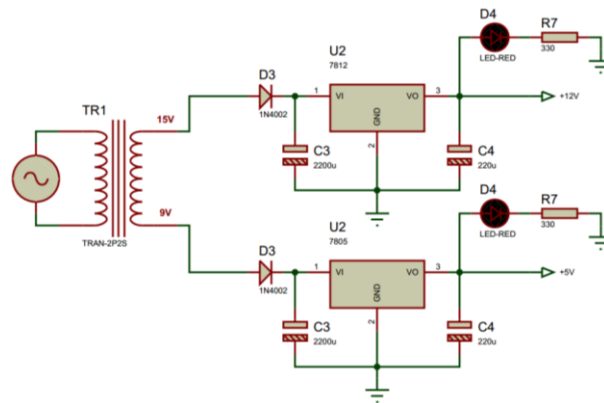


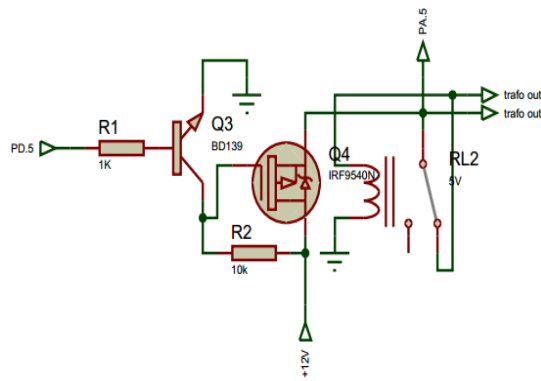
LAMPIRAN

1.1 Rangkaian

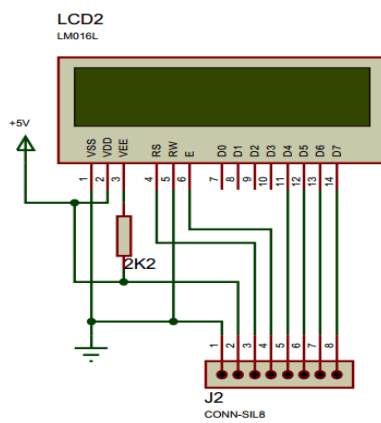
a Rangkaian *power supply*



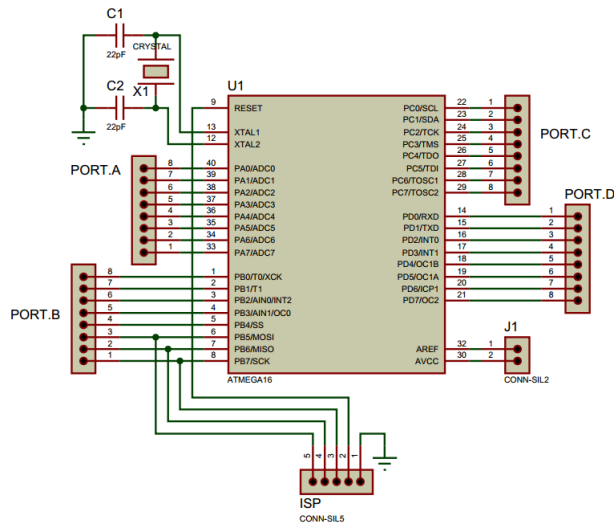
b Rangkaian *driver*



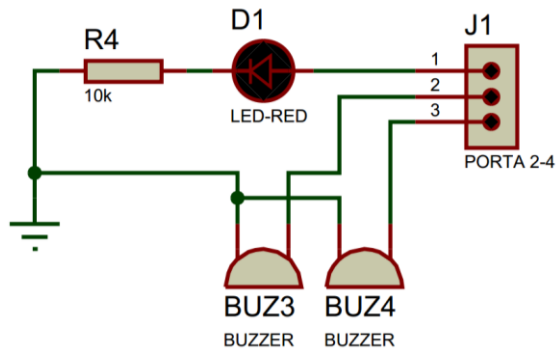
c Rangkaian LCD



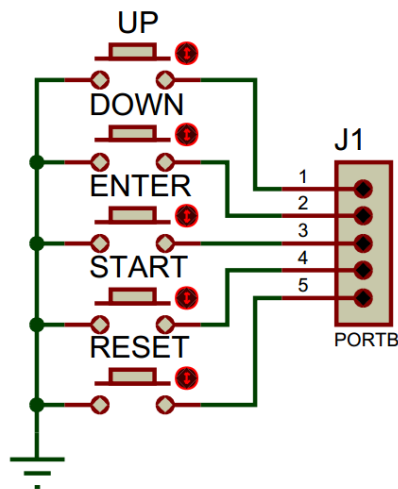
d Rangkaian Minimum System



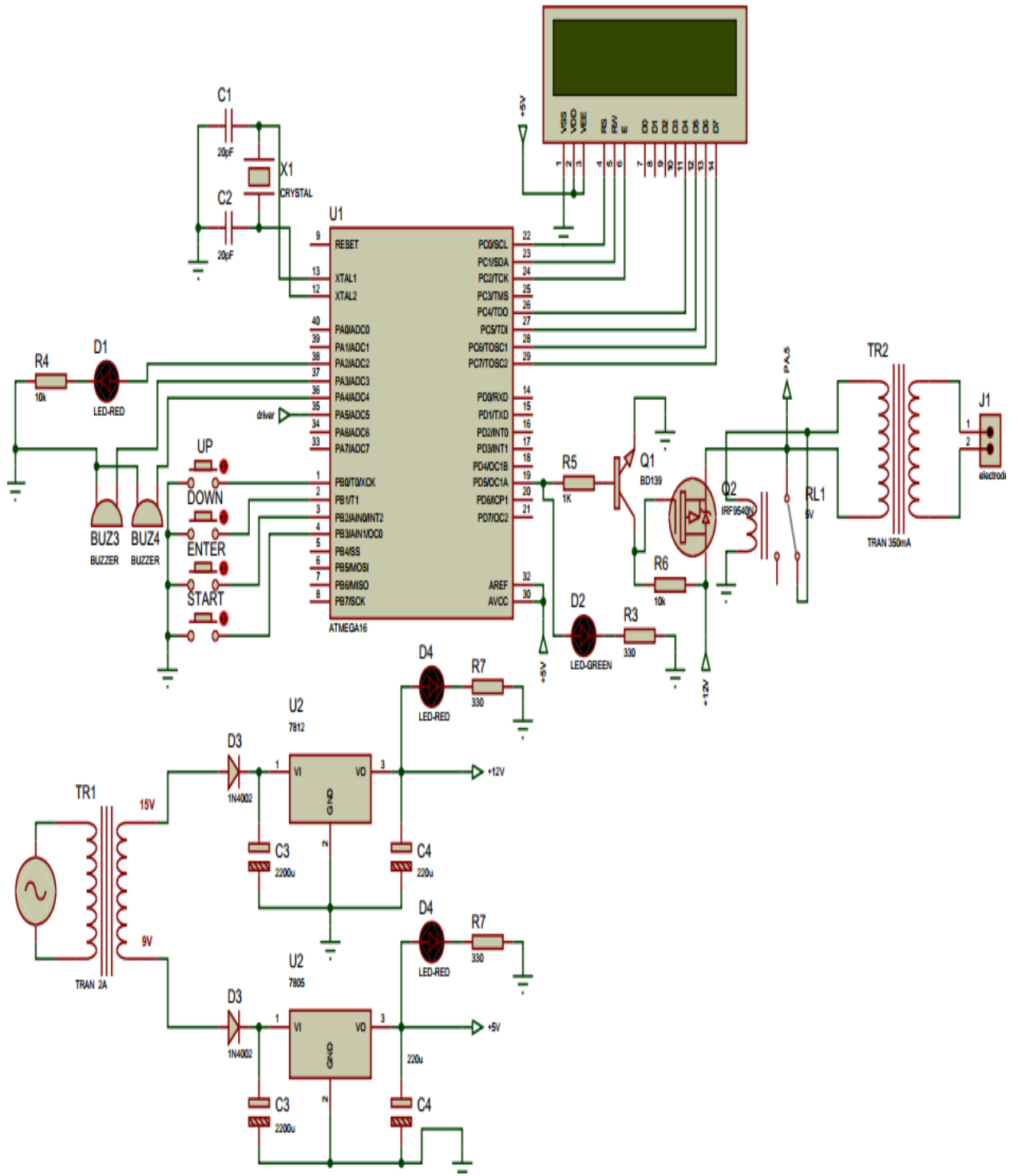
e Rangkaian indikator



f Rangkaian *push button*



g Rangkaian Keseluruhan



2.1 Program

```

#include <mega16.h>
#include <delay.h>
#include <stdio.h>
#include <stdlib.h>
#include <alcd.h>

#define up    PINB.0
#define down  PINB.1
#define enter PINB.2
#define save  PINB.3
#define start PINB.4

#define led1  PORTA.1
#define buz1  PORTA.2
#define led2  PORTA.3
#define buz2  PORTA.4

int detik,loop,menu,waktu,level,loops;
float amp;
long sum = 0;
int i,baca;
float vol,x,in_min,in_max,out_min,out_max;
char buf [33];

// Timer 0 overflow interrupt service routine
interrupt [TIM0_OVF] void timer0_ovf_isr(void)
{
