TUGAS AKHIR

PERENCANAAN DAN PEMBUATAN ALAT PENGEPAKAN OTOMATIS UNTUK GELAS PLASTIK 250 ml BERBASIS MIKROKONTROLLER AT89C51

Disusun Oleh :

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KONSENTRASI TEKNIK ENERGI LISTRIK
JURUSAN TEKNIK ELEKTRO DIPLOMA III
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LEMBAR PERSETUJUAN

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Diajukan Sebagai Salah Satu Syarat Untuk Memperoleh Gelar Diploma Tiga (DIII) Pada Jurusan Elektro Studi Energi Listrik

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Penulis

ABSTRAKSI

Syahfril Asri Subekti, Malang, 01 April 1983, Jurusan Teknik Elektro Diploma Tiga (D III), Program Studi Teknik Energi Listrik, Fakultas Teknologi Industri, Institut Teknologi Nasional Malang, Dosen Pembimbing : Ir. H. Taufik Hidayat. MT

Perencanaan Dan Pembuatan Alat Pengepakan Otomatis untuk Gelas Plastik 250 ml berbasis MIkrokontroller AT89C51

Tujuan dari perancangan dan pembuatan Alat Pengepakan Otomatis pada Gelas Plastik 250 ml ini adalah memberi kemudahan pada manusia dalam melakukan aktifitas kerja. Khususnya bagi pengusaha home industri yang berkecimpung dalam perusahaan air minum dalam kemasan.

System kerja dari alat ini adalah dengan memanfaatkan mikrokontroller AT89C51 sebagai pusat control dalam proses pengisian bahan secara otomatis, pengepakan, dan pembuangan gelas.

Hasil akhir dari perancangan dan pembuatan Alat Pengepakan Otomatis untuk Gelas Plastik 250 ml ini memang masih jauh dari sempurna. Diperlukan daya yang besar dan stabil untuk menyuplai alat agar program tidak meloncat. Pembuatan mekanik harus sepresisi mungkin agar dalam prosesnya tidak ada yang meleset.

Kata Kunci : *Optocoupler, Motor DC, Proximity*

DAFTAR ISI

DAFTAR GAMBAR

DAFTAR TABEL

BAB I

PENDAHULUAN

1.1. Latar Belakang

Dalam perkembangan industri yang semakin pesat sekarang ini, banyak dibutuhkan peralatan yang dapat digunakan secara maksimal sesuai dengan kebutuhan. Oleh karena itu, dibutuhkan suatu peralatan mesin yang sudah ada dan dapat mempermudah kerja maupun proses produksinya. Sebagai contoh adalah penggunaan dan pemanfaatan teknologi tepat guna, pada sektor industri khususnya.

Perguruan tinggi, khususnya di bidang Elektro diharapkan mampu mengembangkan ketrampilan agar dapat meringankan beban manusia dalam menghadapi persaingan yang sangat ketat ini. Oleh karena itu, sangatlah tepat jika digalakkan suatu model industri tepat guna. Dan selain itu, diperlukan sarana yang menunjang, salah satunya adalah alat – alat produksi yang digunakan untuk memproses bahan mentah menjadi bahan jadi. Dalam hal ini, penulis akan mencoba merancang dan membuat sebuah alat yang bisa membantu para pengusaha home industri, dalam hal ini khususnya pengusaha yang skala kecil menengah.

Penulis sangat terinspirasi untuk menciptakan produk yang bermanfaat bagi masyarakat, sehingga dapat menyumbang pemikiran yang merupakan tantangan dalam dunia industri dan pendidikan untuk memberikan solusi bagi pengembangan produksi.

1.2. Rumusan Masalah

Adapun rumusan masalah yang dibahas di dalam pembuatan alat ini adalah sebagai berikut :

1. Bagaimana rangkaian control yang ada di dalam alat tersebut ?
2. Bagaimana jenis motor penggerak yang digunakan ?

1.3. Tujuan

Berdasarkan rumusan masalah tersebut, maka dapat dijelaskan tujuan pembuatan alat, yaitu sebagai berikut :

1. Untuk mengetahui prinsip kerja dari alat Pengepakan Otomatis untuk gelas Plastik 250 ml berbasis Mikrokontroller AT89C51
2. Untuk mengetahui rangkaian kontrol yang ada di dalam alat tersebut
3. Untuk mengetahui jenis motor penggerak yang digunakan

1.4. Batasan Masalah

Agar permasalahan tidak terlalu luas, maka penulis membatasi hanya pada hal-hal berikut:

1. Tidak membahas bahan – bahan penyusun rangka.
2. Tidak membahas Jenis Motor Penggiling
3. Motor Dc hanya digunakan sebagai penggerak sistem pengepres, penggerak meja putar dan pendorong gelas.
4. Alat pengepres ini hanya dirancang khusus untuk gelas plastic berkapasitas 250 ml.

1.5. Sistematika Penulisan Laporan

Sistematika pembahasan dalam proposal ini terdiri dari pokok pembahasan yang saling berkaitan antara satu dengan yang lainnya, yaitu :

BAB I : Merupakan pendahuluan yang berisikan tentang latar belakang, tujuan permasalahan, batasan masalah dan sistimatika pembahasan.

BAB II : Merupakan landasan teori dasar yang menunjang dalam perencanaan sistem kontrol ini.

BAB III : Merupakan pembahasan masalah yang berisikan perencanaan konstruksi alat dan perencanaan kontrol dari alat yang dibuat.

BAB IV : Merupakan analisa yang berisikan tentang deskripsi kerja alat dan rangkaian kontrol.

BAB V : Merupakan bab penutup yang berisikan kesimpulan dan saran-saran

1.6. Metodologi

Untuk mencapai tujuan yang direncanakan dengan hasil optimal, maka dalam pengerjaannya laporan akhir ini dilakukan secara bertahap dengan langkah-langkah sebagai berikut :

1. Studi literature tentang mikrokontroler
2. Survey tentang komponen yang memenuhi
3. Memasukan software ke dalam AT 89C51
4. Pengujian dan perakitan secara menyeluruh
5. Survey dan analisa pada alat terdahulu yang akan dikembangkan.

Adapun hasil survey dan penelitian kami adalah sbb:

Saya merasa alat terdahulu masih memiliki cukup banyak kekurangan, walaupun di dalam segi perancangan, pembuatan dan pengoperasiannya sudah cukup baik.

Kekurangan yang saya analisa dari alat tersebut antara lain:

1. Biaya yang dikeluarkan cukup besar untuk alat yang nantinya akan dipergunakan untuk industri skala kecil-menengah. Alat tersebut masih menggunakan system komunikasi antar relay sebagai rangkaian kontrolnya. Untuk alat ini, relay yang diperlukan cukup banyak, yaitu 26 buah relay. Sedangkan harga relay saat ini cukup tinggi.
2. Kita masih membutuhkan 2 buah timer manual (AC) sebagai pengontrol waktu penggiling bahan yang masih berbentuk padat (belum berbentuk cair), dan sebagai pengontrol waktu untuk proses pengepresan.
3. Mekanik pada alat ini masih belum cukup presisi, sehingga selalu timbul masalah pada meja putar tempat gelas ditempatkan, kondisi poros meja putar tidak

menggunakan metoda yang tepat sehingga sering terjadi gelas tidak berhenti tepat diatas sensor proximity ditempatkan. Apabila hal tersebut terjadi, maka proses pengisian gelas, pengepresan dan pembuangan gelas tidak akan berfungsi secara sempurna. Air yang akan diisikan akan tumpah, proses pengepresan tidak tepat sasaran, dan gelas tidak akan terdorong (proses pembuangan). Meja akan terus berputar sehingga kinerja alat sering tergangu.

Berdasarkan analisa diatas, maka saya akan mencoba merancang dan membuat kembali alat tersebut dengan melakukan beberapa perbaikan dan penyempurnaan antara lain:

1. Untuk rangkaian control, akan diubah dengan menggunakan Mikrokontroller AT89C51 sebagai pusat kontrolnya. Dengan menggunakan Mikrokontroller AT89C51, biaya yang dikeluarkan akan berkurang cukup banyak, karena harga perangkat tersebut cukup murah dipasaran. Kita hanya membutuhkan 1 unit Mikrokontroller AT89C51 beserta minimum systemya, rangkaian driver motor, dan driver pemanas saja.
2. Untuk pengontrol waktu, semuanya bisa diatur dengan program yang diisikan ke MCU. Jadi kita tidak membutuhkan lagi timer manual (AC) sebagai pengontrol waktu di setiap proses.
3. Untuk masalah mekanik, akan dicoba metoda yang tepat sehingga meja putar yang berisi gelas akan bisa berhenti tepat di atas sensor proximity. Dalam hal ini, akan dicoba menambahkan metoda gigi payung yang ditambahkan pada poros (as) meja putar. Ada juga metoda lain, yaitu motor penggerak meja putar akan

diganti dengan motor stepper sehingga putarannya bisa kita atur. (pada alat terdahulu menggunakan motor DC Gear Box sebagai penggerak)

BAB II

DASAR TEORI

Landasan teori sangat membantu untuk dapat memahami suatu sistem. Selain dari pada itu dapat juga dijadikan sebagai bahan acuan di dalam merencanakan suatu sistem. Dengan pertimbangan hal –hal tersebut, maka landasan teori merupakan bagian yang harus dipahami untuk pembahasan selanjutnya. Pengetahuan yang mendukung perencanaan dan realisasi alat meliputi:

2.1. Sistem Mikrokontroller AT89C51

Mikrokrontroller berbeda dengan mikroprosessor karena selain memiliki CPU juga dilengkapi dengan memori dan input-input yang merupakan kelengkapan sistem dalam mikrokomputer dalam keping tunggal *(Single Chip* Mikrokomputer*)* yang dapat berdiri sendiri.

2.1.1. Mikrokontroller AT89C51

Perbedaan mendasar antara mikrokontroller dan mikroprosesor adalah mikrokontroller selain memiliki *CPU* juga dilengkapi dengan memori *input- output* yang merupakan kelengkapan sebagai *system* minimum mikrokomputer sehingga sebuah mikrokontoller dapat dikatakan sebagai mikrokomputer dalam keping tunggal *(single chip Microcomputer*) yang dapat berdiri sendiri.

Mikrokontroller AT89S1 adalah *mikrokontroller* ATMEL yang *kompatibel* penuh dengan mikrokontroller keluarga MCS-51, membutuhkan daya yang rendah, memiliki performa yang tinggi dan merupakan mikrokomputer 8 bit yang dilengkapi 4 Kbyte EPROM (*Erasable and Programable Read Only Memori*) dan 128 byte RAM internal. Program memori dapat diprogram ulang dalam sistem atau dengan menggunakan Program *Nonvolately Memory Konvensional.*

Dalam sistem mikrontroller terdapat dua hal yang mendasar, yaitu: perangkat keras dan perangkat lunak yang keduanya saling terkait dan mendukung. Berikut ini adalah tabel keluarga mikrokontroller MCS- 51, dapat dilihat bahwa mikrokontroller 8031 merupakan *versi* tanpa EPROM dari mikrokontroller 8051.

Tabel 2.1. *Keluarga Mikrokontoller MCS- 51* [1]

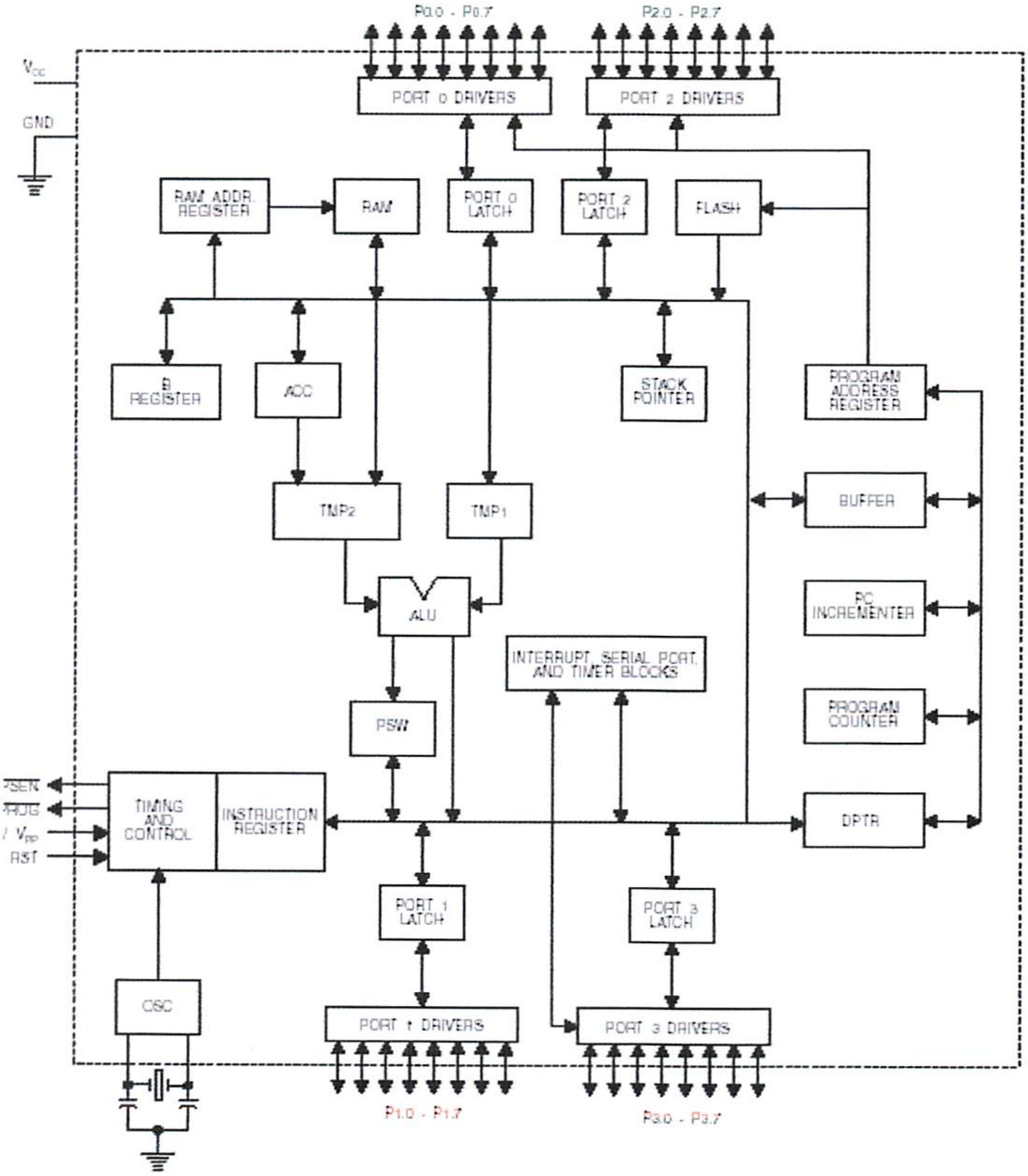
PART NUMBER	ON- CHIP CODE MEMORY	ON CHIP DATA MEMORY	TIMER
8051	4K ROM	128 BYTES	2
8031	0K	128 BYTES	2
8751	4K EOROM	128 BYTES	2
8052	8KROM	256 BYTES	3
8032	0K	256 BYTES	3
8752	8KEPROM	256 BYTES	3
AT89C51	4K EPROM	128 BYTES	2

2.1.2. Arsitektur AT89C51

Sebagai *single chip* yaitu suatu system mikroprosesor yang terintegrasi, mikrokontroller AT89S1 mempunyai konfigurasi sebagai berikut:

1. *CPU* 8 bit termasuk keluarga *MCS*-51.
2. 4 Kbyte alamat untuk *memory program internal* (EEPROM).
3. 128 *byte memory* data dalam (*Internal Data memory*/ RAM).
4. 8 *bit* program status *word* (PSW).
5. 8 *bit stack pointer* (SP).
6. 32 pin I/O tersusun yaitu port 0-port 3 @ 8 bit.
7. 2 buah *timer*/ *counter* 16 *bit.*
8. Data serial *full dupleks.*
9. *Control register.*
10. 5 sumber *interrupt.*
11. Rangkaian *osilator* dan *clock.*

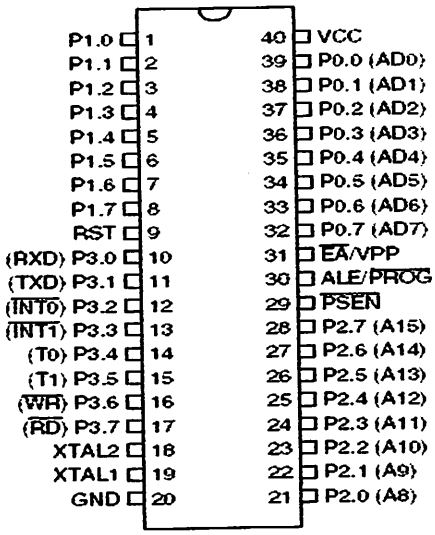
Arsitektur dasar dari mikrokontroller AT89S1 seperti diagram blok berikut ini:



Gambar 2.1. *Blok Diagram AT89C51*

2.1.3 Fungsi Pin Mikrokontroller AT89S51

Susunan *pin-pin* mikrokontroller AT89C51 diperlihatkan pada Gambar 2.2, dan penjelasan dari masing-masing *pin* adalah sebagai berikut:



***Gambar 2.2.** Pin/kaki dari IC AT 89C51*

1. Port 0

Port 0 merupakan port dua fungsi yang berada pada pin 32-39 dari IC AT 89C51 Merupakan port I/O 8 bit dua arah yang serba guna port ini dapat digunakan sebagai ***multlipleks bus*** data dan bus alamat rendah untuk pengaksesan memori eksternal.

2. Port 1

Port 1 merupakan port I/O yang berada pada pin 1-8. Port ini dapat bekerja dengan baik untuk operasi bit maupun *byte*,tergantung dari pengaturan pada *software*.

3. Port 2

Port 2 merupakan port I/O serba guna yang berada pada pin 21- 28, port ini dapat juga digunakan sebagai bus alamat byte tinggi untuk rancangan yang melibatkan pengaksesan *memori* eksternal.

4. Port 3

Port 3 merupakan port I/O yang memiliki dua fungsi yang berada pada pin 10-17, port ini mempunyai multi fungsi, seperi yang terdapat pada Tabel 2.2 berikut:

Tabel 2.2. *Fungsi Alternarif Port 3*[11]

BIT	NAMA	BIT ADDRES	FUNGSI ALTERNATIF
P3.0	RXD	B0H	Penerima data pada port serial
P3.1	TXD	B1H	Pemancar data pada port serial
P3.2	INT0	B2H	Eksternal interupsi 0
P3.3	INT 1	B3H	Eksternal interuposi 1
P3.4	T0	B4H	Input Timer/ counter eksternal
P3.5	T1	B5H	Input Timer / counter
P3.6	WR	B6H	Sinyal pembacaan memori data eksternal
P3.7	RD	B7H	Sinyal penulisan memori data eksternal

5. PSEN (*Programable Store Enable*)

PSEN adalah sebuah sinyal keluaran yang terdapat pada pin 29. Fungsinya adalah sebagai sinyal kontrol untuk memungkinkan mikrokontroller membaca program (code) dari memori eksternal atau dapat dikatakan sebagai sinyal kontrol yang menghubungkan memori *program* eksternal dengan bus selama pengaksesan.

6. ALE (*Address Latch Enable*)

Sinyal output ALE yang berada pada pin 30 fungsinya sama dengan ALE pada mikroprosesor INTEL 8085 atau 8088. Sinyal ALE dipergunakan untuk demultlipleks bus alamat dan bus data. Dan untuk menahan alamat memori eksternal selama pelaksanaan instruksi.

7. EA (*External Acces*)

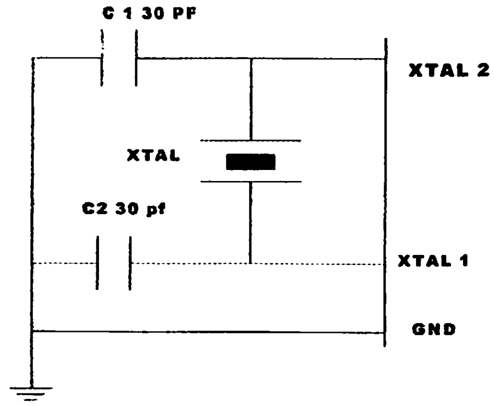
Maksudnya sinyal EA terdapat pada pin 31 yang dapat diberikan logika rendah (ground) atau logika tinggi (+ 5 V). Jika EA diberikan logika tinggi maka mikrokontroller akan mengakses program dari ROM internal (EEPROM/ *flash memori)*.Jika EA diberi logika rendah maka mikrokontroller akan mengakses program dari memori eksternal.

8. RST (*Reset*)

Input *reset* pada pin 9 adalah reset master untuk AT89C51. Perubahan tegangan dari rendah ke tinggi akan merest AT 89C51.

9. Osilator

Osilator yang disediakan pada chip dikemudikan dengan kristal yang dihubungkan pada pin 18 (X2) dan pin 19 (X1) sebesar 12 Mhz.



Gambar 2.3. *Osilator Eksternal AT89C51* [1]

10.Power

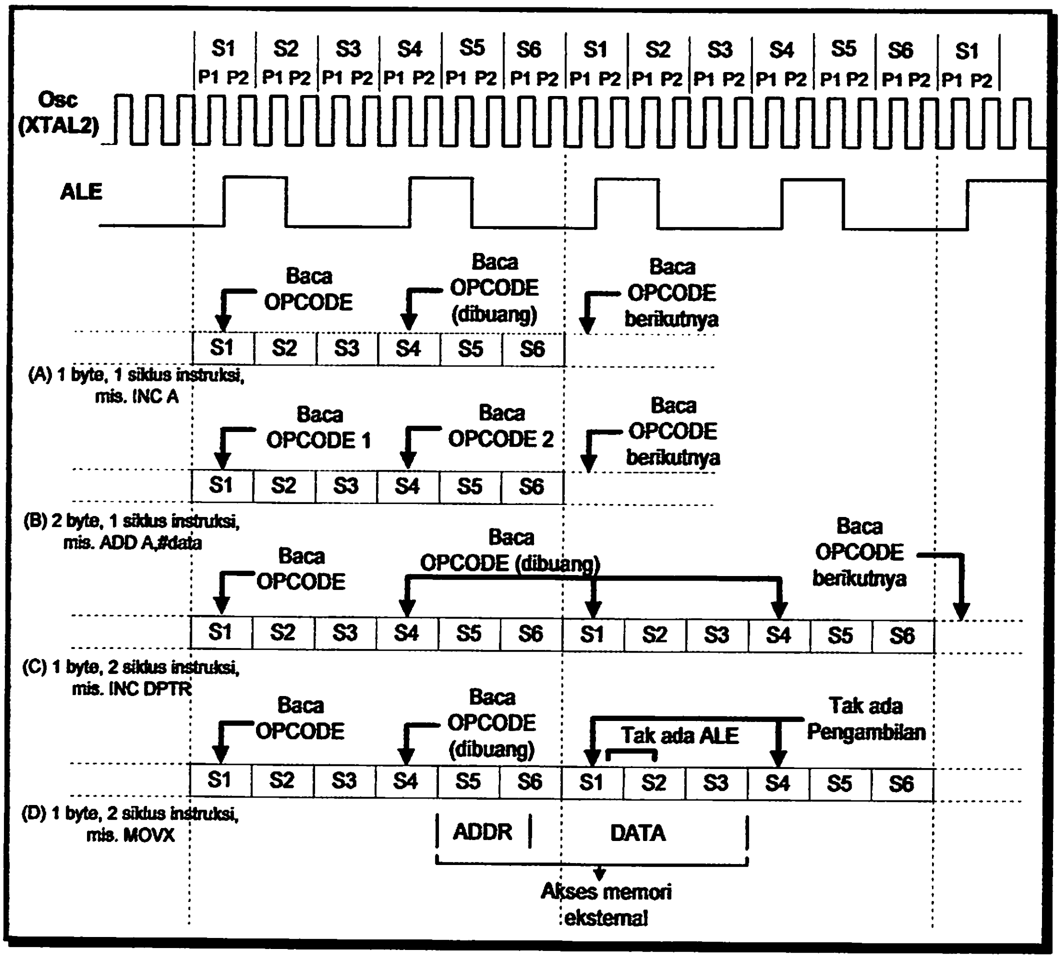
AT89C51 dioperasikan dengan tegangan supply +5v, pin Vcc berada pada pin 40 dan Vss(*ground*) pada pin 20.

2.1.4 Siklus Mesin

Satu siklus mesin terdiri atas 6 kondisi yang berurutan dan diberi nomor S1 sampai S6. Lama waktu untuk masing – masing kondisi adalah sebesar dua periode *oscilatornya*, jadi satu siklus mesin membutuhkan waktu sebesar 12 periode *oscilator* atau sebesar 1 μdetik untuk frekuensi *oscilator* sebesar 12 MHz. Gambar 2.4 menunjukkan kondisi dan tahapan dalam pelaksanaan beberapa macam instruksi.

Pada kondisi normal terjadi dua pengambilan *opcode* dalam satu siklus mesin, walaupun instruksi yang dieksekusi tidak membutuhkannya. Jika instruksi yang dieksekusi tidak membutuhkan opcode lagi, CPU akan mengabaikan pengambilan opcode berikutnya dan cacahan *Program Counter* tidak akan dinaikkan.

Pembacaan memori program eksternal pada mikrokontroller AT89C51 ditandai dengan aktifnya sinyal $\overline{\text{PSEN}}$. Sinyal $\overline{\text{PSEN}}$ normalnya diaktifkan dua kali per-siklus mesin kecuali saat instruksi yang dieksekusi berupa pengaksesan data dari memori data eksternal.



***Gambar 2.4.** Diagram waktu pelaksanaan instruksi MCS®51* [1]

2.1.5 Organisasi Memori

Mikrokontroller *AT89C51 mengimplementasikan* ruang memori yang terpisah antara program (*code*) dan data. Seperti ditunjukkan pada Tabel 2.3, program data keduanya bisa merupakan memori internal, tetapi keduanya dapat diperluas dengan memori eksternal sampai 64 Kb memori program dan 64 Kb memori data.

Memori internal terdiri dari *ROM/* flash memori dan *RAM* data didalam *chip*. *RAM* berisi susunan *general purposes storage, bit addressable storage, register bank dan special function register*. Ruang *internal* pada mikrokontroller AT89C51 dibagi menjadi:

1. *Register* bank (00H-1FH), *bit addressable.*
2. *Bit adresable RAM* (20H-2FH).
3. *General Purpose RAM* (30H-7FH).
4. *Special Fungction register* (80H-FFH).

2.1.6 Timer dan Counter

Mikrokontroller *AT89C51* mempunyai dua buah *timer/ counter* 16 *bit* yang dapat diatur melalui perangkat lunak, yaitu, timer/ *counter* 0 dan timer/ *counter* 1. Periode waktu *timer/ counter* secara umum ditentukan dengan persamaan berikut:

- Sebagai *timer/ counter* 8 bit

T= (255-TLx) *1/(F osc/12)

Dimana *TLX* adalah *register* TLO atau *TL1*

- Sebagai *timer / counter* 16 *bit*

T= (65535-THx TLx)*1 /(Fosc/12)

Dimana :

THx = isi *register* TH0 atau TH1

TLx = isi *register* TLO atau TL1

Pengontrolan kerja timer atau *counter* adalah pada *register timer control* (TCON). Adapun definisi dari bit- bit pada timer control adalah sebagai berikut:

***Tabel 2.3**. Keterangan Register TCON*[1]

Simbol	Posisi	Fungsi
TF1	TCON. 7	Timer 1 *over flow flag*, diset oleh perangkat keras saat *timer/ counter* menghasilkan *over flow*
TR1	TCON. 6	Bit untuk menjalankan *timer* 1. diset oleh *software* untuk membuat *timer ON/OFF.*
TF 0	TCON. 5	*Timer* 0 *over flag*. Diset oleh *hardware*
TR 0	TCON. 4	Bit untuk menjalankan *timer* 0. Diset / clear oleh *software* untuk membuat *timer ON* atau *OFF.*
IE 1	TCON. 3	Eksternal *interupt* 1 *Edge.*
IT 1	TCON. 2	*Interupt* 1 *type control* bit. Diset/ *clear* oleh *software* untuk menspesifikasi sisi turun/ level rendah dari intrupsi eksternal.
IE 0	TCON. 1	Eksternal *interrupt* 0 *edge flaf.*
IT 0	TCON. 0	Interupt 0 *type control bit.*

MSB LSB

TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0

Pengontrolan pemilihan mode operasi *Timer/ counter* adalah register timer mode (TMOD) yang mana definisi *bit-bitnya* adalah sebagai berikut:

MSB LSB

GATE	C/T	M1	M0	GATE	C/T	M1	M0

Keterangan :

GATE : Saat *Trx* dalam TCON diset 1 dan GATE =1, *Timer/ counter* x akan berjalan ketika Trx= 1(timer dikontrol oleh *software*)

C/tT : Pemilhan fungsi *timer* atau *counter*. Clear (0) untuk operasi timer dengan masukan dari sistem *clock internal*. Set (1) untuk operasi counter dengan masukan dari pin TO dan T1.

M1 : Bit pemilih mode 1

M0 : Bit pemilh mode 0

Tabel 2.4. Kombinasi MO dan M1 pada register TMOD[1]

M1	M0	Mode	Operasi
0	0	0	*Timer* 13 bit
1	1	1	*Timer / Counter* 16 bit
1	0	2	*Timer aoto reload* 8 bit (pengisian otomatis)
1	1	3	TLO adalah *timer/ counter* 8 bit yang dikontrol oleh control bit *standart* timer 0. THO adalah *timer* 8 bit dan di kontrol oleh bit *timer* 1

Dibawah ini akan dijelaskan tentang pengertian tentang *mode* yang akan digunakan pada *register* TMOD, sebagai berikut:

- Mode 0

Dalam kode ini *register* timer disusun sebagai *register* 13 bit setelah semua perhitungan selesai, mikrokontroller akan mengeset *timer Interupt Flag* (TF1). Dengan membuat GATE = 1,timer dapat dikontrol oleh masukan liar INT 1,untuk fasilitas pengukuran lebar pulsa.

- Mode 1

Mode 1 sama dengan mode 0 kecuali *register timer* akan bekerja dalam *register* 16-bit.

- Mode 2

Mode 2 menyusun *register timer* sebagai 8-bit counter. Over flow dari TL1 tidak hanya mengeset TF1 tetapi juga mengisi TL1 dengan isi TH 1 yang diatur secara *software*. Pengisian ini tidak mengubah TH1.

- Mode 3

Timer 1 dalam mode 3 semata-mata memegang hitungan. Efeknya sama seperti mengeset TR=0. timer 0 dalam mode 3 menetapkan TL 0 dan TH0 sebagai 2 *counter* terpisah. TL0 menggunakan *control bit timer* 0,yaitu C/T, GATE, TR0, INT0, DAN TF0, TH0 ditetapkan sebagai fungsi *TIMER*.

2.1.7 SFR (*Special Function Register*)

Register internal 8051 tersusun sebagai bagian dari *RAM internal* mikrokontroller. Tentunya setiap *register* mempunyai sebuah alamat. *Special Function Register* (SFR) berjumlah 21 yang terletak pada bagian atas *RAM internal*,yaitu yang beralamat 80H - ffH. Dapat diperlihatkan seperti table berikut ini:

Tabel 2.5. Special Function Register (SFR) [1]

SIMBOL	*NAME*	*ADDRES*
ACC	*ACCUMULATOR*	0E0H
B	*B REGISTER*	0F0H
PSW	*PROGRAM STATUS WORD*	0D0H
IP	*INTERUPT PRIORITY CONTROL*	0B8H
IE	*INTERUPT ENABLE CONTROL*	0A8H
P3	PORT 3	0B0H
P2	PORT 2	0A0H
P1	PORT 1	90H
P0	PORT 0	80H
SBUF	*SERIAL DATA BUFFER*	99H
SCON	*SERIAL CONTROL*	98H
TH1	*TIMER/ COUNTER 1 HIGH CONTROL*	8DH
TH0	*TIMER/ COUNTER 0 HIGH CONTROL*	8CH
TL1	*TIMER/ COUNTER1 LOW CONTROL*	8BH
TL0	*TIMER/ COUNTER 0 LOW CONTROL*	8AH
TMOD	*TIMER/ COUNTER MODE CINTROL*	89H
TCON	*TIMER/ COUNTER CONTROL*	88H
PCON	*POWER CINTROL*	87H
DPH	*HIGH BYTE*	83H
DPL	*LOW BIYTE*	82H
SP	*STACK POINTER*	80H

2.1.8 Program Status Word

Untuk mendefinisikan program status *word* ini dapat dilakukan perbyte maupun secara keseluruhan dari *register* ini, terletak dialamat D0H yang berisi *bit* status. Selengkapnya terdapat pada tabel berikut:

Tabel 2.6. Program Status Word (PSW) [1]

BIT	SIMBOL	*ADDRES*	*BIT DESCRIPTION*
PSW. 7	CY	D7 H	*Carry Flag*
PSW. 6	AC	D6 H	Auxciliaricary Flaf
PSW. 5	F0	D5 H	Flag 0
PSW. 4	RS1	D4 H	*Register bank select 1*
PSW. 3	RS0	D3 H	*Register bank select 0* *00 = bank 0; addresses 00H – 07H* *01 = bank 1; addresses 08 H- 0FH* *10 = bank 2; addresses 10 H- 17 H* *11 = bank 3; addresses 18 H- 1FH*
PSW. 2	0V	D2 H	*Over Flow Flag*
PSW. 1	-	D1 H	*Reserved*
PSW. 0	P	D0 H	*Even Parity flag*

2.1.9 Power Register Control

PCON terletak pada alamat 87 H yang berisi beberapa *bit control* dan dirangkum pada tabel berikut ini.

Tabel 2.7. *Power Control Register*[1]

BIT	SIMBOL	DISKRIPSI
7	SMOD	*Double – baud rate bit*; jika diset maka *baud rate didouble* dan berlaku pada mode serial p[ort 1,2 dan 3
6	-	Tidak didefinisikan
5	-	Tidak didefinisikan
4	-	Tidak didefinisikan
3	GF1	*General purpose flag bit 1*
2	GF2	*General purpose flag bit 0*
1*	PD	*Power down*; kondisi set untuk mengaktifkan mode *power down*, keluar dari mode ini hanya dengan *reset.*
0*	IDL	*Mode idle*; kondisi set untuk mengaktifkan *mode idle*, keluar dari mode ini hanya dengan *interrupt* atau sistem reset

2.1.10 Sistem Interupsi

Mikrokontroller 8051 mempunyai 5 buah sumber interupt yang dapat membangkitkan *interrupt reguest:*

- INT0 : permintaan *interrupt* luar dari kaki P3.2
- INT 1 : Permintaan *interrupt* luar dari kaki P3.3
- *Timer/ counter* 0 : bila terjadi *overflow*
- *Timer/ Counter* 1 : Bila terjadi *overflow*
- Port serial : Bila Pengiriman/ Peneriman satu *frame* telah Lengkap

Saat terjadi *interrupt* mikrokontroller secara otomatis akan menuju ke subrutin pada alamat tersebut. Setelah interrupt service selesai dikerjakan, mikrokontroller akan mengerjakan program semula. Dua sumber merupakan sumber *interupsi eksternal*, INT1. Kedua interupsi eksternal dapat aktif *level* aktif transisi tergantung isi ITO dan IT1. Pada register TCON interupsi timer 1dan timer 0 aktif pada saat *timer* yang sesuai mengalami *rool-over. Interupt* serial dibangkitkan dengan melakukan operasi OR pada R1 dan T1. setiap sumber interupsi dapat *enable* atau *disable* secara *software.*

Tingkat prioritas semua sumber interupsi dapat diprogram sendiri- sendiri dengan *set* atau *clear* bit pada SFR IP (*Interupt Priority).* Interupsi tingkat rendah dapat diinterupsi oleh interupsi yang mempunyai tingkat interupsi yang lebih tinggi, tetapi tidak sebaliknya. Walaupun demikian, interupsi yang tingkat interupsi nya lebih tinggi tidak bisa menginterupsi sumber interupsi yang lain.

2.1.11 Metode Pengalamatan

Metode pengalamatan pada AT 89C51 adalah sebagai berikut:

a. Pengamatan tak langsung : *Operand* pengalamatan tak langsung menunjuk kearah sebuah register yang berisi lokasi alamat memori yang akan digunakan dalam operasi. Lokasi yang nyata tergantung pada isi *register* saat instruksi dijalankan. Untuk melaksanakan pengalamatan tak langsung digunakan symbol @. Berikut ini diberikan beberapa contoh:

ADD A, @ R0	: Tambahan isi RAM yang lokasinya ditunjuk oleh *register* R0 ke akumulator
DEC @R1	: Kurangilah dengan satu, isi RAM yang alamatnya ditunjukan oleh register R1.
MOVX @ DPTR,A	: Pindahkan isi akumullator ke memori luar yang lokasinya ditunjukkan oleh data *pointer* (DPTR).

b.Pengalamatan langsung

Pengalamatan langsung dilakukan dengan memberikan nilai ke suatu register secara langsung. Untuk melaksanakan hal tersebut digunakan tanda #.

Sebagai contoh:

MOVA, # 01 H: isi akumulator dengan bilangan 01 H

MOV DPTR, # 19 ABH: Isi register DPTR dengan bilangan 19AB h

Pengalamatan data langsung dari 0 sampai 127 akan mengakses RAM internal. Sedang pengalamatan dari 128 sampai 255 akan mengakses *register* perangkat keras sebagai contoh:

MOV P3, A : Pindahkan isi akumulator ke alamat data B0 H

(BOH adalah alamat Port 3)

c. Pengalamatan bit

Pengalamatan bit adalah penunjukan alamat lokasi bit baik dalam RAM internal, (byte 32 sampai 47) maupun bit perangkat keras. Untuk melakukan pengalamatan bit digunakan simbol titik misalnya :

SETB 88 H. 6: set bit pad lokasi 88H (Timer 1ON)

d. Pengalamatan kode

Ada tiga macam instruksi yang dibutuhkan dalam pengalamatan kode, yaitu *relative jump, in- blockjump atau call, dan long jump.*

2.2. Relay.

Fungsi dan Macam Relay

Relay adalah suatu perangkat switch (saklar) yang dioperasikan oleh kumparan yang berada di dalamnya. Relay pada umumnya digunakan untuk menyambung atau memutuskan antara suatu bagian yang lain dalam suatu rangkaian elektronik, selain itu juga dimaksudkan untuk mengisolasi switching antara catu daya tinggi dan catu daya rendah. Kerugian yang ditemui pada relayyaitu adanya tanggapan pada respon (response time) saat on ataupun off relative lambat serta adanya efek induksi balik sesaat setelah relay off.

Pada relay terdapat beberapa susunan kontak :

1. Normal terbuka (Normaly Open)

   Kontak kontak tertutup pada saat relay dioperasikan atau ada arus kuat melalui kumparan.

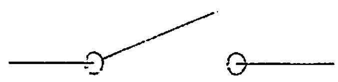
2. Normal tertutup (Normaly Close)

   Kontak – kontak terbuka saat relay terbuka saat relay dioperasikan atau ada arus yang kuat melalui kumparan.

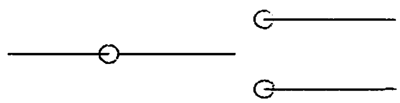
Cara kerja relay pada dasarnya adalah apabila ada arus yang masuk melalui kumparan maka pada kumparan akan terjadi induksi magnetic. Induksi magnetic tersebut nantinya akan menarik pegas kontak untuk merubah posisi awalnya menjadi terhubung kebagian yang diinginkan. Setalah arus berhenti maka tidak terjadi induksi sehingga kontak akan kembaki ke posisi awal.

Macam – Macam Relay

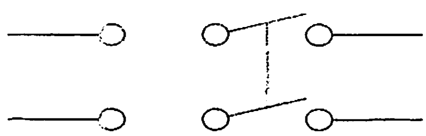
1) Single Pin Single Terminal (SPST)



2) Single Pin Dual Terminal (SPDT)



3) Dual Pin Dual Terminal (DPDT)

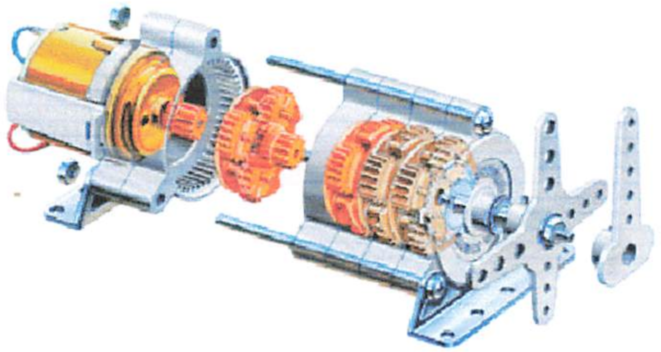


***Gambar 2.5.*.** Gambar Jenis Kontak pada Relay

2.3. Motor DC

Magnet permanent yang dibentuk mengikuti bagian dalam rangka motor. Kedua magnet ini bersama-sama mengimbaskan medan magnet, sehingga dihasilkan medan magnet yang kuat dibagian tengah motor. Mengalirnya arus didalam suatu kawat akan menimbulkan gaya. Gaya ini yang akan menggerakkan rotor sampai arah gayanya sejajar. Motor DC terdiri atas suatu gulungan yang dialiri arus listrik dan ditempatkan dalam suatu medan magnet sehingga gulungan kawat ini akan mengalami gaya yang sebanding dengan arus dan kekuatan medan magnetnya. Arah gaya membentuk sudut siku-siku terhadap arus dan arah medan magnetnya dibalik. Sifat ini memungkinkan motor-motor tertentu dapat berputar dengan arus DC maupun AC

Pada motor dengan medan magnet permanent, medan magnetnya dihasilkan oleh suatu atau beberapa magnet permanent. Magnet-magnet ini digenggam oleh penggeggam besi atau baja, atau kadang-kadang oleh rangka motor itu sendiri. Magnet ini merupakan bagian dari motor yang diam yang disebut *Stator*. Kawat yang menghasilkan arus listrik digulung pada bagian motor yang berputar yang disebut *Rotor*. Umumnya *Rotor* dibuat menjadi 3 kutub kumparan, disekelilingnya dipasang dua buah mengarah medan magnet. Pada keadaan demikian, *Rotor* akan tetap diam dan tidak akan berputar lagi, akan tetapi sekarang arusnya dihubungkan kesalah satu kumparan lainnya, maka *Rotor* akan bergerak kembali sampai berada pada posisi yang baru. Pada motor DC jika kutub positif dan negatifnya dialiri arus secara terbalik, maka arah putaran akan terbalik atau berlawanan. [13]



Gambar 2 .6.

Salah satu contoh Motor DC Gear Box

Motor adalah suatu alat yang mengubah energi listrik menjadi energi mekanik

2.4. Sensor Proximity

Sensor Proximity disebut juga sensor kedekatan. Sensor ini, terdiri dari alat alat elektronik solid – state yang terbungkus rapat untuk melindungi terhadap pengaruh getaran, cairan kimia dan korosif berlebihan yang sering dijumpai pada lingkaran perindustrian. Sensor proximity digunakan karena beberapa alas an di bawah ini :

1. Objek yang dideteksi terlalu kecil, terlalu ringan atau terlalu lunak untuk dapat mengoperasikan mekanis saklar.
2. Diperlukan respon yang cepat dan kecepatan penghubungan yang tinggi seperti pada pemakaian perhitungan atau sitem kendali.
3. Objek harus dirasakan melalui rintangan non logam seperti : gelas, plastic dan kertas karton.
4. Diperlukan ketahanan umur pelayanan dan kehandalan pelayanan,
5. Sistem pengendali elektronis cepat menghendaki sinyal input.

Ada 3 (tiga) macam sensor proximity antara lain :

- **Induktif**

  Sensor ini dapat merasakan objek bersifat logam. Jenis ini sering digunakan, karena ukurannya kecil, mempunyai ketahanan yang tinggi dan harganya relatif murah.

  Catu daya DC digunakan untuk membangkitkan sinyal AC internal coil yang mengakibatkan medan magnet. Apabila tidak ada material yang bersifat konduktif di lingkungan sekitar medan magnet, maka hanya impedansi internal saja yang dirasakan. Sebaliknya jika ada material konduktif maka ada resultan yang naik dalam impedansi di sensor proximity. Sehingga sensor ini dapat mendeteksi apabila ada kenaikan impedansi yang mengakibatkan arus internal AC menurun.

Osilator adalah rangkaian elektronis untuk membangkitkan bentuk gelombang AC dan frekwensi dari sumber energi DC. Ketika energi diberikan, osilator membangkitkan medan frekwensi tinggi. Pada saat itu harus tidak ada bahan konduktif apapun pada medan frekwensi tinggi arus Eddy akan terinduksi pada permukaan target. Hal ini mengakibatkan kerugian energi pada rangkaian osilator sehingga menyebabkan lebih kecilnya amplitude osulasi. Rangkaian detector merasakan perubahan beban spesifik pada amplitude dan mengakibatkan sinyal yang akan menghidupkan atau mematikan output elektronik. Apabila objek logam meninggalkan wilayah sensor, osilator membangkitkan lagi membuat sensor kembali ke status normal.

- **Kapasitif**

Sensor jenis ini merasakan bahan yang bersifat konduktif dan non konduktif seperti kayu, plastic, cairan gula, tepung dan sebagainya. Prinsip kerja sensor proximity jenis kapasitif hamper sama dengan sensor jenis induktif. Hanya saja ketika arus AC tidak menggerakkan koil, maka arus tersebut digunakan untuk pegisian kapasitor. Ketika objek berada pada jarak tertentu, maka akan terimbas oleh pengisian plat kapasitor internal. Hal ini akan direspon baik oleh sensor, sensor akan mengalirkan arus ke dalam atau keluar dari plat internal.

➢ **Optical**

Prinsip kerja sensor ini sama dengan sensor kapasitif. Sensor ini banyak digunakan pada sistem – system otomatis. Sensor proximity optical ini dibagi menjadi 2 (dua) type yaitu :

1. Trough Beam adalah jenis yang mendeteksi objek yang diblok cahaya seperti misalnya sensor cuaca, air dalam botol dan sebagainya.
2. Retroflective Beam adalah jenis yang memiliki transmitter dan receiver dalam satu paket. Misalnya digunakan pada sensor bantuan untuk tuna netra, radar sederhana dan sebagainya.

Gambar 2 .7.

Salah satu contoh Sensor Proximity

2.5. Triac (Transistor Active Current)

Transistor Active Curren (TRIAC) adalah komponen semikonduktor yang beroperasi seperti dua SCR dengan anoda-katoda terhubung. Sebuah triac terdiri atas dua dioda perarel yang dihubungkan pada arah yang berbeda dengan sebuah gerbang. Perbedaan utama antara triak dan SCR adalah dapat mengahantarkan arus tanpa memperhatikan polaritas tegangan dan keadaan bias pemicu yang diberikan pada gerbang. Karena tidak ada lagi terminal anoda dan katoda maka terminal pada triac disebut dengan terminal utama *(main terminal)* MTI dan MT2.

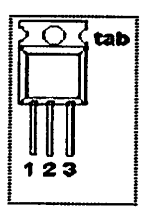
TRIAC menjadi aktif dengan memberikan teganan positif atau negatif pada gerbangnya. Seperti SCR, jika sebuah triac telah menjadi aktif, gerbang tidak dapat mematikan triac. Triac juga dikomutasi dengan menurunkan arus penahan dibawah nilai minimumnya. Kerugian yang utama pada triac dibanding dengan SCR adalah kemampuan menghantarkan arus yang kecil. Kebanyakan triac hanya dapat mengalirkan arus maksimum kurang dari 40A dan tegangan maksimum sebesar 600V. Dalam perencanaan dan pembuatan alat ini TRIAC digunakan sebagai rangkaian driver AC dan tipe TRIAC yang digunakan adalah BT139 yang memiliki deskripsi sebagai berikut:

Gambar 2.8. Deskripsi TRIAC (pin, bentuk fisik dan simbol)

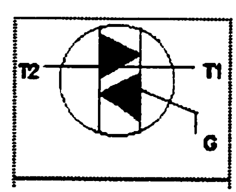
Tabel PIN TRIAC

PIN	DESCRIPTION
1	Main terminal 1
2	Main terminal 2
3	Gate
tab	Main terminal 2

Bentuk Fisik TRIAC



Simbol TRIAC



Sumber : Perencanaan

2.5.1 Keunggulan TRIAC

Dalam penggunaannya TRIAC memiliki beberapa keunggulan antara lain sebagai berikut:

- TRIAC lebih luwes dan sederhana dalam pemakaiannya.
- Banyak ragam terapanya, termasuk pengemudian daya AC
- Triac memungkinkan pengemudian arus yang relatif besar, dari sumber berdaya kecil.
- Tidak terjadi bentuk kontak
- Triac menggrendel setiap peruh daur tegangan bolak-balik
- Triac selalu membuka pada arus nol, karenanya:
  - Tidak terjadi pembusuran atau kilasan tegangan oleh tegangan induksi dari beban ataupun dari jaringan listrik.
  - Tambahan komponen-komponen eksternal sangat minim kalau dibandingkan terhadap jenis-jenis saklar setengah penghantar yang lain.
- Pada umumnya kekalang triac adalah sama seperti kekalang *thystor* lainnya
- Struktur bengunan Triac dan lambangnya sederhana
- Daerah langsung antara MT1 dan MT2 berupa jajaran sekelar p-n-p-n dan n-p-n-p.
- Lambang terdiri dari lambang SCR yang dikombinasi dengan lambang SCR komplementer.
- Triac tidak kenal istilah "anoda" dan "katoda" melainkan dengan angka-angka: MT2 dan MT1 (*MT= Main terminal*)

- Terminal MT1 merupakan titik acuan untuk pengukuran arus dan tergangan diterminal pintu (*gate*) dan terminal MT2.

