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INTELLIGENT TRAFFIC CONTROL SYSTEM (ITCS)

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ABSTRACT

The modernization in the 21st century has led to the rapid increase in the number of vehicles on road. Hence the traffic control system has thus evolved as a major entity of the government.

The major problem in current traffic control system is that even the ambulance has to wait in long traffic irrespective of its privileges to bypass certain traffic rules. Precisely, there is no automated method to sense the ambulance or any high priority vehicles (like police vehicles, fire trucks, etc). This incompetence triggered the development of intelligent traffic control system.

The intelligent traffic control system overrides the normal traffic intervals to provide path for high priority vehicles (HPV) like ambulance using GPS and zigbee. GPS receiver is installed in the HPV. Upon an instruction from the driver, the co-ordinates along with the unique address of the vehicle would be transmitted by the zigbee transceiver. The zigbee normally covers hundred meters even in dense traffic, establishing the ground work of the project.

The subsequent advancement of the project lies in forming a network using zigbees, configuring them as coordinators, routers and end devices. This improves the information sharing and of course the range to several kilometers.

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LIST OF SYMBOLS AND ABBREVIATIONS

1. ITCS	Intelligent Traffic Control system
2. HPV	High Priority Vehicle
3. GPS	Global Positioning System
4. LCD	Liquid Crystal Display
5. IC	Integrated Circuit
6. NMEA	National Marine Electronic Association
7. UART	Universal Asynchronous Receiver/Transmitter
8. SPI	Serial Peripheral Interface
9. LED	Light Emitting Diode
10. DCE	Data Communications Equipment
11. DTE	Data Terminal Equipment
12. EIA	Electronics Industry Association
13. RS-232	Recommended Standard 232
14. TTL	Transistor–transistor logic
15. RTS	Request To Send
16. CTS	Clear To Send
17. IEEE	Institute of Electrical and Electronics Engineers
18. LR-WPANs	Low-Rate Wireless Personal Area Networks
19. OEM	Original Equipment Manufacturer
20. RF	Radio Frequency
21. ISM	Industrial Scientific and Medicine
22. DSSS	Direct Sequence Spread Spectrum
23. DSK	DSP Starter Kit
24. MTK	MediaTek Inc.
25. PRN	Pseudo Random Number

CHAPTER 1

INTRODUCTION

In today's world, traffic is a major problem faced by everyone who owns a vehicle. From a National Highway, to a traffic signal, traffic congestion and traffic jams occurs in every part of the road. A High Priority Vehicle (HPV) like an ambulance gets stuck in the middle of the traffic, during a busy day. The project concentrates on providing path for a HPV bypassing the traffic signal. The project consists of four phases:

a) Data Acquisition
b) Comparison
c) Updating the traffic lights
d) Network formation

a) Data Acquisition

The extraction is done in the High Priority Vehicles to transmit the current position of the vehicle to the traffic control system. This process involves obtaining the GPS data from the receiver and sending the coordinates to the microcontroller. The latitude and the longitude of the GPS data are alone extracted and the rest of the data is neglected by the microcontroller. The extracted data is sent through zigbee to the traffic signal.

b) Comparison

The comparison process is an entity of the traffic control system. The data from the HPV data is received by the zigbee module and transferred to the microcontroller controlling the traffic. The controller continuously compares the latitude and longitude of the traffic signal with the received values and detects vehicle's direction.

c) Updating the traffic lights

The traffic lights follow the normal sequence until interrupted by any high priority vehicle. Once the direction of the vehicle is known to the microcontroller then the updating of the traffic signal takes place depending on the distance of the HPV. The LEDs which are connected with the microcontroller is given a proper signal for the change indication of the traffic signal.

d) Network formation

The network formation is the future scope of the project. The network uses zigbee modules as coordinator, router (optional) and end device to form a network. The coordinator works as a primary device. It is the source to commence the network process. Coordinator sends the information to the router. The routers are secondary medium acting as bridge between coordinator and the end device. The end device works as a receiver.

CHAPTER 2

PROJECT

2.1 BLOCK DIAGRAMS

2.1.1 TRAFFIC CONTROL SYSTEM

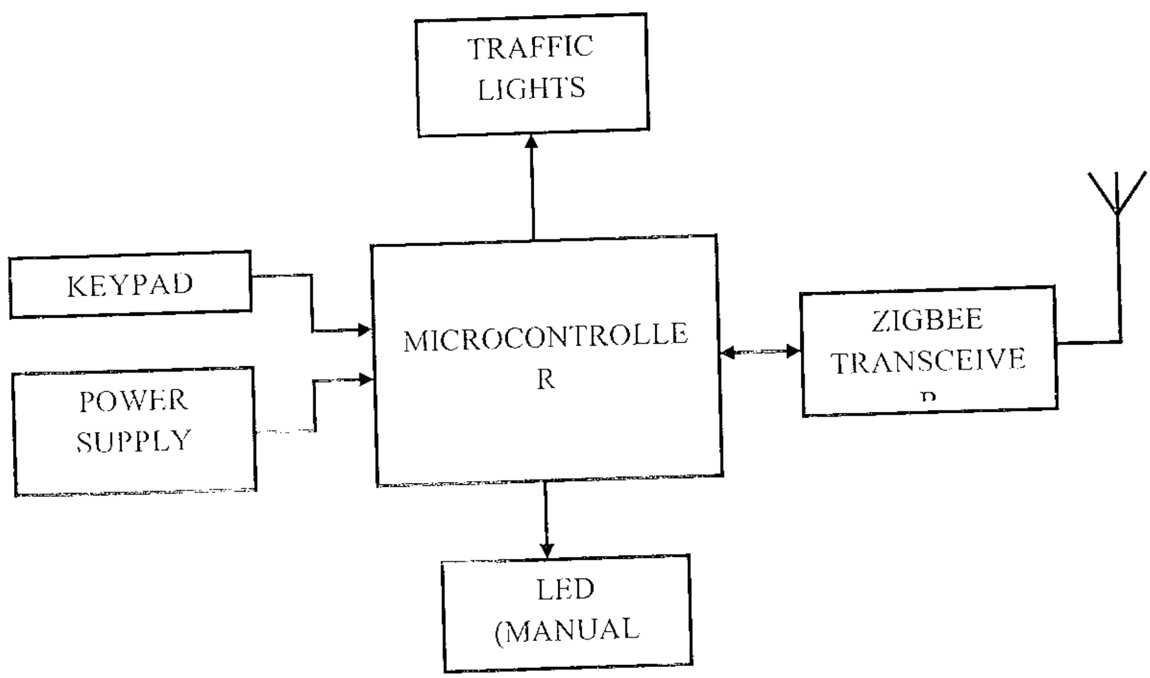


Fig. 2.1 Block Diagram at the Traffic Signal

2.2.2 IN HIGH PRIORITY VEHICLE

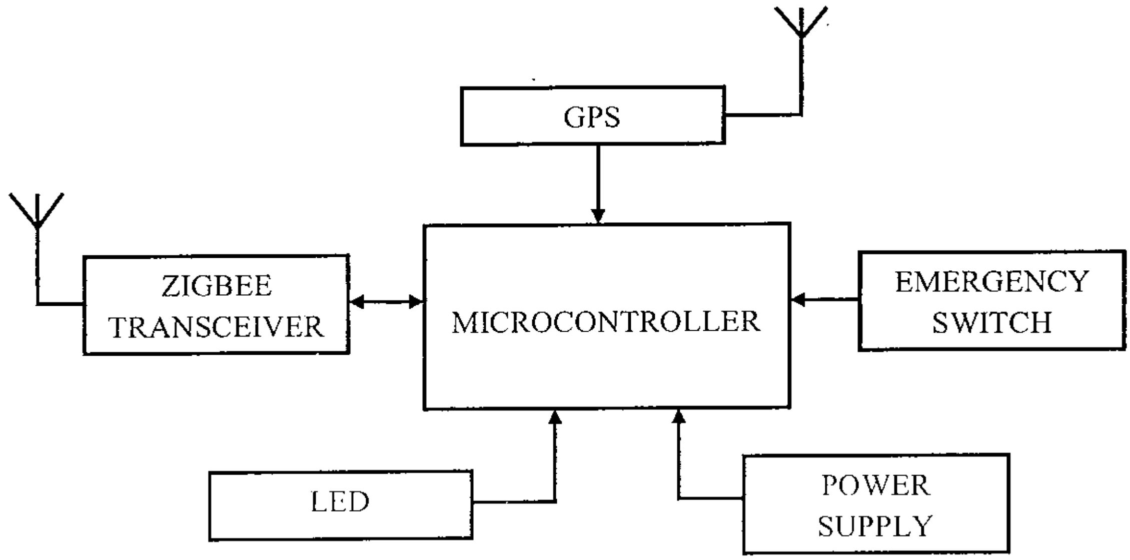


Fig. 2.2 Block Diagram at the High Priority Vehicle

2.2 BLOCK DIAGRAM DESCRIPTION

The intelligent traffic control system has two major functional domains namely

1. Traffic control system.
2. High priority vehicle module.

2.2.1 TRAFFIC CONTROL SYSTEM

The traffic control system assigns the right of way to road users by the use of lights in standard colors (red - amber/yellow - green), using a universal color code. The traffic control system has the following functional blocks

1. Traffic lights
2. Keypad
3. Microcontroller
4. Zigbee transceiver
5. Power supply
6. LED

The traffic lights are used as indicators of the direction. The keypad is used during the manual operations. The microcontroller controls the sequence of the actions to be performed by the system. The zigbee transceiver is used here basically to receive the coordinates denoting the position of the HPV. The power supply module is used to power up all the other modules. The LED is used to indicate the manual override.

2.2.2 HIGH PRIORITY VEHICLE MODULE

The High Priority Vehicle is equipped with a module containing the following functional blocks

1. GPS receiver
2. Zigbee transceiver
3. Microcontroller

4. Emergency switch
5. Power supply

The GPS receiver is used to obtain the position of the vehicle. The zigbee transceiver is used to transmit the coordinates to the traffic control system. The microcontroller is used to process the data from the GPS receiver and control the zigbee. The emergency switch is used to start the priority system in the vehicle when required. The power supply system is used to power various modules in the system.

