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# E-Bike Reference Platform

( R8C/11)

**User ’s Manual**

**RS-SZ**

**1st Edition**
Published by: Renesas System Solutions (Beijing) Co., Ltd., Shenzhen Branch
Date: September 30, 2007 Version 1.00

# About this manual

This user's manual is written for Renesas E-bike Reference Platform.It describes the hardware and software specifications of this platform.Pleas use this user's manual to understand the hardware and how to design R8C/11 for the E-bike application.

The platform controls a Brushless motor with hall sensor by 120-degree trapezoidal wave commutation.

**Section 1 Overview and Features**
Give an introduction to the hardware and software specifications of the platform.
**Section 2 System Requirements**
Introduce the requirements of the system.
**Section 3 Block Diagram**
Give an overview on the functional modules of the platform.
**Section 4 Schematic Diagram**
Give a description of each circuits or modules schematically and functionally.
**Section 5 Control of E-bike Brushless DC Motor**
Give a detail of E-bike Motor control system
**Section6 Bill of Components**
Give a detailed list of the components included in the system.
**Section 7 Sample Software Flowchart**
Give the detailed Sample Software flowchart description for the power meter application.
**Section8 Using E8 Emulator for Debugging**
Demonstrate how to debug in HEW environment by using E8 emulator.

# 1. Overview & Features

The R8C/11 E-bike solution is used to promote R8C/11 for the brushless DC motor with hall Sensor E-bike application. Emulator E8 is used for software development. The demonstration package should be given to customers with a demonstration board, a reference manual and a software package.

Hardware Specification:

- High speed onchip oscillator(8 MHZ)
- DC 36V input for DC5V,12V regulation
- Six MOSFETS and MOSFET driver circuitry
- Current detect circuitry
- Voltage detect circuitry
- Short protect circuitry
- Hall sensor detect circuitry
- One LED

Software Specification:

- 120 degree Trapezoidal Wave Commutation
- Motor speed control function
- Commutation current control function
- MOSFET protection function
- Voltage protection function
- Uart communications

Reference Manual Specification:

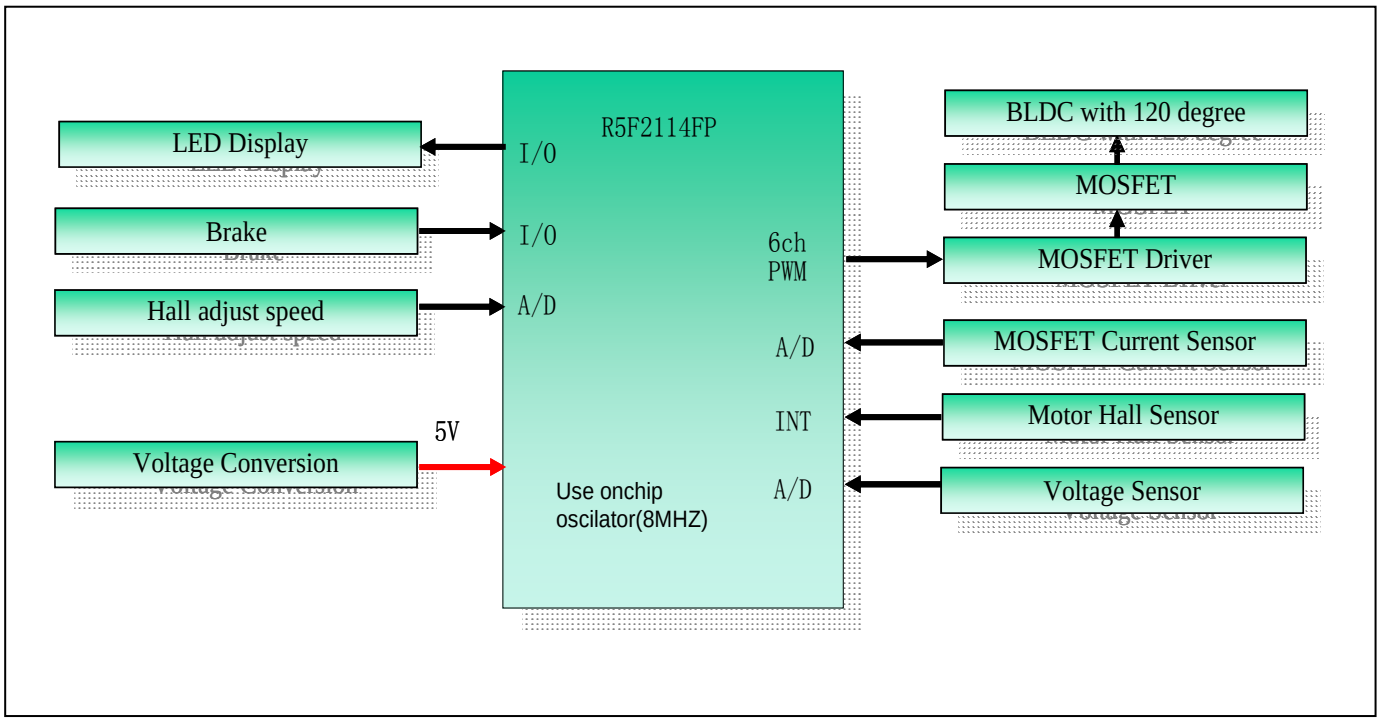
- Demonstration board schematic
- Description of each hardware functions
- Material list
- Description of each software module in the software package

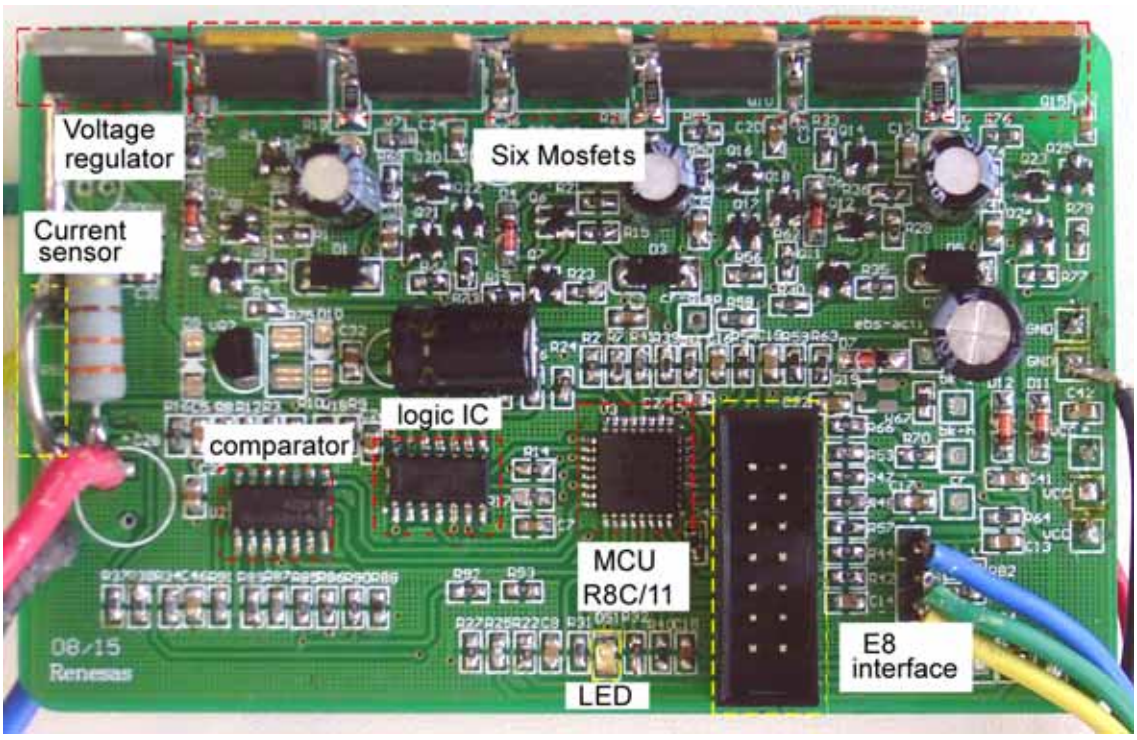
# 2. System Requirements

- 36V DC power supply
- Emulator, E8
- HEW installed in PC
- Compiler Package,NC30WA V.5.40

# 3. Block Diagram

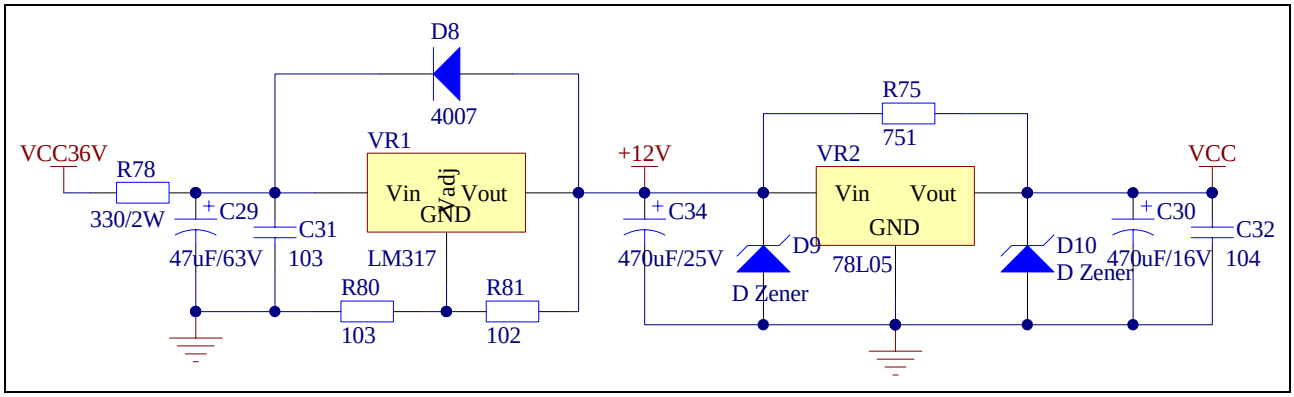
The following diagram describes the system blocks and the figure shows the system components, they help you have a general concept of this application.



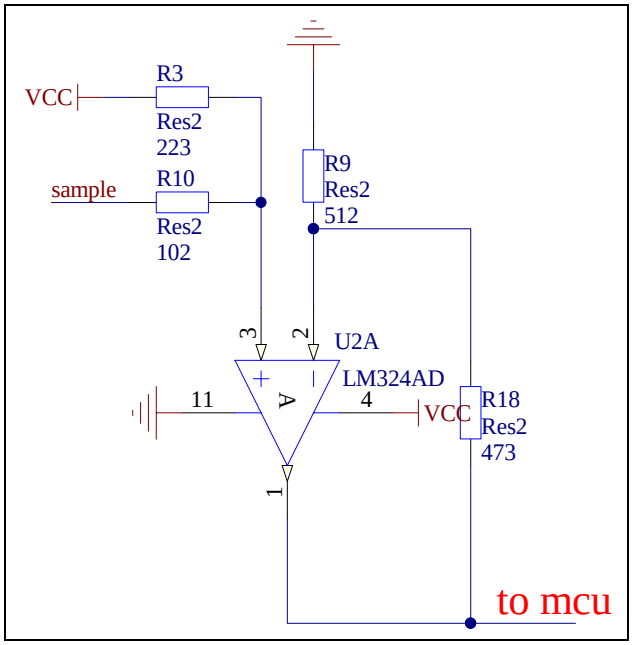
# 4. Schematic Diagram

## 4.1 Voltage Regulating Circuit.

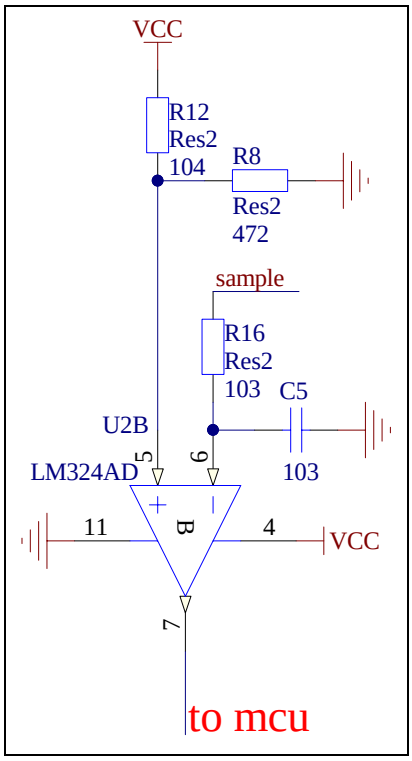



The Voltage regulating circuit change battery voltage 36v into 12V and 5V , It use of 12V for Mosfet driver , 5V for MCU and other circuits.

