B. D1 Lab Work

3.1

I wound 61 turns around the coil.
The value of inductor is 238.48 μH 14.252

The value of output is 1.23 V due to diode and resistor which limit it.

*

*

IL Meta embedded_6st program.

Current limit	Voltage out
0.2 A	~~7~~ 6 V
~~0.330 A~~	10 V
~~0.4 A~~	~~12 V~~
~~0.385 A~~	~~15 V~~

max!

Current	Voltage
0.537 A	15 V
0.358 A	10 V
0.184 A	5 V

Current limit iis 0.537 A.
My voltage do not achieve the 15 V because my inductor value excede 180 μH which mes used in simulations.

max V_{ABE} is 1.4 V. It is save voltage for IL metb.

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For PWM = 240 $V_{out} = 5\,V$ $V_{ADC} = 0.960\,V$

ADC = 205

ADC = 370 $V_{out} = 10\,V$ $V_{ADC} = 1.78\,V$

ADC = 410 $V_{out} = 15\,V$ ~~$V_{ADC} = 1.350\,V$~~

$V_{ADC} = 2.67\,V$

$V_{out} = k \cdot V_{ADC}$

~~$k = \frac{V_{out}}{V_{ADC}} \approx 7.207$~~

$k = \frac{V_{out}}{V_{ADC}}$

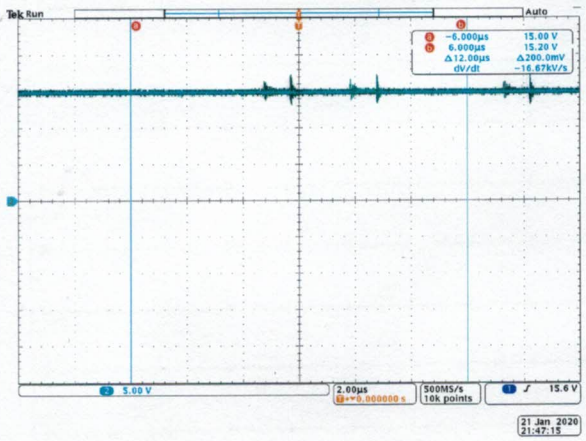
$k_1 = 5.2$

$k_2 = 5.6$ $k \approx 5.46$

$k_3 = 5.6$

```
0350: PWM=240 ==> ADC= 828 --> 14.583 Vload
0351: PWM=240 ==> ADC= 824 --> 14.513 Vload
0352: PWM=240 ==> ADC= 829 --> 14.601 Vload
0353: PWM=240 ==> ADC= 824 --> 14.513 Vload
0354: PWM=240 ==> ADC= 829 --> 14.601 Vload
0355: PWM=240 ==> ADC= 824 --> 14.513 Vload
0356: PWM=240 ==> ADC= 829 --> 14.601 Vload
0357: PWM=240 ==> ADC= 824 --> 14.513 Vload
0358: PWM=240 ==> ADC= 829 --> 14.601 Vload
0359: PWM=240 ==> ADC= 827 --> 14.566 Vload
0360: PWM=240 ==> ADC= 827 --> 14.566 Vload
0361: PWM=240 ==> ADC= 828 --> 14.583 Vload
0362: PWM=240 ==> ADC= 828 --> 14.583 Vload
0363: PWM=240 ==> ADC= 827 --> 14.566 Vload
0364: PWM=240 ==> ADC= 827 --> 14.566 Vload
0365: PWM=240 ==> ADC= 827 --> 14.566 Vload
0366: PWM=240 ==> ADC= 827 --> 14.566 Vload
0367: PWM=240 ==> ADC= 828 --> 14.583 Vload
0368: PWM=240 ==> ADC= 827 --> 14.566 Vload
0369: PWM=240 ==> ADC= 827 --> 14.566 Vload
```

```
uint16_t cnt =0;

init_stdio2uart0();
init_pwm();
init_adc();

for(;;) {
    printf( "%04d:  ", cnt );

    pwm_duty(255);   /* Limited by PWM_DUTY_MAX */

    // printf( "  -->  %5.3f Vadc", v_load() );

    printf( "  -->  %5.3f Vload\r\n", v_load()*K );
    _delay_ms(DELAY_MS);
    cnt++;
}
```



