THE APPLICATION OF TRANSMITTER AND RECEIVER TO DETECT THE PLOUGHING DEPTH

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ABSTRACT

Transmitter and receiver were applied in this research to detect the mole plough. Transmitter was placed outside the farm while receiver was attached on the mole plough construction and then pulled by tractor. Mole plough was used to create drainage channel. However, creating drainage channel at slope of 0,02% is a difficult task as mole ploughing depth is strongly affected by the contour of soil surface. The objective of this research was to design a device which had ability to control mole ploughing depth. Transmitter used a modified green laser beam which used to measure the profile of soil surface. Receiver was used to receive signal. Light receiver sensor used photodiode which formed into matrix sized of (1x8), every row consisted of 40 sensor of photodiode with 8 levels of depth. When transmitter was activated, green laser beam transmitted 1.206 Hz frequency and can be transmitted for maximum 50 m. When photodiode sensor received green laser beam at allowable detection range, the light beam was transmitted to Arduino microcontroller. There were two microcontrollers used to control two units of relay. The first microcontroller was used to detect the contour level of soil surfaceand second microcontroller was used to measure the mole ploughing depth. The research found that there was deviation of mole ploughing depth between setpoint and field testing result.

Key words: mole plough, microcontroller, receiver, drainage channel, transmitter.

1 INTRODUCTION

Water excess in agricultural land could damage the plants and causes financial lose for farmers [1]. To deal with the problem, sub-soiler drainage channel up to 40 cm depth was created using mole plough [2,3]. The mole plough was automatically jointed with hydraulic cylinder piston and mounted to three point hitch in tractor with capacity of 55 kW. Hydraulic hose was used to mount the mole plough-driven component to the external part of a hydraulic system attached to the tractor. However, a problem occurred since the ploughing depth was still influenced by the profile of soil surface. Therefore, transmitter and receiver were applied to detect the profile of soil surface. The objective of this research was to design the transmitter and receiver system and to test the design to obtain data input for microcontroller to control the hydraulic movement.

2 RESEARCH METHOD

The research was conducted from January to June 2014. The construction design and testing was carried out in Laboratory of Instrumentation and Workshop and Laboratory of Agricultural Engineering, Department of Mechanical and Biosystem, Faculty of Agricultural Engineering and Technology, Bogor Agricultural University. Field testing was taken place at Field Laboratory of Siswadhi Soepardjo, Bogor. The construction of mole plough, tractor lay out and a set of transmitter and receiver to detect the profile of soil surface are shown in Fig. 1.

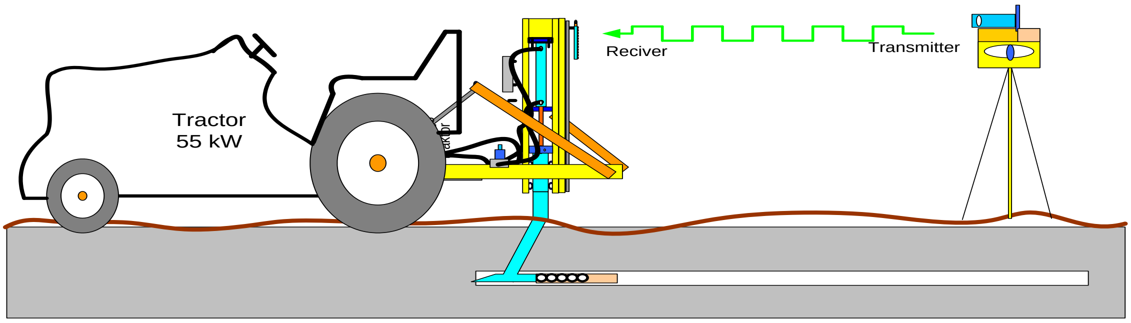

Figure 1 A set of transmitter and receiver on the mole plough construction

2.1 Design of Transmitter and Receiver Circuit

The first stage of this research was to design transmitter circuit which consisted of astable multi vibrator, chooper transistor and green laser beam. Receiver circuit consisted of photodiode light sensor, high pass filter and signal amplifier, inverter, nand gate, microcontroller and program. The diagram block of transmitter and receiver system is shown in Fig. 2.[4]

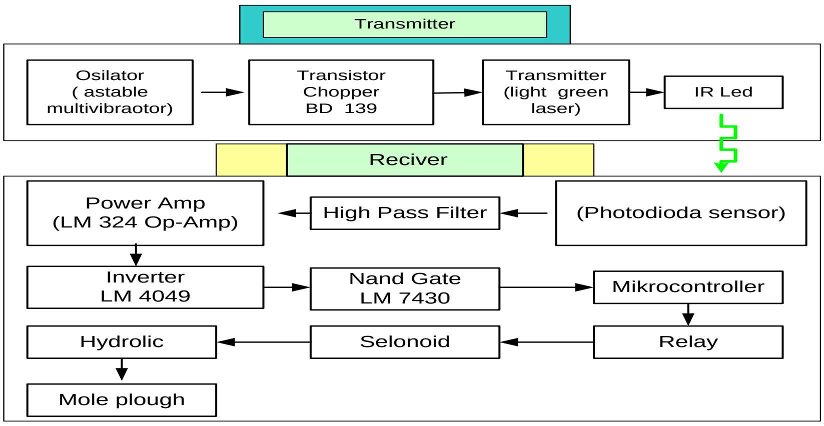

Figure 2 Diagram block of hydraulic control system

The diagram block of hydraulic control system consisted of two systems i.e. transmitter and receiver circuit which separately attached. The two systems were connected through green laser beam which transmitted from IR led light and then received by photodiode sensor.

