SISTEM MONITORING KADAR KARBON MONOKSIDA (CO) DAN SUHU MENGGUNAKAN MODUL WI-FI WIZ610WI BERBASIS MIKROKONTROLER AT89C52

SKRIPSI

Disusun Oleh :

IRVAN LIWAN
NIM : 05.12.207

JURUSAN TEKNIK ELEKTRO S-1
KONSENTRASI TEKNIK ELEKTRONIKA
FAKULTAS TEKNOLOGI INDUSTRI
INSTITUT TEKNOLOGI NASIONAL MALANG
2010

LEMBAR PERSETUJUAN

SISTEM MONITORING KADAR KARBON MONOKSIDA (CO) DAN SUHU MENGGUNAKAN MODUL WI-FI WIZ610WI BERBASIS MIKROKONTROLER AT89C52

SKRIPSI

Disusun dan Diajukan Sebagai Salah Satu Syarat Untuk Memperoleh Gelar Sarjana Teknik Elektronika Strata Satu (S-1)

Disusun Oleh :

IRVAN LIWAN
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PERKUMPULAN PENGELOLA PENDIDIKAN UMUM DAN TEKNOLOGI NASIONAL MALANG
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Tanggal : 21 Agustus 2010
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FORMULIR PERBAIKAN SKRIPSI

Dalam pelaksanaan ujian skripsi jenjang Strata satu (S-1) Jurusan Teknik Elektro konsentrasi Teknik Elektronika, maka perlu adanya perbaikan skripsi untuk mahasiswa :

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Masa Bimbingan : 01 Desember 2009 s/d 01 Juni 2010
Judul Skripsi : Sistem Monitoring Kadar Karbon Monoksida (CO) dan Suhu dengan Menggunakan Modul Wi-Fi WIZ610wi Berbasis Mikrokontroler AT89C52

Tanggal	Uraian	Paraf
Penguji I 16 Agustus 2010	1.Tambahkan Lampiran Gambar Rangkain Keseluruhan. 2.Pengujian Kecepatan Pengukuran dan Penyebab Lamanya Pengukuran	
Penguji II 16 Agustus 2010	-	

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SISTEM MONITORING KADAR KARBON MONOKSIDA (CO) DAN SUHU DENGAN MODUL WI-FI WIZ610WI BERBASIS MIKROKONTROLER AT89C52

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Abstrak

Dewasa ini proses penyampaian informasi terutama pada perubahaan lingkungan dalam hal ini suhu dan kadar karbon monoksida masih mengandalkan media elektronik. Cara tersebut masih kurang efektif karena masyarakat tidak bisa mengetahui informasi tersebut setiap waktu.

Oleh sebab itu untuk memudahkan dalam proses penyampaian informasi tersebut, maka dirancanglah sebuah sistem yang berfungsi untuk memonitoring suhu dan kadar karbon monoksida dalam udara yang dapat diakses melalui jaringan wi-fi. Komponen intinya mikrokontroler AT89C52, modul wi-fi WIZ610wi, TGS2442 (sensor CO), LM35 (sensor suhu), ADC0808, MAX232, MAX3232 dan sebuah software yang dirancang khusus untuk mengakses alat ini. Prinsip kerja alat ini adalah pada software yang dirancang akan mengirimkan perintah yang selanjutnya akan diterima oleh modul WIZ610wi yang akan langsung dikirimkan ke mikrokontroler, yang selanjutnya oleh mikrokontroler akan direspon dengan mengirimkan kembali hasil pengukuran yang oleh software nantinya akan ditampilkan. Hasil sistem monitoring ketinggian air akan di update setiap lima detik sekali.

Kata kunci : Sistem monitoring, TGS2442, LM35, Modul wi-fi WIZ610wi, MAX3232

Abstract

In the current condition, the process to provide information about the environment changes especially the temperature and concentration of carbon monoxide are still depend on the information that provided by the electronic media. And we find that system is less effective because people cannot get the information every time they need.

Based on that reason above, to provide an easier process to inform people about temperature and concentration of carbon monoxide, we design a system that the function is monitoring temperature and concentration of carbon monoxide in the air, that can be accessed by wi-fi. The main component are microcontroller AT89C52, wi-fi modul WIZ610wi, TGS2442 (CO sensor),LM35 (Temperature sensor), ADC0808, MAX232, MAX3232 and a software that design to access this instrument. The working system of this tools is the software will sent a command and will be accepted by WIZ610wi, so microcontroller will be accepted a command, and the microcontroller will respons the command with sent the result of measurement and the software will display the result of measurement. the result of this system will be updated automatically every five second.

Key words: Monitoring system, TGS2442, LM35, wi-fi modul WIZ610wi, MAX3232

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Malang, Juli 2010

Penulis

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BAB I
PENDAHULUAN

1.1 Latar Belakang

Dalam kehidupan sehari-hari peranan informasi dirasa sangat penting baik dalam kondisi apapun dan dimanapun, ada banyak informasi yang dapat kita ketahui dengan cara-cara tertentu. Dengan berkembangnya teknologi internet yang merupakan suatu sistem yang *reliable* maka internet dapat digunakan sebagai media pada monitoring atau pengendali jarak jauh yang cukup baik.

Pertambahan jumlah kendaraan yang cukup tinggi seiring dengan tingkat pertumbuhan ekonomi nasional, berdampak pada peningkatan polusi udara, yang tentu saja berpengaruh bagi tingkat kesehatan masyarakat. Dan salah satu gas yang dihasilkan dari kendaraan bermotor yang mempunyai pembakaran tidak sempurna yakni gas *karbon monoksida* (CO). Akan tetapi sangatlah tidak efesien apabila dalam memonitoring suhu dan kadar gas *karbon monoksida* (CO) dengan menggunakan komputer.

Atas dasar inilah diperlukan suatu alat yang bersifat *stand alone* tanpa menggunakan bantuan komputer untuk mengirim data, yang dapat mengukur besarnya suhu dan kadar *gas karbon monoksida* (CO) dalam udara. Pembuatan alat tersebut dapat membantu dalam memberikan informasi pada masyarakat tentang tingkat polusi yang terjadi. Sistem monitoring ini nantinya dirancang sedemikian rupa agar dapat mengukur suhu dan kadar gas *karbon monoksida* (CO) secara *realtime* dan dapat diamati secara *online* melalui internet.

1.2 Rumusan Masalah

Mengacu pada permasalahan yang ada, maka perumusan masalah ditekankan pada:

1. Bagaimana merancang suatu alat yang dapat mengukur kadar *karbon monoksida* dan suhu.
2. Bagaimana hasil pengukuran tersebut dapat dikirim melalui *wi-fi.*
3. Bagaimana merancang suatu alat yang bersifat *stand alone* tanpa perantara komputer sebagai pengontrol dalam pengiriman data dalam jaringan komputer.

1.3 Tujuan

Tujuan dari penulisan skripsi ini adalah untuk membuat suatu sistem monitoring suhu dan kadar gas *karbon monoksida* (CO) yang dapat diakses dari jarak jauh melalui internet, dengan menggunakan modul WIZ600WI dan mikrokontroller AT89C52 sebagai kontroller.

1.4 Batasan Masalah

Untuk mencapai tujuan penyelesaian skripsi ini secara maksimal, maka diperlukan batasan masalah yang diharapkan agar permasalahan tidak meluas dan tetap fokus pada tujuan utama. Adapun batasan-batasan masalah pada tugas akhir ini yaitu:

1 Menggunakan sensor LM35 untuk sensor suhu

2 Menggunakan sensor TGS2442 untuk sensor *karbon monoksida*

3 Menggunakan Modul WIZ600WI sebagai *serial to wi-fi gateway*

4 Tidak membahas proses pengiriman data dalam jaringan komputer.

1.5 Metodologi Penelitian

Adapun metode-metode yang diambil untuk pemecahan masalah meliputi:

1. Studi literatur

   Mempelajari dan memahami teori-teori yang terkait melalui literatur yang telah ada, yang berhubungan dengan pembahasan masalah.

2. Perencanaan dan Pembuatan Alat

   Membuat diagram blok rangkaian yang sesuai dengan rencana kerja, yang kemudian direalisasikan dengan masalah perencanaan dan pembuatan berdasarkan diagram blok rangkaian yang telah disusun.

3. Studi Analisa Alat

   Dimaksudkan untuk melakukan analisa dan pengujian alat yang telah dirancang apakah sesuai antara fungsi dengan kerja yang diharapkan.

4. Pengambilan Kesimpulan

   Dilakukan setelah mendapatkan hasil dari perancangan dan pengujian alat. Jika hasil yang diperoleh telah sesuai dengan spesifikasi yang ditentukan saat dilakukan perancangan, berarti alat tersebut dianggap selesai dan sesuai dengan harapan.

5. Penyusunan Buku Laporan

   Bertujuan untuk menyusun data laporan yang berpedoman pada alat yang telah selesai dibuat beserta kesimpulan dan cara kerja alat.

1.6 Sistematika

Pembahasan dalam Skripsi/Tugas Akhir ini akan diuraikan dalam lima bab, yang penjabarannya adalah sebagai berikut:

BAB I **: Pendahuluan**

Pada bab ini dibahas tentang latar belakang permasalahan, rumusan masalah, batasan masalah, sistematika pembahasan dari alat yang direncanakan.

BAB II **: Landasan Teori**

Berisi tentang teori-teori dasar yang memiliki relevansi sebagai dasar perancangan dan pembuatan alat.

BAB III **: Perancangan dan Pembuatan Alat**

Bab ini berisi pembahasan tentang perencanaan dan pembuatan keseluruhan sistem perangkat keras yaitu blok diagram rangkaian, prinsip kerja, perancangan setiap komponen yang digunakan dan perancangan perangkat lunak yaitu flowchart kerja dari program yang dibuat.

BAB IV **: Pengujian Sistem**

Membahas tentang pengujian alat, yang didasarkan pada pengukuran-pengukuran, pengujian dilakukan pada tiap blok rangkaian yang digunakan meliputi sensor, pengkondisi sinyal, ADC, modul dan keseluruhan sistem, serta analisis data dari pengujian dari semua pengujian dan program yang telah dibuat.

BAB V **: Penutup**

Merupakan bagian akhir dari laporan yang terdiri dari kesimpulan dan saran.

BAB II

LANDASAN TEORI

2.1 Pendahuluan

Pada bab ini akan dibahas mengenai teori penunjang dari peralatan yang direncanakan. Teori penunjang ini akan membahas tentang komponen dan peralatan pendukung pada alat yang dibuat. Pokok pembahasan pada bab ini adalah:

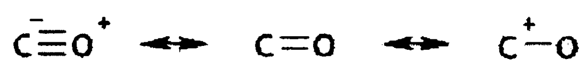
- Sensor Carbon Monoksida (CO)
- Sensor suhu LM35
- Pengkondisi Sinyal
- ADC 0808
- Mikrokontroler AT89C52
- Pengubah Level Tegangan
- WIZ610WI
- TCP/IP

2.2 Gas Karbon Monoksida *(CO)*

Gas *karbon monoksida* adalah gas yang tidak berwarna, tidak berbau dan tidak berasa. Gas ini terdiri dari satu atom karbon yang secara *kovalen* berikatan dengan satu atom *oksigen*. Dalam ikatan ini, terdapat dua ikatan *kovalen* dan satu ikatan *kovalen* koordinasi antara atom *karbon* dan atom *oksigen*.

Karbon monoksida dihasilkan dari pembakaran tidak sempurna dari senyawa karbon, sering terjadi pada mesin pembakaran dalam. *Karbon monoksida* terbentuk apabila terdapat kekurangan *oksigen* dalam proses pembakaran.

Molekul Gas *karbon monoksida* memiliki panjang ikat 0,1128 nm. Panjang ikatan molekul *karbon monoksida* sesuai dengan ikatan rangkap tiga parsialnya. Molekul ini memiliki *momen dipol* ikatan yang sangat kecil dan dapat diwakili dengan dengan tiga struktur resonansi



Gambar 2.1 ***Struktur Resonansi CO***
(Sumber: http://id.wikipedia.org/wiki/Karbon_monoksida)

Resonansi paling kiri adalah bentuk yang paling penting. Hal ini diilustrasikan dengan *reaktivitas karbon monoksida* yang bereaksi dengan *karbokation*.

Gas *karbon monoksida* pertama kali dihasilkan oleh kimiawan Perancis *de Lassone* pada tahun 1776 dengan memanaskan seng *oksida* dengan *kokas*. Kimiawan tersebut menyimpulkan bahwa gas yang dihasilkan adalah *hidrogen* karena ketika dibakar menghasilkan api berwarna biru. Gas ini kemudian diidentifikasi sebagai senyawa yang mengandung *karbon* dan *oksigen* oleh kimiawan Inggris *William Cumberland Cruikshank* pada tahun 1800.

Karbon Monoksida sangatlah beracun, sifat-sifat *karbon monoksida* yang beracun pertama kali diinvestigasi secara seksama oleh fisiolog Perancis *Claude Bernard* sekitar tahun 1846 dengan meracuni beberapa anjing dengan gas tersebut, dar. mendapatkan bahwa dalam darah anjing-anjing tersebut berwarna lebih merah di seluruh pembuluh darah. *Karbon monoksida* dapat menyebabkan keracunan sistem saraf pusat dan jantung. *Karbon monoksida* juga memiliki efek-efek buruk bagi bayi dari wanita hamil. Gejala dari keracunan ringan meliputi sakit kepala dan mual-mual. Pada konsentrasi *667 ppm* dapat menyebabkan 50% *hemoglobin* berubah menjadi *karboksihemogoblin (HbCO)*. *Karboksihemogoblin* cukup stabil, namum perubahan ini reversible. *Karboksihemoglobin* tidaklah efektif dalam menghantarkan *oksigen*, sehingga beberapa bagian tubuh tidak mendapatkan *oksigen* yang cukup dan hal ini sangatlah berbahaya.

Tabel 2.1 Bahaya Kadar Karbon Monoksida (ppm)
Bagi Manusia

Kadar Gas Karbon Monoksida (ppm)	Waktu (jam)	Akibat
< 100	<1	tidak menimbulkan gejala apapun
< 500	<1	batuk dan pusing
< 1000	<1	sesak nafas gelisah/bingung
> 1000	<1	koma dan kematian

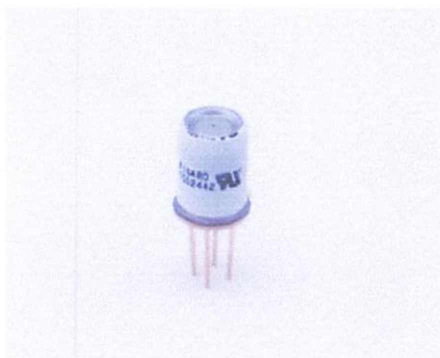
(Sumber: *http://harrie91.wordpress.com/2007/09/13/efek-gas-karbon-monoksida/*)

2.3 Sensor

2.3.1 Sensor Gas Karbon Monoksida *(TGS 2442)*

Sensor yang digunakan dalam pendeteksi gas *karbon monoksida* adalah sensor *TGS 2442*. Sensor ini sangat sensitif dengan gas *karbon monoksida*, dan sensor ini dapat mendeteksi kadar gas *karbon monoksida* dari *30-1000 ppm* dalam udara.

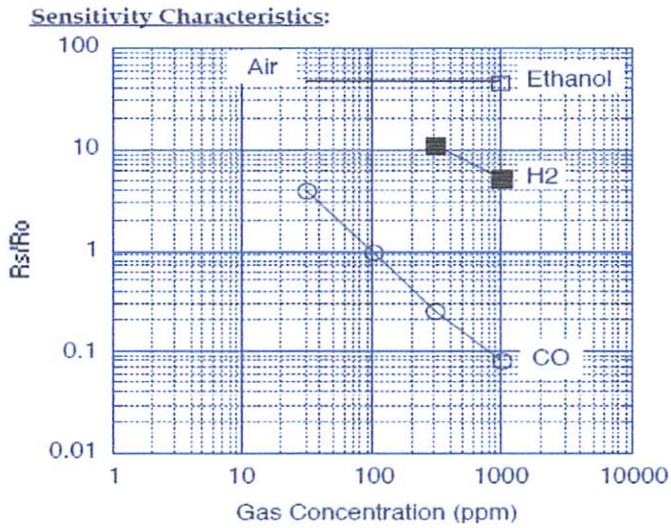
Sensor ini menggunakan *multilayer sensor structure*. Lapisan kaca untuk *thermal insulator* dicetak diantara *ruthenium oxide* (RuO_2) *heater* dan *almunia* *substrate.* Sepasang *Au electrodes* untuk *heater* terbentuk pada *thermal insulator.* Pengindraan lapisan gas yang terbentuk dari *tin dioxide* (SnO_2), adalah yang tercantum pada lapisan isolasi listrik yang meliputi *heater.* Sepasang *Au electrodes* untuk mengukur resistensi terbentuk pada *electrical insulator. Activated charcoal* dipenuhi antara *internal cover* dan sampul luar untuk tujuan mengurangi pengaruh *noise gases.*



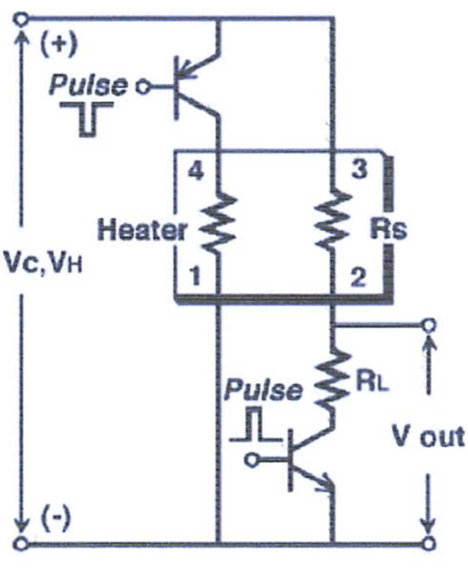
Gambar 2.2 Sensor TGS 2442 / Sensor CO
(*Sumber: Data sheet TGS 2442*)

Grafik di bawah ini menjelaskan karakteristik dari sensitivitas sensor, semua data dikumpulkan pada saat kondisi standar ketika diuji. *Y-axis* diindikasikan sebagai *sensor resistance ratio (Rs/Ro)* yang didefinisikan sebagai berikut :

- *Rs* = Resistansi sensor dari gas-gas yang ditampilkan dalam berbagai macam konsentrasi.
- *Ro* = Resistansi sensor dalam *100 ppm* gas *CO*



Grafik 2.1 ***Sensitivity characteristics TGS 2442***
*(**Sumber:** Data sheet TGS 2442)*

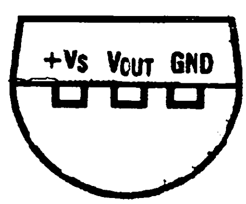


Gambar 2.3 ***Basic measuring circuit***
*(**Sumber:** Data sheet TGS 2442)*

Sensor membutuhkan *circuit voltage (Vc)* dan *heater voltage (V_H)* untuk memberikan inputan pada *transistor* untuk menghasilkan *pulse*.

2.3.2 Sensor Suhu (LM35)

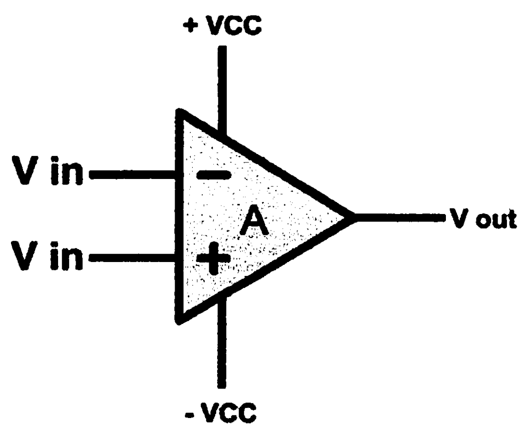
LM35 merupakan sensor suhu yang sangat presisi, hal ini dapat dilihat dari tegangan output yang mempunyai sifat kelinearan yang sesuai yaitu dapat dinyatakan langsung dalam derajat celcius. LM35 mempunyai keuntungan yaitu lebih linear apabila dikalibrasikan ke Kelvin, untuk memperoleh skala celcius tidak perlu mengurangi tegangan konstan dari output. Tipikal akurasi yaitu pada ±25°C untuk suhu kamar dan ±75°C untuk suuhu yang lebih tinggi. Range temperatur antara -55°C sampai +150°C. Sensor LM35 mempunyai impedansi output yang rendah, output yang linear dan juga ketepatan kalibrasi yang merupakan kelebihan dari LM35 yang membuat penginterfacean untuk pembacaan keluar atau control rangkaian sangatlah mudah. LM35 dapat digunakan dengan power supply tunggal plus (+) atau minus (-), selain itu hanya membawa 60μA dari supplynya. Hal ini membuat *self-heating*nya sangat rendah, lebih kecil dari 0,1°C pada udara konstanta.



Gambar 2.4 Tampak Atas LM35
(Sumber: Data sheet LM35)

2.4 Pengkondisi sinyal

Di dalam sistem kontrol sering kali keluaran dari sensor nilainya tidak sesuai yang diharapkan yaitu nilainya mudah untuk diolah. Oleh karena itu perlu adanya pengolah sinyal agar sinyal keluaran dari sensor dapat kita olah terlebih dahulu agar keluarannya seperti yang diharapkan. Penguat operasional atau sering disebut *op-amp (operasional amplifier)* merupakan komponen elektronika yang berfungsi untuk memperkuat sinyal arus searah *(DC)* maupun arus bolak-balik *(AC)*. Pada prinsipnya penguat operasional hanya bekerja sebagai penguat sinyal bukan penguat daya. Penguat operasional terdiri atas transistor, resistor dan kapasitor yang dirangkai dan dikemas dalam rangkaian terpadu *(integrated circuit)*. Simbol *op-amp* ditunjukkan pada gambar di bawah ini. Vin merupakan masukan sinyal, *Vout* keluaran sinyal, *A* besar penguatan dan *VCC* sumber tegangan.



Gambar 2.5 Simbol Op-Amp
*(**Sumber** : http://franzaditya.blogspot.com/2009/02/penguat-operasional-op-amp.html)*

Karakteristik *op-amp* ideal adalah kondisi *op-amp* sesuai dengan teori. Karakteristik **op-amp** ideal adalah sebagai berikut:

1. Faktor penguat tidak terhingga.
2. Tidak memiliki *offset*, maksudnya adalah apabila masukan nol maka keluaran juga nol.

3. *Impedansi* masukan tidak terhingga.
4. *Impedansi* keluaran nol.
5. Lebar *bandwidth* tidak terhingga.
6. *Rise time* nol.
7. Tidak mudah terpengaruh oleh perubahan tegangan sumber maupun perubahan suhu.

Pada kenyataannya dalam pembuatan *op-amp* memiliki keterbatasan sehingga tidak ada *op-amp* yang ideal. *Op-amp* yang ada hanyalah *op-amp* yang mendekati ideal karena karakteristik *op-amp* adalah sebagai berikut :

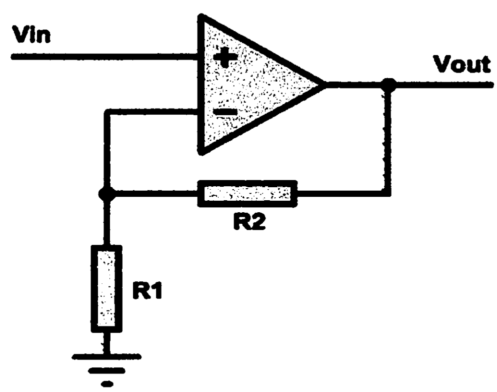
1. Faktor penguat terbatas kurang lebih 100.000 kali
2. Terdapat *offset* dimana saat masukan bernilai nol tegangan keluaran tidak nol.
3. *Impedansi* masukan cukup tinggi namun terbatas sampai kira-kira ratusan kilo *ohm* saja.
4. *Impedansi* keluaran rendah namun terbatas puluhan sampai ratusan *ohm*.
5. *Rise time* tidak nol.
6. Kerja *op-amp* terpengarruh perubahan sumber tegangan dan perubahan pada suhu.

Dalam penggunaannya *op-am*p dibagi menjadi dua jenis yaitu penguat linier dan penguat tidak linier. Penguat linier merupakan penguat yang tetap mempertahankan bentuk sinyal masukan, yang termasuk dalam penguat ini antara lain penguat *non inverting*, penguat *inverting*, penjumlah, penguat *diferensial* dan penguat *instrumentasi*. Sedangkan penguat tidak linier merupakan penguat yang bentuk sinyal keluarannya tidak sama dengan bentuk sinyal masukannya, diantaranya *komparator*, *integrator*, *diferensiator*, pengubah bentuk gelombang dan pembangkit gelombang. Untuk menangani penguatan dari sensor biasanya digunakan penguat linier yang tidak mengubah bentuk sinyal namun hanya memperkuat sinyal saja.

2.4.1 Penguat Non Inverting

Merupakan penguat yang berfungsi memperkuat sinyal masukan tanpa membalik sinyal masukan. Rangkaian penguat dan rumusnya adalah sebagai berikut:

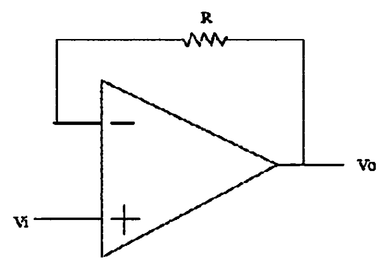
$$Vout = \left(\frac{R2}{R1} + 1\right) \cdot Vin$$



Gambar 2.6 Rangkaian Penguat Non Inverting
(Sumber : http://franzaditya.blogspot.com/2009/02/penguat-operasional-op-amp.html)

2.4.2 Buffer

Rangkaian buffer rangkaian yang inputannya sama dengan outputanya. Dalam hal ini seperti rangkaian common colektor yang berpenguatan 1. Rangkaiannya seperti berikut ini:

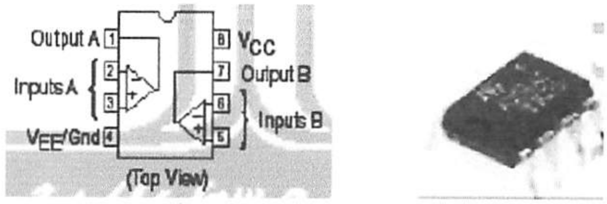


Gambar 2.7 Rangkaian Buffer
(Sumber : http://franzaditya.blogspot.com/2009/02/penguat-operasional-op-amp.html)

Nilai R yang terpasang gunanya untuk membatasi arus yang di keluarkan. Besar nilainya tergantung dari indikasi dari komponennya, biasanya tidak dipasang alias arus dimaksimalkan sesuai dengan kemampuan op-ampnya.

2.4.3 Penguat Non Inverting LM358

Penguat operasional (*op-amp*) merupakan kumpulan puluhan transistor dan resistor dalam bentuk satu chip IC. Op-Amp merupakan komponen aktif linear yang merupakan penguat gandeng langsung (*direct coupling*), dengan penguatan terbuka (*open gain*) yang sangat besar dan dapat dipakai untuk menjumlahkan, mengalikan, membagi, mendiferensialkan, serta mengintegralkan tegangan listrik. IC Op-Amp sering dipakai untuk perhitungan-perhitungan analog, instrumentasi, maupun berbagai macam aplikasi kontrol. IC LM358 didesain secara sempurna dalam hal penggunaan dua buah Op-Amp secarabersamaan dalam satu chip, Gambar 3 adalah IC LM358.



Gambar 2.8 LM358
*(**sumber**: http:\uii\fakultas elektro_telemetri suhu dan kelembapan)*

IC Op-Amp LM358 memiliki keunggulan dalam pemakaian daya yang lebih rendah, kemampuan penggunaan saluran input yang berkorelasi dengan saluran pentanahan, dapat dicatu menggunakan mode catu daya tunggal maupun catu daya ganda.

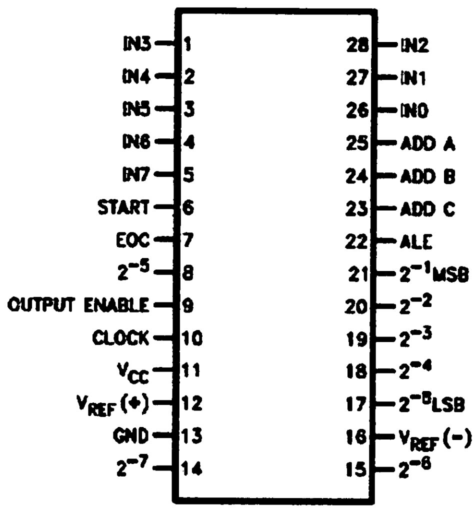
Tabel 2.2 Funsi PIN LM358

No Pin	Fungsi
1	Keluaran A (Output A)
2	Masukan menjungkir (Input inverting)
3	Masukan Tak menjungkir (Input non-inverting)
4	Dihubungkan dengan terminal negatif pencatu daya (V-)
5	Masukan Tak menjungkir (Input non-inverting)
6	Masukan menjungkir (Input inverting)
7	Keluaran B (Output B)
8	Dihubungkan dengan terminal positif pencatu daya (V+)

*(**sumber**: http:\uii\fakultas elektro_telemetri suhu dan kelembapan)*

2.5 Analog to Digital Converter 0808 *(ADC 0808)*

ADC adalah suatu rangkaian yang mengkonversikan sinyal analog menjadi sinyal digital. Sistem mikroprosesor hanya dapat mengolah (memproses) data dalam bentuk biner saja, atau sering disebut besaran digital, oleh sebab itu setiap data analog yang akan diproses oleh mikrokomputer harus diubah terlebih dahulu ke dalam bentuk kode biner (digital). Tegangan analog yang merupakan masukan dari ADC berasal dari *tranducer*. *Tranducer* inilah yang mengubah besaran kontinyu seperti temperatur, tekanan, kecepatan, ataupun putaran motor menjadi tegangan listrik. Tegangan listrik yang dihasilkan oleh *tranducer* akan berubah secara kontinyu pada suatu *range* tertentu dan disebut dengan tegangan analog dan tegangan analog ini kemudian diubah oleh ADC menjadi bentuk digital yang sebanding dengan tegangan analognya.

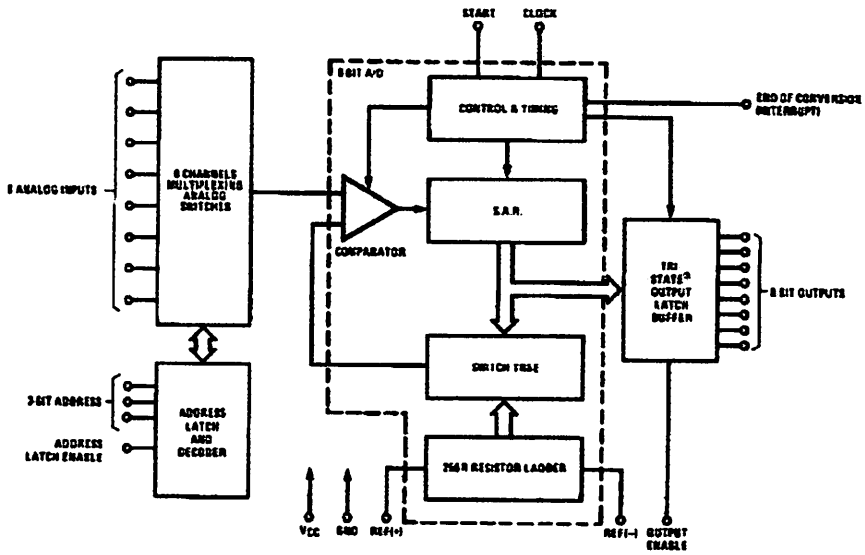


Gambar 2.9 Pin out ADC 0808
*(**Sumber** :Data sheet ADC 0808)*

ADC 0808 mempunyai karakteristik sebagai berikut :

- Resolusi sebesar 8 bit
- *Conversion time* sebesar 100μs
- Total *unadjusted error* : ±½ LSB and ±1 LSB
- Single power : 5 V_{DC}

- Low power : 15 mW



Gambar 2.10 Blok Diagram ADC 0808
*(**Sumber** :Data sheet ADC 0808)*

Pengendali ADC ini pertama memilih saluran masukan yang di inginkan, dengan meletakkan 3 bit alamat pada pin A1, A2, A3 dan input ALE dipulsa positif, untuk mencetak alamat ini ke dalam register alamat multiplexer. Untuk konversi pin START diberi pulsa pada tepi naik dari pulsa ini register internal (SAR) dibersihkan dan pada tepi turun pulsa ini konversi dimulai. Proses konversi yang sedang berlangsung dapat disela (*In terrupt*) oleh sinyal SC yang baru. Jalur EOC akan menjadi *low* setelah 8 periode *Clock* dari tepi naik pulsa START. Ketika sinyal EOC menjadi *High* menunjukkan data konversi siap dibaca. Pin OE (*output enable*) berfungsi untuk mengijinkan data pada register SAR agar bisa dibaca sistem luar.

Tabel 2.3 Menunjukan Saluran Analog ADC 0808

Saluran Anlaog Yang Dipilih	Jalur Alamat		
	C	B	A
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 ADC 0808)

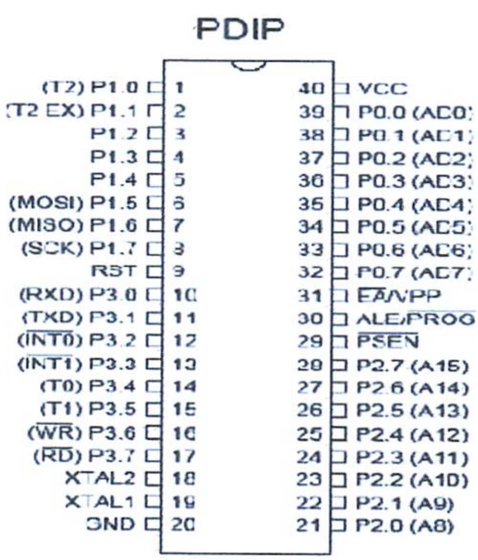
2.6 Mikrokontroller AT89C52

Mikrokontroler merupakan perkembangan dari mikroprosesor. Dalam sebuah chip mikrokontroler telah terintegrasi memori, CPU dan I/O. Hal tersebut membuat mikrokontroler dapat langsung dibuat sistem dengan menambahkan sedikit peripheral lain. Sifat mikrokontroler yang mampu diprogram *(programmable)* menyebabkan mikrokontroler mempunyai kemampuan aplikasi yang sangat luas.

AT89C52 adalah salah satu jenis mikrokontroler buatan Atmel dan merupakan keluarga MCS-51, yang membedakan mikokontroler AT89S52 dengan C52 (seri sebelumnya) adalah cara pengisian program *(Flash Programming)*. Pada mikrokontroler AT89S52 terdapat fasilitas ISP (In System Programming), artinya mikrokontroler ini mampu diprogram meskipun dalam kondisi bekerja. Sedangkan perbedaan pada *hardware* adalah adanya MOSI, MISO, dan SCK, pin ini berguna saat *flash programming.* AT89C52 merupakan mikrokontroler 8 bit dengan spesifikasi sebagai berikut:

1. *CPU (Central Processing Unit)* dengan lebar data 8 bit
2. *Processor Boolean* untuk operasi logika 1 bit
3. Pembangkit *Clock internal*
4. Dua buah *timer/counter* 16 bit
5. Dua buah saluran *Interupsi eksternal*.
6. Jalur I/O dua arah 32 buah
7. Memori program terpisah dengan memori data
8. 8 *Kbyte* memori program (Flash EEPROM)
9. Memori data *internal* 256 *byte*
10. Alamat memori program *eksternal* 64 *kilobyte*
11. Alamat memori data *eksternal* 64 *kilobyte*

Gambar 2.14 Memperlihatkan konfigurasi kaki-kaki pin dari mikrokontroler AT89C52.



Gambar 2.11 Pin-pin AT89C52
*(**Sumber** : Data sheet Mikrokontroller AT89C52)*

Deskripsi fungsi pin-pin dari AT89C52 pada Gambar 2.14 :

1. **Port 0.0/AD0 – port 0.7/AD7** (kaki 32-39). Pada perancangan komponen minimum, port ini dapat digunakan untuk port I/O tujuan umum. Untuk perancangan yang lebih besar (dengan memori luar), port ini menjadi bus data dan alamat multipleks.
2. **Port 1** (kaki 1-8). Port ini dipakai untuk port I/O. Pin-pin ini dirancang sebagai P1.0, P1.1, P1.2 dan seterusnya sampai P1.7 untuk antarmuka dengan *device* luar.
3. **Port 2.0/A8 – port 2.7/A15** (kaki 21-28). Port ini dipakai untuk I/O atau sebagai bus byte tinggi alamat untuk rancangan dengan memori luar.
4. **Port 3** (kaki 10-17). Port ini dipakai untuk I/O tujuan umum atau untuk fungsi khusus, dimana setiap pin mempunyai keistimewaan yang dimiliki AT89C52 seperti pada tabel berikut:

Tabel 2.4
Fungsi Khusus dari Port 3

IN	FUNGSI
P3.0	*RXD (Serial input port)*
P3.1	*TXD (Serial Output Port)*
P3.2	*INT0 (external interrupt 0)*
P3.3	*INT1 (external interrupt 1)*
P3.4	*T0 (Timer 0 external input)*
P3.5	*T1 (Timer 1 external input)*
P3.6	*WR (external data memori write strobe)*
P3.7	*RD (external data memori read strobe)*

*(**Sumber** : Data sheet Mikrokontroller AT89C52)*

5. **PSEN** *(Program store enable,* kaki 29). PSEN merupakan keluaran untuk sinyal kendali yang mengijinkan memori program (kode) luar dan biasanya dihubungkan dengan kaki OE *(Output Enable)* EPROM yang mengjinkan pembacaan byte-byte program.
6. **ALE** *(Address Latch Enable,* kaki 30). Sinyal keluaran ALE untuk *demultiplexing* bus data dan alamat. Jika port 0 digunakan sebagai bus data dan bus Byte rendah alamat, ALE mengunci alamat ke register luar selama setengah pertama siklus memori. Selanjutnya selama setengah kedua siklus memory, jalur -jalur port 0 disediakan untuk data masukan atau keluaran ketika perpindahan data sedang dilakukan.
7. **EA** *(External Access,* kaki 31). Untuk eksekusi program dari memori luar maka kaki ini harus diberi tegangan rendah.
8. **RST** *(Reset,* kaki 9). Jika diberikan tegangan tinggi selama paling sedikit 2 siklus mesin, maka register internal akan diisi dengan harga tertentu untuk kondisi awal sistem.
9. **XTAL 1** merupakan input dari penguat osilator dan *clock* internal untuk pengoperasian rangkaian.
10. **XTALL 2** merupakan *output* dari penguat pembalik osilator. Keluarga MCS-51 yang diproduksi oleh Intel mempunyai konfigurasi yang berbeda-beda sesuai dengan jenis-jenisnya. Masing-masing jenis saling kompatibel serta mempunyai kebihan tersendiri. Misalnya mikrokontroler AT89C52 merupakan persamaan dari mikrokontroler 8052, tetapi tidak mempunyai ROM *internal.*

11. Vcc untuk suplai tegangan.

12. GND untuk ground.

a. Organisasi Memori

Organisasi memori pada mikrokontroler AT89C52 dapat dibagi menjadi dua bagian besar yaitu memori program dan memori data. Pembagian tersebut didasarkan atas fungsi dari penyimpanan data maupun program. Memori program digunakan untuk menyimpan intruksi-intruksi yang akan dijalankan oleh mikrokontroler, sedangkan data digunakan sebagai tempat penyimpanan data.

Program mikrokontroler disimpan dalam memori program berupa ROM. Mikrokontroler AT89C52 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 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 (*program store enable*).

Selain memori program mikrokontroler AT89C52 juga mempunyai memori data internal berkapasitas 256 *byte* dan mampu mengakses memori data eksternal sebesar 64 Kb. Semua memori 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 adalah *operand* adalah 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*.

Memori

Memori dalam mikrokontroler merupakan piranti yang berfungsi untuk menyimpan program dan data yang dibutuhkan oleh mikrokontroler. Memori secara garis besar dibagi menjadi dua macam yaitu memori yang hanya dapat dibaca (*read only memori*) dan memori yang dapat dibaca maupun ditulis (*random access memori*).