Ready 22/1

Lab Code:	None	Poor	OK	Good	Exceptional	Outstanding
Preparation	0	1	2	3	4	5
Progress	0	1	2	3	(4)	5
Understanding	0	1	2	3	(4)	5
Logbook Use	0	1	2	3	(4)	5

Demonstrators only

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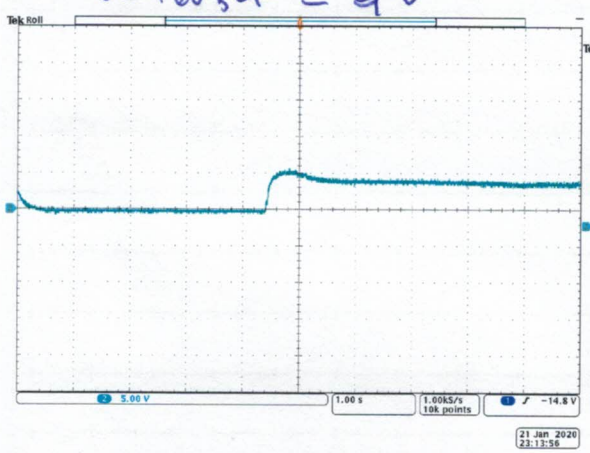
4. Programming

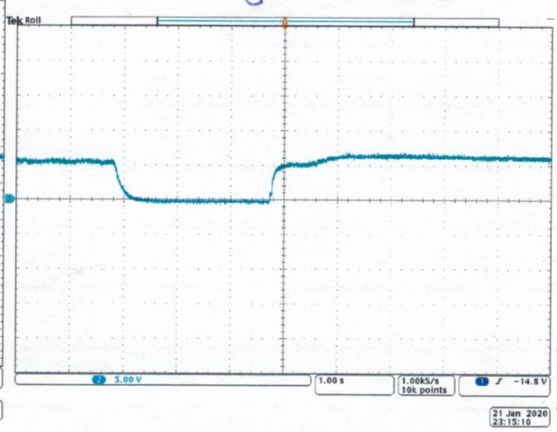
```
for(;;) {
    printf( "%04d:  ", cnt );
    printf( "Error: %5.3f:  ", diferror );
    pwm_duty(dutyCycle);   /* Limited by PWM_DUTY_MAX */

   // printf( "  -->  %5.3f Vadc", v_load() );

    printf( "  -->  %5.3f Vload\r\n", Vout=v_load());
    //PI controller
    //Change duty cycle based on error
    error=Vout-V_target;
    integerror = integerror + error*(DELAY_MS)/1000;     //integral of e(t)
    diferror = (error-errorprev)/DELAY_MS*1000;                 //derivative (slope) of e(t)

    dutyCycle = dutyCycle - error*kP;           // P term
    dutyCycle = dutyCycle - integerror*kI;      // I term
    dutyCycle = dutyCycle - diferror*kD;           // D term

    errorprev = error;
    _delay_ms(DELAY_MS);
    cnt++;

}
}
```

V_target = 4 V



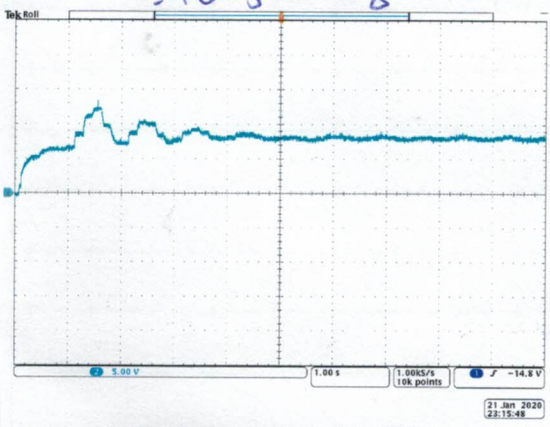
MDO4054B-3 - 16:19:57 21/01/2020

V_target = 6 V



MDO4054B-3 - 16:21:10 21/01/2020

V_target = 8 V



MDO4054B-3 - 16:21:48 21/01/2020

PID controller.

