Design and implementation of laser direction determination electronic and control circuits

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Abstract—**in this project we will introduce the model and implementation for the quadrant detector with laser direction determination electronic and control circuits.the model includes the pre-amplifier, post-amplifier, inverse amplifier and the ADC in addition to the quadrant detector.the main purpose of this project is to extract the ADC output and apply the necessary processing on the ADC output to determine the spot position.**

I. INTRODUCTION

A. Principle

Starting from the output of the quadrant photodiode detector.The output of the photodiode is a current and with a very small value (with range in pA), all the processing made on the signal treat the signal as a volt not as a current (due to the used instruments and equipment work on the voltage). We can overcome this problem with the usage of the Trans impedance (TI) (which transfer the output current from the photodiode into equivalent value of the volt). The low level current can be raised by using the trans-impedance amplifier (TIA) (which is used to transfer and amplify the detector output current into the volt).

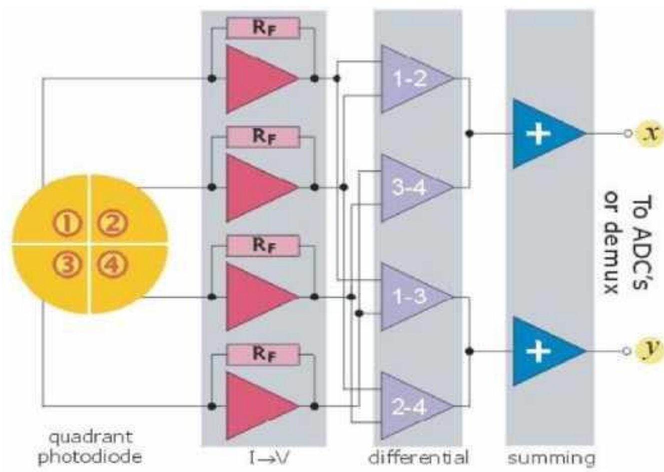

Fig. 1. the general block diagram of the four quadrant detector with processing cicuit for laser position determination/

B. Block diagram

First stage is the quadrant photo diode, in the second stage the photo diode output current is converted into the volt with the use of the trans-impedance amplifier , the third stage is used to differentiate the four signals volts from each other , and in the last stage the summing of the signals with the aim of validate the position equation for the photodiode position determination is done as follows :

$$X = K_Q \frac{(V_1 + V_3) - (V_2 + V_4)}{V_1 + V_2 + V_3 + V_4} \qquad (1)$$

$$Y = K_Q \frac{(V_1 + V_2) - (V_3 + V_4)}{V_1 + V_2 + V_3 + V_4} \qquad (2)$$

Where X and Y represent the position coordinate of the spot and(V_1, V_2, V_3, and V_4) are the four signals from the four photodiode as shown in figure (1). K_Q is the proportional factor for the quadrant detector.

II. SPOT POSITION DETERMINATION CIRCUIT OVERVIEW

A. first stage

Most pre-amplifiers used today are charge sensitive and provide an output pulse with an amplitude proportional to the integrated charge output from the detector. general purpose pre-amplifiers have an RC feedback network which results in a quasi step function output. we can say that pre-amplifiers function is to amplify a low level signal to a line-level. from the circuit shown in figure(2). [1] we can determine the gain of the circuit by the equation :

$$\frac{V_o}{V_i} = G = (1 + \frac{R3}{R4}) \qquad (3)$$

Figure (3) shows the two curves of the input with amplitude (5mv) and the output with amplitude (7.56mv) this prove the gain is G=1.5. [2]

B. Second stage

The second stage circuit (gain circuit) is used to increase the level of the output volt from the pre-amplifier due to that the pre-amplifier has a limited amplified value.By using the non-inverting operational amplifier shown in figure(4) for the gain value determined according to the value of feedback resistance according to the basic equation of the operational amplified. [3] we can determine the gain of the circuit by the equation

