Design of Software Based Target Data Receiver for Radar Networking

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***Abstract*:**
A Target Data Receiver is implemented using software based approach wherein communication with surveillance radar is established and enhanced operation picture is provided to the operator. Hardware and software design details are presented in the paper.

Keywords: Multi-threading, Radar Networking

I. INTRODUCTION

The networked radar air picture is built using inputs from radars in many different locations. Due to various reasons such as target fading, terrain blockage, spurious signals etc. no one radar is able to create a complete surveillance picture [1]. Hence, the need for networking arises. The radar network has the distinct advantages of increasing coverage area, filling in gaps in coverage, improving detection probability and providing support for multiple missions [2].

Target data Receiver (TDR) provides a means to network an external search radar data over radio communication. Normally this feature is implemented in other contemporary radars using hardware only approach on dedicated platform. This paper attempts to present an approach towards the radar networking wherein software based TDR is used for compiling an enhanced operational picture. This system provides a complete Air Situation Picture (ASP) by communicating with surveillance radar which may be deployed in field and can assist in operation by sending advance target information approaching the firing zone. This external data after processing is sent to the ASP display from where the operator can designate the target, which he wishes to take over and cueing Fire Control System (FCS) to the corresponding target. Various module such as co-ordinate conversion, parallax correction, ID's generation and threat evaluation are computed using Multi-threaded application on a General Purpose Computer.

Section II introduces a typical architecture of the traditional TDR system. The proposed system and its detailed design are presented in Section III and Section IV as follows. The case study and results are presented in Section V and some conclusions are given in Section VI.

II. TARGET DATA RECEIVER

There are multiple architectures to establish network between a surveillance radar and FCS. One such network is Peer to Peer (P2P). A P2P network is a type of decentralized and distributed network architecture in which individual nodes in the network can act as suppliers or consumers or both of the resources. This is in contrast to the centralized client–server model where client nodes request access to resources provided by central servers [3].P2P network can be a structured or unstructured P2P networks. Unstructured P2P do not impose a particular structure on the overlay network by design, but rather are formed by nodes that randomly form connections to each other [4].

TDR provides peer to peer unstructured communication between Search Radar and FCS. It has a built in user interface in the form of alphanumeric display wherein target related data is displayed to the operator.

The traditional TDR has some limitations such as: it requires some set up time during which operator has to key-in the tactical data, it does not provide the complete surveillance picture to the operator and all target information is not available at time.

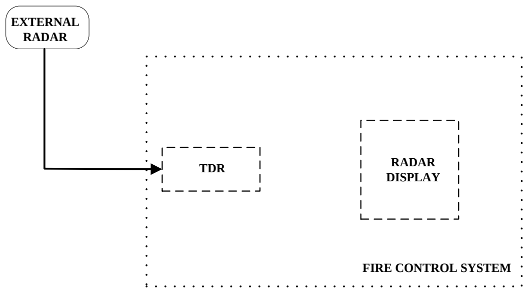

Figure 1: Block Diagram of Traditional TDR

As shown in figure 1, TDR communicates to the external radar but the target data is not linked to the FCS's display.

III. PROPOSED SYSTEM

Figure 2 shows the general block diagram of proposed TDR system, wherein networked data from external search radar is received, processed and sent to the FCS display. The complete surveillance picture is available to the operator at a single location.

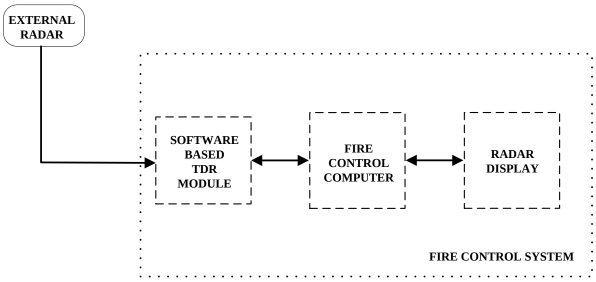

Figure 2: Proposed System

Distinct advantages of this system are:

1) In this approach the TDR processing is carried out using software which resides on a computer provided for Man Machine Interface (MMI) activities for the main radar. So, no additional area or cost is exhibited.
2) Significant reduction in set up time as no data entry is required by the operator. The tactical input data is communicated to the software over LAN by the FCS display computer.
3) Entire air situation picture is available to the operator on a single display.

IV. DESIGN DETAILS

TDR functionality is partitioned into Hardware and Software domains. The dedicated hardware provides interface to the audio data received from external search radar and software performs extraction, processing and communication of this data to the FCS.