- ROM (*Read Only Memori*)

  ROM adalah suatu bentuk memori yang hanya dapat dibaca isinya. Isi ROM tidak mudah dihapus atau tidak mudah hilang meskipun catu daya tidak diberikan kepadanya. Karena sifatnya yang tidak mudah dihapus tersebut, ROM disebut juga *memori non volatile.* Suatu program atau data statis yang diinginkan agar tidak mudah hilang dapat disimmpan dalam ROM. Menurut sifatnya ROMdapat dibagi menjadi bebrapa macam, yaitu:

  1.PROM (*Programmable Read Only Memori*) yaitu jenis ROM yang sekali ditulis dan tidak dapat dihapus kembali.

  2.EPROM (*Erasable Programmable Read Only Memory*) yaitu jenis ROM yang dapat ditulis maupun dihapus kembali. Menurut cara penghapusannya EPROM dapat dibagi menjadi dua yaitu UV-EPROM (*Ultra Violet EPROM*) dan EEPROM (*Electrically EPROM*).

- RAM (*Random Access Memori*)

RAM adalahh memori yang dapat dibaca maupun ditulis. Menurut sifatnya RAM biasa disebut sebagai memori yang mudah menguap (*Volatile*), yaitu bila catu daya yang diberikan pada RAM dihilangkan, maka data pada RAM akan hilang. Ada dua macam RAM yaitu:

1. RAM statik yaitu RAM yang tersusun atas *flip-flop*. Selama catu daya diberikan pada RAM, maka data akan tetap tersimpan.
2. RAM dinamik adalah RAM yang menggunakan kapasitor sebagai penyimpan data. RAM ini memerlukan penyelangaraan data karena sifat kapasitor dapat menurunkan muatannya.

b. Register Fungsi Khusus

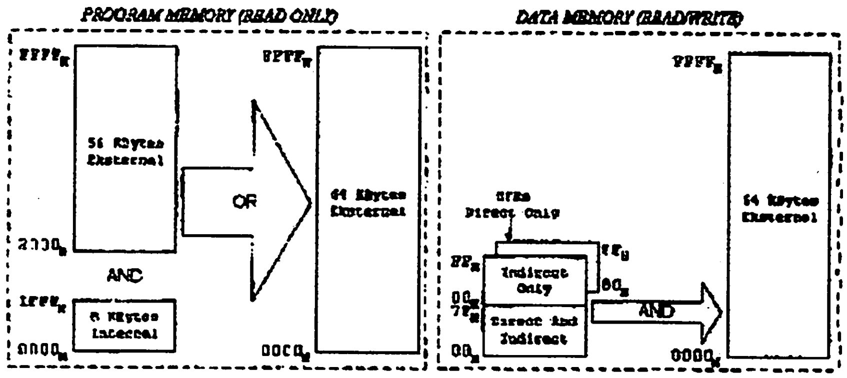
Register fungsi khusus (*Special Function Register*) terletak pada 256 *byte* bagian atas memori data internal dan berisi register-register untuk pelayanan *latch port, timer, program status words, control peripheral* dan sebagainya. Alamat register fungsi khusus ditunjukkan pada tabel 2.4

Tabel 2.5
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	0H	81H
DPTR	Data Pointer 2 byte	-	-
DPL	Low Bytes	0000H	82H
DPH	High Bytes	0000H	83H
P0	Port 0	FFH	80H
P1	Port 1	FFH	90H
P2	Port 2	FFH	0A0H
P3	Port 3	FFH	0B0H
IP	Interrupt Priority Control	XXX00000B	0B8H
IE	Interrupt Enable Control	0XX00000B	0A8H
TMOD	Timer/Counter Mode	00H	89H
TCON	Control	00H	88H
TH0	Timer /Counter Control	00H	8CH
TL0	Timer/Counter 0 high byte	00H	8AH
TH1	Timer/Counter 0 low byte	00H	8DH
TL1	Timer/Counter 1 high byte	00H	8BH
SCON	Timer/Counter 1 low byte	00H	98H
SBUF	Serial Control	Independen	99H
PCON	Serial data buffer	HMOS	87H
	Power Control		

*(**Sumber** : Data sheet Mikrokontroller AT89C52)*

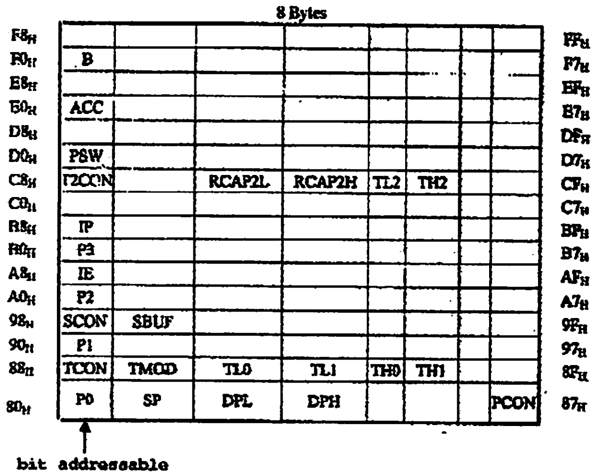
Pada internal memori terbagi menjadi dua bagian yaitu bagian data memori yang berukuran 256 bytes dan bagian *Special Function Register* (SFR) yang diperlukan mikrokontroler untuk menyimpan data penting.



Gambar 2.12 Struktur Memori AT89C52

*(**Sumber** : http//:petra.com/skripsi/ Pengontrol Suhu melalui Jaringan Telepon berbasis Mikrokontroller AT89C52)*

Cara untuk mengakses internal memori dan SFR pada AT89C52 mempunyai aturan tersendiri. Pada internal memori dibagi menjadi 2 bagian yaitu bagian yang dapat diakses secara langsung dan tidak langsung yaitu mulai dari alamat 00H-7Fh sedangkan alamat mulai dari 80H-FFH hanya dapat diakses secara *indirect*. Untuk *Special Function Register* (SFR) hanya dapat diakses secara *direct*. Tabel dari SFR dapat dilihat pada gambar 2.15



Gambar 2.13 *Special Function Register*

*(**Sumber** : http//:petra.com/skripsi/ Pengontrol Suhu melalui Jaringan Telepon berbasis Mikrokontroller AT89C52)*

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

- *Accumulator* (ACC) merupakan registter untuk penambahan dan pengurangan. Perintah *Mnemonic* untuk mengakses akumulator disederhanaka sebagai A.
- Register B merupakan register khusus yang berfungsi melayani operasi perkalian dan pembagian.
- *Program Status Word* (PSW) terdiri dari beberapa bit status yang menggambarkan kejadian di akumulator sebelumnya. Yaitu *Carry bit, auxiliary carry,* dua bit pemilih bank, bendera *overflow,* parity bit, dan dua bendera yang dapat didefenisikan sendiri oleh pemakai.
- *Stack Pointer* (SP) merupakan register 8 bit yang dapat diletakkan dialamat maupun pada RAM internal. Isi register ini ditambah sebelum

data disimpan. Selama instruksi PUSH dan CALL. Pada saat reset, register SP diinisialisasikan pada alamat 07H, sehingga *stack* dimulai pada lokasi alamat 08H.

- *Data Pointer* (DPTR) terdiri dari dua register, yaitu untuk byte tinggi (data pointer high,DPH) dan byte rendah (data pointer low, DPL) yang berfungsi untuk mengunci alamat 16 bit.
- Port 0 sampai port 3 merupakan register yang berfungsi untuk membaca dan mengeluarkan data pada port 0, 1, 2, 3. Masing-masing register ini dapat dialamati per-byte maupun per-bit.
- *Serial data buffer* (SBUF) merupakan dua register terpisah, register *buffer* pengirim dan sebuah register buffer penerima. Meletakkan data pada SBUF berarti meletakkan pada buffer pengirim yang akan mengirimkan data melalui transmisi serial. Membaca data SBUF berarti menerima data dari buffer penerima.
- Control register yang mempunyai fungsi control. Untuk mengontrol system interupsi, terdapat dua register khusus, yaitu register IP (*interrupt priority*) dan register IE (*interupt enable*). Untuk mengontrol pelayanan timer/counter terdapat register khusus, yaitu register TCON (timer/counter control) serta untuk pelayanan port serial menggunakan register SCON (serial port control).

c. Port Masukan dan Keluaran

Mikrokontroler AT89C52 mempunyai 4 port dan masing-masing port terdiri dari 8 saluran bit. Keempat port ini bersifat *bidirectional* yaitu dapat digunakan sebagai masukan atau keluaran. Port 0 digunakan sebagai saluran data yang *dimultipleks* dengan saluran alamat rendah untu mengakses memori eksternal, baik memori program maupun memori data. Port 2 mengeluarkan bagian alamat tinggi untuk mode pengalamatan memori 16 bit. Port1 dan 3 berfungsi sebagai saluran masukan dan keluaran multi fungsi.

d. Sistem Interupsi

Mikrokontroler AT89C52 mempunyai 6 sumber *interrupt*, yaitu dua buah *interrupt* eksternal (INT0 dan INT1), tiga buah *timer/counter* (T0,T1 dan T2), serta satu buah *intrrupt serial*. Keenam *interrupt* diatas memiliki *vector address* yang dapat dilihat pada tabel 2.5

Tabel 2.6
Interrupt

Interrupt Source	Vector Address
IE0	0003h
TF0	[illegible]
IE1	0013h
TF1	001Bh
RI & TI	0023h
TF2 & EXF2	002Bh

*(**Sumber** : http//:petra.com/skripsi/ Pengontrol Suhu melalui Jaringan Telepon berbasis Mikrokontroller AT89C52)*

Jika terjadi *interrupt*, maka program akan melompat ke alamat vektor *interrupt* yang bersangkutan dan baru kembali ke program utama jika menjumpai perintah RET1 (*returnfrom interrupt*).

Keenam *interupsi* ini dapat diaktifkan atau dimatikan melalui register IE (*interrupt enable*). Bit EA berfungsi untuk mengaktifkan sistem *interrupt* secara keseluruhan, sedangkan ET2, ES, ET1, EX1,ET0, EX0 berturut-turut untuk mengaktifkan *timer/counter 2, serial, timer/counter 1, external interrupt 1, timer/counter 0, external interrupt 0* (dapat dilihat pada gambar 2.5).

Interrupt eksternal (INT0 dan INT1) dapat diaktifkan dengan dua mode, yaitu mode aktif level (*level actived*) dan mode aktif transisi (*transition actived*). Jika INT0 dan INT1 diberi logika "0" pada aktif level atau diberi perubahan transisi turun (*falling edge*) dari logika '1' ke logika '0' maka akan menyebabkan terjadinya *interrupt*.

Mode untuk mengaktifkan level ataupun transisi dapat dilakukan pada *register* TCON (*timer/counter control*), yaitu pada bit IT0 dan IT1. *Interrupt timer/counter* T0,T1 dan T2 terjadi jika *overflow* pada *register timer/counter* yang bersangkutan. *Register timer/counter* ituadalah TH0|TL0, TH1|TL1 dan TH2|TL2.

Interrupt serial terjadi apabila dijumpai adanya stop bit baik pada jalur TX maupun pada jalur RX.

EA	-	ET2	ES	ET1	EX1	ET0	EX0

TCON: Timer/Counter Control Register

TF1	TR1	TF0	TR0	E 1	IT1	IE0	IT0

TF2	EXF2	RCLK	TCLK	EXEN2	TR2	C/-T2	CP/-RL2

Gambar 2.14 Register-Register *Interrupt*
*(**Sumber** : http//:petra.com/skripsi/ Pengontrol Suhu melalui Jaringan Telepon berbasis Mikrokontroller AT89C52)*

e. Komunikasi Serial

Pada mikrokontroller AT89C52 terdapat fasilitas komunikasi *serial full duplex.* Dalam mikrokontroler ini terdapat register TX yang berfungsi untuk mengirimkan data lewat *transmitter.*

Register RX yang berfungsi untuk menampung data yang diterima lewat *receiver.* Kedua register ini terpisah secara fisik, sehingga tidak mungkin terjadi data bentrok. Dalam SFR terdapat SBUF (*Serial Buffer*), dimana berfungsi sebagai penghubung antar kedua register dengan program. Jika terjadi penulisan data ke SBUF maka data tersebut akan diteruskan ke register TX, selanjutnya jika pada jalur penerima maka data akan disimpan pada register RX, selanjutnya data tersebut dapat dibaca oleh program dengan memberi perintah pembacaan terhadap SBUF.

Komunikasi serial mempunyai empat macam mode, yaitu mode 0, 1, 2 dan 3. Hal ini berkaitan dengan tipe data dan *baud rate.* Yang digunakan (dapat dilihat pada tabel 2.7

Tabel 2.7
Mode Komunikasi Serial

SM0	SM1	Mode	Description	Baud Rate
0	0	0	Shift Register	Focs/12
0	1	1	8 bit UART	Variable
1	0	2	9 bit UART	Focs/64 or Focs/32
1	1	3	9 bit UART	Variable

*(**Sumber** : http//:petra.com/skripsi/ Pengontrol Suhu melalui Jaringan Telepon berbasis Mikrokontroller AT89C52)*

Hit SM0 dan SM1 terdapat pada register SCON (*serial control*), yang berfungsi untuk memilih mode komuikasi serial.

Untuk mode yang menggunakan 9 bit *universal Asyncrhronous Receiver Transmitter* (UART) mempunyai arti bahwa data akan berukuran 9 bit, yaitu 1 sampai bit 8 akan terletak pada register SBUF sedangkan bit 9 akan diletakkan pada TB8 (untuk transmit) dan RB8 (untuk *receive*). Kedua bit TB8 dan RB8 terdapat pada register SCON.

SM0	SM1	SM2	REN	TB8	RB8	TI	RI

Gambar 2.15 Register Serial Control (SCON)
*(**Sumber** : http//:petra.com/skripsi/ Pengontrol Suhu melalui Jaringan Telepon berbasis Mikrokontroller AT89C52)*

Pada gambar 2.17 dapat dilihat isi dari register SCON. Bit SM2 berfungsi untuk mengaktifkan komunikasi multiprosesor sedangkan bit REN berfungsi untuk menerima data atau tidak menerima data, jika bit REN sama dengan 0, maka tidak akan dapat menerima data tetapi jika bit REN adalah 1 maka dapat menerima data. Bit RI dan TI merupakan bit yang dapat menyebabkan terjadinya *interrupt serial*, dimana bit TI (*transmit interrupt flag*) akan berlogika 1 (terjadi *interrupt serial*) jika pada jalur transmit telah mengirimkan bit terakhir (*stop bit*), sedangkan bit RI (*receive interrupt flag*) akan berlogika 1 (terjadi *interrupt serial*) jika pada jalur *receive* telah menerima bit terakhir (*stop bit*).

Baud rate mode 0 selalu bernilai 1/12 *oscillator*, sedangkan *baud rate* pada mode 2 akan bernilai 1/64 *oscillator* jika pada register PCON (*Power Control*) bit SMOD berlogika '0' jika bit SMOD berlogika '1' maka *baud rate* pada mode 2 akan bernilai 1/32 *oscillator.*

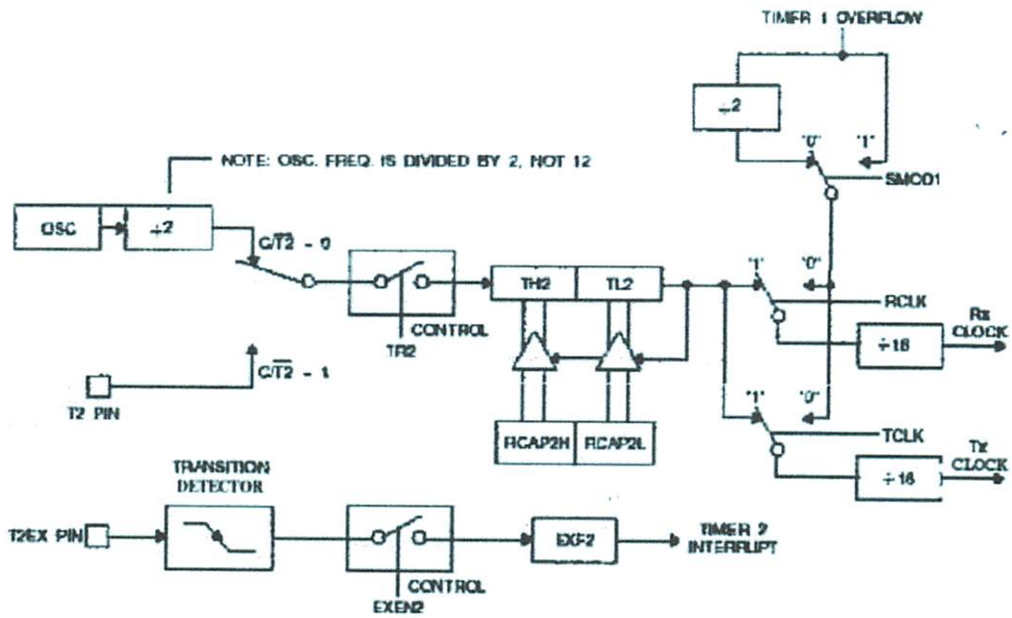
Baud rate pada mode 1 dan 3 dapat dibuat dengan memanfaatkan *overflow* dari *timer 1* dan *timer2.*

$$BaudRate = \frac{2^{SMOD}}{32} x \frac{OscillatorFrequency}{12x[256-(TH1)]} \qquad (2.1)$$

Nilai *baud rate* pada mode 1 dan 3 ini dapat dihitung dengan melihat persamaan (2.1), dimana SMOD bernilai 1 maka *baud rate* akan menjadi dua kali lipat, sedangkan jika bit SMOD bernilai 0 maka *baud rate* hanya dikali 1. Pada persamaan (2.1) diatas perhitungan *baud rate*-nya menggunakan *timer1.* Sedangkan perhitungan dengan menggunakan *timer2* dapat dilihat pada persamaan (2.2) dibawah ini.

$$BaudRate = \frac{OscillatorFrequency}{32x[65536-(RCAP2H, RCAP2L)]} \qquad (2.2)$$

Hal yang harus diperhatikan pada saat melakukan proses serial dengan menggunakan *timer2* yaitu bit RCLK dan TCLK harus diberi logika 1 sedangkan menggunakan *timer1* maka bit RCLK dan TCLK diberi logika 0. Bit RCLK dan TLCK berada pada register T2CON yang dapat dilihat pada gambar 2.15. Proses bit RLCK dan TLCK pada proses perhitungan *baud rate* ini dapat dilihat pada gambar 2.16



Gambar 2.16 Baud Rate Generator Mode
*(**Sumber** : Data Sheet AT89C52)*

2.7 Rangkaian Pengubah Level Tegangan

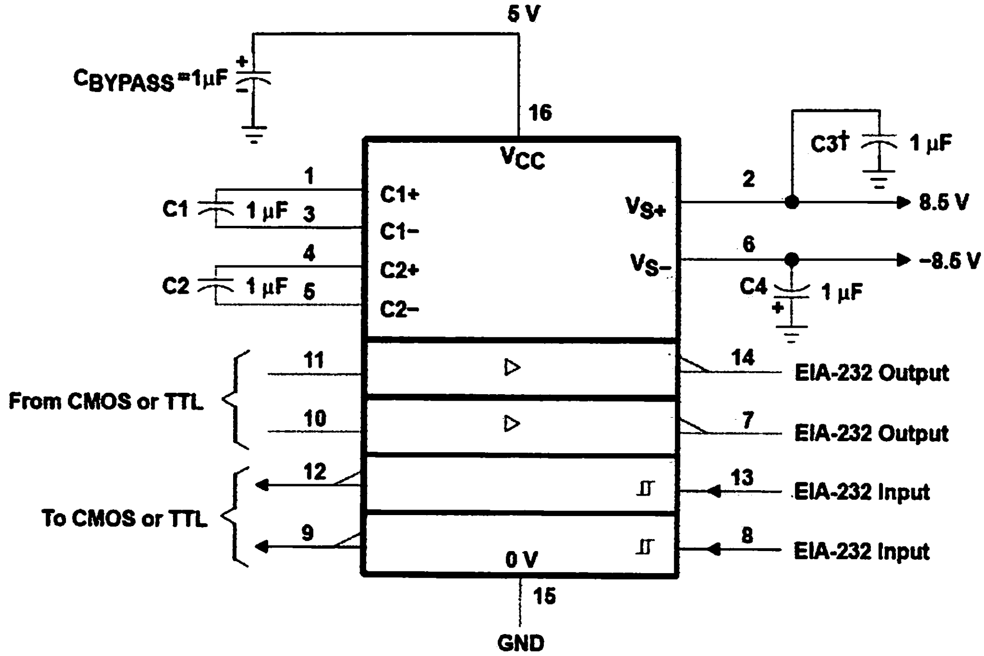
Agar mikrokontroler dapat berkomunikasi dengan modul WIZ610WI maka diperlukan komunikasi serial untuk itu digunakan IC MAX232 untuk TTL dan MAX3232 untuk LVTTL. Modul WIZ610WI ini mempunyai pin untuk komunikasi serial, akan tetapi bekerja pada LVTTL (Low Voltage Transistor Transistor Logic) yakni 3,3 Volt. Karena pada mikrokontroler mendukung komunikasi serial dengan tegangan 5 Volt, dengan adanya kondisi seperti ini maka dibutuhkan suatu komponen yang dapat menyamakan komunikasi diantara keduanya. Untuk itu pada sisi modul tersebut dibutuhkan IC MAX 3232 yang dapat mengkonversikan LVTTL menjadi standar EIA232, sedangkan pada sisi mikrokontroler dibutuhkan IC MAX 232 yang dapat mengkonversikan TTL menjadi standart EIA232. Apabila tegangan serial sudah sama maka komunikasi antara mikrokontroler dan modul dapat berlangsung.

Untuk komunikasi modul WIZ610WI dengan mikrokontroler dilakukan komunikasi secara serial. Untuk itu mikrokontroler memerlukan sebuah piranti yang berfungsi sebagai pengubah level tegangan.

2.5.1 RS232 (TTL to EIA232)

RS232 bekerja pada level tegangan +3 V sampai dengan + 25 V untuk *space* (logika 0) dan -3 V sampai dengan -25 V untuk *mark* (logika 1).

Sedangkan TTL bekerja pada level tegangan 0 s/d +5 V. Piranti tambahan yang kita butuhkan adalah IC MAX232. Pada dasarnya IC ini hanya digunakan sebagai pengubah level tegangan ke level *Transistor Transistor Logic* (TTL), tidak berfungsi sebagai pengkodean sinyal yang melewati RS232, dan juga tidak mengkonversikan data serial ke data paralel.



Gambar 2.17 IC MAX232
*(**Sumber** : Datasheet MAX232)*

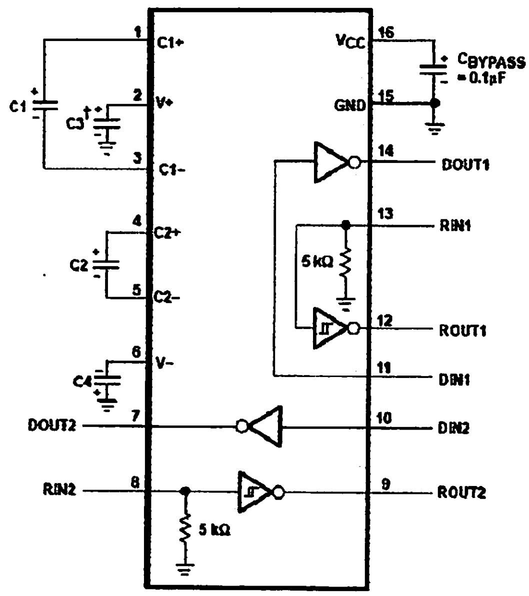
RS 232 sebagai komunikasi serial mempunyai 16 pin yang memiliki fungsi masing-masing. Pin yang sering digunakan adalah pin 12 sebagai *received* data, pin pin 11 sebagai *transmitter* data dan pin 15 sebagai ground sinyal.

2.5.2 RS3232 (EIA232 to LVTTL)

RS3232 bekerja pada level tegangan +3 V sampai dengan + 25 V untuk *space* (logika 0) dan -3 V sampai dengan -25 V untuk *mark* (logika 1).

Sedangkan LVTTL bekerja pada level tegangan 0 s/d +3,3 V. Piranti tambahan yang kita butuhkan adalah IC MAX3232. Pada dasarnya IC ini hanya digunakan sebagai pengubah level tegangan ke level *Low Voltage Transistor Transistor Logic*

(LVTTL), tidak berfungsi sebagai pengkodean sinyal yang melewati RS3232, dan juga tidak mengkonversikan data serial ke data paralel.

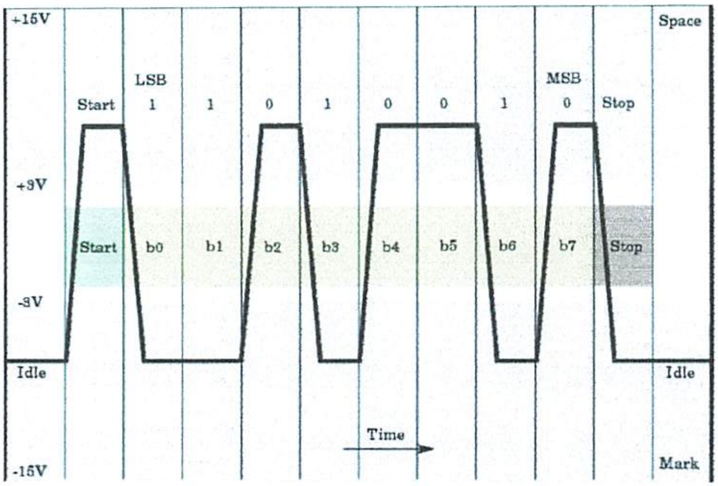


Gambar 2.18 IC MAX3232
(Sumber : Datasheet MAX232)

RS 3232 sebagai komunikasi serial mempunyai 16 pin yang memiliki fungsi masing-masing. Pin yang sering digunakan adalah pin 12 sebagai *received* data, pin pin 11 sebagai *transmitter* data dan pin 15 sebagai ground sinyal.

Standar EIA232 *Electronic Industry Association* (EIA) adalah sebagai berikut :

1. "*Space*" (logika 0) adalah tegangan antara +3V hingga +25V.
2. "*Mark*" (logika 1) adalah tegangan antara -3V hingga -25V.
3. Daerah antara +3V hingga -3V tidak didefinisikan/tidak terpakai.
4. Tegangan *open circuit* tidak boleh melebihi 25V.
5. Arus yang melalui rangkaian tidak boleh melebihi 500 mA, ini dibutuhkan agar sistem yang dibangun bekerja dengan akurat



Gambar 2.19 Bentuk dari Sinyal Standar EIA232
(Sumber : wikipedia)

2.6 Modul *Wi-fi* WIZ610WI

WIZ610WI merupakan suatu produk dari Wiznet. Modul WIZ610WI merupakan modul *gateway* untuk mengkonversi RS-232C atau protokol *TCP/IP* ke IEEE802.11 b/g *wireless protocol*. Dengan menginterfacekan modul WIZ610WI dengan perangkat yang dapat mendukung data serial atau *Ethernet*, maka jaringan *wireless* dapat dibangun untuk membuat suatu perangkat yang dapat mengontrol atau memonitoring suatu alat. Penggunaan modul ini memungkinkan mikrokontroler dapat berkomunikasi dengan *wireless card*. Spesifikasi dari modul ini ditunjukkan pada tabel 2.7

Fungsi utama dari modul ini adalah:

- Support IEEE 802.11 b/g
- Support 54 Mbps wireless LAN dan 10/100Mbps fast ethernet
- Support 4/128/152 bit WEP enkripsi

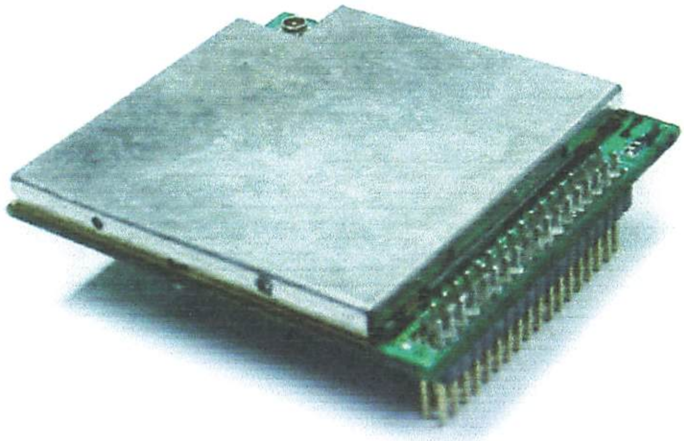
- Support WPA
- Menggunakan IEEE802.1x yang dapat menyuport EAP certification
- Dapat berkomunikasi dengan divice wireless lainnya
- Support pada RS232C dan ethernet
- Support AP, AP client dan server
- Support multiple SSID dan VLAN

Tabel 2.8
Spesifikasi Modul WIZ600WI

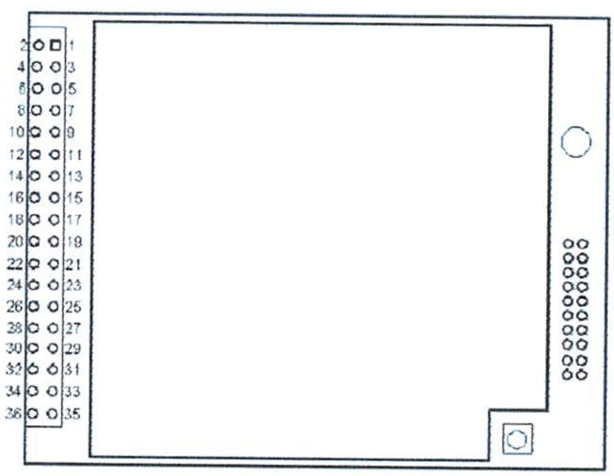
Item	Specification
Standard	IEEE 802.11b/g, IEEE802.3 10/100Mbps Ethernet
Modulation	DBPSK, DQPSK, CCK, OFDM
Frequency	2.400~2.483 GHz
Available Spectrum	83.5 MHz
Channels	13ch (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13)
Data Rate (Mbps)	1,2,5.5,11, 6,9,12,18,24,36,48,54
Out Power	18 dBm

(***Sumber:*** *Data sheet Wiz610wi*)

Modul WIZ600WI ini bekerja pada tegangan 3,3 Volt (LVTTL) dengan arus sebesar 500mA (max 700mA) pada tegangan 3,3 Volt.



Gambar 2.20 WIZ610WI
(***Sumber:*** *Data sheet Wiz610wi*)



Gambar 2.21 WIZ610WI PIN Map
(***Sumber:*** *Data sheet Wiz610wi*)

Tabel 2.9
Fungsi Pin pada WIZ610WI

NO	NAMA	I/O	Fungsi
1	CTS	I	UART : CTS
2	RTS	O	UART : RTS
3	-	-	-
4	HW-Trigger	I	Low : Entering Serial Command
			Mode
5	GPIO7	I/O	High : Exit Serial Command Mode
6	GPIO5	I/O	Reserved
7	SOUT	O	Reserved
8	SIN	I	UART : TXD
9	DC_IN		UART : RXD
10	DC_IN		Power 3,3,Volt
11	GND		Power 3,3 Volt
12	GND		GND
13	RXERR	I	GND
14	COL	I	MII Receive Data Error
15	W_LED	O	MII Collision
16	MDC	I	Wireless LED (Active Low)
17	RESET	I	SMI Clock
			Active High
			If The Signal Asserted more than 3
18	MDIO	I/O	sec, Factory reset performed
19	GND		SMI I/O Data
20	GND		GND
21	RXC	I	GND
22	RXDV	I	MII Receive Clock
23	RXD2	I	MII Receive Data Valid

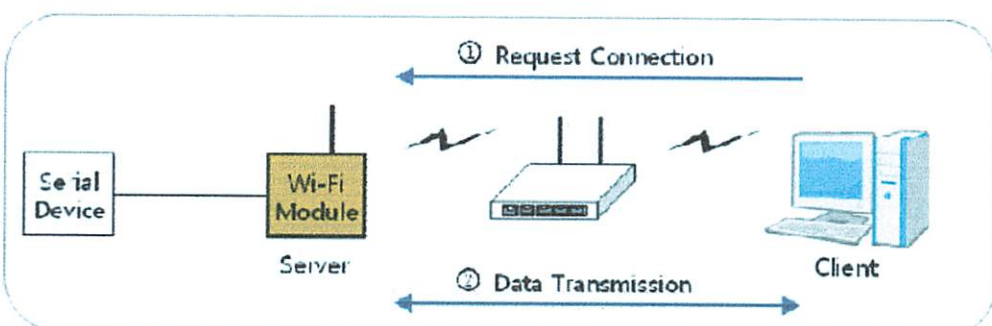
24	RXD0	I	MII Receive Data
25	RXD1	I	MII Receive Data
26	RXD2	I	MII Receive Data
27	GND		MII Receive Data
28	GND		GND
29	TXC	I	GND
30	TXEN	O	MII Transmit Clock
31	TXD3	O	MII Transmit Enable
32	TXD2	O	MII Transmit Data
33	TXD0	O	MII Transmit Data
34	TXD1	O	MII Transmit Data
35	GND		MII Transmit Data
36	CRS	I	GND
			Carrier Sense

(***Sumber:*** *Data sheet Wiz610wi*)

Pada Modul ini terdapat beberapa mode antara lain:

- TCP Server Mode

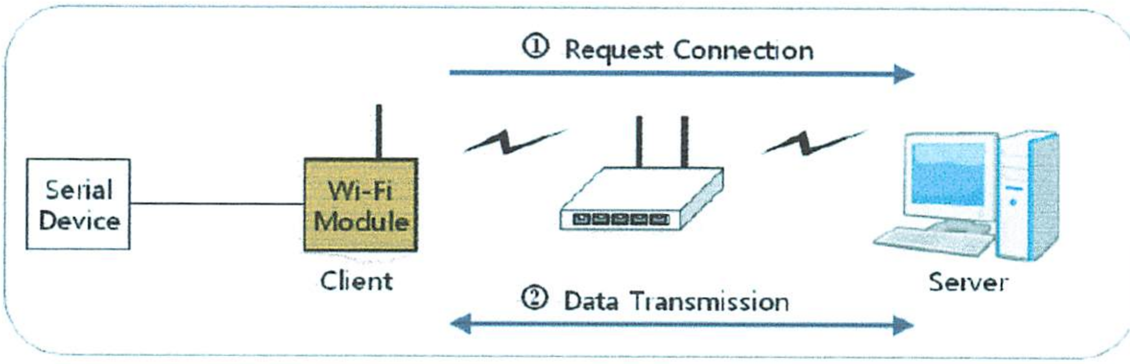
Pada mode ini terlebih dahulu alamat IP, subnetmask dan port harus disetting. Pada dasarnya pada mode ini modul bersifat sebagai server, dimana modul akan merespon ketika terdapat *request* dari *client*.



Gambar 2.22 TCP Server Mode
(***Sumber:*** *Datasheet WIZ610wi*)

- TCP Client Mode

Pada mode ini modul bersifat sebagai *client*. Pada mode ini alamat IP, subnetmask, gateway dan alamat IP *server* yang dituju harus ditentukan terlebih dahulu. Ketika modul diberi *power supply* pada mode ini, maka modul akan segera membagun koneksi dengan *server*. Selanjutnya data dapat ditransmisikan antara *server* dan *client*.



Gambar 2.23 TCP Server Client
(Sumber: Datasheet WIZ610wi)

- Mixed Mode

Pada mode ini, modul WIZ610wi akan bekerja pada mode TCP Server dan menunggu koneksi dari client. Akan tetapi, ketika modul WIZ610wi menerima data dari perangkat serial sebelum terbangunnya suatu koneksi, maka modul WIZ610wi ini akan berubah menjadi TCP client mode, kemudian data dari perangkat serial tersebut akan dikirimkan ke server. Pada mode Mixed, yang menjadi priorittas utama yakni mode TCP server. TCP client mode dapat digunakan ketika terjadi sesuatu yang fatal pada perangkat serial, sehingga mengirimkan data ke server berupa peringatan.

Society (ISOC), *Internet Architecture Board* (IAB), dan *Internet Engineering Task Force* (IETF). Macam-macam protokol yang berjalan di atas *TCP/IP*, skema pengalamatan, dan konsep *TCP/IP* didefinisikan dalam dokumen yang disebut sebagai *Request for Comments (RFC)* yang dikeluarkan oleh *IETF*.

Arsitektur *TCP/IP* tidaklah berbasis model referensi tujuh lapis *OSI*, tetapi menggunakan model referensi *DARPA*. Seperti diperlihatkan dalam diagram, *TCP/IP* merngimplemenasikan arsitektur berlapis yang terdiri atas empat lapis. Empat lapis ini, dapat dipetakan (meski tidak secara langsung) terhadap model referensi *OSI*. Empat lapis ini, kadang-kadang disebut sebagai *DARPA Model*, *Internet Model*, atau *DoD Model*, mengingat TCP/IP merupakan protokol yang awalnya dikembangkan dari proyek *ARPANET* yang dimulai oleh Departemen Pertahanan Amerika Serikat.

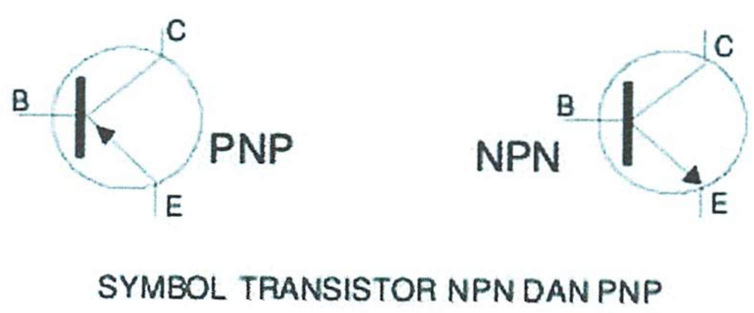
Setiap lapisan yang dimiliki oleh kumpulan protokol (*protocol suite*) TCP/IP diasosiasikan dengan protokolnya masing-masing. Protokol utama dalam protokol TCP/IP adalah sebagai berikut:

- Protokol lapisan aplikasi: bertanggung jawab untuk menyediakan akses kepada aplikasi terhadap layanan jaringan *TCP/IP*. Protokol ini mencakup protokol *Dynamic Host Configuration Protocol* (DHCP), *Domain Name System* (DNS), *Hypertext Transfer Protocol* (HTTP), *File Transfer Protocol* (FTP), *Telnet*, *Simple Mail Transfer Protocol* (SMTP), *Simple Network Management Protocol* (SNMP), dan masih banyak protokol lainnya. Dalam beberapa implementasi *stack protokol*, seperti halnya *Microsoft TCP/IP*, protokol-protokol lapisan aplikasi berinteraksi dengan menggunakan antarmuka *Windows Sockets* (Winsock) atau *NetBIOS over TCP/IP* (NetBT).

- Protokol lapisan antar-*host*: berguna untuk membuat komunikasi menggunakan sesi koneksi yang bersifat *connection-oriented* atau *broadcast* yang bersifat *connectionless*. Protokol dalam lapisan ini adalah *Transmission Control Protocol* (TCP) dan *User Datagram Protocol* (UDP).
- Protokol lapisan *internetwork*: bertanggung jawab untuk melakukan pemetaan (*routing*) dan enkapsulasi paket-paket data jaringan menjadi paket-paket IP. Protokol yang bekerja dalam lapisan ini adalah *Internet Protocol* (IP), *Address Resolution Protocol* (ARP), *Internet Control Message Protocol* (ICMP), dan *Internet Group Management Protocol* (IGMP).
- Protokol lapisan antarmuka jaringan: bertanggung jawab untuk meletakkan *frame-frame* jaringan di atas media jaringan yang digunakan. *TCP/IP* dapat bekerja dengan banyak teknologi transport, mulai dari teknologi transport dalam *LAN* (seperti halnya *Ethernet* dan *Token Ring*), *MAN* dan *WAN* (seperti halnya *dial-up modem* yang berjalan di atas *Public Switched Telephone Network* (PSTN), *Integrated Services Digital Network* (ISDN), serta *Asynchronous Transfer Mode* (ATM)).

