Navigation Aid for Main Battle Tank (MBT) Training Simulators

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Abstract—**Combat Vehicles Research and Development Establishment (CVRDE) has developed Arjun MBT simulator to impart tank level training to the Commander, Gunner and Driver. In the simulator, the route navigation is being done by the commander using the Global positioning System (GPS). The GPS used in MBT has been adapted to the simulator with route navigation page, compass page, feeding of way points and shortest path calculation for commander's decision making. Since the actual GPS cannot be used in the simulator, a workable solution was carried out by emulating the GPS receiver hardware and mimicking the functionality of the system in software. This paper focuses on the design and its implementation carried out in the simulator for the GPS simulation requirements.**

Keywords— ***GPS; MBT; IEU; RS232 C; COTS***

I. INTRODUCTION

A. GPS

The GPS is a satellite based navigation system that provides precise position, velocity and time information. The heart of the GPS consists of twenty one satellites and three spares. Circling the earth twice daily, these satellites are distributed among six orbits approximately 10,900 nautical miles above the earth. Each satellite continuously transmits precise timing waveform and navigation messages including satellite status, orbit data and clock corrections.

The satellite signal is modulated by two high-rate, bi-phase, shifted key codes - a Protected code (P-code) and an unprotected code called Coarse/Acquisition code (C/A code). The P-code is reserved for military use and the C/A code is intended for public access. This signal is extremely resistant to interference from weather, earth based radio signals and electronic equipment. Several ground stations are strategically located to monitor the satellites and accumulate ranging information from the navigation signals. This information is processed at the master control station for determination of orbital data which is then uploaded to the satellites.

The GPS receiver consists of an antenna, signal processing electronics and processor. The primary function of the receiver is to acquire signals, recover orbital data, make range and Doppler measurements and process this information in real time to obtain the user position, velocity and time.

B. *GPS training to Tank commander*

The GPS used in the MBT provides information of current position in grid reference, speed and azimuth angle of tank movement. This information is used by the Tank commander to navigate the tank in different geographical location. To provide GPS training to commander in actual tank will result in driving the tank from one location to another which results in wastage of fuel and wear and tear of the Tank parts. To overcome these problem simulators were developed to train the tank crew. Navigation training for commander involves knowledge of GPS. Using actual GPS receiver in the simulator will be cumbersome in terms of communication link and map pages activation. To overcome this problem, GPS receiver hardware was designed with controls and panels with their functionality was created using software.

II. GPS SYSTEM USED IN THE TANK

A. GPS in MBT

The GPS system used in the Tank is shown in the Fig 1.

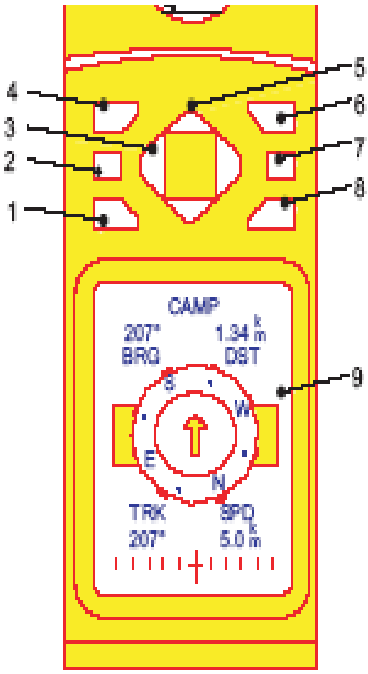


Fig 1. GPS Controls and Indicators

The functions of GPS controls and indicators are given in Table 1.

TABLE 1. FUNCTION OF GPS CONTROLS AND INDICATORS

S.No	CONTROL OR INDICATOR	FUNCTION
1	QUIT	Returns display to a previous page or restoring a data field's previous value.
2	POWER ON/OFF button	Turns the unit on and off and activates screen backlighting.
3	LEFT/RIGHT arrow	Moves the selected character field and moves the field highlighted from field to field.
4	GOTO	Displays GOTO page with the waypoint highlighted for GOTO operation. Pressing GOTO twice activates MOB.
5	UP/DOWN arrow	Selects alphanumerical characters and menu choices and moves the field highlight from field to field.
6	PAGE	Scrolls through the main data pages in sequence and returns display from a submenu page to a primary page.
7	MARK	Captures a position and displays the mark position page.
8	ENTER	Confirms data entry and activates highlighted fields to allow data entry.
9	DISPLAY	Displays various GPS menu pages such as satellite page, position page etc.