2.6 Transistor

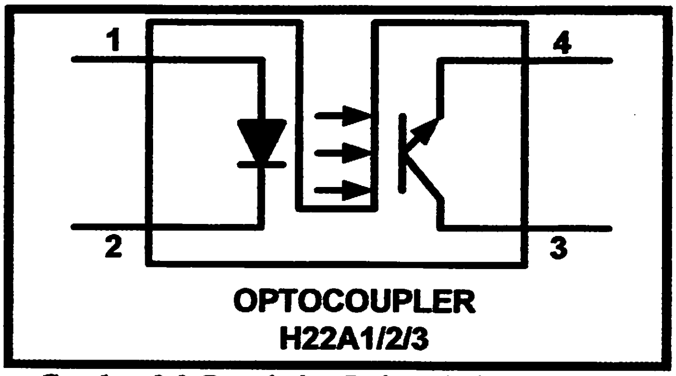
Transistor merupakan sebuah komponen semikonduktor yang banyak dgunakan pada berbagai rangkaian elektronika sebagai saklar, pengua dan lain-lain. Asas kerja dari transistor adalah akan ada arus yang mengalir diantara terminal-terminal kolektor-emitor (Ic) apabila ada arus yang mengalir diantara terminal basis-emitor (Ib). perbandingan antara kuat arus Ic dan kuat arus Ib disebut "bandingan/ hantaran arus maju" (*Forward Current Transistor Ration atau disingkat Hfe),* adapun rumus Hfe sebagai berikut:

$$Hfe = Ic / Ib$$

Jadi transistor harus dioperasikan didaerah linear agar diperoleh keluaran sinyal yang tidak cacat (distorsi). Untuk dapat mengopersikannya secara tepat maka pengertian tentang karakteristik, titik kerja, disipasi daya transistor, dan rangkaian bias (adalah yang menyebutkan dengan pra tegangan, tegangan kerja awal) amatlah penting dan harus dipahami dan dimengerti secara benar.

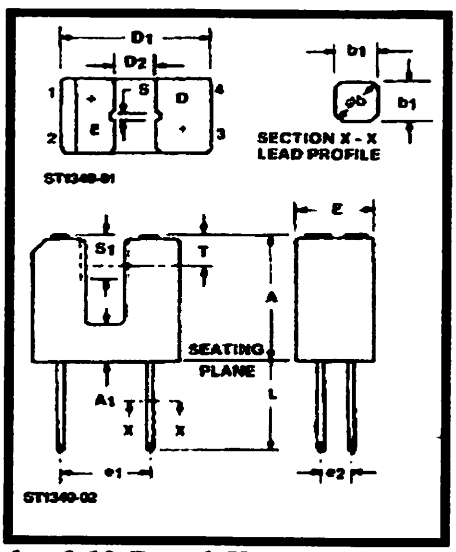
2.7. Ouptocoupler

Pada perencanaan Alat Pengepakan Otomatis Pada Gelas Plastik 250 ml ini, menggunakan Sensor yang terdiri dari Infra Red sebagai Transmitter dan Foto Dioda sebagai Receiver. Sensor ini berfungsi sebagai pembatas maksimun dan minimum gerakan motor DC



.Gambar 2.9. Rangkaian Dalam dari Optocoupler

Prinsip kerja dari sensor ini adalah apabila ada aliran arus yang melewati led, maka led tersebut akan menyala. Cahaya yang dipancarkan led tersebut dipakai sebagai tegangan catu. Pengoperasian sensor ini ada dua macam, yaitu aktif tinggi dan aktif rendah.



Gambar 2.10. Bentuk Kemasan Optocoupler

Pada operasi aktif tinggi, output diambil dari kaki emitor sedangkan operasi aktif rendah, output diambil dari kaki kolektor. Keunggulan dari sensor ini adalah:

- Kecepatan operasi yang tinggi.
- Ukuran dimensi yang kecil.
- Tahan benturan/goncangan dan getaran.
- Tidak mempunyai bagian yang bergerak sehingga tidak saling melekat.
- Kompatibel dengan banyak rangkaian logika dan mikroprossesor.
- Respon frekwensi sampai dengan 100 Khz.

2.8. Transformator

Transformator adalah suatu alat listrik yang dapat memindahkan dan mengubah energi listrik dari satu atau lebih rangkaian listrik yang lain, melalui suatu gandengan magnet dan berdasarkan induksi elektromagnet. Transformator digunakan secara luas, baik dalam bidang tenaga listrik maupun elektronika. Penggunaan transformator dalam sistem tenaga memungkinkan terpilihnya tegangan yang sesuai, dan ekonomis untuk tiap-tiap keperluan.

Dalam bidang elektronika, transformator digunakan antra lain sebagai gandengan impedensi antara sumber dan beban, untuk memisahkan satu rangkaian dari rangkaian lain dan memebuat arus searah sambil tetap melakukan atau mengalirkan arus bolak balik antara rangkaian. Berdasarkan frekuesi, tranformator dapat dikelompokkan sebagai berikut :

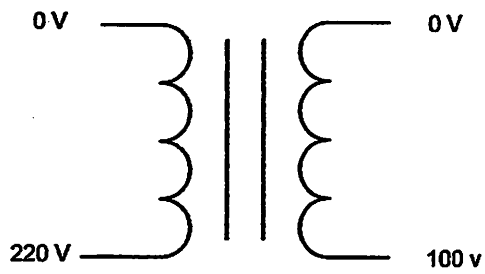
1. Frekuesi daya 50 – 60 c/s
2. Frekuensi pendengaran 50 c/s – 20 kc/s
3. Frekuensi radio diatas 30 kc/s

Dalam bidang tenaga listrik pemakaian transformator dikelompokkan menjadi :

1. Transformator daya
2. Transformator distribusi
3. transformator pengukuran yang terdiri atas tranfomator arus dan transormator tegangan.

Kerja transformator yang berdasarkan induksi elektromagnet, menghendaki adanya gandengan magnet antararangkaian magnet antara rangkaian primer dan sekunder. Gandengan magnet inti besi tempat untuk melakukan fluks bersama.

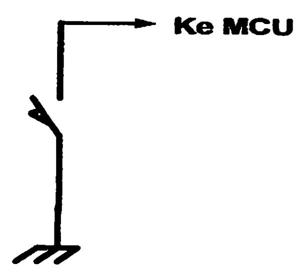
Berdasarkan cara melilitkan kumparan pada inti, dikenal dua macam tranformator, yaitu tipe inti dan tipe cangkang.



Gambar 2.11. *Transformator Step down*

2.9 Limit Switch

Limit switch adalah sensor yang digunakan pada pendeteksi limit dari perubahan mekanik. Limit dari sebuah perpindahan dapat dideteksi dengan menggunakan kontak mekanik yang sederhana untuk menutup pulsa sirkuit atau trigger . Oleh sebab itu maka informasi yang diberikan oleh Limit switch hanyalah dua jenis (*on/off* , ada/tidak) dan dapat dinyatakan dalam satu bit. Dalam hal ini, *Limit switch* terdapat dalam transduser digital . penambahan logic diperlukan apabila *direction contact* diperlukan . *Limit switch* tersedia baik untuk perpindahan rectilinear dan angular . *Mikroswitch* adalah *switch solid state* yang dapat digunakan sebagai *Limit switch. Mikroswitch* biasanya digunakan pada operasi perhitungan , sebagai contoh untuk perhitungan dari kelengkapan produk pada sebuah rumah usaha. Meskipun *mechanical device* terdiri dari persambungan, roda gigi, *ratchet wheels* dan *pawls* , dan *so forth* , dapat digunakan sebagai sebuah *limit switch* , *electrical* dan *solid state switches* biasanya diutamakan untuk ketelitian, daya tahan, syarat gaya rendah (*practical zero*), harga rendah dan ukuran kecil . Beberapa sensor setara dapat digunakan sebagai elemen dari *Limit switch* . sinyal sensor setara digunakan pada *required manner* , sebagai contoh untuk mengaktifkan *counter* , *mechanical switch* , relay sirkuit, atau sebagai input pada sebuah kontrol komputer.



Gambar 2.12. Gambar Limit Switch

BAB III

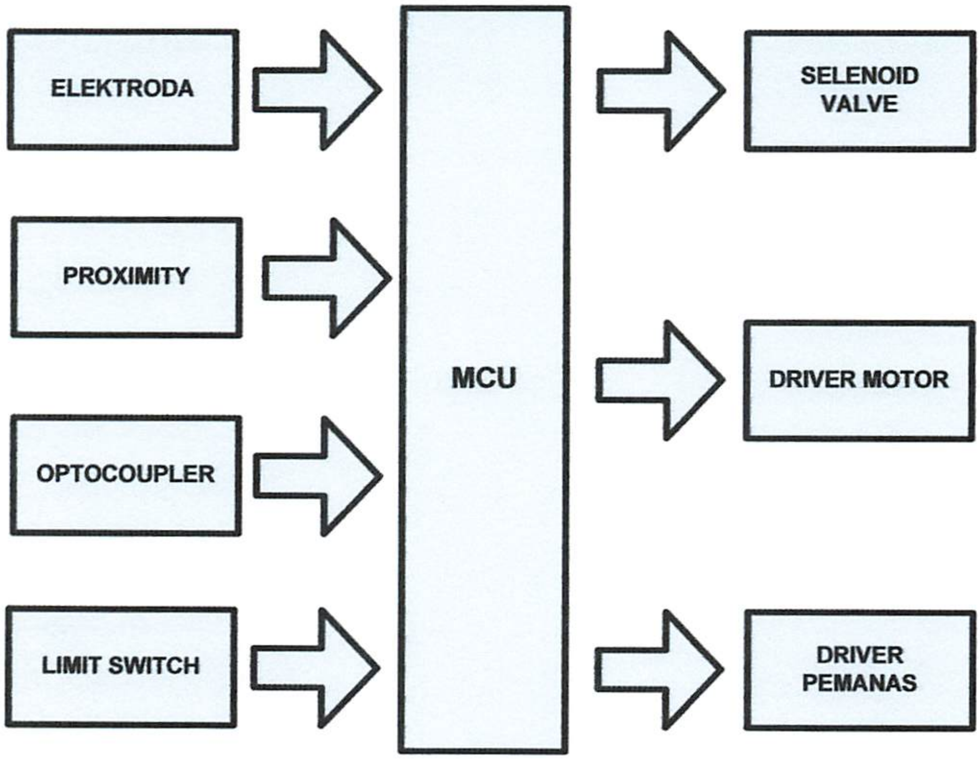
PERENCANAAN DAN PEMBUATAN ALAT

3.1. Pendahuluan.

Perencanaan ini dibagi menjadi 2 bagian yaitu perencanaan perangkat keras (*hardware*) dan perangkat lunak (*software*).

3.2 Perencanaan Perangkat Keras (*Hardware*).

Alat ini dibuat untuk membantu dan mempermudah pengusaha home industri,dalam hal ini khususnya pengusaha yang mengepak hasil produksinya secara otomatis, khususnya dalam hal kemasan. Dalam hal ini, kerja rangkaian kontrol dapat memepercepat dan menyempurnakan proses penghancuran bahan, pengisian gelas dan pengepresan (penutupan gelas dengan plastik). Berdasarkan hal diatas perangkat keras alat ini terdiri dari unit Sensor Proximity, Motor DC, dan Pemanas. Berdasar daftar perangkat keras di atas dapat digambarkan diagram blok alat seperti berikut:

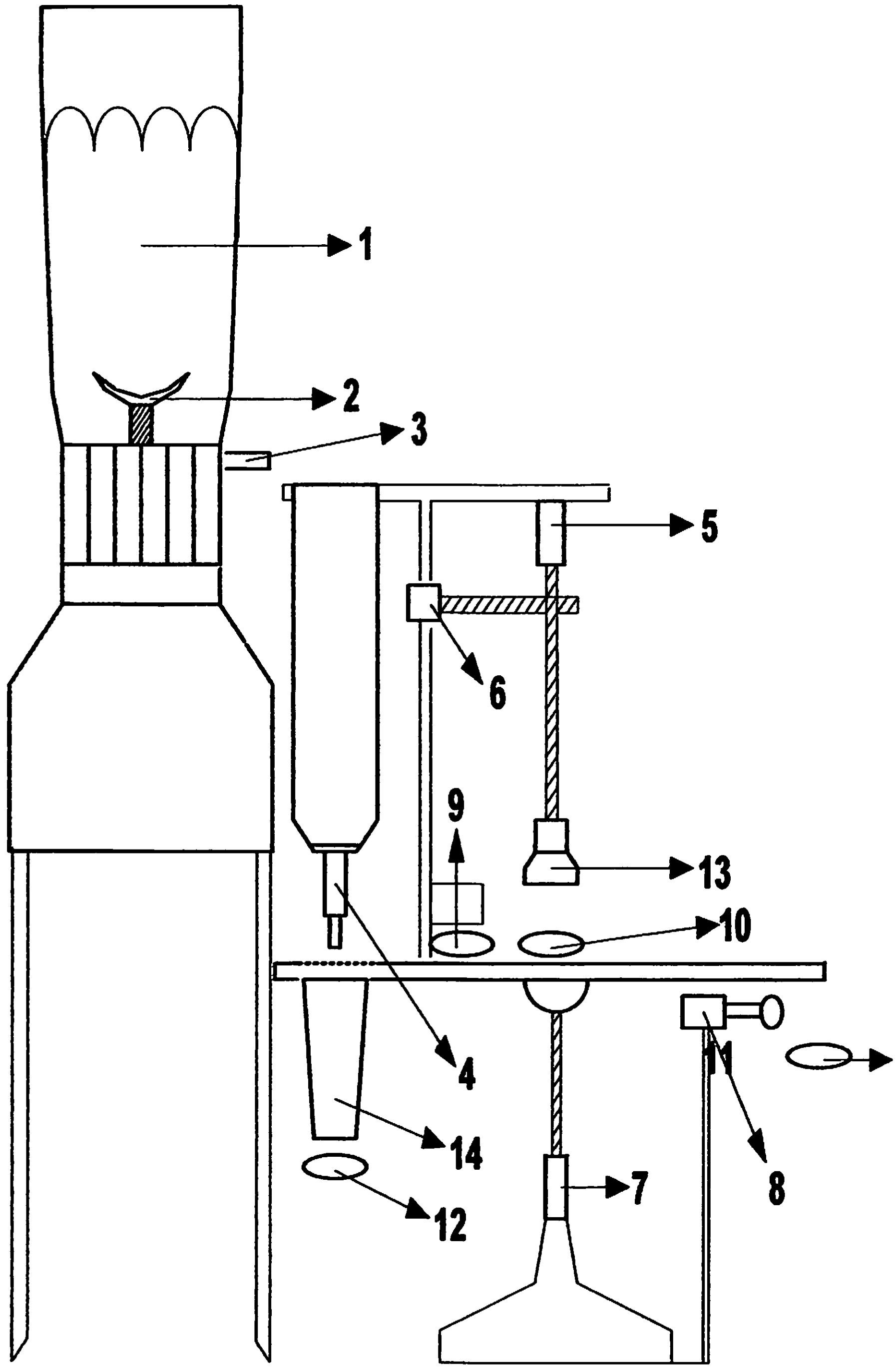


Gambar.3.1

Diagram Blok Rangkaian Alat Pengepakan Otomatis untuk Gelas Plastic 250 ml berbasis Mikrokontroller AT89S51

Fungsi dari masing-masing blok secara umum dijelaskan sebagai berikut :

- Mikrokontroller AT89S51, merupakan bagian utama dari keseluruhan system, unit ini berfungsi mengolah data yang masuk dan mengendalikan kerja dari system.
- Sensor Proximity, digunakan untuk mendeteksi ada atau tidaknya gelas.
- Motor DC 1, berfungsi untuk mendorong tuas yang telah dipasang pemanas, yang berfungsi untuk menutup gelas dengan plastik.
- Motor DC 2, berfungsi untuk mengambil plastik yang telah disiapkan sebagai media penutup gelas.
- Motor DC 3, ditempatkan di bawah meja yang telah dirancang bisa berputar, motor ini berfungsi sebagai pemutar meja.
- Motor DC 4, pada akhir proses Motor ini berfungsi sebagai pendorong gelas yang telah selesai dikemas ke tempat penampungan terakhir.
- Selenoid Valve, berbentuk seperti kran otomatis, alat ini bekerja apabila mendapat tegangan, katup yang ada di dalam akan terbuka, apabila tegangan terputus, maka katup akan tertutup. Alat ini berfungsi sebagai media yang mengalirkan bahan yang telah dihancurkan/ digiling ke dalam gelas.
- Pemanas, alat ini berfungsi sebagai media yang menghantarkan panas dan merekatkan plastic penutup yang telah disiapkan ke ujung gelas.



Gambar 3.2. Prototype Alat

Keterangan Gambar

1. **Bahan yang akan dikemas**
2. **Pisau Blender**
3. **Slang**
4. **Selenoide Valve 2**
5. **Motor DC 1**
6. **Motor DC 2**
7. **Motor DC 3**
8. **Motor DC 4**
9. **Sensor Proximity 1**
10. **Sensor Proximity 2**
11. **Sensor Proximity 3**
12. **Sensor Proximity 4**
13. **Koil Pemanas**
14. **Gelas**

3.3 Cara Kerja Alat.

Untuk memulai proses pengepressan dengan alat ini, kita terlebih dahulu harus menyiapkan bahan yang akan dimasukkan dalam gelas dalam keadaan sudah lunak atau matang, sehingga tidak terlalu keras dan memudahkan proses penggilingan/ penghancuran. Bahan harus kita pastikan steril dan siap untuk dikonsumsi, karena alat ini hanya berfungsi membantu dalam hal penggilingan dan pengemasan.

Pada awal proses, bahan makanan/ minuman yang sudah kita masukkan ke gelas penampung akan digiling/ dihancurkan oleh pisau yang digerakkan oleh motor AC 1 Phasa. Untuk lebih mudahya dalam perancangan perangkat ini, kita menggunakan Blender yang sudah tersedia di pasaran.

Proses selanjutnya, setelah kita setting di rangkaian kontrol waktu penggilingannya, bahan sudah tersaring secara otomatis, karena didalam gelas sudah ditempatkan penyaring yang akan menahan ampas bahan yang akan dikemas. Ketika waktu penggilingan sudah terpenuhi, Selenoid Valve yang telah dipasang di dasar gelas penampung akan mendapat tegangan sehingga katup di dalamnya akan terbuka dan mengalirkan bahan yang sudah tersaring ke dalam gelas yang telah disiapkan di bibir meja.

Proses pengisian gelas ini juga diatur oleh timer, sebelumnya telah dilakukan percobaan, berapa lama waktu yang diperlukan agar gelas dapat terisi penuh. Setelah waktu yang telah disetting terpenuhi dan gelas telah terisi penuh, arus yang mengalir ke Selenoid Valve akan terputus dan akan menutup katupnya secara otomatis. Pada proses pengisian gelas ini, sensor Proximity terlebih dahulu bekerja dengan mendeteksi ada atau tidaknya gelas di bibir meja. Apabila sensor mendeteksi adanya gelas maka proses ini dapat bekerja, apabila tidak ada gelas, proses otomatis akan berhenti.

Ketika proses pengisian telah selesai, Motor DC yang dipasang di poros meja, akan menggerakkan meja secara memutar menuju tempat proses penutupan gelas dengan plastik yang telah disiapkan. Pada proses ini, Sensor Proximity yang telah dipasang juga akan mendeteksi ada atau tidaknya gelas. Apabila sensor sudah mendeteksi adanya gelas, tuas yang digerakkan oleh Motor DC akan bergerak turun untuk mengambil plastik penutup yang telah disiapkan, kemudian akan bergerak maju dan turun lagi menuju gelas untuk memulai proses penutupan. Tuas ini sudah dipasang pemanas yang berfungsi untuk merekatkan plastik ke bibir gelas, agar tidak lengket di dalam prosesnya, pemanas telah dilapisi dengan logam kuningan dan teflon. Proses ini juga dikontrol dengan timer, yang sebelumnya juga telah dilakukan percobaan berapa lama waktu yang diperlukan untuk merekatkan plastik penutup ke bibir gelas.

Setelah proses penutupan ini selesai, meja akan kembali berputar menuju proses akhir yaitu pendorongan gelas yang akan digerakkan oleh Motor DC. Motor DC hanya berfungsi mendorong gelas agar lepas dari bibir meja dan jatuh menuju tempat penampung.

3.4. Perencanaan Masing-Masing Blok Diagram Sistem

Perencanaan masing-masing blok diagram sistem terdiri dari perencanaan Rangkaian Kontrol, dan beberapa rangkaian pendukung seperti, rangkaian Sensor Proximity, Rangkaian Sensor Optocoupler, Sensor Limit Switch dan Driver Motor DC

3.4.1. Sensor Optocoupler

Sensor ini, dalam perancangan digunakan untuk membatasi gerak tuas yang dalam alat ini berfungsi sebagai bagian dari proses pengepresan. Perangkat sensor optic ini terdiri dari 2 bagian yaitu pemancar dan penerima. Sebagai pemancar akan digunakan LED infra merah, sedangkan penerima atau pendeteksi cahaya adalah Photodioda. Kedua komponen ini juga tersedia dipasaran dalam suatu kemasan khusus (Optocoupler).

Photodioda jika menerima sinar dari infra LED maka pada kolektor dan emitor berada dalam keadaan saturasi, dan pada saat photodioda tidak terkena cahaya maka keadaan kolektor dan emitor dalam keadaan cut off.

Unit masukan ini menggunakan sensor optik dan tahanan dengan masukan DC pada power supply. Data mengenai sensor optik dapat dilihat dalam gambar 3.3 dibawah ini, untuk menyalakann led diperlukan Vled sebesar 1,5 Volt dan arus sebesar 20mA. Untuk mendapatkan arus dan tegangan yang sesuai maka besarnya tahanan yang digunakan dapat dihitung :

Untuk menentukan besarnya R_1 dapat dihitung dengan menggunakan rumus :

$$R1 = \frac{Vcc - Vd}{If}$$

Dalam perancangan ini besarnya I_f adalah sebesar 20 mA dan besarnya V_{cc} adalah sebesar 5 V. Dengan I_f sebesar 20 mA, maka besarnya tegangan maju dioda (V_f) sebesar 1,2 V. Maka besarnya R_1 dapat ditentukan, yaitu :

$$R1 = \frac{5 - 1,2}{20mA} = 190 \cong 180\Omega$$

untuk menghitung besarnya R_2 maka :

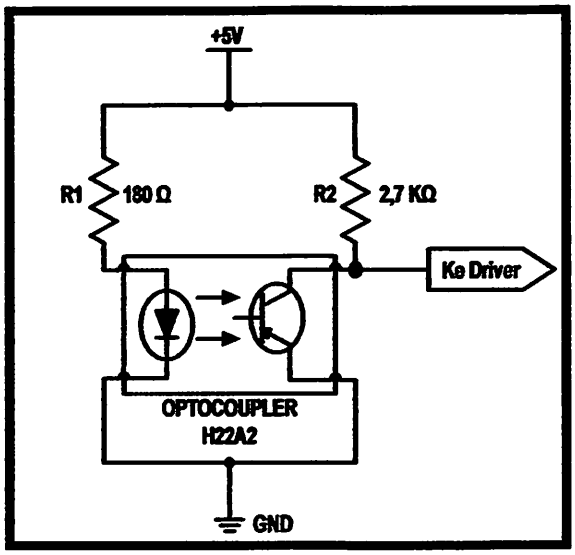
$$R1 = \frac{Vcc - Vce}{Ic}$$

Dalam perancangan ini besarnya I_c bergantung pada besarnya I_f sebesar 20 mA maka besarnya $I_c =$ 1,8 mA dan besarnya $V_{ce} = 0,4$ volt. Maka nilainya R_2 dapat ditentukan

:

$$R2 = \frac{5 - 0,4}{0,0018} = 2555,55\Omega$$

maka resistor yang digunakan sebesar 2K7Ω

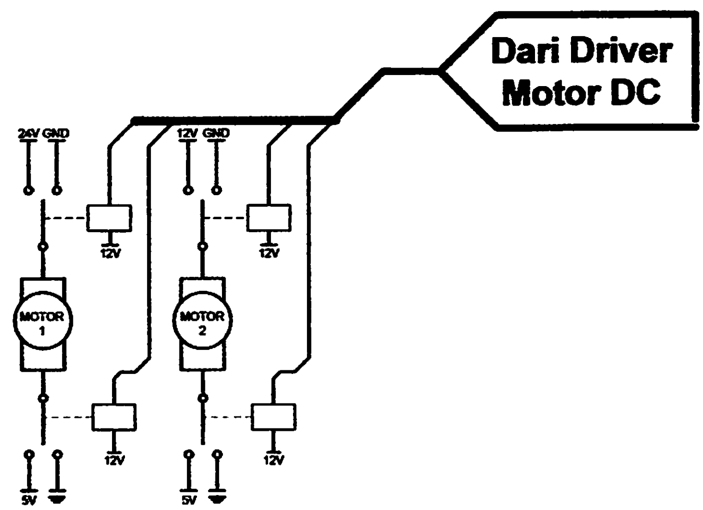


Gambar 3.3. *Gambar Rangkaian Sensor Optocoupler*

3.4.2. Motor DC

Magnet permanent yang dibentuk mengikuti bagian dalam rangka motor. Kedua magnet ini bersama-sama mengimbaskan medan magnet, sehingga dihasilkan medan magnet yang kuat dibagian tengah motor. Mengalirnya arus didalam suatu kawat akan menimbulkan gaya. Gaya ini yang akan menggerakkan rotor sampai arah gayanya sejajar. Motor DC terdiri atas suatu gulungan yang dialiri arus listrik dan ditempatkan dalam suatu medan magnet sehingga gulungan kawat ini akan mengalami gaya yang sebanding dengan arus dan kekuatan medan magnetnya. Arah gaya membentuk sudut siku-siku terhadap arus dan arah medan magnetnya dibalik. Sifat ini memungkinkan motor-motor tertentu dapat berputar dengan arus DC maupun AC.

Pada motor dengan medan magnet permanent, medan magnetnya dihasilkan oleh suatu atau beberapa magnet permanent. Magnet-magnet ini digenggam oleh penggeggam besi atau baja, atau kadang-kadang oleh rangka motor itu sendiri. Magnet ini merupakan bagian dari motor yang diam yang disebut *Stator*. Kawat yang menghasilkan arus listrik digulung pada bagian motor yang berputar yang disebut *Rotor*. Umumnya *Rotor* dibuat menjadi 3 kutub kumparan, disekelilingnya dipasang dua buah mengarah medan magnet. Pada keadaan demikian, *Rotor* akan tetap diam dan tidak akan berputar lagi, akan tetapi sekarang arusnya dihubungkan kesalah satu kumparan lainnya, maka *Rotor* akan bergerak kembali sampai berada pada posisi yang baru. Pada motor DC jika kutub positif dan negatifnya dialiri arus secara terbalik, maka arah putaran akan terbalik atau berlawanan. [13]



Gambar 3.4. Rangkaian Motor Dc

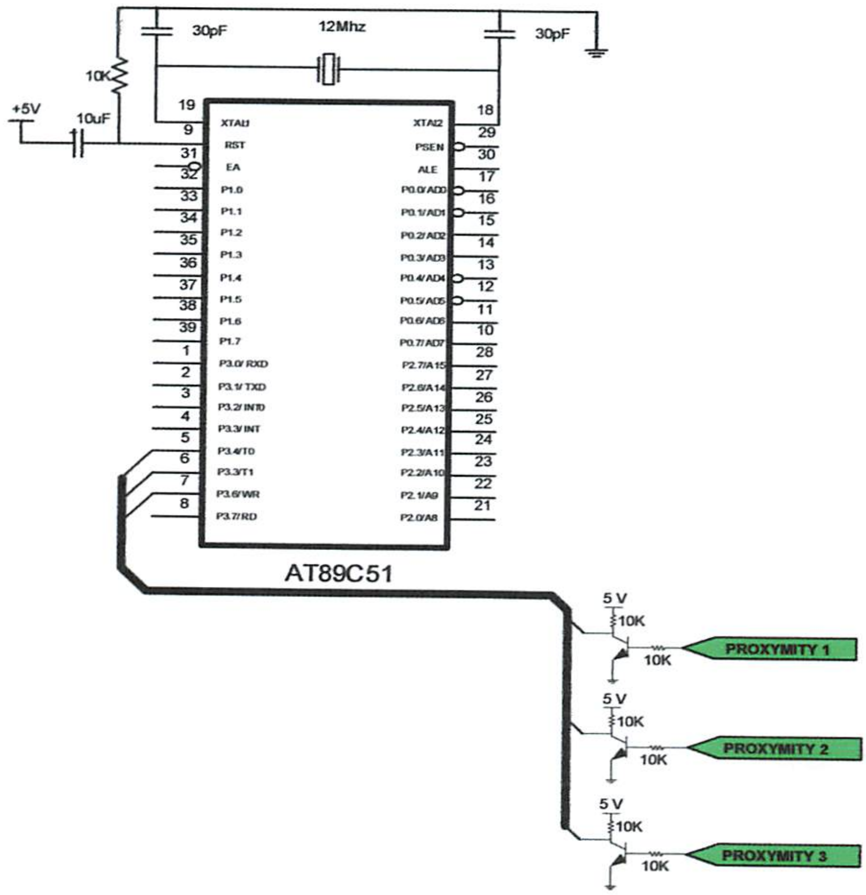
3.4.3. Rangkaian Sensor Proximity

Karena pada gelas penampung diberi label yang terbuat dari kertas logam, maka keberadaan gelas pada alat ini dapat dideteksi dengan sensor logam, atau lebih dikenal dengan Sensor Proximity. Mengapa perancang menggunakan sensor logam (induktif), tidak menggunakan sensor plastic (kapasitif) ? kerena harga sensor plastic (kapasitif) yang sangat mahal, untuk efisiensi biaya pada pembuatan alat ini, perancang membuat fariasi pada gelas penampung dengan menambahkan lebel dagang yang mengandung unsur besi sehingga dapat dideteksi oleh Sensor Proximity jenis Induktif yang lebih murah harganya.

Tipe dari Sensor Proximity ini adalah :

Tipe	: NPN, 3 Terminal, (+, -, Out)
Teg Kerja	: 12 – 24 Vdc
Konsumsi Arus	: 100 mA
Jarak Deteksi Celah Udara	: 5 mm

Keluaran dari Sensor Proximity ini kemudian akan dikirimkan ke rangkaian control. Untuk memisahkan Sensor Proximity dan mengubah level tegangan Output agar sesuai dengan tegangan rangkaian control, maka digunakan rangkaian driver.



Gambar 3.5. Rangkaian Driver Sensor Proximity

Proxymity dalam perencanaan Alat Pengepakan Otomatis ini ini berfungsi sebagai pendeteksi ada atau tidaknya gelas dalam proses pengisian, pengepakan dan pembuangan.. Pada proxymity dalam keadaan tidak aktif maka tegangan dikeluarkan (yang masuk AT89C51) sebesar 0V, tetapi ketika proximity dalam keadaan aktif tagangan keluaran mendekati 5V. Hal ini dapat dicapai dengan pertimbangan sbb:

Diketahui:

Tegangan suplay (VCC) = 5V.

Arus (1) = 0,01 Ma (adalah arus yang diutuhkan IC AT89C51).

Tegangan keluaran (Vout) = 5V (or 4,45 V)

$$VCC = I.R + Vout$$

$$5 = (0{,}01 \,.\, 10^{-3} . R) + 4{,}45$$

$$R = \frac{0{,}1}{0{,}01.10^{-3}}$$

$$R = 10\ K\Omega$$

Maka nilai R1 = R2 = 10 KΩ .

3.4.4. Limit Switch

Limit switch dalam perencanaan Alat Pengepakan Otomatis ini ini berfungsi sebagai pengontrol tuas pembuang gelas yang sudah mengalami proses pengepresan. Pada saat limit switch dalam keadaan tertutup maka tegangan dikeluarkan (yang masuk AT89C51) sebesar 0V, tetapi ketika limit switch dalam keadaan terbuka tagangan keluaran mendekati 5V. Hal ini dapat dicapai dengan pertimbangan sbb:

Diketahui:

Tegangan suplay (VCC) = 5V.

Arus (1) = 0,01 Ma (adalah arus yang diutuhkan IC AT89C51).

Tegangan keluaran (Vout) = 5V (or 4,9 V)

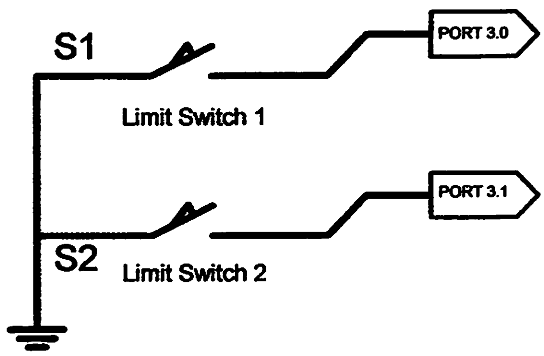
$$VCC = I.R + Vout$$

$$5 = (0,01 \,.\, 10^{-3} . R) + 4,9$$

$$R = \frac{0,1}{0,01.10^{-3}}$$

$$R = 10\,K\Omega$$

Maka nilai R1 = R2 = R3 = 10 $K\Omega$.



Gambar 3.5. Gambar Rangkaian Limit Switch

3.4.5. Perencanaan Power Suplay

Sebagaian besar rangkaian elektronika, membutuhkan tegangan DC untuk dapat bekerja dengan baik. Karena tegangan jala – jala adalah tegangan AC, maka yang harus dilakukan dahulu dalam setiap peralatan elektronika adalah mengubah tegangan AC ke DC. Dengan menggunakan rangkaian penyearah setengah gelombang maupun rangkaian penyearah gelombang penuh. Pada rangkaian Power Suplay ini, perencanaan menggunakan transformator 3A dan Power Suplay yang digunakan adalah D 12 V. rangkaian penyearah gelombang penuh biasanya menggunakan dua buah dioda atau empat buah dioda.

Tegangan Output DC (tegangan rata – rata) adalah:

Diketahui Vef $= 12$ V

Trafo $= 3$ Ampere

$Vm = \sqrt{2} \text{ x } Vef$

$$VDC = \frac{2.Vm}{\pi} = 0.636.Vm$$

$$VDC = \frac{2.\sqrt{2x12}}{\pi}$$

$VDC = 0{,}725 \text{ x } 12$

$VDC = 8{,}700$ V

Frekwensi Output :

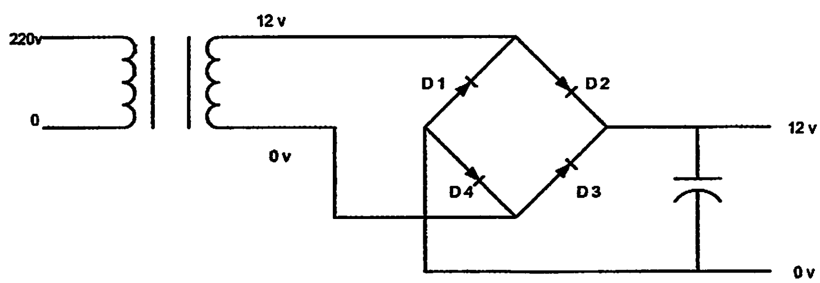
F out $= 2.$ F in

F out $= 2 \text{ x } 50$ Hz

F out $= 100$ Hz

Penyearah gelombang penuh setengah siklus tegangan sekunder yang positif, dioda (D1) mengalami pra tegangan maju dan dioda (D2) mengalami pra tegangan balik, sehingga arus mengalir melalui dioda (D1) tahanan beban. Tegangan beban mempunyai polaritas yang sama. Hal ini disebabkan karena arus mengalir melalui tahanan beban dari arah yang sama tanpa memperhatikan dioda mana yang menghantar. Jadi tegangan beban berbentuk sinyal gelombang penuh.

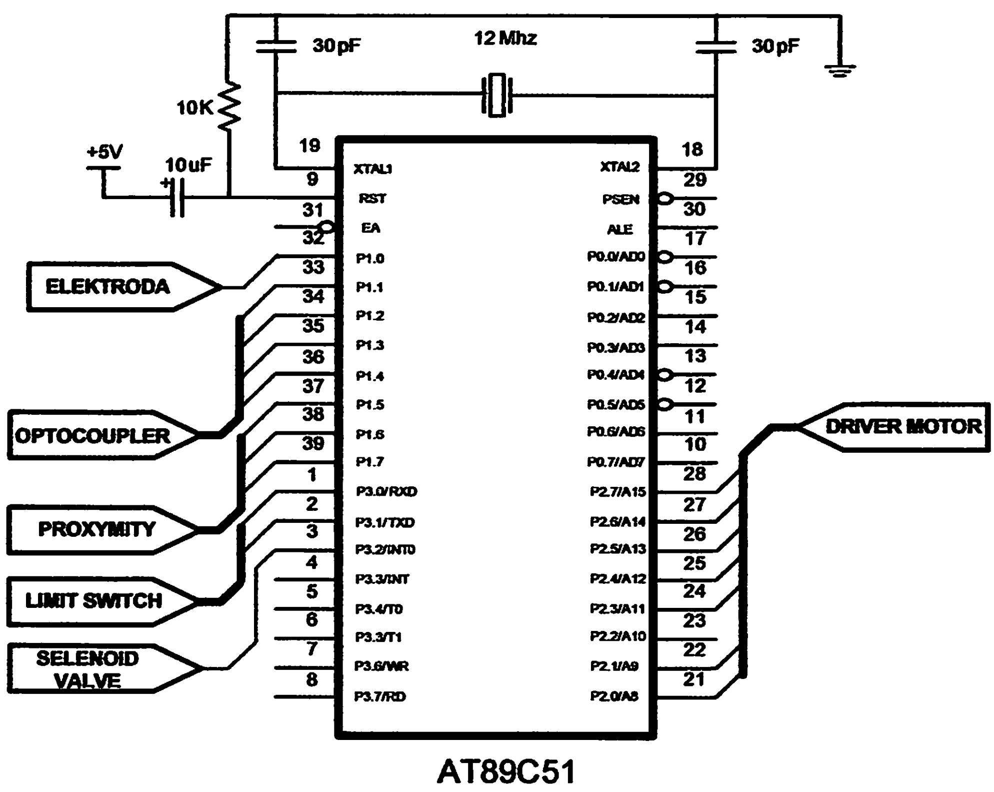
Adapun gambar yang di power supplay yang ditunjukkan pada gambar di bawah ini :



Gambar 3.6. Rangkaian Power Supplay

3.4.6. Rangkaian Kontrol Menggunakan Mikrokontroler AT89S51

Pada rangkaian ini komponen utamanya adalah unit mikrokontroler tipe AT89S51 yang kompatible dengan keluarga MCS-51. Komponen ini merupakan sebuah chip tunggal sebagai pengolah data dan pengontrolan alat. Sedangkan pemilihan AT89S51 karena praktis dalam pemrograman dan banyak terdapat dipasaran. Sebagai otak dari pengolahan data dan pengontrolan alat, pin-pin AT89S51 dihubungkan pada rangkaian pendukung membentuk suatu sistem minimum, pin-pin mikrokontroler yang digunakan yaitu :



Gambar 3.6. Rangkaian Mikokontroler AT89C51

3.5. Perencanaan Perangkat Lunak

3.5.1. Perangkat Lunak Mikrokontroller

Untuk mendukung agar perangkat keras berfungsi sesuai dengan perencanaan, maka diperlukan perangkat lunak sebagai penunjangnya. Untuk mengatur dan mengendalikan keseluruhan system perangkat keras yang telah dibuat, harus dibantu dengan perangkat lunak. System aplikasi mikrokontroller AT89C51 ini dapat mengatur dan mengendalikan keseluruhan system apabila ada urutan instruksi yang mendefinisikan secara jelas urutan tugas yang harus dikerjakannya.

Urutan instruksi ini sangat penting untuk didefinisikan, karena mikrokontroller bekerja secara pasti berdasarkan urutan ini. Susunan logika perancangan yang salah tidak dapat diketahui oleh mikrokontroller. Selama instruksi yang diterima sesuai dengan aturannya, mikrokontroller tetap mengerjakan instruksi tersebut. Kesalahan seperti ini baru diketahui ketika kerja system aplikasi tidak sesuai dengan spesifikasi awal. Oleh karena itu, perancangan perangkat keras sangat menentukan dalam keberhasilan pembuatan perangkat lunak, sama pentingnya dengan perancangan perangkat keras. Sebuah mikrokontroller tidak akan bekerja bila tidak diberikan program kepadanya. Program tersebut memberitahukan apa yang harus dilakukan oleh mikrokontroller.

Perangkat lunak yang digunakan adalah Assemble. Dalam pembuatan perangkat lunak untuk mikrokontroller AT89C51 digunakan program HB2000 produksi atmel yang digunakan khusus untuk pemrograman mikrokontroller AT89C51. dimana fasilitas-fasilitas yang lengkap untuk pembuatan sebuah program terhadap alat yang dibuat telah tersedia dalam program HB 2000. contoh dalam kasus ini adalah:

1. untuk penulisan program sudah tersedia dalam program HB 2000 menggunakan teks editor yang harus disimpan menjadi file berekstensi *H51.
2. untuk proses kompilear juga sudah tersedia. Fasilitas ini digunakan untuk mengubah file yang berekstensi *H51 menjadi file berekstensi *PRN dan *HEX untuk mengetahui program yang dibuat sudah benar atau belum, dapat diketahui dengan membuka file *PRN dalam teks editor, apabila program yang dibuat sudah tidak ada yang salah (error) maka program dapat diproses lebih lanjut dan apabila terdapat kesalahan harus memperbaikinya sampai tidak ada kesalahan dalam program yang dibuat.
3. setelah program yang dibuat tidak ada kesalahan, maka file yang berekstensi *HEX harus dirubah menjadi file berekstensi *BIN. Fasilitas untuk merubah file tersebut juga sudah tersedia deprogram HB 2000 . mendownload program berekstensi *BIN kedalam mikrokontroller AT89C51 yang terdapat fasilitas memori (EEPROM) sebesar 4 Kbyte secara internal

3.6. Perencanaan Daya

Dalam perencanaan dan pembuatan alat ini, akan membahas tentang berapa daya masing – masing blok dan berapa daya total yang dibutuhkan oleh alat.

- **Perencanaan daya untuk Selenoid Valve :**

Berdasarkan spesifikasi yang tertera pada Selenoid Valve adalah:

Beban : 10 Watt

Tegangan : 220 V

Maka daya yang dibutuhkan oleh Solenoid Valve adalah **10 Watt**

- **Perencanaan daya untuk Motor DC :**

Berdasarkan spesifikasi yang tertera pada Motor DC adalah:

Tegangan Kerja : 12 V

Resistansi : 10 Ω

Maka daya yang dibutuhkan oleh Motor DC adalah:

$$P = V \cdot I$$

$$I = \frac{V}{R}$$

$$I = \frac{12}{10}$$

$$I = 1.2 \text{ Ampere}$$

$$P = 12 \cdot 1.2$$

$$P = \mathbf{14{,}4\ Watt}$$

Dalam perancangan dan pembuatan alat ini menggunakan 4 buah motor DC, maka daya total yang dibutuhkan adalah **57.6 Watt**

- **Perencanaan daya untuk Heater (Pemanas)**

Berdasarkan spesifikasi yang tertera pada Heater adalah:

Tegangan Kerja : 240 V

Resistansi : 190 Ω

Beban : 220 Watt

Maka daya yang dibutuhkan oleh Heater adalah **220 Watt**

- **Perencanaan daya untuk Relay**

Berdasarkan spesifikasi yang tertera pada Relay adalah:

Tegangan Kerja : 220 V

Resistansi : 13,3 kΩ

Maka daya yang dibutuhkan oleh Relay adalah:

$$P = V \cdot I$$

$$I = \frac{V}{R}$$

$$I = \frac{220}{13,3}$$

$$I = 0,016 \text{ A}$$

$$P = 220 \cdot 0,016$$

$$P = \mathbf{3,52\ Watt}$$

Dalam perancangan dan pembuatan alat ini menggunakan 7 buah Relay, maka daya total yang dibutuhkan adalah **24,6 Watt**

- **Perencanaan Daya Total**

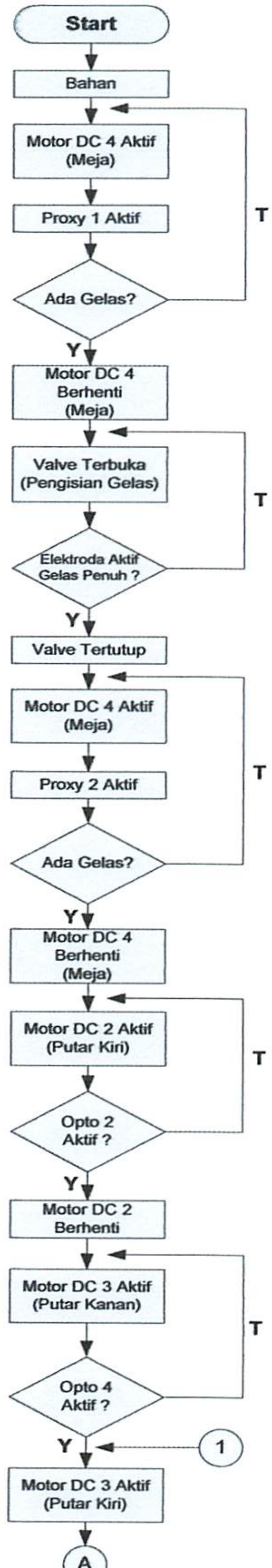
Pada perencanaan dan pembuatan alat ini, perencanaan daya total adalah:

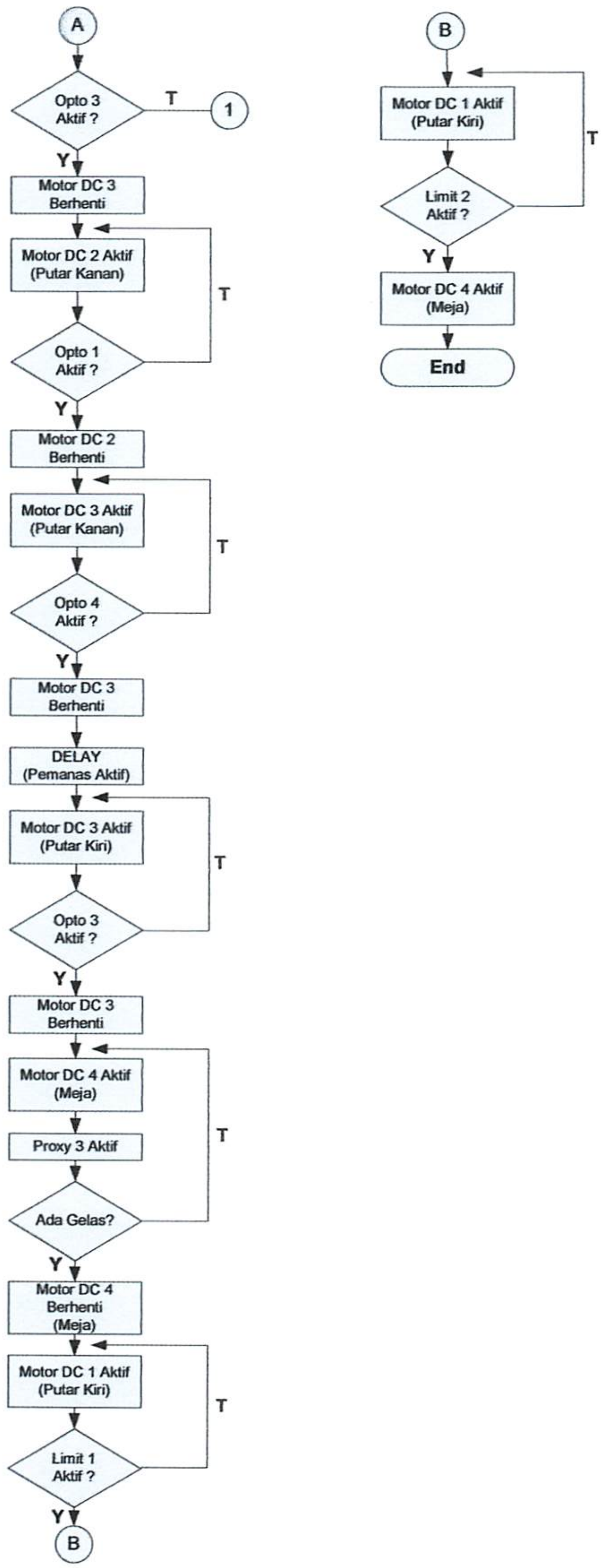
Daya Total $= P_{MotorTotal} + P_{RelayTotal} + P_{SelenoidValve} + P_{Heater}$

$= 57{,}6 + 24{,}6 + 10 + 220$

$= 0{,}31$ kWatt

Maka Daya Total yang dibutuhkan oleh alat adalah **0,31 kW**


Start
Bahan
Motor DC 4 Aktif
(Meja)
Proxy 1 Aktif
Ada Gelas?
T
Y
Motor DC 4
Berhenti
(Meja)
Valve Terbuka
(Pengisian Gelas)
Elektroda Aktif
Gelas Penuh ?
T
Y
Valve Tertutup
Motor DC 4 Aktif
(Meja)
Proxy 2 Aktif
Ada Gelas?
T
Y
Motor DC 4
Berhenti
(Meja)
Motor DC 2 Aktif
(Putar Kiri)
Opto 2
Aktif ?
T
Y
Motor DC 2
Berhenti
Motor DC 3 Aktif
(Putar Kanan)
Opto 4
Aktif ?
T
Y
1
Motor DC 3 Aktif
(Putar Kiri)
A


A
Opto 3 Aktif ?
T
1
Y
Motor DC 3 Berhenti
Motor DC 2 Aktif (Putar Kanan)
T
Opto 1 Aktif ?
Y
Motor DC 2 Berhenti
Motor DC 3 Aktif (Putar Kanan)
T
Opto 4 Aktif ?
Y
Motor DC 3 Berhenti
DELAY (Pemanas Aktif)
Motor DC 3 Aktif (Putar Kiri)
T
Opto 3 Aktif ?
Y
Motor DC 3 Berhenti
Motor DC 4 Aktif (Meja)
Proxy 3 Aktif
T
Ada Gelas?
Y
Motor DC 4 Berhenti (Meja)
Motor DC 1 Aktif (Putar Kiri)
T
Limit 1 Aktif ?
Y
B
B
Motor DC 1 Aktif (Putar Kiri)
T
Limit 2 Aktif ?
Y
Motor DC 4 Aktif (Meja)
End

BAB IV

PENGUJIAN ALAT

Dalam Bab ini akan membahas mengenai pengujian alat yang telah dirancang, dirakit serta direalisasikan. Tujuan pengujian alat ini adalah untuk mengetahui sejauh mana alat yang dirancang telah sesuai dengan apa yang direncanakan dan apakah alat yang sudah dapat berjalan sesuai dengan yang diinginkan.