// Reinitialize Timer 0 value
TCNT0=0x8A;
loop++;
    if (loop>=100)
    {
        detik--;
        loops++;
        if(loops>2){loops=0;}
        loop=0;
    }
}

#define ADC_VREF_TYPE 0x00

// Read the AD conversion result
unsigned int read_adc(unsigned char adc_input)
{

```

```

ADMUX=adc_input | (ADC_VREF_TYPE & 0xff);
// Delay needed for the stabilization of the ADC input
voltage
delay_us(10);
// Start the AD conversion
ADCSRA|=0x40;
// Wait for the AD conversion to complete
while ((ADCSRA & 0x10)==0);
ADCSRA|=0x10;
return ADCW;
}

void sensor_arus(){

baca=read_adc(5);
// ambil nilai rata-rata adc
for(i=0; i<100; i++)
    {
        sum+=baca;
    }
    sum = sum / 100;

vol= ((float)baca*5/1023);
x=vol;
in_min=0;
in_max=0.36143;
out_min=0;
out_max=1.7;
amp=((x - in_min) * (out_max - out_min) / (in_max -
in_min)) + out_min;

//lcd_gotoxy(0,1);
//ftoa(amp,1,buf);
//lcd_puts(buf);}

void run(){
OCR1A=0;
delay_ms(500);
detik=0;
//PORTD.6=1;

while(1){

lcd_gotoxy(0,0);

```

```

sprintf(buf,"TIME: %d:%d    ",waktu,detik) ;
