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Advanced Electronic Stability Control (Esc) With Anti-Lock Braking System (Abs) and Crash Location Sensing Using GSM

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Abstract

A low cost advanced Electronic Stability Control(ESC) assisted with Anti-lock Braking System (ABS) for e-bikes is designed to provide enhanced safety for riders and in addition to this design, during an emergency situation such as crashing, will send the vehicle travelled direction and time to the stored emergency number using GSM. ABS is an electro-mechanical system that helps reduce wheel skid in automobiles by controlling the brake force applied to each wheel, making it easier to stay in control while riding. Active Stability Control or Electronic Stability Control (ESC) is a safety feature that improves the vehicle stability by sensing yaw rate and roll rate in order to improve steering control. This system uses the ABS at its heart for its longitudinal braking control and senses vehicle dynamics and drivers intention in order to stabilize the vehicle by avoiding rolling, skidding and loss of traction.

Keywords: Anti-Lock Braking System (ABS), Electronic Stability Control (ESC), Micro Electro Mechanical System (MEMS), GSM.

Introduction

Vehicles play an important role in everyone’s life, so safety of riders becomes a primary factor. According to a statistics, 40% of the traffic accident was due to the too long braking distance, braking slip and braking deviation, and therefore the automobile brake efficiency is an important guarantee for the safety of driving.

Although ABS for two wheeled vehicles are available, the design of a two wheeled vehicle stability control system constitutes quite a challenging task due to the complexity of two-wheeled vehicles dynamics and to the strong interaction between the vehicle and the driver. For this reason, there is no solution commercially available for two wheeled vehicles that have an active stability control system. But in countries like India, two wheeled vehicles are substantially more than their four wheeled counterpart. Hence we are proposing a project that designs an innovative control architecture which allows us to enhance the active safety and stability of the vehicle while guaranteeing a good driving feeling.

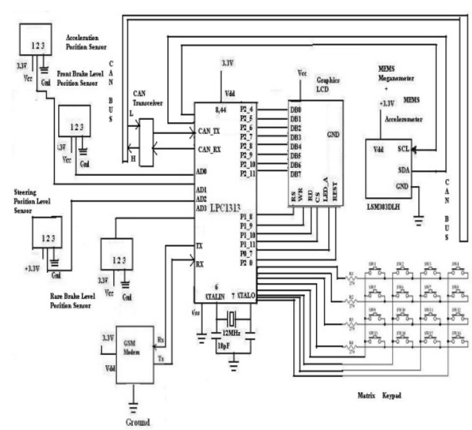

Fig 1: Circuit diagram of ABS and ESC

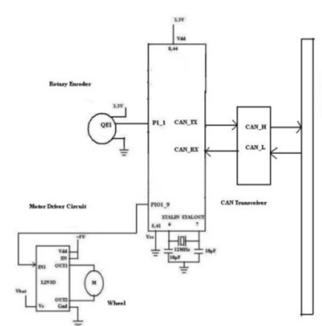

Fig 2: Circuit diagram of front wheel ECU

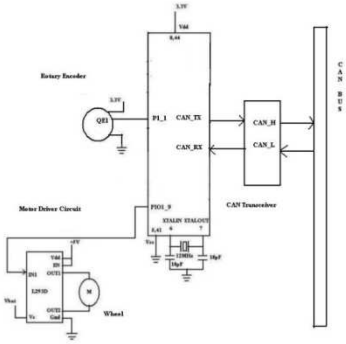

Fig 3: Circuit diagram of rear wheel ECU

Anti-lock Braking system alone does not provide full safety while driving, so it has to be assisted with Electronic Stability Control for efficient working in longitudinal braking as well as in curves or vehicle oversteers or understeers. In case of crash even after all safety measures, the system will sense the crash by using Micro-Electro Mechanical Sensors (MEMS) and send the SMS to the saved number using GSM.

Components Description

A) LPC1313

The LPC1313 is an ARM Cortex-M0 based, low-cost 32-bit MCU family ,designed for 8/16-bit microcontroller applications, offering performance, low power, simple instruction set and memory addressing together with reduced code size compared to existing 8/16-bit architectures. This operates at CPU frequencies of up to 50 MHz. The peripheral complement includes up to 32 kB of flash memory, up to 8 kB of data memory, one C_CAN controller, one Fast-mode Plus I2C-bus interface, one RS-485/EIA-485 UART, up to two SPI interfaces with SSP features, four general purpose timers, a 10-bit ADC, and up to 42 general purpose I/O Pins. On-chip C_CAN drivers and flash In-System Programming tools via C_CAN are included.

