Drive by Wireless System for Vehicle Control using Steering Brake Throttle Sensors and Servo Actuator Wheels

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Abstract: In todays date almost every automobile vehicle functions in a wired connection. Replacing a wired connection with wireless connection could prove to be productive in economic senses as it will have an effect on the weight and cost. In this project we propose a wireless network to accelerating, braking, control steering and other functions in an automobile. Traditional hydraulic or mechanical methods of steering, braking, accelerating and other controls of a vehicle will be replaced by Drive by Wireless Technique using sensors/switches. Maintenance, flexibility of design is increased and installation of sensor module gets easier. IEEE 802.15.4 standard is used in this intra vehicle wireless sensor network.

Keywords: ADC, LPC1313, MiWi, SERVO

1. Introduction

To connect devices without the use of wires have achieved a good success in consumer goods industry. With this success these technology is used by the industry in other settings too. The cost and the time needed for installation and maintenance of the large number of cables normally required in such an environment can be reduced effectively thus making the configuration of the system more easy. Now in today's vehicular system all the functional components are mainly connected together by a wired connection. As a result of which the system becomes congested and in case of any wire malfunctioning it becomes very difficult for the individual to locate which wire is broken or disconnected. It's time consuming process. Wireless communication [4] has lots of utilities such as low power, multifunctional sensors nodes which are small and can have short distance communication ability. The capacity of the wired connection sometimes become congested and can develop acceptable latency. In this busy schedule of people life and in this competitive world if one gets a light weight, low cost, a productive vehicle then it will be a boon to his life. Drive by wireless Technique [2][12] will not only reduce the weight but also bring the cost down to some extent. For any vehicle to work the three important functions involved are the Steering, Brake, Acceleration. The wired connections between the ECU nodes will be replaced wirelessly. Sensors nodes will be used to sense the position and direction of the vehicle. This wireless system will also reduce the capacity limits of the wires that are associated with wired connections. MiWi wireless network protocol would be suitable for intra vehicular system. A maximum of 15 sensors can be put in the network and they work with a throughput of 12kbps. The Miwi protocol is based on IEEE 802.15.4 standard and it also provides reliable direct wireless communication via an easy-to-use programming interface.

2. Sensor Network System

The recent advancement of Wireless Communication and Digital Electronics and Sensor Technology have enabled the development of low-cost and power, multifunctional sensor nodes which senses processes the data within the communicative devices. Another feature of sensor network is the cooperative effort of sensor nodes. So they don't send the raw data instead they use their processing ability to locally carry out simple computations and transmit only required data. In sensor network the sensor nodes are densely populated and sometimes are prone to failures but the topology of sensor network changes very frequently and generally the use broadcast communication which are limited in power, computation capacities, and memories. Sensor nodes may have Global Identification (ID) because of large amount of overhead and large number of sensors. Sensor networks have a very wide area of applications like in military applications- monitoring friendly forces, equipments and ammunition, battlefield surveillance, targeting, battle damage assessment etc. environmental application forest fire detection, precision agriculture, Bio complexity mapping of environment, flood detection etc. Then in health application like tele-monitoring of human physiological data, tracking monitoring doctors inside the hospital, and drug administration in hospitals etc. In home application they function as smart environment, environmental control in office building, detecting and monitoring car theft etc.

2.1 Hardware Constraints

A sensor node [1] shown in Fig 1 is composed of four basic components: processing unit, sensing unit, power unit, and transceiver unit. They may have the application dependent additional component like location finding power generator, system and mobilizer.



Figure 1: The components of sensor node

The project proposed in this paper generally consists of four nodes such as Electronics Control Unit (ECU) node, Dashboard Unit, Steering Wheel Control Unit, and Driving Wheel Control Unit. Though there are wide variety of sensors available like seismic, low sampling rate magnetic, thermal, visual, infrared, and acoustic, radar etc but we have used Analog Resistive Sensors in the form of Linear and Circular Potentiometer.

