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# A Multipurpose Child Tracking System Design and Implementation

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**Abstract**

This paper presents a tracking system which is capable of detecting various danger surrounded by more than one child and trying to decrease the limitations that found in the present systems. The designed system consists of two modules; parent module and child module. When a violation of child safe is detected, a specific sensor in child module will produce a signal. This signal will be sent from these sensors to controller then through transmitter to parent module which will take the required decision and start the violation handling procedure. The parent can set the system to work indoor or outdoor and depending on this selection the parent module can calculate the distance at any moment between each child and their parent. Global Positioning System (GPS) is used for outdoor distance calculation while change amplitude of RF Signal is used for indoor distance calculation. Also, the parent can delimit the safety distance for each child and when it is overtaken the system will alarm both of them the parent and child. The proposed hardware and software for this design is simple and be implemented on a single chip microcontroller with low cost.

**Keywords:** Tracking system, GPS, monitoring system, wireless connection, and microcontroller.

## 1. Introduction

The children, growing up bring with them a mixture of pleasure and pain, love of knowing every thing and need to discover any thing. It would be nice if children are happy and free of troubles or dangerous.

Feeling safe about children is the first importance needs for parents in all worlds. Although there is no substitute for good childcare, which would include constant monitoring, the reality is that constant monitoring of children is not always feasible; especially when a parent must monitor multiple

children at the same time. Developing a tracking system for parents with multiple children could greatly decrease their stress and giving them more freedom during excursions with their children. The top level view of this paper has been designed with two distinct modules; child module and parent module. The child module is attached to each child. Its primary role is to periodically receive messages and in response send messages to the parent module and alert them if the child is in danger. Also, it has a buzzer alarm that sounds whenever the child is in an alarmed state. This allows a parent to more easily locate the troubled child [1, 2, 3, 4]. Child module has the ability to connect different sensors; however, sensors number can increase as necessary with a slight modification. In this work, smoke, temperature and water sensors are used.

The parent module sends requests to each child asking the status of them. The parent module is the computational brain of the entire system. It is responsible for communication with all the children and calculating their distance. It also analyzes incoming packets to see if any child has been in an alarmed state or not. Finally, if any child stops sending packets, the parent assumes it is out of range and also triggers an alarm. Every time the parent module cycles through all the children, it packs the status of every child and displays information on LCD.

## 2. Available Child Tracking Systems

Recently, tracking systems are available with different technologies, such as:

### a. Crossbow Motes technology

Crossbow Motes are very small devices that contain a microprocessor, radio transceiver, and interfaces to connect simple sensors such as smoke, temperature. Figure 1 shows the Crossbow Motes device; these Motes are a new and quickly-growing technology. But there are some disadvantages to use these devices such as: Finite Coverage, affected by trees & walls High cost. The internet website http:// www.xbow.com provides all information about these devices.

**Figure 1:** Crossbow Motes

### b. Gotcha® System

Gotcha it is child monitor that helps parents to protect their children at malls, supermarkets, parks, or everywhere. Gotcha alerts the children and parent whenever they wonder farther than a safe distance. Gotcha is an invisible electronic leash between parents and their kids. The internet website http:// www.nsclocators.com provides all information about it and how to buy this system.

Gotcha Simply attaches the child unit to the little one, turn on the system from the parent unit. Child unit will alarms if the child has wandered beyond the adjustable, predetermined safety perimeter that the parent set the child's unit triggers an alarm to sound if the unit is removed or accidentally falls off. Gotcha is a pager too, simply press the locate button on the parent unit and the Gotcha child unit will beep.But the main disadvantage of using this system that it doesn’t monitor the type of danger which can be used with multi-child.

### c. Global Positioning System (GPS) Technology

The GPS is a cumbersome, satellite-based navigation system, subscription service made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS provides specially

coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time. GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location [5].As shown in figure 2, any device that uses GPS is a lightweight device that attaches to the child and is designed to help parents or guardians keep track of their children and prevent this kind of tragedy. The device alleviates the stress and panic that appear when children get lost, or are difficult to reach. It emits a series of loud beeps, allowing parents to find their children quickly and easily. This is also an ideal solution for disabled adults, the elderly and daycare centers. The internet website www.childsafetytech.com provides all information about how to use GPS Technology in child tracking problems.