The Cortex-M0 processor is an entry-level 32-bit ARM Cortex processor designed for a broad range of embedded applications. It offers significant benefits to developers, including:

- Simple, easy-to-use programmer's model
- Highly efficient ultra-low power operation
- Excellent code density
- Deterministic, high-performance interrupts handling
- Upward compatibility with the rest of the Cortex-M processor family.

The Cortex-M0 processor is built on a high-performance processor core, with a 3-stage pipeline von Neumann architecture, making it ideal for demanding embedded applications. The processor is extensively optimized for low power and area, and delivers exceptional power efficiency through its efficient instruction set, providing high-end processing hardware including either a single-cycle multiplier, in designs optimized for high performance or a 32-cycle multiplier, in designs optimized for low area.

The whole system uses four sensors, they are acceleration position sensor, front brake level position sensor, rear brake position level sensor, steering position level sensors which are used to give details of acceleration applied, braking force in front and rear wheels and steering angles respectively. These values are converted to digital values by ADC in the LPC1313 and these digital values are used to generate PWM waves and run the wheel accordingly.

The controller has 48 General purpose input/ output pins for connecting inputs and outputs. All the pins are inputs as default. A keypad can be connected to this system using this GPIO pins. The ABS, ESC and GSM systems can be activated whenever needed.

B) Can Controller -MPC2515

The three electronic control units which are present in dashboard, front and rear wheel are communicated through CAN protocol. This CAN protocol is basically an automotive protocol which is widely used in automobile industry. It is an event driven protocol and this is very reliable in automobile industry. Here CAN controller MPC2515 is used. The main features of this CAN controller are it Implements CAN V2.0B at 1 Mb/s (0 – 8 byte length in the data field, Standard and extended data and remote frames), high speed SPI interface It is capable of transmitting and receiving both standard and extended data and remote frames. The MPC2515 interfaces with microcontrollers (MCUs) via an industry standard Serial Peripheral Interface (SPI). The communication between the processor and CAN is done through CAN_TX and CAN_RX pins.

C) Graphics LCD – PCD8544

This system uses a graphics LCD to display the values of acceleration, braking force, steering angle, direction of the vehicle and time to which the vehicle travelled in particular direction. This system uses PCD8544 as its display unit. It is a single chip controller/ driver which use 48 rows, 84 column outputs. All necessary functions for the display are provided in a single chip, including on-chip generation of LCD supply and bias voltages, resulting in a minimum of external components and low power consumption. The PCD8544 interfaces to microcontrollers through a serial bus interface.

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D) MEMS Sensor – LSM303DLHC

Here Micro Electro Mechanical system is used to sense vehicle position. It is a 6-Axis MEMS Digital compass is an accurate tilt compensated direction sensor that provides the 360 degree direction by sensing the earth magnetic field orientation. Vehicle dynamics is sensed using this 6 DOF digital MEMS compass module that integrates a 3-axis magnetometer and 3-axis MEMS accelerometer. This system uses LSM303DLHC to sense vehicle dynamics. It is a System-in-line packaging featuring a 3D digital linear acceleration sensor and a 3D digital magnetic sensor. LSM303DLHC has linear acceleration full-scales of ±2*g* / ±4*g* / ±8*g* / ±16*g* and a magnetic field full-scale of ±1.3 / ±1.9 / ±2.5 / ±4.0 / ±4.7 / ±5.6 / ±8.1 gauss. All full-scales available are fully selectable by the user. LSM303DLHC includes an I2C serial bus interface that supports standard and fast mode 100 kHz and 400 kHz. The system can be configured to generate interrupt signals by inertial wakeup/free-fall events as well as by the position of the device itself. Thresholds and timing of interrupt generators are programmable by the end user on the fly. Magnetic and accelerometer parts can be enabled or put into power-down mode separately. The LSM303DLHC features two data-ready signals (RDY) which indicate when a new set of measured acceleration data and magnetic data are available, therefore simplifying data synchronization in the digital system that uses the device.

E) Software Tool Used – LPCXpressO IDE

LPCXpresso is a new, low-cost development platform available from NXP. The software consists of an enhanced, Eclipse-based IDE, a GNU C compiler, linker, libraries, and an enhanced GDB debugger. The hardware consists of the LPCXpresso development board which has an LPC-Link debug interface and an NXP LPC ARM-based microcontroller target. LPCXpresso is an end-to-end solution enabling embedded engineers to develop their applications from initial evaluation to final production.

