More details of circuit board

(This circuit board report is part of my FYP report)

The most important part of circuit board designing is scheduling pins of the STM32 chip. This circuit board uses STM32F103RBT6 chip as main chip and its package is named LQFP64 (cf. Figure 3.1) which means it has 64 pinouts. But we don't use all the pins in this circuit board.

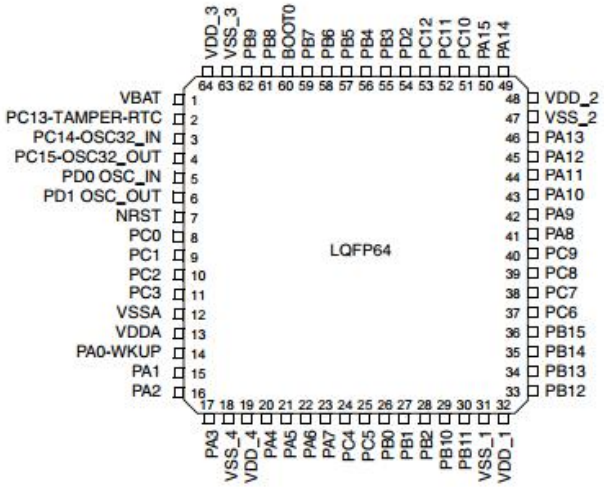

Figure 3.1: LQFP64 Package
Source: (STMicroelectronics 2013)

Manuscript of stm32 chip schedule

As shown in Figure 3.2, this is my original design of the pinout schedule. This circuit will use 52 pinouts of the STM32f103RBT6 chip, not all of pins. The primary function of stm32 is to output six or more PWM signal. Meanwhile, there are other assistant functions such as LED, switch, key, buzzer, WIFI interface, JTAG interface, USART and so on.

