RANCANG BANGUN KUNCI PINTU DAN PENGOPERASIAN PERALATAN LITRIK MENGGUNAKAN RFID PADA RUANG PERKULIAHAN DI IIB DARMAJAYA

SKRIPSI
Diajukan Sebagai Salah Satu Syarat untuk Mencapai Gelar
SARJANA
Pada Program Studi Sistem Komputer
IIB Darmajaya Bandar Lampung

Oleh

ABDUL GHANI SURYA KUSUMA

1411060020

FAKULTAS ILMU KOMPUTER
PROGRAM STUDI SISTEM KOMPUTER
INSTITUT INFORMATIKA DAN BISNIS DARMAJAYA
BANDAR LAMPUNG
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Bandar Lampung, Februari 2019

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ENAM RIBU RUPIAH

ABDUL GHANI SURYA KUSUMA
1411060020

PERSETUJUAN

Judul Skripsi : Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Listrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya

Nama Mahasiswa : **ABDUL GHANI SURYA KUSUMA**

No. Pokok Mahasiswa : **1411060020**

Program Studi : **S1 Sistem Komputer**

Telah diperiksa dan disetujui untuk diajukan dan dipertahankan dalam sidang Tugas Penutup Studi guna memperoleh gelar Sarjana Ilmu Komputer pada Program Studi Sistem Komputer IIB Darmajaya.

Disetujui oleh :

Dosen Pembimbing	Ketua Program Studi, Sistem Komputer
Melia Gripin Setiawati,S.Kom.,MT NIK 0219067901	**Bayu Nugroho S.Kom.,M.Eng** NIK 00200700

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Telah diuji dan dipertahankan didepan tim penguji Skripsi
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Sarjana

Mengesahkan

1. Tim Penguji — Tanda Tangan

   Ketua : Novi Herawadi Sudibyo ....

   Anggota : Triowali Rosandy ....

2. Dekan Fakultas Ilmu Komputer

Zaidir Jamal, S.T.,M.Eng
NIK 00590203

Tanggal Lulus Ujian Skripsi : 22 Maret 2019

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MOTTO

“***KESUKSESAN ADALAH BUAH DARI USAHA USAHA KECIL YANG DIULANGI HARI DEMI HARI*** ”

(ABDUL GHANI SURYA KUSUMA)

ABSTRAK

RANCANG BANGUN KUNCI PINTU DAN PENGOPERASIAN PERALATAN LITRIK MENGGUNAKAN RFID PADA RUANG PERKULIAHAN DI IIB DARMAJAYA

Oleh

Abdul Ghani Surya Kusuma

Pada kampus IIB Darmajaya sering dijumpai suatu masalah tentang mengunci pintu ruangan yang masih manual dan masalah penerangan serta pendingin ruangan yang beroperasi tidak berdasarkan kebutuhan. Hal tersebut mengakibatkan terjadinya pemborosan energi listrik dan biaya. Salah satu cara mengatasi permasalahan ini adalah dengan cara melakukan penghematan energi listrik. Tetapi penghematan ini kurang efektif karena keterbatasan mahasiswa-mahasiswi IIB Darmajaya yang sering lupa dan malas untuk memadamkan lampu dan pendingin ruangan ketika ruangan tersebut tidak sedang dipergunakan, serta sering lupa nya dosen dalam melakukan penguncian pintu ruangan jika jam masuk sudah melebihi batas keterlabatan sehingga mahasiswa dan mahasiswi yang datang terlambat masih dapat masuk, hal ini sangat mengganggu jalan nya perkuliahan. Maka salah satu solusi alternatif dalam mengatasi permasalahan ini akan dibuat suatu sistem yaitu, rancang bangun kunci pintu dan pengoperasian peralatan litrik menggunakan RFID pada ruang perkuliahan di IIB Darmajaya. Sistem kerja dari alat yaitu peneliti menggunakan input berupa RFID, push button, dan RTC DS 1307 yang akan diproses oleh arduino AT Mega sehingga akan menghasilkan output berupa relay aktif, serta hasil dari pembacan sistem akan ditampilkan menggunakan LCD 20x4. Dari hail ujicoba sistem dapat diketahui jika kartu RFID ditempelkan dengan ID yang benar dan waktu menunjukkan sesuai waktu masuk ruang kuliah yaitu jam 7-10 sampai jam 7.25 maka tombol buka pintu masuk ditekan, maka status relay kipas, lampu dan doorlock akan aktif. Sedangkan tombol masuk hanya dapat digunakan selama 14 menit dari jam pertama masuk dan jika waktu masuk ruang kuliah sudah mencapai 7.25, maka tombol buka pintu masuk tidak dapat digunakan meskipun ID dari kartu RFID benar. Serta tombol buka pintu keluar dapat digunakan diluar waktu masuk ruangan kuliah jika ada mahasiswa ingin keluar kelas selama jam perkuliahan berlangsung. Relay kipas akan aktif dari jam 7.00 pagi hingga jam 16.00 sore dari hari senin sampai jum’at.

Kata Kunci : RFID, Push Button, Arduino , kunci , kelistrikan , pintu.

ABSTRACT

DESIGN OF DOOR LOCKING AND ELECTRIC EQUIPMENT OPERATIONS USING RFID IN CLASSROOMS IN IIB DARMAJAYA

By:

Abdul Ghani Surya Kusuma

On IIB Darmajaya campus there were often problems about locking the doors of the classrooms that was still done manually and the lighting and air conditioning that operates was not based on needs. This resulted in waste of electrical energy and costs. One way to overcome this problem is to save electricity. But this savings is less effective because of the limitations of IIB Darmajaya students who often forget and are lazy to turn off the lights and air conditioning when the room is not being used, and often forget the lecturer in locking the door of the room if the entrance time exceeds the limit of the position so that the students who arrive late can still enter, this is very disturbing the way his lectures. So one alternative solution in overcoming this problem was made a system that is, design of door locks *and the operation of electric equipment using RFID in the classroom at IIB* Darmajaya. The working system of the tool the researcher used was the input in the form of RFID, push button, and RTC DS 1307 which were processed by Arduino AT Mega so that it produced an output in the form of an active relay, and the result of reading the system was displayed using a 20x4 LCD. From the results of the system trial, it can be seen if the RFID card is affixed with the correct ID and the time shows according to the time of entering the lecture room ie 7-10 to 7.25 then the open button for the entrance is pressed, then the fan, lamp and doorlock relay status will be active. Whereas the entry button can only be used for 14 minutes from the first hour of entry and if the lecture room entrance time has reached 7.25, the open button for the entrance cannot be used even though the ID of the RFID card is correct. And the exit button can be used outside the time of entering the lecture room if there are students who want to leave the classroom during class hours. The fan relay will be active from 7:00 in the morning until 16:00 in the afternoon from Monday to Friday.

Keywords: RFID, Push Button, Arduino, keys, electricity, doors.

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Bandar Lampung, Februari 2019

Abdul Ghani Surya Kusuma
1411060020

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BAB I
PENDAHULUAN

1.1 Latar Belakang

Seiring perkembangan ilmu teknologi yang begitu pesat. Hal ini dibuktikan dengan banyaknya peralatan-peralatan canggih dan modern. Perkembangan pengetahuan ilmu elektronika inilah yang turut mengembangkan peralatan modern saat ini, dengan pengetahuan yang memadai maka dapat dibuat peralatan yang dapat membantu pekerjaan manusia. Salah satunya sistem keamanan ruangan perkuliahan. Kita ketahaui bahwa saat ini ruangan kuliah masih menggunakan sistem yang manual yaitu dengan menggunakan kunci gembok atau kunci manual. Sehingga perlu adanya perkembangan yang dapat mengunci pintu pada ruangan perkuliahan secara otomatis serta bukan hanya kunci pintu ruangan perkuliahan saja yang jadi permasalahan saat ini permasalahan yang kedua yaitu pemborosan energi listrik.

Penggunaan listrik yang semakin lama semakin tinggi pada bangunan-bangunan publik termasuk pada gedung-gedung perkuliahan yang berada di Bandar Lampung, salah satunya adalah kampus IIB Darmajaya mendasari peneliti untuk melakukan penelitiannya di kampus IIB Darmajaya. Dimana kampus IIB Darmajaya sendiri adalah kampus swasta yang saat ini sedang berkembang dalam melakukan pembangunan sarana dan perasarana perkuliahan. Dengan bertambahnya jumlah ruangan tersebut tentunya memerlukan penambahan daya listrik yang banyak. Penambahan daya listrik tersebut tentunya di barengi dengan penambahan biaya untuk bulanan. Saat ini konsumsi listrik di IIB Darmajaya tergolong tinggi dengan total 312.000 watt (*HWJ/ Teknisi Listrik IIB Darmajaya*).

Dengan bertambahnya sarana dan prasarana tersebut dapat memicu Potensi pemborosan listrik yang cukup besar karena semakin banyaknya perlatan listrik yang terinstal pada setiap ruangan. Selain permasalahan lampu dan pendingin ruangan tersebut, IIB Darmajaya juga memiliki permasalahan dalam penguncian pintu pada ruangan perkuliahan

yang masih menggunakan kunci manual kampus dengan masih menggunakan sistem penguncian yang manual dianggap kurang efektif dimana mahasiswa yang terlambat masih dapat memasukin ruangan kelas sehingga dapat mengganggu jalannya perkuliahan tersebut.

Dari permasalahan diatas, maka peneliti ingin membuat sebuah **“RANCANG BANGUN KUNCI PINTU DAN PENGOPERASIAN PERALATAN LITRIK MENGGUNAKAN RFID PADA RUANG PERKULIAHAN DI IIB DARMAJAYA”**. Sistem kerja dari alat yaitu jika ID card yang ditempelkan benar push button masuk akan aktif selama 15 menit dan relay akan menyalakan kelistrikan pada ruang perkuliahan. Jika waktu masuk sudah lebih dari 15 menit maka push botton masuk sudah tidak bisa digunakan kembali, sehingga push botton keluar akan aktif selama jam perkuliahan berlangsung sedangkan RTC DS1307 digunakan sebagai penjadwalan jam masuk perkuliahan. Jika jam perkuliahan sudah selesai maka kelistrikan akan otomatis mematikan lampu dan pendingin ruangan. Hasil dari RTC DS1307 dan pembacaan RFID akan ditampilkan pada LCD 20x4.

1.2 Ruang Lingkup Penelitian

Berdasarkan dari hasil penelitian yang telah dilakukan, maka ruang lingkup dalam penelitian ini, yaitu;

1. Mikrokontroler yang digunakan adalah AT Mega 2560.
2. Alat ini hanya dapat membuka pintu, mengunci pintu ruangan perkuliahan dan menyalakan kelistrikan .
3. Alat kunci pintu dan menyalakan kelistrikan pada ruangan perkuliahan ini hanya miniature
4. Peneliti melakukan penelitian dikampus IIB Darmjaya

1.3 Rumusan Masalah

Berdasarkan dari latar belakang yang telah dikemukakan, maka rumusan masalah dalam penelitian ini, yaitu:

1. Bagaimana merancang dan membangun sistem kunci pintu dan menyalakan kelistrikan menggunakan RFID dan push botton?
2. Bagaimana menggunakan *RTC DS1307* untuk membuat penjadwalan jam mata kuliah yang dapat digunakan sebagai mengunci dan membuka pintu?

1.4 Tujuan Penelitian

Bagaimana memanfaatkan RTC dan RFID sebagai pengontrol pintu dan listrik pada ruangan perkuliahan..

1.5 Manfaat Penelitian

Manfaat dari penelitian ini adalah

1. Dapat meminimalisir mahasiswa yang terlambat.
2. Mempermudah dalam membuka dan mengunci pintu ruangan.
3. Dapat membantu petugas dalam mematikan kelistrikan.
4. Membantu upaya penghematan energi listrik pada IIB Darmajaya.
5. Dapat meminimalisir terjadinya pemborosan energi listrik akibat dari kelalaian pengguna ruangan.

1.6 Sistematika Penulisan

Sistematika penulisan yang digunakan dalam tugas akhir ini terbagi dalam beberapa pokok bahasan, yaitu :

BAB I PENDAHULUAN

Dalam bab ini berisikan latar belakang masalah, rumusan masalah, batasan masalah, tujuan penelitian dan manfaat penelitian.

BAB II TINJAUAN PUSTAKA

Bab ini berisikan tentang teori – teori yang berkaitan dengan “Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya”.

BAB III METODOLOGI PENELITIAN

Bab ini menjelaskan apa yang akan digunakan dalam uji coba pembuatan alat, tahapan perancangan dari alat, diagram blok dari alat, dan cara kerja alat tersebut.

BAB IV HASIL DAN PEMBAHASAN

Bab ini berisi tentang implementasi alur, analisis dan pembahasan dari alur yang dirancang.

BAB V SIMPULAN DAN SARAN

Bab ini berisikan kesimpulan dari pengujian sistem serta saran apakah rangkaian ini dapat digunakan secara tepat dan dikembangkan perakitannya.

DAFTAR PUSTAKA

LAMPIRAN

BAB II
TINJAUAN PUSTAKA

1.1 Studi Literatur

Penelitian tentang membuat, mengunci pintu dan pengoprasian kelistrikan pada ruangan perkuliahan sudah pernah dilakukan oleh beberapa peneliti. Antara lain iyalah :

Salah satu jurnal yang menjadi referensi peneliti yaitu yang dilakukan oleh (Rahman, 2017) Dengan Judul Rancang Bangun Buka Tutup Pintu Otomatis Menggunakan Pengenalan Isyarat Tutur. uatu alat elektronik yang dapat menambah efisien waktu dalam membuka dan menutuppintu rumah dengan menggunakan pengenalan isyarat tutur. Perancangan alat tersebut mengguankan modul EasyVR yang diprogram melalui modul ArduinoUNO sehingga dapat membuat password dalam bentuk suara. Tingkat keberhasilan alat ini yakni 90% dengan delay 2 detik oleh orang yang sama antara yang suaranya direkam dan disimpan pada modul easyVR dengan memberikan perintah. Sedangkan untuk orang yang berbeda keberhasilan alat ini hanya 8,5%. Keberhasilan atas penerimaan sinyal suara yakni pada jara 4cm hingga 10 cm antara bibir dengan mikrofon.

Selanjutnya Peneliti (Ariyanti, 2018)Sistem Buka Tutup Pintu Otomatis Berbasis Suara Manusia Tujuan penelitian ini adalah untuk mengetahui tingkat keberhasilan pemberian perintah pada sistem buka tutup pintu secara otomatis dengan menggunakan pengenalan suara. Metode yang digunakan dalam penelitian ini adalah metode waterfall yang terdiri atas analisis sistem, perancangan, implementasi, dan pengujian. Sistem ini menggunakan modul Easy VR untuk pengenalan suara. VR 3.0 sebagai perangkat yang mudah menjadi alternatif dalam membangun sistem pengenalan berbasis suara, karena memiliki sejumlah manfaat yaitu berkapasitas kecil, memiliki fitur speaker yang menyesuaikan kebutuhan pengguna, sehingga untuk implementasinya dapat meminimalisir kerumitan instalasi dan konfigurasi fungsi perangkat yang relatif sederhana. Penelitian ini menggunakan dua kata yang digunakan untuk mengkodekan, yaitu kata "buka" dan "tutup". Keberhasilan pemberian perintah pada alat pengujian oleh orang yang berwenang adalah 95% untuk kata "buka", dan 90% untuk kata "tutup".

Selanjutnya peneliti (Fatfa, 2017) *Rancang bangun sistem keamnan rumah dengan dua tingkat pengamanan menggunakan RFID dan pasword.* Peneliti ini menggunakan RFID sebagai pengaman dalam membuka pintu saat sedang diluar rumah sedangkan posword digunakan sebagai pengaman saat sedang berada didalam rumah jika pembacaan RFID atau pasword salah maka Buzzer akan berbunyi.

Selanjutnya peneliti (Falintino, 2016) Perancangan Sistem akses Keamanan Rumah Berbasis RFID dan Mikrokontroler AT Mega 328. Dalam perancangan alat ini peneliti menggunakan RFID dan limit swite yang digunakan sebagai pembuka dan penutup pintu yanh dimana saat ID card RFID ang dimasukan benar maka limit swite akan terbuka sedangkan jika ID card salah maka limit swite akan tetap tertutup dan buzzer akan berbunyi.

Selanjutnya peneliti (M.S, 2015) Sistem kemanan rumah Via Sms Berbasis Modem Dan Mikrokontroler At Mega 16. Sistem kerja dari alat ini yaitu jika sensor ultrasonik <20 terhalang oleh adanya objek maka modem akan mengirimkan sms kepada user serta pembacaan jarak ultrasonik akan ditampilkan pada lcd 16x2.

Selanjutnya dilakukan oleh (Novi Lestari, 2017) dengan judul Rancang Bangun Pintu Otomatis Menggunakan Arduino Uno Dan Pir (Passive Infra Red) Sensor Di Smp Negeri Simpang Semambang. Sistem pintu otomatis ini dapat dirancang dengan menggunakan kendali otomatis yang dipadu dengan sensor dan motor servo. Dari segi peralatan input digunakan sensor PIR (Passive Infrared Receiver) yang dapat mendeteksi adanya manusia yang akan mendekati pintu. Sensor PIR ini akan mengirimkan sinyal ke unit proses Arduino yang didalamnya ada chip mikrokontroler. Mikrokontroler akan mengirimkan data hasil pengolahan ke motor Servo sehingga dapat membuka tutup pintu secara otomatis.

Selanjutnya peneliti (Gumilang, 2017) Rancang Bangun Keamanan Rumah Menggunakan Rfid Dan Sms Berbasis Arduino Uno. Dari hasil percangan alat peneliti mendapatkan hasil yaitu pada ujicoba ke 1 jika pemilik rumah mengirimkan alrmon serta id card RFID (96,8,19,164,223) maka Doorlock akan terbuka sedangkan buzzer bestatus HIGH, sensor PIR berstatus HIGH maka gms akan mengirimkan sms kepemilik rumah hasil pembacaan yaitu akses diterima.sedangkan jika pemilik rumah meritahkan alrmoff serta nomer id card yang dimasuka salah(96,8,19,154,224) maka doorlock akan tetap tertutup, buzzer akan berstatus HIGH sedangkan sensor PIR berstatus low dan Gsm Shield akan mengirimkan sms ada mencoba masuk sehingga tampilan pada lcd akses ditolak. Dengan adanya alat ini maka diharapkan dapat dengan cepat menangkap pencuri yang ada didalam rumah.

2.2 Perangkat Keras Yang Digunakan

2.2.1 *Radio Frequency Identification* (RFID)

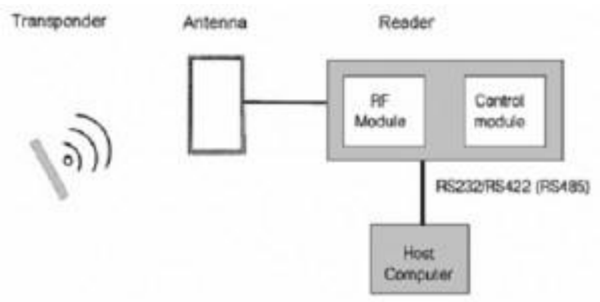
Radio Frequency Identification (RFID) adalah teknologi identifikasi yang fleksibel, mudah digunakan, dan sangat cocok untuk operasi otomatis. *RFID* mengkombinasikan keunggulan yang tidak tersedia pada teknologi identifikasi yang lain. *RFID* dapat disediakan dalam device yang hanya dapat dibaca saja (*Read Only*) atau dapat dibaca dan ditulis (*Read/Write*), tidak memerlukan kontak langsung maupun jalur cahaya untuk dapat beroperasi, dapat berfungsi pada berbagai variasi kondisi lingkungan, dan menyediakan tingkat integritas data yang tinggi. Sebagai tambahan, karena teknologi ini sulit untuk dipalsukan, maka *RFID* dapat menyediakan tingkat keamanan yang tinggi.

Pada sistem *RFID* umumnya, tag atau transponder ditempelkan pada suatu objek. Setiap tag membawa dapat membawa informasi yang unik, di antaranya: serial number, model, warna, tempat perakitan, dan data lain dari objek tersebut. Ketika tag ini melalui medan yang dihasilkan oleh pembaca *RFID* yang kompatibel, tag akan mentransmisikan informasi yang ada pada tag kepada pembaca *RFID*, sehingga proses identifikasi objek dapat dilakukan.

Sistem *RFID* terdiri dari empat komponen, di antaranya seperti dapat dilihat pada gambar berikut :

- Tag: Ini adalah *device* yang menyimpan informasi untuk identifikasi objek. Tag *RFID* sering juga disebut sebagai transponder.
- Antena: untuk mentransmisikan sinyal frekuensi radio antara pembaca *RFID* dengan tag *RFID*. Pembaca *RFID:* adalah device yang kompatibel dengan tag *RFID* yang akan berkomunikasi secara wireless dengan tag.
- Software Aplikasi: adalah aplikasi pada sebuah workstation atau PC yang dapat membaca data dari tag melalui pembaca *RFID*. Baik tag dan pembaca *RFID* diperlengkapi dengan antena sehingga dapat menerima dan memancarkan gelombang elektromagnetik.

2.2.1.1 Sistem *RFID*



Gambar 2.1. Sistem *RFID*

(Sumber https://www.elektronikar,2014)

2.2.1.2 Pembaca *RFID*

Sebuah pembaca *RFID* harus menyelesaikan dua buah tugas, yaitu:

- Menerima perintah dari software aplikasi
- Berkomunikasi dengan tag *RFID*

Pembaca *RFID* adalah merupakan penghubung antara *software* aplikasi dengan antena yang akan meradiasikan gelombang radio ke tag *RFID*. Gelombang radio yang diemisikan oleh antena berpropagasi pada ruangan di sekitarnya. Akibatnya data dapat berpindah secara wireless ke tag *RFID* yang berada berdekatan dengan antena.

2.2.1.3 Tag *RFID*

Tag *RFID* adalah device yang dibuat dari rangkaian elektronika dan antena yang terintegrasi di dalam rangkaian tersebut. Rangkaian elektronik dari tag *RFID* umumnya memiliki memori sehingga tag ini mempunyai kemampuan untuk menyimpan data. Memori pada tag secara dibagi menjadi sel-sel. Beberapa sel menyimpan data *Read Only*, misalnya serial number yang unik yang disimpan pada saat tag tersebut diproduksi. Sel lain pada *RFID* mungkin juga dapat ditulis dan dibaca secara berulang.

Berdasarkan catu daya tag, tag *RFID* dapat digolongkan menjadi:

- **Tag Aktif**: yaitu tag yang catu dayanya diperoleh dari batere, sehingga akan mengurangi daya yang diperlukan oleh pembaca *RFID* dan tag dapat mengirimkan informasi dalam jarak yang lebih jauh. Kelemahan dari tipe tag ini adalah harganya yang mahal dan ukurannya yang lebih besar karena lebih komplek. Semakin banyak fungsi yang dapat dilakukan oleh tag *RFID* maka rangkaiannya akan semakin komplek dan ukurannya akan semakin besar.
- **Tag Pasif**: yaitu tag yang catu dayanya diperoleh dari medan yang dihasilkan oleh pembaca *RFID*. Rangkaiannya lebih sederhana, harganya jauh lebih murah, ukurannya kecil, dan lebih ringan. Kelemahannya adalah tag hanya dapat mengirimkan informasi dalam jarak yang dekat dan pembaca *RFID* harus menyediakan daya tambahan untuk tag *RFID*.

Tag *RFID* telah sering dipertimbangkan untuk digunakan sebagai barcode pada masa yang akan datang. Pembacaan informasi pada tag RFID tidak memerlukan kontak sama sekali. Karena kemampuan rangkaian terintegrasi yang modern, maka tag *RFID* dapat menyimpan jauh lebih banyak informasi dibandingkan dengan *barcode*. Fitur pembacaan jamak pada teknologi RFID sering disebut sebagai *anti collision.*

2.2.2 Real Time Clock (RTC DS1307)

Real Time Clock merupakan suatu chip (IC) yang memiliki fungsi sebagai penyimpan waktu dan tanggal. DS1307 merupakan Real-time clock (RTC) yang dapat meyimpan data-data detik, menit, jam, tanggal, bulan, hari dalam seminggu, dan tahun valid hingga 2100. 56-byte, battery-backed, RAM nonvolatile (NV) RAM untuk penyimpanan. DS1307 merupakan Real-time clock (RTC) dengan jalur data parallel yang memiliki Antarmuka serial Two-wire (I2C), Sinyal luaran gelombang-kotak terprogram (Programmable squarewave), Deteksi otomatis kegagalan-daya (power-fail) dan rangkaian switch, Konsumsi daya kurang dari

Gambar 2.2. *Real Time Clock* (RTC DS1307)

500nA menggunakan mode baterai cadangan dengan operasional osilator. Tersedia fitur industri dengan ketahana suhu: -40°C hingga +85°C. Tersedia dalam kemasa 8-pin DIP atau SOIC.

Berikut Penjelasan Pin-Pin Pada IC DS1307

1. X1

Merupakan pin yang digunakan untuk dihubungkan dengan kristal sebagai pembangkit clock.

2. X2

Berfungsi sebagai keluaran / output dari crystal yang digunakan. Trhubung juga dengan X1.

3. VBAT

Merupakan backup supply untuk RTC dalam menjalankan fungsi waktu dan tanggal. Besarnya adalah 3V dengan menggunakan jenis Lithium Cell atau sumber energy lain. Jika pin ini tidak di gunakan maka harus terhubung dengan Ground. Sumber teganggan dengan 48mAH atau lebih besar dapat digunakan sebagai cadangan energy sampai lebih dar 10 tahun, namun dengan persyaratan untuk pengoprasian dalam suhu 25°C.

4. GND
Berfungsi sebagai Ground.

5. SDA
Barfungsi sebagai masukan / keluaran (I/O) untuk I2C serial interface. Pin ini bersifat open drain, oleh sebab itu membutuhkan eksternal pull up resistor.

6. SCL
Berfungsi sebagai clock untuk input ke I2C dan digunakan untuk mensinkronisasi pergerakan data dalam serial interface. bersifat open drain, oleh sebab itu membutuhkan eksternal pull up resistor.

7. SWQ/OUT
Sebagai square wafe / Output Driver . jika di aktifkan, maka akan menjadi 4 frekuensi gelombang kotak yaitu 1 Hz, 4kHz, 8kHz, 32kHz sifat dari pin ini sama dengan sifat pin SDA dan SCL sehingga membutuhkan eksternal pull up resistor. Dapat dioprasikan dengan VCC maupun dengan VBAT.

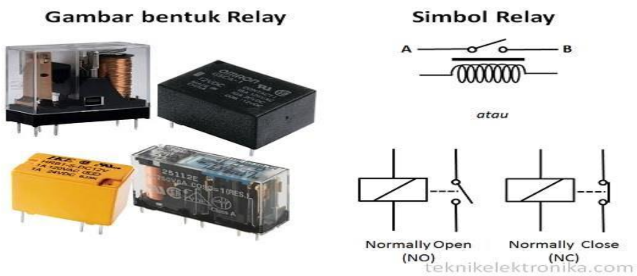
8. VCC
Merupakan sumber tegangan utama. Jika sumber tegangan terhubung dengan baik, maka pengaksesan data dan pembacaan data dapat dilakukan dengan baik. Namun jika backup supply terhubung juga dengan VCC, namun besar VCC di bawah VTP, maka pengaksesan data tidak dapat dilakukan.

2.2.3 Relay

Relay merupakan bentuk hambatan terdiri atas titik-titik kontak bawah dengan gulungan *spool*-nya tidak bergerak dan titik kontak bagian atas yang bergerak. Prinsip kerja hambatan adalah menghubungkan titik-titik kontak bagian bawah dengan titik bagian atas yaitu terletak gulungan *spool* dialiri arus listrik yang timbul elektromagnet. (Handy Wicaksono,1996,1-12). *Relay* merupakan bentuk hambatan terdiri atas titik-titik kontak bawah dengan gulungan *spool*-nya tidak bergerak dan titik kontak bagian atas yang bergerak. Prinsip kerja hambatan adalah menghubungkan titik-titik kontak bagian bawah dengan titik bagian atas yaitu terletak gulungan *spool* dialiri arus listrik yang timbul elektromagnet. (Handy Wicaksono,1996,1-12).Secara sederhana relay elektromekanis ini didefinisikan sebagai berikut :

1. Alat yang menggunakan gaya elektromagnetik untuk menutup (atau membuka) kontak saklar.
2. Saklar yang digerakkan (secara mekanis) oleh daya/energi listrik.

Dibawah ini adalah gambar fisik, bentuk dan Simbol Relay yang sering ditemukan di Rangkaian Elektronika.



Gambar 2.3 Gambar dan Simbol Relay

(http://teknikelektronika.com/pengertian-relay-fungsi-relay/)

Gambar 2.4 Relay

(Sumber : Kilian, Christopher T, Modern Control Technology 2016)

Bagian titik kontak dibagi menjadi 2 bagian yaitu bagian kontak utama dan kontak bantu yaitu : Bagian kontak utama gunanya untuk menghubungkan dan memutuskan arus listrik bagian yang menuju beban/pemakai.Bagian kontak bantu gunanya untuk menghubungkan dan memutuskan arus listrik ke bagian yang menuju bagian pengendali. Kontak Bantu mempunyai 2 kontak yaitu kontak hubung (NC) dan kontak putus (NO) menandakan masing-masing kontak dan gulungan spool.Secara umum, relay digunakan untuk memenuhi fungsi–fungsi berikut :

1. Remote control : dapat menyalakan atau mematikan alat dari jarak jauh.
2. Penguatan daya : menguatkan arus atau tegangan.
3. Pengatur logika kontrol suatu sistem. Susunan kontak pada relay adalah:
4. Normally Open : Relay akan menutup bila dialiri arus listrik.
5. Normally Close : Relay akan membuka bila dialiri arus listrik.
6. Changeover : Relay ini memiliki kontak tengah yang akan melepaskan diri dan membuat kontak lainnya berhubungan.

2.2.3.1 Prinsip Kerja Relay

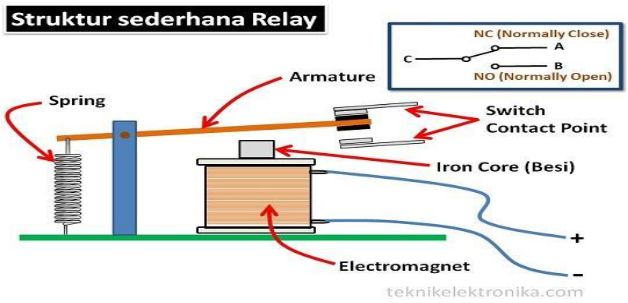
Pada dasarnya, Relay terdiri dari 4 komponen dasar yaitu :

1. Electromagnet (Coil)
2. Armature
3. Switch Contact Point (Saklar
4. Spring

Seperti saklar, relay juga dibedakan berdasar pole dan throw yang dimilikinya.

1. Pole : banyaknya contact yang dimiliki oleh relay
2. Throw : banyaknya kondisi (state) yang mungkin dimiliki contact.

Berikut ini merupakan gambar dari bagian-bagian Relay :



Gambar 2.5 Struktur Sederhana Relay

(http://teknikelektronika.com/pengertian-relay-fungsi-relay/)

Kontak normally open akan membuka ketika tidak ada arus mengalir pada kumparan,tetapi tertutup secepatnya setelah kumparan menghantarkan arus atau diberi tenaga. Kontak normally close akan tertutup apabila kumparan tidak diberi tenaga dan membuka ketika kumparan diberi daya. Masing-masing kontak biasanya digambarkan sebagai kontak yang tampak dengan kumparan tidak diberi tanaga atau daya.

Relay terdiri dari 2 terminal trigger, 1 terminal input dan 1 terminal output.

1. Terminal trigger : yaitu terminal yang akan mengaktifkan relay, seperti alat elektronik lainya relay akan aktif apabila di aliri arus + dan arus -. Pada contoh relay yang kita gunakan terminal trigger ini adalah 85 dan 86.
2. Terminal input : yaitu terminal tempat kita memberikan masukan, pada contoh adalah terminal 30.
3. Terminal output : yaitu tempat keluarnya output pada contoh adalah terminal 87.

2.2.3.2 Fungsi-fungsi *Relay*

Beberapa fungsi *relay* yang telah umum diaplikasikan kedalam peralatan elektronika diantara-nya adalah :

1. *Relay* digunakan untuk menjalankan fungsi logika (*logic function*).
2. *Relay* digunakan untuk memberikan fungsi penundaan waktu (*time delay function*).
3. *Relay* digunakan untuk mengendalikan sirkuit tegangan tinggi dengan

bantuan dari signal tegangan rendah.

4. Ada juga *relay* yang berfungsi untuk melindungi motor ataupun komponen lainnya dari kelebihan tegangan ataupun hubung singkat (*short*).

2.2.4 Door Lock

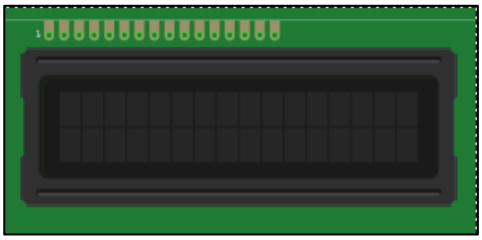
Gambar 2.6 Door Lock Selenoid

(Sumber https://kumpulanrangkaianelektronik.blogspot.co.id)

Kunci selenoid adalah salah satu jenis kumparan yang terbuat dari kebel panjang yang dililitkan secara rapat dan dapat diasumsikan bahwa panjangnya lebih besar dari pada diameter nya. Sedangkan kunci selenoid adalah gabungan antara kunci dan selenoid dimana bisa digunakan dalam elektronisasi suatu alat sebagai pengunci otomatis dan lainnya. Prinsip selenoid ditemukan oleh fisikawan perancis yang bernama Andre Marie Ampere. Pada bidang rekayaa istilah ini menunjukan pada perangkat tanduster yang mengkonversi energi ke gerakan linier. Pada saat kumparan dialiri arus listrik maka gaya *elektromagnetik* akan muncul dan menarik besi yang ada pada bagian tengah kumparan secara linier.

2.2.5 LCD (*Liquid Crystal Display*)

Display LCD (*Liquid Crystal Display*) adalah penampil kristal cair yang terdiri atas tumpukan tipis atau sel dari dua lembar kaca yang sampingnya tertutup rapat. Permukaan luar dari masing-masing keping kaca mempunyai lapisan penghantar tembus cahaya. Sel mempunyai ketebalan sekitar 1x10-5 meter dan diisi dengan kristal cair. Beberapa hal yang perlu diperhatikan untuk pengaksesan LCD yaitu LCD selalu berada pada kondisi tulis (Write) yaitu dengan menghubungkan kaki R/W ke ground. Hal ini dimaksudkan agar LCD tersebut tidak pernah mengeluarkan data (pada kondisi baca) yang mengakibatkan tabrakan data dengan komponen lain di jalur bus. Penampil kristal cair memerlukan catu daya dari power suspply sebesar +5 volt. Bentuk LCD seperti pada gambar 2.7.



Gambar 2.7 Bentuk Fisik LCD

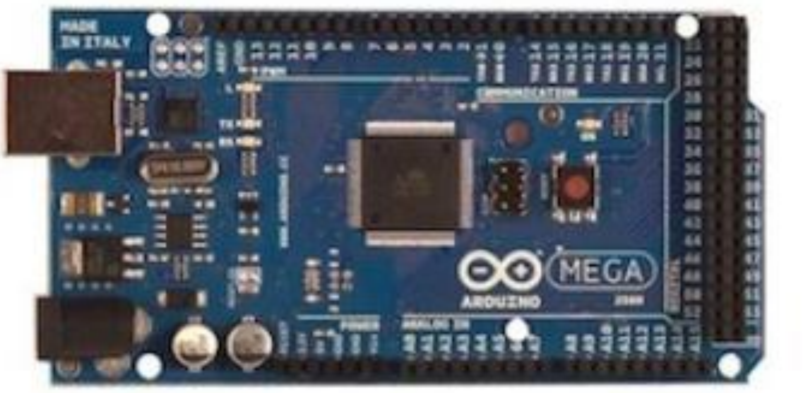
(Sumber http://sainsdanteknologiku.blogspot.co.id/2017)

2.2.6 Mikrokontroller

Mikrocontroller adalah sebuah chip yang berfungsi sebagai pengontrol rangkaian elektronik dan umunya dapat menyimpan program pada umumnya terdiri dari CPU (*Central Processing Unit*), memori, I/O tertentu dan unit pendukung seperti *Analog-to-Digital Converter* (ADC) yang sudah terintegrasi di dalamnya. Kelebihan utama dari *Mikrokontroller* ialah tersedianya RAM dan peralatan I/O pendukung sehingga ukuran board *Mikrokontrolle*r menjadi sangat ringkas. (Arduino, 2016)

2.1.1 Modul Arduino AT *Mega2560*

Arduino Mega 2560 adalah sebuah papan mikrokontroler berbasis Atmega 2560 *(datasheet).* Mempunyai 54 pin digital *input/output* (dimana 14 pun dapat diguanakan sebagai keluaran PWM), 16 pin input analog, 2 UARTs (*Hardware serial ports*), sebuah *crystal oscillator* 16 MHz, sebuah penghubung USB, sebuah colokan listrik, ICSP *header*, dan tombol kembali. Setiap isi dari Arduino Mega 2560 membutuhkan dukungan mikrokontroler; koneksi mudah antara Arduino mega 2560 ke komputer dengan sebuah kabel USB atau daya dengan AC to DC adaptor atau baterai untuk memulai. Arduino mega cocok sebagai rancangan pelindung untuk Arduino *Deumilanove* atau *Diecimila*.



Gambar 2.8 Arduino Mega 2560

2.1.2 Arsitektur Arduino Mega 2560

Arduino Mega 2560 terbentuk dari prosessor yang dikenal dengan Mikrokontroler ATMega 2560. Mikrokontroler ATMega 2560 memiliki beberapa fitur / spesifikasi yang menjadikannya sebagai solusi pengendali yang efektif untuk berbagai keperluan. Fitur-fitur tersebut antara lain :

1. Tegangan Operasi sebesar 5 V
2. Tegangan input sebesar 6 – 20 V tetapi yang direkomendasikan untuk ATMega 2560 sebesar 7 – 12 V.
3. Pin digital I/O sebanyak 54 pin dimana 14 pin merupakan keluaran dari PWM.
4. Pin input analog sebanyak 16 pin
5. Arus DC pin I/O sebesar 40 mA sedangkan Arus DC untuk pin 3.3V sebesar 50 mA
6. Flash memory 156 Kb yang mana 8 Kb digunakan oleh bootloader.
7. SRAM 8 Kbyte
8. EEPROM 4 Kbyte
9. Serta mempunyai 2 Port UARTs untuk komunikasi serial.

Gambar 2.9 ATMega 2560 pada Arduino Mega 2560

(Atmel Corporation.2014)

2.1.3 Konfigurasi Pin Arduino Mega

1. VCC adalah tegangan catu digital

2. GND adalah *Ground*

3.PORT A(PA..PA0)

4. Reset

Input reset. Sebuah level rendah pada pin ini untuk lebih panjang dari pada panjang minimum pulsa akan menghasilkan sebuah reset, bahkan jika waktu tidak berjalan. Panjang minimum pulsa dijelaskan pada “Sistem dan karakter reset” pada halaman 360. Pulsa terpendek tidak dijamin menghasilkan sebuah reset .

5. XTAL1

Input ke *inverting amplifier oscilator* dan input ke internal jalur operasi waktu.

6. XTAL2

Keluaran dari *inverting oscilator amplifier*

7. AVCC

AVCC merupakan pin tegangan catu untuk port F dan A/D *Converter*. AVCC dapat terhubung secara eksternal ke VCC, bahkan jika ADC tidak digunakan jika ADC digunakan, ADC akan terhubung ke VCC melalui sebuah *low pass filter.*

8. AREF

AREF adalah pin referensi analog untuk A/D *Converter* (Atmel Corporation.2014)

2.3 Perangkat Lunak Yang Digunakan

Pengertian perangkat lunak atau biasa disebut software adalah sekumpulan data elektronik yang sengaja disimpan dan diatur oleh komputer berupa program ataupun instruksi yang akan menjalankan sebuah perintah. Perangkat lunak atau software disebut juga sebagai penerjemah perintah-perintah yang dijalankan oleh user untuk diteruskan dan diproses oleh perangkat keras (hardware). Dengan adanya perangkat lunak inilah sebuah sistem mampu menjalankan perintah.

2.3.1 *Software* Mikrokontroller Arduino Uno

Software arduino yang digunakan adalah *driver* dan IDE, walaupun masih ada beberapa *software* lain yang sangat berguna selama pengembangan arduino. *Integrated Development Environment* (IDE), suatu program khusus untuk suatu komputer agar dapat membuat suatu rancangan atau *sketsa* program untuk papan *Arduino*. IDE *arduino* merupakan *software* yang sangat canggih ditulis dengan menggunakan *java*. IDE arduino terdiri dari :

1. Editor Program

Sebuah *window* yang memungkinkan pengguna menulis dan mengedit program dalam bahasa *processing.*

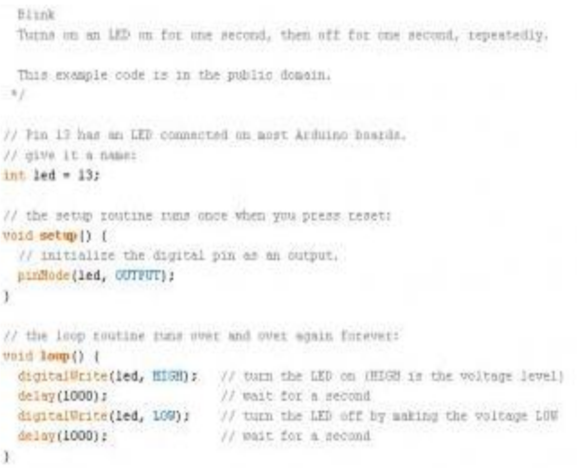
2. *Compiler*

Berfungsi untuk kompilasi *sketch* tanpa unggah ke *board* bisa dipakai untuk pengecekan kesalahan kode *sintaks sketch*. Sebuah modul yang mengubah kode program menjadi kode *biner* bagaimanapun sebuah mikrokontroler tidak akan bisa memahami bahasa *processing.*

3. *Uploader*

Berfungsi untuk mengunggah hasil kompilasi *sketch* ke *board* target. Pesan *error* akan terlihat jika b*oard* belum terpasang atau alamat *port* COM belum terkonfigurasi dengan benar. Sebuah modul yang memuat kode *biner* dari komputer ke dalam *memory* didalam papan *arduino.*(Sumber: B.Gustomo, 2015).