Pengujian alat dibagi menjadi pengujian hardware dan pengujian software adapun cara pengujian hardware yang telah dibuat adalah dengan mengamati masukan dan keluaran masing – masing rangkaian, sedangkan untuk pengujian perangkat lunak dilakukan dengan membuat suatu program dan memasukkan program tersebut dalam IC Mikrikontroler, kemudian mengamati hasil dari program yang dimasukkan kedalam mikrokontroler dan menganalisis apakah bentuk dan besarnya nilai masukan serta keluaran tersebut sudah sesuai dengan yang diharapkan, jika terjadi penyimpangan apa yang menyebabkan penyimpangan itu terjadi. Adapun pengujian perangkat keras dan perangkat lunak yang meliputi :

4.1. Optocoupler

4.1.1. Tujuan pengujian

Untuk mengetahui apakah rangkaian sensor ontik sebagai detector lubang yang dibuat sudah sesuai dengan yang dibutuhkan, dan untuk mengetahui sejauh mana perbedaan antara hasil dan perancangan yang dibuat.

4.1.2 Alat Dan Bahan

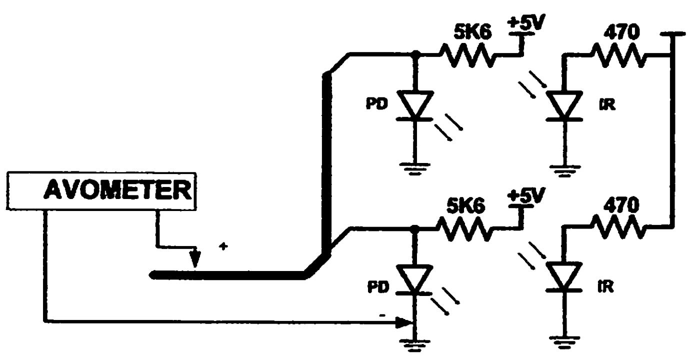
1.Catu Daya 5 Volt DC

2.Avometer.

3. Plat sebagai penghalang Sensor Optic.

4.1.3. Pelaksanaan Pengujian.

1. Merangkai rankaian penguji sensor persenaleng seperti pada gambar 4.1.
2. Mengukur output dari sesor optic pada saat sensor tersebut dihalangi dengan plat dan pada saat sensor tersebut tidak terhalang.



GAMBAR 4.1.

Blok Diagram Pengujian Sensor Optocoupler

4.1.4. Analisa Hasil Pengujian

Pengujian rangkaian sensor optocoupler sudah tidak bisa bekerja sesuai yang direncanakan. Dengan menghalangi sinar infra merah yang mengenai foto dioda maka output foto diodaakan berubah dari kondisi logika tinggi sebasar 5 Volt menjadi logika rendah sebesar 0,65 Volt.

Tabel 4.1. Tabel Pengujian Sensor Optik

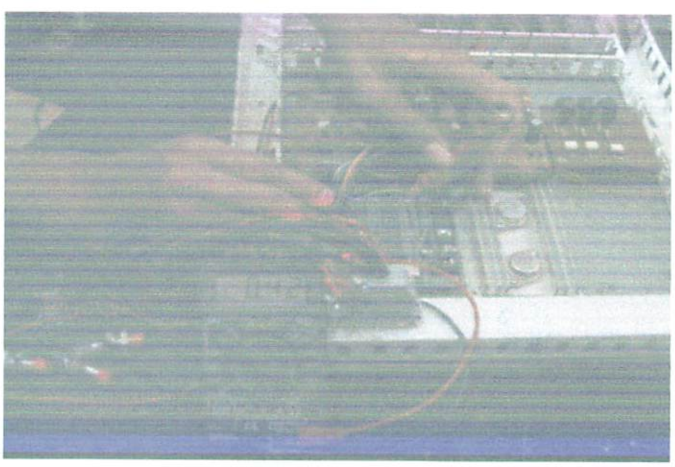
Perlakuan	Pengujian (V)	Perhitungan (V)	Error (%)
Terhalang	4,72	5	6,38%
Tidak Terhalang	0,22	0	1%

Rumus untuk mencari selisih adalah :

Selisih Kondisi Terhalang :

$$\text{Error} = \frac{PERHITUNGAN - PENGUKURAN}{PENGUKURAN} \text{ X } 100\%$$

$$= \frac{5 - 4,72}{4,72} \text{ x } 100\% = 6,05\%$$



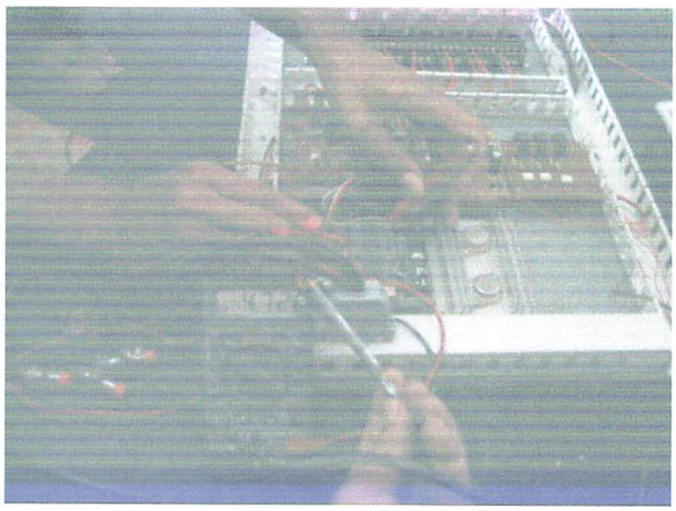
Gambar.4.2. Hasil Pengukuran Rangkaian Sensor Optik

Pada Saat Terhalang

Selisih Kondisi Tak Terhalang :

$$\text{Error} = \frac{PERHITUNGAN - PENGUKURAN}{PENGUKURAN} \text{ X } 100\%$$

$$= \frac{0 - 0{,}42}{0{,}42} \text{ x } 100\% = 4\%$$



Gambar.4.3. *Hasil Pengukuran Rangkaian Sensor Optik*

Pada Saat Tak Terhalang

4.2. Pengujian Rangkaian Driver Motor DC Sebagai Saklar Penggeak Relay

4.2.1. Tujuan

Untuk mengetahui apakah rangkain yang digunakan sebagai penggerak relay dapat berfungsi dengan yang direcanakan.

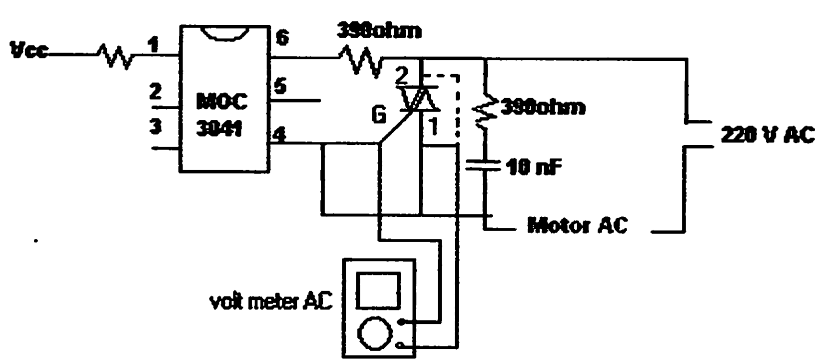
4.2.2. Alat dan Bahan

1.Catu Daya 5 Volt sebagai tegangan control dan catu daya 12 Volt sebagai catu relay.

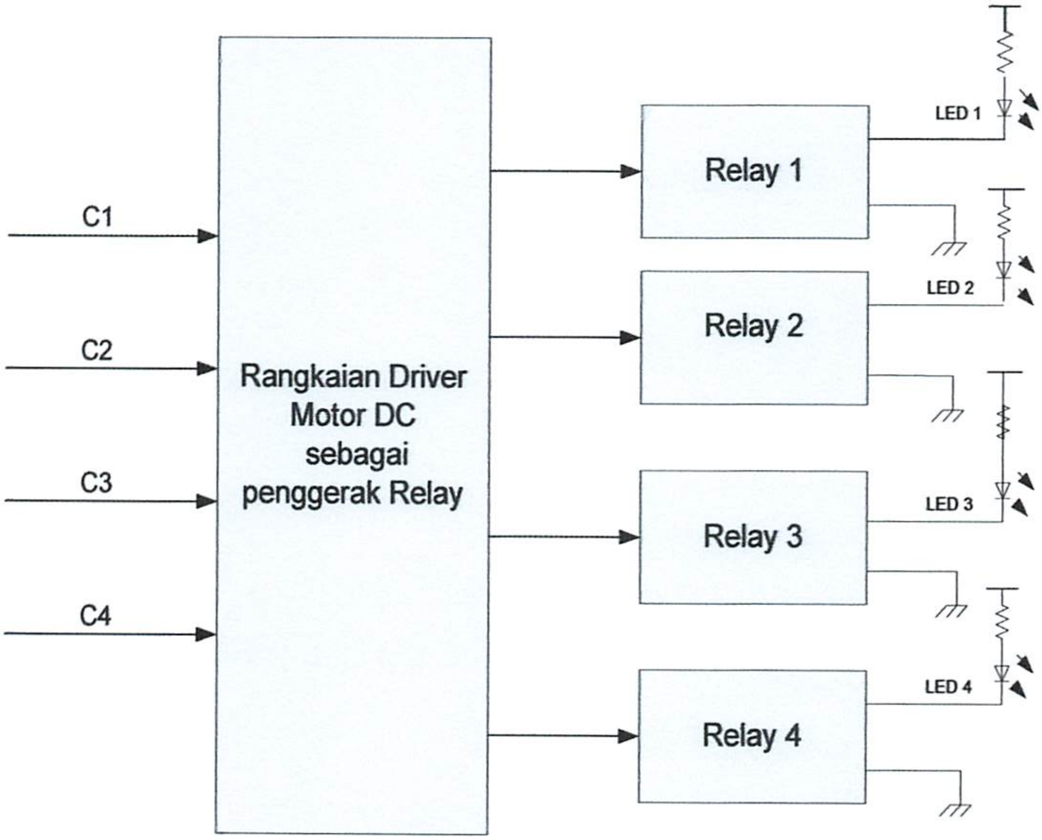
2.LED sebagai indicator.

4.2.3. Pelaksanaan Pengujian

1. Mempersiapkan rangkaian pengujian seperti pada blok diagram gbr 4.5.
2. Memberikan logic kontrol pada kontrol rangkaian, kemudian mengamati nyala LED



Gambar 4.4. Pegujian Driver Motor DC



Gambar 4.5

Diagram Blok Pengujian Rangkaian Driver Motor DC Sebagai Penggerak Relay

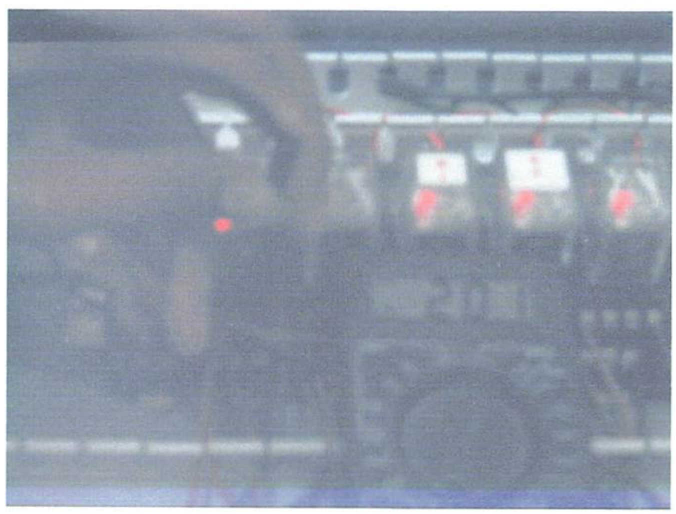
4.2.4. Hasil Analisa Pengujian

Hasil pengujian rangkaian Driver Motor DC sebagai penggerak relay ditunjukkan pada table dibawah ini:

Tabel 4.2. Pengujian Rangkaian Driver Motor DC Sebagai Penggerak Relay

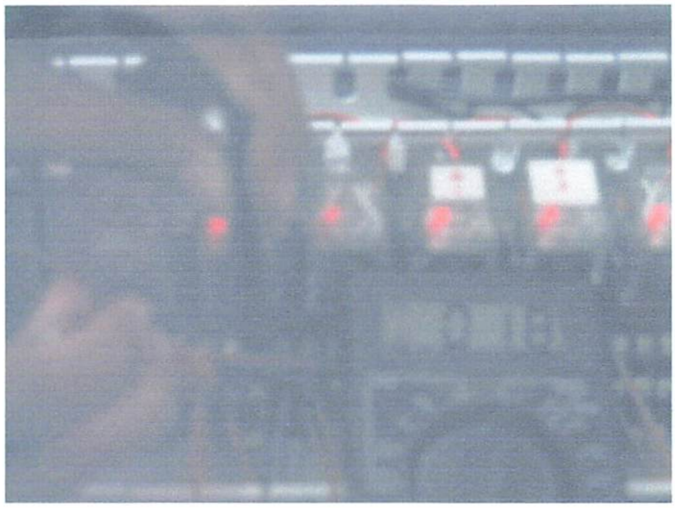
C1	C2	C3	C4	LED1	LED2	LED3	LED4
H	L	L	L	ON	OFF	OFF	OFF
L	H	L	L	OFF	ON	OFF	OFF
L	L	H	L	OFF	OFF	ON	OFF
L	L	L	H	OFF	OFF	OFF	ON

Pada table 4.3 didapatkan pada saat control 1 (c1) diberi logika tinggi maka LED 1 akan menyala, pada saat control 2 (c2) diberi logika tinggi maka LED 2 akan menyala, dan pada saat control 3 (c3) diberi logika tinggi maka LED 3 akan menyala. Dengan demikian maka dapat disimpulkan bahwa rangkaian Driver Motor DC sebagai penggerak relay dapat berfungsi dengan benar.



Gambar 4.6.

Pengujian RangkaianGriver Motor DC) Sebagai Penggerak Relay Saat Aktif



Gambar 4.7.

Pengujian Rangkaian Driver Motor DC Sebagai Penggerak Relay Saat Tidak Aktif

4.3. Pengujian Rangkaian Sensor Limit Switch

4.3.1. Tujuan Pengujian

Pengujian rangkaian sensor limit switch dilakukan untuk mengetahui apakah sensor tersebut sudah bekarja dengan baik sesuai perencanaan. Rangkaian limit switch ini dipergunakan untuk mendeteksi posisi awal meja geser dan posisi awal/ akhir bor. Yitu posisi mundur untuk meja, dan posisi naik pada bor.

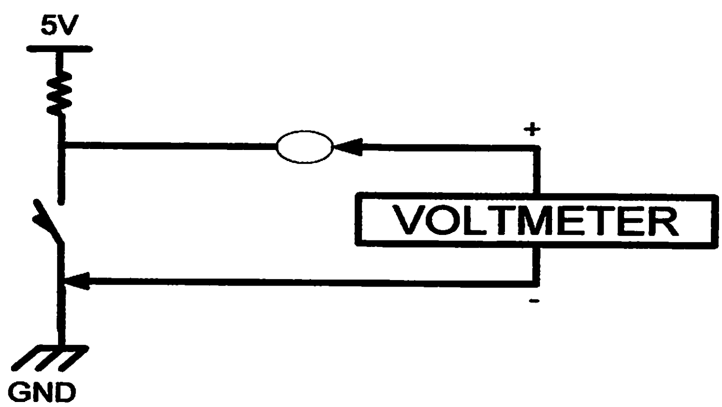
4.3.2. Alat dan Bahan.

1. Rangkaian Limit Switch
2. Voltmeter
3. Catu Daya 5 Volt

4.3.3. Langkah- langkah yang dilakukan.

1. Memberi tegangan pada sensor melalui rangkain yang digunakan.
2. Menganalisa bagaimana kondisi Limit Switch ketika Limit Switch saat aktif (tidak ditekan) dan Limit Switch pada saat tidak aktif (ditekan).

Adapun cara pengujian dapat dilihat pada blok pengujian Limit Switch diperlihatkan pada gambar 4.3 dibawah ini :



***GAMBAR 4.8.** Blok Diagram Pengujian Limit Switch*

4.3.4. Analisa Hasil Pengujian

Pada pengujian rangkain sensor ini, limit switch 1 aktif pada saat bor telah mencapai kondisi semula yaitu kondisi ketika tuas bor menekan tuas limit switch. Untuk Limit Switch 2, kondisi aktif ketika kondisi meja geser mundur sampai dengan menyentuh tuas Limit Switch.

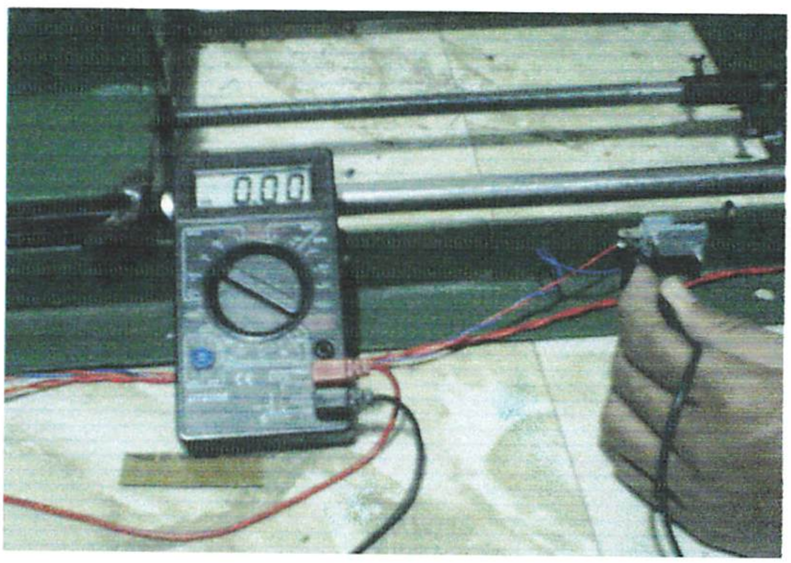
Tabel 4.4. *Hasil Pengujian Limit Switch*

Kondisi Sensor	Pengukuran (V)	Pengujian (V)	Error (%)
Aktif	0	0	0
Tidak Aktif	5	4,95	0.5

Selisih Kondisi Aktif :

$$\text{Error} = \frac{PERHITUNGAN - PENGUKURAN}{PENGUKURAN} \text{ X } 100\%$$

$$= \frac{0-0}{0} \text{ x } 100\% = 0\%$$



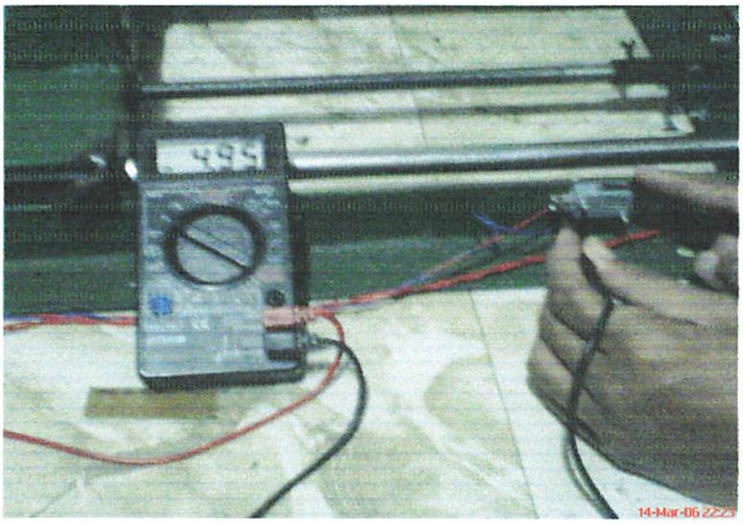
Gambar 4.9. *Hasil Pengujian Limit Switch*

Pada Saat Tidak Ditekan

Selisih Kondisi Tidak Aktif :

$$\text{Error} = \frac{PERHITUNGAN - PENGUKURAN}{PENGUKURAN} \text{ X } 100\%$$

$$= \frac{5 - 4,95}{4,95} \text{ x } 100\% = 0.5\ \%$$

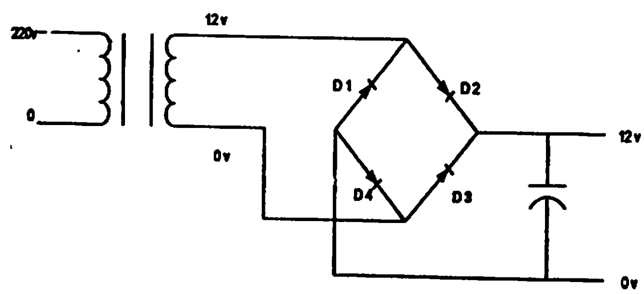


Gambar 4.10. *Hasil Pengujian Limit Switch*

Pada Saat Ditekan

4.4. Pengujian Power Saplay

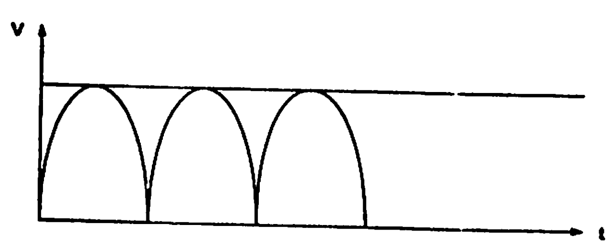
Power supplay dalam perancangan alat pegepakan otomatis pada gelas aqua ini di gunakan sebagai penyearah arus untuk mengaktifkan relay DC dan juga untuk mengaktifkan rangkaian sensor photo dioda. Adapun gambar yang di power supplay yang ditunjukkan pada gambar di bawah ini :



Gambar 4.11. Rangkaian Power Supplay

Pada rangkaian power supplay di atas merupakan rangkaian penyearah gelombang penuh dengan menggunakan rangkaian jembatan (bridge).

Pengetesan dapat dilakukan dengan multitester sebagai penunjuk tegangan dan osciloscop untuk mengetahui betuk gelombang yang dihasilkan seperti yang ditunjukkan pada gambar dibawah ini :

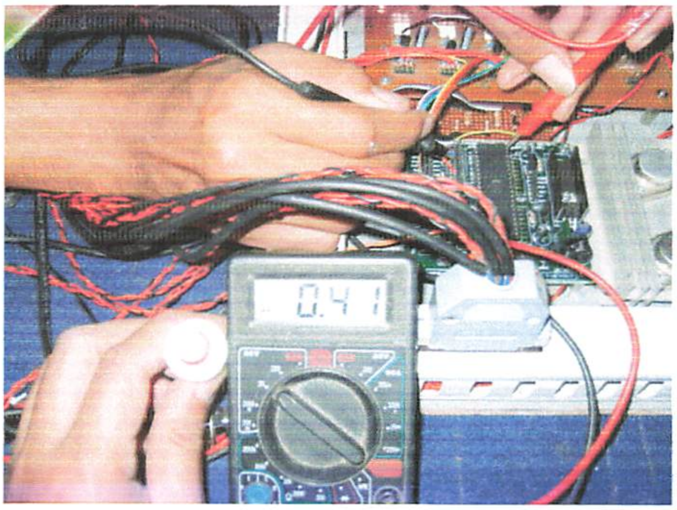


Gambar 4.12. Betuk Penyearah Gelombang Penuh

4.5. Pengujian Sensor Proximity

Dalam pengujian sensor Proximity, penulis hanya menampilkan hasil pengujian pada saat sensor Proximity mendeteksi adanya gelas dan ketika sensor tidak mendeteksi benda kerja.

Fungsi dari sensor ini adalah memastikan adanya gelas yang sudah terpasang tepat di bibir meja dan tepat juga di bawah tempat proses pengisian gelas, penutupan gelas dengan plastic menggunakan pemanas dan tempat akhir dari proses.



Gambar 4.13.

Foto Pengujian Sensor Proximity Pada Saat Tidak Aktif

Gambar 4.14.

Foto Pengujian Sensor Proximity Pada Saat Aktif

4.6. Pengujian Rangkaian Minimum AT89C51

4.6.1. Tujuan Pengujian.

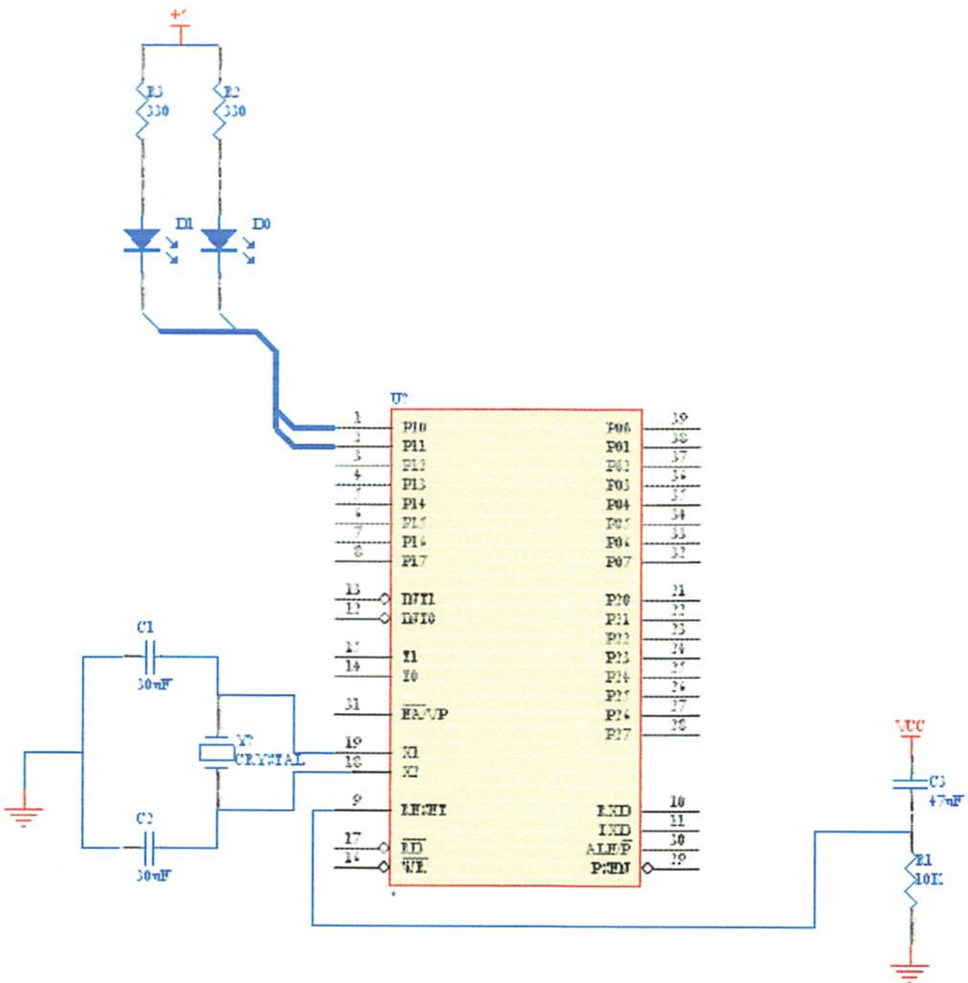
Pada pengujian ini dapat diketahui apakah rangkaian minimum dapat bekerja sesuai dengan program yang di masukan. Rangkaian minimum AT89C51 di hubungkan ke LED melalui port 1. Adapun cara kerja dari program adalah menyalakan lampu secara bergantian gambar 4.7 adalah rangkaian LED dengan MCU.

4.6.2. Alat dan Bahan

1. Rangkaian Mikrokontroller yang akan diuji.
2. Catu Daya.
3. Led peraga output Mikrokotroller
4. Programmer dan Evaluator Board.

4.6.3. Pelaksanaan Pengujian.

1. Merangkai rangkaian mikrokontroller seperti gambar 4.4.
2. Menghubungkan rangkaian mikrokontroller ke catu daya.
3. Membuat Program Software.
4. Memprogaram IC Mikrokontroller kemudian menjalankannya.



Gambar 4.15. Gambar Rangkaian LED pada MCU 89C51

4.6.4. Analisa Hasil Pengujian

Agar sebuah Mikrokontroller dapat mengirim data , terlebih dahulu Mikrokontroler diprogram software HB 2000. Adapun potongan program inisialisasi Mikrokontroller dapat dilihat dibawah ini :

[illegible]

```
        ORG 00H
        JMP Mulai
Satu:   CLR  P1.0
        SETB P1.1
        RET
Dua:    CLR  P1.1
        SETB P1.0
        RET
Delay:  MOV  R2,#0FFH
JUM1:   MOV  R3,#0FFH
        DJNZ R3,$
        DJNZ R2,JUM1
        RET
Mulai:  CALL Satu
        CALL Delay
        CALL Dua
        CALL Delay
        JMP  Mulai
        END
```

BAB V

PENUTUP

5.1.Kesimpulan.

Setelah melalui beberapa tahap perencanaan dan pembuatan alat Pengepakan Otomatis untuk Gelas Aqua ini, dapat disimpulkan sebagai berikut :

1. Untuk mendeteksi ada atau tidaknya gelas yang terpasang di bibir meja putar digunakan Sensor Proximity, rangkaian ini terdiri dari Sensor Proximity yang telah diberi rangkaian penguatan.
2. Rangkaian dengan menggunakan Mikrokontroller AT89C51 merupakan alat pengontrol atau otomatisasi yang sangat murah dan efisien sebagai pengganti rangkaian Relay
3. Untuk proses pengepressan digunakan pemanas yang telah diberi lapisan logam kuningan dan teflon, agar tidak lengket dengan plastic penutup.
4. Apabila saat proses berjalan, sensor tidak mendeteksi adanya gelas, maka proses otomatis akan berhenti.
5. Pada bibir meja putar, telah dibuat tempat untuk gelas penampung yang berjumlah enam buah.
6. Kapasitas gelas penampung bahan yang sudah diproses adalah 250 ml.
7. Kapasitas gelas penampung bahan yang akan digiling adalah 1 liter.

8. Proses ini, memakan waktu kurang lebih 2,5 menit untuk menyelesaikan proses pengisian dan pengepresan sampai mendorong gelas ke tempat penampung.

   Dengan spesifikasi

   1. Proses pengisian bahan pada gelas memakan waktu 90 detik
   2. Proses pengepressan gelas memakan waktu 30 detik
   3. Proses pembuangan gelas memakan waktu 10 detik

9. Untuk menentukan batas atas, depan, bawah dan belakang digunakan sensor optocoupler sebagai pendeteksinya. Sensor yang di dalamnya terdiri dari fotodioda dan infra red dengan resistansi sebesar 220 KΩ ini mampu mengeluarkan tegangan srbesar 4,72 Volt pada saat sinar infra merah terhalang menuju fotodioda, dan jika tidak terhalangi maka tegangan dari rangkaian sebesar 0,42 Volt. Setelah dilakukan pengujian terdapat error antara hasil pengujian dan perhitungan sebesar 6,05 %.

10. Pada saat aktif, limit switch mengeluarkan tegangan sebesar 4,95 Volt, pengujian Limit Switch terdapat Error sebesar 0,5%.

11. Kurangnya arus yang menggerakkan Motor DC, sehingga program yang telah dimasukkan ke dalam mikrokontroller AT89C51 ada yang meloncat, dalam artian ada program yang tidak dilaksanakan oleh mekanik. Masalah ini dapat terseleaikan dengan menambahkan TIP 3055 berkualitas bagus sebanyak 2 buah untuk memperkuat arus yang masuk ke Motor DC. Dengan ditambahkannya komponen ini hasilnya akan memperkecil kesalahan yang terjadi ketika belum diberi komponen ini.

12. Karena alat ini membutuhkan mekanik yang sangat presisi, ketika ada mekanik yang kurang presisi maka hasil pengepressan akan sedikit meleset dari yang direncanakan, tetapi pada alat ini hasil pengepressan hanya meleset sedikit dari perencanaan (sekitar 1-2 milimeter).

5.2. Saran

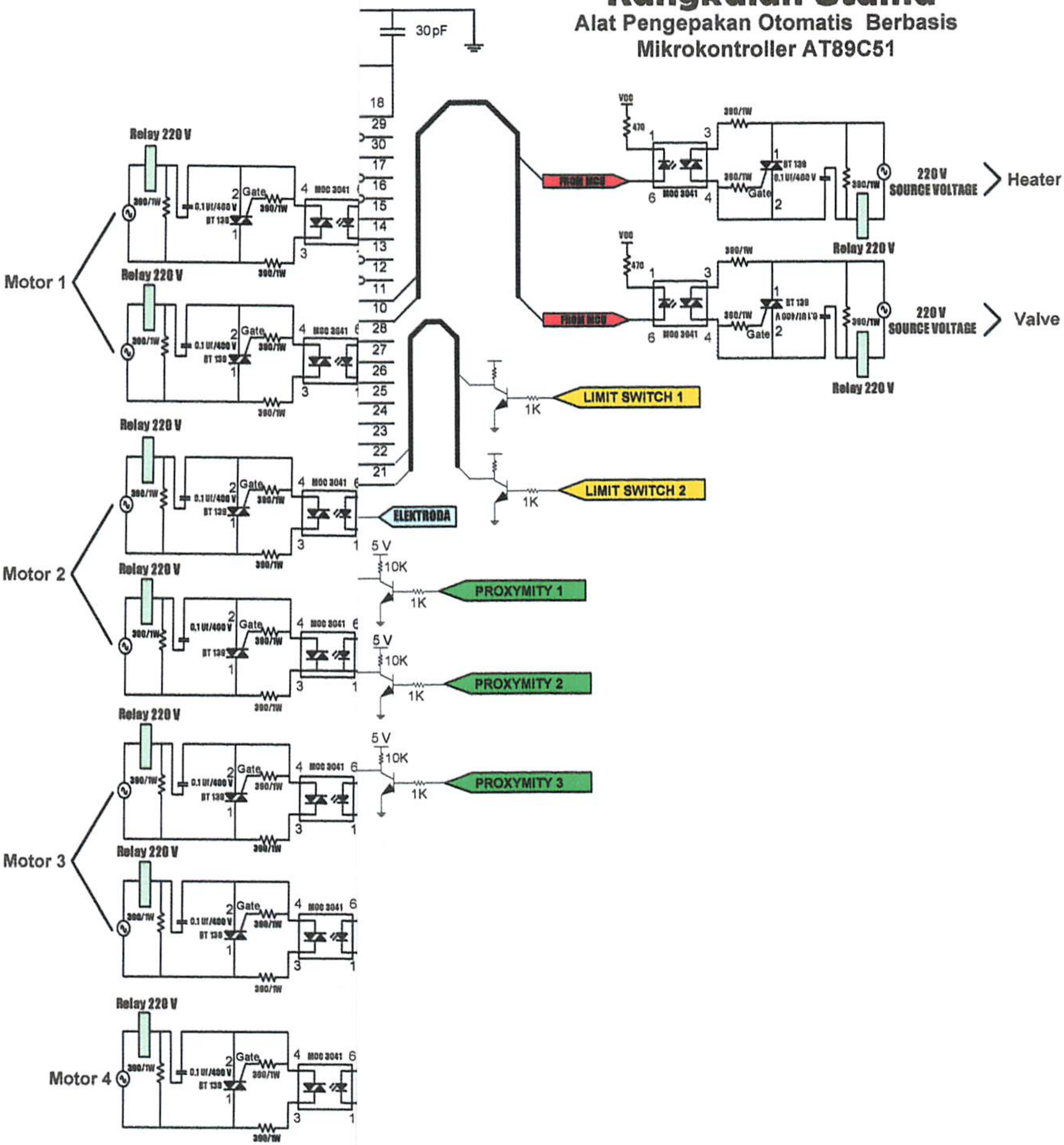
Dalam rancangan bangunan suatu peralatan hendaknya direncanakan secara matang dengan memperhatikan keterbatasan pengetahuan, ketrampilan dan pengalaman yang dimiliki serta sarana dan prasarana yang dibutuhkan. Observasi di lapangan perlu dilakukan untuk melengkapi data-data yang dibutuhkan dan memperluas wawasan.

Bahan dan komponen yang digunakan dalam perancangan dipilih setepat mungkin dengan harga yang terjangkau tetapi masih memenuhi syarat-syarat kenyamanan dan keamanan.

Dalam pengoperasian alat, hendaknya diperhatikan cara pengoperasian yang benar karena akan memberikan hasil yang maksimal sesuai dengan yang diharapkan.

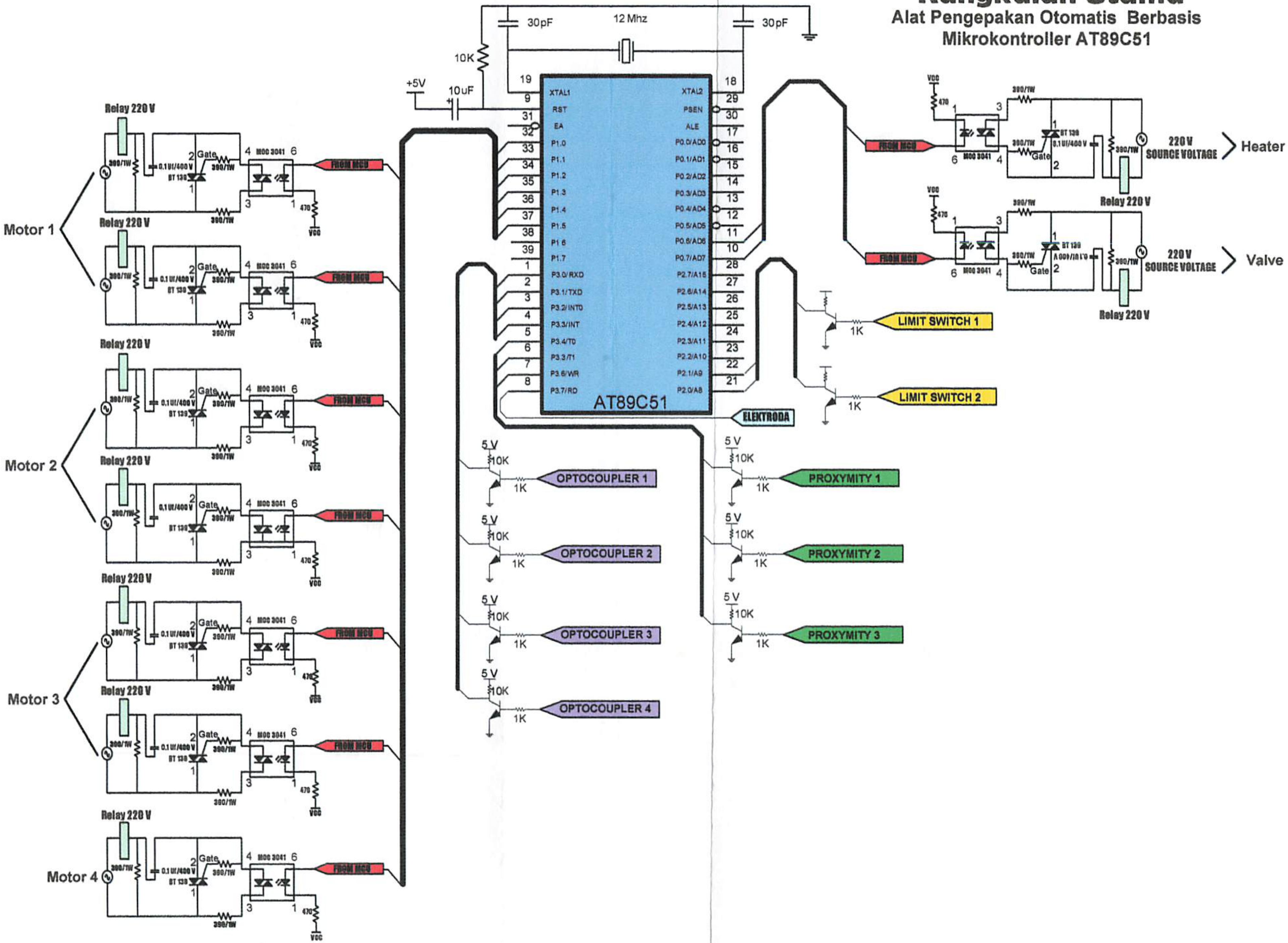
Rangkaian Utama

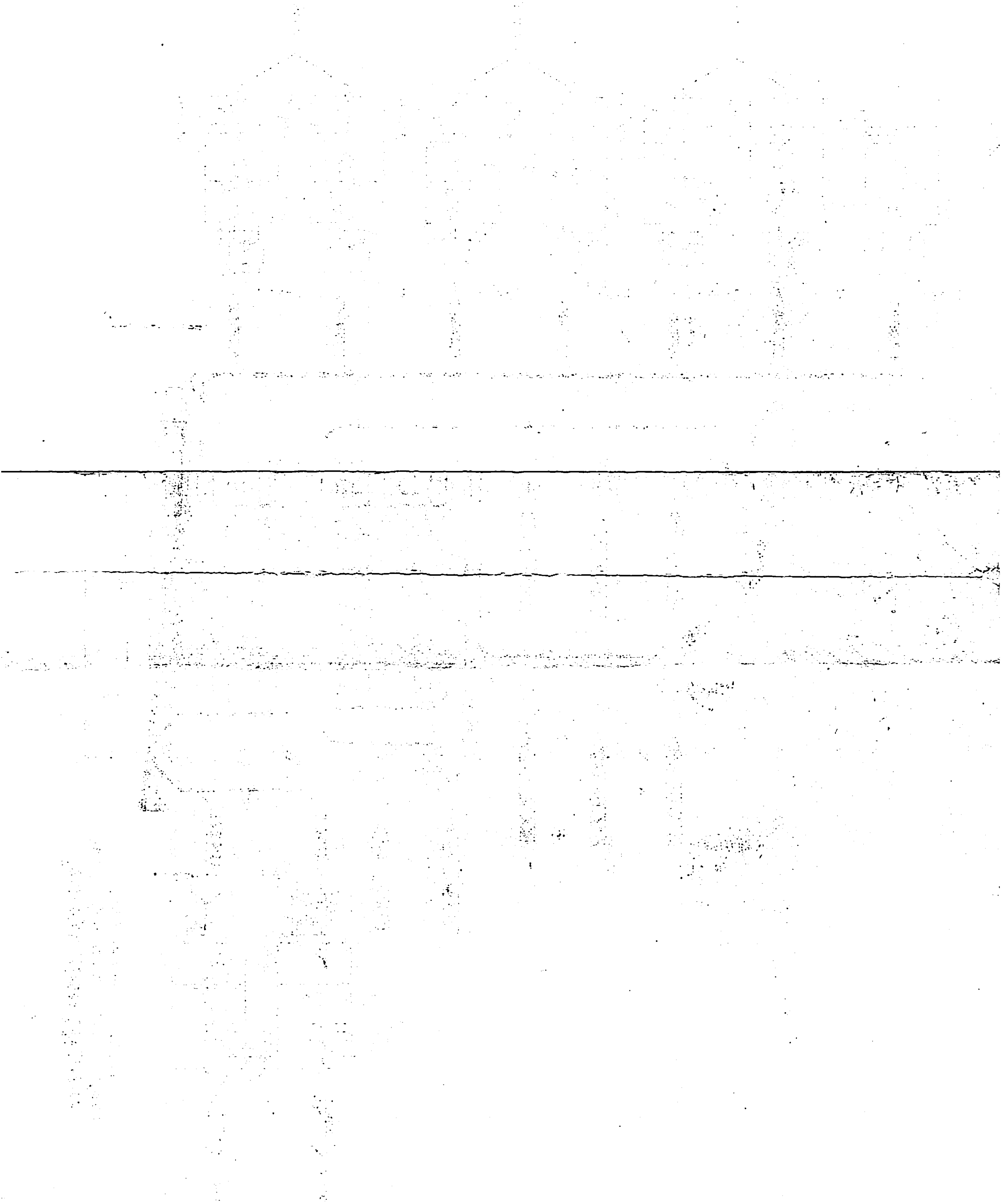
Alat Pengepakan Otomatis Berbasis Mikrokontroller AT89C51



Rangkaian Utama

Alat Pengepakan Otomatis Berbasis Mikrokontroller AT89C51





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8. Instalasi Arus Kuat Jilid 3, Van Harten

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KONSENTRASI TEKNIK ENERGI LISTRIK

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NIM : **03.52.008**
WAKTU BIMBINGAN : 19 Juni s/d 19 Sept 2007.
JUDUL : **Perencanaan Dan Pembuatan Alat Pengepakan Otomatis Untuk Gelas Plastik 250 ml Berbasis MK AT89C51**

No	TANGGAL	MATERI	PARAF
1	20 Juni	Selesaikan bab III, Rancangan	
2		alat, tambahkan gambar rangkaian lengkap.	[paraf]
3	2 Juli 2007	Lanjutkan ke bab IV,	[paraf]
4		Hasil penyusunan alat	
5	10 Juli 2007	buat kesimpulan (bab V)	[paraf]
6	2 Agust 2007	Lanjutkan ke Bab II	[paraf]
7	28 Agust 2007	Revisi bab IV.	[paraf]
8	20 Sept 2007	Acc mengikuti ujian TA	[paraf]
9			

MALANG, 2007

MENGETAHUI
DOSEN PEMBIMBING

[signature]

(Ir. H. Taufik Hidayat, MT)

INSTITUT TEKNOLOGI NASIONAL MALANG
FAKULTAS TENIK INDUSTRI
JURUSAN TEKNIK ENERGI LISTRIK DIII
KONSENTRASI TEKNIK ENERGI LISTRIK

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KONSENTRASI	: T.ENERGI LISTRIK
Judul TA	: Perencanaan Dan Pembuatan Alat Pengepakan Otomatis Untuk Gelas Plastik 250 ml Berbasis MK AT89C51

Di Pertahankan Di Hadapan Team Penguji Tugas Akhir Jenjang Diploma (D III)

Pada :

Hari : SABTU

Tanggal : 22 September 2007

Dengan Nilai : 73,40 (B+)

Panitia Ujian tugas Akhir

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Anggota Penguji

Pertama	Kedua
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INSTITUT TEKNOLOGI NASIONAL
Jl. Bendungan Sigura-gura No. 2
MALANG

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JURUSAN : TEKNIK ELKTRO D- III
PROGRAM STUDI : ENERGI LISTRIK / ELEKTRONIKA *)
HARI / TANGGAL : ....

No.	MATERI PERBAIKAN
	→ Judul di perbaiki (General).
	→ Latar belakang pd bab I. tidak
	balik ada 2.
	→ Penulisan huruf di cek kembali

DOSEN PENGUJI

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

INSTITUT TEKNOLOGI NASIONAL
Jl. Bendungan Sigura-gura No. 2
MALANG

LEMBAR PERBAIKAN TUGAS AKHIR

NAMA : SYAHFRIL ASRI S.
NIM : 03.52.008
JURUSAN : TEKNIK ELKTRO D- III
PROGRAM STUDI : ENERGI LISTRIK / ELEKTRONIKA *)
HARI / TANGGAL : Sabtu / 22 - 09 - 2007

No.	MATERI PERBAIKAN
1	Sensor opto coupler ?
2	perancangan sensor opto coupler ?
3	Rangk. Driver Sens. proximity ?
4	Literatur PLC !
5	Flow Chart .
6	Kesimpulan !
	Gambar lengkap

DOSEN PENGUJI

Komang S. ST, MT

INSTITUT TEKNOLOGI NASIONAL MALANG
FAKULTAS TENIK INDUSTRI
JURUSAN TEKNIK ENERGI LISTRIK DIII
KONSENTRASI TEKNIK ENERGI LISTRIK

LEMBAR PERBAIKAN TUGAS AKHIR

NAMA : **SYAHFRIL ASRI SUBEKTI**
NIM : **03.52.008**
JUDUL : **Perencanaan Dan Pembuatan Alat Pengepakan Otomatis Untuk Gelas Plastik 250 ml Berbasis MK AT89C51**

No	TANGGAL	MATERI	PARAF
1	Sabtu, 22-09-2007	Sensor Optocoupler	
2	Sabtu, 22-09-2007	Perancangan Sensor Optocoupler	
3	Sabtu, 22-09-2007	Rangkaian Driver Sensor Proximity	
4	Sabtu, 22-09-2007	Literatur MOC 3041	
5	Sabtu, 22-09-2007	Flow Chart	
6	Sabtu, 22-09-2007	Kesimpulan & Gambar Lengkap	
7	Sabtu, 22-09-2007	Judul Diperbaiki (General)	
8	Sabtu, 22-09-2007	Latar Belakang Bab I tidak boleh ada 2	
9	Sabtu, 22-09-2007	Penulisan Harap dicek kembali	

MALANG 2007

MENGETAHUI
DOSEN PENGUJI 1

(Ir. H.Choirul Saleh, MT)

DOSEN PENGUJI 2

(I Komang Somawirata, ST.MT)

DOSEN PEMBIMBING

(Ir. H. Taufik Hidayat, MT)

Lampiran

IOTOROLA
EMICONDUCTOR TECHNICAL DATA

Order this document
by MOC3041/D

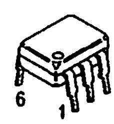
GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

# MOC3041
[IFT = 15 mA Max]
# MOC3042
[IFT = 10 mA Max]
# MOC3043*
[IFT = 5 mA Max]

*Motorola Preferred Device

STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

;-Pin DIP Zero-Cross)ptoisolators Triac Driver Output
;00 Volts Peak)

The MOC3041, MOC3042 and MOC3043 devices consist of gallium arsenide rared emitting diodes optically coupled to a monolithic silicon detector rforming the function of a Zero Voltage Crossing bilateral triac driver.

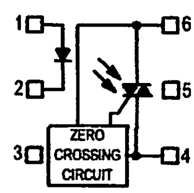
They are designed for use with a triac in the interface of logic systems to uipment powered from 115 Vac lines, such as solid–state relays, industrial ntrols, motors, solenoids and consumer appliances, etc.

