

# DAFTAR ISI

<b>PERNYATAAN KEASLIAN KERYA TUGAS AKHIR</b> .....	<b>i</b>
<b>PERSETUJUAN DOSEN PEMBIMBING TUGAS AKHIR</b> .....	<b>ii</b>
<b>PERSETUJUAN TIM PENGUJI TUGAS AKHIR</b> .....	<b>iii</b>
<b>ABSTRAK</b> .....	<b>iv</b>
<b>ABSTRACT</b> .....	<b>v</b>
<b>KATA PENGANTAR</b> .....	<b>vi</b>
<b>DAFTAR ISI</b> .....	<b>ix</b>
<b>DAFTAR GAMBAR</b> .....	<b>xi</b>
<b>DAFTAR TABEL</b> .....	<b>xiv</b>
<b>DAFTAR LAMPIRAN</b> .....	<b>xv</b>
<b>BAB I PENDAHULUAN</b> .....	<b>1</b>
1.1 Latar Belakang.....	1
1.2 Rumusan Masalah .....	2
1.3 Tujuan Penelitian.....	3
1.4 Batasan Masalah.....	3
1.5 Metodologi Penelitian .....	3
1.6 Sistematika Penulisan.....	5
<b>BAB II LANDASAN TEORI</b> .....	<b>7</b>
2.1 <i>PID Controller</i> .....	7
2.1.1 <i>Proportional (P)</i> .....	7
2.1.2 <i>Integral (I)</i> .....	9
2.1.3 <i>Derivative (D)</i> .....	10
2.1.4 Implementasi Digital .....	11
2.1.5 <i>Tuning parameter PID</i> .....	14
2.2 <i>Arduino Uno R3 Microcontroller</i> .....	16
2.3 <i>Motor DC</i> .....	20
2.4 <i>PING))) Ultrasonic Distance Sensor</i> .....	20
2.5 <i>DT-I/O Infrared Transmitter and Receiver Module</i> .....	22
2.6 <i>Dual H-Bridge DC Motor Driver Controller Board Module L298N</i> .....	22
2.7 <i>PWM (Pulse Width Modulation)</i> .....	24

<b>BAB III PERANCANGAN ROBOT FOLLOWER</b> .....	<b>26</b>
3.1 Diagram Blok .....	26
3.2 Diagram Alur Sistem .....	28
3.2.1 Diagram Sistem PID <i>Controller</i> .....	30
3.3 Desain Robot <i>Follower</i> .....	30
3.3.1 Dimensi Ukuran Robot <i>Follower</i> .....	31
3.3.2 Perancangan Perangkat Keras .....	31
3.3.2.1 Bahan Dasar Rangka Robot .....	31
3.3.2.2 Modul Arduino UNO dan L298N <i>Driver</i> .....	31
3.3.2.3 <i>Ping sensor</i> dan Infrared .....	33
3.3.2.4 Baterai dan Rangkaian Regulator 5V.....	35
3.4 Perancangan Gerakan Robot <i>Follower</i> .....	36
<b>BAB IV PENGUJIAN DAN ANALISA</b> .....	<b>38</b>
4.1 Implementasi Sistem .....	38
4.1.1 Tampilan Perangkat Mekanik.....	38
4.1.1.1 Robot <i>Follower</i> .....	38
4.1.1.2 Pengirim Sinyal .....	43
4.1.2 Implementasi PID .....	44
4.2 Testing <i>Parameter PID Controller</i> .....	46
4.2.1 <i>Tuning</i> Optimal Ziegler-Nichols .....	74
<b>BAB V SIMPULAN DAN SARAN</b> .....	<b>79</b>
5.1 Simpulan.....	79
5.2 Saran.....	80
<b>DAFTAR PUSTAKA</b> .....	<b>82</b>
<b>LAMPIRAN</b> .....	<b>83</b>