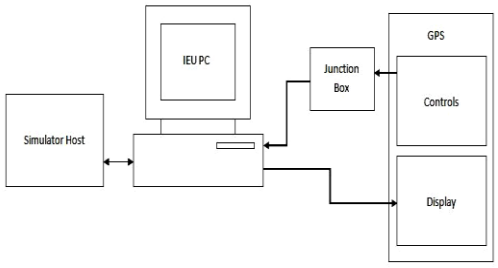
III. GPS IN SIMULATORS

A. Hardware

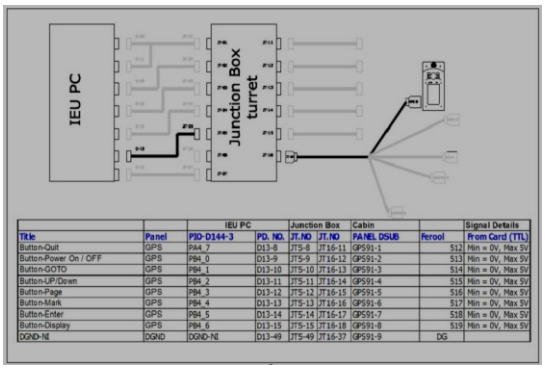
Fig 2. Simulated GPS Hardware

The GPS receiver hardware comprises of controls and indicators. The main part is the display unit which displays page depending on the page selection. For display unit, the COTS electronic kits available in the market has been used. The controls are designed as per the actual hardware. The Interface Electronics unit (IEU) PC is used to capture the control actions done by the commander. This information is sent to the simulator host which in turn generates the corresponding map pages and updates them on the GPS display using RS232C serial communication interface from IEU PC to the display unit.

Simulated GPS hardware developed and used in the simulator is shown in Fig 2. In GPS hardware, the controls are connected to the IEU PC using D type connector. The GPS display unit is connected to the IEU PC through RS 232 connection. The GPS hardware interface diagram is shown in Fig 3. The IO cable layout and routing diagram is shown in Fig 4.



\Fig 3. GPS Hardware interface diagram



		IEU PC		Junction Box		Cabin		Signal Details
Title	Panel	P3D-D144-3	PD. NO.	JT.NO	JT.NO	PANEL DSUB	Feroil	From Card (TTL)
Button-Quit	GPS	PA4_7	D13-8	JT5-8	JT16-11	GPS91-1	512	Min = 0V, Max 5V
Button-Power On / OFF	GPS	PB4_0	D13-9	JT5-9	JT16-12	GPS91-2	513	Min = 0V, Max 5V
Button-GOTO	GPS	PB4_1	D13-10	JT5-10	JT16-13	GPS91-3	514	Min = 0V, Max 5V
Button-UP/Down	GPS	PB4_2	D13-11	JT5-11	JT16-14	GPS91-4	515	Min = 0V, Max 5V
Button-Page	GPS	PB4_3	D13-12	JT5-12	JT16-15	GPS91-5	516	Min = 0V, Max 5V
Button-Mark	GPS	PB4_4	D13-13	JT5-13	JT16-16	GPS91-6	517	Min = 0V, Max 5V
Button-Enter	GPS	PB4_5	D13-14	JT5-14	JT16-17	GPS91-7	518	Min = 0V, Max 5V
Button-Display	GPS	PB4_6	D13-15	JT5-15	JT16-18	GPS91-8	519	Min = 0V, Max 5V
DGND-NI	DGND	DGND-NI	D13-49	JT5-49	JT16-37	GPS91-9	DG	

Fig 4. IO Cable layout and routing diagram

B. Software

The software module used for GPS simulation is running in the IEU PC. The simulator Host system has interface software which will take the user entered input from the GPS unit and compute its own tank position based on the terrain model. This information is then sent to the IEU PC. The GPS software running in the IEU PC will generate bitmap images on the GPS display. The various pages in GPS which are simulated in the simulator are given in Table 2.