2.8 TRANSISTOR

Transistor adalah komponen aktif yang menggunakan aliran electron sebagai prinsip kerjanya didalam bahan. Sebuah transistor memiliki tiga daerah doped yaitu daerah emitter, daerah basis dan daerah disebut kolektor. Transistor ada dua jenis yaitu NPN dan PNP. Transistor memiliki dua sambungan: satu antara emitter dan basis, dan yang lain antara kolektor dan basis. Karena itu, sebuah transistor seperti dua buah dioda yang saling bertolak belakang yaitu dioda emitter-basis, atau disingkat dengan emitter dioda dan dioda kolektor-basis, atau disingkat dengan dioda kolektor.



Gambar 2.24 Transistor
(Sumber: http:// wiki.detikinet.com)

Bagian emitter-basis dari transistor merupakan dioda, maka apabila dioda emitter-basis dibias maju maka kita mengharapkan akan melihat grafik arus terhadap tegangan dioda biasa. Saat tegangan dioda emitter-basis lebih kecil dari potensial barriernya, maka arus basis (Ib) akan kecil. Ketika tegangan dioda melebihi potensial barriernya, arus basis (Ib) akan naik secara cepat.

Transistor Sebagai Penguat Arus

sebagai penguat:

- Transistor bekerja pada mode aktif.
- Transistor berperan sebagai sebuah sumber arus yang dikendalikan oleh tegangan (VCCS).
- Perubahan pada tegangan base-emitter,*vBE*, akan menyebabkan perubahan pada arus collector, *iC*.
- Transistor dipakai untuk membuat sebuah penguatan transkonduktansi.
- Penguatan tegangan dapat diperoleh dengan melalukan arus collector ke sebuah resistansi, *RC*.
- Agar penguat menjadi penguat linier, transistor harus diberi bias, dan sinyal akan ditumpangkan pada tegangan bias dan sinyal yang akan diperkuat harus dijaga tetap kecil

Dengan arus IB yang kecil dapat menghasilkan arus kolektor IC yang besar. Jika arus basis IB kita anggap sebagai input dan arus kolektor IC sebagai output, maka transistor dapat kita anggap sebagai penguat arus atau sering kita sebut penguat arus (*current amplimeter)* Hfe. Karena arus IC lebih besar dari arus keluaran IB jadi penguatan arus / Hfe dapat didefenisikan sebagai perbandingan antara arus keluaran IC dan arus masukan IB

Rumus = $h_{FE} = \frac{I_C}{I_B}$ karena $h_{FE} \approx h_{fe}$

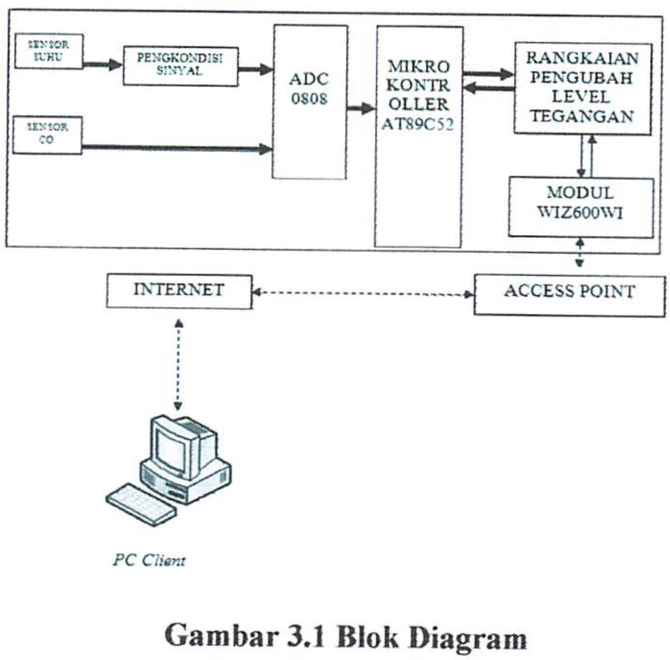
BAB III
PERANCANGAN DAN PEMBUATAN ALAT

3.1 Pendahuluan

Pada dasarnya perencanaan alat yang dibuat dalam tugas akhir ini meliputi perencanaan perangkat keras dan perencanaan perangkat lunak. Komponen yang dipakai dalam perencanaan ini antara lain mikrokontroler AT89C52 sebagai kontrol utama, dengan komponen pendukung meliputi *LM35*, *TGS2442*, Op-Amp, ADC dan modul *serial to wi-fi gateway* WIZ610WI.

3.1.1 Perancangan Perangkat Keras

Sebelum membuat perangkat keras terlebih dahulu direncanakan blok diagram yang akan dibuat, dan membahasnya sesuai dengan blok diagram. Adapun blok diagram yang direncanakan adalah sebagai berikut:



Gambar 3.1 Blok Diagram

Dari blok diagram diatas dapat dijelaskan sebagai berikut:

1. Sensor Suhu

   Digunakan untuk mengukur suhu dengan merubah suhu menjadi tegangan menggunakan LM35.

2. Sensor Karbon Monoksida (CO)

   Digunakan untuk mengukur kadar karbon monoksida yang ada didalam udara dengan mengubah menjadi tegangan dengan menggunakan TGS2442.

3. Pengkondisi Sinyal

   Dalam rangkaian sistem didapat sinyal listrik yang masih terlalu kecil untuk diproses lebih lanjut, untuk itu dibutuhkan sebuah penguatan. Penguatan yang digunakan berupa *Operasional Amplifier* (Op-Amp).

4. ADC (Analog Digital Converter)

   ADC merupakan piranti yang digunakan untuk merubah data yang berbentuk analog menjadi data yang berbentuk digital.

5. Rangkaian Pengubah Tegangan

   - RS232 untuk level tegangan 5 volt untuk komunikasi serial dari mikrokontroler.
   - RS3232 untuk level tegangan 3,3 volt untuk komunikasi serial dari modul WIZ610WI.

6. Modul WIZ610WI

   Merupakan modul interface dari serial ke *wi-fi* gateway atau dengan kata lain sebuah modul yang dapat mengkonversikan data serial ke *wi-fi* atau sebaliknya dari *wi-fi* ke bentuk serial.

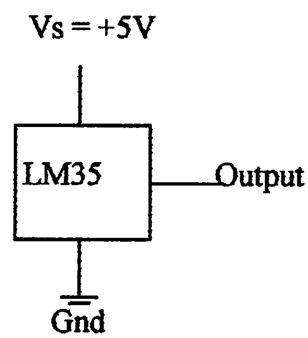
3.1.2 Prinsip Kerja Alat

Prinsip kerja dari alat ini yakni ketika alat ini dinyalakan maka sensor suhu dan *carbon monoksida,* akan mengukur suhu dan kadar *carbon monoksida,* hasil pengukuran dari sensor suhu akan dijadikan input bagi rangkaian Op-Amp untuk dikuatkan terlebih dahulu sebelum menjadi inputan dari ADC. Dikarenakan output dari sensor *TGS2442* dianggap sudah cukup besar, maka outputnya tidak perlu dikuatkan oleh rangkaian Op-Amp. Output dari Op-Amp dan sensor *TGS2442* dijadikan input oleh ADC. Inputan tersebut akan diubah dari bentuk sinyal analog kedalam bentuk sinyal digital, yang selanjutnya di jadikan input oleh mikrokontroler. Mikrokontroler akan memproses inputan tersebut yang kemudian hasilnya dikirimkan melalui port serial pada mikrokontroler. Karena pada modul WIZ610wi bekerja pada LVTTL (*Low Voltage Transistor Transistor Logic*) dengan tegangan 0V - 3,3V dan mikrokontroler pada TTL (*Transistor Transistor Logic*) dengan tegangan 0V - 5V maka output dari mikrokontroler tesebut sebelum dikirim harus diubah oleh rangkaian pengubah level tegangan. Dimaksudkan agar mikrokontroler dapat berkomunikasi dengan modul WIZ610wi.

Untuk dapat mengetahui hasil pengukuran dari alat ini maka sebuah *software* ditanamkan pada komputer yang dilengkapi dengan *wireless card* (Support IEEE 802.11 b/g). *software* ini akan mengirim perintah melalui *wi-fi* yang kemudian akan diterima oleh modul WIZ610wi yang berfungsi sebagai konverter dari *wi-fi* ke serial. Perintah tersebut akan dikirimkan ke mikrokontroler melalui rangkaian pengubah level tegangan. Perintah tersebut akan diterima oleh mikrokontroler yang kemudian oleh mikrokontroler akan direspon dengan mengirim balik hasil pengukuran dari sensor ke modul WIZ610wi yang selanjutnya dikirim melalui *wi-fi*. Sinyal tersebut akan diterima oleh komputer yang selanjutnya akan ditampilkan pada *software* yang telah ditanamkan.

3.1.3 Perancangan Sensor Suhu

Sensor *LM35* merupakan pengindra suhu yang memberkan tegangan keluaran yang berbanding langsung dengan suhu yang diukurnya, dalam derajat celcius. Sehingga pada suhu 0°C, tegangan yang dihasilkan adalah sebesar 0 Volt.



Gambar 3.2 Sensor Suhu LM35

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

Vout= Temp x 10 mV/°C

Dimana:

Vout = Tegangan output dari sensor LM35 (volt)

Temp = Besarnya suhu yang dibaca oleh sensor (°C)

Sebagai contoh suhu adalah 26°C maka tegangan dari sensor adalah:

Vout= Temp x 10 mV/°C

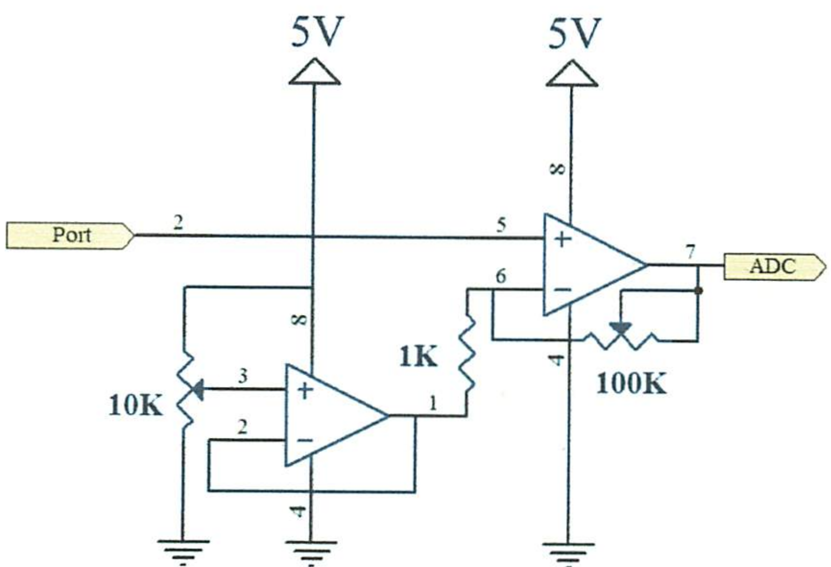
Vout= 26 °C x 10 mV/°C

Vout= 260mV

Karena hasil dari besaran temperatur ke besaran listrik masih dalam bentuk sinyal analog, maka sebelum diinputkan ke ADC terlebih dahulu sinyal tersebut dikuatkan dengan menggunakan Op-Amp.

3.1.4 Perancangan Rangkaian Penguat Operasional (Op-Amp)

Untuk menaikkan resolusi pembacaan data suhu, maka output dari sensor diumpankan ke suatu rangkaian penguat *non inverting* dengan menggunakan *IC Op-Amp LM358*, hal ini dibutuhkan karena output yang dihasilkan oleh sensor masih sangat kecil, untuk itu maka dibutuhkan suatu rangkaian untuk memperkuat output dari sensor tersebut. Untuk lebih jelasnya dapat dilihat pada rangkaian dibawah ini:



Gambar 3.3 Rangkaian Penguat Non-Inverting

Keluaran tegangan dari sensor adalah 10mV/°C, maka besar tegangan ini adalah tidak memenuhi untuk dapat mengubah resolusi satu bit pada ADC. Resolusi ADC0808 dengan Vref sama dengan 5 Volt adalah:

$$\frac{Vref}{2^8} = \frac{5}{2^8} = \frac{5}{255} = 0{,}0196 Volt$$

Maka untuk itu diperlukan suatu penguat. Berikut ini perancangan untuk mendapatkan gain yang tepat:

- Range yang akan diukur ditetapkan yakni 25,0°C – 40,0°C
- Untuk suhu 25,0°C maka output sensor adalah 250 mV
- Untuk suhu 40,0°C maka output sensor adalah 400 mV
- Perubahan bit dari 25,0°C sampai 40°C adalah sebanyak 150, sehingga pada saat suhu 25,0°C maka diharapkan output data pada ADC adalah 0 dan ketika suhu 40,0°C maka data output dari ADC adalah 150.

$$Tampilan\_Layar = \frac{data\_ADC}{10} + 25$$

Vout Op-Amp = data_ADC x 0,0196

ketika suhu 25,0°C maka:

$$Tampilan\_Layar = \frac{0}{10} + 25 = 25{,}0$$

Vout Op-Amp = 0 x 0,0196

= 0 mV

ketika suhu 40,0°C maka:

$$Tampilan\_Layar = \frac{150}{10} + 25 = 40{,}0$$

Vout Op-Amp = 150 x 0,0196

= 2940 mV

Dari hasil perhitungan diatas maka dapat dicari gain yang tepat yakni:

$$Gain = \frac{V_{out\_OP\_Amp}}{V_{in\_OP\_Amp}}$$

$$Gain = \frac{2940 - 0}{400 - 250} = 19{,}6$$

jadi untuk menentukan besarnya nilai hambatan R yang diperlukan untuk mendapatkan gain sebesar 19,6 adalah:

$$Gain = \frac{R2}{R1} + 1 = 19{,}6$$

jika nilai hambatan R1 diketahui sebesar 4K7Ω maka besar nilai hambatan R2 adalah

$$Gain = \frac{R2 + R1}{R1}$$

$$R2 = (Gain.R1) - R1 = (19{,}6x4{,}7K\Omega) - 4{,}7K\Omega = 87{,}42K\Omega$$

karena nilai hambatan sebesar 87,42 KΩ tidak ada dipasaran, maka pada perancangan ini digunakan V_R dengan nilai 100 KΩ dan nilainya diset hingga nilai hambatannya sebesar 87,42 KΩ.

Karena suhu pada perancangan ini diset pada range 25,0°C - 40,0°C, maka perlu dibuat agar pada suhu 25,0°C dalam keadaan 0 mV. Pada perancangan ini trimpot dengan nilai 10KΩ dihubungkan dengan kaki nomor tiga pada IC LM358 yang berfungsi sebagai zero, yaitu membuat tegangan pada keluaran kaki nomor 7 IC LM358 menjadi 0V ketika inputnya 250mV.

Dengan rumus:

$$Vin_{Op\text{-}Amp} = Vin\text{-}Vreff\ (Zero)$$

$$Vout_{Op\text{-}Amp} = (Vin_{Op\text{-}Amp} \cdot Gain) + Vreff\ (Zero)$$

$$Gain = \frac{R2}{R1} + 1$$

Diasumsikan Vout $_{Op\text{-}Amp}$ pada suhu 25°C adalah 0 mV maka

$$Vout_{Op\text{-}Amp} = (Vin_{Op\text{-}Amp} \cdot Gain) + Vreff\ (Zero)$$

$$Vout_{Op-Amp} = ((Vin - Zero)x\left(\frac{R2}{R1} + 1\right) + Zero$$

$$Zero = \left(\frac{Vin\left(\frac{R2}{R1} + 1\right)}{\frac{R2}{R1}}\right)$$

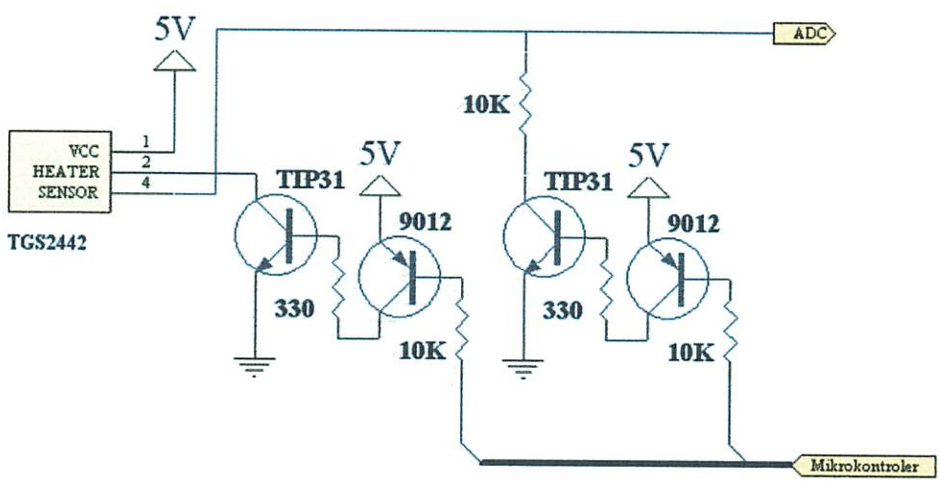
$$Zero = \left(\frac{250mV\left(\frac{87{,}42K\Omega}{4{,}7K\Omega} + 1\right)}{\frac{87{,}42K\Omega}{4{,}7K\Omega}}\right)$$

$$Zero = 263{,}44\ mV$$

Pada perancangan ini digunakan penguatan sebesar 19,6 kali dan zero sebesar 263,44mV. Untuk mendapatkan tegangan sebesar 263.44mV maka R yang digunakan adalah 59Ω untuk itu digunakan trimpot dengan besar 1KΩ dan di set hingga hambatannya sama dengan 59Ω.

3.1.5 Perancangan Sensor CO

Sensor yang digunakan pada perancangan alat ini untuk medeteksi gas karbon monoksida adalah TGS 2442. Dalam kemampuan pendeteksian gas, kondiktifitas sensor bertambah tergantung konsentrasi gas pada udara. Sebuah rangkaian listrik sederhana dapat mengkonversikan perubahan konduktivitas kedalam sebuah signal output yang sesuai dengan kosentrasi gas.



Gambar 3.4 Rangkaian Sensor CO

Pada rangkaian sensor ini digunakan 4 buah transistor, karena sensor ini membutuhkan aplikasi heating cycle selama 1 detik yang terkoneksi pada Vc. Setiap V_H cycle terdiri dari 4,8V yang diterapkan pada heater pada 14 ms pertama.diikuti oleh 0V pulse untuk sisa waktu 986 ms. Vc cycle konsisten 0V untuk 995 ms diikuti dengan 5V untuk 5 ms. Untuk hasil yang maksimal pada karakteristik sensor, sinyal sensor harus diukur setelah 5 ms Vc pulse dari 5V.

Transistor disini berfungsi untuk memanaskan heater dan untuk pembacaan sensor. Pada datasheet sensor TGS2442 dibutuhkan arus sebesar 203 mA, sedangkan arus yang dihasilkan oleh mikrokontroler ketika logika high idealnya adalah 0,5 mA, untuk itu dikuatkan terlebih dahulu.

Bila arus yang dibutuhkan oleh sensor TGS2442 adalah sebesar 203mA maka pada pembuatan alat ini arus yang disediakan adalah 450mA. Untuk itu dibutuhkan penguatan arus sebesar:

$$Ai = \frac{i_o}{i_i} = \frac{Ic}{Ib} = \frac{450mA}{0,5mA} = 900$$

Penguatan arus yang dibutuhkan untuk mengaktifkan sensor ini adalah 900 kali. Karena pada pasaran tidak didapatkan transistor dengan penguatan sekian maka untuk mendapatkan arus sekian digunakan 2 transistor.

- Untuk transistor pertama (TIP31)

  Ic = 450 mA

  Bila digunakan transistor dengan nilai hfe adalah 60 maka besarnya Ib yang mengalir pada basis adalah

  $$Ib = \frac{Ic}{hfe} = \frac{450mA}{60} = 7,5mA$$

  Maka untuk mendapatkan arus sebesar 7,5 mA pada basis maka besar hambatan yang dibutuhkan adalah:

  $$Rb = \frac{V - V_{BE}(sat)}{Ib}$$

  $$Rb = \frac{5 - 0,7}{7,5} = 0,57K\Omega \approx 0,560K\Omega$$

Karena dipasaran tidak ditemukan hambatan sebesar 570 Ω maka digunakan hambatan sebesar 560Ω. Bila digunakan hambatan sebesar 560Ω maka arus pada Ic adalah

$$Ib = \frac{V - V_{BE}(sat)}{Rb} = \frac{5 - 0,7}{0,560} = 7,6mA$$

Ic = Ib . hfe

Ic = 7,6 mA . 60

Ic = 456 mA

Dengan Ic sebesar 456 mA dan hfe sebesar 60 maka pada pembuatan digunakan transistor tipe TIP31. Transistor ini mempunyai hfe sebesar 60 dan arus maksimal pada Ic mencapai 3A sehingga dengan arus Ic = 456 mA TIP31 dianggap memenuhi syarat untuk mengaktifkan sensor.

- Untuk transistor kedua (9012)

Arus dari mikrokontroler yang merupakan arus Ib bagi transistor kedua ketika kondisi high adalah 0,5 mA. Bila hfe dari transistor yang digunakan ditentukan sebesar 60 maka besar Rb untuk transistor kedua

$$Rb = \frac{V - V_{BE}(sat)}{Ib}$$

$$Rb = \frac{5 - 0,7}{0,5} = 8,6K\Omega$$

Nilai hambatan Rb adalah 8,6KΩ ≈ 10 KΩ. dengan menggunakan hambatan dengan nilai 10KΩ maka arus Ib dari transistor adalah

$$Ib = \frac{V - V_{BE}(sat)}{Rb}$$

$$Ib = \frac{5 - 0,7}{10K\Omega} = 0,43mA$$

Sedangkan besarnya Ic adalah

Ic = Ib. hfe

Ic = 0,43 mA . 60

Ic = 25,8 mA

Dengan Ic sebesar 25,8 mA dan hfe sebesar 60 maka pada pembuatan digunakan transistor tipe 9012. Transistor ini mempunyai hfe sebesar 60 dan arus maksimal pada Ic mencapai 800 mA sehingga dengan arus Ic = 25,8 mA, transistor 9012 dianggap memenuhi syarat untuk menguatkan arus dari mikrokontroler yang selanjutnya dikuatkan lagi oleh transistor pertama (TIP31).

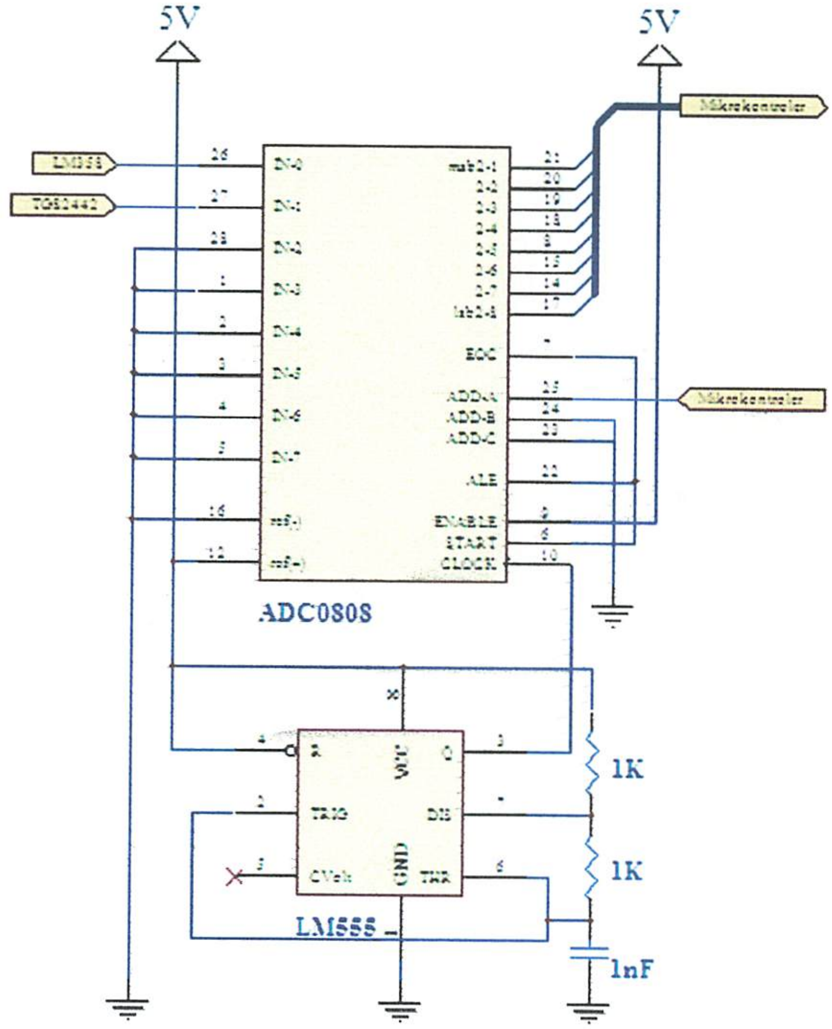
3.1.6 ADC (Analog To Digital Converter)

Dalam perancangan sistem ini juga dibutuhkan pengubah sinyal analog menjadi sinyal digital. Pengubah sinyal tersebut disebut *analog to digital converter* (ADC). Hal ini disebabkan karena sinyal-sinyal yang didapatkan dari sensor suhu dan sensor *carbon monoksida* (CO) adalah berupa sinyal analog sedangkan pada kontrollernya menggunakan sistem digital, untuk itu sebelum output ini diproses maka terlebih dahulu diubah kedalam bentuk digital yang dapat dimengerti oleh kontroller. Jenis ADC yang digunakan adalah ADC 0808 yang memiliki kelebihan yaitu dapat menerima 8 inputan. Akan tetapi pada perancangan alat ini hanya digunakan dua inputan saja, yakni dari sensor suhu dan sensor CO. untuk ADD A (pin 25) berfungsi sebagai selector bagi ADC, sedangkan ADD B (pin24) dan ADD C (pin23) juga berfungsi sebagai selector akan tetapi pada kondisi ini digroundkan karena input ADC hanya 2. Untuk lebih lengkapnya dapat dilihat pada tabel dibawah ini:

Tabel 3.1 Selektor

SELECTED ANALOG CHANNEL	ADDRESS LINE		
	C	B	A
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: datasheet ADC 0808)



Gambar 3.5 Rangkaian ADC0808

$R_1 = R_2 = 1K\Omega$

$C_1 = 1nF$

Penjelasan gambar rangkaian diatas adalah sebagai berikut:

1. IN0 (pin 26) merupakan inputan bagi ADC yang berupa sinyal analog yang merupakan *output* dari pengkondisi sinyal dari sensor suhu *LM35*. IN1 (pin 27) merupakan inputan yang berupa sinyal

analog yang berasal dari sensor CO. sedangkan untuk IN2 sampai IN7 digroundkan karena tidak digunkan.

2. D0-D7 merupakan output dari ADC dan dikirimkan ke mikrokontroler
3. ADD A digunakan untuk menerima sinyal dari mikrokontroler untuk memilih inputan mana yang akan dikonversikan oleh ADC, dari sensor suhu atau dari sensor CO.

Pada ADC 0808 tidak mempunyai *clock internal* untuk itu dibutuhkan *clock eksternal.* Dalam perancangan ini digunakan IC 555 untuk membangkitkan *clock* tersebut.

Dari gambar diatas dapat dihitung frekuensi yang dihasilkan sebagai berikut:

$$F = \frac{1}{1{,}1(Rs.C_1)}.$$

$$F = \frac{1}{1{,}1(1.10^3 + 1.10^3.10.10^{-9})}.$$

F = 45454,54 Hz

F = 45,45 KHz

Berdasarkan perhitungan diatas dapat diketahui bahwa frekuensi yang dihasilkan oleh rangkaian tersebut adalah sebesar 45,45 KHz. Jadi jika dilihat pada *datasheet* dari ADC 0808, frekuensi eksternal yang dibutuhkan oleh ADC adalah antara 10 KHz sampai dengan 280 KHz. Sehingga frekuensi yang dihasilkan oleh rangkaian pembangkit frekuensi diatas telah memenuhi syarat.

Pada ADC 0808 Vref diset pada kondisi *full range* yaitu Vref(-) dihubungkan ke ground dan Vref(+) diset pada tegangan 5 Volt. Pada saat 0 volt yaitu pada 0 dan pada saat 5 Volt pada 255.

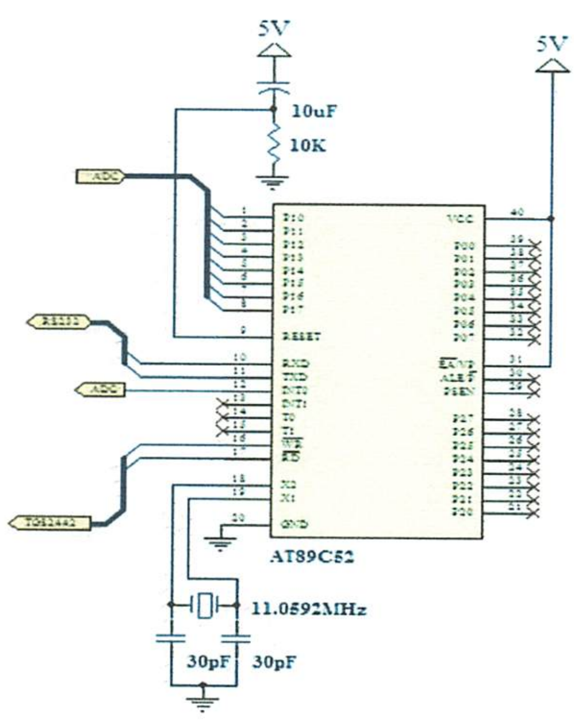
Karena Vrefnya adalah sebesar 5 Volt maka resolusinya adalah:

Resolusi per bit = Vref/255

$$= \frac{5}{2^8} = \frac{5}{255} = 0{,}0196Volt$$

3.1.7 Mikrokontroler AT89C52

Mikrokontroler AT89C52 adalah suatu IC yang terdiri dari 40 pin, dalam perancangan alat ini pin-pin yang digunakan dapat dilihat pada gambar dan dijelaskan sebagai berikut:

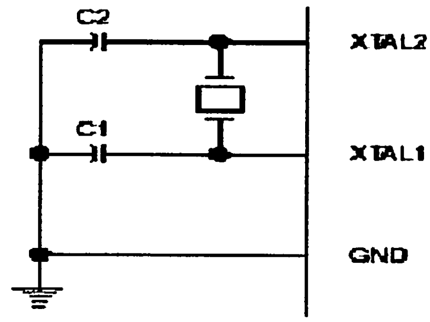


Gambar 3.6 Rangkaian Mikrokontroler AT89C52

- Untuk port 1.0 sampai port 1.7 digunakan sebagai masukan dari ADC.
- Untuk port 3.0 (RXD) dihubungkan ke TXD dari IC MAX 232
- Untuk Port 3.1 (TXD) dihubungkan ke RXD dari IC MAX 232
- Untuk Port 3.2 dan 3.3 dihubungkan ke ADC sebagai selector masukan bagi ADC.
- Untuk Port 3.6 dan 3.7 sebagai pemberi clock kepada sensor TGS2442
- Pin 9 (reset) aktif tinggi, dengan R1 bernilai 10KΩ dan kapasitor dengan kapasitas 10nF.
- Pin 20 untuk ground
- Pin 40 untuk power supply
- Pin 31 diberikan logika high karena menggunakan internal memori, dan untuk mengaktifkannya maka harus berlogika high.
- Pin 18 dan pin 19 dihubungkan ke cristal 11.059Mhz dengan kapasitor dengan kapasitas 30pF.

3.1.7.1 Osilator

Semua keluarga MCS-51 mempunyai clock (rangkaian osilator) dadalam chipnya sendiri yang disebut *on-chip* osilator. Cara mengakses clock internal yang terdapat pada chip mikrokontroler yaitu sebuah kristal pin-pin Xtal1 dan Xtal2 dengan 2 kapasitor yang dihubungkan ke ground. Dalam minimun sistem ini, menggunakan kristal 11,0592 MHz dan C1 = C2 sebesar 33 pF. Dengan rangkaian sebagai berikut :



Gambar 3.7 Rangkaian Clock

Dengan menggunakan nilai kristal diatas maka dapat dihitung waktu yang diperlukan untuk satu siklus mesin.

Diketahui : f = 11,0592 MHz

Sehingga : $T = \frac{1}{f_{kristal}}$

$T = \frac{1}{11,0592 \text{ MHz}}$

$T = 9,0422 \,.\, 10^{-8}$

3.1.7.2 Rangkaian Reset

Rangkaian reset ini diperlukan agar mikrokontroler dapat direset secara otomatis pada saat pertama kali power diaktifkan atau disebut *power on reset*. Saat catu daya dinyalakan rangkaian reset akan menahan logika tinggi pada pin RST untuk jangka waktu tertentu. Jangka waktu tersebtu ditentukan oleh pengosongan muatan pada kondensator. Dengan menggunakan nilai kristal diatas maka dapat dihitung waktu yang diperlukan untuk satu siklus mesin.

Diketahui : f = 11,0592 MHz

Sehingga : $\tau = \frac{1}{f_{kristal}}$

$$\tau = \frac{1}{11{,}0592\ \text{MHz}}$$

$$\tau = 9{,}0422 \,.\, 10^{-8}$$

Sehingga waktu reset minimal yang dibutuhkan adalah:

Reset = τ x periode yang dibutuhkan

= $9{,}0422 \,.\, 10^{-8} \times 24$

= 2,17 μs

Jika R yang digunakan adalah R dengan hambatan 10 KΩ, maka besarnya C yang digunakan adalah:

$$\tau = R \times C$$

$$C = \frac{\tau}{R}$$

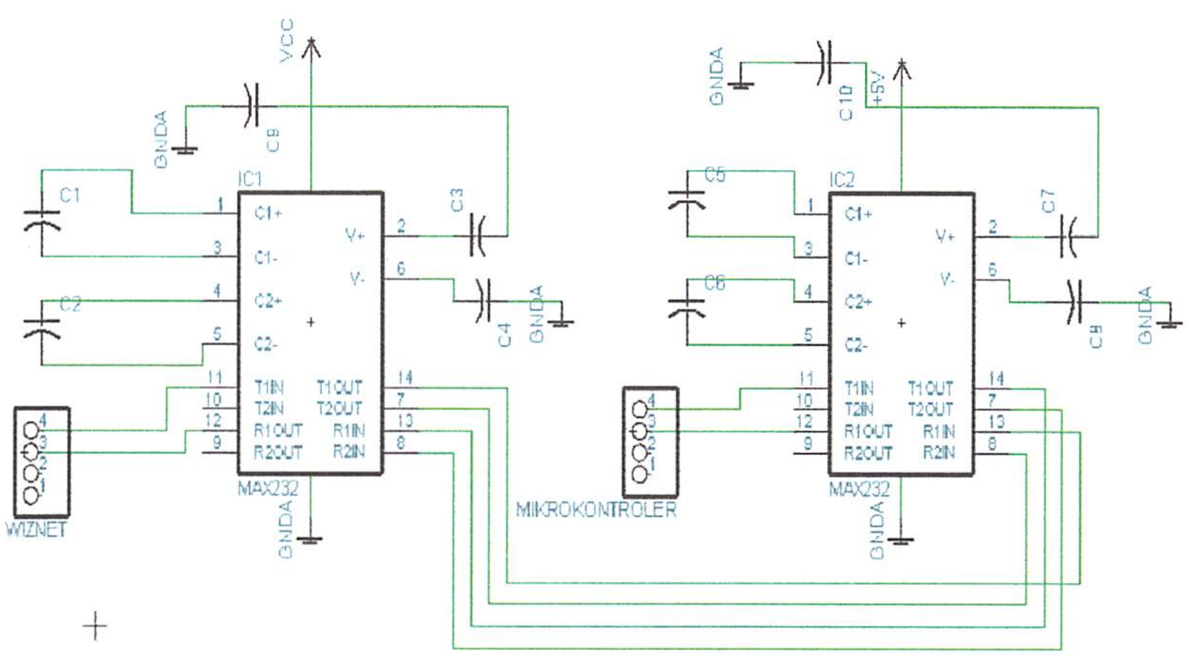
$$C = \frac{9{,}0422.10^{-8}}{10.10^{3}} = 0.90422 \times 10^{-12}$$

Jadi minimal nilai C yang digunakan yakni 0.90422×10^{-12} dan penggunaan kapasitor dengan kapasitas 10μF dianggap telah memenuhi persyaratan tersebut.

3.1.8 Antarmuka Serial RS232 dan RS3232

Agar mikrokontroler dapat berkomunikasi dengan modul WIZ610WI maka diperlukan komunikasi serial untuk itu digunakan IC MAX232 untuk TTL dan MAX3232 untuk LVTTL. Modul WIZ610WI ini mempunyai pin untuk komunikasi serial, akan tetapi bekerja pada LVTTL (Low Voltage Transistor Transistor Logic) yakni 3,3 Volt. Karena pada mikrokontroler mendukung komunikasi serial dengan tegangan 5 Volt, dengan adanya kondisi seperti ini maka dibutuhkan suatu komponen yang dapat menyamakan komunikasi diantara keduanya. Untuk itu pada sisi modul tersebut dibutuhkan IC MAX 3232 yang dapat mengkonversikan LVTTL menjadi standar EIA232, sedangkan pada sisi mikrokontroler dibutuhkan IC MAX 232 yang dapat mengkonversikan TTL menjadi standart EIA232. Apabila tegangan serial sudah sama maka komunikasi antara mikrokontroler dan modul dapat berlangsung.

Dalam pembuatan rangkaian IC MAX 232 memerlukan beberapa kapasitor. Disini digunakan kapasitor sebesar 0,1 μF dengan tegangan 16 Volt pada beberapa pin. IC ini memerlukan input sebesar 5 Volt.



Gambar 3.8 Rangkaian Pengubah Level Tegangan R232 dan RS3232

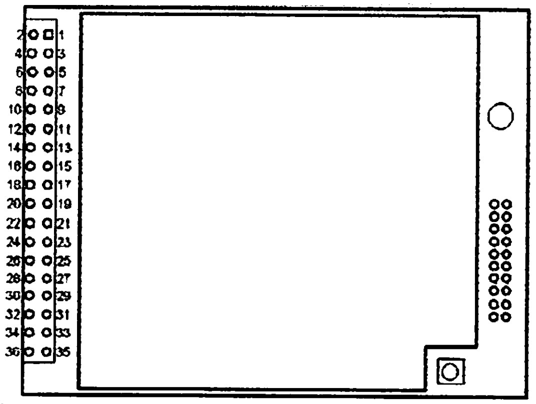
Pada rangkaian diatas semua kapasitor mempunyai kapasitas yang sama dan tegangan yang sama, yakni sebesar 0,1 μF dengan tegangan 16 Volt. Pada IC MAX 232 power supply yang dibutuhkan sebesar 5 Volt, sedangkan untuk IC MAX 3232 power supply yang dibutuhkan yakni sebesar 3,3 Volt.

3.1.9 Modul Serial To Wi-Fi WIZ610WI

Agar mikrokontroler dapat berkomunikasi dengan komputer lain dengan menggunkan wi-fi maka diperlukan suatu interface yang dapat mendukung komunikasi tersebut. Pada perancangan alat ini digunakan suatu modul yang mendukung komunikasi tersebut yakni WIZ610WI yang diproduksi oleh Wiznet. Modul ini mempunyai pin yang mendukung komunikasi serial dengan level tegangan LVTTL (Low Voltage TTL) yaitu sebesar 3,3 Volt.

1. Penggunaan Pin-Pin pada Modul WIZ610WI

Pada gambar 3.9 menunjukkan pin-pin modul WIZ610WI, namun pada perancangan sistem ini hanya menggunakan beberapa pin saja.



Gambar 3.9 Pin pada Modul WIZ610WI
(Sumber: datasheet WIZ610wi)

- Pin 9/10, VCC (3,3,Volt)

  Modul ini dioperasikan dengan menggunakan power supply +3,3 Volt dan pin VCC berada pada pin 9 dan pin 10.

- Pin 7, TXD

  Untuk pengiriman data pada modul ini terletak pada pin 7 TXD (transmitter), atau dengan kata lain merupakan output dari modul ini.

