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Realization research of security based on the criteria in a car tire pressure monitoring system

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ABSTRACT

With the popularity of cars in many families, car driving safety is becoming more and more attention. Among the many problems abnormal tire pressure is to influence the car safety and car key to effective maintenance and maintenance. So real-time monitoring tire pressure has a very important significance. Currently, which has been widely applied in the automotive industry is a kind of known as TPMS (tire pressure monitoring system) of automobile safety equipped with high-tech products. But the major shortcoming of this system is not reflected in the all-weather tire condition monitoring with the needs of real-time monitoring tire pressure, while the vehicle cannot be remote alarm. In order to better solve this deficiency, in this proposed a new type of tire pressure monitoring system design scheme based on nRF9E and GSM module. Program from two aspects of hardware and software introduced the structural characteristics and realization method of this new tire pressure monitoring system, especially a lot of space for the system's low-power design and implementation of key display tire positioning were highlighted. Through some reliable practice tests, proved that the system can not only real-time monitoring tire condition, but also can according to the abnormal situation of vehicle distance range alarm prompt. This message can communicate by means of GSM module timely feedback to the owners. Vehicle CAN network interface is to ensure the sustainability of such a system in a low power state operation. Reliability and safety aspects have been improved significantly.

KEYWORDS

TPMS; nRF9E; Tire positioning; GSM; real-time monitoring.

INTRODUCTION

With the rapid development of China's automobile industry and the continuous improvement of people's living standards, more and more car among ordinary families become one of the major travel tools. The rapid spread of the car brings people travel considerable convenience, but because the driving safety car accidents district brought shocking people make every year. According to some authoritative survey shows that safety accident frequency in recent years in China presents the trend of increased year by year, in the frequent occurrence of the accident nearly 70% because of low tire pressure or caused by leakage of the tire. When the speed was not less than 160 km, the mortality rate due to accidents caused by tire puncture close to 100%. Thus, to ensure the safety and reliability of the tire, the tire situation to improve early warning capabilities for reducing cars with security incidents, reduce mortality in automobile accidents have a very important significance.

As can be seen from the relevant investigation and analysis, the key factor of ensuring a standard tire pressure driving and timely detection for the relevant car tire pressure is automobile tire pressure and temperature coefficient of each related such as continuous real-time monitoring effectively. So in recent years, both domestic and foreign auto industry will TPMS tire real-time monitoring research and development as an important research topic in the automotive industry.

The proposed new type of car tire pressure monitoring system is also the one of the more research direction. Research is expected to solve the current car tire pressure monitoring system to ensure all-weather monitoring tire condition, and can't be remote warning problem. At the same time hope to solve these problems on the basis to build a low-input, high efficiency, real-time monitoring system to ensure that the overall study results. These have good practical value and broad market prospects.

INTRODUCTION THE OVERALL DESIGN OF THE SYSTEM

The overall structure parsing of the system

TPMS development up to now, mainly including two important types. One is the indirect TPMS, the operating principle of this system is to control the use of ABS wheel speed sensors to compare tire wheel speed difference. By analyzing the differences data achieve the purpose of monitoring the tire pressure. The premise of this application are coaxial with at least one tire in a tire that meets the criteria of safety driving. The second is the direct TPMS, the main principle of operation of such a system is controlled by the pressure sensor mounted directly on the tire in the tire pressure measurement operation. It transmitted to the radio modulation by enabling placement of the bridge on the monitor. If tire has problems, this system will make the appropriate alarm operation.

New car tire pressure monitoring system of this design is built on top of the two monitoring systems. On the basis of the existing system modules, it added a tire testing modules, wireless receiver module, human-computer interaction module, GSM module. The overall structure shown in Figure 1.

The whole system main include real-time monitoring process and remote tire vehicle alarm processes these two workflows. Specific for tire real-time monitoring process: the detection module using a tire valve mounted on the external of the tire mounting method, and make real-time measurement of the temperature and pressure, acceleration parameters. The measurement data is transmitted to the wireless receiving module via the communication interface. Wireless receiver module via CAN communication interface to transfer data to human-computer interaction module by way of numbers or charts display the corresponding information. It can help visually observe the condition of the tires owners, such as unusual to timely alarm.

