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VEHICLE CRASHING AVOIDANCE USING WIRELESS SENSOR NETWORK

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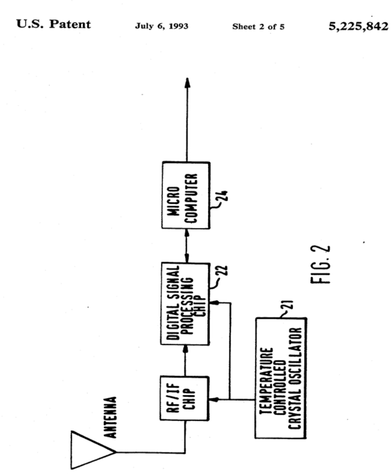
ABSTRACT

A tracking system employing global positioning system (GPS) satellites provides extremely accurate position, velocity, and time information for vehicles or any other animate or inanimate object within any mobile radio communication system or information system, including those operating in high rise urban areas. The tracking system includes a sensor mounted on each object, a communication link, a workstation, and a GPS reference receiver. The sensor operates autonomously following initialization by an external network management facility to sequence through the visible GPS satellites, making pseudo range and delta range or time difference and frequency difference measurements. No navigation functions are performed by the sensor, thereby permitting significant reductions in the cost thereof. The raw satellite measurements, with relevant timing and status information, are provided to the communication link to be relayed periodically back to the workstation. Differential corrections may also be provided at the workstation to increase the accuracy of the object location determination. In normal operation, three satellite measurements are required to compute the location of the object, but for a short time period a minimum of two satellite measurements are acceptable with time, altitude, and map aiding information being provided by the workstation.

Key words: GPS-RPC-Transmitter-Shortest path algorithm.

INRODUCTION

In the event that one of the sensors is activated, the controller determines which sensor the signal is received from, and obtains an alarm code corresponding to this sensor from memory 60. At the same time, the in-built modem or DTMF transmitter 54 automatically goes "Off-Hook" and the transceiver commences scanning all adjacent cellular sites, for their signal strength readings, selecting the highest value readings from readings from the two antennas. At this time, the controller initiates a dialing sequence to the appropriate telephone number, per the numbers stored in memory 60, to link up with the computer at the central monitoring station. In conjunction with the controller, the transceiver transmits an alarm message or packet of information to the central computer. This packet is continuously updated and transmitted at periodic intervals to the telephone number as long as the alarm condition exists. The telephone number dialed automatically corresponds to the computer installed at the central monitoring station.The packet of information will include the type of alarm code, the vehicle i.d., other vehicle identifying information, and the frequency channel information sectoring information, and signal strength information received from all the adjacent cell sites. The data communications between the vehicle unit and the computer at the monitoring station use conventional modem to modem communication with a reliable communication protocol.



ACKGROUND AND SUMMARY OF THE INVENTION

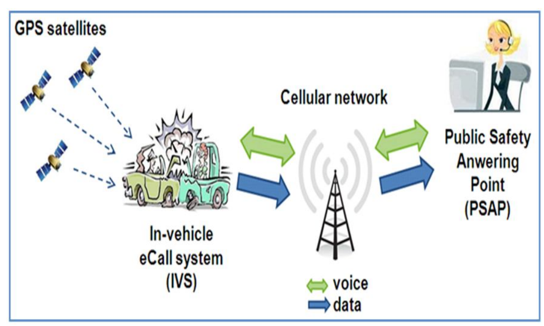
This invention relates generally to navigation systems and more specifically to a system for tracking vehicles and other objects on or near the earth's surface using satellites of the Global Positioning System (GPS). The GPS is a multiple-satellite based radio positioning system in which each GPS satellite transmits data that allows a user to precisely measure the distance from selected ones of the GPS satellites to his antenna and to thereafter compute position, velocity, and time parameters to a high degree of accuracy, using known triangulation techniques. The signals provided by the GPS can be received both globally and continuously. The GPS comprises three major segments, known as the space, control, and user segments.

