unit (DECU) is processed for 30 milliseconds. The data residing in the DECU is converted into packets for the communication between DECU and pilot online monitoring system. Then the packets are transferred to the pilot online monitoring display system through the configured RS-232 serial communication port COM-1.

V. FLOW CHART

The flow chart of the presented application is as shown in Fig IV. It includes four stages.

1) The initialization of RS-232 serial communication port COM-1 is carried out.

2) The configuration of the serial port COM-1 is accomplished. It includes configuration of Start bit, number of data bits to be transmitted, Parity bit and Stop bit as shown in table 1.

3) Every 30milisecound updated data is being packed for transmission.

4) The processed data is transmitted to online monitoring system to the display for the pilot on real time.

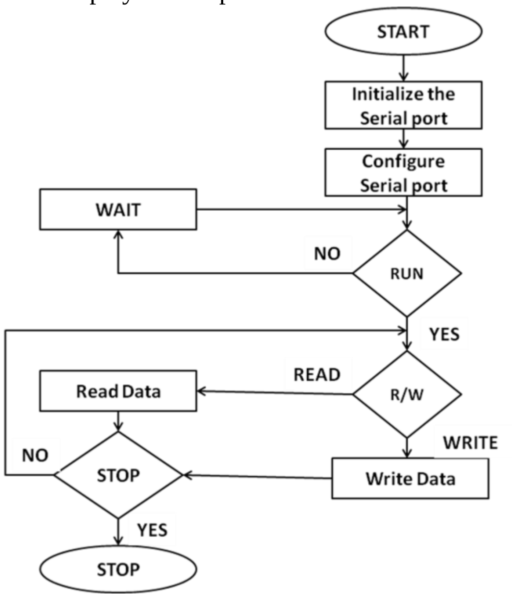

Fig IV: Flow Chart for RS232 Serial Communication

Table 1 Data Format

Start bit	No. of Data bits	Parity bit	Stop bit
1	8	1	2

VI. TEST RESULTS

Due to non availability of actual system, several systems can be tested with simulator. The proposed application is tested for the performance in terms of serial communication interface and exchange of expected messages using pilot online monitoring system simulator. The test results are as shown in Figure V.

The test results show that the proposed application is developed on the target board and information is transmitted to pilot online monitoring system. The application is successfully developed using serial communication interface and message is transmitted between aero gas turbine engine controller and pilot control system.

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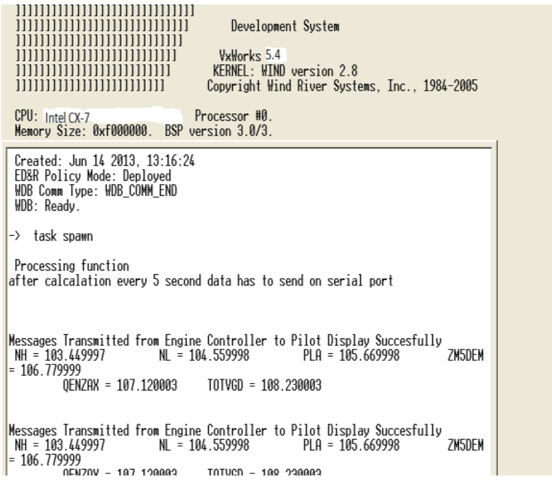

Fig V: Test Results

VII. Conclusion

The design and development for real time communication between aero gas turbine engine controller and pilot online monitoring display is successful. Aero gas turbine engine controller is enclosed by an unique polymorphic approach which could adapt itself easily to any testing environment videlicet rig, ground, altitude, temperature, fuel intake, power dissipated, pressure, amount of air taken, speed etc. To ensure deterministic performance, the application is developed using RS-232 for communication based on the VxWorks RTOS platform and implemented through LabVIEW execution system. Appraisals are used to achieve process synchronization and communication. To ensure data consistency, double buffering mechanism is used to write accumulated blocks of data in real time.

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