2.1.1 Transmitter Circuit

Transmitter circuit was designed from a stable multivibrator circuit using IC NE 555 which used to generate pulsesignal. In this research, transmitter was designed to transmit frequency up to 40 kHz [5]. The design of astable multivibrator with IC 555 is shown in Fig. 3. [6]

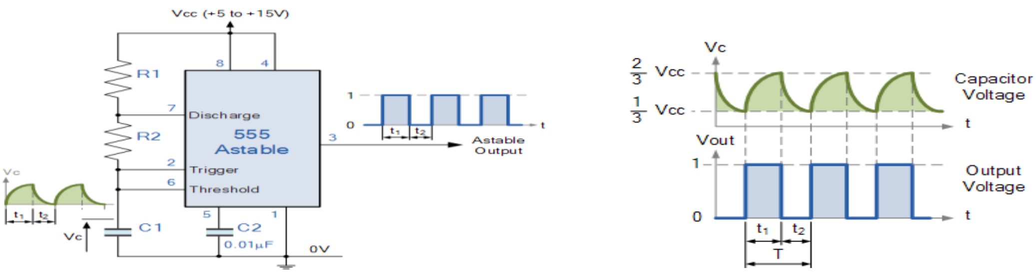

Figure 3 Astable mutivibrator using IC 555

Referring to Fig. 3, astable multivibrator with IC 555 received direct current voltage source through pin 8. Pin 8 received DC voltage supply at 5 to 15 V with current supply 10 mA up to 15 mA. Pin 4 was connected to pin 7 through R1 which used as discharger. This component was used as pin to reset the latch inside IC or to reset the IC work. This pin was connected to the PNP transistor gate and activated the transistor with low logic. Pin 7 was connected to pin 2 and pin 6 through R2 which functioned as trigger. Pin 6 was connected to open collector of the internal transistor (Tr) which the emitter was mounted to ground. Switching transistor was used to clamp the suitable node to the ground at certain time. Negative input from lower comparator (comparator B) maintained the oscillation of capacitor at the lowest voltage i.e. 1/3 Vcc and controlled RS flip-flop. Pin 6 was connected to ground through C1 which functioned as threshold. Moreover, pin 6 was connected to positive input (comparator A) which used to reset RS flip-flop when the voltage was higher than 2/3 Vcc. Pin 5 was connected to the ground through C2 voltage control which used to stabilize the reference voltage of negative input (comparator A). In order to maintain the reference stability of comparator A, pin 5 usually used capacitor with 10 nF to connect to the ground and pin 1 was connected to the ground. Voltage output was received through pin 3. Time required to reach the upper and lower threshold of comparator was calculated using this equation [7].

$$t_1 = 0{,}693(R_1 + R_2)$$
$$and$$
$$t_2 = 0{,}693(R_2 x C) \qquad (1)$$

whereas:

t_1 : time required to reach upper threshold of comparator (second)

t_2 : time required to reach lower threshold of comparator (second)

Period (*T*) and frequency (*f*) which used to obtain one cycle were calculated using these following equations:

$$T = t_1 + t_2$$
$$= 0{,}693(R_1 + 2.R_2).C$$
$$and$$
$$f = \frac{1}{T}$$
$$= \frac{1{,}44}{(R_1 + 2.R_2).C} \qquad (2)$$

The design of astable multivibrator, chooper transistor and green laser beam is shown in Fig. 4

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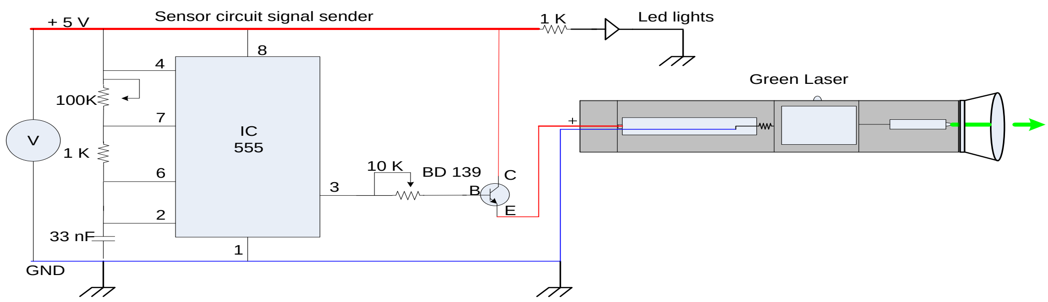


