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FPGA Based Vehicle Tracking and Accident Warning using GPS

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Abstract— In highly populated Countries like India, during accidents, people lose their lives due to unavailability of proper medical facilities at the right time. This project senses any accident in the vehicle and intimates pre-programmed numbers like the owner of the vehicle, ambulance,police etc. The GSM technology is used to send the position of the vehicle as a SMS to thosenumbers. And also the position of the vehicle can be obtained by the owner of the vehicle oranyone with proper permission by sending an SMS to a number. Most of the companies wants tokeep track of their vehicles, with this equipment we can keep track of the vehicle by periodicallysending SMS and the position of the vehicle is sent by the GSM modem as a SMS to the user.To know the position of the vehicle, the owner sends a request through a SMS. This isreceived by a GSM modem in the device and processed by the Spartan processor and theprocessor sends command to a GPS module in the device. The GPS module responds with coordinates position of the vehicle. This position is sent to the user as a SMS to the user with date,time, latitude and longitude positions. When there is an accident, the accelerometer sensor detects the change in position and sends a signal to the processor. The processor analyses the signal and finds there is an accident.
It immediately sends the position of the vehicle and also the information that there is an accident,to pre-programmed numbers such as the owner of the vehicle, police, ambulance etc. So the ambulance arrives in time and the police can arrive in time to clear the traffic. This reduces the time taken by ambulance to arrive and also traffic can be cleared easily.

Index Terms— GPS,GSM,SMS,FPGA,HDL,VHDL VHSIC ,TDMA ,FDMA,GMSK ,LPC,NMEA,LUT,CPLD.

1 Introduction

This paper is mainly used to track the position of the Vehicle by the owner or can also be used in the public transportation system by the people to know the location of the buses or trains. In case of any accident, the system sends automated messages to the pre-programmed numbers. We can send messages to any number of mobiles. The owner of the vehicle, Police to clear the traffic, Ambulance to save the people can be informed by this device. This uses a GPS (Global Positioning System) to know the exact position of the vehicle with an accuracy of a few feet. GSM is used to receive SMS from the user and reply the position of the vehicle through a SMS. A FPGA is used to control and co-ordinate all the parts used in this system. When there is any accident, an accelerometer sensor is triggered and it sends signal to the FPGA. The FPGA circuit processes the input and sends the appropriate output according to the programming done.

This can also be used for other purposes such as asset tracking, Stolen Vehicle recovery, Fleet management, Field Service Management, Field Sales etc. Industries not traditionally known to use vehicle tracking systems have started to use it in creative ways to improve their processes or businesses. The hospitality industry has caught on to this technology to improve customer service. For example, a luxury hotel in Singapore has been known to install vehicle tracking system in their limousines to ensure they can welcome their VIPs when they reach the hotel. Vehicle tracking systems have also been used in food delivery and car rental companies.

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2 System Overview

This paper is custom made for the heavily populated countries like India. Accident warning System is used to save the person's life by making the medical facilities arriving in time. The Vehicular tracking System can be used by the owner of the Vehicle to track the position of the vehicle and also can be used by the people in public transportation Systems.
In public transportation System, People can know the location of the buses or trains which will ease them. The location of the vehicle can be known by using a GPS receiver. Once the SMS is received from user, the response is sent to user via a GSM modem. An accelerometer sensor is used to detect any accident which will trigger a signal in case of any accidents. A FPGA Spartan processor is used to coordinate all the parts in this system according to the program done.

