PENGEMBANGAN SISTEM JALAN ROBOT HUMANOID EPRETIWI-V4 MENGGUNAKAN SENSOR KOMPAS UNTUK KONTES ROBOT SENI TARI INDONESIA (KRSTI)

SKRIPSI

Disusun Oleh :

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NIM. 12.12.216

JURUSAN TEKNIK ELEKTRO S-1

KONSENTRASI TEKNIK ELEKTRONIKA

FAKULTAS TEKNOLOGI INDUSTRI

INSTITUT TEKNOLOGI NASIONAL MALANG

2016

LEMBAR PERSETUJUAN

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Disusun dan Diajukan Untuk Melengkapi dan Memenuhi Persyaratan Guna Mencapai Gelar Sarjana Teknik Strata Satu (S-1)

Disusun oleh :

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ABSTRAK

Robot pada perkembangannya kian pesat, tidak hanya di peruntukkan pada bidang industri namun juga sebagai media belajar yang mudah untuk semua kalangan. Dengan berbagai fungsi kerjanya, robot banyak di minati dunia untuk di kembangkan untuk dapat menggantikan manusia. Robot humanoid didefinisikan sebagai sebuah robot yang memiliki bentuk dan sejumlah karakteristik menyerupai manusia, baik keseluruhan struktur maupun pergerakan dari robot itu sendiri.

KRI (Kontes Robot Indonesia) yang di selenggarkan oleh Direktorat Pembelajaran dan Kemahasiswaan Kemenristekdikti (kementrian riset, teknologi dan pendidikan tinggi) terutama pada devisi KRSTI (kontes robot seni tari indonesia) telah di selenggarkan selama 8 tahun, yaitu sejak tahun 2009 hingga 2016. Keikut sertaan robot epretiwi-v4 ITN (Institut Teknologi Nasional) Malang mampu bersaing pada kontes regional dan nasional.

Pada tugas akhir ini telah di realisasikan dengan konsep jalan menggunakan kompas sehingga dapat memandu robot secara otomatis untuk mengoreksi kesalahan ketika berjalan. Sensor kompas akan mendeteksi derajat yang di gunakan sebagai acuah arah selama robot berjalan. Arduino sebagai kontroler memproses data-data yang nantinya akan di kirimkan ke kontroler servo untuk menggerakkan robot.

***Kata Kunci** : Robot Humaniod, kemenristekdikti, KRI, KRSTI, Sensor Kompas, arduino, kontroler servo.*

KATA PENGANTAR

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Adapun maksud dan tujuan dari penulisan laporan ini merupakan salah satu syarat dalam mendapatkan gelar Sarjana Teknik Elektro S-1.

Sebagai penulis sangat menyadari tanpa adanya kemauan dan usaha serta bantuan dari berbagai pihak, maka laporan ini tidak dapat diselesaikan dengan baik, oleh sebab itu, penulis ingin mengucapkan terima kasih sebanyak banyaknya kepada yang terhormat :

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Malang, Agustus 2016

Penulis

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BAB I
PENDAHULUAN

Bab ini membahas tentang latar belakang masalah, perumusan masalah, identifikasi masalah, tujuan, pembatasan masalah, serta sistematika penulisan laporan skripsi.

1.1 Latar Belakang

Di era saat ini, perkembangan robot sangat pesat dan telah banyak pihak berlomba-lomba dalam menciptakan robot. Robot *humanoid* merupakan salah satu tren riset yang banyak di kembangkan berbagai kalangan. Berbagai bentuk dan metode banyak di kembangkan untuk menciptakan robot semirip mungkin dengan sistem manusia. *Humanoid* robot adalah robot yang di rancang dan di bentuk menyerupai manusia yang di kendalikan atau di kontrol untuk dapat menirukan seperti halnya manusia asli.

Kontes Robot Seni Tari Indonesia (KRSTI) merupakan acara bergengsi antar kampus di indonesia untuk berkompetisi dalam merancang dan membuat robor *humanoid* yang di selenggarakan Direktorat Pembelajaran dan Kemahasiswaan Kemenristekdikti (kementrian riset, teknologi dan pendidikan tinggi). Dimana Kontes Robot Seni Tari Indonesia (KRSI) merupakan kompetisi yang disertai unsur-unsur seni dan budaya[1]. Robot *humanoid* yang di ciptakan harus mampu menyerupai gerak seorang penari sesuai tema tari yang di lombakan [1]. Untuk menciptakan sebuah robot *humanoid* berbagai komponen diperlukan untuk mendukung sistem yaitu kerangka robot, servo, *aktuator*, *controller*, *sensor*, dan *power suply*.

Robot *humanoid* yang telah di buat di laboratorium robotika Institut Teknologi Nasional (ITN) Malang untuk Kontes Robot Seni Tari Indonesia (KRSTI) setiap tahun mengalami perubahan, dimana perubahan itu terus meningkat kesulitannya dalam rancangan dan sistem control robot sesuai dengan tema tari perlombaan. Pada Kontes Robot Seni Tari Indonesia KRSTI 2014-2015 yang di dikerjakan mahasiswa sebagai Tugas Akhir yaitu perancangan dan pembuatan robot *humanoid* 21 dof untuk kontes robot seni tari indonesia (Syahrijal Ugan Dinata, 2014) masih menggunakan 21 *degree of freedom* (DOF) dan menggunakan sistem pendengaran robot yang langsung di dengarkan melalui *loudspeaker* di arena [2]. Pada Kontes Robot Seni Tari Indonesia KRSTI 2016 mengunakan 27 DOF (*degree of fredom*) dan menggunakan sistem pendengaran melalui *bluethooth received*, sehingga terdapat perubahan kerangka mekanik dan sistem control untuk di buat kembali agar semakin baik.

Masalah *humanoid* robot Epretiwi tahun ketahun adalah sistem jalan, diantara penyebabnya adalah konsep jalan, kestabilan, mekanik, aktuator, medan jejak dan telapak kaki sehingga robot kemungkinan robot terjatuh dan berbelok arah sangat besar. Robot *humanoid* yang telah ada di laboratorium robotika Institut Teknologi Nasional (ITN) Malang masih memiliki kekurangan yaitu salah satunya sistem jalan yang melenceng arah jalannya. Salah satu peraturan perlombaan pada saat pertandingan adalah pengurangan nilai jika *retry*, *retry* adalah kesempatan bagi peserta lomba untuk memegang atau menyentuh robot, sehinga setiap kali *retry* terjadi pengurangan nilai. Ketika mulai start robot akan berjalan melangkah maju dan menghasilkan jalan berkelok dan memutar, untuk memperbaiki arah robot masih di lakukan secara manual yaitu mengarahkan robot kembali ke posisi hadap lurus dengan melakukan *retry*, Sehingga jarak yang semestinya dapat di tempuh dengan hanya 3-4 menit robot ini tidak dapat menyelelesaikanya.

Dari beberapa kondisi robot sebelumnya yang telah di buat, maka penulis akan mengembangkan robot Epretiwi-v4 ini dengan sistem penunjuk arah menggunakan kompas agar robot dapat berjalan sesuai arah navigasi yang di tentukan dalam hal ini berjalan lurus dan berbelok arah sehingga meminimalisir terjadinya *retry* atau pengurangan nilai. Dengan harapan pengembangan ini dapat memperbaiki dan menyempurnakaan sistem jalan robot serta dapat digunakan untuk berkompetisi pada Kontes Robot Seni Indonesia (KRSTI).

1.2 Rumusan masalah

Berdasarkan latar belakang yang telah penulis paparkan, dapat di simpulkan permasalahan yang akan di buat dalam karya ilmiah ini, yaitu :

1. Bagaimana membuat konsep jalan robot Epretiwi-v4 agar dapat berjalan secara lurus menggunakan sensor kompas pada arena yang telah di tentukan rulenya?
2. Bagaimana menempatkan sensor kompas pada robot Epretiwi-v4 yang terpengaruhi oleh medan magnetik?
3. Bagaimana menentukan arah navigasi robot mengunakan sensor kompas?

1.3 Tujuan

Pengembangan ini bertujuan untuk melengkapi dan menyempurnakan sistem jalan robot *humanoid* yang sebelumnya telah di buat dan mewujudkan saran dari pengembang sebelumnya tentang "dibutuhkan metoda untuk mendeteksi posisi robot sehingga dapat lebih cepat menentukan arah gerak robot."[2]. Robot yang sebelumnya pada sistem jalan masih sangat banyak kekurangan sehingga ketika berjalan akan mengalami belok dan terus berbelok. Selain itu juga pengembangan ini meminimalisir terjadinya pinalti atau pengurangan nilai akibat *retry* pada saat lomba. Oleh karena itu, dalam karya ilmiah yang akan penulis tuangkan mencoba untuk merancang sistem jalan robot *humanoid* dengan menggunakaan kompas agar robot berjalan lurus dan akan kembali ke jalurnya jika jalan berubah dari arah yang telah di tentukan. Sehingga robot humanoid ini dapat di aplikasikan pada Kontes Robot Seni Indonesia 2016.

1.4 Batasan Masalah

Agar dalam pembahasan pengembangan ini dapat sesuai dengan tujuan yang di harapakan dan tetap fokus pada konsep awal, maka di perlukan batasan-batasan, diantaranya adalah :

1. Robot yang di gunakan sesuai dengan rule Kontes Robot Seni Tari Indonesia (KRSTI) 2016.
2. Arena atau medan jejak yang di gunakan sesuai rule Kontes Robot Seni Tari Indonesia (KRSTI) 2016.
3. Tidak membahas gerak tari robot.
4. Tidak membahasa sistem komunikasi *bluethooth* robot.

1.5 Metodologi pemecahan masalah

Metode yang digunakan dalam penyususan skripsi ini adalah:

1. Kajian Literatur

   Pengumpulan data dan informasi yang dilakukan dengan mencari bahan-bahan kepustakaan dan referensi dari berbagai sumber sebagai landasan teori yang ada hubunganya dengan permasalahan pada pengembangan *device*.

2. Perancangan Mekanik dan Sistem

   Pembuatan design, pencarian bahan untuk pembuatan mekanik serta melakukan pengujian derajat pada unit servo dan perakitan sistem elektronik.

3. Pengujian Sistem

   Proses ujicoba rangkaian dan keseluran sistem untuk mengetahui adanya kesalahan agar sistem sesuai dengan konsep yang telah dirancang.

4. Pelaporan hasil pengujian dan kesimpulan.

1.6 Sistematika Penulisan

Untuk mempermudah dan memahami pembahasan penulisan skripsi ini, sistematika penulisan disusun sebagai berikut:

BAB I : PENDAHULUAN

Berisi tentang latar belakang rumusan masalah, tujuan, batasan masalah, metodologi penelitian, dan sistematika penulisan.

BAB II : TINJAUAN PUSTAKA

Membahas tentang dasar teori mengenai permasalahan yang berhubungan dengan penelitian.

BAB III : PERANCANGAN DAN IMPLEMENTASI

Bab ini membahas perancangan sensor kompas, arduino mega, *USC-32 visual squencer*, motor servo, battery sebagai power, *voltage regulator* meliputi *mini regulator* dan UBEC (*Universal Battery Eliminated Circuit*) serta implementasi hasil perancangan.

BAB VI : PENGUJIAN DAN ANALISA

Bab ini membahas tentang pegujian dan analisa terhadap alat yang telah di buat secara nyata.

BAB V : PENUTUP

Berisi tentang semua kesimpulan yang berhubungan dengan penulisan laporan skripsi, dan saran yang digunakan sebagai pertimbangan dalam pengembangan robot humanoid epretiwi-v4 selanjutnya.

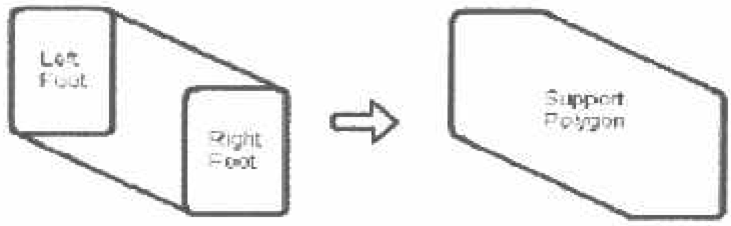
BAB II
TINJAUAN PUSTAKA

Pada bab ini dijelaskan teori-teori penunjang yang diperlukan dalam merancang robot *humanoid* yaitu berupa teori tentang robot *humanoid*, pengontrol mikro, pengontrol servo, sensor kompas dan power supply.

2.1 Robot *Humanoid*[3][4]

Di lihat dari unsur pembentuk katanya, robot *humanoid* terdiri dari kata robot dan *humanoid*. Definisi robot adalah "*An automatic device that performs functions normally ascribed to humans or a machine in the form of a human*". Sedangkan definisi dari *humanoid* adalah segala sesuatu yang memiliki struktur menyerupai manusia. Maka robot *humanoid* dapat didefinisikan sebagai sebuah robot yang memiliki bentuk dan sejumlah karakteristik menyerupai manusia, baik keseluruhan struktur maupun pergerakan dari robot itu sendiri.

Faktor penting dalam merancang robot *humanoid* adalah keseimbangan. Secara sederhana kestabilan dapat dicapai dengan menyeimbangkan (membuat posisi nol) semua gaya - gaya yang bekerja. Titik pada posisi jumlah semua gaya - gaya yang bekerja menjadi nol disebut titik keseimbangan atau *center of gravity*. Keseimbangan dicapai dengan merancang postur stabil dari setiap gerakan robot humanoid. Kestabilan robot paling banyak dipengaruhi oleh bagian kaki. Salah satu teknik yang baik untuk membuat robot seimbang ketika berjalan adalah teknik *support polygon*. *Support polygon* adalah daerah berbentuk segi banyak yang merupakan daerah di antara kedua kaki dengan bantuan garis lurus yang ditarik dari siku luar masing-masing kaki. Prinsip dari teknik ini adalah menempatkan proyeksi vertikal dari titik keseimbangan dari robot *humanoid* untuk selalu berada di dalam *support polygon* ditunjukan pada Gambar 2.1.



Gambar 2. 1 Support Polygon

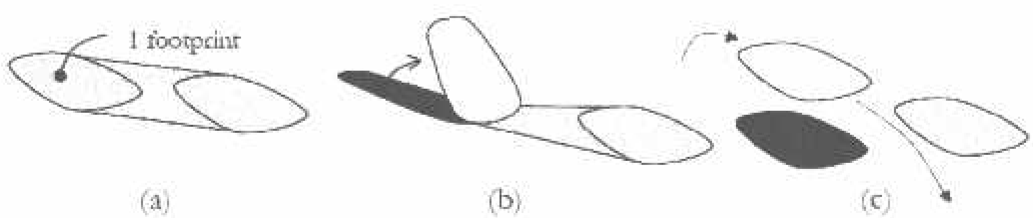
Terdapat 2 macam *support polygon* yang dapat terbentuk pada robot humanoid, yaitu :

1. Double Support Polygon

Double Support Polygon adalah kondisi pada saat robot bertumpu pada kedua kakinya tetapi tidak harus kedua permukaan kakinya menempel penuh pada dasar. Gambaran *Double Support Polygon* ini dapat dilihat pada Gambar 2.2a dan 2.2b.

2. Single Support Polygon

Single Support Polygon adalah kondisi pada saat robot hanya bertumpu pada salah satu telapak kaki seperti pada Gambar 2.2(c).



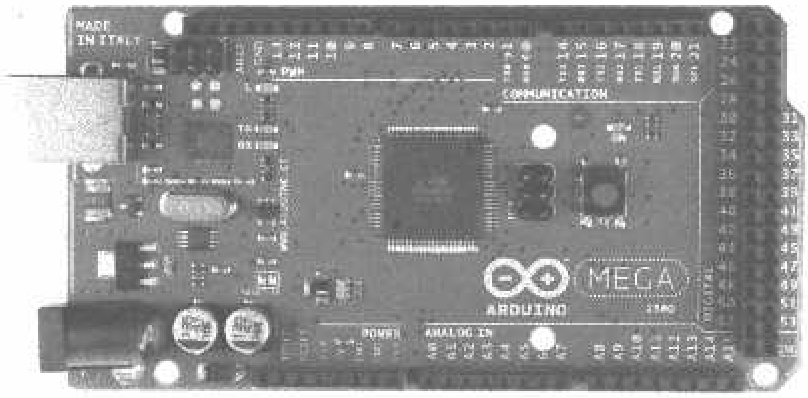
Gambar 2. 2 Support Polygon dengan Warna Abu-abu : (a) Double Support Polygon, (b) Double Support Polygon (Pre-Swing), (c) Single Support Polygon

2.2 Arduino mega 2560[5]

Arduino mega 2560 adalah papan mikrokontroler sesuai dengan ATmega2560 (ATmega2560 *datasheet*). Ic ini memiliki 54 pin digital input / output (dan 14 pin input / output dapat digunakan hasil PWM) , 16 input analog , 4 UART (*Universal Asynchronous Receiver / Transmitter*) untuk antarmuka dengan RS232 port serial perangkat diaktifkan termasuk komputer , 16 MHz osilator , sebuah koneksi USB , *powor jack* , *header* ICSP , bersama dengan tombol sebagai reset. Gambar 2.3 menampilkan arduino mega 2560 secara fisik dan gambar 2.4 skematik arduino mega 2560.

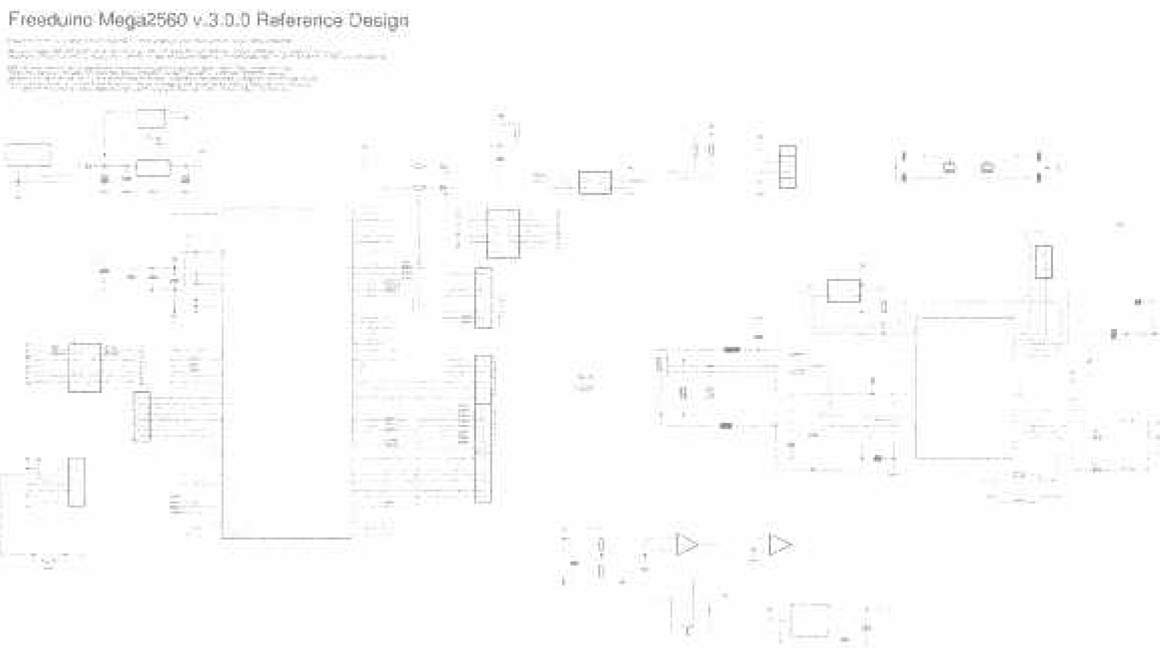
Fitur ATMEGA 2560

- High Performance, Low Power AVR®
    - 8-Bit Microcontroller
- Advanced RISC Architecture
- High Endurance Non-volatile Memory segments
    - 8K Bytes of In-System Self-programmable Flash program memory
    - 4K Bytes EEPROM
    - 8K Bytes Internal SRAM
    - Write/Erase cyles: 10,000 Flash/100,000 EEPROM
    - Data retention: 20 years at 85°C/100 years at 25°C
    - Programming Lock for Software Security
- Peripheral Features
    - 16-channel ADC
    - Programmable Serial USART
    - Master/Slave SPI Serial Interface
    - Byte-oriented 2-wire Serial Interface (Philips IC compatible)
    - Interrupt and Wake-up on Pin Change



Gambar 2. 3 *Bentuk Fisik Arduino Mega2560*

http://go-electronics.weebly.com/uploads/1/4/8/3/14838400/5641902orig.jpg.

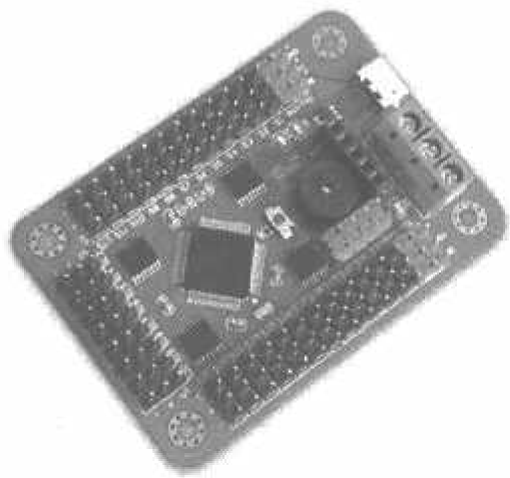


Gambar 2. 4 Skematik Arduino Mega2560

http://go-electronics.weebly.com/uploads/1/4/8/3/14838400/5641902orig.jpg.

2.3 USSC32[6]

USC32 (*servo serial controller*) adalah *servo controller* kecil *preassembled* dengan beberapa fitur besar. *Controller* ini memiliki resolusi tinggi (1uS) untuk posisi yang akurat , dan bergerak sangat halus. Rentang ini 0.50mS untuk 2.50mS untuk jarak sekitar 180°. Kontrol gerak dapat respon langsung, kecepatan dikontrol, gerakan waktu, atau kombinasi keduanya. Yang unik dari USC32 controller ini memungkinkan setiap kombinasi servo untuk memulai dan gerak akhir pada saat yang sama, bahkan jika servos harus pindah jarak yang berbeda. Ini adalah fitur yang sangat kuat untuk membuat sebuah prototipe berjalan kompleks untuk robot multi servo berjalan. Posisi servo atau gerakan dapat merespon permintaan untuk memberikan umpan balik ke komputer host. Bahkan USC32 servo robot *humanoid* ini memungkinkan kontrol penuh terhadap semua aspek bolak balik gerak hanya dengan mentransfer beberapa nilai dari *host controller*. Setiap output dapat digunakan sebagai output dengan tingkat TTL. Ada 4 input digital yang statis atau terkunci, sehingga tidak perlu khawatir kehilangan data. Ada tiga blok terminal untuk pilihan *powering*. Secara fisik USC32 di tunjukkan pada gambar 2.5.



Gambar 2. 5 Bentuk Fisik USC-32 Servo Kontroller

http://www.torobot.com/

Fitur USC-32

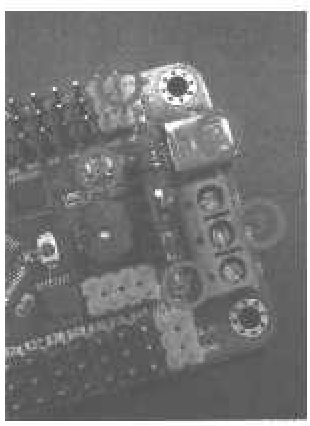
- *Power supply MCU : 6.5 ~ 12 V atau 3,5 ~ 5.5V.*
- *flash: ROM 512K.*
- *Speed = 14.75 MHz*
- *control channel: simultaneous control of 16 paths.Inputs = 4 (Static or Latching, Analog or Digital)*
- *control mode: USB and serial port (TTL) accept the command mode.*
- *Current requirements = 31mA*

- *PC interface = usb or serial port (USART, TTL)*
- *Servo control = Up to 32 servos plug in directly*
- *Servo type supported = Futaba or Hitec*
- *Servo travel range = 180°*
- *Servo resolution = 1uS, .09°*
- *Servo speed resolution = 1uS / Second*
- *Servo motion control = Immediate, Timed, Speed or Synchronized.*
- *PCB size: 51mm * 43.5mm * 1.6mm (mounting hole spacing:42*35.5mm).*
- *signal output: PWM (precision 1US).*
- *Baud Rate : 9600,19200,28400,57600,115200,128000*

2.3.2 USC32 konfigurasi

2.3.2.1 Catu daya

USC32 servo controller dapat di bedakan catu daya IC dengan di tandai VSS dan motor servo di tandai dengan VS, dimana catu daya IC bekerja pada tegangan 6,5v – 12v dan motor servo bekerja pada tegangan sesuai dengan kebutuhan catu daya motor servo, dan catu daya yang di gunakan pada servo 6v. catu daya USC32 servo kontroler di tunjukkan pada gambar 2.6.



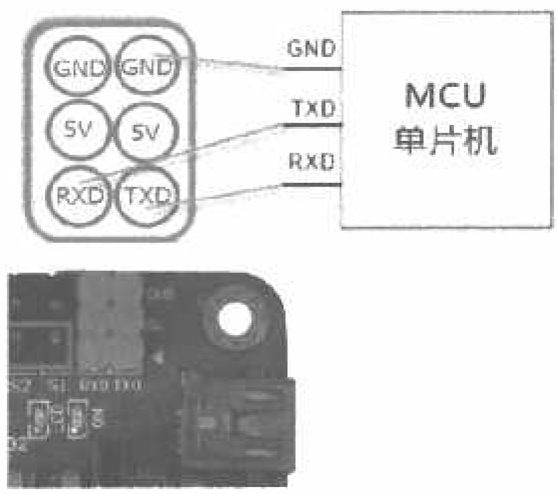
gambar 2. 6 Konfigurasi catu daya

keterangan gambar 2.6 :

1. Supply tegangan external melalui pin
2. Port mini USB
3. Port power supply IC dan servo
4. LED indikator data
5. LED indikator power sullpy

2.3.2.1 port komunikasi

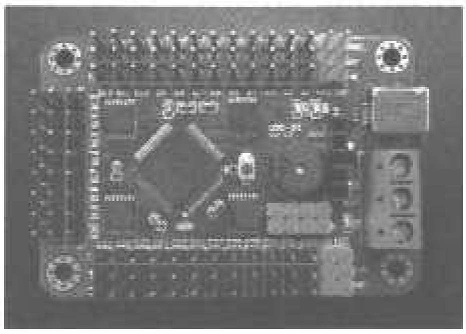
Sebagai jalur komunikasi mikrokontroller dengan USC32 servo kontroler telah di sediakan pin serial Rx dan Tx. USC32 servo *controller* di desain dapat di menjalankan motor servo dengan menyimpan data pada memori internal. Selain itu USC32 dapat menerima data dari external dengan mengunakan port serial yang di tunjukkan pada gambar 2.7.



Gambar 2. 7 pin komunikasi USC ke mikrokontroler

2.3.2.1 port data servo

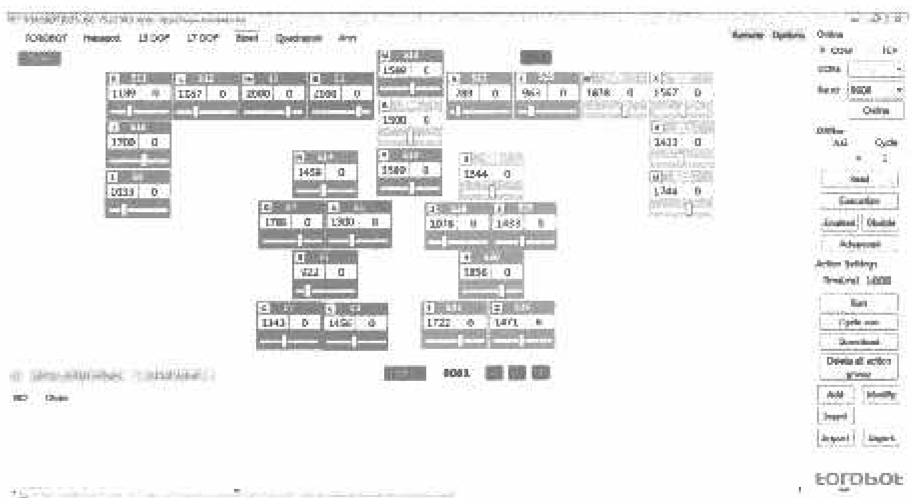
USC32 servo kontroler dapat menjalankan maksimal 32 motor servo secara kontinyu. Pin itu di tunjukkan pada gambar 2.8.



Gambar 2. 8 pin motor servo USC32

2.3.2.1 Software torobot pengontrol servo

Dengan menggunakan *software* torobot pengontrol sevo dapat dengan mudah dalam menentukan gerak robot sesuai dengan keperluan gerak yang di butuhkan. Aplikasi ini sangan mudah di pahami dan mudah dalam menggunaannya seperti yang di tunjukkan pada gambar 2.9.



Gambar 2. 9 Software Torobot Pengontrol Servo

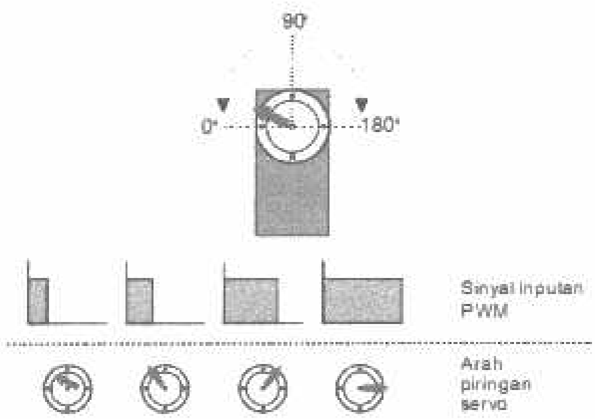
2.4 Motor Servo[7]

Motor servo adalah motor yang mampu bekerja dua arah yaitu searah jarum jam (*clockwise*) dan berlawanan jarum jam (*counterclockwise*) dimana arah dan sudut pergerakan rotornya dapat dikendalikan hanya dengan memberikan pengaturan *duty cycle* sinyal PWM pada bagian pin kontrolnya. Secara fisik motor servo di tunjukkan pada gambar 2.10.

Gambar 2. 10 Bentuk Fisik Motor Servo

http://www.pyroelectro.com/tutorials/servo_motor/servomotor.html

Motor servo pada umumnya terdiri dari dua jenis, yaitu servo *continuous* dan servo standar. Servo *continuous* dapat berputar sebesar 360 derajat, sedangkan motor servo tipe standar hanya mampu berputar 180 derajat. Gambar 2.11 menunjukkan prinsip kerja motor servo.



Gambar 2. 11 Prinsip Kerja Motor Servo

2.5 Voltage Regulator

2.5.1 UBEC[13]

BEC (*Battery Eliminated Circuit*) atau UBEC (*Universal Battery Eliminated Circuit*) adalah perangkat elektronika yang berfungsi untuk menurunkan nilai tegangan dengan nilai yang diinginkan. ubec ini berfungsi layaknya sebagai *voltage regulator*. alat ini biasa di gunakan untuk menurunkan tegangan dari input 6V-23V menjadi 5V dan 6V dengan memilih jumper yang terdapat pada unit BEC *(Universal Battery Eliminated Circuit)*. Bentuk fisik UBEC *(Universal Battery Eliminated Circuit)* di tunjukkna pada gambar 2.12

Gambar 2. 12 Bentuk Fisik UBEC (Universal Battery Eliminated Circuit)

http://www.hobbyking.com/hobbyking/store/ 6233 TURNIGY 8 15A UBEC f or_Lipoly.html

Specification

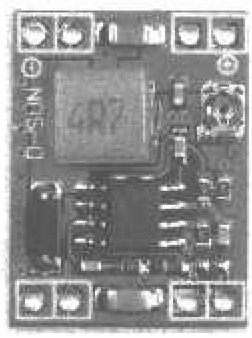
- Output Voltage: 5V or 6V (Changeable with a switch)
- Continuous output current: 8 Amps
- Burst output current: 15 Amps
- Input: 6V-12.6V (2-3S Lipo battery)
- Quiescent current: 60mA
- Size: 42mm*39mm*9mm (length*width*height)
- Weight: 36g

2.5.2 Micro Voltage Stepdown[8]

Micro voltage stepdown ini di fungsikan khusus untuk motor servo kecil dengan catu daya 4,8v yang posisi servo kecil itu berada pada bagian tangan dengan jumlah delapan motor servo. Gambar 2.13 menunjukkan secara fisik penurun tegangan mikro.

Spesifikasi :

- Based on MP1584 high frequency step-down.
- Input: 4.5v - 28v DC
- Output: .8v - 20v DC
- Output current: Sustained 2a, Max 3a (requires a heatsink)
- Efficiency: Max 96%
- Working Frequency: 1MHz
- Operating Temperature: -45*C - 85*C
- Dimensions: 22x 17 x 4mm
- Weight: 3g

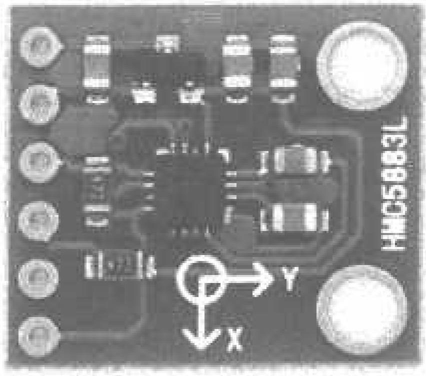


Gambar 2. 13 Micro Voltage Stepdown

http://www.radioc.co.uk/v/vspfiles/photos/7208-2.jpg

2.6 Sensor Kompas[9]

Modul Kompas HMC5883L adalah sebuah sensor magnetometer yang digunakan untuk menunjukkan arah mata angin digital, atau juga disebut kompas digital. Modul ini menggunakan komponen utama berupa IC HMC5883L yang merupakan IC kompas digital 3 axis yang memiliki interface berupa 2 pin I2C. Secara fisik sensor kompas di tunjukkan pada gambar 2.14



Gambar 2. 14 Bentuk Fisik Sensor Kompas

http://zleap.net/adventures-with-arduino-part-13/

HMC5883L memiliki sensor *magneto-resistive* HMC118X series ber-resolusi tinggi, ditambah ASIC dengan konten *amplification, automatic degaussing strap driver, offset cancellation* dan 12 bit ADC yang memungkinkan keakuratan kompas mencapai 1 sampai 2 derajat. Modul ini biasa digunakan untuk keperluan sistem navigasi otomatis, mobile phone, netbook dan perangkat navigasi personal.

Modul ini memiliki 5 pin, diantaranya :

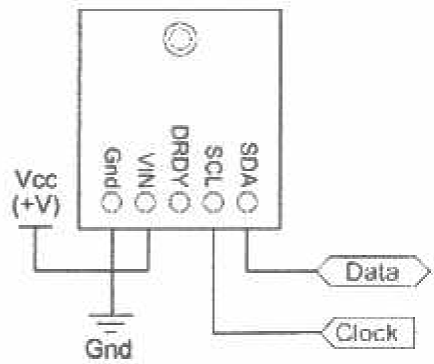
- VCC (5V)
- GND
- SCL
- SDA
- DRDY

Berikut adalah beberapa fitur dari Modul Kompas HMC5883L :
Berbasis sensor magnetoresistive 3 axis.

- 12-Bit ADC terkopling dengan *Low Noise* AMR Sensor yang memiliki 2 mili-gauss Field dengan resolusi kurang lebih 8 Gauss Fields.
- Tegangan kerja 5V DC.
- Menggunakan antarmuka I2C.
- Keluaran rata-rata maksimum 160 Hz.

2.6.1 Konfigurasi pin Sensor Kompas

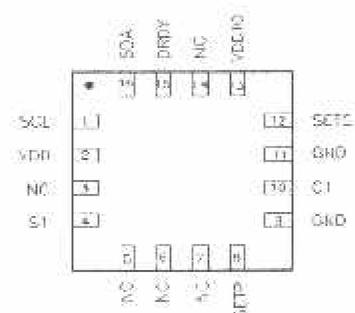
Sensor kompas HMC5883L memiliki empat pin sebagai komunikasi dan catu daya, seperti di tunjukkan pada gambar 3.15 dan konfigurasi pin chip di tunjukkan pada gambar 3.16.



Gambar 2. 15 Pin Sensor Kompas HMC5883L

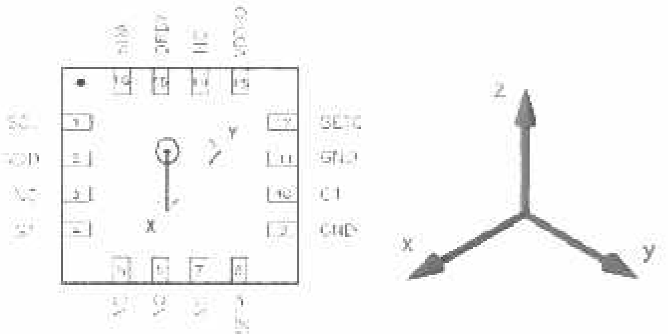
Sensor ini memiliki 5 pin, diantaranya :

1. VCC (5V)
2. GND
3. SCL
4. SDA
5. DRDY



Gambar 2. 16 konfiurasi pin chip HMC5883L

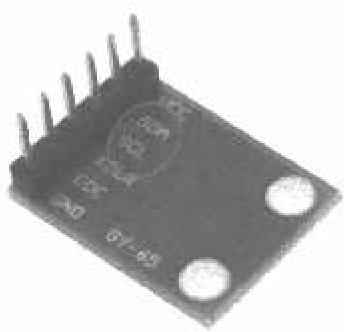
Sensor kompas tipe HMC5883L merupakan sensor magnetometer dengan tiga *axis* data yang di deteksi yaitu sudut X, sudut Y dan sudut Z seperti di tunjukkan pada gambar 3.17.



Gambar 2. 17 Tiga Axis Sensor Kompas Sudut X, Sudut Y, Sudut Z

2.6.2 Komunikasi Sensor HMC5883L

I2C adalah komunikasi serial dua arah yang digunakan sensor HMC5883L dimana menggunakan 2 jalur kabel transmisi SDA dan SCL. Sehingga pada mikrokontroler harus menggunakan pin I2C yang telah di sediakan arduino yaitu pin SDA dan SCL. Pada dasarnya dalam pemrograman arduino I2C telah disediaka *library wire.h* sehinga memudahkan dalam penggunaan jalar komunikasi I2C. pin pada HMC5883L untuk komunikasi I2C di tunjukkan pada gambar 2.18.



Gambar 2. 18 Pin I2C HMC5883L

Sensor kompas yang di gunakan adalah jenis HMC5883L keluaran dari *Honeywell electronik* yang merupakan sensor magnet yang terkemas dalam *surface mount* 3.0x3.0x0.9 mm 16-pin *leadless chip carrier* (LCC) Berbasis *on chip* dengan 3 *axis*[3]. IC HMC5883L merupakan *chip* yang didesain untuk membaca medan magnet bumi yang cocok untuk aplikasi penunjuk arah dan magnetometry. Contoh aplikasi modul ini antara lain untuk sistem navigasi otomatis, serta aplikasi-aplikasi lain yang memerlukan pengukuran medan magnet.

Spesifikasi dari sensor kompas HMC5883L adalah sebagai berikut :

1. Memerlukan catu daya 3,3 VDC dengan konsumsi arus yang rendah (hingga 100uA).
2. Memiliki sensor magnet dengan jenis magnetoresistif 3 sumbu.
3. Memiliki jangkauan pembacaan medan magnet sampai dengan ±8 Gauss dengan resolusi 5 miligauss.
4. Memiliki akurasi kompas hingga 1° sampai 2°.
5. Kecepatan keluaran maksimal data hingga 160 Hz (Single Measurement Mode).
6. Kecepatan keluaran maksimal data 0,75 Hz s.d. 75 Hz (Continuous Measurement Mode).
7. Menggunakan antar muka I2C yang dapat dihubungkan dengan berbagai macam sistem mikrokontroler.
8. Memiliki dimensi modul yang kecil dan ringkas sehingga mudah ditempatkan pada berbagai aplikasi.

2.7 *power supply* robot [10][11]

Power supply pada robot *humanoid* epretiwi-v4 mengunakan baterai tipe lipoly seperti di tunjukkan pada gambar 2.19. Baterai lipoly ini memiliki tegangan *full* 8,4v meski pada sampul baterai tertulis 7,4v, dengan kapasitas baterai persell 3,7v sehingga total 3,7 x 2 = 7,4v. Pengunaan baterai lipoly ini di karenakan beberapa askpek yang memiliki kelebihan dibandingkan dengan baterai tipe lainya.

Spesifikasi baterai :

1. Kapasitas 1300Mah
2. Tegangan 7,4v
3. Ukuran 70,44*34*17,35mm
4. Berat 75g
5. *Discharge rat*e 25C *continous*
6. Soket banana 4.0

kelebihan baterai lipoly :

1. Baterai LiPo memiliki bobot yang ringan dan tersedia dalam berbagai macam bentuk dan ukuran.
2. Baterai LiPo memiliki kapasitas penyimpanan energi listrik yang besar.
3. Baterai LiPo memiliki tingkat discharge rate energi yang tinggi, dimana hal ini sangat berguna sekali dalam mensupply dengan kebutuhan energi yang cukup besar dalam penggunaan rentang waktu yang cukup lama.

Gambar 2. 19 Bentuk Fisik Baterai Lipoly

http://www.gensaceusa.com/98p-25c-1300-2s1p.html

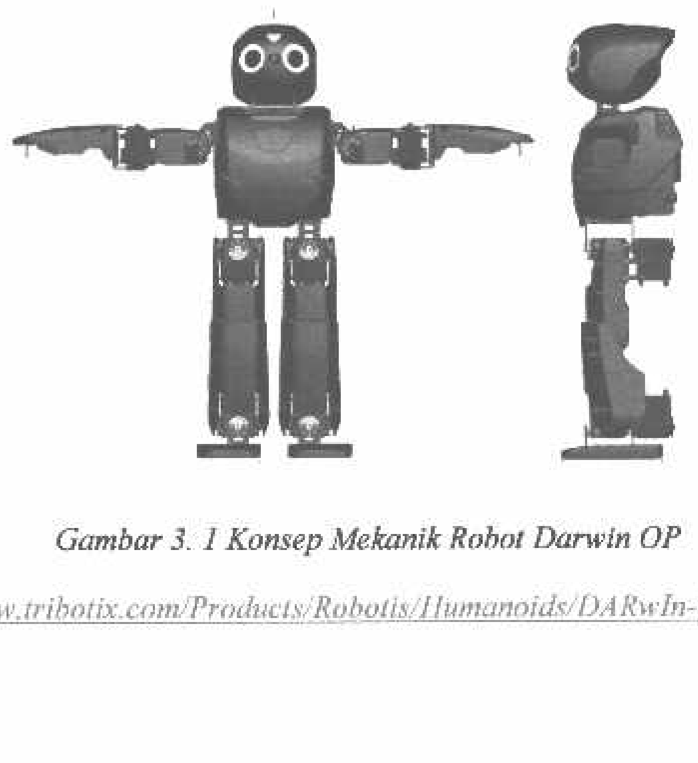
BAB III
PERANCANGAN DAN IMPLEMENTASI

Pada bab ini akan membahas tentang perencangan system robot humanoid, algoritma jalan mengunakan kompas, anlisa kerja sensor kompas, perancangan perangkat keras (hardware) dan power supply robot dan implemetasi pada robot secara nyata.

3.1 Rancangan Robot *Humanoid* Epretiwi-v4

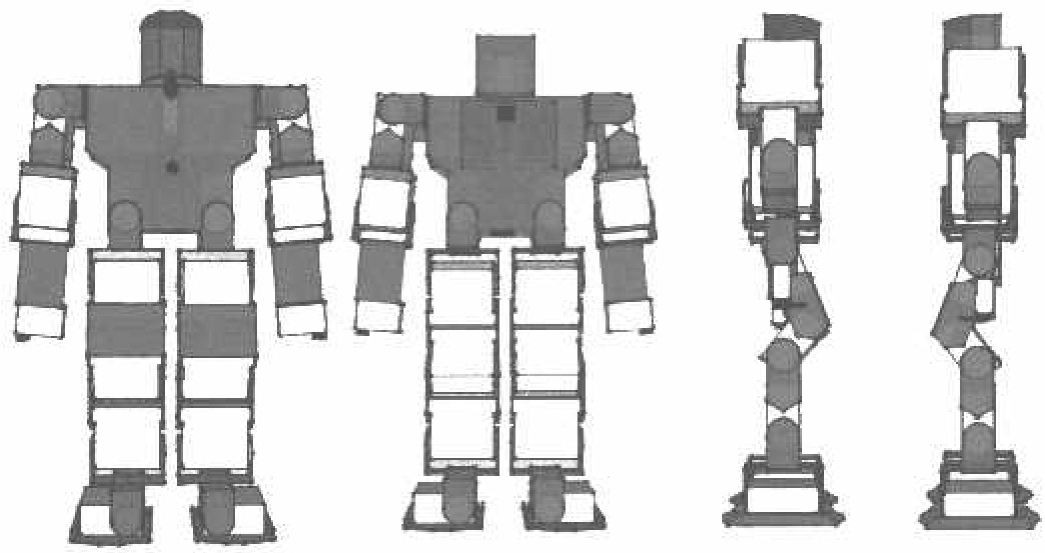
Pada perancangan robot *humanoid* epretiwi-v4 yang di kerjakan pada tugas akhir ini akan lebih berfokus pada sisten jalan, konsep jalan yang sebelumnya banyak terjadi kesalahan dan melenceng dari konsep yang di inginkan.

Konsep mekanik adalah salah satu kunci perancangan robot humanoid, karena system mekanik yang kokoh dan efisien akan mempengaruhi system jalan. Salah satu acuan system kerangka mekanik untuk robot *humanoid* ini adalah robot *soccer* (robot sepak bola) darwinOP seperti yang di tunjukkan pada gambar 3.1, dimana system mekanik yg kokoh dan stabil. Konsep mekanik epretiwi-v3 di tunjukkan pada gambar 3.2 dan Konsep mekanik robot humanoid epretiwi-v4 yang akan di buat seperti pada gambar 3.3.

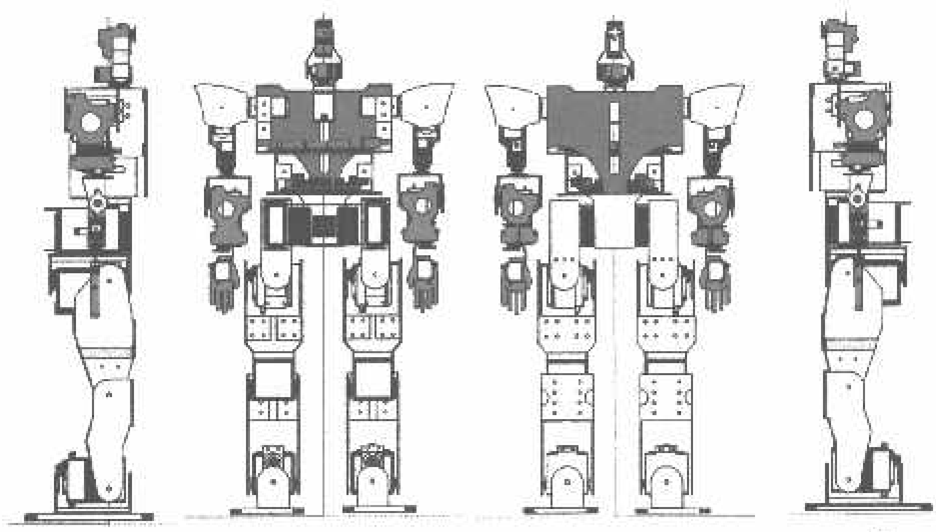


Gambar 3. 1 Konsep Mekanik Robot Darwin OP

http://www.tribotix.com/Products/Robotis/Humanoids/DARwIn-OP_info.htm

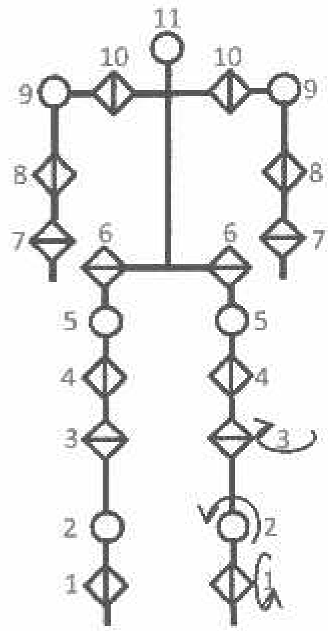


gambar 3. 2 Konsep Mekanik Epretiwi-v3[2]



a b c d

Gambar 3. 3 Konsep Desain Robot Humanoid Epretiwi-v4, (a)Tampak Kanan, (b)Tampak Belakang, (c)Tampak Depan, (d) Ttampak Kiri.