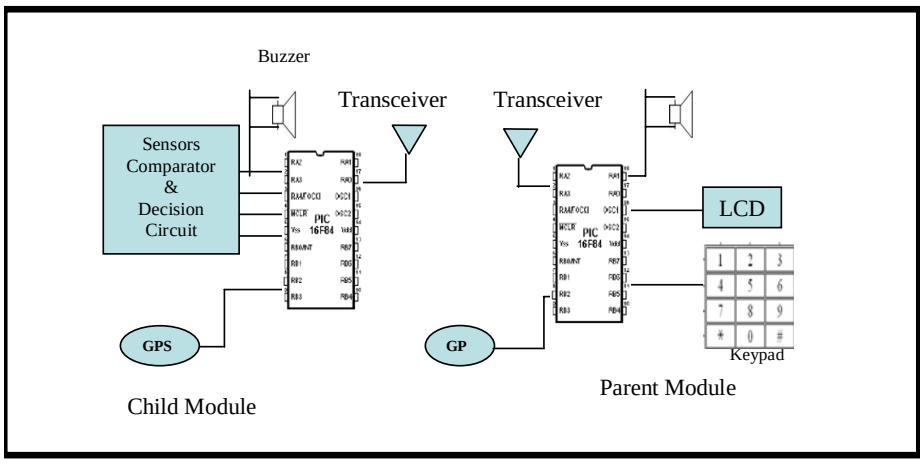
**Figure 2:** GPS Technology

There are many advantages of using GPS in tracking, first its continuous coverage regardless of weather, its worldwide coverage, 3-Dimensional and precise timing standard, but it’s not very useful in keeping children near a parent and systems that use GPS in tracking are too limited in their functionality [6, 7].

## 3. The Proposed System Model

The basic operation of the proposed child tracking system is that when a violation of child safe is detected, a specific sensor in child module will produce a signal. This signal will be sent from these sensors and GPS to microcontroller then through transmitter to parent module. The parent module will take the decision and start the violation handling procedure.As shown in figure 3, the operation of the child tracking system requires certain hardware between child model and parent one. This includes a certain driving circuit that activates the sensors. The main hardware parts of child tracking system are; sensor driving circuits, GPS, PIC, Transceiver, Buzzer, LCD and Keypad. The details of each module will be described in the next sections.

**Figure 3:** The Overall System Description




### 3.1. Child Module

The child module is attached to child. Its primary role is to periodically receive messages and in response send messages to the parent module and alert them if the child is in danger. The child module also has a buzzer alarm that sounds whenever the child is in an alarmed state. This allows a parent to more easily locate the troubled child. The sensors that used with this module are described below.

#### 3.1.1. Smoke Sensor

When a child is in danger regardless the reason of danger, the smoke sensor in child module will produce a signal. This signal will be read from sensor by PIC. An electrical signal is taken from the sensor to the PIC which converts the analog value to digital with respect to a predefined threshold value then transmits it to parent module. The parent module will take the decision and trigger an alarm when it exceeds a predefined value.

#### 3.1.2. Temperature Sensor

When a child is in danger position regardless the reason of danger, the temperature sensor in child module will produce a signal. An electrical signal generated from the sensor is connected to the PIC, which converts the analogue value to digital with respect to a predefined threshold value then transmits it to parent module. The parent module will take the decision and start the violation handling procedure.

#### 3.1.3. Water Detection Circuit

The water detection circuit is responsible for detecting the presence of water; as shown in figure 4. A simple circuit was created that would have a wire connected to the PIC I/O pins, and two wires that would act as leads. If the two leads were in the water, the voltage across the sensor wires would be 5V.Otherwise, the voltage would be zero. These leads would be representative of two metal plates on opposite sides of a packaged child module. When water comes into contact with both plates, the circuit is complete.

### 3.2. Parent Module

The parent module is the computational brain of the entire system. It is responsible for communication with all the children and calculating their distance. It also analyzes incoming packets to see if any child has been in an alarmed state or not. Finally, if any child stops sending packets, the parent assumes it is out of range or in some other danger and also triggers an alarm.

Every time the parent module cycles through all the children, it packs the status of every child and displays information on the LCD. Also, parent module has a keypad which is used to let the parent defining the location of their children (indoor or outdoor) and to give the safety distance for each child.