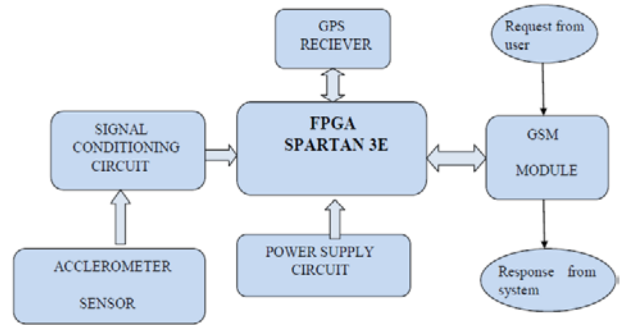

Fig. 1. General Block Diagram

2.1 Linear Power Supply Circuit

A linear power supply is the oldest and simplest type of power supply. In these power supplies, electrical isolation can only

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be provided by bulky line frequency transformers. The ac source can be rectified with a bridge rectifier to get an uncontrolled dc, and then a dc-to-dc converter can be used to get a controlled dc output. The output voltage is regulated by dropping the extra input voltage across a series transistor (therefore, also referred to as a series regulator). They have very small output ripple, theoretically zero noise, large hold-up time (typically 1–2 ms), and fast response.

The action of a transformer is such that a time-varying (AC) voltage or current is transformed to a higher or lower value, as set by the transformer turns ratio.

The transformer does not add power, so it follows that the power (V × I) on either side must be constant. That is the reason that the winding with more turns has higher voltage but lower current, while the winding with less turns has lower voltage but higher current. The step down transformer converts the AC input with the higher level to some lower level. A bridge rectifier converts the AC voltage into DC voltage. A four-transistor converter (Bridge Rectifier) that can generate the highest output power than other types of rectifiers. The filter circuit resists the unwanted AC signals. The regulator down-convert a DC voltage to a lower DC voltage of the same polarity.

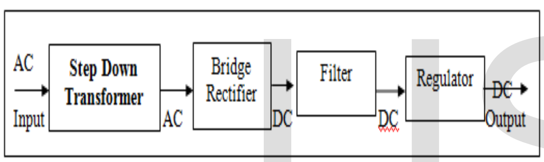

Fig 2 A General block diagram of GSM Modem

2.1.2 Multi Output Power Supply Circuit

It is also possible to generate multiple voltages using linear power supplies. In multi output power supply a single voltage must be converted into the required system voltages.
(for example, +5V, +12V and -12V) with very high power conversion efficiency.

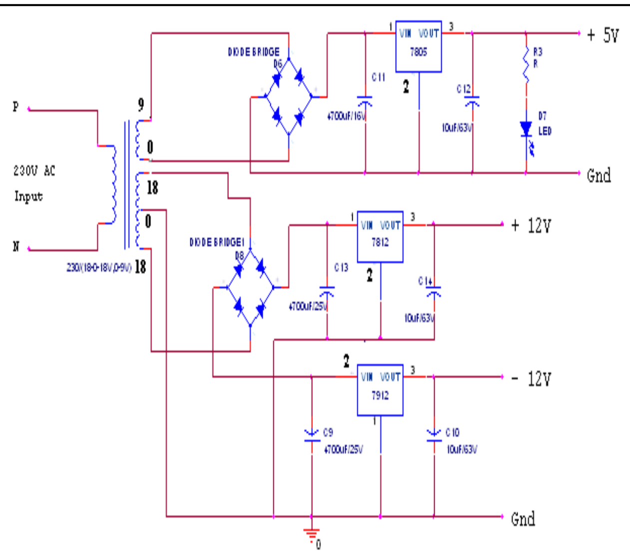

Fig 3 Multi output power supply

2.2 GSM Modem

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves. A GSM modem can be an external device or a PC Card/ PCMCIA Card. Typically, an external GSM modem is connected to a computer through a serial cable or a USB cable. A GSM modem in the form of a PC Card / PCMCIA Card is designed for use with a laptop computer. It should be inserted into one of the PC Card / PCMCIA Card slots of a laptop Computer.
Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate. Both GSM modems and dial-up modems support a common set of standard AT commands. You can use a GSM modem just like a dial-up modem. In addition to the standard AT commands, GSM modems support an extended set of AT commands. These extended AT commands are defined in the GSM standards. With the extended ATcommands, you can do things like:

1. Reading, writing and deleting SMS messages.
2. Sending SMS messages.
3. Monitoring the signal strength.
4. Monitoring the charging status and charge level of the battery.
5. Reading, writing and searching phone book entries.
6. SIM Phonebook management
7. Fixed Dialling Number (FDN)
8. Real time clock

The number of SMS messages that can be processed by a GSM modem per minute is very low only about six to ten SMS messages per minute.

