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STUDYING AND DEVELOPING WIRELESS CAN SYSTEM USING ARM CORTEX-M3 FOR AUTOMATION INDUSTRIAL AND ELECTRIC VEHICLE

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ABSTRACT

The Controller Area Network (CAN) system is recently applied in the industrial area especially in the automation and electric vehicle. It can support effectively the serial network of distributed control and real-time control. However, those CANs bus communications have a limited in the condition of the serial interface bus control. The data might lose when those CANs transmit or receive data in the same time. This article presents the wireless CAN system using the ARM Cortex-M3 to improve the interface bus control. It is basically the 32 bits microcontroller which provides the faster computation time. The ARM Cortex-M3 is used as a core process and the RF module 2.4 GHz is used for transmission data respectively. Hardware and software design is mainly investigated and implemented in the condition of the real time processing. The results show that the bit rate data transmission can be increased to 1 Mbps and operate faster than the serial interface. This system can be adjusted to use as an embedded system in automation industrial and electric vehicle.

INDEX TERMS — controller area network, cortex-M3, wireless interface.

INTRODUCTION

The Controller Area Network (CAN) system [1] is a widely used advanced technology of field bus which uses to communicate and transfer data communication between microcontroller and the controller network. It can support effectively the serial network of distributed control and real-time control. Firstly, it used in automobile industrial area but it was a wire system in that time. Recently, it is improved to be a wireless can system. According to the advantage of the high communication rate, low cost, long transmission distance and high speed transmission, CAN bus technology is widely applied in the embedded system development.

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The STM32F103 is applied to the CAN bus technology as the core [2]. It was adapted to built-in CAN controller and transceiver. It provides a platform for the maintenance of the system failures, and saves maintenance costs and increases efficiency. The CAN bus communication also apply to the robot platform [3-4]. The robot platform using a new generation of 32-bit embedded microcontrollers for data acquisition and CAN bus communication capabilities which more than 485 flexible and reliable. The platform of each module can run independently, meanwhile can be combined to build various types of bionic robots and complete the movement from simple to complex. The CAN bus also uses as data extension for car-2-car network [5-6]. A simulator was created to compare the performance of pure vehicular ad hoc networks and delay tolerant network enabled vehicular ad hoc network under different network conditions. In [7-8] presents a simple design and low cost of CAN system using a Controller area network (CAN) controller (PIC18F4580) a CAN transceiver (MCP2551) with the help of decoders/encoders using a RF Transmitter/Receiver. In order to overcome the conflictions bought from CAN Controller and bus configuration, made use of MAX232 which converts the voltage required by the PC/ CAN module. In [9-10] presents a CAN-over IP tunneling protocol. A number of automotive applications have been identified for which remote operation is feasible. Experiments with the prototype implementation for automotive diagnostics and CAN bus monitoring serves as a proof-of-concept and highlights the potential of the technology for shortening automotive development cycles by making the testing and verification stages more efficient. However, those CANs bus communications have a limited in the condition of the serial interface bus control. The data might lose when those CANs transmit or receive data in the same time. To improve the CAN communication system, this article presents the wireless CAN system using the ARM Cortex-M3. It is focused to increase the bit rate to 1Mbps using the frequency transmission at 2.4GHz.

HARDWARE DESIGN

It consists of 4 parts of hardware design which each part is separated and operated in sequence as shown in Fig 1 and 2.

The ARM-STM32F103 has a special characteristic as follows:

1) It has a frequency clock as 72 MHz which the operation efficiency is 1.25 DMIPS/MHz or Dhrystone 2.1

2) It has a memory flash 128-512 Kbite and statistic RAM 20-64 Kbite

3) The timer clock signal is 4-16 MHz. It can adjusted to increase the timer clock signal to 72 MHz using phase lock loop.

4) It has an energy management system using POR and PDR

5) It has an analog to digital convertor system with a speed at 1 uS 12 bits. Also it has 2 sets of sample and hold circuit to measure temperature while the chip operates.