2.3.1.1 Program Arduino Ide



```
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  This example code is in the public domain.
 */

// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  digitalWrite(led, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);               // wait for a second
  digitalWrite(led, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);               // wait for a second
}
```

Gambar 2.10 Tampilan Program *Arduino Uno*

Kode Program *Arduino* biasa disebut *sketch* dan dibuat menggunakan bahasa pemrograman C. Program atau *sketch* yang sudah selesai ditulis di *Arduino* IDE bisa langsung di*compile* dan di*upload* ke *Arduino Board*. Secara sederhana, *sketch* dalam *Arduin*o dikelompokkan menjadi 3 blok (lihat gambar di atas):

1. Header
2. Setup
3. Loop

2.3.1.2 Header

Pada bagian ini biasanya ditulis definisi-definisi penting yang akan digunakan selanjutnya dalam program, misalnya penggunaan *library* dan pendefinisian *variable*. *Code* dalam blok ini dijalankan hanya sekali pada waktu compile. Di bawah ini contoh *code* untuk mendeklarasikan *variable led* (integer) dan sekaligus di isi dengan angka 13

int led = 13;

2.3.1.3 Setup

Di sinilah awal program *Arduin*o berjalan, yaitu di saat awal, atau ketika *power on Arduino board*. Biasanya di blok ini diisi penentuan apakah suatu pin digunakan sebagai *input* atau *output*, menggunakan perintah *pinMode*. Initialisasi *variable* juga bisa dilakukan di blok ini

// the setup routine runs once when you press reset: void setup() { // initialize the digital pin as an output. pinMode(led, OUTPUT); }

OUTPUT adalah suatu makro yang sudah didefinisikan Arduino yang berarti = 1. Jadi perintah di atas sama dengan pinMode(led, 1);

Suatu pin bisa difungsikan sebagai *OUTPUT* atau *INPUT*. JIka difungsikan sebagai output, dia siap mengirimkan arus listrik (maksimum 100 mA) kepada beban yang disambungkannya. Jika difungsikan sebagai INPUT, pin tersebut memiliki *impedance* yang tinggi dan siap menerima arus yang dikirimkan kepadanya.

2.3.1.4 Loop

Blok ini akan dieksekusi secara terus menerus. Apabila program sudah sampai akhir blok, maka akan dilanjutkan dengan mengulang eksekusi dari awal blok. Program akan berhenti apabila tombol *power Arduino* di matikan. Di sinilah fungsi utama program *Arduino* kita berada.

void loop() {

digitalWrite(led, HIGH); // nyalakan LED delay(1000); // tunggu 1000 milidetik digitalWrite(led, LOW); // matikan LED delay(1000); // tunggu 1000 milidetik }

Perintah *digitalWrite*(pinNumber,nilai) akan memerintahkan arduino untuk menyalakan atau mematikan tegangan di pi*nNumber* tergantung nilainya. Jadi perintah di atas d*igitalWrite*(led,HIGH) akan membuat pin nomor 13 (karena di header dideklarasi led = 13) memiliki tegangan = 5V (HIGH). Hanya ada dua kemungkinan nilai *digitalWrite* yaitu *HIGH* atau *LOW* yang sebetulnya adalah nilai integer 1 atau 0. Kalau sudah dibuat program diatas, selanjutnya kita ambil kabel USB yang diikutsertakan pada saat membeli *Arduino*, pasangkan ke komputer dan *board arduino*, dan *upload* programnya. Lampu LED yg ada di *Arduino* board kita akan kelap-kelip. Sekedar informasi, sebuah LED telah disediakan di *board Arduino Uno* dan disambungkan ke pin 13.

Selain blok *setup()* dan *loop()* di atas kita bisa mendefinisikan sendiri blok fungsi sesuai kebutuhan. Kita akan jumpai nanti pada saat pembahasan proyek. (Sumber: Septa Ajjie, 2016)

2.3.2 *Software* ISIS & ARES Proteus 7.0

Proteus adalah sebuah software untuk mendesain PCB yang juga dilengkapi dengan simulasi PSpice pada level skematik sebelum rangkaian skematik di-upgrade ke PCB sehingga sebelum PCBnya di cetak kita akan tahu apakah PCB yang akan kita cetak apakah sudah benar atau tidak. Proteus mampu mengkombinasikan program ISIS untuk membuat skematik desain rangkaian dengan program ARES untuk membuat layout PCB dari skematik yang kita buat. Software Proteus ini bagus digunakan untuk desain rangkaian mikrokontroller.

Gambar 2.11. Tampilan Software ISIS & ARES Proteus

(Sumber https://www.Anakkendali.com,2018)

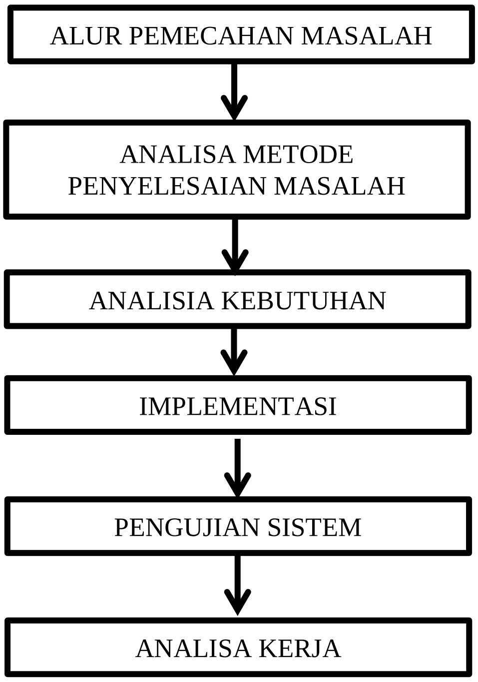
Proteus juga bagus untuk belajar elektronika seperti dasar-dasar elektronika sampai pada aplikasi pada mikrokontroller. Software Proteus ini menyediakan banyak contoh aplikasi desain yang disertakan pada instalasinya. Sehingga memungkinkan bisa belajar dari contoh-contoh yang sudah ada. Fitur- fitur yang terdapat dalam Proteus adalah sebagai berikut :

1. Memiliki kemampuan untuk mensimulasikan hasil rancangan baik digital maupun analog maupun gabungan keduanya.
2. Mendukung simulasi yang menarik dan simulasi secara grafis.
3. Mendukung simulasi berbagai jenis microcontroller seperti PIC 8051 series

4. Memiliki model-model peripheral yang interactive seperti LED, tampilan LCD, RS232, dan berbagai jenis library lainnya.
5. Mendukung instrument-instrument virtual seperti voltmeter, ammeter, oscciloscope, logic analyser, dan lain-lainnya.
6. Memiliki kemampuan menampilkan berbagi jenis analisis secara grafis seperti transient, frekuensi, noise, distorsi, AC dan DC, dan lain-lainnya.
7. Mendukung berbagai jenis komponen-komponen analog.
8. Mendukung open architecture sehingga kita bisa memasukkan program seperti C++
9. untuk keperluan simulasi.
10. Mendukung pembuatan PCB yang di-update secara langsung dari program ISIS ke program pembuat PCB-ARES.

BAB III
METODOLOGI PENELITIAN

Bab ini akan menjelaskan langkah-langkah penelitian yang akan dilakukan dalam "Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya". Alur penelitian yang digunakan seperti pada gambar 3.1.



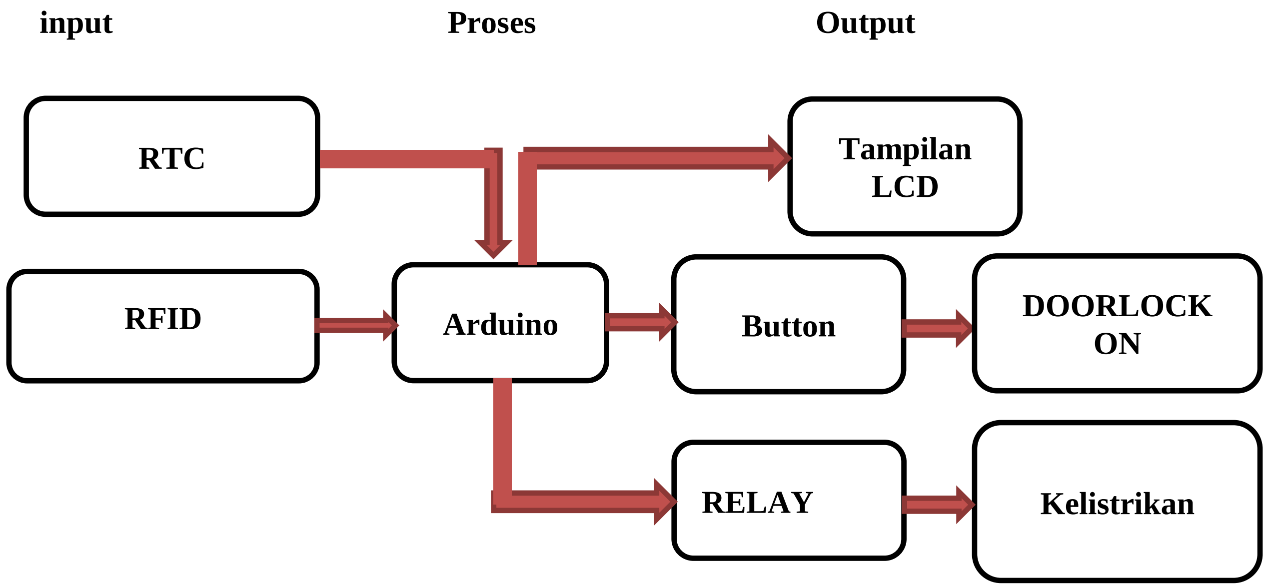
Gambar 3.1. Alur Penelitian

3.1 Alur Pemecahan Masalah

Pada metode ini penulis mencari bahan penulisan skripsi yang diperoleh dari buku, jurnal dan website yang terkait dengan pembuatan "Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya"..

Analisa Metode Penyelesaian Masalah

Perancangan sistem merupakan suatu hal yang dilakukan untuk mempermudah proses pembuatan alat. Konsep “I ... ın Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RI ... ıg Perkuliahan Di IIB Darmajaya”. digambarkan pada diagram blok ... t pada gambar 3.2 Blok diagram menjelaskan gambaran umum mengenai cara kerja dari sistem monitoring kebisingan yang akan dibuat.



Gambar 3.2. Blok Diagram Sistem

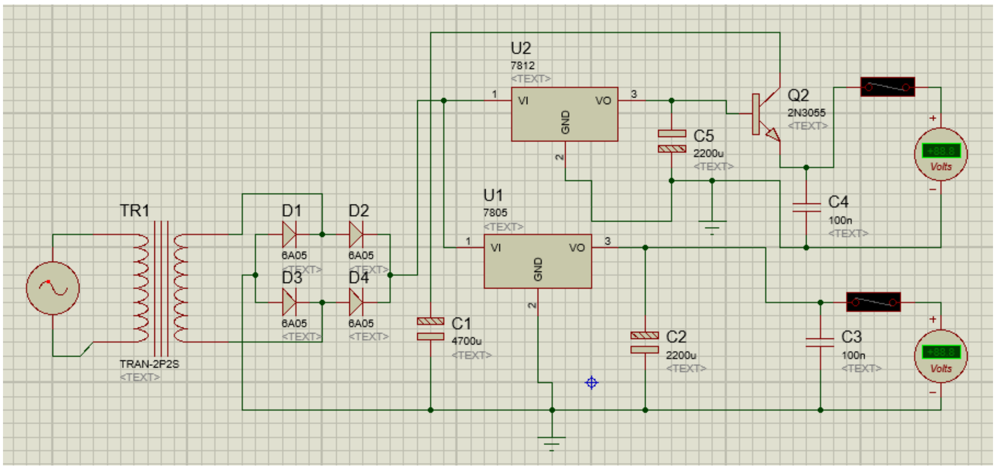
Dari gambar blok diagram sistem dapat diketahui sistem kerja dari alat yaitu jika ID card yang ditempelkan benar push button masuk akan aktif selama 15 menit dan relay akan menyalakan kelistrikan pada ruang perkuliahan. Jika waktu masuk sudah lebih dari 15 menit maka push botton masuk sudah tidak bisa digunakan kembali, sehingga push botton keluar akan aktif selama jam perkuliahan berlangsung sedangkan RTC DS1307 digunakan sebagai penjadwalan jam masuk perkuliahan. Jika jam perkuliahan sudah selesai maka kelistrikan akan otomatis mematikan lampu dan pendingin ruangan. Hasil dari RTC DS130 dan pembacaan RFID akan ditampilkan pada LCD 20x4.

3.1.1 Analisa Sistem Yang Berjalan

Perancangan ini menjadi bagian yang sangat penting dilakukan dalam pembuatan suatu alat karena dengan merancang terlebih dahulu dengan komponen yang tepat akan mengurangi berlebihnya pembelian komponen dan kerja alat sesuai dengan yang diinginkan. Untuk menghindari kerusakan komponen perlu dipahami juga akan karakteristik dari komponen-komponen tersebut.

3.1.1.1 Rangkaian *Power Supply*

Rangakaian power supply digunakan untuk merubah tegangan AC 220V menjadi DC 12V dalam pembuat power suplay 12 volt dan 5 volt peneliti menggunakan IC LM7812 dan LM7805 menyalurkan sumber tegangan ke semua komponen elektronika yang ada pada suatu rangkaian agar rangkaian tersebut dapat bekerja seperti pada gambar 3.3.



Gambar 3.3 Rangkaian *Power Supply*

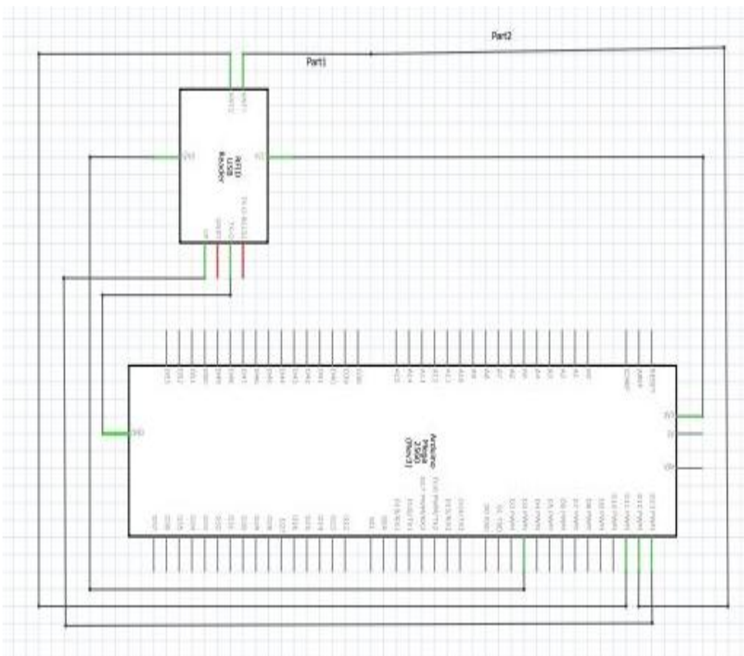
Penjelasan:

- TR1 adalah Transformator Centre Tap dengan 2 kaki input 220V AC dan 2 kaki output 12V
- D1-D4 adalah dioda 6A05 yang dirangkai bridge
- U1 adalah IC Regulator 7805 dengan 1 kaki tegangan masukan, 1 kaki ground, dan 1 kaki tegangan keluaran

- U2 adalah IC Regulator 7812 dengan 1 kaki tegangan masukan, 1 kaki ground, dan 1 kaki tegangan keluaran
- C1 adalah kapasitor (penyaring) dengan besar kapasitansi 4700µF
- C2 dan C5 adalah kapasitor (penyaring) dengan besar kapasitansi 2200µF
- C3 dan C4 adalah kapasitor (penyaring) dengan besar kapasitansi 100nF
- Q2 adalah transistor penguat 2N3055

3.1.1.2 Rangkaian *RFID*

Rangkaian *RFID* digunakan sebagai *inputan* yang akan diproses oleh arduino sehingga akan menghasilkan outputan untuk membuka atau menutup s*elenoid doorlock* yang digunakan sebagai kunci dari pintu dan dapat menyalakan kelistrikan pada ruangan perkuliahan. Gambar rangkaian *RFID* dan tata letak dapat dilihat seperti pada gambar 3.4.



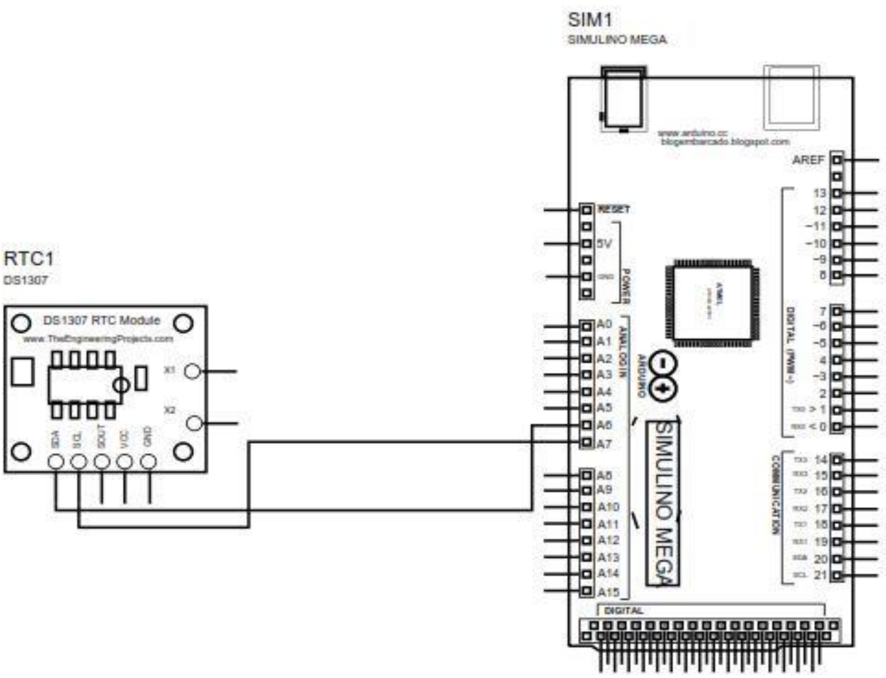
Gambar 3.4 Ragkaian RFID

Pada rangkaian *RFID* hanya beberapa kaki yang dihubungkan ke pin digital arduino At Mega 2560 agar hasil proses pada arduino dapat membuka dan mengunci pintu ruangan menggunakan *solenoid doorlock* serta dapat menghidupkan kelistrikan. Penjelasan penggunaan PIN arduino dan *turbidity* sebagai berikut:

- RFID mendapat tegangan input sebesar +3.3V dari sumber tegangan
- Kaki GND mendapat Ground dari sumber tegangan
- Kaki Data SDA mendapat pin D9 dari mikrokontroler
- Kaki Data SCK mendapat pin D10 dari mikrokontroler
- Kaki Data MOSI mendapat pin D11 dari mikrokontroler
- Kaki Data MISO mendapat pin D12 dari mikrokontroler
- Kaki Data RTS mendapat pin D13 dari mikrokontroler

3.1.1.3 Rangkaian RTC DS1307

Rangkaian *RTC DS1307* digunakan sebagai *inputan* yang akan diproses oleh arduino sehingga akan menghasilkan outputan untuk menutup s*elenoid doorlock* yang digunakan sebagai kunci dari pintu. Gambar rangkaian *RTC 1307* dan tata letak dapat dilihat seperti pada gambar 3.5.



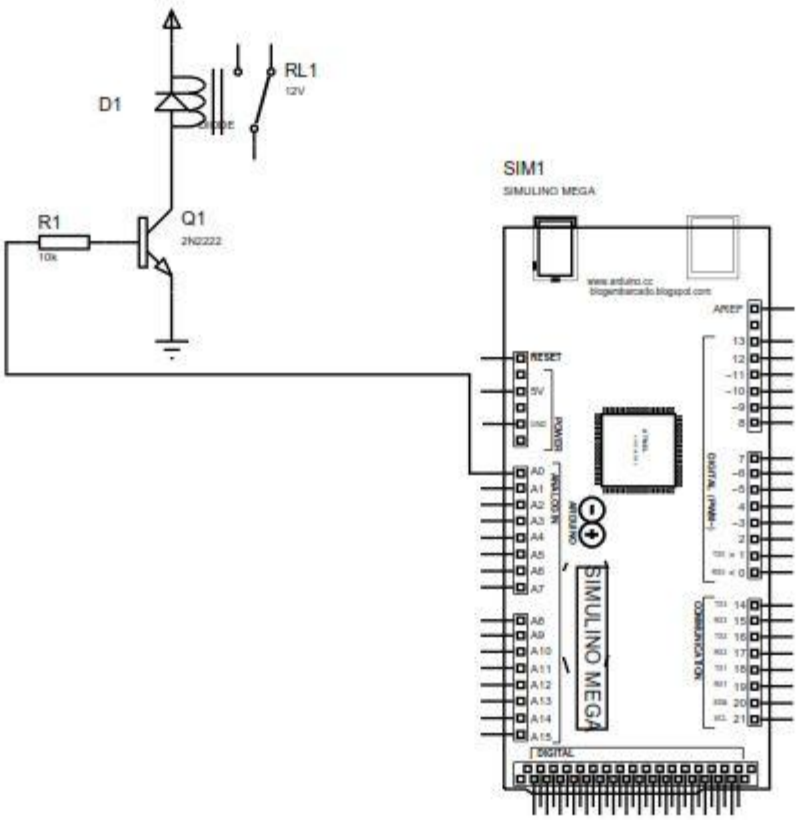
Gambar 3.5 Ragkaian *RTC DS1307*

Pada rangkaian *RTC1307* hanya beberapa kaki yang dihubungkan ke pin analog arduino agar hasil proses pada arduino dapat mengunci pintu ruangan kuliah menggunakan *solenoid doorlock*. Penjelasan penggunaan PIN arduino dan *RTC DS1307* sebagai berikut:

- RTC DS1307 mendapat tegangan input sebesar +5.0V dari sumber tegangan
- Kaki GND RTC DS 1307 mendapat Ground dari sumber tegangan
- Kaki Data SDA mendapat pin A4 dari mikrokontroler
- Kaki Data SCL mendapat pin A5 dari mikrokontroler

3.1.1.4 Rangkaian *Relay*

Rangkaian *relay* digunakan sebagai *outputan* yang akan diproses oleh arduino sehingga akan menghasilkan membuka s*elenoid doorlock* yang digunakan sebagai kunci dari pintu ruangan dari dalam. Gambar rangkaian *relay* dan tata letak dapat dilihat seperti pada gambar 3.6.



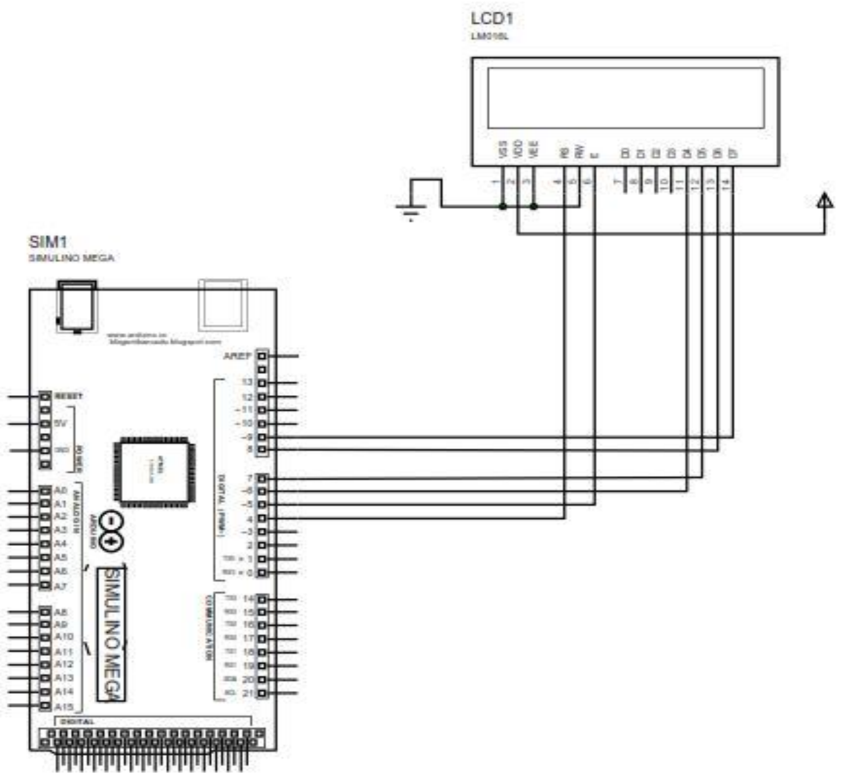
Gambar 3.6 Ragkaian Relay

Pada rangkaian *relay* hanya beberapa kaki yang dihubungkan kepin analog arduino agar hasil proses pada arduino dapat membuka dan mengunci pintu pada ruangan perkuliahan menggunakan *solenoid doorlock*. Penjelasan penggunaan PIN arduino dan *relay* ditampilkan sebagai berikut:

- Pin A0 mikrokontroler mendapat resistor dengan tahanan sebesar 100Ω
- Resistor mendapat kaki basis dari transistor BC547
- Kaki kolektor transistor BC547 terhubung dengan kaki coil relay dan kaki anoda dari dioda 1N4001
- Kaki katoda dari dioda 1N4001 mendapat tegangan masukan sebesar +12V dan kaki coil relay
- Kaki NO Relay terhubung ke NO kontaktor
- Kaki COM Relay terhubung ke coil kontaktor

3.1.1.5 Rangkaian *LCD (Liquid Crystal Display)*

Rangkaian LCD Digunakan sebagai *output* untuk menampilkan informasi berbentuk data yang berasal dari sumber masukan dari *sensor RFID dan keypad* yang telah diolah oleh Arduino. Gambar rangkaian LCD dan tata letak dapat dilihat seperti pada gambar 3.7.



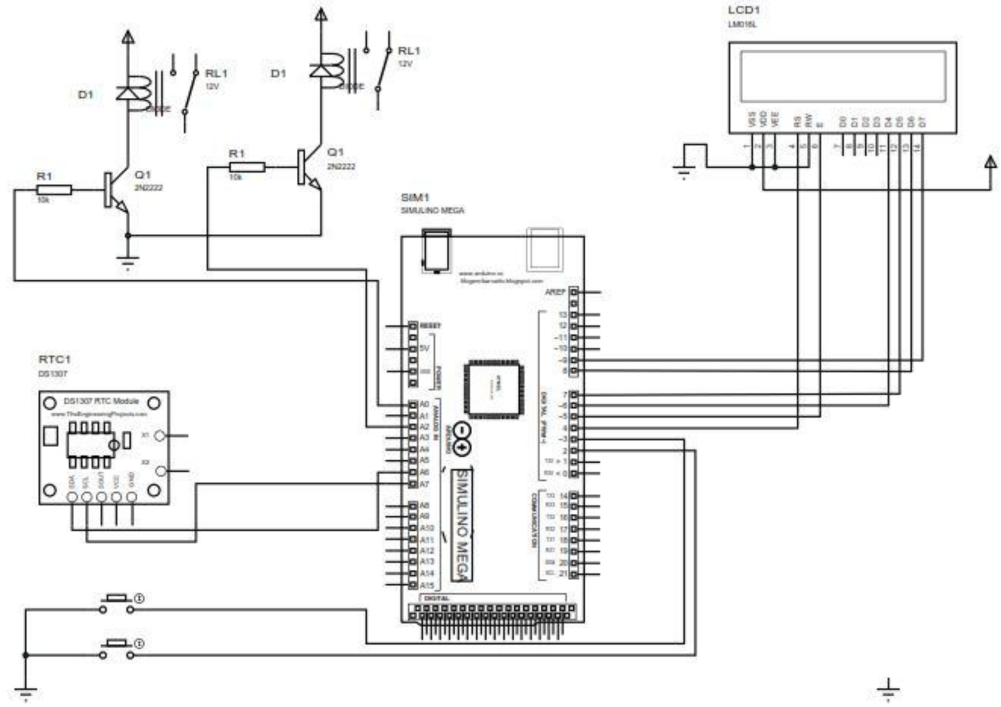
Gambar 3.7. Rangkaian *Liquid Crystal Display* 16 X 2

- Pada rangkaian LCD hanya beberapa kaki yang dihubungkan ke pin digital arduino uno agar hasil proses pada arduino dapat ditampilkan kedalam LCD. Kaki VSS LCD mendapat Ground dari sumber tegangan
- Kaki VCC LCD mendapat tegangan input sebesar +5.0V dari sumber tegangan
- Kaki VEE LCD terhubung dengan Pin Potensio
- Kaki D4 LCD terhubung dengan Pin D4 mikrokontroler
- Kaki D6 LCD terhubung dengan Pin D5 mikrokontroler
- Kaki D11 LCD terhubung dengan Pin D6 mikrokontroler
- Kaki D12 LCD terhubung dengan Pin D7mikrokontroler

- Kaki D13 LCD terhubung dengan Pin D8 mikrokontroler
- Kaki D14 LCD terhubung dengan Pin D9 mikrokontroler
- Kaki A0-A2 mendapat Ground dari sumber tegangan.

3.1.1.6 Rangkaian *Keseluruhan*

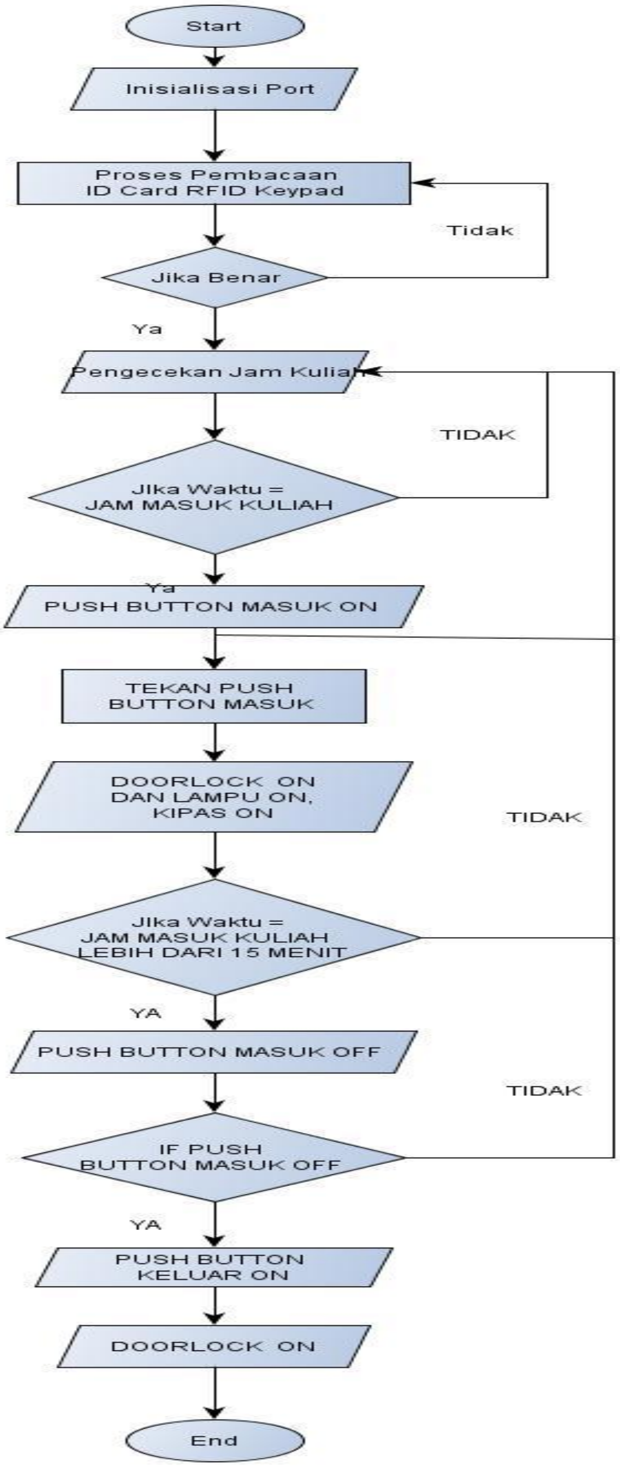
Rangkaian keseluruhan merupakan tahap terakhir dari perancangan yang telah dilakukan. Dalam tahap ini seluruh komponen dipasang sesuai dengan sistem yang telah dibuat, Adapun rangkaian keseluruhan dapat dilihat pada gambar 3.8



Gambar 3.8 Rangkaian Keseluruhan

3.1.2 Perancangan Perangkat Lunak

Perancangan perangkat lunak dibuat dari pembuatan *flowchart* untuk pembuatan pada *hardware*. Pada gambar 3.9. akan ditampilkan *flowchart* dari program yang akan dibuat dalam penelitian ini.



Gambar 3.9 *Flowcart* Prangkat Operasi Sistem

Di bawah ini merupakan penjelasan dari *flowchart* program pada gambar 3.9. :

1. Inisialisasi port adalah proses membaca port pada arduino UNO.
2. Proses pembacaan ID Card pada RFID

3. Ketika Arduino aktif, maka LCD akan menampilkan “Tempelkan Kartu RFID”, ketika kartu RFID ditempelkan dengan ID yang benar dan waktu menunjukkan sesuai waktu masuk ruang kuliah sesuai maka Tombol buka pintu masuk dapat digunakan.
4. Jika waktu masuk ruang kuliah selesai, maka Tombol buka pintu masuk tidak dapat digunakan meskipun ID dari kartu RFID benar.
5. Tombol buka pintu keluar dapat digunakan diluar waktu masuk ruang kuliah.
6. Lampu ruang kuliah aktif jika ID kartu RFID benar dan Tombol pintu masuk ditekan.
7. AC akan aktif dari jam 7 pagi hingga jam 3 sore dari hari senin sampai jumat.
8. End

3.2 Analisa Kebutuhan

Tahapan selanjutnya setelah membuat rancangan perangkat keras dan perangkat lunak yaitu membuat analisa kebutuhan sistem. Analisa kebutuhan sistem dilakukan untuk mengetahui alat dan komponen serta perangkat lunak apa saja yang akan digunakan untuk mengimplementasikan sistem.

3.2.1 Alat

Sebelum membuat “Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya. ada beberapa peralatan yang harus disiapkan. Daftar peralatan yang digunakan dalam penelitian ini akan dituliskan pada Tabel 3.1.

Tabel 3.1 Alat Yang Dibutuhkan

No	Nama Alat	Spesifikasi	Fungsi	Jumlah
1	Komputer/ laptop	Window 7-10 32/64bit	Untuk membuat sebuah aplikasi yang akan di pakai di perangkat keras dan pernangkat lunak	1 unit
2	Multitester	Analog/Digital	digunakan untuk mengukur tegangan (ACV-DCV), dan kuat arus (mA-µA)	1 buah
3	Obeng	Obeng + dan -	Untuk merangkai alat	1 buah

4	Solder	-	Untuk menempelkan timah ke komponen	1 buah
5	Bor pcb	-	Untuk membuat lobang baut atau komponen	1 buah
6	Tang Potong	-	Untuk memotong kabel dan kaki komponen	1 buah
7	Kit Arduino	-	Komponen Komplit arduino UNO	1 buah

3.2.2 Komponen

Sebelum membuat "Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya. ada beberapa peralatan yang harus disiapkan. Daftar komponen yang digunakan dalam penelitian ini akan dituliskan pada Tabel 3.2.

Tabel 3.2 Komponen Yang Dibutuhkan

No	Nama Alat	Sepesifikasi	Fungsi	Jumlah
	Kit Arduino UNO	Atmega328	Sebagai proses printah yang akan di jalankan	1
	RFID	-	Sebagai inputan untuk membaca nomer ID yang akan digunakan sebagai pembuka pintu ruangan.	1
	Push Button	-	Digunakan untuk membuka pintu dapat terkunci	2
	Doorlock		Digunakan sebagai pngunci ruangan	1
	RTC DS1307		Digunakan sebagai pembaca waktu delay dalam mengunci pintu	1
	Relay		Digunakan sebagai on/off *doorlock*	1
	Lcd		Digunakan sebagai tampilan	1
	Jumper		Digunakan sebagai penghubung/menjumper seluruh komponen	30

3.2.3 Software

Sebelum membuat "Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya.ada beberapa peralatan yang harus disiapkan. Daftar Software yang digunakan dalam penelitian ini akan dituliskan pada Tabel 3.3.

Tabel 3.3. Daftar *Software* Yang Digunakan

No	Nama	Spesifikasi	Fungsi
1	IDE Arduino	Arduino 1.6.3	Membuat program yang akan di-download perangkat arduino
2	Proteus	7.1 Profesional	Merancang rangkaian yang akan digunakan untuk membuat alat

3.3 Implementasi

Setelah mengumpulkan alat dan bahan, langkah selanjutnya adalah melakukan implementasi rancangan alat yang telah dibuat. Pada tahap ini hasil rancangan yang telah dibuat akan diimplementasikan untuk menjadi sistem yang sesungguhnya. Implementasi pada penelitian ini dibagi menjadi dua bagian, yaitu: Implementasi perangkat keras dan Implementasi perangkat lunak. Implementasi perangkat keras merupakan tahap terakhir dari perancangan sistem yang dilakukan dalam tahap ini seluruh komponen dipasang sesuai dengan sistem yang telah dibuat.

3.3.1 Implementasi Perangkat Keras

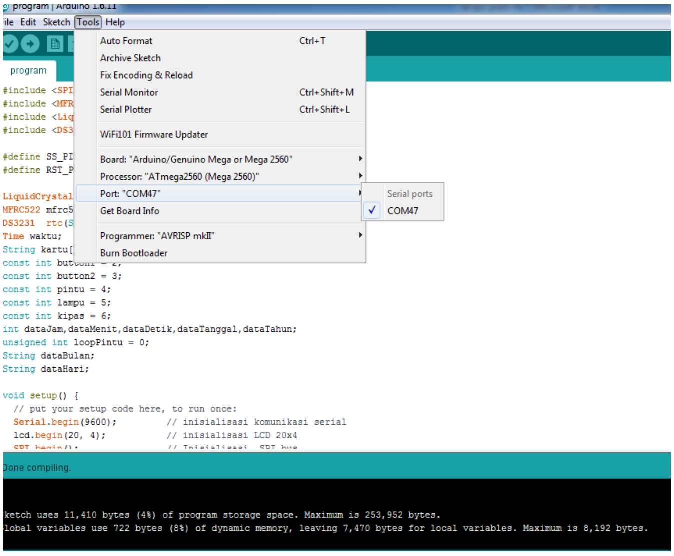
Realisasi perangkat keras merupakan tahap terakhir dari perancangan yang telah dilakukan. Dalam tahap ini seluruh komponen dipasang sesuai dengan sistem yang telah dibuat

3.3.2 Implementasi Perangkat Lunak

Penerapan perangkat lunak merupakan suatu tahap dimana program yang telah dirancang akan disimpan kedalam modul *mikrokontroller* melalui *downloader* dan menggunakan *software* tertentu sesuai dengan bahasa pemograman yang akan digunakan. Disini peneliti menggunakan bahasa C dan menggunakan *software* Arduino. Pada *Software* Arduino program ditulis kemudian di*compile*, tujuanya adalah untuk mengetahui apakah program yang dibuat sudah benar atau belum. Langkah terahir yaitu meng-*upload* program kedalam modul *mikrokontroller*.

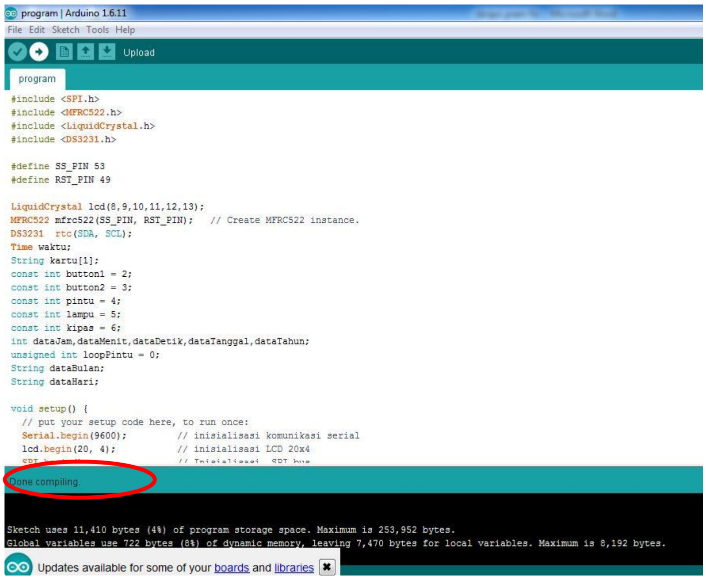
Gambar 3.10 Tampilan *Software* Arduino IDE

Untuk bisa meng-*upload* program ke Arduino Mega yang pertama harus mengatur port yang digunakan oleh Arduino. Pengaturan port Arduino dapat dilihat pada gambar 3.11.



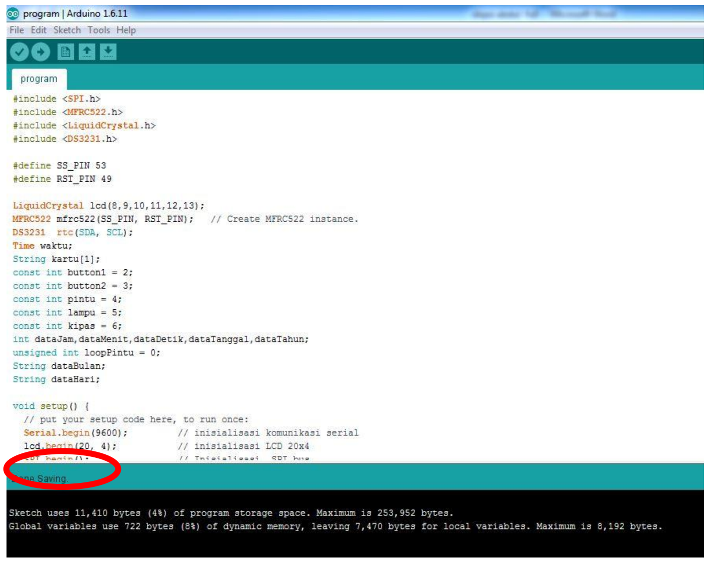
Gambar 3.11 Pengaturan Port Arduino Uno

Pengaturan port Arduino diatas menggunakan port COM47. Setelah pengaturan port langkah selanjutnya yaitu meng-*compile* program. Berikut adalah hasil *compile* program pada gambar 3.12



Gambar 3.12 Hasil Compile Program

Setelah program berhasil di *compile* selanjutnya yaitu meng-*upload* file ke Arduino Mega seperti pada gambar 3.12



Gambar 3.13 Hasil Upload Program

3.4 Pengujian Sistem

Setelah perancangan *hardware* dan *software* selesai, maka yang dilakukan adalah *running* program, pengujian tiap-tiap rangkaian apakah sudah sesuai dengan yang diinginkan atau belum. Pengujian di lakukan pada bagian-bagian seperti pengujian respon, jangkauan sistem, catu daya dan rangkaian keseluruhan pada sistem ini.

3.4.1 Rancangan Pengujian RFID

Pengujian RFID bertujuan untuk mengetahui ketika ID Card yang ditempelkan pada RFID benar apakah arduino dapat dengan baik dalam memproses push button masuk agar aktif yang digunakan sebagai membuka, serta menguji waktu repon yang diperlukan RFID dalam membaca ID card. Dalam pengukuran waktu respon peneliti menggunakan Timer.

3.4.2 Rancangan Pengujian RTC DS1307

Pengujian RTC DS1307 bertujuan untuk mengetahui ketika apakah RTC dapat dengan akurat dalam menyimpan waktu delay sehingga akan digunakan dalm mengunci pintu ruangan perkuliahan.

3.4.3 Rancangan Pengujian Relay

Pengujian relay bertujuan untuk mengetahui ketika relay berstatus high atau low aktip berapa lama respos yang dibutuhkan dalam membuka doorlock yang diguakan sebagai pengunci pintu ruangan perkuliahan, dalam pengujian ini peneliti menggunakan stopwatch untuk mengukur waktu respon.

3.4.4 Rancangan Pengujian Push Button Masuk Dan Keluar

Pengujian push button bertujuan untuk mengetahui ketika ID Card yang ditempelkan pada RFID benar apakah push button masuk agar aktif digunakan sebagai buka pintu selama 15 menit dan jika sudah melebihi 15 menit apakah push button keluar akan berkerja dengan baik.