CHAPTER 3

PROJECT DESCRIPTION

3.1 CIRCUIT DIAGRAM

3.1.1 MICROCONTROLLER

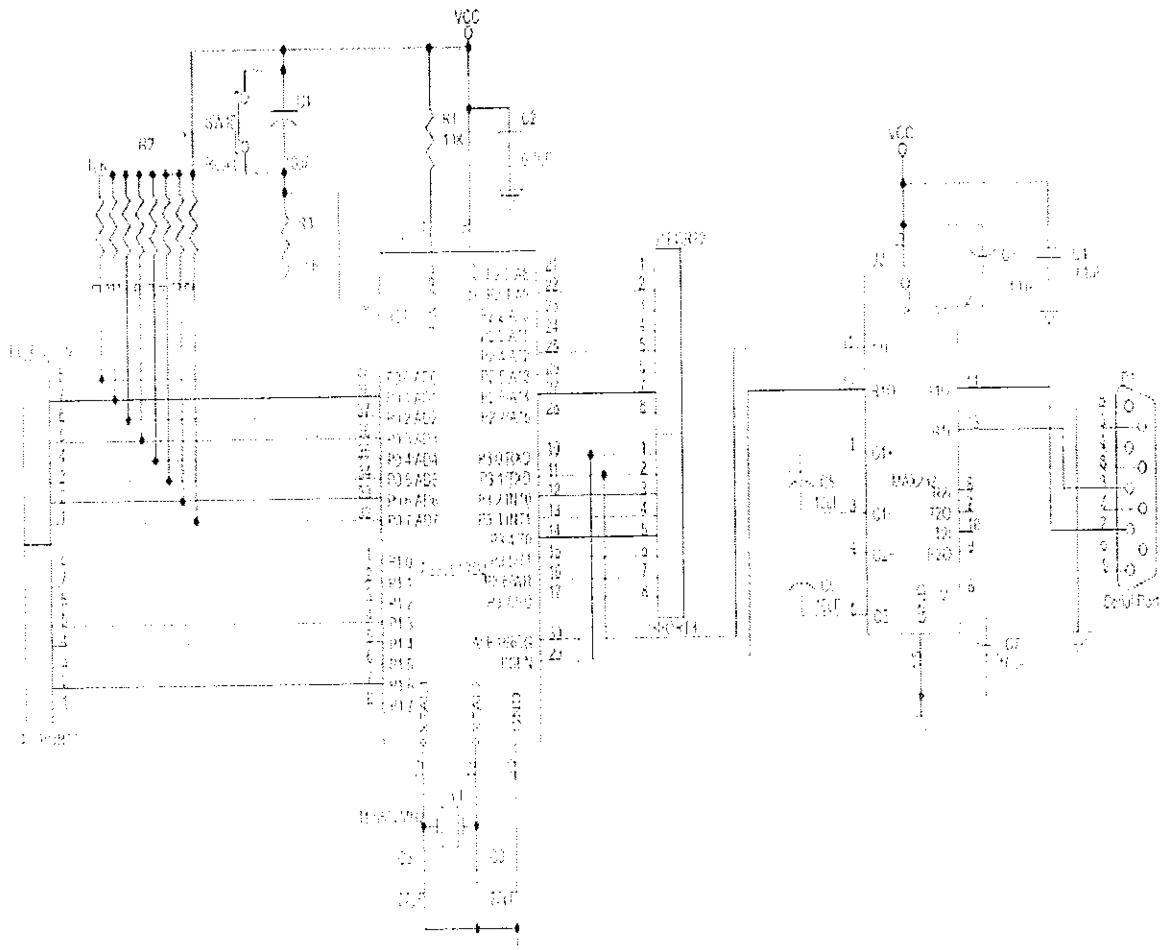


Fig. 3.1 Circuit diagram of Microcontroller board

3.1.2 ZIGBEE

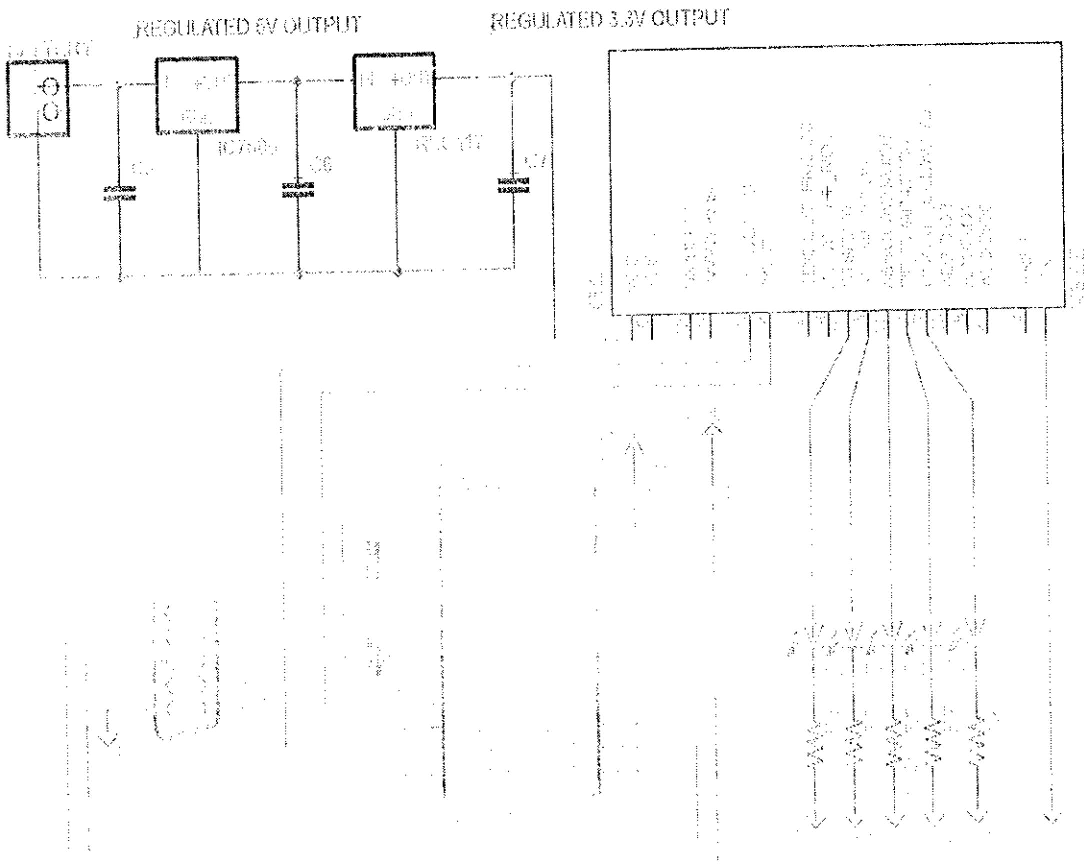


Fig. 3.2 Circuit diagram of zigbee board

3.1.3 POWER SUPPLY

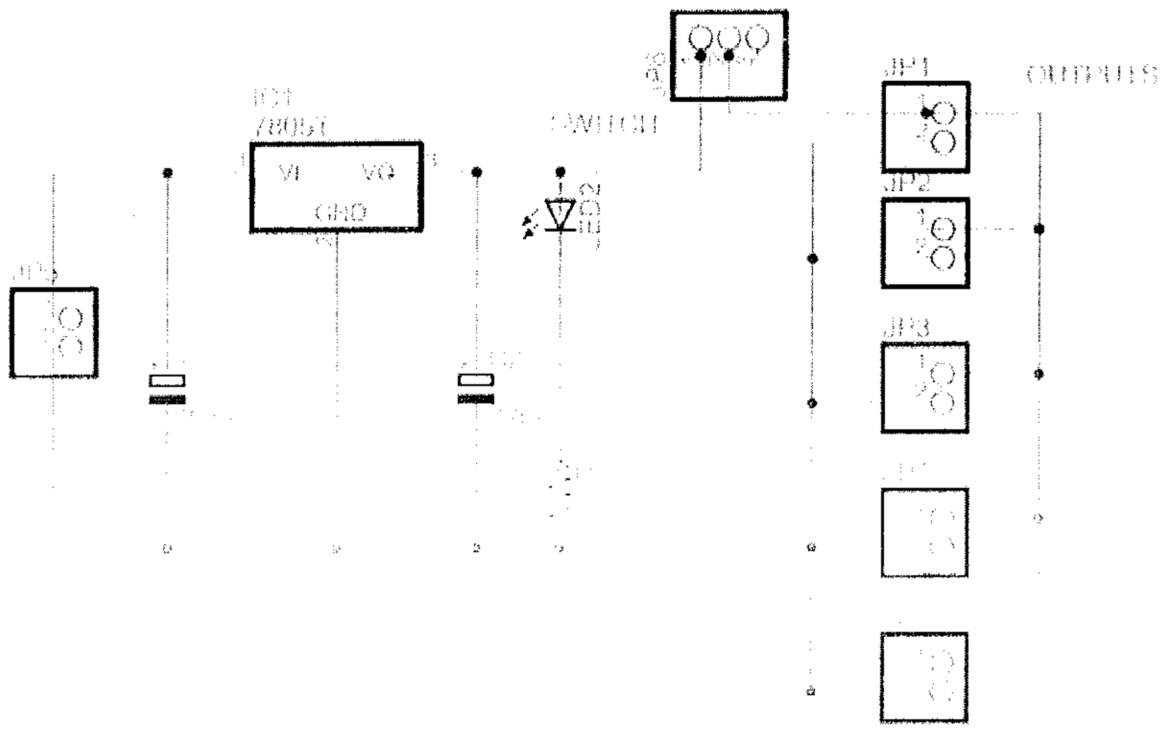


Fig. 3.3 Circuit diagram of Power Supply

3.1.4 GLOBAL POSITIONING SYSTEM RECEIVER

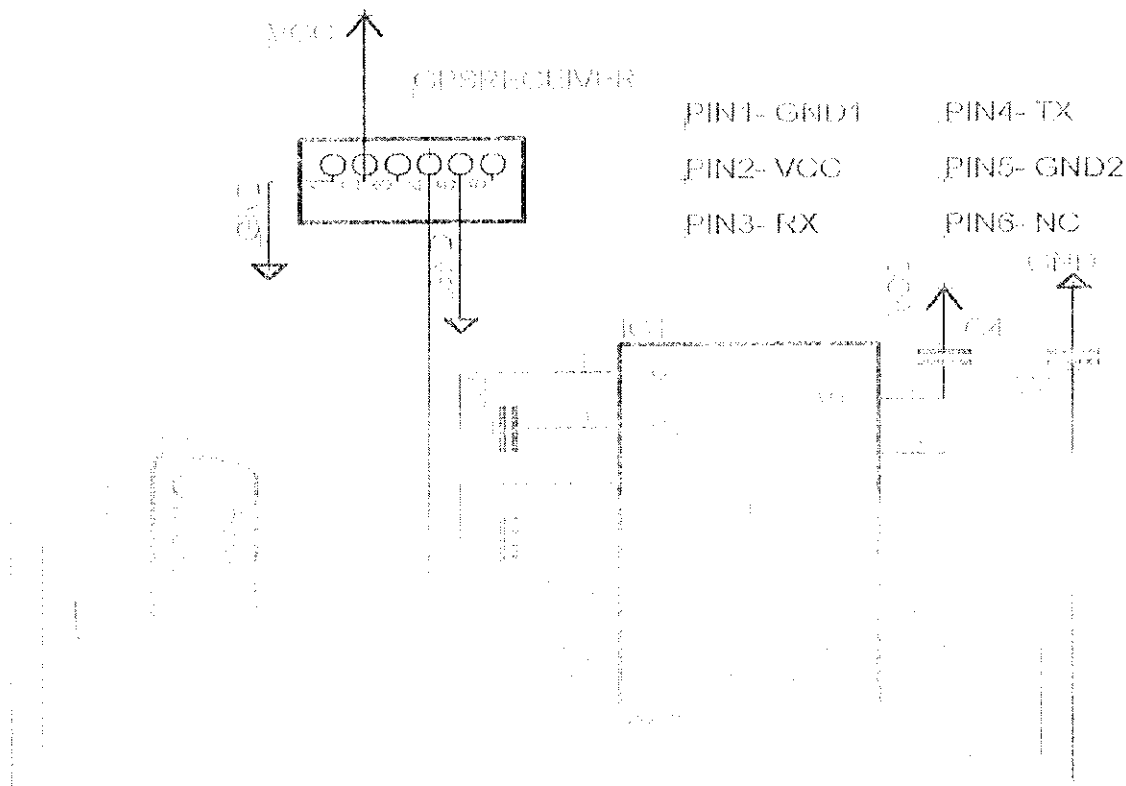


Fig. 3.4 Circuit diagram of GPS receiver

3.2 INDIVIDUAL CIRCUIT DESCRIPTION

3.2.1 MICROCONTROLLER CIRCUIT

The microcontroller circuit diagram is shown in the figure Fig. 3.1. PIN 9 is the reset pin which is used reset the microcontroller's internal registers and ports upon starting up.

The crystal oscillator is connected to pins 18 and 19 to provide clock pulses to the circuit. The oscillator circuit usually runs around 12MHz, although the 8051 (depending on which specific model) is capable of running at a maximum of 40MHz. Each machine cycle in the 8051 is 12 clock cycles, giving an effective cycle rate at 1MHz (for a 12MHz clock) to 3.33MHz (for the maximum 40MHz clock).

Pins 40 and 20 are VCC and ground respectively. The microcontroller needs +5V 500mA power supply. The microcontroller contains a built-in flash memory. If external memory is connected then PIN 31, also called EA/VPP, should be connected to ground to indicate the presence of external memory. PIN 30 is called ALE (address latch enable), which is used when multiple memory chips are connected to the controller and only one of them needs to be selected. We will deal with this in depth in the later chapters. PIN 29 is called PSEN. This is "program store enable". In order to use the external memory it is required to provide the low voltage (0) on both PSEN and EA pins.

The UART programming is performed using the RS232 interfacing provided in the circuit. The MAX232 is provided to perform voltage conversions while programming from a computer.

3.2.2 POWER SUPPLY CIRCUIT

An IC7805 fixed voltage regulator is used in the power supply circuit as shown in Fig. 3.3. For the normal operation of the circuit, it should have the regulated output. Specifically for the microcontroller IC, regulated constant

5V output voltage should be given. For this purpose 78xx regulator should be used in the circuit. In that IC, the number 8 represents the positive voltage and if it is 9, it represents the negative voltage. The xx represents the voltage. If it is 7805, it represent 5V regulator, and if it is 7812, it represent 12V regulator. The function of this regulator is to provide a +5V constant DC supply, even if there are fluctuations to the regulator input. This regulator helps to maintain a constant voltage throughout the circuit operation.

The voltage from the Battery is given to the input Capacitance of 0.1 μF as mentioned in the data-sheet. The capacitance is followed by an LED indicator, to indicate whether the power supply unit is working. Then the voltage is given to voltage regulator IC, where the 12V is reduced to 5V. It is then given to filter capacitor of 0.1μF as mentioned in the IC7805 data-sheet. The capacitors are used to reduce the effect of stray capacitance. Thus the regulated 5V is obtained for Microcontroller, ADC, GPS, LCD and Level-Converter.

3.2.3 GLOBAL POSITIONING SYSTEM RECEIVER

The GPS receiver used here is Quectel L10 which is a surface mount module. The schematic diagram is shown in the figure Fig. 3.4. The diagram shows the procedure in which the GPS signal is taken for serial interface. Tx and Rx are the two pins used for communication between the GPS IC with the serial port.

3.3 WORKING PRINCIPLE OF INTELLIGENT TRAFFIC CONTROL SYSTEM

The implementation of the project basically involves monitoring the position of the HPV and controlling the traffic signal. The link between the two entities is provided by the zigbee. The zigbee network can also be used for information sharing. Thus the progress of the project can be described under the following three phases, i.e.,

1. IN HPV
2. ZIGBEE NETWORK
3. IN THE TRAFFIC SIGNAL

1) IN HPV

The HPV refers to the vehicle that has the privilege of bypassing the traffic signal. Now to perform this, the position of the vehicle must be given to the traffic control system. Hence the HPV is equipped with the GPS and a transmitter circuit which offers an RF link between the HPV and the traffic control system.

The GPS data is received by the GPS receiver through the antenna of the L10 kit. The GPS data received is in the NMEA 0183 format. NMEA stands for National Marine Electronics Association. The NMEA 0183 standard uses a simple ASCII, serial communications protocol that defines how data is transmitted in a "sentence" from one "talker" to multiple "listeners" at a time. This data once received is sent through the RS232 cable to the microcontroller in the High Priority Vehicle using the UART communication protocol.

Since the data has to be sent to the zigbee module for its transmission to the network, another microcontroller comes into action.

The microcontroller which receives the GPS data arranges the data in the format required by the traffic signal. The format used here is:

The first 3 characters are H, P and V followed by the # symbol, next is the latitude of the current location, and then $, followed by character N, next comes %, followed by the longitude of the current location, and then @ and at last the character E.

Syntax

HPV#LATTITUDE$N%LONGITUDE@E

Sample data:

HPV#1103.0654$N%07700.2584@E

HPV#3240.3481$N%11420.4836@E

This data format is transferred from one microcontroller to another microcontroller through the SPI. SPI communication is master-slave architecture. The Serial Peripheral Interface (SPI) allows high-speed synchronous data transfer between the P89V51RD2 and peripheral devices or between several P89V51RD2 devices. The microcontroller which receives the GPS data is assigned as the master and the other microcontroller which transmits the HPV format through the zigbee is assigned as the slave.

SPI receives the HPV data and transfers the data to the slave. The slave device has an UART port which is used for zigbee communication.