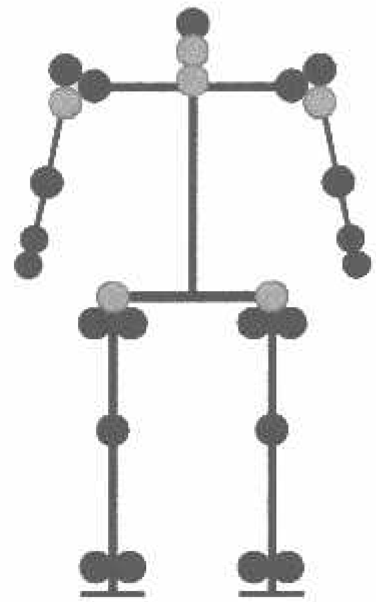


Gambar 3. 4 Robot Epretiwi-v3 dengan 21 Sendi[2]

Jumlah DOF (*degree of freedom*) pada epretiwi-v3 memiliki 21 DOF seperti gambar 3.4 dengan keterangan sebagai berikut[2].

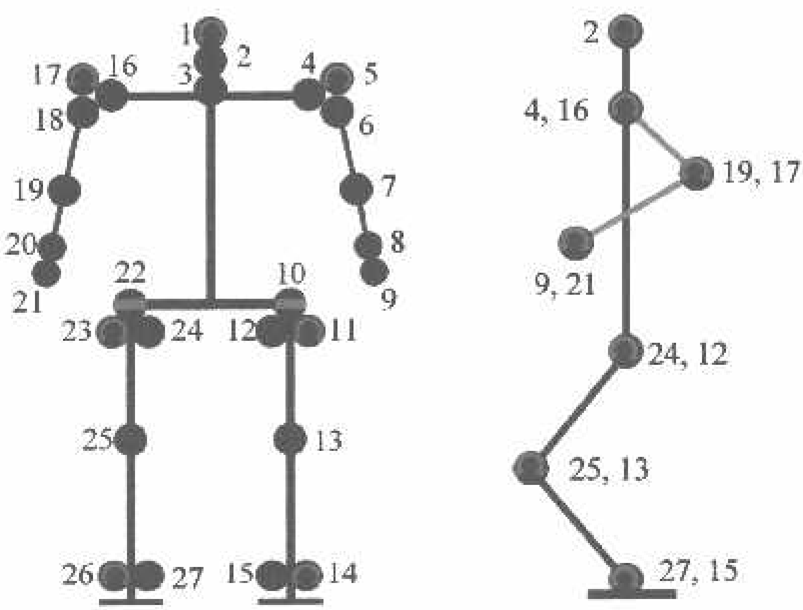
1. Sendi pangkal betis pitch
2. Sendi pangkal betis roll
3. Sendi lutut
4. Sendi pangkal paha pitch
5. Sendi pangkal paha roll
6. Sendi pinggul
7. Sendi pergelangan tangan yaw
8. Sendi siku-siku
9. Sendi pundak roll
10. Sendi pundak pitch
11. Sendi leher roll

Robot epretiwi-v4 pada pengembangannya mengalami penambahan jumlah DOF (*degree of freedom*) sehingga menjadi 27 DOF (*degree of freedom*). Penambahan itu terletak pada bagian tangan dan kepala yang di tunjukkan pada gambar 3.5. Penambahan ini bertujuan untuk memperbanyak jumlah DOF (*degree* *of freedom*) sehingga keluwesan untuk menyerupai gerak manusia dalam implementasi gerak tari sesuai *rule* perlombaan.



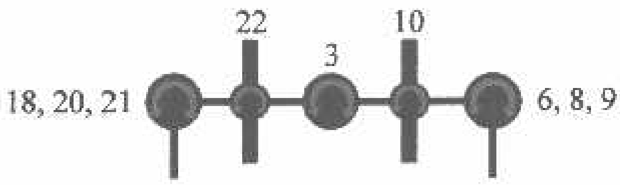
Gambar 3. 5 Letak Penambuhan DOF (degree of freedom) di Tunjukkan dengan Lingkaran Berwarna Hijau.

Pada pengembangan robot epretiwi-v4 yang di kerjakan untuk tugas akhir ini jumlah DOF (*degree of freedom*) di tunjukkan pada gambar 3.6 dengan jumlah 27 DOF (*degree of freedom*).



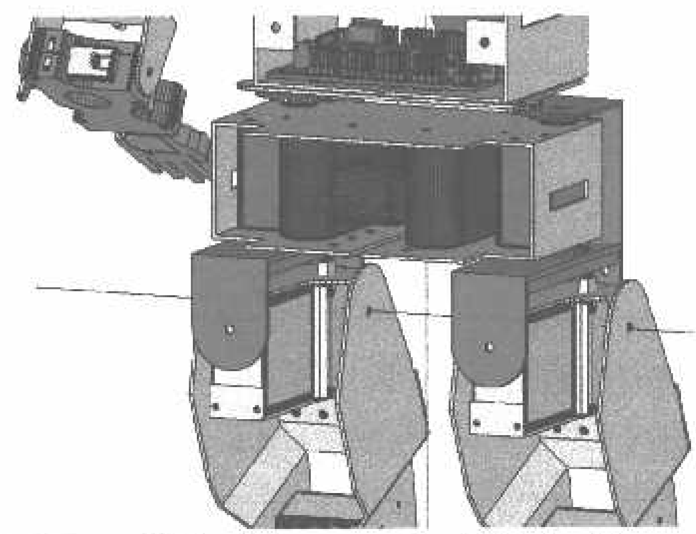
gambar 3. 6 Jumlah DOF (degree of freedom) Epretiwi-v4

DOF (*degree of freedom*) yang di tunjukkan pada gambar 3.6 pergerakan sesuai dengan arah panah. Khusus untuk servo nomer 3, 4, 6, 7, 8, 9, 10, 16, 18, 19, 20, 21, 22 pergerakan di lihat dari atas dengan pergerakan sama seperti arah panah yang lain yang di tunjukkan pada gambar 3.7.



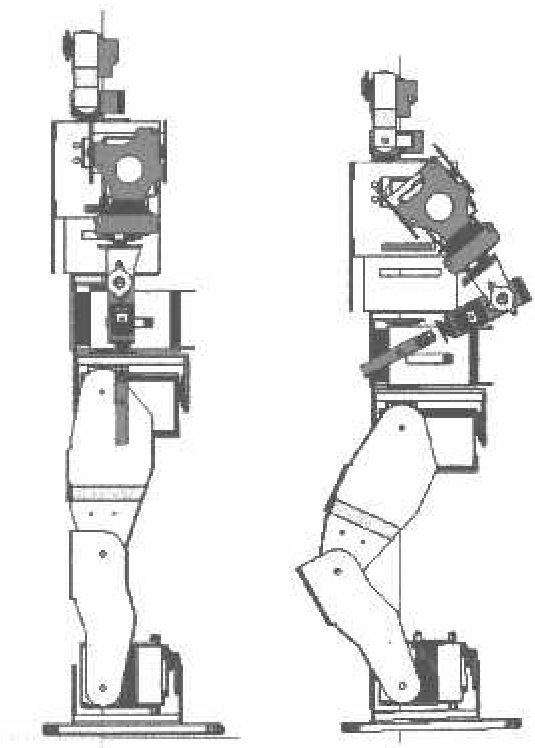
gambar 3. 7 DOF (degree of freedom) Servo Pergerakan dengan Arah Vertikal

Pengontrolan robot menggunakan kompas ini di dukung dengan mekanik penggerak motor servo pada pangkal paha yang tidak ada pada robot humanid epretiwi-v3 sebelumnya. Dengan mengunakan pengontrol gerak pada pangkal paha ini memudahkan robot untuk membuat gerakan berbelok ataupun memutar dengan mudah. Pengontrol untuk penggerak berbelok ataupun memutar di tunjukkan pada gambar 3.8 yang di tunjukkan dengan warna merah dengan nomer DOF (*degree of fredom*) 22 pada gambar 3.6 adalah motor servo dan warna biru mekanik yang menggerakkan kaki dengan nomer DOF (*degree of fredom*) 10 pada gambar 3.6.



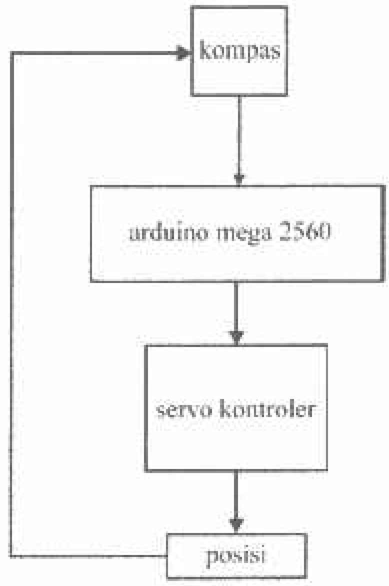
Gambar 3. 8 Sistem Mekanik Pengontrol Berbelok dan Berputar Pada Kaki

Hal utama sebagai posisi awal robot harus di posisikan 0 atau initial value. Untuk dapat membuat robot pada posisi 0 atau posisi initial value dengan seimbang maka titik keseimbagan harus berapa pada pusat *grufity (center of graity)*[1]. Beberapa tipe initial value robot humanoid sesuai dengan rancangan robot *humanoid* epretiwi-v4 di tunjukan pada gambar 3.9. Initial value ini akan menentukan ke stabilan dalam sistem jalan robot sesuai konsep teknik *Support polygon*.



Gambar 3. 9 Tiga Posisi Awal Robot

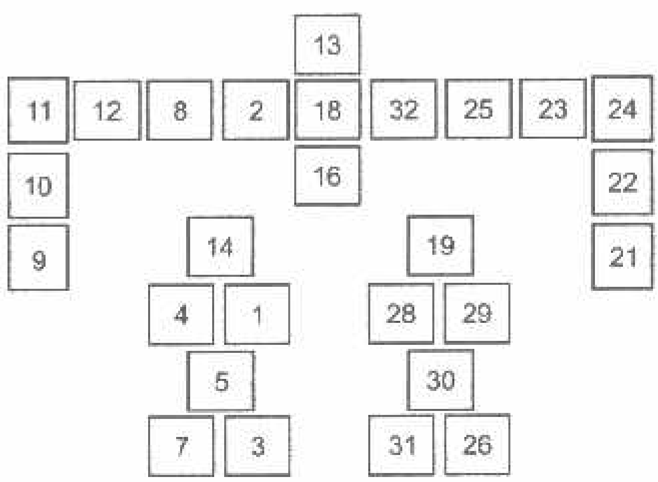
Untuk dapat membuat robot bergerak sesuai dengan yang telah ketentuan meggunakan sensor kompas, maka akan di buat system control secara simple dan mudah. Arduino akan meneriman data dari sonsor kompas melalui jalur komunikasi I2C, dan arduino akan mengolah datanya. Data yang di terima oleh arduino akan menentukan eksekusi pengontrol motor servo apakah jalan lurus atau harus berbelok arah. Arduino mengirimkan data ke pengontrol motor servo melelui jalur serial Rx, Tx. Sistem ini akan terus berjalan selama power supply pengontrol servo dan arduino aktif. Diagram sistem ini di tunjukkan pada gambar 3.10.



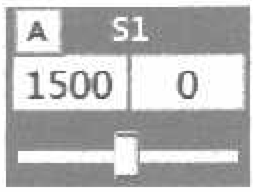
Gambar 3. 10 Blok Alur Kerja Sistem

3.2 Susunan Kontrol Pengerak

Pengontrolan motor servo pada system gerak robot *humanoid* epretiwi-v4 akan mengunakan torobot RIOS USC, susunan panel kontrol motor servo di tunjukkan seperti pada gambar 3.11. Setiap motor servo akan di wakili satu kotak control sehingga pergerakan dapat di control dengan mudah. Dengan mengubah nilai jumlah PWM atau menggeser panel pada panel servo seperti pada gambar 3.12.



Gambar 3. 11 Susunan Panel Pengontrol Servo.



Gambar 3. 12 Kotak Panel Kontrol untuk Mengubah Nilai PWM Motor Servo

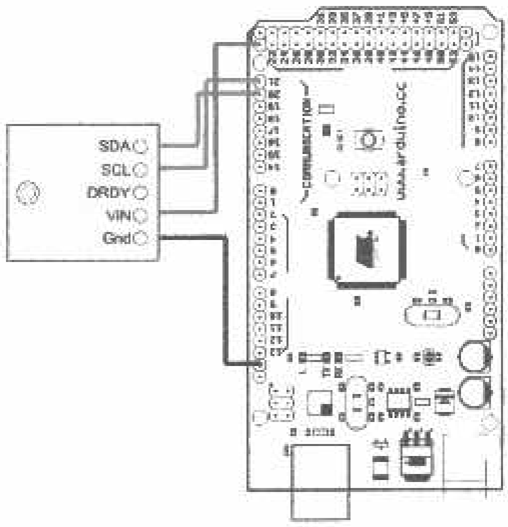
Untuk setiap *port* servo yang di hubungkan dengan panel control di tunjukkan pada table 3.1. Hubungan antara *port* dan panel control akan mewakili setiap DOF (*degree of freedom*) pada robot.

Tabel 3. 1 Hubungan Antara Port dan Setiap DOF (degree of freedom)

Nomer *port*	Nomer sendi pada gambar 3.6	Nomer *port*	Nomer sendi pada gambar 3.6
1	24	17	-
2	16	18	2
3	27	19	10
4	23	20	-
5	25	21	9
6	-	22	8
7	26	23	6
8	17	24	7
9	21	25	5
10	20	26	14
11	19	27	-
12	18	28	12
13	1	29	11
14	22	30	13
15	-	31	15
16	3	32	4

3.3 Sensor Kompas

Wiring sensor HMC5883L yang akan di gunakan sebagai kompas mengunakan arduino mega2560 di tunjukkan pada gambar 3.13.



Gambar 3. 13 Wiring Sensor Kompas

Sensor magnetometer HMC5883L akan menghasilkan data tiga *axis* X, Y, Z data. Untuk menghasilkan data yang sesuia dengan keperluan sebagai kompas digital maka data yang akan di gunakan adalah axis X dan Y. Data secara keseluruhan axis X, Y, Z di tampilkan pada gambar 3.14 dengan percobaan sensor magnetometer HMC5883L.

	X	Y	Z
Scaled:	184.00	162.84	287.04
Scaled:	185.84	163.76	289.80
Scaled:	184.92	166.52	287.04
Scaled:	183.08	162.84	285.20
Scaled:	184.92	161.92	286.12
Scaled:	185.84	161.92	286.12
Scaled:	184.00	160.08	284.28
Scaled:	184.00	161.92	287.04
Scaled:	186.76	163.76	286.12
Scaled:	186.76	161.92	289.80
Scaled:	184.92	161.00	286.12
Scaled:	186.76	163.76	284.28
Scaled:	186.76	163.76	287.96
Scaled:	184.00	161.92	287.04
Scaled:	186.76	161.92	286.12
Scaled:	186.76	163.76	287.04
Scaled:	184.00	162.84	287.96
Scaled:	187.68	162.84	285.20
Scaled:	184.00	164.68	286.12
Scaled:	184.92	163.76	287.04
Scaled:	183.08	161.92	284.28
Scaled:	185.84	163.76	287.96
Scaled:	185.84	163.76	285.20

Gambar 3. 14 Data Axis X, Y, dan Z Dari Sensor Magnetometer HMC5883L

Untuk keperluan di gunakan sebagai kompas magnet digital maka sensor HMC5883L akan di letakkan secara horizontal sehinga data *axis* nya adalah hX dan hY. Dari ke dua axis itu di konfigurasi secara matematis dalam program arduino. Data dari hX ke –hX axis dan hY ke –hY axis yang di gambarkan pada garis kartesius seperti di tunjukkan pada gambar 3.15.

Sensor magnetometer HMC5883L dengan data hX dan hY mula-mula akan di diketahui titik pertemuannya sehinggan di peroleh nilai radian dengan mengunakan fungsi *library* matematik pada arduino yaitu ATAN2 (sumbu hX, sumbu hY). Arka tangen adalah sudut dari sumbu-x ke garis yang berisi asal (0,0) dan titik dengan koordinat (angka_x, angka_y), sudut diberikan dalam radian antara -pi dan pi, tidak termasuk -pi[12].

Misalkan data sumbu hX (35) dan sumbu hY (233), sehingga di peroleh :

ATAN2(35, 233) = 1,42 radian

Setelah di dapatkan nilai radian kemudian data tersebut di konfersi ke derajat sebagai data arah kompas, dengan menggunakan persamaan :

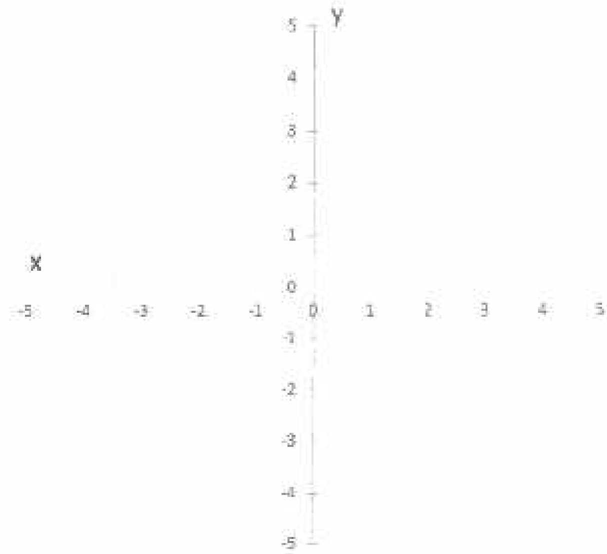
Radian x 180/PI

1,42 x (180/PI) = 81,45 derajat

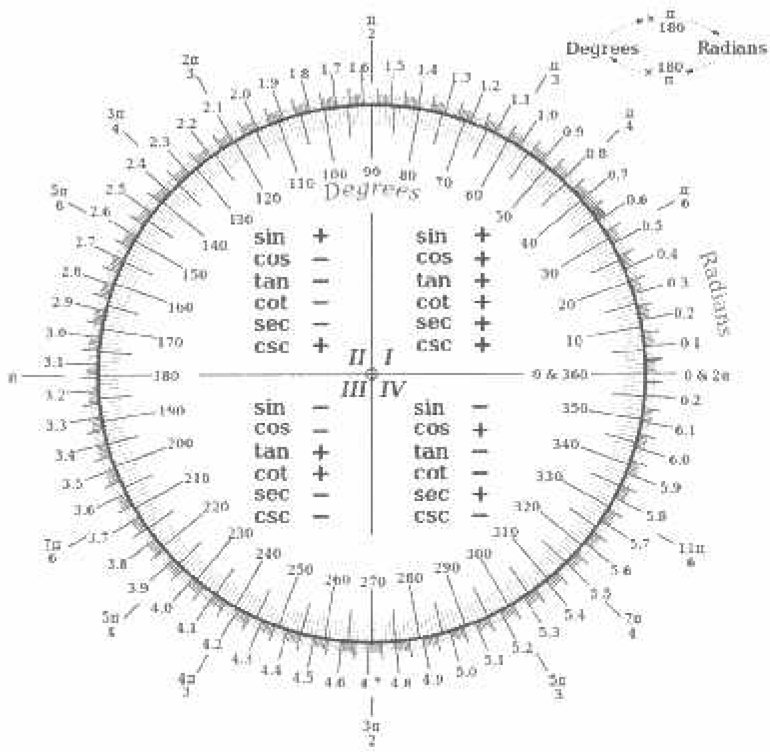
Tabel 3.2 menampilkan hubungan radian dan derajar dan gambar 3.16 menunjukkan satu lingkaran penuh dengan hubungan antara radian dan derajat. Garis kartesius di tunjukkan seperti pada gambar 3.15 dengan sumbu hX dan hY.

Tabel 3. 2 Hubungan Derajat dan Radian

Degrees	Radians (exact)	Radians (approx)
30°	π/6	0.524
45°	π/4	0.785
60°	π/3	1.047
90°	π/2	1.571
180°	π	3.142
270°	3π/2	4.712
360°	2π	6.283



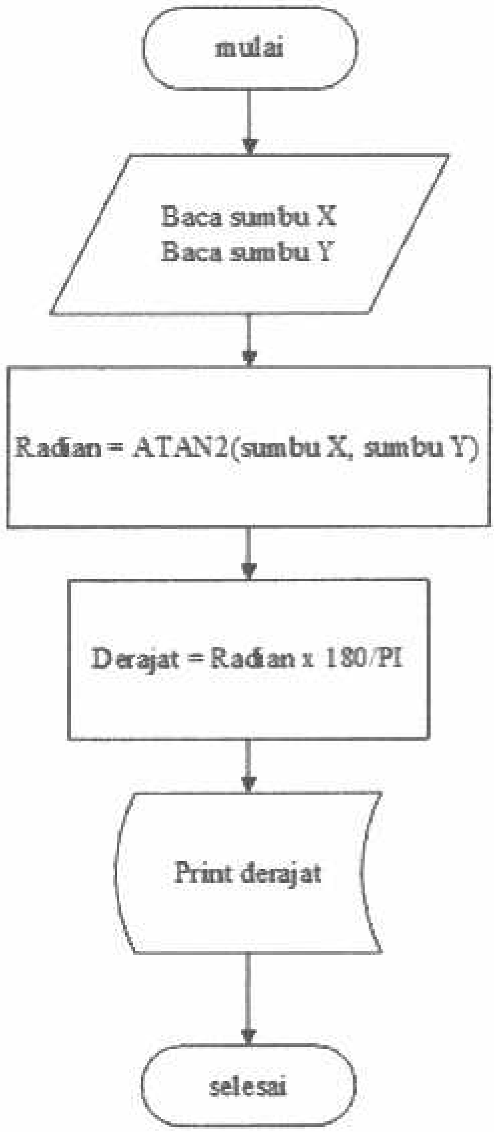
Gambar 3. 15 Degree Axis hX dan hY Dalam Garis Kartesius



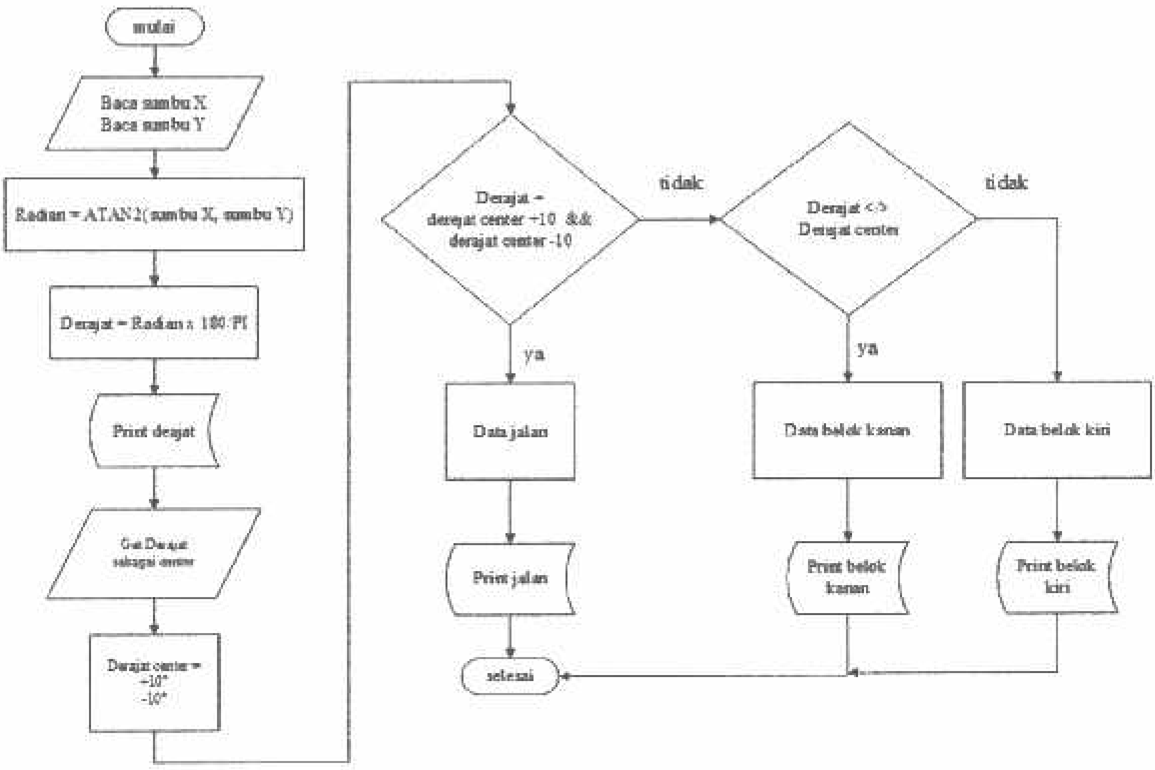
Gambar 3. 16 Lingkaran Hubungan Derajat dan Radian

https://en.wikipedia.org/wiki/Radian

Flowcart sistem kerja sensor kompas di tunjukkan pada gambar 3.17 dan Gambar 3.18 menunjukkan *flowchart* sistem pada Robot secara keseluruhan.



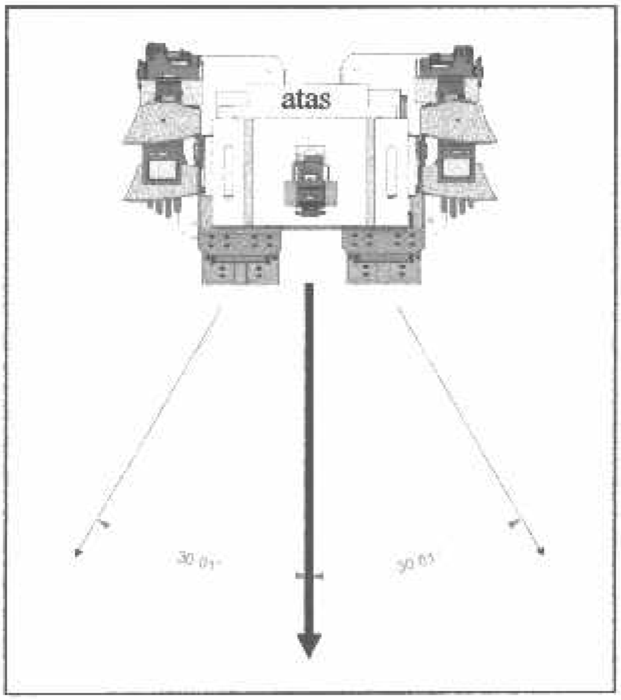
Gambar 3. 17 Flowchart Data Derajat Kompas



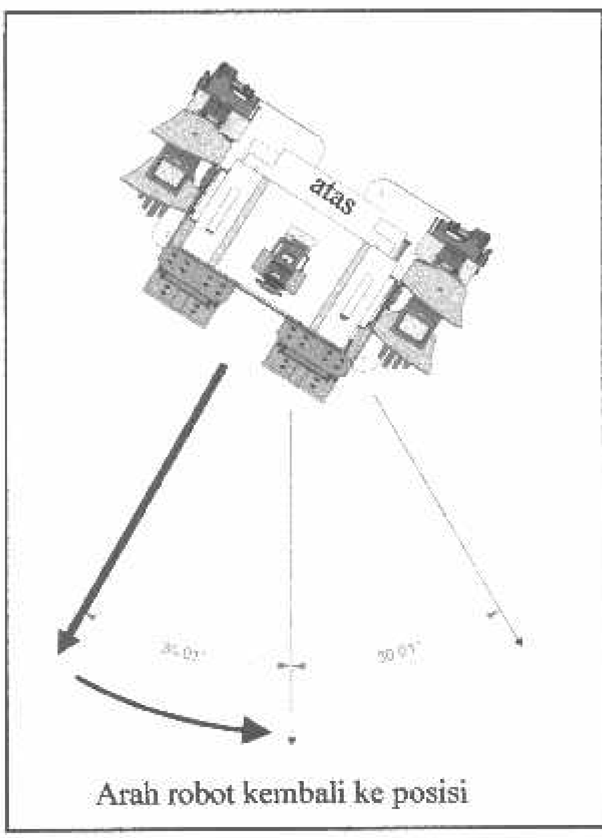
Gamabr 3. 18 Flowchart Ssistem Pada Robot Keseluruhan

3.4 Pengendalian Arah Robot Menggunakan Kompas

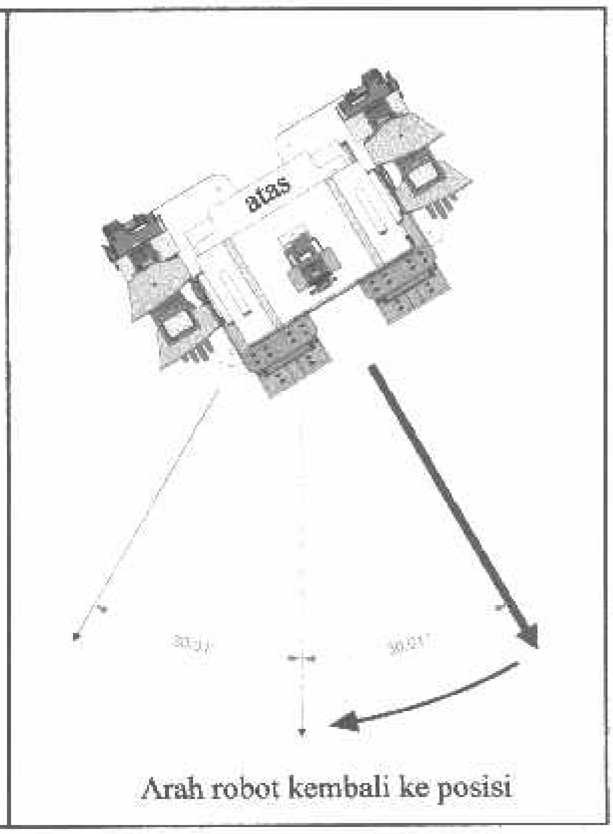
Dengan menggunakan sensor kompas untuk arah gerak robot dapat secara otomatis menentukan nilai derajat. Arah kompas di tentukan dengan memberikan batasan pada logika program yang telah di buat. Hal yang utama yang di tentukan adalah arah tujuan robot. Dengan memberikan rentang robot sebesar 60^0, 30^0 sebelah kana dan 30^0 sebelah kiri yang di anggap sebagai jalan dalam keadaan lurus dan jika robot melebihi dari derajat yang telah di tentukan itu makan robot di anggap melenceng. Secara otomatis ketika kompas memberikan nilai keluar dari yang telah di tentukan maka robot akan berbalik arak ke rentang derajat yang di tentukan sebagai tujuan atau jalan yang di definisikan sebagai lurus. Gambar arah robot di tunjukkan pada gambar 3.19.



Gambar 3. 19 (a) arah tujuan robot



(b) Robot Melenceng ke Kana



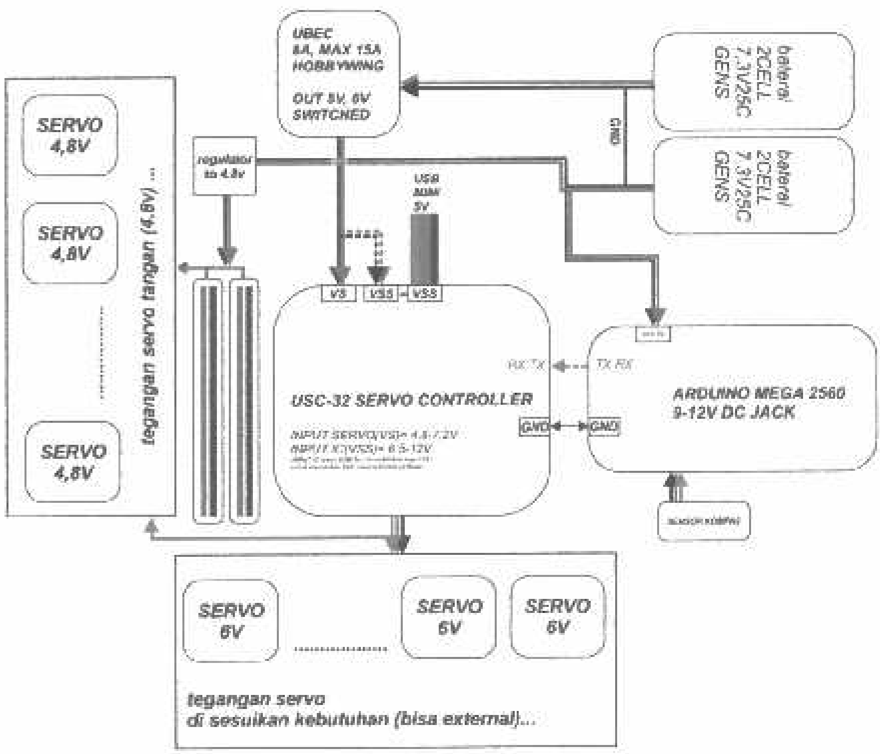
(c) Robot Melenceng ke Kiri

3.5 Sistem *Hardware*

Robot *humanoid* epretiwi-v4 memilki system hardware yang merupakan komponen pendukung supaya dapat bekerja dengan baik. Komponon hardware ini meliputi :

1. Servo
2. Baterai
3. Sensor kompas
4. USC32 servo controller
5. Regulator tegangan

Secara ke seluruhan system hardware di tunjukkan pada gambar 3.20. Dan secara keseluruhan akan di bahas di pembahasan berikunya.



Gambar 3. 20 Diagram Blok Sistem Hardware

Alur kerja system *hardware* :

1. Baterai akan mensupply USC32 servo kontroler, arduino, servo dan sensor kompas di tandai dengan jalur warna merah. Tegangan servo dibagi menjadi dua :
    a. Servo tangan dan kepala dengan *supply* tegangan 4,8v berjumlah 10 buah.
    b. Servo selain tangan dengan *supply* tegangan 6v berjumlah 17 buah.

    Sensor kompas dengan tegangan 3,3v dan *bluethooth* dengan tegangan 5v mendapatkan *supply* tegangan dari arduino mega2560.
2. Komunikasi data di tandai jalur data berwarna kuning, *bluethooth* pin analog dan sensor kompas menggunakan pin I2C dari arduino mega2560. Komunikasi data arduino dengan USC32 servo kontroler melalui jalur serial RX/TX dan servo menerima data dari USC32 servo kontroler.
3. UBEC (*Universal Battery Elimination Circuit*) berfungsi menurunkan tegangan ke 6v, pada gambar 3.14 UBEC (*Universal Battery Elimination Circuit*) secara langsung di pasang setelah baterai karena catu daya USC32 membutuhkan 6v untuk mengaktifkan IC USC32 servo kontroler sebagai pengontrol servo. Regulator 4,8v di fungsikan untuk mensupply tegangan servo kecil yang terletak pada posisi tangan.
4. USBmini di fungsikan untuk koneksi USC32 ke computer. Jika USBmini di gunakan maka *suppy* tegangan IC USC32 sudah terpenuhi dan tidak di butuhkan *supply* dari baterai seperti yg di tunjukkan pada gambar 3.14 dengan garis panah putus-putus.

3.6 Power Supply Robot

Secara keseluruhan kebutuhan dalam pengunaan tegangan dan arus harus dapat di *supply* oleh baterai. Dengan menjumlah secara keseluruhan kebutuhan *supply* tegangan dan arus kebutuhan robot dapat di kalkulasi sesuai dengan kapasitas baterai dan waktu pemakaian yang akan di gunakan. Motor servo pada robot *humanoid* epretiwi-v4 dibagi menjadi dua, yaitu servo dengan supply tegangan 6v dan supply maksimal 4,8v dengan jumlah total motor servo 27 buah. Dimana motor servo dengan tegangan *supply* maksimal 4,8v berada pada bagian tangan dengan struktur motor servo ukuran mini seperti di tunjukkan pada tabel 3.3 sesuai dengan tegangan kerjanya.

Tabel 3. 3 Hubungan Motor Servo Dengan Tegangan Kerja Sesuai Dengan Bagian Servo Pada Gambar 3.6

Motor servo dengan supply tegangan 6v pada gambar 3.6		Motor servo dengan supply tegangan 4,8v pada gambar 3.6	
Nomer servo	Nomer servo	Nomer servo	Nomer servo
3	16	1	21
4	17	2	
5	22	6	
10	23	7	
11	24	8	
12	25	9	
13	26	18	
14	27	19	
15		20	

Jumlah motor servo dengan *supply* tegangan 6v berjumlah 17 dan motor servo dengan supply tegangan 4,8v berjumlah 10. Untuk konsumsi arus dan waktu kerja dari baterai secara keseluruhan akan di kalkulasi. Kapasitas 1300mAh berarti baterai dapat menyalurkan 1,3A dalam 1 jam dimana :

$$1300mAh / 1000A = 1,3 \text{ mAh}$$

Discharge rate adalah kemampuan baterai untuk memberi *supply* melebihi kapasitasnya sendiri. Dengan *Discharge rate* 25C berarti baterai tersebut mampu melepas arus sebesar 25C*1300mAh = 32500 mA = 32,5 A. Arus sebesar ini dapat dikeluarkan oleh baterai dalam waktu sesaat (10-20 detik). Dalam keadaan *full charger* maka satu menit rata-rata baterai dapat mengeluarkan arus sebesar 32,5 A / 60 menit = 0.541 A/menit. Dengan membaginya dengan kapasitas baterai 1300 mAh maka diperoleh waktu sampai baterai habis adalah 1300mAh/541 (mA/menit) = ± 2,4 menit. Ini terjadi jika baterai men*supply* beban dengan arus 0,54 A/menit.

Kalkulasi beban secara keseluruhan dengan dua *supply* baterai :

Baterai 1 :

Baterai kapasitas 1300mAh dengan beban :

- ✓ Motor servo
  - o 6v, total 17 motor servo = ± 2,3A

Total konsumsu arus ±2300mA

Dischard rate baterai = *Capasity* mAh x C

= 1300mAh x 25C = 32500A

Sehingga kapasitas kerja baterai yang dapat di gunakan selama T adalah :

$$T = \frac{Ah}{A} 60\ menit$$

Keterangan :

T = waktu (menit)

Ah = kapasitas baterai (Ampere hours)

A = beban baterai (Ampere)

$$T = \frac{1300mAh}{2300mA} 60\ menit = \pm 33\ menit$$

Baterai 2 :

Baterai kapasitas 1300mAh dengan beban :

- o Arduino mega 2560 = ± 300mA
- o 4,8v, total 10 motor servo = ± 850mA

Total konsumsu arus ±1150mA

Dischard rate baterai = Capasity mAh x C

= 1300mAh x 25C = ±32500A

Sehingga kapasitas kerja baterai yang dapat di gunakan selama T adalah :

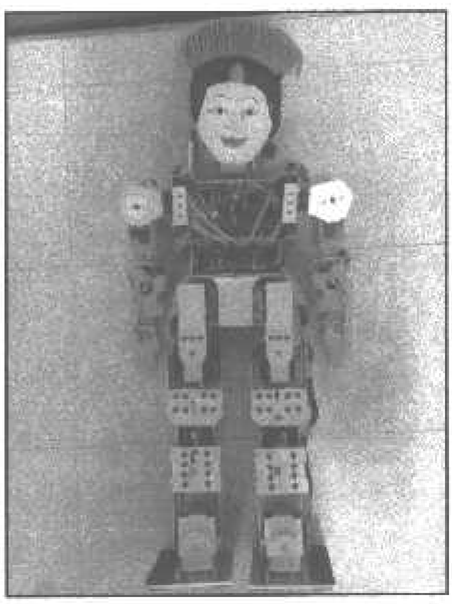
$$T = \frac{1300mAh}{1150mA} 60\ menit = \pm 67\ menit = 1{,}7\ jam$$

3.7 Hasil Perancangan

Hasil perancangan robot *humanoid* epretiwi v4 di terangkan dibawah dan hasil perancangan di tunjukkan pada gambar 3.21.

3.7.1 Data Teknis

1. Terdiri dari 27 servo yang dirangkai dengan plat aluminium, dibuat secara handmade (buatan sendiri).
2. Memiliki 27 derajat kebebasan DOF (*Degree Of Fredom*).
3. Tinggi 550mm.
4. Rentang kaki 320mm.
5. Rentang tangan 600mm..
6. Luas telapak kaki panjang 100mm x 80mm .
7. Bahan yang dipakai plat aluminium dengan ketebalan 2mm.



Gambar 3. 21 Hasil Desain dan Perancangan Robot

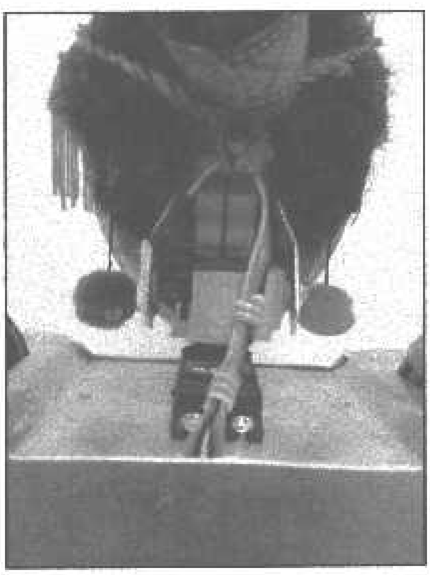
3.7.2 Keterangan DOF (*Degree Of Freedom*)

Tabel 3. 4 Keterangan DOF (*Degree Of Freedom*)

Kepala	Pangkal Lehar	1 DOF
	Leher	1 DOF
	Kepala Atas	1 DOF
Tangan Atas	Bahu	2 DOF x 2 = 4 DOF
	Siku	2 DOF x 2 = 4 DOF
	Pergelangan Tangan	2 DOF x 2 = 4 DOF
Kaki Atas	Pangkal Paha	1 DOF x 2 = 2 DOF
	Paha	2 DOF x 2 = 4 DOF
Kaki Bawah	Lutut	1 DOF x 2 = 2 DOF
	Pergelangan Kaki	2 DOF x 2 = 4 DOF
Total	DOF	27

3.7.3 Sistem Kepala

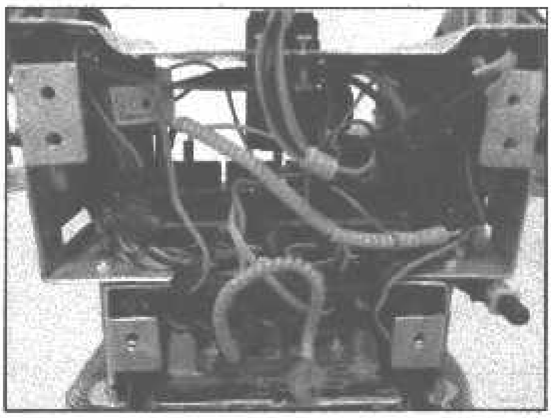
Sistem kepal terdiri dari 3 servo dengan pergerakan menggeleng, hadap kiri, kanan dan mengangguk. Sistem kepala di tunjukkan pada gambar 3.22.



Gambar 3. 22 sistem pergerakan kepala

3.7.4 Sistem badan

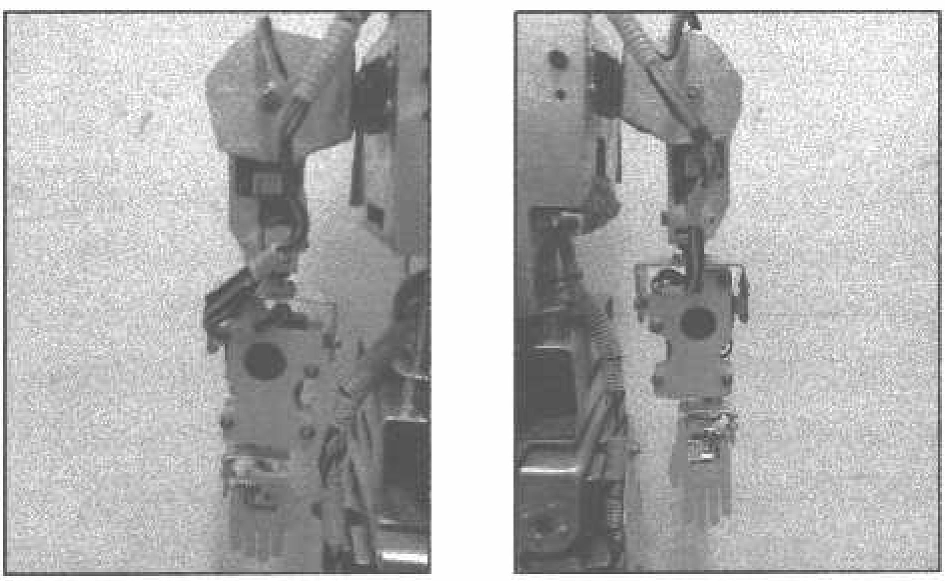
Pada badan di gunakan sebagai penempatan sistem kontrol mulai dari arduino, pengontrol servo dan kompas. Sistem badan di tunjukkan pada gambar 3.23.



Gambar 3. 23 sistem badan

3.7.5 Sistem tangan

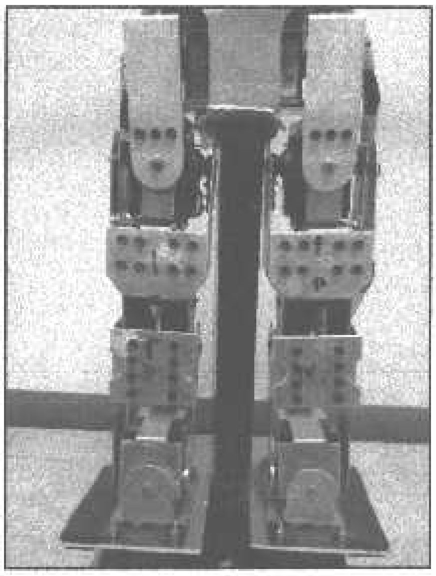
Sistem tangan meliputi bahu, siku dan pergelangan tangan dengan jumlah 6 servo. Sistem tangan di tunjukkan pada gambar 3.24.



Gambar 3. 24 sistem tangan

3.7.6 Sistem kaki

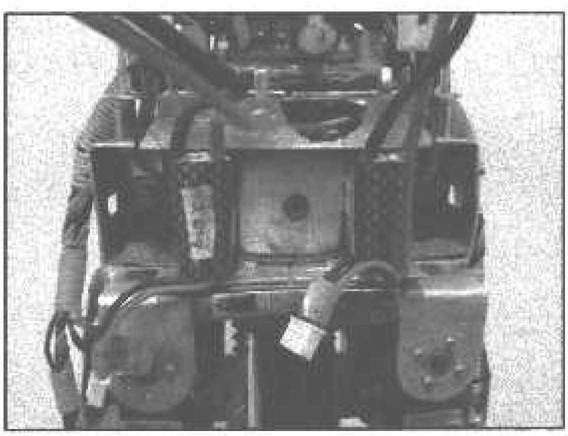
Terdiri dari 12 servo yang dirangkai dengan plat aluminium. Telapak kaki dilapisi dengan busa sehingga ketika melangkah tidak licin. Sistem kaki di tunjukkan pada gambar 3.25.