TABLE 2. GPS SIMULATED PAGES

Welcome Page	This is a static page, which appears when the power button is pressed.
Satellite Page	This appears soon after the welcome page display.
Position Page	The top of the page contains a compass tape which is a graphic representation of user vehicle heading.

	The speed is indicated immediately below the compass tape. The rest of the page shows the current position in three dimensions-latitude, longitude and altitude. A trip odometer and 12/24-hour clock is also provided.
Map Page	A diamond icon in the center of the screen represents the current position. When the vehicle moves, a thin line called a track log appears along the path which has been just covered. Names of stored waypoints and nearby cities can also be seen on the map. The bottom corners of the map will always display the current track and speed.
Compass Page	Once a destination waypoint is selected, the compass page graphic steering guidance appears. It shows the destination waypoints at the top of the page with the bearing (BRG) and distance (DST) to the waypoint. The center of the page contains a compass ring and arrow to show the direction of the waypoint from where the vehicle is moving.
Main Menu Page	The main menu page provides access to the GPS waypoint management, routes and track log, through a list of sub menus. The sub menus are listed below: Waypoint: Waypoint List: Nearest Waypoint: Proximity Waypoint: Routes: Messages:
Nearest Waypoint Page	This page displays nine waypoints nearest to the current position that are within 50km range along with the distance and bearing. This enables to retrieve the waypoint definition page.
Proximity Waypoint Page	This page allows the user to create nine waypoints as proximity waypoints and view them in the Proximity Waypoint Page.
Waypoint List Page	This page displays complete list of all the waypoints currently stored in the GPS with their respective symbols.
Symbol Page	GPS allows the user to select one of the 16 symbols displayed in the symbol page
GOTO Page	The GOTO page appears with a list of waypoints, when the GOTO key is pressed. Once user stores the waypoint in the memory, he may recur to it by performing a GOTO. A waypoint can be selected from the GOTO page. Once selected, the compass page will give steering guidance to the destination until GOTO is cancelled.
MARK Position Page	The mark position page appears when the MARK key is pressed. When the mark key is pressed, the current position is stored in the GPS. The marked position can also be added to a route.
Route definition page	This page is used for route navigation which lets user to plan and navigate a course from one place to another using a set of predefined waypoints. GPS lets user to create and store up to 3 routes of 5 waypoints each.
Waypoint definition page	This page displays the selected waypoint details along with the following functions. Editing an existing waypoint. Deletion of a waypoint. Creation of a new waypoint by entering the latitude and longitude values. Selection of a symbol from the symbol page.
Track Back navigation	Select the TrackBack option from the GOTO page for track back navigation to get activated. The track back feature allows the user to retrace his path.

IV. SIMULATED GPS OPERATION IN SIMULATOR

The simulated GPS functions were tested and successfully installed in the Integrated Arjun MBT simulator. Training for the commander is given with the GPS instrument on various terrain data available in the simulator. The snapshots of some GPS pages in operation are shown in the Fig 5, Fig 6 and Fig 7.

Fig 5. GPS Main menu page

Fig 6. GPS Position page

Fig 7. GPS Compass page

V. CONCLUSIONS

In this paper, we have proposed a design and implementation approach for the GPS receiver which can be emulated by using COTS hardware and customized software used for navigational training in the simulator. This helps the commander to get trained on the operations of GPS effectively. This approach eliminates the costly usage of actual GPS and its customization required for training in the simulator. This GPS can take terrain inputs from any geo specific area running in the simulator. This customization of GPS can be done for any GPS model used in other AFVs like teleoperated BMP, CCPT etc., by selecting the appropriate hardware design in terms of display and front panels, and also emulating the functionality in software.

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