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Preliminary Work for Exp. #3

1) I write a subroutine which sends a GPIO port the necessary signals to demonstrate the Full Step Mode in both directions (clockwise or counterclockwise).

```
1  GPIO_PORTB_ICR      EQU     0X4000541C
2  GPIO_PORTB_RIS      EQU     0X40005414
3  PB_OUT              EQU     0X400053C0
4
5                  AREA isr,   CODE,   READONLY,   ALIGN=2
6                  THUMB
7                  EXPORT  My_ST_ISR
8
9  My_ST_ISR       PROC
10                 CMP     R5,#0
11                 BNE     CCW
12 CW              LDR     R1,=PB_OUT
13                 LDR     R0,[R1]
14                 LSL     R0,#1
15                 CMP     R0,#0X100
16                 MOVEQ   R0,#0X10
17                 STR     R0,[R1]
18                 B       last
19 CCW             LDR     R1,=PB_OUT
20                 LDR     R0,[R1]
21                 LSR     R0,#1
22                 CMP     R0,#0X08
23                 MOVEQ   R0,#0X80
24                 STR     R0,[R1]
25 last            BX      LR
26                 ALIGN
27                 ENDP
28                 END
29
```

Figure 1. ISR OF THE Q1

2) I design a system that has two inputs from push buttons and provides a step to the stepper motor upon input. One button is to provide a step for clockwise rotation and the other is for counterclockwise rotation. I use 4 buttons of the 4x4 Keypad Module introduced in Experiment-2. ,