3.4.5 Perancangan Pengujian Arduino

Pengujian arduino bertujuan untuk dapat mengetahui ketika program yang telah dibuat dapat sukses saat di upload. Agar peneliti dapat mengetahui jika program yang telah dibuat telah benar dan peneliti akan menguji setiap program yang akan digunakan sebagai inputan dan outputan pada alat agar dapat mengetahui jika program yang dibuat telah sesuai dengan yang akan dirancang pada sistem.

3.4.6 Pengujian Sistem Keseluruhan

Pengujian sistem secara keseluruhan bertujuan untuk memastikan semua komponen dapat berjalan dengan sempurna. Mulai dari power supplay RFID, *RTC DS1307, Relay*, push button, blok sistem arduino dan program yang mengatur jalannya sistem keseluruhan.

3.5 Analisis Kerja

Untuk analisa kerja, dilakukan bersama pada saat melakukan uji coba alat yang bertujuan untuk mengetahui kerja alat tersebut. Selain itu yang akan dianalisa adalah jarak, respon dalam untuk inputan pada sistem "Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya". Berdasarkan hasil pengujian sistem yang telah di dapat akan dianalisis untuk memastikan bahwa sistem yang telah dibuat sesuai dengan harapan.

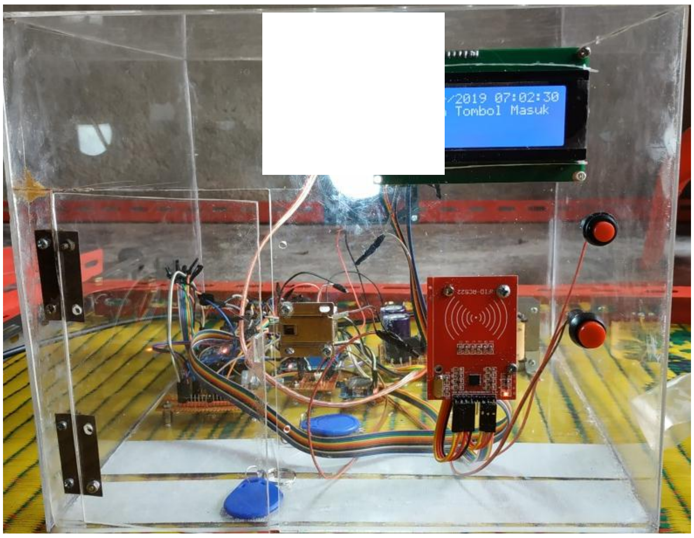
BAB IV
HASIL DAN PEMBAHASAN

Bab ini berisi penjelasan tentang metode dan prosedur pengujian yang dilakukan serta hasil yang diperoleh dari masing-masing blok sistem tersebut. Pengujian dan pembahasan dilakukan untuk mengetahui kesesuaian antara perancangan awal sistem terhadap alat yang akan dihasilkan, apakah sistem dapat bekerja dengan baik atau tidak. Pengujian yang dilakukan secara bertahap per blok-blok sistem dan pengujiannya secara keseluruhannya.

Pengujian dimulai dengan memastikan setiap komponen yang digunakan dalam kondisi bagus (dapat bekerja dengan baik), kemudian mengecek setiap jalur yang terhubung dengan komponen yang digunakan telah terkoneksi, dimana rangkaiannya disesuaikan dengan gambar skematiknya. Pengujian yang dilakukan meliputi pengujian RFID, Push button, output power supply, pengujian relay dan pengujian sistem keseluruhan

4.1 Hasil Prakitan

Uji coba dilakukan untuk memastikan rangkaian yang dihasilkan mampu bekerja sesuai dengan yang diharapkan. maka terlebih dahulu dilakukan langkah pengujian dan mengamati langsung rangkaian serta komponen. Hasil pengukuran ini dapat diketahui rangkaian telah bekerja dengan baik atau tidak, sehingga apabila terdapat kesalahan dan kekurangan akan terdeteksi. Gambar 4.1 berikut ini merupakan gambar dari bentuk fisik alat yang telah dibuat.



Gambar. 4.1. Bentuk Fisik Alat

4.1.1 Hasil Pengujian dan Pembahasan

Pada pengujian ini meliputi pungujian *RFID*, push button masuk, push button keluar dan rangkaian keseluruhan. Pengujian ini dilakukan agar peneliti dapat mengetahuin kelebihan dan kekurangan sistem yang telah dibuat hasil pengujian sebagai berikut:

4.1.2 Hasil Pengujian Catu Daya

Tujuan dilakukannya pengujian catu daya ini adalah untuk memastikan tegangan pada catu daya apakah stabil sesuai dengan kebutuhan dari alat yang dibuat atau dirancang dimana kebutuhan dari alat yang dibuat sebesar 12volt. Maka perlu diadakannya uji coba catu daya sehingga dapat mengetahui apakah hasil rangkaian catu daya sudah sesuai dengan kebutuhan dalam "Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya" yaitu 12 volt.

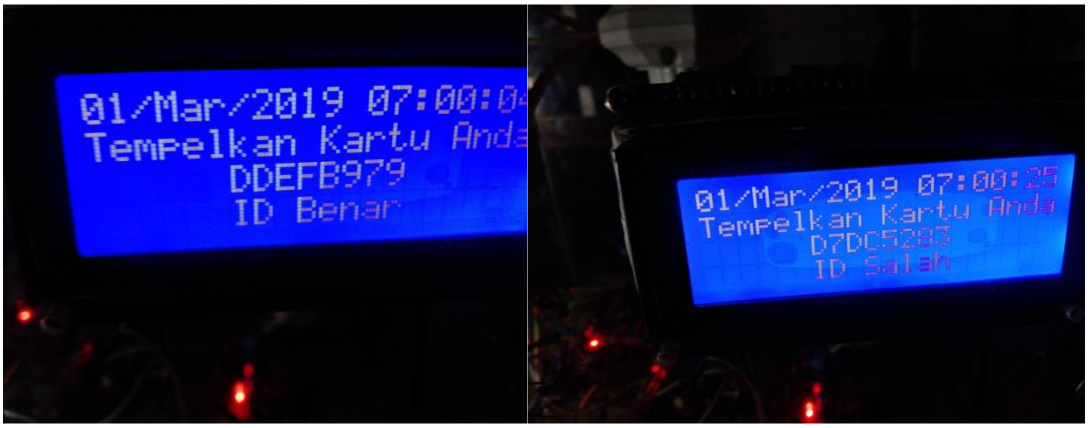
Tabel 4.1. Pengujian Catu Daya

Tahap pengujian	Inputan	Regulator yang digunakan	Output hasil pengukuran (volt)	
			Tanpa beban	Dengan beban
1	220 V	LM 7812	11,864 V DC	9,48V DC

Dari hasil tabel 4.1. Pengujian Catu Daya dapat memberikan keluaran sesuai dengan rancangan dan kebutuhan sebesar 12 volt. Dalam uji coba power supplay peneliti menggunakan *inputan* sebesar 220v dengan regulator LM 7812 sehingga menghasilkan outputan tanpa beban sebesar 11,84 V DC serta apabila dengan ada tambahan beban maka menghasilkan ouputan sebesar 9,48 V DC.

4.1.3 Pengujian RFID

Pada pengujian ini dibutuhkan *RFID* yang akan digunakan sebagai pengganti kunci ruangan perkuliahan yang akan mengaktifkan push button masuk dan doorlock. Dalam melakukan uji coba RFID peneleti hanya melakukan ujicoba saat jam masuk kuliah pada jam 7.00 – 7.15. Apakah printah yang diberikan pada *RFID* ini dapat berfungsi dengan baik dalam membuka pintu rumah disajikan pada table 4.2.



Gambar 4.2 ID BENAR Dan SALAH

Gambar 4.3 Tekan Tombol Masuk

Tabel 4.2. Hasil Pengujian RFID

Uji Coba Ke-	No Card RFID	Waktu masuk	Statu Push Botton Masuk	Status push button Keluar	Tampilan Lcd
1	D7DC5283	7.00 WIB	LOW	LOW	SALAH
2	DDEFB979	7.00 WIB	HIGH	LOW	BENAR
3	DDEFB979	7.15 WIB	LOW	HIGH	BENAR

Dari hasil ujicoba *RFID* dapat diketahui jika kartu RFID ditempelkan dengan ID yang benar dan waktu menunjukkan sesuai waktu masuk ruang kuliah sesuai maka Tombol buka pintu masuk dapat digunakan. Jika waktu masuk ruang kuliah selesai, maka Tombol buka pintu masuk tidak dapat digunakan meskipun ID dari kartu RFID benar. Tombol buka pintu keluar dapat digunakan diluar waktu masuk ruang kuliah.

4.2 Hasil Pengujian Push Button

Uji coba push button dilakukan dengan waktu jam 7.00 dan jam 9.30. dengan ID card RFID benar apakah push button masuk dapat dengan baik dalam membuka pintu dan menyalakan keliistrikan. Serta apakah push button keluar juga telah sesuai dengan perintah dalam program yaitu hanya dapat digunakan jika jam masuk sudah lebih dari 15 menit serta mengtahui jika jam kliah sudah selesai apakah push button keluar dapat dengan baik dalam membuka pintu dan mematikan lampu pada ruangan perkuliahan.

Tabel 4.3. Hasil Pegujian Push Button

No Card RFID	Waktu masuk	Statu Push Botton Masuk	Status push button Keluar	Status relay		
				1	2	3
DDEFB979	7.00 WIB	Tekan Push button	-	High (kipas)	High (lampu)	High (doorlock)
	7.14 WIB	-	Tekan push button	High (kipas)	High (lampu)	Low (doorlock)
	7.15 WIB	-	Tekan push button	High (kipas)	High (lampu)	High (doorlock)
	9.30	-	Tekan push button	High (kipas)	Low (lampu)	High (doorlock)

Tabel 4.3 Dari hasil ujicoba push button dapat diketahui jika kartu RFID ditempelkan dengan ID yang benar dan waktu menunjukkan sesuai waktu masuk ruang kuliah yaitu jam 7-15 sampai jam 7.14 maka Tombol buka pintu masuk ditekan, maka status relay kipas, lampu dan doorlock akan aktif. Sedangkan tombol masuk hanya dapat digunakan selama 14 menit dari jam pertama masuk dan Jika waktu masuk ruang kuliah sudah mencapai 7.15, maka Tombol buka pintu masuk tidak dapat digunakan meskipun ID dari kartu RFID benar. Serta Tombol buka pintu keluar dapat digunakan diluar waktu masuk ruang kuliah jika ada mahasiswa ingin keluar kelas selama jam perkuliahan berlangsung. Jika jam perkuliahan menunjukan jam 9.30 dan push button keluar ditekan maka relay lampu akan low artinya lampu akan mati.

4.2.1 Hasil Pengujian Relay

Uji coba relay dilakukan agar peneliti dapat mengetahui jika relay sudah bekerja dengan baik dalam membuka, menutup dan menyalakan kelistrikan. Hasil pengujian dapat dilihat pada tabel 4.4.

Tabel 4.4. Hasil Pengujian Relay

Uji Coba Ke	Status Button		Status Relay			Keterangan
	Masuk	Keluar	1 Doorlock	2 lampu	3 kipas	
1	High	Low	High	High	High	Pintu terbuka, lampu dan kipas ON
2	Low	Low	Low	High	High	Lampu, kipas ON dan pintu terkunci
3	Low	High	High	High	High	Pintu terbuka, lampu dan kipas ON
4	Low	Low	Low	Low	Low	Lampu, kipas OFF dan pintu terkunci

Tabel 4.4 Dari hasil ujicoba relay dapat diketahui jika push button ditekan (high) maka relay 1,2 dan 3 akan high yang artinya pintu terbuka, lampu dan kipas akan ON. Sedangkan jika push button tidak ditekan maka relay 1 dan 2 yang akan aktif yang artinya hanya konndisi lampu dan kipas saja yang ON. Jika push button kleuar yang ditekan maka pintu akan kembali terbuka dan lampu, kipas akan tetap ON. Kemudian jika push button masuk dan keluar low serta jam perkuliahan selesai maka relay 1,2,3 akan low yang artinya seluruh kelistrikan akan OFF dan Pintu akan terkunci.

4.2.2 Hasil Pengujian LCD 20x4

Uji coba LCD 20x4 dilakukan agar peneliti dapat mengetahui apakah LCD 20x 4 telah dapat menampilkan karakter tulisan yang akan digunakan sebagai hasil pembacaan dari sistem keseluruhan. Hasil pengujian dapat dilihat gambar 4.4.

Gambar 4.4 gambar pengujian LCD 20x4

4.3 Pengujian Sistem Secara Keseluruhan

Pengujian sistem secara keseluruhan dilakukan untuk menguji kinerja sistem, Rancang Bangun Kunci Pintu Dan Pengoperasian Peralatan Litrik Menggunakan RFID Pada Ruang Perkuliahan Di IIB Darmajaya. Peneliti akan menguji coba sistem mulai dari *RFID*, push button masuk, push button keluar, relay, *DoorLock* dan tampilan display lcd 20x4. dilakukan ujicoba sistem agar peneliti dapat mengetahui apakah sistem yang telah dibuat dapat berkerja dengan baik. Dari hasil ujicoba sistem dapat diketahuui bahwa sistem dapat berkerja dengan baik sesuai perintah pada program yang telah dibuat dapat dilihat seperti pada tabel 4.4. berikut hasil pengujian sistem keseluruhan.

Tabel 4.4. Hasil Pengujian Sistem Keseluruhan

No Card RFID	Waktu masuk	Statu Push Botton Masuk	Status push button Keluar	Status relay			Tampilan LCD
				1	2	3	
D7DC5283	7.00 WIB	Ditekan	Ditekan	High (kipas)	Low (lampu)	High (doorlock)	SALAH
DDEFB979	7.00 WIB	Tekan Push button	-	High (kipas)	High (lampu)	High (doorlock)	BENAR
	7.14 WIB	-	Tekan push button	High (kipas)	High (lampu)	Low (doorlock)	BENAR
	7.15 WIB	-	Tekan push button	High (kipas)	High (lampu)	High (doorlock)	BENAR
	9.30	-	Tekan push button	High (kipas)	Low (lampu)	High (doorlock)	BENAR
-	15.00 WIB	-	-	low (kipas)	Low (lampu)	High (doorlock)	JAM PULANG

4.4 Hasil Analisa Kerja Sistem

Dari hasil ujicoba Sistem Keseluruhan dapat diketahui jika kartu RFID ditempelkan dengan ID yang benar dan waktu menunjukkan sesuai waktu masuk ruang kuliah yaitu jam 7-15 sampai jam 7.14 maka Tombol buka pintu masuk ditekan, maka status relay kipas, lampu dan doorlock akan aktif. Sedangkan tombol masuk hanya dapat digunakan selama 14 menit dari jam pertama masuk dan Jika waktu masuk ruang kuliah sudah mencapai 7.15, maka Tombol buka pintu masuk tidak dapat digunakan meskipun ID dari kartu RFID benar. Serta Tombol buka pintu keluar dapat digunakan diluar waktu masuk ruang kuliah jika ada mahasiswa ingin keluar kelas selama jam perkuliahan berlangsung. Relay kipas akan aktif dari jam 7.00 pagi hingga jam 3.00 sore dari hari senin sampai jumat. Sedangkan relay lampu akan aktif selama jam perkuliahan berlangsung. Dari hasil analisa kerja sistem dapat diketahui bahwa sistem telah berkerja dengan baik sesuai dengan program yang telah dibuat serta telah sesuai dengan peneliti inginkan.

BAB V
KESIMPULAN DAN SARAN

5.1 Kesimpulan

Berdasarkan pengujian dan analisa sistem yang telah dilakukan, dapat disimpulkan sebagai berikut:

Dari hasil ujicoba sistem dapat diketahui jika kartu RFID ditempelkan dengan ID yang benar dan waktu menunjukkan sesuai waktu masuk ruang kuliah yaitu jam 7-10 sampai jam 7.15 maka Tombol buka pintu masuk ditekan, maka status relay kipas, lampu dan doorlock akan aktif. Sedangkan tombol masuk hanya dapat digunakan selama 14 menit dari jam pertama masuk dan jika waktu masuk ruang kuliah sudah mencapai 7.15, maka Tombol buka pintu masuk tidak dapat digunakan meskipun ID dari kartu RFID benar. Serta Tombol buka pintu keluar dapat digunakan diluar waktu masuk ruang kuliah jika ada mahasiswa ingin keluar kelas selama jam perkuliahan berlangsung. Relay kipas akan aktif dari jam 7 pagi hingga jam 21.00 malam dari hari senin sampai jumat. Sedangkan relay lampu akan aktif selama jam perkuliahan berlangsung

5.2 Saran

Alat ini masih terdapat kekurangan sehingga perlu diadakanya pengembangan. Berikut saran untuk pengembangan penelitian :

1. Akan lebih baik jika peneliti selanjutnya menambahkan batrai agar jika mati listrik sistem masih dapat digunakan
2. Perlu dilakukan penambahan pemutus sinyal HP didalam ruangan.

Peneliti selanjutnya disarankan, agar peneliti dapat Mengimplementasikan alat Rancang Bangun Sistem Keamanan Kunci Pintu Menggunakan RFID dan Sms Berbasis Arduino Uno ini secara langsung.

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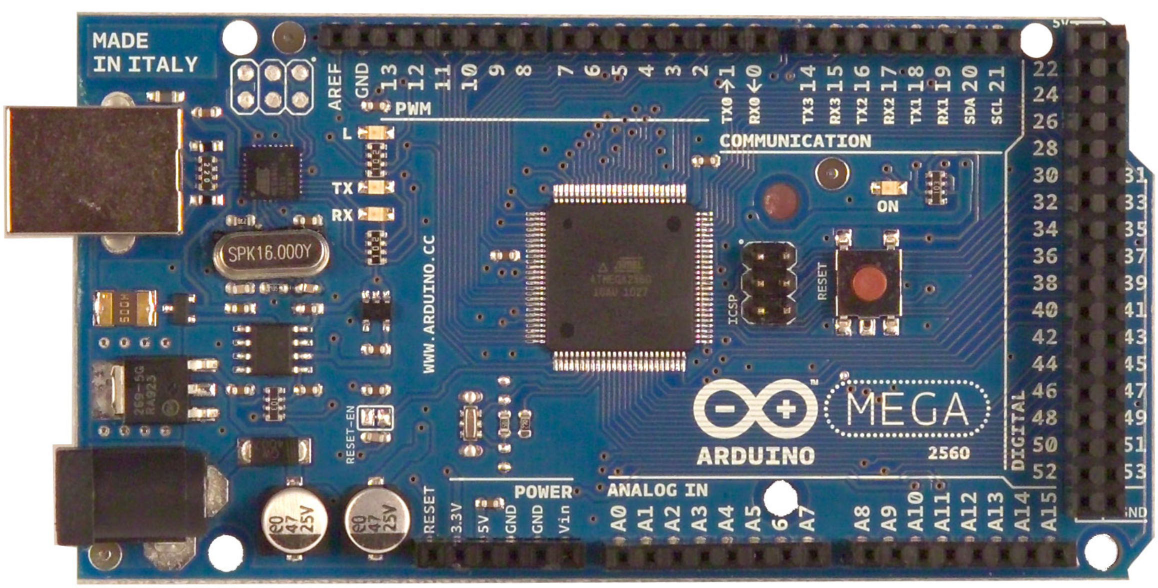
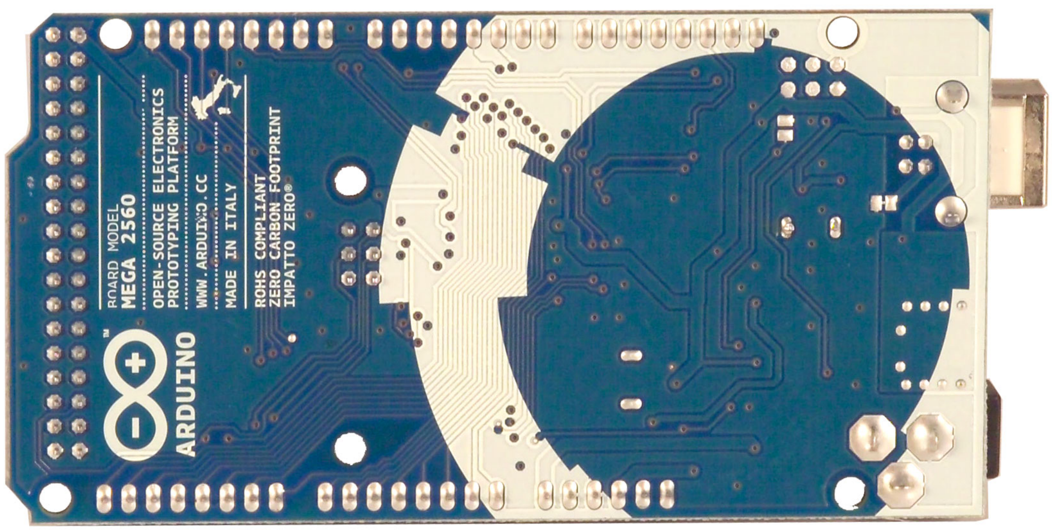
ARDUINO

Arduino Mega 2560 Datasheet





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.

Schematic & Reference Design

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

Power

The Arduino Mega 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 using the SPI library. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Uno, 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 or Diecimila.

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 Mega2560'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. For SPI communication, use the SPI library.

Programming

The Arduino Mega 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.

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 Mega2560 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 Mega2560 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 Mega2560 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 Mega2560 is designed to be compatible with most shields designed for the Uno, 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 Mega2560 and Duemilanove / Diecimila. *Please note that I2C is not located on the same pins on the Mega (20 and 21) as the Duemilanove / Diecimila (analog inputs 4 and 5).*

FAIRCHILD
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Revised October 2005

LM7805 • LM7806 • LM7808 • LM7809 • LM7810 • LM7812 • LM7815 • LM7818 • LM7824 • LM7805A • LM7806A • LM7808A •LM7809A • LM7810A • LM7812A • LM7815A • LM7818A • LM7824A

3-Terminal 1A Positive Voltage Regulator (Preliminary)

General Description

The LM78XX series of three terminal positive regulators are available in the TO-220 package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

Features

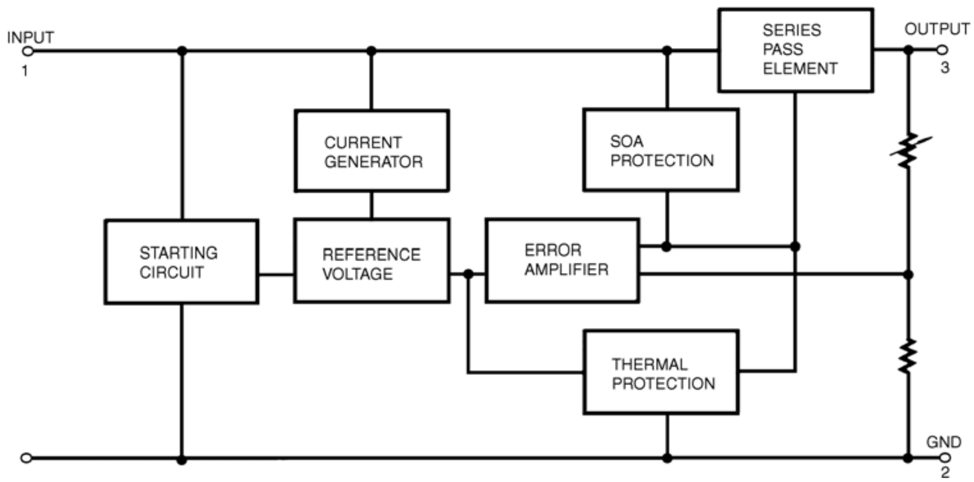
- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 12, 15, 18, 24
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

Ordering Code:

Product Number	Output Voltage Tolerance	Package	Operating Temperature
LM7805CT	±4%	TO-220	–40°C - +125°C
LM7806CT			
LM7808CT			
LM7809CT			
LM7810CT			
LM7812CT			
LM7815CT			
LM7818CT			
LM7824CT			
LM7805ACT	±2%		0°C - +125°C
LM7806ACT			
LM7808ACT			
LM7809ACT			
LM7810ACT			
LM7812ACT			
LM7815ACT			
LM7818ACT			
LM7824ACT			

TO-220

Internal Block Diagram



Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V)	V_I	35	V
(for V_O = 24V)	V_I	40	V
Thermal Resistance Junction-Cases (TO-220)	$R_{\theta JC}$	5	°C/W
Thermal Resistance Junction-Air (TO-220)	$R_{\theta JA}$	65	°C/W
Operating Temperature Range	T_{OPR}	0 ~ +125	°C
LM78xx		–40 ~ +125	°C
LM78xxA		0 ~ +125	°C
Storage Temperature Range	T_{STG}	–65 ~ +150	°C

Note 1: Absolute maximum ratings are those values beyond which damage to the device may occur. The datasheet specifications should be met, without exception, to ensure that the system design is reliable over its power supply, temperature, and output/input loading variables. Fairchild does not recommend operation outside datasheet specifications.

Electrical Characteristics (LM7805)

(Refer to the test circuits. $-40°C < T_J < 125°C$, I_O = 500mA, V_I = 10V, C_I = 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		4.8	5.0	5.2	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 7V to 20V		4.75	5.0	5.25	
Line Regulation	Regline	T_J = +25°C	V_O = 7V to 25V	–	4.0	100	mV
(Note 2)			V_I = 8V to 12V	–	1.6	50.0	
Load Regulation	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	9.0	100	mV
			I_O = 250mA to 750mA	–	4.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	0.03	0.5	mA
		V_I = 7V to 25V		–	0.3	1.3	
Output Voltage Drift (Note 3)	$\Delta V_O/\Delta T$	I_O = 5mA		–	-0.8	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	42.0	–	μV/V_O
Ripple Rejection (Note 3)	RR	f = 120Hz, V_O = 8V to 18V		62.0	73.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 3)	rO	f = 1KHz		–	15.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	230	–	mA
Peak Current (Note 3)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 2: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 3: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7806)

(Refer to the test circuits. $-40°C < T_J < 125°C$, I_O = 500mA, V_I = 11V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		5.75	6.0	6.25	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 8.0V to 21V		5.7	6.0	6.3	
Line Regulation	Regline	T_J = +25°C	V_I = 8V to 25V	–	5.0	120	mV
(Note 4)			V_I = 9V to 13V	–	1.5	60.0	
Load Regulation	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	9.0	120	mV
(Note 4)			I_O = 250mA to 750mA	–	3.0	60.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 8V to 25V		–	–	1.3	
Output Voltage Drift (Note 5)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−0.8	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	45.0	–	μV/V_O
Ripple Rejection (Note 5)	RR	f = 120Hz, V_O = 8V to 18V		62.0	73.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 5)	rO	f = 1KHz		–	19.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 5)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 4: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 5: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7808)

(Refer to the test circuits. $-40°C < T_J < 125°C$, I_O = 500mA, V_I = 14V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		7.7	8.0	8.3	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 10.5V to 23V		7.6	8.0	8.4	
Line Regulation	Regline	T_J = +25°C	V_I = 10.5V to 25V	–	5.0	160	mV
(Note 6)			V_I = 11.5V to 17V	–	2.0	80.0	
Load Regulation	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	10.0	160	mV
(Note 6)			I_O = 250mA to 750mA	–	5.0	80.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	0.05	0.5	mA
		V_I = 10.5V to 25V		–	0.5	1.0	
Output Voltage Drift (Note 7)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−0.8	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	52.0	–	μV/V_O
Ripple Rejection (Note 7)	RR	f = 120Hz, V_O = 11.5V to 21.5V		56.0	73.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 7)	rO	f = 1KHz		–	17.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	230	–	mA
Peak Current (Note 7)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 6: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 7: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7809)

(Refer to the test circuits. $-40°C < T_J < 125°C$, I_O = 500mA, V_I = 15V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		8.65	9.0	9.35	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 11.5V to 24V		8.6	9.0	9.4	
Line Regulation	Regline	T_J = +25°C	V_I = 11.5V to 25V	–	6.0	180	mV
(Note 8)			V_I = 12V to 17V	–	2.0	90.0	
Load Regulation	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	12.0	180	mV
(Note 8)			I_O = 250mA to 750mA	–	4.0	90.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 11.5V to 26V		–	–	1.3	
Output Voltage Drift (Note 9)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	58.0	–	µV/V_O
Ripple Rejection (Note 9)	RR	f = 120Hz, V_O = 13V to 23V		56.0	71.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 9)	rO	f = 1KHz		–	17.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 9)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 8: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 9: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7810)

(Refer to the test circuits. $-40°C < T_J < 125°C$, I_O = 500mA, V_I = 16V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		9.6	10.0	10.4	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 12.5V to 25V		9.5	10.0	10.5	
Line Regulation	Regline	T_J = +25°C	V_I = 12.5V to 25V	–	10.0	200	mV
(Note 10)			V_I = 13V to 25V	–	3.0	100	
Load Regulation	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	12.0	200	mV
(Note 10)			I_O = 250mA to 750mA	–	4.0	400	
Quiescent Current	I_Q	T_J = +25°C		–	5.1	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12.5V to 29V		–	–	1.0	
Output Voltage Drift (Note 11)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	58.0	–	µV/V_O
Ripple Rejection (Note 11)	RR	f = 120Hz, V_O = 13V to 23V		56.0	71.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 11)	rO	f = 1KHz		–	17.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 11)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 10: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 11: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7812)

(Refer to the test circuits. −40°C < T_J < 125°C, I_O = 500mA, V_I = 19V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		11.5	12.0	12.5	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 14.5V to 27V		11.4	12.0	12.6	
Line Regulation (Note 12)	Regline	T_J = +25°C	V_I = 14.5V to 30V	–	10.0	240	mV
			V_I = 16V to 22V	–	3.0	120	
Load Regulation (Note 12)	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	11.0	240	mV
			I_O = 250mA to 750mA	–	5.0	120	
Quiescent Current	I_Q	T_J = +25°C		–	5.1	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	0.1	0.5	mA
		V_I = 14.5V to 30V		–	0.5	1.0	
Output Voltage Drift (Note 13)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	76.0	–	µV/V_O
Ripple Rejection (Note 13)	RR	f = 120Hz, V_I = 15V to 25V		55.0	71.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 13)	rO	f = 1KHz		–	18.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	230	–	mA
Peak Current (Note 13)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 12: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 13: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7815)

(Refer to the test circuits. −40°C < T_J < 125°C, I_O = 500mA, V_I = 23V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		14.4	15.0	15.6	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 17.5V to 30V		14.25	15.0	15.75	
Line Regulation (Note 14)	Regline	T_J = +25°C	V_I = 17.5V to 30V	–	11.0	300	mV
			V_I = 20V to 26V	–	3.0	150	
Load Regulation (Note 14)	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	12.0	300	mV
			I_O = 250mA to 750mA	–	4.0	150	
Quiescent Current	I_Q	T_J = +25°C		–	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 17.5V to 30V		–	–	1.0	
Output Voltage Drift (Note 15)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	90.0	–	µV/V_O
Ripple Rejection (Note 15)	RR	f = 120Hz, V_I = 18.5V to 28.5V		54.0	70.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 15)	rO	f = 1KHz		–	19.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 15)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 14: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 15: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7818)

(Refer to the test circuits. $-40°C < T_J < 125°C$, I_O = 500mA, V_I = 27V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		17.3	18.0	18.7	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 21V to 33V		17.1	18.0	18.9	
Line Regulation (Note 12)	Regline	T_J = +25°C	V_I = 21V to 33V	–	15.0	360	mV
			V_I = 24V to 30V	–	5.0	180	
Load Regulation (Note 12)	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	15.0	360	mV
			I_O = 250mA to 750mA	–	5.0	180	
Quiescent Current	I_Q	T_J = +25°C		–	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 21V to 33V		–	–	1.0	
Output Voltage Drift (Note 17)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	110	–	μV/V_O
Ripple Rejection (Note 17)	RR	f = 120Hz, V_I = 22V to 32V		53.0	69.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 17)	rO	f = 1KHz		–	22.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 17)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 16: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 17: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7824)

(Refer to the test circuits. $-40°C < T_J < 125°C$, I_O = 500mA, V_I = 33V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		23.0	24.0	25.0	V
		5mA ≤ I_O ≤ 1A, P_O ≤ 15W, V_I = 27V to 38V		22.8	24.0	25.25	
Line Regulation (Note 18)	Regline	T_J = +25°C	V_I = 27V to 38V	–	17.0	480	mV
			V_I = 30V to 36V	–	6.0	240	
Load Regulation (Note 18)	Regload	T_J = +25°C	I_O = 5mA to 1.5mA	–	15.0	480	mV
			I_O = 250mA to 750mA	–	5.0	240	
Quiescent Current	I_Q	T_J = +25°C		–	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	0.1	0.5	mA
		V_I = 27V to 38V		–	0.5	1.0	
Output Voltage Drift (Note 19)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.5	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	60.0	–	μV/V_O
Ripple Rejection (Note 19)	RR	f = 120Hz, V_I = 28V to 38V		50.0	67.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 19)	rO	f = 1KHz		–	28.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	230	–	mA
Peak Current (Note 19)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 18: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 19: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7805A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 10V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		4.9	5.0	5.1	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 7.5V to 20V		4.8	5.0'	5.2	
Line Regulation (Note 20)	Regline	V_I = 7.5V to 25V, I_O = 500mA		–	5.0	50.0	mV
		V_I = 8V to 12V		–	3.0	50.0	
		T_J = +25°C	V_I = 7.3V to 20V	–	5.0	50.0	
			V_I = 8V to 12V	–	1.5	25.0	
Load Regulation (Note 20)	Regload	T_J = +25°C, I_O = 5mA to 1.5mA		–	9.0	100	mV
		I_O = 5mA to 1mA		–	9.0	100	
		I_O = 250mA to 750mA		–	4.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.0	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 8V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 7.5V to 20V, T_J = +25°C		–	–	0.8	
Output Voltage Drift (Note 21)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−0.8	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	10.0	–	µV/V_O
Ripple Rejection (Note 21)	RR	f = 120Hz, I_O = 500mA, V_I = 8V to 18V		–	68.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 21)	rO	f = 1KHz		–	17.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 21)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 20: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 21: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7806A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 11V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C		5.58	6.0	6.12	V
		I_O = 5mA to 1A, $P_O \leq$ 15W, V_I = 8.6V to 21V		5.76	6.0	6.24	
Line Regulation (Note 22)	Regline	V_I = 8.6V to 25V, I_O = 500mA		–	5.0	60.0	mV
		V_I = 9V to 13V		–	3.0	60.0	
		T_J = +25°C	V_I = 8.3V to 21V	–	5.0	60.0	
			V_I = 9V to 13V	–	1.5	30.0	
Load Regulation (Note 22)	Regload	T_J = +25°C, I_O = 5mA to 1.5mA		–	9.0	100	mV
		I_O = 5mA to 1mA		–	4.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	4.3	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 19V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 8.5V to 21V, T_J = +25°C		–	–	0.8	
Output Voltage Drift (Note 23)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−0.8	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	10.0	–	µV/V_O
Ripple Rejection (Note 23)	RR	f = 120Hz, I_O = 500mA, V_I = 9V to 19V		–	65.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 23)	rO	f = 1KHz		–	17.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 23)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 22: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 23: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7808A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 14V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage	V_O	T_J = +25°C	7.84	8.0	8.16	V
		I_O = 5mA to 1A, $P_O \le$ 15W, V_I = 10.6V to 23V	7.7	8.0	8.3	
Line Regulation (Note 24)	Regline	V_I = 10.6V to 25V, I_O = 500mA	–	6.0	80.0	mV
		V_I = 11V to 17V	–	3.0	80.0	
		T_J = +25°C, V_I = 10.4V to 23V	–	6.0	80.0	
		T_J = +25°C, V_I = 11V to 17V	–	2.0	40.0	
Load Regulation (Note 24)	Regload	T_J = +25°C, I_O = 5mA to 1.5mA	–	12.0	100	mV
		I_O = 5mA to 1mA	–	12.0	100	
		I_O = 250mA to 750mA	–	5.0	50.0	
Quiescent Current	I_Q	T_J = +25°C	–	5.0	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A	–	–	0.5	mA
		V_I = 11V to 25V, I_O = 500mA	–	–	0.8	
		V_I = 10.6V to 23V, T_J = +25°C	–	–	0.8	
Output Voltage Drift (Note 25)	$\Delta V_O/\Delta T$	I_O = 5mA	–	−0.8	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C	–	10.0	–	µV/V_O
Ripple Rejection (Note 25)	RR	f = 120Hz, I_O = 500mA, V_I = 11.5V to 21.5V	–	62.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C	–	2.0	–	V
Output Resistance (Note 25)	rO	f = 1KHz	–	18.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C	–	250	–	mA
Peak Current (Note 25)	I_{PK}	T_J =+25°C	–	2.2	–	A

Note 24: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 25: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7809A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 15V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Output Voltage	V_O	T_J = +25°C		8.82	9.0	9.16	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 11.2V to 24V		8.65	9.0	9.35	
Line Regulation (Note 26)	Regline	V_I = 11.7V to 25V, I_O = 500mA		–	6.0	90.0	mV
		V_I = 12.5V to 19V		–	4.0	45.0	
		T_J = +25°C	V_I = 11.5V to 24V	–	6.0	90.0	
			V_I = 12.5V to 19V	–	2.0	45.0	
Load Regulation (Note 26)	Regload	T_J = +25°C, I_O = 5mA to 1.0mA		–	12.0	100	mV
		I_O = 5mA to 1mA		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.0	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 11.7V to 25V, T_J = +25°C		–	–	0.8	
Output Voltage Drift (Note 27)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	10.0	–	µV/V_O
Ripple Rejection (Note 27)	RR	f = 120Hz, I_O = 500mA, V_I = 12V to 22V		–	62.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 27)	rO	f = 1KHz		–	17.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 27)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 26: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 27: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7810A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 16V, C_I = 0.33μF, C_O = 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Output Voltage	V_O	T_J = +25°C		9.8	10.0	10.2	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 12.8V to 25V		9.6	10.0	10.4	
Line Regulation (Note 28)	Regline	V_I = 12.8V to 26V, I_O = 500mA		–	8.0	100	mV
		V_I = 13V to 20V		–	4.0	50.0	
		T_J = +25°C	V_I = 12.5V to 25V	–	8.0	100	
			V_I = 13V to 20V	–	3.0	50.0	
Load Regulation (Note 28)	Regload	T_J = +25°C, I_O = 5mA to 1.5mA		–	12.0	100	mV
		I_O = 5mA to 1mA		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.0	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12.8V to 25V, I_O = 500mA		–	–	0.8	
		V_I = 13V to 26V, T_J = +25°C		–	–	0.5	
Output Voltage Drift (Note 29)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	10.0	–	μV/V_O
Ripple Rejection (Note 29)	RR	f = 120Hz, I_O = 500mA, V_I = 14V to 24V		–	62.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 29)	rO	f = 1KHz		–	17.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 29)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 28: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 29: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7812A)

(Refer to the test circuits. $0°C < T_J < 125°C$, I_O = 1A, V_I = 19V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Output Voltage	V_O	T_J = +25°C		11.75	12.0	12.25	V
		I_O = 5mA to 1A, $P_O \leq$ 15W, V_I = 14.8V to 27V		11.5	12.0	12.5	
Line Regulation (Note 30)	Regline	V_I = 14.8V to 30V, I_O = 500mA		–	10.0	120	mV
		V_I = 16V to 22V		–	4.0	120	
		T_J = +25°C	V_I = 14.5V to 27V	–	10.0	120	
			V_I = 16V to 22V	–	3.0	60.0	
Load Regulation (Note 30)	Regload	T_J = +25°C, I_O = 5mA to 1.5mA		–	12.0	100	mV
		I_O = 5mA to 1mA		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.1	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 14V to 27V, I_O = 500mA		–	–	0.8	
		V_I = 15V to 30V, T_J = +25°C		–	–	0.8	
Output Voltage Drift (Note 31)	$\Delta V_O/\Delta T$	I_O = 5mA		–	–1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	10.0	–	µV/V_O
Ripple Rejection (Note 31)	RR	f = 120Hz, I_O = 500mA, V_I = 14V to 24V		–	60.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 31)	rO	f = 1KHz		–	18.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 31)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 30: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 31: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7815A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 23V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Output Voltage	V_O	T_J = +25°C		14.75	15.0	15.3	V
		I_O = 5mA to 1A, $P_O \le$ 15W, V_I = 17.7V to 30V		14.4	15.0	15.6	
Line Regulation (Note 32)	Regline	V_I = 17.4V to 30V, I_O = 500mA		–	10.0	150	mV
		V_I = 20V to 26V		–	5.0	150	
		T_J = +25°C	V_I = 17.5V to 30V	–	11.0	150	
			V_I = 20V to 26V	–	3.0	75.0	
Load Regulation (Note 32)	Regload	T_J = +25°C, I_O = 5mA to 1.5mA		–	12.0	100	mV
		I_O = 5mA to 1mA		–	12.0	100	
		I_O = 250mA to 750mA		–	5.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.2	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 17.5V to 30V, I_O = 500mA		–	–	0.8	
		V_I = 17.5V to 30V, T_J = +25°C		–	–	0.8	
Output Voltage Drift (Note 33)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	10.0	–	µV/V_O
Ripple Rejection (Note 33)	RR	f = 120Hz, I_O = 500mA, V_I = 18.5V to 28.5V		–	58.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 33)	rO	f = 1KHz		–	19.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 33)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 32: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 33: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7818A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 27V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Output Voltage	V_O	T_J = +25°C		17.64	18.0	18.36	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 21V to 33V		17.3	18.0	18.7	
Line Regulation (Note 34)	Regline	V_I = 21V to 33V, I_O = 500mA		–	15.0	180	mV
		V_I = 21V to 33V		–	5.0	180	
		T_J = +25°C	V_I = 20.6V to 33V	–	15.0	180	
			V_I = 24V to 30V	–	5.0	90.0	
Load Regulation (Note 34)	Regload	T_J = +25°C, I_O = 5mA to 1.5mA		–	15.0	100	mV
		I_O = 5mA to 1mA		–	15.0	100	
		I_O = 250mA to 750mA		–	7.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.2	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 12V to 33V, I_O = 500mA		–	–	0.8	
		V_I = 12V to 33V, T_J = +25°C		–	–	0.8	
Output Voltage Drift (Note 35)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.0	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	10.0	–	µV/V_O
Ripple Rejection (Note 35)	RR	f = 120Hz, I_O = 500mA, V_I = 22V to 32V		–	57.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 35)	rO	f = 1KHz		–	19.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 35)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 34: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 35: These parameters, although guaranteed, are not 100% tested in production.

Electrical Characteristics (LM7824A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O = 1A, V_I = 33V, C_I = 0.33µF, C_O = 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Output Voltage	V_O	T_J = +25°C		23.5	24.0	24.5	V
		I_O = 5mA to 1A, P_O ≤ 15W, V_I = 27.3V to 38V		23.0	24.0	25.0	
Line Regulation	Regline	V_I = 27V to 38V, I_O = 500mA		–	18.0	240	mV
(Note 36)		V_I = 21V to 33V		–	6.0	240	
		T_J = +25°C	V_I = 26.7V to 38V	–	18.0	240	
			V_I = 30V to 36V	–	6.0	120	
Load Regulation	Regload	T_J = +25°C, I_O = 5mA to 1.5mA		–	15.0	100	mV
(Note 36)		I_O = 5mA to 1mA		–	15.0	100	
		I_O = 250mA to 750mA		–	7.0	50.0	
Quiescent Current	I_Q	T_J = +25°C		–	5.2	6.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		–	–	0.5	mA
		V_I = 27.3V to 38V, I_O = 500mA		–	–	0.8	
		V_I = 27.3V to 38V, T_J = +25°C		–	–	0.8	
Output Voltage Drift (Note 37)	$\Delta V_O/\Delta T$	I_O = 5mA		–	−1.5	–	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = +25°C		–	10.0	–	µV/V_O
Ripple Rejection (Note 37)	RR	f = 120Hz, I_O = 500mA, V_I = 28V to 38V		–	54.0	–	dB
Dropout Voltage	V_{DROP}	I_O = 1A, T_J = +25°C		–	2.0	–	V
Output Resistance (Note 37)	rO	f = 1KHz		–	20.0	–	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A = +25°C		–	250	–	mA
Peak Current (Note 37)	I_{PK}	T_J =+25°C		–	2.2	–	A

Note 36: Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Note 37: These parameters, although guaranteed, are not 100% tested in production.

