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

PERENCANAAN DAN PEMBUATAN ALAT PENDETEKSI KEMIRINGAN MOBIL DILENGKAPI DENGAN SENSOR: PANAS RADIATOR, KECEPATAN, DAN BAHAN BAKAR DENGAN OUTPUT SUARA DAN DISPLAY DOT MATRIK BERBASIS MIKROKONTROLER AT89C51

SKRIPSI

Disusun Oleh:

AAN YUDHI ARTHA
00.17.272

APRIL 2005

LEMBAR PERSETUJUAN

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SKRIPSI

Disusun dan Diajukan untuk Melengkapi dan Memenuhi Syarat Guna Memperoleh Gelar Sarjana Teknik

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Judul Skripsi :

"PERENCANAAN DAN PEMBUATAN ALAT PENDETEKSI KEMIRINGAN MOBIL DILENGKAPI DENGAN SENSOR PANAS RADIATOR, KECEPATAN DAN BAHAN BAKAR, DENGAN OUTPUT SUARA DAN DISPLAY DOTMATRIK BERBASIS MIKROKONTROLER AT89C51 "

Dipertahankan Dihadapan Team Penguji Skripsi Jenjang Strata Satu (S-1) Pada :

Hari : Rabu

Tanggal : 30 Maret 2005

Dengan nilai : 84,75 (A)

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ABSTRAKSI

Aan Yudhi Artha, Konsentrasi Elektronika S1, Jurusan Teknik Elektro, Fakultas Teknologi Industri, Institut Teknologi Nasional Malang, Maret 2005, "Perencanaan dan Pembuatan Alat Pendeteksi Kemiringan mobil dilengkapi dengan sensor: panas radiator, kecepatan, bahan bakar dengan output suara dan display dotmatrik berbasis mikrokontroler AT89C51" Dosen Pembimbing Ir. F. Yudi Limpraptono, MT.

Dalam sebuah mobil offroad dashboard yang berisi papan display tentang keadaan mobil biasanya dilepas. Untuk lebih memudahkan seorang sopir mobil offroad dalam mengetahui perubahan keadaan mobilnya, maka dibutuhkan sebuah informasi yang jelas tentang kondisi yang bersangkutan dengan mobilnya, Display dibuat dari rangkaian dotmatrik, karena dengan dotmatrik didapat sebuah karakter huruf atau angka yang jelas dibandingkan dengan LCD, Untuk lebih interaktif dilengkapi dengan output suara sebagai peringatan bahaya.

Setelah perencanaan dan perancangan alat ini maka didapatkan berbagai kesimpulan yang bersangkutan dengan rangkaian sensor dan rangkaian display, diantaranya: untuk membuat range pengukuran yang baik maka hendaknya sensor dibuat dengan detail agar selisih antar range pengukuran dapat lebih halus. Untuk blok display menampilkan karakter yang panjang berarti dibutuhkan dotmatrik yang banyak juga, hal ini berpengaruh pada konsumsi daya yang diserap dotmatrik

KATA PENGANTAR

Dengan memanjatkan puji syukur atas semua rahmat, nikmat, musibah yang telah dikaruniakan ALLAH Swt. Alhamdulillahhirobilalamin. Penyusun dapat menyelesaikan skripsi ini dengan judul "Perencanaan dan Pembuatan Alat Pendeteksi Kemiringan mobil dilengkapi dengan sensor: panas radiator, kecepatan, bahan bakar dengan output suara dan display dotmatrik berbasis mikrokontroler AT89C51"

Penyusunan skripsi ini salah satu sarat untuk mendapatkan gelar sarjana (S1) pada konsentrasi Elektronika, jurusan Teknik Elektro, Fakultas Teknologi Industri, Institut Teknologi Nasional Malang.

Dalam penyusunan skripsi ini penyusun telah banyak mendapat bantuan dari berbagai pihak, untuk itu pada kesempatan kali ini penyusun mengucapkan terima kasih kepada

1. Dr. Ir. Abraham Lomi, MSEE selaku Rektor Institut Teknologi Nasional Malang.
2. Ir. Mochtar Asroni, MSME selaku Dekan Fakultas Teknologi Industri, Institut Teknologi Nasional Malang.
3. Ir. F. Yudi Limpraptono, MT. selaku Ketua Jurusan Teknik Elektro dan juga sebagai dosen Pembimbing
4. Semua orang yang telah membantu saya baik moral, spiritual, financial.

Akhir kata semoga skripsi ini dapat bermanfaat. Dan untukmenyempurnakan isi skripsi ini penyusun mengharap adanya kritik dan saran yang bersifat membangun dem,I kesempurnaan skripsi ini

Malang, Maret 2005

Penyusun

hard for describe when I was be a hard
obstacles, temptation, problem, gonna be surround my head
not strong enough ....

Sebetulnya dah nggak ada lagi kata ataupun perbuatan yang sanggup menggantikan pengorbanan m
mereka adalah...,
Kalo definisi mereka sih adalah kata ganti orang ketiga untuk jamak, tapi kalo menurutku mereka adalah
berupa barang , orang, itus bayang
Untuk Tuhaan Yang Maha Esa Alhamdulillah syukur atas semua rahmat, nikmat, musibah, dan semua
yang dia beri untukku, Aku tak bisa melihat kalo tak punya mata aku tak bisa bicara kalo tak punya
aku tak bisa berjalan kalo tak puny
Atas semua kemudahanya, atas semua musibahnya, aku tak paham kalo dalam suatu keterba
dalam suatu kesulitan, kesengsaraan ternyata, telah tercecer hikmah yang begitu b
bisa kalian bayangkan, suatu malam aku tak bisa tidur, melubernya masalah dalam
yang aku nggak kuat memikirkanya, satu per satu masalah itu mengelilingi kepalaku, besok pagi harus maju ke
untuk acc makalah skripsi, padahal makalah itu belum selesai kukerjakan, trus ngerjain alat, yang jelas butuh te
pikiran, uang, pas tubuh fisik ku nggak kuat, ntah mungkin karena sugesti atau keyakinan hingga aku bisa ber
padahal konsisi fisikku dah nggak memungkinkan, belum lagi kalo ada masalah dengan temen ato seseorang yang
mengganggu konsentrasi, trus lagi masalah finansial yang jujur saja nggak selaras dengan pikiran dan keperluanku, masala
yang kadang nggak selaras dengan orang orang disekelilingku, itu membuat aku ewuh pekewuh dengan lingkunganku berin
wah pokoknya nikmat deh, saat seperti itu, saat aku drop, mentalku jatuh, putus asa, tubuh dan fisik lemah, psyco terganggu, perut
banyak utang, aku terkena tremorrrrrrrrr otakku yang hanya beberapa mililiter nggak cukup memikir
Bapak Bambang Suyatno: ntah bagaimana beliau membagi pikiranya, terus terang bukan cuma aku yang dia pikirkan, masih
ibu yang jauh dirumah, memikirkan keluarga di ngawi, memikirkan dirinya sendiri dan segala keperluanya, memikirkan masalah kerja
belum lagi kalo aku menodongnya untuk uang yang harus kubayar sebagai sarat administrasi dikampus. Ibu Puji rahayuningsih di y
doa beliau yang tiap malam dipanjatkan. Walaupun aku jarang pulang ke rumah tapi aku bisa merasakan betapa manjurnya doa
Devi Rian Anarianto manusia yanhg sabar menjalankan hidup dan emosinya, habis ini kamu harus sekolah, masuk masa mudamu c
kerja, masih banyak yang belum kita ketahui diluar
THE NORT FACE seri Recon, tiap saat aku pergi kemanapun selalu menamaniku, celana gabrielle biru yang dah belel, dipadu tas pinggang A
seri ARM/125 emang dah klop. Dompet ALPINA Reg 244627, bandana seri 100%COTTON MADE IN USA C LEA INTERNATIONAL CLOTHIN
Sandal gunung CLAW, sepatu Hitam punk Ser MB.Hp seri ERICSON Gh388, pin TL Cre
Supported team at elka 56 Hadi Purnomo kamar dan tumpanganya tidur selama 4 tahun komputer INTEL PENTIUM III, 933, Naskah skripsiku selsai
komputermu mo. Ahmad rizky nautal punk neverdie boy, kita klop kalo ngomong masalah musik, janji kita akan keliling jawa bahkan ke bar
ampaian, Doni&Doni ngawi banget ne' ulanganya, petuahnya, makasih bangggeeeet, ambar apa dina beneran yah, hanya kamu yang be
kuat mempertahankanya, Nursahid , semua pertunjukan kehidupan yang Beliau tunjukan pada kita,....posti ketawa kalo lihat orang be
dibonceng sepeda motor trus pegangan erattt,mending dilepas mbak Jilbabnya. Hid kamu hanti jadi orang kaya. Hafid pelajaran elektroni
nggak selesa sampai disini, masih ingin tidur bareng di ruang 43.Dodik pegangannmu kuat sekali, sampai aku merasa nyaman saat kompre, ter
kamu dod, Ali muntaha kok bisa analis rangkaian kuat seperti itu lo, aku pingin les.Tony&Ruri bangun rumah dimana nanti? Aku lebaran tak sem
ke probolinggo tapi run harus janji mau serumah dengan maratuwa. YudiPurnomo&YogaAnggoro Kompak pool, mesti lo anak ild 22an
Andi ngrokok kuat, dibagi hari kurangi rokok. JULIANTO ,ST boleh kusebut pak jul? Ilmu yang beliau tularkan menjadi cahaya terang di akherat
Yudi Haryono diakir masa kuliahku membantu
Elka 34 Hendrik dan cita citanya, asyik boy.. tata, arab, semu
elka 12..................... Harusnya dari dulu kita lepas almamater kelas kita nggak ada 12 34 d
jangan kita harus kuat setelah i

analisa rangkaianGede Sumerta jaya, wow gila kalo bikin mekanik Jadi teknisi perusahaan terkenal c
Mbaru mania, ada yehu, haris, ari. Seneng kalo ngobrol bareng kamu,yokopo e
erdi, kak erwin nggak diajak gabung sih nik?. Kian Kalimantan Ari&duy&Achoo selain cakep tajir pula, main bola pinter juga.Republik madiun s
menteri indra biliardi, dan Mentri luar negri Berna S.Kaban, jadilah republik Game, semua orang harus punya komputer dan main Game, kalo
um ngegame harus mabook dulu.ake... Tapi takdoain cepet selasai kuliahmu amieen. Masandro nekat pool, Yusak, akirnya aku diajari gole" d
, teguh,ayo semangat. Yogi &udi.Untung bawa beras.elka 56 yang nggak bisa kusebut namanya...maaf dalam satu halaman kehik nggak mu
ku sebut semua, jasa&kebersamaan kita Aku pengin nagiiiiiissss
Masyarakat Landungsari Asri.......tempat aku membesarkan ide brilant TIRTOUTOM
urungnya semoga nggak pernah sepi obrolan gila. Om nanang&mbakEnd tumpanganya selama 4 tahun,Grapic design muda berbakat. Sad
grafisnya makasih wo, komputer ATHLON2300, menyimpan banyak design dan foto. Eksekutif muda berbakat Nakula, karier dan jaringanmu
lain pinter juga cekatan kalo bekerja,The twin devil adalah orang yang memupuk rasa creativeku dengan memamerkan karya karyanya kepa
Kamarnya mahasiswa, di kamarmu w
Fotografer muda berbakat Anton Kusnanto nggak pernah susah, selalu ceria, ntah gimana ngatur naik turunya e
Tapi sejak pertama ngerti anton belum pernah aku lihat dia meng
beda dengan aku yang mudah naik turun emosinya, apakah kita berdua kelainan. Adi kopi manis habis jam tayang, tapi skripsi jalan terus kan
kita janji ketemu di ambon yah, bukan kamu aja yang pengin kesana.Drummer muda berbakat Hendrum, karya yang dipamerkan selalu
h sama seperti orangnya, gila? Kadang garing juga, spt bocokan, tapi cerita juga kan nrdum. Yudo wujudkan dengan komik kita bisa belajar h
abu cakep, tapi ngongkelan.Hairstyler muda berbakat junet, walaupun males kuliah tapi tetep main ps kar
Nggak kuliah nggak papa tapi tetep ngopi. Makasih mode rambutku.Editorial muda berbakat, fery yang telah menerbitkan playm
ku terinspirasi atau plagiat ya. Mussi muda berbakat Abai, suatu saat kita dengerin jazz di restaurant gede minum capucino dengan cewek c

Elo Stronikst 56

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BAB I

1. Latar Belakang

Pada perkembangan teknologi abad ini, banyak digunakan instrumentasi elektronika yang dapat memudahkan manusia dalam menjalankan tugas keschariannya. Elektronika otomatisasi dinilai dapat menggantikan tugas para pekerja dengan efisiensi, praktis dan nyaman. Seorang sopir mobil offroad dapat mengetahui sesuatu yang terjadi dengan mobilnya dengan cepat karena seperti kita ketahui bahwa mobil offroad tidak menggunakan dashboard, jadi semua informasi dengan mobilnya seperti: kemiringan mobil, panas padiator, jumlah bahan bakar, kecepatan dapat dilihat melalui display dotmatrik, dan output suara.

Karena itulah didesign alat yang dapat memberi informasi pada seorang sopir bahwa mobilnya daalam keadaan bahaya. Pembuatan alat ini memerlukan sensor berupa photodiode dan infrared untuk mendeksi bahwa sisi mobil kanan atau kiri yang miring. Begitu juga untuk sisi depan dan belakang.Ic Lm35 digunakan untuk menyensor panas pada radiator. Floating switch untuk mendeteksi isi bahan bakar pada tangki. Untuk mendeteksi kecepatan digunakan phototransistor dan infrared.

2. Permasalahan

Berdasarkan latar belakang yang telah diuraikan, maka permasalahanya adalah

1. Bagaimana merancang alat tersebut dengan aplikasi komponen komponen elektronikanya

2. Penggunaan berbagai device elektronika seperti mikrokontrol,sensor,ic suara,dotmatrik, yang memerlukan literature, percobaan yang berulang,dan pembelajaran yang lebih detail.

3. **Tujuan**

Adapun tujuan dari penulisan skripsi adalah merancang dan membuat alat pendeteksi kemiringan mobil yang dilengkapi dengan sensor radiator, bahan bakar, kecepatan dengan output suara dan display dotmatrik.

4 **Batasan Masalah**

Dalam penyusunan skripsi ini diperlukan batasan masalah agar tidak menyimpang dari ruang lingkup yang akan dibahas. Adapun batasan masalah adalah sebagai berikut:

a. Alat ini menggunakan InfraRed dan photodiode sebagai sensor yang mendeteksi kemiringan mobil. InfraRed dan photodiode.

b. Untuk sensor panas radiator digunakan icLm35 Case Iron. Tidak menggunakan Sensing bulb yang ada pada radiator.

c. Untuk prototipe alat tidak menggunakan radiator seperti pada mobil pada umumnya.

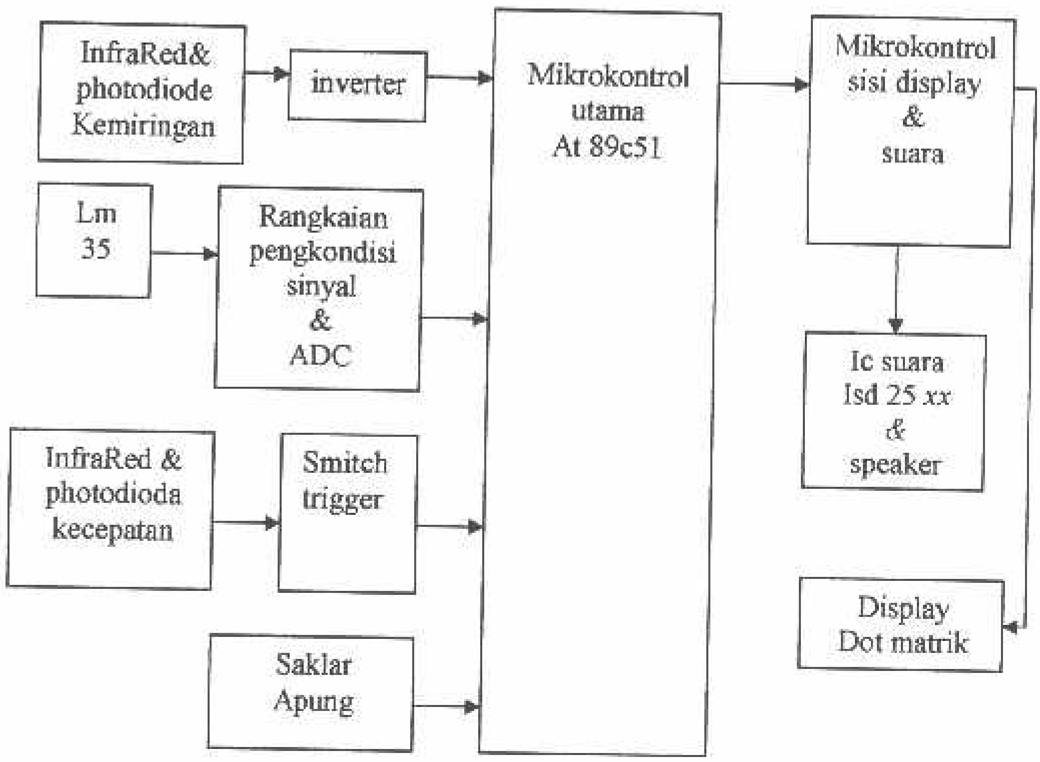
d. Hanya membahas perangkat kerasnya, sedangkan perancangan perngkat lunaknya dibahas secara garis besar

e. Tidak membahas catu daya

5. **Perancangan Perangkat Keras**

Blok diagaram

Adapun prinsip kerja alat. membuat alat pendeteksi kemiringan mobil yang dilengkapi dengan sensor radiator, bahan bakar, kecepatan dengan output suara dan display dotmatrik.



Gambar 1. Diagaram blok perancangan alat

fungsi dari tiap tiap blok dijelaskan dibawah ini:

a. Sisi Sensor

1. Pendeteksi kemiringan

Secara konsep pendeteksi kemiringan ini dibuat dari infrared dan photodiode yang disusun dalam bejana berhubungan. sebanyak dua buah yaitu: untuk depan belakang, dan satunya lagi untuk kanan dan kiri. Air. Dalam satu bejana ada delapan buah infra red dan photodiode.

2. Pendeteksi kecepatan

Dibuat dari dari infrared dan phototransistor ,secara teknis putaran roda yang dideteksi terdapat lubang yang dapat memutus sinar dari infrared ke phototransisitor. Data tersebut dikirim ke Timer

3. Pendeteksi panas Radiator

Menggunakan Ic Lm35 Case TO-46.Yaitu Lm 35 yang memakai Metal Can Package. Ic tipe ini mempunyai ambang suhu -60° - 180°. Letak Sensing bulb yang asli pada sebuah radiator terdapat pada pipa dari water jacket ke termostat. Suhu di tempat ini adalah suhu yang paling panas. Karena suhu setelah melewati termostat menuju ke evaporator suhunya beranjak turun.Suhu berkisar 120°-150°

Output dari Lm 35 masuk ke rangkaian penguat,untuk dikuatkan sehingga dapat diolah oleh ADC 0804.

4 Pendeteksi bahan bakar

Menggunakan float swicht

b Rangkaian penkondisi sinyal dan ADC untuk mengubah sinyal dari lm35 untuk diproses pada mikrokontrol

c Mikrokontrol sisi utama mengolah data dari semua sisi sensor untuk diproses lalu dieksekusi .

d. Ic *ISD 25xx* perekam audio yang pada alamatnya telah diisi data audio yang nanti akan ditunjuk oleh mikrokontrol pada sisi utama

e. speaker untuk mengeluarkan output suara

f. Display dotmatrik untuk menampilkan output scaning

6. Metodologi

Metodologi penelitian yang dipakai dalam pembuatan skripsi adalah :

a. studi literature yang mempelajari teori yang berkaitan dengan pembuatan alat pendeteksi kemiringan mobil yang dilengkapi dengan sensor radiator, bahan bakar, kecepatan dengan output suara dan display dotmatrik.
b. perancangan dan pembuatan alat untuk mengaplikasikan untuk sebuah alat dengan teori penunjangnya
c. pelaksanaan uji coba alat
d. penyusunan laporan skripsi menyimpulkan hasil perancangan dan pembuatan alat

7. Sistematika penulisan

Sistematika penulisan dari penulisan laporan akhir ini adalah sebagai berikut:

a. BAB I : PENDAHULUAN

Dalam bab ini membahas tentang latar belakang permasalahan, tujuan, batasan masalah yang diambil.

b. BAB II : LANDASAN TEORI

Dalam bab ini membahas tentang teori dasar sebagai penunjang dari permasalahan yang diambil.

c. BAB III : PERENCANAAN

Bab ini meliputi pembahasan tentang blok diagram sistem beserta perencanaan rangkaian terdiri hardware dan software.

d. BAB IV : PRINSIP KERJA DAN PENGUJIAN ALAT

Bab ini membahas tentang cara kerja, hasil pengujian alat, beserta spesifikasinya.

e. BAB V : PENUTUP

Merupakan bab penutup yang meliputi kesimpulan dan saran.

BAB II

LANDASAN TEORI

2.1 Pendahuluan

2.1 Mikrokontroller AT89C51

Perbedaan mendasar antara mikrokontroller dengan mikroprosesor adalah mikrokontroller selain memiliki *Central Processing Unit* (CPU) juga dilengkapi dengan memori, input-output yang merupakan kelengkapan sebagai minimum sistem mikrokomputer sehingga sebuah mikrokontroller dapat dikatakan sebagai mikrokomputer dalam keping tunggal (*Single Chip Microcomputer*) yang dapat berdiri sendiri.

Mikrokontroller AT89C51 adalah mikrokrokontroller ATMEL yang kompatibel penuh dengan mikrokontroller keluarga MCS-51, membutuhkan daya yang rendah, memiliki *performance* yang tinggi dan merupakan mikrokomputer 8 *bit* yang dilengkapi 4 Kbyte EEPROM (*Electrical Eraseable Programmable Read Only Memory*) dan 128 Byte RAM internal. Program memori dapat diprogram ulang dalam sistem atau dengan menggunakan *programmer Nonvolately* memori konvensional.

Dalam sistem mikrokontroller terdapat dua hal yang mendasar, yaitu:

dilihat bahwa mikrokontroller 8031 merupakan versi tanpa EPROM dan mikrokontroller 8051

Table 2.1 Keluarga mikrokontroller MCS-51 [1]

Port Number	ON-CHIP Code Code Memori	ON-CHIP Data Memori	Timer
8031	0K	128 Byte	2
8051	4k ROM	128 Byte	2
8751	4K EPROM	128 Byte	2
2805	8K ROM	256 Byte	3
8032	0K	256 Byte	3
8752	8K EPROM	256 Byte	3
AT89C51	4K EEPROM	128 Byte	2
AT 89C52	8K EEPROM	256 Byte	3

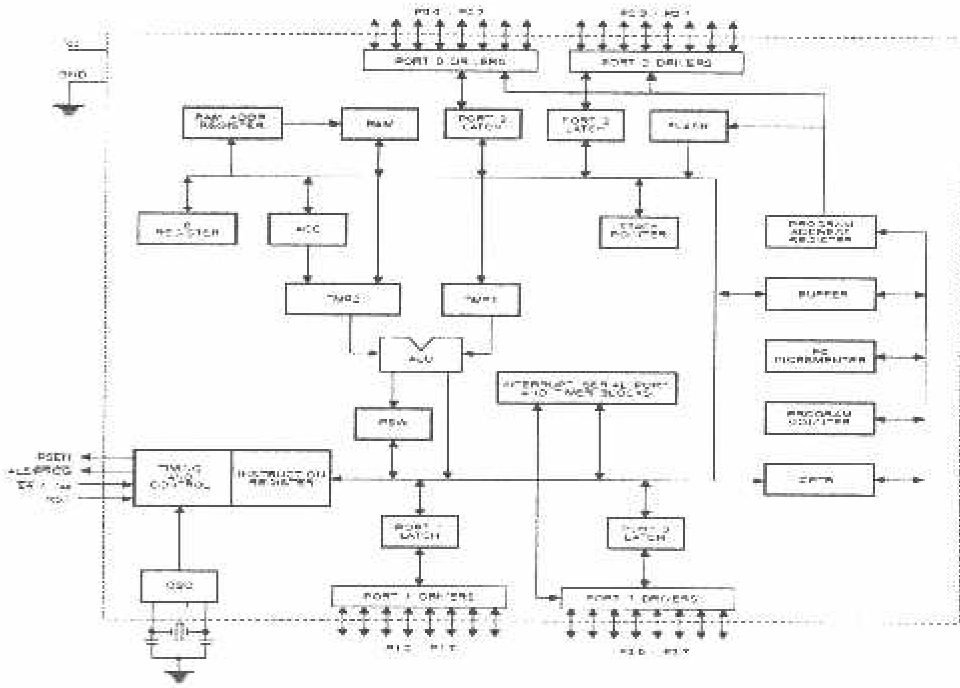
2.1.1 Arsitektur AT89C51

Sebagai *single chip* yaitu suatu sistem mikroprosesor yang terintegrasi, mikrokontroller AT89C51 mempunyai konfigurasi sebagai berikut:

1. *Central Processing Unit* (CPU) 8 *bit* dengan *register* A (*Accumultor*) dan *register* B
2. 16 *bit Program Counter* (PC) dan *Data Pointer* (DPTR)

1. *Central Processing Unit* (CPU) 8 *bit* dengan *register* A (*Accumultor*) dan *register* B
2. 16 *bit Program Counter* (PC) dan *Data Pointer* (DPTR)
3. 8 *bit Program Status Word* (PSW)
4. 4 *bit Stack Pointer* (SP)
5. 4 K *byte internal* EEPROM
6. *128 byte internal* RAM
   - *4 Bank register* masing-masing *8 register*
   - *16 byte* yang dapat dialamati pada *bit level*
   - 80 *byte general purpose memory data*
7. 32 pin input-output tersusun atas P0-P3, masing-masing 8 bit
8. 2 buah *timer / counter* 16 bit
9. *Receiver register data serial full duplex*: SBUF
10. *Central Register* yaitu TCON, TMOP, SCON, PCON, IP dan IE
11. 5 buah sumber interupsi (2 buah *interrupt* eksternal dan 3 buah *interrupt internal*)
12. *Oscillator* dan *clock internal*

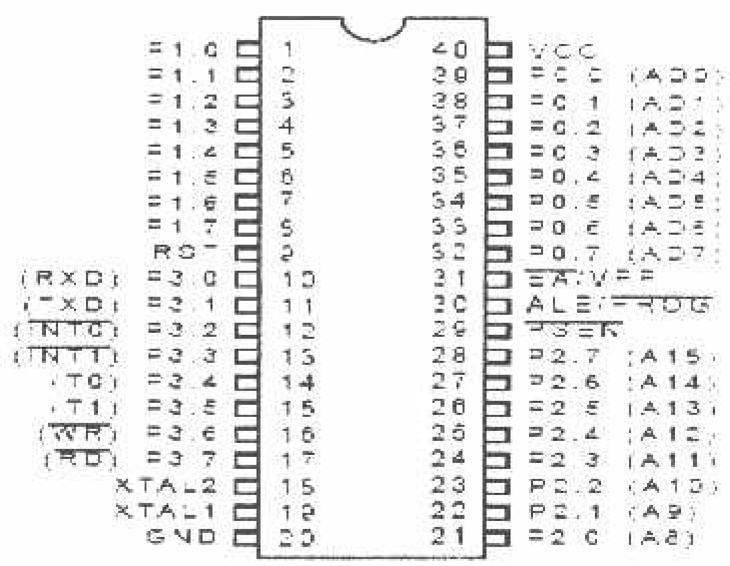
Arsitektur dasar dari mikrokontroller AT89C51 sepeti blok diagram berikut:



Gambar 2.1 Arsitektur Mikrokontroler AT89C51

2.1.2 Konfigurasi pin pada mikrokontroller AT89C51

Susunan pin-pin mikrokontroller terdiri dari 40 pin terlihat pada gambar



Gambar 2.2 Konvigurasi Pin AT 89C51

Penjelasan dari fungsi tiap-tiap pin adalah sebagaiberikut:

1. VCC berada pin 40 (catu daya)
2. GND (*Ground*) berapa pada pin 20
3. *Port* 0

   Port 0 berada pada pin 32-39 merupakan *port* input-output dua arah dan dikonfigurasi sebagai multipleks *data bus* alamat rendah (A0-A7)dan data selama pengaksesan program memori dan data eksternal
4. *Port* 1Port 1 berada pada pin 1-8 merupakan *port* input-output dua arah dengan internal *pull up*
5. *Port* 2

   Port 2 berada pada pin 21-28 merupakan *port* input-output dengan internal *pull up* mengeluarkan *address* tinggi selama pengambilan program memori eksternal dan selama pengaksesan data ke memori eksternal. Selama pengaksesan ke eksternal data memori port 2 mengeluarkan isi P2 SFR (*Special Function Register*) menerima *address* tinggi dan beberapa sinyal kontrol selama pemrogramman dan verifikasi.
6. *Port* 3

   Port 3 berada pada pin 10-17 merupakan input-output dengan internal *pull up*, *port* 3 juga memiliki fungsi khusus yaitu:

- Pin 10 (P3.0) RXD adalah pin input *serial* atau penerima data pada pin *serial* terletak pada *bit address* B0 H.
- Pin 11 (P3.1) TXD adalah pin output serial atau pemancar data pada pin serial terletak pada bit address B1 H.
- Pin 12 (P3.2) INT0 adalah *interrupt* 0 eksternal terletak pada *bit address* B2 H.
- Pin 13 (P3.3) INT1 adalah *interrupt* 1 eksternal terletak pada *bit address* B3 H
- Pin 14 (P3.4) T0 adalah input eksternal timer 0 terletak pada *bit address* B4 H
- Pin 15 (P3.5) T1 adalah input eksternal timer 1 terletak pada *bit address* B5 H
- Pin 16 (P3.6) WR adalah *strobe* tulis data memori eksternal, terletak pada *bit address* B6 H
- Pin 17 (P3.7) RD adalah *strobe* baca data memori eksternal, terletak pada *bit address* B7 H

7. Reset (RST)

Input reset pada pin 9 adalah reset master untuk mikrokontroller AT89C51, perubahan tegangan rendah ke tinggi akan mereset mikrokontroller AT89C51.

8. ALE/ PROG

   Pulsa output ALE (*Address Latch Enable*) digunakan untuk proses latching byte address rendah (A0-A7) selama pengaksesan ke eksternal memori. Pin ini juga digunakan untuk memasukkan pulsa program (PROG) selama pemrogramman.

9. PSEN (*Program Strobe Enable*)

   Merupakan *strobe* baca ke program memori eksternal yang terdapat pada pin 29.

10. EA

    EA (*External Address Enable*) terdapat pada pin 31 digunakan untuk mengakses memori eksternal, untuk mengakses memori internal maka EA dihubungkan ke VCC.

11. XTall 1 dan XTall 2

    Pin ini dihubungkan dengan kristal apabila menggunakan *oscillator* internal XTall 1 merupakan input *inverting oscillator amplifier* sedangkan XTall 2 merupakan output *inverting amplifier*.

2.1.3 Memori Program (ROM)

Memori program merupakan tempat penyimpan data yang permanen. Memori program merupakan memori yang hanya dapat dibaca atau lebih dikenal dengan *Read Only Memory* (ROM). Data dalam ROM tidak akan terhapus meskipun catu daya dimatikan bersifat *nonvolatile*.

Mikkrokontroller AT89C51 memiliki program internal 4 K *byte* dengan ruang alamat 0000H-0FFFH. Jika alamat-alamat program lebih tinggi dari 0FFFH yang melebihi kapasitas ROM internal, menyebabkan mikrokontroller AT89C51 secara otomatis mengambil *byte* code dari program memori eksternal, kode *byte* juga dapat diambil hanya dari eksternal memori dengan alamat 0000H-FFFFH dengan cara menghubungkan pin EA ke ground.

Ada beberapa tipe ROM, diantaranya adalah ROM murni yaitu memori yang sudah di program oleh pabrik, PROM, EPROM dan EEPROM, PROM merupakan memori yang dapat di program oleh pemakai tetapi tidak dapat di program ulang, EPROM merupakan PROM yang dapat di program ulang, pada EPROM ditandai dengan adanya jendela kaca pada konstruksinya yang digunakan untuk menghapus program yang akan diisi program baru (di program ulang), EEPROM prinsipnya sama dengan EPROM perbedaannya terletak pada pengisian dan penghapusan program untuk EPROM menggunakan sinar ultraviolet sedangkan pada EEPROM penghapusan / pengisian secara langsung dengan tegangan sehingga penggunaan EEPROM lebih fleksibel disbanding EPROM.

2.1.4. Memori Data (RAM)

Memori data adalah tempat untuk menyimpan data yang sifatnya sementara, sehingga pada memori data bersifat *volatile*, yaitu data akan hilang jika tidak diberi catu daya. Memori data lebih dikenal dengan nama *Random Access Memory* (RAM)

Ruang memori data (RAM) *internal* terbagi menjadi dua blok yang disebut sebagai *lower* 128, *upper* 128 / ruang SFR *s*. Ruang alamat bawah (*lower*) memori data (RAM) *internal* dengan kapasitas 128 *byte* yaitu 00H-7FH terbagi menjadi 3 daerah yaitu:

1. *4 Bank Register*

setiap *bank* terdiri dari 8 *register* (R0-R7) sehingga jumlah *register* untuk keempat *bank register* (bank0-bank3) menjadi 32 buah *register* yang menempati ruang alamat 00H-1FH. Cara mengaktifkan salah satu *bank register* yaitu dengan mengatur RS0-RS1 pada *Program Status Word* (PSW)

Tabel 2.2 Pengaturan RS0-RS1Untuk *Register Bank* [2]

RS1	RS0	Selek *Register Bank*	Address
0	0	*Bank* 0	00H-07H
0	1	*Bank* 1	08H-0FH
1	0	*Bank* 2	10H-17H
1	1	*Bank* 3	18H-1FH

2. *Bit Address Area*

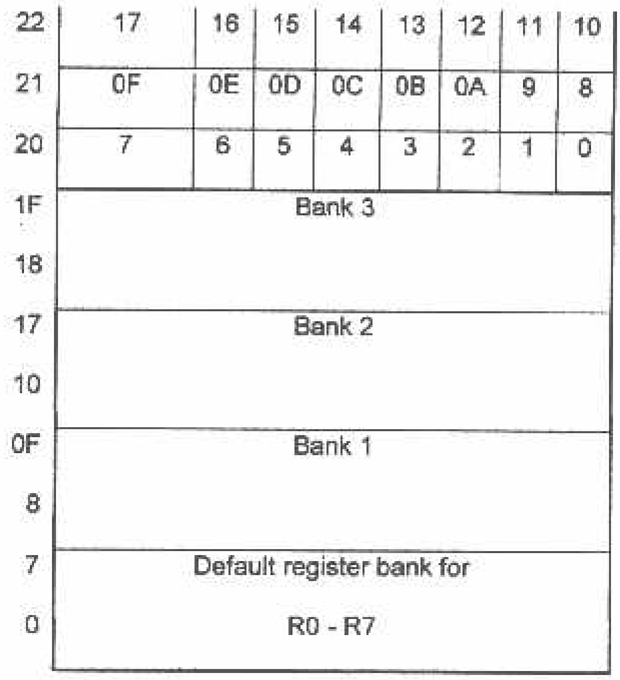
Terdiri dari 16 *byte* yang dimulai dari alamat 20H-2FH masing-masing 128 *bit* lokasi dapat dialamati secara langsung.

3. *Stratch Pad Area*

Terdiri dari 80 *byte* terletak pada alamat 30H-7FH, yang dapat dialamati secara langsung dan digunakan untuk keperluan umum (*General Purpose*) misalnya digunakan untuk lokasi *stack*.

Berikut adalah gambar dari *lower* 128 *byte* lokasi RAM

byte address	Bit address							
7F – 30	General Purpose RAM							
2F	7F	7E	7D	7C	7B	7A	79	78
2E	77	76	75	74	73	72	71	70
2D	6F	6E	6D	6C	6B	6A	69	68
2C	67	66	65	64	63	62	61	60
2B	5F	5E	5D	5C	5B	5A	59	58
2A	57	56	55	54	53	52	51	50
29	4F	4E	4D	4C	4B	4A	49	48
28	47	46	45	44	43	42	41	40
27	3F	3E	3D	3C	3B	3A	39	38
26	37	36	35	34	33	32	31	30
25	2F	2E	2D	2C	2B	2A	29	28
24	27	26	25	24	23	22	21	20
23	1F	1E	1D	1C	1B	1A	19	18



Gambar 2.3 Organisasi RAM Internal

Pada *upper* 128 ditempati oleh suatu *register* yang memiliki fungsi khusus yang disebut *Special Function Register* (SFR_s). *Address* dari fungsi khusus tersebut adalah 80H-FFH, tetapi tidak semua alamat tersebut digunakan SFR_s. Berikut ini adalah contoh dari vektor alamat pada SFR_s.

- *Accumulator* (ACC) atau *register* A dan *register* B, kedua *register* ini digunakan untuk operasi perkalian dan pembagian
- *Program Status Word*, *register* ini meliputi : CY (*Carry*), AC (*Auxcilliary carry*), FO(*Flag*), RS0 dan RS1 (untuk pemilihan *register bank*), OV (*overflow*) dan *Parity* (*parity flag*).

- *Stack Pointer* merupakan *register* yang digunakan untuk menunjuk alamat, *register* ini digunakan bila terdapat suatu *routine* pada program utama.
- *Data Pointer Two Byte Register* (DPTR), DPTR adalah suatu *register* yang digunakan untuk pengalamatan yang tidak langsung, *register* ini digunakan untuk mengakses memori program baik secara eksternal maupun internal yang digunakan untuk alamat eksternal data, DPTR ini dikontrol oleh 2 buah *register* 8 bit yaitu *data pointer low* (DPL) dan *data pointer high* (DPH).
- *Port0, Port1, Port2* dan *Port3,* masing-masing dapat dialamati baik secara *byte* maupun bit, masing-masing merupakan *port bi directional* yang artinya dapat berjalan dua arah (input dan output), *port0* dan *port2* digunkan untuk pengalamatan dari luar, *port1* untuk I/O dari mikrokontroller, sedangkan *port3* berisi sinyal-sinyal kontrol seperti *interrupt, serial*, WR dan RD.
- *Register Priority Interrupt*, merupakan *register* yang berisi bit-bit untuk mengaktifkan prioritas dari suatu *interrupt* yang ada pada mikrokontroller pada taraf yang diinginkan.
- *Interrupt Enable Register*, merupakan register yang berisi bit-bit untuk menghidupkan atau mematikan sumber *interrupt*
- *Timer/Counter Control* (TCON) *Register*, TCON merupakan suatu *register* yang berisi bit-bit untuk memulai atau menghentikan pencacah / pewaktu

- *Serial Control Buffer* (SBUF), register ini digunakan untuk menampung data masukan (SBUF IN) atau keluaran (SBUF OUT) dari *serial port*

Berikut adalah *address* yang digunakan SFR.

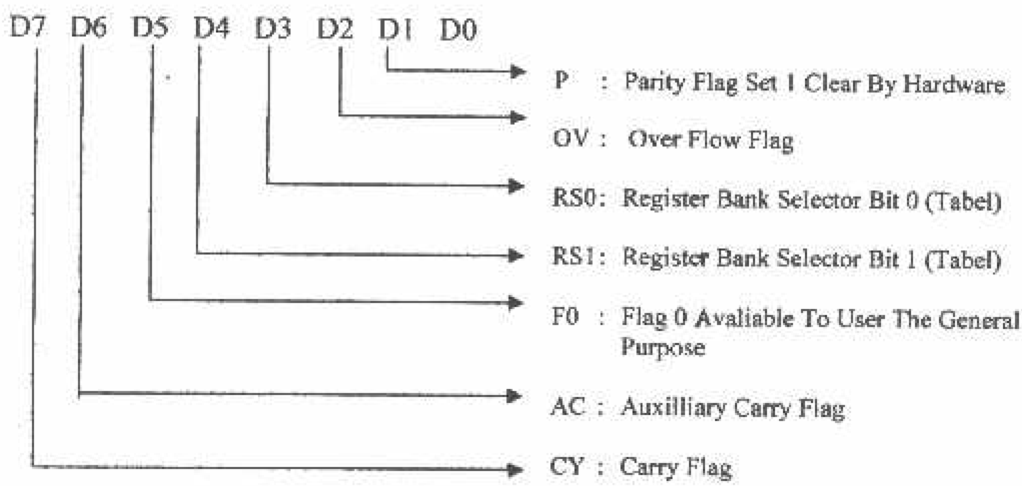
Tabel 2.3 *Special Function Register* (SFR) [3]

Simbol	Nama	*Address*
ACC	*Accumulator*	E0H
B	B *register*	F0H
PSW	*Program Status Word*	D0H
SP	*Stack Pointer*	81H
DPTR	*Data Pointer Two Byte Register*	-
DPL	*Data Pointer Low Byte*	82H
DPH	*Data pointer High Byte*	83H
P0	*Port*0	80H
P1	*Port*1	90H
P2	*Port*2	A0H
P3	*Port*3	B0H
IP	*Interrupt Parity Control*	B8H
IE	*Interrup Enable Control*	ABH
TMOD	*Timer / Counter Mode Control*	89H
TCON	*Timer / Counter Control*	88H
T2CON	*Timer / Counter 2 Control*	C8H
TH0	*Timer / Counter 0 High Control*	8CH
TL0	*Timer / Counter 0 Low Control*	8AH
TH1	*Timer / Counter 1 High Control*	8DH
TL1	*Timer / Counter 1 Low Control*	8BH
TH2	*Timer / Counter 2 High Control*	CDH

TL2	*Timer / Counter 2 Low Control*	CCH
RCAP2H	T/C *Capture Register High Byte*	CBH
RCAP2L	T/C *Capture Register Low Byte*	CAH
SCON	*Serial Control*	98H
SBUF	*Serial Data Buffer*	99H
PCON	*Power Control*	87H

2.1.5 *Program Status Word* (PSW)

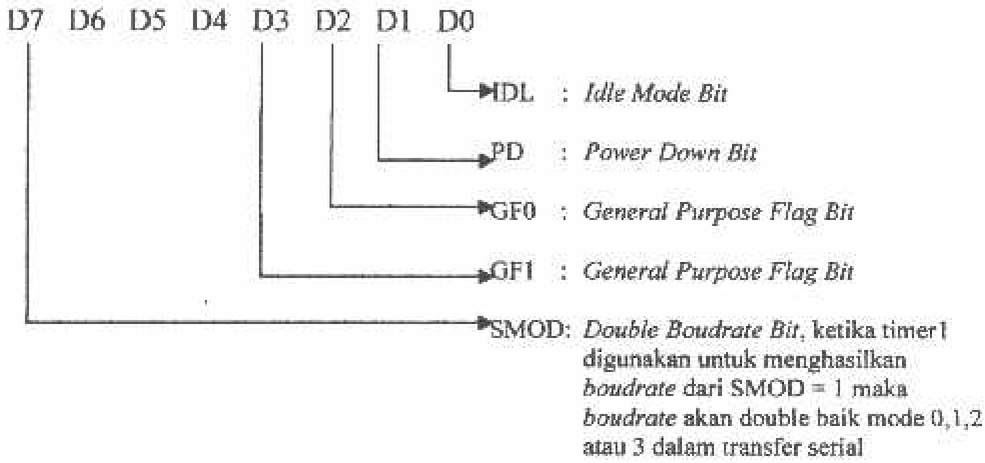
Untuk pendefinisian *program status word* ini dapat dilakukan perbit maupun secara keseluruhan dari *register* ini *register* ini terletak pada alamat D0H. Cara pendefinisian adalah sebagaiberikut :



Gambar 2.4 Skema Pendefinisian PSW

2.1.6 *Power Control* (PCON)

Register ini terletak pada alamat 87H. cara mendefinisikan adalah sebagai berikut:

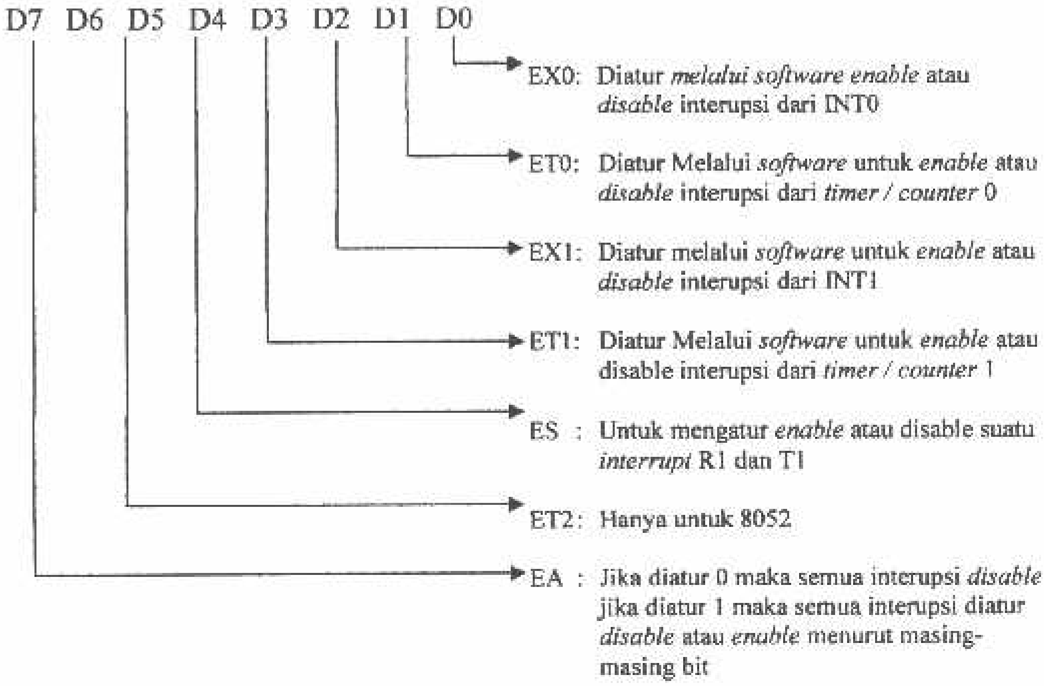


Gambar 2.5 Skema Pendefinisian PCON

2.1.7 System Interrupt

Mikrokontroller AT89C51 mempunyai 5 buah sumber *interrupt* yang dapat membangkitkan permintaan *interrupt* yaitu INT0, INT1, T0, T1 dan *Port serial*. Saat terjadinya *interrupt*, mikrokontroller secara otomatis akan menuju ke *subroutine* pada alamat tersebut. Setelah *interrupt service* selesai dikerjakan

mikrokontroller akan mengerjakan program semula. Dua sumber *interrupt* eksternal adalah INT0 dan INT1, dimana kedua interruptsi eksternal akan aktif level atau alktif transisi tergantung isi IT0 dan IT1 pada register TCON. Interupsi timer0 dan interupsi timer1 aktif pada saat timer yang sesuai mengalami *roll over*. Interupsi serial dibangkitkan dengan melakukan operasi OR pada R1 dan T1 tiap-tiap interupsi dapat enable atau disable secara *soft ware*. Berikut ini adalah susunan dari bit-bit berserta keguanaannya:

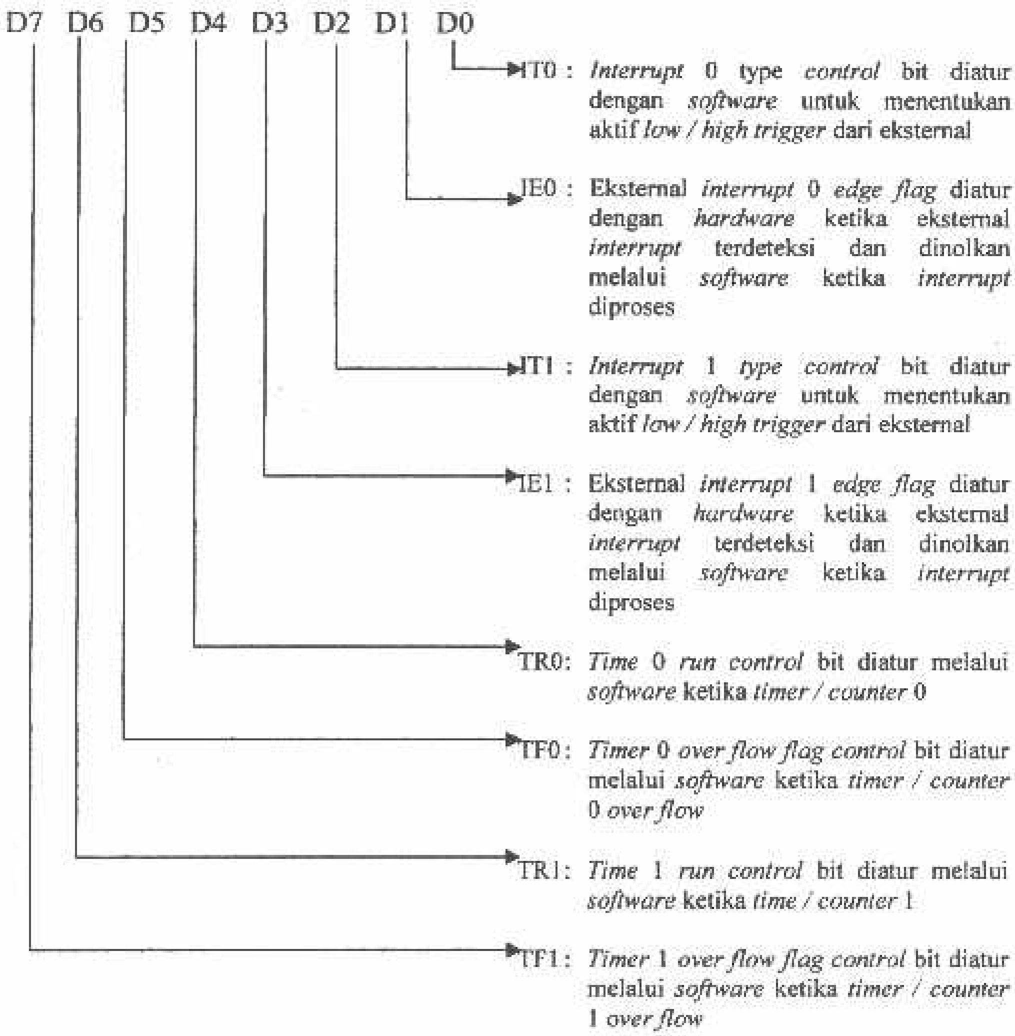


Gambar 2.6 Kegunaan *Interrupt Enable Register*

Tingkat prioritas semua sumber interupsi dapat diprogram sendiri-sendiri dengan *set* atau *clear* bit pada SFR_S IP (*Interrupt Parity*) *register* yang berperan dalam mengatur aktif tidaknya interupsi adalah *interrupt enable register*.

2.1.8 *Timer / Counter*

Pengendalian kerja *timer / counter* dilakukan dengan pengaturan *register* yang berhubungan dengan kerja *timer / counter* yaitu melalui sebuah *timer counter mode control.* Untuk menaktifkan *timer / counter* yang meliputi penentuan fungsi sebagai *timer* atau sebagai *counter* serta pemilihan mode operasi dapat diatur melalui TMOD yang beralamat 89H. konvigurasi yang imaksud



(a)

gate	C/T	M1	M0	*gate*	C/T	M1	M0

Timer 1 *Timer* 0

(b)

Gambar 2.7 (a) Konfigurasi TMOD (b) *Timer / Counter Mode Control Register*

Pengaturan *timer / counter* dilakukan pertama kali dengan mengatur TMOD. Disini akan menentukan fungsi sebagai *timer* atau *counter* lengkap dengan spesifikasinya. Demikian juga dengan pengaktifan interrupsi yang berhubungan dengan penggunaan mode ini.

Tabel 2-4 Mode Operasi *Timer / Counter* [4]

M1	M2	Operation Mode
0	0	*Timer / counter* 13 bit
0	1	*Timer / counter* 16 bit
1	0	8 bit *auto reload timer / counter*
1	1	2.4.2.0 TL0 dari *timer* adalah 8 bit timer / counter dikendalikan oleh kontrol bit *timer*0, TH0 adalah *timer* 8 bit yang dikendalikan oleh *timer*1 kontrol bit.

2.19 Rangkaian *Oscillator*

Jantung dari mikrokontroller AT89C51 terletak pada rangkaian yang membangkitkan pulsa *clock*. Pin Xtal1 dan Xtal2 disediakan untuk disambungkan dengan jaringan resonan untuk membentuk sebuah *oscillator*. Sedangkan untuk jaringan resonannya menggunakan kristal, karen dari beberapa jenis kristal yang ditemukan dialam menunjukkan efek piezoelektrik bila penerapannya tegangan ac melintasi bahan bahan ini maka kristal tersebut bergetar dengan frekwensi yang sama dengan frekwensi tegangan yang diterapkan, sebaliknya bila dipaksa untuk bergetar maka akan membangkitkan tegangan ac. Bahan utama yang dapat menimbulkan efek piezoelektrik ini adalah kuarsa, garam *Rochelle* dan *turnalin.*

Kuarsa merupakan kompromi diantara perilaku piezoelektrik dari garam *Rochelle* dan kuarsa dari *turnalin.* Karena harganya yang murah dan tersedia di alam, kuarsa banyak digunakan pada *oscillator* RF dan penapis. Kristal dibuat untuk bergetar paling baik pada salah satu frekwensi sesonansinya yang biasanya merupakan frekwensi dasar.

Rumus untuk frekwensi dasar sebuah kristal adalah $F = \frac{K}{t}$

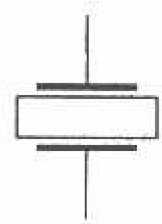
Dimana :

K : tetapan yang tergantung dari jenis potongan dan unsur lainnya

t : ketebalan kristal

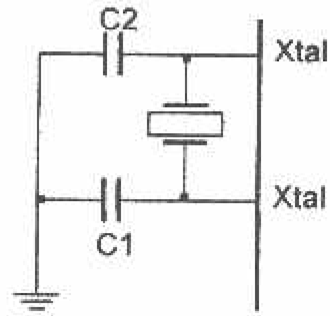
F : frekwensi

Adapun simbol dari kristal adalah seperti gambar 2.8 berikut ini.



gambar 2.8 Simbol Kristal

AT89C51 dirancang untuk running pada frekwensi 3 MHz sampai 24 MHz. penambahan rangkaian oscillator ditunjukkan pada gambar 2.9 berikut ini.



Gambar 2.9 Rangkaian Oscilator

2.2 Perangkat Lunak Mikrokontroller AT89C51

IC AT89C51 memiliki 111 instruksi, 49 *single byte*, 45 instruksi dengan panjang 2 byte dan 17 instruksi dengan panjang 3 byte. Format op-code instruksi sesuai dengan fungsi mnemonik operan berikut "*Destination Service*". Format diatas sama dengan format pada instruksi Z80 – CPU

Menurut fungsinya MCU AT89C51 dibagi menjadi 4 group yaitu :

1. Data Transfer (Perpindahan Data)

Operasi perpindahan data secara umum (*general pupose*) dapat dibagi menjadi tiga kelas :

A. Perpindahan Data

- MOV membentuk transfer bit atau byte dari operand sumber ke operand tujuan

- PUSH menyebabkan *increment register* SP dan *transfer* data dari sumber operand ke areal *stack* didalam RAM yang ditunjuk oleh *stack pointer*
- POP mentransfer data dari areal *stack* yang ditunjukkan oleh *stack pointer* ke operand tujuan kemudian SP di *decrement*

B. Perpindahan Khusus Terhadap *Accumulator*

- XCH menukar isi register operand sumber dengan isi *register accumulator*
- XCHD menukar nible rendah dari data operand sumber dengan *nible* rendah *accumulator*
- MOVX membentuk perpindahan data antara eksternal data memori (RAM) dan *accumulator. Address* eksternal dapat didefinisikan lewat lewat *register* DPTR (16 bit) atau R0 danR1 (8 bit)
- MOVC mengkopikan data dari program memori (ROM) kedalam *accumulator. Operand accumulator* dipergunakan sebagai index *table pointer* sebanyak 256 byte dengan *register* dasar DPTR atau PC.