Gambar 3. 25 sistem Kaki Robot Epretiwi v4

3.7.7 Sistem *Power Supply*

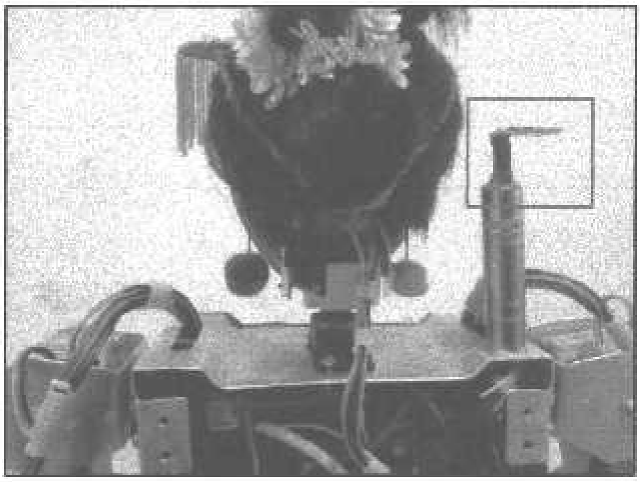
Untuk memenuhi kebutuhan daya pada robot *humanoid* epretiwi v4, makan di mengunakan 2 baterai tipe lipoly (litium polimer) yang di pasang seperti pada gambar 3.26.



Gambar 3. 26 penempatan baterai

3.7.7 Penempatan Sensor Kompas

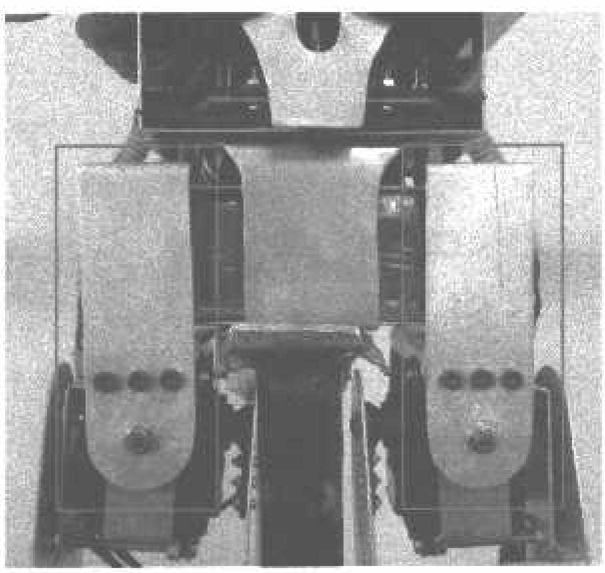
Sensor kompas yang di gunakan pada robot *humanoid* epretiwi v4 peletakannya berada di bahu atas mengunakan penyangga seperti yang dii tunjukkan pada gambar 3.27 sehingga tidak terpengaruh oleh motor-motor yang ada pada robot.



Gambar 3. 27 Peletakan Sensor Kompas

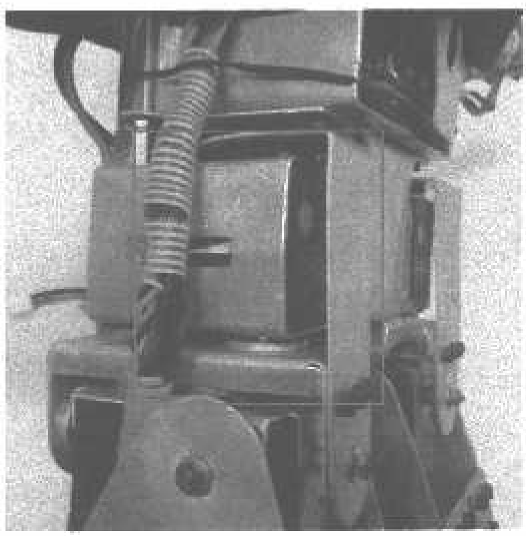
3.7.8 Servo Pengontrol Jalan

Perancanan servo pengontrol di dasarkan untuk dapat mengendalikan jalan robot, hasil perancangan di tunjukkan pada gambar 3.28.



Gambar 3. 28 (a) tampak depan

Gambar 3. 29 (b) tampak sebelah kiri



Gambar 3. 30 (c) Tampak Samping

BAB IV
PENGUJIAN DAN ANALISA

Pada bab ini menampilkan data - data hasil pengamatan dan analisa terhadap pengujian kinerja robot meliputi, pengujian baterai, penurun tegangan dan motor servo, pengujian kemampuan berjalan, berbelok dan beberapa posisi jalan. Pengujian sensor kompas dalam menentukan arah robot dan pengujian kemampuan robot ketika berbelok.

4.1 Sensor kompas

4.1.1 Pengujian Sensor Kompas

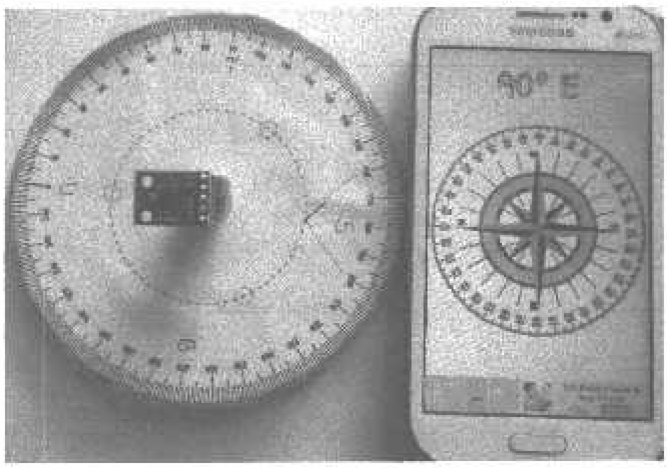
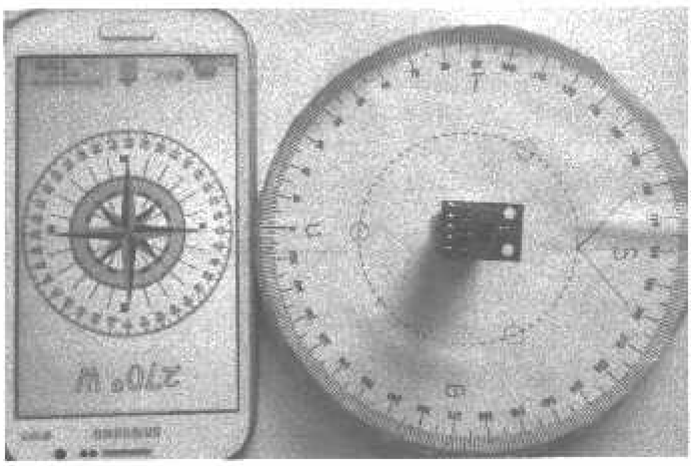
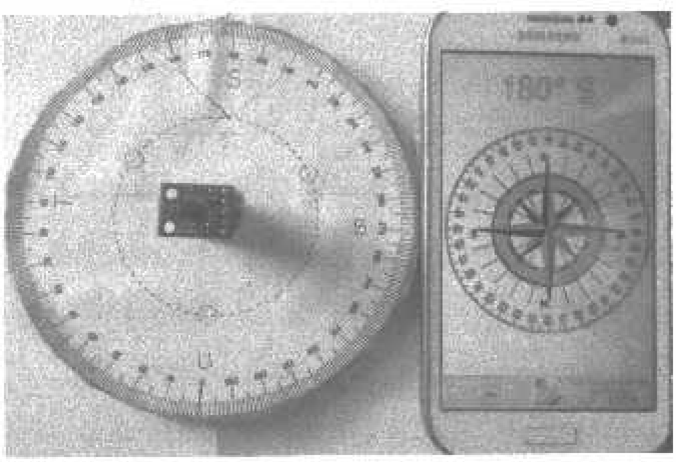
Sensor kompas HMC5883L yang di gunakan akan di uji dan sebagai pembanding adalah menggunkan kompas digital pada *smartphone* android. Penempatan sensor kompas pada robot terletak pada bahu sebelah kanan atas yang di tunjukkan pada gambar 4.1 (a) dengan kondisi 0 derajat berada pada arah utara pada gambar 4.1 (b).

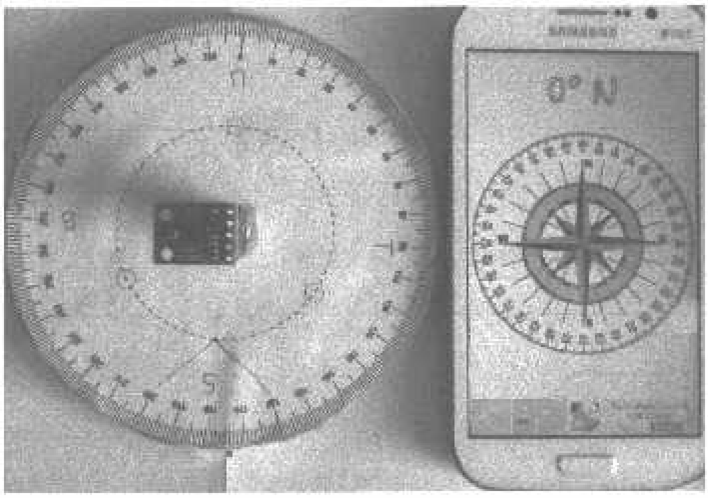
Sejauh dalam impementasi, sensor kompas sudah cukup akurat dalam menentukan arah mata angin yang sesui perencanaan. Tabel 4.1 menunjukkan data pengujian sensor kompas di bandingkan dengan kompas digital pada *smartphone* android. Tabel 4.2 menunjukkan hasil perbandingan pengukuran sensor HMC5883L dengan kompas asli *smartphone*.

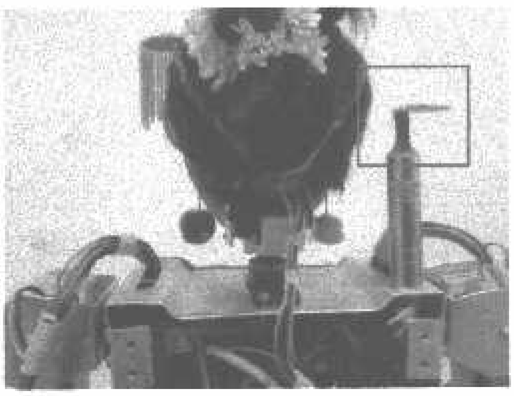
Tabel 4. 1 hasil pengukuran kompas

Arah	**Pengukuran (Derajat)**	**Asli (Derajat)**	**Error (%)**
Timur	93	90	3
Barat	278	270	2,9
Utara	0	0	0
Selatan	189	180	11,1

Tabel 4. 2 Pengujian Arah pada Sensor Kompas Dengan Kompas *Smartphone*

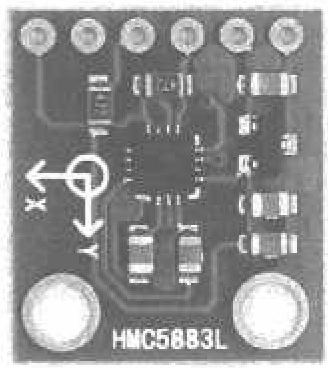
Arah Tujuan	**Sensor Kompas (derajat)**	**Kompas Smartphone (derajat)**	**Eror (%)**
Timur			
Barat			
Selatan			

Utara		



a

Utara



b

Gambar 4. 1 (a) Penempatan Sensor Kompas Pada Robot, (b) arah uata pada kompas

4.1.1.1 Analisa Sensor Kompas

Sensor kompas HMC5883L sebagai pembanding menggunakan kompas *smartphone* memilki perbedaan penyimpangan arah derajat. Penyimpangan itu di presentasikan dengan perhitungan eror sebagai berikut :

$$\%error = \frac{\text{derajat pengukuran} - \text{derajat asli}}{\text{derajat asli}} \times 100\%$$

Timur =

$$\%error = \frac{93 - 90}{90} \times 100\%$$

Error timur = 3%

Barat =

$$\%error = \frac{278 - 270}{270} \times 100\%$$

Error barat =

Utara = 2,9%

$$\%error = \frac{0 - 0}{0} \times 100\%$$

Error utara = 0%

Selatan =

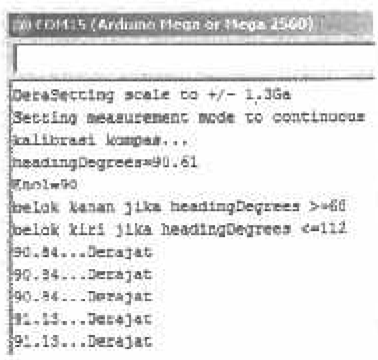
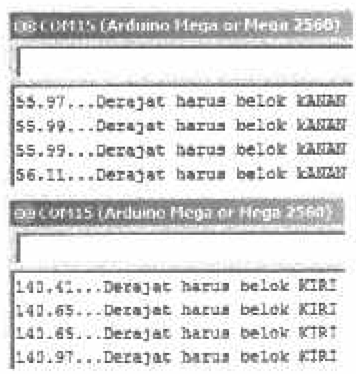
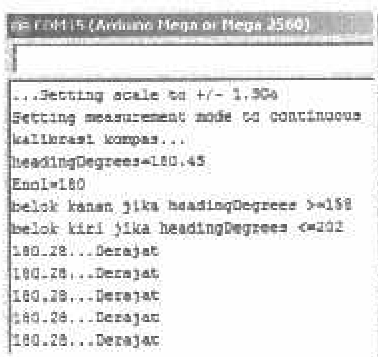
$$\%error = \frac{200 - 180}{180} \times 100\%$$

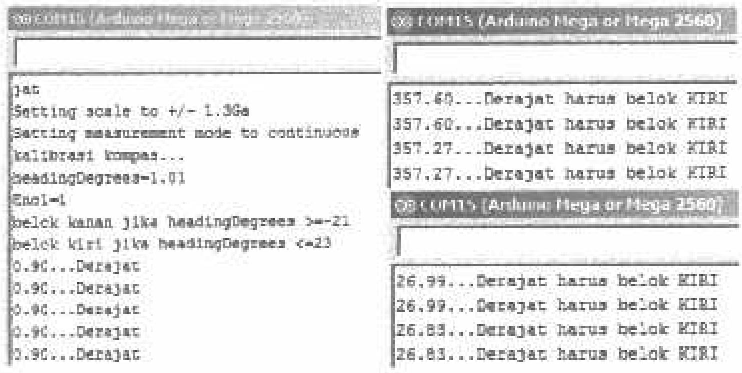
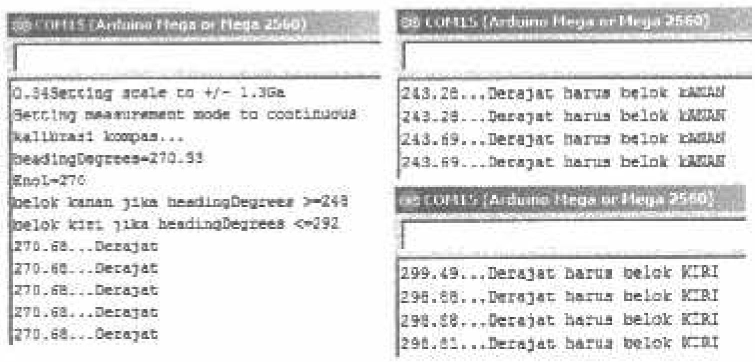
Error selatan = 11,1%

4.1.2 Pengujian Sensor Kompas Sebagai Penunjuk Arah Robot

Menentukan arah robot sesuai arena yang tersedia dengan menggunakan data nilai awal sensor kompas sebagai patokan arah yang akan di tuju dan memberikan nilai untuk batas maksimun dan minimum sebagai indikator bahwa posisi robot menyimpang. Pengujian pada sensor kompas menggunakan serial monitor mikrokontroler arduino mega 2560 di tujukkan pada tabel 4.3.

Tabel 4. 3 Percobaan Sensor Kompas Terhadap Arah Yang Akan di Tuju.

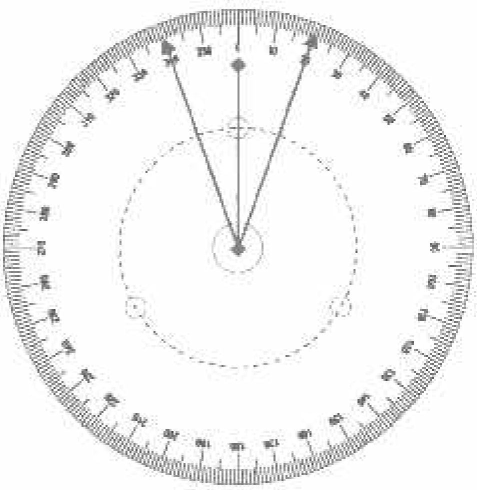
<table>
<tr><th>Arah tujuan Robot</th><th>Min-Max (derajat)</th><th colspan="2">Serial Data Monitor</th></tr>
<tr><td>Ke Timur nyata 90°</td><td>22°</td><td>
</td><td>
</td></tr>
<tr><td>ke selatan nyata 180°</td><td>22°</td><td>
</td><td>
</td></tr>
</table>

<table>
<tr>
<td>Ke
Utara
nyata
0°</td>
<td>22°</td>
<td>
</td>
</tr>
<tr>
<td>Ke
Barat
nyata
270°</td>
<td>22°</td>
<td>
</td>
</tr>
</table>

4.1.2.1 Analisa Sensor kompas Sebagai Penunjuk Arah Robot

Sensor kompas yang di gunakan untuk menunjukkan arah robot di bandingkan dengan kompas *smartphone* sudah cukup akurat. Untuk keperluan pada robot yang di gunakan pada tugas akhir ini sudah cukup baik, di karenakan data derajat hanya sebagai data patokan saja (tidak di fungsikan secara akurat).

Pada pengaplikasinnya saat lomba ada kendala pada sensor kompas, yaitu arena kontes berdekatan dengan *sound sistem* yang cukup besar sehingga magnet yang di hasilkan mempengaruhi sensor kompas. Arah tujuan robot pada pengaplikasiannya dapat bekerja dengan baik, namum jika *heading* pada kompas menunjukkan pada rentang 20° dan 340° pada gambar 4.2 di karenakan batas maksimal dan minimal pada ketentuan robot yang di anggap melenceng, sehingga robot akan melakukan gerakan berbelok ke kiri dan ke kanan secara berulang.



Gambar 4. 2 eror pada posis 0°

Misalkan arah tujuan robot dengan center 12°, dengan max dan min 25° :

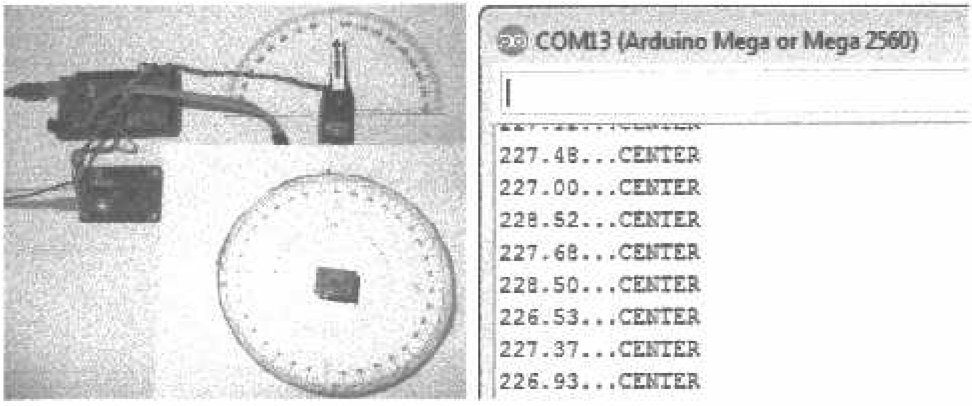
12° max, arah kanan = pada 37°

12° min, arah kiri = pada 0°, kurang 5°

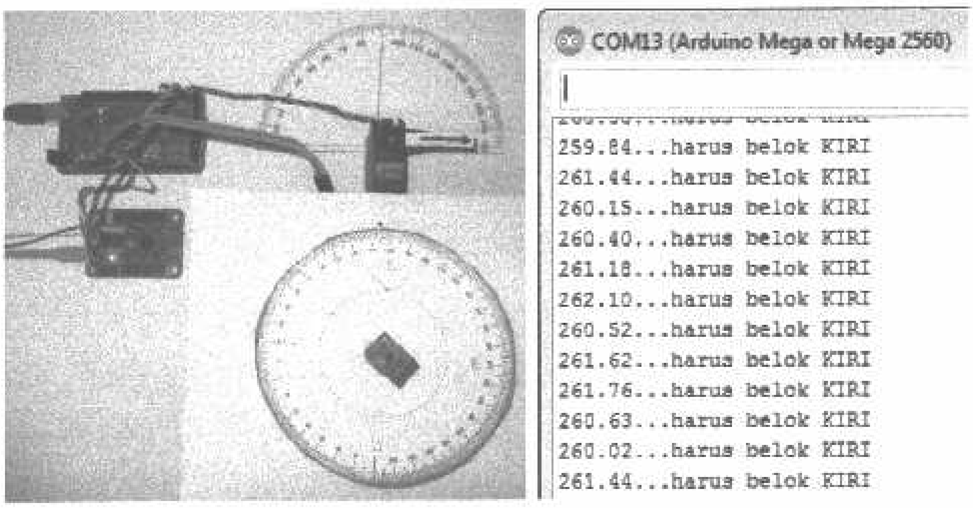
Dengan demikian ketika robot melenceng dengan gerakan berlebihan kompas akan mendeteksi lebih seberang daro 0° yaitu 360° danmengakibatkan robot terus menjalankan garakan belok kiri secara berulang.

4.2 Pengujian Motor Servo Terhadap Sensor Kompas

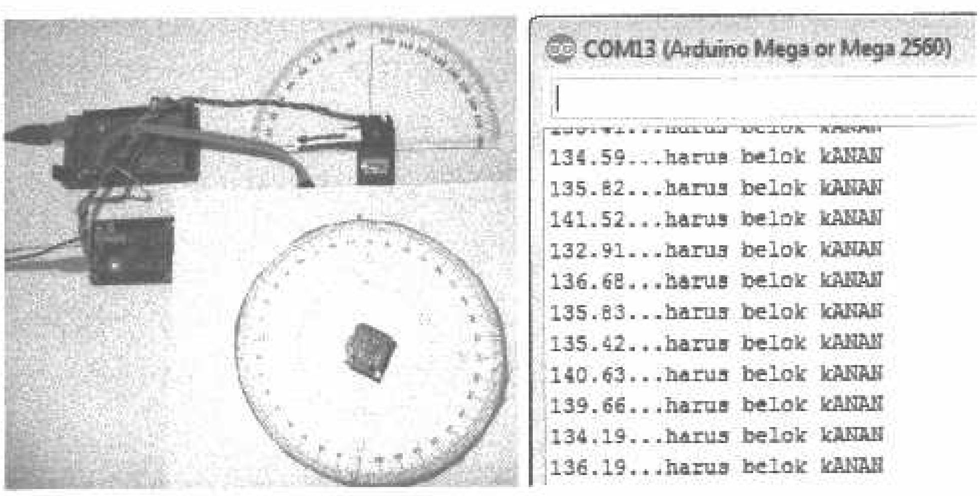
Pengujian motor servo dilakukan menggunakan sensor kompas, arduino mega 25600 dan pengontrol servo USC32. Pengujian ini bertujuan untuk melihat kinerja motor servo terhadap data dari sensor kompas. Dengan data sensor kompas 180° - 240° adalah center, kurang dari 180° belok kiri dan lebih dari 240° adalah belok kanan. Gambar 4.3 menampilkan gerak motor servo keadaan *center* pada saat sensor kompas menunjukkan 180° - 240°, Gambar 4.4 menampilkan gerak motor servo pada saat sensor kompas menunjukkan kurang dari 180°, Gambar 4.5 menampilkan gerak motor servo pada saat sensor kompas menunjukkan lebih dari 240°.



Gambar 4. 3 Motor Servo 90° Data Kompas 180° - 240°.



Gambar 4. 4 Motor Servo 180° Data Kompas lebih dari 240°.



Gambar 4. 5 Motor Servo 0° Data Kompas kurang dari 180°.

4.2.1 Anlisa Pengujian Motor Servo Terhadap Sensor Kompas

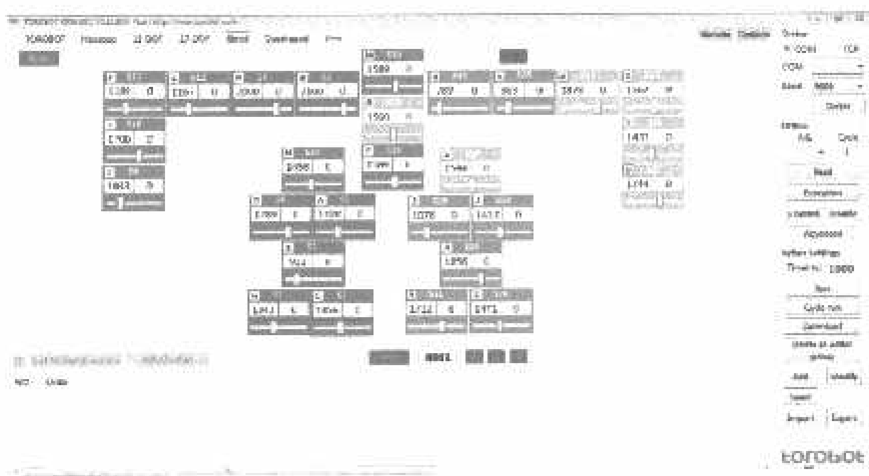
Pengujian motor servo terhadap sensor kompas dilakukan untuk melihat kinerja kompas dan servo yang di program apakah sudah sesuai dengan yang di inginkan. Pada percobaanya sensor kompas telah sesuai dengan derajat di tentukan dan motor servo bergerak sesuai dengan derajat yang di tentukan.

4.3 Initial Value Robot

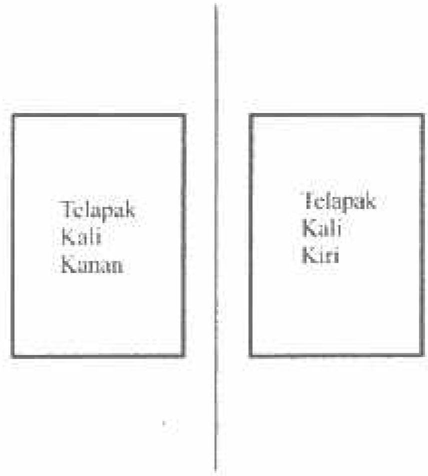
Initial value adalah posisi 0 awal servo yang berfungsi sebagai data posisi awal ketika robot di hidupakan. Posisi *intial value* dalam percobaan tugas akhir ini meliputi *intila value* robot tegak, *intila value* robot setengah jongkok. Data

4.3.1 *Initial Value* Robot tegak

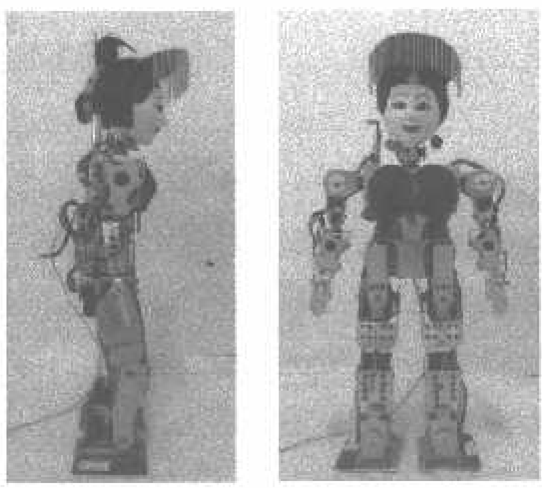
Posisi *initial value* tegak pada pengontrol di tunjukkan pada gambar 4.6 dan gambar 4.7 gambaran telapak kaki *initial value*. Pada tabel 4.4 di tunjukkan posisi servo dengan nilai PWM (*Pulse Width Modulation*) pada setiap motor servo. Gambar 4.8 menunjukkan posisi initial value robot secara nyata dengan tampilan dari sebelah kanan dan depan.



Gambar 4. 6 Tampilan Initial Value robot tegak Pada Pengontrol Motor Servo



Gambar 4. 7 Gambaran Telapak Kaki Initial Value



Gambar 4. 8 menunjukkan posisi initial value robot secara nyata dengan tampilan dari sebelah kanan dan depan.

Tabel 4. 4 Data Posisi *Initial Value* Robot tegak

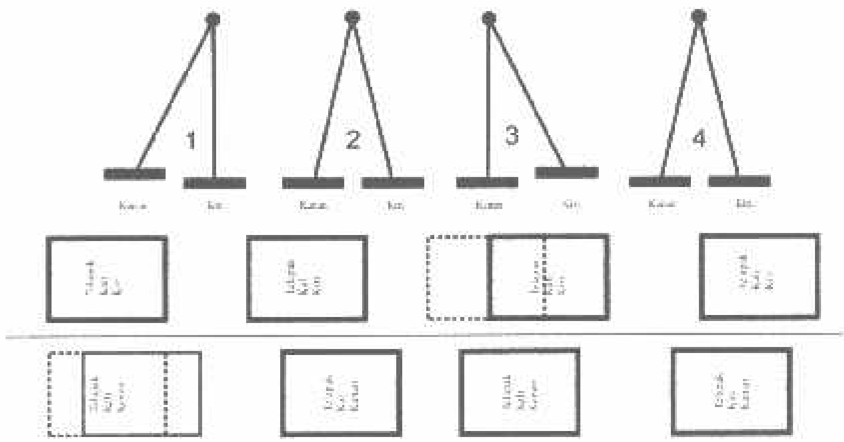
<table>
<tr><th>No Servo</th><th>PWM (μS)</th><th>Waktu (mS)</th><th colspan="2">Keterangan Servo</th></tr>
<tr><td>13</td><td>1589</td><td rowspan="27">1000</td><td colspan="2">kepala</td></tr>
<tr><td>18</td><td>1500</td><td colspan="2">Leher</td></tr>
<tr><td>16</td><td>1589</td><td colspan="2">Pangkal Leher</td></tr>
<tr><td>32</td><td>789</td><td>Dalam</td><td rowspan="2">Bahu kanan</td></tr>
<tr><td>25</td><td>963</td><td>Laur</td></tr>
<tr><td>23</td><td>1878</td><td>Atas</td><td rowspan="2">Siku kanan</td></tr>
<tr><td>24</td><td>1567</td><td>Bawah</td></tr>
<tr><td>22</td><td>1433</td><td colspan="2">Pergelangan tangan kanan</td></tr>
<tr><td>21</td><td>1744</td><td colspan="2">Telapak tangan kanan</td></tr>
<tr><td>2</td><td>2100</td><td>Dalam</td><td rowspan="2">Bahu kiri</td></tr>
<tr><td>8</td><td>2000</td><td>Luar</td></tr>
<tr><td>12</td><td>1167</td><td>Atas</td><td rowspan="2">Siku kiri</td></tr>
<tr><td>11</td><td>1189</td><td>Bawah</td></tr>
<tr><td>10</td><td>1700</td><td colspan="2">Pergelangan tangan kiri</td></tr>
<tr><td>9</td><td>1033</td><td colspan="2">Telapak tangan kanan</td></tr>
<tr><td>19</td><td>1544</td><td colspan="2">Pangkal paha kanan</td></tr>
<tr><td>28</td><td>1078</td><td>Depan</td><td rowspan="2">Paha kanan</td></tr>
<tr><td>29</td><td>1433</td><td>Belakang</td></tr>
<tr><td>30</td><td>1856</td><td colspan="2">Lutut kanan</td></tr>
<tr><td>31</td><td>1722</td><td>Depan</td><td rowspan="2">Telapak kaki kanan</td></tr>
<tr><td>26</td><td>1471</td><td>Belakang</td></tr>
<tr><td>14</td><td>1456</td><td colspan="2">Pangkal paha kiri</td></tr>
<tr><td>4</td><td>1300</td><td>Depan</td><td rowspan="2">Paha kiri</td></tr>
<tr><td>1</td><td>1789</td><td>Belakang</td></tr>
<tr><td>5</td><td>922</td><td colspan="2">Lutut kiri</td></tr>
<tr><td>7</td><td>1456</td><td>Depan</td><td rowspan="2">Telapak kaki kiri</td></tr>
<tr><td>3</td><td>1343</td><td>Belakang</td></tr>
</table>

4.3.1.1 Penerapan Jalan Pada Initial Value Robot Tegak

Pada *initial value* robot tegak dapat di implementasikan konsep jalan yang di rencanakan yaitu dengan konsep *suport poligon*. Pada penerapannya, konsep jalan ini menggunakan dua konsep yang sama namun perbedaannya hanyalah jumlah step.

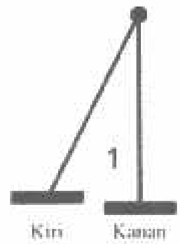
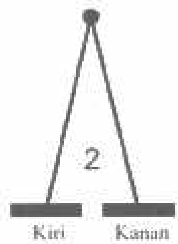
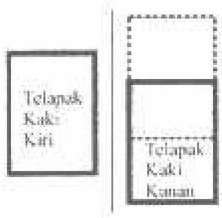
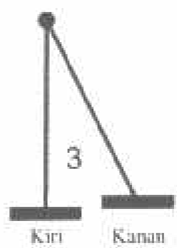
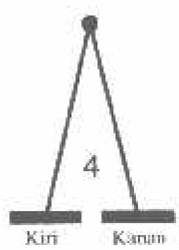
A. Konsep Jalan Empat Step

Secara keseluruhan, konsep jalan dengan empat step ini dapat di lihat dan di tunjukkan pada tabel 4.5. Gambaran keseluruhan kaki robot pada posisi COG (*center of grafity*) di tunjukkan pada gambar 4.9.



Gambar 4. 9 gambaran sistem jalan Empat step tegak

Tabel 4. 5 Konsep Jalan Dengan Empat Step

Step	keterangan	Gambaran Pada Telapak Kaki dan COG (*center of grafity*)		Tampilan Robot Secara Asli
1				
2				
3				
4				

Data nilai PWM (*pulse width mudulation*) pada gerakan per step jalan pada *initial value* robot tegak untuk setiap servo di tunjukkan pada tabel 4.6 untuk step satu, tabel 4.7untuk step dua, tabel 4.8 untuk step tiga, tabel 4.9 untuk step empat.

Tabel 4. 6 Data Nilai PWM Posisi Robot Tegak Step Satu

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589		kepala	
18	1500		Leher	
16	1633		Pangkal Leher	
32	767		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2033		Luar	
12	1167		Atas	Siku kiri
11	1167		Bawah	
10	1700		Pergelangan tangan kiri	
9	1033	700	Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1144		Depan	Paha kanan
29	1344		Belakang	
30	1678		Lutut kanan	
31	1589		Depan	Telapak kaki kanan
26	1344		Belakang	
14	1456		Pangkal paha kiri	
4	1776		Depan	Paha kiri
1	1078		Belakang	
5	1322		Lutut kiri	
7	1322		Depan	Telapak kaki kiri
3	1640		Belakang	

Tabel 4. 7 Data Nilai PWM Posisi Robot Tegak Step Dua

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589		kepala	
18	1500		Leher	
16	1633		Pangkal Leher	
32	767		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2033		Luar	
12	1167		Atas	Siku kiri
11	1167		Bawah	
10	1700	700	Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1078		Depan	Paha kanan
29	1433		Belakang	
30	1567		Lutut kanan	
31	1522		Depan	Telapak kaki kanan
26	1500		Belakang	
14	1456		Pangkal paha kiri	
4	1776		Depan	Paha kiri
1	989		Belakang	
5	1322		Lutut kiri	
7	1335		Depan	Telapak kaki kiri
3	1589		Belakang	

Tabel 4. 8 Data Nilai PWM Posisi Robot Tegak Step Tiga

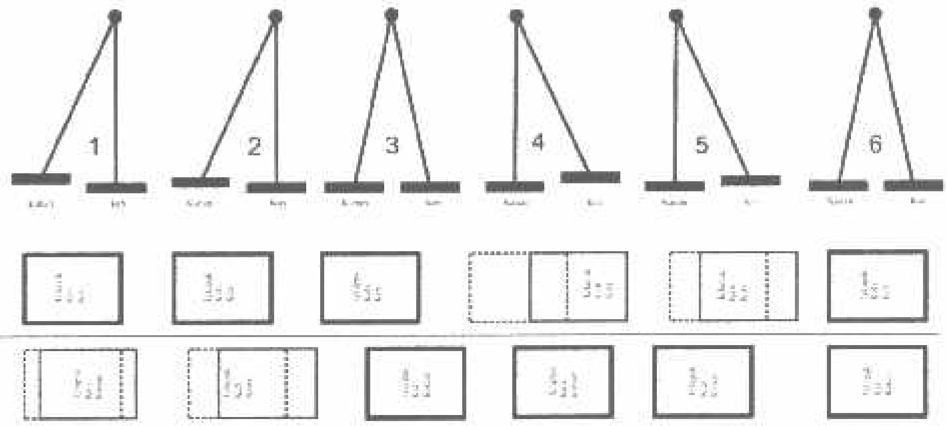
<table>
<tr><th>No Servo</th><th>PWM (μS)</th><th>Waktu (mS)</th><th colspan="2">Keterangan Servo</th></tr>
<tr><td>13</td><td>1589</td><td rowspan="27">700</td><td colspan="2">kepala</td></tr>
<tr><td>18</td><td>1500</td><td colspan="2">Leher</td></tr>
<tr><td>16</td><td>1633</td><td colspan="2">Pangkal Leher</td></tr>
<tr><td>32</td><td>767</td><td>Dalam</td><td rowspan="2">Bahu kanan</td></tr>
<tr><td>25</td><td>963</td><td>Laur</td></tr>
<tr><td>23</td><td>1878</td><td>Atas</td><td rowspan="2">Siku kanan</td></tr>
<tr><td>24</td><td>1567</td><td>Bawah</td></tr>
<tr><td>22</td><td>1433</td><td colspan="2">Pergelangan tangan kanan</td></tr>
<tr><td>21</td><td>1744</td><td colspan="2">Telapak tangan kanan</td></tr>
<tr><td>2</td><td>2233</td><td>Dalam</td><td rowspan="2">Bahu kiri</td></tr>
<tr><td>8</td><td>2033</td><td>Luar</td></tr>
<tr><td>12</td><td>1167</td><td>Atas</td><td rowspan="2">Siku kiri</td></tr>
<tr><td>11</td><td>1167</td><td>Bawah</td></tr>
<tr><td>10</td><td>1700</td><td colspan="2">Pergelangan tangan kiri</td></tr>
<tr><td>9</td><td>1033</td><td colspan="2">Telapak tangan kanan</td></tr>
<tr><td>19</td><td>1544</td><td colspan="2">Pangkal paha kanan</td></tr>
<tr><td>28</td><td>1078</td><td>Depan</td><td rowspan="2">Paha kanan</td></tr>
<tr><td>29</td><td>1433</td><td>Belakang</td></tr>
<tr><td>30</td><td>1500</td><td colspan="2">Lutut kanan</td></tr>
<tr><td>31</td><td>1611</td><td>Depan</td><td rowspan="2">Telapak kaki kanan</td></tr>
<tr><td>26</td><td>1589</td><td>Belakang</td></tr>
<tr><td>14</td><td>1456</td><td colspan="2">Pangkal paha kiri</td></tr>
<tr><td>4</td><td>1833</td><td>Depan</td><td rowspan="2">Paha kiri</td></tr>
<tr><td>1</td><td>1211</td><td>Belakang</td></tr>
<tr><td>5</td><td>1078</td><td colspan="2">Lutut kiri</td></tr>
<tr><td>7</td><td>1456</td><td>Depan</td><td rowspan="2">Telapak kaki kiri</td></tr>
<tr><td>3</td><td>1567</td><td>Belakang</td></tr>
</table>

Tabel 4. 9 Data Nilai PWM Posisi Robot Tegak Step Empat

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589		kepala	
18	1500		Leher	
16	1633		Pangkal Leher	
32	767		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2033		Luar	
12	1167		Atas	Siku kiri
11	1167		Bawah	
10	1700	700	Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1078		Depan	Paha kanan
29	1433		Belakang	
30	1500		Lutut kanan	
31	1662		Depan	Telapak kaki kanan
26	1478		Belakang	
14	1456		Pangkal paha kiri	
4	1776		Depan	Paha kiri
1	1078		Belakang	
5	1233		Lutut kiri	
7	1344		Depan	Telapak kaki kiri
3	1611		Belakang	

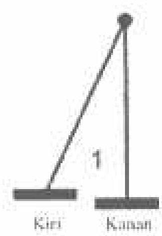
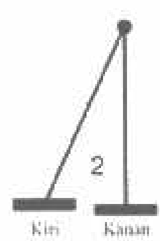
B. Konsep Jalan Enam Step

Secara gambaran, konsep jalan dengan enam step ini ditunjukkan pada tabel 4.10 dan di lihat melalui telapak kaki robot. Gambaran keseluruhan kaki robot pada posisi COG (*center of grafity*) di tunjukkan pada gambar 4.10.

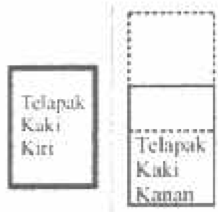
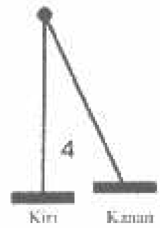
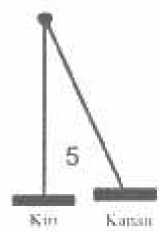
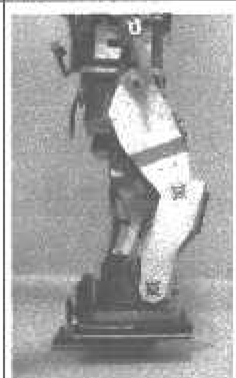
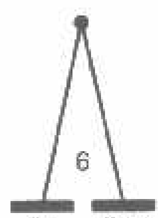


Gambar 4. 10 gambaran Sistem Jalan Tegak Empat Step

Tabel 4. 10 Konsep Jalan Dengan Enam Step

Step	Keterangan	Gambaran Pada Telapak Kaki dan COG (*center of grafity*)		Tampilan Robot Secara Asli
1				
2				

Lanjutan tabel 4.10

3				
4				
5				
6				

Data nilai PWM (*pulse width mudulation*) pada gerakan per step jalan pada initial value robot tegak untuk setiap servo di tunjukkan pada tabel 4.11 untuk step satu, tabel 4.12 untuk step dua, tabel 4.13 untuk step tiga, tabel 4.14 untuk step empat, tabel 4.15 untuk step lima, tabel 4.16 untuk step enam.

Tabel 4. 11 Data Nilai PWM Posisi Robot Tegak Step Satu

No Servo	**PWM** (μS)	**Waktu** (mS)	**Keterangan Servo**	
13	1589		kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	789		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2000		Luar	
12	1167		Atas	Siku kiri
11	1478		Bawah	
10	1700	700	Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1144		Depan	Paha kanan
29	1433		Belakang	
30	1678		Lutut kanan	
31	1544		Depan	Telapak kaki kanan
26	1344		Belakang	
14	1456		Pangkal paha kiri	
4	1776		Depan	Paha kiri
1	1078		Belakang	
5	1322		Lutut kiri	
7	1211		Depan	Telapak kaki kiri
3	1640		Belakang	

Tabel 4. 12 Data Nilai PWM Posisi Robot Tegak Step Dua

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	700	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	789		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2000		Luar	
12	1167		Atas	Siku kiri
11	1478		Bawah	
10	1700		Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1144		Depan	Paha kanan
29	1433		Belakang	
30	1678		Lutut kanan	
31	1544		Depan	Telapak kaki kanan
26	1344		Belakang	
14	1456		Pangkal paha kiri	
4	1776		Depan	Paha kiri
1	1056		Belakang	
5	1322		Lutut kiri	
7	1211		Depan	Telapak kaki kiri
3	1633		Belakang	

Tabel 4. 13 Data Nilai PWM Posisi Robot Tegak Step Tiga

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589		kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	789		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2000		Luar	
12	1167		Atas	Siku kiri
11	1478		Bawah	
10	1700	700	Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1144		Depan	Paha kanan
29	1433		Belakang	
30	1500		Lutut kanan	
31	1597		Depan	Telapak kaki kanan
26	1611		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1211		Belakang	
5	1078		Lutut kiri	
7	1456		Depan	Telapak kaki kiri
3	1567		Belakang	

Tabel 4. 14 Data Nilai PWM Posisi Robot Tegak Step Empat

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	700	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	789		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2000		Luar	
12	1167		Atas	Siku kiri
11	1478		Bawah	
10	1700		Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1144		Depan	Paha kanan
29	1433		Belakang	
30	1500		Lutut kanan	
31	1597		Depan	Telapak kaki kanan
26	1611		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1211		Belakang	
5	1078		Lutut kiri	
7	1456		Depan	Telapak kaki kiri
3	1567		Belakang	

Tabel 4. 15 Data Nilai PWM Posisi Robot Tegak Step Lima

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	700	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	789		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2000		Luar	
12	1167		Atas	Siku kiri
11	1478		Bawah	
10	1700		Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1322		Depan	Paha kanan
29	1433		Belakang	
30	1500		Lutut kanan	
31	1589		Depan	Telapak kaki kanan
26	1611		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1233		Belakang	
5	1078		Lutut kiri	
7	1456		Depan	Telapak kaki kiri
3	1567		Belakang	

Tabel 4. 16 Data Nilai PWM Posisi Robot Tegak Step Enam

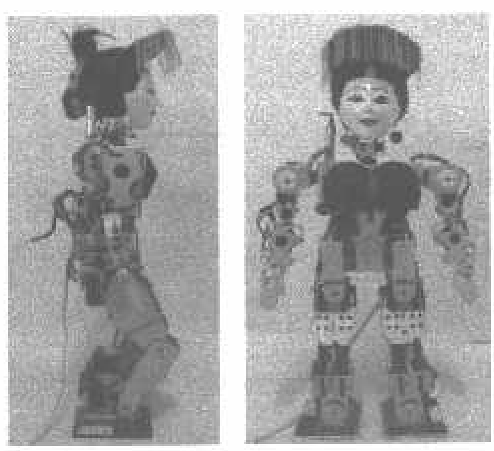
No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	700	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	789		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2233		Dalam	Bahu kiri
8	2000		Luar	
12	1167		Atas	Siku kiri
11	1478		Bawah	
10	1700		Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1344		Depan	Paha kanan
29	1433		Belakang	
30	1500		Lutut kanan	
31	1611		Depan	Telapak kaki kanan
26	1500		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1167		Belakang	
5	1189		Lutut kiri	
7	1367		Depan	Telapak kaki kiri
3	1611		Belakang	

4.3.2 *Initial Value* Robot Setengah Jongkok

Posisi *initial value* setengah jongkok pda pengontrol di tunjukkan pada gambar 4.11, gambar 4.12 merupakan gambaran telapak kaki *initial value* dan Posisi *Initial Value* Robot Setengah Jongkok Secara Nyata di tunjukkan pada gambar 4.13. Pada tabel 4.17 di tunjukkan posisi servo dengan nilai PWM (*Pulse Width Modulation*) pada setiap motor servo.

Gambar 4. 11 Tampilan Initial Value robot setengah jongkok Pada Pengontrol Motor Servo.