2) ZIGBEE NETWORK

The zigbee which is transmitting the HPV format is assigned as the router. The zigbee devices can be of three types, viz., a) coordinator, b) router and c) end device. The router transmitting the HPV has the capacity to join a network. The zigbee network has three or more devices connected to it. The router which is present tries to communicate with the destination node or the coordinator of the network.

Before forming the network, the router first discovers the devices which are present in the network. The network formed here is in the form of a tree. In case, the coordinator is not present at the transmittable distance from the router, it uses the other devices to reach the required destination.

3) IN THE TRAFFIC SIGNAL

The zigbee which receives the HPV data is assigned as the coordinator. The zigbee module transfers the HPV data to the microcontroller at the traffic signal using the RS232 cable. At the microcontroller, the data is checked for rapid variations. The varying data is compared with the location of the traffic signal. If the variations are denoting a certain path of the traffic signal, then the traffic lights are changed.

The LEDs of the traffic signal are connected to the port of the microcontroller. The colour of LED used denotes the rule at the traffic signal (Stop, Go and Wait).

CHAPTER 4

SERIAL INTERFACE UNIT

RS-232 is simple, universal, well understood and supportive. The serial port transmits a '1' as -3 to -25 volts and a '0' as +3 to +25 volts. Devices which use serial cables for their communication are split into two categories. These are DCE (Data Communications Equipment) and DTE (Data Terminal Equipment). Data Communications Equipment is the devices such as the modem, TA adapter, plotter etc while Data Terminal Equipment is your Computer or Terminal.

4.1 PROPERTIES OF SERIAL INTERFACE UNIT

The electrical specifications of the serial port are contained in the EIA (Electronics Industry Association) RS232C standard. It states many parameters such as

1. A "Space" (logic 0) will be between +3 and +25 Volts.

2. A "Mark" (logic 1) will be between -3 and -25 Volts.

3. The region between +3 and -3 Volts is undefined.

4. An open circuit voltage should never exceed 25 Volts (In reference to the GND).

5. A short circuit current should not exceed 500mA. The driver should be able to handle this without damage.

4.2 SERIAL PORT TO TTL SIGNAL CONVERTER

The integrated circuit that converts the signals from an RS-232 serial port into signals suitable for use in TTL compatible digital logic circuits is the MAX232. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals.

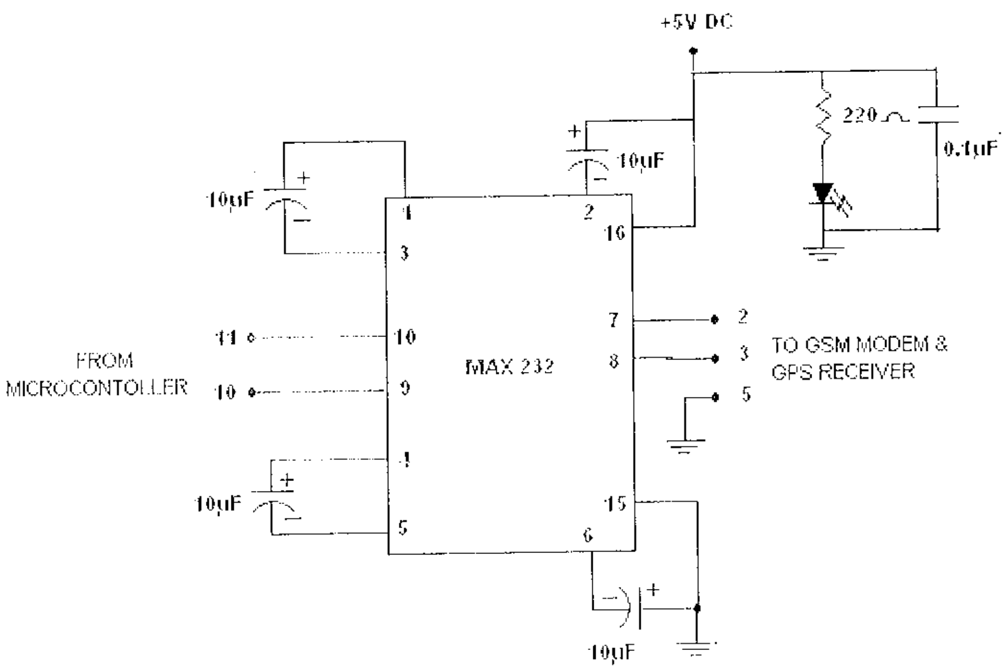
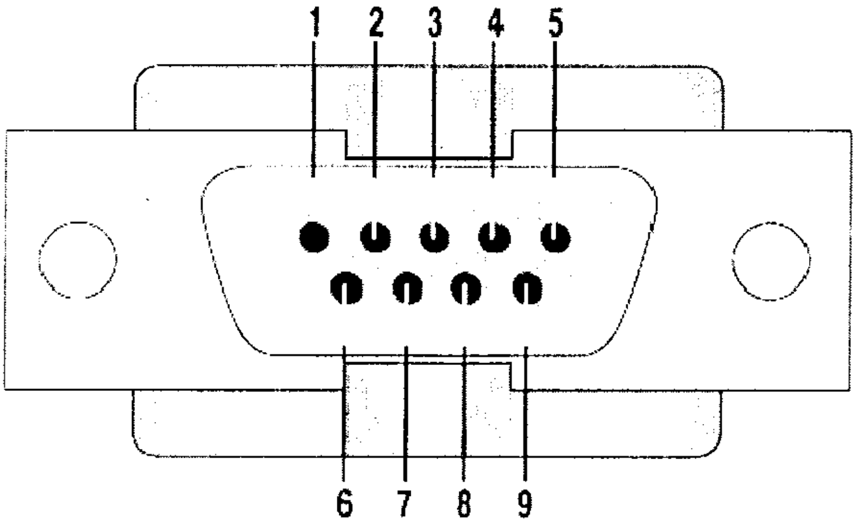


Fig 4.1 Serial Interface Unit Circuit Diagram

The circuit diagram for serial interface unit is shown in Fig 4.1. The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case.

The receivers reduce RS-232 inputs (which may be as high as ± 25V), to standard 5V TTL levels. These receivers have a typical threshold of 1.3V, and a typical hysteresis of 0.5V.

The later MAX232A is backwards compatible with the original MAX232 but may operate at higher baud rates and can use smaller external capacitors – 0.1 μF in place of the 1.0 μF capacitors used with the original device. The serial interface- pin schematic diagram is shown in Fig 4.2 and the function of each pin is tabulated in Table 4.1.



Pin	Signal	Pin	Signal
1	Data Carrier Detect	6	Data Set Ready
2	Received Data	7	Request to Send
3	Transmitted Data	8	Clear to Send
4	Data Terminal Ready	9	Ring Indicator
5	Signal Ground		

Fig 4.2 Serial Interface - Pin Schematic Diagram

Abbreviation		Full Name	Function
1	TD	Transmit Data	Serial Data Output (TXD)
2	RD	Receive Data	Serial Data Input (RXD)
3	CTS	Clear to Send	This line indicates that the Modem is ready to exchange data.
4	DCD	Data Carrier Detect	When the modem detects a "Carrier" from the modem at the other end of the phone

			line, this Line becomes active.
5	DSR	Data Set Ready	This tells the UART that the modem is ready to establish a link.
6	DTR	Data Terminal Ready	This is the opposite of DSR. This tells the Modem that the UART is ready to link.
7	RTS	Request To Send	This line informs the Modem that the UART is ready to exchange data.
8	RI	Ring Indicator	Goes active when modem detects a ringing signal from the PSTN.

Table 4.1 Serial Data Interface

In this project, serial interface unit is used to convert the voltage level between microcontroller and GPS receiver and also between microcontroller and GSM Modem.

4.3 ADVANTAGES OF SERIAL INTERFACE UNIT

- ✓ Serial Cables can be longer than Parallel cables. The serial port transmits a '1' as -3 to -25 volts and a '0' as +3 to +25 volts where as a parallel port transmits a '0' as 0v and a '1' as 5v. Therefore the serial port can have a maximum swing of 50V compared to the parallel port which has a maximum swing of 5 Volts. The cable-loss is less in this case than it was in parallel.

- ✓ Wires are less than parallel transmission.
- ✓ Serial transmission is used where one bit is sent at a time.

CHAPTER 5

ZIGBEE COMMUNICATION PROTOCOL

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio needing low rates of data transfer. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

5.1 ADVANCED NETWORKING & SECURITY

Retries and Acknowledgements DSSS (Direct Sequence Spread Spectrum).Each direct sequence channel has over 65,000 unique network addresses available Point-to-point, point-to-multipoint and peer-to-peer topologies supported Self-routing, self-healing and fault-tolerant mesh networking.

5.2 UART DATA FLOW

Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure below.

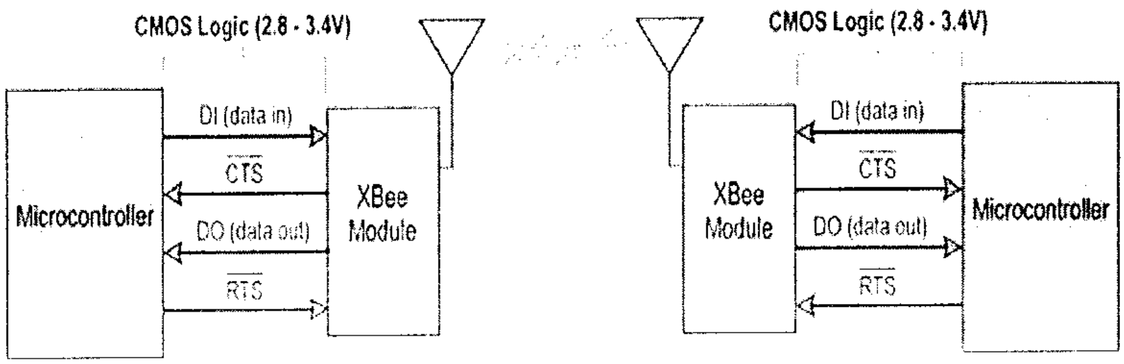


Fig. 5.1 UART data flow

5.2.1 SERIAL DATA

Data enters the module UART through the DIN (pin 3) as an asynchronous serial signal. The signal should idle high when no data is being transmitted. Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following figure illustrates the serial bit pattern of data passing through the module.

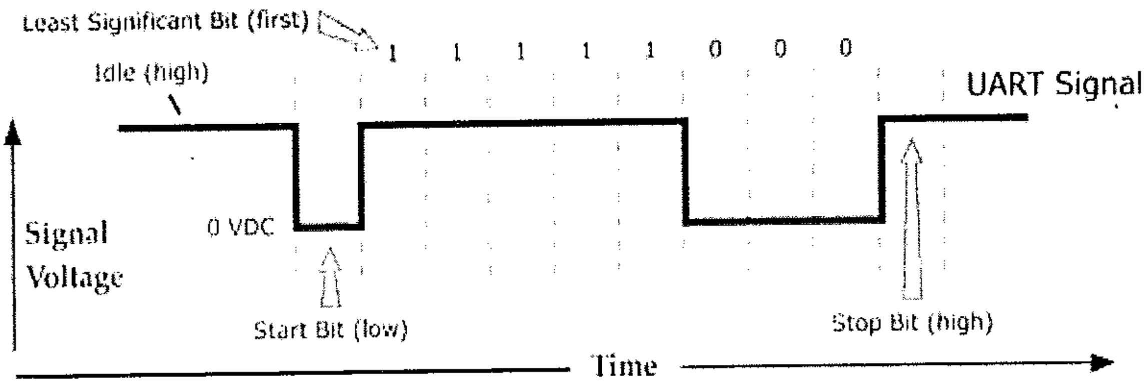


Fig. 5.2 Serial data

5.3 ZIGBEE NETWORK

5.3.1 ZIGBEE NETWORK FORMATION

A ZigBee Personal Area Network (PAN) consists of one coordinator and one or more routers and/or end devices. A ZigBee Personal Area Network (PAN) is created when a coordinator selects a channel and a PAN ID to start on. Once the coordinator has started a PAN, it can allow router and end device nodes to join the PAN. When a router or end device joins a PAN, it receives a 16-bit network address and can transmit data to or receive data from other devices in the PAN. Routers and the coordinator can allow other devices to join the PAN, and can assist in sending data through the network to ensure data is routed correctly to the intended recipient device. When a router or coordinator allows an end device to join the PAN, the end device that joined becomes a child of the router or coordinator that allowed the join. End devices, however can transmit or receive data but cannot route data from one node to another, nor can they allow devices to join the PAN. End devices must always communicate directly to the parent they joined to. The parent router or coordinator can route data on behalf of an end device child to ensure it reaches the correct destination. End devices are intended to be battery powered and can support low power modes.

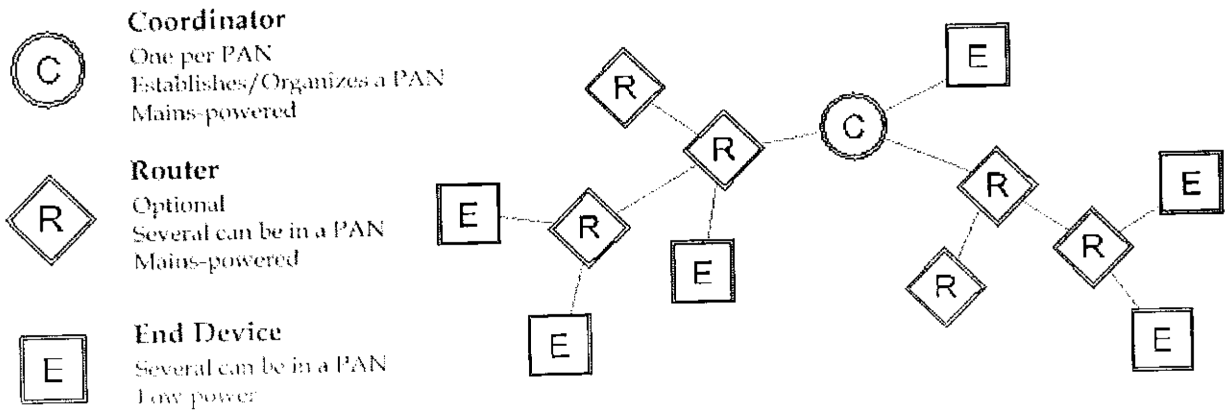


Fig. 5.3 Types of Zigbee Nodes

5.3.2 ZIGBEE NETWORK

The network address of the PAN coordinator is always 0. When a router joins a PAN, it can also allow other routers and end devices to join to it. Joining establishes a parent/child relationship between two nodes. The node that allowed the join is the parent, and the node that joined is the child. The parent/child relationship is not necessary for routing data.