lcd_puts(buf);

if(level==1)
{lcd_gotoxy(0,1);lcd_putsf("0,53 mA");
OCR1A=50;delay_ms(100);//OCR1A=0;delay_ms(500);
  lcd_clear();ftoa(amp,2,buf);lcd_puts(buf);}

if(level==2)
{lcd_gotoxy(0,1);lcd_putsf("3,3 mA");
OCR1A=100;delay_ms(100);//OCR1A=0;delay_ms(500);
  lcd_clear();ftoa(amp,2,buf);lcd_puts(buf);}

if(level==3)
{lcd_gotoxy(0,1);lcd_putsf("6,79 mA");
OCR1A=150;delay_ms(100);//OCR1A=0;delay_ms(500);
  lcd_clear();ftoa(amp,2,buf);lcd_puts(buf);}

if(level==4)
{lcd_gotoxy(0,1);lcd_putsf("11,02 mA");
OCR1A=200;delay_ms(100);//OCR1A=0;delay_ms(500);
lcd_clear();ftoa(amp,2,buf);lcd_puts(buf);}

if(level==5)
{lcd_gotoxy(0,1);lcd_putsf("16,14 mA");
OCR1A=255;delay_ms(100);//OCR1A=0;delay_ms(500);
lcd_clear();ftoa(amp,2,buf);lcd_puts(buf);}

if(detik<0){detik=59;delay_ms(200);waktu=waktu-1;}

  if(loops==2){sensor_arus();}
  if(amp>100){delay_ms(500); // safety system
  lcd_clear();
  OCR1A=0;
  while(1){
  lcd_gotoxy(0,0);
  lcd_putsf("alarm");
  buz2=1;
  led2=1;
  delay_ms(1000);
  buz2=0;
  led2=0;
  delay_ms(200);}}

if(waktu<0){