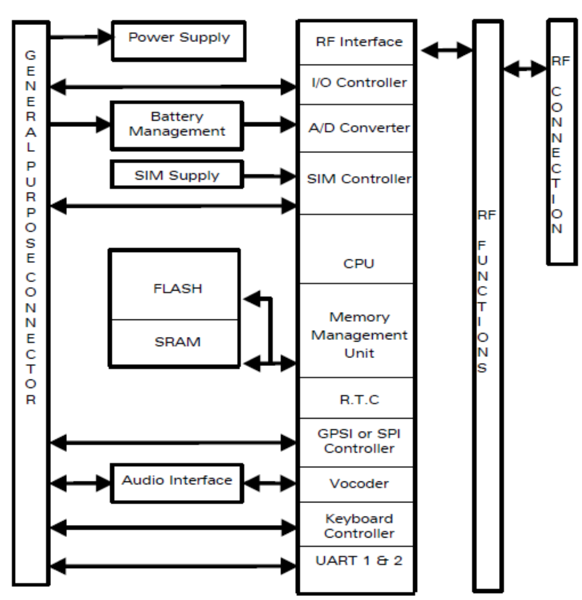

Fig 4 General block diagram of GSM Modem

ISSN 2229-5518

2.3 GPS

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver. When people talk about "a GPS," they usually mean a GPS receiver.

The Global Positioning System (GPS) is actually a constellation of 27 Earth-orbiting satellites (24 in operation and three extras in case one fails). The U.S. military developed and implemented this satellite network as a military navigation system, but soon opened it up to everybody else. Each of these 3,000-to 4,000-pound solar-powered satellites circle the globe at about 12,000 miles (19,300 km), making two complete rotations every day. The orbits are arranged so that at anytime, anywhere on Earth, there are at least four satellites "visible" in the sky.

A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. Each satellite continually transmits messages that include the time the message was transmitted precise orbital information (the ephemeris) the general system health and rough orbits of all GPS satellites (the almanac).

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite. These distances along with the satellites' locations are used with the possible aid of trilateration, depending on which algorithm is used, to compute the position of the receiver. This position is then displayed, perhaps with a moving map display or latitude and longitude; elevation information may be included. Many GPS units show derived information such as direction and speed, calculated from position changes.

2.3.1 GPS Principle

The GPS satellites act as reference points from which receivers on the ground detect their position. The fundamental navigation principle is based on the measurement of pseudo ranges between the user and four satellites. Ground stations precisely monitor the orbit of every satellite and by measuring the travel time of the signals transmitted from the satellite four distances between receiver and satellites will yield accurate position, direction and speed. Though three –range measurements are sufficient, the fourth observation is essential for solving clock synchronization error between receiver and satellite. Thus, the term .pseudo ranges. is derived. The secret of GPS measurement is due to the ability of measuring carrier phases to about 1/100 of a cycle equalling to 2 to 3 mm in linear distance. Moreover the high frequency L1 and L2 carrier signal can easily penetrate the ionosphere to reduce its effect. Dual frequency observations are important for large station separation and for eliminating most of the error parameters.

2.3.2 GPS Reciever

A GPS navigation device is any device that receives Global Positioning System (GPS) signals for the purpose of determining the device's current location on Earth. GPS devices provide latitude and longitude information, and some may also calculate altitude, although this is not considered sufficiently accurate or continuously available enough (due to the possibility of signal blockage and other factors) to rely on exclusively to pilot aircraft. GPS devices are used in military, aviation, marine and consumer product applications.