Gambar 4. 12 Gambaran Telapak Kaki Initial Value



Gambar 4. 13 Posisi Initial Value Robot Setengah Jongkok Secara Nyata

Tabel 4. 17 Data Posisi Initial Value Robot Setengah Jongkok

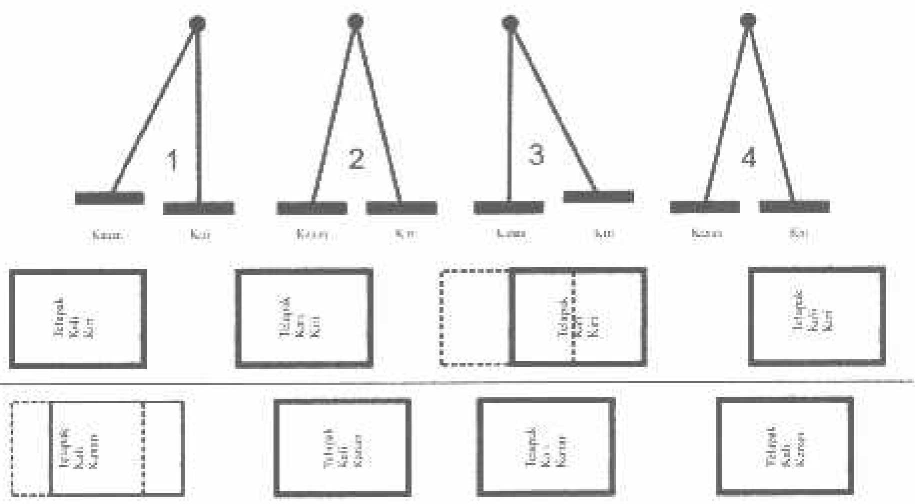
No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	1000	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	789		Dalam	Bahu kanan
25	963		Laur	
23	1878		Atas	Siku kanan
24	1567		Bawah	
22	1433		Pergelangan tangan kanan	
21	1744		Telapak tangan kanan	
2	2100		Dalam	Bahu kiri
8	2000		Luar	
12	1167		Atas	Siku kiri
11	1189		Bawah	
10	1700		Pergelangan tangan kiri	
9	1033		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1078		Depan	Paha kanan
29	1433		Belakang	
30	1856		Lutut kanan	
31	1722		Depan	Telapak kaki kanan
26	1471		Belakang	
14	1456		Pangkal paha kiri	
4	1300		Depan	Paha kiri
1	1789		Belakang	
5	922		Lutut kiri	
7	1456		Depan	Telapak kaki kiri
3	1343		Belakang	

4.3.2.1 Penerapan Jalan Pada Initial Value Robot Setengan Jongkok

Pada *initial value* robot setengah jongkok dapat di implementasikan konsep jalan yang di rencanakan yaitu *suport poligon*. Pada penerapannya, konsep jalan ini menggunakan dua konsep yang sama namun perbedaannya hanyalah jumlah step.

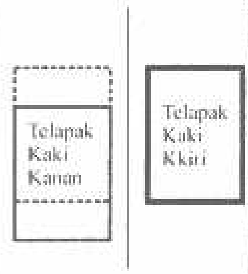
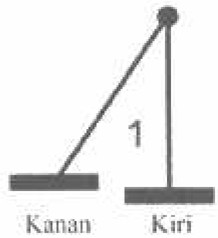
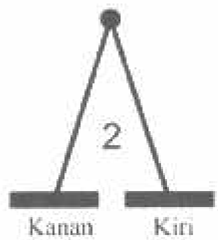
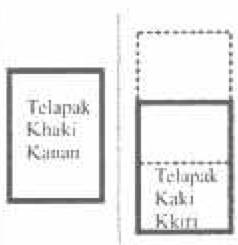
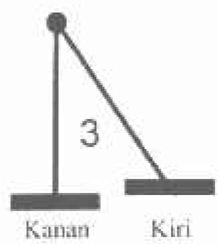
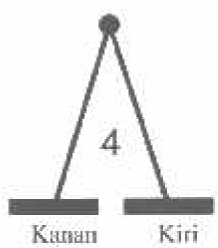
A. Konsep Jalan Empat Step

Secara keseluruhan, konsep jalan dengan empat step ini dapat di lihat pada gambar 4.14 dan di tunjukkan pada tabel 4.18.



Gambar 4. 14 Gambaran Sistem Jalan 4 Setengah Jongkok

Tabel 4. 18 Konsep Jalan Dengan Empat Step

step	keterangan	Gambaran Pada Telapak Kaki dan COG		Tampilan Robot Secara Asli
1				
2				
3				
4				

Data nilai PWM (*pulse width mudulation*) pada gerakan per step jalan pada *initial value* robot tegak untuk setiap servo di tunjukkan pada tabel 4.19 untuk step satu, tabel 4.20 untuk step dua, tabel 4.21 untuk step tiga, tabel 4.22 untuk step empat.

Tabel 4. 19 Data Nilai PWM Posisi Robot Setengah Jongkok Step Satu

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589		kepala	
18	1500		Leher	
16	1567		Pangkal Leher	
32	878		Dalam	Bahu kanan
25	922		Laur	
23	1878		Atas	Siku kanan
24	967		Bawah	
22	1433		Pergelangan tangan kanan	
21	1722		Telapak tangan kanan	
2	2500		Dalam	Bahu kiri
8	2000		Luar	
12	1143		Atas	Siku kiri
11	1989		Bawah	
10	1700	1000	Pergelangan tangan kiri	
9	989		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1078		Depan	Paha kanan
29	1433		Belakang	
30	1856		Lutut kanan	
31	1744		Depan	Telapak kaki kanan
26	1611		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1367		Belakang	
5	947		Lutut kiri	
7	1389		Depan	Telapak kaki kiri
3	1544		Belakang	

Tabel 4. 20 Data Nilai PWM Posisi Robot Setengah Jongkok Step Dua

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	1000	kepala	
18	1500		Leher	
16	1567		Pangkal Leher	
32	878		Dalam	Bahu kanan
25	922		Laur	
23	1878		Atas	Siku kanan
24	967		Bawah	
22	1433		Pergelangan tangan kanan	
21	1722		Telapak tangan kanan	
2	2500		Dalam	Bahu kiri
8	2000		Luar	
12	1143		Atas	Siku kiri
11	1989		Bawah	
10	1700		Pergelangan tangan kiri	
9	989		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1144		Depan	Paha kanan
29	1478		Belakang	
30	1856		Lutut kanan	
31	1789		Depan	Telapak kaki kanan
26	1544		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1322		Belakang	
5	944		Lutut kiri	
7	1367		Depan	Telapak kaki kiri
3	1500		Belakang	

Tabel 4. 21 Data Nilai PWM Posisi Robot Setengah Jongkok Step tiga

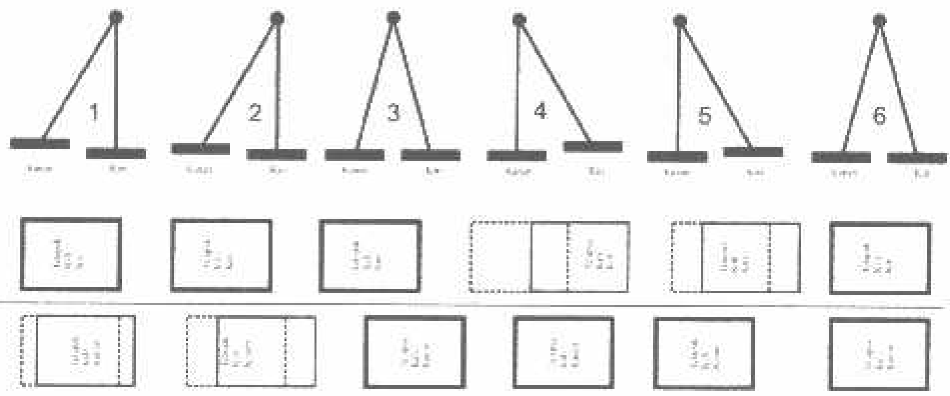
No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	1000	kepala	
18	1500		Leher	
16	1567		Pangkal Leher	
32	878		Dalam	Bahu kanan
25	922		Laur	
23	1878		Atas	Siku kanan
24	967		Bawah	
22	1433		Pergelangan tangan kanan	
21	1722		Telapak tangan kanan	
2	2500		Dalam	Bahu kiri
8	2000		Luar	
12	1143		Atas	Siku kiri
11	1989		Bawah	
10	1700		Pergelangan tangan kiri	
9	989		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	944		Depan	Paha kanan
29	1389		Belakang	
30	1922		Lutut kanan	
31	1656		Depan	Telapak kaki kanan
26	1344		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1322		Belakang	
5	922		Lutut kiri	
7	1213		Depan	Telapak kaki kiri
3	1433		Belakang	

Tabel 4. 22 Data Nilai PWM Posisi Robot Setengah Jongkok Step empat

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	1000	kepala	
18	1500		Leher	
16	1567		Pangkal Leher	
32	878		Dalam	Bahu kanan
25	922		Laur	
23	1878		Atas	Siku kanan
24	967		Bawah	
22	1433		Pergelangan tangan kanan	
21	1722		Telapak tangan kanan	
2	2500		Dalam	Bahu kiri
8	2000		Luar	
12	1143		Atas	Siku kiri
11	1989		Bawah	
10	1700		Pergelangan tangan kiri	
9	989		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1033		Depan	Paha kanan
29	1433		Belakang	
30	1856		Lutut kanan	
31	1678		Depan	Telapak kaki kanan
26	1456		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1233		Belakang	
5	922		Lutut kiri	
7	1344		Depan	Telapak kaki kiri
3	1389		Belakang	

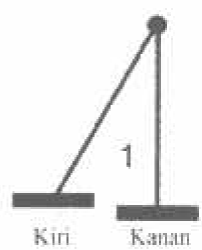
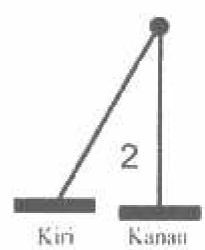
B. Konsep Jalan Enam Step

Secara gambaran, konsep jalan dengan enam step ini ditunjukkan pada tabel 4.23 dan di lihat melalui telapak kaki robot. Gambaran keseluruhan kaki robot pada posisi COG (*center of grafity*) di tunjukkan pada gambar 4.15.

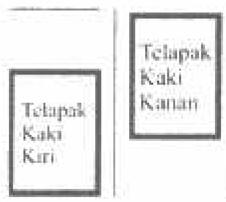
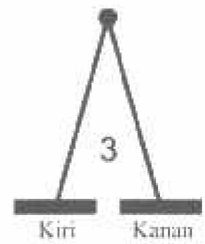
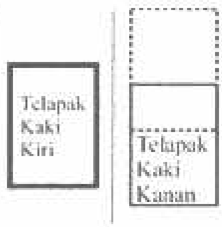
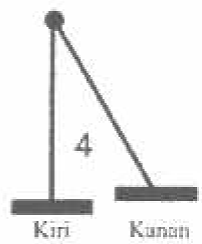
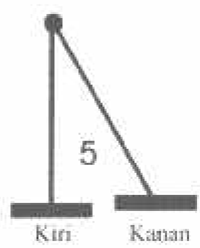
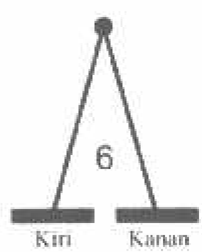


Gambar 4. 15 Gambaran Sistem Jalan Enam Step

Tabel 4. 23 Konsep Jalan Dengan Enam Step

Step	Keterangan	Gambaran Pada Telapak Kaki dan COG (*center of grafity*)		Tampilan Robot Secara Asli
1				
2				

Lanjutan tabel 4.23

3		 	 	
4		 	 	
5		 	 	
6		 	 	

Data nilai PWM (*pulse width mudulation*) pada gerakan per step jalan pada *initial value* robot tegak untuk setiap servo di tunjukkan pada tabel 4.24 untuk step satu, tabel 4.25 untuk step dua, tabel 4.26 untuk step tiga, tabel 4.27 untuk step empat, tabel 4.28 untuk step lima, tabel 4.29 untuk step enam.

Tabel 4. 24 Data Nilai PWM Posisi Robot Setengah Jongkok Step Satu

No Servo	**PWM** (μS)	**Waktu** (mS)	**Keterangan Servo**	
13	1589		kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	522		Dalam	Bahu kanan
25	967		Laur	
23	1878		Atas	Siku kanan
24	856		Bawah	
22	1433		Pergelangan tangan kanan	
21	1411		Telapak tangan kanan	
2	2411		Dalam	Bahu kiri
8	2011		Luar	
12	1189		Atas	Siku kiri
11	1922		Bawah	
10	1678	700	Pergelangan tangan kiri	
9	1456		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1100		Depan	Paha kanan
29	1389		Belakang	
30	1900		Lutut kanan	
31	1789		Depan	Telapak kaki kanan
26	1389		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1278		Belakang	
5	922		Lutut kiri	
7	1224		Depan	Telapak kaki kiri
3	1411		Belakang	

Tabel 4. 25 Data Nilai PWM Posisi Robot Setengah Jongkok Step Dua

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	400	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	522		Dalam	Bahu kanan
25	967		Laur	
23	1878		Atas	Siku kanan
24	856		Bawah	
22	1433		Pergelangan tangan kanan	
21	1411		Telapak tangan kanan	
2	2411		Dalam	Bahu kiri
8	2011		Luar	
12	1189		Atas	Siku kiri
11	1922		Bawah	
10	1678		Pergelangan tangan kiri	
9	1456		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	944		Depan	Paha kanan
29	1433		Belakang	
30	1856		Lutut kanan	
31	1611		Depan	Telapak kaki kanan
26	1456		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1300		Belakang	
5	922		Lutut kiri	
7	1233		Depan	Telapak kaki kiri
3	1424		Belakang	

Tabel 4. 26 Data Nilai PWM Posisi Robot Setengah Jongkok Step tiga

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	600	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	522		Dalam	Bahu kanan
25	967		Laur	
23	1878		Atas	Siku kanan
24	856		Bawah	
22	1433		Pergelangan tangan kanan	
21	1411		Telapak tangan kanan	
2	2411		Dalam	Bahu kiri
8	2011		Luar	
12	1189		Atas	Siku kiri
11	1922		Bawah	
10	1678		Pergelangan tangan kiri	
9	1456		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	961		Depan	Paha kanan
29	1433		Belakang	
30	1856		Lutut kanan	
31	1666		Depan	Telapak kaki kanan
26	1492		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1300		Belakang	
5	922		Lutut kiri	
7	1235		Depan	Telapak kaki kiri
3	1411		Belakang	

Tabel 4. 27 Data Nilai PWM Posisi Robot Setengah Jongkok Step empat

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	700	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	522		Dalam	Bahu kanan
25	967		Laur	
23	1878		Atas	Siku kanan
24	856		Bawah	
22	1433		Pergelangan tangan kanan	
21	1411		Telapak tangan kanan	
2	2411		Dalam	Bahu kiri
8	2011		Luar	
12	1189		Atas	Siku kiri
11	1922		Bawah	
10	1678		Pergelangan tangan kiri	
9	1456		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1078		Depan	Paha kanan
29	1433		Belakang	
30	1856		Lutut kanan	
31	1744		Depan	Telapak kaki kanan
26	1589		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1300		Belakang	
5	833		Lutut kiri	
7	1433		Depan	Telapak kaki kiri
3	1367		Belakang	

Tabel 4. 28 Data Nilai PWM Posisi Robot Setengah Jongkok Step Lima

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	500	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	522		Dalam	Bahu kanan
25	967		Laur	
23	1878		Atas	Siku kanan
24	856		Bawah	
22	1433		Pergelangan tangan kanan	
21	1411		Telapak tangan kanan	
2	2411		Dalam	Bahu kiri
8	2011		Luar	
12	1189		Atas	Siku kiri
11	1922		Bawah	
10	1678		Pergelangan tangan kiri	
9	1456		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1101		Depan	Paha kanan
29	1433		Belakang	
30	1856		Lutut kanan	
31	1759		Depan	Telapak kaki kanan
26	1581		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1411		Belakang	
5	944		Lutut kiri	
7	1411		Depan	Telapak kaki kiri
3	1594		Belakang	

Tabel 4. 29 Data Nilai PWM Posisi Robot Setengah Jongkok Step Enam

No Servo	PWM (μS)	Waktu (mS)	Keterangan Servo	
13	1589	700	kepala	
18	1500		Leher	
16	1589		Pangkal Leher	
32	522		Dalam	Bahu kanan
25	967		Laur	
23	1878		Atas	Siku kanan
24	856		Bawah	
22	1433		Pergelangan tangan kanan	
21	1411		Telapak tangan kanan	
2	2411		Dalam	Bahu kiri
8	2011		Luar	
12	1189		Atas	Siku kiri
11	1922		Bawah	
10	1678		Pergelangan tangan kiri	
9	1456		Telapak tangan kanan	
19	1544		Pangkal paha kanan	
28	1101		Depan	Paha kanan
29	1433		Belakang	
30	1856		Lutut kanan	
31	1789		Depan	Telapak kaki kanan
26	1491		Belakang	
14	1456		Pangkal paha kiri	
4	1789		Depan	Paha kiri
1	1411		Belakang	
5	944		Lutut kiri	
7	1344		Depan	Telapak kaki kiri
3	1544		Belakang	

4.3.3 Analisa *Initial* Value dan Konsep Jalan Robot

Initial value di gunakan pada awal ketika robot di hidupkan atau sebagai posisi 0. *Initial* value akan membuat robot berdiri dengan *delay* sebelum robot melakukan gerakan jalan. Konsep jalan robot tegak dan setengah jongkok pada dasarnya sama hanya berbeda pada jumlah stepnya.

4.3.3.1 Jalan Robot Tegak

Pada keadaan jalan tegak empat step, ketika robot berjalan banyak mengalami guncangan sehingga robot tidak stabil dan sangat mempengaruhi ketika robot berjalan.

Begitu juga pada jalan tegak enam step, yang berbeda adalah langkah robot di tambah dua step pada saat kaki akan mengayunkan langkah ke depan. Pada enam step posisi tegak ini jalan robot sedikit meredam guncangan sehingga sedikit lebih stabil dalam berjalan.

4.3.3.2 Jalan Robot Setengah Jongkok

Pada jalan robot setengah jongkok empat step lebih stabil di bandingkan dengan posisi tegak. Posisi setengan jongkok lebih stabil di karenakan guncangan yang lebih kecil akibat gerakan robot. Posisi jalan setengah jongkok dengan empat step ini masih mengalami beberapa gesekan telapak kaki dengan lantai pada saat kaki melangkah maju sehingga menyebabkan jalan banyak mengalami pembelokan.

Jalan setengah jongkok dengan enam step sejauh percobaan merupakan jalan yang terbaik. Dengan enam step ini, kasus pada empat step ketika terjadi gesekan telapak kaki dengan lantai dapat di hilankan sehingga jalan lebih stabil dan lurus.

4.4 Gerakan Belok Robot

Gerakan belok robot ini adalah gerak robot yang berfungsi untuk mengarahkan robot ketika berjalan dan mengalami perbelokan dari arah lurus yang telah di tentukan. Demikian juga gerakan pada jalan robot, untuk data ini di peroleh dari posisi nomer servo, nilai PWM (*pulse widh modulation*), dan kecepatan eksekusi data per step yang berasal dari *software* USC32 torobot.

4.4.1 Data Gerakan Belok kanan Tegak

Data gerakan dari USC32 torobot untuk robot belok kanan tegak ditunjukkan pada tabel 4.30.

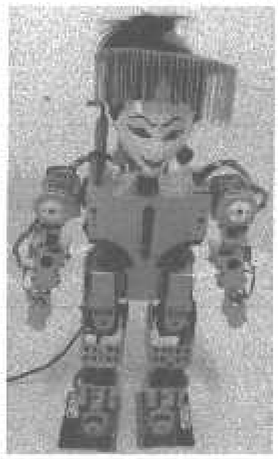
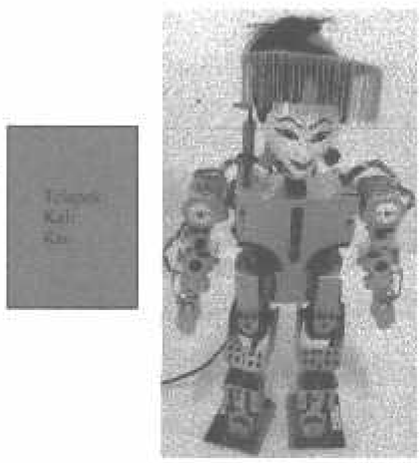
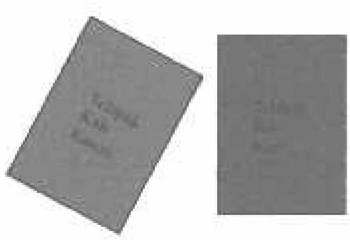
Tabel 4. 30 Data Gerakan Belok kanan Tegak

Step	Data Dari USC32 torobot	Keterangan
1	#1P1091#2P2233#3P1672#4P1789#5P1300#7P1370#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1456#16P1589#18P1433#19P1544#21P1789#22P1433#23P1878#24P1567#25P943#26P1548#28P1278#29P1433#30P1500#31P1554#32P789T700	Contoh : pada data #32P789T700. Data # menyatakan urutan servo. Data P menyatakan jumlah PWM dengn rntang 500 - 2500. Data T menyatakan kecepatan eksekusi data dengan rentang 100 – 9999.
2	#1P1091#2P2233#3P1678#4P1789#5P1300#7P1367#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1278#16P1589#18P1433#19P1544#21P1789#22P1433#23P1878#24P1567#25P943#26P1548#28P1278#29P1433#30P1500#31P1554#32P789T700	
3	#1P1091#2P2233#3P1656#4P1789#5P1300#7P1256#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1278#16P1589#18P1433#19P1544#21P1789#22P1433#23P1878#24P1567#25P943#26P1344#28P1278#29P1433#30P1500#31P1544#32P789T700	
4	#1P1091#2P2233#3P1656#4P1789#5P1300#7P1256#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1478#16P1589#18P1433#19P1544#21P1789#22P1433#23P1878#24P1567#25P943#26P1367#28P1278#29P1433#30P1500#31P1544#32P789T700	
5	#1P1091#2P2233#3P1656#4P1789#5P1300#7P1278#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1478#16P1589#18P1433#19P1544#21P1789#22P1433#23P1878#24P1567#25P943#26P1456#28P1278#29P1433#30P1500#31P1544#32P789T700	

4.4.1.1 Gerakan belok Kanan Tegak

Secara nyata, gerakan belok kanan robot posisi tegak di tunjukkan pada tabel 4.31.

Tabel 4. 31 Gerakan belok Kanan Tegak Secara Gambaran dan Nyata

Step	Gambar gerak robot		keterangan
1			Warna merah merupakan COG (*center og grafity*). Warna hijau telapak sedikit mengangkat miring. Warna putih tanpa beban.
2			
3			

Lanjut tabel 4.31

<table>
<tr><td>4</td><td> </td><td rowspan="2">Warna merah merupakan posisi COG (center og grafity).

Warna hijau pada keadaan telapak sedikit mengangkat miring.

Warna putih pada keadaan tanpa beban.</td></tr>
<tr><td>5</td><td> </td></tr>
</table>

4.4.2 Data Gerakan Belok Kiri Tegak

Data gerakan dari USC32 torobot untuk robot belok kiri tegak ditunjukkan pada tabel 4.32.

Tabel 4. 32 Data Gerakan Belok Kiri Tegak

<table>
<tr><th>Step</th><th>Data Dari USC32 torobot</th><th>Keterangan</th></tr>
<tr><td>1</td><td>#1P1091#2P2233#3P1658#4P1789#5P1300#7P1278#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1456#16P1589#18P1433#19P1544#21P1789#22P1433#23P1878#24P1567#25P943#26P1450#28P1278#29P1433#30P1500#31P1554#32P789T600</td><td rowspan="6">Contoh :
pada data #32P789T700.

Data # menyatakan urutan servo.

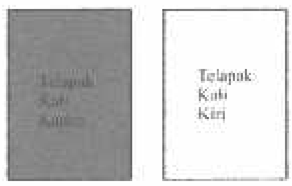
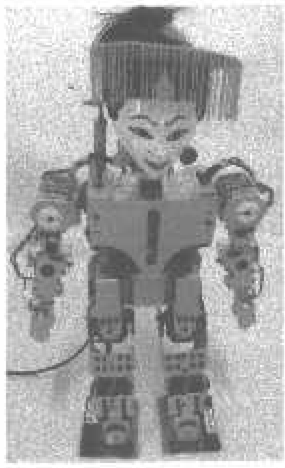
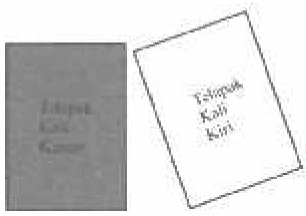
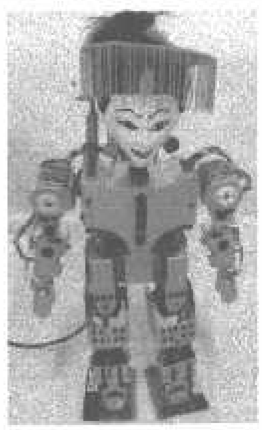
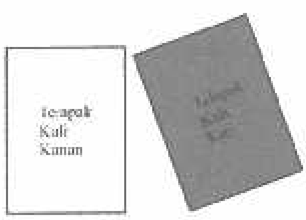
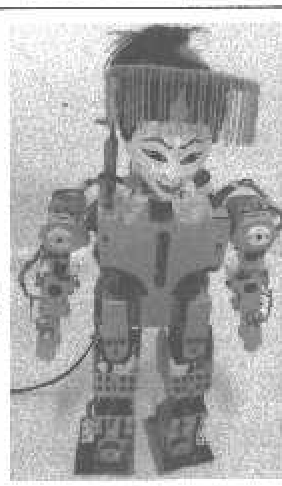
Data P menyatakan jumlah PWM dengn rntang 500 - 2500.

Data T menyatakan kecepatan eksekusi data dengan rentang 100 – 9999.</td></tr>
<tr><td>2</td><td>#1P1091#2P2233#3P1658#4P1789#5P1300#7P1278#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1456#16P1589#18P1433#19P1666#21P1789#22P1433#23P1878#24P1567#25P943#26P1450#28P1278#29P1433#30P1500#31P1554#32P789T600</td></tr>
<tr><td>3</td><td>#1P1091#2P2233#3P1674#4P1789#5P1300#7P1349#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1456#16P1589#18P1433#19P1666#21P1789#22P1433#23P1878#24P1567#25P943#26P1540#28P1278#29P1433#30P1500#31P1580#32P789T600</td></tr>
<tr><td>4</td><td>#1P1091#2P2233#3P1647#4P1789#5P1300#7P1349#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1713#16P1589#18P1433#19P1666#21P1789#22P1433#23P1878#24P1567#25P943#26P1540#28P1278#29P1433#30P1500#31P1580#32P789T600</td></tr>
<tr><td>5</td><td>#1P1091#2P2233#3P1666#4P1789#5P1300#7P1256#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1713#16P1589#18P1433#19P1666#21P1789#22P1433#23P1878#24P1567#25P943#26P1389#28P1278#29P1433#30P1500#31P1547#32P789T600</td></tr>
<tr><td>6</td><td>#1P1091#2P2233#3P1634#4P1789#5P1300#7P1256#8P1998#9P922#10P1700#11P1478#12P1167#13P1422#14P1456#16P1589#18P1433#19P1589#21P1789#22P1433#23P1878#24P1567#25P943#26P1432#28P1278#29P1433#30P1500#31P1547#32P789T600</td></tr>
</table>

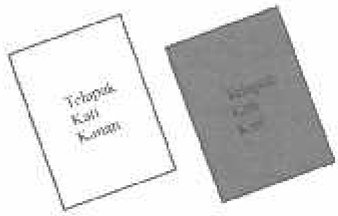
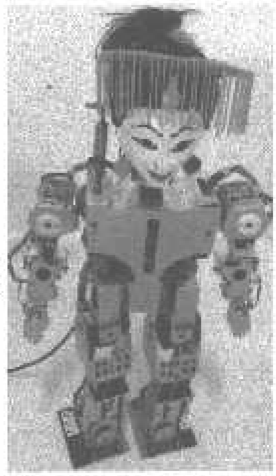
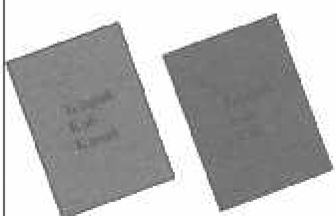
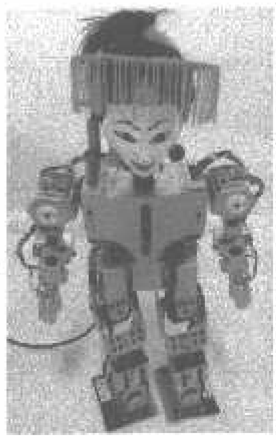
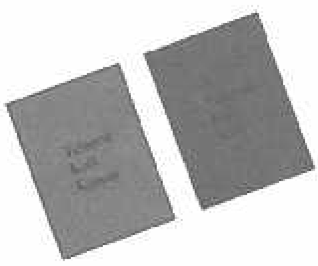
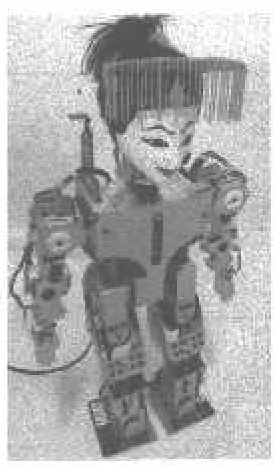
4.4.2.1 Gerakan belok Kiri Tegak

Secara nyata, gerakan belok kiri robot posisi tegak di tunjukkan pada tabel 4.33.

Tabel 4. 33 Gerakan belok Kiri Tegak Secara Gambaran dan Nyata

Step	Gambar gerak robot		keterangan
1			Warna merah merupakan posisi COG (*center og grafity*). Warna hijau pada keadaan telapak sedikit mengangkat miring. Warna putih tanpa beban.
2			
3			

Lanjut tabel 4.33

4	 	Warna merah merupakan posisi COG (*center og grafity*). Warna hijau pada keadaan telapak sedikit mengangkat miring. Warna putih tanpa beban.
5	 	
6	 	

4.4.3 Data Gerakan Belok kanan Setengah Jongkok

Data gerakan dari USC32 torobot untuk robot belok kanan setengah jongkok ditunjukkan pada tabel 4.34.

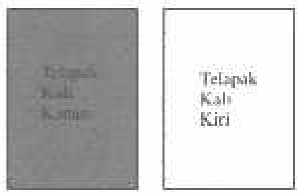
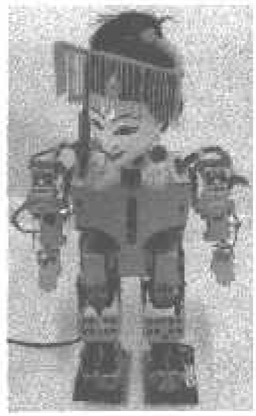
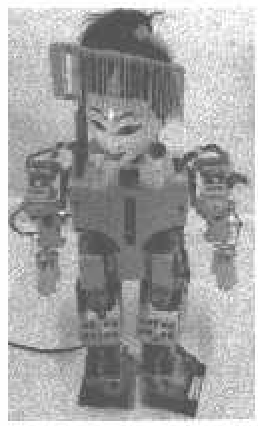
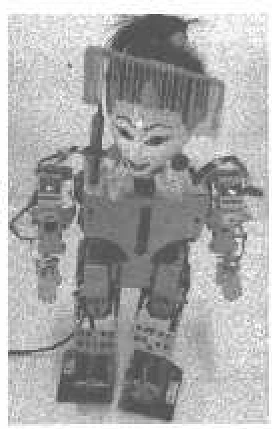
Tabel 4. 34 Data Gerakan Belok Kanan Setengah jongkok

Step	Data Dari USC32 torobot	Keterangan
1	#1P1300#2P2500#3P1433#4P1789#5P922#7P1278#8P2056#9P1211#10P1700#11P1989#12P1152#13P1411#14P1456#16P1856#18P1500#19P1544#21P1411#22P1433#23P1878#24P967#25P967#26P1456#28P1078#29P1433#30P1856#31P1722#32P500T300	Contoh : pada data #32P789T700. Data # menyatakan urutan servo. Data P menyatakan jumlah PWM dengn rntang 500 - 2500. Data T menyatakan kecepatan eksekusi data dengan rentang 100 – 9999.
2	#1P1300#2P2500#3P1433#4P1789#5P922#7P1256#8P2056#9P1211#10P1700#11P1989#12P1152#13P1411#14P1456#16P1767#18P1500#19P1367#21P1522#22P1433#23P1878#24P967#25P967#26P1433#28P1078#29P1411#30P1856#31P1722#32P500T300	
3	#1P1211#2P2500#3P1389#4P1789#5P922#7P1367#8P2056#9P1211#10P1700#11P1989#12P1152#13P1411#14P1456#16P1811#18P1500#19P1344#21P1456#22P1433#23P1878#24P967#25P967#26P1565#28P1078#29P1411#30P1856#31P1722#32P500T500	
4	#1P1233#2P2500#3P1456#4P1789#5P922#7P1366#8P2056#9P1211#10P1700#11P1989#12P1152#13P1411#14P1300#16P1900#18P1500#19P1411#21P1544#22P1433#23P1878#24P967#25P967#26P1544#28P1078#29P1411#30P1856#31P1722#32P500T300	
5	#1P1256#2P2500#3P1433#4P1789#5P922#7P1367#8P2056#9P1211#10P1700#11P1989#12P1152#13P1411#14P1300#16P1856#18P1500#19P1411#21P1544#22P1433#23P1878#24P967#25P967#26P1522#28P1078#29P1411#30P1856#31P1722#32P500T250	

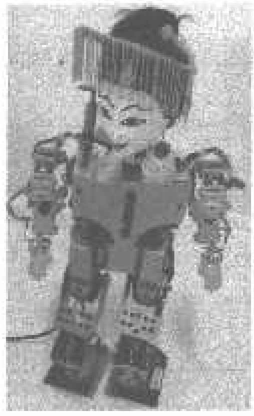
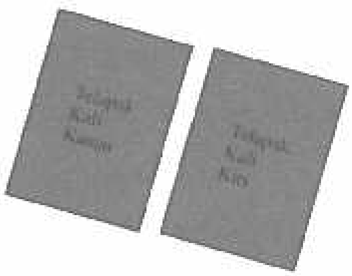
4.4.3.1 Gerakan belok Kanan Setengah Jongkok

Secara nyata, gerakan belok Kanan Setengah Jongkok robot posisi tegak di tunjukkan pada tabel 4.35.

Tabel 4. 35 Gerakan belok Kanan Setengah Jongkok Secara Gambaran dan Nyata

Step	Gambar gerak robot	keterangan
1	 	Warna merah merupakan posisi COG (*center og grafity*). Warna hijau pada keadaan telapak sedikit mengangkat miring. Warna putih tanpa beban.
2	 	
3	 	

Lanjut tabel 4.35

4			Warna merah merupakan posisi COG (*center og grafity*). Warna hijau pada keadaan telapak sedikit mengangkat miring. Warna putih tanpa beban.
5			

4.4.4 Data Gerakan Belok Kiri Setengah Jongkok

Data gerakan dari USC32 torobot untuk robot belok kiri setengah jongkok ditunjukkan pada tabel 4.36.

Tabel 4. 36 Data Gerakan Belok Kiri Setengah jongkok

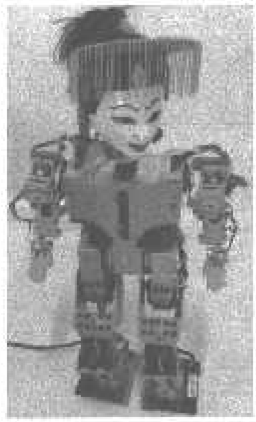
Step	Data Dari USC32 torobot	Keterangan
1	#1P1300#2P2500#3P1433#4P1789#5P922#7P1256#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1456#16P1256#18P1500#19P1544#21P1411#22P1433#23P1878#24P967#25P922#26P1456#28P1078#29P1433#30P1856#31P1700#32P500T300	Contoh : pada data #32P789T700. Data # menyatakan urutan servo. Data P menyatakan jumlah PWM dengn rntang 500 - 2500. Data T menyatakan kecepatan eksekusi data dengan rentang 100 – 9999.
2	#1P1300#2P2500#3P1458#4P1789#5P922#7P1256#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1456#16P1211#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1411#28P1078#29P1389#30P1856#31P1685#32P500T300	
3	#1P1300#2P2500#3P1456#4P1789#5P922#7P1322#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1456#16P1278#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1456#28P1078#29P1389#30P1856#31P1722#32P500T300	
4	#1P1344#2P2500#3P1526#4P1789#5P922#7P1424#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1456#16P1300#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1563#28P1078#29P1389#30P1856#31P1760#32P500T500	
5	#1P1367#2P2500#3P1522#4P1789#5P922#7P1433#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1722#16P1322#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1544#28P1078#29P1389#30P1856#31P1767#32P500T300	
6	#1P1344#2P2500#3P1500#4P1789#5P922#7P1312#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1633#16P1278#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1456#28P1078#29P1389#30P1856#31P1767#32P500T300	

4.4.4.1 Gerakan belok Kiri Setengah Jongkok

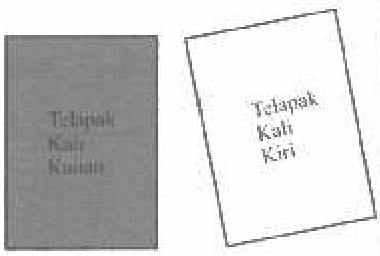
Secara nyata, gerakan belok Kiri Setengah Jongkok robot di tunjukkan pada tabel 4.37.

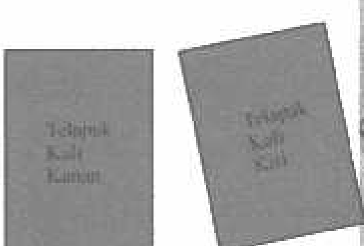
Tabel 4. 37 Gerakan belok Kiri Setengah Jongkok Secara Gambaran dan Nyata

<table>
<tr><th>Step</th><th>Gambar gerak robot</th><th>keterangan</th></tr>
<tr><td>1</td><td>

</td><td rowspan="3">Warna merah merupakan posisi COG (center og grafity).

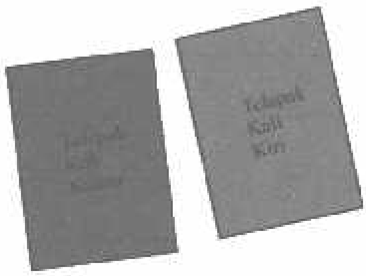
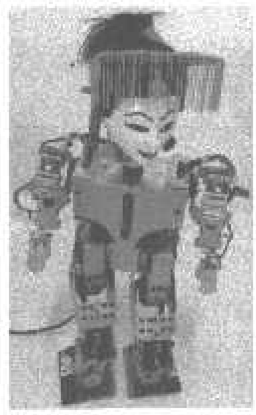
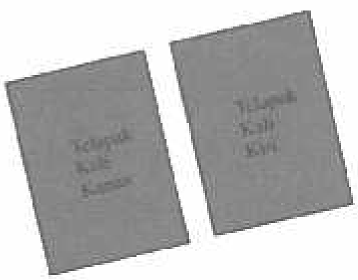
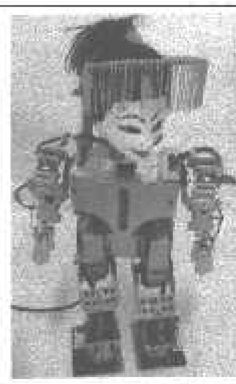
Warna hijau pada keadaan telapak sedikit mengangkat miring.

Warna putih tanpa beban.</td></tr>
<tr><td>2</td><td>

</td></tr>
<tr><td>3</td><td>

</td></tr>
</table>

Lanjut tabel 4.37

4	 	
5	 	
6	 	

4.4.5 Analisa Gerakan Belok Robot

Pada gerakan berbelok ini berfungsi ketika robot mendeteksi arah jalan melenceng dari derajat yang telah di tentukan dan secara otomatis akan melakukan gerakan belok kanan atau belok kiri tersebut. Dalam jarak tempuh jalan robot sejauh dua meter, gerakan belok kanan dan kiri di kerjakan tergantung dari konsep jalan yang menyebabkan jalan melenceng dari arah yang di tentukan.

Pada pengaplikasian jalan robot yang paling baik yaitu setengah jongkok dengan enam step, gerakan melenceng terjadi pada jarak 1,8 meter sehingga gerakan untuk belok terjadi hanya satu kali. Gerakan belok kanan dan kiri ini Pada gerak robot belok ini membutuhkan selama ±10 detik untuk menyelesaikan 1 gerakan belok.

4.5 Pengujian Secara keseluruhan

Setelah melalui dari beberapa pengujian pada setiap bagian, maka hasih dari perancangan dan pembuatan robot humanoid epretiwi-v4 akan di uji secaar keseluruhan. Jalan robot yang telah di buat kemudian di ujicoba pada Medan jejak multiplex berlapis perlak vinil yang ditunjukkan pada gambar 4.16. Alas kaki robot memakai eva spon di tunjukkan pada gambar 4.17.

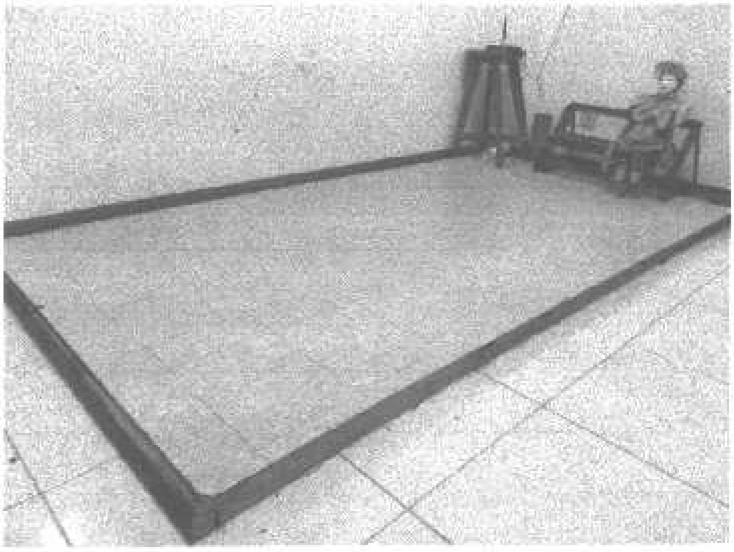
Medan jejak :

- Multiplex berlapis perlak vinil.

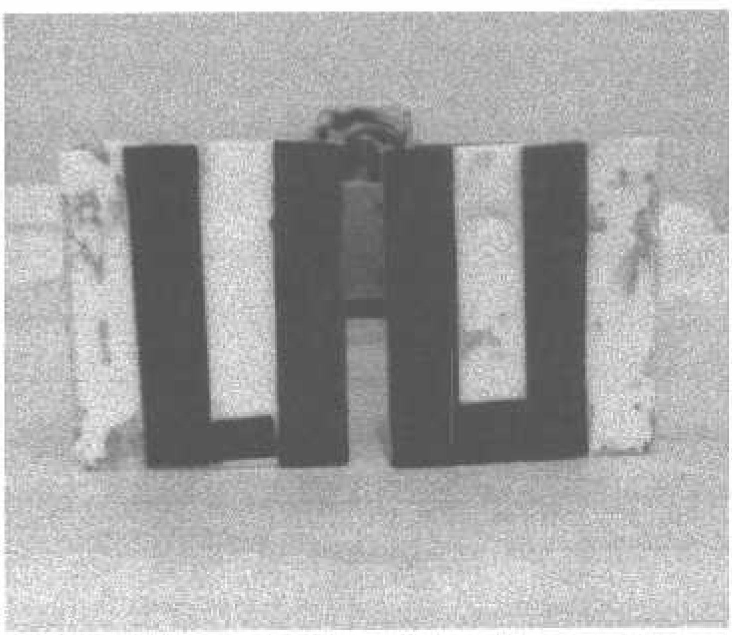
Alas kaki robot :

- Eva spon.

Pengujian pada medan jejak dan dengan alas kaki posisi jalan tegak empat step di tunjukkan pada tabel 4.36, posisi jalan tegak enam step pada tabel 4.37, posisi jalan setengah jongkok empat step pada tabel 4.38, posisi jalan setengah jongkok enam step pada tabel 4.39.



Gambar 4. 16 Medan Jejak Multiplex Berlapis Perlak Vinil



Gambar 4. 17 Alas Kaki Robot dengan eva spon

4.5.1 Pengujian Jalalan Robot Tanpa Kompas

Pengujian jalan kompas tana kompas pada medan jejak di tunjukkan pada tabel 3.8 untuk jalan tegak empat step, tabel 4.39 untuk jalan tegak eman step, tabel 4.40 untuk Jalan setengah Jongkok Empat Step, tabel 4.41 Jalan setengah Jongkok Emam Step.

Tabel 4. 38 Pengujian Medan Jejak dan Alas Kaki Robot Posisi Jalan Tegak Empat Step

Medan	Alas Kaki	Percobaan	Waktu (menit)	perbelokan (meter)	Jarak (meter)
Multiplex berlapis perlak vinil	Eva spon	1	2	1	2
		2	2	1	
		3	2	1	

Tabel 4. 39 Pengujian Medan Jejak dan Alas Kaki Robot Posisi Jalan Tegak Enam Step

Medan	Alas Kaki	Percobaan	Waktu (menit)	perbelokan (meter)	Jarak (meter)
Multiplex berlapis perlak vinil	Eva spon	1	2,30	0,5	2
		2	2,23	0,5	
		3	2,13	0,6	

Tabel 4. 40 Pengujian Medan Jejak dan Alas Kaki Robot Posisi Jalan setengah Jongkok Empat Step

Medan	Alas Kaki	Percobaan	Waktu (menit)	perbelokan (meter)	Jarak (meter)
Multiplex berlapis perlak vinil	Eva spon	1	2,18	0,5	2
		2	2,15	0,7	
		3	2,13	0,5	

Tabel 4. 41Pengujian Medan Jejak dan Alas Kaki Robot Posisi Jalan setengah Jongkok Enam Step

Medan	Alas Kaki	Percobaan	Waktu (menit)	perbelokan (meter)	Jarak (meter)
Multiplex berlapis perlak vinil	Eva spon	1	1,12	1,6	2
		2	1	1,7	
		4	1	1,8	

4.5.1.1 anlisa jalan robot tanpa kompas

Pada setiap Jalan robot akan berbeda waktu tempuh dalam jarak 2 meter, ini di karenakan konsep jalan dan alas pada kaki robot yang mempengaruhi pada pijakan telapak kaki. Untuk penggunaan alas kaki eva spon jalan robot dapat secara baik berpijak untuk berjalan. Sejauh percobaan jalan robot, konsep jalan setengah jongkok dengan enam step merupakan yang terbaik.

Jalan robot tanpa menggunakan kompas jika mengalami perbelokan dari arah yang di tuju akan secara manual kita rubah arah posisi robot untuk mengarahkan robot kembali ke arah yang akan di tuju. Perbelokan robot di akibatkan oleh beberapa sebab, yaitu :

- Gesekan telapak kaki dengan lantai.
- Gerakan kejut yang tiba-tiba terjadi.
- Medan jejek yang tidak rata\bergelombang.

4.5.2 Pengujian Jalalan Robot Menggunkan Kompas

Setelah konsep jalan dan penerapan jalan dengan beberpa pengujian pada medan jejak dan alas kaki robot telah dilakukan maka pengujian jalan robot menggunakan kompas juga di kakukan sebagai perbandingan. Pengujian menggunkan kompas posisi robot Jalan Tegak Empat Step di tunjukkan pada tabel 4.42, posisi robot Jalan Tegak Enam Step pada tabel 4.43, Posisi Robot Jalan setengah Jongkok Empat Step pada tabel 4.44, Posisi Robot Jalan setengah Jongkok Enam Step pada tabel 4.45.