3. Comparison of Existing System and Proposed System

The existing system is not at all disadvantageous but it can be modified for man's benefit. Our existing vehicular system somewhat looks like this as below in Fig 2. As it can be seen its highly wired connection and as result of which the wire capacity can go into strain, difficulties can arise in finding the damaged wires, Fuel consumption is more. But in contrast if we look at the proposed system then it's a whole different story. Fig 3 illustrates the proposed system where Drive by Wireless Technique [3] is used.



Figure 2: Existing System



Figure 3: Proposed System

In this system it's clear that all wired connection is removed and wireless connection comes into play. As a result no capacity limits factors of wires, only limited portions to be checked in case of any problem, weight is reduced, cost also comes down.

4. Block Diagram of the Proposed System

Our block diagram in Figure 4 consists of four nodes as discussed above and IEEE 802.15.4 standard is used for wireless communication.



Figure 4: Block Diagram

The Steering, Brake, Accelerator sensors will be associated with the ECU unit and will give the necessary parameters to the other nodes via wireless communication as per the driver's intention.

5. Components Description

The microcontroller preferred for this project is LPC 1313 which is a very powerful Arm Cortex based controller. Linear potentiometers and Circular potentiometer are used for Brake-Acceleration and Steering respectively. Servo Motor is used for the front wheel and DC Motor is used for the back wheel. Graphics LCD Display is used for displaying the parameter position.

5.1 Brief Descriptions

5.1.1 LPC 1313

They are ARM Cortex-M3 based microcontrollers (shown in Fig 5) for embedded application featuring a high level of integration and low power consumption. The ARM Cortex is next generation core that offers system enhancements such as enhanced debug features and a higher level of support block integration. LPC 1313 [11] operates on a CPU frequencies of up to 72MHz. The ARM Cortex-M3 incorporates a 3 stage pipeline and uses Harvard architecture with separate local instruction and data buses as well as a third bus for peripherals. Some important features can listed below for better understanding. ARM Cortex-M3 processor, running at frequencies of up to 72MHz.ARM Cortex-M3 built in Nested Vectored Interrupt Controller (NVIC).It has a 32kb on chip flash programming memory and 8kb SRAM and In System Programming (ISP) and In-Application

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Programming (IAP) via on chip boot loader software.USB MSC and HID on chip drivers.USB 2.0, UART with fractional baud rate generation, modem, internal First In First Out (FIFO) and RS-485/EIA-485 support. I²C bus interface supporting, SSP controller on LPC 1313FBD48/01.LPC 1313 is having 42 General Purpose (GPIO) pins with configurable pull-up and pull-down resistors,4 counter timers, 1 Programmable Watch Dog Timer (PWDT),a Programmable Windowed Watch Dog Timer and a System Tick timer. It also consists of 10 bit ADC with input multiplexing among pins, Power on Reset, Code Read Protection with different security levels.



Figure 5: LPC13xx Microcontroller.

5.1.2 Potentiometers

A potentiometer [9],[10] informally a pot shown in Fig 6 is a three terminal resistor with a sliding contact forms an adjustable voltage divider and only two terminals are used one end and the wiper acts as a variable resistor or rheostat. Electric potential is measured by potentiometer device. Potentiometers are commonly used to control electrical devices such as volume control on audio equipment and they are generally operated by a mechanism which can be used as position transducers. Potentiometers are very common for manual tuning. Two ways of using pots as resistive position sensors are 3-terminal potentiometer (when pots resistance is small) and 2-terminal potentiometer (when pots resistance is large). Nonlinear Circular pots are designed to turn up to a maximum of 270 degree.



Figure 6: Linear & Circular pots

5.1.3 Graphics LCD display

A Nokia 5110 LCD module shown in Fig 7 uses a Philip Pcd8544 driver/controller, which is designed for mobile phones. The PCD8544 controller can handle 5V but operation at 5V can sometimes cause streaks on the LCD display, so 3.3V is preferred. PCD8544 is a single chip LCD cont<u>roller</u>/driver and has 48 rows, 84 column outputs. External RES (reset) input pin. Serial Interface is maximum up to 4Mbps and the Mux rate is 48. Low power consumption, suitable for battery operated system.