- Pin 8, RXD

  Untuk penerimaan data pada modul ini digunakan pin 8 sebagai RXD, atau dengan kata lain merupakan input dari modul ini.

- Pin 11/12, GND

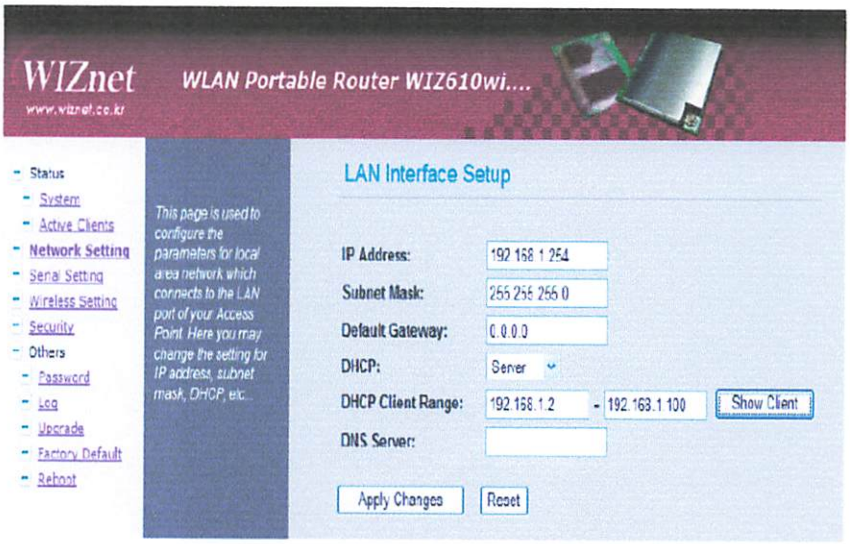
  Untuk ground pada modul ini pin yang digunakan adalah pada pin 11 dan 12. Ground juga pada pin 19, 20, 27, 28 dan pin 35.

- Pin 4

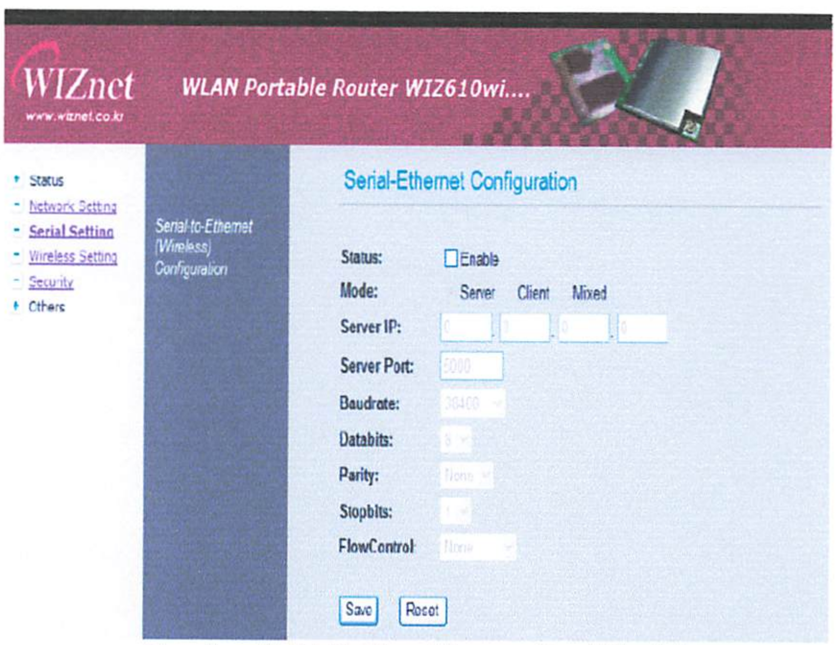
  Pin 4 ini diberi logika high (3,3V) dimaksudkan agar *serial command* dari modul WIZ610wi dinon-aktifkan.

2. Konfigurasi pada Modul WIZ610WI

Untuk setting port, baudrate dan IP yang digunakan oleh WIZ610WI dapat dilakukan dengan mengakses modul ini melalui *web brower* dengan alamat defaultnya 192.168.1.254. pastikan komputer yang digunakan untuk mengakses WIZ610wi berada pada satu kelas dengan alamat default dari modul tersebut. Berikut ini adalah tampilan untuk settingan untuk mendukung komunikasi modul dengan mikrokontroler dan jaringan komputer. Pada aplikasi ini IP yang digunakan adalah 192.168.1.254. subnetmask adalah 255.255.255.0. menggunnakan DHCP server, dan DNS tidak diaktifkan.

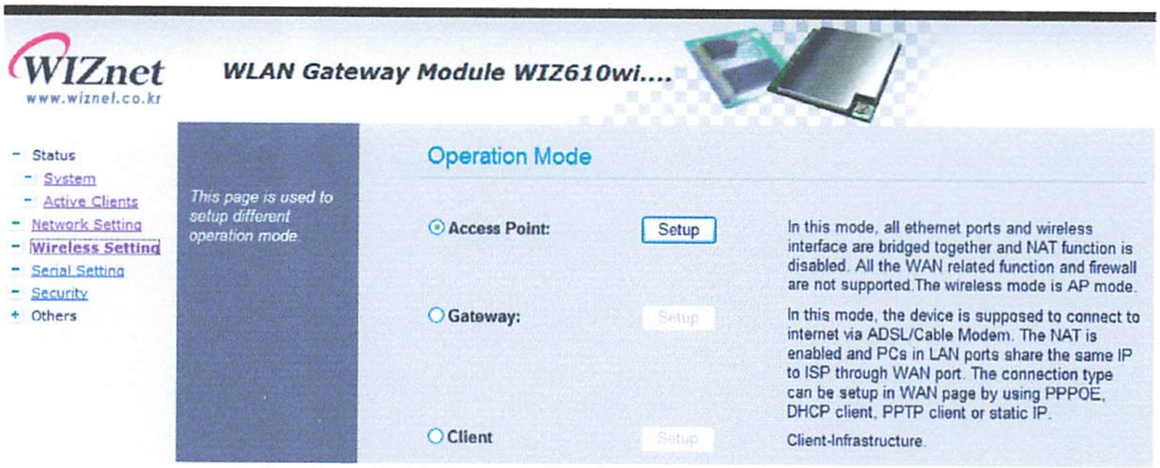


Gambar 3.10 Setting IP dan DHCP



Gambar 3.11 Setting Komunikasi Serial

Karena pada perancangan sistem ini menggunakan software untuk mengaksesnya maka port yang digunakan adalah port 5000. Sedangkan baudratenya disesuaikan dengan mikrokontroler yang mempunyai baudrate sebesar 9600 bps. Databits 8, Parity none dan Flow Controlnya none. Mode yang digunakan adalah mode server dan protocol yang digunakan adalah TCP/IP.



Gambar 3.12 Setting Mode yang Digunakan

3.2 Perancangan Perangkat Lunak (Software)

3.2.1 Perancangan Perangkat Lunak pada Mikrokoontroler

Untuk pemakaian mikrokontroler didalam suatu sistem, perlu direncanakan perangkat lunak mikrokontroler yang dapat mengatur sistem tersebut. Perangkat lunak disini adalah perintah-perintah didalam memori mikrokontroler yang harus dilakukan oleh mikrokontroler.

Didalam suatu mikrokontroler memori merupakan suatu fasilitas utama, karena disinilah disimpan perintah-perintah yang harus dikerjakan oleh mikrokontroler. Perancangan perangkat lunak didasarkan sesuai dengan perancangan perangkat keras yang dibuat sebelumnya. Karena *baudrate* yang digunakan disini yakni 9600bps dan menggunakan kristal dengan frekuensi 11.0592MHz, maka sebelum memulai pembuatan program maka terlebih dahulu kita menentukan nilai dari TH1.

Baudrate = 9600 bps

Frekuensi = 11.0592MHz

Mode yang digunakan yakni SMOD 0

$$Baudrate = \frac{2^{SMOD}}{32} x \frac{Frekuensi\_osc}{12([256] - [TH1])}$$

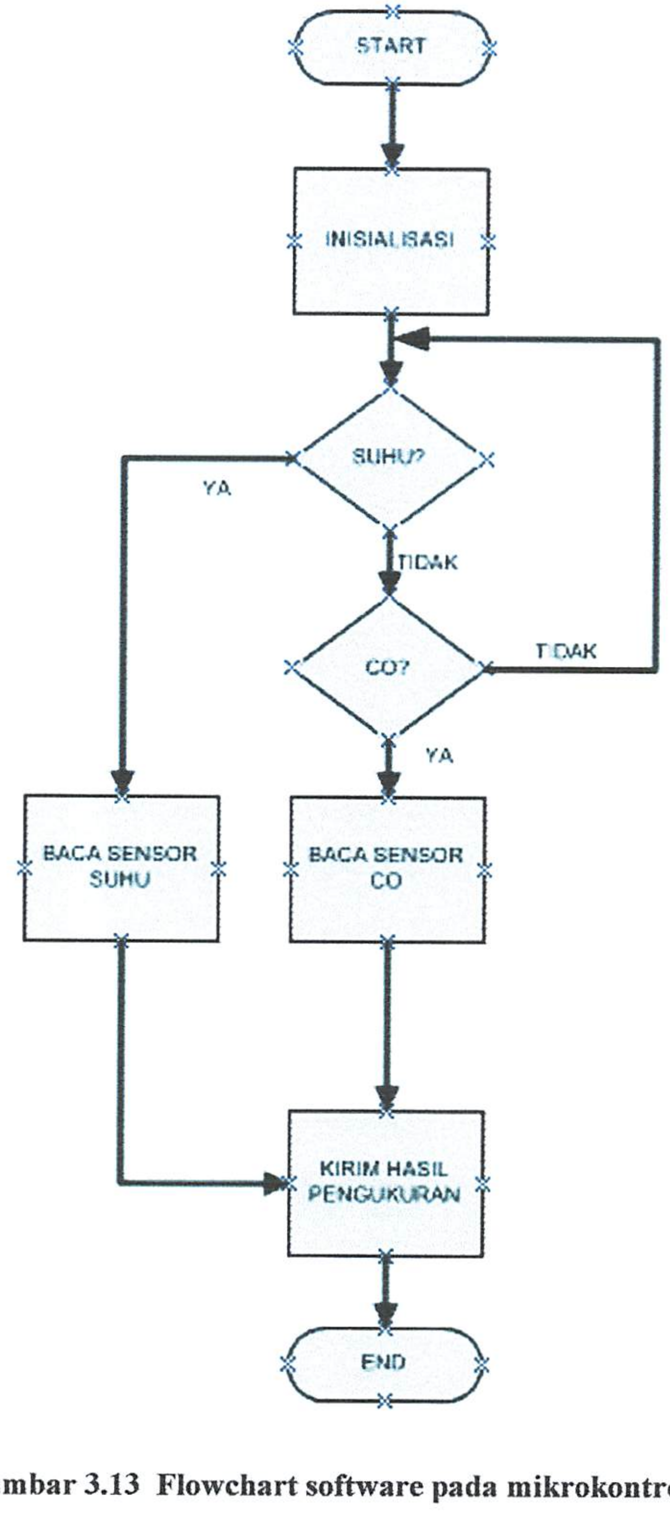
$$256 - TH1 = \frac{2^{1}}{32} x \frac{11.0592.10^{6}}{12(9600)}$$

$$256 - TH1 = 6$$

$$TH1 = 256 - 6 = 250_{D}$$

$$TH1 = FA_{H}$$

Berikut ini adalah flowchart dari perangkat lunak yang ditanamkan pada mikrokontroler.



Gambar 3.13 Flowchart software pada mikrokontroler

Berikut adalah penjelasan dari program pada mikrokontroler:

- Inisialisasi serial

```
mov     TMOD,#20h    ;
mov     TH1,#0FDh    ;// baudrate 9600
mov     SCON,#50h    ;
setb    TR1          ;
setb    ES           ;
setb    EA           ;
ret                  ;
```

- Pengukuran

  - Sensor suhu

```
clr     Slc0          ;\
clr     Slc1          ; | select address ADC ch-
0
mov     Dly1,#3       ; |
lcall   delay1        ; |
mov     Dsn0,P1       ; |
mov     A,Dsn0        ; |
mov     B,#10         ; |
div     AB            ; |
mov     Ds01,B        ; | kalibrasi suhu
mov     B,#25         ; |
add     A,B           ; |
mov     Ds00,A        ; |
ret                   ;/
```

  - Sensor CO

```
setb    Slc0          ; select address ADC ch-1
clr     Slc1          ;
mov     Dly1,#3       ;\ wait
lcall   delay1        ;/ 2.5ms
clr     Cosn          ; nyalakan sensor
mov     Dly1,#3       ;\ wait
lcall   delay1        ;/ 2.5ms
mov     Dsn1,P1       ; baca sensor (adc)
mov     Dly1,#3       ;\ wait
lcall   delay1        ;/ 2.5ms
setb    Cosn          ; matikan sensor ;
clr     Coht          ; nyalakan heater
mov     Dly1,#3       ;\ wait
lcall   delay1        ;/ 14ms
setb    Coht          ; matikan heater
```

- Pembacaan perintah dan pengiriman hasil pengukuran pada serial

a. Suhu

```
cjne    R7,#'S',bccmd0 // apakah R7 sama dengan S
lcall   bc_srl
cjne    R7,#'U',bccmd0 // apakah R7 sama dengan U
lcall   bc_srl
cjne    R7,#'H',bccmd0 // apakah R7 sama dengan H
lcall   bc_srl
cjne    R7,#'U',bccmd0 // apakah R7 sama dengan U
mov     A,Ds00              ;
mov     B,#10               ;
div     AB                  ;
mov     B,#30h              ;
add     A,B                 ;
lcall   kr_srl              ;
mov     A,Ds00              ;
mov     B,#10               ;
div     AB                  ;
mov     A,B                 ;
mov     B,#30h              ;
add     A,B                 ;
lcall   kr_srl              ;
mov     A,#'.'              ;
lcall   kr_srl              ;
mov     A,Ds01              ;
mov     B,#30h              ;
add     A,B                 ;
lcall   kr_srl              ;
mov     A,#0Dh              ;
lcall   kr_srl              ;
```

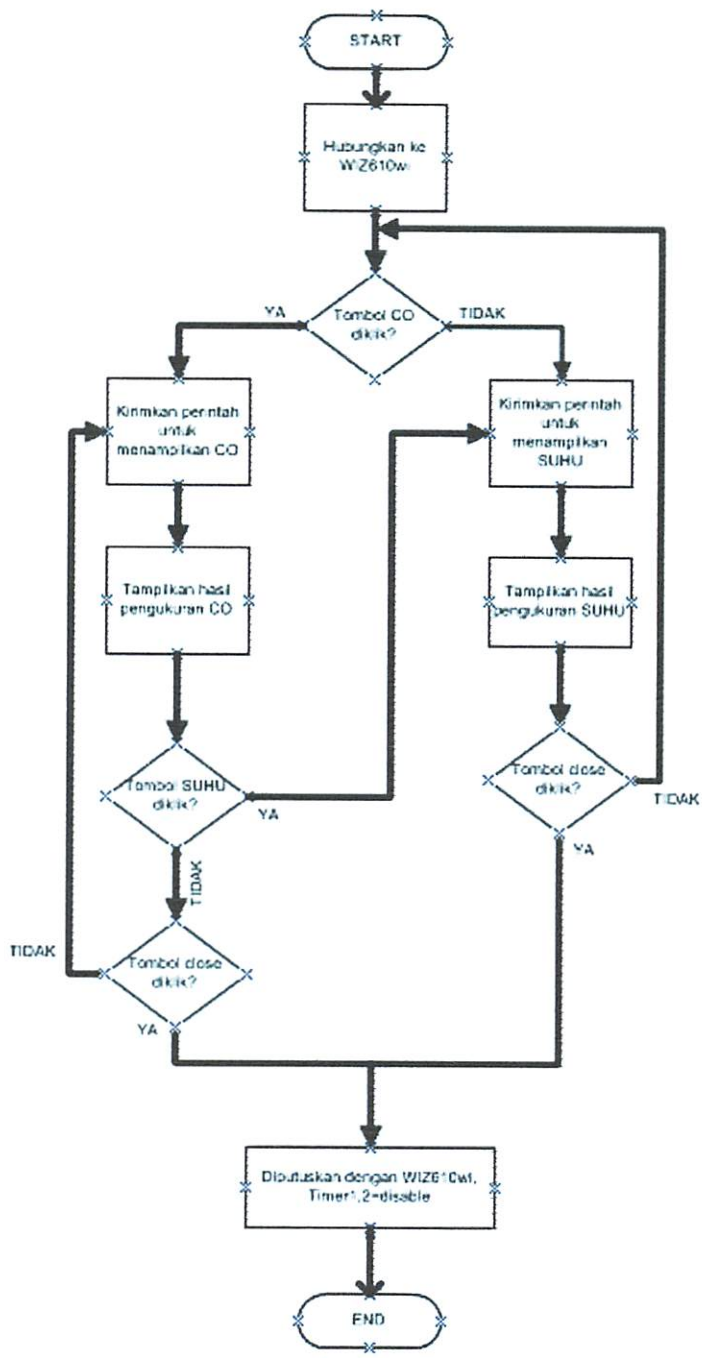
b. CO

```
cjne    R7,#'C',bccmd1 // apakah R7 sama dengan C
lcall   bc_srl
cjne    R7,#'O',bccmd1 // apakah R7 sama dengan O
lcall   bc_srl
cjne    R7,#'C',bccmd1 // apakah R7 sama dengan C
lcall   bc_srl
cjne    R7,#'O',bccmd1 // apakah R7 sama dengan O
mov     A,R3                ;
mov     B,#30h              ;
add     A,B                 ;
lcall   kr_srl              ;
mov     A,R2                ;
mov     B,#30h              ;
```

```
add     A,B         ;
lcall   kr_srl      ;
mov     A,R1        ;
mov     B,#30h      ;
add     A,B         ;
lcall   kr_srl      ;
mov     A,R0        ;
mov     B,#30h      ;
add     A,B         ;
lcall   kr_srl      ;
mov     A,#0Dh      ;
lcall   kr_srl      ;
```

3.2.2 Perancangan Perangkat Lunak pada Komputer

Pembuatan perangkat lunak yang ditanamkan pada komputer, dimaksudkan agar lebih mempermudah pengguna dalam mengakses alat ini. Pada pembuatan perangkat lunak digunakan DELPHI 7. Berikut flowchart dari software yang ditanamkan ke komputer.



Gambar 3.14 Flowchart software pada komputer

Adapun komponen-komponen yang digunakan yakni:

- Edit

  Edit pada sistem ini berfungsi untuk menampilkan hasil pengukuran yang dikirimkan oleh mikrokontroler.

- Label

  Label disini berfungsi untuk memberikan keterangan-keterangan pada program

- Button

  a. Tombol untuk mengaktifkan timer2

```
procedure TForm1.Button4Click(Sender: TObject);
begin
label6.Caption:='CO';
label7.Caption:='Persen';
timer1.Enabled:=false;
timer2.Enabled:=true;
end;
```

  b. Tombol untuk mengaktifkan timer1

```
procedure TForm1.Button3Click(Sender: TObject);
begin
label6.Caption:='SUHU';
label7.Caption:='Derajat Celcius';
timer2.Enabled:=false;
timer1.Enabled:=true;
end;
```

- Clientsocket

  Pada clientsocket alamat IP yang diberikan adalah alamat IP dari modul wiznet, yang pada sistem ini alamat IP WIZ610wi adalah 192.168.1.254 dengan port 5000. Alamat IP dan port ini disesuaikan dengan pengaturan sebelumnya pada WIZ610wi.

```
procedure          TForm1.ClientSocket1Read(Sender:
TObject;
Socket: TCustomWinSocket);
begin
Edit1.text:= socket.ReceiveText;
end;
```

fungsi dari program diatas adalah untuk membaca hasil pengukuran yang dikirimkan oleh modul WIZ610wi yang diletakkan pada edit1.

```
Procedure TForm1.ClientSocket1Connect(Sender: TObject;
Socket: TCustomWinSocket);
begin
Label5.Caption:='Connected With WIZ610wi';
end;

procedure          TForm1.ClientSocket1Disconnect(Sender:
TObject;
Socket: TCustomWinSocket);
begin
label5.Caption:='Disconected With WIZ610wi';
end;
```

fungis program ini adalah memberikan informasi bahwa apakah komputer sudah terkoneksi ke alat tersebut ataukah belum.

- Timer

Timer pada sistem ini digunakan untuk melakukan pengiriman *request* ke mikrokontroler secara terus menerus.

a. Timer1

```
procedure TForm1.Timer1Timer(Sender: TObject);
begin
ClientSocket1.Active := True ;
clientsocket1.Socket.SendText('SUHU');
end;
```

fungsi dari program ini yakni untuk mengirimkan perintah pengukuran suhu dengan perintah 'SUHU'. Program ini akan berjalan terus menerus mengirimkan perintah tersebut selama timer ini aktif.

b. Timer2

```
procedure TForm1.Timer2Timer(Sender: TObject);
begin
clientsocket1.Active:=true;
clientsocket1.Socket.SendText('COCO');
end;
```

fungsi dari program ini yakni untuk mengirimkan perintah pengukuran CO dengan perintah 'COCO'. Program ini akan berjalan terus menerus mengirimkan perintah tersebut selama timer ini aktif.

BAB IV

PENGUJIAN ALAT

4.1. Tujuan

Bab ini akan membahas tentang pengujian alat yang telah dirancang. Adapun tujuan dari pengujian ini adalah untuk mengetahui apakah *hardware* dan *software* dapat bekerja sesuai dengan kondisi yang diinginkan, maka dilakukan pengujian pada alat dan sistem kerja alat, yang mana prosedur pengujian meliputi:

1. Pengujian *Hardware.*
2. Pengujian *Software.*
3. Pengujian sistem secara keseluruhan.

Selain melakukan pengujian dan percobaan pada alat, maka terlebih dahulu dilakukan kalibrasi sensor temperatur dengan menggunakan termometer dan kalibrasi kadar karbon dengan alat pengukur kadar karbon yang telah ada. Kalibrasi ini bertujuan untuk memeriksa apakah pengukuran yang telah ada sama dengan hasil yang ditampilkan oleh alat.

4.2. Pengujian Perangkat Keras *(Hardware).*

Dalam pengujian alat dibagi dalam beberapa sub sistem dari instrumen dan peralatan, diantaranya adalah :

1. Sensor suhu LM35
2. Sensor TGS 2442 (sensor CO)
3. Pengkondisi sinyal

4. Pengujian ADC
5. Pengujian Rangkaian Pengubah Level Tegangan
6. Pengujian Modul WIZ610wi
7. Pengujian Keseluruhan Alat

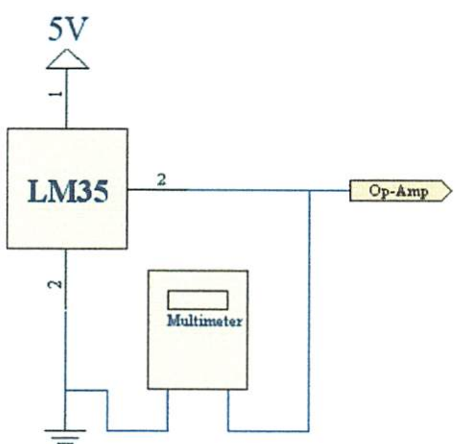
Pengujian perangkat keras ini mencakup pengujian rangkaian elektronika pada masing-masing blok maupun blok secara keseluruhan.

4.3 Pengujian Sensor Suhu (LM35)

Pengujian rangkaian sensor dimaksudkan untuk mengetahui apakah sensor LM35 dapat bekerja dengan baik dalam menentukan atau mengukur suhu. Dan untuk mengetahui berapa tegangan output dari sensor suhu pada setiap pengukuran suhu.

Pengukuran pada sensor LM35 :

1. Rangkai sensor seperti gambar :



Gambar 4.1 Pengukuran Rangkaian Sensor

2. Mengaktifkan catu daya
3. Mengukur Vout dari LM35

Dalam pengujian rangkaian sensor ini dilakukan untuk mengetahui berapa tegangan output dari sensor suhu pada setiap perubahan suhu. Pengujian dan pengukuran rangkaian sensor dilakukan berdasarkan blok diagram diatas. Untuk kalibrasi sensor LM35 dengan menggunakan termometer yang sudah ada yaitu termometer digital .

Untuk mencari kemungkinan kesalahan relative dapat dicari dengan rumus sebagai berikut:

$$\Delta t = |Vout\_Op\text{-}Amp(pengukuran) - Vout\_Op\text{-}Amp(perhitungan)|$$

$$\Delta\% = \left|\frac{Vout\_Op - Amp(pengukuran) - Vout\_Op - Amp(perhitungan)|}{Vout\_Op - Amp(perhitungan)}\right| x100\%$$

$$Kesalahan\_rata - rata = \left|\frac{\Sigma\Delta\%}{\Sigma \text{Pengukuran}}\right|$$

Diambil suatu sampel, suhu ruangan adalah 25,0°C. Jadi pada suhu 25,0°C Vout sensor adalah 25,0 X 10mV = 0,250 Volt. Untuk mengetahui berapa tegangan output yang dihasilkan maka kita dapat mengukurnya pada pin nomor 2 dari LM35.

Vout = Temp x 10mV/°C

= 25,0x 10 mV/°C = 250mV

$$\Delta t = |Vout\_Op\text{-}Amp(pengukuran) - Vout\_Op\text{-}Amp(perhitungan)|$$

$$\Delta t = |0{,}252 - 0{,}250| = 0{,}003$$

$$\Delta\% = \left|\frac{\Delta t}{Vout\_Op - Amp(perhitungan)}\right| x100\%$$

$$\Delta\% = \left|\frac{0,003}{0,252}\right| x100\%$$

$$\Delta\% = 0,2\%$$

Dengan cara yang sama, nilai kesalahan relative dapat dilihat pada tabel 4.1 sebagai berikut:

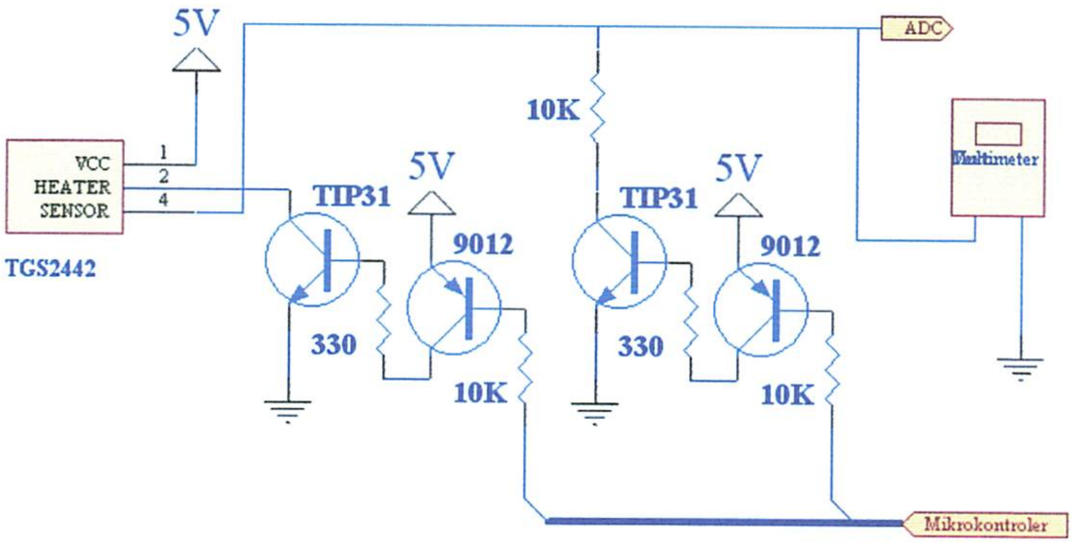
Tabel 4.1
Hasil Pengukuran dan Pengujian Rangkaian Sensor Suhu

NO.	Temperatur (°C)	Vout Sensor Suhu (Volt)		Δt	Δ%
		Perhitungan	Pengukuran		
1	25,0	0,250	0,252	0.002	0,2
2	25,6	0,256	0,258	0,002	0,78
3	26,5	0,265	0,262	0,003	1,13
4	27,0	0,270	0,272	0,002	0,74
5	27,5	0,275	0,278	0,003	1,09
6	28,5	0,285	0,282	0,003	1,05
7	29,6	0,296	0,293	0,003	1,01
Kesalahan rata-rata				0,85%	

(Sumber: pengujian)

4.4. Pengujian Sensor CO

Pada pengujian sensor CO dilakukan dengan cara mendekatkan sensor dengan kenalpot kendaraan dalam keadaan mesin hidup. Untuk proses pengkalibrasian dilakukan dengan menyamakan hasil pengujian antara alat yang dibuat dengan alat uji emisi. Setelah proses pengkalibrasian selesai antara kedua alat tersebut dibandingkan apakah sesuai atau ada selisih antara kedua alat tersebut. Berikut ini adalah gambar untuk pengujian pada output sensor CO TGS2442.



Gambar 4.2 Pengukuran Output Sensor CO TGS2442

Pada alat penguji emisi satuan yang digunakan adalah %CO dalam udara sedangkan alat yang dibuat satuannya adalah ppm, oleh sebab itu hasil pengukuran alat uji emisi harus dikonversi ke satuan ppm sehingga dapat diketahui besarnya error yang terjadi.

1 %CO = 10.000 ppm

Sebagai contoh:

0,015%CO = 150 ppm

Untuk mencari kemungkinan kesalahan relative dapat dicari dengan rumus sebagai berikut:

$$\Delta t = |\text{Vout\_Op-Amp(pengukuran)} - \text{Vout\_Op-Amp(perhitungan)}|$$

$$\Delta\% = \left| \frac{|\text{Vout\_Op - Amp(pengukuran) - Vout\_Op - Amp(perhitungan)}|}{\text{Vout\_Op - Amp(perhitungan)}} \right| x100\%$$

$$Kesalahan\_rata-rata = \left| \frac{\sum \Delta\%}{\sum \text{Pengukuran}} \right|$$

Tabel 4.2
Pembacaan Alat Ukur CO dengan Display pada software

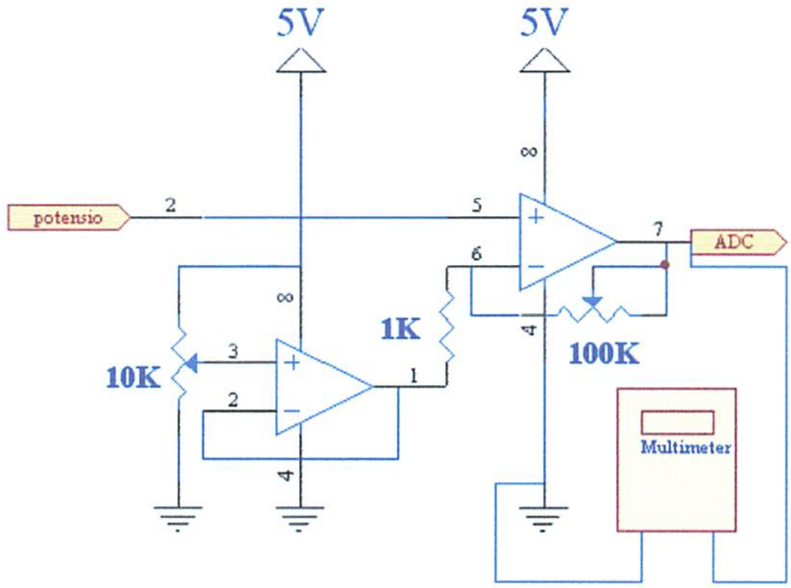
Pembacaan (ppm)		Δt	Δ%
Alat Uji Emisi	Display		
90	97	7	7,7
110	118	8	7,2
150	161	12	8,0
200	215	15	7,5
250	264	14	5,6
270	289	19	7,03
315	342	27	8,5
Kesalahan rata-rata			7,36%

(Sumber: pengujian)

4.5 Pengujian Untuk mencari Kesalahan Rata-rata Vout Op-Amp

Pada pengujian ini untuk mencari kesalahan Vout Op-Amp. Pengujian rangkaian ini dimaksudkan untuk mengetahui berapa tegangan output dari pengkondisi sinyal pada setiap perubahan suhu. Akan tetapi pada pengujian kali ini digunakan potensiometer untuk mengubah-ubah inputan dari pengkondisi sinyal ini.

1. Menyusun rangkaian seperti pada gambar :



Gambar 4.3 Pengukuran op-amp

2. Mengaktifkan catu daya
3. Mengukur Vout pada rangkaian pengkondisi sinyal

Untuk mengetahui berapa tegangan output yang dihasilkan maka kita dapat mengukurnya pada pin nomor 3 dari pengkondisi sinyal. Perhitungan untuk pengkondisi sinyal ini dapat dilakukan sebagai berikut:

- Perubahan tegangan keluaran pada sensor suhu LM35 diasumsikan linear dengan perubahan tegangan tiap kenaikan 1°C adalah 10mV
- Pengutan pada penguatan instrumentasi adalah19,6 kali dan zero sebesar 263,44mV.

$$Vout_{Op-Amp} = ((Vin - Zero)x\left(\frac{R2}{R1} + 1\right) + Zero$$

Dari penghitungan pada saat Vin = 252 mV

$$Vout = 252\ mV - 263{,}44mV\ (\frac{87{,}42}{4{,}7} + 1) + 263{,}44\ mV$$

$$= 252\ mV - 263{,}44\ mV\ (\ 19{,}6\ ) + 263{,}44\ mV$$

$$= (-224{,}224) + 263{,}44\ mV$$

$$= 39{,}216\ mV$$

sehingga untuk setiap kenaikan dapat dihitung sebagai berikut:

$$\Delta t = |Vout\_Op\text{-}Amp(pengukuran)\text{-}Vout\_Op\text{-}Amp(perhitungan)|$$

$$\Delta\% = \left|\frac{|Vout\_Op - Amp(pengukuran) - Vout\_Op - Amp(perhitungan)|}{Vout\_Op - Amp(perhitungan)}\right| x100\%$$

$$Kesalahan\_rata - rata = \left|\frac{\sum \Delta\%\,|}{\sum Pengukuran}\right|$$

Dari hasil pengujian dan pengukuran pada rangkaian amplifier tersebut dapat dilihat berdasarkan tabel dibawah ini:

Tabel 4.3
Perbandingan Vout Op-Amp Perhitungan dengan Vout Op-Amp Pengukuran

NO.	Input (mVolt)	Vout Op-Amp (mVolt)		Δt	Δ%
		Perhitungan	Pengukuran		
1	252	39,216	40	0,784	1,99
2	258	156,816	159	2,184	1,39
3	262	235,216	232	4,216	1,79
4	272	431,216	434	2,784	0,64
5	278	548,816	555	6,184	1.12
6	282	627,216	633	5,784	0,92
7	293	842,816	850	7,184	0,85
Kesalahan rata-rata				1,24%	

(Sumber: pengujian)

4.6 Pengujian ADC

Pengujian terhadap ADC 0808 ini dapat dilakukan dengan menggunakan LED. Input pengujian ADC dibuat dari pencatu daya DC dengan tegangan 0-5 Volt, kemudian potensiometer kita putar perlahan-lahan, kita sesuaikan nilainya pada tegangan tertentu. LED sebagai indikator output dari ADC akan menyala sesuai dengan numeric dari 0 sampai dengan 255 dalam desimal. Pada ADC ini diset pada full range oleh sebab itu resolusinya perbitnya adalah:

$$\text{Resolusi 1 bit} = \frac{Vref}{2^8 - 1}$$

$$= \frac{5.00}{255}$$

$$= 19,6 \text{ mV/step}$$

Untuk perhitungan pada tegangan 0,555V maka inputan tegangan yang dihasilkan oleh ADC adalah

$$\text{output ADC} = \frac{Vin}{\mathrm{Re}\,solusi}$$

$$= \frac{555mV}{19{,}6}$$

$$= 28{,}3 \approx 28 \text{ desimal}$$

Untuk hasil perhitungan dan pengukuran (pembacaan) ADC0808 adalah sebagai berikut:

Tabel 4.4
Hasil Pengujian ADC 0808 dengan Inputan dari LM358

Tegangan (Volt)	Output LED	Nilai Desimal
0,40	00000010	2
0,159	00001000	8
0,232	00001100	12
0,434	00010110	22
0,555	00011100	28
0,633	00100000	32
0,850	00101011	43

(Sumber : pengujian)

Tabel 4.5
Hasil Pengujian ADC 0808 dengan TGS 2442

Tegangan (Volt)	Output LED	Nilai Desimal
1,176	00111100	60
1,96	01100100	100
2.94	10010110	230
3,92	11001000	200
5	11111111	255

(Sumber : pengujian)

4.7 Pengujian Rangkaian Pengubah Level Tegangan

4.7.1 RS232 (TTL to EIA232)

Rangkaian ini berfungsi untuk mengubah level tegangan TTL ke level tegangan EIA232. Pada teori, output dari MAX232 adalah berupa tegangan standar EIA232, dimana ketika input dari MAX232 berlogika high atau 5V maka outputnya antara -3V sampai 15V dan apabila berlogika low atau 0V maka outputnya antara 3V sampai 15V.

Pengujian disini akan dilakukan dengan cara memberikan logika high dengan cara menyambungkan TXD (pin 14) dengan Vcc kemudian mengukur outputnya pada pin 7. Selanjutnya pin 14 diberi logika low dengan menyambungkan pin 14 ke ground lalu mengukur outputnya pada pin 7. Pengukuran ini menggunakan multitester. Pengujian ini bertujuan untuk mengecek apakah rangkaian pengubah level tegangan dari 5V ke EIA232 sudah sesuai dengan datasheet MAX232.

Tabel 4.6
Hasil Pengukuran Output MAX232

	MAX232		OUTPUT
INPUT	LOW	0,24 Volt	8,45 Volt
	HIGH	4,74 Volt	-8.45 Volt

(Sumber: pengujian)

4.7.2 RS3232 (EIA232 to LVTTL)

Rangkaian ini berfungsi untuk mengubah level tegangan EIA232 ke level tegangan LVTTL. Pada teori, output dari MAX3232 adalah berupa tegangan standar EIA232, dimana ketika input dari MAX3232 berlogika high atau 3,3V maka outputnya antara -3V sampai 15V dan apabila berlogika low atau 0V maka outputnya antara 3V sampai 15V.

Pengujian disini pada prinsipnya sama dengan yang dilakukan dengan pengujian RS232 yaitu dengan cara memberikan logika high dengan cara menyambungkan TXD (pin 14) dengan Vcc kemudian mengukur outputnya pada pin 7. Selanjutnya pin 14 diberi logika low dengan menyambungkan pin 14 ke ground lalu mengukur outputnya pada pin 7. Pengukuran ini menggunakan multitester. Pengujian ini bertujuan untuk mengecek apakah rangkaian pengubah level tegangan dari 3,3V ke EIA232 sudah sesuai dengan datasheet MAX3232.