```

```

OCR1A=0;
while(1) {
    OCR1A=0;
    //PORTD.6=0;
    PORTD.5=0;
    lcd_clear();

    lcd_gotoxy(0,0);
    lcd_putsf("tekan reset");
    buz1=1;
    led1=1;
    delay_ms(500);
    buz1=0;
    led1=0;
    delay_ms(100);}}
    lcd_clear();}

void setting()
{
    waktu=5;
    lcd_gotoxy(0,0);
    lcd_putsf("tekan enter");

    if(enter==0){delay_ms(500);
    while(1){
        if(enter==0){delay_ms(500);lcd_clear();menu=menu+1;}
        if(menu>1){menu=0;}
        if(menu==0){
            lcd_gotoxy(0,0);
            sprintf(buf,"Waktu = %d menit",waktu) ;
            lcd_puts(buf);
            if(up==0){delay_ms(500);waktu=waktu+5;}
            if(down==0){delay_ms(500);waktu=waktu-5;}
            if(waktu>15){waktu=5;}
            if(waktu<5){waktu=15;}
        }
    }
    if(menu==1){
        lcd_gotoxy(0,0);
        sprintf(buf,"Level = %d ",level) ;
        lcd_puts(buf);
        if(up==0){delay_ms(500);level=level+1;}
        if(down==0){delay_ms(500);level=level-1;}
        if(level>5){level=1;}
        if(level<1){level=5;}
    }
}

```

```
if(start==0){delay_ms(1000);lcd_clear();run();}

delay_ms(100);
lcd_clear();
lcd_gotoxy(0,13);
lcd_putsf("  ");}}}

void main(void)
{
PORTA=0x00;
DDRA=0x1E;

PORTB=0x1F;
DDRB=0x00;

PORTC=0x00;
DDRC=0x00;

PORTD=0x00;
DDRD=0xFF;

TCCR0=0x05;
TCNT0=0x8A;
OCR0=0x00;

TCCR1A=0xA3;
TCCR1B=0x04;
TCNT1H=0x00;
TCNT1L=0x00;
ICR1H=0x00;
ICR1L=0x00;
OCR1AH=0x02;
OCR1AL=0xFF;
OCR1BH=0x00;
OCR1BL=0x00;

ASSR=0x00;
TCCR2=0x00;
TCNT2=0x00;
OCR2=0x00;

TIMSK=0x01;

ACSR=0x80;
SFIOR=0x00;
```



```

ADMUX=ADC_VREF_TYPE & 0xff;
ADCSRA=0x84;

lcd_init(16);
#asm("sei")
lcd_gotoxy(0,0);
lcd_putsf("Alat Terapi TENS");
OCR1A=0;
delay_ms(1000);
lcd_clear();

while (1){
    sensor_arus();
    setting();
    delay_ms(500);
    lcd_clear();}}

```

2.2 Pengukuran Data Nilai Arus dengan perbedaan 2 jarak

Tabel 2.1 Baca Arus level 1

level 1		
pengukuran data ke-	jarak 15 cm (mA)	jarak 30 cm (mA)
x1	2,69	3,25
x2	2,94	3,16
x3	2,77	3,34
x4	3,14	3,22
x5	2,5	3,13
x6	2,87	3,22
x7	2,95	3,21
x8	3	3,24
x9	3,04	3,25
x10	3	2,93
x11	3,12	3,16
x12	2,51	3,12
x13	3,23	3,26
x14	3,11	3,07
x15	3,03	3,2
x16	3,15	2,98
x17	3,15	3,1
x18	3,16	3,08
x19	3,09	3,33
x20	2,86	3,06
Rata-rata (mA)	2,97	3,17