Figure 4 Green lasertransmitter circuitsignal

Transmitter IC 555 shown in Fig. 4 run with voltage ranging from + 5 volt dc to +12 volt dc and frequency of 1.235 Hz which set through RC configuration at astable multivibrator IC NE 555 and choppertransistor. The level of positive and negative peak of pulse which used to move the green laser beam was controlled through potentiometer R3. Potentiometer R3 was functioned to control the period of "HIGH" pulse-side. The HIGH and LOW pulse-side were maintained to keep the working frequency around 1.206 Hz. The output power from laser was expressed in miliwatt unit (mW).

2.1.2 Receiver Design

Signal receiver consisted eight levels with one row (4x10) of photodiode sized 5 cm x 10 cm. Photodiode was attached in parallel form in order to receive similar voltage. Photodiode was arranged in matrix form sized of 1x8. Each row consisted of (4x10) photodiode sensor and each row was expressed as level, thus the receiver had eight levels. Light sensor which received by photodiode should be filtered using high pass filter. It aimed to avoid disruptive light from intervering the main light which needed to control the system. The working principle of high pass filter (HPF) utilizes the basic characteristic of C and R component where C will pass AC signal in accordance with the value of capacitive reactance and R component more easily passes signals with a low frequency. In detail, the working principle is as follows: if the high pass filter circuit receives input signal with a frequency above the cut-off frequency (ωc) then the signal will be passed through component C. If the input signal is lower than the cut-off frequency (ωc) then the input signal will be lowered to the ground through component R. The resonance frequency of high pass filter followed time constant value (τ) of the RC [8]

$$\tau = R.C \qquad (3)$$

The relationship among capacitor (C), resistor (R) and cutoff frequency followed this equation:

$$f = \frac{1}{2\pi RC} \qquad (4)$$

Electrical current generated from photodiode sensor when exposed to green laser beam was still low i.e. 0,14 mA. Therefore, operational amplifier Op-Amp LM 324 which formed in IC was used in this research [9]. The aim was to strengthen the main signal. Fig. 5 shows the integrated circuit of photodiode sensor, high pass filter and amplifier.

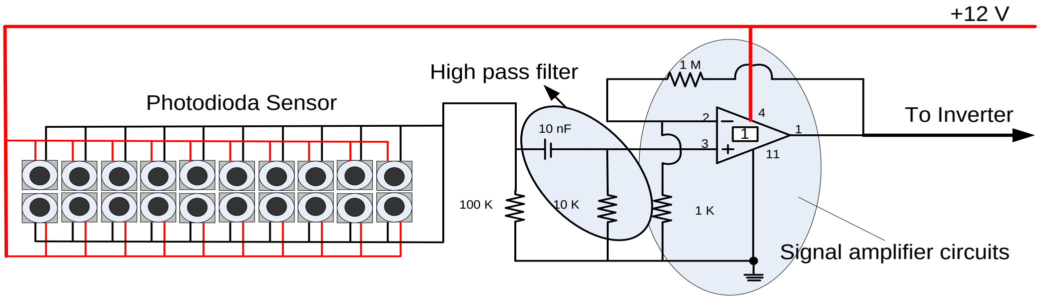


Figure 5 Integrated circuit of photodiode sensor, high pass filter and Op-Amp

The light was then transmitted into signal amplifier (IC 234)10] and to inverter (IC4049) [11] to be converted to 0 or 1 as input for Nand gate (IC 7430). Nand-gate was used as multiplier and the result was used as input for Atemega 328 Arduino microcontroller [12]. Integrated circuit between IC LM 4049 and IC LM 7430 is shown in Fig. 6.

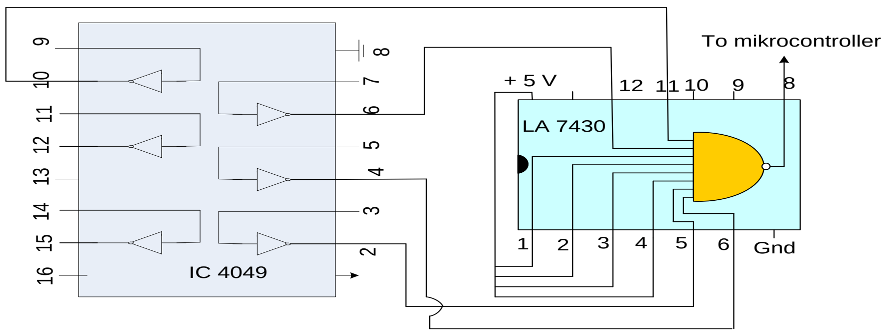


Figure 6 Integrated circuit between IC LM 4049 and IC LM 7430

Output generated from microcontroller was used to move relay 12 V dc [13] to perform valve opening. This mechanism was designed to transfer the pressure generated in tractor hydraulic to the ploughing hydraulic as shown in Fig. 7.