## DAFTAR GAMBAR

Gambar 2.1 Plot perubahan terhadap $K_p$ .....	8
Gambar 2.2 Plot perubahan terhadap $K_i$ .....	9
Gambar 2.3 Plot perubahan terhadap $K_d$ .....	11
Gambar 2.4 Plot respon PID .....	14
Gambar 2.5 Arduino Uno Tampak Depan (Kiri), Belakang (Kanan).....	19
Gambar 2.6 Skematik Arduino Uno R3 .....	19
Gambar 2.7 Motor DC .....	20
Gambar 2.8 <i>PING))) Ultrasonic Distance Sensor</i> .....	21
Gambar 2.9 Cara kerja <i>Ping Sensor</i> .....	21
Gambar 2.10 L298N DC Motor <i>Driver</i> .....	23
Gambar 2.11 PWM .....	25
Gambar 3.1 Diagram Blok Sistem Robot <i>Follower</i> .....	26
Gambar 3.2 Diagram Blok Sistem Pengirim Sinyal .....	27
Gambar 3.3 Diagram Alur Kerja Sistem.....	28
Gambar 3.4 Diagram Alur Kerja PID <i>Controller</i> .....	30
Gambar 3.5 Skematik Robot.....	32
Gambar 3.6 Pancaran Sinyal <i>Ping Sensor</i> .....	34
Gambar 3.7 Diagram Alur Robot <i>Follower</i> .....	37
Gambar 4.1 Tampak atas Robot <i>Follower</i> .....	39
Gambar 4.2 Tampak bawah Robot <i>Follower</i> .....	40
Gambar 4.3 Tampak lain Robot <i>Follower</i> .....	40
Gambar 4.4 Pengirim sinyal.....	43
Gambar 4.5 Grafik reaksi <i>controller</i> , $P = 1$ .....	50
Gambar 4.6 Grafik reaksi <i>controller</i> , $P = 2$ .....	50
Gambar 4.7 Grafik reaksi <i>controller</i> , $P = 3$ .....	51
Gambar 4.8 Grafik reaksi <i>controller</i> , $P = 4$ .....	51
Gambar 4.9 Grafik reaksi <i>controller</i> , $P = 5$ .....	51
Gambar 4.10Grafik reaksi <i>controller</i> , $P = 6$ .....	52
Gambar 4.11 Grafik reaksi <i>controller</i> , $P = 7$ .....	52
Gambar 4.12 Grafik reaksi <i>controller</i> , $P = 8$ .....	52
Gambar 4.13 Grafik reaksi <i>controller</i> , $P = 9$ .....	53

Gambar 4.14 Grafik reaksi <i>controller</i> , $P = 10$ .....	53
Gambar 4.15 Grafik reaksi <i>controller</i> , $P = 1$ .....	54
Gambar 4.16 Grafik reaksi <i>controller</i> , $P = 1.5$ .....	54
Gambar 4.17 Grafik reaksi <i>controller</i> , $P = 2$ .....	55
Gambar 4.18 Grafik reaksi <i>controller</i> , $P = 2.5$ .....	55
Gambar 4.19 Grafik reaksi <i>controller</i> , $P = 3$ .....	55
Gambar 4.20 Grafik reaksi <i>controller</i> , $P = 3.5$ .....	56
Gambar 4.21 Grafik reaksi <i>controller</i> , $P = 4$ .....	56
Gambar 4.22 Grafik reaksi <i>controller</i> , $P = 5$ .....	56
Gambar 4.23 Grafik reaksi <i>controller</i> , $P = 6$ .....	57
Gambar 4.24 Grafik reaksi <i>controller</i> , $P = 7$ .....	57
Gambar 4.25 Grafik reaksi <i>controller</i> , $P = 8$ .....	57
Gambar 4.26 Grafik reaksi <i>controller</i> , $P = 9$ .....	58
Gambar 4.27 Grafik reaksi <i>controller</i> , $P = 10$ .....	58
Gambar 4.28 Grafik reaksi <i>controller</i> , $P = 11$ .....	58
Gambar 4.29 Grafik reaksi <i>controller</i> , $P = 12$ .....	59
Gambar 4.30 Grafik reaksi <i>controller</i> , $P = 13$ .....	59
Gambar 4.31 Grafik reaksi <i>controller</i> , $P = 14$ .....	59
Gambar 4.32 Grafik reaksi <i>controller</i> , $P = 15$ .....	60
Gambar 4.33 Grafik reaksi <i>controller</i> , $P = 16$ .....	60
Gambar 4.34 Grafik reaksi <i>controller</i> , $P = 17$ .....	60
Gambar 4.35 Grafik reaksi <i>controller</i> , $P = 18$ .....	61
Gambar 4.36 Grafik reaksi <i>controller</i> , $P = 19$ .....	61
Gambar 4.37 Grafik reaksi <i>controller</i> , $P = 20$ .....	61
Gambar 4.38 Grafik reaksi <i>controller</i> , $P = 20, I = 1$ .....	62
Gambar 4.39 Grafik reaksi <i>controller</i> , $P = 20, I = 2$ .....	62
Gambar 4.40 Grafik reaksi <i>controller</i> , $P = 20, I = 5$ .....	62
Gambar 4.41 Grafik reaksi <i>controller</i> , $P = 20, I = 10$ .....	63
Gambar 4.42 Grafik reaksi <i>controller</i> , $P = 20, I = 12$ .....	63
Gambar 4.43 Grafik reaksi <i>controller</i> , $P = 20, I = 25$ .....	63
Gambar 4.44 Grafik reaksi <i>controller</i> , $P = 23$ .....	64
Gambar 4.45 Grafik reaksi <i>controller</i> , $P = 23, I = 5$ .....	64
Gambar 4.46 Grafik reaksi <i>controller</i> , $P = 23, I = 10$ .....	64
Gambar 4.47 Grafik reaksi <i>controller</i> , $P = 23, I = 13$ .....	65