$$\frac{V_{oi}}{V_o} \quad (1 + f > \qquad (4)$$

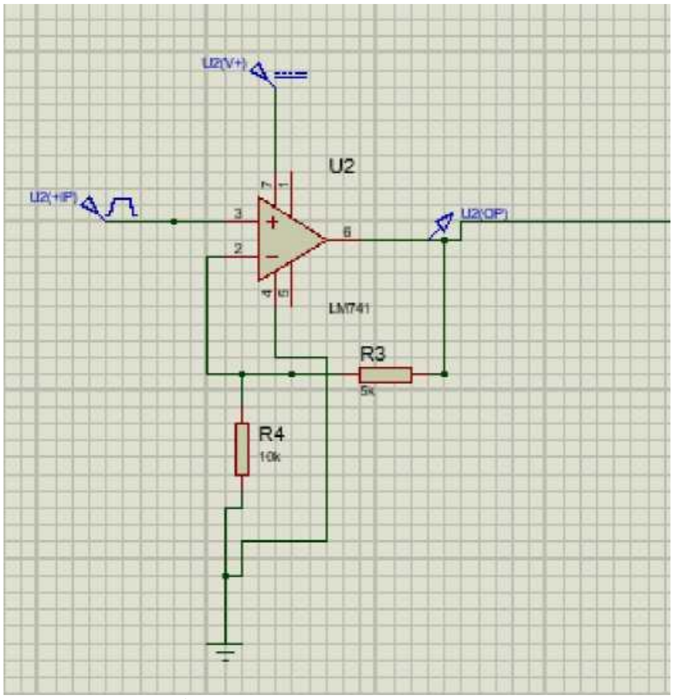

Fig. 2. the Pre-amplifier circuit

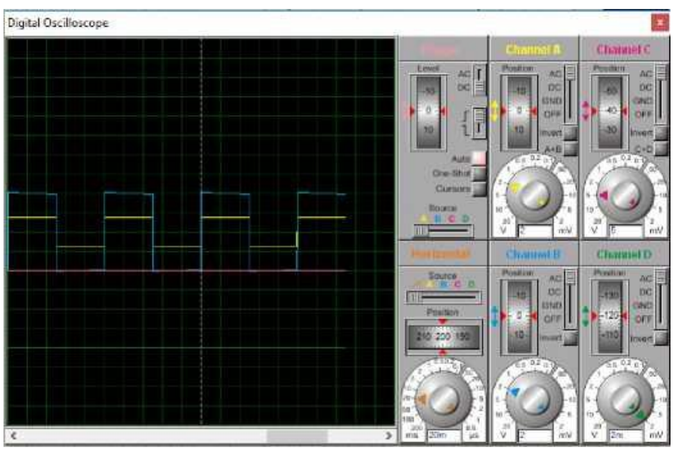

Fig. 3. shows the output of the gain amplifier with the gain amplifier (G=11).

By substituting from equation (3) into equation (4) we have to produce the equation which provide the summing of the two circuit as follows :

$$V_{oi} = V_i\left(1 + \frac{R}{R_2}\right)\left(1 + \frac{R}{R_4}\right) \quad (5)$$

The figure (5) shows the two curves of the input with amplitude (5mv) and the output with amplitude (55.56mv) this prove the gain is G=11. The previous two stages are connected as shown in figure(6).

C. *Third stage*

The third stage is used for the inverse signal circuit (emitter follower) with the gain value To be in positive sign

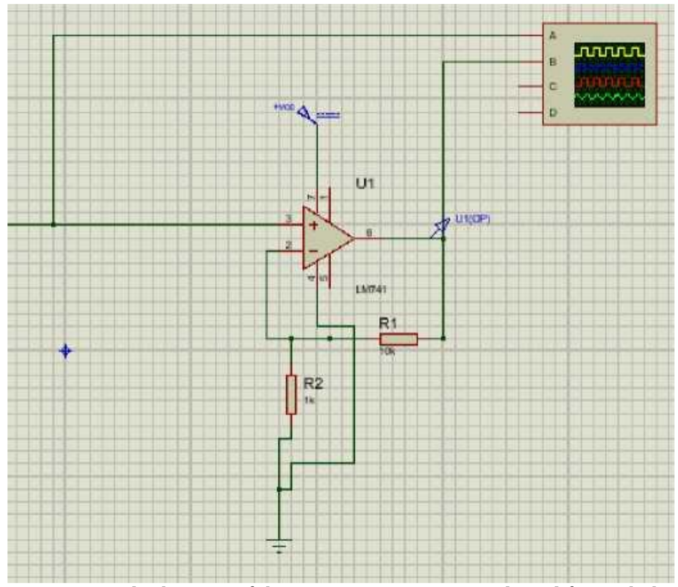

Fig. 4. General schematic of the non-inverting operational amplifier with the gain amplitude with the feedback resistor