5.3.3 STARTING ZIGBEE COORDINATOR

When a coordinator first comes up, it performs an energy scan on multiple channels (frequencies) to select an unused channel to start the PAN. After removing channels with high detected energy levels, the coordinator issues an 802.15.4 beacon request command on the remaining, low energy level channels. Any routers or coordinators respond to the beacon request frame with a small beacon transmission that indicates the PAN identifier (PAN ID) that they are operating on, and whether or not they are allowing joining. The coordinator will attempt to start on an unused PAN ID and channel. After starting, the coordinator may allow other devices to join its PAN.

5.3.4 JOINING A ROUTER

When a router first comes up, it must locate and join a ZigBee PAN. To do this, it issues an 802.15.4 beacon request command on multiple channels to locate nearby PANs. Nearby routers and coordinators respond to the beacon request frame with a small beacon transmission, indicating which channel and PAN ID they are operating on. The router listens on each channel for these beacon frames, and determines which device it should join. If a valid PAN is found from one of the received beacons, the router issues a join request to the device that sent the beacon. If joining succeeds, the router will then receive a join confirmation from the device, indicating the join was successful. Once the router joins the PAN, it can communicate with other devices on the PAN and allow new devices to join to it.

5.3.5 JOINING AN END DEVICE

When an end device first comes up, it must also locate and join a PAN. End devices follow the same process as a router to join a PAN. Once the end device has successfully joined a PAN, it can communicate with other devices on the PAN. However, since end devices cannot route data, it must always communicate directly with its parent and allow the parent to route data in its behalf.

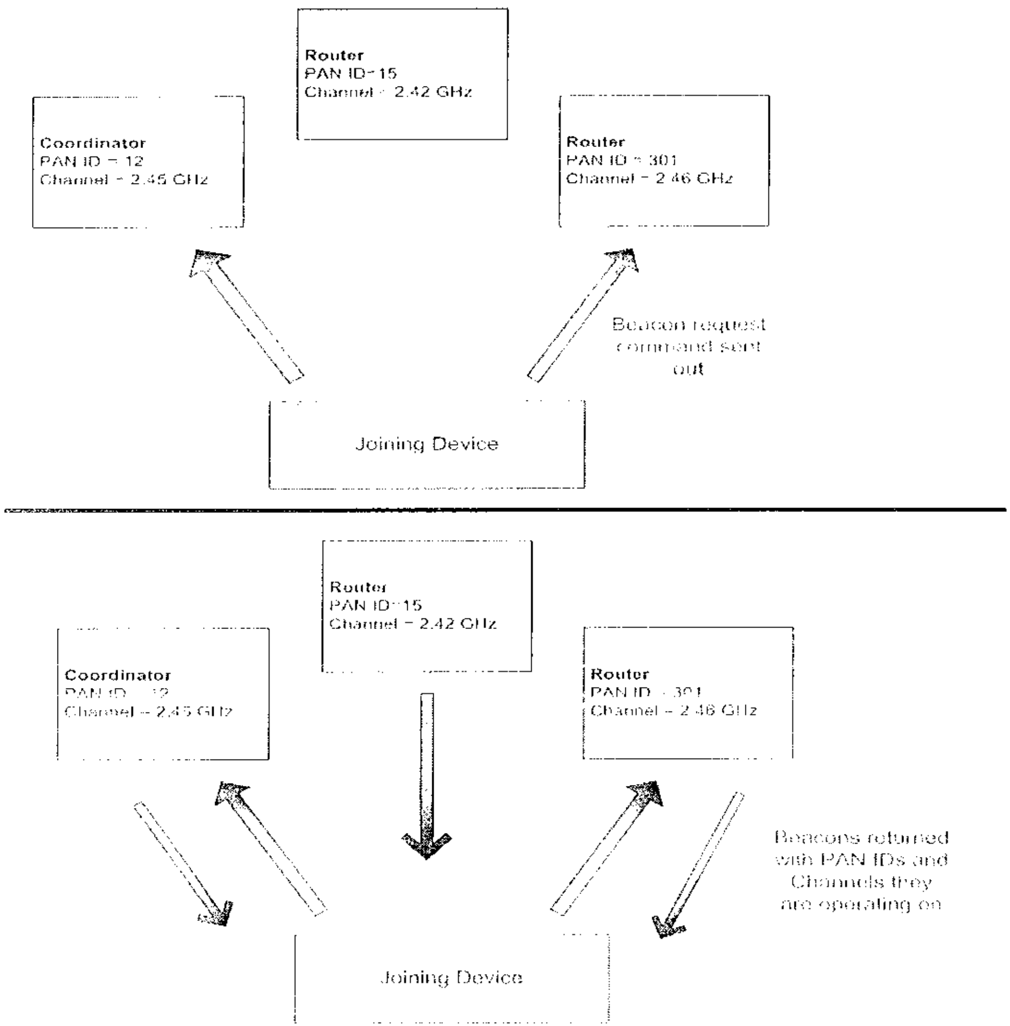


Fig. 5.4 Joining a Network

5.4 NETWORK FORMATION CONCEPTS

5.4.1 DATA TRANSMISSION AND ROUTING

All data packets are addressed using both device and application layer addressing fields. Data can be sent as a broadcast, multicast, or unicast transmission.

5.4.2 BROADCAST TRANSMISSION

Broadcast transmissions within the ZigBee protocol are intended to be propagated throughout the entire network such that all nodes receive the transmission. To accomplish this, all devices that receive a broadcast transmission will retransmit the packet 3 times. Each node that transmits the broadcast will also create an entry in a local broadcast transmission table. This entry is used to keep track of each received broadcast packet to ensure the packets are not endlessly transmitted. Each entry persists for 8 seconds. The broadcast transmission table holds 8 entries. Since broadcast transmissions are retransmitted by each device in the network, broadcast messages should be used sparingly.

5.4.3 MULTICAST TRANSMISSION

Multicast transmissions operate similar to broadcast transmissions. Data packets are broadcast throughout the network in a similar fashion. However, only devices that are part of the multicast group will receive the data packets.

Unicast ZigBee transmissions are always addressed to the 16-bit address of the destination device. However, only the 64-bit address of a device is permanent; the 16-bit address can change. Therefore, ZigBee devices may employ network address discovery to identify the current 16-bit address that corresponds to a known 64-bit address. Once the 16-bit address is known, a route to the destination device must be discovered. ZigBee employs mesh routing using the Ad-hoc On-demand Distance Vector routing (AODV) protocol to establish a route between the source device and the destination.

5.4.4 NETWORK ADDRESS DISCOVERY

Data transmissions are always sent to the 16-bit network address of the destination device. However, since the 64-bit address is unique to each device and is generally known, ZigBee devices must discover the network address that was assigned to a particular device when it joined the PAN before they can transmit data. To do this, the device initiating a transmission sends a broadcast network address discovery transmission throughout the network. This packet contains the 64-bit address of the device the initiator needs to send data to. Devices that receive this broadcast transmission check to see if their 64-bit address matches the 64-bit address contained in the broadcast transmission. If the addresses match, the device sends a response packet back to the initiator, providing the network address of the device with the matching 64-bit address. When this response is received, the initiator can then transmit data.

5.4.5 MESH ROUTING

Mesh routing allows data packets to traverse multiple nodes (hops) in a network to route data from a source to a destination. The route a packet can take in a mesh network is independent of the parent/child relationships established during joining. Before transmitting a data packet from source to destination nodes, a route must be established. Route discovery is based on the AODV (Ad-hoc On-demand Distance Vector routing) protocol.

CHAPTER 6

GLOBAL POSITIONING SYSTEM MODULE

The Global Positioning System (GPS) works on the principle that if you know your distance from several locations, then you can calculate your location. The known are the 24 satellites located in six orbital planes at an altitude of 20,200Km. These satellites circle the earth every 12 hours and broadcast a data stream at the primary frequency L1 of 1.575 GHz which carries the coarse-acquisition **(C/A)** encoded signal to the ground. The GPS receiver measures the time of arrival of the C/A code to a fraction of a millisecond, and thus determines the distance to the satellite.

6.1 WORKING OF GLOBAL POSITIONING SYSTEM

The GPS system consists of three pieces. There are the satellites that transmit the position information, there are the ground stations that are used to control the satellites and update the information, and finally there is the receiver. It is the receiver that collects data from the satellites and computes its location anywhere in the world based on information it gets from the satellites.

6.2 GEOMETRIC VIEW

GPS receiver uses an elaboration of a technique that is tried and true and used by navigators and surveyors for centuries. Basically you use s known set of locations to compute the current location by taking fixes on the known sites. Once you have a compass bearing you can draw a line through the known location and you know that you are somewhere else on that line. Do the same thing to a second point and the two lines will intersect. This is your position. If you try a third point it should intersect at the same place the other two lines intersect. You are somewhere inside the triangle is small enough you consider it good enough, otherwise you need to take another sighting. Accuracy is determined on your ability to get and plot an accurate bearing as well as the geometry of the known sites available.

The GPS receiver uses a slightly different approach. It measures its distance from the satellites and uses this information to compute a fix; it really measures the length of the time the signal takes to arrive at your location and then based on knowing that the signal moves at the speed of light. It can compute the distance based on the travel time. However, unlike the known sites of the olden days, these sites are moving.

The solution to this problem is to have the satellite itself send enough information to calculate its current location relative to the receiver. Now, armed with the satellite location and the distance from the satellite we can expect that we are somewhere on the sphere that is described by the radius and centered at the satellite location. By acquiring the same information from a second satellite we can compute a second sphere that cuts the first one at a plane. Now we know we are somewhere on the circle that is described by the intersection of the two spheres. If we acquire the same information from a third satellite we would notice that the new sphere would intersect the circle at only two points. If we know approximately where we are we can discard one of the points and we are left with our exact fix location in 3D space. The satellite sends the current time along with the message so the GPS can subtract its knowledge of the current time from the satellite time in the message and use this to compute the difference. For this to work the time in your GPS must be pretty accurate - to a precision of well under a microsecond. The satellite itself has an atomic clock to keep the time very precisely, but our unit is probably not big enough and expensive enough to have an atomic clock built in, so our clock is likely to be in error. For this reason, our assumptions about the distance calculation are likely to have considerable error and the fourth satellite fix will reveal this to us.

Similar to the geometry problem we had in the older system of taking bearings on fixed sites, the satellite geometry has a significant effect in the accuracy of our final position. A unit less number representing this geometry is called Dilution of Position, DOP and is used by the GPS in determining which of the satellites available represents the best ones to use. The smaller the number the better is the geometry.

GPS receiver displays speed, time and calculate the speed using algorithms in the Kalman filter. Most receivers compute speed by a combination of movement per unit time and computing the Doppler shift in the pseudo range signals from the satellites. The speed is smoothed and not instantaneous speed. Velocity measured by a GPS is inherently 3 dimensions, but consumer GPS receivers only report 2D speed on their readout.

6.3 GLOBAL POSITIONING SYSTEM COORDINATE CALCULATION

The basics of GPS are "triangulation from satellites''. It's really "trilateration". Trilateration is a method of determining the relative positions of objects using geometry of triangles. To "triangulate", a GPS receiver measures distance using travel time of radio signals. To measure travel time, GPS needs very accurate timing which it achieves with some tricks. Along with distance, the position of the satellites in space must be known. Finally correction must be done for any delays the signal experiences as it travels through the atmosphere.

Step 1:

Suppose we measure our distance from satellite and find it to be 11,000 miles. Knowing that we are 11,000 miles from a particular satellite narrows down all the possible locations we could be in the whole universe to the surface of a sphere that is centered on this satellite and has a radius of 11,000 miles.

Step 2:

Next, we measure our distance to a second satellite and find out that it's 12,000 miles away. That tells us that we're not only on the first sphere but we're also on the second sphere that's 12,000 miles from the second satellite. Or in other words, we're somewhere on the circle where these two spheres intersecting.

Step 3:

If we make a measurement from a third satellite and find that we're 13,000 miles from that one that narrows our position down even further, to the two points where the 13,000 mile sphere cuts through the circle that's the intersection of the first two spheres. So by ranging from three satellites we can narrow our position to just two points in space.

To decide which one is our true location we could make a fourth measurement. But usually one of the two points is a ridiculous answer (either too far from earth or moving at an impossible velocity) and can be rejected without measurement.

6.4 NATIONAL MARINE ELECTRONICS ASSOCIATION

The National Marine Electronics Association (NMEA) has developed a specification that defines the interface between various pieces of marine electronic equipment. The standard permits marine electronics to send information to computers and to other marine equipment. A full copy of this standard is available for purchase at their web site. None of the information on this site comes from this standard and I do not have a copy. Anyone attempting to design anything to this standard should obtain an official copy.

GPS receiver communication is defined within this specification. Most computer programs that provide real time position information understand and expect data to be in NMEA format. This data includes the complete PVT (position, velocity, time) solution computed by the GPS receiver. The idea of

NMEA is to send a line of data called a sentence that is totally self contained and independent from other sentences. There are standard sentences for each device category and there is also the ability to define proprietary sentences for use by the individual company. All of the standard sentences have a two letter prefix that defines the device that uses that sentence type. (For gps receivers the prefix is GP) which is followed by a three letter sequence that defines the sentence contents. In addition NMEA permits hardware manufactures to define their own proprietary sentences for whatever purpose they see fit. All proprietary sentences begin with the letter P and are followed with 3 letters that identifies the manufacturer controlling that sentence. For example a Garmin sentence would start with PGRM and Magellan would begin with PMGN.