Tabel 4.7
Hasil Pengukuran Output MAX3232

	MAX3232		OUTPUT
INPUT	LOW	0,24 Volt	7,40 Volt
	HIGH	3,26 Volt	-7,40 Volt

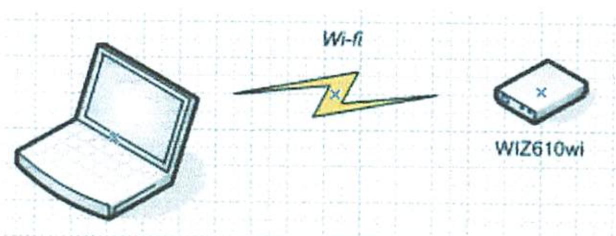
***(Sumber:** pengujian)*

4.8 Pengujian Modul WIZ610wi

Pengujian modul wi-fi WIZ610wi ini dapat didasarkan pada 2 pengujian yaitu:

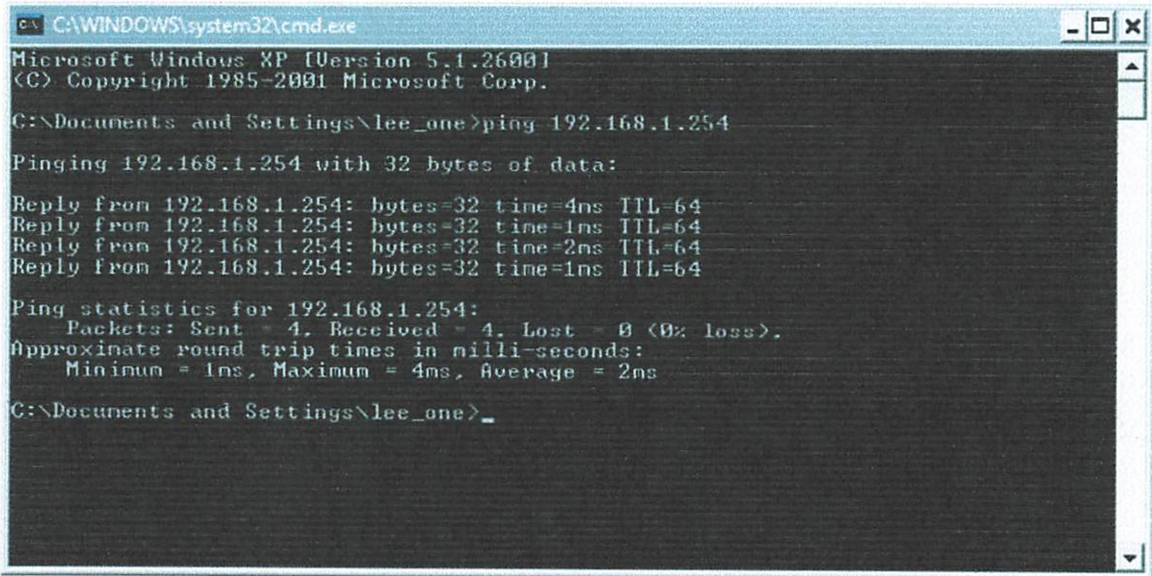
4.8.1 Pengujian TCP/IP (ping 192.168.1.254)

Pengujian ini bertujuan untuk mengetahui apakah modul wi-fi WIZ610wi ini sudah tersambung dengan jaringan komputer ataukah belum.



Gambar 4.4 Konfigurasi untuk Ping ke Modul WIZ610wi

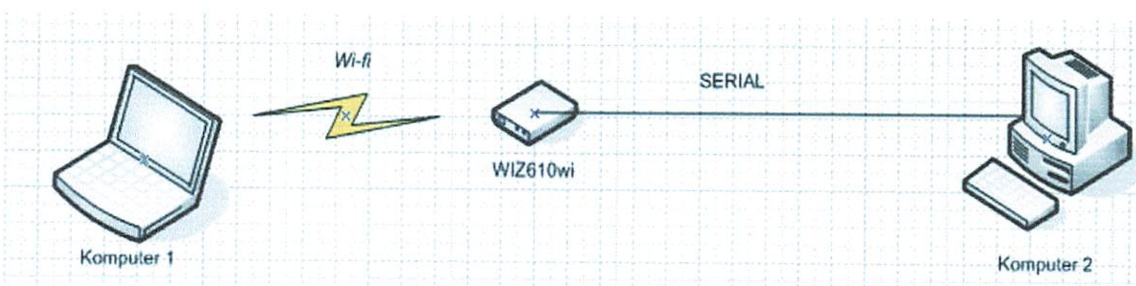
Pengujian ini dilakukan dengan cara melakukan ping 192.168.1.254 yang merupakan alamat IP dari modul wi-fi WIZ610wi. Pada gambar 4.4 terlihat bahwa ada respon dari modul wi-fi WIZ610wi dengan menunjukkan *reply from 192.168.1.254.*



Gambar 4.5 Hasil Ping ke Alamat 192.168.1.254 (Modul WIZ610wi)

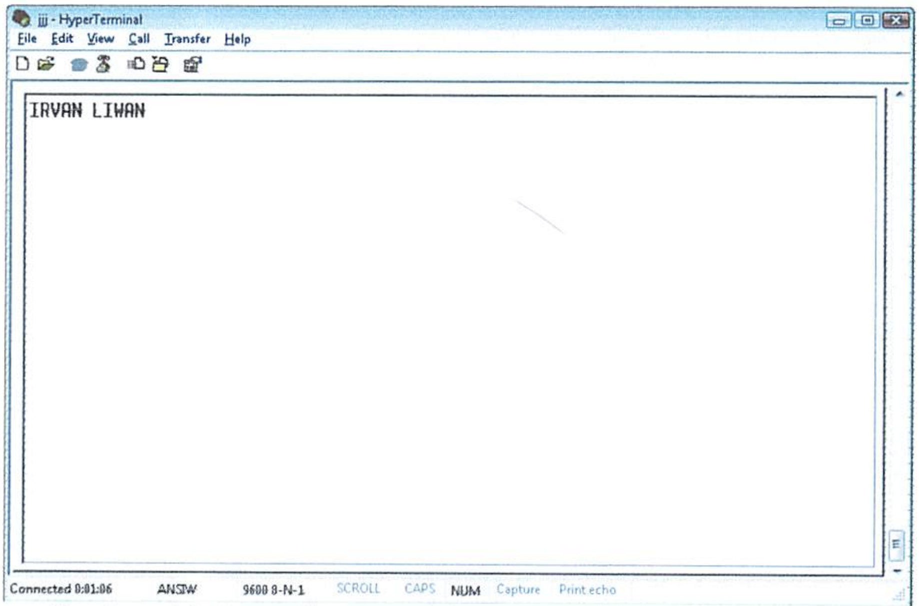
4.8.2 Pengujian Pengiriman Data dari dan ke Modul WIZ610wi

Pengujian dilakukan dengan cara membuka *Hyperterminal* pada komputer 1 lalu memilih komunikasi TCP/IP kemudian menuliskan alamat 192.168.1.254 dan port 5000. Sedangkan pada komputer 2 juga dilakukan dengan membuka *Hyperterminal* akan tetapi digunakan komunikasi serial (*baudrate 9600, COM1*). Data yang dikirim berupa karakter yang diketik pada komputer 1 maupun pada komputer 2.

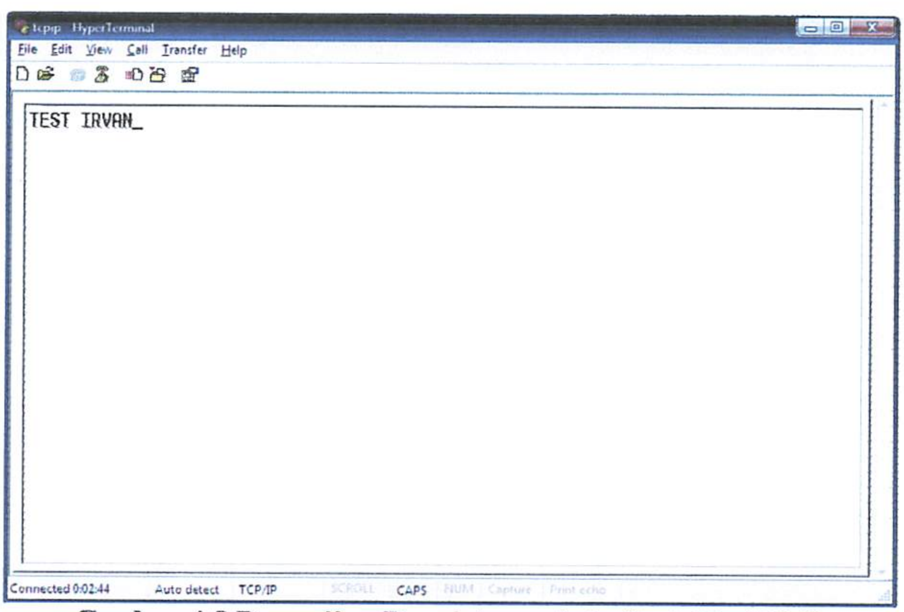


Gambar 4.6 Konfigurasi untuk Pengujian Pengiriman Data dari dan ke Modul WIZ610wi

Tujuan dari pengujian ini adalah untuk memastikan apakah data yang dikirim dari komputer 1 sama dengan data yang diterima oleh modul WIZ610wi dengan cara menyambungkannya dengan komputer 2. Begitu juga sebaliknya dari komputer 2 ke komputer 1. Pada gambar 4.5 menunjukkan data yang diterima oleh komputer 2.



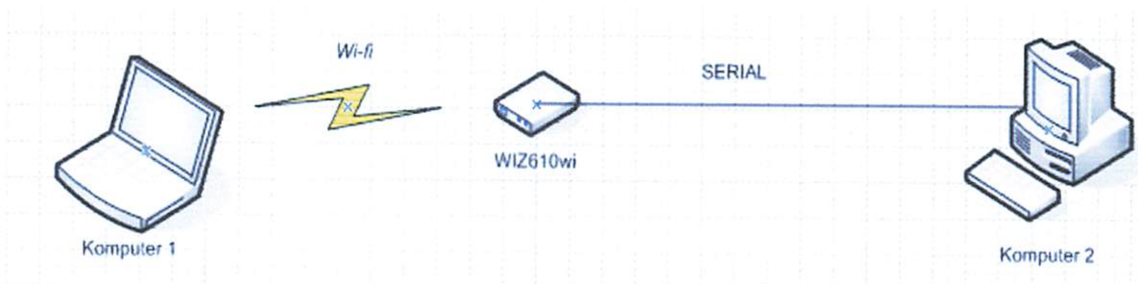
Ganbar 4.7 Pengujian Pengiriman data dari Wi-fi ke Serial



Ganbar 4.8 Pengujian Pengiriman data Serial ke Wi-fi

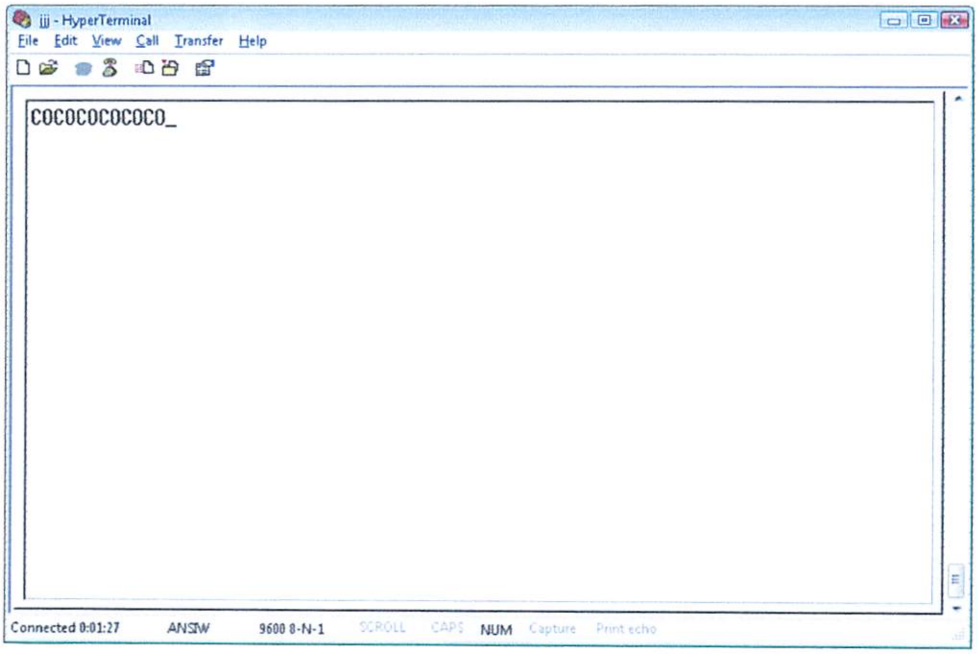
4.9 Pengujian *Software*

Pengujian software disini yakni pengujian software yang dibuat yang digunakan untuk mengakses alat yang telah dibuat. Pada intinya software disini akan mengirimkan perintah ke mikrokontroler melalui Wi-fi dan kemudian mikrokontroler akan meresponnya dengan mengirimkan hasil pengiriman. Untuk pengukuran suhu maka software ini akan mengirimkan perintah "SUHU" dan untuk pengukuran kadar CO maka software mengirimkan perintah "COCO". Pada software ini diberi timer yang berfungsi untuk mengulang pengiriman perintah secara terus menerus sampai software diakhiri. Tujuan pengujian ini adalah untuk mengetahui apakah software yang telah dibuat mengirimkan perintah sesuai dengan yang dimaksudkan. Berikut ini konfigurasi untuk mengetahui pengiriman data tersebut.

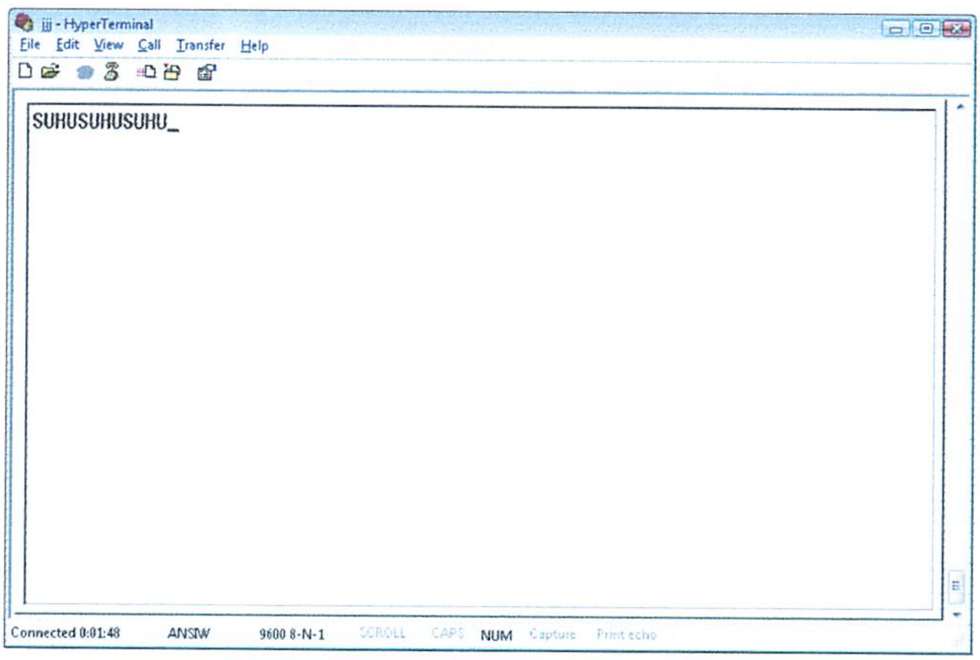


Gambar 4.9 Konfigurasi untuk Pengujian Pengiriman Perintah dari Modul WIZ610wi

Berikut ini adalah hasil pengiriman perintah oleh software yang dibuat yang didapatkan dengan menghubungkan komputer 2 dan WIZ610wi dengan komunikasi serial melalui DB9.



Gambar 4.10 Hasil Pengiriman Perintah oleh Software untuk Pengukuran CO

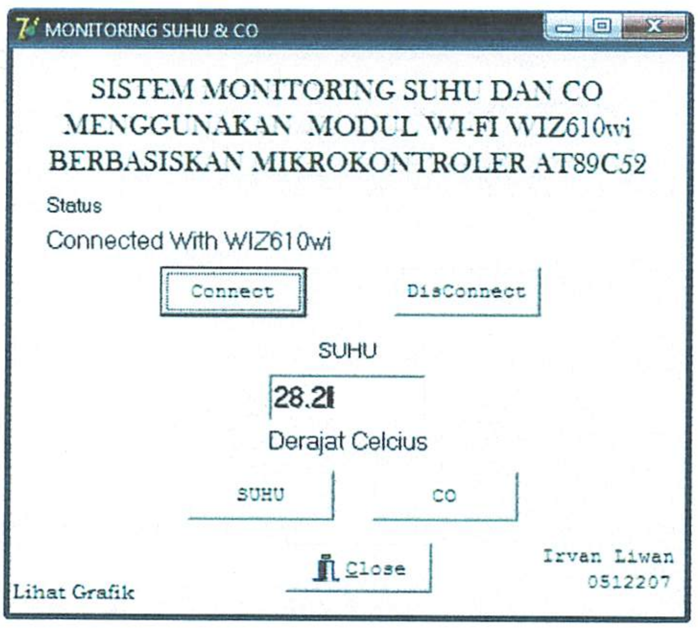


Gambar 4.11 Hasil Pengiriman Perintah oleh Software untuk Pengukuran SUHU

4.10 Pengujian Keseluruhan Sistem

Pengujian ini dilakukan dengan menyertakan software yang telah dirancang sebelumnya. Software ini ditanamkan pada komputer yang ingin mengakses alat ini. Pengujian ini berfungsi untuk mengetahui apakah sistem ini dapat berjalan dengan baik. Pengujian ini dilakukan masih dilakukan dalam jaringan local. Dan dengan bekerjanya sistem ini, selanjutnya dapat diaplikasikan ke jaringan internet.

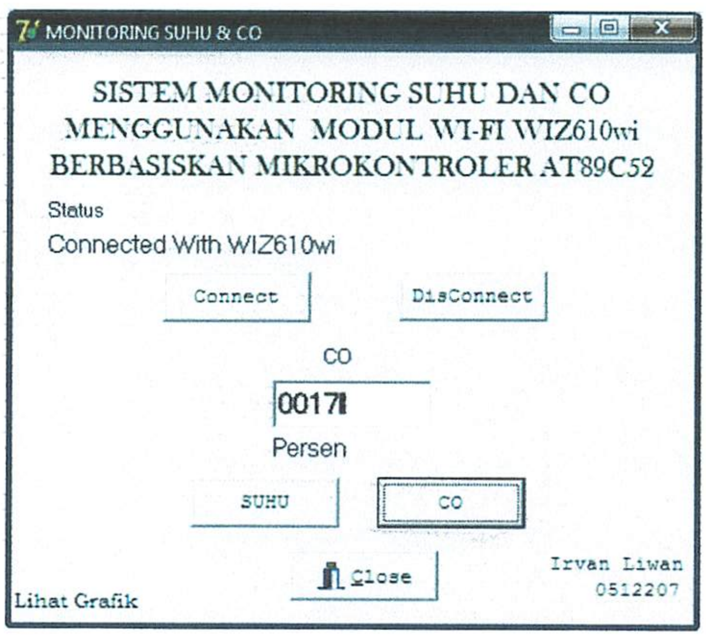
Pada pengujian keseluruhan sistem ini data suhu dan CO yang ditampilkan akan dibandingkan dengan suhu yang tercantum pada termometer.



Gambar 4.12 Hasil Pengukuran SUHU

Tabel 4.8
hasil Perbandingan Pengukuran Suhu dengan Termometer Digital dan Alat diluar ruangan

Pengukuran (°C)		$\Delta t = \lvert \text{Alat} - \text{Termometer Digital} \rvert$	$\Delta\% = \frac{\Delta t}{\text{Termometer}} x100\%$
Termometer Digital	Alat		
25,0	25,3	0,3	1,20
26,3	26,5	0,2	0,76
28,2	28,5	0,3	1,06
29,0	29,5	0,5	1,72
29,5	29,9	0,4	1,35
30,2	30,7	0,5	1,65
31,1	31,4	0,5	1,60
Kesalahan rata-rata			1,33%



Gambar 4.13 Hasil Pengukuran CO

Tabel 4.9
hasil Perbandingan Pengukuran Kadar CO dengan Alat Uji Emisi dan Alat yang dibuat

Pembacaan (ppm)		$\Delta t = \lvert Alat - Alat\ uji\ Emisi \rvert$	$\Delta\% = \frac{\Delta t}{Uji\ Emisi} x100\%$
Alat Uji Emisi	Display		
90	97	7	7,7
110	118	8	7,2
150	161	12	8,0
200	215	15	7,5
250	264	14	5,6
270	289	19	7,03
315	342	27	8,5
Kesalahan rata-rata			7,36%

Selanjutnya adalah pengujian terhadap maksimal jangkauan dari alat ini tanpa dan dengan adanya penghalang. Pada dasarnya selama komputer yang digunakan untuk mengaksesnya masih dalam jangkauan alat, maka hasil pengukuran dapat ditampilkan pada komputer.

Tabel 4.10
Pengujian Jangkauan Komputer dengan Alat Tanpa Penghalang

Jarak (meter)	Pengukuran
1	Berhasil
10	Berhasil
25	Berhasil
50	Berhasil
75	Gagal
85	Gagal

Tabel 4.11
Pengujian Jangkauan Komputer dengan Alat
Dengan Penghalang Tembok

Jarak (meter)	Pengukuran
1	Berhasil
10	Berhasil
25	Berhasil
26	Gagal
50	Gagal
74	Gagal
75	Gagal

Pengujian selanjutnya adalah pengujian kecepatan alat dalam merespon perintah yang dikirimkan oleh client pada jarak-jarak tertentu. Pengujian disini dilakukan tanpa penghalang dan diakses dengan hyperterminal.

Tabel 4.12
Pengujian Kecepatan Pengiriman Hasil
Pengukuran

Jarak (meter)	Waktu (detik)
1	1
10	1
25	2
50	2
75	-
85	-

Selanjutnya pengujian dengan menggunakan software yang telah dibuat. Pada software yang dibuat, terdapat 2 komponen timer yang masing-masing berfungsi untuk mengirimkan perintah ke mikrokontroler. Untuk mengetahui hasil pengukuran suhu maka dikirimkan perintah SUHU, sedangkan untuk mengetahui hasil pengukuran kadar karbon monoksida maka dikirimkan perintah COCO. Timer disini berfungsi agar tampilan hasil pengukuran pada software dapat ter-*update* secara otomatis. Pada software yang dibuat timer yang diberikan adalah sebesar 3000. Settingan ini mengakibatkan tampilan pada software yang dibuat akan terdapat delay yang cukup lama untuk mengetahui hasil pengukuran suhu maupun CO. Selanjutnya untuk mempercepat proses *update* hasil pengukuran, maka setiap timer diberikan nilai yang kecil.

BAB V

PENUTUP

5.1. Kesimpulan

Dari pembahasan Perancangan dan pembuatan Sistem Monitoring Kadar Karbon Monoksida (CO) dan Suhu dengan Modul Wi-fi WIZ610wi Berbasis Mikrokontroler AT89C52, dapat diambil kesimpulan, yaitu :

1. Penyimpangan rata rata pada pengukuran sensor TGS 2442 sebesar 2,96% dan LM35 adalah 0,85%
2. Penyimpangan rata rata pada pengkondisi sinyal LM358 adalah 1,24%
3. Penyimpangan rata rata pada pengujian keseluruhan sistem untuk pengukuran suhu adalah 1,33% dan CO adalah 7,36%.
4. Jarak maksimal yang dapat dijangkau oleh alat tanpa penghalang adalah 50 meter, sedangkan jarak maksimal yang dapat dijangkau dengan penghalang tembok adalah 25 meter.

5.2. Saran

Alat yang dibuat ini masih memiliki keterbatasan, nantinya diharapkan dapat dikembangkan untuk mengatasi keterbatasan itu. Sehingga mendapatkan alat yang diharapkan dapat mendekati alat yang ideal.

1. Bagi peneliti selanjutnya diharapkan menggunakan mikrokontroler yang kecepatan eksekusi lebih cepat dibandingkan dengan AT89C52 sehingga dapat melayani banyak client.

DAFTAR PUSTAKA

[1]. Dedy Irawan, Joseph, *Interfacing Paralel & Serial Menggunakan Delphi*, Graha Ilmu, 2007.

[2]. Wahana Komputer, *"Membuat Program Kreatif dan Profesional dengan DELPHI"*, Elex Media Computindo, Jakarta, 2005.

[3]. Irwanto, *Belajar Assembler dan C pada Mikrokontroler AT89S52*, Graha Ilmu, 2005.

[4]. Prasetyo,Sonny, *Monitoring Infus Melalui TCP/IP Berbasiskan Mikrokontroler*, Skripsi Teknik Elektro ITN Malang, 2007.

[5]. Jamaluddin Malik, Jaja, *Kumpulan Latihan Pemprograman Delphi*, Andy, Jogjakarta, 2005.

[6]. Taufan, Riza, *Manajemen Jaringan TCP/IP*, PT.Elex Media Komputindo, 2002.

[7]. Wahidin, *Jaringan Komputer Untuk Orang Awam*, Maxikom, 2007.

[8]. Andi, *Pemrograman Borland Delph 7i*, Andi, 2002.

[9]. http://franzaditya.blogspot.com/2009/02/penguat-operasional-op-amp.html.

[10]. http://uii/fakultas elektro_telemetri suhu dan kelembapan

[11]. http//:petra.com/skripsi/ Pengontrol Suhu melalui Jaringan Telepon berbasis Mikrokontroller AT89C52)

[12]. http://alldatasheet.com

[13]. http://wiznet.com

LAMPIRAN

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MALANG

FORMULIR BIMBINGAN SKRIPSI

Nama : Irvan Liwan
NIM : 0512207
Masa Bimbingan : 01 Desember 2009 s/d 01 Juni 2010
Judul Skripsi : Sistem Monitoring Kadar Karbon Monoksida (CO) dan Suhu dengan Modul *wi-fi* WIZ600WI Berbasis Mikrokontroller AT89C52

NO	Tanggal	Uraian	Paraf Pembimbing
1	16-3-2010	Bab I → rumusan masalah diperbaiki Bab III → sistem, blok diagram, gambar rangkaian. Bab II → Pembahasan LM358	[signature]
2	19-4-2010	Bab II → LM358 Acc Bab I	[signature]
3	28-4-2010	Analisis rangk. dilengkapi rangk. PS, ADC.	[signature]
4	30-4-2010	Nilai pasaran dilengkapi flow chart.	[signature]
5	18-5-2010	flowchart, BAB IV revisi	[signature]
6	24-5-10	Acc BAB III revisi pengujian keseluruhan	[signature]
7	2-6-10	Acc BAB IV.	[signature]
8		Acc Bab V.	[signature]
9		Acc ujian	[signature]
10		Acc Jilid	[signature]

Malang, 26 Agustus 2010
Dosen Pembimbing

[signature]

Irmalia Suryani Faradisa, ST, MT.
NIP.P. 1030000365

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NIM : 0512207
Masa Bimbingan : 01 Desember 2009 s/d 01 Juni 2010
Judul Skripsi : Sistem Monitoring Kadar Karbon Monoksida (CO) dan Suhu dengan Modul *wi-fi* WIZ600WI Berbasis Mikrokontroller AT89C52

NO	Tanggal	Uraian	Paraf Pembimbing
1	20-4-2010	Teori pada Bab II → Transistor sebagai penguat Teori pada Bab II → Teori OP-AMP BAB III Perhitungan Transistor	[signature]
2	27-4-2010	Bab III Penambahan penjelasan masing-masing program	[signature]
3	29-4-2010	Bab IV tambahkan pengujian kecepatan transfer pada setiap jarak	[signature]
4	18-5-2010	Bab IV tambahkan besar pengukuran sinyal pada setiap pengujian.	[signature]
5			
6			
7			
8			
9			
10			

Malang,
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[signature]

Sotyohadi, ST, MT
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PERKUMPULAN PENGELOLA PENDIDIKAN UMUM DAN TEKNOLOGI NASIONAL MALANG

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Kampus II : Jl. Raya Karanglo, Km 2 Telp. (0341) 417636 Fax. (0341) 417634 Malang

Nomor : ITN- 417 /V.FTI-2/7/08 Malang, 17 Mei 2010
Lampiran : -
Perihal : **Permohonan Penggunaan Fasilitas Laboratorium**

Kepada : Yth. Kepala Laboratorium Otomotif
PPPGT/VEDC
Jl. Teluk Mandar
Di – Arjosari - Malang

Bersama ini dengan hormat kami mohon kebijaksanaan Saudara agar Mahasiswa kami dari Fakultas Teknologi Industri Jurusan Teknik Elektro S-1 Konsentrasi Teknik **Elektronika** dapat diijinkan untuk menggunakan **fasilitas Laboratorium** guna keperluan menyusun Tugas Akhir / Skripsi.

Adapun mahasiswa tersebut adalah :

Irvan Liwan Nim. 05.12.207

Demikian agar maklum dan atas perhatian serta bantuannya kami ucapkan terima kasih.

DEKAN
Fakultas Teknologi Industri

Ir. H. Sidik Noertjahjono, MT.
Nip. Y. 1028700163

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DIREKTORAT JENDERAL
PENINGKATAN MUTU PENDIDIK DAN TENAGA KEPENDIDIKAN
PUSAT PENGEMBANGAN DAN PEMBERDAYAAN PENDIDIK DAN TENAGA KEPENDIDIKAN BIDANG OTOMOTIF DAN ELEKTRONIKA
Jl. Teluk Mandar Arjosari, Tromol Pos 5 Malang 65102
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PPPPTK
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SURAT KETERANGAN

Nomor : 273 / F15.60 / OTO / 2010

Yang bertanda tangan dibawah ini :

Nama : Choesen Wawan Darmawan
NIP : 19670916 200212 1 001
Jabatan : Wakadept. Inovasi

Berdasarkan surat Dekan Fakultas Teknologi Industri Institut Teknologi Nasional Malang nomor: ITN-417 /V.FTI-2/7/08, tentang permohonan ijin pengambilan data untuk Tugas Akhir, maka dengan ini kami menerangkan :

Nama : Irvan Liwan
Pangkat : Mahasiswa Teknik Elektro Institut Teknologi Nasional Malang
Jurusan : Teknik Elektro
NIM : 05.12.207

Mahasiswa tersebut diatas telah melaksanakan pengambilan data pada Departemen Otomotif PPPPTK / VEDC Malang dengan hasil sebagaimana terlampir (1 lembar) berkaitan dengan penyelesaian Tugas Akhir / TA dengan materi :

"Sistem Monitoring Kadar Karbon Monoksida (CO) dan Suhu dengan Modul wi-fi WIZ600WI Berbasis Mikrokontroller AT89C52"

Adapun pengambilan data tersebut dilaksanakan melalui pengujian langsung menggunakan

"Gas Analyzer"

Demikian surat keterangan ini diberikan untuk dapat digunakan sebagaimana mestinya.

Malang, 26 Mei 2010
Wakadept. Inovasi

Choesen Wawan Darmawan
NIP. 19670916 200212 1 001

E/Penelitian/Surat Keterangan Penelitian hasil pengukuran yang dilakukan dilaboratorium otomotif untuk pengukuran kadar karbon monoksida pada hasil pembakaran kendaraan bermotor.

Perbandingan pembacaan alat uji Emisi dengan pembacaan pada display alat ukur yang dibuat

Pembacaan	
%CO	Display
0,09	97
0,011	118
0,015	161
0,020	215
0,025	264
0,027	289
0,031	342

Mengetahui

Koordinator Lapangan

(Moch. Wahyudi)

Kepala Departemen Otomotif
PPPP TK VEDC Malang

(Drs. Bintoro, MT)

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FAKULTAS TEKNOLOGI INDUSTRI
JURUSAN TEKNIK ELEKTRO

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

NAMA : IRWAN LIWAN
NIM : 0512207
Perbaikan meliputi :

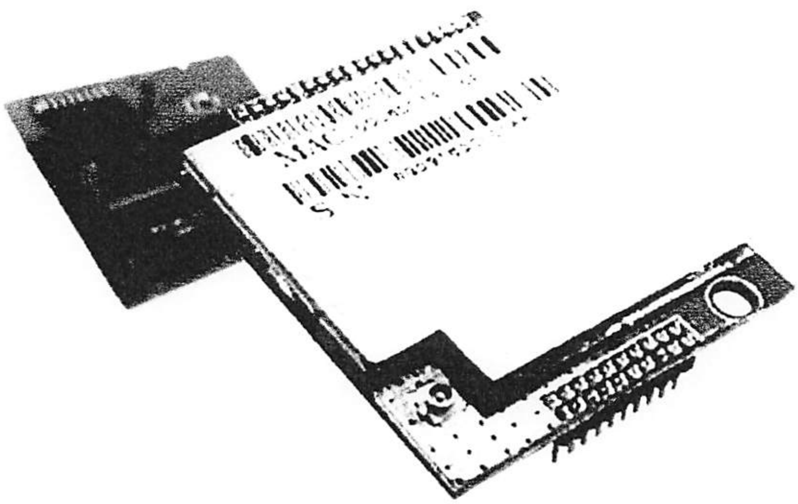
•) RANGKAIAN LENGKAP → LAMPIRAN
•) PENGUJIAN LAMA / KECEPATAN PENGUKURAN
KENAPA BISA LAMA ?"

Malang, 21 - 8 - 2010

(JOSEPH DEDY)

WIZ610wi User's Manual

(Version 1.5)



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Upgrade History

Date	Version	Comment
2009-01-31	V1.0	Release
2009-03-16	V1.1	-Gateway mode 8080 port access added -Client mode WAN setting added -Serial Packing Condition added -Serial Command added
2009-05-18	V1.2	-Client mode IP setting amended -Power Consumption fact amended -IGMP function added -Server connection trying interval function added on the serial client mode. -Data Packet ConditionTime(Second→Millisecond)
2009-06-18	V1.3	-Serial Command Added
2009-07-14	V1.4	-Serial Command Amended
2009-08-11	V1.5	-Serial Command Added Serial Server:Client Connection status checking -Reference Schematic Amended(Pin No. 6, 7)

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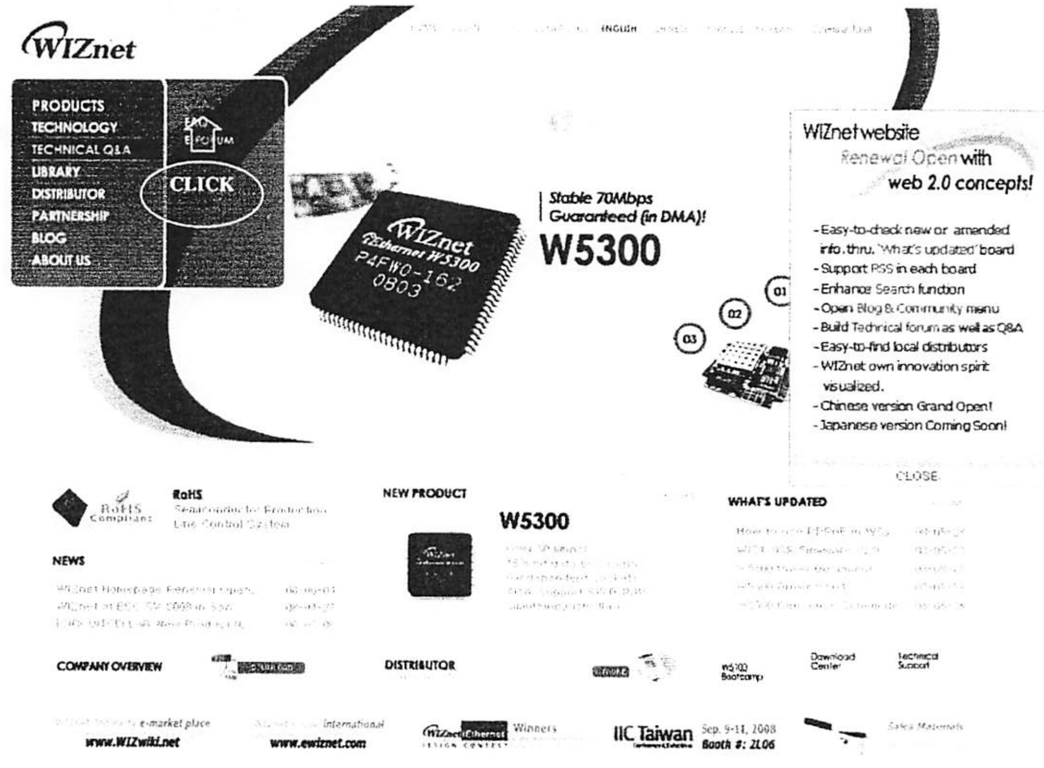
If you have any questions about our products, please visit our website and submit your questions on the Q&A Board. We will reply your questions as soon as possible



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Contents

Figures

Tables

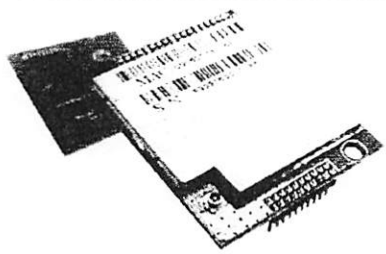
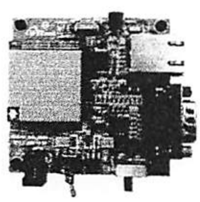
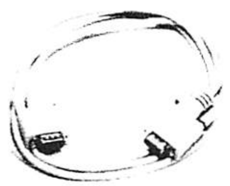
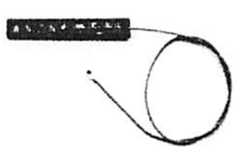
1. Introduction

WIZ610wi is the gate way module which provides a bridge for RS-232 or Ethernet to IEEE802.11 b/g wireless communications. Devices with the interface of RS-232 serial or Ethernet can established a wireless network which can enable remote monitoring, management and controlling.

Main Features

- Embedded 802.11b/g Wireless Networking
- Access Point, Client, Gateway, Serial to WLAN mode Supported
- Ethernet to Wireless Bridging
- Security with 64/128 bit WEP, WPA, WPA2(AES)
- MII, UART, GPIO, U.FL(WLAN) Interface
- Ready to use serial to wireless application
- Max 25Mbps Data Streaming
- Compact Size : 39mm X 32mm X 4.7mm
- RoHS Compliant

Products Contents (WIZ610wi-EVB)

	WIZ610WI Module
	WIZ610wi Evaluation Board
	Serial Cable (Connect Serial Device to Test Board)
	Network Cable (Crossover Cable)
	Power (DC 5V 2A Adaptor)
	Antenna (2dBi PCB type + Coaxial Cable)

	CD (Manual, H/W & SW related Materials)

Table 1. Products Contents.

1.1 Product Specification

1.1.1 WIZ610wi Module

Wireless

ITEM	Specification
Wireless Standard	IEEE802.11b/g
Frequency Range	2.412~2.485GHz
Output Power (Tolerance(+/-1dBm)	802.11b: 16dBm@11Mbps 802.11g: 14dBm@6~54Mbps
Receive Sensitivity	802.11b: -65dBm@11Mbps 802.11g: -76dBm@54Mbps
Data Rates	54Mbps-1Mbps
Modulation Type	11g: OFDM(64QAM, 16QAM, QPSK, BPSK) 11b: DSS(CCK, DQPSK, DBPSK)

Table 2. Products Specification - Wireless

Hardware

ITEM	Specification
Interface	MII, UART, GPIO (0~5), Power, 1.27mm Pitch Header Pin
	U.FL(wireless)
Temperature	Operation: -5℃~55℃ Storage: -20℃~70℃
Humidity	Operation: 10% to 90%, Non-Condensing Storage: 5% to 90%, Non-Condensing
Serial	Baud Rate : 230,400bps

	Stop bits: 1
	Parity: None, Odd, Even
	Flow Control: XON/XOFF(software), CTS/RTS(hardware), none
Power	3.3V
Power Consumption	Under 470mA(3.3V)
Dimension	39mm X 32mm X 4.7mm Ø 3mm hole X 1
Weight	8.0g

Table 3. Products Specification - Hardware

Software

ITEM	Description
Operation Mode	Access Point, Client, Gateway, Serial to Wireless LAN
Protocol	ARP, UDP, TCP, Telnet, ICMP, IGMP, DHCP, PPPoE, BOOTP, HTTP, TFTP
Security	WEP 64/128big WPA/WPA2 PSK/AES/TKIP 802.1x(Radius)
Management	HTTP, Telnet, Serial, UDP
Notification	Event Logging

Table 4. Products Specification - Software

1.1.2 WIZ610wi Test Board

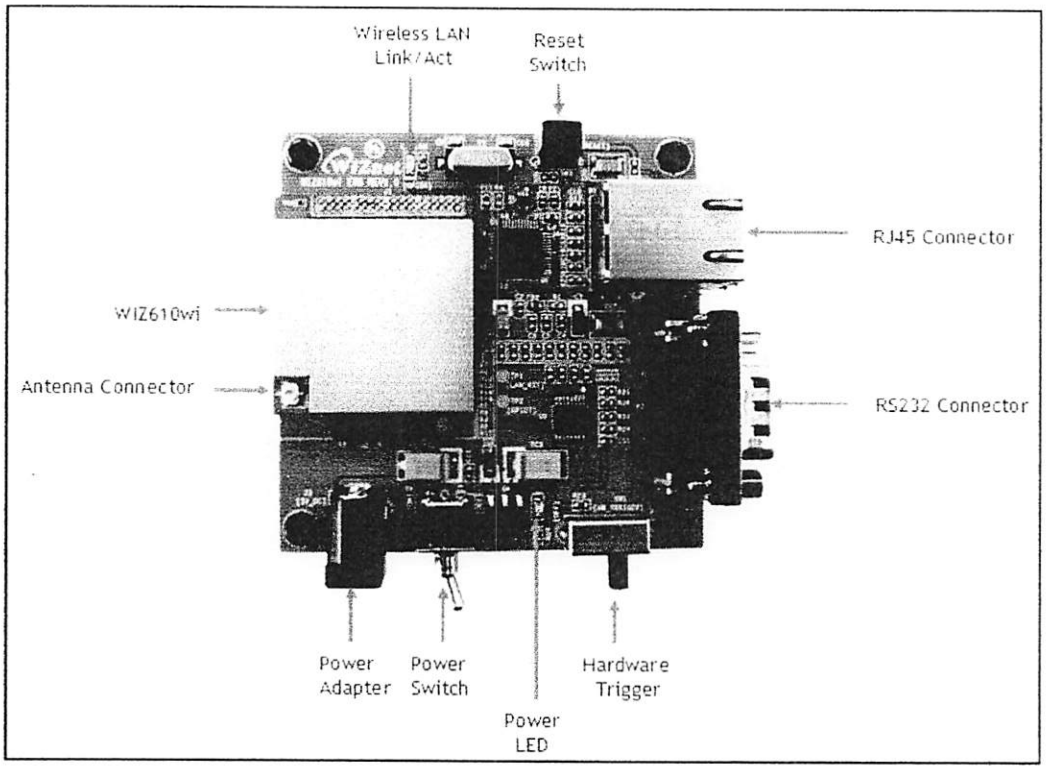


Figure 1. WIZ610wi Test Board

2. Getting Started

This manual describes all configurations in detail. For the quick and easy installation, please refer to "WIZ610wi Quick Installation Guide"

2.1. Hardware Installation

For the testing, module and test board should be prepared.