Remote vehicle alarm process in particular: when owners are away from the vehicle, once the vehicle suffered violent destruction of the situation, GSM module is activated through extensive coverage of GSM networks. The owner will be passed in their mobile devices, such as cell phones receive the appropriate information prompt, thus ensuring the owners to make appropriate and timely response.

The two main advantages of the system, one is the use of the CAN communication interface. It is possible to ensure that the system continued to run at a low-power state, increasing the sustainability of the overall operation of the system. Second is the vehicle through GSM sudden alarm. Covering a wide range of uses GSM as an information medium, as long as the owner is to be able to ensure timely receipt of alarm information in the GSM coverage area, greatly expanding the warning system's ability to adapt to different regions. At the same time, the reason for the break up because of the distance the effectiveness of the shackles of the original system.

Introduction tire positioning function

In order to enhance the chances of the system actually used, this design is very focused on reliability and low cost factors aspects. The new real-time tire pressure monitoring system with the two main design principles basis, use the button to display the tire positioning technology. In this way it can fully use the existing TPMS hardware resources, not adding additional hardware. It just need to take appropriate arrangement and software upgrades complete build new system.

In the building of the actual system, tire replacement and maintenance is very easy to implement. Because tire position detection module's location is the outer area of the valve, so just put the detection module is removed, install the new replacement tires. When the detection module appear damaged, do not need to disassemble the tires just to the detection

module can be replaced, so that greatly simplifies system maintenance and upgrade operations, enhance the usability of the system.

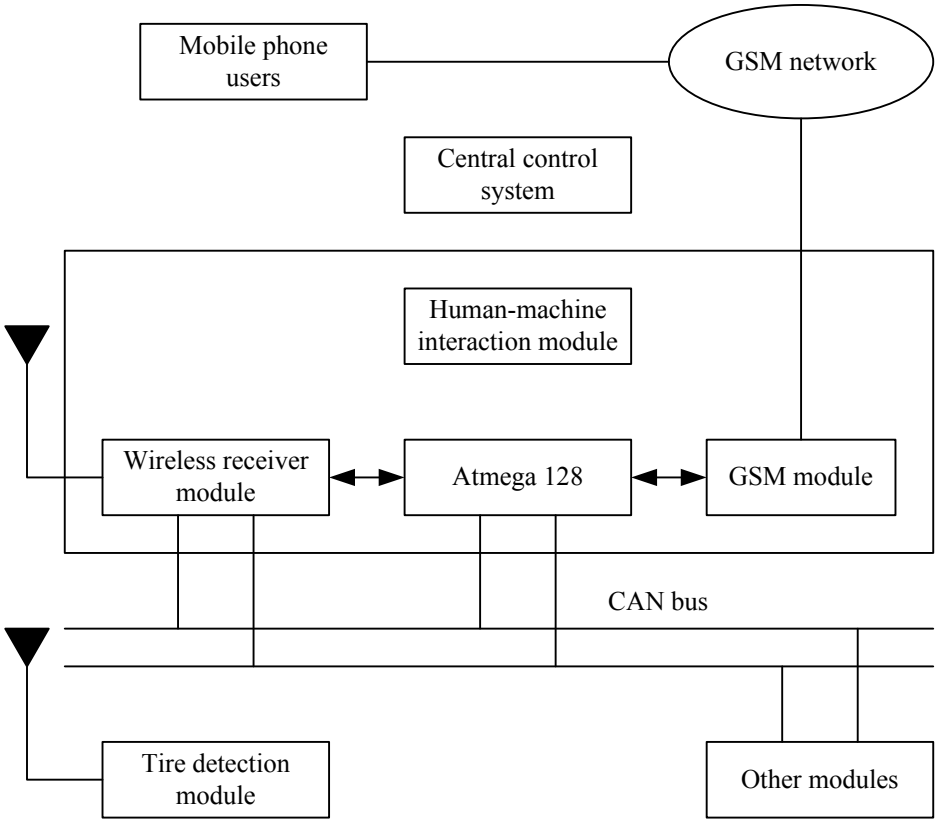

Figure 1 : The overall block diagram of a system diagram

Tire detection module specific steps for installation and replacement:

First, the new detection module access to the serial port module, by setting the button to enter setting module, selected location location, this time should be punished accordingly tire indicator lit, press the OK button to confirm the positioning location. Then display module position information stored in the tire through the serial port detection module and display module to display text or icons to the owners. At last, set a good position information detection module positioned tire valve placed in the external area.