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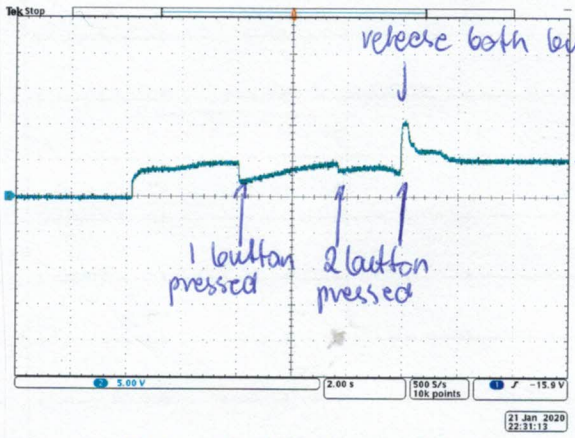
```
0001:  PWM=138  ==>  ADC= 270  -->  4.755 Vload
0002:  PWM=138  ==>  ADC= 292  -->  5.143 Vload
0003:  PWM=137  ==>  ADC= 295  -->  5.196 Vload
0004:  PWM=136  ==>  ADC= 293  -->  5.161 Vload
0005:  PWM=135  ==>  ADC= 294  -->  5.178 Vload
0006:  PWM=134  ==>  ADC= 293  -->  5.161 Vload
0007:  PWM=133  ==>  ADC= 292  -->  5.143 Vload
0008:  PWM=132  ==>  ADC= 292  -->  5.143 Vload
0009:  PWM=131  ==>  ADC= 141  -->  2.483 Vload
0010:  PWM=138  ==>  ADC= 141  -->  2.483 Vload
0011:  PWM=145  ==>  ADC= 150  -->  2.642 Vload
0012:  PWM=152  ==>  ADC= 160  -->  2.818 Vload
0013:  PWM=158  ==>  ADC= 171  -->  3.012 Vload
0014:  PWM=163  ==>  ADC= 180  -->  3.170 Vload
0015:  PWM=168  ==>  ADC= 191  -->  3.364 Vload
0016:  PWM=172  ==>  ADC= 201  -->  3.540 Vload
0017:  PWM=176  ==>  ADC= 210  -->  3.699 Vload
0018:  PWM=179  ==>  ADC= 220  -->  3.875 Vload
0019:  PWM=182  ==>  ADC= 228  -->  4.016 Vload
0020:  PWM=184  ==>  ADC= 235  -->  4.139 Vload
0021:  PWM=186  ==>  ADC= 241  -->  4.245 Vload
0022:  PWM=188  ==>  ADC= 248  -->  4.368 Vload
0023:  PWM=189  ==>  ADC= 254  -->  4.474 Vload
0024:  PWM=190  ==>  ADC= 261  -->  4.597 Vload
0025:  PWM=191  ==>  ADC= 260  -->  4.579 Vload
```

```
59      double kP=3;
60      double Vout;
61      double error;
62
63      for(;;) {
64          printf( "%04d:  ", cnt );
65          //printf( "Error: %5.3f:  ", error );
66          pwm_duty(dutyCycle);   /* Limited by PWM_DUTY_MAX */
67
68          // printf( "  -->  %5.3f Vadc", v_load() );
69
70          printf( "  -->  %5.3f Vload\r\n", Vout=v_load());
71          //Change duty cycle based on error
72      error=Vout-V_target;
73      dutyCycle=dutyCycle-error*kP;
74
75          _delay_ms(DELAY_MS);
76          cnt++;
77
78      }
79  }
80
81  int uputchar0(char c, FILE *stream)
```

C source file — length : 4,085 lines : 175



P controller.