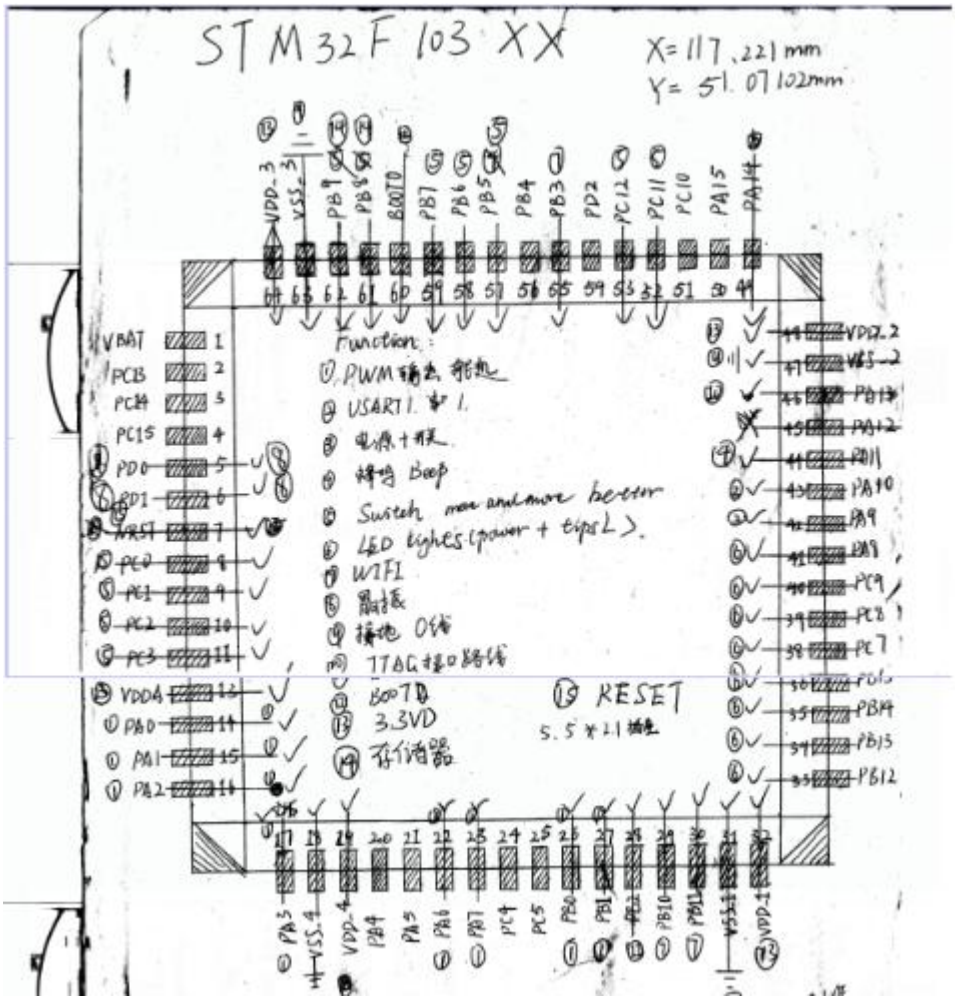

Figure 3.2: Pinout Schedule

Pinout schedule details

In this circuit board diagram there are 14 important parts (cf. Table 3.1)

- STM32F103RBT6 Processor,
- Reset circuit,
- BOOT0&BOOT1,
- decoupling capacitor,
- JTAG interface,
- RS232 serial interface,
- servo motor controlling circuit,
- low level buzzer,
- keys,
- power input, protection switch and indication,
- main power supply 5V transfer 3.3V,
- WIFI interface,
- LED circuit and
- EEPROM 24CXX.

LQFP64	Pin Name	Type	Main Function	Alternate Functions		Function Description
				Default	Remap	
5	OSC_IN	I	OSC_IN		PD0	crystal oscillator
6	OSC_OUT	O	OSC_OUT		PD1	crystal oscillator
7	NRST	I/O	NRST			reset
8	PC0	I/O	PC0	ADC12_IN10		Key
9	PC1	I/O	PC1	ADC12_IN11		Key
10	PC2	I/O	PC2	ADC12_IN12		Key
11	PC3	I/O	PC3	ADC12_IN13		Key
12	VSSA	S	VSSA			ground zero line
13	VDDA	S	VDDA			3.3VD
14	PA0-WKUP	I/O	PA0	TIM2_CH1		PWM signal
15	PA1	I/O	PA1	TIM2_CH2		PWM signal
16	PA2	I/O	PA2	TIM2_CH3		PWM signal
17	PA3	I/O	PA3	TIM2_CH4		PWM signal
18	VSS_4	S	VSS_4			ground zero line
19	VDD_4	S	VDD_4			3.3VD
22	PA6	I/O	PA6	TIM3_CH1		PWM signal
23	PA7	I/O	PA7	TIM3_CH2	TIM1_CH1	PWM signal
26	PB0	I/O	PB0	TIM3_CH3	TIM1_CH2	PWM signal
27	PB1	I/O	PB1	TIM3_CH4	TIM1_CH3	PWM signal
28	PB2	I/O	BOOT1/PB2			BOOT1
29	PB10	I/O	PB10	USART3_TX	TIM2_CH3	WIFI
30	PB11	I/O	PB11	USART3_RX	TIM2_CH4	WIFI
31	VSS_1	S	VSS_1			ground zero line
32	VDD_1	S	VDD_1			3.3VD
33	PB12	I/O	PB12			LED
34	PB13	I/O	PB13			LED
35	PB14	I/O	PB14			LED
36	PB15	I/O	PB15			LED
37	PC6	I/O	PC6		TIM3_CH1	LED
38	PC7	I/O	PC7		TIM3_CH2	LED
39	PC8	I/O	PC8		TIM3_CH3	LED
40	PC9	I/O	PC9		TIM3_CH4	LED
41	PA8	I/O	PA8			LED
42	PA9	I/O	PA9	USART1_TX		USART1
43	PA10	I/O	PA10	USART1_RX		USART1
44	PA11	I/O	PA11	TIM1_CH4		buzzer
46	PA13	I/O	JTMS/SWDIO		PA13	JTAG interface
47	VSS_2	S	VSS_2			ground zero line
48	VDD_2	S	VDD_2			3.3VD
49	PA14	I/O	JTCK/SWCLK		PA14	JTAG interface
52	PC11	I/O	PC11		USART3_RX	Key

