Personalized Global Positioning System

Introductory Description

Knowing where you are is the cornerstone of getting to where you wish to be. In this technological world, global positioning systems are becoming a thriving system for exacting navigation. Developing confidence in the use of recreational GPS systems is essential for safe and enjoyable adventure. With this project I propose to build a personal handheld global positioning device. The major goal of this project will be to simplify and customize the user interface while integrating key features from competing commercial models. The application of this product will be aimed at the outdoor enthusiast who would rather spend time outdoors playing with their GPS than indoors studying a 500 page manual. The Personalized GPS {PGPS} will customize and simplify the operation of commercial handheld GPS systems while at the same time providing essential navigation functions.

General Description

The PGPS will be a low power, battery operated, handheld device. Users will be able to read their location, altitude, time, and heading from the LCD display once the system is powered up and tracking. Figure 1.1 depicts the major system hardware of the PGPS.

Designed for use outdoors, portable power will be supplied by four AA alkaline batteries. Time permitting, batteries may be upgraded to Lithium Ion or Nicad cells with supplemental charging circuitry. The enclosure will be waterproof and shockproof for the final design. Depicted from Figure 1.1, user interface will consist of a Liquid Crystal Display (LCD), 8 Navigation LEDs, and nine-button keypad. The principle feature for this product will be the simplistic functional control for the user. Functions will consist of; position and altitude fixes of
current location, coordinate entry and navigation, and animated LED navigation. Time permitting two optional functions may be included consisting of Backtracking, and Route Setting.

Figure 1.1 System Hardware

The personalized GPS system is designed for the outdoor enthusiast who likes getting lost, but not being lost. With its user-friendly interface even those of us with no technical poise will become master’s of navigation. This personalized GPS system will benefit the user with simplicity and function. Navigation LEDs mounted on the housing will direct the user back to stored waypoints allowing basically hands free navigation. With this GPS system, navigating in areas you’ve never been before will become second nature. If you can read the coordinates from
a map and enter them in your PGPS you will be able to navigate to that location. This GPS system relates to the user a sense of technological safety without imposing on the adventure at hand. All outdoor enthusiasts will be able to enjoy their backwoods adventure in a cool and confident manner with the aid of the PGPS. Figure 1.2 illustrates a sketch of the overall assembled PGPS prototype. Final Product dimensions are not to exceed 8” high, 5” wide, by 2” deep.

Figure 1.2 Sketch of Assembled Hardware

Dimensions: Height 8.0”, Width 5.0”, Depth 2.0”.
**Functional Description of Hardware**

The detailed PGPS hardware block diagram is shown in Figure 1.3. The main items of hardware include the SMK-4 Receiver Antenna, M12 GPS Receiver, M68HC912B32 microcontroller, non-volatile SRAM, Liquid Crystal Display (LCD), 9-Pushbutton Interface, 8 Navigation LEDs, and Portable Power Supply. This project revolves around GPS solutions, therefore a brief account of GPS technology is in order.

![Figure 1.3 Functional Hardware Diagram](image)
M12 Receiver

Global Positioning System is a Satellite Navigation System funded and controlled by the U. S. Department of Defense. GPS provides unique coded satellite signals that can be processed by GPS receivers to compute position, velocity and time. The PGPS project will use an integrated single board GPS receiver module from Motorola designated the M12. This GPS receiver tracks the NAVSTAR GPS constellation of satellites. The NAVSTAR (NAVigation Satellite Timing and Ranging) system is an all weather radio based, satellite navigation system. The NAVSTAR system consists of three major segments: the space segment, the ground control segment, and the user segment. The space segment is composed of 24 satellites in six orbital planes each at an altitude of 20,183km. Figure 1.4 captured from Peter H Dana’s Global Positioning System Overview Website illustrates the NAVSTAR space segment.