The LPCXpresso IDE, powered by Code Red Technologies (www.code-red-tech.com/lpcxpresso/), is based on the popular Eclipse development platform and includes several LPC-specific enhancements. It is an industry-standard GNU toolchain with an optimized C library that gives engineers all the tools necessary to develop high-quality software solutions quickly and cost-effectively. The C programming environment includes professional-level features. There is syntax coloring, source formatting, function folding, on- and offline help, and extensive project management automation.

The LPCXpresso target board, jointly developed by NXP, Code Red Technologies, and Embedded Artists (http://www.embeddedartists.com/products/lpcxpresso/), includes an integrated JTAG debugger (LPC-Link), so there's no need for a separate JTAG debug probe. The target portion of the board can connect to expansion boards to provide a greater variety of interfaces, and I/O devices. The on-board LPC-Link debugger provides a high-speed USB to JTAG/SWD interface to the IDE and it can be connected to other debug targets such as a customer prototype. Users can also use the LPCXpresso IDE with the Red Probe JTAG adapter from Code Red Technologies.

LPCXpresso's IDE is a highly integrated software development environment for NXP's LPC Microcontrollers, which includes all the tools necessary to develop high quality software solutions in a timely and cost effective fashion. LPCXpresso is based on Eclipse with many LPC specific enhancements. It also features the latest version of the industry standard GNU tool chain with a proprietary optimized C library providing professional quality tools at low cost. The LPCXpresso IDE can build an executable of any size with full code optimization and it supports a download limit of 128 kB after registration. LPCXpresso supports the full embedded product design cycle by moving beyond chip evaluation boards and supporting development on external target boards.

F) OS USED - RTOS

The whole system runs under the software Free RTOS. The core of an RTOS is known as the **kernel**. An API is provided to allow access to the kernel for the creation of threads, among other things. A **thread** is like a function that has its own stack, and a Thread Control Block (**TCB**). In addition to the stack, which is private to a thread, each thread control block holds information about the state of that thread.

The kernel also contains a **scheduler**. The scheduler is responsible for executing threads in accordance with a scheduling mechanism. The main difference among schedulers is how they distribute execution time among the various threads they are managing. Priority-based, preemptive scheduling is the most popular and prevalent thread scheduling algorithm for embedded RTOS. Typically, threads of the same priority execute in a round-robin fashion. Most kernels also utilize a system tick interrupt, with a typical frequency of 10ms. Without a system tick in the RTOS, basic scheduling is still available, but time-related services are not. Such time-related services include: software timers, thread sleep API calls, thread time-slicing, and timeouts for API calls.

The system tick interrupt can be implemented with one of the hardware timers in the embedded chip. For example, if you have an energy sensitive application you might not want to run the system tick handler every 10ms if not necessary. Suppose for example the application is idle and the next timer expiration is 1000ms away. In this case, the timer can be reprogrammed to 1000ms and the application can enter low-power mode. Once in this mode, the processor will sleep until either another external event occurs or the 1000ms timer expires. In either case, when the processor resumes execution the RTOS adjust the internal time according to how much time has elapsed and normal RTOS and application processing is resumed. This way, the processor only executes when the application has something to do. During idle periods the processor can sleep and save power.

Working

Active Stability Control system takes multiple sensor inputs to find the optimal braking force to be applied. The system uses acceleration position level sensor to measure acceleration, front and rear brake level position sensor to measure front and rear brakes, steering wheel position sensor to measure steering angle, driver accelerator input along with the wheel speed in order to calculate the braking force. If it detects a vehicle skid situation or vehicle roll situation or wheel lock-up on one or both wheels, the controller calculates the braking pressure needed for each wheel and applies it differentially to them using electrical motors, counteracting the rider's squeezing force on the levers. When the ABS system is activated and if the driver applies brake suddenly, the controller calculates the braking pressure to be applied on each wheel differentially and applies it to reduce the movement of the wheel.Adjustment Keypad allows the rider to set the skid threshold level at which the system activates, allowing for different performance characteristics depending on the trail surface.

Steering position level sensor is used to detect whether the vehicle is oversteering(occurs when a vehicle turns (steers) by more than (over) the amount commanded by the driver) or understeeringundersteering(occurs when a vehicle steers less than (under) the amount commanded by the driver).When the ESC system is activated the controller checks for as well as oversteering. If it detects understeering or oversteering, it controls the speed of rear as well as front wheel accordingly.

Vehicle location is sensed using the 6-DOF Digital MEMS Compass module that integrates a 3-axis MEMS Magnetometer and a 3-axis MEMS Accelerometer. The system uses MEMS magnetometer and accelerometer for tracking the vehicle and in case of any accident, automatically stops the wheel movement and the GSM module sends text message to the number saved already in the SIM. This message is going to give the direction as well as how much time the vehicle travelled through that particular direction. This data gives the approximate location of the vehicle. If the accident occurs in underground area GPS cannot be used and in such cases GSM will be very efficient to use.