GPS receivers are composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock (often a crystal oscillator). They may also include a display for providing location and speed information to the user. A receiver is often described by its number of channels: this signifies how many satellites it can monitor simultaneously.

GPS receivers may include an input for differential corrections, using the RTCM SC-104 format. This is typically in the form of an RS232 port at 4,800 bit/s speed. Data is actually sent at a much lower rate, which limits the accuracy of the signal sent using RTCM. Receivers with internal DGPS receivers can outperform those using external RTCM data. As of 2006, even low-cost units commonly include Wide Area Augmentation System (WAAS) receivers. Many GPS receivers can relay position data to a PC or other device using the NMEA 0183 protocol.The main components of a GPS receiver are

Antenna with pre-amplifier

RF section with signal identification and signal processing

Micro-processor for receiver control, data sampling and data processing oscillator.

Power supply.

User interface, command and display panel.

Memory, data storage.

2.4 Hardware Connections

The hardware interface for GPS units is designed to meet the NMEA requirements. They are also compatible with most computer serial ports using RS232 protocols, however strictly speaking the NMEA standard is not RS232. They recommend conformance to EIA-422. The interface speed can be adjusted on some models but the NMEA standard is 4800 b/s (bit per second rate) with 8 bits of data, no parity, and one stop bit. All units that support NMEA should support this speed. Note that, at a b/s rate of 4800, you can easily send enough data to more than fill a full second of time. For this reason some units only send updates every two seconds or may send some data every second while reserving other data to be sent less often. In addition some units may send data a couple of seconds old while other units may send data that is collected within the second it is sent. Generally time is sent in some field within each second so it is pretty easy to figure out what a particular GPS is doing.

Some sentences may be sent only during a particular action of the receiver such as while following a route while other receivers may always send the sentence and just null out the values. Other difference will be noted in the specific data descriptions defined later in the text.

ISSN 2229-5518

Figure 5: A General block diagram of GSM Modem

2.5 Errors

There are two types of positioning errors: correctable and non-correctable. Correctable errors are the errors that are essentially the same for two GPS receivers in the same area. Non-correctable errors cannot be correlated between two GPS receivers in the same area.

2.5.1 Correctable Errors

Sources of correctable errors include satellite clock, ephemeris data and ionosphere and tropospheric delay. If implemented, SA may also cause a correctable positioning error. Clock errors and ephemeris errors originate with the GPS satellite. A clock error is a slowly changing error that appears as a bias on the pseudorange measurement made by a receiver. An ephemeris error is a residual error in the data used by a receiver to locate a satellite in space. Ionosphere delay errors and tropospheric delay errors are caused by atmospheric conditions. Ionospheric delay is caused by the density of electrons in the ionosphere along the signal path. A tropspheric delay is related to humidity, temperature, and altitude along the signal path. Usually, a tropospheric error is smaller than an ionospheric error. Another correctable error is caused by SA which is used by U.S Department of Defence to introduce errors into Standard Positioning Service (SPS) GPS signals to degrade fix
accuracy. The amount of error and direction of the error at any given time does not change rapidly.
Therefore, two GPS receivers that are sufficiently close together will observe the same fix error, and the size of the fix error can be determined.

2.5.1 Non-correctable Errors

Non-correctable errors cannot be correlated between two GPS receivers that are located in the same general area. Sources of non-correctable errors include receiver noise, which is unavoidably inherent in any receiver, and multipath errors, which are environmental. Multi-path errors are caused by the receiver .seeing. Reflections of signals that have bounced off of surrounding objects. The sub-meter antenna is multipath-resistant; its use is required when logging carrier phase data. Neither error can be eliminated with differential, but they can be reduced substantially with position fix averaging.