Gambar 4.48 Grafik reaksi <i>controller</i> , P = 23, I = 15.....	65
Gambar 4.49 Grafik reaksi <i>controller</i> , P = 23, I = 20.....	65
Gambar 4.50 Grafik reaksi <i>controller</i> , P = 23, I = 25.....	66
Gambar 4.51 Grafik reaksi <i>controller</i> , P = 25 .....	66
Gambar 4.52 Grafik reaksi <i>controller</i> , P = 30 .....	66
Gambar 4.53 Grafik reaksi <i>controller</i> , P = 1 .....	69
Gambar 4.54 Grafik reaksi <i>controller</i> , P = 2 .....	69
Gambar 4.55 Grafik reaksi <i>controller</i> , P = 3 .....	70
Gambar 4.56 Grafik reaksi <i>controller</i> , P = 4 .....	70
Gambar 4.57 Grafik reaksi <i>controller</i> , P = 5 .....	70
Gambar 4.58 Grafik reaksi <i>controller</i> , P = 6 .....	71
Gambar 4.59 Grafik reaksi <i>controller</i> , P = 7 .....	71
Gambar 4.60 Grafik reaksi <i>controller</i> , P = 8 .....	71
Gambar 4.61 Grafik reaksi <i>controller</i> , P = 9 .....	72
Gambar 4.62 Grafik reaksi <i>controller</i> , P = 10 .....	72
Gambar 4.63 Grafik reaksi <i>controller</i> , P = 6.75, I = 18.....	75
Gambar 4.64 Grafik reaksi <i>controller</i> , P = 6.75, I = 18 (Motor) .....	75
Gambar 4.65 Grafik reaksi <i>controller</i> , P = 6.75, I = 18 (Step) .....	76
Gambar 4.66 Grafik reaksi <i>controller</i> , Step (Motor) .....	77
Gambar 4.67 Grafik reaksi <i>controller</i> , P = 6.75, I = 18 (Ramp).....	77
Gambar 4.68 Grafik reaksi <i>controller</i> , Ramp (Motor).....	78

## DAFTAR TABEL

Tabel 2.1 Tabel efek <i>tuning</i> secara individual .....	15
Tabel 2.2 Tabel metode Ziegler-Nichols .....	16
Tabel 2.3 Tabel Spesifikasi Arduino Uno R3 .....	18
Tabel 2.4 Tabel penggunaan <i>driver</i> .....	23
Tabel 4.1 Tabel daftar percobaan.....	48
Tabel 4.2 Tabel metode Ziegler-Nichols .....	74



## **DAFTAR LAMPIRAN**

**LAMPIRAN A : *SOURCE CODE ROBOT FOLLOWER***

**LAMPIRAN B : *INFRARED TRANSMITTER DATASHEET***

**LAMPIRAN C : *INFRARED RECEIVER DATASHEET***