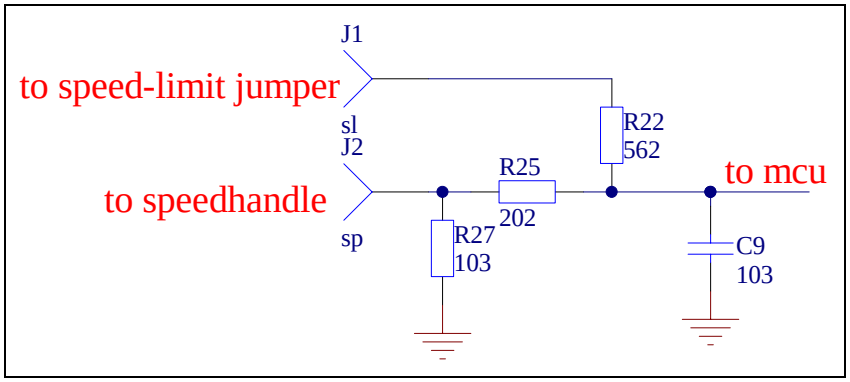
## 4.2 Current Detection Circuit.



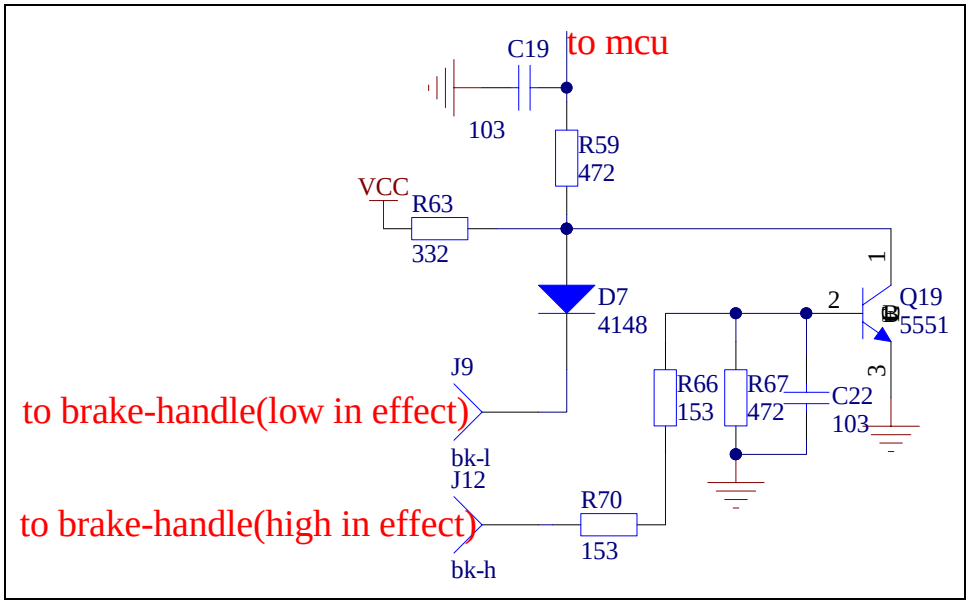
## 4.3 Short Circuit Detection Circuit.



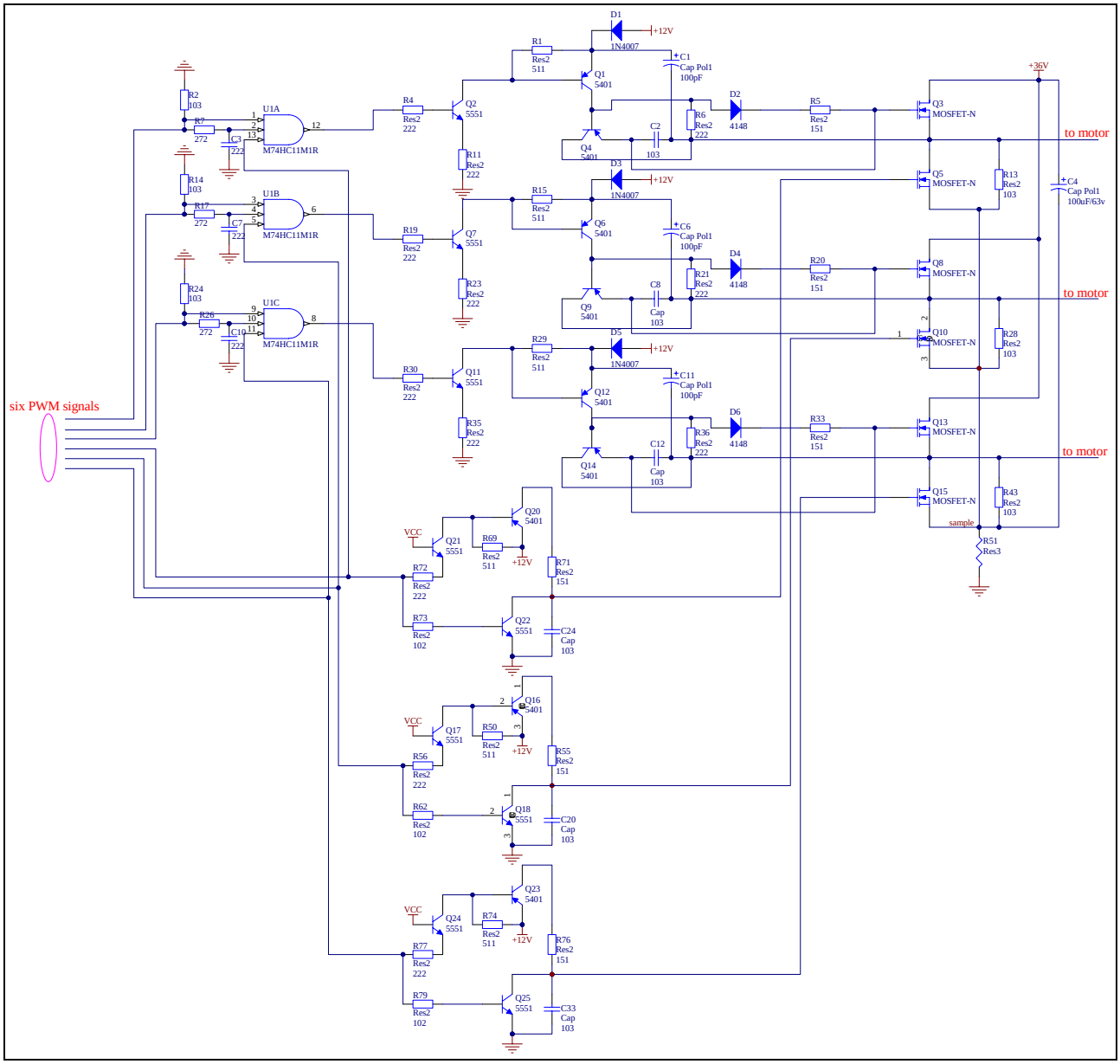

## 4.4 Speedhandle Signal Detection Circuit.



## 4.5 Brakehandle Signal Detection Circuit.



# 4.6 Motor Driver Circuit.



# 5 .0 Control of E-bike Brushless DC Motor

## 5.1 Hardware configuration.

1. The Hardware configuration is show in Figure 3.1.

2.The R8C/11 group detects hall sensoe signals that indicate the positions of the rotor's magnetic poles and operates the motor by producing six PWM waveforms that provide control of the rotating magnetic field according to the positional signals from the motor.

3.The R8C/11 group's built-in timer(TimerC) generates a PWM waveform and six Mosfets that handles chopping control for the motor.

4.The speed command is from handle voltage ,Current overprotection is use a low value resistor in the DC link path, negative current is detected.

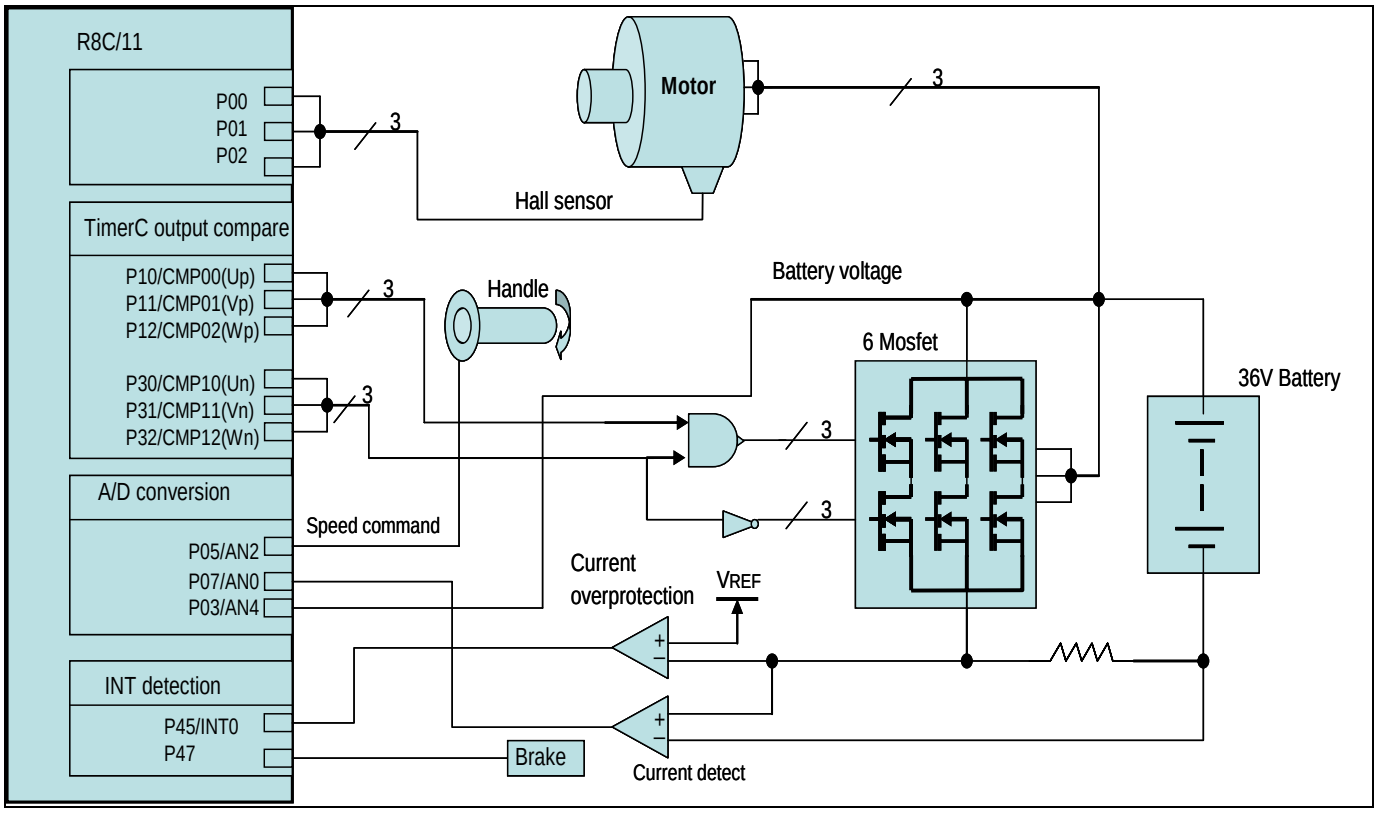



Figure 5.1 Hardware configuration

## 5.2 TimerC

1.Timer C is a 16-bit timer. Figure 12.28 shows a block diagram of Timer C. Figure 5.2 shows a block diagram of CMP waveform generation unit. Figure 12.30 shows a block diagram of CMP waveform output unit.The Timer C has two modes: input capture mode and output compare mode.

2.Count source:

•f1 •f8 •f32 •fRING-fast

3. Output pin:

- CMP00 to CMP02
- CMP10 to CMP12

4.Related interrupt:

- Timer C int
- compare 0 int
- compare 1 int

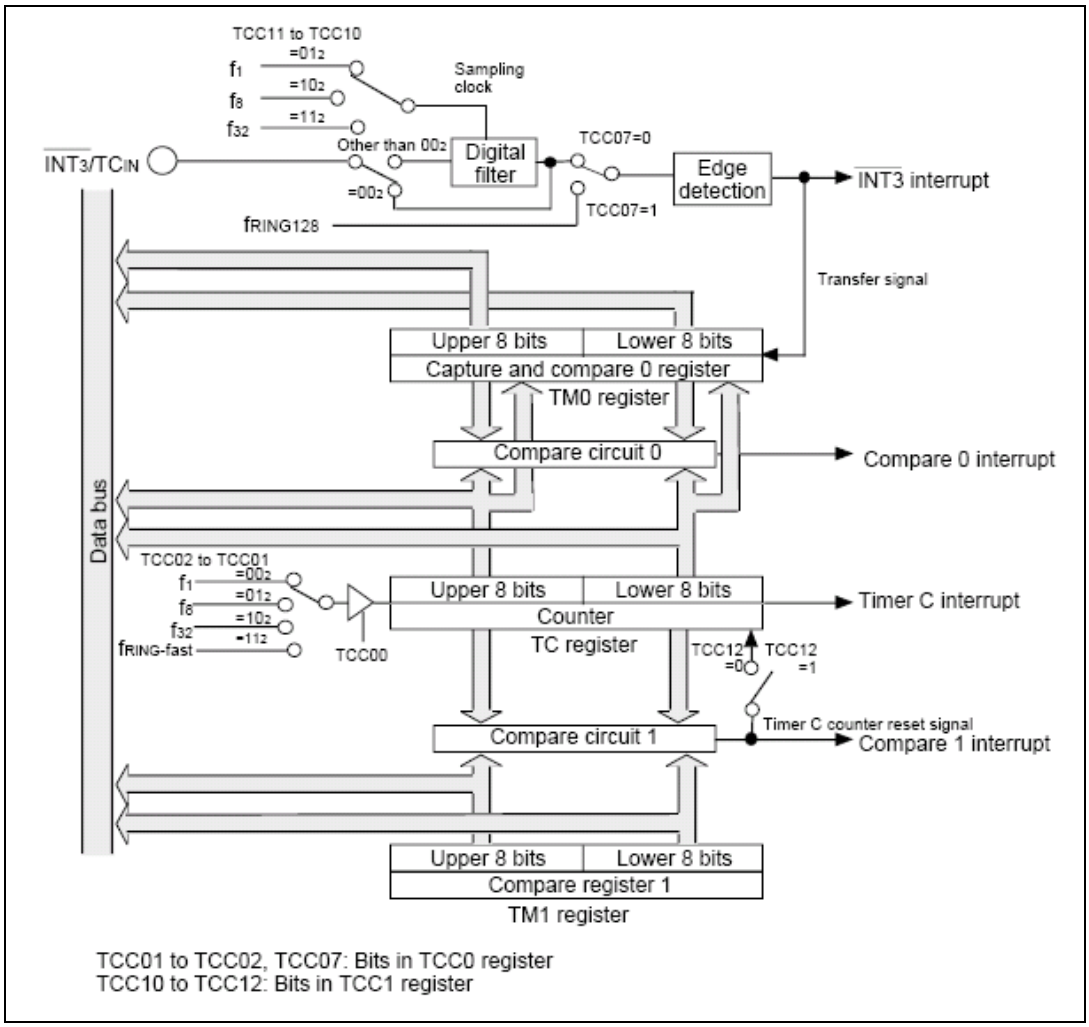



Figure 5.2 Timer C Block Diagram

## 5.3 PWM Output

1. The PWM output is implemented by using the R8C/11output compare mode of Timer C. In output compare
mode, TM1 is used to control the carrier wave period and TM0 to control the PWM output.

