

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



SKRIPSI

**PERANCANGAN DAN PEMBUATAN SISTEM MONITORING
SUHU DAN GAS KARBON MONOKSIDA YANG DAPAT
DIAKSES MELALUI JARINGAN KOMPUTER**

Disusun Oleh :

**I NYOMAN TRISNA ARI NADI HARTA
NIM: 03.17.081**

SEPTEMBER 2007

LEMBAR PERSETUJUAN

PERANCANGAN DAN PEMBUATAN SISTEM MONITORING SUHU UDARA DAN GAS KARBON MONOKSIDA YANG DAPAT DIAKSES MELALUI JARINGAN KOMPUTER

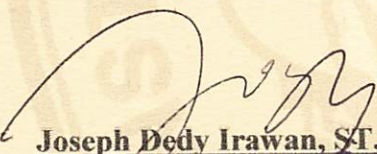
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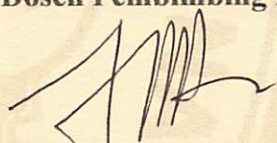
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ABSTRAKSI

PERANCANGAN DAN PEMBUATAN SISTEM MONITORING SUHU UDARA DAN GAS KARBON MONOKSIDA YANG DAPAT DIAKSES MELALUI JARINGAN KOMPUTER

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Dalam kehidupan sehari-hari peranan informasi dirasa sangat penting baik dalam kondisi apapun dan dimanapun. Pertambahan jumlah penduduk dan pertambahan jumlah kendaraan yang cukup tinggi seiring dengan tingkat pertumbuhan ekonomi nasional mengakibatkan beberapa kota besar menerima beban polusi udara yang sangat tinggi, yang tentu saja berpengaruh cukup besar pada tingkat kesehatan masyarakat di kota besar tersebut. Salah satunya adalah polusi udara dari gas karbon monoksida yang terjadi pada tempat parkir pada lantai dasar sebuah gedung, disamping itu akibat yang ditimbulkan dari gas tersebut adalah suhu udara disekitar juga mengalami peningkatan.

Dari permasalahan diperlukan suatu peralatan yang dapat digunakan sebagai pemantauan suhu udara dan gas karbon monoksida pada tempat parkir lantai dasar. Pembuatan alat tersebut dapat membantu dalam memberikan informasi pada masyarakat tentang kondisi udara pada tempat parkir di gedung lantai bawah.

Pada skripsi ini akan dibahas tentang perancangan sistem monitoring suhu udara dan gas karbon monoksida yang dapat diakses melalui jaringan komputer

sebagai pemberi informasi kepada masyarakat tentang kondisi udara pada tempat parkir di lantai dasar sebuah gedung

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BAB I

PENDAHULUAN

1.1.Latar Belakang

Seiring dengan perkembangan pembangunan, teknologi elektronika mengalami kemajuan yang begitu cepat, menyebabkan manusia tidak akan lepas dari penggunaan berbagai macam peralatan elektronika yang ada, baik itu penggunaan peralatan yang menggunakan perangkat keras maupun perangkat lunak elektronika.

Sekarang ini komputer merupakan salah satu teknologi yang paling banyak dipakai dan sudah berkembang sangat luas, banyak orang yang sudah mengenal komputer dan banyak juga peminatnya untuk berbagai macam keperluan

Dalam kehidupan sehari-hari peranan informasi dirasa sangat penting baik dalam kondisi apapun dan dimanapun. Pertambahan jumlah penduduk dan pertambahan jumlah kendaraan yang cukup tinggi seiring dengan tingkat pertumbuhan ekonomi nasional mengakibatkan beberapa kota besar menerima beban polusi udara yang sangat tinggi, yang tentu saja berpengaruh cukup besar pada tingkat kesehatan masyarakat di kota besar tersebut. Salah satunya adalah polusi udara dari gas karbon monoksida yang terjadi pada tempat parkir pada lantai dasar sebuah gedung, disamping itu akibat yang ditimbulkan dari gas tersebut adalah suhu udara disekitar juga mengalami peningkatan.

Dari permasalahan diperlukan suatu peralatan yang dapat digunakan sebagai pemonitoring suhu udara dan gas karbon monoksida pada tempat parkir lantai dasar. Pembuatan alat tersebut dapat membantu sekali dalam memberikan informasi pada masyarakat tentang kondisi udara pada tempat parkir gedung lantai bawah.

1.2.Rumusan Masalah

Berkaitan dengan latar belakang yang telah diuraikan diatas maka untuk membuat suatu system monitoring suhu udara dan kadar gas karbon monoksida yang dapat diakses melalui jaringan komputer dapat dirumuskan sebagai berikut:

1. Bagaimana sensor bekerja untuk memonitor suhu udara dan gas karbon monoksida sesuai yang diharapkan.
2. Bagaimana cara memonitor suhu udara dan gas karbon monoksida kemudian mengolah data sehingga dapat dilihat pada komputer melalui jaringan komputer.

1.3.Batasan Masalah.

Dalam perancangan dan pembuatan sistem monitoring suhu udara dan kadar gas karbon monoksida yang dapat diakses melalui jaringan komputer maka perlu dilakukan pembatasan masalah diantaranya:

1. Suhu udara dan gas karbon monoksida di udara akan ditampilkan melalui komputer.

2. Pengolah data keadaan suhu udara dan gas karbon monoksida di udara menggunakan Mikrokontroler AT89S51.
3. Sensor yang digunakan adalah LM 35 untuk sensor suhu dan AF-30 untuk sensor CO.
4. Alat yang dirancang dan dibuat dalam bentuk simulasi.

1.4.Tujuan

Tujuan dari penulisan ini adalah untuk merancang sistem untuk memonitor suhu udara dan gas karbon monoksida yang dapat diakses melalui jaringan komputer.

1.5.Metodelogi Penelitian.

Dalam penyusunan tugas akhir ini yang dilaksanakan adalah bersifat terapan, langkah-langkah yang perlu dikerjakan untuk merealisasikan sistem yang dirancang adalah:

1. Studi pustaka.

Studi pustaka digunakan untuk mendapatkan dasar-dasar teori yang digunakan dalam perencanaan.

2. Tahap perancangan perangkat keras dan perangkat lunak.

Dalam perancangan perangkat keras menggunakan LM35 sebagai sensor suhu, AF-30 untuk sensor gas karbon monoksida.

3. Pengujian sistem

Sistem tersebut digunakan untuk memonitor suhu udara dan gas karbon monoksida di udara pada suatu tempat.

4. Penulisan laporan.

Analisa data dan pembahasan serta kesimpulan.

1.6.Sistematika Penulisan.

Sistematika dari penulisan dari tugas akhir ini adalah sebagai berikut:

1. BAB I. PENDAHULUAN.

Membahas tentang latar belakang, rumusan masalah, tujuan, batasan masalah, metodologi perencanaan, sistematika penulisan.

2. BAB II DASAR TEORI.

Membahas teori serta pustaka yang relevan dan menunjang perencanaan dan pembuatan rangkaian yang digunakan. Diantaranyab berisi penjelasan tentang sensor yang digunakan yaitu sensor LM35 sebagai sensor suhu, sensor AF56 sebagai sensor karbon monoksida, teori dasar gas karbon monoksida dan teori dasar mikrokontroler serta teori dasar tentang Borland Delphi.

3. BAB III PERENCANAAN DAN PEMBUATAN ALAT.

Membahas perancangan dan pembuatan perangkat keras dan perangkat lunak dari alat.

4. BAB IV PENGUJIAN ALAT.

Membahas tentang pengujian-pengujian terhadap system-sitem yang telah dibuat.

5. PENUTUP.

Merupakan bagian bagian penutup yang berisi kesimpulan dan saran yang bermanfaat bagi pengembangan lebih lanjut.

BAB II

LANDASAN TEORI

2.1. Pendahuluan

Untuk memahami alat yang akan dirancang ini maka dalam bab II ini dijelaskan mengenai teori dasar yang berkaitan dengan sistem ini, diantaranya meliputi, teori tentang karbon monoksida, sensor-sensor yang digunakan, Mikrokontroler AT89S51, Analog to Digital Converter (ADC) serta komponen-komponen pendukungnya.

2.2. Karbon monoksida (CO)

Karbon monoksida adalah suatu komponen yang tidak berbau dan tidak berwarna dan tidak mempunyai rasa yang terdapat dalam gas pada suhu diatas 192C. Komponen yang mempunyai berat sebesar 96.5% dari berat air dan tidak larut dalam air. Karbon monoksida terbentuk melalui pembakaran yang kurang sempurna. Oksidasi tidak lengkap pada karbon atau komponen yang mengandung karbon terjadi jika jumlah oksigen yang tersedia kurang dari jumlah yang dibutuhkan untuk pembakaran sempurna dimana dihasilkan karbon dioksida. Pembentukan karbon monoksida hanya terjadi jika reaktan yang ada terdiri atas karbon dan oksigen murni. Jika yang terjadi adalah pembakaran komponen yang mengandung karbon di udara, prosesnya lebih kompleks dan terdiri dari beberapa tahap reaksi. Reaksi ini sering terjadi pada suhu tinggi yang umumnya terdapat pada industri.

Pada umumnya konsentrasi karbon monoksida di udara kurang dari 110 ppm. Jika terjadi kontak antara manusia dengan karbon monoksida pada konsentrasi tinggi dapat mengakibatkan kematian, sedangkan pada konsentrasi yang relatif rendah(110 ppm atau kurang) dapat mengganggu kesehatan. Faktor yang penting yang memnentukan pengaruh karbon monoksida terhadap manusia adalah konsentrasi COHb yang terdapat dalam darah, dimana semakin tinggi prosentase hemoglobin yang terikat dalam bentuk COHb maka semakin buruk pengaruhnya terhadap kesehatan manusia. Hubungan antara konsentrasi COHb didalam darah dan pengaruhnya terhadap kesehatan dapat dilihat pada table dibawah ini:

Tabel 2.1

Pengaruh konsentrasi COHb di dalam darah terhadap Manusia

Jumlah COHb dalam darah (%)	Gejala-gejala (akibat yang ditimbulkan)
0-10	Tidak ada gejala (normal)
10-20	Sedikit sakit kepala, pengembangan pembuluh-pembuluh darah kulit
20-30	Sakit kepala menghentak-hentak dipelipis, mudah terangsang, emosi labil,cepat letih.
30-40	Sakit kepala hebat, badan lemas, pandangan kabur, mual muntah dan mudah jatuh

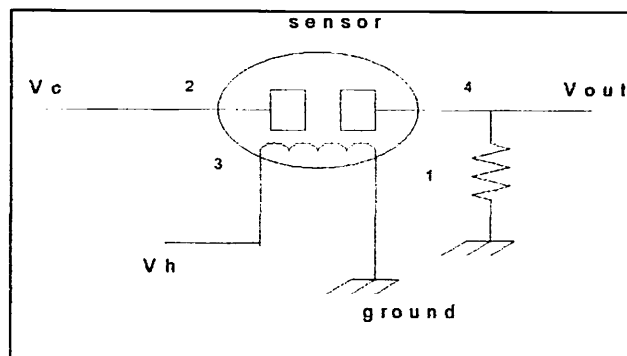
40-50	Sakit kepala hebat, badan lemas pandangan kabur, mual muntah dan mudah jatuh, pingsan, denyut nadi dan pernapasan bertambah
50-60	Sinkope, pernapasan dan denyut nadi bertambah, koma dengan sebentar kejang-kejang
60-70	Koma dengan kejang-kejang, kerja jantung dan pernapasan tertekan dan bias mati
70-80	Denyut jantung sangat lemah, pernapasan lambat kegagalan pernapasan dan menyebabkan kematian

(sumber: Bina cipta, Ilmu kesehatan masyarakat).

2.3. Sensor karbon monoksida(CO) AF 30

Sensor gas karbon monoksida yang digunakan adalah sensor gas AF 30 seri (Scemarec) yang terbuat dari bahan semikonduktor yang memiliki kinerja, kualitas dan ketahanan jangka panjang. Elemen yang semikonduktor yang mendeteksi gas dipanaskan pada salah satu sisi bahan keramik, selanjutnya ditutup dengan keramik film untuk melindungi terhadap debu. Sebuah mikro heater dipasang pada bagian belakang lapisan, dengan demikian cepat memanaskan elemen pendeteksi gas pada suhu operasi yang diinginkan. Elemen yang merasakan gas adalah suatu semikonduktor oksida yang dipanaskan sampai 350C. Jika berhadapan dengan gas yang sesuai, oksigen

dipermukaan akan diserap untuk digunakan dan tahanan elektriknya menurun. Penurunan tahanan ini mengikuti pola yang dapat diprediksi dan berulang-ulang. Dimana keluaran sensor tersebut adalah berupa selisih tegangan, yaitu saat sensor dipengaruhi oleh gas karbon monoksida tegangan tersebut akan naik sesuai dengan banyaknya gas karbon monoksida yang diterima oleh sensor. Sensor karbon monoksida yang digunakan adalah sensor gas tipe AF30 yang merupakan sensor yang dapat bekerja pada temperature -10 Celcius sampai 55 Celcius serta tegangan kerja pada rangkaian berupa DC sebesar 5V dan tegangan kerja untuk pemanas berupa tegangan DC sebesar 5V dengan bias lebih kurang 0.2V



Gambar 2.1.Sensor gas

Sumber: DataSheet sensor AF30

Struktur sensor gas karbon monoksida ini memiliki 4 kaki dimana 3 kaki dan 1 kaki berfungsi sebagai heater sedangkan 2 kaki dan 4 kaki berfungsi sebagai sensor karbon monoksida. Sensor gas ini dirancang untuk

beroperasi dengan tegangan 5V. Ketika sensor mendeteksi gas, tahanan sensor akan menurun.

Sensitivitas rasio (R_{gas}/R_{udara}) dari sensor gas yang diperoleh dalam udara yang berisi gas untuk tahanan sensor yang diperoleh di udara bersih tanpa pencemaran gas> Sedangkan daya sensor (P_s) yang dibutuhkan saat bekerja adalah $P_s \leq 15mV$

Dari gambar diatas dapat diketahui bahwa tahanan sensor (R_s) dapat dihitung dari tegangan output (V_o) dengan menggunakan rumus sebagai berikut:

$$R_s = \frac{V_c - V_{out}}{V_{out}} R_l$$
$$P_s = \frac{V_c^2 - R_s}{(R_s + R_l)}$$

Sedangkan P_s adalah daya sensor pada saat bekerja.

2.4. Sensor Suhu (LM 35)

Seri LM35 adalah sensor temperature atau suhu yang sangat presisi, itu dapat dilihat dari tegangan output yang mempunyai kelinieran yang sesuai yaitu dapat dinyatakan langsung dalam derajat celcius. LM35 mempunyai keuntungan yaitu lebih linier bila dikalibrasi ke Kelvin, untuk memperoleh skala celcius tidak perlu mengurangi tegangan konstan dari output. Untuk pengkalibrasian tidak memerlukan kalibrasi eksternal atau penyesuaian terhadap tipikal akurasi yaitu pada $\pm 0.25C$ untuk temperature ruang dan

0.75C untuk temperature yang lebih tinggi, range temperature antara -55 sampai +150C. Seri LM35 mempunyai impedansi output yang rendah, output yang liner dan ketepatan kalibrasi yang merupakan kelebihan dari LM35 yang membuat penginterfacean untuk pembacaan keluar atau control rangkaian sangat mudah. LM35 juga dapat digunakan dengan menggunakan power supply tunggal yaitu maksudnya supply tegangan plus atau minus. Selain itu membawa 60uA dari supplynya, itu membuat self heatingnya sangat rendah, lebih kecil dari 0.1C pada udara konstan.



Gambar 2.2. Sensor LM 35

Sumber: Datasheet sensor LM35

2.5. Mikrokontroler AT89S51

Mikrokontroler AT89S51 adalah mikrokontroler ATMEL yang kompetibel penuh dengan mikrokontroler keluarga MCS-51, membutuhkan daya yang rendah, memiliki performance yang tinggi dan merupakan mikrokomputer 8 bit yang dilengkapi 4Kbyte EEPROM (Elektrikal Erasable and Programable Read Only Memory) dan 128 Byte RAM internal. Program

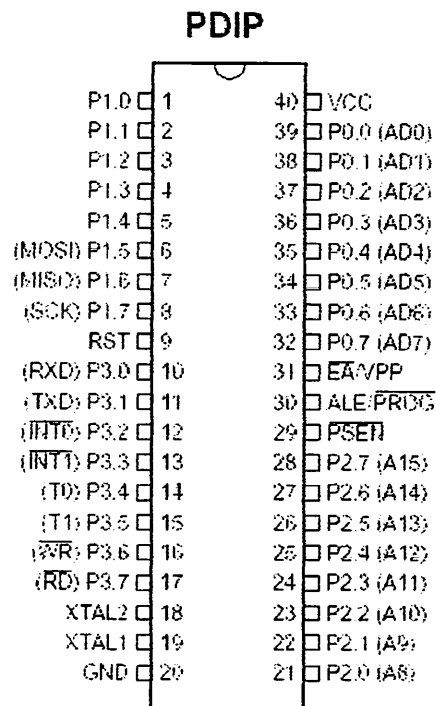
memori yang dapat diprogram ulang dalam system atau menggunakan programmer Nonvolatile Memory konvensional.

2.5.1. Arsitektur Perangkat keras

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

Secara umum mikrokontroler AT89S51 memiliki:

- CPU 8 bit termasuk keluarga MCS-51
- 4 Kb flash memory
- 128 byte internal RAM
- 32 buah port I/o, tersusun atas P0-P3, masing-masing 8 bit.
- 2 timer/ counter 16 bit
- 2 serial port full duplex
- Kecepatan pelaksanaan intruksi persiklus 1 us pada frekuensi clock 12 Mhz
- 2 DPTR (data pointer)
- Watchdog timer
- Fleksible ISP programming



Gambar 2.3

Pin – Pin AT89S51

Sumber : *Datasheet ATMEL AT89S51*

Berikut ini adalah penjelasan dari masing-masing pin mikrokontroler AT89S51:

- Pin 1 sampai 8

Port 1: merupakan 8 bit saluran masukan atau keluaran dua arah, setiap saluran mampu melayani 4 masukan.

- Pin 9

RST : merupakan masukan reset. Logika high yang akan membuat mikrokontroler AT89S51 menjalankan rutin reset.

- Pin 10 sampai 17

Port 3 terdiri dari 8 saluran masukan atau keluaran dua arah. Setiap saluran mampu melayani 4 masukan. Selain sebagai port masukan atau keluaran, port 3 juga mempunyai fungsi-fungsi khusus yang dimiliki keluarga MCS-51

- Pin 18 dan 19

X1 (XTAL1) X2 (XTAL2) : jika dikonfigurasi bersama sebuah kristal akan membentuk rangkaian oscillator on-chip pada mikrokontroler.

- Pin 20 sampai 27

Port 2 terdiri dari 8 saluran atau masukan dua arah. Setiap saluran mampu melayani 4 masukan. Port 2 mengeluarkan alamat bagian high (A8-A15), selama pengambilan instruksi dari memori program eksternal dan pengambilan data dari memori data eksternal yang menggunakan mode pengalamatan 16 bit

- Pin 29

PSEN: Program Store Enable merupakan sinyal baca yang mengeksekusi memori program eksternal.

- Pin 30

ALE/PROG: Address Latch Enable merupakan pulsa yang berfungsi menahan alamat rendah (A0-A7) pada port 0, selama dilakukan proses baca dan tulis memori eksternal. Pin ini juga berfungsi sebagai masukan

pulsa program(PROG), selama dilakukan pemograman EEPROM eksternal.

- Pin 31

EA/VP: eksternal acces. EA dihubungkan dengan Vss untuk memungkinkan pengambilan intruksi pada memori program eksternal yang berlokasi 0000h sampai FFFFh. Jika diinginkan menggunakan program internal, maka EA dihubungkan Vcc.

- Pin 32 sampai 39

Port 0 terdiri dari 8 saluran masukan atau keluaran dua arah. Setiap saluran mampu melayani 8 masukan. Port 0 merupakan saluran alamat bagian low (A0-A7), yang multipleks dengan saluran bus data(D0-D7), yang digunakan pada saat mengakses memori data eksternal dan memori program eksternal.

- Pin 40

Vcc merupakan masukan catu daya 5 volt, dengan toleransi kurang lebih 10us.

2.5.2. Organisasi Memori

Organisasi memori pada mikrikontroler AT89S51 dapat dibagi menjadi dua bagian besar yaitu memori program dan memori data. Pembagian tersebut didasarkan atas dari penyimpanan data atau program. Memori program digunakan menyimpan intruksi-intruksi yang akan dijalankan oleh mikrokontroler, sedangkan memori data digunakan sebagai tempat penyimpanan data yang sedang diolah mikrokontroler.

Program mikrokontroler disimpan dalam memori program berupa ROM. Mikrokontroler AT89S51 dilengkapi dengan ROM internal namun untuk program yang besar digunakan ROM eksternal yang terpisah dari mikrokontroler. Untuk dapat menggunakan memori program eksternal ini penyemat? EA dihubungkan dengan penyemat Vss (logika 0).

Memori program mikrokontroler menggunakan alamat 16 bit mulai dar 0000h-FFFFh, sehingga kapasitas penyimpanan program maksimal adalah $2(16)$ byte atau 64 Kb. Sinyal yang digunakan untuk membaca memori program eksternal adalah sinyal PSEN

Selain memori program mikrokontroler AT89S51 juga memiliki data internal berkapasitas 128 byte dan mampu mengakses memori data eksternal sebesar 64 Kb. Semua data internal dapat dialamati dengan pengalamatan langsung atau tidak langsung. Ciri dari

pengalamatan langsung adalah operand berisi alamat data yang diolah. Sedangkan ciri dari pengalamatan tidak langsung operand alamat register yang berisi alamat data yang akan diolah. Sebagian memori tersebut dapat dialamati dengan pengalamatan register, dan sebagian lagi dapat dialamati dengan memori satu bit. Untuk membaca data digunakan sinyal /RD, sedangkan untuk menulis data digunakan sinyal /WR.

2.5.3. Register fungsi Khusus.

Register Fungsi Khusus terletak pada 64 byte bagian atas memori data internal dan berisi register-register untuk pelayanan latch port, program status word, control peripheral, dan sebagainya. Alamat register fungsi khusus ditunjukkan pada table:

Register-register ini hanya dapat diakses dengan pengalamatan langsung. Enam belas alamat pada register fungsi khusus dapat dialamati per bit maupun per byte yang terletak pada alamat 80h-FFh. Secara perangkat keras, register fungsi khusus ini dibedakan dengan memori data internal.

Tabel 2.2

Nama dan alamat register pada register fungsi khusus

SIMBOL	NAMA REGISTER	Nilai pada saat reset	Alamat
ACC	Accumulator	0000H	0E0H
B	Register B	00H	0F0H
PSW	Program status word	00H	0D0H
SP	Stack pointer	07H	81H
DPTR	Data pointer 2 byte		
DPL	Low byte	0000H	82H
PH	High byte	0000H	83H
P0	Port 0	FFH	80H
P1	Port 1	FFH	90H
P2	Port 2	FFH	0A0H
P3	port 3	FF H	0B0H
IP	Interupt priority control	XXX00000B	0B8H
IE	Interupt enable control	0XX00000B	0A8H
TMOD	Timer/ counter mode control	00H	89H
TCON	Timer/counter control	00H	88H
TH0	Timer/counter 0 highbyte	00H	8CH
TL0	Timer/counter 0 low byte	00H	8AH
TH1	Timer/ counter 1 high byte	00H	8DH
TL1	Timer/ counter 1 low byte	00H	8BH
SCON	Serial control	INDEPENDEN	9BH
SBUF	Serial data buffer	HMOS0XXXXXXXXXB	99H
PCON	Power control	CHMOS0XXX0000B	87H

Sumber : *Datasheet ATMEL AT89S51*

Beberapa macam register fungsi khusus yang sering digunakan dijelaskan sebagai berikut:

- Accumulator (ACC) merupakan register untuk penambahan dan pengurangan. Perintah mnemonic untuk mengakses akumulator disederhanakan sebagai A.
- Register B merupakan register khusus yang berfungsi melayani operasi perkalian dan pembagian.
- Program status word (PSW) terdiri dari beberapa status yang menggambarkan kejadian di akumulator sebelumnya, yaitu carry bit, auxiliary carry, dua bit pemilih bank, bendera over flow, parity bit dan dua bendera yang dapat didefinisikan oleh pemakai.
- Stack pointer(SP) merupakan register 8 bit yang dapat diletakkan di alamat manapun pada RAM internal. Isi register ini ditambah sebelum data disimpan, selama instruksi CALL dan PUSH. Pada saat reset, register SP diinisialisasikan pada alamat 07h sehingga stack akan dimulai pada lokasi 08h.
- Data pointer (DPTR) terdiri dari dua register yaitu byte tinggi (data pointer high, DPH) dan byte rendah (data pointer low, DPL) yang berfungsi untuk mencari alamat 16 bit.
- Port 0 sampai port 3 merupakan register yang berfungsi untuk membaca dan mengeluarkan data pada port 0, 1, 2, 3 masing-masing register ini dapat dialamati per byte maupun per bit.

- Serial data buffer (SBUF) merupakan dua register yang terpisah, register buffer pengirim dan register penerima. Meletakkan data pada SBUF berarti meletakkan pada buffer pengirim yang akan mengirimkan data melalui transmisi sinyal. Membaca data SBUF berarti menerima data dari buffer penerima.
- Control Register terdiri dari register yang mempunyai fungsi control. Untuk mengontrol sistem intrupsi, terdapat dua register khusus yaitu register IP (interup priority) dan register IE (interup enable). Untuk mengontrol pelayanan timer counter terdapat register khusus, yaitu register TCON serta untuk pelayanan port serial menggunakan register SCON (Serial port control).

2.5.4. Port masukan dan port keluaran.

Mikrokontroler AT89S51 mempunyai 4 port dan masing-masing port terdiri dari 8 saluran bit. Ke empat port ini bersifat bidirectional yaitu dapat digunakan sebagai masukan dan keluaran.

Port 0 digunakan sebagai saluran data yang dimultipleks dengan saluran alamat yang rendah untuk mengakses memori eksternal, baik memori program atau memori data. Port 2 mengeluarkan bagian alamat high untuk mode pengalamatan memori 16 bit. Port 1 dan 3 berfungsi sebagai saluran masukan dan keluaran

multifungsi. Jika dibutuhkan port 3 mempunyai fungsi khusus seperti di tunjuk pada table berikut:

Tabel 2.3
Fungsi khusus port 3

Nama penyemat	Fungsi Khusus
Port 3.0	RxD (port masukan serial)
Port 3.1	TxD (port keluaran serial)
Port 3.2	/INT0 (masukan interupsi eksternal
Port 3.3	/INT1 (masukan interupsi)
Port 3.4	T0 (masukan pewaktu eksternal 0)
Port 3.5	T1 (masukan pewaktu eksternal 1)
Port 3.6	/WR (sinyal tulis memori data eksternal)
Port 3.7	/RD (sinyal baca memori data eksternal)

Sumber : Datasheet ATMEL AT89S51

2.5.5 Sistem interupsi

Mikrokontroler At89S51 mempunyai dua sumber interupsi eksternal dan sumber interupsi internal yang dapat diprogram agar sensitive terhadap perubahan level atau transisi. Interupsi timer aktif saat register timer yang bersangkutan mengalami rollover. Interupsi

serial akan aktif pada saat mikrokontroler mengirim/ menerima data. Setiap sumber interupsi dapat diaktifkan/ dimatikan melalui perangkat lunak.

Tabel 2.4
Tingkatan prioritas interupsi

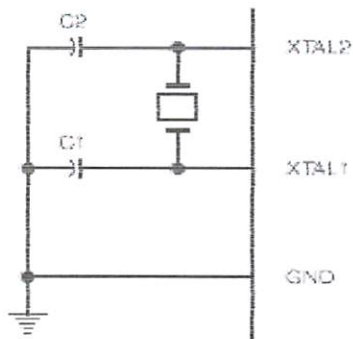
Prioritas interupsi	Sumber interupsi	Alamat vektor
1	IE0 (interupsi eksternal 0)	0003h
2	TF 0 (timer overflow)	000Bh
3	IE1 (interupsi eksternal 1)	0013h
4	TF1 (timer overflow flag 1)	001Bh
5	R1 dan T1	0023h
6	TF2 dan EXF2	002Bh

Sumber : *Datasheet ATMEL AT89S51*

Hirarki tingkatan prioritas interupsi dapat dilihat dalam table diatas. Interupsi yang mempunyai tingkat prioritas lebih tinggi tidak dapat diinterupsi oleh yang lebih rendah. Meskipun demikian melalui perangkat

- **Clock**

Kecepatan proses yang dilakukan oleh mikrokontroler ditentukan oleh sumber clock (pewaktuan) yang mengendalikan mikrokontroler tersebut. Sistem yang dirancang ini akan menggunakan osilator internal yang sudah tersedia di dalam chip AT89S51. Untuk menentukan frekuensi osilatornya, cukup dengan cara menghubungkan kristal pada pin XTAL1 dan XTAL2 serta dua buah kapasitor ke ground. Kristal dengan frekuensi 11,0592 Mhz serta dua buah kapasitor 30pF (sesuai dengan datasheet AT89S51) digunakan untuk menggerakkan osilator internal



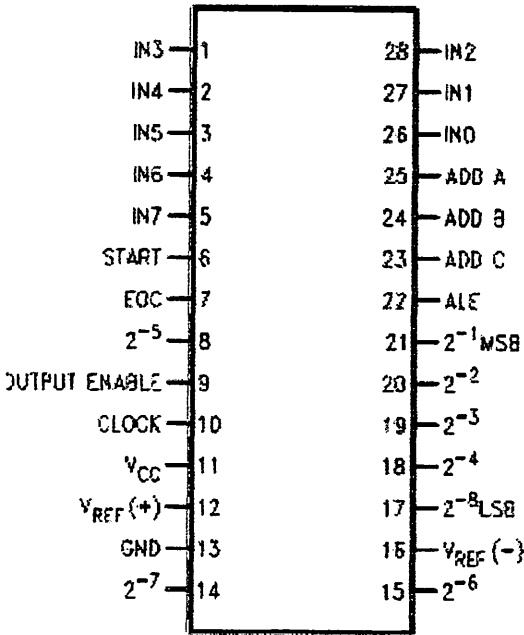
Gambar 2.5

Rangkaian Pewaktuan dengan Osilator Internal

Sumber : www.atmel.com

2.6. Analog to Digital Converter (ADC) 0808

ADC 0808 adalah IC pengubah tegangan analog menjadi digital dengan masukan berupa 8 kanal input yang dapat dipilih. ADC 0808 mempunyai resolusi 8 bit dan dapat menerima 8 inputan serta menggunakan clock eksternal. IC ADC 0808 dapat melakukan proses konversi secara terkontrol ataupun free running.



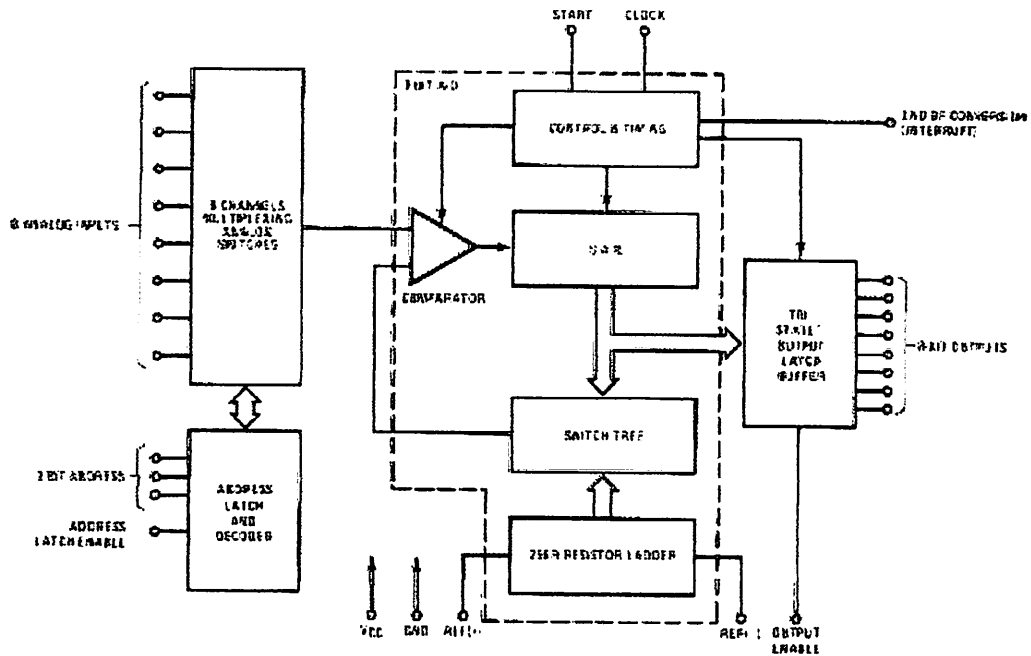
Gambar 2.6

Pin-pin ADC 0808

(sumber: i data sheet National Semiconductor)

ADC ini mempunyai ketelitian sebesar 1 bit LSB, untuk ketelitian yang lebih akurat $\frac{1}{2}$ bit LSB. ADC0808 melakukan konversi tegangan analog

ke digital dengan menggunakan metode SAR (successive approximation register) dengan resolusi 8 bit dan waktu konversi 100 μ S.



Gambar 2.7

Blok Diagram ADC 0808

(sumber data sheet National Semiconductor)

Seperti yang terlihat pada gambar 2.5, ADC ini mempunyai 8 kanal saklar analog multipleks yang diatur oleh *Address Latch and Decoder* di mana multiplexer ini akan meneruskan sinyal analog tersebut ke bagian konversi tegangan. Pada mode terkontrol, proses konversi dilakukan setelah perintah start yaitu logika 1 pada kaki START diberikan. Kecepatan konversi tergantung dari frekwensi clock yang diberikan oleh rangkaian eksternal. Sedangkan hasil konversi dikirimkan ke Tri State Output Latch Buffer yang

kompatibel dengan level TTL, yaitu sebuah buffer penahan yang bersifat tiga tingkat di mana tingkat pertama terjadi pada saat data hasil konversi masuk ke input dari bagian ini. Tingkat kedua saat data tersebut di latch (terjadi secara otomatis dalam IC ini setiap kali konversi) ke dalam buffer internalnya dan tingkat ketiga saat sinyal OE yang berlogika 1 diberikan ke kaki OE IC ini sehingga data yang ada dalam buffer internal dikirim ke bagian output (D0...D7). Selama kaki OE masih berlogika 0 maka jalur output (D0...D7) bersifat *high impedance* (impedansi tinggi) sehingga pada suatu sistem yang kompleks, jalur ini masih dapat digunakan oleh komponen lain yang mempunyai kemampuan akses dengan menggunakan sistem bus

Pemilihan Kanal Input ADC0808

ADC0808 mempunyai 8 buah kanal input yang diatur oleh kaki A0, A1 dan A2 sesuai dengan tabel berikut:

Tabel 2.5
Pemilihan Input ADC 0808

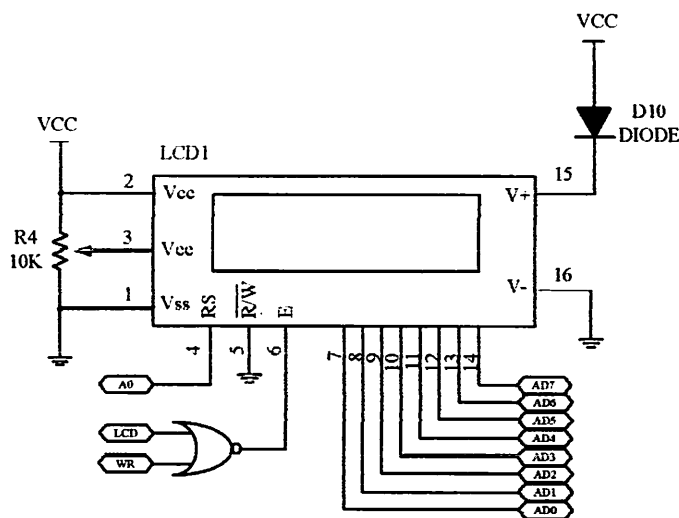
SELECTED ANALOG CHANNEL	ADDRESS LINE		
	A2	A1	A0
IN0	L	L	L
IN1	L	L	H
IN2	L	H	L
IN3	L	H	H
IN4	H	L	L
IN5	H	L	H
IN6	H	H	L
IN7	H	H	H

(sumber: data sheet National Semiconductor)

2.7. LCD

Pada sistem yang direncanakan akan digunakan LCD (Liquid Crystal Display) sebagai tampilan. LCD yang digunakan adalah merupakan LCD dua baris dengan tiap barisnya terdiri dari 16 karakter.

LCD ini membutuhkan 3 sinyal kontrol, R/W (*read/write*) untuk menentukan apakah data akan dibaca atau ditulis, E (*Enable*) yang merupakan sinyal untuk meng-enable-kan dan RS (*Register Select*) untuk memilih register yang diakses.



Gambar 2.8. Konfigurasi LCD

Sumber: modul LCD

Dalam sistem ini, LCD menempati ruang alamat A000H-A001H. Pin R/W dihubungkan ke *ground* atau selalu berlogika 0 karena dalam perancangan. LCD ini hanya selalu dalam operasi tulis dan pin RS dihubungkan ke pin A0 sistem mikrokontroler. Pengaktifan LCD ini

selanjutnya tergantung pada pin E. Dimana pin E ini tergantung dari CS5 dari addres dekoder dan perintah write mikrokontroler. Berikut ini merupakan pin-pin LCD berserta konfigurasinya:

Tabel 2.6
Pin-Pin LCD Dan Konfigurasinya

Nama pin	jumlah	I/O	Tujuan	Fungsi
DB0-DB3	4	I/O	MPU	Tristate bidirectional lower data bus: data dibaca dari modul ke MPU atau dari MPU ditulis ke modul melalui bus
DB4-DB7	4	I/O	MPU	Tristatebidirectional upper fourdata bus: data dibaca dari modul ke MPU atau dari MPU ditulis ke modul melalui bus
E	1	Input	MPU	Sinyal operasi dimulai: sinyal aktif baca/tulis
R/W	1	Input	MPU	Sinyalpilih data dan tulis (0:tulis,1:baca)
RS	1	-	Power supply	Sinyal pilih register 0: Instruction register (write) Busy flag dan address

				counter (read) 1:Data register (write dan read)
VLC	1	-	Power supply	Penyetelan kontras pada tampilan LCD
VDD	1	-	Power supply	+ 5V
VSS	1	-	Power supply	Ground 0V

Sumber : LCD Module User Manual

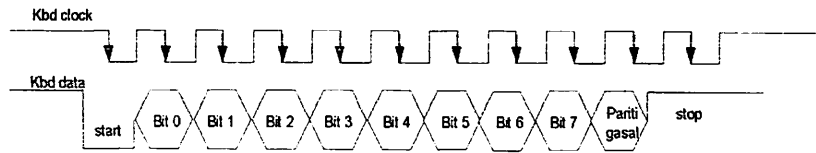
2.8. Komunikasi Serial

Komunikasi serial ialah pengiriman data secara serial (data dikirim satu persatu secara berurutan) sehingga komunikasi serial jauh lebih lambat daripada komunikasi paralel. Kelebihan komunikasi serial ialah jangkauan panjang kabel yang lebih jauh dibandingkan parallel karena serial *port* mengirimkan logika 1 dengan kisaran tegangan -3 hingga -15 volt dan logika 0 sebagai +3 hingga +15 volt sehingga kehilangan daya karena panjangnya kabel bukan merupakan masalah utama.

Komunikasi serial ada dua macam yaitu *synchronous* dan *asynchronous*.

Synchronous adalah komunikasi dimana hanya ada satu pihak (pengirim atau penerima yang menghasilkan *clock* dan mengirimkan *clock* tersebut bersama sama dengan data atau dengan kata lain merupakan bentuk

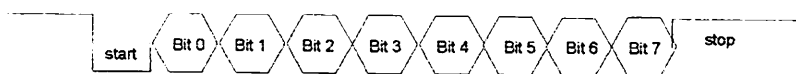
transmisi serial yg mentransmisikan data secara kontinyu. Contoh penggunaan synchronous terdapat pada transmisi data *keyboard*.



Gambar 2.9. Data Serial Sinkron.

Sumber: Catur Edi dan Retna, 2004

Asynchronous, Pada transmisi data asinkron tiap karakter data terdiri atas 5, 6, 7, 8 data dengan penambahan bit yang disisipkan pada kedua ujung karakter data yaitu start dan stop bit. Start bit digunakan untuk memberitahukan penerima agar siap menerima data. Penerima akan mengetahui start bit bila ada perubahan logika 1 ke 0 pada pengiriman satu karakter data. Setelah bit itu karakter akan mengikuti start bit. Setelah bit terakhir dari karakter dikirim, stop akan diketahui ketika saluran berlogika 1 sekurang-kurangnya satu atau dua siklus waktu. Oleh karena itu transmisi asinkron juga dikenal dengan nama start stop transmission.



Gambar 2.10. Data Serial Asinkron.

Sumber: Catur Edi dan Retna, 2004

Metode Transmisi data serial berdasarkan jalur komunikasi

1. Komunikasi Simpleks

Komunikasi simplex adalah komunikasi satu arah. Pengirim dan penerima tugasnya hanya satu saja

2. Komunikasi Half duplex

Transfer data pada komunikasi dilakukan dua, tetapi yang dikirim hanya satu arah pada satu waktu arah. Sebagai contoh pada penggunaan radio handy talky.

3. Komunikasi full duplex

Merupakan komunikasi dua arah, masing- masing peralatan dapat mengirim dan menerima data dalam satu waktu yang bersamaan, sebagai contoh dalam penggunaan pesawat telpon.

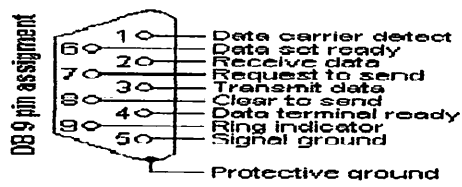
2.9. Serial port RS 232

Interface merupakan suatu piranti yang dapat menghubungkan satu peralatan ke peralatan lain sehingga peralatan tersebut dapat berkomunikasi. Sedangkan suatu cara/ proses untuk menghubungkan dua sistem yang berbeda agar bisa bekerja sama disebut interfacing.

2.9.1. Konfigurasi pin

Jika suatu komputer dihubungkan dengan komputer lain atau suatu periferal lain, maka bisa dilakukan hubungan komunikasi data. Sebuah komputer dapat bertukar informasi melalui *interface port I/O* serial yang disebut *interface RS 232*. RS 232 merupakan interface antara peralatan terminal data dan peralatan komunikasi data dengan menggunakan data

biner serial sebagai data yang ditransmisikan. Salah satu konektor yang biasa digunakan untuk komunikasi serial ini adalah konektor DB 9. Konektor DB 9 ditunjukkan pada Gambar 2 .9.



Gambar 2.11. Konektor DB 9

(sumber: data sheet serial komunikasi)

Pada dasarnya semua pin-pin memiliki fungsi-fungsi tetapi untuk keperluan RS 232 ini hanya beberapa saja yang penting.

Fungsi yang ada untuk konektor DB 9 adalah sebagaimana tampak dalam tabel berikut :

TABEL 2.7. KONFIGURASI PIN DB 9

EIA 232 (RS 232) FUNCTION	PIN
Data Carrier Detect (DCD)	1
Received Data (RxD)	2
Transmitted Data (TxD)	3
Data Terminal Ready (DTR)	4
Sinyal Ground (GND)	5
Data Set Ready (DSR)	6
Request To Send (RTS)	7

Clear To Send (CTS)	8
Ring Indikator (RI)	9

Sumber : B&B Electronics Mfg Co, USA, 2001, halaman 5

Jalur data (TxD dan RxD) untuk transport data, TxD adalah jalur output pada komputer, data dikirim dari pin ini. Sedangkan RxD adalah penerima untuk komputer, data yang datang akan diterima oleh pin ini. Pin ke empat adalah output (RTS) di mana sebuah sinyal akan diberikan pada alat yang dihubungkan dengan maksud meminta kiriman data. CTS adalah sinyal masukan yang menunggu sinyal dari alat yang terhubung. Ketika alat tersebut menerima sinyal RTS dan bisa menerima data maka ia akan mengirimkan sinyal balik yang merupakan CTS. DTR adalah sinyal keluaran yang memberi tanda bahwa ada alat yang terhubung dan akan mengirimkan data. DSR merupakan sinyal input yang mana jika alat yang terhubung menerima sinyal DTR ia akan memberi sinyal balik kemudian diterima sebagai sinyal DSR.

2.9.2. Protokol Komunikasi pada RS 232

Beberapa protokol dalam interface RS 232 adalah:

- Start Bit

Merupakan sebuah bit dengan logic “0” dimana bit ini yang menandakan bahwa akan ada karakter atau data yang mengikutinya. Bit

ini langsung diberikan oleh sinyal device tanpa harus mensetnya terlebih dahulu.

- Data Bit

Merupakan bit yang mewakili dari karakter yang diikutinya *data bit* ini dapat diset sepanjang antara 5 sampai 8 bit.

- Pariti Bit

Merupakan bit yang digunakan sebagai *error checking* pada *receiver* , apabila terjadi kesalahan maka *receiver* akan menset *error flag* (*parity error*) pada special register. *Parity bit* ini menghitung jumlah data yang berlogic '1' pada data bit. Perhitungan jumlah data bit tersebut tergantung dari jenis *parity* yang diset. Untuk parity *EVEN* maka jumlah data bit yang berlogic '1' ditambah dengan *parity bit* akan menghasilkan jumlah yang ganjil. Sedangkan untuk *parity MARK* merupakan *parity bit* selalu berlogic '1' begitu pula pada space, parity bit selalu berlogic '0' dan *parity NONE* disini *parity bit* yang diabaikan.

- Stop Bit

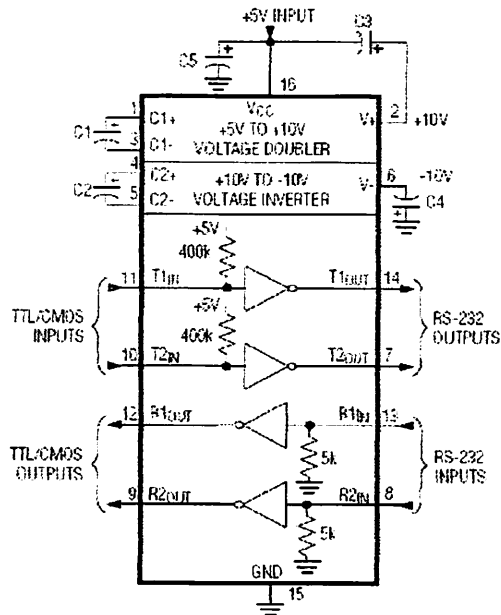
Merupakan bit yang menandakan akhir dari suatu paket data (biasanya 1 byte data). Seperti pada start bit, bit ini langsung diberikan dari serial device. *Stop bit* ini dapat diset panjangnya menjadi satu bit, satu setengah dan dua bit.

- Baud Rate

Sebenarnya *baut rate* berarti pergantian kondisi tiap detik (*State Change of the Line persecond*), tetapi karena hanya ada 2 kondisi pada serial (*logic 0 dan 1*) maka dapat juga digunakan untuk menunjukkan kecepatan dari transmisi (*bits per second*).

Saluran data pada port seri PC menggunakan standard RS232, dimana logic 0 (low) dinyatakan sebagai tegangan antara +3 Volt sampai +15 Volt dan logic 1 (high) dinyatakan sebagai tegangan antara -3 Volt sampai -15 Volt. Level tegangan ini tidak sesuai dengan level tegangan yang dipakai pada port seri AT89S51 yang menggunakan standard TTL (Transistor Transistor Logic), yaitu level tegangan baku dalam rangkaian – rangkaian digital.

Dalam standar TTL logic 0 (low) dinyatakan sebagai tegangan antara 0 Volt sampai 0.8 Volt, dan logic 1 (high) dinyatakan sebagai tegangan antara 3.5 Volt sampai 5 Volt. Karena perbedaan tegangan tersebut, agar port seri PC tidak merusak port seri AT89S51 antara keduanya dipasangkan IC MAX232 sebagai penyesuai tegangan. Rangkaian dasar dari MAX 232 dapat dilihat pada gambar berikut ini:



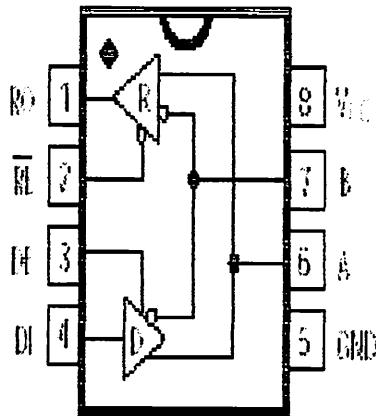
Gambar 2.12. Rangkaian Operasi MAX 232

Sumber : *Data Sheet Maxim Integrated Products*

2.10. Interface RS 485

Standart RS 485 ditetapkan oleh Elektronik Industry Associayion and Telekomunikasion Industry Association pada tahun 1983. Penggerak komunikasi RS 485 adalah pembantu komunikasi serial seperti halnya RS 232 yang sudah umum daipakai dalam transfer data serial sekarang ini. Tetapi dibandingkan dengan RS 232, RS 485 memiliki beberapa keunggulan, diantaranya : memiliki kecepatan maksimum yang lebih tinggi, memiliki jarak jangkauan yang lebih panjang (4000 feet) dan lebih tahan terhadap gangguan-gangguan dari luar seperti teganag listrik dan medan magnet.

RS 485 menangani transmisi data dengan satu saluran bersama dan bekerja dengan metode half duplex. Dalam setiap IC terdapat satu unit pengirim (D = driver) dan satu unit penerima (R=reciver).



Gambar 2.14.PIN RS 485

Sumber : *Data Sheet Maxim Integrated Products*

Pin 1 (RO) merupakan pin keluaran data, pin 2 (RE) berfungsi untuk mengaktifkan unit penerima data, pin 3(DE) berfungsi untuk mengaktifkan unit pengirim data, (D) merupakan pin masukan data, dan pin 6 dan pin 7 merupakan jalur yang akan dihubungkan ke kabel saluran.

2.11. Jaringan Komputer

Jaringan komputer adalah model komputer tunggal yang melayani seluruh tugas-tugas komputasi telah diganti dengan sekumpulan komputer

berjumlah banyak yang terpisah tetapi saling berhubungan dalam melaksanakan tugasnya.

Jaringan komputer dapat diklasifikasikan berdasarkan cara transmisinya yaitu jaringan broadcast dan jaringan point to point, sedangkan berdasarkan jarak : data flow machine, multi computer, Local Area Network, Metropolitan area Network, Wide area network, Jaringan tanpa kabel, Internetwork.

a) Local Area Network

LAN adalah suatu kumpulan komputer dimana terdapat beberapa unit computer (client) dan satu unit komputer sebagai server. Antara masing-masing client maupun antara client dan server dapat saling bertukar file .