Each sentence begins with a '$' and ends with a carriage return/line feed sequence and can be no longer than 80 characters of visible text (plus the line terminators). The data is contained within this single line with data items separated by commas. The data itself is just ascii text and may extend over multiple sentences in certain specialized instances but is normally fully contained in one variable length sentence. The data may vary in the amount of precision contained in the message. For example time might be indicated to decimal parts of a second or location may be show with 3 or even 4 digits after the decimal point. Programs that read the data should only use the commas to determine the field boundaries and not depend on column positions. There is a provision for a checksum at the end of each sentence which may or may not be checked by the unit that reads the data. The checksum field consists of a '*' and two hex digits representing an 8 bit exclusive OR of all characters between, but not including, the '$' and '*'. A checksum is required on some sentences.

6.4.1 NATIONAL MARINE ELECTRONICS ASSOCIATION INPUT AND OUTPUT MESSAGES

Some units also support an NMEA input mode. While not too many programs support this mode it does provide a standardized way to update or add waypoint and route data. Note that there is no handshaking or commands in NMEA mode so you just send the data in the correct sentence and the unit will accept the data and add or overwrite the information in memory. If the data is not in the correct format it will simply be ignored. A carriage return/line feed sequence is required. If the waypoint name is the same you will overwrite existing data but no warning will be issued. The sentence construction is identical to what the unit downloads so you can, for example, capture a WPL sentence from one unit and then send that same sentence to another unit but be careful if the two units support waypoint names of different lengths since the receiving unit might truncate the name and overwrite a waypoint accidently. If you create a sentence from scratch you should create a correct checksum. Be sure you know and have set you unit to the correct datum. Many units support the input of WPL sentences and a few support RTE as well.

On NMEA input the receiver stores information based on interpreting the sentence itself. While some receivers accept standard NMEA input this can only be used to update a waypoint or similar task and not to send a command to the unit. Proprietary input sentences could be used to send commands. Since the Magellan upload and download maintenance protocol is based on NMEA sentences they support a modified WPL message that adds comments, altitude, and icon data.

Some marine units may accept input for alarms such as deep or shallow water based on the DPT sentence or MTW to read the water temperature. For example the Garmin Map76 supports DPT, MTW (temperature), and VHW (speed) input sentences. Other units may use NMEA input to provide initialization data via proprietary sentences, or to select which NMEA sentences to output.

GGA - essential fix data which provide 3D location and accuracy data.

$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47

Where:

GGA	Global Positioning System Fix Data
123519	Fix taken at 12:35:19 UTC
4807.038,N	Latitude 48 deg 07.038' N
01131.000,E	Longitude 11 deg 31.000' E
1	Fix quality: 0 = invalid 1 = GPS fix (SPS) 2 = DGPS fix 3 = PPS fix 4 = Real Time Kinematic

5 = Float RTK

6 = estimated (dead reckoning) (2.3 feature)

7 = Manual input mode

8 = Simulation mode

08	Number of satellites being tracked
0.9	Horizontal dilution of position
545.4,M	Altitude, Meters, above mean sea level
46.9,M	Height of geoid (mean sea level) above WGS84 ellipsoid
	(empty field) time in seconds since last DGPS update
	(empty field) DGPS station ID number
*47	The checksum data, always begins with *

If the height of geoids is missing then the altitude should be suspect. Some non-standard implementations report altitude with respect to the ellipsoid rather than geoid altitude. Some units do not report negative altitudes at all. This is the only sentence that reports altitude.

GSA - GPS DOP and active satellites. This sentence provides details on the nature of the fix. It includes the numbers of the satellites being used in the current solution and the DOP. DOP dilution of precision) is an indication of the effect of satellite geometry on the accuracy of the fix. It is a unitless number where smaller is better. For 3D fixes using 4 satellites a 1.0 would be considered to be a perfect number, however for over determined solutions it is possible to see numbers below 1.0.

There are differences in the way the PRN's are presented which can effect the ability of some programs to display this data. For example, in the example shown below there are 5 satellites in the solution and the null fields are scattered indicating that the almanac would show satellites in the null positions that are not being used as part of this solution. Other receivers might output all of the satellites used at the beginning of the sentence with the null field all stacked up at the end. This difference accounts for some satellite display programs not always being able to display the satellites being tracked. Some units may show all satellites that have ephemeris data without regard to their use as part of the solution but this is non-standard.

$GPGSA,A,3,04,05,,09,12,,,24,,,,,2.5,1.3,2.1*39

Where:

GSA	Satellite status
A	Auto selection of 2D or 3D fix (M = manual)
3	3D fix - values include: 1 = no fix 2 = 2D fix 3 = 3D fix
04,05...	PRNs of satellites used for fix (space for 12)
2.5	PDOP (dilution of precision)
1.3	Horizontal dilution of precision (HDOP)
2.1	Vertical dilution of precision (VDOP)
*39	The checksum data, always begins with *

GSV - Satellites in View shows data about the satellites that the unit might be able to find based on its viewing mask and almanac data. It also shows current ability to track this data. Note that one GSV sentence only can provide data for up to 4 satellites and thus there may need to be 3 sentences for the full information. It is reasonable for the GSV sentence to contain more satellites than GGA might indicate since GSV may include satellites that are not used as part of the solution. It is not a requirement that the GSV sentences all appear in sequence. To avoid overloading the data bandwidth some receivers may place the various sentences in totally different samples since each sentence identifies which one it is.

The field called SNR (Signal to Noise Ratio) in the NMEA standard is often referred to as signal strength. SNR is an indirect but more useful value that raw signal strength. It can range from 0 to 99 and has units of dB according to the NMEA standard, but the various manufacturers send different ranges of numbers with different starting numbers so the values themselves cannot necessarily be used to evaluate different units. The range of working values in a given gps will usually show a difference of about 25 to 35 between the lowest and highest values, however 0 is a special case and may be shown on satellites that are in view but not being tracked.

$GPGSV,2,1,08,01,40,083,46,02,17,308,41,12,07,344,39,14,22,228,45*75

Where:

GSV	Satellites in view
2	Number of sentences for full data

1	Sentence 1 of 2
08	Number of satellites in view
01	Satellite PRN number
40	Elevation, degrees
083	Azimuth, degrees
46	SNR - higher is better for up to 4 satellites per sentence
*75	The checksum data, always begins with *

RMC - NMEA has its own version of essential gps pvt (position, velocity, time) data. It is called RMC, The Recommended Minimum, which will look similar to:

$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A

Where:

RMC	Recommended Minimum sentence C
123519	Fix taken at 12:35:19 UTC
A	Status A=active or V=Void.
4807.038,N	Latitude 48 deg 07.038' N
01131.000,E	Longitude 11 deg 31.000' E
022.4	Speed over the ground in knots
084.4	Track angle in degrees True
230394	Date - 23rd of March 1994
003.1,W	Magnetic Variation

*6A	The checksum data, always begins with *

Note that, as of the 2.3 release of NMEA, there is a new field in the RMC sentence at the end just prior to the checksum.

VTG - Velocity made good. The gps receiver may use the LC prefix instead of GP if it is emulating Loran output.

$GPVTG,054.7,T,034.4,M,005.5,N,010.2,K*48

where:

VTG	Track made good and ground speed
054.7,T	True track made good (degrees)
034.4,M	Magnetic track made good
005.5,N	Ground speed, knots
010.2,K	Ground speed, Kilometers per hour
*48	Checksum

CHAPTER 7

MICROCONTROLLER

A microcontroller (sometimes abbreviated μC, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

7.1 GENERAL DESCRIPTION

The P89V51RB2/RC2/RD2 is 80C51 microcontrollers with 16/32/64 kB flash and1024 B of data RAM.

A key feature of the P89V51RB2/RC2/RD2 is its X2 mode option. The design engineer can choose to run the application with the conventional 80C51 clock rate (12 clocks per machine cycle) or select the X2 mode (six clocks per machine cycle) to achieve twice the throughput at the same clock frequency. Another way to benefit from this feature is to keep the same performance by reducing the clock frequency by half, thus dramatically reducing the EMI.

The flash program memory supports both parallel programming and in serial ISP. Parallel programming mode offers gang-programming at high speed, reducing programming costs and time to market. ISP allows a device to be reprogrammed in the end product under software control. The capability to field/update the application firmware makes a wide range of applications possible.

The P89V51RB2/RC2/RD2 is also capable of IAP, allowing the flash program memory to be reconfigured even while the application is running.

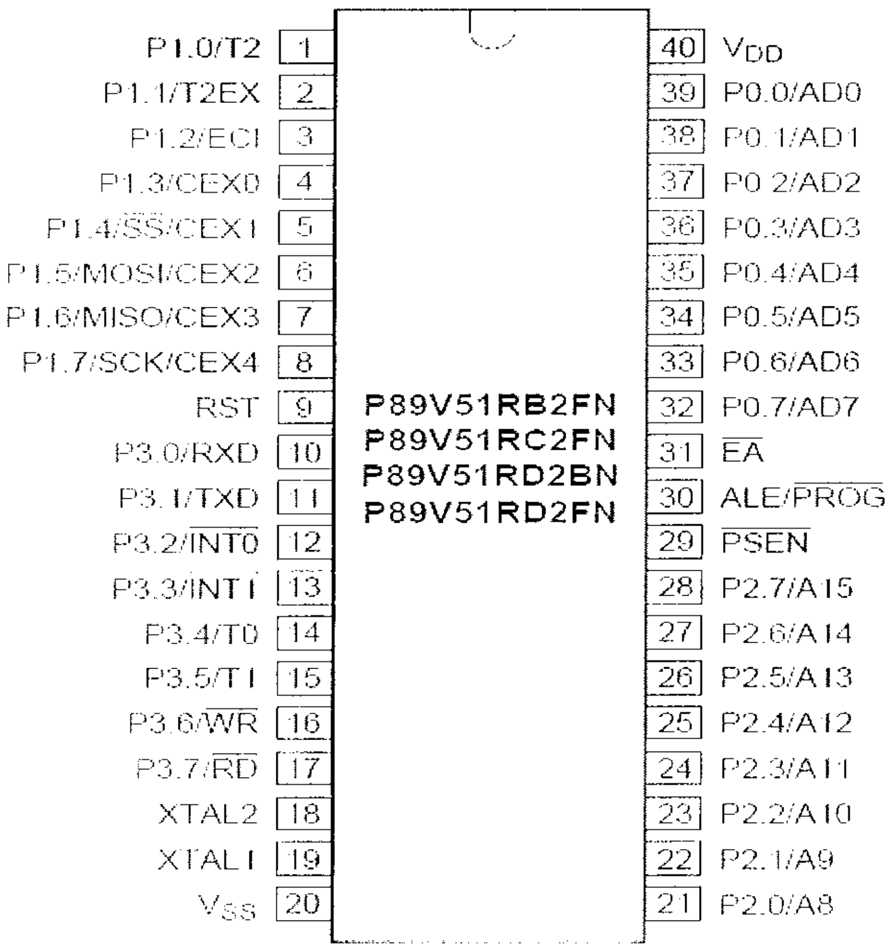


Fig. 7.1 Microcontroller pin configuration

7.2 UART COMMUNICATION

The UART operates in all standard modes. Enhancements over the standard 80C51 UART include Framing Error detection, and automatic address recognition.

7.2.1 MODE 0

Serial data enters and exits through RXD and TXD outputs the shift clock. Only 8 bits are transmitted or received, LSB first. The baud rate is fixed at 1/6 of the CPU clock frequency. UART configured to operate in this mode outputs serial clock on TXD line no matter whether it sends or receives data on RXD line.

7.2.2 MODE 1

10 bits are transmitted (through TXD) or received (through RXD): a start bit (logical 0), 8 data bits (LSB first), and a stop bit (logical 1). When data is received, the stop bit is stored in RB8 in Special Function Register SCON. The baud rate is variable and is determined by the Timer 1/2 overflow rate.

7.2.3 MODE 2

11 bits are transmitted (through TXD) or received (through RXD): start bit (logical 0), 8 data bits (LSB first), a programmable 9th data bit, and a stop bit (logical 1). When data is transmitted, the 9th data bit (TB8 in SCON) can be assigned the value of 0 or (e.g. the parity bit (P, in the PSW) could be moved into TB8). When data is received, the 9th data bit goes into RB8 in Special Function Register SCON, while the stop bit is ignored. The baud rate is programmable to either 1/16 or 1/32 of the CPU clock frequency, as determined by the SMOD1 bit in PCON.

7.2.4 MODE 3

11 bits are transmitted (through TXD) or received (through RXD): a start bit (logical 0), 8 data bits (LSB first), a programmable 9th data bit, and a stop bit (logical 1). In fact, mode 3 is the same as mode 2 in all respects except baud rate. The baud rate in mode 3 is variable and is determined by the Timer 1/2 overflow rate.

7.2.5 SCON - SERIAL PORT CONTROL REGISTER (ADDRESS 98H) BIT ALLOCATION

Bit addressable; Reset value: 00H

Bit	7	6	5	4	3	2	1	0
Symbol	SM0/FE	SM1	SM2	REN	TB8	RB8	TI	RI

Table 7.1 Frame format of SCON register

7.2.6 FRAMING ERROR

Framing error (FE) is reported in the SCON.7 bit if SMOD0 (PCON.6) = 1. If SMOD0 = 0, SCON.7 is the SM0 bit for the UART, it is recommended that SM0 is set up before SMOD0 is set to '1'.