Typical Performance Characteristics

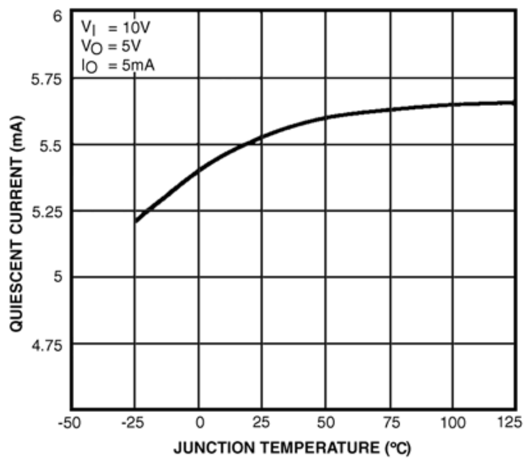


FIGURE 1. Quiescent Current

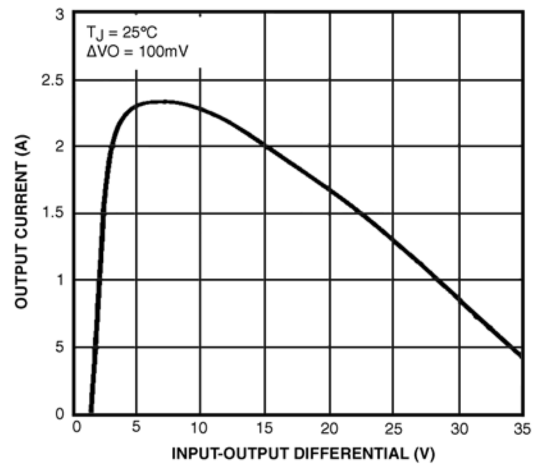


FIGURE 2. Peak Output Current

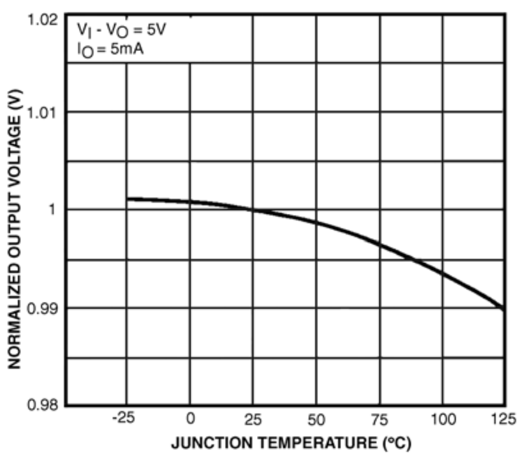


FIGURE 3. Output Voltage

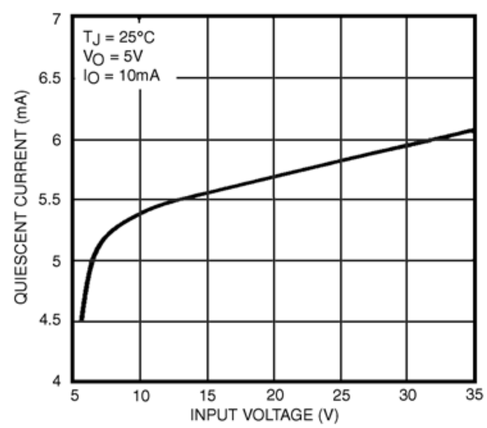


FIGURE 4. Quiescent Current

Typical Applications

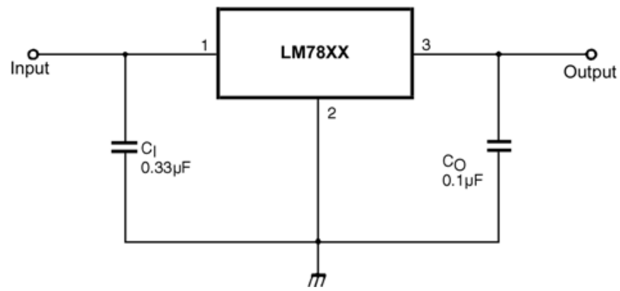


FIGURE 5. DC Parameters

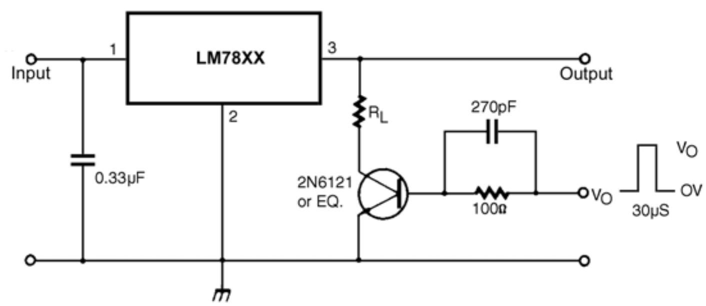


FIGURE 6. Load Regulation

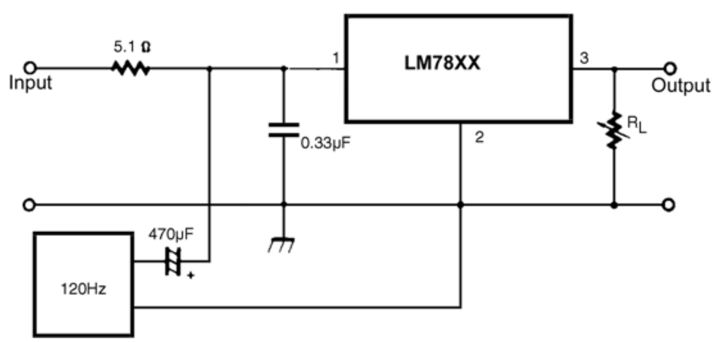


FIGURE 7. Ripple Rejection

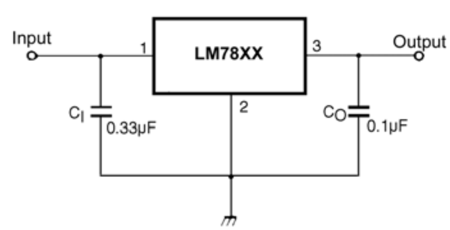
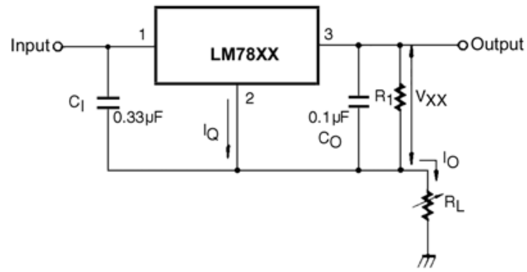


FIGURE 8. Fixed Output Regulator

Typical Applications (continued)



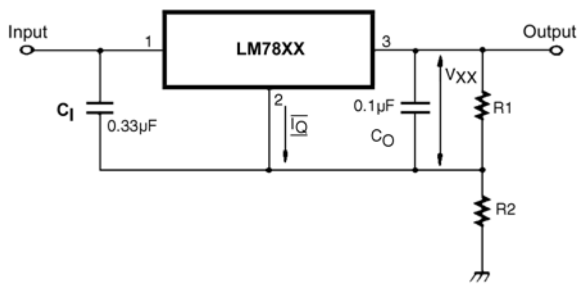
$$I_O = \frac{V_{XX}}{R_1} + I_Q$$

FIGURE 9.

Note: To specify an output voltage, substitute voltage value for "XX". A common ground is required between the Input and the Output voltage. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.

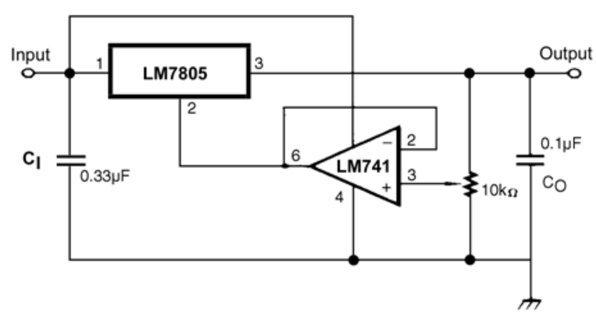
Note: C_I is required if regulator is located an appreciable distance from the power supply filter.

Note: C_O improves stability and transient response.



$$I_{RI} \geq 5\ I_Q$$
$$V_O = V_{XX}\ (1\ R_2\ /\ R_1) + I_Q\ R_2$$

FIGURE 10. Circuit for Increasing Output Voltage



$$I_{RI} \geq 5\ I_Q$$
$$V_O = V_{XX}\ (1\ R_2\ /\ R_1) + I_Q\ R_2$$

FIGURE 11. Adjustable Output Regulator (7V to 30V)

Typical Applications (continued)

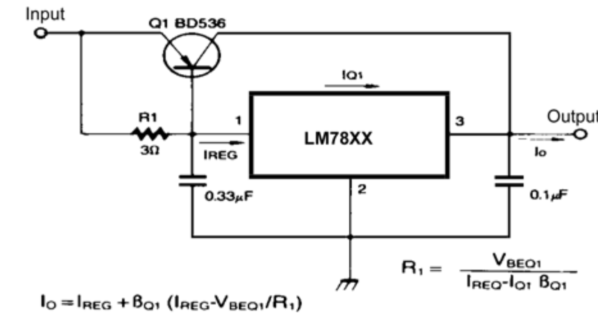


FIGURE 12. High Current Voltage Regulator

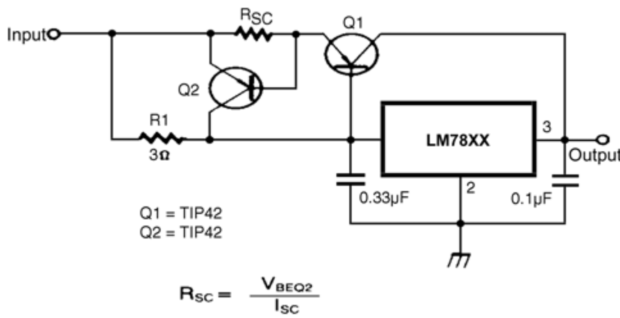


FIGURE 13. High Output Current with Short Circuit Protection

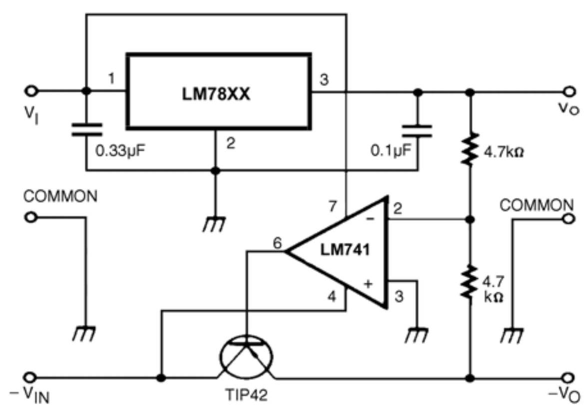


FIGURE 14. Tracking Voltage Regulator

Typical Applications (continued)

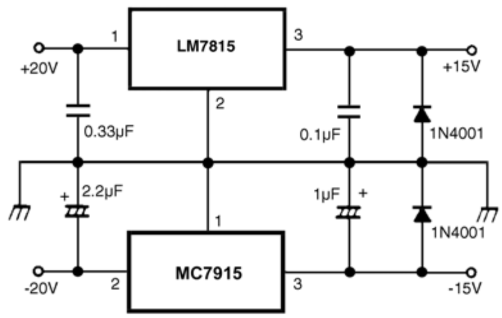


FIGURE 15. Split Power Supply (±15V - 1A)

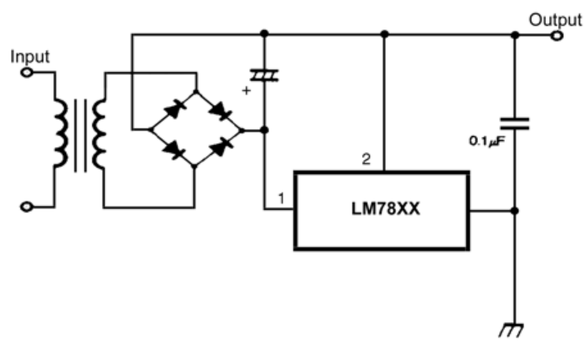


FIGURE 16. Negative Output Voltage Circuit

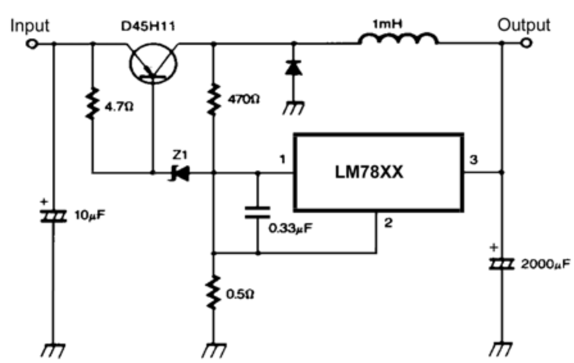
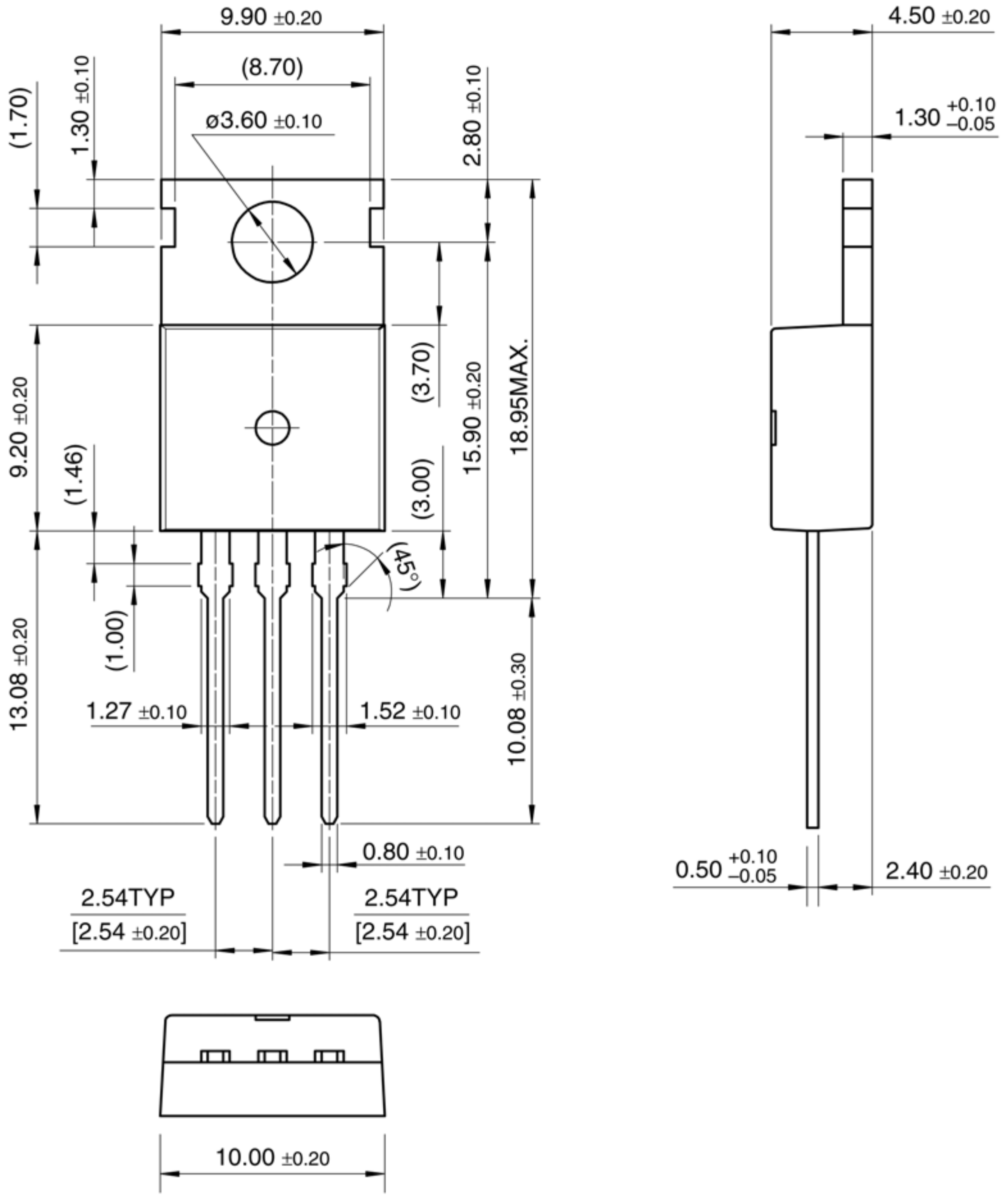


FIGURE 17. Switching Regulator

Physical Dimensions inches (millimeters) unless otherwise noted

TO-220



Package Number TO-220

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Definition of terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild Semiconductor. The datasheet is printed for reference information only.

RFID Read and Write Module

Instruction:

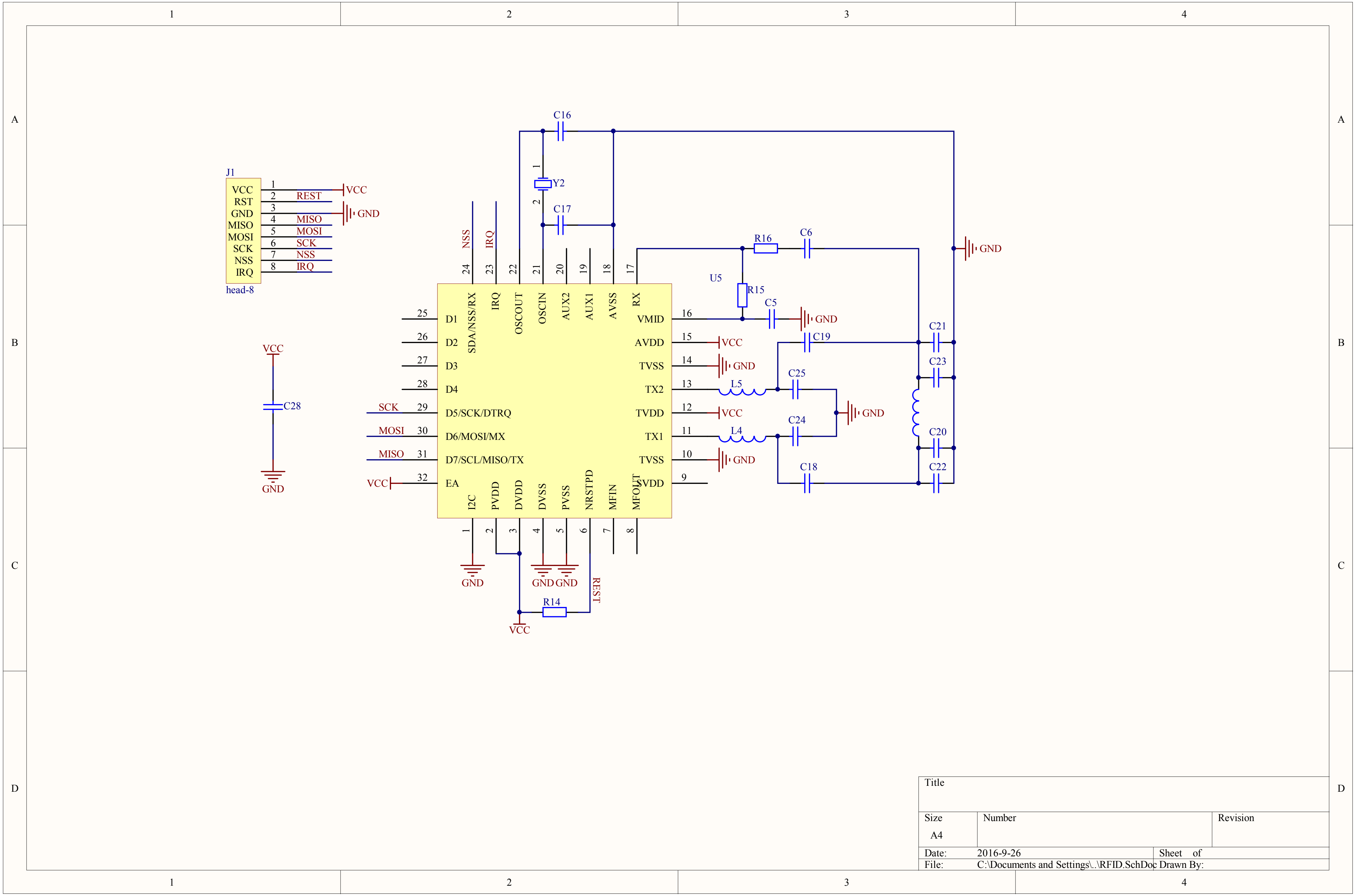
MF RC522 is applied to the highly integrated read and write 13.56MHz contactless communication card chip, NXP launched by the company for the "table" application of a low-voltage, low-cost, small size of non-contact card chip, smart meters and portable handheld devices developed better choice. The MF RC522 use of advanced modulation and demodulation concept completely integrated in all types of 13.56MHz passive contactless communication methods and protocols. In addition, support rapid CRYPTO1 encryption algorithm, terminology validation MIFARE products. MFRC522 support MIFARE series of high-speed non-contact communication, two-way data transmission rate up to 424kbit/s. As new members of the 13.56MHz reader card series of highly integrated chip family, MF RC522 MF RC500 MF RC530 There are a lot of similarities, but also have many of the characteristics and differences. Communication between it and the host SPI mode helps to reduce the connection narrow PCB board volume, reduce costs.

Electrical Parameters

Operating current: 13—26mA/DC 3.3V
Idle current: 10-13mA/ DC 3.3V
Sleep current: <80uA
Peak current: <30mA
Operating frequency: 13.56MHz
Supported Cards: mifare1 S50, mifare1 S70, mifare UltraLight, mifare Pro, mifare Desfire
Physical features: size: 40mm×60mm
Ambient operating temperature: - 20-80 degrees centigrade
Ambient storage temperature: - 40-85 degrees centigrade
Ambient relative humidity: 5%—95%

Module Interface SPI Parameters

Data Transfer Rate: Max. 10Mbit / s

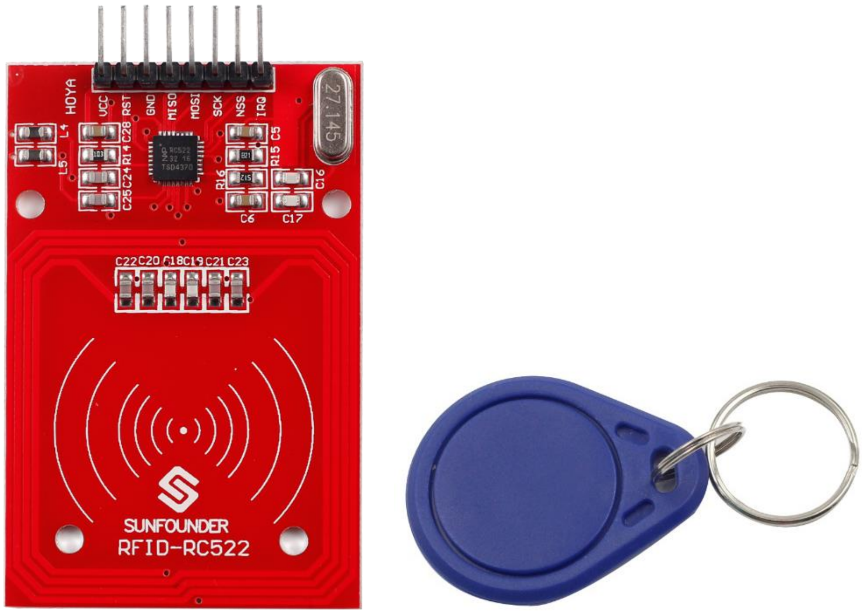


J1
VCC
RST
GND
MISO
MOSI
SCK
NSS
IRQ
head-8
REST
MISO
MOSI
SCK
NSS
IRQ
VCC
GND
C16
Y2
C17
NSS
IRQ
U5
R16
C6
R15
C5
GND
SDA/NSS/RX
IRQ
OSCOUT
OSCIN
AUX2
AUX1
AVSS
RX
D1
D2
D3
D4
D5/SCK/DTRQ
D6/MOSI/MX
D7/SCL/MISO/TX
EA
VMID
AVDD
TVSS
TX2
TVDD
TX1
TVSS
SVDD
I2C
PVDD
DVDD
DVSS
PVSS
NRSTPD
MFIN
MFOUT
C19
C21
C23
C25
L5
C24
L4
C20
C18
C22
C28
SCK
MOSI
MISO
R14
REST
Title
Size
A4
Number
Revision
Date:
2016-9-26
Sheet of
File:
C:\Documents and Settings\..\RFID.SchDoc
Drawn By:

RFID Entrance Guard System

Introduction

RFID is short for radio frequency identification. It is a wireless application to transfer data in the purpose of identifying and tracking tags. In this experiment, we will use an RFID module, a relay, and an I2C LCD1602 to assemble an entrance guard system.



Components

- 1 * SunFounder Uno board
- 1 * USB data cable
- 1 * RFID module
- 1 * RFID key tag
- 1 * Relay
- 1 * I2C LCD1602
- Several jumper wires
- 1 * 3-Pin anti-reverse cable
- 1 * 4-Pin anti-reverse cable
- 1 * Breadboard

Experimental Principle

First, you need to know the ID of the RFID key tag and write the ID to the rfidTest file. Compile the code. We can see "Welcome!" display on the I2C LCD1602. Swipe the RFID key ring on the RFID module. If the password is correct, the normally open contact of the relay will be closed and the LCD will display a string “ID:5AE4C955” "hello SunFounder", and then "Welcome!" two seconds later; if the password is incorrect, the normally open contact of the relay will be disconnected and the LCD will display a string "Hello unknown guy" , and then "Welcome!" two seconds later

Note: For this module, please use a 3.3V power supply, or it will get burnt.

Experimental Procedures

Step 1: Connect the circuit

The wiring between RFID and SunFounder Uno is as follows:

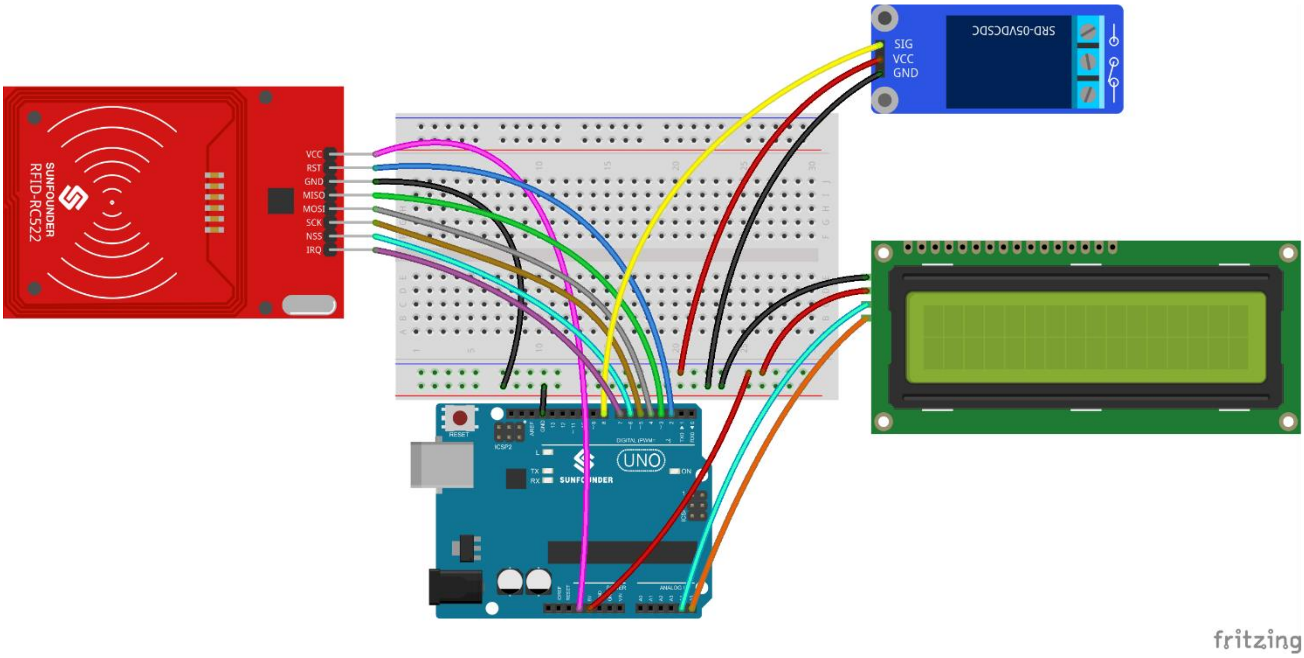
RFID	SunFounder Uno
VCC	3.3V
RST	2
GND	GND
MISO	3
MOSI	4
SCK	5
NSS	6
IRQ	7

The wiring between I2C LCD1602 and SunFounder is as follows:

I2C LCD1602	SunFounder Uno
GND	GND
VCC	5v
SDA	A4
SCL	A5

The wiring between Relay Module and SunFounder is as follows:

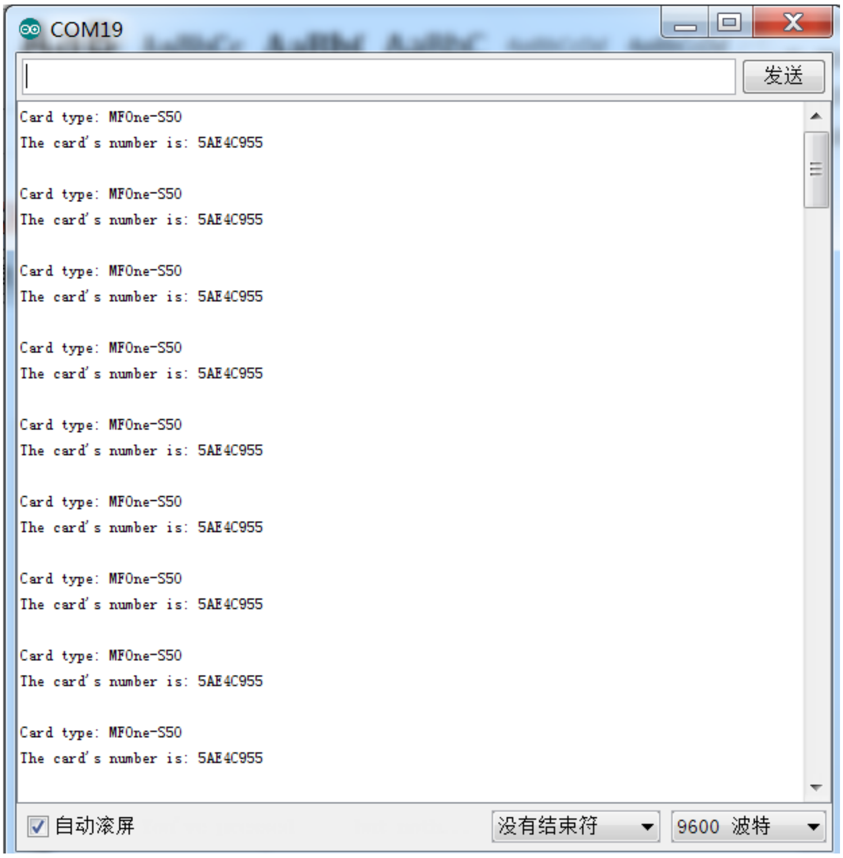
Relay Module	SunFounder Uno
SIG	8
VCC	5V
GND	GND



Step 2: Open the ***getId*** file with Arduino IDE (Please refer to the example **code**). Before you compile the code ,you need to add the three folders under the path RFID-RC522 test experiment\code\library to the Arduino IDE libraries folder,then compile the code.

Step 3: Upload the sketch to the SunFounder Uno board

Then place the RFID key tag in the induction zone of the RFID module. You will see the following values printed on Serial Monitor:



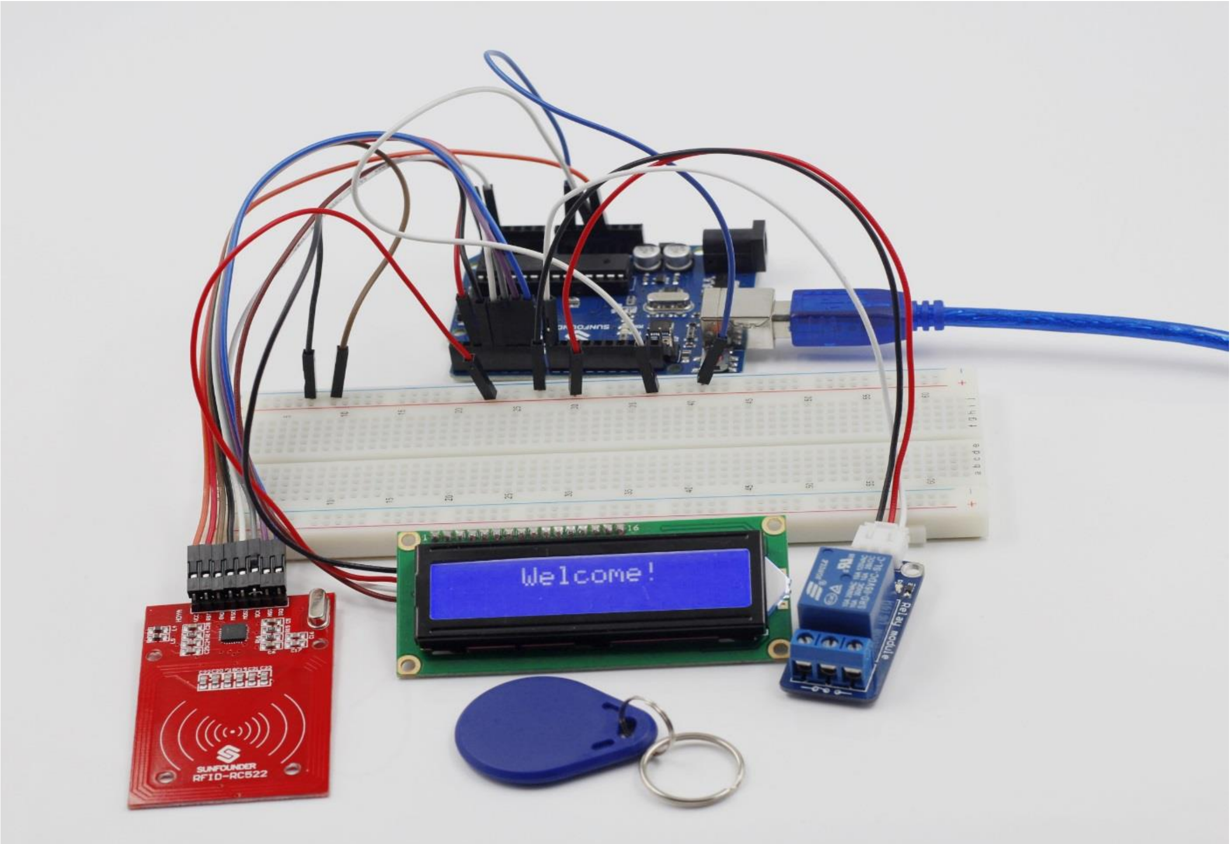
Step 4: Now, you may know the ID of your RFID key tag (e.g. my magnetic card ID is 5AE4C955).

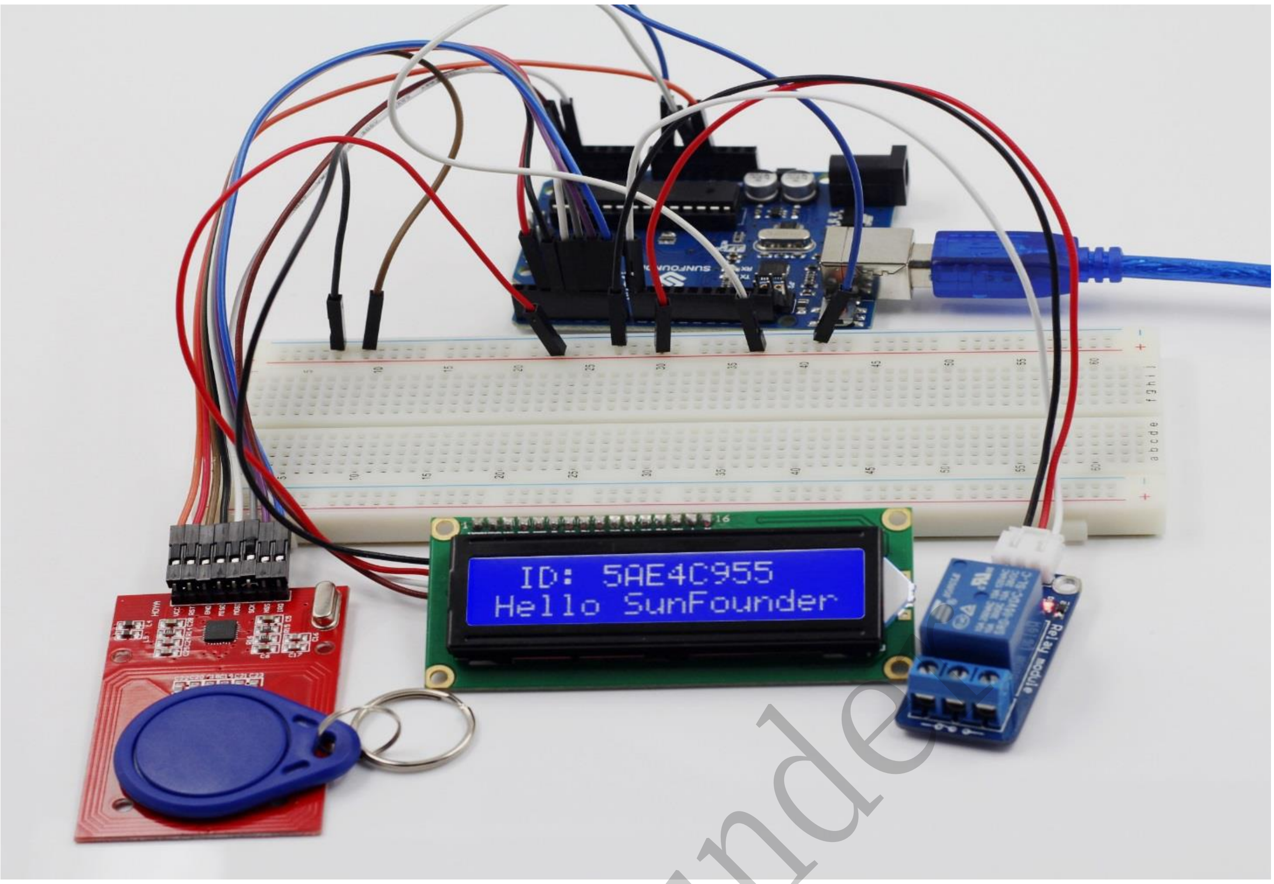
Open the ***rfidTest*** file and replace the ID in the sketch with the ID you just note down (divide the ID into four parts and fill them according to the following format), as follows:

```
else if(id[0]==0x5A && id[1]==0xE4 && id[2]==0xC9 && id[3]==0x55)
{
  digitalWrite(relayPin,LOW);
  //Serial.println("Hello SunFounder");
  lcd.setCursor(0,1);
  lcd.print("Hello SunFounder");
  delay(2000);
  lcd.clear();
  digitalWrite(relayPin,HIGH);
}
```

Step 5: Burn the sketch into SunFounder Uno board

Now, swipe the RFID key tag on the RFID module. If the password is correct, the LCD will display a string "ID:5AE4C955" "Hello SunFounder", and then display "Welcome!" two seconds later. If the password is incorrect, the LCD will display a string "Hello unknown guy", and then display "Welcome!" two seconds later.



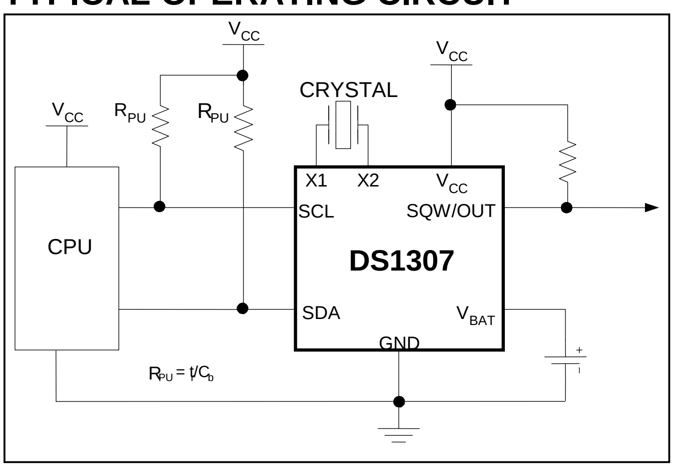

ID: 5AE4C955
Hello SunFounder

DS1307
64 x 8, Serial, I²C Real-Time Clock

GENERAL DESCRIPTION

The DS1307 serial real-time clock (RTC) is a low-power, full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM. Address and data are transferred serially through an I²C, bidirectional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator. The DS1307 has a built-in power-sense circuit that detects power failures and automatically switches to the backup supply. Timekeeping operation continues while the part operates from the backup supply.

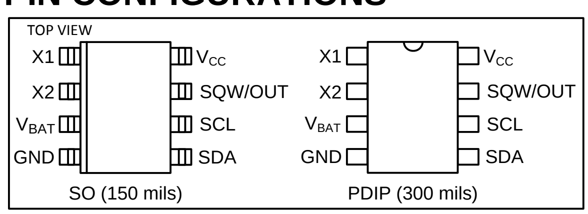
TYPICAL OPERATING CIRCUIT



BENEFITS AND FEATURES

- Completely Manages All Timekeeping Functions
  - Real-Time Clock Counts Seconds, Minutes, Hours, Date of the Month, Month, Day of the Week, and Year with Leap-Year Compensation Valid Up to 2100
  - 56-Byte, Battery-Backed, General-Purpose RAM with Unlimited Writes
  - Programmable Square-Wave Output Signal
- Simple Serial Port Interfaces to Most Microcontrollers
  - I²C Serial Interface
- Low Power Operation Extends Battery Backup Run Time
  - Consumes Less than 500nA in Battery-Backup Mode with Oscillator Running
  - Automatic Power-Fail Detect and Switch Circuitry
- 8-Pin DIP and 8-Pin SO Minimizes Required Space
- Optional Industrial Temperature Range: -40°C to +85°C Supports Operation in a Wide Range of Applications
- Underwriters Laboratories® (UL) Recognized

PIN CONFIGURATIONS



ORDERING INFORMATION

PART	TEMP RANGE	VOLTAGE (V)	PIN-PACKAGE	TOP MARK*
DS1307+	0°C to +70°C	5.0	8 PDIP (300 mils)	DS1307
DS1307N+	-40°C to +85°C	5.0	8 PDIP (300 mils)	DS1307N
DS1307Z+	0°C to +70°C	5.0	8 SO (150 mils)	DS1307
DS1307ZN+	-40°C to +85°C	5.0	8 SO (150 mils)	DS1307N
DS1307Z+T&R	0°C to +70°C	5.0	8 SO (150 mils) Tape and Reel	DS1307
DS1307ZN+T&R	-40°C to +85°C	5.0	8 SO (150 mils) Tape and Reel	DS1307N

+Denotes a lead-free/RoHS-compliant package.
**A "+" anywhere on the top mark indicates a lead-free package. An "N" anywhere on the top mark indicates an industrial temperature range device.*
Underwriters Laboratories, Inc. is a registered certification mark of Underwriters Laboratories, Inc.