C. *Address Object*

- MOV DPTR, # data mengisi data 16 bit secara langsung (*immediate*) kedalam pasangan *register* DPH dan DPL.

2. ***Arithmetik***

MCU AT89C51 empat dasar matematis. Hanya operasi 8 bit yang dapat dilakukan secara langsung

A. Penjumlahan

- INC (*Increment*) menjumlahkan dengan nilai 1 kedalam operand sumber dan hasilnya disimpan didalam operand
- ADD menjumlahkan *accumulator* dengan operand sumber dan hasilnya disimpan didalam operand.
- ADC (ADD *with Carry*) menjumlahkan *accumulator* dengan operand sumber dan kemudian menambahkan lagi dengan *carry* (Cy), hasilnya disimpan didalam *accumulator*.
- DA (*decimal ADD adjust for BCD addition*) mengoreksi hasil penjumlahan dari hasil penjumlahan biner dari dua digit operand decimal.

B. Pengurangan

- SUBB (*substract with borrow*) mengurangi operand sumber kedua terhadap operand pertama (*accumulator*), dan kemudian dikurangi lagi dengan Cy dan hasilnya disimpan didalam accumulator.

- DEC (*decrement*) mengurangkan dengan nilai satu dari operand sumber dan hasilnya disimpan didalam operand.

C. Perkalian

- MUL membentuk perkalian antar *accumulator* dengan *register* B, hasilnya disimpan di *register* B (*high order byte*) dan diakumulator (*low order byte*). OV dalam kondisi clear jika separuh bagian atas dari hasil perkalian bernilai nol, dan set ke 1 jika tidak nol CY dalam kondisi *clear* dan AC tidak berpengaruh.

3. Logic

Mikrokontrolloler AT89C51 membentuk dasar operasi logika dari dua buah bit dan operand byte

A. *Operand single operand*

- CLR meng-*clear accumulator* ke logika 0
- SETB mengeset bit tertentu ke logika 1
- CPL digunakan untuk membentuk komplemen isi dari *accumulator* tanpa mempengaruhi flag
- RL, RLC, RR, RRC dan SWAP. Lima operasi rotasi yang dapat dilakukan didalam *register* A. RL *rotate left*, RR *rotate right*, RLC *rotate left trought* C, RRC *rotate right trought* C dan SWAP untuk menukar *nible high* terhadap *nible low*

B. Operasi Dua Operand

- ANL membentuk fungsi logika AND dari dua sumber operand dan mengembalikan hasilnya ke operand
- ORL membentuk fungsi logika OR dari dua sumber operand dan mengembalikan hasilnya ke operand
- XRL membentuk fungsi logika XOR dari dua sumber operand dan mengembalikan hasilnya ke operand

4. Control Transfer (*jump*)

Ada tiga kelas operasi kontrol transfer : *unconditional call, return* dan *jump, conditional jump* dan *interrupt.*

A *Unconditional call, return* dan *jump* adalah bentuk melompat dari nilai PC tertentu ke target *address*

- ACALL dan LCALL *push address* dari instruksi berikutnya ke *areal stack* kemudian proses pelaksanaan program melompat ke *address* target. ACALL instruksi 2 byte dipergunakan pada saat *address* target pada daerah halaman 2 K (11bit *address*), LCALL instruksi 3 byte yang memiliki *address* target 64 K (16 bit address).
- RET mengembalikan proses pelaksanaan program ke program utama dengan jalan mengambil isi *stack* pada saat terjadi *call*, dimasukkan kedalam PC
- AJUMP, LJUMP dan SJUMP. Operasi AJUMP dan LJUMP mempunyai jangkauan *address* target yang sama dengan

ACALL dan LCALL yaitu 11bit dan 16 bit. Sedangkan SJUMP (*short jump*) memiliki range 256 byte yang dibagi menjadi -128 hingga +127.

- JMP @A+DPTR membentuk *jump* relative dengan dasar *address register* DPTR. Operand A dipergunakan sebagai *offset address* dengan range 0 – 255. sehingga secara efektif *address* target adalah A+DPTR

B. *Conditional Jump* adalah membentuk *jump* yang tergantung pada kondisi tertentu. Tujuan (*address* target) berada pada daerah 256 byte yang dibagi menjadi range -128 sampai dengan +127

- JZ *jump zero*, melompat jika *accumulator* samadengan nol
- JNZ *jump not zero*, melompat jika *accumulator* tidak samadengan nol
- JC *jump carry*, melompat jika *carry* samadengan satu
- JNC *jump not carry*, melompat jika *carry* tidak samadengan satu
- JB *jump bit*, melompat jika *address bit* tertentu dalam keadaan *set* 1
- JNB *jump not bit*, melompat jika *address bit* tertentu dalam keadaan *clear* 0
- JBC *jump bit clear*, melompat jika *address bit* tertentu dalam keadaan *set* 1 dan kemudian meng-*clear*-nya .

- CJNE *compare jump not equal*, membandingkan operand pertama dengan operand kedua, jika tidak sama maka melompat ke alamat target. CY *set* 1 jika operand pertama lebih kecil dari pada operand kedua.
- DJNZ *decrement jump not zero*, mengirangi dengan satu operand sumber dan mengembalikan hasilnya ke operand, dan lompat jika hasilnya tidak sama dengan nol.

C *Interrupt return*

- RETI sama dengan RET ditambah dengan meng-*enable*-kan *interupsi* yang bersangkutan

Bentuk umum dari instruksi-instruksi MCU AT89C51 adalan seperti gambar berikut.

MNEMONIK		OPERAND TUJUAN	OPERAND SUMBER

Gambar 2.10 Bentuk Umum Instruksi MCU AT89C51

Bentuk data dari operand sumber ditentukan oleh jenis mode pengalamatannya. Instruksi-instruksi MCU AT89C51 dibagi menjadi 4 mode pengalamatan yaitu :

1. *Immediate Addressing*
2. *Register Addressing*
3. *Direct Addressing*
4. *Indirect Addressing*

2.2 Sistem Information Storage Device (ISD) 2500

2.2.1 Pendahuluan

IC penyimpan informasi (ISD) 2500 chip corder series memberikan kwalitas yang tinggi sebagai single chip record / playback dengan jangka waktu durasi 60-120 detik, penggunaan, dan didalamnya telah dilengkapi dengan onchip oscillator filter, speaker, amplifier, automatic gain control, antiliasing filter, smoothing filter, speaker amplifier dan penyimpan dengan kepadatan tinggi, selain itu ISD 2500 ini dapat didesain sangat cocok dengan penggunaan mikrokontroler.

Perekam suara disimpan dalam del memori yang tidak mudah hilang. Didalam proses perekaman menggunakan aktif low pada pin record. Pembuatan ISD ini dapat dipatenkan secara langsung oleh Direct Analog Storage Technology (DAST), yang mana sinyal suara dapat disimpan dalam bentuk aslinya secara analog ledalam memori. Penyimpanan ini adalah bentuk natural atau alami sehingga akan memberi kwalitas yang tingggi dan kemampuan suara yang baik.

2.2.2 Jenis-jenis Information Storage Device (ISD)

Ic Suara tipe 25xx mempunyai keluarga IC dengan tipe, performa, dan kapasitas perekaman yang berbeda-beda.Dengan melihat table 2-5 Maka kita bisa mengetahui jenis Information Storage Device (ISD)

Tabel 2-5 Seri ISD 2500 [5]

Tipe	Waktu (detik)	Sample Rate (Khz)	Filter Pas Band (Hz)
ISD-2560	60	8.0	3400
ISD-2575	75	6.4	2700
ISD-2590	90	5.3	2300
ISD-25120	120	4.0	1700

Dengan melihat tabel 2-3 seri ISD 2500 diatas, maka dapat diketahui bahwa IC penyimpan suara ini adalah merupakan jenis EEPROM (*Electrical Eraseable Programeble Read Only Memory*), EEPROM adalah jenis ROM yang dapat diporogram atau dihapus berulang kali secara elektrik tidak menggunakan sinar ultraviolet. IC ISD 2500 ini dapat melakukan perekaman suara atau pesan dengan jangka waktu durasi maksimum 120 detik (2 menit). Media penyimpan suara ini adalah EEPROM 480K *Storage Cell* yang didesain untuk memberi 60-120 detik penyimpanan suara dengan sample rate 4.0-8.0 KHz. Dimana ruang alamat dibagi dalam 600 tingkatan dengan pengalamatan dari 00H sampai 3FFH (A0-A9).

2.2.3 Keutamaan dari ISD 2500 adalah

- Mudah dalam penggunaanya sebagai *single chip voice record* atau *play back*
- Mempunyai kwalitas yang tinggi menghasilkan kembali suara/audio asli
- Kompatibel dengan menggunakan mikrokontroller
- *Single chip* yang lama durasi penyimpanan sampai dengan 120 detik
- Power supply +5 volt *single*
- Dapat menyimpan pesan selama 100 tahun

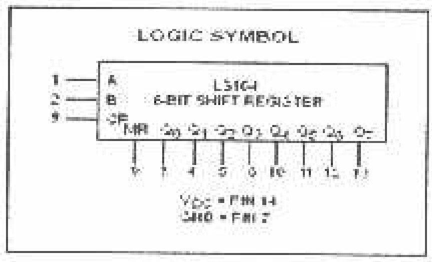
Selanjutnya untuk mengetahui dan melakukan pengontrollan langkah-langkah cara penggunaan dari ISD 2500 yang dikondisikan dalam keadaan *record*, maupun *play back* serta memulai atau mengakhiri suatu perekaman atau *play back*. Untuk lebih jelasnya perhatikan table 2-4 berikut ini.

Tabel 2-6 Sinyal Kontrol ISD 2500 [6]

Langkah Kontrol	Fungsi	Sinyal
1	Pemilihan Record/Play Back Mode	[1] PD = Low [2] P/R= As desired
2	Set Address Memulai Record/Play Back	Pemilihan Alamat A0-A9
3a	Mulai Play Back	P/R = High, CE = Low
3b	Mulai Record	P/R = Low, CE = Low
4a	Mengakhiri Play Back	Automatic
4b	Mengakhiri Record	PD atau CE = High

2.3 Register Geser 8 bit 74LS164

Register adalah memori sementara yang digunakan untuk pengolahan data, register geser (shift register) merupakan memori sementara yang dapat dipindahkan dengan jalan menggeser dari tingkat bit rendah ke tingkat bit yang lebih tinggi, atau sebaliknya. Dalam perencanaan ini menggunakan register geser dengan masukan seri dengan keluaran pararel 8 bit dengan tipe ic 74LS164.

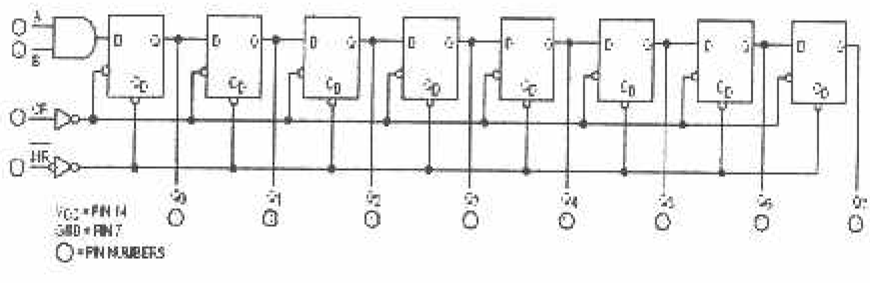


Gambar 2.11 konfigurasi pin IC 74LS164

Prinsip kerja dari register ini adalah bila 1 bit data dimasukkan ke inputan bersama denga menaikan pulsa clock maka satu bit akan disimpan dan dikeluarkan oleh RS Flipflop yang pertama sedangkan keadaan keluaran yang lain Qb---Qh seperti keadaan semula. Dan apabila diinputkan lagi bit kedua bersama dengan clock maka bit yang ada di Qa adalah bit baru,akan digeser ke Qb Sedangkan isi Qa adalah bit baru yang diinputkan tadi. Dan itu termasuk berlaku untuk terus selamanya masukan diberi data bersamaan dengan pulssa clock. Untuk menghapus isi dari tiap register yaitu dengan ,memberikan sinyal low pada clear. Pada tabel 2-? Menunjukkan adanya hubungan antara input dan output pada IC 74LS164.

OPERATING MODE	INPUTS			OUTPUTS	
	MR	A	B	Q0	Q1–Q7
Reset (Clear)	L	X	X	L	L – L
Shift	H	l	l	L	q0 – q6
	H	l	h	L	q0 – q6
	H	h	l	L	q0 – q6
	H	h	h	H	q0 – q6

[illegible]



Gambar 2.12 Diagram blok IC 74LS164

IC 74LS164 merupakan register kiri 8 bit yang memiliki penyemat clear yang jika diberi logika **high** '1' maka register akan bekerja. Tapi saat

Penyemat clear diberi logika low '0' walaupun diberi masukan dan clock diaktifkan clock, maka semua nilai akan berlogika 0. Walaupun diberi masukan dan clock diaktifkan.

2.4 Sensor

2.4.1 InfraRed

Led infra merah digunakan untuk menghasilkan sinar infra merah, prinsip kerjanya adalah pada waktu led infra merah dibias *forward*, elektron dari pita konduksi melewati *junction* dan jatuh kedalam *hole* pita valensi, sehingga elektron-elektron tersebut memancarkan energi, pada dioda penyearah biasa energi ini dikeluarkan sebagai energi panas, tetapi pada led energi ini dipancarkan sebagai cahaya. Led infra merah memancarkan cahaya yang tidak kelihatan oleh mata. Simbol dan bentuk fisik LED inframerah seperti gambar 5-1 berikut ini.

(a) Bentuk Fisik (b) Simbol

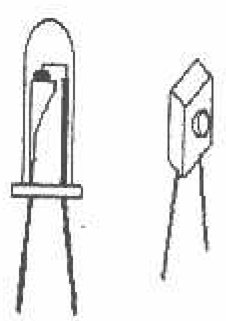
Gambar 2.13 Bentuk Fisik dan Simbol LED Inframerah

Led infra merah merupakan PN *junction* yang memancarkan radiasi infra merah. Apabila anoda diberi tegangan positif dan katoda ke *ground*, maka led menjadi "ON" dan arus akan mengalir dari anoda ke katoda. Pada reaksi semikonduktor suatu dioda akan terjadi perpindahan elektron dari tipe N menuju tipe P dan perpindahan hole dari tipe P ke tipe N, proses rekombinasi antara elektron dan hole mengakibatkan pelepasan energi berupa pancaran cahaya.

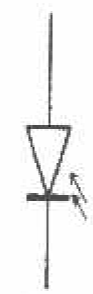
Efisiensi pancaran cahaya akan akan berkurang, dengan berkurangnya arus input dan kenaikan suhu. Pada led infra merah cahaya yang dipancarkan mempunyai panjang gelombang (λ) yang sangat kecil (0.1mm-1μm)

2.4.2 Foto Dioda

Foto dioda merupakan suatu dioda yang peka terhadap cahaya. Suatu sumber cahaya menghasilkan energi panas, begitu pula dengan spektrum infra merah. Karena spektrum infra merah mempunyai efek panas yang lebih besar dari cahaya tampak maka foto dioda lebih peka untuk menangkap radiasi dari sinar inframerah. Simbol dan bentuk fisik foto dioda seperti ditunjukkan pada gambar 5-2 berikut ini.



(a) Bentuk Fisik



(b) Simbol Elektronika

Gambar 2.14 Bentuk Fisik dan Simbol Foto Dioda

Pada foto dioda ini terdapat suatu jendela kecil yang memungkinkan cahaya luar dapat masuk dan mengenai PN *junction*, pada keadaan normal foto dioda berlaku sebagai dioda biasa yang dapat mengantarkan arus listrik dari anoda ke katoda, namun mempunyai tahanan balik yang besar bila cahaya luar mengenai *junction* foto dioda maka tahanan balik akan mengecil dan menimbulkan arus balik sehingga foto dioda berlaku sebagai dioda yang dibalik atau dibias *reverse*.

Semakin besar intensitas cahaya yang diterima maka semakin besar pula arus balik yang ditimbulkannya. Bila energi photon diserap dalam suatu semikonduktor, maka akan menghasilkan pasangan elektron-hole pada lapisan pengosongan. Arus balik akan timbul bila elektron-elektron dan hole-hole yang telah dibangkitkan oleh photon saling memisahkan diri karena pengaruh medan listrik, dimana elektron-elekktron akan menuju anoda, arus balik yang dihasilkan sebanding dengan sinar yang diserap. Karena pengaruh suatu *junction* yang lebih tinggi menciptakan lebih banyak pasangan elektron-hole, sehingga mengakibatkan aliran arus balik yang melewati *junction* bertambah.

Suatu foto dioda biasanya mempunyai karakteristik yang lebih baik dari pada foto transistor dalam responya terhadap cahaya infra merah, foto dioda mempunyai respon 100 kali lebih cepat dari pada foto transistor, tetapi foto transistor mempunyai keunggulan dapat menguatkan arus bocor menjadi ratusan kali jika dibanding dengan foto dioda

2.5 Display Dotmatrik

Display atau alat penampil adalah alat peraga yang dapat menampilkan sandi yang dikodekan atau diterjemahkan. Pada prinsipnya ada tiga macam penampil yang dapat menampilkan angka atau huruf. Salah satunya adalah dislay dotmatrik.

Dotmatrik meruakan sebuah chip yang berisi kumpulan dari beberapa led yang dikemas menjadi satu.

Alat peraga ini biasanya memakai lampu led. Tapi dalam perancangan dan pembuatan kali ini saya menggunakan dot matrik yang biasa dijual dipasaran

Ada beberapa jenis dotmatrik yang ada dipasaran antara lain dot matrik dengan kolom lima baris delapan. Lampu led disusun berjajar lima kolom dan delapan baris, artinya dalam satu dotmatrik terdapat empat puluh led sebagai display suatu karakter

Jenis dotmatrik yang lain, seperti dotmatrik yang mempunyai empat warna dalam satu lampu led. Dot matrik tersebut mempunyai kode kode tersendiri untuk mengoperasikanya.

2.6 Transisror

Transistor adalah komponen yang paling banyak digunakan sebagai penguat saklar dan lain lain. Transistor akan bekerja mengalirkan arus antara kolektor ke emitor. Jika ada arus yang mengalir pada basisnya Ib besar arus basis yang akan mempengaruhi besarnya arus kolektor yang mengalir. Seahingga penguatan didapat dri mengubah arus basisnya yang masuk. Titik kerja transistor dapat dilihat pada garis karakteristik dari masing masing transistor, yang tersusun dibawah ini.

Dari gambar grafik diatas dapat diketahui bahwa untuk embuat Ic mengalir akan mengakibatkan perubahan dengan perbandingan terbalik antara Vcc dengan Ic. Inilah yang mengakibat kan titik kerja transistor berbedabed, yaitu dengan memberi Ib yang berbedabeda sesuai dengan perancangan,

Keadaan dimana Ib max maka akan menghasillkan transistor pada titik jenuh saturation yaitu arus Ic mengalir dengan maksimum, yang seakan akan colektor hubung singkat sengan emitor, ini digunakan sebagai saklar dalam keadan on dan saat Dimana Ib min atau tidak ada maka Vcc sangay tinggi mengakibatkan seakan akan Ic tidak mengalir sehingga , terjadi aliran yang terputus antar colektor emitor , keadaan ini disebut cut-off, digunakan sebagai saklar dalam keadaan open.

Keadaan dimana arus basis berubah ubah sesuai frekwensi atau sinyal input akan pula bekerja seperti cut-off dan saturation yang cepat sesuai sinyal masukan, maka akan menjadi penguat . Rangkaian ni memiliki kategori sesai dengan titik seimbang, yaitu saat dimana nilai rata rata tanpa sinyal masuk ke basis Ib dalam keadaan diam terletak di titik mana.

Untuk penguat kelas A titik kerja terdapat ditengah yaitu pada saat Ib sedan. Untuk Penguat kelas B maka titik kerja cut-off. Sedang pada kelas C titik kerja dibawah cutoff

Transistor C 828

ransistor tipe C 828 adalah transistor yang memiliki spesifikasi umum seperti berikut ini

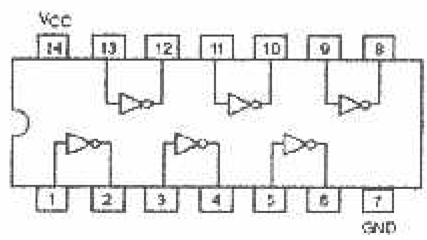
1. Vbe = 0,3 V
2. βdc = 40/140 kali
3. Ie max = 200maA

Bisa digunakan untuk kepeluan umum dengan spesifikasi untuk frekwensi sedang sampai tinggi. Kemasanya yang kecil dan penguatanya yang besar sangat cocok utuk keperluan keperluan digital, kususnya dihubungkan dengan mikrokontroler

2.7 Gerbang NOT (Inverter)

Logika not mempunyai kerja rangkaian seperti pembalik. Diumpamakan saklar yang diseri dengan relay yang mempunyai hubungan Ke saklar Normaly Open dan Normaly Closed. Saat saklar S1 high maka relay aktif dan menggerakkan saklar S2 menjadi normaly open. Sehingga lampu menjadi mati. Saat saklar S1 low maka relay mati yang mengakibatkan saklar S2 menjadi normaly closed. Sehingga lampu menjadi nyala

Dari gambar diatas jelas bahwa untuk menghasilkan lampu nyala maka S1 dalam keadaan low. Cara kerja rangkaian not ttl yang disimbolkan dengan gambar bolean dibawah ini . Gerbang logika not tipe 74ls04 memiliki satu input dan berjumlah enam gerbang not dalam satu Ic



Gambar 2.16 Arsitektur Ic 74ls04

Dengan susunan kaki

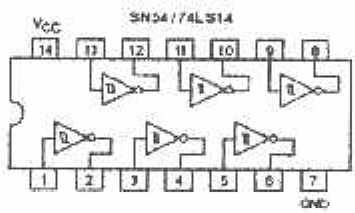
a. 13 input, 12 output, dan lain sebagainya
b. Vcc pin 14, supply 5Vdc ± 10%
c. Ground pin 7

2.8 Pemicu Schmitt

Rangkaian digital lebih menyukai bentuk gelombang dengan waktu naik turun yang cepat. Bentuk gelombang disebelah kanan simbolsimbol balik pada gambar 2.? Merupakan contoh sinyal digital yang baik. Sisi –sisi L-H dan H-L pada gelombang persegi ini, digambarkan vertical. Ini berarti waktu naik turunya sangat cepat(hampir sekejap)

Gambar 2.17 Simbol scmitt trigger

Bentuk gelombang disebelah kiri symbol balik menunjukkan waktu naik turunya yang sangat lambat. Bentuk gelombang yang sangat buruk ini dapat mengakibatkan operasi yang takdapat diandalkan, apabila dialirkan langsung ke penghitung, gerbang, atau rangkaian lainya, dalam contoh ini, inverter "pemicu Schmitt" digunakan untuk mempersegikan sinyal input dan membuat lebih bermanfaat



Gambar 2.18 Arsitektur Ic 74lc14

BAB III

PERANCANGAN DAN PEMBUATAN ALAT

3.1 Pendahuluan

Pada penyusunana alat ini digunakan dua mikrokontroler, satu untuk memproses data. Dan mikrokontroler satunya lagi untuk menyimpan karakter huruf yang akan di tampilkan, dan memanggil alamat pada ISD 25120. Adapun prinsip kerja alat ini yaitu:

Memasukkan data dari sisi sensor kemiringan, sisi sensor suhu, sisi sensor kecepatan, sisi sensor bahan bakar secara bergantian. Data dikirim secara Serial

Maksudnya adalah setelah data dari sisi sensor kemiringan masuk ke mikrokontrol sisi utama, maka mikrokontrol langsung mengeksekusinya, dengan melalui output display dan suara. Tanpa menghiraukan input data dari sensor yang lain.

Selanjutnya setelah data dari sensor suhu masuk ke mikrokontrol sisi utama, mikrokontrol langsung mengeksekusinya melalui output display dan suara, tanpa menghiraukan input data dari sisi sensor yang lain.

3.2 Prinsip Kerja

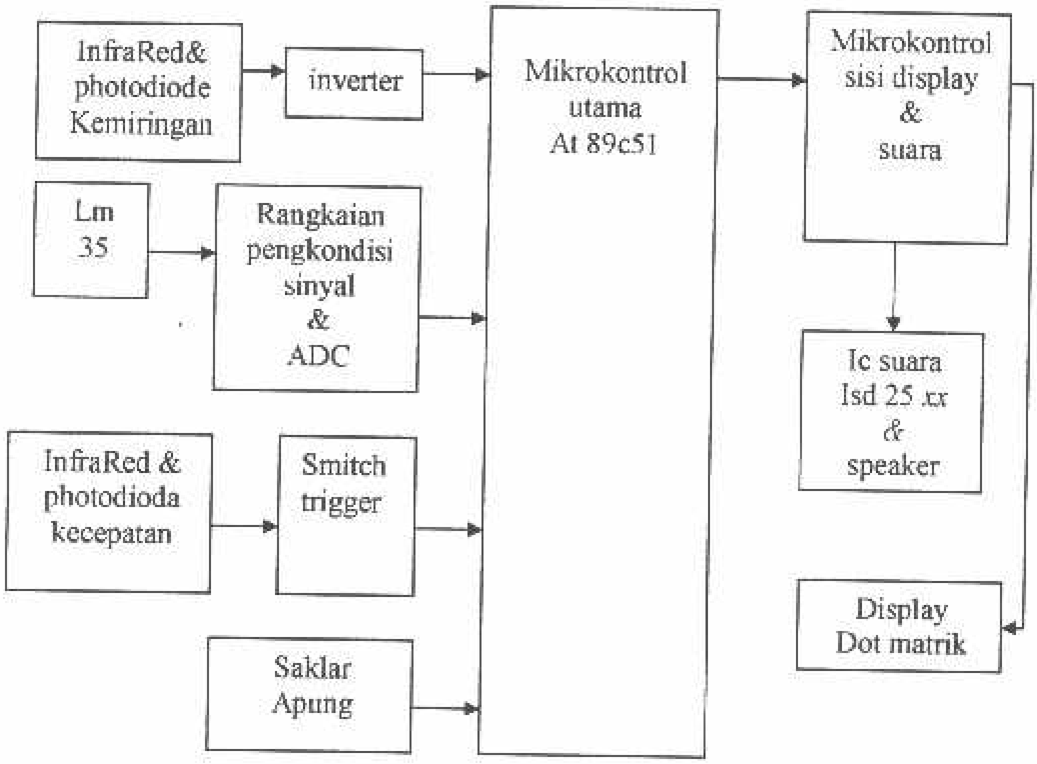
Perancangan dan pembuatan alat ini dibagi menjadi empatbagian yaitu:

a. Perancangan dan pembuatan sisi sensor

b. Perancangan dan pembuatan Sisi Mikrokontroler

c. Perancangan dan pembuatan sisi Display dan Suara

d. Perancangan dan pembuatan software

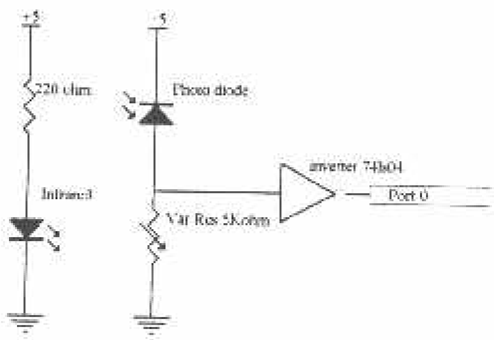


Gambar 3.1 Diagram blok Rangkaian

3.3 Perancanagan dan Pembuatan Alat Sisi Sensor

Sensor kemiringan mobil

Sensor ini dibuat dari Infrared Dan photo diode. Rangkaian ini disusun dengan dua buah bejana air. Dari bejana air tersebut kita dapatkan output photodiode yang dikonfigurasiakn oleh tinggi rendahnya permukaan air dalam bejana



Gambar 3. 2 Rangkaian infrared dan photodiode

Pada blok pendeteksi kemiringan ini menggunakan komponen-komponen dengan spesifikasi sebagai berikut:

- LED Infra Merah : 1,7 Volt / 15 mA
- Foto Dioda : 0.5 mA
- Transistor C828 : ICmax 50 mA

  β: 65

  Vbe 0,3 volt

Sebagai sumber cahaya dipergunakan sebuah rangkaian led infra merah dengan perhitungan untuk mencari nilai resistor beban yang diperlukan seperti berikut ini:

Rumus persamaamnya yaitu

$$R1 = \frac{Vcc - Vinred}{Iinred}$$

$$R1 = \frac{5 - 1{,}7}{15.10^{-3}}$$

$$R1 = \frac{3,3}{15.10^{-3}}$$

$$R1 = 220\ \Omega$$

Sedangkan untuk mencari nilai resistor dari *receiver* inframerah yaitu pada foto dioda adalah sebagai berikut Rumus persamaannya yaitu

Pada saat foto dioda mendapat cahaya nilai resistansi untuk *bias reverse* sangat kecil Vfd untuk *bias reverse* ≈ 0 volt maka:

$$R2 = \frac{Vcc}{Ifd}$$

$$R2 = \frac{5}{0,5.10^{-3}}$$

$$R2 = 10.10^{3}\ \Omega$$

$$R2 = 10K\ \Omega$$

Jadi pada P 3.6 dan P 3.7 mengeluarkan logika. Logika tersebut akan mengkontrol sisi infra red yang akan diaktifkan. Hal ini mengurangi penggunaan port pada sisi mikrokontroler utama. Setelah aktif maka infrared dapat memancarkan sinar.

Sinar dari infrared yang diterima oleh photodiode berlogika high. Sehingga memungkinkan untuk mengirim dari output photodiode sebanyak enam bit menuju ke P 0.0 – P 0.7

Adapun perhitungan rangkaian infrared dan photodiode adalah sebagai berikut:

Tabel 3.1 Nyala photo diode dan kemiringanya

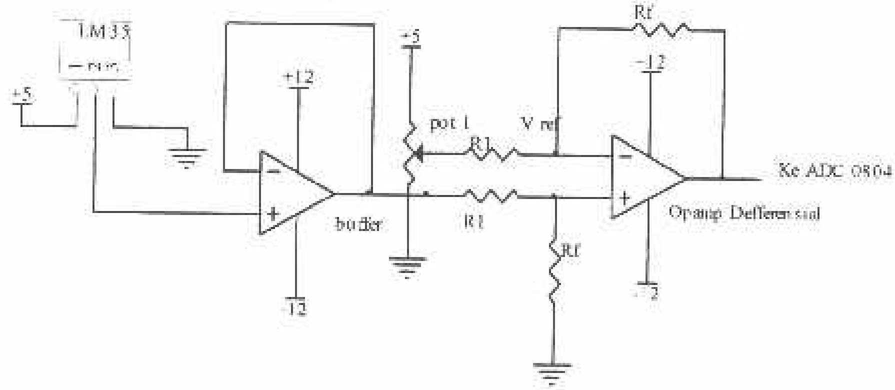
Kanan & Kiri Photodiode Yg Nyala	Data	Kemirimgan	Depan & belakang Photodiode Yg Nyala	Data	Kemirimgan
4	F0 h	Normal	4	F0 h	Normal
3	E0 h	10' kekiri	5	F8 h	10' kedepan
2	C0 h	20' kekiri	6	FC h	20' kedepan
1	80 h	30' kekiri	7	FE h	30' kedepan
0	00 h	40' kekiri	8	FF h	40' kedepan
5	F8 h	10' kekanan	3	E0 h	10'kebelakang
6	FC h	20' kekanan	2	C0 h	20'kebelakang
7	FE h	30' kekanan	1	80 h	30'kebelakang
8	FF h	40' kekanan	0	00 h	40'kebelakang

3.3.1 Sensor panas radiator

Untuk mendeteksi suhu pada radiator secara keseluruhan maka dibutuhkan perancangan yang detail. Untuk suhu yang panasnya paling actual kita tidak boleh meletakkan sensor disembarang tempat. Sebetulnya kita menggunakan sensor suhu berupa ic lm 35 case TO-46, yang merupakan lm 35 dengan case besi. Ambang kerja lm 35 TO-46 berkisar antara -60' – 180 celcius. Dengan speksifikasi range suhu seperti hal tersebut maka dapat mengukur suhu pada permukaan pipa antara blok mesin ke thermostat pada radiator. Namun hal ini mendapat permasalahan karena lm 35 TO-46, Sulit sekali dicari dipasaran. Maka dari itu kita menggunakan sensor suhu yang banyak beredar dipasaran saja.

3.3.2.1 Pengkondisi Sinyal

Biasanya sinyal dari sensor suhu sangat lemah dan cenderung berubah-ubah. Pengkondisi sinyal analog dibutuhkan untuk menguatkan sinyal dan menyangga agar perubahan sinyal tidak mempengaruhi system. Pengkondisi sinyal analog dibuat dengan menggunakan *op-amp (operasional amplifier)* yang difungsikan sebagai penguat penyangga (*buffer*) dan penguat Deferensial.



Gambar 3.3 Rangkaian pengkondisi sinyal

(penguat penyangga dan penguat deffensial)

3.3.2.2. Penguat Penyangga .

Penguat penyangga merupakan penguat yang kegunaannya untuk penguatan tanpa pembalikan fasa. Artinya sinyal output penguat sefasa dengan sinyal input penguat yang diberikan. Seperti ditunjukkan dalam Gambar 3.4 bahwa tahanan umpanbaliknya tidak ada sehingga seluruh tegangan keluaran akan diumpanbalikkan kemasukan. Penguat tegangan dari penguat penyangga ini sama dengan satu, dimana :

$$A = \frac{Vo}{Vi} = 1 \text{ .... (1)}$$

Vi = Tegangan masukan

Vo= Tegangan keluaran

Oleh karena itu penguat penyangga disebut juga dengan pengikut tegangan keluaran penguat mengikuti tegangan masukan baik besarnya maupun fasanya.

Penguat penyangga ini digunakan untuk mengisolasi suatu tingkat penguat dari penguat berikutnya agar tidak terbebani. Selain itu penguat penyangga juga dipakai untuk penyesuaian impedansi yang biasanya mempunyai impendansi input yang tinggi dan impendansi output yang rendah.

3.3.2.3.Operating Amplyfier Deferensial

Dengan penguat deferensial kita bisa menguatkan tegangan dari buffer. Berikut adalah tabel dari output Lm35 dan Buffer, dengan range terendah hingga range tertinggi. Nilai dari penguatan dapat kita hitung dengan rumus sebagaiberikut

$$Av = \frac{5}{V\max - V\min} = \frac{5}{1900.10^{-3} - 300.10^{-3}} = \frac{5}{1,6} = 3,125$$

Dengan nilai penguatan 3,125 kali maka kita bisa menentukan besarnya Rfeedback dan Rin

$$Av = 3,125 = \frac{Rf}{R1} = \frac{3,125K\Omega}{1K\Omega}$$

Adapun besarnya Voutput adalah

$V\ out = (1900.10^{-3} - 1700.10^{-3})3{,}125$

V out=0,625 Volt

- Dengan suhu 160'C .Output Buffer 1600m volt. Maka output penguat defferensial Vout

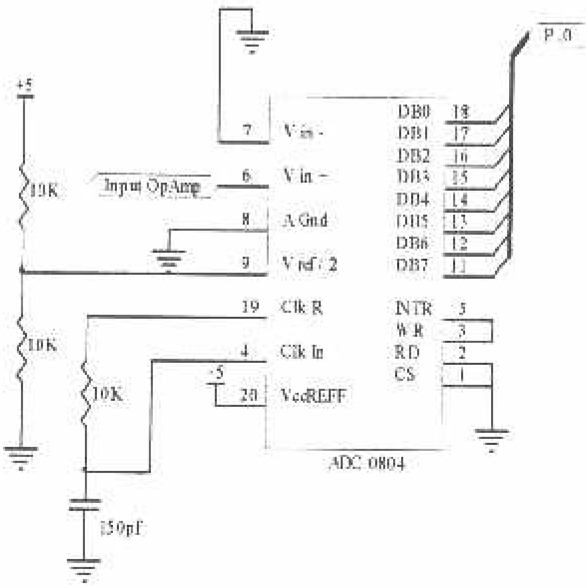
  $V\ out = (Vref - Vin)Av$

  $V\ out = (1900.10^{-3} - 1600.10^{-3})3{,}125$

  V out= 0,9375 Volt

3.3.2.4. Pengubah Analog Ke Digital ADC 0804

Pengubah analog ke digital *(Analog to digital conventer/ADC)* mengubah sinyal analog (kontinyu) ke bentuk sinyal digital dengan pendekatan sesuai jumlah digit yang digunakan. Pada prinsipnya ADC adalah mengukur sinyal analog dan mengubahnya menjadi bilangan biner.Beberapa teknik pengubah telah diciptakan untuk pengubahan analog ke digital. Masing-masing mempunyai kelebihan dan kekurangan parameter utama yang dipakai untuk menilai keunggulan tiap teknik biasanya adalah kecepatan, harga dan kecepatan. yang mana dalam rangkaian tersebut terdapat pin-pin yang mempunyai fungsi masing-masing.



Gambar 3.4 Rangkaian Analog to digital converter

Pin 18 sampai 11 adalah keluaran digital. Apabila pin CS dan RD tidak aktif, keluaran digital akan berlogika tinggi. Sedangkan bila CS dan RD diberi logika rendah, akan menghasilkan keluaran.

Pin WR bila dibuat aktif bersamaan CS akan memulai konversi. Bila WR = 0 konversi akan direset. Setelah WR berubah ke 1 konversi langsung dimulai. Pin 4 merupakan sinyal clock masukan. Clock ini dapat berupa eksternal, atau onternal dengan menambahkan rangkaian RC antara CLK *in* dan CLK *out*.

Vin (+) dan Vin (-) adalah sinyal masukan diferensial. Jika Vin (+) dihubungkan ke ground, Vin (-) digunakan untuk masukan negative. Sedangkan jika Vin (-) yang dihubungkan ke ground, Vin (+) dihubungkan kemasukan positif.

Pin 9 adalah tegangan referensi maksimum sinyal analog. Bila sinyal ini tidak dihubungkan, tegangan referensinya sama dengan Vcc. Jika ingin menggunakan tegangan maksimum yang berbeda dengan Vcc, pin ini dihubungkan dengan tegangan ½ kali tegangan maksimum yang diinginkan.

Pin 5 (INTR) akan menunjukkan bahwa konversi telah selesai. Ketika dimulai konversi INTR akan mengeluarkan logika tinggi. Jika konversi selesai INTR akan mengeluarkan logika rendah.

Untuk mengetahui resolusi ADC 0804 maka digunakan rumus

$$\text{Resolusi} = \frac{Vref\,2}{2^n - 1}$$

Vref = 5 Volt

Vref/2 = 2,5 Volt

$$\text{Resolusi} = \frac{5}{256-1} = \frac{5}{255} = 0{,}0196$$

$$\text{Vout ADC} = \frac{Vin}{Res}$$

Untuk V input 5 volt maka Vout ADC samadengan

$$\text{Vout ADC} = \frac{5}{0{,}02} = 250$$

Output ADC =

$$
\begin{array}{l}
250 : 2 = 125 \quad = 0 \\
125 : 2 = 62 \quad = 1 \\
62 : 2 = 31 \quad = 0 \\
31 : 2 = 15 \quad = 1 \\
15 : 2 = 7 \quad = 1 \\
7 : 2 = 3 \quad = 1 \\
3 : 2 = 1 \quad = 1
\end{array}
$$

Output ADC = 11111010

Untuk output ADC dengan Vin lainya dapat dilihat pada tabel berikut ini

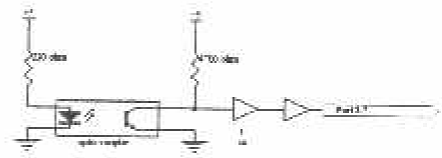
Tabel 3.2 Tabel konversi data opamp defensial ke biner

Tabel Perhitungan Suhu												
suhu	lm 35	buffer	opamp defferensial	A D C								Data
c	m Volt	m Volt	Volt	D0	D1	D2	D3	D4	D5	D6	D7	Heksa
30	300	300	5	1	1	1	1	1	0	1	0	FA
40	400	400	4.6875	1	1	1	0	1	0	1	0	EA
50	500	500	4.375	1	1	0	1	1	0	1	0	DA
50	600	600	4.0625	1	1	0	0	1	0	1	1	CB
70	700	700	3.75	1	0	1	1	1	0	1	1	BB
80	800	800	3.4375	1	0	1	0	1	0	1	1	AB
90	900	900	3.125	1	0	0	1	1	1	0	0	9C
100	1000	1000	2.8125	1	0	0	0	1	1	0	0	8C
110	1100	1100	2.5	0	1	1	1	1	1	0	1	7D
120	1200	1200	2.1875	0	1	1	0	1	1	0	1	6D
130	1300	1300	1.875	0	1	0	1	1	1	0	1	5D
140	1400	1400	1.5625	0	1	0	0	1	1	1	0	4E
150	1500	1500	1.25	0	0	1	1	1	1	1	0	3E
160	1600	1600	0.9375	0	0	1	0	1	1	1	0	2E
170	1700	1700	0.625	0	0	0	1	1	1	1	1	1F
180	1800	1800	0.3125	0	0	0	0	1	1	1	1	0F
190	1900	1900	0	0	0	0	0	0	0	0	0	00

3.3.3 Sensor Kecepatan

InfraRed Dan PhotoTransistor

Sensor Kecepatan terdiridari Ired (infrared) danphoto transistor rangkaian sensor ini untuk mendeteksi kondisi gelap terang yang kemudian digunakan untuk mendeteksi kecepatan putaran roda. Adapun Rangkaian sensor kecepatan terdapat pada gambar berikut



Gambar 3.5 Rangkaian sensor kecepatan

Sebagai sumber cahayaDiguanakan infrared yang diseri dengan resistor untuk mendapatkan nilai resistror perhitunganya adalah sebagai berikut

Arus InfraRed (Iir) = 20Ma

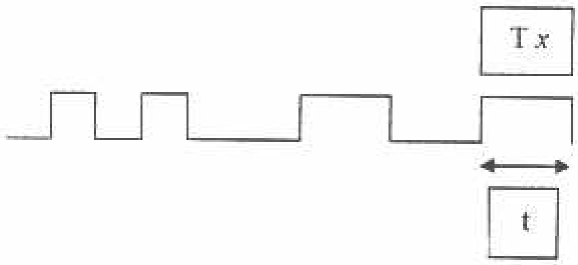
$$R1 = \frac{V_{cc} - V_{ir}}{I_{ir}} = \frac{5-1{,}2}{20.10^{-3}} = 190\Omega$$

Maka dari itu dipasang resistor dengan pendekatan 120Ω

Output dari sensor putaran akan masuk pada rangkaian smitch trigger. Rangkaian SmitchTrigger digunakan untuk menyempurnakan logika high agar mutlak high, begitu juga untuk logika low. Selain itu rangkaian SmitchTrigger digunakan untuk mengurangi SlewRate (kemiringan) yang dapat menyebabkan delay

Prinsip kerja dari rangkaian kecepatan adalah sebagai berikut

Saat phototransistor mengeluarkan ±5 volt, akan dipullup high oleh P3.4. Maka dari itu saat logika high counter mikrokontroler mengcounter pulsa. Saat logika low counter mikrokontroler berhenti mencounter pulsa. Data itulah yang nantinya akan kita hitung.



Gambar 3.6 Pulsa yang disensor phototransistor

$$Tx = \frac{F}{t}$$

counter dalam t = 200 pulsa

Jika Xtal 12Mhz maka 200 counter = 200μsecond

$$T\,x = \text{Jumlah pulsa} \cdot \left(\frac{XtalYangDipakai}{12}\right) \mu Second$$

$$T\,x = 200 \text{ pulsa} \cdot \left(\frac{12Mhz}{12}\right) \mu\, \text{sec}\,ond$$

T x = 200μsecond

Sehingga diperoleh perhitungan sebagai berikut

λ= Jarak lubang yang terdeteksi oleh phototransistor

λ= 0,5 meter

$$V = \lambda \cdot \frac{1}{T?}$$

$$V = 0{,}5 \text{ meter} \cdot \frac{1}{200\mu Second}$$

$$V = 0{,}5 \text{ meter} \cdot \frac{1}{200\mu Second} \cdot \frac{5000}{5000}$$

$$V = \frac{2500 meter}{second}$$

$$V = \frac{2500.3600.meter}{jam}$$

$$V = \frac{9000000 meter}{jam}$$

$$V = 9000 \, {}^{km}\!/_{jam}$$

Jadi dapat ditarik kesimpulan

Jika dalam satu pulsa high terdapat 200 pulsa counter maka identik dengan kecepatan 9000 $^{km}\!/_{jam}$

Berikut Tabel konversi pulsa yang diterima mikrokontrol menjadi data kecepatan

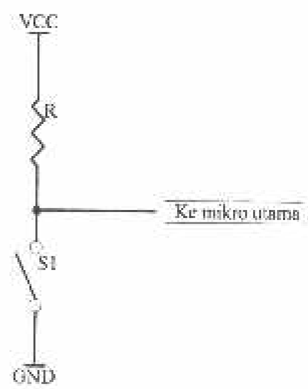
Tabel 3.3 Konversi data pulsa menjadi kecepatan dalam km/jam

V km/jam	V m/second	λ meter	Pulsa
100	27.7	0.5	18000
90	25	0.5	20000
80	22.22	0.5	22500
70.5	19.6	0.5	25500
60	16.6	0.5	30000
50	13.8	0.5	36000
40	11.1	0.5	45000
30	8.33	0.5	60000
20	5.74	0.5	87000
10	2.94	0.5	157000

3.3.4 Sensor Bahan bakar

Untuk sensor bahan bakar hanya dibuat sebuah perancangan yang sederhana. Jika jumlah bahan bakar tidak mencukupi maka akan men-Switch saklar. Rangkaian adalah sebagai berikut

Jika saklar on maka di P3.5 akan berlogika high. Sistem ini akan menginterupsi program utama sehingga mikrokontrol mengekdekusi melaui output display dan suara. Untuk warning bahwa bahan bakar habis.



Gambar 3.7 Rangkaian sensor bahan bakar

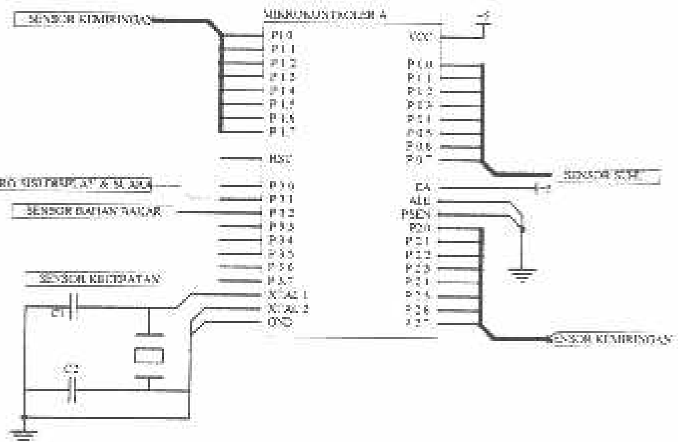
3.4 Perancangan dan pembuatan sisi mikrokontroler

3.4.1 Mikrokontroler sisi utama.

Rangkaian control utama ini adalah pemroses data dari sensor dan juga yang mengaktifkan sisi rangkaian tertentu. Susunan kaki mikrokontrolerAT89C51 sebagai berkut

- P 2 . Untuk membaca data 8bit dari sensor kemiringan kanan & kiri
- P1. Untuk membaca data 8bit dari sensor kemiringan depan& belakang

- P.0. Untuk untuk membaca data 8 bit dari adc 0804(sensor suhu)
- P3.1.Untuk mengirim data serial ke mikro sisi display dan suara.
- P3.2 .Untuk membaca kondisi high/low. Pada sensor bahan bakar
- P3.7 Timer. untuk membaca pulsa dari rangkaian sensor kecepatan



Gambar 3.8 Rangkaian Mikrokontroler utama

Pada rangkaian ini terdapat dua tombol yang difungsikan sebagai reset dan power. Dengan menggunakan kristal sebagai pembangkit pulsa dan kapasitorsebagai resonator keramik dengan susunan seperti ketentuan , menggunakan clock internal

Dengan menghubungkan x1 dan x2 pada dua buah capasitor ke ground seperti terlihat pada gambar dibawah ini

AT89C51 Memiliki ketentuan rangkaian kristal 2 Mhz sampai 26 Mhz, dengan kapasitor resonator27pf sampai 33pf. Berikut gambar rangkaian osilator

Rangkaian tersebut digunakan untuk semua rangkaian mikrokontrol. Sedangakan pin reset pada mikrokontrol digunakan susunan RC. Seperti ada gambar berikut

Dengan perhitungan $T=\frac{1}{f}$

$$F=\frac{1}{T}$$

$$F=\frac{1}{1{,}1.R.C}$$

$$F=\frac{1}{1{,}1.10.10^{3}.47.10^{-6}}$$

$$F=19{,}34 \text{ Hz}$$

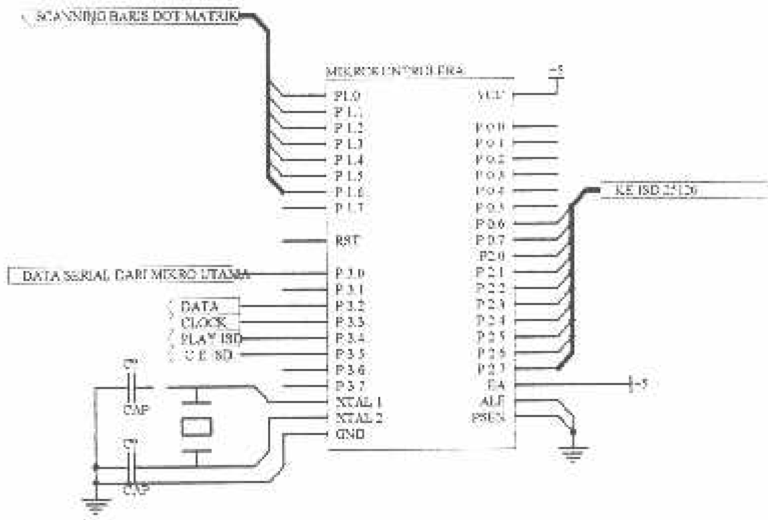
$$T=\frac{1}{19{,}34}=0{,}057\,Second$$

3.4.2 Mikrokontrol sisi Display dan suara

Rangkaian mikrokontrol sisi display dan suara digunakan sebagai penyimpan data, yang nantinya akan ditampilkan berupa karakter huruf pada papan display dot matrik. Adapun susunan kaki mikrokontrol adalah sebagai berikut

- P.0 dan P.2. Un5Tuk menghubungi ISD 25120
- P3.4 Untuk control Play & stop, ISD 25120
- P3.5 Untuk CE (start & pause) ISD 25120
- P. 0. Untuk scanning baris dot matrik

- P3.2 . Untuk data yang dikirim ke shift register (tampilan karakter)
- P 3.3. U ntuk clock shift register



Gambar 39 Rangkaian Mikrokontroler sisi display dan suara

3.5 Display Dan Suara

3.5.1 Rangkaian Papan Display Dotmatrik

Display dotmatrik yang dipakai disini adalah dotmatrik satu warna yaitu berwarna merah. 7x5 berarti terdapat 35 titik dot yang dapat dinyalakan dalam satu sel dotmatrik. Untuk menyalakan satu titik diperlukan arus sebesar 10 mAmp. Pada papan display tersebut disusun sebanyak 8 buah sel dotmatrik. Sehingga untuk menyalakan satu baris , maka arus listrik yang disuply harus mampu untuk menyalakan 8*5=40 titik secara bersamaan. Jika suatu saat semua titik dalam satu baris harus menyala seluruhnya.

Selain itu arus yang disuply saat itu (secara scanning) harus cukup bertahan sampai scanning kembali ke baris tersebut. Hal ini berarti bahwa jumlah arus yang dikalikan 7, karena seluruhnya ada 7 baris dalam tiap sel dot matrik. Untuk arus yang disuply untuk masing masing baris adalah

10 m A * 40* 1 baris =400 m A.

Dalam desain rangkaian tersebut dilakukan scanning secara baris, sedanglan data diberikan dalam kolom. Sinyal scanning diatur oleh software dari program mikrokontroler, proses scanning dotmatrik dilakukan secara terus menerus mulai dari baris satu sampai dengan baris ke tujuh. Kemudian kembali ke baris satu . (yo) sebesar 0 Volt, yaitu dari rangkaian pengontrol mikrokontroler p1.1 maka transistor dalam keadaan cut-off, yang berfungsi sebagai saklar terbuka.