Tabel 4. 42 Pengujian Medan Jejak dan Alas Kaki Robot Dengan Kompas posisi robot Jalan Tegak Empat Step

Medan	Alas Kaki	Percobaan	Waktu (menit)	perbelokan (meter)	Jarak (meter)
Multiplex berlapis perlak vinil	Eva spon	1	1	1	2
		2	1,11	0,8	
		3	1	1	

Tabel 4. 43 Pengujian Medan Jejak dan Alas Kaki Robot Dengan Kompas posisi robot Jalan Tegak Enam Step

Medan	Alas Kaki	Percobaan	Waktu (menit)	perbelokan (meter)	Jarak (meter)
Multiplex berlapis perlak vinil	Eva spon	1	2,20	0,4	2
		2	2,15	0,3	
		3	2,25	0,5	

Tabel 4. 44 Pengujian Medan Jejak dan Alas Kaki Robot Dengan Kompas Posisi Robot Jalan setengah Jongkok Empat Step

Medan	Alas Kaki	Percobaan	Waktu (menit)	perbelokan (meter)	Jarak (meter)
Multiplex berlapis perlak vinil	Eva spon	1	2,20	0,4	2
		2	2,15	0,5	
		3	2,26	0,3	

Tabel 4. 45 Pengujian Medan Jejak dan Alas Kaki Robot Dengan Kompas Posisi Robot Jalan setengah Jongkok Enam Step

Medan	Alas Kaki	Percobaan	Waktu (menit)	perbelokan (meter)	Jarak (meter)
Multiplex berlapis perlak vinil	Eva spon	1	1,18	1,7	2
		2	1,12	1,8	
		3	1,11	1,6	

4.5.2.1 Analisa Jalan Robot Menggunkan Kompas

Dengan menggunakan sensor kompas, robot akan secara otomatis mengoreksi arah yang di tuju dan robot akan melakukan gerakan belok kanan atau belok kiri. Pada percobaan jalan robot menggunkan kompas, arah putar kiri dan kanan untuk meluruskan sudah dapat di lakukan dengan eksekusi gerak sebanyak tiga kali. Eksekusi gerak putar kiri dan kanan tergantung dari derajat perbelokan yang telah di tentukan. Sejauh percobaan menggunakan alas kaki eva spon enam step dengan waktu tempuh 1,11 menit dengan jarak tempuh 2 meter adalah yang terbaik.

4.6 Pengujian Konsumsi Tegangan

4.6.1 Pengujian baterai

Pengujian baterai pada robot di lakukan untuk mengetahui kinerja baterai saaat digunakan selama salang waktu yang telah di perhitungkan. Pengukuran di lakukan pada saat baterai *full charger* dan pada saat indikator *low* baterai. Pengujian baterai pada saat *full charge* di tunjukkan pada gambar 4.18 dan indikoator baterai *low* di tunjukkan pada gambar 4.19.

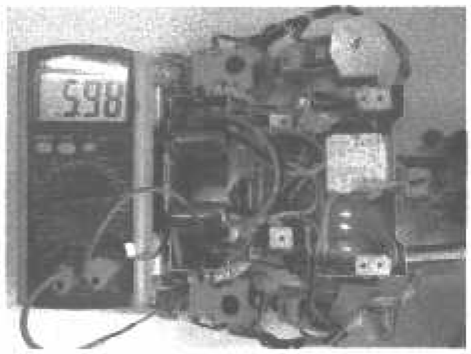
Gambar 4. 18 Pengujian Baterai Saat Full Charger

Gambar 4. 19 Pengujian Baterai Saat Indikator Low

4.6.2 Pengujian Penurun Tegangan

4.6.2.1 UBEC (Universal Battery Eliminated Circuit)

Pengujian UBEC (*Universal Battery Eliminated Circuit*) dilakukan untuk men *supply* tegangan pada motor servo dengan konsumsi tegangan 6v. Gambar 4.20 menunjukkan hasil pengukuran pada saat di bebani oleh motor servo.



Gambar 4. 20 Pengujian Penurun Tegangan Untuk Servo sedang

4.6.2.2 Mini Voltage Regulator

Pengujian *mini voltage regulator* dilakukan untuk men *supply* tegangan pada motor servo dengan konsumsi tegangan di bawah 6v yaitu 4,7V. Gambar 4.21 menunjukkan hasil pengukuran pada saat di bebani oleh motor servo kecil.

Gambar 4. 21 Pengujian Penurun Tegangan Untuk Servo Kecil

4.6.3 Analisa Konsumsi Tegangan

4.6.3.1 baterai

Baterai lipo yang di gunakan memiliki 2 *cell* dengan tegangan spesifikasi masing-masing *cell* 3,7V, namum pada kenyataannya masing *cell* memiliki 4,2V singga pada kenyataan baterai lipo memiliki tegangan *output* 8,4V pada keadaan *full charger* dengan kapaitas arus 1300Mah 25C.

Saat baterai turun pada tegangan ±6,5V robot mengalami lemas di karenakan baterai ke habisan daya dalam memberi *supply* pada semua total servo yang berkerja. Dengan indikator berwarna merah pada UBEC (*Universal Battery Eliminated Circuit*) yang menandakan bahwa baterai sudah dalam keadaan *low.*

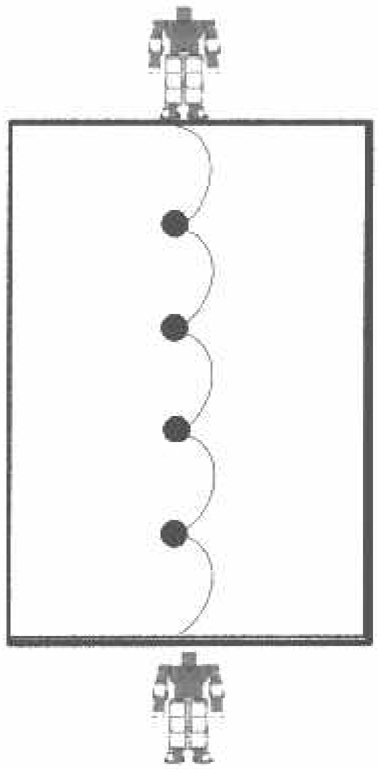
4.6.3.2 baterai Penurun Tegangan

Penurun tegangan dengan menggunakaan UBEC (*Universal Battery Eliminated Circuit*) memiliki *output* tetap dengan *switch* 5V dan 6V. UBEC (*Universal Battery Eliminated Circuit*) dengan *input* baterai lipo yang memberikan *supply* untuk servo sedang dan USC32 *controller.*

Untuk *Mini Voltage Regulator* menggunakan potensio sebagai pengatur *output* sehingga untuk mendapatkan *output* yang di inginkan harus memutar potensio sampai pada tegangan 4,8V yang di butuhkan pada konsumsi tegangan servo kecil. *Supply* arduino satu jalur dengan *Mini Voltage Regulator* namun tidak pada *output* nya melainkan mendapatkan *supply* langsung dari baterai lipo.

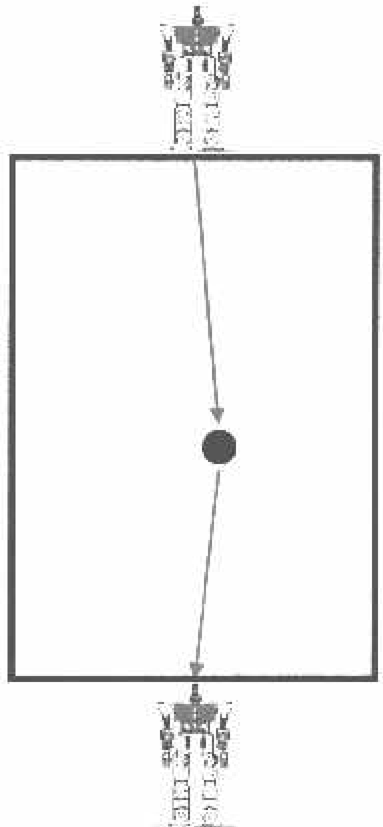
4.7 Hasil Pengujian Secara Keseluruhan

Setelah melalui dari beberapa pengujian pada setiap bagian, maka hasih dari perancangan dan pembuatan robot humanoid epretiwi-v4 ini di tunjukkan pada gambar 4.22 (b) di bandingkan dengan robot epretiwi-v3 dari tugas akhir yang di kerjakan sebelumnya yang di tunjukkna pada gambar 4.22 (a). Pada sistem jalan yang di hasilkan pada robot epretiwi-v4 lebih baik dengan jalan yang tidak berbelok dan dengan sensor kompas robot mampu mengkoreksi jalannya jika terjadi perbelokan. Pengujian pada tahap akhir ini menggunakan konsep jalan setengah jongkok dengan 6 step yang di anggap penulis baik dimana hanya terjadi 1 kali perbelokan saja.



(a)

Robot epretiwi –v3



(b)

Robot epretiwi –v4

Gambar 4. 22 hasil perbandingan konsep jalan robot epretiwi –v3 dan epretiwi –v4

BAB IV
PENUTUP

5.1 Kesimpulan

Setelah dilakukan perancangan, pengujian dan analisa sistem, maka dapat disimpulkan beberapa hal yang dapat digunakan untuk perbaikan dan pengembangan selanjutnya, yaitu :

1. Sensor kompas HMC5883L dapat di gunakan dengan baik dalam menentukan arah derajat sebagai kompas digital untuk kebutuhan robotika.
2. Sensor kompas sangat sensitif terhadap benda-benda mengandung magnetik yang menyebabkan kesalahan pembacaan data derajat pada sensor kompas.
3. Dari beberapa konsep jalan yang telah di buat, posisi setengah jongkok dengan enam step adalah yang terbaik karena lebih stabil dan seimbang dalam melangkah.
4. Dalam jarak 2 meter sesuia dengan arena lomba, dapat di tempuh oleh robot selama 1 menit dengan satu kali koreksi gerakan belok menggunakan posisi setengah jongkok enam step.
5. Telapak kaki robot yang di gunakan yaitu *evaspon* sudah cukup baik, karena tidak licin dan tidak juga terlalu kesat terhadap medan jejak. *Evaspon* di pasang dua sejajar dengan telapak alas kaki robot dan tidak secara keseluruhan karena menyebabkan gesekan pada pinggiran luar telapak kaki terhadap medan jejak saat melangkah.
6. Medan jejak yang di gunakan bukan arena yang di buat secara asli seperti pada kontes sehingga masih memiliki kekurangan karena bergelombang yang mengakibatkan robot tidak stabil saat berjalan dan mengakibatkan data jalan yang berbeda.
7. Penggunaan *battery* lipo pada robot humanoid epretiwi lebih dari baik namun untuk pemilihan battery sebainya memilih *dishchart Rate battery* yang lebih besar supaya lebih lama dalam penggunaannya.

5.2 Saran

Terlepas dari semua kekurangan dan kesalahan dari perancangan sistem maupun peralatan yang penulis kerjakan sebagai tugas akhir ini, maka beberapa saran untuk robot epretiwi-v4 humanoid ini agar dapat di kembangkan lebih baik lagi yaitu :

1. Untuk memudahkan dalam membuat dan memprogram setiap gerakan robot sebaiknya menggunakan kontroler *singgle board controller*.
2. Untuk *event* tahunan KRI (kontes robot indonesia) ini supaya persiapan tidak hanya di lakukan ketika mau lomba saja, namun di persiapkan sejauh mungkin untuk mendapatkan hasil yang baik.
3. Untuk servo yang kurang mampu dalam menahan beban berat misalkan pada bagian kaki, sebaiknya diganti servo dengan torsi yang lebih besar lagi.
4. Sebagai media latihan dan *trial* sebaiknya dibuatkan arena perlombaan secara baik, bagus dan paten, karena pada setiap tahun selalu sama.
5. Untuk kontes robot seni tari indonesia tahun selanjutnya agar supaya merealisasikan 2 robot yang serupa sehingga memudahkan dalam singkronisasi gerakan.

DAFTAR PUSTAKA

[1] Direktorat Jendral Pembelajaran dan Kemahasiswaan Kementrian Riset, Teknologi dan Pendidikan Tinggi. Panduan KRSI 2016-ver NOP 2013. 2016.

[2] Syahrijal Ugan Dinata, 2014. Perancangan dan pembuatan robot humanoid 21 dof untuk kontes robot seni tari indonesia. Malang : Skripsi, Elektro FTI ITN Malang.Andrianto, Heri.(2008).

[3] Gandjar K, Filipus RK, Yohannes TT, Galih S, Akthur F, Perancangan Bentuk Geometri dan Derajat Kebebasan dan Analisa Kestabilan Robot Humanoid "Makara 1", 2005.

[4] ST, MT. Muliady, Drs. Zaenal Abidin, M. Eng, Christian Hadinata, & Mario Kusuma. 2012. Robot humanoid pemain bola soccer humanoid robot. Penelitian tidak diterbitkan. Bandung: Universitas Kristen Maranatha.

[5] Arduino, Arduino Mega 2560, URL:http://www.arduino.org/products/boards/arduino-mega-2560. Di akses 10-02-2016.

[6] Robomart. 32 Channel USB/UART Servo Motor Controller Driver Board for Arduino/Raspberry-Pi/Robotics, URL : https://www.robomart.com/32-channel-usb-uart-servo-motor-controller-driver-board-for-robot. Di akses 10-02-2016.

[7] Purnama, Agus. 2014. Motor Servo. URL:http://elektronika-dasar.web.id/teori-elektronika/motor-servo/. Di akses 10-02-2016.

[8] RadioC,URL:http://www.radioc.co.uk/DC-Step-down-Adjustable-Regulator-p/7208.htm. Diakses 04-mei-2016.

[9] Splashtronic, Modul Kompas GY-273 HMC5883L, URL : https://splashtronic.wordpress.com/2013/10/29/modul-kompas-gy-273-hmc5883l/. Di akses 10-02-2016. Di akses 04-mei-2016.

[10] Musbikhin, Baterai LI-PO (LITHIUM-POLIMER), URL :http://about-unitomo.blogspot.co.id/2013/02/arti-c-mah-dan-s-pada-baterai-lipo.html. Di akses 05-04-2016. Di akses 10-mey-2016.

[11] gensaceUSA, GENS ACE 1300mAh 2S 7.4V 25C LiPo Battery for 1/10 RC Crawler and 1/16, 1/18 Cars, URL :http://www.gensaceusa.com/98p-25c-1300-2s1p.html. di akses 10-mey-2016.

[12] Microsoft, fungsiAtan, URL :https://support.office.com/id-id/article/ATAN2-Fungsi-ATAN2. Di akses 12-april-2016.

[13] Christianto Tjahyadi, UBEC , URL : http://christianto.tjahyadi.com/?s=DC-DC+Converter. Di akses 10-02-2016

LAMPIRAN

BERITA ACARA SEMINAR PROPOSAL SKRIPSI
PROGRAM STUDI TEKNIK ELEKTRO S1

KONSENTRASI	Teknik Elektronika

1.	Nama Mahasiswa	Gunawan Eko Hendiyono			NIM	1212216	
2.	Keterangan	Tanggal		Waktu		Tempat / Ruang	
	Pelaksanaan	20 maret 2016		09.00		1.5	
3.	Spesifikasi Judul (berilah tanda silang) *)						
	a.	Sistem Tenaga Elektrik	e.	Embbeded System	i.	Sistem Informasi	
	b.	Konversi Energi	f.	Antar Muka	j.	Jaringan Komputer	
	c.	Sistem Kendali	g.	Elektronika Telekomunikasi	k.	Web	
	d.	Tegangan Tinggi	h.	Elektronika Instrumentasi	l.	Algoritma Cerdas	
4.	Judul Proposal yang diseminarkan Mahasiswa	Pengembangan Sistem Jalan Robot v4 Menggunakan Sensor Kompas Untuk Kontes Robot Seni Tari Indonesia (KRSTI)					
5.	Perubahan Judul yang diusulkan oleh Kelompok Dosen Keahlian	....					
6.	Catatan :						
	Catatan :						
7.	Persetujuan Judul Skripsi						
	Disetujui, Dosen Keahlian I			Disetujui, Dosen Keahlian II			
	Mengetahui, Ketua Jurusan M. Ibrahim Ashari,ST,MT NIP. P. 1030100358		Disetujui, Calon Dosen Pembimbing — Pembimbing I: DR. Aryuanto Soetedjo, ST.MT		Pembimbing II: DR. Eng Komang Somawirata,ST,MT		

Keterangan :
*) dilingkari a, b, c, ... sesuai dengan bidang keahlian

Form S-3c

INSTITUT TEKNOLOGI NASIONAL
FAKULTAS TEKNOLOGI INDUSTRI
JURUSAN TEKNIK ELEKTRO S-1
Jl. Raya Karanglo, Km. 2 MALANG

PERMOHONAN PERSETUJUAN SKRIPSI

Yang Bertanda Tangan Dibawah Ini:

Nama : GUNAWAN EKO HENDROYONO
N I M : 1212216
Semester : VIII
Fakultas :Teknologi Industri
Jurusan :Teknik Elektro S-I
Konsentrasi :~~TEKNIK ENERGI LISTRIK~~
TEKNIK ELEKTRONIKA
~~TEKNIK KOMPUTER DAN INFORMATIKA~~
~~TEKNIK KOMPUTER~~
~~TEKNIK TELEKOMUNIKASI~~
Alamat : BUALEMO B, KEC. BUALEMO, KABUPATEN BANGGAI, SULAWESI TENGAH

Dengan ini kami mengajukan permohonan untuk mendapatkan persetujuan untuk membuat SKRIPSI Tingkat Sarjana. Untuk melengkapi permohonan tersenut, bersama ini kami lampirkan persyaratan-persyaratan yang harus dipenuhi.

Adapun persyaratan- persyaratan pengambilan SKRIPSI adalah sebagai berikut:

1. Telah melaksanakan semua praktikum sesui dengan konsentrasinya (...✓...)
2. Telah lulus dan menyerahkan laporan Praktek Kerja (...✓...)
3. Telah lulus seluruh mata kuliah keahlian (MKB)sesuai konsentrasinya (...✓...)
4. Telah menempuh matakuliah> 134 sks dengan IPK > 2 dan tidak ada nilai E (...✓...)
5. Telah mengikuti secara aktif kegiatan seminar Skripsi yang diadakan Jurusan (.........)
6. Memenuhi persyaratan administrasi (.........)

Demikian permohonan ini untuk mendapatkan penyelesaian lebih lanjut dan atas perhatiannya kami ucapkan terima kasih.

Telah diteliti kebenarannya data tersebut diatas
Recording Teknik Elektro S-I

(..Puja Handayani..)

Malang, ... FEBRUARI ... 2016
Pemohon

(GUNAWAN EKO H.)

Disetujui
Ketua Prodi Teknik Elektro S-I

M. Ibrahim Ashari, ST, MT
NIP. P. 1030100358

Mengetahui
Dosen Wali

(DR. IRRINE BUDI SULISTIAWATI ... ST, MT)

Catatan:
Bagi mahasiswa yang telah memenuhi persyaratan mengambil SKRIPSI agar membuat proposal dan mendapat persetujuan dari Ketua Prodi T. elektro S-I

1 ... 461 / ... = 3.34
2 ... 138

JURUSAN TEKNIK ELEKTRO S-1
FAKULTAS TEKNOLOGI INDUSTRI
INSTITUT TEKNOLOGI NASIONAL MALANG

BERITA ACARA SEMINAR PROGRESS SKRIPSI
PROGRAM STUDI TEKNIK ELEKTRO S1

KONSENTRASI	T. Elektronika

1.	Nama Mahasiswa	Gunawan eko Haendroyono	NIM	1212216
2.	Keterangan Pelaksanaan	Tanggal	Waktu	Tempat / Ruang
3.	Judul Skripsi	Penembangan Sisten Jalan Robot Humanoi Epretiwi V4 Menggunakan Sensor Kompas Untuk Kontes Robot Seni Tari Indonesia (KRSTI)		
4.	Perubahan Judul	Pengembangan Sistem Jalan Robot Humanoi E Pretiwi V4 menggunakan sensor kompas untuk Kontes Robot Seni tari indonesia (KRSTI)		
5.	Catatan :			
6.	Mengetahui, Ketua Jurusan, M. Ibrahim Ashari, ST, MT	Disetujui, Dosen Pembimbing — Pembimbing I: Dr. Eng. I Komang Somawirata, ST, MT	Pembimbing II: Dr. Eng. Aryuanto Soetedjo, ST, MT	

PERKUMPULAN PENGELOLA PENDIDIKAN UMUM DAN TEKNOLOGI NASIONAL MALANG
INSTITUT TEKNOLOGI NASIONAL MALANG
FAKULTAS TEKNOLOGI INDUSTRI
FAKULTAS TEKNIK SIPIL DAN PERENCANAAN
PROGRAM PASCASARJANA MAGISTER TEKNIK

PT. BNI (PERSERO) MALANG
BANK NIAGA MALANG

Kampus I : Jl. Bendungan Sigura-gura No. 2 Telp. (0341) 551431 (Hunting), Fax. (0341) 553015 Malang 65145
Kampus II : Jl. Raya Karanglo, Km 2 Telp. (0341) 417636 Fax. (0341) 417634 Malang

BERITA ACARA UJIAN SKRIPSI
FAKULTAS TEKNOLOGI INDUSTRI

Nama	: GUNAWAN EKO HENDROYONO
NIM	: 1212216
Program Studi	: TEKNIK ELEKTRO S-1
Konsentrasi	: TEKNIK ELEKTRONIKA
Judul Skripsi	: PENGEMBANGAN SISTEN JALAN ROBOT HUMANOID EPRETIWI-V4 MENGGUNAKAN SENSOR KOMPAS UNTUK KONTES ROBOT SENI TARI INDONESIA (KRSTI)

Dipertahankan dihadapan Majelis Penguji Skripsi Jenjang Strata Satu (S-1) pada :

Hari	**: Kamis**
Tanggal	**: 4 Agustus 2016**
Dengan Nilai	**: 85,5 (A)**

Panitia Ujian Skripsi

Ketua Majelis Penguji	**Sekretaris Majelis Penguji**
M. IbrahimAshari, ST, MT	**Dr. Eng. I Komang Somawirata, ST, MT**
NIP.P. 1030100358	**NIP.P. 1030100361**

Anggota Penguji

Penguji I	**Penguji II**
M. IbrahimAshari, ST, MT	**Dr. Ir. F. Yudi Limprapto, MT**
NIP.P. 1030100358	**NIP.P. 1039500274**

INSTITUT TEKNOLOGI NASIONAL
FAKULTAS TEKNOLOGI INDUSTRI
JURUSAN TEKNIK ELEKTRO S-1
Jl. Raya Karanglo, Km. 2 MALANG

Formulir Perbaikan Ujian Skripsi

Dalam Pelaksanaan Ujian Skripsi Jenjang Strata 1 Jurusan Teknik Elektro Konsentrasi T.Energi Listrik,/ T. Elektronika, /T. Komputer, / T.Telekomunikasi, Maka Perlu Adanya Perbaikan Skripsi Untuk Mahasiswa:

Nama : Gunawan Eko H.
NIM : 1212216
Perbaikan Meliputi :

tambahkan catatan cerita pada Tabel pengujian

Malang, 4 agus 2016

(......................................)

LEMBAR PERSETUJUAN PERBAIKAN SKRIPSI

Dalam pelaksanaan ujian skripsi jenjang Strata Satu (S-1) Jurusan Teknik Elektro Konsentrasi Teknik Elektrtonika, maka perlu adanya perbaikan skripsi untuk mahasiswa :

NAMA : GUNAWAN EKO HENDROYONO
NIM : 12.12.216
JURUSAN : TEKNIK ELEKTRO S-1
KONSENTRASI : TEKNIK ELEKTRONIKA
MASA BIMBINGAN : SEMESTER GENAP 2015/2016
JUDUL : PENGEMBANGAN SISTEM JALAN ROBOT HUMANOID EPRETIWI-V4 MENGGUNAKAN SENSOR KOMPAS UNTUK KONTES ROBOT SENI TARI INDONSESIA (KRSTI)

Tanggal	Uraian	Paraf
Penguji I 04-08-2016	–	
Penguji II 04-08-2016	Penambahan keterangan pada tabel	

Disetujui,

Dosen Penguji I

Dr. F. Yudi Limpraptono, ST, MT
NIP.Y.1039500274

Dosen Penguji II

M. Ibrahim Ashari, ST, MT
NIP.P. 1030100358

Mengetahui,

Dosen Pembimbing I

Dr, Eng. I Komang Somawirata, ST, MT
NIP.P. 1030100361

Dosen Pembimbing II

Dr, Eng. Aryuanto Soetedjo, ST, MT
NIP.Y. 1030800417

PERKUMPULAN PENGELOLA PENDIDIKAN UMUM DAN TEKNOLOGI NASIONAL MALANG
INSTITUT TEKNOLOGI NASIONAL MALANG
FAKULTAS TEKNOLOGI INDUSTRI
FAKULTAS TEKNIK SIPIL DAN PERENCANAAN
PROGRAM PASCASARJANA MAGISTER TEKNIK
PT. BNI (PERSERO) MALANG
BANK NIAGA MALANG

Nomor Surat : ITN-181/EL-FTI/2015 8 Maret 2016
Lampiran : -
Perihal : BIMBINGAN SKRIPSI (**Baru**)

Kepada : Yth. Bapak/Ibu **DR.Eng.Komang Somawirata.ST,MT**
Dosen Teknik Elektro S-1
ITN MALANG

Dengan Hormat
Sesuai dengan permohonan dan persetujuan dalam Proposal Skripsi untuk mahasiswa:

Nama	: Gunawan Eko Hendiyono
Nim	: 1212216
Fakultas	: **Teknologi Industri**
Program Studi	: **Teknik Elektro S-1**
Konsentrasi	: Teknik Elektronika

Maka dengan ini pembimbingan tersebut kami serahkan sepenuhnya kepada Saudara/i selama masa waktu :

" Semester Genap Tahun Akademik 2015-2016"

Demikian atas perhatian serta bantuannya kami sampaikan terima kasih.

Mengetahui
Ketua Program Studi Teknik Elektro S-1

M. Ibrahim Ashari, ST, MT
NIP.P. 1030100358

PROGRAM STUDI TEKNIK ELEKTRO S-1
FAKULTAS TEKNOLOGI INDUSTRI
INSTITUT TEKNOLOGI NASIONAL MALANG
Kampus II , Jl. Raya Karanglo Km. 2 Malang

MONITORING BIMBINGAN SKRIPSI
SEMESTER GENAP TAHUN AKADEMIK 2015-2016

Nama Mahasiswa	: Gunawan Eko Hendroyono
NIM	: 1212216
Nama Pembimbing	: Dr. Eng. I Komang Somawirata, ST., MT
Judul Skripsi	: PENGEMBANGAN SISTEM JALAN ROBOT HUMANOID EPRETIWI-V4 MENGGUNAKAN SENSOR KOMPAS UNTUK KONTES ROBOT SENI TARI INDONESIA (KRSTI)

Minggu Ke-	Hari, Tanggal	Waktu Bimbingan	Materi Bimbingan	Paraf
1	Selasa 5/4/16	13.30	Konsultasi perancangan, lanjutkan penulisan bab!	
2	Selasa 12/4/16	13.30	Konsultasi bab I & II dilanjutkan ke bab III	
3	Senin 18/4/16	13.30	Konsultasi bab III perbaikan akuisisi sensor kompas	
4	Selasa 19/4/16	13.30	Konsultasi sensor kompas	
5	Rabu 27/4/16	14.30	Acc bab III lanjut ke bab IV	
6	Senin 2/5/16	14.30	Konsultasi bab IV ke pengujian!	
7	Kamis 12-5-16	13.30	Melakukan seminar [illegible]	

Malang, ...

Pembimbing

Dr. Eng. I Komang Somawirata, ST., MT
NIP. P. 1030100361

PROGRAM STUDI TEKNIK ELEKTRO S-1
FAKULTAS TEKNOLOGI INDUSTRI
INSTITUT TEKNOLOGI NASIONAL MALANG
Kampus II Jl. Raya Karanglo Km. 2 Malang

MONITORING BIMBINGAN SKRIPSI
SEMESTER GENAP TAHUN AKADEMIK 2015-2016

Nama Mahasiswa : Gunawan Eko Hendroyono
NIM : 1212216
Nama Pembimbing : Dr. Eng. I Komang Somawirata, ST, MT
Judul Skripsi : PENGEMBANGAN SISTEM JALAN ROBOT HUMANOID EPRETIWI-V4 MENGGUNAKAN SENSOR KOMPAS UNTUK KONTES ROBOT SENI TARI INDONESIA (KRSTI)

Minggu Ke-	Hari, Tanggal	Waktu Bimbingan	Materi Bimbingan	Paraf
8	Rabu 15/6/2016	12.50	Konsultasi bab IV - lanjut ke simulasi gambar	
9	Senin 20/6/2016	10:00	Konsultasi simulasi gambar	
10	Selasa 21/6/2016	10:00	Konsultasi simulasi gambar	
11				
12				
13				
14				

Malang, ...

Pembimbing

Dr. Eng. I Komang Somawirata, ST, MT
NIP. P. 1030100361

PERKUMPULAN PENGELOLA PENDIDIKAN UMUM DAN TEKNOLOGI NASIONAL MALANG

INSTITUT TEKNOLOGI NASIONAL MALANG

FAKULTAS TEKNOLOGI INDUSTRI
FAKULTAS TEKNIK SIPIL DAN PERENCANAAN
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Kampus II : Jl. Raya Karanglo, Km 2 Telp. (0341) 417636 Fax. (0341) 417634 Malang

Nomor Surat : ITN-181/EL-FTI/2015 8 Maret 2016
Lampiran : -
Perihal : BIMBINGAN SKRIPSI (Baru)

Kepada : Yth. Bapak/Ibu **DR.Aryuanto Soetedjo, ST.MT**
Dosen Teknik Elektro S-1
ITN MALANG

Dengan Hormat
Sesuai dengan permohonan dan persetujuan dalam Proposal Skripsi untuk mahasiswa:

Nama	: Gunawan Eko Hendiyono
Nim	: 1212216
Fakultas	: **Teknologi Industri**
Program Studi	: **Teknik Elektro S-1**
Konsentrasi	: Teknik Elektronika

Maka dengan ini pembimbingan tersebut kami serahkan sepenuhnya kepada Saudara/i selama masa waktu :

" Semester Genap Tahun Akademik 2015-2016 "

Demikian atas perhatian serta bantuannya kami sampaikan terima kasih.

Mengetahui
Ketua Program Studi Teknik Elektro S-1

INSTITUT TEKNOLOGI NASIONAL MALANG FAKULTAS TEKNOLOGI INDUSTRI JURUSAN TEKNIK ELEKTRO

M. Ibrahim Ashari, ST, MT
NIP.P. 1030100358

PROGRAM STUDI TEKNIK ELEKTRO S-1
FAKULTAS TEKNOLOGI INDUSTRI
INSTITUT TEKNOLOGI NASIONAL MALANG
Kampus II : Jl. Raya Karanglo Km. 2 Malang

MONITORING BIMBINGAN SKRIPSI
SEMESTER GENAP TAHUN AKADEMIK 2015-2016

Nama Mahasiswa : Gunawan Eko Hendroyono
NIM : 12122216
Nama Pembimbing : Dr. Eng. Aryuanto Soetedjo, ST, MT
Judul Skripsi : PENGEMBANGAN SISTEM JALAN ROBOT HUMANOID EPRETIWI-V4 MENGGUNAKAN SENSOR KOMPAS UNTUK KONTES ROBOT SENI TARI INDONESIA (KRSTI)

Minggu Ke-	Hari, Tanggal	Waktu Bimbingan	Materi Bimbingan	Paraf
1	2/4/16	11:00	- Algoritma Servo Kontrol	[signature]
2	12/4/16	08:30	Bab 2	[signature]
3	14/4/16	09:00	Bab 3 rancangan	[signature]
4	16/4/16	09:30	Bab 3 [illegible]	[signature]
5	23/4/16	09:00	Bab 3 Rancangan Perjelas "ide rancangan"	[signature]
6	25/4/16	13:30	Bab 3	[signature]
7	4/5/16	09:00	Bab 4 → Pengujian? [illegible]	[signature]

Malang, ...

Pembimbing

Dr. Eng. Aryuanto Soetedjo, ST, MT
NIP. P. 1030800417

PROGRAM STUDI TEKNIK ELEKTRO S-1
FAKULTAS TEKNOLOGI INDUSTRI
INSTITUT TEKNOLOGI NASIONAL MALANG
Kampus II : Jl. Raya Karanglo Km. 2 Malang

MONITORING BIMBINGAN SKRIPSI
SEMESTER GENAP TAHUN AKADEMIK 2015-2016

Nama Mahasiswa : Gunawan Eko Hendroyono
NIM : 12122216
Nama Pembimbing : Dr. Eng. Aryuanto Soetedjo, ST, MT
Judul Skripsi : PENGEMBANGAN SISTEM JALAN ROBOT HUMANOID EPRETIWI-V4 MENGGUNAKAN SENSOR KOMPAS UNTUK KONTES ROBOT SENI TARI INDONESIA (KRSTI)

Minggu Ke-	Hari, Tanggal	Waktu Bimbingan	Materi Bimbingan	Paraf
8	12/5/16	13:00	Makalah seminar progress	[signature]
9	15/6/16	9:15	Bab 4	[signature]
10	21/6/16	10:30	Makalah semhas	[signature]
11				
12				
13				
14				

Malang, ...

Pembimbing

Dr. Eng. Aryuanto Soetedjo, ST, MT
NIP. P. 1030800417

SURAT PENYATAAN ORISINALITAS

Yang bertanda tangan di bawah ini :

Nama	: Gunawan Eko Hendroyono
NIM	: 12.12.216
Program Studi	: Teknik Elektro S-1
Konsentrasi	: Teknik Elektronika

Dengan ini menyatakan bahwa Skripsi yang saya buat adalah hasil karya sendiri, tidak merupakan plagiasi dari karya orang lain. Dalam Skripsi ini tidak memuat karya orang lain, kecuali di cantumkan sumbernya sesuai dengan ketentuan yang berlaku.

Demikian surat penyataan ini saya buat, dan apabila di kemudian hari ada pelanggaran atas surat pernyataan ini, saya bersedia menerima sangsinya.

Malang, 12 Agustus 2016

Yang membuat Pernyataan,

Gunawan Eko Hendroyono

NIM : 12.12.216

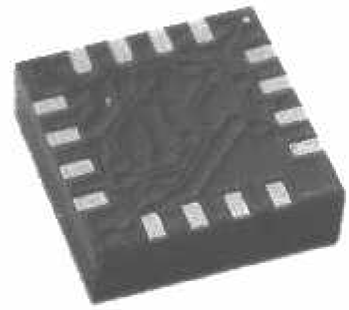
DATA SHEET

Honeywell

·Axis Digital Compass IC MC5883L

Advanced Information

Honeywell HMC5883L is a surface-mount, multi-chip module designed for ·field magnetic sensing with a digital interface for applications such as low- : compassing and magnetometry. The HMC5883L includes our state-of-the- high-resolution HMC118X series magneto-resistive sensors plus an ASIC taining amplification, automatic degaussing strap drivers, offset cancellation, a 12-bit ADC that enables 1° to 2° compass heading accuracy. The I²C al bus allows for easy interface. The HMC5883L is a 3.0x3.0x0.9mm surface ınt 16-pin leadless chip carrier (LCC). Applications for the HMC5883L ıde Mobile Phones, Netbooks, Consumer Electronics, Auto Navigation tems, and Personal Navigation Devices.



: HMC5883L utilizes Honeywell's Anisotropic Magnetoresistive (AMR) technology that provides advantages over other ȷnetic sensor technologies. These anisotropic, directional sensors feature precision in-axis sensitivity and linearity. ;se sensors' solid-state construction with very low cross-axis sensitivity is designed to measure both the direction and magnitude of Earth's magnetic fields, from milli-gauss to 8 gauss. Honeywell's Magnetic Sensors are among the most sitive and reliable low-field sensors in the industry.

EATURES	BENEFITS
3-Axis Magnetoresistive Sensors and ASIC in a 3.0x3.0x0.9mm LCC Surface Mount Package	▶ Small Size for Highly Integrated Products. Just Add a Micro-Controller Interface, Plus Two External SMT Capacitors Designed for High Volume, Cost Sensitive OEM Designs Easy to Assemble & Compatible with High Speed SMT Assembly
12-Bit ADC Coupled with Low Noise AMR Sensors Achieves 2 milli-gauss Field Resolution in ±8 Gauss Fields	▶ Enables 1° to 2° Degree Compass Heading Accuracy
Built-In Self Test	▶ Enables Low-Cost Functionality Test after Assembly in Production
Low Voltage Operations (2.16 to 3.6V) and Low Power Consumption (100 µA)	▶ Compatible for Battery Powered Applications
Built-In Strap Drive Circuits	▶ Set/Reset and Offset Strap Drivers for Degaussing, Self Test, and Offset Compensation
I²C Digital Interface	▶ Popular Two-Wire Serial Data Interface for Consumer Electronics
Lead Free Package Construction	▶ RoHS Compliance
Wide Magnetic Field Range (+/-8 Oe)	▶ Sensors Can Be Used in Strong Magnetic Field Environments with a 1° to 2° Degree Compass Heading Accuracy
Software and Algorithm Support Available	▶ Compassing Heading, Hard Iron, Soft Iron, and Auto Calibration Libraries Available
Fast 160 Hz Maximum Output Rate	▶ Enables Pedestrian Navigation and LBS Applications

ECIFICATIONS (* Tested at 25°C except stated otherwise.)

ıracteristics	Conditions*	Min	Typ	Max	Units
ver Supply					
;upply Voltage	VDD Referenced to AGND	2.16	2.5	3.6	Volts
	VDDIO Referenced to DGND	1.71	1.8	VDD+0.1	Volts
,verage Current Draw	Idle Mode	-	2	-	µA
	Measurement Mode (7.5 Hz ODR; No measurement average, MA1:MA0 = 00) VDD = 2.5V, VDDIO = 1.8V (Dual Supply) VDD = VDDIO = 2.5V (Single Supply)	-	100	-	µA
formance					
'ield Range	Full scale (FS)	-8		+8	gauss
lag Dynamic Range	3-bit gain control	±1		±8	gauss
;ensitivity (Gain)	VDD=3.0V, GN=0 to 7, 12-bit ADC	230		1370	LSb/gauss
)igital Resolution	VDD=3.0V, GN=0 to 7, 1-LSb, 12-bit ADC	0.73		4.35	milli-gauss
loise Floor Field Resolution)	VDD=3.0V, GN=0, No measurement average, Standard Deviation 100 samples (See typical performance graphs below)		2		milli-gauss
.inearity	±2.0 gauss input range			0.1	±% FS
lysteresis	±2.0 gauss input range		±25		ppm
;ross-Axis Sensitivity	Test Conditions: Cross field = 0.5 gauss, Happlied = ±3 gauss		±0.2%		%FS/gauss
)utput Rate (ODR)	Continuous Measurment Mode	0.75		75	Hz
	Single Measurement Mode			160	Hz
leasurement Period	From receiving command to data ready		6		ms
'urn-on Time	Ready for I2C commands		200		µs
	Analog Circuit Ready for Measurements		50		ms
;ain Tolerance	All gain/dynamic range settings		±5		%
²C Address	8-bit read address		0x3D		hex
	8-bit write address		0x3C		hex
²C Rate	Controlled by I²C Master			400	kHz
²C Hysteresis	Hysteresis of Schmitt trigger inputs on SCL and SDA - Fall (VDDIO=1.8V)		0.2*VDDIO		Volts
	Rise (VDDIO=1.8V)		0.8*VDDIO		Volts
;elf Test	X & Y Axes		±1.16		gauss
	Z Axis		±1.08		
	X & Y & Z Axes (GN=5) Positive Bias	243		575	LSb
	X & Y & Z Axes (GN=5) Negative Bias	-575		-243	
Sensitivity Tempco	T_A = -40 to 125°C, Uncompensated Output		-0.3		%/°C
neral					
ESD Voltage	Human Body Model (all pins)			2000	Volts
	Charged Device Model (all pins)			750	
Operating Temperature	Ambient	-30		85	°C
Storage Temperature	Ambient, unbiased	-40		125	°C

racteristics	Conditions*	Min	Typ	Max	Units
eflow Classification	MSL 3, 260 °C Peak Temperature				
ackage Size	Length and Width	2.85	3.00	3.15	mm
ackage Height		0.8	0.9	1.0	mm
ackage Weight			18		mg

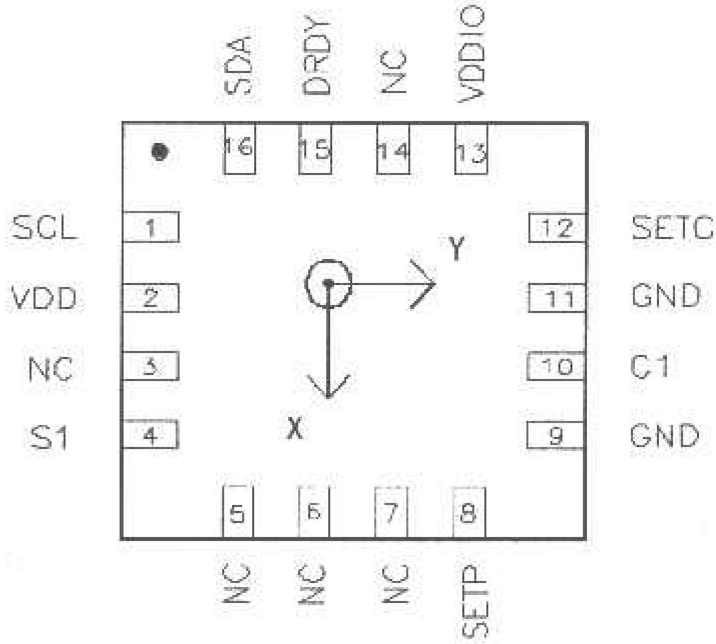
solute Maximum Ratings (* Tested at 25°C except stated otherwise.)

racteristics	Min	Max	Units
upply Voltage VDD	-0.3	4.8	Volts
upply Voltage VDDIO	-0.3	4.8	Volts

I CONFIGURATIONS

Pin	Name	Description
1	SCL	Serial Clock – I²C Master/Slave Clock
2	VDD	Power Supply (2.16V to 3.6V)
3	NC	Not to be Connected
4	S1	Tie to VDDIO
5	NC	Not to be Connected
6	NC	Not to be Connected
7	NC	Not to be Connected
8	SETP	Set/Reset Strap Positive – S/R Capacitor (C2) Connection
9	GND	Supply Ground
10	C1	Reservoir Capacitor (C1) Connection
11	GND	Supply Ground
12	SETC	S/R Capacitor (C2) Connection – Driver Side
13	VDDIO	IO Power Supply (1.71V to VDD)
14	NC	Not to be Connected
15	DRDY	Data Ready, Interrupt Pin. Internally pulled high. Optional connection. Low for 250 µsec when data is placed in the data output registers.
16	SDA	Serial Data – I²C Master/Slave Data

Table 1: Pin Configurations

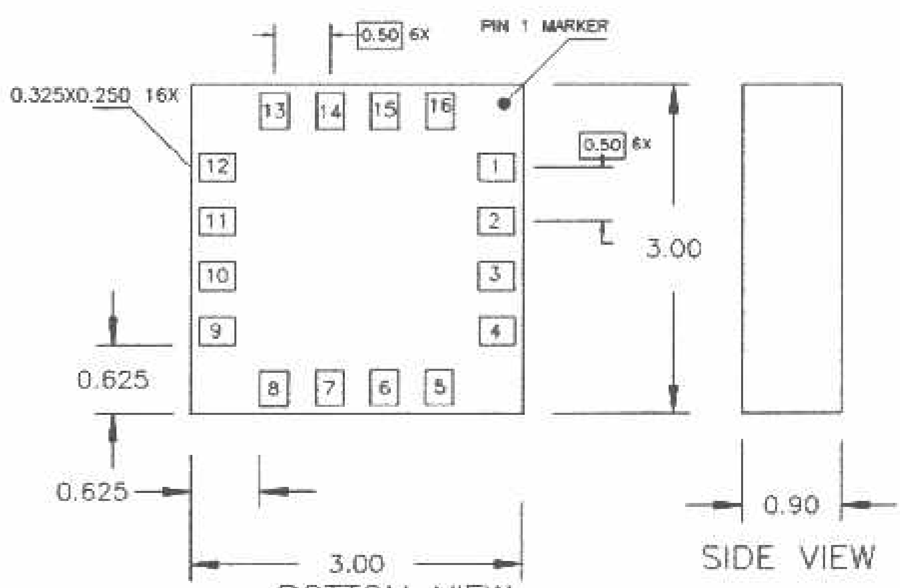


TOP VIEW (looking through)

ow indicates direction of magnetic field that generates a positive output reading in Normal Measurement configuration.

CKAGE OUTLINES

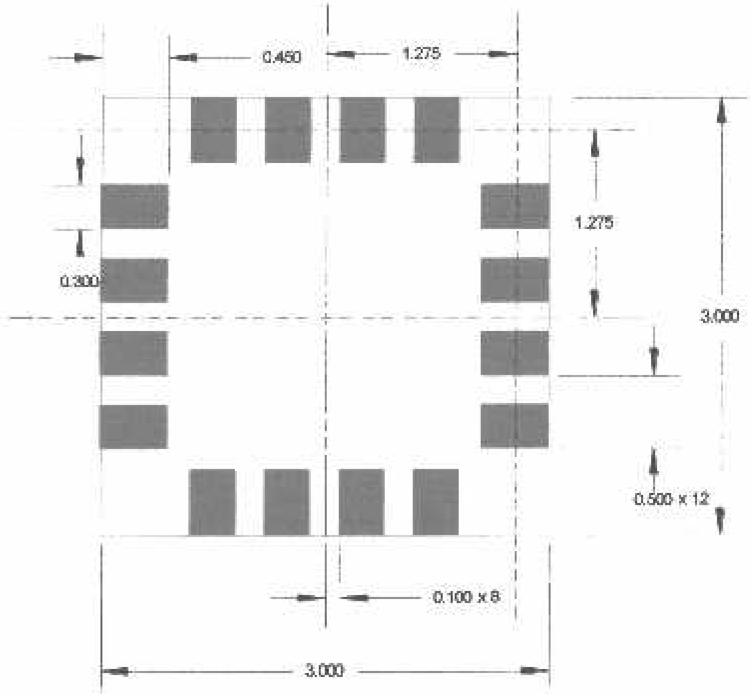
CKAGE DRAWING HMC5883L (16-PIN LPCC, dimensions in millimeters)



BOTTOM VIEW
(Dimensions in mm)

OUNTING CONSIDERATIONS

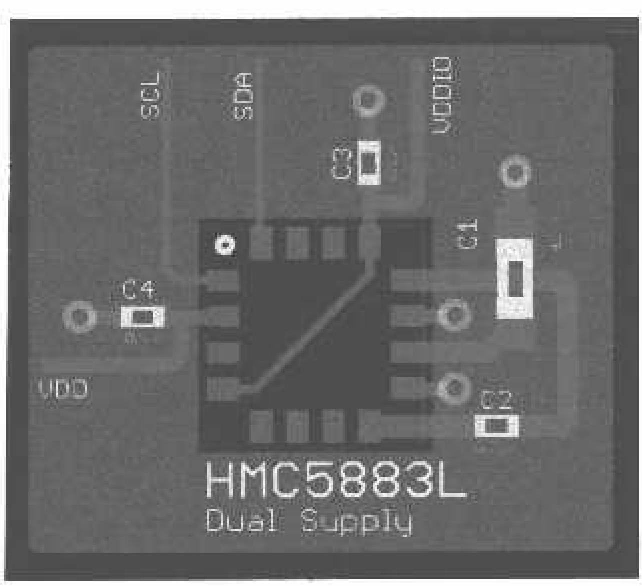
e following is the recommend printed circuit board (PCB) footprint for the HMC5883L.

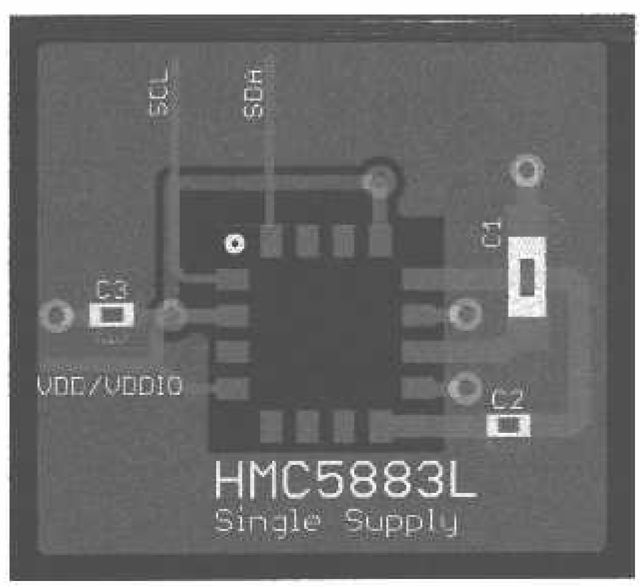


HMC5883 Land Pad Pattern
(All dimensions are in mm)

YOUT CONSIDERATIONS

ides keeping all components that may contain ferrous materials (nickel, etc.) away from the sensor on both sides of PCB, it is also recommended that there is no conducting copper under/near the sensor in any of the PCB layers. See ommended layout below. Notice that the one trace under the sensor in the dual supply mode is not expected to carry ve current since it is for pin 4 pull-up to VDDIO. Power and ground planes are removed under the sensor to minimize sible source of magnetic noise. For best results, use non-ferrous materials for all exposed copper coding.