- Simplifies Logic Control of 115 Vac Power
- Zero Voltage Crossing
- dv/dt of 2000 V/µs Typical, 1000 V/µs Guaranteed
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

commended for 115/240 Vac(rms) Applications:

- Solenoid/Valve Controls
- Lighting Controls
- Static Power Switches
- AC Motor Drives
- Temperature Controls
- E.M. Contactors
- AC Motor Starters
- Solid State Relays

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE DO NOT CONNECT
6. MAIN TERMINAL

\XIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
'RARED EMITTING DIODE			
₹everse Voltage	V_R	6	Volts
'orward Current — Continuous	I_F	60	mA
otal Power Dissipation @ T_A = 25°C Negligible Power in Output Driver)erate above 25°C	P_D	120 1.41	mW mW/°C
'TPUT DRIVER			
)ff–State Output Terminal Voltage	V_{DRM}	400	Volts
'eak Repetitive Surge Current (PW = 100 µs, 120 pps)	I_{TSM}	1	A
otal Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TAL DEVICE			
;olation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
otal Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
unction Temperature Range	T_J	–40 to +100	°C
mbient Operating Temperature Range(2)	T_A	–40 to +85	°C
torage Temperature Range(2)	T_{stg}	–40 to +150	°C
oldering Temperature (10 s)	T_L	260	°C

Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating.
For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
erred devices are Motorola recommended choices for future use and best overall value.
»alOptoisolator is a trademark of Motorola, Inc.

places MOC3040/D)

MOTOROLA

.ECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
PUT LED					
ʾeverse Leakage Current (V_R = 6 V)	I_R	—	0.05	100	µA
·orward Voltage (I_F = 30 mA)	V_F	—	1.3	1.5	Volts
ITPUT DETECTOR (I_F = 0 unless otherwise noted)					
.eakage with LED Off, Either Direction (Rated V_{DRM}(1))	I_{DRM1}	—	2	100	nA
ʾeak On–State Voltage, Either Direction (I_{TM} = 100 mA Peak)	V_{TM}	—	1.8	3	Volts
;ritical Rate of Rise of Off–State Voltage(3)	dv/dt	1000	2000	—	V/µs
IUPLED					
.ED Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3 V(2))	I_{FT}				mA
MOC3041		—	—	15	
MOC3042		—	—	10	
MOC3043		—	—	5	
ıolding Current, Either Direction	I_H	—	250	—	µA
solation Voltage (f = 60 Hz, t = 1 sec)	V_{ISO}	7500	—	—	Vac(pk)
RO CROSSING					
ıhibit Voltage (I_F = Rated I_{FT}, MT1–MT2 Voltage above which device will not trigger.)	V_{IH}	—	5	20	Volts
eakage in Inhibited State (I_F = Rated I_{FT}, Rated V_{DRM}, Off State)	I_{DRM2}	—	—	500	µA

Test voltage must be applied within dv/dt rating.
All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between I_{FT} (15 mA for MOC3041, 10 mA for MOC3042, 5 mA for MOC3043) and absolute max I_F (60 mA).
This is static dv/dt. See Figure 7 for test circuit. Commutating dv/dt is a function of the load–driving thyristor(s) only.

TYPICAL ELECTRICAL CHARACTERISTICS

T_A = 25°C

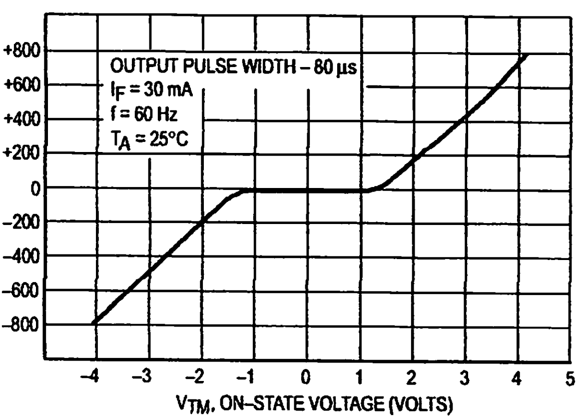


Figure 1. On–State Characteristics

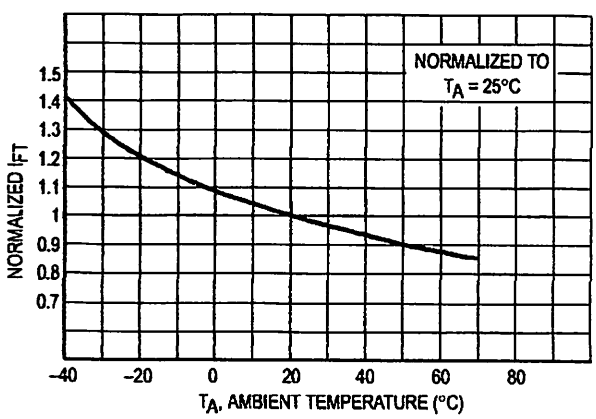


Figure 2. Trigger Current versus Temperature

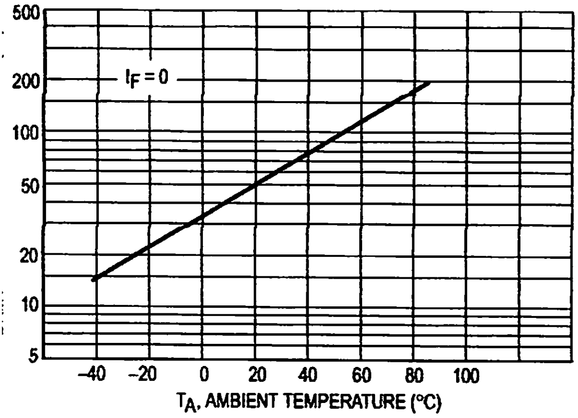


Figure 3. I_{DRM1}, Peak Blocking Current versus Temperature

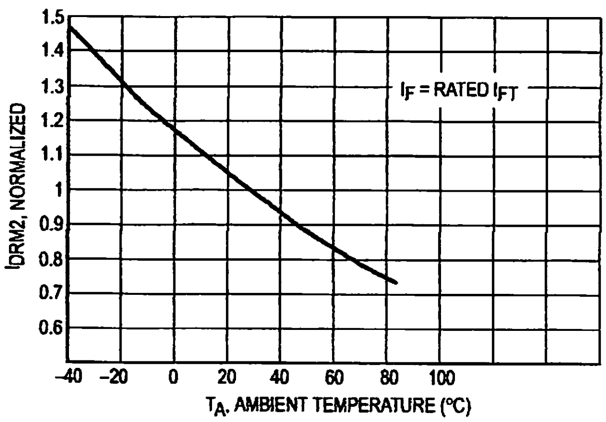


Figure 4. I_{DRM2}, Leakage in Inhibit State versus Temperature

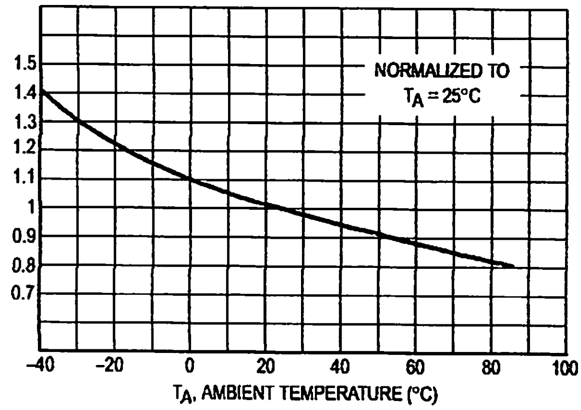


Figure 5. Trigger Current versus Temperature

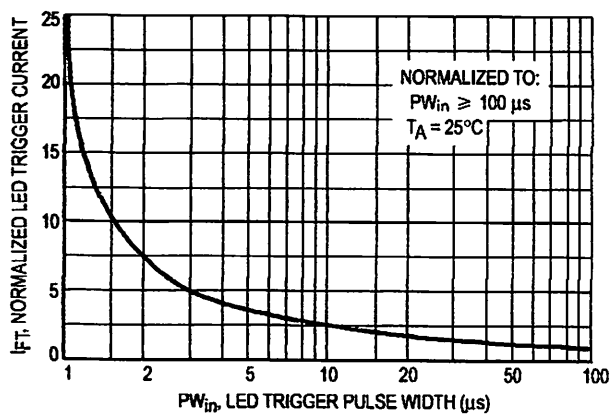
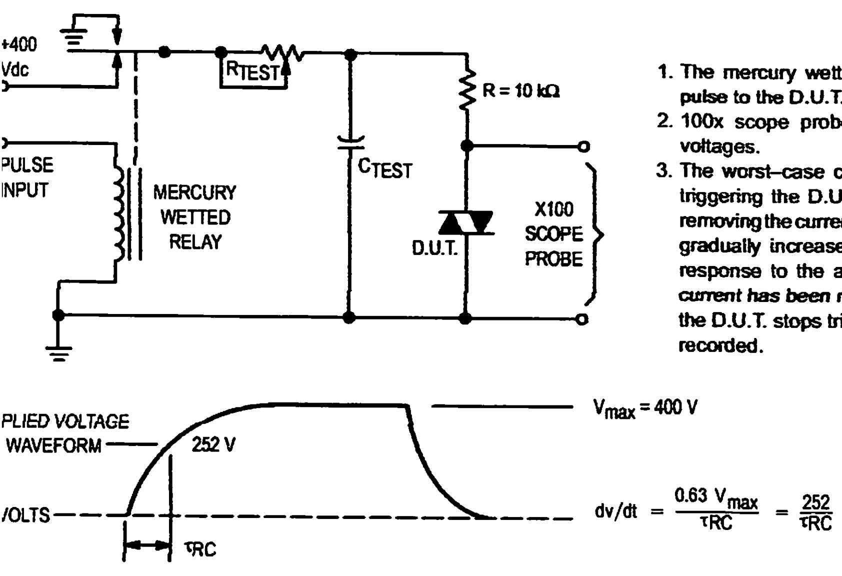
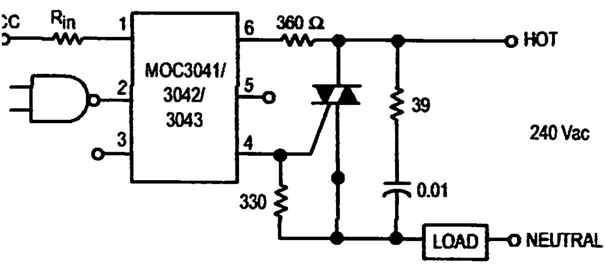


Figure 6. LED Current Required to Trigger versus LED Pulse Width



1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.

Figure 7. Static dv/dt Test Circuit

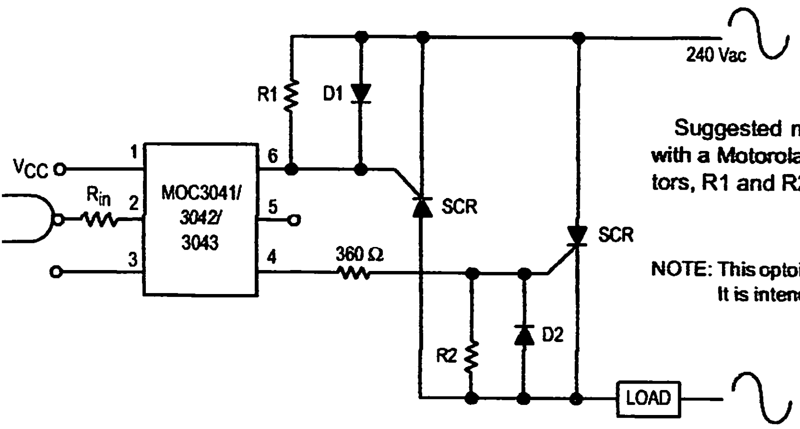


Typical circuit for use when hot line switching is required. In this circuit the "hot" side of the line is switched and the load connected to the cold or neutral side. The load may be connected to either the neutral or hot line.

R_{in} is calculated so that I_F is equal to the rated I_{FT} of the part, 5 mA for the MOC3043, 10 mA for the MOC3042, or 15 mA for the MOC3041. The 39 ohm resistor and 0.01 μF capacitor are for snubbing of the triac and may or may not be necessary depending upon the particular triac and load used.

or highly inductive loads (power factor < 0.5), change this value to 60 ohms.

Figure 8. Hot–Line Switching Application Circuit

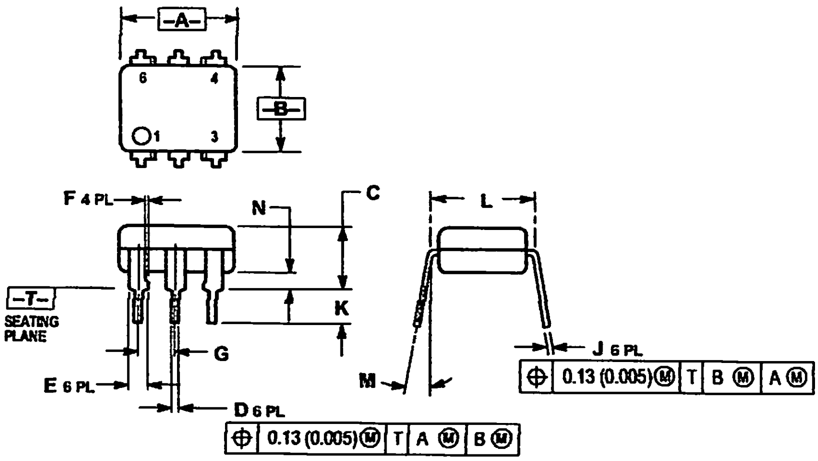


Suggested method of firing two, back–to–back SCR's, with a Motorola triac driver. Diodes can be 1N4001; resistors, R1 and R2, are optional 330 ohms.

NOTE: This optoisolator should not be used to drive a load directly. It is intended to be a trigger device only.

Figure 9. Inverse–Parallel SCR Driver Circuit

PACKAGE DIMENSIONS

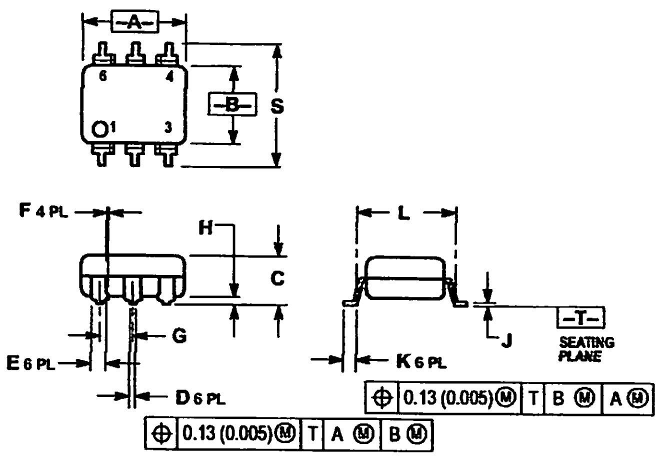


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
J	0.008	0.012	0.21	0.30
K	0.100	0.150	2.54	3.81
L	0.300 BSC		7.62 BSC	
M	0°	15°	0°	15°
N	0.015	0.100	0.38	2.54

STYLE 6:
PIN 1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE
6. MAIN TERMINAL

CASE 730A–04
ISSUE G

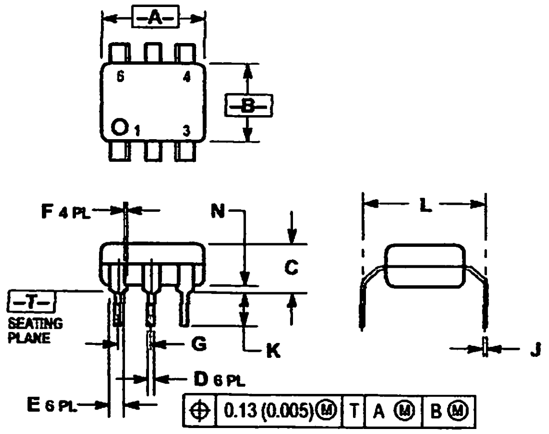


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
H	0.020	0.025	0.51	0.63
J	0.008	0.012	0.20	0.30
K	0.006	0.035	0.16	0.88
L	0.320 BSC		8.13 BSC	
S	0.332	0.390	8.43	9.90

Consult factory for leadform option availability

CASE 730C–04
ISSUE D



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
J	0.008	0.012	0.21	0.30
K	0.100	0.150	2.54	3.81
L	0.400	0.425	10.16	10.80
N	0.015	0.040	0.38	1.02

***Consult factory for leadform option availability**

CASE 730D–05
ISSUE D

ı to reach us:
ι / EUROPE: Motorola Literature Distribution;
Box 20912; Phoenix, Arizona 85036. 1–800–441–2447

JAPAN: Nippon Motorola Ltd.; Tatsumi–SPD–JLDC, Toshikatsu Otsuki,
6F Seibu–Butsuryu–Center, 3–14–2 Tatsumi Koto–Ku, Tokyo 135, Japan. 03–3521–8315

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51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852–26629298

MOTOROLA

Photodiode/Phototransistor Application Circuit

JNDAMENTAL PHOTODIODE CIRCUITS

Figures 1 and 2 show the fundamental photodiode cuits.

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

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

Figure 2 shows a circuit in which the photodiode is erse-biased by V_{CC} and a photocurrent (I_P) is trans- med 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 photo- diode causes the dark current (I_d) to increase, leaving a voltage of $Id \times R_L$ 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.

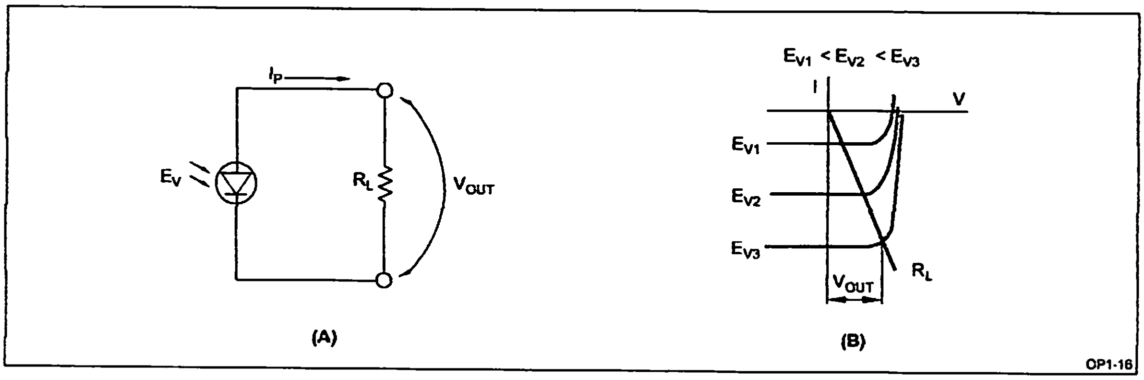


Figure 1. Fundamental Circuit of Photodiode (Without Bias)

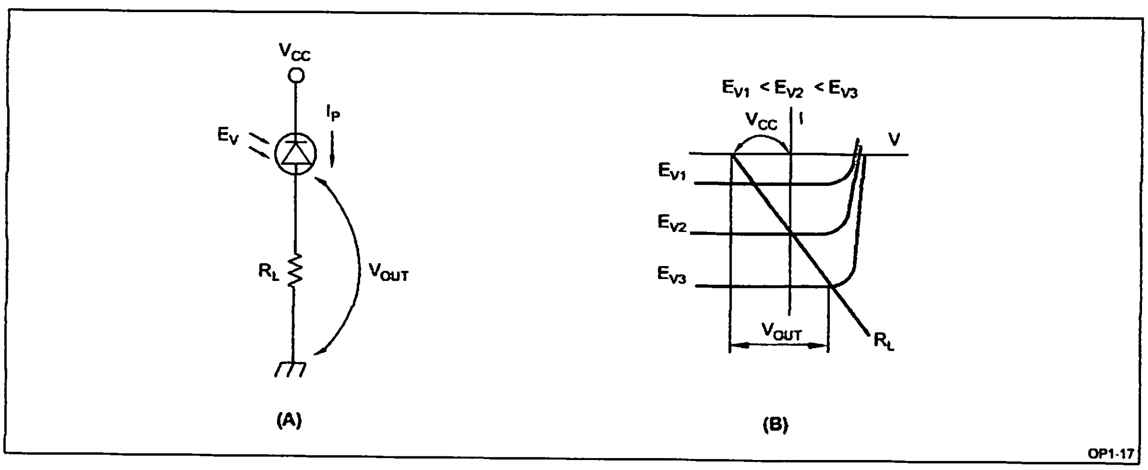


Figure 2. Fundamental Circuit of Photodiode (With Bias)

The response time is inversely proportional to the verse 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 SING THE TRANSISTOR OF HOTODIODE

Figures 3 and 4 show photocurrent amplifiers using ınsistors.

The circuit shown in Figure 3 are most basic combina- ns of a photodiode and an amplifying transistor. In the 'angement of Figure 3 (A), the photocurrent produced the photodiode causes the transistor (Tr_1) to decrease output (V_{OUT}) from high to low. In the arrangement of ȷure 3 (B), the photocurrent causes the V_{OUT} to :rease from low to high. Resistor R_{BE} in the circuit is ective for suppressing the influence of dard current (I_d) d 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 ·dback.

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.

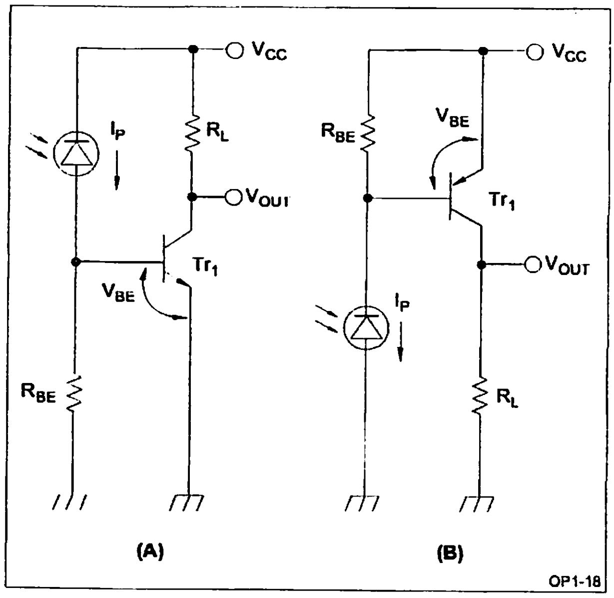


Figure 3. Photocurrent Amplifier Circuit using Transistor

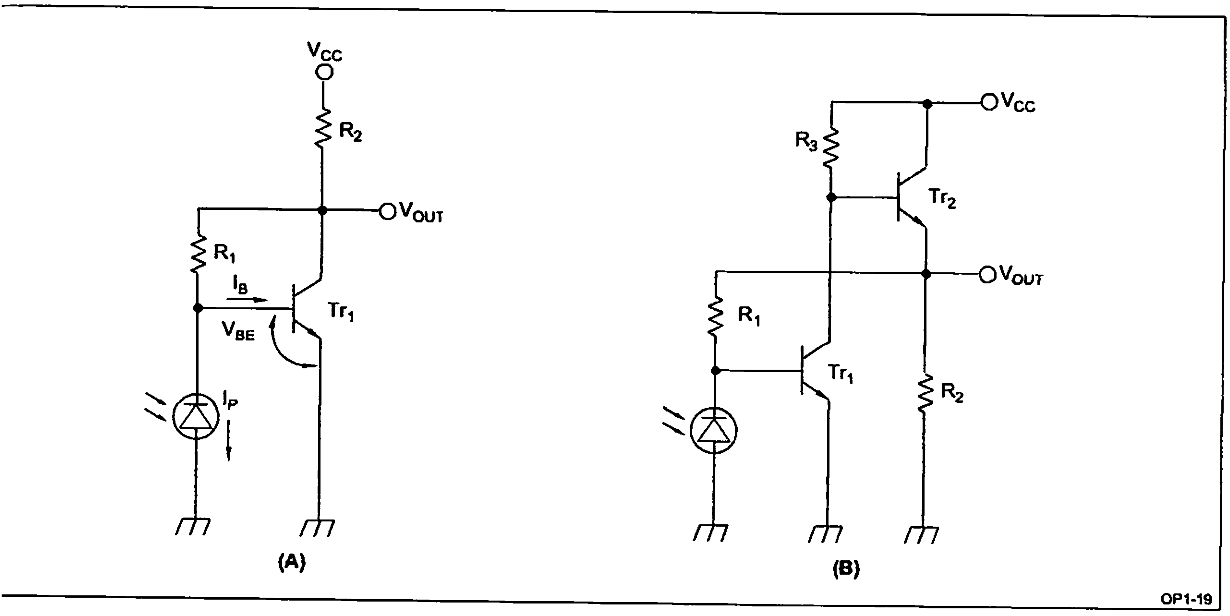


Figure 4. Photocurrent Amplifier Circuit with Negative Feedback

MPLIFIER CIRCUIT USING 'PERATIONAL AMPLIFIER

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

Figure 6 (B) shows the output voltage vs. radiant ensity characteristics. An arrangement with no bias d high impedance loading to the photodiode proles 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 ing an operating amplifier. The circuit uses a logarithc diode for the logarithmic conversion of photocurnt into an output voltage. In dealing with a very wide adiation 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.

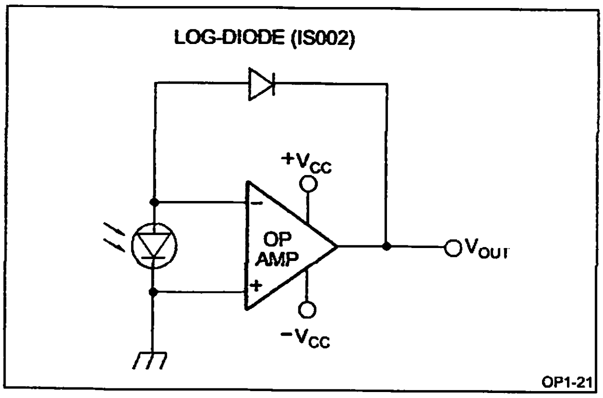


Figure 5. Logarithmic Photocurrent Amplifier using an Operational Amplifier

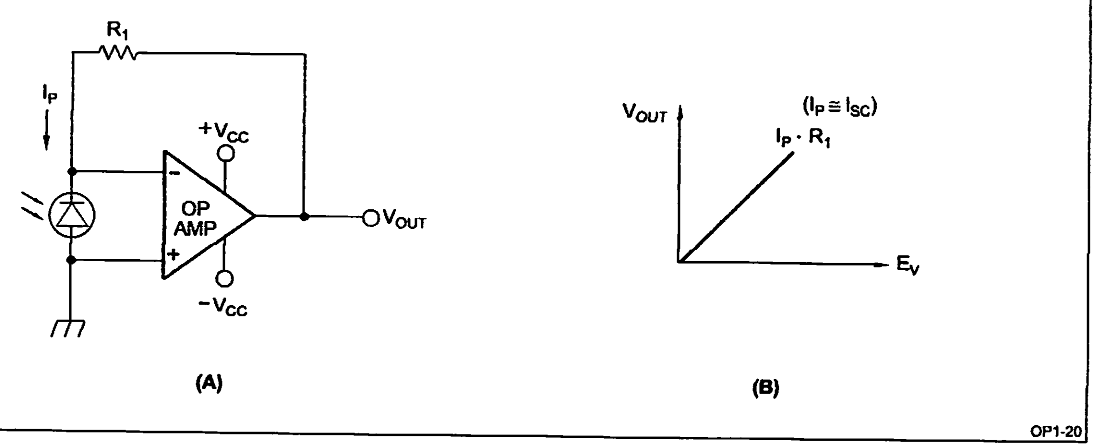


Figure 6. Photocurrent Amplifier using an Operational Amplifier (Without Bias)

IGHT DETECTING CIRCUIT FOR IODULATED LIGHT INPUT

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

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

OLOR SENSOR AMPLIFIER CIRCUIT

Figure 8 shows a color sensor amplifier using a miconductor color sensor. Two short circuit currents $_{SC1}$, I_{SC2}) conducted by two photodiodes having dif-ent spectral sensitivities are compressed logarithmi-lly and applied to a subtraction circuit which ɔduces a differential output (V_{OUT}). The output volt-e (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.

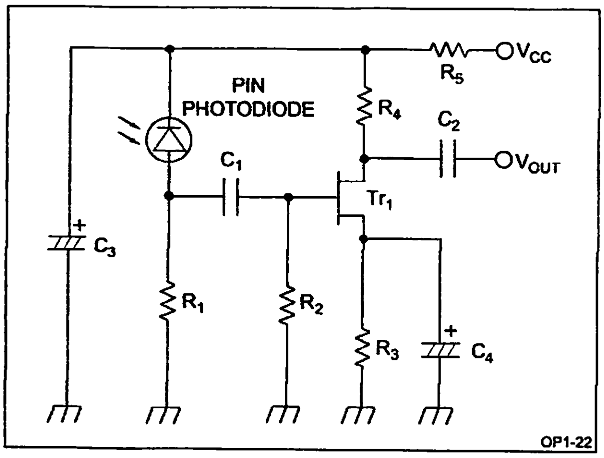


Figure 7. Light Detecting Circuit for Modulated Light Input PIN Photodiode

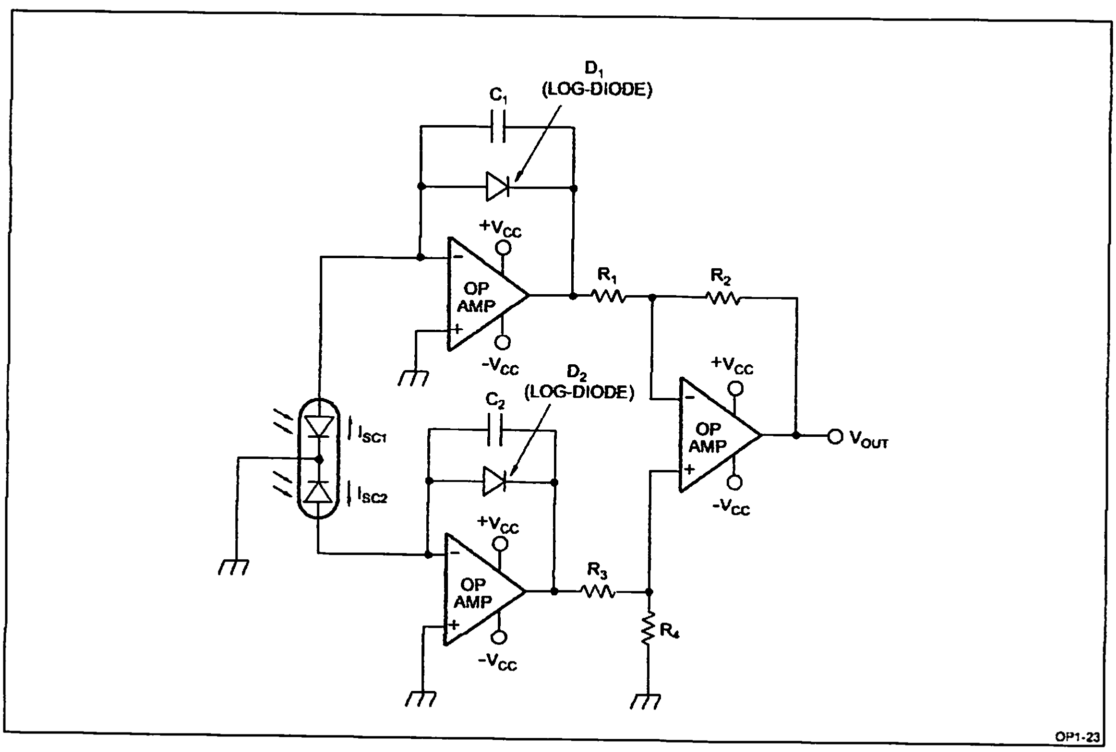


Figure 8. Color Sensor Amplifier Circuit

UNDAMENTAL PHOTOTRANSISTOR :IRCUITS

Figures 9 and 10 show the fundamental phototrans-tor circuits. The circuit shown in Figure 9 (A) is a com-on-emitter amplifier. Light input at the base causes e output (V_{OUT}) to decrease from high to low. The cir-*iit shown in Figure 9 (B) is a common-collector ampli-*ɛr with an output (V_{OUT}) increasing from low to high in sponse to light input. For the circuits in Figure 9 to ɔerate in the switching mode, the load resistor (R_L) ıould be set in relation with the collector current (I_C) ; $V_{CC} < R_L \times I_C$.

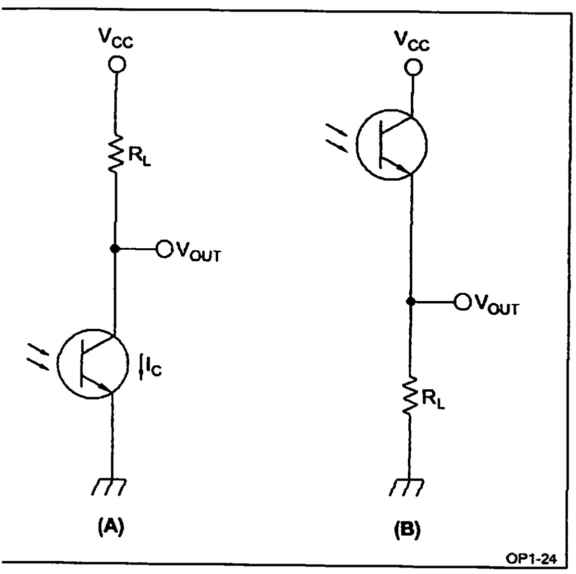
The circuit shown Figure 10 (A) uses a phototrans-tor with a base terminal. A R_{BE} resistor connected ɛtween the base and emitter alleviates the influence a dark current when operating at a high temperature. ıe circuit shown in Figure 10 (B) features a cascade ɔnnection of the grounded-base transistor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

MPLIFIER CIRCUIT USING TRANSISTOR

Figure 11 shows the transistor amplifiers used to nplify the collector current of the phototransistor ;ing a transistor (Tr_1). The circuit in Figure 11 (A) ɔreases the output from high to low in response to a ht input. The value of resistor R_1 depends on the ɔut light intensity, ambient temperature, response eed, 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 d I_C is the collector current.



gure 9. Fundamental Phototransistor Circuit (I)

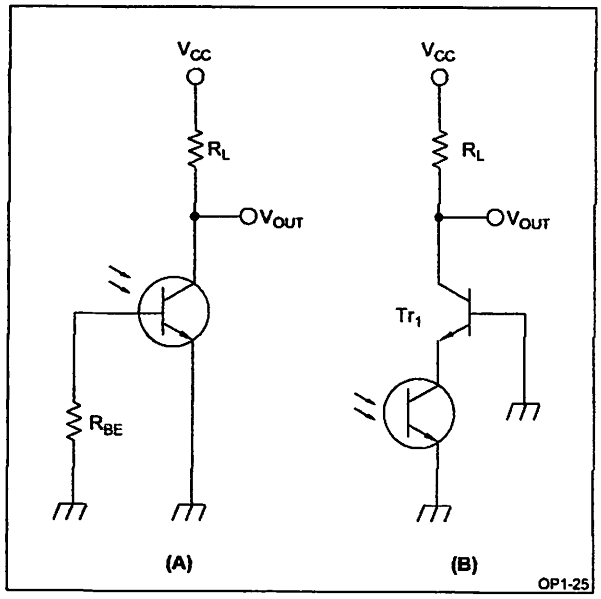


Figure 10. Fundamental Phototransistor Circuit (II)

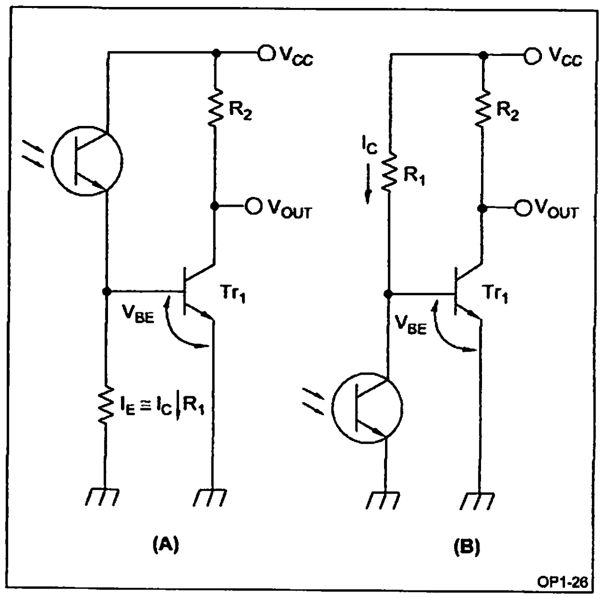


Figure 11. Amplifier Circuit using Transistor

IODULATED SIGNAL DETECTION CIRCUIT

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

,MPLIFIER CIRCUIT USING IPERATIONAL AMPLIFIER

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

The current-voltage conversion circuit for the pho-transistor is basically identical to that of the photo-ode, except that the phototransistor requires a bias. ıe circuit shown if Figure 13 (A) has a negative bias V) for the emitter against the virtually grounded col-ctor potential. Figure 13 (B) shows the output voltage ;. irradiation intensity characteristics.

UTO-STROBOSCOPE CIRCUIT

Figure 14 shows the auto-stroboscope circuit of the ırrent cut type. This circuit is most frequently used ıcause of advantages such as continuous light emis-ɔn 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.

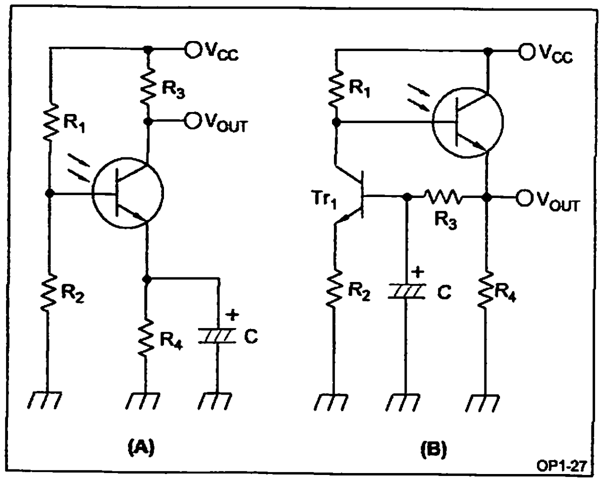


Figure 12. Modulated Signal Detection Circuit

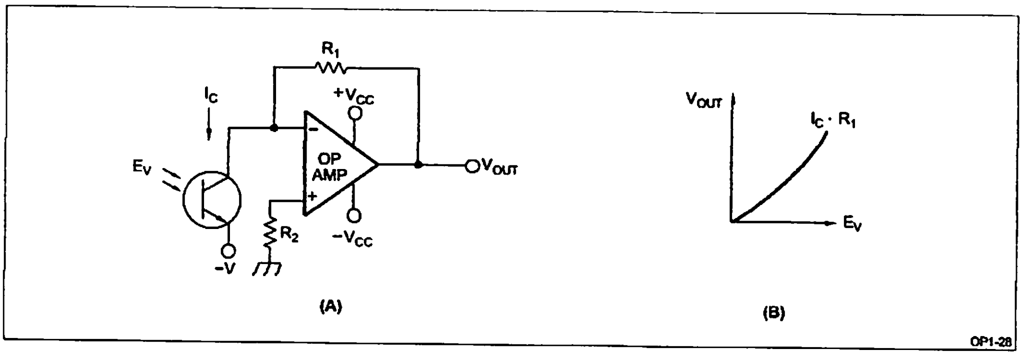


Figure 13. Amplifier Circuit using an Operational Amplifier

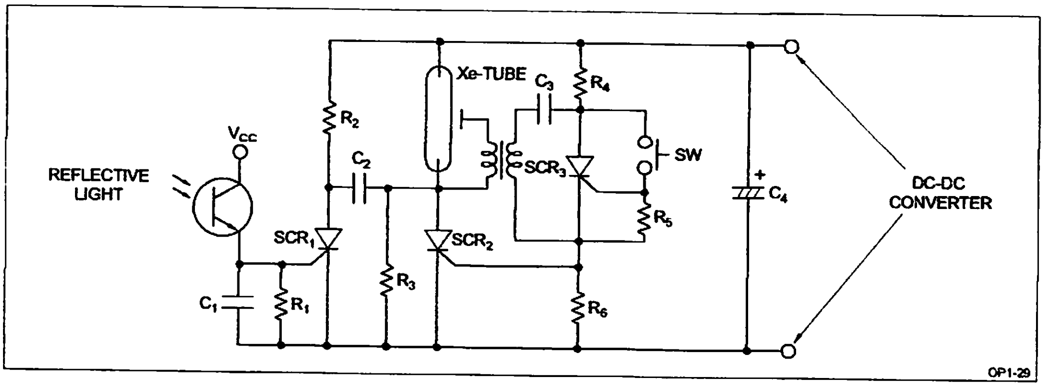


Figure 14. Auto-Stroboscope Circuit

FE SUPPORT POLICY

HARP components should not be used in medical devices with life support functions or in safety equipment (or similiar applications where mponent failure would result in loss of life or physical harm) without the written approval of an officer of the SHARP Corporation.

MITED WARRANTY

HARP warrants to its Customer that the Products will be free from defects in material and workmanship under normal use and service for a riod of one year from the date of invoice. Customer's exclusive remedy for breach of this warranty is that SHARP will either (i) repair or place, at its option, any Product which fails during the warranty period because of such defect (if Customer promptly reported the failure to HARP in writing) or, (ii) if SHARP is unable to repair or replace, refund the purchase price of the Product upon its return to SHARP. This arranty does not apply to any Product which has been subjected to misuse, abnormal service or handling, or which has been altered or odified in design or construction, or which has been serviced or repaired by anyone other than Sharp. The warranties set forth herein are in u of, and exclusive of, all other warranties, express or implied. ALL EXPRESS AND IMPLIED WARRANTIES, INCLUDING THE ARRANTIES OF MERCHANTABILITY, FITNESS FOR USE AND FITNESS FOR A PARTICULAR PURPOSE, ARE SPECIFICALLY CLUDED. In no event will Sharp be liable, or in any way responsible, for any incidental or consequential economic or property damage.

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http://www.sharp.co.jp/e-device/index.html

Reference Code SMA99017

FUJITSU THE POSSIBILITIES ARE INFINITE

MINIATURE RELAY

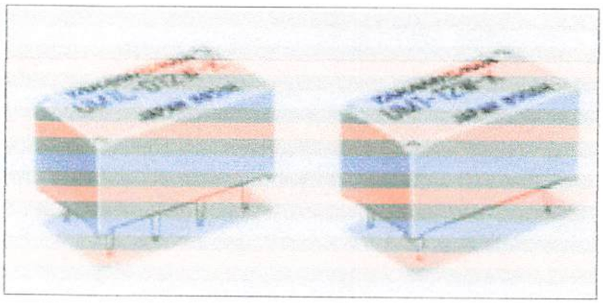
1 POLE

(HIGH FREQUENCE SIGNAL SWITCHING)

UM1 SERIES

RoHS Compliant

FEATURES



- Subminiature polarized relay
- Excellent high frequency characteristics at 900 MHz (Impedance of the measuring devices is 75Ω)
  - —Isolation : min. 60 dB
  - —Insertion loss : max. 1 dB
  - —V.S.W.R. : max. 1.2
- High reliability—Bifurcated contacts
- Wide operating range
- DIL pitch terminals
- Plastic sealed type
- Latching type available
- RoHS compliant since date code: 0437T2
  Please see page 7 for more information

ORDERING INFORMATION

[Example] UM1 (a) L (b) – D (c) 12 (d) W (e) – K (f)

(a)	Series Name	UM1: UM1 Series
(b)	Operation Function	Nil : Standard type L : Latching type
(c)	Number of Coil	Nil : Single winding type D : Double winding type
(d)	Nominal Voltage	Refer to the COIL DATA CHART
(e)	Contact	W : Bifurcated type
(f)	Enclosure	K : Plastic sealed type

SPECIFICATIONS

Item			Standard Type UM1-( ) W-K	Single Winding Latching Type UM1L-( ) W-K	Double Winding Latching Type UM1L-D ( ) W-K
Contact	Arrangement		1 form C (SPDT)		
	Material		Gold clad (stationary contact), gold plate (movable contact)		
	Style		Bifurcated		
	Resistance (initial)		*Maximum 100 mΩ*		
	Rating (resistive)		10 mA 24 VDC 1 W (at 900 MHz)		
	Maximum Carrying Current		0.5 A		
	Maximum Switching Power		1 W (DC) 10 W (at 900 MHz)		
	Maximum Switching Voltage		30 VDC		
	Maximum Switching Current		100 mA		
	Minimum Switching Load*1		0.01 mA 10 mVDC		
Excellent High Frequency Character-istics	Isolation		Minimum 60 dB(at 900 MHz), impedance of the measuring devices is 75Ω		
	Insertion Loss		Maximum 1 dB(at 900 MHz), impedance of the measuring devices is 75Ω		
	V.S.W.R.		Maximum 1.2(at 900 MHz), impedance of the measuring devices is 75Ω		
Coil	*Nominal Power (at 20°C)*		*0.2 to 0.22 W*	*0.2 W*	*0.4 W*
	Operate Power (at 20°C)		0.1 to 0.11 W	0.1 W	0.2 W
	Operating Temperature		−30°C to +80°C (no frost)		−30°C to +60°C (no frost)
Time Value	Operate (at nominal voltage)		Maximum 6 ms	Maximum 6 ms (set)	
	Release (at nominal voltage)		Maximum 5 ms	Maximum 6 ms (reset)	
Insulation	Resistance (at 500 VDC)		Minimum 1,000 MΩ		
	Dielectric Strength	between open contacts *between contacts* and shield terminals	*500 VAC 1 minute*		
		between coil and contacts, between coil and shield terminals	1,000 VAC 1 minute		
Life	Mechanical		1×10^6 operations minimum		
	Electrical		3×10^5 operations minimum (at nominal load)		
Other	Vibration Resistance	Misoperation	10 to 55 Hz (double amplitude of 3.3 mm)		
		Endurance	10 to 55 Hz (double amplitude of 5.0 mm)		
	Shock Resistance	Misoperation	500 m/s^2 (11 ±1 ms)		
		Endurance	1,000 m/s^2 (6 ±1 ms)		
	Weight		*Approximately 4 g*		

Minimum switching loads mentioned above are reference values. Please perform the confirmation test with the actual load before production since reference values may vary according to switching frequencies, environmental conditions and expected reliability levels.

▮ COIL DATA CHART

	MODEL	Nominal voltage	Coil resistance (±10%)	Must operate voltage*1	Must release voltage*1	Nominal power
Standard Type	UM1- 1.5 W-K	1.5 VDC	11.2Ω	+1.05 VDC	+0.08 VDC	200 mW
	UM1- 3 W-K	3 VDC	45 Ω	+2.1 VDC	+0.15 VDC	200 mW
	UM1- 4.5 W-K	4.5 VDC	101 Ω	+3.15 VDC	+0.23 VDC	200 mW
	UM1- 5 W-K	5 VDC	125 Ω	+3.5 VDC	+0.25 VDC	200 mW
	UM1- 6 W-K	6 VDC	180 Ω	+4.2 VDC	+0.3 VDC	200 mW
	UM1- 9 W-K	9 VDC	405 Ω	+6.3 VDC	+0.45 VDC	200 mW
	UM1- 12 W-K	12 VDC	720 Ω	+8.4 VDC	+0.6 VDC	200 mW
	UM1- 18 W-K	18 VDC	1,620 Ω	+12.6 VDC	+0.9 VDC	200 mW
	UM1- 24 W-K	24 VDC	2,880 Ω	+16.8 VDC	+1.2 VDC	200 mW
	UM1- 48 W-K	48 VDC	10,472 Ω	+33.6 VDC	+2.4 VDC	220 mW

ote: *1 Specified values are subject to pulse wave voltage.
ll values in the table are measured at 20°C.

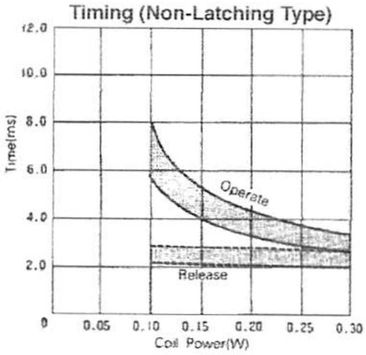
	MODEL	Nominal voltage	Coil resistance (±10%)	Set voltage*1	Reset voltage*1	Nominal power
Single Winding Latching Type	UM1L- 1.5 W-K	1.5 VDC	11.2Ω	+1.05 VDC	-1.05 VDC	200 mW
	UM1L- 3 W-K	3 VDC	45 Ω	+2.1 VDC	-2.1 VDC	200 mW
	UM1L- 4.5 W-K	4.5 VDC	101 Ω	+3.15 VDC	-3.15 VDC	200 mW
	UM1L- 5 W-K	5 VDC	125 Ω	+3.5 VDC	-3.5 VDC	200 mW
	UM1L- 6 W-K	6 VDC	180 Ω	+4.2 VDC	-4.2 VDC	200 mW
	UM1L- 9 W-K	9 VDC	405 Ω	+6.3 VDC	-6.3 VDC	200 mW
	UM1L- 12 W-K	12 VDC	720 Ω	+8.4 VDC	-8.4 VDC	200 mW
	UM1L- 18 W-K	18 VDC	1,620 Ω	+12.6 VDC	-12.6 VDC	200 mW
	UM1L- 24 W-K	24 VDC	2,880 Ω	+16.8 VDC	-16.8 VDC	200 mW
	UM1L- 48 W-K	48 VDC	11,520 Ω	+33.6 VDC	-33.6 VDC	200 mW
Double Winding Latching Type	UM1L-D1.5 W-K	1.5 VDC	P 5.6Ω	+1.05 VDC		400 mW
			S 5.6Ω		+1.05 VDC	
	UM1L-D 3 W-K	3 VDC	P 22.5Ω	+2.1 VDC		400 mW
			S 22.5Ω		+2.1 VDC	
	UM1L-D4.5 W-K	4.5 VDC	P 50.6Ω	+3.15 VDC		400 mW
			S 50.6Ω		+3.15 VDC	
	UM1L-D 5 W-K	5 VDC	P 62.5Ω	+3.5 VDC		400 mW
			S 62.5Ω		+3.5 VDC	
	UM1L-D 6 W-K	6 VDC	P 90 Ω	+4.2 VDC		400 mW
			S 90 Ω		+4.2 VDC	
	UM1L-D 9 W-K	9 VDC	P 202.5Ω	+6.3 VDC		400 mW
			S 202.5Ω		+6.3 VDC	
	UM1L-D 12 W-K	12 VDC	P 360 Ω	+8.4 VDC		400 mW
			S 360 Ω		+8.4 VDC	
	UM1L-D 18 W-K	18 VDC	P 810 Ω	+12.6 VDC		400 mW
			S 810 Ω		+12.6 VDC	
	UM1L-D 24 W-K	24 VDC	P 1,440 Ω	+16.8 VDC		400 mW
			S 1,440 Ω		+16.8 VDC	
	UM1L-D 48 W-K	48 VDC	P 5,760 Ω	+33.6 VDC		400 mW
			S 5,760 Ω		+33.6 VDC	

te: *1 Specified values are subject to pulse wave voltage.
values in the table are measured at 20°C.