Dengan spesifikasi transistor maka didapat nilai dari resistor basisnya dengan nilai

Ie adalah beban led 70 mA

Satu scanning transistor terbebani oleh 40 led

Ie = 70 m A . 40 = 2.8 Amp

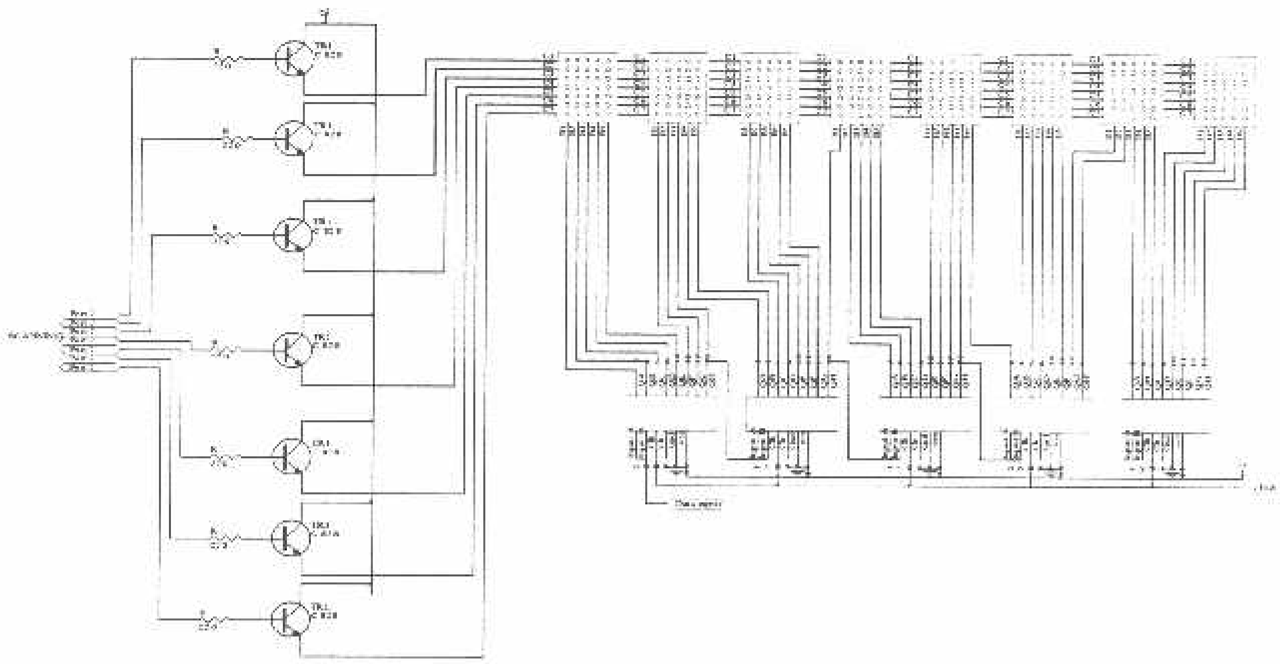
Vb adalah kondisi high 1 = 5 Volt

Ve = Vled = 1 Volt

$$Ib = \frac{Ie}{\beta + 1} = \frac{2{,}8Amp}{41} = 68mA$$

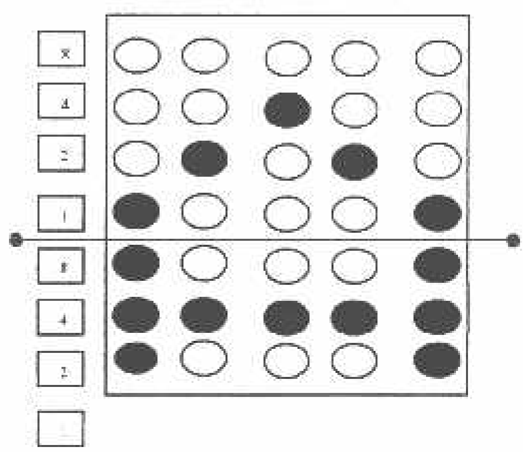
Untuk Driver Display dotmatrik maka

$$R\ basis = \frac{Vr}{Ib} = \frac{3}{68mA} = 44\Omega$$



Gambar 3.10 Rangkaian sisi dotmatrik

Untuk menampilkan satu huruf maka dibutuhkan 5 kolom dotmatrik untuk menggambarkanya. Sebagai contoh huruf A dibentuk oleh nyala led seperti pada gambar dibawah ini, yang nantinya dapat kita alamati sesuai dengan logika biner pada tiap kolomnya



Gambar 3.11 Nyala karakter huruf A

Berikut tabel Data Karakter yang akan didisplaykan

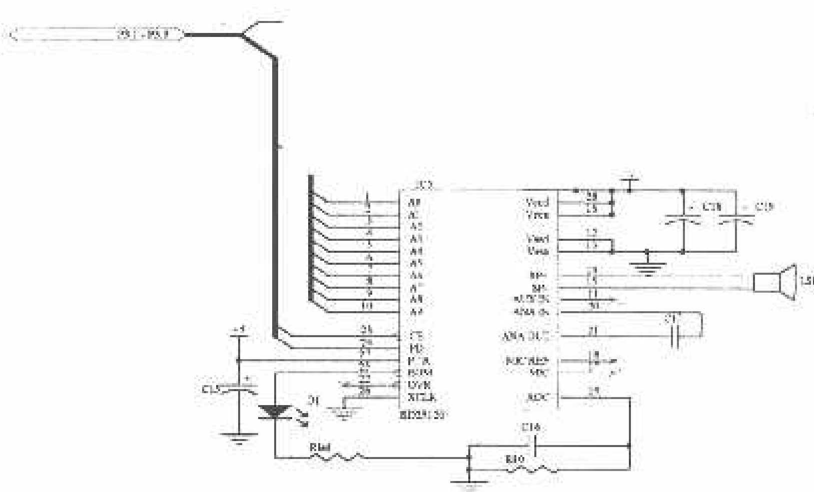
Tabel 3.4 Karakter yang akan didisplaykan

KARAKTER HURUF DAN ANGKA					
A	0,1FH	24H	44H	24H	1FH
B	0,7FH	49H	49H	49H	36H
C	0,3EH	41H	41H	41H	22H
D	0,7FH	41H	41H	41H	3EH
E	0,7FH	49H	49H	49H	41H
F	0,7FH	48H	48H	48H	40H
G	0,3EH	41H	41H	45H	47H
H	0,7FH	08H	08H	08H	7FH
I	0,00H	41H	7FH	41H	00H
J	0,02H	01H	01H	01H	7EH
K	0,7FH	08H	14H	22H	41H
L	0,7FH	01H	01H	01H	01H
M	0,7FH	20H	18H	20H	7FH
N	0,7FH	10H	08H	04H	7FH
O	0,3EH	41H	41H	41H	3EH
P	0,7FH	48H	48H	48H	30H
Q	0,3EH	41H	45H	42H	3DH
R	0,FH	48H	4CH	4AH	31H
S	0,32H	49H	49H	49H	26H
T	0,40H	40H	7FH	40H	40H
U	0,7EH	01H	01H	01H	7EH
V	0,7EH	02H	01H	02H	7FH
W	0,7FH	02H	0CH	02H	7FH
X	0,63H	14H	08H	14H	63H
Y	0,60H	10H	0FH	10H	60H
Z	0,43H	45H	49H	51H	61H
0	0,3EH	45H	49H	51H	3EH
1	0,21H	7FH	01H	00H	00H
2	0,23H	45H	49H	49H	31H
3	0,42H	41H	49H	59H	66H
4	0,0CH	14H	24H	7FH	04H
5	0,72H	51H	51H	51H	4EH
6	0,1EH	29H	49H	49H	46H
7	0,40H	47H	48H	50H	60H
8	0,36H	49H	49H	49H	36H
9	0,31H	49H	49H	4AH	3CH
'	00H	02H	0H	00H	0H
/	20H	10H	08H	04H	02H

3.5.2 Sisi Suara

Rangkaian ini digunakan untuk menghasilkan suara yang diperlukan sistem agar lebih interaktif. Suara tersebut berisikan informasi atau suara sesuai yang ada pada tabel dibawah ini. Yang masing-masing kata teralamati secara otomatis pada waktu pengisian (*recording*) suara pada ISD 25120.

Perekam suara yang digunakan adalah ic type *information storage device* ISD 25120. Sisi suara Isd 25120 dikontrol oleh mikrokontrol utama melaluipin P 3.4. (play) dan pin P 3.5 (CE). Data 10 bit dikirim secara pararel melalui port serial P 2 dan P.0



Gambar 3.12 Rangkaian sisi suara ISD 25120

Output dari ISD 25120 langsung menuju speaker dan jika dinginkan suara yang lebih keras dapat dilakukan secara amplifier secara eksternal dapat dihitung kapasitas suara yang digunakan perekaman yaitu dengan rumus :

$$\text{Lama suara tiap bit} = \frac{120}{767} = 0{,}156 \text{ second}$$

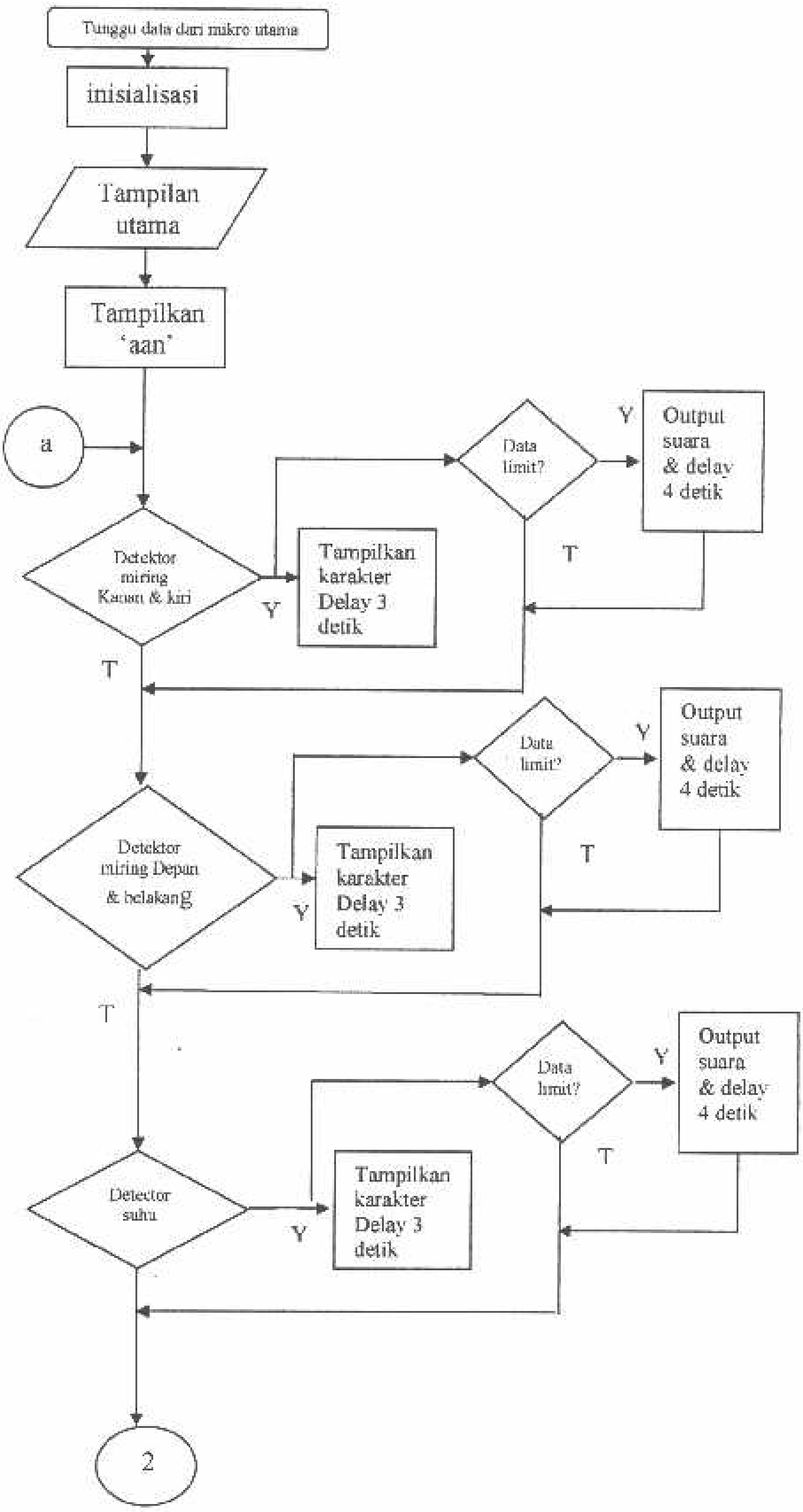
Dengan suara yang dibutuhkan diatas diketahui waktu yang digunakan saat diputar ulang secara keseluruhan ± ? detik. Sehingga ic dengan kapasitas diatasnya sedikit bisa kita gunakan. Yaitu tipe isd 25120. denga kelebihan waktu untuk persediaan kesalahan.

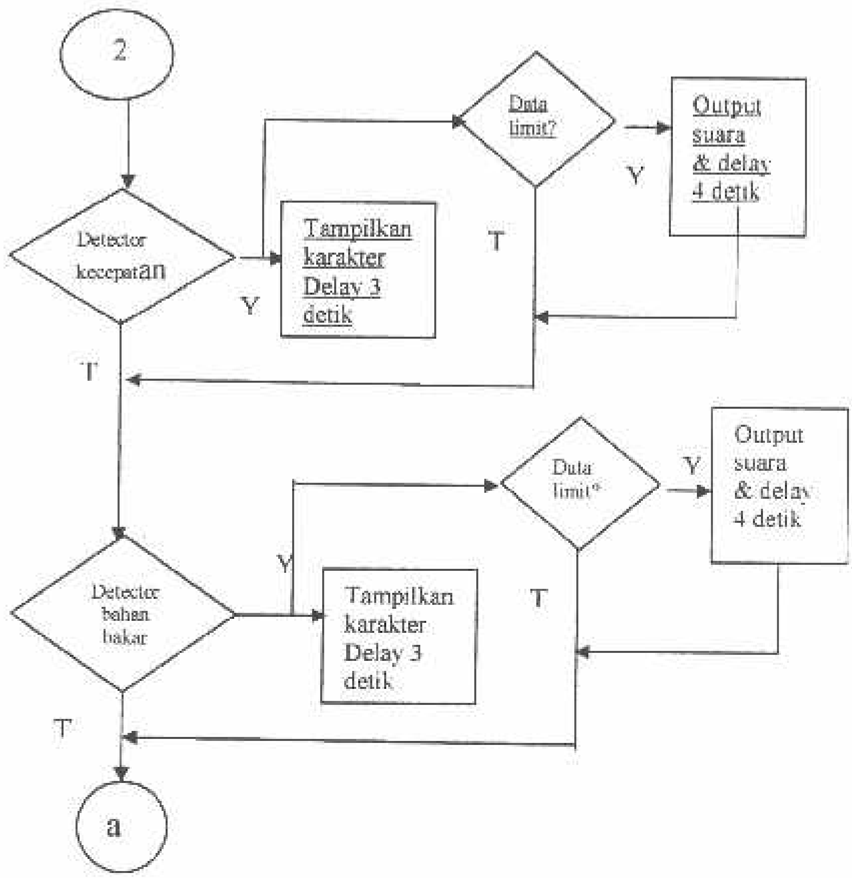
3.6 Perancangan Perangkat Lunak (Software)

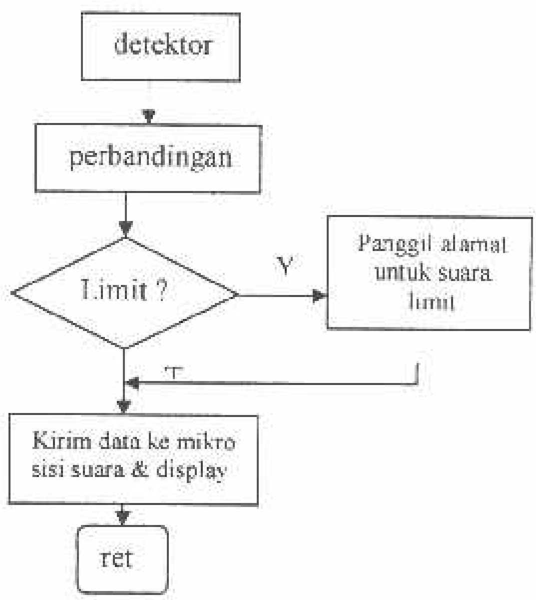
Program adalah kumpulan dari instruksi untuk mengendalikan atau mengoperasikan sistem perangkat keras (*Hardware*). Adapun langkah - langkah pembuatan program ini adalah sebagai berikut :

a. Membuat diagram alir (*flowchart*) program yang akan dibuat
b. Mengubah diagram aliran tersebut ke dalam bahasa pemrograman
c. Penulisan program dengan menggunakan teks editor atau edit plus dan disimpan dengan ekstensi H51.
d. Mengkompilasikan program yang telah dibuat ke dalam memori, sampai menghasilkan program dengan ekstensi HEX.
e. Merubah file berekstensi HEX menjadi file berekstensi BIN
f. men-*download* file berekstensi BIN ke dalam PEROM mikrokontroller AT89S51. Kemudian memasukkan program yang telah selesai, dan sistem akan bekerja dengan baik jika perancangan perangkat lunak (*software*) sesuai dengan perangkat keras (*hardware*) yang mendukung.

Berikut ini merupakan *flowchart* dari mikrokontroler utama dan mikrokontroler sisi dot matrik


Tunggu data dari mikro utama
inisialisasi
Tampilan utama
Tampilkan 'aan'
a
Detektor miring Kanan & kiri
Y
Tampilkan karakter Delay 3 detik
Data limit?
Y
Output suara & delay 4 detik
T
T
Detektor miring Depan & belakang
Y
Tampilkan karakter Delay 3 detik
Data limit?
Y
Output suara & delay 4 detik
T
T
Detector suhu
Y
Tampilkan karakter Delay 3 detik
Data limit?
Y
Output suara & delay 4 detik
T
2





Gambar 313
Flowchart

BAB IV
PENGUJIAN ALAT

Dalam bab ini diuraikan tentang pengujian alat yang telah dibuat berdasarkan perencanaan. Maksud dari pengujian ini adalah untuk mengetahui bahwa alat yang dirancang dapat berfungsi dengan baik serta bermanfaat bagi pengguna.

4.1 Pengujian Level Tegangan

4.1.1 Tujuan pengujian

Tujuan pengujian yang harus dicapai adalah mengetahui output dari tiap blok rangkaian sensor. Dan memastikan bahwa output pada saat kondisi low tetap dibaca low dan kondisi high tetap dibaca high, karena Mikrokontroler tidak dapat membaca data yang ambigu. Berdasarkan level tegangan. Untuk pengujianya menggunakan multimeter.

4.1.2 Alat dan Bahan

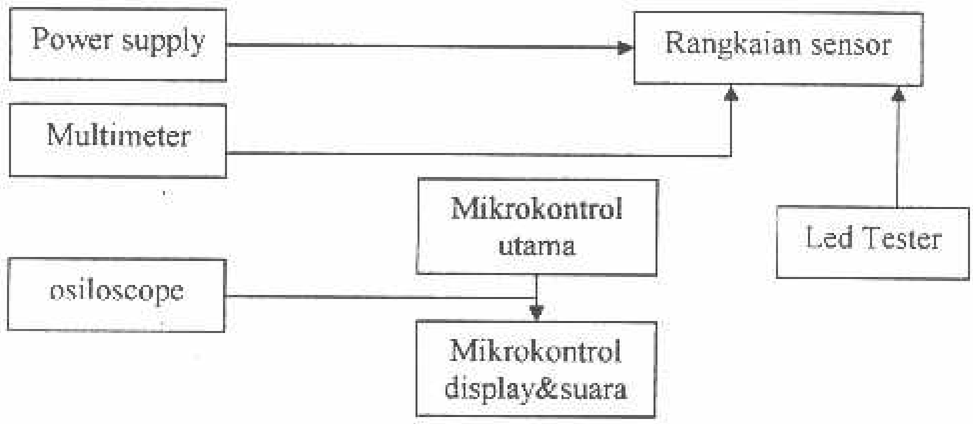
Peralatan yang digunakan antara lain :

1. Rankaian sensor
2. Multimeter
3. Ledtester

4.1.3 Pelaksanaan Pengujian

Langkah-langkah yang dilakukan dalam pengujian sebagai berikut

1. Menghubungkan rangkaian sebagai berikut :



Gambar 4.1
Gambar diagram Blok pengukuran

2. Multimeter diset pada DC Volt
3. Mengukur output dari tiap-tiap inverter pada blok sensor kemiringan, Output ADC 0804, Output Phototransisitor sensor kecepatan, .
4. Untuk melihat data output dari sensor, maka dilakukan simulasi kemiringan, simulasi suhu, simulasi kecepatan, simulasi sensor bahan bakar. Selanjutnya menyambung ledtester pada tiap outputnya.
5. Untuk melihat data serial yang dikirim dari mikrokontroler utama ke mikrokontroler display & suara, maka dilakukan pengukuran dengan menggunakan osiloscope

4.1.4 Pengujian Alat

1. Percobaan 1 (output inverter 74ls04)

dengan perhitungan R= $\frac{Vcc}{Iforward} = \frac{5}{0{,}5.10^{-3}} = 10k\Omega$. Pada saat photo dioda mendapat sinar masukan dari infrared, maka photo dioda tersebut dibias forward, maka photodiode berkerja sesuai dengan yang diinginkan yaitu mengeluarkan output: Kondisi low : 0,10 volt

Kondisi high : 4,68 volt

Gambar 4.2

Gambar pengukuran blok kemiringan

Terlihat pada multimeter 1 level tegangan 4,68 volt.di balik oleh inverter menjadi logika low. Berarti pada bit 0 logika low, dan pada multimeter 1 menunjukan tegangan 0,10 volt dibalikoleh inverter menjadi logika high, berarti pada bit 7 logika high

2. Percobaan 2 (output Penguat deferensial)

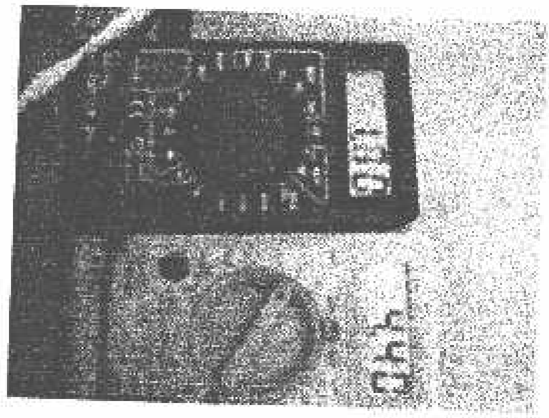
   Pada perhitungan rangkaian penguat deferensial besar output adalah

   Vout= $(Vinput - Vreferensi)\frac{Rf}{R1}$

   Sedangkan Vreferensi sebesar *Vref - V input min.(190 m volt).* Jadi saat Vinput maksimum maka Voutput = 5 volt. Sedangkan saat Vinput min maka Vout = 0 volt

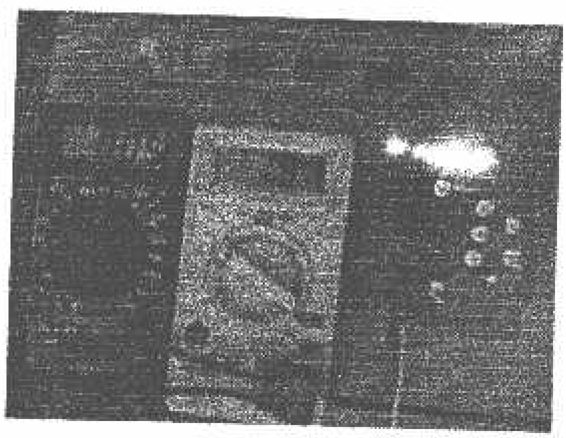
   Hal ini sesuai dengan hasil pengukuran.

   Pada multimeter output buffer yaitu kaki 1 ic LM324 sebesar 180 mVolt, dan pada multimeter 2 out penguatan deferensial menunjukan 4,4 0 volt



Gambar 4.3
Gambar pengukuran penguat deferensial

3. Percobaan 3 output ADC 0804



Gambar 4.4
Gambar pengukuran Outout ADC 0804

Pada saat input kaki 6 adc0804 sebesar 5 volt Outputnya berlogika 1111111. Dalam hasil perhitungan ditunjukan dengan rumus

$$\text{Resolusi}=\frac{\frac{Vref}{2}}{2^n-1}$$

Vref = 5 Volt

Vref/2 = 2,5 Volt

$$\text{Resolusi} = \frac{5}{256-1} = \frac{5}{255} = 0{,}0196$$

$$= 20 \text{ mili}$$

$$\text{Vout ADC} = \frac{Vin}{Res}$$

Untuk V input 5 volt maka Vout ADC samadengan

$$\text{Vout ADC} = \frac{5}{0{,}02} = 250$$

Output ADC =

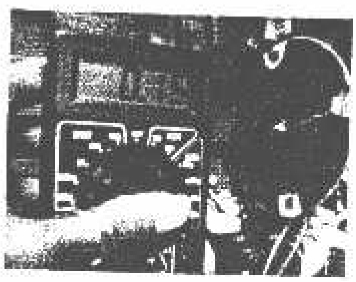
2 | 250 = 0
2 | 125 = 1
2 | 62 = 0
2 | 31 = 1
2 | 15 = 1
2 | 7 = 1
2 | 3 = 1
1

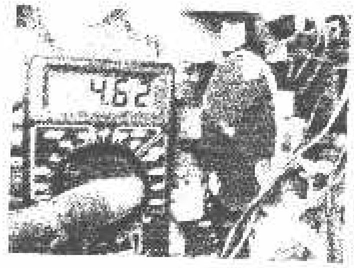
Output ADC = 11111010

Dalam hasil pengujian

Pada multimeter 1 output penguat deferensial menunjukkan tegangan 5 volt, dan pada output adc 0804 = 11111101 ditunjukan oleh ledtester (normaly high). Terjadi selisih beberapa bit dari hasil perhitungan, hal itu dikarenakan pada saat melakukan perhitungan resolusi dibulatkan dari 0,0196 menjadi 0,020

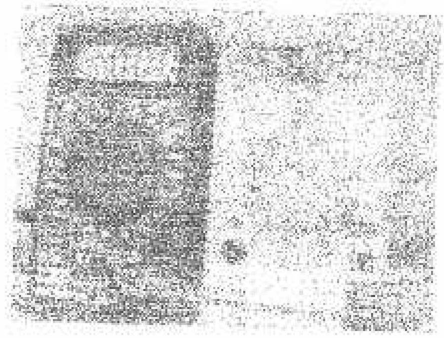
4. Percobaan 4, output Smitch trigger rangkaian sensor kecepatan
   Kondisi low : 0,15 volt
   Kondisi high : 4,62 volt





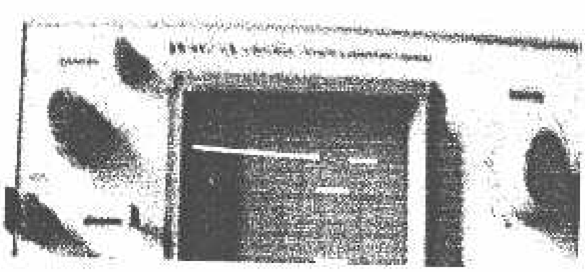
Gambar 4.5
Gambar pengukuran Output Smitch trigger 74ls14

5. Percobaan 5, output sensor bahan bakar
   Kondisi low : 0,00volt
   Kondisi high : 5,00 volt



Gambar 4.6
Gambar pengukuran Output bahan bakar

6. Percobaan 5, data komunikasi serial
   Kondisi low : 0,56 volt
   Kondisi high : 4,95 volt



Gambar 4.6
Gambar pengukuran level tegangan data komunikasi serial

Antara perbedaan dua level tegangan tersebut dapat ditarik kesimpulan bahwa tegangan 0,56 dibaca "0" dan tegangan 4,85 dibaca "1". Karena level tegangan 0,8 – 2,8 volt dibaca ambigu oleh mikrokontroler.

4.2 Pengujian Papan Display

Pengujian papan display dilakukan untuk mengetes apakah semua led pada dotmatrik dapat berfungsi. Driver dotmatrik berupa rangkian transistor C828 (NPN), Untuk pengujiannya maka driver scanning dotmatrik pada kaki basisnya diberi input tegangan

Semua driver berjumlah tujuh buah basisnya diberi tegangan, maka colektor emitor short. Jika led pada semua barisnya nyala maka dotmatrik dapat berfungsi dengan baik

Percobaan dilakukan pada tiap barisnya yang berjumlah tujuh. Selanjutnya dilakukan percobaan untuk mengetes IC 74LS164 (Register geser)

Basis (volt)	Emitor
0	0
5	5

4.3 Pengujian IC 74LS164 (Register geser)

Untuk mengetahui apakah register geser berfungsi dengan baik maka dilakukan percobaan sebagai berikut.

1. Pada saat semua scan baris nyala (semua led nyala), kaki 1 dan 2 IC 74LS164 (data) dihubung ke ground.
2. Berikan logika high ke low secara berulang (sebagai clock) pada kaki 8 IC 74LS164
3. Pada kolom ke satu led harus mati semua
4. Jika logika yang diberikan dari high ke low pada kaki 8 IC74LS164 dilakukan secara berulang, maka karakter led yang mati harus berupa satu kolom bergeser ke kolom kedua, begitu seterusnya sesuai dengan clock yang diberikan

5. Sehinnga kita dapat menyeleksi IC 74ls164 sebelah mana yang tidak bisa berfungsi dengan baik

4.4 Pengujian Rangkaian suara

Setelah melakukan perekaman maka kita harus tahu dimana letak alamat untuk satu karakter suara tertentu. Pengujian dilakukan dengan menggunakan dip switch 10. hal ini sesuai dengan jumlah inputan ISD 25120 sebanyak 10 bit.

1. Lakukan perekaman dengan karakter suara yang berbeda beda
2. Menyeleksi alamat untuk suara tertentu, mulai dari bit terendah 000 H
3. Mencatat letak alamat untuk suara suara tertentu.
4. Setelah semua alamat tercatat dalam tabel maka kit adapt merangkai alamat untuk satu konfigurasi suara tertentu
5. Menghubungkan 10 bit alamat ISD 25120 dengan port pada mikrokontroler
6. Menghubungkan pin PD (Reset address), dan CE (Play) pada mikrokontroler
7. Menghubungkan push button dari Vcc ke mikrokontroler sebagai simulasi.
8. Membuat subroutin untuk memanggil alamat ISD 25120, dan mengaktifkan pin PD dan CE.
9. Melakukan pengetesan dengan menekan tombol pushbutton.
10. Jika suara yang dihasilkan sesuai dengan alamat yang kia kirim maka ISD dapat berfungsi dengan baik

4.5 Pengujian Arus

Tujuan pengujian yang harus dicapai adalah mengetahui apakah arus yang disupply oleh power supply terdistribusi secara benar sesuai dengan kebutuhan daya yang dibutuhkan semua rangkaian.

4.5.1 Alat dan Bahan

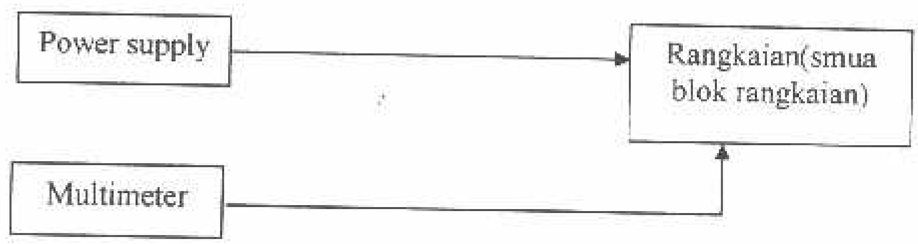
1. Rangkaian (semua blok rangkaian)

2. Multimeter

4.5.2 Pelaksanaan Pengujian

Langkah-langkah pengujian yang dilakukan adalah sebagai berikut :

1. Menghubuingkan rangkaian sebagai berikut



Gambar 4.7
Gambar diagram pengukuran

2 Multimeter diset pada DC maA

3 Mengukur arus pada tiap blok rangkaian

4.5.3 Hasil Pengukuran

Hasil pengukuran arus adalah sebagai berikut

Tabel 4.1
Hasil pengukuran arus

Blok rangkaian	Arus (Ma)
Dot matrik	150 m Amp
Sensor kemiringan	300 m Amp
Mikrokontroler	400 m Amp
ISD 25120	500 m Amp

Pada Rangkaian display dot matrik arus yang dibutuhkan untuk menyalakan satu baris dot matrik ialah : 40 * 10m amp * 1 – 400 m amp, sedangkan arus maksimum transistor C828 sebesar 200 m Amp,

Idealnya beban dirangkai pada colektor bukan pada emitor sehingga tidak membebani transistor dengan arus yang besar.

Namun dalam perancangan alat ini, tidak pernah sampai menampilkan karakter dengan menyalakan arus led secara bersamaan.

Sehinngga transistor tidak mengalami kerusakan.

Pada tabel terlihat keluaran arus sebesar 1 mA hal tersebut telah sesuai dengan konsumsi daya semua rangkaian. Untuk pengujian sensor kecepatan , maka menggunakan dua power supply, karena jika tetap memakai satu powersuply dengan arus 1mA tegangan pada semua rangkaian mengalami drop.

4.6 Pengujian Secara Keseluruhan

4.6.1 Tujuan Pengujian

Tujuan pengujian yang harus dicapai adalah mengetahui apakah alat pendeteksi kemiringan, suhu, kecepatan, bahan bakar, dapat bekerja sesuai dengan tampilan karakter dan output suara peringatan.

4.6.2 Alat dan Bahan

Peralatan yang digunakan antara lain:

1. Blok rangkaian sensor
2. Blok mikrokontroler
3. Blok display dan suara

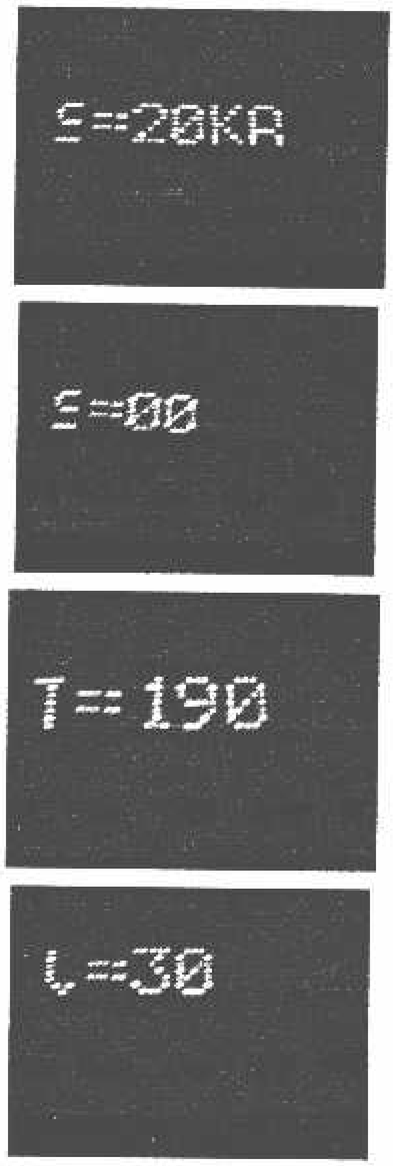
4.6.3 Pelaksanaan Pengujian

Langkah langkah yang dilakukan adalah sebagai berikut:

1. Menghubungkan semua blok rangkaian
2. Melakukan simulasi pada tiap tiap blok sensor
3. mendokumentasikan tampilan dotmatrik
4. Mendengarkan output suara pada keadaan bahaya

4.6.4 Hasil Pengujian

Hasil pengujian alat pendeteksi: kemiringan mobil, panas radiator, kecepatan, bahan bakar dengan output dotmatrik dan suara ditunjukan pada gambar berikut



Gambar 4.8

Gambar pengujian alat

Pada gambar tampak untuk tiap tiap kondisi ditampilkan secara berurutan dengan waktu selama tiga detik. Untuk output suara maka dapat dilihat pada tabel berikut ini

BAB V

PENUTUP

5.1. Kesimpulan

Setelah melalui tahap perancangan dan pembuatan alat, maka dapat diambil beberapa kesimpulan, yaitu

1. Transistor yang dipakai untuk driver scanning hendaknya transistor dengan Ic maks yang tinggi, hal itu dikarenakan untuk menyalakan beban yang cukup banyak.. Transistor C 828 sebagai driver scanning dapat berfungsi dengan baik ,hal ini karena transistor dinyalakan secara bergantian atau disebut dengan scanning. Jika transistor dinyalakan sepenuhnya (tujuh transistor saturasi semua, transistor tersebut dapt terbakar hal itu dikarenakan beban pada emitor cukup banyak yaitu = 40 led = 40 * 10 m * 1.
2. Untuk mendapatkan output tegangan yang baik maka driver yang menggunakan transistor lebih bagus beban dirangkai pada colektor, bukan pada emitor. Sebetulnyapun hal itu sama saja Namun untuk beban yang lebih banyak lebih baik beban dirangkai pada colektor. Karena jika dirangkai pada emitor saat beban banyak *I beban > I maksimum* maka transistor bisa terbakar
3. Untuk menghasilkan data 8 bit dari data serial maka digunakan IC 74LS164. Namun hasil konversi dari ic tersebut kurang sempurna karena output pada bit bit tertentu belum sepenuhnya berlogika low (0 volt) dan belum sepenuhnya berlogika high (5 volt). Untuk mengeser data ke kanan, apalagi ic 74ls164 digunakan untuk pengalamatan display seperti perancangan alat ini, hendaknya digunakan ic dengan type 74HCT164. Karena ic type HCT mempunyaI karkteristik yang bagus dalam mengkonversidata.

4. Untuk meredam adanya tegangan ripple hendaknya dirangkai capasitor 100 nano Farad, pada vcc ke ground. Lebih sempurna lagi pad tisap tiap ic dipasang capasitor coupling untuk menghilangkan ripple tersebut
5. Untuk mendapatkan hasil konversi yang bagus pada rangkaian adc 0804 hendaknya memperhatika , Vreferensinya, karena V referensi berpengaruh pada resolusi konversinya.

5.2. Saran

1. Agar sistem dapat berfungsi sesuai perencanaan maka, hendaknya dilakukan pengujian secara berturut turut terhadap tiap blok rangkaian
2. Untuk mengantisipasi tidak adanya perubahan kemiringan dalam simulasi maka hendaknya dbuat sebuah teknis sensor dengan baik.

DAFTAR PUSTAKA

[1] Avianto, Belajar Mikrokontroler, Gava Media, 2000

[2] Datasheet ISD 25XX. www.semiconductor.com

[3] RogerL. Tokheim, Elektronika Digital Edisi Kedua, 1995

[4] Atmel, Mikrokontroler AT89C51 DATA SHEET

[5] S. Wasito, Vademekum Elektronika, ElexMedia Komputindo, 1995

INSTITUT TEKNOLOGI NASIONAL MALANG
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FORMULIR PERBAIKAN SKRIPSI

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NIM : 00 17 272

Masa Bimbingan : 7 Feb 2005 s/d 10 Agustus 2005

Judul :

"PERENCANAAN DAN PEMBUATAN ALAT PENDETEKSI KEMIRINGAN MOBIL DILENGKAPI DENGAN SENSOR PANAS RADIATOR, KECEPATAN DAN BAHAN BAKAR, DENGAN OUTPUT SUARA DAN DISPLAY DOTMATRIK BERBASIS MIKROKONTROLER AT89C51"

No	Tanggal	Uraian	Paraf
1.	30 Maret 2005	Bab IV diperbaiki jangan seperti percobaan, tapi pengujian Bab III Diagram alir Susunan Pembuatan skripsi	

Disetujui

Penguji I

(Ir. Usman Djuanda, MM)

Penguji II

(Ir. Mimien Mustikawati)

Mengetahui
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4. Konsentrasi : Teknik Elektronika
5. Judul Skripsi : PERENCANAAN DAN PEMBUATAN ALAT PENDETEKSI KEMIRINGAN MOBIL DILENGKAPI DENGAN SENSOR PANAS RADIATOR, KECEPATAN DAN BAHAN BAKAR, DENGAN OUTPUT SUARA DAN DISPLAY DOTMATRIK BERBASIS MIKROKONTROLER AT89C51
6. Tanggal Pengajuan Skripsi : 15 September 2004
7. Selesai menulis skripsi : 25 April 2005
8. Dosen Pembimbing : Ir. F. Yudi Limpraptono, MT
9. Telah Dievaluasi Dengan Nilai : 90

Mengetahui,	Diperiksa dan Disetujui
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JL. BENDUNGAN SIGURA-GURA 2
MALANG

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Nim : 0017272
Masa Bimbingan : 7-Feb-2005 s/d 10-Aug-2005
Judul Skripsi : Perencanaan dan pembuatan alat pendeteksi kemiringan mobil dilengkapi dengan sensor; panas radiator, bahan bakar, kecepatan dengan output suara dan display dot matrik berbasis Mikrokontroller AT89C51

NO	Tanggal	Uraian	Paraf Pembimbing
1.	4/3 '05	Bab I & II, III	[signature]
2.		Bab II, III Revisi	[signature]
3.		Bab IV	[signature]
4.		Seminar	[signature]
5.		Presentasi alat	[signature]
6.		Bab V	[signature]
7.			
8.			
9.			
10.			

Malang, 2005
Dosen Pembimbing

Ir. F. Yudi Limpraptono, MT

Form. S-4a

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

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Malang 15-Sep-2004

Nomor : ITN-158/7/TA.GJL/2005
Lampiran :
Perihal : ***Bimbingan Skripsi***

Kepada : Yth. Sdr. **Ir. F. Yudi Limpraptono, MT**
Dosen Pembimbing
Jurusan Teknik Elektro S-1
di
Malang

Dengan hormat,
Sesuai dengan permohonan dan persetujuan dalam proposal skipsi untuk mahasiswa:

Nama	: Aan Yudhi Artha
Nim	: 0017272
Semester	: IX
Fakultas	: Teknologi Industri
Jurusan	: Teknik Elektro S-1
Konsentrasi	: Teknik Elektronika

Maka dengan ini pembimbingan tersebut kami serahkan sepenuhnya kepada Saudara/i selama masa waktu 6 (enam) bulan, terhitung mulai tanggal:

7-Feb-2005 s/d 10-Aug-2005

Sebagai satu syarat untuk menempuh Ujian Akhir Sarjana.
Demikian agar maklum, atas perhatian dan bantuannya kami ucapkan banyak terima kasih.