Pad Definition and Traces

HMC5883L is a fine pitch LCC package. Refer to previous figure for recommended PCB footprint for proper package ering. Size the traces between the HMC5883L and the external capacitors (C1 and C2) to handle the 1 ampere peak ent pulses with low voltage drop on the traces.

ncil Design and Solder Paste

mil stencil and 100% paste coverage is recommended for the electrical contact pads.

ow Assembly

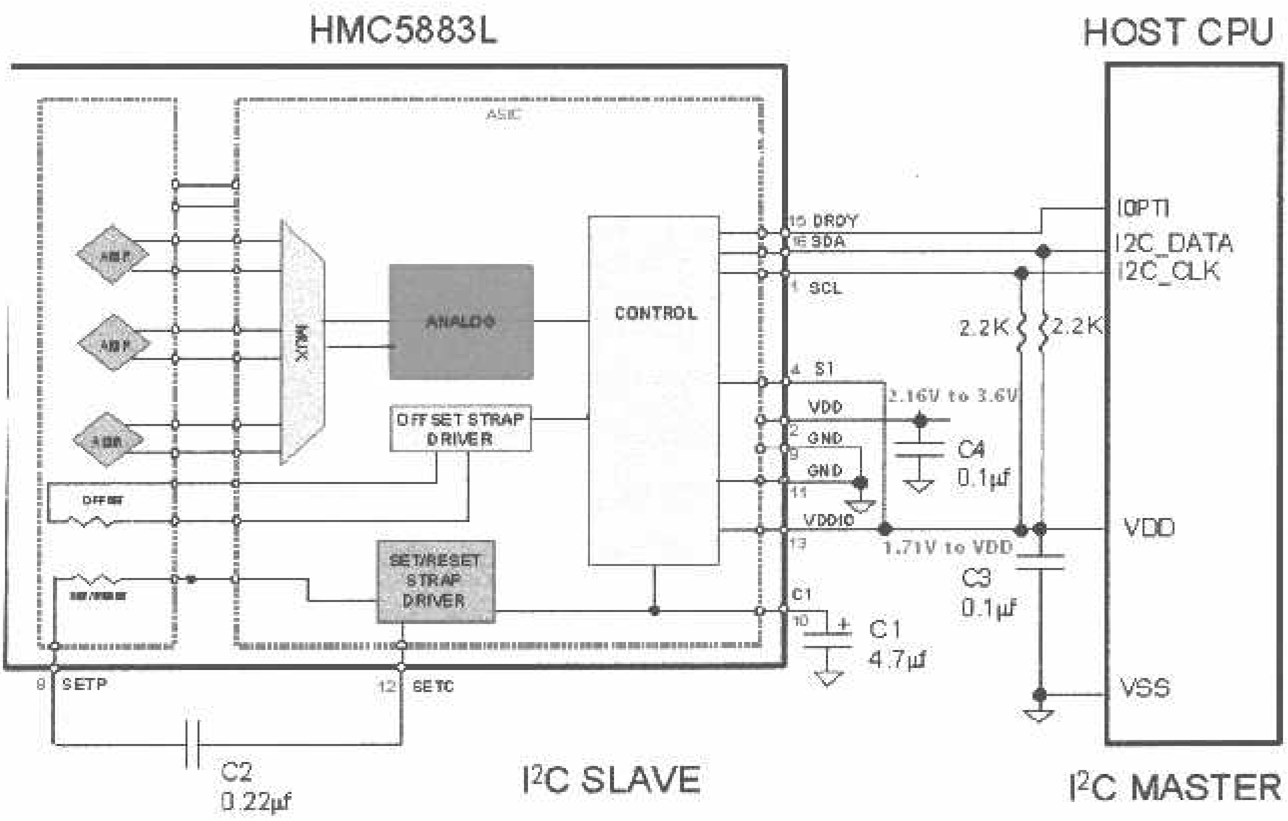
device is classified as MSL 3 with 260°C peak reflow temperature. A baking process (125°C, 24 hrs) is required if ce is not kept continuously in a dry (< 10% RH) environment before assembly. No special reflow profile is required for 5883L, which is compatible with lead eutectic and lead-free solder paste reflow profiles. Honeywell recommends erence to solder paste manufacturer's guidelines. Hand soldering is not recommended. Built-in self test can be used erify device functionalities after assembly.

rnal Capacitors

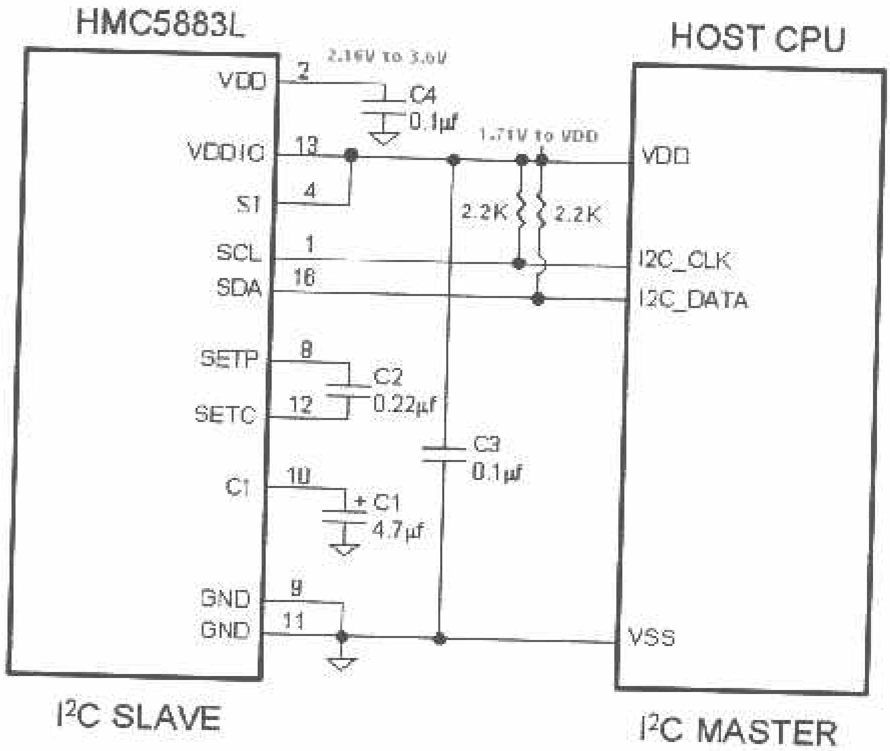
two external capacitors should be ceramic type construction with low ESR characteristics. The exact ESR values are critical but values less than 200 milli-ohms are recommended. Reservoir capacitor C1 is nominally 4.7 µF in acitance, with the set/reset capacitor C2 nominally 0.22 µF in capacitance. Low ESR characteristics may not be in ly small SMT ceramic capacitors (0402), so be prepared to up-size the capacitors to gain Low ESR characteristics.

'ERNAL SCHEMATIC DIAGRAM

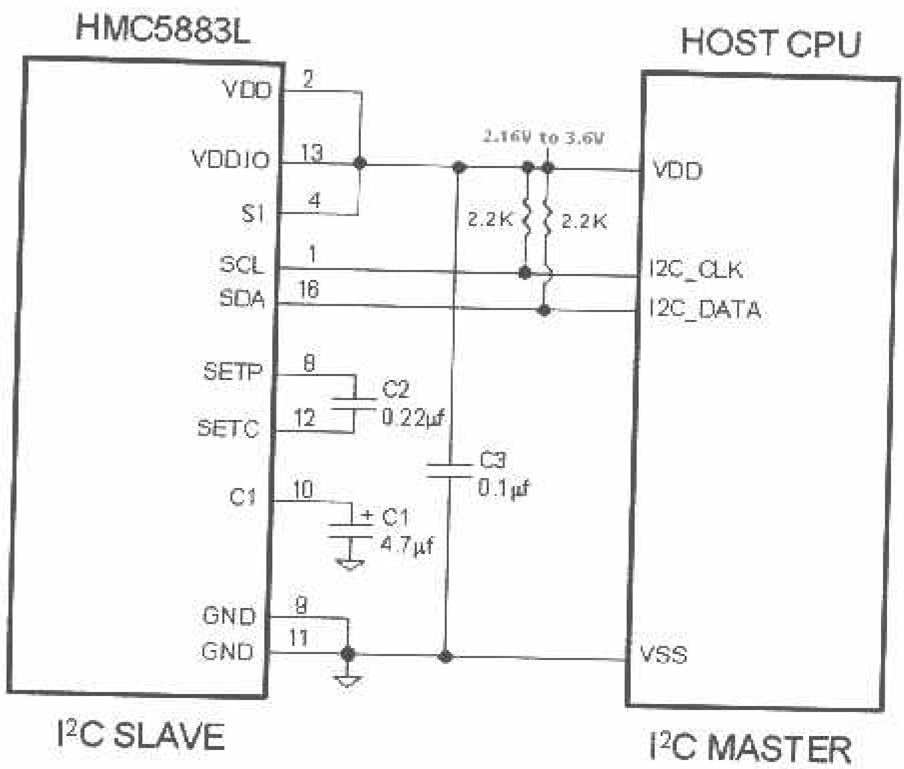
C5883L



AL SUPPLY REFERENCE DESIGN



IGLE SUPPLY REFERENCE DESIGN



SIC DEVICE OPERATION

sotropic Magneto-Resistive Sensors

Honeywell HMC5883L magnetoresistive sensor circuit is a trio of sensors and application specific support circuits to sure magnetic fields. With power supply applied, the sensor converts any incident magnetic field in the sensitive axis ctions to a differential voltage output. The magnetoresistive sensors are made of a nickel-iron (Permalloy) thin-film and erned as a resistive strip element. In the presence of a magnetic field, a change in the bridge resistive elements ses a corresponding change in voltage across the bridge outputs.

se resistive elements are aligned together to have a common sensitive axis (indicated by arrows in the pinout ram) that will provide positive voltage change with magnetic fields increasing in the sensitive direction. Because the ut is only proportional to the magnetic field component along its axis, additional sensor bridges are placed at ogonal directions to permit accurate measurement of magnetic field in any orientation.

Test

heck the HMC5883L for proper operation, a self test feature in incorporated in which the sensor is internally excited a nominal magnetic field (in either positive or negative bias configuration). This field is then measured and reported. function is enabled and the polarity is set by bits MS[n] in the configuration register A. An internal current source erates DC current (about 10 mA) from the VDD supply. This DC current is applied to the offset straps of the magneto-stive sensor, which creates an artificial magnetic field bias on the sensor. The difference of this measurement and the isurement of the ambient field will be put in the data output register for each of the three axes. By using this built-in tion, the manufacturer can quickly verify the sensor's full functionality after the assembly without additional test setup. self test results can also be used to estimate/compensate the sensor's sensitivity drift due to temperature.

each "self test measurement", the ASIC:

1. Sends a "Set" pulse
2. Takes one measurement (M1)
3. Sends the (~10 mA) offset current to generate the (~1.1 Gauss) offset field and takes another measurement (M2)
4. Puts the difference of the two measurements in sensor's data output register:

Output = [M2 – M1] (i.e. output = offset field only)

SELF TEST OPERATION section later in this datasheet for additional details.

ver Management

device has two different domains of power supply. The first one is VDD that is the power supply for internal rations and the second one is VDDIO that is dedicated to IO interface. It is possible to work with VDDIO equal to VDD; gle Supply mode, or with VDDIO lower than VDD allowing HMC5883L to be compatible with other devices on board.

Interface

ntrol of this device is carried out via the I^{2}C bus. This device will be connected to this bus as a slave device under the trol of a master device, such as the processor.

s device is compliant with *I^{2}C-Bus Specification*, document number: 9398 393 40011. As an I^{2}C compatible device, device has a 7-bit serial address and supports I^{2}C protocols. This device supports standard and fast modes, 100kHz 400kHz, respectively, but does not support the high speed mode (Hs). External pull-up resistors are required to port these standard and fast speed modes.

ivities required by the master (register read and write) have priority over internal activities, such as the measurement. purpose of this priority is to not keep the master waiting and the I^{2}C bus engaged for longer than necessary.

ernal Clock

device has an internal clock for internal digital logic functions and timing management. This clock is not available to ernal usage.

ridge for Set/Reset Strap Drive

ASIC contains large switching FETs capable of delivering a large but brief pulse to the Set/Reset strap of the sensor. strap is largely a resistive load. There is no need for an external Set/Reset circuit. The controlling of the Set/Reset tion is done automatically by the ASIC for each measurement. One half of the difference from the measurements n after a set pulse and after a reset pulse will be put in the data output register for each of the three axes. By doing he sensor's internal offset and its temperature dependence is removed/cancelled for all measurements. The set/reset es also effectively remove the past magnetic history (magnetism) in the sensor, if any.

each "measurement", the ASIC:

1. Sends a "Set" pulse
2. Takes one measurement (Mset)
3. Sends a "Reset" pulse
4. Takes another measurement (Mreset)
5. Puts the following result in sensor's data output register:

Output = [Mset – Mreset] / 2

rge Current Limit

current that reservoir capacitor (C1) can draw when charging is limited for both single supply and dual supply figurations. This prevents drawing down the supply voltage (VDD).

DES OF OPERATION

device has several operating modes whose primary purpose is power management and is controlled by the Mode ister. This section describes these modes.

tinuous-Measurement Mode

ng continuous-measurement mode, the device continuously makes measurements, at user selectable rate, and es measured data in data output registers. Data can be re-read from the data output registers if necessary; however, e master does not ensure that the data register is accessed before the completion of the next measurement, the data out registers are updated with the new measurement. To conserve current between measurements, the device is ed in a state similar to idle mode, but the Mode Register is not changed to Idle Mode. That is, MD[n] bits are hanged. Settings in the Configuration Register A affect the data output rate (bits DO[n]), the measurement figuration (bits MS[n]), when in continuous-measurement mode. All registers maintain values while in continuous-isurement mode. The I²C bus is enabled for use by other devices on the network in while continuous-measurement le.

gle-Measurement Mode

s is the default power-up mode. During single-measurement mode, the device makes a single measurement and es the measured data in data output registers. After the measurement is complete and output data registers are ated, the device is placed in idle mode, and the Mode Register *is* changed to idle mode by setting MD[n] bits. Settings ne configuration register affect the measurement configuration (bits MS[n])when in single-measurement mode. All sters maintain values while in single-measurement mode. The I²C bus is enabled for use by other devices on the work while in single-measurement mode.

Mode

ing this mode the device is accessible through the I²C bus, but major sources of power consumption are disabled, h as, but not limited to, the ADC, the amplifier, and the sensor bias current. All registers maintain values while in idle de. The I²C bus is enabled for use by other devices on the network while in idle mode.

3ISTERS

device is controlled and configured via a number of on-chip registers, which are described in this section. In the wing descriptions, *set* implies a logic 1, and *reset* or *clear* implies a logic 0, unless stated otherwise.

ister List
table below lists the registers and their access. All address locations are 8 bits.

Address Location	Name	Access
00	Configuration Register A	Read/Write
01	Configuration Register B	Read/Write
02	Mode Register	Read/Write
03	Data Output X MSB Register	Read
04	Data Output X LSB Register	Read
05	Data Output Z MSB Register	Read
06	Data Output Z LSB Register	Read
07	Data Output Y MSB Register	Read
08	Data Output Y LSB Register	Read
09	Status Register	Read
10	Identification Register A	Read
11	Identification Register B	Read
12	Identification Register C	Read

Table2: Register List

jister Access

section describes the process of reading from and writing to this device. The devices uses an address pointer to :ate which register location is to be read from or written to. These pointer locations are sent from the master to this e device and succeed the 7-bit address (0x1E) plus 1 bit read/write identifier, i.e. 0x3D for read and 0x3C for write.

ninimize the communication between the master and this device, the address pointer updated automatically without ster intervention. The register pointer will be incremented by 1 automatically after the current register has been read cessfully.

address pointer value itself cannot be read via the I^2C bus.
attempt to read an invalid address location returns 0's, and any write to an invalid address location or an undefined bit in a valid address location is ignored by this device.

nove the address pointer to a random register location, first issue a "write" to that register location with no data byte wing the commend. For example, to move the address pointer to register 10, send 0x3C 0x0A.

figuration Register A

configuration register is used to configure the device for setting the data output rate and measurement configuration. .0 through CRA7 indicate bit locations, with *CRA* denoting the bits that are in the configuration register. CRA7 denotes irst bit of the data stream. The number in parenthesis indicates the default value of that bit.CRA default is 0x10.

CRA7	CRA6	CRA5	CRA4	CRA3	CRA2	CRA1	CRA0
(0)	MA1(0)	MA0(0)	DO2 (1)	DO1 (0)	DO0 (0)	MS1 (0)	MS0 (0)

Table 3: Configuration Register A

Location	Name	Description
CRA7	CRA7	Bit CRA7 is reserved for future function. Set to 0 when configuring CRA.
CRA6 to CRA5	MA1 to MA0	Select number of samples averaged (1 to 8) per measurement output. 00 = 1(Default); 01 = 2; 10 = 4; 11 = 8
CRA4 to CRA2	DO2 to DO0	Data Output Rate Bits. These bits set the rate at which data is written to all three data output registers.
CRA1 to CRA0	MS1 to MS0	Measurement Configuration Bits. These bits define the measurement flow of the device, specifically whether or not to incorporate an applied bias into the measurement.

Table 4: Configuration Register A Bit Designations

Table below shows all selectable output rates in continuous measurement mode. All three channels shall be ısured within a given output rate. Other output rates with maximum rate of 160 Hz can be achieved by monitoring)Y interrupt pin in single measurement mode.

DO2	DO1	DO0	Typical Data Output Rate (Hz)
0	0	0	0.75
0	0	1	1.5
0	1	0	3
0	1	1	7.5
1	0	0	15 (Default)
1	0	1	30
1	1	0	75
1	1	1	Reserved

Table 5: Data Output Rates

MS1	MS0	Measurement Mode
0	0	Normal measurement configuration (Default). In normal measurement configuration the device follows normal measurement flow. The positive and negative pins of the resistive load are left floating and high impedance.
0	1	Positive bias configuration for X, Y, and Z axes. In this configuration, a positive current is forced across the resistive load for all three axes.
1	0	Negative bias configuration for X, Y and Z axes. In this configuration, a negative current is forced across the resistive load for all three axes..
1	1	This configuration is reserved.

Table 6: Measurement Modes

figuration Register B

configuration register B for setting the device gain. CRB0 through CRB7 indicate bit locations, with *CRB* denoting the that are in the configuration register. CRB7 denotes the first bit of the data stream. The number in parenthesis :ates the default value of that bit. CRB default is 0x20.

CRB7	CRB6	CRB5	CRB4	CRB3	CRB2	CRB1	CRB0
GN2 (0)	GN1 (0)	GN0 (1)	(0)	(0)	(0)	(0)	(0)

Table 7: Configuration B Register

Location	Name	Description
CRB7 to CRB5	GN2 to GN0	Gain Configuration Bits. These bits configure the gain for the device. The gain configuration is common for all channels.
CRB4 to CRB0	0	These bits must be cleared for correct operation.

Table 8: Configuration Register B Bit Designations

table below shows nominal gain settings. Use the "Gain" column to convert counts to Gauss. The "Digital Resolution" mn is the theoretical value in term of milli-Gauss per count (LSb) which is the inverse of the values in the "Gain" mn. The effective resolution of the usable signal also depends on the noise floor of the system, i.e.

ctive Resolution = Max (Digital Resolution, Noise Floor)

ose a lower gain value (higher GN#) when total field strength causes overflow in one of the data output registers uration). Note that the very first measurement after a gain change maintains the same gain as the previous setting. **new gain setting is effective from the second measurement and on.**

GN2	GN1	GN0	Recommended Sensor Field Range	Gain (LSb/ Gauss)	Digital Resolution (mG/LSb)	Output Range
0	0	0	± 0.88 Ga	1370	0.73	0xF800–0x07FF (-2048–2047)
0	0	1	± 1.3 Ga	1090 (default)	0.92	0xF800–0x07FF (-2048–2047)
0	1	0	± 1.9 Ga	820	1.22	0xF800–0x07FF (-2048–2047)
0	1	1	± 2.5 Ga	660	1.52	0xF800–0x07FF (-2048–2047)
1	0	0	± 4.0 Ga	440	2.27	0xF800–0x07FF (-2048–2047)
1	0	1	± 4.7 Ga	390	2.56	0xF800–0x07FF (-2048–2047)
1	1	0	± 5.6 Ga	330	3.03	0xF800–0x07FF (-2048–2047)
1	1	1	± 8.1 Ga	230	4.35	0xF800–0x07FF (-2048–2047)

Table 9: Gain Settings

e Register

mode register is an 8-bit register from which data can be read or to which data can be written. This register is used to ct the operating mode of the device. MR0 through MR7 indicate bit locations, with *MR* denoting the bits that are in the e register. MR7 denotes the first bit of the data stream. The number in parenthesis indicates the default value of that Mode register default is 0x01.

MR7	MR6	MR5	MR4	MR3	MR2	MR1	MR0
HS(0)	(0)	(0)	(0)	(0)	(0)	MD1 (0)	MD0 (1)

Table 10: Mode Register

Location	Name	Description
MR7 to MR2	HS	Set this pin to enable High Speed I2C, 3400kHz.
MR1 to MR0	MD1 to MD0	Mode Select Bits. These bits select the operation mode of this device.

Table 11: Mode Register Bit Designations

MD1	MD0	Operating Mode
0	0	Continuous-Measurement Mode. In continuous-measurement mode, the device continuously performs measurements and places the result in the data register. RDY goes high when new data is placed in all three registers. After a power-on or a write to the mode or configuration register, the first measurement set is available from all three data output registers after a period of $2/f_{DO}$ and subsequent measurements are available at a frequency of f_{DO}, where f_{DO} is the frequency of data output.
0	1	Single-Measurement Mode (Default). When single-measurement mode is selected, device performs a single measurement, sets RDY high and returned to idle mode. Mode register returns to idle mode bit values. The measurement remains in the data output register and RDY remains high until the data output register is read or another measurement is performed.
1	0	Idle Mode. Device is placed in idle mode.
1	1	Idle Mode. Device is placed in idle mode.

Table 12: Operating Modes

Output X Registers A and B

data output X registers are two 8-bit registers, data output register A and data output register B. These registers : the measurement result from channel X. Data output X register A contains the MSB from the measurement result, data output X register B contains the LSB from the measurement result. The value stored in these two registers is a it value in 2's complement form, whose range is 0xF800 to 0x07FF. DXRA0 through DXRA7 and DXRB0 through B7 indicate bit locations, with *DXRA* and *DXRB* denoting the bits that are in the data output X registers. DXRA7 and B7 denote the first bit of the data stream. The number in parenthesis indicates the default value of that bit.

e event the ADC reading overflows or underflows for the given channel, or if there is a math overflow during the bias surement, this data register will contain the value -4096. This register value will clear when after the next valid surement is made.

DXRA7	DXRA6	DXRA5	DXRA4	DXRA3	DXRA2	DXRA1	DXRA0
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
DXRB7	**DXRB6**	**DXRB5**	**DXRB4**	**DXRB3**	**DXRB2**	**DXRB1**	**DXRB0**
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)

Table 13: Data Output X Registers A and B

ı Output Y Registers A and B

data output Y registers are two 8-bit registers, data output register A and data output register B. These registers ə the measurement result from channel Y. Data output Y register A contains the MSB from the measurement result, data output Y register B contains the LSB from the measurement result. The value stored in these two registers is a ıit value in 2's complement form, whose range is 0xF800 to 0x07FF. DYRA0 through DYRA7 and DYRB0 through ₹B7 indicate bit locations, with *DYRA* and *DYRB* denoting the bits that are in the data output Y registers. DYRA7 and ₹B7 denote the first bit of the data stream. The number in parenthesis indicates the default value of that bit.

ıe event the ADC reading overflows or underflows for the given channel, or if there is a math overflow during the bias ısurement, this data register will contain the value -4096. This register value will clear when after the next valid ısurement is made.

DYRA7	DYRA6	DYRA5	DYRA4	DYRA3	DYRA2	DYRA1	DYRA0
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
DYRB7	**DYRB6**	**DYRB5**	**DYRB4**	**DYRB3**	**DYRB2**	**DYRB1**	**DYRB0**
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)

Table 14: Data Output Y Registers A and B

a Output Z Registers A and B

data output Z registers are two 8-bit registers, data output register A and data output register B. These registers 'e the measurement result from channel Z. Data output Z register A contains the MSB from the measurement result, data output Z register B contains the LSB from the measurement result. The value stored in these two registers is a ɔit value in 2's complement form, whose range is 0xF800 to 0x07FF. DZRA0 through DZRA7 and DZRB0 through ₹B7 indicate bit locations, with *DZRA* and *DZRB* denoting the bits that are in the data output Z registers. DZRA7 and ₹B7 denote the first bit of the data stream. The number in parenthesis indicates the default value of that bit.

he event the ADC reading overflows or underflows for the given channel, or if there is a math overflow during the bias asurement, this data register will contain the value -4096. This register value will clear when after the next valid asurement is made.

DZRA7	DZRA6	DZRA5	DZRA4	DZRA3	DZRA2	DZRA1	DZRA0
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
DZRB7	**DZRB6**	**DZRB5**	**DZRB4**	**DZRB3**	**DZRB2**	**DZRB1**	**DZRB0**
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)

Table 15: Data Output Z Registers A and B

ı Output Register Operation

ın one or more of the output registers are read, new data cannot be placed in any of the output data registers until all lata output registers are read. This requirement also impacts DRDY and RDY, which cannot be cleared until new is placed in all the output registers.

us Register

status register is an 8-bit read-only register. This register is used to indicate device status. SR0 through SR7 :ate bit locations, with *SR* denoting the bits that are in the status register. SR7 denotes the first bit of the data stream.

SR7	SR6	SR5	SR4	SR3	SR2	SR1	SR0
(0)	(0)	(0)	(0)	(0)	(0)	LOCK (0)	RDY(0)

Table 16: Status Register

Location	Name	Description
SR7 to SR2	0	These bits are reserved.
SR1	LOCK	Data output register lock. This bit is set when: 1.some but not all for of the six data output registers have been read, 2. Mode register has been read. When this bit is set, the six data output registers are locked and any new data will not be placed in these register until one of these conditions are met: 1.all six bytes have been read, 2. the mode register is changed, 3. the measurement configuration (CRA) is changed, 4. power is reset.
SR0	RDY	Ready Bit. Set when data is written to all six data registers. Cleared when device initiates a write to the data output registers and after one or more of the data output registers are written to. When RDY bit is clear it shall remain cleared for a 250 μs. DRDY pin can be used as an alternative to the status register for monitoring the device for measurement data.

Table 17: Status Register Bit Designations

tification Register A

identification register A is used to identify the device. IRA0 through IRA7 indicate bit locations, with *IRA* denoting the that are in the identification register A. IRA7 denotes the first bit of the data stream. The number in parenthesis ates the default value of that bit.

identification value for this device is stored in this register. This is a read-only register.
ster values. ASCII value *H*

IRA7	IRA6	IRA5	IRA4	IRA3	IRA2	IRA1	IRA0
0	1	0	0	1	0	0	0

Table 18: Identification Register A Default Values

tification Register B

identification register B is used to identify the device. IRB0 through IRB7 indicate bit locations, with *IRB* denoting the that are in the identification register A. IRB7 denotes the first bit of the data stream.

ster values. ASCII value *4*

IRB7	IRB6	IRB5	IRB4	IRB3	IRB2	IRB1	IRB0
0	0	1	1	0	1	0	0

Table 19: Identification Register B Default Values

tification Register C

identification register C is used to identify the device. IRC0 through IRC7 indicate bit locations, with *IRC* denoting the that are in the identification register A. IRC7 denotes the first bit of the data stream.

ister values. ASCII value *3*

IRC7	IRC6	IRC5	IRC4	IRC3	IRC2	IRC1	IRC0
0	0	1	1	0	0	1	1

Table 20: Identification Register C Default Values

COMMUNICATION PROTOCOL

HMC5883L communicates via a two-wire I^2C bus system as a slave device. The HMC5883L uses a simple protocol the interface protocol defined by the I^2C bus specification, and by this document. The data rate is at the standard-le 100kbps or 400kbps rates as defined in the I^2C Bus Specifications. The bus bit format is an 8-bit Data/Address d and a 1-bit acknowledge bit. The format of the data bytes (payload) shall be case sensitive ASCII characters or ry data to the HMC5883L slave, and binary data returned. Negative binary values will be in two's complement form. default (factory) HMC5883L 8-bit slave address is 0x3C for write operations, or 0x3D for read operations.

HMC5883L Serial Clock (SCL) and Serial Data (SDA) lines require resistive pull-ups (Rp) between the master device ually a host microprocessor) and the HMC5883L. Pull-up resistance values of about 2.2K to 10K ohms are ommended with a nominal VDDIO voltage. Other resistor values may be used as defined in the I^2C Bus Specifications can be tied to VDDIO.

SCL and SDA lines in this bus specification may be connected to multiple devices. The bus can be a single master to tiple slaves, or it can be a multiple master configuration. All data transfers are initiated by the master device, which is onsible for generating the clock signal, and the data transfers are 8 bit long. All devices are addressed by I^2C's que 7-bit address. After each 8-bit transfer, the master device generates a 9th clock pulse, and releases the SDA line. receiving device (addressed slave) will pull the SDA line low to acknowledge (ACK) the successful transfer or leave SDA high to negative acknowledge (NACK).

:he I²C spec, all transitions in the SDA line must occur when SCL is low. This requirement leads to two unique itions on the bus associated with the SDA transitions when SCL is high. Master device pulling the SDA line low while ;CL line is high indicates the Start (S) condition, and the Stop (P) condition is when the SDA line is pulled high while ;CL line is high. The I²C protocol also allows for the Restart condition in which the master device issues a second condition without issuing a stop.

us transactions begin with the master device issuing the start sequence followed by the slave address byte. The ess byte contains the slave address; the upper 7 bits (bits7-1), and the Least Significant bit (LSb). The LSb of the ess byte designates if the operation is a read (LSb=1) or a write (LSb=0). At the 9th clock pulse, the receiving slave ɔe will issue the ACK (or NACK). Following these bus events, the master will send data bytes for a write operation, or slave will clock out data with a read operation. All bus transactions are terminated with the master issuing a stop ɪence.

ɔus control can be implemented with either hardware logic or in software. Typical hardware designs will release the and SCL lines as appropriate to allow the slave device to manipulate these lines. In a software implementation, care t be taken to perform these tasks in code.

ERATIONAL EXAMPLES

HMC5883L has a fairly quick stabilization time from no voltage to stable and ready for data retrieval. The nominal 56 seconds with the factory default single measurement mode means that the six bytes of magnetic data registers RA, DXRB, DZRA, DZRB, DYRA, and DYRB) are filled with a valid first measurement.

hange the measurement mode to continuous measurement mode, after the power-up time send the three bytes:

: 0x02 0x00

writes the 00 into the second register or mode register to switch from single to continuous measurement mode ng. With the data rate at the factory default of 15Hz updates, a 67 milli-second typical delay should be allowed by the naster before querying the HMC5883L data registers for new measurements. To clock out the new data, send:

), and clock out DXRA, DXRB, DZRA, DZRB, DYRA, and DYRB located in registers 3 through 8. The HMC5883L will matically re-point back to register 3 for the next 0x3D query. All six data registers must be read properly before new can be placed in any of these data registers.

ɪw is an example of a (power-on) initialization process for "continuous-measurement mode":

1. Write CRA (00) – send **0x3C** 0x00 **0x70** (8-average, 15 Hz default, normal measurement)
2. Write CRB (01) – send **0x3C** 0x01 **0xA0** (Gain=5, or any other desired gain)
3. Write Mode (02) – send **0x3C** 0x02 **0x00** (Continuous-measurement mode)
4. Wait 6 ms or monitor status register or DRDY hardware interrupt pin
5. Loop
   - Send **0x3D 0x06** (Read all 6 bytes. If gain is changed then this data set is using previous gain)
   - Convert three 16-bit 2's compliment hex values to decimal values and assign to X, Z, Y, respectively.
   - Send **0x3C 0x03** (point to first data register 03)
   - Wait about 67 ms (if 15 Hz rate) or monitor status register or DRDY hardware interrupt pin

   End_loop

ɔw is an example of a (power-on) initialization process for "single-measurement mode":

1. Write CRA (00) – send **0x3C** 0x00 **0x70** (8-average, 15 Hz default or any other rate, normal measurement)
2. Write CRB (01) – send **0x3C** 0x01 **0xA0** (Gain=5, or any other desired gain)
3. For each measurement query:
   - Write Mode (02) – send **0x3C** 0x02 **0x01** (Single-measurement mode)
   - Wait 6 ms or monitor status register or DRDY hardware interrupt pin
   - Send **0x3D 0x06** (Read all 6 bytes. If gain is changed then this data set is using previous gain)
   - Convert three 16-bit 2's compliment hex values to decimal values and assign to X, Z, Y, respectively.

.F TEST OPERATION

heck the HMC5883L for proper operation, a self test feature in incorporated in which the sensor offset straps are ed to create a nominal field strength (bias field) to be measured. To implement self test, the least significant bits (MS1 MS0) of configuration register A are changed from 00 to 01 (positive bias) or 10 (negetive bias).

ı, by placing the mode register into single or continuous-measurement mode, two data acquisition cycles will be made ach magnetic vector. The first acquisition will be a set pulse followed shortly by measurement data of the external The second acquisition will have the offset strap excited (about 10 mA) in the positive bias mode for X, Y, and Z to create about a 1.1 gauss self test field plus the external field. The first acquisition values will be subtracted from econd acquisition, and the net measurement will be placed into the data output registers.

e self test adds ~1.1 Gauss additional field to the existing field strength, using a reduced gain setting prevents sensor being saturated and data registers overflowed. For example, if the configuration register B is set to 0xA0 (Gain=5), es around +452 LSb (1.16 Ga * 390 LSb/Ga) will be placed in the X and Y data output registers and around +421 Ga * 390 LSb/Ga) will be placed in Z data output register. To leave the self test mode, change MS1 and MS0 bit of configuration register A back to 00 (Normal Measurement Mode). Acceptable limits of the self test values depend on gain setting. Limits for Gain=5 is provided in the specification table.

w is an example of a "positive self test" process using continuous-measurement mode:

1. Write CRA (00) – send **0x3C** 0x00 **0x71** (8-average, 15 Hz default, positive self test measurement)
2. Write CRB (01) – send **0x3C** 0x01 **0xA0** (Gain=5)
3. Write Mode (02) – send **0x3C** 0x02 **0x00** (Continuous-measurement mode)
4. Wait 6 ms or monitor status register or DRDY hardware interrupt pin
5. Loop
   - Send **0x3D 0x06** (Read all 6 bytes. If gain is changed then this data set is using previous gain)
   - Convert three 16-bit 2's compliment hex values to decimal values and assign to X, Z, Y, respectively.
   - Send **0x3C 0x03** (point to first data register 03)
   - Wait about 67 ms (if 15 Hz rate) or monitor status register or DRDY hardware interrupt pin

   End_loop
6. Check limits –

   If all 3 axes (X, Y, and Z) are within reasonable limits (243 to 575 for Gain=5, adjust these limits basing on the gain setting used. See an example below.) Then
   - All 3 axes pass positive self test
   - Write CRA (00) – send **0x3C** 0x00 **0x70** (Exit self test mode and this procedure)

   Else
   - If Gain<7
     - Write CRB (01) – send **0x3C** 0x01 **0x_0** (Increase gain setting and retry, skip the next data set)
   - Else
     - At least one axis did not pass positive self test
     - Write CRA (00) – send **0x3C** 0x00 **0x70** (Exit self test mode and this procedure)

   End If

ow is an example of how to adjust the "positive self" test limits basing on the gain setting:

1. If Gain = 6, self test limits are:
   Low Limit = 243 * 330/390 = 206
   High Limit = 575 * 330/390 = 487
2. If Gain = 7, self test limits are:
   Low Limit = 243 * 230/390 = 143
   High Limit = 575 * 230/390 = 339

ιLE FACTOR TEMPERATURE COMPENSATION

built-in self test can also be used to periodically compensate the scaling errors due to temperature variations. A ɔensation factor can be found by comparing the self test outputs with the ones obtained at a known temperature. For ıple, if the self test output is 400 at room temperature and 300 at the current temperature then a compensation factor 00/300) should be applied to all current magnetic readings. A temperature sensor is not required using this method.

w is an example of a temperature compensation process using positive self test method:

1. If self test measurement at a temperature "when the last magnetic calibration was done":
   X_STP = 400
   Y_STP = 410
   Z_STP = 420
2. If self test measurement at a different tmperature:
   X_STP = 300 (Lower than before)
   Y_STP = 310 (Lower than before)
   Z_STP = 320 (Lower than before)

   Then
   X_TempComp = 400/300
   Y_TempComp = 410/310
   Z_TempComp = 420/320
3. Applying to all new measurements:
   X = X * X_TempComp
   Y = Y * Y_TempComp
   Z = Z * Z_TempComp

   Now all 3 axes are temperature compensated, i.e. sensitivity is same as "when the last magnetic calibration was done"; therefore, the calibration coefficients can be applied without modification.
4. Repeat this process periodically or,for every Δt degrees of temperature change measured, if available.

DERING INFORMATION

Ordering Number	Product
HMC5883L-T	Cut Tape
HMC5883L-TR	Tape and Reel 4k pieces/reel

Caution
This part is sensitive to damage by electrostatic discharge. Use ESD precautionary procedures when touching, removing or inserting

CAUTION: ESDS CAT. 1B

D OUT MORE

more information on Honeywell's Magnetic Sensors visit us online at www.magneticsensors.com or contact us at)0-323-8295 (763-954-2474 internationally).

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nouth, MN 55441
800-323-8295
v.magneticsensors.com

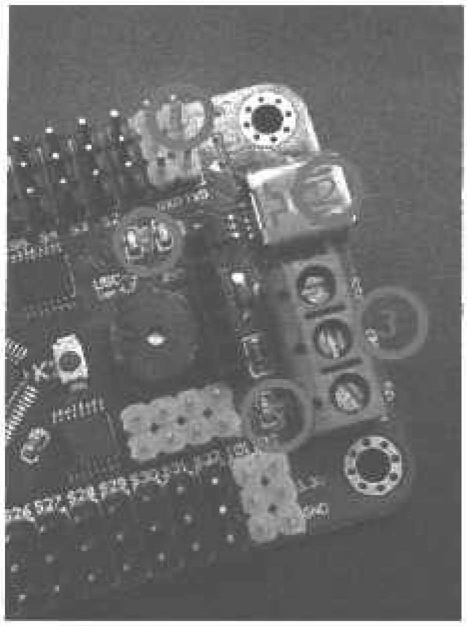
Form # 900405 Rev E
February 2013

Honeywell

Servo Controller Instructions for Use

Power Supply

The servo controller needs two power supplies: servo power supply and chip power supply.



Servo power supply (+): VS (left of the blue connecting terminal at Position 3 in the figure)

Servo power supply (-): GND (middle of the blue connecting terminal at Position 3 in the figure)

Servo power supply's parameters depend on the parameters of the attached servo. For example, if the TR213 servo has a power supply of 4.8-7.2V, the servo power supply can use the power source of 4.8-7.2V.

Chip power supply (+): VSS (right of the blue connecting terminal at Position 3 in the figure)

Chip power supply (-): GND (middle of the blue connecting terminal at Position 3 in the figure)

There is a VSS requirement of 6.5-12V. If the chip power is input through the VSS port, the power supply has to range from 6.5 to 12V.

Notes:

1. The USB port at Position 2 in the figure can supply power to the chip. So it is adequate to choose the USB port or alternatively the VSS port.
2. Position 1 in the figure can supply power to the chip as well, marked 5V and GND, where 5V is the anode and GND is the cathode. The power supply has to be 5V.
3. Positions 1, 2 and 3 can supply power to the chip. It is adequate to choose any of them.
4. The green LED light at Position 4 in the figure is the chip power indicator. If the green light is on, it indicates the chip power works correctly; if the light is off, it indicates the chip power malfunctions.
5. The green LED light at Position 5 in the figure is the servo power indicator. If the green light is on, it indicates the servo power works correctly; if the light is off, it indicates the servo power malfunctions.

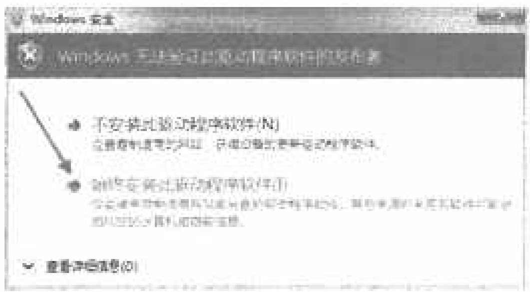
It is necessary for both green LED lights to be on to control the servo.

Install the Driver

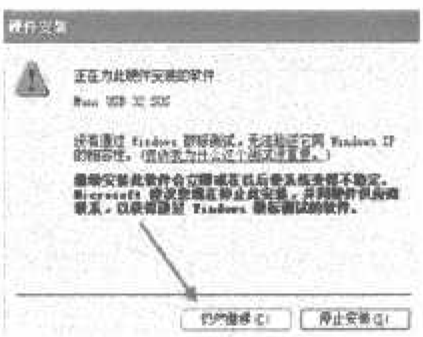
The driver is available at http://dl.torobot.com/down/usc_driver.exe (case-sensitive)

Directly double click on USC_driver.exe; click on Next and the driver will be installed automatically.

If the prompt below occurs during installation, please choose "always install this driver".

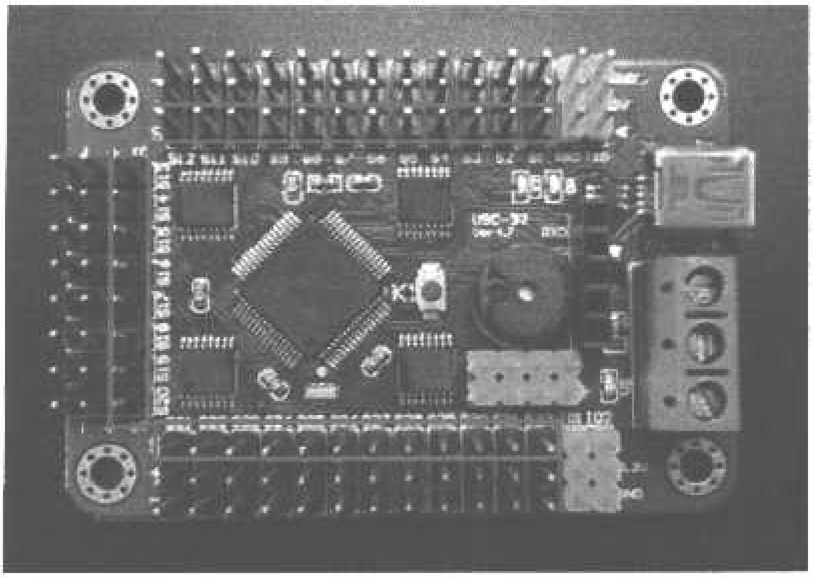


If the prompt below occurs during installation, please choose "continue".



After the driver is installed successfully, enter the computer's device manager and you will see the hardware device of the servo controller. For example, the mini USB servo control in the figure below is the device name, and the COM1 is the port number. The device's port number is needed when the computer software control is exercised on the servo.

Connect the servo to the servo controller



What is marked red in the figure are the servo's connectors for signal wires (be careful about the direction when connecting to the servo).

What is marked yellow in the figure are not the servo's connectors.

Pay attention to the white textual symbols aside when connecting to the servo. For example, S1, S2,..., S32 refers to the servo channels that correspond to the computer software.

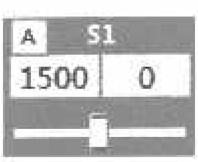
Download the Software

The software can be downloaded at
http://dl.torobot.com/down/rios_usc.exe (case-sensitive).

Control one single servo

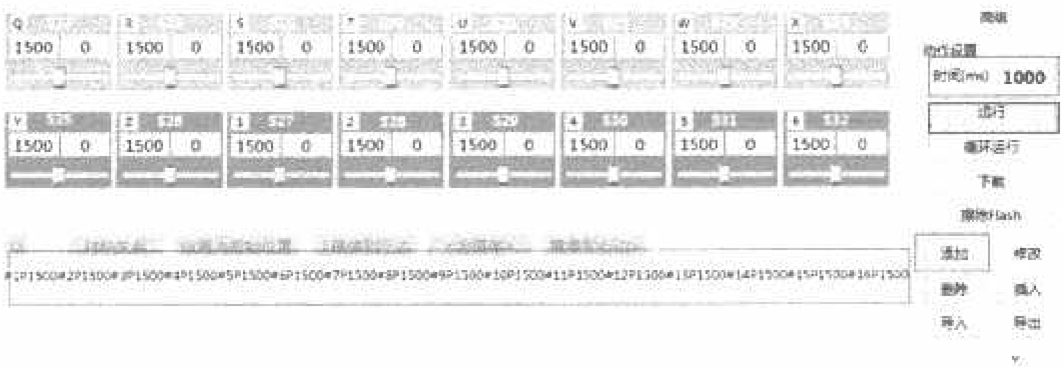
Run RIOS_USC.exe, choose the right port number, and then click the button "open".

Use the mouse to drag the slider in the servo panel (drag the servo panel corresponding to the channel with which the servo is connected; at the upper part of the panel is the serial number, such as the S1 in the figure below).



Control Multiple Servos Simultaneously

After multiple servos are controlled in sequence by following the steps above, set the time (e.g. in the figure below, the setting, referred to as the rotary speed, is 1000ms; it has to fall in the range 100-9999; the higher the value, the slower the speed). Then click on the button "add" at the lower part of the software. The software will produce a command at the lower part of the software which can exercise simultaneous control over all the servos that are controlled earlier (if 10 servos are controlled earlier, the command can control these 10 servos simultaneously).



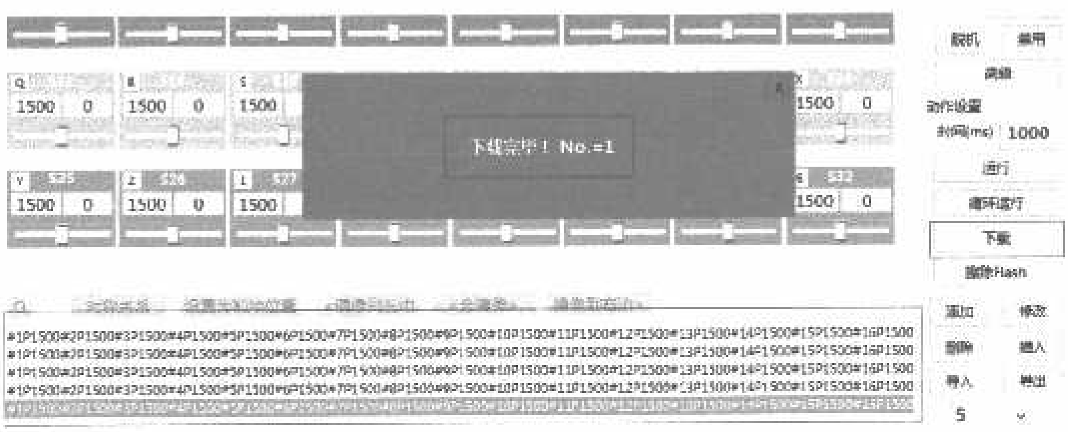
Download the Action Group

If several or dozens of commands are produced by following the steps above, you can click on the button "run" at the right of the software to test these commands.