53	PC12	I/O	PC12		USART3_CK	Key
55	PB3	I/O	JTDO			WIFI
57	PB5	I/O	PB5			Key
58	PB6	I/O	PB6			Key
59	PB7	I/O	PB7			Key
60	BOOT0	I	BOOT0			BOOT0
61	PB8	I/O	PB8	TIM4_CH3	I2C1_SCL/ CANRX	AT24LC0x storage
62	PB9	I/O	PB9	TIM4_CH4	I2C1_SDA/ CANTX	AT24LC0x storage
63	VSS_3	S	VSS_3			ground zero line
64	VDD_3	S	VDD_3			3.3VD

(I = input, O = output, S = supply).

Table 3.1: More Detailed Design

Table 4.1 gives the circuit board design components. It lists each component's serial number, name, weld package, welding pad number, quantity, parameter, tab and polarity (if it has polarity).

Serial Number	**Name**	**Package**	**Welding Pad Number**	**Quantity**	**Parameter**	**Tab**	**Polarity**
R1, R2, R15, R16, R12, R29, R11, R21, R22	Resistance	0805	2	9	10k	103	
R17, R14	Resistance	0805	2	2	1K	102	
R18	Resistance	0805	2	1	220	220	
AR1, AR2, AR3, AR4	Network Resistor	0603	8	4	10K*4	103	
R13	Resistance	0805	2	1	1M	105	
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C17, C19, C21, C22	Capacitance	0805	2	18	0.1uF		
C15, C16	Capacitance	0805	2	2	22pF		
C18, C20	Capacitance	YJ-TAN-7343	2	1	1000uF		
SW1, SW2, SW3, SW4, SW5, SW6, SW7, SW8, SW9, SW10	Key	Double Pad	2	10	6 * 3.6		
Q1	Bipolar Junction Transistor	SOT23	3	1	8550	2TF	Polar direction

LED1, LED2, LED3, LED4, LED5, LED6, LED7, LED8, LED10. LED10	LED	0805	2	10	Red		Polar direction
U1	IC	SO16NB	16	1	MAX3232		Polar direction
U2	IC	TO-252L	4	1	AMS1117-3.3		Polar direction
U3	Double line Female Header	WIFI-8P	8	1	WIFI		Polar direction
U4	IC	SO8NB	8	1	AT24CXX		Polar direction
U6	IC (STM32)	LQFP-64	64	1	STM32F103 RBT6		
Y1	Quartz crystal resonator	XTAL	2	1	8MHz		
FUSE2	Fuse	1812	2	1	117P		
JP3	Source jack-socket	DCIN	3	1	5.5 * 2.1		Polar direction
JP1	DR9 female header	DSUB1.385	11	1	DR9 female header		Polar direction
JP2	Pin header	HX2.54-5P	5	1	2.54		Polar direction
S1	Toggle switch	DH-K6-2	8	1	Toggle switch		
P1, P2, P3	Pin Header	HDR1X8	8	3	1 * 8		
D1		DH-1N4007	2	1	1N4007	M7	Polar direction
LS1	Buzzer	BEEP001	2	1	3V		Polar direction

Table 4.1: Circuit Board Design Components

In this project, I used Altium Designer 9 to draw a schematic circuit diagram (cf. Figure 4.1 and Figure 4.2).

STM32F103R Processor: ARM 32-bit Cortex™-M3 CPU Core
In this project, a STM32 processor is one of essential materials that will drive the circuit board to control the mechanical arm. I use the STM32F103RB as my processor. The STM32F103xx medium-density performance line family incorporates the high performance ARM Cortex™-M3 32-bit RISC core operating at 72 MHz frequency, with high speed embedded memories (Flash memory up to 128 K bytes and SRAM up to 20 K bytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses.