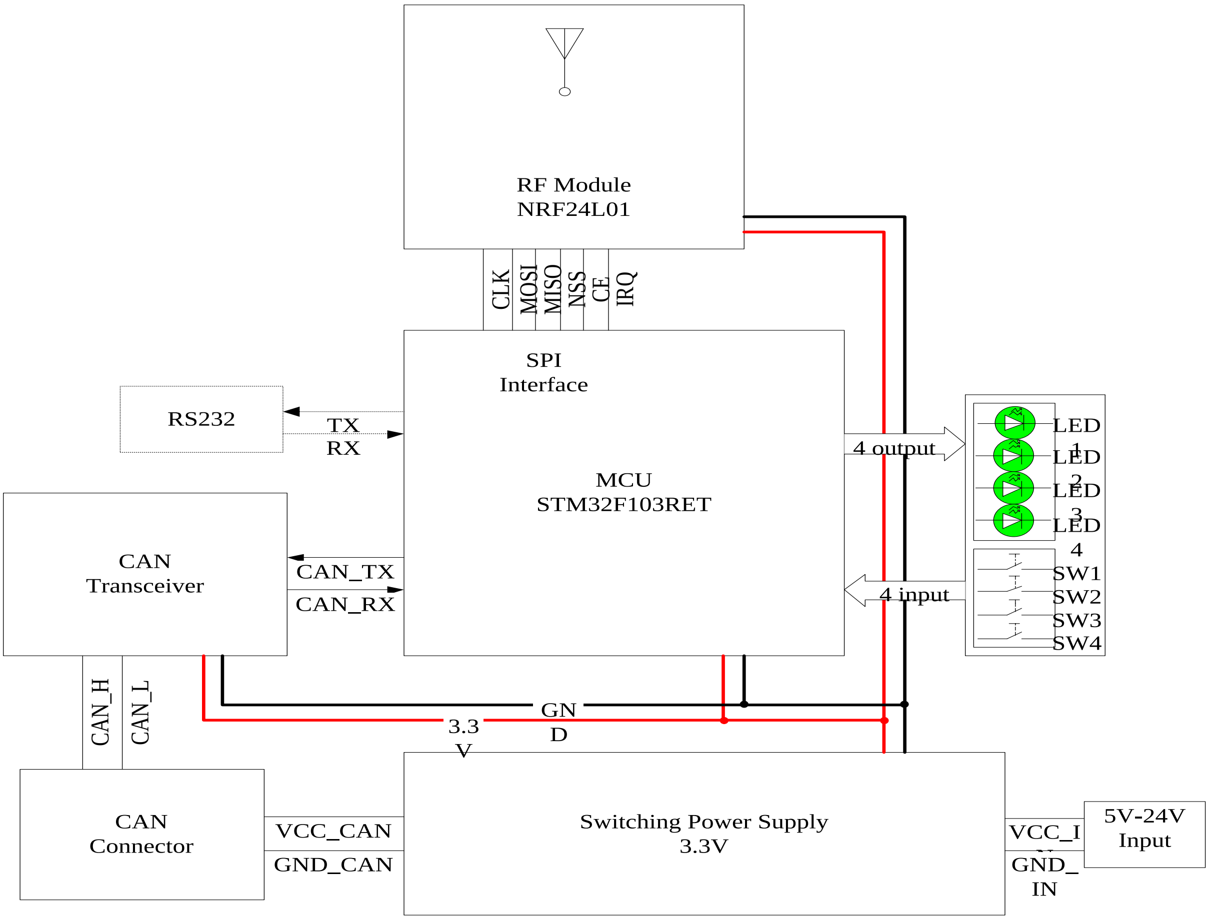

Fig. 1. Hardware design

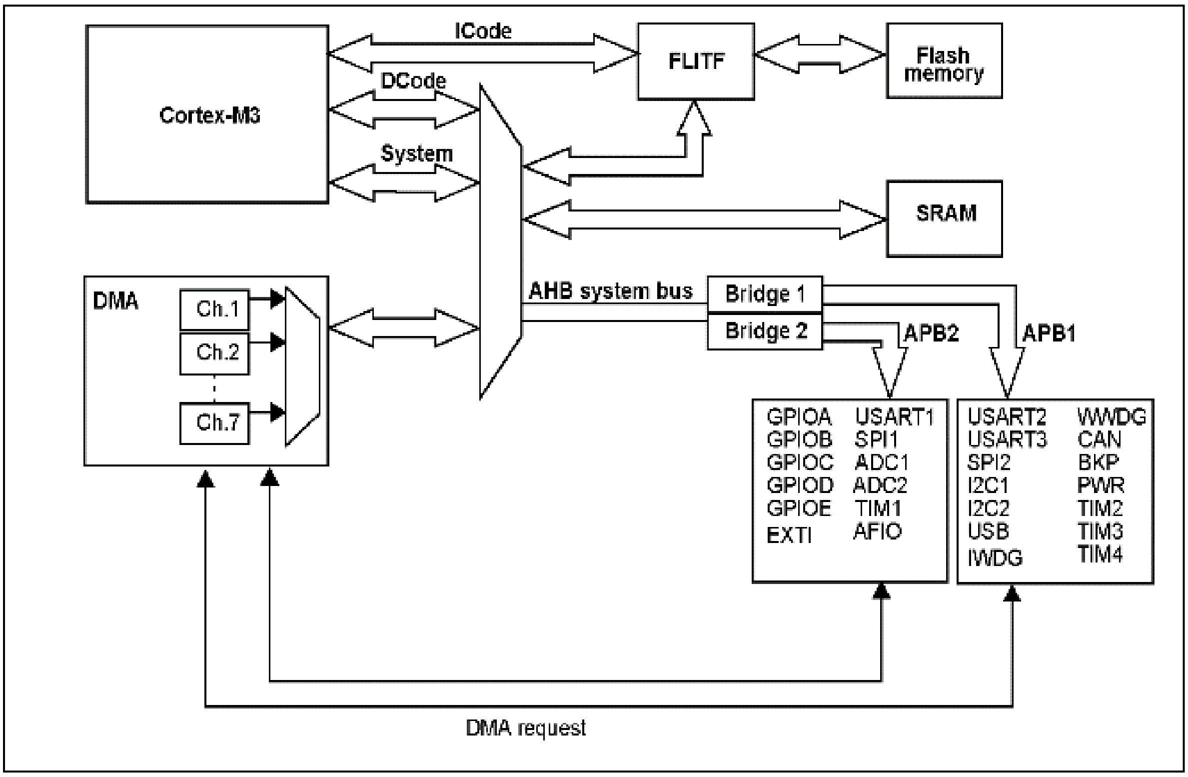

Fig. 2. Generation and decoding of cyclic codes

SOFTWARE DESIGN

To design the operation codes, it consists of 2 parts: transmission and receiver.

A. Generator and Parity-Check

For cyclic codes, a very convenient operator is the bit position operator. If v_j is the j^{th} element of a vector $\overline{v}$, its bit position is j and it can described this using the bit position operator x^j [11]. The bit position (or polynomial) transform of a vector

$$\overline{v} = [v_0 v_1 \cdots v_{n-1}] \quad (1)$$

is defined to be

$$v(x) = v_0 x^0 + v_1 x^1 + \cdots + v_{n-1} x^{n-1} = \sum_{j=0}^{n-1} v_j x^j \quad (2)$$

Then the mathematics of binary polynomial algebra can be represent a nonsystematic (n, k) cyclic code word in the polynomial form as

$$c(x) = m(x)g(x), \quad (3)$$

$$\deg[m(x)] \leq k - 1 \quad (4)$$

and the generator polynomial $g(x)$ has

$$\deg[g(x)] = r = n - k \quad (5)$$

By analogy, the polynomial $h(x)$ is called the parity-check polynomial. Then the received block vector $\overline{v}$ in polynomial form as

$$v(x) = c(x) + e(x) \quad (6)$$

Where $e(x)$ is the error polynomial. It can defined a syndrome polynomial

$$\frac{v(x)h(x)}{x^n - 1} = \frac{c(x)h(x)}{x^n - 1} + \frac{e(x)h(x)}{x^n - 1} = \frac{e(x)h(x)}{x^n - 1} \quad (7)$$

The syndrome depends only on the error polynomial and not the transmitted code polynomial.

B. Systematic Cyclic Codes

There are many advantage in using systematic block codes. In polynomial form, a systematic code word is of the form

$$(x) = x^{'}m(x) - d(x) = x^{'}m(x) + d(x) \quad (8)$$

Where $r = n - k$

$$d(x) = x'm(x)/g(x) \quad (9)$$

Since $g(x)$ is constrained, the syndrome polynomial defined by

$$s(x) = \frac{c(x)}{g(x)} = \frac{x'm(x)}{g(x)} + \frac{d(x)}{g(x)} \quad (10)$$