Ketua Jurusan
Teknik Elektro S-1

Ir. I Made Wartana, MT
NIP 131 991 182

Form S-4a

```
;------- Port And Pin
        Play   Bit P3.7
        ISDe   Bit P3.6
        BData  Bit P3.2
        Clock  Bit P3.3
;------ Konstanta
      ;VTR0 Equ 0FEh          ;FE
      ;VTL0 Equ 80h            ;BF
;------- Variabel Byte
      Roww  Equ 08h            ;Varibel Penunjuk Row Aktif
      Ekol  Equ 09h
      KolSel       Equ 0ah
      EKolChar     Equ 0bh
      Ebit  Equ 0ch
      Serial       Equ 0dh
      Disp1 Equ 11h
      Disp2 Equ 12h
      Disp3 Equ 13h
      Disp4 Equ 14h
      Disp5 Equ 15h
      Disp6 Equ 16h
      Disp7 Equ 17h

;----------------------------
; ROM VECTOR
;----------------------------
          Org 00h
          lJmp Mulai

          Org 0Bh
          lJmp IntTmr0

          org 23h
          ljmp IntSer

;---------------------------
; Rutin Inisialisasi
;---------------------------
InitSoft:   mov SCON,#50h
            Mov TMOD,#21h       ;T1 M2, T0 M1
            mov TH1,#0F3h       ;2404
                Mov TH0,#CFEh
                Mov TL0,#95h
            mov IP,#10h ;S
            mov TCON,#50h
                Mov IE,#92h     ;ES,T0
                ;SetB IT0       ;INT 0 Transisi Turun
                  Ret

;---------------------------
;delay
;---------------------------
del05sec:   push 04h
            push 05h
            push 06h
            mov r4,#06h         ;05detik
dela:       mov r5,#0a5h
delb:       mov r6,#0ffh
            djnz r6,$
            djnz r5,delb
            djnz r4,dela
```

```
            pop 06h
            pop 05h
            pop 04h
            ret

del025sec:  push 04h
            push 05h
            push 06h
            mov r4,#03h         ;025detik
delc:       mov r5,#0a3h
deld:       mov r6,#0ffh
            djnz r6,$
            djnz r5,deld
            djnz r4,delc
            pop 06h
            pop 05h
            pop 04h
            ret

del01sec:   push 05h            ;01detk
            push 06h
            mov r5,#0c3h
dele:       mov r6,#0ffh
            djnz r6,$
            djnz r5,dele
            pop 06h
            pop 05h
            ret

delay_1:    push 04h            ;count 20
            mov r4,#14h
            djnz r4,$
            pop 04h
            ret

delay_2:    push 05h            ;count 1000
            mov r5,#32h
delay_2a:   lcall delay_1
            djnz r5,delay_2a
            pop 05h
            ret

;----------------------------
; DEFAULT
;----------------------------
Default:    mov Roww,#01h
            mov EKol,#28h       ;40d
            mov KolSel,#0Ch
            mov EkolChar,#06h
            mov Ebit,#01h
            mov P1,#01h
            clr Bdata
            Setb Clock

            push 01h
            mov r1,#10h
Defa:       mov @r1,#30h
            inc r1
            cjne r1,#18h,Defa
            pop 01h
            ret
```

```
;--------------BLANK
Blank:          Push 02h
            mov r2,#29h
            Setb BData
            nop
            nop
            nop
Blanka:         clr Clock
            lcall Delay_1
            setb Clock
            lcall Delay_1
            djnz r2,Blanka
            pop 02h
            ret
;------------------------------------
; serial in
;------------------------------------
SerIn:          clr RI
            jnb RI,$
            mov a,SBUF
            clr RI
            lcall Delay_1
            ret

;----------------------------
; Interrupt Serial
;----------------------------
IntSer:         clr EA
            clr TR0
                push P0
                push P1
                Push P2
                mov P1,#00h
            Push DPH
            Push DPL
            Push ACC
            Push PSW
            Push 00h
            mov a,SBUF
            mov serial,a
            clr RI
                cjne a,#99h,Serib
            mov r0,#11h
Seria:          lcall Delay_1
            lcall SerIn
            mov @r0,a
            inc r0
            cjne r0,#18h,Seria
                ljmp SeriX

Serib:          cjne a,#01h,Seric
                mov P2,#00h
                mov P0,#00h
                clr ISDe
                clr Play
                lcall Del05sec
                setb Play
                lcall del05sec
                lcall Del05sec
                lcall del05sec
```

```
        lcall Del05sec
        Setb ISDe
        ljmp SeriX
Seric:  cjne a,#02h,Serid
        mov P2,#00h
        mov P0,#19h
        clr ISDe
        clr Play
        lcall Del05sec
        setb Play
        lcall del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec

        Setb ISDe
        ljmp SeriX
Serid:  cjne a,#03h,Serie
        mov P2,#00h
        mov P0,#2ah
        clr ISDe
        clr Play
        lcall Del05sec
        setb Play

        lcall Del05sec
        lcall Del05sec
        lcall del05sec
        lcall Del05sec
        lcall Del05sec
        lcall del05sec
        Setb ISDe
        ljmp SeriX
Serie:  cjne a,#04h,Serif
        mov P2,#00h
        mov P0,#3ah
        clr ISDe
        clr Play
        lcall Del05sec
        setb Play

        lcall Del05sec
        lcall Del05sec
        lcall del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        Setb ISDe
        ljmp SeriX
Serif:  cjne a,#05h,Serig
        mov P2,#00h
        mov P0,#49h
        clr ISDe
        clr Play
        lcall Del05sec
        setb Play
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
```

```
                lcall del05sec
                lcall del05sec
                lcall Del05sec
                Setb ISDe
                ljmp SeriX
Serig:          cjne a,#06h,Serih
                mov P2,#00h
                mov P0,#5bh
                clr ISDe
                clr Play
                lcall Del05sec
                setb Play
                lcall Del05sec
                lcall Del05sec
                lcall Del05sec
                lcall del05sec
                lcall del05sec
                lcall Del05sec
                Setb ISDe
                ljmp SeriX
Serih:          cjne a,#07h,Serii
                mov P2,#00h
                mov P0,#6eh
                clr ISDe
                clr Play
                lcall Del05sec
                setb Play
                lcall Del05sec
                lcall Del05sec
                lcall Del05sec
                lcall del05sec
                lcall del05sec
                lcall Del05sec
                Setb ISDe
                ljmp SeriX

Serii:          cjne a,#08h,Serix
                mov [illegible],#00h
                mov P0,#7eh
                clr ISDe
                clr Play
                lcall Del05sec
                setb Play
                lcall Del05sec
                lcall Del05sec
                lcall Del05sec
                lcall del05sec
                lcall del05sec
                lcall Del05sec
                Setb ISDe

SeriX:            Pop 0Ch
             pop PSW
             Pop ACC
             Pop DPL
             Pop DPH
                pop p2
                pop P1
                pop p0
             Setb EA
             Setb TR0
```

```
        reti

;-----------------------------
; Interrupt Timer0
;-----------------------------
IntTmr0:    clr EA
            Push DPH
            Push DPL
            Push ACC
            Push PSW
            Push 00h
            Push 01h
            Push 02h
            Clr TR0
            Mov TH0,#0FEh
                Mov TL0,#95h
            ;lcall Blank
            mov P1,#00h
            mov r1,#17h
InT0a:          mov a,@r1
            cjne a,#00h,InT0b
InT0c:          dec r1
            cjne r1,#10h,InT0a
            ljmp InT0d
InT0b:          Lcall AmbilTBL
            setb Bdata
            lcall SendBit
            ljmp InT0c

InT0d:          mov P1,Roww
            mov a,roww
            rl a
            mov roww,a
            inc Ebit
            cjne a,#80h,InT0X
            mov roww,#01h
            mov Ebit,#01h

InT0X:          Pop 02h
            Pop 01h
            Pop 00h
            pop PSW
            Pop ACC
            Pop DPL
            Pop DPH
            setb TR0
            setb EA
            Reti

;----------------SendBit
SendBit:    push 01h
            mov EKol,#05h
            mov a,dpl
            add a,#05h
            mov dpl,a
            mov r2,Roww
Sendb:          dec dpl
            mov r1,Ebit
            clr a
            movc a,@a+dptr
            nop
```

```
            anl a,r2
Sendd:          clr c
            rrc a
            djnz r1,Sendd
            ;cpl c
            ;clr a
            mov BData,c
            nop
            nop
            clr Clock
            lcall Delay_1
            setb Clock
            nop
            nop
            djnz EKol,Sendb
            Setb BData
            nop
            clr Clock
            lcall Delay_1
            setb clock
            nop
            pop 01h
            ret

;-----------------------------------
; TAMPIL
;-----------------------------------
;---------------Tampil1
Tampil1:    push 01h
            mov r1,#11h
Tmpla:          clr a
            movc a,@a+dptr
            nop
            mov @r1,a
            cjne r1,#17h,Tmplb
            pop 01h
            ret

Tmplb:          inc r1
            inc dptr
            ljmp Tmpla

;------------------------------
; MULAI
;------------------------------
Mulai:          mov sp,#40h
            lcall Default
            lcall InitSoft
            lcall Blank
Mulai1:         clr EA
            clr ES
            mov dptr,#Text1
            lcall Tampil1
            setb EA
            lcall del025sec
            clr EA
            mov dptr,#Text2
            lcall Tampil1
            setb EA
            lcall del025sec
            clr EA
```

```
            mov dptr,#Text3
            lcall Tampil1
            setb EA
            lcall del025sec
            mov dptr,#Text4
            lcall Tampil1
            setb EA
            setb ES
            ajmp $

Text1:      DB 'AAN YD ',00h
Text2:      DB 'CEPAT  ',00h
Text3:      DB 'LULUS  ',00h
Text4:      DB '03-05  ',00h

;---------------------------------------
; Ambil Tabel
;---------------------------------------
ambilTBL:   clr    C
            subb   A,#20H
            push   Acc
            anl    A,#0FH
            swap   A
            mov    DPL,A
            pop    ACC
            anl    A,#0F0H
            swap   A
            add    A,#09H
            mov    DPH,A
            ret

;--------------------------------------------;
;                 ASCII TABEL                ;
;--------------------------------------------;
      ORG   0900H
DB 0FFH,0FFH,0FFH,0FFH,0FFH,00,00,00,00,00,00,00,00,CC,00,00 ;space
DB 0FFH,0FFH,061H,0FFH,0FFH,00,00,00,00,00,00,00,00,CC,00,00 ;seru
DB 0FFH,0F1H,0FFH,0F1H,0FFH,00,00,00,00,00,00,00,00,CC,00,00 ;ptik2
DB 0D7H,001H,0D7H,001H,0D7H,00,00,00,00,00,00,00,00,CC,00,00 ;pager
DB 0B7H,0ABH,001H,0ABH,0DBH,00,00,00,00,00,00,00,00,CC,00,00 ;dolar
DB 05CH,0D9H,0EFH,037H,03BH,00,00,00,00,00,00,00,00,CC,00,00 ;prsen
DB 093H,06DH,055H,0BBH,05FH,00,00,00,00,00,00,00,00,CC,00,00 ;and
DB 0FFH,0F5H,0F9H,0FFH,0FFH,00,00,00,00,00,00,00,00,CC,00,00 ;ptik1
DB 0FFH,0C7H,0BBH,07DH,0FFH,00,00,00,00,00,00,00,00,CC,00,00 ;koka
DB 0FFH,07DH,0BBH,0C7H,0FFH,00,00,00,00,00,00,00,00,CC,00,00 ;kttup
DB 0D7H,0EFH,083H,0EFH,0D7H,00,00,00,00,00,00,00,00,CC,00,00 ;bntng
DB 0EFH,0EFH,083H,0EFH,0EFH,00,00,00,00,00,00,00,00,CC,00,00 ;plus
DB 0FFH,0AFH,0CFH,0FFH,0FFH,00,00,00,00,00,00,00,00,CC,00,00 ;koma
DB 0F7H,0F7H,0F7H,0F7H,0F7H,00,00,00,00,00,00,00,00,00,00,00 ;min
DB 0FFH,09FH,09FH,0FFH,0FFH,00,00,00,00,00,00,00,00,CC,00,00 ;ttik
DB 0DFH,0EFH,0F7H,0FBH,0FDH,00,00,00,00,00,00,00,00,00,00,00 ;garinq
DB 0C1H,0AEH,0B6H,0BAH,0C1H,00,00,00,00,00,00,00,00,CC,00,00 ;0
DB 0FFH,0FFH,0BDH,080H,0BFH,00,00,00,00,00,00,00,00,00,00,00 ;1
DB 0BDH,09EH,0AEH,0B6H,0B9H,00,00,00,00,00,00,00,00,CC,00,00 ;2
DB 0DEH,0BEH,0BAH,0B4H,0CEH,00,00,00,00,00,00,00,00,00,00,00 ;3
DB 0E7H,0EBH,0EDH,080H,0EFH,00,00,00,00,00,00,00,00,CC,00,00 ;4
DB 0D0H,0B6H,0B6H,0B6H,0CEH,00,00,00,00,00,00,00,00,00,00,00 ;5
DB 0C3H,0B5H,0B5H,0B6H,0CFH,00,00,00,00,00,00,00,00,00,00,00 ;6
DB 0FEH,0BEH,0F6H,0FAH,0FCH,00,00,00,00,00,00,00,00,00,00,00 ;7
DB 0C9H,0B6H,0B6H,0B6H,0C9H,00,00,00,00,00,00,00,00,00,00,00 ;8
DB 0F9H,0B6H,0B6H,0D6H,0E1H,00,00,00,00,00,00,00,00,00,00,00 ;9
```

```
DB 0FFH,0C9H,0C9H,0FFH,0FFH,00,00,00,00,00,00,00,00,00,00,00 ;ttik2
DB 0FFH,0A9H,0C9H,0FFH,0FFH,00,00,00,00,00,00,00,00,00,00,00 ;tikoma
DB 0F7H,0EBH,0DDH,0BEH,0FFH,00,00,00,00,00,00,00,00,00,00,00 ;lkcl
DB 0EBH,0EBH,0EBH,0EBH,0EBH,00,00,00,00,00,00,00,00,00,00,00 ;smdng
DB 0BEH,0DDH,0EBH,0F7H,0FFH,00,00,00,00,00,00,00,00,00,00,00 ;lbsr
DB 0FDH,0FEH,0AEH,0F6H,0F9H,00,00,00,00,00,00,00,00,00,00,00 ;ttnya
DB 0CDH,0B6H,086H,0BEH,0C1H,00,00,00,00,00,00,00,00,00,00,00 ;akurng
DB 081H,0EEH,0EEH,0EEH,081H,00,00,00,00,00,00,00,00,00,00,00 ;A
DB 080H,0B6H,0B6H,0B6H,0C9H,00,00,00,00,00,00,00,00,00,00,00 ;B
DB 0C1H,0BEH,0BEH,0BEH,0DDH,00,00,00,00,00,00,00,00,00,00,00 ;C
DB 080H,0BEH,0BEH,0DDH,0E3H,00,00,00,00,00,00,00,00,00,00,00 ;D
DB 080H,0B6H,0B6H,0B6H,0BEH,00,00,00,00,00,00,00,00,00,00,00 ;E
DB 080H,0F6H,0F6H,0F6H,0FEH,00,00,00,00,00,00,00,00,00,00,00 ;F
DB 0C1H,0BEH,0B6H,0B6H,085H,00,00,00,00,00,00,00,00,00,00,00 ;G
DB 080H,0F7H,0F7H,0F7H,080H,00,00,00,00,00,00,00,00,00,00,00 ;H
DB 0FFH,0BEH,080H,0BEH,0FFH,00,00,00,00,00,00,00,00,00,00,00 ;I
DB 0DFH,0BFH,0BEH,0C0H,0FEH,00,00,00,00,00,00,00,00,00,00,00 ;J
DB 080H,0F7H,0EBH,0DDH,0BEH,00,00,00,00,00,00,00,00,00,00,00 ;K
DB 080H,0BFH,0BFH,0BFH,0BFH,00,00,00,00,00,00,00,00,00,00,00 ;L
DB 080H,0FDH,0F3H,0FDH,080H,00,00,00,00,00,00,00,00,00,00,00 ;M
DB 080H,0FBH,0F7H,0EFH,080H,00,00,00,00,00,00,00,00,00,00,00 ;N
DB 0C1H,0B2H,0BEH,0BEH,0C1H,00,00,00,00,00,00,00,00,00.00,00 ;O
DB 080H,0F6H,0F6H,0F6H,0F9H,00,00,00,00,00,00,00,00,00,00,00 ;P
DB 0C1H,0BEH,0AEH,0DEH,0A1H,00,00,00,00,00,00,00,00,00,00,00 ;Q
DB 080H,0F6H,0E6H,0D6H,0B9H,00,00,00,00,00,00,00,00,00,00,00 ;R
DB 0B9H,0B6H,0B6H,0B6H,0CEH,00,00,00,00,00,00,00,00,00,00,00 ;S
DB 0FEH,0FEH,080H,0FEH,0FEH,00,00,00,00,00,00,00,00,00,00,00 ;T
DB 0C0H,0BFH,0BFH,0BFH,0C0H,00,00,00,00,00,00,00,00,00,00,00 ;U
DB 0E0H,0DFH,0BFH,0DFH,0E0H,00,00,00,00,00,00,00,00,00,00,00 ;V
DB 0C0H,0BFH,0CFH,0BFH,0C0H,00,00,00,00,00,00,00,00,00,00,00 ;W
DB 09CH,0EBH,0F7H,0EBH,09CH,00,00,00,00,00,00,00,00,00,00,00 ;X
DB 0F8H,0F7H,08FH,0F7H,0F8H,00,00,00,00,00,00,00,00,00,00,00 ;Y
DB 09EH,0AEH,0B6H,0BAH,0BCH,00,00,00,00,00,00,00,00,00,00,00 ;Z
DB 0FFH,080H,0BEH,0BEH,0FFH,00,00,00,00,00,00,00,00,00,00,00 ;kbka kotk
DB 0EAH,0E9H,083H,0E9H,0EAH,00,00,00,00,00,00,00,00,00,00,00 ;garing kr
DB 0FFH,0BEH,0BEH,0BEH,0FFH,00,00,00,00,00,00,00,00,00,00,00 ;kttupktk
DB 0FBH,0FDH,0FEH,0FDH,0FBH,00,00,00,00,00,00,00,00,00,00,00 ;capil
DB 0BFH,0BFH,0BFH,0BFH,0BFH,00,00,00,00,00,00,00,00,00,00,00 ;gr bwh
DB 0FFH,0FEH,0FDH,0FBH,0FFH,00,00,00,00,00,00,00,00,00,00,00 ;ptk bwh
End
```

```
;-------------------------------------------
; EQUATION
;-------------------------------------------
        MDeBe    Equ P2
        Suhu   Equ P1
        MKiKa    Equ P0
        ;SelMir  Bit P3.2
        SelD     Bit P3.7
        SelC     Bit P3.6
        Play     Bit P3.2
        ISDe     Bit P3.3
        Count    Bit P3.4

;-------------------------------------------
; VEKTOR ROM
;-------------------------------------------
            org 00h
            ljmp Mulai

;-------------------------------------------
; Timer 0
;-------------------------------------------
IntT0:          push acc
            push PSW
            push dph
            push dpl
                mov TH0,#0F5h   ;10d
                mov TL0,#9bh    ;100d
            dec r3
            cjne r3,#00H,InT0X
            clr TR0
            mov r5,#99h
InT0X:          pop dpl
            pop dph
            pop PSW
            pop acc
            reti

;-------------------------------------------
; serial out
;-------------------------------------------
Serout:         ;clr TI
            mov SBUF,A
            jnb TI,$
            clr TI
            lcall delay_1
            lcall delay_1
            ret

;-------------------------------------------
; INISIALISASI
;-------------------------------------------
InitHard:   mov SCON,#50h       ;serial mode 1 REN
                mov TMOD,#25h    ;Timer 1 mode 2 auto reload c0 ml
                mov TH0,#00h
                mov TL0,#00h
            mov TH1,#0F3h       ;Reload  for 2404 @ 12 Mhz
                ;mov IE,#80h
                ;setb ET0
            setb TR1     ;Turn on timer 1
```

```
        ret

InitSoft:   push 01h

            pop 01h
            ret

;-------------------------------
;delay
;-------------------------------
del05sec:   push 04h
            push 05h
            push 06h
            mov r4,#06h         ;05detik
dela:       mov r5,#0a5h
delb:       mov r6,#0ffh
            djnz r6,$
            djnz r5,delb
            djnz r4,dela
            pop 06h
            pop 05h
            pop 04h
            ret

del025sec:  push 04h
            push 05h
            push 06h
            mov r4,#03h         ;025detik
delc:       mov r5,#0a3h
deld:       mov r6,#0ffh
            djnz r6,$
            djnz r5,deld
            djnz r4,delc
            pop 06h
            pop 05h
            pop 04h
            ret

del01sec:   push 05h            ;01detk
            push 06h
            mov r5,#0c3h
dele:       mov r6,#0ffh
            djnz r6,$
            djnz r5,dele
            pop 06h
            pop 05h
            ret

delay_1:    push 04h            ;count 20
            mov r4,#14h
            djnz r4,$
            pop 04h
            ret

delay_2:    push 05h            ;count 1000
            mov r5,#32h
delay_2a:   lcall delay_1
            djnz r5,delay_2a
            pop 05h
            ret
```

```
;---------------------------------
; SEND DATA
;---------------------------------
SendD:          push 01h
        mov a,#99h
        lcall SerOut
        lcall Delay_2
        mov r1,#11h
Senda:          mov a,@r1
        lcall SerOut
        inc r1
        cjne r1,#18h,Senda
        pop 01h
        ret

;---------------------------------
; DETEKSI SUHU
;---------------------------------
DetSuhu:    push 01h
        mov 11h,#'T'
        mov 12h,#'='
        mov 13h,#'0'
        mov 14h,#'0'
        mov 15h,#' '
        mov 16h,#' '
        mov 17h,#' '
            mov a,suhu
            ;lcall baca_acc
            anl a,#0f0h
        mov r1,a
            cjne a,#00h,Cel40
            mov 13h,#'4'
        mov 14h,#'0'
        ljmp DSuhuX
Cel40:          cjne a,#10h,Cel50
            mov 13h,#'5'
        mov 14h,#'0'
        ljmp DSuhuX
Cel50:          cjne a,#20h,Cel60
            mov 13h,#'6'
        mov 14h,#'0'
        ljmp DSuhuX
Cel60:          cjne a,#30h,Cel70
            mov 13h,#'7'
        mov 14h,#'0'
        ljmp DSuhuX
Cel70:          cjne a,#40h,Cel80
            mov 13h,#'8'
        mov 14h,#'0'
        ljmp DSuhuX
Cel80:          cjne a,#50h,Cel90
            mov 13h,#'9'
        mov 14h,#'0'

        ljmp DSuhuX
Cel90:          cjne a,#60h,Cel100
            mov 13h,#'1'
        mov 14h,#'0'
            mov 15h,#'0'
        ljmp DSuhuX
Cel100:         cjne a,#70h,Cel110
```

```
        mov 13h,#'1'
            mov 14h,#'1'
        mov 15h,#'0'
        ljmp DSuhuX
Cel110:     cjne a,#80h,Cel120
        mov 13h,#'1'
            mov 14h,#'2'
        mov 15h,#'0'
        ljmp DSuhuX
Cel120:     cjne a,#90h,Cel130
        mov 13h,#'1'
            mov 14h,#'3'
        mov 15h,#'0'
        ljmp DSuhuX
Cel130:     cjne a,#0a0h,Cel140
        mov 13h,#'1'
            mov 14h,#'4'
        mov 15h,#'0'
        ljmp DSuhuX
Cel140:     cjne a,#0b0h,Cel150
        mov 13h,#'1'
            mov 14h,#'5'
        mov 15h,#'0'
        ljmp DSuhuX
Cel150:     cjne a,#0c0h,Cel160
        mov 13h,#'1'
            mov 14h,#'6'
        mov 15h,#'0'
        ljmp DSuhuX
Cel160:     cjne a,#0d0h,Cel170
        mov 13h,#'1'
            mov 14h,#'7'
        mov 15h,#'0'
        ljmp DSuhuX
Cel170:     cjne a,#0e0h,Cel180
        mov 13h,#'1'
            mov 14h,#'8'
        mov 15h,#'0'
        ljmp DSuhuX
Cel180:     cjne a,#0f0h,DSuhux
        mov 13h,#'1'
            mov 14h,#'9'
        mov 15h,#'0'
            mov a,#06h
            lcall SerOut            ;play ISD ???????????
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
        lcall Del05sec
            lcall Del05sec
            lcall Del05sec

DSuhuX:         pop 01h
        ret

eocADC  Bit     p3.6
wr_adc  Bit     p3.7

baca_adc:
        setb wr_adc
```

```
        nop
        nop
        nop
        nop
        nop
        nop
        nop
        nop
        nop
        nop

        clr wr_adc
        nop
        nop
        nop
        nop
        nop
        nop
        nop
        nop
        nop
        nop
        nop
        setb wr_adc
waiteoc1:
        jnb eocADC,waiteoc1
        setb eocADC
        nop
        mov a,p0
      ret

;--------------------------------
; DETEKSI MIRING
;--------------------------------
DetMirKiKa: push 01h
            mov 11h,#'S'
            mov 12h,#'='
            mov 13h,#'0'
            mov 14h,#'0'
                mov 15h,#' '
                mov 16h,#' '
            mov 17h,#' '
                ;Setb SelMir
                mov a,MKiKa
                mov r1,a
                cjne a,#0f0h,DMir10a
            ljmp DMirX
DMir10a:        ;anl a,#0fh
                cjne a,#0f8h,DMir20a
            mov 13h,#'1'
                mov 15h,#'K'
                mov 16h,#'A'
            ljmp DMirX
DMir20a:        cjne a,#0fch,DMir30a
            mov 13h,#'2'
                mov 15h,#'K'
                mov 16h,#'A'
            ljmp DMirX
DMir30a:        cjne a,#0feh,DMir40a
            mov 13h,#'3'
                mov 15h,#'K'
```

```
        mov 16h,#'A'
        ljmp DMirX
DMir40a:        cjne a,#0ffh,DMir10i
        mov 13h,#'4'
        mov 15h,#'K'
        mov 16h,#'A'
        mov a,#02h
        lcall SerOut
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec

        ljmp DMirX
DMir10i:        mov a,r1
        ;anl a,#0f0h
        cjne a,#0e0h,DMir20i
        mov 13h,#'1'
        mov 15h,#'K'
        mov 16h,#'I'
        ljmp DMirX
DMir20i:        cjne a,#0c0h,DMir30i
        mov 13h,#'2'
        mov 15h,#'K'
        mov 16h,#'I'
        ljmp DMirX
DMir30i:        cjne a,#80h,DMir40i
        mov 13h,#'3'
        mov 15h,#'K'
        mov 16h,#'I'
        ljmp DMirX
DMir40i:        cjne a,#00h,DMirX
        mov 13h,#'4'
        mov 15h,#'K'
        mov 16h,#'I'
        mov a,#03h
        lcall SerOut
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec


DMirX:          pop 01h
        ret


;---------------Depan Blakang
DetMirDB:   push 01h
            mov 11h,#'S'
            mov 12h,#'='
            mov 13h,#'0'
            mov 14h,#'0'
            mov 15h,#' '
            mov 16h,#' '
```

```
              mov 17h,#' '
                    ;clr SelMir
                    mov a,MDeBe
                    cjne a,#0f0h,DMir10d
              ljmp MirDBX
DMir10d:            cjne a,#0f8h,DMir20d
              mov 13h,#'1'
              mov 16h,#'D'
              ljmp MirDBX
DMir20d:            cjne a,#0fch,DMir30d
              mov 13h,#'2'
              mov 16h,#'D'
              ljmp MirDBX
DMir30d:            cjne a,#0feh,DMir40d
              mov 13h,#'3'
              mov 16h,#'D'
              ljmp MirDBX
DMir40d:            cjne a,#0ffh,DMir10b
              mov 13h,#'4'
              mov 16h,#'D'
                    mov a,#04h
                    lcall SerOut
                    lcall Del05sec
                    lcall Del05sec
                    lcall Del05sec
                    lcall Del05sec
              lcall Del05sec
                    lcall Del05sec
                    lcall Del05sec

              ljmp MirDBX
DMir10b:            cjne a,#0e0h,DMir20b
              mov 13h,#'1'
              mov 16h,#'B'
              ljmp MirDBX
DMir20b:            cjne a,#0c0h,DMir30b
              mov 13h,#'2'
              mov 16h,#'B'
              ljmp MirDBX
DMir30b:            cjne a,#80h,DMir40b
              mov 13h,#'3'
              mov 16h,#'B'
              ljmp MirDBX
DMir40b:            cjne a,#00h,MirDBX
              mov 13h,#'4'
              mov 16h,#'B'
                    mov a,#05h
                    lcall SerOut
                    lcall Del05sec
                    lcall Del05sec
                    lcall Del05sec
                    lcall Del05sec
              lcall Del05sec
                    lcall Del05sec
                    lcall Del05sec

MirDBX:               pop 01h
              ret

;-----------------------------
; DETEKSI PUTAR
```

```
;---------------------------
DelPutar:       push 03h
        push 04h
        push 05h
                push 06h
                push 07h
        mov 11h,#'V'
        mov 12h,#'-'
        mov 13h,#'0'
        mov 14h,#'0'
        mov 15h,#' '
        mov 16h,#' '
        mov 17h,#' '
                mov TL0,#00h
                mov TH0,#00h
                setb TR0
                lcall Del05sec
                clr TR0
                mov a,TL0
                mov r4,a
                mov a,TH0
                mov r3,a

                mov a,r4
                clr c
                subb a,#10h
                jnc putara
                mov 13h,#'1'
                ljmp PutarX

Putara:         clr c
                mov a,r4
                subb a,#20h
                jnc putarb
                mov 13h,#'2'
                ljmp PutarX

Putarb:         clr c
                mov a,r4
                subb a,#30h
                jnc putarc
                mov 13h,#'3'
                ljmp PutarX

Putarc:         clr c
                mov a,r4
                subb a,#40h
                jnc putard
                mov 13h,#'4'
                ljmp PutarX

Putard:         clr c
                mov a,r4
                subb a,#50h
                jnc putare
                mov 13h,#'5'
                ljmp PutarX

Putare:         clr c
                mov a,r4
                subb a,#60h
```

```
                jnc putarf
                mov 13h,#'6'
                ljmp PutarX

Putarf:         clr c
                mov a,r4
                subb a,#73h
                jnc putarg
                mov 13h,#'7'
                ljmp PutarX

Putarg:         clr c
                mov a,r4
                subb a,#80h
                jnc putarh
                mov 13h,#'8'
                ljmp PutarX

Putarh:         clr c
                mov a,r4
                subb a,#90h
                jnc putari
                mov 13h,#'9'
                ljmp PutarX

Putari:         mov 13h,#'1'
                mov 15h,#'0'
                mov a,#07h
                lcall SerOut
                lcall Del05sec
                lcall Del05sec
                lcall Del05sec
                lcall Del05sec
            lcall Del05sec
                lcall Del05sec
                lcall Del05sec

PutarX:         pop 07h
                pop 06h
            pop 05h
            pop 04h
            pop 03h
            ret

;--------------------------------
; VOICE OF AAN D.Y.
;---------------------------------
VAan:   mov a,#01h
        lcall SerOut
        ret

;--------------------------------
; Program Mulai
;--------------------------------
Mulai:          mov SP,#5Fh       ;32 reg
            lcall InitSoft
            lcall InitHard
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
```

```
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
                lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec

                lcall Del05sec
                lcall VAan
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec
            lcall Del05sec

                lcall Del05sec
                lcall del05sec
                lcall del05sec
Mulail:           lcall DetMirKiKa
                lcall SendD
            lcall Del05sec
                lcall Del05sec
                lcall Del05sec
                lcall Del05sec
            lcall Del05sec
            lcall Del05sec

                lcall DetMirDB
                lcall SendD
            lcall Del05sec
                lcall Del05sec
                lcall Del05sec
            lcall Del05sec
            lcall Del05sec
                lcall Del05sec

            lcall DetSuhu
                lcall SendD
                lcall Del05sec
                lcall Del05sec
                lcall Del05sec
                lcall Del05sec
            lcall Del05sec
                lcall Del05sec

            lcall DetPutar
                lcall SendD
                lcall Del05sec
```

```
        lcall Del05sec
    lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec

        jb p3.2,mulai2
        mov a,#00h
        lcall scrout
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
        lcall Del05sec
mulai2: lcall Del05sec
    ljmp Mulai1

    end
```

Features

- Compatible with MCS-51™ Products
- 4K Bytes of In-System Reprogrammable Flash Memory
  - Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-Level Program Memory Lock
- 128 x 8-Bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-Bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial Channel
- Low Power Idle and Power Down Modes

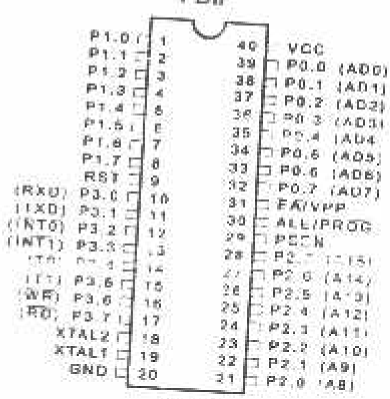
escription

e AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K tes of Flash Programmable and Erasable Read Only Memory (PEROM). The vice is manufactured using Atmel's high density nonvolatile memory technology l is compatible with the industry standard MCS-51™ instruction set and pinout. The chip Flash allows the program memory to be reprogrammed in-system or by a contional nonvolatile memory programmer. By combining a versatile 8-bit CPU with sh on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which vides a highly flexible and cost effective solution to many embedded control applions.

Configurations

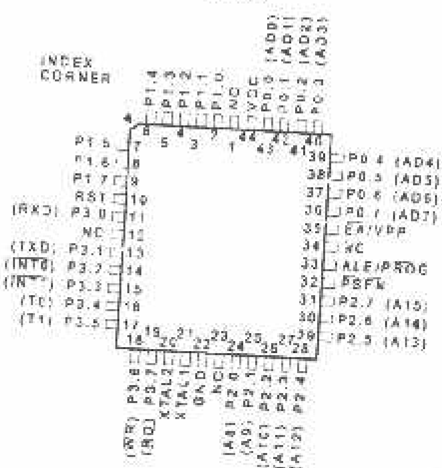
(continued)

PDIP



PQFP/TQFP

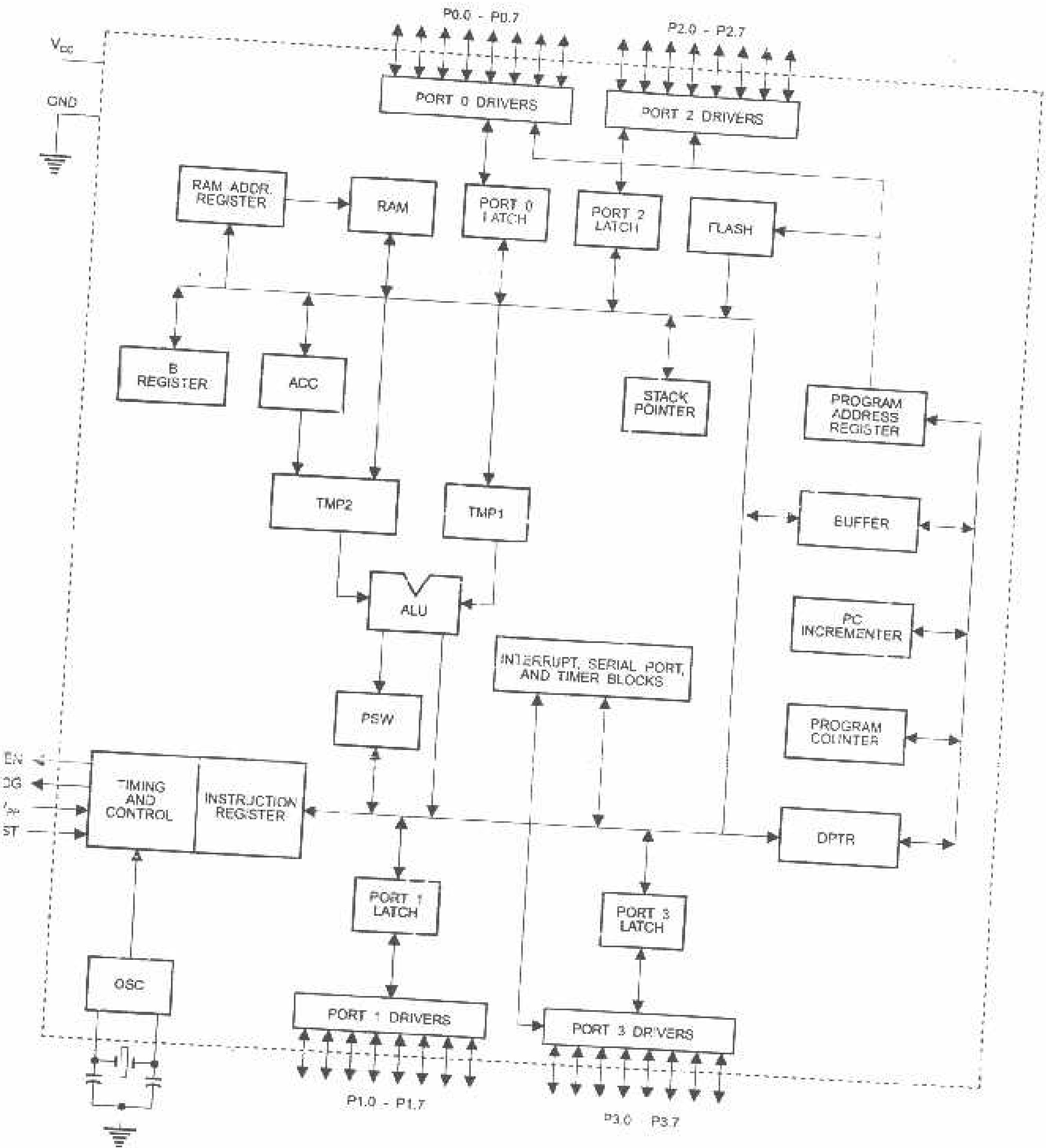
PLCC



8-Bit Microcontroller with 4K Bytes Flash

AT89C51

0265F-A-12/97


P0.0 - P0.7
P2.0 - P2.7
VCC
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
TMP2
TMP1
BUFFER
ALU
PC INCREMENTER
INTERRUPT, SERIAL PORT, AND TIMER BLOCKS
PSW
PROGRAM COUNTER
TIMING AND CONTROL
INSTRUCTION REGISTER
DPTR
PORT 1 LATCH
PORT 3 LATCH
OSC
PORT 1 DRIVERS
PORT 3 DRIVERS
P1.0 - P1.7
P3.0 P3.7

The AT89C51 provides the following standard features: 4K
bytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, a five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power Down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

Pin Description

VCC

Supply voltage.

GND

Ground.

Port 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 may 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 pullups.

Port 0 also receives the code bytes during Flash programming, and outputs the code bytes during program verification. External pullups are required during program verification.

Port 1

Port 1 is an 8-bit bidirectional I/O port with internal pullups. 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 pullups 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 pullups.

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

Port 2

Port 2 is an 8-bit bidirectional I/O port with internal pullups. 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 pullups 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 pullups.

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 it uses strong internal pullups 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.

Port 3

Port 3 is an 8-bit bidirectional I/O port with internal pullups. 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 pullups 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 pullups.

Port 3 also serves the functions of various special features of the AT89C51 as listed below:

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

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

RST

Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

ALE/$\overline{\text{PROG}}$

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

$\overline{\text{PSEN}}$

Program Store Enable is the read strobe to external program memory.

When the AT89C51 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.

$\overline{EA}/V_{PP}$

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, for parts that require 12-volt V_{PP}.

‹TAL1

nput to the inverting oscillator amplifier and input to the nternal clock operating circuit.

(TAL2

Jutput from the inverting oscillator amplifier.

)scillator Characteristics

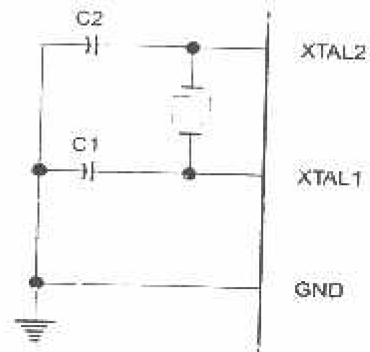
'TAL1 and XTAL2 are the input and output, respectively, f an inverting amplifier which can be configured for use as n on-chip oscillator, as shown in Figure 1. Either a quartz ·ystal or ceramic resonator may be used. To drive the avice from an external clock source, XTAL2 should be left ıconnected while XTAL1 is driven as shown in Figure 2. ıere are no requirements on the duty cycle of the external ock signal, since the input to the internal clocking circuitry through a divide-by-two flip-flop, but minimum and maxi- um voltage high and low time specifications must be ›served.

lle Mode

idle mode, the CPU puts itself to sleep while all the on- ip peripherals remain active. The mode is invoked by ftware. The content of the on-chip RAM and all the spe- l functions registers remain unchanged during this ›de. The idle mode can be terminated by any enabled ›rrupt or by a hardware reset.

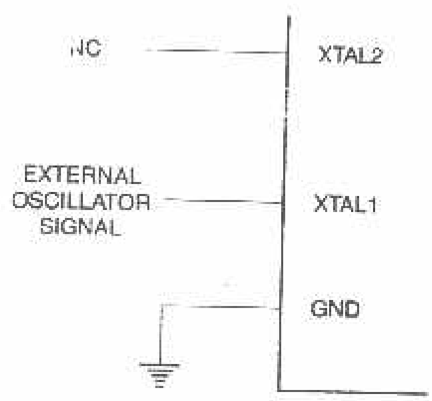
It should be noted that when idle is terminated by a hard ware reset, the device normally resumes program execution, from where it left off, up to two machine cycles before the internal reset algorithm takes control. On-chip hardware inhibits access to internal RAM in this event, but access to the port pins is not inhibited. To eliminate the possibility of an unexpected write to a port pin when Idle is terminated by reset, the instruction following the one that invokes Idle should not be one that writes to a port pin or to external memory.

Figure 1. Oscillator Connections



Note: C1, C2 = 30 pF ± 10 pF for Crystals
= 40 pF ± 10 pF for Ceramic Resonators

Figure 2. External Clock Drive Configuration



atus of External Pins During Idle and Power Down Modes

ode	Program Memory	ALE	$\overline{PSEN}$	PORT0	PORT1	PORT2	PORT3
e	Internal	1	1	Data	Data	Data	Data
e	External	1	1	Float	Data	Address	Data
wer Down	Internal	0	0	Data	Data	Data	Data
wer Down	External	0	0	Float	Data	Data	Data

Power Down Mode

In the power down mode the oscillator is stopped, and the instruction that invokes power down is the last instruction executed. The on-chip RAM and Special Function Registers retain their values until the power down mode is terminated. The only exit from power down is a hardware reset. Reset redefines the SFRs but does not change the on-chip RAM. The reset should not be activated before V_{CC} is restored to its normal operating level and must be held active long enough to allow the oscillator to restart and stabilize.

Program Memory Lock Bits

On the chip are three lock bits which can be left unprogrammed (U) or can be programmed (P) to obtain the additional features listed in the table below:

When lock bit 1 is programmed, the logic level at the $\overline{EA}$ pin is sampled and latched during reset. If the device is powered up without a reset, the latch initializes to a random value, and holds that value until reset is activated. It is necessary that the latched value of $\overline{EA}$ be in agreement with the current logic level at that pin in order for the device to function properly.

Lock Bit Protection Modes

	Program Lock Bits			Protection Type
	LB1	LB2	LB3	
1	U	U	U	No program lock features.
2	P	U	U	MOVC instructions executed from external program memory are disabled from fetching code bytes from internal memory, $\overline{EA}$ is sampled and latched on reset, and further programming of the Flash is disabled.
3	P	P	U	Same as mode 2, also verify is disabled.
4	P	P	P	Same as mode 3, also external execution is disabled.

Programming the Flash

The AT89C51 is normally shipped with the on-chip Flash memory array in the erased state (that is, contents = FFH) and ready to be programmed. The programming interface accepts either a high-voltage (12-volt) or a low-voltage (V_{CC}) program enable signal. The low voltage programming mode provides a convenient way to program the AT89C51 inside the user's system, while the high-voltage programming mode is compatible with conventional third party Flash or EPROM programmers.

The AT89C51 is shipped with either the high-voltage or low-voltage programming mode enabled. The respective top-side marking and device signature codes are listed in the following table.

	V_{PP} = 12V	V_{PP} = 5V
Top-Side Mark	AT89C51 xxxx yyww	AT89C51 xxxx-5 yyww
Signature	(030H)=1EH (031H)=51H (032H)=FFH	(030H)=1EH (031H)=51H (032H)=05H

The AT89C51 code memory array is programmed byte-by-byte in either programming mode. *To program any non-blank byte in the on-chip Flash Memory, the entire memory must be erased using the Chip Erase Mode.*

Programming Algorithm: Before programming the AT89C51, the address, data and control signals should be set up according to the Flash programming mode table and Figures 3 and 4. To program the AT89C51, take the following steps.

1. Input the desired memory location on the address lines.
2. Input the appropriate data byte on the data lines.
3. Activate the correct combination of control signals.
4. Raise $\overline{EA}/V_{PP}$ to 12V for the high-voltage programming mode.
5. Pulse ALE/$\overline{PROG}$ once to program a byte in the Flash array or the lock bits. The byte-write cycle is self-timed and typically takes no more than 1.5 ms. Repeat steps 1 through 5, changing the address and data for the entire array or until the end of the object file is reached.

$\overline{\text{Data}}$ Polling: The AT89C51 features $\overline{\text{Data}}$ Polling to indicate the end of a write cycle. During a write cycle, an attempted read of the last byte written will result in the complement of the written datum on PO.7. Once the write cycle has been completed, true data are valid on all outputs, and the next cycle may begin. $\overline{\text{Data}}$ Polling may begin any time after a write cycle has been initiated.

Ready/$\overline{\text{Busy}}$: The progress of byte programming can also be monitored by the RDY/$\overline{BSY}$ output signal. P3.4 is pulled low after ALE goes high during programming to indicate BUSY. P3.4 is pulled high again when programming is done to indicate READY.

Program Verify: If lock bits LB1 and LB2 have not been programmed, the programmed code data can be read back via the address and data lines for verification. The lock bits cannot be verified directly. Verification of the lock bits is achieved by observing that their features are enabled.

Chip Erase: The entire Flash array is erased electrically by using the proper combination of control signals and by holding ALE/$\overline{PROG}$ low for 10 ms. The code array is written with all "1"s. The chip erase operation must be executed before the code memory can be re-programmed.

Reading the Signature Bytes: The signature bytes are read by the same procedure as a normal verification of locations 030H,

031H, and 032H, except that P3.6 and P3.7 must be pulled to a logic low. The values returned are as follows.

(030H) = 1EH indicates manufactured by Atmel
(031H) = 51H indicates 89C51
(032H) = FFH indicates 12V programming
(032H) = 05H indicates 5V programming

Programming Interface

Every code byte in the Flash array can be written and the entire array can be erased by using the appropriate combination of control signals. The write operation cycle is self-timed and once initiated, will automatically time itself to completion.

All major programming vendors offer worldwide support for the Atmel microcontroller series. Please contact your local programming vendor for the appropriate software revision.

Flash Programming Modes

Mode		RST	$\overline{PSEN}$	ALE/$\overline{PROG}$	$\overline{EA}/V_{PP}$	P2.6	P2.7	P3.6	P3.7
Write Code Data		H	L	‾_/‾	H/12V	L	H	H	H
Read Code Data		H	L	H	H	L	L	H	H
Write Lock	Bit - 1	H	L	‾_/‾	H/12V	H	H	H	H
	Bit - 2	H	L	‾_/‾	H/12V	H	H	L	L
	Bit - 3	H	L	‾_/‾	H/12V	H	L	H	L
Chip Erase		H	L	‾_/‾ (1)	H/12V	H	L	L	L
Read Signature Byte		H	L	H	H	L	L	L	L

Note: 1. Chip Erase requires a 10-ms PROG pulse.

Figure 3. Programming the Flash

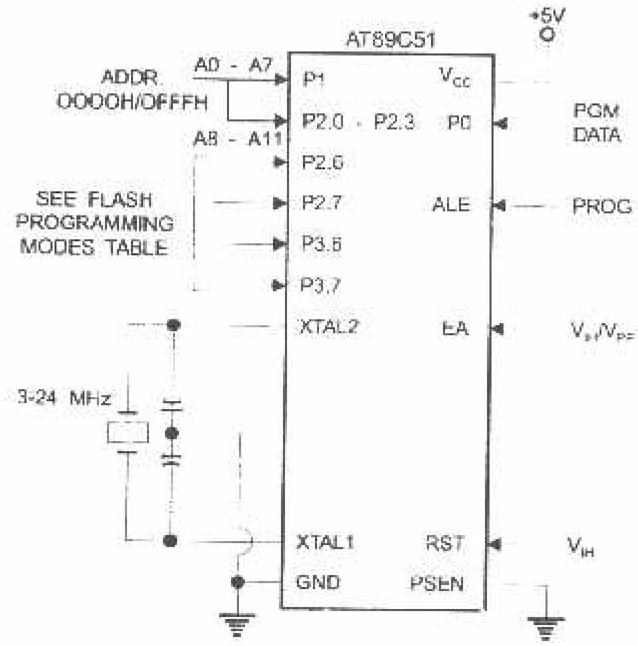
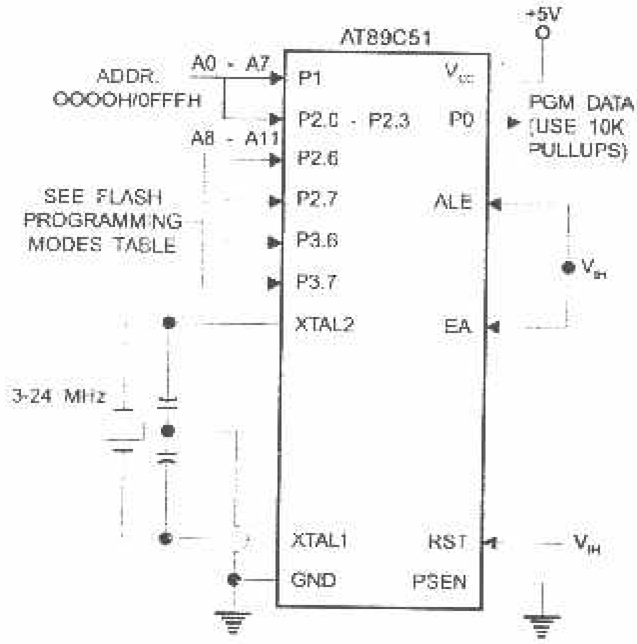


Figure 4. Verifying the Flash



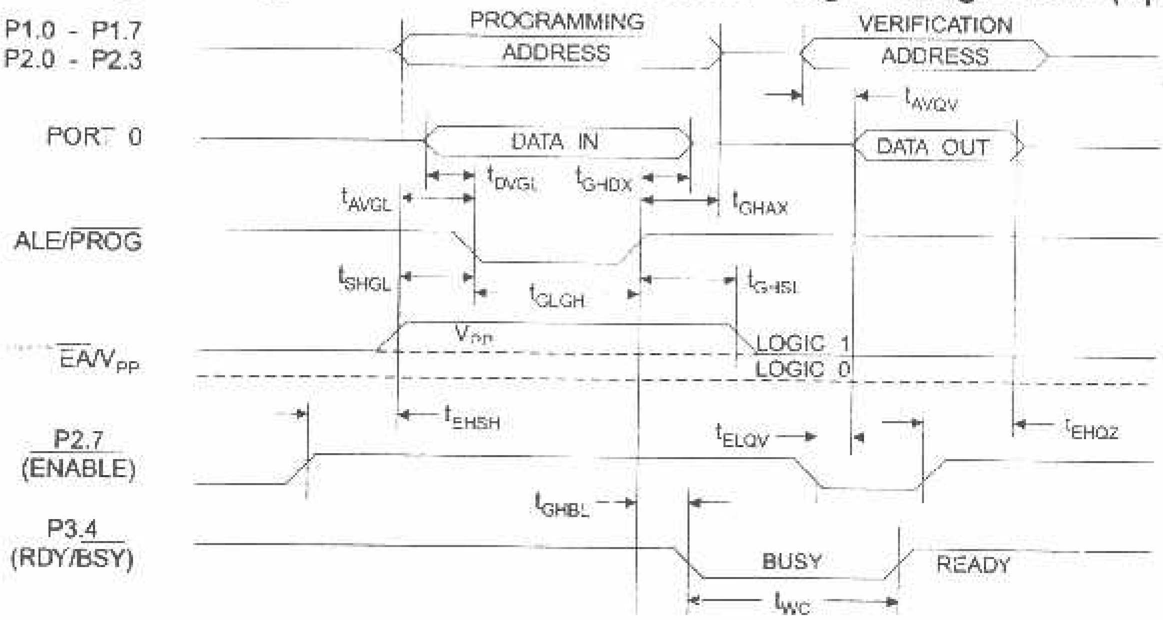
Flash Programming and Verification Characteristics

T_A = 0°C to 70°C, V_{CC} = 5.0 ± 10%

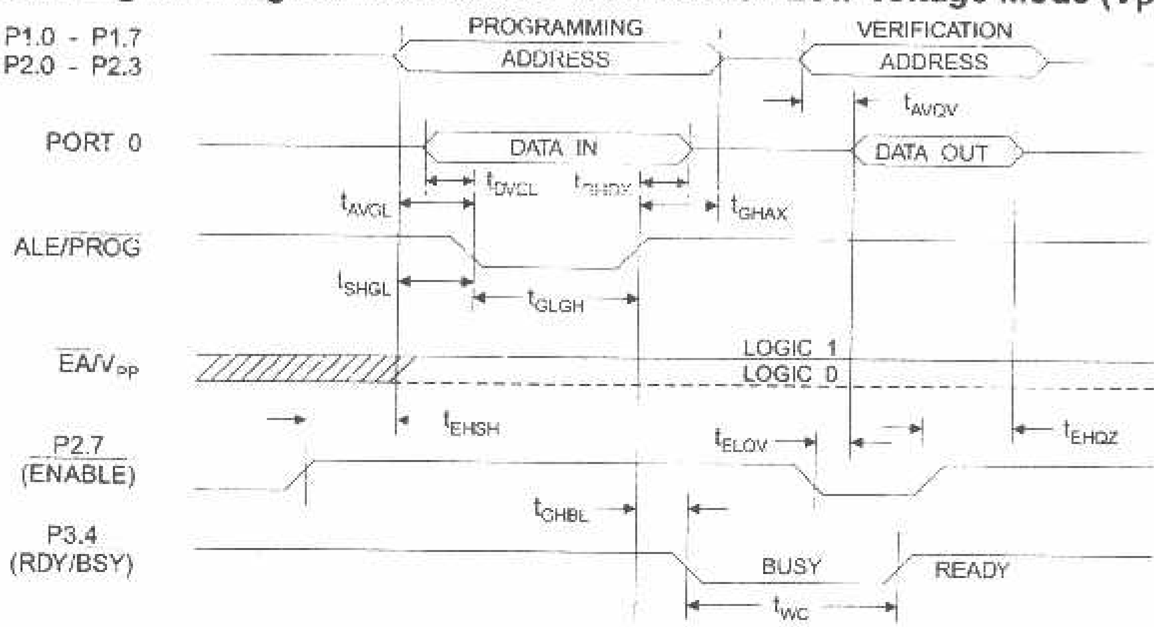
Symbol	Parameter	Min	Max	Units
V_{PP}(1)	Programming Enable Voltage	11.5	12.5	V
I_{PP}(1)	Programming Enable Current		1.0	mA
$1/t_{CLCL}$	Oscillator Frequency	3	24	MHz
t_{AVGL}	Address Setup to $\overline{PROG}$ Low	$48t_{CLCL}$		
t_{GHAX}	Address Hold After $\overline{PROG}$	$48t_{CLCL}$		
t_{DVGL}	Data Setup to $\overline{PROG}$ Low	$48t_{CLCL}$		
t_{GHDX}	Data Hold After $\overline{PROG}$	$48t_{CLCL}$		
t_{EHSH}	P2.7 ($\overline{ENABLE}$) High to V_{PP}	$48t_{CLCL}$		
t_{SHGL}	V_{PP} Setup to $\overline{PROG}$ Low	10		µs
t_{GHSL}(1)	V_{PP} Hold After $\overline{PROG}$	10		µs
t_{GLGH}	$\overline{PROG}$ Width	1	110	µs
t_{AVQV}	Address to Data Valid		$48t_{CLCL}$	
t_{ELQV}	$\overline{ENABLE}$ Low to Data Valid		$48t_{CLCL}$	
t_{EHQZ}	Data Float After $\overline{ENABLE}$	0	$48t_{CLCL}$	
t_{GHBL}	$\overline{PROG}$ High to BUSY Low		1.0	µs
t_{WC}	Byte Write Cycle Time		2.0	ms

Note: 1. Only used in 12-volt programming mode.

Flash Programming and Verification Waveforms - High Voltage Mode (V_{PP} = 12V)



Flash Programming and Verification Waveforms - Low Voltage Mode (V_{PP} = 5V)



```
3D00   3E90     MVI 90
3D02   D3E7     Out Control Port                                   ; Program PPI
3D04   2601     MVI H 01              Auto-Zero Subroutine
3D06   7C       MOV A,H
3D07   D3E8     OUT C                                              ; Close SW1 open SW2
3D09   0680     MVI B 80                                           ; Initialize SAR bit pointer
3D0B   3E7F     MVI A 7F                                           ; Initialize SAR code
3D0D   4F       MOV C,A               Return
3D0E   D3E5     OUT B                                              ; Port B = SAR code
3D10   31AA3D   LXI SP 3DAA           Start                        ; Dimension stack pointer
3D13   D3E4     OUT A                                              ; Start A/D
3D15   FB       IE
3D16   00       NOP                   Loop                         ; Loop until INT asserted
3D17   C3163D   JMP Loop
3D1A   7A       MOV A,D               Auto-Zero
3D1B   C600     ADI 00
3D1D   CA2D3D   JZ Set C                                           ; Test A/D output data for zero
3D20   78       MOV A,B               Shift B
3D21   F600     ORI 00                                             ; Clear carry
3D23   1F       RAR                                                ; Shift "1" in B right one place
3D24   FE00     CPI 00                                             ; Is B zero? If yes last
3D26   CA373D   JZ Done                                            ; approximation has been made
3D29   47       MOV B,A
3D2A   C3333D   JMP New C
3D2D   79       MOV A,C               Set C
3D2F   B0       ORA B                                              ; Set bit in C that is in same
3D2F   4F       MOV C,A                                            ; position as "1" in B
3D30   C3203D   JMP Shift B
3D33   A9       XRA C                 New C                        ; Clear bit in C that is in
3D34   C30D3D   JMP Return                                         ; same position as "1" in B
3D37   47       MOV B,A               Done                         ; then output new SAR code.
3D38   7C       MOV A,H                                            ; Open SW1, close SW2 then
3D39   EE03     XRI 03                                             ; proceed with program. Preamp
3D3B   D3E6     OUT C                                              ; is now zeroed.
3D3D            •                     Normal
                •
                •
                Program for processing
                proper data values
3C3D   DBE4     IN A                  Read A/D Subroutine          ; Read A/D data
3C3F   EEFF     XRI FF                                             ; Invert data
3C41   57       MOV D,A
3C42   78       MOV A,B                                            ; Is B Reg = C? If not stay
3C43   E6FF     ANI FF                                             ; in auto zero subroutine
3C45   C21A3D   JNZ Auto-Zero
3C48   C33D3D   JMP Normal
```

Note: All numerical values are hexadecimal representations.

FIGURE 20. Software for Auto-Zeroed Differential A/D

5.3 Multiple A/D Converters in a Z-80® Interrupt Driven Mode (Continued)

The following notes apply:

1) It is assumed that the CPU automatically performs a RST 7 instruction when a valid interrupt is acknowledged (CPU is in interrupt mode 1). Hence, the subroutine starting address of X0038.

2) The address bus from the Z-80 and the data bus to the Z-80 are assumed to be inverted by bus drivers.

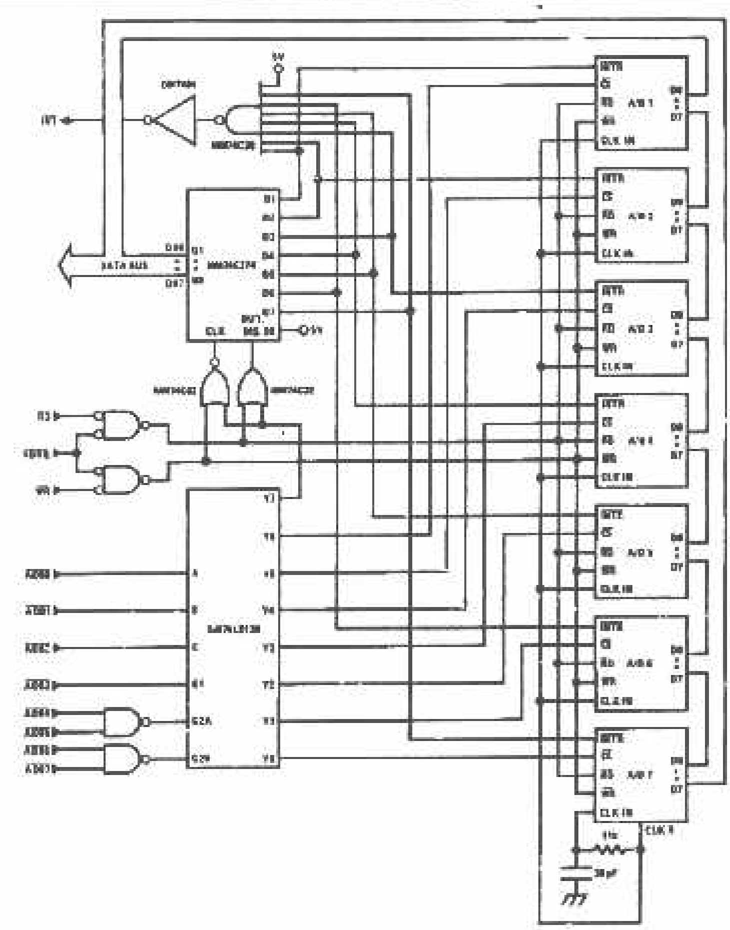
3) A/D data and identifying words will be stored in sequential memory locations starting at the arbitrarily chosen address X 3E00.

4) The stack pointer must be dimensioned in the main program as the RST 7 instruction automatically pushes the PC onto the stack and the subroutine uses an additional 6 stack addresses.

5) The peripherals of concern are mapped into I/O space with the following port assignments:

HEX PORT ADDRESS	PERIPHERAL
00	MM74C374 8-bit flip-flop
01	A/D 1
02	A/D 2
03	A/D 3
04	A/D 4
05	A/D 5
06	A/D 6
07	A/D 7

This port address also serves as the A/D identifying word in the program.



TL/H/5671-29

FIGURE 21. Multiple A/Ds with Z-80 Type Microprocessor

INTERRUPT SERVICING SUBROUTINE

```
                            SOURCE
LOC    OBJ CODE            STATEMENT                          COMMENT
0038   E5                  PUSH HL          ; Save contents of all registers affected by
0039   C5                  PUSH BC          ; this subroutine.
003A   F5                  PUSH AF          ; Assumed INT mode 1 earlier set.
003B   21 00 3E            LD (HL),X3E00    ; Initialize memory pointer where data will be stored.
003E   0E 01               LD C, X01        ; C register will be port ADDR of A/D converters.
0040   D300                OUT X00, A       ; Load peripheral status word into 8-bit latch.
0042   DB00                IN A, X00        ; Load status word into accumulator.
0044   47                  LD B,A           ; Save the status word.
0045   79          TEST    LD A,C           ; Test to see if the status of all A/D's have
0046   FE 08               CP, X08          ; been checked. If so, exit subroutine
0048   CA 60 00            JPZ, DONE
004B   78                  LD A,B           ; Test a single bit in status word by looking for
004C   1F                  RRA              ; a "1" to be rotated into the CARRY (an INT
004D   47                  LD B,A           ; is loaded as a "1"). If CARRY is set then load
004E   DA 5500             JPC, LOAD        ; contents of A/D at port ADDR in C register.
0051   0C          NEXT    INC C            ; If CARRY is not set, increment C register to point
0052   C3 4500             JP,TEST          ; to next A/D, then test next bit in status word.
0055   ED 78       LOAD    IN A, (C)        ; Read data from interrupting A/D and invert
0057   EE FF               XOR FF           ; the data.
0059   77                  LD (HL),A        ; Store the data
005A   2C                  INC L
005B   71                  LD (HL),C        ; Store A/D identifier (A/D port ADDR).
005C   2C                  INC L
005D   C3 51 00            JP,NEXT          ; Test next bit in status word.
0060   F1          DONE    POP AF           ; Re-establish all registers as they were
0061   C1                  POP BC           ; before the interrupt.
0062   E1                  POP HL
0063   C9                  RET              ; Return to original program
```

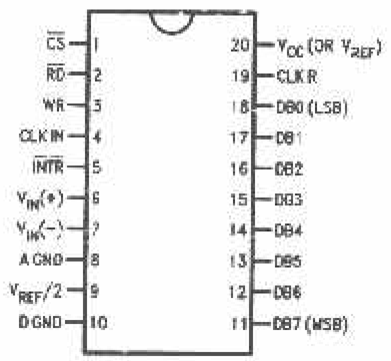
Ordering Information

TEMP RANGE		0°C TO 70°C	0°C TO 70°C	0°C TO 70°C	−40°C TO +85°C
ERROR	±¼ Bit Adjusted				ADC0801LCN
	±½ Bit Unadjusted	ADC0802LCWM	ADC0802LCV		ADC0802LCN
	±½ Bit Adjusted	ADC0803LCWM	ADC0803LCV		ADC0803LCN
	±1 Bit Unadjusted	ADC0804LCWM	ADC0804LCV	ADC0804LCN	ADC0805LCN
PACKAGE OUTLINE		M20B—Small Outline	V20A—Chip Carrier	N20A—Molded DIP	

TEMP RANGE		−40°C TO +85°C	−55°C TO +125°C
ERROR	±¼ Bit Adjusted	ADC0801LCJ	ADC0801LJ
	±½ Bit Unadjusted	ADC0802LCJ	ADC0802LJ, ADC0802LJ/883
	±½ Bit Adjusted	ADC0803LCJ	
	±1 Bit Unadjusted	ADC0804LCJ	
PACKAGE OUTLINE		J20A—Cavity DIP	J20A—Cavity DIP

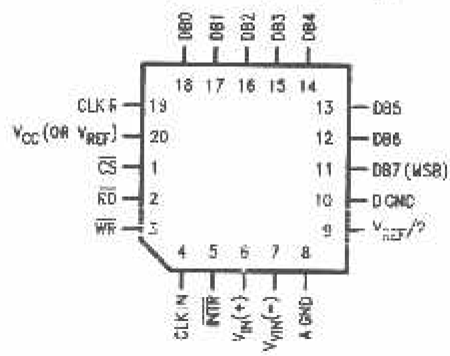
Connection Diagrams

ADC080X
Dual-In-Line and Small Outline (SO) Packages



TL/H/5671-30

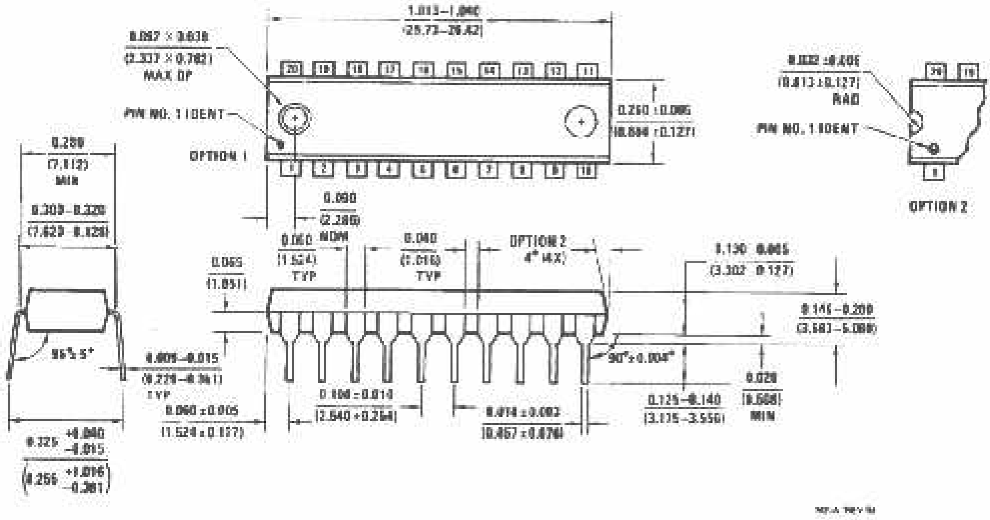
ADC080X
Molded Chip Carrier (PCC) Package



TL/H/5671-32

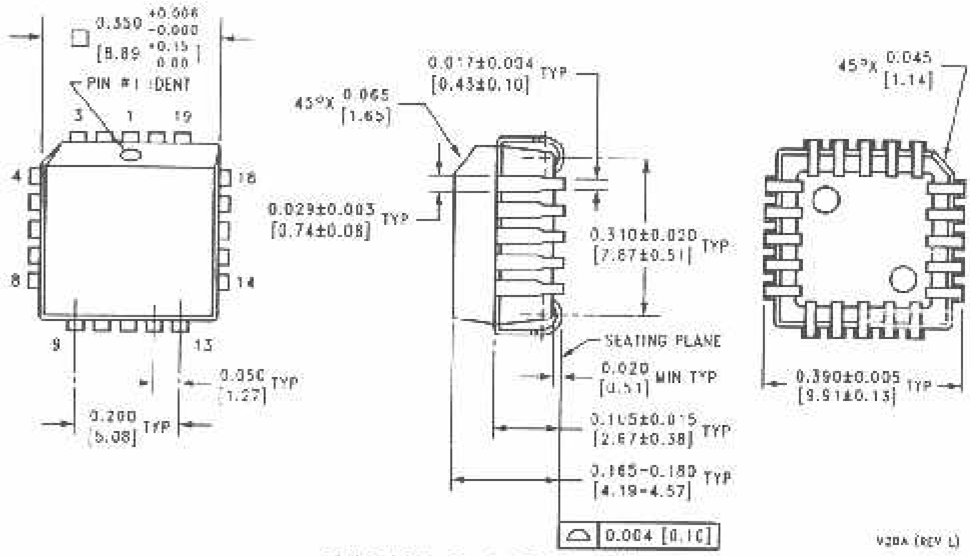
See Ordering Information

Physical Dimensions inches (millimeters) (Continued)



Molded Dual-In-Line Package (N)
Order Number ADC0801LCN, ADC0802LCN,
ADC0803LCN, ADC0804LCN or ADC0805LCN
NS Package Number N20A

Physical Dimensions inches (millimeters) (Continued)



Molded Chip Carrier Package (V)
Order Number ADC0802LCV, ADC0803LCV or ADC0804LCV
NS Package Number V20A

National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

National Semiconductor Europe
Fax: (+49) 0-180-530 85 86
Email: cnjwge@tevm2.nsc.com
Deutsch Tel: (+49) 0-180-530 85 85
English Tel: (+49) 0-180-532 78 32
Français Tel: (+49) 0-180-532 93 58
Italiano Tel: (+49) 0-180-534 16 80

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-043-299-2309
Fax: 81-043-299-2408

In Figure 8, the circuit operates in the positive logic mode, and current I_F is stabilized by constant current driving so that the radiant flux of LED is stabilized against variations in the supply voltage (V_{CC}).