Keuntungan dari jaringan LAN

- Pertukaran file dapat dilakukan lebih mudah
- Pemakaian printer dapat dilakukan oleh semua unit.
- File-file dapat disimpan pada server, sehingga dapat diakses dari semua client sesuai dengan otoritas
- File data yang keluar atau masuk dari atau ke server dapat dikontrol.
- Proses back up data jadi lebih mudah
- Resiko kehilangan data oleh virus menjadi sangat kecil, karena memiliki data back up yang terpusat

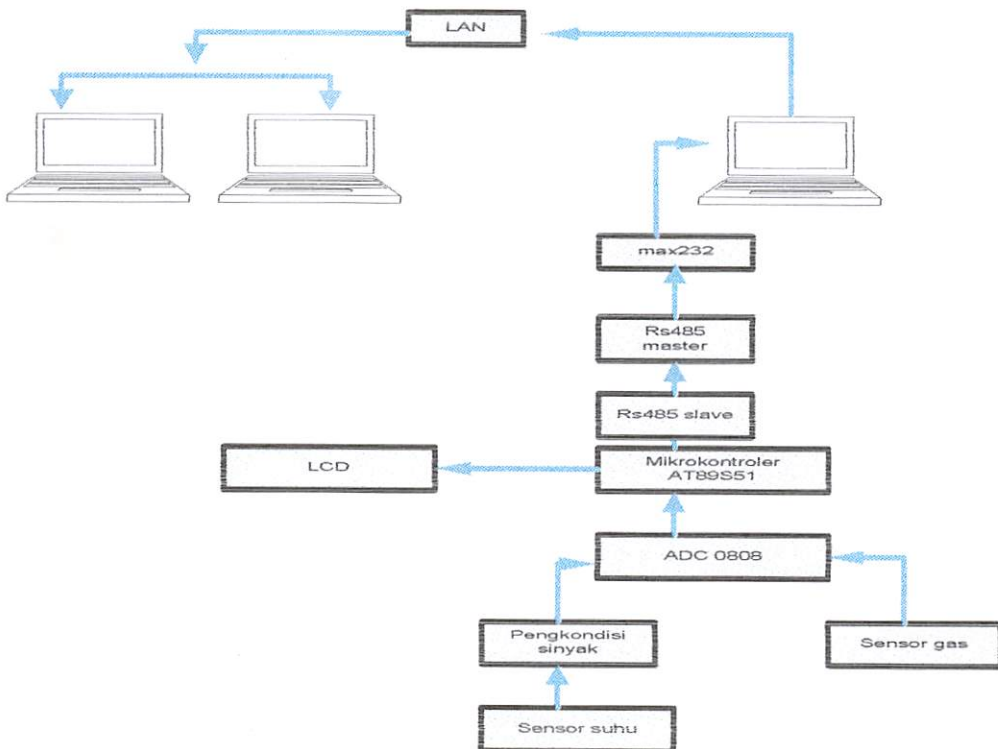
BAB III

PERANCANGAN DAN PEMBUATAN ALAT

3.1 Pendahuluan.

Dalam perancangan dan pembuatan alat monitoring suhu dan gas karbon monoksida (CO) ini terdiri dari beberapa rangkaian yang saling berhubungan satu dengan yang lainnya. Diantaranya terdiri dari mikrokontroler AT89S51, Sensor gas karbon monoksida dan sensor suhu, LCD, ADC 0808, pengkondisi sinyal, RS 485, Hub LAN. Dari beberapa komponen tersebut digabung menjadi beberapa rangkaian yang saling berhubungan.

3.2 Blok diagram sistem



Gambar 3.1. Rangkaian blok system

3.3 Cara kerja alat

1. Untuk sensor gas AF 30 outputnya langsung dimasukkan ke ADC tanpa rangkaian pengkondisi sinyal, sedangkan untuk rangkaian sensor suhu LM35 outputnya dimasukkan ke pengkondisi sinyal agar outputnya sesuai dengan tegangan dalam ADC yaitu antara 0-5 volt.
2. Output yang telah dikondisikan dimasukkan kedalam ADC 0808 pada pin IN0, sedangkan untuk sensor gas masuk ke pin IN1. Didalam ADC data yang masih berupa data analog dirubah menjadi data digital.
3. Data yang telah dirubah menjadi data digital oleh ADC 0808 masuk ke mikrokontroler yaitu port 1 sebagai input. Didalam mikrokontroler data tersebut diolah atau diproses untuk mengetahui besarnya suhu dan kadar gas karbon monoksida yang terdeteksi.

Data yang diolah pada mikrontroler akan ditampilkan pada LCD, dan dikirim kekomputer server melalui MAX232. MAX 232 lalu dihubungkan dengan RS 485, RS 485 ini digunakan untuk menghubungkan antara computer dengan alat atau mikrokontroler sebagai interfacenya dengan driver sensor dan pengatur suhu

4. Pada komputer server akan ditampilkan perubahan yang terjadi pada gas atau suhu dan akan ditampilkan dalam tampilan visual.
5. Data yang ada pada komputer server akan di kirim ke komputer client .

3.4 Perancangan perangkat keras

3.4.1. Sensor suhu

Pada dasarnya sensor suhu pada alat ini adalah untuk mengetahui suhu. Pada perancangan dan pembuatan alat ini menggunakan sensor LM35, yang memiliki kelebihan pada outputnya yang linier yaitu tegangan outputnya sebesar 10mV setiap kenaikan suhu 1C. sehingga memudahkan dalam pengolahan datanya

Untuk menghitung tegangan output dari sensor ini pada saat membaca temperature adalah:

$$V_{out} = Temp \times 10 \text{ mV/C}$$

Dimana:

Vout : Tegangan output dari sensor suhu LM35.

Temp : Besarnya suhu yang dibaca sensor (C)

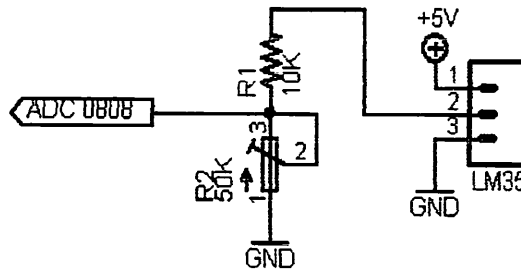
Sebagai contoh :

Jika suhu yang di ukur 50 C maka tegangan output sensor LM35 adalah :

$$V_{out} = 50C \times 10 \text{ mV/C}$$

$$V_{out} = 500 \text{ mV}$$

Untuk menaikkan resolusi pembacaan data suhu maka output dari sensor agar keluaran tegangan menjadi 10mV setiap kenaikannya maka dikondisikan dengan pembagi tegangan. Untuk lebih jelasnya dapat dilihat pada rangkaian berikut:

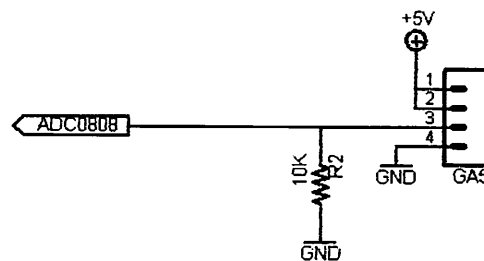


Gambar 3.2. Rangkaian sensor suhu

Sumber: perancangan

3.4.2. Sensor gas CO

Pada perancangan ini sensor digunakan untuk mengukur berapa kadar gas karbon monoksida (CO). Sensor yang digunakan adalah tipe (scimarec) AF-30 yang dapat bekerja dengan temperature-10°C sampai 55C. Dari sensor ini bias diketahui besar kadar CO sesuai dengan output yang dihasilkan berupa tegangan. Berikut ini adalah gambar rangkaian sensor gas AF-30:



Gambar 3.3. Rangkaian sensor gas

Sumber: perancangan

Besarnya tahanan sensor (R_s) dapat diketahui dengan persamaan sebagai berikut:

$$R_s = \frac{V_c - V_{out}}{V_{out}} \cdot R_L$$

Maka dari sana kita dapat mencari besarnya daya yang dibutuhkan sensor (P_s) dengan rumus:

Dimana:

R_s = tahanan sensor

R_L = Tahanan beban

V_c = Tegangan kerja pada rangkaian

V_{out} = Tegangan keluaran

P_s = Daya yang dibutuhkan oleh sensor ($P_s \leq 15 \text{ mW}$)

Diketahui hasil pengukuran diperoleh kadar CO adalah 1,2%, $R_1 = 5000 \text{ ohm}$, $V_{out} = 2,95 \text{ Volt}$, tahanan sensornya R_s adalah:

$$R_s = \frac{V_c - V_{out}}{V_{out}} \cdot R_L$$

$$R_s = \frac{5 - 2,95}{2,95} 5000 = 3474,5 \Omega = 3,474 \text{ K } \Omega$$

Diketahui hasil pengukuran diperoleh kadar CO adalah 1,5%, $R_1 = 5000 \text{ ohm}$, $V_{out} = 3,19 \text{ volt}$, tahanan sensornya (R_s) adalah:

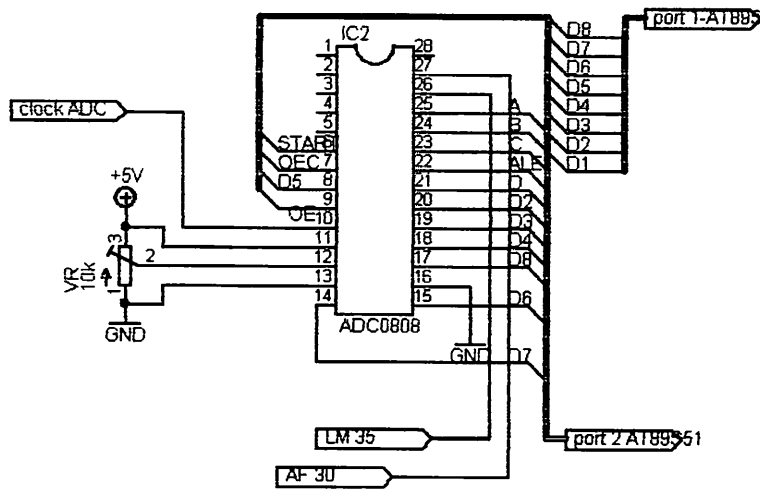
$$R_s = \frac{V_c - V_{out}}{V_{out}} \cdot R_L$$

$$R_s = \frac{5 - 3,19}{3,19} 5000 = 2836,9\Omega = 2,836 \text{ K}\Omega$$

3.4.3. ADC (analog to digital converter)

Dalam pembuatan alat ini juga dibutuhkan pengubah sinyal analog menjadi sinyal digital atau disebut Analog to Digital Converter (ADC), hal ini disebabkan karena sinyal-sinyal yang didapat dari sensor suhu dan sensor CO adalah berupa sinyal analog sedangkan rangkaian kontrolnya menggunakan system digital sehingga membutuhkan input berupa sinyal digital. Jenis ADC yang digunakan adalah ADC 0808 yang memiliki kelebihan yaitu dapat menerima hingga 8 inputan. Pada alat ini hanya menggunakan 2 inputan saja yaitu ADD A (pin 25) sebagai inputan dari pengkondisi sinyal sensor suhu, sedangkan ADD B (pin 24) dan ADD C (pin 23) digroundkan karena input yang dipakai hanya 2 saja.

Berikut ini adalah gambar dari rangkaian ADC 0808:



Gambar 3.4.Rangkaian ADC 0808

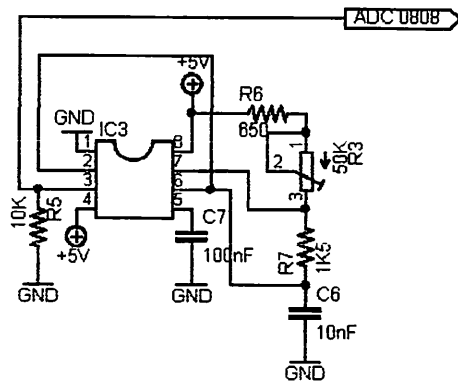
Sumber: perancangan

Penjelasan dari gambar diatas :

1. Pin 26 merupakan inputan yang berupa sinyal analaog dari pengkondisi sinyal sensor suhu LM35, pin 27 merupakan inputan yang berupa sinyal analog yang berasal dari sensor CO (AF30).
2. D0-D7 digunakan untuk mengirim data digital ke mikrokontoler.
3. ADD A digunakan untuk menerima sinyal dari mikrokontroler untuk memilih data antara sensor suhu atau sensor CO
4. Pin 10 digunakan sebagai clock eksternal dari ADC 0808.

Pada ADC 0808 tidak memiliki clock internal sehingga untuk mengaktifkan diperlukan clock eksternal. Dalam hal ini menggunakan IC 555.

Berikut ini adalah gambar dari rangkaian clock eksternal ADC 0808 :



Gambar 3.5. Rangkaian Clock ADC

$$f = \frac{1,44}{(RA + 2RB).C}$$

$$f = \frac{1,44}{(650 + 2.1500)10.10^{-9}} = 39452,05 = 39,45 \text{ KHz}$$

Berdasarkan perencanaan clock ADC, clock ADC disetting sesuai keinginan. Dalam perencanaan ADC diketahui frekuensi yang disetting atau dihasilkan oleh rangkaian clock eksternal adalah 39,45 KHz. Jadi jika dilihat dari datasheet ADC 0808, frekuensi clock yang dibutuhkan oleh ADC 0808 adalah anatara 10-1280 KHz. Sehingga frekuensi yang diahasilkan oleh rangkaian clock eksternal ini sudah sesuai dan memenuhi syarat.

Pada ADC 0808 Vref diset pada kondisi Full Range yaitu Vref (-) diset pada 0 volt, sedangkan untuk Vref (+) diset pada 5 volt. Pada saat 0 volt yaitu pada 0 sedangkan pada 5 volt pada 255. karena kondisi tersebut maka Vrefnya dapat diketahui yaitu sebesar 5 volt. Dari data Vref tersebut dapat dicari output dari ADC dengan persamaan sebagai berikut:

$$V_{ref} = 5 \text{ volt}$$

$$Resolusi \text{ per bit nya} = \frac{V_{ref}}{2^8} = \frac{5}{255} = 0,0196V$$

Contoh

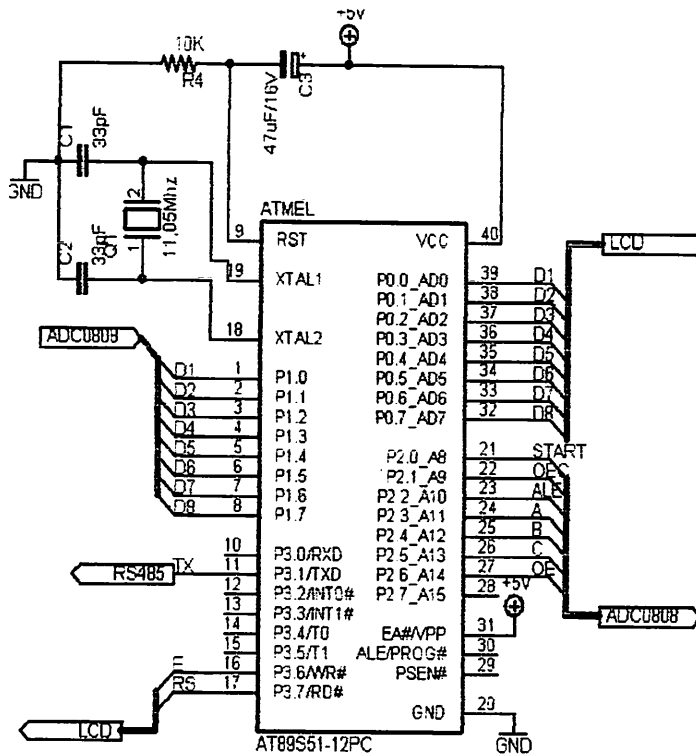
$$V_{analog} = 0,5 \text{ Volt}$$

$$\text{Data ADC} = \frac{V_{analog}}{resolusi} = \frac{0,5}{0,0196V} = 25_{(10)}$$

3.4.4. Mikrokontroler AT89S51

Pada perancangan dan pembuatan alat ini menggunakan mikrokontroler 8 bit buatan ATMEL yaitu AT89S51. AT89S51 digunakan untuk menyimpan data dan mengolah data dari ADC yang selanjutnya akan ditampilkan di LCD dan ditampilkan pada layar monitor komputer.

Berikut ini adalah gambar rangkaian mikrokontroler AT89S51 :



Gambar 3.6. Rangkaian mikrokontroler AT89S51

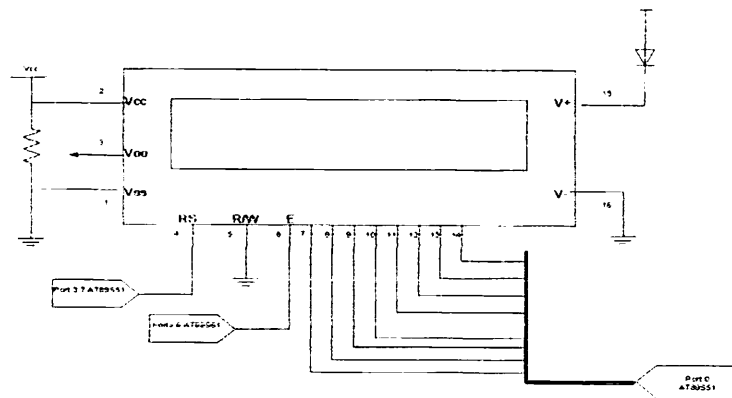
Berikut ini merupakan penjelasan dari gambar diatas:

1. Port 0 digunakan sebagai port data LCD
2. Port 1 digunakan sebagai port data dari ADC 0808
3. Port 2 dihubungkan dengan ADC 0808
4. Port 3.1 (TXD) digunakan sebagai komunikasi data yaitu sebagai port keluaran serial yang mengirim data ke RS 485.

3.4.5. Rangkaian LCD (Liquid Crystal Display)

Pada sistem yang direncanakan akan digunakan LCD (Liquid Crystal Display) sebagai tampilan. LCD yang digunakan adalah merupakan LCD dua baris dengan tiap barisnya terdiri dari 16 karakter.

LCD ini membutuhkan 3 sinyal kontrol, R/W (*read/write*) untuk menentukan apakah data akan dibaca atau ditulis, E (*Enable*) yang merupakan sinyal untuk meng-enable-kan dan RS (*Register Select*) untuk memilih register yang diakses .



Gambar 3.7. Rangkaian LCD

Sumber: perancangan

Berikut ini merupakan penjelasan dari gambar diatas:

1. AD0 – AD7 pada LCD dihubungkan ke port 0 pada mikrokontroler AT89S51.
2. Port R/W dihubungkan langsung ke ground

3. Port RS LCD dihubungkan ke port 3.7 mikrokontroler
4. Port E LCD dihubungkan ke port 3.6 mikrokontroler.
5. Port Vcc dan Vss dihubungkan dengan potensiometer 50K untuk dapat mengubah nilai Vee.

3.4.6. Rangkaian Komunikasi Serial.

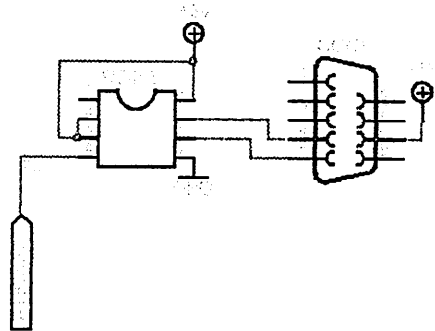
Data yang keluar masuk port serial komputer menggunakan standar komunikasi serial RS232. Pada standart komunikasi serial sesuai dengan spesifikasi standart RS 232-C, level tegangan yang digunakan adalah level tegangan yang berkisar antara -3 volt hingga -15 volt untuk kondisi logika '1' atau yang disebut dengan keadaan *mark* dan antara +3 volt hingga +15 volt untuk kondisi logika '0' atau disebut dengan keadaan *space* atau dengan kata lain standart RS 232-C menggunakan logika negatif/terbalik. Untuk dapat digunakan pada RS485, dalam membentuk jaringan komunikasi data antara komputer sentral dengan PPDS, level tegangan RS232 dari komputer harus diubah menjadi level tegangan TTL karena masukan DI (*driver input*) RS485 menggunakan level tegangan TTL. Begitu pula jika RS485 akan menyampaikan data ke komputer, maka level tegangan data tersebut harus diubah dulu sesuai standar RS232. Nilai kapasitor yang

digunakan telah ditentukan sebesar 1 uF sesuai dengan *datasheet* MAX232.

3.4.6.1 Rangkaian interface RS 485

Dalam alat ini menggunakan rangkaian RS 485 yang mempunyai jarak pengiriman data lebih jauh dibandingkan dengan RS 232, jarak maksimal pengiriman data RS 485 adalah 1200 meter.

Gambar rangkaian RS 485 adalah sebagai berikut:

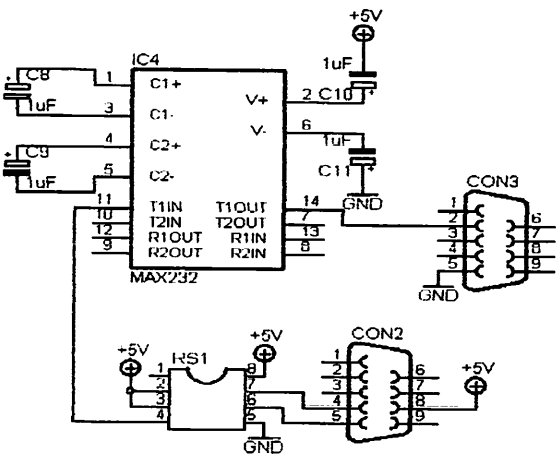


Gambar 3.8. Rangkaian RS 485 slave

3.4.6.2 Rangkaian interface RS 232

Proses pengiriman dan penerimaan data serial terlebih dahulu dilakukan dengan merubah level tegangan serial terlebih dahulu, yaitu level TTL menjadi level RS 232. Kabel penghubung antara MAX 232 dengan computer digunakan DB 9. Pin 5 dari DB9 dihubungkan dengan ground, pin 2 dihubungkan dengan pin 14 dari RS 232 dan pin

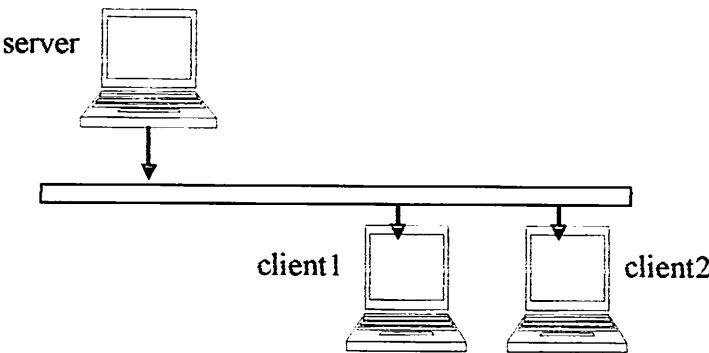
11 dari max 232 dihubungkan ke pin 4 dari RS 485 supaya dapat berkomunikasi mengirim data ke komputer.



Gambar 3.9.Rangkaian MAX 232 dan Rs 485 master

3.5 Perancangan Jaringan Komputer

Perancangan jaringan disini menggunakan jaringan *Local Area Network* (LAN) yang menggunakan satu computer sebagai server dan 2 komputer sebagai client.



Gambar 3.10 Rangkaian blok jaringan computer

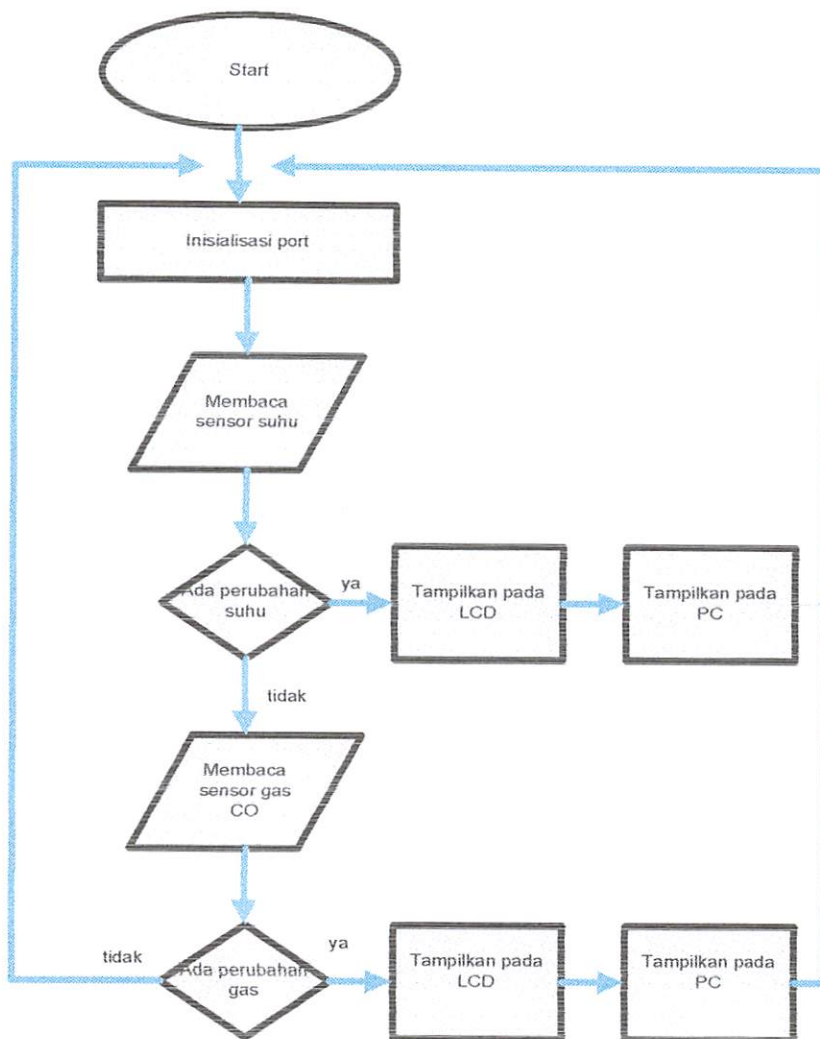
3.6 Perancangan soft ware

Perancangan software disini menggunakan bahasa pemrograman menggunakan bahasa assembler untuk memprogram mikrokontroler dan Program Borland Delphi menampilkan data dan menyimpan data pada komputer.

3.6.1. Software Mikrokontroller

Untuk pemakaian mikrokontroler di dalam suatu sistem, perlu direncanakan perangkat lunak mikrokontroler yang dapat mengatur sistem tersebut. Perangkat lunak disini adalah susunan perintah – perintah (program) di dalam memori yang harus dilaksanakan oleh mikrokontroler.

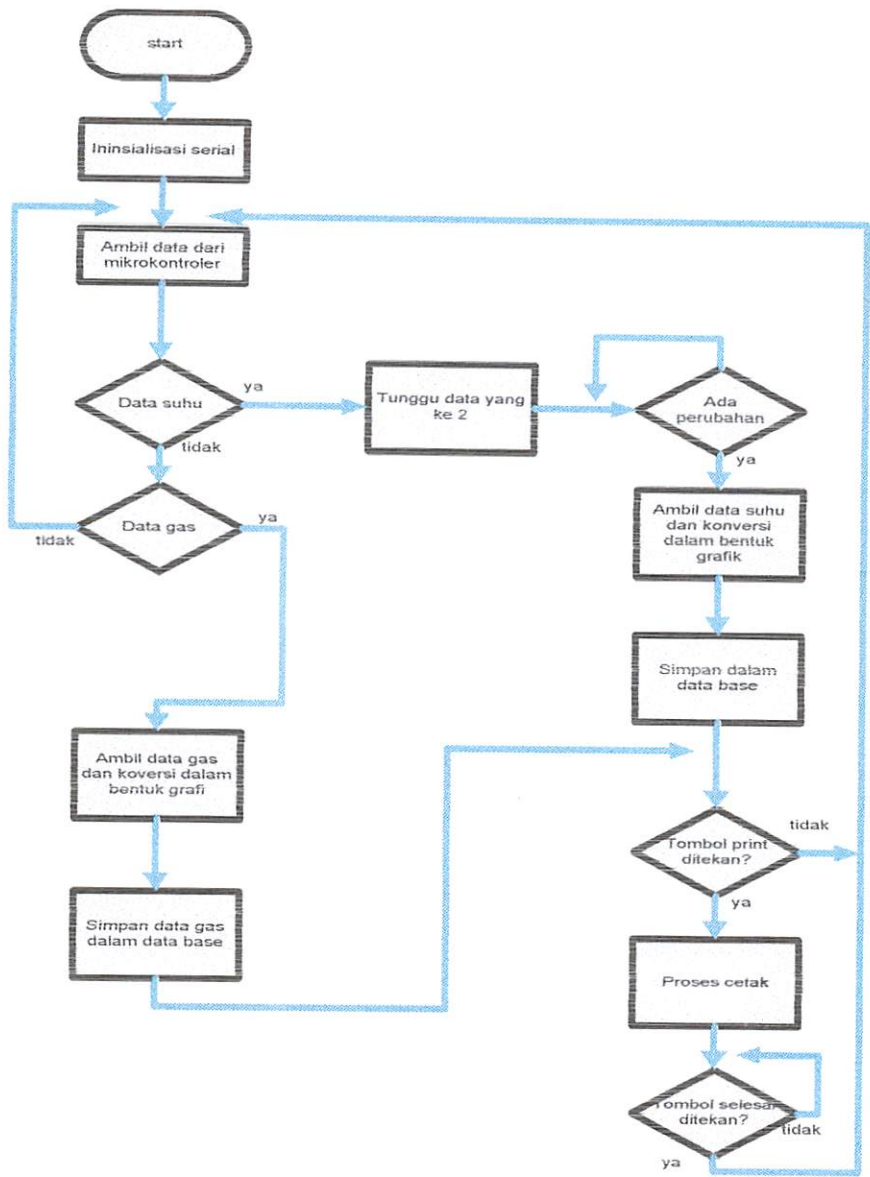
Perencanaan perangkat lunak (*software*) didasarkan perencanaan perangkat keras yang telah dibuat sebelumnya, untuk mendapatkan sistem kerja yang diharapkan. Software dari alat tersebut terdapat dibagian lampiran dan diagram alirnya adalah sebagai berikut



Gambar 3.11
Flowchart Mikrokontroler

3.6.2. Software Tampilan Komputer

Perancangan software tampilan dengan menggunakan Borland Delphi



Gambar 3.12

Flowchart Software Borland Delphi

BAB IV

PENGUJIAN ALAT

4.1. Pendahuluan

Pada bab ini membahas tentang pengujian alat yang telah dibuat. Secara umum, pengujian ini bertujuan untuk mengetahui apakah alat dapat bekerja sesuai dengan spesifikasi perencanaan yang telah ditetapkan. Pengujian dilakukan pada masing – masing blok diagram sesuai pada gambar dan juga pengujian alat secara keseluruhan.

4.2. Pengujian Rangkaian Sistem Mikrokontroller

Untuk mengetahui apakah mikrokontroller dapat melaksanakan program yang tersimpan dalam *flash memory* dan RAM dengan benar, maka dilakukan pengujian. Pada pengujian mikrokontroler kita menggunakan komputer dan led sebagai display. Pada mikrokontroler kita membuat program *assembler* yang digunakan dalam pengujian mikrokontroler, ini merupakan program sederhana yang meletakkan FFH dan 00H pada ACC secara bergantian kemudian memindahkannya pada port 1 AT89S51. Maka kita dapat mengamati keluaran pada led sebagai displaynya.

```
ORG          0000H

              JMP    START

START:        MOV    A,#0FH

              MOV    P1,A
```

```

CALL    TUNDA

MOV     A,#FFH

MOV     P1,A

JMP     START

TUNDA:  MOV     R3,#0FFH

TUNDA1: MOV     R2,#0FFH

        DJNZ    R2,S

        MOV     R1,#00H

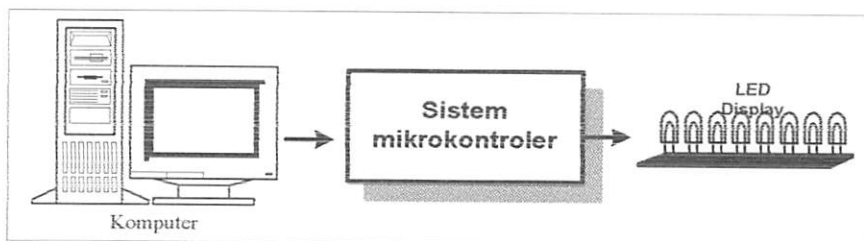
        DJNZ    R1,S

        DJNZ    R3,TUNDA1

RET

END

```



Gambar 4 – 1
Diagram Blok Pengujian Mikrokontroler

Tabel 4 – 1

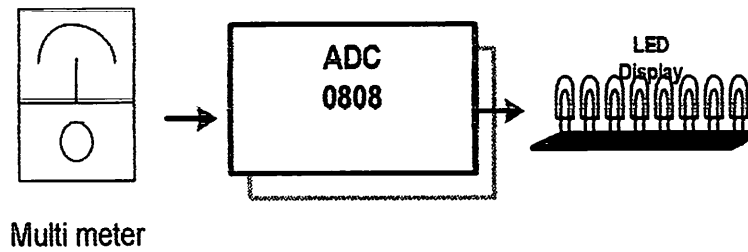
Pengujian Mikrokontroler

Kondisi	Keluaran pada LED Display							
	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
Satu	1	1	1	1	1	1	1	1
Dua	0	0	0	0	0	0	0	0

Dari hasil pengujian dalam tabel 4 – 1 dapat dilihat bahwa *port* 1 memberikan logika FF_H dan 00_H secara bergantian sesuai dengan isi program.

4.3. Pengujian ADC 0808

Pengujian terhadap ADC 0808 ini dapat dilakukan dengan menggunakan LED. Input pengujian ADC dibuat dari pencatu daya tegangan DC dari 0-5 volt, kemudian potesimeter kita putar perlahan-lahan, kita sesuaikan nilainya pada tegangan tertentu. LED sebagai indicator output dari ADC akan menyala sesuai dengan numeric dari 0 sampai dengan 255 dalam decimal.



Gambar 4.2

Diagram blok pengujian ADC 0808

Untuk perhitungan beda tegangan/ bit dari output ADC 0808 dapat dicari dengan menggunakan rumus sebagai berikut:

$$\begin{aligned}
 \text{Beda_tegangan/bit} &= \frac{V_{ref}^{(+)} - V_{ref}^{(-)}}{2^8 - 1} \\
 &= \frac{5 - 0}{256 - 1} \\
 &= \frac{5}{255} = 0,0196 \text{ Volt}
 \end{aligned}$$

Dan untuk keluaran ADC 0808 dapat dicari dengan menggunakan rumus sebagai berikut:

$$\text{Out}_{ADC(\text{desimal})} = \frac{V_{in}}{\text{Beda_tegangan/bit}}$$

Jika diketahui $V_{in} = 1,01$ volt. Maka keluaran ADC 0808 adalah:

Penyelesaian:

$$Out_{ADC(desimal)} = \frac{Vin}{Beda_tegangan/bit}$$

$$Out_{ADC(desimal)} = \frac{1,01}{0,0196}$$

$$= 51,53 \approx 52_{(10)}$$

$$Out_{ADC(desimal)} = 00110100_{(2)}$$

Dari tabel tersebut dapat dicari selisih antara hasil perhitungan dan hasil pembacaan keluaran ADC 0808. Berikut merupakan tabel perbandingan tegangan output antara hasil pengukuran dan hasil perhitungan dari keluaran ADC 0808:

Tabel 4 – 2

Perbandingan Perhitungan dan pembacaan ADC0808

No	Tegangan Input ADC	Output ADC (perhitungan)		Output ADC (pembacaan)	
		Biner	Desimal	D7-D0	Desimal
1	0	00000000	0	00000000	0
2	1,01	00110100	52	00110011	51
3	1,5	01001101	77	01001100	76
4	2,02	01100111	103	01100111	103
5	2,5	10000000	128	01111111	127
6	3,0	10011001	153	10011001	153

7	3,75	10111111	191	10111111	191
8	4,0	11001100	204	11001100	204
9	4,25	11011001	217	11011000	216
10	5,0	11111111	255	11111111	255

Dari tabel diatas dapat dicari persentase kesalahan(% error). Untuk persentase kesalahan dapat dicari dengan menggunakan persamaan sebagai berikut:

$$\text{Error rata-rata} = \frac{\text{jumlah_error}}{\text{jumlah_perhitungan}} \times 100\%$$

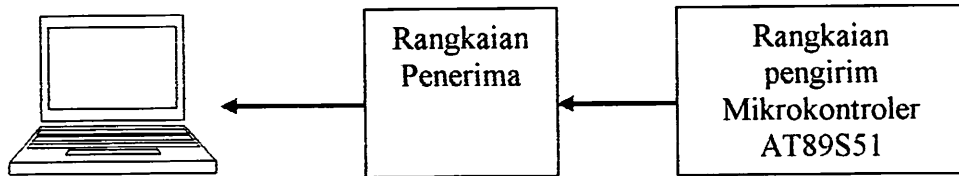
$$\text{Diketahui: } \begin{aligned} \sum \text{Perhitungan} &= 1380 \\ \sum \text{error} &= 4_{(10)} \end{aligned}$$

$$\begin{aligned} \text{Sehingga kesalahan rata-rata} &= \frac{\text{JumlahError}}{\text{JumlahPerhitungan}} \times 100\% \\ &= \frac{4}{1380} \times 100\% \\ &= 0,289\% \end{aligned}$$

4.6. Pengujian Transfer Data Serial

Untuk mengetahui apakah data yang dikirim mikrokontroler ke komputer dapat diterima dengan benar, maka pengiriman data serial di uji dengan membuat program yang digunakan dalam pengujian komunikasi serial. Program yang digunakan dalam pengujian ini merupakan program

sederhana yang mengirimkan 34h secara kontinyu dari mikrokontroler ke PC dengan menggunakan hyperterminal.



Gambar 4.3

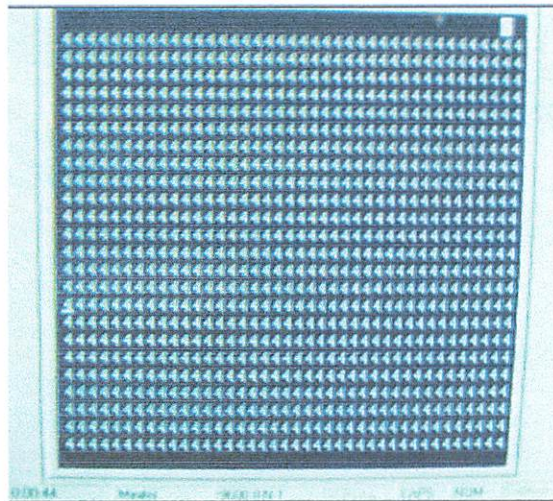
Diagram blok pengujian transfer data

```

mulai:    setb    EA
          mov     TMOD,#20h
          mov     TH1,#0FDH
          setb    TRI
          mov     SCON,#50h

tulis:
next_1:
          JB      P3.7,TULIS

KIRIM:
          MOV     A,#34H
          clr     ES
          mov     sbuf,A
          jnb     ti,$
          clr     ti
          setb    ES
          jmp     tulis
  
```



Gambar. 4-2
Foto Tampilan Pada Hyperterminal

Hasil pengujian komunikasi serial ditunjukkan pada table sebagai berikut:

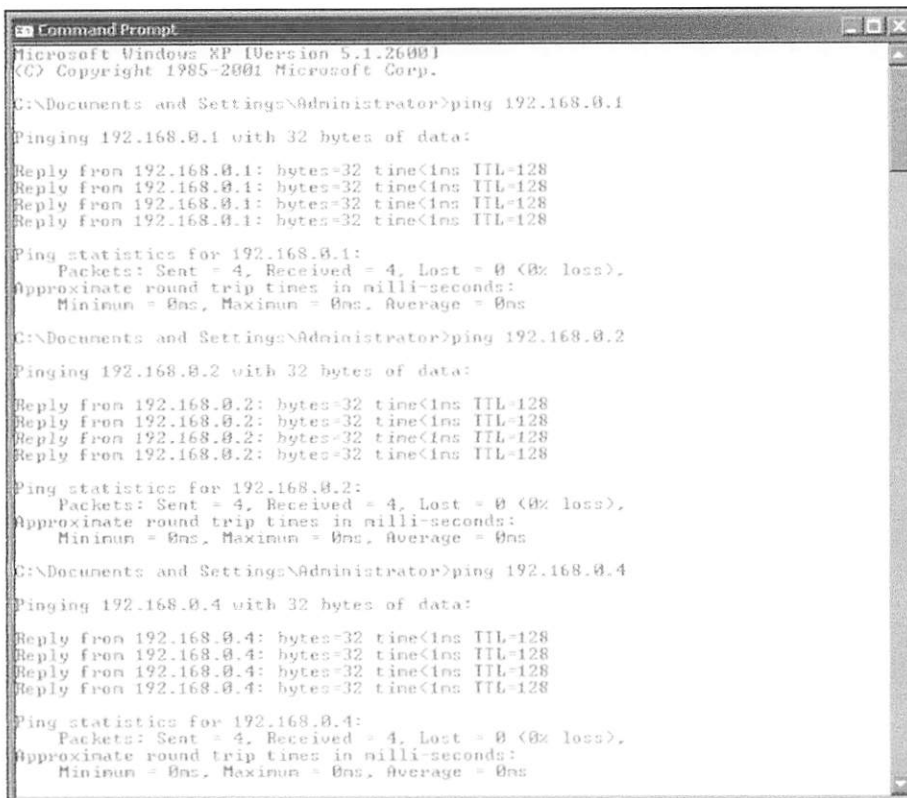
Tabel 4 – 3
Diagram blok Pengujian komunikasi serial

Data Mikrokontroler	Display pada computer
44444444444.....	44444444444.....

Dalam melakukan pengujian komunikasi serial pada PC data diterima dan ditampilkan menggunakan hyperterminal yang telah digunakan windows. Dengan hasil pengujian seperti gambar berikut yang ditunjuk terlihat bahwa PC menerima data sesuai dengan isi program yang dikirimkan mikrokontroler