The new system of low-power design ideas

This new type of tire in low power real-time monitoring system design ideas mainly reflected in two aspects of hardware and software. First of hardware, it mainly through lower energy consumption of some components to achieve. Low power software aspect is the use of efficient algorithms combine coordination system, which can be swapped sleep mode to ensure the system in low power state normal operation.

Hardware components used in low-power design presentation

(1) Transmitter chip

Taking into account the difficulty of detection module volume for the the impact of the installation, the program selected MCU and launch chip integrated device-nRF9E5. nRF9E5 is NordieVLSI introduced system-level RF chip, has been widely used in the automotive industry. Using the characteristics of the chip by the built-in high-performance enhanced 51 single-chip microcomputer and guarantee under the working voltage of 1.9 to 3.6 V, the power consumption of the single chip computer to run at full speed to 1 mA @ 4 m, standby power consumption for 2 mu A, through conventional battery can keep the chips in the condition of low power operation. According to the power consumption from big to small order, the chip can be divided into to send, receive, standby and sleep four states. Among them, the energy consumption of the largest is sending state, the typical current of 3 0mA. Receiving state followed by a typical current of 1 2. 5 mA. Typical standby current is 3 2μA. While in power-down (sleep) state, the energy consumption is minimized, the typical current of only 2. 5 μA.

This ensures that the user can be based on the actual tires need to switch between different states to monitor.It can improve the efficiency of data communication, reduce unnecessary to send and receive, thus greatly improve the overall sustainability of the ability to run the system, reduce the system power consumption.

(2) Sensor

Sensor is a normal operation of the joint of the whole system, which play very important role for the system continuous and stable operation. For sensors, it is necessary to meet the real-time high, strong stability requirements but also meet the low-power design principles, so the program uses the Infineon SP12 multi-functional sensors.

The SP12 versatile sensor-specific wake transient mode, it can ensure that every 6s work unit outputs a wake-up signal, every 50min output a reset signal. When replacement to sleep mode, this sensor current consumption is only 0.6 μA / s. In order to ensure the efficiency of communication transmission tell, through the integration of the acceleration sensor on the wheel enough manner module wake up mechanism to further accelerate the sensor. The greater the speed of the wheels, the greater the centrifugal force can be provided, thus also providing a wake-up mechanism of acceleration the larger. Vice versa when the smaller vehicle speed, the centrifugal acceleration becomes smaller, the speed is very small even when the car is stopped, the system will automatically go to sleep.

By the equation $a = w^2r$ (where w is the angular velocity of rotation of the wheel, a is centrifugal acceleration of the wheel rotation, r is the distance from the axle to the transmitter module) can be easily calculated by the centrifugal acceleration of the wheels, and then determining the size of the centrifugal acceleration. The use of software the program set in advance and the transmission data measurement interval spacing to achieve effective control of the number of communications and the communication speed of the sensor module with the MCU, so the power consumption of the sensor will be placed in a very high control ability of the low-power control state to ensure the system running at a steady low-power state.

(3) Central microprocessor

Central microprocessor centralized data processing and conversion module, so as to run the large amount of power in the overall system occupies a large proportion. In order to reduce the power consumption of of the hardware impact, the program uses based AVRRISC structure ATmegal128 type 8 low-power CMOS microprocessor. By adjusting the software configuration, this microprocessor can be swapped six different power-saving mode. The different power saving mode can be switched directly to the operating mode provides the user with hardware-based micro-power consumption under the control of the premise.