## 4. Detection of Safety Distance

When parent starts the system, she/he should select where they stay; indoor or outdoor; in order to calculate the distance between them and each child. Indoor option limit child range to 3m by reducing child transmitter source so signal attenuated will not be detected. But if parent selects outdoor option, distance will be calculated by taking child and parent locations from GPS chips [5]. Child module will send its GPS reading to parent module which calculates distance and compares it with distance threshold; this threshold value should be entered by parent after selecting outdoor option.

### 4.1. Indoor Circuit Calculation

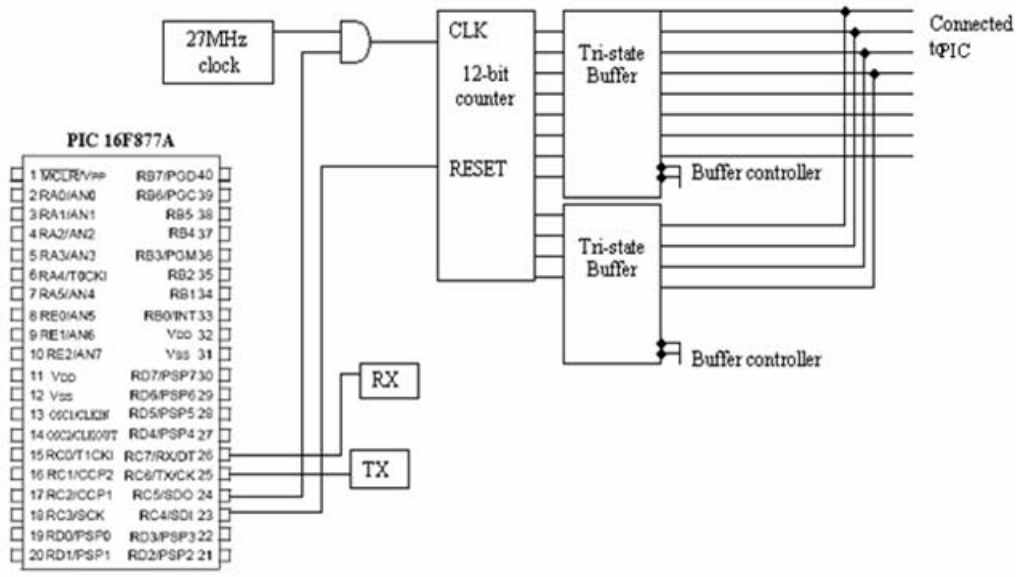
In order to determine indoor distance between each child and their parents, three methods were tested: Time of Flight, Using logic gates with RF and change amplitude of RF signal.

#### 4.1.1. Time of Flight

In this method, the distance will be determined by calculating the time that RF signal will take in flight. The hardware implementation of this method is shown in figure 4 with the following steps that must be applied:

- Reset the counter.
- Send request from parent for a predefined character.
- Start the counter.
- Wait until receive the character from child.
- Stop the counter and take its reading.

**Figure 4:** Hardware Implementation of Time of Flight Method.




The problem in this method is that the differ of distance will affect the time by number of nanoseconds but the problem with child program will affect time by microseconds or less, so this approach failed.

### 4.1.2. Using logic gates with RF

In this method the Manchester encoder and decoder were used in order to avoid the problem mentioned in the previous method. The hardware connection of Manchester encoder and decoder are shown in figures 5 and 6.