4.6. Pengujian jaringan

Pada pengujian jaringan dilakukan untuk mengetahui apakah telah terjadi koneksi antara computer. Dalam melakukan pengujian jaringan dilakukan dengan melakukan ping pada *command prompt* sesuai dengan IP komputer yang dituju. Dengan hasil pengujian seperti gambar terlihat bahwa komputer mengirim data ke komputer lainnya sesuai dengan IP dan data tersebut di reply kembali yang menandakan adanya koneksi.



```
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\Administrator>ping 192.168.0.1

Pinging 192.168.0.1 with 32 bytes of data:

Reply from 192.168.0.1: bytes=32 time<1ms TTL=128
Reply from 192.168.0.1: bytes=32 time<1ms TTL=128
Reply from 192.168.0.1: bytes=32 time<1ms TTL=128
Reply from 192.168.0.1: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.0.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Documents and Settings\Administrator>ping 192.168.0.2

Pinging 192.168.0.2 with 32 bytes of data:

Reply from 192.168.0.2: bytes=32 time<1ms TTL=128
Reply from 192.168.0.2: bytes=32 time<1ms TTL=128
Reply from 192.168.0.2: bytes=32 time<1ms TTL=128
Reply from 192.168.0.2: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.0.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Documents and Settings\Administrator>ping 192.168.0.4

Pinging 192.168.0.4 with 32 bytes of data:

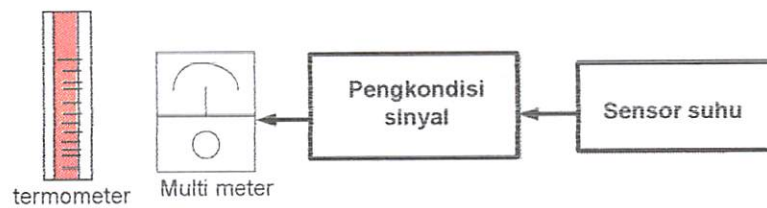
Reply from 192.168.0.4: bytes=32 time<1ms TTL=128
Reply from 192.168.0.4: bytes=32 time<1ms TTL=128
Reply from 192.168.0.4: bytes=32 time<1ms TTL=128
Reply from 192.168.0.4: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.0.4:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Gambar 4.4.
Pengujian koneksi jaringan.

4.7. Pengujian sensor suhu

Pada pengujian sensor suhu dilakukan pada ruangan dengan menggunakan termometer air raksa. Tujuan dilaksanakan percobaan ini adalah untuk mengetahui apakah besarnya keluaran tegangan dari sensor suhu sesuai dengan tegangan keluaran sensor suhu yaitu $10 \text{ mV}/^{\circ}\text{C}$.



Gambar 4.5

Diagram blok pengujian sensor suhu

Untuk mencari kesalahan pembacaan kadar gas pada display LCD dengan pembacaan pada alat uji emisi dengan menggunakan persamaan sebagai berikut:

$$\Delta t = |Pembacaan(LCD) - Pembacaan(termometer)|$$

$$\Delta \% = \left| \frac{Pembacaan(LCD) - Pembacaan(termometer)}{Pembacaan(termometer)} \times 100\% \right|$$

$$Kesalahan_rata - rata = \left| \frac{\sum \Delta \%}{\sum Pembacaan} \right|$$

$$\Delta t = |26 - 25| = 1$$

$$\Delta \% = \left| \frac{26 - 25}{25} \times 100\% \right| = 4\%$$

$$Kesalahan_rata - rata = \left| \frac{22,72}{7} \right| = 3,24\%$$

Hasil pengujian sensor suhu ditunjukkan pada table sebagai berikut

Tabel 4 – 4.

Perbandingan Tampilan pada LCD dan termometer

No	Temperatur(C)	Tampilan pada LCD	Vout sensor (mV)	Δt	$\Delta \%$
1	25	26	260	1	4,00
2	27	28	280	1	3,70
3	29	30	300	1	3,44
4	31	32	320	1	3,22
5	33	34	340	1	3,03
6	36	37	370	1	2,77
7	39	40	400	1	2,56
Kesalahan rata-rata					3,24 %

4.8. Pengujian sensor gas

Pada pengujian sensor gas karbon monoksida dilakukan dengan mendekatkan sensor dengan knalpot kendaraan dalam keadaan mesin hidup. Untuk proses kalibrasinya dilakukan dengan menyamakan hasil pengujian antara data yang dibuat dengan alat alat uji emisi. Setelah proses pengkalibrasian selesai antara kedua alat tersebut dibandingkan apakah sesuai atau ada selisih antara kedua alat tersebut.

Pada pengujian ini mencari kesalahan pembacaan kadar gas pada display LCD dengan pembacaan pada alat uji emisi dengan menggunakan persamaan sebagai berikut:

$$\Delta t = |Pembacaan(LCD) - Pembacaan(alat_uji_emisi)|$$

$$\Delta\% = \left| \frac{Pembacaan(LCD) - Pembacaan(alat_uji_emisi)}{Pembacaan(alat_uji_emisi)} \times 100\% \right|$$

$$Kesalahan_rata - rata = \left| \frac{\sum \Delta\%}{\sum Pembacaan} \right|$$

$$\Delta t = |1,5 - 1,46| = 0,04$$

$$\Delta\% = \left| \frac{1,5 - 1,46}{1,46} \times 100\% \right| = 2,73\%$$

$$Kesalahan_rata - rata = \left| \frac{43,77}{4} \right| = 10,94\%$$

Tabel 4-6

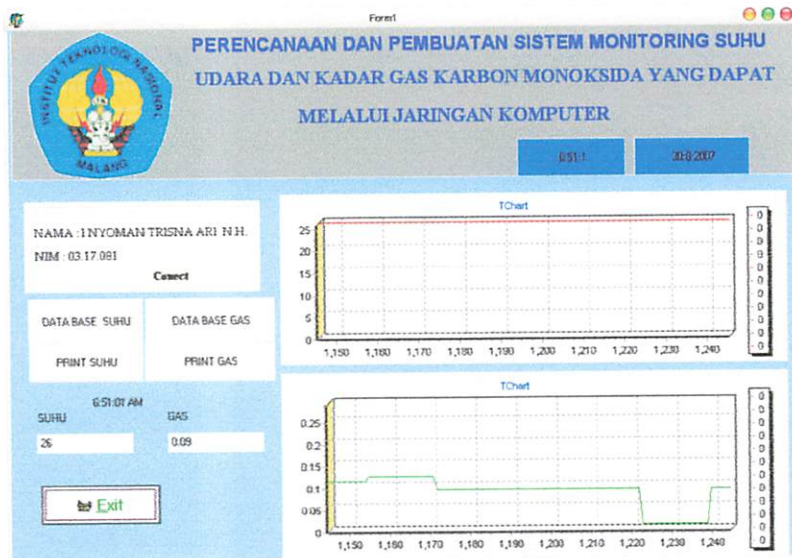
Pembacaan Alat ukur CO dengan tampilan pada LCD

No	RPM motor	Pembacaan(%)		Δt	$\Delta \%$
		Alat uji emisi	Pada LCD		
1	760	1,31	1,28	0,03	2,29
2	1550	1,46	1,5	0,04	2,73
3	2030	0,20	0,24	0,04	20
4	2550	0,16	0,19	0,03	18,75
Kesalahan rata-rata (error)					10,94%

4.9. Pengujian sistem keseluruhan

Untuk mengetahui data yang dikirimkan mikrokontroler sama dengan data yang diterima PC. Dengan cara melihat data set point suhu dan kadar gas karbon monoksida pada LCD sama dengan data pada interface PC.

Pengujian secara keseluruhan, dilakukan dengan melakukan akses perangkat mikrokontroler. Mikrokontroler akan memberikan data perubahan gas karbon dioksida dan suhu udara dan akan ditampilkan pada monitor komputer berupa tampilan visual.



Gambar 4.6
Tampilan monitoring pada komputer dan LCD

TABEL SUHU

TABEL DATA SUHU

	data_suhu	waktu	tanggal
28	3:12:11 PM	8/27/2007	
▶ 29	3:12:28 PM	8/27/2007	
29	3:12:45 PM	8/27/2007	
27	3:13:02 PM	8/27/2007	
25	3:13:19 PM	8/27/2007	
24	3:13:36 PM	8/27/2007	

◀ ▶ - ▲ ↺

Exit

Gambar 4.7
Tampilan data suhu

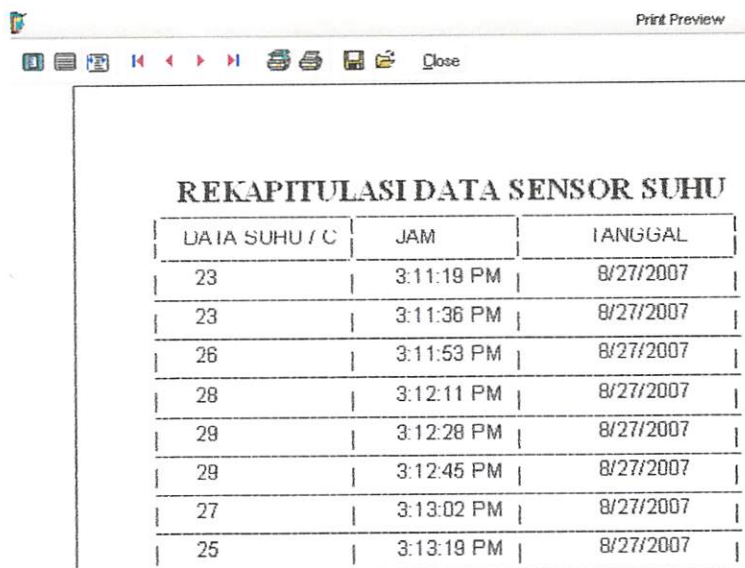
Form3

TABEL DATA GAS

	Data_gas	waktu	tanggal
	0.02	3:22:07 PM	8/27/2007
	0.02	3:22:24 PM	8/27/2007
	0.01	3:22:58 PM	8/27/2007
	0.01	3:24:07 PM	8/27/2007
	0.01	3:25:32 PM	8/27/2007

Exit

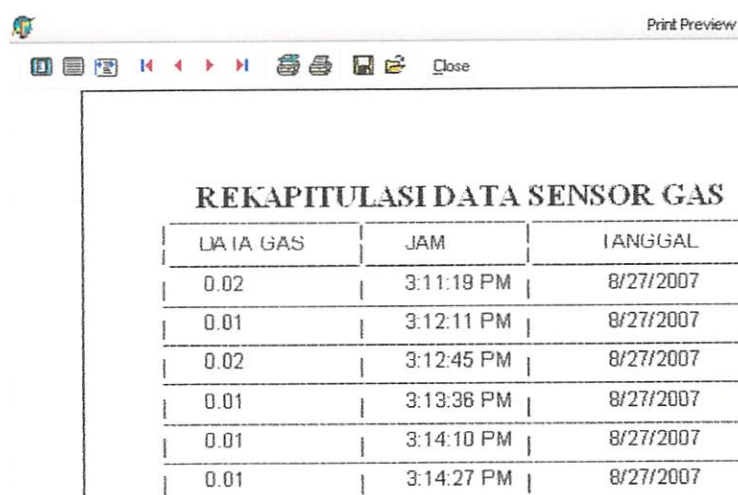
Gambar 4.8
Tampilan data gas



The screenshot shows a 'Print Preview' window with a toolbar at the top containing icons for print, save, and other functions. The main content is a table titled 'REKAPITULASI DATA SENSOR SUHU'.

DATA SUHU / C	JAM	TANGGAL
23	3:11:19 PM	8/27/2007
23	3:11:36 PM	8/27/2007
26	3:11:53 PM	8/27/2007
28	3:12:11 PM	8/27/2007
29	3:12:28 PM	8/27/2007
29	3:12:45 PM	8/27/2007
27	3:13:02 PM	8/27/2007
25	3:13:19 PM	8/27/2007

Gambar 4.9
Tampilan print data suhu



The screenshot shows a 'Print Preview' window with a toolbar at the top. The main content is a table titled 'REKAPITULASI DATA SENSOR GAS'.

DATA GAS	JAM	TANGGAL
0.02	3:11:19 PM	8/27/2007
0.01	3:12:11 PM	8/27/2007
0.02	3:12:45 PM	8/27/2007
0.01	3:13:36 PM	8/27/2007
0.01	3:14:10 PM	8/27/2007
0.01	3:14:27 PM	8/27/2007

Gambar 4.10
Tampilan print data gas



Gambar 4.11.
Foto alat sensor suhu dan gas karbon monoksida

BAB V

PENUTUP

Pada bab ini penulis akan menyampaikan kesimpulan dan saran setelah melakukan pengujian alat monitoring suhu udara dan kadar gas karbon monoksida yang dapat diakses melalui jaringan komputer.

5.1 Kesimpulan

- 1) Dalam perbandingan nilai pengukuran suhu pada termoter dan LCD alat, kesalahan rata-ratanya adalah 3,24%. Untuk sensor suhu nilai pengukuran yang tertinggi mencapai 40 derajat celcius.
- 2) Dalam perbandingan nilai pengukuran gas karbon monoksida pada alat uji emisi dengan tampilan pada LCD kesalahan rata-ratanya sebesar 10,94%
- 3) Untuk sensor kadar carbon monoxide, jika sensor mendeteksi adanya carbon monoksida maka resistensi yang ada pada sensor akan berkurang sehingga tegangan outputnya akan semakin tinggi tergantung seberapa kadar gas carbon monoxide dideteksi.

5.2 Saran

Dalam pembuatan skripsi ini masih banyak terdapat beberapa kekurangan sehingga untuk mencapai hasil yang sempurna maka perlu diberikan saran sebagai berikut:

- 1) Alat ini nantinya bisa dikembangkan untuk bisa mendeteksi gas-gas lainnya yang nantinya digunakan untuk bisa menganalisis suatu data.
- 2) Alat ini bisa lebih dikembangkan menjadi sebuah alat ukur sehingga perlu untuk dilakukan suatu pengkalibrasian yang tepat sehingga hasilnya akan lebih akurat.

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LAMPIRAN



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MALANG

FORMULIR BIMBINGAN SKRIPSI

Nama : I NYOMAN TRISNA ARI NADI HARTA
Nim : 03.17.081
Masa Bimbingan : 05 JUNI 2007 s/d 05 DESEMBER 2007
Judul Skripsi : PERANCANGAN DAN PEMBUATAN SYSTEM
MONITORING SUHU UDARA DAN KADAR GAS KARBON
MONOKSIDA YANG DAPAT DIAKSES MELALUI
JARINGAN KOMPUTER

NO.	Tanggal	Uraian	Paraf Dosen
1.	9/8/07	Bab I - II perbaiki	
2.	10/8/07	Bab III perbaiki flowchart	
3.	14/8/07	Bab IV perbaiki pengujian	
4.	15/8/07	Bab IV tambahkan pengujian	
5.	18/8/07	Bab V perbaiki kesimpulan	
6.	20/8/07	Bab I - V	
7.	21/8/07	Atk Seminar	
8.	31/8/2007	Atk komputer	
9.			
10.			

Malang,
Dosen Pembimbing I

Joseph Dedy Irawan, ST, MT.
NIP.P. 132315178



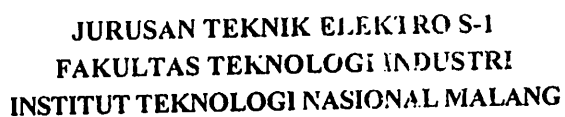
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Nama : I NYOMAN TRISNA ARI NADI HARTA
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Masa Bimbingan : 05 JUNI 2007 s/d 05 DESEMBER 2007
Judul Skripsi : PERANCANGAN DAN PEMBUATAN SYSTEM
MONITORING SUHU UDARA DAN KADAR GAS KARBON
MONOKSIDA YANG DAPAT DIAKSES MELALUI
JARINGAN KOMPUTER

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1.		Bab I, II, III	
2.		Bab I, II, III, IV	
3.		Makalah TA	
4.		Revisi Bab II	
5.		Revisi Keseluruhan	
6.		Pengujian System.	
7.		Revisi pengujian suhu	
8.		Revisi Pengujian CO2.	
9.		Acc Kompre	
10.			

Malang,
Dosen Pembimbing II

M ASHAR, ST, MT.



Dalam pelaksanaan Ujian Skripsi, perlu adanya perbaikan skripsi untuk mahasiswa :

Nama	:	I NYOMAN TRISNA
NIM	:	0317081
Fakultas	:	Teknologi Industri
Jurusan	:	Teknik Elektro S-1
Konsentrasi	:	1. Teknik Energi Listrik *)
	:	2. Teknik Elektronika *)
	:	3. Teknik Komputer dan Informatika *)

Perbaikan meliputi :

*)

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SURAT KETERANGAN
PENDIDIKAN SISTIM GANDA (PSG)
Nomor. AS.108/PSG/SERV.004/VIII/2007

Yang bertanda tangan dibawah ini kami pimpinan ,

PT. ASTRA INTERNATIONAL.Tbk.

TOYOTA SALES OPERATION AUTO 2000 Cabang Malang Sukun

dengan alamat Jl. S. Supriadi No. 35 Malang . Menerangkan bahwa ,

Nama Siswa	: I Nyoman Trisna Ari
N I M	: 03 . 17 . 081
Prodi/Keahlian	: Teknik Elektronika S1
Asal Sekolah	: INSTITUT TEKNOLOGI NASIONAL MALANG
A l a m a t	: Jl. Raya Karang lo Km. 2 Malang Jawa Timur

Telah melaksanakan survey perbandingan alat ukur uji Emisi pada bengkel
Auto 2000 Malang Sukun , sebagai bahan tugas akhir yang berjudul ,

Perencanaan dan pembuatan sistem monitoring Suhu udara dan Gas

Karbon Monoksida yang dapat diakses melalui jaringan komputer.

Yang dilaksanakan selama 1 (Satu) hari , pada tanggal : 14 Agustus 2007

Demikian Surat Keterangan ini dibuat untuk dipergunakan sebagaimana
Mestinya.

Malang, 24 Agustus 2007

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T. Wibowo
Service Manager

cc.
- File

Perbandingan pengukuran Alat uji emisi yang dilakukan di Bengkel Auto 2000 Sukun Malang

Pembacaan Alat ukur CO dengan tampilan pada LCD

RPM motor	Pembacaan(%)	
	Alat uji emisi	Pada LCD
760	1,31	1,28
1550	1,46	1,5
2030	0,20	0,24
2550	0,16	0,19

Mengetahui Instruktur Bengkel

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TOYOTA SALES OPERATIONS
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(Sutikno .)

Features

- Compatible with MCS-51® Products
- 4K Bytes of In-System Programmable (ISP) Flash Memory
 - Endurance: 1000 Write/Erase Cycles
- 4.0V to 5.5V Operating Range
- Fully Static Operation: 0 Hz to 33 MHz
- Three-level Program Memory Lock
- 128 x 8-bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-bit Timer/Counters
- Six Interrupt Sources
- Full Duplex UART Serial Channel
- Low-power Idle and Power-down Modes
- Interrupt Recovery from Power-down Mode
- Watchdog Timer
- Dual Data Pointer
- Power-off Flag
- Fast Programming Time
- Flexible ISP Programming (Byte and Page Mode)

Description

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

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



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

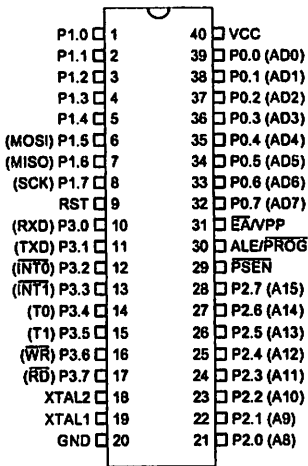
AT89S51

Rev. 2487A-10/01

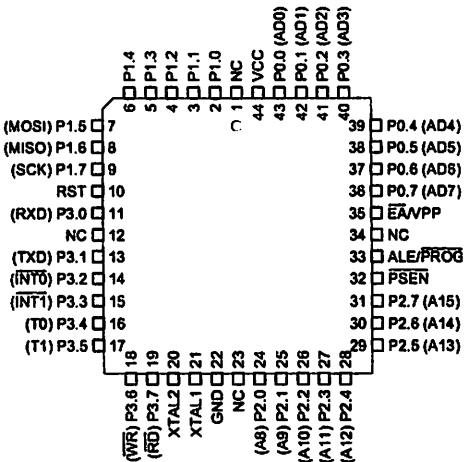


Pin Configurations

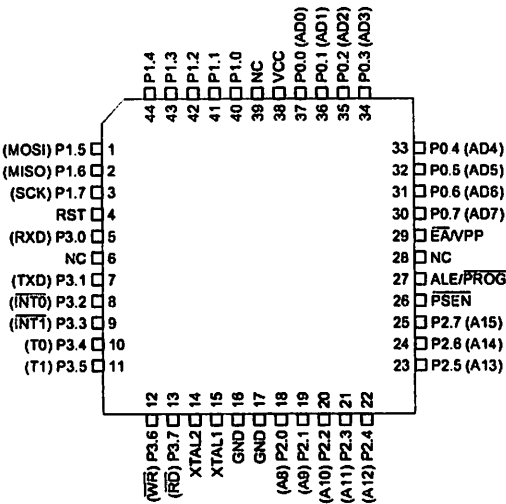
PDIP



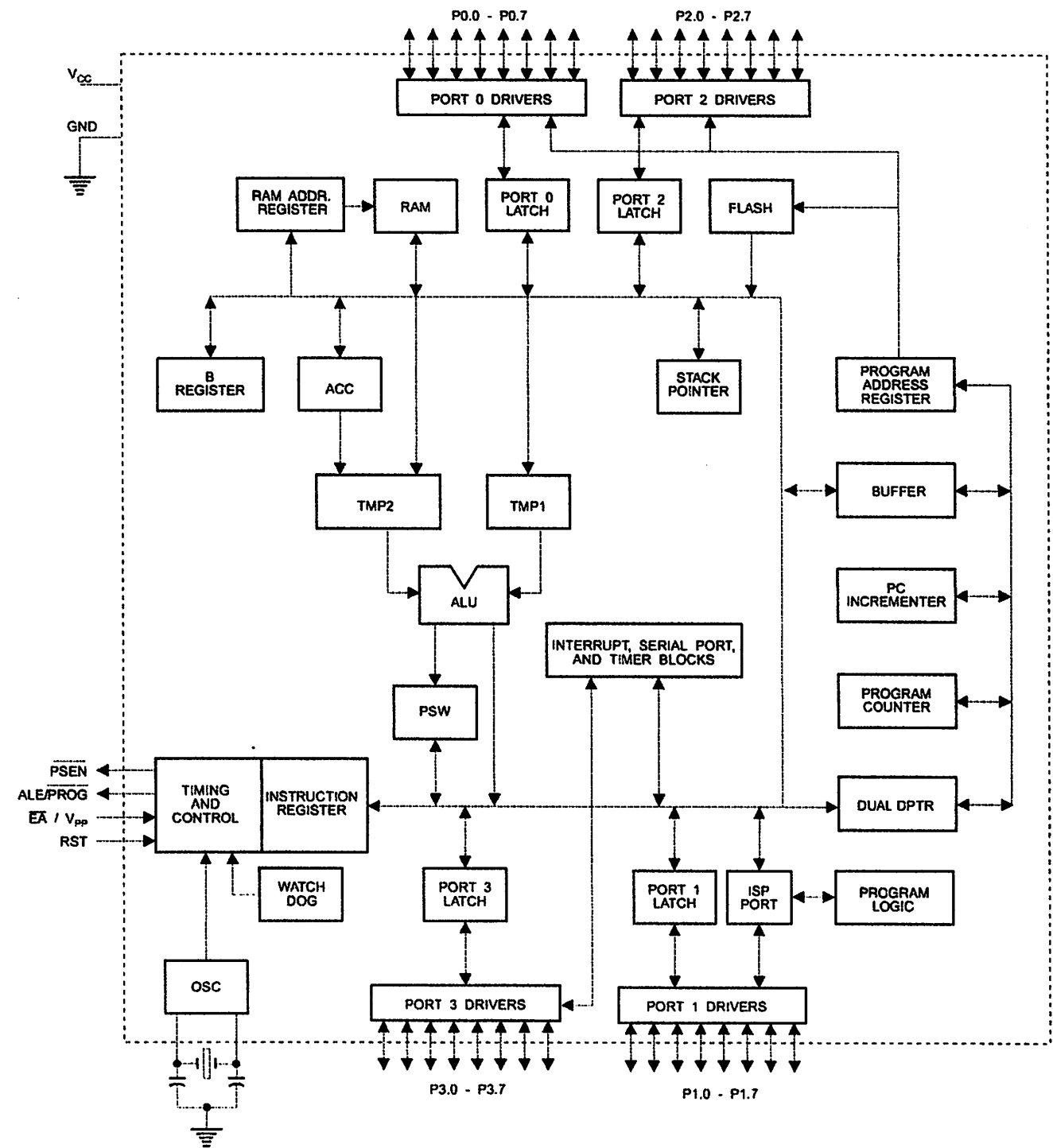
PLCC



TQFP



Block Diagram





Pin Description

VCC Supply voltage.

GND Ground.

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

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

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

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

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

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

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

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

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

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

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

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

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{\text{INT0}}$ (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)

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

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

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

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

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

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

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

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

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

XTAL1 Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

XTAL2 Output from the inverting oscillator amplifier



Special Function Registers

A map of the on-chip memory area called the Special Function Register (SFR) space is shown in Table 1.

Note that not all of the addresses are occupied, and unoccupied addresses may not be implemented on the chip. Read accesses to these addresses will in general return random data, and write accesses will have an indeterminate effect.

Table 1. AT89S51 SFR Map and Reset Values

0F8H								0FFH
0F0H	B 00000000							0F7H
0E8H								0EFH
0E0H	ACC 00000000							0E7H
0D8H								0DFH
0D0H	PSW 00000000							0D7H
0C8H								0CFH
0C0H								0C7H
0B8H	IP XX000000							0BFH
0B0H	P3 11111111							0B7H
0A8H	IE 0X000000							0AFH
0A0H	P2 11111111		AUXR1 XXXXXXXX0				WDTRST XXXXXXXXX	0A7H
98H	SCON 00000000	SBUF XXXXXXXXX						9FH
90H	P1 11111111							97H
88H	TCON 00000000	TMOD 00000000	TL0 00000000	TL1 00000000	TH0 00000000	TH1 00000000	AUXR XXX00XX0	8FH
80H	P0 11111111	SP 00000111	DP0L 00000000	DP0H 00000000	DP1L 00000000	DP1H 00000000		PCON 0XXX0000 87H

User software should not write 1s to these unlisted locations, since they may be used in future products to invoke new features. In that case, the reset or inactive values of the new bits will always be 0.

Interrupt Registers: The individual interrupt enable bits are in the IE register. Two priorities can be set for each of the five interrupt sources in the IP register.

Table 2. AUXR: Auxiliary Register

AUXR

Address = 8EH

Reset Value = XXX00XX0B

Not Bit
Addressable

	-	-	-	WDIDLE	DISRTO	-	-	DISALE
Bit	7	6	5	4	3	2	1	0

-

Reserved for future expansion

DISALE

Disable/Enable ALE

DISALE

Operating Mode

0

ALE is emitted at a constant rate of 1/6 the oscillator frequency

1

ALE is active only during a MOVX or MOVC instruction

DISRTO

Disable/Enable Reset out

DISRTO

0

Reset pin is driven High after WDT times out

1

Reset pin is input only

WDIDLE

Disable/Enable WDT in IDLE mode

WDIDLE

0

WDT continues to count in IDLE mode

1

WDT halts counting in IDLE mode

Dual Data Pointer Registers: To facilitate accessing both internal and external data memory, two banks of 16-bit Data Pointer Registers are provided: DP0 at SFR address locations 82H-83H and DP1 at 84H-85H. Bit DPS = 0 in SFR AUXR1 selects DP0 and DPS = 1 selects DP1. The user should always initialize the DPS bit to the appropriate value before accessing the respective Data Pointer Register.





Power Off Flag: The Power Off Flag (POF) is located at bit 4 (PCON.4) in the PCON SFR. POF is set to "1" during power up. It can be set and rest under software control and is not affected by reset.

Table 3. AUXR1: Auxiliary Register 1

AUXR1

Address = A2H

Reset Value = XXXXXX0B

Not Bit Addressable

	-	-	-	-	-	-	-	DPS
Bit	7	6	5	4	3	2	1	0

- Reserved for future expansion

DPS Data Pointer Register Select

DPS

0 Selects DPTR Registers DP0L, DP0H

1 Selects DPTR Registers DP1L, DP1H

Memory Organization

MCS-51 devices have a separate address space for Program and Data Memory. Up to 64K bytes each of external Program and Data Memory can be addressed.

Program Memory

If the $\overline{EA}$ pin is connected to GND, all program fetches are directed to external memory.

On the AT89S51, if $\overline{EA}$ is connected to V_{CC} , program fetches to addresses 0000H through FFFH are directed to internal memory and fetches to addresses 1000H through FFFFH are directed to external memory.

Data Memory

The AT89S51 implements 128 bytes of on-chip RAM. The 128 bytes are accessible via direct and indirect addressing modes. Stack operations are examples of indirect addressing, so the 128 bytes of data RAM are available as stack space.

Watchdog Timer (One-time Enabled with Reset-out)

The WDT is intended as a recovery method in situations where the CPU may be subjected to software upsets. The WDT consists of a 14-bit counter and the Watchdog Timer Reset (WDTRST) SFR. The WDT is defaulted to disable from exiting reset. To enable the WDT, a user must write 01EH and 0E1H in sequence to the WDTRST register (SFR location 0A6H). When the WDT is enabled, it will increment every machine cycle while the oscillator is running. The WDT timeout period is dependent on the external clock frequency. There is no way to disable the WDT except through reset (either hardware reset or WDT overflow reset). When WDT overflows, it will drive an output RESET HIGH pulse at the RST pin.

Using the WDT

To enable the WDT, a user must write 01EH and 0E1H in sequence to the WDTRST register (SFR location 0A6H). When the WDT is enabled, the user needs to service it by writing 01EH and 0E1H to WDTRST to avoid a WDT overflow. The 14-bit counter overflows when it reaches 16383 (3FFFH), and this will reset the device. When the WDT is enabled, it will increment every machine cycle while the oscillator is running. This means the user must reset the WDT at least every 16383 machine cycles. To reset the WDT the user must write 01EH and 0E1H to WDTRST. WDTRST is a write-only register. The WDT counter cannot be read or written. When WDT overflows, it will generate an output RESET pulse at the RST pin. The RESET pulse duration is $98 \times TOSC$, where $TOSC = 1/FOSC$. To make the best use of the WDT, it

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

WDT During Power-down and Idle

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

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

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

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

UART

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

Timer 0 and 1

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

Interrupts

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

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

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

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

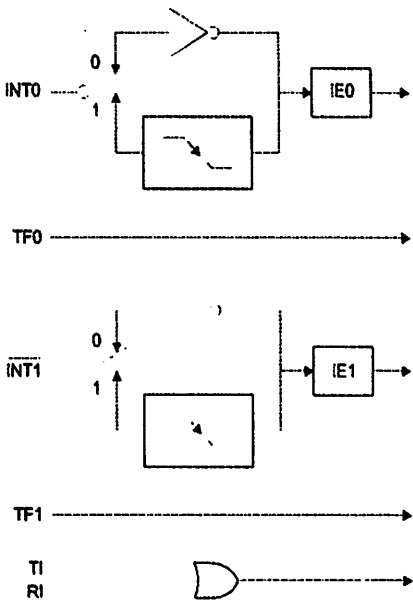
Table 4. Interrupt Enable (IE) Register

(MSB)				(LSB)			
EA	–	–	ES	ET1	EX1	ET0	EX0
Enable Bit = 1 enables the interrupt.							
Enable Bit = 0 disables the interrupt.							

Symbol	Position	Function
EA	IE.7	Disables all interrupts. If EA = 0, no interrupt is acknowledged. If EA = 1, each interrupt source is individually enabled or disabled by setting or clearing its enable bit.
–	IE.6	Reserved
–	IE.5	Reserved
ES	IE.4	Serial Port interrupt enable bit
ET1	IE.3	Timer 1 interrupt enable bit
EX1	IE.2	External Interrupt 1 enable bit
ET0	IE.1	Timer 0 interrupt enable bit
EX0	IE.0	External interrupt 0 enable bit

User software should never write 1s to reserved bits, because they may be used in future AT89 products.

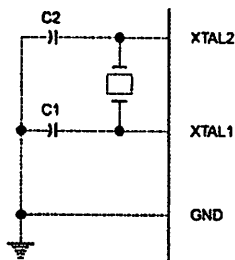
Figure 1. Interrupt Sources



Oscillator Characteristics

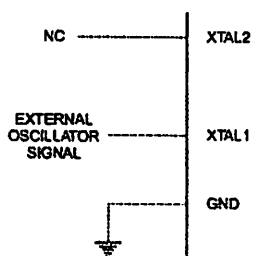
XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier that can be configured for use as an on-chip oscillator, as shown in Figure 2. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven, as shown in Figure 3. 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.

Figure 2. Oscillator Connections



Note: C1, C2 = 30 pF $\pm$ 10 pF for Crystals = 40 pF $\pm$ 10 pF for Ceramic Resonators

Figure 3. External Clock Drive Configuration



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 function registers remain unchanged during this mode. The idle mode can be terminated by any enabled interrupt or by a hardware reset.

Note that when idle mode is terminated by a hardware 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 mode is terminated by a reset, the instruction following the one that invokes idle mode should not write to a port pin or to external memory.

Power-down Mode

In the Power-down mode, the oscillator is stopped, and the instruction that invokes Power-down is the last instruction executed. The on-chip RAM and Special Function Registers retain their values until the Power-down mode is terminated. Exit from Power-down mode can be initiated either by a hardware reset or by activation of an enabled external interrupt into $\overline{\text{INT0}}$ or $\overline{\text{INT1}}$. 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.

Table 5. Status of External Pins During Idle and Power-down Modes

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

Program Memory Lock Bits

The AT89S51 has three lock bits that can be left unprogrammed (U) or can be programmed (P) to obtain the additional features listed in the following table.

Table 6. Lock Bit Protection Modes

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

When lock bit 1 is programmed, the logic level at the $\overline{\text{EA}}$ 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. The latched value of $\overline{\text{EA}}$ must agree with the current logic level at that pin in order for the device to function properly.

Programming the Flash – Parallel Mode

The AT89S51 is shipped with the on-chip Flash memory array ready to be programmed. The programming interface needs a high-voltage (12-volt) program enable signal and is compatible with conventional third-party Flash or EPROM programmers.

The AT89S51 code memory array is programmed byte-by-byte.

Programming Algorithm: Before programming the AT89S51, the address, data, and control signals should be set up according to the Flash programming mode table and Figures 13 and 14. To program the AT89S51, take the following steps:

1. Input the desired memory location on the address lines.
2. Input the appropriate data byte on the data lines.
3. Activate the correct combination of control signals.
4. Raise $\overline{\text{EA}}/\text{V}_{\text{PP}}$ to 12V.
5. Pulse ALE/ $\overline{\text{PROG}}$ once to program a byte in the Flash array or the lock bits. The byte-write cycle is self-timed and typically takes no more than 50 μs . Repeat steps 1 through 5, changing the address and data for the entire array or until the end of the object file is reached.

Data Polling: The AT89S51 features $\overline{\text{Data}}$ Polling to indicate the end of a byte write cycle. During a write cycle, an attempted read of the last byte written will result in the complement of the written data on P0.7. Once the write cycle has been completed, true data is valid on all outputs, and the next cycle may begin. Data Polling may begin any time after a write cycle has been initiated.

Ready/Busy: The progress of byte programming can also be monitored by the RDY/ $\overline{\text{BSY}}$ output signal. P3.0 is pulled low after ALE goes high during programming to indicate $\overline{\text{BUSY}}$. P3.0 is pulled high again when programming is done to indicate $\overline{\text{READY}}$.

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 status of the individual lock bits can be verified directly by reading them back.

Reading the Signature Bytes: The signature bytes are read by the same procedure as a normal verification of locations 000H, 100H, and 200H, except that P3.6 and P3.7 must be pulled to a logic low. The values returned are as follows.

(000H) = 1EH indicates manufactured by Atmel
(100H) = 51H indicates 89S51
(200H) = 06H

Chip Erase: In the parallel programming mode, a chip erase operation is initiated by using the proper combination of control signals and by pulsing ALE/ $\overline{\text{PROG}}$ low for a duration of 200 ns - 500 ns.

In the serial programming mode, a chip erase operation is initiated by issuing the Chip Erase instruction. In this mode, chip erase is self-timed and takes about 500 ms.

During chip erase, a serial read from any address location will return 00H at the data output.

Programming the Flash – Serial Mode

The Code memory array can be programmed using the serial ISP interface while RST is pulled to V_{CC} . The serial interface consists of pins SCK, MOSI (input) and MISO (output). After RST is set high, the Programming Enable instruction needs to be executed first before other operations can be executed. Before a reprogramming sequence can occur, a Chip Erase operation is required.