The new wheel tire pressure monitoring system for software programming that is based on the use of the characteristics of this central microprocessor. Through the preparation of an application to the central microprocessor do proper settings. Specific settings state: When there is no data receiving and processing can be placed in a low power mode MCU. When data need to be addressed the receiver is able to quickly wake up in low-power mode, enter the working mode. After work, it can automatically enter a low-power mode, thus forming a low-power mode- operating modes-low-power mode mode conversion mechanism to avoid unnecessary receiving and processing, improve data processing efficiency central microprocessor. But also to ensure the effective delivery of real-time monitoring information under the premise, not the central processor power consumption to a minimum.

Software low-power design ideas

If the selection of hardware for the new type of tire pressure real-time monitoring system for the possibility of a minimum energy consumption, the software of low power consumption design is to help as much as possible in the process of system and the owner in the actual operation of this kind of low energy consumption may be excavated. System software aspects of low-power design is another important aspect to achieve low power systems. In the design of the scheme, an important task is to ensure that adequate inter-module communication has a high efficiency, stable communications with information support. Overall coordination of the system can continue to operate in a stable low-power state.

As can be seen from the user's habits, most of the time the vehicle is in a stopped state, so can achieve low-power operation of the system by letting the system automatically enters sleep mode way to extend battery life. In normal driving the process, it can wake up and accelerate sensors through a combination of selective mode of operation of the exchange system, enabling the system during normal driving in the car with lower power consumption can also be functioning properly.

Specific workflow: The wakeup signal through sensors SP12, when the test acceleration is 0, the car is stopped. If the wake-up signal transmission five times, the test acceleration is still displayed as 0, tire pressure anomaly or destruction can be explained. When the test acceleration is greater than 0 and greater than the set threshold, the vehicle is in the high-speed running state, set the parameters of the tire measured once every 1s by measuring these parameters. The parameters set in advance in the comparing the standard current draw the actual state of the tire. When the test acceleration is greater than 0 and less than the set threshold, indicating that the vehicle is in a low speed running state. It can be set to a longer time interval measuring a parameter of the tire, and then these measured parameters are comparison of the standard parameter set in advance to process obtains the current actual state of the tire. This will ensure that real-time monitoring of the effectiveness and sustainability of vehicle tires can guarantee real-time monitoring system for vehicle tires have lower energy consumption.

From a number of practical applications in data analysis can be found transmit power RF signal is tire pressure detection module power consumption. In order to effectively reduce power consumption, in this way the new monitoring system is taken in the state when the vehicle is traveling, the central microprocessor a threshold set in advance. When the detected pressure is greater than this threshold will not achieve information the complete transmission, i.e. The realization of

a complete cycle of the RF signal in the system, or the RF signal is only transmitted to the central microprocessor to avoid unnecessary transmission of RF signals caused by unwanted power consumption.

When the vehicle is traveling in the road more complex environment, sometimes instantaneous peak detection data. In order to avoid false alarms caused by the peak pressure. module has the added value of a filtering function, so that when the transmission to the central processor is not the pressure value exceeded then the peak is determined as the peak, stop the transmission of the RF signal. When the pressure value measured is indeed exceeded, it can be passed fast transmission mode. Transmit RF signals carried effective and timely alarm. By median filtering module, a central processor interrupt mode operation can be achieved to avoid false alarms invalid information transmission,to improve the accuracy of the alarm and also to reduce power consumption.

SYSTEM HARDWARE STRUCTURE

Power source system is lithium batteries, wake-up signal of SP12 type sensor and turned on by the timer interrupt way to achieve single-chip operating modes swapped. While as information collection and transmission via CAN interface and nRF9E5 achieved. So for reducing overall energy consumption of the system can achieve high efficiency and stability and signal transmission system have a good performance.

The overall circuit frame shown in Figure 2.