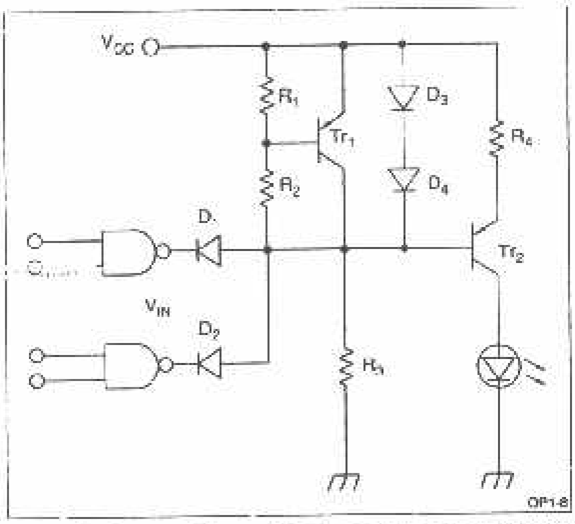


Figure 8. Connection with the TTL Logic Circuit (3)

DRIVING CIRCUIT WITH AN AC SIGNAL

Figure 9 (A) shows a circuit in which an AC power source supplies the forward current (I_{F1}) to an LED. A diode (D_1) in inverse parallel connection with the LED protects the LED against reverse voltage, suppressing the reverse voltage applied to the LED lower than V_{F2} by using a reverse voltage protection diode of an LED. The LED provides a radiant flux proportional to the applied AC current, (emitting only in half wave).

Figure 9 (B) shows the driving waveform of the AC power source.

Figure 10 (A) shows a driving circuit which modulates the radiant flux of LED in response to a sine wave or modulation signal. Figure 10 (B) shows modulation operation.

If an LED and light detector are used together in an environment of high intensity disturbing light, it is difficult for the light detector to detect the optical signal. In this case, modulating the LED drive signal alleviates the influence of disturbing light and facilitates signal detection.

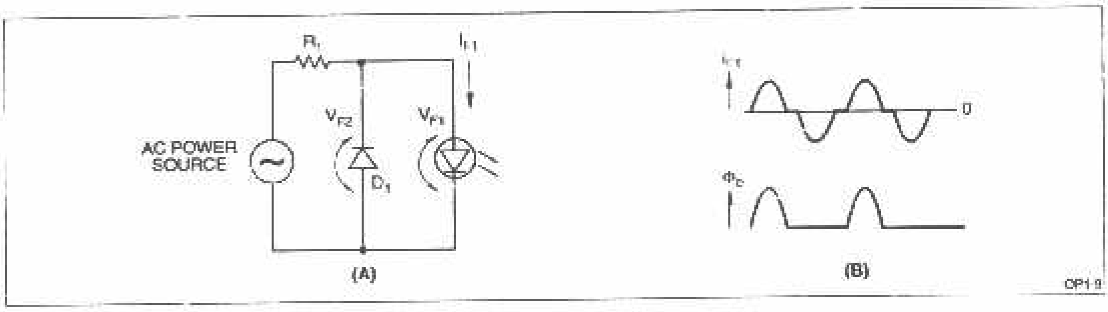


Figure 9. Driving Circuit with AC Power Source (A) and Driving Waveform (B)

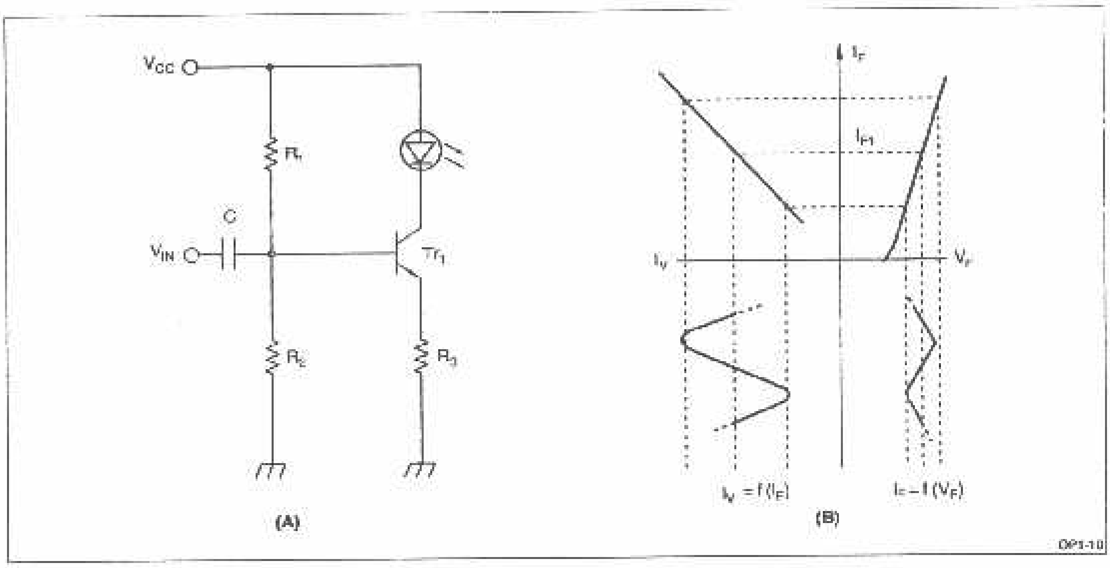


Figure 10. Modulation Driving Circuit (A) and Modulation Operation (B)

To drive an LED with a continuous modulation signal, it is necessary to operate the LED in the linear region of the light-emitting characteristics. In the arrangement of Figure 10, a fixed bias (I_{F1}) is applied to the LED using R_1 and R_2 so that the maximum amplitude of the modulation signal voltage (V_{IN}) lies within the linear portion of the LED characteristics. Moreover, to stabilize the radiant flux of the LED, it is driven by a constant current by the constant current driving circuit shown in Figure 3. The capacitor (C) used in Figure 10 (A) is a DC signal blocking capacitor.

PULSE DRIVING

LED driving systems fall into three categories: DC driving system, AC driving system (including modulation systems), and pulse driving system.

Features of the Pulse Driving System

- Large radiant flux
- Less influence of disturbing light
- Information transmission

The radiant flux of the LED is proportional to its forward current (I_F), but in reality a large I_F heats up the LED by itself, causing the light-emitting efficiency to fall and thus saturating the radiant flux. In this circumstance, a relatively large I_F can be used with no risk of heating through the pulse drive of the LED. Consequently, a large radiant flux can be obtained.

When an LED is used in the outdoors where disturbing light is intense, the DC driving system or AC driving system which superimposes an AC signal on a fixed bias current provides low radiant flux, making it difficult to distinguish the signal (irradiation of LED) from disturbing light. In other words, the S/N ratio is small enough to reliably detect the signal. The pulse driving system provides high radiant flux and allows the detection of signal variations at the rising and falling edges of pulses, thereby enabling the use of LED-light detector where disturbing light is intense.

Transmission of information is possible by variations in pulse width or counting of the number of pulse used to encode the LED emission.

Figures 11 through 14 show typical pulse driving circuits. Figure 15 shows the pulse driving circuit used in the optical remote control. The circuit shown in Figure 11 uses an N-gate thyristor with voltage between the anode and cathode oscillated at a certain interval determined by the time constant of C × R so that the LED emits light pulse. To turn off the N-gate thyristor, resistor R_3 must be used so that the anode current is smaller than the holding current (I_H), i.e., $I_H > V_{CC}/R_3$. Therefore, R_3 has a large value, resulting in a large time constant ($\tau \pm C \times R_3$) and the circuit operates for a relatively long period to provide short pulse widths. The circuit shown in Figure 12 uses a type 555 timer IC to form an astable multi-vibrator to produce light pulses on the LED. The off-period (t_1) and the on-period (t_2) of the LED are calculated by the following equations.

$t_1 = 1n2 \times (R_1 + R_2) \times C_1$

$t_2 = 1n2 \times R_2 \times C_1$

The value of R1 is determined so that the rating of I_{IN} of a 555 timer IC is not exceeded, i.e. $S_1 > V_{CC}/I_{IN}$.

This pulse driving circuit uses a 555 timer IC to provide wide variable range in the oscillation period and light-on time. It is used extensively.

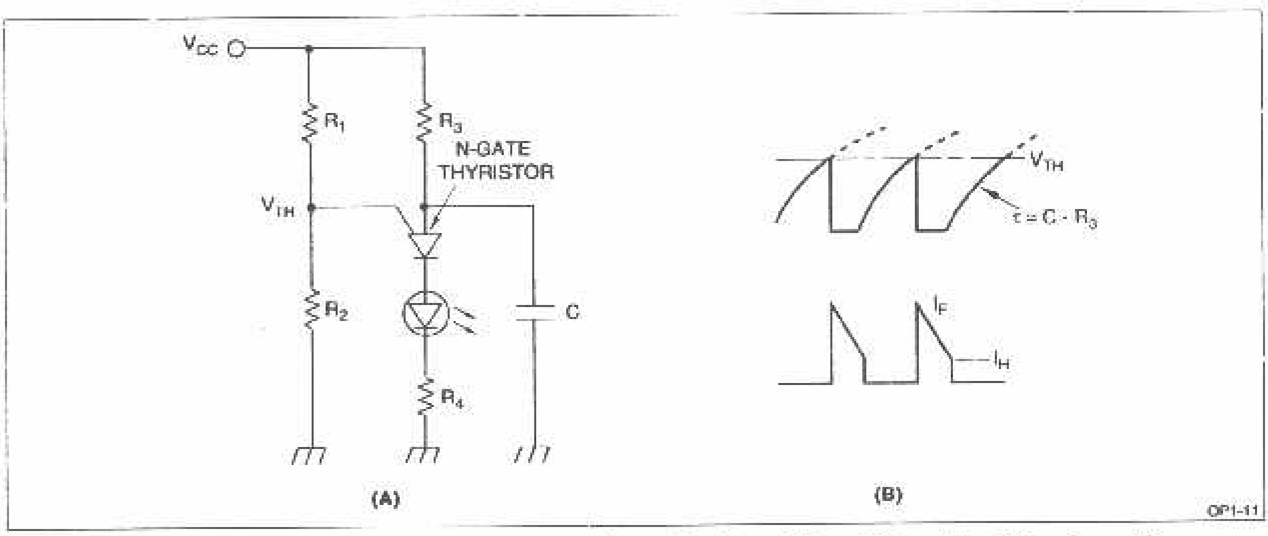


Figure 11. Pulse Driving Circuit using N-Gate Thyristor (A) and Operating Waveform (B)

The circuit shown in Figure 13 uses transistors to form an astable multi-vibrator for pulse driving an LED. The off-period (t_1) of the LED is given by $C_1 \times R_1$, while its on-period (t_2) is given by $C_2 \times R_2$. For oscillation of this circuit, resistors must be chosen so that the R_1/R_3 and R_2/R_5 ratios are large.

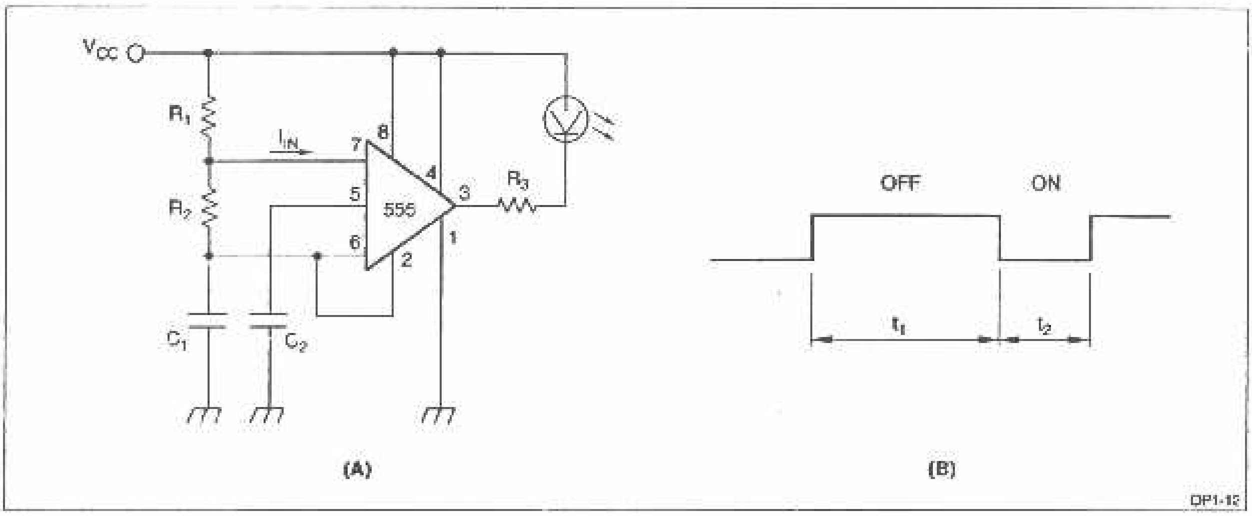


Figure 12. Pulse Driving using a 555 Timer IC (A) and Output Waveform (B)

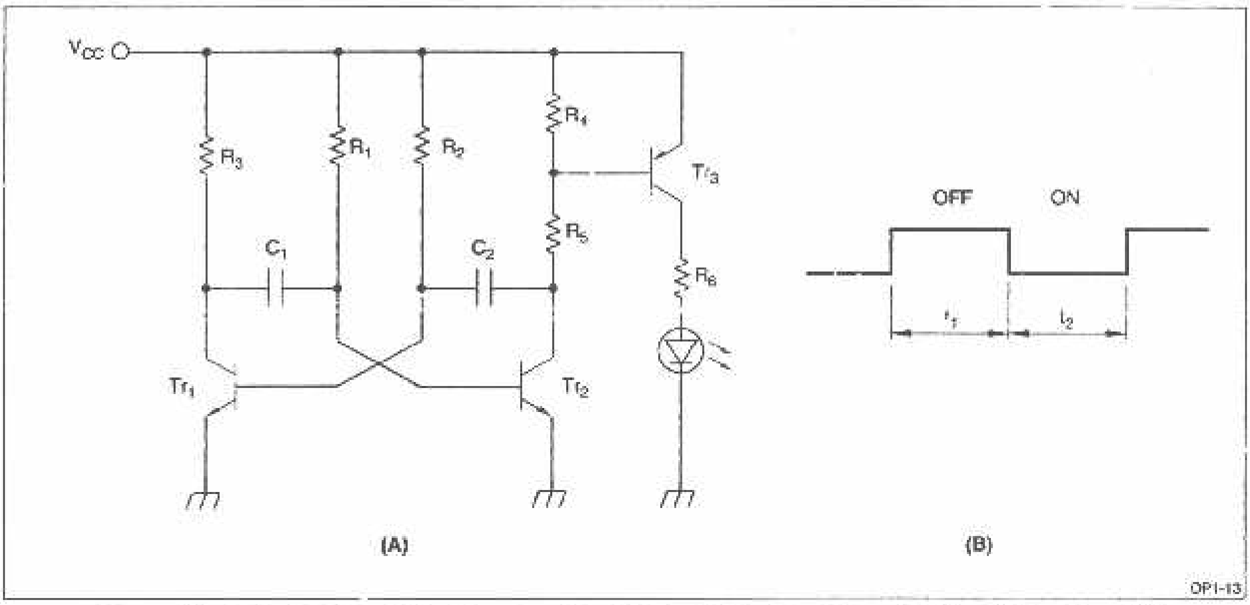


Figure 13. Pulse Driving Circuit using Astable Multi-vibrator (A) and Output Waveform (B)

The circuit shown in Figure 14 uses a CMOS logic IC (inverter) to form an oscillation circuit for pulse driving an LED. The pulse driving circuit using a logic IC provides a relatively short oscillation period with a 50% duty cycle.

Figure 15 (A) shows an LED pulse driving circuit used for the light projector of the optical remote control and optoelectronic switch. The circuit is arranged by combining two different oscillation circuits i.e., a long period oscillation (f_1) superimposed with a short period oscillation (f_2) as shown in Figure 15 (B). Frequencies f_1 and f_2 can be set independently.

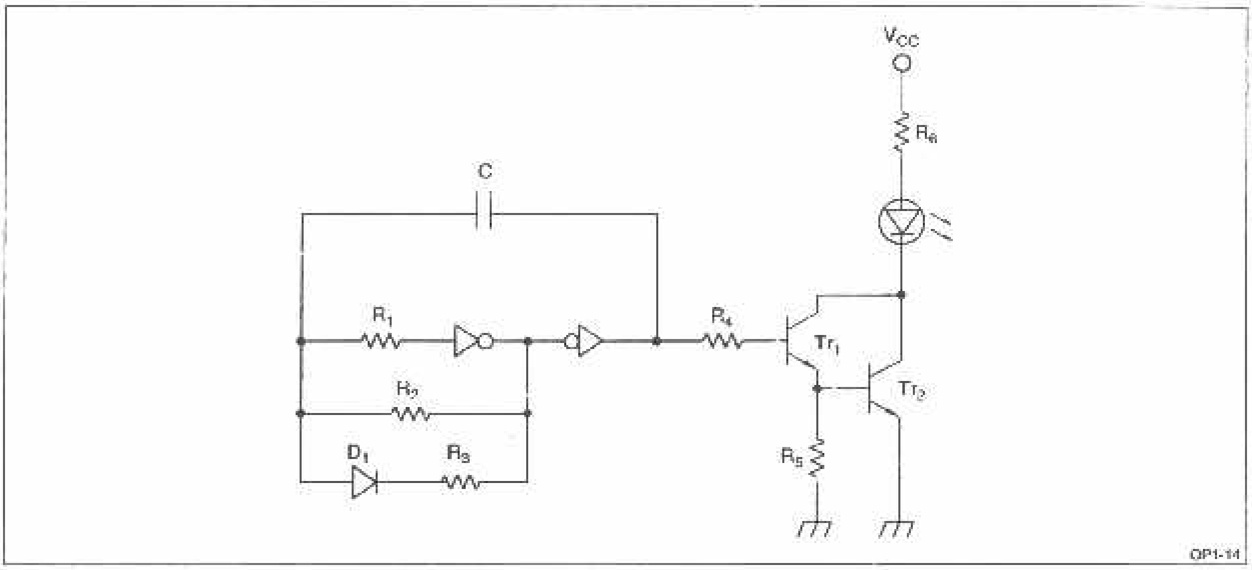


Figure 14. Pulse Driving Circuit using CMOS Logic IC

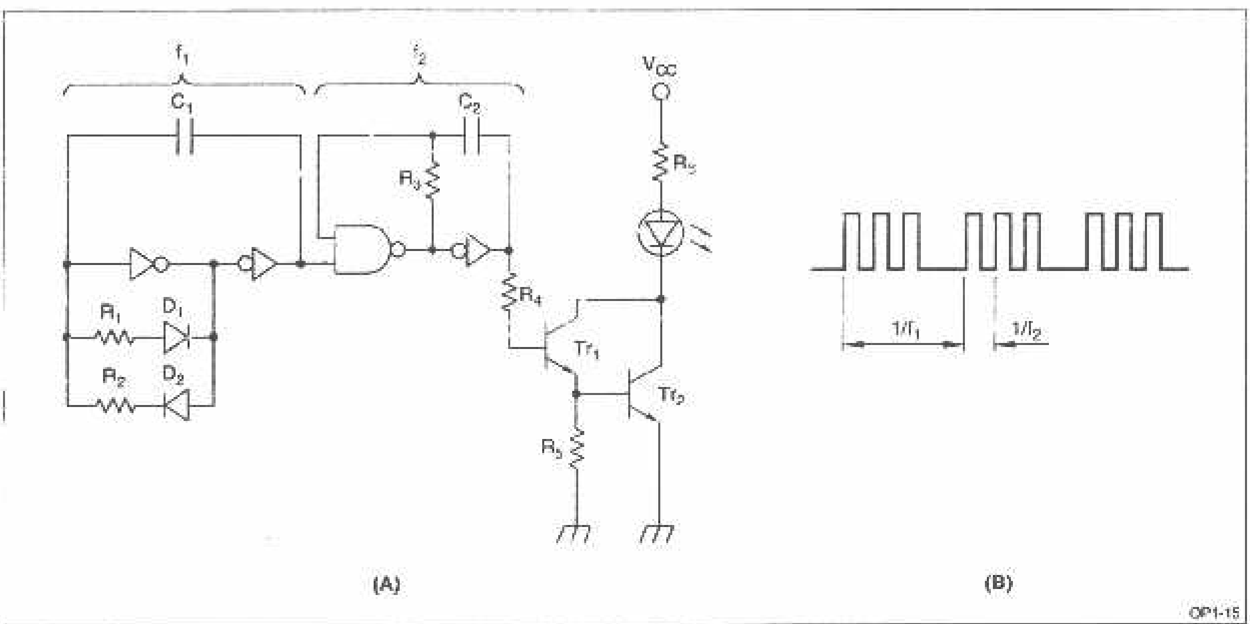


Figure 15. Pulse Driving Circuit (A) and Output Waveform (B)

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Reference Code SMA99016

bsolute Maximum Ratings*

'perating Temperature	-55°C to +125°C
torage Temperature	-65°C to +150°C
oltage on Any Pin 'ith Respect to Ground	-1.0V to +7.0V
taximum Operating Voltage	6.6V
C 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.

C Characteristics

= -40°C to 85°C, V_{CC} = 5.0V ± 20% (unless otherwise noted)

ymbol	Parameter	Condition	Min	Max	Units
L	Input Low Voltage	(Except $\overline{EA}$)	-0.5	0.2 V_{CC} - 0.1	V
L1	Input Low Voltage ($\overline{EA}$)		-0.5	0.2 V_{CC} - 0.3	V
H	Input High Voltage	(Except XTAL1, RST)	0.2 V_{CC} + 0.9	V_{CC} + 0.5	V
H1	Input High Voltage	(XTAL1, RST)	0.7 V_{CC}	V_{CC} + 0.5	V
OL	Output Low Voltage[1] (Ports 1,2,3)	I_{OL} = 1.6 mA		0.45	V
OL1	Output Low Voltage[1] (Port 0, ALE, $\overline{PSEN}$)	I_{OL} = 3.2 mA		0.45	V
OH	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
OH1	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, VCC = 5V ± 10%		-650	µA
	Input Leakage Current (Port 0, $\overline{EA}$)	0.45 < V_{IN} < V_{CC}		±10	µA
RST	Reset Pulldown Resistor		50	300	KΩ
O	Pin Capacitance	Test Freq. = 1 MHz, T_A = 25°C		10	pF
C	Power Supply Current	Active Mode, 12 MHz		20	mA
		Idle Mode, 12 MHz		5	mA
	Power Down Mode[2]	V_{CC} = 6V		100	µA
		V_{CC} = 3V		40	µA

es: 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.

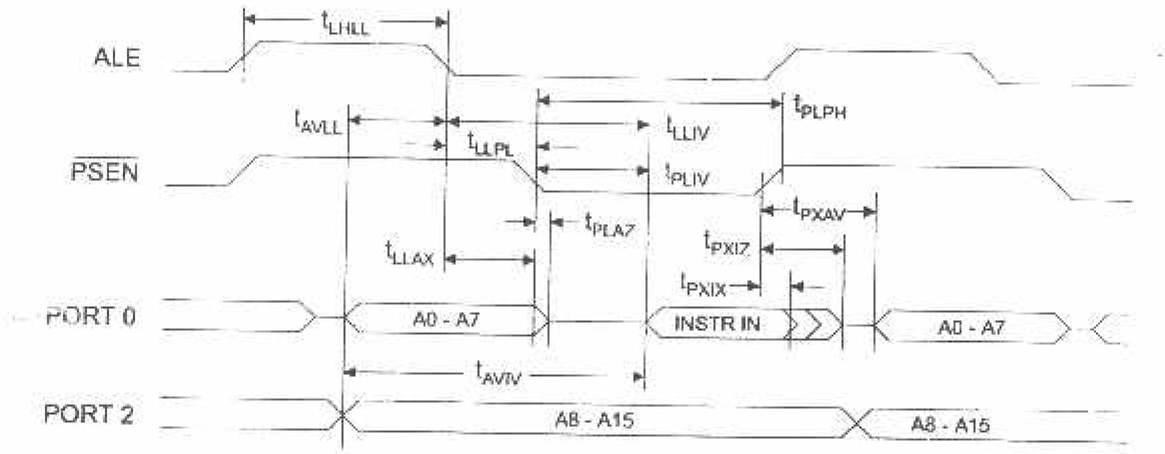
AC Characteristics

(Under Operating Conditions; Load Capacitance for Port 0, ALE/$\overline{PROG}$, and $\overline{PSEN}$ = 100 pF; Load Capacitance for all other outputs = 80 pF)

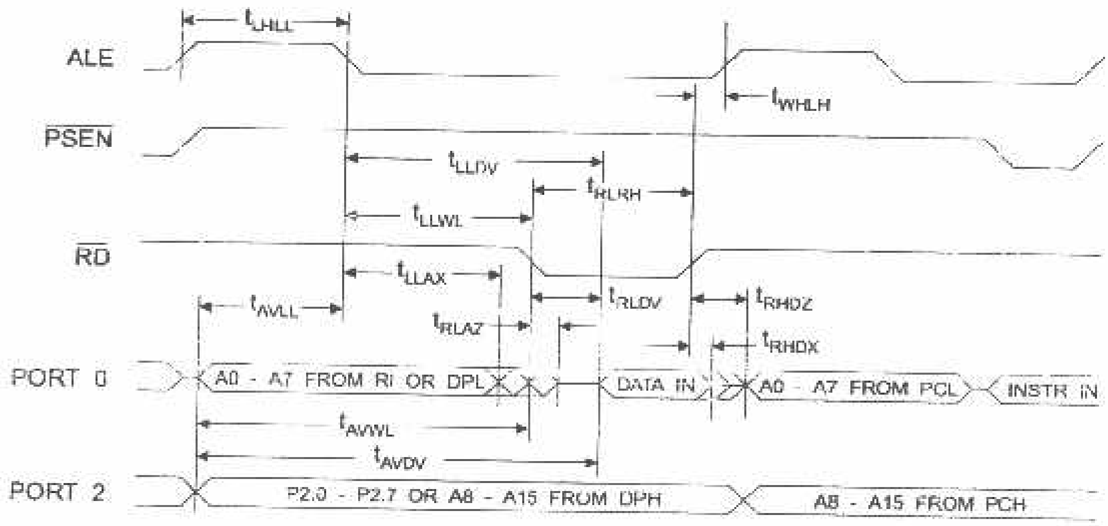
External Program and Data Memory Characteristics

Symbol	Parameter	12 MHz Oscillator		16 to 24 MHz Oscillator		Units
		Min	Max	Min	Max	
$1/t_{CLCL}$	Oscillator Frequency			0	24	MHz
t_{LHLL}	ALE Pulse Width	127		$2t_{CLCL}$-40		ns
t_{AVLL}	Address Valid to ALE Low	43		t_{CLCL}-13		ns
t_{LLAX}	Address Hold After ALE Low	48		t_{CLCL}-20		ns
t_{LLIV}	ALE Low to Valid Instruction In		233		$4t_{CLCL}$-65	ns
t_{LLPL}	ALE Low to $\overline{PSEN}$ Low	43		t_{CLCL}-13		ns
t_{PLPH}	$\overline{PSEN}$ Pulse Width	205		$3t_{CLCL}$-20		ns
t_{PLIV}	$\overline{PSEN}$ Low to Valid Instruction In		145		$3t_{CLCL}$-45	ns
t_{PXIX}	Input Instruction Hold After $\overline{PSEN}$	0		0		ns
t_{PXIZ}	Input Instruction Float After $\overline{PSEN}$		59		t_{CLCL}-10	ns
t_{PXAV}	$\overline{PSEN}$ to Address Valid	75		t_{CLCL}-8		ns
t_{AVIV}	Address to Valid Instruction In		312		$5t_{CLCL}$-55	ns
t_{PLAZ}	$\overline{PSEN}$ Low to Address Float		10		10	ns
t_{RLRH}	$\overline{RD}$ Pulse Width	400		$6t_{CLCL}$-100		ns
t_{WLWH}	$\overline{WR}$ Pulse Width	400		$6t_{CLCL}$-100		ns
t_{RLDV}	$\overline{RD}$ Low to Valid Data In		252		$5t_{CLCL}$-90	ns
t_{RHDX}	Data Hold After $\overline{RD}$	0		0		ns
t_{RHDZ}	Data Float After $\overline{RD}$		97		$2t_{CLCL}$-28	ns
t_{LLDV}	ALE Low to Valid Data In		517		$8t_{CLCL}$-150	ns
t_{AVDV}	Address to Valid Data In		585		$9t_{CLCL}$-165	ns
t_{LLWL}	ALE Low to $\overline{RD}$ or $\overline{WR}$ Low	200	300	$3t_{CLCL}$-50	$3t_{CLCL}$+50	ns
t_{AVWL}	Address to $\overline{RD}$ or $\overline{WR}$ Low	203		$4t_{CLCL}$-75		ns
t_{QVWX}	Data Valid to $\overline{WR}$ Transition	23		t_{CLCL}-20		ns
t_{QVWH}	Data Valid to $\overline{WR}$ High	433		$7t_{CLCL}$-120		ns
t_{WHQX}	Data Hold After $\overline{WR}$	33		t_{CLCL}-20		ns
t_{RLAZ}	$\overline{RD}$ Low to Address Float		0		0	ns
t_{WHLH}	$\overline{RD}$ or $\overline{WR}$ High to ALE High	43	123	t_{CLCL}-20	t_{CLCL}+25	ns

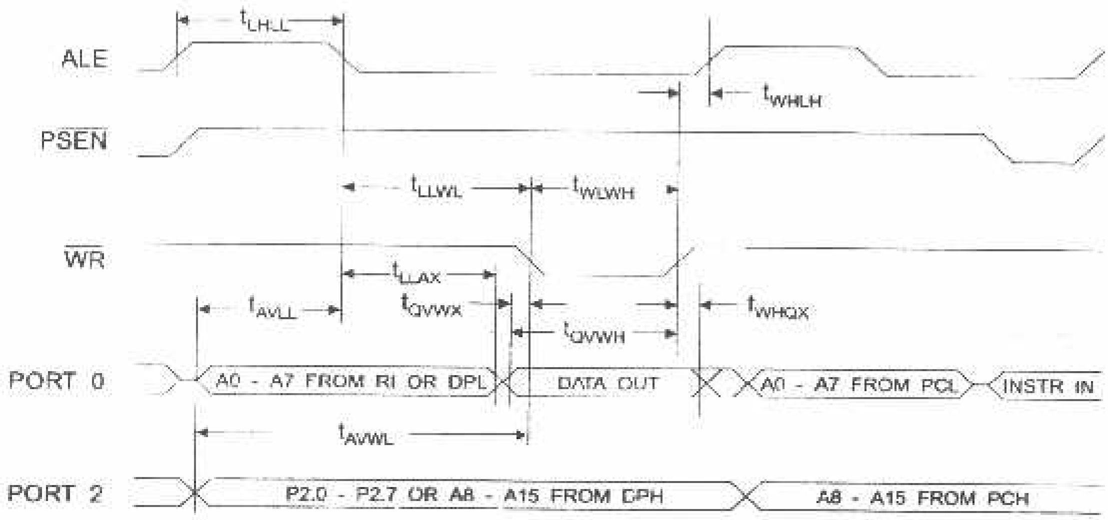
External Program Memory Read Cycle



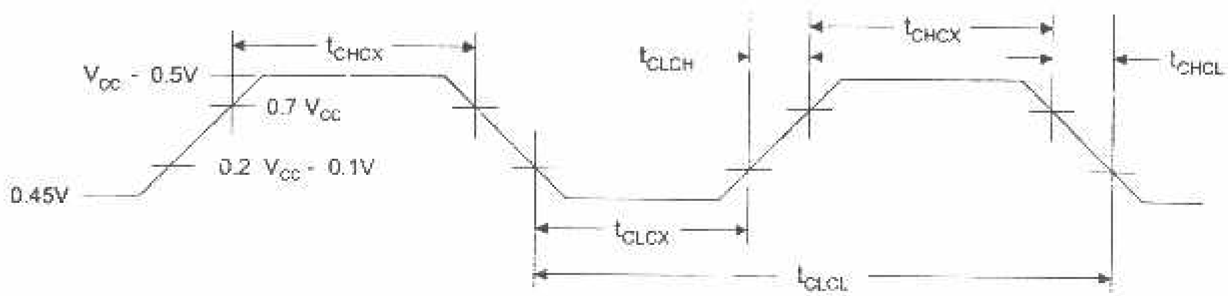
External Data Memory Read Cycle



External Data Memory Write Cycle



External Clock Drive Waveforms



External Clock Drive

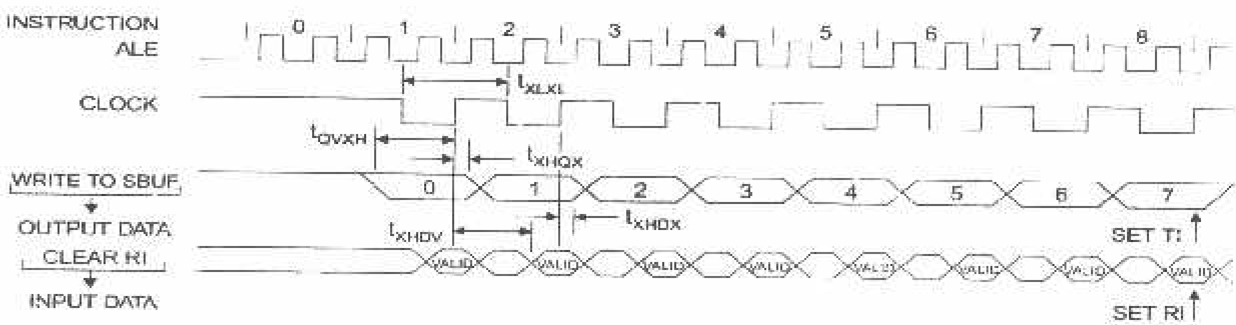
Symbol	Parameter	Min	Max	Units
$1/t_{CLCL}$	Oscillator Frequency	0	24	MHz
t_{CLCL}	Clock Period	41.6		ns
t_{CHCX}	High Time	15		ns
t_{CLCX}	Low Time	15		ns
t_{CLCH}	Rise Time		20	ns
t_{CHCL}	Fall Time		20	ns

Serial Port Timing: Shift Register Mode Test Conditions

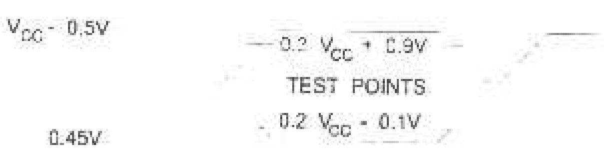
(V_{CC} = 5.0 V ± 20%; Load Capacitance = 80 pF)

Symbol	Parameter	12 MHz Osc		Variable Oscillator		Units
		Min	Max	Min	Max	
t_{XLXL}	Serial Port Clock Cycle Time	1.0		$12t_{CLCL}$		µs
t_{QVXH}	Output Data Setup to Clock Rising Edge	700		$10t_{CLCL}$-133		ns
t_{XHQX}	Output Data Hold After Clock Rising Edge	50		$2t_{CLCL}$-117		ns
t_{XHDX}	Input Data Hold After Clock Rising Edge	0		0		ns
t_{XHDV}	Clock Rising Edge to Input Data Valid		700		$10t_{CLCL}$-133	ns

Shift Register Mode Timing Waveforms



AC Testing Input/Output Waveforms(1)



Note: 1. AC Inputs during testing are driven at V_{CC} - 0.5V for a logic 1 and 0.45V for a logic 0. Timing measurements are made at V_{IH} min. for a logic 1 and V_{IL} max. for a logic 0.

Float Waveforms(1)

Note: 1. For timing purposes, a port pin is no longer floating when a 100 mV change from load voltage occurs. A port pin begins to float when 100 mV change from the loaded V_{OH}/V_{OL} level occurs.

Ordering Information

Speed (MHz)	Power Supply	Ordering Code	Package	Operation Range
12	5V ± 20%	AT89C51-12AC	44A	Commercial (0°C to 70°C)
		AT89C51-12JC	44J	
		AT89C51-12PC	40P6	
		AT89C51-12QC	44Q	
		AT89C51-12AI	44A	Industrial (-40°C to 85°C)
		AT89C51-12JI	44J	
		AT89C51-12PI	40P6	
		AT89C51-12QI	44Q	
		AT89C51-12AA	44A	Automotive (-40°C to 105°C)
		AT89C51-12JA	44J	
		AT89C51-12PA	40P6	
		AT89C51-12QA	44Q	
16	5V ± 20%	AT89C51-16AC	44A	Commercial (0°C to 70°C)
		AT89C51-16JC	44J	
		AT89C51-16PC	40P6	
		AT89C51-16QC	44Q	
		AT89C51-16AI	44A	Industrial (-40°C to 85°C)
		AT89C51-16JI	44J	
		AT89C51-16PI	40P6	
		AT89C51-16QI	44Q	
		AT89C51-16AA	44A	Automotive (-40°C to 105°C)
		AT89C51-16JA	44J	
		AT89C51-16PA	40P6	
		AT89C51-16QA	44Q	
20	5V ± 20%	AT89C51-20AC	44A	Commercial (0°C to 70°C)
		AT89C51-20JC	44J	
		AT89C51-20PC	40P6	
		AT89C51-20QC	44Q	
		AT89C51-20AI	44A	Industrial (-40°C to 85°C)
		AT89C51-20JI	44J	
		AT89C51-20PI	40P6	
		AT89C51-20QI	44Q	

Ordering Information

Speed (MHz)	Power Supply	Ordering Code	Package	Operation Range
24	5V ± 20%	AT89C51-24AC	44A	Commercial (0°C to 70°C)
		AT89C51-24JC	44J	
		AT89C51-24PC	44P6	
		AT89C51-24QC	44Q	
		AT89C51-24AI	44A	Industrial (-40°C to 85°C)
		AT89C51-24JI	44J	
		AT89C51-24PI	44P6	
		AT89C51-24QI	44Q	

	Package Type
44A	44 Lead, Thin Plastic Gull Wing Quad Flatpack (TQFP)
44J	44 Lead, Plastic J-Leaded Chip Carrier (PLCC)
40P6	40 Lead, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44Q	44 Lead, Plastic Gull Wing Quad Flatpack (PQFP)

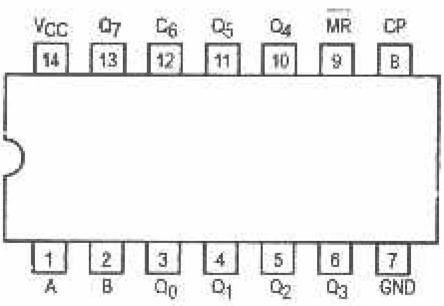
MOTOROLA

SERIAL-IN PARALLEL-OUT SHIFT REGISTER

The SN54/74LS164 is a high speed 8-Bit Serial-In Parallel-Out Shift Register. Serial data is entered through a 2-Input AND gate synchronous with the LOW to HIGH transition of the clock. The device features an asynchronous Master Reset which clears the register setting all outputs LOW independent of the clock. It utilizes the Schottky diode clamped process to achieve high speeds and is fully compatible with all Motorola TTL products.

- Typical Shift Frequency of 35 MHz
- Asynchronous Master Reset
- Gated Serial Data Input
- Fully Synchronous Data Transfers
- Input Clamp Diodes Limit High Speed Termination Effects
- ESD > 3500 Volts

CONNECTION DIAGRAM DIP (TOP VIEW)



NOTE:
The Flatpak version has the same pinouts (Connection Diagram) as the Dual In-Line Package.

PIN NAMES

		LOADING (Note a) HIGH	LOW
A, B	Data Inputs	0.5 U.L.	0.25 U.L.
CP	Clock (Active HIGH Going Edge) Input	0.5 U.L.	0.25 U.L.
MR	Master Reset (Active LOW) Input	0.5 U.L.	0.25 U.L.
Q_0-Q_7	Outputs (Note b)	10 U.L.	5 (2.5) U.L.

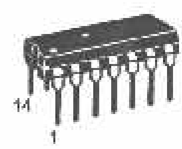
NOTES:
a) 1 TTL Unit Load (U.L.) = 40 µA HIGH/1.6 mA LOW.
b) The Output LOW drive factor is 2.5 U.L. for Military (54) and 5 U.L. for Commercial (74) Temperature Ranges.

SN54/74LS164

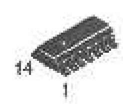
SERIAL-IN PARALLEL-OUT SHIFT REGISTER

LOW POWER SCHOTTKY

J SUFFIX
CERAMIC
CASE 632-08



N SUFFIX
PLASTIC
CASE 646-06

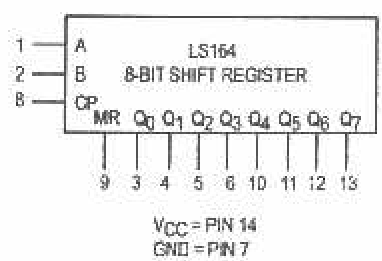


D SUFFIX
SOIC
CASE 751A-02

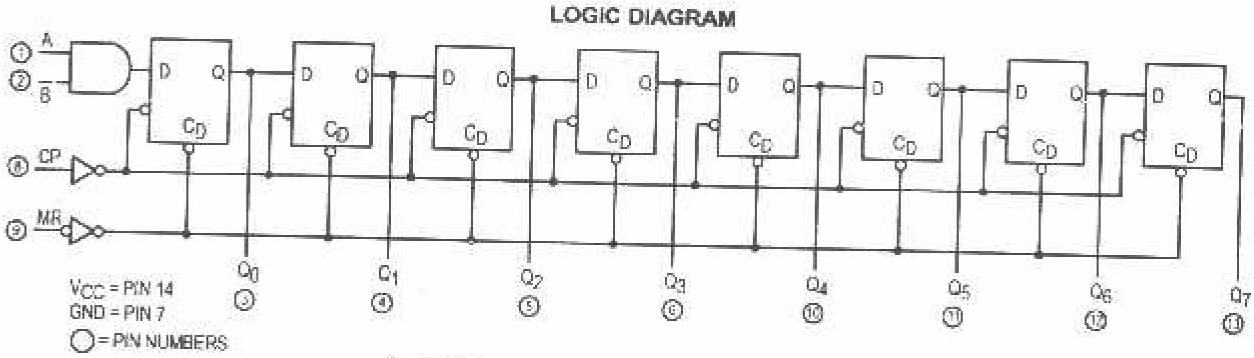
ORDERING INFORMATION

SN54LSXXXJ	Ceramic
SN74LSXXXN	Plastic
SN74LSXXXD	SOIC

LOGIC SYMBOL



LOGIC DIAGRAM



FUNCTIONAL DESCRIPTION

The LS164 is an edge-triggered 8-bit shift register with serial data entry and an output from each of the eight stages. Data is entered serially through one of two inputs (A or B); either of these inputs can be used as an active HIGH Enable for data entry through the other input. An unused input must be tied HIGH, or both inputs connected together.

Each LOW-to-HIGH transition on the Clock (CP) input shifts data one place to the right and enters into Q_0 the logical AND of the two data inputs (A•B) that existed before the rising clock edge. A LOW level on the Master Reset (MR) input overrides all other inputs and clears the register asynchronously, forcing all Q outputs LOW.

MODE SELECT — TRUTH TABLE

OPERATING MODE	INPUTS			OUTPUTS	
	MR	A	B	Q_0	Q_1–Q_7
Reset (Clear)	L	X	X	L	L – L
Shift	H	l	l	L	q_0 – q_6
	H	l	h	L	q_0 – q_6
	H	h	l	L	q_0 – q_6
	H	h	h	H	q_0 – q_6

L (l) = LOW Voltage Levels
H (h) = HIGH Voltage Levels
X = Don't Care
q_n = Lower case letters indicate the state of the referenced input or output one set-up time prior to the LOW to HIGH clock transition.

GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
CC	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
OH	Output Current — High	54, 74			−0.4	mA
OL	Output Current — Low	54 74			4.0 8.0	mA

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Typ	Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage		2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage	54			0.7	V	Guaranteed Input LOW Voltage for All Inputs	
		74			0.8			
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage	54	2.5	3.5		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
		74	2.7	3.5				
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	I_{OL} = 4.0 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IH} or V_{IL} per Truth Table
		74		0.35	0.5	V	I_{OL} = 8.0 mA	
I_{IH}	Input HIGH Current				20	µA	V_{CC} = MAX, V_{IN} = 2.7 V	
					0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current				−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{OS}	Short Circuit Current (Note 1)		−20		−100	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current				27	mA	V_{CC} = MAX	

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C)

Symbol	Parameter	Limits Min	Typ	Max	Unit	Test Conditions
f_{MAX}	Maximum Clock Frequency	25	36		MHz	V_{CC} = 5.0 V, C_L = 15 pF
t_{PHL}	Propagation Delay MR to Output Q		24	36	ns	
t_{PLH} t_{PHL}	Propagation Delay Clock to Output Q		17 21	27 32	ns	

AC SETUP REQUIREMENTS (T_A = 25°C)

Symbol	Parameter	Limits Min	Typ	Max	Unit	Test Conditions
t_W	CP, MR Pulse Width	20			ns	V_{CC} = 5.0 V
t_s	Data Setup Time	15			ns	
t_h	Data Hold Time	5.0			ns	
t_{rec}	MR to Clock Recovery Time	20			ns	

AC WAVEFORMS

*The shaded areas indicate when the input is permitted to change for predictable output performance.

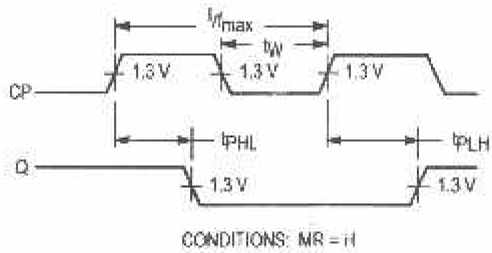


Figure 1. Clock to Output Delays and Clock Pulse Width

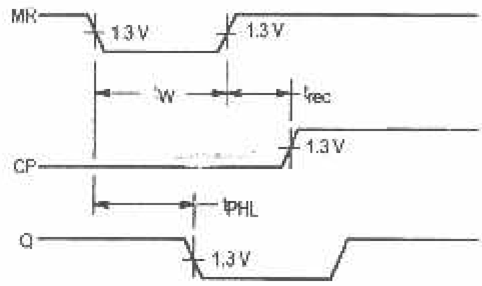


Figure 2. Master Reset Pulse Width, Master Reset to Output Delay and Master Reset to Clock Recovery Time

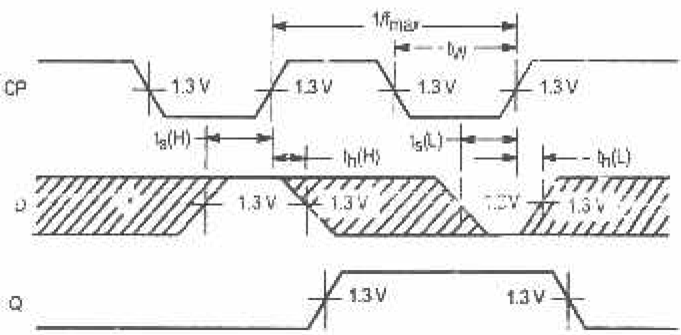
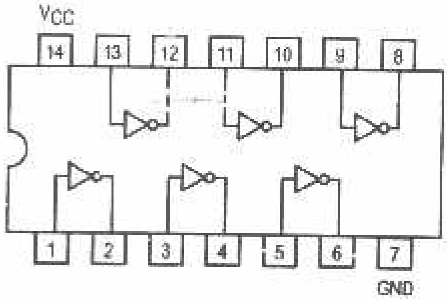


Figure 3. Data Setup and Hold Times

MOTOROLA

HEX INVERTER

SN54/74LS04

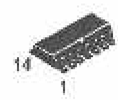


HEX INVERTER

LOW POWER SCHOTTKY

J SUFFIX
CERAMIC
CASE 632-08

N SUFFIX
PLASTIC
CASE 646-06



D SUFFIX
SOIC
CASE 751A-02

ORDERING INFORMATION

SN54LSXXJ	Ceramic
SN74LSXXN	Plastic
SN74LSXXD	SOIC

GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T_A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
I_{OH}	Output Current — High	54, 74			−0.4	mA
I_{OL}	Output Current — Low	54 74			4.0 8.0	mA

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Typ	Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage		2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage	54			0.7	V	Guaranteed Input LOW Voltage for All Inputs	
		74			0.8			
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage	54	2.5	3.5		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
		74	2.7	3.5		V		
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	I_{OL} = 4.0 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
		74		0.35	0.5	V	I_{OL} = 8.0 mA	
I_{IH}	Input HIGH Current				20	µA	V_{CC} = MAX, V_{IN} = 2.7 V	
					0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current				−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{OS}	Short Circuit Current (Note 1)		−20		−100	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current Total, Output HIGH				2.4	mA	V_{CC} = MAX	
	Total, Output LOW				6.6			

te 1: Not more than one output should be shorted at a time, nor for more than 1 second.

: CHARACTERISTICS (T_A = 25°C)

ymbol	Parameter	Limits Min	Typ	Max	Unit	Test Conditions
LH	Turn-Off Delay, Input to Output		9.0	15	ns	V_{CC} = 5.0 V C_L = 15 pF
HL	Turn-On Delay, Input to Output		10	15	ns	

MOTOROLA

SN54/74LS13
SN54/74LS14

SCHMITT TRIGGERS DUAL GATE/HEX INVERTER

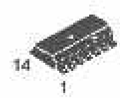
SCHMITT TRIGGERS
DUAL GATE/HEX INVERTER
LOW POWER SCHOTTKY

The SN54LS/74LS13 and SN54LS/74LS14 contain logic gates/inverters which accept standard TTL input signals and provide standard TTL output levels. They are capable of transforming slowly changing input signals into sharply defined, jitter-free output signals. Additionally, they have greater noise margin than conventional inverters.

Each circuit contains a Schmitt trigger followed by a Darlington level shifter and a phase splitter driving a TTL totem pole output. The Schmitt trigger uses positive feedback to effectively speed-up slow input transitions, and provide different input threshold voltages for positive and negative-going transitions. This hysteresis between the positive-going and negative-going input thresholds (typically 800 mV) is determined internally by resistor ratios and is essentially insensitive to temperature and supply voltage variations.

J SUFFIX
CERAMIC
CASE 632-08

N SUFFIX
PLASTIC
CASE 646-06



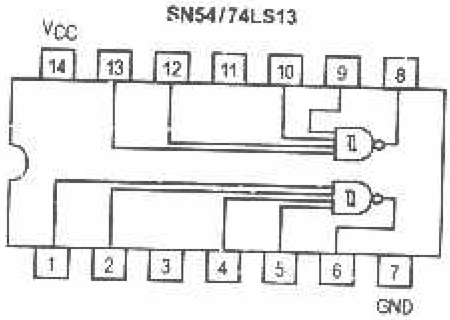
D SUFFIX
SOIC
CASE 751A-02

ORDERING INFORMATION

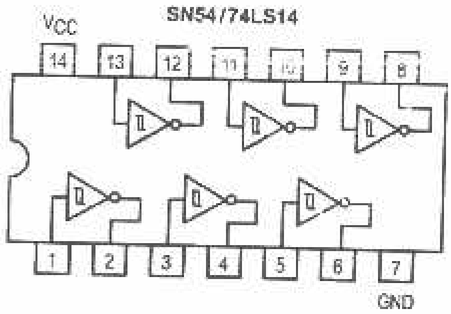
SN54LSXXJ	Ceramic
SN74LSXXN	Plastic
SN74LSXXD	SOIC

LOGIC AND CONNECTION DIAGRAMS

SN54/74LS13



SN54/74LS14



GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T_A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
I_{OH}	Output Current — High	54, 74			−0.4	mA
I_{OL}	Output Current — Low	54 74			4.0 8.0	mA

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Typ	Max	Unit	Test Conditions
V_{T+}	Positive-Going Threshold Voltage		1.5		2.0	V	V_{CC} = 5.0 V
V_{T-}	Negative-Going Threshold Voltage		0.6		1.1	V	V_{CC} = 5.0 V
$V_{T+}-V_{T-}$	Hysteresis		0.4	0.8		V	V_{CC} = 5.0 V
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA
V_{OH}	Output HIGH Voltage	54	2.5	3.4		V	V_{CC} = MIN, I_{OH} = −400 µA, V_{IN} = V_{IL}
		74	2.7	3.4		V	
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	V_{CC} = MIN, I_{OL} = 4.0 mA, V_{IN} = 2.0 V
		74		0.35	0.5	V	V_{CC} = MIN, I_{OL} = 8.0 mA, V_{IN} = 2.0 V
I_{T+}	Input Current at Positive-Going Threshold			−0.14		mA	V_{CC} = 5.0 V, V_{IN} = V_{T+}
I_{T-}	Input Current at Negative-Going Threshold			−0.18		mA	V_{CC} = 5.0 V, V_{IN} = V_{T-}
I_{IH}	Input HIGH Current			1.0	20	µA	V_{CC} = MAX, V_{IN} = 2.7 V
					0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V
I_{IL}	Input LOW Current				−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V
I_{OS}	Short Circuit Current (Note 1)		−20		−100	mA	V_{CC} = MAX, V_{OUT} = 0 V
I_{CC}	Power Supply Current Total, Output HIGH	LS13		2.9	6.0	mA	V_{CC} = MAX
		LS14		8.6	16		
	Total, Output LOW	LS13		4.1	7.0		
		LS14		12	21		

Note 1. Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C)

Symbol	Parameter	Max LS13	LS14	Unit	Test Conditions
t_{PLH}	Propagation Delay, Input to Output	22	22	ns	V_{CC} = 5.0 V C_L = 15 pF
t_{PHL}	Propagation Delay, Input to Output	27	22	ns	

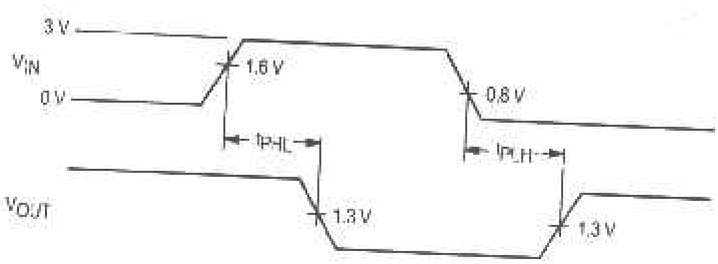


Figure 1. AC Waveforms

National Semiconductor

December 1994

LM35/LM35A/LM35C/LM35CA/LM35D Precision Centigrade Temperature Sensors

General Description

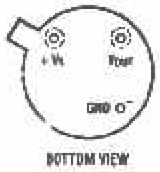
The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-202 package.