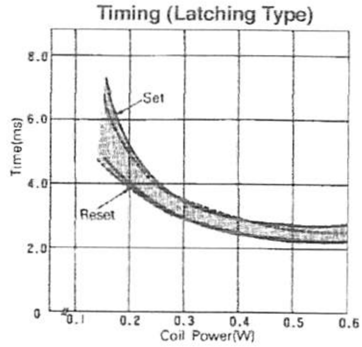
P: Primary coil S: Secondary coil

CHARACTERISTIC DATA

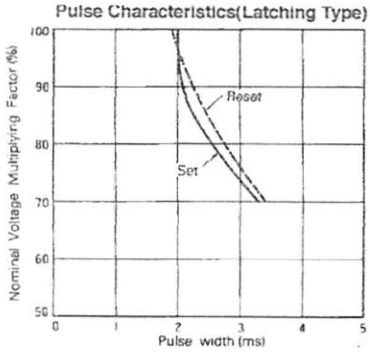
Timing (Non-Latching Type)



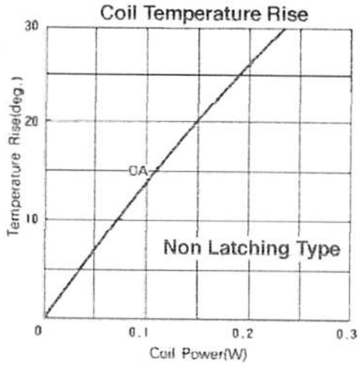
Timing (Latching Type)



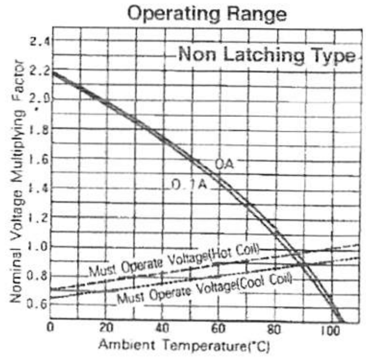
Pulse Characteristics(Latching Type)



Coil Temperature Rise

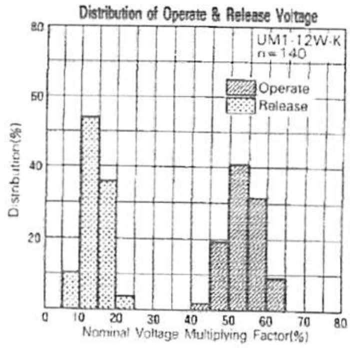


Operating Range

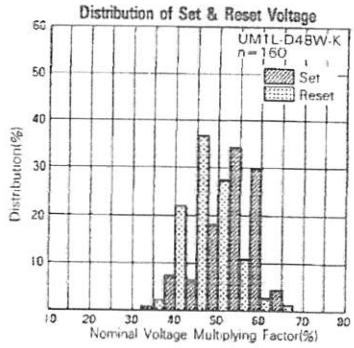


REFERENCE DATA

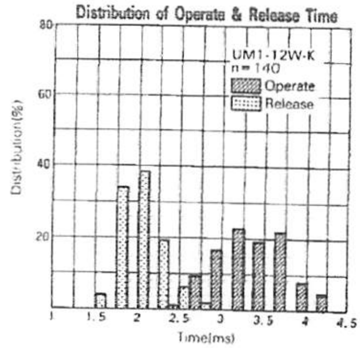
Distribution of Operate & Release Voltage



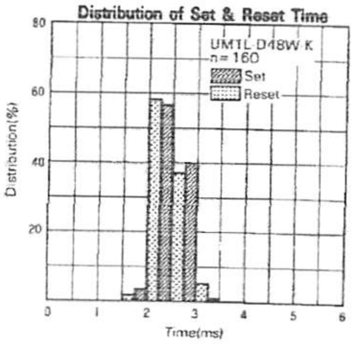
Distribution of Set & Reset Voltage



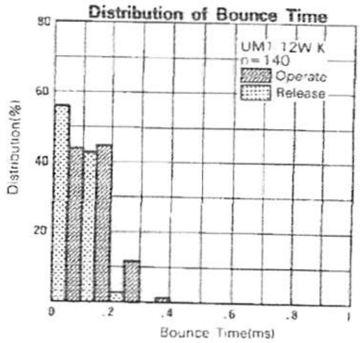
Distribution of Operate & Release Time



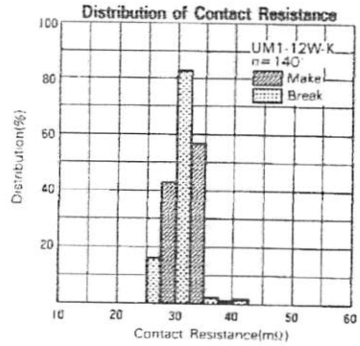
Distribution of Set & Reset Time

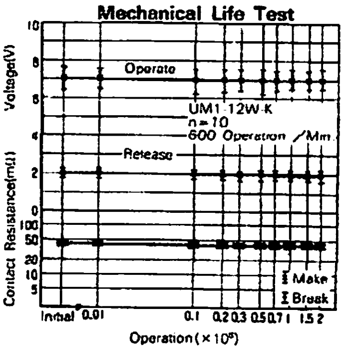


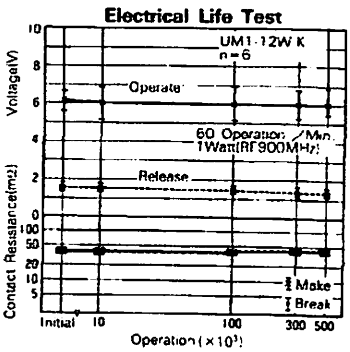
Distribution of Bounce Time

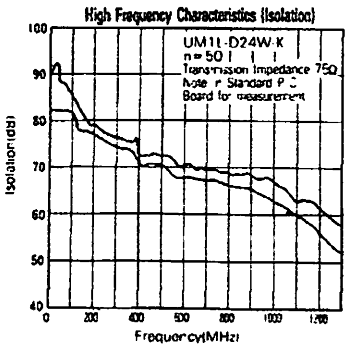


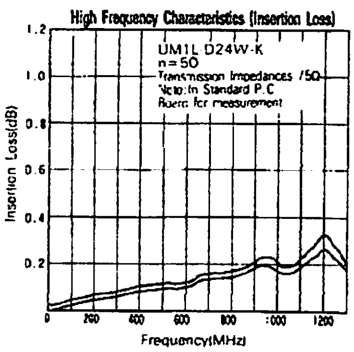
Distribution of Contact Resistance

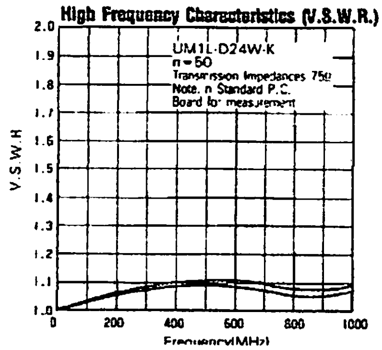








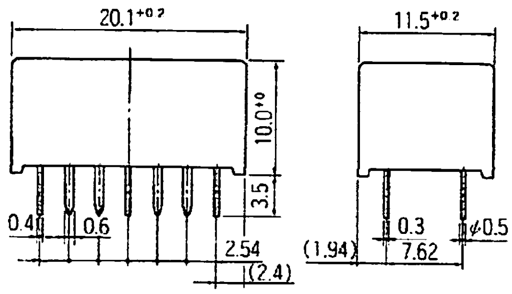


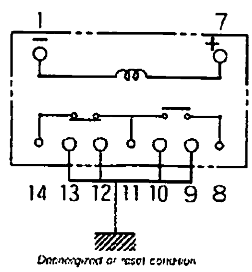


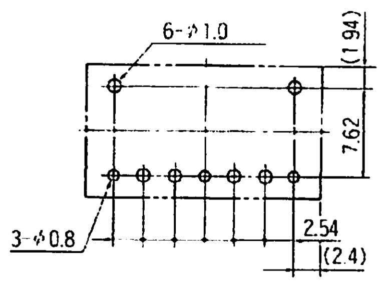
I DIMENSIONS

●Dimensions **●Schematics** (Bottom view) **●PC board mounting hole layout** (Bottom view)

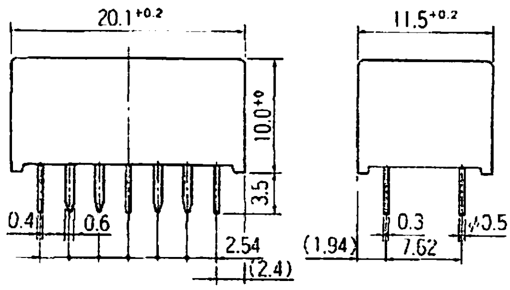
M1, UM1L type (Non-latching type, single winding latching type)

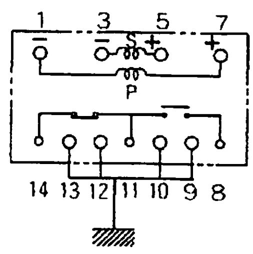


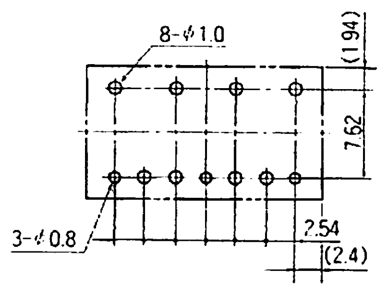




M1L-D type (Double winding latching type)







Unit: mm

RoHS Compliance and Lead Free Relay Information

1. General Information

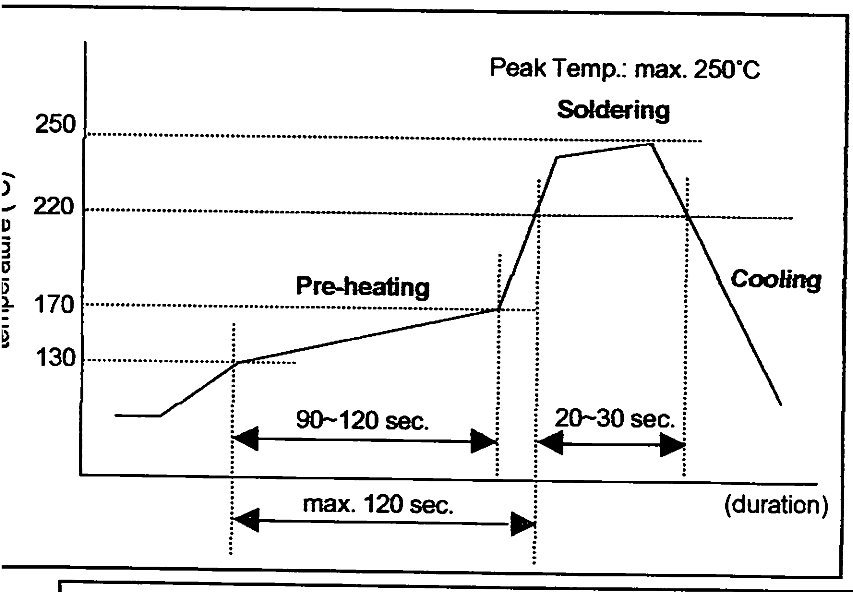
- Relays produced after the specific date code that is indicated on each data sheet are lead-free now. Most of our signal and power relays are lead-free. Please refer to Lead-Free Status Info. (http://www.fcai.fujitsu.com/pdf/LeadFreeLetter.pdf)
- Lead free solder paste currently used in relays is Sn-3.0Ag-0.5Cu. From February 2005 forward Sn-3.0Cu-Ni will be used for FTRB3 and FTR-B4 series relays.
- Most signal and some power relays also comply with RoHS. Please refer to individual data sheets. Relays that are RoHS compliant do not contain the 6 hazardous materials that are restricted by RoHS directive (lead, mercury, cadmium, chromium IV, PBB, PBDE).
- It has been verified that using lead-free relays in leaded assembly process will not cause any problems (compatible).
- "LF" is marked on each outer and inner carton. (No marking on individual relays).
- To avoid leaded relays (for lead-free sample, etc.) please consult with area sales office.

We will ship leaded relays as long as the leaded relay inventory exists.

2. Recommended Lead Free Solder Profile

- Recommended solder paste Sn-3.0Ag-0.5Cu and Sn-3.0 Cu-Ni (only FTR-B3 and FTR-B4 from February 2005)

eflow Solder condtion



Flow Solder condtion:

Pre-heating:	maximum 120°C
Soldering:	dip within 5 sec. at 260°C soler bath

Solder by Soldering Iron:

Soldering Iron

Temperature:	maximum 360°C
Duration:	maximum 3 sec.

We highly recommend that you confirm your actual solder conditions

Moisture Sensitivity

Moisture Sensitivity Level standard is not applicable to electromechanical realys.

Tin Whisker

SnAgCu solder is known as low riskof tin whisker. No considerable length whisker was found by our in-house test.

Solid State Relays

Each lead terminal will be changed from solder plating to Sn plating and Nickel plating. A layer of Nickel plating between the terminal and the Sn plating to avoid whisker.

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tures

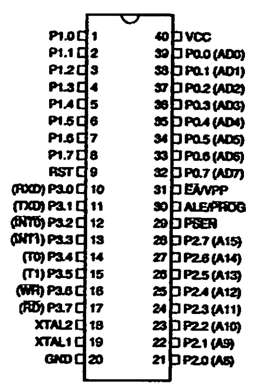
npatible with MCS-51™ Products
Bytes of In-System Reprogrammable Flash Memory
 Endurance: 1,000 Write/Erase Cycles
y Static Operation: 0 Hz to 24 MHz
ee-level Program Memory Lock
 x 8-bit Internal RAM
'rogrammable I/O Lines
 16-bit Timer/Counters
Interrupt Sources
grammable Serial Channel
-power Idle and Power-down Modes

cription

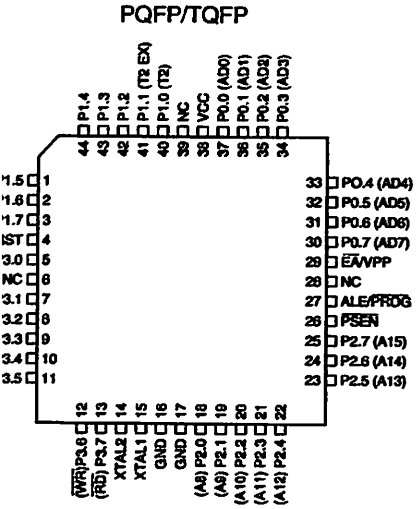
T89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K of Flash programmable and erasable read only memory (PEROM). The device nufactured using Atmel's high-density nonvolatile memory technology and is atible with the industry-standard MCS-51 instruction set and pinout. The on-chip allows the program memory to be reprogrammed in-system or by a conven- nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash nonolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides ly-flexible and cost-effective solution to many embedded control applications.

Configurations

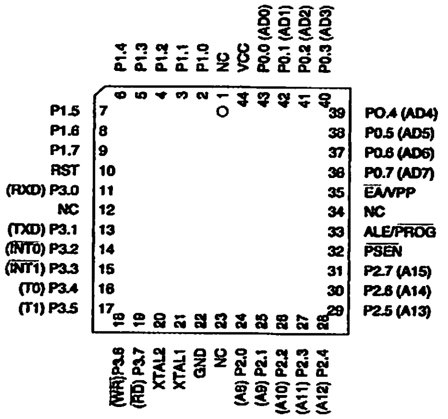
PDIP



PQFP/TQFP



PLCC

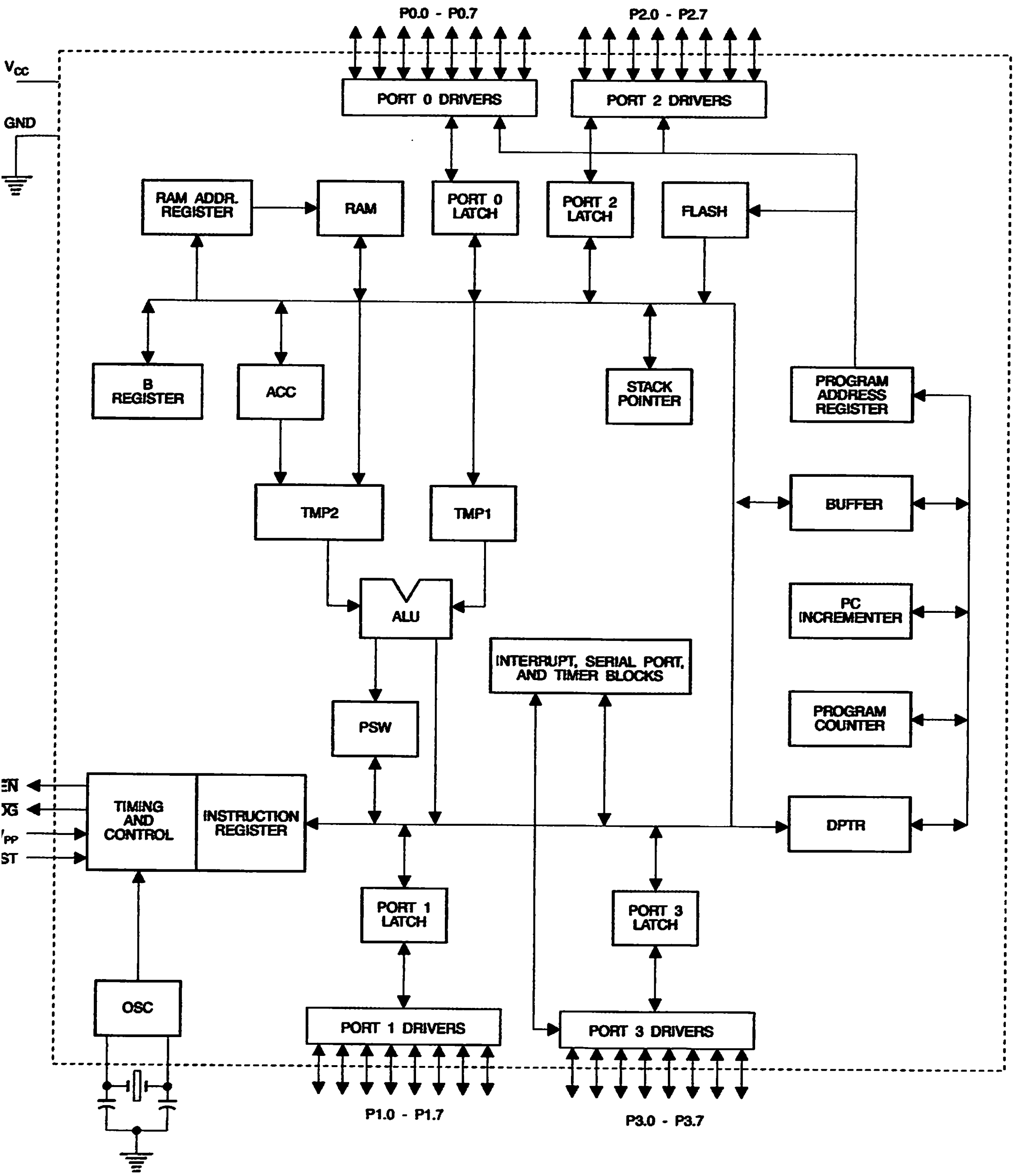


8-bit Microcontroller with 4K Bytes Flash

AT89C51

Rev. 0265G–02/00

ck Diagram


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
BUFFER
TMP2
TMP1
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

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

Description

ly voltage.

nd.

0

0 is an 8-bit open-drain bi-directional I/O port. As an
t port, each pin can sink eight TTL inputs. When 1s
ritten to port 0 pins, the pins can be used as high-
dance inputs.

0 may also be configured to be the multiplexed low-
address/data bus during accesses to external pro-
and data memory. In this mode P0 has internal
s.

0 also receives the code bytes during Flash program-
, and outputs the code bytes during program
cation. External pullups are required during program
ation.

1

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

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

2

is an 8-bit bi-directional I/O port with internal pullups.
ort 2 output buffers can sink/source four TTL inputs.
1s are written to Port 2 pins they are pulled high by
ternal 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 bi-directional 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

› is skipped during each access to external Data ory.

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

Ī

am Store Enable is the read strobe to external pro- memory.

ı the AT89C51 is executing code from external pro- memory, $\overline{PSEN}$ is activated twice each machine , except that two $\overline{PSEN}$ activations are skipped during access to external data memory.

PP

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

hould be strapped to V_{CC} for internal program itions.

in also receives the 12-volt programming enable volt- $/_{PP}$) during Flash programming, for parts that require lt V_{PP}.

1

to the inverting oscillator amplifier and input to the al clock operating circuit.

2

t from the inverting oscillator amplifier.

illator Characteristics

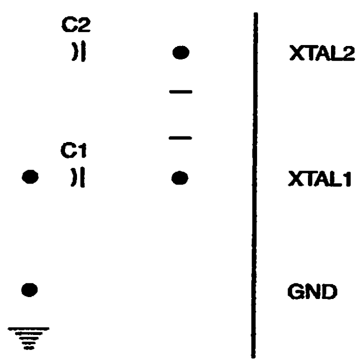
1 and XTAL2 are the input and output, respectively, nverting amplifier which can be configured for use as -chip oscillator, as shown in Figure 1. Either a quartz l or ceramic resonator may be used. To drive the › from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 2. There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.

Idle Mode

In idle mode, the CPU puts itself to sleep while all the on-chip peripherals remain active. The mode is invoked by software. The content of the on-chip RAM and all the special functions registers remain unchanged during this mode. The idle mode can be terminated by any enabled interrupt 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

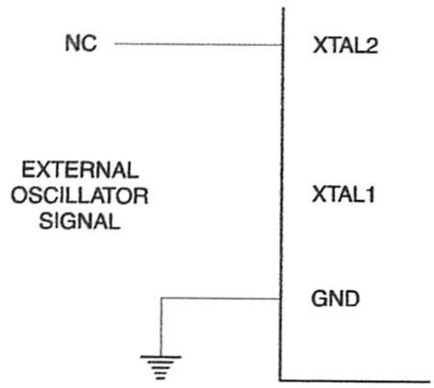


Note: C1, C2 = 30 pF ± 10 pF for Crystals
= 40 pF ± 10 pF for Ceramic Resonators

us of External Pins During Idle and Power-down Modes

›	Program Memory	ALE	$\overline{PSEN}$	PORT0	PORT1	PORT2	PORT3
	Internal	1	1	Data	Data	Data	Data
	External	1	1	Float	Data	Address	Data
r-down	Internal	0	0	Data	Data	Data	Data
r-down	External	0	0	Float	Data	Data	Data

re 2. External Clock Drive Configuration



ver-down Mode

power-down mode, the oscillator is stopped, and the ction that invokes power-down is the last instruction uted. 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.

k Bit Protection Modes

	Program Lock Bits			
	LB1	LB2	LB3	Protection Type
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

gramming the Flash

ʌT89C51 is normally shipped with the on-chip Flash ory array in the erased state (that is, contents = FFH) eady to be programmed. The programming interface pts either a high-voltage (12-volt) or a low-voltage program enable signal. The low-voltage program- mode provides a convenient way to program the C51 inside the user's system, while the high-voltage amming mode is compatible with conventional third- Flash or EPROM programmers.

ʌT89C51 is shipped with either the high-voltage or oltage programming mode enabled. The respective ide marking and device signature codes are listed in llowing table.

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

ʌT89C51 code memory array is programmed byte-by- n either programming mode. *To program any non- byte in the on-chip Flash Memory, the entire memory be erased using the Chip Erase Mode.*

ramming Algorithm: Before programming the C51, the address, data and control signals should be according to the Flash programming mode table and 3 and Figure 4. To program the AT89C51, take the ing steps.

put the desired memory location on the address ies.

put the appropriate data byte on the data lines.

ctivate the correct combination of control signals.

aise $\overline{EA}/V_{PP}$ to 12V for the high-voltage program- ing mode.

ılse ALE/$\overline{PROG}$ once to program a byte in the ash array or the lock bits. The byte-write cycle is lf-timed and typically takes no more than 1.5 ms.

epeat 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.

...sh Programming Modes

...e		RST	$\overline{PSEN}$	ALE/$\overline{PROG}$	$\overline{EA}/V_{PP}$	P2.6	P2.7	P3.6	P3.7
...e Code Data		H	L	¯_/¯	H/12V	L	H	H	H
...d Code Data		H	L	H	H	L	L	H	H
...e 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
...Erase		H	L	¯_/¯ (1)	H/12V	H	L	L	L
...l Signature Byte		H	L	H	H	L	L	L	L

1. Chip Erase requires a 10 ms $\overline{PROG}$ pulse.

...e 3. Programming the Flash

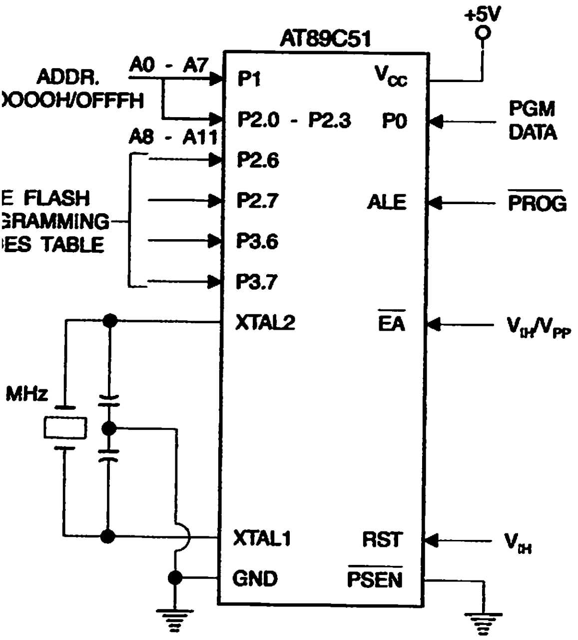
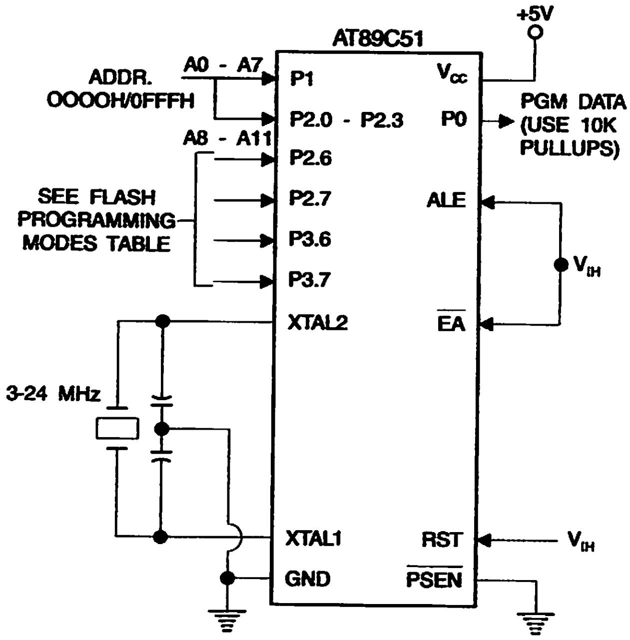
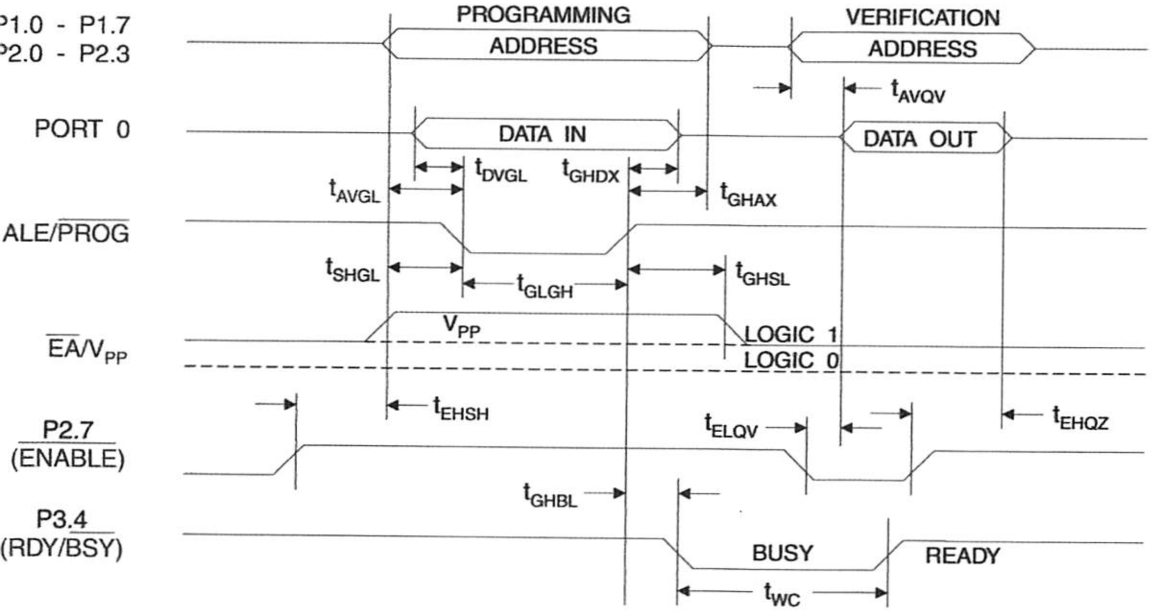


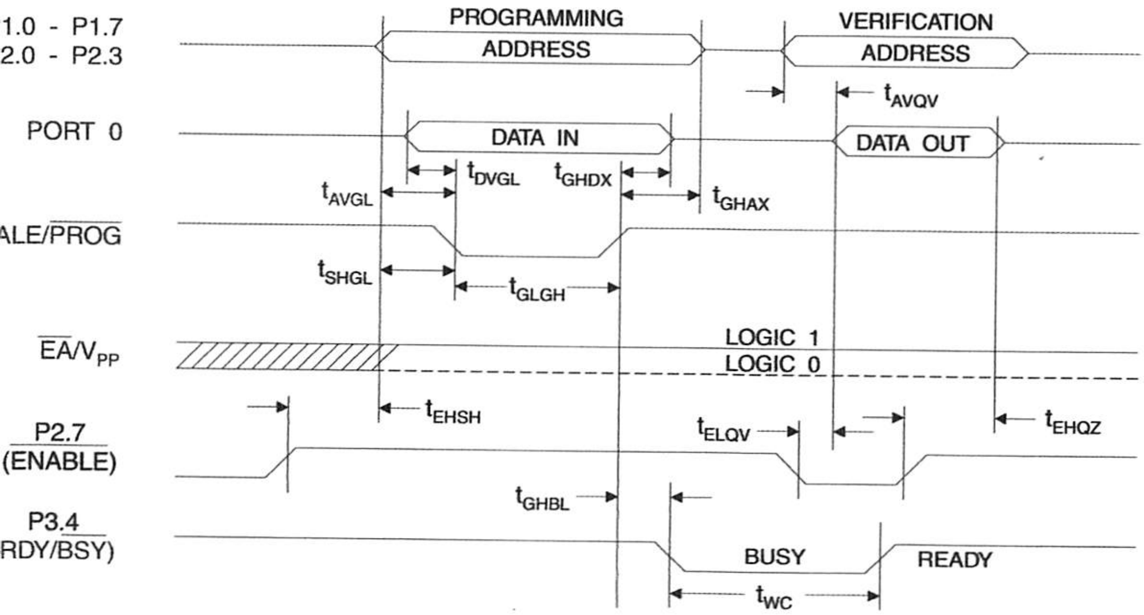
Figure 4. Verifying the Flash



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



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



sh Programming and Verification Characteristics

0°C to 70°C, V_{CC} = 5.0 ± 10%

bol	Parameter	Min	Max	Units
1)	Programming Enable Voltage	11.5	12.5	V
	Programming Enable Current		1.0	mA
CL	Oscillator Frequency	3	24	MHz
	Address Setup to $\overline{PROG}$ Low	$48t_{CLCL}$		
	Address Hold After $\overline{PROG}$	$48t_{CLCL}$		
	Data Setup to $\overline{PROG}$ Low	$48t_{CLCL}$		
	Data Hold After $\overline{PROG}$	$48t_{CLCL}$		
	P2.7 ($\overline{ENABLE}$) High to V_{PP}	$48t_{CLCL}$		
	V_{PP} Setup to $\overline{PROG}$ Low	10		µs
(1)	V_{PP} Hold After $\overline{PROG}$	10		µs
	$\overline{PROG}$ Width	1	110	µs
	Address to Data Valid		$48t_{CLCL}$	
	$\overline{ENABLE}$ Low to Data Valid		$48t_{CLCL}$	
	Data Float After $\overline{ENABLE}$	0	$48t_{CLCL}$	
	$\overline{PROG}$ High to $\overline{BUSY}$ Low		1.0	µs
	Byte Write Cycle Time		2.0	ms

1. Only used in 12-volt programming mode.

solute Maximum Ratings*

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

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

Characteristics

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

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

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.

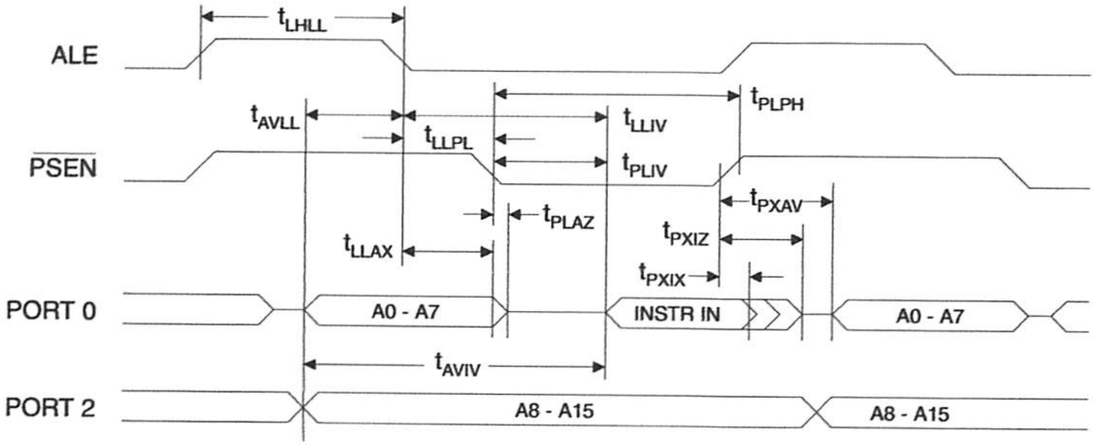
Characteristics

r operating conditions, load capacitance for Port 0, ALE/$\overline{\text{PROG}}$, and $\overline{\text{PSEN}}$ = 100 pF; load capacitance for all other ts = 80 pF.

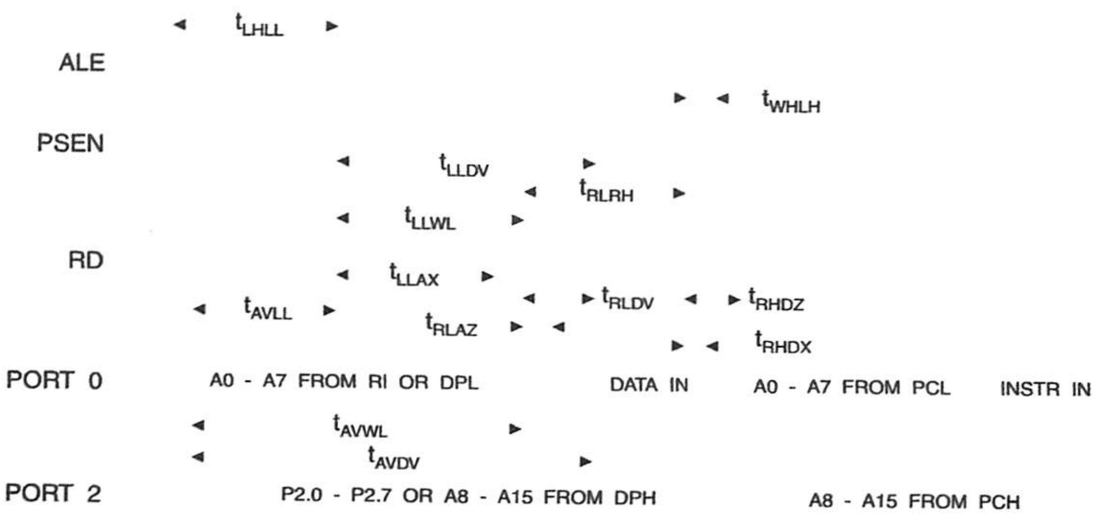
ernal Program and Data Memory Characteristics

bol	Parameter	12 MHz Oscillator		16 to 24 MHz Oscillator		Units
		Min	Max	Min	Max	
CL	Oscillator Frequency			0	24	MHz
	ALE Pulse Width	127		$2t_{CLCL}$-40		ns
	Address Valid to ALE Low	43		t_{CLCL}-13		ns
	Address Hold After ALE Low	48		t_{CLCL}-20		ns
	ALE Low to Valid Instruction In		233		$4t_{CLCL}$-65	ns
	ALE Low to $\overline{\text{PSEN}}$ Low	43		t_{CLCL}-13		ns
	$\overline{\text{PSEN}}$ Pulse Width	205		$3t_{CLCL}$-20		ns
	$\overline{\text{PSEN}}$ Low to Valid Instruction In		145		$3t_{CLCL}$-45	ns
	Input Instruction Hold After $\overline{\text{PSEN}}$	0		0		ns
	Input Instruction Float After $\overline{\text{PSEN}}$		59		t_{CLCL}-10	ns
	$\overline{\text{PSEN}}$ to Address Valid	75		t_{CLCL}-8		ns
	Address to Valid Instruction In		312		$5t_{CLCL}$-55	ns
	$\overline{\text{PSEN}}$ Low to Address Float		10		10	ns
	$\overline{\text{RD}}$ Pulse Width	400		$6t_{CLCL}$-100		ns
	$\overline{\text{WR}}$ Pulse Width	400		$6t_{CLCL}$-100		ns
	$\overline{\text{RD}}$ Low to Valid Data In		252		$5t_{CLCL}$-90	ns
	Data Hold After $\overline{\text{RD}}$	0		0		ns
	Data Float After $\overline{\text{RD}}$		97		$2t_{CLCL}$-28	ns
	ALE Low to Valid Data In		517		$8t_{CLCL}$-150	ns
	Address to Valid Data In		585		$9t_{CLCL}$-165	ns
	ALE Low to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ Low	200	300	$3t_{CLCL}$-50	$3t_{CLCL}$+50	ns
	Address to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ Low	203		$4t_{CLCL}$-75		ns
	Data Valid to $\overline{\text{WR}}$ Transition	23		t_{CLCL}-20		ns
	Data Valid to $\overline{\text{WR}}$ High	433		$7t_{CLCL}$-120		ns
	Data Hold After $\overline{\text{WR}}$	33		t_{CLCL}-20		ns
	$\overline{\text{RD}}$ Low to Address Float		0		0	ns
	$\overline{\text{RD}}$ or $\overline{\text{WR}}$ High to ALE High	43	123	t_{CLCL}-20	t_{CLCL}+25	ns

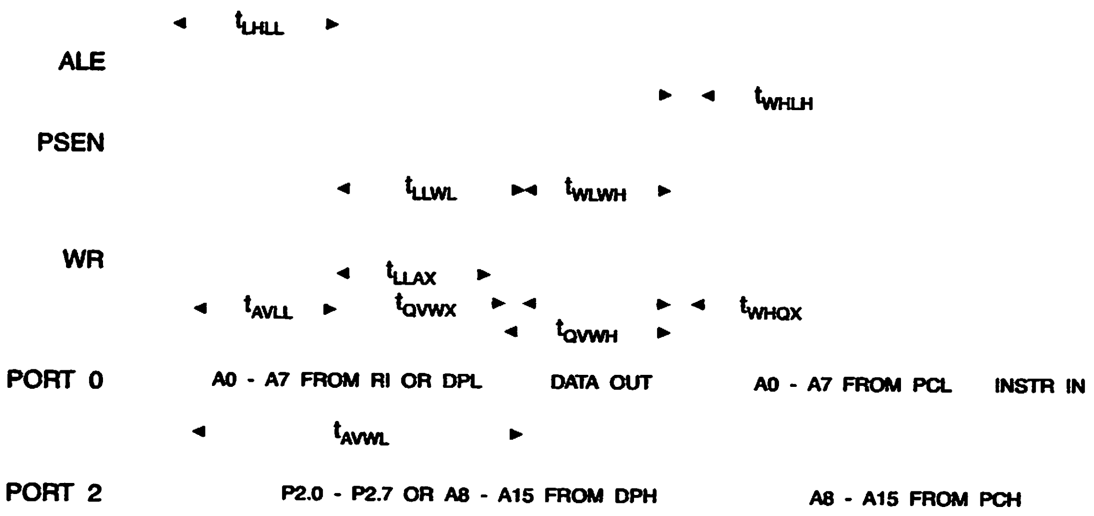
ernal Program Memory Read Cycle



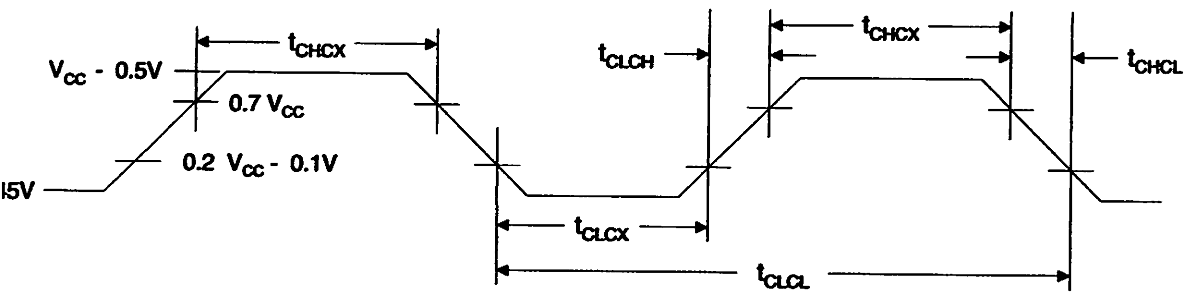
ernal Data Memory Read Cycle



ernal Data Memory Write Cycle



ernal Clock Drive Waveforms



ernal Clock Drive

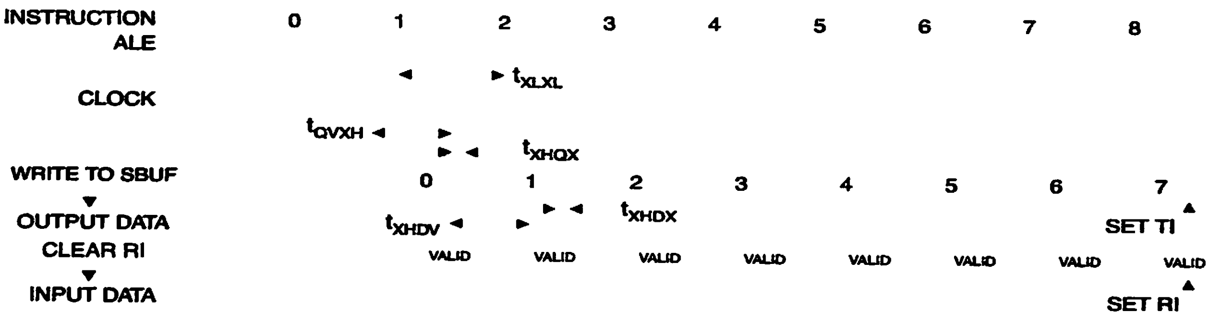
ol	Parameter	Min	Max	Units
L	Oscillator Frequency	0	24	MHz
	Clock Period	41.6		ns
	High Time	15		ns
	Low Time	15		ns
	Rise Time		20	ns
	Fall Time		20	ns

ial Port Timing: Shift Register Mode Test Conditions

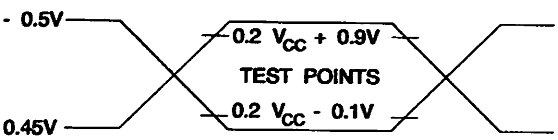
= 5.0 V ± 20%; Load Capacitance = 80 pF)

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

t Register Mode Timing Waveforms

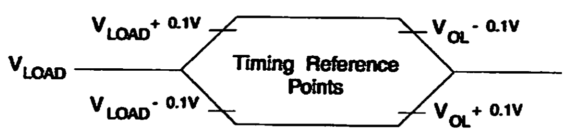


Testing Input/Output Waveforms[1]



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.

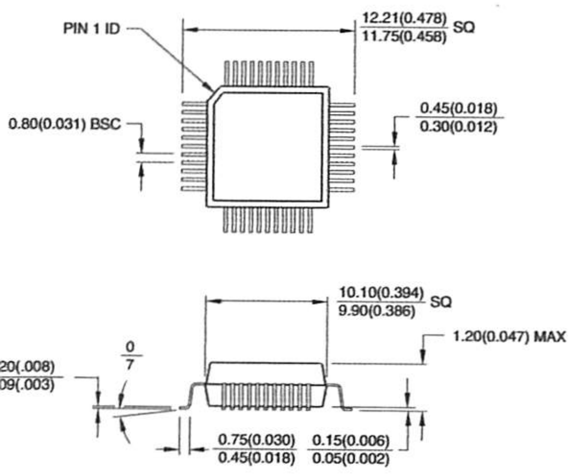
ering Information

eed (IHz)	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	
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	
:0	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	
4	5V ± 20%	AT89C51-24AC	44A	Commercial (0°C to 70°C)
		AT89C51-24JC	44J	
		AT89C51-24PC	40P6	
		AT89C51-24QC	44Q	
		AT89C51-24AI	44A	Industrial (-40°C to 85°C)
		AT89C51-24JI	44J	
		AT89C51-24PI	40P6	
		AT89C51-24QI	44Q	

	Package Type
	44-lead, Thin Plastic Gull Wing Quad Flatpack (TQFP)
	44-lead, Plastic J-leaded Chip Carrier (PLCC)
	40-lead, 0.600" Wide, Plastic Dual Inline Package (PDIP)
	44-lead, Plastic Gull Wing Quad Flatpack (PQFP)

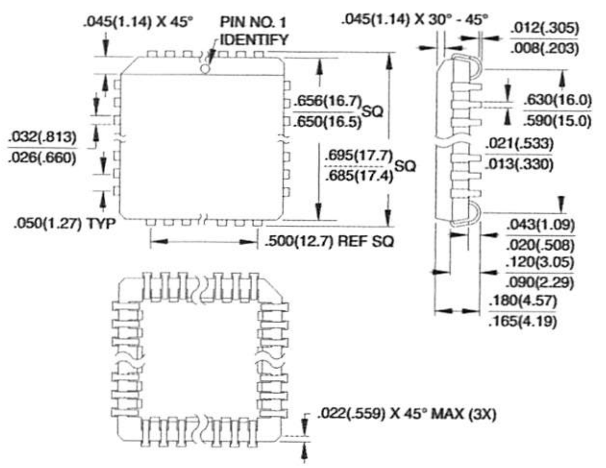
ckaging Information

4A, 44-lead, Thin (1.0 mm) Plastic Gull Wing Quad
latpack (TQFP)
imensions in Millimeters and (Inches)*
EDEC STANDARD MS-026 ACB

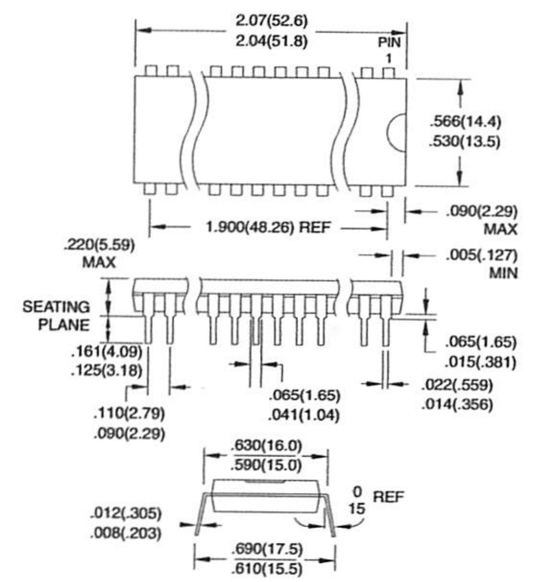


ontrolling dimension: millimeters

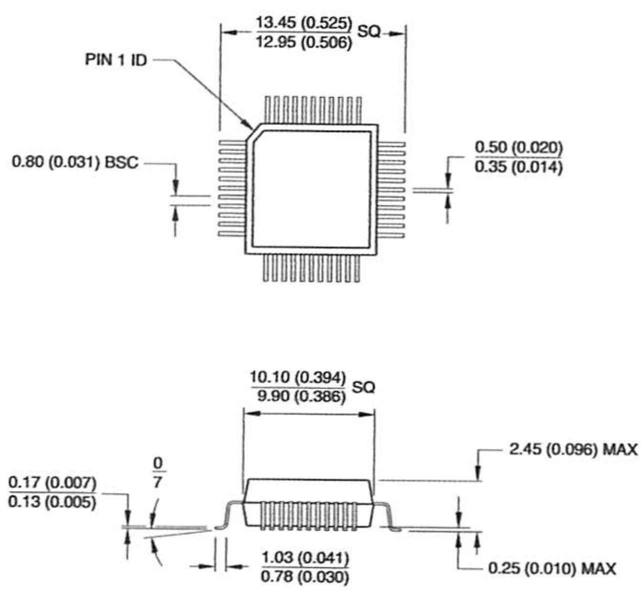
44J, 44-lead, Plastic J-leaded Chip Carrier (PLCC)
Dimensions in Inches and (Millimeters)
JEDEC STANDARD MS-018 AC



0P6, 40-lead, 0.600" Wide, Plastic Dual Inline
ackage (PDIP)
imensions in Inches and (Millimeters)



44Q, 44-lead, Plastic Quad Flat Package (PQFP)
Dimensions in Millimeters and (Inches)*
JEDEC STANDARD MS-022 AB



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'Infrared' Light-Emitting Diode Application Circuit

ıERIAL CONNECTION AND 'ARALLEL CONNECTION

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

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

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

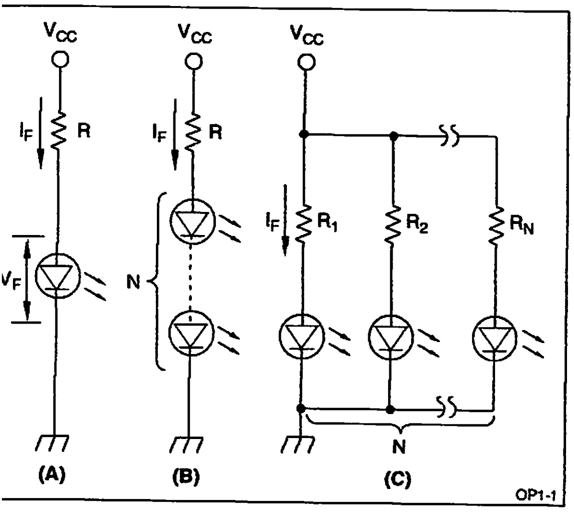


Figure 1. Driving Circuit of Light-Emitting Diode (LED)

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

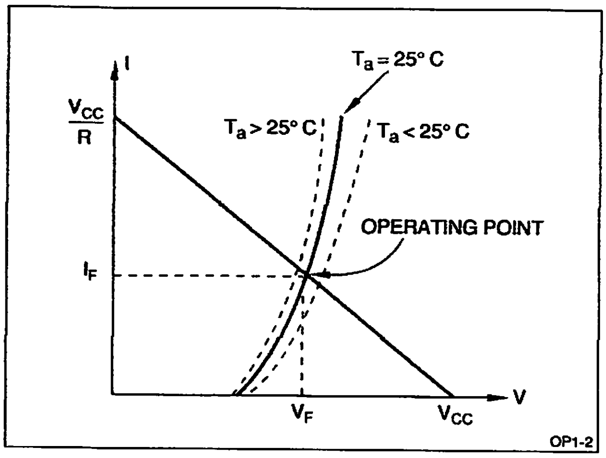


Figure 2. Current versus Voltage of Light-Emitting Diode (LED)

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.

