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SOCCER ROBOT DESIGN FOR FIRA MIROSOT LEAGUE

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***Abstract* - In this paper, a soccer robot design method for FIRA MiroSot League is proposed. A control IP that conforms the functionality of the robot soccer game is designed by using VHDL, and the design control IP is implemented on a FPGA chip. The control IP include the following functions: baud rate generator, serial to parallel data extractor based on RS232 protocol, control command decoder, ID selector of soccer robot, plus width modulation (PWM) generator, and motor feedback signal analysis. Some simulation results of the MAX+PLUSII are given to demonstrate the functionality of the control IP. From practical test, we can see that the implemented robot indeed meets the basic terms of multi-function and high efficiency for the robot soccer game.**

Index Terms - Robot soccer game, Soccer robot, VHDL, FPGA.

I. INTRODUCTION

Robot soccer games [1-2] are teams organized by several robots to play soccer games under fixed restriction and rules. To complete a robot soccer game, it must have three main parts: (a) Vision system, (b) Host computer system, and (c) Soccer robot. In the vision system, the messages of objects (robots of both teams and the ball) are extracted in the image process based on the captured image of the global vision on the game field from the CCD. In the host computer system, there are three main parts: (a) Strategy decision mechanism, (b) Path planning, and (c) Command encoder. The strategy decision mechanism decides the position and forward direction of the destination for our robots based on all extracted messages from the image process. Then, the path planning determines the command for each robot and the command encoder encodes this command so that the communication system can transmit it to each robot. In the soccer robot, each robot has a receiver to get control instruction from the host computer through wireless communication, and a micro control chip to control the actions of move, offence, defend or shoot based on the received instruction. Each robot basically has the following motion functions: left and right sides turn revolving, and front and rear motion so that it could move on all sides based on the command. If the soccer robots do not have a good architecture, the team with a good vision system and a good strategy decision mechanism still cannot exert its ability to win the game because the robot cannot execute the desired robotic control. Therefore, a good architecture of robot plays an important role in the robot soccer system. In this paper, a control IP for soccer robots with multi-function is proposed, and the implemented soccer robot will conform to the regulation size 7.5x7.5x7.5 cm^2 of FIRA MiroSot league.

The rest of this paper is organized as follows: In Section 2, the introduction of the robot soccer games is described. In Section 3, the proposed control IP of the soccer robot is described. In Section 4, the proposed circuit and mechanism of the soccer robot are described. In Section 5, the simulation and experiment discussions of the soccer robot are described. Finally, in Section 6, some conclusions are made.

II. INTRODUCTION FOR THE ROBOT SOCCER GAMES

According to the rules of MiroSot: Large League of FIRA, each team consists of eleven robots, a global vision system, a host computer, and a wireless communication system. The field must be a black wooden rectangular playground and its length and width are 440 cm x 280 cm. The enclosing walls that surround the field are 5cm high and 2.5cm thick black side-walls. The ball used in game is a standard orange golf ball with 42.7 mm in diameter. A CCD camera is put on the center and 3 m high upper on the field to capture all the objects in the whole game field from above. The host computer will use the global image which is extracted by the CCD camera to analysis the locations and angles of robots of both teams and ball through the image process. The strategy decision mechanism decides the actions of each robot, then the host computer transmits data packets through a wireless communication modem, thus each robot can get its own control signal to move, stop, pass the ball and kick the ball. The system achieves real time control by means of the image feedback from CCD.

III. Control IP Design for The Soccer Robot

In this section, a design method of the control IP which is written in VHDL [3] is proposed for the soccer robot. The top level of the whole IP includes two main modules: (a) Data extraction module, and (b) Motor control module. The function of the data extraction module is designed to extract correct commands from data packets and decode the received command, which are received from the wireless modem, thus three modules are constructed: (a) Baud rate generation module, (b) Asynchronous serial data receiving module, and (c) Command decoding module. The function of the motor control module is designed to create the corresponding signals to control motors and analyze the feedback signal from motors, thus two modules are constructed: (a) PWM generation module, and (b) Motor feedback signal analysis module. The I/O diagram of the control IP for the soccer robot is shown in Fig. 1. In order to explain the proposed control IP, five modules: (a) Baud rate generation module, (b) Asynchronous serial data receiving module, (c) Command decoding module, (d) PWM generation module, and (e) Motor feedback signal analysis module are respectively described as follows:

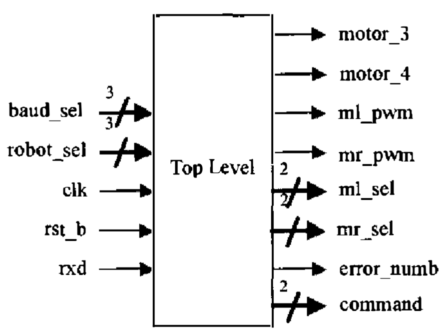

Fig. 1. I/O diagram of the proposed control IP for the soccer robot.

3.1. Baud Rate Generation Module

Various kinds of baud rate are needed to provide the system to transmit data. To design a baud rate generation that possesses such different baud rate, we need a 3 to 8 multiplexer. To generate serial baud rate, the method we use is: first find out the regularity among those baud rates, then choose an oscillation to generate those baud rate by using a division. The diagram of the baud rate generation module is shown in Fig. 2. We divide 7.3728MHz (clk) by 12 division to equal 614.4k (clkdiv12) frequency, then go a step further to be divided by 256 to get a sampling frequency (bclkx8) which is chosen by baud_sel choosing signals. Finally, the baud rate (bclk) is obtained from that the sampling frequency is divided by 8.

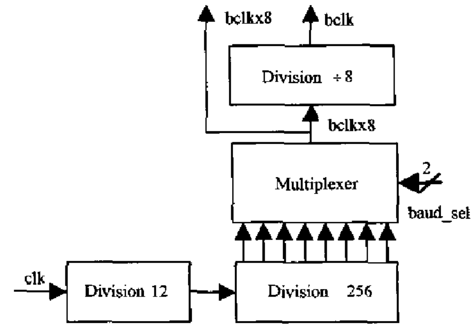

Fig. 2. Design diagram of the baud rate generation module.

3.2. Asynchronous Serial Data Receiving Module

In the problem of time synchronous, the transmitter transmits serial data in accordance with the fixed frequency, then the receiver must also obtain the same receiving rate. Because we have to sample data while data is stable, therefore, sampling data at the half time of each bit, in other words, we sample data at the middle time of bit which is much safe. Thus we use 8 times the frequency of baud rate to be the sampling frequency. The asynchronous serial data receiving method is shown in Fig. 3.

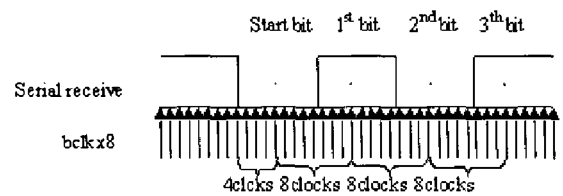

Fig. 3. Asynchronous serial data receiving method.

In the robot soccer system, the host computer transmits control commands to eleven robots through the wireless communication, thus all eleven robots on the field will get the same commands. In order to let each robot extracts its own control command correctly, a transmitting data packet is proposed to be a standard. The multi-control command serial signals are shown in Fig. 4. In the data packet, "01H" is the start byte, when the robot extracts the start byte, it will start to count to get its own control command until the stop byte "FFH" is extracted, then waiting for next data packet all the time. The block diagram of the data extraction module is shown in Fig. 5, where robot_sel is the selected number of soccer robot that can be 0000 to 1010. Since each team has eleven robots, eleven kinds of forms need to be encoded. If the other code is set, there will be a error_numb output signal. Rxd is the receiving serial data input. Command is the extracted control commands from robot itself.