3.FPGA

A Field-programmable Gate Array (FPGA) is an integrated circuit designed to be configured by the customer or designer after manufacturing—hence "field-programmable". The
FPGA configuration is generally specified using a hardware description language (HDL), similar to that used for an application-specific integrated circuit (ASIC) (circuit diagrams were previously used to specify the configuration, as they were for ASICs, but this is increasingly rare). FPGAs can be used to implement any logical function that an ASIC could perform. The ability to update the functionality after shipping, partial re-configuration of the portion of the design and the low non-recurring engineering costs relative to an ASIC design (notwithstanding the generally higher unit cost), offer advantages for many applications.
FPGAs contain programmable logic components called "logic blocks", and a hierarchy of reconfigurable interconnects that allow the blocks to be "wired together"—somewhat like many
(Changeable) logic gates that can be inter-wired in (many) different configurations. Logic blocks can be configured to perform complex combinational functions, or merely simple logic gates like AND and XOR. In most FPGAs, the logic blocks also include memory elements, which may be simple flip-flops or more complete blocks of memory.
In addition to digital functions, some FPGAs have analog features. The most common analog feature is programmable slew rate and drive strength on each output pin, allowing the
engineer to set slow rates on lightly loaded pins that would otherwise ring unacceptably, and to set stronger, faster rates on heavily loaded pins on high-speed channels that would otherwise run too slow. Another relatively common analog feature is differential comparators on input pins designed to
be connected to differential signalling channels. A few "mixed signal FPGAs" have integrated peripheral Analog-to-Digital Converters (ADCs) and Digital-to-Analog Converters (DACs) with analog signal conditioning blocks allowing them to operate as a system-on-a-chip. Such devices blur the line between an FPGA, which carries digital ones and zeros on its internal programmable interconnect fabric, and field-programmable analog array (FPAA), which carries analog values on its
internal programmable interconnect fabric.
Architecture of FPGA:
The most common FPGA architecture consists of an array of logic blocks (called Configurable Logic Block, CLB, or Logic Array Block, LAB, depending on vendor), I/O pads, and routing channels. Generally, all the routing channels have the same width (number of wires). Multiple I/O pads may fit into the height of one row or the width of one column in the array.
An application circuit must be mapped into an FPGA with adequate resources. While the number of CLBs/LABs and I/Os required is easily determined from the design, the number of routing tracks needed may vary considerably even among designs with the same amount of logic. For example,
a crossbar switch requires much more routing than a systolic array with the same gate count. Since unused routing tracks increase the cost (and decrease the performance) of the part without providing any benefit, FPGA manufacturers try to

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provide just enough tracks so that most designs that will fit in terms of LUTs and IOs can be routed. This is determined by estimates such as those derived from Rent's rule or by experiments with existing designs.

In general, a logic block (CLB or LAB) consists of a few logical cells (called ALM, LE, Slice etc). A typical cell consists of a 4-input Lookup table (LUT), a Full adder (FA) and a D-type flip-flop, as shown below. The LUTs are in this figure split into two 3-input LUTs. In normal mode those are combined into a 4-input LUT through the left mux. In arithmetic mode, their outputs are fed to the FA. The selection of mode is programmed into the middle mux. The output can be either synchronous or asynchronous, depending on the programming of the mux to the right, in the figure example. In practice, entire or parts of the FA are put as functions into the LUTs in order to save space.

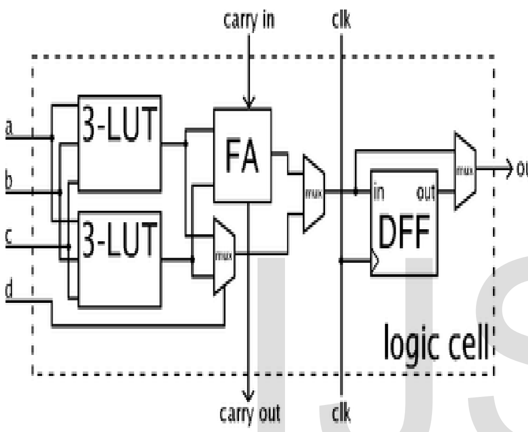

Fig 6 Example of Logic cell

4 Spartan 3E Board

Power Switch: The Spartan-3E Low Cost Kit has a slide power switch. Moving the power switch Up for Power On and down for power off.