Lab Code: PI week	None	Poor	OK	Good	Exceptional	Outstanding
Preparation	0	1	2	3	4	5
Progress	0	1	2	3	4	5
Understanding	0	1	2	3	4	5
Logbook Use	0	1	2	3	4	5
Demonstrators only						
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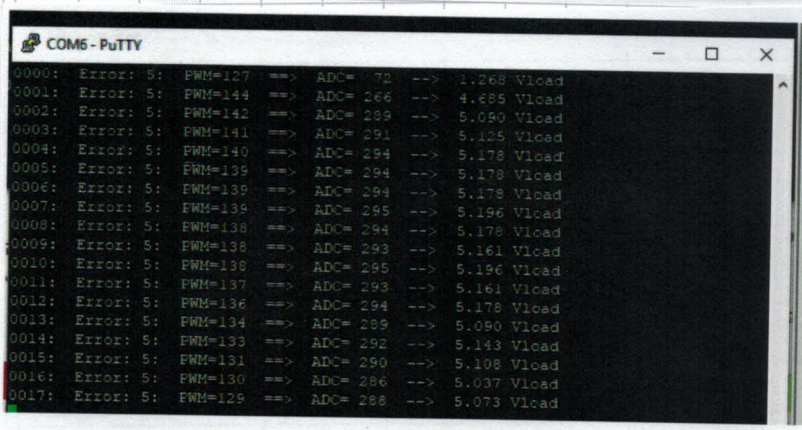


```
68
69      V_targetc = ugetchar0(stdin);
70      V_target = V_targetc - '0';
71
72
73
74      for(;;) {
75          printf( "%04d:  ", cnt );
76          printf( "Error: %d:  ", V_t
77          pwm_duty(dutyCycle);   /* L
78
79      // printf( "  -->  %5.3f Vad
80
81          printf( "  -->  %5.3f Vload
82          //PI controller
83          //Change duty cycle based o
84          error=Vout-V_target;
85          integerror = integerror + e
86          diferror = (error-errorprev
87
88          dutyCycle = dutyCycle - err
```

Keyboard controll

The keyboard control, char is getting from keyboard

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end program set V_target;

```
ISR(INT0_vect)
{

V_targetc = ugetchar0(stdin);
V_target = V_targetc - '0';
if(!V_target)V_target = 10;
//if(V_target > 10 && V_target < 2) PORTD |= _BV(PB7); //turn on led
//else PORTD &= ~_BV(PB7);
diferror = 0;
integerror = 0;
error = 0;
}
```

ISR: Externel interupt is tuggered by button. While button is pressed, V_terget can be intered from keyboard.

Drawing functions

```
void draw_rectangle(int x,int y, uint16_t c){

    rectangle r = {x,x+100,y,y+20};
    fill_rectangle(r, c);
    rectangle r2 = {x+1,x+99,y+1,y+19};
    fill_rectangle(r2,BLACK);

}

void init_pwm1(int x,int y, uint16_t c){


    rectangle r1 = {x,x+200,y,y+10};
    fill_rectangle(r1,c);

    rectangle r2 = {x+1,x+199,y+1,y+9};
    fill_rectangle(r2,BLACK);

}
```