ABSOLUTE MAXIMUM RATINGS

Voltage Range on Any Pin Relative to Ground ....-0.5V to +7.0V
Operating Temperature Range (Noncondensing)
Commercial....................0°C to +70°C
Industrial ....-40°C to +85°C
Storage Temperature Range .... -55°C to +125°C
Soldering Temperature (DIP, leads) ....+260°C for 10 seconds
Soldering Temperature (surface mount)....................Refer to the JPC/JEDEC J-STD-020 Specification.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED DC OPERATING CONDITIONS

(T_A = 0°C to +70°C, T_A = -40°C to +85°C.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Logic 1 Input	V_{IH}		2.2		V_{CC} + 0.3	V
Logic 0 Input	V_{IL}		-0.3		+0.8	V
V_{BAT} Battery Voltage	V_{BAT}		2.0	3	3.5	V

DC ELECTRICAL CHARACTERISTICS

(V_{CC} = 4.5V to 5.5V; T_A = 0°C to +70°C, T_A = -40°C to +85°C.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Leakage (SCL)	I_{LI}		-1		1	µA
I/O Leakage (SDA, SQW/OUT)	I_{LO}		-1		1	µA
Logic 0 Output (I_{OL} = 5mA)	V_{OL}				0.4	V
Active Supply Current (f_{SCL} = 100kHz)	I_{CCA}				1.5	mA
Standby Current	I_{CCS}	(Note 3)			200	µA
V_{BAT} Leakage Current	I_{BATLKG}			5	50	nA
Power-Fail Voltage (V_{BAT} = 3.0V)	V_{PF}		1.216 x V_{BAT}	1.25 x V_{BAT}	1.284 x V_{BAT}	V

DC ELECTRICAL CHARACTERISTICS

(V_{CC} = 0V, V_{BAT} = 3.0V; T_A = 0°C to +70°C, T_A = -40°C to +85°C.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{BAT} Current (OSC ON); SQW/OUT OFF	I_{BAT1}			300	500	nA
V_{BAT} Current (OSC ON); SQW/OUT ON (32kHz)	I_{BAT2}			480	800	nA
V_{BAT} Data-Retention Current (Oscillator Off)	I_{BATDR}			10	100	nA

WARNING: Negative undershoots below -0.3V while the part is in battery-backed mode may cause loss of data.

AC ELECTRICAL CHARACTERISTICS
(V_{CC} = 4.5V to 5.5V; T_A = 0°C to +70°C, T_A = -40°C to +85°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SCL Clock Frequency	f_{SCL}		0		100	kHz
Bus Free Time Between a STOP and START Condition	t_{BUF}		4.7			µs
Hold Time (Repeated) START Condition	$t_{HD:STA}$	(Note 4)	4.0			µs
LOW Period of SCL Clock	t_{LOW}		4.7			µs
HIGH Period of SCL Clock	t_{HIGH}		4.0			µs
Setup Time for a Repeated START Condition	$t_{SU:STA}$		4.7			µs
Data Hold Time	$t_{HD:DAT}$		0			µs
Data Setup Time	$t_{SU:DAT}$	(Notes 5, 6)	250			ns
Rise Time of Both SDA and SCL Signals	t_R				1000	ns
Fall Time of Both SDA and SCL Signals	t_F				300	ns
Setup Time for STOP Condition	$t_{SU:STO}$		4.7			µs

CAPACITANCE
(T_A = +25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Pin Capacitance (SDA, SCL)	$C_{I/O}$				10	pF
Capacitance Load for Each Bus Line	C_B	(Note 7)			400	pF

Note 1: All voltages are referenced to ground.

Note 2: Limits at -40°C are guaranteed by design and are not production tested.

Note 3: I_{CCS} specified with V_{CC} = 5.0V and SDA, SCL = 5.0V.

Note 4: After this period, the first clock pulse is generated.

Note 5: A device must internally provide a hold time of at least 300ns for the SDA signal (referred to the $V_{IH(MIN)}$ of the SCL signal) to bridge the undefined region of the falling edge of SCL.

Note 6: The maximum $t_{HD:DAT}$ only has to be met if the device does not stretch the LOW period (t_{LOW}) of the SCL signal.

Note 7: C_B—total capacitance of one bus line in pF.

TIMING DIAGRAM

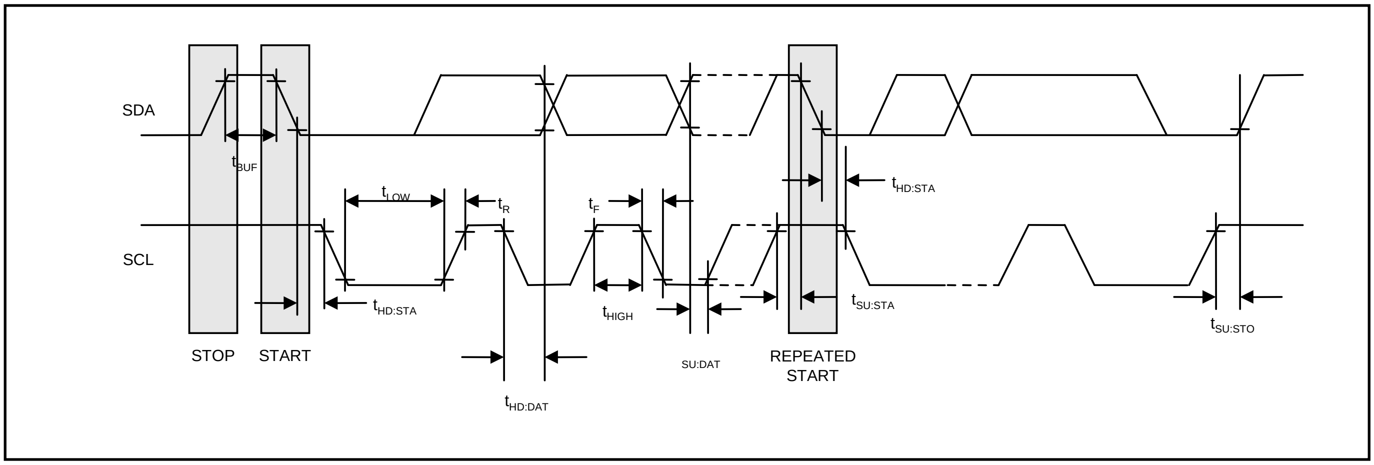
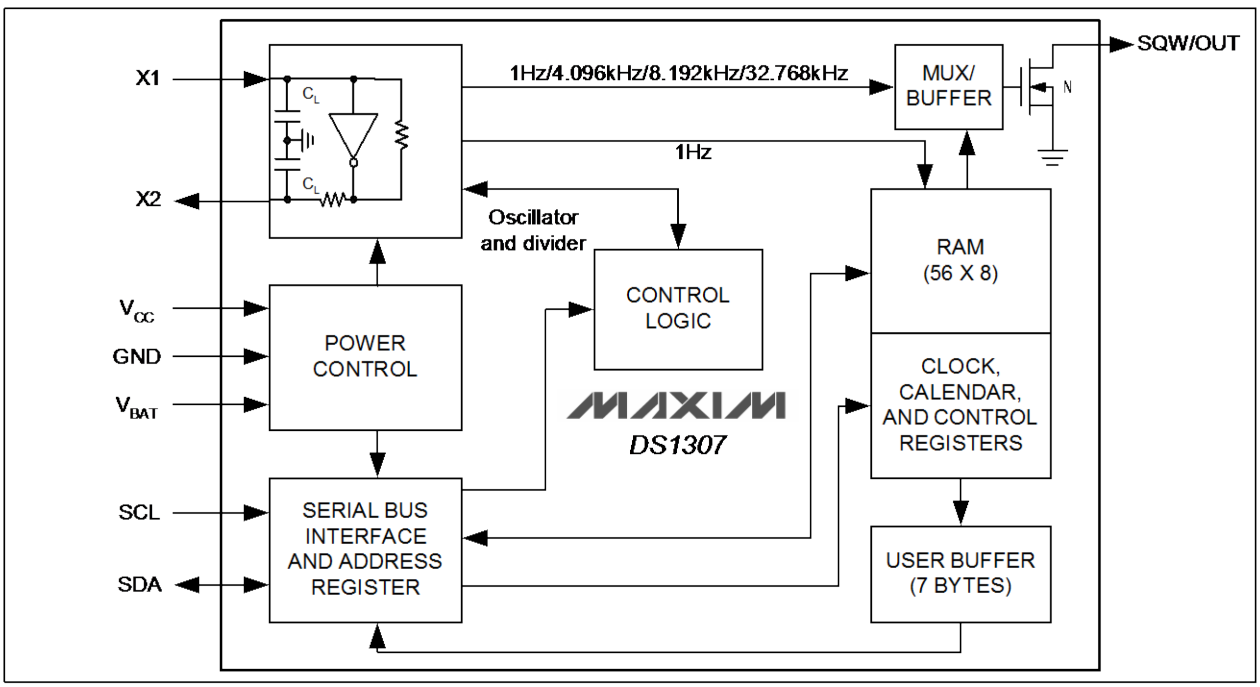
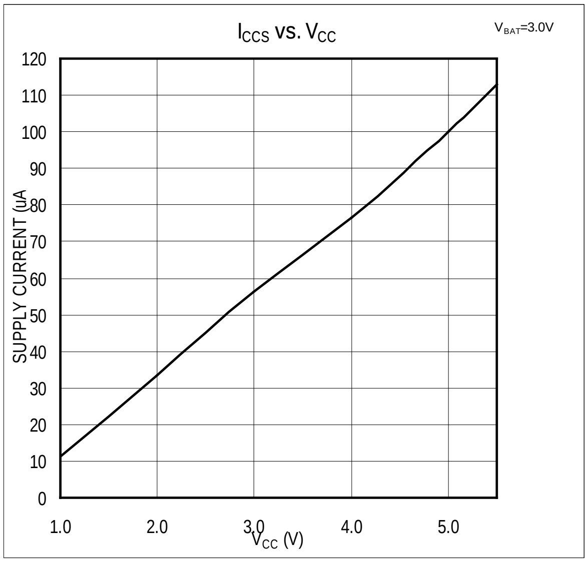


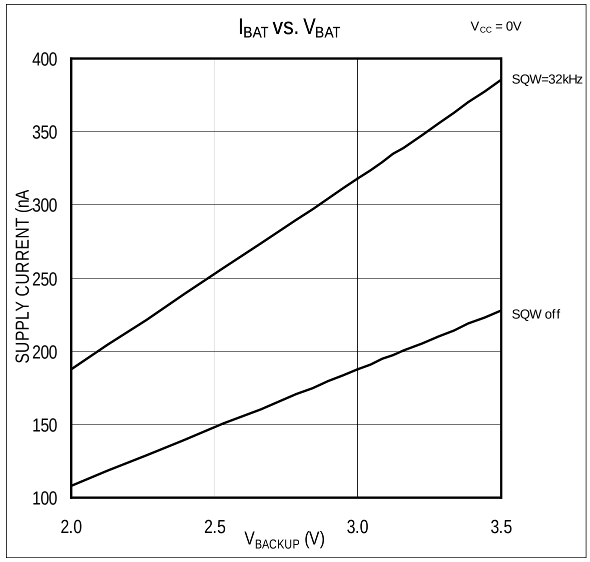
Figure 1. Block Diagram

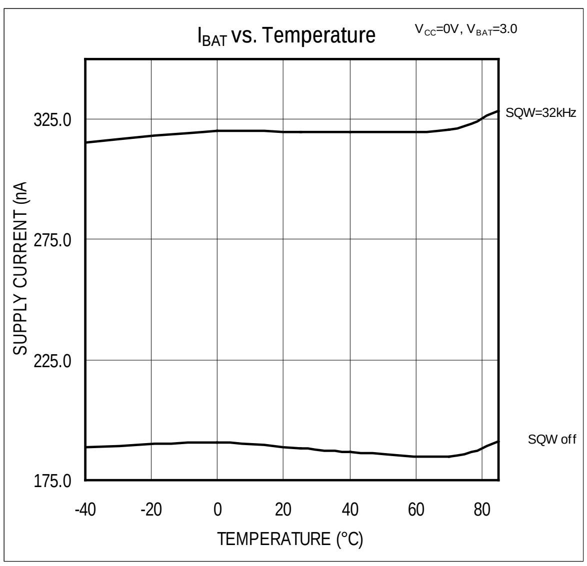


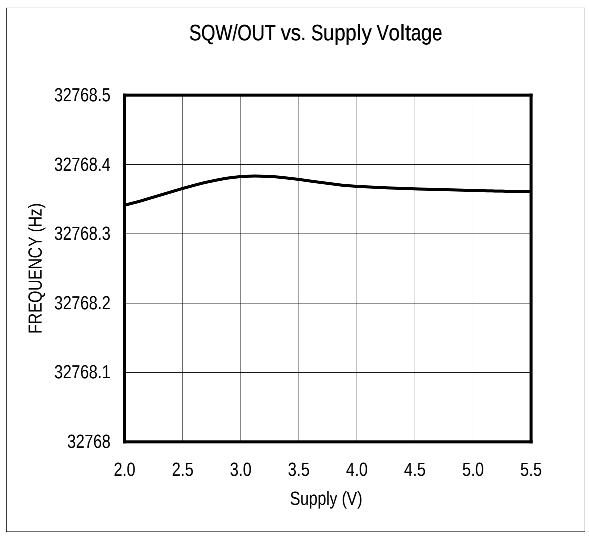
TYPICAL OPERATING CHARACTERISTICS

(V_{CC} = 5.0V, T_A = +25°C, unless otherwise noted.)









PIN DESCRIPTION

PIN	NAME	FUNCTION
1	X1	Connections for Standard 32.768kHz Quartz Crystal. The internal oscillator circuitry is designed for operation with a crystal having a specified load capacitance (C_L) of 12.5pF. X1 is the input to the oscillator and can optionally be connected to an external 32.768kHz oscillator. The output of the internal oscillator, X2, is floated if an external oscillator is connected to X1. **Note:** For more information on crystal selection and crystal layout considerations, refer to *Application Note 58: Crystal Considerations with Dallas Real-Time Clocks*.
2	X2	
3	V_{BAT}	Backup Supply Input for Any Standard 3V Lithium Cell or Other Energy Source. Battery voltage must be held between the minimum and maximum limits for proper operation. Diodes in series between the battery and the V_{BAT} pin may prevent proper operation. If a backup supply is not required, V_{BAT} must be grounded. The nominal power-fail trip point (V_{PF}) voltage at which access to the RTC and user RAM is denied is set by the internal circuitry as 1.25 x V_{BAT} nominal. A lithium battery with 48mAh or greater will back up the DS1307 for more than 10 years in the absence of power at +25°C. UL recognized to ensure against reverse charging current when used with a lithium battery. Go to: www.maxim-ic.com/qa/info/ul/.
4	GND	Ground
5	SDA	Serial Data Input/Output. SDA is the data input/output for the I^2C serial interface. The SDA pin is open drain and requires an external pullup resistor. The pullup voltage can be up to 5.5V regardless of the voltage on V_{CC}.
6	SCL	Serial Clock Input. SCL is the clock input for the I^2C interface and is used to synchronize data movement on the serial interface. The pullup voltage can be up to 5.5V regardless of the voltage on V_{CC}.
7	SQW/OUT	Square Wave/Output Driver. When enabled, the SQWE bit set to 1, the SQW/OUT pin outputs one of four square-wave frequencies (1Hz, 4kHz, 8kHz, 32kHz). The SQW/OUT pin is open drain and requires an external pullup resistor. SQW/OUT operates with either V_{CC} or V_{BAT} applied. The pullup voltage can be up to 5.5V regardless of the voltage on V_{CC}. If not used, this pin can be left floating.
8	V_{CC}	Primary Power Supply. When voltage is applied within normal limits, the device is fully accessible and data can be written and read. When a backup supply is connected to the device and V_{CC} is below V_{TP}, read and writes are inhibited. However, the timekeeping function continues unaffected by the lower input voltage.

DETAILED DESCRIPTION

The DS1307 is a low-power clock/calendar with 56 bytes of battery-backed SRAM. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The date at the end of the month is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The DS1307 operates as a slave device on the I^2C bus. Access is obtained by implementing a START condition and providing a device identification code followed by a register address. Subsequent registers can be accessed sequentially until a STOP condition is executed. When V_{CC} falls below 1.25 x V_{BAT}, the device terminates an access in progress and resets the device address counter. Inputs to the device will not be recognized at this time to prevent erroneous data from being written to the device from an out-of-tolerance system. When V_{CC} falls below V_{BAT}, the device switches into a low-current battery-backup mode. Upon power-up, the device switches from battery to V_{CC} when V_{CC} is greater than V_{BAT} +0.2V and recognizes inputs when V_{CC} is greater than 1.25 x V_{BAT}. The block diagram in Figure 1 shows the main elements of the serial RTC.

OSCILLATOR CIRCUIT
The DS1307 uses an external 32.768kHz crystal. The oscillator circuit does not require any external resistors or capacitors to operate. Table 1 specifies several crystal parameters for the external crystal. Figure 1 shows a functional schematic of the oscillator circuit. If using a crystal with the specified characteristics, the startup time is usually less than one second.

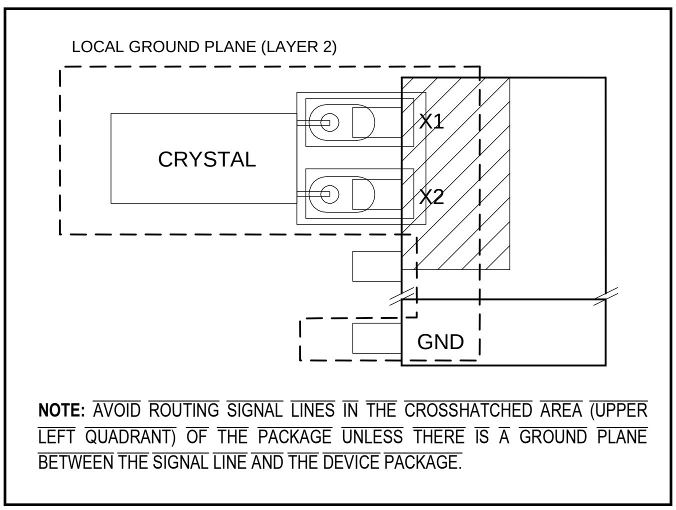
CLOCK ACCURACY
The accuracy of the clock is dependent upon the accuracy of the crystal and the accuracy of the match between the capacitive load of the oscillator circuit and the capacitive load for which the crystal was trimmed. Additional error will be added by crystal frequency drift caused by temperature shifts. External circuit noise coupled into the oscillator circuit may result in the clock running fast. Refer to Application Note 58: *Crystal Considerations with Dallas Real-Time Clocks* for detailed information.

Table 1. Crystal Specifications*

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS
Nominal Frequency	f_O		32.768		kHz
Series Resistance	ESR			45	kΩ
Load Capacitance	C_L		12.5		pF

**The crystal, traces, and crystal input pins should be isolated from RF generating signals. Refer to* Application Note 58: Crystal Considerations for Dallas Real-Time Clocks *for additional specifications.*

Figure 2. Recommended Layout for Crystal



RTC AND RAM ADDRESS MAP
Table 2 shows the address map for the DS1307 RTC and RAM registers. The RTC registers are located in address locations 00h to 07h. The RAM registers are located in address locations 08h to 3Fh. During a multibyte access, when the address pointer reaches 3Fh, the end of RAM space, it wraps around to location 00h, the beginning of the clock space.

CLOCK AND CALENDAR

The time and calendar information is obtained by reading the appropriate register bytes. Table 2 shows the RTC registers. The time and calendar are set or initialized by writing the appropriate register bytes. The contents of the time and calendar registers are in the BCD format. The day-of-week register increments at midnight. Values that correspond to the day of week are user-defined but must be sequential (i.e., if 1 equals Sunday, then 2 equals Monday, and so on.) Illogical time and date entries result in undefined operation. Bit 7 of Register 0 is the clock halt (CH) bit. When this bit is set to 1, the oscillator is disabled. When cleared to 0, the oscillator is enabled. On first application of power to the device the time and date registers are typically reset to 01/01/00 01 00:00:00 (MM/DD/YY DOW HH:MM:SS). The CH bit in the seconds register will be set to a 1. The clock can be halted whenever the timekeeping functions are not required, which minimizes current (I_{BATDR}).

The DS1307 can be run in either 12-hour or 24-hour mode. Bit 6 of the hours register is defined as the 12-hour or 24-hour mode-select bit. When high, the 12-hour mode is selected. In the 12-hour mode, bit 5 is the AM/PM bit with logic high being PM. In the 24-hour mode, bit 5 is the second 10-hour bit (20 to 23 hours). The hours value must be re-entered whenever the 12/24-hour mode bit is changed.

When reading or writing the time and date registers, secondary (user) buffers are used to prevent errors when the internal registers update. When reading the time and date registers, the user buffers are synchronized to the internal registers on any I^{2}C START. The time information is read from these secondary registers while the clock continues to run. This eliminates the need to re-read the registers in case the internal registers update during a read. The divider chain is reset whenever the seconds register is written. Write transfers occur on the I^{2}C acknowledge from the DS1307. Once the divider chain is reset, to avoid rollover issues, the remaining time and date registers must be written within one second.

Table 2. Timekeeper Registers

<table>
<tr><th>ADDRESS</th><th>BIT 7</th><th>BIT 6</th><th>BIT 5</th><th>BIT 4</th><th>BIT 3</th><th>BIT 2</th><th>BIT 1</th><th>BIT 0</th><th>FUNCTION</th><th>RANGE</th></tr>
<tr><td>00h</td><td>CH</td><td colspan="3">10 Seconds</td><td colspan="4">Seconds</td><td>Seconds</td><td>00–59</td></tr>
<tr><td>01h</td><td>0</td><td colspan="3">10 Minutes</td><td colspan="4">Minutes</td><td>Minutes</td><td>00–59</td></tr>
<tr><td rowspan="2">02h</td><td rowspan="2">0</td><td>12</td><td>10 Hour</td><td rowspan="2">10 Hour</td><td rowspan="2" colspan="4">Hours</td><td rowspan="2">Hours</td><td rowspan="2">1–12 +AM/PM
00–23</td></tr>
<tr><td>24</td><td>PM/ AM</td></tr>
<tr><td>03h</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td colspan="3">DAY</td><td>Day</td><td>01–07</td></tr>
<tr><td>04h</td><td>0</td><td>0</td><td colspan="2">10 Date</td><td colspan="4">Date</td><td>Date</td><td>01–31</td></tr>
<tr><td>05h</td><td>0</td><td>0</td><td>0</td><td>10 Month</td><td colspan="4">Month</td><td>Month</td><td>01–12</td></tr>
<tr><td>06h</td><td colspan="4">10 Year</td><td colspan="4">Year</td><td>Year</td><td>00–99</td></tr>
<tr><td>07h</td><td>OUT</td><td>0</td><td>0</td><td>SQWE</td><td>0</td><td>0</td><td>RS1</td><td>RS0</td><td>Control</td><td>—</td></tr>
<tr><td>08h–3Fh</td><td colspan="8"></td><td>RAM 56 x 8</td><td>00h–FFh</td></tr>
</table>

0 = Always reads back as 0.

CONTROL REGISTER

The DS1307 control register is used to control the operation of the SQW/OUT pin.

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
OUT	0	0	SQWE	0	0	RS1	RS0

Bit 7: Output Control (OUT). This bit controls the output level of the SQW/OUT pin when the square-wave output is disabled. If SQWE = 0, the logic level on the SQW/OUT pin is 1 if OUT = 1 and is 0 if OUT = 0. On initial application of power to the device, this bit is typically set to a 0.

Bit 4: Square-Wave Enable (SQWE). This bit, when set to logic 1, enables the oscillator output. The frequency of the square-wave output depends upon the value of the RS0 and RS1 bits. With the square-wave output set to 1Hz, the clock registers update on the falling edge of the square wave. On initial application of power to the device, this bit is typically set to a 0.

Bits 1 and 0: Rate Select (RS[1:0]). These bits control the frequency of the square-wave output when the square-wave output has been enabled. The following table lists the square-wave frequencies that can be selected with the RS bits. On initial application of power to the device, these bits are typically set to a 1.

RS1	RS0	SQW/OUT OUTPUT	SQWE	OUT
0	0	1Hz	1	X
0	1	4.096kHz	1	X
1	0	8.192kHz	1	X
1	1	32.768kHz	1	X
X	X	0	0	0
X	X	1	0	1

I²C DATA BUS

The DS1307 supports the I²C protocol. A device that sends data onto the bus is defined as a transmitter and a device receiving data as a receiver. The device that controls the message is called a master. The devices that are controlled by the master are referred to as slaves. The bus must be controlled by a master device that generates the serial clock (SCL), controls the bus access, and generates the START and STOP conditions. The DS1307 operates as a slave on the I²C bus.

Figures 3, 4, and 5 detail how data is transferred on the I²C bus.

- Data transfer can be initiated only when the bus is not busy.
- During data transfer, the data line must remain stable whenever the clock line is HIGH. Changes in the data line while the clock line is high will be interpreted as control signals.

Accordingly, the following bus conditions have been defined:

Bus not busy: Both data and clock lines remain HIGH.

START data transfer: A change in the state of the data line, from HIGH to LOW, while the clock is HIGH, defines a START condition.

STOP data transfer: A change in the state of the data line, from LOW to HIGH, while the clock line is HIGH, defines the STOP condition.

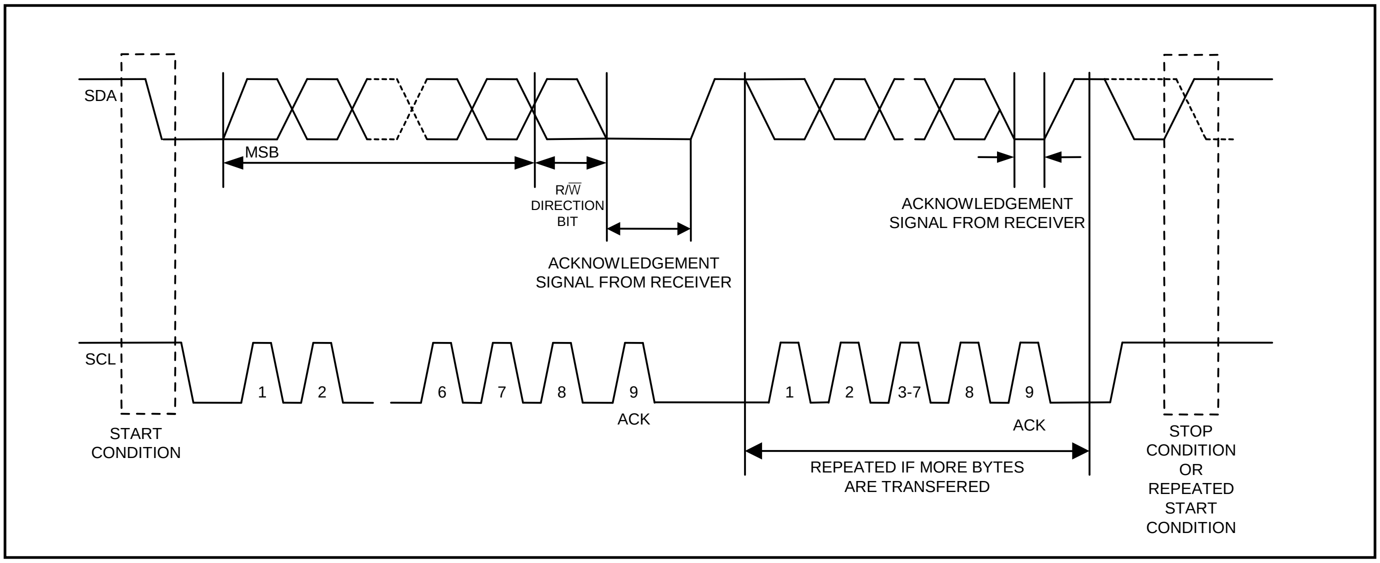
Data valid: The state of the data line represents valid data when, after a START condition, the data line is stable for the duration of the HIGH period of the clock signal. The data on the line must be changed during the LOW period of the clock signal. There is one clock pulse per bit of data.

Each data transfer is initiated with a START condition and terminated with a STOP condition. The number of data bytes transferred between START and STOP conditions is not limited, and is determined by the master device. The information is transferred byte-wise and each receiver acknowledges with a ninth bit. Within the I²C bus specifications a standard mode (100kHz clock rate) and a fast mode (400kHz clock rate) are defined. The DS1307 operates in the standard mode (100kHz) only.

Acknowledge: Each receiving device, when addressed, is obliged to generate an acknowledge after the reception of each byte. The master device must generate an extra clock pulse which is associated with this acknowledge bit.

A device that acknowledges must pull down the SDA line during the acknowledge clock pulse in such a way that the SDA line is stable LOW during the HIGH period of the acknowledge related clock pulse. Of course, setup and hold times must be taken into account. A master must signal an end of data to the slave by not generating an acknowledge bit on the last byte that has been clocked out of the slave. In this case, the slave must leave the data line HIGH to enable the master to generate the STOP condition.

Figure 3. Data Transfer on I2C Serial Bus



Depending upon the state of the R/W bit, two types of data transfer are possible:

1. **Data transfer from a master transmitter to a slave receiver.** The first byte transmitted by the master is the slave address. Next follows a number of data bytes. The slave returns an acknowledge bit after each received byte. Data is transferred with the most significant bit (MSB) first.

2. **Data transfer from a slave transmitter to a master receiver.** The first byte (the slave address) is transmitted by the master. The slave then returns an acknowledge bit. This is followed by the slave transmitting a number of data bytes. The master returns an acknowledge bit after all received bytes other than the last byte. At the end of the last received byte, a “not acknowledge” is returned.

   The master device generates all the serial clock pulses and the START and STOP conditions. A transfer is ended with a STOP condition or with a repeated START condition. Since a repeated START condition is also the beginning of the next serial transfer, the bus will not be released. Data is transferred with the most significant bit (MSB) first.

The DS1307 can operate in the following two modes:

1. **Slave Receiver Mode (Write Mode):** Serial data and clock are received through SDA and SCL. After each byte is received an acknowledge bit is transmitted. START and STOP conditions are recognized as the beginning and end of a serial transfer. Hardware performs address recognition after reception of the slave address and direction bit (see Figure 4). The slave address byte is the first byte received after the master generates the START condition. The slave address byte contains the 7-bit DS1307 address, which is 1101000, followed by the direction bit ($R/\overline{W}$), which for a write is 0. After receiving and decoding the slave address byte, the DS1307 outputs an acknowledge on SDA. After the DS1307 acknowledges the slave address + write bit, the master transmits a word address to the DS1307. This sets the register pointer on the DS1307, with the DS1307 acknowledging the transfer. The master can then transmit zero or more bytes of data with the DS1307 acknowledging each byte received. The register pointer automatically increments after each data byte are written. The master will generate a STOP condition to terminate the data write.

2. **Slave Transmitter Mode (Read Mode):** The first byte is received and handled as in the slave receiver mode. However, in this mode, the direction bit will indicate that the transfer direction is reversed. The DS1307 transmits serial data on SDA while the serial clock is input on SCL. START and STOP conditions are recognized as the beginning and end of a serial transfer (see Figure 5). The slave address byte is the first byte received after the START condition is generated by the master. The slave address byte contains the 7-bit DS1307 address, which is 1101000, followed by the direction bit ($R/\overline{W}$), which is 1 for a read. After receiving and decoding the slave address the DS1307 outputs an acknowledge on SDA. The DS1307 then begins to transmit data starting with the register address pointed to by the register pointer. If the register pointer is not written to before the initiation of a read mode the first address that is read is the last one stored in the register pointer. The register pointer automatically increments after each byte are read. The DS1307 must receive a Not Acknowledge to end a read.

Figure 4. Data Write—Slave Receiver Mode

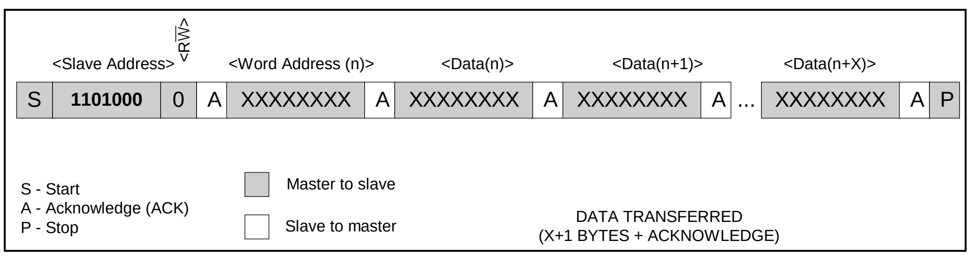


Figure 5. Data Read—Slave Transmitter Mode

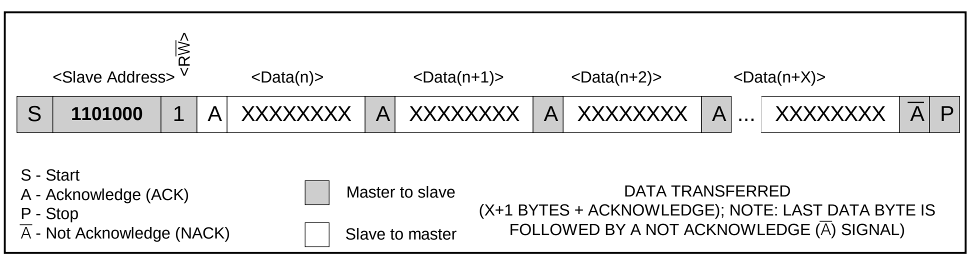
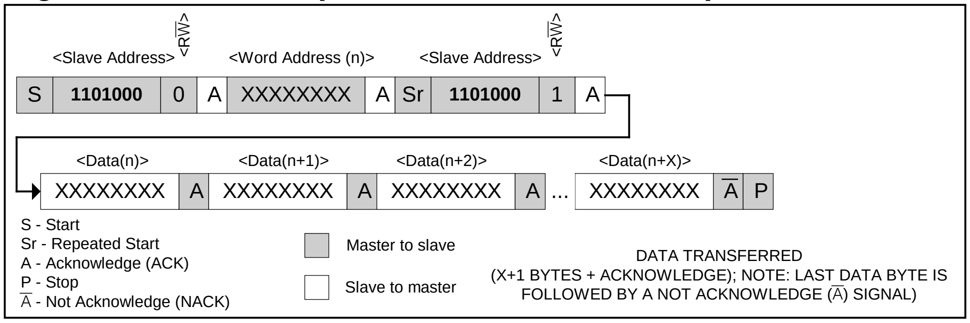


Figure 6. Data Read (Write Pointer, Then Read)—Slave Receive and Transmit



PACKAGE INFORMATION

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

PACKAGE TYPE	PACKAGE CODE	DOCUMENT NO.
8 PDIP	—	**21-0043**
8 SO	—	**21-0041**

REVISION HISTORY

REVISION DATE	DESCRIPTION	PAGES CHANGED
100208	Moved the *Typical Operating Circuit* and *Pin Configurations* to first page.	1
	Removed the leaded part numbers from the *Ordering Information* table.	1
	Added an open-drain transistor to SQW/OUT in the block diagram (Figure 1).	4
	Added the pullup voltage range for SDA, SCL, and SQW/OUT to the *Pin Description* table and noted that SQW/OUT can be left open if not used.	6
	Added default time and date values on first application of power to the *Clock and Calendar* section and deleted the note that initial power-on state is not defined.	8
	Added default on initial application of power to bit info in the *Control Register* section.	9
	Updated the *Package Information* section to reflect new package outline drawing numbers.	13
3/15	Updated *Benefits and Features* section	1

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Solid-State Relays

Features

- Rugged, epoxy encapsulation construction
- 4,000 volts of optical isolation
- Subjected to full load test and six times the rated current surge before and after encapsulation
- Unique heat-spreader technology
- Guaranteed for life

Opto 22 Power Series SSR

Overview

In 1974, Opto 22 introduced the first liquid epoxy-filled line of power solid-state relays (SSR). This innovation in SSR design greatly improved the reliability and reduced the cost of manufacturing. At that time, we also incorporated into our manufacturing process 100% testing under full load conditions of every relay we produced.

By 1978, Opto 22 had gained such a reputation for reliability that we were recognized as the world's leading manufacturer of solid-state relays. Through continuous manufacturing improvements and the same 100% testing policy established over 40 years ago, Opto 22 is still recognized today for the very high quality and reliability of all our solid-state relays.

Description

Opto 22 offers a complete line of SSRs, from the rugged 120/240/380-volt AC Series to the small footprint MP Series, designed for mounting on printed circuit boards. All Opto 22 SSRs feature 4,000 volts of optical isolation, and most are UL and CSA recognized. The innovative use of room-temperature liquid epoxy encapsulation, coupled with Opto 22's unique heat-spreader technology, are key to mass producing the world's most reliable solid state relays.

Every Opto 22 solid state relay is subjected to full load test and six times the rated current surge both before and after

Part Numbers

Part	Description
AC Switching	
120A10	120 VAC, 10 Amp, AC Control
120A25	120 VAC, 25 Amp, AC Control
240A10	240 VAC, 10 Amp, AC Control
240A25	240 VAC, 25 Amp, AC Control
240A45	240 VAC, 45 Amp, AC Control
120D3	120 VAC, 3 Amp, DC Control
120D10	120 VAC, 10 Amp, DC Control
120D25	120 VAC, 25 Amp, DC Control
120D45	120 VAC, 45 Amp, DC Control
240D3	240 VAC, 3 Amp, DC Control
240D10	240 VAC, 10 Amp, DC Control
240Di10	240 VAC, 10 Amp, DC Control, with LED Indicators
240D25	240 VAC, 25 Amp, DC Control
240Di25	240 VAC, 25 Amp, DC Control, with LED Indicators
240D30-HS	240 VAC, 30 Amp, DC Control, with integrated heatsink
240D45	240 VAC, 45 Amp, DC Control
240Di45	240 VAC, 45 Amp, DC Control, with LED Indicators
380D25	380 VAC, 25 Amp, DC Control
380D45	380 VAC, 45 Amp, DC Control
480D10-12	480 VAC, 10 Amp, DC Control, Transient Proof
480D15-12	480 VAC, 15 Amp, DC Control, Transient Proof
480D25-12	480 VAC, 25 Amp, DC Control, Transient Proof
480D25-HS	480 VAC, 25 Amp, DC Control, Transient Proof, with integrated heatsink
480D45-12	480 VAC, 45 Amp, DC Control, Transient Proof

Part	Description
AC Switching	
575D15-12	575 VAC, 15 Amp, DC Control, Transient Proof
575D45-12	575 VAC, 45 Amp, DC Control, Transient Proof
575D30-HS	575 VAC, 30 Amp, DC Control, Transient Proof, with integrated heatsink
575Di45-12	575 VAC, 45 Amp, DC Control, Transient Proof, with LED Indicators
MP120D2 or P120D2	120 VAC, 2 Amp, DC Control. P model is low profile.
MP120D4 or P120D4	120 VAC, 4 Amp, DC Control. P model is low profile.
MP240D2 or P240D2	240 VAC, 2 Amp, DC. P model is low profile.
MP240D4 or P240D4	240 VAC, 4 Amp, DC. P model is low profile.
MP380D4	380 VAC, 4 Amp, DC
Z120D10	Z Model, 120 VAC, 10 Amp, DC Control
Z240D10	Z Model, 240 VAC, 10 Amp, DC Control

DC Switching	
DC60P or DC60MP	60 VDC, 3 Amp, DC Control. P model is low profile.
DC200P or DC200MP	200 VDC, 1 Amp, DC Control. P model is low profile.
DC60S-3	60 VDC, 3 Amp, DC Control
DC60S-5	60 VDC, 5 Amp, DC Control

Accessories	
SAFETY COVER	Power Series SSR safety cover
SSR-HS	Power Series SSR heatsink
SSR-THERMOPAD	Thermal conductive pad (pack of 10)

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encapsulation. This double testing of every part before it leaves the factory means you can rely on Opto 22 solid state relays. All Opto 22 SSRs are guaranteed for life.

Accessories for the Power-Series SSRs include a safety cover, a heatsink, and a matching thermal conductive pad. See page 3.

Power Series SSRs

Opto 22 provides a full range of Power Series relays with a wide variety of voltage (120–575 volts) and current options (3–45 amps). All Power Series relays feature 4,000 volts of optical isolation and have a high PRV rating. Some Power Series relays include built-in LEDs to indicate operation. See page 4.

DC Series

The DC Series delivers isolated DC control to large OEM customers worldwide. All DC control SSRs are LS TTL compatible.

AC Series

The AC Series offers the ultimate in solid state reliability. All AC Power Series relays feature a built-in snubber as well as zero-voltage turn-on and zero-current turn-off. Transient-proof models offer self protection for noisy electrical environments.

Z Series SSRs

The Z Series employs a unique heat transfer system that makes it possible for Opto 22 to deliver a low-cost, 10-amp, solid state relay in an all-plastic case. The push-on, tool-free quick-connect terminals make the Z Series ideal for high-volume OEM applications. Operating temperature: –40 °C to 100 °C. See page 7.

Printed Circuit Series SSRs

Opto 22's Printed Circuit Series allows OEMs to easily deploy solid state relays on printed circuit boards. Two unique packages are available, both of which will switch loads up to four amps. Operating temperature: –40 °C to 100 °C. See page 9.

MP Series

The MP Series packaging is designed with a minimum footprint to allow maximum relay density on the printed circuit board.

P Series

The P Series power relays provide low-profile [0.5 in. (12.7 mm)] center mounting on printed circuit boards.

HS Series SSRs

The HS Series features an integrated heatsink, which makes them so *cool.* These relays have less thermal resistance inside, so heat dissipates more easily than in a standard SSR mounted to the same heatsink. With the heatsink built-in, you don't have to select one from a catalog, and installation is much easier. Includes a DIN-rail adapter. See page 13.

Specifications (all Power Series models)

- 4,000 V optical isolation, input to output
- Zero voltage turn-on
- Zero-current turn-off
- Turn-on time: 0.5 cycle maximum
- Turn-off time: 0.5 cycle maximum
- Operating temperature: –40 °C to 100 °C
- Operating frequency: 25 to 65 Hz
  (operates at 400 Hz with six times off-state leakage)
- Coupling capacitance, input to output: 8 pF maximum
- Hermetically sealed
- DV/DT Off-state: 200 volts per microsecond
- DV/DT commutating: snubbed for rated current at 0.5 power factor
- UL recognized
- CSA certified
- CE component
- Torque specs for screws (this spec is both the recommended torque and the maximum torque you should use):
  Control terminals, 10 in-lb (1.13 N-m)
  Field terminals, 18 in-lb (2.03 N-m)

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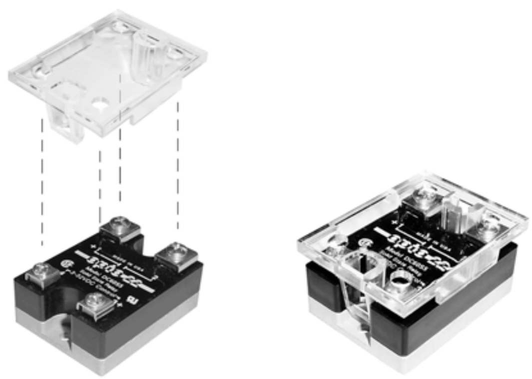
Solid-State Relays

Power Series SSR Accessories

Safety Cover

A plastic safety cover (Opto 22 part number SAFETY COVER) is available for use with Opto 22 Power Series SSRs. The safety cover reduces the chance of accidental contact with relay terminals, while providing access holes for test instrumentation.