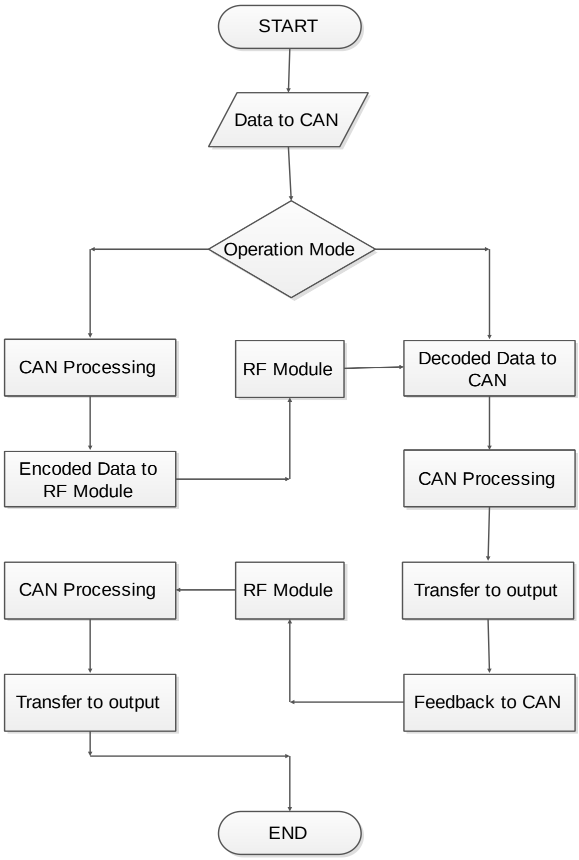

Fig. 3. The process of software command

EXPERIMENT RESULTS

The experiment results are tested in two parts: CAN process and interface process with RF module.

A. CAN Signal

Fig. 4. shows the CAN High and Low signal. The CAN High signal is 3.3V

B. **Interface Signal**

Fig. 5. shows the interface signal (SPI) between microcontroller and NRF24L01 RF module. The signal is the "reading" signal from the NRF24L01 RF module. This can guarantee that the microcontroller is connected to the NRF24L01 RF module.

Fig. 6. shows the SPI signal between microcontroller and RF module in the transmission section which it consists of TX_CLK, TX_MISO, TX_MOSI, TX_CSN and TX_IRQ.

1) TX_CLK is the clock signal of SPI from microcontroller.

2) TX_MISO is the MISO signal of SPI which it is a "0" in the transmission mode.

3) TX_MOSI is the MOSI of SPI from microcontroller to RF module

4) TX_CS is the Chip Select (CS) signal of SPI form microcontroller to RF module which it always operates in the status "1" to "0".

5) TX_IRQ is the interrupt signal of RF module.