Features

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guaranteeable (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 μA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ±¼°C typical
- Low impedance output, 0.1 Ω for 1 mA load

Connection Diagrams

TO-46
Metal Can Package*



TL/H/5516–1

*Case is connected to negative pin (GND)

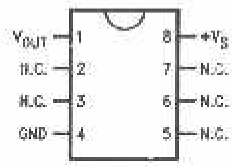
Order Number LM35H, LM35AH, LM35CH, LM35CAH or LM35DH
See NS Package Number H03H

TO-92
Plastic Package

TL/H/5516–2

Order Number LM35CZ, LM35CAZ or LM35DZ
See NS Package Number Z03A

SO-8
Small Outline Molded Package



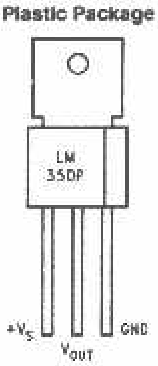
TL/H/5516–21

Top View

N.C. = No Connection

Order Number LM35DM
See NS Package Number M08A

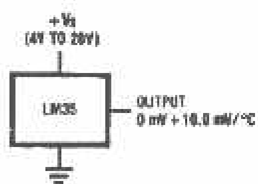
TO-202
Plastic Package



TL/H/5516–24

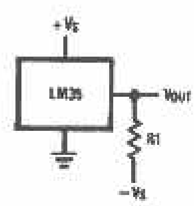
Order Number LM35DP
See NS Package Number P03A

Typical Applications



TL/H/5516–3

FIGURE 1. Basic Centigrade Temperature Sensor (+2°C to +150°C)



TL/H/5516–4

Choose $R_1 = -V_S/50\ \mu A$

$V_{OUT} = +1{,}500$ mV at +150°C
= +250 mV at +25°C
= −550 mV at −55°C

FIGURE 2. Full-Range Centigrade Temperature Sensor

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Absolute Maximum Ratings (Note 10)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage	+35V to −0.2V
Output Voltage	+6V to −1.0V
Output Current	10 mA
Storage Temp., TO-46 Package,	−60°C to +180°C
TO-92 Package,	−60°C to +150°C
SO-8 Package,	−65°C to +150°C
TO-202 Package,	−65°C to +150°C
Lead Temp.:	
TO-46 Package, (Soldering, 10 seconds)	300°C
TO-92 Package, (Soldering, 10 seconds)	260°C
TO-202 Package, (Soldering, 10 seconds)	+230°C
SO Package (Note 12):	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
ESD Susceptibility (Note 11)	2500V
Specified Operating Temperature Range: T_{MIN} to T_{MAX} (Note 2)	
LM35, LM35A	−55°C to +150°C
LM35C, LM35CA	−40°C to +110°C
LM35D	0°C to +100°C

Electrical Characteristics (Note 1) (Note 6)

Parameter	Conditions	LM35A			LM35CA			Units (Max.)
		Typical	Tested Limit (Note 4)	Design Limit (Note 5)	Typical	Tested Limit (Note 4)	Design Limit (Note 5)	
Accuracy (Note 7)	$T_A = +25°C$ $T_A = -10°C$ $T_A = T_{MAX}$ $T_A = T_{MIN}$	±0.2 ±0.3 ±0.4 ±0.4	±0.5 ±1.0 ±1.0		±0.2 ±0.3 ±0.4 ±0.4	±0.5 ±1.0	 ±1.0 ±1.5	°C °C °C °C
Nonlinearity (Note 8)	$T_{MIN} \le T_A \le T_{MAX}$	**±0.18**		**±0.35**	**±0.15**		**±0.3**	°C
Sensor Gain (Average Slope)	$T_{MIN} \le T_A \le T_{MAX}$	**+10.0**	**+9.9, +10.1**		**+10.0**		**+9.9, +10.1**	mV/°C
Load Regulation (Note 3) $0 \le I_L \le 1$ mA	$T_A = +25°C$ $T_{MIN} \le T_A \le T_{MAX}$	±0.4 **±0.5**	±1.0	 **±3.0**	±0.4 **±0.5**	±1.0	 **±3.0**	mV/mA mV/mA
Line Regulation (Note 3)	$T_A = +25°C$ $4V \le V_S \le 30V$	±0.01 **±0.02**	±0.05	 **±0.1**	±0.01 **±0.02**	±0.05	 **±0.1**	mV/V mV/V
Quiescent Current (Note 9)	$V_S = +5V$, +25°C $V_S = +5V$ $V_S = +30V$, +25°C $V_S = +30V$	56 **105** 56.2 **105.5**	67 68	 **131** **133**	56 **91** 56.2 **91.5**	67 68	 **114** **116**	μA μA μA μA
Change of Quiescent Current (Note 3)	$4V \le V_S \le 30V$, +25°C $4V \le V_S \le 30V$	0.2 **0.5**	1.0	 **2.0**	0.2 **0.5**	1.0	 **2.0**	μA μA
Temperature Coefficient of Quiescent Current		**+0.39**		**+0.5**	**+0.39**		**+0.5**	μA/°C
Minimum Temperature for Rated Accuracy	In circuit of *Figure 1*, $I_L = 0$	+1.5		+2.0	+1.5		+2.0	°C
Long Term Stability	$T_J = T_{MAX}$, for 1000 hours	±0.08			±0.08			°C

Note 1: Unless otherwise noted, these specifications apply: $-55°C \le T_J \le +150°C$ for the LM35 and LM35A; $-40° \le T_J \le +110°C$ for the LM35C and LM35CA; and $0° \le T_J \le +100°C$ for the LM35D. $V_S = +5Vdc$ and $I_{LOAD} = 50$ μA, in the circuit of *Figure 2*. These specifications also apply from +2°C to T_{MAX} in the circuit of *Figure 1*. Specifications in **boldface** apply over the full rated temperature range.

Note 2: Thermal resistance of the TO-46 package is 400°C/W, junction to ambient, and 24°C/W junction to case. Thermal resistance of the TO-92 package is 180°C/W junction to ambient. Thermal resistance of the small outline molded package is 220°C/W junction to ambient. Thermal resistance of the TO-202 package is 85°C/W junction to ambient. For additional thermal resistance information see table in the Applications section.

Electrical Characteristics (Note 1) (Note 6) (Continued)

Parameter	Conditions	LM35			LM35C, LM35D			Units (Max.)
		Typical	Tested Limit (Note 4)	Design Limit (Note 5)	Typical	Tested Limit (Note 4)	Design Limit (Note 5)	
Accuracy, LM35, LM35C (Note 7)	$T_A = +25°C$	±0.4	±1.0		±0.4	±1.0		°C
	$T_A = -10°C$	±0.5			±0.5		±1.5	°C
	$T_A = T_{MAX}$	±0.8	±1.5		±0.8		±1.5	°C
	$T_A = T_{MIN}$	±0.8		±1.5	±0.8		±2.0	°C
Accuracy, LM35D (Note 7)	$T_A = +25°C$				±0.6	±1.5		°C
	$T_A = T_{MAX}$				±0.9		±2.0	°C
	$T_A = T_{MIN}$				±0.9		±2.0	°C
Nonlinearity (Note 8)	$T_{MIN} \le T_A \le T_{MAX}$	**±0.3**		**±0.5**	**±0.2**		**±0.5**	°C
Sensor Gain (Average Slope)	$T_{MIN} \le T_A \le T_{MAX}$	**+10.0**	**+9.8, +10.2**		**+10.0**		**+9.8, +10.2**	mV/°C
Load Regulation (Note 3) $0 \le I_L \le 1$ mA	$T_A = +25°C$	±0.4	±2.0		±0.4	±2.0		mV/mA
	$T_{MIN} \le T_A \le T_{MAX}$	**±0.5**		**±5.0**	**±0.5**		**±5.0**	mV/mA
Line Regulation (Note 3)	$T_A = +25°C$	±0.01	±0.1		±0.01	±0.1		mV/V
	$4V \le V_S \le 30V$	**±0.02**		**±0.2**	**±0.02**		**±0.2**	mV/V
Quiescent Current (Note 9)	$V_S = +5V$, +25°C	56	80		56	80		μA
	$V_S = +5V$	**105**		**158**	**91**		**138**	μA
	$V_S = +30V$, +25°C	56.2	82		56.2	82		μA
	$V_S = +30V$	**105.5**		**161**	**91.5**		**141**	μA
Change of Quiescent Current (Note 3)	$4V \le V_S \le 30V$, +25°C	0.2	2.0		0.2	2.0		μA
	$4V \le V_S \le 30V$	**0.5**		**3.0**	**0.5**		**2.0**	μA
Temperature Coefficient of Quiescent Current		**+0.39**		**+0.7**	**+0.39**		**+0.7**	μA/°C
Minimum Temperature for Rated Accuracy	In circuit of *Figure 1*, $I_L = 0$	+1.5		+2.0	+1.5		+2.0	°C
Long Term Stability	$T_J = T_{MAX}$, for 1000 hours	±0.08			±0.08			°C

Note 3: Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output due to heating effects can be computed by multiplying the internal dissipation by the thermal resistance.

Note 4: Tested Limits are guaranteed and 100% tested in production.

Note 5: Design Limits are guaranteed (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.

Note 6: Specifications in **boldface** apply over the full rated temperature range.

Note 7: Accuracy is defined as the error between the output voltage and 10mv/°C times the device's case temperature, at specified conditions of voltage, current, and temperature (expressed in °C).

Note 8: Nonlinearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the device's rated temperature range.

Note 9: Quiescent current is defined in the circuit of *Figure 1*.

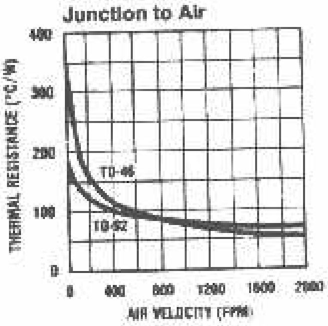
Note 10: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions. See Note 1.

Note 11: Human body model, 100 pF discharged through a 1.5 kΩ resistor.

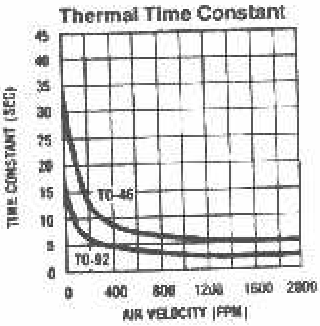
Note 12: See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" or the section titled "Surface Mount" found in a current National Semiconductor Linear Data Book for other methods of soldering surface mount devices.

Typical Performance Characteristics

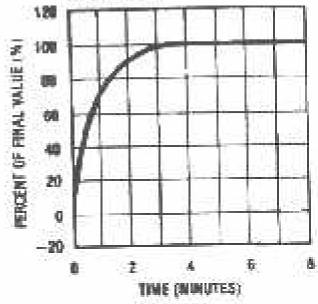
Thermal Resistance Junction to Air



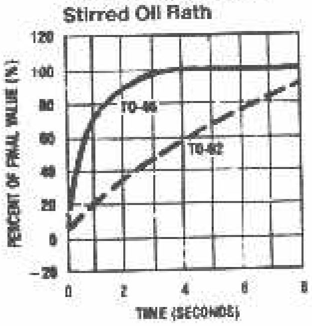
Thermal Time Constant



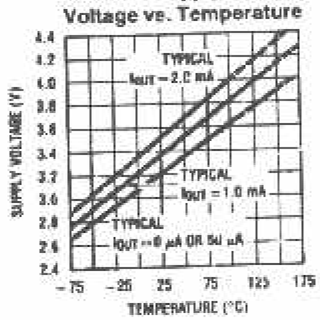
Thermal Response in Still Air



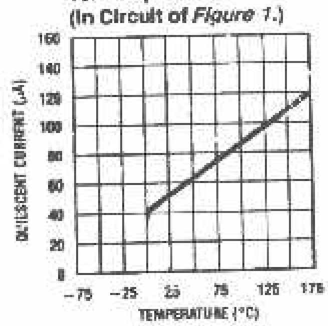
Thermal Response in Stirred Oil Bath



Minimum Supply Voltage vs. Temperature



Quiescent Current vs. Temperature (In Circuit of *Figure 1*.)



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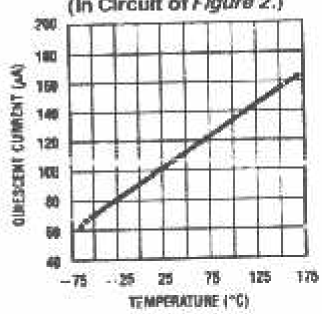
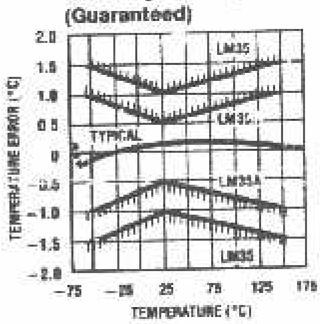
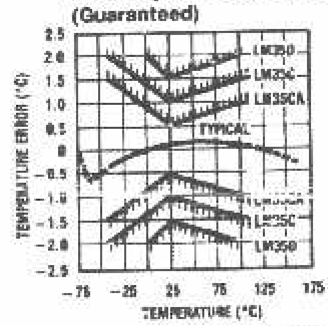
Quiescent Current vs. Temperature (In Circuit of *Figure 2*.)



Accuracy vs. Temperature (Guaranteed)



Accuracy vs. Temperature (Guaranteed)



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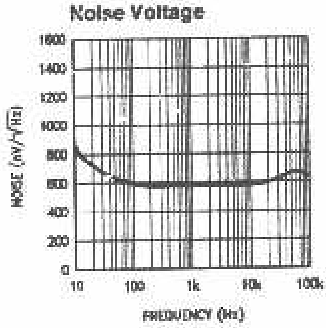
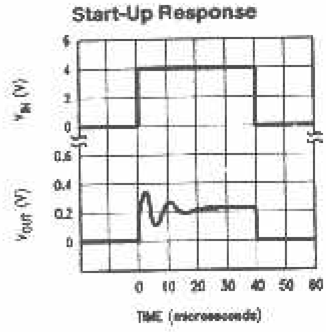
Noise Voltage



Start-Up Response



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Applications

The LM35 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01°C of the surface temperature.

This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the LM35 die would be at an intermediate temperature between the surface temperature and the air temperature. This is expecially true for the TO-92 plastic package, where the copper leads are the principal thermal path to carry heat into the device, so its temperature might be closer to the air temperature than to the surface temperature.

To minimize this problem, be sure that the wiring to the LM35, as it leaves the device, is held at the same temperature as the surface of interest. The easiest way to do this is to cover up these wires with a bead of epoxy which will insure that the leads and wires are all at the same temperature as the surface, and that the LM35 die's temperature will not be affected by the air temperature.

The TO-46 metal package can also be soldered to a metal surface or pipe without damage. Of course, in that case the V− terminal of the circuit will be grounded to that metal. Alternatively, the LM35 can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the LM35 and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. Printed-circuit coatings and varnishes such as Humiseal and epoxy paints or dips are often used to insure that moisture cannot corrode the LM35 or its connections.

These devices are sometimes soldered to a small light-weight heat fin, to decrease the thermal time constant and speed up the response in slowly-moving air. On the other hand, a small thermal mass may be added to the sensor, to give the steadiest reading despite small deviations in the air temperature.

Temperature Rise of LM35 Due To Self-heating (Thermal Resistance)

	TO-46, no heat sink	TO-46, small heat fin*	TO-92, no heat sink	TO-92, small heat fin**	SO-8 no heat sink	SO-8 small heat fin**	TO-202 no heat sink	TO-202*** small heat fin
Still air	400°C/W	100°C/W	180°C/W	140°C/W	220°C/W	110°C/W	65°C/W	60°C/W
Moving air	100°C/W	40°C/W	90°C/W	70°C/W	105°C/W	90°C/W	25°C/W	40°C/W
Still oil	100°C/W	40°C/W	90°C/W	70°C/W				
Stirred oil	50°C/W	30°C/W	45°C/W	40°C/W				
(Clamped to metal Infinite heat sink)	(24°C/W)				(55°C/W)			(23°C/W)

* Wakefield type 201, or 1" disc of 0.020" sheet brass, soldered to case, or similar.

** TO-92 and SO-8 packages glued and leads soldered to 1" square of 1/16" printed circuit board with 2 oz. foil or similar.

Typical Applications (Continued)

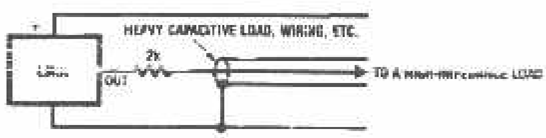

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FIGURE 3. LM35 with Decoupling from Capacitive Load

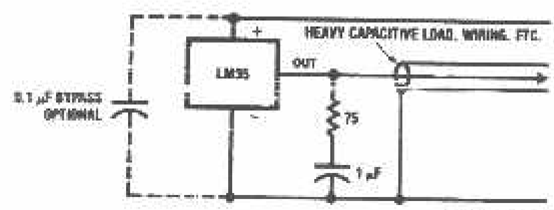

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FIGURE 4. LM35 with R-C Damper

CAPACITIVE LOADS

Like most micropower circuits, the LM35 has a limited ability to drive heavy capacitive loads. The LM35 by itself is able to drive 50 pf without special precautions. If heavier loads are anticipated, it is easy to isolate or decouple the load with a resistor; see *Figure 3*. Or you can improve the tolerance of capacitance with a series R-C damper from output to ground; see *Figure 4*.

When the LM35 is applied with a 200Ω load resistor as shown in *Figure 5, 6,* or *8*, it is relatively immune to wiring capacitance because the capacitance forms a bypass from ground to input, not on the output. However, as with any linear circuit connected to wires in a hostile environment, its performance can be affected adversely by intense electromagnetic sources such as relays, radio transmitters, motors with arcing brushes, SCR transients, etc, as its wiring can act as a receiving antenna and its internal junctions can act as rectifiers. For best results in such cases, a bypass capacitor from V_{IN} to ground and a series R-C damper such as 75Ω in series with 0.2 or 1 μF from output to ground are often useful. These are shown in *Figures 13, 14,* and *16.*

Typical Applications (Continued)

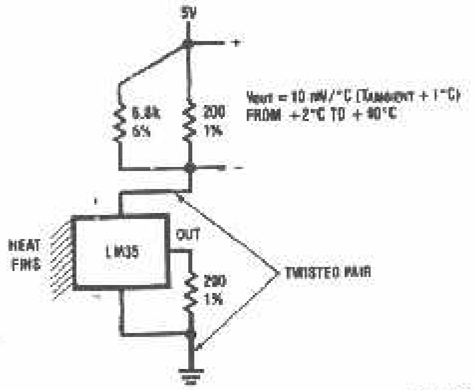

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FIGURE 5. Two-Wire Remote Temperature Sensor (Grounded Sensor)

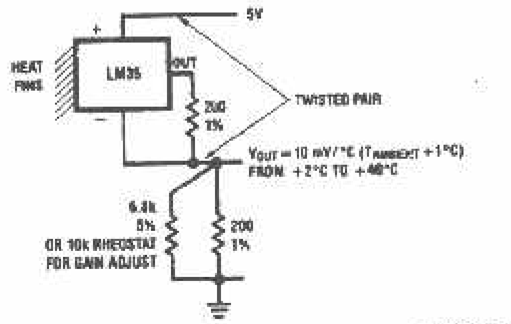

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FIGURE 6. Two-Wire Remote Temperature Sensor (Output Referred to Ground)

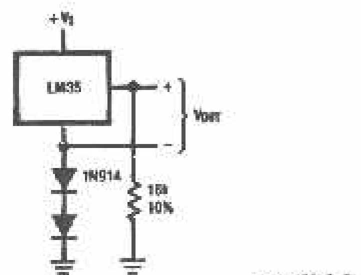

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FIGURE 7. Temperature Sensor, Single Supply, −55° to +150°C

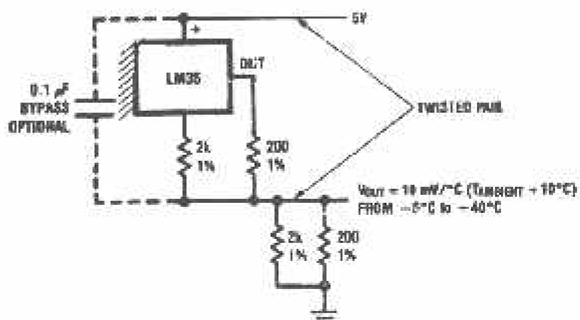

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FIGURE 8. Two-Wire Remote Temperature Sensor (Output Referred to Ground)

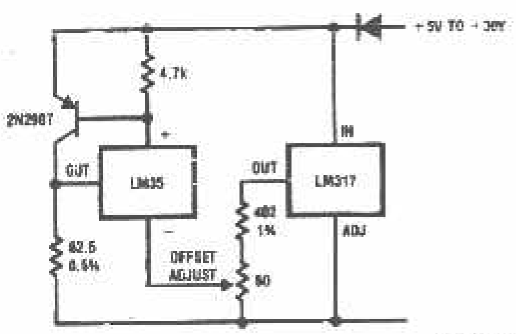

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FIGURE 9. 4-To-20 mA Current Source (0°C to +100°C)

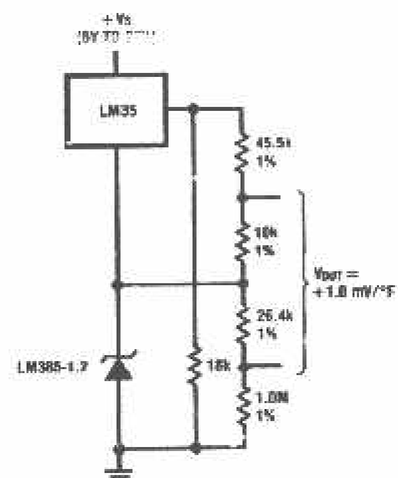

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FIGURE 10. Fahrenheit Thermometer

Typical Applications (Continued)

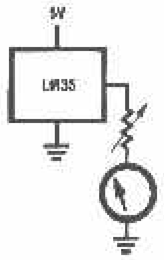

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FIGURE 11. Centigrade Thermometer (Analog Meter)

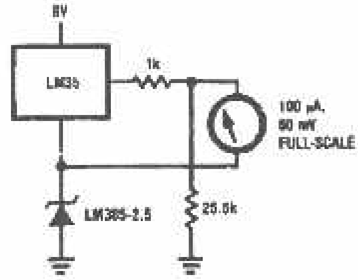

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FIGURE 12. Expanded Scale Thermometer (50° to 80° Fahrenheit, for Example Shown)

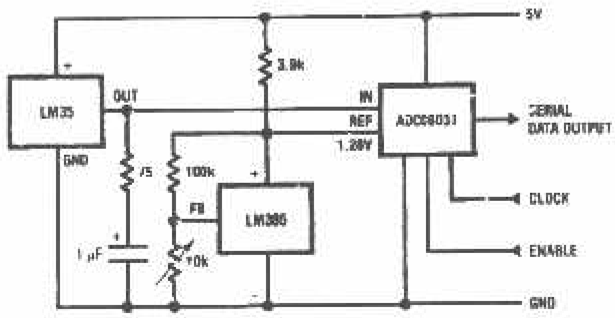

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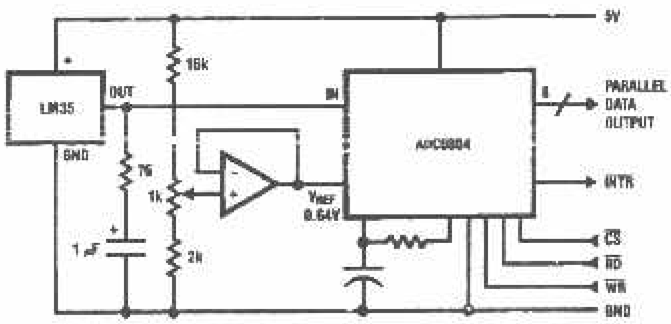
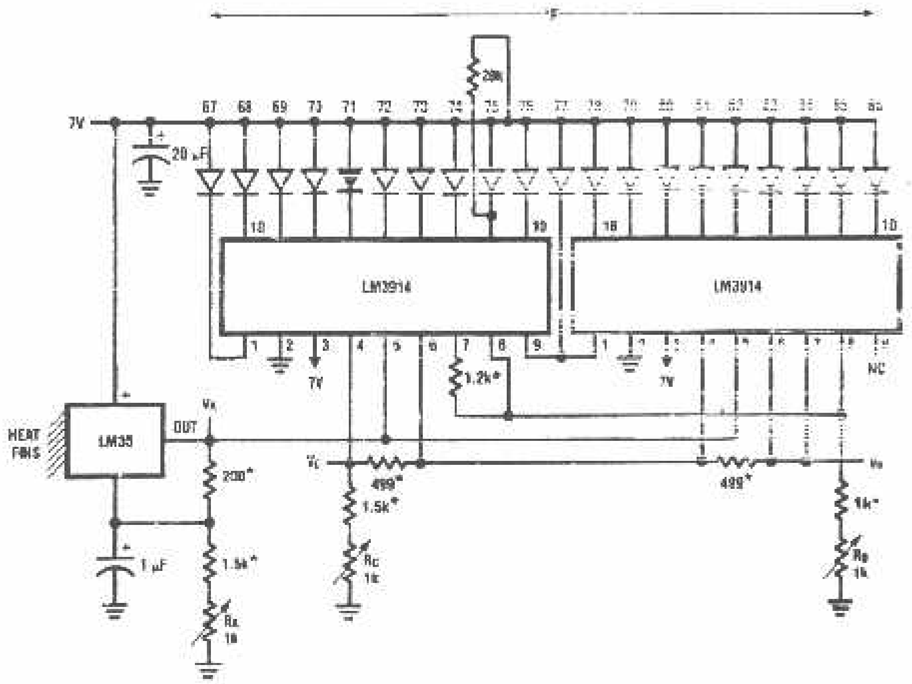
FIGURE 13. Temperature To Digital Converter (Serial Output) (+128°C Full Scale)



TL/H/5516-14

FIGURE 14. Temperature To Digital Converter (Parallel TRI-STATE® Outputs for Standard Data Bus to µP Interface) (128°C Full Scale)

Typical Applications (Continued)



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* = 1% or 2% film resistor
-Trim R_B for V_B = 3.075V
-Trim R_C for V_C = 1.955V
-Trim R_A for V_A = 0.075V + 100mV/°C × $T_{ambient}$
-Example, V = 2.275V at 22°C

FIGURE 15. Bar-Graph Temperature Display (Dot Mode)

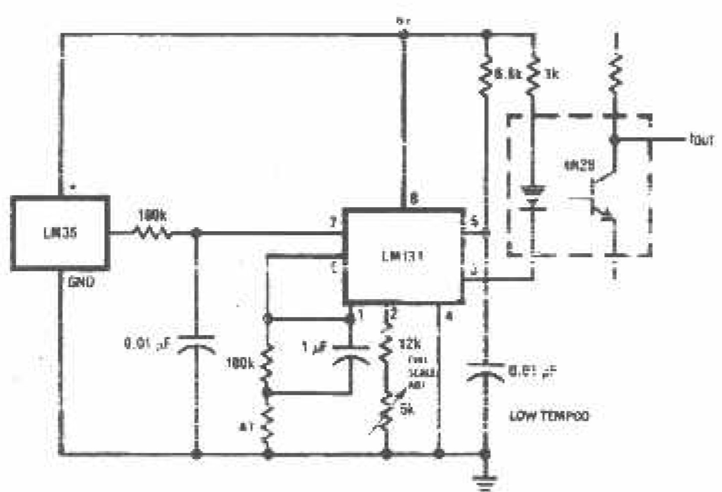

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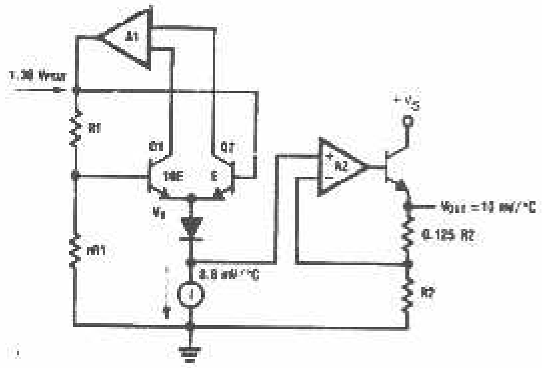
FIGURE 16. LM35 With Voltage-To-Frequency Converter And Isolated Output
(2°C to +150°C; 20 Hz to 1500 Hz)

Block Diagram



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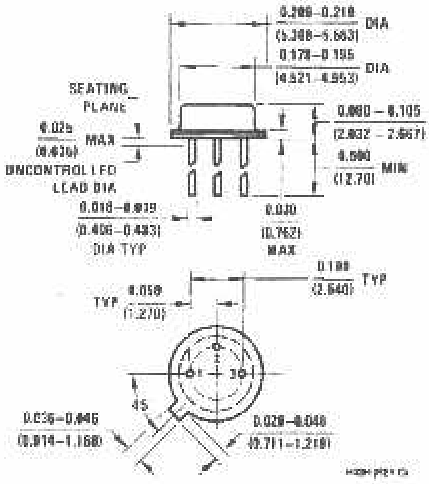
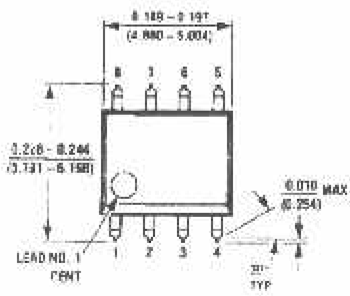
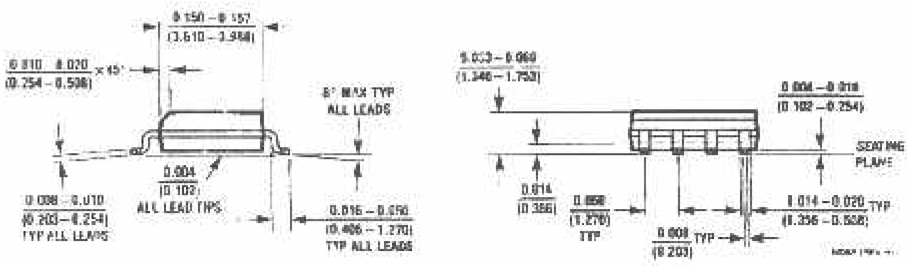
Physical Dimensions inches (millimeters)



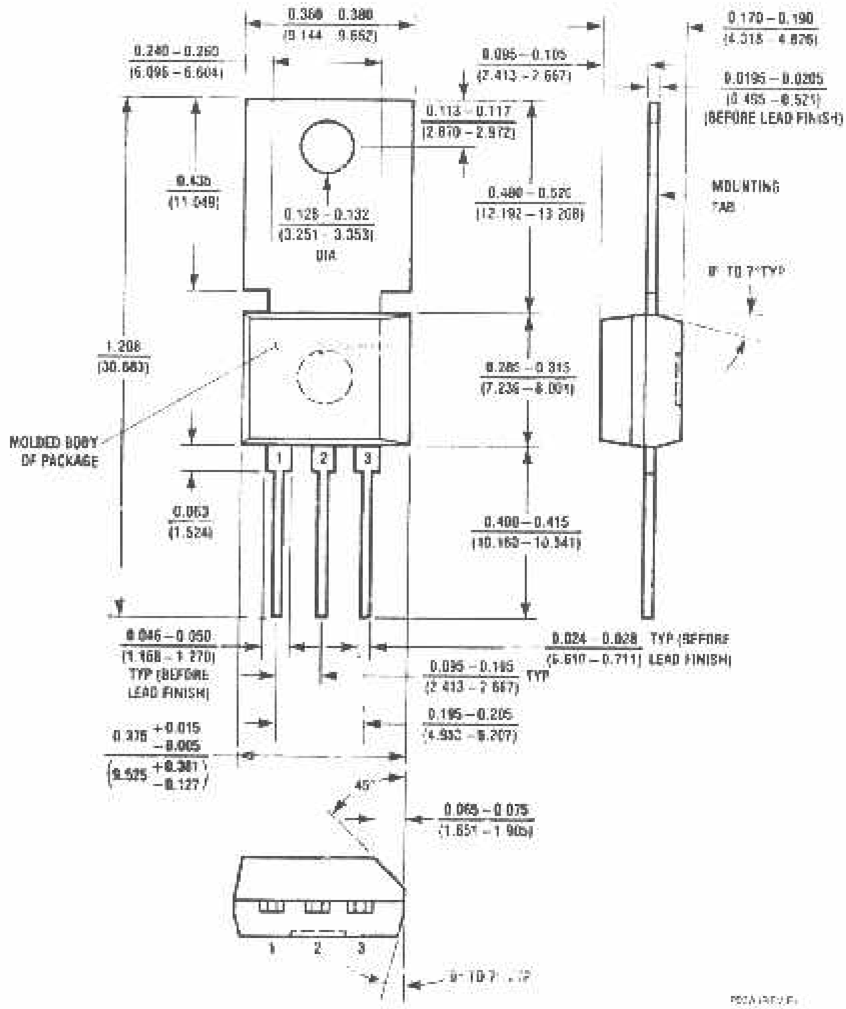
TO-46 Metal Can Package (H)
Order Number LM35H, LM35AH, LM35CH, LM35CAH, or LM35DH
NS Package Number H03H





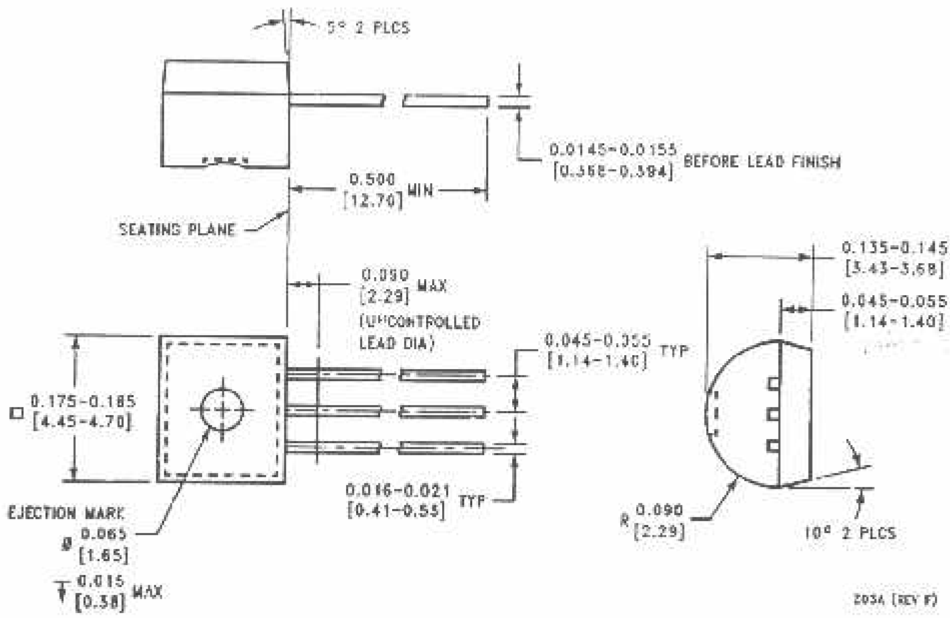
SO 8 Molded Small Outline Package (M)
Order Number LM35DM
NS Package Number M08A

Physical Dimensions inches (millimeters) (Continued)



Power Package TO-202 (P)
Order Number LM35DP
NS Package Number P03A

Physical Dimensions inches (millimeters) (Continued)



TO-92 Plastic Package (Z)
Order Number LM35CZ, LM35CAZ or LM35DZ
NS Package Number Z03A

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Photodiode/Phototransistor Application Circuit

FUNDAMENTAL PHOTODIODE CIRCUITS

Figures 1 and 2 show the fundamental photodiode circuits.

The circuit shown in Figure 1 transforms a photocurrent produced by a photodiode without bias into a voltage. The output voltage (V_{OUT}) is given as $V_{OUT} = I_P \times R_L$. It is more or less proportional to the amount of incident light when $V_{OUT} < V_{OC}$. It can also be compressed logarithmically relative to the amount of incident light when V_{OUT} is near V_{OC}. (V_{OC} is the open-terminal voltage of a photodiode).

Figure 1 (B) shows the operating point for a load resistor (R_L) without application of bias to the photodiode.

Figure 2 shows a circuit in which the photodiode is reverse-biased by V_{CC} and a photocurrent (I_P) is transformed into an output voltage. Also in this arrangement, the V_{OUT} is given as $V_{OUT} = I_P \times R_L$. An output voltage proportional to the amount of incident light is obtained. The proportional region is expanded by the amount of V_{CC} (proportional region: $V_{OUT} < (V_{OC} + V_{CC})$). On the other hand, application of reverse bias to the photodiode causes the dark current (I_d) to increase, leaving a voltage of $I_d \times R_L$ when the light is interrupted, and this point should be noted in designing the circuit.

Figure 2 (B) shows the operating point for a load resistor R_L with reverse bias applied to the photodiode.

Features of a circuit used with a reverse-biased photodiode are:

- High-speed response
- Wide-proportional-range of output

Therefore, this circuit is generally used.

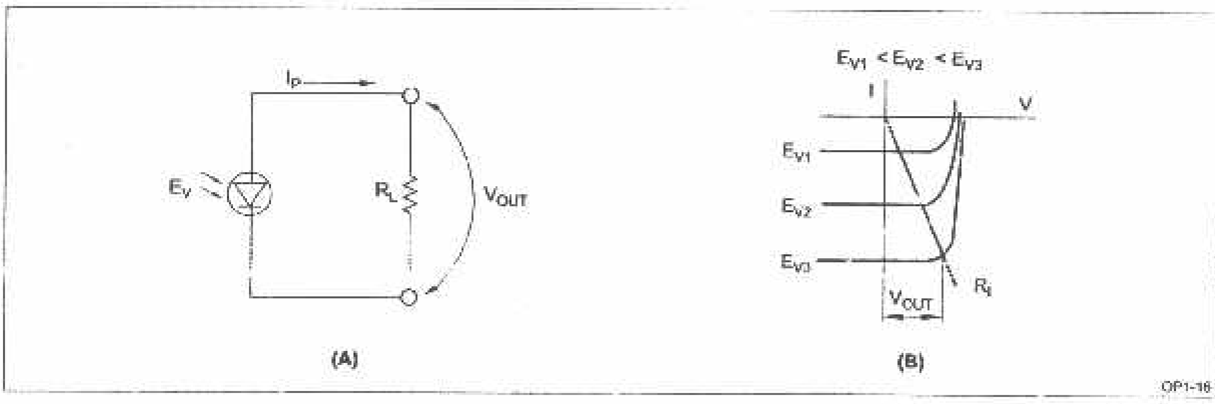

Figure 1. Fundamental Circuit of Photodiode (Without Bias)

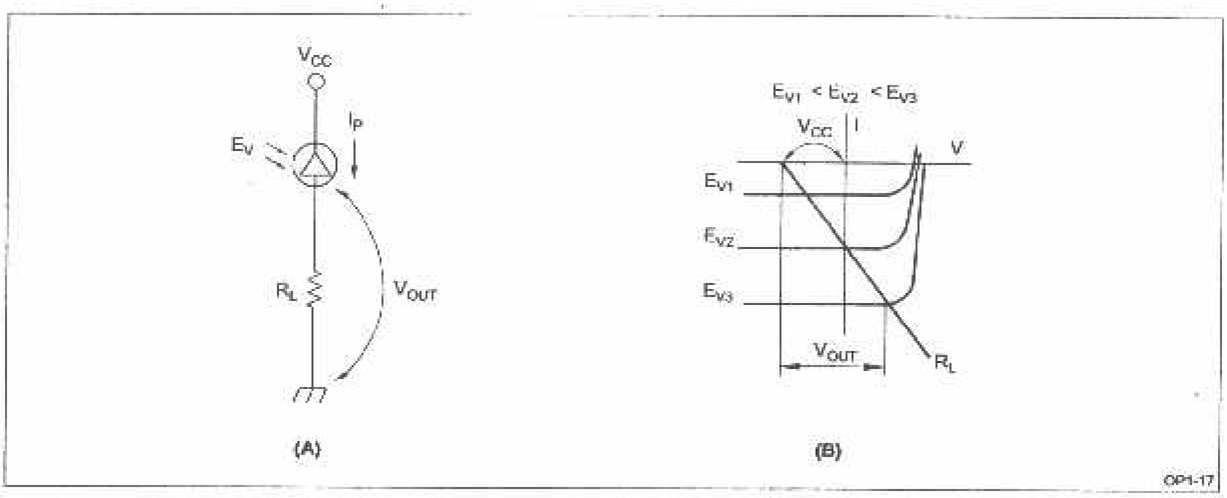

Figure 2. Fundamental Circuit of Photodiode (With Bias)

The response time is inversely proportional to the reverse bias voltage and is expressed as follows:

$r = C_j \times R_L$

$C_j = A(V_D - V_R) - \frac{1}{n}$

C_j: junction capacitance of the photodiode

R_L: load resistor

V_D: diffusion potential (0.5 V - 0.9 V)

V_R: Reverse bias voltage (negative value)

n: 2 - 3

'HOTOCURRENT AMPLIFIER CIRCUIT JSING THE TRANSISTOR OF 'HOTODIODE

Figures 3 and 4 show photocurrent amplifiers using 'ansistors.

The circuit shown in Figure 3 are most basic combina- ons of a photodiode and an amplifying transistor. In the rrangement of Figure 3 (A), the photocurrent produced y the photodiode causes the transistor (Tr_1) to decrease s output (V_{OUT}) from high to low. In the arrangement of igure 3 (B), the photocurrent causes the V_{OUT} to :crease from low to high. Resistor R_{BE} in the circuit is ffective for suppressing the influence of dard current (I_d) nd is chosen to meet the following conditions:

$R_{BE} < V_{BD}/I_d$

$R_{BE} > V_{BE}/\{I_P - V_{CC}/(R_L \times h_{FE})\}$

Figure 4 shows simple amplifiers utilizing negative 'edback.

In the circuit of Figure 4 (A), the output (V_{OUT}) is given as:

$V_{OUT} = I_P \times R_1 + I_B \times R_1 + V_{BE}$

This arrangement provides a large output and relatively fast response.

The circuit of Figure 4 (B) has an additional transistor (Tr_2) to provide a larger output current.

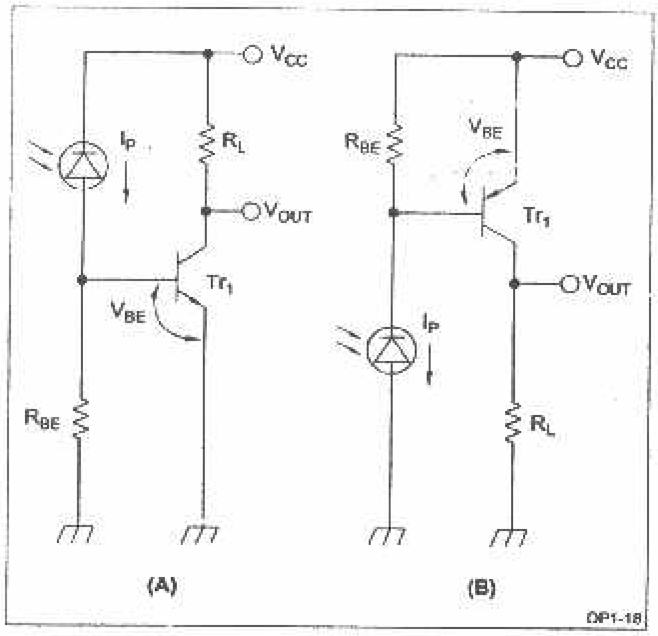

Figure 3. Photocurrent Amplifier Circuit using Transistor

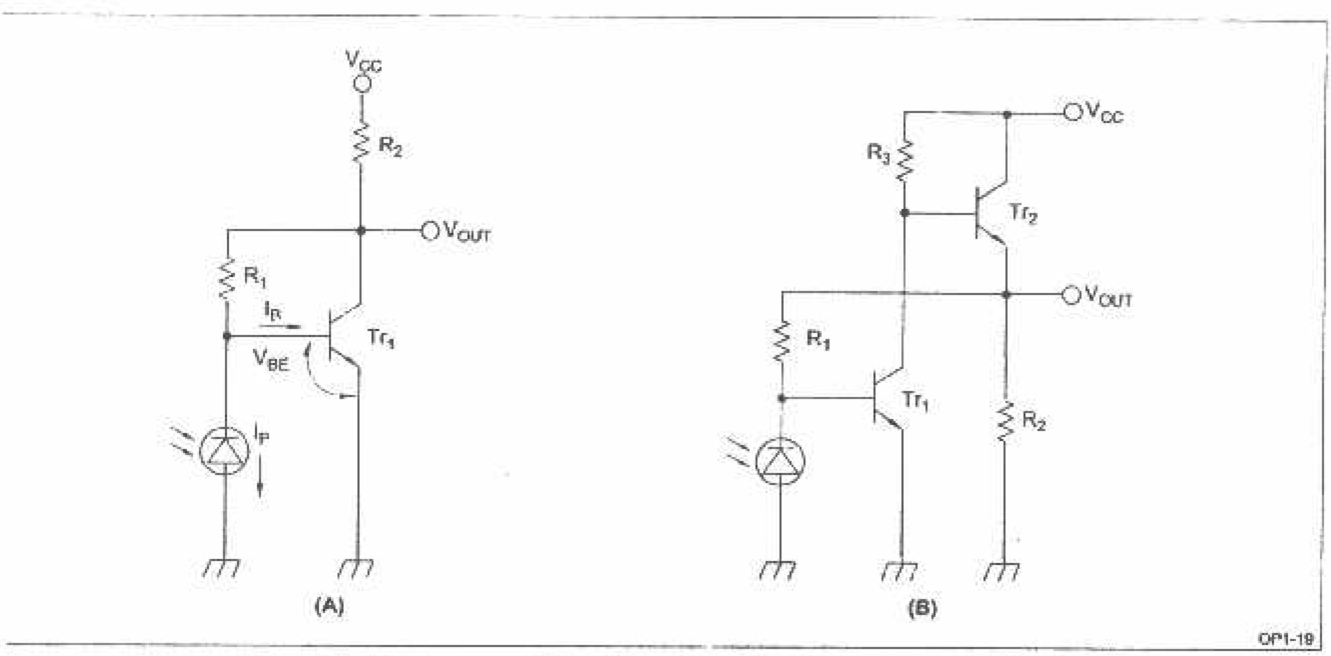

Figure 4. Photocurrent Amplifier Circuit with Negative Feedback

AMPLIFIER CIRCUIT USING OPERATIONAL AMPLIFIER

Figure 6 shows a photocurrent-voltage conversion circuit using an operational amplifier. The output voltage (V_{OUT}) is given as $V_{OUT} = I_F \times R_1$ ($I_P \equiv I_{SC}$). The arrangement utilizes the characteristics of an operational amplifier with two input terminals at about zero voltage to operate the photodiode without bias. The circuit provides an ideal short-circuit current (I_{SC}) in a wide operating range.

Figure 6 (B) shows the output voltage vs. radiant intensity characteristics. An arrangement with no bias and high impedance loading to the photodiode provides the following features:

Less influence by dark current

Wide linear range of the photocurrent relative to the radiant intensity.

Figure 5 shows a logarithmic photocurrent amplifier using an operating amplifier. The circuit uses a logarithmic diode for the logarithmic conversion of photocurrent into an output voltage. In dealing with a very wide radiation intensity range, linear amplification results in a saturation of output because of the limited linear region of the operational amplifier, whereas logarithmic compression of the photocurrent prevents the saturation of output. With its wide measurement range, the logarithmic photocurrent amplifier is used for the exposure meter of cameras.

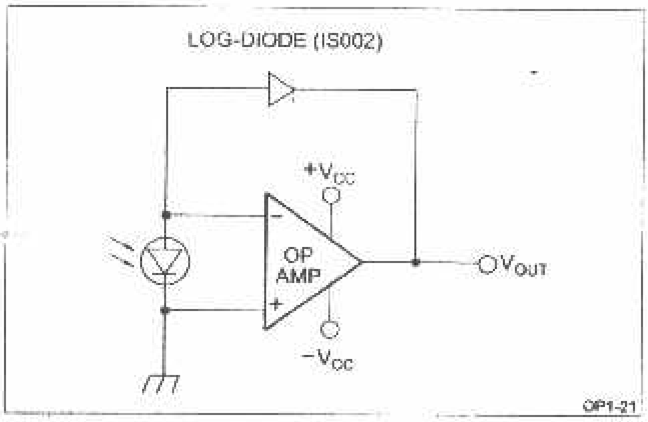

Figure 5. Logarithmic Photocurrent Amplifier using an Operational Amplifier

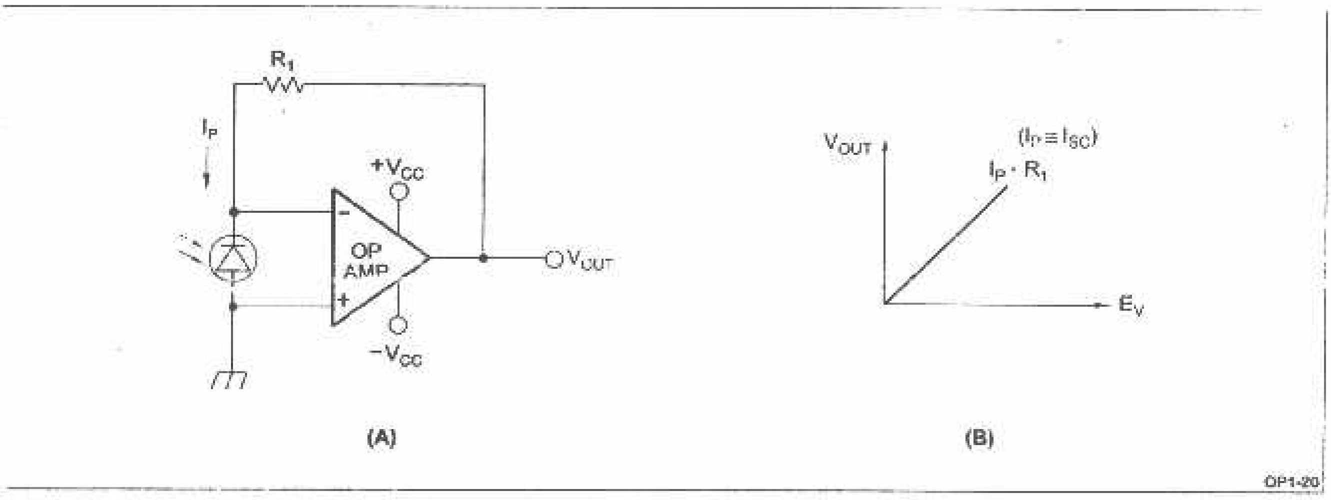

Figure 6. Photocurrent Amplifier using an Operational Amplifier (Without Bias)

LIGHT DETECTING CIRCUIT FOR MODULATED LIGHT INPUT

Figure 7 shows a light detecting circuit which uses an optical remote control to operate a television set, air conditioner, or other devices. Usually, the optical remote control is used in the sunlight or the illumination of a fluorescent lamp. To alleviate the influence of such a disturbing light, the circuit deals with pulse-modulation signals.

The circuit shown in Figure 7 detects the light input by differentiating the rising and falling edges of a pulse signal. To amplify a very small input signal, an FET providing a high input impedance is used.

COLOR SENSOR AMPLIFIER CIRCUIT

Figure 8 shows a color sensor amplifier using a semiconductor color sensor. Two short circuit currents (I_{SC1}, I_{SC2}) conducted by two photodiodes having different spectral sensitivities are compressed logarithmically and applied to a subtraction circuit which produces a differential output (V_{OUT}). The output voltage (V_{OUT}) is formulated as follows:

$$V_{OUT} = \frac{kT}{q} \times \log\left(\frac{I_{SC2}}{I_{SC1}}\right) \times A$$

Where A is the gain of the differential amplifier. The gain becomes $A = R_2/R_1$ when $R_1 = R_3$ and $R_2 = R_4$, then:

$$V_{OUT} = \frac{kT}{q} \times \log\left(\frac{I_{SC2}}{I_{SC1}}\right) \times \frac{R_2}{R_1}$$

The output signal of the semiconductor color sensor is extremely low level. Therefore, great care must be taken in dealing with the signal. For example, low-biased, low-drift operational amplifiers must be used, and possible current leaks of the surface of P.W.B. must be taken into account.

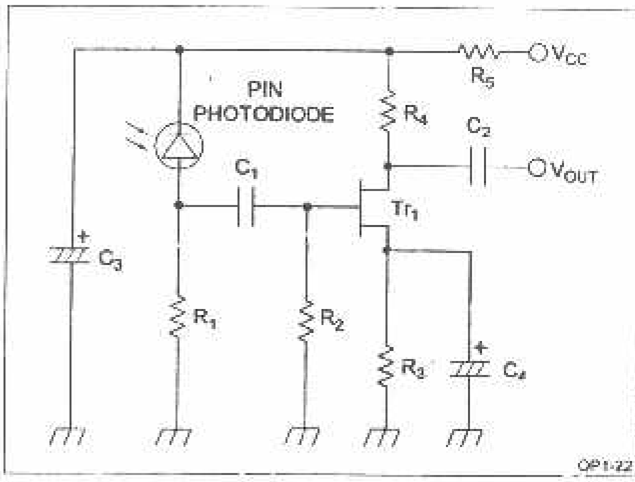

Figure 7. Light Detecting Circuit for Modulated Light Input PIN Photodiode

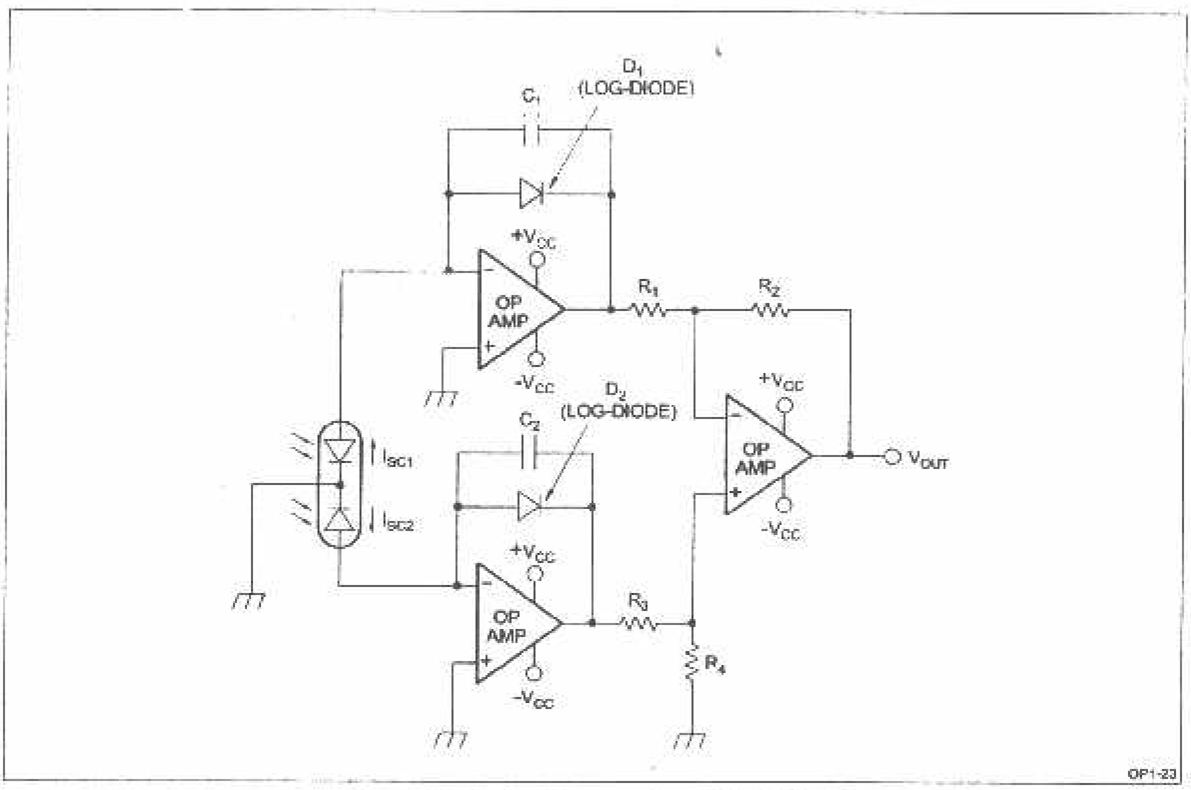

Figure 8. Color Sensor Amplifier Circuit

FUNDAMENTAL PHOTOTRANSISTOR CIRCUITS

Figures 9 and 10 show the fundamental phototransistor circuits. The circuit shown in Figure 9 (A) is a common-emitter amplifier. Light input at the base causes the output (V_{OUT}) to decrease from high to low. The circuit shown in Figure 9 (B) is a common-collector amplifier with an output (V_{OUT}) increasing from low to high in response to light input. For the circuits in Figure 9 to operate in the switching mode, the load resistor (R_L) should be set in relation with the collector current (I_C) as $V_{CC} < R_L \times I_C$.