If the test result is acceptable, you can click on the button "download" at the right of the software to download the action group.

On completion of the download, the software will prompt "download is complete! No.=1", where the number refers to the serial number of this action group.

Afterwards, all commands in the group can be executed by executing the action group.



Run the Action Group

First click on the button "read" to get all serial numbers of groups, then input the number of times of executions, click the button "run", and the selected action group will be executed.

Use the Off-Line Working

First click on the button "read" to get all serial numbers of groups, input the number of times of executions, click the button "off-line", and then the selected action group will be executed off-line (off-line means that the group of actions will not be executed until the controller power is turned on).

If off-line working of the controller is no longer needed, you can click the button "disable" to turn off the function.

Erase Flash

Erase all action group already downloaded to the controller.

Secondary development

The servo controller is a slave device, meaning that it can either accept commands or execute preset commands. It cannot think at all.

Communication protocol: serial communication (TTL level), baud rate 9600, no check bit, 8 data bits, 1 stop bit

To control the servo through the servo controller, users can self-develop computer software or use the MCU to send commands to the servo controller.

Command format:

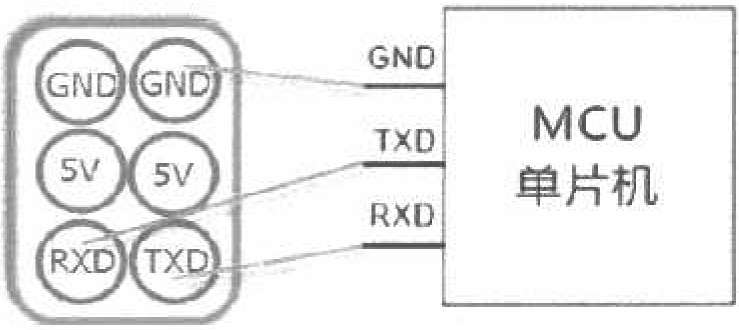
Name	Command	Description
Control one single servo	#1P1500T100\r\n	Data 1 refers to the servo's channel Data 1500 refers to the servo' location, in the range 500-2500 Data 100 refers to the time of execution and represents the speed, in the range 100-9999
Control multiple servos	#1P600#2P900#8P2500T100\r\n	Data 1, 2, and 8 refer to the servo's channels Data 600, 900, and 2500 refer to the locations of the servos that correspond to three channels Data 100 refers to the time of execution and represents the speed of three servos. Regardless of the number of servos, there is only one time, or one T. The command is executed at the same time; that is, all servos operate simultaneously.
Execute one single action group	#1GC2\r\n	Data 1 refers to the serial number of the action group Data 2 refers to the number of cycles
Execute multiple action groups	#1G#3G#1GC2\r\n	Execute the first, third and first action group,The number of cycles is 2. One particular group of action can appear repeatedly. There can be only one number of cycles or C. The command is executed in sequence; that is, the action groups are executed in sequence.

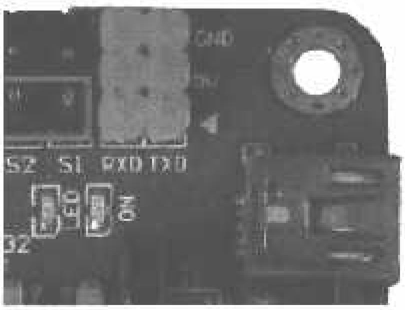
All commands above contain \r\n. It is the end mark of the command and is mandatory.

All commands are no spaces.

\r\n represents two characters of carrier return and linefeed, and are the hexadecimal 0x0D and 0x0A, or Chr(13) and Chr(10).

Connect to the MCU





ɜr Manual of 8A UBEC

8 Amps Switch-Mode UBEC

Why do you need UBEC?

8A-UBEC is a switch-mode DC-DC regulator supplied with a 2-3 cells lithium battery pack and ıts a consistent safe voltage for your receiver, gyro and servos. It is very suitable for nitro powered ıelicopter (above 30 class) and big fixed-wing aircraft.

pared with the linear mode UBEC, the overall efficiency of the switch-mode BEC is much higher, so ı extend the working time of the receiver battery pack, and because a switch mode UBEC can ficantly reduce the heat emission, it can avoid the loss of control caused by the over-heat problem ı is frequently happened with the linear mode UBEC.

Specification:

Output: 5V/8A or 6V/8A (Changeable with an output-voltage select switch)

Input: 6V-12.6V (2-3 cells lithium battery pack)

Size: 42mm*39mm*9mm (length*width*height)

Weight: 38g

Quiescent current: 60mA

Features:

Designed with an advanced switch mode DC-DC regulator IC.

The output current is very large, the continuous output current is up to 8A, and the burst output current is 15A.

With the output short-circuit protection function.

A metal shield covers almost all the electronic components, and a specially made filter (ferrite ring) is attached with the output wires to significantly reduce the electromagnetic interference.

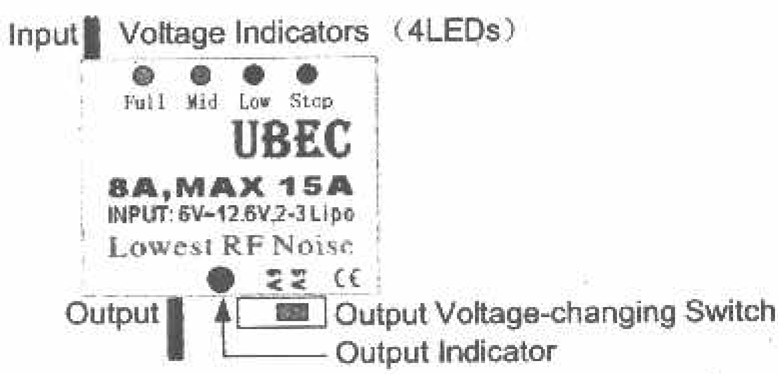
Automatically detects the number of the lithium battery pack (2 cells or 3 cells), and shows the battery capacity with 4 indicators (LEDs).

Shows the working status with an indicator (LED), lights when the output is in normal range.

2 output leads to reduce the resistance when connecting the UEBC to the receiver.

Accessory:　A step-down voltage regulator with 0.7V down (from 6.0V to 5.3V).

Wiring Method



Special Explanation

Although we have tried our best to reduce the electromagnetic interference caused by switch model UBEC, it still may cause some interference to the receiver. So please install the filter far away from the UBEC's main board, and DON'T stack the filter on the main board. Please put the whole UBEC as far as possible away from the receiver.

This UBEC is only designed for using lithium batter pack; we don't recommend the use of NiMh / NiCd battery pack.

The input polarity must be correct; otherwise the UBEC will be damaged. Please check the polarity carefully before connecting the battery pack.

How to Use the UBEC?

Change the output voltage

The voltage is chosen by an output-voltage select switch.

Working status indicator (LED)

The LED shows whether the output is normal or not. It lights when the UBEC has the normal output. If it doesn't light, please check the battery connections.

Battery capacity indicators (4 LEDs)

LED Status				The voltage of the lithium battery pack	
Full	Mid	Low	Stop	2S battery pack	3S battery pack
○	○	○	○	7.8－8.4V	11.7－12.6V
●	○	○	○	7.2－7.8V	10.8－11.7V
●	●	○	○	6.6－7.2V	9.9－10.8V
●	●	●	○	5.4－6.6V	<9.9V
4 LEDs flash at the same time				1)The voltage <5.4V 2)The voltage >13.5V	1)The voltage >13.5V
One LED flashes for a short time				The voltage of the battery pack is just at the critical edge of each range.	

○ means the LED lights, ● means the LED does not light

When you are using a 3 cells lithium battery pack, if there is only one LED ("STOP") lights, that means the voltage is less than 9.9v, please change the battery pack as soon as possible, otherwise it will be damaged because of over-discharging. For such a fully-discharged 3S battery pack, if the voltage is less than 9V, please don't use it again before it is recharged, otherwise the UBEC may mistakenly consider this battery as 2 cells, so the power capacity indication function will be confused.

Turn on or turn off the output

Set the main switch to the "ON" position to turn on the output; Set the main switch to the "OFF" position to turn off the output.

About the 0.7V step-down voltage regulator

Allowing use of Futaba servo models 9241, 9251, 9253, 9254, 9255, 9256 and other digital servos not capable of handling 6V. This small device can change the voltage from 6V to 5.3V. When the UBEC output is set to 6V, the step-down voltage regulator is useful.

Method: Just connect the regulator inline between the Gyro and the rudder servo (Or between the receiver and the servo), that's OK.

If you are using a servo that can accept 6V input, the regulator is not required.

The Future of Analog IC Technology®

DESCRIPTION

The MP1584 is a high frequency step-down switching regulator with an integrated internal high-side high voltage power MOSFET. It provides 3A output with current mode control for fast loop response and easy compensation.

The wide 4.5V to 28V input range accommodates a variety of step-down applications, including those in an automotive input environment. A 100µA operational quiescent current allows use in battery-powered applications.

High power conversion efficiency over a wide load range is achieved by scaling down the switching frequency at light load condition to reduce the switching and gate driving losses.

The frequency foldback helps prevent inductor current runaway during startup and thermal shutdown provides reliable, fault tolerant operation.

By switching at 1.5MHz, the MP1584 is able to prevent EMI (Electromagnetic Interference) noise problems, such as those found in AM radio and ADSL applications.

The MP1584 is available in a thermally enhanced SOIC8E package.

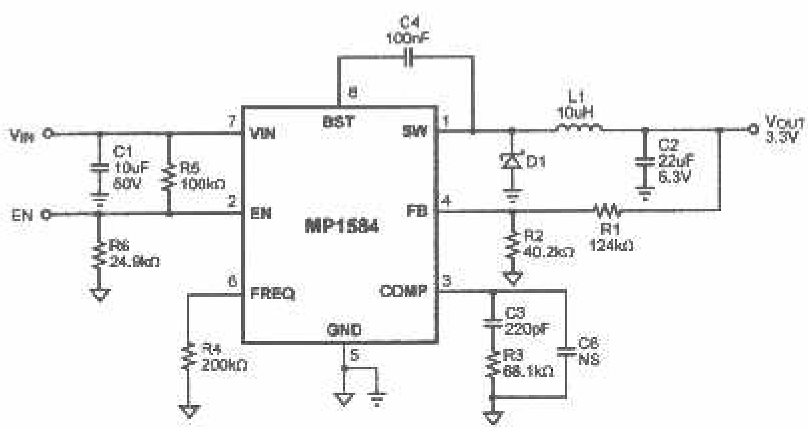
FEATURES

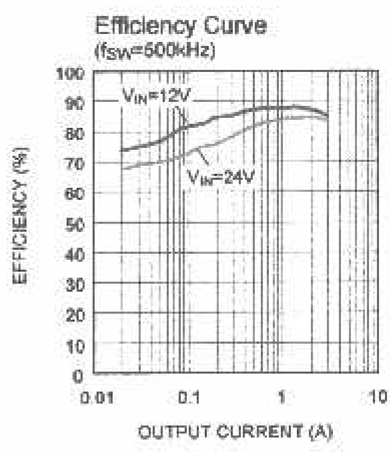
- Wide 4.5V to 28V Operating Input Range
- Programmable Switching Frequency from 100kHz to 1.5MHz
- High-Efficiency Pulse Skipping Mode for Light Load
- Ceramic Capacitor Stable
- Internal Soft-Start
- Internally Set Current Limit without a Current Sensing Resistor
- Available in SOIC8E Package.

APPLICATIONS

- High Voltage Power Conversion
- Automotive Systems
- Industrial Power Systems
- Distributed Power Systems
- Battery Powered Systems

TYPICAL APPLICATION



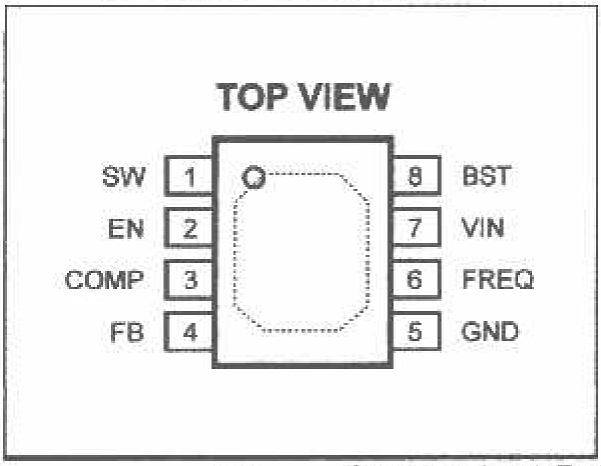


ORDERING INFORMATION

Part Number*	Package	Top Marking	Free Air Temperature (T_A)
MP1584EN	SOIC8E	MP1584EN	–20°C to +85°C

* For Tape & Reel, add suffix –Z (e.g. MP1584EN–Z);
For RoHS Compliant Packaging, add suffix –LF. (e.g. MP1584EN–LF–Z)

PACKAGE REFERENCE



ABSOLUTE MAXIMUM RATINGS (1)

Supply Voltage (V_{IN})....................–0.3V to +30V
Switch Voltage (V_{SW})...........–0.3V to V_{IN} + 0.3V
BST to SW.......................................–0.3V to +6V
All Other Pins..................................–0.3V to +6V
Continuous Power Dissipation (T_A = +25°C)(2)
.... 2.5W
Junction Temperature...............................150°C
Lead Temperature ....260°C
Storage Temperature............. –65°C to +150°C

Recommended Operating Conditions (3)

Supply Voltage V_{IN} ....4.5V to 28V
Output Voltage V_{OUT} ....0.8V to 25V
Operating Junct. Temp (T_J) .....–20°C to +125°C

Thermal Resistance (4)	θ_{JA}	θ_{JC}	
SOIC8E	50	10...	°C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J(MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_D(MAX)=(T_J(MAX)-T_A)/\theta_{JA}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, V_{EN} = 2.5V, V_{COMP} = 1.4V, T_A= +25°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Feedback Voltage	V_{FB}	4.5V < V_{IN} < 28V	0.776	0.8	0.824	V
Upper Switch On Resistance	$R_{DS(ON)}$	V_{BST} – V_{SW} = 5V		150		mΩ
Upper Switch Leakage		V_{EN} = 0V, V_{SW} = 0V, V_{IN} = 28V		1		μA
Current Limit			4.0	4.7		A
COMP to Current Sense Transconductance	G_{CS}			9		A/V
Error Amp Voltage Gain [5]				200		V/V
Error Amp Transconductance		I_{COMP} = ±3μA	40	60	80	μA/V
Error Amp Min Source current		V_{FB} = 0.7V		5		μA
Error Amp Min Sink current		V_{FB} = 0.9V		–5		μA
VIN UVLO Threshold			2.7	3.0	3.3	V
VIN UVLO Hysteresis				0.35		V
Soft-Start Time [5]		0V < V_{FB} < 0.8V		1.5		ms
Oscillator Frequency		R_{FREQ} = 100kΩ		900		kHz
Shutdown Supply Current		V_{EN} = 0V		12	20	μA
Quiescent Supply Current		No load, V_{FB} = 0.9V		100	125	μA
Thermal Shutdown				150		°C
Thermal Shutdown Hysteresis				15		°C
Minimum Off Time [5]				100		ns
Minimum On Time [5]				100		ns
EN Up Threshold			1.35	1.5	1.65	V
EN Hysteresis				300		mV

Note:

5) Guaranteed by design.

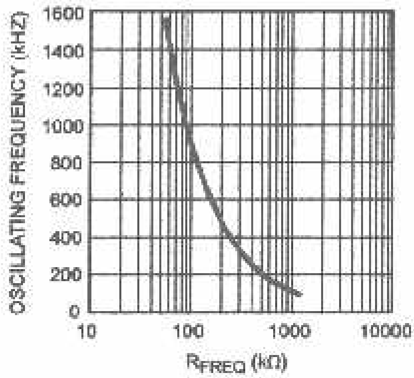
PIN FUNCTIONS

SOIC Pin #	Name	Description
1	SW	Switch Node. This is the output from the high-side switch. A low forward drop Schottky diode to ground is required. The diode must be close to the SW pins to reduce switching spikes.
2	EN	Enable Input. Pulling this pin below the specified threshold shuts the chip down. Pulling it up above the specified threshold or leaving it floating enables the chip.
3	COMP	Compensation. This node is the output of the error amplifier. Control loop frequency compensation is applied to this pin.
4	FB	Feedback. This is the input to the error amplifier. The output voltage is set by a resistive divider connected between the output and GND which scales down V_{OUT} equal to the internal +0.8V reference.
5	GND Exposed Pad	Ground. It should be connected as close as possible to the output capacitor to shorten the high current switch paths. Connect exposed pad to GND plane for optimal thermal performance.
6	FREQ	Switching Frequency Program Input. Connect a resistor from this pin to ground to set the switching frequency.
7	VIN	Input Supply. This supplies power to all the internal control circuitry, both BS regulators and the high-side switch. A decoupling capacitor to ground must be placed close to this pin to minimize switching spikes.
8	BST	Bootstrap. This is the positive power supply for the internal floating high-side MOSFET driver. Connect a bypass capacitor between this pin and SW pin.

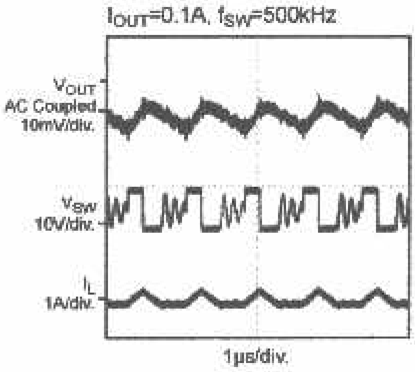
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 12V, V_{OUT}=5V, C1 = 10µF, C2 = 22µF, L1= 10µH, T_A = +25°C, unless otherwise noted.

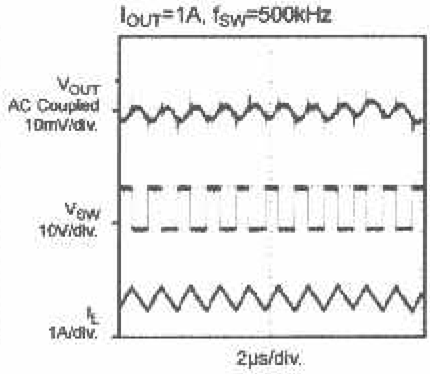
Oscillating Frequency vs. R_{freq}



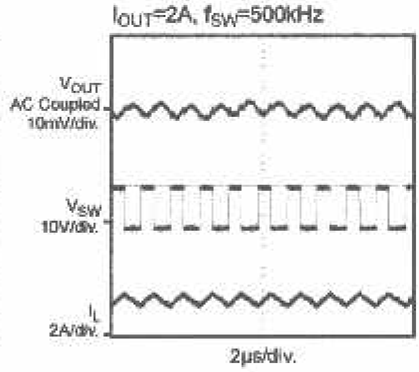
Steady State
I_{OUT}=0.1A, f_{SW}=500kHz



Steady State
I_{OUT}=1A, f_{SW}=500kHz



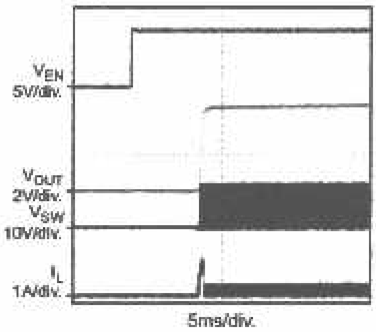
Steady State
I_{OUT}=2A, f_{SW}=500kHz



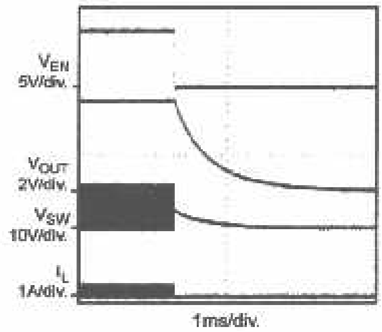
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 12V, C1 = 10μF, C2 = 22μF, L1 = 10μH, f_{SW}=500kHz, and T_A = +25°C, unless otherwise noted.

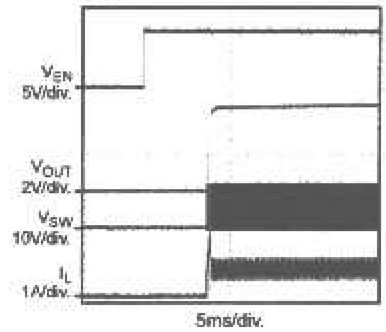
Startup
I_{OUT} = 0.1A



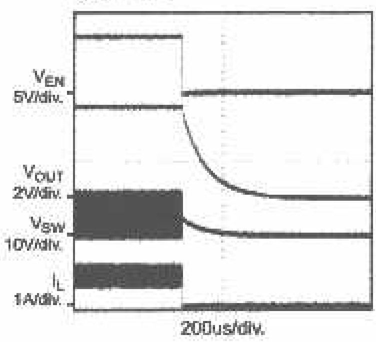
Shutdown
I_{OUT} = 0.1A



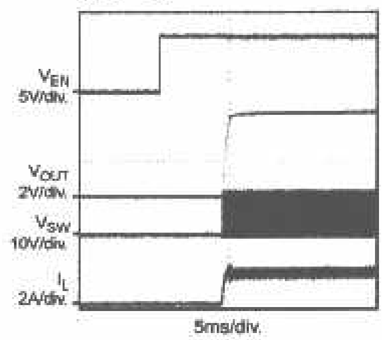
Startup
I_{OUT} = 1A



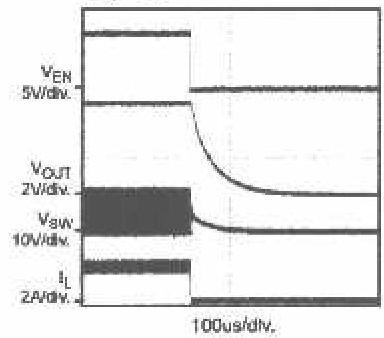
Shutdown
I_{OUT} = 1A



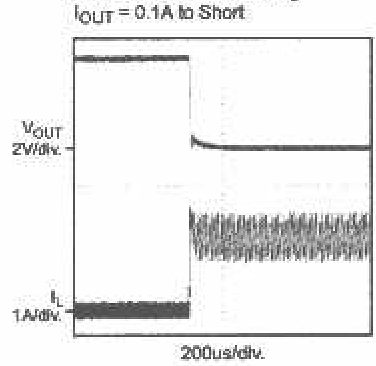
Startup
I_{OUT} = 2A



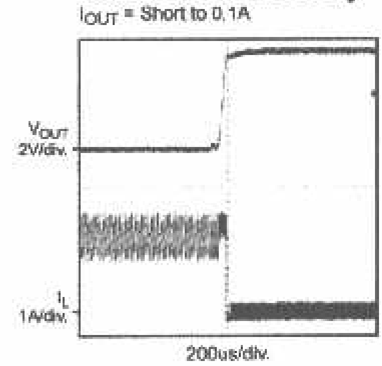
Shutdown
I_{OUT} = 2A



Short Circuit Entry
I_{OUT} = 0.1A to Short



Short Circuit Recovery
I_{OUT} = Short to 0.1A



BLOCK DIAGRAM

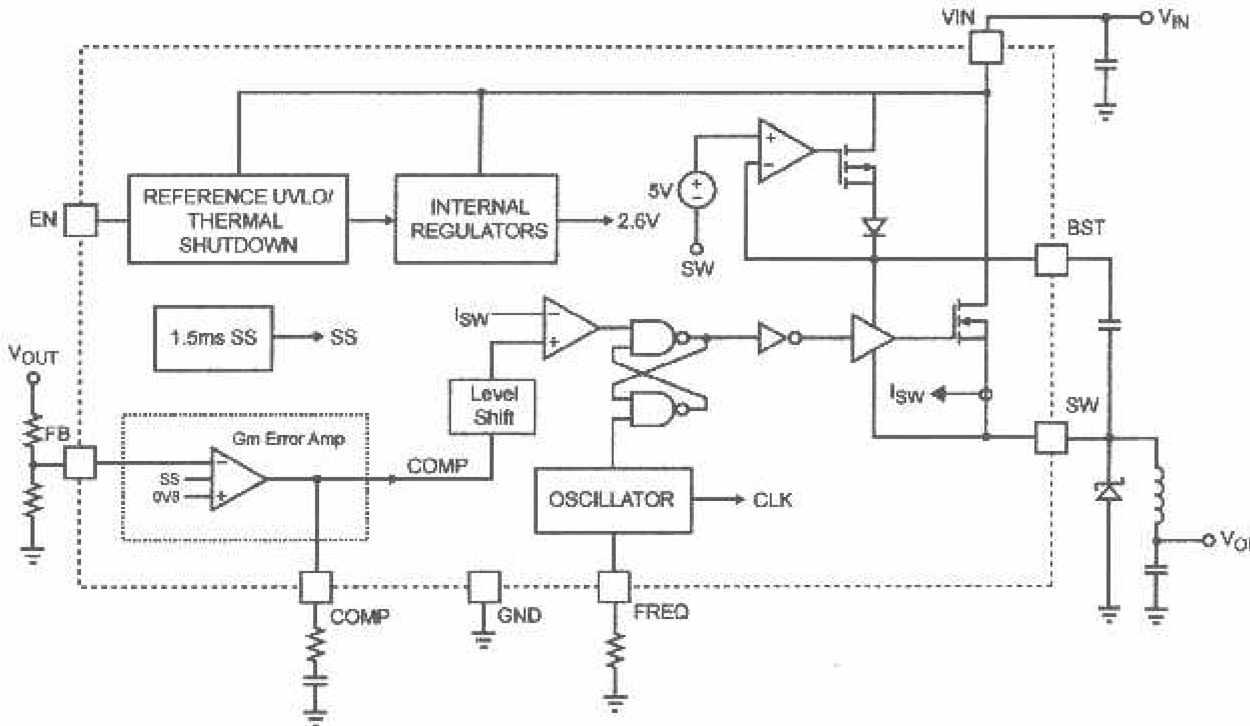


Figure 1—Functional Block Diagram

OPERATION

The MP1584 is a variable frequency, non-synchronous, step-down switching regulator with an integrated high-side high voltage power MOSFET. It provides a highly efficient solution with current mode control for fast loop response and easy compensation. It features a wide input voltage range, internal soft-start control and precision current limiting. Its very low operational quiescent current makes it suitable for battery powered applications.

PWM Control

At moderate to high output current, the MP1584 operates in a fixed frequency, peak current control mode to regulate the output voltage. A PWM cycle is initiated by the internal clock. The power MOSFET is turned on and remains on until its current reaches the value set by the COMP voltage. When the power switch is off, it remains off for at least 100ns before the next cycle starts. If, in one PWM period, the current in the power MOSFET does not reach the COMP set current value, the power MOSFET remains on, saving a turn-off operation.

Error Amplifier

The error amplifier compares the FB pin voltage with the internal reference (REF) and outputs a current proportional to the difference between the two. This output current is then used to charge the external compensation network to form the COMP voltage, which is used to control the power MOSFET current.

During operation, the minimum COMP voltage is clamped to 0.9V and its maximum is clamped to 2.0V. COMP is internally pulled down to GND in shutdown mode. COMP should not be pulled up beyond 2.6V.

Internal Regulator

Most of the internal circuitries are powered from the 2.6V internal regulator. This regulator takes the VIN input and operates in the full VIN range. When VIN is greater than 3.0V, the output of the regulator is in full regulation. When VIN is lower than 3.0V, the output decreases.

Enable Control

The MP1584 has a dedicated enable control pin (EN). With high enough input voltage, the chip can be enabled and disabled by EN which has positive logic. Its falling threshold is a precision 1.2V, and its rising threshold is 1.5V (300mV higher).

When floating, EN is pulled up to about 3.0V by an internal 1µA current source so it is enabled. To pull it down, 1µA current capability is needed.

When EN is pulled down below 1.2V, the chip is put into the lowest shutdown current mode. When EN is higher than zero but lower than its rising threshold, the chip is still in shutdown mode but the shutdown current increases slightly.

Under-Voltage Lockout (UVLO)

Under-voltage lockout (UVLO) is implemented to protect the chip from operating at insufficient supply voltage. The UVLO rising threshold is about 3.0V while its falling threshold is a consistent 2.6V.

Internal Soft-Start

The soft-start is implemented to prevent the converter output voltage from overshooting during startup. When the chip starts, the internal circuitry generates a soft-start voltage (SS) ramping up from 0V to 2.6V. When it is lower than the internal reference (REF), SS overrides REF so the error amplifier uses SS as the reference. When SS is higher than REF, REF regains control.

Thermal Shutdown

Thermal shutdown is implemented to prevent the chip from operating at exceedingly high temperatures. When the silicon die temperature is higher than its upper threshold, it shuts down the whole chip. When the temperature is lower than its lower threshold, the chip is enabled again.

Floating Driver and Bootstrap Charging

The floating power MOSFET driver is powered by an external bootstrap capacitor. This floating driver has its own UVLO protection. This UVLO's rising threshold is 2.2V with a threshold of 150mV.

The bootstrap capacitor is charged and regulated to about 5V by the dedicated internal bootstrap regulator. When the voltage between the BST and SW nodes is lower than its regulation, a PMOS pass transistor connected from VIN to BST is turned on. The charging current path is from VIN, BST and then to SW. External circuit should provide enough voltage headroom to facilitate the charging.

As long as VIN is sufficiently higher than SW, the bootstrap capacitor can be charged. When the power MOSFET is ON, VIN is about equal to SW so the bootstrap capacitor cannot be charged. When the external diode is on, the difference between VIN and SW is largest, thus making it the best period to charge. When there is no current in the inductor, SW equals the output voltage V_{OUT} so the difference between V_{IN} and V_{OUT} can be used to charge the bootstrap capacitor.

At higher duty cycle operation condition, the time period available to the bootstrap charging is less so the bootstrap capacitor may not be sufficiently charged.

In case the internal circuit does not have sufficient voltage and the bootstrap capacitor is not charged, extra external circuitry can be used to ensure the bootstrap voltage is in the normal operational region. Refer to *External Bootstrap Diode* in Application section.

The DC quiescent current of the floating driver is about 20μA. Make sure the bleeding current at the SW node is higher than this value, such that:

$$I_O + \frac{V_O}{(R1+R2)} > 20\mu A$$

Current Comparator and Current Limit

The power MOSFET current is accurately sensed via a current sense MOSFET. It is then fed to the high speed current comparator for the current mode control purpose. The current comparator takes this sensed current as one of its inputs. When the power MOSFET is turned on, the comparator is first blanked till the end of the turn-on transition to avoid noise issues. The comparator then compares the power switch current with the COMP voltage. When the sensed current is higher than the COMP voltage, the comparator output is low, turning off the power MOSFET. The cycle-by-cycle maximum current of the internal power MOSFET is internally limited.

Startup and Shutdown

If both VIN and EN are higher than their appropriate thresholds, the chip starts. The reference block starts first, generating stable reference voltage and currents, and then the internal regulator is enabled. The regulator provides stable supply for the remaining circuitries.

While the internal supply rail is up, an internal timer holds the power MOSFET OFF for about 50μs to blank the startup glitches. When the internal soft-start block is enabled, it first holds its SS output low to ensure the remaining circuitries are ready and then slowly ramps up.

Three events can shut down the chip: EN low, VIN low and thermal shutdown. In the shutdown procedure, power MOSFET is turned off first to avoid any fault triggering. The COMP voltage and the internal supply rail are then pulled down.

Programmable Oscillator

The MP1584 oscillating frequency is set by an external resistor, R_{freq} from the FREQ pin to ground. The value of R_{freq} can be calculated from:

$$R_{freq}(k\Omega) = \frac{180000}{[f_s(kHz)]^{1.1}}$$

APPLICATION INFORMATION

COMPONENT SELECTION

Setting the Output Voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB pin. The voltage divider divides the output voltage down to the feedback voltage by the ratio:

$$V_{FB} = V_{OUT}\frac{R2}{R1+R2}$$

Thus the output voltage is:

$$V_{OUT} = V_{FB}\frac{(R1+R2)}{R2}$$

About 20µA current from high side BS circuitry can be seen at the output when the MP1584 is at no load. In order to absorb this small amount of current, keep R2 under 40KΩ. A typical value for R2 can be 40.2kΩ. With this value, R1 can be determined by:

$$R1 = 50.25 \times (V_{OUT} - 0.8)(k\Omega)$$

For example, for a 3.3V output voltage, R2 is 40.2kΩ, and R1 is 127kΩ.

Inductor

The inductor is required to supply constant current to the output load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will result in lower output ripple voltage. However, the larger value inductor will have a larger physical size, higher series resistance, and/or lower saturation current.

A good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum switch current limit. Also, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L1 = \frac{V_{OUT}}{f_S \times \Delta I_L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where V_{OUT} is the output voltage, V_{IN} is the input voltage, f_S is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum inductor peak current. The peak inductor current can be calculated by:

$$I_{LP} = I_{LOAD} + \frac{V_{OUT}}{2 \times f_S \times L1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where I_{LOAD} is the load current.

Table 1 lists a number of suitable inductors from various manufacturers. The choice of which style inductor to use mainly depends on the price vs. size requirements and any EMI requirement.

Table 1—Inductor Selection Guide

Part Number	Inductance (µH)	Max DCR (Ω)	Current Rating (A)	Dimensions L x W x H (mm^3)
Wurth Electronics				
7447789003	3.3	0.024	3.42	7.3x7.3x3.2
744066100	10	0.035	3.6	10x10x3.8
744771115	15	0.025	3.75	12x12x6
744771122	22	0.031	3.37	12x12x6
TDK				
RLF7030T-3R3	3.3	0.02	4.1	7.3x6.8x3.2
RLF7030T-4R7	4.7	0.031	3.4	7.3x6.8x3.2
SLF10145T-100	10	0.0364	3	10.1x10.1x4.5
SLF12565T-220M3R5	22	0.0316	3.5	12.5x12.5x6.5
Toko				
FDV0630-3R3M	3.3	0.031	4.3	7.7x7x3
FDV0630-4R7M	4.7	0.049	3.3	7.7x7x3
919AS-100M	10	0.0265	4.3	10.3x10.3x4.5
919AS-160M	16	0.0492	3.3	10.3x10.3x4.5
919AS-220M	22	0.0776	3	10.3x10.3x4.5

Output Rectifier Diode

The output rectifier diode supplies the current to the inductor when the high-side switch is off. To reduce losses due to the diode forward voltage and recovery times, use a Schottky diode.

Choose a diode whose maximum reverse voltage rating is greater than the maximum input voltage, and whose current rating is greater than the maximum load current. Table 2 lists example Schottky diodes and manufacturers.

Table 2—Diode Selection Guide

Diodes	Voltage/ Current Rating	Manufacturer
B340A-13-F	40V, 3A	Diodes Inc.
CMSH3-40MA	40V, 3A	Central Semi

Input Capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice.

For simplification, choose the input capacitor with RMS current rating greater than half of the maximum load current.

The input capacitor (C1) can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple caused by capacitance can be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{f_S \times C1} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Output Capacitor

The output capacitor (C2) is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C2}\right)$$

Where L is the inductor value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor.

In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^2 \times L \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The MP1584 can be optimized for a wide range of capacitance and ESR values.

Compensation Components

MP1584 employs current mode control for easy compensation and fast transient response. The system stability and transient response are controlled through the COMP pin. COMP pin is the output of the internal error amplifier. A series capacitor-resistor combination sets a pole-zero combination to control the characteristics of the control system. The DC gain of the voltage feedback loop is given by:

$$A_{VDC} = R_{LOAD} \times G_{CS} \times A_{VEA} \times \frac{V_{FB}}{V_{OUT}}$$

Where A_{VEA} is the error amplifier voltage gain, 200V/V; G_{CS} is the current sense transconductance, 9A/V; R_{LOAD} is the load resistor value.

The system has two poles of importance. One is due to the compensation capacitor (C3), the output resistor of error amplifier. The other is due to the output capacitor and the load resistor. These poles are located at:

$$f_{P1} = \frac{G_{EA}}{2\pi \times C3 \times A_{VEA}}$$

$$f_{P2} = \frac{1}{2\pi \times C2 \times R_{LOAD}}$$

Where, G_{EA} is the error amplifier transconductance, 60μA/V.

The system has one zero of importance, due to the compensation capacitor (C3) and the compensation resistor (R3). This zero is located at:

$$f_{Z1} = \frac{1}{2\pi \times C3 \times R3}$$

The system may have another zero of importance, if the output capacitor has a large capacitance and/or a high ESR value. The zero, due to the ESR and capacitance of the output capacitor, is located at:

$$f_{ESR} = \frac{1}{2\pi \times C2 \times R_{ESR}}$$

n this case (as shown in Figure 2), a third pole set by the compensation capacitor (C6) and the compensation resistor (R3) is used to compensate the effect of the ESR zero on the loop gain. This pole is located at:

$$f_{P3} = \frac{1}{2\pi \times C6 \times R3}$$

The goal of compensation design is to shape the converter transfer function to get a desired loop gain. The system crossover frequency where the feedback loop has the unity gain is important. Lower crossover frequencies result in slower line and load transient responses, while higher crossover frequencies could cause system unstable. A good rule of thumb is to set the crossover frequency to approximately one-tenth of the switching frequency. The Table 3 lists the typical values of compensation components for some standard output voltages with various output capacitors and inductors. The values of the compensation components have been optimized for fast transient responses and good stability at given conditions.

Table 3—Compensation Values for Typical Output Voltage/Capacitor Combinations

V_{OUT} (V)	L (µH)	C2 (µF)	R3 (kΩ)	C3 (pF)	C6
1.8	4.7	47	105	100	None
2.5	4.7 - 6.8	22	54.9	220	None
3.3	6.8 -10	22	68.1	220	None
5	15 - 22	22	100	150	None
12	22 - 33	22	147	150	None

To optimize the compensation components for conditions not listed in Table 3, the following procedure can be used.

1. Choose the compensation resistor (R3) to set the desired crossover frequency. Determine the R3 value by the following equation:

$$R3 = \frac{2\pi \times C2 \times f_C}{G_{EA} \times G_{CS}} \times \frac{V_{OUT}}{V_{FB}}$$

Where f_C is the desired crossover frequency.

2. Choose the compensation capacitor (C3) to achieve the desired phase margin. For applications with typical inductor values, setting the compensation zero, f_{Z1}, below one forth of the crossover frequency provides sufficient phase margin. Determine the C3 value by the following equation:

$$C3 > \frac{4}{2\pi \times R3 \times f_C}$$

3. Determine if the second compensation capacitor (C6) is required. It is required if the ESR zero of the output capacitor is located at less than half of the switching frequency, or the following relationship is valid:

$$\frac{1}{2\pi \times C2 \times R_{ESR}} < \frac{f_S}{2}$$

If this is the case, then add the second compensation capacitor (C6) to set the pole f_{P3} at the location of the ESR zero. Determine the C6 value by the equation:

$$C6 = \frac{C2 \times R_{ESR}}{R3}$$

High Frequency Operation

The switching frequency of MP1584 can be programmed up to 1.5MHz with an external resistor.

With higher switching frequencies, the inductive reactance (X_L) of capacitor comes to dominate, so that the ESL of input/output capacitor determines the input/output ripple voltage at higher switching frequency. As a result of that, high frequency ceramic capacitor is strongly recommended as input decoupling capacitor and output filtering capacitor for such high frequency operation.

Layout becomes more important when the device switches at higher frequency. It is essential to place the input decoupling capacitor, catch diode and the MP1584 (Vin pin, SW pin and PGND) as close as possible, with traces that are very short and fairly wide. This can help to greatly reduce the voltage spike on SW node, and lower the EMI noise level as well.

Try to run the feedback trace as far from the inductor and noisy power traces as possible. It is often a good idea to run the feedback trace on the side of the PCB opposite of the inductor with a ground plane separating the two. The compensation components should be placed closed to the MP1584. Do not place the compensation components close to or under high dv/dt SW node, or inside the high di/dt power loop. If you have to do so, the proper ground plane must be in place to isolate those. Switching loss is expected to be increased at high switching frequency. To help to improve the thermal conduction, a grid of thermal vias can be created right under the exposed pad. It is recommended that they be small (15mil barrel diameter) so that the hole is essentially filled up during the plating process, thus aiding conduction to the other side. Too large a hole can cause 'solder wicking' problems during the reflow soldering process. The pitch (distance between the centers) of several such thermal vias in an area is typically 40mil.

External Bootstrap Diode

It is recommended that an external bootstrap diode be added when the input voltage is no greater than 5V or the 5V rail is available in the system. This helps improve the efficiency of the regulator. The bootstrap diode can be a low cost one such as IN4148 or BAT54.

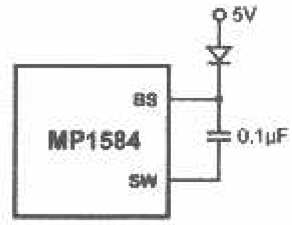


Figure 2—External Bootstrap Diode

This diode is also recommended for high duty cycle operation (when V_{OUT}/V_{IN} >65%) or low V_{IN} (<5Vin) applications.

At no load or light load, the converter may operate in pulse skipping mode in order to maintain the output voltage in regulation. Thus there is less time to refresh the BS voltage. In order to have enough gate voltage under such operating conditions, the difference of $V_{IN} - V_{OUT}$ should be greater than 3V. For example, if the V_{OUT} is set to 3.3V, the V_{IN} needs to be higher than 3.3V+3V=6.3V to maintain enough BS voltage at no load or light load. To meet this requirement, EN pin can be used to program the input UVLO voltage to Vout+3V.

TYPICAL APPLICATION CIRCUITS

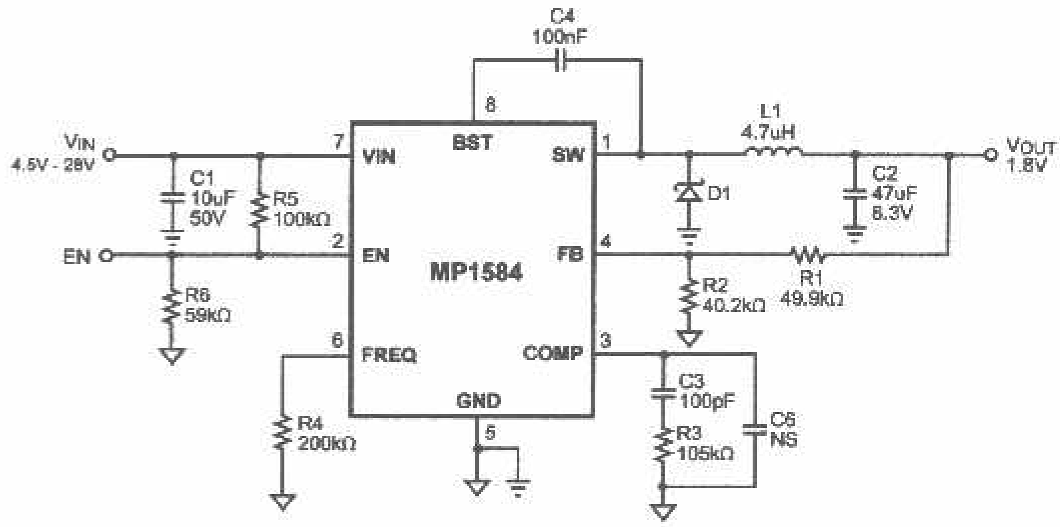


Figure 3—1.8V Output Typical Application Schematic

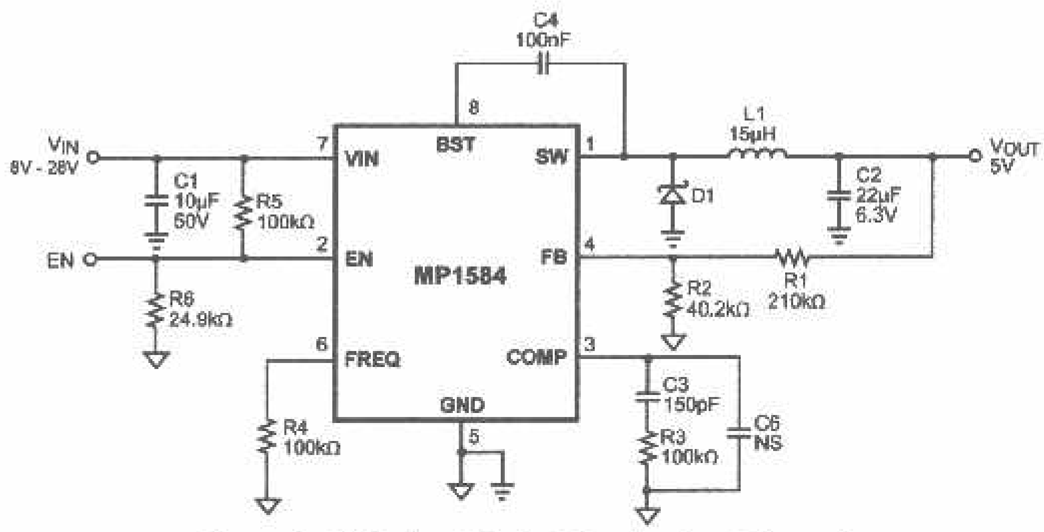


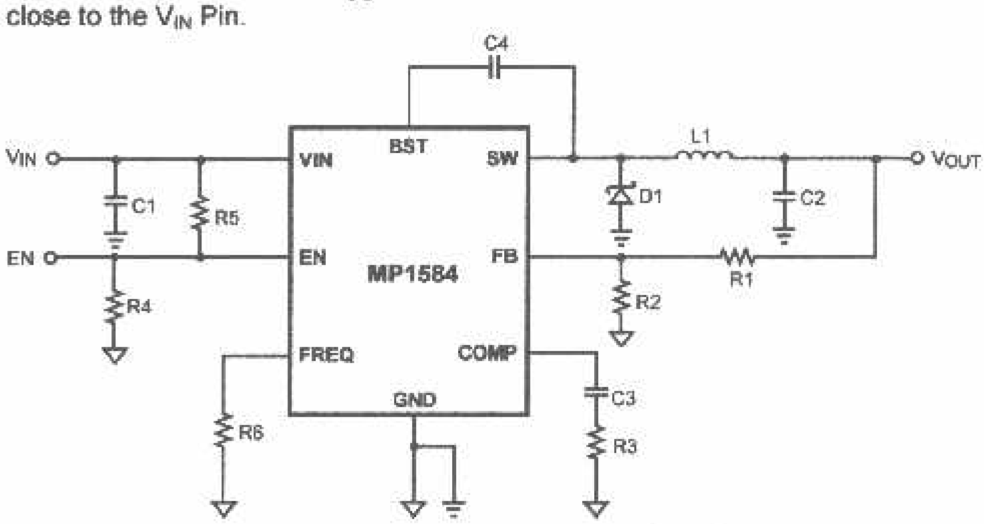
Figure 4—5V Output Typical Application Schematic

PCB LAYOUT GUIDE

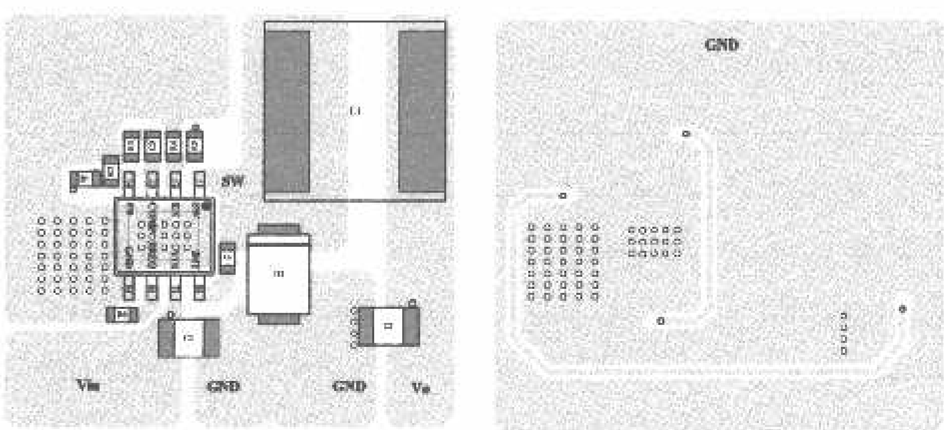
PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance.

