PERANCANGAN ALAT PERAGA PENAMPIL TITIK MERIDIAN PADA ANATOMI TUBUH MANUSIA UNTUK TERAPI *AL-HIJAMAH* (BEKAM)

SKRIPSI

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LEMBAR PENGESAHAN

PERANCANGAN ALAT PERAGA PENAMPIL TITIK MERIDIAN PADA ANATOMI TUBUH MANUSIA UNTUK TERAPI *AL-HIJAMAH* (BEKAM)

SKRIPSI

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Judul Skripsi	:	Perancangan Alat Peraga Penampil Titik Meridian Pada Anatomi Tubuh Manusia Untuk Terapi *Al-Hijamah* (Bekam)

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ABSTRAK

Khrismana, Indra Ari. 9917236. 2007. *Perancangan Alat Peraga Penampil Titik Meridian Untuk Terapi Al-Hijamah (Bekam)*. Skripsi Jurusan Teknik Elektro S1, Konsentrasi Teknik Elektronika, Fakultas Teknologi Industri, Institut Teknologi Nasional Malang. Pembimbing (1) Ir. Eko Nurcahyo., (2) Irmalia Suryani F., ST.

Kata kunci: Alat Peraga, Al- Hijamah, Kombinasi Titik

Perkataan "*Al-Hijamah*" berasal dari istilah Bahasa Arab yang berarti "pelepasan darah kotor" dan bukan "*Al-Fashd*" (pembuang darah). atau dalam bahasa Inggris disebut dengan "*Cupping*". Dan dalam bahasa melayu dikenal dengan istilah "Bekam". Di Indonesia kita kenal denan istilah Kop atau Cantuk. Bekam merupakan suatu teknik pengobatan Sunnah Rasulullah S.a.w yang telah lama dipraktekkan oleh manusia sejak zaman dahulu kala, kini pengobatan ini dimodernkan dan mengikuti kaidah - kaidah ilmiah, dengan menggunakan suatu alat yang praktis dan efektif sera tanpa efek samping.

Teknik pengobatan bekam adalah suatu proses membuang darah kotor (toksid-racun yang berbahaya dari dalam tubuh, melalui permukaan kulit. Toksid / toksin adalah endapan racun / zat kimia yang tidak dapat diuraikan oleh tubuh kita. Toksin ini berada pada hampir setiap orang. Toksin - toksin ini berasal dari pencemaran udara, maupun dari makanan yang banyak mengandung zat pewarna, zat pengembang, penyedap rasa, pemanis, pestisida sayuran dll.

Kulit adalah organ yang terbesar dalam tubuh manusia, karena itu banyak toksid / racun berkumpul disana. Dengan berbekam dapat membersihkan darah yang mengalir dalam tubuh manusia. Inilah salah satu DETOKSIFIKASI (proses pengeluaran toksid / racun) yang sangat berkesan / mujarab serta tiada efek samping.
(Sumber : [Ar-Royyan-2280] BEKAM (AL-HIJAMAH.htm).

Sepintas, bekam terdengar menyeramkan, karena berbau-bau "darah". Padahal kenyataannya tidaklah seseram itu. Bekam mengambil darah di dermis (kulit jangat) dan bukan pada pembuluh darah. "Jumlahnya sedikit sekali, seperempat liter saja tidak ada," jelas Ustad La Ode Aly Abi Ilahy, terapis bekam dari Rumah Sehat Herba Care di kawasan Tegal Parang, Jakarta Selatan.

Pengambilan darah dilakukan menggunakan alat berbentuk mangkuk (cupping set) yang ditempelkan pada kulit. Bagian tubuh yang merupakan titik bekam terlebih dulu "dilukai" memakai jarum lancet atau bisa juga pisau cukur (silet). Dengan pompa pengisap, udara di mangkuk kemudian disedot perlahan-lahan. Akibat perbedaan tekanan udara, kulit akan terangkat dan darah merembes keluar.

Jika dalam pengobatan akupunktur yang dihasilkan hanyalah rangsangan terhadap titik saraf, sedangkan dalam pengobatan bekam, selain dihasilkan rangsangan pada titiktitik saraf, juga terjadi pergerakan aliran darah dan rangsangan terhadap organ kekebalan tubuh (Sumber : Syihab Al-Badri Yasin, Bekam Sunnah Nabi & Mukjizat Medis).

Meski dimulai sejak zaman Mesir Kuno, bahkan kemudian berkembang di banyak negara (termasuk Cina), bekam yang kini dipraktikkan di Indonesia begitu kental dengan nilai-nilai Islam. Terapi hijamah ini telah disesuaikan dengan sunah Nabi Muhammad. Tak heran, para terapis umumnya berasal dari pondok-pondok pesantren.

Nuansa Islami terlihat dari pemilihan titik bekam, yang sepintas mirip titik-titik akupuntur. Aslinya, bekam mengenal lebih dari 350 titik di seluruh tubuh. Kumpulan titik-titik hijamah sehingga membentuk suatu garis ini disebut sebagai meridian. Namun, dalam praktik Aly mengutamakan 12 titik, seperti anjuran Nabi Muhammad, yang terletak di seputar kepala, leher, pinggang, dada, dan kaki. Dari situ terdapat tiga titik utama yaitu ummu mughits dan dua titik qumahduah.

Ummu mughits yang berada di atas kepala merupakan titik utama bekam, yang sekaligus merupakan pertemuan ratusan titik dari seluruh tubuh.

Sedangkan qumahduah terletak di leher bagian belakang, tepatnya antara rambut dan cuping telinga, baik kanan maupun kiri. Titik qumahduah dan ummu mughits itu titik utama yang selalu digarap dalam sebuah terapi, ditambah sejumlah titik-titik lain sesuai keluhan pasien.

(Sumber : Departemen Kesehatan, Indonesia.htm).

Oleh karena itu perlu adanya suatu alat peraga untuk memudahkan pencarian titik hijamah untuk terapi berdasarkan penyakit yang telah ditentukan. Sehingga diharapkan dengan alat ini seorang awam dapat mengetahui dengan mudah titik hijamah yang akan diterapi sesuai dengan penyakit yang diderita.

Alat ini terdiri dari keypad yang berfungsi memasukkan ID penyakit, encoder keypad yang berfungsi untuk konversi data dari keypad, PPI berjumlah empat buah untuk perluasan output. Alat ini dikontrol oleh mikrokontroler dengan display LCD 16 x 2 sebagai tampilan menu serta LED yang berfungsi untuk tampilan titik hijamah.

Alat peraga ini dilengkapi dengan gambar anatomi hijamah berkelamin laki-laki, data penyakit yang tersedia berjumlah 26 jenis penyakit dengan menggunakan 60 LED untuk tampilan titik hijamah. Kombinasi titik untuk tiap jenis penyakit minimal 2 titik dan maksimal 9 titik.

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where are you friends ???

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The Poharintini of Block C 337, dr Ipoel, dr Jo, dr Toma (The Boss), dr Tommy, Oo', The white cat, and penghuni-penghuni di gudang atas hiii....

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Malang, April 2007

Penulis

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BAB I

PENDAHULUAN

1.1. Latar Belakang

Pengobatan *Al-Hijamah*[1] merupakan metode pengobatan klasik yang dikenal luas di kalangan banyak bangsa, baik di timur maupun barat. Metode ini sudah populer di Cina, India, Eropa dan Amerika sejak beberapa abad lalu. Metode pengobatan ini memiliki kedudukan sendiri dalam berbagai jurnal dan referensi ilmiah hingga pertengahan abad 19. (sumber : Syihab Al-Badri Yasin, Bekam Sunnah Nabi & Mukjizat Medis).

Metode *Al-Hijamah* dikenalkan di eropa melalui negri-negri Andalusia pada saat para dokter muslim serta karya tulis mereka menjadi referensi pertama dalam ilmu kedokteran.

Pengobatan bekam ini sama dengan teori yang digunakan untuk pengobatan tusuk jarum (*akupunktur*) Cina yaitu memberikan rangsangan pada titik-titik tertentu yang memiliki hubungan dengan organ tubuh yang akan disembuhkan. Pemberian rangsangan ini dengan menyayat tipis kulit lalu dihisap menggunakan alat khusus pada titik-titik tertentu (meridian) untuk mengeluarkan darah rusak,toxin, atau unsur-unsur berbahaya dari dalam tubuh yang menghambat berjalannya fungsi-fungsi dan tugas-tugas organ tubuh secara sempurna.

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[1] Istilah Arab Untuk Bekam, di Indonesia di sebut Kop atau Cantuk di Eropa di kenal dengan istilah *Anaerob Cupping Methode.*

Jika dalam pengobatan akupunktur yang dihasilkan hanyalah rangsangan terhadap titik saraf, sedangkan dalam pengobatan bekam, selain dihasilkan rangsangan pada titik-titik saraf, juga terjadi pergerakan aliran darah dan rangsangan terhadap organ kekebalan tubuh[2].

Semakin banyak jenis penyakit, semakin banyak pula titik-titik kombinasi untuk tiap-tiap penyakit. Oleh karena itu diperlukan daya ingat yang tinggi bagi seorang awam. Dengan adanya permasalahan tersebut maka, kami mencoba menawarkan solusi untuk memudahkan pencarian titik-titik dengan menggunakan alat bantu penampil titik *Al-Hijamah* (bekam) secara terprogram.

1.2. Rumusan Masalah

Dari permasalahan yang diuraikan pada latar belakang, maka rumusan masalah dapat ditekankan pada:

1. Bagaimana menampilkan titik-titik bekam sesuai dengan penyakit yang di derita.
2. Bagaimana perancangan *Light Emitting Dioda* (LED) yang digunakan untuk menampilkan titik-titik bekam.

Sehubungan dengan rumusan masalah tersebut judul skripsi ini adalah :

"Perancangan Alat Peraga Penampil Titik Meridian Pada Anatomi Tubuh Manusia Untuk Terapi Al-Hijamah (bekam)"

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[2] Syihab Al-Badri Yasin, Bekam Sunnah Nabi & Mukjizat Medis Hal. 61.

1.3. Tujuan

Tujuan pembuatan tugas akhir ini adalah:

1. Mempelajari teknik aplikasi dari Mikrokontroler.
2. Menampilkan titik-titik *Al-Hijamah* pada anatomi tubuh manusia.
3. Mempermudah pencarian titik-titik *Al-Hijamah* sesuai dengan jenis penyakit.

1.4. Batasan Masalah

Dalam pembahasan ini, permasalahan yang akan dibahas meliputi:

1. Perancangan menggunakan Mikrokontroler AT89S51, *Keypad* (3X4), *buffer* DM74LS244, *Key encoder* MM74C922, PPI 8255A, *decoder* DM74LS138, LCD (16X2), *Latch* DM74LS573 dan LED warna biru.
2. Tidak membahas proses pengobatan *Al-Hijamah* (bekam).
3. Menampilkan titik meridian untuk 26 macam penyakit.
4. Gambar Anatomi yang digunakan berkelamin laki-laki.
5. Tidak membahas Power Supply.

1.5. Metodologi

Metodologi penulisan yang digunakan penulis dalam penyelesaian penulisan skripsi ini adalah :

☑ **Studi Pustaka**

Dilakukan untuk memperoleh referensi yang mendukung penyusunan skripsi yaitu dengan mempelajari kepustakaan tentang perangkat keras dan perangkat lunak.

☑ **Perencanaan dan Pembuatan Perangkat Keras & Perangkat Lunak**

Dari permasalahan yang sudah dirumuskan, maka dirancang sistem mulai dari logika dasar sistem, pemilihan komponen yang akan digunakan serta perencanaan perangkat lunak.

☑ **Pengujian dan Analisa**

Setelah semua sistem selesai dibuat, diadakan pengujian dan analisa untuk diambil suatu hasil apakah sistem sudah berjalan sesuai dengan perancangan.

☑ **Penyusunan Laporan**

Penyusunan laporan skripsi dibuat sesuai dengan sistematika pembahasan yang telah ditetapkan.

1.6. Sistematika penulisan

Adapun sistematika dari penyusunan laporan tugas akhir ini adalah :

BAB I : PENDAHULUAN

Pada bab ini membahas tentang Latar Belakang, Rumusan Masalah, Tujuan, Batasan Masalah, Metodologi seta Sistematika Penulisan.

BAB II : LANDASAN TEORI

Pada bab ini membahas tentang teori-teori dasar yang mendukung dalam perencanaan sistem yang dibuat. Selain itu digunakan untuk

memberikan bahan penunjang untuk memahami sistem yang dirancang.

BAB III : PERENCANAAN DAN PEMBUATAN ALAT

Pada bab ini membahas tentang perancangan dan pembuatan perangkat keras yang membentuk sistem serta perangkat lunak yang digunakan untuk mengkonfigurasi IC Mikrokontroler.

BAB IV : PERCOBAAN DAN PENGUJIAN ALAT

Pada bab ini membahas tentang pengujian alat, pengamatan, pengukuran dan analisa dari sistem yang dibuat.

BAB V : PENUTUP

Pada bab ini membahas tentang kesimpulan yang diambil dari perancangan dan pembuatan sistem serta saran-saran untuk pengembangan lebih lanjut.

BAB II

LANDASAN TEORI

2.1. Pengertian *Al-Hijamah* (Bekam)

" Apakah anda pernah mengenal istilah bekam ? Apakah anda pernah dibekam ?" Berbahagialah apabila Anda menjawab, "pernah". Sebab dari kuisioner yang ditujukan secara acak pada kaum muslimin menunjukkan bahwa yang belum mendengar istilah bekam (atau istilah bekam lain yang sejenis) sebanyak 80%, sedangkan yang belum pernah dibekam sebanyak 90% (Sumber : Syihab Al-Badri Yasin, Bekam Sunnah Nabi & Mukjizat Medis).

Al-Hijamah berasal dari kata *al-hajmu* yang menurut bahasa berarti penghisapan / penyedotan, karena ia merupakan upaya untuk menghisap darah dari bagian yang disayat, sehingga *hijaamah* berarti perbuatan atau aktivitas orang yang membekam.

Imam Ibnu Qayyim al-Jauziyyah mengatakan : "Hijamah merupakan pemisahan yang berhubungan dan berdasarkan kehendak yang didikuti oleh proses pengeluaran darah melalui urat secara total, khususnya urat yang tidak sering dilakukan *venesection / al-fashdu*[1]. Untuk *fashdu* masing-masing urat memiliki manfaat tersendiri" (Sumber : Syihab Al-Badri Yasin, Bekam Sunnah Nabi & Mukjizat Medis).

[1] Al-fashdu / vanesection adalah melukai urat vena tertentu dengan menggunakan pisau bedah dengan cara dan ukuran tertentu untuk mengeluarkan darah untuk pengobatan

2.2. Sejarah *Al-Hijamah* (Bekam)

Menurut Islam bekam merupakan salah satu metode penyembuhan warisan Nabi (Thibbun Nabawi), yaitu salah satu metode yang dahulu digunakan oleh para Nabi yang dipercaya dapat menyembuhkan berbagai macam penyakit atas ijin Allah.

Metode *Al-Hijamah* (bekam) dikenalkan di eropa pada pertengahan abad 19 melalui negri-negri Andalusia pada saat para dokter muslim serta karya tulis mereka menjadi referensi pertama dalam ilmu kedokteran.

2.3. Jenis-jenis Bekam

2.3.1. Bekam Kering (bekam tanpa sayatan)

Proses bekam tanpa adanya penyayatan kulit, sehingga tidak keluar darah pada daerah yang di bekam, namun darah akan keluar dari urat-urat kecil yang menimbulkan bekas seperti memar sementara.

Bekam kering ini dimungkinkan juga untuk menggantikan metode pengobatan *autohemotherapy* pada anak-anak atau orang tua yang sulit ditemukan urat venanya karena usia yang sudah tua.

2.3.2. Bekam Basah (bekam dengan sayatan)

Proses bekam dengan adanya penyayatan kulit pada daerah yang dibekam. sehingga akan mengeluarkan darah kotor, rusak atau tidak berfungsi yang dapat menghambat proses sirkulasi darah dan mengganggu sistem kerja organ tubuh.

Saat terjadi penyayatan pada kulit maka tubuh akan menghasilkan beberapa zat seperti *histamine, slow reacting substance* (SRS), serta zat-zat lain. Zat-zat ini

menyebabkan terjadinya dilatasi kapiler yang menyebabkan terjadi perbaikan mikrosirkulasi pembuluh darah. Akibatnya timbul efek relaksasi (pelemasan) otot-otot yang kaku serta akan menurunkan tekanan darah secara stabil. Sedangkan golongan *histamine* mempunyai manfaat dalam proses reparasi (perbaikan) sel dan jaringan yang rusak, sehingga akan meninggikan resistensi (daya tahan) dan imunitas (kekebalan) tubuh.

2.4. Darah Bekam

Darah bekam adalah darah yang dikeluarkan oleh juru bekam dari dalam tubuh, Ada Beberapa ciri darah bekam :

- ☑ Teroksidasinya darah tanpa udara (anaerob)
- ☑ Terpisahnya plasma dari darah
- ☑ Mengandung sepersepuluh kadar sel darah putih (Leukosit) yang ada dalam darah biasa, padahal secara medis tidak bisa darah keluar tanpa disertai sel-sel darah putih.
- ☑ Semua sel darah merah (eritrosit) memiliki bentuk yang aneh, artinya sel-sel tersebut tidak mampu melakukan aktivitas, di samping juga menghambat sel-sel lain yang masih muda dan aktif.
- ☑ Kandungan sel darah merah maupun sel darah putih dalam darah bekam tinggi sekali. Ini menunjukkan bahwa proses bekam berhasil mengeluarkan kotoran, sisa, dan endapan darah sehingga mendorong kembali aktifnya seluruh sistem dan organ tubuh.

2.5. Titik Meridian

Menurut kedokteran tradisional, bahwa dibawah kulit, otot, maupun fascia terdapat suatu poin atau titik yang mempunyai sifat istimewa. Antara poin satu dengan poin lainnya saling berhubungan membujur dan melintang membentuk jaring-jaring atau jala. Jala ini dapat disamakan dengan *meridian.*

Dengan adanya titik meridian ini, maka terdapat hubungan yang erat antara bagian tubuh bagian bawah dengan bagian atas, antara bagian dalam dengan bagian luar, antara sebelah kiri tubuh dengan sebalah kanan tubth, antara organ-organ tubuh dengan jaringan bawah kulit, antara organ padat dengan organ berongga, dan lain sebagainya, sehingga membentuk suatu kesatuan yang tak terpisahkan dan dapat bereaksi secara serentak.

Kelainan yang terjadi pada satu poin ini dapat mempengaruhi poin yang lainnya, juga sebaliknya, pengobatan pada satu poin akan menyembuhkan poin lainnya. Teori ini dapat menjelaskan bahwa seseorang yang sakit matanyatidak perlu dibekam pada matanya, namun dapat dibekam di daerah kepala atau sekitar tengkuknya.

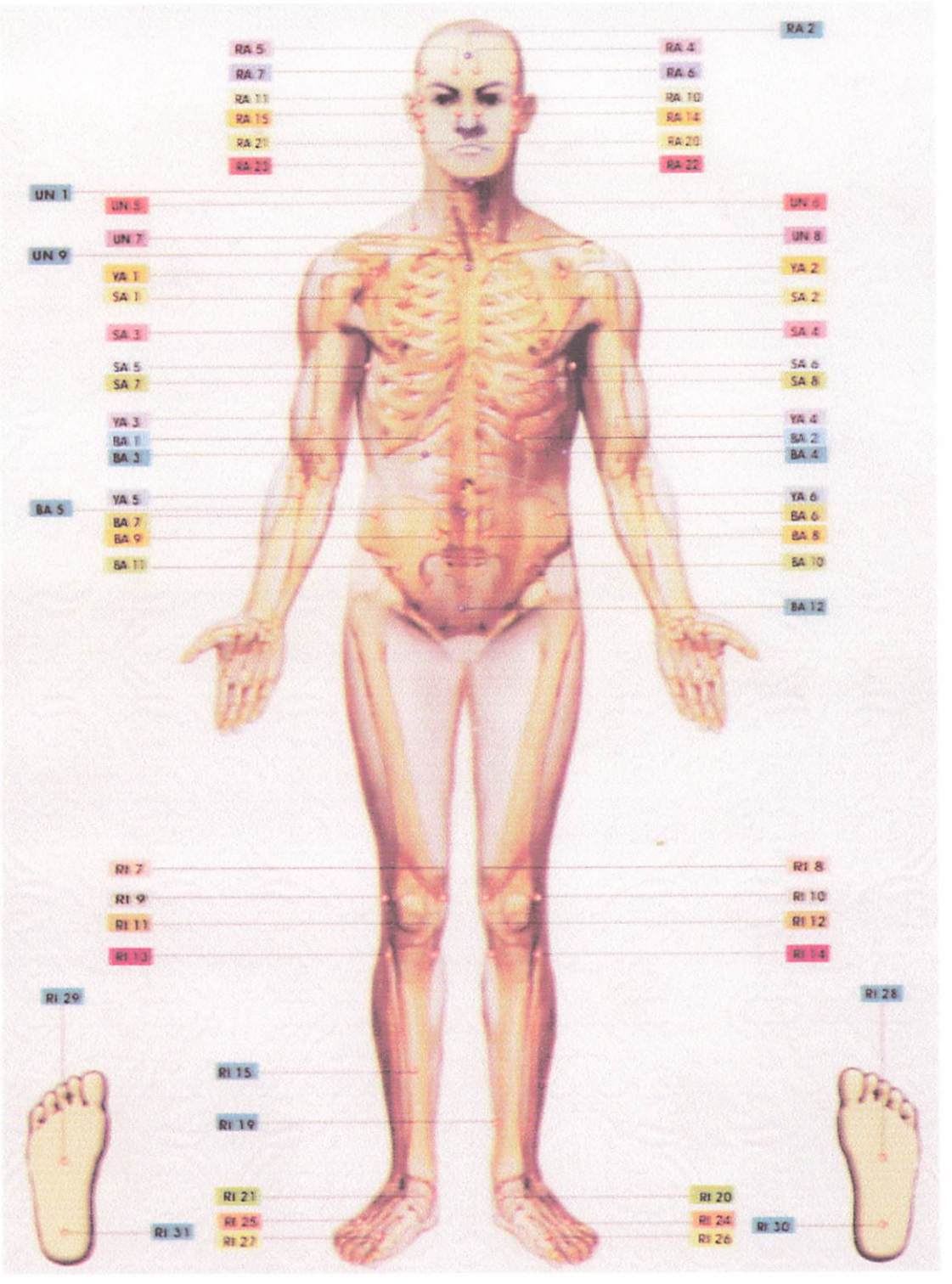
Jumlah titik Meridian Utama dan posisinya pada anatomi tubuh dapat dilihat pada table 2-1.

Tabel 2-1. Meridian utama dengan jumlah titik bekam

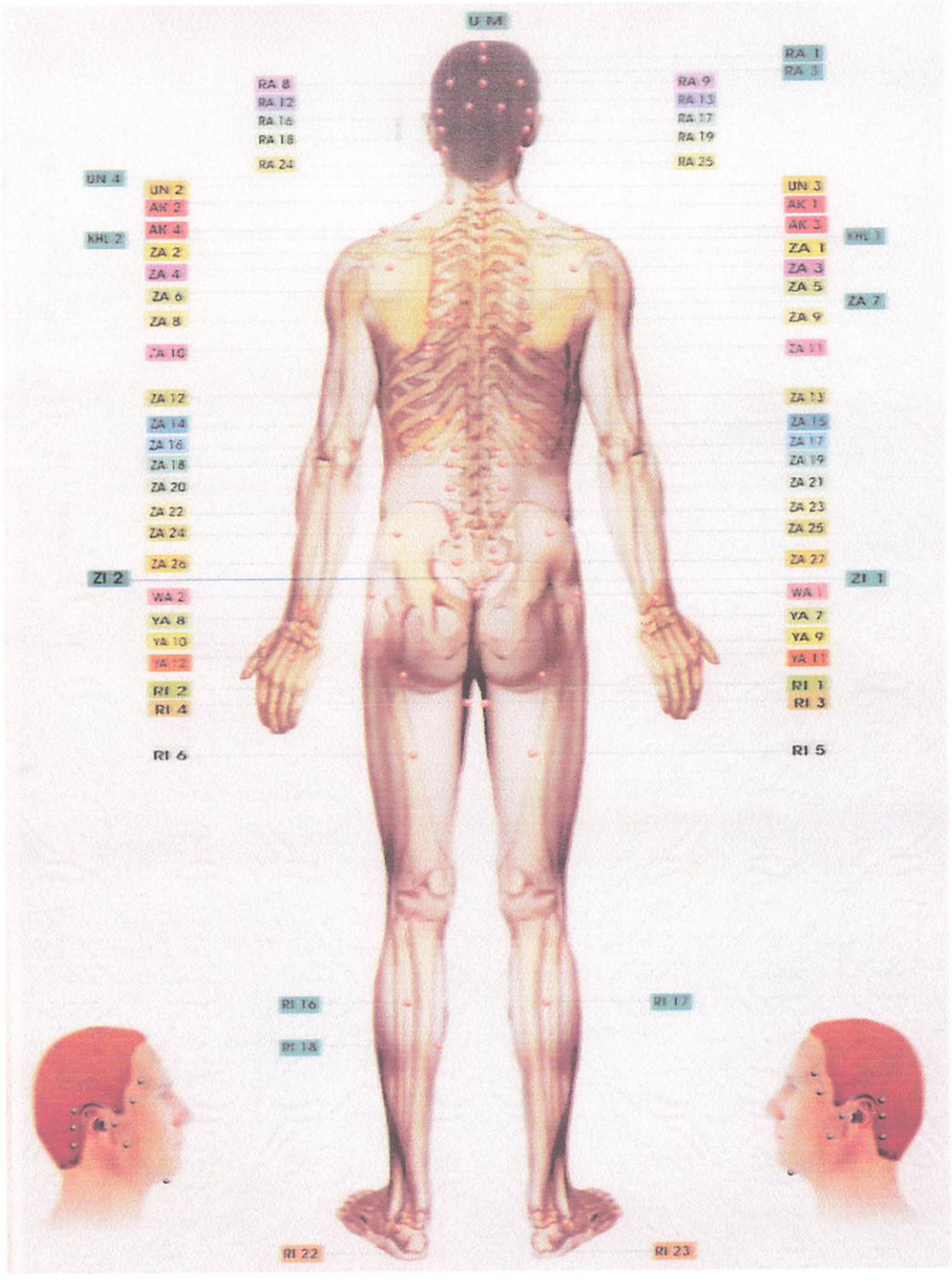
Nama Titik	Posisi Pada Anatomi Tubuh	Jumlah Titik
UM	Di Kepala Bagian Atas Tengah	1
RA	Di Bagian Wajah dan Belakang Kepala	25
KHL	Di Bawah Leher Belakang	2
YA	Di Tangan Bagian Depan dan Belakang	12
UN	Di Bagian Leher, Depan dan Belakang	9
AK	Di Bagian Bahu atau Pundak	4
SA	Di Bagian Dada	8
BA	Di Bagian Perut	12
ZA	Di Bagian Punggung	27
ZI	Di Bagian Tulang Ekor	2
WA	Di Pangkal Paha Atas	2
RI	Di Bagian Kaki	31

Sumber: Uraian Kode Anatomi Hijamah (Titik-titik Bekam)
Pustaka As-Sabil, Jakarta 2006

Letak dari titik-titik bekam menyebar di seluruh tubuh. Untuk mengetahui letak yang lebih tepat dalam Gambar 2-2a serta 2-2b digambarkan anatomi manusia dari sisi muka dan belakang. Letak titik tersebut sesuai dengan jenis penyakit yang ingin diterapi.



Gambar 2.2a. Anatomi Al-Hijamah Bagian Depan
Sumber: Uraian Kode Anatomi Hijamah (Titik-titik Bekam)
Pustaka As-Sabil, Jakarta 2006



Gambar 2.2b. Anatomi Al-Hijamah Bagian Belakang
Sumber: Uraian Kode Anatomi Hijamah (Titik-titik Bekam)
Pustaka As-Sabil, Jakarta 2006

Pada perancangan ditekankan hanya pada titik utama saja tidak melibatkan titik tambahan. Daftar nama penyakit beserta titik-titik yang ingin diterapi ditunjukkan dalam Tabel 2.2.

Tabel 2-2. Nama penyakit, serta titik utamanya

No.	Nama Penyakit	Nama titik
1.	Amandel	KHL_I, UN_7, UN_8, UN_9
2.	Asma	KHL_I, SA_3, SA_4, UN_9
3.	Asam Urat	KHL_I, ZA_{16}, ZA_{17}
4.	Bronchitis	KHL_I, UN_9, ZA_8, ZA_9
5.	Cacingan	KHL_I, ZA_{24}, ZA_{25}, BA_8, BA_9
6.	Diabetes	KHL_I, ZA_{14}, ZA_{15}
7.	Encok (artritis)	KHLI, ZA_{18}, ZA_{19}
8.	Epilepsi	KHL_I, UM, ZA_{10}, ZA_{11}
9.	Gigi	KHL_I, UN_I
10.	Gondok	KHL_I, UN_5, UN_6
11.	Hipertensi	KHL_I, UM, UN_2, UN_3
12.	Insomnia	KHL_2, ZA_{10}, ZA_{11}
13.	Jerawat (penuh di muka)	KHL_I, RA_{22}, RA_{23}
14.	Kaki (telapak) Pecah-pecah	KHLI, RI_{30}, RI_{31}
15.	Kanker Ginjal	KHL_I, ZA_{16}, ZA_{17}
16.	Kanker Prostat	KHL_I, ZA_{26}, ZA_{27}
17.	Kanker Otak	KHL_I, UM

18.	Kolesterol Tinggi	KHL_I, UN_2, UN_3, AK_I, AK_2
19.	Kesuburan (Pria)	KHL_I, BA_5, BA_{IO}, BA_{II}, RI_{I5}, RI_{I8}
20.	Maag (keasaman lambung)	KHL_I, BA_2
21.	Migran	KHL_I, RA_6, RA_7, RA_8, RA_9,
22.	Obesitas	KHL_I, BA_2, BA_3
23.	Pengapuran di Lutut	KHL_I,RI_7, RI_8, RI_9, RI_{IO}, RI_{II}, RI_{I2}, RI_{I3}, RI_{I4}
24.	Sembelit	KHL_I, BA_6, BA_7, ZI_I, AK_3, AK_4
25.	Vertigo	KHL_I, UM, UN_2, UN_3
26.	Wasir	KHL_I, ZI_2

Sumber: Uraian Kode Anatomi Hijamah (Titik-titik Bekam)
Pustaka As-Sabil, Jakarta 2006

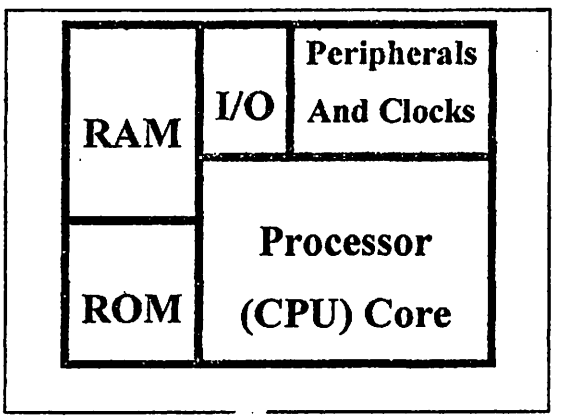
Harus diakui, bahwa kaum muslimin saat ini jarang sekali yang mau mendalami dan mengamalkan ilmu kedokteran warisan Nabi (*Thibbun nabawi*), diantaranya adalah *Al-Hijamah* (Bekam), dimana bekam adalah Sunnah Nabi yang memiliki mukjizat medis sebagai penyembuh dari setiap penyakit dengan izin Allah.

Demikian sekilas informasi tentang Terapi Al-Hijamah (bekam), walaupun terkesan islami, namun tidak menutup kemungkinan bagi yang non muslim untuk mencoba, seperti beberapa penelitian yang dilakukan para ahli bekam dari barat, antara lain penelitian Kohler D. (1990) dengan bukunya *The Connective Tissue as The Physical Medium for Conduction of Healing Energy in Cupping Therapeutic Methode* (Jaringan sebagai Media Fisik untuk Menghantarkan Energi Pengobatan Dengan Bekam), atau Thomas W. Anderson (1985) dengan tulisannya *100 Diseases*

Treated by Cupping Method (100 Penyakit yang Dapat Diobati Dengan Bekam) (Sumber : Syihab Al-Badri Yasin, Bekam Sunnah Nabi & Mukjizat Medis).

2.6. Mikrokontroler

Perbedaan mendasar antara mikrokontroler dan mikroprosesor adalah mikrokontroler dapat berdiri sendiri sehingga sebuah mikrokontroler dapat dikatakan sebagai mikrokomputer dalam keping tunggal *(Single Chip Microcomputer)* yang terdiri atas empat unsur yaitu prosessor (CPU), memori, perangkat I/O dan perangkat lain yang merupakan kelengkapan sebagai sistem minimum mikrokomputer seperti ditunjukkan dalam Gambar 2-2.



Gambar 2-2. Arsitektur Mikrokontroler
Sumber : http://www.atmel.com/89S51.pdf

Blok CPU, memori dan I/O merupakan blok utama sebuah mikrokontroler. Setiap MK pasti memiliki blok tersebut. Selain tiga blok utama tersebut terdapat perangkat (*peripheral*) lain. Ketersediaan peripheral-peripheral dalam MK tersebut dapat mengurangi adanya perangkat eksternal sehingga memperkecil ukuran alat elektronik secara keseluruhan.

Mikrokontroler didesain dengan instruksi-instruksi lebih luas dan 8 bit instruksi yang digunakan membaca data instruksi dari *internal memori* ke ALU.

Banyak instruksi yang digabung dei ,an pin-pin chipnya. Pin tersebut yaitu pin yang dapat diprogram (*programmable*) yang mempunyai beberapa fungsi yang berbeda tergantung pada kehendak *programmer*. Sedangkan *mikroprossesor* didesain sangat fleksibel dan mempunyai banyak *byte* instruksi. Semua instruksi bekerja dalam sebuah konfigurasi perangkat keras yang membutuhkan banyak ruang *memori* dan perangkat I/O dihubungkan ke alamat dan pin-pin data bus pada *chip*.

2.6.1. Mikrokontroler AT89S51

Mikrokontroler AT89S51 adalah mikrokontroler ATMEL yang kompatibel penuh dengan mikrokontroler keluarga MCS – 51, membutuhkan daya rendah, memiliki *performance* yang tinggi dan merupakan mikrokomputer 8 bit yang dilengkapi 4Kbyte EEPROM *(Electrical Erasable and Programmable Read Only Memory)* dan 128 Byte RAM internal. Program memori yang dapat diprogram ulang dalam sistem atau menggunakan *Programmer Nonvolatile* Memori konvensional.

Dalam sistem mikrokontroler terdapat dua hal yang mendasar, yaitu: perangkat lunak dan perangkat keras yang keduanya saling terkait dan mendukung.

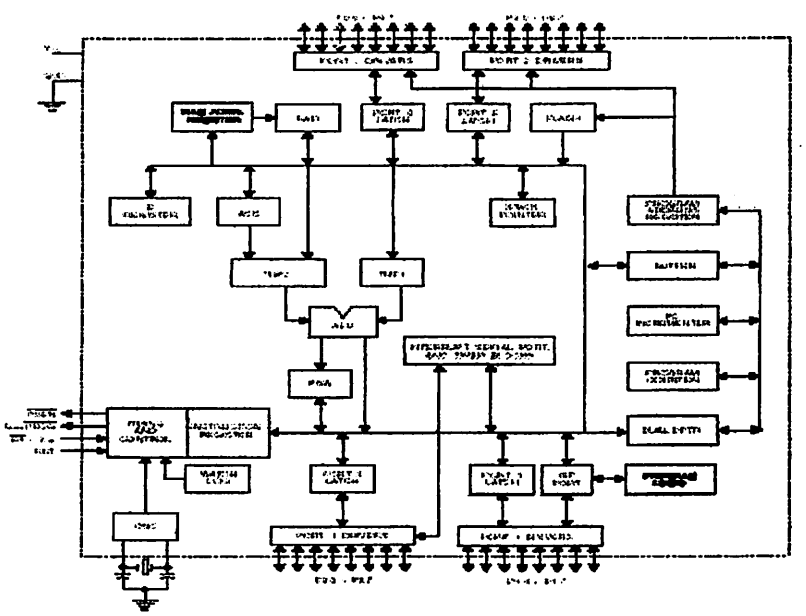
2.6.2. Perangkat keras mikrokontroler AT89S51

Secara umum Mikrokontroller AT89S51 memiliki :

☑ CPU 8 bit termasuk keluarga MCS-51

- ☑ 4 Kb Flash memory
- ☑ 128 byte Internal RAM
- ☑ 32 buah Port I / O, masing – masing terdiri atas 8 jalur I / O
- ☑ 2 Timer/ counter 16 bit
- ☑ 2 Serial Port Full Duplex
- ☑ Kecepatan pelaksanaan intruksi/siklus 1us pada frekuensi clock 12 Mhz
- ☑ 2 DPTR (Data Pointer)
- ☑ Watchdog Timer
- ☑ Fleksibel ISP Programming

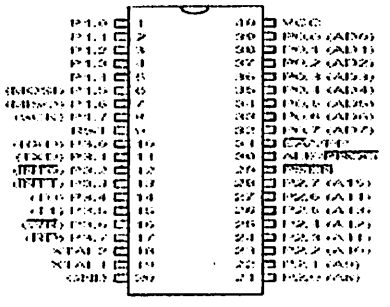
Dengan keistimewaan diatas pembuatan alat menggunakan AT89S51 menjadi lebih sederhana dan tidak memerlukan IC pendukung yang banyak. Blok diagram dari Mikrokontroler AT89S51 seperti pada gambar 2-3.



Gambar 2-3. Diagram Blok Mikrokontroler AT89S51
Sumber : Data Sheet Microcontroller AT89S51, http://www.atmel.com.

2.6.3. Konfigurasi Pin Mikrokontroler AT89S51

Mikrokontroler AT89S51 memiliki 40 Pin yang didefinisikan seperti pada gambar 2-4.



Gambar 2-4. Konfigurasi pin AT89S51

Sumber : Data Sheet Microcontroller AT89S51, http://www.atmel.com.

1. Vcc : Catu daya (supply tegangan).
2. Gnd : Ground.
3. Port 0 : Port 0 merupakan port 8 bit yang bersifat open drain dua arah. Sebagai port keluaran, tiap pin dapat menerima 8 masukan TTL. Saat logika 1 dituliskan pada port, pin port dapat digunakan sebagai masukan dengan impedansi tinggi.
4. Port 1 : Port ini merupakan port I / O biderectional dengan internal pull-up. Out put Port ini dapat mendayai atau menerima 4 masukan TTL. Jika suatu logika 1 dituliskan pada port ini, maka port akan dibuat tinggi oleh *pull-up* internal dan dapat digunakan sebagai masukan. Pada saat sebagai port masukan, port ini akan dibuat rendah dan port ini akan

mendayai karena adanya *pull-up* internal.

5. Port 2 : Port ini merupakan port I/O biderectional dengan internal pull-up. Penyangga pada port ini mampu menangani 4 masukan TTL. Jika logika 1 dituliskan pada port ini, maka port akan dibuat tinggi oleh *pull-up* internalnya.

6. Port 3 : Port ini merupakan port I/O bidirectional dengan internal pull-up. Out put Port ini dapat mendayai atau menerima 4 masukan TTL. Jika suatu logika 1 dituliskan pada port ini, maka port akan dibuat tinggi oleh *pull-up*. Selain sebagai port parallel port ini juga mempunyai fungsi khusus yaitu :

Tabel 2-3 Fungsi khusus Port 3

Port Pin	Fungsi Khusus
P3.0	RXD (masukan port serial (UART))
P3.1	TXD (keluaranan port serial (UART))
P3.2	INT0 (masukan interupsi luar 0)
P3.3	INT1 (masukan interupsi luar1)
P3.4	T0 (masukan luar Timer / Counter 0)
P3.5	T1 (masukan luar Tmer)
P3.6	WR (pulsa penulisan data memori luar)
P3.7	RD (pulsa pembacaan memori luar)

7. Reset : Masukan untuk reset. Suatu logika high selama dua siklus pada pin reset akan menyebabkan terjadinya proses reset.

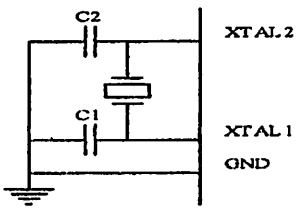
8. ALE : Addres latch enable merupakan suatu pulsa keluaran untuk mengaitkan (latch) byte bawah dari alamat selama mengakses memori luar.

9. PSEN : Program store enable adalah pulsa pengaktif untuk membaca program memori luar. Saat Mikrokontroler melaksanakan instruksi dari program memori luar, PSEN akan diaktifkan dua kali siklus mesin, kecuali pada saat mengakses data memori luar.

10. EA/VPP : External access enable. EA harus dihubungkan dengan ground jika ingin mengakses dari program memori luar dengan alamat 0000H sampai FFFFH. EA harus dihubungkan ke V_{CC} jika menggunakan program memori internal.

11. X-TAL 1 dan X-TAL 2

Pin ini dihubungkan dengan kristal bila menggunakan osilator internal. X-TAL 1 merupakan masukan ke rangkaian osilator internal sedangkan X-TAL 2 keluaran dari rangkaian osilator internal.Untuk keperluan ini diperlukan kapasitor penstabil sebesar 30pF. Dan nilai dari X-TAL tersebut antara 4 – 24 Mhz. Untuk lebih jelasnya dapat dilihat gambar pemasangan X-TAL serta kapasitor yang digunakannya.

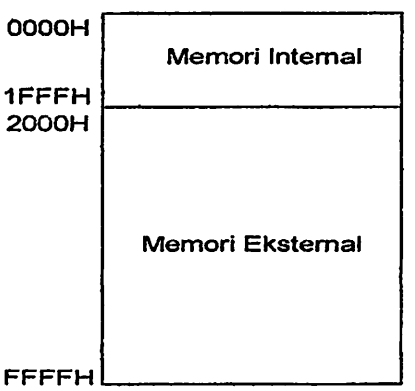


Gambar 2-5. Osilator Eksternal AT89S51

Sumber : Data Sheet Microcontroller AT89S51, http://www.atmel.com.

2.6.4. Organisasi Memori

Organisasi memori pada mikrokontroler AT89S51 dapat dibagi menjadi dua bagian besar yaitu memori program dan memori data. Pembagian tersebut didasarkan atas fungsi dari penyimpanan data maupun program. Memori program digunakan untuk menyimpan instruksi-instruksi yang akan dijalankan oleh mikrokontroler, sedangkan memori data digunakan sebagai tempat yang sedang diolah mikrokontroler. Organisasi memori mikrokontroler AT89S51 dapat dilihat pada gambar 2-6.



Gambar 2-6. Organisasi Program memori

Sumber : Data Sheet Microcontroller AT89S51, http://www.atmel.com.

Mikrokontroler AT89S51 dilengkapi dengan ROM internal, sehingga untuk menyimpan program tidak digunakan ROM eksternal yang terpisah dari mikrokontroler. Agar tidak menggunakan memori program eksternal, penyemat/EA dihubungkan dengan Vcc (logika 1).

Memori program mikrokontroler menggunakan alamat 16 bit mulai 0000_H-$0FFF_H$, sehingga kapasitas penyimpanan program maksimal adalah 4Kb. Sinyal /PSEN (*Program Store Enable*) tidak digunakan jika digunakan memori program internal.

Selain program mikrokontroler AT89S51 juga memiliki data internal 128 *byte* dan mampu mengakses memori data eksternal sebesar 64 Kb. Semua memori data internal dapat dialamati dengan data langsung atau tidak langsung. Ciri dari pengalamatan langsung adalah *operand* yaitu alamat register yang berisi alamat data yang akan diolah. Sebagian memori tersebut dapat dialamati dengan pengalamatan register, dan sebagian lagi dapat dialamati dengan memori satu bit. Untuk membaca data digunakan sinyal / RD sedangkan untuk menulis digunakan sinyal / WR.

2.6.5. SFR (*Special Function Register*)

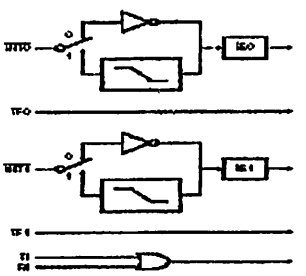
Register Fungsi Khusus (*Special Function Register*) terletak pada 128 byte bagian atas memori data internal dan berisi register-register untuk pelayanan latch port, timer, program status words, control peripheral, dan sebagainya.

Beberapa macam register fungsi khusus yang sering digunakan adalah sebagai berikut ini :

- ☑ *Accumulator* (ACC) merupakan register untuk penambahan dan pengurangan. Perintah *mnemonic* untuk mengakses akumulator disederhanakan sebagai A.
- ☑ *Register B* merupakan register khusus yang berfungsi melayani operasi perkalian dan pembagian.
- ☑ *Stack Pointer* (SP) merupakan register 8 bit yang dapat diletakkan di alamat manapun pada RAM internal.
- ☑ *2 Data Pointer* (DPTR) terdiri dari dua register, yaitu untuk byte tinggi (*Data Pointer High*, DPH) dan byte rendah (*Data Pointer Low*, DPL) yang berfungsi untuk mengunci alamat 16 bit.
- ☑ *Port 0* sampai *Port 3* merupakan register yang berfungsi untuk membaca dan mengeluarkan data pada port 0, 1, 2, 3. Masing-masing register ini dapat dialamati per-byte maupun per-bit.
- ☑ *Control Register* terdiri dari register yang mempunyai fungsi kontrol. Untuk mengontrol sistem interupsi, terdapat dua register khusus, yaitu register IP (*Interupt Priority*) dan register IE (*Interupt Enable*). Untuk mengontrol pelayanan timer/counter terdapat register khusus, yaitu register TCON (*timer/counter control*) serta pelayanan port serial menggunakan register SCON (*Serial Port Control*).

2.6.6. Sistem Interupsi

Mikrokontroller AT89S51 mempunyai 5 buah sumber interupsi yang dapat membangkitkan permintaan interupsi, yaitu INT0, INT1, T1, T2 dan Port Serial.



Gambar 2-7 Sumber Interupsi Mikrokontroler AT89S51

Sumber : Data Sheet Microcontroller AT89S51, http://www.atmel.com.

Saat terjadinya interupsi mikrokontroler secara otomatis akan menuju ke subrutin pada alamat tersebut. Setelah interupsi selesai dikerjakan, mikrokontroller akan mengerjakan program semula. Tiap-tiap sumber interupsi dapat *enable* atau *disable* secara software.

Tingkat prioritas semua sumber *interupt* dapat diprogram sendiri-sendiri dengan *set* atau *clear* bit pada (*Interupt Priorit*). Jika dua permintaan interupsi dengan tingkat prioritas yang berbeda diterima secara bersamaan, permintaan interupsi dengan prioritas tertinggi yang akan dilayani. Jika permintaan interupsi dengan prioritas yang sama diterima bersamaan, akan dilakukan polling untuk menentukan mana yang akan dilayani.

Tabel 2-4 Alamat Sumber Interupsi

Sumber interupsi	*Alamat Awal*
Interupt Luar 0 (INT 0)	03_H
Pewaktu/ pencacah 0 (T0)	$0B_H$
Interupt Luar 1 (INT 0)	13_H
Pewaktu/ pencacah 0 (T0)	$1B_H$
Port Serial	23_H

Sumber : Data Sheet Microcontroller AT89S51, http://www.atmel.com.

2.6.7. Perbedaan dengan Mikrokontroler AT89C51

Atmel berhasil 'menghidupkan kembali' mikrokontroler MCS51, dengan cara menggunakan Flash PEROM sebagai memori program. AT89C51 adalah anggota keluarga mikrokontroler MCS51 yang paling dikenal. Chip ini setara dengan dengan chip asli buatan intel 8051, bedanya adalah memori program dalam AT89C51 menggunakan Flash PEROM. Selain AT89C51 banyak pula dipakai AT89C52, yang kapasitas memori programnya dua kali lebih besar. Pemakaian Flash PEROM untuk memori program membuat harga kedua chip ini menjadi sangat murah, dan pengisian/penghapusan memori program jadi lebih mudah. Namun cara pengisian program ke Flash PEROM di dalam chip AT89C51/52 dirasa sangat rumit, untuk meningkatkan pemakaian mikrokontroler

buatannya, baru-baru ini Atmel meluncurkan AT89S51 dan AT89S52 yang jauh lebih mudah diisi.

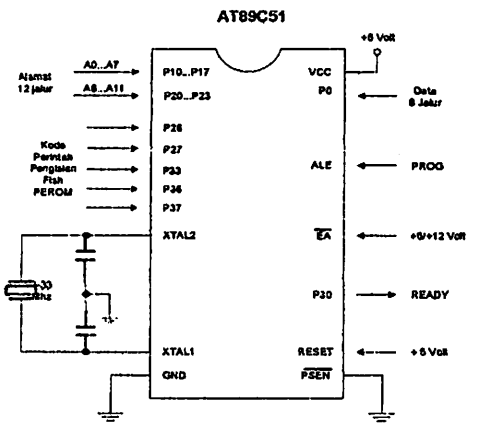
Gambar 2-8a dan gambar 2-8b memperlihatkan diagram pengisian program ke Flash PEROM. Gambar 2-8a dipakai untuk mengisi memori program chip AT89C51 dan AT89C52, dikatakan sebagai pengisian secara pararel karena data dan alamat chip AT89C51/52 dikendalikan secara pararel lewat 12 (13 untuk AT89C52) jalur alamat dan 8 jalur data.

Gambar 2-8b memperlihatkan cara pengisian Flash PEROM secara seri , perintah/ata dikirim ke Flash PEROM secara seri melalui P15 / MOSI, dan isi Flash PEROM diambil secara seri melalui P16 / MISO, untuk transmisi data secara seri tersebut diperlukan clock di P17 / SCK. Pengisian secara pararel memerlukan jalur yang jauh lebih banyak,selain itu diperlukan pula dua sumber tegangan (+5V / 12 V) pada kaki EA, dan pengaturan sinyal yang cukup rumit pada P26;P27;P33;P36;P37 dan ALE, sehingga rangkaian menjadi rumit,hal ini dirasa sangat merepotkan, karena pengisian harus dilakukan di alat tersendiri (biasa dikatakan sebagai Flash PEROM Programer).

Pengisian secara seri hanya memerlukan 3 jalur saja dan sumber tegangan 5 Volt. Rangkaian yang diperlukan sangat sederhana, sehingga pengisian Flash PEROM bisa dilakukan langsung di tempat, tanpa harus melepaskan chip mikrokontroler dari PCB-nya, cara pengisian semacam ini disebut sebagai In System Programing (ISP). Atmel sejak lama sudah memproduksi AT89S8252 dan AT89S53 yang mempunyai fasilitas serupa, bahkan semua mikrokontroler

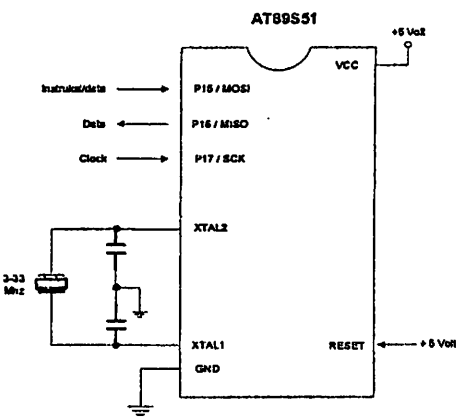
AVR buatan Atmel juga bisa diisi secara seri. Program ini memerlukan "AT89ISP Cable", yang dipakai untuk menghubungkan port pararel PC ke PCB, pada ujung kabel sebelah port pararel terdapat rangkaian yang diperlukan.

Selain kemampuan ISP, AT89S51/52 mempunyai tambahan kemampuan baru di banding AT89C51/52, meskipun demikian semua program dan rancangan rangkaian untuk AT89C51/52 bisa dipakai sepenuhnya untuk AT89S51.



Gambar 2-8a

Pengisian Flash Secara Pararel



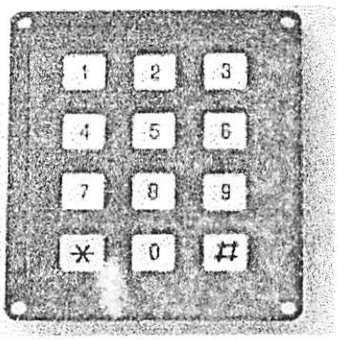
Gambar 2-8b

Pengisian Flash Secara Seri

Sumber : Tabloid Komputek, edisi 3243, minggu ke II, Juli, tahun 2003.

2.7. *Keypad*

Pemberian *input* pada mikrokontroller dibutuhkan sebuah *keypad* yang digunakan untuk memasukkan kode akses ke mikrokontroller. *Keypad* yang digunakan adalah yang bermatrik 3x4 dengan dihubungkan pada *encoder keypad.* Penggunaan *encoder keypad* akan menyederhanakan rangkaian dari perangkat keras yang akan kita disain.



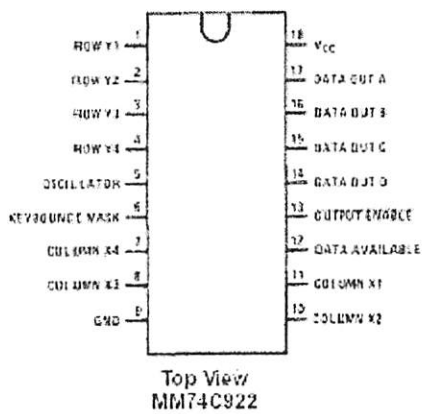
Gambar 2-9. *Keypad 3X4*

Sumber: http://www.oitkeypad.com/pdf/BEZELANDKEYCAPS.pdf

Prinsip kerja dari *keypad* ini sama dengan sakelar SPST *(Single Pole Single Trught)* yang bersifat *normally open*. Namun yang membedakan adalah susunannya yang dibuat seperti matrik serta proses seleksi datanya menggunakan *scanning*.

2.8. *Encoder keypad*

Perangkat ini berguna untuk membaca data dari *keypad* kemudian dikeluarkan melalui pin data *out*. Data yang keluar melalui pin data *out* berupa data biner. IC MM74C922 merupakan *encoder keypad* matrik dengan ukuran 4x4.



Gambar 2-10. Konfigurasi pin MM74C922

Sumber: Fairchild Semiconductor, October 1987:1

Dalam Gambar 2-10 pin 1 – 4 untuk baris *keypad* 1 – 4, pin 11,10,8,7 untuk kolom *keypad* 1 – 4, pin 14 – 17 untuk keluaran data. Pin osilator dan *keybonce mask* dihubungkan dengan capasitor. Nilai dari capasitor tersebut ditentukan sebagai berikut:

$$C_{keybonce\ mask} = 10\ x\ C_{osilator} \quad \text{.....} \quad (2.1)$$

Persamaan 2.1. diambil dari *datasheet encoder keypad* MM74C922.

Untuk mengetahui fungsi logika dari data keluaran keypad. Tabel kebenaran dari MM74C922 ditunjukkan dalam Table 2.5.

Tabel 2.5. Tabel kebenaran *encoder keypad* MM74C922

(Pins 0 through 11)

Switch Position	0 Y1, X1	1 Y1, X2	2 Y1, X3	3 Y1, X4	4 Y2, X1	5 Y2, X2	6 Y2, X3	7 Y2, X4	8 Y3, X1	9 Y3, X2	10 Y3, X3	11 Y3, X4
DATA A	0	1	0	1	0	1	0	1	0	1	0	1
DATA B	0	0	1	1	0	0	1	1	0	0	1	1
DATA C	0	0	0	0	1	1	1	1	0	0	0	0
DATA D	0	0	0	0	0	0	0	0	1	1	1	1
DATA E (Note 1)	0	0	0	0	0	0	0	0	0	0	0	0

(Pins 12 through 19)

Switch Position	12 Y4, X1	13 Y4, X2	14 Y4, X3	15 Y4, X4	16 Y5(Note 1), X1	17 Y5 (Note 1), X2	18 Y5 (Note 1), X3	19 Y5 (Note 1), X4
DATA A	0	1	0	1	0	1	0	1
DATA B	0	0	1	1	0	0	1	1
DATA C	1	1	1	1	0	0	0	0
DATA D	1	1	1	1	0	0	0	0
DATA E (Note 1)	0	0	0	0	1	1	1	1

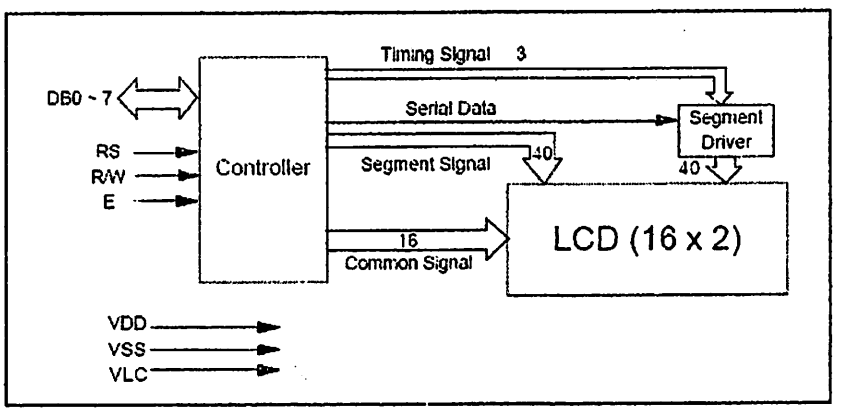
Note 1: Only for MM74C922

Sumber: Fairchild Semiconductor, October 1987:2

2.9. *Liquid Crystal Display*

Liquid Crystal Display atau LCD adalah salah satu jenis penampil yang digunakan untuk menampilkan angka, karakter, atau bahkan angka dan karakter.

LCD terdiri atas tumpukan tipis atau sel dari dua lembar kaca dengan pinggiran tertutup rapat. Antara dua lembar kaca tersebut diberi bahan kristal cair (*liquid crystal*), yang tembus cahaya. Permukaan luar dari masing-masing keping kaca mempunyai lapisan penghantar tembus cahaya seperti oxida timah (*tin oxide*) atau oxida indium (*indium oxide*). Sel mempunyai ketebalan sekitar 1×10^{-5} meter dan diisi dengan kristal cair (*liquid crystal*). Blok diagram LCD ditunjukkan dalam Gambar 2-11.



Gambar 2-11. Diagram Blok LCD Seiko Instrument M1632

Sumber: *Seiko Manual*, 1998:13

LCD adalah suatu modul tampilan yang mempunyai konsumsi daya yang relatif rendah. LCD memiliki keistimewaan dibandingkan tampilan yang lain seperti *sevent segment* yaitu kemampuan untuk menampilkan karakter dan berbagai macam simbol. Salah satu jenis LCD diantaranya adalah LCD tipe *dot matriks* 5x7, tersusun sebanyak dua baris dan masing-masing baris terdiri atas 20 karakter. Setiap karakter dibentuk oleh 5x7 buah titik, sehingga jenis huruf yang

mampu ditampilkan akan lebih banyak dan lebih baik dibandingkan dengan penampil 7 *segment* atau 16 *segment*.

Dalam gambar terlihat bahwa dengan adanya controler pada LCD maka LCD dapat dianggap sebagai suatu lokasi memori dari suatu unit prosessor, sehingga instruksi penampilan ka ..kternya dapat digabungkan menjadi satu dangan unit prosesor.

Untuk dapat menggunakan LCD maka hal-hal yang perlu diperhatikan adalah sinyal kontrol dari LCD yaitu : RS, R/W dan EN. Instruksi operasi meliputi operasi dasar *register*, *busy flag*, *address cunter*, *display data RAM*, *character generator ROM*.

2.9.1. Konfigurasi Pin-pin LCD

Konfigurasi dan fungsi-fungsi umum pin-pin LCD ditunjukkan dalam Tabel 2.6.

Tabel 2.6. Konfigurasi pin-pin LCD

No	SIMBOL	LEVEL	FUNGSI	
1	Vss	-	Power Supply	0 Volt (*Ground*)
2	Vcc	-		5 Volt +/- 10 %
3	Vee	-		For LCD Drive
4	RS	H/L	H = *Input* Data L = *Input* Instruksi	
5	R/W	H/L	H = Read L = *Write*	
6	E	H	Data Bus	

7	DB0	H/L		
8	DB1	H/L		
9	DB2	H/L		
10	DB3	H/L		
11	DB4	H/L		
12	DB5	H/L		
13	DB6	H/L		
14	DB7	H/L		
15	V+ BL	-	Back Light Supply	4 – 4,2 Volt, 50 – 200 mA
16	V- BL	-		0 Volt (*Ground*)

Sumber: EL-TECH Electronics, *LCD Module User Manual,* 1987:2

2.9.2. Fungsi-fungsi Terminal

Fungsi-fungsi terminal LCD Seiko M1632 ditunjukkan dalam Tabel 2.7.