The space segment, when fully operational, will consist of twenty-one operational satellites and three spares. These satellites will be positioned in a constellation such that typically seven, but a minimum of four, satellites will be observable by a user anywhere on or near the earth's surface. Each satellite transmits signals on two frequencies known as L1 (1575.42 MHz) and L2 (1227.6 MHz), using spread spectrum techniques that employ two types of spreading functions. C/A and P pseudo random noise (PRN) codes are transmitted on frequency L1, and P code only is transmitted on frequency L2. The C/A or coarse/acquisition code, is available to any user, military or civilian, but the P code is only available to authorized military and civilian users. Both P and C/A codes contain data that enable a receiver to determine the range between a satellite and the user. Superimposed on both the P and C/A codes is the navigation (Nav) message. The Nav message contains 1) GPS system time; 2) a handover word used in connection with the transition from C/A code to P code tracking; 3) ephemeris data for the particular satellites being tracked; 4) almanac data for all of the satellites in the constellation, including information regarding satellite health, coefficients for the ionospheric delay model for C/A code users, and coefficients used to calculate universal coordinated time (UTC).

The control segment comprises a master control station (MCS) and a number of monitor stations. The monitor stations passively track all GPS satellites in view, collecting ranging data and satellite clock data from each satellite. This information is passed on to the MCS where the satellites' future ephemeris and clock drift are predicted. Updated ephemeris and clock data are uploaded to each satellite for re-transmission in each satellite's navigation message. The purpose of the control segment is to ensure that the information transmitted from the satellites is as accurate as possible.

GPS is intended to be used in a wide variety of applications, including space, air, sea, and land vehicle navigation, precise positioning, time transfer, attitude reference, surveying, etc. GPS will be used by a variety of civilian and military organizations all over the world. A number of prior art GPS receivers have been developed to meet the needs of the diverse group of users. These prior art GPS receivers are of a number of different types, including sequential tracking, continuous reception, multiplex, all in view, time transfer, and surveying receivers.

A GPS receiver comprises a number of subsystems, including an antenna assembly, an RF assembly, and a GPS processor assembly. The antenna assembly receives the L-band GPS signal and amplifies it prior to insertion into the RF assembly. A significant factor affecting the accuracy of the computed position, velocity or time parameters is the positional geometry of the satellites selected for measurement of ranges. Generally, the best position solution is obtained using satellites having wide angles of separation. Considerable emphasis has therefore been placed on designing antenna systems to receive, with uniform gain, signals from any point on the hemisphere.



This design approach tends to result in an expensive antenna assembly.

The RF assembly mixes the L-band GPS signal down to a convenient IF frequency. Using various known techniques, the PRN code modulating the L-band signal is tracked through code-correlation to measure the time of transmission of the signals from the satellite. The doppler shift of the received L-band signal is also measured through a carrier tracking loop. The code correlation and carrier tracking function can be performed using either analog or digital processing.

The control of the code and carrier tracking loops is provided by the GPS processor assembly. By differencing this measurement with the time of reception, as determined by the receiver's clock, the pseudo range between the receiver and the satellite being tracked may be determined. This pseudo range includes both the range to the satellite and the offset of the receiver's clock from the GPS master time reference. The pseudo range measurements and navigation data from four satellites are used to compute a three dimensional position and velocity fix, to calibrate the receiver's clock offset, and to provide an indication of GPS time.

Information deliver to RPC Method

In some known receivers, the receiver processor controller (RPC) functions are performed using a computer separate from that on which the navigation functions are performed. In other known receivers, both types of functions are performed by a single computer. The RPC processing and memory functions that a typical GPS receiver performs include monitoring channel status and control, signal acquisition and reacquisition, code and carrier tracking loops, computing pseudo range (PR) and delta range (DR) measurements, determining data edge timing, acquisition and storage of almanac and ephemeris data broadcast by the satellites, processor control and timing, address and command decoding, timed interrupt generation, interrupt acknowledgment control, and GPS timing, for example. These functions are fixed point operations and do not require a floating point coprocessor.

The navigation processing and memory functions performed by a typical GPS receiver include satellite orbit calculations and satellite selection, atmospheric delay correction calculations, navigation solution computation, clock bias and rate estimates, computation of output information, and preprocessing and coordinate conversion of aiding information, for example. These functions require significant amounts of processing and memory and are generally performed using a floating point coprocessor.

