行政院國家科學委員會專題研究計畫　成果報告

可攜式 GSM-GPS 行動衛星導航器之 DSP/CPLD 設計

計畫類別：個別型計畫
計畫編號：NSC93-2622-E-164-003-CC3
執行期間：93 年 05 月 01 日至 94 年 04 月 30 日
執行單位：修平技術學院電機工程系

計畫主持人：金之業

計畫參與人員：林宣斌　陳育瑜

報告類型：精簡報告

處理方式：本計畫為提升產業技術及人才培育研究計畫，不提供公開查詢

中　華　民　國 94 年 5 月 26 日

行政院國家科學委員會補助專題研究計畫 ■ 成 果 報 告 □期中進度報告

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中　華　民　國　94　年　5　月　26　日

DSP/CPLD design for a portable GSM-GPS navigator

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A prototype MCU module is developed to execute mobile communication on where's personal location or vehicle's tracking, and is well-considered for the GPS (Global Positioning System) applications and for the future ITS (Intelligent Transport System) implementations. Auxiliary visual and audio outputs will be utilized to warn the driver of the approaching of the Emergency Vehicle once it is driving into the certain range. The warning will be enhanced in severity whenever they are closing to each other. After the Emergency Vehicle is moving away, the alerting signal shall be ceased gradually. Hereinafter the analog and digital circuits designed with dual PIC18F452/16F877 MCU and CPLD/FPGA technologies.

Key Words *— Complex Programmable Logic Device/Field Programmable Gain Array* (*CPLD/FPGA*), *Global Positioning System* (*GPS*), *Intelligent Transport System* (*ITS*), *Micro-Control-Unit* (*MCU*)

1. INTRODUCTION

This proposed system is composed of a transmitter mounted in an Emergency Vehicle and a receiver that can be added into on-way's vehicles. And a GPRS/GSM modem will be used to warn the approach drivers as soon as they are within the given ranges. Also the signal will be refined with GPS coordinate [1] to alert those vehicles, which were in the path of the emergency vehicle for Highway Safety.

Conclusively, the outcomes of this project will be anticipated to show that it will alert unaware drivers from preventing an traffic accident, recognizing some unusual situations or gaining more response time whenever the EV (Emergency Vehicle) was approaching. Furthermore, its commercial achievements will especially be used in ITS (Intelligent Transport System). It will pre-warn the involving drivers to avoid the emergencies and accidents as soon as he encounters an EV along the roadways.

2. GSM/GPS MODELING

Using the stand-alone GPS receivers [2, 3], a person is able to identify his own position. Moreover the friendly achievement of GPRS/GSM module was to provide a wireless information-exchange as well. We adopt both of features to develop the system for the vehicle tracking and emergency communication using Microchip PIC18/16 with HOLUX GM-83 and WAVECOM Q2406A [4]. To design this, we integrated the GPS's ability to announce user's coordinates along with the GSM's function for communicating with control center in a wireless fashion.

In order to monitor vehicles nearby an interest spot, each vehicle will be equipped with a GSM/GPS mobile tracker. Each tracker shall receive GPS information and sends them to the control center. Refers to these coordinates, control center can display all of vehicle's positions on an electronic map for easily monitoring and controlling their routes. Besides the control center can also maintain a wireless communication to update alarms, status and parameters.

2.1. Circuit arrangement

This GSM/GPS mobile tracker could be considered as a main part of the Intelligent Transport System. There are two distinct and capable technologies were integrated in this project in a single handset.

This tracker is based on a MCU adopting with GPS receiver transmitting in the 4800-bps rate and GSM module operating in the 900-MHz band [5]. The vehicle's position and identity are either transmitted periodically or sent message out at once a specified condition interrupted.

Usually the information would be presented as a Short Message Service (SMS) message to the control center. Then the data will be displayed on a digitised map and stored for debriefing or evaluation of a special mission. Hardware block diagram is shown in Figure 1.