All devices offer two 12-bit ADCs, three general purposes 16-bit timers plus one PWM timer, as well as standard and advanced communication interfaces: up to two I2Cs and SPIs, three USARTs, an USB and a CAN. These feature make the STM32F103 suitable for wide range of applications such as motor drives, application control, medical and handheld equipment, PC and gaming peripherals, GPS platforms, industrial applications, PLCs, inverters, printers, scanners, alarm systems, video intercoms, and HVACs.

Reset circuit: Once you click the key in reset circuit, the program in STM32 will restart.

BOOT0&BOOT1: Pins BOOT0 and BOOT1 select how the STM32 starts. Both BOOT0 and BOOT1 connects to ground and with a 10K resistance, which can easy to control how to start (cf. Table 4.2)

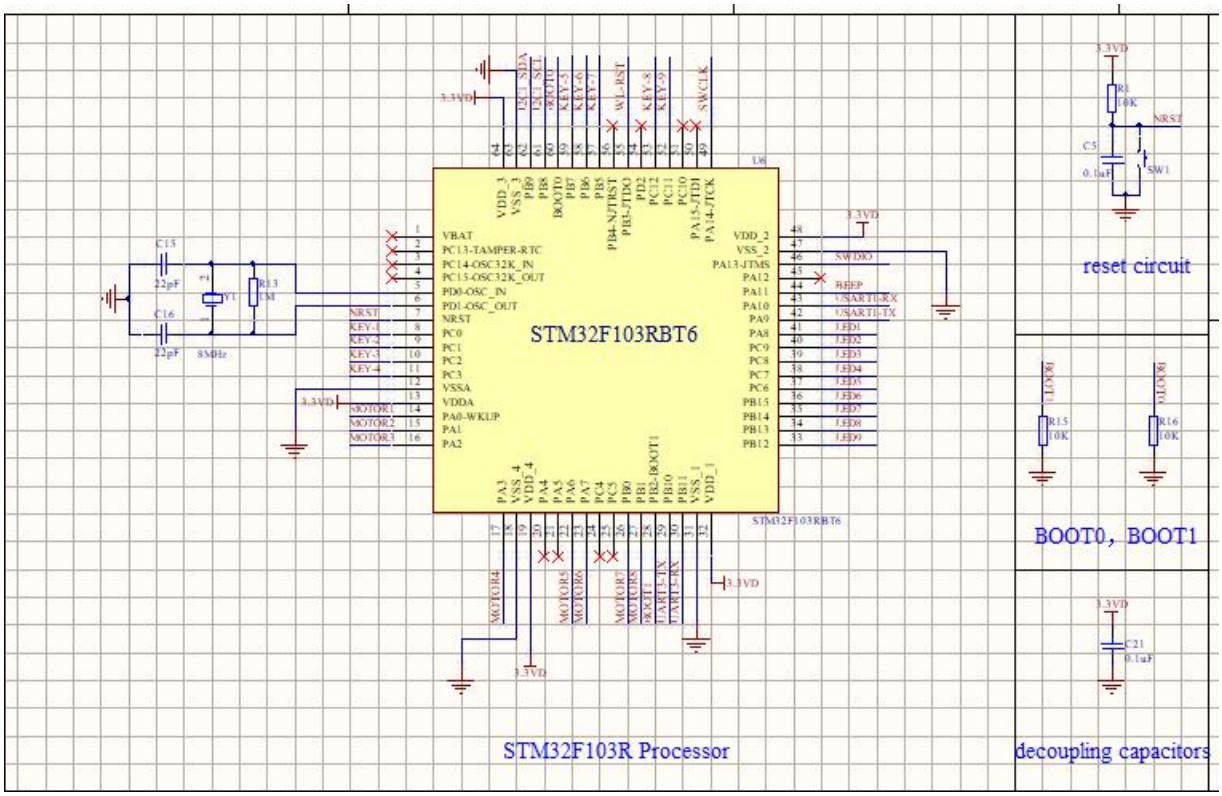

Figure 4.1: Schematic Circuit Board

BOOT1	BOOT0	Boot mode
X	0	User Flash memory
0	1	System memory (bootloader)
1	1	Embedded SRAM

Table 4.2: Pins BOOT0 and BOOT1

Decoupling capacitors: The purposes of decoupling capacitors to reduce or cut electric current fluctuations.