The Chip Erase operation turns the content of every memory location in the Code array into FFH.

Either an external system clock can be supplied at pin XTAL1 or a crystal needs to be connected across pins XTAL1 and XTAL2. The maximum serial clock (SCK) frequency should be less than 1/16 of the crystal frequency. With a 33 MHz oscillator clock, the maximum SCK frequency is 2 MHz.

Serial Programming Algorithm

To program and verify the AT89S51 in the serial programming mode, the following sequence is recommended:

1. Power-up sequence:
Apply power between VCC and GND pins.
Set RST pin to "H".
If a crystal is not connected across pins XTAL1 and XTAL2, apply a 3 MHz to 33 MHz clock to XTAL1 pin and wait for at least 10 milliseconds.
2. Enable serial programming by sending the Programming Enable serial instruction to pin MOSI/P1.5. The frequency of the shift clock supplied at pin SCK/P1.7 needs to be less than the CPU clock at XTAL1 divided by 16.
3. The Code array is programmed one byte at a time in either the Byte or Page mode. The write cycle is self-timed and typically takes less than 0.5 ms at 5V.
4. Any memory location can be verified by using the Read instruction that returns the content at the selected address at serial output MISO/P1.6.
5. At the end of a programming session, RST can be set low to commence normal device operation.



Power-off sequence (if needed):

Set XTAL1 to "L" (if a crystal is not used).

Set RST to "L".

Turn V_{CC} power off.

Data Polling: The Data Polling feature is also available in the serial mode. In this mode, during a write cycle an attempted read of the last byte written will result in the complement of the MSB of the serial output byte on MISO.

Serial Programming Instruction Set

The Instruction Set for Serial Programming follows a 4-byte protocol and is shown in Table 8 on page 18.

Programming Interface – Parallel Mode

Every code byte in the Flash array can be programmed 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.

Table 7. Flash Programming Modes

Mode	V_{CC}	RST	$\overline{PSEN}$	ALE/ $\overline{PROG}$	$\overline{EA}/$ V_{PP}	P2.6	P2.7	P3.3	P3.6	P3.7	P0.7-0 Data	P2.3-0	P1.7-0
												Address	
Write Code Data	5V	H	L	(2)	12V	L	H	H	H	H	D_{IN}	A11-8	A7-0
Read Code Data	5V	H	L	H	H	L	L	L	H	H	D_{OUT}	A11-8	A7-0
Write Lock Bit 1	5V	H	L	(3)	12V	H	H	H	H	H	X	X	X
Write Lock Bit 2	5V	H	L	(3)	12V	H	H	H	L	L	X	X	X
Write Lock Bit 3	5V	H	L	(3)	12V	H	L	H	H	L	X	X	X
Read Lock Bits 1, 2, 3	5V	H	L	H	H	H	H	L	H	L	P0.2, P0.3, P0.4	X	X
Chip Erase	5V	H	L	(1)	12V	H	L	H	L	L	X	X	X
Read Atmel ID	5V	H	L	H	H	L	L	L	L	L	1EH	0000	00H
Read Device ID	5V	H	L	H	H	L	L	L	L	L	51H	0001	00H
Read Device ID	5V	H	L	H	H	L	L	L	L	L	06H	0010	00H

- Notes:
1. Each $\overline{PROG}$ pulse is 200 ns - 500 ns for Chip Erase.
 2. Each $\overline{PROG}$ pulse is 200 ns - 500 ns for Write Code Data.
 3. Each $\overline{PROG}$ pulse is 200 ns - 500 ns for Write Lock Bits.
 4. RDY/BSY signal is output on P3.0 during programming.
 5. X = don't care.

Figure 4. Programming the Flash Memory (Parallel Mode)

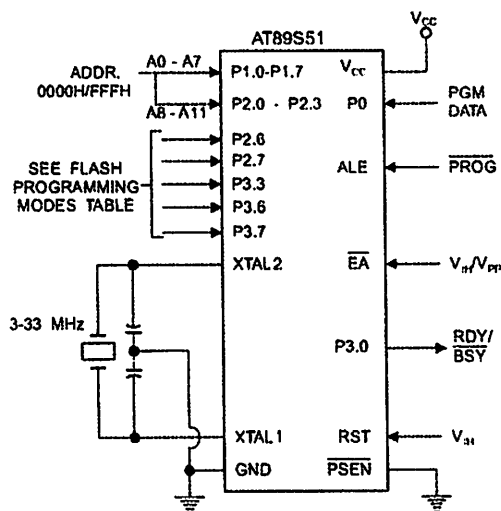
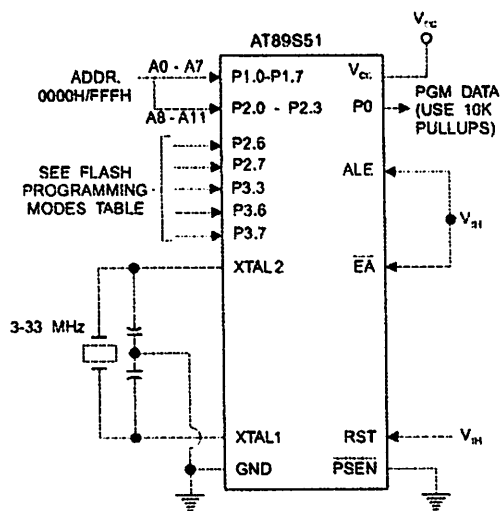


Figure 5. Verifying the Flash Memory (Parallel Mode)



Flash Programming and Verification Characteristics (Parallel Mode)

T_A = 20°C to 30°C, V_{CC} = 4.5 to 5.5V

Symbol	Parameter	Min	Max	Units
V _{PP}	Programming Supply Voltage	11.5	12.5	V
I _{PP}	Programming Supply Current		10	mA
I _{CC}	V _{CC} Supply Current		30	mA
1/t _{CLCL}	Oscillator Frequency	3	33	MHz
t _{AVGL}	Address Setup to $\overline{\text{PROG}}$ Low	48t _{CLCL}		
t _{GHAX}	Address Hold After $\overline{\text{PROG}}$	48t _{CLCL}		
t _{DVGL}	Data Setup to $\overline{\text{PROG}}$ Low	48t _{CLCL}		
t _{GHDx}	Data Hold After $\overline{\text{PROG}}$	48t _{CLCL}		
t _{EHSx}	P2.7 ($\overline{\text{ENABLE}}$) High to V _{PP}	48t _{CLCL}		
t _{SHGL}	V _{PP} Setup to $\overline{\text{PROG}}$ Low	10		μs
t _{GHSL}	V _{PP} Hold After $\overline{\text{PROG}}$	10		μs
t _{GLGH}	$\overline{\text{PROG}}$ Width	0.2	1	μs
t _{AVQV}	Address to Data Valid		48t _{CLCL}	
t _{ELQV}	$\overline{\text{ENABLE}}$ Low to Data Valid		48t _{CLCL}	
t _{EHQZ}	Data Float After $\overline{\text{ENABLE}}$	0	48t _{CLCL}	
t _{GHBx}	$\overline{\text{PROG}}$ High to $\overline{\text{BUSY}}$ Low		1.0	μs
t _{WC}	Byte Write Cycle Time		50	μs

Figure 6. Flash Programming and Verification Waveforms – Parallel Mode

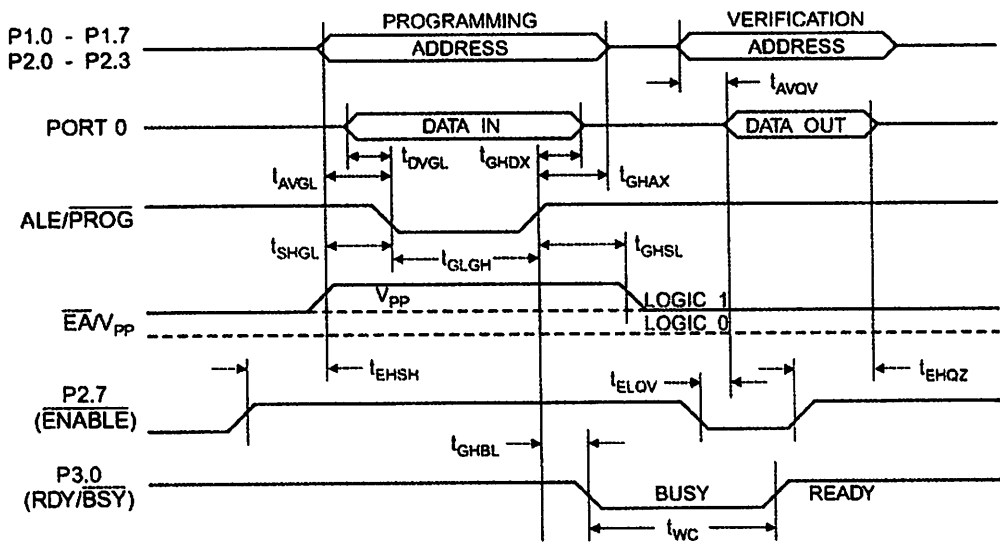
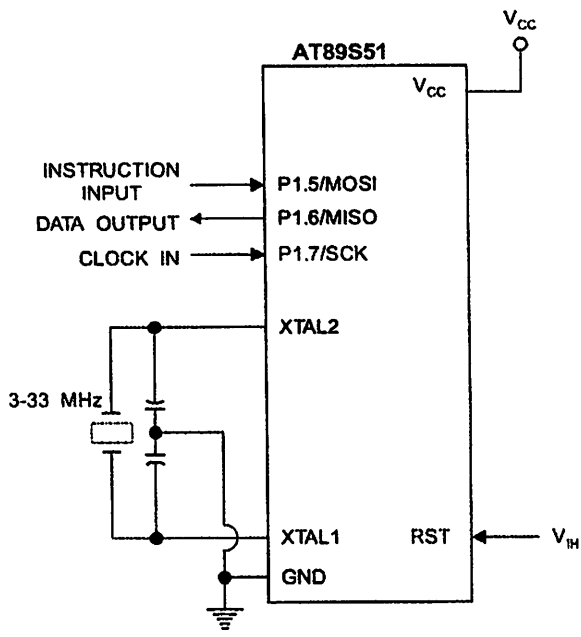


Figure 7. Flash Memory Serial Downloading



Flash Programming and Verification Waveforms – Serial Mode

Figure 8. Serial Programming Waveforms

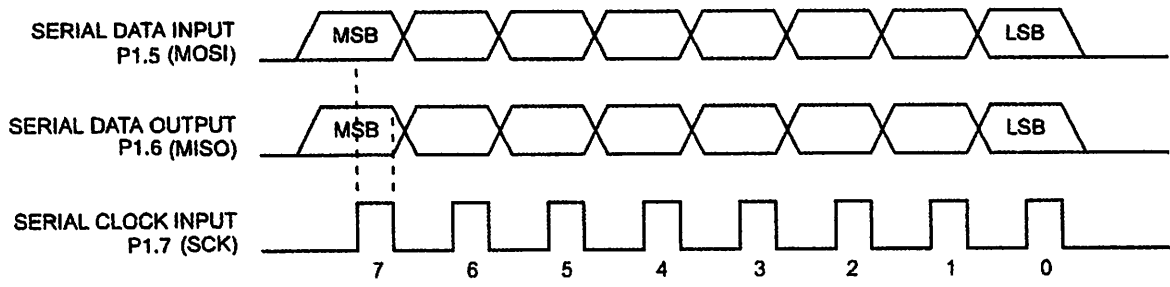


Table 8. Serial Programming Instruction Set

Instruction	Instruction Format				Operation
	Byte 1	Byte 2	Byte 3	Byte 4	
Programming Enable	1010 1100	0101 0011	xxxx xxxx	xxxx xxxx 0110 1001 (Output)	Enable Serial Programming while RST is high
Chip Erase	1010 1100	100x xxxx	xxxx xxxx	xxxx xxxx	Chip Erase Flash memory array
Read Program Memory (Byte Mode)	0010 0000	xxxx A11 A10 A9 A8	A9 A8 A7 A6 A5 A4 A3 A2 A1 A0	A9 A8 A7 A6 A5 A4 A3 A2 A1 A0	Read data from Program memory in the byte mode
Write Program Memory (Byte Mode)	0100 0000	xxxx A11 A10 A9 A8	A9 A8 A7 A6 A5 A4 A3 A2 A1 A0	A9 A8 A7 A6 A5 A4 A3 A2 A1 A0	Write data to Program memory in the byte mode
Write Lock Bits ⁽²⁾	1010 1100	1110 00 1001	xxxx xxxx	xxxx xxxx	Write Lock bits. See Note (2).
Read Lock Bits	0010 0100	xxxx xxxx	xxxx xxxx	xx 00 1001 xx	Read back current status of the lock bits (a programmed lock bit reads back as a "1")
Read Signature Bytes ⁽¹⁾	0010 1000	xxx A5 A4 A3 A2 A1	0 xxx xxxx	Signature Byte	Read Signature Byte
Read Program Memory (Page Mode)	0011 0000	xxxx A11 A10 A9 A8	Byte 0	Byte 1... Byte 255	Read data from Program memory in the Page Mode (256 bytes)
Write Program Memory (Page Mode)	0101 0000	xxxx A11 A10 A9 A8	Byte 0	Byte 1... Byte 255	Write data to Program memory in the Page Mode (256 bytes)

Notes: 1. The signature bytes are not readable in Lock Bit Modes 3 and 4.

2. B1 = 0, B2 = 0 → Mode 1, no lock protection
 B1 = 0, B2 = 1 → Mode 2, lock bit 1 activated
 B1 = 1, B2 = 0 → Mode 3, lock bit 2 activated
 B1 = 1, B2 = 1 → Mode 4, lock bit 3 activated

Each of the lock bits needs to be activated sequentially before Mode 4 can be executed.

After Reset signal is high, SCK should be low for at least 64 system clocks before it goes high to clock in the enable data bytes. No pulsing of Reset signal is necessary. SCK should be no faster than 1/16 of the system clock at XTAL1.

For Page Read/Write, the data always starts from byte 0 to 255. After the command byte and upper address byte are latched, each byte thereafter is treated as data until all 256 bytes are shifted in/out. Then the next instruction will be ready to be decoded.

Serial Programming Characteristics

Figure 9. Serial Programming Timing

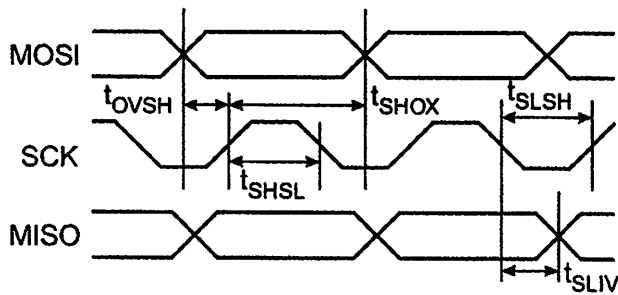


Table 9. Serial Programming Characteristics, $T_A = -40^{\circ}\text{C}$ to 85°C , $V_{CC} = 4.0 - 5.5\text{V}$ (Unless Otherwise Noted)

Symbol	Parameter	Min	Typ	Max	Units
$1/t_{CLCL}$	Oscillator Frequency	0		33	MHz
t_{CLCL}	Oscillator Period	30			ns
t_{SHSL}	SCK Pulse Width High	$8 t_{CLCL}$			ns
t_{SLSH}	SCK Pulse Width Low	$8 t_{CLCL}$			ns
t_{OVSH}	MOSI Setup to SCK High	t_{CLCL}			ns
t_{SHOX}	MOSI Hold after SCK High	$2 t_{CLCL}$			ns
t_{SLIV}	SCK Low to MISO Valid	10	16	32	ns
t_{ERASE}	Chip Erase Instruction Cycle Time			500	ms
t_{SWC}	Serial Byte Write Cycle Time			$64 t_{CLCL} + 400$	μs





Absolute Maximum Ratings*

Operating Temperature.....	-55°C to +125°C
Storage Temperature.....	-65°C to +150°C
Voltage on Any Pin with Respect to Ground	-1.0V to +7.0V
Maximum Operating Voltage	6.6V
DC 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.

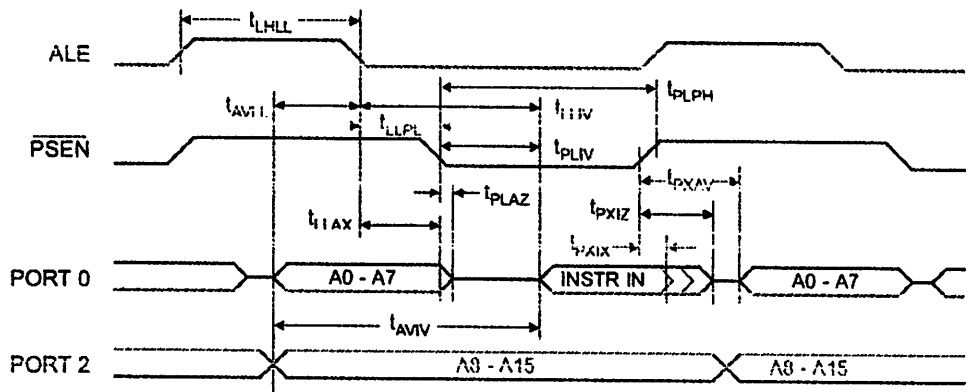
DC Characteristics

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

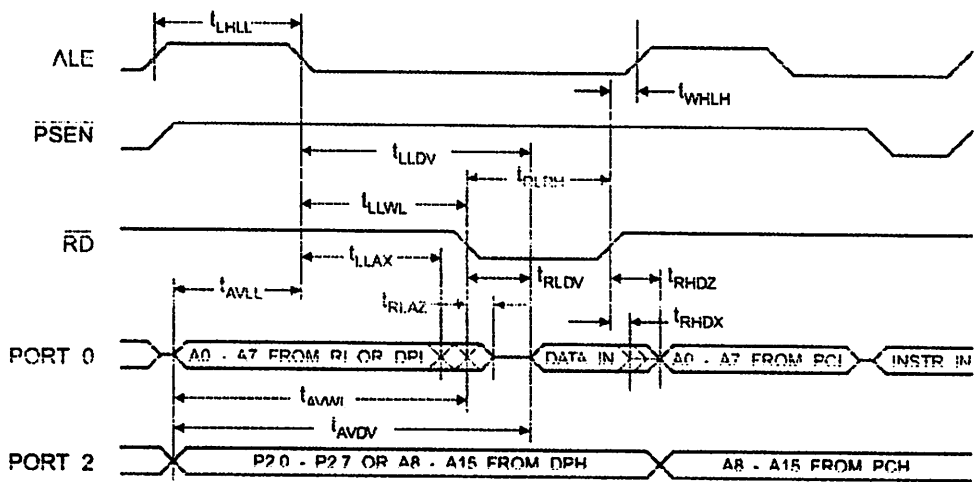
Symbol	Parameter	Condition	Min	Max	Units
V _{IL}	Input Low Voltage	(Except $\overline{EA}$)	-0.5	0.2 V _{CC} -0.1	V
V _{IL1}	Input Low Voltage ($\overline{EA}$)		-0.5	0.2 V _{CC} -0.3	V
V _{IH}	Input High Voltage	(Except XTAL1, RST)	0.2 V _{CC} +0.9	V _{CC} +0.5	V
V _{IH1}	Input High Voltage	(XTAL1, RST)	0.7 V _{CC}	V _{CC} +0.5	V
V _{OL}	Output Low Voltage ⁽¹⁾ (Ports 1,2,3)	I _{OL} = 1.6 mA		0.45	V
V _{OL1}	Output Low Voltage ⁽¹⁾ (Port 0, ALE, $\overline{PSEN}$)	I _{OL} = 3.2 mA		0.45	V
V _{OH}	Output High Voltage (Ports 1,2,3, ALE, $\overline{PSEN}$)	I _{OH} = -60 μ A, V _{CC} = 5V $\pm$ 10%	2.4		V
		I _{OH} = -25 μ A	0.75 V _{CC}		V
		I _{OH} = -10 μ A	0.9 V _{CC}		V
		I _{OH} = -800 μ A, V _{CC} = 5V $\pm$ 10%	2.4		V
V _{OH1}	Output High Voltage (Port 0 in External Bus Mode)	I _{OH} = -300 μ A	0.75 V _{CC}		V
		I _{OH} = -80 μ A	0.9 V _{CC}		V
I _{IL}	Logical 0 Input Current (Ports 1,2,3)	V _{IN} = 0.45V		-50	μ A
	Logical 1 to 0 Transition Current			-650	μ A
	Input Leakage Current (Port 0)			$\pm$ 10	μ A
	External Pullup Resistance			200	Ω
	Input capacitance	Tested at V _{IN} = 0, V _{CC} = 5V		10	pF
	Output capacitance	Tested at V _{OUT} = 0, V _{CC} = 5V		10	pF
	Power supply current	V _{CC} = 5V, f = 0 Hz, T _A = 25°C		100	μ A
	Power supply current	V _{CC} = 5V, f = 1 MHz, T _A = 25°C		100	μ A

NOTES: 1. Under steady state condition specified 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: 20 mA Ports 1, 2, 3: 10 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 operation is 4.0V.

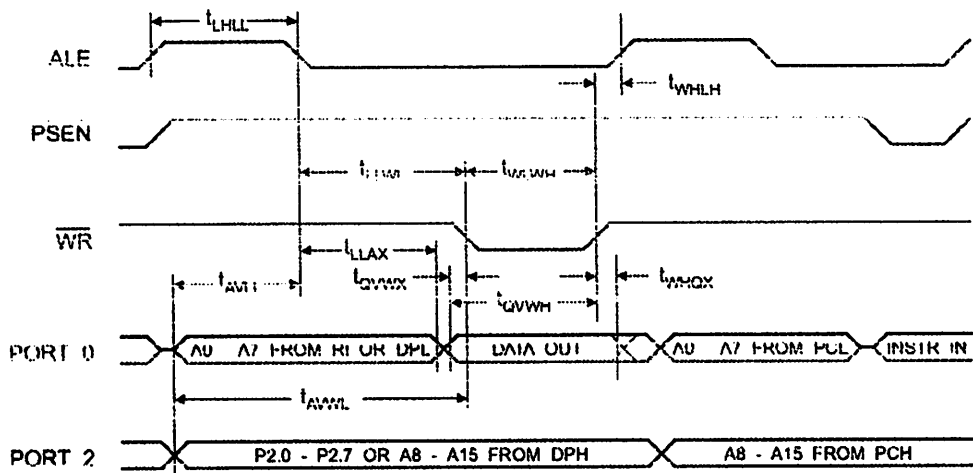
External Program Memory Read Cycle



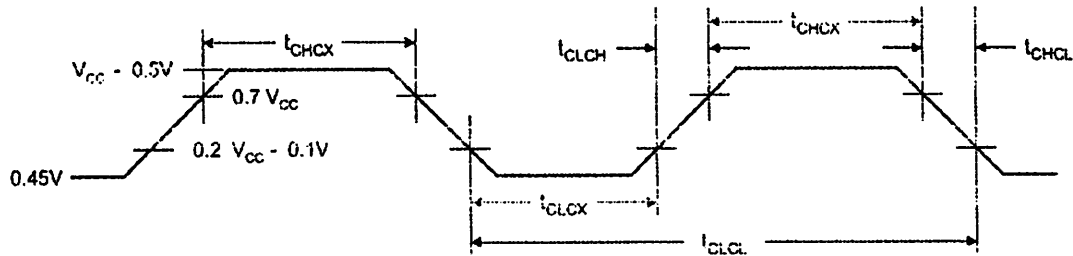
External Data Memory Read Cycle



External Data Memory Write Cycle



External Clock Drive Waveforms



External Clock Drive

Symbol	Parameter	Min	Max	Units
$1/t_{CLL}$	Oscillator Frequency	0	33	MHz
t_{CLL}	Clock Period	30		ns
t_{CHCX}	High Time	12		ns
t_{CLCX}	Low Time	12		ns
t_{CLCH}	Rise Time		5	ns
t_{CHCL}	Fall Time		5	ns

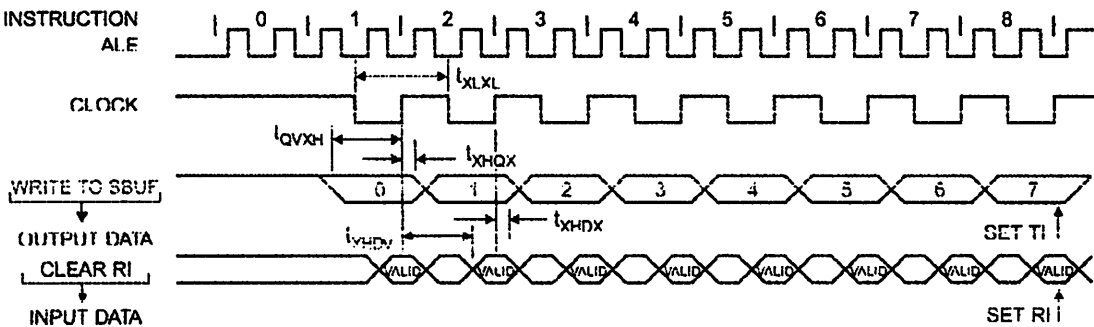


Serial Port Timing: Shift Register Mode Test Conditions

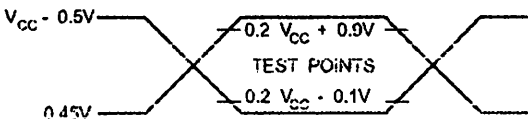
The values in this table are valid for $V_{CC} = 4.0V$ to $5.5V$ and Load Capacitance = 80 pF .

Symbol	Parameter	12 MHz Osc		Variable Oscillator		Units
		Min	Max	Min	Max	
t_{LXL}	Serial Port Clock Cycle Time	1.0		$12t_{CLCL}$		μs
t_{OVXH}	Output Data Setup to Clock Rising Edge	700		$10t_{CLCL}-133$		ns
t_{XHGX}	Output Data Hold After Clock Rising Edge	50		$2t_{CLCL}-80$		ns
t_{XHDX}	Input Data Hold After Clock Rising Edge	0		0		ns
t_{VHDV}	Clock Rising Edge to Input Data Valid		700		$10t_{CLCL}-133$	ns

Shift Register Mode Timing Waveforms

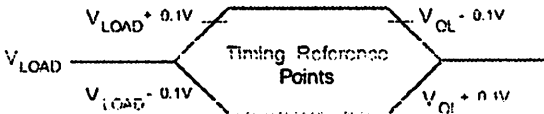


AC Testing Input/Output Waveforms⁽¹⁾



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

Float Waveforms⁽¹⁾



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

Ordering Information

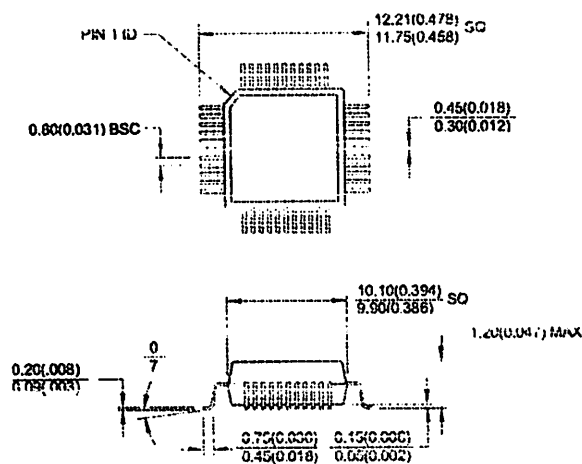
Speed (MHz)	Power Supply	Ordering Code	Package	Operation Range
24	4.0V to 5.5V	AT89S51-24AC	44A	Commercial (0° C to 70° C)
		AT89S51-24JC	44J	
		AT89S51-24PC	40P6	
		AT89S51-24AI	44A	Industrial (-40° C to 85° C)
		AT89S51-24JI	44J	
		AT89S51-24PI	40P6	
33	4.5V to 5.5V	AT89S51-33AC	44A	Commercial (0° C to 70° C)
		AT89S51-33JC	44J	
		AT89S51-33PC	40P6	

= Preliminary Availability

Package Type	
44A	44-lead, Thin Plastic Gull Wing Quad Flatpack (TQFP)
44J	44-lead, Plastic J-leaded Chip Carrier (PLCC)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)

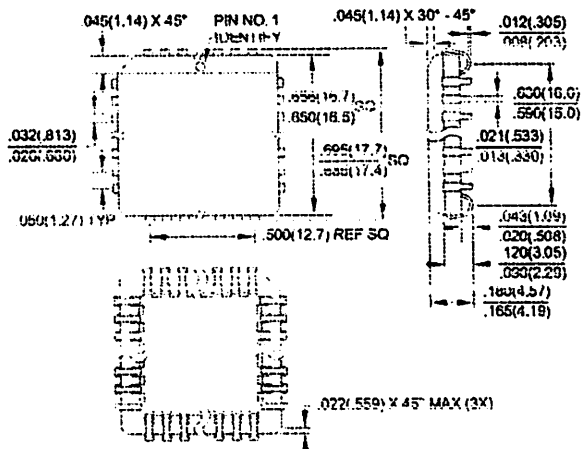
Packaging Information

44A, 44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP)
Dimensions in Millimeters and (Inches)*

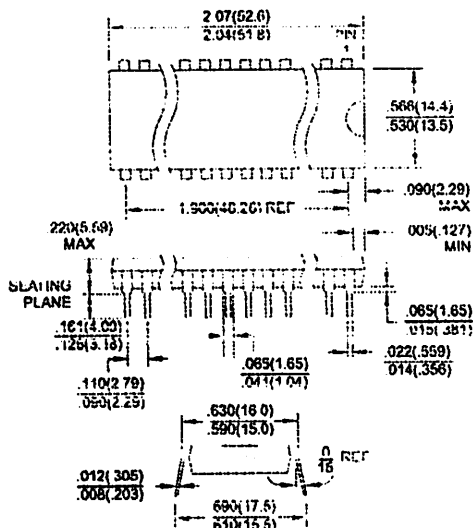


*Controlling dimension: millimeters

44J, 44-lead, Plastic J-leaded Chip Carrier (PLCC)
Dimensions in Inches and (Millimeters)



40P6, 40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
Dimensions in Inches and (Millimeters)
JEDEC STANDARD MS-011 AC





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2487A-10/01/xM



±15kV ESD-Protected, +5V RS-232 Transceivers

General Description

The MAX202E–MAX213E, MAX232E/MAX241E line drivers/receivers are designed for RS-232 and V.28 communications in harsh environments. Each transmitter output and receiver input is protected against ±15kV electrostatic discharge (ESD) shocks, without latchup. The various combinations of features are outlined in the *Selection Guide*. The drivers and receivers for all ten devices meet all EIA/TIA-232E and CCITT V.28 specifications at data rates up to 120kbps, when loaded in accordance with the EIA/TIA-232E specification.

The MAX211E/MAX213E/MAX241E are available in 28-pin SO packages, as well as a 28-pin SSOP that uses 60% less board space. The MAX202E/MAX232E come in 16-pin narrow SO, wide SO, and DIP packages. The MAX203E comes in a 20-pin DIP/SO package, and needs no external charge-pump capacitors. The MAX205E comes in a 24-pin wide DIP package, and also eliminates external charge-pump capacitors. The MAX206E/MAX207E/MAX208E come in 24-pin SO, SSOP, and narrow DIP packages. The MAX232E/MAX241E operate with four 1µF capacitors, while the MAX202E/MAX206E/MAX207E/MAX208E/MAX211E/MAX213E operate with four 0.1µF capacitors, further reducing cost and board space.

Applications

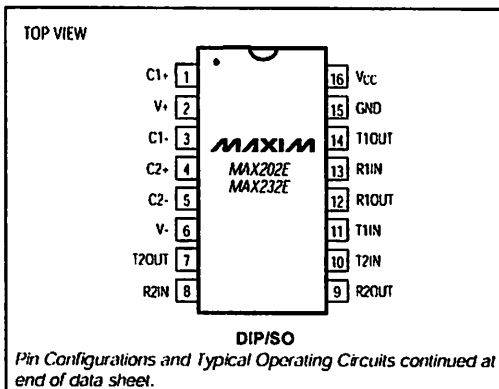
Notebook, Subnotebook, and Palmtop Computers
Battery-Powered Equipment
Hand-Held Equipment

Ordering information appears at end of data sheet.

Features

- ♦ ESD Protection for RS-232 I/O Pins:
 - ±15kV—Human Body Model
 - ±8kV—IEC1000-4-2, Contact Discharge
 - ±15kV—IEC1000-4-2, Air-Gap Discharge
- ♦ Latchup Free (unlike bipolar equivalents)
- ♦ Guaranteed 120kbps Data Rate—LapLink™ Compatible
- ♦ Guaranteed 3V/µs Min Slew Rate
- ♦ Operate from a Single +5V Power Supply

Pin Configurations



Selection Guide

PART	No. of RS-232 DRIVERS	No. of RS-232 RECEIVERS	RECEIVERS ACTIVE IN SHUTDOWN	No. of EXTERNAL CAPACITORS	LOW-POWER SHUTDOWN	TTL THREE-STATE
MAX202E	2	2	0	4 (0.1µF)	No	No
MAX203E	2	2	0	None	No	No
MAX205E	5	5	0	None	Yes	Yes
MAX206E	4	3	0	4 (0.1µF)	Yes	Yes
MAX207E	5	3	0	4 (0.1µF)	No	No
MAX208E	4	4	0	4 (0.1µF)	No	No
MAX211E	4	5	0	4 (0.1µF)	Yes	Yes
MAX213E	4	5	2	4 (0.1µF)	Yes	Yes
MAX232E	2	2	0	4 (1µF)	No	No
MAX241E	4	5	0	4 (1µF)	Yes	Yes

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Maxim Integrated Products 1

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MAX202E–MAX213E, MAX232E/MAX241E

±15kV ESD-Protected, +5V RS-232 Transceivers

ABSOLUTE MAXIMUM RATINGS

VCC	0.3V to +6V	20-Pin SO (derate 10.00mW/°C above +70°C).....800mW
V+	(VCC - 0.3V) to +14V	24-Pin Narrow Plastic DIP
V-	-14V to +0.3V	(derate 13.33mW/°C above +70°C) 1.07W
Input Voltages		24-Pin Wide Plastic DIP
T_IN	0.3V to (V+ + 0.3V)	(derate 14.29mW/°C above +70°C) 1.14W
R_IN	±30V	24-Pin SO (derate 11.76mW/°C above +70°C).....941mW
Output Voltages		24-Pin SSOP (derate 8.00mW/°C above +70°C) 640mW
T_OUT	(V- - 0.3V) to (V+ + 0.3V)	28-Pin SO (derate 12.50mW/°C above +70°C).....1W
R_OUT	-0.3V to (VCC + 0.3V)	28-Pin SSOP (derate 9.52mW/°C above +70°C) 762mW
Short-Circuit Duration, T_OUT		Operating Temperature Ranges
Continuous Power Dissipation (TA = +70°C)		MAX2_ _EC_ _ 0°C to +70°C
16-Pin Plastic DIP (derate 10.53mW/°C above +70°C).....842mW		MAX2_ _EE_ _-40°C to +85°C
16-Pin Narrow SO (derate 8.70mW/°C above +70°C) 696mW		Storage Temperature Range-65°C to +165°C
16-Pin Wide SO (derate 9.52mW/°C above +70°C) 762mW		Lead Temperature (soldering, 10sec)+300°C
20-Pin Plastic DIP (derate 11.11mW/°C above +70°C).....889mW		

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

ELECTRICAL CHARACTERISTICS

(VCC = +5V ±10% for MAX202E/206E/208E/211E/213E/232E/241E; VCC = +5V ±5% for MAX203E/205E/207E; C1-C4 = 0.1µF for MAX202E/206E/207E/208E/211E/213E; C1-C4 = 1µF for MAX232E/241E; TA = TMIN to TMAX; unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DC CHARACTERISTICS							
Vcc Supply Current	Icc	No load, TA = +25°C	MAX202E/203E	8	15	mA	
			MAX205E-208E	11	20		
			MAX211E/213E	14	20		
			MAX232E	5	10		
			MAX241E	7	15		
Shutdown Supply Current		TA = +25°C, Figure 1	MAX205E/206E	1	10	µA	
			MAX211E/241E	1	10		
			MAX213E	15	50		
LOGIC							
Input Pull-Up Current		T_IN = 0V (MAX205E-208E/211E/213E/241E)		15	200	µA	
Input Leakage Current		T_IN = 0V to VCC (MAX202E/203E/232E)		±10		µA	
Input Threshold Low	VIL	T_IN; EN, SHDN (MAX213E) or EN, SHDN (MAX205E-208E/211E/241E)		0.8		V	
Input Threshold High	VIH	T_IN		2.0		V	
		EN, SHDN (MAX213E) or EN, SHDN (MAX205E-208E/211E/241E)		2.4			
Output Voltage Low	VOL	R_OUT; IOUT = 3.2mA (MAX202E/203E/232E) or IOUT = 1.6mA (MAX205E/208E/211E/213E/241E)		0.4		V	
Output Voltage High	VOH	R_OUT; IOUT = -1.0mA		3.5 VCC - 0.4		V	
Output Leakage Current		EN = VCC, EN = 0V, 0V ≤ ROUT ≤ VCC, MAX205E-208E/211E/213E/241E outputs disabled		±0.05	±10	µA	

±15kV ESD-Protected, +5V RS-232 Transceivers

ELECTRICAL CHARACTERISTICS (continued)

(VCC = +5V ±10% for MAX202E/206E/208E/211E/213E/232E/241E; VCC = +5V ±5% for MAX203E/205E/207E; C1-C4 = 0.1µF for MAX202E/206E/207E/208E/211E/213E; C1-C4 = 1µF for MAX232E/241E; TA = TMIN to TMAX; unless otherwise noted. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
EIA/TIA-232E RECEIVER INPUTS							
Input Voltage Range				-30		30	V
Input Threshold Low		T _A = +25°C, V _{CC} = 5V	All parts, normal operation	0.8	1.2		V
			MAX213E, SHDN = 0V, EN = V _{CC}	0.6	1.5		
Input Threshold High		T _A = +25°C, V _{CC} = 5V	All parts, normal operation		1.7	2.4	V
			MAX213E (R4, R5), SHDN = 0V, EN = V _{CC}		1.5	2.4	
Input Hysteresis		V _{CC} = 5V, no hysteresis in shutdown		0.2	0.5	1.0	V
Input Resistance		T _A = +25°C, V _{CC} = 5V		3	5	7	kΩ
EIA/TIA-232E TRANSMITTER OUTPUTS							
Output Voltage Swing		All drivers loaded with 3kΩ to ground (Note 1)		±5	±9		V
Output Resistance		V _{CC} = V ₊ = V ₋ = 0V, V _{OUT} = ±2V		300			Ω
Output Short-Circuit Current					±10	±60	mA
TIMING CHARACTERISTICS							
Maximum Data Rate		R _I = 3kΩ to 7kΩ, C _I = 50pF to 1000pF, one transmitter switching		120			kbps
Receiver Propagation Delay	t _{PLIR} , t _{PHLR}	C _L = 150pF	All parts, normal operation		0.5	10	μs
			MAX213E (R4, R5), SHDN = 0V, EN = V _{CC}		4	40	
Receiver Output Enable Time		MAX205E/206E/211E/213E/241E normal operation, Figure 2			600		ns
Receiver Output Disable Time		MAX205E/206E/211E/213E/241E normal operation, Figure 2			200		ns
Transmitter Propagation Delay	t _{PLHT} , t _{PHLT}	R _L = 3kΩ, C _L = 2500pF, all transmitters loaded			2		μs
Transition-Region Slew Rate		T _A = +25°C, V _{CC} = 5V, R _L = 3kΩ to 7kΩ, C _L = 50pF to 1000pF, measured from -3V to +3V or +3V to -3V, Figure 3		3	6	30	V/μs
ESD PERFORMANCE: TRANSMITTER OUTPUTS, RECEIVER INPUTS							
ESD Protection Voltage		Human Body Model			±15		kV
		IEC1000 4 2, Contact Discharge			±8		
		IEC1000 4 2, Air Gap Discharge			±15		

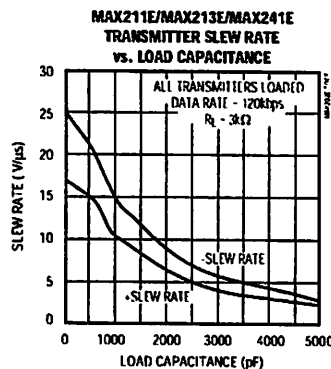
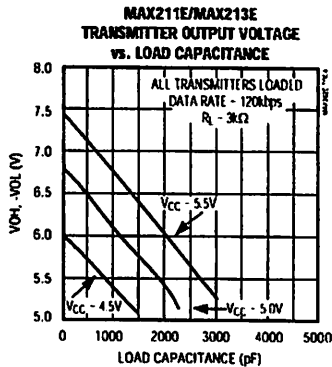
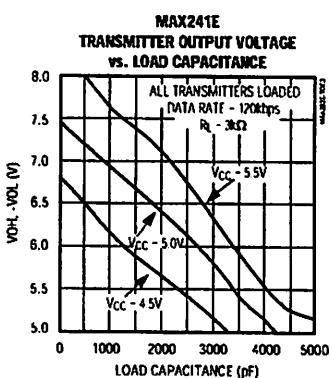
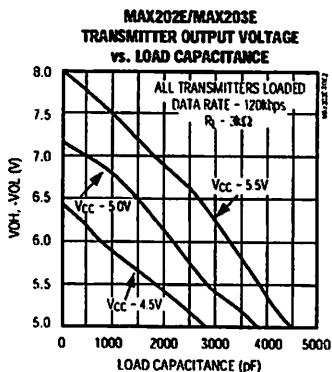
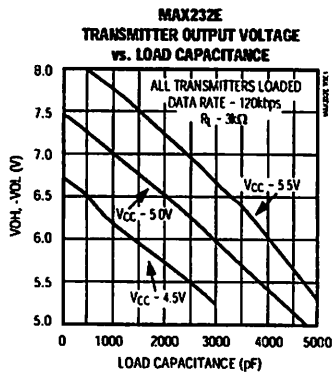
Note 1: MAX211EE_ _ tested with VCC = +5V ±5%.

MAX202E-MAX213E, MAX232E/MAX241E

±15kV ESD-Protected, +5V RS-232 Transceivers

Typical Operating Characteristics

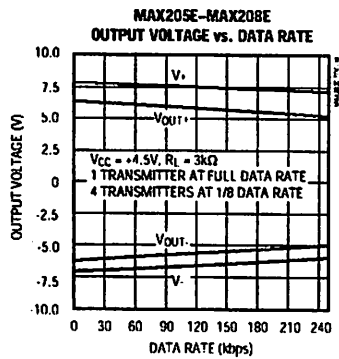
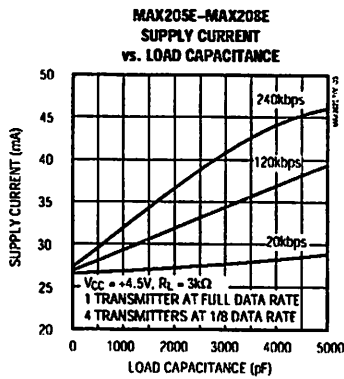
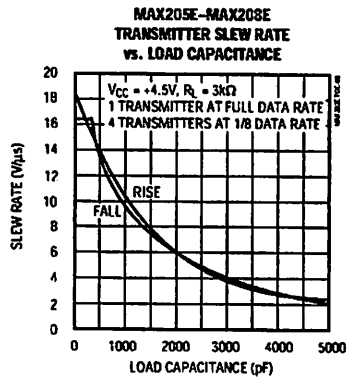
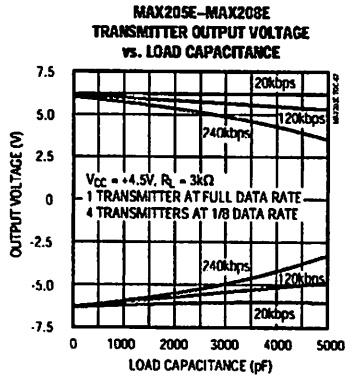
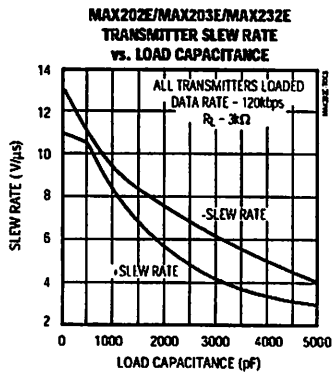
(Typical Operating Circuits, VCC = +5V, TA = +25°C, unless otherwise noted.)



±15kV ESD-Protected, +5V RS-232 Transceivers

Typical Operating Characteristics (continued)

(Typical Operating Circuits, VCC = +5V, TA = +25°C, unless otherwise noted.)



MAX202E-MAX213E, MAX232E/MAX241E

±15kV ESD-Protected, +5V RS-232 Transceivers

Pin Descriptions

MAX202E/MAX232E

PIN		NAME	FUNCTION
DIP/SO	LCC		
1, 3	2, 4	C1+, C1-	Terminals for positive charge-pump capacitor
2	3	V+	+2V _{CC} voltage generated by the charge pump
4, 5	5, 7	C2+, C2-	Terminals for negative charge-pump capacitor
6	8	V-	-2V _{CC} voltage generated by the charge pump
7, 14	9, 18	T_OUT	RS-232 Driver Outputs
8, 13	10, 17	R_IN	RS-232 Receiver Outputs
9, 12	12, 15	R_OUT	RS-232 Receiver Outputs
10, 11	13, 14	T_IN	RS-232 Driver Inputs
15	19	GND	Ground
16	20	V _{CC}	+4.5V to +5.5V Supply-Voltage Input
—	1, 6, 11, 16	N.C.	No Connect—not internally connected.

MAX203E

PIN		NAME	FUNCTION
DIP	SO		
1, 2	1, 2	T_IN	RS-232 Driver Inputs
3, 20	3, 20	R_OUT	RS-232 Receiver Outputs
4, 19	4, 19	R_IN	RS-232 Receiver Inputs
5, 18	5, 18	T_OUT	RS-232 Transmitter Outputs
6, 9	6, 9	GND	Ground
7	7	V _{CC}	+4.5V to +5.5V Supply-Voltage Input
8	13	C1+	Make no connection to this pin.
10, 16	11, 16	C2-	Connect pins together.
12, 17	10, 17	V-	-2V _{CC} voltage generated by the charge pump. Connect pins together.
13	14	C1-	Make no connection to this pin.
14	8	V+	+2V _{CC} voltage generated by the charge pump
11, 15	12, 15	C2+	Connect pins together.

MAX205E

PIN	NAME	FUNCTION
1–4, 19	T_OUT	RS-232 Driver Outputs
5, 10, 13, 18, 24	R_IN	RS-232 Receiver Inputs
6, 9, 14, 17, 23	R_OUT	TTL/CMOS Receiver Outputs. All receivers are inactive in shutdown.
7, 8, 15, 16, 22	T_IN	TTL/CMOS Driver Inputs. Internal pull-ups to V _{CC} .
11	GND	Ground
12	V _{CC}	+4.75V to +5.25V Supply Voltage
20	EN	Receiver Enable—active low
21	SHDN	Shutdown Control—active high

±15kV ESD-Protected, +5V RS-232 Transceivers

Pin Descriptions (continued)

MAX206E

PIN	NAME	FUNCTION
1, 2, 3, 24	T_OUT	RS-232 Driver Outputs
4, 16, 23	R_IN	RS-232 Receiver Inputs
5, 17, 22	R_OUT	TTL/CMOS Receiver Outputs. All receivers are inactive in shutdown.
6, 7, 18, 19	T_IN	TTL/CMOS Driver Inputs. Internal pull-ups to V _{CC} .
8	GND	Ground
9	V _{CC}	+4.5V to +5.5V Supply Voltage
10, 12	C1+, C1-	Terminals for positive charge-pump capacitor
11	V+	+2V _{CC} generated by the charge pump
13, 14	C2+, C2-	Terminals for negative charge-pump capacitor
15	V-	-2V _{CC} generated by the charge pump
20	EN	Receiver Enable—active low
21	SHDN	Shutdown Control—active high

MAX207E

PIN	NAME	FUNCTION
1, 2, 3, 20, 24	T_OUT	RS-232 Driver Outputs
4, 16, 23	R_IN	RS-232 Receiver Inputs
5, 17, 22	R_OUT	TTL/CMOS Receiver Outputs. All receivers are inactive in shutdown.
6, 7, 18, 19, 21	T_IN	TTL/CMOS Driver Inputs. Internal pull-ups to V _{CC} .
8	GND	Ground
9	V _{CC}	+4.75V to +5.25V Supply Voltage
10, 12	C1+, C1-	Terminals for positive charge-pump capacitor
11	V+	+2V _{CC} generated by the charge pump
13, 14	C2+, C2-	Terminals for negative charge-pump capacitor
15	V-	-2V _{CC} generated by the charge pump

MAX208E

PIN	NAME	FUNCTION
1, 2, 20, 24	T_OUT	RS-232 Driver Outputs
3, 7, 16, 23	R_IN	RS-232 Receiver Inputs
4, 6, 17, 22	R_OUT	TTL/CMOS Receiver Outputs. All receivers are inactive in shutdown.
5, 18, 19, 21	T_IN	TTL/CMOS Driver Inputs. Internal pull-ups to V _{CC} .
8	GND	Ground
9	V _{CC}	+4.5V to +5.5V Supply Voltage
10, 12	C1+, C1-	Terminals for positive charge-pump capacitor
11	V+	+2V _{CC} generated by the charge pump
13, 14	C2+, C2-	Terminals for negative charge-pump capacitor
15	V-	-2V _{CC} generated by the charge pump

±15kV ESD-Protected, +5V RS-232 Transceivers

Pin Descriptions (continued)

MAX211E/MAX213E/MAX241E

PIN	NAME	FUNCTION
1, 2, 3, 28	T_OUT	RS-232 Driver Outputs
4, 9, 18, 23, 27	R_IN	RS-232 Receiver Inputs
5, 8, 19, 22, 26	R_OUT	TTL/CMOS Receiver Outputs. For the MAX213E, receivers R4 and R5 are active in shutdown mode when EN = 1. For the MAX211E and MAX241E, all receivers are inactive in shutdown.
6, 7, 20, 21	T_IN	TTL/CMOS Driver Inputs. Only the MAX211E, MAX213E, and MAX241E have internal pull-ups to VCC.
10	GND	Ground
11	VCC	+4.5V to +5.5V Supply Voltage
12, 14	C1+, C1-	Terminals for positive charge-pump capacitor
13	V+	+2VCC voltage generated by the charge pump
15, 16	C2+, C2-	Terminals for negative charge-pump capacitor
17	V-	-2VCC voltage generated by the charge pump
24	EN	Receiver Enable—active low (MAX211E, MAX241E)
	EN	Receiver Enable—active high (MAX213E)
25	SHDN	Shutdown Control—active high (MAX211E, MAX241E)
	SHDN	Shutdown Control—active low (MAX213E)

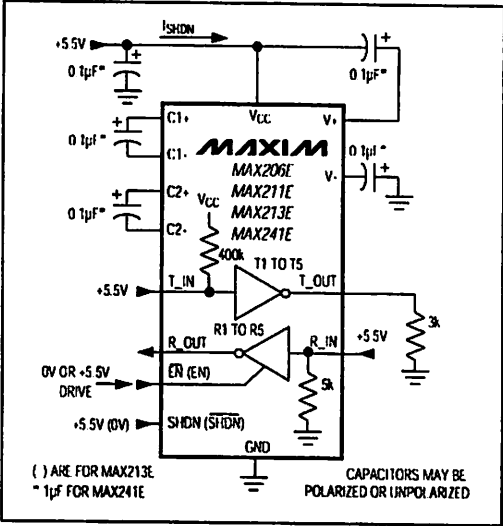


Figure 1. Shutdown-Current Test Circuit (MAX206E, MAX211E/MAX213E/MAX241E)

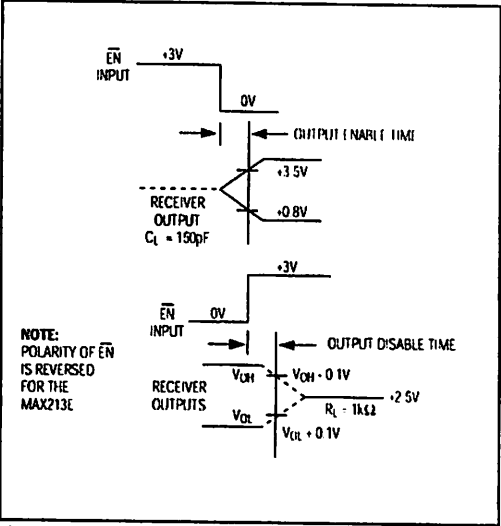


Figure 2. Receiver Output Enable and Disable Timing (MAX205E/MAX206E/MAX211E/MAX213E/MAX241E)

±15kV ESD-Protected, +5V RS-232 Transceivers

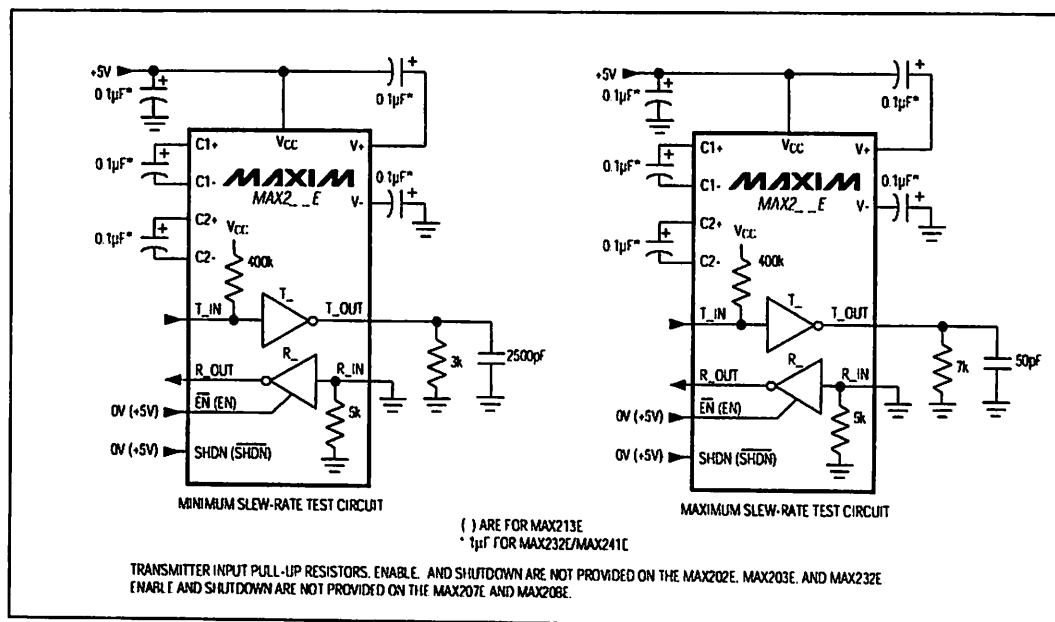


Figure 3. Transition Slew-Rate Circuit

Detailed Description

The MAX202E-MAX213E, MAX232E/MAX241E consist of three sections: charge-pump voltage converters, drivers (transmitters), and receivers. These E versions provide extra protection against ESD. They survive ±15kV discharges to the RS-232 inputs and outputs, tested using the Human Body Model. When tested according to IEC1000-4-2, they survive ±8kV contact-discharges and ±15kV air-gap discharges. The rugged E versions are intended for use in harsh environments or applications where the RS-232 connection is frequently changed (such as notebook computers). The standard (non-"E") MAX202, MAX203, MAX205-MAX208, MAX211, MAX213, MAX232, and MAX241 are recommended for applications where cost is critical.

+5V to ±10V Dual Charge-Pump Voltage Converter

The +5V to ±10V conversion is performed by dual charge-pump voltage converters (Figure 4). The first charge-pump converter uses capacitor C1 to double the +5V into +10V, storing the +10V on the output filter capacitor, C3. The second uses C2 to invert the +10V