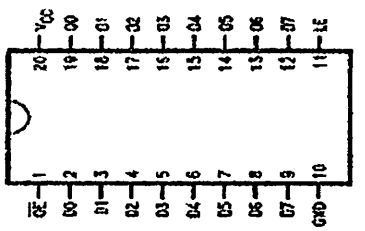
Tabel 2.7. Fungsi-fungsi Terminal

NAMA SINYAL	NO. TERM.	I/O	TUJUAN	FUNGSI
$DB_0 - DB_3$	4	I/O	MPU	Lalu lintas data dan instruksi, lower *byte*
$DB_4 - DB_7$	4	I/O	MPU	Lalu lintas data dan instruksi, upper *byte*
E	1	*INPUT*	MPU	Sinyal Start (Read/*Write*)
R/W	1	*INPUT*	MPU	Sinyal seleksi instruksi
RS	1	*INPUT*	MPU	Sinyal seleksi *register*
V_{LC}	1	-	Power Supply	Driver LCD
V_{DD}	1	-	Power Supply	5 Volt
V_{SS}	1	-	Power Supply	0 Volt (*Ground*)

Sumber: EL-TECH Electronics, *LCD Module User Manual*, 1987:7

2.10. Penahan Alamat

Rangkaian penahan alamat berguna untuk memisahkan antara jalur data dengan alamat. Sehingga apabila terdapat perintah untuk mengirimkan data maka alamat tetap tertahan pada perangkat ini. 74LS573 salah satu jenis IC TTL untuk keperluan penahan alamat delapan bit. Gambar 2-12 merupakan susunan pin dari IC tersebut.

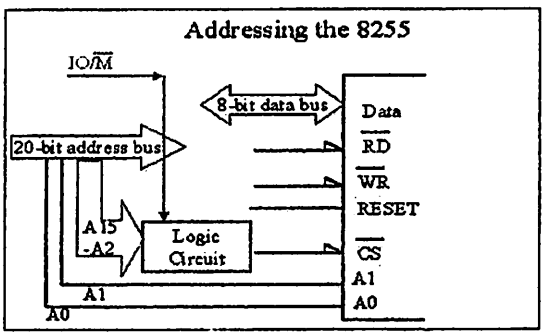


Gambar 2-12. Susunan Pin dari 74LS573
Sumber: Fairchild Semiconductor, *Datasheet*, SN74LS573

Dari Gambar 2-12 terdapat pin $D_0 - D_7$ yang berfungsi sebagai *input*, pin $O_0 - O_7$ berfungsi sebagai *output*. Proses masuk serta keluarnya data dikendalikan oleh sinyal kontrol LE *(Latch Enable)* serta OE *(Ouput Enable)*.

2.11. Dekoder Alamat

Rangkaian dekoder alamat berupa rangkaian logika yang berfungsi untuk mengaktifkan sinyal CS *(Chip Select)* dari PPI 8255. *input* dari rangkaian logika ini berasal dari alamat CPU, sedangkan ouput dari rangkaian logika dimasukkan ke CS *(Chip Select)* PPI 8255.

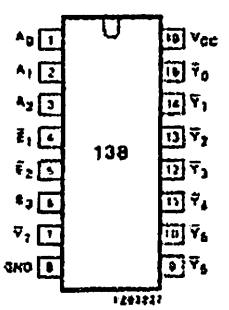


Gambar 2-13. Rangkaian Pengendali *Chip Select*

Sumber: http//:www.olemiss.edu/course/EE/ELE_485/Fall1999/485_L13_99/sld004.htm

Dari Gambar 2-13 A0 dan A1 langsung dihubungkan ke Address Bus CPU sedangkan sisanya didekoderkan sesuai dengan alamat yang kita tentukan terlebih dahulu. CS *(Chip Select)* pada PPI 8255 akan aktif apabila dalam kondisi *low*, sehingga dalam perancangan rangkaian dekoder harus menyesuaikan syarat tersebut.

Dekoder 74LS138 merupakan salah satu rangkaian logika yang secara umum digunakan untuk pengendalian *chip select* pada suatu minimum sistem. Konfigurasi pin dari 74LS138 dapat dilihat dalam Gambar 2.14.



Gambar 2-14. Konfigurasi pin 74LS138

Sumber: Philip Semiconductor, *Datasheet*, September 1993:3

Dalam hal perancangan sebelum kita menggunakan perangkat ini, terlebih dahulu mengetahui fungsi dari tiap-tiap pin dari 74LS138. Tabel 2.8 merupakan tabel yang berisi nomer pin, simbol serta fungsinya.

Tabel 2.8. Fungsi pin 74LS138

No. Pin	Simbol	Fungsi
1,2,3	$A_0 - A_2$	*Address Input*
4,5	E_1, E_2	Aktif *low*
6	E_3	Aktif *high*
8	Gnd	Ground (0V)
15,14,13,12,11,10,9,7	$Y_0 - Y_7$	*Output* aktif *low*
16	Vcc	Positif *power supply*

Sumber: Philip Semiconductor, *Datasheet*, September 1993:3

Untuk mengetahui fungsi logika dari masing-masing pin 74LS138 dalam Gambar 2.14, Tabel 2.9 merupakan tabel kebenaran dari perangkat ini.

Tabel 2.9. Fungsi logika 74LS138

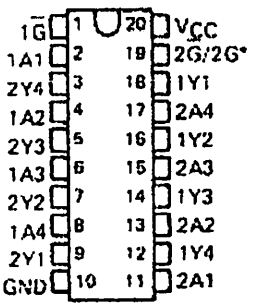
INPUTS						OUTPUTS							
$\overline{E}_1$	$\overline{E}_2$	E_3	A_0	A_1	A_2	$\overline{Y}_0$	$\overline{Y}_1$	$\overline{Y}_2$	$\overline{Y}_3$	$\overline{Y}_4$	$\overline{Y}_5$	$\overline{Y}_6$	$\overline{Y}_7$
H	X	X	X	X	X	H	H	H	H	H	H	H	H
X	H	X	X	X	X	H	H	H	H	H	H	H	H
X	X	L	X	X	X	H	H	H	H	H	H	H	H
L	L	H	L	L	L	L	H	H	H	H	H	H	H
L	L	H	H	L	L	H	L	H	H	H	H	H	H
L	L	H	L	H	L	H	H	L	H	H	H	H	H
L	L	H	H	H	L	H	H	H	L	H	H	H	H
L	L	H	L	L	H	H	H	H	H	L	H	H	H
L	L	H	H	L	H	H	H	H	H	H	L	H	H
L	L	H	L	H	H	H	H	H	H	H	H	L	H
L	L	H	H	H	H	H	H	H	H	H	H	H	L

Keterangan : H : Aktif *high*, L : Aktif *low*, X : *Don't Care*

Sumber: Philip Semiconductor, *Datasheet*, September 1993:4

2.12. *Buffer* Tegangan

Buffer tegangan merupakan rangkaian penyangga tegangan yang digunakan untuk memperbaiki kinerja dari suatu level tegangan tertentu. Pada sistem bus yang mengendalikan beberapa perangkat keras serta keakuratan data maka diperlukannya suatu buffer untuk memperbaiki level tegangan sesuai yang diinginkan. Konfigurasi pin dari 74LS244 sebagai buffer untuk jalur bus 8 bit ditunjukkan dalam Gambar 2-15.



Gambar 2-15. Konfigurasi Pin 74LS244

Sumber: Texas Instrument, *Datasheet*, Maret, 1988:1

Fungsi logika dari 74LS244 ditunjukkan dalam Tabel 2.10. Pada sisi *input* terdapat pin G yang berfungsi untuk mengaktifkan fungsi *buffer*. Pin ini aktif apabila diberi logika rendah. Sedangkan A merupakan masukan data dan pin Y sebagai keluaran

Tabel 2.10. Fungsi logika 74LS244

Inputs		Output
$\overline{G}$	A	Y
L	L	L
L	H	H
H	X	Z

Sumber: FairChild Semiconductor, *Datasheet*, Agustus, 1986:1

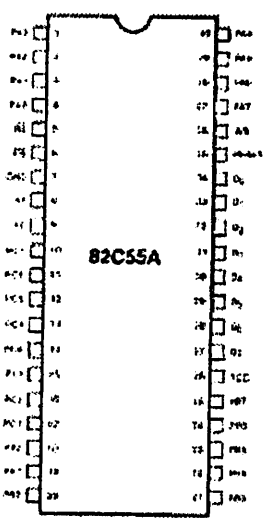
Keterangan :

H : *high logic level*, L : *low logic level.*

X : *Don't Care*, Z : *High Impedance*

2.13. PPI 8255

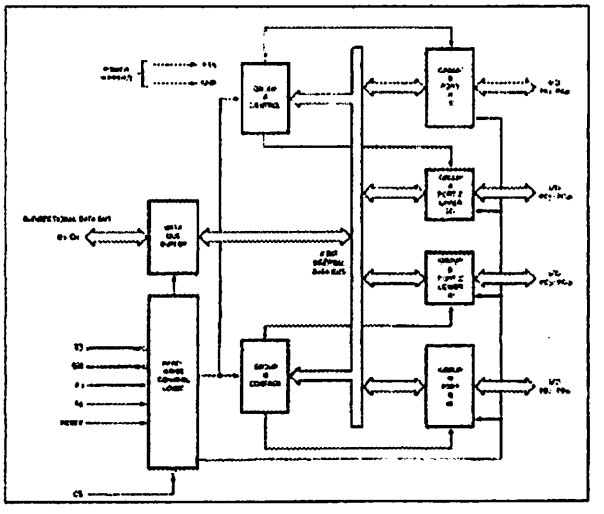
PPI *(Programmable Pheriperal Interfacing)* merupakan *peripheral* yang dapat diprogram serta secara luas untuk antarmuka *input/output*. PPI jenis 8255 ini sengaja diproduksi oleh Intel secara masal untuk keperluan industri. Fitur yang ditawarkan antara lain 24 *programmable port* I/O, 3 mode pengoperasian, arus DC untuk seluruh I/O sebesar 2,5 mA, daya konsumsi rendah, kompatibel dengan TTL. Gambar 2-16 merupakan konfiguarasi pin dari PPI Intel 82C55A.



Gambar 2-16. Konfigurasi Pin PPI 8255

Sumber: Intel, PPI 82C55A, *Datasheet*, October 1995

Gambar 2-17 merupakan blok diagram dari PPI 8255 yang terdiri dari *read write control logic*, *data bus buffer*, group *A control*, group B *control*, Port A, Port B, Port C *upper* dan Port C *lower*.



Gambar 2-17. Blok Diagram PPI 8255

Sumber: Intel, PPI 8.. :55A, *Datasheet*, October 1995

2.13.1. Mode Pengoperasian

PPI 8255 memiliki 3 mode pengoperasian antara lain :

1. Mode 0 : Basic *Input/Output*
2. Mode 1 : *Strobed Input/Output*
3. Mode 2 : Bi-directional Bus

2.13.1.1. Mode 0

Pada mode ini port-port pada PPI digunakan sebagai *input* atau *output*. Mode merupakan mode yang paling sederhana. Tidak diperlukannya sinyal *hanshaking* untuk pembacaan atau penulisan data

dari port yang telah dit .itukan. Menurut *datasheet* dari Intel 82C55 mode 0 memiliki 16 konfigurasi *input/output* yang berbeda.

2.13.1.2. Mode 1

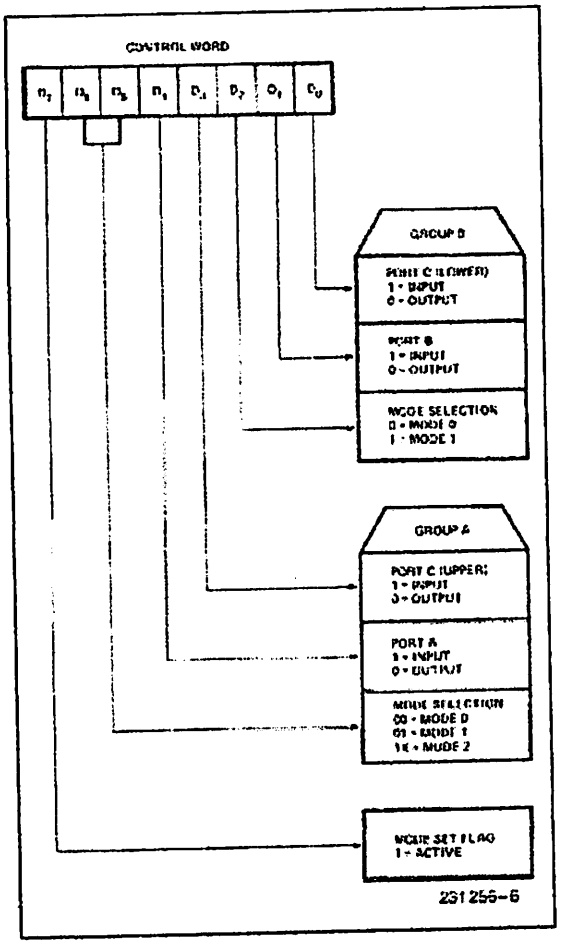
Pada mode ini trasfer data dari atau ke port didukung dengan sinyal *hashaking* atau *strobe*. Sehingga penggunaan port untuk *input/output* selalu dikontrol oleh singal *strobe*. Jalur data yang bisa digunakan yaitu pada Port A dan B. Sedangkan untuk port C digunakan sebagai pembangkit atau penerima sinyal *hanshaking*.

2.13.1.3. Mode 2

Transfer data pada mode dilakukan secara dua arah *(bidirectional)*. Pada mode ini data selalu dikontrol oleh sinyal *strobe*. Penggunaan mode ini juga disediakan fungsi *interupt*. Port yang dapat diakses sebagai jalur data adalah port A saja. Sedangkan port C sebagai sinyal kontrol dan port B tidak bisa bekerja pada mode ini.

2.13.2. *Control word*

Konfigurasi *input*/ouput, pemilihan mode pengoperasian serta pengaturan aktif tidaknya dari PPI ini dikontrol melalui suatu register yang disebut sebagai *control word*. Sebelum trasfer data dari atau ke port dilakukan maka *control word* ini harus diinisialisasi terlebih dahulu secara perangkat lunak. Gambar 2-18 merupakan delapan bit dari *control word* PPI 82C55A.



Gambar 2-18. Diagram *Control Word* PPI Intel 82C55A

Sumber: Intel, PPI 82C55A, *Datasheet*, October 1995:5

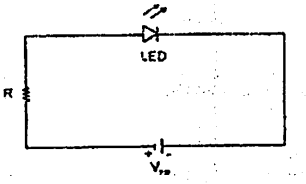
2.14. LED *(Light Emitting Diode)*

LED merupakan jenis khusus dari diode semikonduktor. Seperti halnya diode normal, yang tersusun dari sebuah serpih yang dipenuhi oleh bahan semikonduktor, dengan ketidakmurnian untuk membentuk struktur yang disebut sebagai p-n *junction*. (Sumber:http://en.wikipedia.org/wiki/Light-emitting_diode).

Apabila p-n junction tersebut diberi prategangan maju, elektron-elektron bebas akan bergabung kembali dengan lubang-lubang di sekitar persambungan. Ketika meluruh dari tingkat energi lebih tinggi ke tingkat energi lebih rendah elektron-elektron tersebut akan mengeluarkan energinya dalam bentuk radiasi.Dalam diode penyearah hampir semua energi ini dilepaskan dalam bentuk panas. Tetapi dalam LED, sebagian dari selisih energi ini dilepaskan sebagai radiasi cahaya. (Sumber: Aproks...nasi Rangkaian Semikonduktor, Malvino, 1986:54)

Untuk mengoperasikan LED terdapat beberapa parameter yang perlu diketahui seperti tegangan *forward*, arus *forward*, suhu pengoperasian dan suhu penyimpanan. Sebagai contoh untuk warna pancar merah dengan *lens color* transparan memiliki parameter $V_{f\ (typical)}$ = 1.9 V, I_f = 10 mA, T_{op} = -30 – 85 °C, T_{stg} = -30 – 100 °C. (Sumber: Sanken LED, Buletin No. LO1 EBO, Jan 2001). Pada Gambar 2-19 merupakan rangkaian elektrik untuk mengoperasikan suatu LED. Sesuai dengan teori rangkaian elektrik seri, nilai resistansi R dapat dicari dengan menggunakan persamaan :

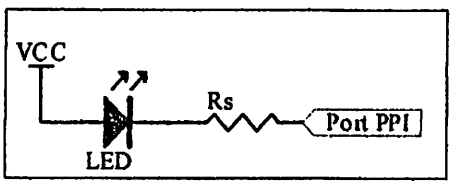
$$R = \frac{Vcc - V_f}{I_f} \qquad \text{.....} \qquad (2.6)$$



Gambar 2-19. Rangkaian Elektrik LED

Sumber: http://zone.ni.com/devzone/conceptd.nsf/webmain

Dalam perancangan LED tersebut akan aktif apabila dalam keadaan *low*. Gambar 2-20 merupakan rangkaian driver LED yang dihubungkan dengan port PPI 82C55A.



Gambar 2-20. Rangkaian indicator titik pada port PPI 82C55A

Dari Gambar 2-20 nilai resistansi LED dapat dicari dengan menggunakan persamaan 2.7.

$$R_s = \frac{Vcc - V_f - V_{OL}}{I_f} \quad \text{.....} \quad (2.7)$$

Keterangan :

R_s : Resistansi seri

Vcc : Tegangan catu

V_f : Tegangan *forward* dari LED

V_{OL} : Tegangan *output low*.

I_f : Arus *forward* LED.

Warna pancaran LED itu sendiri tergantung dari material semikonduktor penyusunnya. Sebagai contoh untuk LED warna merah terbuat dari material (AlGaAs), warna hijau terbuat dari material (AlGaP) dan masih banyak warna yang lainnya. (Sumber: http://en.wikipedia.org/wiki/Light-emitting_diode).

BAB III

PERENCANAAN DAN PEMBUATAN ALAT

Bab ini berisi penjelasan mengenai spesifikasi alat, diagram blok rangkaian dan penjelasan cara kerja rangkaian, serta penjelasan tentang perencanaan perangkat keras dan perangkat lunak.

3.1. Spesifikasi Alat

Perancangan alat ini mempunyai beberapa spesifikasi diantaranya:

1. Gambar anatomi tubuh manusia yang sudah lengkap dengan titik-titik bekam
2. Data penyakit berisi 26 jenis penyakit, antara lain :

☑	Amandel	☑	Kaki (telapak) Pecah-pecah
☑	Asma	☑	Kanker Prostat
☑	Asam Urat	☑	Kanker Otak
☑	Bronchitis	☑	Kanker Ginjal
☑	Cacingan	☑	Kolesterol Tinggi
☑	Diabetes	☑	Kesuburan (Pria)
☑	Encok (artritis)	☑	Maag (keasaman lambung)
☑	Epilepsi	☑	Migran
☑	Gigi	☑	Obesitas
☑	Gondok	☑	Pengapuran di Lutut
☑	Hipertensi	☑	Sembelit
☑	Insomnia	☑	Vertigo
☑	Jerawat (penuh di muka)	☑	Wasir

3. Menggunakan *keypad* ukuran 3x4 sebagai masukkan data.
4. Sebagai tampilan menu digunakan LCD 16x2.
5. Menggunakan AT89S51 sebagai pusat pengendali.

BAB III

PERENCANAAN DAN PEMBUATAN ALAT

Lab: an berisi pemolesan mengenai spesifikasi alat, diagram blok rangkaian dan penjelasan cara kerja rangkaian, serta penjelasan tentang pembuatan perangkat keras dan perangkat lunak

3.1. Spesifikasi Alat

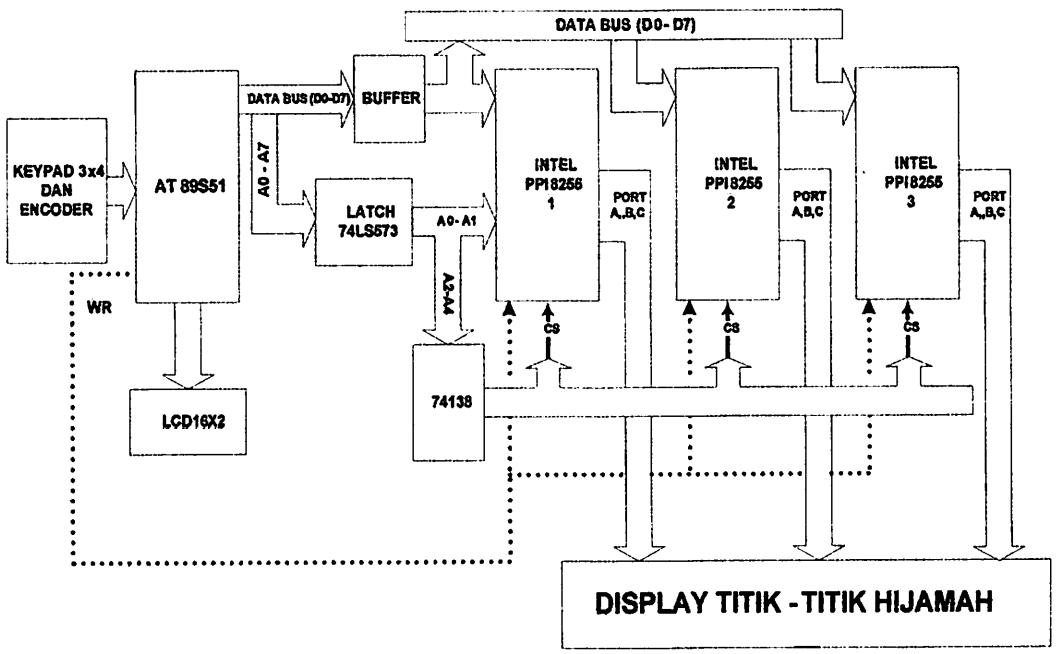
Pernyataan alat ini mempunyai beberapa spesifikasi diantaranya:

1. *Dapat mendeteksi tubuh manusia yang sudah lengkap dengan tulang-tulik beksan*
2. *Data pengukuran berupa 24 jenis pengukuran*

- ☒ *Anggota*
- ☒ *Asma*
- ☒ *Asam Urat*
- ☒ *Bronchitis*
- ☒ *Cacingan*
- ☒ *Diabetes*
- ☒ *Impotensi (ganguan)*
- ☒ *Hipertensi*
- ☒ *Kolesterol*
- ☒ *Obesitas*
- ☒ *Pengapuran di Lutut*
- ☒ *Sembelit*
- ☒ *Varises*
- ☒ *Wasir*
- ☒ *Kaki (telapak) Pecah-pecah*
- ☒ *Kanker Prostat*
- ☒ *Kanker Otak*
- ☒ *Kanker Ginjal*
- ☒ *Kolesterol Tinggi*
- ☒ *Kesehatan Gigi*
- ☒ *Wasir (kesasaran lambung)*
- ☒ *Migran*
- ☒ *Obesitas*
- ☒ *Pengapuran di Lutut*
- ☒ *Sembelit*
- ☒ *Varises*
- ☒ *Wasir*

3. *Menggunakan keypad sebagai input masukkan data.*
4. *Sebagai tampilan menu digunakan LCD 16x2.*
5. *Menggunakan ATMega51 sebagai pusat pengendali.*

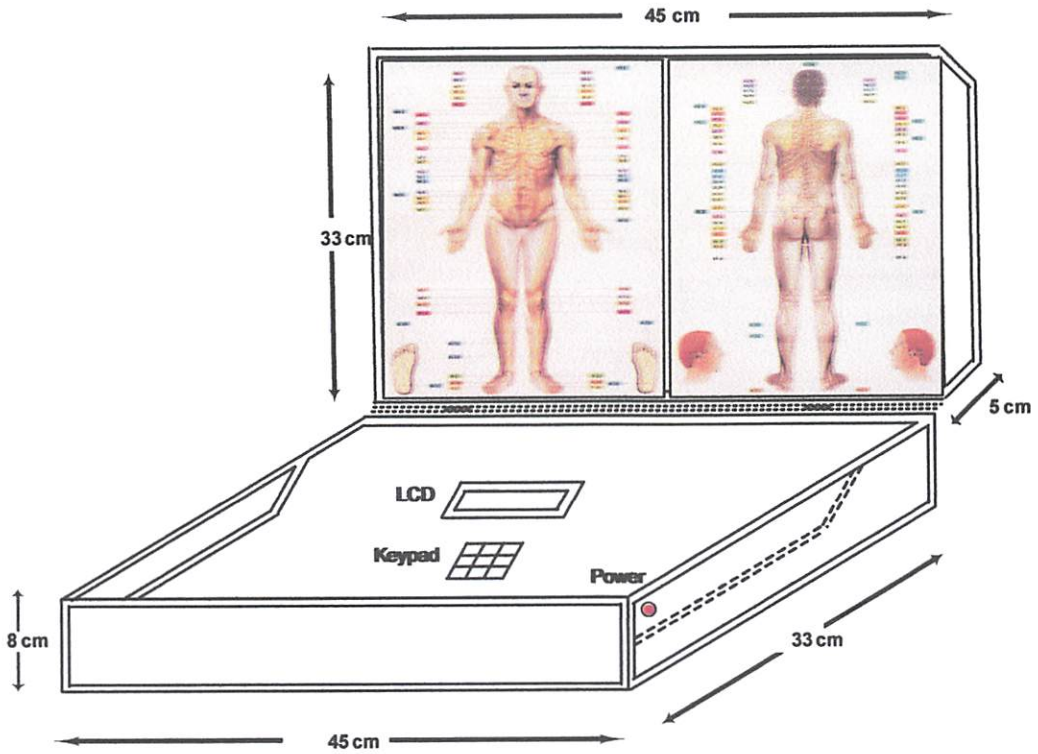
3.2. Blok Diagram Rangkaian



Gambar 3.1. Blok Diagram Keseluruhan Sistem

Secara garis besar cara kerja alat ini adalah seseorang memasukkan ID penyakit sesuai dengan daftar penyakit yang telah ada melalui *keypad.* Apabila ID dikenali mikrokontroler maka proses dilanjutkan dengan tampilan jenis penyakit pada LCD 16X2. setelah tampilan menu tersebut, apabila seseorang telah yakin dengan jenis penyakit tersebut maka proses dilanjutkan dengan menyalakan LED sebagai pengganti titik-titik hijamah sesuai dengan jenis penyakit yang telah ditentukan. Setelah itu proses berulang sampai pengguna memasukkan ID penyakit lainnya. Proses ini melibatkan perangkat yang lainnya seperti *decoder* alamat, PPI 82C55A sebagai *output* serta rangkaian penahan alamat *(latching).*

Gambar berikut merupakan bentuk fisik dari alat :



KETERANGAN	:	
Panjang	:	45 cm
Lebar	:	33 cm
Tinggi bawah	:	8 cm
Tinggi Atas	:	5 cm
Bahan	:	*Fiber Glass*
Warna	:	Hitam
Tebal	:	3 mm

3.3. Perangkat Keras

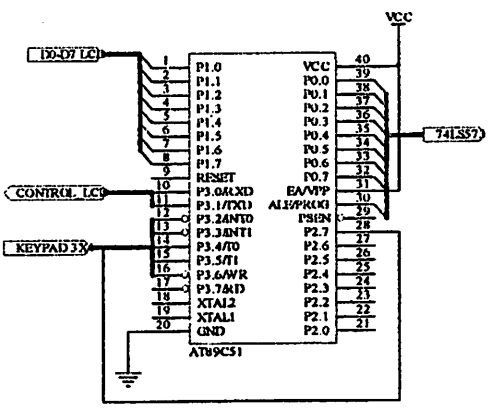
3.3.1. Mikrokontroler

Mikrokontroler didalam perancangan ini merupakan komponen utama, karena komponen mengontrol semua *switch* dan merupakan otak dari sistem agar dapat bekerja dengan baik dan optimal.

Mikrokontroler AT89S51 digunakan sebagai kendali sistem alat ini. Pemilihan mikrokontroler AT89S51 mengingat MCS ini mempunyai internal memori sehingga tidak perlu menambah memori luar, selain itu MCS ini sangat mudah didapatkan dipasaran dengan harga yang relatif murah.

3.3.1.1. Port AT9S51

Penggunaan port pada mikrokontoler AT89S51 ditunjukkan dalam Gambar 3.2.



Gambar 3.2. Penggunaan Port AT89S51

Dalam Gambar 3.2 penggunaan port dapat dijelaskan secara detail sebagai berikut:

1 Port 1 : Digunakan untuk D0-D7 pada LCD 16x2 karakter.

2 Port 0 : Digunakan untuk jalur data dan alamat yang dihubungkan dengan 74LS573.

3 Port 3.0 dan 3.1 dihubungkan dengan pin *control LCD* yaitu E dan RS.

4 Port 3.2 – 3.5 dihubungkan dengan *data out* dari keypad 3x4.

5 Port 2.7 dihubungkan dengan strobe pada *encoder keypad.*

6 Pin ALE dihubungkan dengan LE pada 74LS573.

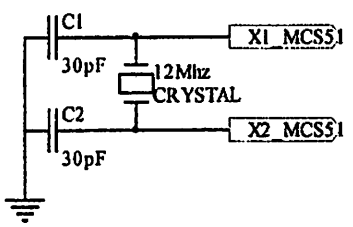
7 Pin Reset dihubungkan dengan rangkaian reset.

8 Pin XTAL1 dan XTAL2 dihubungkan dengan rangkaian osilator.

3.3.1.2. Rangkaian Osilator

Osilator internal MCS AT89S51 dapat dibangkitkan dengan menggunakan kristal sebagai pembangkit pulsa dimana besarnya kristal yang diijinkan sebesar 0 – 24 MHz. Dalam perancangan ditentukan sebesar 12 MHz, sehingga kecepatan pelaksanaan intruksi persiklus sebesar 1 μs ((1/12MHz)x12 siklus perioda).

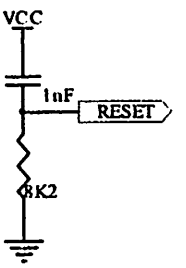
Rangkaian osilator yang telah digunakan ditunjukkan dalam Gambar 3.3. Kristal dihubungkan ke kaki 18 dan 19 pada MCS AT89S51 dengan menambahkan C_1 dan C_2 sebesar 30 pF. Penentuan nilai kapasitor sebesar 30 pF berdasarkan *datasheet.* (*Atmel datasheet* : 4).



Gambar 3.3. Rangkaian Osilator

3.3.1.3. Rangkaian Reset

MCS AT89S51 dapat bekerja jika ada rangkaian resetnya. AT89S51 memakai reset aktif *high* sehingga *input* reset harus tinggi minimal selama 2 siklus mesin (24 periode osilator) saat pertama kali MCS AT89S51 dijalankan. (*Atmel datasheet* : 3). Rangkaian reset terdiri atas resistor dan kapasitor yang dihubungkan ke kaki 9 pada MCS AT89S51 seperti ditunjukkan dalam Gambar 3.4.



Gambar 3.4. Rangkaian reset

Karena kristal yang digunakan mempunyai frekuensi sebesar 12 MHz, maka satu periode membutuhkan waktu sebesar :

$$T = \frac{1}{f_{XTAL}} = \frac{1}{12MHz} s = 0{,}833 \cdot 10^{-8} s$$

Sehingga waktu minimal logika tinggi yang dibutuhkan untuk m*ereset* mikrokontroler adalah :

$$\begin{aligned} t_{reset(\min)} &= T \times \text{ periode yang dibutuhkan} \\ &= 0{,}833 \cdot 10^{-8} \times 24 \\ &= 2\,\mu S \end{aligned}$$

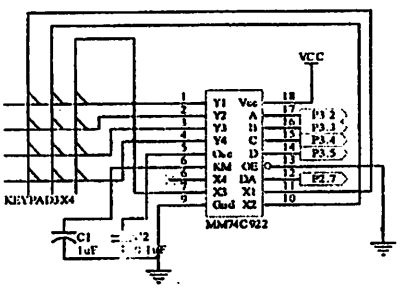
Jadi mikrokontroler membutuhkan waktu minimal 2 μs untuk m*ereset*. Waktu minimal inilah yang dijadikan pedoman untuk menentukan nilai R dan C. Dari persamaan 2.7 dengan menentukan nilai R = 8,2 kΩ

$$t = 0{,}357 \cdot R \cdot C$$
$$2 \cdot 10^{-6} = 0{,}357 \cdot 8{,}2 \cdot 10^{3} C$$
$$C = 0{,}683 \cdot 10^{-9} F$$

Jadi dengan nilai komponen R = 8,2 kΩ nilai kapasitor yang dapat memenuhi syarat untuk m*ereset* mikrokontroler harus diatas 0,683 nF. Untuk kemudahan perancangan dipilih C = 1 nF.

3.3.2. *Encoder Keypad*

Pengambilan data serta proses *scanning* dari *keypad* menggunakan perantara IC MM74C922. Keluaran dari perangkat ini berupa data biner 4 bit. Pin A,B,C, dan D merupakan data *output* dari perangkat ini yang kemudian dimasukkan kedalam port 3.2 – port 3.5 AT89S51. Data yang telah diterima oleh mikrokontroler akan diolah sesuai dengan yang dikehendaki. Dalam Gambar 3.5 merupakan rangkaian dari *encoder keypad* dengan *keypad* ukuran 3x4. Pin Y_1 – Y_4 merupakan konfigurasi baris dari *keypad.* Pin X_1 – X_4 merupakan konfigurasi kolom dari *keypad.*



Gambar 3.5. Rangkaian *Encoder Keypad*

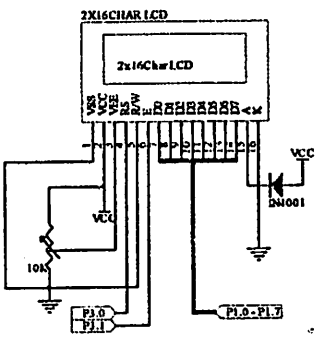
Nilai C_1 dan C_2 dapat ditentukan sesuai dengan persamaan 2.1. Dimana C1 sebagai kapasitor untuk *keybouncemask*, sedangkan C_2 sebagai kapasitor osilator untuk proses *scanning keypad.*

$$C_1 = 10 \; x \; 0.1 \; \mu F$$
$$C_1 = 1 \mu F$$

Dalam perancangan C_2 diambil nilai 0.1 µF. Hal ini dikarenakan sesuai ketentuan dari *datasheet* MM74C922 nilai yang diijinkan antara 0.01 µF – 10 µF.

3.3.3. *Liquid Crystal Display*

Piranti yang digunakan untuk menampilkan data dari MCU adalah berupa LCD dengan tipe M1632 (16 kolom x 2 baris). LCD M1632 adalah suatu jenis piranti *output* yang menggunakan daya rendah dengan pengontrol kontras dan kecerahan. Pengontrol utamanya adalah pada *ROM generator* dan *display* data RAM yang menghasilkan data ASCII, jika diberikan *input*an kode ASCII. Perencanaan rangkaian LCD selengkapnya ditunjukkan dalam Gambar 3.6.



Gambar 3.6. Rangkaian LCD

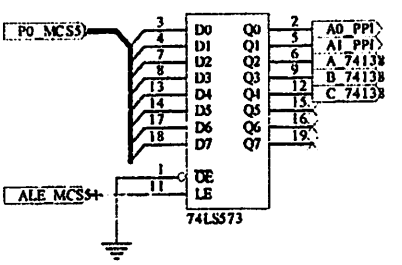
LCD tipe M1632 ini memiliki spesifikasi sebagai berikut:

- LCD ini terdiri dari 32 karakter dengan 2 baris masing-masing 16 karakter dengan *display* dot matrik 5x7.

- Karakter generator ROM dengan 192 tipe karakter.
- Karakter generator RAM dengan 8 bit karakter.
- 80x8 bit display data RAM.
- Dapat diinterfacekan ke MCU 8 atau 4.
- Dilengkapi fungsi tambahan antara lain *display clear, cursor home, display on/off, cursor on/off, display character blink, cursor shift, display shift.*
- *Internal* data.
- *Internal* otomatis, *reset* pada saat *power on*
- Tegangan +5 volt PSU tunggal

3.3.4. Rangkaian Penahan Alamat

Dalam Gambar 3.7 merupakan perangkat yang digunakan untuk memisahkan jalur data dengan jalur alamat. Dalam bab 2 telah disebutkan konfigurasi dari masing-masing pin 74HC573.

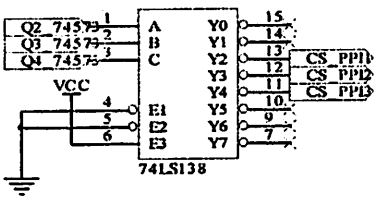


Gambar 3.7. Rangkaian Penahan Alamat 74HC573

Dalam Gambar 3.7 jalur data (D0 – D7) dihubungkan dengan port 0 pada AT89S51. Sedangkan Q0 dan Q1 dihubungkan dengan A0 dan A1 dari PPI 82C55A. Pin LE *(Latch Enable)* dihubungkan dengan ALE pada pin AT89C51. pin ini aktif *high.* Sedangkan OE dihubungkan ke *ground.*

3.3.5. Rangkaian Dekoder Alamat

Dekoder alamat digunakan untuk mengaktifkan pin *chip select* pada PPI 82C55. Chip select akan aktif apabila diberi logika *low*.Rangkaian dekoder 74LS138 ditunjukkan dalam Gambar 3.8. Dekoder ini sebagai selektor pada *chip select* PPI yang berjumlah tiga buah.



Gambar 3.8. Rangkaian Dekoder Alamat

Pada perencanaan ini pin A, B, C dihubungkan dengan alamat mikrokontroler A13 – A15. Merupakan alamat *upper byte* dari AT89S51. Perangkat ini akan bekerja apabila pin E1 dan E2 dihubungkan dengan ground serta E3 dihubungkan dengan Vcc. Dalam Tabel 4.1 disebutkan posisi alamat untuk Chip Select PPI 1 – PPI 3 sesuai dengan rangkaian dalam Gambar 4.8

Tabel 3.1. Alamat Chip Select PPI

A4/P0.4	A3/P0.3	A2/P0.2	CS-PPI
0	1	0	PPI 1
0	1	1	PPI 2
1	0	0	PPI 3

3.3.6. PPI 82C55A

PPI 82C55A memiliki 24 port untuk keperluan I/O. Dari 24 port yang tersedia terbagi kedalam tiga kelompok port yaitu port A, port B dan port C. Masing-masing port terdiri dari delapan jalur I/O. Pada perancangan ini PPI digunakan untuk mengeluarkan data berupa tampilan. Tampilan yang digunakan adalah LED. Sesuai dengan jumlah LED yang telah ditentukan, maka keperluan jumlah dari perangkat PPI juga menyesuaikan. Tiap satu perangkat dari PPI 882C55A terdiri dari 24 port. Apabila terdapat 60 LED, maka diperlukan tiga perangkat dari PPI 82C55A. Sehingga total port yang bisa digunakan adalah 72 port.

Mode pengoperasian dari perangkat ini menggunakan mode 0. Merupakan mode yang paling sederhana. Dengan menggunakan mode ini maka seluruh port dalam PPI dapat digunakan untuk keperluan I/O. Seperti yang telah dijelaskan pada bab 2.5.2 sebelum PPI dapat digunakan sebagai periperal I/O terlebih dahulu diinisialisasi isi dari *Control Word.* Konfigurasi dari *Control Word (CW)* ditunjukkan dalam Tabel 4.2.

Tabel 3.2. Konfigurasi *Control Word*

D7	D6	D5	D4	D3	D2	D1	D0
1	0	0	0	0	0	0	0

Konfigurasi yang ada dalam Tabel 4.2 digunakan untuk mode 0 dan penggunaan semua port sebagai *output.* Data CW tersebut apabila dikonversi kedalam bilangan hexadesimal bernilai 80h. Data CW ini nantinya didalam program akan dimasukkan kedalam *address* CW sebagai inisialisasi PPI.

Alamat port A,B,C, serta CW ditentukan dari maping I/O antara dekoder alamat dengan mikrokontroler. Untuk mengetahui alamat masing-masing PPI beserta port yang digunakan ditunjukkan dalam Tabel 3.3.

Tabel 3.3. Maping Alamat PPI 82C55A

A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0	Hex.	Ket.
0	0	0	0	1	0	0	0	08	P_{A1}
0	0	0	0	1	0	0	1	09	P_{B1}
0	0	0	0	1	0	1	0	0A	P_{C1}
0	0	0	0	1	0	1	1	0B	CW_1
0	0	0	0	1	1	0	0	0C	P_{A2}
0	0	0	0	1	1	0	1	0D	P_{B2}
0	0	0	0	1	1	1	0	0E	P_{C2}
0	0	0	0	1	1	1	1	0F	CW_2
0	0	0	1	0	0	0	0	10	P_{A3}
0	0	0	1	0	0	0	1	11	P_{B3}
0	0	0	1	0	0	1	0	12	P_{C3}
0	0	0	1	0	0	1	1	13	CW_3

Masing-masing port dalam PPI 82C55A dihubungkan dengan titik-titik *Al-Hijamah* yang sesuai dengan jenis penyakit. Dalam perencanaan ini untuk mempermudah pengolahan data secara perangkat lunak, maka diperlukannya maping antara port dalam PPI 82C55A dengan nama-nama titik hijamah yang

ada dalam **anatomi hijamah.** . *Mapping* port PPI dengan nama titik *Al-Hijamah* ditunjukkan dalam Tabel 3.4a dan 3.4b.

Tabel 3.4a *Mapping* port PPI dengan nama titik hijamah

No.	Periperal I/O	Port PPI	Nama Titik	No.	Periperal I/O	Port PPI	Nama Titik
1.	PPI - 1	A0	UM	25.	PPI - 2	A0	BA_3
2.		A1	RA_6	26.		A1	BA_5
3.		A2	RA_7	27.		A2	BA_6
4.		A3	RA_8	28.		A3	BA_7
5.		A4	RA_9	29.		A4	BA_8
6.		A5	RA_{22}	30.		A5	BA_9
7.		A6	RA_{23}	31.		A6	BA_{10}
8.		A7	KHL_1	32.		A7	BA_{11}
9.		B0	KHL_2	33.		B0	ZA_8
10.		B1	UN_1	34.		B1	ZA_9
11.		B2	UN_2	35.		B2	ZA_{10}
12.		B3	UN_3	36.		B3	ZA_{11}
13.		B4	UN_5	37.		B4	ZA_{14}
14.		B5	UN_6	38.		B5	ZA_{15}
15.		B6	UN_7	39.		B6	ZA_{16}
16.		B7	UN_8	40.		B7	ZA_{17}
17.		C0	UN_9	41.		C0	ZA_{18}
18.		C1	AK_1	42.		C1	ZA_{19}
19.		C2	AK_2	43.		C2	ZA_{24}
20.		C3	AK_3	44.		C3	ZA_{25}
21.		C4	AK_4	45.		C4	ZA_{26}
22.		C5	SA_3	46.		C5	ZA_{27}
23.		C6	SA_4	47.		C6	ZI_1
24.		C7	BA_2	48.		C7	ZI_2

Tabel 3.4b *Mapping* port PPI dengan nama titik hijamah (Lanjutan)

No.	Periperal I/O	Port PPI	Nama Titik	No.	Periperal I/O	Port PPI	Nama Titik
49.	PPI - 3	A0	RI_7	61.	PPI – 3	B4	NC
50.		A1	RI_8	62.		B5	NC
51.		A2	RI_9	63.		B6	NC
52.		A3	RI_{10}	64.		B7	NC
53.		A4	RI_{11}	65.		C0	NC
54.		A5	RI_{12}	66.		C1	NC
55.		A6	RI_{13}	67.		C2	NC
56.		A7	RI_{14}	68.		C3	NC
57.		B0	RI_{15}	69.		C4	NC
58.		B1	RI_{18}	70.		C5	NC
59.		B2	RI_{30}	71.		C6	NC
60.		B3	RI_{31}	72.		C7	NC

3.3.7. *Light Emitting Diode*

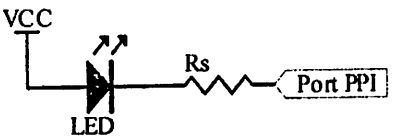
Pada perancangan ini digunakan sebanyak 60 LED dengan warna biru. LED yang digunakan memiliki diameter 3 mm. Sesuai dengan *datasheet* diperoleh data elektrik LED ditunjukkan dalam Tabel 4.5.

Tabel 3.5. Data Elektrik LED

Warna Emisi	Warna Lensa	Tegangan *Forward*		Arus *Forward*	Bahan serpih
		Typ	Max	*If* (mA)	
Biru Ultra Tinggi	Clear	3.3	4.0	20	InGaN

Sumber: Sanken Electric, Buletin No. L01 EBO Januari 2001:22

Rangkaian driver LED sesuai dengan Gambar 3.9 Rangkaian ini akan dihubungkan ke port PPI 82C55A.



Gambar 3.9. Driver LED pada port PPI 82C55A

Pada perancangan ini LED dioperasikan pada tengangan catu 5 volt, V_{OL} = 0.4 volt (Datasheet PPI 82C55A), V_f = 3.3 volt dan I_f yang diambil = 10 mA. Resistansi seri dapat dicari dengan menggunakan persamaan 2.2.

$$R_s = \frac{5 - 3{,}3 - 0{,}4}{1.10^{-2}}$$

$$R_s = \frac{1{,}3}{1.10^{-2}}$$

$$R_s = 130\,\Omega$$

$$R_s \approx 150\,\Omega$$

Sesuai dengan jumlah titik yang diperlukan, maka dalam perancangan ini LED sebanyak 60 buah tersebut diberikan penomoran sesuai dengan posisi titik-titik *Al-Hijamah* yang ada. Dalam Tabel 3.6a dan 3.6b merupakan *mapping* dari LED sebagai indikator titik akupunktur dengan nama-nama titik *Al-Hijamah* yang telah ditentukan sesuai dengan jenis penyakit yang telah direncanakan.

Tabel 3.6a *Mapping* LED dengan titik hijamah

No. LED	Nama Titik	No. LED	Nama Titik
1.	UM	9.	KHL_2
2.	RA_6	10.	UN_1
3.	RA_7	11.	UN_2
4.	RA_8	12.	UN_3
5.	RA_9	13.	UN_5
6.	RA_{22}	14.	UN_6
7.	RA_{23}	15.	UN_7
8.	KHL_1	16.	UN_8

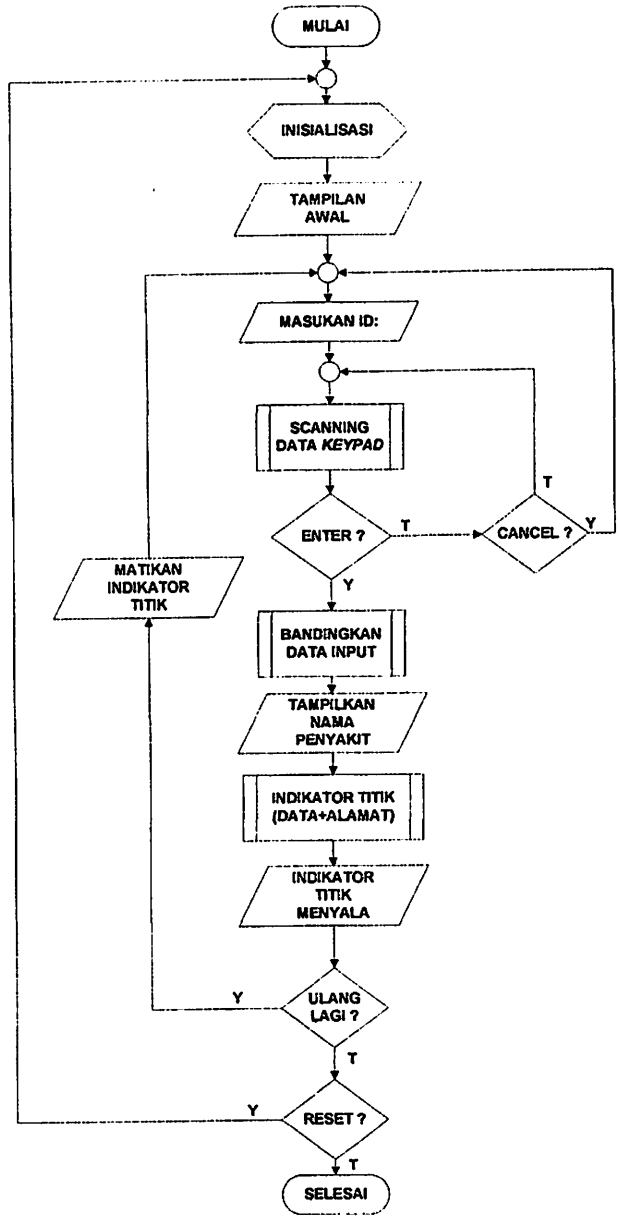
Tabel 3.6b *Mapping* LED dengan titik hijamah (Lanjutan)

No. LED	Nama Titik	No. LED	Nama Titik
17.	UN_9	39.	ZA_{16}
18.	AK_1	40.	ZA_{17}
19.	AK_2	41.	ZA_{18}
20.	AK_3	42.	ZA_{19}
21.	AK_4	43.	ZA_{24}
22.	SA_3	44.	ZA_{25}
23.	SA_4	45.	ZA_{26}
24.	BA_2	46.	ZA_{27}
25.	BA_3	47.	ZI_1
26.	BA_5	48.	ZI_2
27.	BA_6	49.	RI_7
28.	BA_7	50.	RI_8
29.	BA_8	51.	RI_9
30.	BA_9	52.	RI_{10}
31.	BA_{10}	53.	RI_{11}
32.	BA_{11}	54.	RI_{12}
33.	ZA_8	55.	RI_{13}
34.	ZA_9	56.	RI_{14}
35.	ZA_{10}	57.	RI_{15}
36.	ZA_{11}	58.	RI_{18}
37.	ZA_{14}	59.	RI_{30}
38.	ZA_{15}	60.	RI_{31}

3.4. Perangkat Lunak

Perangkat lunak yang telah dirancang dengan menggunakan bahasa assembler mikrokontroler MCS-51. Untuk memberikan gambaran umum jalannya program dan memudahkan pembuatan perangkat lunak, maka dibuat diagram alir

yang menunjukan jalannya program. Diagram alir utama perancangan perangkat lunak ditunjukkan dalam Gambar 3.10.



Gambar 3.10. *Flowchart* Sistem

Penjelasan dari diagram alir dalam Gambar 3.10 sebagai berikut:

- Program diawali dengan inisialisasi. Inisialisasi meliputi konfigurasi CW dari PPI, data awal yang akan dikeluarkan serta LCD *dot matrix*.
- Kemudian pada LCD dituliskan tampilan awal.
- Pada saat pada layar LCD tampil " **Masukan ID** : ". Proses ekesekusi program dilanjutkan dengan pengambilan data melalui *keypad*. Data yang dimasukkan merupakan data numerik dua digit.
- Apabila data numerik tersebut sudah dimasukkan. Kemudian ada perintah " **Tekan *enter* (#)** ". jika tombol '#; di tekan maka proses dilanjutkan dengan membandingkan data dua digit numerik tersebut dengan nama penyakit yang telah tersusun secara urut abjad. Setelah itu proses untuk menampilkan nama penyakit pada LCD. Eksekusi program dilanjutkan dengan mengambil subroutin penyakit yang berisi alamat beserta data port PPI untuk dikeluarkan melalui LED yang ada pada permukaan anatomi hijamah. Kemudian ada perintah lagi lagi " **Ulang → * / Tidak → #** ". Jika tombol '*' di tekan, maka eksekusi program dilanjutkan kembali ke tampilan " **Masukkan ID: "**. Jika tombol '#' ditekan maka eksekusi program selesai, dan indikator titik mati, jika ingin mengulang tekan tombol reset maka program akan mulai eksekusi pada alamat memori 00H. Jika tidak maka program selesai dan power dapat dimatikan.

BAB IV

PENGUJIAN DAN ANALISIS ALAT

Untuk mengetahui sistem dapat bekerja dengan baik sesuai dengan perencanaan, maka diperlukan serangkaian pengujian. Pengujian dilakukan dengan dua cara, yaitu secara perangkat keras dan secara perangkat lunak. Secara perangkat keras pengujian dilakukan dengan alat ukur, sedangkan secara perangkat lunak pengujian dilakukan melalui pembuatan perangkat lunak untuk bagian rangkaian yang akan diuji.

Pengujian setiap bloknya dibagi menjadi, yaitu :

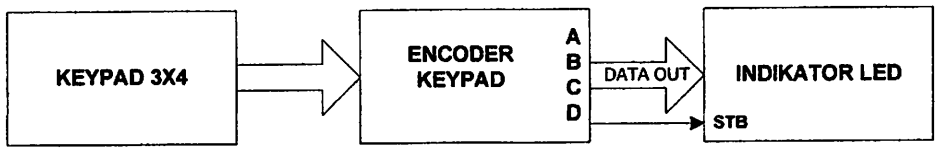
- Pengujian *keypad* dengan *encoder*.
- Pengujian mikrokontroler AT89S51
- Pengujian LCD 16x2 karakter.
- Pengujian rangkaian pengunci alamat.
- Pengujian rangkaian dekoder.
- Pengujian PPI 82C55A.
- Pengujian Sistem

Alat-alat bantu yang digunakan dalam pengujian ini menggunakan beberapa instrumen diantaranya adalah sebagai berikut:

1. Multimeter HELES SP-20D.
2. Modul LED.
3. *Motherboard Accupoint*
4. DIP Switch 8 bit
5. Catu daya 5 volt.
6. *Project Board.*

4.1 Pengujian Rangkaian *Keypad* dengan *Encoder*

Pengujian rangkaian *keypad* dengan *encoder* ini bertujuan untuk mengetahui apakah data yang dikeluarkan oleh *encoder* sesuai dengan datasheet. Rangkaian pengujian *keypad* dengan *encoder* ditunjukkan dalam Gambar 4.1



Gambar 4.1 Blok Pengujian *Keypad* dengan *Encoder*

Hasil pengujian data keluaran dari *encoder keypad* MM74C922 ditunjukkan dalam Tabel 4.1

Tabel 4.1 Hasil pengujian *keypad* dengan *encoder*

Posisi Switch	Pengukuran				Datasheet				Data Tombol
	D	C	B	A	D	C	B	A	
Y_1,X_1	0	0	0	0	0	0	0	0	1
Y_1,X_2	0	0	0	1	0	0	0	1	2
Y_1,X_3	0	0	1	0	0	0	1	0	3
Y_2,X_1	0	1	0	0	0	1	0	0	4
Y_2,X_2	0	1	0	1	0	1	0	1	5
Y_2,X_3	0	1	1	0	0	1	1	0	6
Y_3,X_1	1	0	0	0	1	0	0	0	7
Y_3,X_2	1	0	0	1	1	0	0	1	8
Y_3,X_3	1	0	1	0	1	0	1	0	9
Y_4,X_1	1	1	0	0	1	1	0	0	*
Y_4,X_2	1	1	0	1	1	1	0	1	0
Y_4,X_3	1	1	1	0	1	1	1	0	#

Keterangan:

Y_n = Baris ke-n

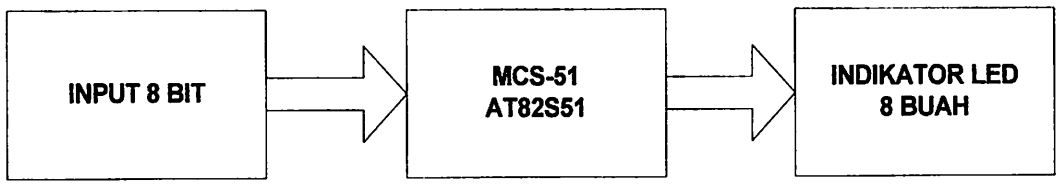
X_n = Kolom ke-n

Hasil pengujian kemudian dibandingkan dengan *datasheet* ternyata sesuai. Data biner dari hasil pengujian tidak sesuai dengan data pada tombol *keypad* karena sesuai dengan *datasheet* susunan tiap-tiap baris dan kolom tidak sesuai dengan tombol *keypad* yang sebenarnya. Masalah ini dapat diselesaikan dengan perangkat lunak. Dalam Gambar 4.1 terdapat sinyal *strobe* pada sisi keluaran *encoder*. Sinyal ini aktif tinggi pada saat ada penekanan tombol pada *keypad*.

Pada saat tombol dilepas maka sinyal *strobe* kembali berlogika rendah. Indikator LED yang digunakan aktif *high.*

4.2 Pengujian Mikrokontroler AT89S51

Pengujian mikrokontroler ini bertujuan untuk mengetahui kondisi port I/O dari AT89S51. Gambar 4.2 merupakan blok pengujian mikrokontroler AT89S51. Dalam pengujian ini diambil port 1 sebagai *input* dan port 2 bit sebagai *output.*



Gambar 4.2 Blok Pengujian Mikrokontroler AT89S51

Input sebanyak 8 bit menggunakan *push button* sedangkan untuk keluaran menggunakan LED sebanyak 8 buah. Tabel 4.2 merupakan hasil pengujian dari mikrokontroler AT89S51

Tabel 4.2 Hasil pengujian mikrokontroler AT89S51

Input								***Output***							
Port 1								**Port 2**							
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
1	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0
1	1	0	1	1	1	1	1	0	0	1	0	0	0	0	0
1	1	1	0	1	1	1	1	0	0	0	1	0	0	0	0
1	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0
1	1	1	1	1	0	1	1	0	0	0	0	0	1	0	0
1	1	1	1	1	1	0	1	0	0	0	0	0	0	1	0
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1

Keterangan:

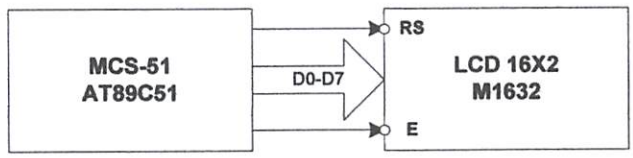
1 : Keadaan nyala

0 : Keadaan mati

Push button yang telah digunakan pada port 1 merupakan *push button* yang aktif *low*. Sedangkan pada sisi *output* aktif *high*. Hasil pengujian dalam Tabel 4.2 menggunakan perangkat lunak sesuai dengan lampiran B1.

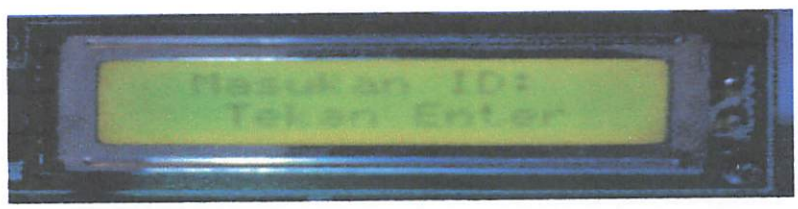
4.3 Pengujian LCD 16x2 Karakter

Pengujian LCD 16x2 bertujuan untuk mengetahui baik buruknya kondisi LCD yang telah dipakai. Gambar 4.3 merupakan blok rangkaian pengujian LCD 16x2.



Gambar 4.3 Blok Pengujian LCD 16x2 Karakter

Pengujian yang telah dilakukan hanya untuk menampilkan karakter pada LCD. Untuk menampilkan bentuk-bentuk karakter kedalam LCD dibantu dengan perangkat lunak. Listing program untuk pengujian LCD 16x2 dapat dilihat pada lampiran B2. Gambar 4.4 merupakan hasil pengujian LCD 16x2.



Gambar 4.4 Hasil Pengujian LCD 16x2

4.4 Pengujian Rangkaian Pengunci Alamat

Pengujian rangkaian pengunci alamat bertujuan untuk mengetahui prinsip kerja dari rangkaian tersebut. Gambar 4.5 merupakan blok pengujian rangkaian pengunci alamat.

Gambar 4.5 Blok Pengujian Pengunci Alamat

Push button yang telah digunakan pada port 1 merupakan push button yang aktif low. Sedangkan pada sisi output aktif high. Hasil pengujian dalam Tabel 4.2 menggunakan perangkat lunak sesuai dengan lampiran B1.

4.3 Pengujian LCD 16x2 Karakter

Pengujian LCD 16x2 bertujuan untuk mengetahui baik buruknya kondisi LCD yang telah dipakai. Gambar 4.3 merupakan blok rangkaian pengujian LCD 16x2.

Gambar 4.3 Blok Pengujian LCD 16x2 Karakter

Pengujian yang telah dilakukan hanya untuk menampilkan karakter pada LCD. Untuk menampilkan bentuk-bentuk karakter kedalam LCD dibantu dengan perangkat lunak. Listing program untuk pengujian LCD 16x2 dapat dilihat pada lampiran B2. Gambar 4.4 merupakan hasil pengujian LCD 16x2.