An optional plastic safety cover can be installed on a Power Series SSR.

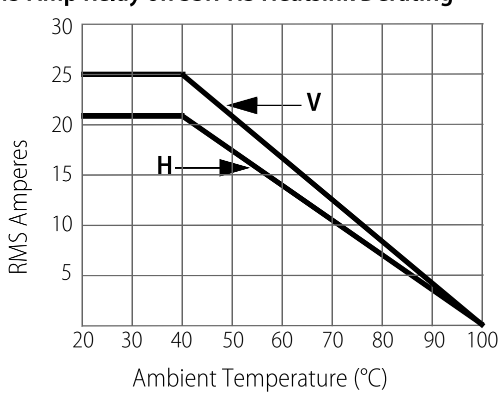
SSR-HS Heatsink

Custom designed for the Power Series SSRs, the SSR-HS heatsink provides excellent heat dissipation when mounted to the SSR with a matching thermal conductive pad, used in place of silicon grease. One thermal pad is included with the heatsink. Additional pads may be purchased in packs of 10 (part number SSR-THERMOPAD). DIN-rail adapter is included.

Thermal Ratings

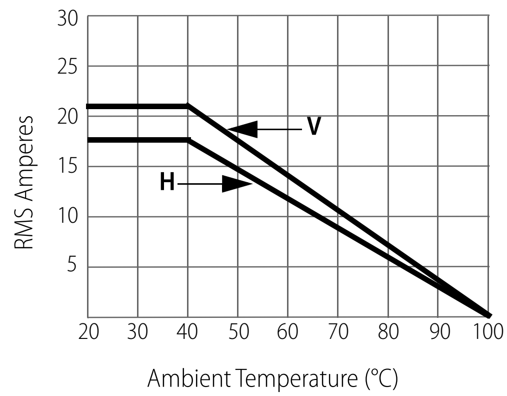
The thermal ratings shown in the following graphs were obtained with an SSR attached to a heatsink using a thermal conductive pad.

45 Amp Relay on SSR-HS Heatsink Derating



V: Heatsink mounted to a **vertical** surface
H: Heatsink mounted to a **horizontal** surface.

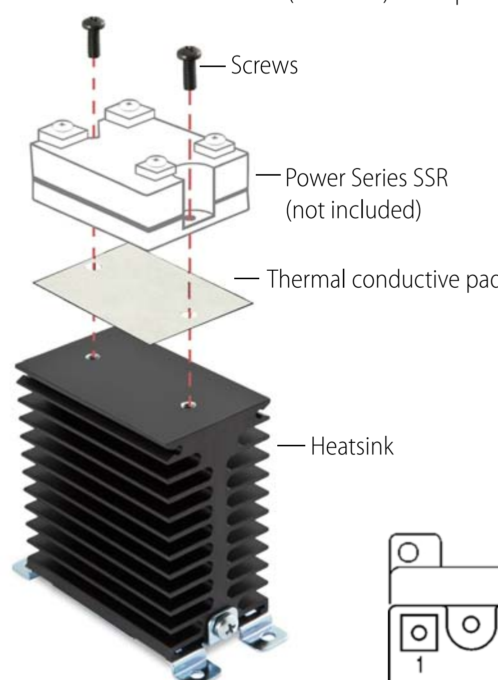
25 Amp Relay on SSR-HS Heatsink Derating



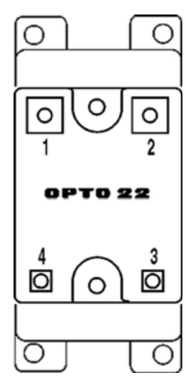
V: Heatsink mounted to a **vertical** surface
H: Heatsink mounted to a **horizontal** surface.

Heatsink Assembly

Before attaching the SSR, remove the protective film from both sides of the thermal pad, then place the pad on the heatsink making sure to align the holes. Secure the SSR to the heatsink with the two 8-32 x 3/8″ panhead Phillips screws included in the kit. Use 20 in-lb (2.26 N-m) of torque.



NOTE: To take advantage of the cooling effect of natural air flow, mount the SSR/heatsink assembly to a vertical surface with the Opto 22 logo right side up as shown here.



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AC Power Series Specifications

Opto 22 provides a full range of Power Series relays with a wide variety of voltage (120–575) and current options (3–45 amps). All Power Series relays feature 4,000 volts of optical isolation and have a high PRV rating. Operating temperature is –40 °C to 100 °C.

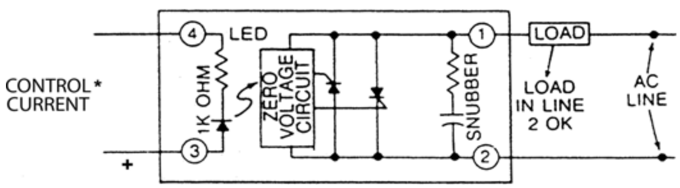
120/240/380 Volt

NOTE: Model numbers ending in -17 are replacement parts only. Their specifications are identical to the same model number without the -17. For example, 240D10-17 is identical to 240D10.

Model Number	Nominal AC Line Voltage	Nominal Current Rating (Amps)	1 cycle Surge (Amps) Peak	Nominal Signal Input Resistance (Ohms)	Signal Pick-up Voltage	Signal Drop-out Voltage	Peak Repetitive Voltage Maximum	Maximum Output Voltage Drop	Off-State Leakage (mA) Maximum**	Operating Voltage Range (Volts AC)	I^2t Rating t=8.3 (ms)	Isolation Voltage	θjc* (°C/Watt)	Dissipation (Watts/ Amp)
120D3	120	3	85	1000	3VDC (32V allowed)	1 VDC	600	1.6 volts	2.5mA	12–140	30	$4,000V_{RMS}$	11	1.7
120D10	120	10	110	1000	3VDC (32V allowed)	1 VDC	600	1.6 volts	7 mA	12–140	50	$4,000V_{RMS}$	1.3	1.6
120D25	120	25	250	1000	3VDC (32V allowed)	1 VDC	600	1.6 volts	7 mA	12–140	250	$4,000V_{RMS}$	1.2	1.3
120D45	120	45	650	1000	3VDC (32V allowed)	1 VDC	600	1.6 volts	7 mA	12–140	1750	$4,000V_{RMS}$	0.67	0.9
240D3	240	3	85	1000	3VDC (32V allowed)	1 VDC	600	1.6 volts	5 mA	24–280	30	$4,000V_{RMS}$	11	1.7
240D10	240	10	110	1000	3VDC (32V allowed)	1 VDC	600	1.6 volts	14 mA	24–280	50	$4,000V_{RMS}$	1.3	1.6
240Di10	240	10	110	730	3VDC (32V allowed)	1 VDC	600	1.6 volts	14 mA	24–280	50	$4,000V_{RMS}$	1.3	1.6
240D25	240	25	250	1000	3VDC (32V allowed)	1 VDC	600	1.6 volts	14 mA	24–280	250	$4,000V_{RMS}$	1.2	1.3
240Di25	240	25	250	730	3VDC (32V allowed)	1 VDC	600	1.6 volts	14 mA	12–280	250	$4,000V_{RMS}$	1.2	1.3
240D45	240	45	650	1000	3VDC (32V allowed)	1 VDC	600	1.6 volts	14 mA	24–280	1750	$4,000V_{RMS}$	0.67	0.9
240Di45	240	45	650	730	3VDC (32V allowed)	1 VDC	600	1.6 volts	14 mA	24–280	1750	$4,000V_{RMS}$	0.67	0.9
380D25	380	25	250	1000	3VDC (32V allowed)	1 VDC	800	1.6 volts	12 mA	24–420	250	$4,000V_{RMS}$	1.2	1.3
380D45	380	45	650	1000	3VDC (32V allowed)	1 VDC	800	1.6 volts	12 mA	24–420	1750	$4,000V_{RMS}$	0.67	0.9
120A10	120	10	110	33K	85VAC (280V allowed)	10 VAC	600	1.6 volts	7 mA	12–140	50	$4,000V_{RMS}$	1.3	1.6
120A25	120	25	250	33K	85VAC (280V allowed)	10 VAC	600	1.6 volts	7 mA	12–140	250	$4,000V_{RMS}$	1.2	1.3
240A10	240	10	110	33K	85VAC (280V allowed)	10 VAC	600	1.6 volts	14 mA	24–280	50	$4,000V_{RMS}$	1.3	1.6
240A25	240	25	250	33K	85VAC (280V allowed)	10 VAC	600	1.6 volts	14 mA	24–280	250	$4,000V_{RMS}$	1.2	1.3
240A45	240	45	650	33K	85VAC (280V allowed)	10 VAC	600	1.6 volts	14 mA	24–280	1750	$4,000V_{RMS}$	0.67	0.9

Note: θjc* = Thermal resistance from internal junction to base. Maximum internal junction temperature is 110 °C.
** Operating Frequency: 25 to 65 Hz (operates at 400 Hz with 6 times the offstate leakage)

Connection Diagram, DC Power Series



*Control Current varies with control voltage. See "Control Current Calculation" on page 17 for information.

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Solid-State Relays

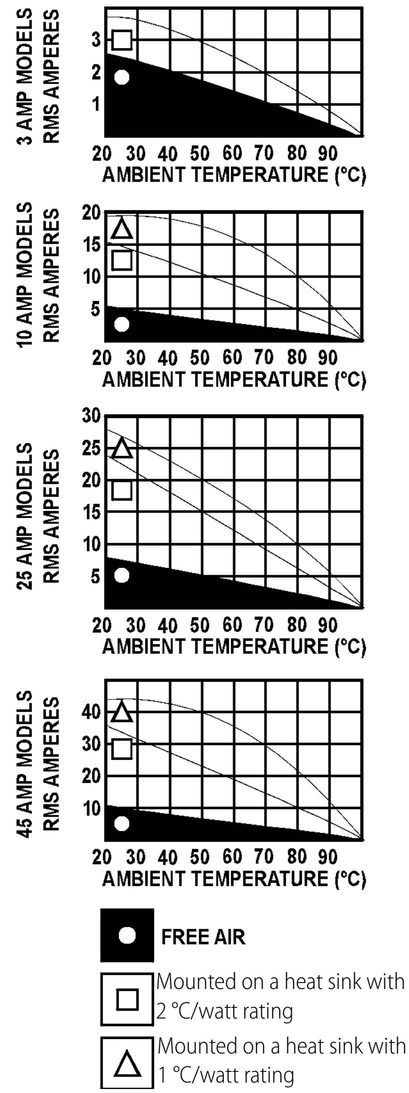
120/240/380 Volt (cont.)

Surge Current Data

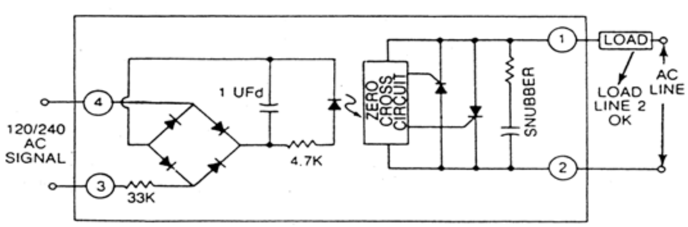
Time (Seconds)	Time* (Cycles)	3-Amp Peak Amps	10-Amp Peak Amps	25-Amp Peak Amps	45-Amp Peak Amps
0.017	1	85	110	250	650
0.050	3	66	85	175	420
0.100	6	53	70	140	320
0.200	12	45	60	112	245
0.500	30	37	50	80	175
1	60	31	40	67	134
2	120	28	33	53	119
3	180	27	32	49	98
4	240	26	31	47	95
5	300	25	30	45	91
10	600	24	28	42	84

Note: *60 Hz.

Thermal Ratings

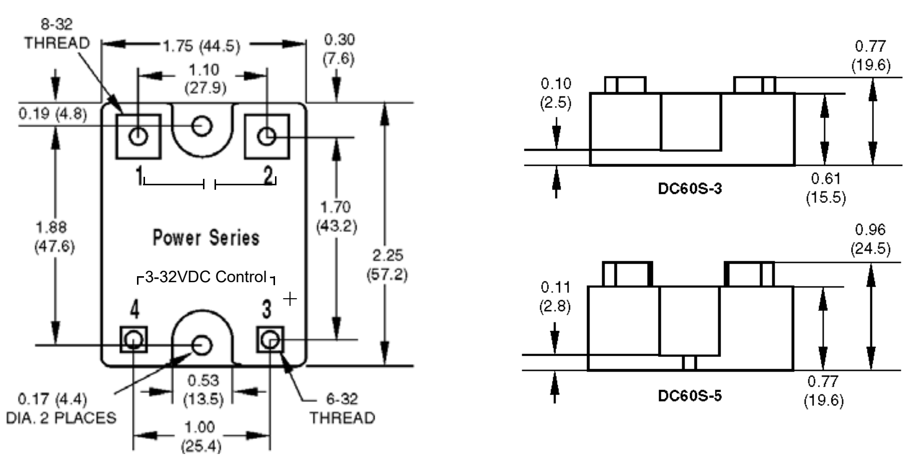


Connection Diagram, AC Power Series



Dimensional Drawings

NOTE: All dimensions are nominal. We do not recommend mounting the terminal side of the SSR to a flat PCB (printed circuit board) or other flat surface, because there may be some variation in terminal height from one terminal to another and from one SSR to another.



Side view: Part numbers DC60S3, 120D3, and 240D3 only

Side view: All other part numbers

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480/575 Volt

Model Number	Nominal AC Line Voltage	Nominal Current Rating (Amps)	1 cycle Surge (Amps) Peak	Nominal Signal Input Resistance (Ohms)	Signal Pick-up Voltage	Signal Drop-out Voltage	Peak Repetitive Voltage Maximum	Maximum Output Voltage Drop	Off-State Leakage (mA) Maximum**	Operating Voltage Range (Volts AC)	I^2t Rating t=8.3 (ms)	Isolation Voltage	θjc* (°C/Watt)	Dissipation (Watts/Amp)
480D10-12	480	10	110	1000	3VDC (32V allowed)	1 VDC	1200	3.2 volts	11 mA	100–530	50	4,000V_{RMS}	1.2	2.5
480D15-12	480	15	150	1000	3VDC (32V allowed)	1 VDC	1200	3.2 volts	11 mA	100–530	50	4,000V_{RMS}	1.2	2.5
480D25-12	480	25	250	1000	3VDC (32V allowed)	1 VDC	1000	1.6 volts	11 mA	100–530	250	4,000V_{RMS}	1.3	1.3
480D45-12	480	45	650	1000	3VDC (32V allowed)	1 VDC	1000	1.6 volts	11 mA	100–530	1750	4,000V_{RMS}	0.67	0.9
575D15-12	575	15	150	1000	3VDC (32V allowed)	1 VDC	1200	3.2 volts	15 mA	100–600	90	4,000V_{RMS}	1.2	2.5
575D45-12	575	45	650	1000	3VDC (32V allowed)	1 VDC	1000	1.6 volts	15 mA	100–600	1750	4,000V_{RMS}	0.67	0.9
575Di45-12	575	45	650	730	3VDC (32V allowed)	1 VDC	1000	1.6 volts	15 mA	100–600	1750	4,000V_{RMS}	0.67	0.9

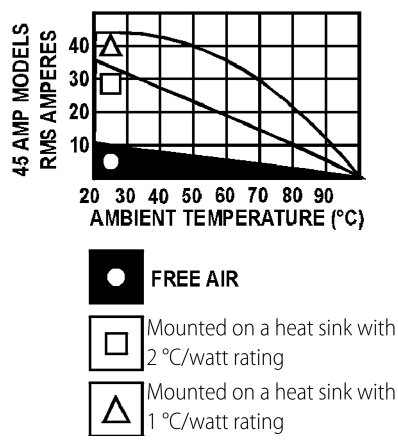
Note: θjc* = Thermal resistance from internal junction to base. Maximum internal junction temperature is 110 °C.
** Operating Frequency: 25 to 65 Hz (operates at 400 Hz with 6 times the offstate leakage)

Surge Current Data

Time Second	Time*** (Cycles)	10-Amp Peak Amps	15-Amp Peak Amps	25-Amp Peak Amps	45-Amp Peak Amps
0.017	1	110	150	250	650
0.050	3	85	140	175	420
0.100	6	70	110	140	320
0.200	12	60	90	112	245
0.500	30	50	70	80	175
1	60	40	55	67	134
2	120	33	49	53	119
3	180	32	47	49	98
4	240	31	43	47	95
5	300	30	40	45	91
10	600	28	35	42	84

Note: ***60 Hz

Thermal Ratings



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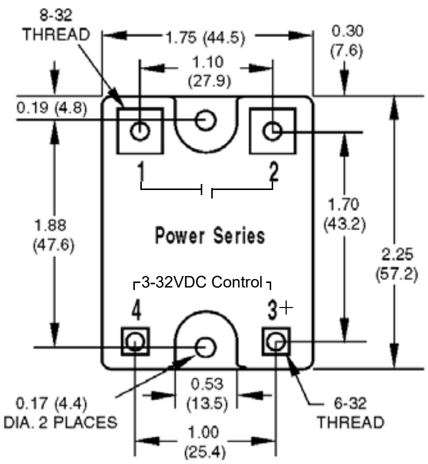
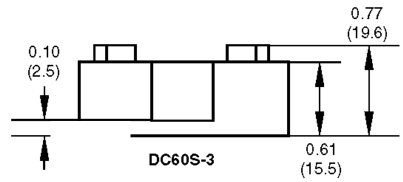
Solid-State Relays

480/575 Volt (cont)

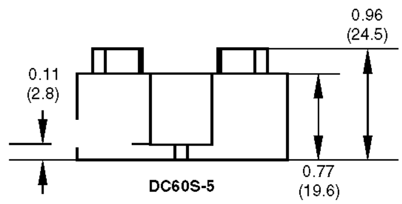
Dimensional Drawings

NOTE: All dimensions are nominal. We do not recommend mounting the terminal side of the SSR to a flat PCB (printed circuit board) or other flat surface, because there may be some variation in terminal height from one terminal to another and from one SSR to another.





Side view: Part numbers DC60S3, 120D3, and 240D3 only



Side view: All other part numbers

Z Series Specifications

AC Power: 120/240 Volt

The Z Series employs a unique heat transfer system that makes it possible for Opto 22 to deliver a low-cost, 10-amp, solid-state relay in an all-plastic case. The push-on tool-free quick-connect terminals make the Z Series ideal for high-volume OEM applications. Operating temperature is –40 °C to 100 °C.

	Z120D10	Z240D10
Nominal AC Line Voltage Nominal	120	240
Current Rating (Amps)	10	10
1 cycle Surge (Amps) Peak	110	110
Nominal Signal Input Resistance (Ohms)	1000	1000
Signal Pick-up Voltage	3VDC (32V allowed)	3VDC (32V allowed)
Signal Drop-out Voltage	1 VDC	1 VDC
Peak Repetitive Voltage Maximum	600	600
Maximum Output Voltage Drop	1.6 volts	1.6 volts
Off-State Leakage (mA) Maximum**	6 mA	12 mA
Operating Voltage Range (Volts AC)	12–140	24–280
I^2t Rating t=8.3 (ms)	50	50
Isolation Voltage	4,000 V_{RMS}	4,000 V_{RMS}
θjc* (°C/Watt) Dissipation (Watts/Amp)	4	4

Notes: θjc* = Thermal resistance from internal junction to base. Maximum internal junction temperature is 110°C.
** Operating Frequency: 25–65 Hz (operates at 400 Hz with 6 times the offstate leakage)

NOTE: Part number Z240D10-17 is a replacement part only. Its specifications are identical to Z240D10.

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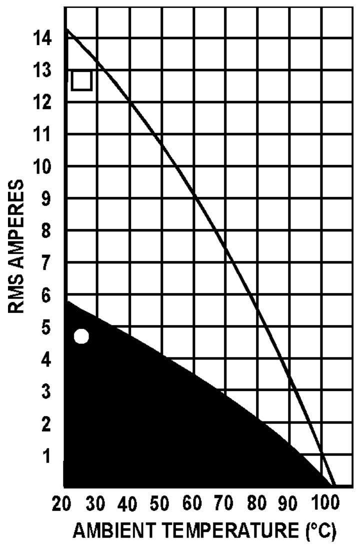
AC Power: 120/240 Volt (cont.)

Current vs. Ambient Ratings



FREE AIR

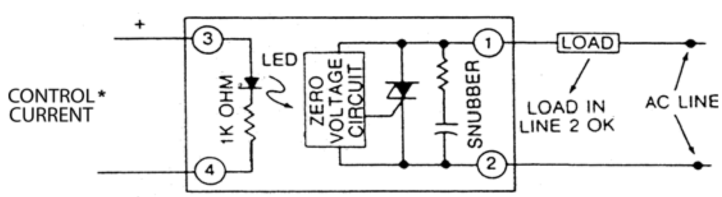
Mounted on a heat sink with 2 °C/watt rating

Surge Current Data

Time Second	Time*** (Cycles)	Peak Amps
0.017	1	110
0.050	3	85
0.100	6	70
0.200	12	60
0.500	30	50
1	60	40
2	120	33
3	180	32
4	240	31
5	300	30
10	600	28

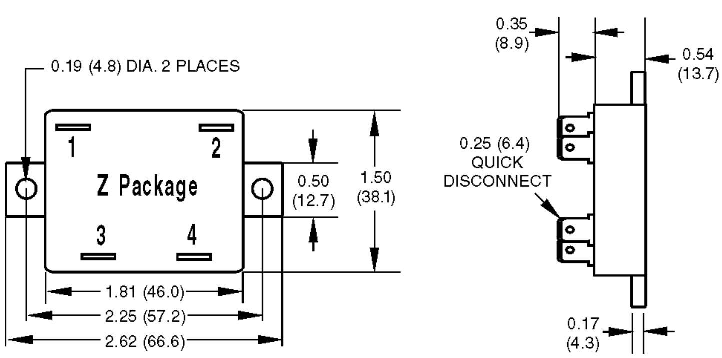
Note: ***60 Hz

Connection Diagram



*Control Current varies with control voltage. See "Control Current Calculation" on page 17 for information.

Dimensional Drawings



NOTE: All dimensions are nominal. We do not recommend mounting the terminal side of the SSR to a flat PCB (printed circuit board) or other flat surface, because there may be some variation in terminal height or alignment from one terminal to another and from one SSR to another.

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Solid-State Relays

Printed Circuit Series Specifications

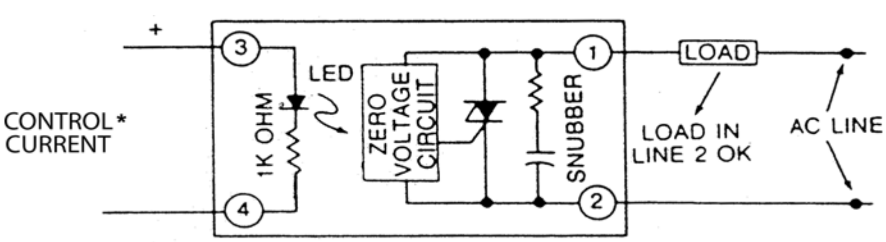
AC Power: MP and P Series

The MP Series packaging is designed with a minimum footprint to allow maximum relay density on the printed circuit board. The P Series power relays provide low-profile for 0.5-inch (12.7 mm) center mounting on printed circuit boards. Operating temperature: –40 °C to 100 °C.

	MP120D2 or P120D2	**MP120D4 or P120D4**	**MP240D2 or P240D2**	**MP240D4 or P240D4**	**MP380D4**
Nominal AC Line Voltage	120	120	240	240	380
Nominal Current Rating Amps	2	4	2	4	4
1 cycle Surge (Amps) Peak	20	85	20	85	85
Nominal Signal Input Resistance (Ohms)	1000	1000	1000	1000	1000
Signal Pick-up Voltage	3VDC*** (24V allowed)	3VDC*** (24V allowed)	3VDC*** (24V allowed)	3VDC*** (24V allowed)	3VDC*** (24V allowed)
Signal Drop-out Voltage	1 VDC	1 VDC	1 VDC	1 VDC	1 VDC
Peak Repetitive Voltage Maximum	600	600	600	600	800
Maximum Output Voltage Drop	1.6 volts	1.6 volts	1.6 volts	1.6 volts	1.6 volts
Off-State Leakage mA Maximum**	5 mA	5 mA	5 mA	5 mA	5 mA
Operating Voltage Range (Volts AC)	12–140	12–140	24–280	24–280	24–420
I^2t Rating t=8.3 (ms)	2	30	2	30	30
Isolation Voltage	4,000 V_{RMS}	4,000 V_{RMS}	4,000 V_{RMS}	4,000 V_{RMS}	4,000 V_{RMS}
θjc* °C/Watt	20	6.5	20	6.5	6.5
Dissipation Watts/Amp	1.2	1.2	1.2	1.2	1.2
Rating (Motor Load)	1 FLA at 120 VAC 6 LRA at 120 VAC	2.5 FLA at 240 VAC 6 LRA at 240 VAC	1 FLA at 120 VAC 15 LRA at 120 VAC	2.5 FLA at 240 VAC 15 LRA at 240 VAC	2.5 FLA at 380 VAC 15 LRA at 380 VAC

Notes: θjc* = Thermal resistance from internal junction to base. Maximum internal junction temperature is 110 °C.
** Operating Frequency: 25 to 65 Hz (operates at 400 Hz with 6 times the offstate leakage)
*** = P Series 32 volts maximum.

Connnection Diagram



NOTE: Part numbers ending in -17 are replacement parts only. Their specifications are identical to the same part number without the -17. For example, P240D4-17 is identical to P240D4.

*Control Current varies with control voltage. See "Control Current Calculation" on page 17 for information.

AC Power: MP and P Series (cont.)

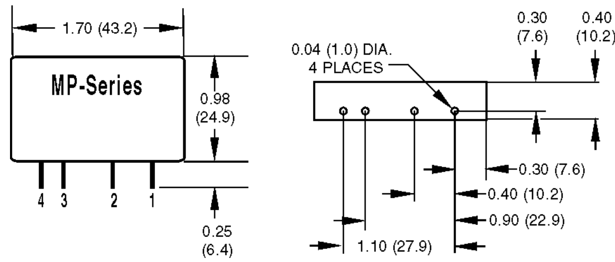
Surge Current Data

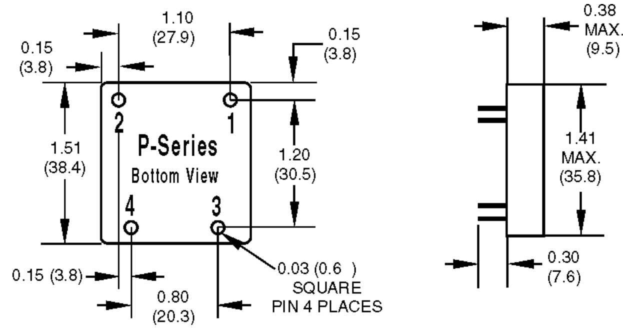
Time (Seconds)	Time* (Cycles)	2-Amp Peak Amps	4-Amp Peak Amps
0.017	1	20	85
0.050	3	18	66
0.100	6	15	53
0.200	12	11	45
0.500	30	9	37
1	60	8.5	31
2	120	8	28
3	180	7.5	27
4	240	7	26
5	300	6.5	25
10	600	6	24

Note: *60 Hz

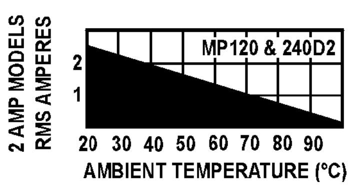
Dimensional Drawings

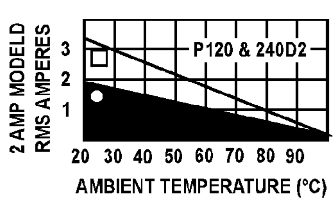
NOTE: All dimensions are nominal.

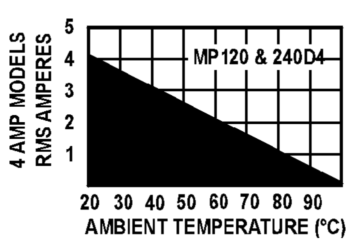


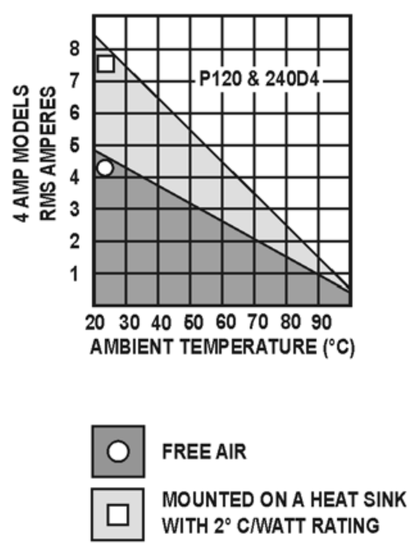


Thermal Ratings









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Solid-State Relays

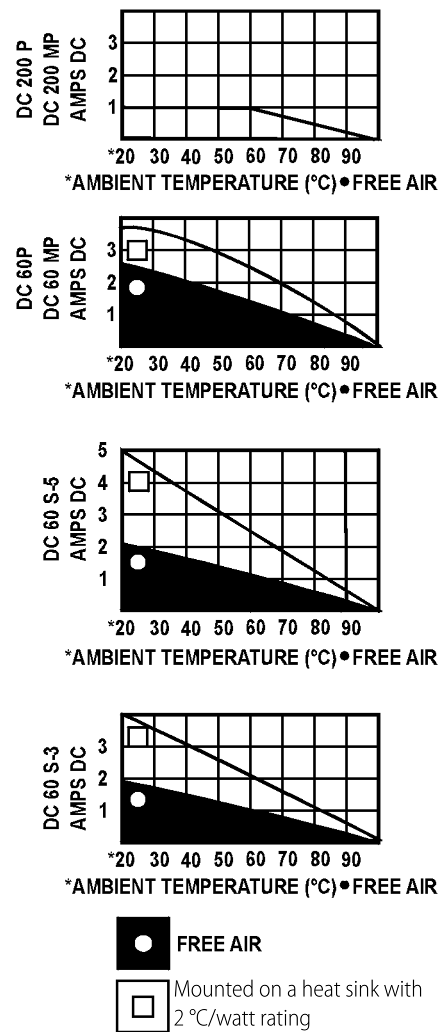
DC Switching Series Specifications

	DC60P or DC60MP	DC200P or DC200MP	DC60S-3	DC60S-5
Operating Voltage Range	5–60 VDC	5–200 VDC	5–60 VDC	5–60 VDC
Forward Voltage Drop	1.5 volts at 3 amps	1.5 volts at 1 amp	1.5 volts at 3 amps	1.5 volts at 5 amps
Nominal Currrent Rating	3 amps	1 amp	3 amps	5 amps
Off-State Blocking	60 VDC	250 VDC	60 VDC	60 VDC
Signal Pickup Voltage	3 VDC 32 Volts* allowed	3 VDC 32 Volts* allowed	3 VDC 32 Volts allowed	3 VDC 32 Volts allowed
Signal Dropout Voltage	1 VDC	1 VDC	1 VDC	1 VDC
Signal Input Impedance	1,000 ohms	1,000 ohms	1,000 ohms	1,000 ohms
1 Second Surge	5 amps	2 amps	5 amps	10 amps
Operating Temp. Range	–40 °C to 100 °C	–40 °C to 100 °C	–40 °C to 100 °C	–40 °C to 100 °C
Isolation Voltage	4,000 V_{RMS}	4,000 V_{RMS}	4,000 V_{RMS}	4,000 V_{RMS}
Off-State Leakage	1 mA maximum	1 mA maximum	1 mA maximum	1 mA maximum
Package Type	P/MP series	P/MP series	Power series	Power series
Turn-on Time	100 usec	100 usec	100 usec	100 usec
Turn-off Time	750 usec	750 usec	750 usec	750 usec

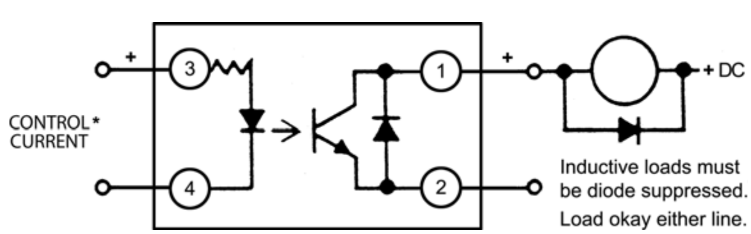
Note: *MP series maximum allowed control signal is 24 VDC.

NOTE: When controlling an inductive load, like a solenoid or coil, a commutating diode must be used. Install the commutating diode across the terminals of the load (not the SSR terminals). This will protect the SSR from damage caused by voltage spikes when turning off the load.

Thermal Ratings



Model DC60MP Basic Schematic (also applies to the other SSRs on this page)

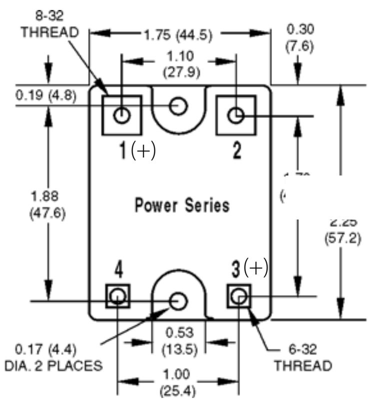


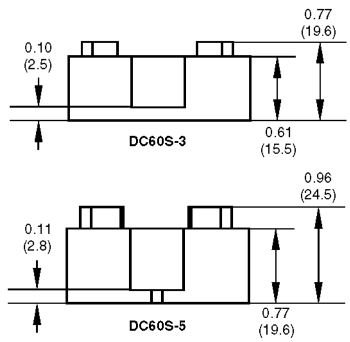
*Control Current varies with control voltage. See "Control Current Calculation" on page 17 for information.

Dimensional Drawings

NOTE: All dimensions are nominal. We do not recommend mounting the terminal side of a Power Series or Z series SSR to a flat PCB (printed circuit board) or other flat surface, because there may be some variation in terminal height or alignment from one terminal to another and from one SSR to another.

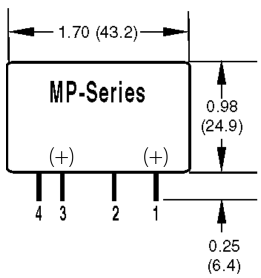
MP series and P series are designed to mount on PCBs.

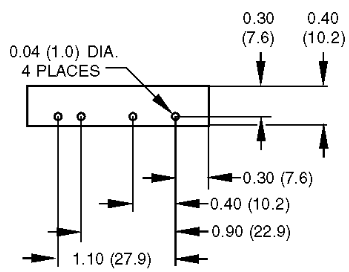


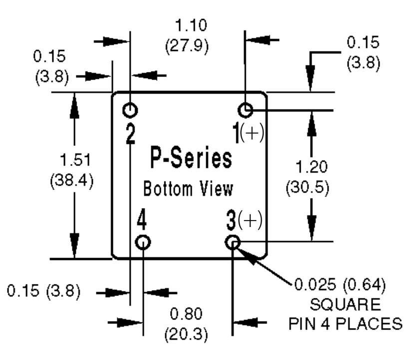


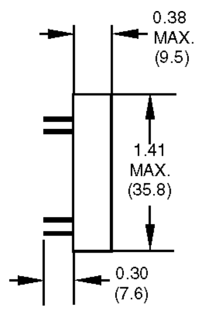
Side view: Part numbers DC60S3, 120D3, and 240D3 only

Side view: All other part numbers









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HS Series Specifications

The HS Series features an integrated heatsink, which makes them so cool. Because there is less thermal resistance internal to the unit than in a standard SSR mounted to the same heat sink, heat dissipates more easily. The built-in heatsink means you don't have to select a heatsink, and installation is much easier. Each HS-series SSR has built-in hardware for screw mounting and a built-in DIN-rail adapter clip for mounting to a 35mm DIN rail.

Model Number	**240D30-HS**	**480D25-HS**	**575D30-HS**
Nominal AC Line Voltage	240	480	575
Operating Voltage Range (Volts AC)	24–280	100–530	100–600
Peak Repetitive Voltage Maximum	600	1000	1200
Off-State Leakage (mA) Maximum**	5 mA	10 mA	12 mA
Nominal Output Voltage Drop (RMS)	1.0 volts	1.0 volts	1.0 volts
Nominal Current Rating (Amps)	30	25	30
1 cycle Surge (Amps) Peak	610	610	610
I^2t Rating t=8.3 (ms)	1550	1550	1550
Isolation Voltage (transient 4KV)	$2{,}500V_{RMS}$	$2{,}500V_{RMS}$	$2{,}500V_{RMS}$
Dissipation (Nominal Watts/Amp)	1.0	1.0	1.0
Signal Pick-up Voltage	4VDC (32V allowed)	4VDC (32V allowed)	4VDC (32V allowed)
Signal Drop-out Voltage	1 VDC	1 VDC	1 VDC
Nominal Signal Input Resistance (Ohms)	730	1000	1000
θja* (°C/Watt)	2.2	2.2	2.2

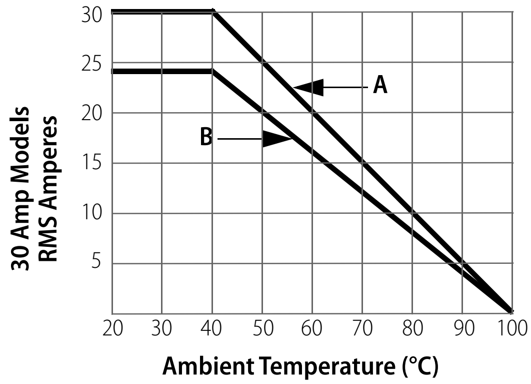
Note: θja* = Thermal resistance from internal junction to ambient. Maximum internal junction temperature is 110 °C.
** Operating Frequency: 25 to 65 Hz (operates at 400 Hz with 6 times the offstate leakage)

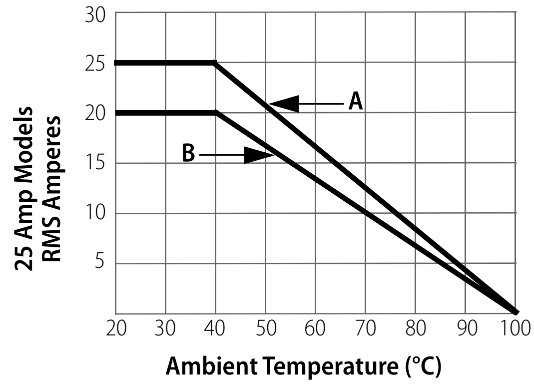
Surge Current Data, Peak Amps

Time Second	**60HZ**	**50HZ**
0.0167	610	580
0.05	394	375
0.1	300	386
0.2	230	219
0.5	164	156
1	126	120
2	112	106
3	92	87
4	89	85
5	85	81
10	79	75

HS-series (cont.)

Thermal Ratings



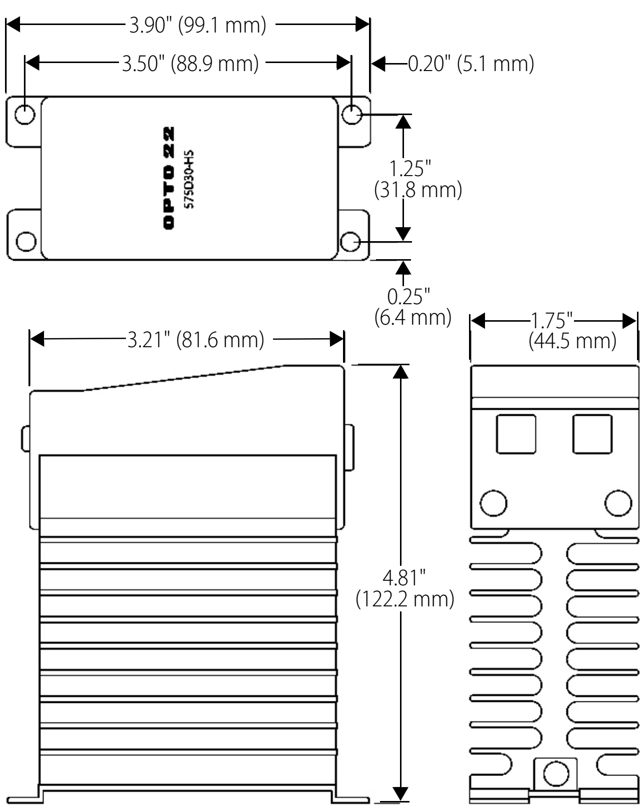


A: Single relay or with 0.75″ spacing between relays. Derate above 40 °C; subtract 0.5 amp/°C.

B: Three relays side by side with 0.25″ spacing. All relays with the same load. Derate above 40 °C; subtract 0.4 amp/°C.

NOTE: This data is for SSRs mounted to a horizontal surface. To take advantage of the cooling effect of natural air flow, we recommend mounting HS-series SSRs to a vertical surface with the Opto 22 logo right side up as shown here.

Dimensional Drawing



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Applications: Tips

Heat Sink Calculation

Like all semiconductor devices, SSR current ratings must be based on maximum internal junction temperature. All Opto 22 SSRs operate conservatively at maximum internal junction temperatures of 110 °C. Use the equation below to calculate the maximum allowable heat sink thermal resistance for your application. It is good engineering practice to provide a margin for error instead of running the application right at the limits. If your application is near the thermal limit, it can be helpful to add a fan to move air across the heat sink.

$$\text{Heat Sink Max Thermal Resistance (°C/Watt)} = \frac{\left[\text{SSR Max allowed internal junction temp} - \text{Max Ambient Temp} - \left[\text{Max Load Current} \times \text{SSR Heat Dissipation Factor} \times \text{SSR Thermal Resistance}\right]\right]}{\left[\text{Max Load Current} \times \text{SSR Heat Dissipation Factor}\right]}$$

IMPORTANT: Thermally conductive grease must be used between the relay base and the heat sink.

Sample Calculation 1

120-volt, 20-amp load; 50 °C ambient air temperature

Model: 120D25 SSR.

See the last two columns of the table on page 4 for *thermal resistance* and *dissipation* values for the 120D25. Also, see the note at the bottom of the table.

Dissipation: 1.3 watts/amp
Thermal resistance: 1.2 °C/watt
Maximum junction temperature: 110 °C

The calculation would be as follows:

Example for 120D25

			Units	
Max Ambient Temp	=	50.00	° C	
Max Load Current	=	20.00	Amps	
SSR Heat Dissipation Factor	=	1.30	Watts/Amp	From Data Sheet
SSR Thermal Resistance	=	1.20	° C/Watt	
SSR Max allowed internal junction temp	=	110.00	° C	
Heat Sink Max Thermal Resistance (°C/Watt)	=	(110 - 50 - (20 x 1.3 x 1.2)) / (20 x 1.3)	° C/Watt	
Heat Sink Max Thermal Resistance (°C/Watt)	=	28.8 / 26	° C/Watt	
Heat Sink Max Thermal Resistance (°C/Watt)	=	1.1	° C/Watt	

This calculation indicates that you should select a heat sink with a thermal resistance of less than 1.1 °C/watt.

Sample Calculation 2

240-volt,18-amp load, 25 °C ambient air temperature

Model: 240D45

See the last two columns of the table on page 4 for thermal resistance and dissipation values for the 240D45. Also, see the note at the bottom of the table.