Drawing table and values on LCD screen

```
    init_lcd();
display.background = BLACK;
display.foreground = WHITE;
clear_screen();
set_orientation(North);

    clear_screen();

    char buf [20];

    draw_rectangle(5,5,WHITE);

    display.x = 18; display.y = 13; display_string("VOLTAGE LOAD");

    draw_rectangle(5,25,WHITE);

    display.x = 18; display.y = 33; display_string("VOLTAGE ADC");

    draw_rectangle(5,45,WHITE);

    display.x = 18; display.y = 53; display_string("VOLTAGE TARGET");

    draw_rectangle(5,65,WHITE);

    display.x = 18; display.y = 73; display_string("ERROR");

    draw_rectangle(5,85,WHITE);

    display.x = 18; display.y = 93; display_string("DUTY CYCLE");

    draw_rectangle(5,105,WHITE);

    init_pwm1(20,200,WHITE);

    display.x = 110;
    display.y = 180;
    display_string("PWM %");

    display.x = 20;
    display.y = 180;
    display_string("0 %");

    display.x = 200;
    display.y = 180;
    display_string("100 %");

    //LCD
            draw_pwm(20,200,dutyCycle,WHITE);

            dtostrf(Vout, 6, 2, buf);
            display.x = 120; display.y = 13; display_string(buf); //DISPLAY V LOAD
            dtostrf(Vadc, 6, 2, buf);
            display.x = 120; display.y = 33; display_string(buf); //DISPLAY V ADC

            display.x = 120; display.y = 53; display_string(Vchar); //DISPLAY V TARGET
            dtostrf(error, 6, 2, buf);
            display.x = 120; display.y = 73; display_string(buf); //DISPLAY Error


            //dtostrf(dutyCycle, 6, 2, buf);
            //display.x = 120; display.y = 93; display_string(buf); //DISPLAY Duty Cycle
            _delay_ms(DELAY_MS);
```

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Thu.

Lab Code 21.	None	Poor	OK	Good	Exceptional	Outstandin
Preparation	0	1	2	3	4	5
Progress	0	1	2	3	4	5
Understanding	0	1	2	3	4	5
Logbook Use	0	1	2	3	4	5
Demonstrators only						
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Tuning

P slow 7 0 0

P1 6.5 0.5 0

PID 5 0.5 0.005

```
inp:

printf("=====MENU=====\n");
printf("1. Change target load voltage\n");
printf("2. Change control system\n");
printf("3. Resume\n");
fail = scanf("%d",&input);

if(fail != 1 || (input != 1 && input != 2 && input != 3)){
    if(fail != 1){
        scanf("%c",&bill);
        printf("Input: %c\n", bill);
    }
    else printf("Input: %d\n", input);

    goto erroruser;
}
printf("Input: %d\n", input);
```

The program wait for input and checks if output is correct.

```
switch (input)
{
    case 1: goto volchange;
            break;
    case 2: goto ctrchange;
            break;
    case 3: goto start;
            break;
    default: goto erroruser;
```

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```
//CHANGE TARGET VOLTAGE MENU
volchange:
printf("=====TARGET VOLTAGE CHANGE=====\n");
printf("Type desire target load voltage: [range 2-10]\n");
fail = scanf("%d",&V_target);
Vchar = V_target + '0';
if(V_target > 10 || V_target < 2 || fail != 1){

    if(fail != 1){scanf("%c",&bill);
        printf("Input: %c\n", bill);
    }
    else
        printf("Input: %d\n", V_target);

        printf("Error, input not valid.\n");
    goto erroruser;

}
printf("Input: %d\n", V_target);
goto start;
```

```
        fgets(string1,5,stdin);
        kP = (string1[0] - '0') + ((double) (string1[2] - '0'))*0.1 + ((double) (string1[3] - '0'))*0.01;
        goto ctrchange;
        break;
    case 6:
        fgets(string1,5,stdin);
        kI = (string1[0] - '0') + ((double) (string1[2] - '0'))*0.1 + ((double) (string1[3] - '0'))*0.01;
        goto ctrchange;
        break;
    case 7:
        fgets(string1,5,stdin);
        kD = (string1[0] - '0') + ((double) (string1[2] - '0'))*0.1 + ((double) (string1[3] - '0'))*0.01;
        goto ctrchange;
        break;
```

fgets() function get input from keyboard. Then, the value is converted into float by algorithm.

System error detector.

```
//SYSTEM ERROR RECEIVER
if(cnt > 40 && (error > 4 || error < -4)){
    pwm_duty(5);
    break;
}
```

The program checks if the boost converter is in steady state mode. ~~and then can~~ If its not, and error keeps high, system error is detected.

Users error:

Program blink diode for 0.1 sec if user input error is detected.

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