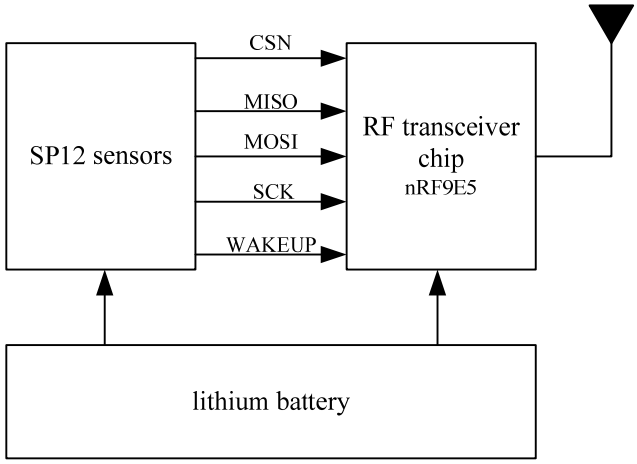

Figure 2 : Tire transmitter module circuit diagram

SYSTEM SOFTWARE DESIGN

The wireless communication protocol

Wireless transmission protocol adopted CFSK modulation, through the microcontroller hardware automatically Manchester encoding/decoding approach to achieve a variety of automatic conversion and signal transmission modes of human-computer interaction. Tire pressure sensing module send the data packets (frames) in the form of data, the specific data frame format as shown in TABLE 1.

TABLE 1 : Data frame format

leading position	tire ID	pressure value	temperature value	voltage value	status bits	parity bit
10	32	8	8	8	8	16

Specific representative meaning: the first six bytes are used to confirm the status of vehicle tire pressure, temperature, voltage value whether does appear to exceed bid, whether is more than the pre-set alarm threshold, whether to need to start the GSM remote alarm communication. Status the remaining two bytes are used to identify real-time location of the tire, the tire ID confirmed by combining the previous improve the reliability of the system in real-time monitoring of vehicle tires and vehicle emergency situation timely warning area.

Tire detection module operating procedures

All-weather detection system operation process follows the tire as shown in Figure 3.

First, when the car is stationary, sensor every once in a while test the pressure of the tire parameters. After the central microprocessor and comparative analysis of pre-set parameters, confirm the data is normal. If the air pressure is normal, it is not down to a module send alarm information. If it exceeds the threshold set, it rapidly transfer the warning

messages. Therefore, when the car is stationary, nRF9E5 most of the time is standby mode, power consumption of the entire system is very small.