Dissipation: 0.9 watts/amp
Thermal resistance: 0.67 °C/watt
Maximum junction temperature: 110 °C

The calculation would be as follows:

Example for 240D45			Units	
Max Ambient Temp	=	25.00	° C	
Max Load Current	=	18.00	Amps	
SSR Heat Dissipation Factor	=	0.90	Watts/Amp	From Data Sheet
SSR Thermal Resistance	=	0.67	° C/Watt	From Data Sheet
SSR Max allowed internal junction temp	=	110.00	° C	From Data Sheet
Heat Sink Max Thermal Resistance (°C/Watt)	=	(110 - 25 - (18 x 0.9 x 0.67)) / (18 x 0.9)	° C/Watt	
Heat Sink Max Thermal Resistance (°C/Watt)	=	74.146 / 16.2	° C/Watt	
Heat Sink Max Thermal Resistance (°C/Watt)	=	4.6	° C/Watt	

This calculation indicates that you should select a heat sink with a thermal resistance of less than 4.6 °C/watt.

Duty Cycle Calculation

When solid-state relays are operated in an on/off mode, it may be advantageous to calculate the RMS value of the current through the SSR for heat sinking or determining the proper current rating of the SSR for the given application.

I_{RMS} = RMS value of load or SSR

T_1 = Time current is on

T_2 = Time current is off

I_{ON} = RMS value of load current during on period

$$I_{RMS} = \sqrt{\frac{(I_{ON})^2 \times T_1}{T_1 + T_2}}$$

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Solid-State Relays

Transformer Loads

Careful consideration should be given to the selection of the proper SSR for driving a given transformer. Transformers are driven from positive saturation of the iron core to negative saturation of the core each half cycle of the alternating voltage. Large inrush currents can occur during the first half cycle of line voltage if a zero-voltage SSR happens to turn on during the positive half cycle of voltage when the core is already in positive saturation. Inrush currents greater than 10 times rated transformer current can easily occur. The following table provides a guide for selecting the proper SSR for a given transformer rating.

120-Volt Transformers	
SSR MODEL	TRANSFORMER
P or MP 120D2	100 VA
Z120D10	500 VA
120D3	100 VA
P or MP 120D4	250 VA
120D10 or 120A10	500 VA
120D25 or 120A25	1 KVA
120D45	2 KVA
240-Volt Transformers	
P or MP240D2	200 VA
Z240D10	1 KVA
120D3	200 VA
P or MP240D4	500 VA
240D10 or 240A10	1 KVA
240D25 or 240A25	2 KVA
240D45	4 KVA
480-Volt Transformers	
SSR MODEL	TRANSFORMER
480D10-12	5-Amp Primary
480D15-12	5-Amp Primary

Solenoid Valve and Contactor Loads

All Opto 22 SSRs are designed to drive inductive loads such as solenoid valves and electromechanical contactors. The built-in snubber in each SSR assures proper operation into inductive loads. The following table is a guide in selecting an SSR to drive a solenoid or contactor.

120-Volt Coils		
SSR CURRENT RATING	SOLENOID	CONTACTOR
2-Amp	1-Amp	NEMA Size 4
4-Amp	3-Amp	NEMA Size 7
240-Volt Coils		
SSR CURRENT RATING	SOLENOID	CONTACTOR
2-Amp	1-Amp	NEMA Size 7
4-Amp	3-Amp	NEMA Size 7

Control Current Calculation

All Opto 22 DC-controlled SSRs have a control circuit consisting of 1000 ohms in series with an Optocoupler LED. The LED will drop 1 volt, so the voltage across the internal resistor will be 1 volt less than the control voltage.

The control current (I_C) can be calculated from the control voltage (V_C) as follows:

$I_C = (V_C - 1)/1000$

Examples:

3 VDC control voltage:
$I_C = (3 - 1)/1000 = 0.002$ A (2 mA)

32 VDC control voltage:
$I_C = (32 - 1)/1000 = 0.031$ A (31 mA)

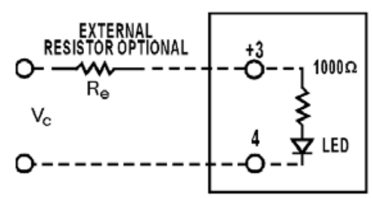
For control voltages above 32 VDC, an external resistor can be added in series with the SSR to limit the control current. Also, if the device driving the control current to the SSR is limited, you can limit the control current by using an external resistor (R_e).

$I_C = (V_C - 1)/ (R_e + 1000)$

$R_e = [(V_C - 1)/(I_C)] -1000$

To limit the control current to 2 mA, this simplifies to:

$R_e = 500 (V_C - 3)$



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Solid-State Relays

Opto 22 SSRs for controlling single-phase motors are shown in the following tables:

120-Volt Single-Phase Non-Reversing Motors	
SSR Model	MOTOR RATING
P or MP120D2	1 Amp
Z120D10	1/4 HP
120D3	1-1/2 Amp
P or MP120D4	1-1/2 Amp
120D10 or 120A10	1/4 HP
120D25 or 120A25	1/3 HP
120D45	3/4 HP

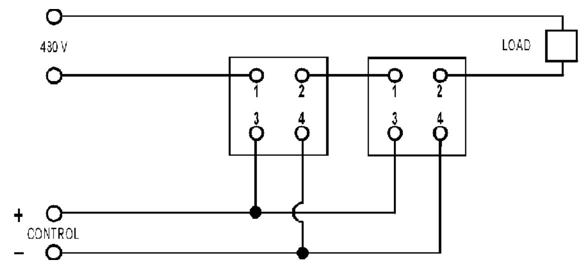
240-Volt Single Phase Non-Reversing Motors	
SSR Model	MOTOR RATING
P or MP240D2	1 Amp
Z240D10	1/4 HP
240D3	1-1/2 Amp
P or MP240D4	1-1/2 Amp
240D10 or 240A10	1/3 HP
240D25 or 120A25	1/2 HP
240D45	1-1/2 HP

120-Volt Single-Phase Reversing Motors	
SSR Model	MOTOR RATING
P or MP240D2	1 Amp
Z240D10	1/4 HP
240D3	1-1/2 Amp
P or MP240D4	1-1/2 Amp
240D10 or 240A10	1/4 HP
240D25 or 120A25	1/3 HP
240D45	3/4 HP

240-Volt Single-Phase Reversing Motors	
SSR Model	MOTOR RATING
480D10-12	1/4 HP
480D15-12	1/4 HP

Solid-State Relays in Series

In applications requiring higher voltage, two Opto 22 SSRs may be operated in series for double the voltage rating. The built-in snubber in each SSR assures proper voltage sharing of the two SSRs in series. In the following diagram, two 240-volt, 45-amp SSRs are connected in series for operation on a 480-volt line. The control is shown with a parallel hook-up but it should be noted that a serial connection can also be implemented.



Lamp Loads

Since all Opto 22 AC output SSRs use zero-voltage turn-on, they are ideal for driving incandescent lamps, because the initial inrush current into a cold filament is reduced. The life of the lamp is increased when switched by a zero-voltage turn-on SSR. The following table is a guide to selecting an Opto 22 SSR for switching a given incandescent lamp.

120 Volt Lamps	
SSR CURRENT RATING	LAMP RATING
2-Amp	100 Watt
4-Amp	400 Watt
10-Amp	1 Kilowatt
25-Amp	2 Kilowatt
45-Amp	3 Kilowatt
240 Volt Rating	
SSR CURRENT RATING	LAMP RATING
2-Amp	200 Watt
4-Amp	800 Watt
10-Amp	2 Kilowatt
25-Amp	4 Kilowatt
45-Amp	6 Kilowatt

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Solid-State Relays

Heater Loads

Care should be taken in selecting a SSR for driving a heater load if the load is cycled on and off in a continuous manner as might occur in a temperature control application. Constant cycling can cause thermal fatigue in the thyristor chip at the point where the chip bonds to the lead frame. Opto 22 employs a thick copper lead frame for mounting the SCR chips in the power series SSRs to eliminate thermal fatigue failures. In addition, Opto 22 recommends operating any SSR at 75% rated current for cycling heater loads to ensure complete reliability.

The following table is a guide to selecting the proper SSR for a given heater load.

Nominal SSR Current Rating	Maximum Recommended Heater Current
2-Amp	1½-Amp
4-Amp	2½-Amp
10-Amp	7½-Amp
25-Amp	18-Amp
45-Amp	35-Amp
10 480V	8-Amp
10 480V	8-Amp

Single-Phase Reversing Motor Control

The circuit diagram below illustrates a typical 1 Ø motor winding inductance and the phase shift capacitor can cause twice-line voltage to appear across the open SSR. A 240-volt SSR should be used for a 120-volt line. During the transition period when one SSR is turned on and the other SSR is going off, both SSRs may be on. In this case, the capacitor may discharge through the two SSRs, causing large currents to flow, which may destroy the SSRs. The addition of RL as shown will protect the SSRs from the short circuit capacitor discharge current.

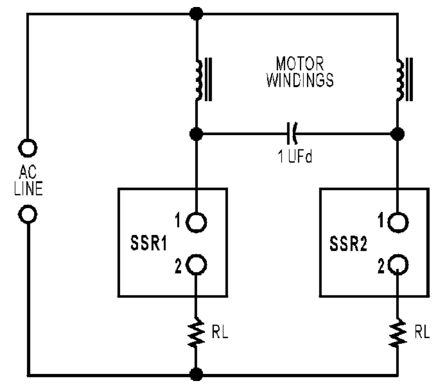
CALCULATE RL as:

$$RL = \frac{1.4\ EAC}{10 \times \text{SSR full load rating}}$$

EXAMPLE: 10 amp SSR
120 V AC Line

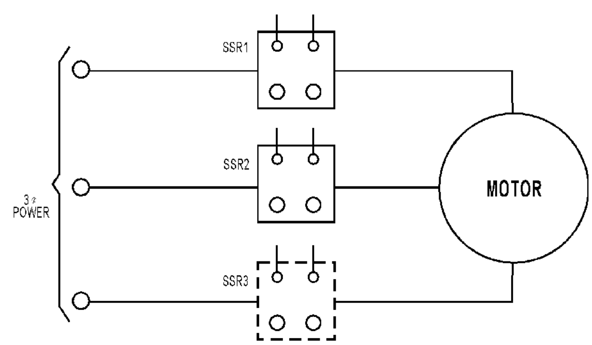
$$RL = \frac{1.4 \times 120}{10 \times 10} = 1.7\ \text{ohm}$$

Single-Phase Reversing Motor Control (cont.)



The resistors are unnecessary if the control circuit is designed to ensure that one SSR is off before the other SSR is on.

Three-Phase Motor Control



Three-phase motors may be controlled by solid-state relays as shown. A third SSR as shown is optional, but not necessary. The control windings may be connected in series or parallel. Care should be taken to ensure that the surge current drawn by the motor does not exceed the surge current rating of the SSR.

240 Volt Three-Phase Motor	
SSR MODEL	MOTOR
Z240D10	3/4 HP
240D10	3/4 HP
240A10	3/4 HP
240D25	2 HP
240A25	2 HP
240D45	3 HP

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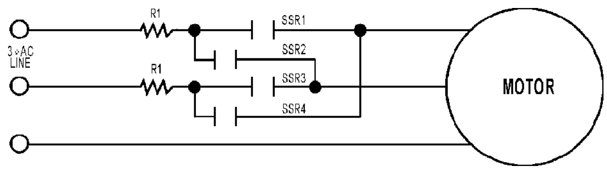
480 Volt Three-Phase Motors	
SSR MODEL	MOTOR
480D10-12	1-½ HP
480D15-12	1-½ HP

Three-Phase Reversing Motor Control



Three-phase reversing motor control can be implemented with four SSRs as shown in the connection diagram. The SSRs work in pairs with SSR1 and SSR3 operated for rotation in one direction and SSR2 and SSR4 operated for rotation in the reverse direction. The resistor R1 as shown in the connection diagram protects against line-to-line shorts if SSR1 and SSR4 or SSR3 and SSR2 are on at the same time during the reversing transition period. Use the following table as a guide to the proper selection of an SSR for this application.

Opto 22 Relay	Motor Full Load Rating	Resistor for 120V line	Resistor for 240V line
3-Amp	1.25-Amp	4 ohm 50 W	8 ohm 50 W
10-Amp	5-Amp	1 ohm 100 W	2 ohm 100 W
25-Amp	8-Amp	.5 ohm 100 W	1 ohm 100 W
45-Amp	16-Amp	.25 ohm 150 W	.5 ohm 150 W
15-Amp	5-Amp	1 ohm 100 W	2 ohm 100 W

FAQ: SSR Applications

Q : What is a solid-state relay?

A: A solid-state relay (SSR) is a semiconductor device that can be used in place of a mechanical relay to switch electricity to a load in many applications. Solid-state relays are purely electronic, normally composed of a low current "control" side (equivalent to the coil on an electromechanical relay) and a high-current load side (equivalent to the contact on a conventional relay). SSRs typically also feature electrical isolation to several thousand volts between the control and load sides. Because of this isolation, the load side of the relay is actually powered by the switched line; both line voltage and a load (not to mention a control signal) must be present for the relay to operate.

Q : What are the advantages of using an SSR over a mechanical relay?

A: There are many applications that require a moderate amount of power (W to kW) to be switched on and off fairly rapidly. A good example would be the operation of a heater element in a controlled-temperature system. Typically, the amount of heat put into the system is regulated using pulse-width modulation turning a fixed-power heating element on and off for time periods ranging from seconds to minutes. Mechanical relays have a finite cycle life, as their components tend to wear out over thousands to millions of cycles. SSRs do not have this problem; in the proper application, they could be operated almost infinitely.

Q : What are the limitations of using an SSR?

A: SSRs have a few limitations when compared to the capabilities of their mechanical counterparts. First, because the relay is semiconductor-based, it will never turn all the way on, nor off. This means that in the "on" state, the relay still has some internal resistance to the flow of electricity, causing it to get hot. When in the "off" state, the relay will exhibit a small amount of leakage current, typically a few mA. This leakage can conspire to keep some loads, especially ones with a high impedance, from turning off! Additionally, SSRs are more sensitive to voltage transients; while Opto 22 relays are very well transient-protected, if a relay gets hit hard enough a sufficient number of times, it will die or degrade. This makes SSRs less ideal for driving highly inductive electromechanical loads, such as some solenoids or motors. SSRs should also never be used for applications such as safety power disconnects, because even in the off state, leakage current is present. Leakage current through an SSR also implies the presence of a potentially high voltage. Even though the relay is not conducting a large amount of current, the switched terminal will still be "hot," and thus dangerous.

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Solid-State Relays

Q: Which SSRs should I use with a printed circuit board (PCB)?

A: If you are mounting SSRs to a PCB, use the MP or P series SSRs , which are designed for that purpose.

We do not recommend mounting the terminal side of a Power Series or Z series SSR to a flat PCB (or to any other flat surface), because there may be some variation in terminal height or alignment from one terminal to another and from one SSR to another.

Q : Do you make multi-pole or multi-throw SSRs?

A: Opto 22 manufactures only single-pole, single-throw SSRs. If multi-phase operation is required, just use a relay on each phase. Because of the limitations on semiconductor devices of the type used in SSRs, it is not practical to build single-device multi-throw SSRs. However, an alternative to multi-throw operation may be accomplished with multiple relays.

Q : Can I hook up SSRs in parallel to achieve a higher current rating?

A: No. There is no way to guarantee that two or more relays will turn on simultaneously when operated in parallel. Each relay requires a minimum voltage across the output terminals to function; because of the optical isolation feature, the "contact" part of the SSR is actually powered by the line it switches. One relay turning on before the other will cause the second relay to lose its turn-on voltage, and it won't ever turn on, or at least not until the first relay fails from carrying too much current.

Q : What does a "zero-crossing" turn-on circuit refer to?

A: An AC sine wave will be positive for the first half of each cycle and negative for the second half of each cycle. The voltage will cross through zero when the sine wave changes from the positive half-cycle to the negative half-cycle, and vice versa. So the voltage crosses through zero twice with each full AC sine wave cycle. "Zero-crossing" turn-on means that the SSR will only turn on when the AC sine wave passes through zero voltage. The actual turn-on will occur at or near zero voltage. All Opto 22 AC output solid-state relays are designed with a zero-crossing turn-on circuit. Zero-voltage turn-on has the benefit of minimizing electrical noise. All Opto 22 AC output solid-state relays use a zero-current turn-off circuit as well.

Q : Can I use an AC SSR to switch DC?

A: No. Because of the zero-crossing circuit described above, the relay will most likely never turn on, and even if it is on, it will most likely not be able to be turned off.

Q : Can I use a DC SSR to switch AC?

A: No. The semiconductor device used in Opto 22's DC SSRs is polarized. It may break down and conduct for the portion of the waveform that is reversed in polarity.

Q : Can a DC SSR be used to switch an analog signal?

A: This is not recommended at all. First, the voltage drop across the relay will cause signal loss. Second, the conduction characteristics of the SSR are very non-linear at low operating voltages and currents. Use a mechanical relay; it will work much better.

Q : What agency approvals do your SSRs carry?

A: In general, Opto 22 relays carry UL, CSA, and CE approval. See **http://support.opto22.com.** Additionally, some SSRs contain VDE-approved optocouplers; contact Opto 22 for more information.

FAQ: SSR Troubleshooting

Q : My SSR does not function anymore. What may have happened?

A: There is no "normal" mode of failure for SSRs. They just stop working, by refusing to turn on or off. An improper installation is often to blame for an SSR failure, as these are very simple, reliable devices. If you have a failed SSR, it is important to look at the normal operating parameters of that relay within the larger system to make sure that the relay being used is appropriate to the application, and that the relay is being properly installed in the system. The three most common causes of SSR failure are as follows:

- **SSR improperly matched to load.** The relay was destroyed by overheating from carrying too much current too long.
- **SSR insufficiently protected.** Remember, a semiconductor is less tough than a simple metal contact. Reverse voltages exceeding the PRV rating of the relay will cause damage. Voltage spikes on the switched line, perhaps from inductive kickback, may have destroyed one or more of the internal switching devices. Remember to use snubbers, transorbs, MOVs, and/or commutating diodes on highly inductive loads.
- **SSR improperly installed.** The SSR was not mounted to a large enough heat sink, or no thermal compound was used, causing the relay to overheat. Also, insufficient tightening of the load terminals can cause arcing and ohmic heating of the relay. Opto 22 recommends 18 inch-pounds of torque on the load screw terminals. Similar failures have also been attributed to the use of

crimp-on terminal lugs or spades; make sure such terminals are tightly crimped, and even drip some solder into the joint to ensure good electrical contact and protection from corrosion.

Q : How can I test my SSR?

A: It is not possible to test an SSR by the same methods used to test mechanical relays; a typical SSR will always show an infinite impedance to a resistance meter placed across the output terminals. There are a few reasons for this. First, the SSR requires a small amount of power to operate, derived from whatever voltage source is placed on the load terminals. A typical multimeter will not supply sufficient voltage to cause the relay to change state. Second, AC SSRs contain zero-voltage turn-on and zero-current turn-off circuits. The SSR will not be able to turn on unless there is AC voltage connected to the output terminals. Most test equipment will supply a DC voltage to the relay, so it will never see the zero-voltage transition it requires to turn on. To test an SSR, it is best to operate it at the actual line voltage it will be used at, driving a load such as a large light bulb.

Q : I have an SSR driving a load. The load turns on okay, but never seems to turn off, unless I remove power from the relay entirely. What might be happening?

A: This is normally a problem when using an SSR with a high-impedance load, such as a neon lamp or a small solenoid. Loads like these often have relatively large initial currents, but relatively small "hold in" currents. The result is that the off-state leakage current through the relay (see previous section) is insufficient to cause the load to turn on to start with, but sufficient to keep it on, once started. The solution is to place a power resistor, sized for 8–10 times the rated maximum leakage current for the SSR in parallel with the load. Make sure that this resistor has a high enough power rating for the application. For example, for a 5 mA leakage current at 120 VAC, a resistor drawing 50 mA would be desirable. Using Ohm's Law, the resistor value becomes 2,400 ohms. This resistor will dissipate 6 watts, so a 7.5 or 10-watt size power resistor should be used.

Q : I have a new AC SSR driving a solenoid. It turns on okay once, but will not turn on again. What is going on?

A: Some solenoids, some types of halogen lights, and some types of strobe lights incorporate a diode in series with the coil or filament. This causes the light to behave as a half-wave rectifier. Opto 22 SSRs have a built-in R-C snubber circuit in parallel with the output. The capacitor in this circuit charges up but cannot discharge through the series diode, causing a voltage to appear across the SSR terminals. Because the SSR must detect the AC waveform cross through zero volts on the load terminals, it will not be able to turn on again. The solution here would be to put a high-value resistor (several tens of Kohms) across the terminals of the relay, to allow the capacitor to drain its charge.

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- PAC Project™ Software Suite
- SNAP PAC brains
- SNAP I/O™

SNAP PAC Controllers

SNAP PAC programmable automation controllers handle a wide range of digital, analog, and serial functions for data collection, remote monitoring, process control, and discrete and hybrid manufacturing.

For IIoT applications and easier integration with company systems, standalone and rack-mounted SNAP PACs include a built-in HTTP/HTTPS server and **RESTful API** (application program interface). The REST API gives you secure, direct access to I/O and variable data using your choice of programming languages. No middleware, protocol converters, drivers, or gateways needed.

Based on open Ethernet and Internet Protocol (IP) standards, SNAP PACs make it easier to build or extend a system without the expense and limitations of proprietary networks and protocols.

PAC Project Software Suite

Opto 22's PAC Project Software Suite offers full-featured, cost-effective control programming, HMI (human machine interface), OPC server, and database connectivity software.

Control programming includes both easy-to-learn flowcharts and optional scripting. Commands are in plain English; variables and I/O point names are fully descriptive.

PAC Project Basic offers control and HMI tools and is free for download on our website, www.opto22.com. PAC Project Professional, available for separate purchase, adds one SoftPAC software-based controller, OptoOPCServer, OptoDataLink, options for controller redundancy or segmented networking, and support for legacy Opto 22 serial *mistic*™ I/O units.

SNAP PAC Brains

While SNAP PAC controllers provide central control and data distribution, SNAP PAC brains provide distributed intelligence for I/O processing and communications. Brains offer analog, digital, and serial functions, including thermocouple linearization, local PID loop control, watchdog, totalizing, and much more.

SNAP I/O

I/O provides the local connection to sensors and equipment. Opto 22 SNAP I/O offers 1 to 32 points of reliable I/O per module. Analog, digital, and serial modules are mixed on one mounting rack and controlled by a SNAP PAC brain or rack-mounted PAC.

Quality

Founded in 1974, Opto 22 has established a worldwide reputation for high-quality products. All are made in the U.S.A. at our manufacturing facility in Temecula, California.

Because we test each product twice before it leaves our factory, rather than only testing a sample of each batch, we can guarantee most solid-state relays and optically isolated I/O modules for life.

Free Product Support

Opto 22's California-based Product Support Group offers free, comprehensive technical support for Opto 22 products from engineers with decades of training and experience. Support is available in English and Spanish by phone or email, Monday–Friday, 7 a.m. to 5 p.m. PST.

Additional support is always available on our website: how-to videos, OptoKnowledgeBase, self-training guide, troubleshooting and user's guides, and OptoForums.

In addition, hands-on training is available for free at our Temecula, California headquarters, and you can register online.

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Opto 22 products are sold directly and through a worldwide network of distributors, partners, and system integrators. For more information, contact Opto 22 headquarters at 800-321-6786 (toll-free in the U.S. and Canada) or 951-695-3000, or visit our website at www.opto22.com.

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- Standards and EC Directives:
  - Conforms to the following EC Directives:
    Machinery Directive
    Low Voltage Directive
    EN50047
    EN1088
    SUVA

- Approved Standards

Agency	Standard	File No.
TÜV Rheinland	EN60947-5-1	J9650735 (Positive opening: approved) ⊖
BIA	GS-ET-19	Mechanical lock: 9610568 Solenoid lock: 9704054
UL (see note)	UL508, CSA C22.2 No.14	E76675
SUVA	SUVA	Mechanical lock: E6190.d Solenoid lock: E6191.d

Note: CSA C22.2 No. 14 compliance was verified and approved by UL (Marked with c(UL)).

Ordering Information

MODEL NUMBER LEGEND

Switch

D4DL-□□□□-□
1 2 3 4 5

1. **Conduit Size (2-conduit)**
   1: Pg13.5
   2: $G^1/_2$
2. **Built-in Switch (with Safety Switch and Lock Monitor Switch Contacts)**
   C: 1NC/1NO slow-action contacts plus 1NC slow-action contact
   D: 2NC slow-action contacts plus 1NC slow-action contact
3. **Head Mounting Direction**
   F: Four mounting directions possible (Front-side mounting at shipping)
4. **Door Lock and Release**
   A: Mechanical lock / 24-VDC solenoid release
   B: Mechanical lock / 110-VAC solenoid release
   C: Mechanical lock / 230-VAC solenoid release
   G: 24-VDC solenoid lock / mechanical release
   H: 110-VAC solenoid lock / mechanical release
   J: 230-VAC solenoid lock / mechanical release
5. **Indicator**
   B: 10 to 115 VAC/VDC (with orange LED indicator)
   E: 100 to 250 VAC (with orange neon lamp indicator)

Operation Key

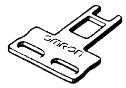
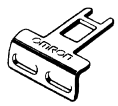
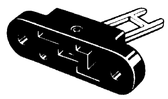
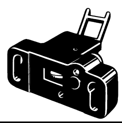
D4DS-K□
1

1. **Key Type**
   1: Horizontal mounting
   2: Vertical mounting
   3: Adjustable mounting (Horizontal)
   5: Adjustable mounting (Horizontal/Vertical)

SWITCHES

Description				Part number
Solenoid voltage/indicator	Lock and release types	Contact configuration (Slow-action) Approved force-separation NC contact	Connector size	
Solenoid: 24 VDC Orange LED: 10 to 115 VDC/VAC	Mechanical lock Solenoid release	1NC/1NO+1NC	PG13.5	**D4DL-1CFA-B**
			G1/2	**D4DL-2CFA-B**
		2NC+1NC	PG13.5	**D4DL-1DFA-B**
			G1/2	**D4DL-2DFA-B**
	Solenoid lock Mechanical release	1NC/1NO+1NC	PG13.5	**D4DL-1CFG-B**
			G1/2	**D4DL-2CFG-B**
		2NC+1NC	PG13.5	**D4DL-1DFG-B**
			G1/2	**D4DL-2DFG-B**
Solenoid: 110 VAC Orange LED: 10 to 115 VDC/VAC	Mechanical lock Solenoid release	1NC/1NO+1NC	PG13.5	**D4DL-1CFB-B**
			G1/2	**D4DL-2CFB-B**
		2NC+1NC	PG13.5	**D4DL-1DFB-B**
			G1/2	**D4DL-2DFB-B**
	Solenoid lock Mechanical release	1NC/1NO+1NC	PG13.5	**D4DL-1CFH-B**
			G1/2	**D4DL-2CFH-B**
		2NC+1NC	PG13.5	**D4DL-1DFH-B**
			G1/2	**D4DL-2DFH-B**
Solenoid: 230 VAC Orange neon lamp: 100 to 250 VAC	Mechanical lock Solenoid release	1NC/1NO+1NC	PG13.5	**D4DL-1CFC-E**
			G1/2	**D4DL-2CFC-E**
		2NC+1NC	PG13.5	**D4DL-1DFC-E**
			G1/2	**D4DL-2DFC-E**
	Solenoid lock Mechanical release	1NC/1NO+1NC	PG13.5	**D4DL-1CFJ-E**
			G1/2	**D4DL-2CFJ-E**
		2NC+1NC	PG13.5	**D4DL-1DFJ-E**
			G1/2	**D4DL-2DFJ-E**

■ OPERATION KEYS (ORDER SEPARATELY)

Type	Part number
Horizontal mounting 	**D4DS-K1**
Vertical mounting 	**D4DS-K2**
Adjustable mounting (Horizontal) 	**D4DS-K3**
Adjustable mounting (Horizontal/Vertical) 	**D4DS-K5**

Note: The operation keys are the same as for D4DS models.

■ ACCESSORIES (AVAILABLE IN US ONLY)

Description	Part number
Cable gland for D4DL 	**PG13.5 FITTING**
Conduit change adapter PG13.5 to 1/2-14NPT 	**PG13.5 to NPT ADAPTOR**

Specifications

■ APPROVED STANDARD RATINGS

TÜV (EN60947-5-1)

Item	LED type	Neon lamp type
Utilization category	AC-15	AC-15
Rated operating current (I_e)	6 A	3 A
Rated operating voltage (U_e)	115 V	250 V

Note: Use a 10-A fuse type gI or gG as a short-circuit protection device that conforms to IEC269.

UL/CSA (UL508, CSA C22.2 No. 14) A300

Rated voltage	Carry current	Current		Volt-amperes	
		Make	Break	Make	Break
120 VAC	10A	60 A	6 A	7,200 VA	720 VA
240 VAC		30 A	3 A		

■ CHARACTERISTICS

Degree of protection (see note 2)	IP65 (EN60947-5-1)
Life expectancy (see note 3)	Mechanical: 1,000,000 times min. Electrical: 500,000 times min.
Operating speed	0.05 to 0.5 m/s
Operating frequency	30 operations/minute max.
Rated frequency	50/60 Hz
Contact gap	2 x 2 mm min.
Positive opening force (see note 4)	58.84 N min. (EN60947-5-1)
Positive opening travel (see note 4)	10 mm min. (EN60947-5-1)
Holding force	500 N min. (GS-ET-19)
Insulation resistance	100 MΩ min. (at 500 VDC)
Rated insulation voltage (U_i)	300 V (EN60947-5-1)
Conventional enclosed thermal current (I_{the})	10 A (EN60947-5-1)
Rated impulse voltage (U_{imp})	Between terminals of same or different polarity, each terminal and ground, and each terminal and non-current-carrying metal part: 4 kV Between the solenoid and non-current-carrying metal part: 0.8 kV for 24 VDC solenoid, 2.5 kV for 110 VAC solenoid, and 4 kV for 230 VAC solenoid (EN60947-5-1)
Conditional short-circuit current	100 A (EN60947-5-1)
Pollution degree (operating environment)	3 (EN60947-5-1)
Protection against electric shock	Class II (double insulation)
Switching overvoltage	1,500 V max. (EN60947-5-1)
Contact resistance	25 mΩ max. (initial value)
Vibration resistance	Malfunction: 10 to 55 Hz, 0.75-mm single amplitude
Shock resistance	Mechanical: 1,000 m/s^2 min. Malfunction: 300 m/s^2 min.
Ambient temperature	Operating: −10°C to 55°C with no icing
Ambient humidity	Operating: 95% max.
Weight	Approx. 340 g (D4DL-1CFA-B)

Note: 1. The above values are initial values.
2. Although the switch box is protected from dust or water penetration, do not use the D4DL in places where foreign material may penetrate through the key hole on the head, otherwise switch damage or malfunctioning may occur.
3. The above mechanical or electrical life is ensured at an ambient temperature of 5°C to 35°C and an ambient humidity of 40% to 70%.
4. These values must be satisfied to ensure safe operation.

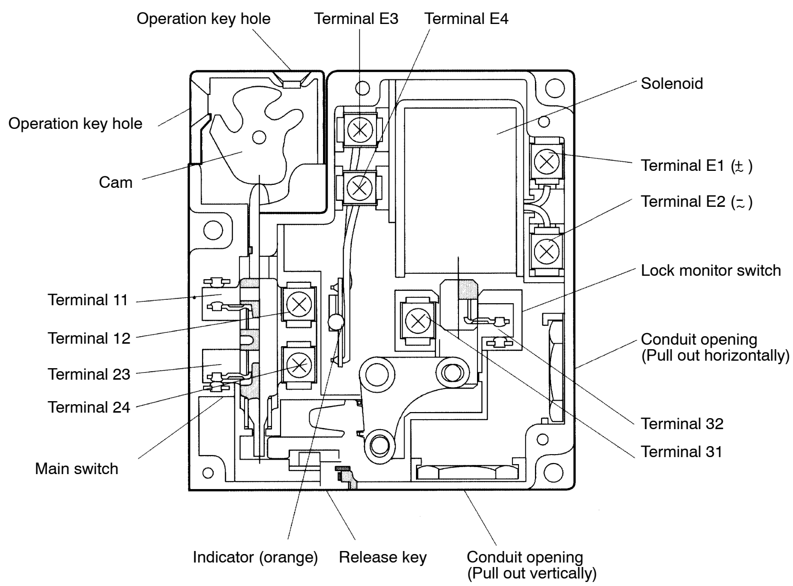
Solenoid Characteristics

Item	24 VDC	110 VAC	230 VAC
Rated operating voltage	24 VDC $^{+10\%}/_{-15\%}$ (100% ED)	110 VAC ±10% (100% ED)	230 VAC ±10% (100% ED)
Current consumption	Approx. 200 mA	Approx. 50 mA	Approx. 30 mA
Insulation	Class F (130°C max.)	Class F (130°C max.)	Class F (130°C max.)

Indicator

Item	LED	Neon lamp
Rated voltage	10 to 115 VAC/VDC	100 to 250 VAC
Current leakage	Approx. 1 mA	Approx. 1.9 mA
Color (LED)	Orange	Orange

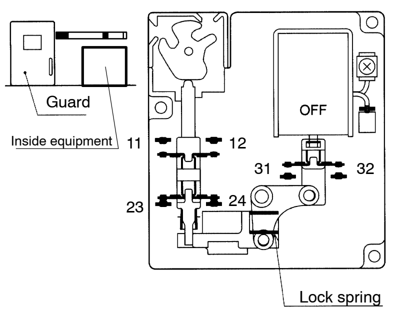
Nomenclature

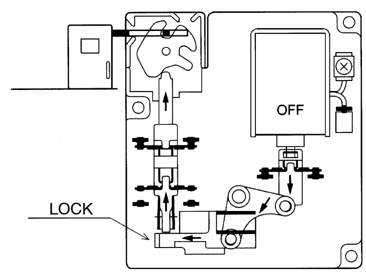


Operation

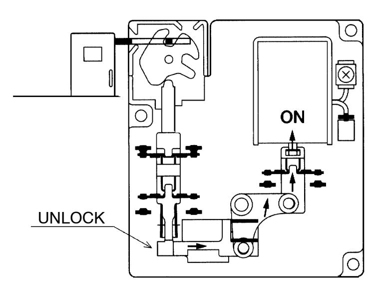
■ OPERATION PRINCIPLES

Mechanical lock model



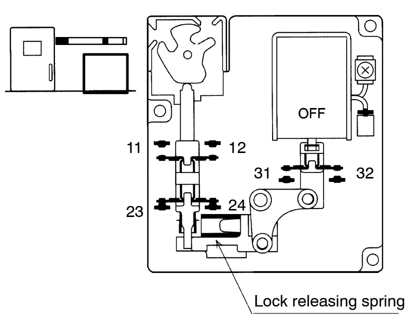


- Door closed
- Access to machine is not allowed.
- Lock spring locks the door.

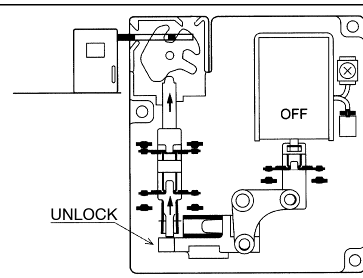


- Power to solenoid
- Door can be opened.

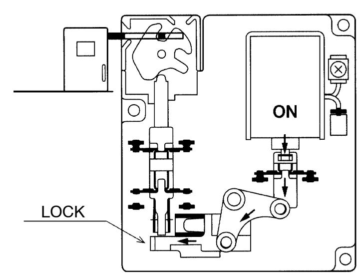
Solenoid lock model



- Door opened
- Access to machine is allowed.
- Solenoid: OFF
- Lock releasing spring releases the door lock.



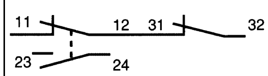
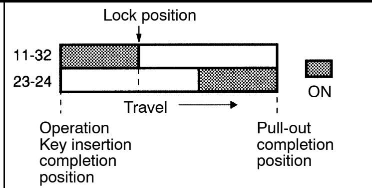
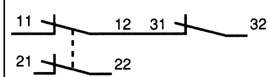
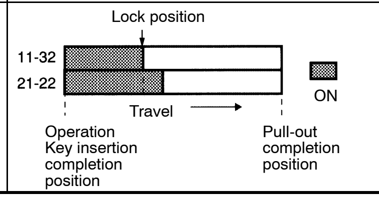
- Solenoid: OFF
- Door can be opened.



- Solenoid: ON
- Door locked
- Access to the machine is not allowed.

■ CONTACT FORM (DIAGRAMS SHOW STATE WITH KEY INSERTED)

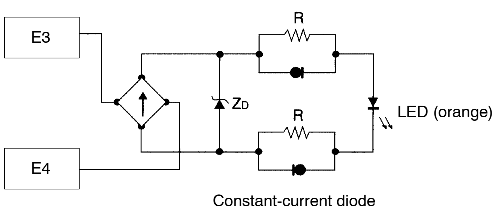
Indicates conditions where the Key is inserted and the lock is applied. Connect the terminals 12 to 31 to conform to BIA GS-ET-19.

Model	Contact	Contact form	Diagram	Remarks
D4DL-□C□□-□	1NC/1NO + 1NC			Only NC contacts 11-12 and 31-32 have an approved positive opening mechanism. ⊖ The terminals 11-12 and 23-24 can be used as unlike poles.
D4DL-□D□□-□	2NC + 1NC			NC contacts 11-12, 21-22, and 31-32 have an approved positive opening mechanism. ⊖ The terminals 11-12 and 21-22 can be used as unlike poles.

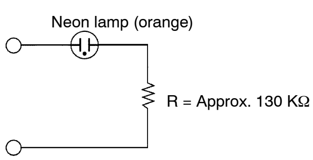
■ INDICATOR

Internal Circuit Diagram

LED Type (10 to 115 VAC/DC)



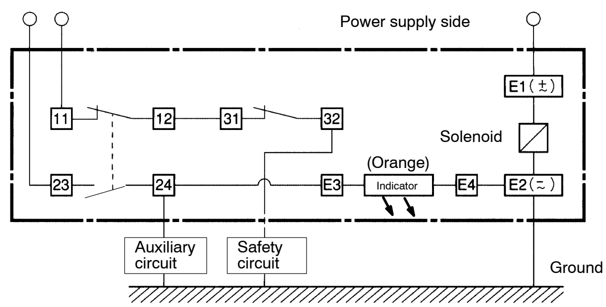
Neon Lamp Type (100 to 250 VAC)



Circuit Connection Example

Circuit is to be connected by user.

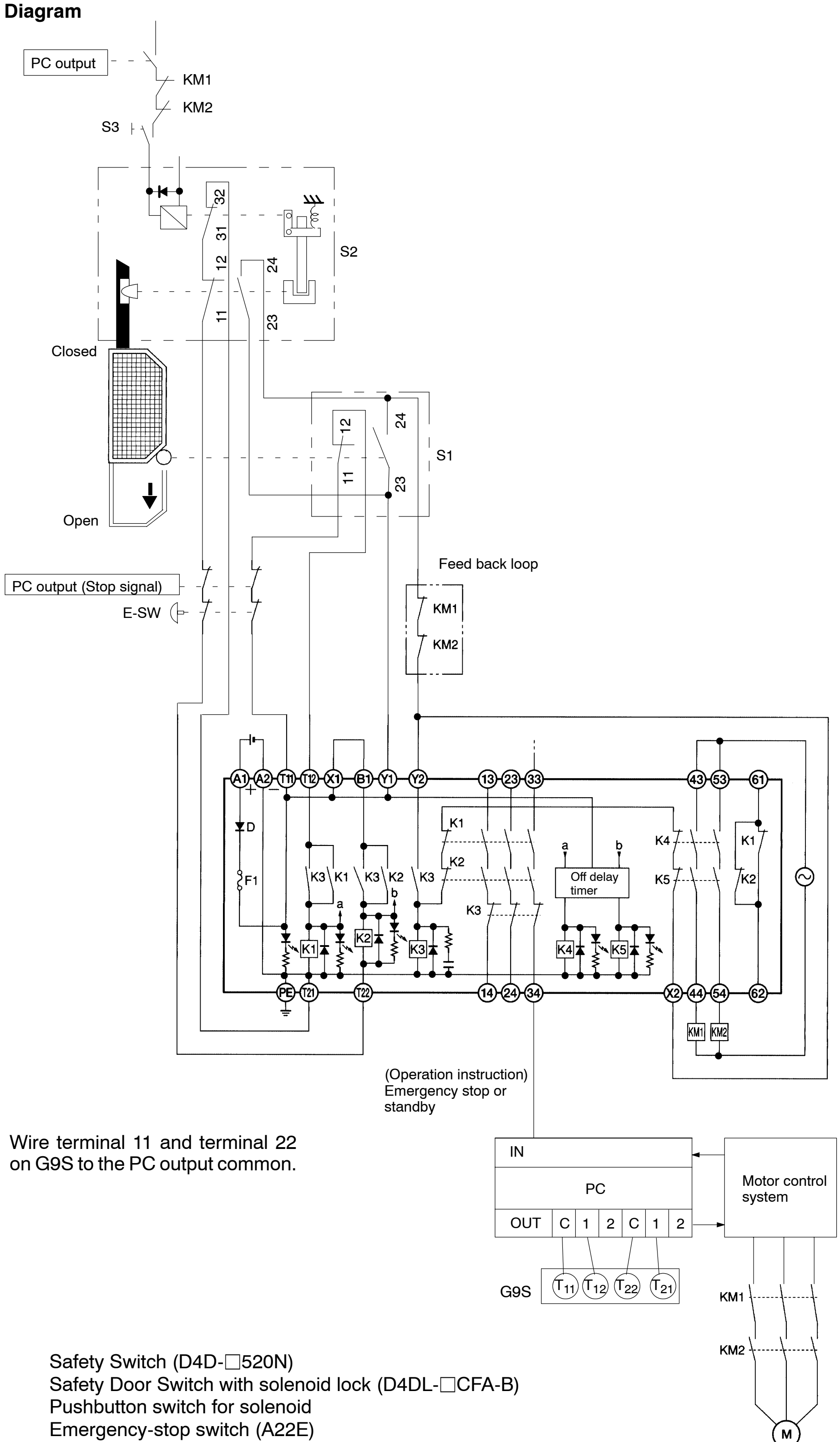
- Connect terminals 12 to 31. (To conform to BIA GS-ET-19.)
- Do not connect the indicator in parallel to the contacts. Doing so may allow short-circuit current to flow while the indicator is damaged, causing equipment malfunction.
- The 24-VDC solenoid has polarity. Be sure not to make wiring mistakes.
- In the following connection example, the indicator will be lit when the door is open. (D4DL-1CFA-B)



■ CONNECTION EXAMPLE WITH OMRON G9S SAFETY RELAY UNIT

G9S-321-T□ (24 VDC)+D4DL-□CFA-□/-□CFB-□/-CFC-□ (Mechanical Lock Type)+D4D-□520N

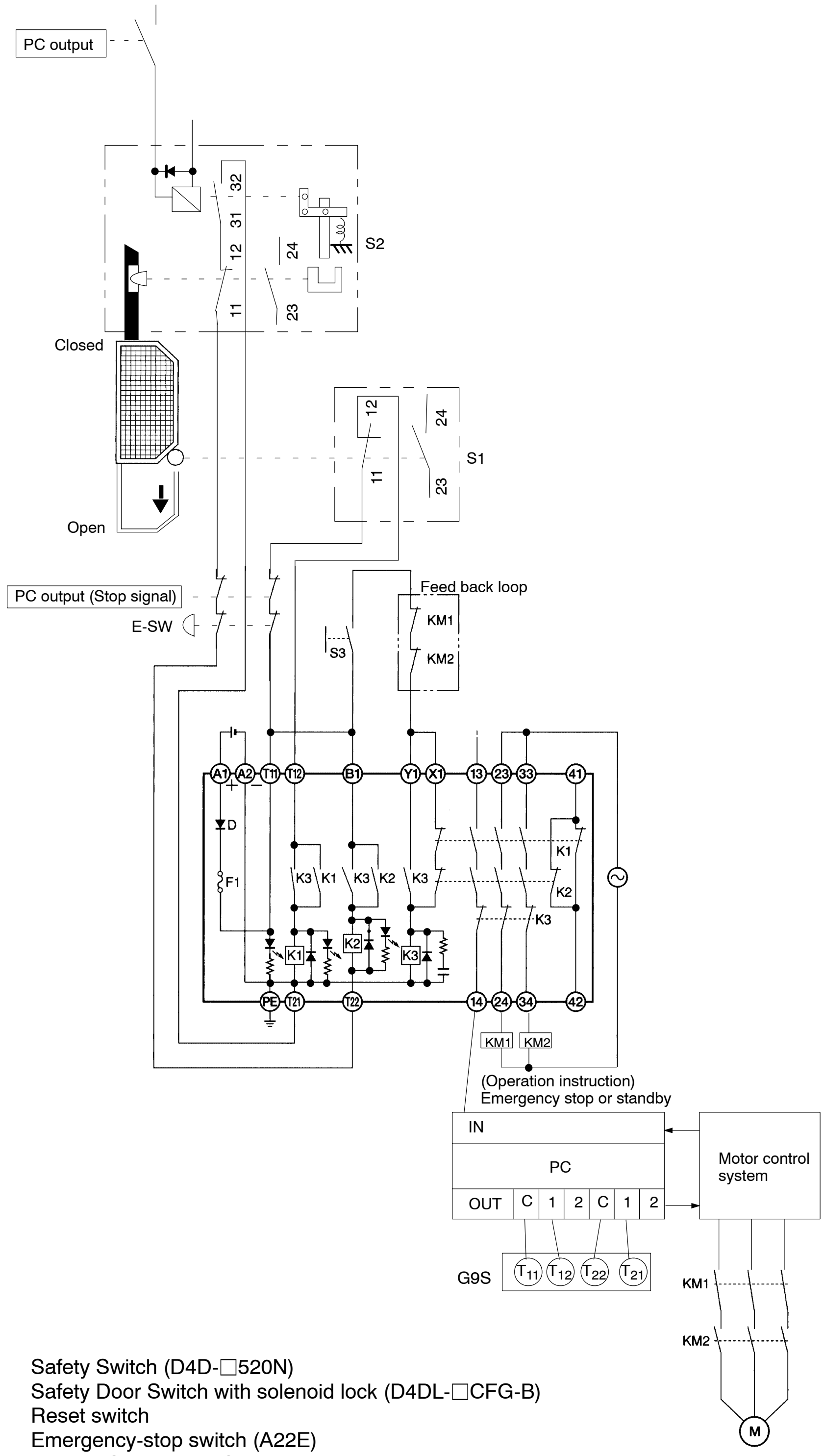
Circuit Diagram



Note: Wire terminal 11 and terminal 22 on G9S to the PC output common.