Gambar 4.4 Hasil Pengujian LCD 16x2

4.4 Pengujian Rangkaian Pengunci Alamat

Pengujian rangkaian pengunci alamat bertujuan untuk mengetahui prinsip kerja dari rangkaian tersebut. Gambar 4.5 merupakan blok pengujian rangkaian pengunci alamat.

Gambar 4.5 blok Pengujian Pengunci Alamat

Input dalam Gambar 4.5 menggunakan DIP switch 8 bit sedangkan *output* menggunakan LED sebanyak 8 buah. Hasil pengujian rangkaian pengunci alamat ini dapat dilihat dalam Tabel 4.3.

Tabel 4.3 Hasil Pengujian Rangkaian Pengunci Alamat

Input								*Output*								LE
D7	D6	D5	D4	D3	D2	D1	D0	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0

Dalam Tabel 4.3 kondisi LE *(Latch Enable)* pada awalnya diberikan logika tinggi. Hal ini berarti LE dalam keadaan aktif. Pada saat LE berubah ke logika rendah data pada sisi keluaran tetap seperti sebelumnya. Kondisi ini alamat yang telah dikirim pada sisi *input* telah dikunci oleh pin LE. Setelah alamat dikunci oleh perangkat ini maka secara perangkat lunak data dapat dilewatkan melalui data bus. Indikator LED yang digunakan aktif *high.*

4.5 Pengujian Rangkaian Dekoder

Pengujian rangkaian dekoder ini bertujuan untuk mengetahui kondisi logika antara masukan dengan keluaran yang sesuai dengan perancangan. Pengujian ini dilakukan dengan merangkai rangkaian dekoder 74LS138 di *project board.* Untuk masukan diberi sakelar SPDT yang dihubungkan ke Vcc dan Ground. Keluaran dari rangkaian ini dihubungkan dengan indikator LED. Gambar 4.6 merupakan rangkaian pengujian dekoder.

Gambar 4.6 Blok Pengujian Dekoder

Hasil pengujian dari rangkaian dekoder ditunjukkan dalam Tabel 4.4 sudah sesuai dengan perencanaan.

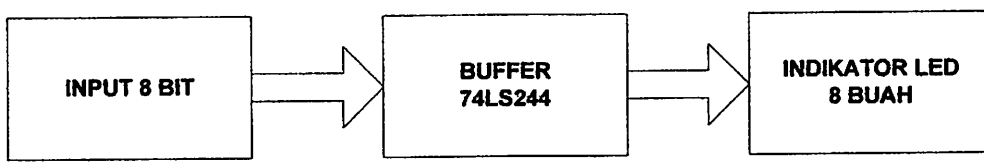
Tabel 4.4 Hasil Pengujian Rangkaian Dekoder

Pengukuran						**Datasheet**					
Masukan			*Keluaran*			*Masukan*			*Keluaran*		
C	**B**	**A**	**Y4**	**Y3**	**Y2**	**C**	**B**	**A**	**Y4**	**Y3**	**Y2**
0	1	0	1	1	0	0	1	0	1	1	0
0	1	1	1	0	1	0	1	1	1	0	1
1	0	0	0	1	1	1	0	0	0	1	1

Indikator LED yang digunakan dalam Tabel 4.4 pada sisi keluaran aktif *high.*

4.6 Pengujian *Buffer* Tegangan

Pengujian *buffer* tegangan ini bertujuan untuk mengetahui prinsip kerja serta kondisi logika dari 74LS244. Gambar 4.7 merupakan blok pengujian dari *buffer* tegangan.



Gambar 4.7 Blok Pengujian *Buffer* Tegangan

Tabel 4.5a merupakan hasil pengujian dari *buffer* tegangan untuk *low nibble*. Pin 1G pada IC diberi logika *low* karena untuk meneruskan logika yang diberikan *input* ke *output*.

Tabel 4.5a Hasil Pengujian *Buffer* Tegangan

Input				**1G**	***Output***			
1A1	**1A2**	**1A3**	**1A4**		**1Y1**	**1Y2**	**1Y3**	**1Y4**
0	0	0	0	0	0	0	0	0
1	1	1	1	0	1	1	1	1

Tabel 4.5b merupakan hasil pengujian dari *buffer* tegangan untuk *high nibble*. Pin 2G pada IC diberi logika *low* karena untuk meneruskan logika yang diberikan *input* ke *output*.

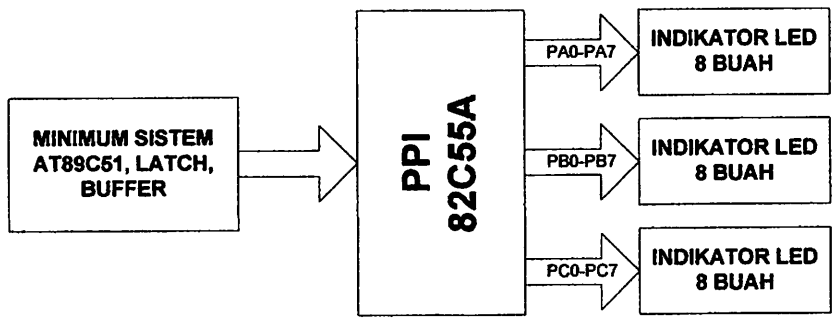
Tabel 4.5b Hasil Pengujian *Buffer* Tegangan

Input				2G	*Output*			
2A1	2A2	2A3	2A4		2Y1	2Y2	2Y3	2Y4
0	0	0	0	0	0	0	0	0
1	1	1	1	0	1	1	1	1

Pin 1G dan 2G pada IC 74LS244 apabila diberikan logika tinggi maka keadaan *output* akan berimpedansi tinggi. Sehingga level tegangan logika yang diberikan *input* tidak dapat diteruskan ke pin *output* IC. Seluruh indikator LED yang digunakan aktif *high*. Hasil pengujian dalam Tabel 4.5a dan 4.5b sudah sesuai dengan perencanaan.

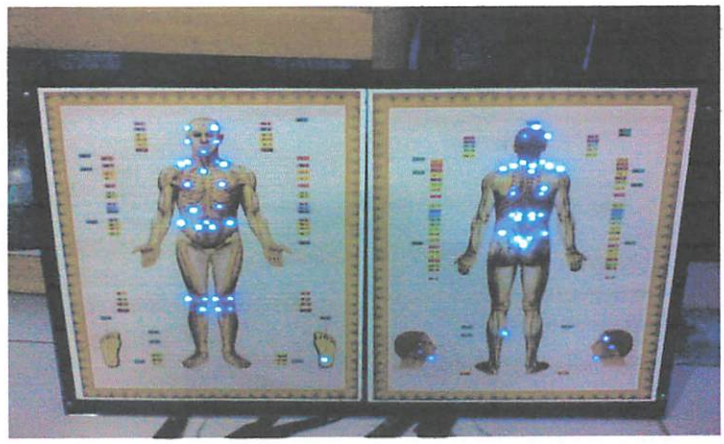
4.7 Pengujian PPI 82C55A

Pengujian PPI 82C55A ini bertujuan untuk mengetahui apakah sesuai dengan perencanaan atau tidak. Gambar 4.8 merupakan blok pengujian PPI 82C55A. *Input* dari PPI berasal dari minimum sistem, sedangkan port *output* dihubungkan dengan indikator LED.



Gambar 4.8 Blok Pengujian PPI 82C55A

Hasil pengujian PPI 82C55A ditunjukkan dalam Tabel 4.6. Pengujian pada tiga buah PPI ini menggunakan mode 0 dengan port A, B serta C sebagai *output*.



Gambar 4.9 Pengujian PPI 82C55A pada Alat

Hasil pengujian PPI 82C55A ditunjukkan dalam Tabel 4.6. Pengujian pada tiga buah PPI ini menggunakan mode 0 dengan port A, B serta C sebagai *output*.

Tabel 4.6 Hasil Pengujian PPI 82C55A

Data	PA1	PB1	PC1	PA2	PB2	PB3	PC1	PC2	PC3
00H	00H	00H	00H	00H	00H	00H	00H	00H	00H
FFH	FFH	FFH	FFH	FFH	FFH	FFH	FFH	FFH	FFH

Hasil pengujian yang ditunjukkan dalam Tabel 4.6 dibantu dengan perangkat lunak. Listing program untuk pengujian PPI 82C55A dapat dilihat dalam lampiran B3. Indikator LED yang digunakan dalam Tabel 4.6 pada sisi *output* aktif *low*. Dari hasil pengujian dalam Tabel 4.6 ternyata sesuai dengan perencaan sebelumnya.

Gambar 4.9 Pengujian PPI 82C55A pada Alat

Hasil pengujian PPI 82C55A ditunjukkan dalam Tabel 4.6. Pengujian pada tiga buah PPI ini menggunakan mode 0 dengan port A, B serta C sebagai output.

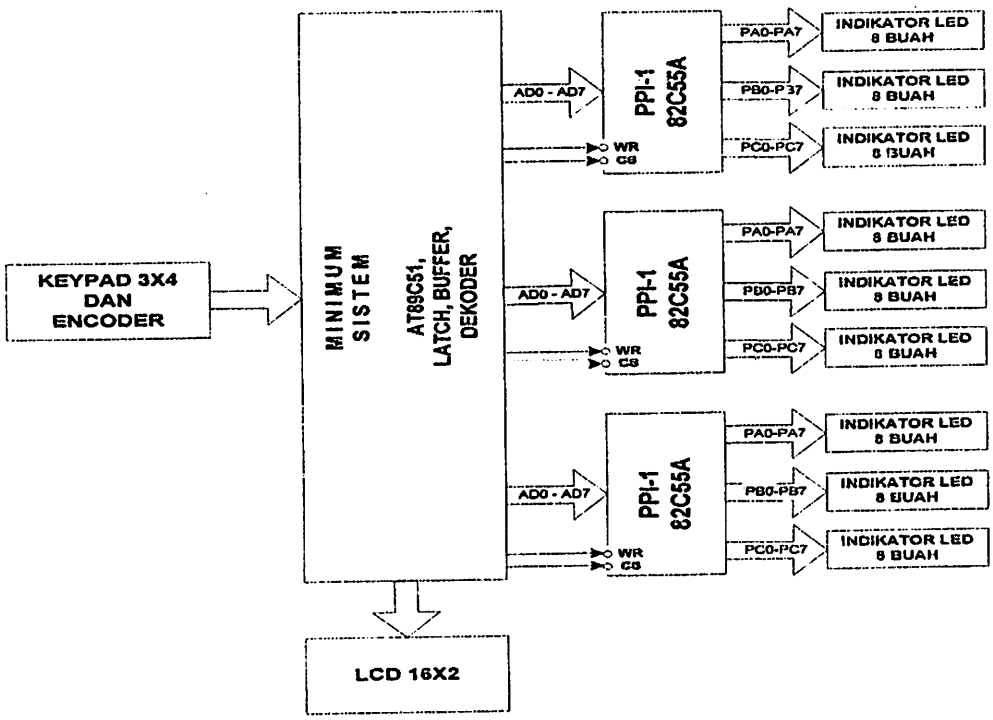
Tabel 4.6 Hasil Pengujian PPI 82C55A

Data	PA1	PB1	PC1	PA2	PB2	PB3	PC1	PC2	PC3
00H	00H	00H	00H	00H	00H	00H	00H	00H	00H
FFH	FFH	FFH	FFH	FFH	FFH	FFH	FFH	FFH	FFH

Hasil pengujian yang ditunjukkan dalam Tabel 4.6 dibantu dengan perangkat lunak. Listing program untuk pengujian PPI 82C55A dapat dilihat dalam lampiran B3. Indikator LED yang digunakan dalam Tabel 4.6 pada sisi output aktif low. Dan hasil pengujian dalam Tabel 4.6 tersyata sesuai dengan perencanan sebelumnya.

4.8 Pengujian Seluruh Sistem

Pengujian keselurahan sistem bertujuan untuk apakah sistem yang telah kita uji secara keseluruhan sesuai dengan perencaan sebelumnya. Gambar 4.8 merupakan blok pengujian sistem secara kesuluruhan.



Gambar 4.9 Blok Pengujian Keseluruhan Sistem

Hasil pengujian dari keseluruhan sistem ditunjukkan dalam Tabel 4.7. Angka yang diperoleh dalam Tabel 4.7 merupakan hasil penggabungan dari mapping port PPI dengan nama titik hijamah serta mapping nomer LED dengan nama titik hijamah.

ID penyakit, alamat port serta data port dalam Tabel 4.7 digunakan oleh perangkat lunak sebagai *routin* penyakit.

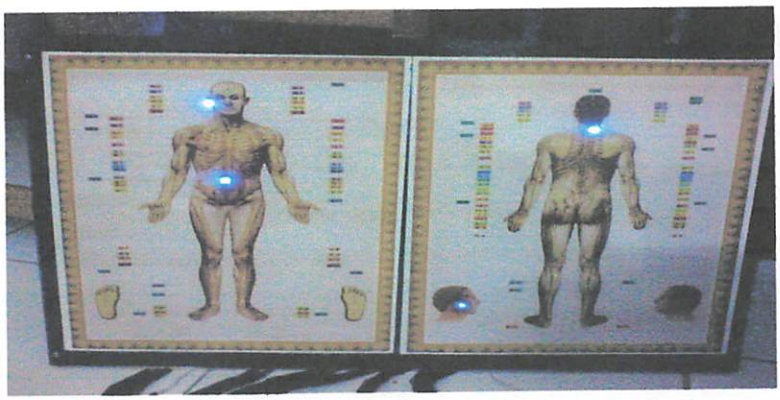
Tabel 4.7 Hasil Keseluruhan Sistem

ID.	ALAMAT PORT (Heksa)							DATA PORT (Heksa)						
01	08	09	0A					7F	3F	FE				
02	08	10						7F	9E					
03	08	0D						7F	3F					
04	08	0D	0A					7F	FC	FE				
05	08	0C	0E					7F	CF	F3				
06	08	0D						7F	CF					
07	08	0E						7F	FC					
08	08	0D						7E	F3					
09	08	09						7F	FD					
10	08	09						7F	CF					
11	08	09						7E	F3					
12	09	0D						FE	F3					
13	08							1F						
14	08	11						7F	F3					
15	08	0D						7F	3F					
16	08	0E						7F	CF					
17	08							7E						
18	08	09	0A					7F	F3	F9				
19	08	0C	11					7F	3D	FC				
20	08	09						7F	7F					
21	08							61						
22	08	0A	0C					7F	7F	FE				
23	08	10						7F	00					
24	08	0C	0A	0E				7F	E7	F3	BF			
25	08	09						7E	F3					
26	08	0E						7F	7F					

Dalam Tabel 4.7 indikator LED yang digunakan pada sisi *output* seluruhnya aktif *low*.

Gambar 4.11 merupakan bentuk fisik keseluruhan dari alat. Sedangkan dalam Gambar 4.12a merupakan hasil dari tampilan peraga anatomi hijamah untuk Asma Bronchitis dan Gambar 4.12b tampilan pada LCD.

Gambar 4.11 Bentuk Fisik Alat

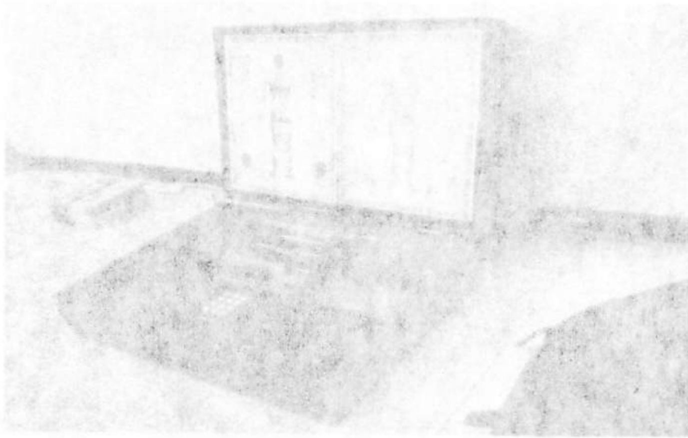


Gambar 4.12a Hasil Pengujian untuk Penyakit Asma Bronkritis

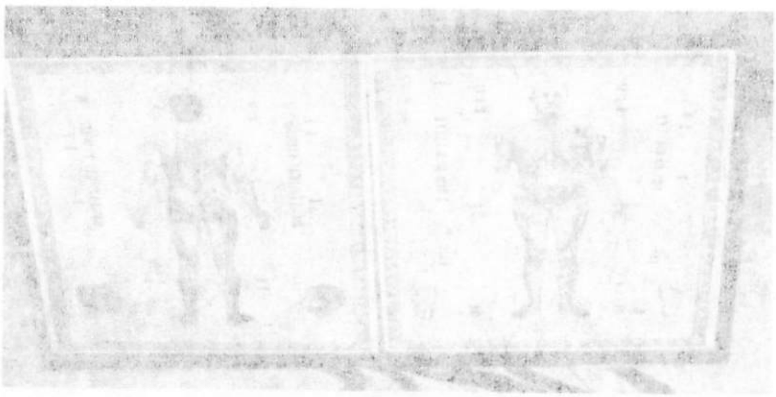
Gambar 4.12b Tampilan pada LCD

Gambar hasil pengujian yang kami ambil hanya dua jenis penyakit saja. Sedangkan untuk keseluruhan penyakit dapat dilihat dalam lampiran. Dari hasil pengujian secara keseluruhan sistem dapat sesuai dengan perencanaan sebelumnya.

Gambar 4.11 merupakan bentuk fisik keseluruhan dari alat. Sedangkan dalam Gambar 4.12a merupakan hasil dari tampilan peraga anatomi hijamah untuk Asma Bronchitis dan Gambar 4.12b tampilan pada LCD.



Gambar 4.11 Bentuk Fisik Alat



Gambar 4.12a Hasil Pengujian untuk Penyakit Asma Bronkritis

Gambar 4.12b Tampilan pada LCD

Gambar hasil pengujian yang kami ambil hanya dua jenis penyakit saja. Sedangkan untuk keseluruhan penyakit dapat dilihat dalam lampiran. Dari hasil pengujian secara keseluruhan sistem dapat sesuai dengan perencanaan sebelumnya.

BAB V

PENUTUP

5.1. Kesimpulan

Dari perancangan alat yang di buat, dapat di ambil kesimpulan :

1. Alat peraga tampilan pada anatomi tubuh manusia untuk terapi *Al-Hijamah* (bekam) ini di batasi hanya menampilkan titik meridian untuk 26 jenis penyakit.
2. Jumlah keseluruhan titik yang dipakai untuk alat peraga ini berjumlah 60 titik sehingga menggunakan 3 buah PPI, 60 port terhubung ,12 port *no connect* (NC).
3. Jumlah titik kombinasi paling sedikit 2 titik sedangkan paling banyak 9 titik untuk tiap jenis penyakit.
4. Sistem pengkabelan (*wiring*) pada LED dan proses penyolderan komponen pada PCB harus diperhatikan karena dapat mengganggu sistem kerja alat.

5.2 Saran dan Pengembangan

Dari perancangan alat yang di buat, ada beberapa saran untuk pengembangan :

1. Penggunaan seluruh titik hijamah dapat dimaksimalkan sehingga dapat memperbanyak jenis penyakit.
2. Penggunaan output suara untuk memperjelas titik-titik hijamah yang di tampilkan dan memberikan informasi lain yang dibutuhkan.
3. Pengembangan sistem lebih lanjut dapat ditambahkan gejala-gejala penyakit dengan menggunakan teknik *Artificial Intellegent (AI)* serta untuk tampilan dapat menggunakan pemrograman *3D Graphic* bebasis *Personal Computer (PC)*.

DAFTAR PUSTAKA

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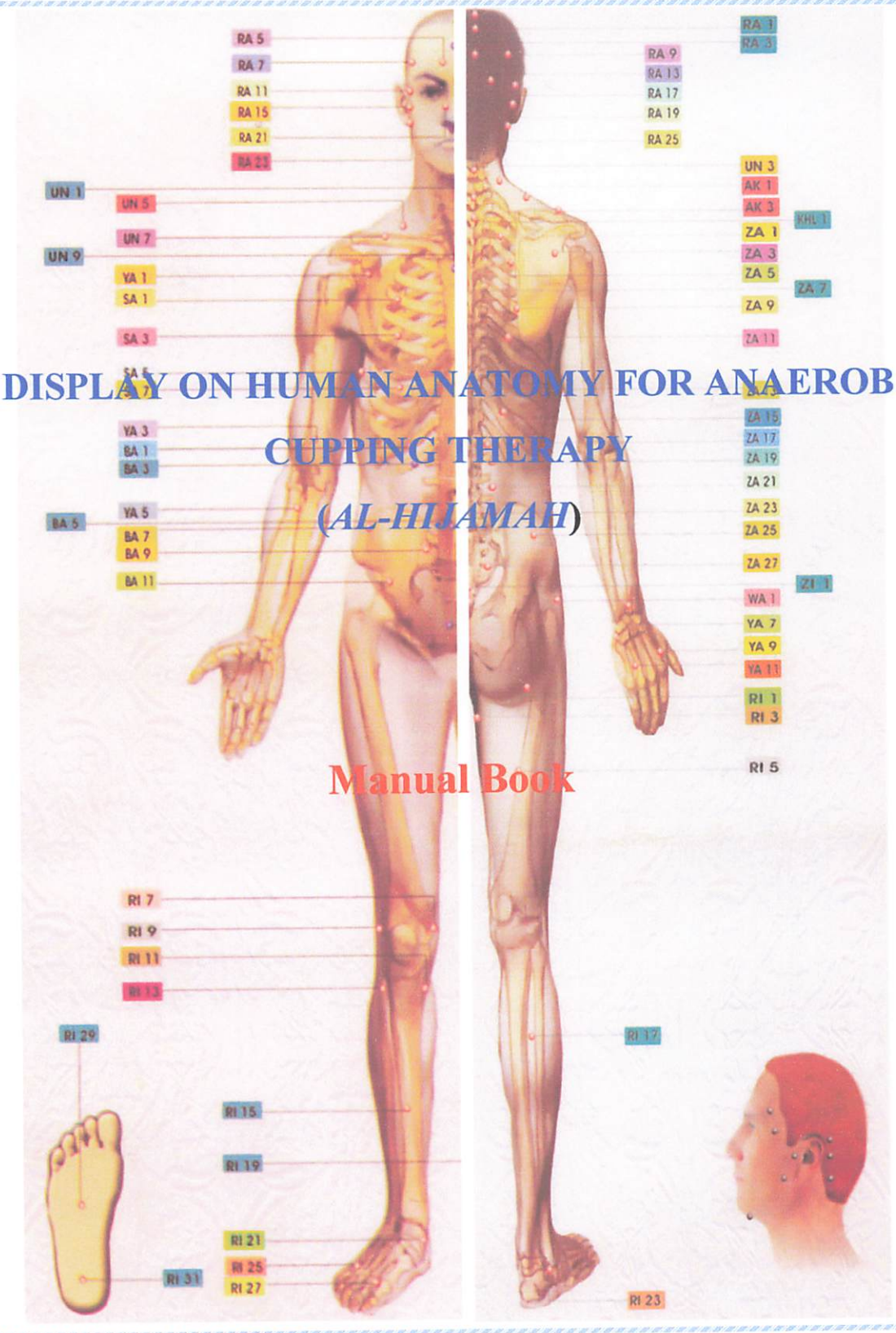


DISPLAY ON HUMAN ANATOMY FOR ANAEROB CUPPING THERAPY (*AL-HIJAMAH*)

Manual Book

Allah Subhanahuwata'ala Berfirman :

"(1) Demi masa , (2) Sesungguhnya manusia itu benar-benar dalam kerugian, (3) Kecuali orang-orang yang beriman dan mengerjakan amal saleh dan nasehat menasehati supaya mentaati kebenaran dan nasehat menasehati supaya menetapi kesabaran"
(Q.S. Al 'Ashr : 1-3)

☑ Dari Jabir bin 'Abdillah radhiallahu anhu ia berkata, saya pernah mendengar Nabi Shalallahu'alaihi wassalam bersabda:

((إنْ كان في شيْء منْ أدْويتكُمْ أوْ يكُوْنُ في شيْء منْ أدْويتكُمْ خيْرٌ ففي شرْطة محْجمٍ، أوْشربة عسلٍ، أوْلذْعة بنار توْافقُ الدّاء وما أحبُّ أنْ أكْتوي))

" Jika ada yang terbaik pada obat-obatan kalian, maka itu terdapat pada sayatan alat bekam, minuman madu, atau sundutan dengan api yang tepat pada penyakit. Tetapi aku tidak suka berobat dengan 'kay'.
(Shohîhu `l-Bukhôrî)

☑ Rasulullah Shalallahu'alaihi wassalam telah bersabda :

((أخْبرني جبْريْلُ أنّ الْحجْمَ أنْفعُ ما تداوى به النّاسُ))

" Jibril mengabarkan kepadaku bahwa bekam merupakan metode pengobatan paling bermanfaat yang digunakan oleh manusia".
(Shohîhu `l-Jâmi')

I dedicate this work to:

My dearest Parents & My lovely Sisters

Introduction:

Display on human anatomy for Anaerob Cupping Therapy (*Al-Hijamah*) usefull for fast and easy searching the accupoint according kind of desease was detected.

Specification:

***Al-Hijamah* Device:**

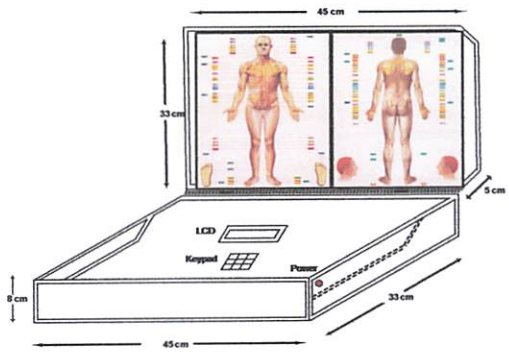
- Made from black glass fibre 0.3 mm.
- Included 26 kind of disease.
- Incuded 60 accupoint used only.
- Use traveling bag which easy to bring The device anywhere.
- Physical Dimension: see Fig. 1.

Electronic Component:

- 60 Blue LEDs (60 accupoint)
- LCD 16x2 Character as menus display.
- Keypad 3X4 as ID number input.
- Colour cable as data lines will connect The PPI port to LEDs
- 26 kind of desease has programmed. (See table:1)
- Physical Dimension: see Fig. 3.

All Dimension in centimeter

Fig. 1 Physical Dimension (General View)



Operating Voltage: 220-240 volt AC.

Fig. 2: Internal Block Diagram

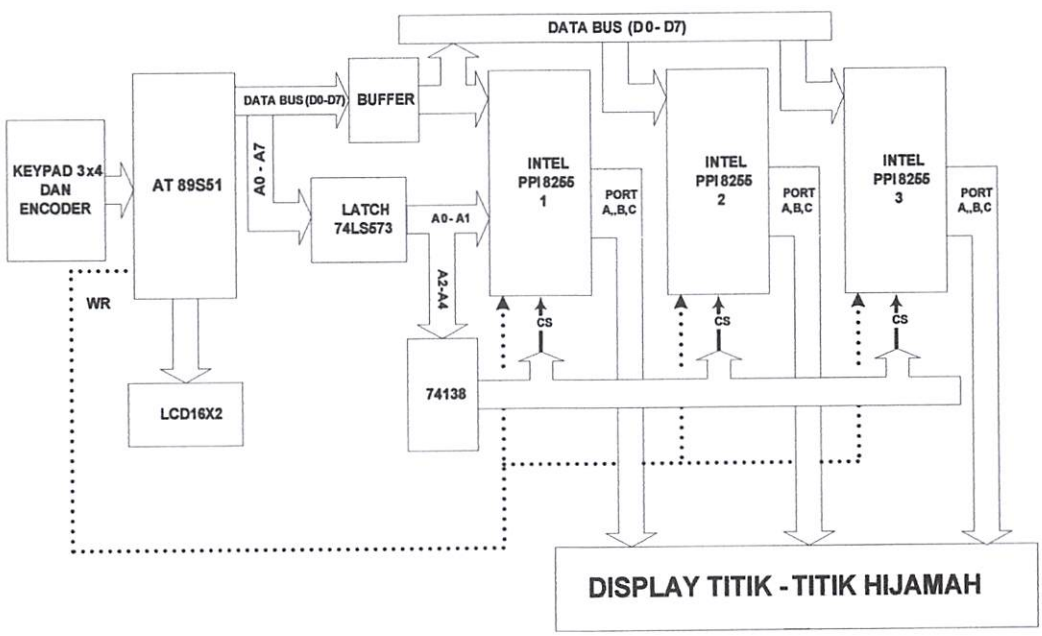
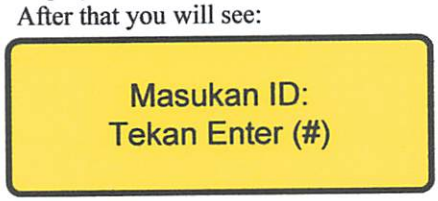


Table 1: List of ID and Name of Desease

ID.	Name of Desease	ID.	Name of Desease
01.	Amandel	14.	Kaki (Telapak Pecah-pecah)
02.	Asma	15.	Kanker Ginjal
03.	Asam Urat	16.	Kanker Prostat
04.	Bronchitis	17.	Kanker Otak
05.	Cacingan	18.	Kolesterol Tinggi
06.	Diabetes	19.	Kesuburan (Pria)
07.	Encok (Artritis)	20.	Maag
08.	Epilepsi	21.	Migrain
09.	Gigi	22.	Obesitas
10.	Gondok	23.	Pengapuran di Lutut
11.	Hipertensi	24.	Sembelit
12.	Insomnia	25.	Vertigo
13.	Jerawat (penuh di muka)	26.	Wasir

Operation Manual

1. Plug in the power plug into AC 220V source.
2. Switch on the power.
3. At the first time you will see opening display on LCD.
4. After that you will see:



This menu allow to enter the ID desease from keypad.
(ID contain 2 digit number).

5. Then you should press enter button (#)
6. After processing ID number LCD will appear name of desease in fist line:

7. Then LEDs on human anatomy of *Al-Hijamah* turn on. This process give us information which accupoint to do therapy.
8. If you want to cancel or try again this device you should press (*) button.
9. If you want to finish this device you should press (#) button then you will see on LCD :

10. If the ID number unrecognize then you will see on LCD:

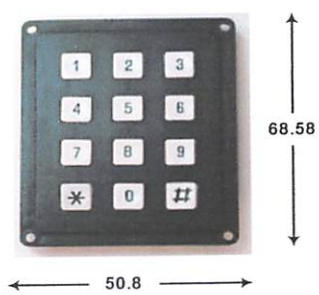
Fig. 3: Physical Dimension (General View)

All Dimension in milimeter

Note:

1. Physical Dimension of LCD.

2. Physical Dimension of Keypad



Note:

0-9	: Numeric Button.
*	: Cancel Button.
#	: Enter Button.

INSTITUT TEKNOLOGI NASIONAL MALANG
FAKULTAS TEKNOLOGI NASIONAL
JURUSAN TEKNIK ELEKTRO

FORMULIR BIMBINGAN SKRIPSI

Nama : **Indra Ari Khrismana**
Nim : **9917236**
Masa Bimbingan : **15 Agustus 2006 s/d 15 Pebruari 2007**
Judul Skripsi : **Perancangan Alat Peraga Penampil Titik Meridian Pada Anatomi Tubuh Manusia Untuk Terapi Al-Hijamah (Bekam)**

No.	Tgl.	CATATAN DOSEN PEMBIMBING	PARAF PEMBIMBING
1	21-Agt-07	Revisi Batasan Masalah	
2	25-Agt-07	ACC Bab I & Bab II	
3	27-Nop-07	Revisi Bab III + Rangkaian Lengkap	
4	03-Jan-07	ACC Bab III	
5	30-Jan-07	Revisi Bab IV & V	
6	15-Feb-07	ACC Bab IV &V	
7	01-Mar-07	Demo Alat	
8	03-Mar-07	ACC Maju Seminar Hasil	
9	09-Mar-07	Perbaikan & Revisi	
10	12-Mar-07	ACC Maju Ujian Skripsi	

Malang, 15 Maret 2007
Dosen Pembimbing I,

(Ir. Eko Nurcahyo)
NIP. 1029700172

INSTITUT TEKNOLOGI NASIONAL MALANG
FAKULTAS TEKNOLOGI NASIONAL
JURUSAN TEKNIK ELEKTRO

FORMULIR BIMBINGAN SKRIPSI

Nama : **Indra Ari Khrismana**
Nim : **9917236**
Masa Bimbingan : **15 Agustus 2006 s/d 15 Pebruari 2007**
Judul Skripsi : **Perancangan Alat Peraga Penampil Titik Meridian Pada Anatomi Tubuh Manusia Untuk Terapi Al-Hijamah (Bekam)**

No.	Tgl.	CATATAN DOSEN PEMBIMBING	PARAF PEMBIMBING
1	22/07/05	Acc BAB I Perbaiki. M.	
2		Acc milih sumber Acc BAB II	
3		Acc BAB IV, V.	
4			
5			
6			
7			
8			
9			
10			

Malang, 12 ~~April~~ Maret 2007
Dosen Pembimbing II,

(Irmalia Suryani F., ST.)
NIP. 1030100365

INSTITUT TEKNOLOGI NASIONAL
FAKULTAS TEKNOLOGI INDUSTRI
JURUSAN TEKNIK ELEKTRO

Formulir Perbaikan Ujian Skripsi

Dalam pelaksanaan Ujian Skripsi Janjang Strata 1 Jurusan Teknik Elektro Konsentasi T. Energi Listrik / T. Elektronika, maka perlu adanya perbaikan skripsi untuk mahasiswa :

NAMA : Indra Aki
N I M : 9917236
Perbaikan meliputi :

① Kesimpulan dari penyu-
perangkat keras / alat

② alat kurang jadi

Malang,

(_____)

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

Formulir Perbaikan Ujian Skripsi

Dalam Pelaksanaan Ujian Skipsi Jenjang Strata 1 Jurusan Teknik Elektro Konsentrasi Teknik Elektronika, maka perlu adanya perbaikan skripsi untuk mahasiswa :

Nama	:	Indra Ari Khrismana
Nim	:	9917236
Masa Bimbingan	:	15 Agustus 2006 s/d 15 Februari 2007
Judul Skripsi	:	Perancangan Alat Peraga Penampil Titik Meridian Pada Anatomi Tubuh Manusia Untuk Terapi *Al-Hijamah* (Bekam)

Perbaikan Meliputi :

No	Perbaikan Skripsi	Paraf
1	Sistem Kerja Alat	
2	Kesimpulan Pengujian Hardware / Alat	

Telah Diperiksa dan Disetujui :

Anggota Penguji

Penguji I

(Ir. F. Yudi Limpraptono, MT)

Penguji II

17/4 '07

(Sotyohadi, ST, MSc)

Pembimbing I

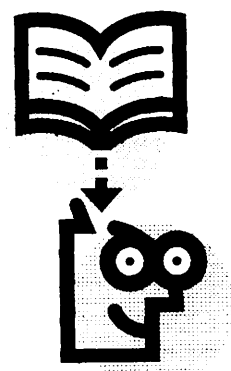
(Ir. Eko Nurcahyo)

Pembimbing II

(Irmalia Suryani F., ST)

Lampiran A

Perangkat Lunak



```
;=============================
;PROGRAM UJI MIKROKONTROLLER
;=============================
satu    bit     p1.0
dua     bit     p1.1
tiga    bit     p1.2
empat   bit     p1.3
lima    bit     p1.4
enam    bit     p1.5
tujuh   bit     p1.6
lapan   bit     p1.7
;-----------------------------
;Indikator LED aktif high
;-----------------------------
        org     00h
ulang:
        acall   ceking
        sjmp    ulang

ceking:
        jb      satu,lp1
        mov     p2,#00000001b
        ret
lp1:
        jb      dua,lp2
        mov     p2,#00000010b
        ret
lp2:
        jb      tiga,lp3
        mov     p2,#00000100b
        ret
lp3:
        jb      empat,lp4
        mov     p2,#00001000b
        ret
lp4:
        jb      lima,lp5
        mov     p2,#00010000b
        ret
lp5:
        jb      enam,lp6
        mov     p2,#00100000b
        ret
lp6:
        jb      tujuh,lp7
        mov     p2,#01000000b
        ret
lp7:
        jb      lapan,lp8
        mov     p2,#10000000b
lp8:
        ret
        end
```

```
;=============================
;PROGRAM  UJI LCD 16X2
;=============================

LCD_EN      bit     p3.0
LCD_RS      bit     p3.1

        org     00h
mulai:
        mov     a,#03fh
        acall   write_inst
        acall   write_inst
        mov     a,#0dh
        acall   write_inst
        mov     a,#06h
        acall   write_inst
        mov     a,#01h
        acall   write_inst
        mov     a,#0ch
        acall   write_inst
tulis:
        mov     r4,#1
        mov     dptr,#sulis
lagi:
        acall   baris_a
        acall   baris_b
        acall   Ldelay
        djnz    r4,lagi
        sjmp    tulis

;===menulis instruksi ke LCD
write_inst:
        clr     LCD_RS
        mov     p1,A
        clr     LCD_EN
        setb    LCD_EN
        acall   delay
        ret

;====menulis data ke LCD
write_data:
        setb    LCD_RS
        mov     p1,A
        clr     LCD_EN
        setb    LCD_EN
        acall   delay
        ret

;===menulis data LCD baris atas
baris_a:
        mov     r3,#16
        mov     a,#80h
bb:
        acall   write_inst


tulis1:
        clr     a
        movc    a,@a+dptr
        inc     dptr
        acall   write_data
        djnz    r3,tulis1
        ret

;====menulis baris bawah
baris_b:
        mov     r3,#16
        mov     a,#0C0h
        sjmp    bb

;=====routin delay
delay:
        mov     r0,#0
delay1:
        mov     r5,#50h
        djnz    r5,$
        djnz    r0,delay1
        ret

;=====routin Ldelay
Ldelay:
        mov     r2,#30h
Ld1:
        acall   delay
        djnz    r2,Ld1
        ret

sulis:
        DB      ' Masukan ID:  '
        DB      '  Tekan Enter '
        End
```

```
;=============================
;PROGRAM UJI PPI 82C55A
;=============================
pa1     equ     08h     ;PPI 1
pb1     equ     09h
pc1     equ     0ah
cw1     equ     0bh

pa2     equ     0ch     ;PPI 2
pb2     equ     0dh
pc2     equ     0eh
cw2     equ     0fh

pa3     equ     10h     ;PPI 3
pb3     equ     11h
pc3     equ     12h
cw3     equ     13h
;-----------------------------
;Indikator LED aktif low
;-----------------------------
        org     00h
mulai:
        mov     r0,#cw1
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa1
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#0ffh
        movx    @r0,a

        mov     r0,#cw2
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa2
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb2
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#0ffh
        movx    @r0,a

        mov     r0,#cw3
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa3
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb3
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc3
        mov     a,#0ffh
        movx    @r0,a
        acall   delay
        mov     r0,#cw1
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa1
        mov     a,#00h
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#00h
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#00h
        movx    @r0,a

        mov     r0,#cw2
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa2
        mov     a,#00h
        movx    @r0,a
        mov     r0,#pb2
        mov     a,#00h
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#00h
        movx    @r0,a

        mov     r0,#cw3
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa3
        mov     a,#00h
        movx    @r0,a
        mov     r0,#pb3
        mov     a,#00h
        movx    @r0,a
        mov     r0,#pc3
        mov     a,#00h
        movx    @r0,a
        acall   delay
        ajmp    mulai
delay:
        mov     r2,#100
del2:
        mov     r3,#100
del1:
        mov     r4,#100
        djnz    r4,$
        djnz    r3,del1
        djnz    r2,del2
        ret
        end
```

```
;=============================
;PROGRAM ACUPOINT DISPLAY
;=============================

LCD_EN      bit     p3.0
LCD_RS      bit     p3.1
strobe      bit     p2.7
bufer       equ     40h
data1       equ     41h
data2       equ     42h
data25      equ     45h
bu_dat      equ     43h
cursor      equ     44h
data_gab    equ     46h

;INISIALISASI PPI
pa1     equ     08h     ;PPI 1
pb1     equ     09h
pc1     equ     0ah
cw1     equ     0bh

pa2     equ     0ch     ;PPI 2
pb2     equ     0dh
pc2     equ     0eh
cw2     equ     0fh

pa3     equ     10h     ;PPI 3
pb3     equ     11h
pc3     equ     12h
cw3     equ     13h

start:
;Inisialisasi PPI (off)

        mov     r0,#cw1
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa1
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#0ffh
        movx    @r0,a

        mov     r0,#cw2
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa2
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb2
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#0ffh
        movx    @r0,a

        mov     r0,#cw3
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa3
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb3
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc3
        mov     a,#0ffh
        movx    @r0,a

;inisialisasi LCD 16x2

        mov     a,#03fh
        acall   write_inst
        acall   write_inst
        mov     a,#0dh
        acall   write_inst
        mov     a,#06h
        acall   write_inst
        mov     a,#01h
        acall   write_inst
        mov     a,#0ch
        acall   write_inst
tulis:
        mov     r4,#5
        mov     dptr,#Indra
muter:
        acall   baris_atas
        acall   baris_bawah
        lcall   Ldelay
        djnz    r4,muter
cancel:
        mov     dptr,#id_penyakit
        acall   baris_atas
        acall   baris_bawah
        mov     a,#8dh
        acall   write_inst
        mov     a,#0fh
        acall   write_inst
        mov     bufer,#8dh
        mov     cursor,#8dh

scan_again:
        acall   scan_key
        sjmp    scan_again
```

```
;==============================
;SCANNING KEYPAD 3X4 PAKE ENCODER
;==============================
scan_key:
        mov     dptr,#data_key
        jnb     strobe,trus1
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#00h,trus1
        mov     bu_dat,#1       ;key = 1
        acall   baris_a
        ret
trus1:
        inc     dpl
        jnb     strobe,trus2
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#04h,trus2
        mov     bu_dat,#2       ;key = 2
        acall   baris_a
        ret
trus2:
        inc     dpl
        jnb     strobe,trus3
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#08h,trus3
        mov     bu_dat,#3       ;key = 3
        acall   baris_a
        ret
trus3:
        inc     dpl
        jnb     strobe,trus4
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#10h,trus4
        mov     bu_dat,#4       ;key = 4
        acall   baris_a
        ret
trus4:
        inc     dpl
        jnb     strobe,trus5
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#14h,trus5
        mov     bu_dat,#5       ;key = 5
        acall   baris_a
        ret
trus5:
        inc     dpl
        jnb     strobe,trus6
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#18h,trus6
        mov     bu_dat,#6       ;key = 6
        acall   baris_a
        ret
trus6:
        inc     dpl
        jnb     strobe,trus7
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#20h,trus7
        mov     bu_dat,#7       ;key = 7
        acall   baris_a
        ret

trus7:
        inc     dpl
        jnb     strobe,trus8
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#24h,trus8
        mov     bu_dat,#8       ;key = 8
        acall   baris_a
        ret
trus8:
        inc     dpl
        jnb     strobe,trus9
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#28h,trus9
        mov     bu_dat,#9       ;key = 9
        acall   baris_a
        ret
trus9:
        inc     dpl
        jnb     strobe,trus10
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#34h,trus10
        mov     bu_dat,#0       ;key = 0
        acall   baris_a
        ret
trus10:
        jnb     strobe,trus11
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#30h,trus11   ;cancel
        ljmp    cancel
trus11:
        jnb     strobe,akhir
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#38h,akhir
        acall   penyakit        ;enter
akhir:
        ret
```

```
;==================
;menulis instruksi ke LCD
;==================
write_inst:
        clr     LCD_RS
        mov     p1,A
        clr     LCD_EN
        setb    LCD_EN
        acall   delay
        ret
;==================
;menulis data ke LCD
;==================
write_data:
        setb    LCD_RS
        mov     p1,A
        clr     LCD_EN
        setb    LCD_EN
        acall   delay
        ret
;======================
;menulis data LCD baris atas
;======================
baris_atas:
        mov     r3,#16
        mov     a,#80h
        acall   write_inst
tulis1:
        clr     a
        movc    a,@a+dptr
        inc     dptr
        acall   write_data
        djnz    r3,tulis1
        ret
;==================
;menulis baris bawah
;==================
baris_bawah:
        mov     r3,#16
        mov     a,#0C0h
        acall   write_inst
tulis2:
        clr     a
        movc    a,@a+dptr
        inc     dptr
        acall   write_data
        djnz    r3,tulis2
        ret
;-------------------------------
;KHUSUS UNTUK DATA KEYPAD
;-------------------------------
baris_a:
        acall   pos_cursor
        acall posisi
        clr     a
        movc    a,@a+dptr
        acall   write_data
back:
        ret

pos_cursor:
        mov     a,cursor
        acall   write_inst
        mov     a,#0fh
        acall   write_inst
        inc     cursor
        mov     a,cursor
        cjne    a,#8fh,back_pos
        mov     a,#8fh
        acall   write_inst
        mov     a,#0ch
        acall   write_inst
        mov     cursor,#8dh
back_pos:
        ret
posisi:
        mov a,bufer
        acall write_inst
        acall simpan_data
        inc bufer
        mov a,bufer
        cjne a,#8fh,out
        mov bufer,#8dh
out:
        ret

simpan_data:
        mov a,bufer
        cjne a,#8dh,gak
        mov data1,bu_dat
        sjmp keluar
gak:
        mov data2,bu_dat
keluar:
        ret

;=======routin delay
delay:
        mov     r0,#0
delay1:
        mov     r5,#50h
        djnz    r5,$
        djnz    r0,delay1
        ret

;========routin Ldelay
Ldelay:
        mov     r2,#30h
Ld1:
        acall   delay
        djnz    r2,Ld1
        ret

penyakit:
        mov     dptr,#blank
        acall   baris_atas
        acall   baris_bawah
        mov     a,data1
        swap    a
        orl     a,data2
```

```
        mov     data_gab,a
        mov     a,#25h
        subb    a,data_gab
        jnc     mari2
        mov     dptr,#tiada
        acall   baris_atas
        acall   try_again
        acall   batal
        ljmp    mari
mari2:
        mov     a,data1
        cjne    a,#00,loop1
        sjmp    berikut
loop1:
        ljmp    jump_adoh
berikut:
        mov     a,data2
        cjne    a,#1,bs1
        mov     dptr,#p_01
        acall   baris_atas
        acall   try_again
        lcall   ill_1
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
bs1:
        cjne    a,#2,bs2
        mov     dptr,#p_02
        acall   baris_atas
        acall   try_again
        lcall   ill_2
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
bs2:
        cjne    a,#3,bs3
        mov     dptr,#p_03
        acall   baris_atas
        acall   try_again
        lcall   ill_3
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari

bs3:
        cjne    a,#4,bs4
        mov     dptr,#p_04
        acall   baris_atas
        acall   try_again
        lcall   ill_4
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
bs4:
        cjne    a,#5,bs5
        mov     dptr,#p_05
        acall   baris_atas
        acall   try_again
        lcall   ill_5
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
bs5:
        cjne    a,#6,bs6
        mov     dptr,#p_06
        acall   baris_atas
        acall   try_again
        lcall   ill_6
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
bs6:
        cjne    a,#7,bs7
        mov     dptr,#p_07
        acall   baris_atas
        acall   try_again
        lcall   ill_7
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
bs7:
        cjne    a,#8,bs8
        mov     dptr,#p_08
        acall   baris_atas
        acall   try_again
        lcall   ill_8
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
bs8:
        mov     dptr,#p_09
        acall   baris_atas
        acall   try_again
        lcall   ill_9
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari


jump_adoh:
        cjne    a,#01,loop2

        mov     a,data2
        cjne    a,#0,cs0
        mov     dptr,#p_10
        acall   baris_atas
        acall   try_again
        lcall   ill_10
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
loop2:
        ljmp    loop22
cs0:
        cjne    a,#1,cs1
        mov     dptr,#p_11
        acall   baris_atas
        acall   try_again
        lcall   ill_11
        lcall   batal
```

```
        lcall   matikan_ppi
        ljmp    mari
cs1:
        cjne    a,#2,cs2
        mov     dptr,#p_12
        acall   baris_atas
        acall   try_again
        lcall   ill_12
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
cs2:
        cjne    a,#3,cs3
        mov     dptr,#p_13
        acall   baris_atas
        acall   try_again
        lcall   ill_13
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
cs3:
        cjne    a,#4,cs4
        mov     dptr,#p_14
        acall   baris_atas
        acall   try_again
        lcall   ill_14
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
cs4:
        cjne    a,#5,cs5
        mov     dptr,#p_15
        acall   baris_atas
        acall   try_again
        lcall   ill_15
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
cs5:
        cjne    a,#6,cs6
        mov     dptr,#p_16
        acall   baris_atas
        acall   try_again
        lcall   ill_16
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
cs6:
        cjne    a,#7,cs7
        mov     dptr,#p_17
        acall   baris_atas
        acall   try_again
        lcall   ill_17
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
cs7:
        cjne    a,#8,cs8
        mov     dptr,#p_18
        acall   baris_atas
        acall   try_again
        lcall   ill_18
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
cs8:
        mov     dptr,#p_19
        acall   baris_atas
        acall   try_again
        lcall   ill_19
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
loop22:
        mov     a,data2
        cjne    a,#0,ls2
        mov     dptr,#p_20
        acall   baris_atas
        acall   try_again
        lcall   ill_20
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
ls2:
        cjne    a,#1,ls3
        mov     dptr,#p_21
        acall   baris_atas
        acall   try_again
        lcall   ill_21
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
ls3:
        cjne    a,#2,ls4
        mov     dptr,#p_22
        acall   baris_atas
        acall   try_again
        lcall   ill_22
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
ls4:
        cjne    a,#3,ls5
        mov     dptr,#p_23
        acall   baris_atas
        acall   try_again
        lcall   ill_23
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
ls5:
        cjne    a,#4,ls6
        mov     dptr,#p_24
        acall   baris_atas
        acall   try_again
        lcall   ill_24
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
```

```
ls6:
        cjne    a,#5,mari
        mov     dptr,#p_25
        acall   baris_atas
        acall   try_again
        lcall   ill_25
        lcall   batal
        lcall   matikan_ppi
        ljmp    mari
ls7:
        cjne    a,#6,mari
        mov     dptr,#p_26
        acall   baris_atas
        acall   try_again
        lcall   ill_26
        lcall   batal
        lcall   matikan_ppi

mari:
        ret

;*************************************
;DATABASE ROUTIN PENYAKIT
;*************************************
ill_1:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#3fh
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#0feh
        movx    @r0,a
        ret
ill_2:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pa3
        mov     a,#9eh
        movx    @r0,a
        ret
ill_3:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#3fh
        movx    @r0,a
        ret
ill_4:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#0fch
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#0feh
        movx    @r0,a
        ret
ill_5:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pa2
        mov     a,#0cfh
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#0f3h
        movx    @r0,a
        ret
ill_6:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb2
        mov     a,#0cfh
        movx    @r0,a
        ret
ill_7:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#0fch
        movx    @r0,a
        ret
ill_8:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb2
        mov     a,#0f3h
        movx    @r0,a
        ret
ill_9:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#0fdh
        movx    @r0,a
        ret
ill_10:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#0cfh
        movx    @r0,a
        ret
ill_11:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#0f3h
        movx    @r0,a
```

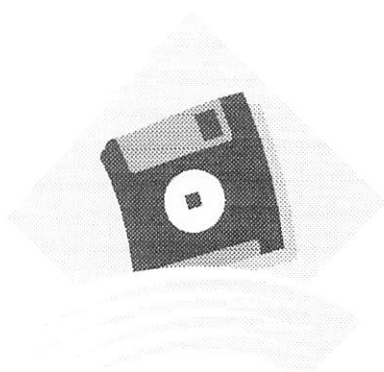
```
        ret
ill_12:
        mov     r0,#pb1
        mov     a,#0feh
        movx    @r0,a
        mov     r0,#pb2
        mov     a,#0f3h
        movx    @r0,a

        ret
ill_13:
        mov     r0,#pa1
        mov     a,#1fh
        movx    @r0,a
        ret
ill_14:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb3
        mov     a,#f3h
        movx    @r0,a
        ret
ill_15:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb2
        mov     a,#3fh
        movx    @r0,a
        ret
ill_16:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#cfh
        movx    @r0,a
        ret
ill_17:
        mov     r0,#pa1
        mov     a,#7eh
        movx    @r0,a
        ret
ill_18:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#0f3h
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#0f9h
        movx    @r0,a
        ret
ill_19:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pa2
        mov     a,#3dh
        movx    @r0,a
        mov     r0,#pa3
        mov     a,#0fch
        movx    @r0,a
        ret
ill_20:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#7fh
        movx    @r0,a
        ret
ill_21:
        mov     r0,#pa1
        mov     a,#61h
        movx    @r0,a
        ret
ill_22:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pa2
        mov     a,#0feh
        movx    @r0,a
        ret
ill_23:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pa3
        mov     a,#00h
        movx    @r0,a
        ret
ill_24:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pa2
        mov     a,#e7h
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#0f3h
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#0bfh
        movx    @r0,a
        ret
ill_25:
        mov     r0,#pa1
        mov     a,#7eh
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#0f3h
        movx    @r0,a
```

```
ill_26:
        mov     r0,#pa1
        mov     a,#7fh
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#7fh
        movx    @r0,a
        ret

try_again:
        mov     dptr,#coba_lagi
        acall   baris_bawah
        ret
batal:
        jnb     strobe,$
        mov     a,p3
        anl     a,#00111100b
        cjne    a,#30h,batal    ;di cancel
        acall   Entek
        ret

Entek : DB  '----Selesai----'

matikan_ppi:
        mov     r0,#cw1
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa1
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb1
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc1
        mov     a,#0ffh
        movx    @r0,a

        mov     r0,#cw2
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa2
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb2
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc2
        mov     a,#0ffh
        movx    @r0,a

        mov     r0,#cw3
        mov     a,#80h
        movx    @r0,a
        mov     r0,#pa3
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pb3
        mov     a,#0ffh
        movx    @r0,a
        mov     r0,#pc3
        mov     a,#0ffh
        movx    @r0,a
        ret
```

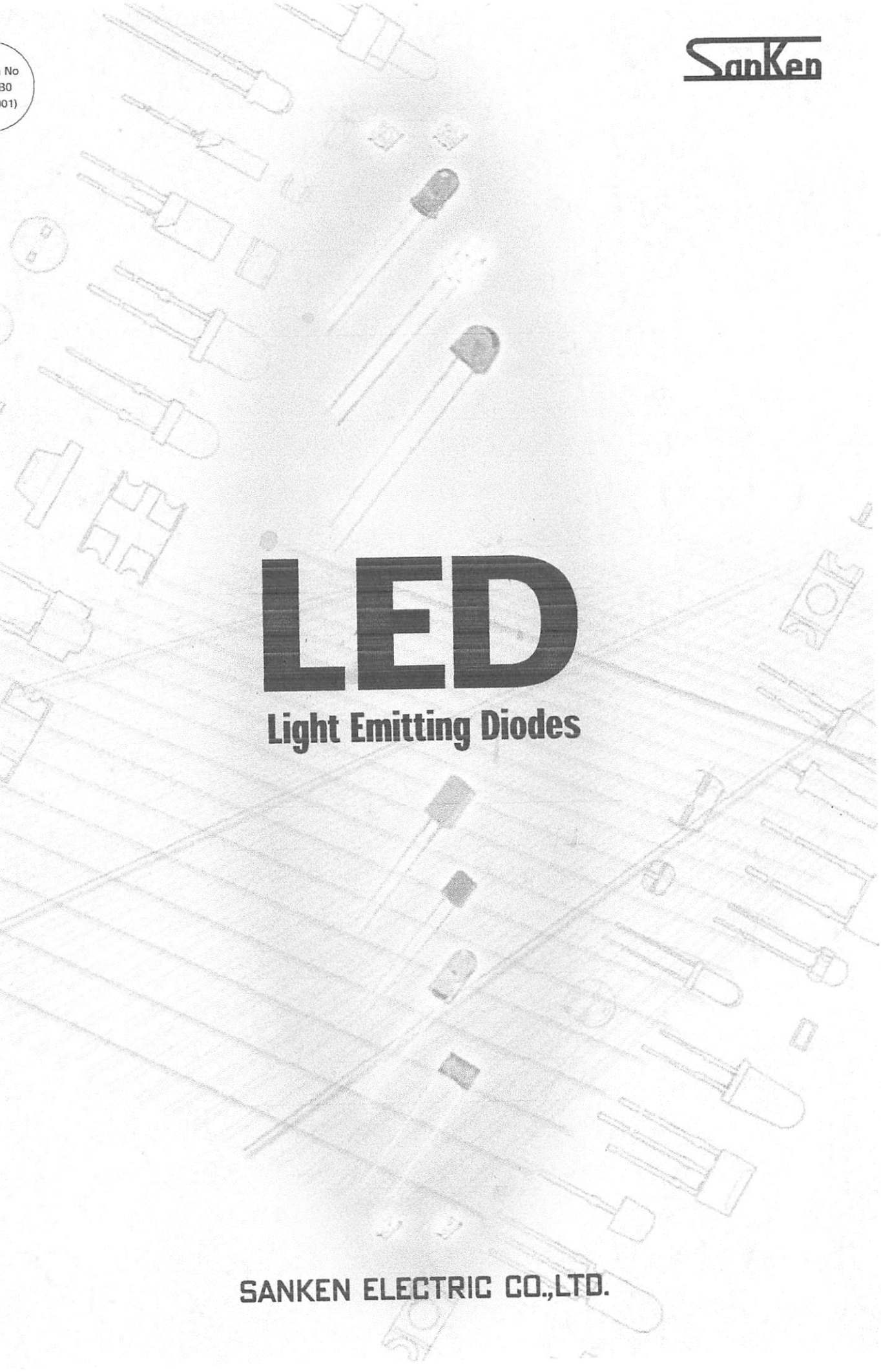
```
;*************************************
; MENU AWAL
;*************************************
Indra:
        DB      ' --Bismillah-- '
        DB      ' Assalamu'alaikum '
        DB      '  Alat Peraga  '
        DB      'Tampilan Anatomi'
        DB      ' Tubuh Manusia  '
        DB      '  Untuk Terapi  '
        DB      'Al-Hijamah (Bekam)'
        DB      ' Oleh: Indra Ari K. '
        DB      ' ------ITN------- '
        DB      ' --- MALANG --- '

id_penyakit:
        DB      ' Masukan ID:   '
        DB      '  Tekan Enter  '
data_key:
        DB      '1234567890'
blank:
        DB      '               '
        DB      '               '
coba_lagi:
        DB      'Coba lagi--> * '
p_01:
        DB      'Amandel        '
p_02:
        DB      'Asma '
p_03:
        DB      'Asam Urat    '
p_04:
        DB      'Bronchitis       '
p_05:
        DB      'Cacingan       '
p_06:
        DB      'Diabetes     '
p_07:
        DB      'Encok (Artritis)  '
p_08:
        DB      'Epilepsi   '

p_09:
        DB      'Gigi     '
p_10:
        DB      'Gondok       '
p_11:
        DB      'Hipertensi       '
p_12:
        DB      'Insomnia         '
p_13:
        DB      'Jerawat (Penuh di muka) '
p_14:
        DB      'Kaki (telapak pecah2)  '
p_15:
        DB      'Kanker Ginjal          '
p_16:
        DB      'Kanker Prostat       '
p_17:
        DB      ' Kanker Otak    '
p_18:
        DB      'Kolesterol Tinggi      '
p_19:
        DB      'Kesuburan (pria)  '
p_20:
        DB      'Maag'
p_21:
        DB      'Migrain '
p_22:
        DB      'Obesitas       '
p_23:
        DB      'Pengapuran di Lutut '
p_24:
        DB      'Sembelit  '
p_25:
        DB      'Vertigo        '
p_26:
        DB      'Wasir          '
tiada:
        DB      'Maaf tidak ada..'

        end
```

Lampiran B

DATASHEET



SanKen



LED

Light Emitting Diodes

SANKEN ELECTRIC CO.,LTD.