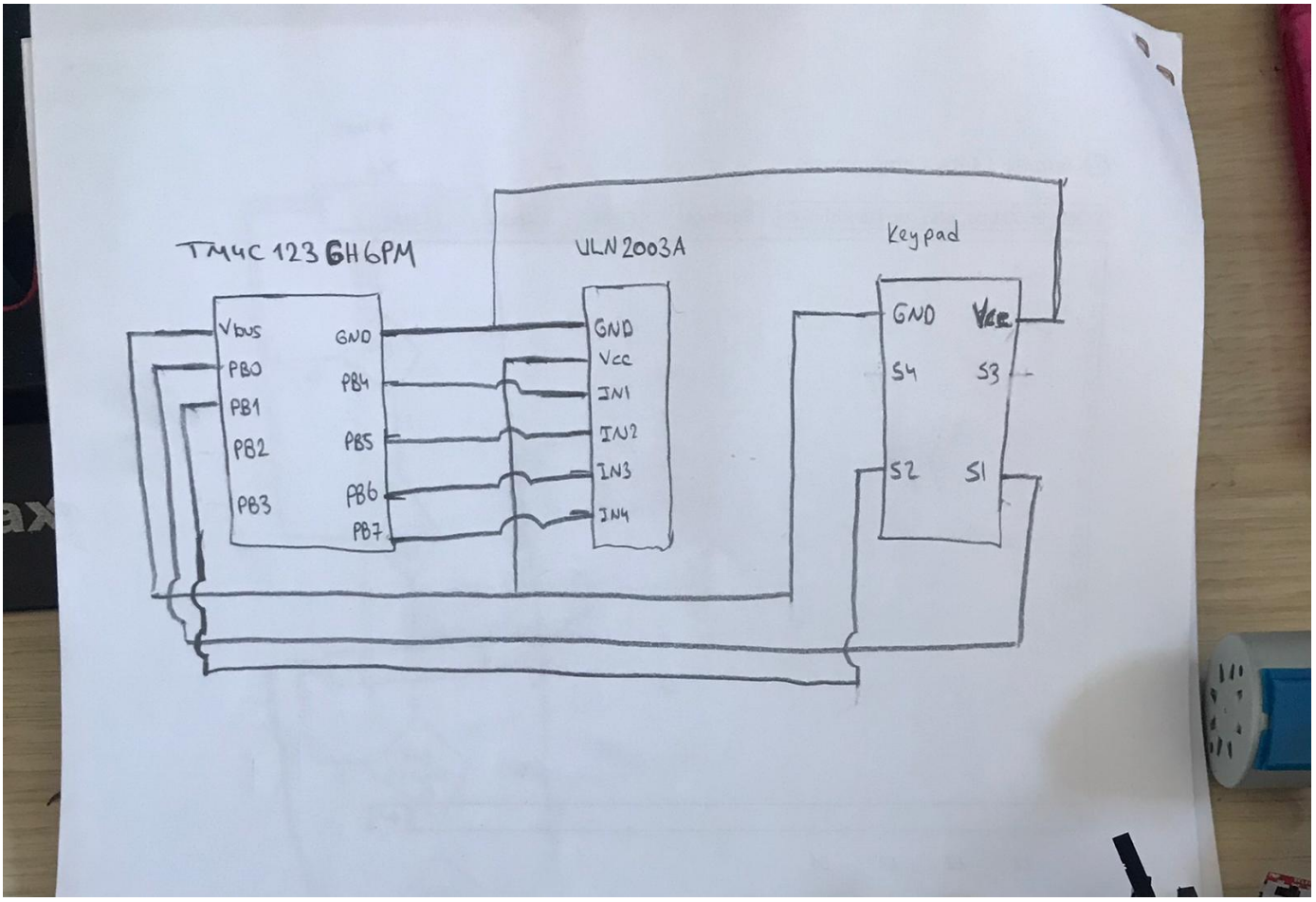

Figure 2. Drawing the connections between TM4C123G, ULN2003A's board, 4x4 Keypad Module.

3) According to my hardware design in step-2, I write a program that, in an infinite loop, gives a step upon the release of one button and gives a step in the opposite direction upon the release of the other button. I assume that the other button is never pushed until the pressed button is released. The response of the motor should be after the button release. I am aware of bouncing inherent in the buttons.

```
1  PB_OUT              EQU     0X400053C0
2  PB_INP              EQU     0X4000503C
3
4
5
6          AREA main,  CODE,   READONLY,   ALIGN=2
7          THUMB
8          IMPORT      PORTB_Init
9          IMPORT      DELAY100
10         EXPORT      __main
11
12
13 __main          PROC
14                 ;BL         InitSysTick
15                 BL          PORTB_Init
16                 MOV         R5,#2
17
18
19 LOOP            LDR         R0,=PB_INP
20                 LDRB        R1,[R0]
21                 BL          DELAY100
22                 LDRB        R2,[R0]
23                 CMP         R1,R2
24                 BNE         LOOP
25                 CMP         R1,#0X00
26                 BEQ         LOOP
27                 CPY         R4,R1
28 RELEASE         LDRB        R1,[R0]
29                 BL          DELAY100
30                 LDRB        R2,[R0]
31                 CMP         R1,R2
32                 BNE         RELEASE
33                 CMP         R1,#0X00
34                 BNE         RELEASE
35                 CPYEQ       R5,R4
36
37                 CMP     R5,#1
38                 BNE     CCW
38                 BNE     CCW
39
40 CW              LDR     R1,=PB_OUT
41                 LDR     R0,[R1]
42                 LSL     R0,#1
43                 CMP     R0,#0X100
44                 MOVEQ   R0,#0X10
45                 STR     R0,[R1]
46                 B       last
47
48 CCW             LDR     R1,=PB_OUT
49                 LDR     R0,[R1]
50                 LSR     R0,#1
51                 CMP     R0,#0X08
52                 MOVEQ   R0,#0X80
53                 STR     R0,[R1]
54
55 last            B           LOOP
56                 ENDP
57                 END
```

Figure 3. MAIN OF THE Q3

```
1  PB_OUT              EQU     0X400053C0
2
3          AREA isr,   CODE,   READONLY,   ALIGN=2
4          THUMB
5          EXPORT  My_ST_ISR
6
7  My_ST_ISR       PROC
8
9                  CMP     R5,#1
10                 BNE     CCW
11
12 CW               LDR     R1,=PB_OUT
13                 LDR     R0,[R1]
14                 LSL     R0,#1
15                 CMP     R0,#0X100
16                 MOVEQ   R0,#0X10
17                 STR     R0,[R1]
18                 B       last
19
20 CCW              LDR     R1,=PB_OUT
21                 LDR     R0,[R1]
22                 LSR     R0,#1
23                 CMP     R0,#0X08
24                 MOVEQ   R0,#0X80
25                 STR     R0,[R1]
26
27
28 last             BX      LR
29                 ALIGN
30                 ENDP
31                 END
```

Figure 4. ISR OF THE Q3

4) At this stage, I design a system that has 4 inputs from push buttons to control a stepper motor. One button is for speeding up, one is for slowing down, the other two are for directions. I use 4 buttons of the 4x4 Keypad Module introduced in Experiment-2.