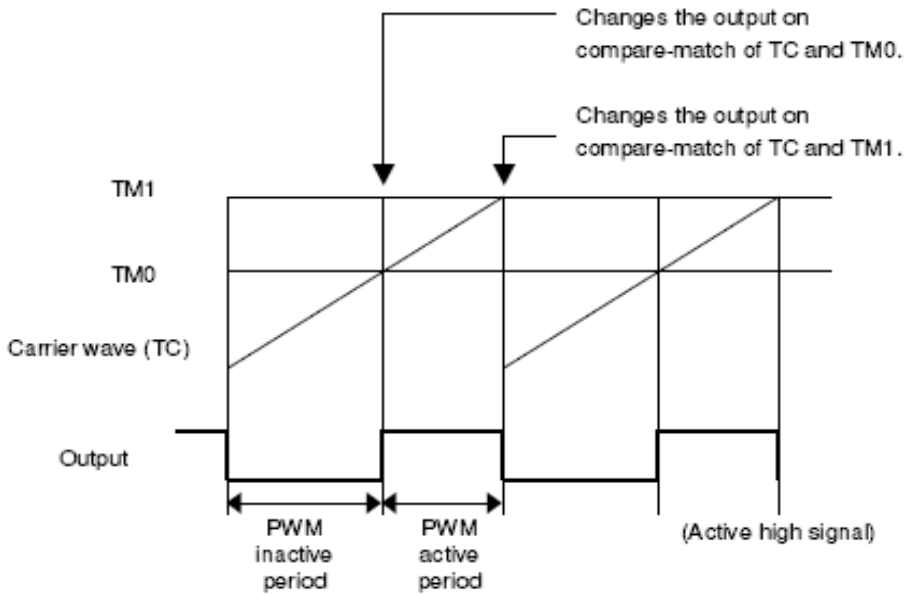



Figure 5.3 PWM Output

2. Interrupt:

Compare 1 interrupt (A compare 1 interrupt is generated on compare-match of the TC register and TM1 register.)

Timer-counter clock source : fRing-fast (8 MHz)

Timer C reload selection :

The TC register is set to 0000h on a match of compare 1

3.Compare 0 and 1 output mode selection:

The CMP output is driven high on a match of compare 0.

The CMP output is driven low on a match of compare 1.

## 5.4 Output Waveforms for 120-Degree Commutation

1.Described below is an example of waveform output for 120-degree commutation that is implemented through the use of the Timer C function.

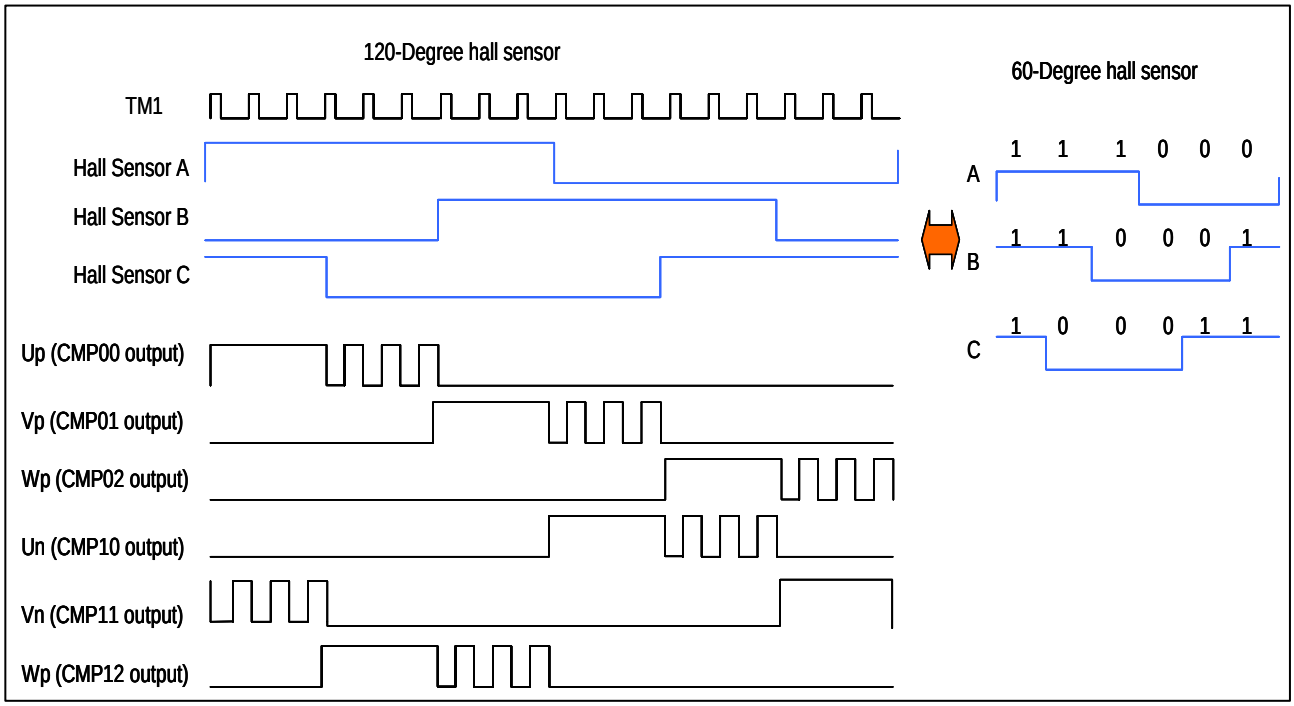
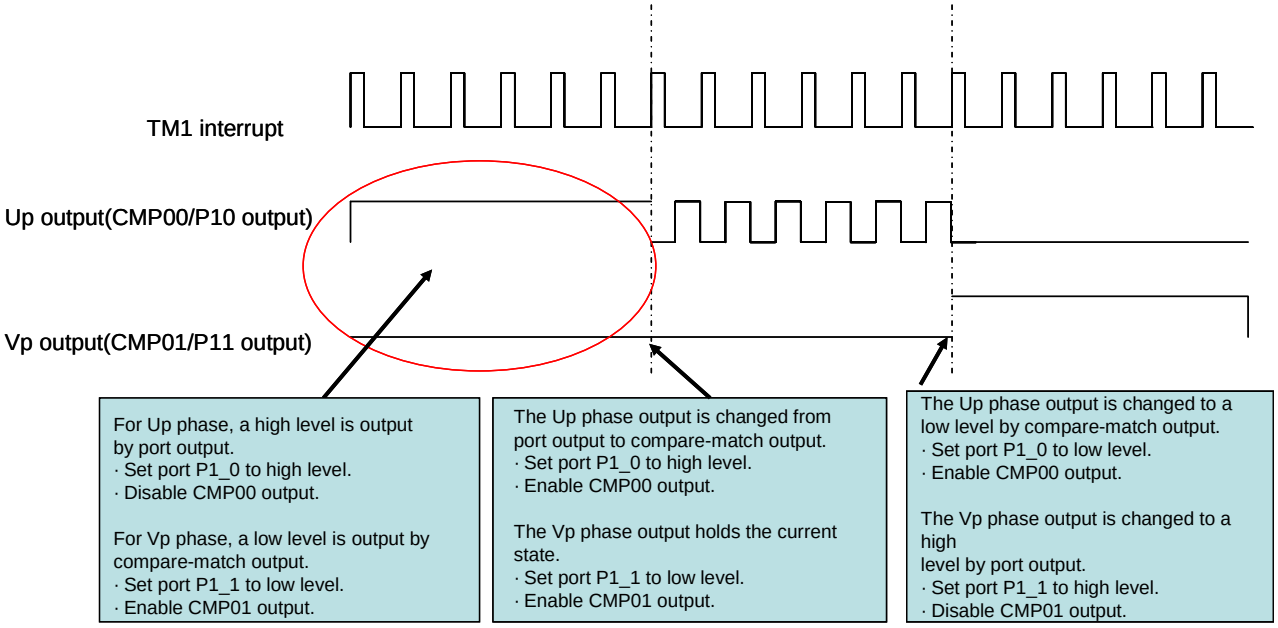



**Figure 5.4 Sensor Inputs and Output Waveforms for 120-Degree Trapezoidal Wave Commutation**

2.Three-phase output is implemented by port outputs and timer C compare match outputs.

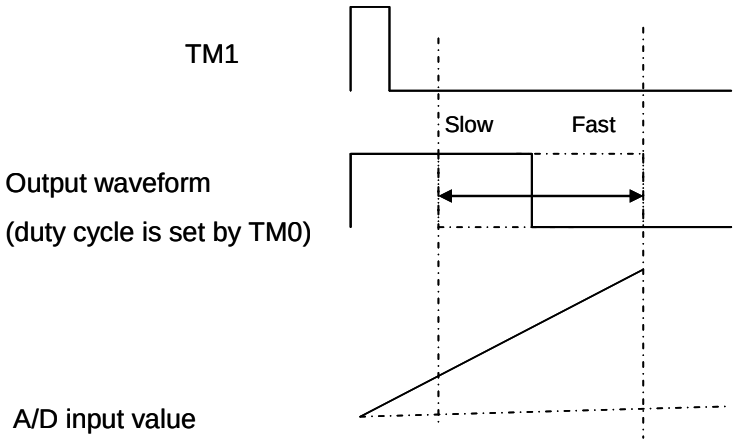


## 5.5 Speed control

In 120-degree commutation using trapezoidal waves, the speed of rotation is basically proportional to the voltage.

The active period of the output waveform is controlled by rewriting the TM0

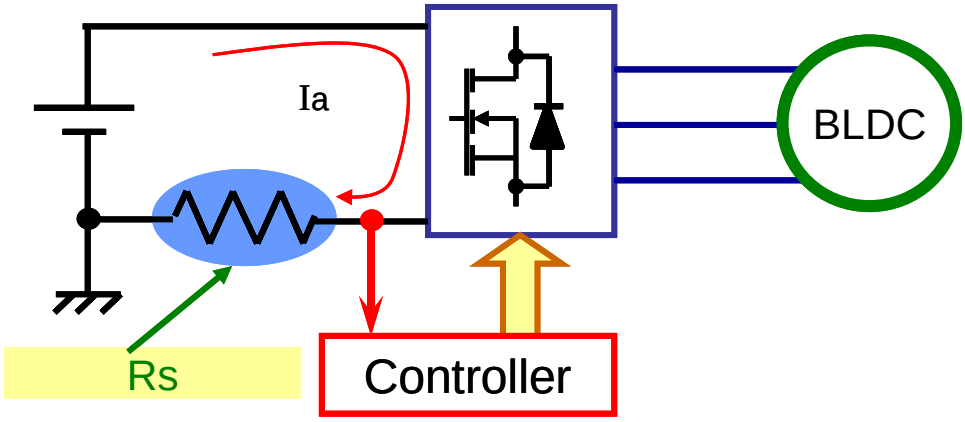
Detect handle A/D value and setting each time the rotation speed command is changed.




## 5.6 Commutation Current Control

1.120-Degree Trapezoidal Wave Commutation produces high torque ripple and audible noise , especially during transition of commutation. Because torque is directly proportional to current, we wish to regulate torque (current) or shorten dynamic response time, motor current may be regulated.