The entire system has three ECU (Electronic Control Unit) interconnected with each other. Couple of ECUs dedicated for individual front and rear wheel control. The wheels are controlled by two DC Motors, one for front and the other rear side. The ECU interfaces with Rotary Encoders to measure the speed and direction of the wheels. The third ECU is the dashboard unit. It interfaces with driver input sensors such as brake lever position sensors, accelerator position sensor and steering wheel position sensor. It is also interfaced with a Graphics LCD that acts as front dashboard display and provides a GUI to monitor the vehicle status. MEMS compass is connected to this unit.

All three ECU are connected with each other over the most popular vehicular network called CAN (Controller Area Network). CAN is an event-driven protocol that is very reliable for automotive applications. To meet the real-time deadlines, and to make the system robust, the software runs under FreeRTOS, the most popular open source real-time kernel in the world.

Advantages

The advantages of this system are:

- Vehicle stability control is not available in two wheelers. This is one of the first attempts.
- Less costly vehicle tracking system without GPS module.
- Electronic ABS control is superior to the currently available mechanical models.
- Less wire harness with the use of CAN communication network.
- Efficient real-time operation with the use of RTOS kernel in the main dashboard ECU.
- ARM Cortex-M0 microcontroller with inbuilt CAN controller provides a next generation hardware platform, ideal for networking ECU's in E-bicycles.
- 6-Axis MEMS Digital compass is an accurate tilt compensated direction sensor

that gives the 360 degree direction by sensing the earth magnetic field orientation.

Conclusion

In this system, an attempt has been made to implement Electronic Stability Control in two wheelers which determine the vehicle's oversteering and understeering. This is basically featured in four wheelers. In case of any crash, vehicle tracking in this part is done using GSM and this can be enhanced by implementing GPS in future for accurate tracking of vehicle location.

References

[1] XU Shengming, SUN Renyun, HUANG Xianqi. The research and analysis of a accidental car equipped with ABS[J].TianJing:Small Combustion Engines and Motorcycle, 2009;38(2) : 33~36. WANG Shiwei QIAN Yongzhe ZHANG Yuan.The selections of automobile management and maintenance standards [M].Beijing: Chines Criterion Press.1998:117~118

[2] Ki-Chang Lee;Jeong-WooJeon;Don-HaHwang;Yong-Joo Kim; Performance evaluation of antilock brack controller for pneumatic brake system ,Oct.2003Page(s):301-307

[3] ZHANG Yunqing, XIONG Xiaoyang, CHEN Wei, QINN Gang, CHEN Lipin: ABS fuzzy control simulation research based on ADAMS and Matable [J].BeiJing Road transportation Technology. 2007; 24(11):150~152.

[4] BAI Xin, HUANG Bo, The Double module Control Research Based on Fuzzy Control[J].Beijing Machine Tool and Hydraulic Pressure , 2007 35(1) ,170-172

[5] CHEN Jiong, WANG Huicha, SONG Jian, The ABS Fuzzy Control Simulation Research Based on Slip Rate and Deceleration[J].Beijing, Automobile Engineering.2006:28(2):148~150

[6] G. A. Magallan, C. H. D. Angelo, and G. O. Garcia, "Maximization of the traction forces in a 2WD electric vehicle," *IEEE Trans. Veh. Technol.*, vol. 60, no. 2, pp. 369–380, Feb. 2011.

[7] S. Sakai, H. Sado, and Y. Hori, "Motion control in an electric vehicle with four independently driven in-wheel motors," *IEEE/ASME Trans. Mechatronics*, vol. 4, no. 1, pp. 9–16, Mar. 1999.

[8] D. Piyabongkarn, R. Rajamani, J. Grogg, and J. Lew, "Development and experimental evaluation of a slip angle estimator for vehicle stability control," *IEEE Trans. Control Syst. Technol.*, vol. 17, no. 1, pp. 78–88, Jan. 2009.

[9] H. F. Grip, L. Imsland, T. A. Johansen, J. C. Kalkkuhl, and A. Suissa, "Vehicle sideslip estimation," *IEEE Control Syst. Mag.*, vol. 29, no. 5, pp. 36–52, Oct. 2009.

[10] M. Doumiati, A. C. Victorino, A. Charara, and D. Lechner, "Onboard real-time estimation of vehicle lateral tire-road forces and sideslip angle," *IEEE/ASME Trans. Mechatron.*, vol. 16, no. 4, pp. 601–614, Aug. 2011.