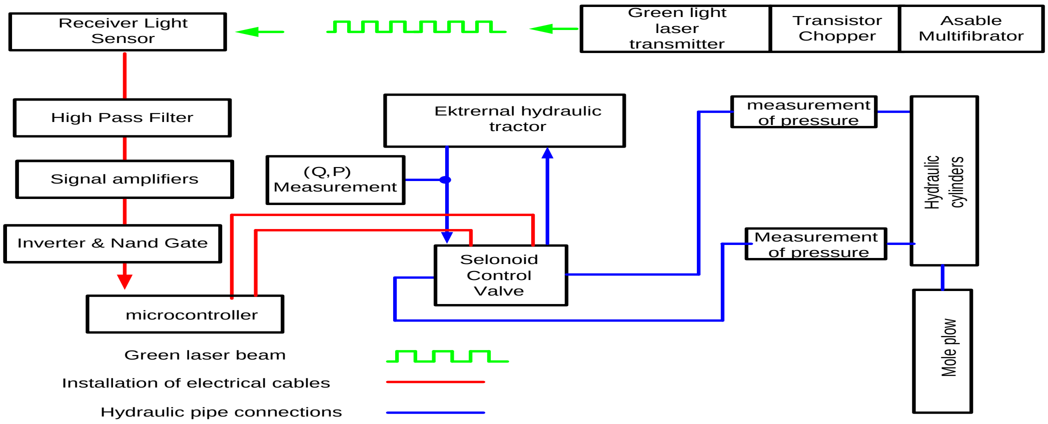


Figure 7 Diagram block of ploughing hydraulic control system

2.2 Soil Surface Profile Measurement Method

Field preparation was carried out by measuring soil surface profile [14]. The profile was carried out using a set of laser beam and stake meter. Elevation was measured by placing one stake as bench mark and placing others stakes at each field corner and then leveled as shown in Figure 8. The stake meter was placed at 2 m, 4 m until 30 m. The measurement was conducted at each tracks and the result was written on the table.

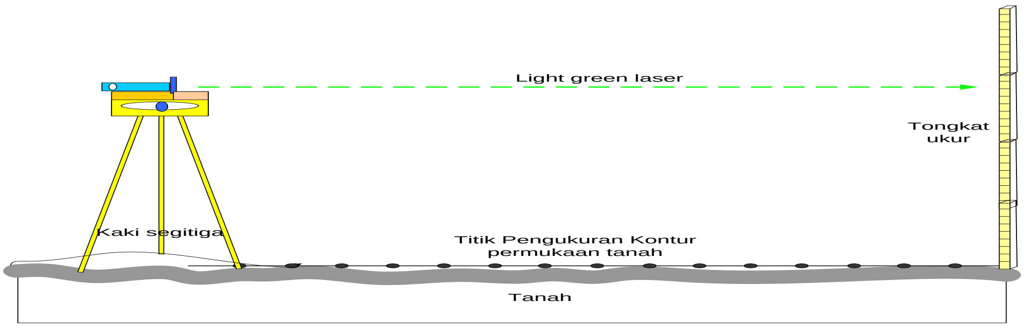


Figure 8 Field measurement and stake position for tractor track

2.2.1 Tractor Track

The track was created for tractor movement. In order to avoid crossing over, the distance among tracks was designed as 1,5 m ofwidth. The width of rear wheel was 1,5 m. After completing the works at A track, tractor then moved to B track. This position rotated the right-wheel side into the left-hand side of the tractor. The track of the tractor is shown in Figure 9.

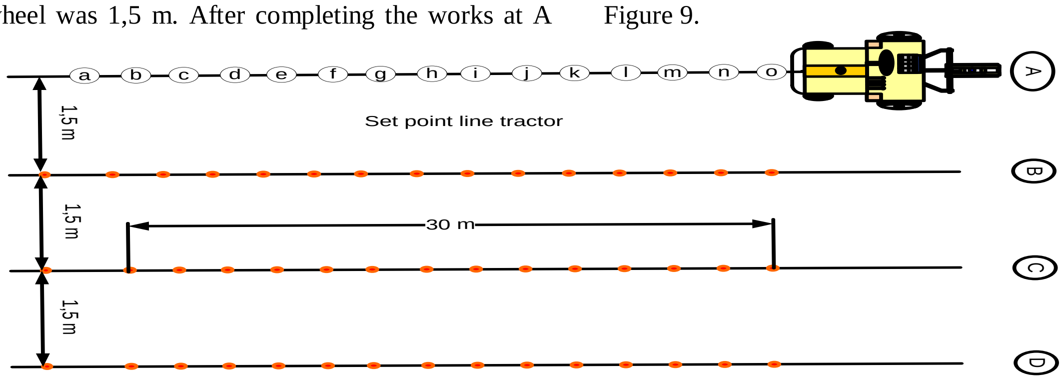


Figure 9 The position of stake meter and tractor track

2.2.2 Method on Creating Mole Drainage Channel

Mole drainage channel was created by activating the tractor's hydraulic lever alongthe track. As the tractor moved forward, the mole plough was pulled up to 20cm depth of soil and then stop at the initial measurement point. Drainage mole was created at four testing tracks. A track was created manually without using controller. B track was created at 0% slope, C track was created at 0,01% slope and D track was created at 0,02% slope. Slope controlling method was carried out by setting the program.