The GPS standard positioning service provides a navigation accuracy of 100 m 2dRMS. A number of applications of the GPS require higher levels of accuracy. Accuracy can be improved using a technique known as differential GPS (DGPS). This technique involves operating a GPS receiver in a known location. The receiver is used to compute satellite pseudo range correction data using prior knowledge of the correct satellite pseudo ranges, which are then broadcast to users in the same geographic area. The pseudo range corrections are incorporated into the navigation solution of another GPS receiver to correct the observed satellite pseudo range measurements, thereby improving the accuracy of the position determination. Correlation of the errors experienced at the reference station and at the user location is dependent on the distance between them, but they are normally highly correlated for a user within 350 kilometers of the reference station.

An alternative to the GPS receiver known in the prior art is the GPS translator, which includes only the antenna assembly and RF assembly portions of a GPS receiver. Translators are typically employed in missile tracking applications where small, lightweight, expendable sensors are required. The GPS C/A code spread spectrum signals received by the translator are combined with a pilot carrier and transmitted at S-band frequencies (2200 to 2400 MHz). A GPS translator processor located at the telemetry tracking site receives these translated GPS C/A code signals and estimates the position and velocity of the vehicle.

Known variants of the GPS translator are the digital translator and the transdigitizer. A vehicle-borne GPS digital translator or transdigitizer operates to convert the GPS C/A code spread spectrum signals to base band and Perform in-phase and quadrature phase sampling at a rate of about 2 MHz. Transdigitized GPS signals in a ground based translator processing system are processed much like GPS signals.

In summary, prior art GPS receivers may be one of two types. In the first type, all navigation processing activities occur at the receiver, which outputs the vehicle position and velocity using either a single computer or an RPC and navigation computer, in which there is substantial interconnection between the RPC functions and the navigation functions for satellite selection and acquisition. In the second type of GPS receiver, the GPS signal is remoted by translation or variations thereof and the signal is tracked at a ground processing facility where the vehicle position and velocity are derived. In accordance with this latter approach, significant bandwidth is required to transmit the translated signal.

It is therefore the principal object of the present invention to provide a low cost tracking system for vehicles and other objects, using GPS satellites, that is capable of tracking several hundred vehicles or platforms using a low bandwidth data link.

It is a further object of the present invention to provide a low cost vehicle tracking system, using GPS satellites, that has the ability to function accurately in high rise urban areas by employing an antenna system optimized for high elevation satellites and by employing mapping aiding functions in a VLS workstation to reduce the number of satellites that the system is required to receive for short periods of time.

VLS network transmission

These and other objects are accomplished in accordance with the illustrated preferred embodiment of the present invention by providing a GPS sensor module that supplies the data required to locate a particular vehicle, a two-way vehicle location system (VLS) communication link, and a VLS workstation to process the data and display the vehicle location. The GPS sensor module comprises an antenna and a sensor. The sensor operates autonomously following initialization by the network management facility. The sensor sequences through the visible GPS satellites, making pseudo range (PR) and delta range (DR) or time difference (TD) and frequency difference (FD) measurements. No navigation functions are performed by the sensor, thereby permitting significant reductions in the cost thereof. The raw satellite measurements, with relevant timing and status information, are provided to the VLS communication link to be relayed periodically back to the VLS workstation. Using this set of raw satellite measurements, the location of the sensor can be determined to a precision of 100 meters. If differential corrections are also provided at the VLS workstation, the accuracy of the vehicle location determination can be improved to better than 10 meters. In normal operation, three satellite measurements are required to compute the location of the vehicle, but for a short time period a minimum of two satellite measurements are acceptable with time, altitude, and map aiding information being provided from the VLS workstation. The principal advantage afforded by the present invention is its ability to provide extremely accurate position, velocity, and time information for vehicles, including those in high rise urban areas, using a low cost vehicle sensor and any mobile radio communication system or information system. By eliminating the navigation functions performed in prior art GPS sensors, a low cost computer may be used, thereby providing a significant cost reduction over existing GPS receiver designs.

CONCLUSION

Under heterogeneous vehicular network, a FSMT mechanism has been proposed to transmit safety messages. When the V2V network is inappropriate for safety message transmission, the VLS network will been abled to help in transmitting safety message and completing accident and diversion notifications. Simulation results revealed that, in the high density environment, when V2V network failed to pass safety message out due to media congestion, safety message can be received ahead of time to 0.86 second through networks help. On the other hand, in low density environment, safety message can be received significantly ahead of time to 0.85 minute by leveraging VLS networks wide transmission range to allow the rear vehicles well prepared in advance, and thus minimize accident damage.

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