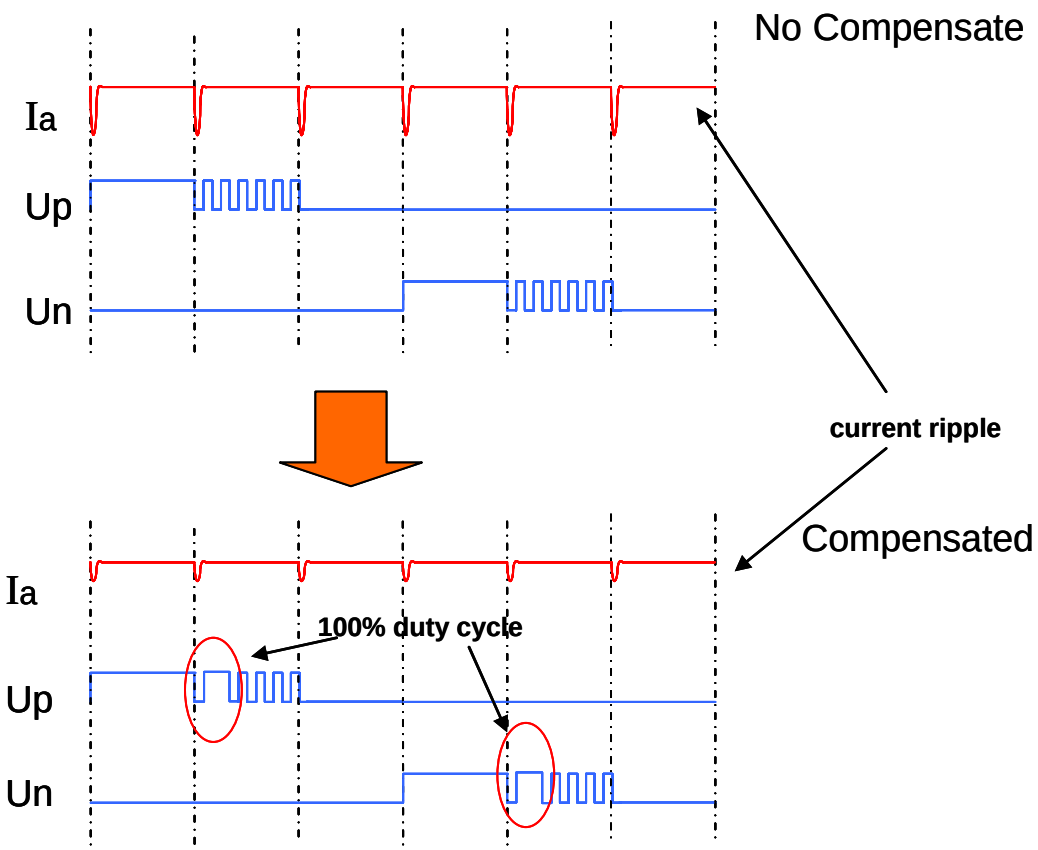
One of the simplest method of measuring current is inserting a low value resistor (Rs)
in the DC link path, negative of one of the phase current is detected.



2.Compensate Torque Ripple
Before transition of commutation detect the average bus current Ia ,

if Ia >Iset

Setting100% duty cycle in next output compare step.



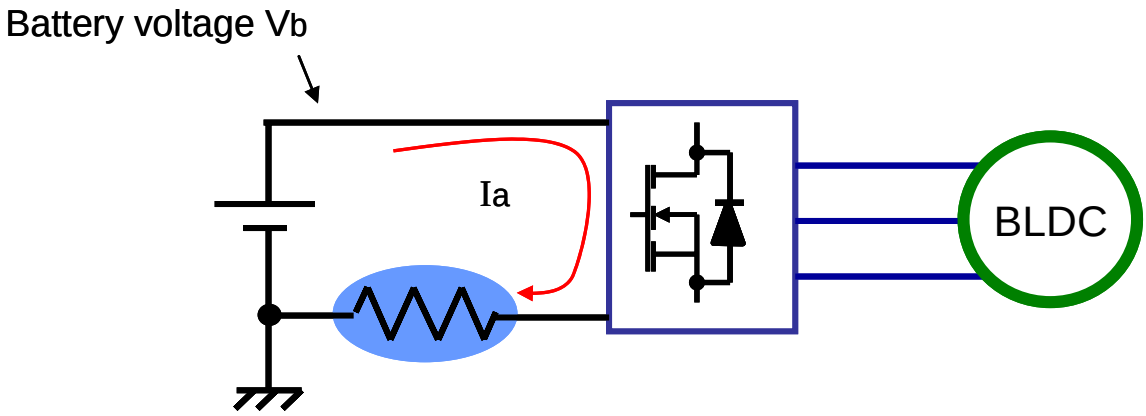
## 5.7 MOSFET and Battery Protection

Detect Battery voltage

Vb ,Ia.

If Vb < Vset
Or Ia >Ia_set

Close the PWM output




# 6. Bill of Components

| Comment | Designator | Footprint | Quantity | Value |
|---|---|---|---|---|
| Cap Pol1 | C1 | CAPPR2-5x6.8 | 1 | 100pF |
| Cap | C2 | C1608-0603 | 1 | 103 |
| Cap | C3 | C1608-0603 | 1 | 222 |
| Cap Pol1 | C4 | CAPPR2-5x6.8 | 1 | 100uF/63v |

| | | | | |
|---|---|---|---|---|
| Cap | C5 | C1608-0603 | 1 | 103 |
| Cap Pol1 | C6 | CAPPR2-5x6.8 | 1 | 100pF |
| Cap | C7 | C1608-0603 | 1 | 222 |
| Cap | C8 | C1608-0603 | 1 | 103 |
| Cap | C9 | C1608-0603 | 1 | 103 |
| Cap | C10 | C1608-0603 | 1 | 222 |
| Cap Pol1 | C11 | CAPPR2-5x6.8 | 1 | 100pF |
| Cap | C12 | C1608-0603 | 1 | 103 |
| Cap | C13 | C1608-0603 | 1 | 103 |
| Cap | C14 | C1608-0603 | 1 | 103 |
| Cap | C15 | C1608-0603 | 1 | 103 |
| Cap | C16 | C1608-0603 | 1 | 103 |
| Cap | C17 | C1608-0603 | 1 | 103 |
| Cap | C19 | C1608-0603 | 1 | 103 |
| Cap | C20 | C1608-0603 | 1 | 103 |
| Cap | C22 | C1608-0603 | 1 | 103 |
| Cap | C24 | C1608-0603 | 1 | 103 |
| Cap | C25 | C1608-0603 | 1 | 104 |
| Cap | C26 | C1608-0603 | 1 | 104 |
| Cap | C27 | C1608-0603 | 1 | 104 |
| Cap Pol1 | C28 | RB7.6-15 | 1 | 470uF/63V |
| Cap Pol1 | C29 | CAPPR2-5x6.8 | 1 | 47uF/63V |
| Cap Pol1 | C30 | CAPPR2-5x6.8 | 1 | 470uF/16V |
| Cap | C31 | C1608-0603 | 1 | 103 |
| Cap | C32 | C1608-0603 | 1 | 104 |
| Cap | C33 | C1608-0603 | 1 | 103 |
| Cap Pol1 | C34 | CAPPR2-5x6.8 | 1 | 470uF/25V |
| Cap | C35 | CR0805 | 1 | 104 |
| Cap | C36 | CR0805 | 1 | 104 |
| Cap | C37 | CR0805 | 1 | 104 |
| Cap | C38 | C1608-0603 | 1 | 104 |
| Cap | C39 | C1608-0603 | 1 | 104 |
| Cap | C40 | C1608-0603 | 1 | 104 |
| Cap | C41 | C1608-0603 | 1 | 103 |
| Cap | C42 | C1608-0603 | 1 | 103 |
| Cap | C46 | C1608-0603 | 1 | 103 |
| Header 7X2 | CON1 | HDR2X7 | 1 | |
| 1N4007 | D1 | DSO-C2/X2.3 | 1 | |
| 4148 | D2 | SO4148 | 1 | |
| 1N4007 | D3 | DSO-C2/X2.3 | 1 | |
| 4148 | D4 | SO4148 | 1 | |

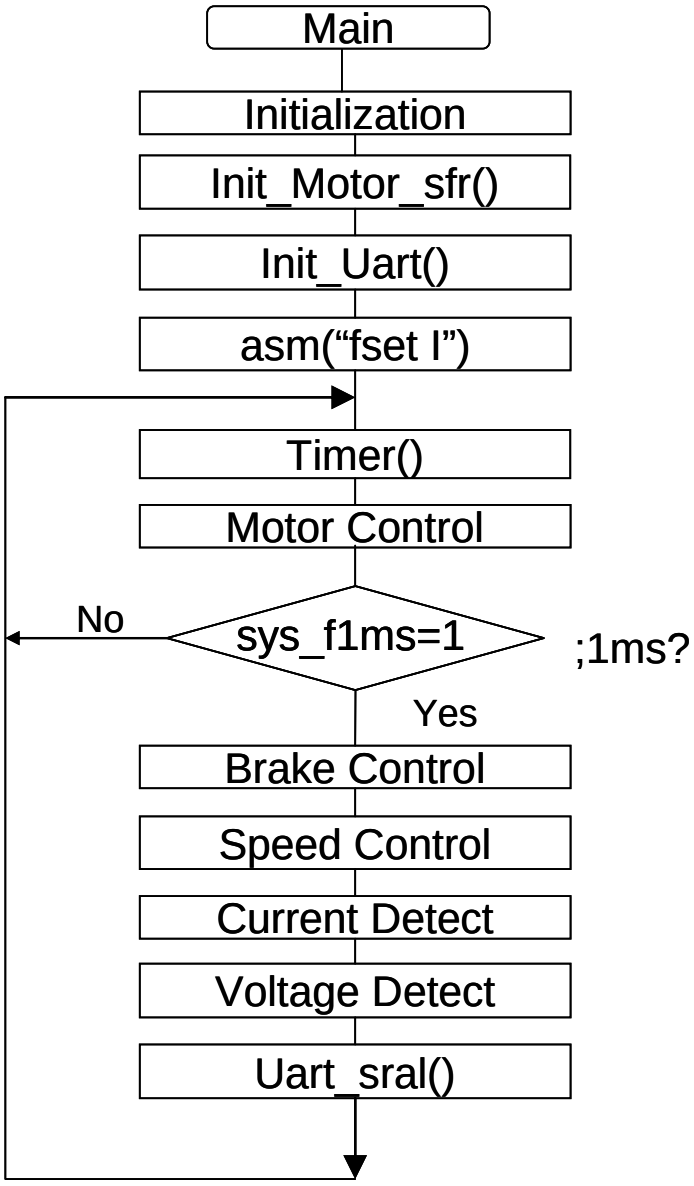
| | | | | |
|---|---|---|---|---|
| 1N4007 | D5 | DSO-C2/X2.3 | 1 | |
| 4148 | D6 | SO4148 | 1 | |
| 4148 | D7 | SO4148 | 1 | |
| 4007 | D8 | DSO-C2/X2.3 | 1 | |
| D Zener | D9 | SO4148 | 1 | |
| D Zener | D10 | SO4148 | 1 | |
| 4148 | D11 | SO4148 | 1 | |
| 4148 | D12 | SO4148 | 1 | |
| LED0 | DS1 | SMD _LED | 1 | |
| 5401 | Q1 | NPN | 1 | |
| 5551 | Q2 | NPN | 1 | |
| 5401 | Q4 | NPN | 1 | |
| 5401 | Q6 | NPN | 1 | |
| 5551 | Q7 | NPN | 1 | |
| 5401 | Q9 | NPN | 1 | |
| 5551 | Q11 | NPN | 1 | |
| 5401 | Q12 | NPN | 1 | |
| 5401 | Q14 | NPN | 1 | |
| 5401 | Q16 | NPN | 1 | |
| 5551 | Q17 | NPN | 1 | |
| 5551 | Q18 | NPN | 1 | |
| 5551 | Q19 | NPN | 1 | |
| 5401 | Q20 | NPN | 1 | |
| 5551 | Q21 | NPN | 1 | |
| 5551 | Q22 | NPN | 1 | |
| 5401 | Q23 | NPN | 1 | |
| 5551 | Q24 | NPN | 1 | |
| 5551 | Q25 | NPN | 1 | |
| Res2 | R1 | C1608-0603 | 1 | 511 |
| Res2 | R2 | C1608-0603 | 1 | 103 |
| Res2 | R3 | C1608-0603 | 1 | 223 |
| Res2 | R4 | C1608-0603 | 1 | 222 |
| Res2 | R5 | C1608-0603 | 1 | 151 |
| Res2 | R6 | C1608-0603 | 1 | 222 |
| Res2 | R7 | C1608-0603 | 1 | 272 |
| Res2 | R8 | C1608-0603 | 1 | 472 |
| Res2 | R9 | C1608-0603 | 1 | 332 |
| Res2 | R10 | C1608-0603 | 1 | 102 |
| Res2 | R11 | C1608-0603 | 1 | 222 |
| Res2 | R12 | C1608-0603 | 1 | 104 |
| Res2 | R13 | CR1206 | 1 | 103 |