Product Designation

ıgle-color LED

Ex: **SEL 1 1 10 R TP1**

Product type	Structure	Emitting color	Shape	Lens color	Taping number
SEL: General-purpose single-color LED SELU/SELS: Ultra-high-intensity single-color LED	1: 5φ type 2: 3φ type 4: 4φ type 5: 5 mm pitch lead type - Direct mount 6: 3φ type - Direct mount	(See next page)		(See next page)	(See taping list)

color LED

Ex: **SML 1 6 7 16 W N TP4**

Product type	Structure	Emitting color	Shape	Lens color	Common	Taping number
SML: General-purpose bicolor LED SMLU/SMLS: Ultra-high-intensity bicolor LED	1: 5φ type 7: Direct mount	(See next page) In case of single digit 2: Red/green 5: Deep red/pure green 8: Amber/green		(See next page)	- : Common cathode N: Common anode	(See taping list)

ırface Mount LEDs

Ex: **SEC 1 1 0 1 C**

Product type	Structure	Emitting color	Shape	Lens color	
SEC: General-purpose surface mount LED SECU/SECS: Ultra-high-intensity surface mount LED	1: Single color 2: Bilcolor	(See next page) (Right-hand digit 0 for single color LED)	1,2: Flat lens type 3,4: Inner lens type	(See next page)	

Product Designation

frared LED (1)

Ex: **SID 1 0 10 C M TP7**

- SID — Product type: SID: Infrared
- 1 — Structure: 1 : 5φ type; 2 : 3φ type
- 0 — Chip type: 0 : Standard (λP=940 nm); K: High output (λP=940 nm); G: High output (λP=850 nm)
- 10 — Shape
- C — Lens color (See below)
- M — Lead frame shape: - : Standard; M: Straight
- TP7 — Taping number (See taping list)

frared LED (2)

Ex: **SID 303 C TP18**

- SID — Product type: SID: Infrared
- 303 — Shape
- C — Lens color (See below)
- TP18 — Taping number (See taping list)

Color code		Standard type			Ultra-high-intensity type		
		Emitting color	Chip material	Peak wavelength (nm)	Emitting color	Chip material	Peak wavelength (nm)
1	:	Deep red	GaP	700			
2	:	Red	GaAsP	630	Ultra-high-intensity red	AlGaInP	635
4	:	Green	GaP	560/558			
5	:	Pure green	GaP	555			
6	:	High-intensity red	GaAlAs	660			
7	:	Yellow	GaP	570	Ultra-high-intensity yellow	AlGaInP	572
8	:	Amber	GaAsP	610	Ultra-high-intensity amber	AlGaInP	615
9	:	Orange	GaAsP	587	Ultra-high-intensity orange	AlGaInP	590
B	:				Ultra-high-intensity light amber	AlGaInP	600
D	:				Ultra-high-intensity pure green	InGaN	525
E	:	Blue	GaN	430	Ultra-high-intensity blue	InGaN	470

Lens color			
R	Diffused red	K	Transparent yellow
W	Diffused white	G	Diffused green
S	Transparent red	E	Transparent green
C	Clear	B	Transparent blue
D	Diffused orange	BR	Transparent dark blue
A	Transparent orange	BP	Transparent Violet
Y	Diffused yellow	BQ	Transparent light dark blue

Selection Guide

ngle-color LEDs/Single-color surface mount LEDs

Shape	Lens diameter	Feature	Direct mount	Series	Emitting color and peak wavelength																Page
					Blue	Ultra-high-intensity blue	Ultra-high-intensity pure green	Pure green	Deep green	Green	Yellow	Ultra-high-intensity yellow	Orange	Ultra-high-intensity orange	Ultra-high-intensity light amber	Amber	Ultra-high-intensity amber	Red	Ultra-high-intensity red	High-intensity red	Deep red	
				Color code⇒	E	E	D	5	4	4	7	7	9	9	B	8	8	2	2	6	1	
				Peak wavelength[nm]⇒	430	470	525	555	558	560	570	572	587	590	600	610	615	630	635	660	700	
	5φ	Standard	N	SEL1010				O		O	O		O			O		O		O	O	10
			N	SEL1010M				O		O	O		O			O		O				11
		Wide directivity	N	SEL1010XM		O	O										O		O			12
		Narrow directivity	Y	SEL1050M		O*	O*	O		O			O			O		O	O			13
			N	SEL1015																O		14
			N	SEL1011						O	O		O			O		O			O	15
	5.6×4.6φ	Egg-shaped	N	SEL1053M						O							O		O			16
und	4φ	Standard	N	SEL4010				O		O	O		O			O		O			O	17
		Wide directivity	Y	SEL4014				O		O	O		O			O		O			O	18
	3φ	Standard	Y	SEL6010				O		O	O		O			O		O			O	19
		Wide directivity	Y	SEL6014				O	O	O	O		O		O	O		O				20
		Narrow directivity	Y	SEL6015				O		O	O		O					O				21
		Standard	N	SEL2010	O	O	O	O		O	O	O	O			O		O		O	O	22
		Narrow directivity	N	SEL2015				O		O	O		O			O		O				23
			N	SEL2011						O			O								O	24
	2φ		N	SEL4017						O	O		O			O					O	25
	5φ	For surface illumination	N	SEL1013				O		O	O		O			O		O				26
erted	3φ		Y	SEL6013				O		O												27
ine	3φ		N	SEL2013				O		O	O		O			O		O		O		28
	3×5		N	SEL1021						O	O		O			O					O	30
	2.5×5		N	SEL1022						O	O		O			O		O				31
angular	2×5		N	SEL1020						O	O		O			O		O			O	32
	1×5		N	SEL1024				O		O	O		O			O					O	33
	2×4		N	SEL4025				O		O	O		O			O		O				34
	2×4		Y	SEL4026						O	O		O			O		O				35
	4φ		N	SEL4027						O								O				36
shaped	3.1φ		N	SEL4028				O	O	O	O		O			O		O		O		37
	3.1φ		Y	SEL4029						O	O		O			O		O				38
	4φ		Y	SEL6027						O			O					O				39
	Rectangular		Y	SEL5020		O		O		O			O			O		O		O		40
mm	3φ	Narrow directivity	Y	SEL5021				O		O	O		O			O		O				41
h lead	Bow-shaped	Wide directivity	Y	SEL5023	O	O		O		O	O	O	O	O	O	O	O	O	O			42
	5.6×4.6φ		Y	SEL5055							O		O					O				43
rface	Flat lens	SMD		SEC1001	O	O	O	O	O	O	O		O			O		O		O	O	50
ount	Inner lens	SMD		SEC1003				O	O	O	O		O	O		O	O	O	O	O		51

Y···Supported
N···Not supported
★···Not supported

Selection Guide

color LEDs/Bicolor surface mount LEDs

Shape	Lens diameter	Feature	Direct mount	Series	Emitting color and peak wavelength																Page
					Deep red	Red	Amber	Orange	High-intensity red	Red	Ultra-high-intensity orange	Ultra-high-intensity red	Red	Ultra-high-intensity amber	Orange	Red	High-intensity red	Orange	green	Pure green	Yellow	
				Color code⇒	1	2	8	9	6	2	9	2	2	8	9	2	6	9	4	5	7	
				Peak wavelength[nm]⇒	700	630	610	587	660	630	590	635	630	615	587	630	660	587	560	555	570	
				Series	Pure green	green	green	green	Yellow	Orange	Yellow	Ultra-high-intensity yellow	Yellow	Ultra-high-intensity yellow	Red	Yellow	green	Pure green	green	Pure green	Yellow	
				Color code⇒	5	4	4	4	7	9	7	7	7	7	2	7	4	5	4	5	7	
				Peak wavelength[nm]⇒	555	560	560	560	570	587	570	572	570	572	630	570	560	555	560	555	570	
	5φ	Standard	N	SML1016/10016	O	O	O	O														44
			N	SML10016N					O													44
und			N	SML10051		O																45
			N	SML10051N					O													45
	5.6×4.6φ	Egg-shaped	Y	SML70055				O				O	O	O	O							49
			Y	SML70055N												O						49
	2.5×5		N	SML10060		O		O														46
ngul			N	SML10060N					O													46
	3.3×6		Y	SML70020		O	O	O														47
	Bow-shaped		Y	SML70023		O	O	O		O	O											48
face	Flat lens	SMD		SEC2002		O		O	O									O	O	O	O	52
unt	Inner lens	SMD		SEC2004			O	O	O												O	53

Y···Supported
N···Not supported

frared LED lamps

Profile	Lens diameter	Direct mount	Series	High-output infrared	High-output infrared	Infrared	Page
			Chip type⇒	G	K	0	
			Peak wavelength[nm]⇒	850	940	940	
und	5φ	N	SID1010		O	O	54
		Y	SID1050		O		55
		N	SID300/1003	O		O	56
	3φ	N	SID2010		O	O	57

Y···Supported
N···Not supported

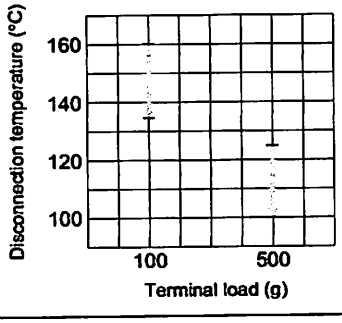
Application Notes

ıken Electric's light emitting diodes (LEDs) are all molded in
in molds.
en using Sanken's LEDs, observe the following cautions:

leat resistance of mold resin

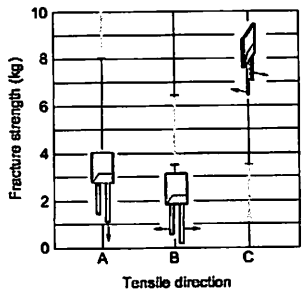
ce an LED must emit internally generated light with high
ciency, a highly transparent resin is used for molding. To
ıure high transparency, the molding material must be free from
additives(silica, glass fiber, and others) that are used to
ırove the heat and moisture resistance of other semiconductor
nponents(such as transistors).
ce the resin used for LEDs generally has a low heat resistance,
following cautions must be fully considered.
ver apply an external force, stress, or excess vibration to the
ninals (leads) at high temperature. The glass transition point of
epoxy resin used in LEDs is about 120 to 130°C. Beyond this
ıperature range, the coefficient of linear thermal expansion
:omes more than double that at room temperature, and the

igure 1 Disconnection temperature - Terminal load



ıin softens as well.
ıder this condition, an external force or stress may budge the
rminals, and may result in disconnection of the internal wire.
ıure 1 shows reference data for the disconnection temperature
d terminal load for the SEL1010 Series.
Do not apply heat beyond the absolute maximum rating of the
storage temperature (100°C for ordinary LEDs, 90°C for chip
_EDs). (For soldering, see the soldering conditions.)

Fracture strength

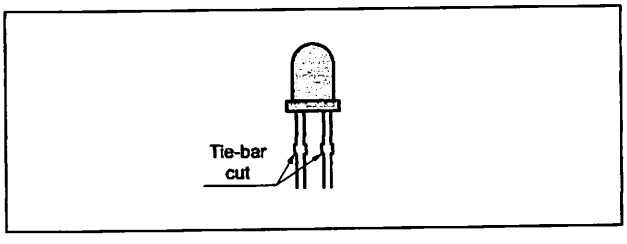


■Mechanical strength

If an excessive mechanical force is applied between the lens resin and the terminals, the lens resin or internal connections may be damaged. The previous figure shows the fracture strength of the SEL1000 Series according to the direction of the force applied to the terminals. When aligning or forming the terminals after soldering, do not bend or twist them with a force beyond the limits shown in the diagram below.

■Forming

1. Be sure to form terminals before soldering.
2. When forming the terminals, hold tightly them at a point closer to the lens resin than the forming position to prevent stress from being applied between the lens resin and the terminals.
3. Form the terminals only below the tie-bar cuts(protruding part of the terminals).
4. Make the forming pitch equal to the board hole pitch.



■Chemical resistance

For washing after soldering, the following chemicals are recommended:

- •Isopropyl alcohol
- •Ethyl alcohol

In addition, keep the dip time within five minutes and work at room temperature.

- •Freon-substitute cleaning liquid

Depending on the constituents, the chemicals may discolor the resin. Make sure that there will be no problems before use.

■Mounting method

Do not mount the LED in such a way that there is a residual stress between the terminal and lens resin.

■Soldering

1. Mounting holes

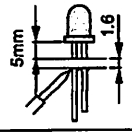
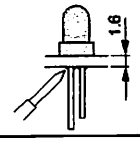
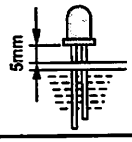
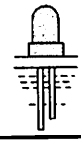
The recommended PCB hole diameters are as follows:

Lead diameter	PCB hole diameter
0.4×0.45mm	ϕ0.9 to 1.0
□0.5mm	ϕ1.0 to 1.1
□0.6mm	ϕ1.0 to 1.2

Application Notes

ɔldering conditions

amp Type

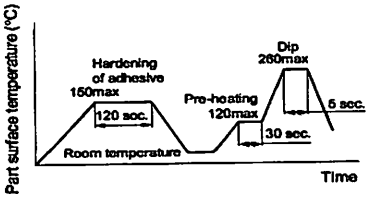
		Standard	Manual contact mount insertion	Automatic contact mount insertion	
dering iron	Temperature	Iron bit: 320 to 340°C	Iron bit: 320 to 340°C		
	Time	3 sec. or less	3 sec. or less		
	Position				
Dip	Temperature	Soldering Bath: 250±5°C	Soldering Bath: 250±5°C	Preheat: 90°C (back of the PCB)	Soldering Bath: 250°C
	Time	3 sec. or less	3 sec. or less	2 min. or less	3 sec. or less
	Position				

ıe heat resistance of the mold-resin of the direct mount type is almost equal to that of the standard type. Be careful not to apply a load when the LED is heated. hen thermally curing the adhesive of chip components on the same board after LED mounting, keep the temperature of the curing oven below 120°C and the curing ne to less than 60 seconds. (For soldering a Surface Mount LED, see the soldering conditions.)
hen an LED is mounted by means of automatic contact mount insertion, note that soldering defects may occur depending on the conditions of insertion even under e above conditions.

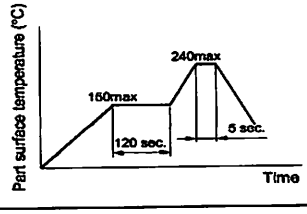
ırface Mount Type

oldering iron Iron bit temperature: 300°C max, 3 sec max

Dip



Reflow



Overcurrent

ıce an overcurrent may burn the LED, connect a protective ɜistor in series to prevent a current in excess of 100 mA in the se of a spontaneous pulse (excluding infrared LED).

Contact mount LEDs

rinted circuit board(PCB)

ngle-faced PCBs are recommended. (Do not use through hole ɔes when using double-faced PCBs.) If chip components coexist ı the same board, insert the LEDs after curing the chip adhesive.

ɔonditions of insertion

ɜep the insertion pressure as low as possible. The T pattern of ana-sert is recommended for cut & clinch. When using the N ıttern, maximize the clinch angle on the anode side of the LED.

Moisture-proof packaging of Surface Mount LEDs

Influence of moisture absorption on resin of chip LEDs

f the resin is unusually damp, solder dipping may cause interfacial defoliation. This phenomenon, generally called "popcorn phenomenon", occurs when a drastic temperature change causes moisture in the resin to evaporate and to swell.

- Due to this defoliation, the efficiency of light emission might worsen and the luminosity could lower.

2. Moisture-proof packaging

- Surface Mount LEDs are protected by a moisture-proof packaging (baked on by Sanken) to minimize moisture absorption by the resin before use.
- Aluminum laminates with high moisture resistance are used for packaging.
- Silica gel packs are enclosed in each package to further improve moisture-proof efficiency.

3. Storage after opening

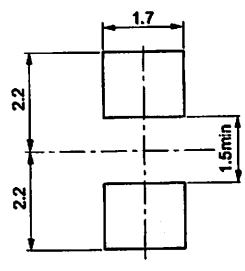
- Once the package has been opened, solder dipping should be carried out within seven days.

4. Handling of Remaining LED Chips

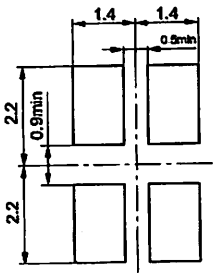
- If some Surface Mount LEDs have not been used, put them back into the moisture-proof packaging, seal the package completely and store it in a dry place.

■Reference mounting pattern for Surface Mount LED (Unit: mm)

Single-color SEC1001/1003 Series



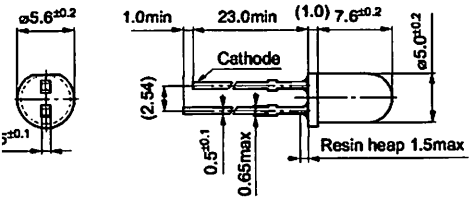
Bicolor SEC2002/2004 Series



5φ Round Standard LED

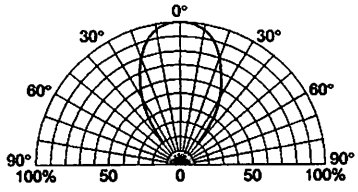
SEL1010M Series

ternal Dimensions (Unit: mm)

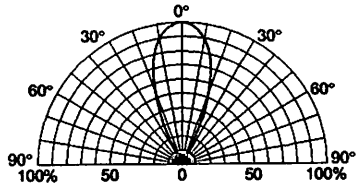


Tolerance: ±0.3

Directivity (Typical)



Diffuse lens



Transparent lens

solute maximum ratings (Ta=25°C)

Symbol	Unit	Rating	Condition
I_F	mA	30	
ΔI_F	mA/°C	−0.45	Above 25°C
I_{FP}	mA	100	f=1kHz, tw≤100μs
V_R	V	3	
Top	°C	−30 to +85	
Tstg	°C	−30 to +100	

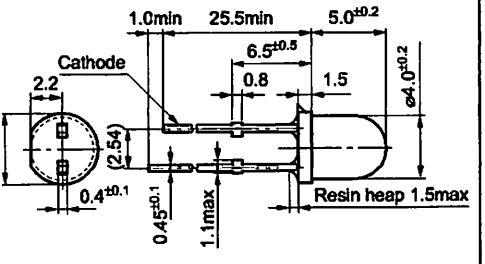
ectrical Optical characteristics (Ta=25°C)

nitting color	Part Number	Lens color	Forward voltage V_F (V) typ	Forward voltage V_F (V) max	Condition I_F (mA)	Reverse current I_R (μA) max	Condition V_R (V)	Intensity I_V (mcd) typ	Condition I_F (mA)	Peak wavelength λP (nm) typ	Condition I_F (mA)	Spectrum half width Δλ (nm) typ	Condition I_F (mA)	Chip material
Red	SEL1210RM	Diffused red	1.9	2.5	10	50	3	36	20	630	10	35	10	GaAsP
	SEL1210SM	Transparent red						75						
Amber	SEL1810DM	Diffused orange	1.9	2.5	10	50	3	18	10	610	10	35	10	
	SEL1810AM	Transparent orange						37						
Orange	SEL1910DM	Diffused orange	1.9	2.5	10	50	3	19	10	587	10	33	10	
	SEL1910AM	Transparent orange						34						
Yellow	SEL1710KM	Transparent yellow	2.0	2.5	10	50	3	65	10	570	10	30	10	GaP
Green	SEL1410GM	Diffused green	2.0	2.5	10	50	3	30	20	560	10	20	10	
	SEL1410EM	Transparent green						84						
ure green	SEL1510CM	Clear	2.0	2.5	10	50	3	50	20	555	10	20	10	

4ϕ Round Standard LED

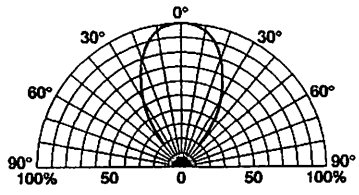
SEL4010 Series

ternal Dimensions (Unit: mm)

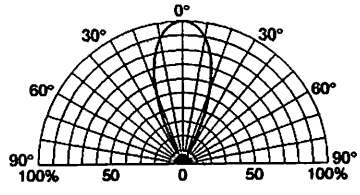


Tolerance: ±0.3

Directivity (Typical)



Diffuse lens



Transparent lens

)solute maximum ratings (Ta=25°C)

Symbol	Unit	Rating	Condition
I_F	mA	30	
ΔI_F	mA/°C	−0.45	Above 25°C
I_{FP}	mA	100	f=1kHz, tw≤100μs
V_R	V	3	
Top	°C	−30 to +85	
Tstg	°C	−30 to +100	

ectrical Optical characteristics (Ta=25°C)

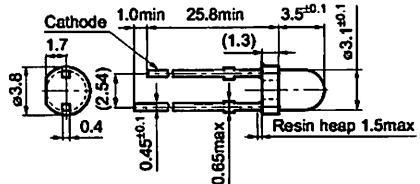
nitting color	Part Number	Lens color	Forward voltage V_F (V) typ	Forward voltage V_F (V) max	Condition I_F (mA)	Reverse current I_R (μA) max	Condition V_R (V)	Intensity I_V (mcd) typ	Condition I_F (mA)	Peak wavelength λP (nm) typ	Condition I_F (mA)	Spectrum half width Δλ (nm) typ	Condition I_F (mA)	Chip material
)eep red	SEL4110S	Transparent red	2.0	2.5	10	50	3	2.4	5	700	10	100	10	GaP
	SEL4110R	Diffused red						1.7						
Red	SEL4210S	Transparent red	1.9	2.5	10	50	3	30	20	630	10	35	10	GaAsP
	SEL4210R	Diffused red						17						
Amber	SEL4810A	Transparent orange	1.9	2.5	10	50	3	20	10	610	10	35	10	
	SEL4810D	Diffused orange						15						
Orange	SEL4910A	Transparent orange	1.9	2.5	10	50	3	26	10	587	10	33	10	
	SEL4910D	Diffused orange						16						
Yellow	SEL4710K	Transparent yellow	2.0	2.5	10	50	3	36	10	570	10	30	10	GaP
	SEL4710Y	Diffused yellow						14	10					
Green	SEL4410E	Transparent green	2.0	2.5	10	50	3	87	20	560	10	20	10	
	SEL4410G	Diffused green						34	20					
'ure green	SEL4510C	Clear	2.0	2.5	10	50	3	45	20	555	10	20	10	

3φ Round Standard LED

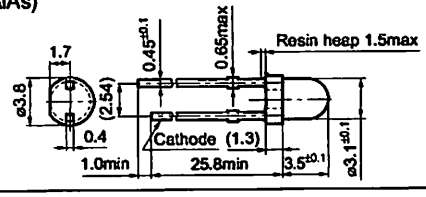
SEL2010 Series

ternal Dimensions (Unit: mm)

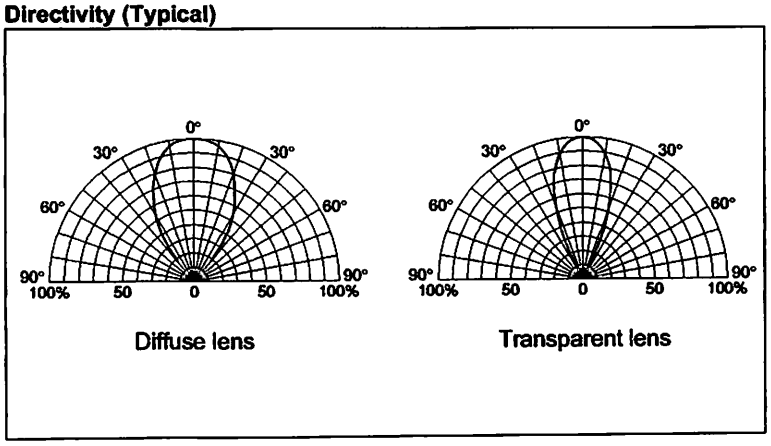
ther than GaAlAs chip) Tolerance: ±0.3



aAlAs)



Directivity (Typical)



solute maximum ratings (Ta=25°C)

Symbol	Unit	Rating						Condition
		GaP	GaAsP	GaAlAs	AlGaInP	InGaN	GaN	
I_F	mA	30						
ΔI_F	mA/°C	−0.45						Above 25°C
I_{FP}	mA	100					70	f=1kHz, tw≤100μs
V_R	V	3			4	5		
Top	°C	−30 to +85				−25 to +85		
Tstg	°C	−30 to +100						

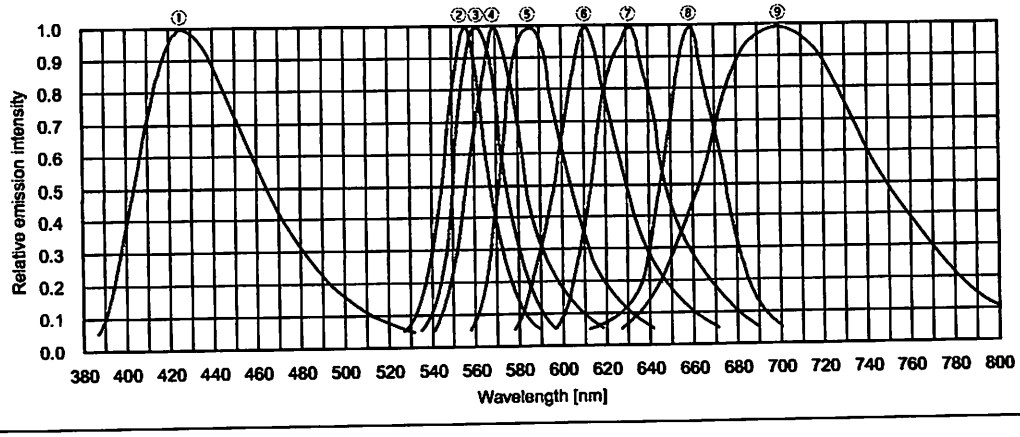
ectrical Optical characteristics (Ta=25°C)

mitting color	Part Number	Lens color	Forward voltage V_F (V) typ	Forward voltage V_F (V) max	Condition I_F (mA)	Reverse current I_R (μA) max	Condition V_R (V)	Intensity I_V (mcd) typ	Condition I_F (mA)	Peak wavelength λP (nm) typ	Condition I_F (mA)	Spectrum half width Δλ (nm) typ	Condition I_F (mA)	Chip material
Deep red	SEL2110S	Transparent red	2.0	2.5	10	50	3	4.0	10	700	10	100	10	GaP
	SEL2110R	Diffused red						1.8						
	SEL2110W	Diffused white						1.8						
gh-ensity red	SEL2610C	Clear	1.75	2.2	10	100	3	350	20	660	10	30	10	GaAlAs
Red	SEL2210S	Transparent red	1.9	2.5	10	50	3	40	20	630	10	35	10	GaAsP
	SEL2210R	Diffused red						15						
	SEL2210W	Diffused white						15						
Amber	SEL2810A	Transparent orange	1.9	2.5	10	50	3	22	10	610	10	35	10	
	SEL2810D	Diffused orange						9.0						
Orange	SEL2910A	Transparent orange	1.9	2.5	10	50	3	16	10	587	10	33	10	
	SEL2910D	Diffused orange						8.0						
ra-high-ensity yellow	SELU2710C	Clear	2.0	2.5	10	100	4	270	20	572	10	15	10	AlGaInP
Yellow	SEL2710K	Transparent yellow	2.0	2.5	10	50	3	40	10	570	10	30	10	GaP
	SEL2710Y	Diffused yellow						14						
Green	SEL2410E	Transparent green	2.0	2.5	10	50	3	77	20	560	20	20	10	
	SEL2410G	Diffused green						20						
ure green	SEL2510C	Clear	2.0	2.5	10	50	3	43	20	555	10	20	10	
	SEL2510G	Diffused green						8.2						
ra-high-intensity e green	SELU2D10C	Clear	3.3	4.0	20	10	5	1200	20	525	10	35	10	InGaN
ra-high-tensity blue	SELU2E10C	Clear						400	20	470	10	35	10	
Blue	SEL2E10C	Clear	3.8	4.8	20	10	5	60	20	430	10	65	10	GaN

Characteristic Curves

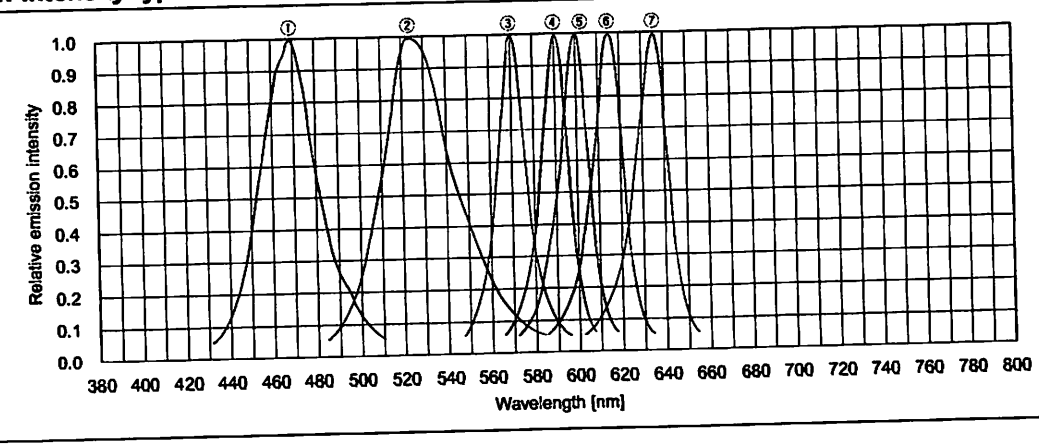
Spectral distribution

andard type



	Light color	Chip material	Peak Wavelength(nm)
①	Blue	GaN	430
②	Pure green	GaP	555
③	Green/deep green	GaP	560/558
④	Yellow	GaP	570
⑤	Orange	GaAsP	587
⑥	Amber	GaAsP	610
⑦	Red	GaAsP	630
⑧	High-intensity red	GaAlAs	660
⑨	Deep red	GaP	700

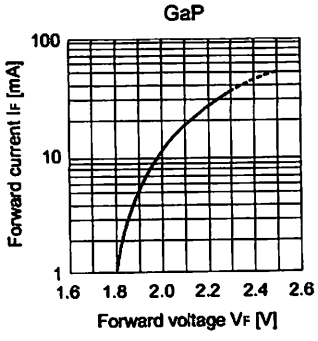
ltra-high-intensity type

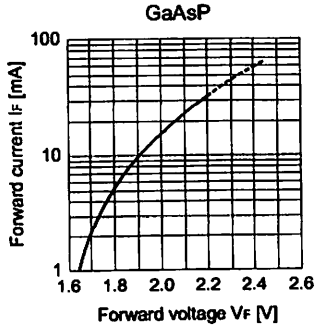


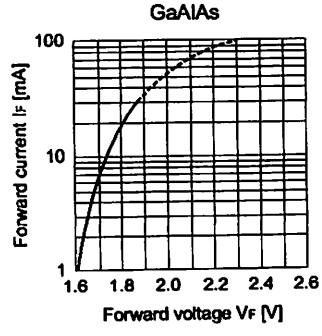
	Light color	Chip material	Peak Wavelength(nm)
①	Ultra-high-intensity blue	InGaN	470
②	Ultra-high-intensity pure green	InGaN	525
③	Ultra-high-intensity yellow	AlGaInP	572
④	Ultra-high-intensity orange	AlGaInP	590
⑤	Ultra-high-intensity light amber	AlGaInP	600
⑥	Ultra-high-intensity amber	AlGaInP	615
⑦	Ultra-high-intensity red	AlGaInP	635

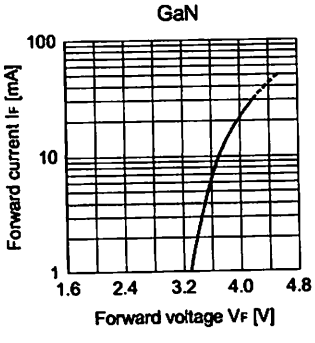
Characteristic Curves

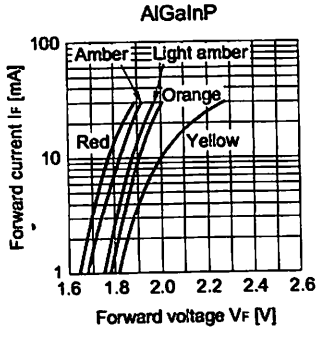
- VF characteristic

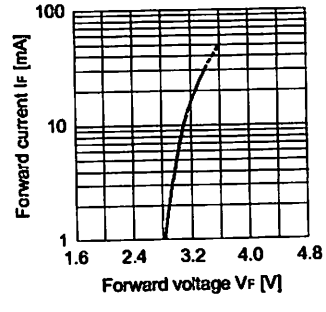




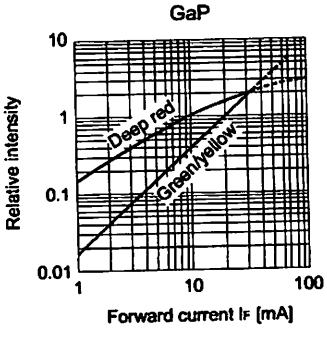


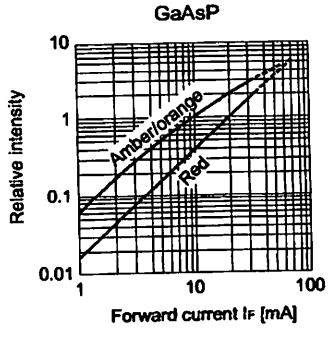


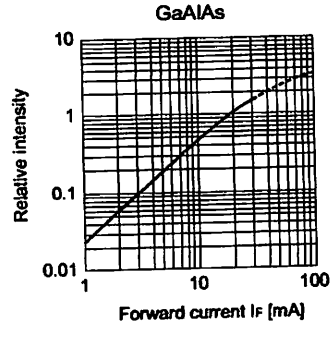


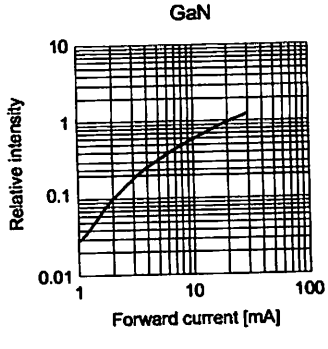


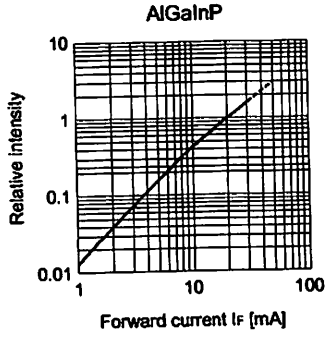
Relative intensity - IF characteristic

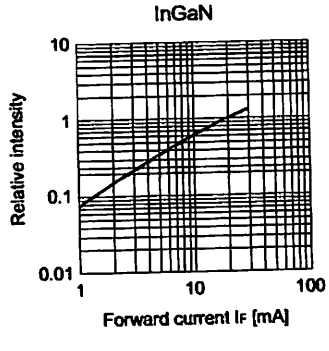








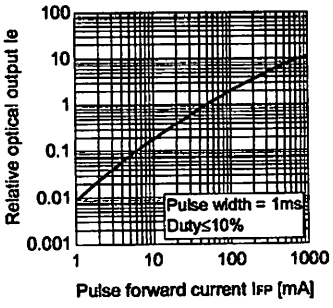




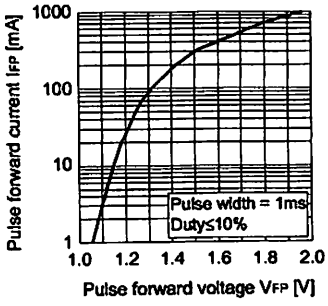
Characteristic Curves

frared LED

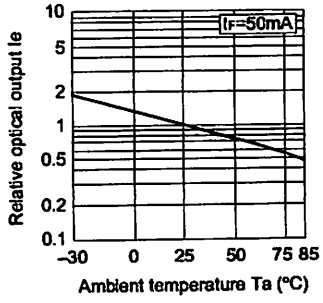
I_{FP} - Ie characteristic



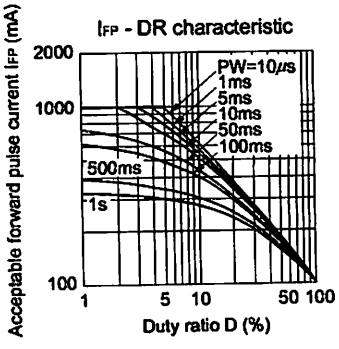
V_{FP} - IFP characteristic



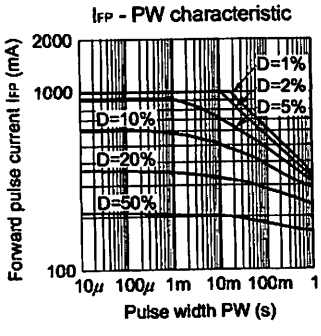
Ie - Ta characteristic



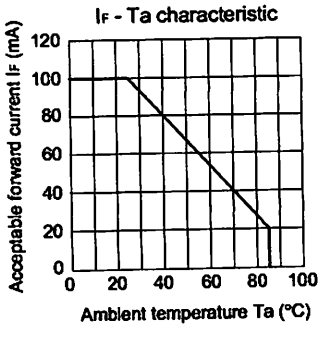
I_{FP} - DR characteristic



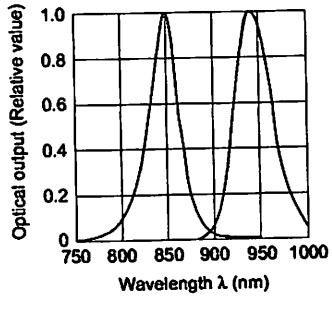
I_{FP} - PW characteristic



I_F - Ta characteristic



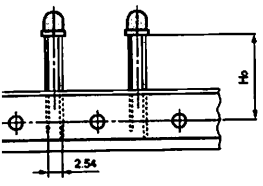
Spectral distribution



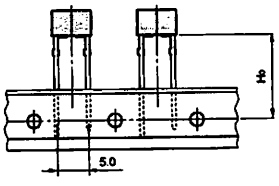
Taping Specifications

ıp Types
raight type

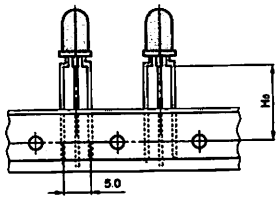
2. Forming (5 mm pitch) type



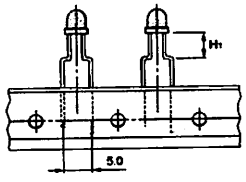
Straight standard shape



Straight standard shape
(5 mm pitch lead)



Bicolor straight standard shape



Forming standard shape

Taping shape (unit: mm)

ing compatibility table

Series name	Forming (5 mm pitch) type							Straight type						With holder*			Package contents	Page
Taping No.⇒	TP1	TP2	TP3	TP6	TP7	TP8	TP19	TP4	TP5	TP15	TP16	TP17	TP18	TH8F	TH10D	TH12E		
r H0 dimension⇒	4.5	7.5	6.0	3.5	5.0	9.0	7.4	17.0	20.5	20.5	19.0	23.5	25.0					
010		○	○		○	○											2500	10
010M	○	○	○	○	○	○											2500	11
010XM	○	○	○	○	○	○											2500	12
050M	○	○	○	○	○	○			○								2500	13
015		○	○		○	○											2500	14
011		○	○		○	○											2500	15
053M																	2500	16
010		○	○		○	○											3000	17
014	○	○	○	○	○	○			○								3000	18
010	Use SEL2010								○						○	○	4000	19
014		○	○		○	○			○								4000	20
015	Use SEL2015								○								4000	21
010	○	○	○	○	○	○											4000	22
015	○	○	○	○	○	○											4000	23
011	○	○	○	○	○	○											4000	24
017	○	○	○	○	○	○											4000	25
013		○	○		○	○											2500	26
013	Use SEL2013								○								4000	27
013	○	○	○	○	○	○											4000	28
021		○	○		○	○											2500	30
022		○	○		○	○											2500	31
020		○	○		○	○											3000	32
024		○	○		○	○											3000	33
025	○	○	○	○	○	○											6000	34
026	○	○	○	○	○	○		○									6000	35
027	○	○	○	○	○	○											6000	36
028	○	○	○	○	○	○											6000	37
029	○	○	○	○	○	○											6000	38
027	Use SEL4027								○								6000	39
020										○				○			4000	40
021										○							4000	41
023										○							4000	42
055										○							4000	43
1016/10016								○									2500	44
10051								○									2500	45
10060								○									6000	46
70020										○							4000	47
70023										○							4000	48
70055										○							3000	49
1010	○	○	○	○	○	○											2500	54
1050	○	○	○	○	○	○			○								2500	55
300/1003											○	○	○				2000	56
2010																	3000	57

* The package contents for taping with holder are 1200.

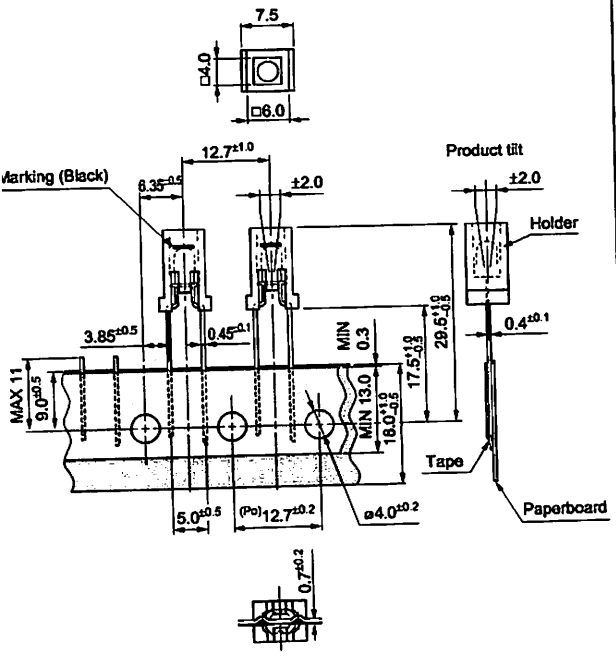
Taping Specifications

Taping with holder

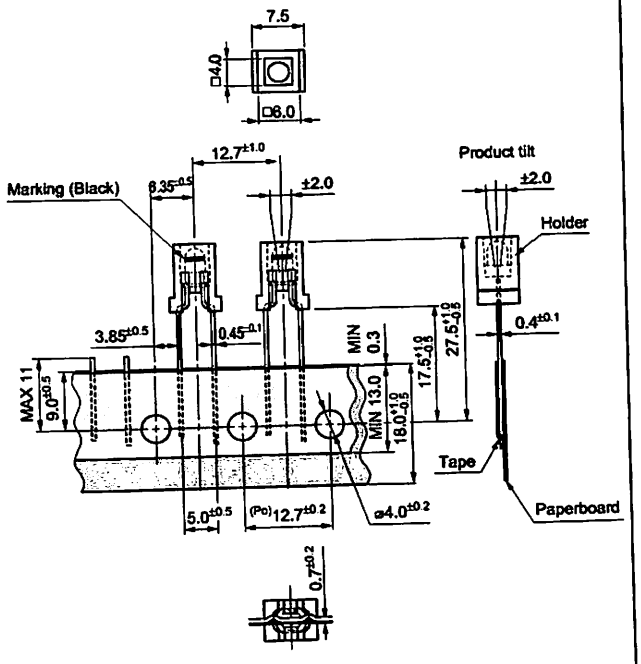
tures

is taping format saves the customer the trouble of attaching a holder.
y available inserter can be used with the 5 mm lead pitch radial taping.

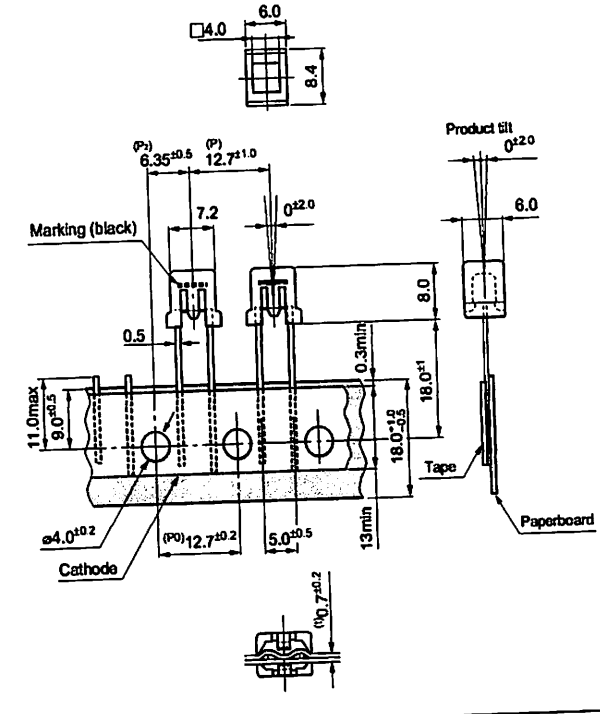
12E



TH10D



H8F



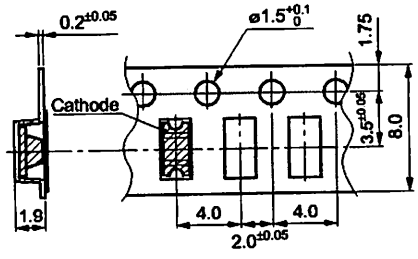
Po: The cumulative pitch error is ±1.0 mm per 20.
Dimensional tolerance: ±0.3
Unit: mm

See the previous page for the product names and package contents (standard per box).

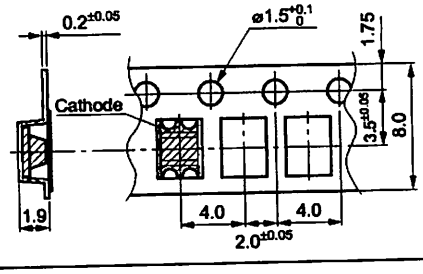
Taping Specifications

› type

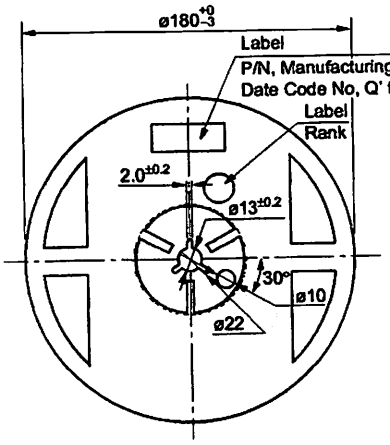
ɪle-color SEC1001/1003 Series

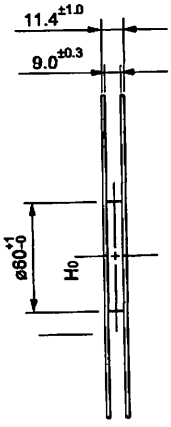


›lor SEC2002/2004 Series



Reel specifications





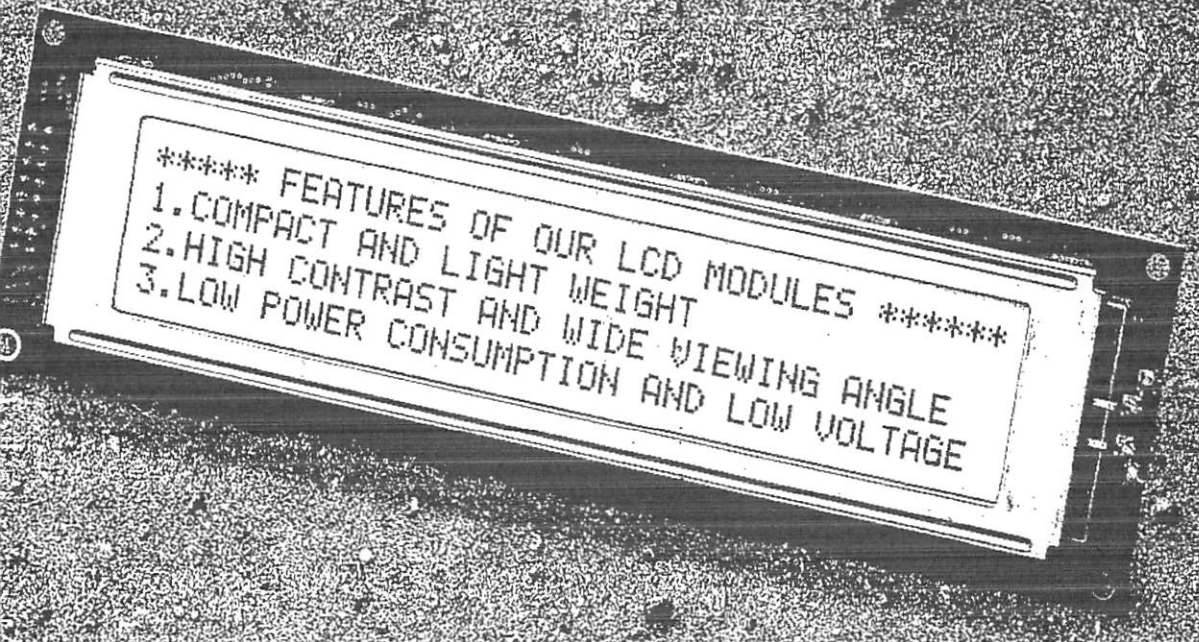
General tolerance: ±0.2

Package contents: 3000

Liquid Crystal Displays

Standard Character Modules

Application Notes



Seiko Instruments GmbH

Dot Matrix Liquid Crystal Display Module

Character Type

■ FEATURES

- Slim, light-weight and low power consumption
- High contrast and wide viewing angle
- Built-in controller for easy interface
- Available EL and LED backlight type
- Available in wide temperature type

The table below shows a quick reference guide of the character LCD modules. You can see the standard specifications and other optical specifications on the reference page of each model shown in the table below.

Character Format (character x line)		16 x 1	16 x 2	16 x 2	16 x 2	16 x 4	20 x 2
Model		M1641	M1632	L1642	L1652	L1614	L2012
Reflective		M16410AS	M16320AS	L164200J000S	L165200J200S	L161400J000S	L201200J000S
EL backlight		M16419DWS	M16329DWS	L164221J000S	L165221J200S	L161421J000S	L201221J000S
LED backlight		M16417DYS	M16327DYS	L1642B1J000S	L1652B1J200S	L1614B1J000S	L2012B1J000S
Reflective (wide temp)		M16410CS	M16320CS	L164200L000S	L165200L200S	L161400L000S	L201200L000S
LED backlight (wide temp)		M16417JYS	M16327JYS	L1642B1L000S	L1652B1L200S	L1614B1L000S	L2012B1L000S
Character font		5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor	5x7 dots + cursor
Module size (HxVxT) mm	Reflective	80,0 x 36,0 x 11,3	85,0 x 30,0 x 10,1	80,0 x 36,0 x 11,3	122,0 x 44,0 x 11,3	87,0 x 60,0 x 11,6	116,0 x 37,0 x 11,3
	EL backlight	80,0 x 36,0 x 11,3	85,0 x 30,0 x 10,1	80,0 x 36,0 x 11,3	122,0 x 44,0 x 11,3	87,0 x 60,0 x 11,6	116,0 x 37,0 x 11,3
	LED backlight	80,0 x 36,0 x 15,8	80,0 x 30,0 x 15,8	80,0 x 36,0 x 15,8	122,0 x 44,0 x 15,8	87,0 x 60,0 x 15,8	116,0 x 37,0 x 15,8
Viewing area (HxV) mm		64,5 x 13,8	62,0 x 16,0	64,5 x 13,8	99,0 x 24,0	61,8 x 25,2	83,0 x 18,6
Character size (HxV) mm		3,07 x 5,73	2,78 x 4,27	2,95 x 3,80	4,84 x 8,06	2,95 x 4,15	3,20 x 4,85
Dot size (HxV) mm		0,55 x 0,75	0,50 x 0,55	0,50 x 0,55	0,92 x 1,10	0,55 x 0,55	0,60 x 0,65
Power supply voltage (VDD-VSS)		+ 5 V	+ 5 V	+ 5 V	+ 5 V	+ 5 V	+ 5 V
Current consumption (mA,typ)	IDD	1,5	2,0	1,6	2,0	2,7	2,0
	ILC	0,2	0,2	0,3	0,4	1,1	0,4
Driving method (duty)		1/16	1/16	1/16	1/16	1/16	1/16
Built-in LSI		KS0066 or equivalent	KS0066 MSM5839 or equivalent	KS0066 MSM5839 or equivalent	KS0066 MSM5839 or equivalent	KS0066 KS0063 or equivalent	KS0066 KS0063 or equivalent
Operating temperature (°C)	normal temp.	0 to + 50	0 to + 50	0 to + 50	0 to + 50	0 to + 50	0 to + 50
	wide temp.	- 20 to + 70	- 20 to + 70	- 20 to + 70	- 20 to + 70	- 20 to + 70	- 20 to + 70
Storage temperature (°C)	normal temp.	- 20 to + 60	- 20 to + 60	- 20 to + 60	- 20 to + 60	- 20 to + 60	- 20 to + 60
	wide temp.	- 30 to + 80	- 30 to + 80	- 30 to + 80	- 30 to + 80	- 30 to + 80	- 30 to + 80
Weight (g, typ.)	Reflective	25	25	25	50	50	40
	EL backlight	30	30	30	55	55	45
	LED backlight	35	40	35	65	65	60
Inverters for EL	Model	5S	5S	5S	5C	5A	5A
	Power supply (V)	+ 5.0	+ 5,0	+ 5.0	+ 5.0	+ 5.0	+ 5.0
	current consumption (mA	10	10	10	35	45	45
LED backlight	Forward current consumption (mA)	100	112	100	240	200	154
	Forward input voltage (V,typ.)	+ 4,1	+ 4,1	+ 4,1	+ 4,1	+ 4,1	+ 4,1
Page		9	12	15	18	21	24

Quality Assurance

1.1 Conformity

The performances, functions, and reliability of the products conform to the Product Specification.

1.2 Responsibility

Customers are responsible for any defect in quality caused after incoming inspection.

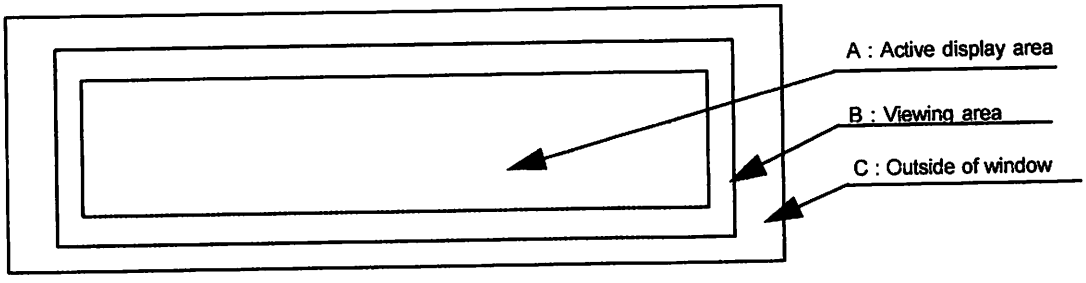
1.3 Warranty

The quality warranty is valid for one year after the delivery.

Shipping assurance level is as follows

Rank	Zone		Defect	AQL
Major defect	A	Display area (Appearance) (Functions)	Display functions current consumption Missing display functions No display	0.4%
Minor defect	A	Display area	Polarizer defect Uneven contrast Crosstalk Black spots	1.0%
	B	Boundary of display area to view ing area	Black streaks Bubbles Cromaticity Uniformity	
	C	Panel frame Circuit board	Scratches Dirt	

Zone definition



A : active display area
B : viewing area excluding active display area
C : area of entire module excluding viewing area (metal frame, PCB etc)

Appearance Defect

See individual defects standards in Delivery Specifications

Reliability Test

Normal Temperature type

tem	Test Conditions	result
ition at emperature umidity	40 °C ± 2 °C 90% RH for 500 hours	No abnormalities in functions* and appearance**
ition at emperature	60 °C ± 2 °C for 500hrs	No abnormalities in functions* and appearance**
shock	-20 °C ⇔ +60 °C Left for 1 hour at each temperature, transition time 5 minutes repeated 10 times	No abnormalities in functions* and appearance**
Temperature	-20 °C ± 2 °C for 500hrs	No abnormalities in functions* and appearance**
tion	Sweep for 1 min. at 10Hz, 55Hz, 10Hz amplitude 1.5mm 2 hours each in the X,Y and Z directions	No abnormalities in functions* and appearance**
shock	Dropped onto a board from a height of 30cm	No abnormalities in functions* and appearance**

ssipation current, contrast and display functions
arizer deterioration, other appearance defect

Wide Temperature type

Item	Test Conditions	result
ration at temperature humidity	60 °C ± 2 °C 90% RH for 500 hours	No abnormalities in functions* and appearance**
ration at temperature	80 °C ± 2 °C for 500hrs	No abnormalities in functions* and appearance**
t shock	-30 °C ⇔ +80 °C Left for 1 hour at each temperature, transition time 5 minutes repeated 10 times	No abnormalities in functions* and appearance**
Temperature	-30 °C ± 2 °C for 500hrs	No abnormalities in functions* and appearance**
ration	Sw eep for 1 min. at 10Hz, 55Hz, 10Hz amplitude 1.5mm 2 hours each in the X,Y and Z directions	No abnormalities in functions* and appearance**
p shock	Dropped onto a board from a height of 30cm	No abnormalities in functions* and appearance**

issipation current, contrast and display functions
olarizer deterioration, other appearance defect

2. LCD Life Time

Item	Conditions	Standard	Unit
Life time	25 °C ± 10 °C < 65 %RH	100,000 or more	hours

3. Definition of LCD service life

- Contrast becomes 30% of initial value
- Current consumption becomes three times higher than initial value
- Remarkable alignment deterioration occurs in LCD cell layer
- Unusual operation occurs in display functions

ow To Use LCD Module

afety

he LCD panel is damaged, be careful not to get the liquid
stal in your mouth and not to be injured by crushed
ss.
ou should swallow the liquid crystal , first wash your
uth thoroughly with water, then drink a lot of water
luce vomiting and then consult a physician.
he liquid crystal should get in your eyes, flush your eyes
h running water for at least fifteen minutes.
he liquid crystal touches your skin or clothes, remove it
d wash the affected part of your skin or clothes with soap
d running water.
gh voltage is applied to the lead terminals of the EL lamp.
not touch any part of the lead terminals. (For LCD
dule with EL backlight)
not use EL inverters without a load or in the short-circuit
de.
e the LCD module within the rated voltage to prevent
erheating and/or damage. Also, take steps to ensure that
connector does not come off.

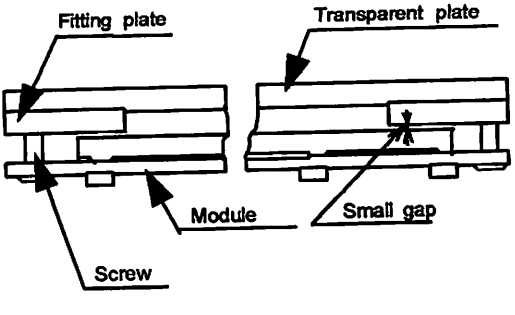
_CD Handling

lease keep the temperature within the specified range for
e and storage. Polarization degradation, bubble
eneration or polarizer peel-off may occur with high
mperature and high humidity.
o not touch, push or rub the exposed polarizers with
ything harder than hardness of 3B (glass, tweezers,
c..).
hen the display surface becomes dusty, wipe gently with
bsorbent cotton or other soft material like chamois soaked
petroleum benzene. Do not scrub hard to avoid damaging
e display surface.
ipe off saliva or water drops immediately. Contact with
ater over a long period of time may cause deformation or
olor fading.
void contact with oil and fats.
ondensation on the surface and contact terminals due to
old will damage, stain or dirty the polarizers. After products
re tested at low temperatures they must be warmed up in a
ontainer before coming in contact with room temperature
ir.
o not put or attach anything on the display area to avoid
eaving marks on.
o not touch the display area with bare hands, damage the
isplay area and degrade insulation between terminals.
some cosmetics are detrimental to the polarizers)
s glass is fragile, it tends to become cracked or chipped
uring handling especially on the edges, Please avoid
dropping or jarring.

LCD Module

I Mounting LCD module

Use the specified mounting parts and holes to mount the module.
Connect a 10 μF capacitor between the power supply terminals to eliminate noise.



- Make sure that no stress is applied on the module when it is mounted. The application of stress for a long time may damage the LCD panel and the ICs substrates.
- To protect the polarizer and the LCD panel, cover the display surface with a transparent plate, for example, acrylic or glass, with a small gap between the transparent plate and the LCD surface.
- Do not apply input signals when power supply voltage isn't applied.

3.2 Precaution for handling LCD module

Since the module has been assembled and adjusted with a high degree of precision, avoid applying excessive shocks to the module or making any modifications to it.

- Do not alter, modify or change the shape of the tab on the metal frame.
- Do not make extra holes on the PCB, modify its shape or change the positions of components attached.
- Do not damage or modify the pattern wiring on the PCB
- Do not modify the zebra rubber or touch it with another materials.
- Do not make any modifications with a soldering iron except indicating area.
- Do not drop, bend or twist the module.

3.3 Electro-static discharge

Since CMOS ICs are mounted on the module, special attention has to be paid to the electric-static discharge.

- Make sure that you are connected to the ground during handling of the module.
- Before removing the module from packing unit make sure that the module and yourself have the same electric potential.
- When soldering the terminal of the module, make sure that the AC power source for the soldering iron does not leak.
- When using an electric screwdriver to attach the module, the screwdriver should be grounded to minimise as much as possible any transmission of electro-magnetic waves produced by sparks coming from the accumulator of the motor.
- Make your clothes and working bench the ground potential as much as possible.
- Avoid to generate static electricity, relative humidity should be 50 ~ 60 %RH.