into -10V, storing the -10V on the V- output filter capacitor, C4.

In shutdown mode, V+ is internally connected to VCC by a 1kΩ pull-down resistor, and V- is internally connected to ground by a 1kΩ pull-up resistor.

RS-232 Drivers

With VCC = 5V, the typical driver output voltage swing is ±8V when loaded with a nominal 5kΩ RS-232 receiver. The output swing is guaranteed to meet EIA/TIA-232E and V.28 specifications that call for ±5V minimum output levels under worst-case conditions. These include a 3kΩ load, minimum VCC, and maximum operating temperature. The open-circuit output voltage swings from (V+ - 0.6V) to V-.

Input thresholds are CMOS/TTL compatible. The unused drivers' inputs on the MAX205E-MAX208E, MAX211E, MAX213E, and MAX241E can be left unconnected because 400kΩ pull-up resistors to VCC are included on-chip. Since all drivers invert, the pull-up resistors force the unused drivers' outputs low. The MAX202E, MAX203E, and MAX232E do not have pull-up resistors on the transmitter inputs.

±15kV ESD-Protected, +5V RS-232 Transceivers

When in low-power shutdown mode, the MAX205E/MAX206E/MAX211E/MAX213E/MAX241E driver outputs are turned off and draw only leakage currents—even if they are back-driven with voltages between 0V and 12V. Below -0.5V in shutdown, the transmitter output is diode-clamped to ground with a 1kΩ series impedance.

RS-232 Receivers

The receivers convert the RS-232 signals to CMOS-logic output levels. The guaranteed 0.8V and 2.4V receiver input thresholds are significantly tighter than the ±3V thresholds required by the EIA/TIA-232E specification. This allows the receiver inputs to respond to TTL/CMOS-logic levels, as well as RS-232 levels.

The guaranteed 0.8V input low threshold ensures that receivers shorted to ground have a logic 1 output. The 5kΩ input resistance to ground ensures that a receiver with its input left open will also have a logic 1 output.

Receiver inputs have approximately 0.5V hysteresis. This provides clean output transitions, even with slow rise/fall-time signals with moderate amounts of noise and ringing.

In shutdown, the MAX213E's R4 and R5 receivers have no hysteresis.

Shutdown and Enable Control (MAX205E/MAX206E/MAX211E/ MAX213E/MAX241E)

In shutdown mode, the charge pumps are turned off. V₊ is pulled down to V_{CC}. V₋ is pulled to ground, and the transmitter outputs are disabled. This reduces supply current typically to 1μA (15μA for the MAX213E). The time required to exit shutdown is under 1ms, as shown in Figure 5.

Receivers

All MAX213E receivers, except R4 and R5, are put into a high-impedance state in shutdown mode (see Tables 1a and 1b). The MAX213E's R4 and R5 receivers still function in shutdown mode. These two awake-in-shutdown receivers can monitor external activity while maintaining minimal power consumption.

The enable control is used to put the receiver outputs into a high-impedance state, to allow wire-OR connection of two EIA/TIA-232E ports (or ports of different types) at the UART. It has no effect on the RS-232 drivers or the charge pumps.

Note: The enable control pin is active low for the MAX211E/MAX241E (EN), but is active high for the MAX213E (EN). The shutdown control pin is active high for the MAX205E/MAX206E/MAX211E/MAX241E (SHDN), but is active low for the MAX213E (SHDN).

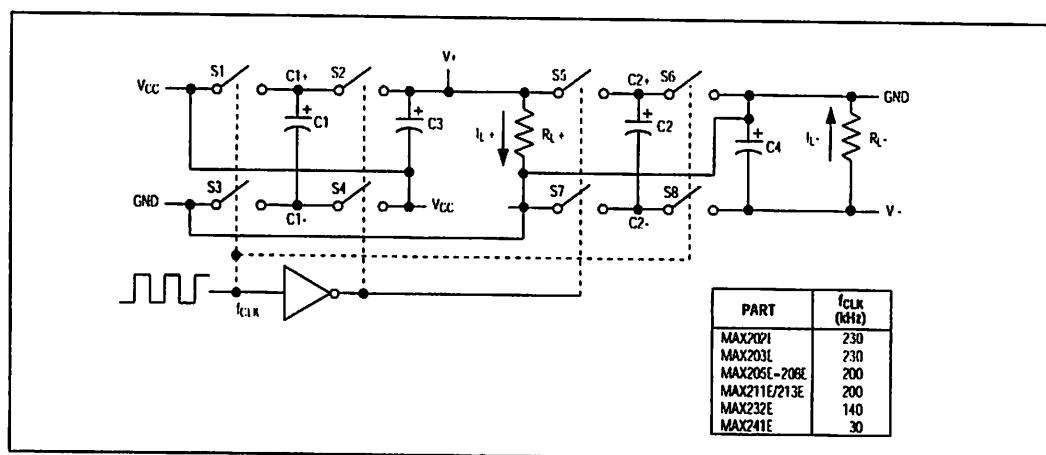


Figure 4. Charge-Pump Diagram

±15kV ESD-Protected, +5V RS-232 Transceivers

The MAX213E's receiver propagation delay is typically 0.5µs in normal operation. In shutdown mode, propagation delay increases to 4µs for both rising and falling transitions. The MAX213E's receiver inputs have approximately 0.5V hysteresis, except in shutdown, when receivers R4 and R5 have no hysteresis.

When entering shutdown with receivers active, R4 and R5 are not valid until 80µs after SHDN is driven low. When coming out of shutdown, all receiver outputs are invalid until the charge pumps reach nominal voltage levels (less than 2ms when using 0.1µF capacitors).

±15kV ESD Protection

As with all Maxim devices, ESD-protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The driver outputs and receiver inputs have extra protection against static electricity. Maxim's engineers developed state-of-the-art structures to protect these pins against ESD of ±15kV without damage. The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. After an ESD event, Maxim's E versions keep working without latchup, whereas competing RS-232 products can latch and must be powered down to remove latchup.

ESD protection can be tested in various ways: the transmitter outputs and receiver inputs of this product family are characterized for protection to the following limits:

- 1) +15kV using the Human Body Model
- 2) +8kV using the contact-discharge method specified in IEC1000-4-2
- 3) ±15kV using IEC1000-4-2's air-gap method.

ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test set-up, test methodology, and test results.

Human Body Model

Figure 6a shows the Human Body Model, and Figure 6b shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5kΩ resistor.

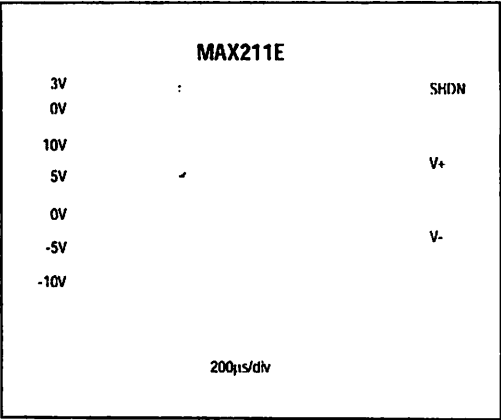


Figure 5. MAX211E V+ and V- when Exiting Shutdown (0.1µF capacitors)

Table 1a. MAX205E/MAX206E/MAX211E/MAX241E Control Pin Configurations

SHDN	EN	OPERATION STATUS	Tx	Rx
0	0	Normal Operation	All Active	All Active
0	1	Normal Operation	All Active	All High-Z
1	X	Shutdown	All High-Z	All High-Z

X = Don't Care

Table 1b. MAX213E Control Pin Configurations

SHDN	EN	OPERATION STATUS	Tx 1-4	Rx	
				1-3	4, 5
0	0	Shutdown	All High-Z	High-Z	High-Z
0	1	Shutdown	All High-Z	High-Z	Active*
1	0	Normal Operation	All Active	High-Z	High-Z
1	1	Normal Operation	All Active	Active	Active

*Active = active with reduced performance

±15kV ESD-Protected, +5V RS-232 Transceivers

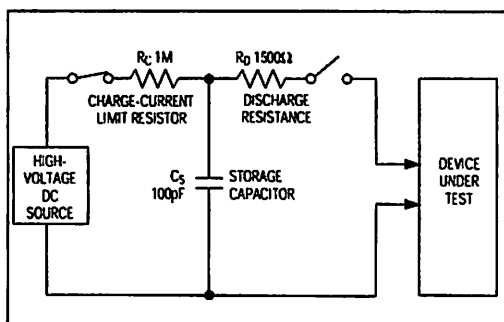


Figure 6a. Human Body ESD Test Model

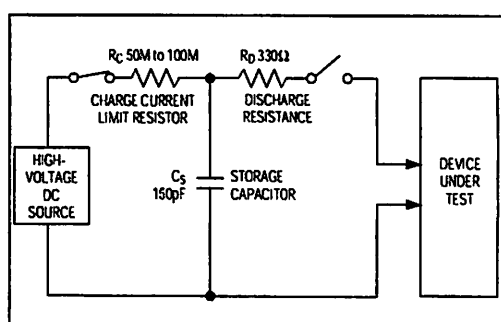


Figure 7a. IEC1000-4-2 ESD Test Model

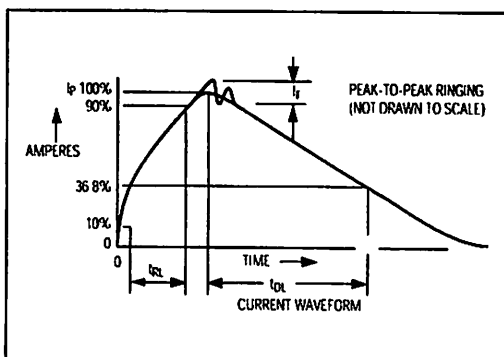


Figure 6b. Human Body Model Current Waveform

IEC1000-4-2

The IEC1000-4-2 standard covers ESD testing and performance of finished equipment; it does not specifically refer to integrated circuits. The MAX202E/MAX203E-MAX213E, MAX232E/MAX241E help you design equipment that meets level 4 (the highest level) of IEC1000-4-2, without the need for additional ESD-protection components.

The major difference between tests done using the Human Body Model and IEC1000-4-2 is higher peak current in IEC1000-4-2, because series resistance is lower in the IEC1000-4-2 model. Hence, the ESD withstand voltage measured to IEC1000-4-2 is generally lower than that measured using the Human Body Model. Figure 7b shows the current waveform for the 8kV IEC1000-4-2 level-four ESD contact-discharge test.

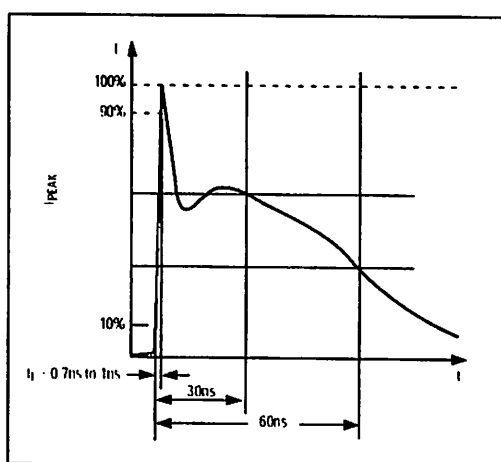


Figure 7b. IEC1000-4-2 ESD Generator Current Waveform

The air-gap test involves approaching the device with a charged probe. The contact-discharge method connects the probe to the device before the probe is energized.

Machine Model

The Machine Model for ESD tests all pins using a 200pF storage capacitor and zero discharge resistance. Its objective is to emulate the stress caused by contact that occurs with handling and assembly during manufacturing. Of course, all pins require this protection during manufacturing, not just RS-232 inputs and outputs. Therefore, after PC board assembly, the Machine Model is less relevant to I/O ports.

±15kV ESD-Protected, +5V RS-232 Transceivers

Applications Information

Capacitor Selection

The capacitor type used for C1-C4 is not critical for proper operation. The MAX202E, MAX206-MAX208E, MAX211E, and MAX213E require 0.1µF capacitors, and the MAX232E and MAX241E require 1µF capacitors, although in all cases capacitors up to 10µF can be used without harm. Ceramic, aluminum-electrolytic, or tantalum capacitors are suggested for the 1µF capacitors, and ceramic dielectrics are suggested for the 0.1µF capacitors. When using the minimum recommended capacitor values, make sure the capacitance value does not degrade excessively as the operating temperature varies. If in doubt, use capacitors with a larger (e.g., 2x) nominal value. The capacitors' effective series resistance (ESR), which usually rises at low temperatures, influences the amount of ripple on V+ and V-.

Use larger capacitors (up to 10µF) to reduce the output impedance at V+ and V-. This can be useful when "stealing" power from V+ or from V-. The MAX203E and MAX205E have internal charge-pump capacitors.

Bypass VCC to ground with at least 0.1µF. In applications sensitive to power-supply noise generated by the charge pumps, decouple VCC to ground with a

capacitor the same size as (or larger than) the charge-pump capacitors (C1-C4).

V+ and V- as Power Supplies

A small amount of power can be drawn from V+ and V-, although this will reduce both driver output swing and noise margins. Increasing the value of the charge-pump capacitors (up to 10µF) helps maintain performance when power is drawn from V+ or V-.

Driving Multiple Receivers

Each transmitter is designed to drive a single receiver. Transmitters can be paralleled to drive multiple receivers.

Driver Outputs when Exiting Shutdown

The driver outputs display no ringing or undesirable transients as they come out of shutdown.

High Data Rates

These transceivers maintain the RS-232 ±5.0V minimum driver output voltages at data rates of over 120kbps. For data rates above 120kbps, refer to the Transmitter Output Voltage vs. Load Capacitance graphs in the *Typical Operating Characteristics*. Communication at these high rates is easier if the capacitive loads on the transmitters are small; i.e., short cables are best.

Table 2. Summary of EIA/TIA-232E, V.28 Specifications

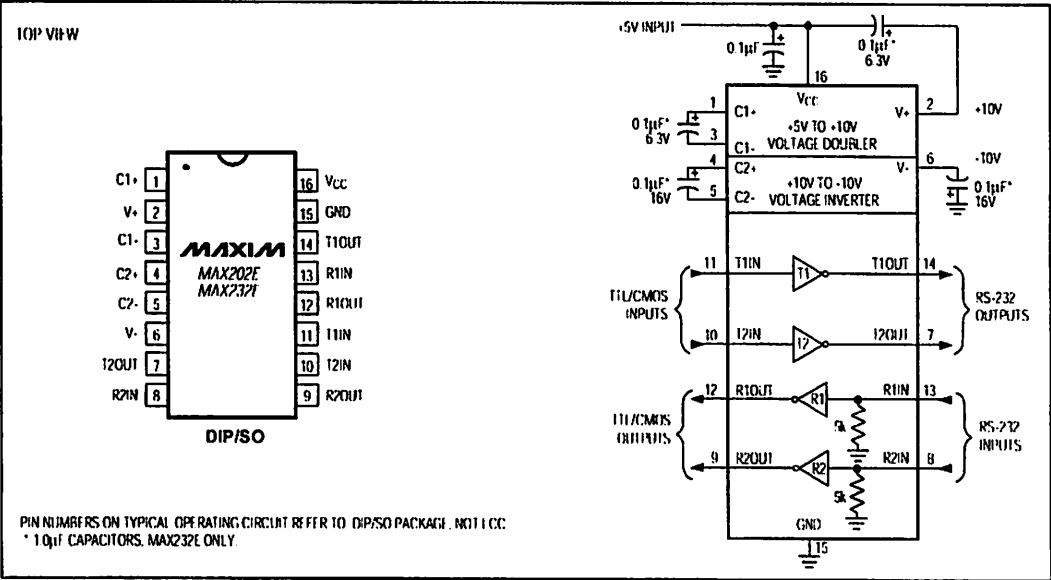
PARAMETER		CONDITIONS	EIA/TIA-232E, V.28 SPECIFICATIONS
Driver Output Voltage	0 Level	3kΩ to 7kΩ load	+5V to +15V
	1 Level	3kΩ to 7kΩ load	-5V to -15V
Driver Output Level, Max		No load	±25V
Data Rate		3kΩ ≤ R _L ≤ 7kΩ, C _L ≤ 2500pF	Up to 20kbps
Receiver Input Voltage	0 Level		+3V to +15V
	1 Level		-3V to -15V
Receiver Input Level			±25V
Instantaneous Slew Rate, Max		3kΩ ≤ R _L ≤ 7kΩ, C _L ≤ 2500pF	30V/μs
Driver Output Short-Circuit Current, Max			100mA
Transition Rate on Driver Output		V.28	1ms or 3% of the period
		EIA/TIA-232E	4% of the period
Driver Output Resistance		-2V < V _{OUT} < +2V	300Ω

±15kV ESD-Protected, +5V RS-232 Transceivers

Table 3. DB9 Cable Connections
Commonly Used for EIA/TIAE-232E and
V.24 Asynchronous Interfaces

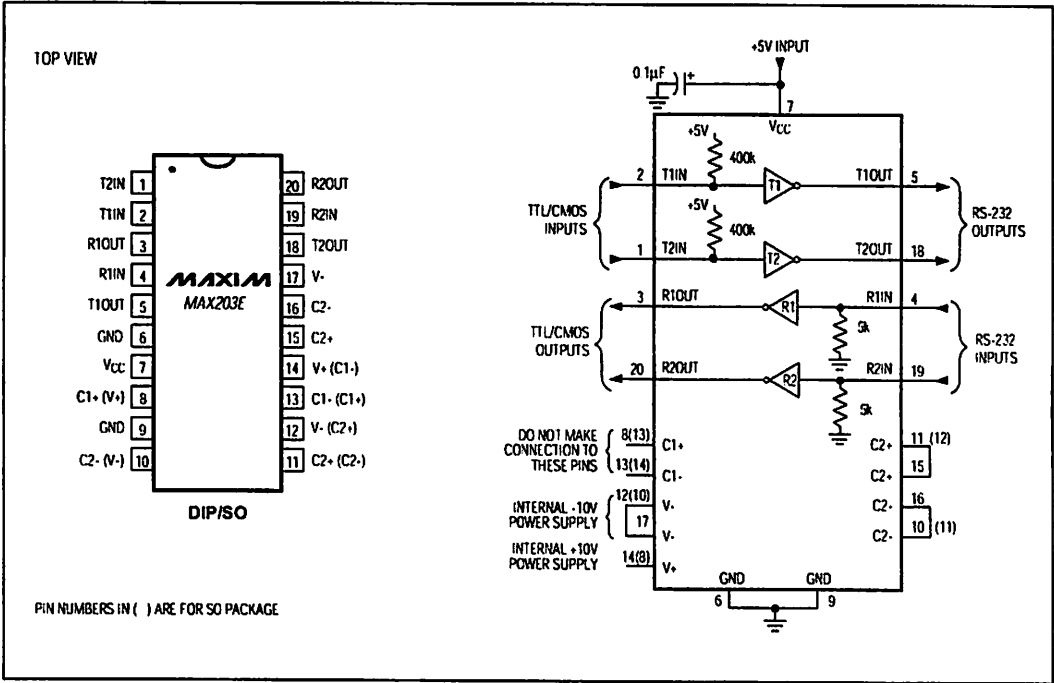
PIN	CONNECTION	
1	Received Line Signal Detector (sometimes called Carrier Detect, DCD)	Handshake from DCE
2	Receive Data (RD)	Data from DCE
3	Transmit Data (TD)	Data from DTE
4	Data Terminal Ready	Handshake from DTE
5	Signal Ground	Reference point for signals
6	Data Set Ready (DSR)	Handshake from DCE
7	Request to Send (RTS)	Handshake from DTE
8	Clear to Send (CTS)	Handshake from DCE
9	Ring Indicator	Handshake from DCE

Pin Configurations and Typical Operating Circuits (continued)



±15kV ESD-Protected, +5V RS-232 Transceivers

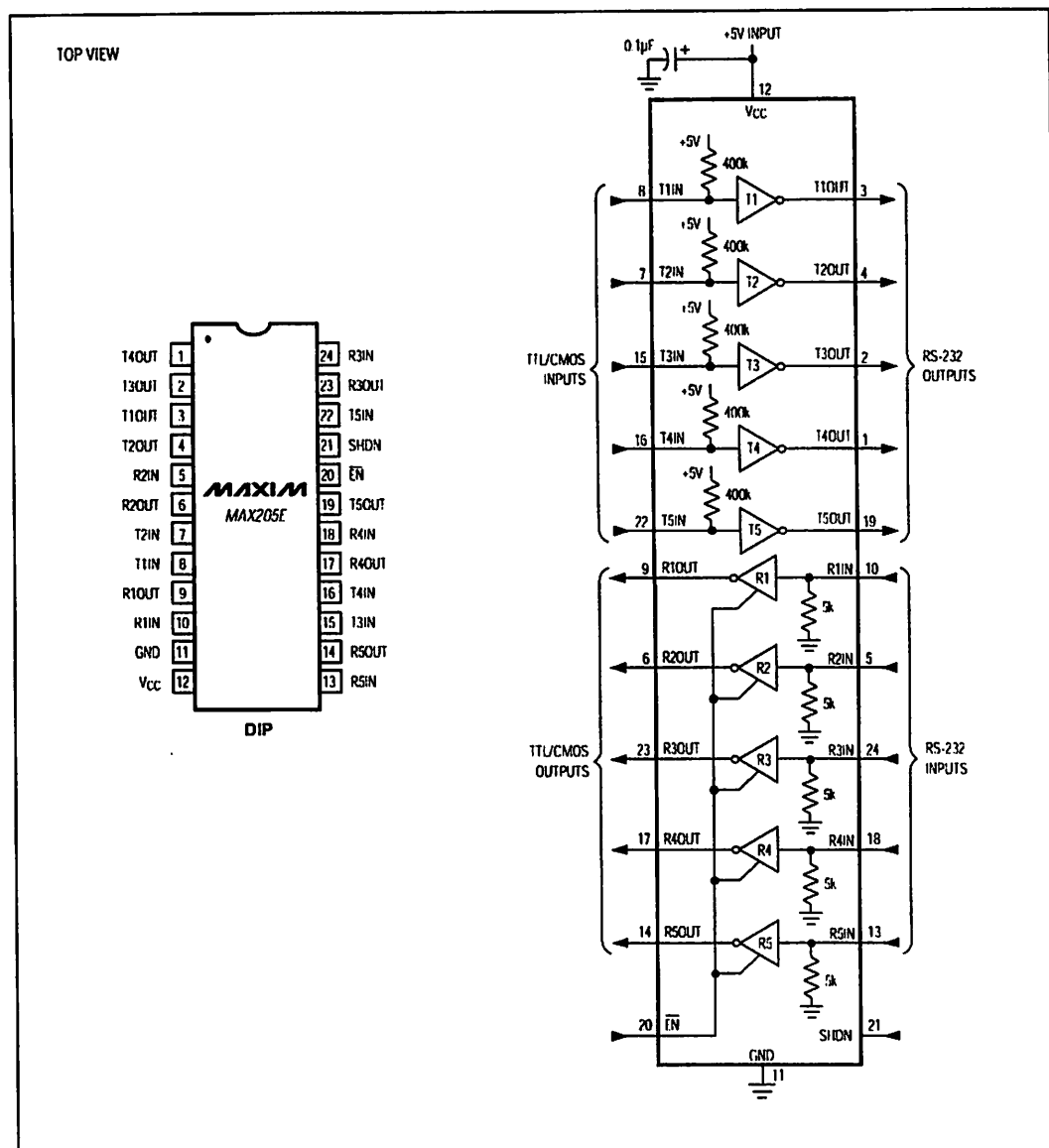
Pin Configurations and Typical Operating Circuits (continued)



MAX202E-MAX213E, MAX232E/MAX241E

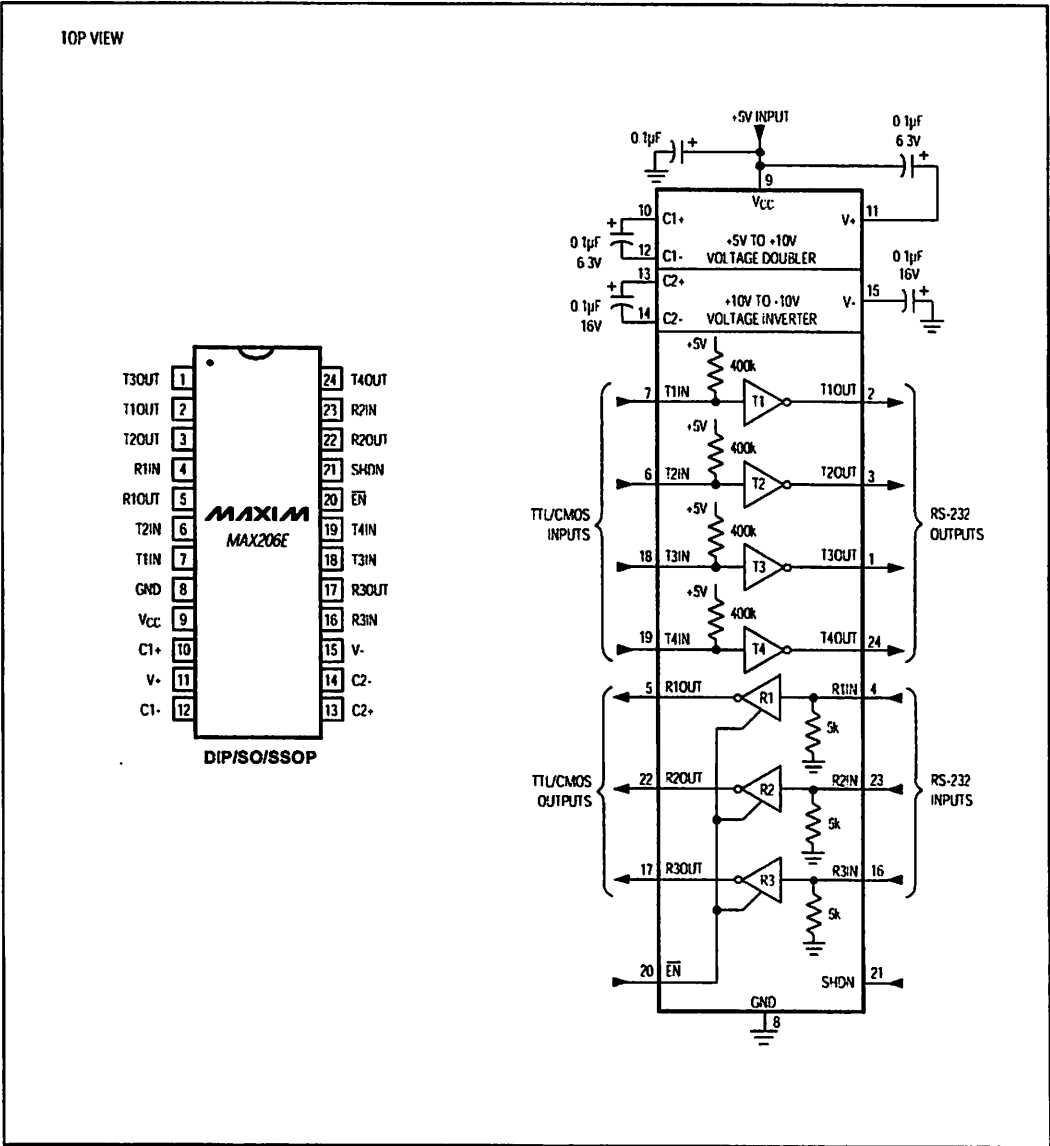
±15kV ESD-Protected, +5V RS-232 Transceivers

Pin Configurations and Typical Operating Circuits (continued)



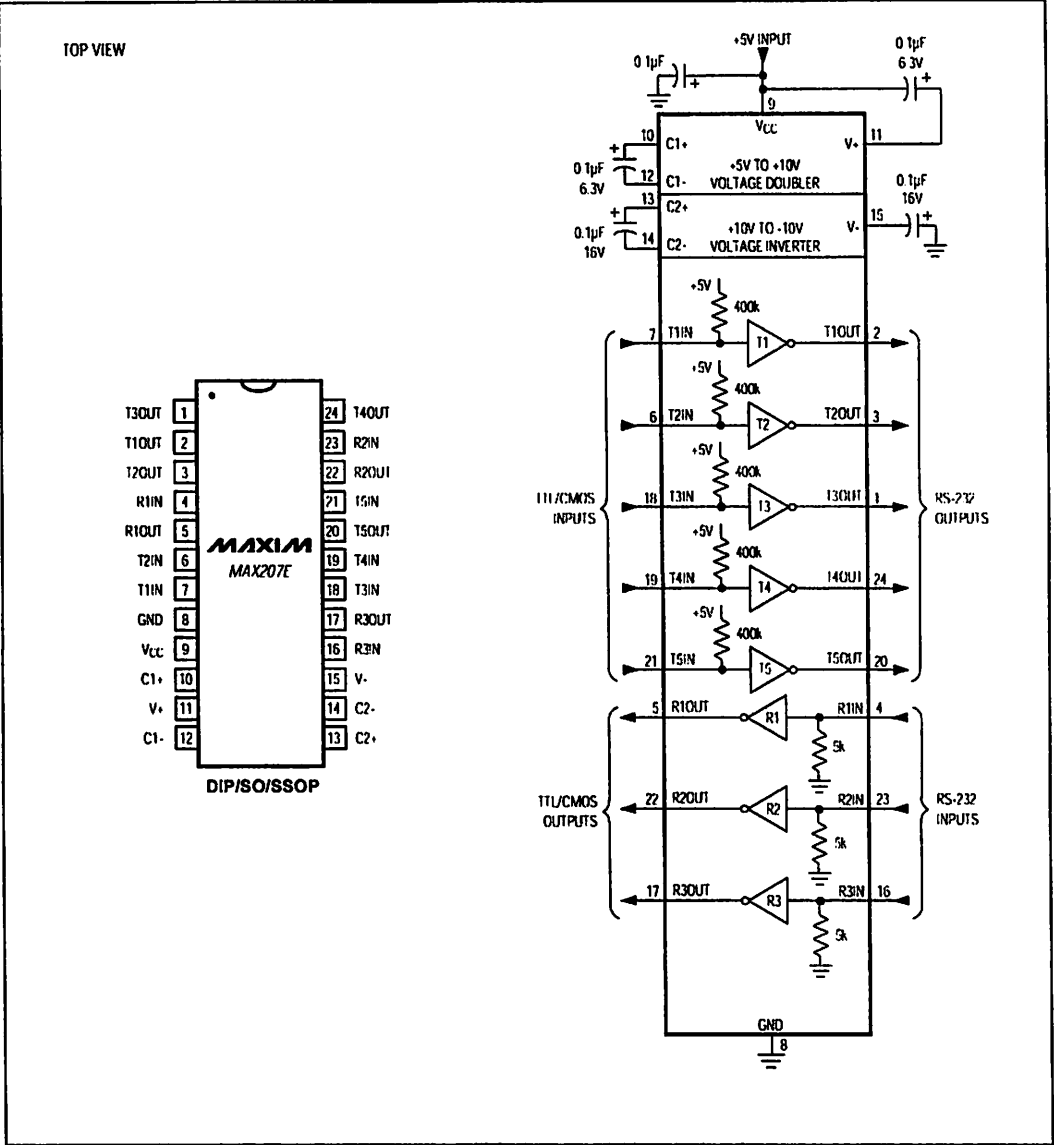
±15kV ESD-Protected, +5V RS-232 Transceivers

Pin Configurations and Typical Operating Circuits (continued)



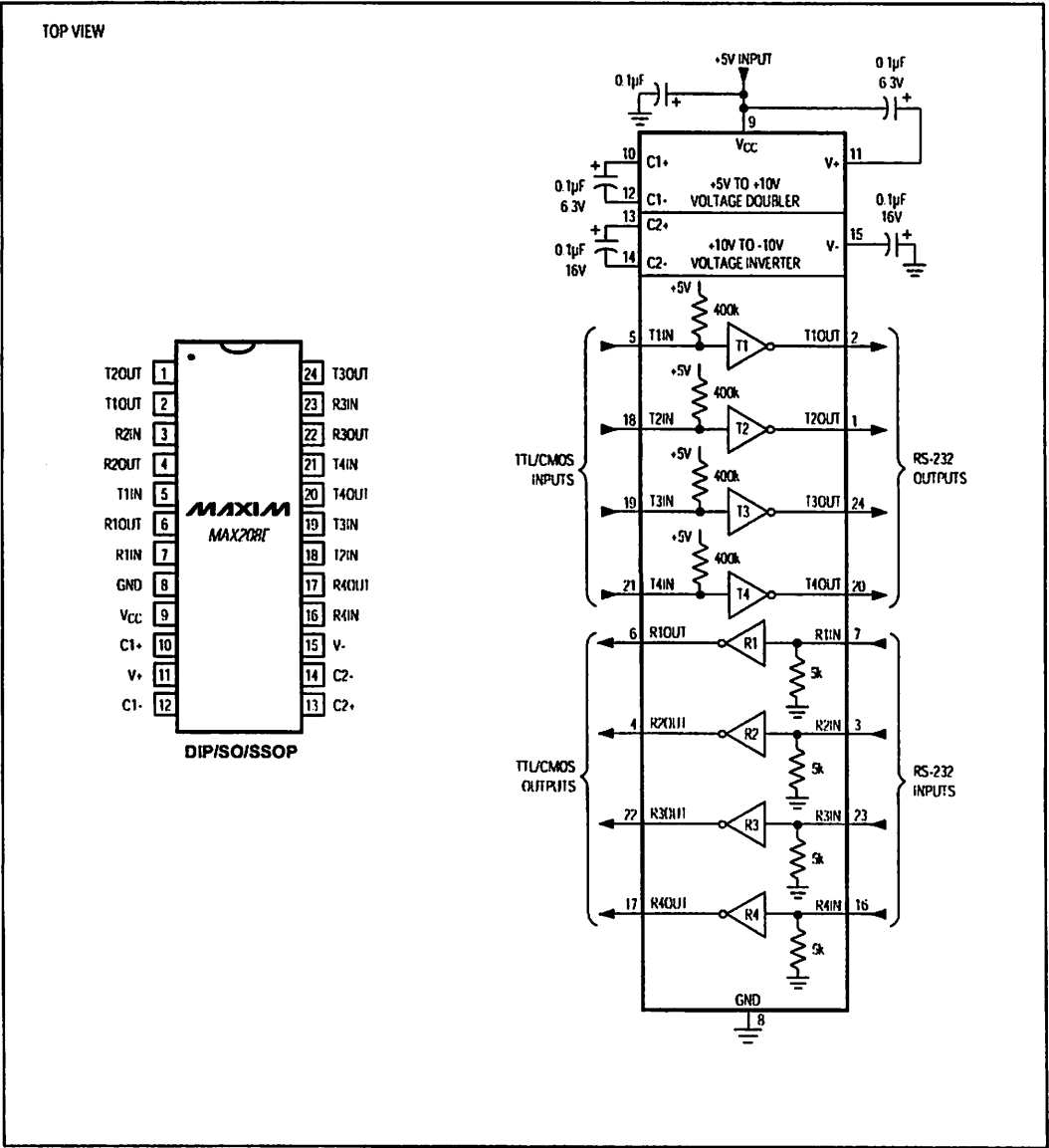
$\pm 15\text{kV}$ ESD-Protected, $+5\text{V}$ RS-232 Transceivers

Pin Configurations and Typical Operating Circuits (continued)



$\pm 15\text{kV}$ ESD-Protected, +5V RS-232 Transceivers

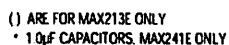
Pin Configurations and Typical Operating Circuits (continued)



MAX202E-MAX213E, MAX232E/MAX241E

MAX202E-MAX213E, MAX232E/MAX241E

TOP VIEW



±15kV ESD-Protected, +5V RS-232 Transceivers

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX202ECPE	0°C to +70°C	16 Plastic DIP
MAX202ECSE	0°C to +70°C	16 Narrow SO
MAX202ECWE	0°C to +70°C	16 Wide SO
MAX202EC/D	0°C to +70°C	Dice*
MAX202EEPE	-40°C to +85°C	16 Plastic DIP
MAX202EESE	-40°C to +85°C	16 Narrow SO
MAX202EEWE	-40°C to +85°C	16 Wide SO
MAX203ECPP	0°C to +70°C	20 Plastic DIP
MAX203ECWP	0°C to +70°C	20 SO
MAX203EPP	-40°C to +85°C	20 Plastic DIP
MAX203EEWP	-40°C to +85°C	20 SO
MAX205ECPG	0°C to +70°C	24 Wide Plastic DIP
MAX205EEPG	-40°C to +85°C	24 Wide Plastic DIP
MAX206ECNG	0°C to +70°C	24 Narrow Plastic DIP
MAX206ECWG	0°C to +70°C	24 SO
MAX206ECAG	0°C to +70°C	24 SSOP
MAX206EENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX206EEWG	-40°C to +85°C	24 SO
MAX206EEAG	-40°C to +85°C	24 SSOP
MAX207ECNG	0°C to +70°C	24 Narrow Plastic DIP
MAX207ECWG	0°C to +70°C	24 SO
MAX207ECAG	0°C to +70°C	24 SSOP
MAX207FENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX207EEWG	-40°C to +85°C	24 SO
MAX207EEAG	-40°C to +85°C	24 SSOP

PART	TEMP. RANGE	PIN-PACKAGE
MAX208ECNG	0°C to +70°C	24 Narrow Plastic DIP
MAX208ECWG	0°C to +70°C	24 SO
MAX208ECAG	0°C to +70°C	24 SSOP
MAX208EENG	-40°C to +85°C	24 Narrow Plastic DIP
MAX208EEWG	-40°C to +85°C	24 SO
MAX208EEAG	-40°C to +85°C	24 SSOP
MAX211ECWI	0°C to +70°C	28 SO
MAX211ECAI	0°C to +70°C	28 SSOP
MAX211EEWI	-40°C to +85°C	28 SO
MAX211EEAI	-40°C to +85°C	28 SSOP
MAX213ECWI	0°C to +70°C	28 SO
MAX213ECAI	0°C to +70°C	28 SSOP
MAX213EEWI	-40°C to +85°C	28 SO
MAX213EEAI	-40°C to +85°C	28 SSOP
MAX232ECPE	0°C to +70°C	16 Plastic DIP
MAX232ECSE	0°C to +70°C	16 Narrow SO
MAX232ECWE	0°C to +70°C	16 Wide SO
MAX232EC/D	0°C to +70°C	Dice*
MAX232EEPE	-40°C to +85°C	16 Plastic DIP
MAX232EESE	-40°C to +85°C	16 Narrow SO
MAX232EEWE	-40°C to +85°C	16 Wide SO
MAX241ECWI	0°C to +70°C	28 SO
MAX241ECAI	0°C to +70°C	28 SSOP
MAX241EEWI	-40°C to +85°C	28 SO
MAX241EEAI	-40°C to +85°C	28 SSOP

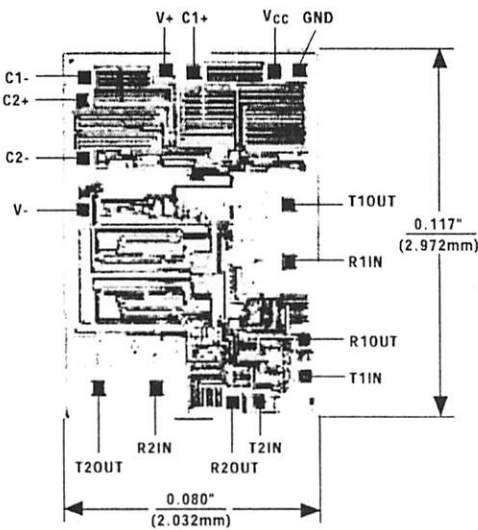
*Dice are specified at $T_A = +25^{\circ}\text{C}$.

MAX202E-MAX213E, MAX232E/MAX241E

$\pm 15\text{kV}$ ESD-Protected, +5V RS-232 Transceivers

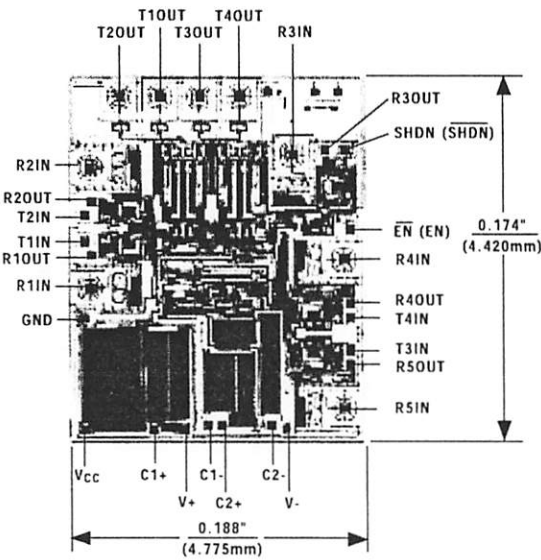
Chip Topographies

MAX202E/MAX232E



TRANSISTOR COUNT: 123
SUBSTRATE CONNECTED TO GND

MAX211E/MAX213E/MAX241E



() ARE FOR MAX213E ONLY

TRANSISTOR COUNT: 542
SUBSTRATE CONNECTED TO GND

Chip Information

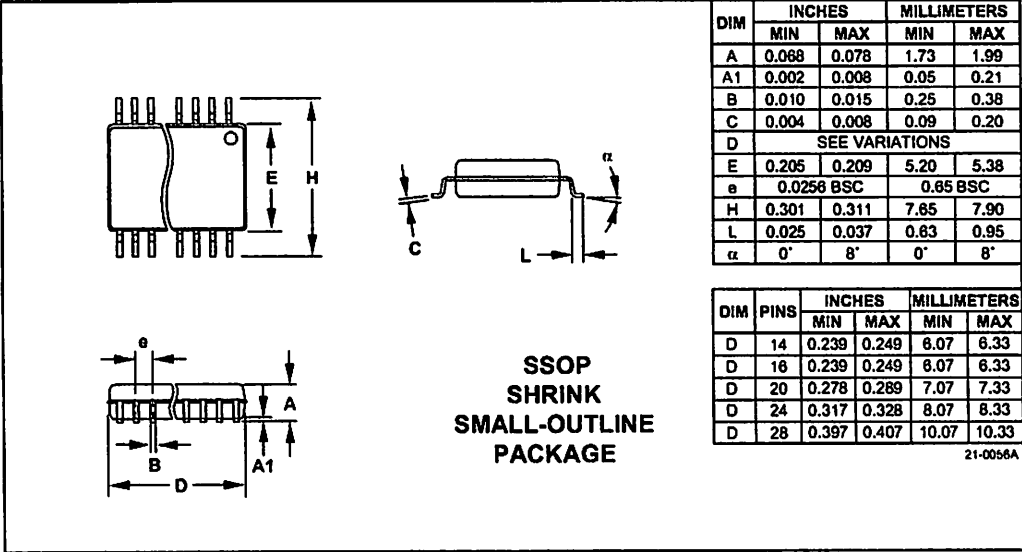
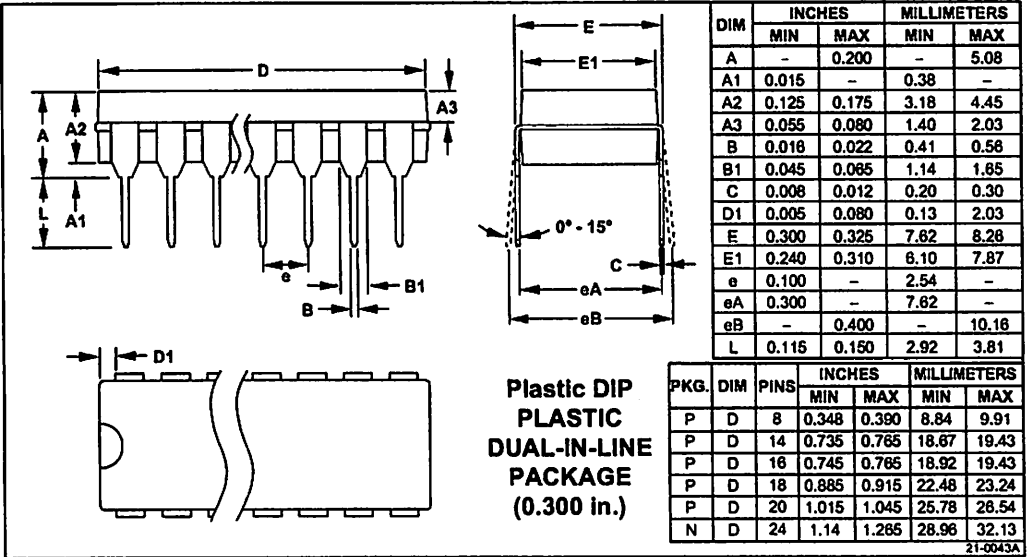
MAX205E/MAX206E/MAX207E/MAX208E

TRANSISTOR COUNT: 328
SUBSTRATE CONNECTED TO GND

±15kV ESD-Protected, +5V RS-232 Transceivers

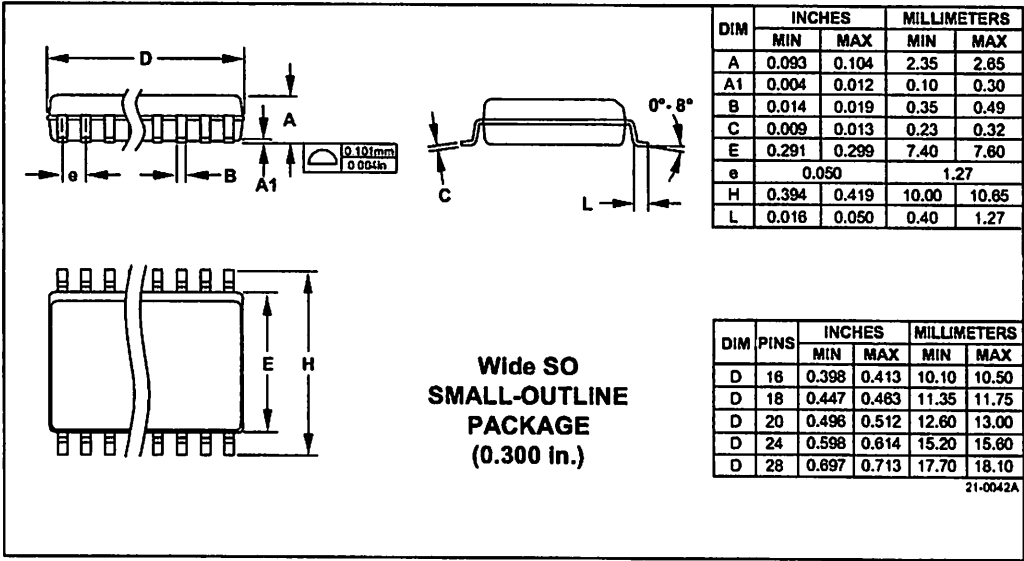
Package Information

MAX202E-MAX213E, MAX232E/MAX241E



±15kV ESD-Protected, +5V RS-232 Transceivers

Package Information (continued)



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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Low-Power, Slew-Rate-Limited
RS-485/RS-422 Transceivers

General Description

The MAX481, MAX483, MAX485, MAX487-MAX491, and MAX1487 are low-power transceivers for RS-485 and RS-422 communication. Each part contains one driver and one receiver. The MAX483, MAX487, MAX488, and MAX489 feature reduced slew-rate drivers that minimize EMI and reduce reflections caused by improperly terminated cables, thus allowing error-free data transmission up to 250kbps. The driver slew rates of the MAX481, MAX485, MAX490, MAX491, and MAX1487 are not limited, allowing them to transmit up to 2.5Mbps.

These transceivers draw between 120µA and 500µA of supply current when unloaded or fully loaded with disabled drivers. Additionally, the MAX481, MAX483, and MAX487 have a low-current shutdown mode in which they consume only 0.1µA. All parts operate from a single 5V supply.

Drivers are short-circuit current limited and are protected against excessive power dissipation by thermal shutdown circuitry that places the driver outputs into a high-impedance state. The receiver input has a fail-safe feature that guarantees a logic-high output if the input is open circuit.

The MAX487 and MAX1487 feature quarter-unit-load receiver input impedance, allowing up to 128 MAX487/MAX1487 transceivers on the bus. Full-duplex communications are obtained using the MAX488-MAX491, while the MAX481, MAX483, MAX485, MAX487, and MAX1487 are designed for half-duplex applications.

Applications

- Low-Power RS-485 Transceivers
- Low-Power RS-422 Transceivers
- Level Translators
- Transceivers for EMI-Sensitive Applications
- Industrial-Control Local Area Networks

Features

- ◆ In µMAX Package: Smallest 8-Pin SO
- ◆ Slew-Rate Limited for Error-Free Data Transmission (MAX483/487/488/489)
- ◆ 0.1µA Low-Current Shutdown Mode (MAX481/483/487)
- ◆ Low Quiescent Current:
120µA (MAX483/487/488/489)
230µA (MAX1487)
300µA (MAX481/485/490/491)
- ◆ -7V to +12V Common-Mode Input Voltage Range
- ◆ Three-State Outputs
- ◆ 30ns Propagation Delays, 5ns Skew (MAX481/485/490/491/1487)
- ◆ Full-Duplex and Half-Duplex Versions Available
- ◆ Operate from a Single 5V Supply
- ◆ Allows up to 128 Transceivers on the Bus (MAX487/MAX1487)
- ◆ Current-Limiting and Thermal Shutdown for Driver Overload Protection

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX481CPA	0°C to +70°C	8 Plastic DIP
MAX481CSA	0°C to +70°C	8 SO
MAX481CUA	0°C to +70°C	8 µMAX
MAX481C/D	0°C to +70°C	Dice*

Ordering Information continued at end of data sheet.
* Contact factory for dice specifications.

Selection Table

PART NUMBER	HALF/FULL DUPLEX	DATA RATE (Mbps)	SLEW-RATE LIMITED	LOW-POWER SHUTDOWN	RECEIVER/ DRIVER ENABLE	QUIESCENT CURRENT (µA)	NUMBER OF TRANSMITTERS ON BUS	PIN COUNT
MAX481	Half	2.5	No	Yes	Yes	300	32	8
MAX483	Half	0.25	Yes	Yes	Yes	120	32	8
MAX485	Half	2.5	No	No	Yes	300	32	8
MAX487	Half	0.25	Yes	Yes	Yes	120	128	8
MAX488	Full	0.25	Yes	No	No	120	32	8
MAX489	Full	0.25	Yes	No	Yes	120	32	14
MAX490	Full	2.5	No	No	No	300	32	8
MAX491	Full	2.5	No	No	Yes	300	32	14
MAX1487	Half	2.5	No	No	Yes	230	128	8



MAX481/MAX483/MAX485/MAX487-MAX491/MAX1487

MAX487/MAX485/MAX483/MAX481/MAX480/MAX477/MAX475/MAX473/MAX471/MAX470/MAX467/MAX465/MAX463/MAX461/MAX460/MAX457/MAX455/MAX453/MAX451/MAX450/MAX447/MAX445/MAX443/MAX441/MAX440/MAX437/MAX435/MAX433/MAX431/MAX430/MAX427/MAX425/MAX423/MAX421/MAX420/MAX417/MAX415/MAX413/MAX411/MAX410/MAX407/MAX405/MAX403/MAX401/MAX400/MAX397/MAX395/MAX393/MAX391/MAX390/MAX387/MAX385/MAX383/MAX381/MAX380/MAX377/MAX375/MAX373/MAX371/MAX370/MAX367/MAX365/MAX363/MAX361/MAX360/MAX357/MAX355/MAX353/MAX351/MAX350/MAX347/MAX345/MAX343/MAX341/MAX340/MAX337/MAX335/MAX333/MAX331/MAX330/MAX327/MAX325/MAX323/MAX321/MAX320/MAX317/MAX315/MAX313/MAX311/MAX310/MAX307/MAX305/MAX303/MAX301/MAX300/MAX297/MAX295/MAX293/MAX291/MAX290/MAX287/MAX285/MAX283/MAX281/MAX280/MAX277/MAX275/MAX273/MAX271/MAX270/MAX267/MAX265/MAX263/MAX261/MAX260/MAX257/MAX255/MAX253/MAX251/MAX250/MAX247/MAX245/MAX243/MAX241/MAX240/MAX237/MAX235/MAX233/MAX231/MAX230/MAX227/MAX225/MAX223/MAX221/MAX220/MAX217/MAX215/MAX213/MAX211/MAX210/MAX207/MAX205/MAX203/MAX201/MAX200/MAX197/MAX195/MAX193/MAX191/MAX190/MAX187/MAX185/MAX183/MAX181/MAX180/MAX177/MAX175/MAX173/MAX171/MAX170/MAX167/MAX165/MAX163/MAX161/MAX160/MAX157/MAX155/MAX153/MAX151/MAX150/MAX147/MAX145/MAX143/MAX141/MAX140/MAX137/MAX135/MAX133/MAX131/MAX130/MAX127/MAX125/MAX123/MAX121/MAX120/MAX117/MAX115/MAX113/MAX111/MAX110/MAX107/MAX105/MAX103/MAX101/MAX100/MAX97/MAX95/MAX93/MAX91/MAX90/MAX87/MAX85/MAX83/MAX81/MAX80/MAX77/MAX75/MAX73/MAX71/MAX70/MAX67/MAX65/MAX63/MAX61/MAX60/MAX57/MAX55/MAX53/MAX51/MAX50/MAX47/MAX45/MAX43/MAX41/MAX40/MAX37/MAX35/MAX33/MAX31/MAX30/MAX27/MAX25/MAX23/MAX21/MAX20/MAX17/MAX15/MAX13/MAX11/MAX10/MAX9/MAX8/MAX7/MAX6/MAX5/MAX4/MAX3/MAX2/MAX1/MAX0

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (Vcc).....	12V	14-Pin SO (derate 8.33mW/°C above +70°C).....	667mW
Control Input Voltage (RE, DE).....	-0.5V to (Vcc + 0.5V)	8-Pin µMAX (derate 4.1mW/°C above +70°C).....	830mW
Driver Input Voltage (DI).....	-0.5V to (Vcc + 0.5V)	8-Pin CERDIP (derate 8.00mW/°C above +70°C).....	640mW
Driver Output Voltage (A, B).....	-8V to +12.5V	14-Pin CERDIP (derate 9.09mW/°C above +70°C).....	727mW
Receiver Input Voltage (A, B).....	-8V to +12.5V	Operating Temperature Ranges	
Receiver Output Voltage (RO).....	-0.5V to (Vcc + 0.5V)	MAX4_C_/MAX1487C_A.....	0°C to +70°C
Continuous Power Dissipation (TA = +70°C)		MAX4_E_/MAX1487E_A.....	-40°C to +85°C
8-Pin Plastic DIP (derate 9.09mW/°C above +70°C).....	727mW	MAX4_MJ/MAX1487MJA.....	-55°C to +125°C
14-Pin Plastic DIP (derate 10.00mW/°C above +70°C).....	800mW	Storage Temperature Range.....	
8-Pin SO (derate 5.88mW/°C above +70°C).....	471mW	Lead Temperature (soldering, 10sec).....	
		+300°C	

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

DC ELECTRICAL CHARACTERISTICS

(Vcc = 5V ±5%, TA = TMIN to TMAX, unless otherwise noted.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Differential Driver Output (no load)	VOD1				5	V
Differential Driver Output (with load)	VOD2	R = 50Ω (RS-422)	2			V
		R = 27Ω (RS-485), Figure 4	1.5		5	
Change in Magnitude of Driver Differential Output Voltage for Complementary Output States	ΔVOD	R = 27Ω or 50Ω, Figure 4			0.2	V
Driver Common-Mode Output Voltage	VOC	R = 27Ω or 50Ω, Figure 4			3	V
Change in Magnitude of Driver Common-Mode Output Voltage for Complementary Output States	ΔVOD	R = 27Ω or 50Ω, Figure 4			0.2	V
Input High Voltage	VIH	DE, DI, RE	2.0			V
Input Low Voltage	VIL	DE, DI, RE			0.8	V
Input Current	IIN1	DE, DI, RE			±2	µA
Input Current (A, B)	IIN2	DE = 0V; VCC = 0V or 5.25V, all devices except MAX487/MAX1487	VIN = 12V		1.0	mA
			VIN = -7V		-0.8	
		MAX487/MAX1487, DE = 0V, VCC = 0V or 5.25V	VIN = 12V		0.25	mA
			VIN = -7V		-0.2	
Receiver Differential Threshold Voltage	VTH	-7V ≤ VCM ≤ 12V	-0.2		0.2	V
Receiver Input Hysteresis	ΔVTH	VCM = 0V		70		mV
Receiver Output High Voltage	VOH	IO = -4mA, VID = 200mV	3.5			V
Receiver Output Low Voltage	VOL	IO = 4mA, VID = -200mV			0.4	V
Three-State (high impedance) Output Current at Receiver	IOZR	0.4V ≤ VO ≤ 2.4V			±1	µA
Receiver Input Resistance	RIN	-7V ≤ VCM ≤ 12V, all devices except MAX487/MAX1487	12			kΩ
		-7V ≤ VCM ≤ 12V, MAX487/MAX1487	48			kΩ

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

DC ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = 5V ±5%, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
No-Load Supply Current (Note 3)	I _{CC}	MAX488/MAX489, DE, DI, RE = 0V or V _{CC}		120	250	μA
		MAX490/MAX491, DE, DI, RE = 0V or V _{CC}		300	500	
		MAX481/MAX485, RE = 0V or V _{CC}	DE = V _{CC}	500	900	
			DE = 0V	300	500	
		MAX1487, RE = 0V or V _{CC}	DE = V _{CC}	300	500	
			DE = 0V	230	400	
		MAX483/MAX487, RE = 0V or V _{CC}	DE = 5V	MAX483 350	650	
				MAX487 250	400	
			DE = 0V	120	250	
Supply Current in Shutdown	I _{SHDN}	MAX481/483/487, DE = 0V, RE = V _{CC}		0.1	10	μA
Driver Short-Circuit Current, V _O = High	I _{OSD1}	-7V ≤ V _O ≤ 12V (Note 4)	35		250	mA
Driver Short-Circuit Current, V _O = Low	I _{OSD2}	-7V ≤ V _O ≤ 12V (Note 4)	35		250	mA
Receiver Short-Circuit Current	I _{OSR}	0V ≤ V _O ≤ V _{CC}	7		95	mA

SWITCHING CHARACTERISTICS—MAX481/MAX485, MAX490/MAX491, MAX1487

(V_{CC} = 5V ±5%, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Driver Input to Output	t _{PLH}	Figures 6 and 8, R _{DIFF} = 54Ω, C _{L1} = C _{L2} = 100pF	10	30	60	ns
	t _{PHL}		10	30	60	
Driver Output Skew to Output	t _{SKEW}	Figures 6 and 8, R _{DIFF} = 54Ω, C _{L1} = C _{L2} = 100pF		5	10	ns
Driver Rise or Fall Time	t _R , t _F	Figures 6 and 8, R _{DIFF} = 54Ω, C _{L1} = C _{L2} = 100pF	MAX481, MAX485, MAX1487 3	15	40	ns
			MAX490C/E, MAX491C/E 5	15	25	
			MAX490M, MAX491M 3	15	40	
Driver Enable to Output High	t _{ZH}	Figures 7 and 9, C _L = 100pF, S2 closed		40	70	ns
Driver Enable to Output Low	t _{ZL}	Figures 7 and 9, C _L = 100pF, S1 closed		40	70	ns
Driver Disable Time from Low	t _{LZ}	Figures 7 and 9, C _L = 15pF, S1 closed		40	70	ns
Driver Disable Time from High	t _{HZ}	Figures 7 and 9, C _L = 15pF, S2 closed		40	70	ns
Receiver Input to Output	t _{PIH} , t _{PII}	Figures 6 and 10, R _{DIFF} = 54Ω, C _{L1} = C _{L2} = 100pF	MAX481, MAX485, MAX1487 20	90	200	ns
			MAX490C/E, MAX491C/E 20	90	150	
			MAX490M, MAX491M 20	90	200	
t _{PLH} - t _{PHL} Differential Receiver Skew	t _{SKD}	Figures 6 and 10, R _{DIFF} = 54Ω, C _{L1} = C _{L2} = 100pF		13		ns
Receiver Enable to Output Low	t _{ZL}	Figures 5 and 11, C _R L = 15pF, S1 closed		20	50	ns
Receiver Enable to Output High	t _{ZH}	Figures 5 and 11, C _R L = 15pF, S2 closed		20	50	ns
Receiver Disable Time from Low	t _{LZ}	Figures 5 and 11, C _R L = 15pF, S1 closed		20	50	ns
Receiver Disable Time from High	t _{HZ}	Figures 5 and 11, C _R L = 15pF, S2 closed		20	50	ns
Maximum Data Rate	f _{MAX}		2.5			Mbps
Time to Shutdown	t _{SHDN}	MAX481 (Note 5)	50	200	600	ns

MAX481/MAX483/MAX485/MAX487-MAX491/MAX1487

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

SWITCHING CHARACTERISTICS—MAX481/MAX485, MAX490/MAX491, MAX1487 (continued)

(VCC = 5V ±5%, TA = TMIN to TMAX, unless otherwise noted.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Driver Enable from Shutdown to Output High (MAX481)	tZIH(SHDN)	Figures 7 and 9, CL = 100pF, S2 closed		40	100	ns
Driver Enable from Shutdown to Output Low (MAX481)	tZL(SHDN)	Figures 7 and 9, CL = 100pF, S1 closed		40	100	ns