Tabel 2.2 Baca Arus Level 2

level 2		
pengukuran data ke-	jarak 15 cm (mA)	jarak 30 cm (mA)
x1	3,8	4,08
x2	3,92	4,24
x3	4	4,29
x4	3,85	4,25
x5	3,98	4,32
x6	3,96	4,23
x7	4	4,26
x8	4,01	4,15
x9	4,16	4,14
x10	4,04	4,18
x11	4,04	4,12
x12	4,04	4,06
x13	4,3	4,1
x14	4,06	4,06
x15	3,99	4,11
x16	4,05	4,18
x17	4,05	4,1
x18	4,16	4,1
x19	4,15	4,16
x20	4,14	3,06
Rata-rata (mA)	4,04	4,11

Tabel 2.3 Baca Arus Level 3

level 3		
pengukuran data ke-	jarak 15 cm (mA)	jarak 30 cm (mA)
x1	7,83	8,15
x2	8,1	8,29
x3	8,4	8,4
x4	8,22	8,5
x5	8,23	8,46
x6	8,3	8,6
x7	8,23	8,6
x8	8,13	8,45
x9	8,27	8,59
x10	8,3	8,65
x11	8,29	8,6
x12	8,54	8,69
x13	8,41	8,85
x14	8,24	8,55

Lanjut

Lanjut

level 3		
pengukuran data ke-	jarak 15 cm (mA)	jarak 30 cm (mA)
x15	8,45	8,58
x16	8,45	8,59
x17	8,66	8,5
x18	8,51	8,53
x19	8,49	8,49
x20	8,71	8,65
Rata-rata (mA)	8,55	8,56

Tabel 2.4 Baca Arus Level 4

level 4		
pengukuran data ke-	jarak 15 cm (mA)	jarak 30 cm (mA)
x1	13,15	13,55
x2	13,06	13,61
x3	13,44	13,48
x4	13,65	13,62
x5	13,46	14,14
x6	13,33	14,05
x7	13,34	13,95
x8	13,75	13,86
x9	13,67	14,15
x10	13,12	13,69
x11	13,21	13,72
x12	13,2	14,03
x13	13,33	13,55
x14	13,28	13,62
x15	13,16	13,68
x16	13,29	13,99
x17	13,81	13,76
x18	13,45	13,53
x19	13,44	13,58
x20	13,55	13,59
Rata-rata (mA)	13,38	13,76

Tabel 2.5 Baca Arus Level 5

level 5		
pengukuran data ke-	jarak 15 cm (mA)	jarak 30 cm (mA)
x1	18,9	19,57
x2	18,8	19,42
x3	18,71	19,32
x4	18,82	19,4
x5	18,8	19,4
x6	18,79	19,23
x7	18,85	19,37
x8	19,05	19,05
x9	19	19,37
x10	18,8	19,54
x11	18,81	19,46
x12	18,95	19,28
x13	18,92	19,43
x14	18,92	19,8
x15	18,78	19,35
x16	18,89	19,59
x17	19,32	19,6
x18	19,02	19,54
x19	18,85	19,56
x20	18,88	19,45
Rata-rata (mA)	18,89	19,45

1.2 Perhitungan Pengukuran Data Timer dan Nilai Arus

1.3 Perhitungan 5 menit

a. Rata-rata

$$\text{Rata-rata } \bar{X} = \frac{\sum Xi}{n}$$

Diketahui :

$$\bar{X} = \text{rata-rata.....?}$$

$$\sum Xi = 6027 \text{ (hasil penjumlahan 20 data)}$$

$$n = 20$$

Dimana :

$$\bar{X} = \frac{6027}{20} = 301,35 \text{ detik}$$

b. %Simpangan

$$\% \text{Simpangan} = \bar{X} - Y$$

Diketahui:

%Simpangan = ...?

$Y = 300$ detik

$\bar{X} = 301,35$ detik

Dimana:

%Simpangan = $301,35 - 300 = 1,35$ %

c. % *Error*

$$\% \text{ Error} = \frac{Y - \bar{X}}{Y} \times 100$$

Diketahui:

% *Error* =?