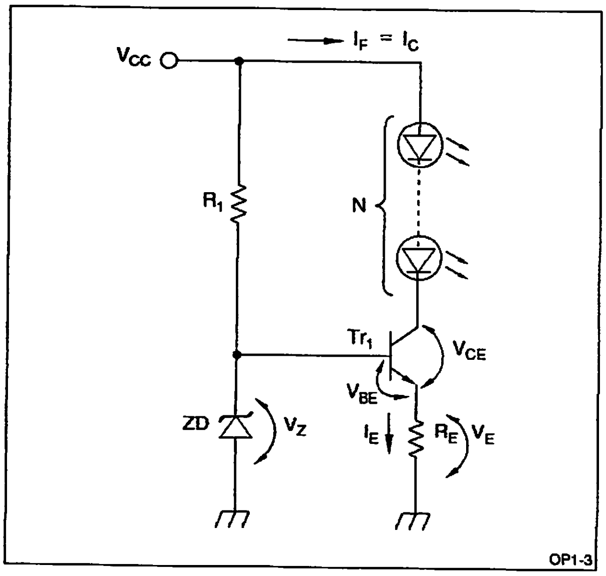


Figure 3. Constant Current Driving Circuit (1)

The transistor (Tr_1) is biased by a constant voltage ıpplied by a zener diode (ZD) so that the voltage across e emitter follower loaded by resistor R_E is constant, ereby making the collector current ($I_C = I_F$) constant. ıe 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 gion and does not operate as a constant current circuit. ıe number of LEDs (N) which can be connected in ıries 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 cuits that use diodes or transistors, instead of zener odes.

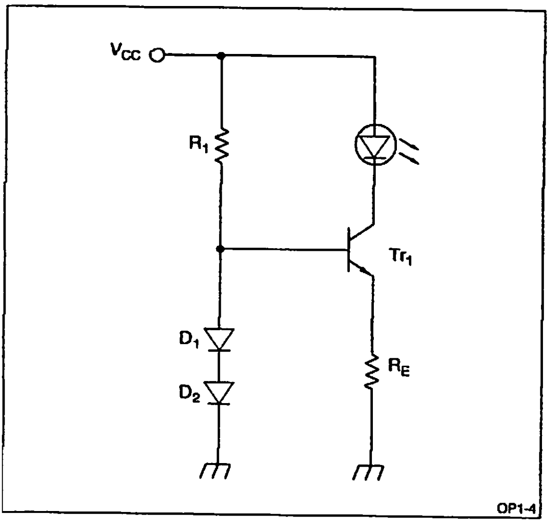


Figure 4. Constant Current Driving Circuit (2)

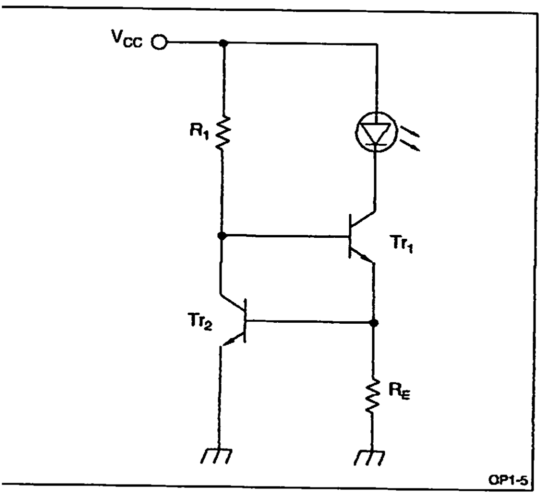


Figure 5. Constant Current Driving Circuit (3)

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.

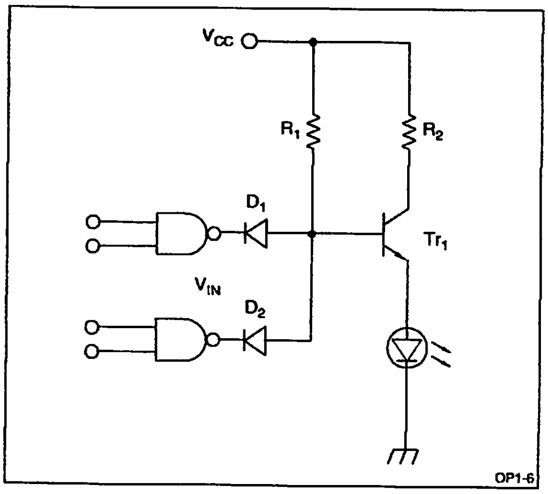


Figure 6. Connection with the TTL Logic Circuit (2)

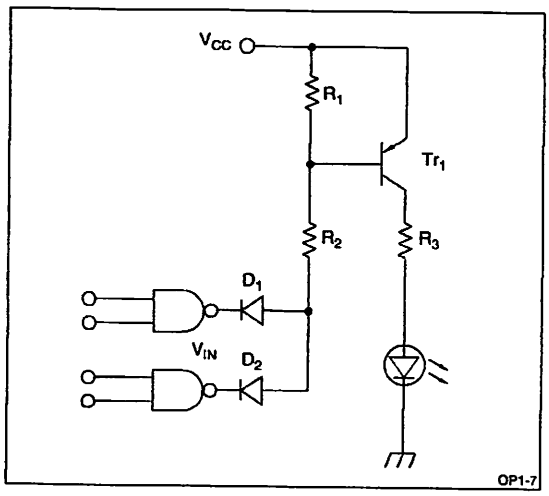
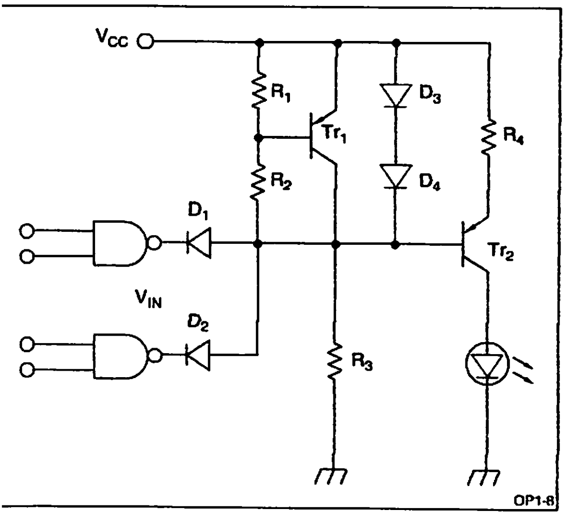


Figure 7. Connection with the TTL Logic Circuit (2)

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



gure 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.

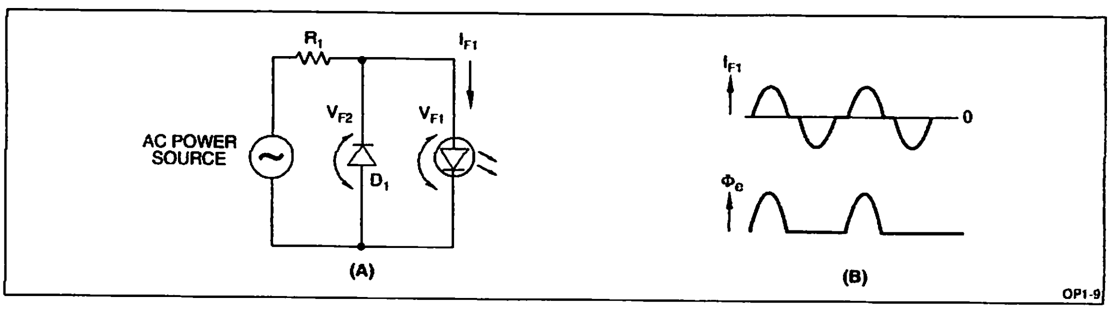


Figure 9. Driving Circuit with AC Power Source (A) and Driving Waveform (B)

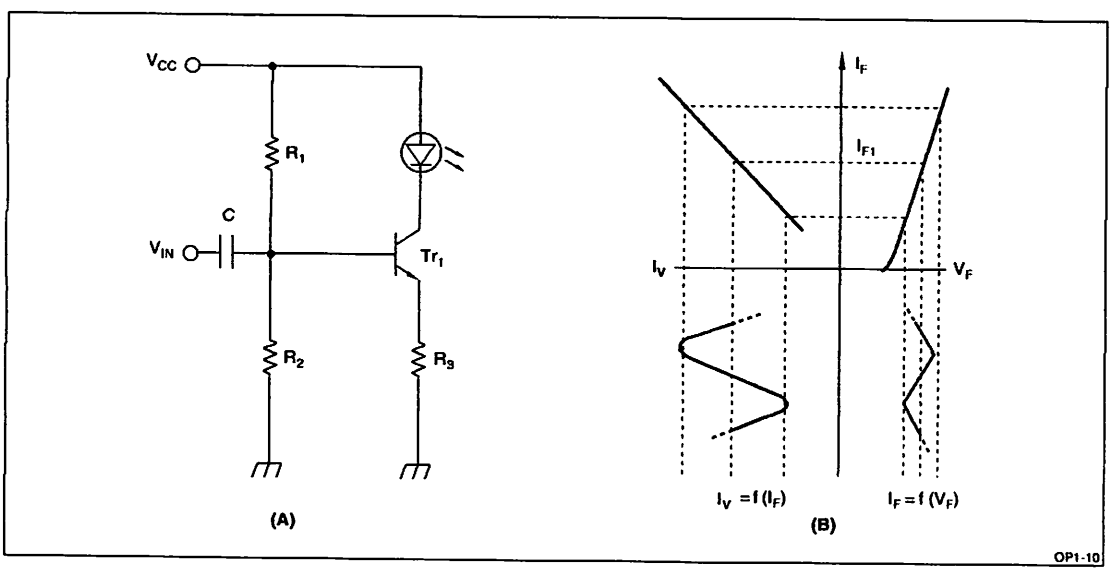


Figure 10. Modulation Driving Circuit (A) and Modulation Operation (B)

To drive an LED with a continuous modulation sig- al, it is necessary to operate the LED in the linear ·gion of the light-emitting characteristics. In the ·rangement of Figure 10, a fixed bias (I_{F1}) is applied the LED using R_1 and R_2 so that the maximum nplitude of the modulation signal voltage (V_{IN}) lies ithin the linear portion of the LED characteristics. oreover, to stabilize the radiant flux of the LED, it is iven by a constant current by the constant current ·iving circuit shown in Figure 3. The capacitor (C) ;ed in Figure 10 (A) is a DC signal blocking capacitor.

ULSE DRIVING

LED driving systems fall into three categories: DC iving system, AC driving system (including modula- ·n systems), and pulse driving system.

·atures 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 for- ırd current (I_F), but in reality a large I_F heats up the :D by itself, causing the light-emitting efficiency to fall d thus saturating the radiant flux. In this circum- ınce, a relatively large I_F can be used with no risk of ating through the pulse drive of the LED. Conse- ently, a large radiant flux can be obtained.

When an LED is used in the outdoors where disturb- | light is intense, the DC driving system or AC driving stem which superimposes an AC signal on a fixed ıs current provides low radiant flux, making it difficult 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.*

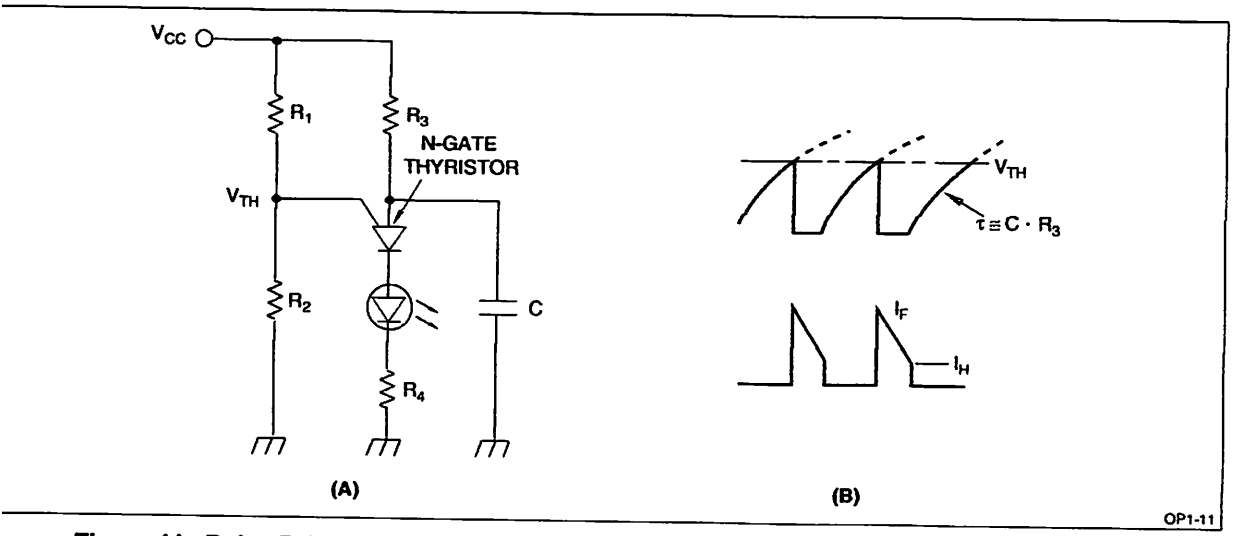


Figure 11. Pulse Driving Circuit using N-Gate Thyristor (A) and Operating Waveform (B)

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.

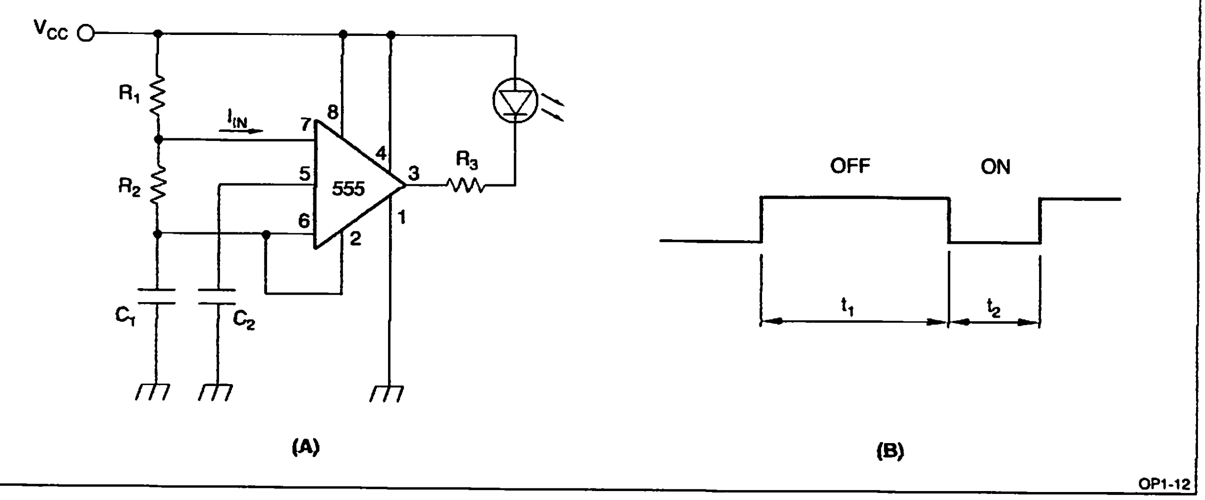


Figure 12. Pulse Driving using a 555 Timer IC (A) and Output Waveform (B)

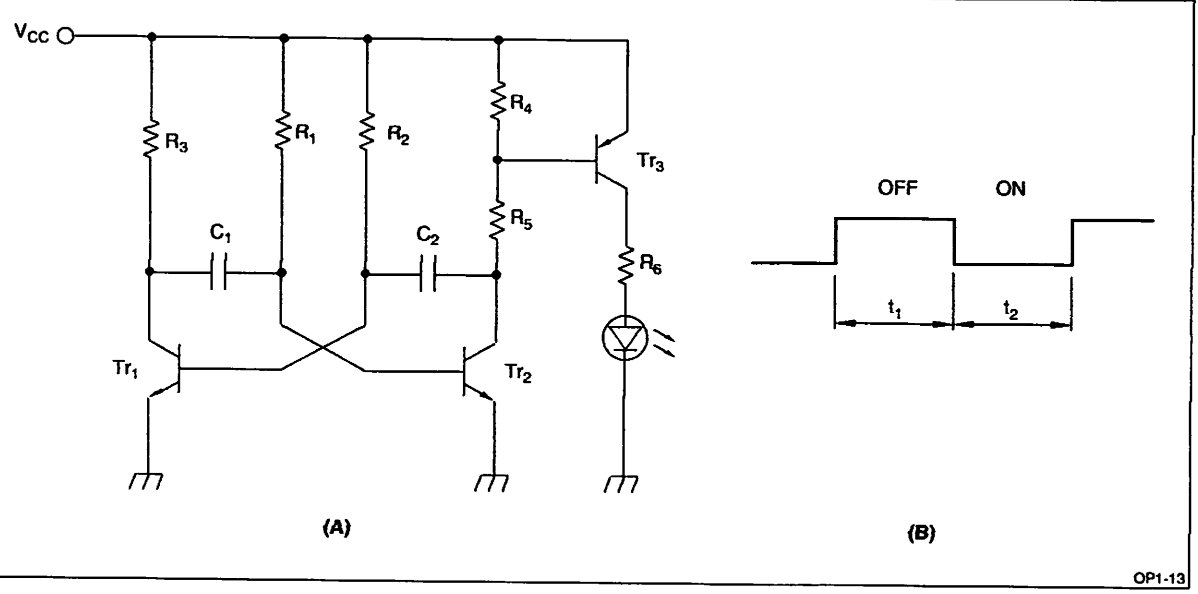


Figure 13. Pulse Driving Circuit using Astable Multi-vibrator (A) and Output Waveform (B)

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

Figure 15 (A) shows an LED pulse driving circuit ɜed 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.

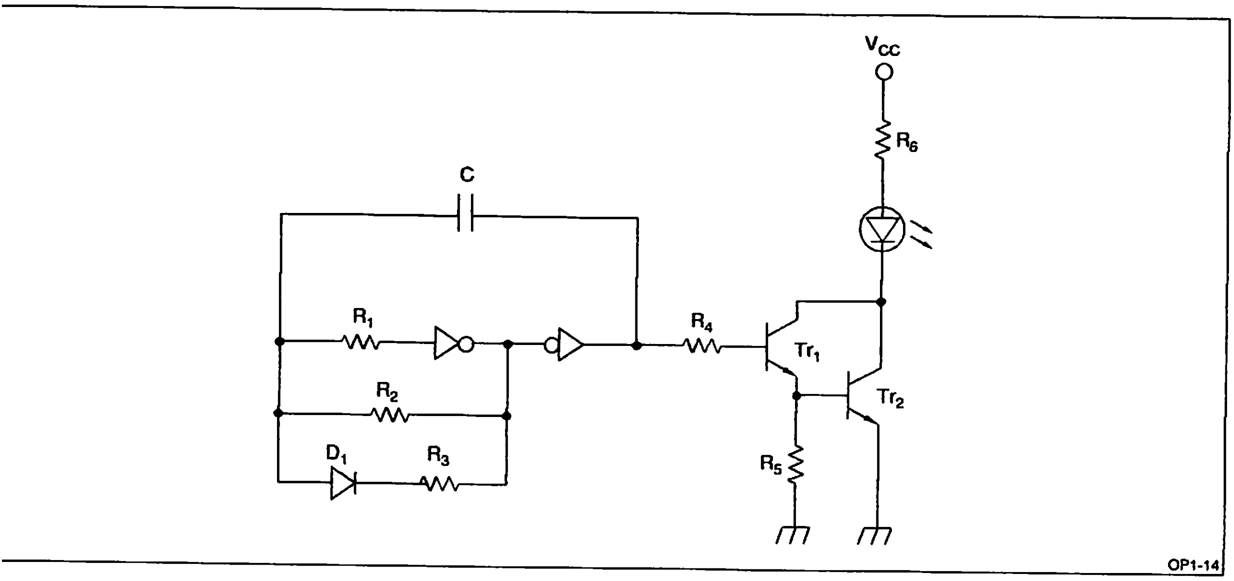


Figure 14. Pulse Driving Circuit using CMOS Logic IC

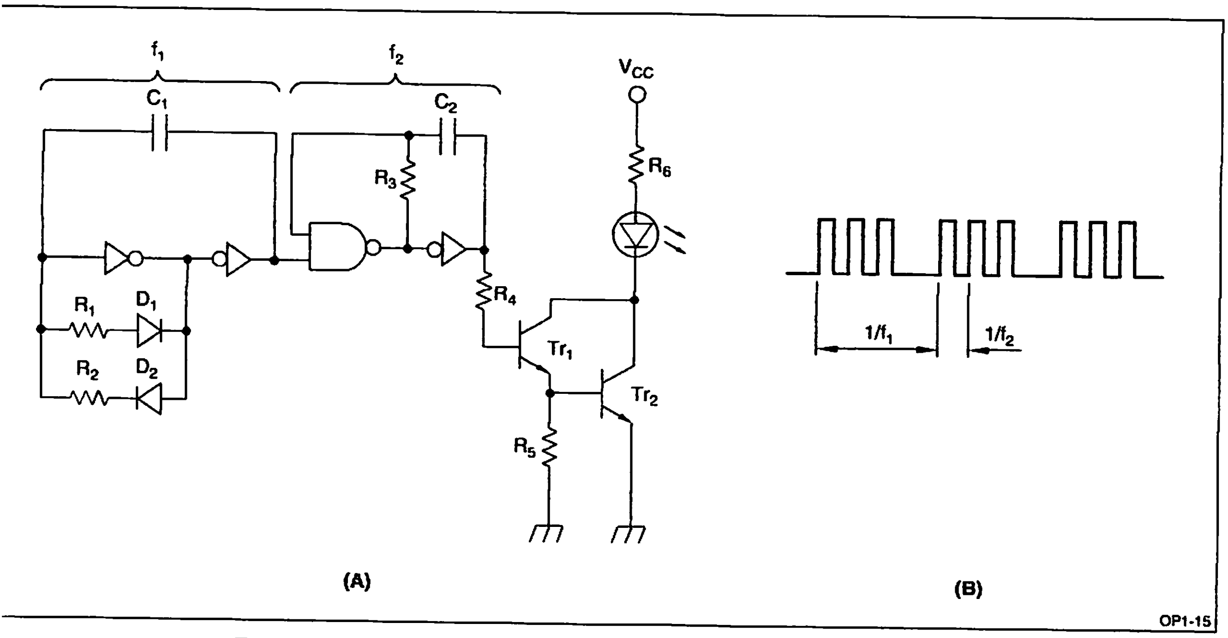


Figure 15. Pulse Driving Circuit (A) and Output Waveform (B)

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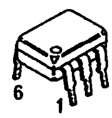
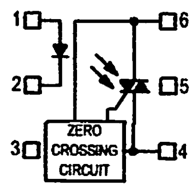
STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE DO NOT CONNECT
6. MAIN TERMINAL

XIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RARED EMITTING DIODE			
everse Voltage	V_R	6	Volts
rward Current — Continuous	I_F	60	mA
tal Power Dissipation @ T_A = 25°C Negligible Power in Output Driver erate above 25°C	P_D	120 1.41	mW mW/°C
PUT DRIVER			
f–State Output Terminal Voltage	V_{DRM}	400	Volts
ak Repetitive Surge Current (PW = 100 µs, 120 pps)	I_{TSM}	1	A
tal Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
AL DEVICE			
lation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
tal Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
nction Temperature Range	T_J	–40 to +100	°C
bient Operating Temperature Range(2)	T_A	–40 to +85	°C
rage Temperature Range(2)	T_{stg}	–40 to +150	°C
ldering Temperature (10 s)	T_L	260	°C

olation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating.
or this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
efer to Quality and Reliability Section in Opto Data Book for information on test conditions.
red devices are Motorola recommended choices for future use and best overall value.
alOptoisolator is a trademark of Motorola, Inc.

laces MOC3040/D)

MOTOROLA

ECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
'UT LED					
everse Leakage Current (V_R = 6 V)	I_R	—	0.05	100	µA
orward Voltage (I_F = 30 mA)	V_F	—	1.3	1.5	Volts
TPUT DETECTOR (I_F = 0 unless otherwise noted)					
eakage with LED Off, Either Direction (Rated V_{DRM}[1])	I_{DRM1}	—	2	100	nA
eak On–State Voltage, Either Direction (I_{TM} = 100 mA Peak)	V_{TM}	—	1.8	3	Volts
itical Rate of Rise of Off–State Voltage[3]	dv/dt	1000	2000	—	V/µs
UPLED					
:D Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3 V[2])	I_{FT}				mA
MOC3041		—	—	15	
MOC3042		—	—	10	
MOC3043		—	—	5	
olding Current, Either Direction	I_H	—	250	—	µA
olation Voltage (f = 60 Hz, t = 1 sec)	V_{ISO}	7500	—	—	Vac(pk)
O CROSSING					
hibit Voltage (I_F = Rated I_{FT}, MT1–MT2 Voltage above which device will not trigger.)	V_{IH}	—	5	20	Volts
akage in Inhibited State (I_F = Rated I_{FT}, Rated V_{DRM}, Off State)	I_{DRM2}	—	—	500	µA

'est voltage must be applied within dv/dt rating.
ll devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between I_{FT} 15 mA for MOC3041, 10 mA for MOC3042, 5 mA for MOC3043) and absolute max I_F (60 mA).
his is static dv/dt. See Figure 7 for test circuit. Commutating dv/dt is a function of the load–driving thyristor(s) only.

TYPICAL ELECTRICAL CHARACTERISTICS

T_A = 25°C

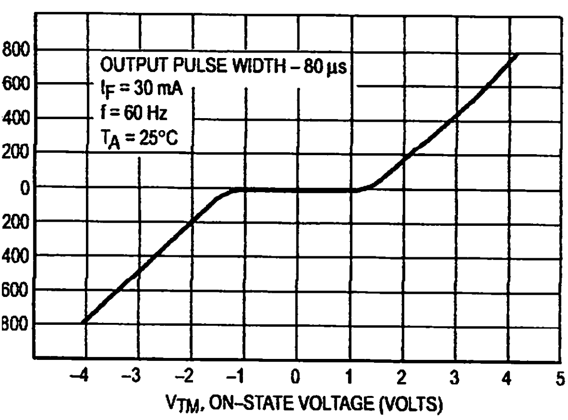


Figure 1. On–State Characteristics

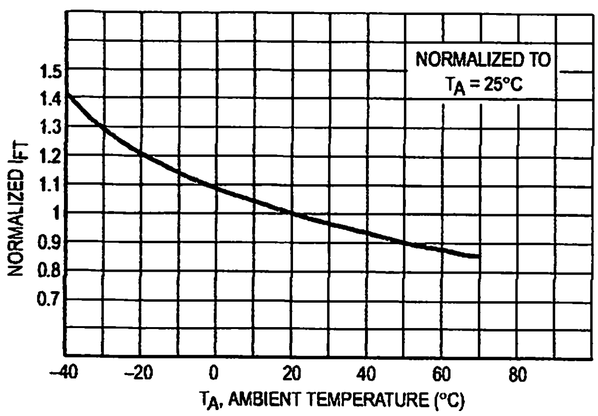


Figure 2. Trigger Current versus Temperature

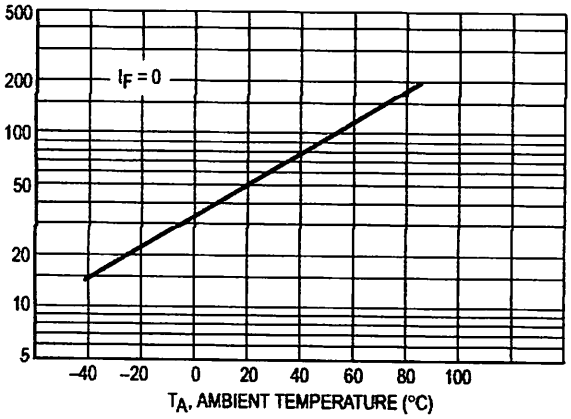


Figure 3. I_{DRM1}, Peak Blocking Current versus Temperature

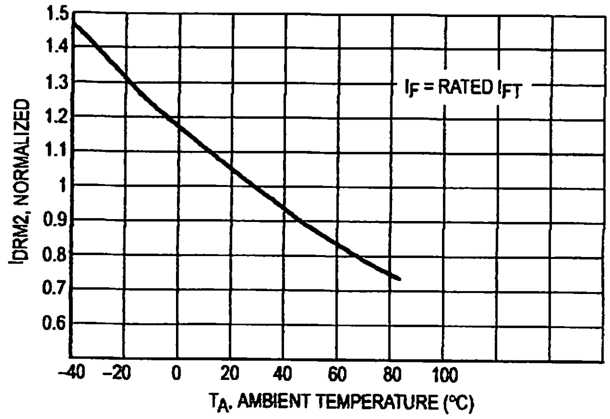


Figure 4. I_{DRM2}, Leakage in Inhibit State versus Temperature

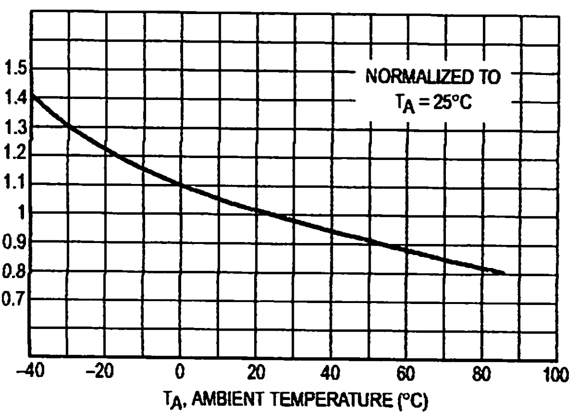


Figure 5. Trigger Current versus Temperature

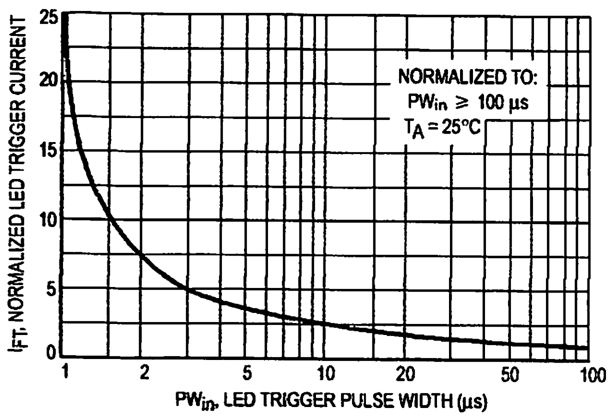
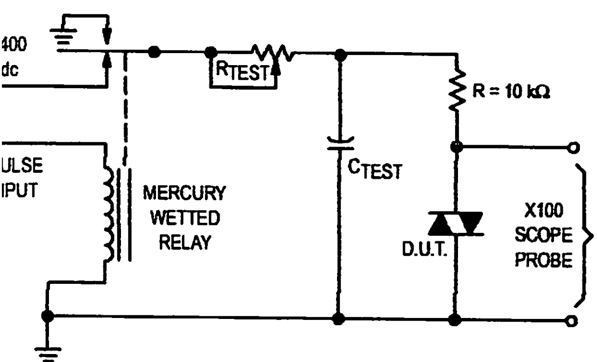
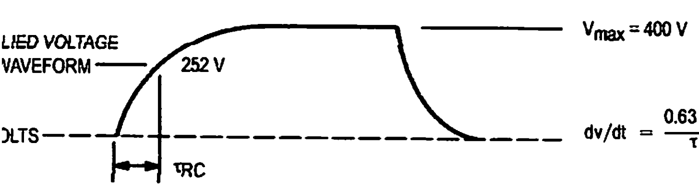


Figure 6. LED Current Required to Trigger versus LED Pulse Width

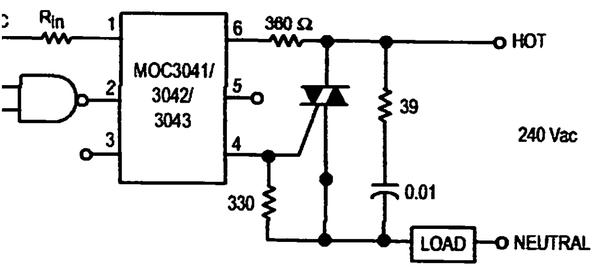


1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.



$$dv/dt = \frac{0.63\ V_{max}}{\tau_{RC}} = \frac{252}{\tau_{RC}}$$

Figure 7. Static dv/dt Test Circuit

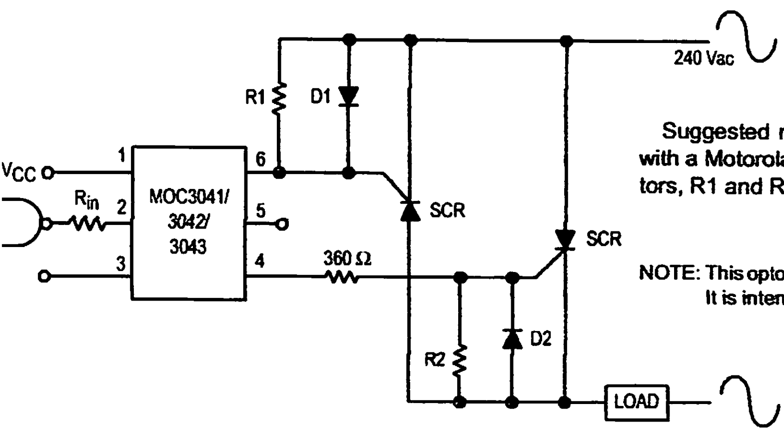


Typical circuit for use when hot line switching is required. In this circuit the "hot" side of the line is switched and the load connected to the cold or neutral side. The load may be *connected to either the neutral or hot line.*

R_{in} is calculated so that I_F is equal to the rated I_{FT} of the part, 5 mA for the MOC3043, 10 mA for the MOC3042, or 15 mA for the MOC3041. The 39 ohm resistor and 0.01 μF capacitor are for snubbing of the triac and may or may not be necessary depending upon the particular triac and load used.

r highly inductive loads (power factor < 0.5), change this value to 0 ohms.

Figure 8. Hot–Line Switching Application Circuit

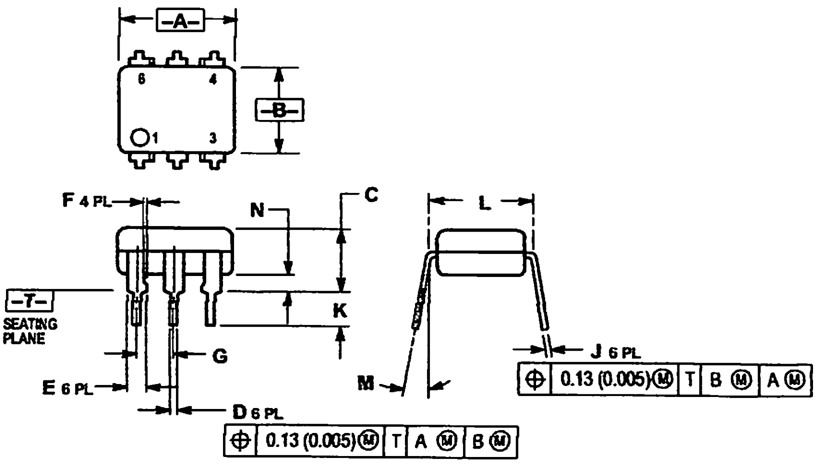


Suggested method of firing two, back–to–back SCR's, with a Motorola triac driver. Diodes can be 1N4001; resistors, R1 and R2, are optional 330 ohms.

NOTE: This optoisolator should not be used to drive a load directly. It is intended to be a trigger device only.

Figure 9. Inverse–Parallel SCR Driver Circuit

PACKAGE DIMENSIONS

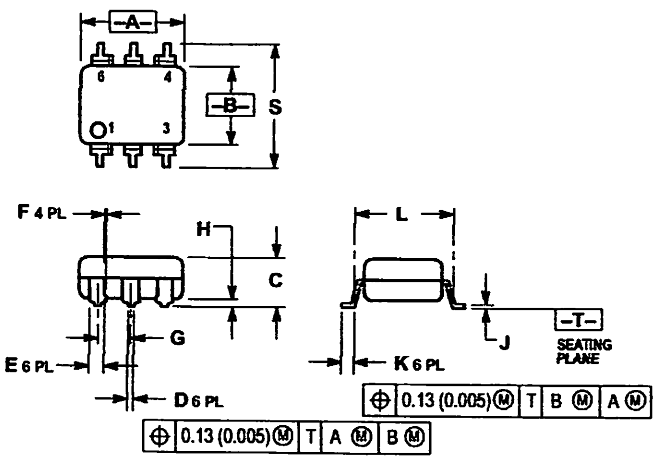


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
J	0.008	0.012	0.21	0.30
K	0.100	0.150	2.54	3.81
L	0.300 BSC		7.62 BSC	
M	0°	15°	0°	15°
N	0.015	0.100	0.38	2.54

STYLE 6:
PIN 1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE
6. MAIN TERMINAL

CASE 730A–04
ISSUE G

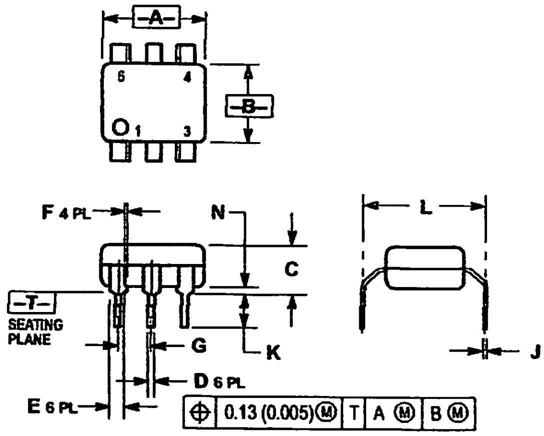


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
H	0.020	0.025	0.51	0.63
J	0.008	0.012	0.20	0.30
K	0.006	0.035	0.16	0.88
L	0.320 BSC		8.13 BSC	
S	0.332	0.390	8.43	9.90

Consult factory for leadform option availability

CASE 730C–04
ISSUE D



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
J	0.008	0.012	0.21	0.30
K	0.100	0.150	2.54	3.81
L	0.400	0.425	10.16	10.80
N	0.015	0.040	0.38	1.02

***Consult factory for leadform option availability**

CASE 730D–05
ISSUE D

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◊

Photodiode/Phototransistor Application Circuit

JNDAMENTAL PHOTODIODE CIRCUITS

Figures 1 and 2 show the fundamental photodiode cuits.

The circuit shown in Figure 1 transforms a photorrent produced by a photodiode without bias into a ltage. The output voltage (V_{OUT}) is given as $_{UT}$ = $1_P \times R_L$. It is more or less proportional to the nount of incident light when $V_{OUT} < V_{OC}$. It can also compressed logarithmically relative to the amount of cident light when V_{OUT} is near V_{OC}. (V_{OC} is the openminal voltage of a photodiode).

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

Figure 2 shows a circuit in which the photodiode is erse-biased by V_{CC} and a photocurrent (I_P) is transmed 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 Id × 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.

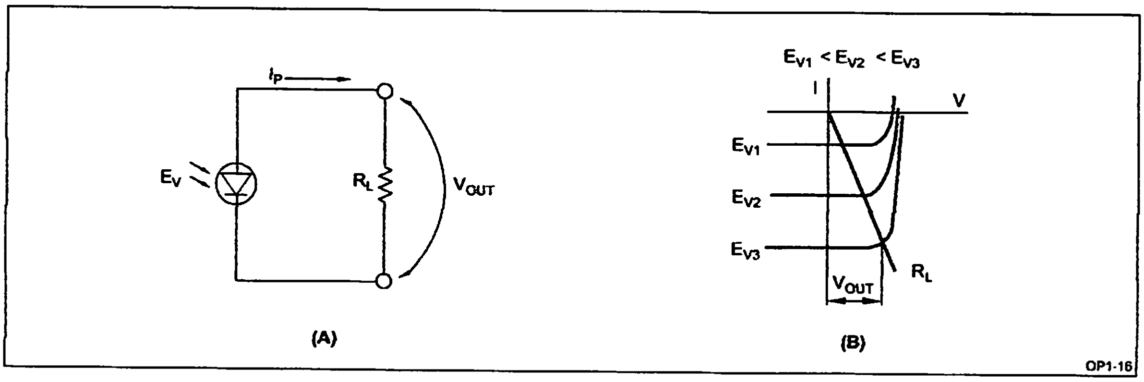


Figure 1. Fundamental Circuit of Photodiode (Without Bias)

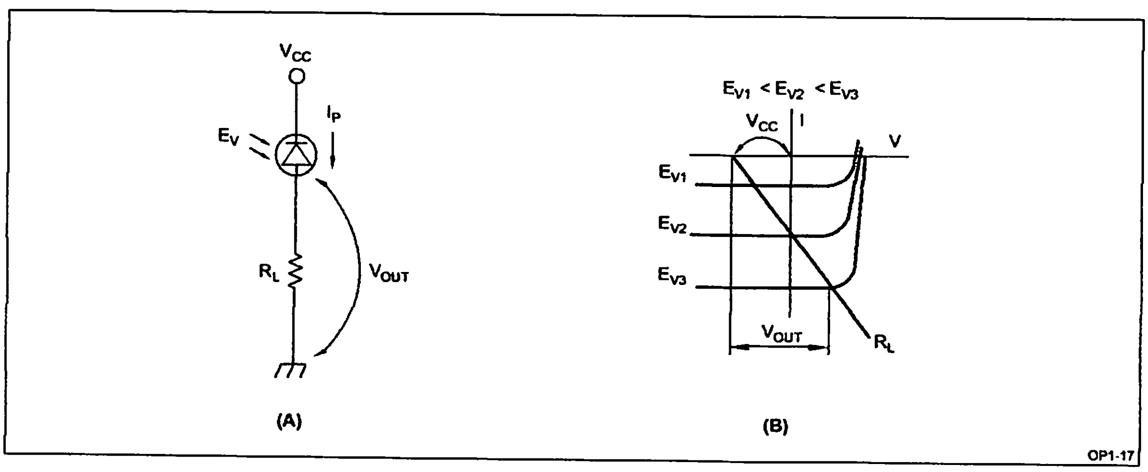


Figure 2. Fundamental Circuit of Photodiode (With Bias)

The response time is inversely proportional to the verse 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 SING THE TRANSISTOR OF HOTODIODE

Figures 3 and 4 show photocurrent amplifiers using nsistors.

The circuit shown in Figure 3 are most basic combinans of a photodiode and an amplifying transistor. In the angement of Figure 3 (A), the photocurrent produced the photodiode causes the transistor (Tr_1) to decrease output (V_{OUT}) from high to low. In the arrangement of gure 3 (B), the photocurrent causes the V_{OUT} to rease from low to high. Resistor R_{BE} in the circuit is ective for suppressing the influence of dard current (I_d) d 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.

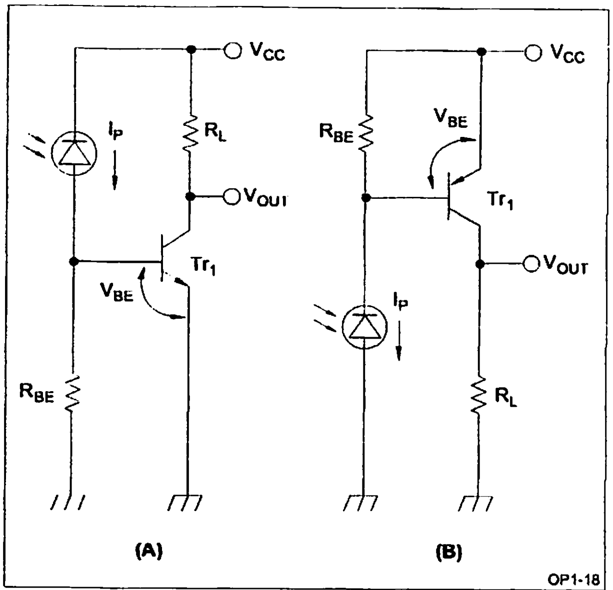


Figure 3. Photocurrent Amplifier Circuit using Transistor

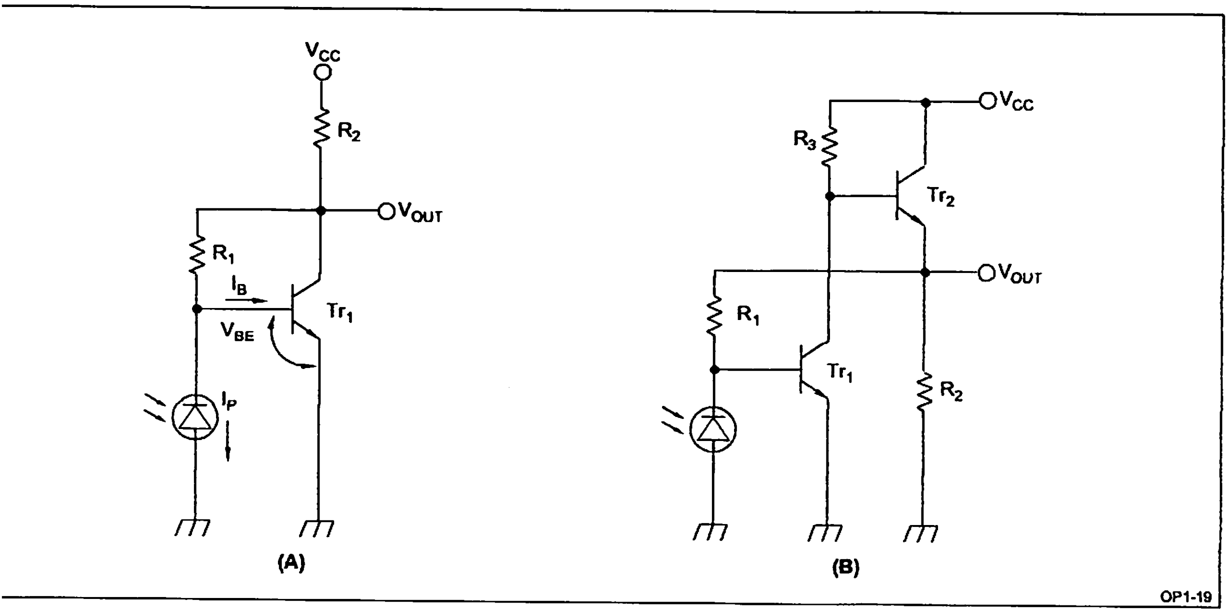


Figure 4. Photocurrent Amplifier Circuit with Negative Feedback

MPLIFIER CIRCUIT USING PERATIONAL AMPLIFIER

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

Figure 6 (B) shows the output voltage vs. radiant ensity characteristics. An arrangement with no bias d high impedance loading to the photodiode pro-les 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 ng an operating amplifier. The circuit uses a logarith-: diode for the logarithmic conversion of photocur-ıt into an output voltage. In dealing with a very wide ıdiation 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 satura-tion of output. With its wide measurement range, the logarithmic photocurrent amplifier is used for the expo-sure meter of cameras.