Figure 7: Graphics LCD display

5.1.4 DC Motor

A DC motor has a two wire connection. All drive power is supplied over these wires. When a DC motor (Fig 8) is turned on it just starts spinning round and round. Most DC motors are pretty fast of about 5000 rpm. The DC motor speed is controlled by a technique called pulse width modulation or PWM. The idea of controlling motors power level by strobing the power on and off. The concept here is duty cycle- the %age of 'on time' vs 'off time'. If the power is on only 1/2 of the time the motor runs with 1/2 the power of its full on operation.



Figure 8: A DC motor

5.1.5 Servo Motor

The servo motor in the Fig 9 is actually an assembly of four things: a normal DC motor, gas reduction unit, control circuit and position sensing device. The function of the servo is to receive a control signal that represents a desired output position of the servo shaft, and apply power to its DC motor until the shaft turns to that position. It uses position sensing device to rotate the shaft. The shaft can turn a maximum of 200 degree so back and forth. The servo is a three wire connection: ground, power and control. The power source must be constantly applied and the control signal is the PWM but the duration of the positive going pulse determines the position of the servo shaft.



Figure 9: Servo motor

6. Protocols Used

6.1 IEEE 802.15.4

The Microchip MiWiTM P2P Wireless Protocol is a variation of IEEE 802.15.4[6], using Microchip's MRF24J40MA 2.4 GHz transceiver and any Microchip 8, 16 or 32-bit microcontroller with a Inter Integrated Circuit (I^2C) shown in Fig 10. It's having an easy to use programming interface which provides reliable direct wireless [6] communication. It has a rich feature set that can be compiled in and out of the stack to meet a wide range of customer needs – while minimizing the stack footprint.



Figure 10: IEEE 802.15.4 RF Transceiver

MiWi P2P is a proprietary protocol stack developed by Microchip for short range wireless networking [7] applications based on the IEEE 802.15.4 (WPAN) specification. The MiWi P2P protocol modifies the IEEE 802.15.4 specification's Media Access Control (MAC) layer by adding commands that simplify the handshaking process. It provides 16 channels in the 2.4 GHz spectrum (using an MRF24J40 transceiver) as shown in Figure 10 and supports Microchip C18, C30 and C32 compiler, enables frequency agility (channel hopping). Supports a sleeping device at the end of the communication and enables Energy Detect (ED) scanning to operate on the least-noisy channel and also provides active scan for detecting existing connections. Supports all of the security modes defined in IEEE 802.15.4. This protocol is useful for simple, shot range, wireless node to node communication.

6.2 Serial Peripheral Interface

The serial peripheral interface (SPI) is a synchronous interface which allows several SPI microcontrollers or SPItype peripherals to be interconnected. In SPI separate wires are signal are required for data and clock. The MC68HC11A8 SPI system may be configured either as a master or as a slave. The important features includes that it's full duplex and supports master or slave operation. The master bit frequency is 1.5 MHz and the slave bit frequency is maximum 3 MHZ. It has four programmable master bit rates. It has Write collision flag protection, master-master mode fault protection, end of transmission interrupt flag, and programmable clock polarity and phase. The four basic SPI signals are MISO, MOSI, SCK; SS. LPC1313 supports SPI in the pins 2, 13, 26, 38.

6.3 Analog to Digital Converter

A number of sensors have analog output rather than digital signals. So A/D converter is required. LPC1313 supports 10 bit ADC with input multiplexing among 8 pins. Some of the features includes it has a power down mode; its measurement range is 0V to $V_{\rm DD}$. It has a burst conversion mode for single

or multiple inputs and it also having individual results register for each ADC channel to reduce interrupt overhead. The analog signals from the sensors are converted and fed into the controller and later transmitted to the network.