2.2.3 Method on Controlling Depth Program

Depth controlling was carried out by directing the green laser beam onto light receiver photodiode which placed at level 4. Push and pull timing were programmable designed. Illustration of the receiver sensor movement toward the shifting of green laser beam is shown in Table 1.

Tabel 1. The movement of receiver sensor toward the shifting of green laser beam

Input position	Depth (cm)	Function
Level 4 to 1	15	Lifting
Level 4 to 2	10	Lifting
Level 4 to 3	5	Lifting
Level 4	0	Initial position
Level 4 to 5	-5	Lowering
Level 4 to6	-10	Lowering
Level 4 to7	-15	Lowering
Level 4 to8	-20	Lowering

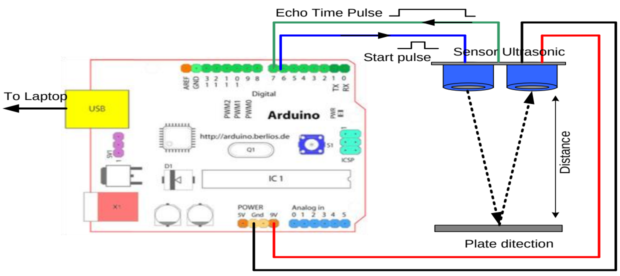
According to Table 1, it was predicted that receiver sensor moved continually as photodiode sensor was attached on the mole plough construction which pulled by the tractor. The ploughing depth was suited to the level of light receiver sensor. The distance among level was 5 cm. The initial position was adjusted to the desired set point. The ploughing elevation control was tested at three levels ranging from 0%, 0,01% and 0,02% of the total 30 m length. The movement of up and down only performed by hydraulic mole plough which aimed to perform elevation depth control system [15].

2.2.4 Method to Measure the Ploughing Depth

Measurement of mole ploughing depth was carried out using three methods [4]. The first method was carried out by cracking the soil surface and then measured using 60 cm of stainless ruler. The second method was carried out by digging the soil at several stake points. The third method was carried out using ploughing depth sensor as shown in Figure 10.

a.Measurement using ruler

b.Measurement by digging



c.Measurement using ploghing depth sensor

Figure 10. Method to measure mole ploughing depth

2.3 Program Algorithm

The algorithm [15,16] to detect the light-pointed level of photodiode sensor was performed by dividing the ploughing depth into two parts. The setting point of ploughing depth was 20 cm, the green laser beam was pointed to photodiode sensor at level 4. Level 1, 2 and 3 were used to pull the hydraulic. Level 5, 6, 7, and 8 were used to push the hydraulic. Each level was shifted in 0,5 second and the distance between push and pull motion was 5 cm. Hydraulic push and pull process was set at $90^{o}$of valve opening. Two units of relay which controlled by microcontroller were used for valve opening. The first relay was activated if sensor level 3, 2 and 1 received the light from green laser beam. The second relay was activated is sensor level 5, 6, 7 and 8 received the light from green laser beam. The programming algorithm is shown in Fig. 11.