JTAG interface: This is interface point where we download the programming to the STM32 core chip.

RS232 serial interface: Communication interface for circuit board and PC or other device.

Keys: Designed for testing various function written in C (different arm action controlling codes).

Servo motor controlling interface: There are eight line pin headers which can control eight servo motors simultaneously. But this project will use just six pin headers to control six joint motors.

Low level buzzer: Buzzer is an audio signalling device. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a key click or communication signal.

Power input, protection switch and indication: Main switch of power supply, there is a switch and a fuse to avoid voltage overloading which protects whole circuit components on the board. And a LED light can indicate whether circuit board has a suitable power supply.

Main power supply 5V transfer 3.3V: Main power will be translate 5V into 3.3V which is suitable voltage for STM32 chip.

WIFI interface: Alternative communication interface for circuit board. It can use WIFI signal to communicate with whose device who can receive and connect this WIFI signal.

LED circuit: There are nine LED lights for code testing.

EEPROM 24CXX: It is an additional ATM storage which can store the data even though there is no power supply.

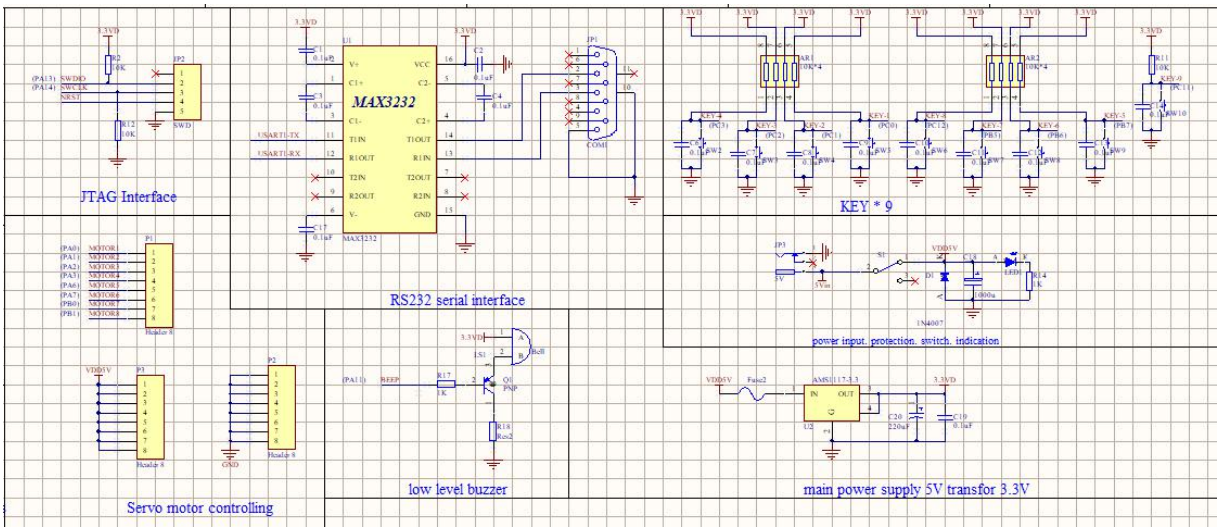

Figure 4.2: Schematic Circuit Board

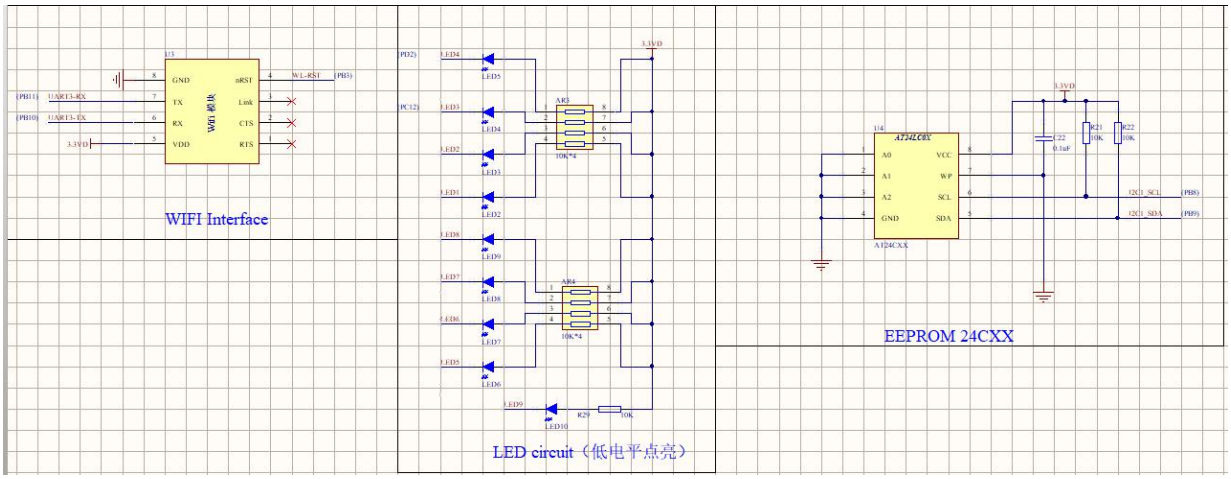

Figure 4.3: Printed Circuit Board Diagram

Figure 4.4 shows the Top Layer of the circuit board while Figure 4.5 shows the Bottom Layer of the circuit board.

