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Real time universal digital clock implementation using GPS

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Abstract:

Global Positioning System (GPS) provides continuous positioning and accurate timing information, anywhere in the world. For running train it is essential that the clocks of all control rooms must show correct time. Atomic clocks give accurate time but it is not economical to provide so many atomic clocks. Therefore, to get accurate time digital clocks with GPS are provided. For everyday motivation, the household clocks are accurate enough. When it comes to sending data down a phone line or navigating by satellite we need as much accuracy as possible. Applications from global communications to satellite navigation, surveying and transport systems are underpinned by precise timing, and the same stable and accurate time scale must be in use everywhere for such systems to operate synchronously. To address all these issues, an accurate digital clock is designed using GPS. Arduino uno is used at the transmitter and receiver side. In the hardware implementation, this digital clock shows the accurate time.

Keywords: GPS, Atomic clocks, Digital clocks, Satellite Navigation, Precise timing, GPS

I. INTRODUCTION

"Time lost is lost forever" is the saying. Improper time will cause lots of loss in the working hours of the staff and the whole facility will work like an un-organized sector. So it is very important to maintain the perfect time in any business or office. In fact, proper time consciousness among the employees, staff or workers will Enhance the productivity and also the personal working output of your facility. Imagine all clocks in your facility are perfectly synchronized, all keeping accurate time. Every official work is time bound. So it is necessary to keep the time synchronized to attain the maximum objective of your facility. To achieve the goals in a specified time frame, it is necessary to keep right time in your facility all-round the year.

A. Aim and Objectives

The main aim of this project is Design and Implementation of GPS Digital clock. To fulfill this main aim the following objectives are carried out: 1. Study of GPS receiver and their data formats. 2. Study of Arduino board and its interfacing. 3. Interfacing of dot matrix LEDs to Arduino in cascaded fashion. 4. Integration of Arduino board with GPS Receiver and also with HC12 Module to transmit the data. 5. Interface the DS3231 RTC with the Arduino.

II. GLOBAL POSITIONING SYSTEM

The Global Positioning System (GPS) is a space-based navigation system (Constellation of 24 Satellites) that provides location and time information in all weather conditions, anywhere on or near the earth. The GPS concept is based on time. The satellites carry very stable atomic clocks that are synchronized to each other and ground clocks. Any drift from true time maintained on the ground is corrected daily. Likewise, the satellite locations are monitored precisely. GPS receivers have clocks as well however; they are not synchronized with true time, and are less stable. GPS satellites continuously transmit their current time and position. A GPS receiver monitors multiple satellites and solves equations to determine the exact position of the receiver and its deviation from true time. At a minimum, four satellites must be in view of the receiver for it to compute four unknown quantities. GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time.



Fig 1. Constellation of 24 Satellites

A. History of GPS

It all started with Sputnik. The Russians launched the Sputnik satellite in 1957, surprising the world. That was the first man-made artificial satellite. Scientists at MIT (Massachusetts Institute Of Technology) noticed that the frequency of the radio signals transmitted by the small Russian satellite increased as it approached and decreased as it moved away. This gave the scientists a grand idea. Satellites could be tracked from the ground by measuring the frequency of the radio signals they emitted, and conversely, the locations of receivers on the ground could be tracked by their distance from the satellites. In 1959 The Navy built the first real satellite navigation system, which it called TRANSIT. The system was designed to locate submarines, and started out with six satellites and eventually grew to ten. But this system is not that much compatible. So, the US Department Of Defence (DOD) came out with a new idea called GPS system. In 1978, they launched the first satellite of a proposed 24 satellite GPS system called NAVSTAR. By 1995 it became fully operational. In the early 20th century several radio-based navigation systems were developed. A few ground-based radio-navigation systems are still in use today.