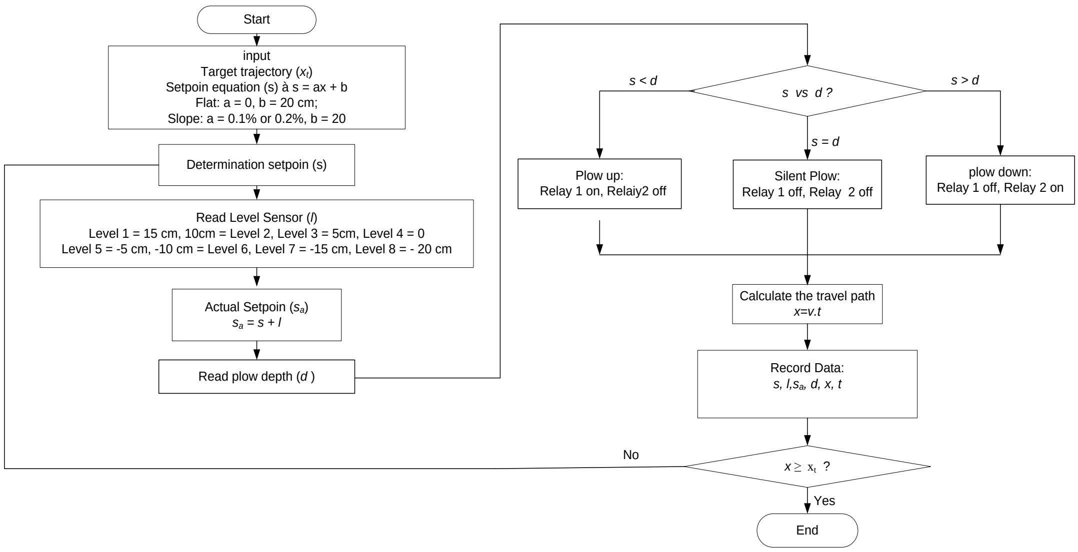


Figure 11 The algorithm of the program

3 RESULT AND DISCUSSION

3.1 Testing the Transmitter Circuit

The testing result of transmitter circuit design was conducted to obtain the output voltage and frequency to be transmitted to photodiode sensor. Fig. 12 shows the measurement of output frequency of green laser beam.

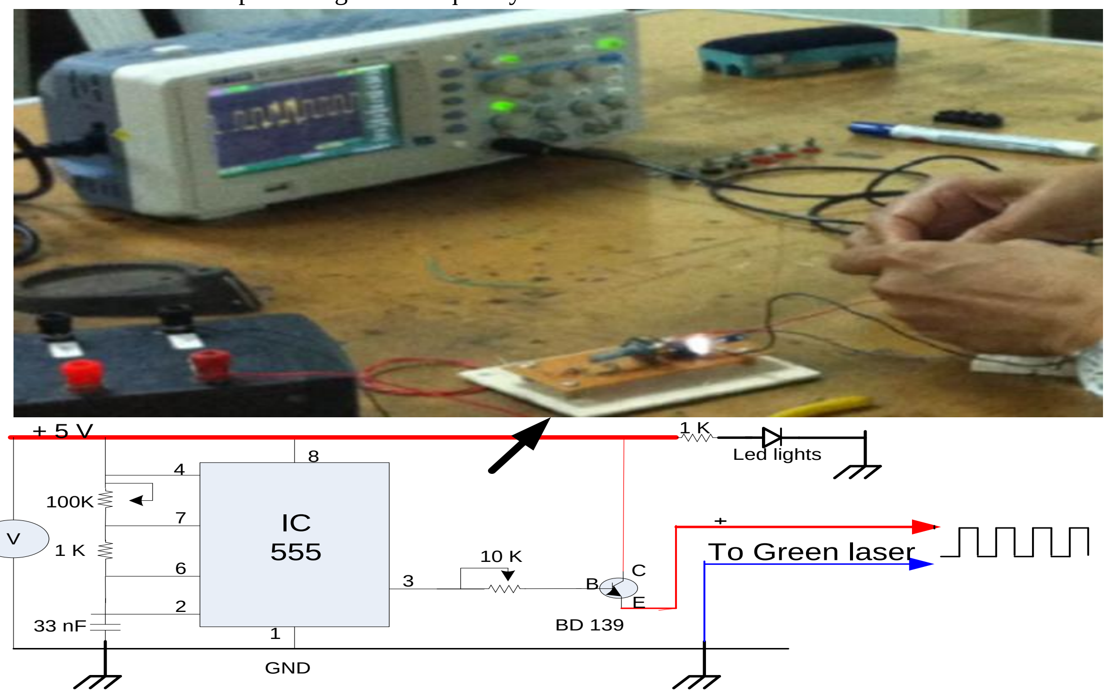


Figure 12 Frequency measurement in astable multivibrator and transistor *hopper*

According to Fig. 12, it can be seen that pulse signal was formed from astable multivibrator and transistor chopper. The maximum voltage was 0,74 V, the maximum current was 180 mA and the generated frequency was 1.206 Hz.

3.2 Testing the transmitter signal at receiver sensor

The testing of transmitter signal was conducted by placing photodiode at 10, 20, 30, 40, 50 and 60 m distance. Laser beam was pointed to photodiode receiver sensor which started from level 1, 2, 3 to 8. The result of transmitter signal received by photodiode sensor is shown in Table 2.

Table 2 Transmitter signal at different distance

Level	Voltage (mV) and Distance (m)						
	Laser off	Laser on					
	Distance	10 m	20m	30 m	40 m	50 m	60 m
1	78	3,740	3,400	3,200	2,850	2,200	1,200
2	82	4,800	4,600	4,200	3,500	3,100	1,400
3	79	4,600	4,300	4,000	3,800	3,200	1,200
4	74	4,000	3,800	3,900	3,800	3,000	1,500
5	68	3,200	3,000	3,200	3,000	2,600	1,200
6	67	3,200	3,200	3,200	3,000	2,600	900
7	74	4,000	3,800	3,600	3,400	3,000	1,200
8	70	3,700	3,600	3,400	3,200	2,200	1,400

It can be seen from Table 2 that increasing distance of receiver sensor would lowered the output voltage. This condition was due to the smaller intensity of green laser beam along the increasing of measuring distance.