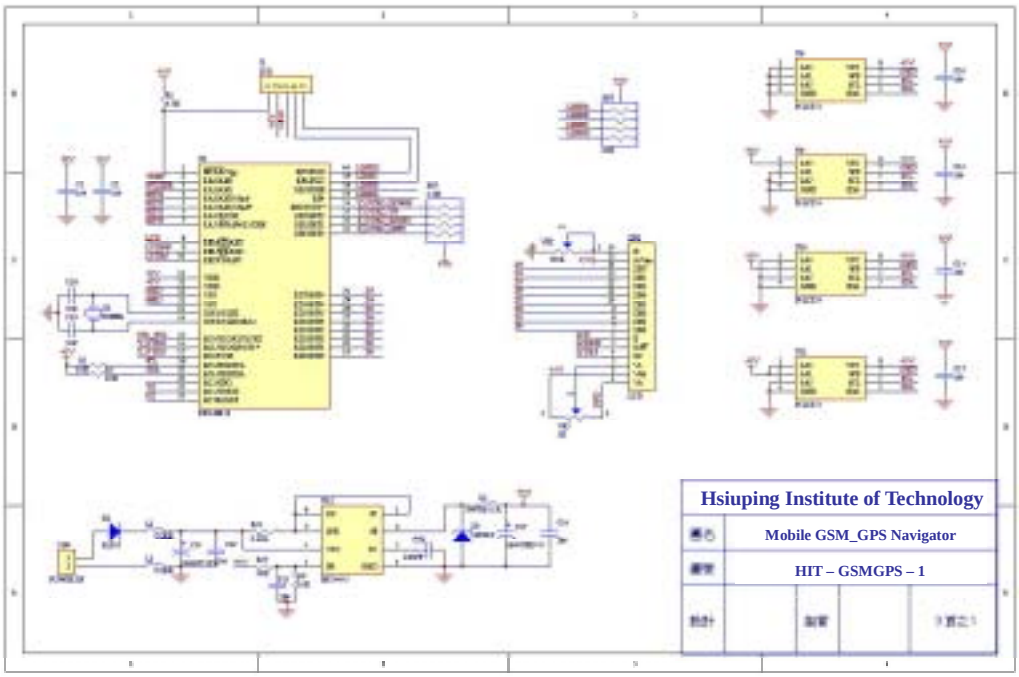

Figure 1_A: GPS 25LP to MCU controller

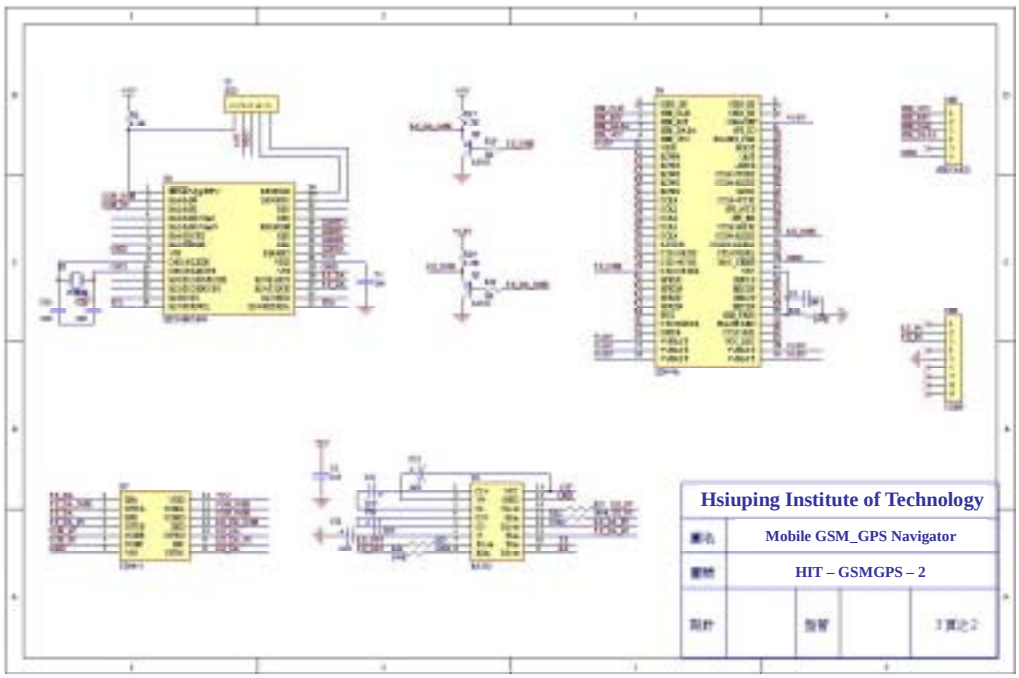

Figure 1_B: Schematic diagram connecting MCU with GSM, GPS, and PC

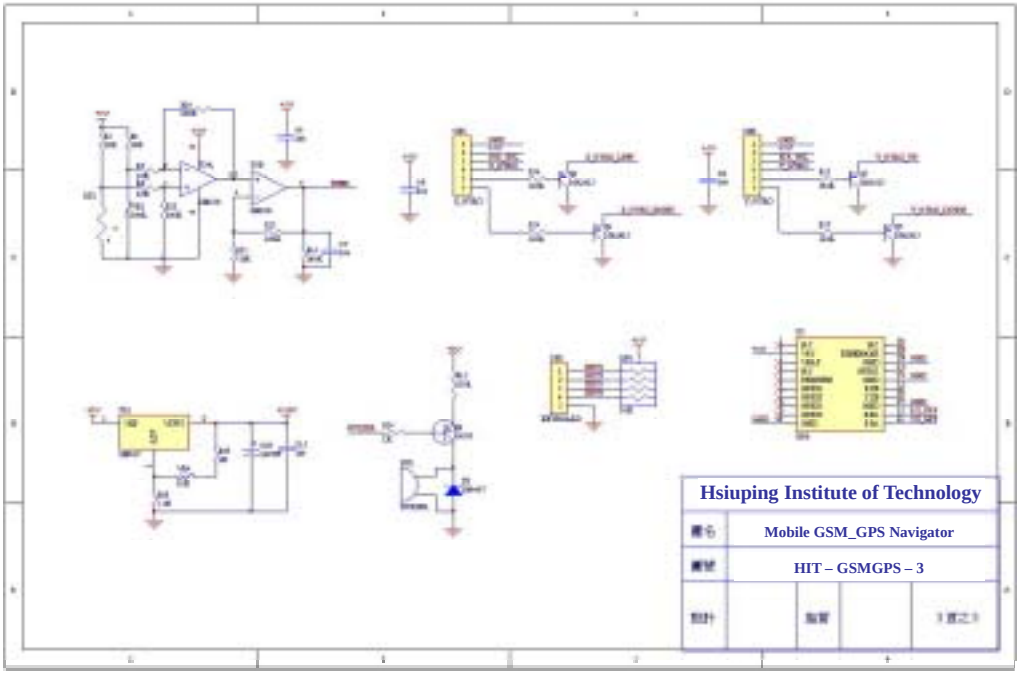

Figure 1_C: Schematic diagram connecting MCU with GSM, GPS, and PC

Herein two MCUs were used to control all incoming and outgoing messages as well as the I/O operations. One PIC18F452 [6] processes GPS information through GM-83 receiver with a TTL-level asynchronous serial (USART) interface, Another PIC16F876A communicates with Q2406A to upload/download data to/from the control center in a GSM network; furthermore a RS-232 interface is also used to maintain the software with a PC optionally. The vehicle's coordinates and messages were stored in four Microchip 24LC256 I^2C EEPROMs (256Kbit), up to 3000 pieces of information approximately. Four control buttons, a 2×20 LCD display module, and a buzzer to recognize the status, annunciation and alarm.

2.2. System architecture

As aforementioned, the GPS module inputs the vehicle location as longitude, latitude, and Universal Coordinated Time (UTC) in every 1 sec, and then stored them every 30 sec in EEPROM. Notes that the wireless communications is based on a GSM network established in a valid region and with a valid service provider. Therefore the position information and the status are sent to the control center via GSM_SMS provided by the GSM/GPRS network. Meanwhile, the mobile tracker could also receive the instruction via the same network. Two alarms systems; warned by a buzzer and showed on the LCD whenever it receives the emergent call from control center, or oppositely sent the alarm to control center by pushing a button.

3. DESIGN CONSIDERATION

Microchip 24LC256 I^2C EEPROM is arranged with its 256 k bits capacity to relocate roughly 800 cells of 40 bytes each. In addition, a serial interface facilitates the hardware layout to increases system reliability and reduces the package size and the active pin count. CD4066 is used to multiplex the active port among different UART ports, and MAX232A accomplishes the compatibility between CMOS and TTL level.

With three control pins and eight data pins, the MCU gives the LCD specific instructions. RA2 to RA5 individually sense the four push-buttons. There is a Menu button designed to mode selection, and "Enter" is to confirm it. Others are used to transfer/receive command and message to/from the control center.

3.1. GPS data retrieved

The GPS data is normally transmitted in a standard NMEA-0183 format, and HOLUX GM-83 module is used for this project. It is intended as a component for OEM product that continuously tracks all satellites

in view and provides accurate satellite positioning data.