The necessary connections between TM4C123G, ULN2003A's board, 4x4 Keypad Module and stepper motor is like part2. However, in this part I connect PB4 to S4, PB2 to S3. So, I use 3rd button for speed up, and 4th button for speed down.

5) According to my hardware design in part-4, write a program that, in an infinite loop, drives a stepper motor speed and direction of which can be controlled by external push buttons. I assume that the no button is ever pushed until a pressed button is released. The controls should be applied upon releasing the corresponding button. I am aware of bouncing inherent in the buttons.

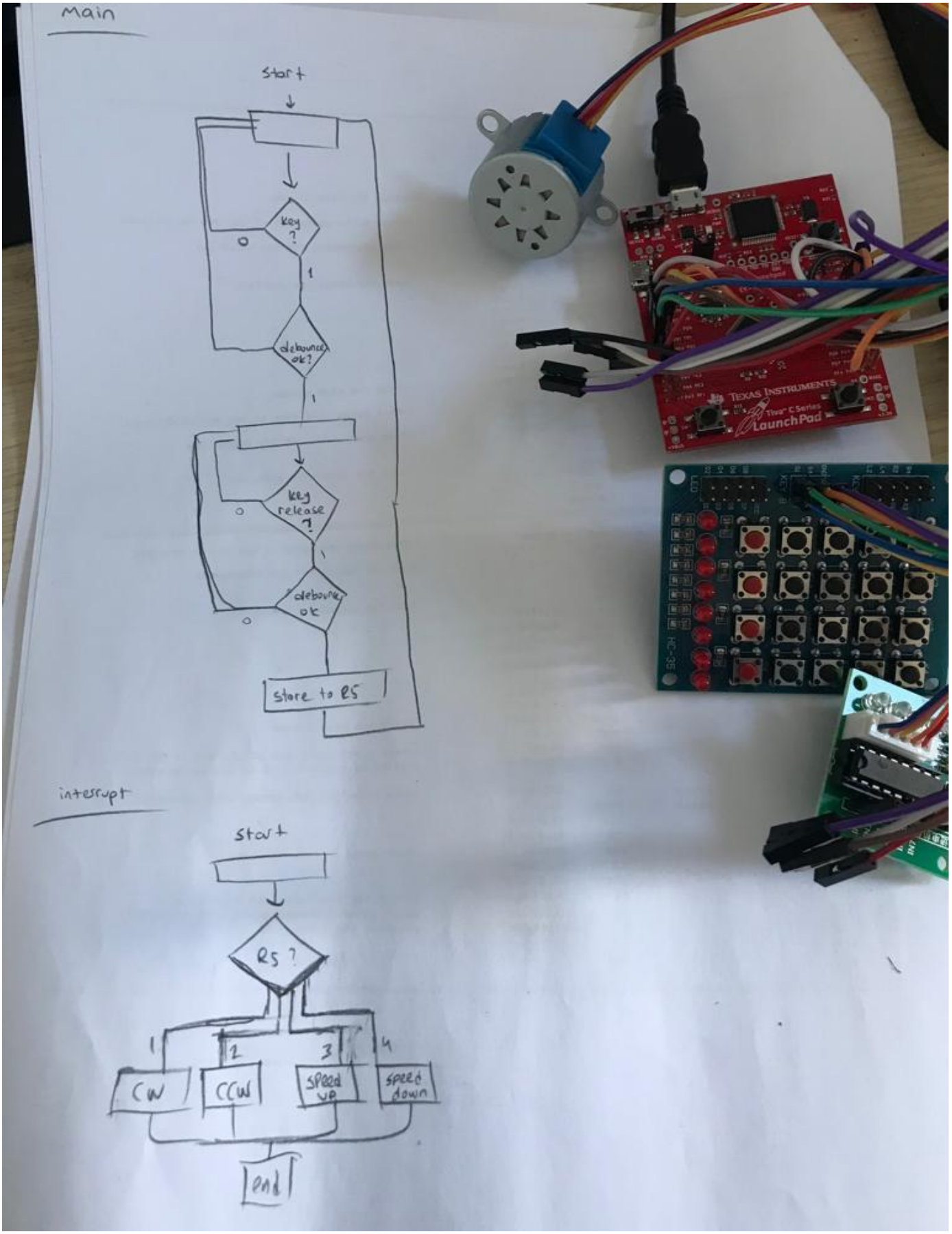

Figure5. Flowchart of my algorithm

```
1  PB_INP              EQU     0X4000503C
2          AREA main,  CODE,   READONLY,   ALIGN=2
3          THUMB
4          IMPORT      PORTB_Init
5          IMPORT      DELAY100
6          IMPORT      InitSysTick
7          EXPORT      __main
8
9
10 __main          PROC
11                 BL          InitSysTick
12                 BL          PORTB_Init
13                 MOV         R5,#1
14
15 LOOP            LDR         R0,=PB_INP
16                 LDRB        R1,[R0]
17                 BL          DELAY100
18                 LDRB        R2,[R0]
19                 CMP         R1,R2
20                 BNE         LOOP
21                 CMP         R1,#0X00
22                 BEQ         LOOP
23                 CPY         R4,R1
24 RELEASE         LDRB        R1,[R0]
25                 BL          DELAY100
26                 LDRB        R2,[R0]
27                 CMP         R1,R2
28                 BNE         RELEASE
29                 CMP         R1,#0X00
30                 BNE         RELEASE
31                 CPYEQ       R5,R4
32                 B           LOOP
33                 ENDP
34                 END
```

Figure 6. MAIN OF THE Q5

```
1            AREA subroutine,    READONLY,   CODE
2            THUMB
3            EXPORT  DELAY100
4
5  DELAY100
6          PUSH    {R0}
7          MOV32   R0,#600000
8  LOOP    SUBS    R0,#1
9          BNE     LOOP
10         POP     {R0}
11         BX      LR
12         ALIGN
13         END
```

Figure 7. DELAY100

```
1  GPIO_PORTB_ICR      EQU     0X4000541C
2  GPIO_PORTB_RIS      EQU     0X40005414
3  PB_OUT              EQU     0X400053C0