Receiver Enable from Shutdown to Output High (MAX481)	tZH(SHDN)	Figures 5 and 11, CL = 15pF, S2 closed, A - B = 2V		300	1000	ns
Receiver Enable from Shutdown to Output Low (MAX481)	tZL(SHDN)	Figures 5 and 11, CL = 15pF, S1 closed, B - A = 2V		300	1000	ns

SWITCHING CHARACTERISTICS—MAX483, MAX487/MAX488/MAX489

(VCC = 5V ±5%, TA = TMIN to TMAX, unless otherwise noted.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Driver Input to Output	tPLH	Figures 6 and 8, RDIFF = 54Ω, CL1 = CL2 = 100pF	250	800	2000	ns
	tPHL		250	800	2000	
Driver Output Skew to Output	tSKEW	Figures 6 and 8, RDIFF = 54Ω, CL1 = CL2 = 100pF		100	800	ns
Driver Rise or Fall Time	tr, tf	Figures 6 and 8, RDIFF = 54Ω, CL1 = CL2 = 100pF	250		2000	ns
Driver Enable to Output High	tZIH	Figures 7 and 9, CL = 100pF, S2 closed	250		2000	ns
Driver Enable to Output Low	tZL	Figures 7 and 9, CL = 100pF, S1 closed	250		2000	ns
Driver Disable Time from Low	tLZ	Figures 7 and 9, CL = 15pF, S1 closed	300		3000	ns
Driver Disable Time from High	tHZ	Figures 7 and 9, CL = 15pF, S2 closed	300		3000	ns
Receiver Input to Output	tPLH	Figures 6 and 10, RDIFF = 54Ω, CL1 = CL2 = 100pF	250		2000	ns
	tPHL		250		2000	
tPLH - tPHL Differential Receiver Skew	tSKD	Figures 6 and 10, RDIFF = 54Ω, CL1 = CL2 = 100pF		100		ns
Receiver Enable to Output Low	tZL	Figures 5 and 11, CRL = 15pF, S1 closed		20	50	ns
Receiver Enable to Output High	tZH	Figures 5 and 11, CRL = 15pF, S2 closed		20	50	ns
Receiver Disable Time from Low	tLZ	Figures 5 and 11, CRL = 15pF, S1 closed		20	50	ns
Receiver Disable Time from High	tHZ	Figures 5 and 11, CRL = 15pF, S2 closed		20	50	ns
Maximum Data Rate	fMAX	tPLH, tPHL < 50% of data period	250			kbps
Time to Shutdown	tSHDN	MAX483/MAX487 (Note 5)	50	200	600	ns
Driver Enable from Shutdown to Output High	tZH(SHDN)	MAX483/MAX487, Figures 7 and 9, CL = 100pF, S2 closed			2000	ns
Driver Enable from Shutdown to Output Low	tZL(SHDN)	MAX483/MAX487, Figures 7 and 9, CL = 100pF, S1 closed			2000	ns
Receiver Enable from Shutdown to Output High	tZH(SHDN)	MAX483/MAX487, Figures 5 and 11, CL = 15pF, S2 closed			2500	ns
Receiver Enable from Shutdown to Output Low	tZL(SHDN)	MAX483/MAX487, Figures 5 and 11, CL = 15pF, S1 closed			2500	ns

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

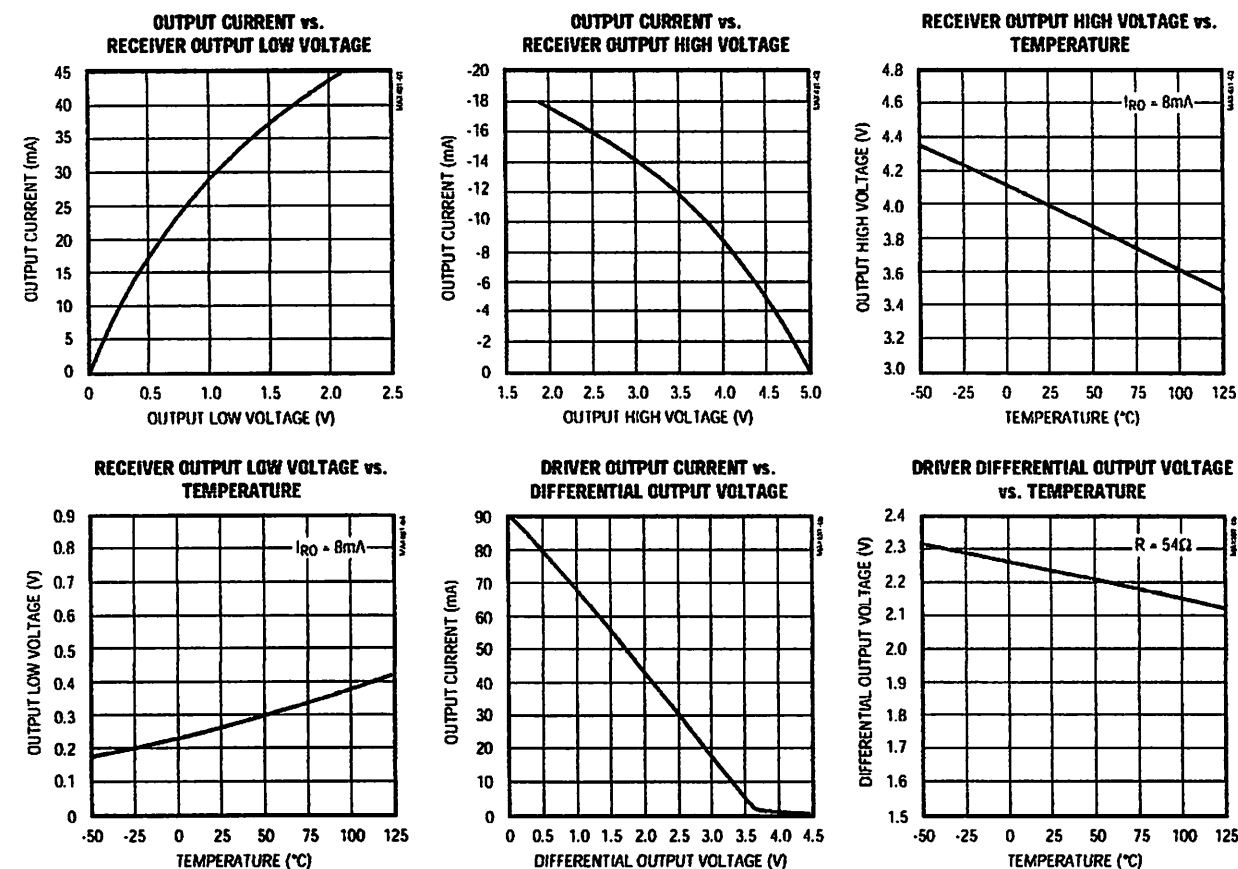
MAX481/MAX483/MAX485/MAX487-MAX491/MAX1487

NOTES FOR ELECTRICAL/SWITCHING CHARACTERISTICS

- Note 1:** All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.
- Note 2:** All typical specifications are given for $V_{CC} = 5V$ and $T_A = +25^{\circ}C$.
- Note 3:** Supply current specification is valid for loaded transmitters when $DE = 0V$.
- Note 4:** Applies to peak current. See *Typical Operating Characteristics*.
- Note 5:** The MAX481/MAX483/MAX487 are put into shutdown by bringing $\overline{RE}$ high and DE low. If the inputs are in this state for less than 50ns, the parts are guaranteed not to enter shutdown. If the inputs are in this state for at least 600ns, the parts are guaranteed to have entered shutdown. See *Low-Power Shutdown Mode* section.

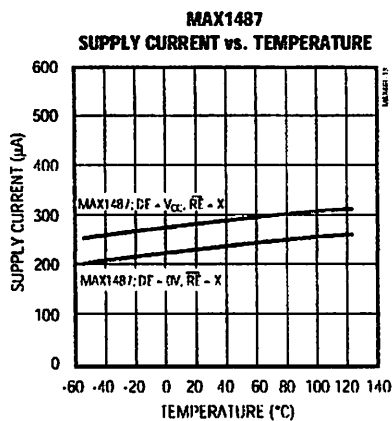
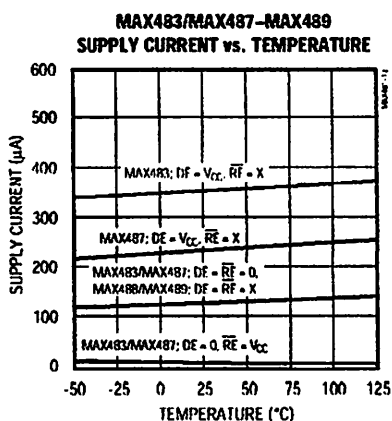
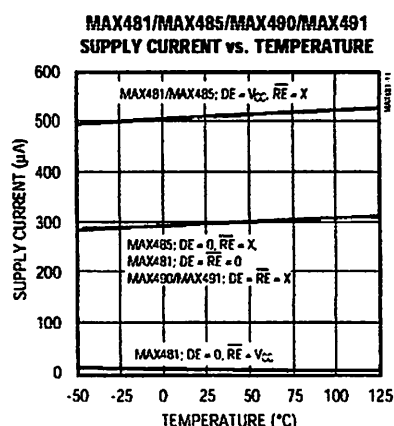
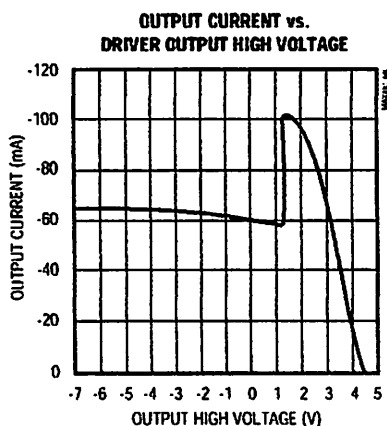
Typical Operating Characteristics

($V_{CC} = 5V$, $T_A = +25^{\circ}C$, unless otherwise noted.)



MA X 487/VIH X 485/VIH X 483/VIH X 481/VIH X 479/VIH X 477/VIH X 475/VIH X 473/VIH X 471/VIH X 469/VIH X 467/VIH X 465/VIH X 463/VIH X 461/VIH X 459/VIH X 457/VIH X 455/VIH X 453/VIH X 451/VIH X 449/VIH X 447/VIH X 445/VIH X 443/VIH X 441/VIH X 439/VIH X 437/VIH X 435/VIH X 433/VIH X 431/VIH X 429/VIH X 427/VIH X 425/VIH X 423/VIH X 421/VIH X 419/VIH X 417/VIH X 415/VIH X 413/VIH X 411/VIH X 409/VIH X 407/VIH X 405/VIH X 403/VIH X 401/VIH X 399/VIH X 397/VIH X 395/VIH X 393/VIH X 391/VIH X 389/VIH X 387/VIH X 385/VIH X 383/VIH X 381/VIH X 379/VIH X 377/VIH X 375/VIH X 373/VIH X 371/VIH X 369/VIH X 367/VIH X 365/VIH X 363/VIH X 361/VIH X 359/VIH X 357/VIH X 355/VIH X 353/VIH X 351/VIH X 349/VIH X 347/VIH X 345/VIH X 343/VIH X 341/VIH X 339/VIH X 337/VIH X 335/VIH X 333/VIH X 331/VIH X 329/VIH X 327/VIH X 325/VIH X 323/VIH X 321/VIH X 319/VIH X 317/VIH X 315/VIH X 313/VIH X 311/VIH X 309/VIH X 307/VIH X 305/VIH X 303/VIH X 301/VIH X 299/VIH X 297/VIH X 295/VIH X 293/VIH X 291/VIH X 289/VIH X 287/VIH X 285/VIH X 283/VIH X 281/VIH X 279/VIH X 277/VIH X 275/VIH X 273/VIH X 271/VIH X 269/VIH X 267/VIH X 265/VIH X 263/VIH X 261/VIH X 259/VIH X 257/VIH X 255/VIH X 253/VIH X 251/VIH X 249/VIH X 247/VIH X 245/VIH X 243/VIH X 241/VIH X 239/VIH X 237/VIH X 235/VIH X 233/VIH X 231/VIH X 229/VIH X 227/VIH X 225/VIH X 223/VIH X 221/VIH X 219/VIH X 217/VIH X 215/VIH X 213/VIH X 211/VIH X 209/VIH X 207/VIH X 205/VIH X 203/VIH X 201/VIH X 199/VIH X 197/VIH X 195/VIH X 193/VIH X 191/VIH X 189/VIH X 187/VIH X 185/VIH X 183/VIH X 181/VIH X 179/VIH X 177/VIH X 175/VIH X 173/VIH X 171/VIH X 169/VIH X 167/VIH X 165/VIH X 163/VIH X 161/VIH X 159/VIH X 157/VIH X 155/VIH X 153/VIH X 151/VIH X 149/VIH X 147/VIH X 145/VIH X 143/VIH X 141/VIH X 139/VIH X 137/VIH X 135/VIH X 133/VIH X 131/VIH X 129/VIH X 127/VIH X 125/VIH X 123/VIH X 121/VIH X 119/VIH X 117/VIH X 115/VIH X 113/VIH X 111/VIH X 109/VIH X 107/VIH X 105/VIH X 103/VIH X 101/VIH X 99/VIH X 97/VIH X 95/VIH X 93/VIH X 91/VIH X 89/VIH X 87/VIH X 85/VIH X 83/VIH X 81/VIH X 79/VIH X 77/VIH X 75/VIH X 73/VIH X 71/VIH X 69/VIH X 67/VIH X 65/VIH X 63/VIH X 61/VIH X 59/VIH X 57/VIH X 55/VIH X 53/VIH X 51/VIH X 49/VIH X 47/VIH X 45/VIH X 43/VIH X 41/VIH X 39/VIH X 37/VIH X 35/VIH X 33/VIH X 31/VIH X 29/VIH X 27/VIH X 25/VIH X 23/VIH X 21/VIH X 19/VIH X 17/VIH X 15/VIH X 13/VIH X 11/VIH X 9/VIH X 7/VIH X 5/VIH X 3/VIH X 1/VIH X 0/VIH X

($V_{CC} = 5V$, $T_A = +25^{\circ}C$, unless otherwise noted.)



Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

Pin Description

PIN					NAME	FUNCTION
MAX481/MAX483/ MAX485/MAX487/ MAX1487		MAX488/ MAX490		MAX489/ MAX491		
DIP/SO	μMAX	DIP/SO	μMAX	DIP/SO		
1	3	2	4	2	RO	Receiver Output: If $A > B$ by 200mV, RO will be high; If $A < B$ by 200mV, RO will be low.
2	4	—	—	3	RE	Receiver Output Enable. RO is enabled when RE is low; RO is high impedance when RE is high.
3	5	—	—	4	DE	Driver Output Enable. The driver outputs, Y and Z, are enabled by bringing DE high. They are high impedance when DE is low. If the driver outputs are enabled, the parts function as line drivers. While they are high impedance, they function as line receivers if RE is low.
4	6	3	5	5	DI	Driver Input. A low on DI forces output Y low and output Z high. Similarly, a high on DI forces output Y high and output Z low.
5	7	4	6	6, 7	GND	Ground
—	—	5	7	9	Y	Noninverting Driver Output
—	—	6	8	10	Z	Inverting Driver Output
6	8	—	—	—	A	Noninverting Receiver Input and Noninverting Driver Output
—	—	8	2	12	A	Noninverting Receiver Input
7	1	—	—	—	B	Inverting Receiver Input and Inverting Driver Output
—	—	7	1	11	B	Inverting Receiver Input
8	2	1	3	14	VCC	Positive Supply. $4.75V \leq V_{CC} \leq 5.25V$
—	—	—	—	1, 8, 13	N.C.	No Connect—not internally connected

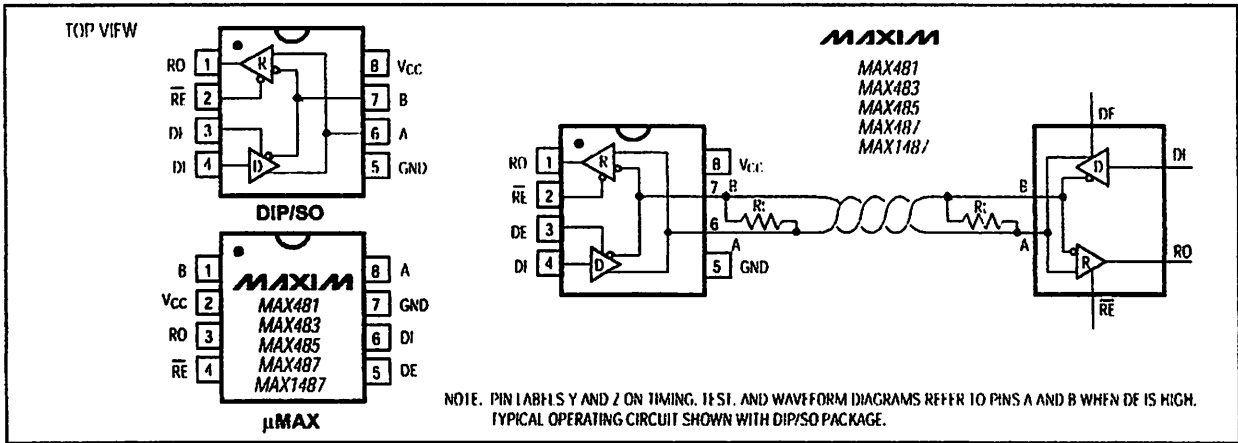


Figure 1. MAX481/MAX483/MAX485/MAX487/MAX1487 Pin Configuration and Typical Operating Circuit

MAX481/MAX483/MAX485/MAX487-MAX491/MAX1487

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

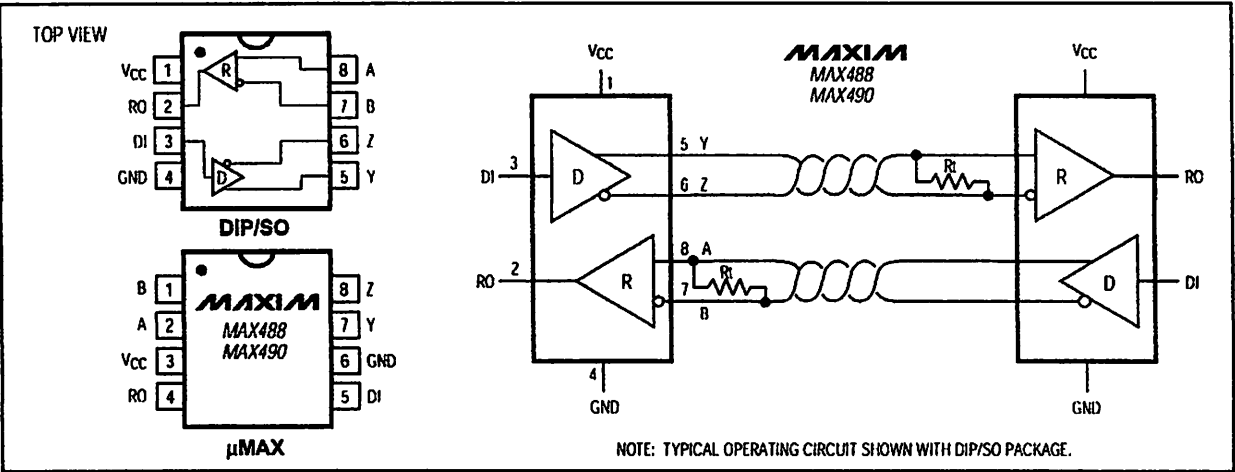


Figure 2. MAX488/MAX490 Pin Configuration and Typical Operating Circuit

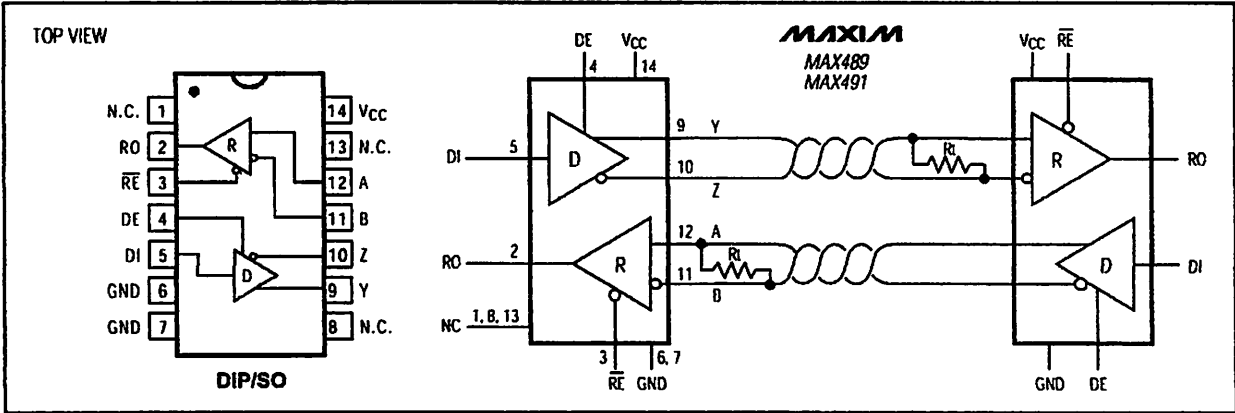


Figure 3. MAX489/MAX491 Pin Configuration and Typical Operating Circuit

Applications Information

The MAX481/MAX483/MAX485/MAX487-MAX491 and MAX1487 are low-power transceivers for RS-485 and RS-422 communications. The MAX481, MAX485, MAX490, MAX491, and MAX1487 can transmit and receive at data rates up to 2.5Mbps, while the MAX483, MAX487, MAX488, and MAX489 are specified for data rates up to 250kbps. The MAX488-MAX491 are full-duplex transceivers while the MAX481, MAX483, MAX485, MAX487, and MAX1487 are half-duplex. In addition, Driver Enable (DE) and Receiver Enable (RE) pins are included on the MAX481, MAX483, MAX485, MAX487, MAX489, MAX491, and MAX1487. When disabled, the driver and receiver outputs are high impedance.

MAX487/MAX1487: 128 Transceivers on the Bus

The 48kΩ, 1/4-unit-load receiver input impedance of the MAX487 and MAX1487 allows up to 128 transceivers on a bus, compared to the 1-unit load (12kΩ input impedance) of standard RS-485 drivers (32 transceivers maximum). Any combination of MAX487/MAX1487 and other RS-485 transceivers with a total of 32 unit loads or less can be put on the bus. The MAX481/MAX483/MAX485 and MAX488-MAX491 have standard 12kΩ Receiver Input impedance.

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

Test Circuits

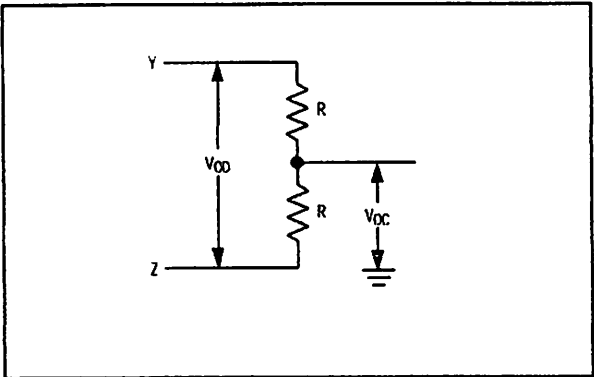


Figure 4. Driver DC Test Load

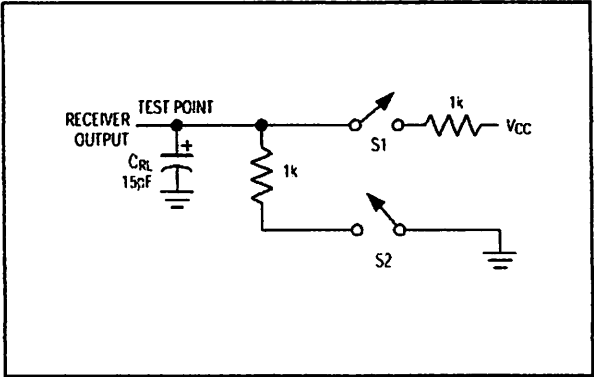


Figure 5. Receiver Timing Test Load

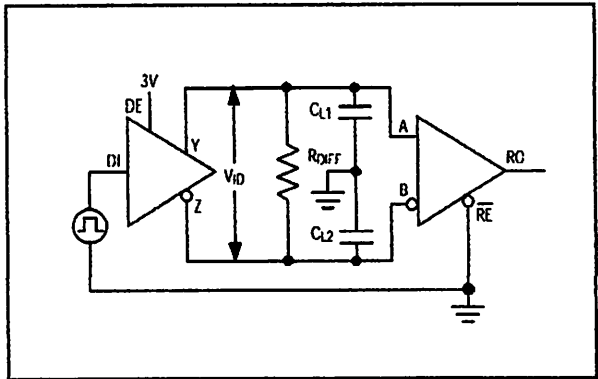


Figure 6. Driver/Receiver Timing Test Circuit

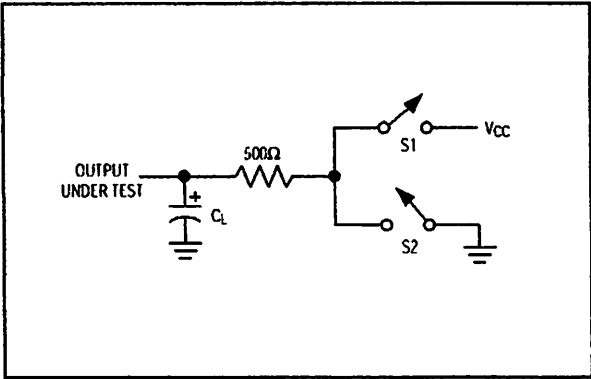


Figure 7. Driver Timing Test Load

MAX483/MAX487/MAX488/MAX489:
Reduced EMI and Reflections
 The MAX483 and MAX487-MAX489 are slew-rate limited, minimizing EMI and reducing reflections caused by improperly terminated cables. Figure 12 shows the driver output waveform and its Fourier analysis of a 150kHz signal transmitted by a MAX481, MAX485, MAX490, MAX491, or MAX1487. High-frequency har-

monics with large amplitudes are evident. Figure 13 shows the same information displayed for a MAX483, MAX487, MAX488, or MAX489 transmitting under the same conditions. Figure 13's high-frequency harmonics have much lower amplitudes, and the potential for EMI is significantly reduced.

MAX481/MAX483/MAX485/MAX487-MAX491/MAX1487

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

Switching Waveforms

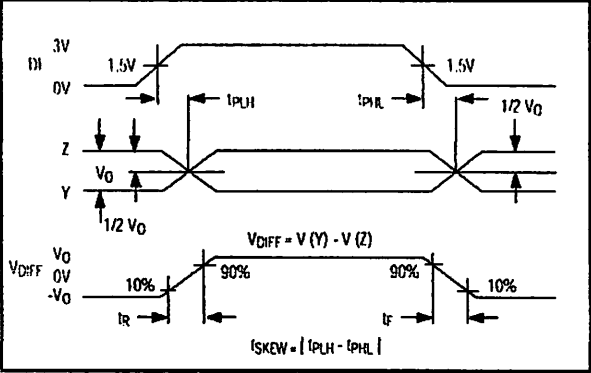


Figure 8. Driver Propagation Delays

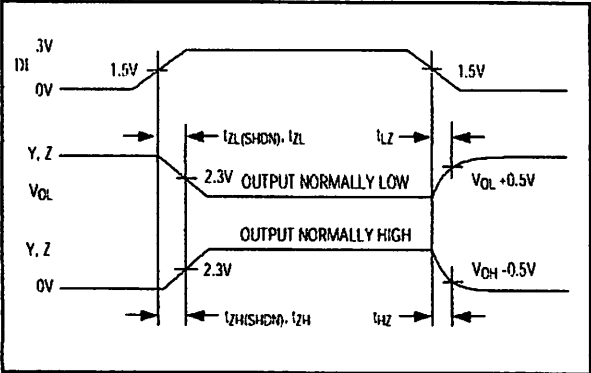


Figure 9. Driver Enable and Disable Times (except MAX488 and MAX490)

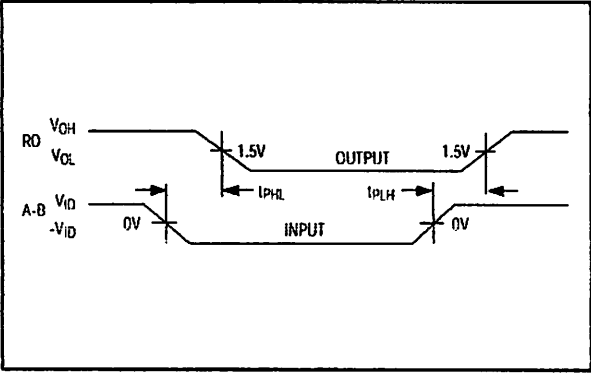


Figure 10. Receiver Propagation Delays

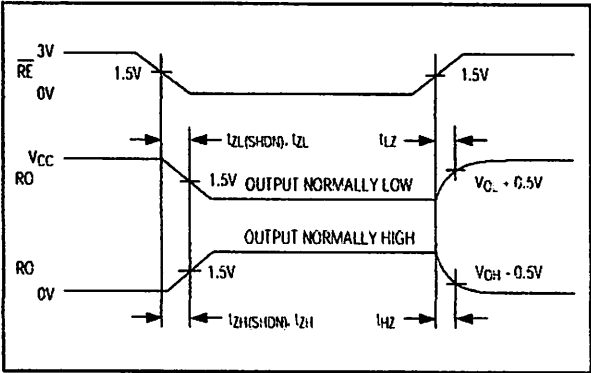


Figure 11. Receiver Enable and Disable Times (except MAX488 and MAX490)

Function Tables (MAX481/MAX483/MAX485/MAX487/MAX1487)

Table 1. Transmitting

INPUTS			OUTPUTS	
RE	DE	DI	Z	Y
X	1	1	0	1
X	1	0	1	0
0	0	X	High-Z	High-Z
1	0	X	High-Z*	High-Z*

X = Don't care
High-Z = High impedance
* Shutdown mode for MAX481/MAX483/MAX487

Table 2. Receiving

INPUTS			OUTPUT
RE	DE	A-B	RO
0	0	$\geq -0.2V$	1
0	0	$\leq -0.2V$	0
0	0	Inputs open	1
1	0	X	High-Z*

X = Don't care
High-Z = High impedance
* Shutdown mode for MAX481/MAX483/MAX487

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

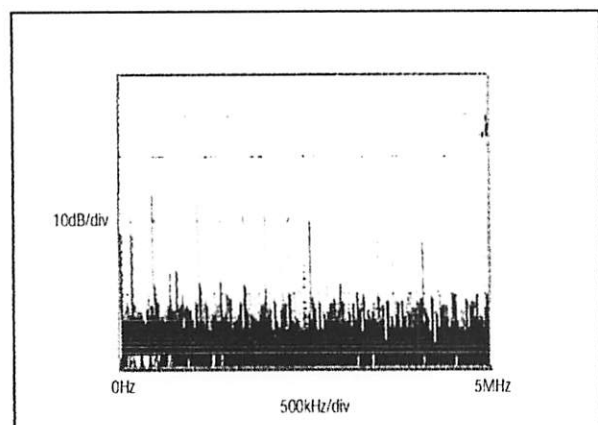


Figure 12. Driver Output Waveform and FFT Plot of MAX481/MAX485/MAX490/MAX491/MAX1487 Transmitting a 150kHz Signal

Low-Power Shutdown Mode (MAX481/MAX483/MAX487)

A low-power shutdown mode is initiated by bringing both $\overline{\text{RE}}$ high and DE low. The devices will not shut down unless both the driver and receiver are disabled. In shutdown, the devices typically draw only 0.1 μA of supply current.

$\overline{\text{RE}}$ and DE may be driven simultaneously; the parts are guaranteed not to enter shutdown if $\overline{\text{RE}}$ is high and DE is low for less than 50ns. If the inputs are in this state for at least 600ns, the parts are guaranteed to enter shutdown.

For the MAX481, MAX483, and MAX487, the t_{ZH} and t_{ZL} enable times assume the part was not in the low-power shutdown state (the MAX485/MAX488-MAX491 and MAX1487 can not be shut down). The $t_{\text{ZH}}(\text{SHDN})$ and $t_{\text{ZL}}(\text{SHDN})$ enable times assume the parts were shut down (see *Electrical Characteristics*).

It takes the drivers and receivers longer to become enabled from the low-power shutdown state ($t_{\text{ZH}}(\text{SHDN})$, $t_{\text{ZL}}(\text{SHDN})$) than from the operating mode (t_{ZH} , t_{ZL}). (The parts are in operating mode if the $\overline{\text{RE}}$, DE inputs equal a logical 0, 1 or 1, 1 or 0, 0.)

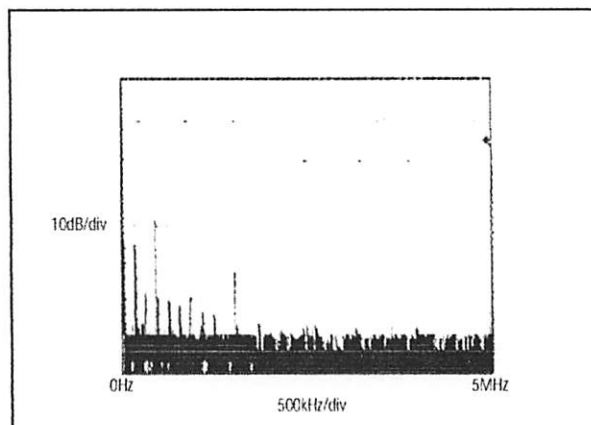


Figure 13. Driver Output Waveform and FFT Plot of MAX483/MAX487-MAX489 Transmitting a 150kHz Signal

Driver Output Protection

Excessive output current and power dissipation caused by faults or by bus contention are prevented by two mechanisms. A foldback current limit on the output stage provides immediate protection against short circuits over the whole common-mode voltage range (see *Typical Operating Characteristics*). In addition, a thermal shutdown circuit forces the driver outputs into a high-impedance state if the die temperature rises excessively.

Propagation Delay

Many digital encoding schemes depend on the difference between the driver and receiver propagation delay times. Typical propagation delays are shown in Figures 15-18 using Figure 14's test circuit.

The difference in receiver delay times, $|t_{\text{PLH}} - t_{\text{PHL}}|$, is typically under 13ns for the MAX481, MAX485, MAX490, MAX491, and MAX1487 and is typically less than 100ns for the MAX483 and MAX487-MAX489.

The driver skew times are typically 5ns (10ns max) for the MAX481, MAX485, MAX490, MAX491, and MAX1487, and are typically 100ns (800ns max) for the MAX483 and MAX487-MAX489.

MAX481/MAX483/MAX485/MAX487-MAX491/MAX1487

MAX481/MAX483/MAX485/MAX487-MAX489/MAX491/MAX493/MAX495/MAX497-MAX499/MAX501/MAX503/MAX505/MAX507-MAX509/MAX511/MAX513/MAX515/MAX517-MAX519/MAX521/MAX523/MAX525/MAX527-MAX529/MAX531/MAX533/MAX535/MAX537-MAX539/MAX541/MAX543/MAX545/MAX547-MAX549/MAX551/MAX553/MAX555/MAX557-MAX559/MAX561/MAX563/MAX565/MAX567-MAX569/MAX571/MAX573/MAX575/MAX577-MAX579/MAX581/MAX583/MAX585/MAX587-MAX589/MAX591/MAX593/MAX595/MAX597-MAX599/MAX601/MAX603/MAX605/MAX607-MAX609/MAX611/MAX613/MAX615/MAX617-MAX619/MAX621/MAX623/MAX625/MAX627-MAX629/MAX631/MAX633/MAX635/MAX637-MAX639/MAX641/MAX643/MAX645/MAX647-MAX649/MAX651/MAX653/MAX655/MAX657-MAX659/MAX661/MAX663/MAX665/MAX667-MAX669/MAX671/MAX673/MAX675/MAX677-MAX679/MAX681/MAX683/MAX685/MAX687-MAX689/MAX691/MAX693/MAX695/MAX697-MAX699/MAX701/MAX703/MAX705/MAX707-MAX709/MAX711/MAX713/MAX715/MAX717-MAX719/MAX721/MAX723/MAX725/MAX727-MAX729/MAX731/MAX733/MAX735/MAX737-MAX739/MAX741/MAX743/MAX745/MAX747-MAX749/MAX751/MAX753/MAX755/MAX757-MAX759/MAX761/MAX763/MAX765/MAX767-MAX769/MAX771/MAX773/MAX775/MAX777-MAX779/MAX781/MAX783/MAX785/MAX787-MAX789/MAX791/MAX793/MAX795/MAX797-MAX799/MAX801/MAX803/MAX805/MAX807-MAX809/MAX811/MAX813/MAX815/MAX817-MAX819/MAX821/MAX823/MAX825/MAX827-MAX829/MAX831/MAX833/MAX835/MAX837-MAX839/MAX841/MAX843/MAX845/MAX847-MAX849/MAX851/MAX853/MAX855/MAX857-MAX859/MAX861/MAX863/MAX865/MAX867-MAX869/MAX871/MAX873/MAX875/MAX877-MAX879/MAX881/MAX883/MAX885/MAX887-MAX889/MAX891/MAX893/MAX895/MAX897-MAX899/MAX901/MAX903/MAX905/MAX907-MAX909/MAX911/MAX913/MAX915/MAX917-MAX919/MAX921/MAX923/MAX925/MAX927-MAX929/MAX931/MAX933/MAX935/MAX937-MAX939/MAX941/MAX943/MAX945/MAX947-MAX949/MAX951/MAX953/MAX955/MAX957-MAX959/MAX961/MAX963/MAX965/MAX967-MAX969/MAX971/MAX973/MAX975/MAX977-MAX979/MAX981/MAX983/MAX985/MAX987-MAX989/MAX991/MAX993/MAX995/MAX997-MAX999

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

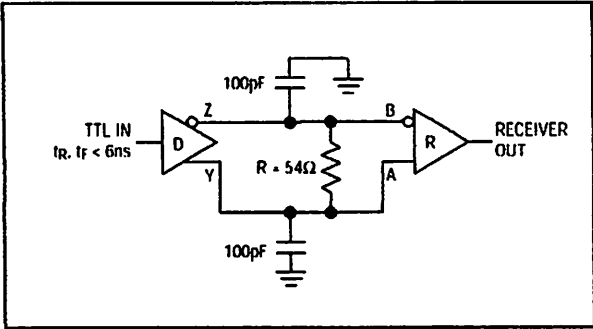


Figure 14. Receiver Propagation Delay Test Circuit

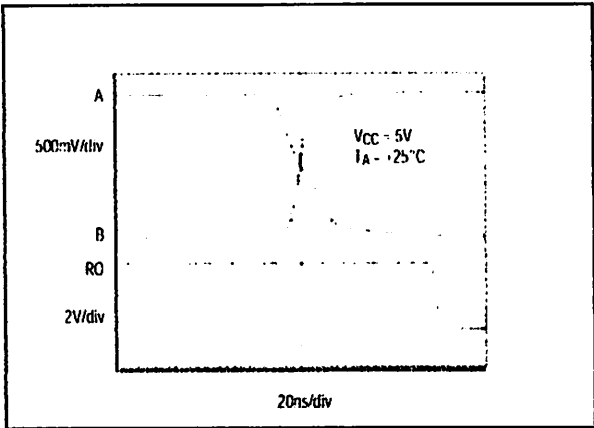


Figure 15. MAX481/MAX485/MAX490/MAX491/MAX1487 Receiver tPHL

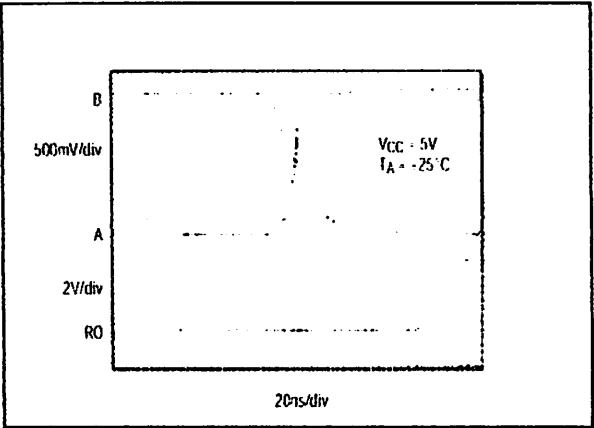


Figure 16. MAX481/MAX485/MAX490/MAX491/MAX1487 Receiver tPLH

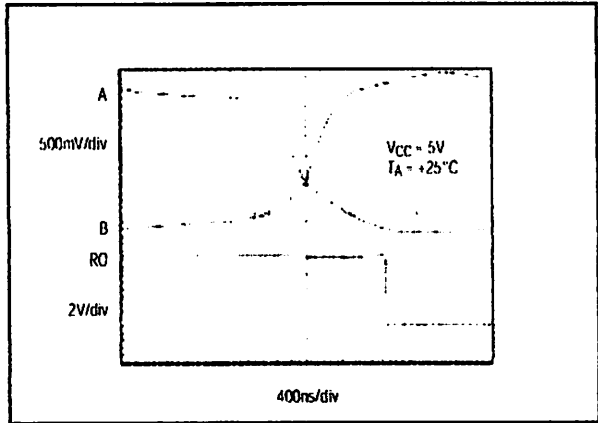


Figure 17. MAX483, MAX487-MAX489 Receiver tPHL

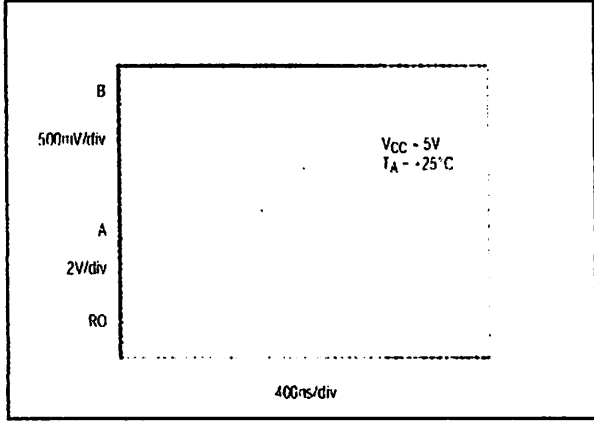


Figure 18. MAX483, MAX487-MAX489 Receiver tPLH

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

Line Length vs. Data Rate

The RS-485/RS-422 standard covers line lengths up to 4000 feet. For line lengths greater than 4000 feet, see Figure 23.

Figures 19 and 20 show the system differential voltage for the parts driving 4000 feet of 26AWG twisted-pair wire at 110kHz into 120Ω loads.

Typical Applications

The MAX481, MAX483, MAX485, MAX487-MAX491, and MAX1487 transceivers are designed for bidirectional data communications on multipoint bus transmission lines.

Figures 21 and 22 show typical network applications circuits. These parts can also be used as line repeaters, with cable lengths longer than 4000 feet, as shown in Figure 23.

To minimize reflections, the line should be terminated at both ends in its characteristic impedance, and stub lengths off the main line should be kept as short as possible. The slew-rate-limited MAX483 and MAX487-MAX489 are more tolerant of imperfect termination.

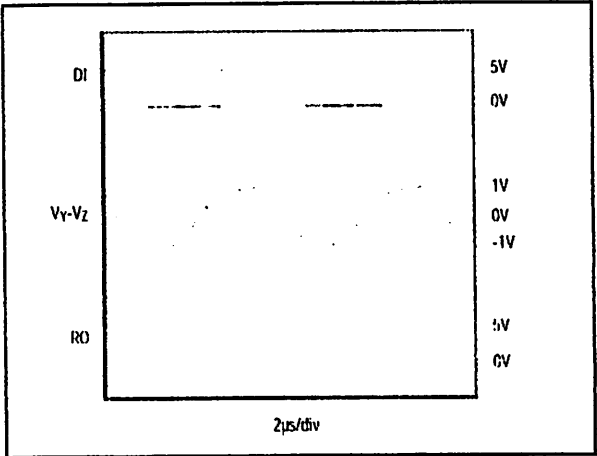


Figure 19. MAX481/MAX485/MAX490/MAX491/MAX1487 System Differential Voltage at 110kHz Driving 4000ft of Cable

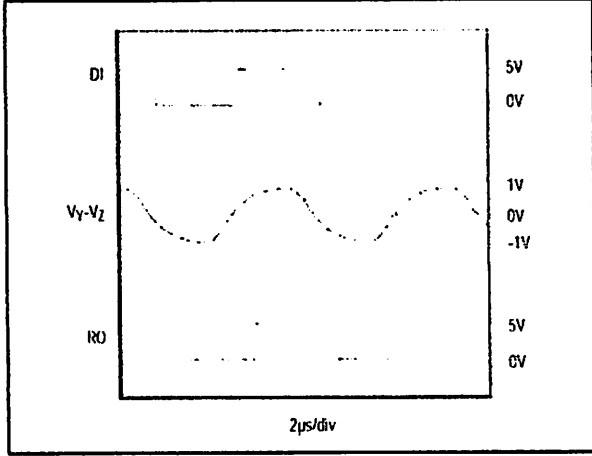


Figure 20. MAX483, MAX487-MAX489 System Differential Voltage at 110kHz Driving 4000ft of Cable

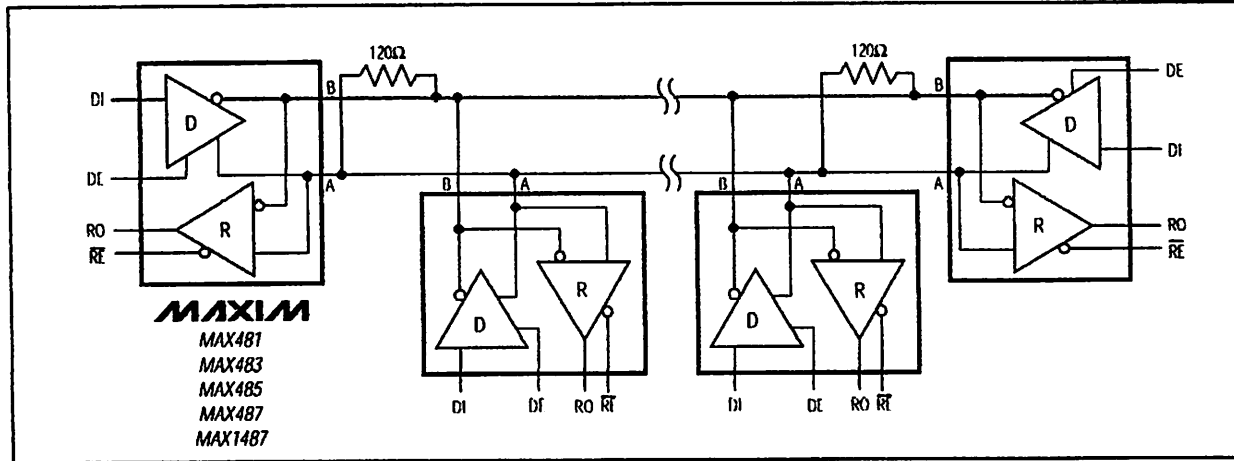


Figure 21. MAX481/MAX483/MAX485/MAX487/MAX1487 Typical Half-Duplex RS-485 Network

MAX481/MAX483/MAX485/MAX487-MAX491/MAX1487

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

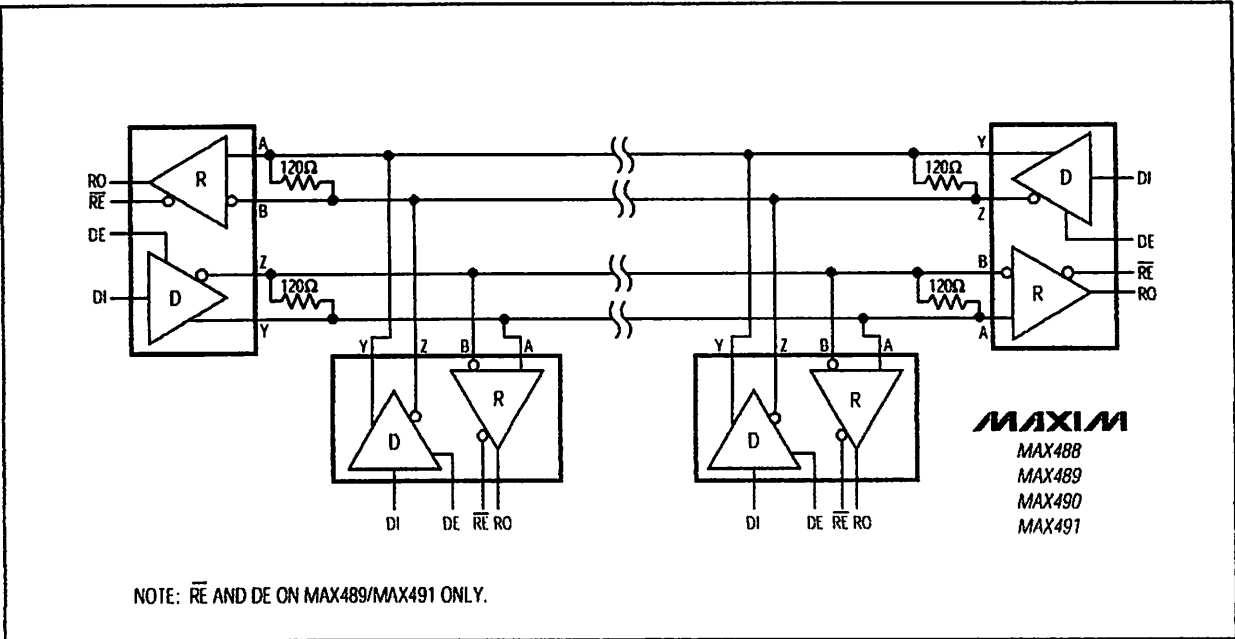


Figure 22. MAX488–MAX491 Full-Duplex RS-485 Network

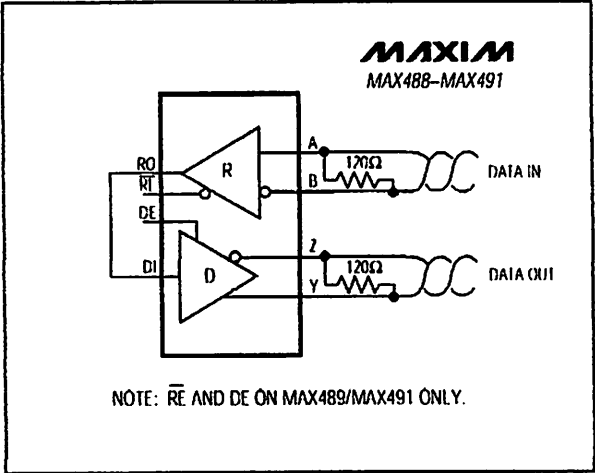


Figure 23. Line Repeater for MAX488–MAX491

Isolated RS-485
For isolated RS-485 applications, see the MAX253 and MAX1480 data sheets.

Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX481FPA	-40°C to +85°C	8 Plastic DIP
MAX481ESA	-40°C to +85°C	8 SO
MAX481MJA	-55°C to +125°C	8 CERDIP
MAX483CPA	0°C to +70°C	8 Plastic DIP
MAX483CSA	0°C to +70°C	8 SO
MAX483CUA	0°C to +70°C	8 μ MAX
MAX483C/D	0°C to +70°C	Dice*
MAX483EPA	-40°C to +85°C	8 Plastic DIP
MAX483ESA	-40°C to +85°C	8 SO
MAX483MJA	-55°C to +125°C	8 CERDIP
MAX485CPA	0°C to +70°C	8 Plastic DIP
MAX485CSA	0°C to +70°C	8 SO
MAX485CUA	0°C to +70°C	8 μ MAX
MAX485C/D	0°C to +70°C	Dice*
MAX485EPA	-40°C to +85°C	8 Plastic DIP
MAX485ESA	-40°C to +85°C	8 SO
MAX485MJA	-55°C to +125°C	8 CERDIP
MAX487CPA	0°C to +70°C	8 Plastic DIP
MAX487CSA	0°C to +70°C	8 SO
MAX487CUA	0°C to +70°C	8 μ MAX
MAX487C/D	0°C to +70°C	Dice*
MAX487EPA	-40°C to +85°C	8 Plastic DIP
MAX487ESA	-40°C to +85°C	8 SO
MAX487MJA	-55°C to +125°C	8 CERDIP
MAX488CPA	0°C to +70°C	8 Plastic DIP
MAX488CSA	0°C to +70°C	8 SO
MAX488CUA	0°C to +70°C	8 μ MAX
MAX488C/D	0°C to +70°C	Dice*
MAX488EPA	-40°C to +85°C	8 Plastic DIP
MAX488ESA	-40°C to +85°C	8 SO
MAX488MJA	-55°C to +125°C	8 CERDIP
MAX489CPD	0°C to +70°C	14 Plastic DIP
MAX489CSD	0°C to +70°C	14 SO
MAX489C/D	0°C to +70°C	Dice*
MAX489EPD	-40°C to +85°C	14 Plastic DIP
MAX489ESD	-40°C to +85°C	14 SO
MAX489MJD	-55°C to +125°C	14 CERDIP

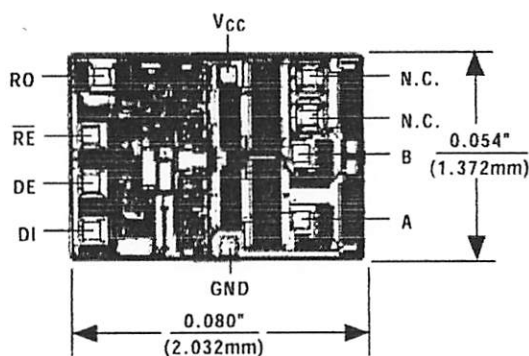
Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX490CPA	0°C to +70°C	8 Plastic DIP
MAX490CSA	0°C to +70°C	8 SO
MAX490CUA	0°C to +70°C	8 μ MAX
MAX490C/D	0°C to +70°C	Dice*
MAX490EPA	-40°C to +85°C	8 Plastic DIP
MAX490ESA	-40°C to +85°C	8 SO
MAX490MJA	-55°C to +125°C	8 CERDIP
MAX491CPD	0°C to +70°C	14 Plastic DIP
MAX491CSD	0°C to +70°C	14 SO
MAX491C/D	0°C to +70°C	Dice*
MAX491EPD	-40°C to +85°C	14 Plastic DIP
MAX491ESD	-40°C to +85°C	14 SO
MAX491MJD	-55°C to +125°C	14 CERDIP
MAX1487CPA	0°C to +70°C	8 Plastic DIP
MAX1487CSA	0°C to +70°C	8 SO
MAX1487CUA	0°C to +70°C	8 μ MAX
MAX1487C/D	0°C to +70°C	Dice*
MAX1487EPA	-40°C to +85°C	8 Plastic DIP
MAX1487ESA	-40°C to +85°C	8 SO
MAX1487MJA	-55°C to +125°C	8 CERDIP

* Contact factory for dice specifications.

Chip Topographies

MAX481/MAX483/MAX485/MAX487/MAX1487



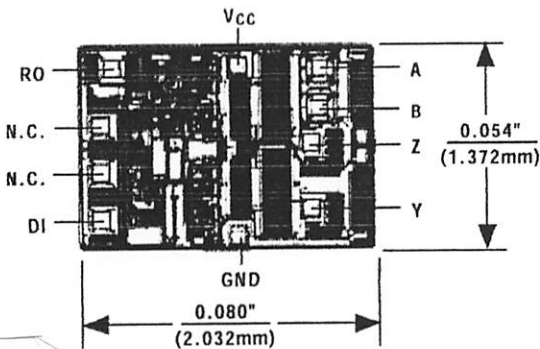
MAX481/MAX483/MAX485/MAX487-MAX491/MAX1487

MAX481/MAX483/MAX485/MAX487/MAX489/MAX491

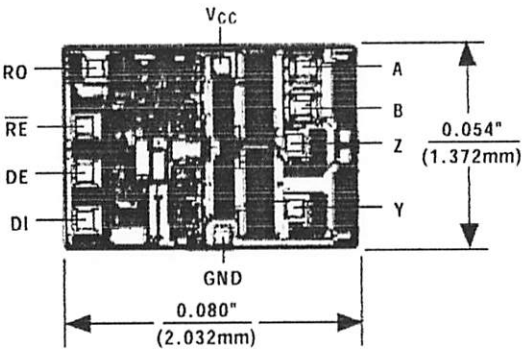
Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

Chip Topographies (continued)

MAX488/MAX490

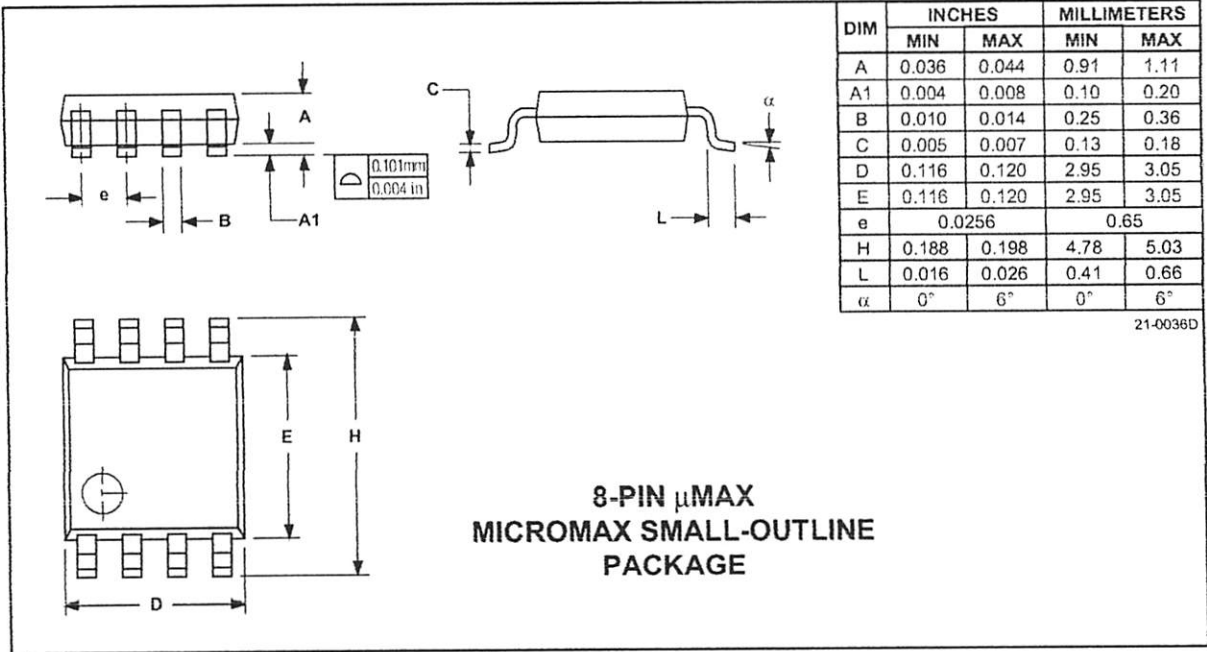


MAX489/MAX491



TRANSISTOR COUNT: 248
SUBSTRATE CONNECTED TO GND

Package Information



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ADC0808/ADC0809

8-Bit μ P Compatible A/D Converters with 8-Channel Multiplexer

General Description

The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals.

The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE® outputs.

The design of the ADC0808, ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications. For 16-channel multiplexer with common output (sample/hold port) see ADC0816 data sheet. (See AN-247 for more information.)

Features

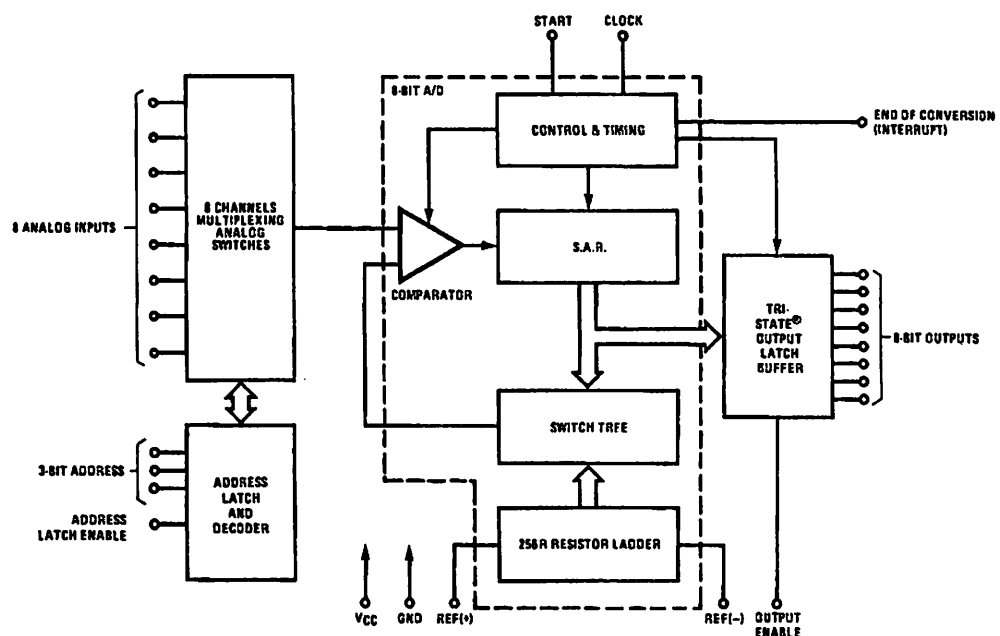
- Easy interface to all microprocessors
- Operates ratiometrically or with 5 V_{DC} or analog span adjusted voltage reference
- No zero or full-scale adjust required
- 8-channel multiplexer with address logic
- 0V to 5V input range with single 5V power supply
- Outputs meet TTL voltage level specifications
- Standard hermetic or molded 28-pin DIP package
- 28-pin molded chip carrier package
- ADC0808 equivalent to MM74C949
- ADC0809 equivalent to MM74C949-1

Key Specifications

- Resolution: 8 Bits
- Total Unadjusted Error: $\pm \frac{1}{2}$ LSB and ± 1 LSB
- Single Supply: 5 V_{DC}
- Low Power: 15 mW
- Conversion Time: 100 μ s

TRI STATE® is a registered trademark of National Semiconductor Corp.

Block Diagram



See Ordering
Information

DS005672-1

Absolute Maximum Ratings (Notes 1, 2)

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

Supply Voltage (V_{CC}) (Note 3)	6.5V
Voltage at Any Pin	-0.3V to ($V_{CC}+0.3V$)
Except Control Inputs	
Voltage at Control Inputs	-0.3V to +15V
(START, OE, CLOCK, ALE, ADD A, ADD B, ADD C)	
Storage Temperature Range	-65°C to +150°C
Package Dissipation at $T_A=25^\circ\text{C}$	875 mW
Lead Temp. (Soldering, 10 seconds)	
Dual-In-Line Package (plastic)	260°C

Dual-In-Line Package (ceramic)	300°C
Molded Chip Carrier Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
ESD Susceptibility (Note 8)	400V

Operating Conditions (Notes 1, 2)

Temperature Range (Note 1)	$T_{MIN} \leq T_A \leq T_{MAX}$
ADC0808CJ	-55°C $\leq T_A \leq$ +125°C
ADC0808CCJ, ADC0808CCN,	
ADC0809CCN	-40°C $\leq T_A \leq$ +85°C
ADC0808CCV, ADC0809CCV	-40°C $\leq T_A \leq$ +85°C
Range of V_{CC} (Note 1)	4.5 V_{DC} to 6.0 V_{DC}

Electrical Characteristics

Converter Specifications: $V_{CC}=5 V_{DC}=V_{REF+}$, $V_{REF-}=GND$, $T_{MIN} \leq T_A \leq T_{MAX}$ and $f_{CLK}=640$ kHz unless otherwise stated.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
	ADC0808					
	Total Unadjusted Error	25°C			$\pm 1/2$	LSB
	(Note 5)	T_{MIN} to T_{MAX}			$\pm 3/4$	LSB
	ADC0809					
	Total Unadjusted Error	0°C to 70°C			± 1	LSB
	(Note 5)	T_{MIN} to T_{MAX}			$\pm 1 1/4$	LSB
	Input Resistance	From Ref(+) to Ref(-)	1.0	2.5		k Ω
	Analog Input Voltage Range	(Note 4) V(+) or V(-)	GND-0.10		$V_{CC}+0.10$	V_{DC}
$V_{REF(+)}$	Voltage, Top of Ladder	Measured at Ref(+)		V_{CC}	$V_{CC}+0.1$	V
$\frac{V_{REF(+)} + V_{REF(-)}}{2}$	Voltage, Center of Ladder		$V_{CC}/2-0.1$	$V_{CC}/2$	$V_{CC}/2+0.1$	V
$V_{REF(-)}$	Voltage, Bottom of Ladder	Measured at Ref(-)	-0.1	0		V
I_{IN}	Comparator Input Current	$f_c=640$ kHz, (Note 6)	-2	± 0.5	2	μA

Electrical Characteristics

Digital Levels and DC Specifications: ADC0808CJ 4.5V $\leq V_{CC} \leq$ 5.5V, -55°C $\leq T_A \leq$ +125°C unless otherwise noted
ADC0808CCJ, ADC0808CCN, ADC0808CCV, ADC0809CCN and ADC0809CCV, 4.75V $\leq V_{CC} \leq$ 5.25V, -40°C $\leq T_A \leq$ +85°C unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
ANALOG MULTIPLEXER						
$I_{OFF(+)}$	OFF Channel Leakage Current	$V_{CC}=5V$, $V_{IN}=5V$, $T_A=25^\circ\text{C}$ T_{MIN} to T_{MAX}		10	200 1.0	nA μA
$I_{OFF(-)}$	OFF Channel Leakage Current	$V_{CC}=5V$, $V_{IN}=0$, $T_A=25^\circ\text{C}$ T_{MIN} to T_{MAX}	-200 -1.0	-10		nA μA
CONTROL INPUTS						
$V_{IN(1)}$	Logical "1" Input Voltage		$V_{CC}-1.5$			V
$V_{IN(0)}$	Logical "0" Input Voltage				1.5	V
$I_{IN(1)}$	Logical "1" Input Current (The Control Inputs)	$V_{IN}=15V$			1.0	μA
$I_{IN(0)}$	Logical "0" Input Current (The Control Inputs)	$V_{IN}=0$	-1.0			μA
I_{CC}	Supply Current	$f_{CLK}=640$ kHz		0.3	3.0	mA

Electrical Characteristics (Continued)

Digital Levels and DC Specifications: ADC0808CJ $4.5V \leq V_{CC} \leq 5.5V$, $-55^{\circ}C \leq T_A \leq +125^{\circ}C$ unless otherwise noted
 ADC0808CCJ, ADC0808CCN, ADC0808CCV, ADC0809CCN and ADC0809CCV, $4.75 \leq V_{CC} \leq 5.25V$, $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
DATA OUTPUTS AND EOC (INTERRUPT)						
$V_{OUT(1)}$	Logical "1" Output Voltage	$I_O = -360 \mu A$	$V_{CC} - 0.4$			V
$V_{OUT(0)}$	Logical "0" Output Voltage	$I_O = 1.6 \text{ mA}$			0.45	V
$V_{OUT(0)}$	Logical "0" Output Voltage EOC	$I_O = 1.2 \text{ mA}$			0.45	V
I_{OUT}	TRI-STATE Output Current	$V_O = 5V$ $V_O = 0$	-3		3	μA μA

Electrical Characteristics

Timing Specifications $V_{CC} = V_{REF(+)} = 5V$, $V_{REF(-)} = GND$, $t_r = t_f = 20 \text{ ns}$ and $T_A = 25^{\circ}C$ unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{WS}	Minimum Start Pulse Width	(Figure 5)		100	200	ns
t_{WALE}	Minimum ALE Pulse Width	(Figure 5)		100	200	ns
t_s	Minimum Address Set-Up Time	(Figure 5)		25	50	ns
t_H	Minimum Address Hold Time	(Figure 5)		25	50	ns
t_D	Analog MUX Delay Time From ALE	$R_S = 0\Omega$ (Figure 5)		1	2.5	μS
t_{H1}, t_{H0}	OE Control to Q Logic State	$C_L = 50 \text{ pF}$, $R_L = 10k$ (Figure 8)		125	250	ns