3.4 Precaution for operation

- Proper operating voltage for LCD gives optimum viewing angle.
- If LCD surface is pressed harder during operation, the display becomes abnormal and then will return to normal after the pressure is released. However, it may generate bubbles and cause permanent damage to the LCD.
- Condensation may generate electrochemical reaction and then it may cause open or short circuit on the terminal.

3.5 Cleaning

- Do not wipe the polarizer with a dry cloth, as it may scratch the surface.
- Wipe the module gently with a soft cloth soaked with a petroleum benzene.
- Do not use ketonic solvents (ketone, acetone etc.) or aromatic solvents (toluene and xylenen) as they may damage the polarizing plate.

4. Storage

- Store the module in the dark place. Keep the temperature between 15 ℃ and 35 ℃ and the humidity below 65%RH.
- Do not store the module near organic solvents or corrosive gases.
- Make sure that no stress or vibration is applied to the module when it is stored.
- Use the products with EL backlight within 6 months after receiving them.

Handling the LED backlight

When soldering the LED connector, the soldering iron emperature should not exceed 260 ℃ and soldering time should be within 3 seconds

For cleaning, wipe with soft cloth and use only the following chemicals

Ethanol

Isopropyl alcohol

Handling the EL backlight

Your design should make it easy to replace the EL backlight since they have a shorter service life than the other components of LCD modules.

Do not bend the EL leads when soldering them on the circuit board of the LCD modules otherwise they may break.

To set the EL backlight into the LCD module, push the EL backlight with its emitting side up, without pushing the rubber connectors too hard. If you damage them, the LCD module may not work properly.

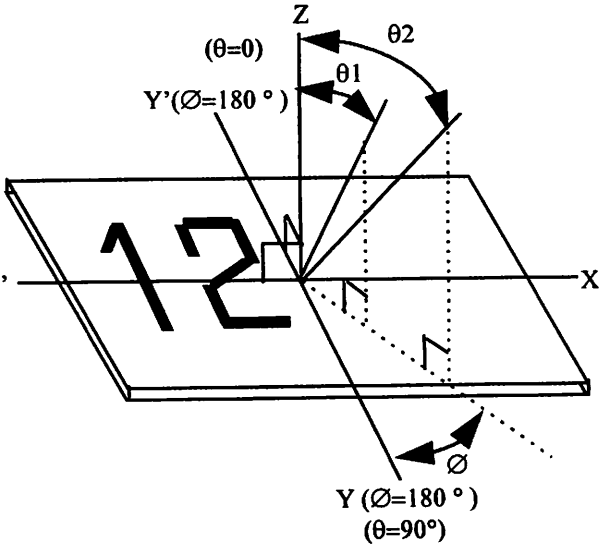
Do not damage the film surface of the EL backlight otherwise the backlight will be damaged by humidity.

Since high voltage is applied to the EL lead terminals, be careful not to touch the EL terminals.

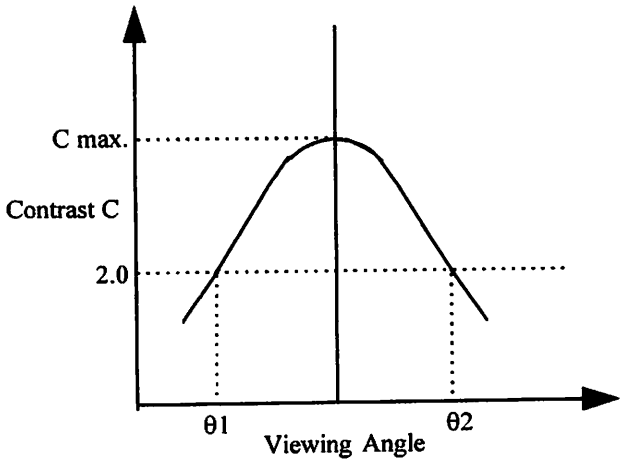
Do not use EL inverters without a load or in the short-circuit mode.

efinition of Optical Characteristics Term

ngles Ø and θ

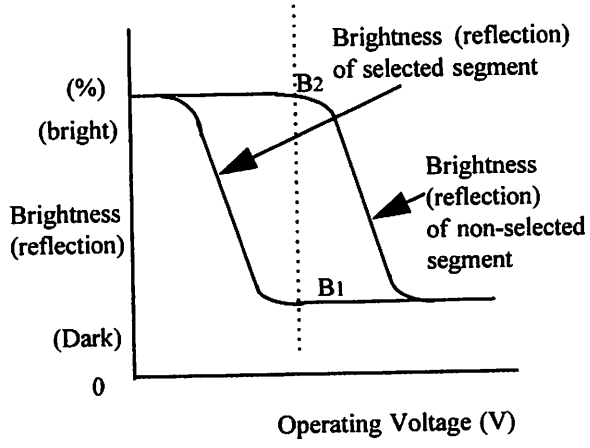


■ Viewing Angle θ1 and θ2

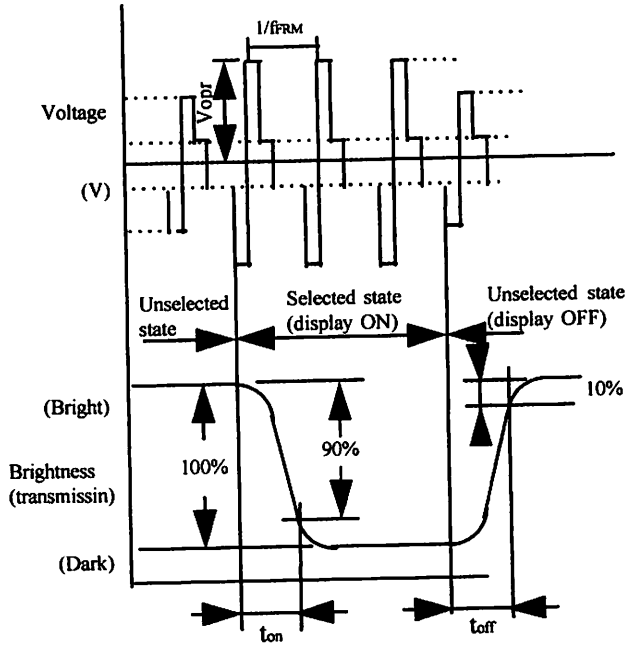


Contrast C

$$C = \frac{\text{Brightness (reflection) of non-selected segment (B2)}}{\text{Brightness (reflection) of selected segment (B1)}}$$



■ Response Time



Vopr : Operating Voltage
fFRM : Frame Frequency
ton : Response time (rise)
toff : Response time (fall)

6 Characters x 2 line
x 7 Dot Matrix + Cursor
/16 Duty
V single Power Supply
Available in EL and LED
Backlight type

Absolute Maximum Ratings

Vss=0V, Ta=25°C

	Symbol	Conditions	Min.	Max.	Unit
er supply	VDD		-0.3	6.0	V
age	VLC		-0.3	VDD	V
t voltage	Vin		-0.3	VDD +0.3	V
rating temperature					
ormal	Topr		0	+50	°C
Vide	Topr		-20	+70	°C
rage temperature					
ormal	Tstg		-20	+60	°C
Vide	Tstg		-30	+80	°C
rage		< 48 hrs	+20	+85	%RH
nidity		<1000 hrs	+20	+65	%RH

Mechanical Characteristics

		Specifications	Unit
n			
dule size (H x V)		85.0 x 30.0	mm
ckness	Reflective/EL	10.1	mm
	LED	15.8	mm
w ing area (H x V)		62.0 x 16.0	mm
aracter size with cursor (H x V)		2.78 x 4.89	mm
unting hole distance (H x V)		82.0 x 24.0	mm
	Reflective	25	g
ight	EL backlight	30	g
	LED backlight	40	g

Horizontal, V : Vertical

Electrical Characteristics

VDD=5V± 5%, Vss=0V, Ta=0 ~ 50°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Pow er supply	VDD		4.75	5.00	5.25	V
voltage	VDD - VLC		3.0	-	6.3	V
Input High	VIH1		2.2	-	VDD	V
voltage Low	VIL1		0	-	0.6	V
Output High	VOH1	-IOH=0.205mA	2.4	-	-	V
voltage Low	VLH1	-IOL=1.2mA	-	-	0.4	V
Current consumption *						
Normal Temp	IDD	Ta=25°C	-	1.6	2.5	mA
type	ILC	VLC=0.25V	-	0.2	1.0	mA
Wide Temp.	IDD	Ta=25°C	-	1.6	2.5	mA
type	ILC	VLC=-0.6V	-	0.3	1.0	mA

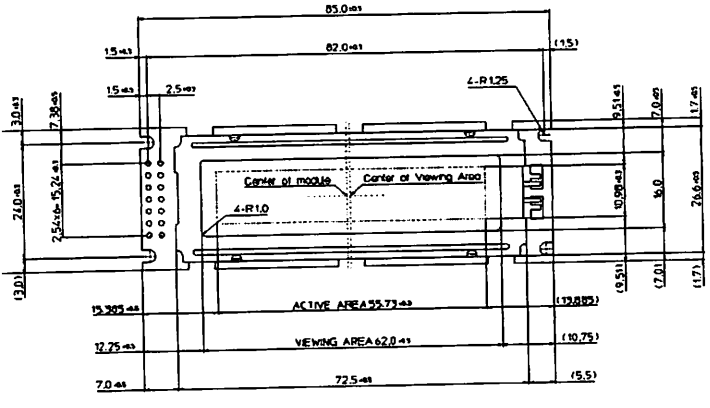
* test pattern : check board pattern

Pin Function

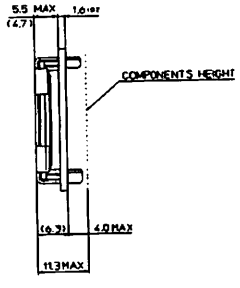
No.	Name	Function
1	VSS	GND
2	VDD	Pow er supply voltage +5V
3	VLC	Liquid crystal driving voltage
4	RS	L : Instruction code input H: Data input
5	R/W	L : Data w rite from MPU to LCM H : Data read from LCM to MPU
6	E	Enable
7	DB0	Data bus line
8	DB1	Data bus line
9	DB2	Data bus line
10	DB3	Data bus line
11	DB4	Data bus line
12	DB5	Data bus line
13	DB6	Data bus line
14	DB7	Data bus line
(15)	A	Anode (+) for LED backlight
(16)	K	Cathode (-) for LED backlight

Dimensions

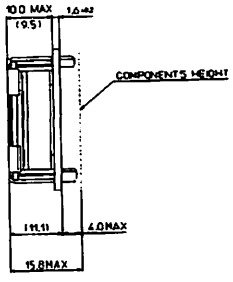
M1632 (2x16) Unit: mm, General tolerance ±0.5 mm



Reflective/EL Backlight

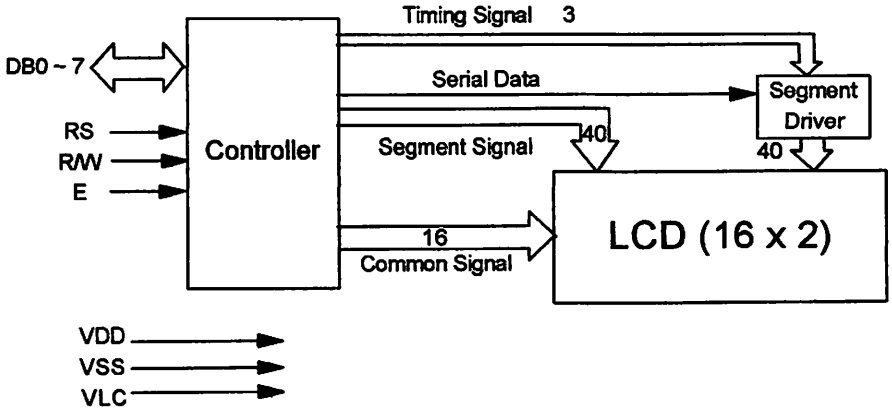


LED Backlight



Note : Only dimension changes between Reflective/EL and LED backlight is the thickness.

Circuit Block diagram



Recommended Operating Voltage

recommended value (Vopr) for an ambient temperature
s follow s. Vopr=VDD - VLC

perature (°C)		-20	0	+25	+50	+70
r (V)	Normal	-	5.00	4.75	4.50	-
	Wide	6.20	5.90	5.60	5.40	5.20

Optical Characteristics

Normal Temperature Range Type

Ta=21°C, 1/16 Duty, Vopr=4.75V

	Symbol	Conditions	Min.	Typ.	Max.	Unit
w ing	θ 1	C≥2	-	-	-15	deg.
le	θ 2	Φ =0°	55	-	-	
	θ 2- θ 1		70	-	-	
ntrast	C	θ =+25°, Φ =0°	-	5	-	-
	ton (rise)	θ =0°	-	150	200	msec
sponse	toff (fall)	Φ =0°	-	200	220	msec
	ton (rise)	θ =0°, Φ =0°	-	750	800	msec
	toff (fall)	Ta = 0°C, Vopr=5.0V	-	600	700	msec

asuring equipment : Canon illuminater LC-4SR

Wide Temperature Range Type

Ta=21°C, 1/16 Duty, Vopr=VDD - VLC

	Symbol	Conditions	Min.	Typ.	Max.	Unit
n						
w ing	θ 1	C≥2	-	-	-15	deg.
gle	θ 2	Φ =0°	55	-	-	
	θ 2- θ 1	Vop=5,6v	70	-	-	
ntrast	C	θ =+20°, Φ =0° Vop=5,6v	-	5	-	-
	ton (rise)	θ =0°, Φ =0°	-	150	200	msec
sponse	toff (fall)	Ta = 21°C, Vopr=5.6V	-	200	220	msec
e	ton (rise)	θ =0°, Φ =0°	-	750	800	msec
	toff (fall)	Ta = 0°C, Vopr=5.9V	-	600	700	msec

asuring equipment : Canon illuminater LC-4SR

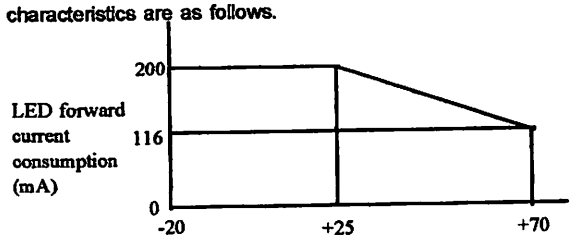
■ LED Backlight

1. Absolute Maximum Ratings

Ta=25°C

Item	Symbol	Specifications	Unit
LED forw ard current consumption *	IF	200	mA
LED reverse voltage	VR	8	V
Allow able loss	PD	0.92	W
Operating Temperature	Topr	- 20 ~ +70	°C
Storage Temperature	Tstg	- 40 ~ + 80	°C

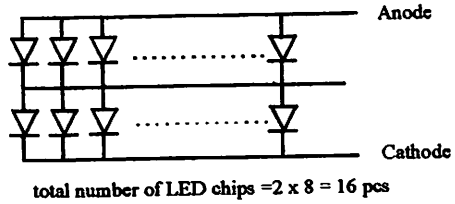
* LED forward current consumption and operating temperature characteristics are as follows.



2. Electrical Characteristics

Ta=25°C

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
LED forw ard input voltage	VF	IF=112mA	3.8	4.1	4.4	V
LED reverse current	IR	VR=8V	-	-	0.16	mA
Brightness	L	IF=112mA*	40	50	-	cd/m²



total number of LED chips =2 x 8 = 16 pcs

:L Backlight

Absolute Maximum Ratings

	Symbol	Standard	Unit
rating ıge	Vopr	AC 150V, 1KHz Sinew ave	V
rating ›erature	Topr	-10 ~ +50	°C
age ›erature	Tstg	-20 ~ + 60	°C
age idity		0 ~ 10 % RH (60 °C) 0 ~ 30 % RH (40 °C)	

Brightness, Current, Life Characteristics

	Conditions	Specifications	Unit
htness	100V, 400Hz Sinew ave	30 min. 35 typ.	cd/m²
ent	100V, 400Hz Sinew ave	1.2 typ. 1.7 max	mA
*	100V, 400Hz, Sinew ave 25°C,50%RH	1,500	hrs
	Using 5S Inverter 25°C,50%RH	4,000	

efinition of Life : Used continuously dow n to 10 cd/m²

Suitable Inverter 5S

1 Electrical Characteristics (When combined with EL lamp)

Ta=25°C

Item	Symbol	Conditions	Specifications	Unit
illating ıuency	fINV	VIN=5VDC	550 typ.	Hz
put voltage	VOUT	VIN=5VDC	100 typ.	V
put current	IOUT	VIN=5VDC	1.5 typ.	mA
ut current	VIN		5 typ	VDC
age	IIN	VIN=5VDC	10 typ	mA
al brightness	B	VIN=5VDC	35 typ.	cd/m²
face brightness nel upper side)	BP	VIN=5VDC Vopr=0V	7 typ.	cd/m²

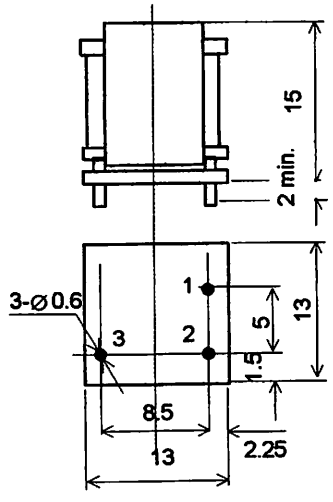
.2 Tolerance (Inverter only)

Item	Specifications	Unit
ut voltage	3.0 to 6.0	V
ad range	5 to 15	cm²

3.3 Maximum Ratings (Inverter only)

Item	Specifications	Unit
Input voltage	7.0	V
Load range	50	cm²
Operating temperature	-10 to +60	°C
Storage temperature	-20 to +70	°C

3.4 Inverter Dimensions (unit : mm)



Pin No.	Function
1	Input : 5V DC
2	Common : GND
3	Output

I. Timing Characteristics

1.1 Write operation

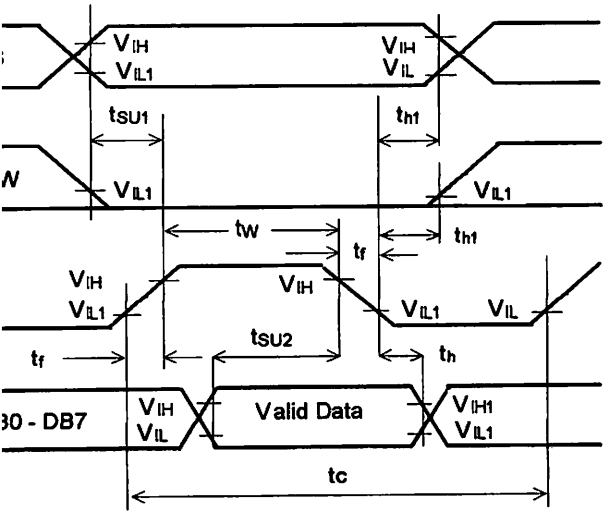
VDD=5V ± 10%. VSS=0V, Ta=25°C

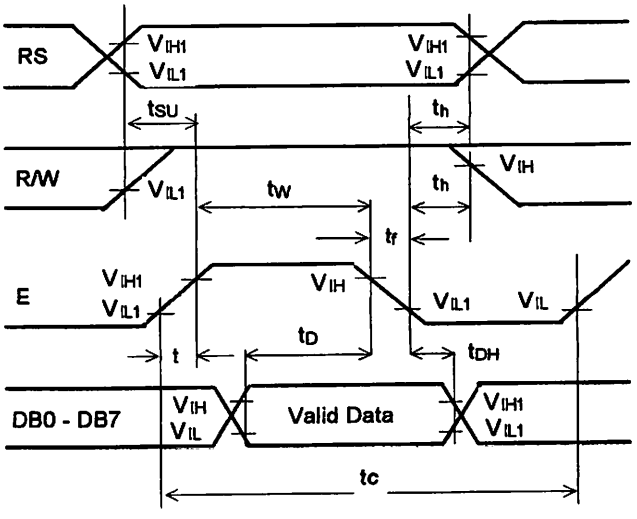
Item	Symbol	Min.	Max.	Unit
abel cycle time	tc	500	-	ns
able rise time	tr	-	25	ns
able fall time	tf	-	25	ns
able pulse width	tw	220	-	ns
tup time R/W, RS	tsu1	40	-	ns
ld time R/S, RS	th1	10	-	ns
ta setup time	tsu2	60	-	ns
ta hold time	th2	10	-	ns

1.2 Read operation

VDD=5V ± 10%. VSS=0V, Ta=25°C

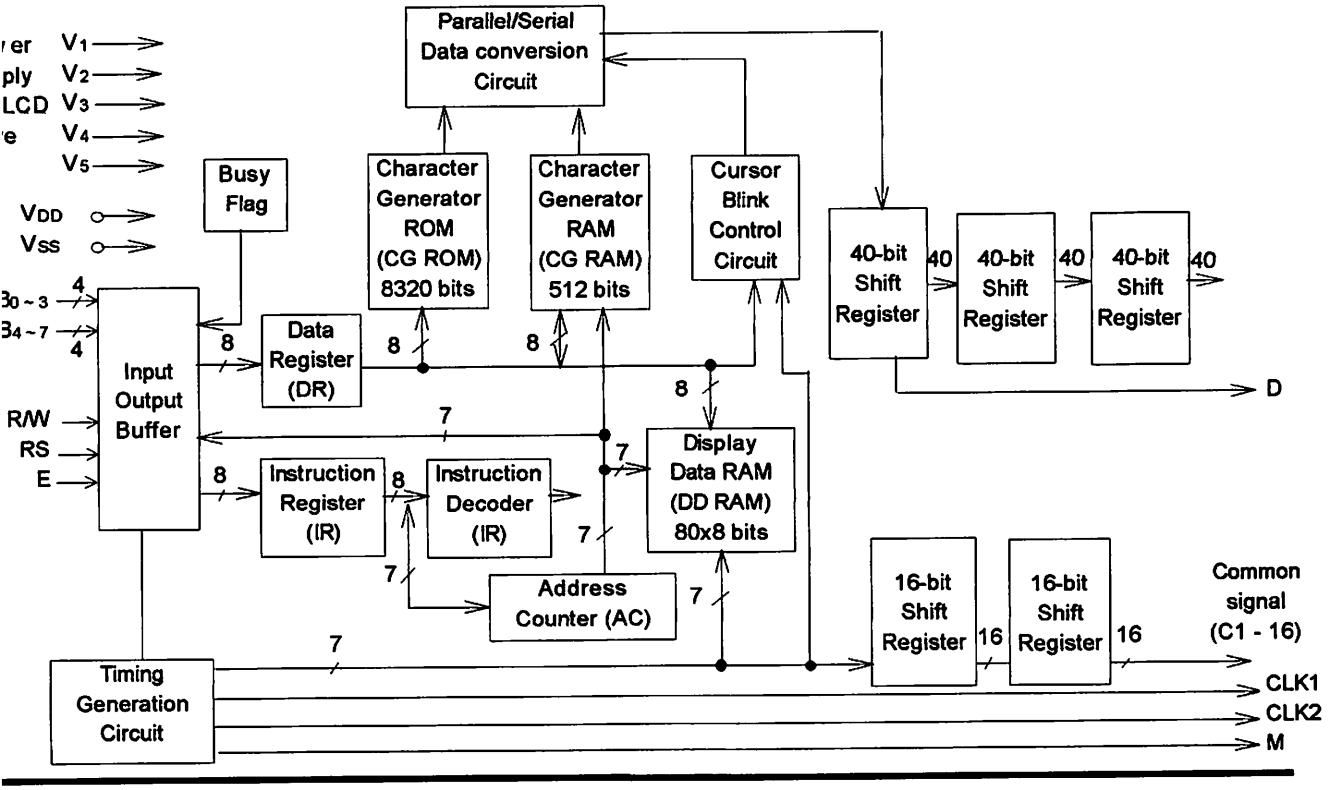
Item	Symbol	Min.	Max.	Unit
Enabel cycle time	tc	500	-	ns
Enable rise time	tr	-	25	ns
Enable fall time	tf	-	25	ns
Enable pulse width	tw	220	-	ns
Setup time R/W, RS	tsu	40	-	ns
Hold time R/S, RS	th	10	-	ns
Data delay time	tD	-	120	ns
Data hold time	tDH	10	-	ns





II. Basic Operation

II.1 Block Diagram of Controller KS0066



:.2 Registers

he controller (KS0066) has to kinds of eight-bit registers ; the instruction register (IR) and the data register (DR). They are selected by ie register select (RS) signal as shown below table 1. The IR stores instruction codes such as Display Clear and Cursor Home, and the ddress information of display data RAM (DD RAM) and character generator RAM (CG RAM). They can be written from the MPU, but an not be read to the MPU. The DR temporarily stores data to be written into DD RAM or CG RAM, or data read from D RAM or CG :AM. For data write, the data written into the DR from the MPU is automatically written into DD RAM or CG RAM by internal operation. or data read, when the data address is written into the IR, the specified data is read out to the DR by internal operation. Then the MPU :ads it from the DR. After the read operation, the next address is set and DD RAM or CG RAM data at the address is read into the DR)r the next read operation.

Table 1 Register Selection

RS	R/W	Operation
0	0	IR selection, IR w rite. Internal operation : Display Clear, Cursor Home, etc
0	1	Busy flag (DB7) and address counter (DB0 to DB6) read
1	0	DR selection, DR w rite. Internal operation : DR to DD RAM or to CG RAM
1	1	DR selection, DR read. Internal operation : DD RAM or CG RAM to DR

:.3 Busy Flag (BF)

he busy flag indicates whether the module is ready to accept the next instruction. As shown in table, the signal is output to DB_7, if :S=0 and R/W=1. If the busy flag is 0, the next instruction can be written. Therefore, the busy flag status needs to be checked before xecuting an instruction. To execute an instruction without checking the flag status, wait for more than the execution time of prior istruction. For the execution time of each instruction, see section 3 "Instruction Outline".

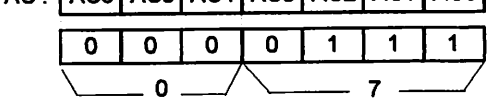
:.4 Address Counter (AC)

he address counter specifies an address when data is written into DD RAM or CG RAM and when the data stored in DD RAM or CG :AM is read out. If an address Set instruction (for DD RAM orCG RAM) is written into IR, the address information is transferred from the R to the AC. When display data is written into or read from DD RAM or CG RAM, the AC is automatically incremented or decremented y one according to the Entry Mode Set. The contents of the AC are output to DB_0 to DB_6 if RS=0 and R/W=1 as shown in table 1.

:.5 Display Data RAM (DD RAM)

DD RAM has a capacity of up to 80 x 8 bits and stores display data of 80 eight-bit character codes. Some storage areas of DD RAM that re not used for display can be used as general data RAM. A DD RAM address to be set in the AC is expressed in hexadecimal form as)llows. Example : DD RAM address "07"

he correspondence between the DD RAM address and the display digits of the LCD panel is described in the followings.



:.6 Address Location

he DD RAM address and the display digit of the LCD panel correspond as follows for LCD modules driven by 1/16duty and one ontroller can display maximum 80 characters.

	1	2	3	———	15	16	17	18	19	20	———	38	39	40	Display digit
Line 1	00	01	02	———	0E	0F	10	11	12	13	———	25	26	27	DD RAM
Line 2	40	41	42	———	4E	4F	50	51	52	53	———	65	66	67	address (HEX)

Vhen the display digits are less than 40, the display begins at the head positions of the two lines. In this case, first line end address nd the second line start address are not consecutive.

:.6.1 M1641

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Display digit
Line 1	00	01	02	03	04	05	06	07	40	41	42	43	44	45	46	47	DD RAM address (HEX)

Note : This is initialised as a 2 line display because of no LCD driver. Character No.9 must be addressed as first position of 2nd line, which is 40 (HEX).

:.6.2 M1632, L1642, L1652

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	DD RAM
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	address (HEX)

:.6.3 L1614

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	DD RAM
Line 3	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	address (HEX)
Line 4	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	

Consequently, the end address of line 1 and the start address of line 3 are consecutive. Also, the end address of line 2 and the start address of line 4 are consecutive. The DD RAM address 00H to 27H are displayed in line 1 and line 3 and 40H to 67H in line 2 and line 4 by executing Display Shift.

6.4 L2012, L2022

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	DD RAM
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	address (HEX)

6.5 L2014

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	DD RAM
Line 3	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27	address (HEX)
Line 4	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	64	65	66	67	

Consequently, the end address of line 1 and the start address of line 3 are consecutive. Also, the end address of line 2 and the start address of line 4 are consecutive. The DD RAM address 00H to 27H are displayed in line 1 and line 3 and 40H to 67H in line 2 and line 4 by executing Display Shift

6.6 L2432

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16	17	DD RAM
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	54	55	56	57	address (HEX)

6.3 L4042

	1	2	3	———	15	16	17	18	19	20	———	38	39	40	Display digit
Line 1	00	01	02	———	0E	0F	10	11	12	13	———	25	26	27	DD RAM
Line 2	40	41	42	———	4E	4F	50	51	52	53	———	65	66	67	address (HEX)

6.4 M4024

	1	2	3	———	15	16	17	18	19	20	———	38	39	40	Display digit
Line 1	00	01	02	———	0E	0F	10	11	12	13	———	25	26	27	
Line 2	40	41	42	———	4E	4F	50	51	52	53	———	65	66	67	DD RAM
Line 3	00	01	02	———	0E	0F	10	11	12	13	———	25	26	27	address (HEX)
Line 4	40	41	42	———	4E	4F	50	51	52	53	———	65	66	67	

M4024 has two LCD controllers. Since the capacity for each is 80 characters (40 characters x 2 lines), M4024 can display 160 characters (40 characters x 4 lines) by using two LCD controllers. Line 1 and 2 are activated by E1. Line 3 and 4 are activated by E2. All the four lines cannot be shifted at the same time. Instructions must be written using E1 and E2 to distinguish the upper two lines from the lower two lines.

2.7 Character Generator ROM (CG ROM)

CG ROM generates 5x7 dot-matrix character patterns from eight-bit character codes. In LCD modules of 5x7 dot-matrix character pattern, CG generates 192 types of 5x7 characters. Table 2 shows the correspondence between the CG ROM character codes and character patterns of 5x7 dot-matrix.

2.8 Character Generator RAM (CG RAM)

CG RAM is used to create character patterns freely by program. Eight types of 5x7 dot-matrix character patterns can be written into a CG RAM. Table 3 shows the character patterns created from CG RAM addresses and CG RAM data. To display a created character pattern, the character code in the left column of the table is written into DD RAM corresponding to the display position (digit). The areas not used for display are available as general data RAM.

2.9 Cursor/Blink Control Circuit

The circuit generates the cursor or blink. When the address counter (AC) selects the address of DD RAM, the cursor or the blink appears on the digit corresponding to the address. When the address counter is 08H, a cursor or blink position is in the 9th digit in line 1 as shown below.

The cursor or blink also appears when the character generator RAM (CG RAM) is selected by the address counter. In this case, the cursor or blink position has no meaning.

	AC_6	AC_5	AC_4	AC_3	AC_2	AC_1	AC_0
AC	0	0	0	1	0	0	0

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Display digit
Line 1	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	DD RAM
Line 2	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	address (HEX)

Table 2 Correspondence between character codes and character pattern (5x7 dot -matrix)

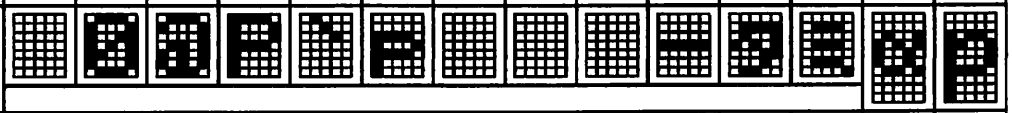
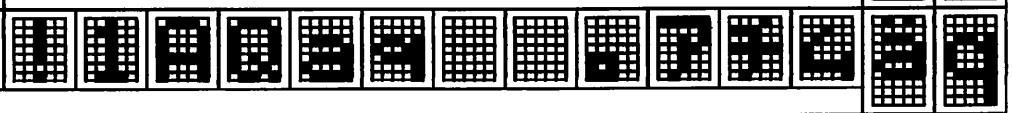
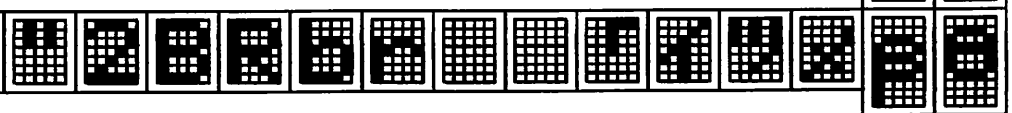
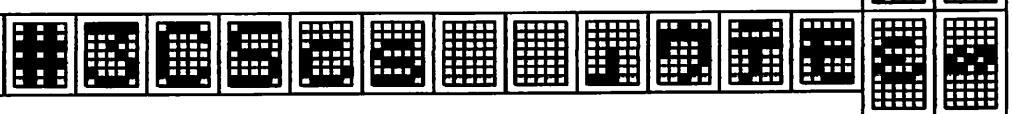
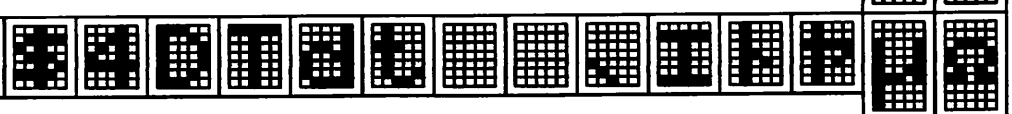
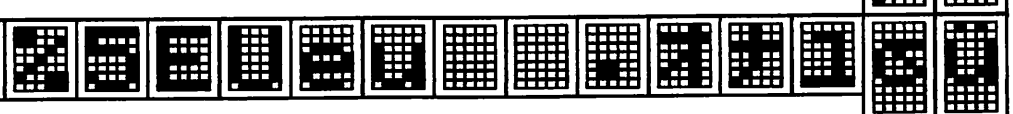
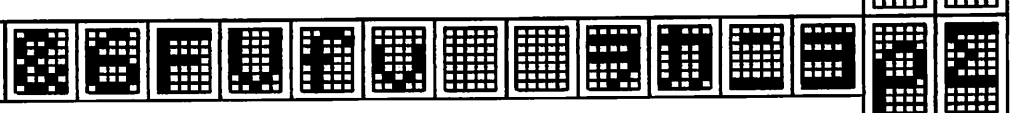
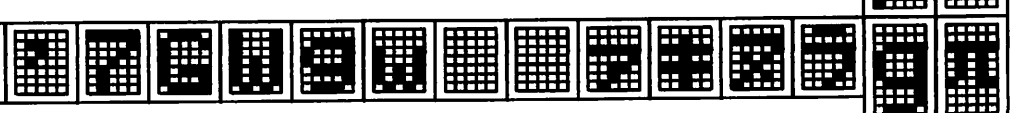
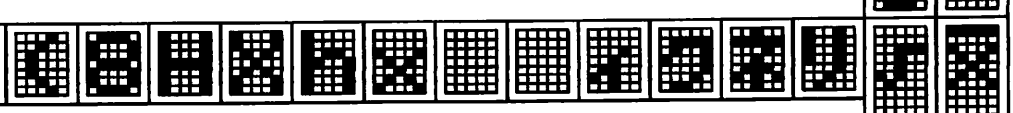
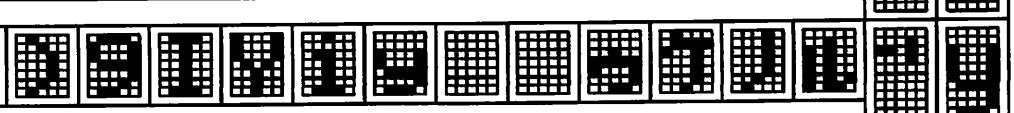
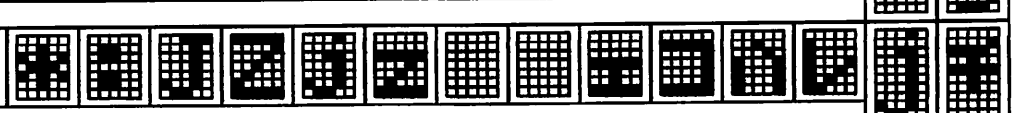
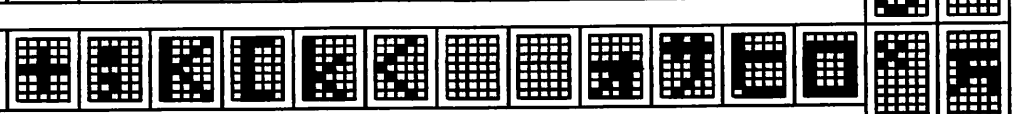
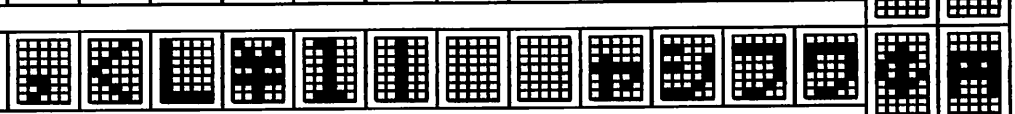
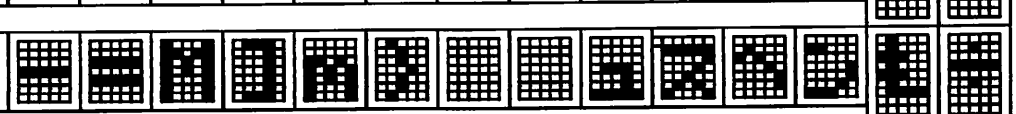
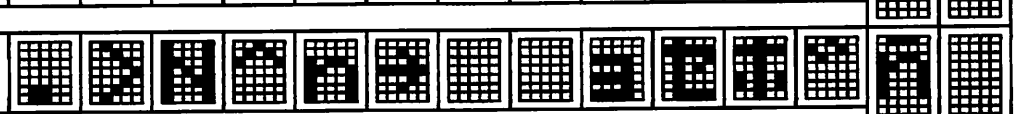
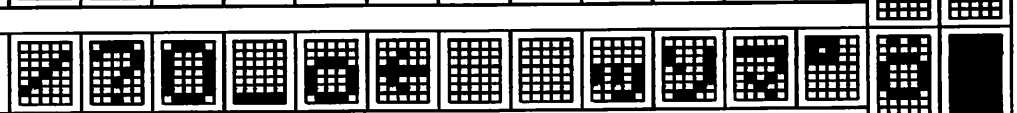
Upper 4 bits / Lower 4 bits	0000	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
XXXX0000	CG RAM (1)														
XXXX0001	(2)														
XXXX0010	(3)														
XXXX0011	(4)														
XXXX0100	(5)														
XXXX0101	(6)														
XXXX0110	(7)														
XXXX0111	(8)														
XXXX1000	(1)														
XXXX1001	(2)														
XXXX1010	(3)														
XXXX1011	(4)														
XXXX1100	(5)														
XXXX1101	(6)														
XXXX1110	(7)														
XXXX1111	(8)														

Table 3 Relation between CG RAM addresses and character codes (DD RAM) and character patterns (CG RAM) (5x7 dot-matrix)

Character Code (DD RAM data)								CG RAM Address						Character Pattern (CG RAM data)							
7	6	5	4	3	2	1	0	5	4	3	2	1	0	7	6	5	4	3	2	1	0
← Upper bit					Lower bit →			← Upper bit			Lower →			← Upper bit			Lower bit →				
0	0	0	0	*	0	0	0	0	0	0	0	0	0	*	*	*	1	1	1	1	0
											0	0	1				1	0	0	0	1
											0	1	0				1	0	0	0	1
											0	1	1				1	1	1	1	0
											1	0	0				1	0	1	0	0
											1	0	1				1	0	0	1	0
											1	1	0				1	0	0	0	1
											1	1	1	*	*	*	0	0	0	0	0
0	0	0	0	*	0	0	1	0	0	1	0	0	0	*	*	*	1	0	0	0	1
											0	0	1				0	1	0	1	0
											0	1	0				1	1	1	1	1
											0	1	1				0	0	1	0	0
											1	0	0				1	1	1	1	1
											1	0	1				0	0	1	0	0
											1	1	0				0	0	1	0	0
											1	1	1	*	*	*	0	0	0	0	0
0	0	0	0	*	1	1	1	1	1	1	0	0	0	*	*	*					
											0	0	1								
											0	1	0								
											1	0	1								
											1	1	0								
											1	1	1	*	*	*					

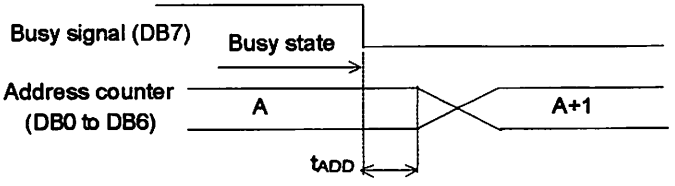
Example of character pattern (R) and (¥)

* : don't care bit

Notes :
- In CG RAM data, "1" corresponds to Selection and "0" to Non-selection on the display.
- Character code bits 0 to 2 and CG RAM address bits 3 to 5 correspond to each other (three bits, eight bytes).
- CG RAM address bits 0 to 2 specify a line position for a character pattern, Line 8 of a character pattern is the cursor position where the logical OR of the cursor and CG RAM data is displayed. Set the data of line 8 to "0" to display the cursor. If the data is changed to "1" , bit 1 lights, regardless of the cursor.
- The character pattern column positions correspond to CG RAM data bits 0 to 4 and bit 4 comes to the left end. CG RAM data bits 5 to 7 are not displayed but can be used as general data RAM.
- When regarding a character pattern from CG RAM, set to "0" all of character code bits 4 to 7. Bits 0 to 2 determine which pattern will be read out. Since bit 3 is not valid, 00H and 08H select the same character.

3. Instruction Outline

When MPU controls LCD controller on the LCD module, MPU directly controls only two registers of the controllers; the Instruction Register (IR) and the Data Register (DR). Prior to internal operation start, the controller temporarily stores control information in these registers, so as to interface with various types of MPUs or peripheral control ICs which operate at different speeds from speed of controller internal operation.
Table 4 shows the instructions and their execution time.
While the controller is executing an instruction and internal operation is in progress, the controller will accept and execute no instruction other than the Busy Flag/Address Read instruction.
Since the busy flag is set to "1" while an instruction is being executed, check the busy flag status and make sure it is "0" before sending an instruction from the MPU to the controller.
To send instructions without checking the busy flag, make sure that the interval between two instructions is much longer than the execution time of the prior instruction.
After the execution of writing/reading data instruction to/from CG/DD RAM, RAM address counter is automatically incremented or decrement by one. This increment/decrement / is executed after the busy flag is set to "0". The time from the fall edge of busy flag to the end of address counter renewal (tADD) is as shown below.



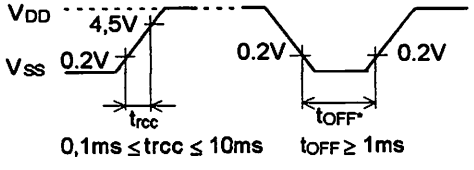
tADD depends on the clock oscillation frequency (fosc)

$t_{ADD} = \frac{1.5\ (s)}{fosc}$

4. Initialization

4.1 Automatic Initialisation

The system is automatically initialised at power-on if the following power supply conditions are satisfied.



tOFF* : Time w hen pow er supply is OFF if cut instantaneously or turned ON and OFF repeatedly

In automatic initialisation, the following instructions are executed.

* Display Clear
* Function Set
  DL = 1 : Interface data length : Eight bits
  N = 0, F = 0 : 1/8 duty, character font : 5 x 7 dot-matrix
* Display ON/OFF control
  D = 0 : Display OFF
  C = 0 : Cursor OFF
  B = 0 : Blink OFF
* Entry Mode Set
  I/D = 1 : Increment
  S = 0 : No display shift

Since some conditions set by initialisation may not be suitable for the LCD module, execute further Function Set instruction.
The busy flag (BF) is kept busy until initialisation ends. The busy state remains for 20ms after VDD reaches to 4.5V.
If the power supply conditions are not satisfied and automatic initialisation is not executed. Execute initialisation using instruction according to section 4.2, "Initialisation by Instruction".

4.2 Initialisation by Instruction

If automatic initialisation is not executed because the power supply conditions are not satisfied, use interface data length of eight bits or four bits instructions shown in table 4 and table 5 to implement initialisation.
Since it is unknown whether the interface data length is set to eight bits or four bits at power on, execute Function Set twice to set the interface data length to eight bits and then set the required interface data length by executing further Function Set instruction.

Table 4 List of Instruction

Instruction	Code										Function	Execution time **
	RS	R/W	DB_7	DB_6	DB_5	DB_4	DB_3	DB_2	DB_1	DB_0		
(1) Display Clear	0	0	0	0	0	0	0	0	0	1	Clears all display and returns cursor to home position (address 0)	1,64 ms
(2) Cursor Home	0	0	0	0	0	0	0	0	1	*	Returns cursor to home position, shifted display returns to home position and DD RAM contents do not change	1,64 ms
(3) Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets direction of cursor movement and w hether display w ill be shifted w hen data is w ritten or read	40 µm
(4) Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Turns ON/OFF total display (D) and cursor (C), and makes cursor position column start blinking (B)	40 µm
(5) Cursor/Display Shift	0	0	0	0	0	1	S/C	R/L	*	*	Moves cursor and shifts display w ithout changing DD RAM contents.	40 µm
(6) Function Set	0	0	0	0	1	DL	N	F	*	*	Sets interface data length (DL), the duty (N), and character fonts (F)	40 µm
(7) CG RAM Address Set	0	0	0	1	A_{CG}						Sets CG RAM address to start transmitting or receiving CG RAM data	40 µm
(8) DD RAM Address Set	0	0	1	A_{DD}							Sets DD RAM address to start transmitting or receiving DD RAM data	40 µm
(9) BF/Address Read	0	1	BF	AC							Reads BF indicating module in internal operation and AC contents (use for both CG RAM and DD RAM)	0 µm
(10) Data Write to CG RAM or DD RAM	0	1	Write Data								Writes data into DD RAM or CG RAM	40 µm t_{ADD}=6µm
(11) Data Read from CG RAM or DD RAM	1	1	Read Data								Reads data from DD RAM or CG RAM	40 µm t_{ADD}=6µm

* : Don't care bit
A_{CG} : CG RAM address
A_{DD} : DD RAM address
AC : Address counter

I/D = 1 : Increment
I/D = 0 : Decrement

S = 1 : Display shift
S = 0 : No display shift

D = 1 : Display ON
D = 0 : Display OFF

C = 1 : Cursor ON
C = 0 : Cursor OFF

B = 1 : Blink ON
B = 0 : Blink OFF

S/C = 1 : Display shift
S/C = 0 : Cursor movement

R/L = 1 : Right shift
R/L = 0 : Left shift:

DL = 1 : 8 bits
DL = 0 : 4 bits

N = 1 : 1/16 duty
N = 0 : 1/8 duty or 1/11 duty

F = 1 : 5 x 10 dot matrix
F = 0 : 5 x 7 dot matrix

BF = 1 : Internal operation in progress
BF = 0 : Instruction can be accepted

** Execution time in the above Table indicated the maximum value w hen fosc is 250KHz. It changes w hen fosc changes.
When fosc = 270 KHz : 40 µs x 250 / 270 = 37 µs

Table 5. Interface Data Length : Eight bits

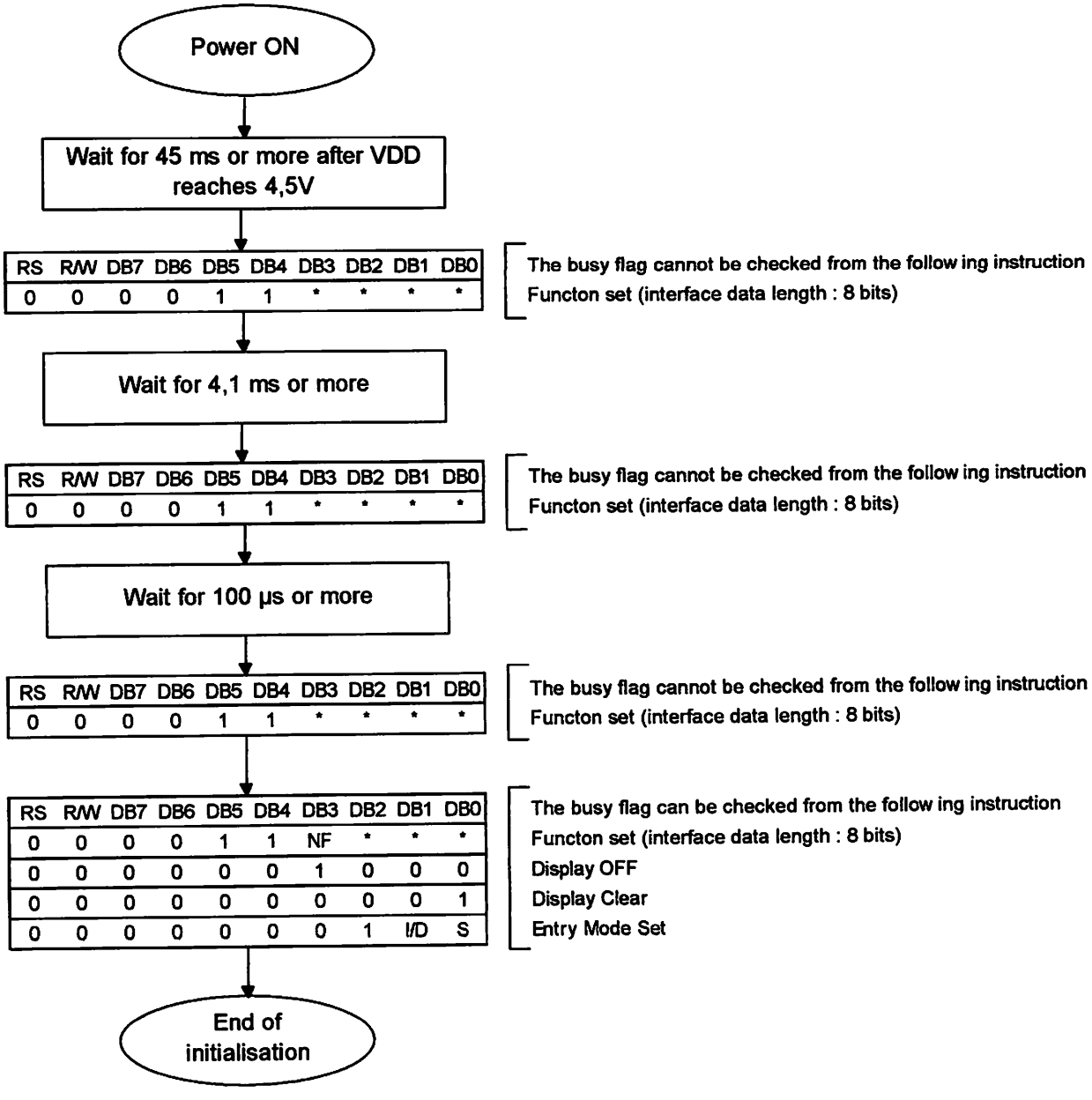
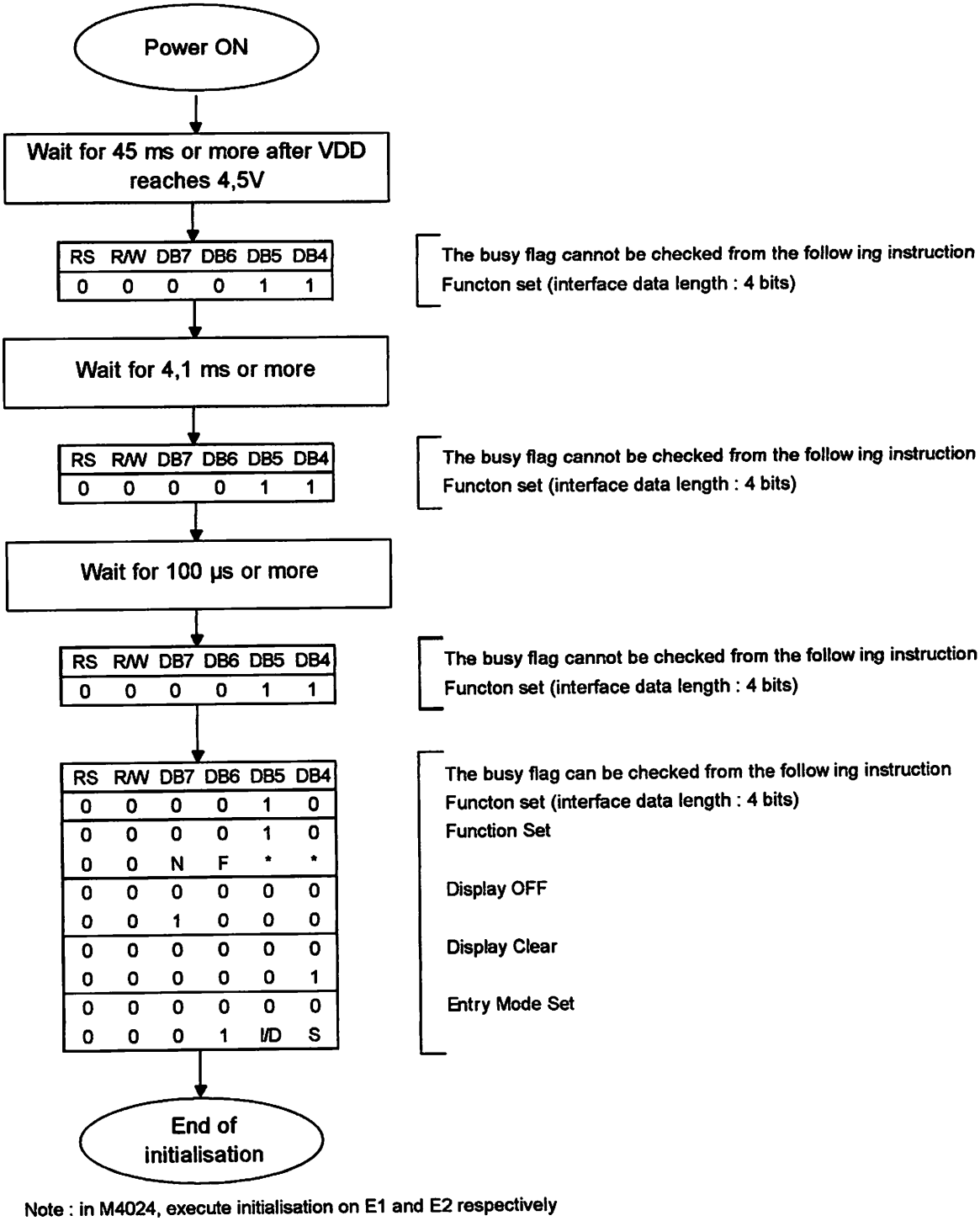


Table 6. Interface Data Length : Four bits



Note : in M4024, execute initialisation on E1 and E2 respectively

5. Instruction Detail

2.5.1 Display Clear

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	0	0	1

isplay CLEAR clears all display and returns cursor to home position (address 0). Space code 20H is written into all the addresses of D RAM, and DD RAM address 0 is set to the AC, if it was shifted, the display returns to the original position. The cursor or blink go to ie left end on line 1, except M4024. In M4024, if the cursor or blink is on line 3 or line 4, it returns to the left end of line 3. After execution f the Display Clear instruction, I/D = 1 (increment) of Entry Mode is set.

2.5.2 Cursor Home

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	0	1	*

URSOR Home returns cursor to home position (address 0). DD RAM address 0 is set to the AC. The display returns to the original osition if it was shifted. The DD RAM contents do not change. If the cursor or blinking is ON, it returns to the left end, except M4024. In I4024, if the cursor or blink on line 3 or line 4, it returns to the left end of line 3.

2.5.3 Entry Mode Set

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	1	I/D	S

NTRY Mode Set sets the direction of cursor movement and determines whether display is shifted.
D :The DD RAM address is incremented or decremnted by one when a character code is written into or read from DD RAM. This is also true for writing into or reading from CG RAM.
When I/D = 1, the address is incremented by one and the cursor or blink moves to the right.
When I/D = 0, the address is decremented by one and the cursor or blink moves to the left.
: If S = 1, the entire display is shifted either to the right or left for writing into DD RAM. The cursor position does not changed only the display moves, There is no display shift for reading form DD RAM.
When S = 1 and I/D = 1, the display shifts one digit to the left after data write to DD RAM.
When S = 1 and I/D = 0, the display shifts one digit to the right after data write to DD RAM.
If S = 0, the display does not shift.

2.5.4 Display ON/OFF Control

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	1	D	C	B

)isplay ON/OFF Control turns the total display and the cursor ON and OFF, and makes the character on the cursor position start linking Cursor ON/OFF and blinking is done at the digit indicated by the DD RAM address specified by the AC
): When D = 1, the display is turned ON
When D = 0, the display is turned OFF
If D = 0 is used, display data remains in DD RAM. Therefore the data can be displayed again by setting D = 1.
: When C = 1, the cursor is displayed
When C = 0, the cursor is not displayed.
The cursor is displayed in the dot line below the character fonts.
: When B = 1, the character at the cursor position starts blinking.
When B = 0, it does not blink.
For blinking, all-black dots and the character are switched about every 0.4 seconds when fosc is 250KHz. The cursor and blinking can be set at the same time.

2.5.5 Cursor/Display Shift

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	1	S/C	R/L	*	*

* : don't care bit

Cursor/Display Shift moves the cursor and shifts the display without changing the DD RAM contents. The cursor position and the AC contents match. This instruction is useful for display correction and retrieval because the cursor position or display can be shifted without writing or reading display data, In a 2-line display, the cursor is shifted from digit 40 (DD RAM address 27) of line 1 to digit 1 of line 2. Displays of lines 1 and 2 are shifted at the same time Display shift moves the display of each line only horizontally. Therefore, the display pattern of line 2 is not shifted to line 1 and display pattern of line 1 is not shifted to line 2.
Note : M1641 operates internally as 8 characters x 2 line display, L1614 as 32 characters x 2 line-display, L2014 as 40 characters x 2 line-display and M4024 as two 40 characters x 2 line-display. See section 2.6 Address Location.

S/C	R/L	Operation
0	0	The cursor position is shifted to the left (the AC is decremented by one)
0	1	The cursor position is shifted to the right (the AC is incremented by one)
1	0	The entire display is shifted to the left w ith the cursor
1	1	The entire display is shifted to the right w ith the cursor

.5.6 Function Set

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	1	DL	N	F	*	*

* : don't care bit

unction Set sets the interface data length, the number of display lines and the character font.
L : Interface data length
When DL = 1, the data length is set at eight bits (DB7 to DB0)
When DL = 0, the data length is set at four bits (DB7 to DB4). In 4-bit interface, the upper four bits are transferred first, then the lower four bits follow.
: When N = 1, the duty is set to 1/16
When N = 0, the duty is set to 1/8 or 1/11
: Character font
When F = 1, the character font is set to 5 x10 dot matrix
When F = 0, the character font is set to 5 x 7 dot matrix.
If N is set to 1, F becomes " Don't care bit"

N	F	Number of display line	Character font	Duty	LCD module
0	0	1	5 x 7	1/8	-
0	1	1	5 x 10	1/11	-
1	*	2	5 x 7	1/16	M1641, M1632, L1642, L1652, L1614, L2012 L2022, L2014, L2432, L4042, M4024

unction Set instruction must be executed prior to all other instructions except Busy Flag/Address Read. If another instruction is xecuted first, no interface data length is effective.

.5.7 CG RAM Address Set

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	1	A	A	A	A	A	A

← Upper bit Lower bit →

CG RAM addresses expressed as binary AAAAAA are set to the AC. The data written from or read to the MPU is for the CG RAM.

.5.8 DD RAM Address Set

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	1	A	A	A	A	A	A	A

← Upper bit Lower bit →

DD RAM address expressed as binary AAAAAA are set to the AC. Then data written from or read to the MPU is for the DD RAM. When N = 0 (one-line display) the addresses are 00H to 4HH. When N=1 (two-line display : M1632, L1642, L1652, L2012, L2022, L2432, L4042), the addresses used for display in line 1 (AAAAAA) are 00H to 27H and those for line 2 (AAAAAA) are 40H to 67H. As for M1641, L1614, L2014 and M4024, see section 2.6 Address Location.

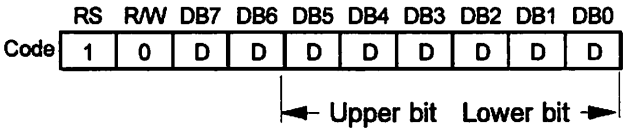
.5.9 Busy Flag/Address Read

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	BF	1	A	A	A	A	A	A

← Upper bit Lower bit →

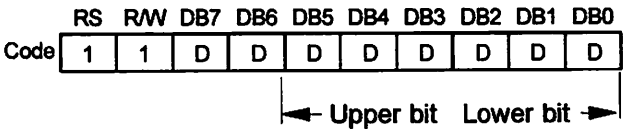
The BF signal is read out, indicating whether the module is working internally because of the previous instruction.
When BF = 1, the module is working internally and the next instruction cannot be accepted until the BF value becomes 0.
When BF = 0, the next instruction can be accepted, Therefore, make sure that BF = 0 before writing the next instruction.
The AC values binary AAAAAA are read out at the same time as the busy flag read. The AC addresses are used for both CG RAM and DD RAM, and the Address Set before the execution of this instruction determines whether the address is for CF RAM or DD RAM.