6.4 PWM

Pulse-width modulation (PWM) of a power source involves the modulation of its duty cycle to control the amount of power which is sent to the load. Pulse width modulation uses a square wave whose duty cycle is modulated resulting in the variation of the average value of the waveform. The 48 pin Cortex-M3 NXP LPC 1313 CPU device capable of running up to 72 MHz, board ADC controller. 2 x 32 bit general purpose timers with PWM & capture compare capability.2 x 16 bit general purpose timers with PWM. PWM controls the percentage of time the chip is enabled. The two parameters that affect the behavior of the PWM are frequency and the length of the pulses. The length of the pulse is called the duty cycle.

7. Circuit Diagram and System Architecture

The project is comprised of four nodes which communicates with each other and can be understood by the block diagram. The ECU unit comprises of the steering, brake, and acceleration sensors [5]. The signals are converted to digital and are sent to network. The other nodes receive the signal and functions. For each module the controller [8] is programmed accordingly by LPC development tool LPCXpresso software. The Fig 11-14 shows the functional circuit diagrams of ECU, dashboard unit, rear wheel unit and steering wheel unit followed by system architecture shown in Fig 15.



Figure 12: Dashboard unit



8. Software Requirements

LPCXpresso is a development platform available from NXP which is new and very cost effective shown in Fig 16. The software consist an Eclipse-based IDE, GNU C compiler, linker, libraries, and GDB debugger. The hardware consists of the LPCXpresso development board which includes a LPC-Link debug interface and also NXP LPC ARM-based microcontroller target. LPCXpresso is the powerful tool which helps the embedded engineers to develop their application from initial processing to final development. The LPCXpresso IDE is powered by Code Red Technologies. There is syntax coloring source formatting folding, on-and offline help and extensive project management automation. Some of the features of LPCXpresso IDE are that it's an eclipse based IDE shown in Figure 16. It's a complete tool chain for LPC1300 series of Cortex-M microcontrollers. It has enhanced Debugger and also supports LPC- Link Programmer and Debugger.

8.1 Operating System

Free RTOS is used which is professional grade, license free, robust, open Source Real-Time Kernel. RTOS supports semaphores, mutex, Queues and C configured for both Preemptive and co-operative schedulers. They are both Preemptive and Co-operative schedulers and are ported to Cortex-M3 (LPC1300). RTOS works with LPCXpresso tool chain and takes less than 4kb of Flash memory.

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Figure 16: LPCXpresso IDE

9. Algorithm

The pseudo-codes are shown for the explanation of each node's functional ability. In ECU unit the acceleration, brake, and angle channels are defined. Some reference values are taken as the maximum and minimum value. The pseudo code is as

acc factor=100/acc max - acc min acc data= value received from acc channel / 4 if(data>accmin)&&(data<=accmax) accpos=(data-accmin)*accfactor else if(data>accmax) accpos=100

So by calculating from the reference values the sensors pass the data over the network. In the GLCD unit it checks from which network id the packets came from. One common id has been defined for the whole system and individual id's are also defined. The sensor values will be stored in some registers and then the data is fetched and displayed.

Mainly in front wheel the dc maximum and minimum value are defined. Then again the factor is calculated by fac=(servodcmax - servodcmin)/100

PWM duty cycle is also initialized and the packet is received and ids are matched and the angle position is received and the wheel will turn the same angle. In driving wheel generally acceleration and brake data are fetched from the respective registers and pwm is found out by the node as;

 $Pwm = pwm_offset + (accpos-brakepos)/2$ And the duty cycle too determines the speed of the vehicle.

10. Conclusion

We have explored the design of a prototype model for wireless driving controls of steering, brake, and acceleration

system in a vehicle. This project has an advantageous nature of cutting down the present cost of the vehicle. It also helps in the reduction of the vehicle weight. If this project idea is implemented in present vehicular system then the detection of mechanical problems in vehicles will also become easy. Since in present system if there is a problem with broken wire then it's considered somewhat difficult for the mechanic man to find the correct wire and fix. So to avoid these conditions this project seems to have some advantages to be noticed. Hence if the wired connection of the present vehicular system is replaced by wireless network communication then it will be a boon to the automobile industry as well as to mankind.

11. Future Scope

In future this Wireless Technique can be used for the clutch along with the gear box and also other functions of the vehicle.

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