t_{1H}, t_{0H}	OE Control to Hi-Z	$C_L = 10 \text{ pF}$, $R_L = 10k$ (Figure 8)		125	250	ns
t_c	Conversion Time	$f_c = 640 \text{ kHz}$, (Figure 5) (Note 7)	90	100	116	μS
f_c	Clock Frequency		10	640	1280	kHz
t_{EOC}	EOC Delay Time	(Figure 5)	0		$8 \pm 2 \mu S$	Clock Periods
C_{IN}	Input Capacitance	At Control Inputs		10	15	pF
C_{OUT}	TRI-STATE Output Capacitance	At TRI-STATE Outputs		10	15	pF

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

Note 2: All voltages are measured with respect to GND, unless otherwise specified.

Note 3: A zener diode exists, internally, from V_{CC} to GND and has a typical breakdown voltage of 7 V_{DC} .

Note 4: Two on-chip diodes are tied to each analog input which will forward conduct for analog input voltages one diode drop below ground or one diode drop greater than the V_{CCN} supply. The spec allows 100 mV forward bias of either diode. This means that as long as the analog V_{IN} does not exceed the supply voltage by more than 100 mV, the output code will be correct. To achieve an absolute $0V_{DC}$ to $5V_{DC}$ input voltage range will therefore require a minimum supply voltage of $4.900 V_{DC}$ over temperature variations, initial tolerance and loading.

Note 5: Total unadjusted error includes offset, full-scale, linearity, and multiplexer errors. See Figure 2. None of these A/Ds requires a zero or full-scale adjust. However, if an all zero code is desired for an analog input other than 0.0V, or if a narrow full-scale span exists (for example: 0.5V to 4.5V full-scale) the reference voltages can be adjusted to achieve this. See Figure 13.

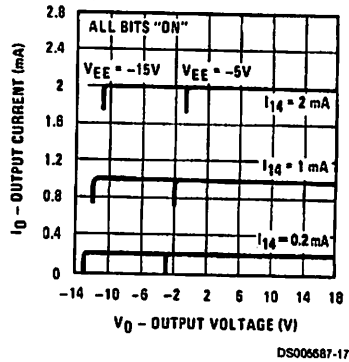
Note 6: Comparator input current is a bias current into or out of the chopper stabilized comparator. The bias current varies directly with clock frequency and has little temperature dependence (Figure "NO TGT: fig NS0592"). See paragraph 4.0.

Note 7: The outputs of the data register are updated one clock cycle before the rising edge of EOC.

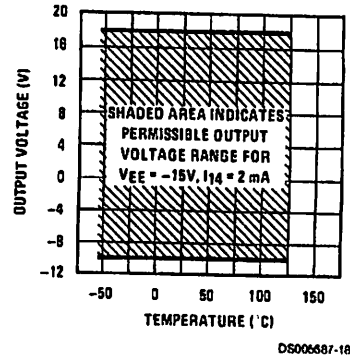
Note 8: Human body model, 100 pF discharged through a 1.5 k Ω resistor.

Typical Performance Characteristics $V_{CC} = 5V$, $V_{EE} = -15V$, $T_A = 25^\circ C$, unless otherwise noted (continued)

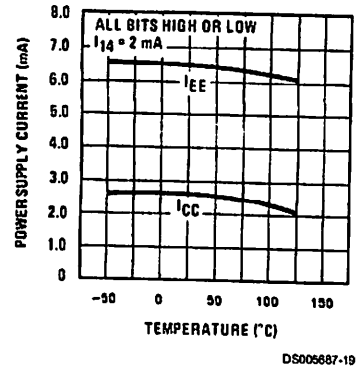
Output Current vs Output Voltage (Output Voltage Compliance)



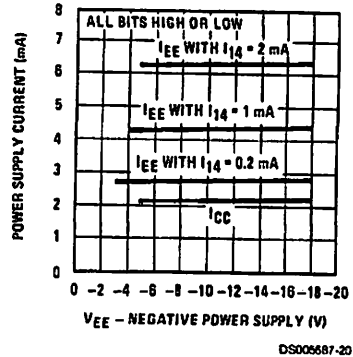
Output Voltage Compliance vs Temperature



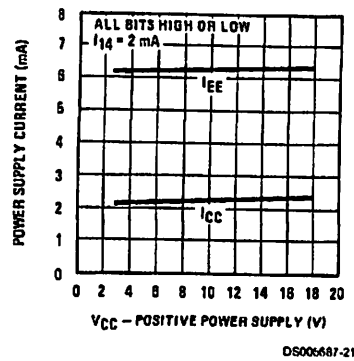
Typical Power Supply Current vs Temperature



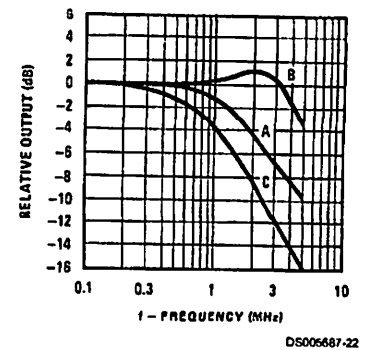
Typical Power Supply Current vs VEE



Typical Power Supply Current vs VCC



Reference Input Frequency Response



Unless otherwise specified: $R_{14} = R_{15} = 1\text{ k}\Omega$, $C = 15\text{ pF}$, pin 16 to V_{EE} ; $R_L = 50\Omega$, pin 4 to ground.

Curve A: Large Signal Bandwidth Method of Figure 7, $V_{REF} = 2\text{ Vp-p}$ offset 1V above ground.

Curve B: Small Signal Bandwidth Method of Figure 7, $R_L = 250\Omega$, $V_{REF} = 50\text{ mVp-p}$ offset 200 mV above ground.

Curve C: Large and Small Signal Bandwidth Method of Figure 9 (no op amp, $R_L = 50\Omega$), $R_S = 50\Omega$, $V_{REF} = 2V$, $V_S = 100\text{ mVp-p}$ centered at 0V.

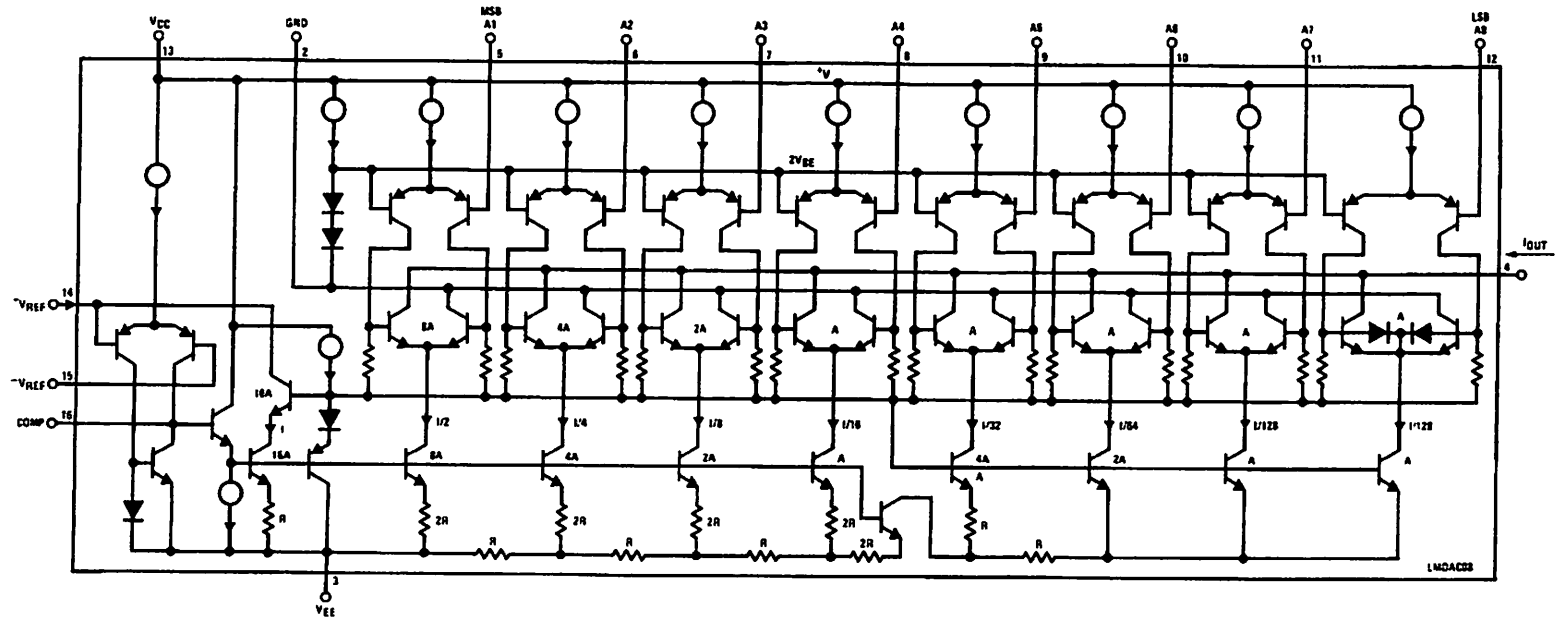
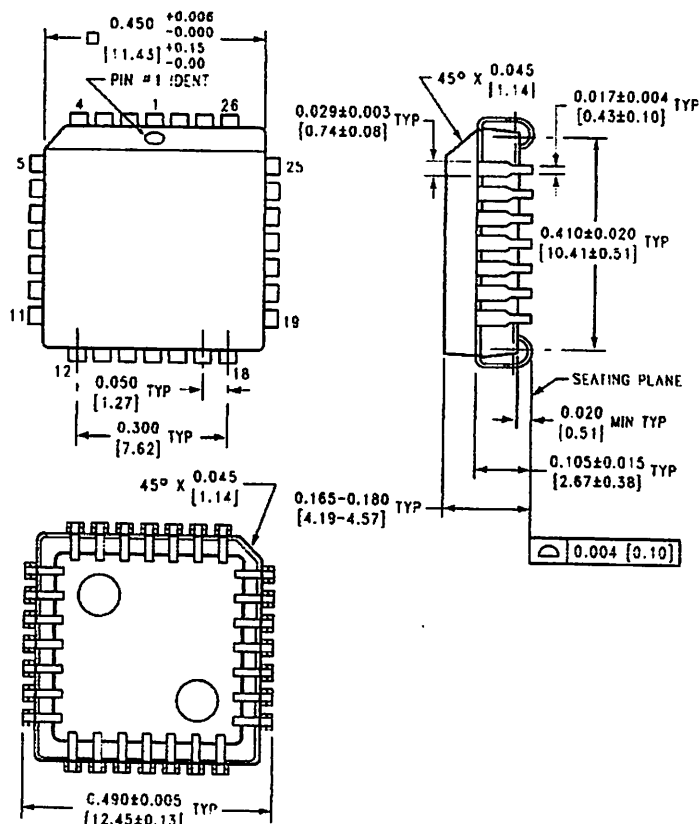


FIGURE 2. Equivalent Circuit of the DAC0808 Series (Note 8)

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



Molded Chip Carrier (V)
Order Number ADC0808CCV or ADC0809CCV
NS Package Number V28A

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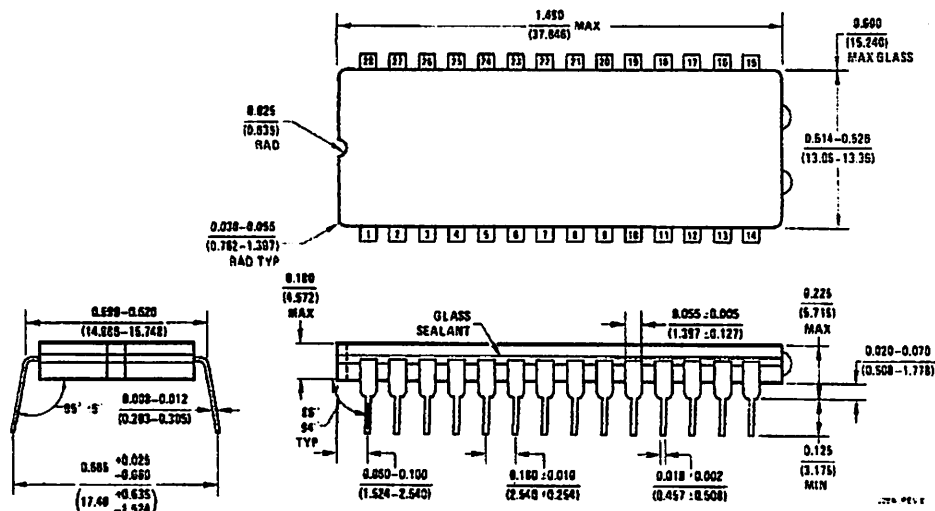
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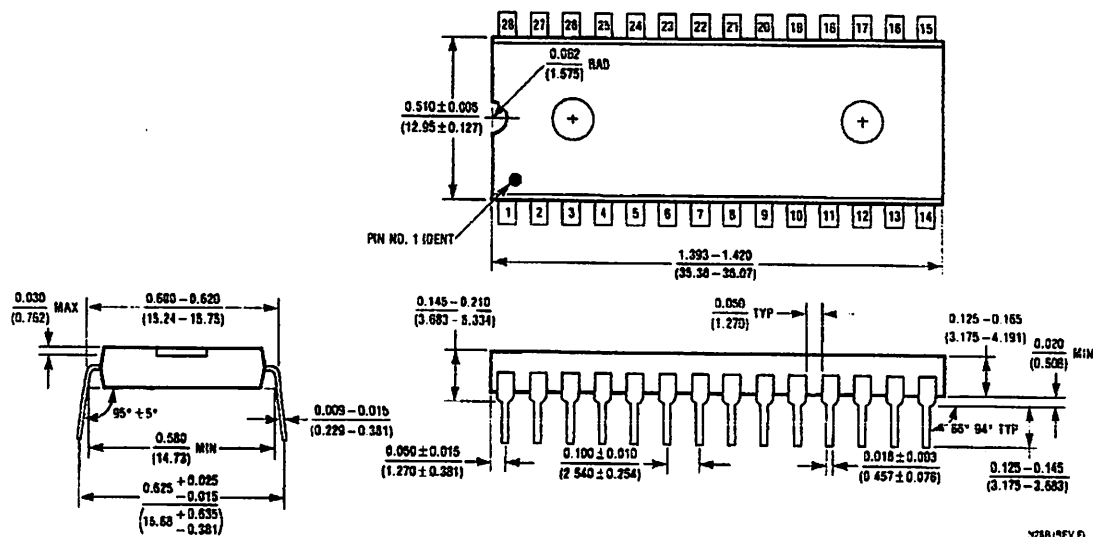
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Physical Dimensions inches (millimeters) unless otherwise noted



Ceramic Dual-In-Line Package (J)
Order Number ADC0808CCJ or ADC0808CJ
NS Package Number J28A



Molded Dual-In-Line Package (N)
Order Number ADC0808CCN or ADC0809CCN
NS Package Number N28B

Applications Information (Continued)

4.0 ANALOG COMPARATOR INPUTS

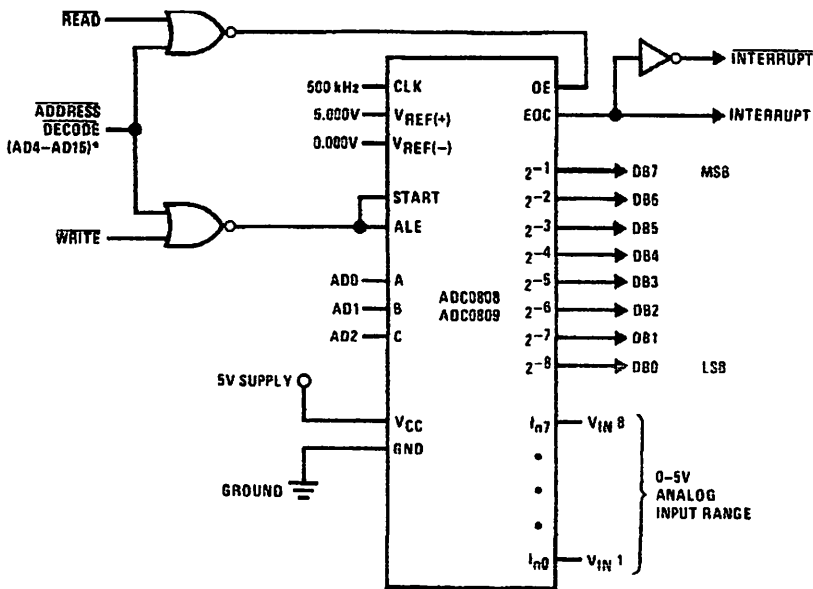
The dynamic comparator input current is caused by the periodic switching of on-chip stray capacitances. These are connected alternately to the output of the resistor ladder/switch tree network and to the comparator input as part of the operation of the chopper stabilized comparator.

The average value of the comparator input current varies directly with clock frequency and with V_{IN} as shown in Figure 6.

If no filter capacitors are used at the analog inputs and the signal source impedances are low, the comparator input current should not introduce converter errors, as the transient created by the capacitance discharge will die out before the comparator output is strobed.

If input filter capacitors are desired for noise reduction and signal conditioning they will tend to average out the dynamic comparator input current. It will then take on the characteristics of a DC bias current whose effect can be predicted conventionally.

Typical Application



*Address latches needed for 8085 and SC/MP interfacing the ADC0808 to a microprocessor

D5005672 10

MICROPROCESSOR INTERFACE TABLE

PROCESSOR	READ	WRITE	INTERRUPT (COMMENT)
8080	MEMR	MEMW	INTR (Thru RST Circuit)
8085	R $\overline{D}$	W $\overline{R}$	INTR (Thru RST Circuit)
Z-80	R $\overline{D}$	W $\overline{R}$	INT $\overline{T}$ (Thru RST Circuit, Mode 0)
SC/MP	NRDS	NWDS	SA (Thru Sense A)
6800	VMA $\cdot\phi$ 2 $\cdot$ R/W	VMA $\cdot\phi$ $\cdot$ R/W	IRQA or IRQB (Thru PIA)

Ordering Information

TEMPERATURE RANGE		-40°C to +85°C			-55°C to +125°C
Error	$\pm\frac{1}{2}$ LSB Unadjusted	ADC0808CCN	ADC0808CCV	ADC0808CCJ	ADC0808CJ
	± 1 LSB Unadjusted	ADC0809CCN	ADC0809CCV		
Package Outline		N28A Molded DIP	V28A Molded Chip Carrier	J28A Ceramic DIP	J28A Ceramic DIP

Applications Information (Continued)

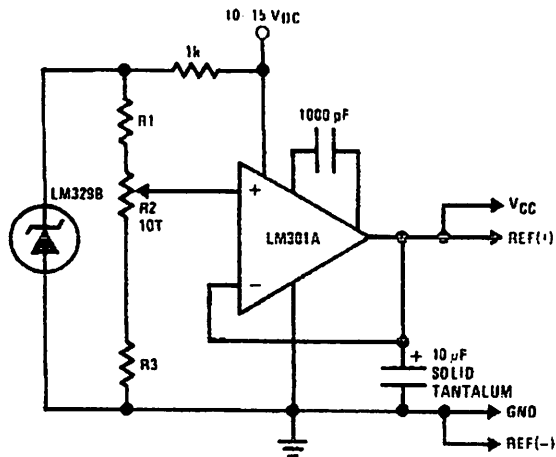


FIGURE 12. Typical Reference and Supply Circuit

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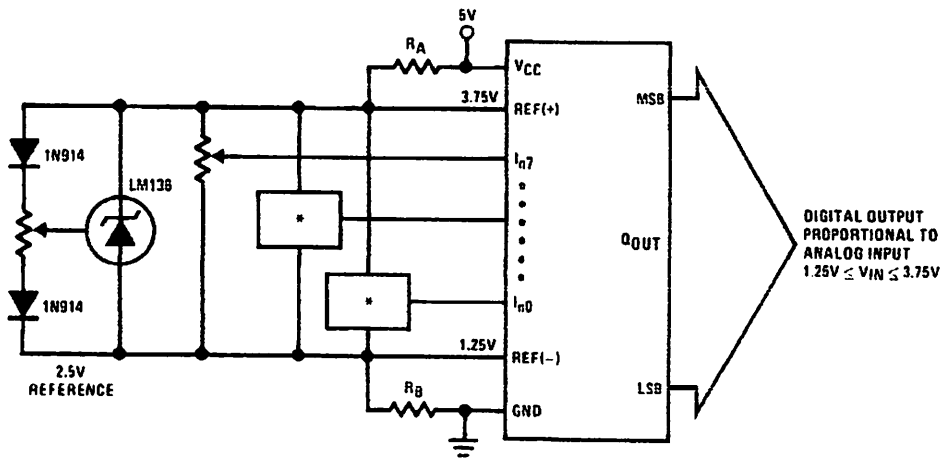


FIGURE 13. Symmetrically Centered Reference

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$R_A = R_B$
*Ratiometric transducers

3.0 CONVERTER EQUATIONS

The transition between adjacent codes N and N+1 is given by:

$$V_{IN} = \left\{ (V_{REF(+)} - V_{REF(-)}) \left[\frac{N}{256} + \frac{1}{512} \right] \pm V_{TUE} \right\} + V_{REF(-)} \quad (2)$$

The center of an output code N is given by:

$$V_{IN} \left\{ (V_{REF(+)} - V_{REF(-)}) \left[\frac{N}{256} \right] + V_{TUE} \right\} + V_{REF(-)} \quad (3)$$

The output code N for an arbitrary input are the integers within the range:

$$N = \frac{V_{IN} - V_{REF(-)}}{V_{REF(+)} - V_{REF(-)}} \cdot 256 \pm \text{Absolute Accuracy} \quad (4)$$

where: V_{IN} = Voltage at comparator input
 $V_{REF(+)}$ = Voltage at Ref(+)
 $V_{REF(-)}$ = Voltage at Ref(-)
 V_{TUE} = Total unadjusted error voltage (typically $V_{REF(+)} + 512$)

Applications Information (Continued)

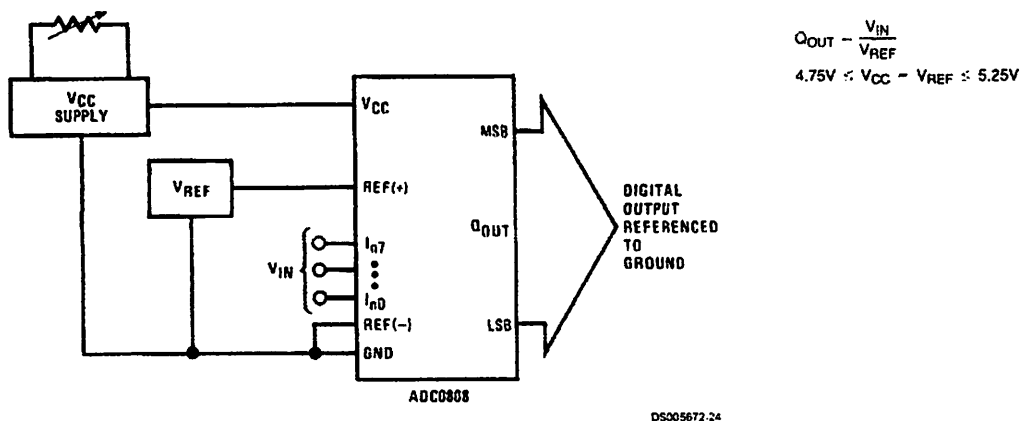


FIGURE 10. Ground Referenced Conversion System Using Trimmed Supply

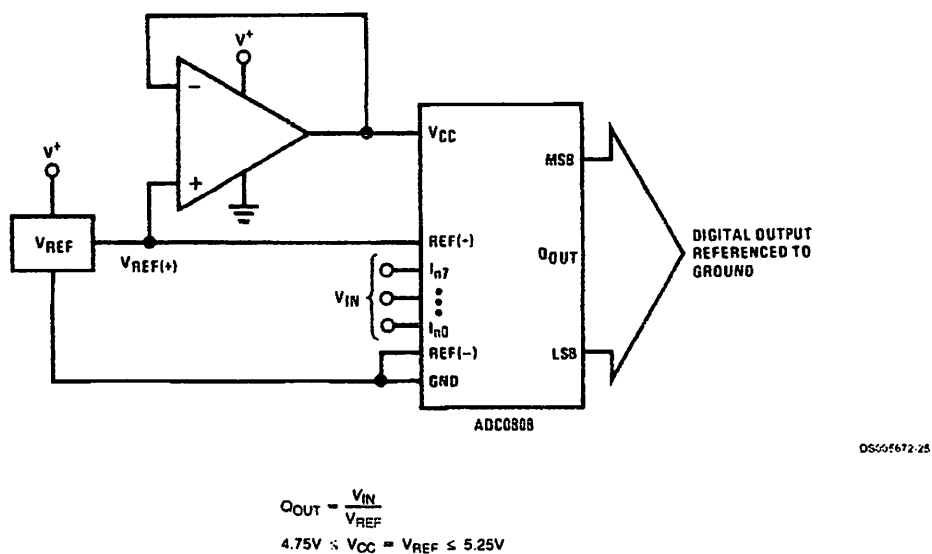


FIGURE 11. Ground Referenced Conversion System with Reference Generating V_{CC} Supply

Applications Information (Continued)

suitable for measuring proportional relationships; however, many types of measurements must be referred to an absolute standard such as voltage or current. This means a system reference must be used which relates the full-scale voltage to the standard volt. For example, if $V_{CC} = V_{REF} = 5.12V$, then the full-scale range is divided into 256 standard steps. The smallest standard step is 1 LSB which is then 20 mV.

2.0 RESISTOR LADDER LIMITATIONS

The voltages from the resistor ladder are compared to the selected into 8 times in a conversion. These voltages are coupled to the comparator via an analog switch tree which is referenced to the supply. The voltages at the top, center and bottom of the ladder must be controlled to maintain proper operation.

The top of the ladder, Ref(+), should not be more positive than the supply, and the bottom of the ladder, Ref(-), should not be more negative than ground. The center of the ladder voltage must also be near the center of the supply because the analog switch tree changes from N-channel switches to P-channel switches. These limitations are automatically satisfied in ratiometric systems and can be easily met in ground referenced systems.

Figure 10 shows a ground referenced system with a separate supply and reference. In this system, the supply must be trimmed to match the reference voltage. For instance, if a 5.12V is used, the supply should be adjusted to the same voltage within 0.1V.

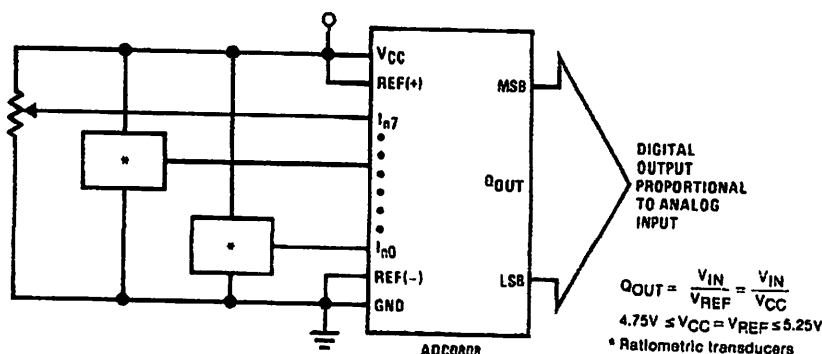


FIGURE 9. Ratiometric Conversion System

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The ADC0808 needs less than a milliamp of supply current so developing the supply from the reference is readily accomplished. In Figure 11 a ground referenced system is shown which generates the supply from the reference. The buffer shown can be an op amp of sufficient drive to supply the milliamp of supply current and the desired bus drive, or if a capacitive bus is driven by the outputs a large capacitor will supply the transient supply current as seen in Figure 12. The LM301 is overcompensated to insure stability when loaded by the 10 μF output capacitor.

The top and bottom ladder voltages cannot exceed V_{CC} and ground, respectively, but they can be symmetrically less than V_{CC} and greater than ground. The center of the ladder voltage should always be near the center of the supply. The sensitivity of the converter can be increased, (i.e., size of the LSB steps decreased) by using a symmetrical reference system. In Figure 13, a 2.5V reference is symmetrically centered about $V_{CC}/2$ since the same current flows in identical resistors. This system with a 2.5V reference allows the LSB bit to be half the size of a 5V reference system.

Typical Performance Characteristics

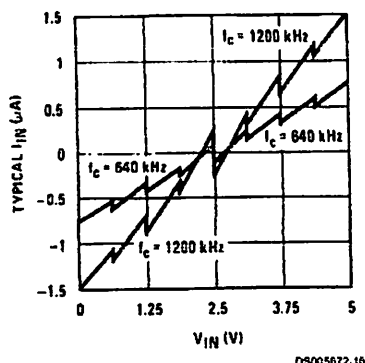


FIGURE 6. Comparator I_{IN} vs V_{IN}
($V_{CC}=V_{REF}=5V$)

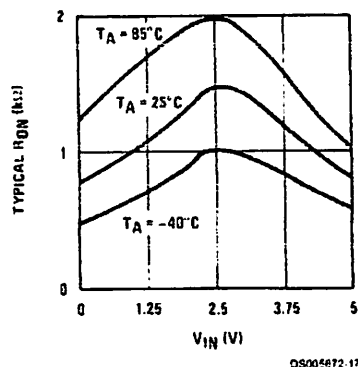


FIGURE 7. Multiplexer R_{ON} vs V_{IN}
($V_{CC}=V_{REF}=5V$)

TRI-STATE Test Circuits and Timing Diagrams

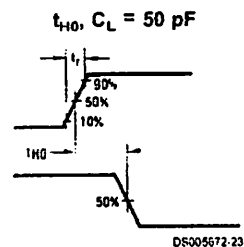
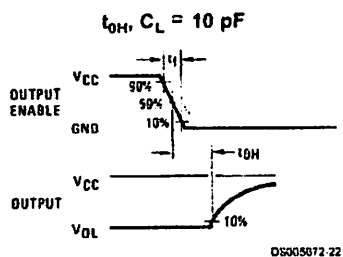
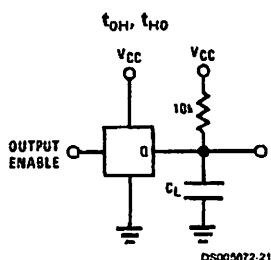
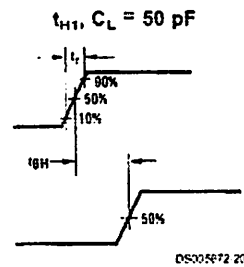
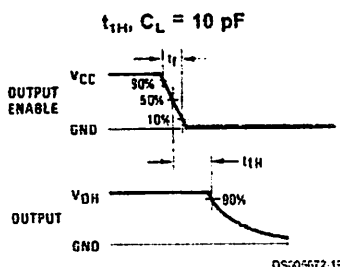
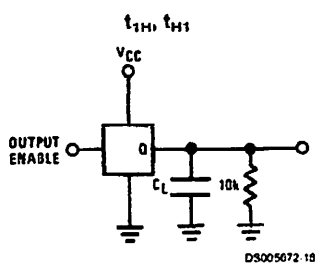


FIGURE 8.

Applications Information

OPERATION

1.0 RATIOMETRIC CONVERSION

The ADC0808, ADC0809 is designed as a complete Data Acquisition System (DAS) for ratiometric conversion systems. In ratiometric systems, the physical variable being measured is expressed as a percentage of full-scale which is not necessarily related to an absolute standard. The voltage input to the ADC0808 is expressed by the equation

$$\frac{V_{IN}}{V_{FS}-V_Z} = \frac{D_X}{D_{MAX}-D_{MIN}} \quad (1)$$

V_{IN} =Input voltage into the ADC0808

V_{FS} =Full-scale voltage

V_Z =Zero voltage

D_X =Data point being measured

D_{MAX} =Maximum data limit

D_{MIN} =Minimum data limit

A good example of a ratiometric transducer is a potentiometer used as a position sensor. The position of the wiper is directly proportional to the output voltage which is a ratio of the full-scale voltage across it. Since the data is represented as a proportion of full-scale, reference requirements are greatly reduced, eliminating a large source of error and cost for many applications. A major advantage of the ADC0808, ADC0809 is that the input voltage range is equal to the supply range so the transducers can be connected directly across the supply and their outputs connected directly into the multiplexer inputs, (Figure 9).

Ratiometric transducers such as potentiometers, strain gauges, thermistor bridges, pressure transducers, etc., are

LM35

Precision Centigrade Temperature Sensors

General Description

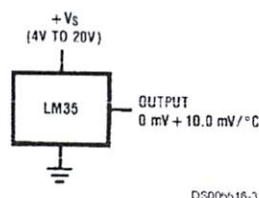
The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of $\pm 1/4^\circ\text{C}$ at room temperature and $\pm 1/2^\circ\text{C}$ over a full -55 to $+150^\circ\text{C}$ temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only $60\text{ }\mu\text{A}$ from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a -55° to $+150^\circ\text{C}$ temperature range, while the LM35C is rated for a -40° to $+110^\circ\text{C}$ range (-10° with improved accuracy). The LM35 series is available pack-

aged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

Features

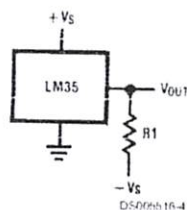
- Calibrated directly in $^\circ\text{Celsius}$ (Centigrade)
- Linear $+10.0\text{ mV}/^\circ\text{C}$ scale factor
- 0.5°C accuracy guaranteeable (at $+25^\circ\text{C}$)
- Rated for full -55° to $+150^\circ\text{C}$ range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than $60\text{ }\mu\text{A}$ current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only $\pm 1/4^\circ\text{C}$ typical
- Low impedance output, $0.1\text{ }\Omega$ for 1 mA load

Typical Applications



DS00516-3

FIGURE 1. Basic Centigrade Temperature Sensor
($+2^\circ\text{C}$ to $+150^\circ\text{C}$)



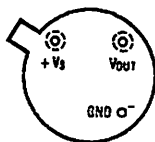
DS00516-4

Choose $R_1 = -V_S/50\text{ }\mu\text{A}$
 $V_{OUT} = +1.500\text{ mV}$ at $+150^\circ\text{C}$
 $= +250\text{ mV}$ at $+25^\circ\text{C}$
 $= -550\text{ mV}$ at -55°C

FIGURE 2. Full-Range Centigrade Temperature Sensor

Connection Diagrams

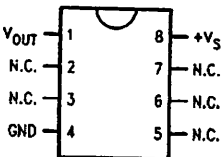
TO-46
Metal Can Package*



BOTTOM VIEW
DS00055 18-1

*Case is connected to negative pin (GND)
Order Number LM35H, LM35AH, LM35CH, LM35CAH or LM35DH
See NS Package Number H03H

SO-8
Small Outline Molded Package

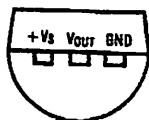


DS00055 18-21

N.C. = No Connection

Top View
Order Number LM35DM
See NS Package Number M08A

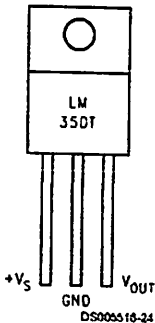
TO-92
Plastic Package



BOTTOM VIEW
DS00055 18-2

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

TO-220
Plastic Package*



DS00055 18-24

*Tab is connected to the negative pin (GND).
Note: The LM35DT pinout is different than the discontinued LM35DP.

Order Number LM35DT
See NS Package Number TA03F

Absolute Maximum Ratings (Note 10)

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

Supply Voltage	+35V to -0.2V
Output Voltage	+6V to -1.0V
Output Current	10 mA
Storage Temp.:	
TO-46 Package,	-60°C to +180°C
TO-92 Package,	-60°C to +150°C
SO-8 Package,	-65°C to +150°C
TO-220 Package,	-65°C to +150°C
Lead Temp.:	
TO-46 Package, (Soldering, 10 seconds)	300°C

TO-92 and TO-220 Package, (Soldering, 10 seconds)	260°C
SO Package (Note 12)	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
ESD Susceptibility (Note 11)	2500V
Specified Operating Temperature Range: T_{MIN} to T_{MAX} (Note 2)	
LM35, LM35A	-55°C to +150°C
LM35C, LM35CA	-40°C to +110°C
LM35D	0°C to +100°C

Electrical Characteristics

(Notes 1, 6)

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

Electrical Characteristics

(Notes 1, 6)

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

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

Note 2: Thermal resistance of the TO-46 package is 400°C/W , junction to ambient, and 24°C/W junction to case. Thermal resistance of the TO-92 package is 180°C/W junction to ambient. Thermal resistance of the small outline molded package is 220°C/W junction to ambient. Thermal resistance of the TO-220 package is 90°C/W junction to ambient. For additional thermal resistance information see table in the Applications section.

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

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

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

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

Note 7: Accuracy is defined as the error between the output voltage and $10\text{mV}/^\circ\text{C}$ times the device's case temperature, at specified conditions of voltage, current, and temperature (expressed in $^\circ\text{C}$).

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

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

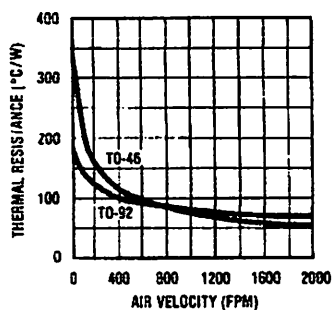
Note 10: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions. See Note 1.

Note 11: Human body model, 100 pF discharged through a $1.5\text{ k}\Omega$ resistor.

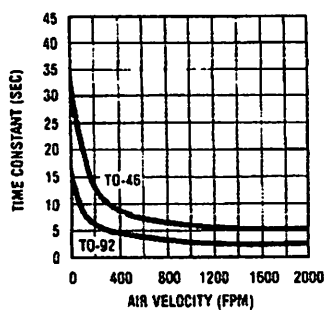
Note 12: See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" or the section titled "Surface Mount" found in a current National Semiconductor Linear Data Book for other methods of soldering surface mount devices.

Typical Performance Characteristics

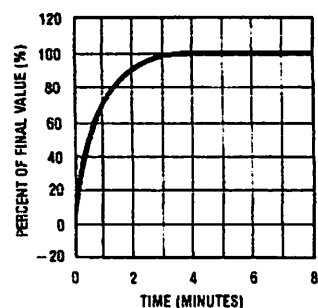
**Thermal Resistance
Junction to Air**



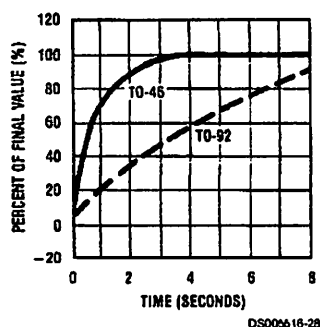
Thermal Time Constant



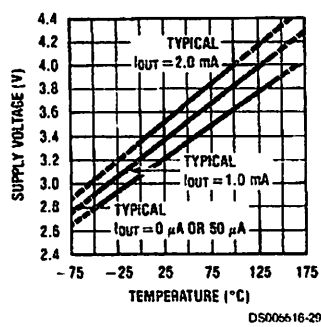
**Thermal Response
In Still Air**



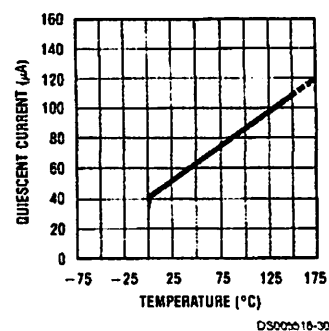
**Thermal Response in
Stirred Oil Bath**



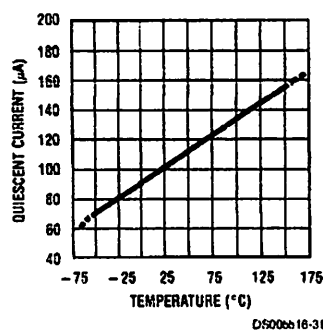
**Minimum Supply
Voltage vs. Temperature**



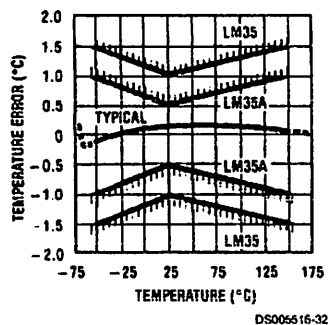
**Quiescent Current
vs. Temperature
(In Circuit of Figure 1.)**



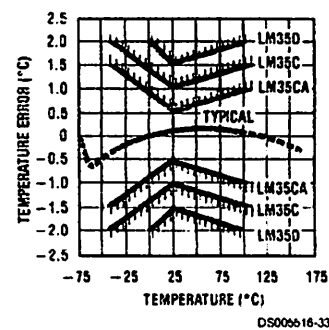
**Quiescent Current
vs. Temperature
(In Circuit of Figure 2.)**



**Accuracy vs. Temperature
(Guaranteed)**

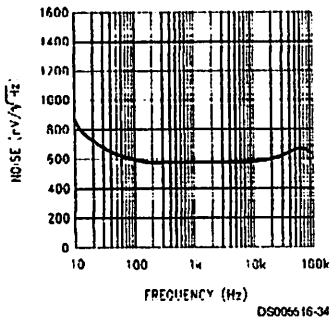


**Accuracy vs. Temperature
(Guaranteed)**

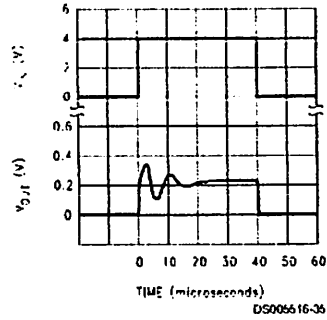


Typical Performance Characteristics (Continued)

Noise Voltage



Start-Up Response



Applications

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

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

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

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

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

Temperature Rise of LM35 Due To Self-heating (Thermal Resistance, θ_{JA})

	TO-46, no heat sink	TO-46*, small heat fin	TO-92, no heat sink	TO-92**, small heat fin	SO-8 no heat sink	SO-8**, small heat fin	TO-220 no heat sink
Still air	400°C/W	100°C/W	180°C/W	140°C/W	220°C/W	110°C/W	90°C/W
Moving air	100°C/W	40°C/W	60°C/W	70°C/W	105°C/W	50°C/W	26°C/W
Still oil	100°C/W	40°C/W	90°C/W	70°C/W			
Stirred oil	50°C/W	30°C/W	45°C/W	40°C/W			
(Clamped to metal, infinite heat sink)		(24°C/W)				(55°C/W)	

*Wakefield type 201, or 1" disc of 0.020" sheet brass, soldered to case, or similar.
**TO-92 and SO-8 packages glued and leads soldered to 1" square of 1/16" printed circuit board with 2 oz. foil or similar.

Typical Applications (Continued)

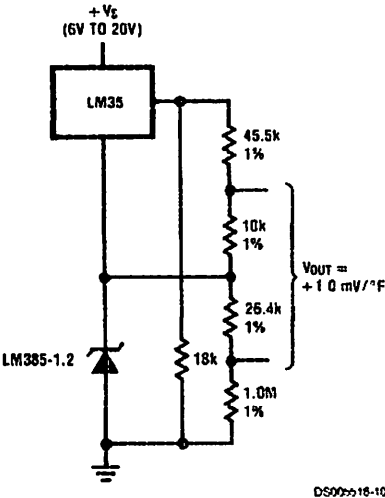


FIGURE 10. Fahrenheit Thermometer

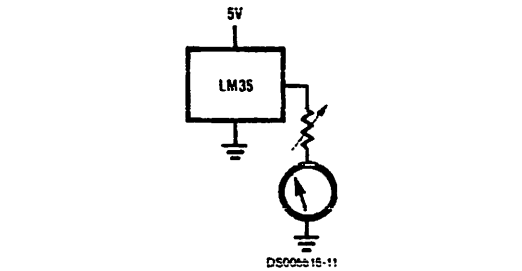


FIGURE 11. Centigrade Thermometer (Analog Meter)

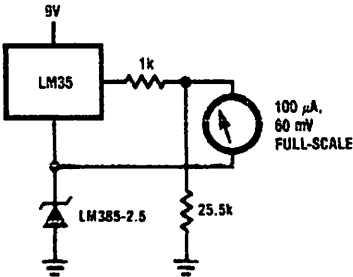


FIGURE 12. Fahrenheit Thermometer Expanded Scale Thermometer (50° to 80° Fahrenheit, for Example Shown)

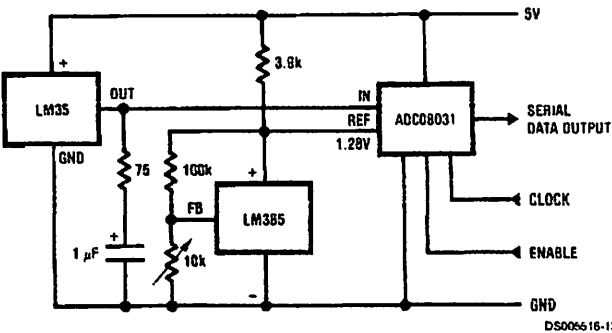


FIGURE 13. Temperature To Digital Converter (Serial Output) (+128°C Full Scale)

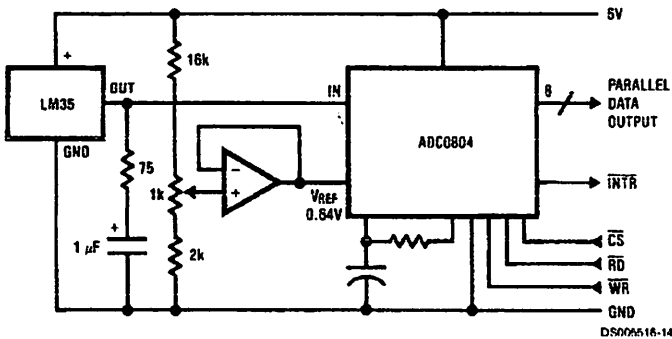
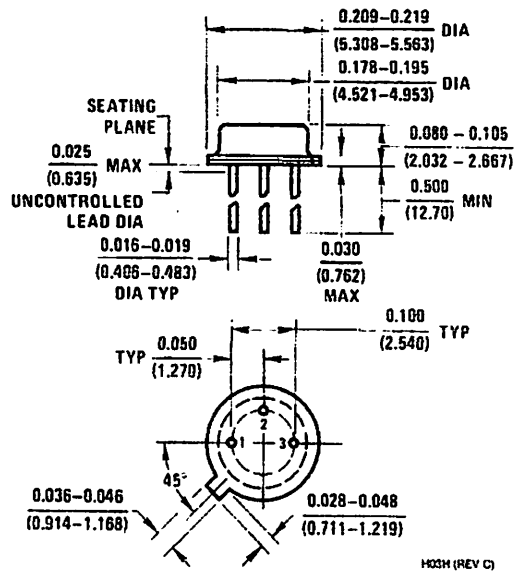
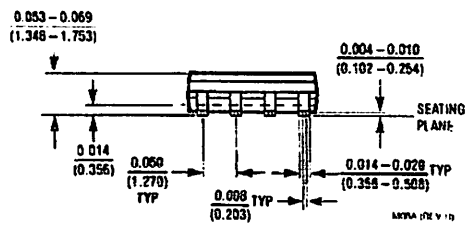
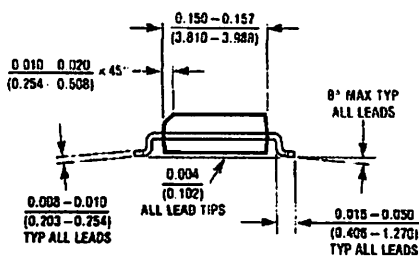
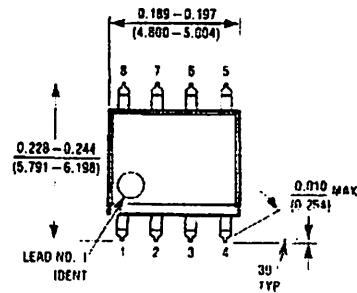


FIGURE 14. Temperature To Digital Converter (Parallel TRI-STATE™ Outputs for Standard Data Bus to μP Interface) (128°C Full Scale)

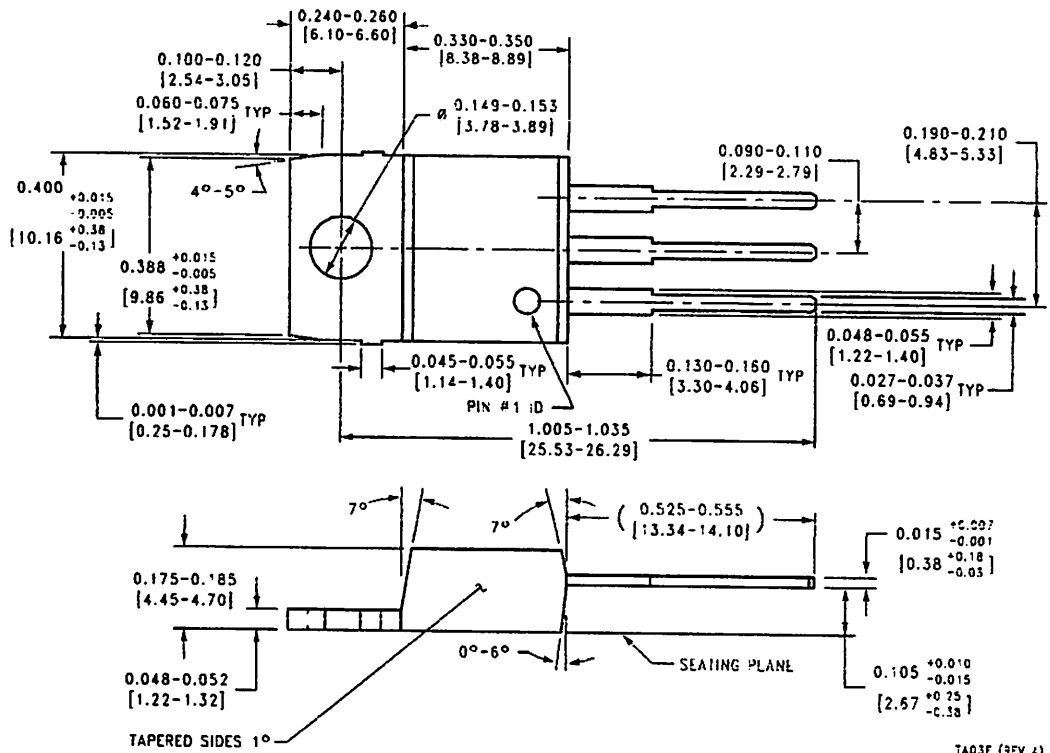
Physical Dimensions inches (millimeters) unless otherwise noted

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



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

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

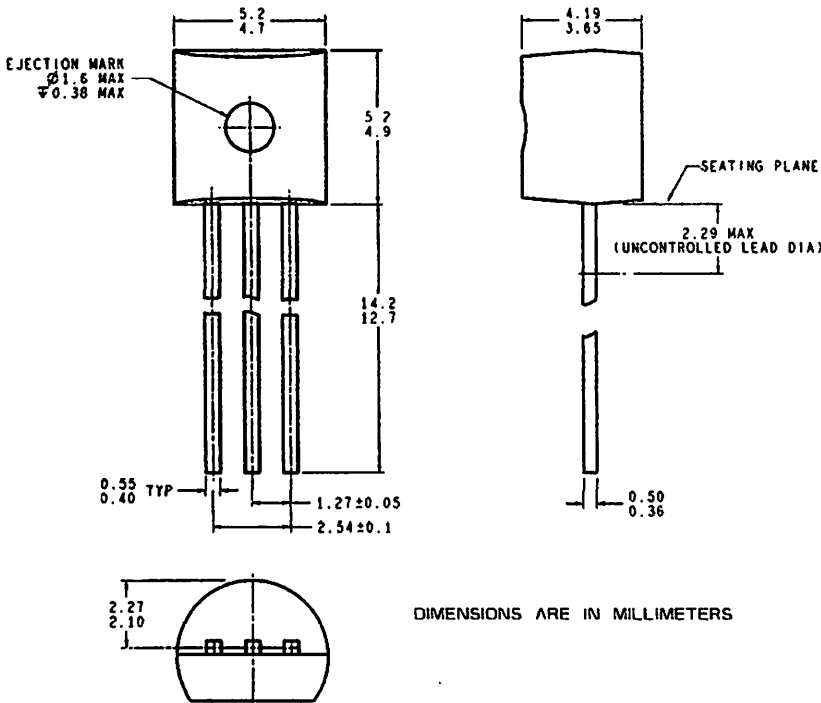


Power Package TO-220 (T)
Order Number LM35DT
NS Package Number TA03F

TA03F (REV 4)

Physical Dimensions

Inches (millimeters) unless otherwise noted (Continued)



Z03A (Rev. G)

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

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

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THICK FILM GAS SENSOR AF-SERIES

Scimarec's thick film gas sensors are a new type of semiconductor gas sensor. They offer outstanding performance, quality and long-term reliability because of their unique film printing process on a flat substrate.

The gas sensing semiconductor element is fired to one side of a ceramic substrate. It is covered with a porous ceramic film for protection against dust, foreign matter or undesired gases. A micro-heater is fused to the back of the substrate. This quickly heats the gas sensing element to the desired operating temperature. The strong structure with sensor and heater both fused to the substrate offers maximum protection against vibration and shock.

DESIGN FEATURES

- High sensitivity and fast response
- Less temperature dependency
- Long life
- Superior shock and vibration resistance
- Simple drive circuitry
- Stability

GAS DETECTION MECHANISM

The gas sensing element is an oxide semiconductor heated to 350°C. When exposed to the appropriate gas, absorbed oxygen on the surface is consumed and the electrical resistance drops.

The drop in resistance follows a predictable and repeatable plot. The proper circuitry responds to this with an alarm actuation or an optical readout.

Operating Conditions

Table 1: Operating Conditions of the AF-Series

Parameter	Ratings
Operating Temperature	-10°C~55°C
Storage Temperature	-30°C~85°C
Load Resistor R_L	Variable
Rated Sensor power consumption P_s	$P_s \leq 15\text{mW}$
Rated Working Voltage of Circuit V_c	DC or AC 5V (Max 12V)
Rated Working Voltage of Heater	DC or AC 5V $\pm$ 0.2V

$$P_s = \frac{V_c^2 \cdot R_s}{(R_s + R_L)^2} \quad R_s: \text{Sensor Resistance}$$

Basic Test Circuit

The pin allocation of the AF-Series gas sensors are shown in Fig. 1 and the basic test circuit for use with the AF-Series gas sensors are shown in Fig. 2, where pins No.1 and No.3 are connected to the heater section, and pins No.2 and No.4 to the sensor section. AF-series gas sensors are designed to operated with a stabilized 5V.

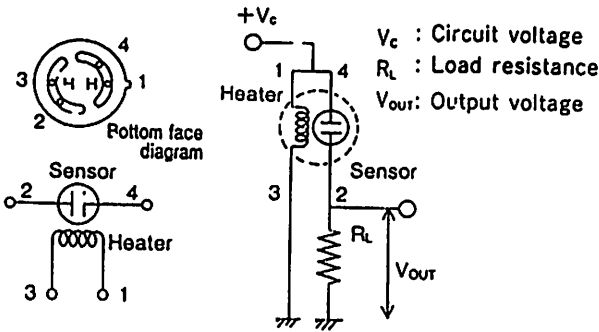


Fig.1: Pin Allocation

Fig.2: Basic Test Circuit

In this test circuit, as the sensor detects the gases, the sensor resistance is decreased. The sensor resistance (R_s) is calculated from output voltage (V_{out}) by the following formula.

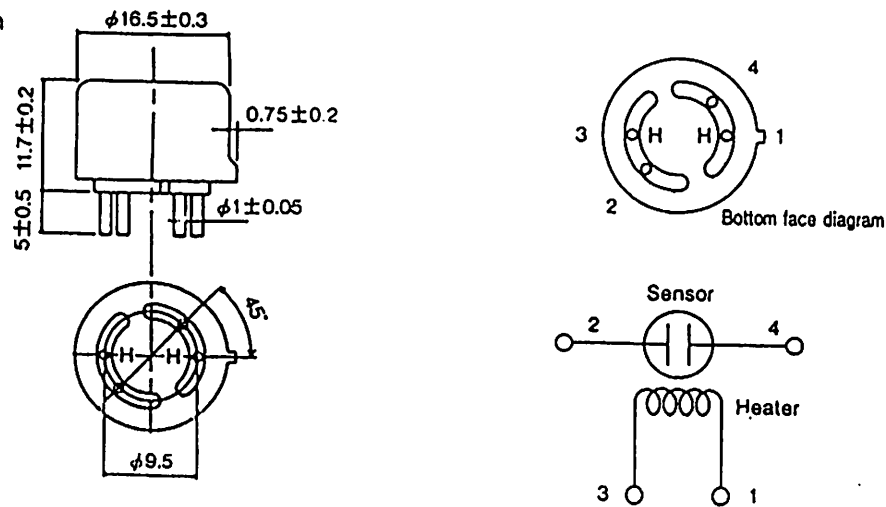
$$R_s = \frac{V_c - V_{out}}{V_{out}} \cdot R_L$$

The sensitivity denotes the ratio (R_{GAS}/R_{AIR}) of the sensor resistance obtained in the gas-containing air (R_{GAS}) to the sensor resistance obtained in the clean air without noise gases (R_{AIR}).

Specifications

Type Name	AF30	AF50	AF55	AF63	AF63P
Detection Gases	Cigarette Smoke	Methane	LP-Gas (propane, butane)	Alcohol Toluene Gasoline vapor	Ethanol Water
Detection Range		500ppm ~ 10000ppm		100ppm ~ 5000ppm	
Power Consumption mW (Max)	535	630		680	
Sensing Element	Semiconducting Oxide				
Pin Material	Ni alloy				
Case Material	Nylon 66				PPS
Flame Arrestor	Double 100-mesh stainless steel gauze (SUS316)				

Dimensions and
Pin configuration



*** Test Conditions ***

The technical data of this catalogue has been obtained by measurements carried out on the following conditions unless otherwise specified.

- Atmospheric Conditions : Clean air
 - with $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and R.H. $50 \pm 5\%$
 - without noise gases
- Circuit Voltage : $5\text{V} \pm 0.05\text{V}$
- Heater Voltage : $5\text{V} \pm 0.05\text{V}$
- Load Resistance : $5\text{k}\Omega \sim 10\text{k}\Omega \pm 1\%$
- Preheating Time : more than 48 hours.

(NOTES)

- If the gas sensor is used after it is left for a long time under high humidity, it will take some time until its characteristics are stabilized. In general, the longer it is left under high humidity, the longer it will take to stabilize.
- The temperature of the gas sensor case, heated by the built-in heater, will be 30°C to 40°C higher than the ambient temperature during operation.

The following must be observed

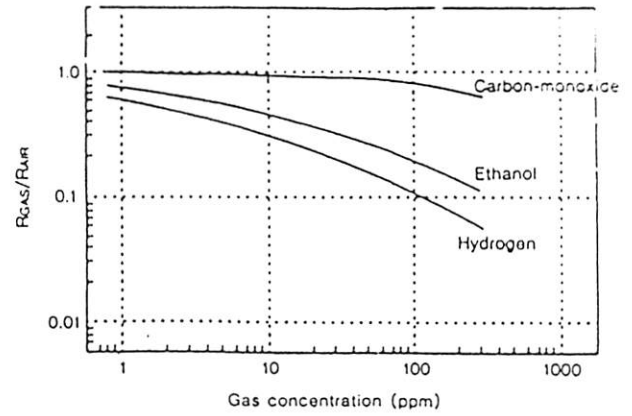
- Measure the gas sensor characteristics after operating more than 24 hours to fully stabilize the sensor.
- The gas sensor characteristics must be measured in clean air without noise gases.

AF30



- ☐ **Features**
 - General purpose
 - High sensitivity
- ☐ **Applications**
 - Air purifier

R_{GAS} : Resistor value in gas
 R_{AIR} : Resistor value in atmosphere

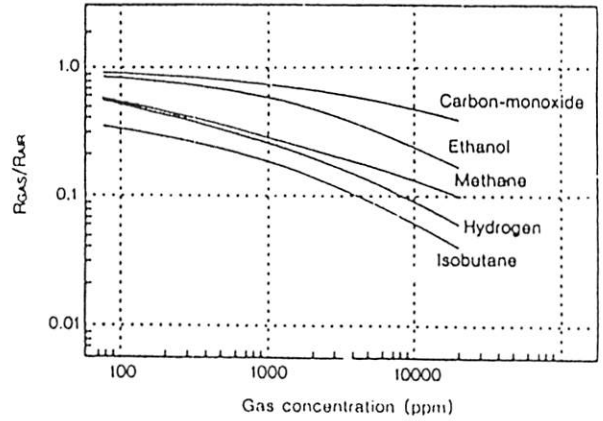


AF50

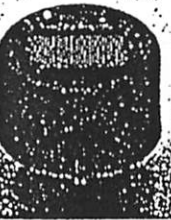


- ☐ **Features**
 - High sensitivity
 - Good sensitivity
- ☐ **Applications**
 - Gas leak detector

R_{GAS} : Resistor value in gas
 R_{AIR} : Resistor value in atmosphere

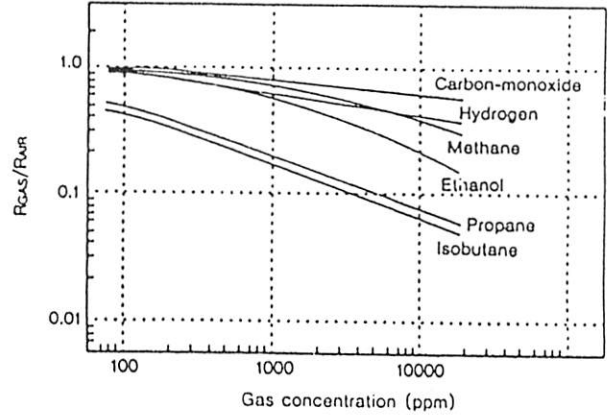


AF56



- ☐ **Features**
 - High sensitivity
 - Good sensitivity
 - Small dependence on humidity
- ☐ **Applications**
 - Gas leak detector

R_{GAS} : Resistor value in gas
 R_{AIR} : Resistor value in atmosphere

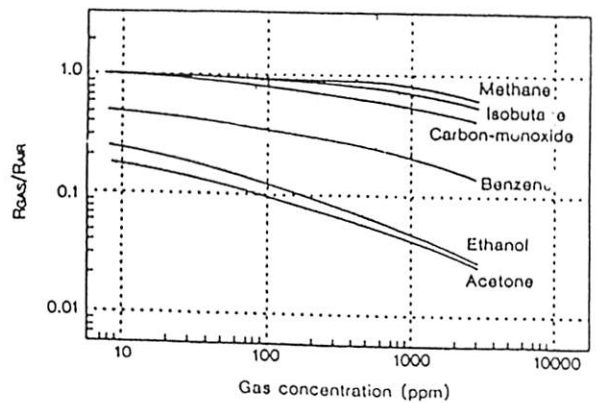


AF63, AF63P



- ☐ **Features**
 - Low sensitivity to H_2 and cigarette smoke
 - Small dependence on humidity
 - Initial stabilization time is short
- ☐ **Applications**
 - Gas leak detector (AF63)
 - Alcohol checker (AF63)
 - Microwave oven (AF63P)

R_{GAS} : Resistor value in gas
 R_{AIR} : Resistor value in atmosphere



kmgjo2.h51