.5.10 Data Write to CG RAM or DD RAM



inary eight-bit data DDDDDDDD is written into CG RAM or DD RAM. CG RAM Address Set or DD RAM Address Set before this struction selects either RAM. After the write operation, the address is incremented or decremented automatically according to Entry lode Set. Entry Mode Set also determines whether display shifts or not after the write operation.

5.11 Data Read from CG RAM or DD RAM



ıary eight-bit data DDDDDDDD is read from CG RAM or from DD RAM. CG RAM Address Set or the DD RAM Address Set before this ıtruction selects either RAM. CG RAM Address Set or the DD RAM Address Set must be executed immediately before this instruction. ıo Address Set instruction is executed before a read instruction, the first read data is invalid. Data is normally read from the second ıe, if read instructions are executed consecutively. For DD RAM, if Cursor Shift instruction is executed just before reading DD RAM< ıre is no need to execute an Address set instruction because the Cursor Shift instruction does this.
ıer a read operation, the address is automatically incremented or decremented by one according to Entry Mode Set, but the display ı't shifted regardless of Entry Mode set.

ıte : The AC is automatically incremented or deremented by one according to Entry Mode Set after Data Write to CG RAM or DD RAM ıtruction is executed. If a read instruction is executed immediately after this instruction, RAM data specified by the AC is not read out. ırrect data is read out under the following conditions.

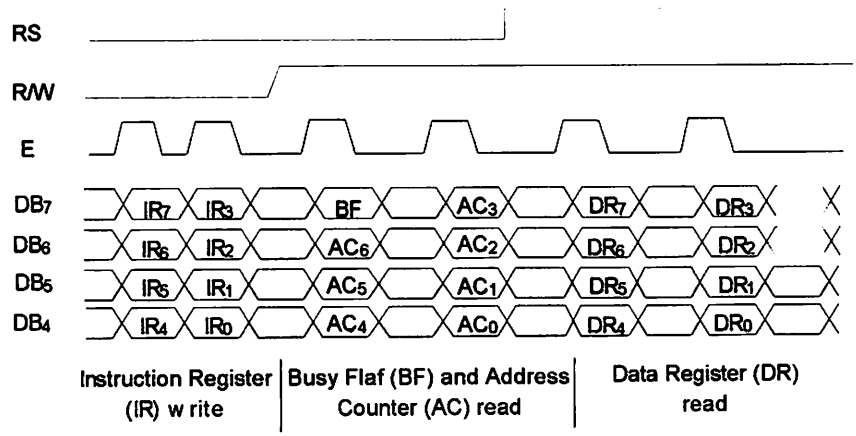
An Address Set instruction is executed immediately before a read instruction
For DD RAM. the Cursor Shift instruction is executed immediately before a read instruction
The second, or later, instruction is executed in consecutive execution of read instructions

5. Interfacing to MPU

LCD modules containing controller can interface to both 4-bit and 8-bit MPU

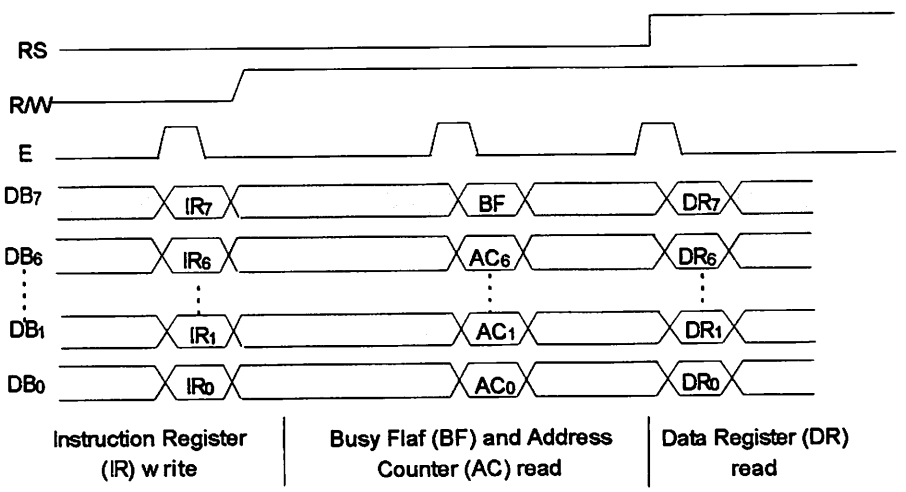
5.1 Interface in 4-bit operation

When interface data is 4 bits long, data is transferred using only four buses; DB_4 to DB_0. DB_0 to DB_3 are not used. Data transfer between the controller and the MPU ends when 4-bit data is transferred twice. Data of the higher order 4 bits (contents of DB_4 to DB_7 when interface data is 8 bits long) are transferred first, then lower order 4 bits (content of DB_0 to DB_3 when interface data is 8 bits long) are transferred. Check the busy flag after 4-bit data has been transferred twice. Then the busy flag and address counter data are read out by two transfers.



5.2 Interface in 8-bit operation

When interface data is 8 bits long, data is transferred using the 8 data buses of DB_0 to DB_7.



tures

- mpatible with MCS-51® Products
- Bytes of In-System Programmable (ISP) Flash Memory
  - Endurance: 1000 Write/Erase Cycles
- V to 5.5V Operating Range
- ly Static Operation: 0 Hz to 33 MHz
- ree-level Program Memory Lock
- 3 x 8-bit Internal RAM
- Programmable I/O Lines
- o 16-bit Timer/Counters
- Interrupt Sources
- ll Duplex UART Serial Channel
- w-power Idle and Power-down Modes
- errupt Recovery from Power-down Mode
- tchdog Timer
- al Data Pointer
- wer-off Flag
- st Programming Time
- xible ISP Programming (Byte and Page Mode)

scription

AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4K s of in-system programmable Flash memory. The device is manufactured using el's high-density nonvolatile memory technology and is compatible with the indus- tandard 80C51 instruction set and pinout. The on-chip Flash allows the program nory to be reprogrammed in-system or by a conventional nonvolatile memory pro- mmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a olithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a y-flexible and cost-effective solution to many embedded control applications.

AT89S51 provides the following standard features: 4K bytes of Flash, 128 bytes of M, 32 I/O lines, Watchdog timer, two data pointers, two 16-bit timer/counters, a five- or two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and k circuitry. In addition, the AT89S51 is designed with static logic for operation n to zero frequency and supports two software selectable power saving modes. Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and rupt system to continue functioning. The Power-down mode saves the RAM con- s but freezes the oscillator, disabling all other chip functions until the next external rupt or hardware reset.

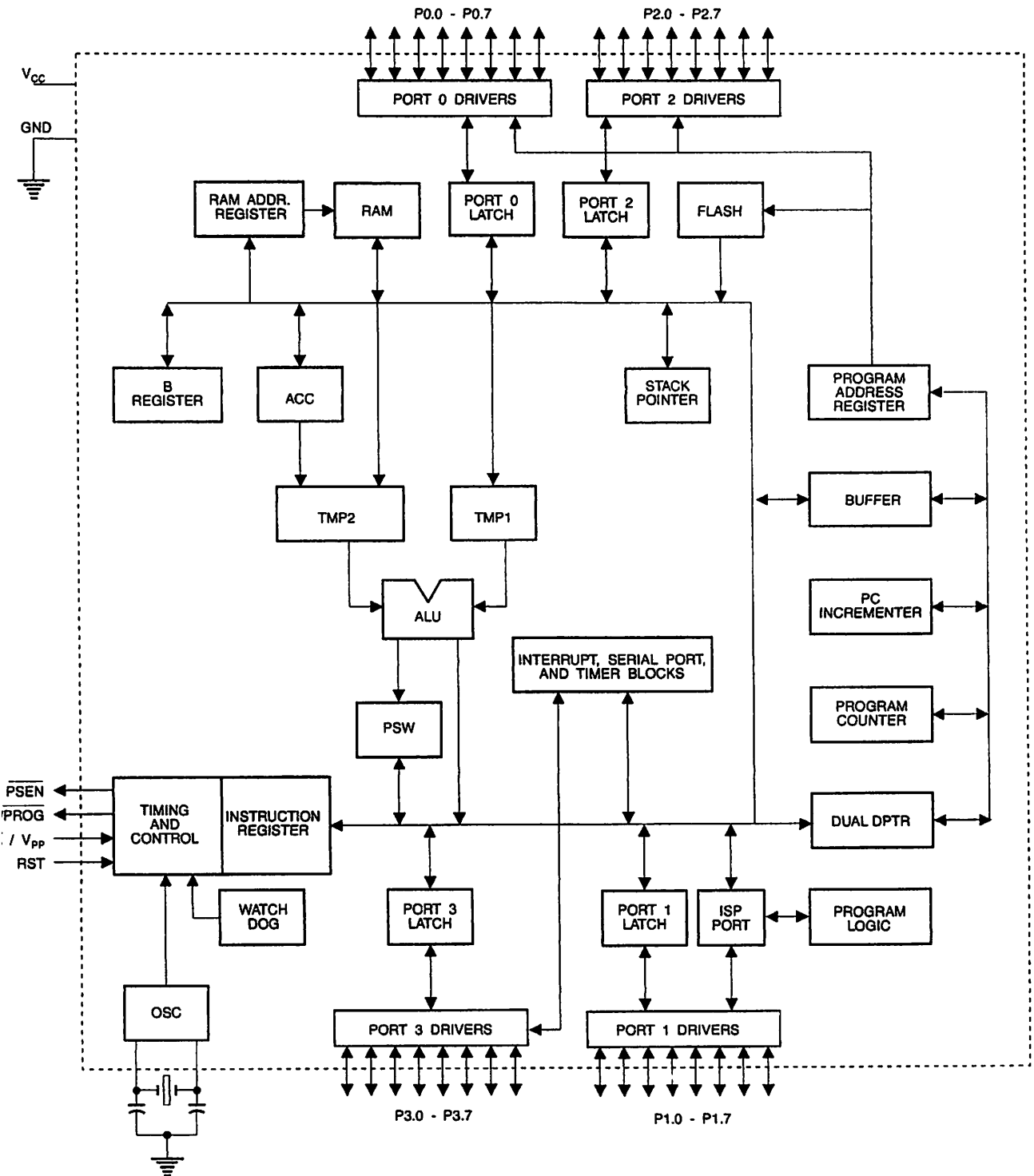
8-bit Microcontroller with 4K Bytes In-System Programmable Flash

AT89S51

Preliminary

Rev. 2487A–10/01

ck Diagram


P0.0 - P0.7
P2.0 - P2.7
V_{CC}
GND
PORT 0 DRIVERS
PORT 2 DRIVERS
RAM ADDR. REGISTER
RAM
PORT 0 LATCH
PORT 2 LATCH
FLASH
B REGISTER
ACC
STACK POINTER
PROGRAM ADDRESS REGISTER
BUFFER
TMP2
TMP1
ALU
PC INCREMENTER
INTERRUPT, SERIAL PORT, AND TIMER BLOCKS
PROGRAM COUNTER
PSW
PSEN
PROG
/ V_{PP}
RST
TIMING AND CONTROL
INSTRUCTION REGISTER
DUAL DPTR
WATCH DOG
PORT 3 LATCH
PORT 1 LATCH
ISP PORT
PROGRAM LOGIC
OSC
PORT 3 DRIVERS
PORT 1 DRIVERS
P3.0 - P3.7
P1.0 - P1.7

;olute Maximum Ratings*

rating Temperature	-55°C to +125°C
ıge Temperature	-65°C to +150°C
ıge on Any Pin Respect to Ground	-1.0V to +7.0V
mum Operating Voltage	6.6V
Output Current	15.0 mA

*NOTICE: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Characteristics

alues shown in this table are valid for T_A = -40°C to 85°C and V_{CC} = 4.0V to 5.5V, unless otherwise noted.

bol	Parameter	Condition	Min	Max	Units
	Input Low Voltage	(Except $\overline{EA}$)	-0.5	0.2 V_{CC}-0.1	V
	Input Low Voltage ($\overline{EA}$)		-0.5	0.2 V_{CC}-0.3	V
	Input High Voltage	(Except XTAL1, RST)	0.2 V_{CC}+0.9	V_{CC}+0.5	V
	Input High Voltage	(XTAL1, RST)	0.7 V_{CC}	V_{CC}+0.5	V
	Output Low Voltage[1] (Ports 1,2,3)	I_{OL} = 1.6 mA		0.45	V
	Output Low Voltage[1] (Port 0, ALE, $\overline{PSEN}$)	I_{OL} = 3.2 mA		0.45	V
	Output High Voltage (Ports 1,2,3, ALE, $\overline{PSEN}$)	I_{OH} = -60 µA, V_{CC} = 5V ± 10%	2.4		V
		I_{OH} = -25 µA	0.75 V_{CC}		V
		I_{OH} = -10 µA	0.9 V_{CC}		V
	Output High Voltage (Port 0 in External Bus Mode)	I_{OH} = -800 µA, V_{CC} = 5V ± 10%	2.4		V
		I_{OH} = -300 µA	0.75 V_{CC}		V
		I_{OH} = -80 µA	0.9 V_{CC}		V
	Logical 0 Input Current (Ports 1,2,3)	V_{IN} = 0.45V		-50	µA
	Logical 1 to 0 Transition Current (Ports 1,2,3)	V_{IN} = 2V, V_{CC} = 5V ± 10%		-650	µA
	Input Leakage Current (Port 0, $\overline{EA}$)	0.45 < V_{IN} < V_{CC}		±10	µA
ST	Reset Pulldown Resistor		50	300	KΩ
	Pin Capacitance	Test Freq. = 1 MHz, T_A = 25°C		10	pF
	Power Supply Current	Active Mode, 12 MHz		25	mA
		Idle Mode, 12 MHz		6.5	mA
	Power-down Mode[2]	V_{CC} = 5.5V		50	µA

:
1. Under steady state (non-transient) conditions, I_{OL} must be externally limited as follows:
   Maximum I_{OL} per port pin: 10 mA
   Maximum I_{OL} per 8-bit port:
   Port 0: 26 mA Ports 1, 2, 3: 15 mA
   Maximum total I_{OL} for all output pins: 71 mA
   If I_{OL} exceeds the test condition, V_{OL} may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test conditions.
2. Minimum V_{CC} for Power-down is 2V.

Description

Supply voltage.

Ground.

0

Port 0 is an 8-bit open drain bidirectional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance inputs.

Port 0 can also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode, P0 has internal pull-ups.

Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification. **External pull-ups are required during program verification.**

1

Port 1 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (I_{IL}) because of the internal pull-ups.

Port 1 also receives the low-order address bytes during Flash programming and verification.

Port Pin	Alternate Functions
P1.5	MOSI (used for In-System Programming)
P1.6	MISO (used for In-System Programming)
P1.7	SCK (used for In-System Programming)

t 2

Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (I_{IL}) because of the internal pull-ups.

Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @ DPTR). In this application, Port 2 uses strong internal pull-ups when emitting 1s. During accesses to external data memory that use 8-bit addresses (MOVX @ RI), Port 2 emits the contents of the P2 Special Function Register.

Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

t 3

Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (I_{IL}) because of the pull-ups.

Port 3 receives some control signals for Flash programming and verification.

Port 3 also serves the functions of various special features of the AT89S51, as shown in the following table.

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{INT0}$ (external interrupt 0)
P3.3	$\overline{INT1}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{WR}$ (external data memory write strobe)
P3.7	$\overline{RD}$ (external data memory read strobe)

Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device. This pin drives High for 98 oscillator periods after the Watchdog times out. The DISRTO bit in SFR AUXR (address 8EH) can be used to disable this feature. In the default state of bit DISRTO, the RESET HIGH out feature is enabled.

:/$\overline{PROG}$

Address Latch Enable (ALE) is an output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input ($\overline{PROG}$) during Flash programming.

In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory.

If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

$\overline{EN}$

Program Store Enable ($\overline{PSEN}$) is the read strobe to external program memory.

When the AT89S51 is executing code from external program memory, $\overline{PSEN}$ is activated twice each machine cycle, except that two $\overline{PSEN}$ activations are skipped during each access to external data memory.

/VPP

External Access Enable. $\overline{EA}$ must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, $\overline{EA}$ will be internally latched on reset.

$\overline{EA}$ should be strapped to V_{CC} for internal program executions.

This pin also receives the 12-volt programming enable voltage (V_{PP}) during Flash programming.

'AL1

Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

'AL2

Output from the inverting oscillator amplifier

should be serviced in those sections of code that will periodically be executed within the time required to prevent a WDT reset.

T During ver-down l Idle

In Power-down mode the oscillator stops, which means the WDT also stops. While in Power-down mode, the user does not need to service the WDT. There are two methods of exiting Power-down mode: by a hardware reset or via a level-activated external interrupt, which is enabled prior to entering Power-down mode. When Power-down is exited with hardware reset, servicing the WDT should occur as it normally does whenever the AT89S51 is reset. Exiting Power-down with an interrupt is significantly different. The interrupt is held low long enough for the oscillator to stabilize. When the interrupt is brought high, the interrupt is serviced. To prevent the WDT from resetting the device while the interrupt pin is held low, the WDT is not started until the interrupt is pulled high. It is suggested that the WDT be reset during the interrupt service for the interrupt used to exit Power-down mode.

To ensure that the WDT does not overflow within a few states of exiting Power-down, it is best to reset the WDT just before entering Power-down mode.

Before going into the IDLE mode, the WDIDLE bit in SFR AUXR is used to determine whether the WDT continues to count if enabled. The WDT keeps counting during IDLE (WDIDLE bit = 0) as the default state. To prevent the WDT from resetting the AT89S51 while in IDLE mode, the user should always set up a timer that will periodically exit IDLE, service the WDT, and reenter IDLE mode.

With WDIDLE bit enabled, the WDT will stop to count in IDLE mode and resumes the count upon exit from IDLE.

RT

The UART in the AT89S51 operates the same way as the UART in the AT89C51. For further information on the UART operation, refer to the ATMEL Web site (http://www.atmel.com). From the home page, select 'Products', then '8051-Architecture Flash Microcontroller', then 'Product Overview'.

ner 0 and 1

Timer 0 and Timer 1 in the AT89S51 operate the same way as Timer 0 and Timer 1 in the AT89C51. For further information on the timers' operation, refer to the ATMEL Web site (http://www.atmel.com). From the home page, select 'Products', then '8051-Architecture Flash Microcontroller', then 'Product Overview'.

errupts

The AT89S51 has a total of five interrupt vectors: two external interrupts ($\overline{INT0}$ and $\overline{INT1}$), two timer interrupts (Timers 0 and 1), and the serial port interrupt. These interrupts are all shown in Figure 1.

Each of these interrupt sources can be individually enabled or disabled by setting or clearing a bit in Special Function Register IE. IE also contains a global disable bit, EA, which disables all interrupts at once.

Note that Table 4 shows that bit position IE.6 is unimplemented. In the AT89S51, bit position IE.5 is also unimplemented. User software should not write 1s to these bit positions, since they may be used in future AT89 products.

The Timer 0 and Timer 1 flags, TF0 and TF1, are set at S5P2 of the cycle in which the timers overflow. The values are then polled by the circuitry in the next cycle

82C55A
CHMOS PROGRAMMABLE PERIPHERAL INTERFACE

- **Compatible with all Intel and Most Other Microprocessors**
- **High Speed, "Zero Wait State" Operation with 8 MHz 8086/88 and 80186/188**
- **24 Programmable I/O Pins**
- **Low Power CHMOS**
- **Completely TTL Compatible**
- **Control Word Read-Back Capability**
- **Direct Bit Set/Reset Capability**
- **2.5 mA DC Drive Capability on all I/O Port Outputs**
- **Available in 40-Pin DIP and 44-Pin PLCC**
- **Available in EXPRESS**
  - **—Standard Temperature Range**
  - **—Extended Temperature Range**

The Intel 82C55A is a high-performance, CHMOS version of the industry standard 8255A general purpose programmable I/O device which is designed for use with all Intel and most other microprocessors. It provides 24 I/O pins which may be individually programmed in 2 groups of 12 and used in 3 major modes of operation. The 82C55A is pin compatible with the NMOS 8255A and 8255A-5.

In MODE 0, each group of 12 I/O pins may be programmed in sets of 4 and 8 to be inputs or outputs. In MODE 1, each group may be programmed to have 8 lines of input or output. 3 of the remaining 4 pins are used for handshaking and interrupt control signals. MODE 2 is a strobed bi-directional bus configuration.

The 82C55A is fabricated on Intel's advanced CHMOS III technology which provides low power consumption with performance equal to or greater than the equivalent NMOS product. The 82C55A is available in 40-pin DIP and 44-pin plastic leaded chip carrier (PLCC) packages.

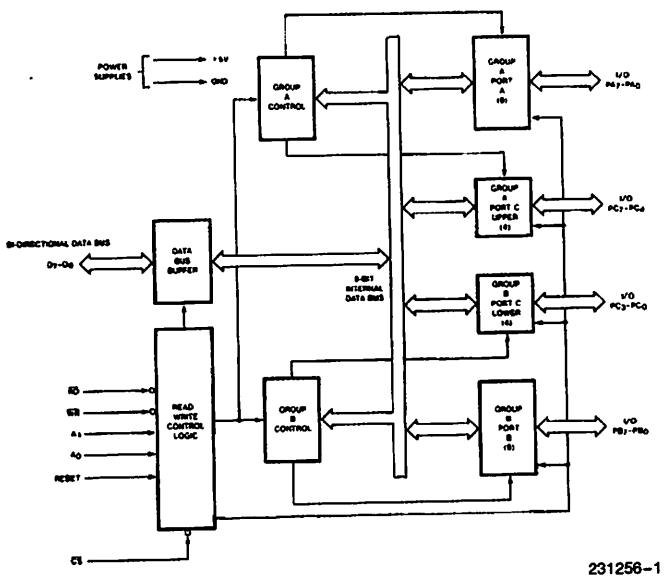
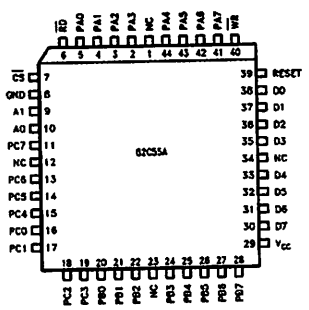


Figure 1. 82C55A Block Diagram



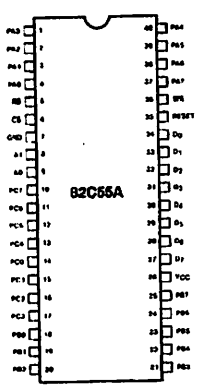


Figure 2. 82C55A Pinout
Diagrams are for pin reference only. Package sizes are not to scale.

Table 1. Pin Description

Symbol	Pin Number Dip	Pin Number PLCC	Type	Name and Function
PA_{3-0}	1–4	2–5	I/O	**PORT A, PINS 0–3:** Lower nibble of an 8-bit data output latch/ buffer and an 8-bit data input latch.
$\overline{RD}$	5	6	I	**READ CONTROL:** This input is low during CPU read operations.
$\overline{CS}$	6	7	I	**CHIP SELECT:** A low on this input enables the 82C55A to respond to $\overline{RD}$ and $\overline{WR}$ signals. $\overline{RD}$ and WR are ignored otherwise.
GND	7	8		**System Ground**
A_{1-0}	8–9	9–10	I	**ADDRESS:** These input signals, in conjunction $\overline{RD}$ and $\overline{WR}$, control the selection of one of the three ports or the control word registers.

A_1	A_0	$\overline{RD}$	$\overline{WR}$	$\overline{CS}$	Input Operation (Read)
0	0	0	1	0	Port A - Data Bus
0	1	0	1	0	Port B - Data Bus
1	0	0	1	0	Port C - Data Bus
1	1	0	1	0	Control Word - Data Bus
					Output Operation (Write)
0	0	1	0	0	Data Bus - Port A
0	1	1	0	0	Data Bus - Port B
1	0	1	0	0	Data Bus - Port C
1	1	1	0	0	Data Bus - Control
					Disable Function
X	X	X	X	1	Data Bus - 3 - State
X	X	1	1	0	Data Bus - 3 - State

PC_{7-4}	10–13	11,13–15	I/O	**PORT C, PINS 4–7:** Upper nibble of an 8-bit data output latch/ buffer and an 8-bit data input buffer (no latch for input). This port can be divided into two 4-bit ports under the mode control. Each 4-bit port contains a 4-bit latch and it can be used for the control signal outputs and status signal inputs in conjunction with ports A and B.
PC_{0-3}	14–17	16–19	I/O	**PORT C, PINS 0–3:** Lower nibble of Port C.
PB_{0-7}	18–25	20–22, 24–28	I/O	**PORT B, PINS 0–7:** An 8-bit data output latch/buffer and an 8-bit data input buffer.
V_{CC}	26	29		**SYSTEM POWER:** + 5V Power Supply.
D_{7-0}	27–34	30–33, 35–38	I/O	**DATA BUS:** Bi-directional, tri-state data bus lines, connected to system data bus.
RESET	35	39	I	**RESET:** A high on this input clears the control register and all ports are set to the input mode.
$\overline{WR}$	36	40	I	**WRITE CONTROL:** This input is low during CPU write operations.
PA_{7-4}	37–40	41–44	I/O	**PORT A, PINS 4–7:** Upper nibble of an 8-bit data output latch/ buffer and an 8-bit data input latch.
NC		1, 12, 23, 34		No Connect

82C55A FUNCTIONAL DESCRIPTION

General

The 82C55A is a programmable peripheral interface device designed for use in Intel microcomputer systems. Its function is that of a general purpose I/O component to interface peripheral equipment to the microcomputer system bus. The functional configuration of the 82C55A is programmed by the system software so that normally no external logic is necessary to interface peripheral devices or structures.

Data Bus Buffer

This 3-state bidirectional 8-bit buffer is used to interface the 82C55A to the system data bus. Data is transmitted or received by the buffer upon execution of input or output instructions by the CPU. Control words and status information are also transferred through the data bus buffer.

Read/Write and Control Logic

The function of this block is to manage all of the internal and external transfers of both Data and Control or Status words. It accepts inputs from the CPU Address and Control busses and in turn, issues commands to both of the Control Groups.

Group A and Group B Controls

The functional configuration of each port is programmed by the systems software. In essence, the CPU "outputs" a control word to the 82C55A. The control word contains information such as "mode", "bit set", "bit reset", etc., that initializes the functional configuration of the 82C55A.

Each of the Control blocks (Group A and Group B) accepts "commands" from the Read/Write Control Logic, receives "control words" from the internal data bus and issues the proper commands to its associated ports.

Control Group A - Port A and Port C upper (C7–C4)
Control Group B - Port B and Port C lower (C3–C0)

The control word register can be both written and read as shown in the address decode table in the pin descriptions. Figure 6 shows the control word format for both Read and Write operations. When the control word is read, bit D7 will always be a logic "1", as this implies control word mode information.

Ports A, B, and C

The 82C55A contains three 8-bit ports (A, B, and C). All can be configured in a wide variety of functional characteristics by the system software but each has its own special features or "personality" to further enhance the power and flexibility of the 82C55A.

Port A. One 8-bit data output latch/buffer and one 8-bit input latch buffer. Both "pull-up" and "pull-down" bus hold devices are present on Port A.

Port B. One 8-bit data input/output latch/buffer. Only "pull-up" bus hold devices are present on Port B.

Port C. One 8-bit data output latch/buffer and one 8-bit data input buffer (no latch for input). This port can be divided into two 4-bit ports under the mode control. Each 4-bit port contains a 4-bit latch and it can be used for the control signal outputs and status signal inputs in conjunction with ports A and B. Only "pull-up" bus hold devices are present on Port C.

See Figure 4 for the bus-hold circuit configuration for Port A, B, and C.

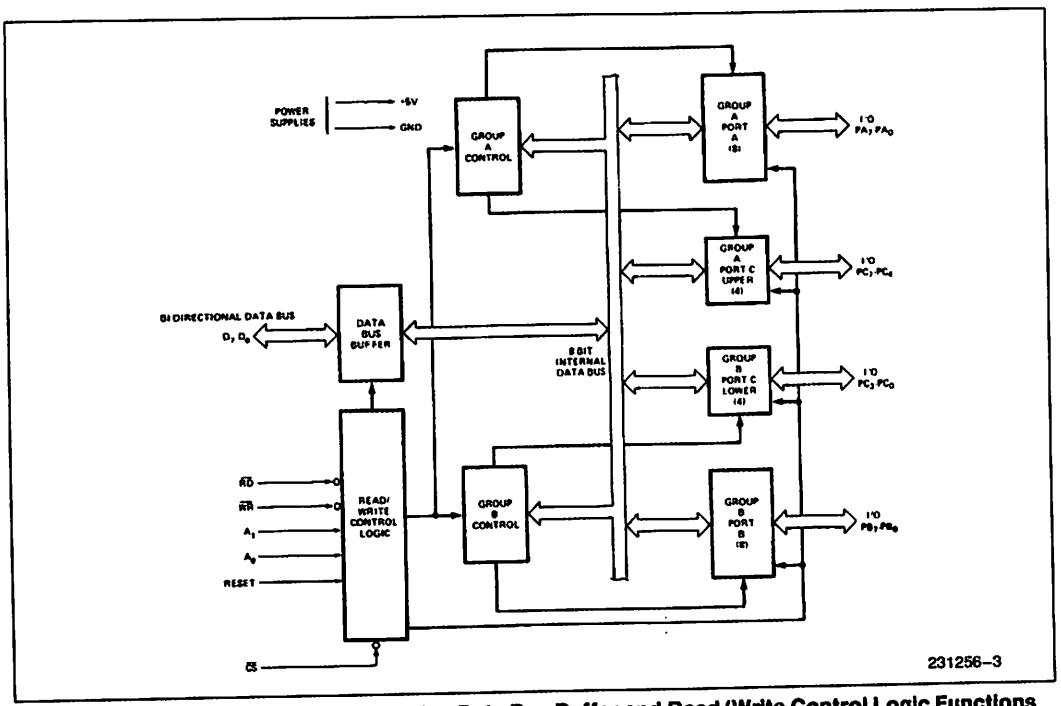
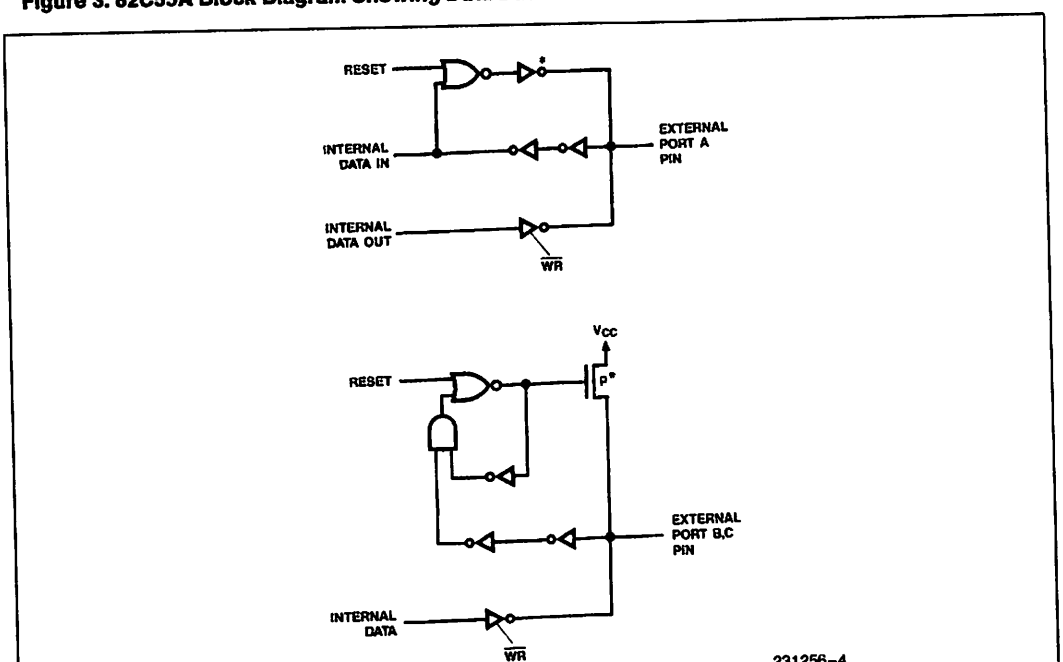


Figure 3. 82C55A Block Diagram Showing Data Bus Buffer and Read/Write Control Logic Functions



***NOTE:**
Port pins loaded with more than 20 pF capacitance may not have their logic level guaranteed following a hardware reset.

Figure 4. Port A, B, C, Bus-hold Configuration

82C55A OPERATIONAL DESCRIPTION

Mode Selection

There are three basic modes of operation that can be selected by the system software:

Mode 0 — Basic input/output
Mode 1 — Strobed Input/output
Mode 2 — Bi-directional Bus

When the reset input goes "high" all ports will be set to the input mode with all 24 port lines held at a logic "one" level by the internal bus hold devices (see Figure 4 Note). After the reset is removed the 82C55A can remain in the input mode with no additional initialization required. This eliminates the need for pullup or pulldown devices in "all CMOS" designs. During the execution of the system program, any of the other modes may be selected by using a single output instruction. This allows a single 82C55A to service a variety of peripheral devices with a simple software maintenance routine.

The modes for Port A and Port B can be separately defined, while Port C is divided into two portions as required by the Port A and Port B definitions. All of the output registers, including the status flip-flops, will be reset whenever the mode is changed. Modes may be combined so that their functional definition can be "tailored" to almost any I/O structure. For instance; Group B can be programmed in Mode 0 to monitor simple switch closings or display computational results, Group A could be programmed in Mode 1 to monitor a keyboard or tape reader on an interrupt-driven basis.

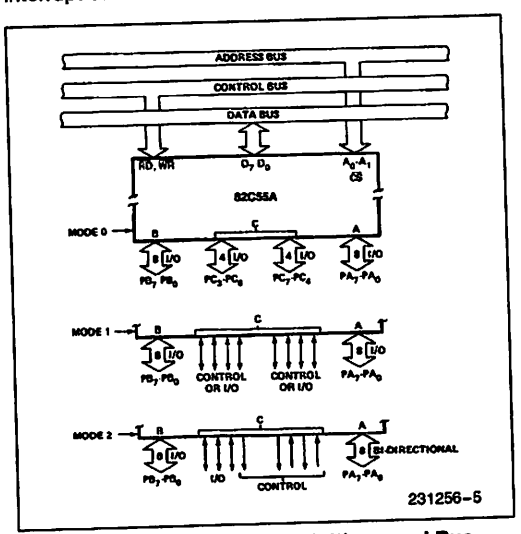


Figure 5. Basic Mode Definitions and Bus Interface

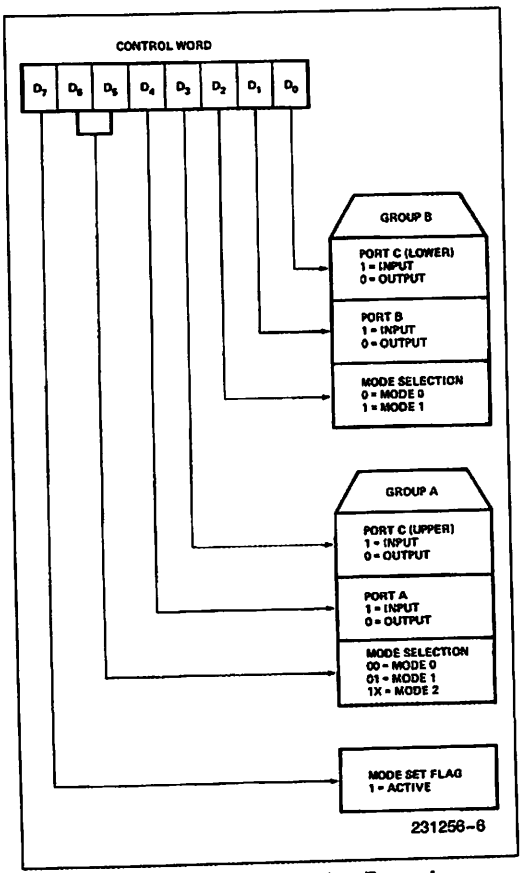


Figure 6. Mode Definition Format

The mode definitions and possible mode combinations may seem confusing at first but after a cursory review of the complete device operation a simple, logical I/O approach will surface. The design of the 82C55A has taken into account things such as efficient PC board layout, control signal definition vs PC layout and complete functional flexibility to support almost any peripheral device with no external logic. Such design represents the maximum use of the available pins.

Single Bit Set/Reset Feature

Any of the eight bits of Port C can be Set or Reset using a single OUTput instruction. This feature reduces software requirements in Control-based applications.

When Port C is being used as status/control for Port A or B, these bits can be set or reset by using the Bit Set/Reset operation just as if they were data output ports.

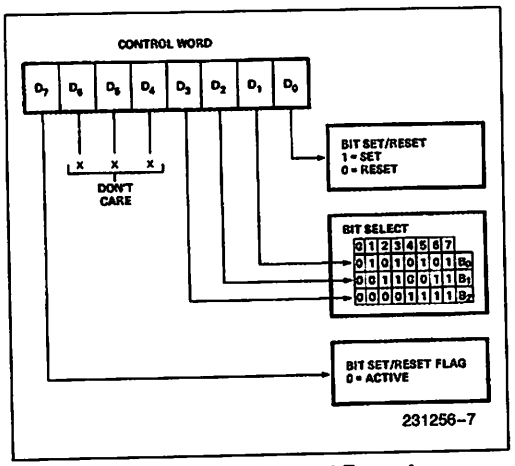


Figure 7. Bit Set/Reset Format

Interrupt Control Functions

When the 82C55A is programmed to operate in mode 1 or mode 2, control signals are provided that can be used as interrupt request inputs to the CPU. The interrupt request signals, generated from port C, can be inhibited or enabled by setting or resetting the associated INTE flip-flop, using the bit set/reset function of port C.

This function allows the Programmer to disallow or allow a specific I/O device to interrupt the CPU without affecting any other device in the interrupt structure.

INTE flip-flop definition:

(BIT-SET)—INTE is SET—Interrupt enable
(BIT-RESET)—INTE is RESET—Interrupt disable

Note:
All Mask flip-flops are automatically reset during mode selection and device Reset.

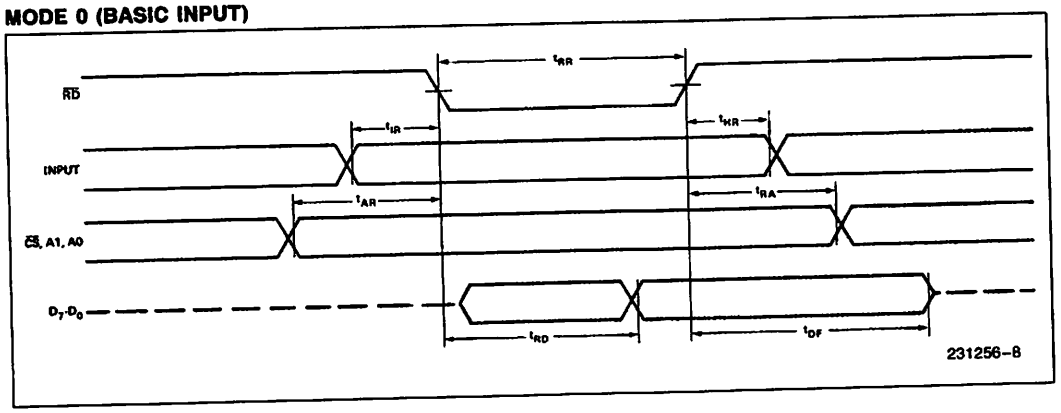
Operating Modes

Mode 0 (Basic Input/Output). This functional configuration provides simple input and output operations for each of the three ports. No "handshaking" is required, data is simply written to or read from a specified port.

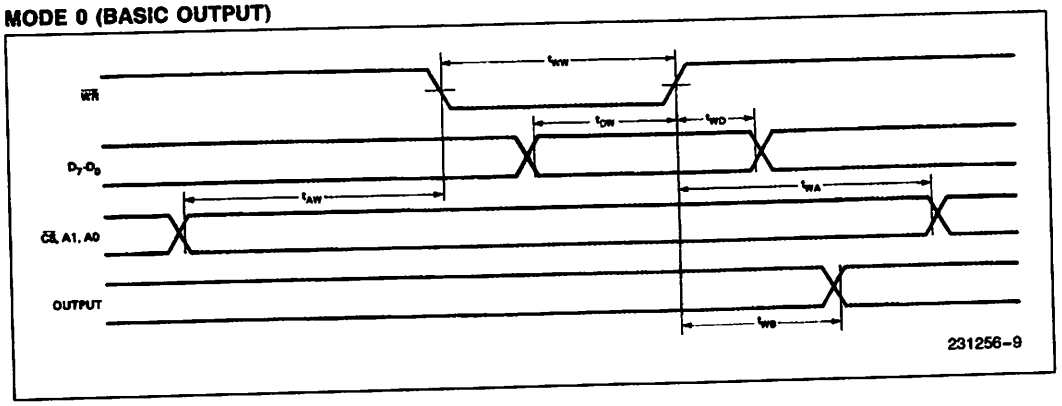
Mode 0 Basic Functional Definitions:

- Two 8-bit ports and two 4-bit ports.
- Any port can be input or output.
- Outputs are latched.
- Inputs are not latched.
- 16 different Input/Output configurations are possible in this Mode.

MODE 0 (BASIC INPUT)



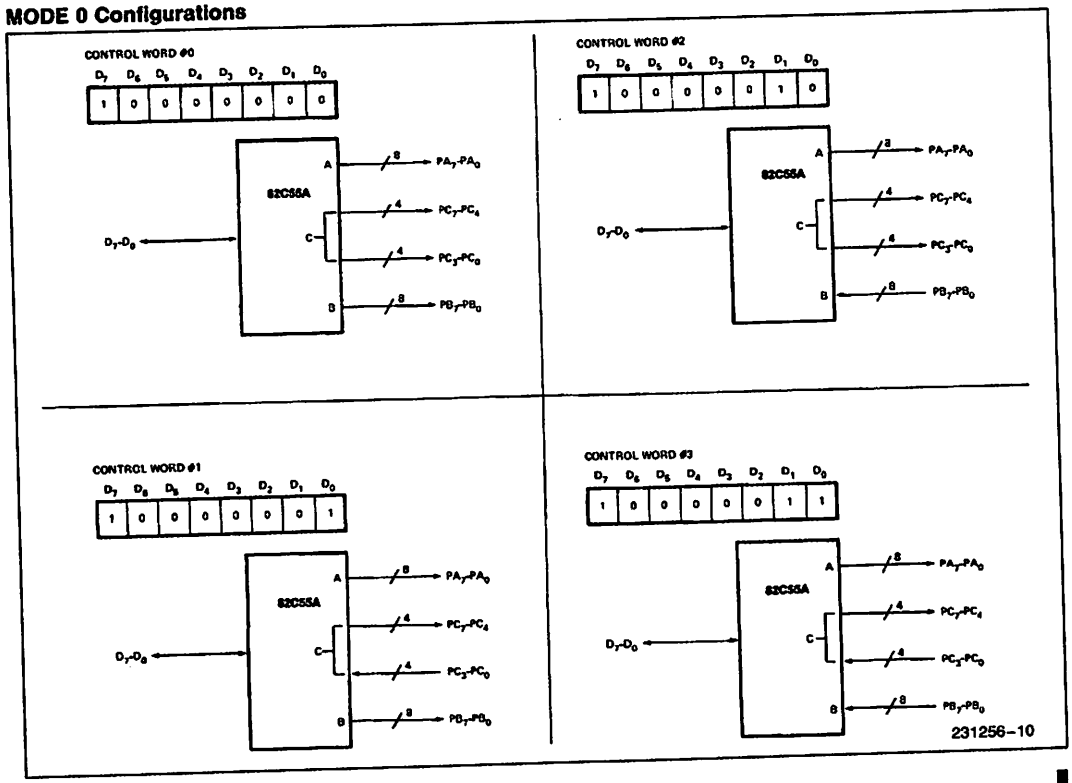
MODE 0 (BASIC OUTPUT)



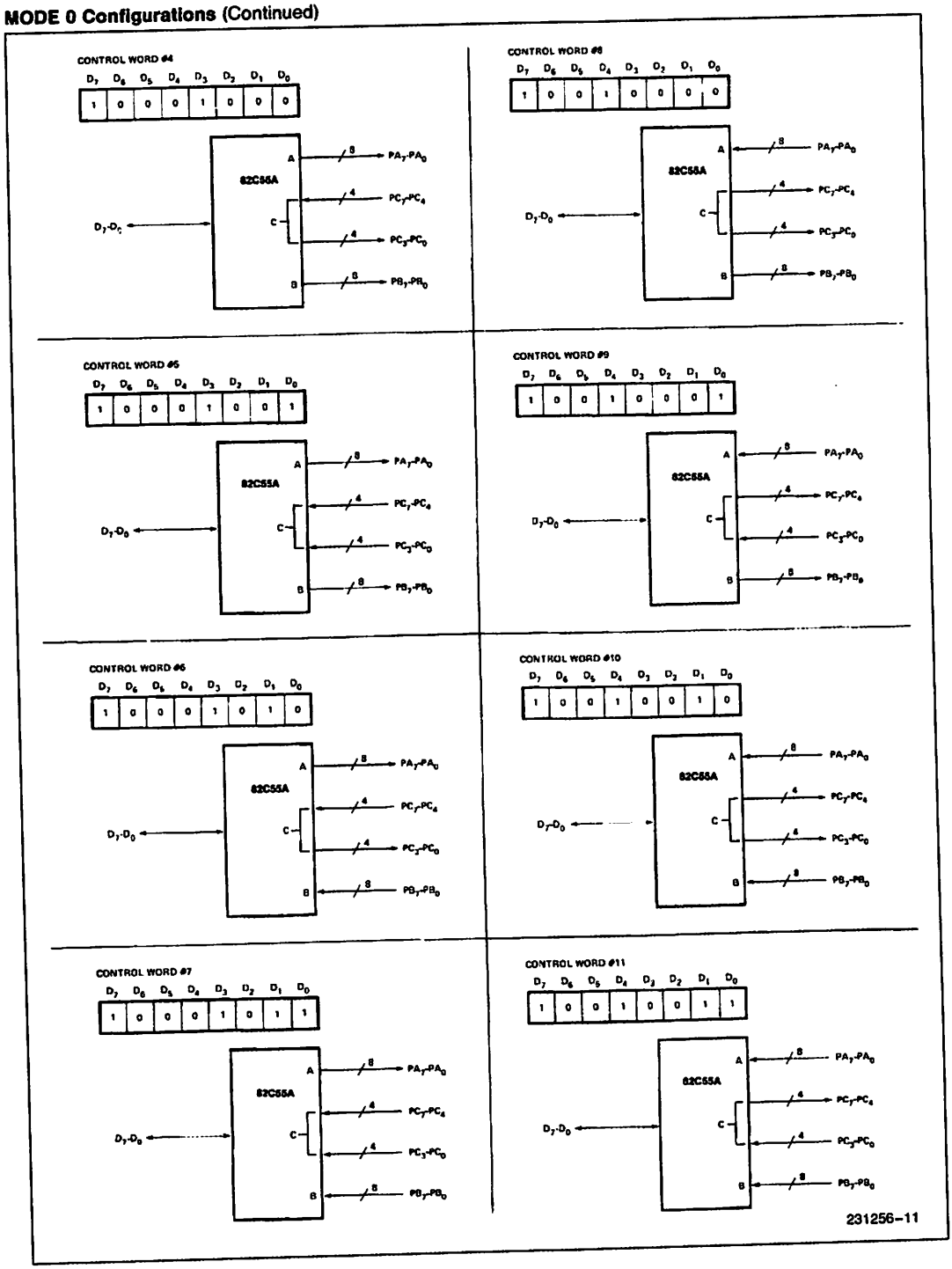
MODE 0 Port Definition

A		B		GROUP A			GROUP B	
D_4	D_3	D_1	D_0	PORT A	PORT C (UPPER)	#	PORT B	PORT C (LOWER)
0	0	0	0	OUTPUT	OUTPUT	0	OUTPUT	OUTPUT
0	0	0	1	OUTPUT	OUTPUT	1	OUTPUT	INPUT
0	0	1	0	OUTPUT	OUTPUT	2	INPUT	OUTPUT
0	0	1	1	OUTPUT	OUTPUT	3	INPUT	INPUT
0	1	0	0	OUTPUT	INPUT	4	OUTPUT	OUTPUT
0	1	0	1	OUTPUT	INPUT	5	OUTPUT	INPUT
0	1	1	0	OUTPUT	INPUT	6	INPUT	OUTPUT
0	1	1	1	OUTPUT	INPUT	7	INPUT	INPUT
1	0	0	0	INPUT	OUTPUT	8	OUTPUT	OUTPUT
1	0	0	1	INPUT	OUTPUT	9	OUTPUT	INPUT
1	0	1	0	INPUT	OUTPUT	10	INPUT	OUTPUT
1	0	1	1	INPUT	OUTPUT	11	INPUT	INPUT
1	1	0	0	INPUT	INPUT	12	OUTPUT	OUTPUT
1	1	0	1	INPUT	INPUT	13	OUTPUT	INPUT
1	1	1	0	INPUT	INPUT	14	INPUT	OUTPUT
1	1	1	1	INPUT	INPUT	15	INPUT	INPUT

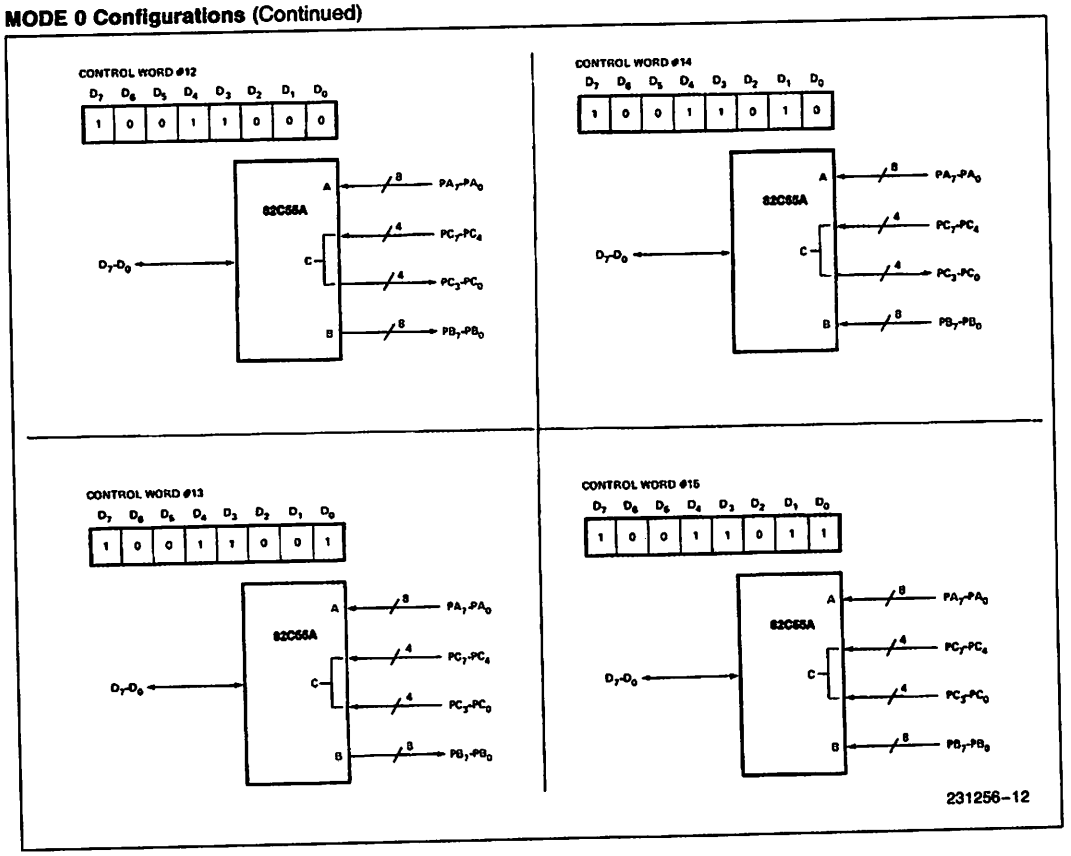
MODE 0 Configurations



MODE 0 Configurations (Continued)



MODE 0 Configurations (Continued)



Operating Modes

MODE 1 (Strobed Input/Output). This functional configuration provides a means for transferring I/O data to or from a specified port in conjunction with strobes or "handshaking" signals. In mode 1, Port A and Port B use the lines on Port C to generate or accept these "handshaking" signals.

Mode 1 Basic functional Definitions:

- Two Groups (Group A and Group B).
- Each group contains one 8-bit data port and one 4-bit control/data port.
- The 8-bit data port can be either input or output Both inputs and outputs are latched.
- The 4-bit port is used for control and status of the 8-bit data port.

Input Control Signal Definition

$\overline{STB}$ (Strobe Input). A "low" on this input loads data into the input latch.

IBF (Input Buffer Full F/F)

A "high" on this output indicates that the data has been loaded into the input latch; in essence, an acknowledgement. IBF is set by $\overline{STB}$ input being low and is reset by the rising edge of the $\overline{RD}$ input.

INTR (Interrupt Request)

A "high" on this output can be used to interrupt the CPU when an input device is requesting service. INTR is set by the $\overline{STB}$ is a "one", IBF is a "one" and INTE is a "one". It is reset by the falling edge of $\overline{RD}$. This procedure allows an input device to request service from the CPU by simply strobing its data into the port.

INTE A

Controlled by bit set/reset of PC_4.

INTE B

Controlled by bit set/reset of PC_2.

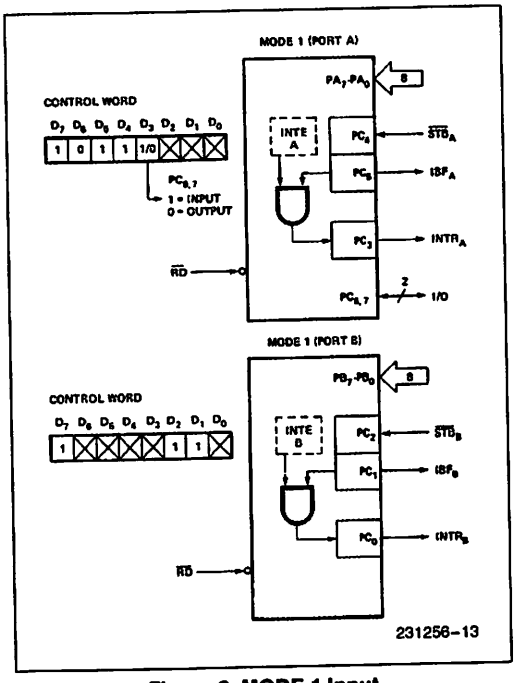


Figure 8. MODE 1 Input

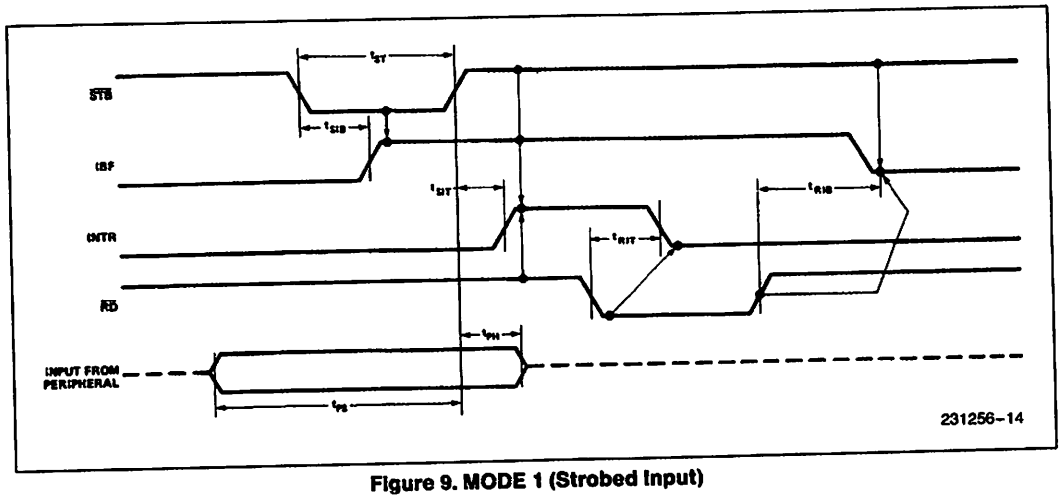


Figure 9. MODE 1 (Strobed Input)

Output Control Signal Definition

$\overline{OBF}$ (Output Buffer Full F/F). The $\overline{OBF}$ output will go "low" to indicate that the CPU has written data out to the specified port. The $\overline{OBF}$ F/F will be set by the rising edge of the $\overline{WR}$ input and reset by $\overline{ACK}$ Input being low.

$\overline{ACK}$ (Acknowledge Input). A "low" on this input informs the 82C55A that the data from Port A or Port B has been accepted. In essence, a response from the peripheral device indicating that it has received the data output by the CPU.

INTR (Interrupt Request). A "high" on this output can be used to interrupt the CPU when an output device has accepted data transmitted by the CPU. INTR is set when $\overline{ACK}$ is a "one", $\overline{OBF}$ is a "one" and INTE is a "one". It is reset by the falling edge of $\overline{WR}$.

INTE A

Controlled by bit set/reset of PC_6.

INTE B

Controlled by bit set/reset of PC_2.

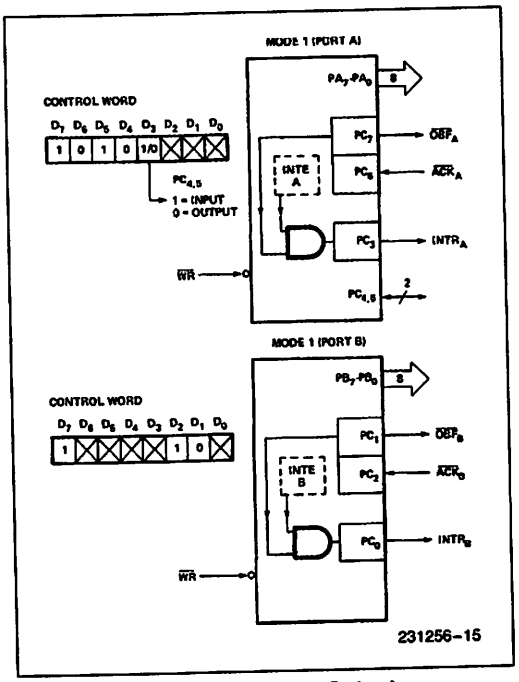


Figure 10. MODE 1 Output

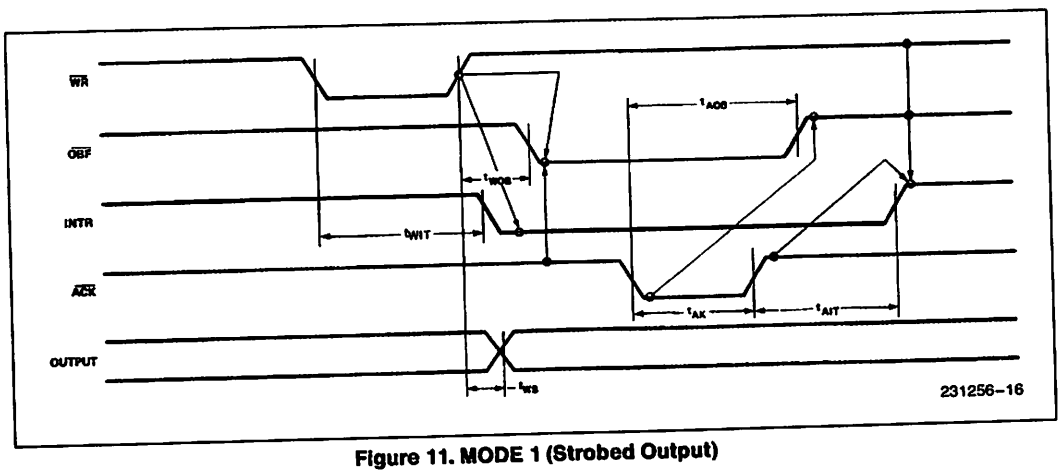


Figure 11. MODE 1 (Strobed Output)

Combinations of MODE 1

Port A and Port B can be individually defined as input or output in Mode 1 to support a wide variety of strobed I/O applications.