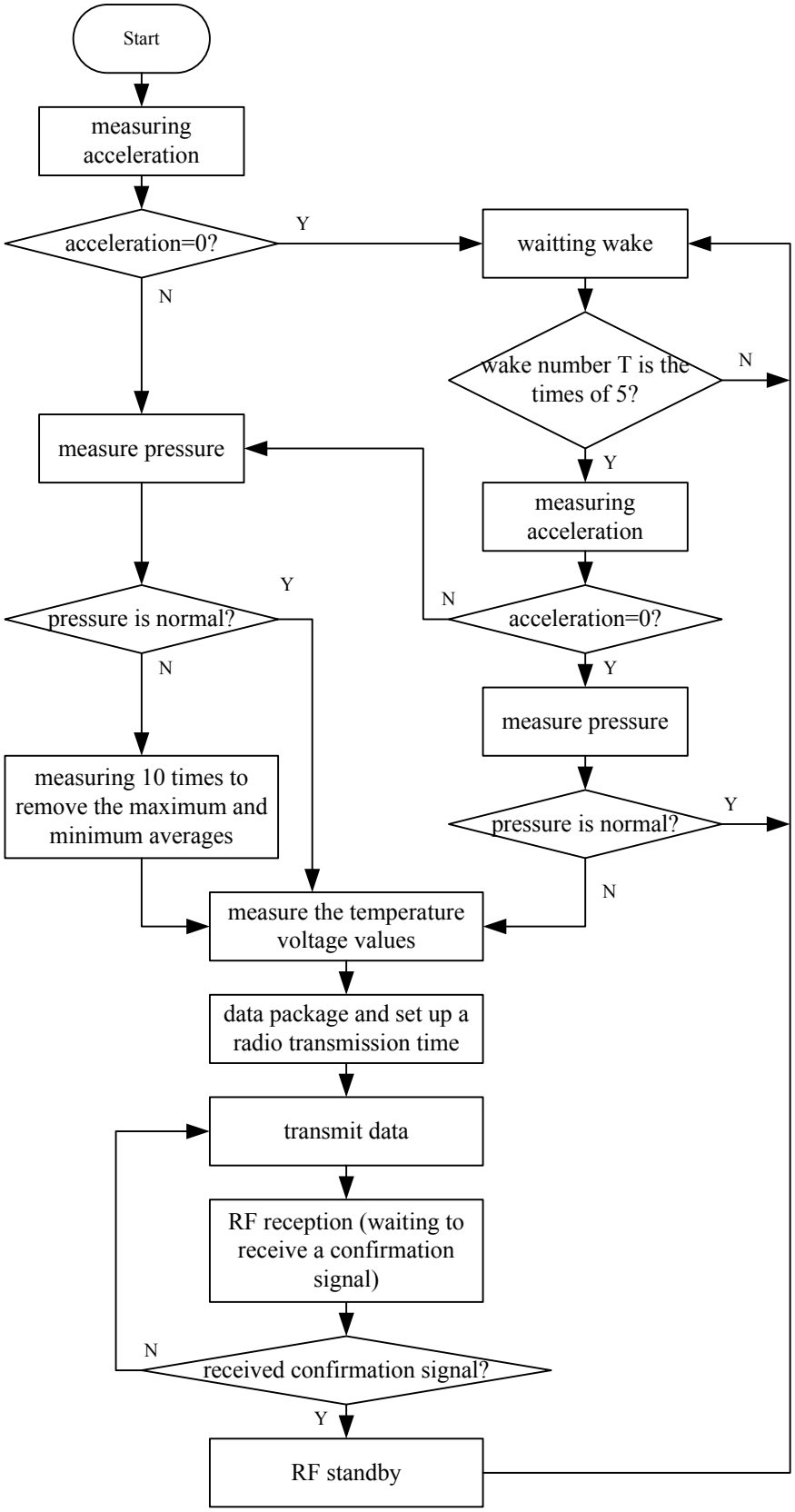

Figure 3 : Tire detection module flowchart

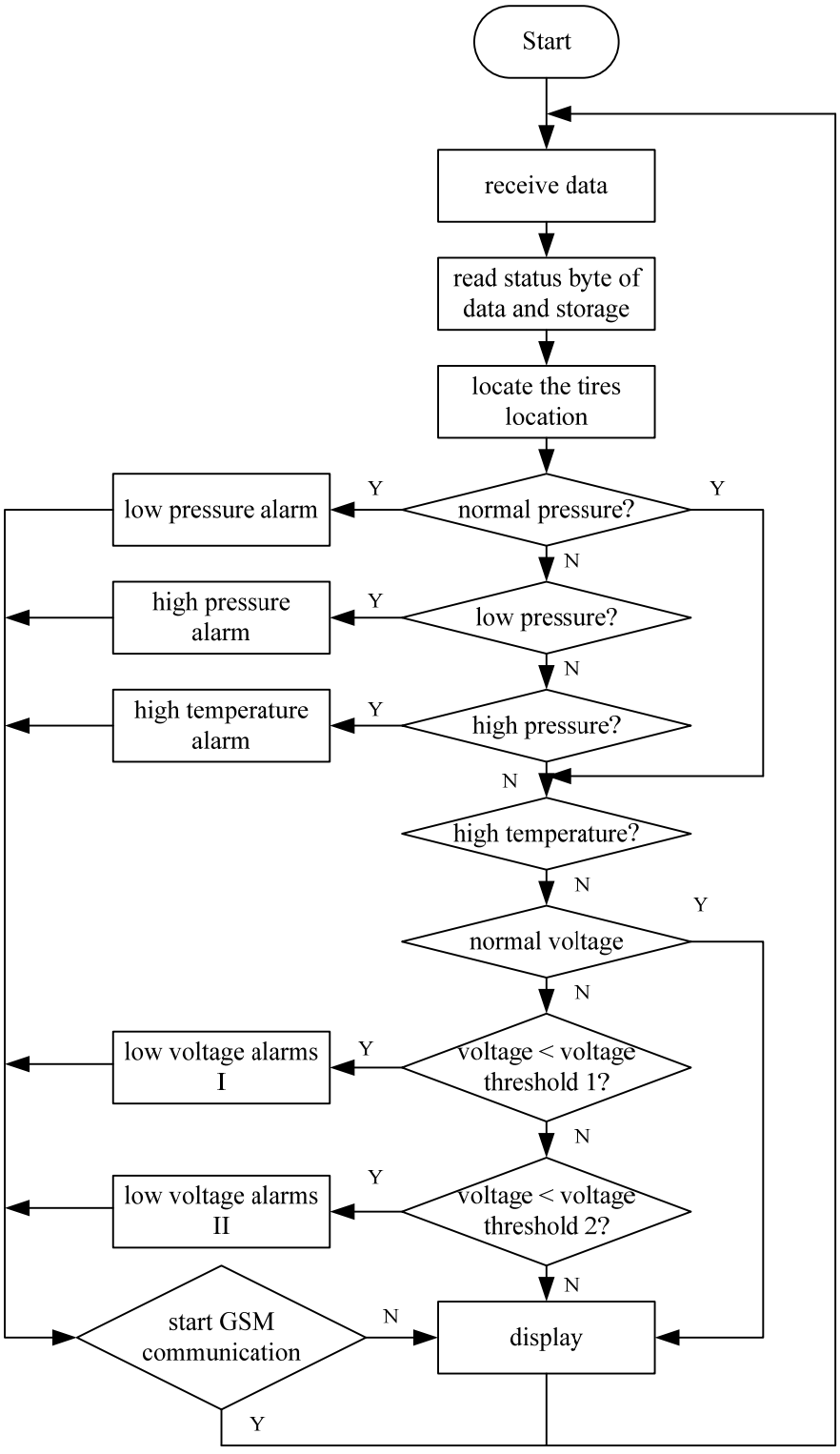

Figure 4 : Alarm displays the flow

Second, when the vehicle is traveling slowly, tire monitoring module every small time interval on the real-time information of the tire testing and transmission. Through the central microprocessor comparative analysis with pre-set parameters, confirm whether the data is normal. If the air pressure is normal, it is not down a module sends an alarm message. If it exceeds the threshold sett, it rapidly transfer the warning messages. In this driving state, nRF9E5 most of the time is standby mode, the power consumption of the entire system is not so big.

Third, when the vehicle is in high speed, tire detection module for real-time information monitoring time interval becomes small tire. Then determination if the central processor is about normal data transmission over 1min device, like a man-machine monitoring data show that once monitor data. If the tire pressure exceeds the threshold, then enter the fast

transmission mode. The alarm information is displayed quickly on the display device in human-computer interaction, to remind owners and timely response measures.

Alarm display operation process module

In the design of the alarm program, alarms into a pressure alarm, temperature alarm, voltage alarm three categories. Through the inside of the car first close transformation LED or LCD display equipment information, such as mosquito, icon and so on. Specific operational flow alarm display module shown in Figure 4.

The alarm process is divided into two conditions under alarm. One is for real-time data to detect wheel over security alarm threshold data anomalies. The other is away from the car when the owner, once the car suffered violent destruction of the GSM system can be realized module remote communication alarm. The two alarm modes can be prompted by the owners in a timely manner, to help owners take faster response measures to avoid personal and property safety of their own to bring more losses.

CONCLUSION

In the scheme design of the new type of car tire real-time monitoring system to solve the traditional TPMS systems in all-weather detection tire situation and can't realize remote alarm. At the same time, low-power components through a number of low power consumption achieved the objectives using the overall system operation, and therefore power consumption, safety, stability, reliability, and other aspects have an considerable advantage. The first to use the button to display the tire positioning methods, the overall operation is simple,and hardware and operating costs are relatively low. In line with the manufacturers constantly need to reduce production costs, in the practical application of market value has very good prospects. Through the wide coverage of the GSM network, realizes the remote vehicle safety warning, also conforms to the future research and manufacturing of on-board network and intelligent vehicle development trend.

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