S1: Safety Switch (D4D-□520N)
S2: Safety Door Switch with solenoid lock (D4DL-□CFA-B)
S3: Pushbutton switch for solenoid
E-SW: Emergency-stop switch (A22E)
KM1, KM2: Magnet Contactor (LC1-D)
M: 3-phase motor

G9S-301 (24 VDC)+D4DL-□CFG-□/-□CFH-□/-□CFJ-□ (Solenoid Lock Type)+D4D-□520 N
Circuit Diagram



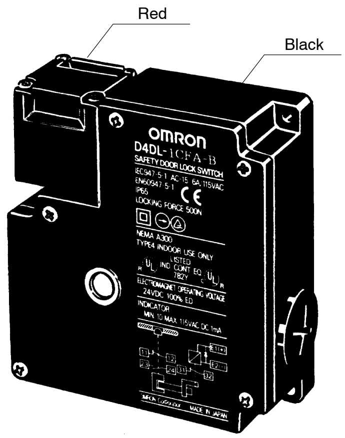
S1: Safety Switch (D4D-□520N)
S2: Safety Door Switch with solenoid lock (D4DL-□CFG-B)
S3: Reset switch
E-SW: Emergency-stop switch (A22E)
KM1, KM2: Magnet Contactor (LC1-D)
M: 3-phase motor

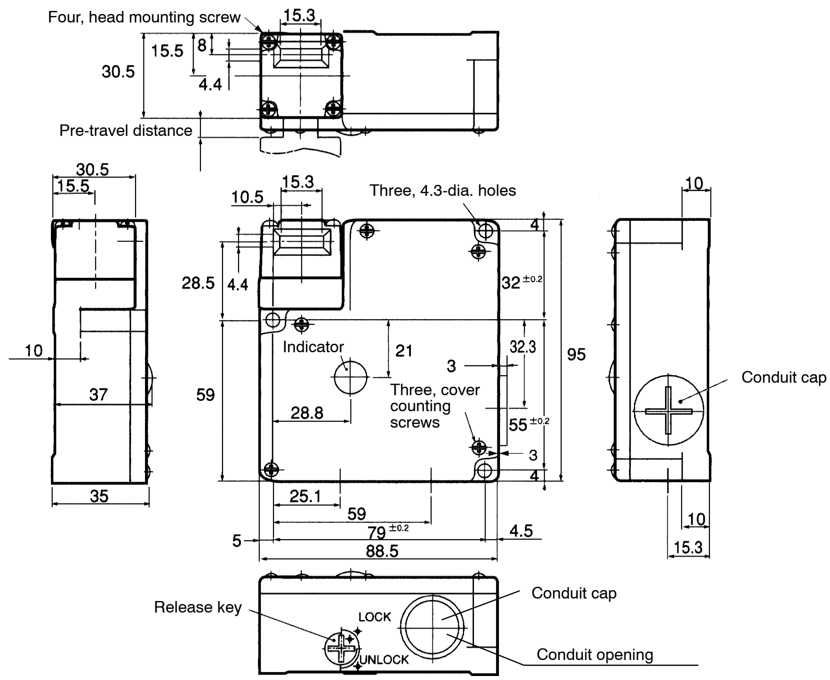
Dimensions

Unit: mm (inch)

■ SWITCHES

D4DL-□□□□-□



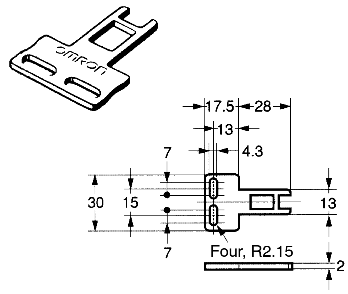


Operating characteristics	Model
Key insertion force	14.71 N max.
Key extraction force	29.42 N max.
Pre-travel distance	9 mm max.
Movement before being locked	3 mm min.

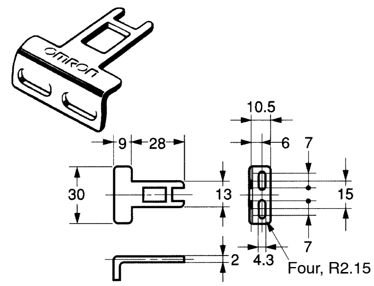
■ OPERATION KEYS

Note: Each dimension has a tolerance of ±0.4 mm unless otherwise specified.

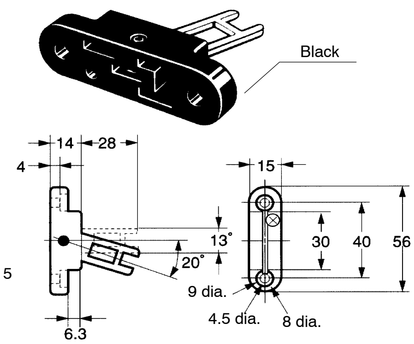
Horizontal Mounting
D4DS-K1



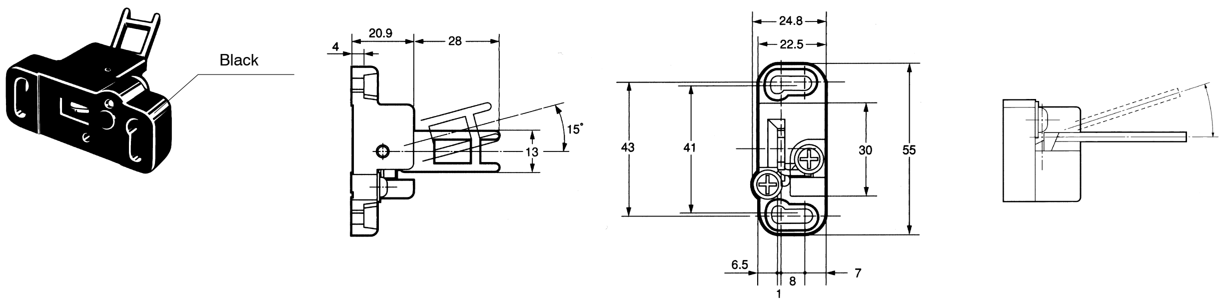
Vertical Mounting
D4DS-K2



Adjustable Mounting (Horizontal)
D4DS-K3



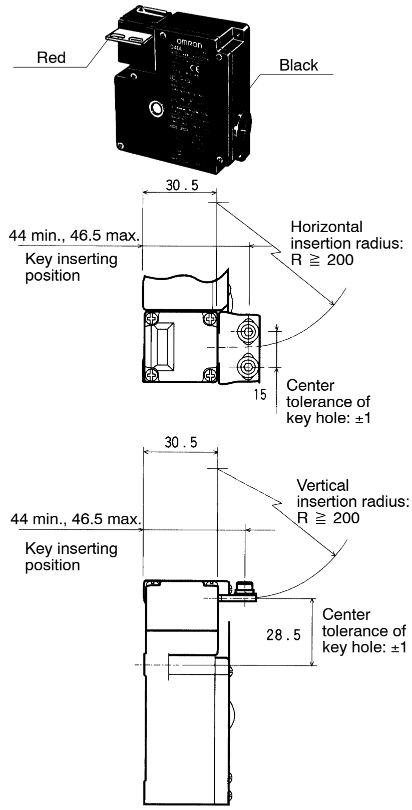
Adjustable Mounting (Horizontal/Vertical)
D4DS-K5



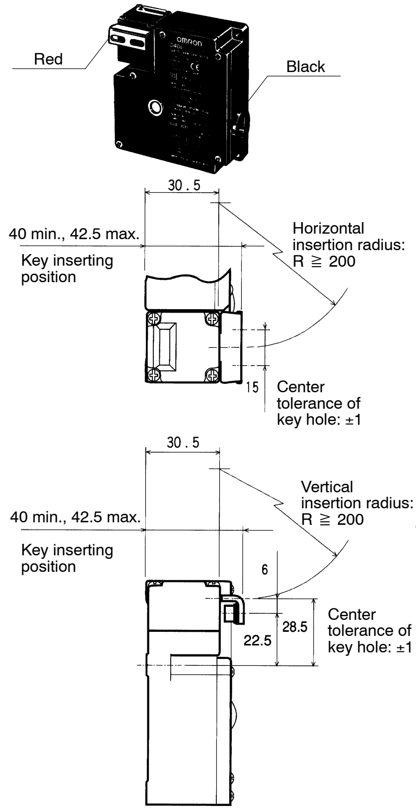
■ WITH OPERATION KEY INSERTED

Note: Each dimension has a tolerance of ±0.4 mm unless otherwise specified.

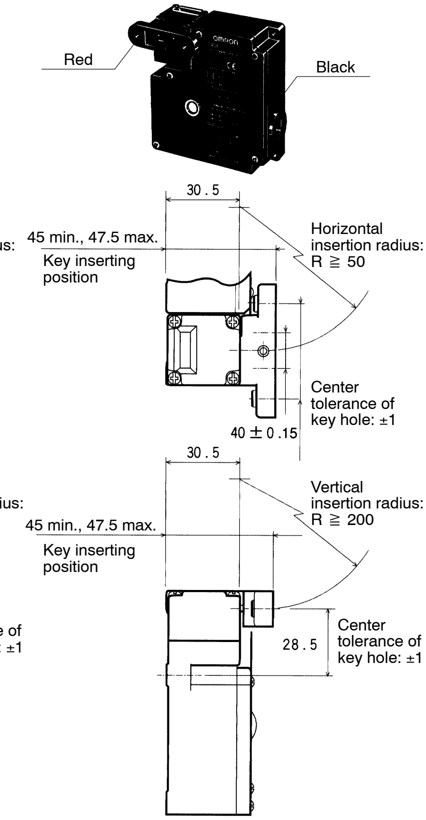
D4DL + D4DS-K1



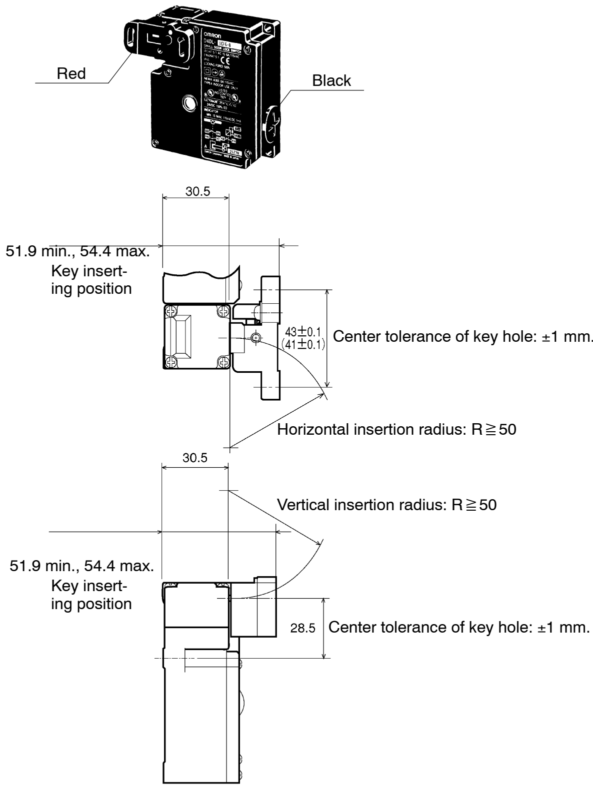
D4DL + D4DS-K2



D4DL + D4DS-K3



D4DL + D4DS-K5



Precautions

⚠ CAUTION

Do not remove the operation key from the door intentionally and insert it into the switch with the door open. The machine may start operating, and injury or death may be caused.
Do not use metal connectors or conduits with this switch. Rigid connectors and conduits may damage the switch. The broken conduit hole may cause an electrical shock hazard.
After-changing the release key to the UNLOCK position or inserting the operation key, change the head direction. Otherwise, the switch may malfunction and injuries may occur due to mis-operation of the device.

■ NOTICE

Install the operation key so that it will not hit the operator when the door is open.

If the D4DL is applied to an emergency stop circuit or safety circuit for prevention of injury, use the NC contact, which incorporates a positive opening mechanism, and make sure that the D4DL operates in positive mode. Furthermore, secure the D4DL with screws or equivalent parts that are tightened in a single direction so that the D4DL or operation key cannot be easily removed or provide a protection cover to the D4DL and post a warning label near the D4DL.

To protect the D4DL from damage due to short-circuits, connect the D4DL in parallel to a fuse that has a breaking current 1.5 to 2 times the rated current of the D4DL. If the D4DL is used under EN-approved rating conditions, use a 10-A fuse, type gI or gG conforming to IEC 269.

Do not supply power to the D4DL while wiring the D4DL.

In order to prevent the D4DL from burning due to overvoltage, insertion of a protection fuse into the solenoid circuits is recommended.

Do not use the D4DL in locations subject to explosive or flammable gases.

Make sure that the load current does not exceed the rated current and that the load terminals are wired correctly.

Pay utmost attention to correctly wire each terminal.

After mounting and adjusting the D4DL, make sure that the D4DL operates properly.

If the D4DL is imposed with force exceeding the lock strength, the D4DL may break and the equipment may continue operating.

Do not drop or disassemble the D4DL.

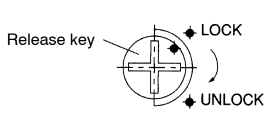
Release Key

The release key is used to unlock the D4DL in case of emergency or if the power supply to the D4DL fails.

Use an appropriate tool to set the release key to UNLOCK so that the lock will be released and the door can be opened.

The release key is set at the UNLOCK position. Set the release key to the LOCK position before use.

Mechanical Lock Type



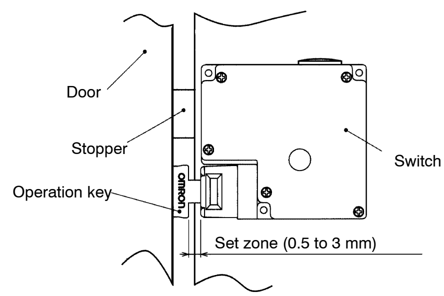
The release key applied to the door of a machine room ensures the safety of people adjusting the equipment in the machine room. If the release key is set to UNLOCK, the door will not be locked when the door is closed and no power will be supplied to the equipment.

Do not use the release key to start or stop machines.

To prevent the release key from being used carelessly by unauthorized people, set the release key of the D4DL in normal operation to UNLOCK and seal the release key with seal wax.

Mount with a Stopper

Be sure to mount the D4DL with a stopper as shown in the following illustration. Do not use the D4DL Switch as a stopper.



Solenoid Lock Type

The solenoid lock locks the door only when power is supplied to the solenoid. Therefore, the door will be unlocked if the power supply to the solenoid fails. Therefore, do not use the solenoid lock type for machines that may be operating and dangerous even after the machine stops operating because of inertia.

Life Expectancy

The life of the D4DL will vary with the switching conditions. Before applying the D4DL, test the D4DL under actual operating conditions and be sure to use the D4DL in actual operation within switching times that will not lower the performance of the D4DL.

■ CORRECT USE

Operating Environment

The D4DL is for indoor use only. Do not use the D4DL outdoors, or the D4DL may malfunction.

Do Not Use the D4DL in the Following Locations

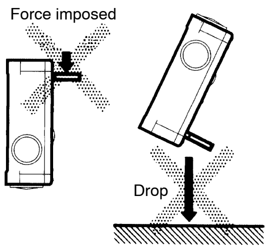
- Locations with severe changes in temperature
- Locations with excessive humidity that may cause condensation
- Locations with excessive vibration
- Locations where metal dust, oil, or chemical may be sprayed onto the D4DL

Operation Key

Be sure to use the dedicated Operation Key only.

Do not operate the D4DL with anything other than the dedicated Operation Key, or the safety of the system may not be maintained.

Do not impose excessive force on the Operation Key inserted into the D4DL or drop the D4DL with the Operation Key inserted, or the Operation Key may be deformed or broken.

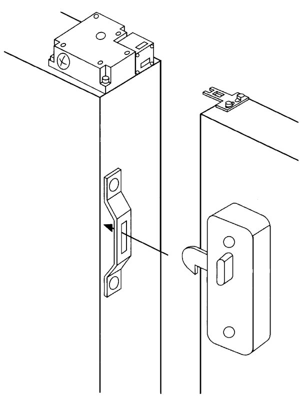


Locking the Door

The D4DL may eventually break if the door opens accidentally due to the weight of the door, the vibration of the machine, or the bouncing of the door against the rubber bumper.

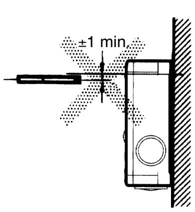
Furthermore, the door may not unlocked if force is imposed on the operation key.

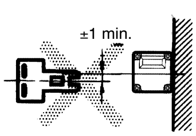
Do not use the casing of the D4DL as a locking mechanism for the door in such cases and be sure to prepare a special lock within the lock range of the D4DL (i.e., 0.5 to 3 mm).



Mounting Dimensions

Refer to the *Dimensions section* for the mounting dimensions of the Operation Key. Be sure that the Operation Key can be inserted properly with a tolerance of ±1 mm in the upward, downward, left, or right direction, or the D4DL may be damaged.

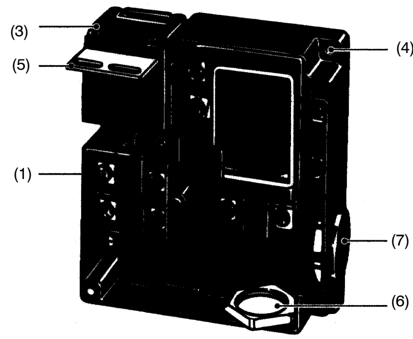


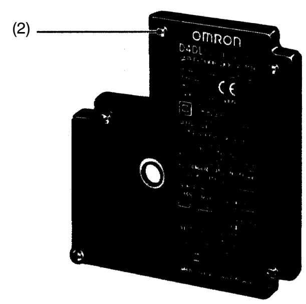


■ MOUNTING

Tightening Torque

Be sure to tighten each screw of the D4DL properly, or the D4DL may malfunction.





	Type	Proper tightening torque
(1)	Terminal screw (M3.5)	0.59 to 0.78 N • m
(2)	Cover mounting screw	0.78 to 0.88 N • m
(3)	Head mounting screw	0.78 to 0.88 N • m
(4)	Body mounting screw (M4) (see note)	0.49 to 0.69 N • m
(5)	Operation Key mounting screw	2.35 to 2.75 N • m
(6)	Connector at conduit opening	1.77 to 2.16 N • m
(7)	Cap screw	1.27 to 1.67 N • m

Note: Tighten each screw together with a washer to the specified torque.

After Mounting

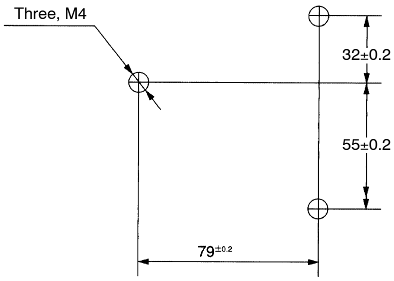
Be sure the that D4DL operates properly after mounting and adjusting the D4DL.

Use M4 screws (one-way screws, etc.) and washers to mount the D4DL and Operation Key securely.

Switch and Operation Key Mounting

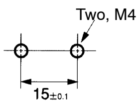
Mounting Dimensions

Switch Mounting Holes

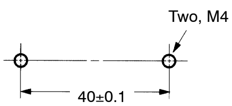


Operation Key Mounting Holes

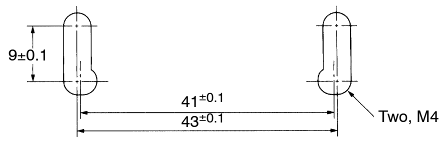
- Horizontal/Vertical Mounting
  D4DS-K1/D4DS-K2



- Adjustable Mounting (Horizontal)
  D4DS-K3



- Adjustable Mounting (Horizontal/Vertical)
  D4DS-K5

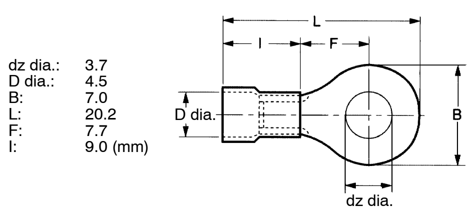


Head Direction

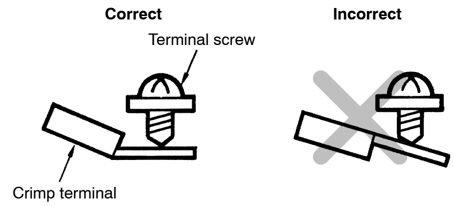
By removing the four screws of the head, the mounting direction of the head can be changed. The head can be mounted in four directions.

Wiring

Do not connect lead wires directly to the terminals. Be sure to connect the lead wires through insulation tubes and crimp terminals. The lead wires must be an AWG20 to AWG18 type (i.e., 0.5 to 10 mm^2 thick).



Wire the crimp terminal as shown in the following diagram so that it will not come in contact with the case or cover.



Conduit Opening

Connect a recommended connector (see following table) to the opening of the conduit and tighten the connector to the proper torque. The casing may be damaged if an excessive tightening torque is applied.

Be sure that the diameter of the cable connected to the connector is correct.

Attach and tighten a conduit cap to the unused conduit opening when wiring the D4DL. The conduit cap is provided with the D4DL.

Recommended Connectors

Size	Manufacturer	Model	Proper cable diameter
$G^{1}/_{2}$	OMRON	SC-6	7.5 to 9.0 mm
	LAPP	ST-PF1/2 5380-1002	6.0 to 12.0 mm
	Ohm Denki	OA-W1609	7.0 to 9.0 mm
Pg13.5	LAPP	ST13.5 5301-5030	5.0 to 12.0 mm

Note: LAPP is a German manufacturer. Ohm Denki is a Japanese manufacturer.

Maintenance and Repairs

Please note in the machine manufacturer's instruction manual that the user must not repair or maintain the switch and must contact the machine manufacturer for any repairs or maintenance.

Using the D4DL

The solenoid radiates heat when power is supplied to the solenoid. Do not touch the solenoid while the power is supplied.

Use the D4BL for conditions requiring greater rigidity, sealing performance, and oil resistance.

ALL DIMENSIONS SHOWN ARE IN MILLIMETERS. To convert millimeters into inches, divide by 25.4

OMRON ELECTRONICS LLC
One Commerce Drive
Schaumburg, IL 60173
847-843-7900
For US technical support or other inquiries:
800-556-6766

OMRON CANADA, INC.
885 Milner Avenue
Toronto, Ontario M1B 5V8
416-286-6465

OMRON ON-LINE
Global - http://www.omron.com
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Cat. No. GC SAFETY-2 2/03 Specifications subject to change without notice Printed in USA

Systronix 20x4 LCD
Brief Technical Data

July 31, 2000

Here is brief data for the Systronix 20x4 character LCD. It is a DataVision part and uses the Samsung KS0066 LCD controller. It's a clone of the Hitachi HD44780. We're not aware of any incompatabilities between the two - at least we have never seen any in all the code and custom applications we have done.

This 20x4 LCD is electrically and mechanically interchangeable with 20x4 LCDs from several other vendors. The only differences we've seen among different 20x4 LCDs are:

1) LED backlight brightness, voltage and current vary widely, as does the quality of the display

2) There is a resistor "Rf" which sets the speed of the LCD interface by controlling the internal oscillator frequency. Several displays we have evaluated have a low resistor value. This makes the display too slow. Looking at the Hitachi data sheet page 56, it appears that perhaps the "incorrect" resistor is really intended for 3V use of the displays.

At 5V the resistor Rf should be 91 Kohms. At 3V it should be 75 Kohms. Using a 3V display at 5V is acceptable from a voltage standpoint (the display can operate on 3-5V) but the oscillator will then be running too slowly. One fix is to always check the busy flag and not use a fixed time delay in your code, then it will work regardless of the LCD speed. The other option is to always allow enough delay for the slower display.

All Systronix 20x4 LCDs have the 91 Kohm resistor and are intended for 5V operation.

Thank you for purchasing Systronix embedded control products and accessories. If you have any other questions please email to support@systronix.com or phone +1-801-534-1017, fax +1-801-534-1019.

■ ABSOLUTE MAXIMUM RATINGS

Item	Symbol	Standard Value			Unit
		Min.	Typ.	Max.	
Supply Voltage for Logic	V_{DD}-	0	—	7.0	V
Supply Voltage for LCD Driver	V_{DD}-V_{EE}	—	—	13.5	V
Input Voltage	V_I	V_{SS}	—	V_{DD}	V
Operature Temp.	Topr	0	—	50	°C
Storage Temp.	Tstg	-20	—	70	°C

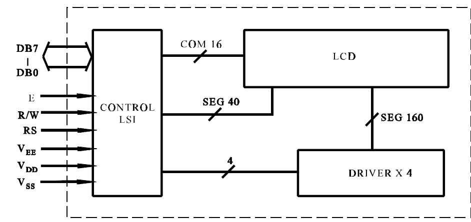
■ ELECTRICAL CHARACTERISTICS (REFLECTIVE TYPE)

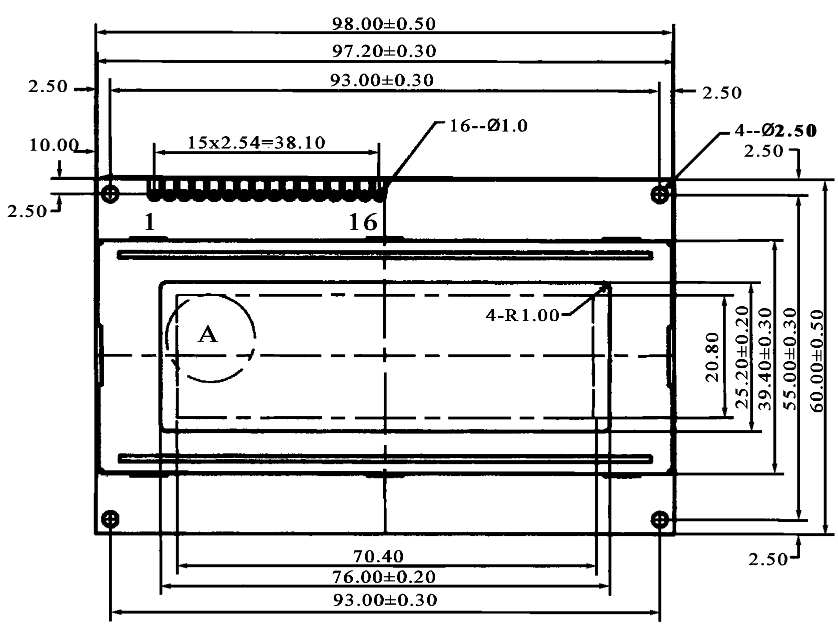
Item	Symbol	Test Condition	Standard Value			Unit
			Min.	Typ.	Max.	
Input "High" Voltage	V_{IH}	—	2.2	—	V_{EE}	V
Input "Low" Voltage	V_{IL}	—	—	—	0.6	V
Output "High" Voltage	V_{OH}	I_{OH}=0.2mA	2.2	—	—	V
Output "Low" Voltage	V_{OL}	I_{OL}=1.2mA	—	—	0.4	V
Supply Current	I_{DD}	V_{DD}=5.0A	—	2.5	4.0	mA

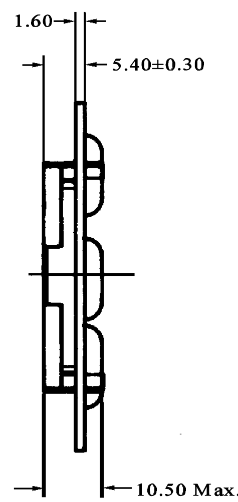
■ PIN FUNCTIONS

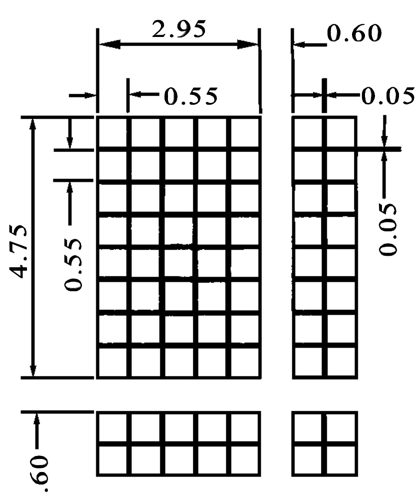
No	Symbol	Function	No	Symbol	Function
1	V_{SS}	GND, 0V	10	DB3	Data Bus
2	V_{DD}	+5V	11	DB4	—
3	V_{EE}	for LCD Drive	12	DB5	—
4	RS	Function Select	13	DB6	—
5	R/W	Read/Write	14	DB7	—
6	E	Enable Signal	15	LEDA	LED Power Supply
7-9	DB0-DB2	Data Bus Line	16	LEDA	

■ BLOCK DIAGRAM









A BLOCK

Table 4 Correspondence between Character Codes and Character Patterns (ROM Code: A00)

Lower 4 Bits \ Upper 4 Bits	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
xxxx0000	CG RAM (1)			0	@	P	`	p				ー	タ	ミ	α	p
xxxx0001	(2)		!	1	A	Q	a	q			。	ア	チ	ム	ä	q
xxxx0010	(3)		"	2	B	R	b	r			「	イ	ツ	メ	β	θ
xxxx0011	(4)		#	3	C	S	c	s			」	ウ	テ	モ	ε	∞
xxxx0100	(5)		$	4	D	T	d	t			、	エ	ト	ヤ	μ	Ω
xxxx0101	(6)		%	5	E	U	e	u			・	オ	ナ	ユ	σ	ü
xxxx0110	(7)		&	6	F	V	f	v			ヲ	カ	ニ	ヨ	ρ	Σ
xxxx0111	(8)		'	7	G	W	g	w			ァ	キ	ヌ	ラ	g	π
xxxx1000	(1)		(	8	H	X	h	x			ィ	ク	ネ	リ	√	x̄
xxxx1001	(2)		)	9	I	Y	i	y			ゥ	ケ	ノ	ル	⁻¹	y
xxxx1010	(3)		*	:	J	Z	j	z			ェ	コ	ハ	レ	j	千
xxxx1011	(4)		+	;	K	[	k	{			ォ	サ	ヒ	ロ	ˣ	万
xxxx1100	(5)		,	<	L	¥	l	|			ャ	シ	フ	ワ	¢	円
xxxx1101	(6)		-	=	M	]	m	}			ュ	ス	ヘ	ン	£	÷
xxxx1110	(7)		.	>	N	^	n	→			ョ	セ	ホ	゛	ñ	
xxxx1111	(8)		/	?	O	_	o	←			ッ	ソ	マ	゜	ö	█

Note: The user can specify any pattern for character-generator RAM.

Initializing by Instruction

If the power supply conditions for correctly operating the internal reset circuit are not met, initialization by instructions becomes necessary.

Refer to Figures 25 and 26 for the procedures on 8-bit and 4-bit initializations, respectively.

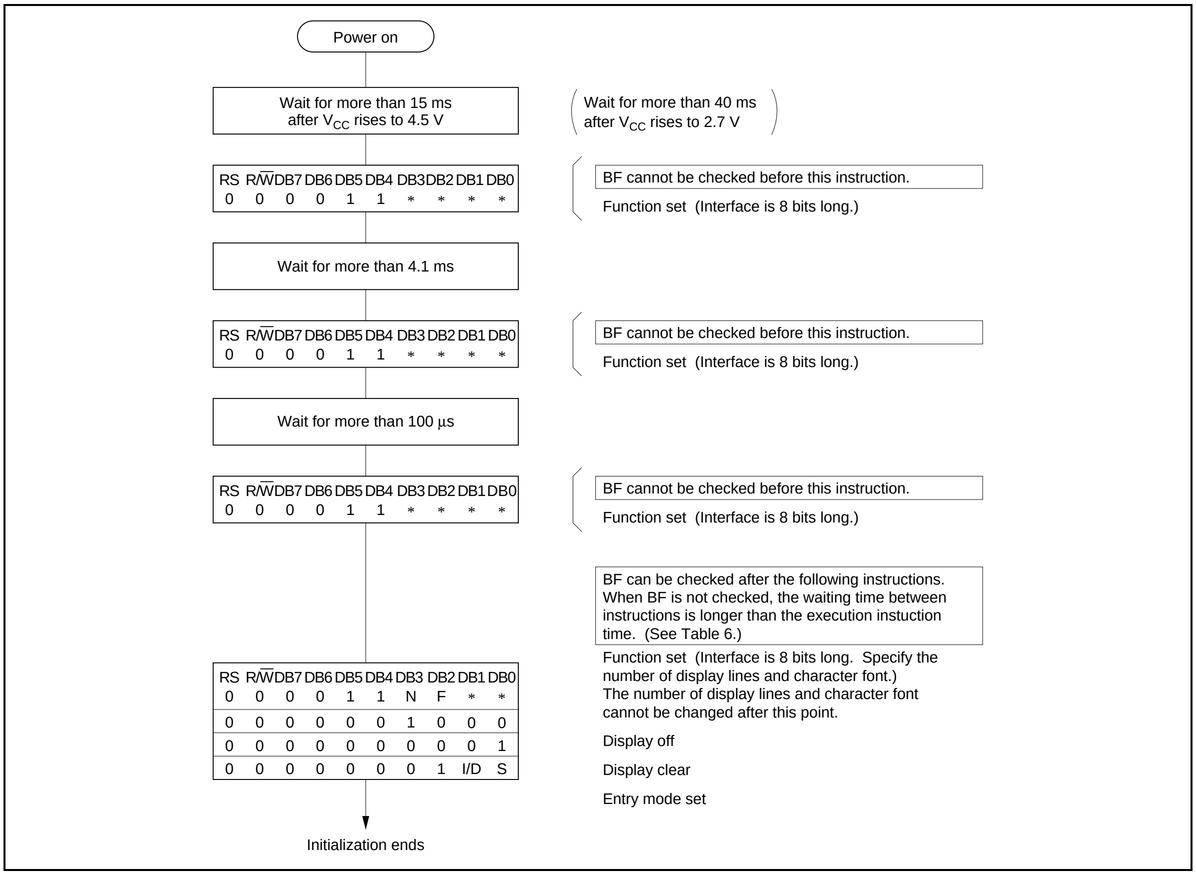


Figure 25 8-Bit Interface

Reset Function

Initializing by Internal Reset Circuit

An internal reset circuit automatically initializes the HD44780U when the power is turned on. The following instructions are executed during the initialization. The busy flag (BF) is kept in the busy state until the initialization ends (BF = 1). The busy state lasts for 10 ms after V_{CC} rises to 4.5 V.

1. Display clear
2. Function set:
   DL = 1; 8-bit interface data
   N = 0; 1-line display
   F = 0; 5 × 8 dot character font
3. Display on/off control:
   D = 0; Display off
   C = 0; Cursor off
   B = 0; Blinking off
4. Entry mode set:
   I/D = 1; Increment by 1
   S = 0; No shift

Note: If the electrical characteristics conditions listed under the table Power Supply Conditions Using Internal Reset Circuit are not met, the internal reset circuit will not operate normally and will fail to initialize the HD44780U. For such a case, initial-ization must be performed by the MPU as explained in the section, Initializing by Instruction.

Instructions

Outline

Only the instruction register (IR) and the data register (DR) of the HD44780U can be controlled by the MPU. Before starting the internal operation of the HD44780U, control information is temporarily stored into these registers to allow interfacing with various MPUs, which operate at different speeds, or various peripheral control devices. The internal operation of the HD44780U is determined by signals sent from the MPU. These signals, which include register selection signal (RS), read/

write signal (R/$\overline{W}$), and the data bus (DB0 to DB7), make up the HD44780U instructions (Table 6). There are four categories of instructions that:

- Designate HD44780U functions, such as display format, data length, etc.
- Set internal RAM addresses
- Perform data transfer with internal RAM
- Perform miscellaneous functions

Normally, instructions that perform data transfer with internal RAM are used the most. However, auto-incrementation by 1 (or auto-decrementation by 1) of internal HD44780U RAM addresses after each data write can lighten the program load of the MPU. Since the display shift instruction (Table 11) can perform concurrently with display data write, the user can minimize system development time with maximum programming efficiency.

When an instruction is being executed for internal operation, no instruction other than the busy flag/address read instruction can be executed.

Because the busy flag is set to 1 while an instruction is being executed, check it to make sure it is 0 before sending another instruction from the MPU.

Note: Be sure the HD44780U is not in the busy state (BF = 0) before sending an instruction from the MPU to the HD44780U. If an instruction is sent without checking the busy flag, the time between the first instruction and next instruction will take much longer than the instruction time itself. Refer to Table 6 for the list of each instruc-tion execution time.

Table 6 Instructions

	Code											Execution Time (max) (when f_{cp} or
Instruction	**RS**	**R/$\overline{W}$**	**DB7**	**DB6**	**DB5**	**DB4**	**DB3**	**DB2**	**DB1**	**DB0**	**Description**	**f_{osc} is 270 kHz)**
Clear display	0	0	0	0	0	0	0	0	0	1	Clears entire display and sets DDRAM address 0 in address counter.	
Return home	0	0	0	0	0	0	0	0	1	—	Sets DDRAM address 0 in address counter. Also returns display from being shifted to original position. DDRAM contents remain unchanged.	1.52 ms
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	37 µs
Display on/off control	0	0	0	0	0	0	1	D	C	B	Sets entire display (D) on/off, cursor on/off (C), and blinking of cursor position character (B).	37 µs
Cursor or display shift	0	0	0	0	0	1	S/C	R/L	—	—	Moves cursor and shifts display without changing DDRAM contents.	37 µs
Function set	0	0	0	0	1	DL	N	F	—	—	Sets interface data length (DL), number of display lines (N), and character font (F).	37 µs
Set CGRAM address	0	0	0	1	ACG	ACG	ACG	ACG	ACG	ACG	Sets CGRAM address. CGRAM data is sent and received after this setting.	37 µs
Set DDRAM address	0	0	1	ADD	ADD	ADD	ADD	ADD	ADD	ADD	Sets DDRAM address. DDRAM data is sent and received after this setting.	37 µs
Read busy flag & address	0	1	BF	AC	AC	AC	AC	AC	AC	AC	Reads busy flag (BF) indicating internal operation is being performed and reads address counter contents.	0 µs

Table 6 Instructions (cont)

Instruction	Code										Description	Execution Time (max) (when f_{cp} or f_{OSC} is 270 kHz)
	RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Write data to CG or DDRAM	1	0	Write data								Writes data into DDRAM or CGRAM.	37 µs t_{ADD} = 4 µs*
Read data from CG or DDRAM	1	1	Read data								Reads data from DDRAM or CGRAM.	37 µs t_{ADD} = 4 µs*
	I/D = 1: Increment I/D = 0: Decrement S = 1: Accompanies display shift S/C = 1: Display shift S/C = 0: Cursor move R/L = 1: Shift to the right R/L = 0: Shift to the left DL = 1: 8 bits, DL = 0: 4 bits N = 1: 2 lines, N = 0: 1 line F = 1: 5 × 10 dots, F = 0: 5 × 8 dots BF = 1: Internally operating BF = 0: Instructions acceptable										DDRAM: Display data RAM CGRAM: Character generator RAM ACG: CGRAM address ADD: DDRAM address (corresponds to cursor address) AC: Address counter used for both DD and CGRAM addresses	Execution time changes when frequency changes Example: When f_{cp} or f_{OSC} is 250 kHz, $37\ \mu s \times \frac{270}{250} = 40\ \mu s$

Note: — indicates no effect.

* After execution of the CGRAM/DDRAM data write or read instruction, the RAM address counter is incremented or decremented by 1. The RAM address counter is updated after the busy flag turns off. In Figure 10, t_{ADD} is the time elapsed after the busy flag turns off until the address counter is updated.

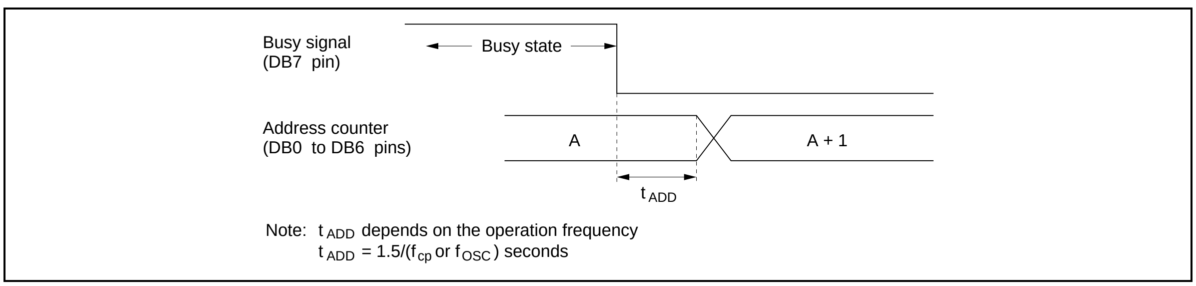


Figure 10 Address Counter Update