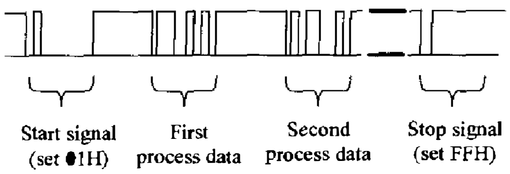

Fig. 4. Serial signals of the multi-control command

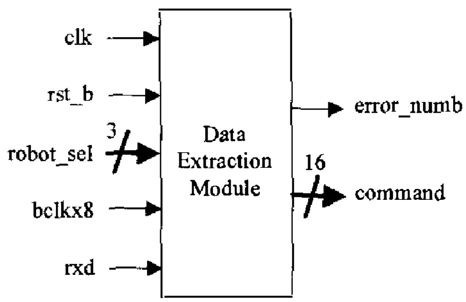

Fig. 5. Block diagram of the data extraction module.

3.3. Command Decoding Module

The command decoding module controls the PWM and rotation signals of left and right wheels. The command decoding module diagram is shown in Fig. 6 in which ml_pwm and mr_pwm separately are the pwm signals of left and right wheels, and ml_sel and mr_sel control the rotate of left and right wheels separately.

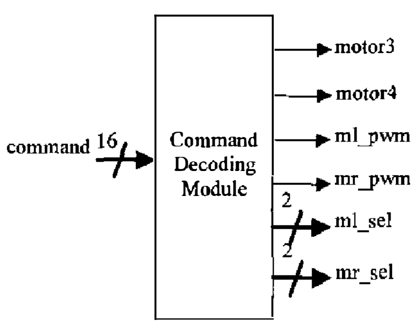

Fig. 6. Block diagram of the command decoding module.

3.4. PWM Generation Module

In order to control the speed of DC motor, PWM signals are used to generate analog voltages to control the DC motors of left and right wheels. We design a 6-bits PWM signals generation module, which is made up of a 6-bits register, a 6-bits down-counter, and a comparison. It is shown in Fig. 7 in witch pwm_data is the PWM digital signal input that composed by 6 bits.

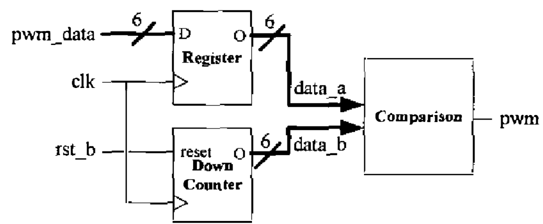

Fig. 7. Architecture diagram of the PWM signal generation module.

3.5. Motor Feedback Signal Analysis Module

The design flow diagram of motor feedback controller is shown in Fig. 8. When the feedback signals Channel A and Channel B are analyzed by wave detecting then we can get the motor actual speed signal CNT. Comparing CNT with the desirable speed signal SPEED that from the host computer. If CNT $<$ SPEED, then make the motor to speed up; and else if CNT $>$ SPEED, then make the motor to slow down or else CNT = SPEED, it means the motor's actual speed conform to the desirable speed, and then no need to change anymore.

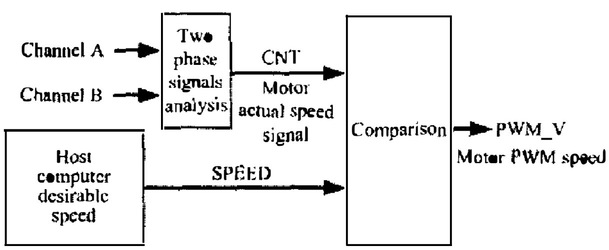

Fig. 8. Design flow diagram of motor feedback controller

IV. Circuit Board and Mechanism Design of Soccer Robot

The architecture of the implemented soccer robot is shown in Fig. 9. The architecture has two main parts: control circuit board and mechanism design of robot. The picture of the control circuit board of the soccer robot is shown in Fig. 10. In mechanism design of the soccer robot, we use aluminum as material to fabricate the robot. The external view of the soccer robot is shown in Fig. 11.