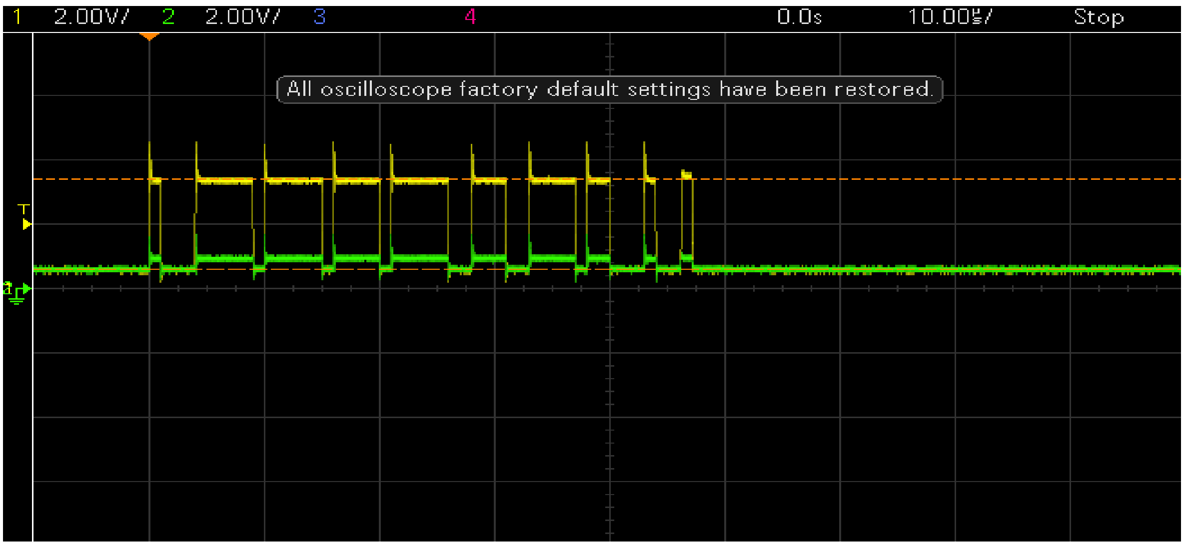

Fig. 4. CAN High และ CAN Low

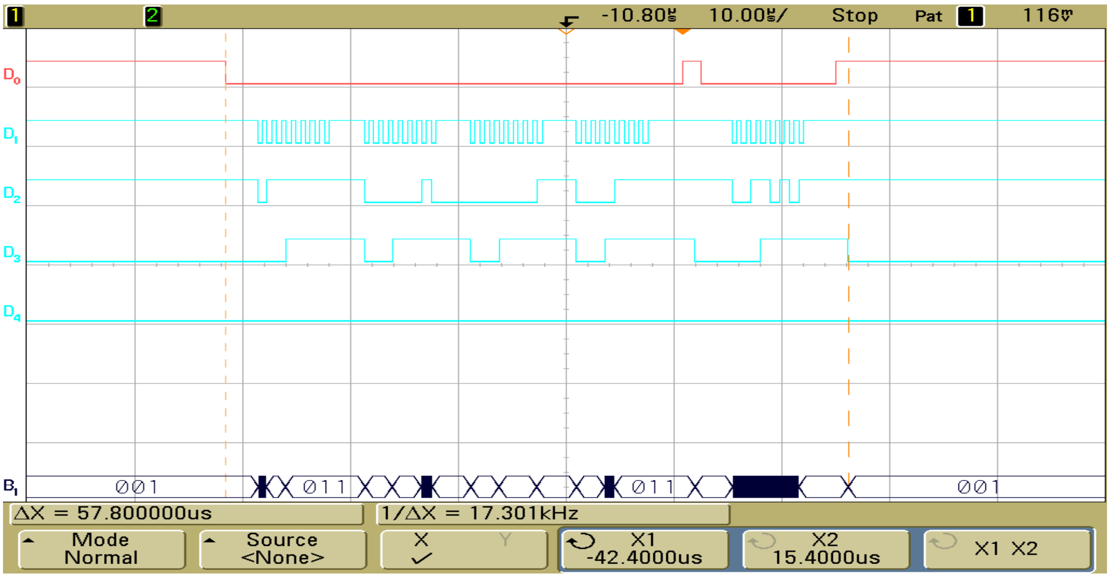

Fig. 5. Interface Signal using PCAN-USB

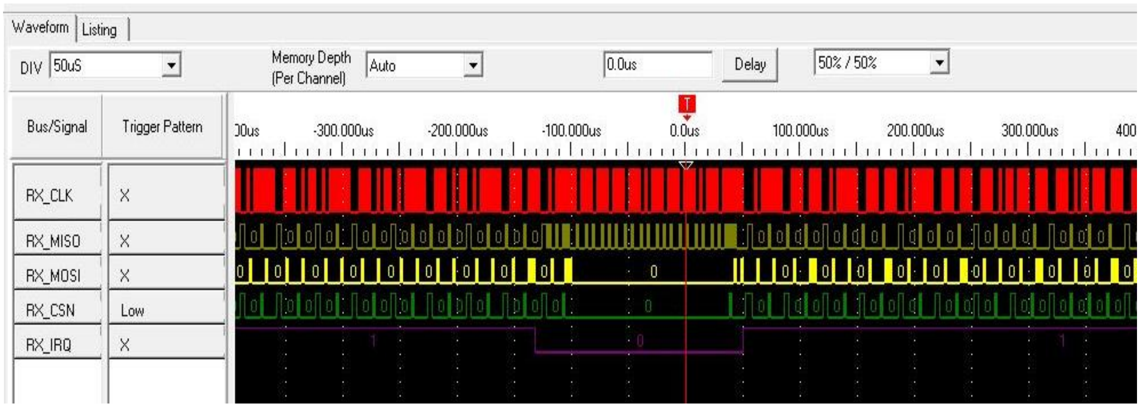

Fig. 6. Interface Signal on NRF24L01 RF module

Fig. 7. The signal SPI at the receiver

CONCLUSIONS

This article presents the wireless CAN system using the ARM Cortex-M3 to improve the communication of CAN bus, according to the CANs bus communications have a limited in the condition of the serial interface bus control. The ARM Cortex-M3 is the 32 bits microcontroller which provides the faster computation time. It uses to interface with the RF module 2.4 GHz. The results show that the communication at a range of 1Mbps can work completely in the 5 meters distance of each module. It requires also no obstacles present. This can be applying to use with in the industrial area such as automation industrial and electric vehicle which uses in the short distance to control.

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