**Figure 5:** Hardware connection of Manchester Decoder with receiver.

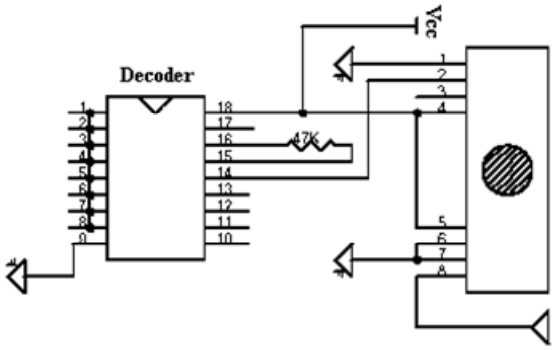
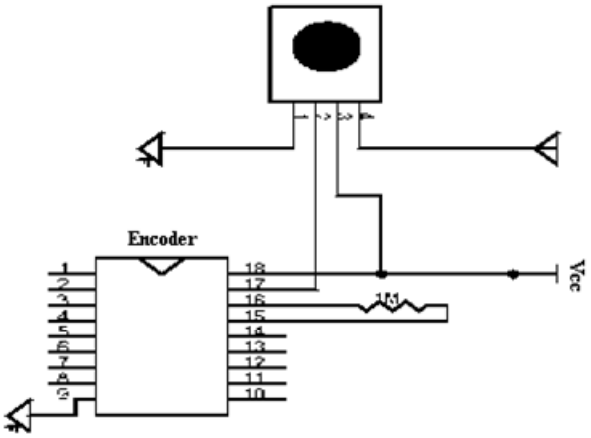
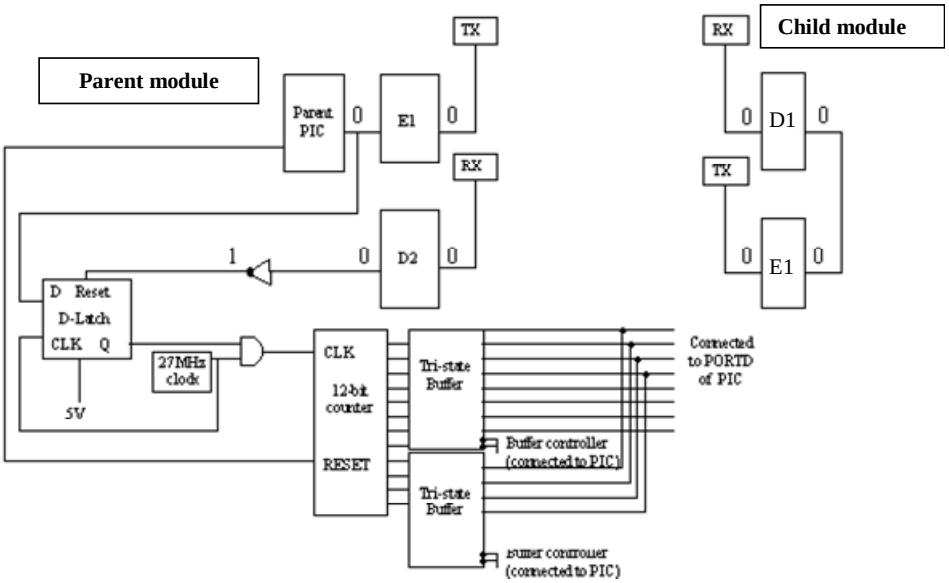



**Figure 6:** Hardware connection of Manchester Encoder with transmitter.




As shown in figure 7, the hardware implementation of this method is starting by sending logic 0 from parent PIC to its transmitter which will be received by child. Child transmitter will detect the signal which comes from receiver, and then it will reply to parent receiver. This signal will reset the D-Latch, which control the counter and stops it. But unfortunately, the delay in logic gates was not fixed which affect time by microseconds or less as in the previous method, so this approach failed also.

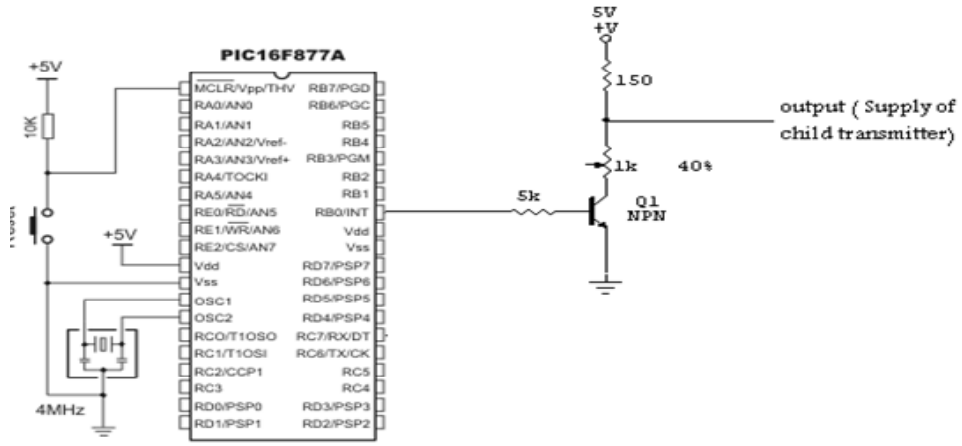
**Figure 7:** The hardware implementation of Encoder & Decoder method.