The HOLUX has 2 full-duplex TTL-level asynchronous serial interfaces. NMEA or RCTA messages [7, 8] are transmitted and received, the HOLUX GM-83 is cold booted after 45-second's warm-up to transmit a set of data, and NMEA GPS messages generally includes: GGA, GLL, GSA, GSV and RMC group-sets. Herein the most useful RMC-Recommended Minimum Specific GNSS data message was only chosen to build our navigation system as well (definition was listed in Table 1).

Syntax		Content
UTC Time	153245.68	hhmmss.ss
Status	A	A: valid; V: warn
Latitude	2405.7848	ddmm.mmmm
N or S	N	N: North, S: South
Longitude	12042.7460	dddmm.mmmm
E or W	E	E: East, W: West
Speed	0.30	Unit: knots
Track made good	-	True
UTC Date	180804	Ddmmyy
Magnetic Variation	330.74	Unit: degree
E or W	-	E: East, W: West
Checksum	*0B	End of message

Table 1: NMEA-0183 response $GPRMC message

In this system, using ASCII codes screens the UTC time, date, longitude, and latitude in WGS84 format [9, 10]. After that, all of them were reorganized into a standard fixed-length package combining with other optional INS information, which might include the pitch/yaw's acceleration and angular variation of the vehicle. Consequently, this data packet will be transmitted to control center and/or pre-stored in 24LC256 EEPROM waiting for being transmitted to the control center later.

The primarily transmitted protocol is defined as a 40-byte long ASCII string, which includes the tracker ID, system password, (optional package order), tracker's coordinates, UTC time/date, and start and stop. Table 2 exhibits that data packet's format of a well reformed message protocol and example ready to be saved or transmitted as: "**:002010N24057848N120427460E1532450000#**"

Name	Byte	Definition	Description
Start codes	1	:	Start symbol of data package
Package ID	1	0 ~ 9	Package ID is repeated from 0 to 9
User's password	2	00 ~ 99	User's password
Vehicle's ID	3	000 ~ 999	Vehicle's ID
GPS positioning	10	E000000000 ~ E180000000	E means longitude, 000^{O} 00.0000
	9	N00000000 ~ E90000000	N means latitude, 000 ^{O} 00.0000
UTC time	6	hhmmss	Greenwich Time (hour minute second)
Upload rate	3	0~255(Baud considered)	Upload time interval = 10 ms ╳ rate
Alarm information	4	XXXX	"0" means Okay; "1" means Alarm
		"1000"	Byte 1: aberrance alarm
		"0100"	Byte 2: over-speed alarm
		"0010"	Byte 3: dangerous alarm
		"0001"	Byte 4: manual alarm
Stop codes	1	#	Stop symbol of data package

Table 2: 40-byte data packet format for applications

3.2. GSM data transmitted

Today European Telecommunication Standards Institute (ETSI) assigns the GSM as a standard digital wireless communication system. Its commercial service began in 1991, at the beginning of 1994; there are approximately 1.3 million subscribers worldwide. GSM/GPRS is the dominant communication standard in Taiwan; no communication-base-station is needed, so it reduces the initial set-up cost significantly.

The most fundamental service supported by GSM was wireless-phone. Group III fax, an analogue method described in ITU-T recommendation T.30, it also supports an appropriate fax adapter. For point-to-point SMS system, message will be sent to another subscriber in service, and sender calls an acknowledgment of receipt. SMS also can be used in Cell Broadcast mode to send messages of traffic report or news updates. Furthermore, messages can then be stored on the SIM card for later retrieval. Working with GPS modules, a stand-alone WAVECOM Q2406A is compatible with dual-band embedded (GSM900/DCS1800) system. By issuing concise AT command, GSM_SMS data could be processed (as listed in Table 3), and it is also followed by GSM 07.07 and GSM 07.05 protocols [11, 12].