7.2.7 MULTIPROCESSOR COMMUNICATIONS

UART modes 2 and 3 have a special provision for multiprocessor communications. In these modes, 9 data bits are received or transmitted. When data is received, the 9th bit is stored in RB8. The UART can be programmed so that when the stop bit is received, the serial port interrupt will be activated only if RB8 = 1. This feature is enabled by setting bit SM2 in SCON. One way to use this feature in multiprocessor systems is as follows:

When the master processor wants to transmit a block of data to one of several slaves, it first sends out an address byte which identifies the target slave. An address byte differs from a data byte in a way that the 9th bit is '1' in an address byte and '0' in the data byte.

With SM2 = 1, no slave will be interrupted by a data byte, i.e. the received 9th bit is '0'.

However, an address byte having the 9th bit set to '1' will interrupt all slaves, so that each slave can examine the received byte and see if it is being addressed or not. The addressed slave will clear its SM2 bit and prepare to receive the data (still 9 bits long) that follow. The slaves that weren't being addressed leave their SM2 bits set and go on about their business, ignoring the subsequent data bytes.

SM2 has no effect in mode 0, and in mode 1 can be used to check the validity of the stop bit, although this is better done with the Framing Error flag. When UART receives data in mode 1 and SM2 = 1, the receive interrupt will not be activated unless a valid stop bit is received.

7.2.8 AUTOMATIC ADDRESS RECOGNITION

Automatic Address Recognition is a feature which allows the UART to recognize certain addresses in the serial bit stream by using hardware to make the comparisons. This feature saves a great deal of software overhead by eliminating the need for the software to examine every serial address which passes by the serial port. This feature is enabled for the UART by setting the SM2 bit in SCON. In the 9 bit UART modes, mode 2 and mode 3, the Receive Interrupt flag (RI) will be automatically set when the received byte contains either the 'Given' address or the 'Broadcast' address. The 9 bit mode requires that the 9^{th} information bit is a '1' to indicate that the received information is an address and not data.

Using the Automatic Address Recognition feature allows a master to selectively communicate with one or more slaves by invoking the Given slave address or addresses. All of the slaves may be contacted by using the Broadcast address. Two Special Function Registers are used to define the slave's address, SADDR, and the address mask, SADEN. SADEN is used to define which bits in the SADDR are to be used and which bits are 'don't care'.

The SADEN mask can be logically ANDed with the SADDR to create the 'Given' address which the master will use for addressing each of the slaves. Use of the 'Given' address allows multiple slaves to be recognized while excluding others.

This device uses the methods presented in figure to determine if a 'Given' or 'Broadcast' address has been received or not.

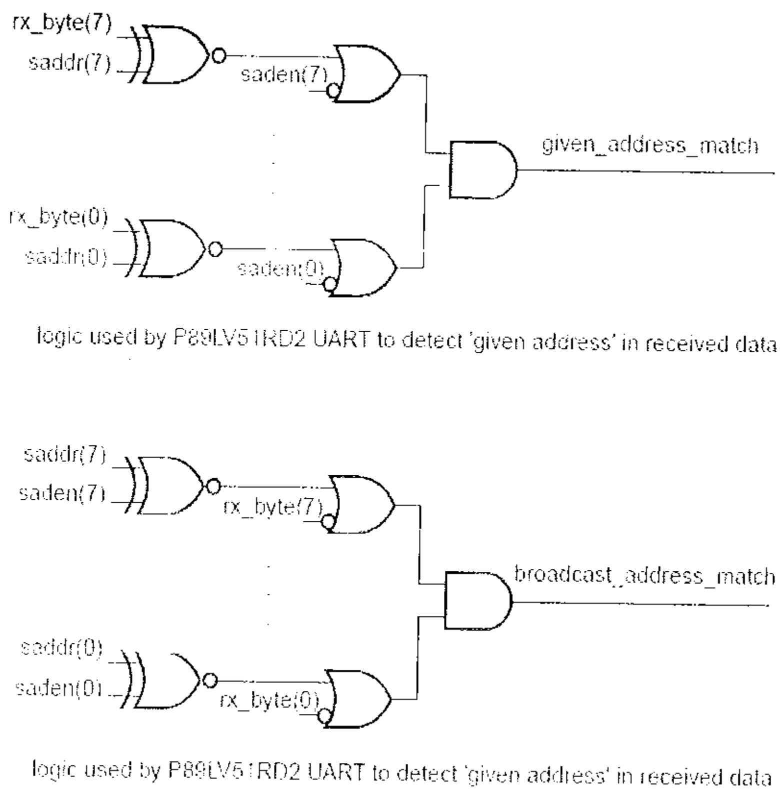


Fig. 7.2 Logic used by UART to detect 'given address' in received data

7.3 SERIAL PERIPHERAL INTERFACE (SPI) COMMUNICATION

7.3.1 SPI FEATURES

- Master or slave operation
- 10 MHz bit frequency (max)
- LSB first or MSB first data transfer
- Four programmable bit rates
- End of transmission (SPIF)
- Write collision flag protection (WCOL)
- Wake-up from idle mode (slave mode only)

7.3.2 SPI DESCRIPTION

The SPI allows high-speed synchronous data transfer between the P89V51RB2/RC2/RD2 and peripheral devices or between several P89V51RB2/RC2/RD2 devices. The block diagram shows the correspondence between master and slave SPI devices.

7.3.3 MASTER SLAVE INTERCONNECTION

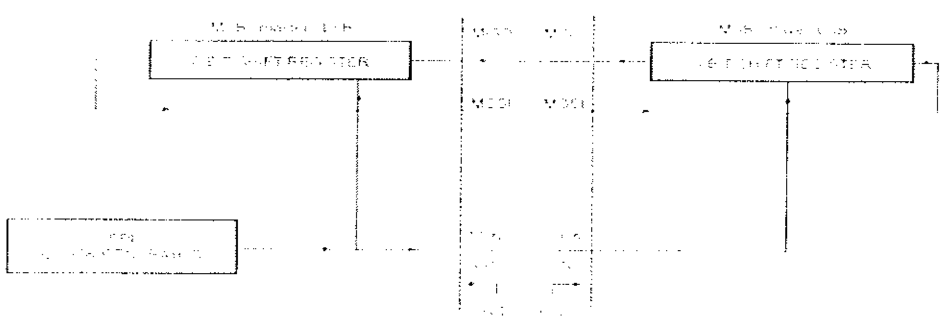


Fig. 7.3 Master Slave Interconnection

The SCK pin is the clock output and input for the master and slave modes, respectively. The SPI clock generator will start following a write to the master devices SPI data register. The written data is then shifted out of the MOSI pin on the master device into the MOSI pin of the slave device. Following a complete transmission of one byte of data, the SPI clock generator is stopped and the SPIF flag is set. An SPI interrupt request will be generated if the SPI Interrupt Enable bit (SPIE) and the Serial Port Interrupt Enable bit (ES) are both set.

7.3.4 SPCR - SPI CONTROL REGISTER (ADDRESS D5H) BIT ALLOCATION

Bit addressable; Reset source(s): any reset; Reset value: 0000 0000B

Bit	7	6	5	4	3	2	1	0
Symbol	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0

Table 7.2 Frame format of SPCR

SPR1	**SPR0**	**SCK=fosc divided by**
0	0	4
0	1	16
1	0	64
1	1	128

Table 7.3 Clock Rate Selection by SPCR

7.3.5 SPSR - SPI STATUS REGISTER (ADDRESS AAH) BIT ALLOCATION

Bit addressable; Reset source(s): any reset; Reset value: 0000 0000B

Bit	7	6	5	4	3	2	1	0
Symbol	SPIF	WCOL	-	-	-	-	-	-

Table 7.4 Frame format of SPSR

An external master drives the Slave Select input pin, SS/P1[4], low to select the SPI module as a slave. If SS/P1[4] has not been driven low, then the slave SPI unit is not active and the MOSI/P1[5] port can also be used as an input port pin. CPHA and CPOL control the phase and polarity of the SPI clock. The timing diagrams below show the four possible combinations of these two bits.

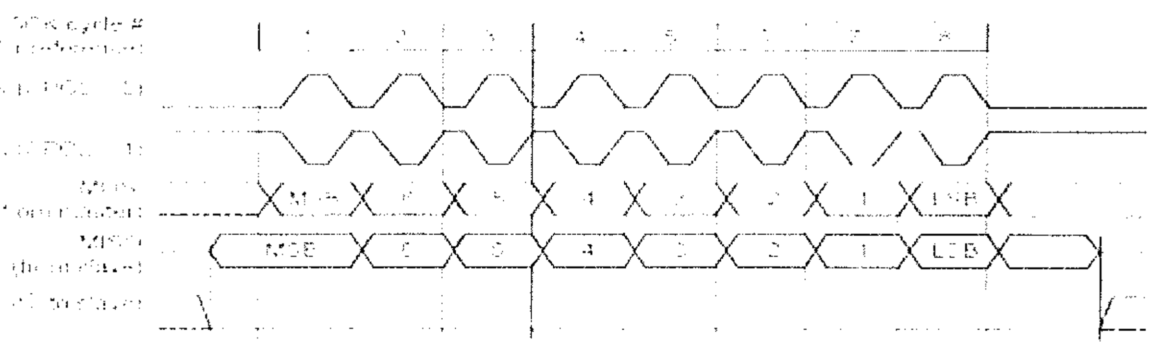


Fig. 7.4 SPI Transfer Format with CPHA=0

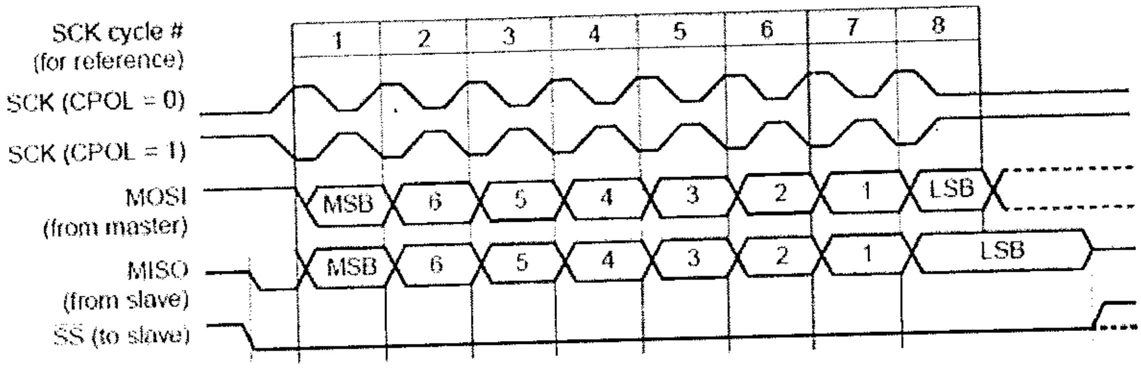


Fig. 7.5 SPI Transfer Format with CPHA=1

CHAPTER 8

SOFTWARE DESCRIPTION

As mentioned in the block diagram, the project consists of two parts. So, the software code is written as two sections. They can be explained in algorithm as:

8.1 ALGORITHM

8.1.1 IN HIGH PRIORITY VEHICLE

Step 1: Switch on the GPS module.

Step 2: Initialize UART of the microcontroller and receive the GPS data through UART.

Step 3: Initialize SPI.

Step 4: Convert the data into HPV format by extracting the coordinates from RMC output of GPS at the master.

Step 5: Master sends this HPV data to the slave.

Step 6: Slave checks whether the data received is in the HPV format. If not, the data is discarded.

Step 6: UART at the slave is initialized. Slave initializes the Zigbee device connected to the UART of slave microcontroller.

Step 7: The HPV data is sent from the Zigbee module at HPV to the Zigbee module at the traffic signal by setting the destination node.

Step 8: Each time a data is sent by the Zigbee, the destination node is checked.

8.1.2 IN THE TRAFFIC SIGNAL

Step 1: The HPV data is received by the microcontroller through the UART port after its initialization.

Step 2: The data is checked if it retains in the same HPV format.

Step 3: The coordinates are extracted from this format and converted to double.

Step 4: The data are checked for their update in the coordinates.

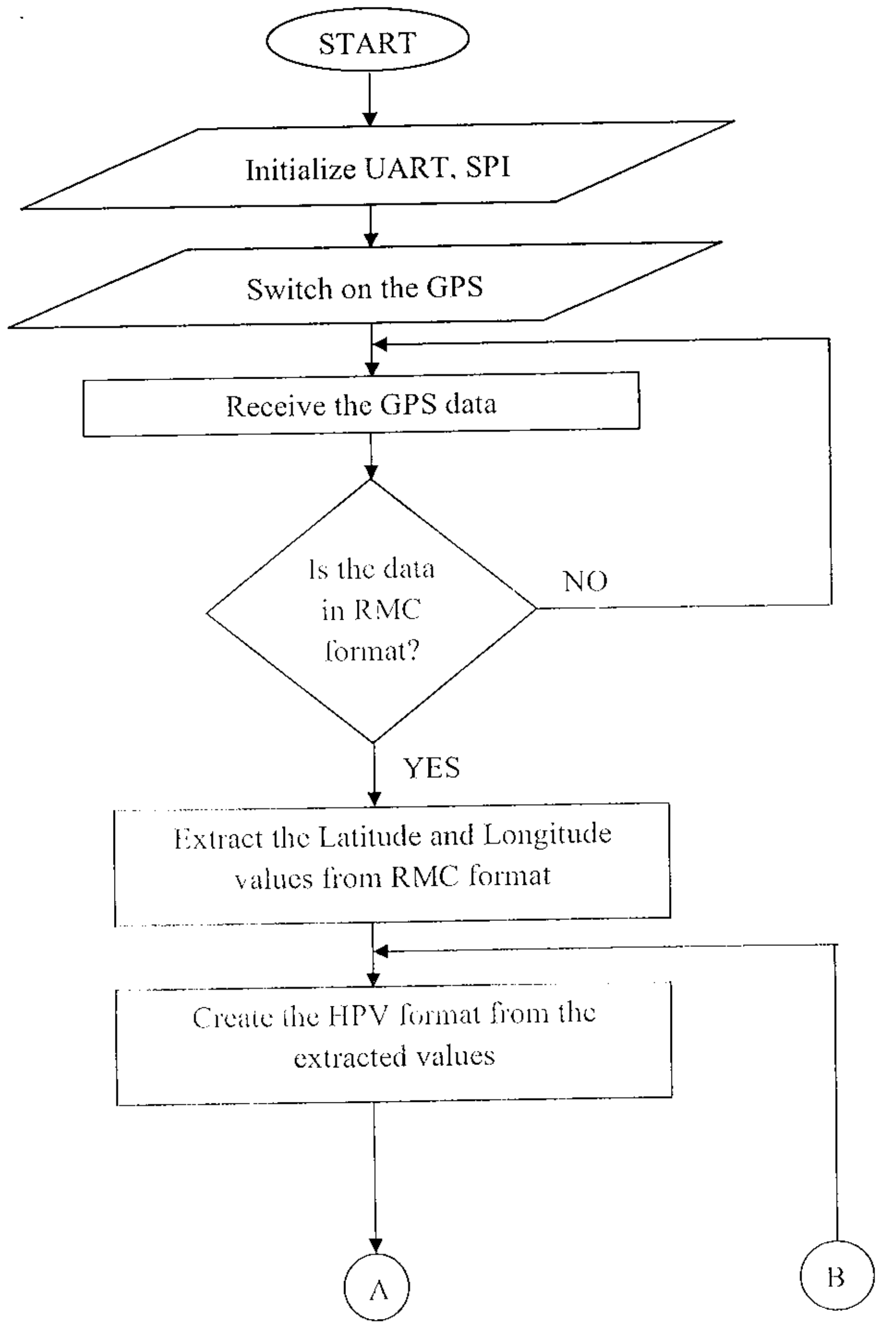
Step 4: The converted values are checked with the coordinates at the traffic signal.