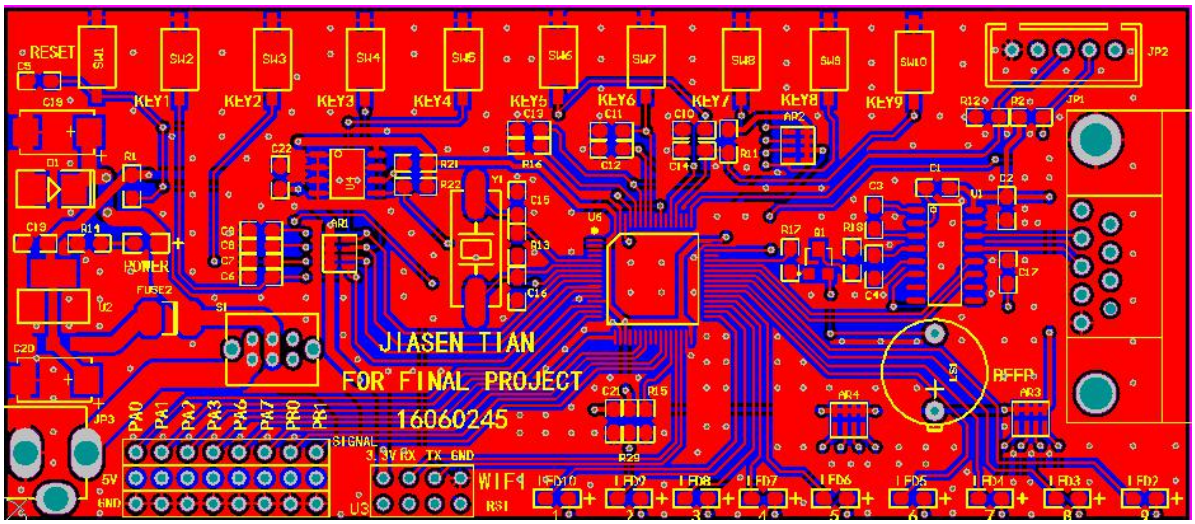

Figure 4.4: Top Layer of Circuit Board

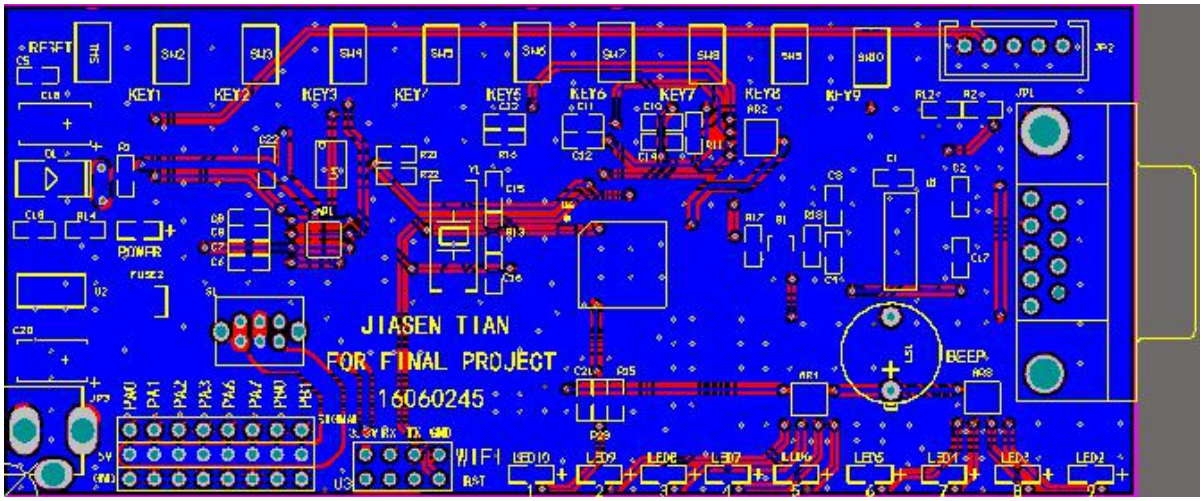

Figure 4.5: Bottom Layer of Circuit Board

After finishing the circuit board PCB file, I sent my PCB file to J&C CO. LTD which is a famous circuit board manufacturer in China. One week later, I got my new empty circuit board (cf. Figure 4.6).

Figure 4.6: Empty Circuit Board

Next, the various components were welded onto the circuit board (cf. Figure 4.7).

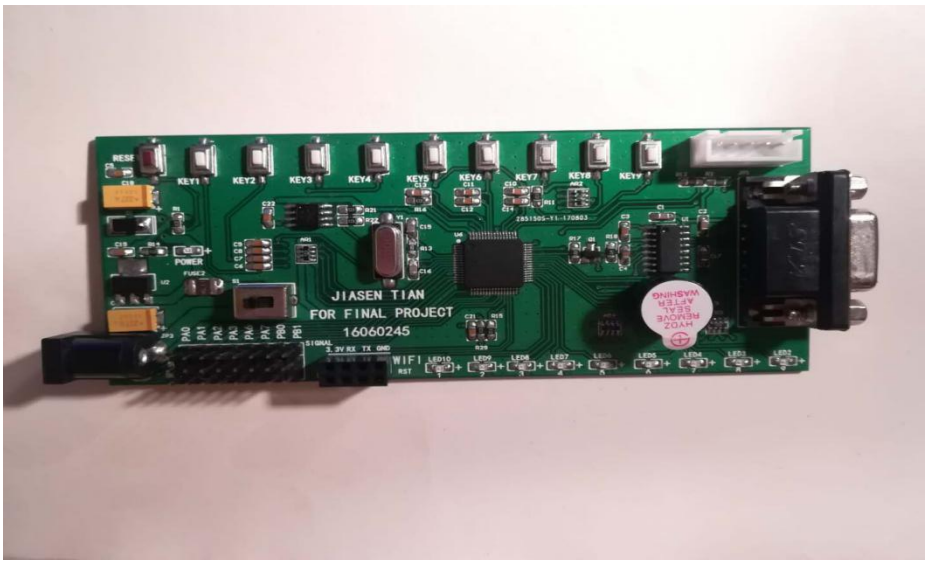

Figure 4.7: Circuit Board with Welded Components

The function of each key component:

- Pin PA0 will drive Joint 1 (cf. Section 4.2);
- Pin PA1 will drive Joint 2;
- Pin PA2 will drive Joint 3;
- Pin PA3 will drive Joint 4;
- Pin PA6 will drive Joint 5;
- Pin PA7 will drive Joint 6.
- Ten LED lights are used for testing functions and data.
- Ten Key switches are also used for testing functions and switching the code fragments.
- Testing of each component was successful.
- This controlling circuit board is now accessible to control the mechanical arm.