3.3 Testing result of high pass filter and amplifier

High pass filter and signal amplifier circuit were tested under two conditions i.e. using high pass filter and without using high pass filter. The testing method and measurement result are shown in Fig. 13.

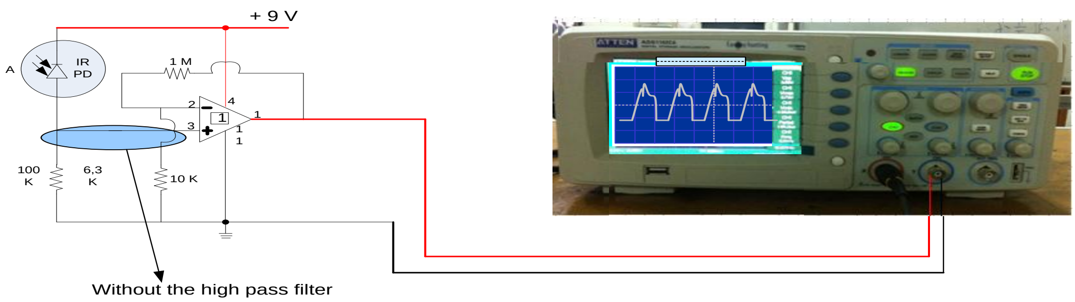


Figure 13 Amplifier testing without using high pass filter

According to Fig. 13, the beam frequency that received by photodiode sensor before the application of high pass filter was 0,520 kHz which still contained noise from other beam occurred in location. Therefore, high pass filter was used to separate the laser beam and disruptive beam. The testing result is shown in Fig. 14. The cutoff frequency was 600 Hz which carried out by capacitor 42 nF and resistor 6,3 kOhm. The voltage magnitude at each level which measured at 30 m distance is shown in Table 5.

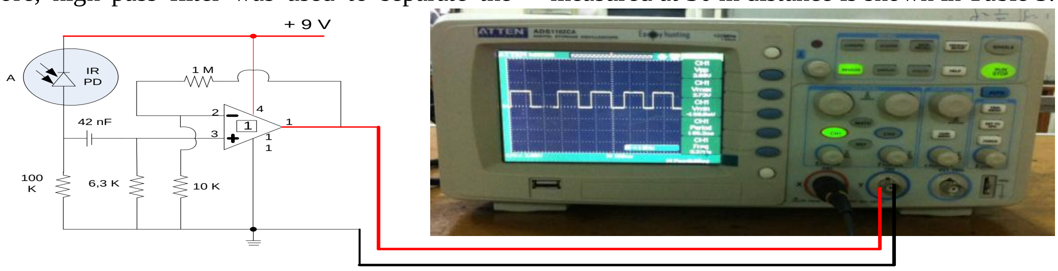
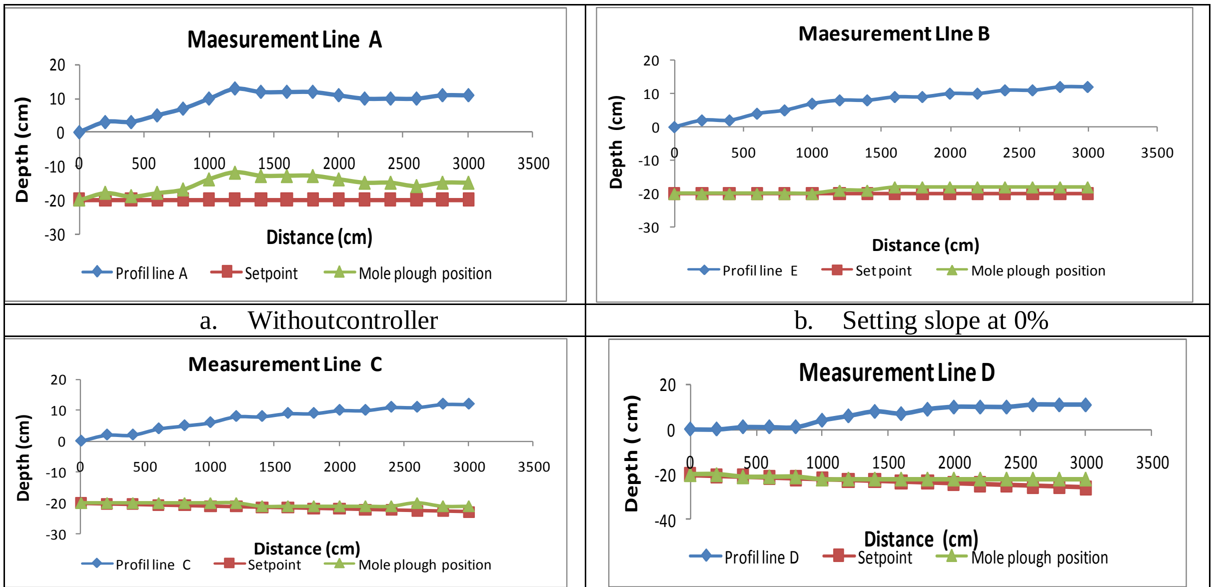


Figure 14 Amplifier testing using *high pass filter*

At the time when sensor didn't receive the light of laser beam, the output voltage occurred in amplifier IC 324 was less than 100 mVolt. On the contrary, the voltage reached up to 3.000 – 4.500 mV. Signal was amplified 10 times due to input voltage received by photodiode sensor was 0,3 to 0,5 volt.