$Y = 300$ detik

$\bar{X} = 301,35$ detik

Dimana:

$$\% \text{ Error} = \frac{300 - 301,35}{300} \times 100 = -0,45 \%$$

1.4 Perhitungan 10 menit

a. Rata-rata

$$\text{Rata-rata } \bar{X} = \frac{\sum Xi}{n}$$

Diketahui :

\bar{X} = rata-rata.....?

$\sum Xi = 12065$ (Hasil penjumlahan 20 data)

$n = 20$

Dimana :

$$\bar{X} = \frac{12065}{20} = 603,25 \text{ detik}$$

b. %Simpangan

$$\% \text{ Simpangan} = \bar{X} - Y$$

Diketahui:

%Simpangan = ...?

$Y = 600$ detik

$\bar{X} = 603,25$ detik

Dimana:

%Simpangan = $603,25 - 600 = 3,25$ %

c. % *Error*

$$\% \text{ Error} = \frac{Y - \bar{X}}{Y} \times 100$$

Diketahui:

$$\% \text{ Error} = \dots?$$

$$Y = 600 \text{ detik}$$

$$\bar{X} = 603,25 \text{ detik}$$

Dimana:

$$\% \text{ Error} = \frac{600 - 603,25}{600} \times 100 = -0,54 \%$$

1.5 Perhitungan 15 menit

a. Rata-rata

$$\text{Rata-rata } \bar{X} = \frac{\sum Xi}{n}$$

Diketahui :

$$\bar{X} = \text{rata-rata} \dots?$$

$$\sum Xi = 18098 \text{ (Hasil penjumlahan 20 data)}$$

$$n = 20$$

Dimana :

$$\bar{X} = \frac{18098}{20} = 904,9 \text{ detik}$$

b. % Simpangan

$$\% \text{ Simpangan} = \bar{X} - Y$$

Diketahui:

$$\% \text{ Simpangan} = \dots?$$

$$Y = 900 \text{ detik}$$

$$\bar{X} = 904,9 \text{ detik}$$

Dimana:

$$\% \text{ Simpangan} = 301,35 - 300 = 1,35 \%$$

c. % Error

$$\% \text{ Error} = \frac{Y - \bar{X}}{Y} \times 100$$

Diketahui:

$$\% \text{ Error} = \dots?$$

$$Y = 900$$

$$\bar{X} = 904,9$$

Dimana:

$$\% \text{ Error} = \frac{900 - 904,9}{900} \times 100 = -0,54 \%$$

1.6 Perhitungan *level 1*

a Rata-rata

$$\text{Rata-rata } \bar{X} = \frac{\sum Xi}{n}$$

Diketahui :

$$\bar{X} = \text{rata-rata} \dots ?$$

$$\sum Xi = 10,63 \text{ (Hasil penjumlahan 20 data)}$$

$$n = 20$$

Dimana :

$$\bar{X} = \frac{10,63}{20} = 0,5315 \text{ mA}$$

b %Simpangan

$$\% \text{Simpangan} = \bar{X} - Y$$

Diketahui:

$$\% \text{Simpangan} = \dots ?$$

$$Y = 0,53 \text{ mA}$$

$$\bar{X} = 0,5315 \text{ mA}$$

Dimana:

$$\% \text{Simpangan} = 0,5315 - 0,53 = 0,0015 \%$$

c % Error

$$\% \text{ Error} = \frac{Y - \bar{X}}{Y} \times 100$$

Diketahui:

$$\% \text{ Error} = \dots ?$$

$$Y = 0,53 \text{ mA}$$

$$\bar{X} = 0,5315 \text{ mA}$$

Dimana:

$$\% \text{ Error} = \frac{0,53 - 0,5315}{0,53} \times 100 = -0,28\%$$

1.7 Perhitungan *level 2*

a Rata-rata

$$\text{Rata-rata } \bar{X} = \frac{\sum Xi}{n}$$

Diketahui :