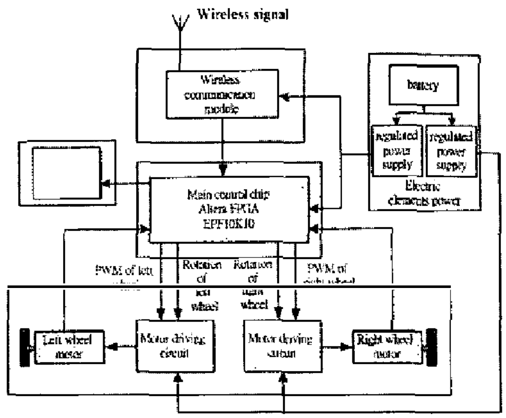

Fig. 9. The architecture of the soccer robot.

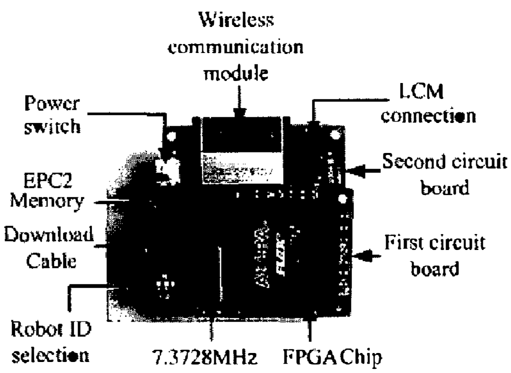

Fig. 10. The photograph of the control circuit board.

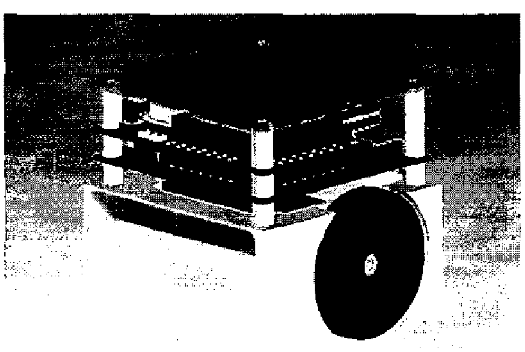

Fig. 11. The external view of the soccer robot.

V. Simulation and Experiment of The Proposed Control IP

The synthesis and layout of the control IP are completed by the Altera FPGA developing software: MAX+PLUSII. In this section, the MAX+PLUSII's simulation diagram is used to illustrate the functions of control IP. The simulation diagram of data extracting function of control IP is shown in Fig. 12, where we can see that the number of robot is set to be 3 (numb_sel=3). When "rxd" get the data of stop byte "FFH", then the asynchronous serial data receiving module can extract the third data (command = 91D5) from data packets correctly. The simulation diagram of motor control of control IP is shown in Fig. 13. We can find that the control IP indeed give correct rotating control signal of left and right wheels, and pwm signals of left and right wheel motors from Fig. 13.

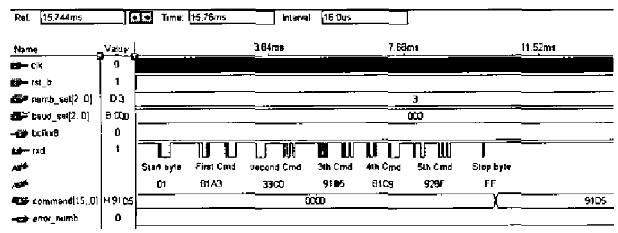

Fig. 12. The simulation diagram of the function data extraction.

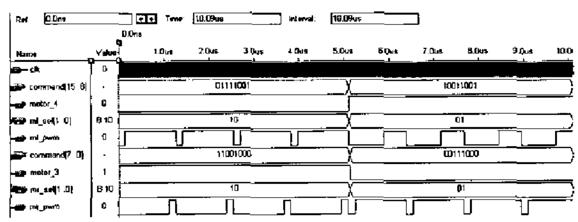

Fig. 13. The simulation diagram of the motor control.

VI. Conclusions

The robot soccer game is a mechanism and electric integrating system, each part of this system is very important. In this paper, a method is proposed to design a multi-function soccer robot. Multi-function and high efficiency are basic terms in the design and realization of the soccer robots. From practical verify and test, we can see that the implemented robot indeed meets these basic terms for the robot soccer game.

Acknowledgement

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