Traction control system module design, development, construction and testing.

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Intermediate Project
under instructions of
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Abstract

Project was focused on development from the scratch a printed circuit board for future traction control system module. This implies component selection, layout and trace placement, etching, soldering, writing software and testing. Project ended with success with minor remarks and problems. The project fact functioning in desired way, ale peripherals were on-line. Project will be developed more in the future.

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Contents

1 Introduction

This project was treated as introduction to future Master's degree project, to create a firm foundation and detect possible problems early on.
The aim of this project was to complete following points:

- Define tasks that will be realized by completed project.
  - Two DC motor drive based on H-bridge IC (inegrated circuit)
  - Accelerometer and gyroscope readings
  - Wireless communication
  - Two encoders readings
  - Servo control for front axis turn angle
  - Measure current draw of DC motors
- Choose proper electronic parts and integrated circuits for project purposes.
- Design printed circuit board capable of realizing project tasks.
- Etch and solder printed circuit board
- Test circuit and find flaws and mistakes made during the design stage
- Write microcontroller software capable of completing project tasks.
- Write PC software that is able to communicate with remote microcontroller and gather data.

2 Electronic component selection

This part was very vital for project because it influences nearly all further steps.

2.1 DC motor H-bridge selection

I have decided to search for proper parts in Freescale (NXP) product offer, because of their sample shipping policy for academic use.
After measuring maximum current draw and supply voltage for DC motors I have found proper ICs: **MC33886pvw**. It provides all desired functionalities for project purposes like:

- Failure output
- Over current protection
- Over temperature protection
- Power failure protection

2.2 Accelerometer and gyroscope

I have decided to use MPU6050 accelerometer with gyroscope because of its popularity, good documentation, well prepared troubleshooting, internal filtering, decent accuracy (16-bit).

2.3 Wireless communication

Module chosen to service wireless communication was Wi-Fi ESP8266 module with integrated antenna. I wanted to check if Wi-Fi communication is reliable enough to simultaneously send and receive data from microcontroller, and how difficult it is to achieve it.

2.4 Wheel encoders

I have decided to use rotary incremental quadrature encoders provided by Austria Microsystems. The main reason behind that decision was that I already had them ready to use.

2.5 Microcontroller

I have decided to use K64 microcontroller by Freescale. Reasons:

- Provides enough timers to avoid multi-channeling and switching between timer settings and peripherals.
- Provides various build in serial communication interfaces spread around the chip. This makes the design state a lot less troublesome.
- Has internal $3.3V$ linear voltage regulator to provide proper work stability and analogue converters accuracy.

2.6 Current measurement of DC motors

Allegro microsystems - ACS712 chip was selected to provide this functionality because of basing on hall-effect (doesen't require current shunt resistor to measure voltage drop across it), and had high current tolerance (up to $20A$).

3 Design stage

To design the printed circuit board I have used open source KiCad. First step was to prepare schematic diagram, that later served as basis to they physical layout design stage.

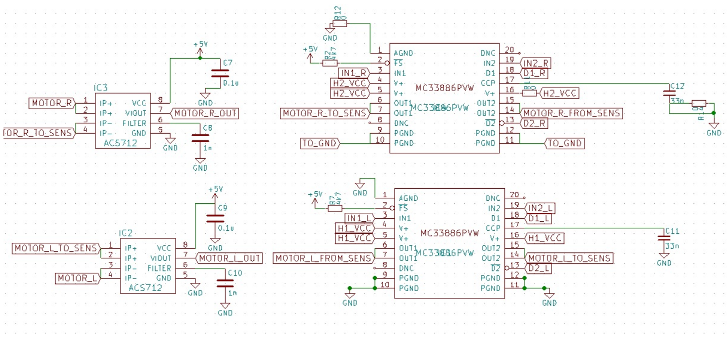

Figure 1: Part of schematic diagram containing H-bridge and current sensing

3.1 Physical layout design

This step was very complicated and required a significant amount of time to complete because of wiring and trace routing complexity. Another thing that required a lot of time was preparing own footprints for ICs with not common packages, like H-bridge MC33886pvw. It is housed in HSSOP-20.

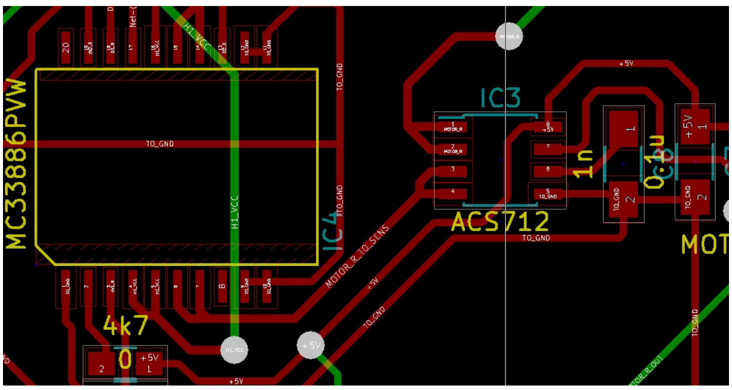

Figure 2: Part of layout editor containing H-bridge and current sensing

4 Physical creation

To etch the printed circuit board I have decided to use photo-chemical method involving UV-sensitive positive varnish(lacquer) covered laminate. After successfully etching the board I proceeded with placing and soldering all the surface mounted parts.