### 4.1.3. Change Amplitude of RF Signal

This method concentrates on the change of RF signal amplitude. To reduce the attenuation of the signal, the child's transmitter voltage source of RF will be limited to 3 meter only. In this paper this method was used to determine the indoor distance between each child and their parent. So, when the parent choose the indoor option; this system start working by transmitting a signal from parent to child in an equal intervals of time and waiting child's response. If the parent doesn't receive any reply from the child; the parent module will know that the child is out of range. Then the result will be displayed on the LCD and the buzzers will turned ON. Figure 8 shows the hardware implementation of this method.

**Figure 8:** Hardware Implementation of Change Amplitude of RF Signal

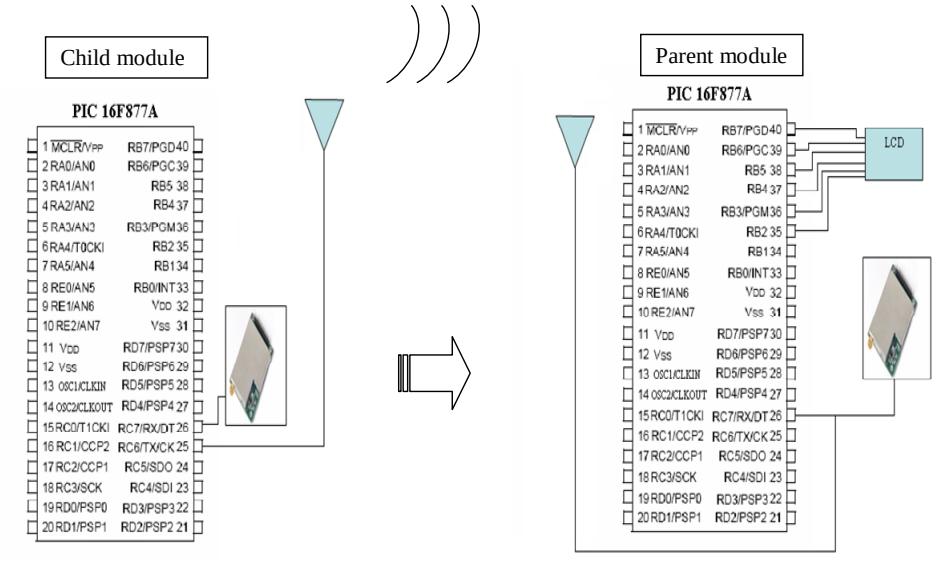



### 4.2. Outdoor Circuit Calculation

As shown figure 9 there are two GPS receivers one in child module and the other in parent module. The GPS in child module was used to receive data (Altitude & Longitude) and send them through PIC 16F877A to parent module which is also connected to another GPS.After that some calculation must be

performed in parent module to know how far the child is from his/her parent and give an alarm if the child exceeds the entered distance. The following approximate distance calculations are relatively simple, but can produce distance errors of 10 percent. These approximate calculations are performed using latitude and longitude values in degrees.

**Figure 9:** Hardware Connections of GPS




After that some calculation must be performed in parent module to know how far the child is from his/her parent and give an alarm if the child exceeds the entered distance. The following approximate distance calculations are relatively simple, but can produce distance errors of 10 percent. These approximate calculations are performed using latitude and longitude values in degrees.
The first approximation requires only simple math functions to approximate distance in miles:

$$\text{Distance} = \sqrt{x^2 + y^2} \tag{1}$$

Where: x = 69.1 * (lat2 - lat1), y = 53.0 * (lon2 - lon1)