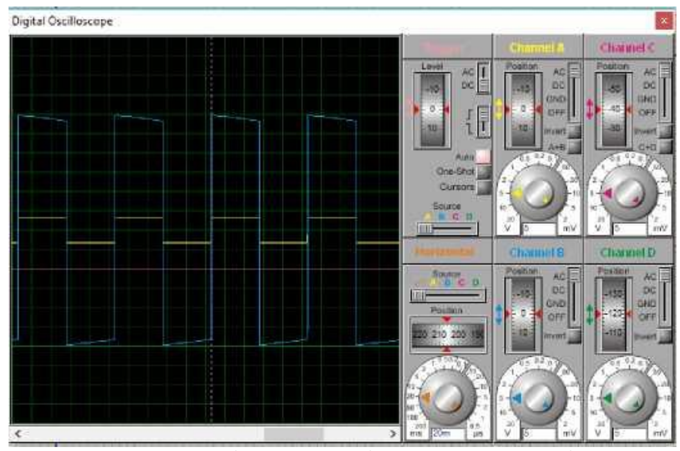

Fig. 5. shows the output of the gain amplifier with the gain amplifier (G=11).

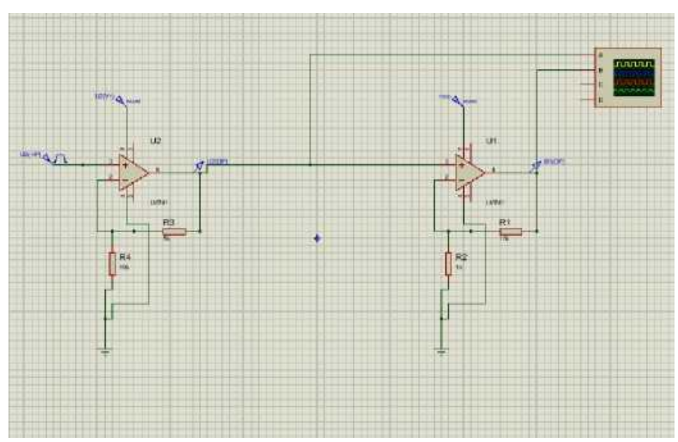

Fig. 6 Two stages circuit

and can be read with the analog to digital converter (ADC). From the circuit shown in figure(7) we can determine the gain of the circuit by the equation: [4]

$$\frac{V_{02}}{} = -\left(\frac{R_5}{R_6}\right) V01 \qquad (6)$$

by substituting from equation(5) into equation (6) we have to produce the equation which provide the summing of the two circuits as follows:

$$V_{02} = V_i \left(1 + \frac{R}{R_2}\right)\left(1 + \frac{R_3}{R_4}\right)\left(-\frac{R_5}{R_6}\right) \qquad (7)$$

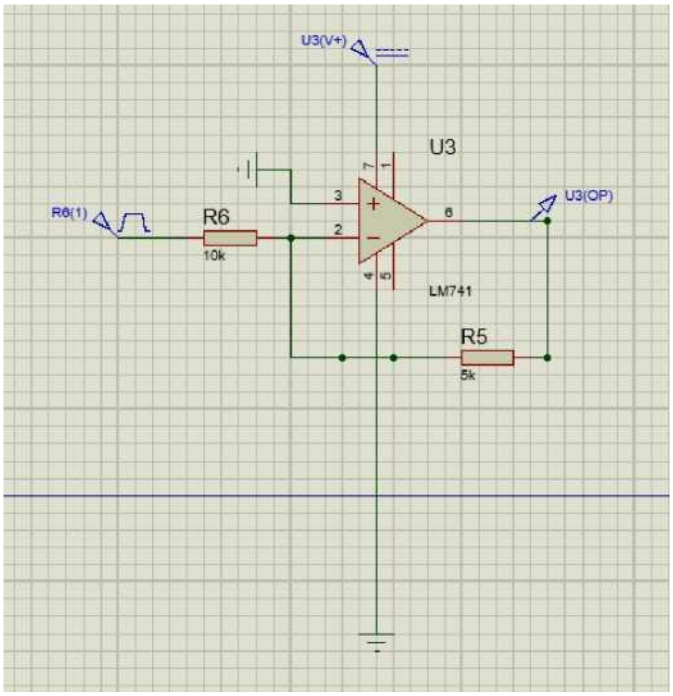

Fig. 7. general schematic of the inverting operational amplifier with the gain amplitude with the feedback resistor