$$\begin{aligned}\bar{X} &= \text{rata-rata.....?} \\ \sum Xi &= 64,85 \text{ (Hasil penjumlahan 20 data)} \\ n &= 20 \\ \text{Dimana :} \\ \bar{X} &= \frac{64,85}{20} = 3,24 \text{ mA}\end{aligned}$$

b %Simpangan

$$\% \text{Simpangan} = \bar{X} - Y$$

Diketahui:

$$\% \text{Simpangan} = \dots?$$

$$Y = 3,3 \text{ mA}$$

$$\bar{X} = 3,24 \text{ mA}$$

Dimana:

$$\% \text{Simpangan} = 3,24 - 3,3 = -0,06 \%$$

c % Error

$$\% \text{ Error} = \frac{Y - \bar{X}}{Y} \times 100$$

Diketahui:

$$\% \text{ Error} = \dots?$$

$$Y = 3,3 \text{ mA}$$

$$\bar{X} = 3,24 \text{ mA}$$

Dimana:

$$\% \text{ Error} = \frac{3,3 - 3,24}{3,3} \times 100 = 1,74 \%$$

1.8 Perhitungan level 3

a. Rata-rata

$$\text{Rata-rata } \bar{X} = \frac{\sum Xi}{n}$$

Diketahui :

$$\bar{X} = \text{rata-rata.....?}$$

$$\sum Xi = 134,52 \text{ (Hasil penjumlahan 20 data)}$$

$$n = 20$$

Dimana :

$$\bar{X} = \frac{134,52}{20} = 6,73 \text{ mA}$$

b. %Simpangan

$$\% \text{Simpangan} = \bar{X} - Y$$

Diketahui:

$$\% \text{Simpangan} = \dots?$$

$$Y = 6,79 \text{ mA}$$

$$\bar{X} = 6,73 \text{ mA}$$

Dimana:

$$\% \text{Simpangan} = 6,73 - 6,79 = -0,06 \%$$

c. % *Error*

$$\% \text{ Error} = \frac{Y - \bar{X}}{Y} \times 100\%$$

Diketahui:

$$\% \text{ Error} = \dots?$$

$$Y = 6,79 \text{ mA}$$

$$\bar{X} = 6,73 \text{ mA}$$

Dimana:

$$\% \text{ Error} = \frac{6,79 - 6,73}{6,79} \times 100\% = 0,94\%$$

1.9 Perhitungan *level 4*

a. Rata-rata

$$\text{Rata-rata } \bar{X} = \frac{\sum Xi}{n}$$

Diketahui :

$$\bar{X} = \text{rata-rata} \dots?$$

$$\sum Xi = 219,8 \text{ (Hasil penjumlahan 20 data)}$$

$$n = 20$$

Dimana :

$$\bar{X} = \frac{219,8}{20} = 10,99 \text{ mA}$$

b. %Simpangan

$$\% \text{Simpangan} = \bar{X} - Y$$

Diketahui:

$$\% \text{Simpangan} = \dots?$$

$$Y = 11,02 \text{ mA}$$

$$\bar{X} = 10,99 \text{ mA}$$

Dimana:

$$\% \text{Simpangan} = 10,99 - 11,02 = -0,03 \%$$

c. % *Error*

$$\% \text{ Error} = \frac{Y - \bar{X}}{Y} \times 100$$

Diketahui:

$$\% \text{ Error} = \dots?$$

$$Y = 11,02 \text{ mA}$$

$$\bar{X} = 10,99 \text{ mA}$$

Dimana:

$$\% \text{ Error} = \frac{11,02 - 10,99}{11,02} \times 100 = 0,27 \%$$

1.10 Perhitungan level 5

a. Rata-rata

$$\text{Rata-rata } \bar{X} = \frac{\sum Xi}{n}$$

Diketahui :

$$\bar{X} = \text{rata-rata} \dots?$$

$$\sum Xi = 324,63 \text{ (Hasil penjumlahan 20 data)}$$

$$n = 20$$

Dimana :