- **STEP1**: Insert WIZ610wi module in the socket of test board.
- **STEP2:** Connect the test board to the HUB or PC by using a network cable.
- **STEP3:** Connect the test board to the serial device by using the RS-232 serial cable.
- **STEP4:** Insert the power supply connector to the test board by using the 5V (200mA) DC power adaptor.

2.2. Configuration

2.2.1 Connecting the Web page of WIZ610wi

1) Open a web browser on your PC and input "192.168.1.254", the default IP address of WIZ610wi.

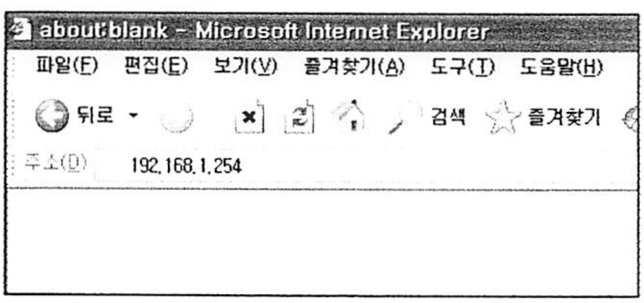


Figure 2. Connecting to the Web page of WIZ610wi

Notice : Configure the network parameters of WIZ610wi and your PC.

➢ The default IP address of WIZ610wi is "192.168.1.254". Your PC's IP address should start with these three sets of numbers "192.168.1.XXX".

➢ WIZ610wi and PC can be connected through wireless network. Connect to WIZ610wi from PC by using default SSID "WIZ610wi"

2) A pop up will request you to input your User ID and Password.

Default User ID : admin   Password : admin

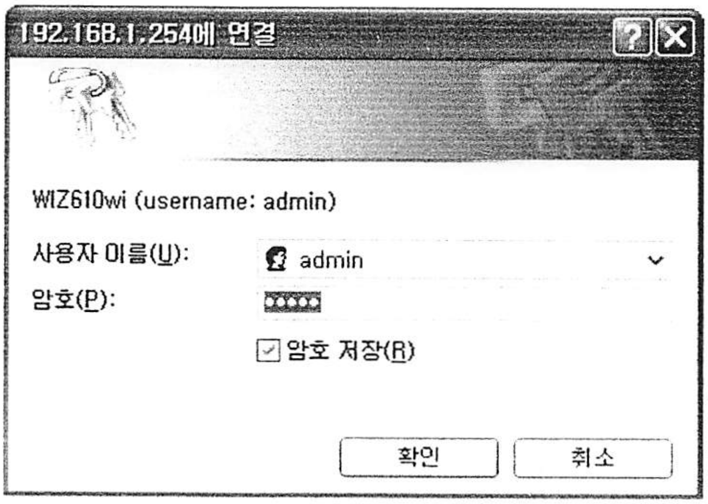


Figure 3. Input ID & Password

2.2.2 Checking Status

1) System Data

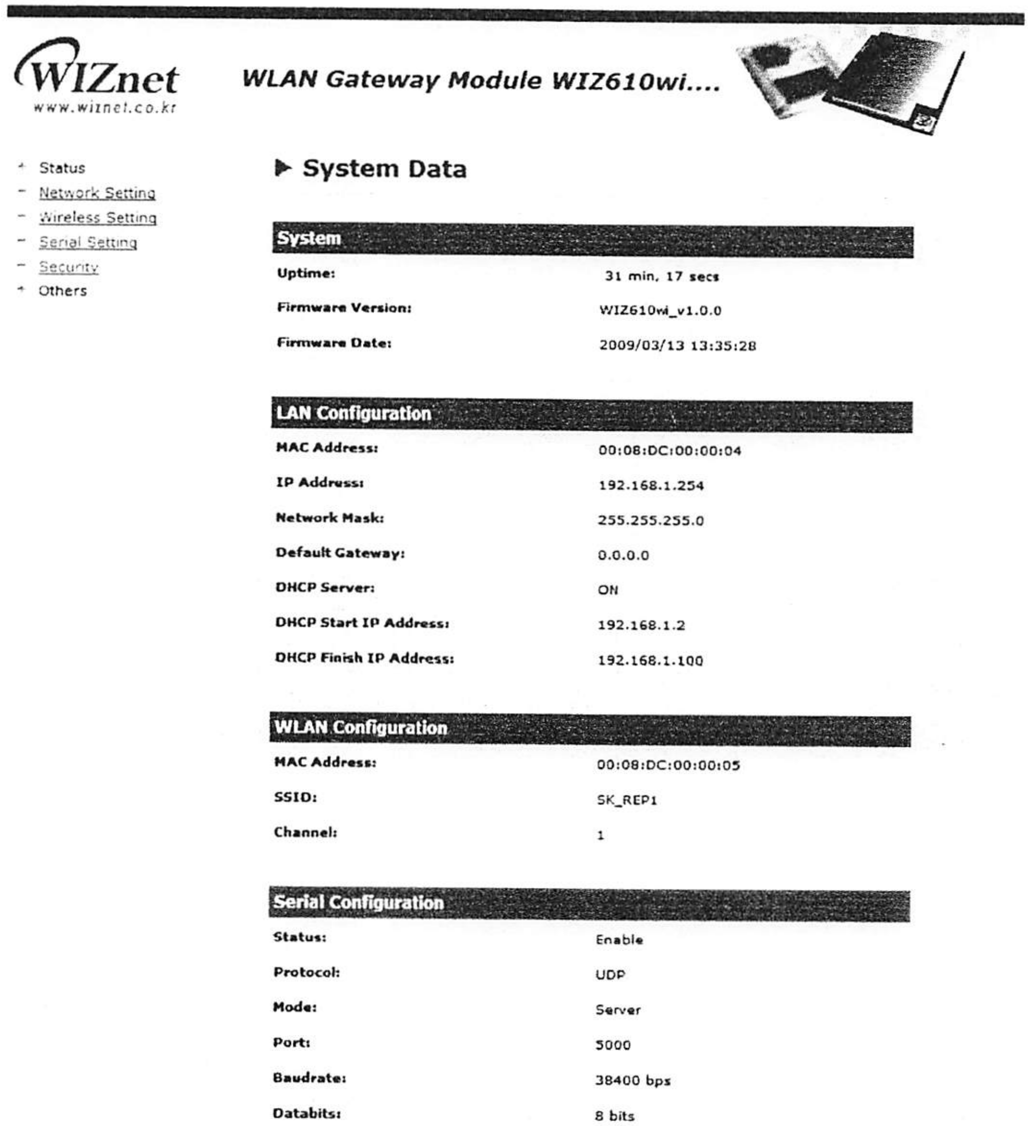


Figure 4. System Data

ITEM	Description
Firmware Version	The firmware version of WIZ610wi is displayed
Firmware Date	The last date and time of firmware upgrade
MAC Address(LAN)	the MAC Address of WIZ610wi for Ethernet communication.
IP Address	the IP address of WIZ610wi.

Network Mask	the Network Mask of WIZ610wi.
Default Gateway	the Gateway of WIZ610wi.
DHCP Server	shows the DHCP server function is activated or not.
DHCP Start IP Address	shows the first IP address to be assigned from DHCP server.
DHCP Finished IP Address	shows the last IP address to be assigned from DHCP server.
MAC Address(WLAN)	the MAC Address for wireless communication.
SSID	the SSID of WIZ610wi.
Channel	the wireless channel of WIZ610wi.

Table 5. System Data

Notice : WIZ610wi supports the MAC addresses for both Ethernet and Wireless interfaces.

2) Active Client

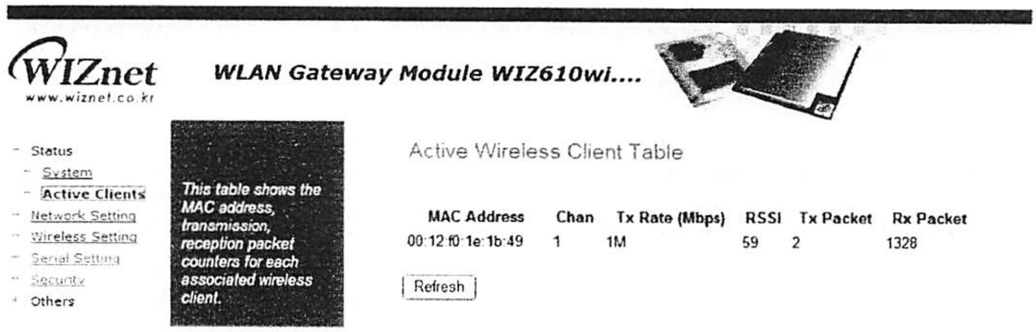


Figure 5. Active Clients

In this page, the information of clients connecting to WIZ610wi is displayed. If you click "Refresh" button, the client list and information are updated.

2.2.3 Network Setting

You can configure network parameters of WIZ610wi.

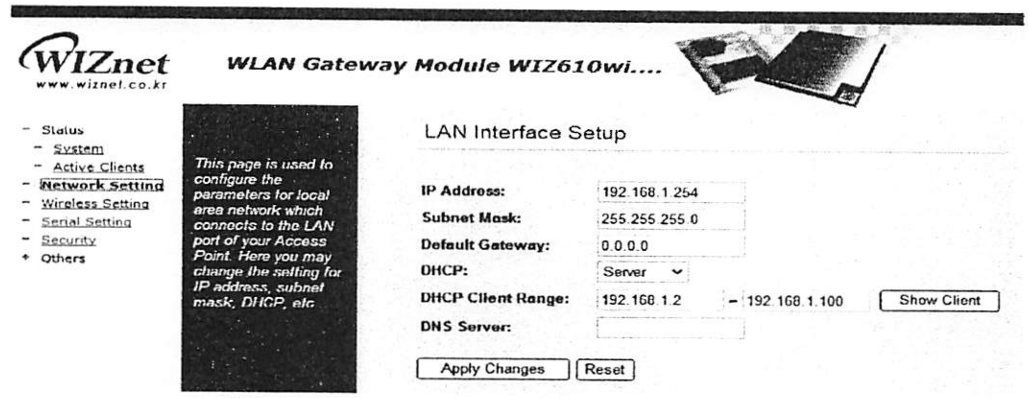


Figure 6. Network Setting

- **IP Address**: The default IP Address is set as "192.168.1.254".
- **Subnet Mask**: The default Subnet Mask is set as "255.255.255.0".
- **Default Gateway**: The default Gateway is set as "0.0.0.0".
- **DHCP**: If you want to activate the DHCP Server function, select the "Server". If not, select "Disable".

Notice: When the WIZ610wi's IP address is managed by another DHCP server in the upper layer, the DHCP function in your wireless module will be disabled. All your clients connecting to your WIZ610wi can not recognize your module as a DHCP server.

- **DHCP Client Range**: When WIZ610wi operates as the DHCP Server, the IP address range must be assigned in order for the clients to connect. If the DHCP server function is disabled, this DHCP Client Range is not activated.
- **Show Client :** If you click the "Show Client" button, a window is popped up to show a list of clients.

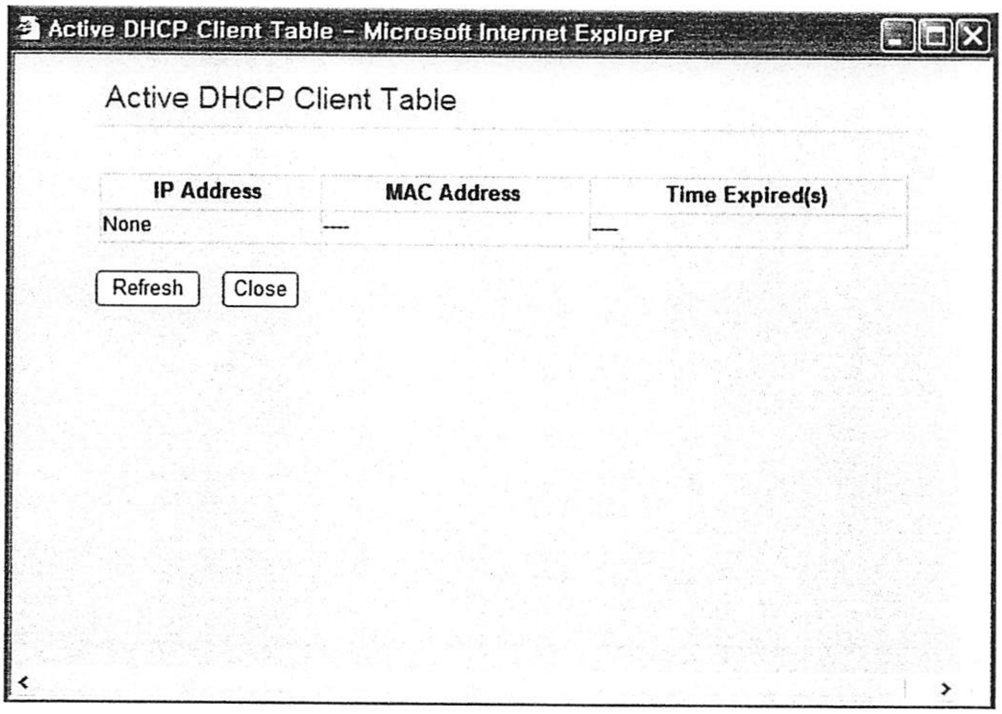


Figure 7. Active DHCP Client Table

- **Apply Changes** : By clicking this button, the modified values are applied. After changing, the page is refreshed to re-connected to the new IP address.

2.2.4. Wireless Setting

2.2.4.1. Mode Selection

You can select one of Access Point, Gateway and Client for the wireless connection mode.

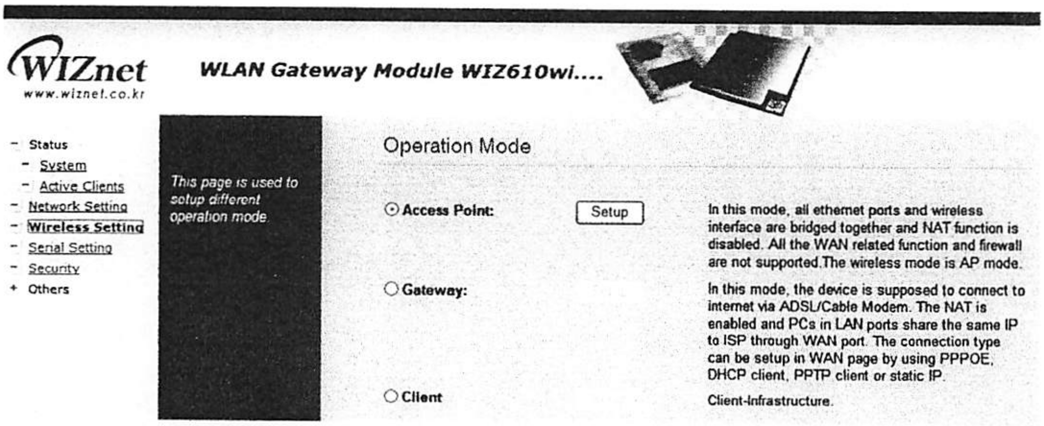


Figure 8. Operation Mode

Access Point is the default mode. If you select Gateway or Client and click the "Setup" button, the progress bar will be shown.

Please wait a moment to let the new settings take effect...

Please wait...

Figure 9. Changing Operation Mode

1) Access Point Mode

In this mode, all Ethernet ports and wireless interface are bridged together and NAT function is disabled. All the WAN related function and firewall are not supported.

2) Gateway Mode

In this mode, your device can connect to the internet via ADSL/Cable Modem. The NAT is enabled and PCs in LAN ports share the same IP to ISP through WAN port. WAN connection type can be setup in WAN page by using PPPOE, DHCP client, PPTP client or static IP.

3) Client Mode

In this mode, your device act as a client. If you configure PC or application device as DHCP client, Access Point will be the DCHP Server and WIZ610wi doesn't act as DHCP Server.

2.2.4.2. IP Configuration in Each Mode

1) Access Point Mode

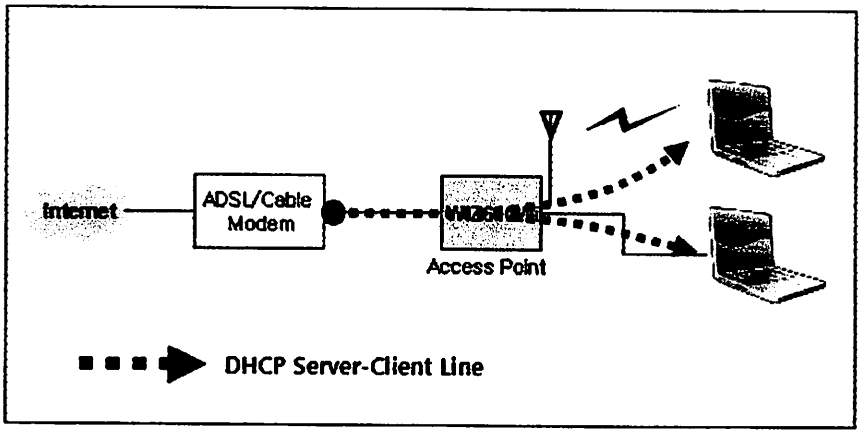


Figure 10. Access Point Mode - 1

- The IP address assigned to WIZ610wi is for administration and web configuration.
- Even though the WIZ610wi is configured as DHCP Server, the PC will acquire IP address from IP Sharing device or ADSL/Cable Modem.

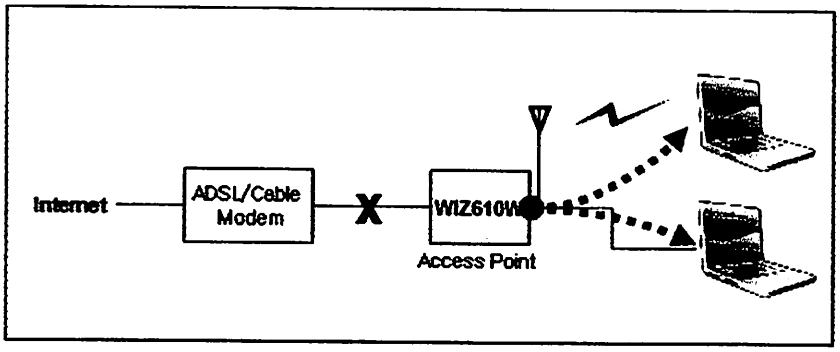


Figure 11. Access Point Mode -2

- If there is not IP Sharing Device or ADSL/Cable modem, WIZ610wi will assign the IP addresses which is in DHCP IP range to PCs through wired or wireless network.

2) Gateway Mode

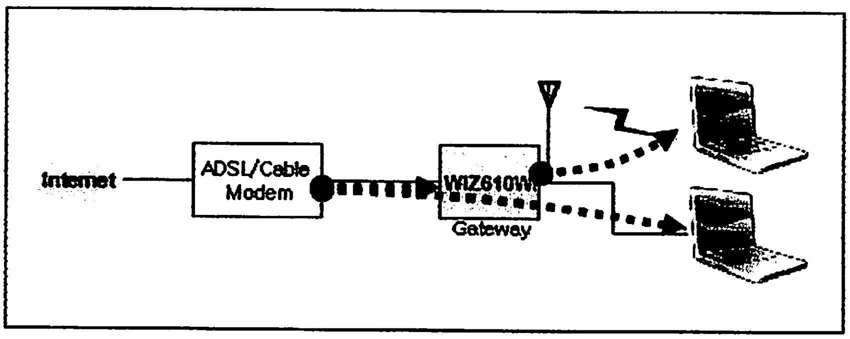


Figure 12. Gateway Mode

WIZ610wi operates as DHCP Server for the wireless communication.
WIZ610wi operates as Static/DHCP/Client/PPPoE for the wired (Ethernet) communication.

3) Client Mode

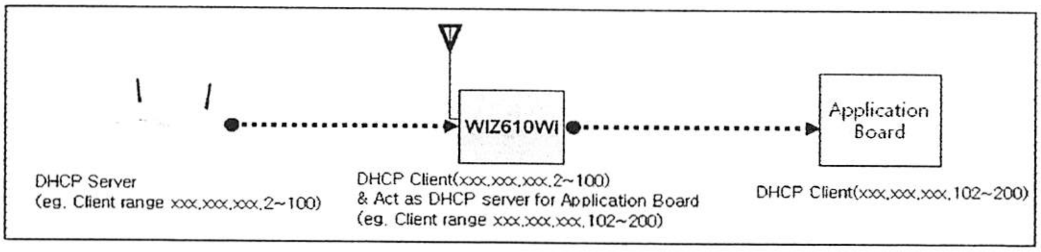


Figure 13. Client Mode

WIZ610wi can be set IP as Static or DHCP client at 'Client Setup>WAN Port Setup'. And also WIZ610wi can be act DHCP Server simultaneously by assigning adding 100 of first DHCP server. For example, if DHCP server's client range is XXX.XXX.XXX.2~100, then WIZ610wi's assigning DHCP Client IP address to application board is XXX.XXX.XXX.102~200.

2.2.4.3. Access Point Setup

After selecting the AP mode and please click "Setup" button, the page below is shown.

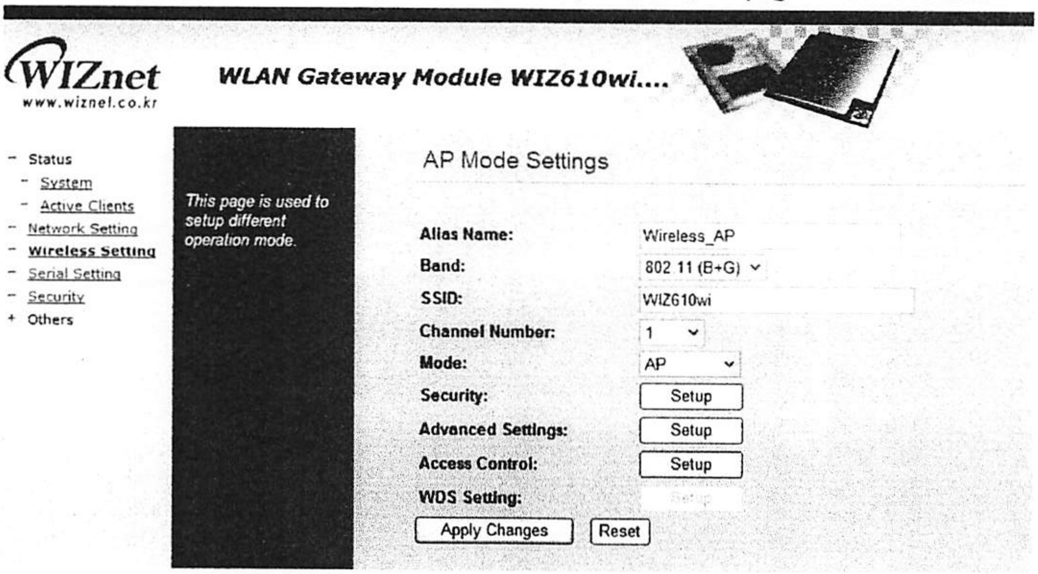


Figure 14. AP Mode Settings

- **Alias Name** : Input the name for WIZ610wi.
- **Band** : Select communication protocol of WIZ610wi.

802.11g protocol is compatible with 802.11b.

• **SSID**: Input SSID for wireless communication.

All devices on the same wireless network should have same SSID. The SSID can have max 32bytes characters composed of alphabets and numbers.

Notice:	this field is case-sensitive

Channel Number: : Select the channel frequency which you will use for wireless communication.

Auto: If you select Auto, the connection is automatically processed to the channel assigned by AP. When AP is booted, it investigates wireless channel environment and selects the lowest using channel.

Manually Select a Channel : You can select a channel in the range of 1~13..

• **Mode :**

AP : IF AP is selected, WIZ610wi operates as Access Point.

WDS Repeater : WDS(Wireless Distribution System) that can be used for the communication between WIZ610wi and WIZ610wi. When this mode is selected, AP function operates at the same time.

• **Security :** Configure the security options for WIZ610wi. When you click "Setup" button, below page appears.

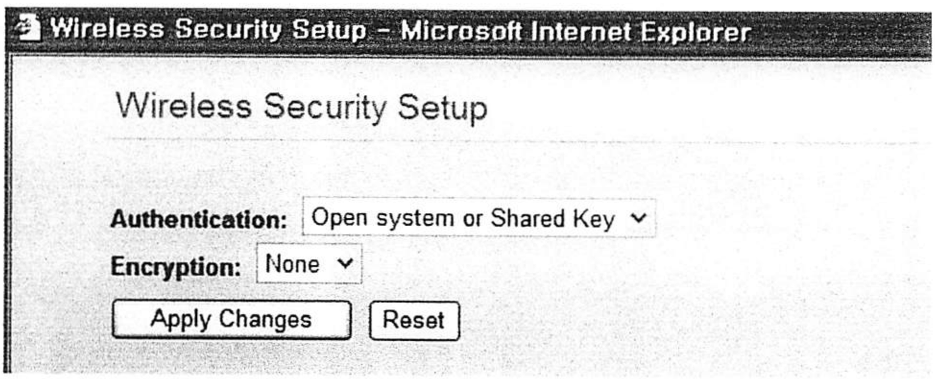


Figure 15. Wireless Security Setup

Authentication : You can select an authentication method for the clients to connect to AP.

Field	Description
Open System or Shared Key	No authentication is imposed to the WIZ610wi. When enabling WEP, the configuration is activated.

Open System with 802.1x	The client authentication is performed by RADIUS server. Configure the port number, IP address and Password of RADIS server.
Shared Key	WEB function is activated. Input the Key value.
WPA RADIUS	WPA: Wi-Fi Protected Access WPA is based on TKIP(Temporal Key Integrity Protocol) IEEE802.11i standard which complements WEP(Wired Equivalent Privacy). WPA is the upgraded authentication methods by applying 802.1x and EAP (Extensible Authentication Protocol).
WPA PSK	WPA Pre-Shared-Key is the authentication method using Pre-Shared Key. Configure PSK format and input value for PSK.
WPA2 RADIUS	WPA2 is using AES(Advanced Encryption Shared) algorithm. AES is more strengthened encryption method rather than RC4 which is used for WEP or WPA. WPA2 RADIUS performs AES encryption and RADIUS server authentication. If WIZ610wi uses WPA2, it can be compatible with devices using WPA1.
WPA2 PSK	WPA2-PSK uses Advanced Encryption Standard(AES) for encryption Keys together with WPA PSK method.

Table 6. Authentication Method

Encryption : It configures authentication mode for security of wireless network. There are options of WEP and None. If WEP is selected, the below items are activated for configuration.

ITEM	Description
key Length	Configure the length of WEP Key. Option : 64 or 128bit
Key Format	Configure the format of WEP Key. Option : ASCII(5 Characters) or Hex(10 Character)
Default Tx Key	Max 4 Tx Key values can be configured. Select one of them.
Encryption Key 1~4	Input the key value.

Table 7. WEP Configuration

• Advanced Settings : If you click the "Setup" button, below page is appeared.

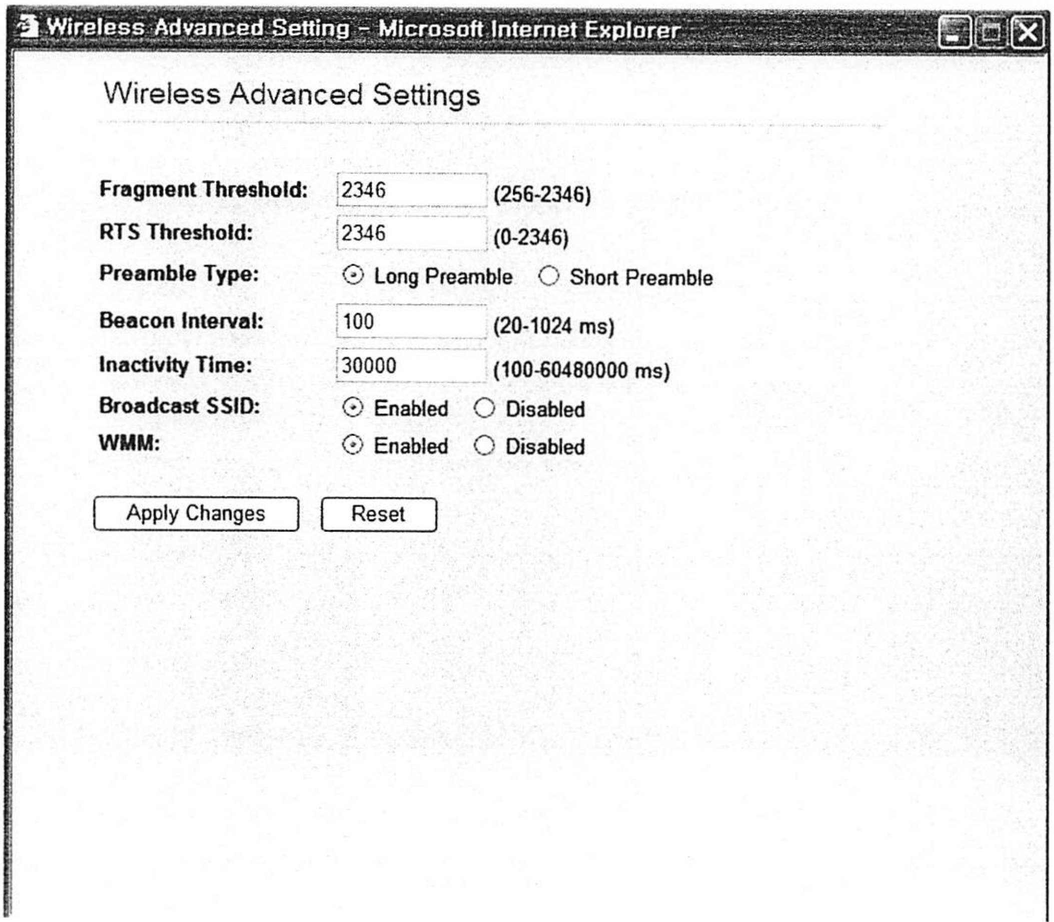


Figure 16. Wireless Advanced Settings

Field	Description
Fragment Threshold	This value specifies the maximum size for a packet before data is fragmented into multiple packets. If you experience a high packet error rate, you may slightly increase the Fragmentation Threshold. Setting the Fragmentation Threshold too low may result in poor network performance. Only minor reduction of the default value is recommended. In most cases, it should remain as its default value of **2346**.
RTS Threshold	When you encounter inconsistent data flow, only minor reduction of the default value, **2347**, is recommended. If a network packet is smaller than the preset RTS threshold size, the RTS/CTS mechanism

	will not be enabled. The Router sends Request to Send (RTS) frames to a particular receiving station and negotiates the sending of a data frame. After receiving an RTS, the wireless station responds with a Clear to Send (CTS) frame to acknowledge the right to begin transmission. The RTS Threshold value should remain as its default value of **2347**.
Preamble Type	
Beacon Interval	The default value is **100**. Enter a value between 1 and 65,535 milliseconds. The Beacon Interval value indicates the frequency interval of the beacon. A beacon is a packet broadcast by the Router to synchronize the wireless network.

Table 8. Wireless Advanced Settings

- **Access Control** : By registering the MAC address of a client, WIZ610wi blocks or allows the client to access. If you click the "Setup" button, page below appears.

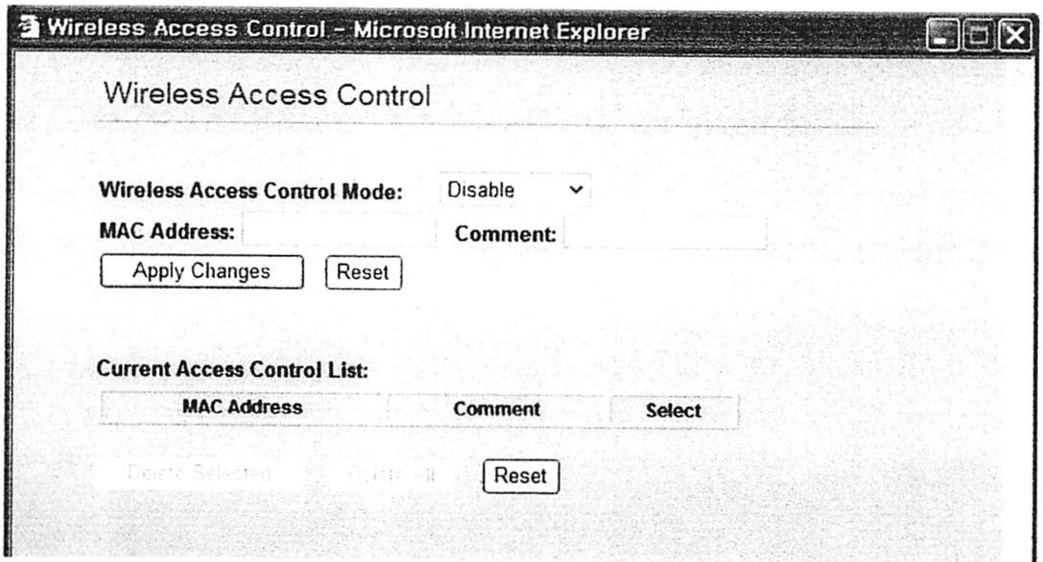


Figure 17. Wireless Access Control

Wireless Access Control Mode : This option allows you to enable or disable the "Wireless Access Control Mode". (Options: Disable / Allow Listed / Deny Listed)

Disable: Not use "Wireless Access Control Mode".

Allow Listed: clients with their MAC registered in the Control List are permitted to access WIZ610wi

Deny Listed: clients with their MAC registered in the Control List are denied to access

• **WDS Setting** : If AP mode is set as WDS Repeater, WDS Setting button is activated. WDS is Wireless Distribution System that is working as a wireless bridge between AP and AP. If you click the "Setup" button, the page below appears.

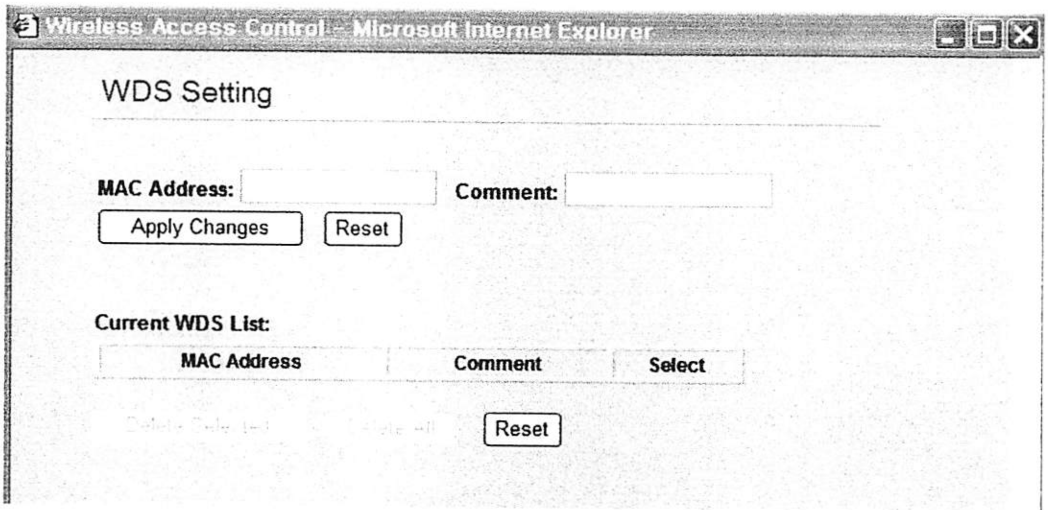


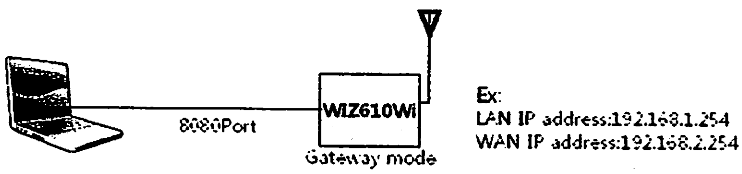
Figure 18. WDS Setting

Input wireless MAC address of the device to be connected.

Apply Changes : Add the MAC address into the WDS list
Reset : Discard all changes in all fields

2.2.4.4. Gateway Setup

<Notice>



When changed to Gateway mode, wired network is disconnected, It because WIZ610wi's wire port act as WAN Port. So to solve this problem..

1. Connect WIZ610wi through wireless
2. Check WAN IP of Gateway mode setup page
3. Connect 'http://WAN_IPaddress:8080 (8080 port)

First time it must be input '8080', but next time no need to add '8080'

Gateway mode can be used when you want to connect to the Internet through an ADSL/Cable Modem, or IP Sharing Device. By clicking the "Setup" button, you can configure your PPPoE, DHCP Client, PPTP or Static IP settings

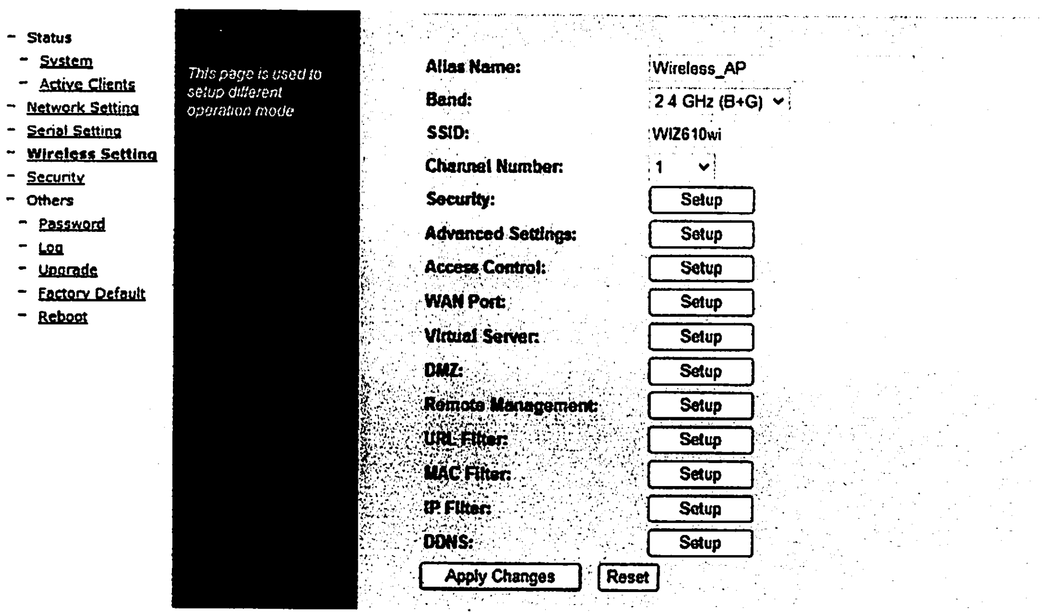


Figure 19. Gateway Setup

- **Alias Name**: Refer to "2.2.4.3 Access Point Setup".
- **Band**: Refer to "2.2.4.3 Access Point Setup".