C. System Description

GPS Technology and its application can be conceived by understanding the three components of GPS. Its three components are:

Space Segment: This part consists of satellites or space vehicles, manufactured by Rockwell International, which are

- launched into space by rockets, from Cape Canaveral, Florida. They are about the size of a car, and weigh about 19,000lbs. Each satellite is in orbit above the earth at an altitude of 11,000 nautical miles, and takes 12 miles, and takes 12 hours to orbit one time. Satellites transmit

signals from space of which time and position of the user is measured. There are 6 orbital planes with 55 degrees inclination, each orbital plane consists of 4 satellites. Control Segment: Consists of ground stations (located around the world) that makes sure the satellites are working

• properly. There are 3 stations for the control segment. They are o Master Control Stations o Monitor Stations o Ground Antennas o Master Control Station: It is located near Colorado Springs in US. They receive the signals from Monitor Stations and pass it to antennas. They are the intermediator between the Monitor Stations and Antennas. The Demodulation and transmission of signals are done here. o Monitor Stations: There are 6 Monitor Stations all over the world. They receive signals from satellites and pass to Master Control Stations. They can receive the modulated signal. They are the one for the maintenance of the satellite and for the control. o Ground Antennas: They monitor and track the satellites from horizon to horizon. They receive demodulated signals from Monitor Control Stations to air and receiver receives those signals. Thus the desired result will be shown in the display. User Segment: The user's GPS receiver is the user segment (US) of the GPS. In general, GPS receivers 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. Originally limited to four or five, this has progressively increased over the years so that, as of 2007, receivers typically have between 12 and 20 channels. Four satellites are required to pinpoint location of the user.

D. Working of GPS

Wherever you are on the planet, at least four GPS satellites are 'visible' at any time. Each one transmits information about its position and the current time at regular intervals. These signals, travelling at the speed of light, are intercepted by your GPS receiver, which calculates how far away each satellite is based on how long it took for the messages to arrive. To find out the distance between the GPS satellites and the GPS receiver, the formula can be taken as Distance = Speed * Time. Once it has information on how far away at least three satellites are, your GPS receiver can pinpoint your location using a process called Trilateration. Trilateration method: Imagine you are standing somewhere on Earth with three satellites in the sky above you. If you

• know how far away you are from satellite A, then you know you must be located somewhere in the region A. If you do for satellite B you can work out your location by seeing where the two circles intersect. If you do the same for satellite C then your position will narrow down to just two points. One point will be far away from the earth. So, you can eliminate that point and you will remain with only one point which is your exact location. This is just what your GPS receiver does, although it uses overlapping spheres rather than circles. The more satellites there are above the horizon the more accurately your GPS unit can determine where you are.

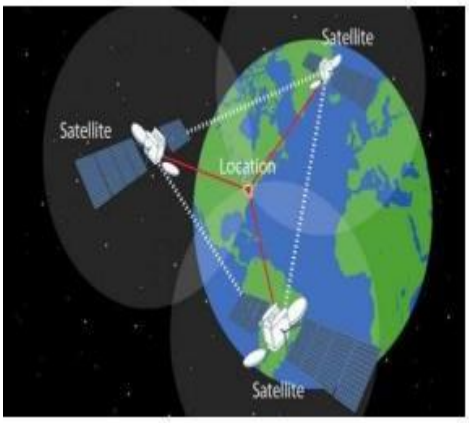


Fig 2. Pinpointing the user by Trilateration method

E. GPS Signals:

GPS satellites transmit two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight, it means they will pass through clouds, glass and plastic but will not go through most solid objects such as buildings and mountains. A GPS signal contains three different bits of information. They are

•**Pseudorandom code:** In cryptography, pseudorandom noise (PRN) is a signal similar to noise which satisfies one or more of the standard tests for statistical randomness. Although it seems to lack any definite pattern, pseudorandom noise consists of a deterministic sequence of pulses that will repeat itself after its period. This is identification or ID code that identifies which satellite is transmitting the information. It is possible to view this information on many SatNav systems. It's a binary code, complicated but a repeated pattern. There is a different PRN code for different satellites. The GPS satellites are actually identified by which PRN code they are transmitting.

•**Ephemeris data:** This data constantly transmitted by each satellite, contains important information about the status of the satellite (healthy or unhealthy), current date and time. This part of the signal is essential for determining a position.

•**Almanac data:** This tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits almanac data showing the orbital information for that satellite and for every other satellite in the system.