AT Commands	Function Description
AT+CMGC	Send an SMS command
AT+CMGD	Delete SMS message
AT+CMGF	Select SMS message format（0：PDU;　1：Text）
AT+CMGL	List SMS message from preferred storage
AT+CMGR	Read SMS message
AT+CMGS	Send SMS message
AT+CMGW	Write SMS message to SIM Card
AT+CMSS	Send SMS message from SIM Card
AT+CNMI	New SMS message indications
AT+CPMS	Preferred SMS message storage
AT+CSCA	SMS service center address (SMS Center No.: +886932400851)
AT+CSCB	Select cell broadcast messages
AT+CSMP	Set SMS text mode parameters
AT+CSMS	Select Message Service

Table 3: Related SMS samples under GSM07.07 protocol

First initialises the GSM module with AT commands as AT+CSCA and AT+CMGF, next formats code of SMS center with outgoing SMS messages. Finally two different modes, Text mode and Protocol Data Unit (PDU) mode, are used to handle the short messages. Herein we choose the easier AT+CMGF = 1 (Text mode), and AT+CMGS to send a short message as:

AT+CMGS = <DA> <CR> Message Texts <CTRL-Z>

Here <DA> is subscriber mobile phone number whom you want to send the short message sent to. The GSM module then can receive incoming short message and save them on the SIM card automatically. Moreover, you can also use the AT+CMGR command to read an incoming short message as required, and use the AT+CMGD command to delete it after you had finished. Furthermore, subscriber can simply send the “AT+CMGR = n” command to tell the GSM module that the “nth” short message he would like to read optionally.

4. HRDWARE DECRIPTION

The difficulty of this project was learning the NMEA-GPS sentences and the GSM/GPRS-AT command protocols. As you see three jack terminals existed, JP1 is designed for GPS receiver, JP2 is for GSM module, and JP3 is for communication with PC. PIC18F452 is a MCU core and low-power CMOS 8-bit MCU structured on a high performance RISC architecture. This MCU achieves 1 MIPS throughput and optimised power consumption versus processing speed. It features 8K×14 words of flash program memory, 368×8 bytes of data memory RAM, and 32 general-purpose I/O lines.

PIC16F876A MCU has only one UART serial port, but its high speed makes it possible to complete multiple tasks between PC and GSM modules. And the chosen EEPROM makes it possible to store data for off-line survey. Others are a 4-channel Multiplexer, a 2×20 LCD, a buzzer, and four push buttons.

5. SOFTWARE DESCRIPTION

We used the powerful MPLAB_ICD2 to develop the software, and MAPLAB IDE is provided with the internal Assembler. Additionally, the MAPLAB_ICD2 also has a build-in MPASM programmer and a hardware emulator [13]. Therefore, designer can easily design his firmware, edit the program and test the simulation straightforwardly. The flowcharts in Figures 3 and 4, shows the outcomes of the evaluations. Additionally, it allow user to evaluate the system parameters as desired in mode 0, to retrieve the tracing data history, which stored in EEPROM, to PC in mode 2, and to reset the system parameters in mode 3. During mode 1, the GPS signals was retrieved every three seconds; the coordinate was then saved in EEPROM every 30 seconds; meanwhile GSM module should transmit the position information to control center periodically. Furthermore the tracker also receives the instruction or updates from control center through GSM telecommunication channel.