$V_i (1 + \frac{R}{R_2})(1 +$

D. Analog to Digital Converter (ADC) Stag

After modifying the output from the quad detector by the three stages as discussed previously, the signal will be converted from analog to digital by using ”ADC” .The used ”ADC” is designed by using ”FARES PCB ” kit which operate with ”ATMEGA” microcontroller by this code as shown in figure (10). This is done by using ”Proteus” software for making simulation, also we used ”EasyEDA” for drawing the full circuit of ADC as shown in fig (8). then we convert the circuit to Gerber file as shown in fig (9) for fabrication of the card, also we use ”Atmel Studio ” for programming of the ADC. finally we use a learning kit to make a simulation of the code shown in fig(10 , 11) before fabrication . [5] [6]

E. Hardware and Experiment

In practical, we connect the quad detector with the PCB that contains the analog to digital converter.A microcontroller was used to do process on the signal and calculate

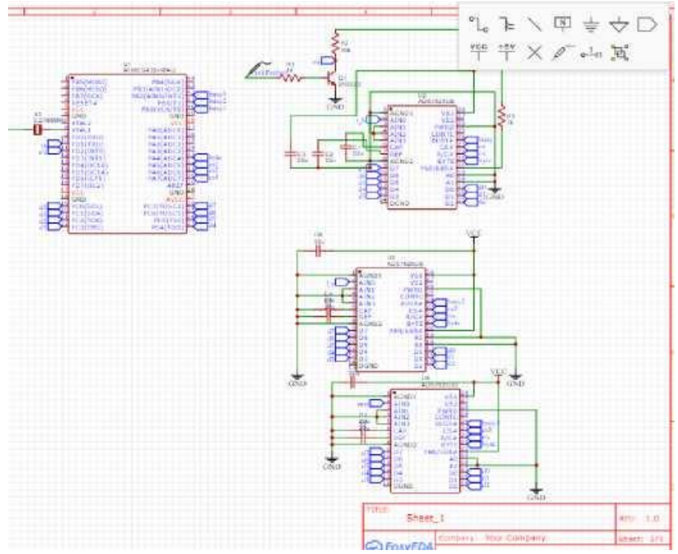

Fig. 8. three channel ADC

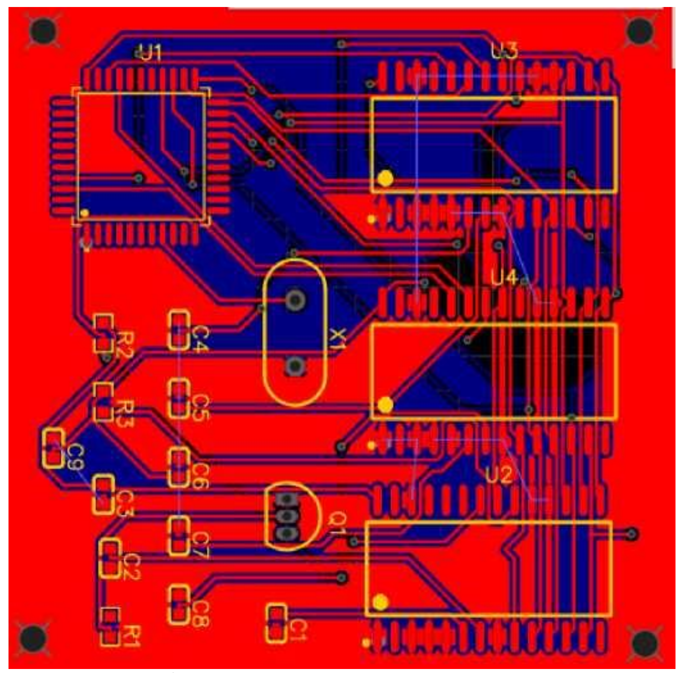

Fig. 9. the routing file

the spot position on the detector as shown in figure(12).the seeker is mounted on the moving mechanical system to be directed to different angles in the direction of the laser, with the help of specific algorithm in equation (1 , 2).the spot position is calculated. [7] [9] we check the full system by making a laser testing for laser spot position determination so the quad detector receive the signal and transmit it to the microcontroller for signal processing as shown in figure(12). [10]