III. DIGITAL CLOCKS

Prior to the institutionalization of standard time, clocks were set using local meridians or local mean time, and they varied widely. A digital clock is a type of clock that displays the time digitally as opposed to an analog clock, where the time is indicated by the positions of rotating hands. Digital clocks are often associated with electronic drives, but the "digital" description refers only to the display, not to the drive mechanism. The biggest digital clock is the Lichtzelt Pegel ("Light Time Level") on the television tower Rheinturm Düsseldorf, Germany. In 1970, the first digital wristwatch with an LED display was mass-produced. Over the years, many different types of digital alarm clocks have been developed. Digital clocks are used in different kinds of devices such as cars, radios, televisions, microwave ovens, standard ovens, computers and cell phones.

A. Construction

Digital clocks typically use the 50 or 60 hertz oscillation of AC power or a 32,768 hertz crystal oscillator as in a quartz clock to keep time. Most digital clocks display

the hour of the day in 24-hour format; in the United States and a few other countries, a more commonly used hour sequence option is 12-hour format. Some timepieces, such as many digital watches, can be switched between 12-hour and 24-hour modes. Emulations of analog-style faces often use an LCD screen, and these are also sometimes described as "digital".

Displays: To represent the time, most digital clocks use a seven-segment LED, VFD, or LCD for each of four digits. They generally also include other elements to indicate whether the time is AM or PM, whether or not an alarm is set, and so on.

B. Advantages of digital clocks

• Less expensive

• Easy to understand time concept

• Give time more accurately than analog clock

• Easier to read time

• They can be incorporated into all kinds of devices such as cars, radios, televisions, microwave ovens, computers, cellphones

• Automatic synchronization by a radio time signal

IV. GPS DIGITAL CLOCK

Block Diagram Description

Transmitter:-

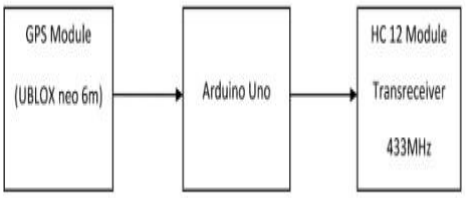


Fig 3. Transmitter

The transmitter part consists of a GPS Receiver module, HC-12 Module, transreceiver and Arduino Uno. The GPS Module which is Ublox neo 6m receives the data sentences called NMEA (National Marine Electronics Association) format from the constellation satellites around earth and the data is given to Arduino Uno. The Arduino is programmed to extract the required time sentence called “$GPRMC” sentence from the list of all sentences. When the required sentence is found then we have to check the sentence till the first comma (‘,’) symbol appear because the data after the first comma is the Universal time data. The time data consists of 6 characters with 2 belonging to hour and the other 2 belong to minutes and the remaining 2 are of seconds data, these 6 characters are stored in a string with a terminating character and the Time data is given to a string and is transmitted with the help of HC12 Module which operates at 433MHz frequency and has a range up to 1000 meters.

Receiver:-

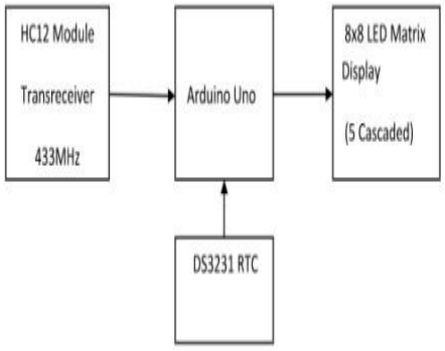


Fig 4. Receiver

The Receiver part of the circuit consists of a HC-12 module transreceiver, DS3231

RTC clock module and five cascaded 8x8 LED matrix display. All the devices require the 5V DC supply which is given by the Arduino Uno. Here, the HC12 Module receives the data that is transmitted from the HC12 Module at the transmitter. This data is given to Arduino which is programmed to calculate the time at the given location such that the first characters are assigned to hour integer type and the next two to minute integer and the other two characters to the second integer type. Now these integers are manipulated such that the time at the particular location is obtained and are set to 24 hour format. For example the time at our location is 5 hour 30 minutes ahead of the Universal time. So the hour integer is added with 5 and the minute integer is added 30 minutes. This calculated time is used to sync with the Real Time Clock (RTC). If there is any loss in Transmission then the RTC clock becomes active and is used to calculate time. The time is displayed using the 5 Cascaded 8x8 LED matrix display

V. HARDWARE DESCRIPTION

Arduino Uno:-

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. We can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so we use the Arduino programming language (based on wiring), and the Arduino Software (IDE), based on Processing. The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16MHz quartz crystal, an ICSP header and a reset button.