The circuit shown Figure 10 (A) uses a phototransistor with a base terminal. A R_{BE} resistor connected between the base and emitter alleviates the influence of a dark current when operating at a high temperature. The circuit shown in Figure 10 (B) features a cascade connection of the grounded-base transistor (Tr_1) so that the phototransistor is virtually less loaded, thereby improving the response.

AMPLIFIER CIRCUIT USING TRANSISTOR

Figure 11 shows the transistor amplifiers used to amplify the collector current of the phototransistor using a transistor (Tr_1). The circuit in Figure 11 (A) increases the output from high to low in response to a light input. The value of resistor R_1 depends on the input light intensity, ambient temperature, response speed, etc., to meet the following conditions:

$R_1 < V_{BE}/I_{CEO}, R_1 > V_{BE}/I_C$

Where I_{CBO} is the dark current of phototransistor and I_C is the collector current.

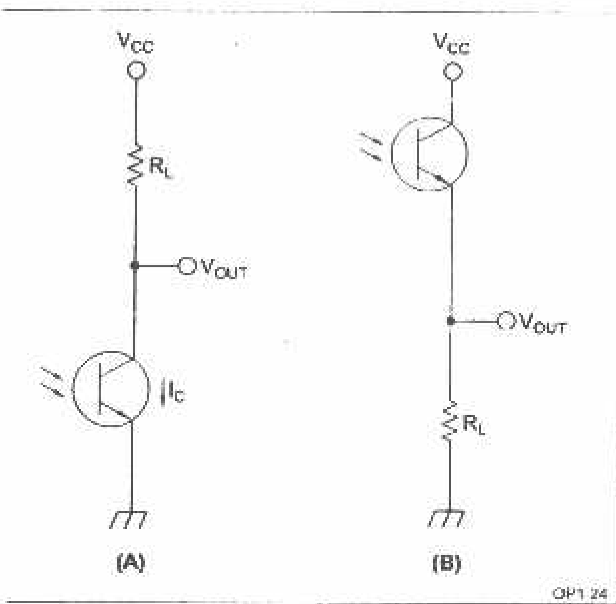

Figure 9. Fundamental Phototransistor Circuit (I)

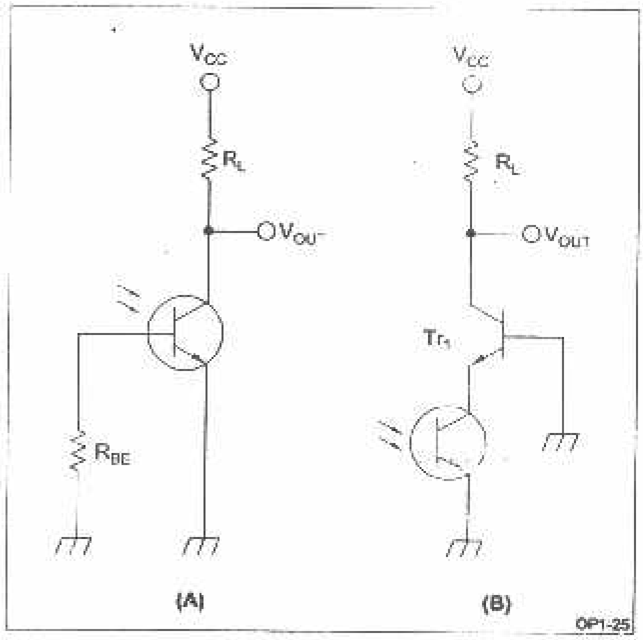

Figure 10. Fundamental Phototransistor Circuit (II)

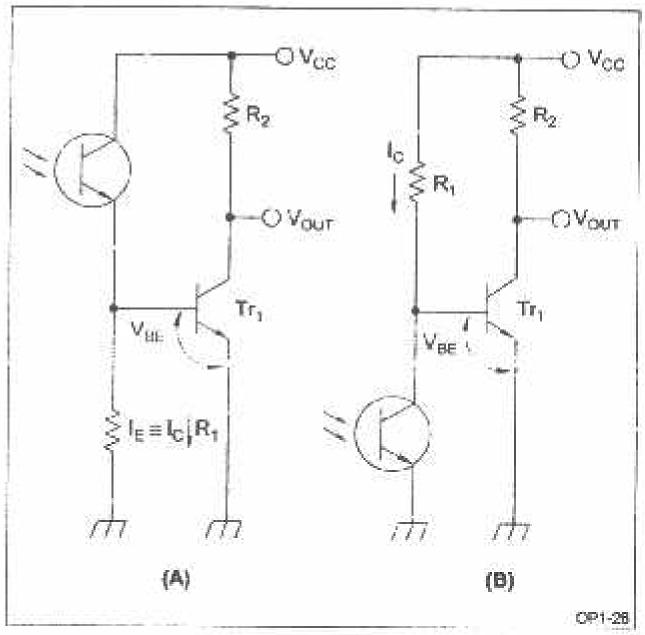

Figure 11. Amplifier Circuit using Transistor

MODULATED SIGNAL DETECTION CIRCUIT

Figure 12 shows the circuits used to detect a modulated signal such as an AC or pulse signal. The phototransistor has a base terminal with a fixed bias through resistors R_1 and R_2. An R_4 emitter resistor maintains the DC output voltage constant. A modulated signal provides a base current through bypass capacitor C causing current amplification so that the signal is greatly amplified.

AMPLIFIER CIRCUIT USING OPERATIONAL AMPLIFIER

Figure 13 shows a current-voltage conversion circuit using an operational amplifier. Its output voltage (V_{OUT}) is expressed as $V_{OUT} = I_C \times R_1$.

The current-voltage conversion circuit for the phototransistor is basically identical to that of the photodiode, except that the phototransistor requires a bias. The circuit shown if Figure 13 (A) has a negative bias (-V) for the emitter against the virtually grounded collector potential. Figure 13 (B) shows the output voltage vs. irradiation intensity characteristics.

AUTO-STROBOSCOPE CIRCUIT

Figure 14 shows the auto-stroboscope circuit of the current cut type. This circuit is most frequently used because of advantages such as continuous light emission and lower battery power consumption.

When the switch is in the ON-state, the SCR_2 and SCR_3 turn on to discharge capacitor C_4 so that the xenon lamp is energized to emit light. The anode of the SCR_2 is then reverse-biased, causing it to turn off and light emission of the xenon lamp ceases. The irradiation time is set automatically in response to variations in the collector current of the phototransistor. This follows the intensity of reflected light from the object and the value of C_1 in the circuit. In other words, the irradiation time is long for a distant object, and short for a near object.

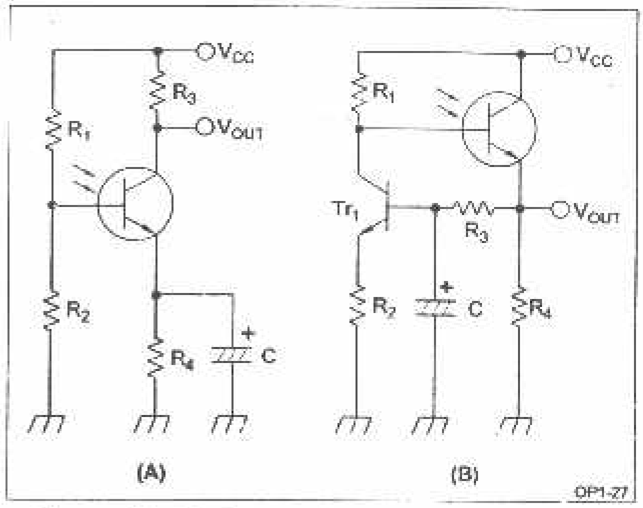

Figure 12. Modulated Signal Detection Circuit

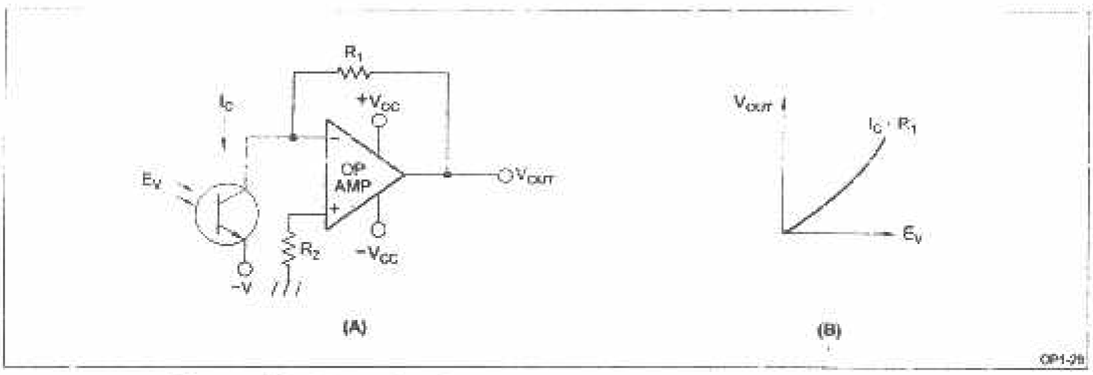

Figure 13. Amplifier Circuit using an Operational Amplifier

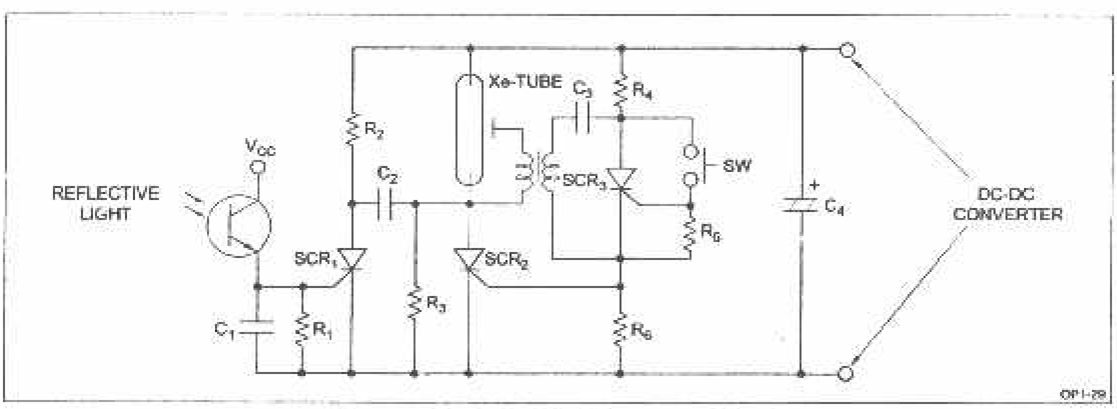

Figure 14. Auto-Stroboscope Circuit

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'Infrared' Light-Emitting Diode Application Circuit

SERIAL CONNECTION AND PARALLEL CONNECTION

Figure 1 shows the most basic and commonly used circuits for driving light-emitting diodes.

In Figure 1(A), a constant voltage source (V_{CC}) is connected through a current limiting resistor (R) to an LED so that it is supplied with forward current (I_F). The I_F current flowing through the LED is expressed as $I_F = (V_{CC} - V_F)/R$, providing a radiant flux proportional to the I_F. The forward voltage (V_F) of the LED is dependent on the value of I_F, but it is approximated by a constant voltage when setting R.

Figures 1(B) and 1(C) show the circuits for driving LEDs in serial connection and parallel connection, respectively. In arrangement (B), the current flowing through the LED is expressed as $I_F = (V_{CC} - V_F \times N)/R$, while in arrangement (C), the current flowing through each LED is expressed as $I_F = (V_{CC} - V_F)/R$ and the total supply current is $N \times I_F$, where N is the number of LEDs.

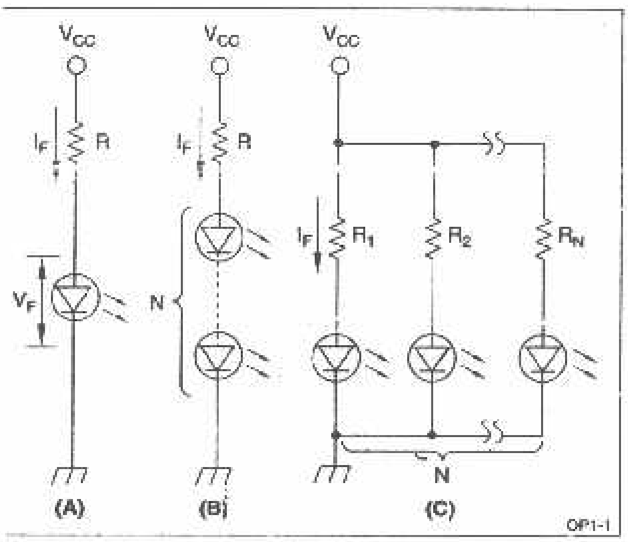


Figure 1. Driving Circuit of Light-Emitting Diode (LED)

The V_F of an LED has a temperature dependency of approximately -1.9 mV/°C. The operating point for the load R varies in response to the ambient temperature as shown in Figure 2.

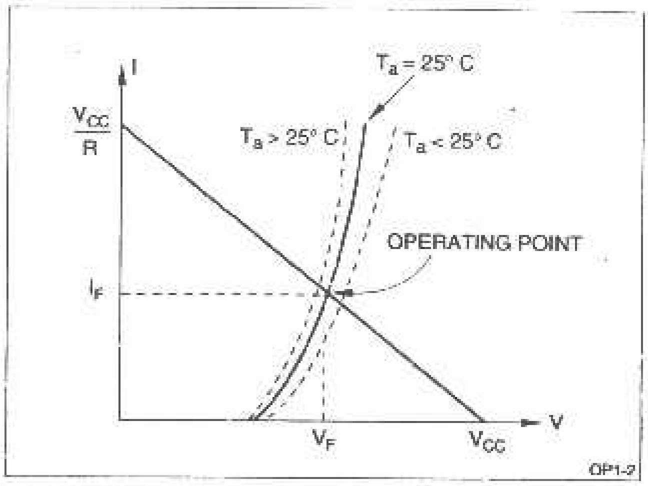


Figure 2. Current versus Voltage of Light-Emitting Diode (LED)

CONSTANT CURRENT DRIVE

To stabilize the radiant flux of the LED, the forward current (I_F) must be stabilized by using a constant current source. Figure 3 shows a circuit for constantly driving several LEDs using a transistor.

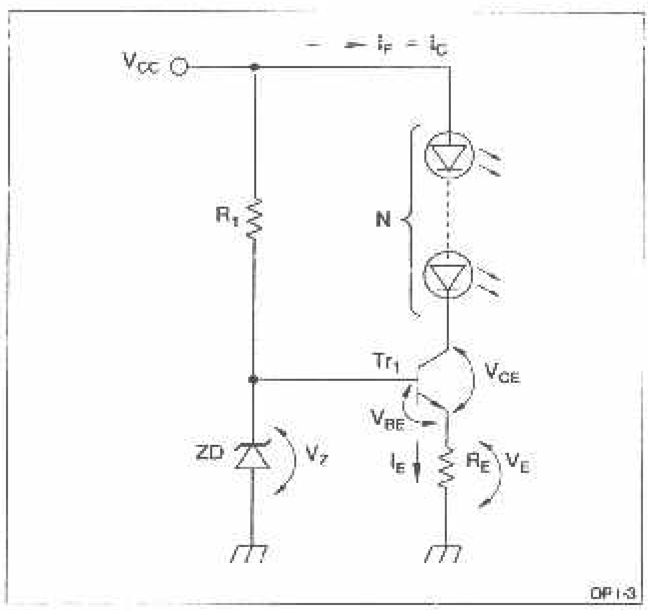


Figure 3. Constant Current Driving Circuit (1)

The transistor (Tr_1) is biased by a constant voltage ;upplied by a zener diode (ZD) so that the voltage across he emitter follower loaded by resistor R_E is constant, hereby making the collector current ($I_C = I_F$) constant. 'he I_C is given as $I_C = I_E = (V_Z = V_{BE})/R_E$. If too many .EDs are connected, the transistor enters the saturation egion and does not operate as a constant current circuit. 'he number of LEDs (N) which can be connected in eries is calculated by the following equations.

$V_{CC} - N \times V_F - V_E > V_{CE}$ (sat)

$V_E = V_Z - V_{BE}$

These equations give:

$N < (V_{CC} - V_Z + V_{BE} - V_{CE}(sat))/V_F$

Figures 4 and 5 show other constant current driving ircuits that use diodes or transistors, instead of zener iodes.

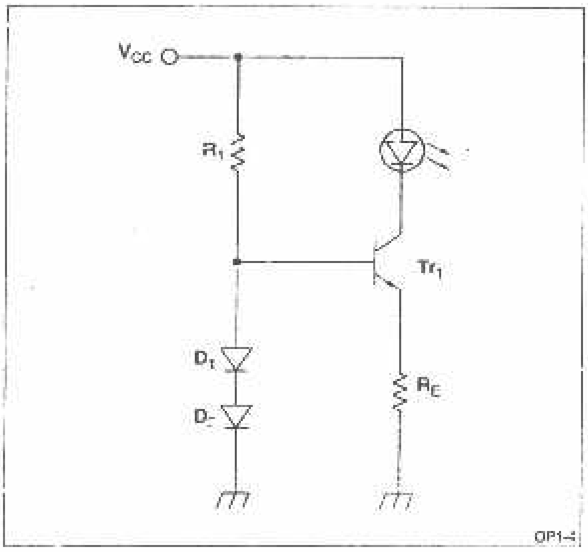


Figure 4. Constant Current Driving Circuit (2)

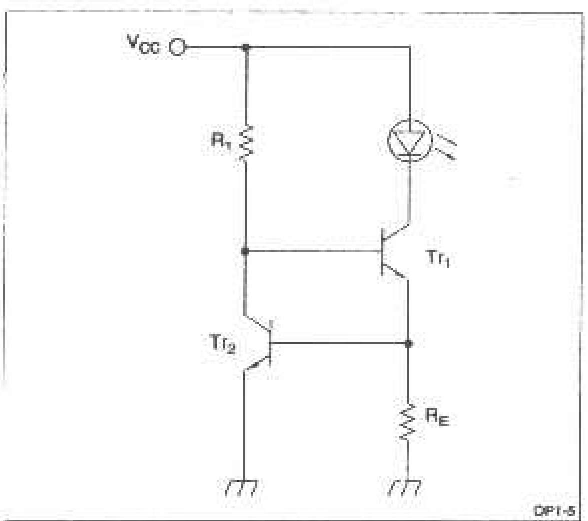


Figure 5. Constant Current Driving Circuit (3)

DRIVING CIRCUIT ACTIVATED BY A LOGIC IC

Figures 6 and 7 show LED driving circuits that operate in response to digital signals provided by TTL or CMOS circuits.

Figure 8 shows a driving circuit connected with a high level logic circuit.

In Figure 6, a high input signal V_{IN} from a TTL circuit makes the NPN transistor (Tr_1) conductive so that the forward current (I_F) flows through the LED. Accordingly, this circuit operates in the positive logic mode, in which a high input activates the LED.

In Figure 7, a low input signal V_{IN} from a TTL circuit makes the PNP transistor (Tr_1) conductive so that the forward current flows through the LED. This circuit operates in the negative logic mode, in which a low input activates the LED.

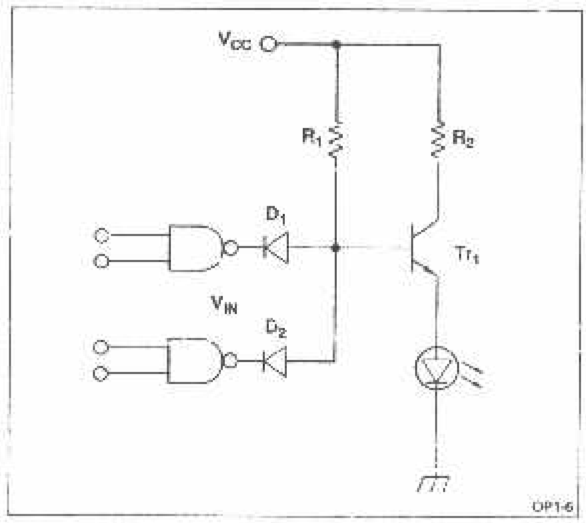


Figure 6. Connection with the TTL Logic Circuit (2)

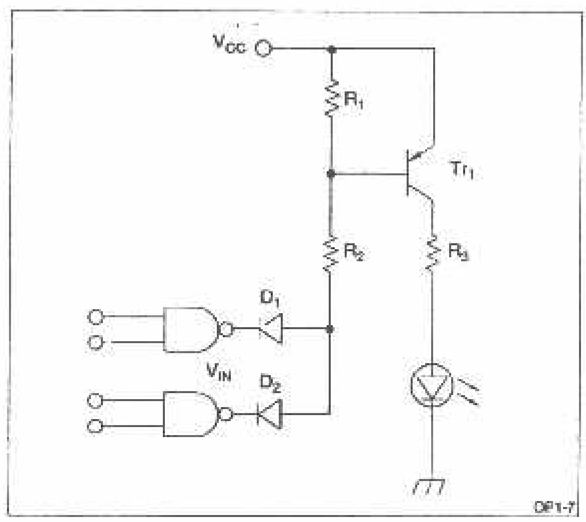


Figure 7. Connection with the TTL Logic Circuit (2)

In Figure 8, the circuit operates in the positive logic mode, and current I_F is stabilized by constant current driving so that the radiant flux of LED is stabilized against variations in the supply voltage (V_{CC}).

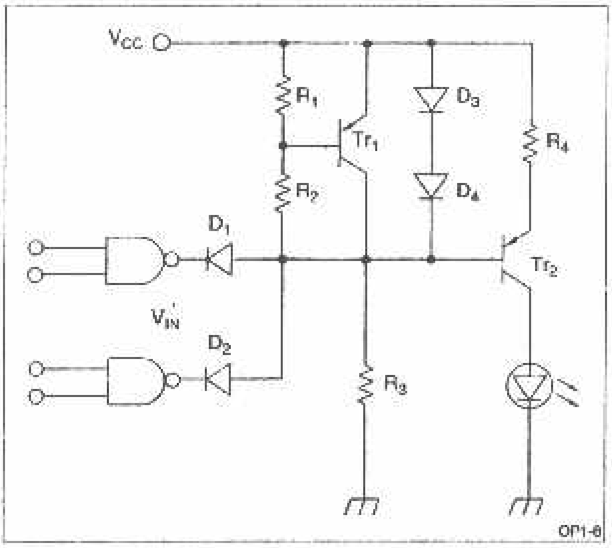


Figure 8. Connection with the TTL Logic Circuit (3)

DRIVING CIRCUIT WITH AN AC SIGNAL

Figure 9 (A) shows a circuit in which an AC power source supplies the forward current (I_{F1}) to an LED. A diode (D_1) in inverse parallel connection with the LED protects the LED against reverse voltage, suppressing the reverse voltage applied to the LED lower than V_{F2} by using a reverse voltage protection diode of an LED. The LED provides a radiant flux proportional to the applied AC current, (emitting only in half wave).

Figure 9 (B) shows the driving waveform of the AC power source.

Figure 10 (A) shows a driving circuit which modulates the radiant flux of LED in response to a sine wave or modulation signal. Figure 10 (B) shows modulation operation.

If an LED and light detector are used together in an environment of high intensity disturbing light, it is difficult for the light detector to detect the optical signal. In this case, modulating the LED drive signal alleviates the influence of disturbing light and facilitates signal detection.

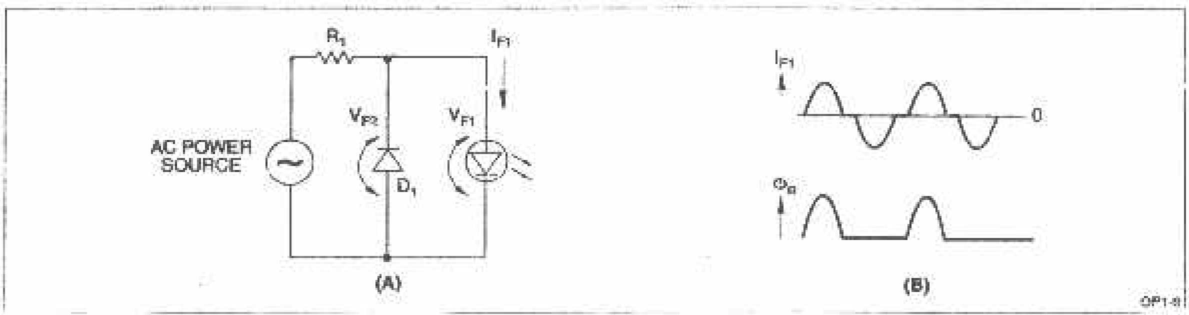


Figure 9. Driving Circuit with AC Power Source (A) and Driving Waveform (B)

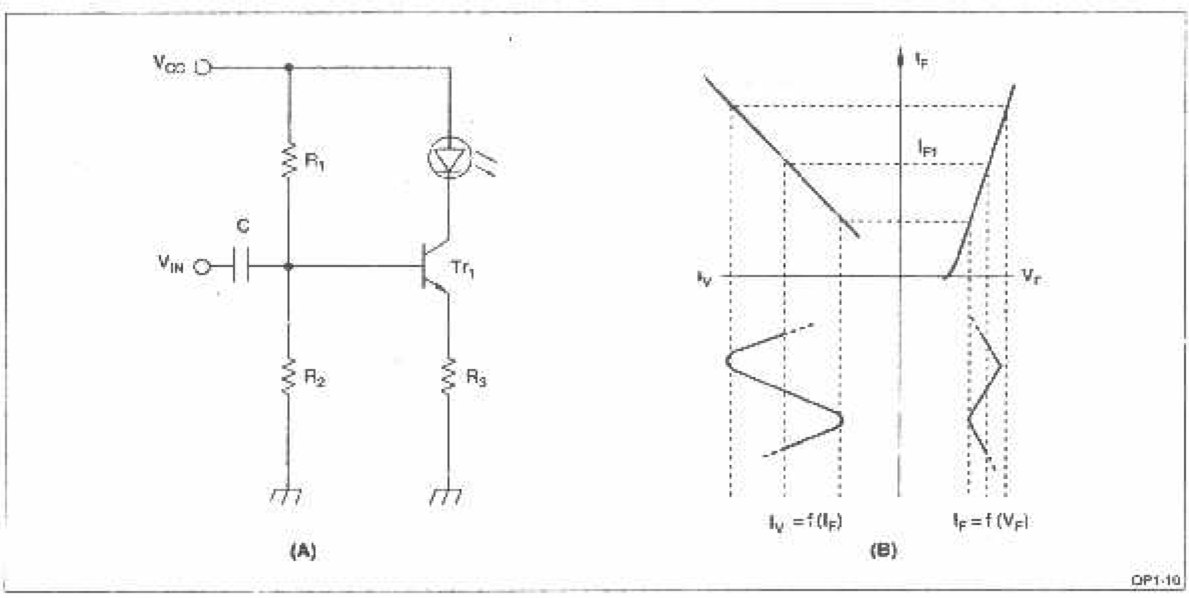


Figure 10. Modulation Driving Circuit (A) and Modulation Operation (B)

To drive an LED with a continuous modulation signal, it is necessary to operate the LED in the linear region of the light-emitting characteristics. In the arrangement of Figure 10, a fixed bias (I_{F1}) is applied to the LED using R_1 and R_2 so that the maximum amplitude of the modulation signal voltage (V_{IN}) lies within the linear portion of the LED characteristics. Moreover, to stabilize the radiant flux of the LED, it is driven by a constant current by the constant current driving circuit shown in Figure 3. The capacitor (C) used in Figure 10 (A) is a DC signal blocking capacitor.

PULSE DRIVING

LED driving systems fall into three categories: DC driving system, AC driving system (including modulation systems), and pulse driving system.

Features of the Pulse Driving System

- Large radiant flux
- Less influence of disturbing light
- Information transmission

The radiant flux of the LED is proportional to its forward current (I_F), but in reality a large I_F heats up the LED by itself, causing the light-emitting efficiency to fall and thus saturating the radiant flux. In this circumstance, a relatively large I_F can be used with no risk of heating through the pulse drive of the LED. Consequently, a large radiant flux can be obtained.

When an LED is used in the outdoors where disturbing light is intense, the DC driving system or AC driving system which superimposes an AC signal on a fixed bias current provides low radiant flux, making it difficult to distinguish the signal (irradiation of LED) from disturbing light. In other words, the S/N ratio is small enough to reliably detect the signal. The pulse driving system provides high radiant flux and allows the detection of signal variations at the rising and falling edges of pulses, thereby enabling the use of LED-light detector where disturbing light is intense.

Transmission of information is possible by variations in pulse width or counting of the number of pulse used to encode the LED emission.

Figures 11 through 14 show typical pulse driving circuits. Figure 15 shows the pulse driving circuit used in the optical remote control. The circuit shown in Figure 11 uses an N-gate thyristor with voltage between the anode and cathode oscillated at a certain interval determined by the time constant of C × R so that the LED emits light pulse. To turn off the N-gate thyristor, resistor R_3 must be used so that the anode current is smaller than the holding current (I_H), i.e., $I_H > V_{CC}/R_3$. Therefore, R_3 has a large value, resulting in a large time constant ($\tau \pm C \times R_3$) and the circuit operates for a relatively long period to provide short pulse widths. The circuit shown in Figure 12 uses a type 555 timer IC to form an astable multi-vibrator to produce light pulses on the LED. The off-period (t_1) and the on-period (t_2) of the LED are calculated by the following equations.

$$t_1 = 1n2 \times (R_1 + R_2) \times C_1$$

$$t_2 = 1n2 \times R_2 \times C_1$$

The value of R1 is determined so that the rating of I_{IN} of a 555 timer IC is not exceeded, i.e. $S_1 > V_{CC}/I_{IN}$.

This pulse driving circuit uses a 555 timer IC to provide wide variable range in the oscillation period and light-on time. It is used extensively.

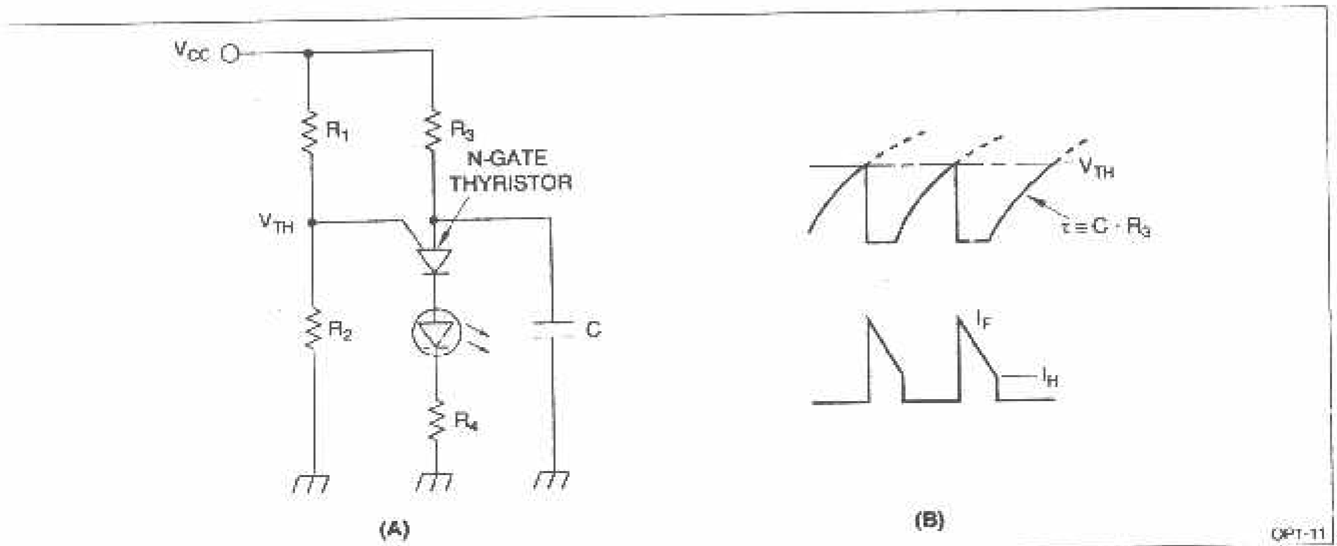


Figure 11. Pulse Driving Circuit using N-Gate Thyristor (A) and Operating Waveform (B)

The circuit shown in Figure 13 uses transistors to rm an astable multi-vibrator for pulse driving an LED. ıe off-period (t_1) of the LED is given by $C_1 \times R_1$, while its on-period (t_2) is given by $C_2 \times R_2$. For oscillation of this circuit, resistors must be chosen so that the R_1/R_3 and R_2/R_5 ratios are large.

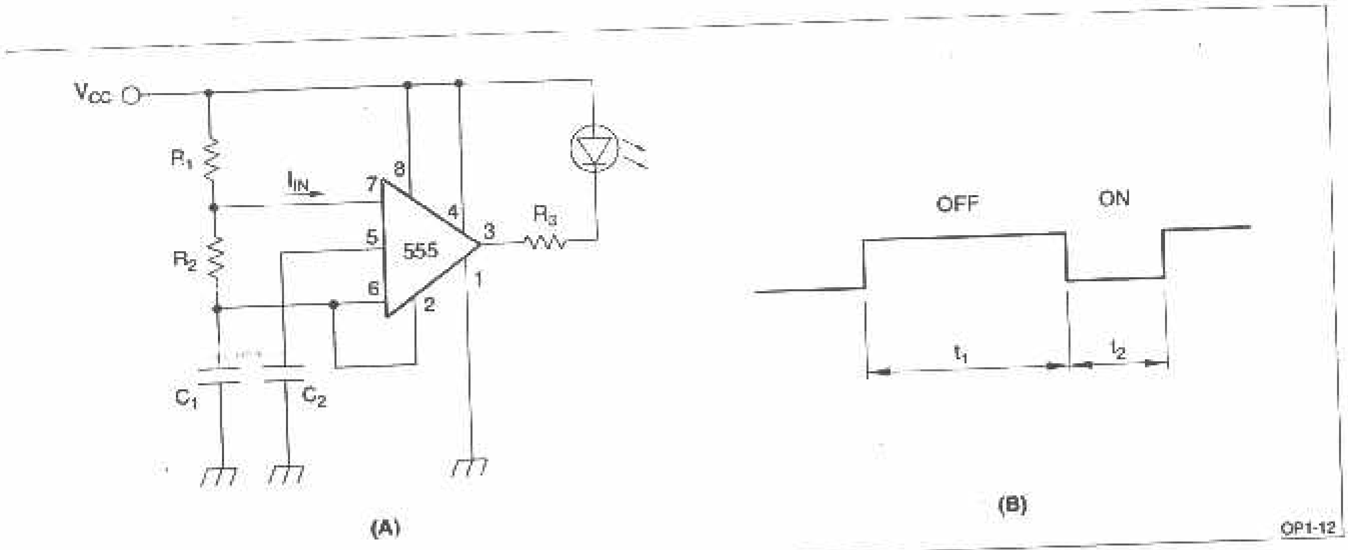


Figure 12. Pulse Driving using a 555 Timer IC (A) and Output Waveform (B)

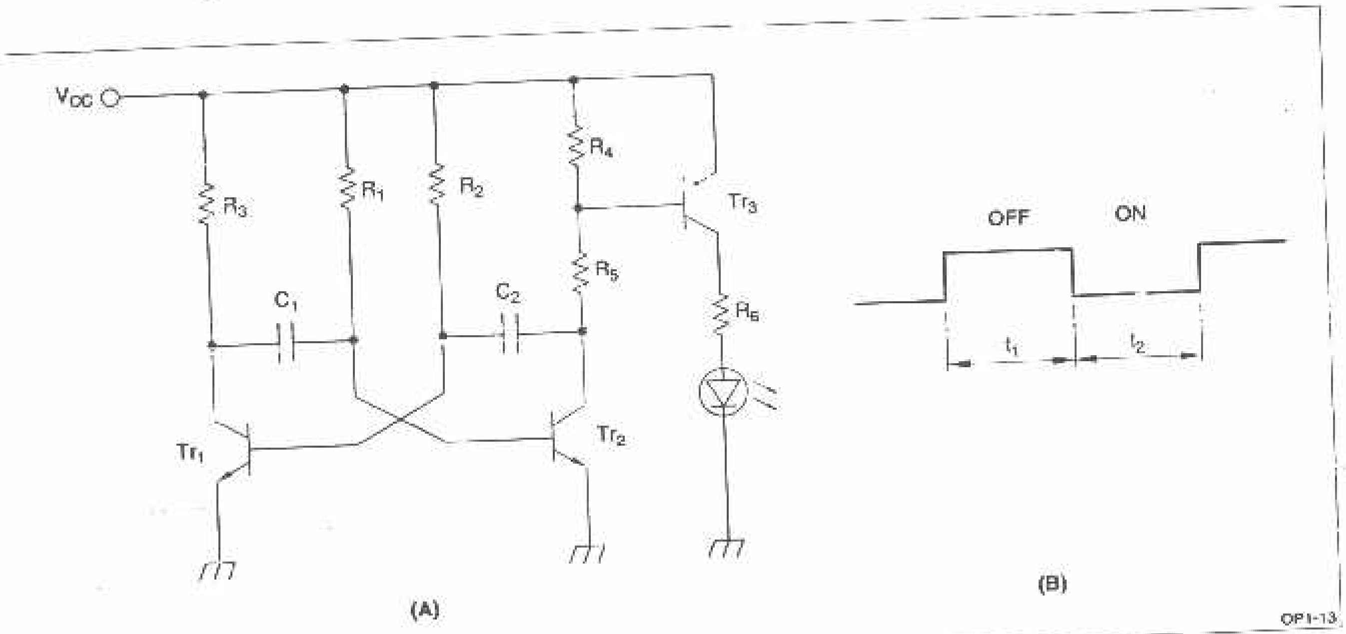


Figure 13. Pulse Driving Circuit using Astable Multi-vibrator (A) and Output Waveform (B)

The circuit shown in Figure 14 uses a CMOS logic IC (inverter) to form an oscillation circuit for pulse driving an LED. The pulse driving circuit using a logic IC provides a relatively short oscillation period with a 50% duty cycle.

Figure 15 (A) shows an LED pulse driving circuit used for the light projector of the optical remote control and optoelectronic switch. The circuit is arranged by combining two different oscillation circuits i.e., a long period oscillation (f_1) superimposed with a short period oscillation (f_2) as shown in Figure 15 (B). Frequencies f_1 and f_2 can be set independently.

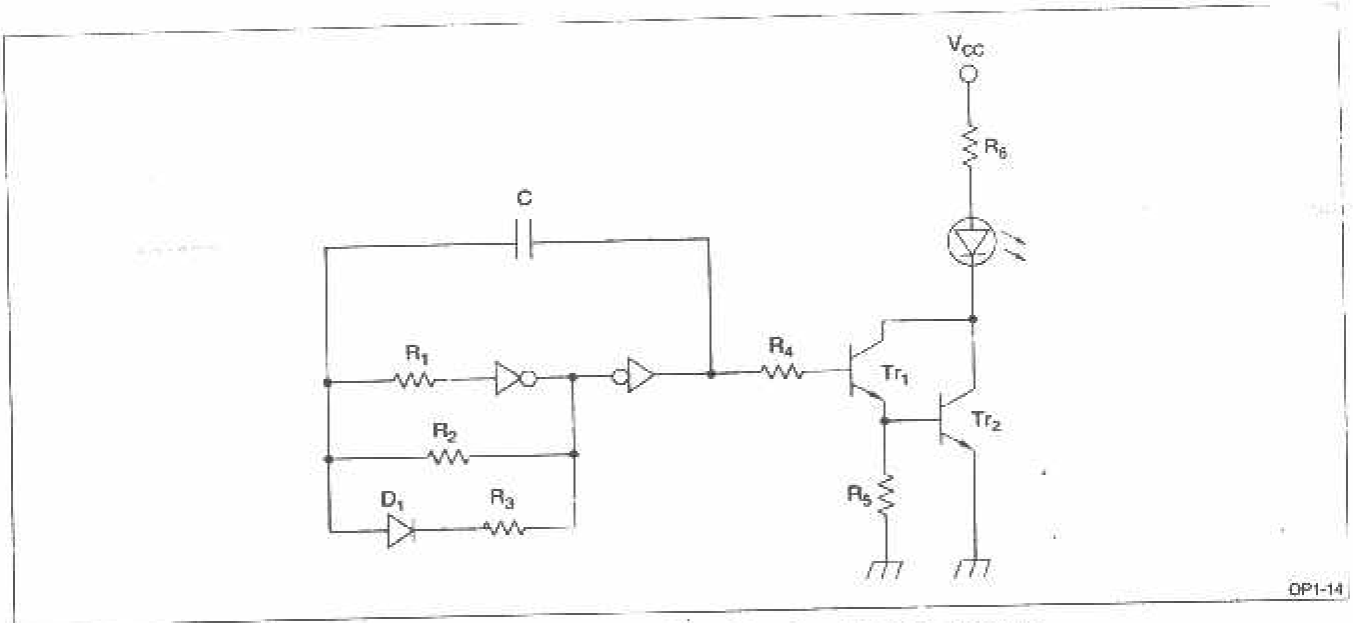


Figure 14. Pulse Driving Circuit using CMOS Logic IC

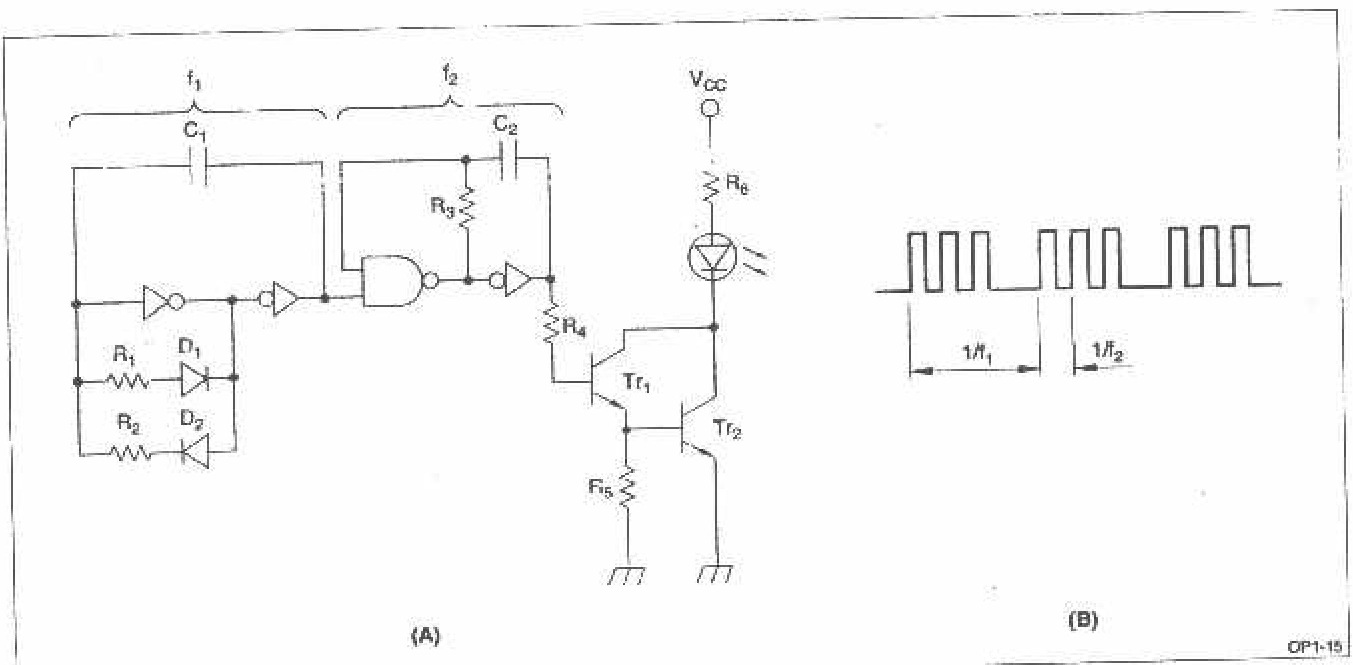


Figure 15. Pulse Driving Circuit (A) and Output Waveform (B)

INFORMATION STORAGE DEVICES

ISD2500 Series

Single-Chip Voice Record/Playback Devices 45-, 60-, 75-, and 90-Second Durations

IERAL DESCRIPTION

·mation Storage Devices' ISD2500 Series provides -quality, single-chip record/playback solutions for o 90-second messaging applications. The CMOS ces include an on-chip oscillator, microphone nplifier, automatic gain control, antialiasing filter, othing filter, and speaker amplifier. In addition, the 500 is fully microprocessor-compatible, allowing plex messaging and addressing to be achieved.

rdings are stored in on-board non-volatile ory cells, providing zero-power message storage. unique solution is made possible through ISD's ted Direct Analog Storage Technology (DAST™), eby voice and audio signals are stored directly, in natural analog form, into memory. Direct analog ge allows natural voice reproduction in a single- solid-state solution.

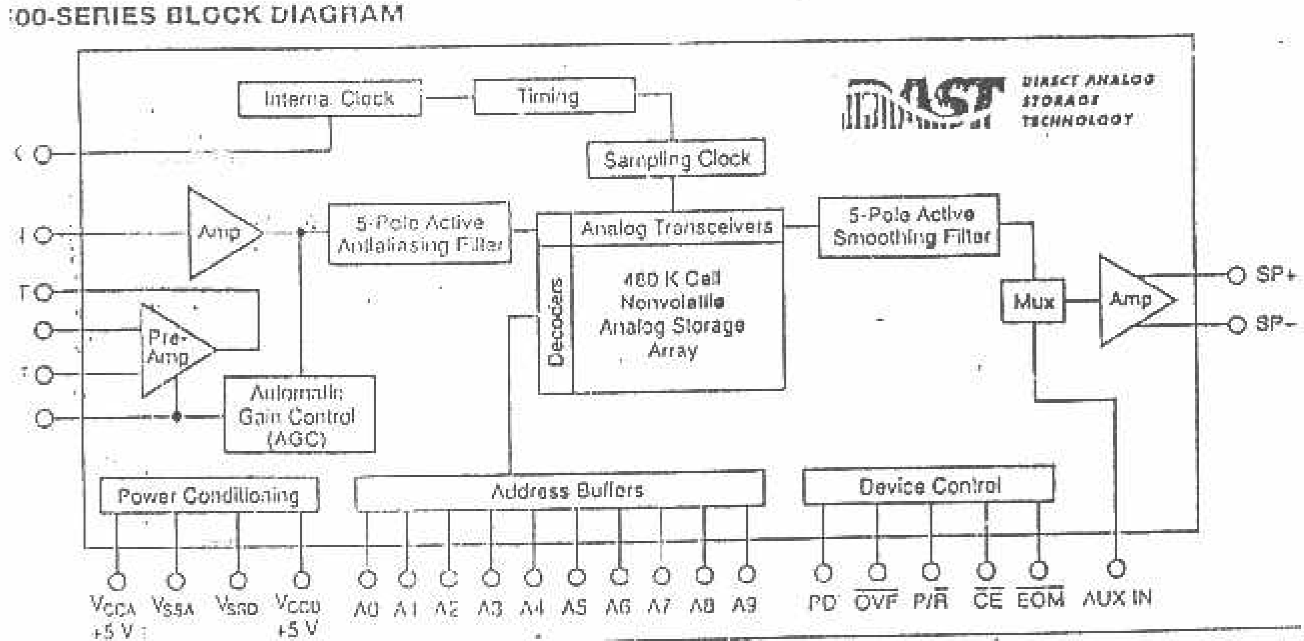
500-SERIES SUMMARY

rt iber	Duration (Seconds)	Input Sample Rate (KHz)	Upper Pass Band (KHz)
2545	45	10.6	4.5
2560	60	8.0	3.4
2575	75	6.4	2.7
2590	90	5.33	2.3

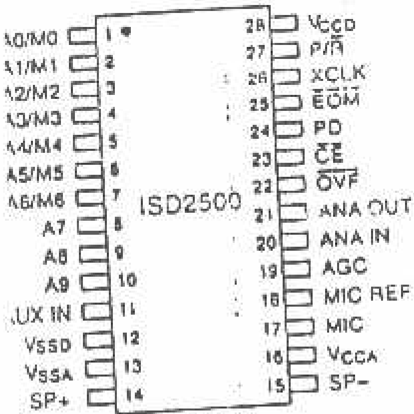
FEATURES

- Easy-to-use single-chip voice record/playback solution
  - No external ICs required
  - No development system required
- High-quality, natur voice/audio reproduction
- Manual switch or microprocessor controllable
  - Playback can be edge- or level-activated
- Single-chip durations of 45, 60, 75, and 90 seconds
- Directly cascadable for longer durations
- Zero-power message storage
  - Eliminates battery backup circuits
- Automatic Power-Down (Push-Button Mode)
  - 1 µA standby current (typical)
- Fully addressable to handle multiple messages
- 100-year message retention (typical)
- 100K record cycles (typical)
- On-chip clock source
- On-chip Automatic Gain Control (AGC)
- Programmer support for play-only applications
- Single +5 volt supply (4.5 V to 6.5 V operating range)
  - Low-voltage (3.6 V to 4.0 V) versions available
- Available in die form, DIP, SOIC, and TSOP packaging
- Industrial-temperature (-40°C to 85°C) versions available

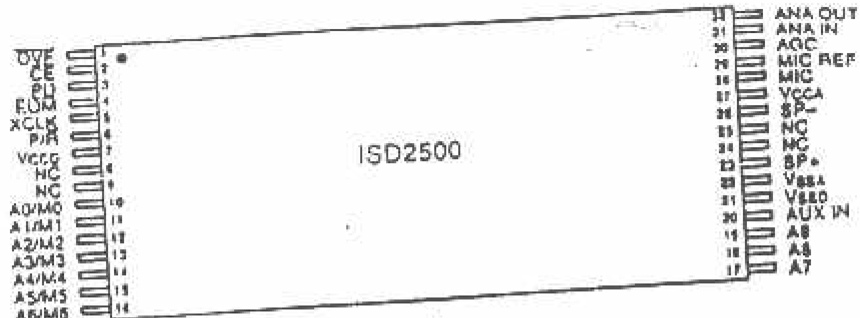
00-SERIES BLOCK DIAGRAM



ISD2500 SERIES PINOUTS



DIP/SOIC



TSOP

ISD2500 SERIES — DETAILED DESCRIPTIONS

Speech/Sound Quality

The ISD2500 Series includes devices offered at 5.3, 6.4, 8.0, and 10.6 KHz sampling frequencies, allowing the user a choice of speech quality options. The speech samples are stored directly into on-board non-volatile memory without the digitization and compression associated with other solutions. Direct analog storage provides a very true, natural sounding reproduction of voice, music, tones, and sound effects not available with most solid-state digital solutions.

Duration

To meet end system requirements, the ISD2500 Series offers single-chip solutions at 45, 60, 75, and 90 seconds. Parts may also be cascaded together for longer durations.

EEPROM Storage

One of the benefits of ISD's DAST technology is the use of on-board non-volatile memory, providing zero-power message storage. The message is retained for up to 100 years without power. In addition, the device can be re-recorded over 100,000 times.

Microcontroller Interface

In addition to its simplicity and ease of use, the ISD2500 Series includes all the interfaces necessary for microcontroller-driven applications. The address and control lines can be interfaced to a microcontroller and manipulated to perform a variety of tasks, including message assembly, message concatenation, predefined fixed message segmentation, and message management.

Programming

The ISD2500 Series is also ideal for playback-only applications, where single or multiple messages are referenced through buttons, switches, or a micro-controller. Once the desired message configuration is created, duplicates can easily be generated via an ISD programmer.

ISD2500 SERIES — PIN DESCRIPTIONS

Microphone Input (MIC)

The microphone input transfers its signal to the on-chip preamplifier. An on-board Automatic Gain Control (AGC) circuit controls the gain of this preamplifier from -15 to 24 dB. An external microphone should be AC coupled to this pin via a series capacitor. The capacitor value, together with the internal 10 K Ohm resistance on this pin, determines the low frequency cutoff for the ISD2500-Series passband.

Microphone Reference Input (MIC REF)

By connecting this pin to V_{SSA} (analog ground) via a series capacitor, common mode noise can be rejected at the preamplifier. The capacitor value should be exactly the same value as the input coupling capacitor used for microphone input. Using this approach may provide up to a 10 dB noise improvement. IF THIS INPUT IS UNUSED, IT MUST BE LEFT DISCONNECTED.

Analog Output (ANA OUT)

This pin provides the preamplifier output to the user. The voltage gain of the preamplifier is determined by the voltage level at the AGC pin.

Analog Input (ANA IN)

The analog input pin transfers its signal to the chip for recording. For microphone inputs, the ANA OUT pin should be connected via an external capacitor to the ANA IN pin. This capacitor value, together with the 3.0 KΩ input impedance of ANA IN, can be selected to give additional cutoff at the low-frequency end of the voice passband. If the desired input is derived from a source other than a microphone, the signal can be fed, capacitively coupled, into the ANA IN pin directly.

Automatic Gain Control Input (AGC)

The AGC dynamically adjusts the gain of the preamplifier to compensate for the wide range of microphone input levels. The AGC allows the full range of whispers to loud sounds to be recorded with minimal distortion. The "attack" time is determined by the time constant of a 5 KΩ internal resistance and an external capacitor (C2 on the schematic on page 7) connected from the AGC pin to V_{SSA} analog ground. The "release" time is determined by the time constant of an external resistor (R2) and an external capacitor (C2) connected in parallel between the AGC Pin and V_{SSA} analog ground. Nominal values of 470 KΩ and 4.7 µF give satisfactory results in most cases.

Speaker Outputs (SP+/SP-)

All devices in the ISD2500 Series include an on-chip differential speaker driver, capable of driving 50 milliwatts into 16 Ω.

The speaker outputs are held at V_{SSA} levels during record and power down. It is therefore not possible to parallel speaker outputs of multiple ISD2500 devices or the outputs of other speaker drivers.

CONNECTION OF SPEAKER OUTPUTS IN PARALLEL MAY CAUSE DAMAGE TO THE DEVICE.

While a single output may be used alone (including a coupling capacitor between the SP pin and the speaker), he two opposite-polarity outputs used together yield a 4:1 improvement in output power.

NEVER GROUND OR DRIVE AN UNUSED SPEAKER OUTPUT.

ower Down Input (PD)

Vhen not recording or playing back, the PD pin should e pulled HIGH to place the part in a very low power ode (see I_{SB} specification). When $\overline{OVF}$ pulses LOW for n overflow condition, PD should be brought HIGH to eset the address pointer back to the beginning of the ecord/Playback space. The PD pin has additional unctionality in the M6 (Push-Button) Operational Mode escribed later in the Operational Mode section.

hip Enable Input ($\overline{CE}$)

e $\overline{CE}$ pin is taken LOW to enable all Playback and ecord operations. The address inputs and Playback/ ecord input (P/$\overline{R}$) are latched by the falling edge of $\overline{CE}$. $\overline{E}$ has additional functionality in the M6 (Push-Button) perational Mode described later in the Operational ode section.

ayback/Record Input (P/$\overline{R}$)

e P/$\overline{R}$ input is latched by the falling edge of the $\overline{E}$ pin. A HIGH level selects a Playback cycle while a W level selects a Record cycle. For a Record cycle, the dress inputs provide the starting address and recording continues until PD or $\overline{CE}$ is pulled HIGH or an overflow is detected (i.e. the chip is full). When a Record cycle is terminated by pulling PD or $\overline{CE}$ HIGH, an End-Of-Message ($\overline{EOM}$) marker is stored at the current address in memory. For a Playback cycle, the address inputs provide the starting address and the device will play until an $\overline{EOM}$ marker is encountered. The device can continue past an $\overline{EOM}$ marker in an operational mode, or if $\overline{CE}$ is held LOW in address mode. (See Table 1, Page 5 for more Operational Modes).