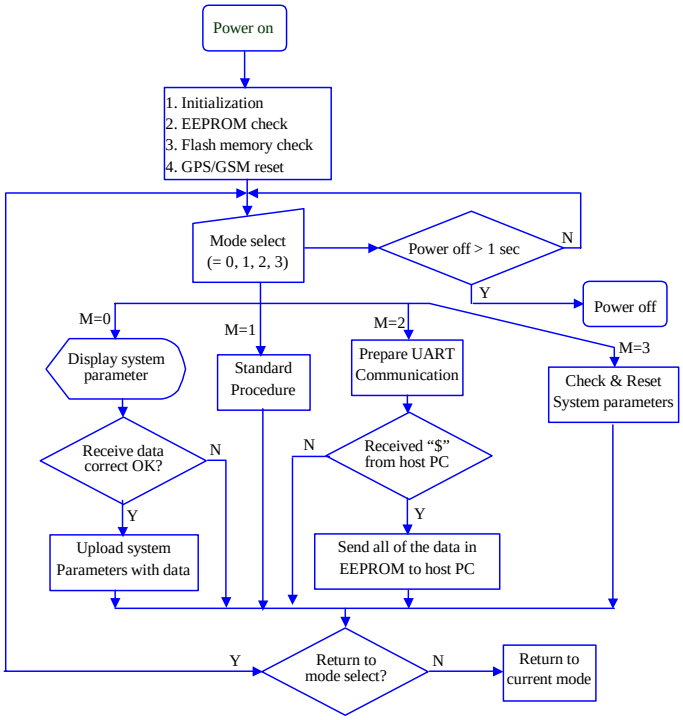

Figure 3: Selected function modes & its performance

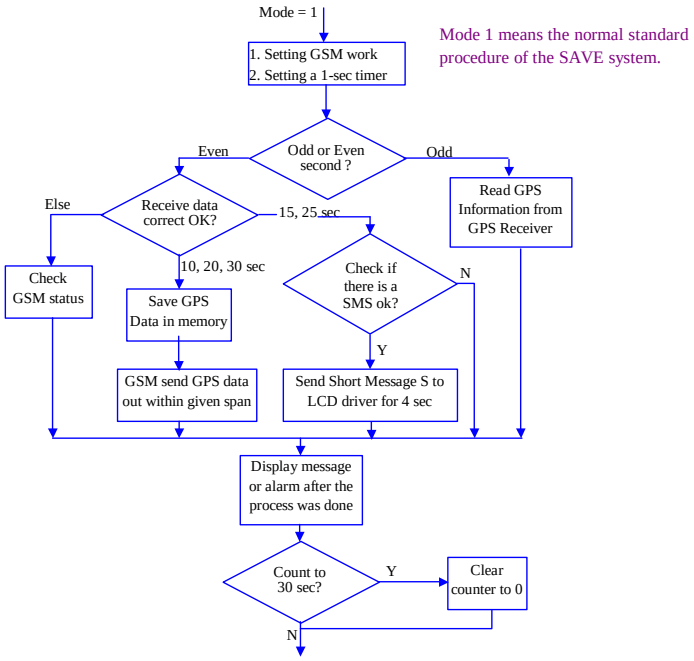

Figure 4: Flowchart of main function within <u>mode 1</u>

6. DISCUSSIONS AND SUMMARY

This proposed system had being tested in Hsiuping Institute of Technology, now for partner's evaluating on the navigation and monitoring of vehicles. In phase I, technical objectives included the implement of a software simulator to act as the Emergency Vehicle (EV) signal. This evaluation built various filters being applied to the EV signal for evaluating the real environmental conditions such as some different types of interference (weather, SNR issues, low signal strength, etc).

During phase II of the project, we create a LabVIEW based software [14, 15], which shown in Figure 5, for the GPS/GSM performance verification and this system enables end-user to process the GPS signal filtering, positioning, transformation between geodetic spheroid and Cartesian coordinates, and UTM map projection, which was specified in WGS84 system.

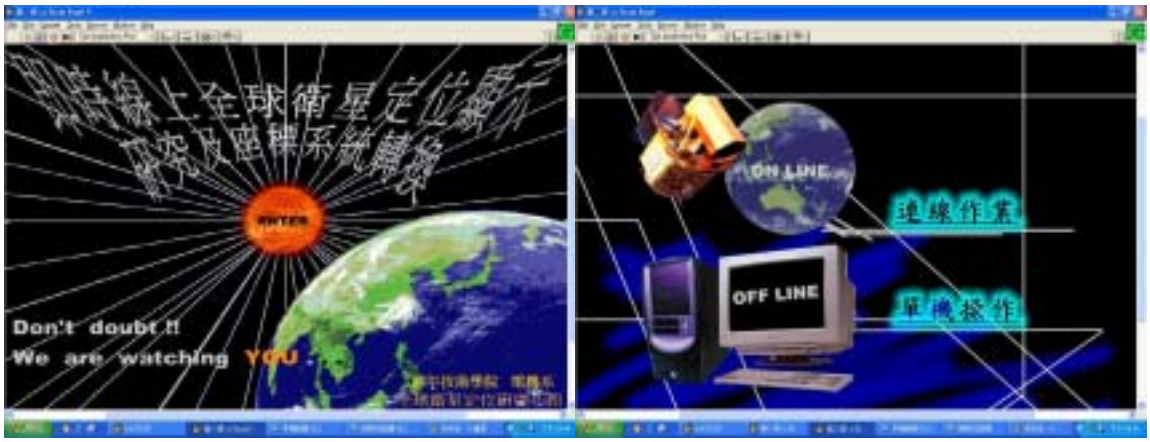

Figure 5: Software Entrance to GPS/GSM system

Using this system, we can handle larger data sets quickly and efficiently. Based on GPS technology option, it then toke the GPS data, encode it into transmission format and pass it to the monitoring display.

Figure 6 had shown that an observed satellite signal level, UTC time and date, azimuth orientation and elevation, NMEA-0183 message sentence, vehicle's position and speed.