1 Hardware Design

A dedicated hardware module (TDR-PCB) provides signal conditioning and level conversions on the received signal. TDR-PCB is plugged on to a custom designed mother board of MMI computer.

a. Motherboard Design

PC104 Express Base-board is custom built multi-layer PCB wherein all the I/O ports are taken out from the high-density connectors of CPU module to the appropriate individual function connectors. CPU module is mounted on one side of Base-board and the connectors are suitably placed on the Base-board. Apart from these connectors it has power supply protection circuit, PC/104 connectors for power supply module and CPU Module. Figure 3 indicates the position of various modules that are plugged on to the base-board.

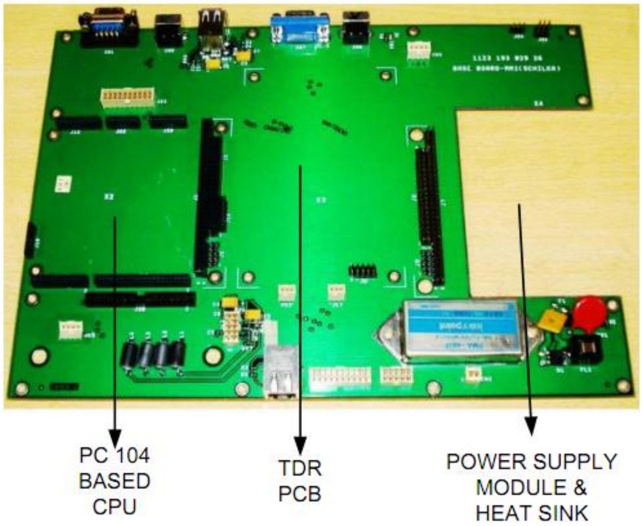

Figure 3: Base-board Design with Available Slots

MMI computer is designed in such a way that it assist in regular operational requirements of data entry, information display and execution of Built in Test (BITs). Additionally, the base-board design is suitably modified to house the TDR-PCB to provide an interface between surveillance data and the computer.

b. TDR-PCB Design

As shown in figure 4, external data is received over a radio, the output of radio is fed to the TDR-PCB where the signal is amplified, clipped and band limited. The purpose of this is to amplify the received signal while rejecting the interference noise. The signal is passed through multiple feedback band pass filter elements and feed to a limiter circuit.

The demodulator section of the PCB measures each half cycle periods in reference to an accurate time base to determine if the received frequency is a one or a zero. The demodulator of modem mandates the requirement of symmetrically limiting of the signal in order to produce equal half cycle periods.

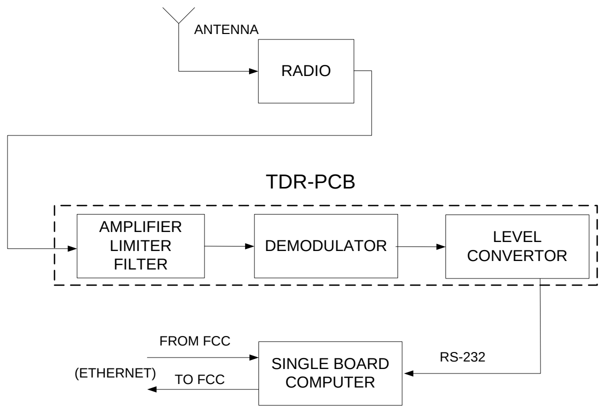

Figure 4: TDR Design - Hardware

Demodulated signal is fed to the level converter IC that converts this TTL signal to RS232 levels suitable for feeding to the serial port of the Single Board Computer.

2 *Software Design*

TDR software provides following functionalities:

- *Serial interfacing of TDR-PCB data,*
- *Receive tactical data from FCS,*
- *Process the target information, and*
- *Communicate most threatening targets to FCS display.*

As shown in figure 5, a combination of equally prioritized threads is implemented for the above requirements.