```
; LCD KONSTANTA
DISPCLR      EQU 00000001B
BLINK        EQU 00001101B
ENTRMODE     EQU 00000110B
DISPON       EQU 00001100B
CURSOR       EQU 00011100B
FUNCSET      EQU 00111000B
;
;DEVICE ADDRESS [LCD]
RS           BIT P3.7    ;LCD
RW           BIT P2.2    ;LCD
E            BIT P3.6    ;LCD

START        bit        P2.0 ;ADC
EOC           bit        P2.1 ;ADC
ALE           bit        P2.2 ;ADC
DDA           bit        P2.3 ;ADC
DDB           bit        P2.4 ;ADC
DDC           bit        P2.5 ;ADC
OE            bit        P2.6 ;ADC

MY_COUNTER   EQU 31H
MY_TEMP      EQU 32H
KEYDATA      EQU 33H

COD1          EQU 27H
COD2          EQU 28H
COD3          EQU 29H
DATAKEY0      EQU 34H
DATAKEY1      EQU 35H
DATAKEY2      EQU 36H
DATAKEY3      EQU 37H
DATAKEY4      EQU 38H
DATAKEY5      EQU 39H
DATAKEY6      EQU 40H
DATAKEY7      EQU 41H
DATAKEY8      EQU 42H
DATAKEY9      EQU 43H
DATAKEY10     EQU 44H
DATAKEY11     EQU 45H
DATAKEY12     EQU 46H
LOKASI        EQU 47H
DATAKEY13     EQU 48H
DATAKEY14     EQU 49H
DATAKEY15     EQU 50H
DATAKEY16     EQU 51H
DATAKEY17     EQU 52H
DATAKEY18     EQU 53H
DATAKEY19     EQU 54H
DATAKEY20     EQU 55H
DATAKEY21     EQU 56H
DATAKEY22     EQU 57H
DATAKEY23     EQU 58H
DATAKEY24     EQU 59H
DATAKEY25     EQU 60H
DATAKEY26     EQU 61H
```

```
ORG    0000H
AJMP   MULAI
```

```
; Mulai dari alamat reset
; Loncat ke label mulai
```

```

                                kmgjo2.h51
ORG      0013H                ; Alamat interrupt

ORG      23H                  ; alamat untuk serial comm. interrupt
CLR      ES                   ; matikan interrupt serial
JNB      RI,$                  ; tunggu sampai selesai menerima
CLR      RI                   ; clear receive interrupt flag
MOV      R1,SBUF
MOV      B,R1

MOV      A,LOKASI
INC      A
MOV      LOKASI,A

PIL0:    CJNE      A,#1,PILL1
MOV      DATAKEY1,B
AJMP     TAMPILL

PILL1:   JMP      pil0

TAMPILL: SETB      ES
RETI

MULAI:

ACALL    init_serial
ACALL    INIT_LCD

TUNDA_T: MOV      R7,#100
LOOP10:  MOV      R6,#100
LOOP9:   MOV      R5,#100
         DJNZ     R5,$
         DJNZ     R6,LOOP9
         DJNZ     R7,LOOP10
         RET

TUNDA_TAM:
MOV      R7,#100
LOP10:   MOV      R6,#100
LOP9:    MOV      R5,#100
         DJNZ     R5,$
         DJNZ     R6,LOP9
         DJNZ     R7,LOP10
         RET

init_serial:
MOV      SCON,#50H
MOV      TMOD,#20H
MOV      TL1,#0FDH
MOV      TH1,#0FDH
SETB     TR1
SETB     EA                ; enable interrupt
SETB     ES                ; enable serial interrupt
RET

```

INISIALISASI:

```

;*****
;*  INISIALISASI LCD      *
;*****

```

```

DELAY_INIT_LCD:
    MOV R6,#20H

```

```

DLY_LCD_LP:

```

```

    MOV     R7,#0
    DJNZ    R7,$
    DJNZ    R6,DLY_LCD_LP
    RET

```

```

INIT_LCD:

```

```

    SETB RS

```

```

    CLR E
    MOV A,#DISPCLR
    LCALL CONTROLOUT
    LCALL DELAY_INIT_LCD
    MOV     A,#FUNCSET
    LCALL   CONTROLOUT
    MOV     A,#DISPON
    LCALL   CONTROLOUT
    MOV     A,#ENTRMOD
    LCALL   CONTROLOUT
;
    MOV     DPTR,#NAMA
    LCALL   PRINTSTRING1
    MOV     DPTR,#NIM
    LCALL   PRINTSTRING2
    CALL    TUNDA_TAM
    MOV     DPTR,#UNIV
    LCALL   PRINTSTRING1
    MOV     DPTR,#UNIV1
    LCALL   PRINTSTRING2
    CALL    TUNDA_TAM
    MOV     DPTR,#PRO
    LCALL   PRINTSTRING1
    MOV     DPTR,#PRO1
    LCALL   PRINTSTRING2

```

```

KEYLOOP:

```

```

next_sampling:

```

```

    CLR     DDA
    CLR     DDB
    CLR     DDC      ; aktifkan ADC0804
    CLR     ALE      ; start of conversion
    CLR     START
    SETB    OE

```

```

    DJNZ    R2,$

```

```

    CLR     DDA
    CLR     DDB
    CLR     DDC      ; aktifkan ADC0804
    SETB    ALE      ; start of conversion
    SETB    START
    SETB    OE

```

```

    DJNZ    R2,$

```

```

CLR    DDA
CLR    DDB
CLR    DDC      ; aktifkan ADC0804
CLR    ALE      ; start of conversion
CLR    START
SETB   OE

```

```

not_EOC:
    jb    EOC,not_EOC

```

```

delay:  DJNZ  R2,$
        DJNZ  R3,delay
        DJNZ  R3,$
        MOV   A,P1
        MOV   COD1,A
        CLR   ALE      ; start of conversion
        CLR   START
        CLR   OE

```

```

LOOPKEY:
    MOV     A,cod1
    CLR     C
    SUBB    A,#04H
    JNC     LOOPKEY1
    MOV     A,#00H
    JMP     LAYAR

```

```

LOOPKEY1:
    MOV     A,cod1
    CLR     C
    SUBB    A,#45H
    JNC     LOOPKEY2
    MOV     A,#01H
    JMP     LAYAR

```

```

LOOPKEY2:
    MOV     A,cod1
    CLR     C
    SUBB    A,#5AH
    JNC     LOOPKEY3
    MOV     A,cod1
    CLR     C
    SUBB    A,#3CH
    JMP     LAYAR

```

```

LOOPKEY3:
    MOV     A,cod1
    CLR     C
    SUBB    A,#96H
    JNC     LOOPKEY4
    MOV     A,cod1
    CLR     C
    SUBB    A,#4CH
    JMP     LAYAR

```

```

LOOPKEY4:
    MOV     A,cod1
    CLR     C
    SUBB    A,#0A0H
    JNC     LOOPKEY5
    MOV     A,cod1
    CLR     C
    SUBB    A,#1EH
    JMP     LAYAR

```

```

LOOPKEY5:

```

```

MOV     A,cod1
CLR     C
SUBB    A,#0FFH
JNC     LOOPKEY3
MOV     A,cod1
CLR     C
SUBB    A,#32H
JMP     LAYAR

```

YAR:

```

MOV     COD1,A
MOV     A,COD1
MOV     B,#10
DIV     AB
MOV     COD1,B
MOV     B,#10
DIV     AB
MOV     COD2,B
MOV     COD3,A

```

```

MOV     A,#13
LCALL   POSISI2
MOV     A,COD3
ADD     A,#30H
LCALL   DATAOUT
MOV     A,#','
LCALL   DATAOUT
MOV     A,COD2
ADD     A,#30H
LCALL   DATAOUT
MOV     A,COD1
ADD     A,#30H
LCALL   DATAOUT
;CALL   TUNDA

```

```

SETB    DDA
CLR     DDB
CLR     DDC      ; aktifkan ADC0804
CLR     ALE      ; start of conversion
CLR     START
SETB    OE

```

```

DJNZ    R2,$

```

```

SETB    DDA
CLR     DDB
CLR     DDC      ; aktifkan ADC0804
SETB    ALE      ; start of conversion
SETB    START
SETB    OE

```

```

DJNZ    R2,$

```

```

SETB    DDA
CLR     DDB
CLR     DDC      ; aktifkan ADC0804
CLR     ALE      ; start of conversion
CLR     START
SETB    OE

```

```

not_EOC1:
jb      EOC,not_EOC1

```

```

delay1: DJNZ     R2,$                               kmgjo2.h51
        DJNZ     R3,delay1
        DJNZ     R3,$
        MOV      A,P1
        MOV      DATAKEY1,A
        CLR      ALE      ; start of conversion
        CLR      START
        CLR      OE
        MOV      DATAKEY1,A
        MOV      A,DATAKEY1
        MOV      B,#10
        DIV      AB
        MOV      DATAKEY1,B
        MOV      B,#10
        DIV      AB
        MOV      DATAKEY2,B
        MOV      DATAKEY3,A

        MOV      A,#13
        LCALL    POSISI1
        MOV      A,DATAKEY3
        ADD      A,#30H
        LCALL    DATAOUT
        MOV      A,DATAKEY2
        ADD      A,#30H
        LCALL    DATAOUT
        MOV      A,DATAKEY1
        ADD      A,#30H
        LCALL    DATAOUT

        MOV      A,'#A'
        MOV      B,A
        CALL     KIRIM
        CALL     TUNDA1
        MOV      A,COD3
        ADD      A,#30H
        MOV      B,A
        CALL     KIRIM
        MOV      A,COD2
        ADD      A,#30H
        MOV      B,A
        CALL     KIRIM
        MOV      A,COD1
        ADD      A,#30H
        MOV      B,A
        CALL     KIRIM

        MOV      A,DATAKEY3
        ADD      A,#30H
        MOV      B,A
        CALL     KIRIM
        MOV      A,DATAKEY2
        ADD      A,#30H
        MOV      B,A
        CALL     KIRIM
        MOV      A,DATAKEY1
        ADD      A,#30H
        MOV      B,A
        CALL     KIRIM
        JMP      KEYLOOP

```

```

TRIM:  CLR     ES           ; matikan serial interrupt saat mengirim
      MOV     A,B
      MOV     SBUF,A       ; isi serial buffer dengan data yg dikirim
      JNB     TI,$         ; tunggu pengiriman selesai
      CLR     TI           ; clear transmit interrupt flag
      MOV     50H,#50

TUNDA1:
      MOV     51H,#50
      DJNZ    51H,$
      DJNZ    50H,TUNDA1
      SETB    ES           ; hidupkan kembali serial interrupt
      SETB    EA
      CALL    TUNDA1
      RETI

```

```

*****
* KUMPULAN RUTIN PELAYANAN LCD *
*****

```

```

POSISI2_1:
      MOV     A,#1
POSISI2:
      ADD     A,#11000000B
      SJMP    POSISI_SUB

```

```

POSISI1_1:
      MOV     A,#1
POSISI1:
      ADD     A,#10000000B
POSISI_SUB:
      DEC     A
      LCALL   CONTROLOUT
      RET

```

```

PRINTSTRING2:
      LCALL   POSISI2_1
      SJMP    PRINTSTRING

```

```

PRINTSTRING1:
      LCALL   POSISI1_1

```

```

PRINTSTRING:
      SJMP    OUTSTRING

```

```

PRINTSTRINGLOOP:
      LCALL   DATAOUT
      INC     DPTR

```

```

OUTSTRING:
      CLR     A
      MOVC    A,@A+DPTR
      JNZ     PRINTSTRINGLOOP
      RET

```

```

CONTROLOUT:
      CPL     RS

      CPL     E
      MOV     P0,A
      CPL     E

```

```
CPL RS
MOV P0,#0FFH
SJMP LCD_OUT
```

DATAOUT:

```
CPL E
MOV P0,A
CPL E
```

```
LCD_OUT:
MOVX @DPTR,A
```

```
DELAY_LCD:
PUSH ACC
MOV A,#250
DJNZ ACC,$
POP ACC
RET
```

;

```
NAMA: DB 'NYOMAN TRISNA' ,0
NIM: DB 'NIM:0317081' ,0
UNIV: DB 'APLIKASI SENSOR' ,0
UNIV1: DB 'GAS DAN SUHU' ,0

PRO: DB 'SENSOR SUHU:00 C' ,0
PRO1: DB 'SENSOR GAS :00 %' ,0
PRO2: DB ' ' ,0
PRO3: DB ' ' ,0
TUNDA:
```

```
MOV R7,#100
OOPA: MOV R6,#100
OOPB: MOV R5,#50
DJNZ R5,$
DJNZ R6,OOPB
DJNZ R7,OOPA
RET
```

```
TUNDA1:
MOV R7,#50
OA: MOV R6,#50
OB: MOV R5,#50
DJNZ R5,$
DJNZ R6,OB
DJNZ R7,OA
RET

END
```

SOFTWARE PADA DELPHI

//FORM1

unit Unit1;

interface

uses

Windows, Messages, SysUtils, Variants, Classes, Graphics, Controls, Forms,
Dialogs, ExtCtrls, StdCtrls, TeEngine, Series, TeeProcs, Chart, Buttons,
VaClasses, VaComm, DB, DBTables, ADOdb, ScktComp;

type

TForm1 = class(TForm)

Panel1: TPanel;

Panel3: TPanel;

Panel2: TPanel;

Chart1: TChart;

BitBtn4: TBitBtn;

Series1: TFastLineSeries;

Series2: TFastLineSeries;

Edit1: TEdit;

Edit2: TEdit;

Label1: TLabel;

Label2: TLabel;

Timer1: TTimer;

Timer2: TTimer;

Timer3: TTimer;

Edit3: TEdit;

Edit4: TEdit;

Memo1: TMemo;

Button4: TButton;

Label5: TLabel;

Label6: TLabel;

Timer4: TTimer;

Timer5: TTimer;

VaComm1: TVaComm;

Button5: TButton;

Edit5: TEdit;

Edit6: TEdit;

DataSource1: TDataSource;

DataSource2: TDataSource;

Edit7: TEdit;

Edit8: TEdit;

Edit9: TEdit;

Edit10: TEdit;

Edit11: TEdit;

```

Edit12: TEdit;
Edit13: TEdit;
Edit14: TEdit;
Label3: TLabel;
Button9: TButton;
Edit15: TEdit;
Chart2: TChart;
Label4: TLabel;
Timer6: TTimer;
Series3: TFastLineSeries;
Series4: TFastLineSeries;
GroupBox1: TGroupBox;
Label7: TLabel;
Label8: TLabel;
Label9: TLabel;
Label33: TLabel;
Label34: TLabel;
Label35: TLabel;
Button1: TButton;
Button2: TButton;
Button3: TButton;
Button6: TButton;
ADOConnection1: TADOConnection;
ADOQuery1: TADOQuery;
ADOQuery2: TADOQuery;
ADOCommand1: TADOCommand;
Button7: TButton;
Label18: TLabel;
Timer7: TTimer;
Button8: TButton;
ClientSocket1: TClientSocket;
Image1: TImage;
ClientSocket2: TClientSocket;
procedure Timer1Timer(Sender: TObject);
procedure Timer2Timer(Sender: TObject);
procedure Button4Click(Sender: TObject);
procedure BitBtn4Click(Sender: TObject);
procedure FormCreate(Sender: TObject);
procedure VaComm1RxChar(Sender: TObject; Count: Integer);
procedure Button5Click(Sender: TObject);
procedure Timer4Timer(Sender: TObject);
procedure Button1Click(Sender: TObject);
procedure Button2Click(Sender: TObject);
procedure Button3Click(Sender: TObject);
procedure Button6Click(Sender: TObject);
procedure Button2Click(Sender: TObject);
procedure Timer6Timer(Sender: TObject);
procedure Button7Click(Sender: TObject);

```

```
procedure Timer7Timer(Sender: TObject);
procedure Button8Click(Sender: TObject);
```

```
private
{ Private declarations }
  Pesan : String;
public
{ Public declarations }
end;
```

```
var
  Form1: TForm1;
  x:string;
implementation
```

```
uses Unit2, Unit3, Unit4, Unit5;
```

```
{ $R *.dfm }
```

```
procedure TForm1.Timer1Timer(Sender: TObject);
var
```

```
  datajam,perwaktu,conter : integer;
  Jam,Mcnit,Detik,MiliDetik,year,month,day : Word;
  Jam1,menit1,detik1,msec1:word;
  Totalwaktu      :TDateTime;
```

```
begin
  DecodeTime(Time, Jam , Menit, Detik, MiliDetik);
  decodeDate( Date,day,month,year);
```

```
inc (datajam);
```

```
Panel3.Caption := IntToStr(Jam) + ':' +
  IntToStr(Menit) + ':' +
  IntToStr(Detik);
panel2.Caption := inttostr(year) + ':' +
  IntToStr(month) + ':' +
  IntToStr(day);
inc (perwaktu);
end;
```

```
procedure TForm1.Timer2Timer(Sender: TObject);
var
```

```
  t:longint;
  y:array[1..2] of REAL;
  V1,V2:string;
begin
  x := form1.Edit4.Text;
```

```

y[1] := strttoFloat(form1.Edit1.Text);
y[2] := strttoFloat(form1.Edit15.Text);
V1 := floattostrf(y[1],ffixed,4,0);
V2 := floattostrf(y[2],ffixed,4,0);

form1.memo1.Lines.Add((x)+"+V1"+"+V2);
  LABEL5.Caption:=': '+V1+ ' C';
  LABEL6.Caption:=': '+V2+ ' %';
  timer2.enabled:= false;
  for t := 0 to chart1.SeriesCount -1 do
    with chart1.Series[t] do
      add(y[t+1],"clteecolor);
      with chart1.BottomAxis do
        begin
          automatic := false;
          maximum := series1.XValues.Last;
          minimum:=maximum - 100;
        end;
      timer2.Enabled:=true;
    end;
  end;

```

```

procedure TForm1.Button4Click(Sender: TObject);
var
  t:longint;
  y:array[1..2] of REAL;
  V1,V2:string;
begin
  x := form1.Edit4.Text;
  y[1] := strttoFloat(form1.Edit1.Text);
  y[2] := strttoFloat(form1.Edit2.Text);
  V1 := floattostrf(y[1],ffixed,4,0);
  V2 := floattostrf(y[2],ffixed,4,0);

```

```

form1.memo1.Lines.Add((x)+"+V1"+"+V2);
  LABEL1.Caption:=': '+V1+ ' mVolt';
  LABEL2.Caption:=': '+V2+ ' mVolt';

  for t := 0 to chart1.SeriesCount -1 do
    with chart1.Series[t] do
      add(y[t+1],"clteecolor);
      with chart1.BottomAxis do
        begin
          automatic := false;
          maximum := series1.XValues.Last;
          minimum:=maximum - 100;
        end;
      end;
    end;
  end;

```

end;

```
procedure TForm1.BitBtn4Click(Sender: TObject);  
begin  
  application.Terminate ;  
end;
```

```
procedure TForm1.FormCreate(Sender: TObject);  
begin  
  Label18.Caption:=TimeToStr(now);  
  ClientSocket1.Active:=True;  
  ClientSocket2.Active:=True;  
  FORM1.Memo1.Hide;  
  FORM1.Edit3.Hide;  
  FORM1.Edit4.Hide;  
  FORM1.Edit5.Hide;  
  FORM1.Edit6.Hide;  
  FORM1.Edit7.Hide;  
  FORM1.Edit8.Hide;  
  FORM1.Edit9.Hide;  
  FORM1.Edit10.Hide;  
  FORM1.Edit11.Hide;  
  FORM1.Edit12.Hide;  
  FORM1.Edit13.Hide;  
  FORM1.Edit14.Hide;  
  FORM1.Button4.Hide;  
  FORM1.Button5.Hide;  
  FORM1.Button9.Hide;  
  FORM1.Edit15.Hide;  
  VaComm1.Open;  
  form1.Timer4.Enabled := false;  
end;
```

```
procedure TForm1.VaComm1RxChar(Sender: TObject; Count: Integer);  
var  
  I: Integer;  
  Tmp: string;  
begin  
  //baca data yang diterima oleh comport  
  Tmp := VaComm1.ReadText;  
  form1.Edit4.Text := ' ';  
  for I := 1 to Length(Tmp) do  
    case Tmp[I] of  
      #10:; //lewatkan  
      #13: //Tunggu Enter  
    begin  
      form1.Memo1.Lines.Add(Pesan);;  
      Pesan := ''; //reset Pesan  
    end  
  end  
end;
```

```

    end;
else //bukan #10 atau #13
    Pesan := Pesan + Tmp[1];
    form1.Edit4.Text := Pesan;
    Pesan := "";
    form1.Timer4.Enabled := true;
    //Button7.Click;

```

```

end;

```

```

end;

```

```

procedure TForm1.Button5Click(Sender: TObject);
var
    nilai : byte;
begin
    nilai := $3f;
    edit3.Text := inttostr (nilai);
    VaComm1.WriteText(edit3.Text);
    VaComm1.WriteChar(chr(13)); // tanda enter sebagai akhir pengiriman
end;

```

```

procedure TForm1.Timer4Timer(Sender: TObject);
var dataseri,dataseri1 : STRING;
    xa,ya,za,AA,AB,AC,AD,BA,BB,BC,BD : REAL;
begin
    form1.Timer4.Enabled := false;
    dataseri:= form1.Edit4.Text;
    xa := Strtoint (edit5.Text);
    za := xa + 1 ;
    edit5.Text := FLOATtostr (za);
    dataseri1 := FLOATtostr (za);
    begin
        label9.Caption :='Conect';
        if dataseri1 = '1' then
            Begin
                if dataseri = 'A' then
                    BEGIN
                        edit5.Text := '0';
                        END
                    ELSE
                        form1.Edit6.Text := dataseri ;
                        AA := STRTOINT (form1.Edit6.Text);
                        AA := AA*100;
                        form1.Edit7.Text := FLOATtostr(AA);
                        end;
                if dataseri1 = '2' then

```

```

Begin
if dataseri = 'A' then
BEGIN
edit5.Text := '0';
END
ELSE
form1.Edit6.Text := dataseri ;
AB := STRTOINT (form1.Edit6.Text);
AB := AB*10;
form1.Edit8.Text := FLOATtostr(AB);
end;
if dataseri1 = '3' then
Begin
if dataseri = 'A' then
BEGIN
edit5.Text := '0';
END
ELSE
form1.Edit6.Text := dataseri ,
AC := STRTOINT (form1.Edit6.Text);
form1.Edit9.Text := FLOATtostr(AC);
AD := STRTOINT(FORM1.Edit7.Text) + STRTOINT(FORM1.Edit8.Text) +
STRTOINT(FORM1.Edit9.Text);
AD := AD / 100;
form1.Edit10.Text := FLOATtostr(AD);
end;
if dataseri1 = '4' then
Begin
if dataseri = 'A' then
BEGIN
edit5.Text := '0';
END
ELSE
form1.Edit6.Text := dataseri ;
BA := STRTOINT (form1.Edit6.Text);
BA := BA*100;
form1.Edit11.Text := FLOATtostr(BA);
end;
if dataseri1 = '5' then
Begin
if dataseri = 'A' then
BEGIN
edit5.Text := '0';
END
ELSE
form1.Edit6.Text := dataseri ;
BB := STRTOINT (form1.Edit6.Text);
BB := BB*10;

```

```

form1.Edit12.Text := FLOATtostr(BB);
end;
if dataseri1 = '6' then
Begin
if dataseri = 'A' then
BEGIN
edit5.Text := '0';
END
ELSE
form1.Edit6.Text := dataseri ;
BC := STRTOINT (form1.Edit6.Text);
form1.Edit13.Text := FLOATtostr(BC);
BD := STRTOINT(FORM1.Edit11.Text) + STRTOINT(FORM1.Edit12.Text)
+ STRTOINT(FORM1.Edit13.Text);
//BD := BD / 10;
form1.Edit14.Text := FLOATtostr(BD);
edit5.Text := '0';
form1.Edit2.Text := form1.Edit10.Text ;
form1.Edit1.Text := form1.Edit14.Text ,
Button7.Click;
// Button8.Click;
end;
//end;
{ With ADOCommand1 do
begin
CommandText := 'insert into T_suhu '+
'(data_suhu,waktu,tanggal) '+
'VALUES (:data_suhu,:waktu,:tanggal) ';
Parameters.ParamByName('data_suhu').Value:= Edit1 .Text;
Parameters.ParamByName('waktu').Value:= Label8.Caption;
Parameters.ParamByName('tanggal').Value :=Label8.Caption;
CommandType := cmdText;
Execute;
ADOQuery1.Last;
//ADOQuery1.Close;
//ADOQuery1.Open;
end;

```

```

With ADOCommand1 do
begin
CommandText := 'insert into T_gas'+
'(data_gas,waktu,tanggal) '+
'VALUES (:data_gas,:waktu,:tanggal) ';
Parameters.ParamByName('data_gas').Value:= Edit2 .Text;
Parameters.ParamByName('waktu').Value:= Label8.Caption;
Parameters.ParamByName('tanggal').Value :=Label8.Caption;
CommandType := cmdText;
Execute;

```

```
ADOQuery2.Last;  
// ADOQuery2.Close;  
//ADOQuery2.Open;  
///Timer7.Enabled:=False;  
end;      }  
end;
```

```
{ form1.Table1.Insert;  
form1.Table1.Datasuhu.Value:= FORM1.Edit1.Text;  
form1.Table1.Tanggal.AsDateTime:=date;  
form1.Table1.Jam.AsDateTime:=time;  
form1.Table1.Post;
```

```
form1.Table2.Insert;  
form1.Table2.Tanggal.AsDateTime:=date;  
form1.Table2.Jam.AsDateTime:=time;  
form1.Table2.Datagas.Value:= FORM1.Edit2.Text;  
form1.Table2.Post;  }  
//end,
```

```
// end;  
end;
```

```
procedure TForm1.Button1Click(Sender: TObject);  
begin
```

```
FORM2.Show;  
end;
```

```
procedure TForm1.Button2Click(Sender: TObject);  
begin  
FORM3.Show;  
end;
```

```
procedure TForm1.Button3Click(Sender: TObject);  
begin  
FORM4.QuickRep1.Preview;  
end;
```

```
procedure TForm1.Button6Click(Sender: TObject);  
begin  
FORM5.QuickRep2.Preview;  
end;
```

```
procedure TForm1.Button9Click(Sender: TObject);
```

```

begin
form1.Timer4.Enabled := TRUE;
end;

procedure TForm1.Timer6Timer(Sender: TObject);
var
t:longint;
y:array[1..2] of REAL;
V1,V2:string;
begin
x := form1.Edit4.Text;
y[1] := strttoFloat(form1.Edit15.Text);
y[2] := strttoFloat(form1.Edit2.Text);
V1 := floattostrf(y[1],ffixed,4,0);
V2 := floattostrf(y[2],ffixed,4,0);

form1.memo1.Lines.Add((x)+" "+V1+" "+V2);
LABEL5.Caption:=': ' +V1+ ' C';
LABEL6.Caption:=': ' +V2+ ' °C';
timer6.enabled:= false;
for t := 0 to chart2.SeriesCount -1 do
with chart2.Series[t] do
add(y[t+1],"",clteecolor);
with chart2.BottomAxis do
begin
automatic := false;
maximum := series3.XValues.Last;
minimum:=maximum - 100;
end;
timer6.Enabled:=true;
end;

procedure TForm1.Button7Click(Sender: TObject);
begin
With ADOCommand1 do
begin
CommandText := 'insert into T_suhu '+
'(data_suhu,waktu,tanggal) '+
'VALUES (:data_suhu,:waktu,:tanggal)';
Parameters.ParamByName('data_suhu').Value:= Edit1.Text;
Parameters.ParamByName('waktu').value :=Label18.Caption;
Parameters.ParamByName('tanggal').Value :=Date;
CommandType := cmdText;
Execute;

form2.ADOQuery1.Close;
form2.ADOQuery1.Open;
form2.ADOQuery1.Last;

```

end;

With ADOCommand1 do

begin

CommandText := 'insert into T_gas '+

'(data_gas,waktu,tanggal) '+

'VALUES (:data_gas,:waktu,:tanggal) ';

Parameters.ParamByName('data_gas').Value:= Edit2.Text;

Parameters.ParamByName('waktu').value :=Label18.Caption;

Parameters.ParamByName('tanggal').Value :=Date;

CommandType := cmdText;

Execute;

form3.ADOQuery1.Close;

form3.ADOQuery1.Open;

form3.ADOQuery1.Last;

///Timer7.Enabled:=False;

Button8.Click;

end;

end;

procedure TForm1.Timer7Timer(Sender: TObject);

begin

Label18.Caption:=TimeToStr(now);

//Button7.Click;

end;

procedure TForm1.Button8Click(Sender: TObject);

begin

ClientSocket1.Socket.SendText('#01');

ClientSocket1.Socket.SendText(Edit1.Text);

ClientSocket1.Socket.SendText('#02');

ClientSocket1.Socket.SendText(Edit2.Text);

ClientSocket2.Socket.SendText('#01');

ClientSocket2.Socket.SendText(Edit1.Text);

ClientSocket2.Socket.SendText('#02');

ClientSocket2.Socket.SendText(Edit2.Text);

end;

end.

//FORM2

unit Unit2;

interface

uses

Windows, Messages, SysUtils, Variants, Classes, Graphics, Controls, Forms,
Dialogs, StdCtrls, Buttons, ExtCtrls, Grids, DBGrids, DB, DBCtrls,
DBTables, ADODB;

type

```
TForm2 = class(TForm)
  Panel1: TPanel;
  Label35: TLabel;
  BitBtn4: TBitBtn;
  DBNavigator1: TDBNavigator;
  DataSource1: TDataSource;
  ADOQuery1: TADOQuery;
  DBGrid2: TDBGrid;
  procedure BitBtn4Click(Sender: TObject);
  procedure FormCreate(Sender: TObject);
private
  { Private declarations }
public
  { Public declarations }
end;
```

var

```
Form2: TForm2;
```

implementation

```
uses Unit1;
```

```
{ $R *.dfm }
```

```
procedure TForm2.BitBtn4Click(Sender: TObject);
begin
  FORM2.Close;
end;
```

```
procedure TForm2.FormCreate(Sender: TObject);
begin
  ADOQuery1.Last;
end;
```

```
end.
```

```
//FORM3
unit Unit3;
```

interface

uses

Windows, Messages, SysUtils, Variants, Classes, Graphics, Controls, Forms,

Dialogs, StdCtrls, Buttons, DB, DBTables, DBCtrls, Grids, DBGrids,
ExtCtrls, ADODB;

type

```
TForm3 = class(TForm)
  Panel1: TPanel;
  Label35: TLabel;
  DBGrid1: TDBGrid;
  DBNavigator1: TDBNavigator;
  DataSource1: TDataSource;
  BitBtn4: TBitBtn;
  ADOQuery1: TADOQuery;
  procedure BitBtn4Click(Sender: TObject);
  procedure FormCreate(Sender: TObject);
private
  { Private declarations }
public
  { Public declarations }
end;
```

var

```
Form3: TForm3;
```

implementation

```
uses Unit1;
```

```
{ $R *.dfm }
```

```
procedure TForm3.BitBtn4Click(Sender: TObject);
begin
  FORM3.Close;
end;
```

```
procedure TForm3.FormCreate(Sender: TObject);
begin
  ADOQuery1.Last;
end;
```

```
end.
```

```
//FORM4
unit Unit4;
```

interface

uses

Windows, Messages, SysUtils, Variants, Classes, Graphics, Controls, Forms,
Dialogs, QRCuils, QuickRpt, ExtCtrls, DB, DBTables, ADODB;

type

```
TForm4 = class(TForm)
  QuickRep1: TQuickRep;
  DetailBand1: TQRBand;
  TitleBand1: TQRBand;
  QRLabel1: TQRLabel;
  QRLabel2: TQRLabel;
  QRLabel3: TQRLabel;
  QRLabel4: TQRLabel;
  QRLabel5: TQRLabel;
  QRLabel6: TQRLabel;
  QRLabel7: TQRLabel;
  QRLabel8: TQRLabel;
  QRLabel9: TQRLabel;
  QRLabel10: TQRLabel;
  QRLabel11: TQRLabel;
  QRLabel12: TQRLabel;
  QRLabel13: TQRLabel;
  QRLabel14: TQRLabel;
  QRDBText1: TQRDBText;
  QRDBText2: TQRDBText;
  QRDBText3: TQRDBText;
  QRLabel15: TQRLabel;
  QRLabel16: TQRLabel;
  QRLabel17: TQRLabel;
  QRLabel18: TQRLabel;
  QRLabel19: TQRLabel;
  ADOQuery1: TADOQuery;
  procedure FormClick(Sender: TObject);
  procedure FormCreate(Sender: TObject);
private
  { Private declarations }
public
  { Public declarations }
end;
```

var

```
Form4: TForm4;
```

implementation

```
uses Unit1,unit2;
```

```
{ $R *.dfm }
```

```
procedure TForm4.FormClick(Sender: TObject);
```

```
begin
```

```
//FORM4.QUICKREP1.PREVIEW;
```

end;

procedure TForm4.FormCreate(Sender: TObject);
begin

end;

end.

//FORM5
unit Unit5;

interface

uses

Windows, Messages, SysUtils, Variants, Classes, Graphics, Controls, Forms,
Dialogs, DB, DBTables, QRCtrls, QuickRpt, ExtCtrls, ADODB;

type

TForm5 = class(TForm)
 QuickRep2: TQuickRep;
 QRBand1: TQRBand;
 QRDBText4: TQRDBText;
 QRDBText5: TQRDBText;
 QRDBText6: TQRDBText;
 QRLabel20: TQRLabel;
 QRLabel21: TQRLabel;
 QRLabel22: TQRLabel;
 QRLabel23: TQRLabel;
 QRLabel24: TQRLabel;
 QRBand2: TQRBand;
 QRLabel25: TQRLabel;
 QRLabel26: TQRLabel;
 QRLabel27: TQRLabel;
 QRLabel28: TQRLabel;
 QRLabel29: TQRLabel;
 QRLabel30: TQRLabel;
 QRLabel31: TQRLabel;
 QRLabel32: TQRLabel;
 QRLabel33: TQRLabel;
 QRLabel34: TQRLabel;
 QRLabel35: TQRLabel;
 QRLabel36: TQRLabel;
 QRLabel37: TQRLabel;
 QRLabel38: TQRLabel;
 ADOQuery1: TADOQuery;
 procedure FormCreate(Sender: TObject);
private

```
    { Private declarations }  
public  
    { Public declarations }  
end;  
  
var  
    Form5: TForm5;  
  
implementation  
uses Unit1,unit3;  
  
{$R *.dfm}  
  
procedure TForm5.FormCreate(Sender: TObject);  
begin  
  
end;  
  
end.
```