Address/Mode Inputs (Ax/Mx)

The Address/Mode Inputs have two functions depending on the level of the two Most Significant Bits (MSB) of the address.

If either of the two MSBs is LOW, the inputs are ALL interpreted as address bits and are used as the start address for the current Record or Playback cycle. The address pins are inputs only and do not output internal address information as the operation progresses. Address inputs are latched by the falling edge of $\overline{CE}$.

If both MSBs are HIGH, the Address/Mode Inputs are interpreted as Mode bits according to the Operational Mode Table 1 on page 4. There are six (6) operational modes (M0..M6) available as indicated on Table 1. It is possible to use multiple operational modes simultaneously. Operational Modes are sampled on EACH falling edge of $\overline{CE}$, and thus Operational Modes and direct addressing are mutually exclusive.

External Clock Input (XCLK)

The ISD2500 devices are configured at the factory with an internal sampling clock frequency centered to ±1 % of specification. The frequency is maintained to a total variation of ±2.25 % over the entire commercial temperature and operating voltage ranges. If greater precision is required, the device can be clocked through the XCLK pin as follows:

Part Number	Sample Rate	Required Clock
ISD2590	5.33 KHz	682.7 KHz
ISD2575	6.4 KHz	819.2 KHz
ISD2560	8.0 KHz	1024 KHz
ISD2545	10.6 KHz	1365.3 KHz

These recommended clock rates should not be varied because the anti-aliasing and smoothing filters are fixed, and aliasing problems can occur if the sample rate differs from the one recommended. The duty cycle on the input clock is not critical, as the clock is immediately divided by two. IF THE XCLK IS NOT USED, THIS INPUT MUST BE CONNECTED TO GROUND.

ISD2500 SERIES — PIN DESCRIPTIONS, CONT.

End-Of-Message / RUN Output ($\overline{EOM}$)

A non-volatile marker is automatically inserted at the end of each recorded message. It remains there until the message is recorded over. The $\overline{EOM}$ output pulses LOW for a period of T_{EOM} at the end of each message.

In addition, the ISD2500 Series has an internal V_{CC} detect circuit to maintain message integrity should V_{CC} fall below 3.5V. In this case, $\overline{EOM}$ goes LOW and the device is fixed in Playback-only mode.

When the device is configured in Operational Mode M6 (Push-Button Mode), this pin provides an active-HIGH RUN signal, indicating the device is currently recording or playing. This signal can conveniently drive an LED for a visual indicator of a Record or Playback operation in process.

Overflow Output ($\overline{OVF}$)

This signal pulses LOW at the end of memory space, indicating the device has been filled and the message has overflowed. The $\overline{OVF}$ output then follows the $\overline{CE}$ input until a PD pulse has reset the device. This pin can be used to cascade several ISD2500 devices together to increase Record/Playback durations.

Auxiliary Input (AUX IN)

The Auxiliary Input is multiplexed through to the output amplifier and speaker output pins when $\overline{CE}$ is HIGH and Playback has ended, or if the device is in overflow. When cascading multiple ISD2500 devices, the AUX IN pin is used to connect a Playback signal from a following device to the previous output speaker drivers. For noise considerations, it is suggested that the auxiliary input not be driven when the storage array is active.

Voltage Inputs (V_{CCA}, V_{CCD})

To minimize noise, the analog and digital circuits in the ISD2500 Series devices use separate power busses. These +5 V busses are brought out to separate pins and should be tied together as close to the supply as possible. In addition, these supplies should be decoupled as close to the package as possible.

Ground Inputs (V_{SSA}, V_{SSD})

The ISD2500 Series of devices utilizes separate analog and digital ground busses. These pins should be tied together as close to the package as possible and connected through a low-impedance path to power supply ground.

OPERATIONAL MODES

The ISD2500 Series is designed with several built-in operational modes provided to allow maximum functionality with a minimum of additional components. These are described in detail below. The operational modes use the address pins on the ISD2500 devices, but are mapped outside the valid address range. When the two Most Significant Bits (MSBs) are HIGH, the remaining address signals are interpreted as mode bits and NOT as address bits. Therefore, operational modes and direct addressing are not compatible and cannot be used simultaneously.

There are two important considerations for using operational modes. First, all operations begin initially at address 0, which is the beginning of the ISD2500 address space. Later operations can begin at other address locations, depending on the operational mode(s) chosen. In addition, the address pointer is reset to 0 when the device is changed from Record to Playback, Playback to Record (except M6 mode), or when a Power-Down cycle is executed.

Second, Operational Modes are executed when $\overline{CE}$ goes LOW and the two MSBs are HIGH. This Operational Mode remains in effect until the next LOW-going $\overline{CE}$ signal, at which point the current address/mode levels are sampled and executed.

OPERATIONAL MODE DESCRIPTIONS

The Operational Modes can be used in conjunction with a microcontroller, or they can be hard-wired to provide the desired system operation.

TABLE 1. OPERATIONAL MODES

Mode Control	Function	Typical Use	Jointly* Compatible
M0	Message cueing	Fast-forward through messages	M4, M5, M6
M1	Delete $\overline{EOM}$ markers	Position $\overline{EOM}$ marker at the end of the last message	M3, M4, M5, M6
M2	Not applicable	Reserved	N/A
M3	Looping	Continuous playback from address 0	M1, M5, M6
M4	Consecutive addressing	Record/Play multiple consecutive messages	M0, M1, M5
M5	$\overline{CE}$ level-activated	Allows message pausing	M0, M1, M3, M4
M6	Push-button control	Simplified device interface	M0, M1, M3

* *Indicates additional operational modes which can be used simultaneously with the given mode.*

M0 — Message Cueing

Message Cueing allows the user to skip through messages, without knowing the actual physical addresses of each message. Each $\overline{CE}$ LOW pulse causes the internal address pointer to skip to the next message. This mode should be used for Playback only, and is typically used with the M4 Operational Mode.

M1 — Delete $\overline{EOM}$ Markers

The M1 Operational Mode allows sequentially recorded messages to be concatenated into a single message with only one $\overline{EOM}$ marker set at the end of the combined message. When this operational mode is configured, messages recorded sequentially are played back as one continuous message.

M2 — Unused

When operational modes are selected, the M2 pin should be LOW.

M3 — Message Looping

The M3 Operational Mode allows for the automatic, continuously repeated playback of the message located at the beginning of the address space. A message CAN completely fill the ISD2500 device and will loop from beginning to end without $\overline{OVF}$ going LOW.

M4 — Consecutive Addressing

During normal operations, the address pointer will reset when a message is played through to an $\overline{EOM}$ marker. The M4 Operational Mode inhibits the address pointer reset on $\overline{EOM}$, allowing messages to be played back consecutively.

M5 — $\overline{CE}$ Level Activated

The default mode for ISD2500 devices is for $\overline{CE}$ to be edge-activated on Playback and level-activated on Record. The M5 Operational Mode causes the $\overline{CE}$ pin to be interpreted as level-activated as opposed to edge-activated during Playback. This is specifically useful for terminating Playback operations using the $\overline{CE}$ signal.

In this mode, $\overline{CE}$ LOW begins a Playback cycle, $\overline{CE}$ HIGH stops the cycle, and $\overline{CE}$ LOW again will begin playing at the point where the message was stopped without resetting the address pointer.

M6 — Push-Button Mode

The ISD2500 Series of devices contain a push-button operational mode. The push-button mode is used primarily in very low-cost applications and is designed to minimize external circuitry and components, thereby reducing system cost. In order to configure the device in push-button operational mode, the two most significant address bits (pins 9 and 10) must be HIGH, and the M6 mode pin (pin 7) must also be HIGH. A device in this mode always powers down at the end of each Playback or Record cycle after $\overline{CE}$ goes HIGH.

When this operational mode is implemented, several of the pins on the device have alternate functionality:

Pin Name	Alternate Functionality In Push-Button Mode
Pin 23, $\overline{CE}$	Start/Pause Push-Button (LOW Pulse-Activated)
Pin 24, PD	Stop/Reset Push-Button (HIGH Pulse-Activated)
Pin 25, $\overline{EOM}$	Active-HIGH Run Indicator

Pin 23: $\overline{CE}$ ($\overline{Start/Pause}$)

In push-button Operational Mode, $\overline{CE}$ acts as a LOW-going pulse-activated Start/Pause signal. If no operation is currently in progress, a LOW-going pulse on this signal will initiate a Playback or a Record cycle according to the level on the P/$\overline{R}$ pin. A subsequent pulse on the $\overline{CE}$ pin, before an End-Of-Message is reached in Playback or an overflow condition occurs, will cause the device to pause. The address counter is not reset, and another $\overline{CE}$ pulse will cause the device to continue the operation from the place where it was paused.

Pin 24: PD (Stop/Reset)

In push-button Operational Mode, PD acts as a HIGH-going pulse-activated Stop/Reset signal. When a Playback or Record cycle is in progress and a HIGH-going pulse is observed on PD, the current cycle is terminated and the address pointer is reset to address 0, the beginning of the message space.

Pin 25: $\overline{EOM}$ (Run)

In push-button Operational Mode, $\overline{EOM}$ becomes an active-HIGH run signal which can be used to drive an LED or other external device. It is HIGH whenever a Record or Playback operation is in progress.

Recording in Push-Button Mode

1) The PD pin should be LOW, usually using a pulldown resistor.
2) The P/$\overline{R}$ pin is taken LOW.
3) The $\overline{CE}$ pin is pulsed LOW. Recording starts, $\overline{EOM}$ goes HIGH to indicate an operation in progress.
4) The $\overline{CE}$ pin is pulsed LOW. Recording pauses, $\overline{EOM}$ goes back LOW. The internal address pointers are not

OPERATIONAL MODE DESCRIPTIONS, CONT.

cleared, but an $\overline{EOM}$ marker is stored in memory to point to the message end. The P/$\overline{R}$ pin may be taken HIGH at this time. Any subsequent $\overline{CE}$ would start a playback at address 0.

5) The $\overline{CE}$ pin is pulsed LOW. Recording starts at the next address after the previous set $\overline{EOM}$ marker. $\overline{EOM}$ goes back HIGH. (Note: if the M1 operational mode pin is also HIGH, the just previously written $\overline{EOM}$ bit is erased, and recording starts at that address.)

6) When the recording sequences are finished, the final $\overline{CE}$ pulse LOW will end the last Record cycle, leaving a set $\overline{EOM}$ marker at the message end. Recording may also be terminated by a HIGH level on PD, which will leave a set $\overline{EOM}$ marker.

Playback in Push-Button Mode

1) The PD pin should be LOW.

2) The P/$\overline{R}$ pin is taken HIGH.

3) The $\overline{CE}$ pin is pulsed LOW. Playback starts, $\overline{EOM}$ goes HIGH to indicate an operation in progress.

4) If the $\overline{CE}$ pin is pulsed LOW or an $\overline{EOM}$ marker is encountered during an operation, the part will pause. The internal address pointers are not cleared, and $\overline{EOM}$ goes back LOW. The P/$\overline{R}$ pin may be changed at this time. A subsequent Record operation would not reset the address pointers and the recording would begin where Playback ended.

5) $\overline{CE}$ is again pulsed LOW. Playback starts where it left off, with $\overline{EOM}$ going HIGH to indicate an operation in progress.

6) Playback continues as in 4) and 5) until PD is pulsed HIGH or overflow occurs.

7) If in overflow, pulling $\overline{CE}$ LOW will reset the address pointer and start Playback from the beginning. After a PD pulse, the part is reset to address 0.

Note : Push-button mode can be used in conjunction with modes M0, M1, and M3.

ISD1000A COMPATIBILITY

The ISD2500 Series of devices is designed to provide upward compatibility from the ISD1000A family. When designing with the ISD2500 Series, the following differences should be noted.

Addressing

The ISD2500-Series devices have 480 K storage cells designed to provide 60 seconds of storage at a sampling rate of 8.0 KHz. This is approximately four times the storage of the ISD1000A family. To enable the same addressing resolution, two additional address pins have been added. The address space of each device is divisible into 600 increments with valid addressing from 00 to 257 Hex. Some higher addresses are mapped into the Operational Modes. All other addresses are invalid.

Overflow

The ISD1000A family combined two functions on the $\overline{EOM}$ pin: end-of-message indication and overflow. The ISD2500 Series separates these two functions. Pin 25 remains as $\overline{EOM}$, but outputs only the $\overline{EOM}$ signal indication. Pin 22 becomes $\overline{OVF}$ and pulses LOW only when the device reaches its end of memory, or is "full." This change allows easy message cueing and addressability across device boundaries. This also means that the M2 operational mode found in the ISD1000A family is not implemented in the ISD2500 Series.

Push-Button Mode

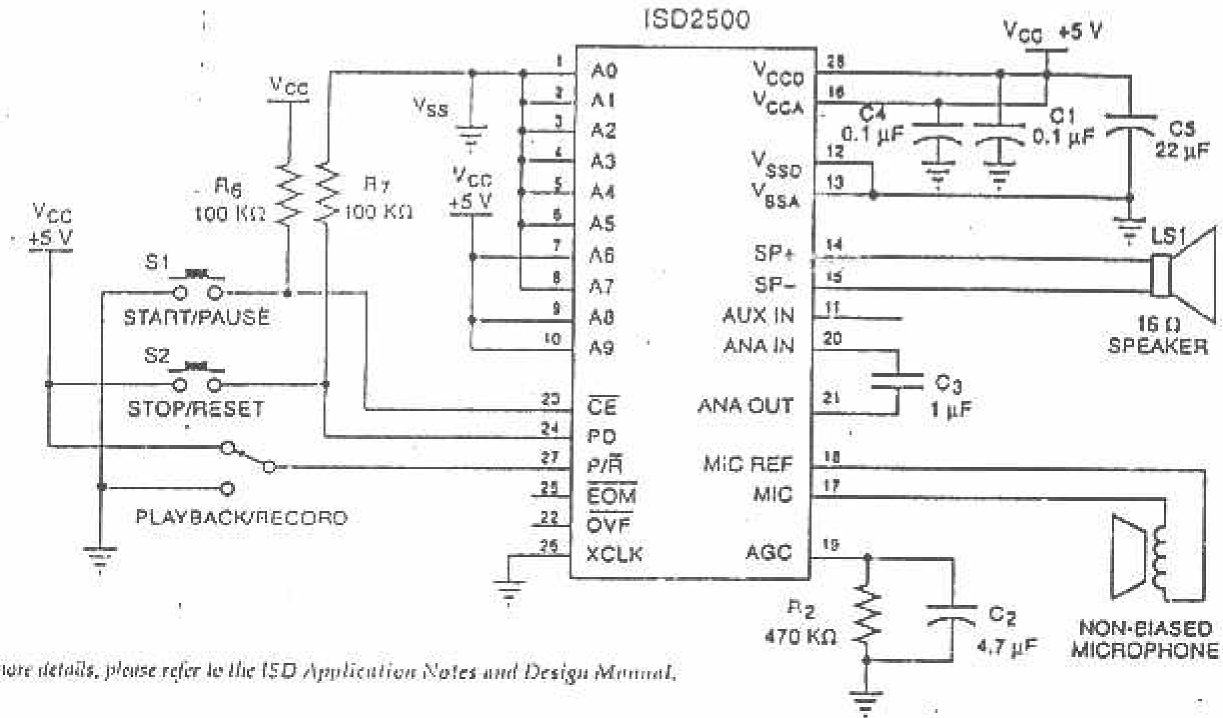
The ISD2500 Series includes an additional Operational Mode called Push-Button mode. This provides an alternative interface to the Record and Playback functions of the part. The $\overline{CE}$ and PD pins become redefined as edge-activated "push-buttons." A pulse on $\overline{CE}$ initiates a cycle, and if triggered again, pauses the current cycle without resetting the address pointer (i.e., a Start or Pause function). PD stops any current cycle and resets the address pointer to the beginning of the message space (i.e., a Stop and Reset function). Additionally, the $\overline{EOM}$ pin functions as an active-HIGH run indicator, and can be used to drive an LED indicating a Record or Playback operation is in progress. Devices in the Push-Button mode cannot be cascaded.

Looping Mode

The ISD2500 Series can loop with a message that completely fills the memory space.

*Note: Additional descriptions of ISD1000A device functionality and application examples are provided in the ISD **Application Notes and Design Manual**.*

APPLICATION EXAMPLE – PUSH-BUTTON



...r more details, please refer to the ISD Application Notes and Design Manual.

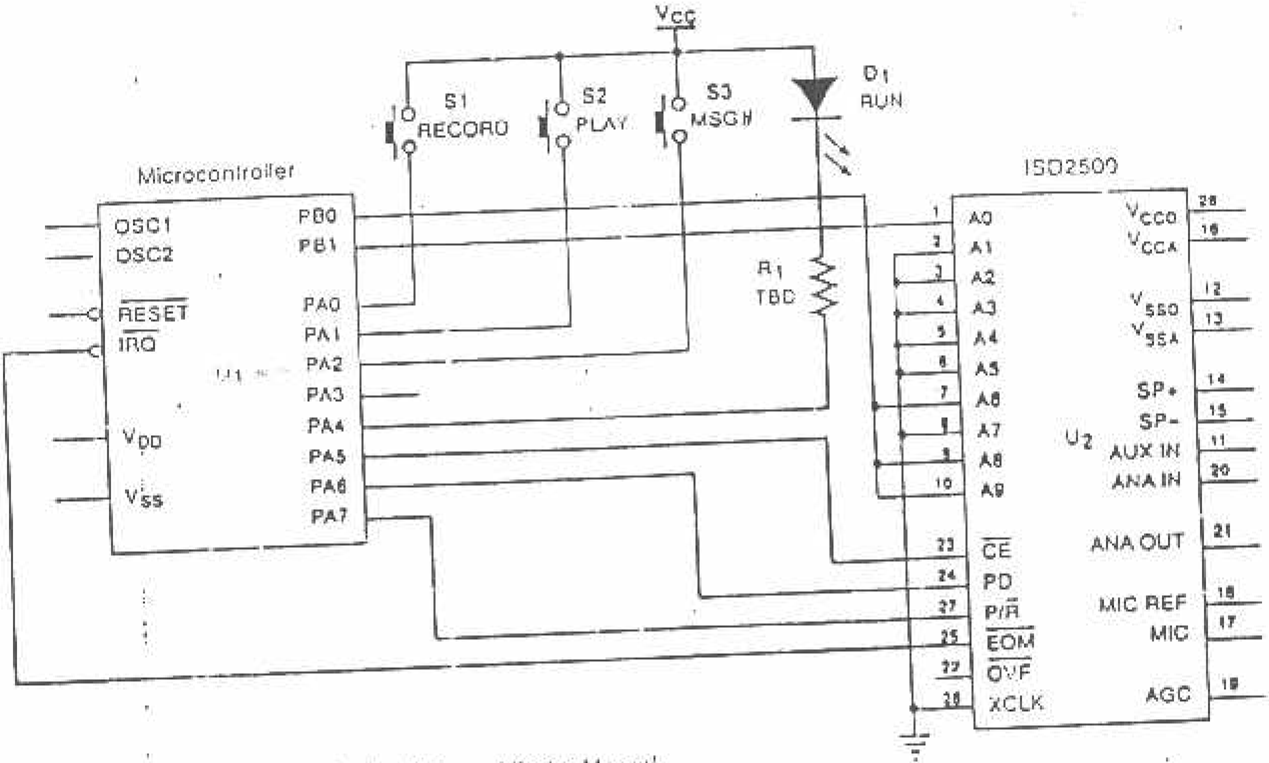
...PPLICATION EXAMPLE – ...USH-BUTTON CONTROL

...ontrol Step	Function	Action
1	Select record/playback mode	$P/\overline{R}$ = As desired
2A	Begin playback	$P/\overline{R}$ = HIGH $\overline{CE}$ = Pulsed LOW
2B	Begin record	$P/\overline{R}$ = LOW $\overline{CE}$ = Pulsed LOW
3	Pause record or playback	$\overline{CE}$ = Pulsed LOW
...A	End playback	Automatic at $\overline{EOM}$ marker or PD Pulsed HIGH
...B	End record	PD = Pulsed HIGH

APPLICATION EXAMPLE – PASSIVE COMPONENT FUNCTIONS

Part	Function	Comments
R2	Release time constant	Sets release time for AGC
C2	Attack/Release time constant	Sets attack/release time for AGC
C3	Low-frequency cutoff capacitor	Provides additional pole for low-frequency cutoff
R6, R7	Pull-up and pull-down resistors	Defines static state of inputs
C1, C4 C5	Power supply capacitors	Filters and bypass of power supply

APPLICATION EXAMPLE – MICROCONTROLLER/ISD2500 INTERFACE

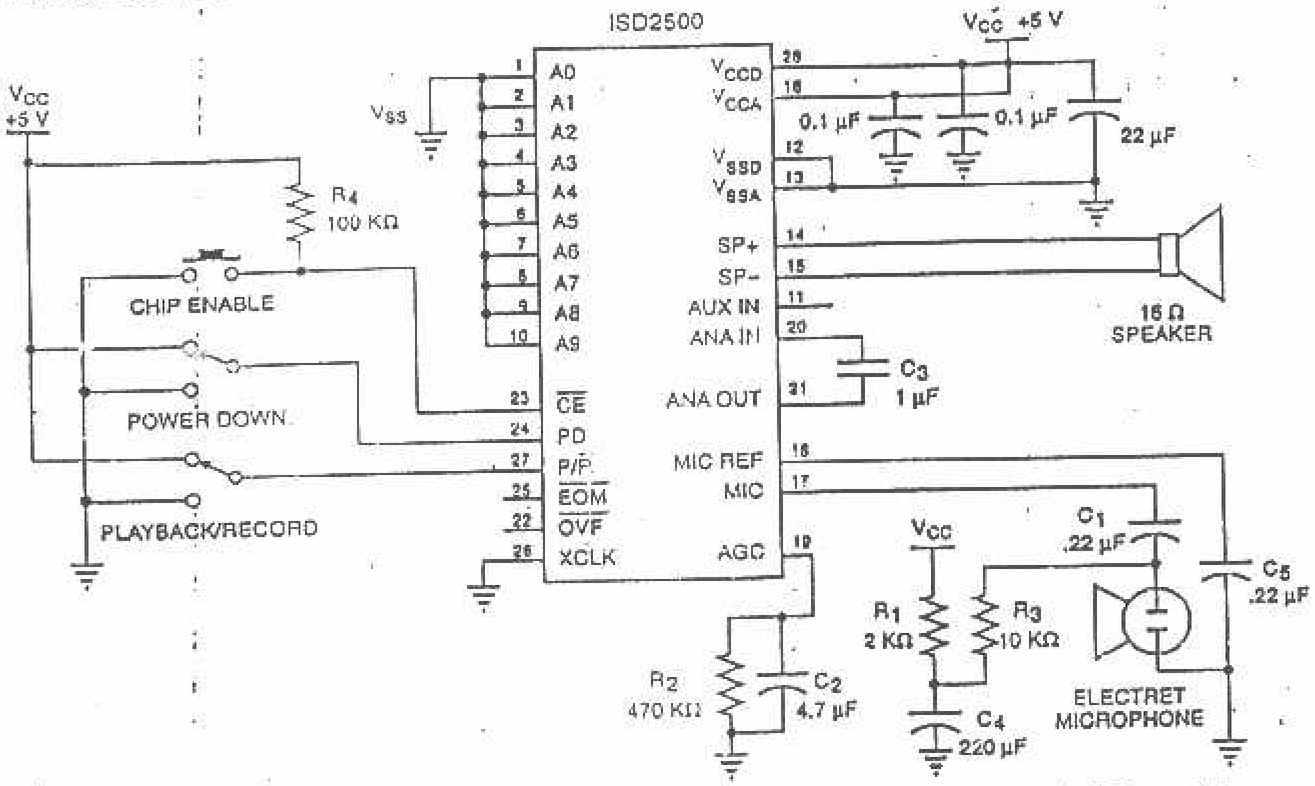


For more details, please refer to the ISD Application Notes and Design Manual.

EXPLANATION

In this simplified block diagram of a microcontroller application, the Push-Button mode and message cueing are used. The microcontroller is a 16-pin version with enough port pins for buttons, an LED, and the ISD2500-Series device. The software can be written to use three buttons: one each for play and record, and one for message selection. Because the microcontroller is interpreting the buttons and commanding the ISD2500 device, software can be written for any functions desired in a particular application.

APPLICATION EXAMPLE – DESIGN SCHEMATIC



Note: *If desired, pin 18 may be left unconnected (microphone preamplifier noise will be higher). In this case, pin 18 must not be tied to any other signal or voltage. For more details, please refer to the ISD Application Notes and Design Manual.*

APPLICATION EXAMPLE – BASIC DEVICE CONTROL

Control Step	Function	Action
1	Power up chip and select record/playback mode	1. PD = LOW 2. P/$\overline{R}$ = As desired
2	Set message address for record/playback	Set addresses A0–A7
3A	Begin playback	P/$\overline{R}$ = HIGH $\overline{CE}$ = Pulsed LOW
3B	Begin record	P/$\overline{R}$ = LOW $\overline{CE}$ = LOW
4A	End playback	Automatic
4B	End record	PD or $\overline{CE}$ = HIGH

APPLICATION EXAMPLE – PASSIVE COMPONENT FUNCTIONS

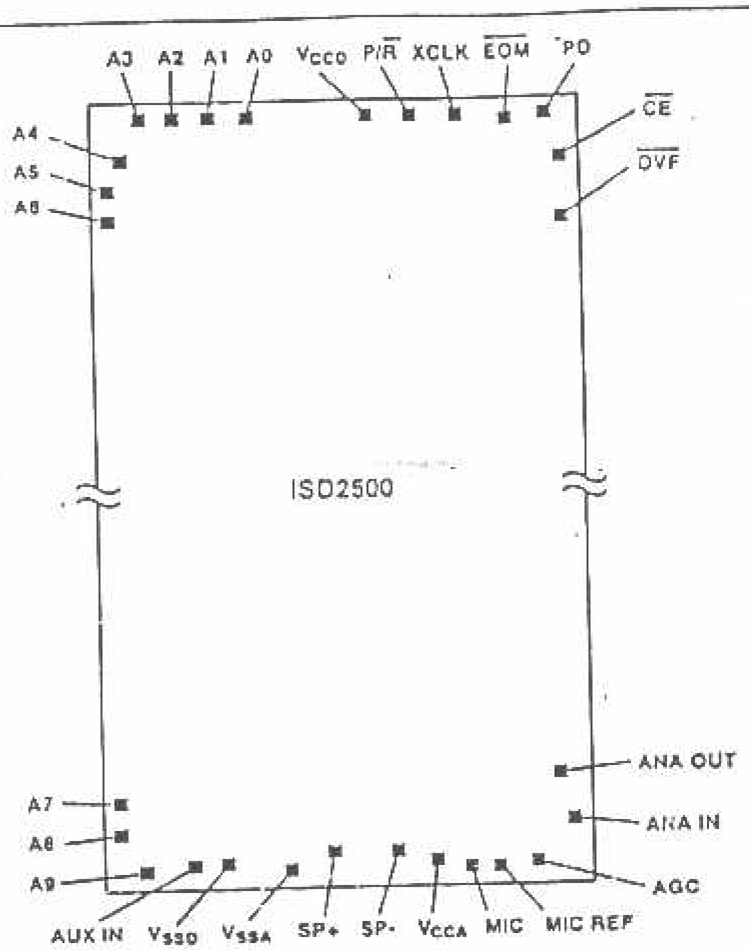
Part	Function	Comments
R1	Microphone power supply decoupling	Reduces power supply noise
R2	Release time constant	Sets release time for AGC
R3	Microphone biasing resistor	Provides biasing for microphone operation
C1	Microphone DC-blocking capacitor. Low-frequency cutoff	Decouples microphone bias from chip. Provides single-pole low-frequency cutoff
C2	Attack/Release time constant	Sets attack/release time for AGC
C3	Low-frequency cutoff capacitor	Provides additional pole for low-frequency cutoff
C4	Microphone power supply decoupling network	Reduces power supply noise
C5	Common-mode capacitor	Provides common-mode noise rejection

DIE BONDING PHYSICAL LAYOUT

I. Die Dimensions
X: 187 ±1 mils
Y: 399 ±1 mils

II. Die Thickness
21 mils

III. Pad Opening
109 microns (4.3 mils)



PIN/PAD DESIGNATIONS

Pin	Pin Name	X Axis	Y Axis	Pin	Pin Name	X Axis	Y Axis
A0	Address 0	-1148.9	4898.2	SP-	Speaker Output -	425.6	-4790.8
A1	Address 1	-1406.9	4898.2	V_{CCA}	V_{CC} Analog Power Supply	865.1	-4848.3
A2	Address 2	-1661.9	4898.2	MIC	Microphone Input	1320.7	-4897.3
A3	Address 3	-1916.9	4898.2	MIC REF	Microphone Reference	1605.1	-4897.3
A4	Address 4	-2069.9	4608.2	AGC	Automatic Gain Control	1877.6	-4871.3
A5	Address 5	-2194.9	4358.2	ANA IN	Analog Input	2202.11	-4269.8
A6	Address 6	-2194.9	4108.2	ANA OUT	Analog Output	2123.1	-3910.8
A7	Address 7	-2194.9	-4212.3	$\overline{OVF}$	Overflow Output	2142.6	4154.7
A8	Address 8	-2194.9	-4456.3	$\overline{CE}$	Chip Enable Input	2202.1	4558.7
A9	Address 9	-2076.4	-4897.3	PD	Power Down Input	2048.1	4898.2
AUX IN	Auxilary Input	-1607.9	-4868.3	$\overline{EOM}$	End of Message	1648.1	4865.7
V_{SSD}	V_{SS} Digital Power Supply	-1343.9	-4850.8	XCLK	External Clock	1221.1	4898.2
V_{SSA}	V_{SS} Analog Power Supply	-551.9	-4884.8	P/$\overline{R}$	Playback/Record	965.6	4898.2
SP+	Speaker Output +	-111.4	-4790.8	V_{CCD}	V_{CC} Digital Power Supply	646.1	4895.7

ABSOLUTE MAXIMUM RATINGS

Condition	Value
Temperature under bias	-65° C to +125° C
Storage temperature range	-65° C to +150° C
Voltage applied to any pin	(V_{SS} - 0.3 V) to (V_{CC} + 0.3 V)
Voltage applied to any pin (Input current limited to ± 20 mA)	(V_{SS} - 1.0 V) to (V_{CC} + 1.0 V)
Lead temperature (soldering – 10 seconds)	300° C
V_{CC} - V_{SS}	- 0.3 V to + 7.0 V

Stresses above those listed may cause permanent damage to the device. Exposure to the absolute maximum ratings may affect device reliability. Functional operation is not implied at these conditions.

DC PARAMETERS

Operating Conditions: T_A = 0° C to 70° C [4], V_{CC} = 4.5 V to 6.5 V [5], V_{SS} = 0 V [6]; unless otherwise noted

Symbol	Parameters	Min	Typ [1]	Max	Units	Conditions
V_{IL}	Input Low Voltage			0.8	V	
V_{IH}	Input High Voltage	2.0			V	
V_{OL}	Output Low Voltage			0.4	V	I_{OL} = 4.0 mA
V_{OH}	Output High Voltage	V_{CC} – 0.4			V	I_{OH} = - 10 µA
V_{OH1}	$\overline{OVF}$ Output High Voltage	2.4			V	I_{OH} = - 1.6 mA
V_{OH2}	$\overline{EOM}$ Output High Voltage		V_{CC} – 1.0		V	I_{OH} = - 3.2 mA
I_{CC}	V_{CC} Current (Operating)		25	30	mA	R_{EXT} = ∞ [7]
I_{SB}	V_{CC} Current (Standby)		1	10	µA	[7]
I_{IL}	Input Leakage Current			±1	µA	
R_{EXT}	Output Load Impedance	16			Ω	Speaker Load
R_{MIC}	Preamp In Input Resistance		10		KΩ	Pins 17, 18
R_{AUX}	Aux Input Resistance		10		KΩ	
$R_{ANA IN}$	Ana In Input Resistance		3.0		KΩ	
A_{PRE1}	Preamp Gain 1		24		dB	AGC = 0.0 V
A_{PRE2}	Preamp Gain 2		-15	5	dB	AGC = 2.5 V
A_{AUX}	Aux In/SP+ Gain		0.98	1.0	V/V	
A_{ARP}	Ana In to SP+/-		22		dB	
R_{AGC}	AGC Output Resistance		5		KΩ	

Notes: 1. *Typical values @ T_A = 25° C and 5.0 V.*
2. *With 12 KΩ series resistor at ANA IN.*
3. *Low-frequency cutoff depends upon value of external capacitors (see Pin Descriptions).*
4. *Case temperature.*
5. *V_{CC} = V_{CCA} = V_{CCD}.*
6. *V_{SS} = V_{SSA} = V_{SSD}.*
7. *V_{CCA} and V_{CCD} connected together.*

AC PARAMETERS

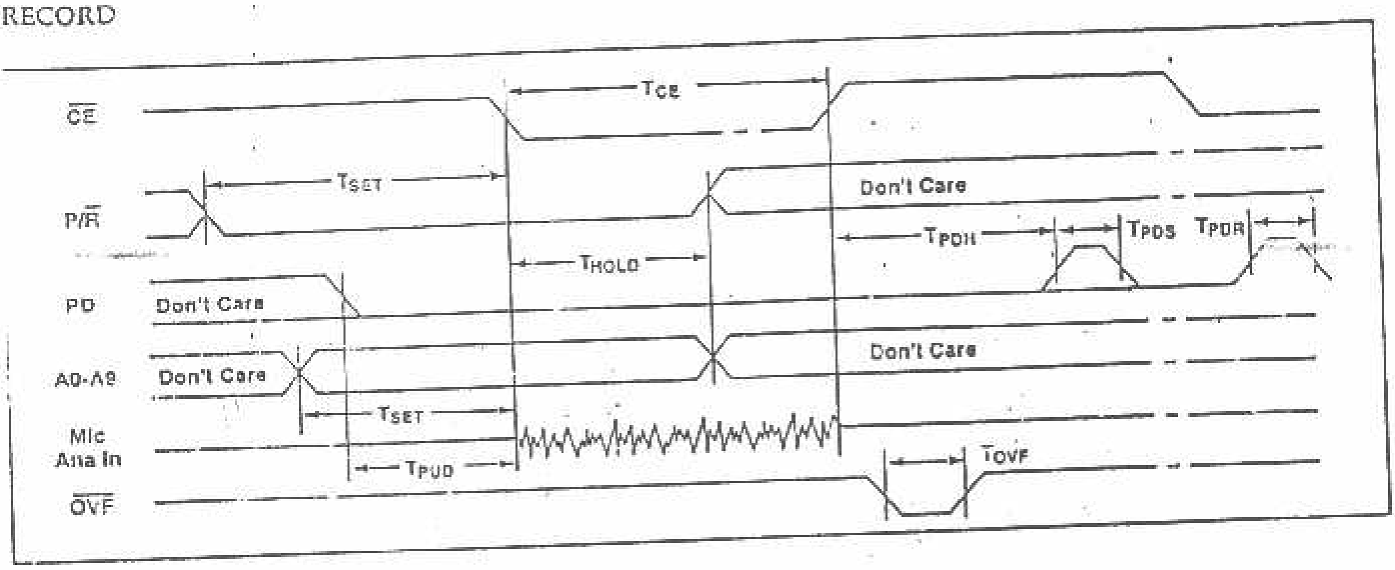
Operating Conditions: $T_A = 0°$ C to 70° C [4], $V_{CC} = 4.5$ V to 6.5 V [5], $V_{SS} = 0$ V [6]; unless otherwise noted

Symbol	Characteristic	Min	Typ [1]	Max	Units	Conditions
THD	Total Harmonic Distortion		1		%	@ 1 KHz [2]
P_{OUT}	Speaker Output Power		12.2	50	mW	$R_{EXT} = 16\ \Omega$ [8]
V_{OUT}	Voltage Across Speaker Pins			2.5	V p-p	$R_{EXT} = 600\ \Omega$
V_{IN1}	Mic Input Voltage			20	mV	Peak-to-Peak [2]
V_{IN2}	Ana In Input Voltage			50	mV	Peak-to-Peak
V_{IN3}	Aux In Input Voltage			1.25	V	Peak-to-Peak; $R_{EXT} = 16\ \Omega$
T_{SET}	Control/Address Setup Time		300		nsec	
T_{HOLD}	Control/Address Hold Time		0		nsec	
T_{CE}	$\overline{CE}$ Pulse Width		100		nsec	
T_{PUD}	Power-Up Delay – ISD2545 – ISD2560 – ISD2575 – ISD2590		18.75 25 31.25 37.5		msec msec msec msec	
T_{EOM}	$\overline{EOM}$ Pulse Width – ISD2545 – ISD2560 – ISD2575 – ISD2590		9.375 12.5 15.625 18.75		msec msec msec msec	
T_{PDR}	PD Pulse Width Record – ISD2545 – ISD2560 – ISD2575 – ISD2590		18.75 25 31.25 37.5		msec msec msec msec	
T_{PDP}	PD Pulse Width Play – ISD2545 – ISD2560 – ISD2575 – ISD2590		9.375 12.5 15.625 18.75		msec msec msec msec	
T_{PDS} [9]	PD Pulse Width Static		100		nsec	
T_{PDH}	Power Down Hold		0		nsec	
T_{OVF}	Overflow Pulse Width		10		µsec	

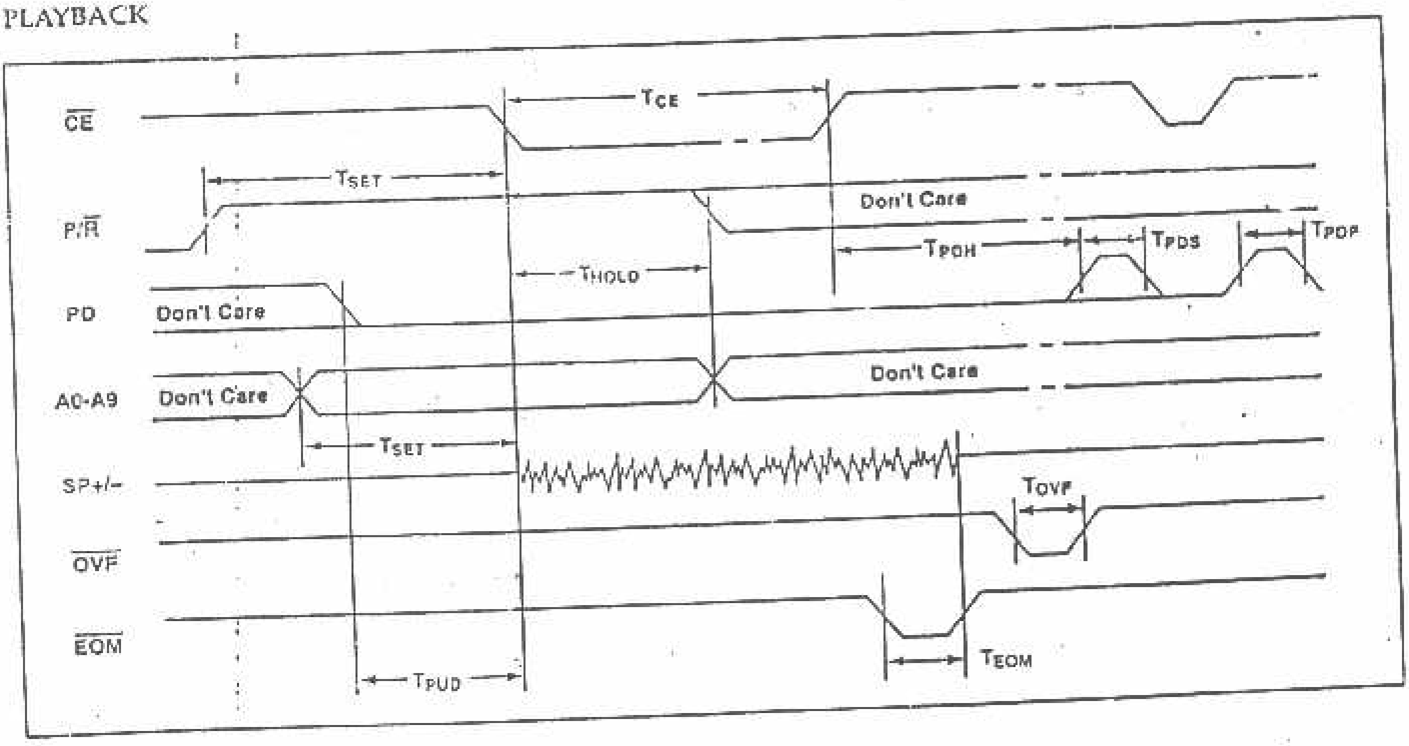
Notes: 1. *Typical values @ $T_A = 25°$ C and 5.0 V.*
2. *With 12 KΩ series resistor at ANA IN. Required for 6.5 V operation to minimize distortion.*
3. *Low-frequency cutoff depends upon value of external capacitors (see Pin Descriptions).*
4. *Case temperature.*
5. *$V_{CC} = V_{CCA} = V_{CCD}$.*
6. *$V_{SS} = V_{SSA} = V_{SSD}$.*
7. *V_{CCA} and V_{CCD} connected together.*
8. *From AUX IN; if ANA IN is driven at 50 mV p-p, the $P_{OUT} = 12.2$ mW, typical.*
9. *T_{PDS} is required during a static condition, typically overflow.*

TIMING DIAGRAMS (ISD2500 SERIES)

RECORD



PLAYBACK



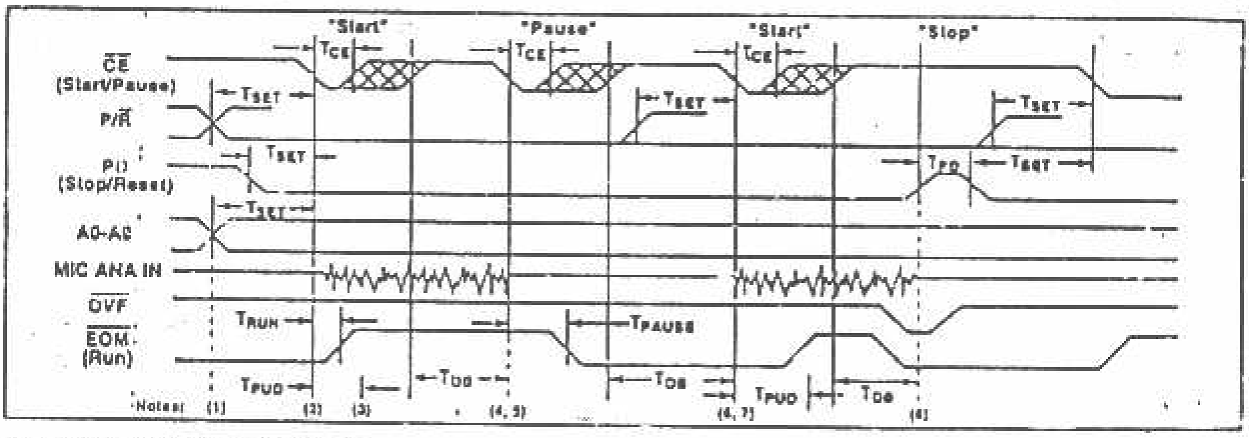
PUSH-BUTTON AC PARAMETERS

Symbol	Characteristic	Min	Typ [1]	Max	Units	Conditions
T_{CE}	$\overline{CE}$ Pulse Width [Start/Pause]		300		nsec	
T_{SET}	Control/Address Setup Time		300		nsec	
T_{PUD}	Power-Up Delay – ISD2545 – ISD2560 – ISD2575 – ISD2590		18.75 25 31.25 37.25		msec msec msec msec	
T_{PD}	PD Pulse Width [Stop/Reset]		300		nsec	
T_{RUN}	$\overline{CE}$ to $\overline{EOM}$ HIGH	25		400	nsec	
T_{PAUSE}	$\overline{CE}$ to $\overline{EOM}$ LOW	50		400	nsec	
T_{DB}	$\overline{CE}$ HIGH Debounce – ISD2545 – ISD2560 – ISD2575 – ISD2590	50 70 85 105		80 105 135 160	msec msec msec msec	

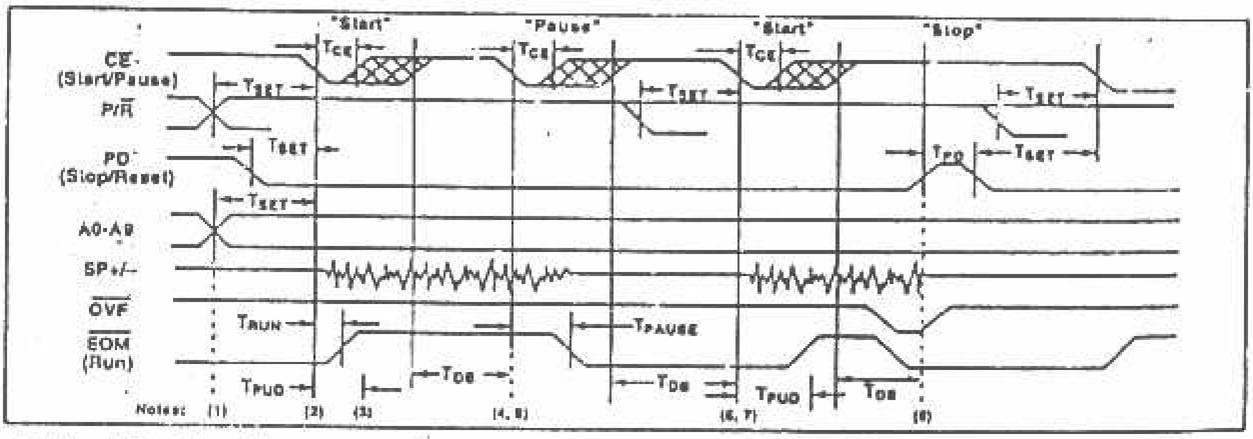
Notes: 1. Typical values @ T_A = 25° C and 5.0 V.

TIMING DIAGRAMS (ISD2500 SERIES)

PUSH-BUTTON MODE RECORD



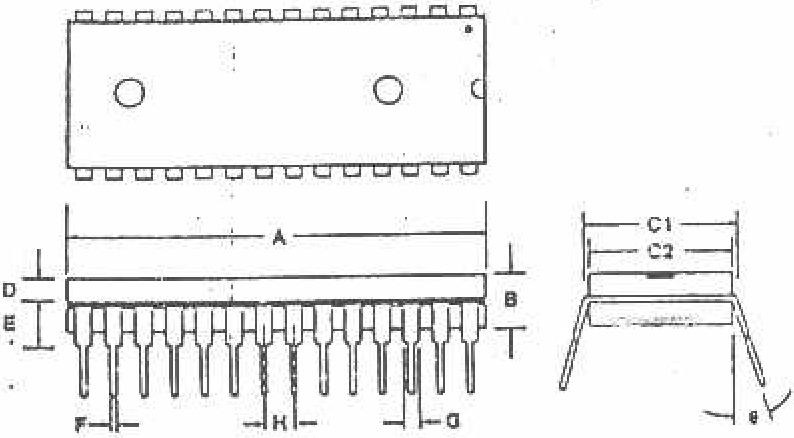
PUSH-BUTTON MODE PLAYBACK



Notes: 1. *A9, A8, and A6 = 1 for push-button operation.*
2. *The first $\overline{CE}$ LOW pulse performs a Start function.*
3. *The part will begin to play or record after a power-up delay T_{PUD}.*
4. *The part must have $\overline{CE}$ HIGH for a debounce period T_{DB} before it will recognize another falling edge of $\overline{CE}$ and pause.*
5. *The second $\overline{CE}$ LOW pulse, and every even pulse thereafter, performs a Pause function.*
6. *Again, the part must have $\overline{CE}$ HIGH for a debounce period T_{DB} before it will recognize another falling edge of $\overline{CE}$, which would restart an operation. In addition, the part will not do an internal power down until $\overline{CE}$ is HIGH for the T_{DB} time.*
7. *The third $\overline{CE}$ LOW pulse, and every odd pulse thereafter, performs a Resume function.*
8. *At any time, a HIGH level on PD will stop the current function, reset the address counter, and power down the device.*

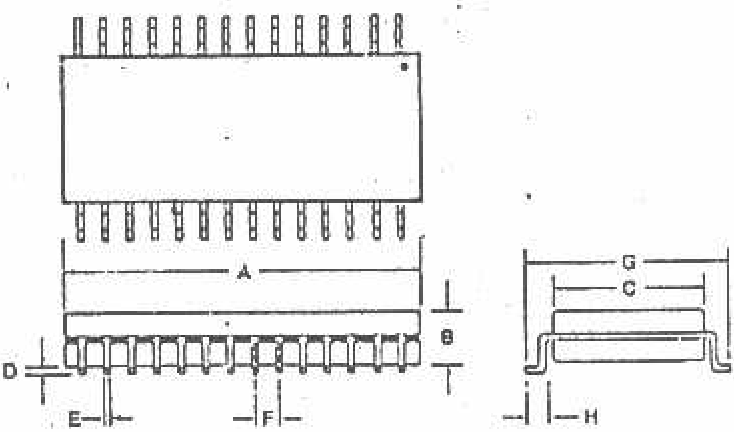
PACKAGE DIAGRAMS

28-Lead Plastic Dual In-Line Package (DIP) Type P



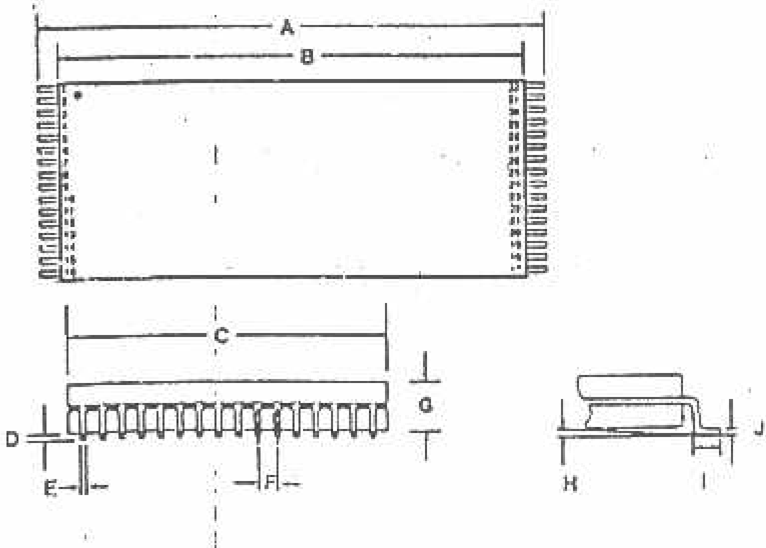
	INCHES			MILLIMETERS		
	Min	Nom	Max	Min	Nom	Max
A	1.445	1.450	1.455	36.7	36.83	36.95
B		.150			3.89	
C1	.600		.625	15.24		15.88
C2	.530	.540	.550	13.46	13.72	13.97
D	1.25	1.30	1.35	2.92	3.05	3.18
E	.125	.130	.135	3.18		3.43
F	.015	.018	.022	0.38	0.46	0.56
G	.055	.060	.065	1.40	1.52	1.65
H		.100			2.54	
θ	0°	7°	15°	0°	7°	15°

28-Lead Plastic Small Outline Package (SOIC) Type J



	INCHES			MILLIMETERS		
	Min	Nom	Max	Min	Nom	Max
A	.706	.714	.718	17.93	18.14	18.24
B	.086	.088	.090	2.18	2.24	2.29
C	.340	.346	.350	8.64	8.79	8.89
D	.004	.007	.010	.102	.178	.254
E	.014	.016	.020	.360	.410	.480
F		.050			1.27	
G	.463	.470	.477	11.76	12.00	12.12
H	.020	.031	.042	.510	.790	1.07

32-Lead Thin Plastic Small-Outline Package (TSOP) Type I



	INCHES			MILLIMETERS		
	Min	Nom	Max	Min	Nom	Max
A	.780	.790	.795	19.80	20.00	20.20
B	.720	.724	.728	18.30	18.40	18.50
C	.307	.315	.323	7.80	8.00	8.20
D	.000	.003	.006	0.00	0.08	0.15
E	.006	.008	.010	0.15	0.20	0.25
F		.0197			0.50	
G	.037	.039	.041	0.95	1.00	1.05
H	0°	3°	5°	0°	3°	5°
I	.016	.020	.024	0.40	0.50	0.60
J	.004	.006	.008	0.10	0.15	0.20

ORDERING INFORMATION

When placing an order for the ISD2500-Series devices, please refer to the following part numbers:

Part No.	Rec/Play Duration	Description
ISD2545P	45 sec.	28-pin plastic dual in-line package (DIP)
ISD2545PI	45 sec.	Industrial Temperature, -40°C to 85°C (DIP)
ISD2545G	45 sec.	28-lead small-outline integrated circuit (SOIC)
ISD2545GI	45 sec.	Industrial Temperature, -40°C to 85°C (SOIC)
'SD2545T	45 sec.	32-lead thin small-outline package (TSOP)
SD2545TI	45 sec.	Industrial Temperature, -40°C to 85°C (TSOP)
SD2560P	60 sec.	28-pin plastic dual in-line package (DIP)
SD2560PI	60 sec.	Industrial Temperature, -40°C to 85°C (DIP)
SD2560PL	60 sec.	Low Voltage, 3.6 V to 4.0 V (DIP)
SD2560G	60 sec.	28-lead small-outline integrated circuit (SOIC)
SD2560GI	60 sec.	Industrial Temperature, -40°C to 85°C (SOIC)
SD2560GL	60 sec.	Low Voltage, 3.6 V to 4.0 V (SOIC)
SD2560GLI	60 sec.	Low Voltage, Industrial Temperature (SOIC)
SD2560T	60 sec.	32-lead thin small-outline package (TSOP)
SD2560TI	60 sec.	Industrial Temperature, -40°C to 85°C (TSOP)
SD2560TL	60 sec.	Low Voltage, 3.6 V to 4.0 V (TSOP)
D2560TLI	60 sec.	Low Voltage, Industrial Temperature (TSOP)
D2560X	60 sec.	Bare unpackaged die
D2575P	75 sec.	28-pin plastic dual in-line package (DIP)
D2575PI	75 sec.	Industrial Temperature, -40°C to 85°C (DIP)
D2575PL	75 sec.	Low Voltage, 3.6 V to 4.0 V (DIP)
D2575G	75 sec.	28-lead small-outline integrated circuit (SOIC)
D2575GI	75 sec.	Industrial Temperature, -40°C to 85°C (SOIC)
D2575GL	75 sec.	Low Voltage, 3.6 V to 4.0 V (SOIC)
D2575GLI	75 sec.	Low Voltage, Industrial Temperature (SOIC)
D2575T	75 sec.	32-lead thin small-outline package (TSOP)
D2575TI	75 sec.	Industrial Temperature, -40°C to 85°C (TSOP)
D2575TL	75 sec.	Low Voltage, 3.6 V to 4.0 V (TSOP)
D2575TLI	75 sec.	Low Voltage, Industrial Temperature (TSOP)
D2575X	75 sec.	Bare unpackaged die
D2590P	90 sec.	28-pin plastic dual in-line package (DIP)
D2590G	90 sec.	28-lead small-outline integrated circuit (SOIC)
D2590X	90 sec.	Bare unpackaged die

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