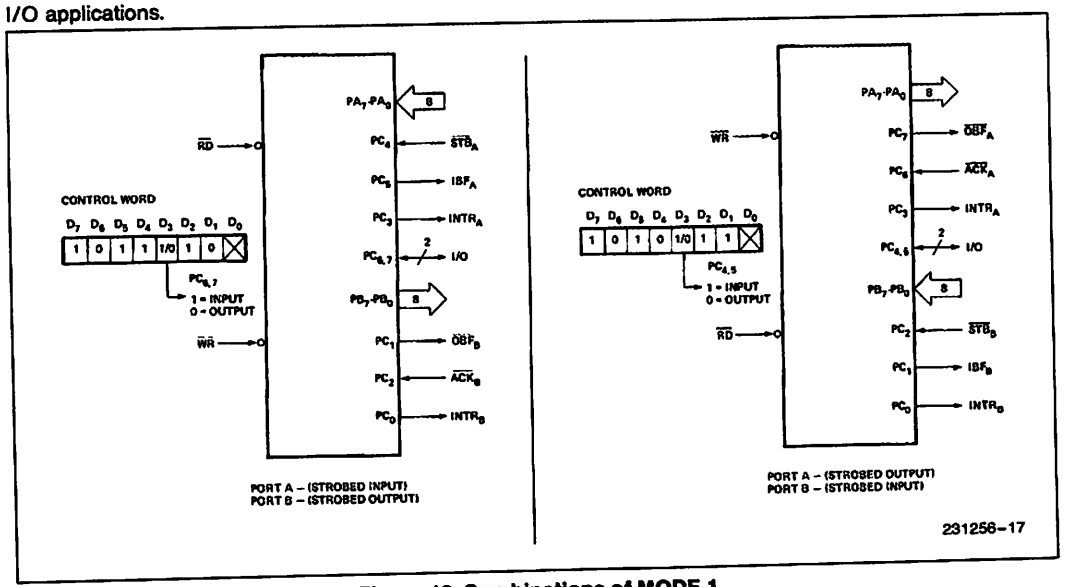


Figure 12. Combinations of MODE 1

Operating Modes

MODE 2 (Strobed Bidirectional Bus I/O). This functional configuration provides a means for communicating with a peripheral device or structure on a single 8-bit bus for both transmitting and receiving data (bidirectional bus I/O). "Handshaking" signals are provided to maintain proper bus flow discipline in a similar manner to MODE 1. Interrupt generation and enable/disable functions are also available.

MODE 2 Basic Functional Definitions:

- Used in Group A **only**.
- One 8-bit, bi-directional bus port (Port A) and a 5-bit control port (Port C).
- Both inputs and outputs are latched.
- The 5-bit control port (Port C) is used for control and status for the 8-bit, bi-directional bus port (Port A).

Bidirectional Bus I/O Control Signal Definition

INTR (Interrupt Request). A high on this output can be used to interrupt the CPU for input or output operations.

Output Operations

$\overline{OBF}$ (Output Buffer Full). The $\overline{OBF}$ output will go "low" to indicate that the CPU has written data out to port A.

$\overline{ACK}$ (Acknowledge). A "low" on this input enables the tri-state output buffer of Port A to send out the data. Otherwise, the output buffer will be in the high impedance state.

INTE 1 (The INTE Flip-Flop Associated with $\overline{OBF}$). Controlled by bit set/reset of PC_6.

Input Operations

$\overline{STB}$ (Strobe Input). A "low" on this input loads data into the input latch.

IBF (Input Buffer Full F/F). A "high" on this output indicates that data has been loaded into the input latch.

INTE 2 (The INTE Flip-Flop Associated with IBF). Controlled by bit set/reset of PC_4.

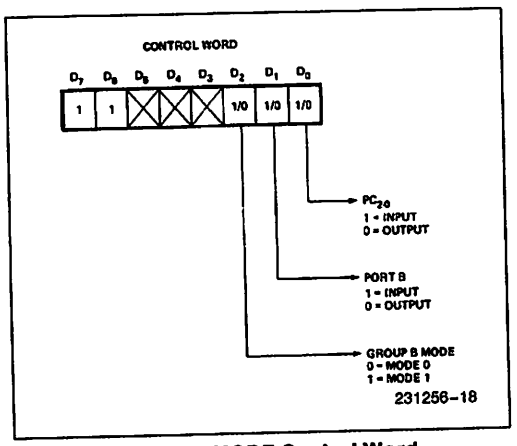


Figure 13. MODE Control Word

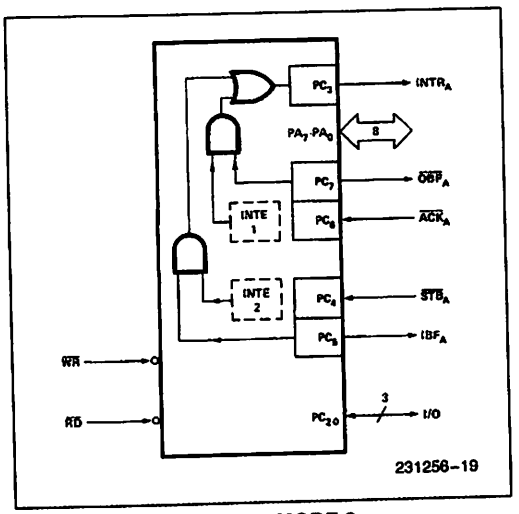


Figure 14. MODE 2

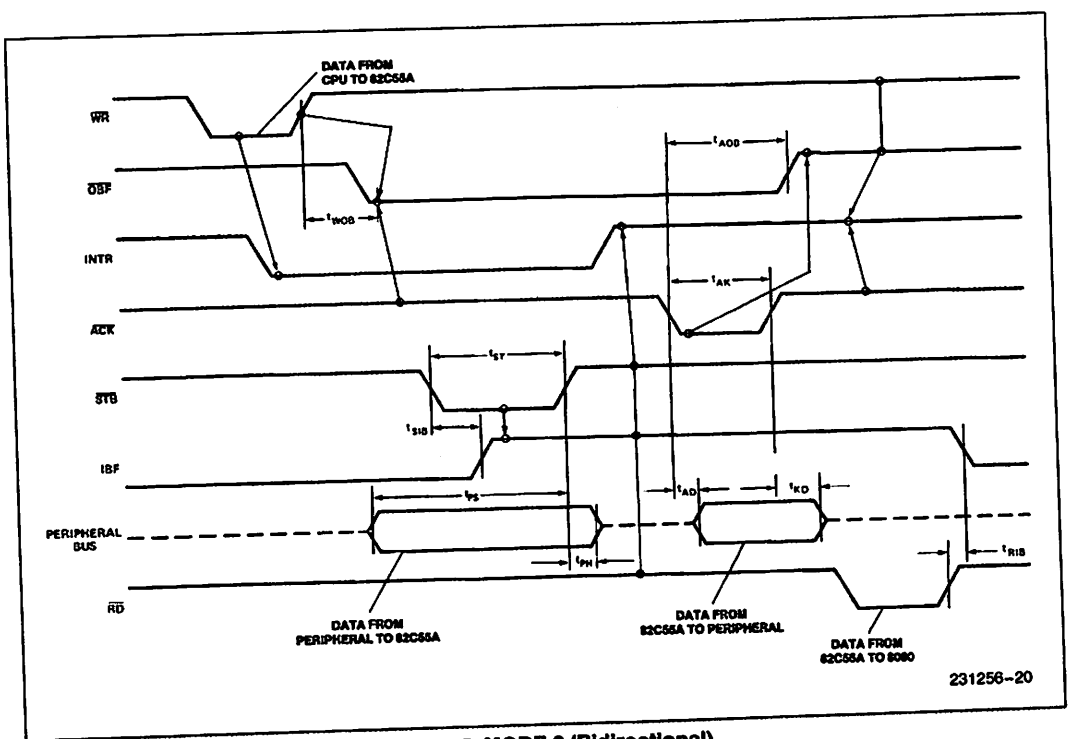


Figure 15. MODE 2 (Bidirectional)

NOTE:
Any sequence where $\overline{WR}$ occurs before $\overline{ACK}$, and $\overline{STB}$ occurs before $\overline{RD}$ is permissible.
(INTR = IBF • $\overline{MASK}$ • $\overline{STB}$ • $\overline{RD}$ + $\overline{OBF}$ • $\overline{MASK}$ • $\overline{ACK}$ • $\overline{WR}$)

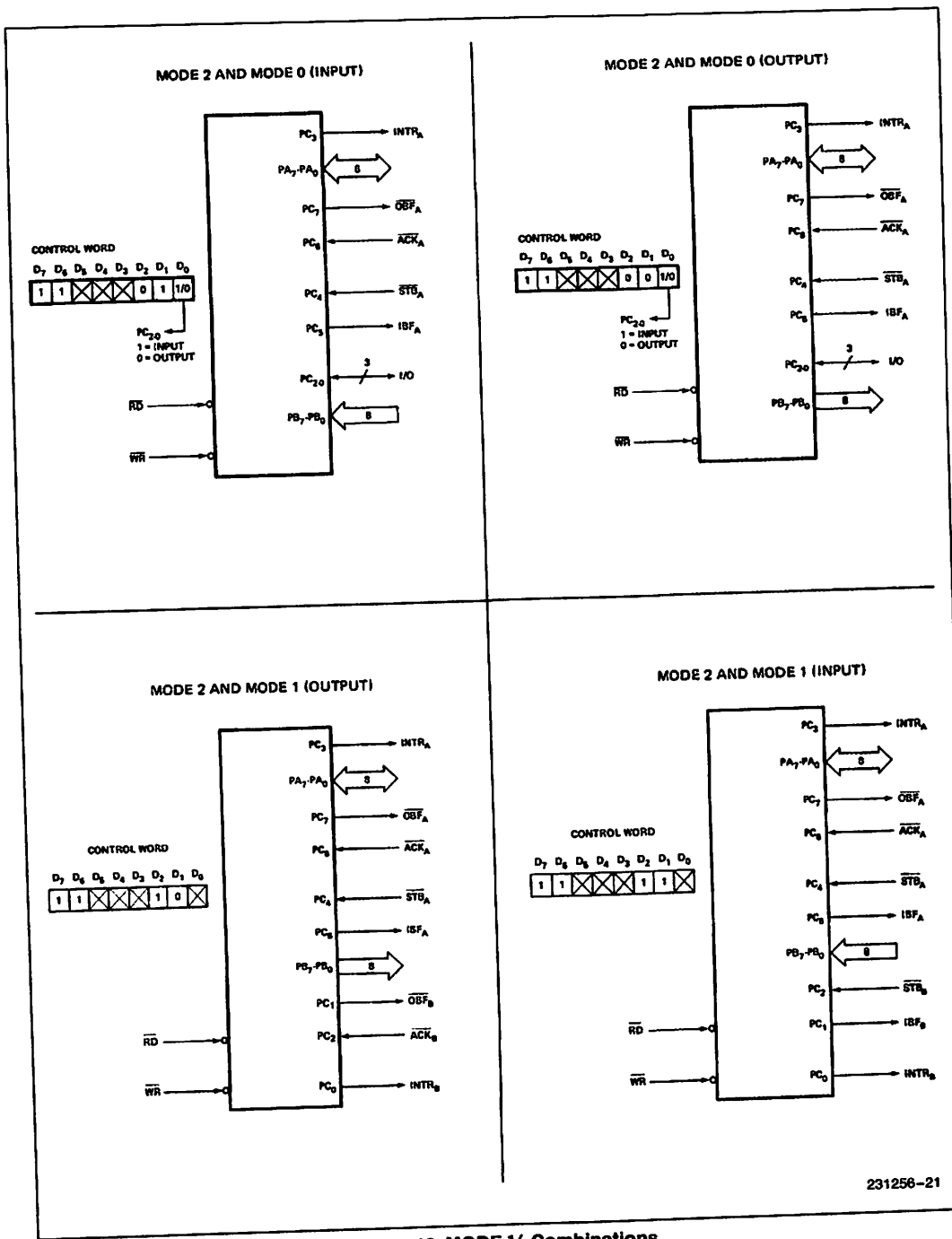


Figure 16. MODE 1/4 Combinations

Mode Definition Summary

	MODE 0	
	IN	OUT
PA_0	IN	OUT
PA_1	IN	OUT
PA_2	IN	OUT
PA_3	IN	OUT
PA_4	IN	OUT
PA_5	IN	OUT
PA_6	IN	OUT
PA_7	IN	OUT
PB_0	IN	OUT
PB_1	IN	OUT
PB_2	IN	OUT
PB_3	IN	OUT
PB_4	IN	OUT
PB_5	IN	OUT
PB_6	IN	OUT
PB_7	IN	OUT
PC_0	IN	OUT
PC_1	IN	OUT
PC_2	IN	OUT
PC_3	IN	OUT
PC_4	IN	OUT
PC_5	IN	OUT
PC_6	IN	OUT
PC_7	IN	OUT

MODE 1	
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
IN	OUT
$INTR_B$	$INTR_B$
IBF_B	$\overline{OBF}_B$
$\overline{STB}_B$	$\overline{ACK}_B$
$INTR_A$	$INTR_A$
$\overline{STB}_A$	I/O
IBF_A	I/O
I/O	$\overline{ACK}_A$
I/O	$\overline{OBF}_A$

MODE 2
GROUP A ONLY
↔
↔
↔
↔
↔
↔
↔
↔
—
—
—
—
—
—
—
—
I/O
I/O
I/O
$INTR_A$
$\overline{STB}_A$
IBF_A
$\overline{ACK}_A$
$\overline{OBF}_A$

MODE 0 OR MODE 1 ONLY

Special Mode Combination Considerations

There are several combinations of modes possible. For any combination, some or all of the Port C lines are used for control or status. The remaining bits are either inputs or outputs as defined by a "Set Mode" command.

During a read of Port C, the state of all the Port C lines, except the $\overline{ACK}$ and $\overline{STB}$ lines, will be placed on the data bus. In place of the $\overline{ACK}$ and $\overline{STB}$ line states, flag status will appear on the data bus in the PC2, PC4, and PC6 bit positions as illustrated by Figure 18.

Through a "Write Port C" command, only the Port C pins programmed as outputs in a Mode 0 group can be written. No other pins can be affected by a "Write Port C" command, nor can the interrupt enable flags be accessed. To write to any Port C output programmed as an output in a Mode 1 group or to change an interrupt enable flag, the "Set/Reset Port C Bit" command must be used.

With a "Set/Reset Port C Bit" command, any Port C line programmed as an output (including INTR, IBF and $\overline{OBF}$) can be written, or an interrupt enable flag can be either set or reset. Port C lines programmed as inputs, including $\overline{ACK}$ and $\overline{STB}$ lines, associated with Port C are not affected by a "Set/Reset Port C Bit" command. Writing to the corresponding Port C bit positions of the $\overline{ACK}$ and $\overline{STB}$ lines with the "Set/Reset Port C Bit" command will affect the Group A and Group B interrupt enable flags, as illustrated in Figure 18.

Current Drive Capability

Any output on Port A, B or C can sink or source 2.5 mA. This feature allows the 82C55A to directly drive Darlington type drivers and high-voltage displays that require such sink or source current.

Reading Port C Status

In Mode 0, Port C transfers data to or from the peripheral device. When the 82C55A is programmed to function in Modes 1 or 2, Port C generates or accepts "hand-shaking" signals with the peripheral device. Reading the contents of Port C allows the programmer to test or verify the "status" of each peripheral device and change the program flow accordingly.

There is no special instruction to read the status information from Port C. A normal read operation of Port C is executed to perform this function.

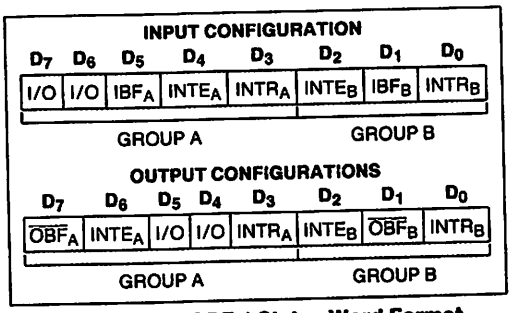


Figure 17a. MODE 1 Status Word Format

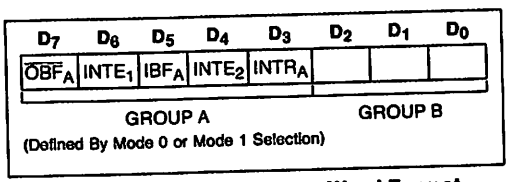


Figure 17b. MODE 2 Status Word Format

Interrupt Enable Flag	Position	Alternate Port C Pin Signal (Mode)
INTE B	PC2	$\overline{ACK}_B$ (Output Mode 1) or $\overline{STB}_B$ (Input Mode 1)
INTE A2	PC4	$\overline{STB}_A$ (Input Mode 1 or Mode 2)
INTE A1	PC6	$\overline{ACK}_A$ (Output Mode 1 or Mode 2

Figure 18. Interrupt Enable Flags in Modes 1 and 2

ABSOLUTE MAXIMUM RATINGS*

Ambient Temperature Under Bias....0°C to + 70°C
Storage Temperature .....− 65°C to + 150°C
Supply Voltage .....− 0.5 to + 8.0V
Operating Voltage .....+ 4V to + 7V
Voltage on any Input.....GND−2V to + 6.5V
Voltage on any Output ..GND−0.5V to V_{CC} + 0.5V
Power Dissipation .....1 Watt

NOTICE: This is a production data sheet. The specifications are subject to change without notice.

**WARNING: Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.*

D.C. CHARACTERISTICS

T_A = 0°C to 70°C, V_{CC} = +5V ±10%, GND = 0V (T_A = −40°C to +85°C for Extended Temperture)

Symbol	Parameter	Min	Max	Units	Test Conditions
V_{IL}	Input Low Voltage	−0.5	0.8	V	
V_{IH}	Input High Voltage	2.0	V_{CC}	V	
V_{OL}	Output Low Voltage		0.4	V	I_{OL} = 2.5 mA
V_{OH}	Output High Voltage	3.0 V_{CC} − 0.4		V V	I_{OH} = −2.5 mA I_{OH} = −100 µA
I_{IL}	Input Leakage Current		±1	µA	V_{IN} = V_{CC} to 0V (Note 1)
I_{OFL}	Output Float Leakage Current		±10	µA	V_{IN} = V_{CC} to 0V (Note 2)
I_{DAR}	Darlington Drive Current	±2.5	(Note 4)	mA	Ports A, B, C R_{ext} = 500Ω V_{ext} = 1.7V
I_{PHL}	Port Hold Low Leakage Current	+50	+300	µA	V_{OUT} = 1.0V Port A only
I_{PHH}	Port Hold High Leakage Current	−50	−300	µA	V_{OUT} = 3.0V Ports A, B, C
I_{PHLO}	Port Hold Low Overdrive Current	−350		µA	V_{OUT} = 0.8V
I_{PHHO}	Port Hold High Overdrive Current	+350		µA	V_{OUT} = 3.0V
I_{CC}	V_{CC} Supply Current		10	mA	(Note 3)
I_{CCSB}	V_{CC} Supply Current-Standby		10	µA	V_{CC} = 5.5V V_{IN} = V_{CC} or GND Port Conditions If I/P = Open/High O/P = Open Only With Data Bus = High/Low $\overline{CS}$ = High Reset = Low Pure Inputs = Low/High

NOTES:
1. Pins A_1, A_0, $\overline{CS}$, $\overline{WR}$, $\overline{RD}$, Reset.
2. Data Bus: Ports B. C.
3. Outputs open.
4. Limit output current to 4.0 mA.

CAPACITANCE

T_A = 25°C, V_{CC} = GND = 0V

Symbol	Parameter	Min	Max	Units	Test Conditions
C_{IN}	Input Capacitance		10	pF	Unmeasured pins returned to GND f_c = 1 MHz(5)
$C_{I/O}$	I/O Capacitance		20	pF	

NOTE:
5. Sampled not 100% tested.

A.C. CHARACTERISTICS

T_A = 0° to 70°C, V_{CC} = +5V ±10%, GND = 0V

T_A = −40°C to +85°C for Extended Temperature

BUS PARAMETERS

READ CYCLE

Symbol	Parameter	82C55A-2		Units	Test Conditions
		Min	Max		
t_{AR}	Address Stable Before $\overline{RD}\downarrow$	0		ns	
t_{RA}	Address Hold Time After $\overline{RD}\uparrow$	0		ns	
t_{RR}	$\overline{RD}$ Pulse Width	150		ns	
t_{RD}	Data Delay from $\overline{RD}\downarrow$		120	ns	
t_{DF}	$\overline{RD}\uparrow$ to Data Floating	10	75	ns	
t_{RV}	Recovery Time between $\overline{RD}/\overline{WR}$	200		ns	

WRITE CYCLE

Symbol	Parameter	82C55A-2		Units	Test Conditions
		Min	Max		
t_{AW}	Address Stable Before $\overline{WR}\downarrow$	0		ns	
t_{WA}	Address Hold Time After $\overline{WR}\uparrow$	20		ns	Ports A & B
		20		ns	Port C
t_{WW}	$\overline{WR}$ Pulse Width	100		ns	
t_{DW}	Data Setup Time Before $\overline{WR}\uparrow$	100		ns	
t_{WD}	Data Hold Time After $\overline{WR}\uparrow$	30		ns	Ports A & B
		30		ns	Port C

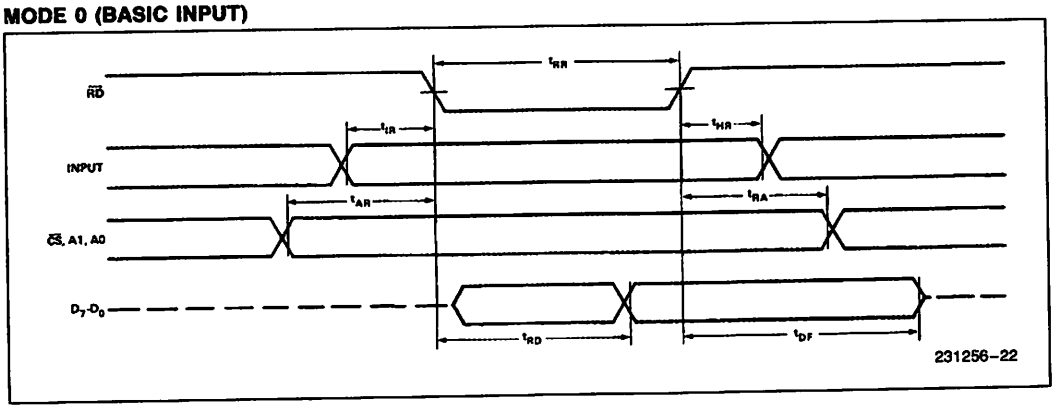
OTHER TIMINGS

Symbol	Parameter	82C55A-2		Units Conditions	Test
		Min	Max		
t_{WB}	$\overline{WR}$ = 1 to Output		350	ns	
t_{IR}	Peripheral Data Before $\overline{RD}$	0		ns	
t_{HR}	Peripheral Data After $\overline{RD}$	0		ns	
t_{AK}	$\overline{ACK}$ Pulse Width	200		ns	
t_{ST}	$\overline{STB}$ Pulse Width	100		ns	
t_{PS}	Per. Data Before $\overline{STB}$ High	20		ns	
t_{PH}	Per. Data After $\overline{STB}$ High	50		ns	
t_{AD}	$\overline{ACK}$ = 0 to Output		175	ns	
t_{KD}	$\overline{ACK}$ = 1 to Output Float	20	250	ns	
t_{WOB}	$\overline{WR}$ = 1 to $\overline{OBF}$ = 0		150	ns	
t_{AOB}	$\overline{ACK}$ = 0 to $\overline{OBF}$ = 1		150	ns	
t_{SIB}	$\overline{STB}$ = 0 to IBF = 1		150	ns	
t_{RIB}	$\overline{RD}$ = 1 to IBF = 0		150	ns	
t_{RIT}	$\overline{RD}$ = 0 to INTR = 0		200	ns	
t_{SIT}	$\overline{STB}$ = 1 to INTR = 1		150	ns	
t_{AIT}	$\overline{ACK}$ = 1 to INTR = 1		150	ns	
t_{WIT}	$\overline{WR}$ = 0 to INTR = 0		200	ns	see note 1
t_{RES}	Reset Pulse Width	500		ns	see note 2

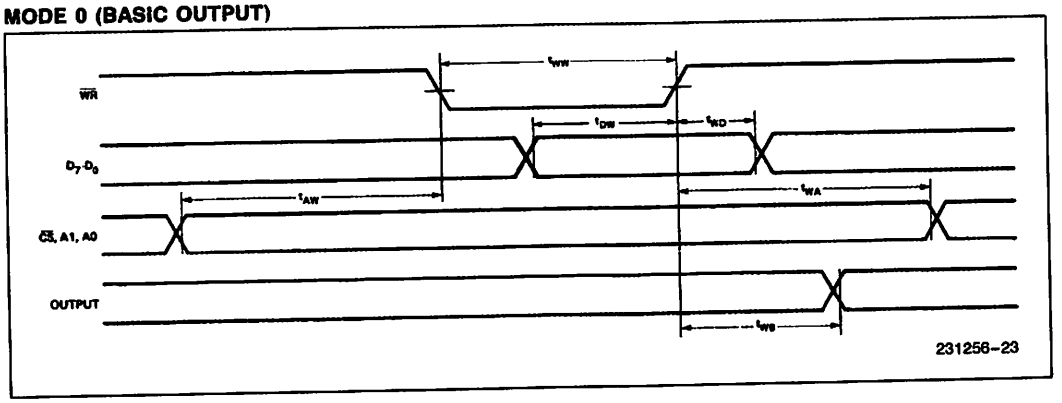
NOTE:
1. INTR ↑ may occur as early as $\overline{WR}$ ↓.
2. Pulse width of initial Reset pulse after power on must be at least 50 μSec. Subsequent Reset pulses may be 500 ns minimum. The output Ports A, B, or C may glitch low during the reset pulse but all port pins will be held at a logic "one" level after the reset pulse.

WAVEFORMS

MODE 0 (BASIC INPUT)

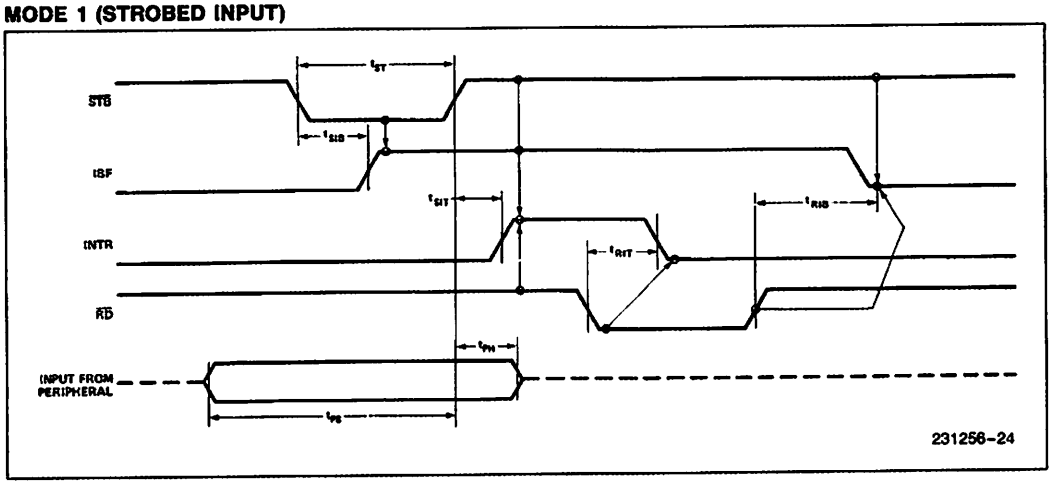


MODE 0 (BASIC OUTPUT)

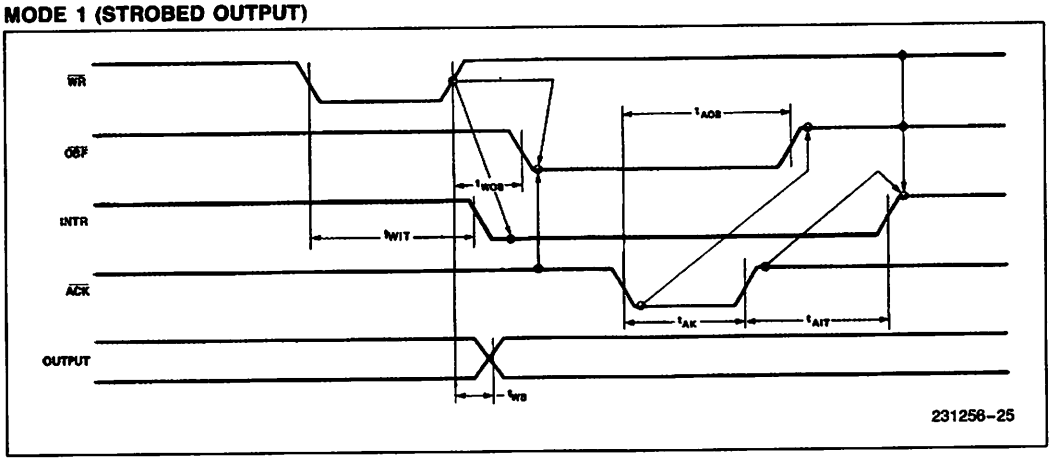


WAVEFORMS (Continued)

MODE 1 (STROBED INPUT)

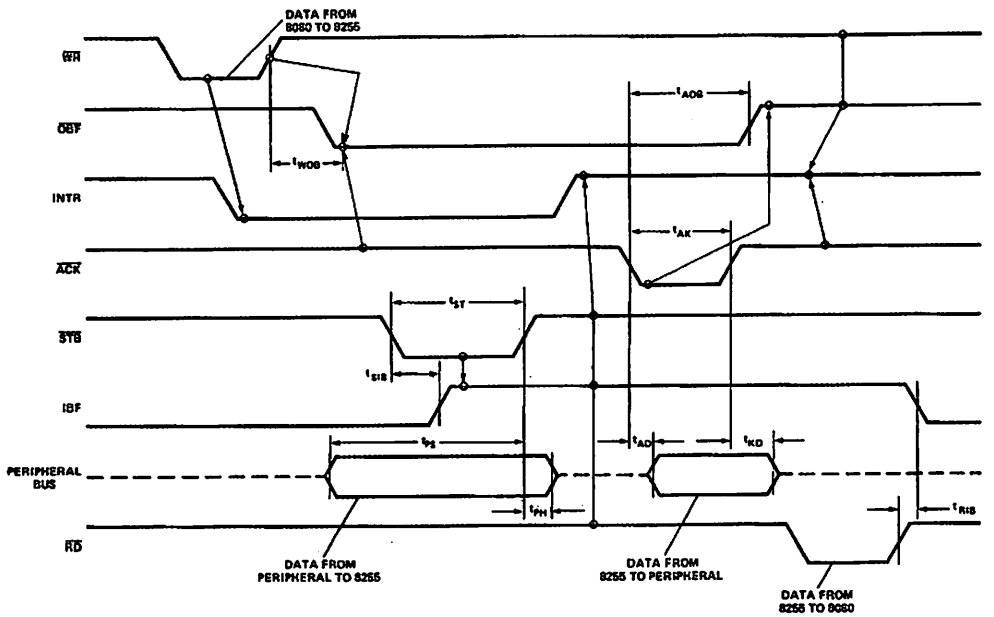


MODE 1 (STROBED OUTPUT)



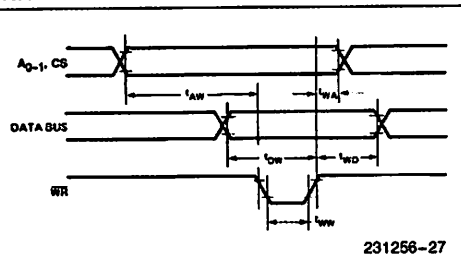
WAVEFORMS (Continued)

MODE 2 (BIDIRECTIONAL)

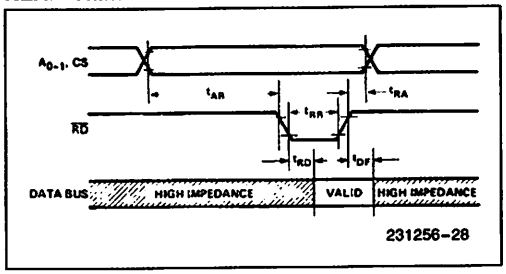


Note:
Any sequence where $\overline{WR}$ occurs before $\overline{ACK}$ AND $\overline{STB}$ occurs before $\overline{RD}$ is permissible.
(INTR = IBF • $\overline{MASK}$ • $\overline{STB}$ • $\overline{RD}$ + $\overline{OBF}$ • $\overline{MASK}$ • $\overline{ACK}$ • $\overline{WR}$)

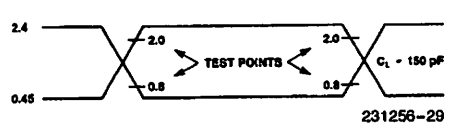
WRITE TIMING



READ TIMING

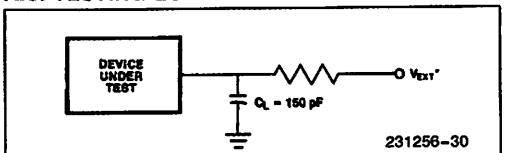


A.C. TESTING INPUT, OUTPUT WAVEFORM



A.C. Testing Inputs Are Driven At 2.4V For A Logic 1 And 0.45V For A Logic 0 Timing Measurements Are Made At 2.0V For A Logic 1 And 0.8 For A Logic 0.

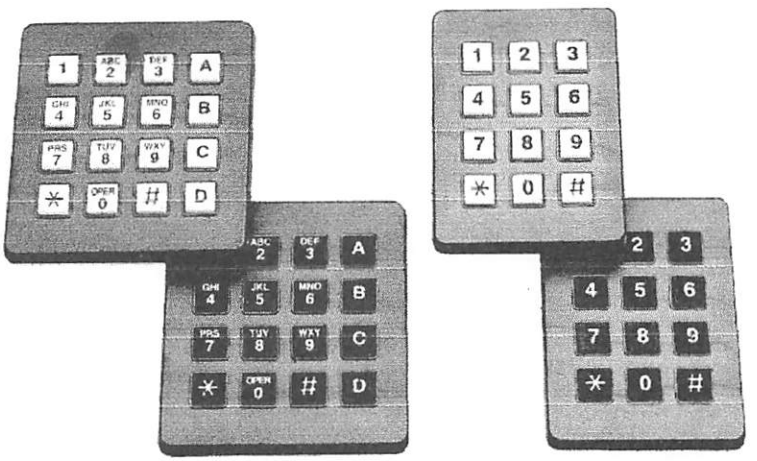
A.C. TESTING LOAD CIRCUIT



*V_{EXT} Is Set At Various Voltages During Testing To Guarantee The Specification. C_L Includes Jig Capacitance.

SERIES 96
Conductive Rubber

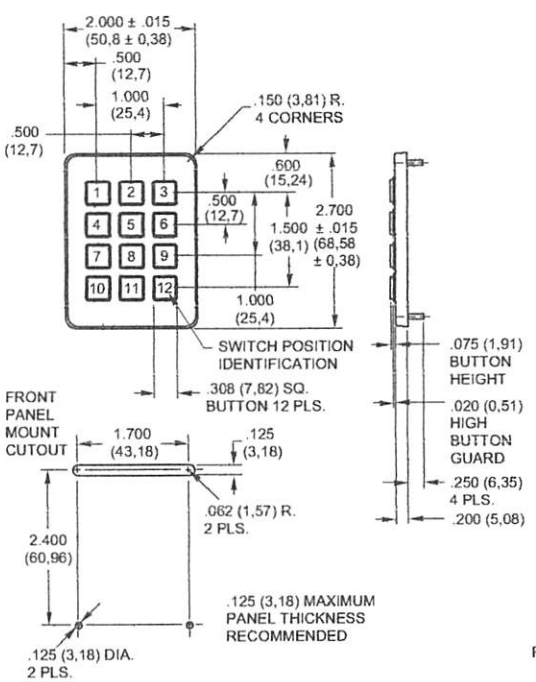
FEATURES
- Quality, Economical Keyboards
- Easily Customized Legends
- Matrix Circuitry
- Backlit and Shielded Options Available
- Termination Mates With Standard Connectors
- Tactile Feedback to Operator
- 1,000,000 Operations per Button
- Compatible With High Resistance Logic Inputs



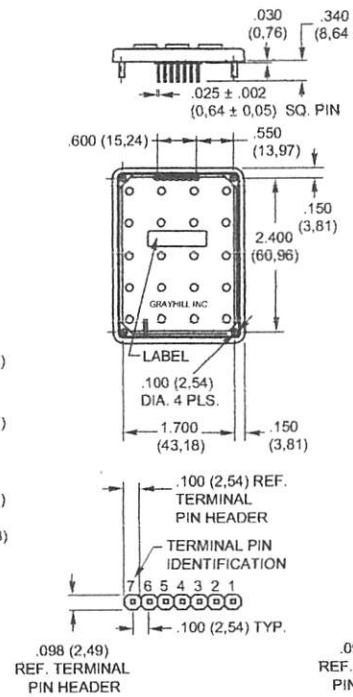
The Series 96 is Grayhill's most economical 3x4 and 4x4 keypad family. The contact system utilizes conductive rubber to mate the appropriate PC board traces. Offered in matrix circuitry, with shielded and backlit options. Built with quality component parts, the Series 96 is subjected to our rigid statistical process control to insure that it meets our reliability standards.

DIMENSIONS In inches (and millimeters)

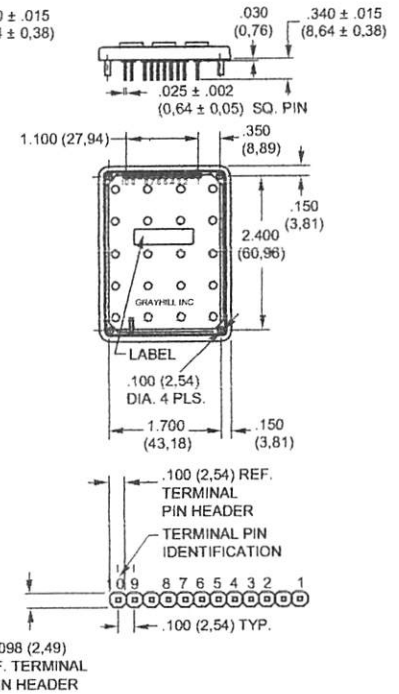
3x4 Front Mount Keyboard

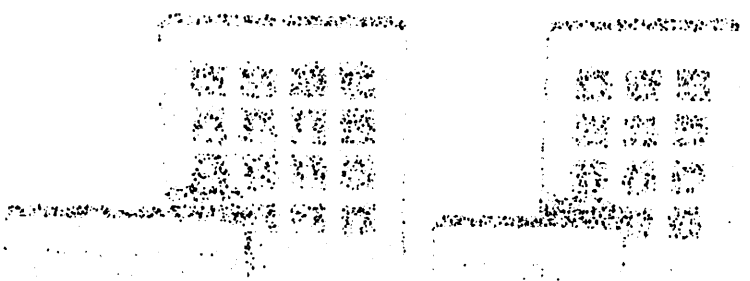


Standard Versions



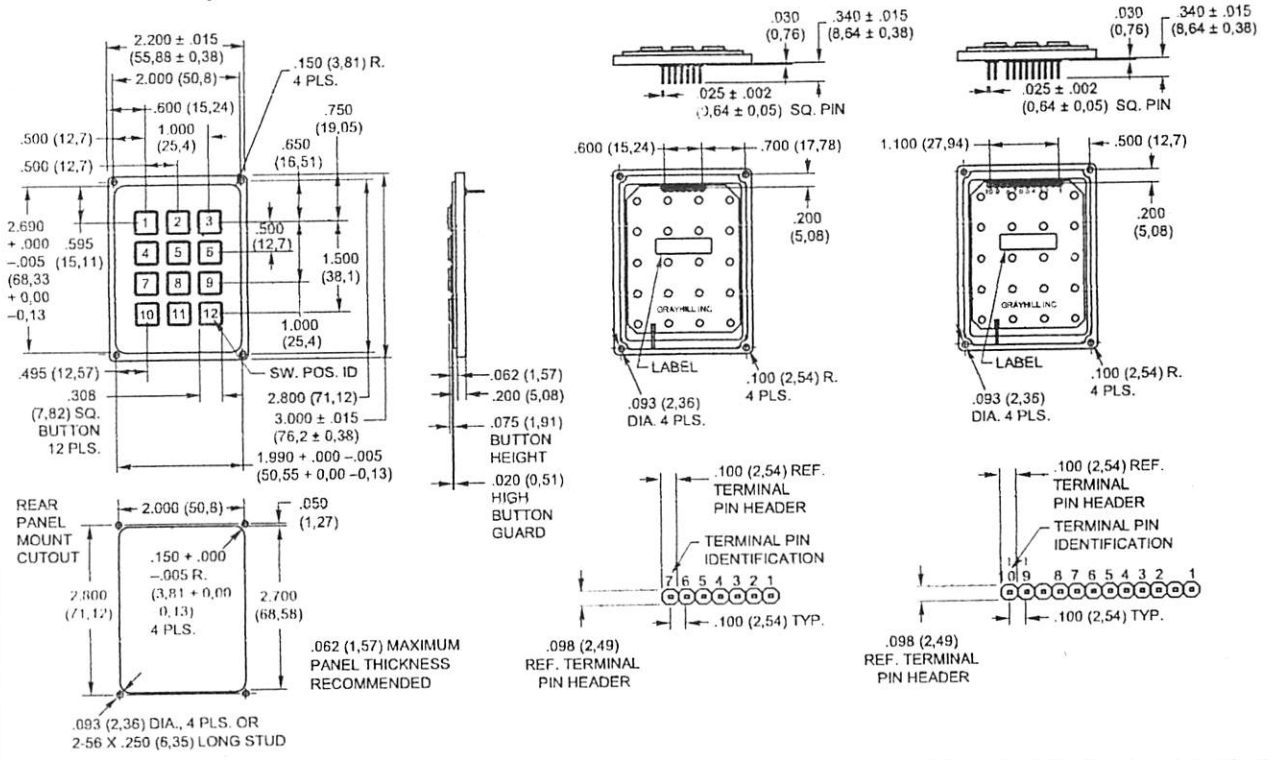
Shielded/Backlit Versions





DIMENSIONS In inches (and millimeters)

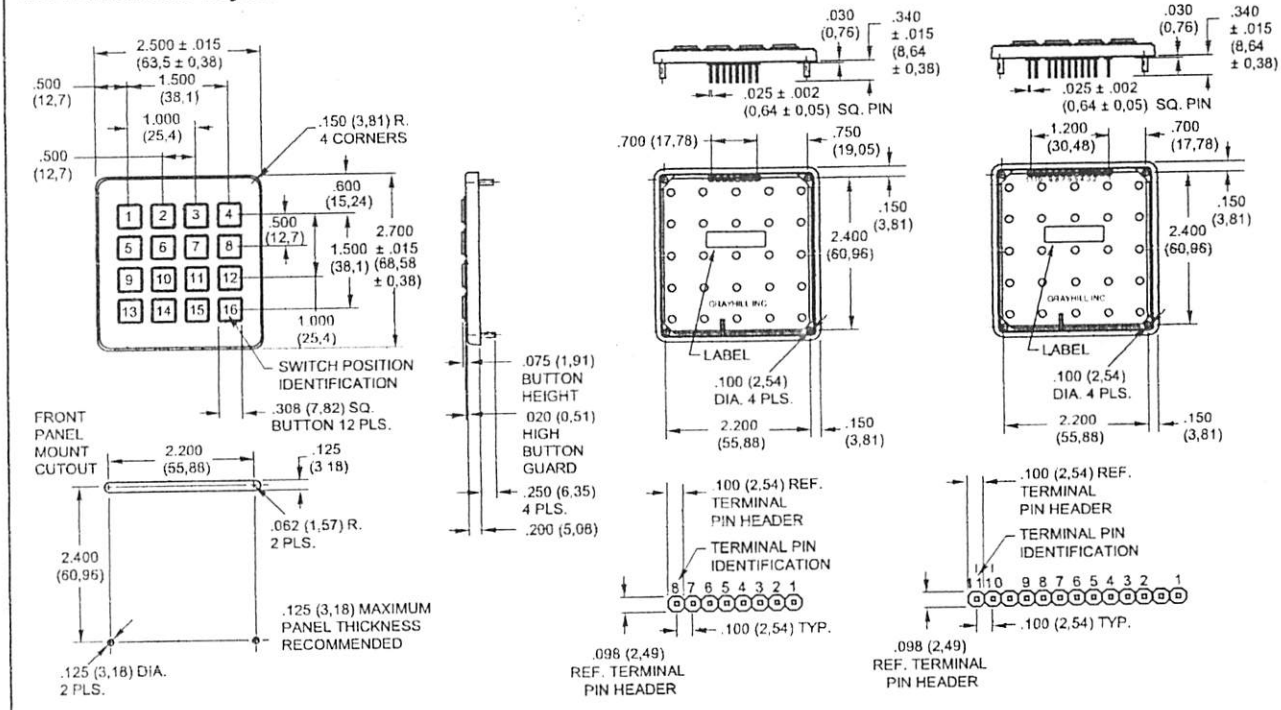
3x4 Rear Mount Keyboard



Standard Versions

Shielded/Backlit Versions

4x4 Front Mount Keyboard

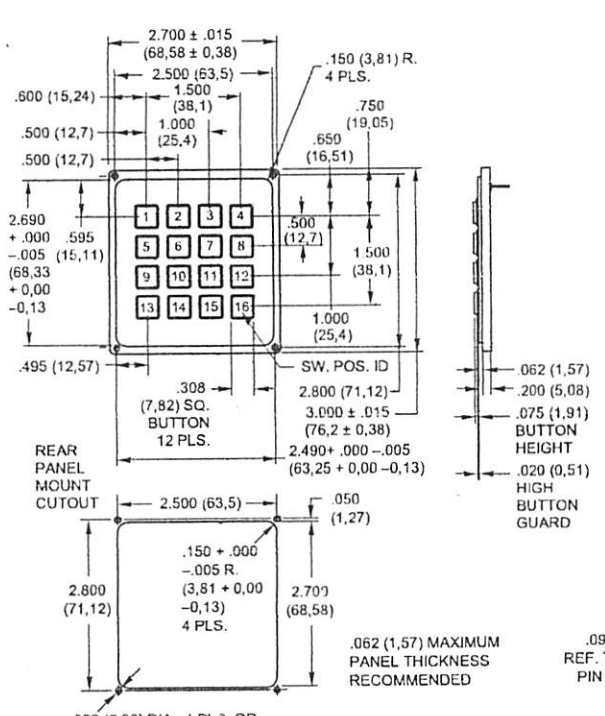


Standard Versions

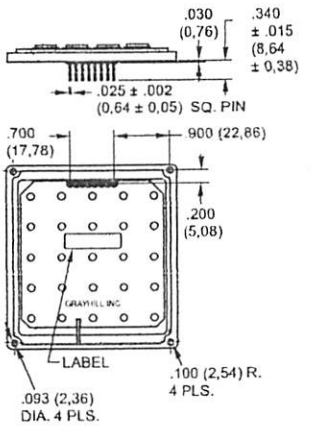
Shielded/Backlit Versions

DIMENSIONS In inches (and millimeters)

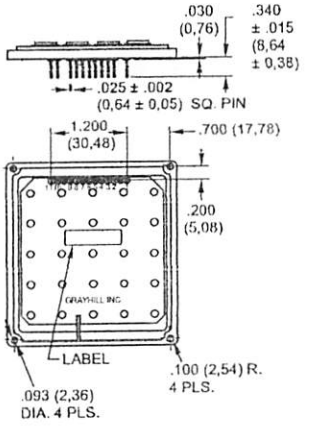
4x4 Rear Mount Keyboard

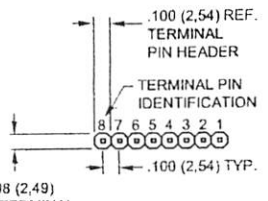


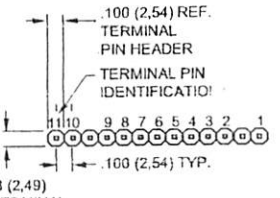
Standard Versions



Shielded/Backlit Versions







CODE AND TRUTH TABLES

Dots in the chart indicate connected terminals when switch is closed.
Terminals are identified on the keyboard.

12 Button Keypads

3x4	MATRIX CODES											
	Standard						Shielded/Backlit					
BUTTON LOCATION	1	•		•			•		•			
	2		•	•				•	•			
	3				•	•				•	•	
	4	•			•		•			•		
	5		•			•		•			•	
	6			•		•			•		•	
	7	•				•	•				•	
	8		•			•		•			•	
	9			•		•			•		•	
	10	•				•	•				•	
	11		•			•		•			•	
	12			•		•			•		•	
		5	6	7	1	2	3	4	6	7	8	2	3	4	5	1	9	10
	TERMINAL LOCATION																	

Shielded keypad = Shielded
Backlit keypad = NC
Shielded and backlit keypad = Shielded

Shielded keypad = NC
Backlit keypad = EL Panel 1
Shielded and backlit keypad = EL Panel 1

Shielded keypad = NC
Backlit keypad = EL Panel 2
Shielded and backlit keypad = EL Panel 2

16 Button Keypads

4x4	MATRIX CODES																	
	Standard								Shielded/Backlit									
BUTTON LOCATION	1	•			•				•			•						
	2		•		•					•		•						
	3			•	•						•	•						
	4					•	•						•	•				
	5	•				•			•				•					
	6		•			•				•			•					
	7			•		•					•		•					
	8				•	•						•	•					
	9	•					•		•					•				
	10		•				•			•				•				
	11			•			•				•			•				
	12				•		•					•		•				
	13	•						•	•						•			
	14		•					•		•					•			
	15			•				•			•				•			
	16				•			•				•			•			
		5	6	7	8	1	2	3	4	6	7	8	9	2	3	4	5	1	10	11
	TERMINAL LOCATION																			

Shielded keypad = Shielded
Backlit keypad = NC
Shielded and backlit keypad = Shielded

Shielded keypad = NC
Backlit keypad = EL Panel 1
Shielded and backlit keypad = EL Panel 1

Shielded keypad = NC
Backlit keypad = EL Panel 2
Shielded and backlit keypad = EL Panel 2

SPECIFICATIONS

Rating Criteria

Rating at 12 Vdc: 5 milliamps for .5 seconds
Contact Bounce: < 12 milliseconds
Contact Resistance: < 100 ohms (at stated operating force)
Voltage Breakdown: 250 Vac between components
Mechanical Operation Life: 1,000,000 operations per key
Insulation Resistance: > 10^{12} ohms @ 500 Vdc
Push Out Force Per Pin: 5 lbs.

Operating Features

Travel: .040 minimum
Operating Force: 175 ± 40 grams
Operating Temperature: -30°C to +80°C

Material and Finishes

Terminal Pin: Phosphor bronze, solder-plated
PC Board: FR-4 glass cloth epoxy
Keypad: Silicone rubber, durometer 50 ± 5
Housing: ABS, cycolac "KJW"
Housing Color: Black

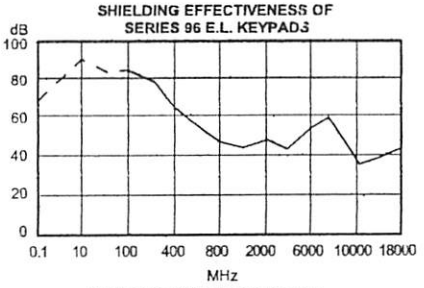
Shielding Effectiveness

Results shown are typical for a standard Grayhill Series 84S keyboard. A conductive gasket will generally increase the shielding, depending on the size and shape of the gasket and its material. Data derived for E-Field Radiation.

Test Method:
Measurements were made with the keyboard mounted to a brass plate, which in turn was mounted to a shielded enclosure containing the receiving equipment. A signal generator provided the frequency source that was radiated from the transmitting antenna to the enclosed receiving antenna. The spacing between antennas was maintained constant throughout the frequency range. The effectiveness rating is determined by establishing a reference reading without obstruction between the two antennas and determining the difference between that reading and the test setup reading.

Note:
When measured in actual equipment, shielding effectiveness is determined by many factors. This method accurately represents the shielding effectiveness of the Grayhill Series 84S under ideal test conditions.

SHIELDING EFFECTIVENESS OF SERIES 96 E.L. KEYPADS



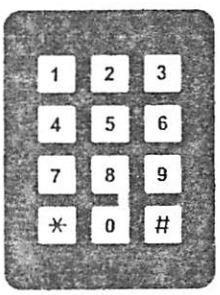
— – Represents shielding effectiveness greater than or equal to line.

Frequency M Hz	Rating in dB
0.1	≥ 66.2
10	≥ 94.8
100	90.5
400	64.2
800	42.3
2,000	40.5
6,000	33.1
10,000	34.4
18,000	37.0

STANDARD LEGENDS

Available through Grayhill Distributors

To order one of the configurations below, use the dash number shown here; select the keypad size and code, and order the part number with the appropriate legend dash number.



-102

-006

-152

-056

ORDERING INFORMATION

96AB2-102-FS-EL

Grayhill Series Number
Keyboard Size: A = 3x4, B = 4x4
Circuitry: B2 = Matrix (terminal pin header)

E.L. Panel Backlighting Option
EL = Backlit, Blank = Non-backlit
EMI/RFI Shielding Option
S = Shielded, Blank = Non-shielded
Mounting Option: F = Front panel mount, R = Rear panel mount
Standard Legend Choices
12 Position legends
102 = Black legends on a white button
152 = White legends on a black button
16 Position legends
006 = Black legends on a white button
056 = White legends on a black button

Available from your local Grayhill Distributor. For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

FAIRCHILD SEMICONDUCTOR™

October 1987
Revised April 2001

MM74C922 • MM74C923
16-Key Encoder • 20-Key Encoder

General Description

The MM74C922 and MM74C923 CMOS key encoders provide all the necessary logic to fully encode an array of SPST switches. The keyboard scan can be implemented by either an external clock or external capacitor. These encoders also have on-chip pull-up devices which permit switches with up to 50 kΩ on resistance to be used. No diodes in the switch array are needed to eliminate ghost switches. The internal debounce circuit needs only a single external capacitor and can be defeated by omitting the capacitor. A Data Available output goes to a high level when a valid keyboard entry has been made. The Data Available output returns to a low level when the entered key is released, even if another key is depressed. The Data Available will return high to indicate acceptance of the new key after a normal debounce period; this two-key roll-over is provided between any two switches.

An internal register remembers the last key pressed even after the key is released. The 3-STATE outputs provide for easy expansion and bus operation and are LPTTL compatible.

Features

- 50 kΩ maximum switch on resistance
- On or off chip clock
- On-chip row pull-up devices
- 2 key roll-over
- Keybounce elimination with single capacitor
- Last key register at outputs
- 3-STATE output LPTTL compatible
- Wide supply range: 3V to 15V
- Low power consumption

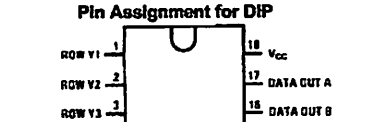
Ordering Code:

Order Number	Package Number	Package Description
MM74C922WM	M20B	20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300" Wide
MM74C922N	N18B	18-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide
MM74C923WM	M20B	20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300" Wide
MM74C923N	N20A	20-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide

Device also available in Tape and Reel. Specify by appending suffix letter "X" to the ordering code.

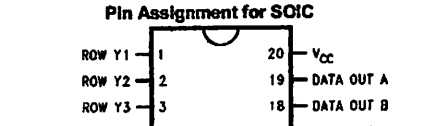
Connection Diagrams

Pin Assignment for DIP



Top View
MM74C922

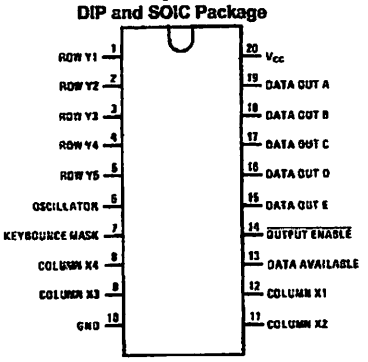
Pin Assignment for SOIC



Top View
MM74C922

Connection Diagrams (Continued)

Pin Assignment for DIP and SOIC Package



Top View
MM74C923

Truth Tables

(Pins 0 through 11)

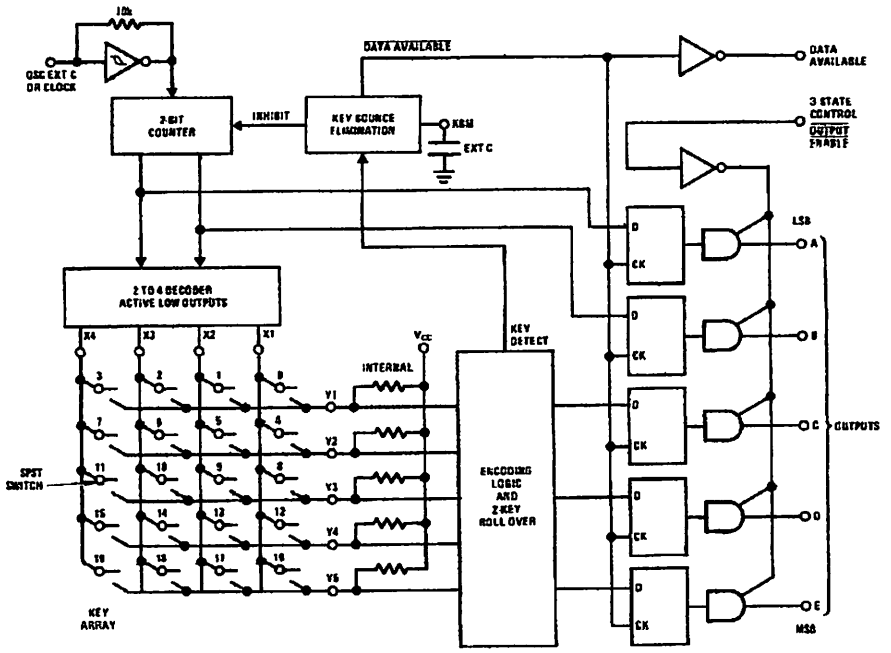
Switch Position	0 Y1, X1	1 Y1, X2	2 Y1, X3	3 Y1, X4	4 Y2, X1	5 Y2, X2	6 Y2, X3	7 Y2, X4	8 Y3, X1	9 Y3, X2	10 Y3, X3	11 Y3, X4
DATA A	0	1	0	1	0	1	0	1	0	1	0	1
DATA B	0	0	1	1	0	0	1	1	0	0	1	1
DATA C	0	0	0	0	1	1	1	1	0	0	0	0
DATA D	0	0	0	0	0	0	0	0	1	1	1	1
DATA E (Note 1)	0	0	0	0	0	0	0	0	0	0	0	0

(Pins 12 through 19)

Switch Position	12 Y4, X1	13 Y4, X2	14 Y4, X3	15 Y4, X4	16 Y5(Note 1), X1	17 Y5 (Note 1), X2	18 Y5 (Note 1), X3	19 Y5 (Note 1), X4
DATA A	0	1	0	1	0	1	0	1
DATA B	0	0	1	1	0	0	1	1
DATA C	1	1	1	1	0	0	0	0
DATA D	1	1	1	1	0	0	0	0
DATA E (Note 1)	0	0	0	0	1	1	1	1

Note 1: Omit for MM74C922

Block Diagram



Absolute Maximum Ratings(Note 2)

Voltage at Any Pin	V_{CC} − 0.3V to V_{CC} + 0.3V
Operating Temperature Range	
MM74C922, MM74C923	−40°C to +85°C
Storage Temperature Range	−65°C to +150°C
Power Dissipation (P_D)	
Dual-In-Line	700 mW
Small Outline	500 mW
Operating V_{CC} Range	3V to 15V
V_{CC}	18V
Lead Temperature	
(Soldering, 10 seconds)	260°C

Note 2: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. Except for "Operating Temperature Range" they are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" provides conditions for actual device operation.