| | | | | |
|---|---|---|---|---|
| Res2 | R14 | C1608-0603 | 1 | 103 |
| Res2 | R15 | C1608-0603 | 1 | 511 |
| Res2 | R16 | C1608-0603 | 1 | 103 |
| Res2 | R17 | C1608-0603 | 1 | 272 |
| Res2 | R18 | C1608-0603 | 1 | 223 |
| Res2 | R19 | C1608-0603 | 1 | 222 |
| Res2 | R20 | C1608-0603 | 1 | 151 |
| Res2 | R21 | C1608-0603 | 1 | 222 |
| Res2 | R22 | C1608-0603 | 1 | 562 |
| Res2 | R23 | C1608-0603 | 1 | 222 |
| Res2 | R24 | C1608-0603 | 1 | 103 |
| Res2 | R25 | C1608-0603 | 1 | 202 |
| Res2 | R26 | C1608-0603 | 1 | 272 |
| Res2 | R27 | C1608-0603 | 1 | 103 |
| Res2 | R28 | CR1206 | 1 | 103 |
| Res2 | R29 | C1608-0603 | 1 | 511 |
| Res2 | R30 | C1608-0603 | 1 | 222 |
| Res2 | R31 | C1608-0603 | 1 | 102 |
| Res2 | R32 | C1608-0603 | 1 | 103 |
| Res2 | R33 | C1608-0603 | 1 | 151 |
| Res2 | R34 | C1608-0603 | 1 | 512 |
| Res2 | R35 | C1608-0603 | 1 | 222 |
| Res2 | R36 | C1608-0603 | 1 | 222 |
| Res2 | R37 | C1608-0603 | 1 | 123 |
| Res2 | R38 | C1608-0603 | 1 | 473 |
| Res2 | R39 | C1608-0603 | 1 | 433 |
| Res2 | R40 | C1608-0603 | 1 | 332 |
| Res2 | R41 | C1608-0603 | 1 | 103 |
| Res2 | R42 | C1608-0603 | 1 | 332 |
| Res2 | R43 | CR1206 | 1 | 103 |
| Res2 | R44 | C1608-0603 | 1 | 102 |
| Res2 | R45 | C1608-0603 | 1 | 332 |
| Res2 | R46 | C1608-0603 | 1 | 512 |
| Res2 | R47 | C1608-0603 | 1 | 103 |
| Res2 | R48 | C1608-0603 | 1 | 102 |
| Res2 | R50 | C1608-0603 | 1 | 511 |
| Res3 | R51 | AXIAL-0.5 | 1 | |
| Res2 | R53 | C1608-0603 | 1 | 215 |
| Res2 | R54 | C1608-0603 | 1 | 472 |
| Res2 | R55 | C1608-0603 | 1 | 151 |
| Res2 | R56 | C1608-0603 | 1 | 222 |

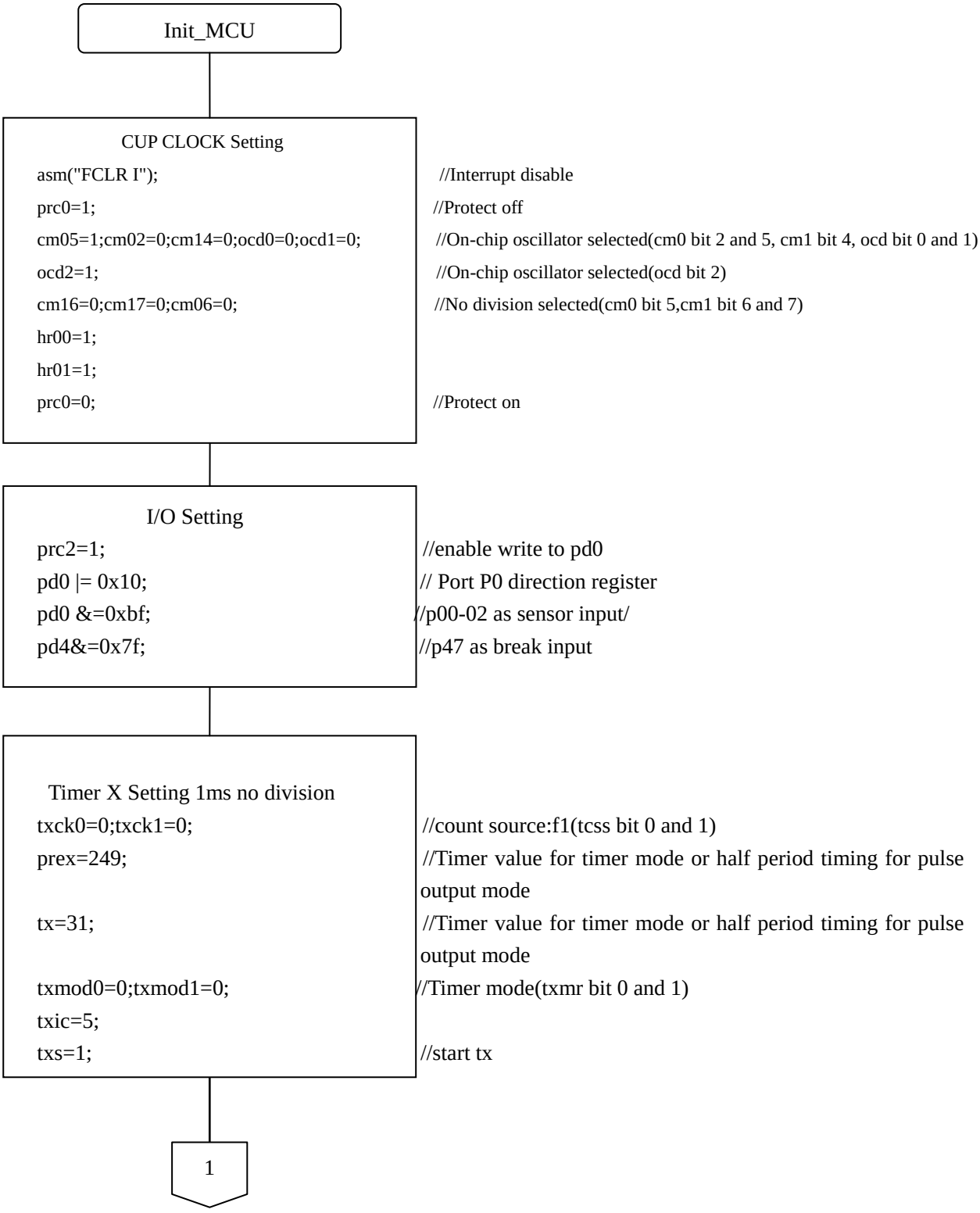
| | | | | |
|---|---|---|---|---|
| Res2 | R57 | C1608-0603 | 1 | 332 |
| Res2 | R58 | C1608-0603 | 1 | 223 |
| Res2 | R59 | C1608-0603 | 1 | 472 |
| Res2 | R62 | C1608-0603 | 1 | 102 |
| Res2 | R63 | C1608-0603 | 1 | 332 |
| Res2 | R64 | C1608-0603 | 1 | 332 |
| Res2 | R66 | C1608-0603 | 1 | 153 |
| Res2 | R67 | C1608-0603 | 1 | 472 |
| Res2 | R69 | C1608-0603 | 1 | 511 |
| Res2 | R70 | C1608-0603 | 1 | 153 |
| Res2 | R71 | C1608-0603 | 1 | 151 |
| Res2 | R72 | C1608-0603 | 1 | 222 |
| Res2 | R73 | C1608-0603 | 1 | 102 |
| Res2 | R74 | C1608-0603 | 1 | 511 |
| Res2 | R75 | CR1206 | 1 | 751 |
| Res2 | R76 | C1608-0603 | 1 | 151 |
| Res2 | R77 | C1608-0603 | 1 | 222 |
| Res2 | R78 | AXIAL-0.6 | 1 | 330/2W |
| Res2 | R79 | C1608-0603 | 1 | 102 |
| Res2 | R80 | C1608-0603 | 1 | 103 |
| Res2 | R81 | C1608-0603 | 1 | 102 |
| Res2 | R82 | C1608-0603 | 1 | 103 |
| Res2 | R83 | C1608-0603 | 1 | 103 |
| Res2 | R84 | C1608-0603 | 1 | 103 |
| Res2 | R85 | C1608-0603 | 1 | 223 |
| Res2 | R86 | C1608-0603 | 1 | 102 |
| Res2 | R87 | C1608-0603 | 1 | 512 |
| Res2 | R88 | C1608-0603 | 1 | 472 |
| Res2 | R89 | C1608-0603 | 1 | 473 |
| Res2 | R90 | C1608-0603 | 1 | 104 |
| Res2 | R91 | C1608-0603 | 1 | 103 |
| Res2 | R92 | C1608-0603 | 1 | 103 |
| Res2 | R93 | C1608-0603 | 1 | 103 |
| M74HC11M1R | U1 | SO14 | 1 | |
| LM324AD | U2 | SO14 | 1 | |
| R8C/11 | U3 | TQFP32 | 1 | |
| LM317 | VR1 | SFM-T3/X1.6V | 1 | |
| 78L05 | VR2 | BCY-W3 | 1 | |