Figure 1.4 NAVSTAR Space Segment
The ground control segment consists of a master control center and a number of widely separated monitoring stations. This ground network tracks and maintains these satellites with periodic upgrades of system correction data and almanacs. The user segment consists of individual signal receivers. The PGPS project revolves around the user segment of the NAVSTAR system. The M12 represents the user segment this project will be designed around. Figure 1.3 represents an overall hardware block diagram for the PGPS.

**Antenna/M12:**

The SMK-4 antenna receives the coded GPS satellite signals, which are tracked using 12 parallel channels. These signals are then digitally processed by the M12 receiver to obtain a full navigation solution consisting of position, velocity, time, and heading. Figure 1.5 captured from Peter H Dana’s Global Positioning System Overview website illustrates a simple breakdown of the M12 receiver function. The navigation solution is then processed via a serial link to a Motorola M68HC12B32 microcontroller (MCU).
M68HC912B32:

The micro-controller in the PGPS performs the tasks of handling user interface between display and keypad and executing recreational GPS functions mentioned earlier. (These functions will be fully explained in the User Interface section of this description.) Initially the optimum choice of micro-controller was an Atmel Atmega128L. This microcontroller incorporated some premium advantages over the HC12 including high efficiency, faster instruction execution, and lower power consumption. However, after researching development support and considering the time required to learn a new assembly language and hardware configuration I decided to use the Motorola HC12. With the time allotted for this project and the funds available using the Atmel MCU became unfeasible.

Once the navigation solution is determined by the M12 it is received in serial TTL form through the SPI port of the M68HC912B32 MCU operating in single chip mode. Data received from the M12 is then processed according to user interface commands requested. Resource allocations of the MCU are visually depicted in Figure 1.3. Port A (PA0-7) and Port B (PB0-3) provide the 11 I/O lines required to operate and control the LCD. The LCD displays information to the user enabling user interface. (An in depth description of LCD interface will be addressed in the User Interface Section). Port B (PB4-7) provide the 4 I/O lines for the LED navigation feature. The SCI on pins PS0-1 will provide the serial link to the M12 receiver, transmitting position data and receiving system instructions. Port AD (PAD0-7) and Port S (PS2) provide the 9 I/O lines required for pushbutton user interface. Port DLC (PDLC0-7), Port T (PT0-5), and Port P (PP0-7) provide the 22 I/O lines required for nonvolatile Static RAM access.

Memory allocations for the PGPS will be provided by memory present on the HC12 and external non-volatile SRAM. The main program will be stored in the 32k bytes of Flash
EEPROM. The 1k byte of RAM will be used for storing temporary variables and running the pre-emptive Kernel, MicroC/OS-II. The 786 bytes of EEPROM will not be allocated during prototype development of the PGPS. It may be used at a later date for storing nonvolatile parameters for the M12 receiver. The external nonvolatile RAM will be used for storing and retrieving marked positions. The Non-Volatile SRAM has a 10-year minimum data retention without external power and automatically protects stored data during power loss.

Power supplied to the PGPS will consist of four AA batteries wired in series. Input voltage will be 6 VDC. The input voltage will be regulated by two DC-to-DC converter integrated circuits. One will supply a regulated 5.0 VDC output and the other will supply a regulated 3.0 VDC output. Maximum power dissipation for the PGPS hardware is as follows:

- **5 Volt Supply**
  - LCD 102mA (Backlit) 429mW (Backlit)
  - MCU 45mA 225mW
  - NV SRAM 85mA 404mW
- **5V Source Power Dissipation** 232mA 1.058W

- **3 Volt Supply**
  - SMK-4 Antenna 11mA 33mW
  - M12 Receiver 81mA 243mW
  - LED 30mA 90mW
- **3V Source Power Dissipation** 122mA 366mW
Software Description

The software components for the PGPS will be written in the C programming language and consist of seven modules. These modules will contain groups of related tasks corresponding to that module. These software modules will include KERNEL, MAIN, DISPLAY, GET_NAV_SOLUTION, LED_NAV, UPDATE, and USER_INTERFACE. Descriptions of the PGPS modules are as follows:

<table>
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<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KERNEL</td>
<td>MicroC/OS-II will be used as a preemptive kernel to handle task switching, scheduling, and event services.</td>
</tr>
<tr>
<td>BUTTON</td>
<td>This module will monitor button debouncing and activation and handle functional state transitions.</td>
</tr>
<tr>
<td>DISPLAY</td>
<td>The DISPLAY module will include tasks to perform initialization, cursor placement, scrolling, and backlight operation. It will also include six major screen configurations.</td>
</tr>
<tr>
<td>GET_NAV_SOL</td>
<td>This module will read in the navigation solution from the M12 and sort the data into corresponding variables.</td>
</tr>
<tr>
<td>LED_NAV</td>
<td>This module will compare the users current position to their destination position and flash one of the eight LED’s corresponding to the proper direction of travel.</td>
</tr>
<tr>
<td>UPDATE</td>
<td>The UPDATE module will continuously update the display state, button state, and position.</td>
</tr>
</tbody>
</table>
USER_INTERFACE

The user interface module will contain the bulk of the system software for the PGPS. The user interface is the MAIN module for this embedded system. Tasks will include the following:

- **Display State**: This task monitors the LCD display state and state functions.
- **Update States**: This task updates all system states at a rate yet to be determined.

**User Interface Description**

User interface will consist of a Liquid Crystal Display, 9-button keypad, and a directional cluster of LEDs. Figure 1.2 visually depicts the PGPS user interface. The liquid crystal display will be a 4 row by 20-column edge lit display. This size display was determined to be the minimum size required for efficient user-interface. Holding the Power button for 2 seconds turns the PGPS system either on or off depending on its current state. Upon initial power-up the LCD will display the Main Navigation screen shown below in Figure 1.6.

![Figure 1.6 Main](image)

Once the receiver initialization is complete and the receiver is tracking, indicated by a T in the upper right hand corner of the display, position data will be updated continuously at a selected rate between 1 –255 HZ. As displayed in Figure 1.6 the number associated with the T in the
upper right hand corner indicates the number of satellites currently being tracked. The current mode of operation is displayed in the lower right hand corner of the LCD.

When the menu button is pressed four selections appear on the screen. Figure 1.7 displays the selection choices.

![Figure 1.7 Menu Mode](image)

The cursor is parked at the first selection. Keying the up or down arrows moves the cursor to the next selection. An Enter key press selects the highlighted selection. If no key press is detected the display returns to the Main screen after 7 seconds. An enter key press for selection number one, Mark Position, directs the user to the Mark Position window indicated in the lower right hand corner of Figure 1.8.

![Figure 1.8 Mark Mode](image)

The cursor appears at the beginning of a generic MARK1 waypoint designator. The user is then able to scroll through characters A-9 by pressing and holding either the Up or Down button over the highlighted character. The Left and Right buttons move the cursor to the next character. Eight characters represent the maximum allowable mark designation. Once all characters are
selected an Enter button press saves the mark under the user-defined name and returns the user to the main navigation window.

When Menu choice two, Goto Mark, is selected by an enter key press the user is directed to the Goto window. The GOTO window is displayed in Figure 1.9.

![Figure 1.9 Goto Mode](image)

At the GOTO window the user is presented with a list of stored waypoints or Marks. The cursor is placed at the top of the list and the user is able to scroll through the list by pressing either the Up or Down button. When the user comes to the Mark they desire and presses the enter key the user is taken to the Main navigation window shown in figure 1.10.

![Figure 1.10 Goto Mark Mode](image)

Directional navigation is supplied by a cluster of eight LEDs. The flashing LED points to the direction of travel required to arrive at the specified mark. The LED’s update continuously coinciding with the receiver updates and user position. Figure 1.11 shows the directed LED
navigation. At anytime the goto mode may be terminated and the user returned to the Main window by pressing the ENTER button.