3.4 Profile of Soil Surface

The profile of soil surface passed by tractor is shown in Figure 15.



a. Withoutcontroller

b. Setting slope at 0%

c. Setting slope at 0,01%

d. Setting slope at 0,02%

Figure15 Mole ploughing depth

4 CONCLUSION

Based on the laboratory testing result, transmitter circuit which consisted of green laser beam used for photodiode sensor input should be modified by adding astable multivibrator and chopper transistor. This modification could generate frequency 1.206 Hz and the maximum transmission distance reached up to 50 m. Receiver which consisted of photodiode sensor was still influenced by noise at the surrounding location. Therefore, high pass filter was used and cutoff frequency was 600 Hz. The output signal which generated from high pass filter was still weak. Thus, signal was amplified 10 times by applying amplifier circuit Op-Amp which increased the voltage from 3.200 mV to 4.500 mV at 50 m distance. The output signal from amplifier was then transmitted to inverter to convert 1 to 0 or vice-versa that can be used by nand-gate as input for microcontroller to control the relay.

According to the result of field testing without using controller, desired set point at A track was not achieved as mole plough still followed soil surface profile. The deviation occurred at A track was 4.19 cm. Using control system, deviation occurred at B track with 0% slope was 1.13 cm, at C track with 0.01% was 1.81 cm and D track was 1.56 cm

REFERENCE

[1] Adinegara, K.,*Due toClimate Anomalies Hortikultular Thousands Dead Plant, Page1-2*.Availableat http ://manisrenggo.klaten.info. 2014.

[2] Setiawan, R.P.A, W. Hermawan, I.N. Suastawa, E.N. Sembiring.,*Subsoil Plough Pulldecline inprisoners with vibrationl*. Department ofAgricultural Engineering, FATETA, IPB. Bogor.2002

[3] Hariansyah M, Setiawan RPA, Desrial, Made DS.,*Design And Response Characteristics Of Electronic Kontrol Sistem On Hydraulic-Driven Mole Plough*, IJSR (International Journal of Science and Research, ISSN (Online): 2319-7064,Volume 2 Issue 11. 2013

[4] Hariansyah M, Radite P.A Setiawan, Asep Sapei, Desrial dan Dewa Made Subrata.,*The Application Of Ultrasonic Sensor And ATmega 328 Arduino To Measure The Ploughing Depth Elevation Of Drainage Channel*.IJSR (Internasional Journal of Science and Research) online: 2319-7064, Volume 3 Issue 8, August 2014. ISSN (Online): 2319-7064, Impact Factor (2012): 3.358, Index Copernicus Value

2012:5.34 , www.ijsr.net. 2014.

[5] Irfan I., *How it works Series of IC(Integrated Circuit) 555,Journal of Technology Institute of Science and Technology* (ISTN)-.Jakarta . 2011

[6] Datasheeat. Harris., Semiconductor CA555, CA555C, LM555, LM555C, NE555, *Timers for Timing Delays and Oscillator Application in Commercial Industrial and Military Equipment*. File Number. 834.4. USA. 1997

[7] James C.,*The 555 Oscillator*. Electronics – tutorial, ws. pp 1-9. Availableathttp://www.electronics-tutorials.ws. 2014

[8] Hanafi.,*Design of Digital Low Pass Filters From Analog Filters Implementation In Matlab Program For Learning Signal Processing*.Journal ofElectrical Engineering. State PolytechnicL hokseumawe. Banda Aceh. pp 1-9. 2012

[9] Ryan V.,*Op-Amp Linear Amplifier*. Electronics – tutorial, ws.. Halaman 1-6. Tersedia pada http://www.electronics-tutorials.ws. 2014

[10] Datasheeat., National Semiconductor. *LM124/LM224/LM324/LM2902 Low Power Quad Operational Amplifiers.*USA. 2000

[11] Datasheeat.,*Texas Intruments CD4049UB, CMOS Hex Inverting Buffer/Converter.* USA. 2011.

[12] Robert. Mc Michael.,*Beginning Arduino.* Apress.com. ISBN-13: 978-1-4302-3241-4. Springer Science Media. New York.2010

[13] Prawiroredjo K & Asteria N.,*Ultrasonic Distance Detector With Sensor-Based Microcontroller*. JETri. Volume 7. No 2. ISSN 1412-0372. Department of Electrical Engineering. 2008. FTI Trisakti University. Pp 41-52. 2008