4.1 Testing

During preliminary tests to detect mistakes and short circuits I have noticed that linear voltage regulators were different than what I have ordered. As an result they had different pinouts, and if I plugged the power into the board they would explode and damage the rest of the board. It was necessary to use a "bodge" wire and mount those voltage regulators sideways.

5 Software development

5.1 Microcontroller software

Software for the microcontroller was developed in CodeWarrior Development Studio Special Edition - free licence under certain constraints like non commercial use.
All begun with the processor configuration and input/output configuration. After completing the configuration I could begin to write code for the Wi-Fi communication using ESP8266 AT Commands.

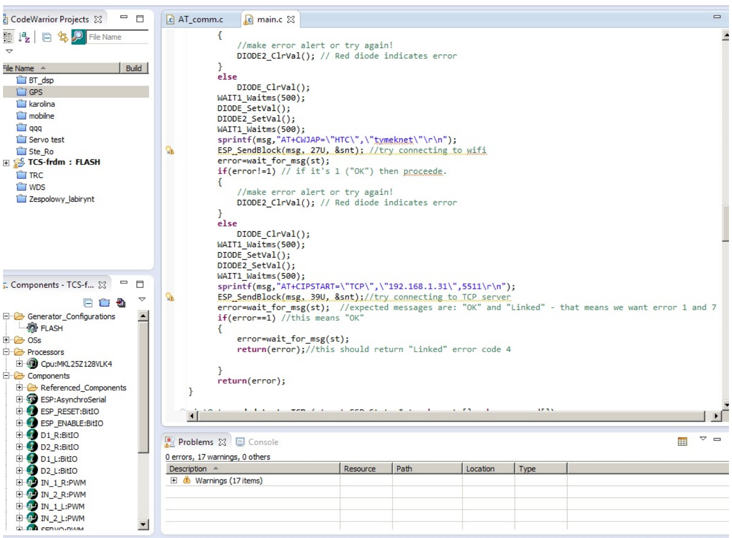

Figure 3: CodeWarrior window with code and components - logic devices

5.2 PC software - TCP server

TCP server working as reference point for ESP8266 module was written in C# using Microsoft Visual Studio. It provides only basic functionality like receiving messages from the module (client) and sending messages to client.

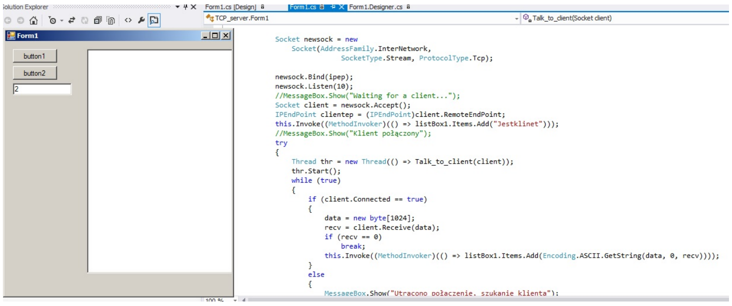

Figure 4: Visual Studio during run of TCP server with basic functionalities

6 Summary

Overall project was completed with success. All tasks defined at very beginning were completed. Not many problems were encountered, but some of them were very severe.
This project delivered a lot of new experience to me, and helped me to understand better the course of electronics development which was omitted during course of our studies. Now I have created foundations that I can base on and create better projects in the future.

6.1 First problem

The first encountered problem was with etching printed circuit board with K64 microcontroller unit on it. K64 is housed in LQFP144 package with 0.5mm pin pitch. With use of home methods I was unable to properly etch that footprint. There were leftover, undissolved copper between the pads.
That lead to a solution: Replace on board micronontroler with goldpin header for develpment board - FRDM-KL-25Z.

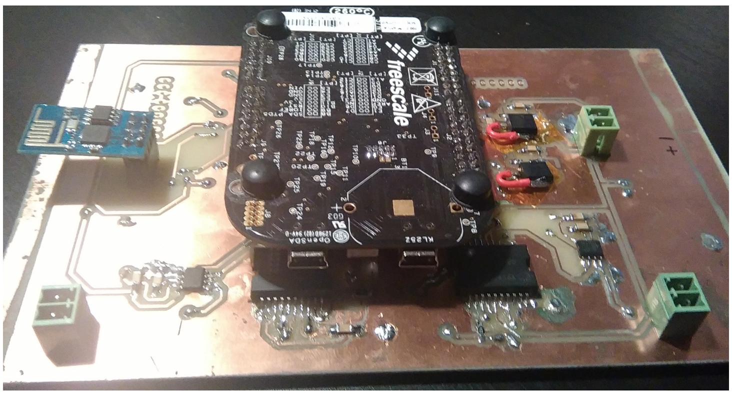

Figure 5: Etched board with replaced MCU by development board

6.2 Second problem

The second problem is the transmission speed which is utterly to low for control and data collection (4Hz - the best result). Problem may be caused by Wi-Fi delays or power problems of the ESP8266 module. It needs to be diagnosed.
To avoid such problems in the future, it is better tu use direct wireless serial communication transceivers using free band range around $433MHz$. Modules like HC-11 are the perfect fit for that task. They provide up to $1000m$ of range with low speed (9200baud).