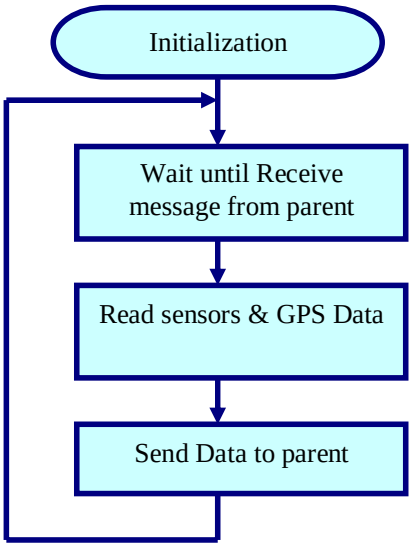
If you need greater accuracy, you can use the Great Circle Distance Formula. This formula requires use of spherical geometry and a high level of floating point mathematical accuracy - about 15 digits of accuracy (sometimes called "double-precision"). To convert latitude or longitude from decimal degrees to radians, divide the latitude and longitude values in this database by 180/pi, or approximately 57.29577951. The radius of the Earth is assumed to be 6,378.8 kilometres, or 3,963.0 miles. So, the Great Circle Distance Formula (GD) by using radians can be calculated as below:

GD= 3963* arccos[sin(lat1) * sin(lat2) + cos(lat1) * cos(lat2) * cos(lon2 - lon1)] (2)

## 5. System software

The underlying structure of the two system modules (parent and child) are shown in figures 10and 11. As shown in figure 10, when the parent switches the child module on, the program will put all the initialization and will ready to work. Then it waits until receive message from parent asking to send its state which include sensors data & GPS reading. After the child module receiving this message it will read its available data and send it to parent. This operation will continue on same loop till the parent switch the module off.

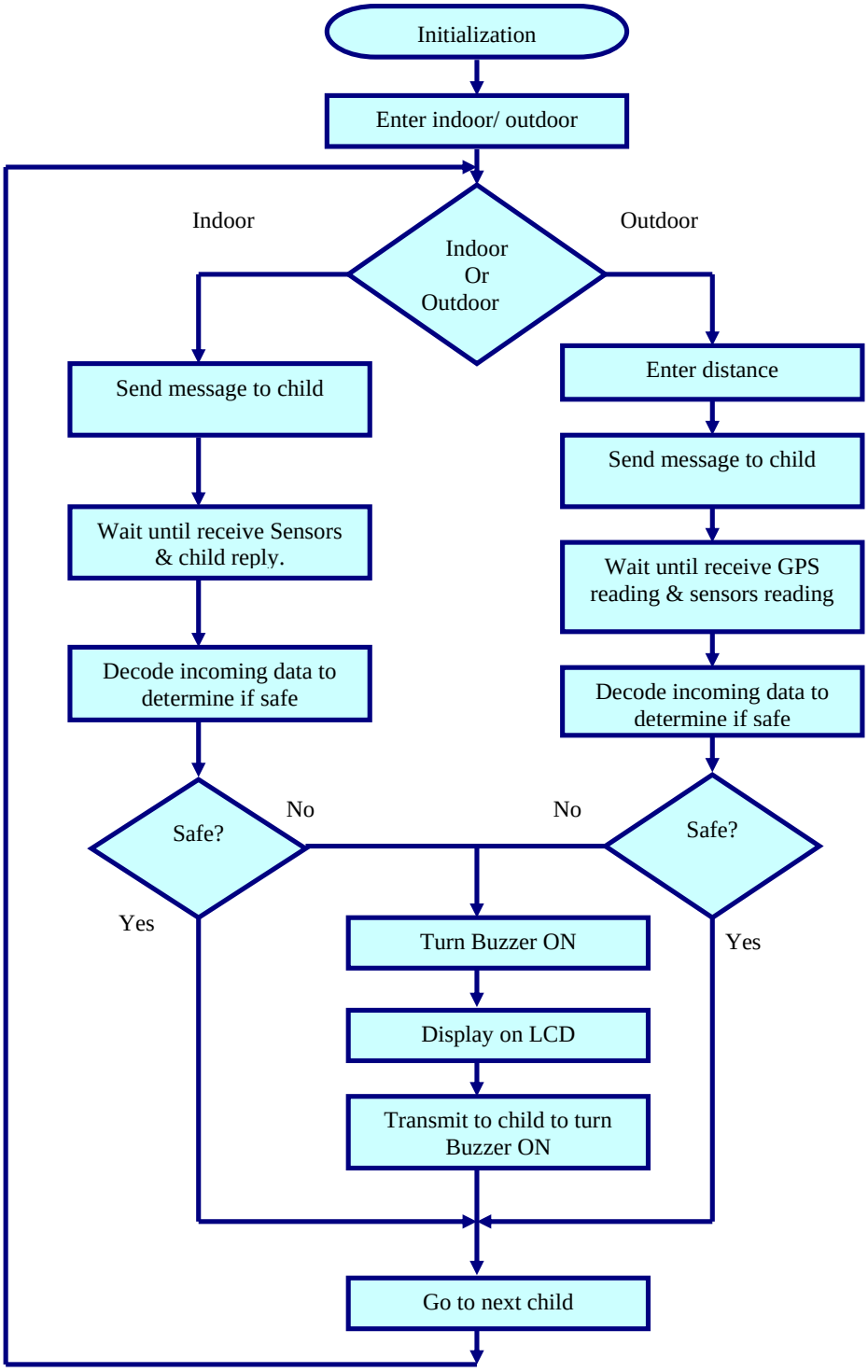
**Figure 10:** Flow chart diagram of Child Module