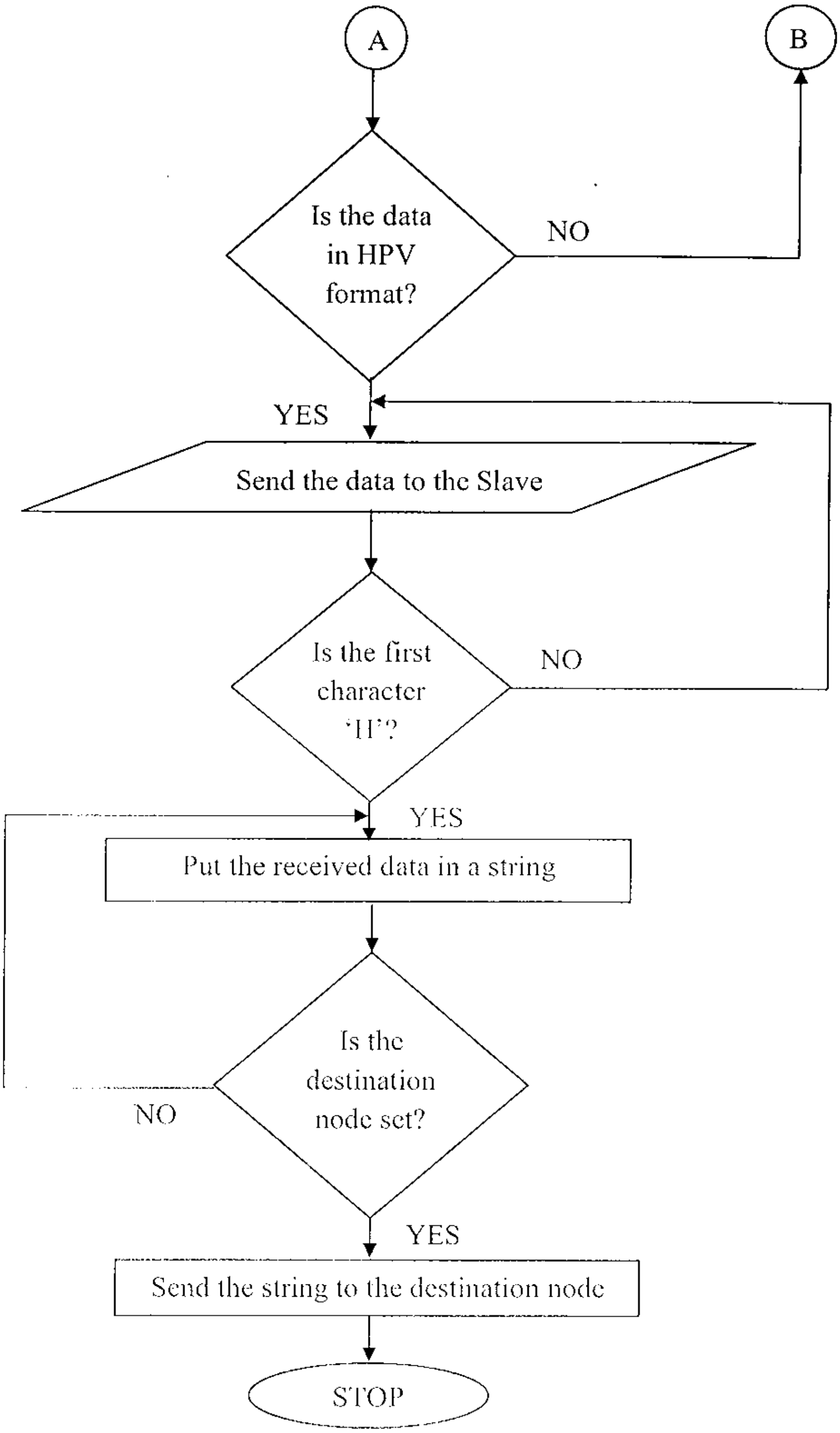
Step 5: Depending on the differences in the values the traffic signal is updated.

Step 6: The difference in type of coordinate (N or E) is required for updating the traffic signal.

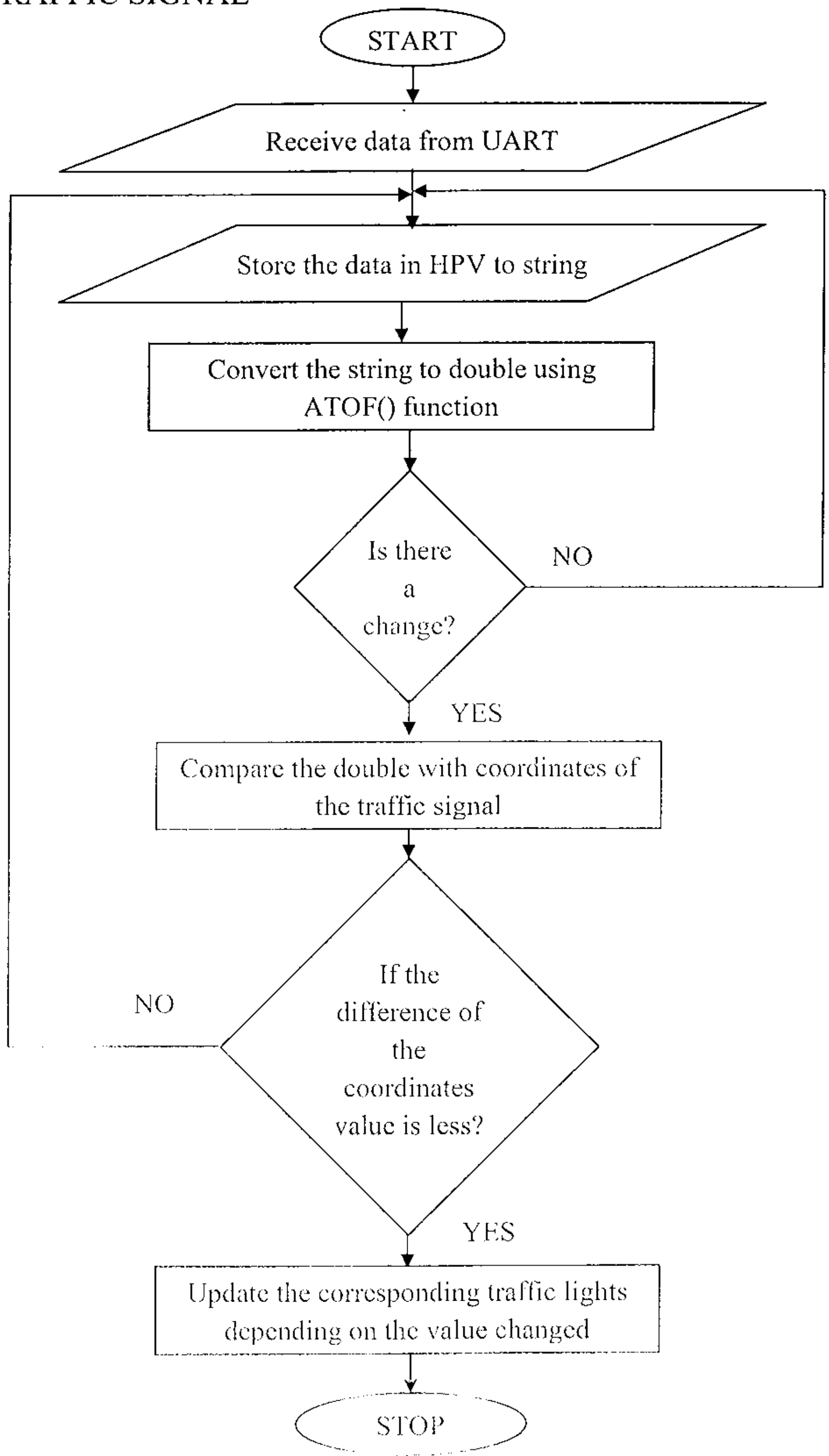
8.2 PROGRAM FLOW

8.2.1 IN HIGH PRIORITY VEHICLE




A
B
Is the data in HPV format?
NO
YES
Send the data to the Slave
Is the first character 'H'?
NO
YES
Put the received data in a string
Is the destination node set?
NO
YES
Send the string to the destination node
STOP

8.2.2 IN THE TRAFFIC SIGNAL



CHAPTER 9

CONCLUSION AND FUTURE DEVELOPMENT

9.1 CONCLUSION

Thus the project Intelligent Traffic Control System eliminates the incompetence of the present traffic control system. The ITCS senses the presence of HPV and resets the traffic signals accordingly. This feature will save a lot of emergency vehicles from being delayed at any instance. The project just needs the installation of two simple modules, one in the HPV and the other in the traffic control system. With the use of advanced zigbee and GPS technologies, the efficiency of the method has been enhanced.

9.2 FUTURE DEVELOPMENT

1. The future scope of the project lies in the formation of a network using the zigbee modules present in each vehicle. This will aid the communication of necessary information between vehicles. This will also increase the range of information sharing.

2. The emergency situations can be conveyed to the hospitals, fire stations, police stations and other buildings in case of a large network.

APPENDIX 1

MICROCONTROLLER

FEATURES

- 80C51 CPU
- 5 V operating voltage from 0 MHz to 40 MHz
- 16/32/64 kB of on-chip flash user code memory with ISP and IAP
- Supports 12-clock (default) or 6-clock mode selection via software or ISP
- SPI and enhanced UART
- PCA with PWM and capture/compare functions
- Four 8-bit I/O ports with three high-current port 1 pins (16 mA each)
- Three 16-bit timers/counters
- Programmable watchdog timer
- Eight interrupt sources with four priority levels
- Second DPTR register
- Low EMI mode (ALE inhibit)
- TTL- and CMOS-compatible logic levels
- Brownout detection
- Low power modes
    - Power-down mode with external interrupt wake-up
    - Idle mode
- DIP40, PLCC44 and TQFP44 packages

BLOCK DIAGRAM

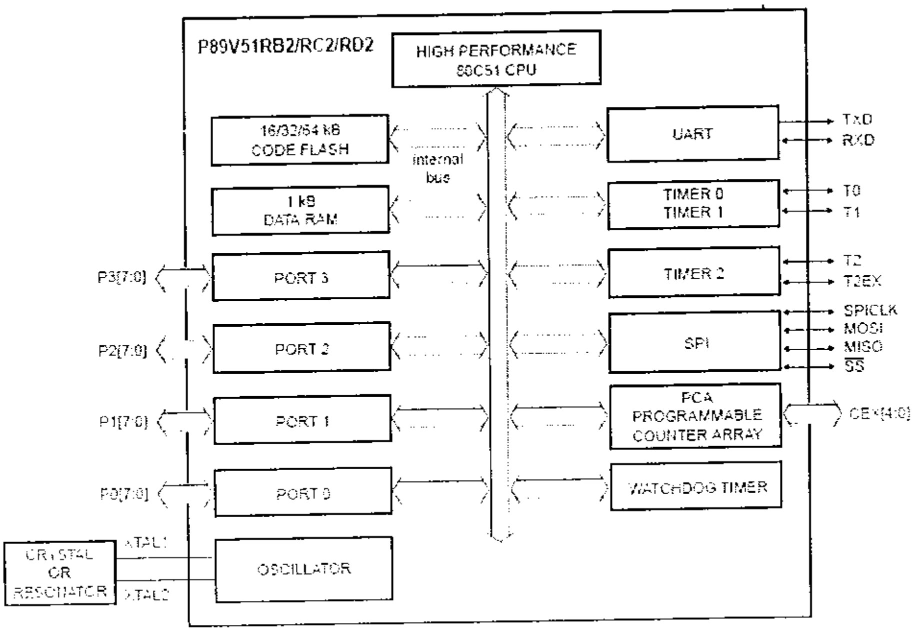


Fig. A 1.1 Microcontroller block diagram

FLASH MEMORY IAP

FLASH ORGANIZATION

The P89V51RB2/RC2/RD2 program memory consists of a 16/32/64 kB block. ISP capability, in a second 8 kB block, is provided to allow the user code to be programmed in-circuit through the serial port. There are three methods of erasing or programming of the flash memory that may be used. First, the flash may be programmed or erased in the end-user application by calling low-level routines through a common entry point (IAP). Second, the on-chip ISP boot loader may be invoked. This ISP boot loader will, in turn, call low-level routines through the same common entry point that can be used by the end-user application. Third, the flash may be programmed or erased using the parallel method by using a commercially available EPROM programmer which supports this device.