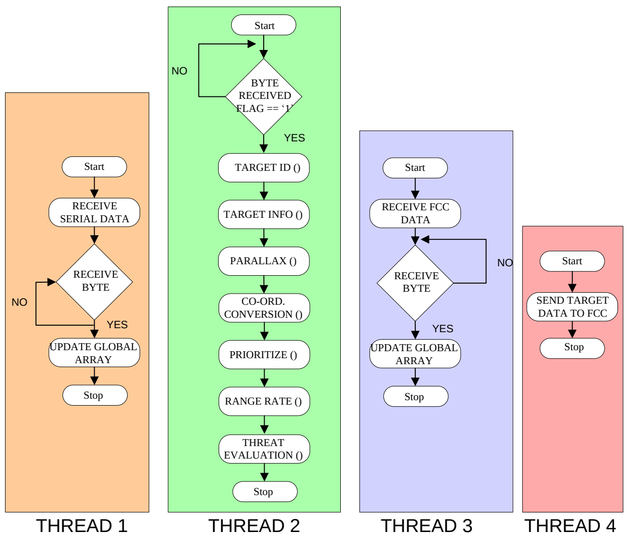

Figure5: TDR Design - Software

Thread 1 enables serial interface to TDR-PCB data. As there are no header bytes in the received data packet, a thread is initiated on receiving a byte and the data is collected on time base characteristics available in the protocol. The data is checked for parity errors, on successful reception the received data is passed to the global array.

Thread 3 establishes communication with FCS. The tactical data is received over LAN and updated in global array. Thread 2 is responsible for processing the target information. Thread 4 communicates to the display computer and updates the information on approaching target.

V. CASE STUDY AND RESULTS

A case study is performed to evaluate the total thread execution time.

1 *Set up description*

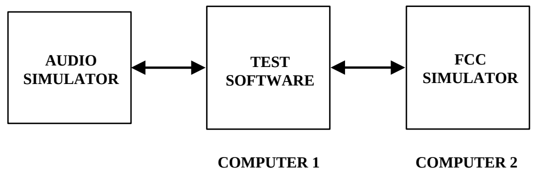

Figure 6: Test Set up

As shown in figure 6, a set-up is made to evaluate the performance of the threads. The test software is ported on the actual system and connected to the audio simulator which provides advance target information. A FCC simulator is connected over LAN to provide tactical data for initiating the TDR software.

2 *Test methodology*

A sample set of 100 packets is captured and corresponding time to execution of threads is evaluated by time stamping on incoming and outgoing data. Figure 7 shows the plot between the time to execution and frequency of the samples.

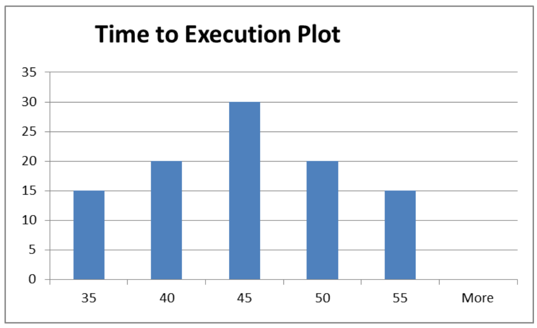

Figure 7: Time to Execution plot of Threads

The sample data provides a mean value of 42.86 m sec and standard deviation of 6.492 m sec.

3 *Test results*

The scatter plot between median rank and observed thread execution time is shown in figure 8.

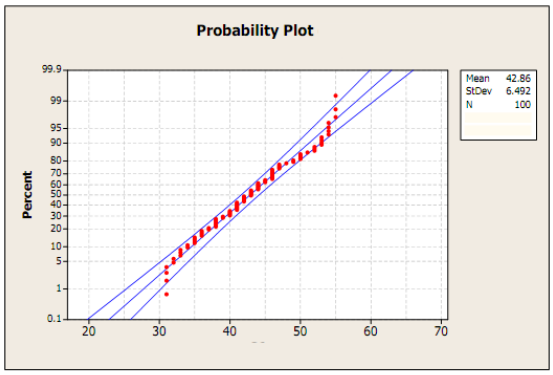

Figure 8: Probability Plot

The Table 1 provides the test results. It is evaluated with 90% confidence and 95% probability that thread execution time is less than 54.37 m sec (upper limit).

TABLE 1: TEST RESULTS

No. of Samples	100
Distribution	Normal
Mean	42.86 m sec
Std. Deviation	6.492 m sec
Time to Execution	54.37 m sec

VI. CONCLUSION

The software based approach for TDR design is adopted in this paper. It provides a distinct advantage in terms of space required, ease of up-gradation and executable with other co-software. Detailed information is focused on the system design, hardware design and software programming. Test results shows that software based TDR can process a serial string at given baud rate and generate corresponding target information for ASP display. The test results evaluate an execution time of 54.37 m sec which is very less as compared to the data rate from surveillance radar. So it can be concluded with 90% confidence that thread processing will be completed before arrival of the new packet.

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