Furthermore, there were few road-on experiments held around Dali Industry-Zone and the more extensive trails had also been proved, the round-off errors didn't affect its specification, as shown on Figure 7.

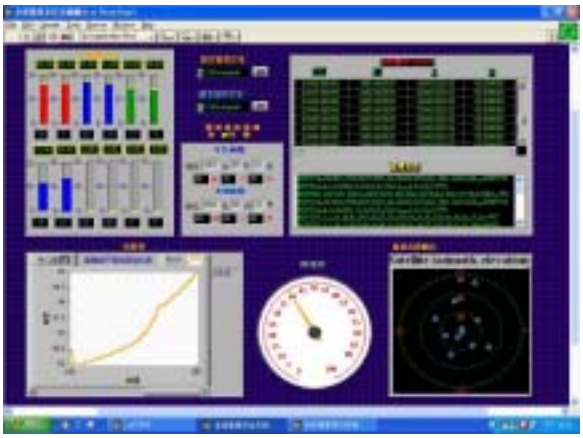

Figure 7: GPS data presentations on display

Figure 8: Road-on test by Dali Industry-Zone

Programming with LabVIEW and MATLAB was satisfied with graphic-oriented operation purpose [16, 17], and hierarchic subroutine branch was shown in Figure 9. It also provides an interaction of knowledge between Pseudo-range measurement and the intricacies of geodetic or geocentric coordinates [18].

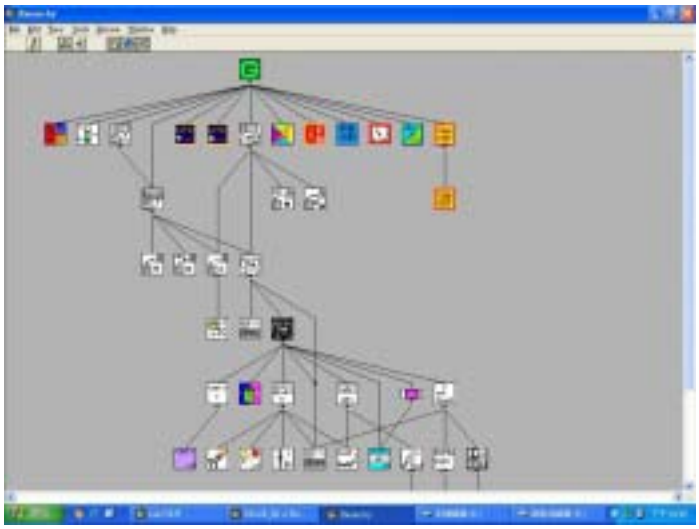

Figure 9: Hierarchic programming on GPS/GSM Module

In Figure 10 and 11, it shows the GSM/GPS PCB by using MPLAB IDE development tooling; and the navigation tracker can also be considered in other applications, such as taxis dispatching system, remote monitoring center and etc. Consequently this designed task works quite well, we believe its performance advantage will be especially suitable to the ITS (Intelligent Transport System) environment. And it would prevent the drivers from an accident as soon as he encounters an EV along the roadways or pre-warn the vehicle moving away from the spot.