$$\bar{X} = \frac{324,63}{20} = 16,24 \text{ mA}$$

b. % Simpangan

$$\% \text{ Simpangan} = \bar{X} - Y$$

Diketahui:

$$\% \text{ Simpangan} = \dots?$$

$$Y = 16,14 \text{ mA}$$

$$\bar{X} = 16,24 \text{ mA}$$

Dimana:

$$\% \text{ Simpangan} = 16,24 - 16,14 = 0,1 \%$$

c. % *Error*

$$\% \text{ Error} = \frac{Y - \bar{X}}{Y} \times 100$$

Diketahui:

$$\% \text{ Error} = \dots?$$

$$Y = 16,14 \text{ mA}$$

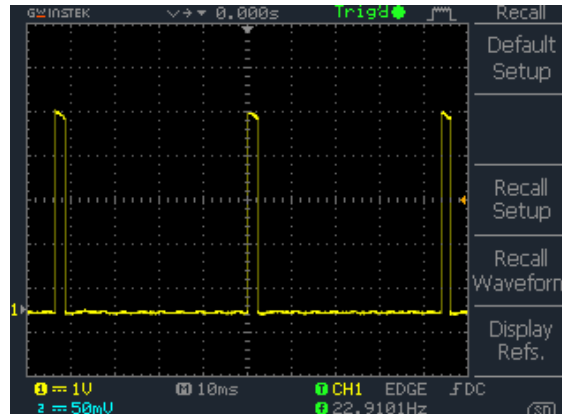
$$\bar{X} = 16,24 \text{ mA}$$

Dimana:

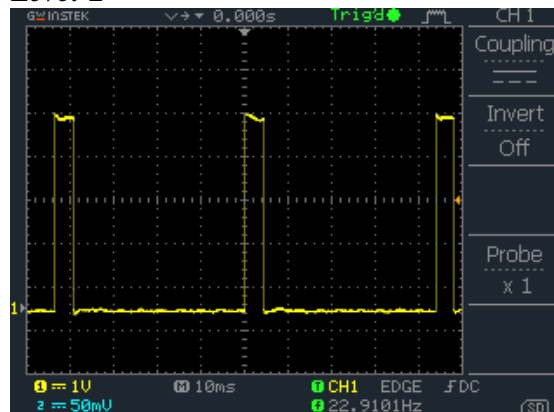
$$\% \text{ Error} = \frac{16,14 - 16,24}{16,14} \times 100 = -0,62\%$$

5.1 Gambar Gelombang tiap-tiap level

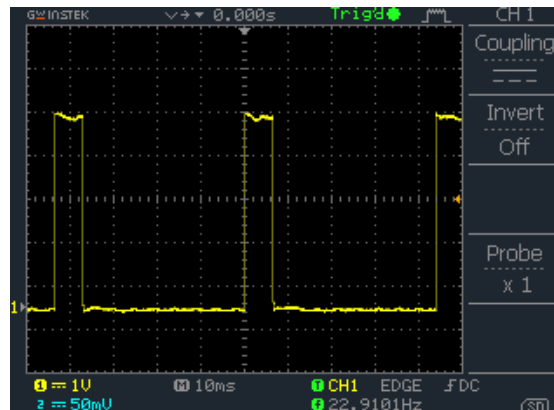
a. Level 1



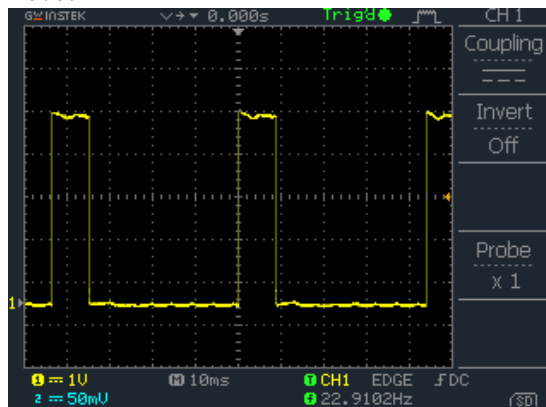
b. Level 2



c. Level 3



d. *Level 4*



e. *Level 5*