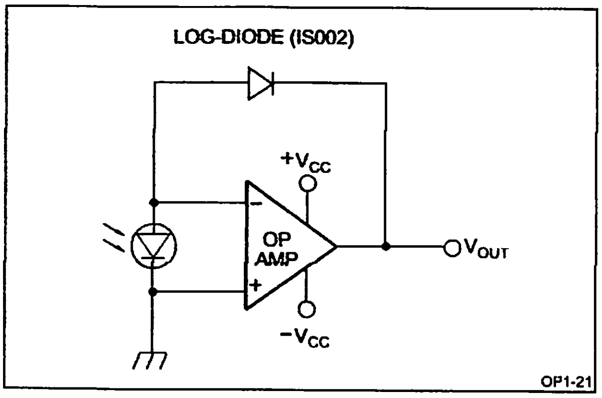


Figure 5. Logarithmic Photocurrent Amplifier using an Operational Amplifier

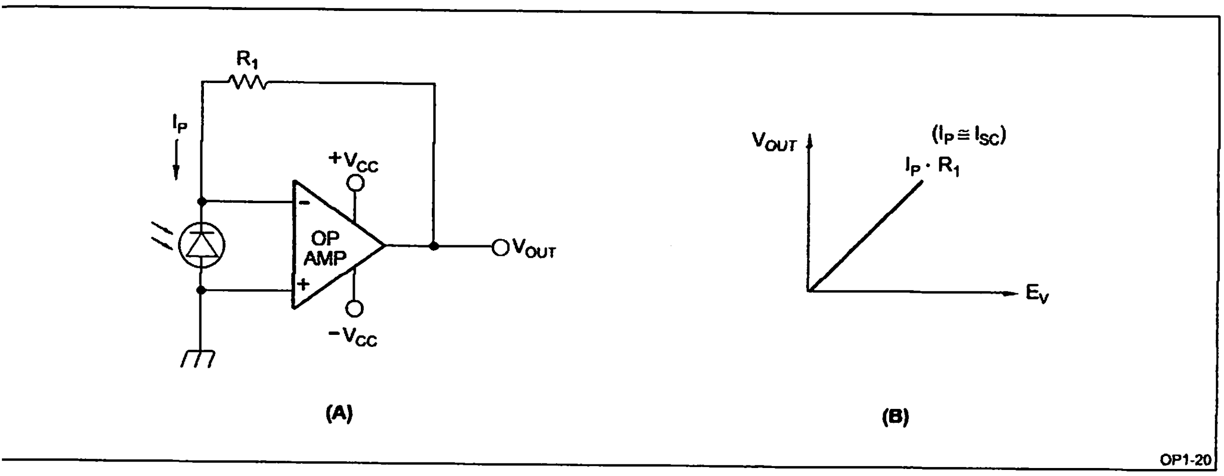


Figure 6. Photocurrent Amplifier using an Operational Amplifier (Without Bias)

IGHT DETECTING CIRCUIT FOR ODULATED LIGHT INPUT

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

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

OLOR SENSOR AMPLIFIER CIRCUIT

Figure 8 shows a color sensor amplifier using a miconductor color sensor. Two short circuit currents (I_{SC1}, I_{SC2}) conducted by two photodiodes having dif- ent spectral sensitivities are compressed logarithmi- lly and applied to a subtraction circuit which oduces a differential output (V_{OUT}). The output volt- e (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.

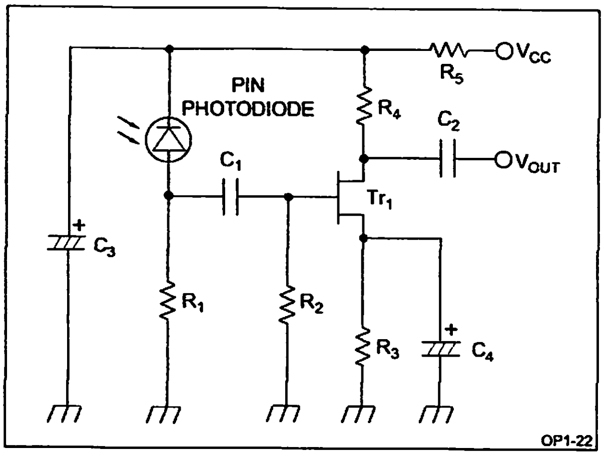


Figure 7. Light Detecting Circuit for Modulated Light Input PIN Photodiode

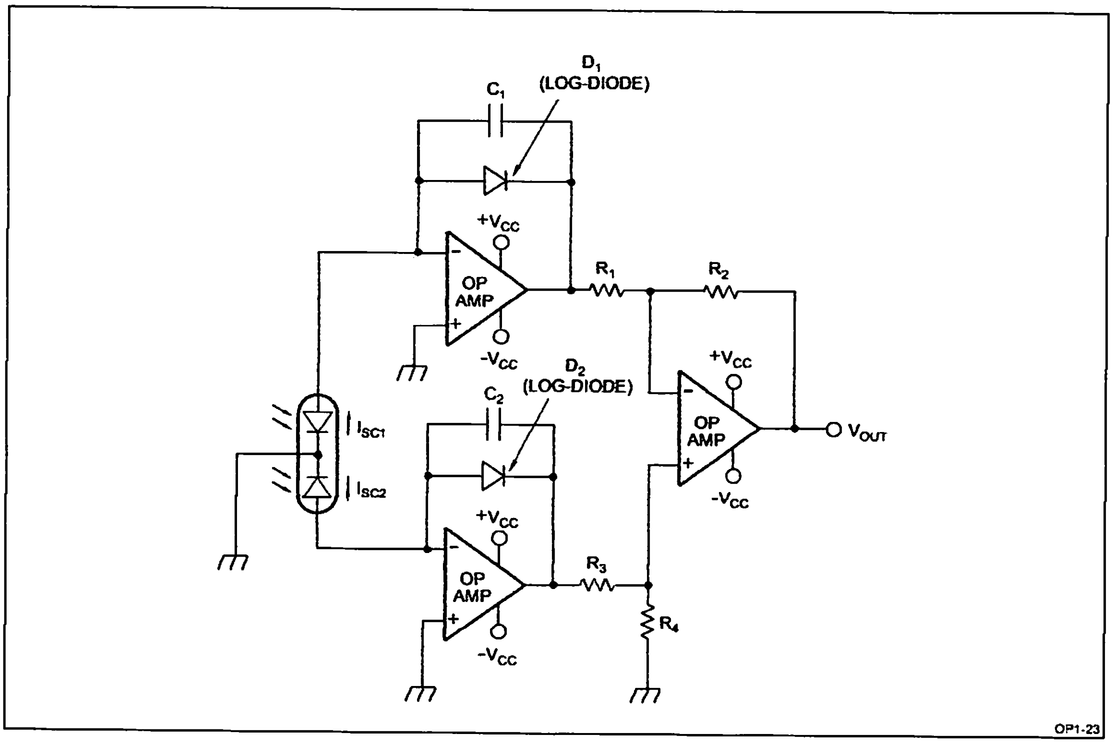


Figure 8. Color Sensor Amplifier Circuit

ɟNDAMENTAL PHOTOTRANSISTOR RCUITS

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

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

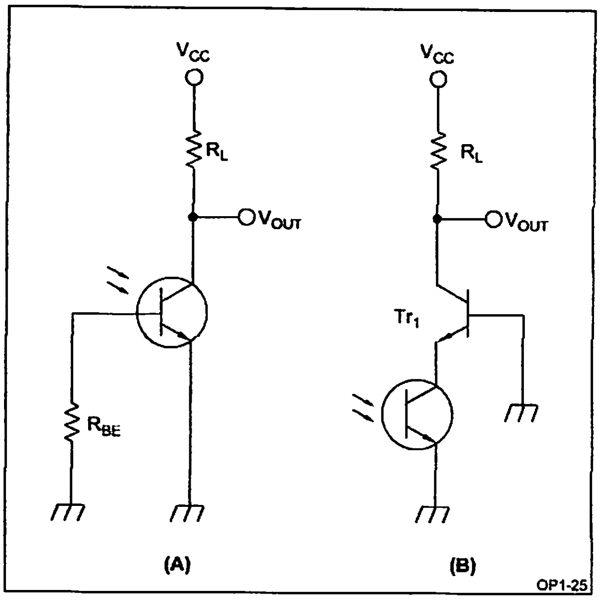


Figure 10. Fundamental Phototransistor Circuit (II)

ɪIPLIFIER CIRCUIT USING TRANSISTOR

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

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

Vhere I_{CBO} is the dark current of phototransistor ɪ I_C is the collector current.

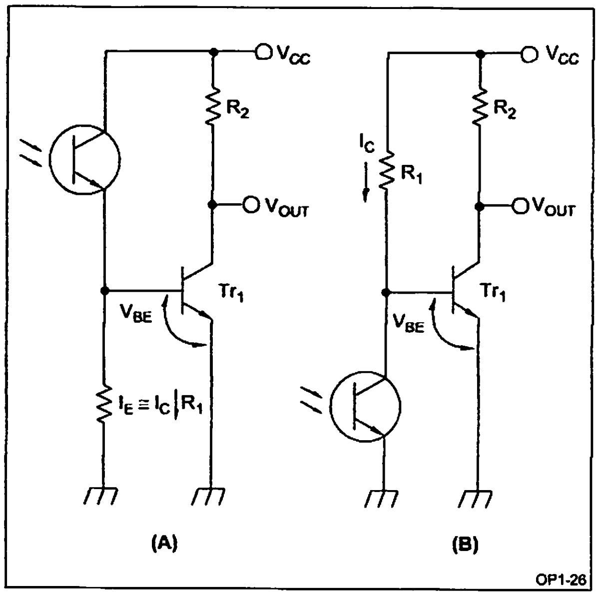
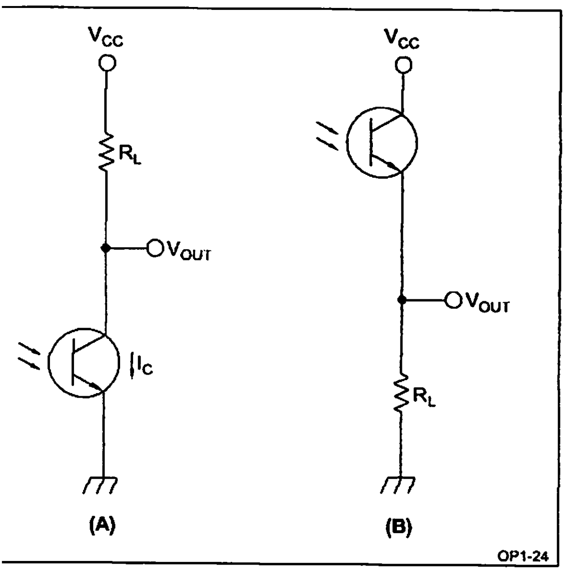


Figure 11. Amplifier Circuit using Transistor



ɟure 9. Fundamental Phototransistor Circuit (I)

ODULATED SIGNAL DETECTION CIRCUIT

Figure 12 shows the circuits used to detect a modu-
ed signal such as an AC or pulse signal. The pho-
ransistor has a base terminal with a fixed bias through
sistors R_1 and R_2. An R_4 emitter resistor maintains the
; output voltage constant. A modulated signal provides
ɔase current through bypass capacitor C causing cur-
ıt amplification so that the signal is greatly amplified.

ИPLIFIER CIRCUIT USING PERATIONAL AMPLIFIER

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

The current-voltage conversion circuit for the pho- ransistor is basically identical to that of the photo- ıde, except that the phototransistor requires a bias. e circuit shown if Figure 13 (A) has a negative bias ') for the emitter against the virtually grounded col- tor potential. *Figure 13 (B) shows the output voltage* irradiation intensity characteristics.

JTO-STROBOSCOPE CIRCUIT

Figure 14 shows the auto-stroboscope circuit of the 'rent cut type. This circuit is most frequently used ;ause of advantages such as continuous light emis- n 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.

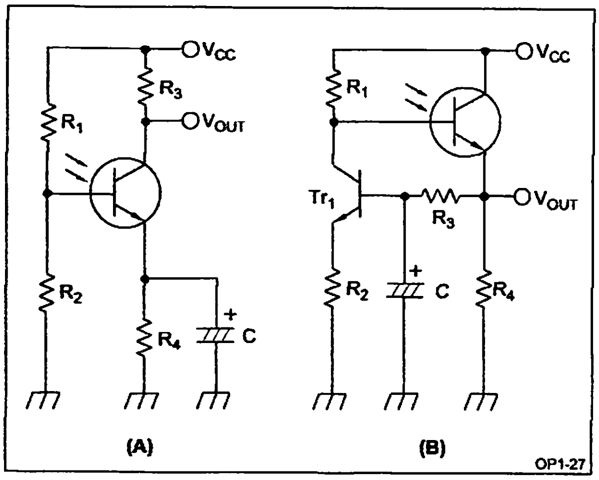


Figure 12. Modulated Signal Detection Circuit

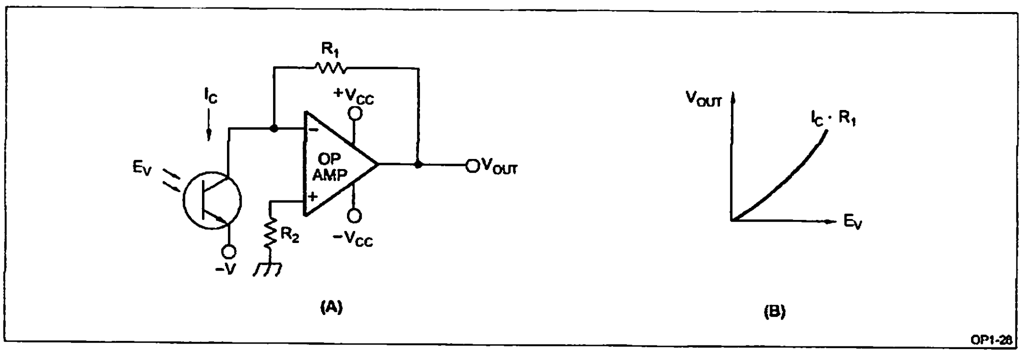


Figure 13. Amplifier Circuit using an Operational Amplifier

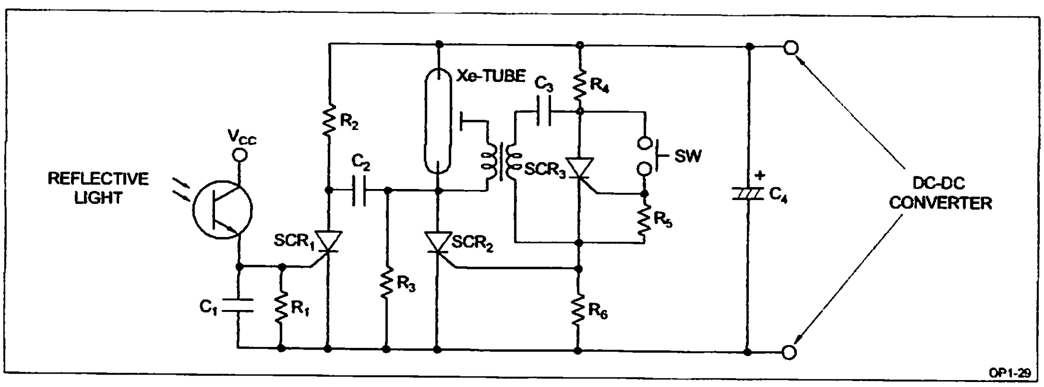


Figure 14. Auto-Stroboscope Circuit

E SUPPORT POLICY

RP components should not be used in medical devices with life support functions or in safety equipment (or similiar applications where ponent failure would result in loss of life or physical harm) without the written approval of an officer of the SHARP Corporation.

ITED WARRANTY

RP warrants to its Customer that the Products will be free from defects in material and workmanship under normal use and service for a d of one year from the date of invoice. Customer's exclusive remedy for breach of this warranty is that SHARP will either (i) repair or ice, at its option, any Product which fails during the warranty period because of such defect (if Customer promptly reported the failure to RP in writing) or, (ii) if SHARP is unable to repair or replace, refund the purchase price of the Product upon its return to SHARP. This anty does not apply to any Product which has been subjected to misuse, abnormal service or handling, or which has been altered or ified in design or construction, or which has been serviced or repaired by anyone other than Sharp. The warranties set forth herein are in of, and exclusive of, all other warranties, express or implied. ALL EXPRESS AND IMPLIED WARRANTIES, INCLUDING THE RANTIES OF MERCHANTABILITY, FITNESS FOR USE AND FITNESS FOR A PARTICULAR PURPOSE, ARE SPECIFICALLY LUDED. In no event will Sharp be liable, or in any way responsible, for any incidental or consequential economic or property damage.

above warranty is also extended to Customers of Sharp authorized distributors with the following exception: reports of failures of Products g the warranty period and return of Products that were purchased from an authorized distributor must be made through the distributor. se Sharp is unable to repair or replace such Products, refunds will be issued to the distributor in the amount of distributor cost.

RP reserves the right to make changes in specifications at any time and without notice. SHARP does not assume any responsibility e use of any circuitry described; no circuit patent licenses are implied.

HARP®

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Facsimile: (81) 6117-725300
http://www.sharp.co.jp/e-device/index.html

Reference Code SMA99017

MINIATURE RELAY

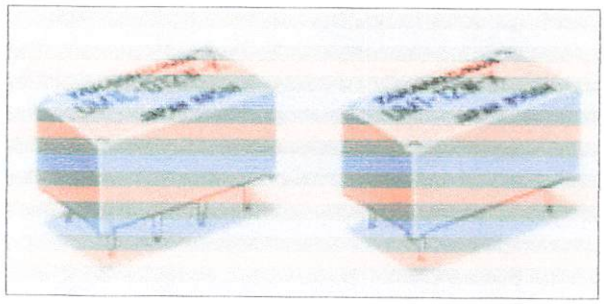
1 POLE

(HIGH FREQUENCE SIGNAL SWITCHING)

UM1 SERIES

RoHS Compliant

■ FEATURES



- Subminiature polarized relay
- Excellent high frequency characteristics
  - —Isolation : min. 60 dB
  - —Insertion loss : max. 1 dB
  - —V.S.W.R. : max. 1.2

  } at 900 MHz (Impedance of the measuring devices is 75Ω)
- High reliability—Bifurcated contacts
- Wide operating range
- DIL pitch terminals
- Plastic sealed type
- Latching type available
- RoHS compliant since date code: 0437T2
  Please see page 7 for more information

■ ORDERING INFORMATION

[Example] UM1 (a) L (b) – D (c) 12 (d) W (e) – K (f)

(a)	Series Name	UM1: UM1 Series
(b)	Operation Function	Nil : Standard type L : Latching type
(c)	Number of Coil	Nil : Single winding type D : Double winding type
(d)	Nominal Voltage	Refer to the COIL DATA CHART
(e)	Contact	W : Bifurcated type
(f)	Enclosure	K : Plastic sealed type

SPECIFICATIONS

Item			Standard Type UM1-( ) W-K	Single Winding Latching Type UM1L-( ) W-K	Double Winding Latching Type UM1L-D ( ) W-K
;ontact	Arrangement		1 form C (SPDT)		
	Material		Gold clad (stationary contact), gold plate (movable contact)		
	Style		Bifurcated		
	Resistance (initial)		*Maximum 100 mΩ*		
	Rating (resistive)		10 mA 24 VDC 1 W (at 900 MHz)		
	Maximum Carrying Current		0.5 A		
	Maximum Switching Power		1 W (DC) 10 W (at 900 MHz)		
	Maximum Switching Voltage		30 VDC		
	Maximum Switching Current		100 mA		
	Minimum Switching Load[*1]		0.01 mA 10 mVDC		
xcellent igh requency ;haracter- ;tics	Isolation		Minimum 60 dB(at 900 MHz), impedance of the measuring devices is 75Ω		
	Insertion Loss		Maximum 1 dB(at 900 MHz), impedance of the measuring devices is 75Ω		
	V.S.W.R.		Maximum 1.2(at 900 MHz), impedance of the measuring devices is 75Ω		
oil	*Nominal Power (at 20°C)*		*0.2 to 0.22 W*	*0.2 W*	*0.4 W*
	Operate Power (at 20°C)		0.1 to 0.11 W	0.1 W	0.2 W
	Operating Temperature		–30°C to +80°C (no frost)		–30°C to +60°C (no frost)
ime Value	Operate (at nominal voltage)		Maximum 6 ms	Maximum 6 ms (set)	
	Release (at nominal voltage)		Maximum 5 ms	Maximum 6 ms (reset)	
ısulation	Resistance (at 500 VDC)		Minimum 1,000 MΩ		
	Dielectric Strength	between open contacts *between contacts* and shield terminals	*500 VAC 1 minute*		
		between coil and contacts, between coil and shield terminals	1,000 VAC 1 minute		
fe	Mechanical		1×10^6 operations minimum		
	Electrical		3×10^5 operations minimum (at nominal load)		
ther	Vibration Resistance	Misoperation	10 to 55 Hz (double amplitude of 3.3 mm)		
		Endurance	10 to 55 Hz (double amplitude of 5.0 mm)		
	Shock Resistance	Misoperation	500 m/s^2 (11 ±1 ms)		
		Endurance	1,000 m/s^2 (6 ±1 ms)		
	Weight		*Approximately 4 g*		

Minimum switching loads mentioned above are reference values. Please perform the confirmation test with the actual load before production since reference values may vary according to switching frequencies, environmental conditions and expected reliability levels.

COIL DATA CHART

MODEL	Nominal voltage	Coil resistance (±10%)	Must operate voltage*1	Must release voltage*1	Nominal power
UM1- 1.5 W-K	1.5 VDC	11.2Ω	+1.05 VDC	+0.08 VDC	200 mW
UM1- 3 W-K	3 VDC	45 Ω	+2.1 VDC	+0.15 VDC	200 mW
UM1- 4.5 W-K	4.5 VDC	101 Ω	+3.15 VDC	+0.23 VDC	200 mW
UM1- 5 W-K	5 VDC	125 Ω	+3.5 VDC	+0.25 VDC	200 mW
UM1- 6 W-K	6 VDC	180 Ω	+4.2 VDC	+0.3 VDC	200 mW
UM1- 9 W-K	9 VDC	405 Ω	+6.3 VDC	+0.45 VDC	200 mW
UM1- 12 W-K	12 VDC	720 Ω	+8.4 VDC	+0.6 VDC	200 mW
UM1- 18 W-K	18 VDC	1,620 Ω	+12.6 VDC	+0.9 VDC	200 mW
UM1- 24 W-K	24 VDC	2,880 Ω	+16.8 VDC	+1.2 VDC	200 mW
UM1- 48 W-K	48 VDC	10,472 Ω	+33.6 VDC	+2.4 VDC	220 mW

te: *1 Specified values are subject to pulse wave voltage.
values in the table are measured at 20°C.

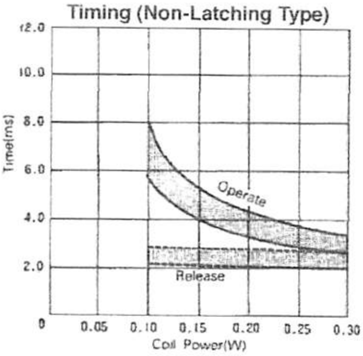
MODEL	Nominal voltage	Coil resistance (±10%)	Set voltage*1	Reset voltage*1	Nominal power
UM1L- 1.5 W-K	1.5 VDC	11.2Ω	+1.05 VDC	-1.05 VDC	200 mW
UM1L- 3 W-K	3 VDC	45 Ω	+2.1 VDC	-2.1 VDC	200 mW
UM1L- 4.5 W-K	4.5 VDC	101 Ω	+3.15 VDC	-3.15 VDC	200 mW
UM1L- 5 W-K	5 VDC	125 Ω	+3.5 VDC	-3.5 VDC	200 mW
UM1L- 6 W-K	6 VDC	180 Ω	+4.2 VDC	-4.2 VDC	200 mW
UM1L- 9 W-K	9 VDC	405 Ω	+6.3 VDC	-6.3 VDC	200 mW
UM1L- 12 W-K	12 VDC	720 Ω	+8.4 VDC	-8.4 VDC	200 mW
UM1L- 18 W-K	18 VDC	1,620 Ω	+12.6 VDC	-12.6 VDC	200 mW
UM1L- 24 W-K	24 VDC	2,880 Ω	+16.8 VDC	-16.8 VDC	200 mW
UM1L- 48 W-K	48 VDC	11,520 Ω	+33.6 VDC	-33.6 VDC	200 mW
UM1L-D1.5 W-K	1.5 VDC	P 5.6Ω	+1.05 VDC		400 mW
		S 5.6Ω		+1.05 VDC	
UM1L-D 3 W-K	3 VDC	P 22.5Ω	+2.1 VDC		400 mW
		S 22.5Ω		+2.1 VDC	
UM1L-D4.5 W-K	4.5 VDC	P 50.6Ω	+3.15 VDC		400 mW
		S 50.6Ω		+3.15 VDC	
UM1L-D 5 W-K	5 VDC	P 62.5Ω	+3.5 VDC		400 mW
		S 62.5Ω		+3.5 VDC	
UM1L-D 6 W-K	6 VDC	P 90 Ω	+4.2 VDC		400 mW
		S 90 Ω		+4.2 VDC	
UM1L-D 9 W-K	9 VDC	P 202.5Ω	+6.3 VDC		400 mW
		S 202.5Ω		+6.3 VDC	
UM1L-D 12 W-K	12 VDC	P 360 Ω	+8.4 VDC		400 mW
		S 360 Ω		+8.4 VDC	
UM1L-D 18 W-K	18 VDC	P 810 Ω	+12.6 VDC		400 mW
		S 810 Ω		+12.6 VDC	
UM1L-D 24 W-K	24 VDC	P 1,440 Ω	+16.8 VDC		400 mW
		S 1,440 Ω		+16.8 VDC	
UM1L-D 48 W-K	48 VDC	P 5,760 Ω	+33.6 VDC		400 mW
		S 5,760 Ω		+33.6 VDC	

e: *1 Specified values are subject to pulse wave voltage.
values in the table are measured at 20°C.

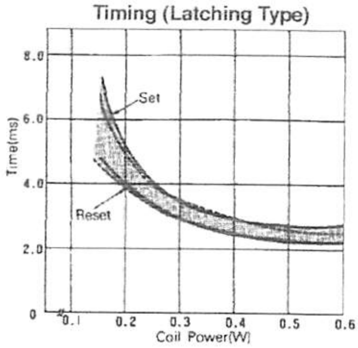
P: Primary coil S: Secondary coil

CHARACTERISTIC DATA

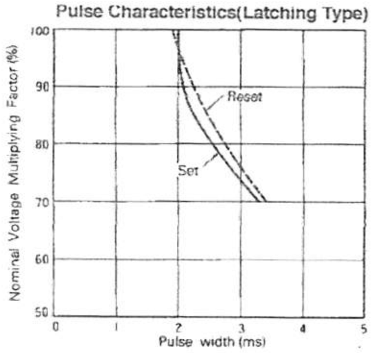
Timing (Non-Latching Type)



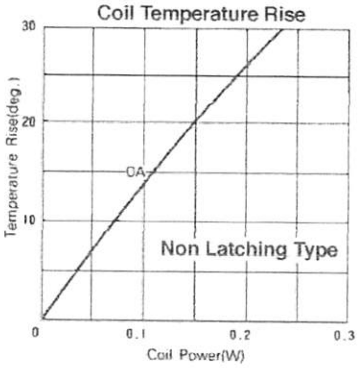
Timing (Latching Type)



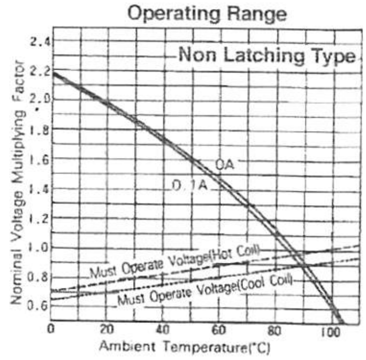
Pulse Characteristics(Latching Type)



Coil Temperature Rise

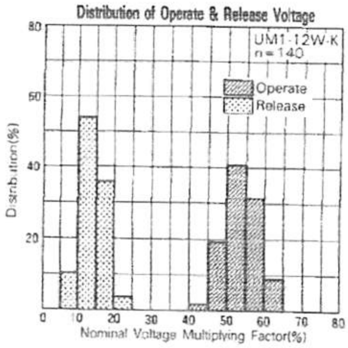


Operating Range

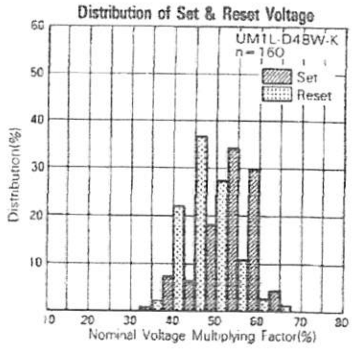


REFERENCE DATA

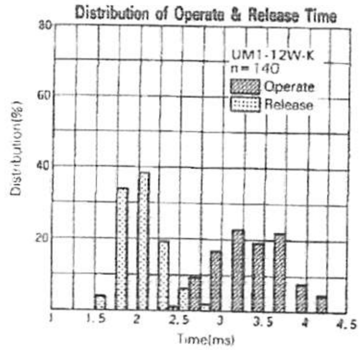
Distribution of Operate & Release Voltage



Distribution of Set & Reset Voltage



Distribution of Operate & Release Time



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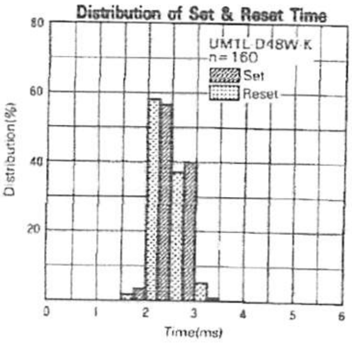
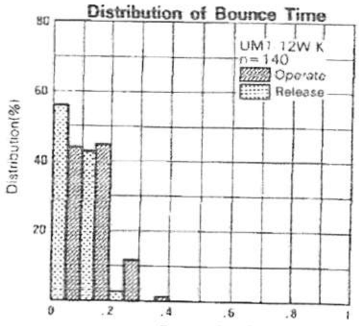
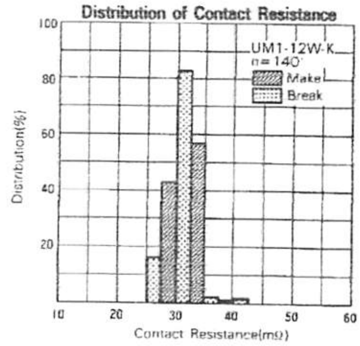
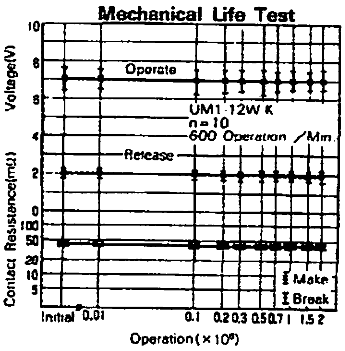


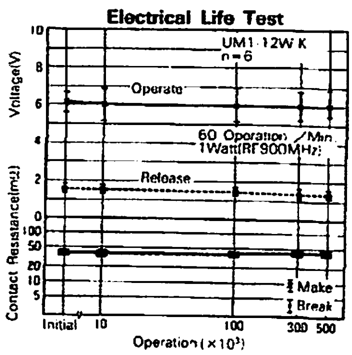
Distribution of Bounce Time

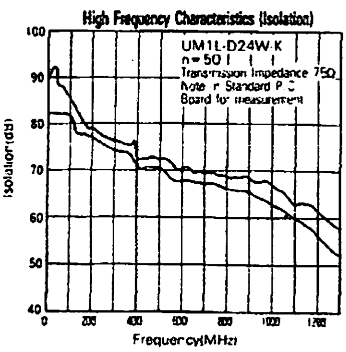


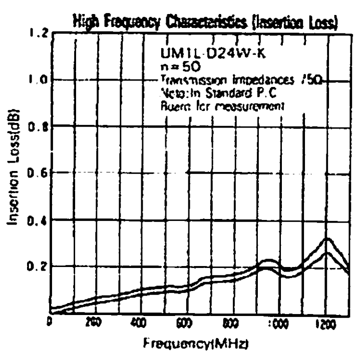
Distribution of Contact Resistance

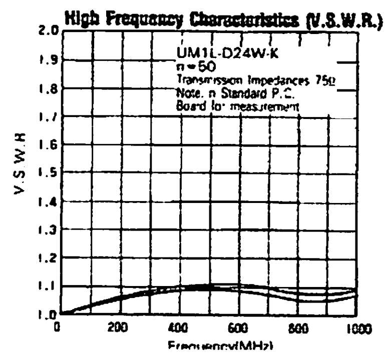












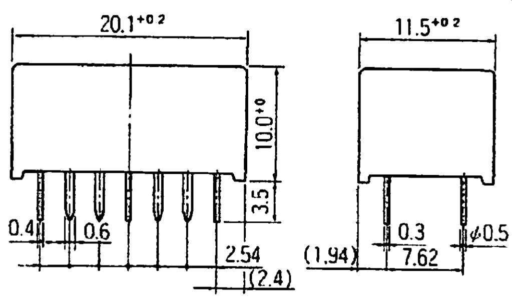
DIMENSIONS

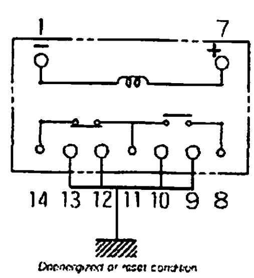
●Dimensions

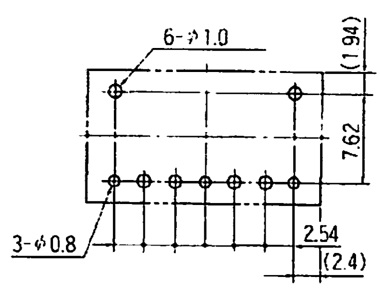
●Schematics
(Bottom view)

●PC board mounting hole layout
(Bottom view)

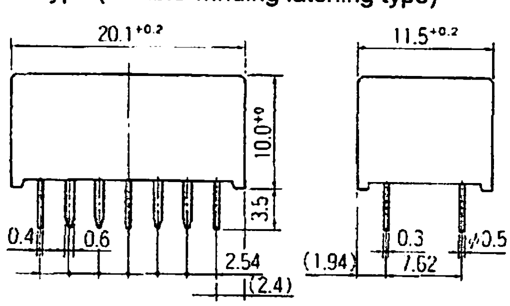
/1, UM1L type (Non-latching type, single winding latching type)

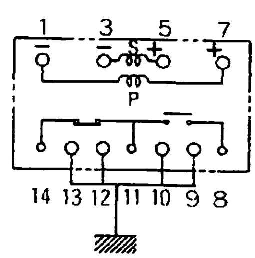


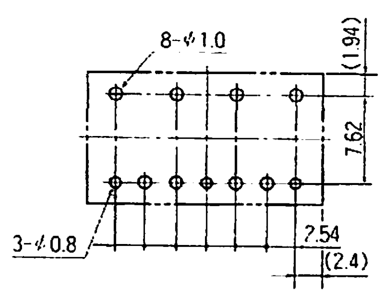




l1L-D type (Double winding latching type)







Unit: mm

RoHS Compliance and Lead Free Relay Information

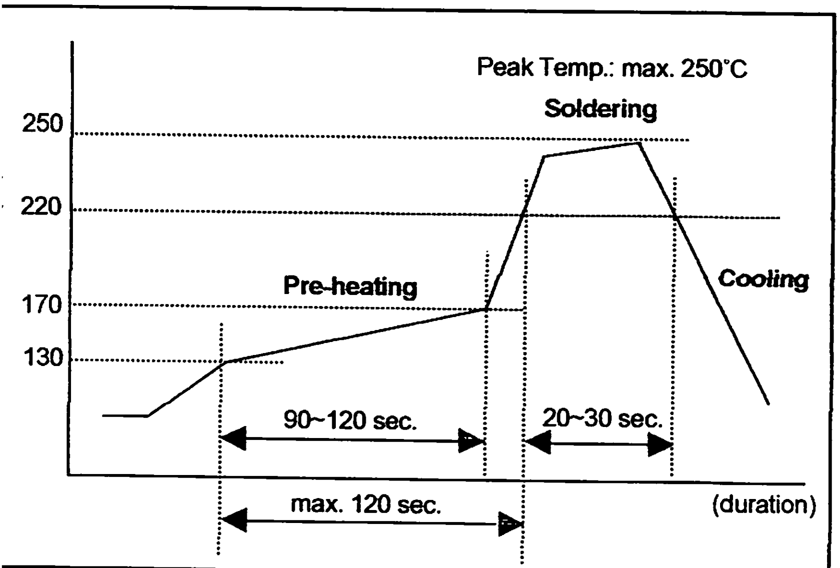
l. General Information

- Relays produced after the specific date code that is indicated on each data sheet are lead-free now. Most of our signal and power relays are lead-free. Please refer to Lead-Free Status Info. (http://www.fcai.fujitsu.com/pdf/LeadFreeLetter.pdf)
- Lead free solder paste currently used in relays is Sn-3.0Ag-0.5Cu. From February 2005 forward Sn-3.0Cu-Ni will be used for FTRB3 and FTR-B4 series relays.
- Most signal and some power relays also comply with RoHS. Please refer to individual data sheets. Relays that are RoHS compliant do not contain the 6 hazardous materials that are restricted by RoHS directive (lead, mercury, cadmium, chromium IV, PBB, PBDE).
- It has been verified that using lead-free relays in leaded assembly process will not cause any problems (compatible).
- "LF" is marked on each outer and inner carton. (No marking on individual relays).
- To avoid leaded relays (for lead-free sample, etc.) please consult with area sales office.
- /e will ship leaded relays as long as the leaded relay inventory exists.

:. Recommended Lead Free Solder Profile

Recommended solder paste Sn-3.0Ag-0.5Cu and Sn-3.0 Cu-Ni (only FTR-B3 and FTR-B4 from February 2005)

›flow Solder condtion



Flow Solder condtion:

Pre-heating:	maximum 120°C
Soldering:	dip within 5 sec. at 260°C soler bath

Solder by Soldering Iron:

Soldering Iron

Temperature:	maximum 360°C
Duration:	maximum 3 sec.

We highly recommend that you confirm your actual solder conditions

Moisture Sensitivity

Moisture Sensitivity Level standard is not applicable to electromechanical realys.

Tin Whisker

SnAgCu solder is known as low riskof tin whisker. No considerable length whisker was found by our in-house test.

Solid State Relays

Each lead terminal will be changed from solder plating to Sn plating and Nickel plating. A layer of Nickel plating ›etween the terminal and the Sn plating to avoid whisker.

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www.fcal.fujitsu.com

ures

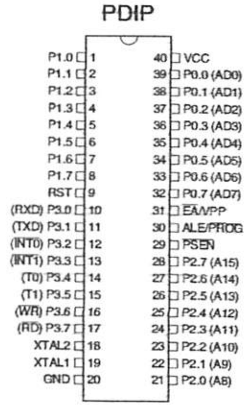
- *patible with MCS-51™ Products*
- ytes of In-System Reprogrammable Flash Memory
- Endurance: 1,000 Write/Erase Cycles
- Static Operation: 0 Hz to 24 MHz
- e-level Program Memory Lock
- x 8-bit Internal RAM
- rogrammable I/O Lines
- 16-bit Timer/Counters
- nterrupt Sources
- *rammable Serial Channel*
- -power Idle and Power-down Modes

cription

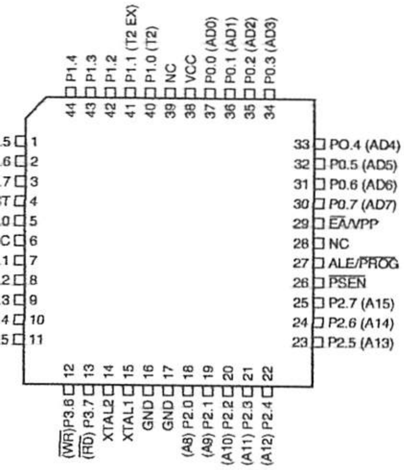
T89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K of Flash programmable and erasable read only memory (PEROM). The device ufactured using Atmel's high-density nonvolatile memory technology and is *tible with the industry-standard MCS-51 instruction set and pinout. The on-chip* allows the program memory to be reprogrammed in-system or by a conven- nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash onolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides *y-flexible and cost-effective solution to many embedded control applications.*

Configurations

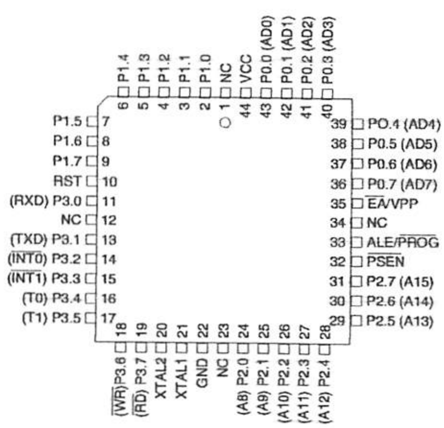
PDIP



PQFP/TQFP



PLCC

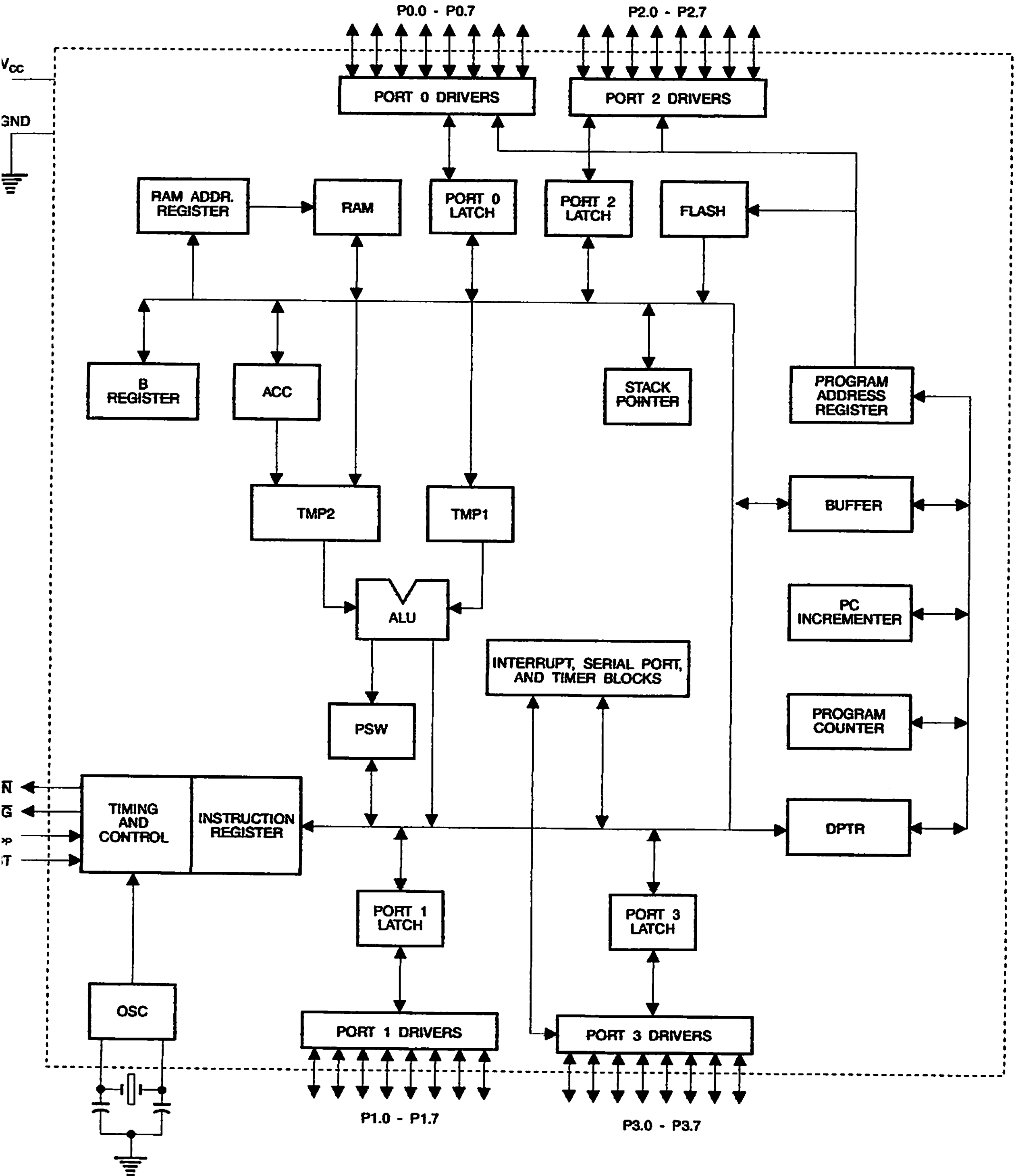


8-bit Microcontroller with 4K Bytes Flash

AT89C51

Rev. 0265G–02/00

ck Diagram


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
BUFFER
TMP2
TMP1
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

T89C51 provides the following standard features: 4K of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit counters, a five vector two-level interrupt architecture, duplex serial port, on-chip oscillator and clock cir- In addition, the AT89C51 is designed with static logic eration down to zero frequency and supports two are selectable power saving modes. The Idle Mode the CPU while allowing the RAM, timer/counters, port and interrupt system to continue functioning. The r-down Mode saves the RAM contents but freezes cillator disabling all other chip functions until the next are reset.

Description

voltage.

d.

is an 8-bit open-drain bi-directional I/O port. As an port, each pin can sink eight TTL inputs. When 1s itten to port 0 pins, the pins can be used as high- ance inputs.

may also be configured to be the multiplexed low- address/data bus during accesses to external pro- and data memory. In this mode P0 has internal s.

also receives the code bytes during Flash program- and outputs the code bytes during program ation. External pullups are required during program ation.

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

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

s an 8-bit bi-directional I/O port with internal pullups. rt 2 output buffers can sink/source four TTL inputs. ls are written to Port 2 pins they are pulled high by ernal 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 bi-directional 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	$\overline{INT0}$ (external interrupt 0)
P3.3	$\overline{INT1}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{WR}$ (external data memory write strobe)
P3.7	$\overline{RD}$ (external data memory read strobe)

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/$\overline{PROG}$

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 ($\overline{PROG}$) 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 is skipped during each access to external Data ry.

'ed, ALE operation can be disabled by setting bit 0 of ›cation 8EH. With the bit set, ALE is active only dur- MOVX or MOVC instruction. Otherwise, the pin is / pulled high. Setting the ALE-disable bit has no f the microcontroller is in external execution mode.

ım Store Enable is the read strobe to external pro- nemory.

the AT89C51 is executing code from external pro- memory, $\overline{PSEN}$ is activated twice each machine except that two $\overline{PSEN}$ activations are skipped during ccess to external data memory.

P

al Access Enable. $\overline{EA}$ must be strapped to GND in o enable the device to fetch code from external pro- nemory locations starting at 0000H up to FFFFH. ıowever, that if lock bit 1 is programmed, $\overline{EA}$ will be lly latched on reset.

ould be strapped to V_{CC} for internal program ions.

n also receives the 12-volt programming enable volt- $_{PP}$) during Flash programming, for parts that require V_{PP}.

ɔ the inverting oscillator amplifier and input to the l clock operating circuit.

from the inverting oscillator amplifier.

llator Characteristics

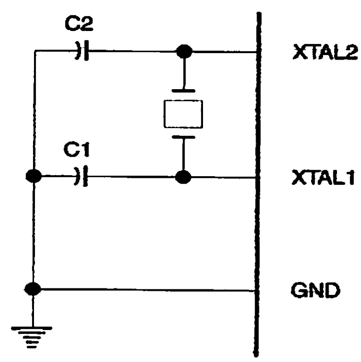
and XTAL2 are the input and output, respectively, verting amplifier which can be configured for use as :hip oscillator, as shown in Figure 1. Either a quartz or ceramic resonator may be used. To drive the from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 2. There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.

Idle Mode

In idle mode, the CPU puts itself to sleep while all the on-chip peripherals remain active. The mode is invoked by software. The content of the on-chip RAM and all the special functions registers remain unchanged during this mode. The idle mode can be terminated by any enabled interrupt 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

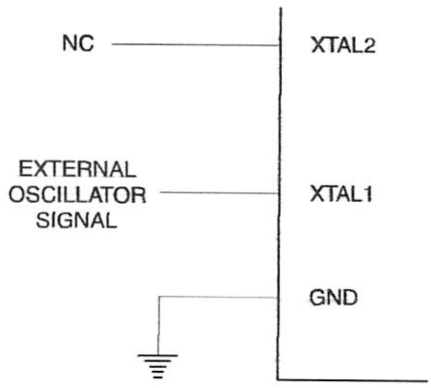


Note: C1, C2 = 30 pF ± 10 pF for Crystals
= 40 pF ± 10 pF for Ceramic Resonators

ıs of External Pins During Idle and Power-down Modes

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

e 2. External Clock Drive Configuration



er-down Mode

power-down mode, the oscillator is stopped, and the tion that invokes power-down is the last instruction ted. 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.

k Bit Protection Modes

Program Lock Bits			
LB1	LB2	LB3	Protection Type
U	U	U	No program lock features
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
P	P	U	Same as mode 2, also verify is disabled
P	P	P	Same as mode 3, also external execution is disabled

ɹramming the Flash

T89C51 is normally shipped with the on-chip Flash ry array in the erased state (that is, contents = FFH) ady *to be programmed. The programming interface* ts either a high-voltage (12-volt) or a low-voltage program enable signal. The low-voltage program-mode provides a convenient way to program the *:51 inside the user's system, while the high-voltage* ımming mode is compatible with conventional third-Flash or EPROM programmers.

T89C51 is shipped with either the high-voltage or ıltage programming mode enabled. The respective le marking and device signature codes are listed in lowing table.

	V_{PP} = 12V	V_{PP} = 5V
ide Mark	AT89C51 xxxx yyww	AT89C51 xxxx-5 yyww
ture	(030H) = 1EH (031H) = 51H (032H) =F FH	(030H) = 1EH (031H) = 51H (032H) = 05H

T89C51 code memory array is programmed byte-by-ı either programming mode. *To program any non-yte in the on-chip Flash Memory, the entire memory e erased using the Chip Erase Mode.*

amming Algorithm: Before programming the :51, the address, data and control signals should be according to the Flash programming mode table and 3 and Figure 4. To program the AT89C51, take the ıg steps.

ıut the desired memory location on the address ɜs.

ıut the appropriate data byte on the data lines.

tivate the correct combination of control signals.

ise $\overline{EA}/V_{PP}$ to 12V for the high-voltage program-ıg mode.

lse ALE/$\overline{PROG}$ once to program a byte in the sh array or the lock bits. The byte-write cycle is f-timed and typically takes no more than 1.5 ms.

peat steps 1 through 5, changing the address and data for the entire array or until the end of the object file is reached.

$\overline{Data}$ Polling: The AT89C51 features $\overline{Data}$ 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. $\overline{Data}$ Polling may begin any time after a write cycle has been initiated.