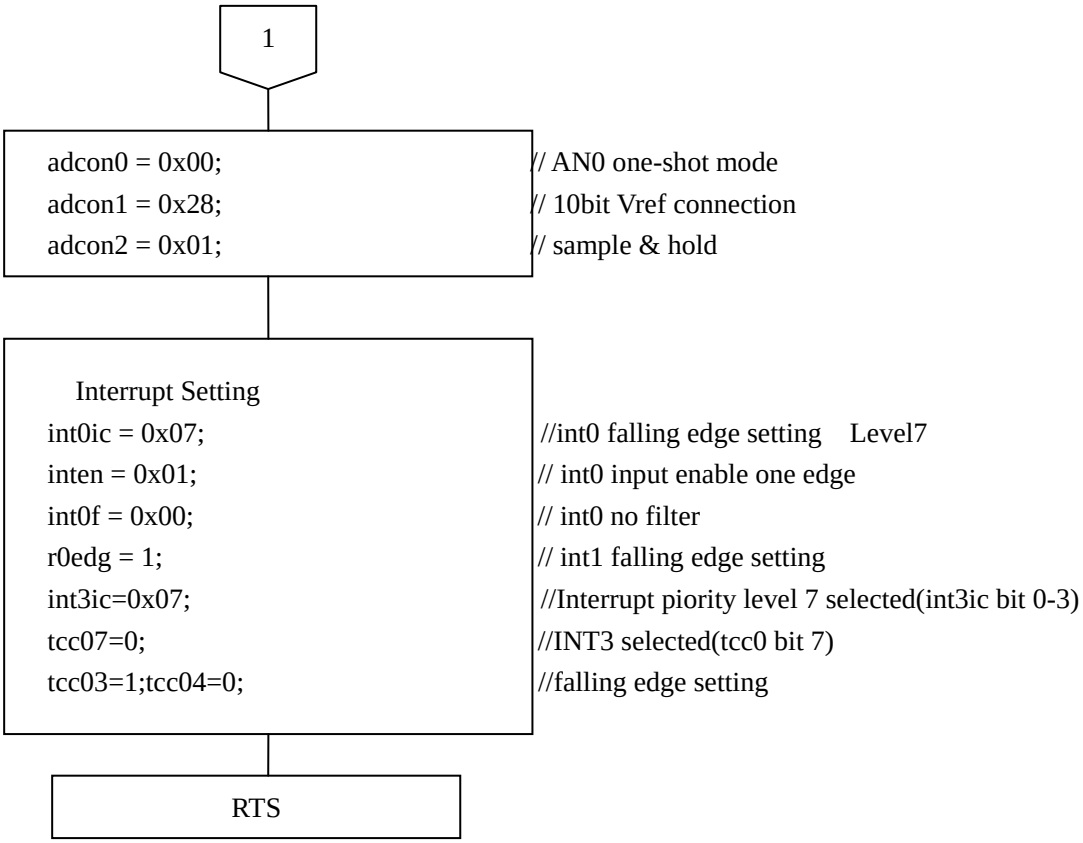
# 7. Software Description

7.1 main function

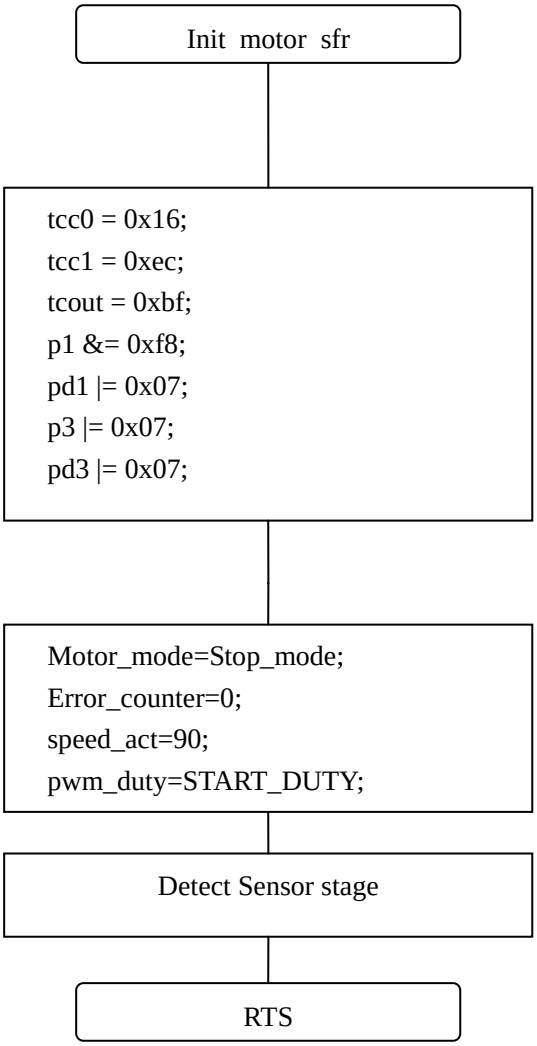


## 7.2InitMcu

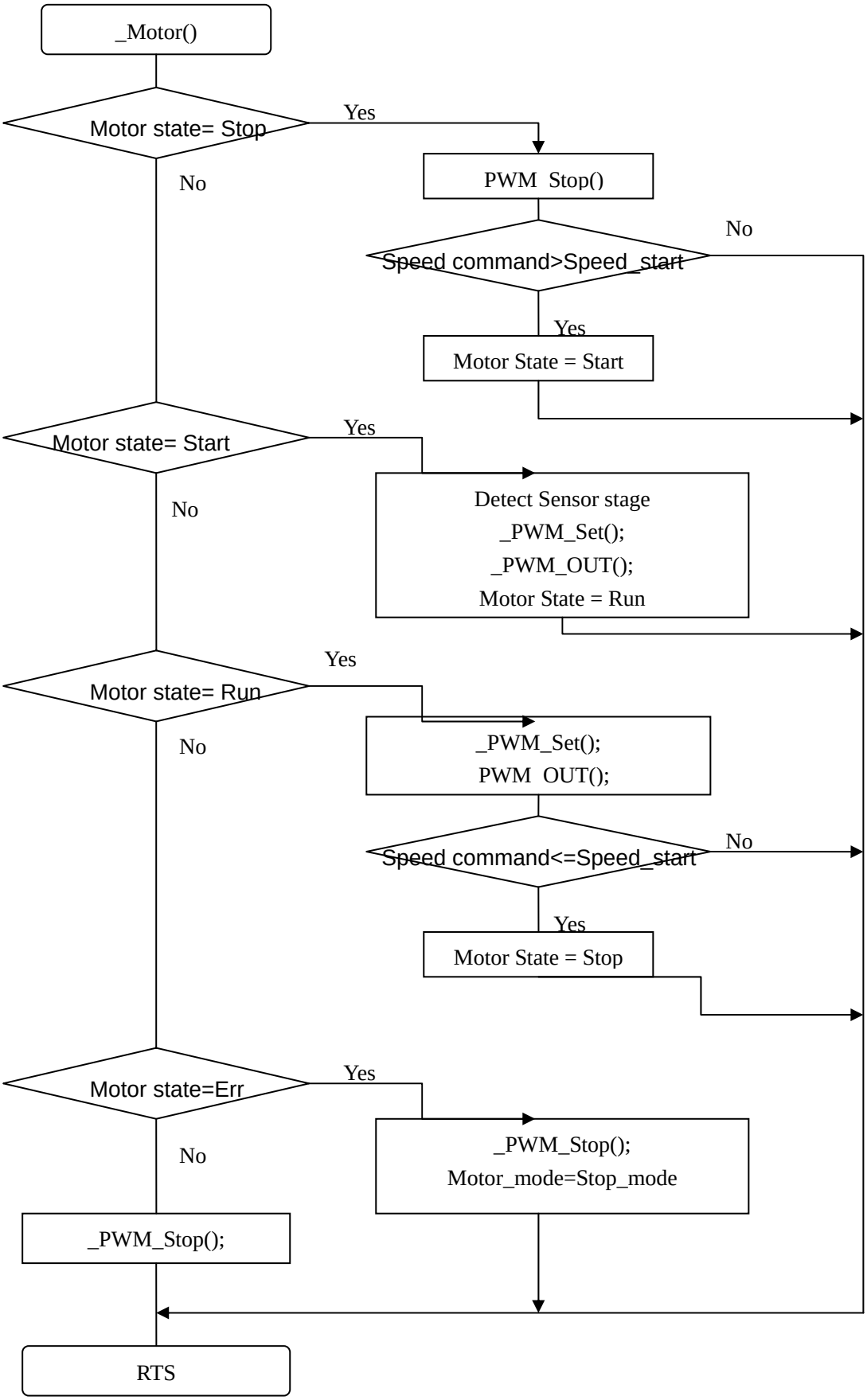

Init_MCU
CUP CLOCK Setting
asm("FCLR I");
//Interrupt disable
prc0=1;
//Protect off
cm05=1;cm02=0;cm14=0;ocd0=0;ocd1=0;
//On-chip oscillator selected(cm0 bit 2 and 5, cm1 bit 4, ocd bit 0 and 1)
ocd2=1;
//On-chip oscillator selected(ocd bit 2)
cm16=0;cm17=0;cm06=0;
//No division selected(cm0 bit 5,cm1 bit 6 and 7)
hr00=1;
hr01=1;
prc0=0;
//Protect on
I/O Setting
prc2=1;
//enable write to pd0
pd0 |= 0x10;
// Port P0 direction register
pd0 &=0xbf;
//p00-02 as sensor input/
pd4&=0x7f;
//p47 as break input
Timer X Setting 1ms no division
txck0=0;txck1=0;
//count source:f1(tcss bit 0 and 1)
prex=249;
//Timer value for timer mode or half period timing for pulse output mode
tx=31;
//Timer value for timer mode or half period timing for pulse output mode
txmod0=0;txmod1=0;
//Timer mode(txmr bit 0 and 1)
txic=5;
txs=1;
//start tx
1


1
adcon0 = 0x00;
adcon1 = 0x28;
adcon2 = 0x01;
// AN0 one-shot mode
// 10bit Vref connection
// sample & hold
Interrupt Setting
int0ic = 0x07;
inten = 0x01;
int0f = 0x00;
r0edg = 1;
int3ic=0x07;
tcc07=0;
tcc03=1;tcc04=0;
//int0 falling edge setting Level7
// int0 input enable one edge
// int0 no filter
// int1 falling edge setting
//Interrupt piority level 7 selected(int3ic bit 0-3)
//INT3 selected(tcc0 bit 7)
//falling edge setting
RTS

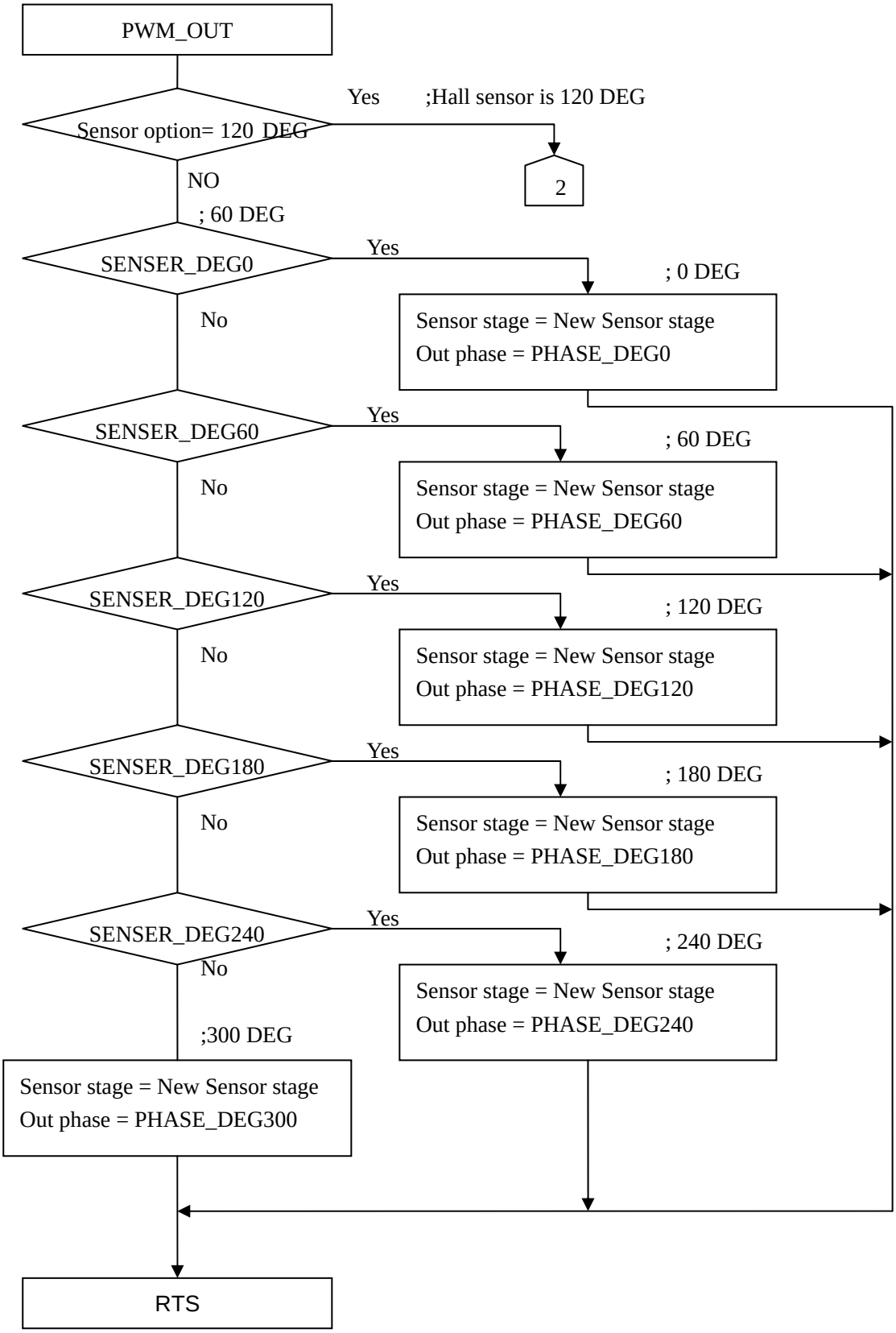
## 7.3 Initialize SFRs for Motor control