Figure 10: GSM_GPS with Dual PIC18F452/16F877

Figure 11: GPS/GSM allocation on an automobile

ACKNOWLEDGEMENTS

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可供推廣之研發成果資料表

□ 可申請專利　■ 可技術移轉　日期：94 年 05 月 26 日

國科會補助計畫	計畫名稱：可攜式 GSM-GPS 行動衛星導航器之 DSP/CPLD 設計 計畫主持人：金之業 計畫編號：NSC 93–2212–E–164–003–CC3　學門領域：電磁學門
技術/創作名稱	可攜式 GSM-GPS 行動衛星導航器
發明人/創作人	金之業
技術說明	本計畫係利用 MicroChip PIC16F877/PIC16f452 MCU, 所開發出『可攜式 GSM-GPS 行動衛星導航器』之設計矽智財，將妥適展延以提升合作廠商電子量測儀錶類產品的附加價值。 考量低價位、高性能設計硬體架構下，發展嵌入式 DSP/CPLD 高速數位邏輯處理結合 MCU/GSM/GPS/Gyro 技術與 PC 作 Client/Server 連線監測與控制船機載具之行動座標及方位。軟體則整合行動通信之簡訊傳輸(GSM_SMS)及全球定位之座標時基(GPS_NMEA)與慣性量具(陀螺儀)，藉規劃靈活的副程式模組大幅增加遠端載具操控監測等功能。 此計畫不僅可使合作廠商實質獲利，研究人員亦可在高速數位邏輯微處理的技術獲得突破性進展。另電路開發完全以硬體描述語言自行設計完成，所獲得的矽智財不僅可以加惠合作廠商，也將成為本校重要的智慧財產。 關鍵詞：可程式邏輯元件、微處理晶片、全球衛星定位、行動通信 矽智財
	This project will utilize the Microchip PIC16F877/PIC16f452 MCU to develop the mobile GPS-GSM navigator with a Globe Special Mobile. This Silicon IP will properly assist the cooperative company to upgrade additive values of the proposed GPS Navigator or Tracker's positioning and monitoring performance. Without a vast modification to systematic architecture, a highest-speed digital processing technique of embedded DSP/CPLD is well designed uploading MCU/GSM/GPS/Gyro to PC for monitoring the controller vehicle, and the software integrates GSM_SMS and GPS_NMEA with the inertial Gyroscopes. Conclusively, the over-all functionality of this designed GPS-GSM navigator is performed dramatically. This derived silicon IP greatly benefits the partner's product quality, but also let the R/D team gaining a plenty of experience through this joint-venture implementation. Keywords：CPLD、MCU、GPS、GSM/GPRS、Silicon IP

合作企業	合作企業名稱：博洋科技有限公司 計畫聯絡人：楊澤中 資本額：500 萬元 產品簡介：電子電機教學輔具及實習器材 電話：04 – 23580073
人才培育成果	1. 跨校際合作與中華技術學院電子所毛大喜副教授培育林宣斌研究生，養成新世代之無線通訊 DSP/CPLD 軟硬體設計技與相關系統製作能力。 2. 經由電路設計(Schematic Design)與多層板規劃(PCB Layout)，指導本校陳育瑜同學熟習無線通訊 DSP/CPLD 軟硬體 IC 設計模擬系統專業技能。
可利用之產業及可開發之產品	1. 智慧型公路(ITS)載具之車載無線通訊定位模組。 2. GSM/GPRS 衛星影像汽車防盜系統。 3. 計程車及大眾傳輸車輛派遣(GPS_GSM Dispatcher)管制系統。 4. 無人駕駛載具(Unmanned Autonomous Vehicle）遠端操控監測。 5. 航站飛機或港口船隻(Multi-Vehicles)進出場監測管制。
技術研發成果	1. 具體研發出一具可攜式行動衛星導航監控系統。 2. 此計畫的成功將為傳統電子量測儀器業創造新商機。 3. 此計畫由 4 位教師共同參與開發矽智財(IP)，產品測試符合原設計規範，擬儘速開發的矽智財複製至其他相關產品。
技術特點	1. 簡化模組設計採雙 MCU (PIC16F877 and PIC16F452)操控完成可攜式行動衛星導航監控系統設計。 2. 內含兩軸精密陀螺儀強化慣性導航性能，未來可結合智慧型公路傳輸系統(Intelligent Transportation System)作自動導航監控之必要產品的技術開發。 3. 無線通信(GSM/GPRS)技術，不僅降低遠端信息傳輸成本；亦提升衛星定位的附加價值，創造通信電子產業的嶄新商機。 4. 開發出行動通信規範的 GPS-GSM/GPRS 衛星導航監控儀器。
推廣及運用的價值	1. 本研究標的較市售類似產品，增添慣性導航量具可直接升級為無人駕駛載具車載遙控模組，大幅提昇產品附加價值或營利。 2. 本研究標的逕採雙 MCU 元件不僅降低 GSM/GPS 通訊中斷副程式相互干擾，更精準的控制時序的運行提昇產品品質。 3. 本研究標的電路設計含 PCB 規劃簡易，且配合車用 12VDC 電源，大幅降低投資/設廠成本。 4. 市場目前尚無同級商品，合作廠商即時生產可獲較佳利潤，若能結合現有儀器開發將能實質提高公司產值。

※ 1.每項研發成果請填寫一式二份，一份隨成果報告送繳本會，一份送 貴單位研發成果推廣單位（如技術移轉中心）。

※ **2.本項研發成果若尚未申請專利，請勿揭露可申請專利之主要內容。**

※ 3.本表若不敷使用，請自行影印使用。