When the Edit Mark choice is selected by an enter key press the user is directed to the EDIT window shown in Figure 1.12.

The user can scroll through the list as explained earlier with the Up and Down buttons and is able to select the Mark they wish to edit by placing the cursor on their selection and pressing the Enter key. This takes them to a window shown in Figure 1.13 with two selections available Delete Mark and Rename Mark. If the user selects Delete Mark the Mark is removed from the list of stored waypoints.
If the user selects the Rename Mark the mark designation appears in a window by itself and the user can change characters in the manner explained earlier. This edit window appears in Figure 1.14. An Enter key press stores the new Mark designator and returns the user to the main navigation window.

![Figure 1.14](image1)

When Menu choice four, Enter Mark, is selected by an enter key press the user is directed to the Enter Mark window shown in Figure 1.15.

![Figure 1.15](image2)

This function lets the user enter co-ordinates from a map or online source into PGPS memory for future navigation. The cursor is placed in the upper left-hand corner of the display with the first character of the generic MARK1 designator selected. A user-defined name can be entered by using the previously mentioned scrolling techniques. Once the specified mark characters are set the user presses the Down button once and the cursor moves to the latitude field. This field is blank waiting for the user’s input. The user will enter the Latitude using the same scrolling
techniques stated previously. With the latitude entered another Down key press moves the
cursor to the longitude line. Once the user enters the longitude an Enter key press checks the
entry for valid coordinates and displays an error message if the coordinates are not valid. If they
are valid they are stored as a Mark in the Mark list.

The Menu and Enter key functions have been explained in some detail. The Light button
will control the backlight LED’s of the display for low light conditions. The Goto button will
provide a shortcut key to the Goto menu for immediate mark navigation.

**Development Plan**

Project development during fall quarter has consisted of research and planning up to this
point. By the end of the fall quarter I would like to have all major hardware gathered for
prototype assembly during Christmas break. I will have an extensive range of tools available for
use while home for Christmas break. I plan on taking full advantage of this by assembling major
hardware components while those tools are available. Project success revolves around three
major aspects, a functional user interface, manipulating the M12 navigation solution, and
portability. The user interface is going to involve some serious programming. Winter quarter I
take the 454 embedded systems class, which focuses on programming embedded systems in the
“C” programming language. My goal during winter quarter is to parallel the class lessons with
my project software. More explicitly, I will begin a rough draft of the project software as the
class goes on. Once the class is over I should have all the tools necessary to fine tune my “rough
draft” code into a final product. Allowing two quarters for software development should let me
complete the user interface specified.
Along with beginning my software development winter quarter, I will concentrate on interfacing the M12 with the HC12 microcontroller. The HC12 operates at five volts and the M12 at three volts which may cause logic level conflicts. Detailed analysis of this conflict and manipulation of the M12 navigation solution will be addressed.

Focusing on the portability of the PGPS will also be concentrated on during winter quarter. I have researched portable power management IC’s extensively to date and have developed a preliminary power supply system. My major concerns include the power up and power down characteristics of the M12 and HC12. I plan on contacting Motorola’s technical support along with Dallas Semiconductors about what precautions need to be incorporated into my portable power supply design to ensure proper operation. A specific breakdown of tasks to be accomplished during winter and spring quarters is as follows:

Fall Quarter 2001

Week 10: Order final parts for prototype construction over Xmas break. Study for finals.

Week 11: Finals Week. Study hard then take a break!

Xmas Break 2001

Week 1: Study Oncore Receiver manuals and Embedded Microcontrollers text concentrating on interfacing the M12 and HC12.

Week 2: Enjoy Christmas with my family.

Week 3: Test fit and mount LCD, LEDs, M12, HC12, and circuitry in prototype housing.

Week 4: Enjoy Newyear’s then concentrate on the portable power supply design.