4  NVIC_ST_RELOAD      EQU     0XE000E014
5  NVIC_ST_CURRENT     EQU     0XE000E018
6  RELOAD_VALUE        EQU     0X20000400
7
8
9
10         AREA isr,   CODE,   READONLY,   ALIGN=2
11         THUMB
12         EXPORT      My_ST_ISR
13 My_ST_ISR       PROC
14                 CMP         R5,#0X01
15                 BEQ         CW
16                 CMP         R5,#0X02
17                 BEQ         CCW
18                 CMP         R5,#0X04
19                 BEQ         FAST
20                 CMP         R5,#0X08
21                 BEQ         SLOW
22
23 FAST            LDR         R1,=RELOAD_VALUE
24                 LDR         R0,[R1]
25                 CMP         R0,#0X3000
26                 CPYEQ       R5,R6
27                 BEQ         EXIT
28                 SUB         R0,#0X3000
29                 STR         R0,[R1]
30                 LDR         R1,=NVIC_ST_RELOAD
31                 STR         R0,[R1]
32                 ;LDR            R1,=NVIC_ST_CURRENT
33                 ;STR            R0,[R1]
34                 CPY         R5.R6
34                 CPY         R5,R6
35                 B           last
36 SLOW            LDR         R1,=RELOAD_VALUE
37                 LDR         R0,[R1]
38                 ADD         R0,#0X3000
39                 STR         R0,[R1]
40                 LDR         R1,=NVIC_ST_RELOAD
41                 STR         R0,[R1]
42                 ;LDR            R1,=NVIC_ST_CURRENT
43                 ;STR            R0,[R1]
44                 CPY         R5,R6
45                 B           last
46 CW              LDR         R1,=PB_OUT
47                 LDR         R0,[R1]
48                 LSL         R0,#1
49                 CMP         R0,#0X100
50                 MOVEQ       R0,#0X10
51                 STR         R0,[R1]
52                 CPY         R6,R5
53                 B           last
54 CCW             LDR         R1,=PB_OUT
55                 LDR         R0,[R1]
56                 LSR         R0,#1
57                 CMP         R0,#0X08
58                 MOVEQ       R0,#0X80
59                 STR         R0,[R1]
60                 CPY         R6,R5
61                 B           last
62 last            BX          LR
63                 ALIGN
64                 ENDP
65                 END
66
```