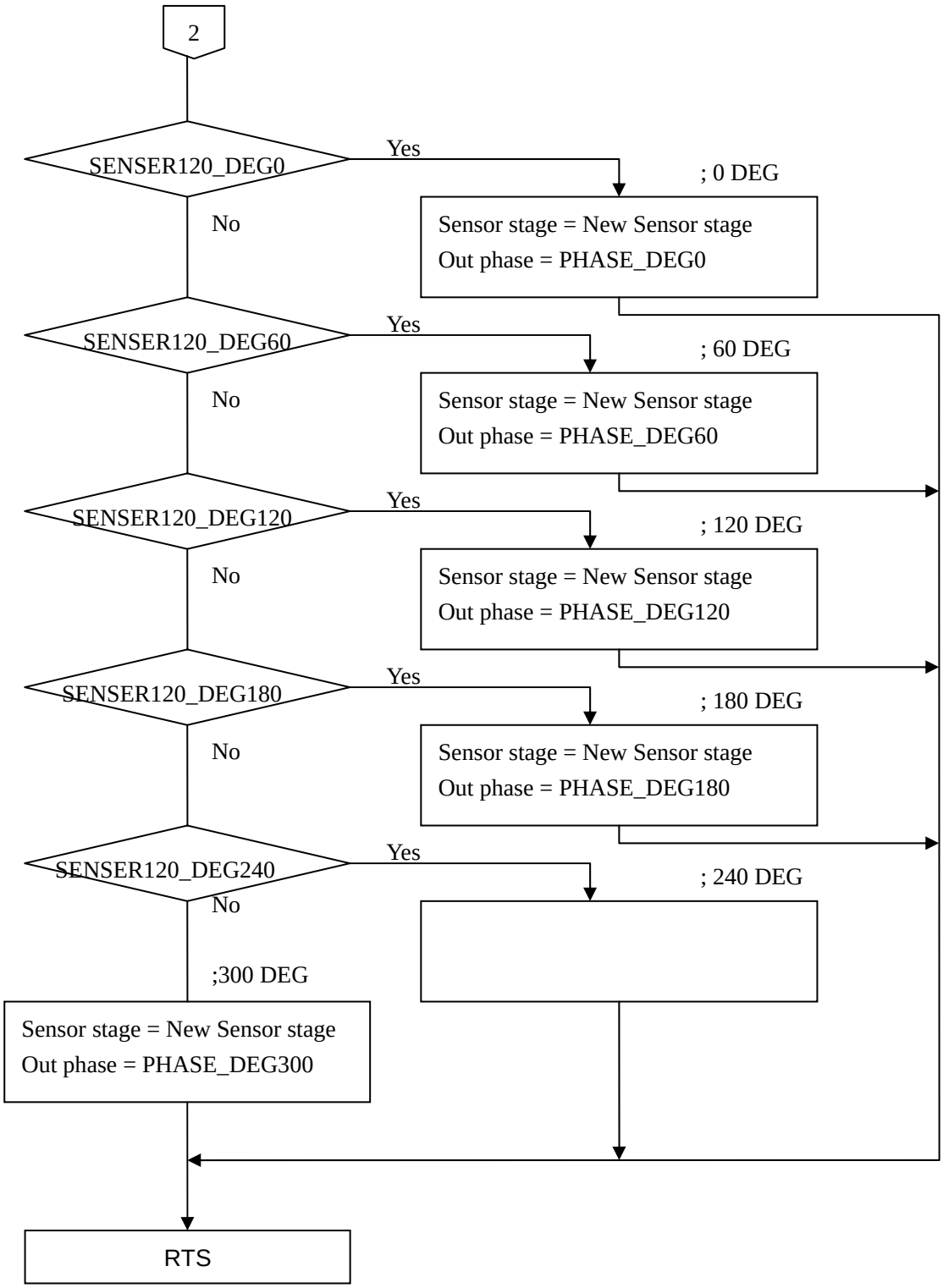



## 7.4 Motor Control

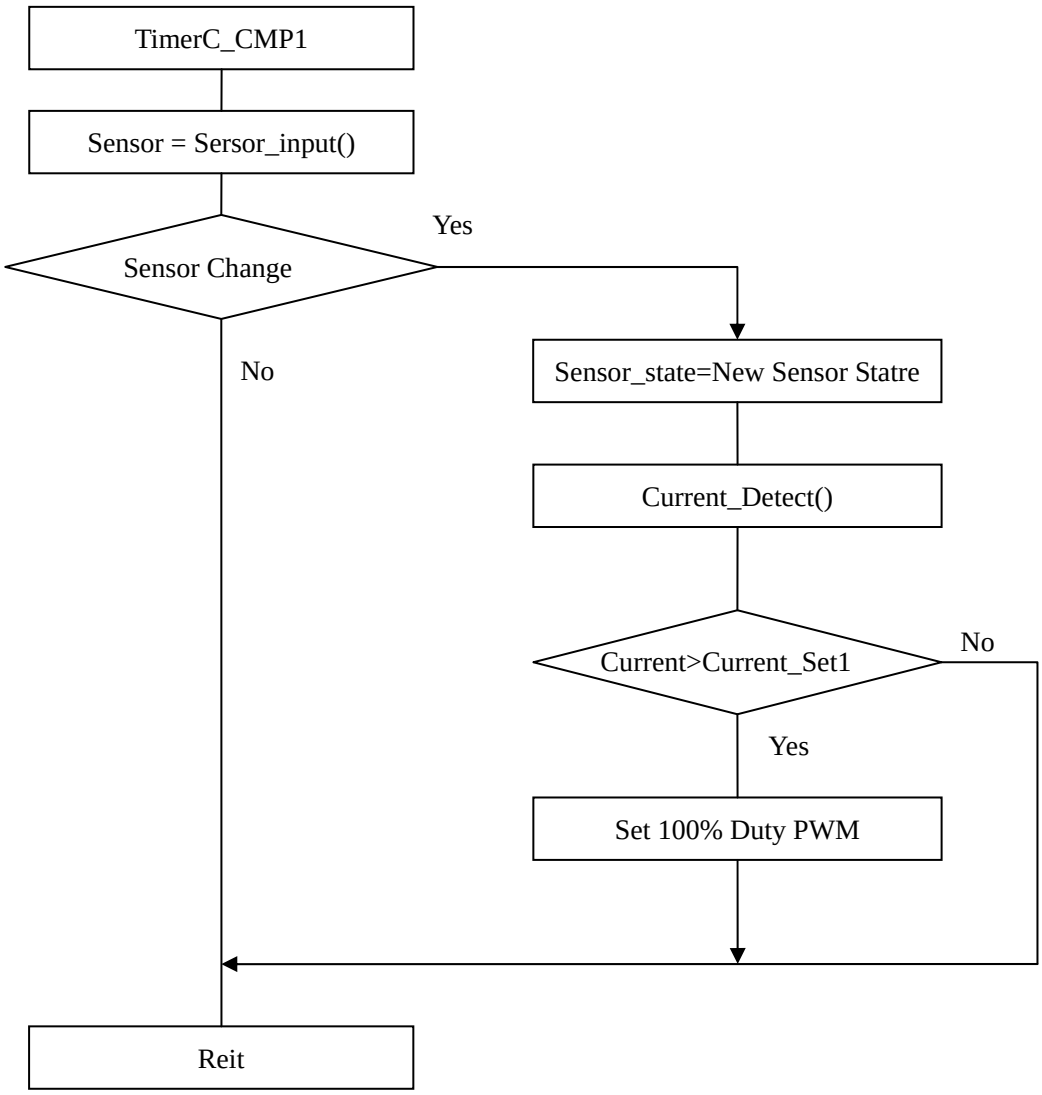

_Motor()
Motor state= Stop
Yes
No
PWM Stop()
Speed command>Speed_start
No
Yes
Motor State = Start
Motor state= Start
Yes
No
Detect Sensor stage
_PWM_Set();
_PWM_OUT();
Motor State = Run
Motor state= Run
Yes
No
_PWM_Set();
PWM OUT();
Speed command<=Speed_start
No
Yes
Motor State = Stop
Motor state=Err
Yes
No
_PWM_Stop();
Motor_mode=Stop_mode
_PWM_Stop();
RTS

## 7.5 PWM Out processing

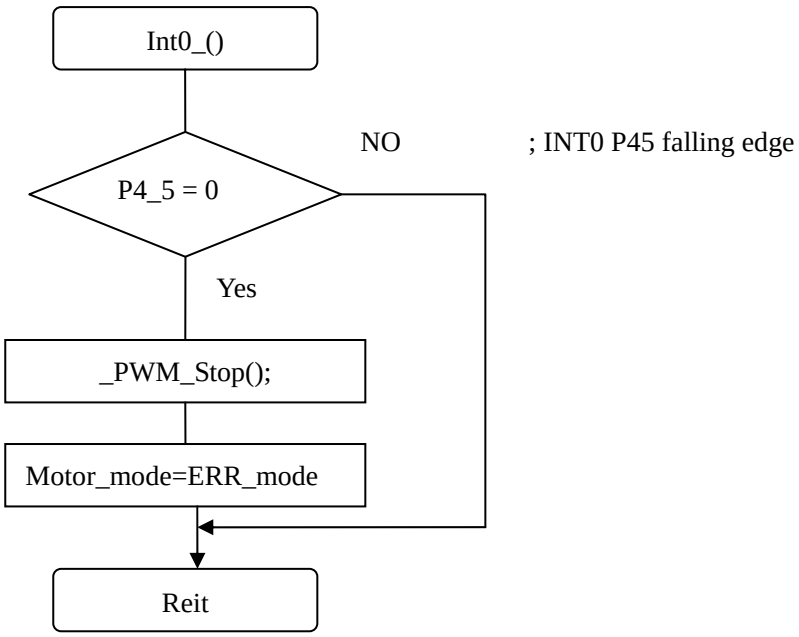



2
SENSER120_DEG0
Yes
; 0 DEG
Sensor stage = New Sensor stage
Out phase = PHASE_DEG0
No
SENSER120_DEG60
Yes
; 60 DEG
Sensor stage = New Sensor stage
Out phase = PHASE_DEG60
No
SENSER120_DEG120
Yes
; 120 DEG
Sensor stage = New Sensor stage
Out phase = PHASE_DEG120
No
SENSER120_DEG180
Yes
; 180 DEG
Sensor stage = New Sensor stage
Out phase = PHASE_DEG180
No
SENSER120_DEG240
Yes
; 240 DEG
No
;300 DEG
Sensor stage = New Sensor stage
Out phase = PHASE_DEG300
RTS

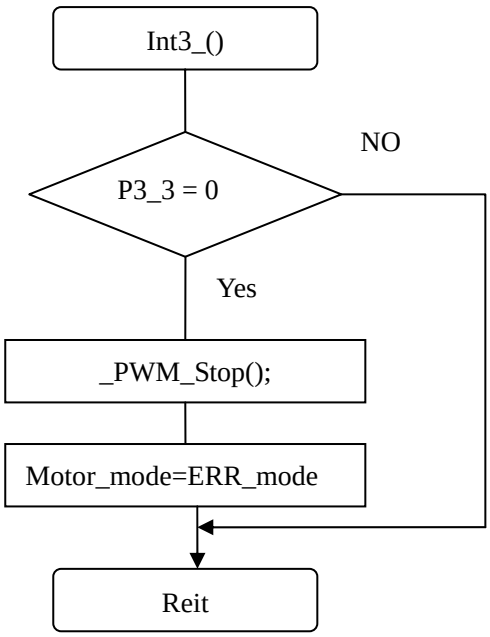
## 7.6 TimerC CMP1 interrupt routine



## 7.7 Short detection input (IN0)interrupt routine



## 7.8 Over current detection input (IN3)interrupt routine



# 8. Using E8 Emulator for Debugging

In this section it demonstrates how to use the power meter platform, and how to use the E8 Emulator for debugging.

Please follow these steps:

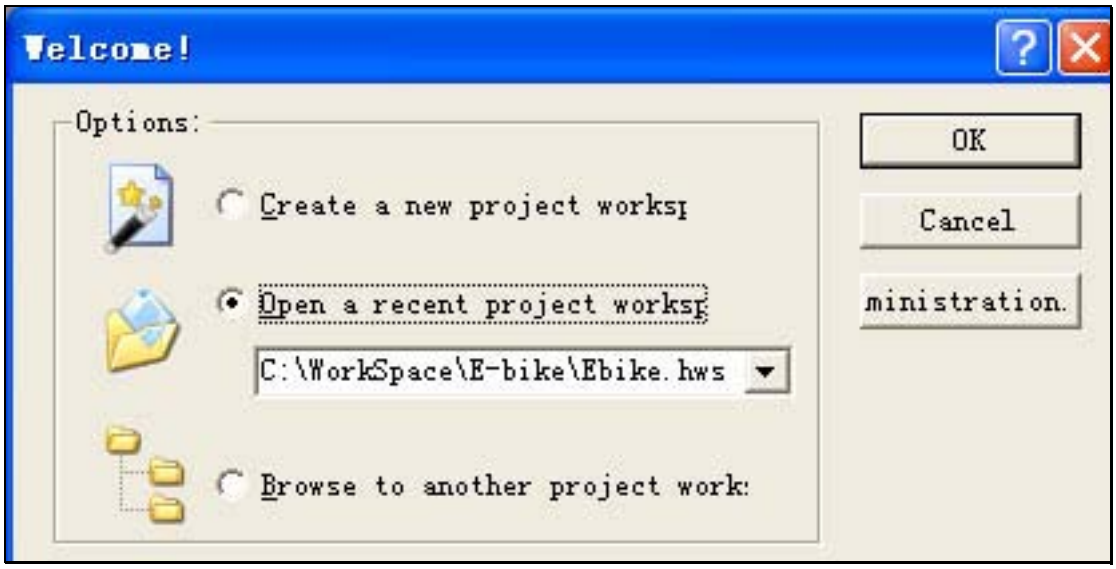
1. Bring out R8C/11E-bike reference platform.

2. Connect E8 to the platform.

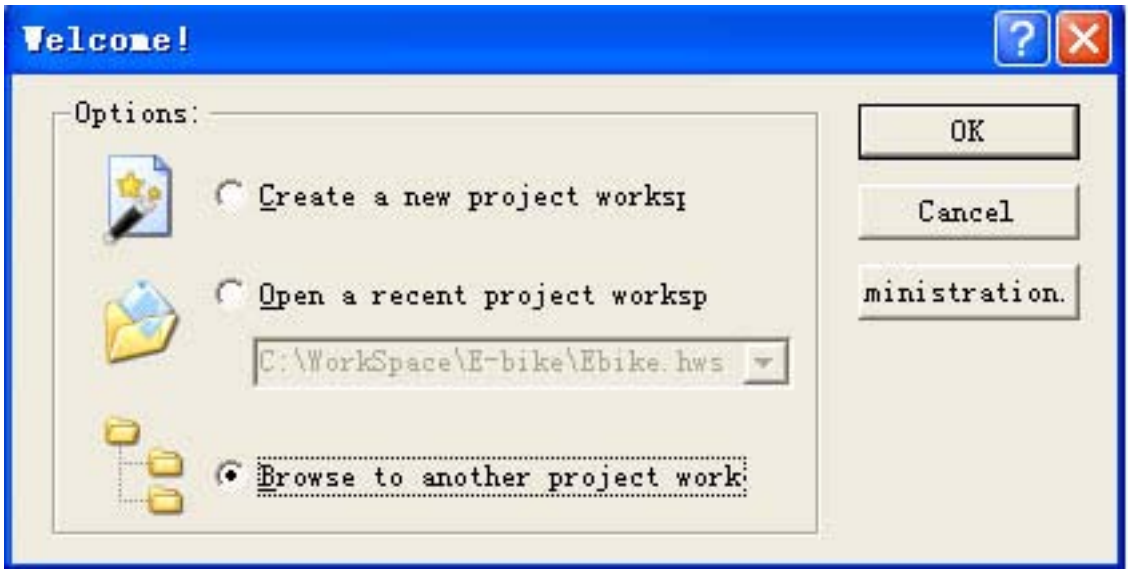
3. Provide power supply to the platform.