Winter Quarter 2001

Week 1: Research power up/down characteristics for operating the HC12 and M12 simultaneously.
Week 2: Concentrate on interfacing the M12 with the HC12 and begin work on software.

Week 3: Integrate power supply solution in prototype and keep outlining code segments.

Week 4: Modify existing 2 by 16 LCD code for use with my 4 by 20 LCD.

Week 5: Build rough draft LCD formatting modules, Scroll A – 9, and Cursor.

Week 6: Work on rough draft for LCD code and determine Algorithms for Navigation LEDs.

Week 7: Work on rough draft for LED Navigation code.

Week 8: Work on Rough Draft for Button Interface code.

Week 9: Work on Rough Draft for Initialization code.

Week 10: Dead week, study for finals and continue coding.

Week 11: Study for Finals and take Finals.

Spring Quarter 2002

Week 1: Work on finalizing user interface code.

Week 2: Work on finalizing user interface code.

Week 3: Work on finalizing user interface code.

Week 4: Week open for unexpected delays

Week 5: Project Design Review

Week 6: Final software integration in prototype.

Week 7: Prototype testing

Week 8: Prototype testing

Week 9: Code review

Week 10: Dead Week Project Demonstration and study for finals.
Week 11: Finals Week  Study up, take my last finals… and school is out!!

Development Hardware

Development of the PGPS project will take place in Western Washington University’s ETEC lab, EET 340. This lab contains all major development tools for this project. The lab tools used most frequently will consist of, the digital multimeter, digital oscilloscope, PC, Noral debugger pod, programmable power supply, and solder iron. System development hardware will include evaluation boards for the HC12 and M12 and corresponding software. Software packages will include Motorola’s Winoncore12, the ETEC departments’ Introl compiler, CodeWright 6.0, and Flex High Level Debugger. Additional software may be used on demand including Microsoft Office suite and P-spice.

Demonstration Prototype

The PGPS demonstration prototype will be a standalone project. Construction of the prototype will include custom mounting the LCD, navigation LEDs, buttons, and internal circuitry in an enclosure not to exceed 8.0” by 5.0” by 2.0 “. Developing the PGPS prototype in a rather large enclosure will exclude the time and cost factors associated with building small handheld devices. Once the PGPS is entirely operational the final product may be scaled down for final demonstration. Soldering components will be done once all components part sections of the PGPS test one hundred percent operational.

Demonstration of a product built to operate in the great outdoors presents some problems for demonstration indoors. My indoor demonstration will include a detailed poster describing the user interface instructions along with some interesting GPS information. The PGPS user
interface will be able to be demonstrated but my receiver will not track indoors to facilitate a functional demonstration. I am still researching solutions to this predicament. A fully functional demonstration can be demonstrated outdoors with department permission. I would like to demonstrate my PGPS at select times as not to interfere with any other project demonstrations.

For the functional demonstration one preset mark will appear in the PGPS goto list. This will be the location outside the ETEC building in front of the main office. The demonstration will call for a volunteer to navigate to another position of the users choice, mark that position, and then navigate back to the ETEC steps. Supplemental demonstrations will vary according to this procedure.
Electrical Specifications

• Accuracy:
  • Position: 100m
  • Altitude: 156m
  • Velocity: 0.02m/s
  • Time: ±500 ns

• Startup Time (TTFF)
  • Hot: 15s
  • Warm: 45s
  • Cold: 70s

• Reacquisition Time
  • After 60s Obst.: 3.5s

• Data Rate:
  • 1–255Hz Variable Navigation Solution Update Rate

• Power Requirements
  • 4 – AA Alkaline Batteries
    • Estimated Life 15 hours
    • Worst Case Power dissipation 400mA

• Special Environmental Requirement
  • Outdoor Operation Preferably Unobstructed
  • Water Proof (Final Product)
  • Shock Proof Housing (Final Product)
  • Normal Operating Temperature: 0° to 85°C
## Preliminary Parts List

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