Configuration Switch: The Spartan-3E Low Cost Kit has a push button Switch to Configure the FPGA from Xilinx Serial Flash PROM.

Input Switches: The Spartan-3E Low Cost Kit has 8 way Dip switches for giving inputs to the FPGA I/O lines.

5. Accelerometer Sensor

3 Axis Acceleration Sensor Board based on ADXL3XX from Analog devices. It is a first generation 3 axis acceleration sensor. User could get acceleration value of X, Y, and Z axis. And it is widely used in shock, slope, and moving detection. Output sensitivity could be select by simply set voltage level on few pins. The output of MMA7260Q is analog mode, so you need a A/D converter to read the acceleration value.

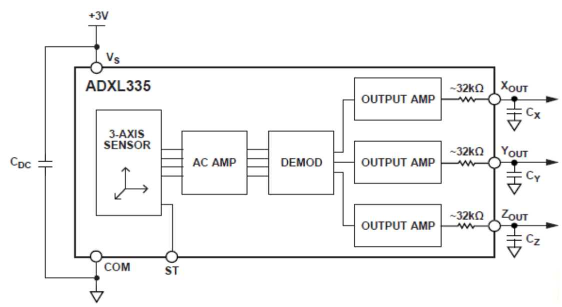

Fig 7 Functional block diagram of ADXL335

5.1.2 Theory of Operation

The ADXL335 is a complete 3-axis acceleration measurement system. The ADXL335 has a measurement range of ±3 g minimum. It contains a polysilicon surface-micromachined sensor and signal conditioning circuitry to implement an open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

The sensor is a polysilicon surface-micromachined structure built on top of a silicon wafer. Polysilicon springs suspend the structure over the surface of the wafer and provide a resistance against acceleration forces. Deflection of the structure is meas-ured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves. Acceleration deflects the moving mass and unbalances the differential capacitor resulting in a sensor output whose amplitude is proportional to acceleration.

Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration.

The demodulator output is amplified and brought off-chip through a 32 kΩ resistor. The user then sets the signal bandwidth of the device by adding a capacitor. This filtering improves measurement resolution and helps prevent aliasing.

2.5.1 Conclusion and Future scope

This version of our paper will send a reply when we send a SMS and also sends the position of the vehicle in terms of latitude and longitude when there is any accident. It doesn't tell the exact nature of the accident, whether it is severe or just a mild one. With the help of accelerometer sensor, we can tell the exact position of the vehicle. We can predict whether the vehicle is in normal position or upside down.

This can be enhanced in future by modifying in the program to find out the actual position of the vehicle and also in accident prevention. This can also be enhanced by automatically locking all the brakes in case of accident. In many accidents, it becomes severe as the drivers lose control and can't stop the vehicle. During the accident, the accelerometer sensor will triggered due to vibrations which is received and processed by the Spartan processor. The processor should be connected to devices which can lock the brakes when triggered. By this enhancement, we
can stop the vehicle and can reduce the impact of the accident.
This can be used to prevent vehicle theft. In case of any theft, the owner can track the location of the vehicle.
In public transport system, the implementation of this equipment will ease the people. When public transport systems like bus, trains these are installed with this equipment, People can know the location of the vehicle and arrive in the stop in time. Modifying the code, we can make it to send the position of the vehicle periodically to a subscribed mobile number so that companies can keep an eye on their vehicles.
Thus we can make use of the available technology to the benefit of the people by saving the lives of the people and helping the owners of the vehicle to keep track of their vehicles.

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