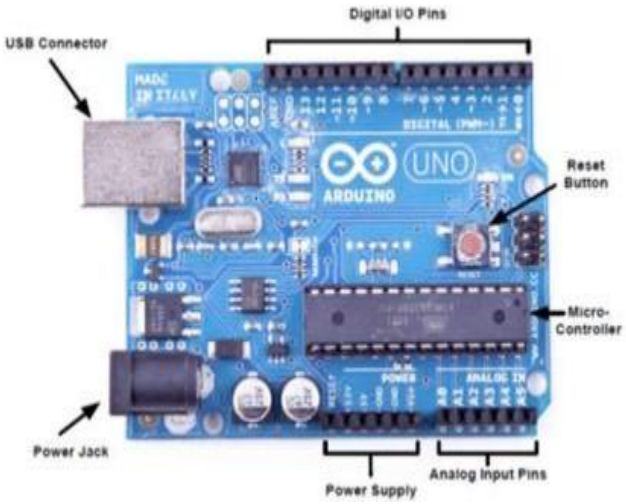


Fig 5. Arduino Uno

GPS module:

The ublox neo 6m GPS module consists of four pins and also it has patch antenna. National Marine Electronics Association (NMEA) controls the GPS receive data. The pins are vcc, ground, transmitter and

receiver. Patch antenna is used to receive the data from the satellites. These satellites transmit three bits of information – the satellite's number, its position in space, and the time the information is sent.



Fig 6 GPS Module (Ublox neo 6m)

ADVANTAGES

• GPS digital clock provides the accurate timing and synchronization of time for every device.

• Instead of using more GPS receiver modules only one can be used in the premises.

• There will be no confusion with different clock timings.

• The power consumption of GPS receiver decreases.

• If the transmitter range is more we can effectively cover large areas.

• The signal from transmitter is strong so the time can be easily updated.

• LED display with no back light.

• The LED Display has the maximum visible range.

DISADVANTAGES:-

• When the Environmental conditions are bad the GPS receiver does not work properly.

• The RTC clock which has to be synchronized with GPS clock has battery issue problems.

APPLICATIONS

Indian Railway Stations: Generally, in Indian Railways the master-slave method is used to display time in different

• platforms but they all are wired connection and there is a lot of power consumption. By using this wireless transmission, the power consumption decreases. Aviation: In Airplanes, the weak GPS signals are received and they are strengthened using the RF Transmitters.

• Banking: In banking services the time plays the key role. To synchronize the time in all areas we use the GPS time.

• Stock Markets: In stock markets to synchronize time all around the world we use GPS time signals.

• Organizations: In Organizations like educational institutions the time in the whole premises around the organization is

• controlled using only one GPS receiver module.

FUTURE SCOPE

If the GPS signals are strong then we can receive the signals even in the indoor areas and we can avoid non line of sight

• problem We can also share the other types of from the received GPS signals

like location, behavior and altitude of the satellite.

- All the devices can be synchronized with this wireless transmission.

- The GPS signals are also used in the automatic driving vehicle to trace the location.

CONCLUSION

GPS is an essential element of the global information infrastructure and revolutionary technology that is changing and operating in various fields of development. Every official work is time bound. So it is necessary to keep the time synchronized to attain the maximum objective of your facility. A GPS digital clock is a type of clock which displays time digitally. The GPS digital clocks have many pros than cons, as the time is very important in the present day world the time has to be accurate with no clock errors. So it is better to implement the GPS digital clocks where ever it is important.

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