- **SSID**: Refer to "2.2.4.3 Access Point Setup".
- **Channel Number**: Refer to "2.2.4.3 Access Point Setup".
- **Security**: Refer to "2.2.4.3 Access Point Setup".
- **Advanced Settings**: Refer to "2.2.4.3 Access Point Setup".
- **Access Control**: Refer to "2.2.4.3 Access Point Setup".
- **WAN Port** : If configures WAN port. It configures the network environment for the connection to WIZ610wi.

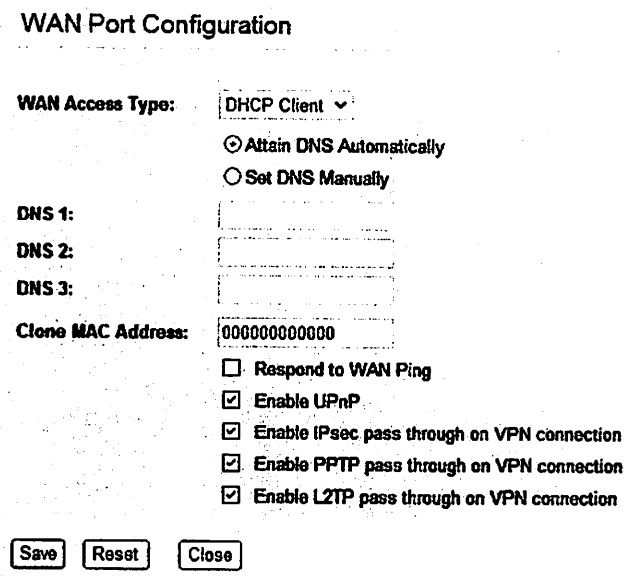


Figure 20. WAN Port Configuration

✓ **WAN Access Type**

➤ **Static IP** : Manually input your IP address, Subnet Mask, Default Gateway and DNS.

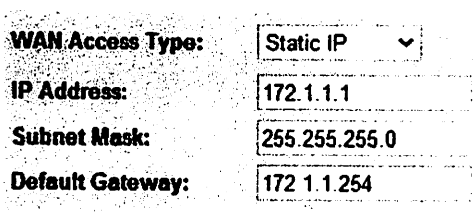


Figure 21. WAN Access Type – Static IP

➤**DHCP Client** : An IP address can be acquired from a DHCP server. The

DNS information can be automatically acquired from a DHCP server or set manually (Set DNS Manually).

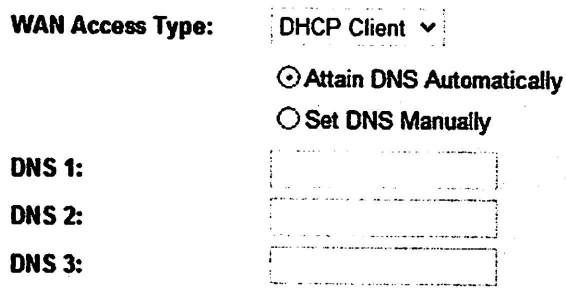


Figure 22. WAN Access Type – DHCP Client

✓ **PPTP**

➤**Virtual Server:** Virtual Server also known as Port Forwarding associates a port number with a private IP address(internal network). This technique allows clients from outside a network to access devices within the LAN (internal network).

➤**DMZ:** This feature allows one network user to be exposed to the Internet for special-purposes such as Internet gaming or videoconferencing. DMZ hosting forwards all the ports at the same time to one PC. The Port Range Forward enhances the security of your device because only a range of ports are opened for access. DHCP should be disabled in order to avoid any changes in your IP address. Static IP address is recommended when using the DMZ

➤**Remote Management** : Configure the port number for the connection to WIZ610wi from a remote site. Default Port Number is set as "8080".

➤**URL Filter:** It enables to connect or disconnect to the specified URL.

➤**MAC Filter:** Prevent access from a device with a specific MAC address

➤**IP Filter:** Prevent acess from a device with a specific IP address

➤**DDNS**(Dynamic DNS) : Once the DDNS server registers yours MAC address, your device can connect to the internet regardless of your address. DDNS service can be provided by www.no-ip.com. (You need to pay some fee). After registering some information at www.no-ip.com, input your E-mail address and password in the figure shown below. When you click the "Update" button, the status will change from"Not Connected" to "Connected"

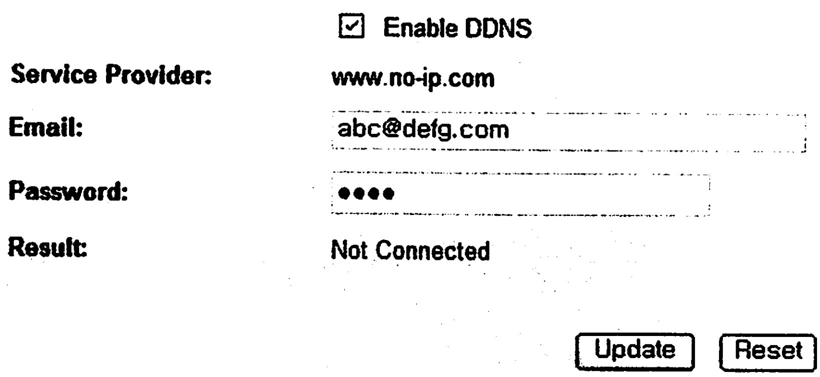


Figure 23. WAN Access Type - PPPoE

2.2.4.5. Client Setup

In client mode, WIZ610wi connects to an access point.

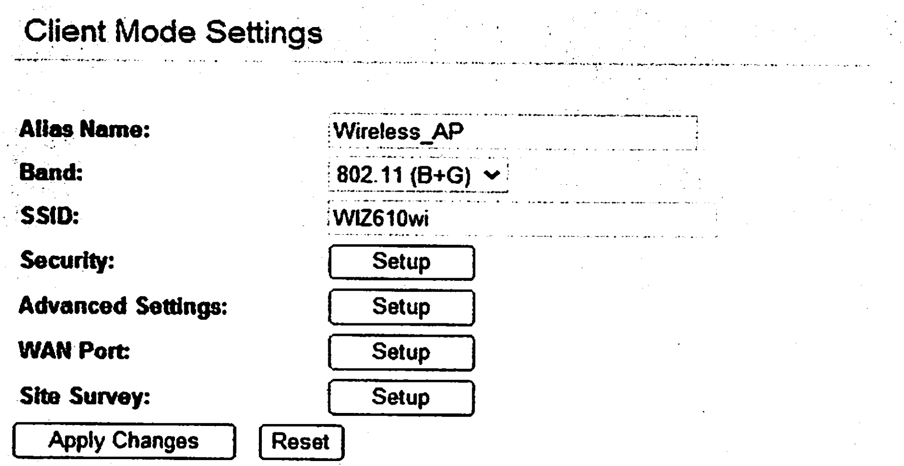
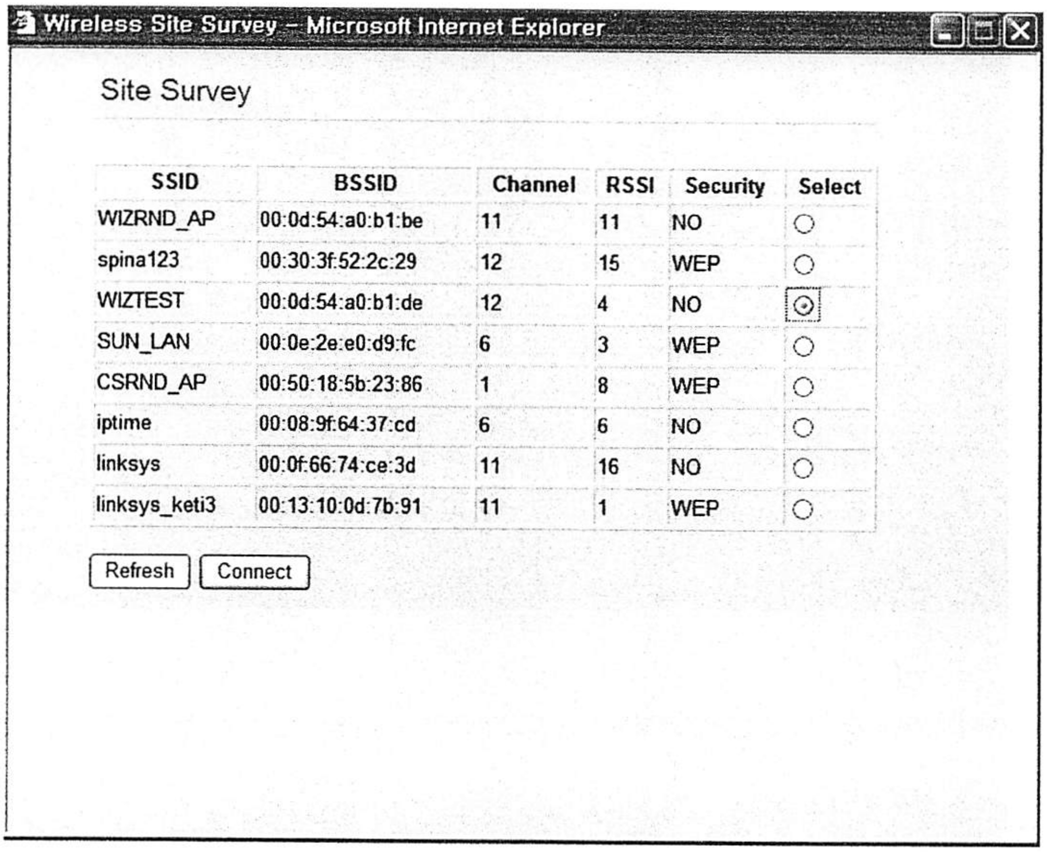


Figure 24. Client Setup

- **Alias Name**: Input the name for WIZ610wi.
- **Band**: Select a communication protocol for your module. It supports 802.11b, 802.11g and 802.11b/g mode.
- **SSID**: Input the SSID of an access point. If you don't know your SSID, you can use the "Site Survey" to search and connect to an AP.
- **Security**: Configure security settings (these should match your AP's settings)
- **Advanced Settings**: Refer to "2.2.4.3 Access Point Setup".
- **Site Survey**: If you click the "Site Survey" button, all access points near your module are listed as shown in the figure below. Please select one AP and click "Connect"

button. If PC or application device is set as DHCP Client, the AP will operates as its DHCP server and WIZ610wi doesn't act as DHCP Server. When you connect to an AP with security enabled ,the "Wireless Security Setup Page" will appear automatically to set-up your security settings. By using the "Site Survey", Band, SSID and Security can be configured all at the same time.



SSID	BSSID	Channel	RSSI	Security	Select
WIZRND_AP	00:0d:54:a0:b1:be	11	11	NO	○
spina123	00:30:3f:52:2c:29	12	15	WEP	○
WIZTEST	00:0d:54:a0:b1:de	12	4	NO	⊙
SUN_LAN	00:0e:2e:e0:d9:fc	6	3	WEP	○
CSRND_AP	00:50:18:5b:23:86	1	8	WEP	○
iptime	00:08:9f:64:37:cd	6	6	NO	○
linksys	00:0f:66:74:ce:3d	11	16	NO	○
linksys_keti3	00:13:10:0d:7b:91	11	1	WEP	○

Figure 25. Site Survey

2.2.5. Serial Setting

For the 'Serial to Wireless' communication, you can configure serial parameters.

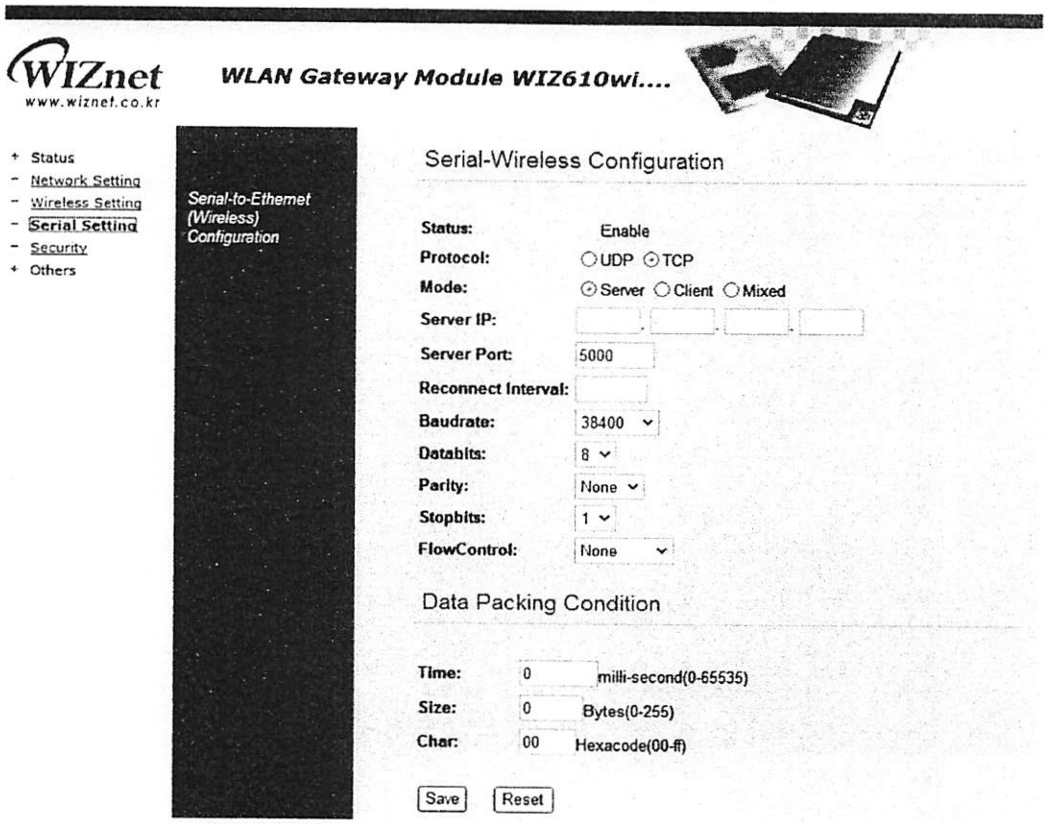


Figure 26. Serial to Ethernet Configuration

- **Status:** Check this combo box to enable serial communication
- **Mode:** Select one mode among Server, Client and Mixed.

This mode is to select the communication method based on TCP. TCP is the protocol which establishes the connection before data communication. In server mode, WIZ610wi waits for the connection from a client. In client mode, WIZ610wi operates as client at the TCP Client mode on the process of connection, and tries to connect to the server's IP and Port. Mixed modes supports both of Server and Client at the same time.

Below describes in details regarding each mode

✓ **TCP server mode**

In order to operate this mode, Local IP, Subnet, Gateway Address and Local Port Number should be configured. In monitoring applications, the server mode can be useful since it can listen for any connection from clients, and establish a connection for remote management.

1. A client connects to the WIZ610wi which is in TCP Server mode.
2. As the connection is established, data can be transmitted in both directions – from the host to the WIZ610wi, and from the WIZ610wi to the host

✓ **TCP client mode**

In TCP Client mode, your module will attempt to connect to a specified server.
In order to operate this mode, Local IP, Subnet, Gateway Address, Server IP, and Server port number should be set. If the server IP has a domain name, please use the DNS function.
1. When power is supplied, WIZ610wi board operating as TCP client mode actively establishes a connection to the server.
2. Once the connection is established, data can be transmitted in both directions – from the host to the WIZ610wi and from WIZ610wi to the host

✓ **Mixed mode**

In this mode, WIZ610wi normally operates as a TCP Server and waits for a connection request from a client. However, if WIZ610wi receives data from the serial device before connection is established, WIZ610wi changes to the client mode and sends the data to the server. Therefore, in the mixed mode, the server mode has higher priority than the client mode. Mixed mode takes advantages of both client and server mode. The client mode may be used for sending out emergency reports in an urgent situation while the server mode may be used for remote management.

- **Server IP :** Input server IP.
- **Server Port :** Input server port.
- **-Reconnect Interval:** Set the interval retrying connecting to server.
- **Baudrate:** Configure serial communication speed.

- **Databits:** Configure databits.
- **Parity:** Configure parity checking option. (option: None, Odd, Even)
- **Stopbits:** Configure stop bit option.(Option: 1, 2)
- **FlowControl:** Configure flow control option. (option: none, Xon/Xoff, RTS/CTS)
- **Data Packing Condition :**

  You can specify how the serial data can be packed to be sent to the Ethernet. There are 3 delimiters -

  time, size and character. If all of them are set as '0', whenever the serial data is arrived, they are sent to the Ethernet immediately.

- Time: This field specifies the waiting time. When there is no more input from the serial port, the module will wait for the specified time and then send out the serial data to the network. For example, if 2000 ms is specified, the module will send out the packet at 2000 ms after the last input from the serial port. If there is no data in the serial buffer, the module will not send out any data packets.

  ('0': Function Disable)

- Size: This field specifies the size limit in the serial buffer. Once the serial buffer reaches this limit, the data will be sent out to the Ethernet. If the serial buffer is greater than the size limit, the module will create an Ethernet packet and store the extra data, and send out to the Ethernet when the limit is reached again.

  ('0': Function Disable)

- Character: Register a character to trigger the conversion of serial data to network packets. Whenever the registered character is inside the serial buffer, all the data before the registered character is sent out to the network excluding the character itself. The character must be in Hexadecimal.

  ('0' : Function Disable)

If any one of these conditions is met, the data will be sent to Ethernet.

Ex) Delimiter: Size=10, Char=0x0D

Serial data : 0123456789abc

Ethernet data : 0123456789

☞ "abc" remains in the serial buffer of the module and will not be sent until the specified size or character has been fulfilled.

- **Save :** Save the configuration values.
- Reset : Discard all changes in all fields

2.2.6. Security Setup

Refer to "2.2.4.3. Access Point Setup'.

2.2.7. Others

2.2.7.1. Password

You can change the password of WIZ610wi

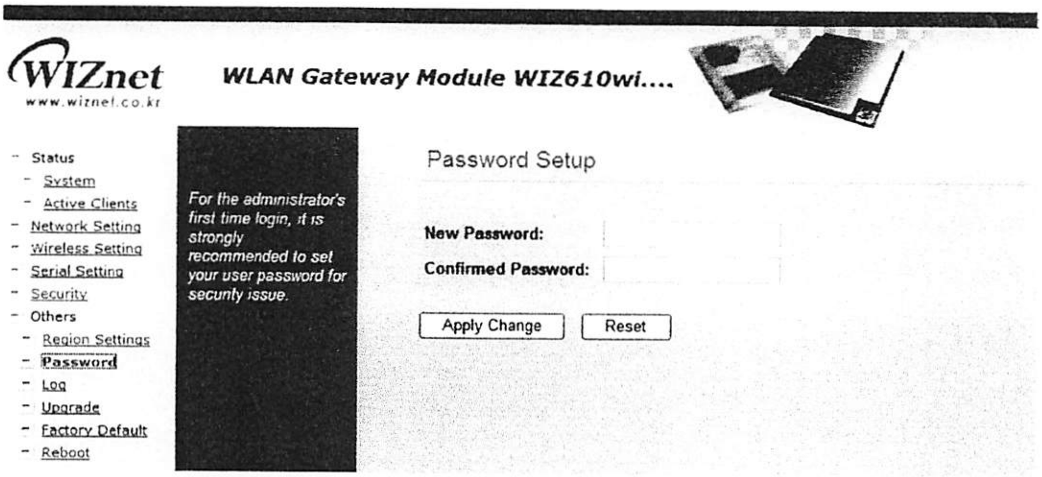


Figure 27. Password Setup

2.2.7.2. Log

The log information can be saved. In order to use this function, check the combo box "Enable Log". The log will include information such as wireless, DDNS, WAN and DHCP.

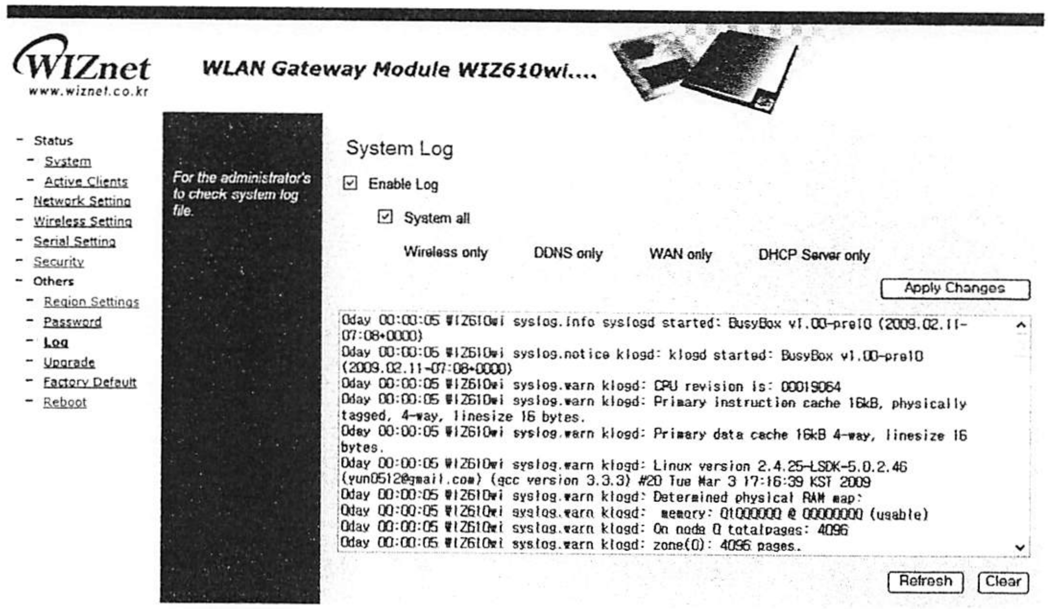


Figure 28. System Log

2.2.7.3. Upgrade

In this page, you can upgrade the firmware of your WIZ610wi.

Browse the firmware file by clicking the "Find" button. If you click "Upload" button after selecting firmware file, the firmware starts uploading. This process will take about 60 seconds.

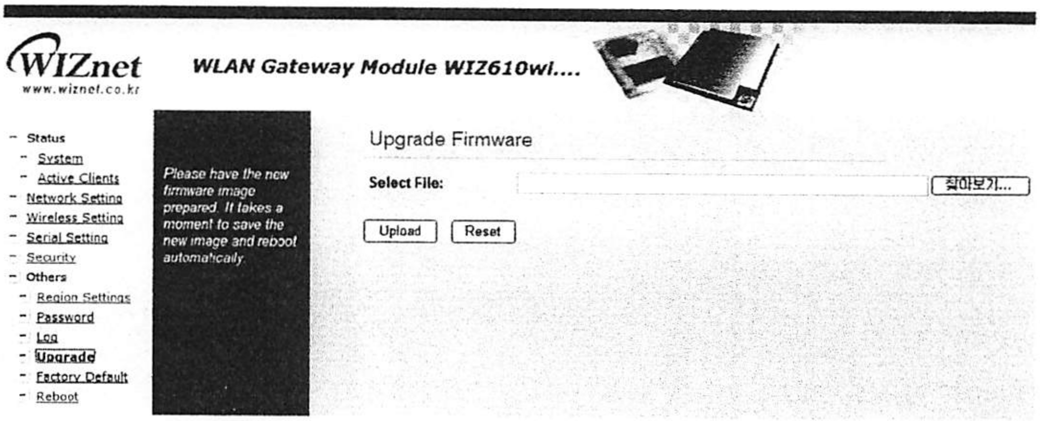


Figure 29. Upgrade Firmware

2.2.7.4 Factory Default

If you click the "Factory Default" button, all settings value are restored to the factory default setting.

The factory default values are shown below:

Field	Default Value
IP Address	192.168.1.254
Subnet Mask	255.255.255.0
Default Gateway	0.0.0.0
DHCP	Server
DHCP Client Range	192.168.1.2~192.168.1.100
DNS Server	0.0.0.0
Serial Status	Disable
Serial Mode	Server
Server IP	0.0.0.0
Server Port	5000
Baudrate	38400
Databits	8
Parity	None
Flow Control	None
Wireless Mode	AP
Alias Name	Wireless_AP
Band	2.4GHz (B +G)
SSID	WIZ610wi
Channel	1
AP Mode	AP
Authentication	Open system or Shared Key
Encryption	None
Fragment Threshold	2346
RTS Threshold	2346
Preamble Type	Long Preamble
Beacon Interval	100ms
Inactivity Time	30000ms
Broadcast SSID	Enable
WMM	Enable
Password	Admin
Log	Disable

Table 9. Factory Default Value

2.2.7.5. Reboot

In this page, you can reboot your module.

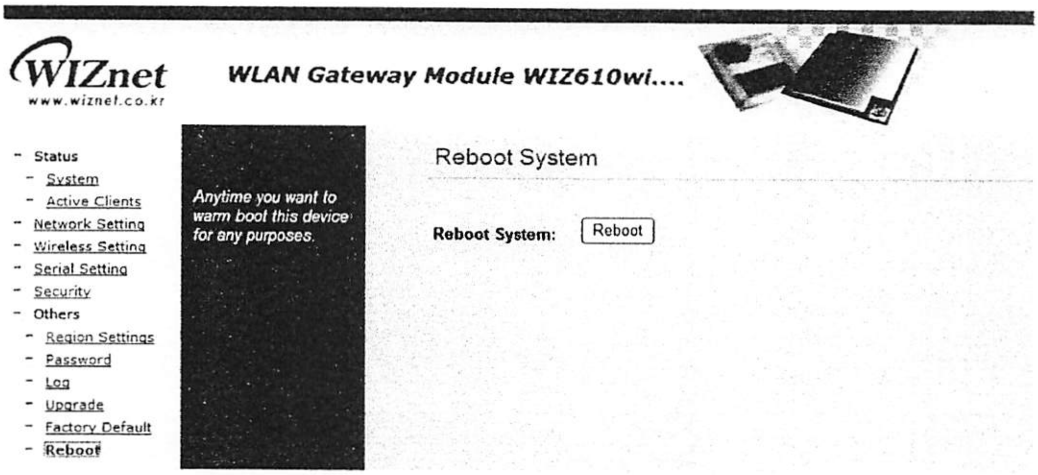


Figure 30. Reboot System

3. Pin Assignment and Module Size

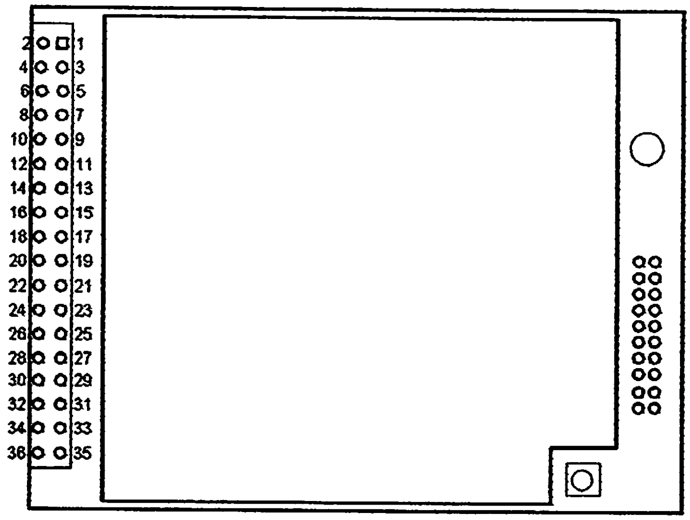


Figure 31. WIZ610WI PIN Map

No	Name	In/Out	Description
1	CTS	I	UART : CTS
2	RTS	O	UART : RTS
3	-	-	-
4	HW_Trigger	I	Low : Entering serial command mode High : Exit serial command mode
5	GPIO7	I/O	Reserved
6	GPIO5	I/O	Reserved
7	SOUT	O	UART : TXD
8	SIN	I	UART : RXD
9	DC_IN		3.3V Power
10	DC_IN		3.3V Power
11	GND		GND
12	GND		GND
13	RXERR	I	MII Receive Data Error
14	COL	I	MII collision
15	W_LED	O	Wireless LED (Active Low)
16	MDC	I	SMI Clock
17	RESET	I	Active High

			If this signal asserted more than 3 sec, factory reset performed.
18	MDIO	I/O	SMI In/Out Data
19	GND		GND
20	GND		GND
21	RXC	I	MII receive clock
22	RXDV	I	MII receive data valid
23	RXD2	I	MII receive data
24	RXD0	I	MII receive data
25	RXD1	I	MII receive data
26	RXD3	I	MII receive data
27	GND		GND
28	GND		GND
29	TXC	I	MII transmit clock
30	TXEN	O	MII transmit enable
31	TXD3	O	MII transmit data
32	TXD2	O	MII transmit data
33	TXD0	O	MII transmit data
34	TXD1	O	MII transmit data
35	GND		GND
36	CRS	I	Carrier sense

Table 10. WIZ610wi Pin Function

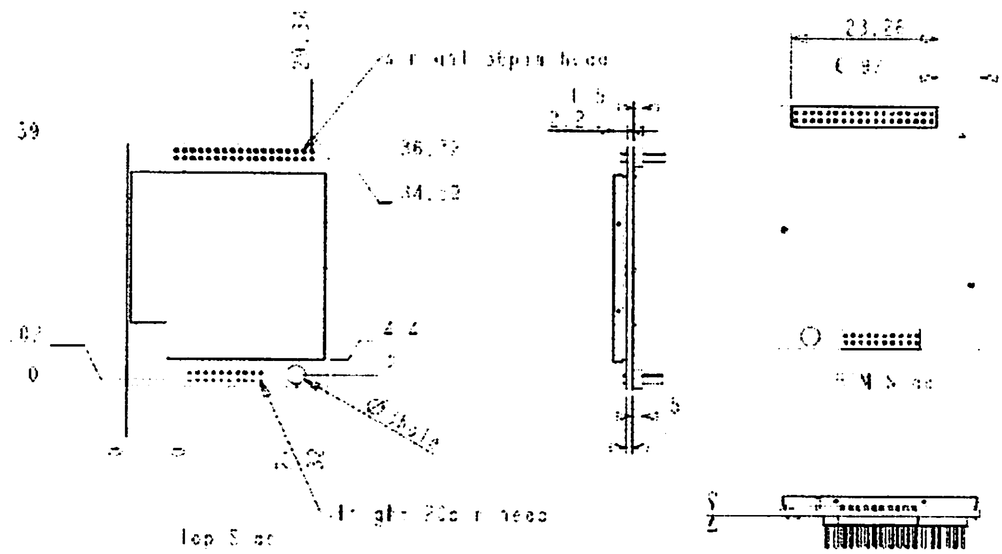


Figure 32. WIZ610WI Board Dimensions (unit : mm)

4. Demonstration and Test

In this chapter, an example is provided for you to test the functionality of WIZ610wi. The testing environments are the followings:

<Hardware>

- A PC equipped with a RS-232 serial port
- WIZ610WI module and WIZ610WI base board
- Connect PC and module's Ethernet port by using an Ethernet Cable(Direct or Crossover)
- Connect PC and module's serial port by using a serial cable

<Software>

- WIZ610WI Configuration tool
- Hyper Terminal (or any other terminal program)

STEP1.

① Connect the PC and WIZ610wi base board by using a serial cable.

② Connect the PC and WIZ610wi base board by using an Ethernet cable.

③ Turn on the power switch of WIZ610WI base board.

STEP2. (WIZ610wi Environment Setup)

① On your PC, go to the "Network Setting" and connect to your WIZ610wi in the "Wireless Network Connection".

② In your web browser, input IP address of WIZ610wi (Default : 192.168.1.254). If configuration page appears, click "Serial setup" menu and set the serial parameters.

STEP3. (Data Transmission)

① Execute terminal program at the PC. (Ex: Hyper Terminal)

Figure 34. Network Terminal Program configuration

⑤ Input any characters in the Hyper Terminal for Serial. (In the example below, "01234567890" is input). The same characters are outputted in the Hyper Terminal for Network. A Serial to Wireless LAN test was performed.

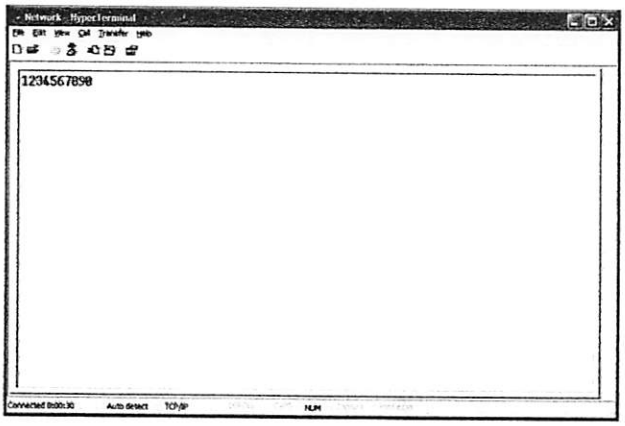


Figure 35. Received Data by Network Terminal Program

⑥ In the same way, input any character at the screen of terminal program for network, and check if same character is displayed at the screen for serial. (Ethernet to Serial)

※ The above test can also be performed in a program called, "Device Terminal program", which is easy and simple to use.

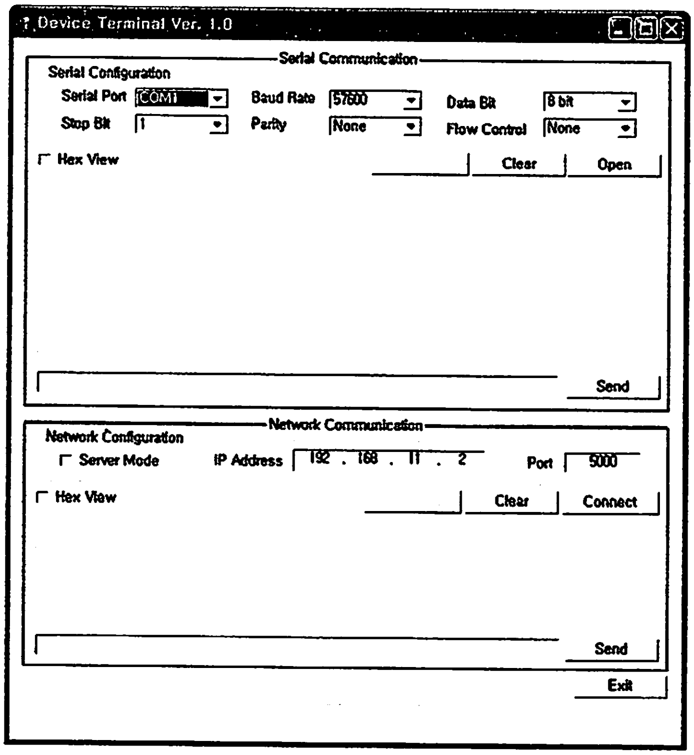


Figure 36. Device Terminal Program

Device Terminal is a program which integrates both serial and network communications into one user interface so that you can test your WIZnet gateway module easily.

As shown in above Figure, the upper part of the program allows you to configure your serial setting of WIZ610wi. By clicking the "Open" button, serial communication is enabled.

The lower part of the program allows you to configure the network settings. You can test both TCP Client and TCP Server modes at the same time. If the Server Mode is enabled, Device Terminal will operate as server mode, and the WIZ610wi module will work as client mode. The PC where the Device Terminal is operating will work as a server, the IP address of the PC should be set as Server IP of the module. If Server mode is not checked, Device Terminal will operate as client mode, and the module as server. For the IP address and port, please input your IP address and port number of WIZ610wi and click the "Connect" button to start a network communication.

When serial and network terminals are connected, input any character in the Data Input window and click "Send" button. You can check the data is transferred into the another window.

5. Serial Configuration

Serial Command Format

It is possible to configure WIZ610wi by using serial command.
By inputting specified 3 characters you can enter into the configuration mode. The characters can be set via Web browser.