DC Electrical Characteristics

Min/Max limits apply across temperature range unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units
CMOS TO CMOS						
V_{T+}	Positive-Going Threshold Voltage at Osc and KBM Inputs	V_{CC} = 5V, $I_{IN} \geq$ 0.7 mA	3.0	3.6	4.3	V
		V_{CC} = 10V, $I_{IN} \geq$ 1.4 mA	6.0	6.8	8.6	V
		V_{CC} = 15V, $I_{IN} \geq$ 2.1 mA	9.0	10	12.9	V
V_{T-}	Negative-Going Threshold Voltage at Osc and KBM Inputs	V_{CC} = 5V, $I_{IN} \geq$ 0.7 mA	0.7	1.4	2.0	V
		V_{CC} = 10V, $I_{IN} \geq$ 1.4 mA	1.4	3.2	4.0	V
		V_{CC} = 15V, $I_{IN} \geq$ 2.1 mA	2.1	5	6.0	V
$V_{IN(1)}$	Logical "1" Input Voltage, Except Osc and KBM Inputs	V_{CC} = 5V	3.5	4.5		V
		V_{CC} = 10V	8.0	9		V
		V_{CC} = 15V	12.5	13.5		V
$V_{IN(0)}$	Logical "0" Input Voltage, Except Osc and KBM Inputs	V_{CC} = 5V		0.5	1.5	V
		V_{CC} = 10V		1	2	V
		V_{CC} = 15V		1.5	2.5	V
I_{rp}	Row Pull-Up Current at Y1, Y2, Y3, Y4 and Y5 Inputs	V_{CC} = 5V, V_{IN} = 0.1 V_{CC}		−2	−5	μA
		V_{CC} = 10V		−10	−20	μA
		V_{CC} = 15V		−22	−45	μA
$V_{OUT(1)}$	Logical "1" Output Voltage	V_{CC} = 5V, I_O = −10 μA	4.5			V
		V_{CC} = 10V, I_O = −10 μA	9			V
		V_{CC} = 15V, I_O = −10 μA	13.5			V
$V_{OUT(0)}$	Logical "0" Output Voltage	V_{CC} = 5V, I_O = 10 μA			0.5	V
		V_{CC} = 10V, I_O = 10 μA			1	V
		V_{CC} = 15V, I_O = 10 μA			1.5	V
R_{on}	Column "ON" Resistance at X1, X2, X3 and X4 Outputs	V_{CC} = 5V, V_O = 0.5V		500	1400	Ω
		V_{CC} = 10V, V_O = 1V		300	700	Ω
		V_{CC} = 15V, V_O = 1.5V		200	500	Ω
I_{CC}	Supply Current Osc at 0V, (one Y low)	V_{CC} = 5V		0.55	1.1	mA
		V_{CC} = 10V		1.1	1.9	mA
		V_{CC} = 15V		1.7	2.6	mA
$I_{IN(1)}$	Logical "1" Input Current at $\overline{\text{Output Enable}}$	V_{CC} = 15V, V_{IN} = 15V		0.005	1.0	μA
$I_{IN(0)}$	Logical "0" Input Current at $\overline{\text{Output Enable}}$	V_{CC} = 15V, V_{IN} = 0V	−1.0	−0.005		μA
CMOS/LPTTL INTERFACE						
$V_{IN(1)}$	Except Osc and KBM Inputs	V_{CC} = 4.75V	V_{CC} − 1.5			V
$V_{IN(0)}$	Except Osc and KBM Inputs	V_{CC} = 4.75V			0.8	V
$V_{OUT(1)}$	Logical "1" Output Voltage	I_O = −360 μA, V_{CC} = 4.75V, I_O = −360 μA	2.4			V

DC Electrical Characteristics (Continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{OUT(0)}$	Logical "0" Output Voltage	$I_O = -360\ \mu A$ $V_{CC} = 4.75V$ $I_O = -360\ \mu A$			0.4	V
OUTPUT DRIVE (See Family Characteristics Data Sheet) (Short Circuit Current)						
I_{SOURCE}	Output Source Current (P-Channel)	$V_{CC} = 5V$, $V_{OUT} = 0V$, $T_A = 25°C$	−1.75	−3.3		mA
I_{SOURCE}	Output Source Current (P-Channel)	$V_{CC} = 10V$, $V_{OUT} = 0V$, $T_A = 25°C$	-8	−15		mA
I_{SINK}	Output Sink Current (N-Channel)	$V_{CC} = 5V$, $V_{OUT} = V_{CC}$, $T_A = 25°C$	1.75	3.6		mA
I_{SINK}	Output Sink Current (N-Channel)	$V_{CC} = 10V$, $V_{OUT} = V_{CC}$, $T_A = 25°C$	8	16		mA

AC Electrical Characteristics (Note 3)

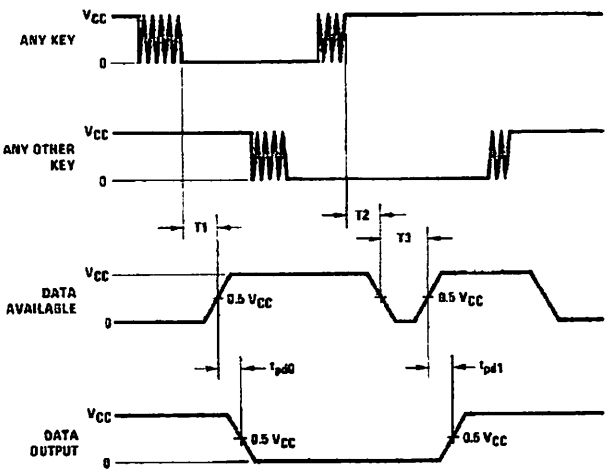
$T_A = 25°C$, $C_L = 50$ pF, unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{pd0}, t_{pd1}	Propagation Delay Time to Logical "0" or Logical "1" from D.A.	$C_L = 50$ pF (Figure 1) $V_{CC} = 5V$ $V_{CC} = 10V$ $V_{CC} = 15V$		60 35 25	150 80 60	ns ns ns
t_{0H}, t_{1H}	Propagation Delay Time from Logical "0" or Logical "1" into High Impedance State	$R_L = 10k$, $C_L = 10$ pF (Figure 2) $V_{CC} = 5V$, $R_L = 10k$ $V_{CC} = 10V$, $C_L = 10$ pF $V_{CC} = 15V$		80 65 50	200 150 110	ns ns ns
t_{H0}, t_{H1}	Propagation Delay Time from High Impedance State to a Logical "0" or Logical "1"	$R_L = 10k$, $C_L = 50$ pF (Figure 2) $V_{CC} = 5V$, $R_L = 10k$ $V_{CC} = 10V$, $C_L = 50$ pF $V_{CC} = 15V$		100 55 40	250 125 90	ns ns ns
C_{IN}	Input Capacitance	Any Input (Note 4)		5	7.5	pF
C_{OUT}	3-STATE Output Capacitance	Any Output (Note 4)		10		pF

Note 3: AC Parameters are guaranteed by DC correlated testing.

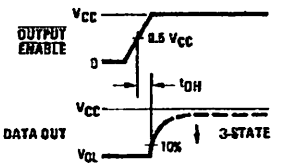
Note 4: Capacitance is guaranteed by periodic testing.

Switching Time Waveforms



T1 = T2 = RC, T3 = 0.7 RC, where R = 10k and C is external capacitor at KBM input.

FIGURE 1.



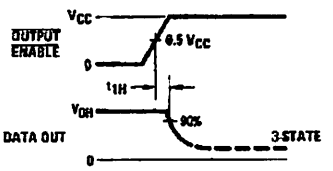
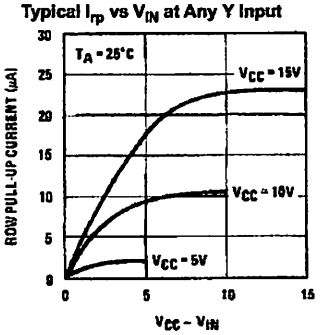


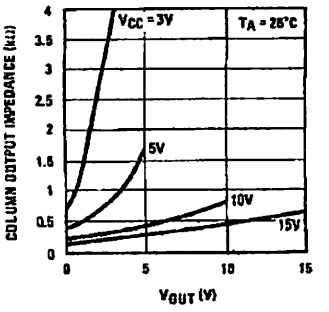
FIGURE 2.

Typical Performance Characteristics

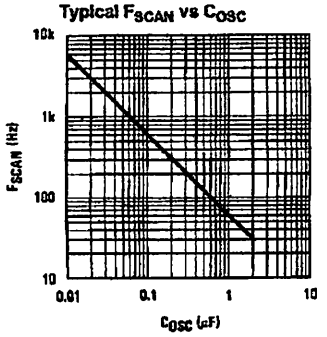
Typical I_{rp} vs V_{IN} at Any Y Input



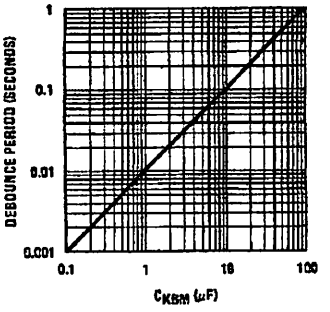
Typical R_{on} vs V_{OUT} at Any X Output



Typical F_{SCAN} vs C_{OSC}

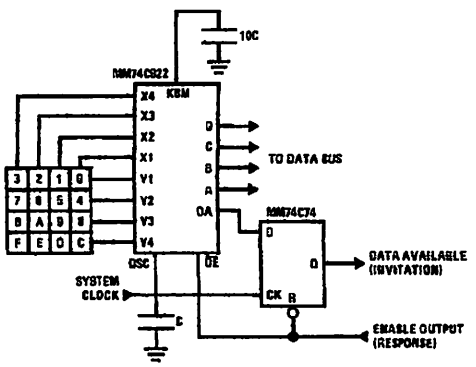


Typical Debounce Period vs C_{KBM}



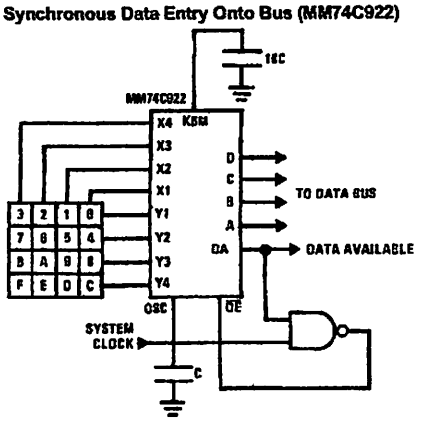
Typical Applications

Synchronous Handshake (MM74C922)



The keyboard may be synchronously scanned by omitting the capacitor at osc. and driving osc. directly if the system clock rate is lower than 10 kHz

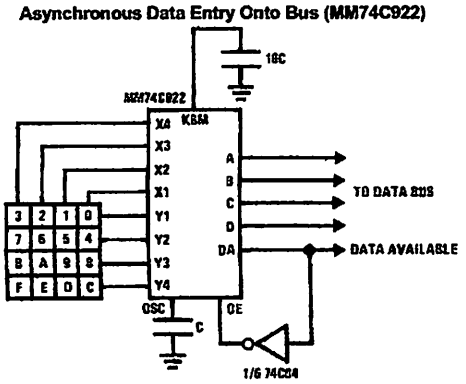
Synchronous Data Entry Onto Bus (MM74C922)



Outputs are enabled when valid entry is made and go into 3-STATE when key is released.

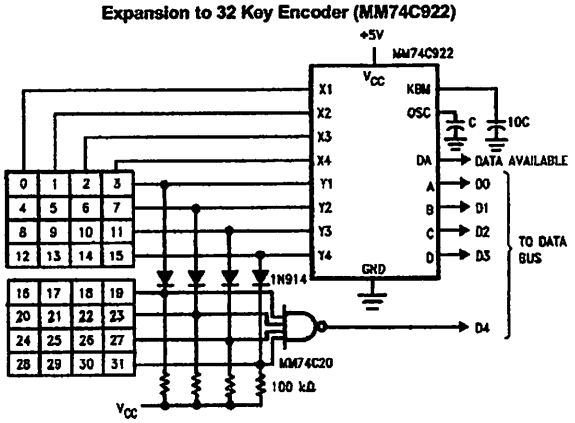
The keyboard may be synchronously scanned by omitting the capacitor at osc. and driving osc. directly if the system clock rate is lower than 10 kHz

Asynchronous Data Entry Onto Bus (MM74C922)



Outputs are in 3-STATE until key is pressed, then data is placed on bus. When key is released, outputs return to 3-STATE.

Expansion to 32 Key Encoder (MM74C922)



Theory of Operation

The MM74C922/MM74C923 Keyboard Encoders implement all the logic necessary to interface a 16 or 20 SPST key switch matrix to a digital system. The encoder will convert a key switch closer to a 4(MM74C922) or 5(MM74C923) bit nibble. The designer can control both the keyboard scan rate and the key debounce period by altering the oscillator capacitor, C_{OSE}, and the key bounce mask capacitor, C_{MSK}. Thus, the MM74C922/MM74C923's performance can be optimized for many keyboards.

The keyboard encoders connect to a switch matrix that is 4 rows by 4 columns (MM74C922) or 5 rows by 4 columns (MM74C923). When no keys are depressed, the row inputs are pulled high by internal pull-ups and the column outputs sequentially output a logic "0". These outputs are open drain and are therefore low for 25% of the time and otherwise off. The column scan rate is controlled by the oscillator input, which consists of a Schmitt trigger oscillator, a 2-bit counter, and a 2–4-bit decoder.

When a key is depressed, key 0, for example, nothing will happen when the X1 input is off, since Y1 will remain high. When the X1 column is scanned, X1 goes low and Y1 will go low. This disables the counter and keeps X1 low. Y1 going low also initiates the key bounce circuit timing and locks out the other Y inputs. The key code to be output is a combination of the frozen counter value and the decoded Y inputs. Once the key bounce circuit times out, the data is latched, and the Data Available (DAV) output goes high.

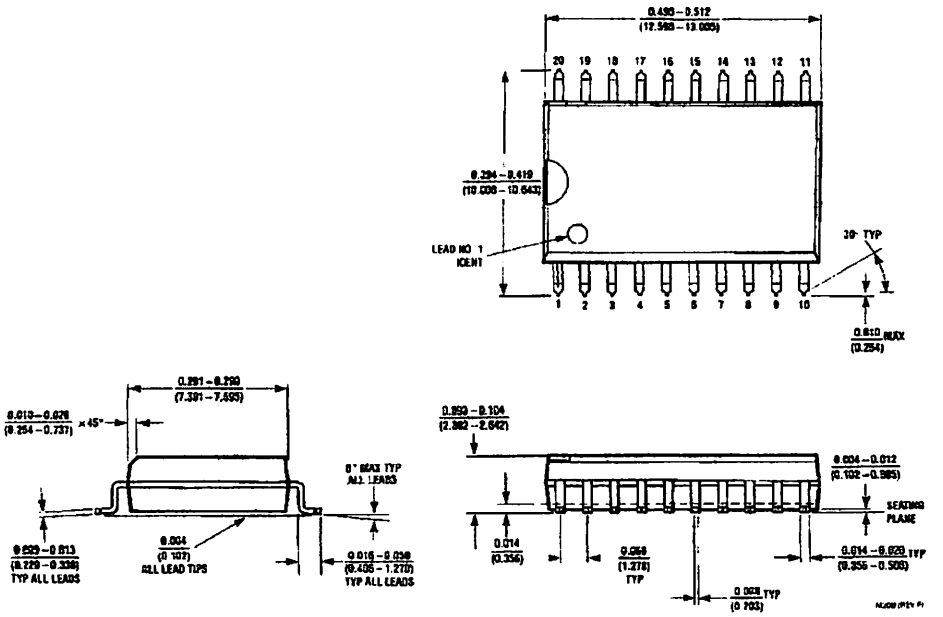
If, during the key closure the switch bounces, Y1 input will go high again, restarting the scan and resetting the key bounce circuitry. The key may bounce several times, but as soon as the switch stays low for a debounce period, the closure is assumed valid and the data is latched.

A key may also bounce when it is released. To ensure that the encoder does not recognize this bounce as another key closure, the debounce circuit must time out before another closure is recognized.

The two-key roll-over feature can be illustrated by assuming a key is depressed, and then a second key is depressed. Since all scanning has stopped, and all other Y inputs are disabled, the second key is not recognized until the first key is lifted and the key bounce circuitry has reset.

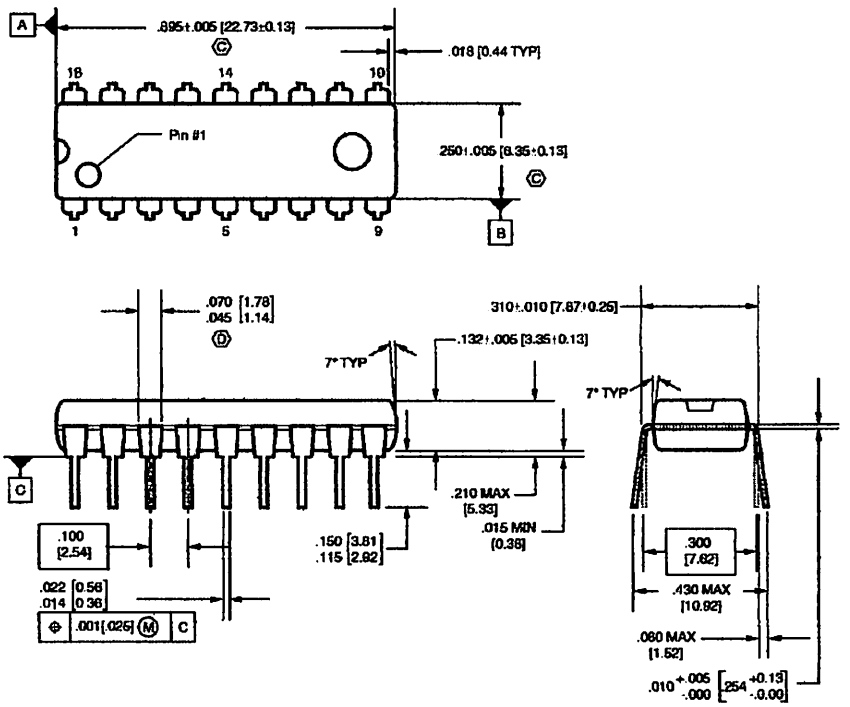
The output latches feed 3-STATE, which is enabled when the Output Enable ($\overline{OE}$) input is taken low.

Physical Dimensions inches (millimeters) unless otherwise noted



20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300" Wide
Package Number M20B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

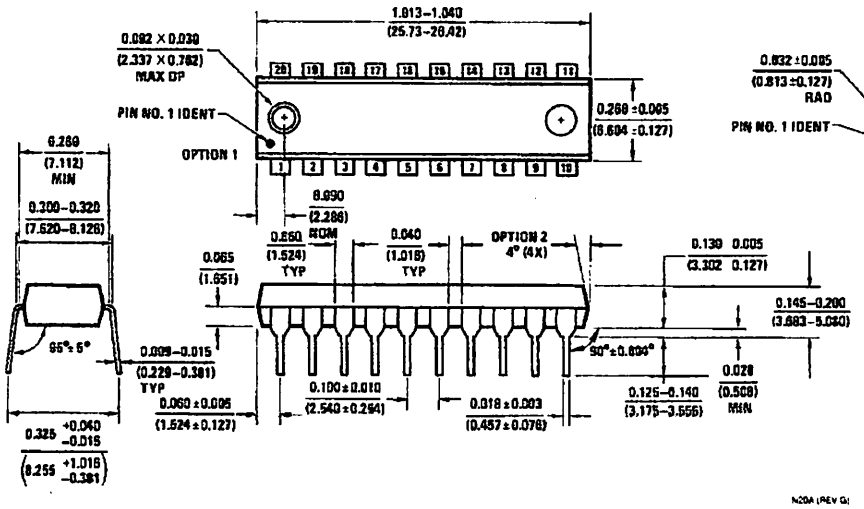


NOTES:
A. CONFORMS TO JEDEC REGISTRATION MS-001, VARIATIONS AC, DATED 6/1993.
B. CONTROLLING DIMENSIONS ARE IN INCHES REFERENCE DIMENSIONS ARE IN MILLIMETERS.
C. DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCHES OR 0.25MM.
D. DOES NOT INCLUDE DAMBAR PROTRUSIONS. DAMBAR PROTRUSIONS SHALL NOT EXCEED .010 INCHES OR 0.25MM.
E. DIMENSIONING AND TOLERANCING PER ASMEY14.5M-1994.

N18BrevA

18-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide
Package Number N18B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



20-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide
Package Number N20A

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2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

www.fairchildsemi.com

March 1998

FAIRCHILD SEMICONDUCTOR™

DM74LS573
Octal D Latch with 3-STATE Outputs

General Description

The 'LS573 is a high speed octal latch with buffered common Latch Enable (LE) and buffered common Output Enable ($\overline{OE}$) inputs.

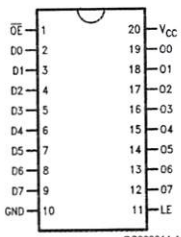
This device is functionally identical to the 'LS373, but has different pinouts. For truth tables, discussion of operations and AC and DC specifications, please refer to the 'LS373 data sheet.

Features

- Inputs and outputs on opposite sides of package allowing easy interface with microprocessors
- Useful as input or output port for microprocessors
- Functionally identical to 'LS373
- Input clamp diodes limit high speed termination effects
- Fully TTL and CMOS compatible

Connection Diagram

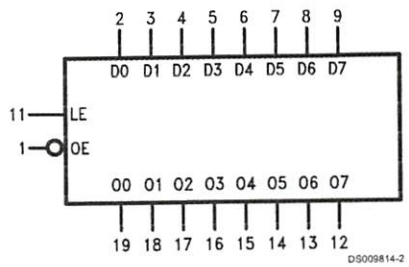
Dual-In-Line Package



DS009814-1

Order Number DM74LS573WM or DM74LS573N
See Package Number M20B or N20A

Logic Symbol



DS009814-2

V_{CC} = Pin 20
GND = Pin 10

Pin Names	Description
D0–D7	Data Inputs
LE	Latch Enable Input (Active HIGH)
$\overline{OE}$	3-STATE Output Enable Input (Active LOW)
O0–O7	3-STATE Latch Outputs

Function Table

$\overline{OUTPUT}$ Enable	Latch Enable	D	Output $\overline{O}$
L	H	H	H
L	H	L	L
L	L	X	Q_O
H	X	X	Z

L = Low State, H = High State, X = Don't Care
Z = High Impedance State
Q_O = Previous Condition of O

Absolute Maximum Ratings (Note 1)

Supply Voltage	7V
Input Voltage	7V
Operating Free Air Temperature Range	
DM74LS	0°C to +70°C
Storage Temperature Range	−65°C to +150°C

Recommended Operating Conditions

Symbol	Parameter	DM74LS			Units
		Min	Nom	Max	
V_{CC}	Supply Voltage	4.75	5	5.25	V
V_{IH}	High Level Input Voltage	2			V
V_{IL}	Low Level Input Voltage			0.8	V
I_{OH}	High Level Input Current			−2.6	mA
I_{OL}	Low Level Output Current			24	mA
T_A	Free Air Operating Temperature	0		70	°C

Note 1: *The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the "Electrical Characteristics" table are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.*

Electrical Characteristics

Over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ (Note 2)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −18 mA			−1.5	V
V_{OH}	High Level Output Voltage	V_{CC} = Min, I_{OH} = Max, V_{IL} = Max	2.7	3.4		V
V_{OL}	Low Level Output Voltage	V_{CC} = Min, I_{OL} = Max, V_{IH} = Min		0.35	0.5	V
		I_{OL} = 4 mA, V_{CC} = Min		0.25	0.4	
I_I	Input Current @ Max Input Voltage	V_{CC} = Max, V_I = 7V			1	mA
I_{IH}	High Level Input Current	V_{CC} = Max, V_I = 2.7V			20	µA
I_{IL}	Low Level Input Current	V_{CC} = Max, V_I = 0.4V			−0.4	mA
I_{OS}	Short Circuit Output Current	V_{CC} = Max (Note 3)	−30		−130	mA
I_{CC}	Supply Current	V_{CC} = Max			50	mA
I_{OZH}	3-STATE Output off Current High	V_{CC} = V_{CCH} V_{OZH} = 2.7V			20	µA
I_{OZL}	3-STATE Output off Current Low	V_{CC} = V_{CCH} V_{OZL} = 0.4V			−20	µA

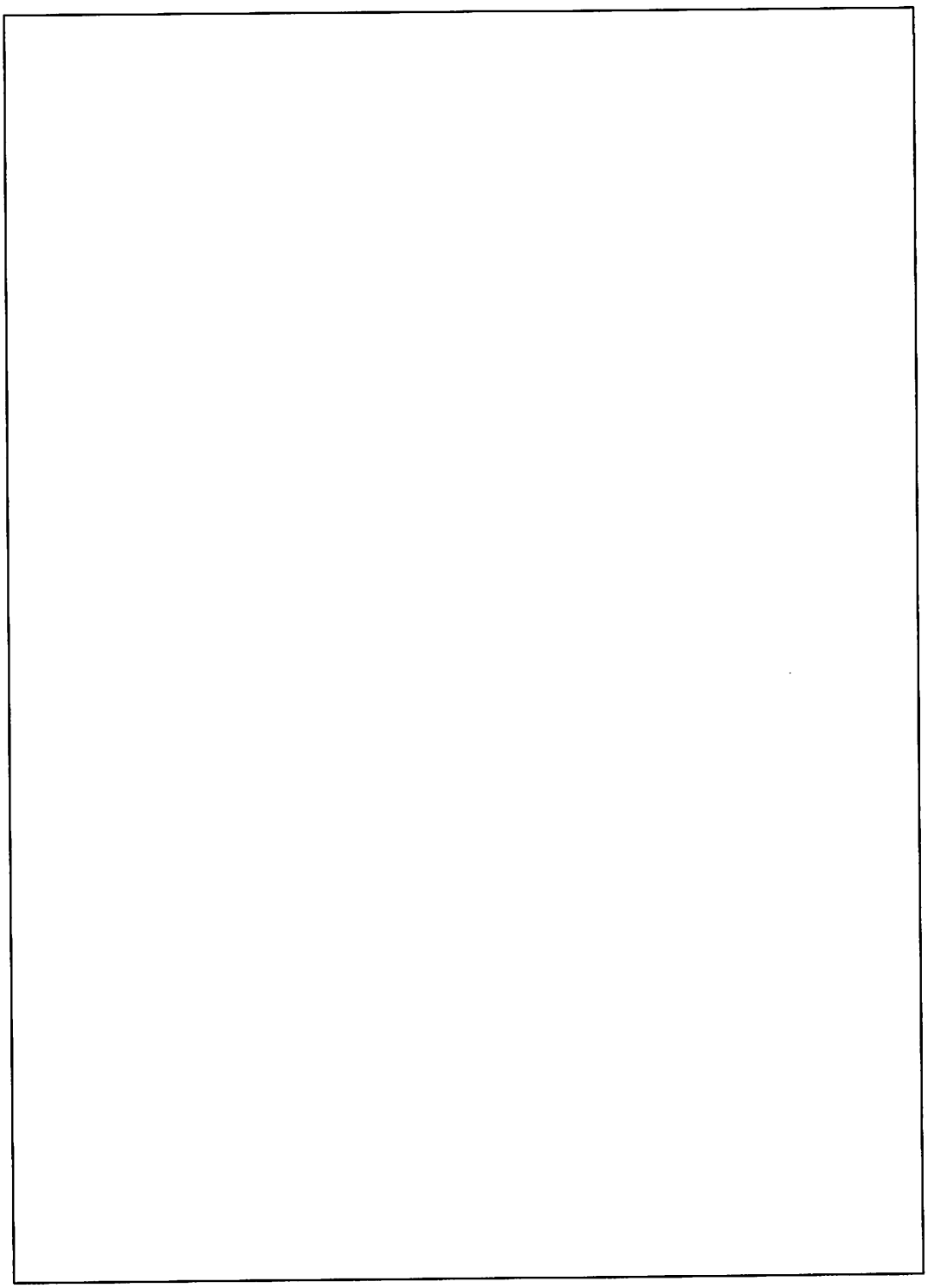
Note 2: All typicals are at V_{CC} = 5V, T_A = 25°C.

Note 3: Not more than one output should be shorted at a time, and the duration should not exceed one second.

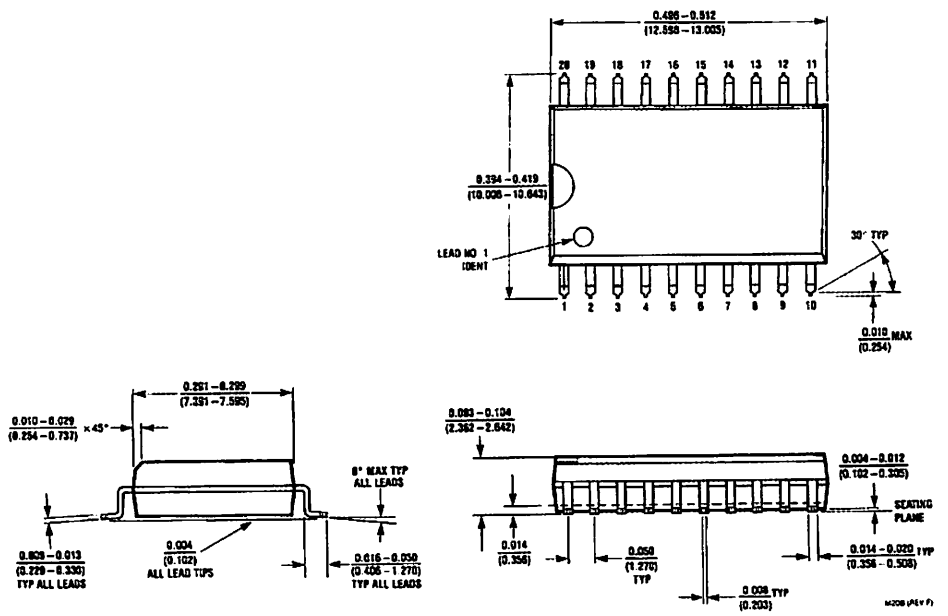
Switching Characteristics

at V_{CC} = 5V and T_A = 25°C (see Section 1 for Test Waveforms and output loading)

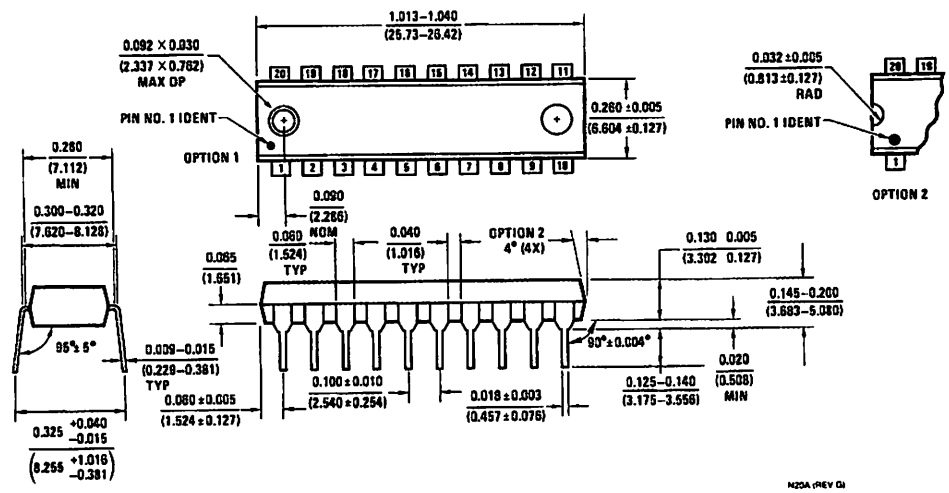
Symbol	Parameter	R_L = 2 kΩ, C_L = 50 pF		Units
		Min	Max	
t_{PLH}	Propagation Delay		27	ns
t_{PHL}	Data to Q		18	
t_{PLH}	Propagation Delay		36	ns
t_{PHL}	LE to Q		25	
t_{PZH}	3-STATE Enable Time		20	ns
t_{PZL}	$\overline{OE}$ to Q		25	
t_{PHZ}	3-STATE Enable Time		20	ns
t_{PLZ}	$\overline{OE}$ to Q		25	
$t_s(H)$	Setup Time (High/Low)	3		ns
$t_s(L)$	Data to LE	7		
$t_h(H)$	Hold Time (High/Low)	10		ns
$t_h(L)$	Data to LE	10		
$t_w(H)$	Pulse Width (High)	15		ns
	Data to LE			



Physical Dimensions inches (millimeters) unless otherwise noted



20-Lead Wide Small Outline Molded Package (M)
Order Number DM74LS573WM
Package Number M20B



20-Lead Molded Dual-In-Line Package (N)
Order Number DM74LS573N
Package Number N20A

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2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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August 1986
Revised March 2000

DM74LS138 • DM74LS139
Decoder/Demultiplexer

General Description

These Schottky-clamped circuits are designed to be used in high-performance memory-decoding or data-routing applications, requiring very short propagation delay times. In high-performance memory systems these decoders can be used to minimize the effects of system decoding. When used with high-speed memories, the delay times of these decoders are usually less than the typical access time of the memory. This means that the effective system delay introduced by the decoder is negligible.

The DM74LS138 decodes one-of-eight lines, based upon the conditions at the three binary select inputs and the three enable inputs. Two active-low and one active-high enable inputs reduce the need for external gates or inverters when expanding. A 24-line decoder can be implemented with no external inverters, and a 32-line decoder requires only one inverter. An enable input can be used as a data input for demultiplexing applications.

The DM74LS139 comprises two separate two-line-to-four-line decoders in a single package. The active-low enable input can be used as a data line in demultiplexing applications.

All of these decoders/demultiplexers feature fully buffered inputs, presenting only one normalized load to its driving circuit. All inputs are clamped with high-performance Schottky diodes to suppress line-ringing and simplify system design.

Features

- Designed specifically for high speed:
  - Memory decoders
  - Data transmission systems
- DM74LS138 3-to-8-line decoders incorporates 3 enable inputs to simplify cascading and/or data reception
- DM74LS139 contains two fully independent 2-to-4-line decoders/demultiplexers
- Schottky clamped for high performance
- Typical propagation delay (3 levels of logic)
  - DM74LS138 21 ns
  - DM74LS139 21 ns
- Typical power dissipation
  - DM74LS138 32 mW
  - DM74LS139 34 mW

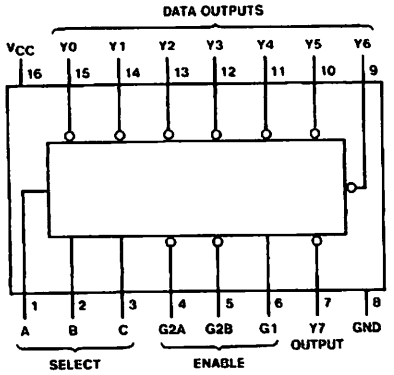
Ordering Code:

Order Number	Package Number	Package Description
DM74LS138M	M16A	16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150 Narrow
DM74LS138SJ	M16D	16-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
DM74LS138N	N16E	16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide
DM74LS139M	M16A	16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150 Narrow
DM74LS139SJ	M16D	16-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
DM74LS139N	N16E	16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide

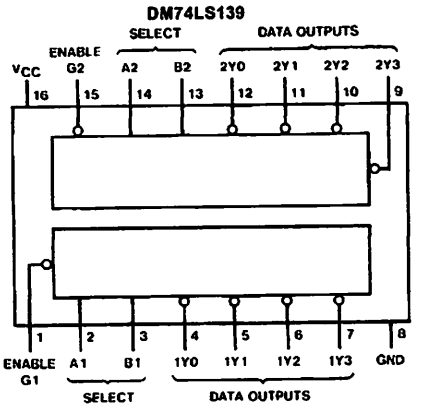
Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

Connection Diagrams

DM74LS138



DM74LS139



Function Tables

DM74LS138

Inputs					Outputs							
Enable		Select										
G1	G2 (Note 1)	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	H	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	H	H	H	H	H	L	H	H	H	H
H	L	H	L	L	H	H	H	H	L	H	H	H
H	L	H	L	H	H	H	H	H	H	L	H	H
H	L	H	H	L	H	H	H	H	H	H	L	H
H	L	H	H	H	H	H	H	H	H	H	H	L

DM74LS139

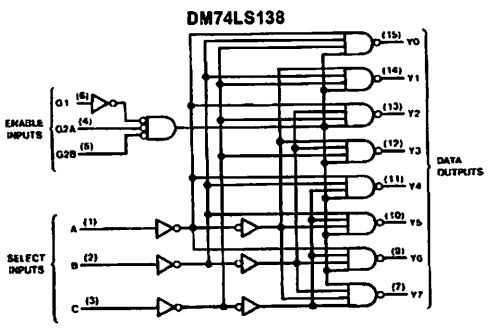
Inputs			Outputs			
Enable	Select					
G	B	A	Y0	Y1	Y2	Y3
H	X	X	H	H	H	H
L	L	L	L	H	H	H
L	L	H	H	L	H	H
L	H	L	H	H	L	H
L	H	H	H	H	H	L

H = HIGH Level
L = LOW Level
X = Don't Care

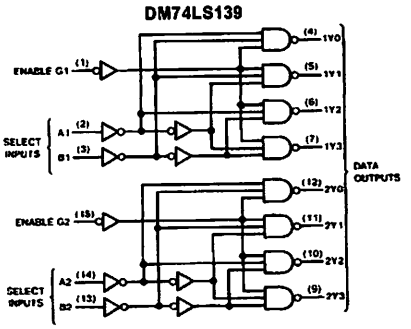
Note 1: G2 = G2A + G2B

Logic Diagrams

DM74LS138



DM74LS139



Absolute Maximum Ratings(Note 2)

Supply Voltage	7V
Input Voltage	7V
Operating Free Air Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C

Note 2: The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

DM74LS138 Recommended Operating Conditions

Symbol	Parameter	Min	Nom	Max	Units
V_{CC}	Supply Voltage	4.75	5	5.25	V
V_{IH}	HIGH Level Input Voltage	2			V
V_{IL}	LOW Level Input Voltage			0.8	V
I_{OH}	HIGH Level Output Current			−0.4	mA
I_{OL}	LOW Level Output Current			8	mA
T_A	Free Air Operating Temperature	0		70	°C

DM74LS138 Electrical Characteristics

over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ (Note 3)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −18 mA			−1.5	V
V_{OH}	HIGH Level Output Voltage	V_{CC} = Min, I_{OH} = Max, V_{IL} = Max, V_{IH} = Min	2.7	3.4		V
V_{OL}	LOW Level Output Voltage	V_{CC} = Min, I_{OL} = Max, V_{IL} = Max, V_{IH} = Min		0.35	0.5	V
		I_{OL} = 4 mA, V_{CC} = Min		0.25	0.4	
I_I	Input Current @ Max Input Voltage	V_{CC} = Max, V_I = 7V			0.1	mA
I_{IH}	HIGH Level Input Current	V_{CC} = Max, V_I = 2.7V			20	µA
I_{IL}	LOW Level Input Current	V_{CC} = Max, V_I = 0.4V			−0.36	mA
I_{OS}	Short Circuit Output Current	V_{CC} = Max (Note 4)	−20		−100	mA
I_{CC}	Supply Current	V_{CC} = Max (Note 5)		6.3	10	mA

Note 3: All typicals are at V_{CC} = 5V, T_A = 25°C.

Note 4: Not more than one output should be shorted at a time, and the duration should not exceed one second.

Note 5: I_{CC} is measured with all outputs enabled and OPEN.

DM74LS138 Switching Characteristics

at V_{CC} = 5V and T_A = 25°C

Symbol	Parameter	From (Input) To (Output)	Levels of Delay	R_L = 2 kΩ				Units
				C_L = 15 pF		C_L = 50 pF		
				Min	Max	Min	Max	
t_{PLH}	Propagation Delay Time LOW-to-HIGH Level Output	Select to Output	2		18		27	ns
t_{PHL}	Propagation Delay Time HIGH-to-LOW Level Output	Select to Output	2		27		40	ns
t_{PLH}	Propagation Delay Time LOW-to-HIGH Level Output	Select to Output	3		18		27	ns
t_{PHL}	Propagation Delay Time HIGH-to-LOW Level Output	Select to Output	3		27		40	ns
t_{PLH}	Propagation Delay Time LOW-to-HIGH Level Output	Enable to Output	2		18		27	ns
t_{PHL}	Propagation Delay Time HIGH-to-LOW Level Output	Enable to Output	2		24		40	ns
t_{PLH}	Propagation Delay Time LOW-to-HIGH Level Output	Enable to Output	3		18		27	ns
t_{PHL}	Propagation Delay Time HIGH-to-LOW Level Output	Enable to Output	3		28		40	ns

DM74LS139 Recommended Operating Conditions

Symbol	Parameter	Min	Nom	Max	Units
V_{CC}	Supply Voltage	4.75	5	5.25	V
V_{IH}	HIGH Level Input Voltage	2			V
V_{IL}	LOW Level Input Voltage			0.8	V
I_{OH}	HIGH Level Output Current			−0.4	mA
I_{OL}	LOW Level Output Current			8	mA
T_A	Free Air Operating Temperature	0		70	°C

DM74LS139 Electrical Characteristics

over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ (Note 6)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −18 mA			−1.5	V
V_{OH}	HIGH Level Output Voltage	V_{CC} = Min, I_{OH} = Max, V_{IL} = Max, V_{IH} = Min	2.7	3.4		V
V_{OL}	LOW Level Output Voltage	V_{CC} = Min, I_{OL} = Max, V_{IL} = Max, V_{IH} = Min		0.35	0.5	V
		I_{OL} = 4 mA, V_{CC} = Min		0.25	0.4	
I_I	Input Current @ Max Input Voltage	V_{CC} = Max, V_I = 7V			0.1	mA
I_{IH}	HIGH Level Input Current	V_{CC} = Max, V_I = 2.7V			20	µA
I_{IL}	LOW Level Input Current	V_{CC} = Max, V_I = 0.4V			−0.36	mA
I_{OS}	Short Circuit Output Current	V_{CC} = Max (Note 7)	−20		−100	mA
I_{CC}	Supply Current	V_{CC} = Max (Note 8)		6.8	11	mA

Note 6: All typicals are at V_{CC} = 5V, T_A = 25°C.

Note 7: Not more than one output should be shorted at a time, and the duration should not exceed one second.

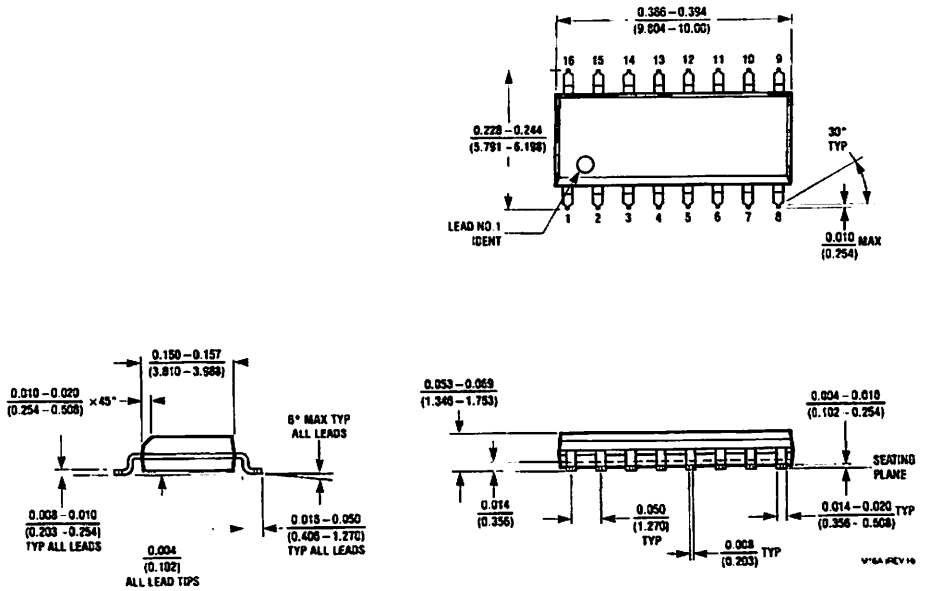
Note 8: I_{CC} is measured with all outputs enabled and OPEN.

DM74LS139 Switching Characteristics

at V_{CC} = 5V and T_A = 25°C

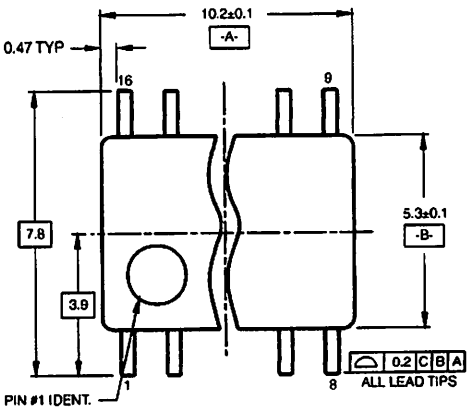
Symbol	Parameter	From (Input) To (Output)	R_L = 2 kΩ				Units
			C_L = 15 pF		C_L = 50 pF		
			Min	Max	Min	Max	
t_{PLH}	Propagation Delay Time LOW-to-HIGH Level Output	Select to Output		18		27	ns
t_{PHL}	Propagation Delay Time HIGH-to-LOW Level Output	Select to Output		27		40	ns
t_{PLH}	Propagation Delay Time LOW-to-HIGH Level Output	Enable to Output		18		27	ns
t_{PHL}	Propagation Delay Time HIGH-to-LOW Level Output	Enable to Output		24		40	ns

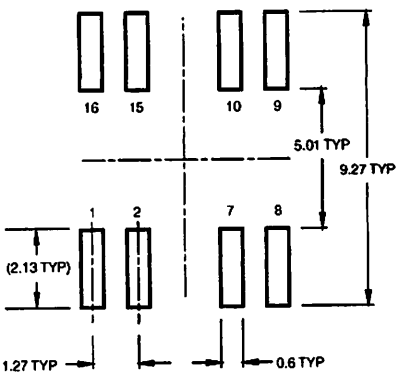
Physical Dimensions inches (millimeters) unless otherwise noted



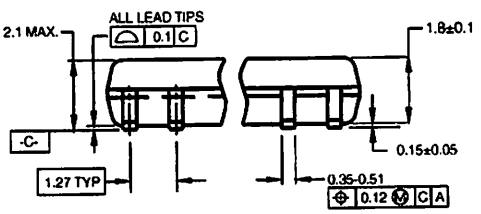
16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150 Narrow
Package Number M16A

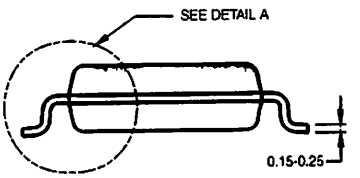
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



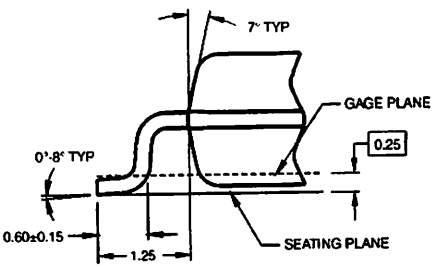


LAND PATTERN RECOMMENDATION





DIMENSIONS ARE IN MILLIMETERS



DETAIL A

NOTES:

A. CONFORMS TO EIAJ EDR-7320 REGISTRATION, ESTABLISHED IN DECEMBER, 1998.

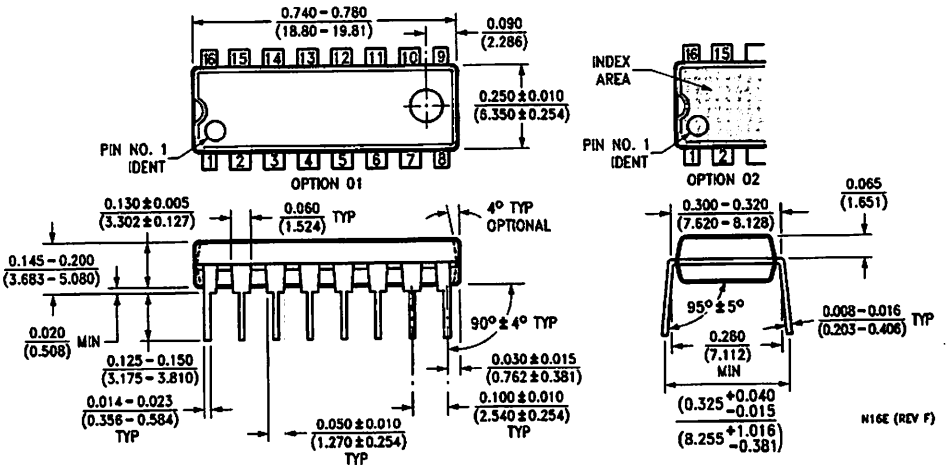
B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.

M16DRevB1

16-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
Package Number M16D

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide
Package Number N16E

FAIRCHILD
SEMICONDUCTOR™

August 1986
Revised March 2000

DM74LS244
Octal 3-STATE Buffer/Line Driver/Line Receiver

General Description

These buffers/line drivers are designed to improve both the performance and PC board density of 3-STATE buffers/drivers employed as memory-address drivers, clock drivers, and bus-oriented transmitters/receivers. Featuring 400 mV of hysteresis at each low current PNP data line input, they provide improved noise rejection and high fanout outputs and can be used to drive terminated lines down to 133Ω.

Features

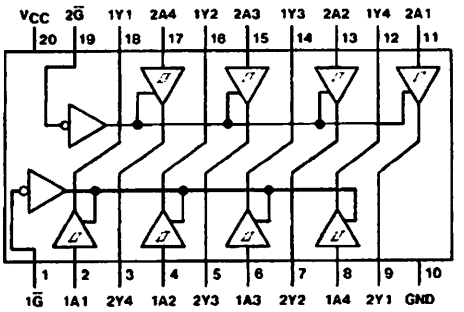
- 3-STATE outputs drive bus lines directly
- PNP inputs reduce DC loading on bus lines
- Hysteresis at data inputs improves noise margins
- Typical I_{OL} (sink current) 24 mA
- Typical I_{OH} (source current) −15 mA
- Typical propagation delay times
  - Inverting 10.5 ns
  - Noninverting 12 ns
- Typical enable/disable time 18 ns
- Typical power dissipation (enabled)
  - Inverting 130 mW
  - Noninverting 135 mW

Ordering Code:

Order Number	Package Number	Package Description
DM74LS244WM	M20B	20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300 Wide
DM74LS244SJ	M20D	20-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
DM74LS244N	N20A	20-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide

Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

Connection Diagram



Function Table

Inputs		Output
$\overline{G}$	A	Y
L	L	L
L	H	H
H	X	Z

L = LOW Logic Level
H = HIGH Logic Level
X = Either LOW or HIGH Logic Level
Z = High Impedance

Absolute Maximum Ratings(Note 1)

Supply Voltage	7V
Input Voltage	7V
Operating Free Air Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C

Note 1: The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

Recommended Operating Conditions

Symbol	Parameter	Min	Nom	Max	Units
V_{CC}	Supply Voltage	4.75	5	5.25	V
V_{IH}	HIGH Level Input Voltage	2			V
V_{IL}	LOW Level Input Voltage			0.8	V
I_{OH}	HIGH Level Output Current			−15	mA
I_{OL}	LOW Level Output Current			24	mA
T_A	Free Air Operating Temperature	0		70	°C

Electrical Characteristics

over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions		Min	Typ (Note 2)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −18 mA				−1.5	V
HYS	Hysteresis ($V_{T+} - V_{T-}$) Data Inputs Only	V_{CC} = Min		0.2	0.4		V
V_{OH}	HIGH Level Output Voltage	V_{CC} = Min, V_{IH} = Min V_{IL} = Max, I_{OH} = −1 mA		2.7			V
		V_{CC} = Min, V_{IH} = Min V_{IL} = Max, I_{OH} = −3 mA		2.4	3.4		
		V_{CC} = Min, V_{IH} = Min V_{IL} = 0.5V, I_{OH} = Max		2			
V_{OL}	LOW Level Output Voltage	V_{CC} = Min V_{IL} = Max V_{IH} = Min	I_{OL} = 12 mA			0.4	V
			I_{OL} = Max			0.5	
I_{OZH}	Off-State Output Current, HIGH Level Voltage Applied	V_{CC} = Max V_{IL} = Max V_{IH} = Min	V_O = 2.7V			20	µA
I_{OZL}	Off-State Output Current, LOW Level Voltage Applied		V_O = 0.4V			−20	µA
I_I	Input Current at Maximum Input Voltage	V_{CC} = Max	V_I = 7V			0.1	mA
I_{IH}	HIGH Level Input Current	V_{CC} = Max	V_I = 2.7V			20	µA
I_{IL}	LOW Level Input Current	V_{CC} = Max	V_I = 0.4V	−0.5		−200	µA
I_{OS}	Short Circuit Output Current	V_{CC} = Max (Note 3)		−40		−225	mA
I_{CC}	Supply Current	V_{CC} = Max, Outputs Open	Outputs HIGH		13	23	mA
			Outputs LOW		27	48	
			Outputs Disabled		32	54	

Note 2: All typicals are at V_{CC} = 5V, T_A = 25°C.

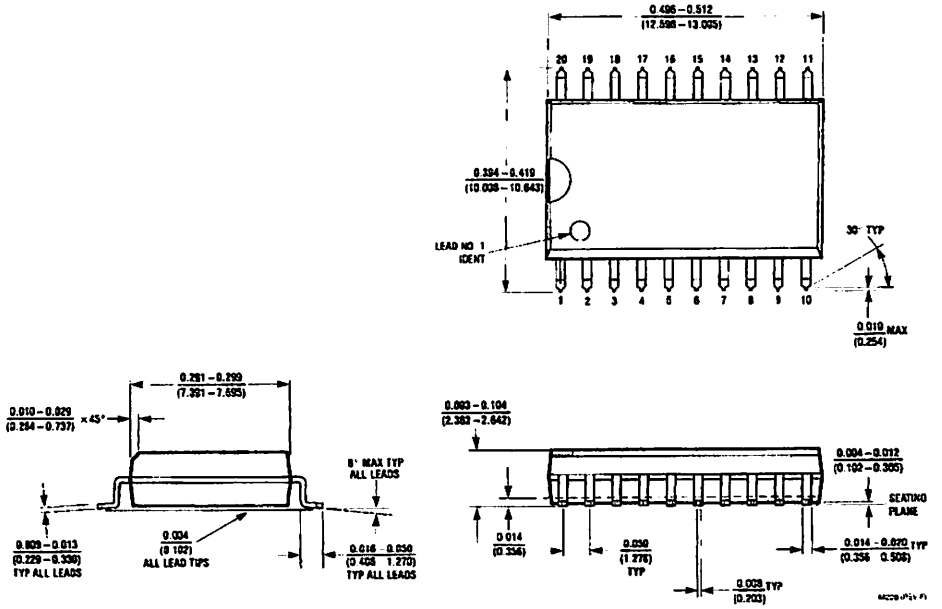
Note 3: Not more than one output should be shorted at a time, and the duration should not exceed one second.

Switching Characteristics

at V_{CC} = 5V, T_A = 25°C

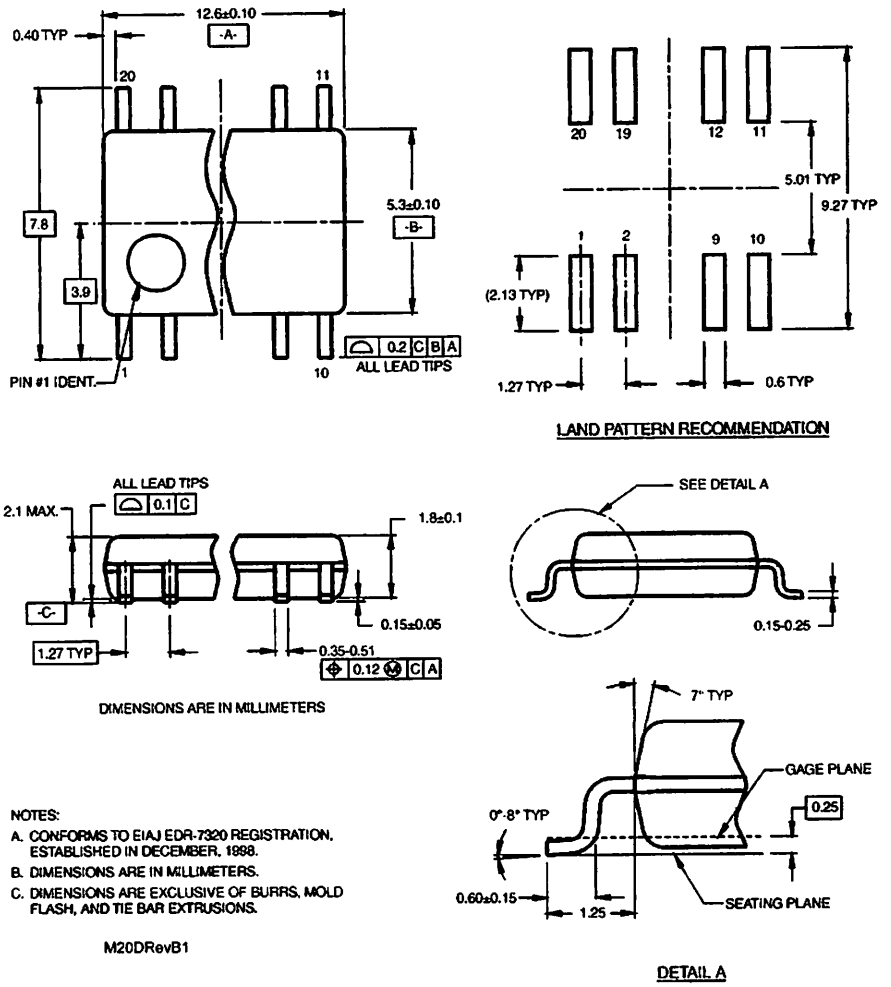
Symbol	Parameter	Conditions	Max	Units
t_{PLH}	Propagation Delay Time LOW-to-HIGH Level Output	C_L = 45 pF R_L = 667Ω	18	ns
t_{PHL}	Propagation Delay Time HIGH-to-LOW Level Output	C_L = 45 pF R_L = 667Ω	18	ns
t_{PZL}	Output Enable Time to LOW Level	C_L = 45 pF R_L = 667Ω	30	ns
t_{PZH}	Output Enable Time to HIGH Level	C_L = 45 pF R_L = 667Ω	23	ns
t_{PLZ}	Output Disable Time from LOW Level	C_L = 5 pF R_L = 667Ω	25	ns
t_{PHZ}	Output Disable Time from HIGH Level	C_L = 5 pF R_L = 667Ω	18	ns
t_{PLH}	Propagation Delay Time LOW-to-HIGH Level Output	C_L = 150 pF R_L = 667Ω	21	ns
t_{PHL}	Propagation Delay Time HIGH-to-LOW Level Output	C_L = 150 pF R_L = 667Ω	22	ns
t_{PZL}	Output Enable Time to LOW Level	C_L = 150 pF R_L = 667Ω	33	ns
t_{PZH}	Output Enable Time to HIGH Level	C_L = 150 pF R_L = 667Ω	26	ns

Physical Dimensions inches (millimeters) unless otherwise noted



20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300 Wide
Package Number M20B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



NOTES:

A. CONFORMS TO EIAJ EDR-7320 REGISTRATION, ESTABLISHED IN DECEMBER, 1998.

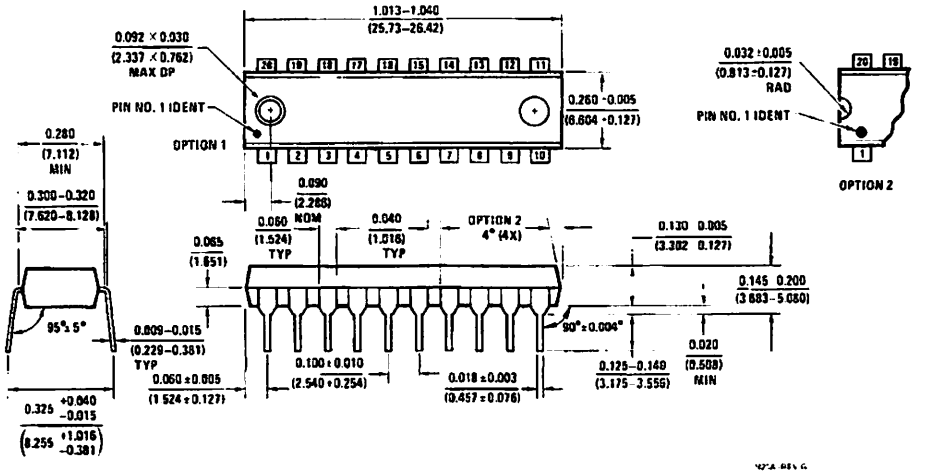
B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.

M20DRevB1

20-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
Package Number M20D

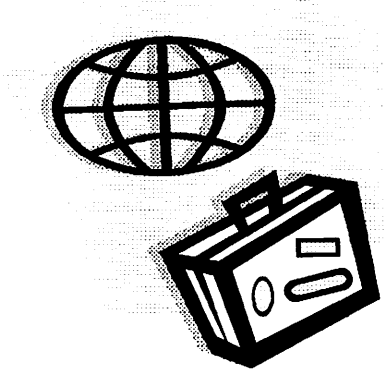
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



20-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide
Package Number N20A

Lampiran C

Perangkat Keras



Gambar Rangkaian Keseluruhan