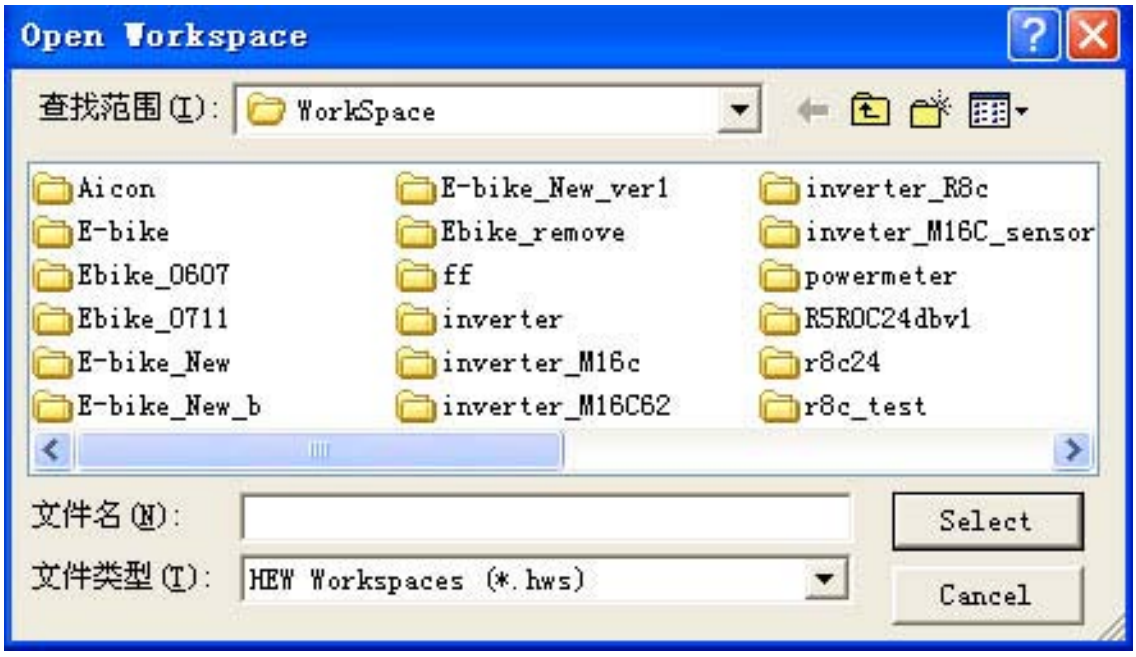
4. Copy the sample software from the CD-ROM to your PC.

5. Open HEW, the following picture appears.



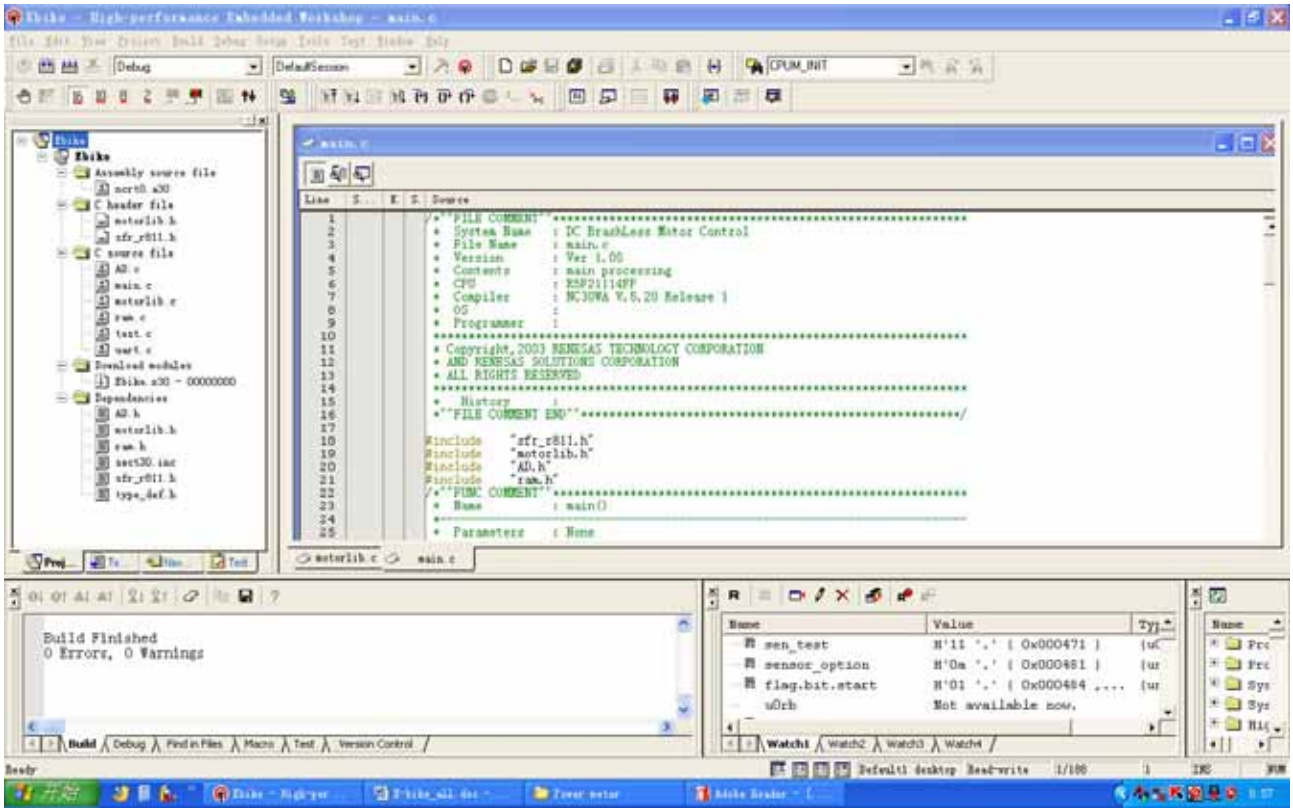
6. Choose the sample project.



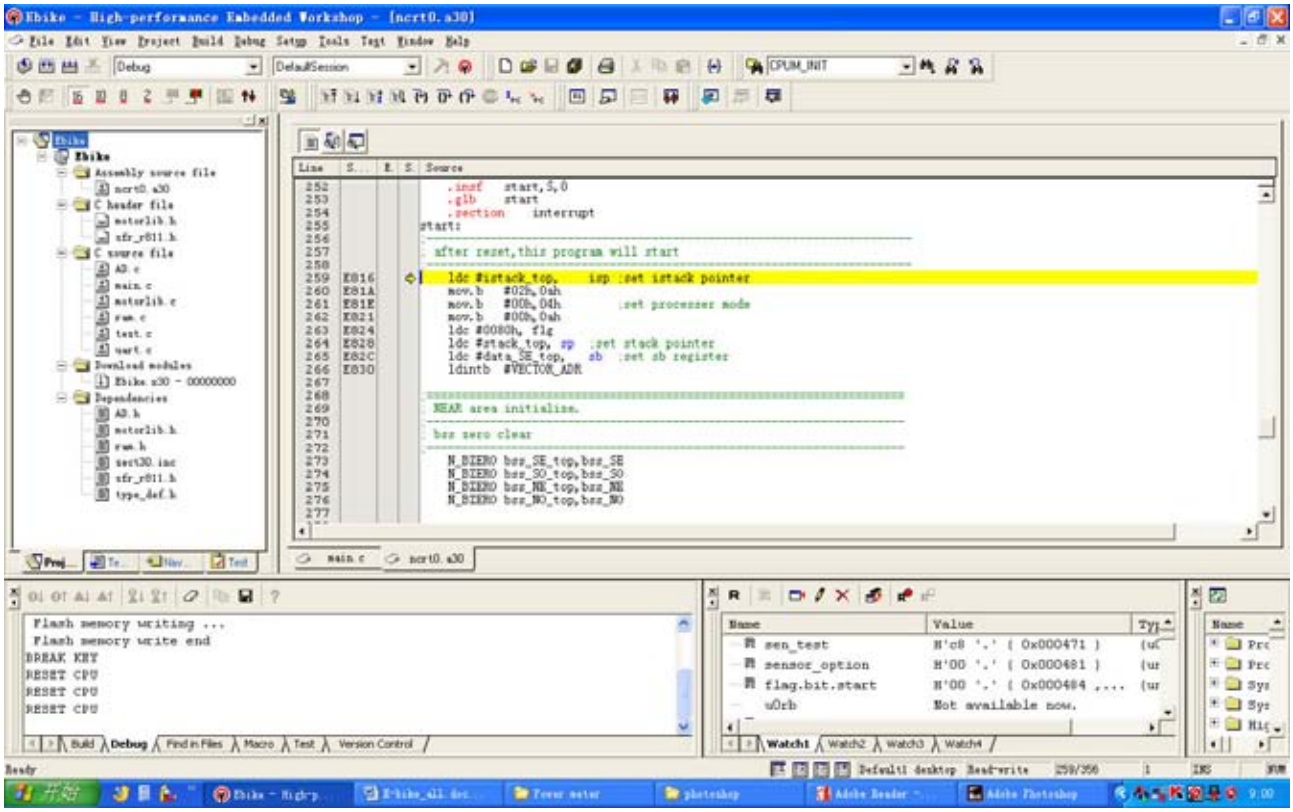



7. Choose E8 Emulator, set emulator mode.

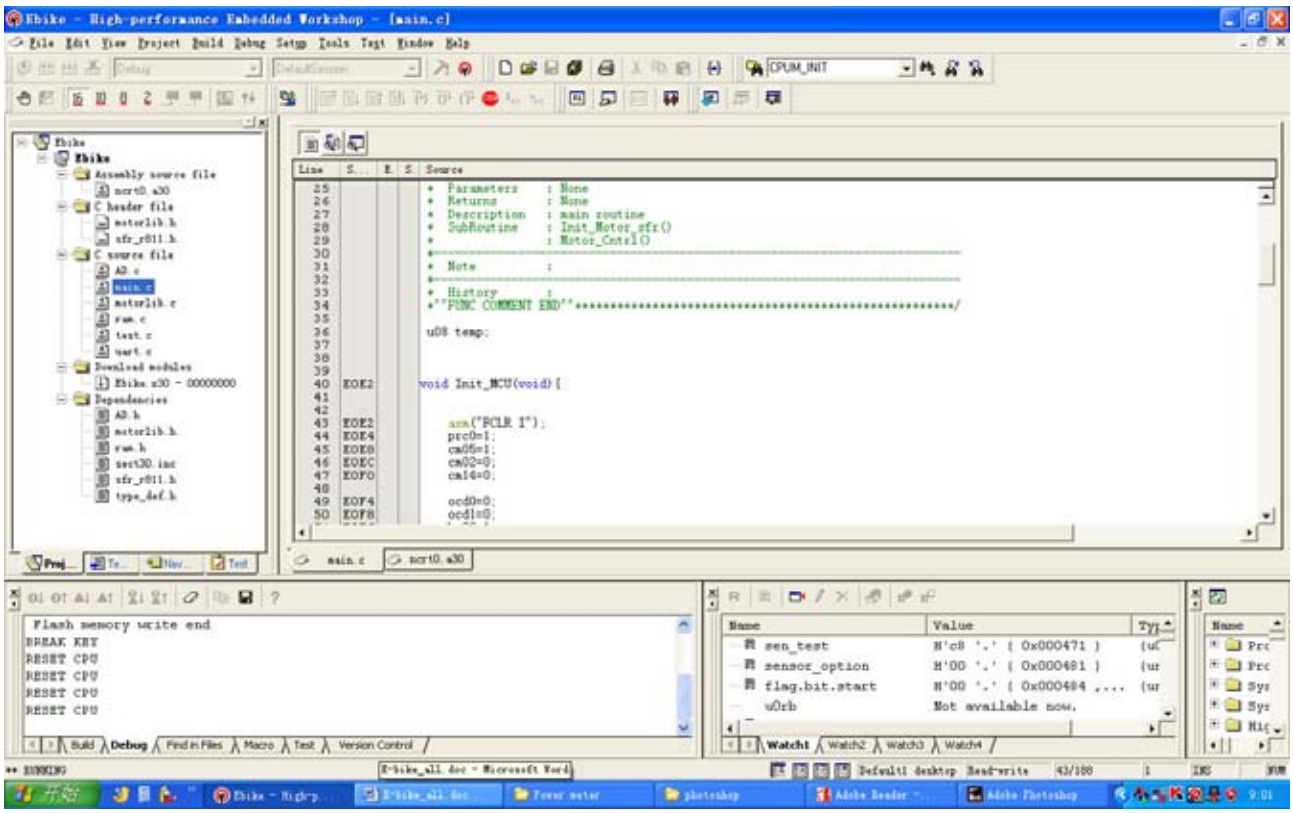

8. Build all.


Build Finished
0 Errors, 0 Warnings

9. Reset.


Flash memory writing ...
Flash memory write end
BREAK KEY
RESET CPU
RESET CPU
RESET CPU

10. Run.




Now you can debug and evaluate the platform.

*Note: About how to use HEW, please refer to the user manual of HEW.*

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**R8C/11 E-bike reference Platform**

**User ’s manual**

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