III. CONCLUSION

Analog to digital converter (ADC) is a very useful tool in many applications specially digital signal processing (DSP).

```
TCCR1B |= (1«CS10) | (1«CS11);
TCCR1B &= ™(1«CS12);                    //PRESCALER =64
//FREQ OF PUR = 16MHZ /64 =250KHZ

//CONFIGURE THE OUTPUT COMPARE PIN AS O/P DDRD |= (1«DDD5);
//ENABLE THE GLOBAL INTERRUPT ENABLE BIT sei()i
//ENABLE ADC I INTERRUPT
ADCSRA |=(l<<ADIE)j
//SET REFRANCE TO NO AVCC AND INPUT TO ADCO //SET DATA
alignment in data register ADMUX = OκOO'
//enable ADC
ADCSRA |= (1«ADEN) | (1«ADATE);
//SET FREQ OF ADC CONVERSION ADCSRA |=
(1«ADP52)j
ADCSRA &=       (1< <ADP S  1  )  <  A  D  P  S  O  )  )   j // PRESCALER = 16 CLOCK =16MHZ /16=1MHZ
//STARTTHE CONVERSION ADCSRA
|=(1<<ADSC)j

while(l)
{
PORTC=ADCj
}

//ISA FUNCTION I5R(ADC
vect)
{
        ADC;
```

Fig. 10. ADC code by using ”Atmel studio ” software

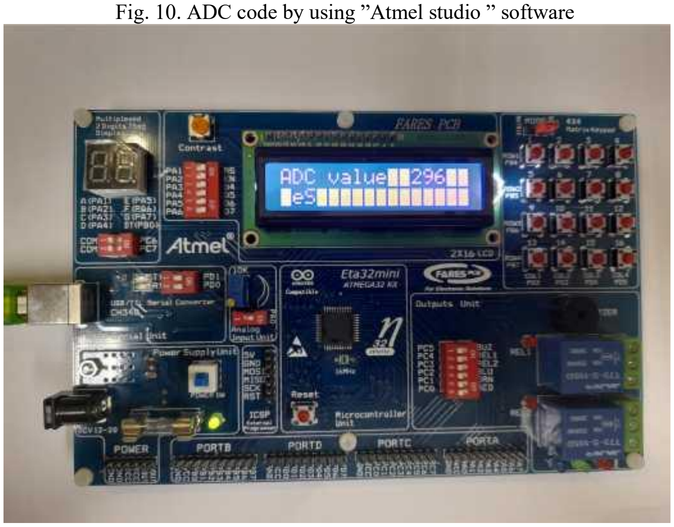

Fig. 11. Monitoring the ADC output using Fares PCB based on Atmel code

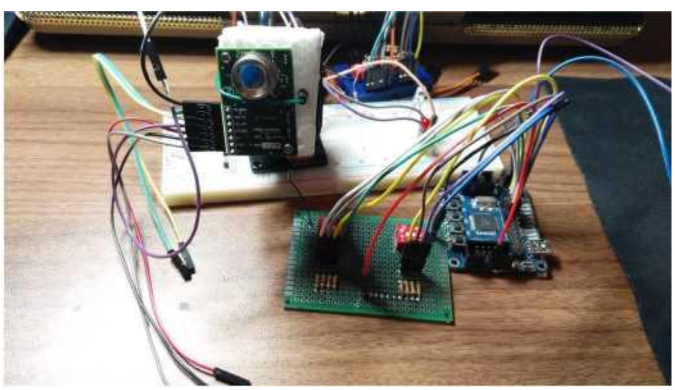

Fig. 12. full system implementation

[8]

The main purpose of this work is to modify the signal from the quad detector by the three stage and make it ready to be as an input to the ADC and extract the output of the ADC and apply the necessary processing on the ADC output by microcontroller to determine the spot position.

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