If change is necessary, please follow these guidelines and take Figure 5 for reference.

1) Keep the path of switching current short and minimize the loop area formed by Input cap, high-side MOSFET and external switching diode.
2) Bypass ceramic capacitors are suggested to be put close to the V_{IN} Pin.
3) Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.
4) Route SW away from sensitive analog areas such as FB.
5) Connect IN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.



MP1584 Typical Application Circuit



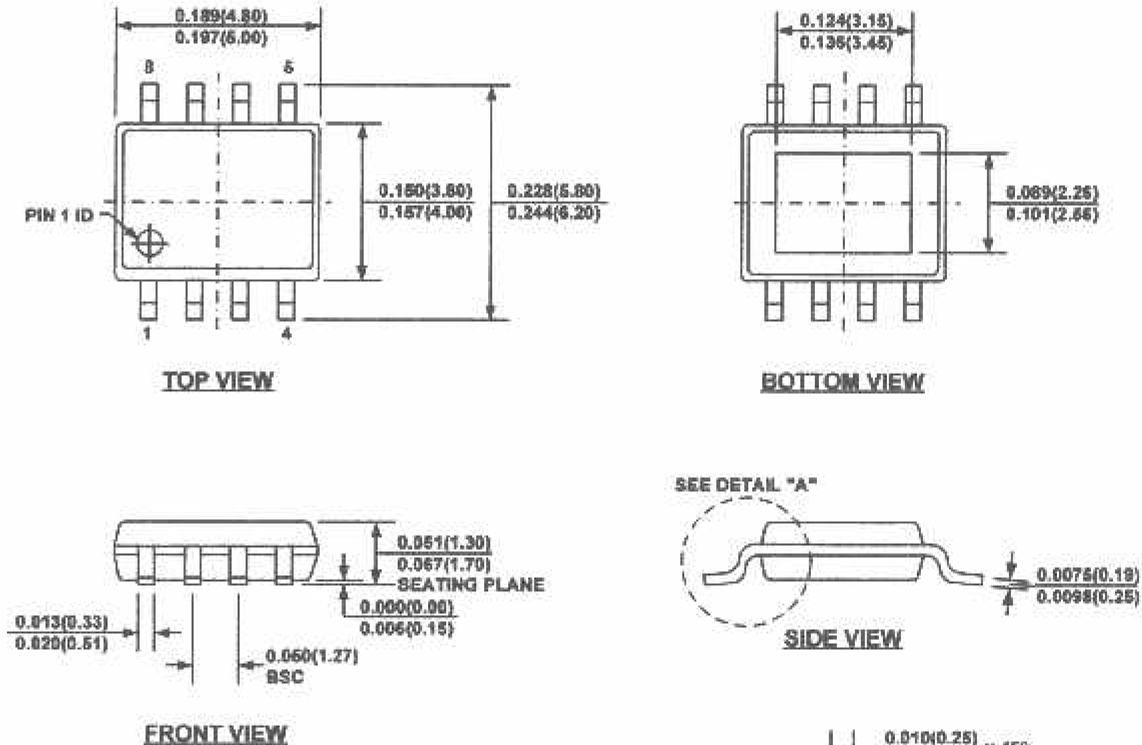
Top Layer

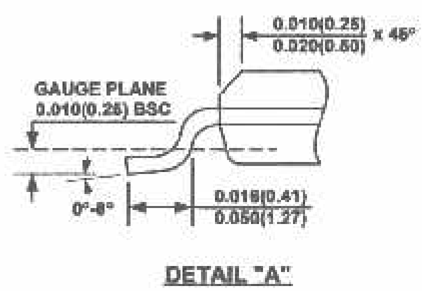
Bottom Layer

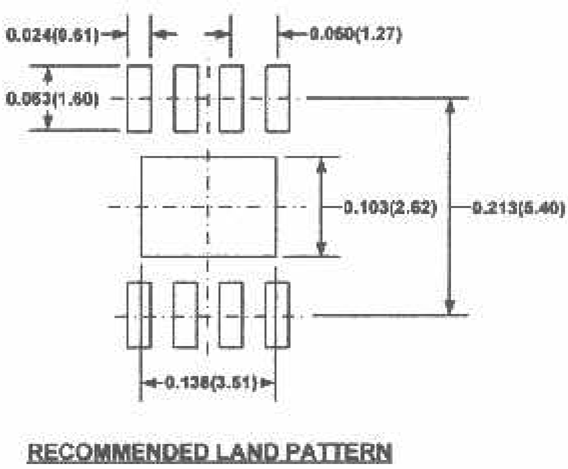
Figure 5—MP1584 Typical Application Circuit and PCB Layout Guide

PACKAGE INFORMATION

SOIC8E (EXPOSED PAD)







NOTE:

1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5) DRAWING CONFORMS TO JEDEC MS-012, VARIATION BA.
6) DRAWING IS NOT TO SCALE.

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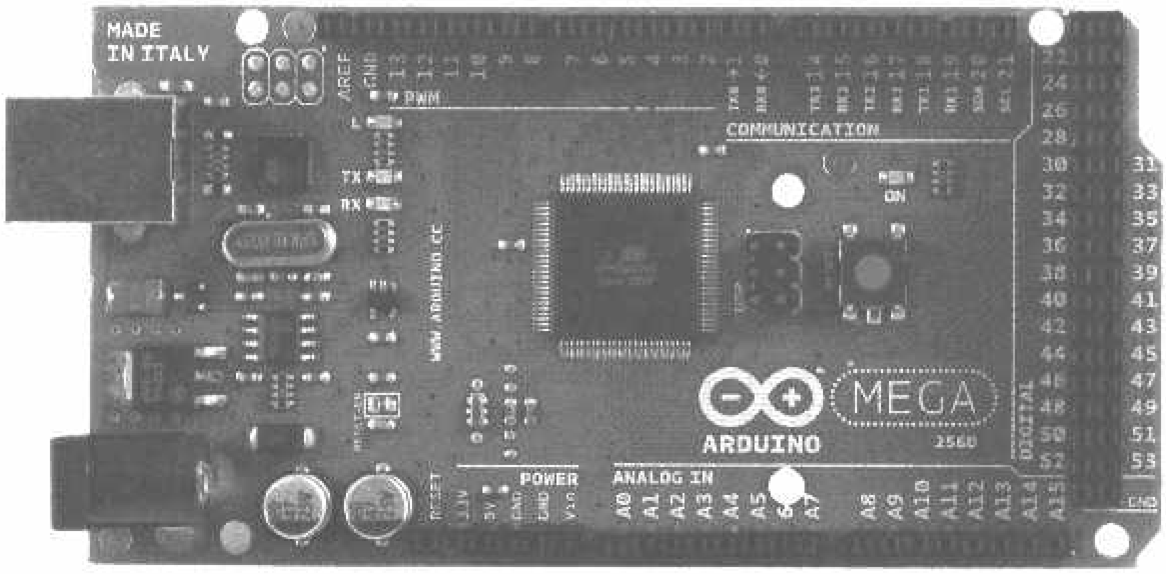
Arduino MEGA 2560



Product Overview

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

Index

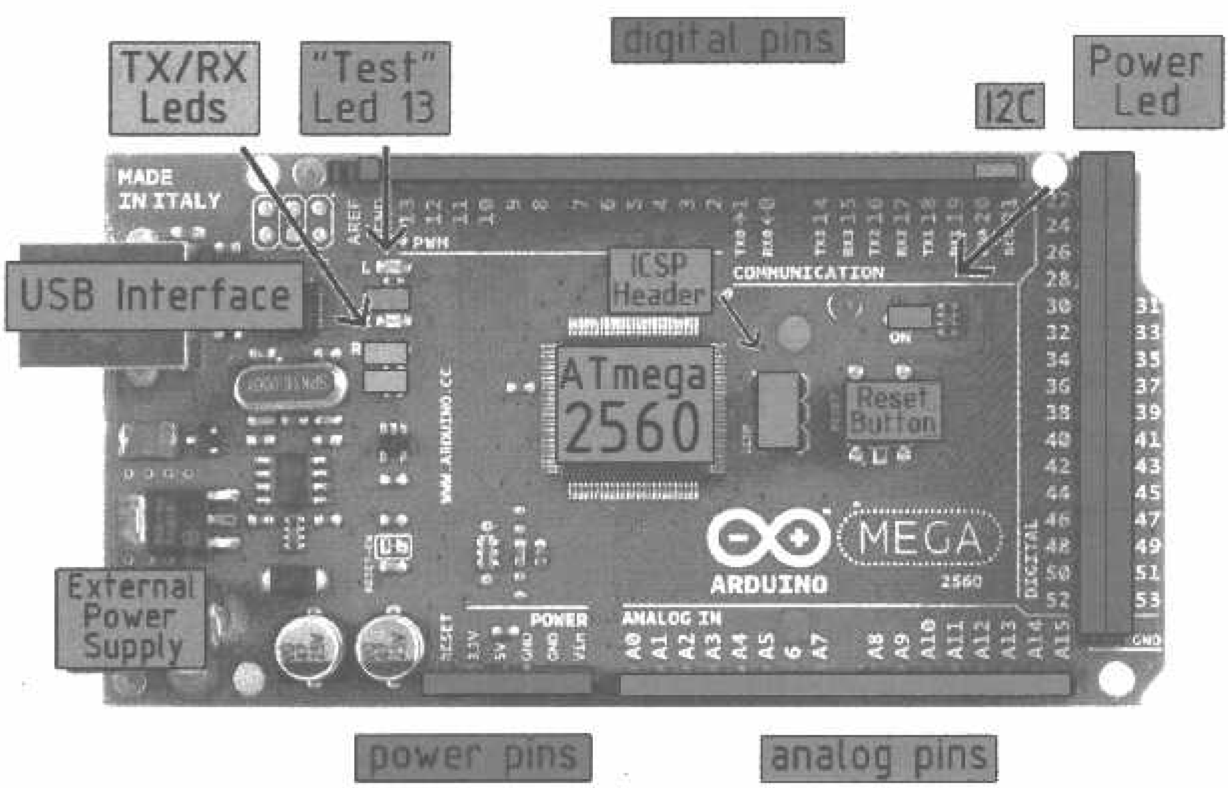
Technical Specification

EAGLE files: arduino-mega2560-reference-design.zip Schematic: arduino-mega2560-schematic.pdf

Summary

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

the board



Power

The Arduino Mega2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .
- **External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2).** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 0 to 13.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Duemilanove and Diecimila.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- **I²C: 20 (SDA) and 21 (SCL).** Support I²C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I²C pins on the Duemilanove.

The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication. An ATmega8U2 on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Mega's digital pins.

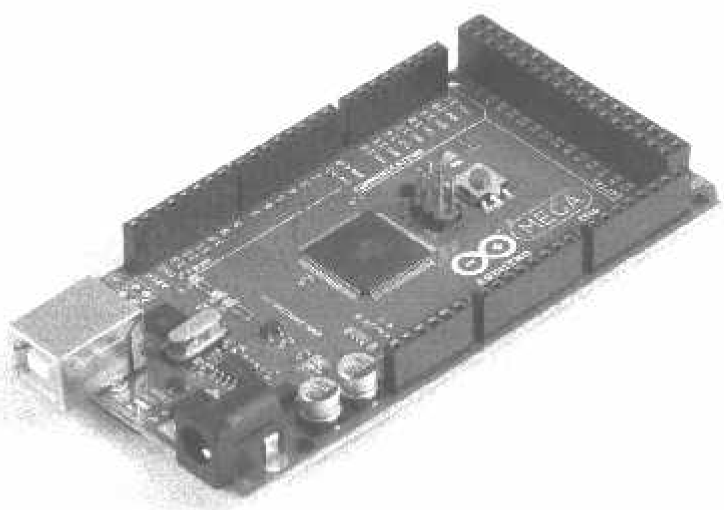
The ATmega2560 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation on the Wiring website for details. To use the SPI communication, please see the ATmega2560 datasheet.

Programming

The Arduino Mega2560 can be programmed with the Arduino software (download). For details, see the reference and tutorials.

The Atmega2560 on the Arduino Mega comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.



radiospares RADIONICS

Automatic (Software) Reset

Rather then requiring a physical press of the reset button before an upload, the Arduino Mega2560 is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega2560 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Mega2560 is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Mega2560. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Mega contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Mega has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics and Shield Compatibility

The maximum length and width of the Mega PCB are 4 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

The Mega is designed to be compatible with most shields designed for the Diecimila or Duemilanove. Digital pins 0 to 13 (and the adjacent AREF and GND pins), analog inputs 0 to 5, the power header, and ICSP header are all in equivalent locations. Further the main UART (serial port) is located on the same pins (0 and 1), as are external interrupts 0 and 1 (pins 2 and 3 respectively). SPI is available through the ICSP header on both the Mega and Duemilanove / Diecimila. **Please note that I^2C is not located on the same pins on the Mega (20 and 21) as the Duemilanove / Diecimila (analog inputs 4 and 5).**

How to use Arduino

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

Arduino is a cross-platoform program. You'll have to follow different instructions for your personal OS. Check on the Arduino site for the latest instructions. *http://arduino.cc/en/Guide/HomePage*

Linux Install **Windows Install** **Mac Install**

Once you have downloaded/unzipped the arduino IDE, you can Plug the Arduino to your PC via USB cable.

Blink led

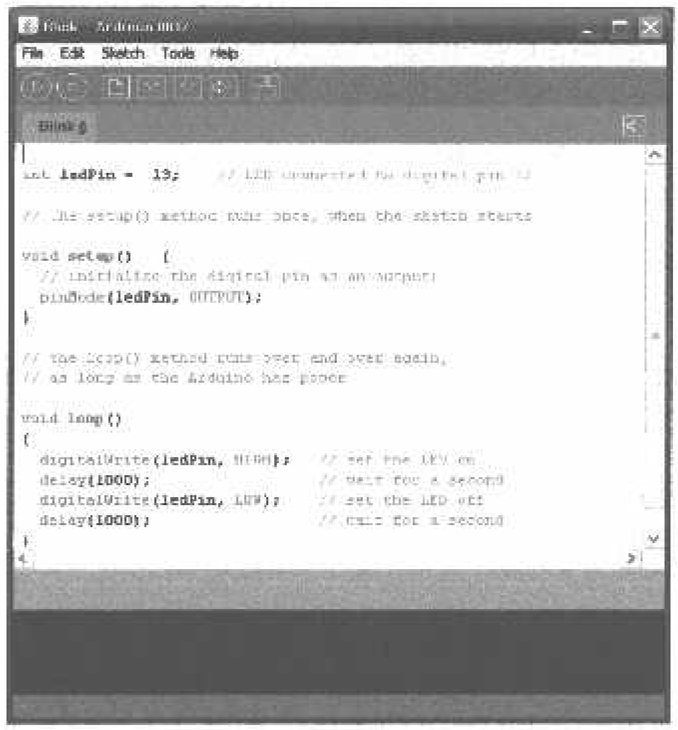
Now you're actually ready to "burn" your first program on the arduino board. To select "blink led", the physical translation of the well known programming "hello world", select

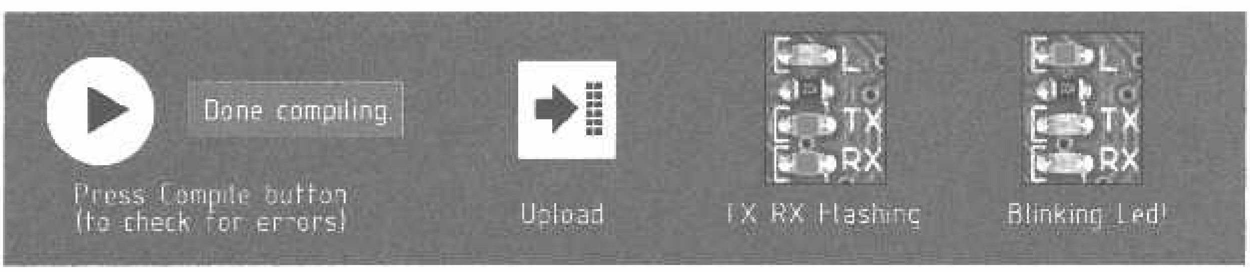
File>Sketchbook> Arduino-0017>Examples> Digital>Blink

Once you have your skecth you'll see something very close to the screenshot on the right.

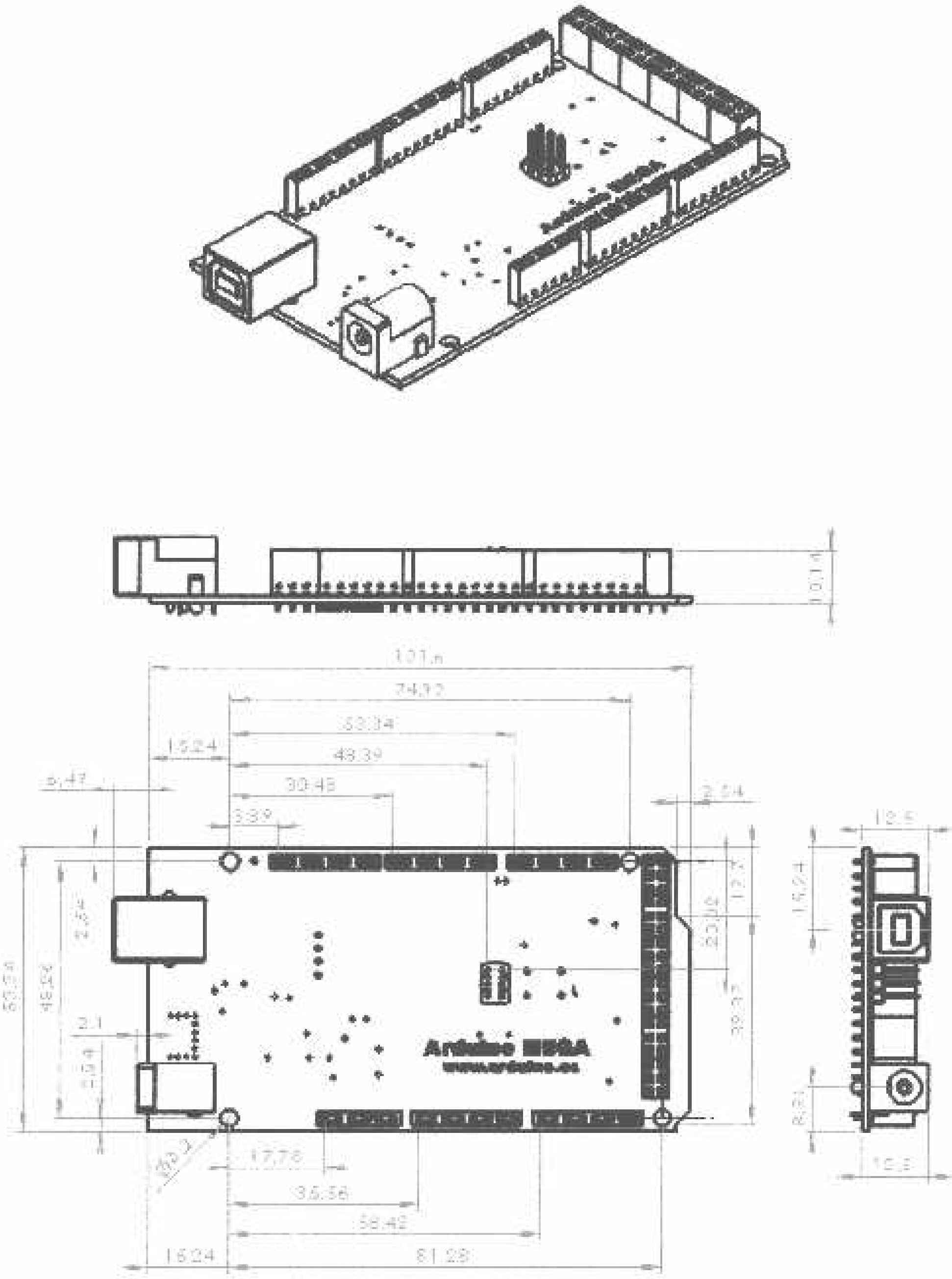
In **Tools>Board** select MEGA

Now you have to go to **Tools>SerialPort** and select the right serial port, the one arduino is attached to.





Dimensioned Drawing



Terms & Conditions

1. Warranties

1.1 The producer warrants that its products will conform to the Specifications. This warranty lasts for one (1) years from the date of the sale. The producer shall not be liable for any defects that are caused by neglect, misuse or mistreatment by the Customer, including improper installation or testing, or for any products that have been altered or modified in any way by a Customer. Moreover, The producer shall not be liable for any defects that result from Customer's design, specifications or instructions for such products. Testing and other quality control techniques are used to the extent the producer deems necessary.

1.2 If any products fail to conform to the warranty set forth above, the producer's sole liability shall be to replace such products. The producer's liability shall be limited to products that are determined by the producer not to conform to such warranty. If the producer elects to replace such products, the producer shall have a reasonable time to replacements. Replaced products shall be warranted for a new full warranty period.

1.3 EXCEPT AS SET FORTH ABOVE, PRODUCTS ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." THE PRODUCER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING PRODUCTS, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE

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1.5 The Arduino™ products are not authorized for use in safety-critical applications where a failure of the product would reasonably be expected to cause severe personal injury or death. Safety-Critical Applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Arduino™ products are neither designed nor intended for use in military or aerospace applications or environments and for automotive applications or environment. Customer acknowledges and agrees that any such use of Arduino™ products which is solely at the Customer's risk, and that Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

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The Customer acknowledges and agrees to defend, indemnify and hold harmless the producer from and against any and all third-party losses, damages, liabilities and expenses it incurs to the extent directly caused by: (i) an actual breach by a Customer of the representation and warranties made under this terms and conditions or (ii) the gross negligence or willful misconduct by the Customer.

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4. Changes to specifications

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Enviromental Policies

The producer of Arduino™ has joined the Impatto Zero® policy of LifeGate.it. For each Arduino board produced is created / looked after half squared Km of Costa Rica's forest's.

LIST PROGRAM ARDUINO

```
#include <Wire.h>
#include <HMC5883L.h>
HMC5883L compass;

 int reset =1;
 int enol,bkiri,bkanan;

void setup()
{
 // put your setup code here, to run once:
 Serial1.begin(9600);
  {
   Wire.begin();
   Serial.begin(9600);
   compass = HMC5883L();

   Serial.println("Setting scale to +/- 1.3Ga");
   int error = compass.SetScale(1.3);
   if(error != 0)
   Serial.println(compass.GetErrorText(error));

   Serial.println("Setting measurement mode to continuous");
   error = compass.SetMeasurementMode(Measurement_Continuous);
    if(error != 0)
   Serial.println(compass.GetErrorText(error));
  }
}
```

```
void luruskan()
{
  while(1)
{
 Serial.println("pos 0");
Serial.println(F("#1P1233#2P2233#3P1433#4P1789#5P922#7P1343#8P2000#9P1033#10P1700#11P1478#12P1167#13P1413#14P1456#16P1589#18P1500#19P1544#21P1744#22P1433#23P1922#24P1567#25P963#26P1471#28P1144#29P1433#30P1856#31P1742#32P789T1000"));
delay(900);
Serial.println(F("#1P1233#2P2233#3P1433#4P1789#5P922#7P1343#8P2000#9P1033#10P1700#11P1478#12P1167#13P1413#14P1456#16P1589#18P1500#19P1544#21P1744#22P1433#23P1922#24P1567#25P963#26P1471#28P1144#29P1433#30P1856#31P1742#32P789T1000"));
delay(900);
break;
//////////////////////////////////////////////////////////////
}
while (1)
{
  MagnetometerRaw raw = compass.ReadRawAxis();
  float heading = atan2(raw.YAxis, raw.XAxis);


  float declinationAngle = 0.45;
  heading += declinationAngle;


if(heading < 0)
heading += 2*PI;


//  if(heading > 0)
//  heading -= 2*PI;
```

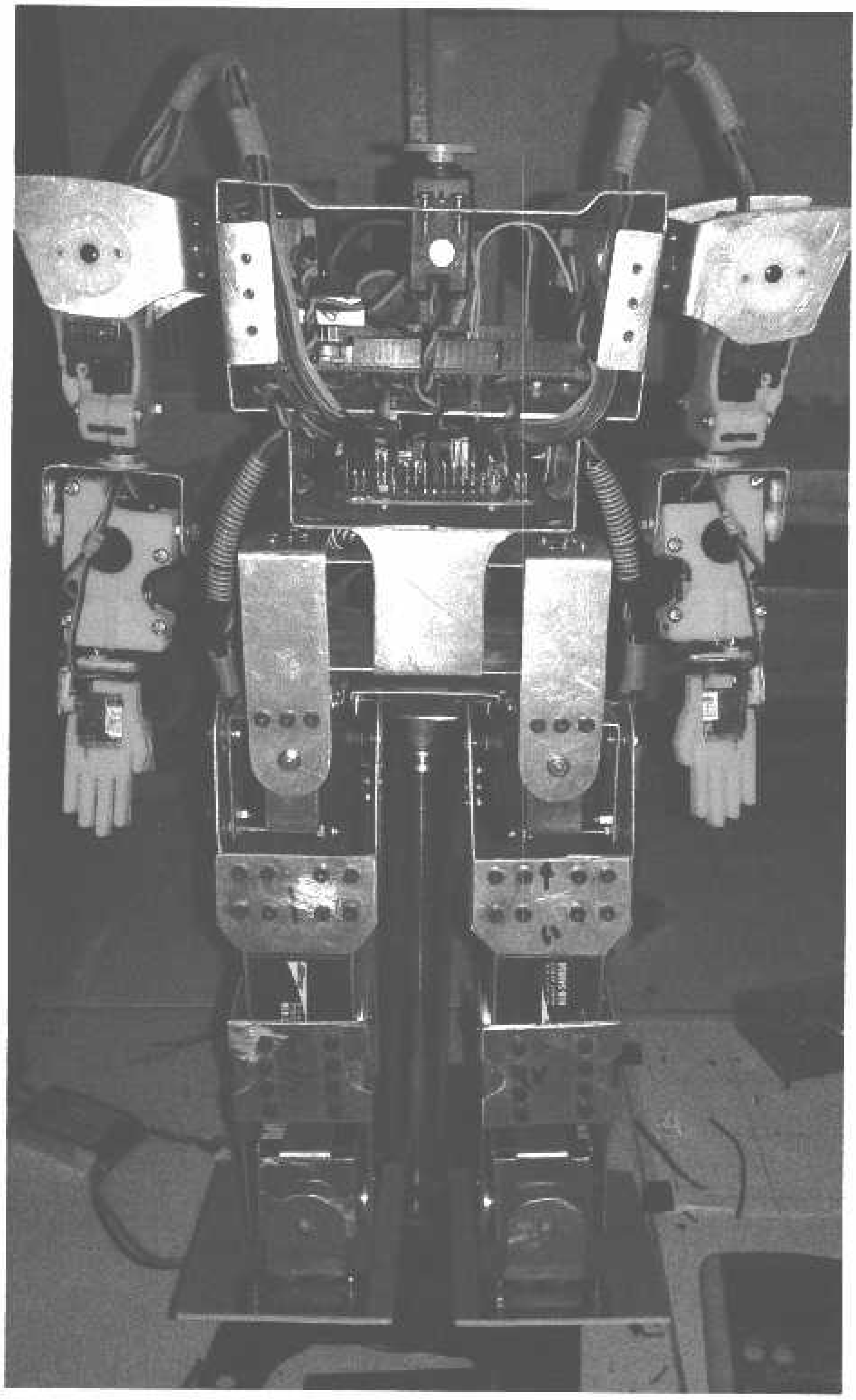
```
float headingDegrees = heading * 180/M_PI;
//Serial.println(headingDegrees);
//delay(10);
if(reset == 1)
{
 Serial.println("kalibrasi kompas...");
 enol = headingDegrees;
 bkiri=enol +21;
 bkanan =enol -21;
 reset=2;
 Serial.print("headingDegrees=");
 Serial.println(headingDegrees);
 Serial.print("Enol=");
 Serial.println(enol);
 Serial.print("belok kanan jika headingDegrees >=");
 Serial.println(bkanan);
 Serial.print("belok kiri jika headingDegrees <=");
 Serial.println(bkiri);
 delay(200);
}
else if (headingDegrees >= bkanan && headingDegrees <= bkiri)
 {
  {
}
    Serial.print(headingDegrees);
    Serial.println("...Derajat");
    //JLN
```

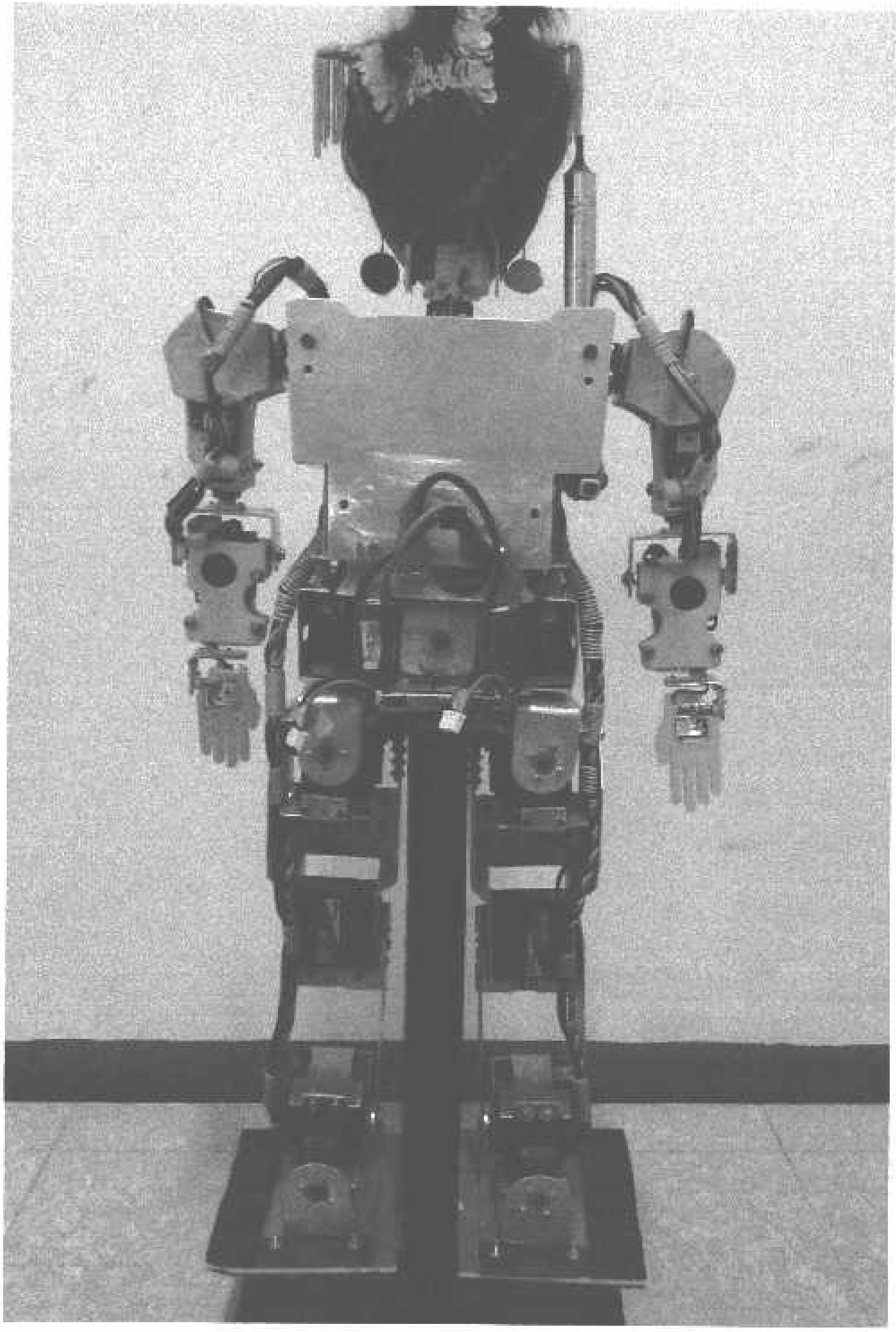
```
Serial.println(F("#1P1300#2P2500#3P1424#4P1789#5P922#7P1233#8P2011#9P1456#10P1678#11P1922#12P1189#13P1411#14P1456#16P1589#18P1500#19P1544#21P1411#22P1433#23P1878#24P967#25P922#26P1389#28P1078#29P1433#30P1856#31P1737#32P500T600"));

delay(450);

Serial.println(F("#1P1300#2P2500#3P1424#4P1789#5P922#7P1233#8P2011#9P1456#10P1678#11P1922#12P1189#13P1411#14P1456#16P1589#18P1500#19P1544#21P1411#22P1433#23P1878#24P967#25P922#26P1456#28P944#29P1433#30P1856#31P1611#32P500T300"));

delay(150);

Serial.println(F("#1P1300#2P2500#3P1411#4P1789#5P922#7P1335#8P2011#9P1456#10P1678#11P1922#12P1189#13P1411#14P1456#16P1589#18P1500#19P1544#21P1411#22P1433#23P1878#24P967#25P922#26P1492#28P961#29P1433#30P1856#31P1666#32P500T600"));

delay(450);

Serial.println(F("#1P1300#2P2500#3P1367#4P1789#5P833#7P1433#8P2011#9P1456#10P1678#11P1922#12P1189#13P1411#14P1456#16P1589#18P1500#19P1544#21P1411#22P1411#23P1878#24P967#25P922#26P1589#28P1078#29P1433#30P1856#31P1744#32P500T700"));

delay(550);

Serial.println(F("#1P1411#2P2500#3P1611#4P1789#5P944#7P1411#8P2011#9P1456#10P1678#11P1922#12P1189#13P1411#14P1456#16P1589#18P1500#19P1544#21P1411#22P1433#23P1878#24P967#25P922#26P1581#28P1056#29P1433#30P1856#31P1722#32P500T300"));

delay(150);

Serial.println(F("#1P1456#2P2500#3P1522#4P1789#5P922#7P1322#8P2011#9P1456#10P1678#11P1922#12P1189#13P1411#14P1456#16P1589#18P1500#19P1544#21P1456#22P1433#23P1878#24P967#25P922#26P1478#28P1011#29P1433#30P1856#31P1722#32P567T600"));

delay(450);
```

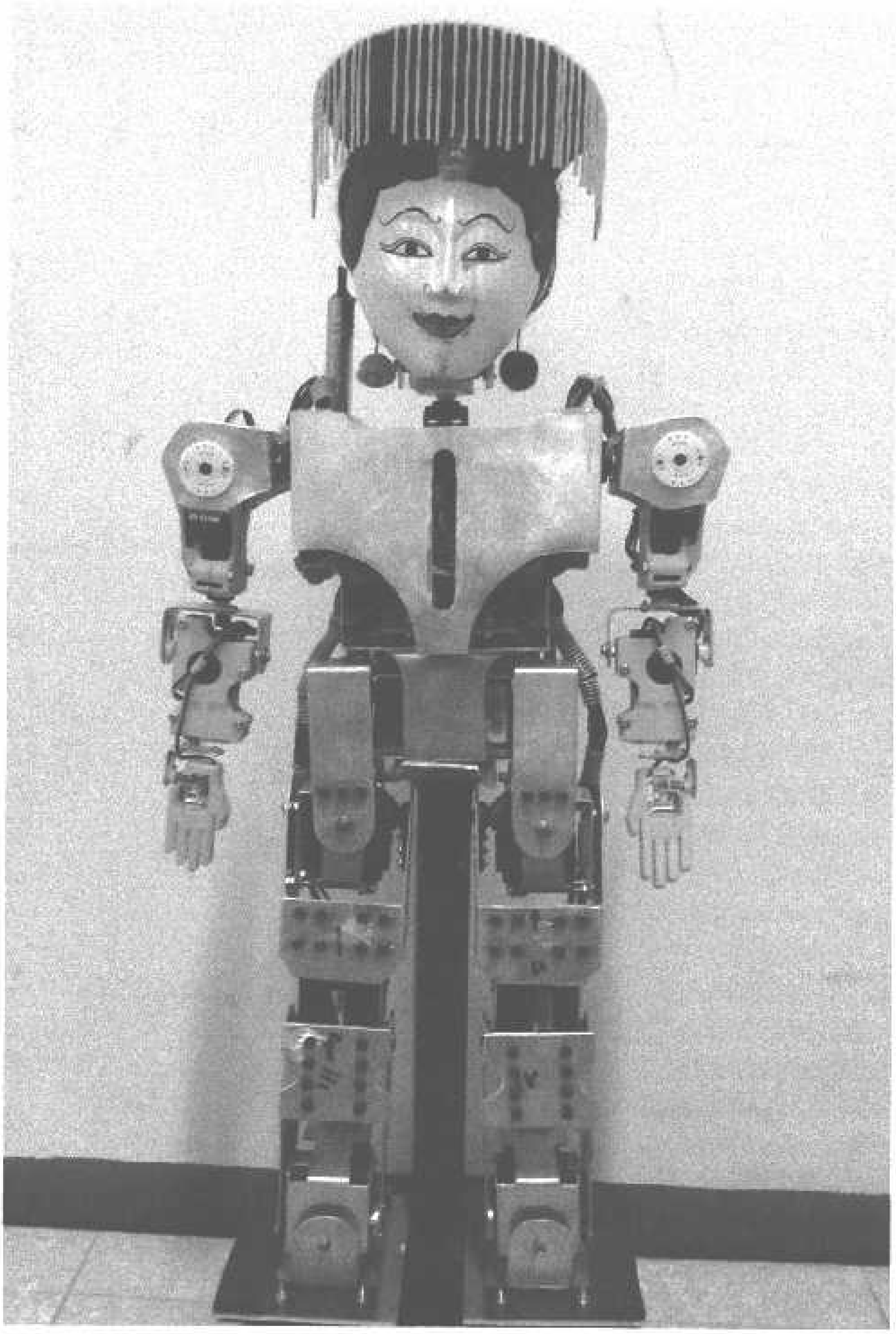
```
}
else if (headingDegrees <= bkanan)
{
 { Serial.print(headingDegrees);
  Serial.println("...Derajat harus belok kANAN");
  }
//BELOK KANAN
for(int g1=0; g1<2; g1++)
{
Serial.println(F("#1P1300#2P2500#3P1433#4P1789#5P922#7P1278#8P2056#9P
1211#10P1700#11P1989#12P1152#13P1411#14P1456#16P1856#18P1500#19P1
544#21P1411#22P1433#23P1878#24P967#25P967#26P1456#28P1078#29P1433
#30P1856#31P1722#32P500T300"));
delay(300);
Serial.println(F("#1P1300#2P2500#3P1433#4P1789#5P922#7P1256#8P2056#9P
1211#10P1700#11P1989#12P1152#13P1411#14P1456#16P1767#18P1500#19P1
367#21P1522#22P1433#23P1878#24P967#25P967#26P1433#28P1078#29P1411
#30P1856#31P1722#32P500T300"));
delay(300);
Serial.println(F("#1P1211#2P2500#3P1389#4P1789#5P922#7P1367#8P2056#9P
1211#10P1700#11P1989#12P1152#13P1411#14P1456#16P1811#18P1500#19P1
344#21P1456#22P1433#23P1878#24P967#25P967#26P1565#28P1078#29P1411
#30P1856#31P1722#32P500T500"));
delay(500);
Serial.println(F("#1P1233#2P2500#3P1456#4P1789#5P922#7P1366#8P2056#9P
1211#10P1700#11P1989#12P1152#13P1411#14P1300#16P1900#18P1500#19P1
411#21P1544#22P1433#23P1878#24P967#25P967#26P1544#28P1078#29P1411
#30P1856#31P1722#32P500T300"));
delay(300);
Serial.println(F("#1P1256#2P2500#3P1433#4P1789#5P922#7P1367#8P2056#9P
1211#10P1700#11P1989#12P1152#13P1411#14P1300#16P1856#18P1500#19P1
411#21P1544#22P1433#23P1878#24P967#25P967#26P1522#28P1078#29P1411
#30P1856#31P1722#32P500T250"));
delay(250);
```

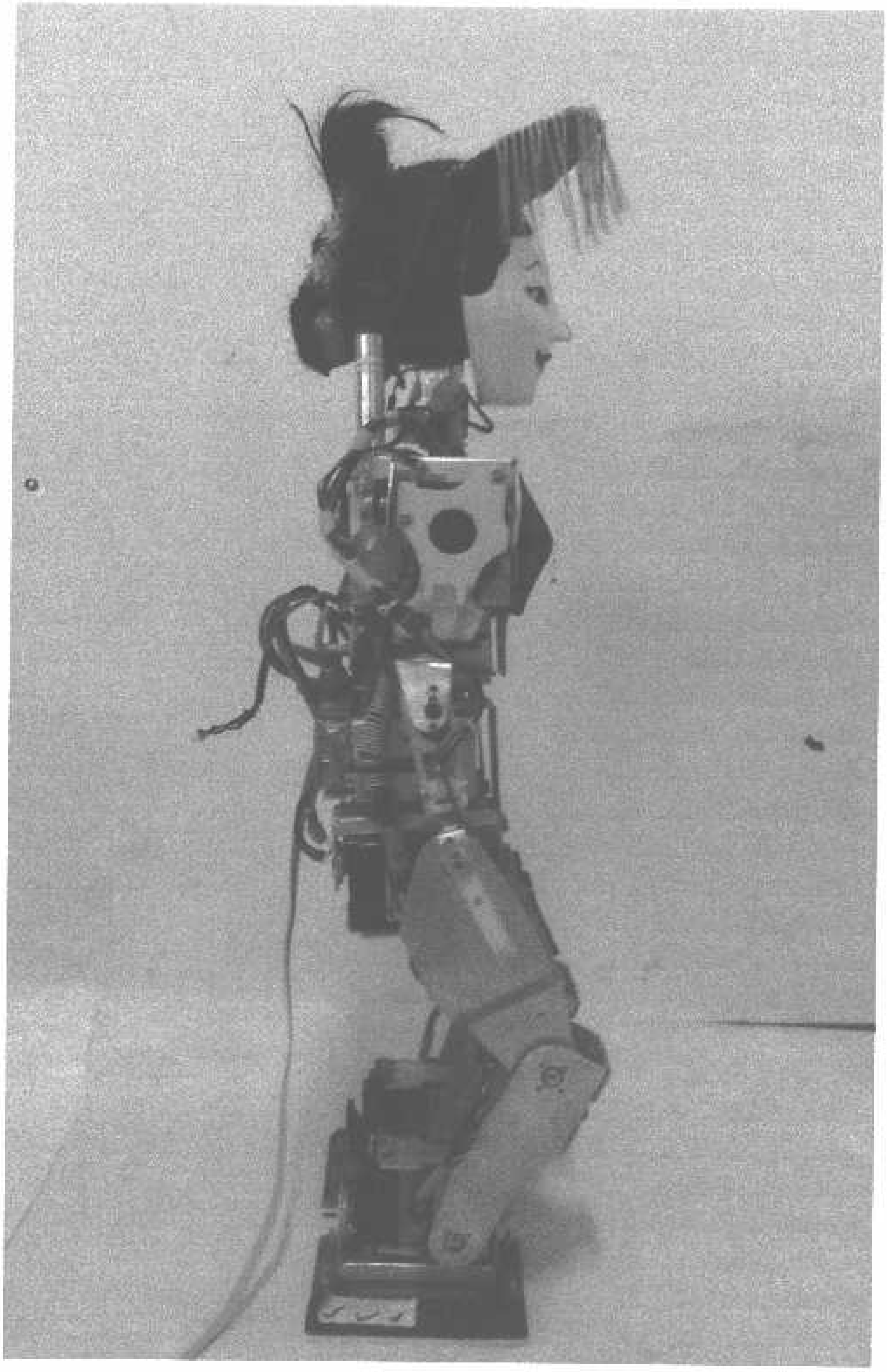
```
}}
else if (headingDegrees >= bkiri)
{{
  Serial.print(headingDegrees);
  Serial.println("...Derajat harus belok KIRI");
 }
//BELOK KIRI
for(int g1=0; g1<1; g1++)
{
Serial.println(F("#1P1300#2P2500#3P1433#4P1789#5P922#7P1256#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1456#16P1256#18P1500#19P1544#21P1411#22P1433#23P1878#24P967#25P922#26P1354#28P1078#29P1352#30P1856#31P1745#32P500T500"));
delay(500);
Serial.println(F("#1P1300#2P2500#3P1458#4P1789#5P922#7P1256#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1456#16P1211#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1411#28P1078#29P1389#30P1856#31P1685#32P500T300"));
delay(400);
Serial.println(F("#1P1300#2P2500#3P1456#4P1789#5P922#7P1322#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1456#16P1278#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1456#28P1078#29P1389#30P1856#31P1722#32P500T300"));
delay(400);
Serial.println(F("#1P1344#2P2500#3P1526#4P1789#5P922#7P1424#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1456#16P1300#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1563#28P1078#29P1389#30P1856#31P1760#32P500T500"));
delay(600);
Serial.println(F("#1P1367#2P2500#3P1522#4P1789#5P922#7P1433#8P2000#9P1167#10P1700#11P1989#12P1152#13P1411#14P1722#16P1322#18P1500#19P1700#21P1411#22P1433#23P1878#24P967#25P922#26P1544#28P1078#29P1389#30P1856#31P1767#32P500T300"));
delay(400);
```

FOTO ROBOT
“EPRETIWI-V4”
ITN MALANG
2016









BIOGRAFI

Gunawan Eko Hendroyono sebagai penulis skripsi ini lahir pada tanggal 21 Oktober 1993 di Longkoga, Luwuk Banggai, Sulawesi Tengan. Anak pertama dari dua bersaudara dengan adik bernama Kartika Dwi Ulfiyanti dari pasangan Mujiono dan Ulfina Hatibie yang sekarang berdomisili di Bualemo A Luwuk Banggai Sulawesi Tengah.

Menempuh pendidikan Taman Kanak-kanak Khadija di Seneporejo Siliragung Banyuwangi tahun 1997 – 2000. Melanjutkan jenjang pendidikan di Madrasah Ibtidaiyah Darul Huda Kesilir Siliragung Banyuwangi pada tahun 2000 – 2003 dan berpindah ke Sekoah Dasar di Sampaka I Bualemo Luwuk Banggai Sulawesi Tengah pada tahun 2003 – 2006. Dilanjutkan dengan jenjang Sekolah Menengah Pertama pada tahun 2006 – 2009 di SMP 1 Bualemo Luwuk Banggai Sulawesi Tengah. Pada tahun 2009 – 2012 melanjutkan pendidikan Sekolah Menengah Kejuruan di SMK 2 Raha di Raha Sulawesi Tenggara dan menempuh jenjang kuliah di Institut Teknologi Nasional Malang di Malang Jawa Timur pada tahun 2012 – 2016.

Sebagai siswa dan mahasiswa penulis banyak kegitatan dan organisasi yang telah di ikuti, mulai dari Pramuka, OSIS, LKS SMK, Himpunan Mahasiswa Elektro, angota dan ketua koordinator LAB Elektronika Analog, anggota LAB robot ITN Malang, Kontes Robot Indonesia dan lainnya.

dengan moto *"sabar, tawakal dan kerja keras untuk terus lebih baik"* akhirnya penulis telah berhasil menyelesaikan tugas akhir skripsi ini. Semoga dengan penulisan tugas akhir ini mampu memberikan kontribusi positif bagi dunia pendidikan.

Akhir kata penulis mengucapkan terimaksaih atas semua yang telah penulis lalui, terutama kepada Allah SWT, terimakasih kepada keluarga, ayah dan ibu selaku orangtua, terimakasih kepada guru dan dosen selaku wali didik, terimakasih kepada teman dan sahabat.

"Wassalamualikum warahmatullahi wabarokatu"