When the parent switches his/her module on, he/she will enter the place where they are want to stay (indoor or outdoor), and then he/she will enter the required distance.

If the parent will enter indoor choice, the system start by sending message to the selected child to start timer, then waits until receiving data (sensors & GPS reading) from that child. After that parent module stops the timer and calculate the distance by solving some equations and compare the result with the entered one and determine whether the child is in safe state or not.The parent module will do the same thing if parent enters the outdoor choice but without starting the timer because parent module will wait the GPS reading.Now, if the decoding result will be not in safe state, the buzzer will be turned on and the result will display on LCD and finally, transmit to child to turn the buzzer on also, and then go to check the next child. But if the decoding result will be in safe state, so the module will switch to the next child to check his/her state.These operations will continue on same loop until the parent switch the module off.

**Figure 11:** Flow chart diagram of Parent Module




## 6. Result

In this paper it's very important to be aware about the size, cost, style and performance of the designed child tracking system as below:

### a. Size Format

The parent module and child module will be held by parent and child all time they needed, some hours for example, so they should be small with low weight.

**b. The cost**

The product will be very open for commercialization according to its specification which represented by monitoring more than one child for more than one dangerous situation and it can be easily updated as customer request. So it's useful to make a complete system for parents with little cost.

**c. Product style**

Product should be accepted by customers especially by children. So, the child module is designed to be as back bag with different colours for boys and girls, while parent module as a box can be handled by parent easily as shown in figure 12

**Figure 12:** The shape of End Products

**d. Product performance**

The designed system has the following performances:

- The system will nearly solve the problem of actually tracking children problems.
- The designed system has saved parents time.
- It also greatly eases stress and allows parent more freedom during excursions with their children.
- The flexibility of the designed system, since child holds a small device, also parent has to hold a small device that runs automatically after parent turning it on and it can be used anywhere.
- The system can be easily updated as customer's need, for example connecting a new sensor to monitor certain dangerous or adding a new child.
- Suitable for many children.

## 7. Conclusions and Future Work

All parent wish to shield their children from real dangerous they will inevitably undergo hard times. Normal behavior of any child depends on the child's age, personality, and at the end the physical and emotional development. A child's behavior may be a problem if it doesn't match the expectations of the family or if it is disruptive.So Parents may face many problems with their children, when they let them free without any observation especially if they have many children that may face many dangers.

There are many tracking system available in present time, these systems use different technologies but each of them has one or more limitation such as not suitable for many children or monitor how far the child from their parent without monitoring the environment surrounded the children or can monitor only one state at a time. While the designed tracking system allows parent to monitor multiple children and they will be alarmed if any child be in danger state. The danger states that were taken in the consideration are: missing far away from their parent, falling into a swimming

pool, leaving in a hot car, leaving behind gas heater. The flexibility of the designed system makes it easy to add new sensors for any child.

Upon the completion of this project the following conclusions can be drawn:

- The designed system can be extended and updated to be used in other practical applications as:
  - Monitoring patients in hospitals by connecting medical devices to the patient to be in contact with their doctor.
  - Monitoring an adults, specials needs peoples and elderly family members.
  - Monitoring and locating animals, and any dependant who needs special supervision.
- There is no monthly fee associated with any of tracking system.
- As a future work it better to replace normal LCD by Graphical LCD (GLCD) in order to display path of each child when child goes out of range.

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