Ready/$\overline{Busy}$: 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.

h Programming Modes

‚		RST	$\overline{PSEN}$	ALE/$\overline{PROG}$	$\overline{EA}/V_{PP}$	P2.6	P2.7	P3.6	P3.7
Code Data		H	L	‾_/‾	H/12V	L	H	H	H
Code Data		H	L	H	H	L	L	H	H
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
Erase		H	L	‾_/‾ (1)	H/12V	H	L	L	L
Signature Byte		H	L	H	H	L	L	L	L

1. Chip Erase requires a 10 ms PROG pulse.

3. Programming the Flash

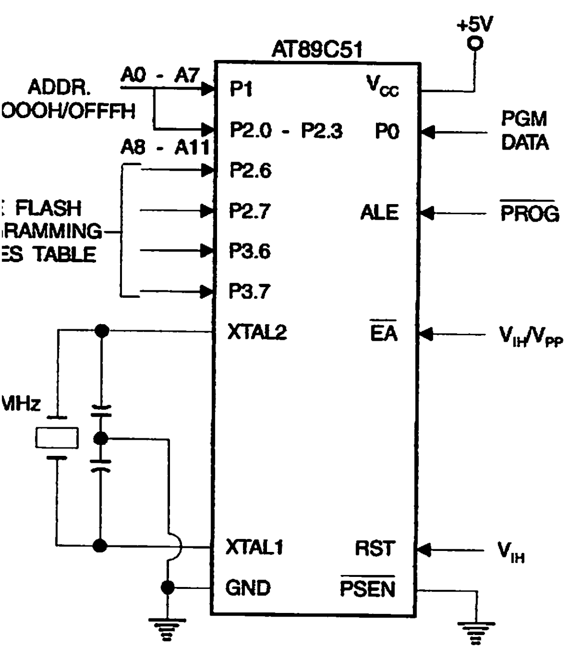
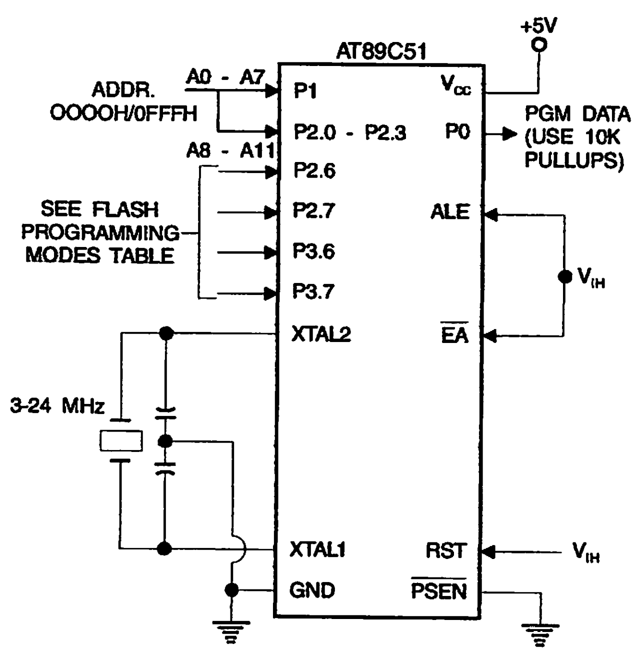
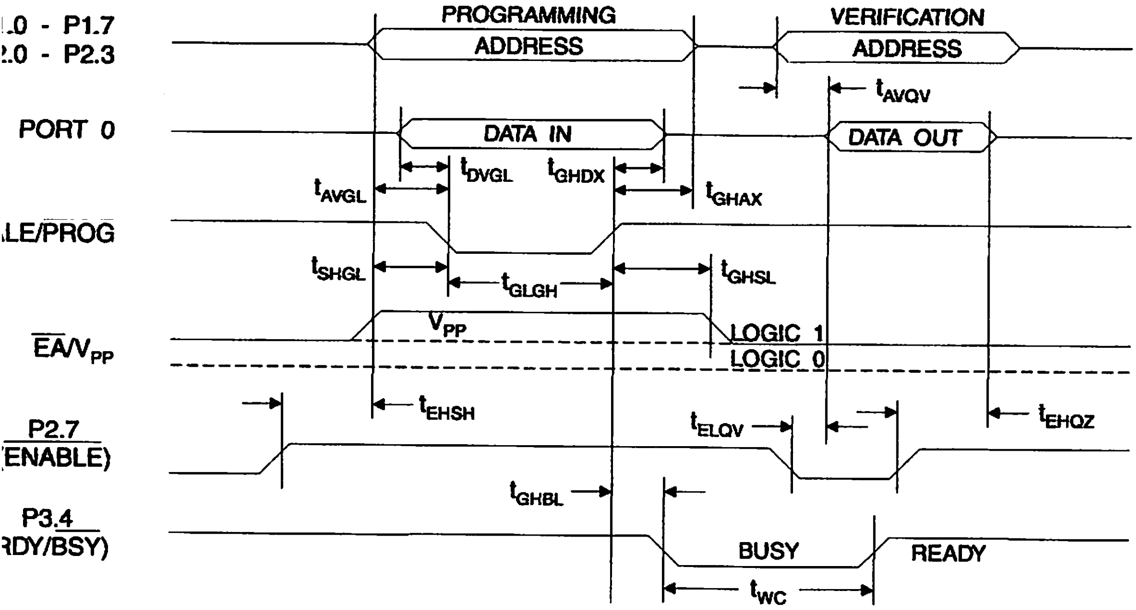


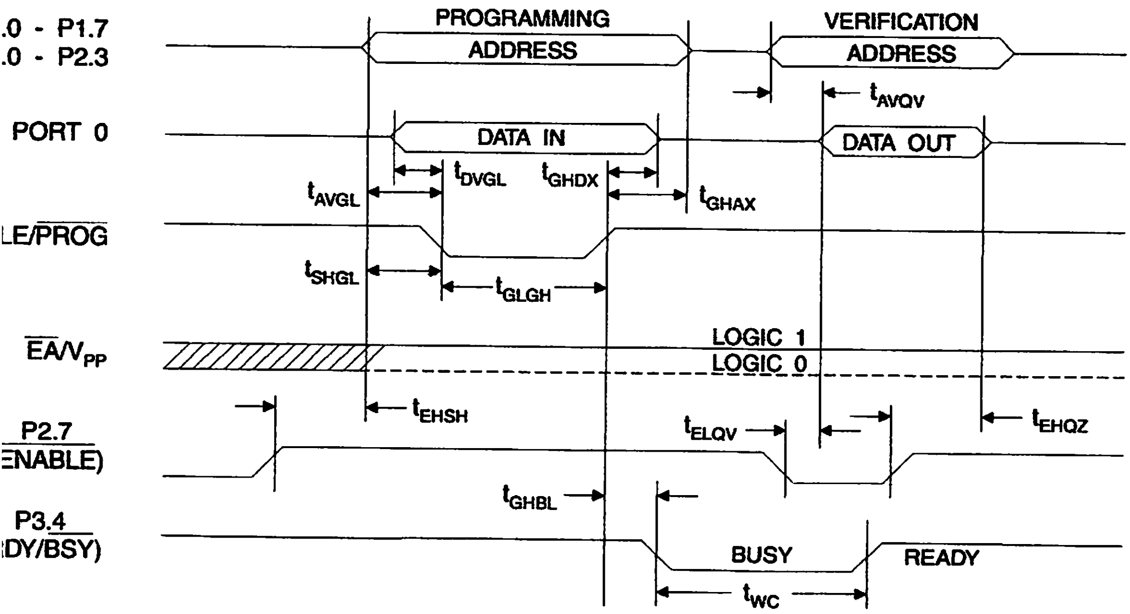
Figure 4. Verifying the Flash



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



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



h Programming and Verification Characteristics

°C to 70°C, V_{CC} = 5.0 ± 10%

ol	Parameter	Min	Max	Units
	Programming Enable Voltage	11.5	12.5	V
	Programming Enable Current		1.0	mA
L	Oscillator Frequency	3	24	MHz
	Address Setup to $\overline{PROG}$ Low	$48t_{CLCL}$		
	Address Hold After $\overline{PROG}$	$48t_{CLCL}$		
	Data Setup to $\overline{PROG}$ Low	$48t_{CLCL}$		
	Data Hold After $\overline{PROG}$	$48t_{CLCL}$		
	P2.7 ($\overline{ENABLE}$) High to V_{PP}	$48t_{CLCL}$		
	V_{PP} Setup to $\overline{PROG}$ Low	10		μs
)	V_{PP} Hold After $\overline{PROG}$	10		μs
	$\overline{PROG}$ Width	1	110	μs
	Address to Data Valid		$48t_{CLCL}$	
	$\overline{ENABLE}$ Low to Data Valid		$48t_{CLCL}$	
	Data Float After $\overline{ENABLE}$	0	$48t_{CLCL}$	
	$\overline{PROG}$ High to $\overline{BUSY}$ Low		1.0	μs
	Byte Write Cycle Time		2.0	ms

1. Only used in 12-volt programming mode.

olute Maximum Ratings*

ting Temperature	-55°C to +125°C
je Temperature	-65°C to +150°C
je on Any Pin lespect to Ground	-1.0V to +7.0V
ıum Operating Voltage	6.6V
utput Current	15.0 mA

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

Characteristics

0°C to 85°C, V_{CC} = 5.0V ± 20% (unless otherwise noted)

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

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.

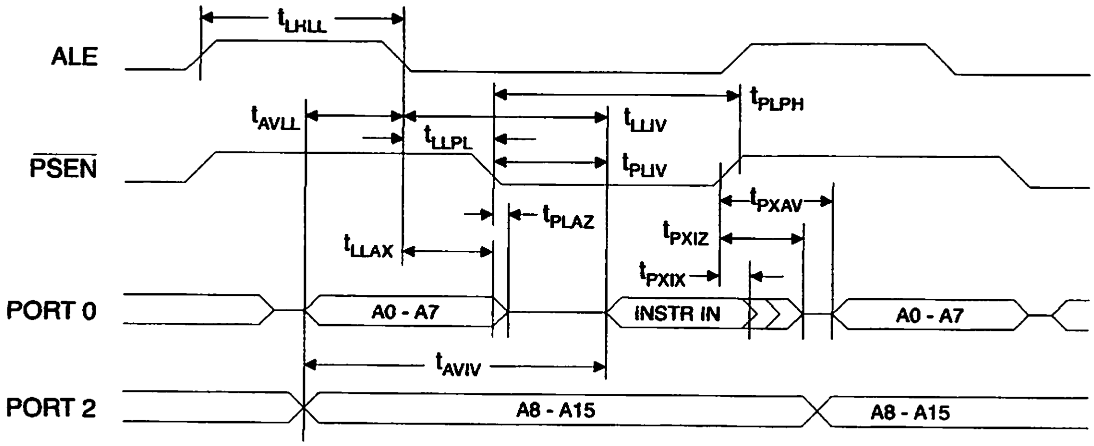
:haracteristics

operating conditions, load capacitance for Port 0, ALE/$\overline{PROG}$, and $\overline{PSEN}$ = 100 pF; load capacitance for all other
s = 80 pF.

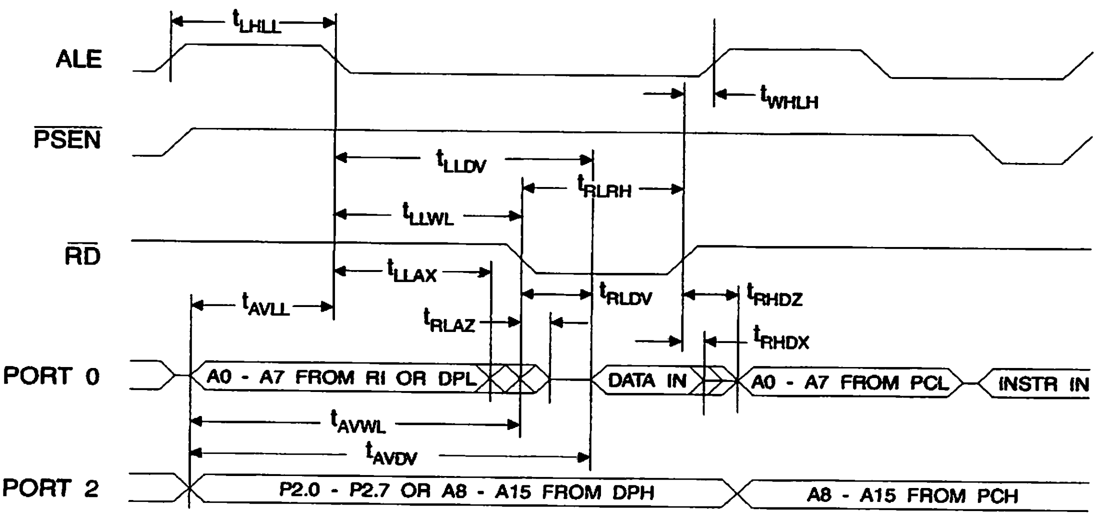
rnal Program and Data Memory Characteristics

		12 MHz Oscillator		16 to 24 MHz Oscillator		
ol	Parameter	Min	Max	Min	Max	Units
-	Oscillator Frequency			0	24	MHz
	ALE Pulse Width	127		$2t_{CLCL}$-40		ns
	Address Valid to ALE Low	43		t_{CLCL}-13		ns
	Address Hold After ALE Low	48		t_{CLCL}-20		ns
	ALE Low to Valid Instruction In		233		$4t_{CLCL}$-65	ns
	ALE Low to $\overline{PSEN}$ Low	43		t_{CLCL}-13		ns
	$\overline{PSEN}$ Pulse Width	205		$3t_{CLCL}$-20		ns
	$\overline{PSEN}$ Low to Valid Instruction In		145		$3t_{CLCL}$-45	ns
	Input Instruction Hold After $\overline{PSEN}$	0		0		ns
	Input Instruction Float After $\overline{PSEN}$		59		t_{CLCL}-10	ns
	$\overline{PSEN}$ to Address Valid	75		t_{CLCL}-8		ns
	Address to Valid Instruction In		312		$5t_{CLCL}$-55	ns
	$\overline{PSEN}$ Low to Address Float		10		10	ns
	$\overline{RD}$ Pulse Width	400		$6t_{CLCL}$-100		ns
	$\overline{WR}$ Pulse Width	400		$6t_{CLCL}$-100		ns
	$\overline{RD}$ Low to Valid Data In		252		$5t_{CLCL}$-90	ns
	Data Hold After $\overline{RD}$	0		0		ns
	Data Float After $\overline{RD}$		97		$2t_{CLCL}$-28	ns
	ALE Low to Valid Data In		517		$8t_{CLCL}$-150	ns
	Address to Valid Data In		585		$9t_{CLCL}$-165	ns
	ALE Low to $\overline{RD}$ or $\overline{WR}$ Low	200	300	$3t_{CLCL}$-50	$3t_{CLCL}$+50	ns
	Address to $\overline{RD}$ or $\overline{WR}$ Low	203		$4t_{CLCL}$-75		ns
	Data Valid to $\overline{WR}$ Transition	23		t_{CLCL}-20		ns
	Data Valid to $\overline{WR}$ High	433		$7t_{CLCL}$-120		ns
	Data Hold After $\overline{WR}$	33		t_{CLCL}-20		ns
	$\overline{RD}$ Low to Address Float		0		0	ns
	$\overline{RD}$ or $\overline{WR}$ High to ALE High	43	123	t_{CLCL}-20	t_{CLCL}+25	ns

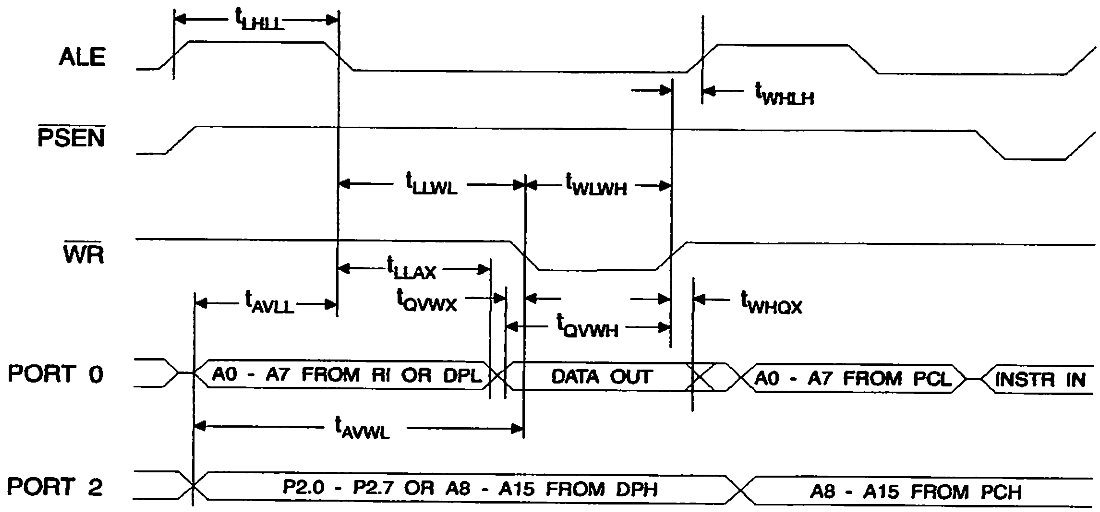
rnal Program Memory Read Cycle



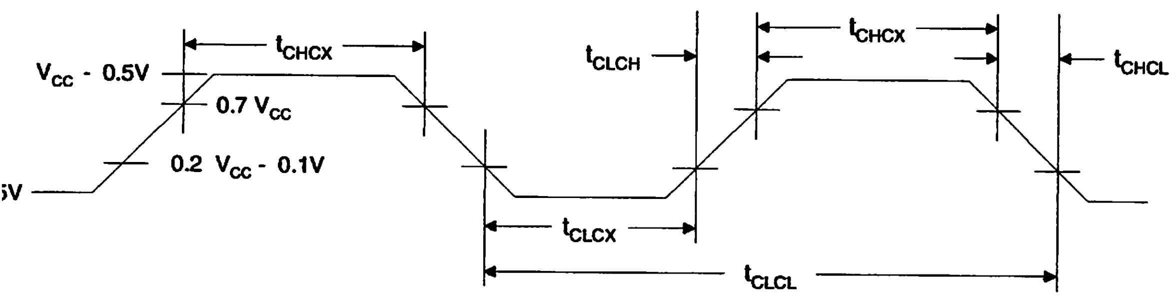
rnal Data Memory Read Cycle



rnal Data Memory Write Cycle



rnal Clock Drive Waveforms



rnal Clock Drive

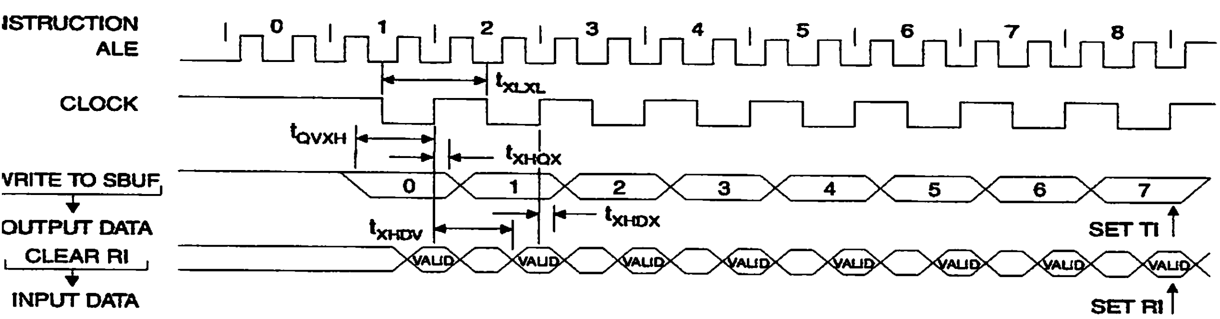
l	Parameter	Min	Max	Units
	Oscillator Frequency	0	24	MHz
	Clock Period	41.6		ns
	High Time	15		ns
	Low Time	15		ns
	Rise Time		20	ns
	Fall Time		20	ns

ıl Port Timing: Shift Register Mode Test Conditions

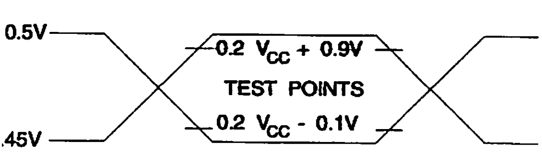
ꞅ.0 V ± 20%; Load Capacitance = 80 pF)

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

Register Mode Timing Waveforms

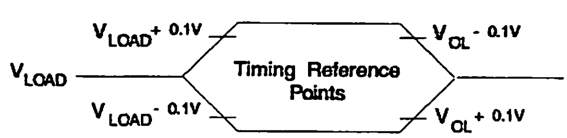


esting Input/Output Waveforms(1)



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.

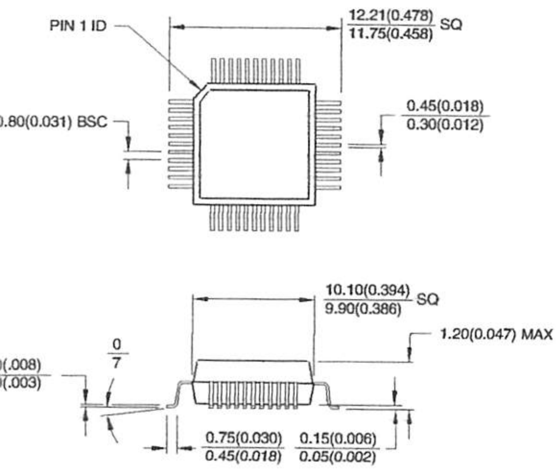
ring Information

ed tz)	Power Supply	Ordering Code	Package	Operation Range
	5V ± 20%	AT89C51-12AC	44A	Commercial
		AT89C51-12JC	44J	(0°C to 70°C)
		AT89C51-12PC	40P6	
		AT89C51-12QC	44Q	
		AT89C51-12AI	44A	Industrial
		AT89C51-12JI	44J	(-40°C to 85°C)
		AT89C51-12PI	40P6	
		AT89C51-12QI	44Q	
	5V ± 20%	AT89C51-16AC	44A	Commercial
		AT89C51-16JC	44J	(0°C to 70°C)
		AT89C51-16PC	40P6	
		AT89C51-16QC	44Q	
		AT89C51-16AI	44A	Industrial
		AT89C51-16JI	44J	(-40°C to 85°C)
		AT89C51-16PI	40P6	
		AT89C51-16QI	44Q	
	5V ± 20%	AT89C51-20AC	44A	Commercial
		AT89C51-20JC	44J	(0°C to 70°C)
		AT89C51-20PC	40P6	
		AT89C51-20QC	44Q	
		AT89C51-20AI	44A	Industrial
		AT89C51-20JI	44J	(-40°C to 85°C)
		AT89C51-20PI	40P6	
		AT89C51-20QI	44Q	
	5V ± 20%	AT89C51-24AC	44A	Commercial
		AT89C51-24JC	44J	(0°C to 70°C)
		AT89C51-24PC	40P6	
		AT89C51-24QC	44Q	
		AT89C51-24AI	44A	Industrial
		AT89C51-24JI	44J	(-40°C to 85°C)
		AT89C51-24PI	40P6	
		AT89C51-24QI	44Q	

	Package Type
	44-lead, Thin Plastic Gull Wing Quad Flatpack (TQFP)
	44-lead, Plastic J-leaded Chip Carrier (PLCC)
	40-lead, 0.600" Wide, Plastic Dual Inline Package (PDIP)
	44-lead, Plastic Gull Wing Quad Flatpack (PQFP)

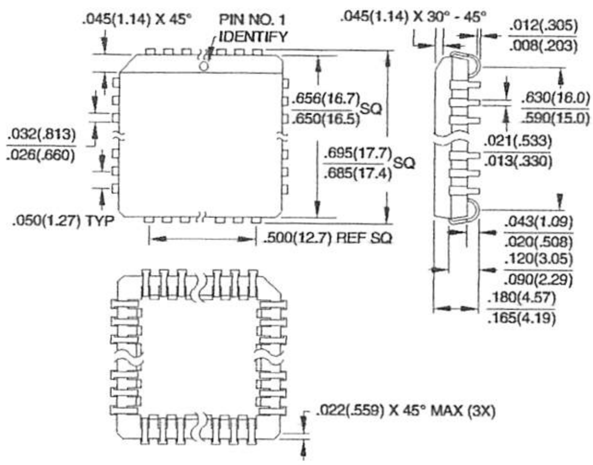
kaging Information

A, 44-lead, Thin (1.0 mm) Plastic Gull Wing Quad
atpack (TQFP)
mensions in Millimeters and (Inches)*
DEC STANDARD MS-026 ACB

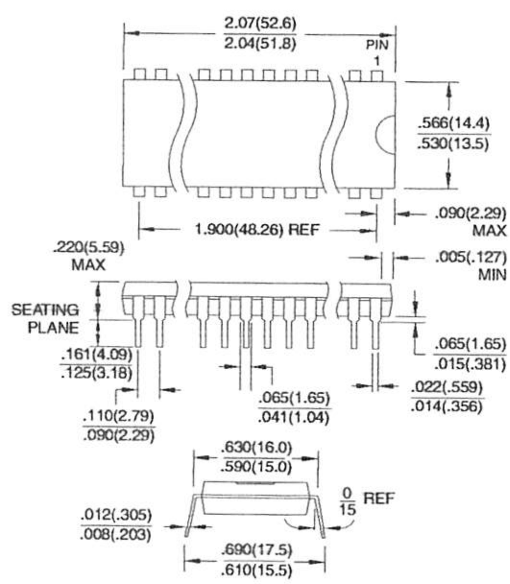


ntrolling dimension: millimeters

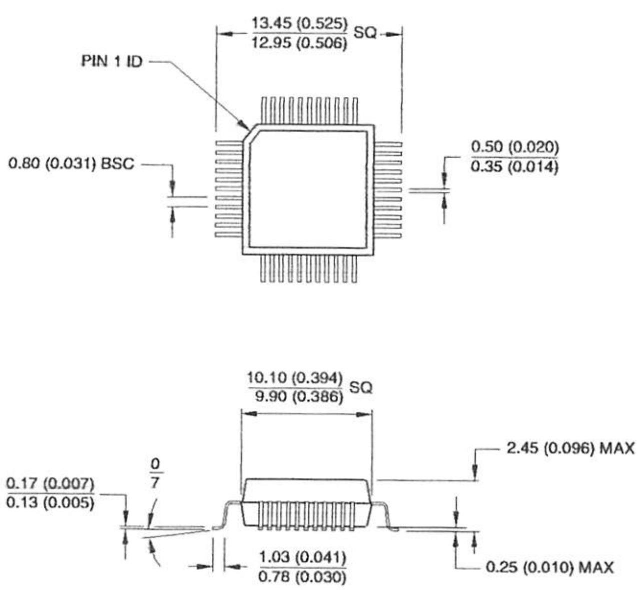
44J, 44-lead, Plastic J-leaded Chip Carrier (PLCC)
Dimensions in Inches and (Millimeters)
JEDEC STANDARD MS-018 AC



P6, 40-lead, 0.600" Wide, Plastic Dual Inline
ckage (PDIP)
nensions in Inches and (Millimeters)



44Q, 44-lead, Plastic Quad Flat Package (PQFP)
Dimensions in Millimeters and (Inches)*
JEDEC STANDARD MS-022 AB



Controlling dimension: millimeters

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'Infrared' Light-Emitting Diode Application Circuit

RIAL CONNECTION AND RALLEL CONNECTION

igure 1 shows the most basic and commonly used uits for driving light-emitting diodes.

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

igures 1(B) and 1(C) show the circuits for driving)s in serial connection and parallel connection, ectively. *In arrangement* (B), *the current flowing* ugh the LED is expressed as $I_F = (V_{CC} - V_F \times N)/R$, e in arrangement (C), the current flowing through n LED is expressed as $I_F = (V_{CC} - V_F)/R$ and the total ply current is $N \times I_F$, where N is the number of LEDs.

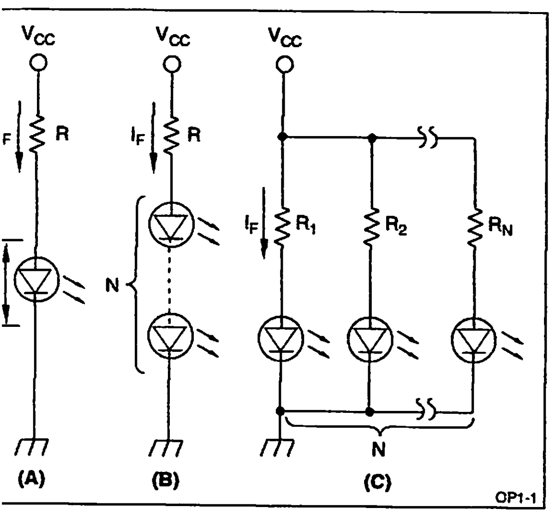


Figure 1. Driving Circuit of Light-Emitting Diode (LED)

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

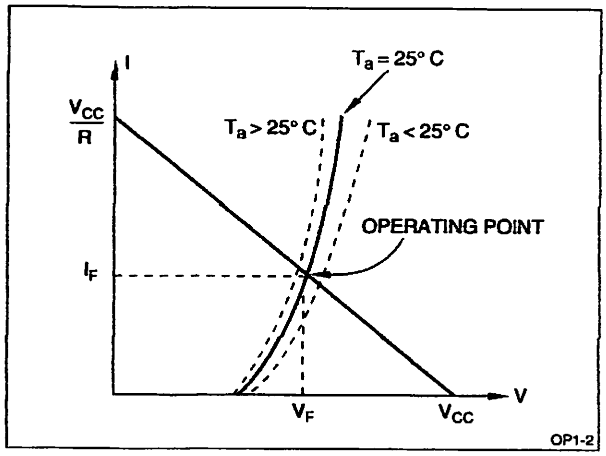


Figure 2. Current versus Voltage of Light-Emitting Diode (LED)

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.

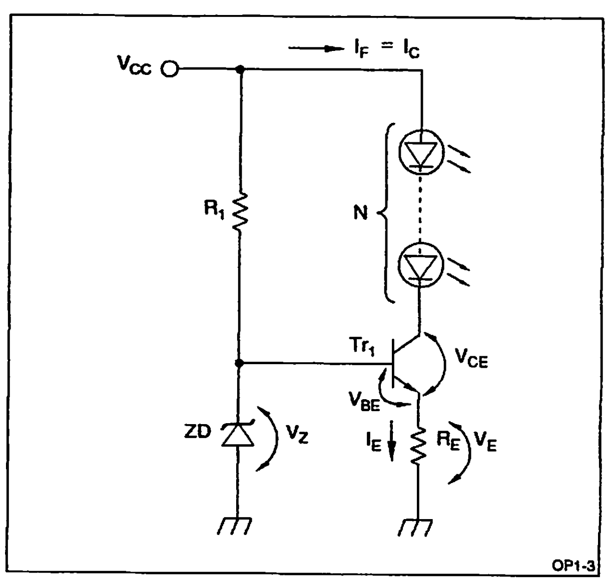


Figure 3. Constant Current Driving Circuit (1)

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

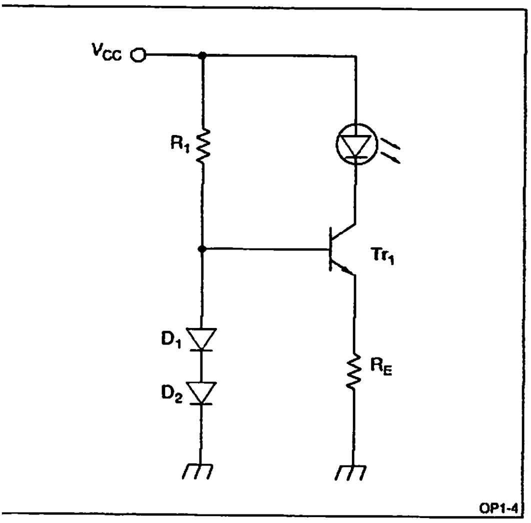
$'_{CC} - N \times V_F - V_E > V_{CE}$ (sat)

$'_E = V_Z - V_{BE}$

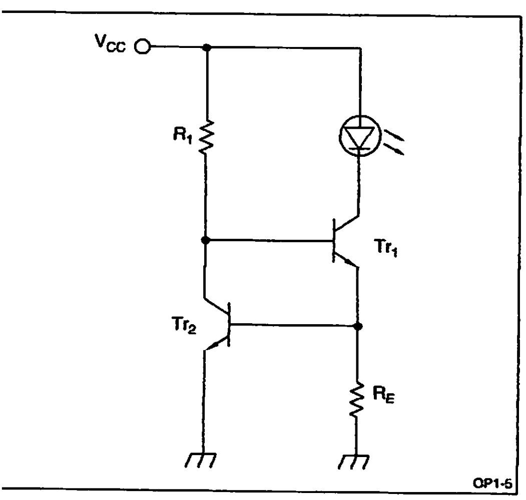
hese equations give:

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

igures 4 and 5 show other constant current driving uits that use diodes or transistors, instead of zener les.



igure 4. Constant Current Driving Circuit (2)



gure 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.

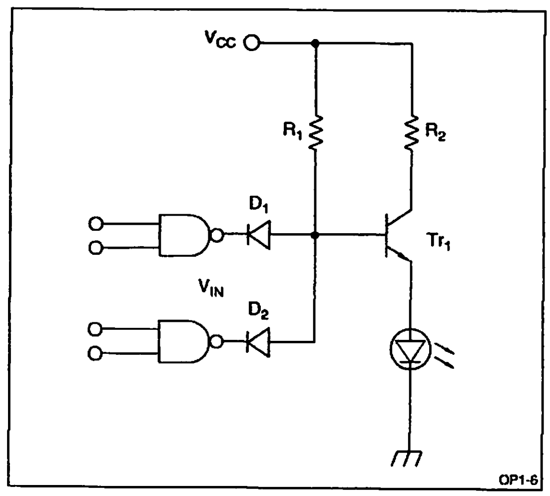


Figure 6. Connection with the TTL Logic Circuit (2)

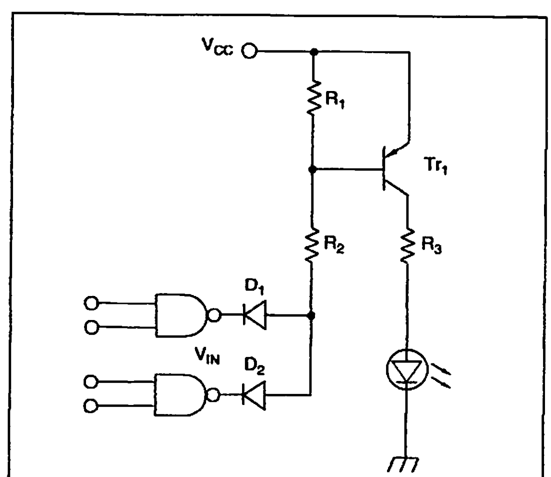
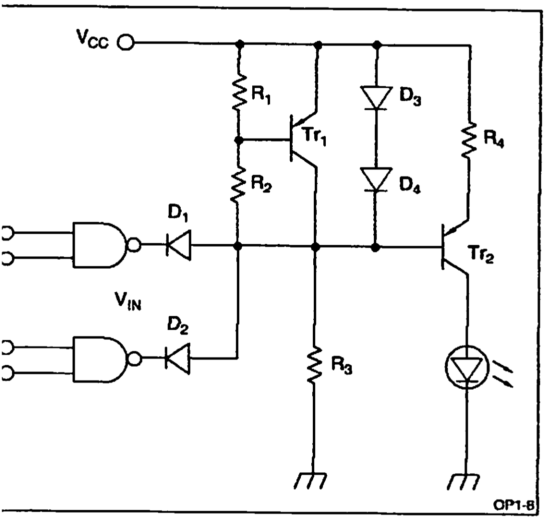


Figure 7. Connection with the TTL Logic Circuit (2)

n Figure 8, the circuit operates in the positive logic de, and current I_F is stabilized by constant current 'ing so that the radiant flux of LED is stabilized ،inst variations in the supply voltage (V_{CC}).



ɹre 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.

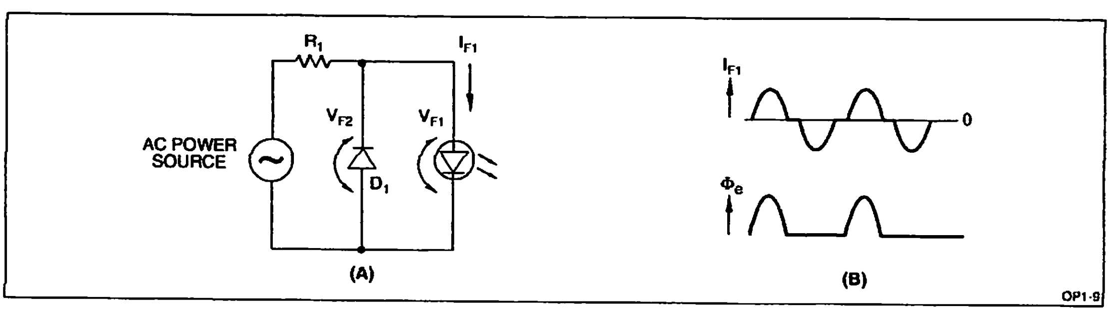


Figure 9. Driving Circuit with AC Power Source (A) and Driving Waveform (B)

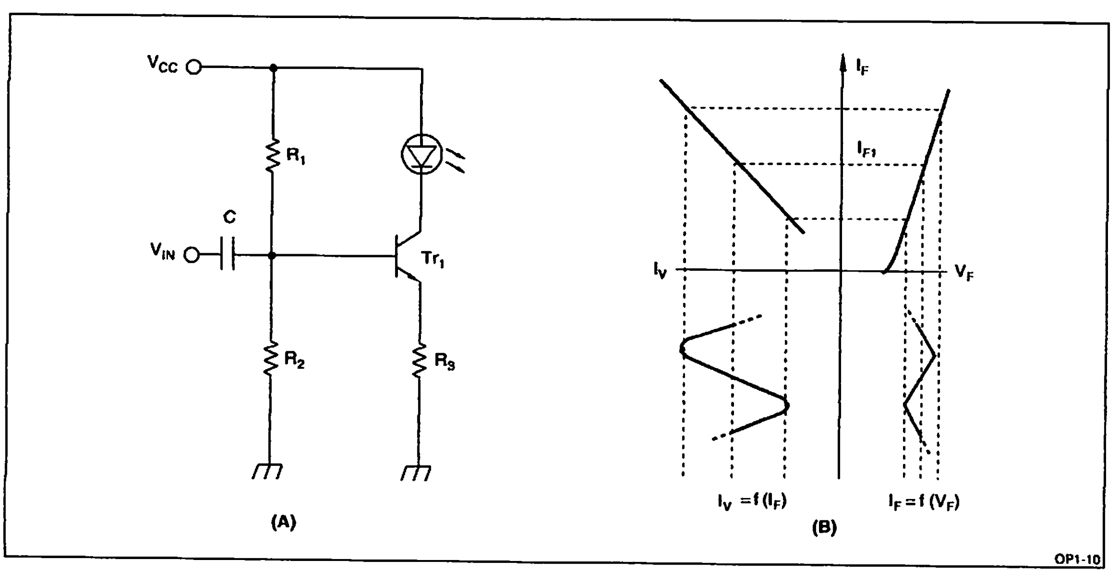


Figure 10. Modulation Driving Circuit (A) and Modulation Operation (B)

To drive an LED with a continuous modulation sig-, it is necessary to operate the LED in the linear ion of the light-emitting characteristics. In the angement of Figure 10, a fixed bias (I_{F1}) is applied the LED using R_1 and R_2 so that the maximum plitude of the modulation signal voltage (V_{IN}) lies hin the linear portion of the LED characteristics. reover, to stabilize the radiant flux of the LED, it is en by a constant current by the constant current ing circuit shown in Figure 3. The capacitor (C) d in Figure 10 (A) is a DC signal blocking capacitor.

LSE DRIVING

ED driving systems fall into three categories: DC ing system, AC driving system (including modula- systems), and pulse driving system.

atures of the Pulse Driving System

arge radiant flux

ess influence of disturbing light

nformation transmission

he radiant flux of the LED is proportional to its for- d current (I_F), but in reality a large I_F heats up the) by itself, causing the light-emitting efficiency to fall thus saturating the radiant flux. In this circum- nce, a relatively large I_F can be used with no risk of ting through the pulse drive of the LED. Conse- ntly, a large radiant flux can be obtained.

When an LED is used in the outdoors where disturb- light is intense, the DC driving system or AC driving em which superimposes an AC signal on a fixed current provides low radiant flux, making it difficult istinguish 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.

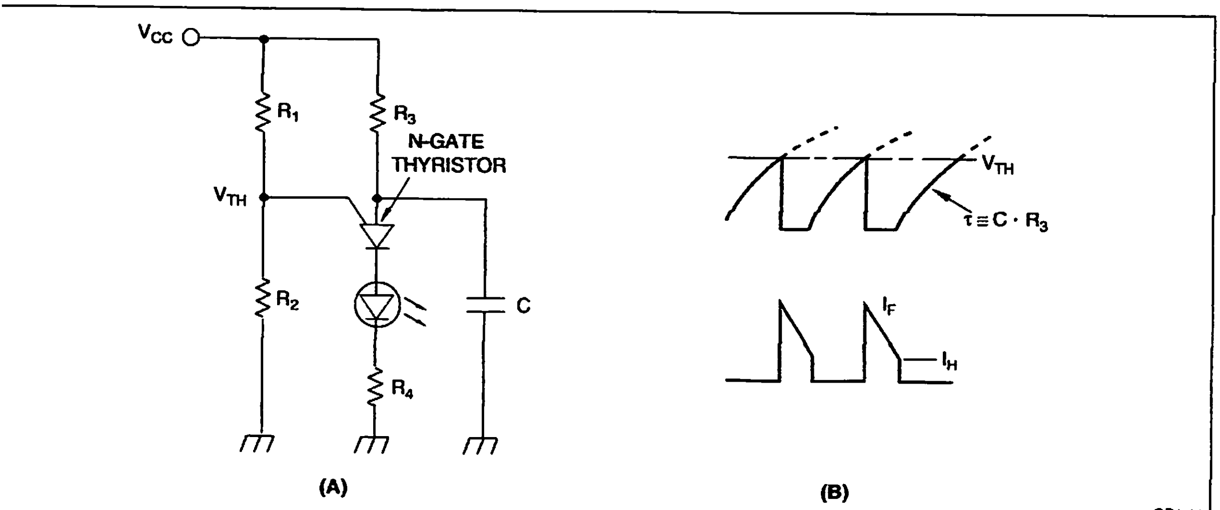


Figure 11. Pulse Driving Circuit using N-Gate Thyristor (A) and Operating Waveform (B)

The circuit shown in Figure 13 uses transistors to n an astable multi-vibrator for pulse driving an LED. 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.

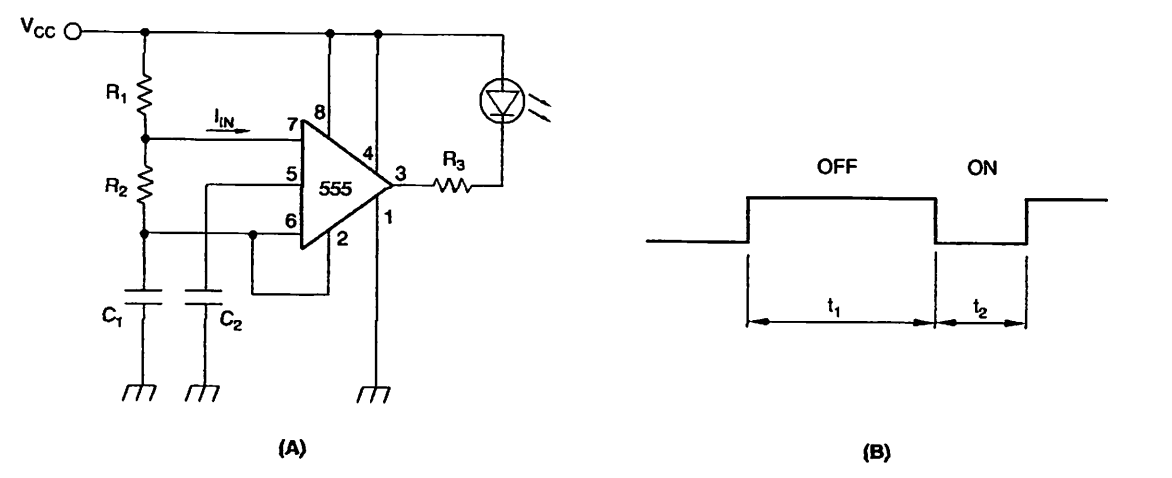


Figure 12. Pulse Driving using a 555 Timer IC (A) and Output Waveform (B)

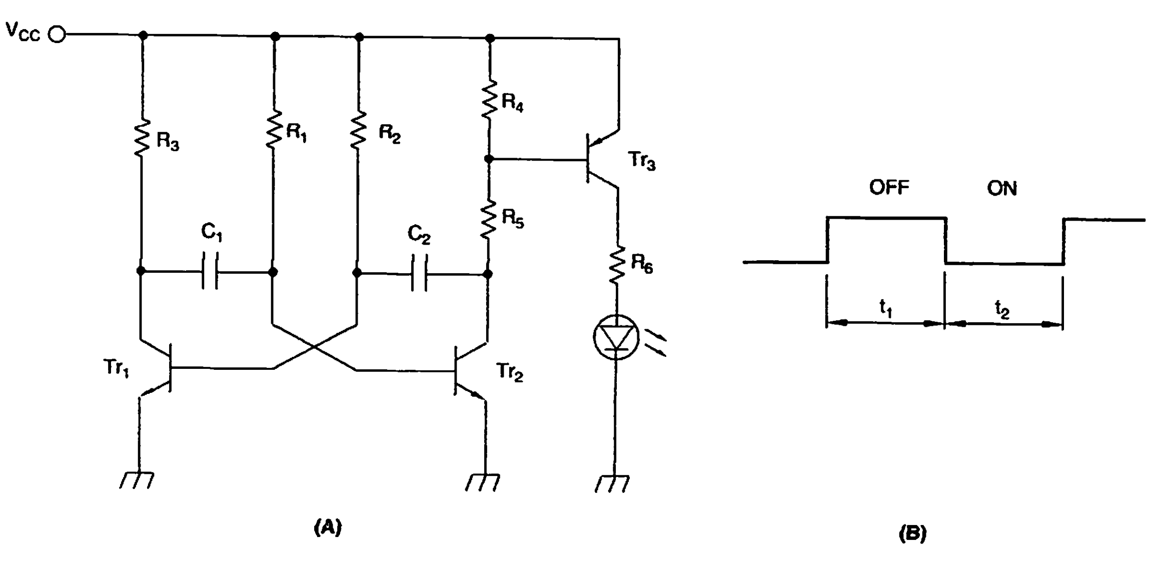


Figure 13. Pulse Driving Circuit using Astable Multi-vibrator (A) and Output Waveform (B)

‑he circuit shown in Figure 14 uses a CMOS logic IC erter) to form an oscillation circuit for pulse driving an). The pulse driving circuit using a logic IC provides latively short oscillation period with a 50% duty cycle.

‑igure 15 (A) shows an LED pulse driving circuit d 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.

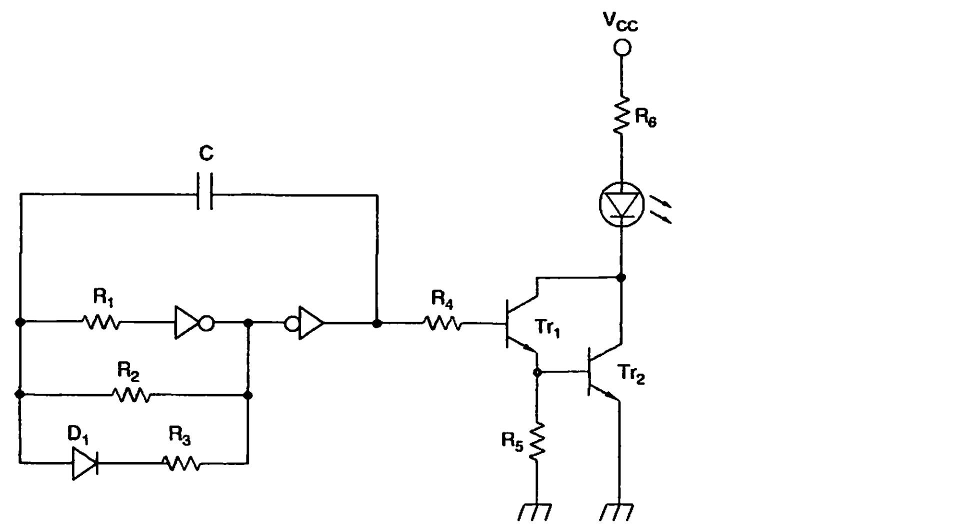


Figure 14. Pulse Driving Circuit using CMOS Logic IC

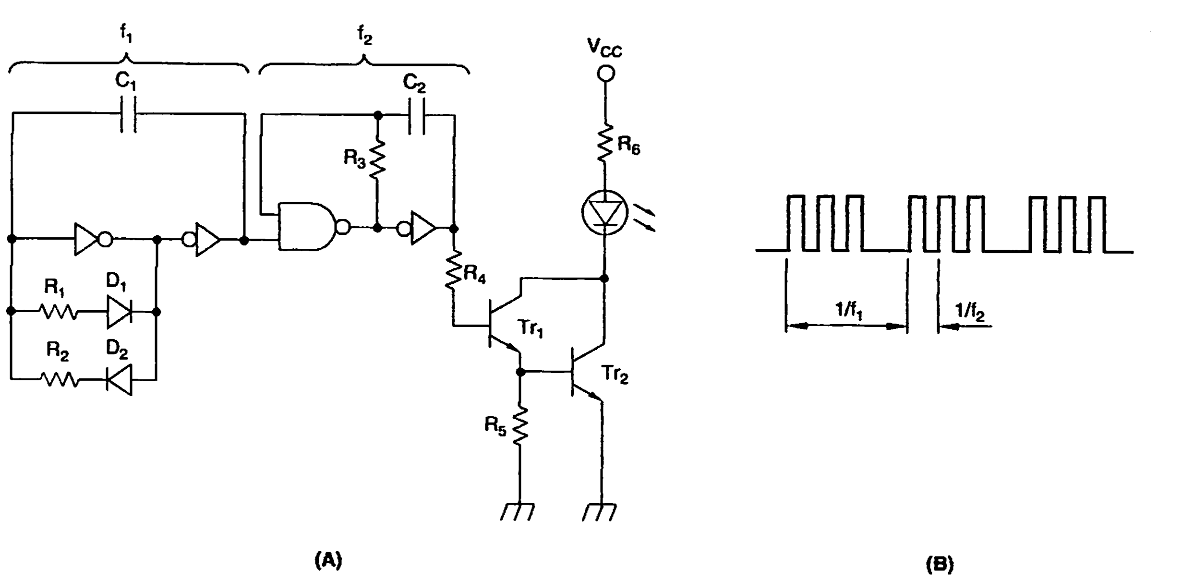


Figure 15. Pulse Driving Circuit (A) and Output Waveform (B)

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