ISP

ISP is performed without removing the microcontroller from the system. The ISP facility consists of a series of internal hardware resources coupled with internal firmware to facilitate remote programming of the P89V51RB2/RC2/RD2 through the serial port. This firmware is provided by NXP and embedded within each P89V51RB2/RC2/RD2 device. The NXP ISP facility has made in-circuit programming in an embedded application possible with a minimum of additional expense in components and circuit board area. The ISP function uses five pins (VDD, VSS, TXD, RXD, and RST). Only a small connector needs to be available to interface your application to an external circuit in order to use this feature.

POWER-ON RESET CODE EXECUTION

At initial power up, the port pins will be in a random state until the oscillator has started and the internal reset algorithm has weakly pulled all pins high. Powering up the device without a valid reset could cause the MCU to start executing instructions from an indeterminate location. Such undefined states may inadvertently corrupt the code in the flash. A system reset will not affect the 1 kB of on-chip RAM while the device is running; however, the contents of the on-chip RAM during power up are indeterminate.

When power is applied to the device, the RST pin must be held high long enough for the oscillator to start up (usually several milliseconds for a low frequency crystal), in addition to two machine cycles for a valid power-on reset. An example of a method to extend the RST signal is to implement a RC circuit by connecting the RST pin to VDD through a 10 mF capacitor and to VSS through an 8.2 kW resistor as shown in Figure. Note that if an RC circuit is being used, provisions should be made to ensure the VDD rise time does not exceed 1 ms and the oscillator start-up time does not exceed 10 ms. For a low frequency oscillator with slow start-up time the reset signal must be extended in order to account for the slow start-up time. This method maintains the necessary relationship between VDD and RST to avoid programming at an indeterminate location, which may cause corruption in the code of the flash. The power-on detection is designed to work during initial power up, before the voltage reaches the brownout detection level. The POF flag in the PCON register is set to indicate an initial power up condition. The POF flag will remain active until cleared by software.

Following a power-on or external reset the P89V51RB2/RC2/RD2 will force the SWR and BSEL bits (FCF[1:0]) = 00. This causes the boot block to be mapped into the lower 8 kB of code memory and the device will execute the ISP code in the boot block and attempt to auto baud to the host. If the auto baud is successful the device will remain in ISP mode. If, after approximately 400 ms, the auto baud is unsuccessful the boot block code will check to see if the SoftICE flag is set (from a previous programming operation). If the SoftICE flag is set the device will enter SoftICE mode. If the SoftICE flag is cleared, the boot code will execute a software reset causing the device to execute the user code from block 0 starting at address 0000H. Note that an external reset applied to the RST pin has the same effect as a power-on reset.

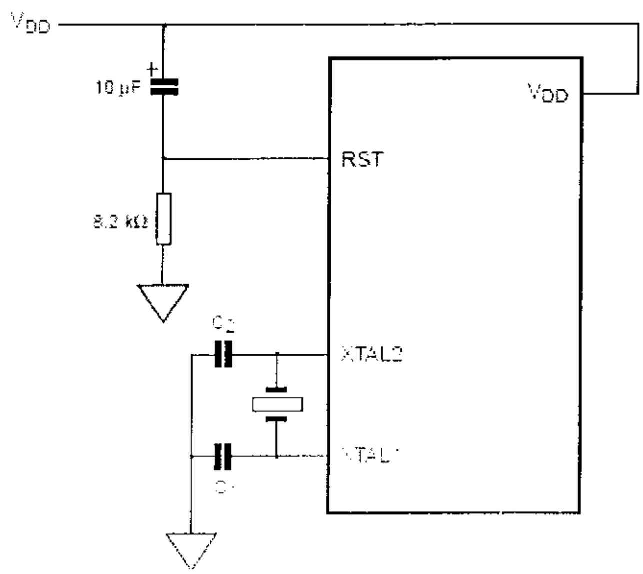


Fig. A 1.2 Reset circuit

APPENDIX 2

ZIGBEE

XBEE SERIES 2 OEM RF MODULES

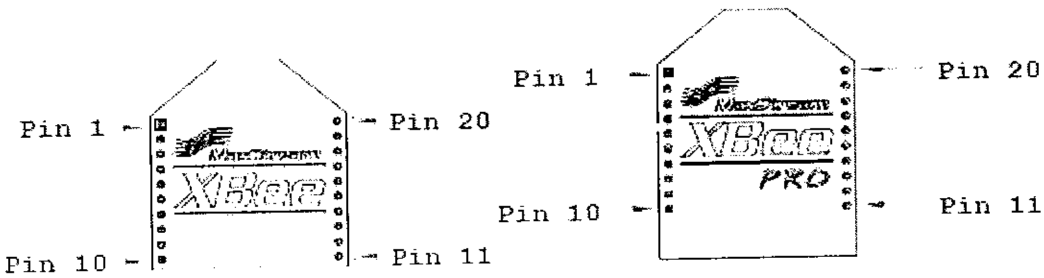


Fig. A 2.1 XBee Series 2

The XBee Series 2 OEM RF Modules were engineered to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within the ISM 2.4 GHz frequency band.

KEY FEATURES

- High Performance, Low Cost
- Indoor/Urban: up to 133' (40 m)
- Outdoor line-of-sight: up to 400' (120 m)
- Transmit Power: 2 mW (+3 dBm)

- Receiver Sensitivity: -95 dBmRF Data Rate: 250,000 bps
- Low Power
- TX Current: 40 mA (@3.3 V)
- RX Current: 40 mA (@3.3 V)
- Power-down Current: < 1 µA

DESIGN NOTES:

• Minimum connections: VCC, GND, DOUT & DIN

• Minimum connections for updating firmware: VCC, GND, DIN, DOUT, RTS & DTR

◦ Signal Direction is specified with respect to the module

◦ Module includes a 50k Ω pull-up resistor attached to **RESET**

◦ Several of the input pull-ups can be configured using the PR command • Unused pins should be left disconnected.

API OPERATION

API (Application Programming Interface) Operation is an alternative to the default Transparent Operation. The frame-based API extends the level to which a host application can interact with the networking capabilities of the module. When in API mode, all data entering and leaving the module is contained in frames that define operations or events within the module. Transmit Data Frames (received through the DI pin (pin 3)) include:

- RF Transmit Data Frame
- Command Frame (equivalent to AT commands)

Receive Data Frames (sent out the DO pin (pin 2)) include:

- RF-received data frame
- Command response
- Event notifications such as reset, associate, disassociate, etc.

The API provides alternative means of configuring modules and routing data at the host application layer. A host application can send data frames to the module that contain address and payload information instead of using command mode to modify addresses. The module will send data frames to the application containing status packets; as well as source, RSSI and payload information from received data packets.

NETWORK RESET

Once a coordinator has started, or a router or end device has joined the network, the device will continue operating on that channel and PAN ID unless one of the following occurs: 1. The ID parameter changes, and is saved using the WR command 2. The SC parameter changes and is saved using the WR command, such that the current operating channel is not included in the new SC parameter 3. The NR command is issued with either 0 or 1 as a parameter If any of the above occurs on a coordinator, the coordinator will attempt to restart on a channel and PAN ID based on the new saved ID and SC commands. On a router or end device, the above conditions will cause the device to leave the network (if previously joined) and attempt to join a new PAN using the saved ID and SC parameters.

APPENDIX - 3

GPS MODULE

The L10-EVB Development Starter Kit provides a convenient and flexible evaluation environment for a quick and easy development of fleet management, tracking, and navigation applications. The RS-232 interface enables the DSK to easily connect to any PC for speedy application development.

DETAILS ABOUT THE GPS L10 MODULE

The L10 GPS module brings the high performance of the MTK positioning engine to the industrial standard. The module supports 210 PRN channels. With 66 search channels and 22 simultaneous tracking channels, it acquires and rack satellite in the shortest time even at the indoor signal level. This versatile, stand-alone receiver combines an extensive array of features with flexible connectivity options. The embedded FLASH memory provides capacity for storing user-specific configuration settings and allows for future updates. L1 advanced jamming suppression mechanism and innovative RF architecture provides a high level of immunity for jamming, ensuring maximum GPS performance. The module supports location, navigation, industrial application including autonomous GPS C/A, SBAS (including WAAS, EGNOS and MSAS), DGPS (RTCM) and AGPS.

SPECIFICATIONS FOR GPS MODULE (L10)

GENERAL SPECIFICATIONS

- **L1 Band Receiver (1575.42MHz)**
  - Channel Number — 22 TRK / 66 ACQ
  - SBAS — 19 C/A (WAAS, EGNOS, MSAS)
  - QZSS — 5 C/A, 5 SAIF
  - Total — 210 PRN channels

- **Position Accuracy**
  - Without Aid — 3.0 m 2D-RMS
  - DGPS — 2.5 m

- **Velocity Accuracy**
  - Without Aid — 0.1 m/s
  - DGPS — 0.05 m/s

- **Acceleration Accuracy**
  - Without Aid — 0.1 m/s^2
  - DGPS — 0.05 m/s^2

- **Timing Accuracy** — < 100 ns

- **Reacquisition Time** — < 1 s

- **TTFF (Time To First Fix)**
  - Cold start — <35s

- Warm start <35s
- Hot start <1s
- EPO, BEE * 5-10s (optional)
- SUPL** 5-10s (optional)

  - *EPO: Extended Prediction Orbit
  - *BEE: Broadcast ephemeris extension
  - **Without counting data link time

- **Sensitivity**
  - Autonomous Acquisition -148dBm
  - Reacquisition -160dBm
  - Hot start -160dBm
  - Tracking -165dBm
- **Max Update Rate** 5Hz
- **Environmental**
  - Operating Temperature -40°C to 85°C
  - Storage Temperature -45°C to 125°C
- **Dynamic Performance**
  - Maximum Altitude 18,000 m
  - Maximum Velocity 515m/s Maximum
  - Acceleration 4 G
- **Dimensions** 22.4mm×17.0mm×3.0mm

- **Weight** Approx. 2.0g

INTERFACES

- **Serial Interfaces**
  - 1 UART with baud rate 2.4 ~ 115.2 Kbps
  - 1 USB V2.0 Full Speed
  - 1 I2C (optional)
- **Digital I/O** Configurable time pulse 1 Reset
- **Serial and I/O Voltage** 2.7V ~ 2.9V
- **Protocols**
  - NMEA
  - PMTK

ELECTRICAL DATA

- **Power Supply** 3.0 to 4.3V
- **Power Acquisition** 43mA (passive antenna)
- **Power Tracking** 38mA (passive antenna)
- **Antenna Type** Active and passive
- **Antenna power** External or internal VCC_RF

- **Antenna Supervision** Integrated short-circuit detection and antenna shutdown, open circuit detection is supported with AADET input and little external circuitry

TECHNICAL DESCRIPTION FOR GPS MODULE

The satellites circle the Earth every 12 hours and broadcast a data stream at the primary frequency L1 of 1.575GHz which carries the Coarse-acquisition encoded signal to the ground. The GPS receiver measures the time of arrival of the C/A code to a fraction of a millisecond, and thus determines the distance to the satellite. The basic block diagram for GPS module is shown in figure.

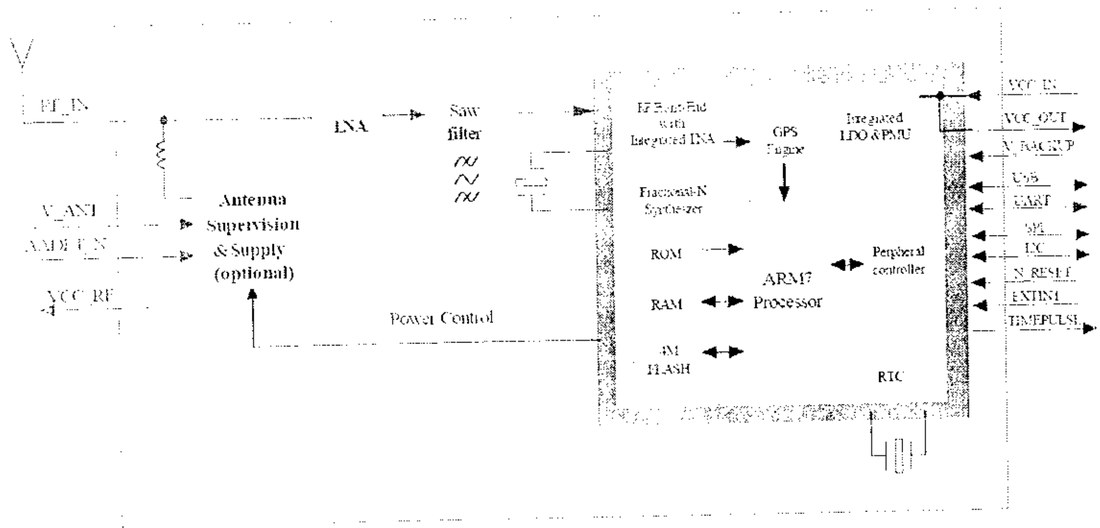


Fig A 3.1 Block Diagram of Global Positioning System

FEATURES OF GPS RECEIVER

- 210 PRN channels, with 66 search channels and 22 simultaneous tracking channels
- -165dBm tracking sensitivity
- Highest autonomous mode acquisition sensitivity, -148dBm
- Low tracking power consumption, 38mA (passive antenna)
- Full ESD protection on all pins
- Embedded with one 4Mbits flash memory
- Superior anti-jamming design for best integration with other wireless application, such as WiFi, WiMax, CDMA and GSM
- Multi-path detection and correction for accurate navigation in harsh urban canyon
- Up to 5Hz update rate
- USB 2.0 full speed compliant interface

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