Figure 8. ISR OF THE Q5

```
GPIO_PORTB_DIR_R    EQU     0X40005400
GPIO_PORTB_AFSEL_R  EQU     0X40005420
GPIO_PORTB_DEN_R    EQU     0X4000551C
GPIO_PORTB_AMSEL_R  EQU     0X40005528
GPIO_PORTB_PDR      EQU     0X40005514
GPIO_PORTB_IS       EQU     0X40005404
GPIO_PORTB_IBE      EQU     0X40005408
GPIO_PORTB_IEV      EQU     0X4000540C
GPIO_PORTB_IM       EQU     0X40005410
GPIO_PORTB_ICR      EQU     0X4000541C
GPIO_PORTB_RIS      EQU     0X40005414
PB_INP              EQU     0X4000503C
PB_OUT              EQU     0X400053C0
SYSCTL_RCGC2_R      EQU     0X400FE608

        AREA init_gpio, CODE,   READONLY,   ALIGN=2
        THUMB
        EXPORT      PORTB_Init


PORTB_Init  PROC

            LDR     R1,=SYSCTL_RCGC2_R
            LDR     R0,[R1]
            ORR     R0,R0,#0X02 ;only port b
            STR     R0,[R1]
            NOP
            NOP
            NOP
            LDR     R1,=GPIO_PORTB_DIR_R
            LDR     R0,[R1]
            ORR     R0,R0,#0XF0
            BIC     R0,R0,#0X0F
            STR     R0,[R1]
```

```
            LDR     R1,=SYSCTL_RCGC2_R
            LDR     R0,[R1]
            ORR     R0,R0,#0X02 ;only port b
            STR     R0,[R1]
            NOP
            NOP
            NOP
            LDR     R1,=GPIO_PORTB_DIR_R
            LDR     R0,[R1]
            ORR     R0,R0,#0XF0
            BIC     R0,R0,#0X0F
            STR     R0,[R1]
            LDR     R1,=GPIO_PORTB_AFSEL_R
            LDR     R0,[R1]
            BIC     R0,R0,#0XFF
            STR     R0,[R1]
            LDR     R1,=GPIO_PORTB_PDR
            MOV     R0,#0X0F
            STR     R0,[R1]
            LDR     R1,=GPIO_PORTB_DEN_R
            LDR     R0,[R1]
            ORR     R0,R0,#0XFF
            STR     R0,[R1]
            LDR     R1,=GPIO_PORTB_AMSEL_R
            LDR     R0,[R1]
            BIC     R0,R0,#0XFF
            STR     R0,[R1]
            LDR     R1,=PB_OUT
            MOV     R0,#0X20
            STR     R0,[R1]
            BX      LR
            ENDP
            END
```

Figure 9. GPIO PORTB INITIALIZATION OF Q5

```
RELOAD_VALUE     EQU      0X0000C000
RELOAD_ADDRESS   EQU      0X20000400
NVIC_ST_CTRL     EQU      0XE000E010
NVIC_ST_RELOAD   EQU      0XE000E014
NVIC_ST_CURRENT  EQU      0XE000E018
SHP_SYSPRI3      EQU      0XE000ED20
PB_OUT           EQU      0X400053C0

                 AREA init_isr,  CODE,   READONLY,   ALIGN=2
                 THUMB
                 EXPORT      InitSysTick

InitSysTick      PROC
                 LDR         R1,=NVIC_ST_CTRL
                 MOV         R0,#0
                 STR         R0,[R1]
                 LDR         R1,=NVIC_ST_RELOAD
                 LDR         R0,=RELOAD_VALUE
                 STR         R0,[R1]
                 LDR         R1,=RELOAD_ADDRESS
                 STR         R0,[R1]
                 LDR         R1,=NVIC_ST_CURRENT
                 LDR         R0,=RELOAD_VALUE
                 STR         R0,[R1]
                 LDR         R1,=SHP_SYSPRI3
                 MOV         R0,#0X40000000
                 STR         R0,[R1]
                 LDR         R1,=NVIC_ST_CTRL
                 MOV         R0,#0X03
                 STR         R0,[R1]
                 CPSIE       I
                 BX      LR
                 ENDP
                 END
```

Figure 10. SYSTICK INITIALIZATION OF Q5