< Frame Format >

Command Frame format

Descriptor	STX	Command code	Parameter	ETX
Length(bytes)	1	2	Variable	1

Table 11. Serial Configuration Frame format

Reply Frame format

Descriptor	STX	Reply code	Parameter	ETX
Length(bytes)	1	1	Variable	1

Table 12. Serial Configuration Reply Frame format

STX & ETX

Setting	Comments
STX	'<' : Hex = 3Ch
ETX	'>' : Hex = 3Eh

Table 13. Serial Configuration STX & ETX

Reply Code

Reply	Comments
S	Command was successful
F	Command failed

0	Invalid STX
1	Invalid command
2	Invalid parameter
3	Invalid ETX
E	Enter Serial Command Mode

Table 14. Serial Configuration Reply Code

Command Code

Com mand	Get/ Set	Comments	Parameter	Time
Network				
RF	Get	Firmware Version	vx.x.x	1
RA	Get	MAC Address	0:Ethernet MAC address, 1:Wireless MAC address, <0xx.xx.xx.xx.xx.xx_1xx.xx.xx.xx.xx.xx>	1
RI	Get	IP Address	<Sxxx.xxx.xxx.xxx>	1
WI	Set	IP Address	<xxx.xxx.xxx.xxx>	2
RS	Get	Subnet Mask	<Sxxx.xxx.xxx.xxx>	1
WS	Set	Subnet Mask	<xxx.xxx.xxx.xxx>	2
RG	Get	Gateway	<Sxxx.xxx.xxx.xxx>	1
WG	Set	Gateway	<xxx.xxx.xxx.xxx>	2
RD	Get	DHCP Server	1:Enable, 0:Disable <Sx>	1
WD	Set	DHCP Server	1:Enable, 0:Disable <x>	2
RH	Get	DHCP Start/End IP	Start address_End address <Sxxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx>	1
WH	Set	DHCP Start/End IP	Start address_End address <xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx>	3
DL	Get	Wireless Active Client List	MAC address_Channel_TxRate_RSSI <Sxxxxxxxxxxxx_xx_xx_xx[:xxxxxxxxxxxx_xx_xx_xx...]>	1

RL	Get	DHCP Client List	<IP address_MAC address> <Sxxx.xxx.xxx.xxx_xxxxxxxxxxxx[:xxx.xxx.xxx.xxx_xxxxxxxxxxxx:...] >	1
WV	Set	DNS Server	1:Enable, 0:Disable <1:xxx.xxx.xxx.xxx[_xx.xx.xx.xx]> or<0>	1
RV	Get	DNS Server	1:Enable, 0:Disable_DNS Server IP address <Sx_xxx.xxx.xxx.xxx[_xx.xx.xx.xx]> or<0>	1
RT	Get	WAN Port	0:Static, 1:DHCP Client, 2:PPPoE, 3:PPTP -Static: 0_Ipaddress_Subnet_Gateway_DNS <S0_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.x xx> -DHCP Client: 1_IPaddress_Subnet_Gateway <S1_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx> PPPoE: 2_UserName_Password <S2_User Name_Password> -PPTP: 3_IP_Subnet_Gateway_ServerIP_UserName_ Password <S3_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.x xx_UserName_Password>	2
WT	Set	WAN Port	0:Static, 1:DHCP Client, 2:PPPoE, 3:PPTP -Static: 0_Ipaddress_Subnet_Gateway_DNS <0_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xx x> -DHCP Client: 1 <1> PPPoE: 2_UserName_Password <2_User Name_Password> -PPTP: 3_IP_Subnet_Gateway_ServerIP_UserName_ Password <3_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xxx_xxx.xxx.xxx.xx x_UserName_Password>	1
Wireless				
DB	Get	Wireless Band	0: 11b+g, 2: 11b, 3:11g, 6: n, 9:b+g+n <Sx>	1
GB	Set	Wireless	0: 11b+g, 2: 11b, 3:11g, 6: n, 9:b+g+n	20

		Band	<x>	
DO	Get	Operation Mode	0:AP, 1:Gateway, 2: AP+WDS, 3:Client <Sx>	1
GO	Set	Operation Mode	0:AP, 1:Gateway, 2: AP+WDS, 3:Client <x>	45
DS	Get	SSID	1~32 chars <Sxxxx~>	1
GS	Set	SSID	1~32 chars <xxxx~>	1
DC	Get	Channel	Auto_0, 1~13 <Sx>	1
GC	Set	Channel	Auto_0, 1~13 <x>	2
DW	Get	WDS	1:Master,2:Slave, _count_MACaddress_Comment[_MACaddress_Comment_..] <Sx_x_xxxxxxxxxxxx_xxx~>	1
GW	Set	WDS	1:Master, 2:Slave_1:add, 2:delete_count_MACaddress_Comment[_MACaddress_Comment_..] <x_x_x_xxxxxxxxxxxx_xxx~>	1
DP	Get	Tx Power	0: off, 1-16: power(dBm), <Sxx>	1
GP	Set	Tx Power	0: off, 1-16: power(dBm), <xx>	2
DR	Get	Data Rate	<Sxx>	1
GR	Set	Data Rate	<xx>	3
DH	Get	Broadcast SSID	0:Enable, 1:Disable <Sx>	1
GH	Set	Broadcast SSID	0:Enable, 1:Disable <x>	1
DM	Get	WMM	1:Enable, 0:Disable <Sx>	1
GM	Set	WMM	1:Enable, 0:Disable <x>	1

DA	Get	MAC Access Control	0:Disable,1:AllowListed,2:DenyListed[_count[_MACaddress_Comment]] <Sx_x_xxxxxxxxxxxx_xxx~>	1
GA	Set	MAC Access Control	0:Disable,1:AllowListed,2:DenyListed[_1:add,2:delete_count_MACaddress_Comment] <x_x_x_xxxxxxxxxxxx_xxx~>	5
DI	Get	Site Survey	SSID_BSSID_Channel_RSSI_Security <Sxxxx_xxxxxxxxxxxx_xx_xx_x>	15
DN	Get	Alias Name	Alias Name <Sxxx>	1
GN	Set	Alias Name	Alias Name, Max Length: 29bytes <xxx>	1
QP	Get	Module Status Checking	connection status_SSID_BSSID_CHAN_RATE_RSSI Conn_status: '0' is not connected, '1' is connected. <Sx_xxxx_xxxxxxxxxxxx_xx_xxM_xx>	2
Security				
DU	Get	Security Status	AuthMode_Encrypt[_KeyLength_KeyFormat_KeyValue_radiusPasswd_radiusIP_radiusPort] AuthMode: 0(Open or Shared), 1(Open), 2(802.1x), 3(Shared), 4(WPA), 5(WPA-PSK), 6(WPA2), 7(WPA2-PSK), Encrypt: 0(None),1 (WEP), 2(TKIP), 3(AES), 4(TKIP_AES) KeyLength: 0(None), 1(WEP64), 2(WEP128) KeyFormat(WEP): 0(Ascii), 1(Hex) KeyFormat(WPA-PSK): 0(Passphrase), 1(Hex) <Sx_x_x_x_x_x_x_x>	1
GU	Set	Security Control	AuthMode_Encrypt[_KeyLength_KeyFormat_KeyValue_radiusPasswd_radiusIP_radiusPort] AuthMode: 0(Open or Shared), 1(Open), 2(802.1x), 3(Shared), 4(WPA), 5(WPA-PSK), 6(WPA2), 7(WPA2-PSK), Encrypt: 0(None),1 (WEP), 2(TKIP), 3(AES), 4(TKIP_AES) KeyLength: 0(None), 1(WEP64), 2(WEP128) KeyFormat(WEP): 0(Ascii), 1(Hex) KeyFormat(WPA-PSK): 0(Passphrase), 1(Hex) (WPA-PSK KeyValue: 8~63byte) <x_x_x_x_x_x_x_x>	30

Serial				
RK	Get	Protocol	TCP_0, UDP_1 <Sx>	2
WK	Set	Protocol	TCP_0, UDP_1 <x>	1
RM	Get	Mode	0:Client, 1:Mixed, 2:Server <Sx>	2
WM	Set	Mode	0:Client, 1:Mixed, 2:Server <x>	1
RX	Get	Server IP	Server IP address <Sxxx.xxx.xxx.xxx>	1
WX	Set	Server IP	Server IP address <xxx.xxx.xxx.xxx>	2
RP	Get	Port	0~65535 <Sxxxxx>	1
WP	Set	Port	0~65535 <xxxxx>	1
RB	Get	Baudrate_DataBit_Parity_Flow_Stopbits	eg. [Baudrate]1: 115200, 2: 57600, 3: 38400, 4: 19200, 5: 9600, 6: 4800, 7: 2400,8: 1200 [data byte] 7: 7bit, 8: 8bit [parity] 0: no parity, 1: Odd, 2: Even [Flow] 0: no, 1: Xon/Xoff, 2: RTS/CTS [Stopbits]; 1: 1stop, 2:2stop <Sxxxxx>	2
WB	Set	Baudrate_DataBit_Parity_Flow_Stopbits	eg. [Baudrate]1: 115200, 2: 57600, 3: 38400, 4: 19200, 5: 9600, 6: 4800, 7: 2400,8: 1200 [data byte] 7: 7bit, 9: 8bit [parity] 0: no parity, 1: Odd, 2: Even [Flow] 0: no, 1: Xon/Xoff, 2: RTS/CTS [Stopbits]; 1: 1stop, 2:2stop <xxxxx>	5
QT	Get	Time	0~65535 <Sxxxxx>	1

OT	Set	Time	0~65535 <xxxxx>	1
QS	Get	Size	0~255 <Sxxx>	1
OS	Set	Size	0~255 <Sxxx>	1
QC	Get	Char	00~ff <Sxx>	1
OC	Set	Char	00~ff <xx>	1
QI	Get	Inactivity Time	00~60 <Sxx>	1
OI	Set	Inactivity Time	00~60 <xx>	1
RC	Get	Connection Status (Server:Client)	0: Not Connect, 1:Connect <Sx>	1
Others				
WF	Set	Factory Default	<WF>	55
WR	Set	Restart	<WR>	55

error code	S	<S> or <Sxx...>	Commend is successfully applied
	F	<F>	Failed to apply
	0	<0>	"<" is wrong
	1	<1>	There is not in command list
	2	<2>	Wrong Parameter factor
	3	<3>	">" is wrong
	4	<4>	Do not work in current mode
	5	<5>	No more add list. -Limit-

			*WDS: 4 list *ACL: 16 list

Notice	If input "_" in fact, should input"__" instead of "_". For example SSID, PSK etc. <DS> --> <S11__22>: SSID: 11_22 <GS11_22> --> <S>: SSID: 11_22 <QP> --> <S1_11__22_000102030405_...>: SSID: 11_22
	If multi command input, response time be delayed For example DA, GA, DW, GW
	Security Available mode **AP/GW Mode** AuthMode: 0-7 EncryptType: 0-3 **Client Mode** AuthMode: 1,3,5,7 EncryptType: 0,1,4

Security Example parameter
<GU5_2_0_0_12345678>
<GU4_2_0_0_12345678_abcd_192.168.123.111_1812>

6. Reference Schematics

In this chapter, the reference schematics are provided for the WIZ610wi's MII & UART interfaces.

6.1 WIZ610wi Module Pin assign

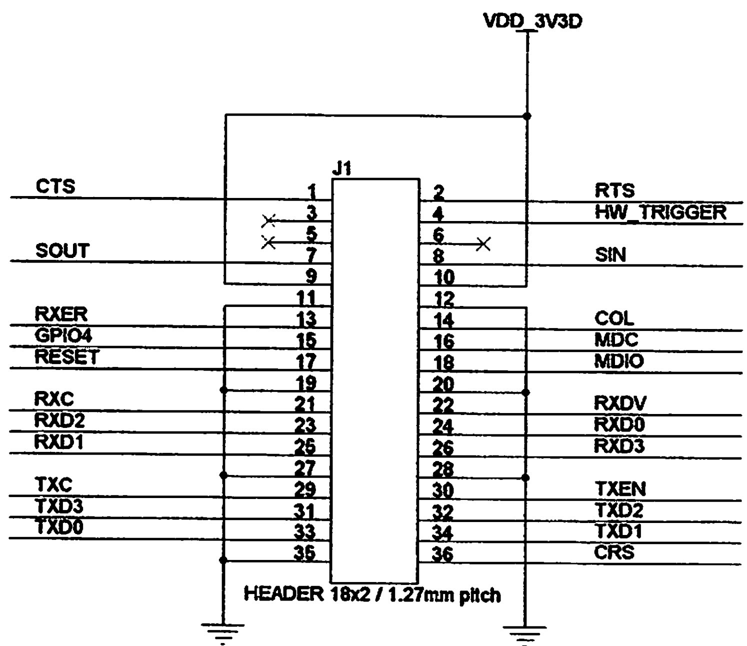


Figure 37. WIZ610wi Module Pin Assignment

MII interface signal			
TXD[0..3]	MII transmit data	TXEN	MII transmit enable
TXC	MII transmit clock	RXDV	MII receive data valid
RXD[0..3]	MII receive data	RXC	MII receive clock
COL	MII collision	CRS	MII Carrier sense
RXER	MII Receive Data Error		

UART interface signal			
SIN	RS-232C RXD	SOUT	RS-232C TXD
CTS	RS-232C CTS	RTS	RS-232C RTS

Table 15. WIZ610wi Pin Assignment

6.2 External PHY interface using MII

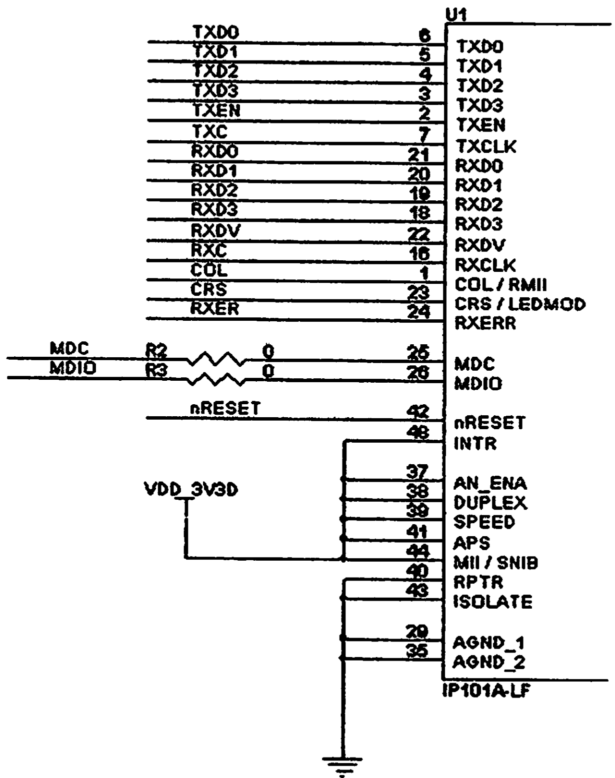


Figure 38. Schematic - External PHY Interface using MII

As shown in the above schematic, each MII interface signal of WIZ610wi can be connected to MII interface by using an external PHY chip.

6.3 RS-232C interface

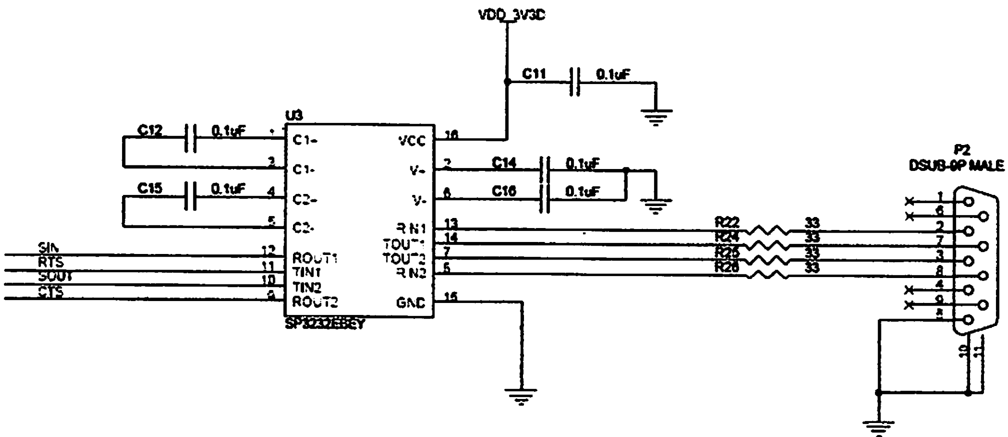
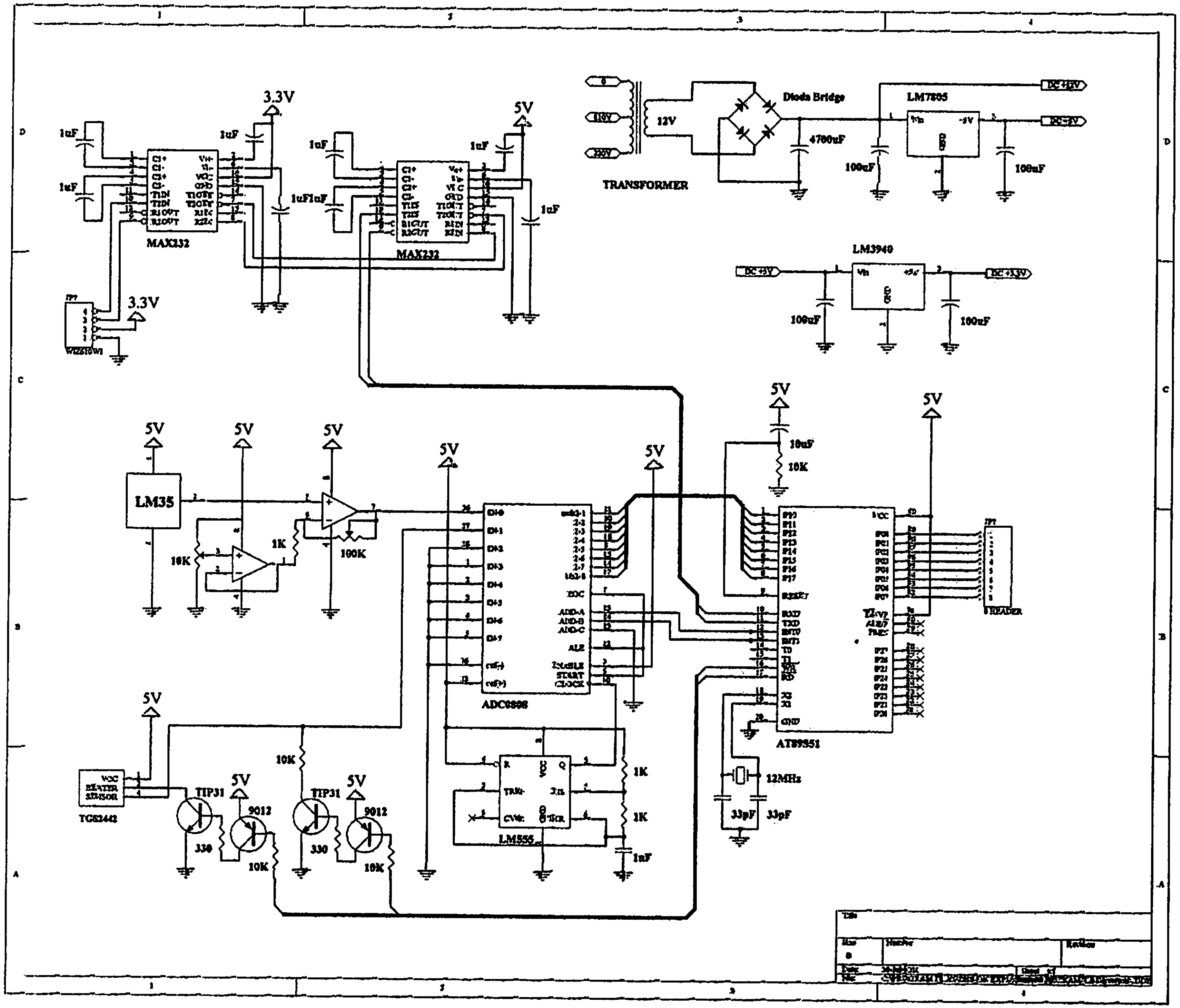


Figure 39. Schematic – RS-232C Interface

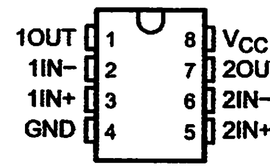
As shown above diagram, each UART interface signal can be connected to the interface of RS-232C transceiver chip. (e.g. Sipex's SP3232EBEY RS-232C Transceiver chip)



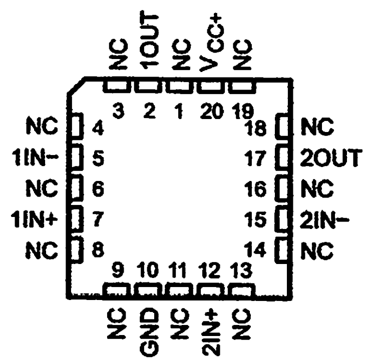
MAX232
MAX232
3.3V
5V
1uF
TRANSFORMER
12V
Diode Bridge
4700uF
LM7805
100uF
LM3940
DC +5V
DC +3.3V
WIZ810MJ
LM35
10K
1K
100K
ADC0808
AT89S51
10uF
12MHz
33pF
HEADER
TGS2442
HEATER
SENSOR
TIP31
9012
330
LM555
Title
Size
Number
Revision
Date
File
Sheet

- **Wide Supply Range:**
  - **Single Supply . . . 3 V to 32 V (26 V for LM2904)**
  - **or Dual Supplies . . . ±1.5 V to ±16 V (±13 V for LM2904)**
- **Low Supply-Current Drain, Independent of Supply Voltage . . . 0.7 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground**
- **Low Input Bias and Offset Parameters:**
  - **Input Offset Voltage . . . 3 mV Typ**
    A Versions . . . 2 mV Typ
  - **Input Offset Current . . . 2 nA Typ**
  - **Input Bias Current . . . 20 nA Typ**
    A Versions . . . 15 nA Typ
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . . 32 V (26 V for LM2904)**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

LM158, LM158A . . . JG PACKAGE
LM258, LM258A . . . D, DGK, OR P PACKAGE
LM358 . . . D, DGK, P, PS, OR PW PACKAGE
LM358A . . . D, DGK, P, OR PW PACKAGE
LM2904 . . . D, DGK, P, PS, OR PW PACKAGE
(TOP VIEW)



LM158, LM158A . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

description/ordering information

These devices consist of two independent, high-gain, frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 32 V (3 V to 26 V for the LM2904), and V_{CC} is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be implemented more easily in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5-V supply used in digital systems and easily can provide the required interface electronics without additional ±5-V supplies.

lescription/ordering information (continued)

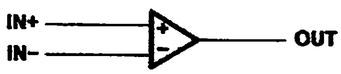
ORDERING INFORMATION

T_A	V_{IO}max AT 25°C	MAX TESTED V_{CC}	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	7 mV	30 V	PDIP (P)	Tube of 50	LM358P	LM358P
			SOIC (D)	Tube of 75	LM358D	LM358
				Reel of 2500	LM358DR	
			SOP (PS)	Reel of 2000	LM358PSR	L358
			TSSOP (PW)	Tube of 150	LM358PW	L358
				Reel of 2000	LM358PWR	
			MSOP/VSSOP (DGK)	Reel of 2500	LM358DGKR	M5_‡
	3 mV	30 V	PDIP (P)	Tube of 50	LM358AP	LM358AP
			SOIC (D)	Tube of 75	LM358AD	LM358A
				Reel of 2500	LM358ADR	
			TSSOP (PW)	Tube of 150	LM358APW	L358A
				Reel of 2000	LM358APWR	
			MSOP/VSSOP (DGK)	Reel of 2500	LM358ADGKR	M6_‡
−25°C to 85°C	5 mV	30 V	PDIP (P)	Tube of 50	LM258P	LM258P
			SOIC (D)	Tube of 75	LM258D	LM258
				Reel of 2500	LM258DR	
			MSOP/VSSOP (DGK)	Reel of 2500	LM258DGKR	M2_‡
	3 mV	30 V	PDIP (P)	Tube of 50	LM258AP	LM258AP
			SOIC (D)	Tube of 75	LM258AD	LM258A
				Reel of 2500	LM258ADR	
			MSOP/VSSOP (DGK)	Reel of 2500	LM258ADGKR	M3_‡
−40°C to 125°C	7 mV	26 V	PDIP (P)	Tube of 50	LM2904P	LM2904P
			SOIC (D)	Tube of 75	LM2904D	LM2904
				Reel of 2500	LM2904DR	
			SOP (PS)	Reel of 2000	LM2904PSR	L2904
			TSSOP (PW)	Tube of 150	LM2904PW	L2904
				Reel of 2000	LM2904PWR	
			MSOP/VSSOP (DGK)	Reel of 2500	LM2904DGKR	MB_‡
	7 mV	32 V	SOIC (D)	Reel of 2500	LM2904VQDR	L2904V
			TSSOP (PW)	Reel of 2000	LM2904VQPWR	L2904V
	2 mV	32 V	SOIC (D)	Reel of 2500	LM2904AVQDR	L2904AV
			TSSOP (PW)	Reel of 2000	LM2904AVQPWR	L2904AV
−55°C to 125°C	5 mV	30 V	CDIP (JG)	Tube of 50	LM158JG	LM158JG
			LCCC (FK)	Tube of 55	LM158FK	LM158FK
	2 mV	30 V	CDIP (JG)	Tube of 50	LM158AJG	LM158AJG
			LCCC (FK)	Tube of 55	LM158AFK	LM158AFK

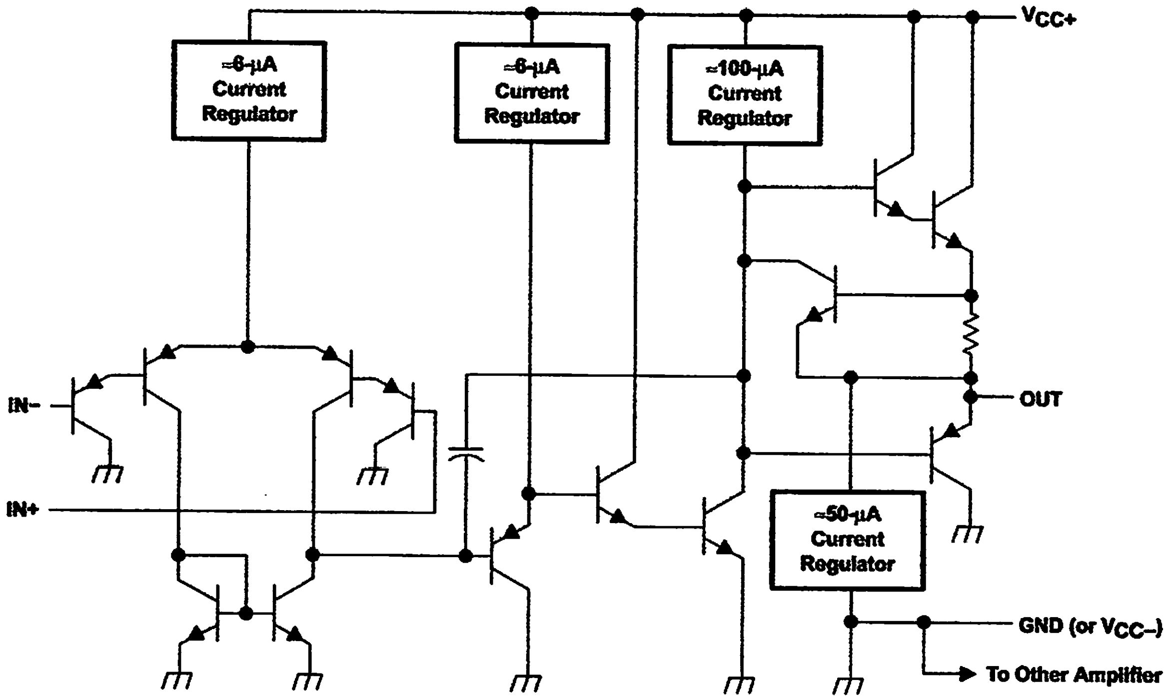
† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

‡ The actual top-side marking has one additional character that designates the assembly/test site.

symbol (each amplifier)



schematic (each amplifier)



COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	7
Transistors	51
Capacitors	2

ıbsolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

		LM158, LM158A LM258, LM258A LM358, LM358A LM2904V	LM2904	UNIT
Supply voltage, V_{CC} (see Note 1)		±16 or 32	±13 or 26	V
Differential input voltage, V_{ID} (see Note 2)		±32	±26	V
Input voltage, V_I (either input)		−0.3 to 32	−0.3 to 26	V
Duration of output short circuit (one amplifier) to ground at (or below) 25°C free-air temperature ($V_{CC} \leq 15$ V) (see Note 3)		Unlimited	Unlimited	
Package thermal impedance, θ_{JA} (see Notes 4 and 5)	D package	97	97	°C/W
	DGK package	172	172	
	P package	85	85	
	PS package	95	95	
	PW package	149	149	
Package thermal impedance, θ_{JC} (see Notes 6 and 7)	FK package	5.61		°C/W
	JG package	14.5		
Operating free-air temperature range, T_A	LM158, LM158A	−55 to 125		°C
	LM258, LM258A	−25 to 85		
	LM358, LM358A	0 to 70		
	LM2904	−40 to 125	−40 to 125	
Operating virtual junction temperature, T_J		150	150	°C
Case temperature for 60 seconds	FK package	260		°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	JG package	300	300	°C
Storage temperature range, T_{stg}		−65 to 150	−65 to 150	°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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

IOTES: 1. All voltage values, except differential voltages and V_{CC} specified for measurement of I_{OS}, are with respect to the network ground terminal.
2. Differential voltages are at IN+ with respect to IN−.
3. Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
4. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
5. The package thermal impedance is calculated in accordance with JESD 51-7.
6. Maximum power dissipation is a function of T_J(max), θ_{JC}, and T_C. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_J(max) - T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
7. The package thermal impedance is calculated in accordance with MIL-STD-883.

electrical characteristics at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	T_A‡	LM158, LM258 MIN	LM158, LM258 TYP§	LM158, LM258 MAX	LM358 MIN	LM358 TYP§	LM358 MAX	UNIT
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX, V_{IC} = $V_{ICR(min)}$, V_O = 1.4 V	25°C		3	5		3	7	mV
			Full range			7			9	
$\alpha_{V_{IO}}$	Average temperature coefficient of input offset voltage		Full range		7			7		µV/°C
I_{IO}	Input offset current	V_O = 1.4 V	25°C		2	30		2	50	nA
			Full range			100			150	
$\alpha_{I_{IO}}$	Average temperature coefficient of input offset current		Full range		10			10		pA/°C
I_{IB}	Input bias current	V_O = 1.4 V	25°C		–20	–150		–20	–250	nA
			Full range			–300			–500	
V_{ICR}	Common-mode input voltage range	V_{CC} = 5 V to MAX	25°C	0 to V_{CC} – 1.5			0 to V_{CC} – 1.5			V
			Full range	0 to V_{CC} – 2			0 to V_{CC} – 2			
V_{OH}	High-level output voltage	R_L ≥ 2 kΩ	25°C	V_{CC} – 1.5			V_{CC} – 1.5			V
		R_L ≥ 10 kΩ	25°C							
		V_{CC} = MAX, R_L = 2 kΩ	Full range	26			26			
		V_{CC} = MAX, R_L ≥ 10 kΩ	Full range	27	28		27	28		
V_{OL}	Low-level output voltage	R_L ≤ 10 kΩ	Full range		5	20		5	20	mV
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, R_L ≥ 2 kΩ	25°C	50	100		25	100		V/mV
			Full range	25			15			
CMRR	Common-mode rejection ratio	V_{CC} = 5 V to MAX, V_{IC} = $V_{ICR(min)}$	25°C	70	80		65	80		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	V_{CC} = 5 V to MAX	25°C	65	100		65	100		dB
V_{O1}/V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz	25°C		120			120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0, Source	25°C	–20	–30		–20	–30		mA
			Full range	–10			–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V, Sink	25°C	10	20		10	20		
			Full range	5			5			
I_O	Output current	V_{ID} = –1 V, V_O = 200 mV	25°C	12	30		12	30		µA
I_{OS}	Short-circuit output current	V_{CC} at 5 V, GND at –5 V, V_O = 0	25°C		±40	±60		±40	±60	mA
I_{CC}	Supply current (two amplifiers)	V_O = 2.5 V, No load	Full range		0.7	1.2		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5 V, No load	Full range		1	2		1	2	

† All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for the LM2904 and 30 V for others.
‡ Full range is –55°C to 125°C for LM158, –25°C to 85°C for LM258, 0°C to 70°C for LM358, and –40°C to 125°C for LM2904.
§ All typical values are at T_A = 25°C.

Electrical characteristics at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		T_A‡	LM2904 MIN	LM2904 TYP§	LM2904 MAX	UNIT
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX, $V_{IC} = V_{ICR(min)}$, V_O = 1.4 V	Non-A devices	25°C		3	7	mV
				Full range			10	
			A-suffix devices	25°C		1	2	
				Full range			4	
$\alpha_{V_{IO}}$	Average temperature coefficient of input offset voltage			Full range		7		µV/°C
I_{IO}	Input offset current	V_O = 1.4 V	Non-V device	25°C		2	50	nA
				Full range			300	
			V-suffix device	25°C		2	50	
				Full range			150	
$\alpha_{I_{IO}}$	Average temperature coefficient of input offset current			Full range		10		pA/°C
I_{IB}	Input bias current	V_O = 1.4 V		25°C		−20	−250	nA
				Full range			−500	
V_{ICR}	Common-mode input voltage range	V_{CC} = 5 V to MAX		25°C	0 to V_{CC} − 1.5			V
				Full range	0 to V_{CC} − 2			
V_{OH}	High-level output voltage	$R_L \geq 10\ k\Omega$		25°C	V_{CC} − 1.5			V
		V_{CC} = MAX, Non-V device	$R_L = 2\ k\Omega$	Full range	22			
			$R_L \geq 10\ k\Omega$	Full range	23	24		
		V_{CC} = MAX, V-suffix device	$R_L = 2\ k\Omega$	Full range	26			
			$R_L \geq 10\ k\Omega$	Full range	27	28		
V_{OL}	Low-level output voltage	$R_L \leq 10\ k\Omega$		Full range		5	20	mV
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, $R_L \geq 2\ k\Omega$		25°C	25	100		V/mV
				Full range	15			
CMRR	Common-mode rejection ratio	V_{CC} = 5 V to MAX, $V_{IC} = V_{ICR(min)}$	Non-V device	25°C	50	80		dB
			V-suffix device	25°C	65	80		
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	V_{CC} = 5 V to MAX		25°C	65	100		dB
V_{O1}/V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz		25°C		120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0	Source	25°C	−20	−30		mA
				Full range	−10			mA
		V_{CC} = 15 V, V_{ID} = −1 V, V_O = 15 V	Sink	25°C	10	20		mA
				Full range	5			mA
		V_{ID} = −1 V, V_O = 200 mV	Non-V device	25°C		30		µA
			V-suffix device	25°C	12	40		
I_{OS}	Short-circuit output current	V_{CC} at 5 V, GND at −5 V, V_O = 0		25°C		±40	±60	mA
I_{CC}	Supply current (two amplifiers)	V_O = 2.5 V, No load		Full range		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5 V, No load		Full range		1	2	

† All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for the LM2904, 32 V for the LM2904V, and 30 V for others.
‡ Full range is −55°C to 125°C for LM158, −25°C to 85°C for LM258, 0°C to 70°C for LM358, and −40°C to 125°C for LM2904.
§ All typical values are at T_A = 25°C.

electrical characteristics at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	T_A‡	LM158A			LM258A			UNIT
				MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, V_{IC} = $V_{ICR(min)}$, V_O = 1.4 V	25°C			2		2	3	mV
			Full range			4			4	
$\alpha_{V_{IO}}$	Average temperature coefficient of input offset voltage		Full range		7	15*		7	15	µV/°C
I_{IO}	Input offset current	V_O = 1.4 V	25°C		2	10		2	15	nA
			Full range			30			30	
$\alpha_{I_{IO}}$	Average temperature coefficient of input offset current		Full range		10	200		10	200	pA/°C
I_{IB}	Input bias current	V_O = 1.4 V	25°C		−15	−50		−15	−80	nA
			Full range			−100			−100	
V_{ICR}	Common-mode input voltage range	V_{CC} = 30 V	25°C	0 to V_{CC} − 1.5			0 to V_{CC} − 1.5			V
			Full range	0 to V_{CC} − 2			0 to V_{CC} − 2			
V_{OH}	High-level output voltage	R_L ≥ 2 kΩ	25°C	V_{CC} − 1.5			V_{CC} − 1.5			V
		V_{CC} = 30 V, R_L = 2 kΩ	Full range	26			26			
		V_{CC} = 30 V, R_L ≥ 10 kΩ	Full range	27	28		27	28		
V_{OL}	Low-level output voltage	R_L ≤ 10 kΩ	Full range		5	20		5	20	mV
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, R_L ≥ 2 kΩ	25°C	50	100		50	100		V/mV
			Full range	25			25			
CMRR	Common-mode rejection ratio		25°C	70	80		70	80		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)		25°C	65	100		65	100		dB
V_{O1}/V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz	25°C		120			120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0, Source	25°C	−20	−30	−60	−20	−30	−60	mA
			Full range	−10			−10			
		V_{CC} = 15 V, V_{ID} = −1 V, V_O = 15, Sink	25°C	10	20		10	20		
			Full range	5			5			
		V_{ID} = −1 V, V_O = 200 mV	25°C	12	30		12	30		µA
I_{OS}	Short-circuit output current	V_{CC} at 5 V, GND at −5 V, V_O = 0	25°C		±40	±60		±40	±60	mA
I_{CC}	Supply current (two amplifiers)	V_O = 2.5 V, No load	Full range		0.7	1.2		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5 V, No load	Full range		1	2		1	2	

*On products compliant to MIL-PRF-38535, this parameter is not production tested.
† All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for LM2904 and 30 V for others.
‡ Full range is −55°C to 125°C for LM158A, −25°C to 85°C for LM258A, and 0°C to 70°C for LM358A.
§ All typical values are at T_A = 25°C.

lectrical characteristics at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		T_A‡	LM358A MIN	LM358A TYP§	LM358A MAX	UNIT
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, V_{IC} = $V_{ICR(min)}$, V_O = 1.4 V		25°C		2	3	mV
				Full range			5	
$\alpha_{V_{IO}}$	Average temperature coefficient of input offset voltage			Full range		7	20	µV/°C
I_{IO}	Input offset current	V_O = 1.4 V		25°C		2	30	nA
				Full range			75	
$\alpha_{I_{IO}}$	Average temperature coefficient of input offset current			Full range		10	300	pA/°C
I_{IB}	Input bias current	V_O = 1.4 V		25°C		−15	−100	nA
				Full range			−200	
V_{ICR}	Common-mode input voltage range	V_{CC} = 30 V		25°C	0 to V_{CC} − 1.5			V
				Full range	0 to V_{CC} − 2			
V_{OH}	High-level output voltage	$R_L \geq 2$ kΩ		25°C	V_{CC} − 1.5			V
		V_{CC} = 30 V	R_L = 2 kΩ	Full range	26			
			$R_L \geq 10$ kΩ	Full range	27	28		
V_{OL}	Low-level output voltage	$R_L \leq 10$ kΩ		Full range		5	20	mV
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, $R_L \geq 2$ kΩ		25°C	25	100		V/mV
				Full range	15			
CMRR	Common-mode rejection ratio			25°C	65	80		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)			25°C	65	100		dB
V_{O1}/V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz		25°C		120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0	Source	25°C	−20	−30	−60	mA
				Full range	−10			
		V_{CC} = 15 V, V_{ID} = −1 V, V_O = 15 V	Sink	25°C	10	20		
				Full range	5			
		V_{ID} = −1 V, V_O = 200 mV		25°C		30		µA
I_{OS}	Short-circuit output current	V_{CC} at 5 V, GND at −5 V, V_O = 0		25°C		±40	±60	mA
I_{CC}	Supply current (two amplifiers)	V_O = 2.5 V, No load		Full range		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5 V, No load		Full range		1	2	

† All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for LM2904 and 30 V for others.
‡ Full range is −55°C to 125°C for LM158A, −25°C to 85°C for LM258A, and 0°C to 70°C for LM358A.
§ All typical values are at T_A = 25°C.

operating conditions, V_{CC} = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	TYP	UNIT
SR	Slew rate at unity gain	R_L = 1 MΩ, C_L = 30 pF, V_I = ±10 V (see Figure 1)	0.3	V/μs
B_1	Unity-gain bandwidth	R_L = 1 MΩ, C_L = 20 pF (see Figure 1)	0.7	MHz
V_n	Equivalent input noise voltage	R_S = 100 Ω, V_I = 0 V, f = 1 kHz (see Figure 2)	40	nV/√Hz

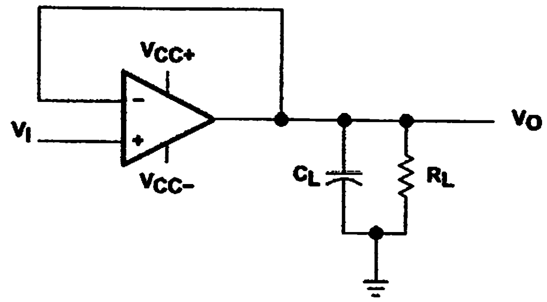


Figure 1. Unity-Gain Amplifier

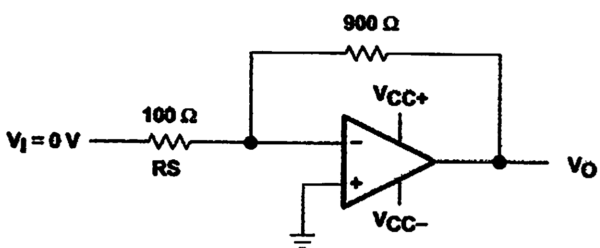


Figure 2. Noise-Test Circuit

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
5962-87710012A	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
5962-8771001PA	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
5962-87710022A	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
5962-8771002PA	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
LM158AFKB	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
LM158AJG	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
LM158AJGB	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
LM158FKB	ACTIVE	LCCC	FK	20	1	None	POST-PLATE	Level-NC-NC-NC
LM158JG	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
LM158JGB	ACTIVE	CDIP	JG	8	1	None	A42 SNPB	Level-NC-NC-NC
LM258AD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LM258ADGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
LM258ADR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LM258AP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
LM258D	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LM258DGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
LM258DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM258P	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
LM2904AVQDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
LM2904AVQPWR	ACTIVE	TSSOP	PW	8	2000	None	CU NIPDAU	Level-1-250C-UNLIM
LM2904D	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LM2904DGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
LM2904DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2904P	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
LM2904PSR	ACTIVE	SO	PS	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LM2904PW	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LM2904PWLE	OBSOLETE	TSSOP	PW	8		None	Call TI	Call TI
LM2904PWR	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LM2904QD	OBSOLETE	SOIC	D	8		None	Call TI	Call TI
LM2904QDR	OBSOLETE	SOIC	D	8		Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
LM2904QP	OBSOLETE	PDIP	P	8		None	Call TI	Call TI
LM2904VQDR	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
LM2904VQPWR	ACTIVE	TSSOP	PW	8	2000	None	CU NIPDAU	Level-1-250C-UNLIM
LM358AD	ACTIVE	SOIC	D	8	75	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LM358ADGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
LM358ADR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM358AP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
LM358APW	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LM358APWR	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LM358D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM358DGKR	ACTIVE	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
LM358DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM358P	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	Level-NC-NC-NC
LM358PSLE	OBSOLETE	SO	PS	8		None	Call TI	Call TI
LM358PSR	ACTIVE	SO	PS	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-2-260C-1 YEAR/ Level-1-235C-UNLIM
LM358PW	ACTIVE	TSSOP	PW	8	150	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
LM358PWLE	OBSOLETE	TSSOP	PW	8		None	Call TI	Call TI
LM358PWR	ACTIVE	TSSOP	PW	8	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - May not be currently available - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
None: Not yet available Lead (Pb-Free).
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.

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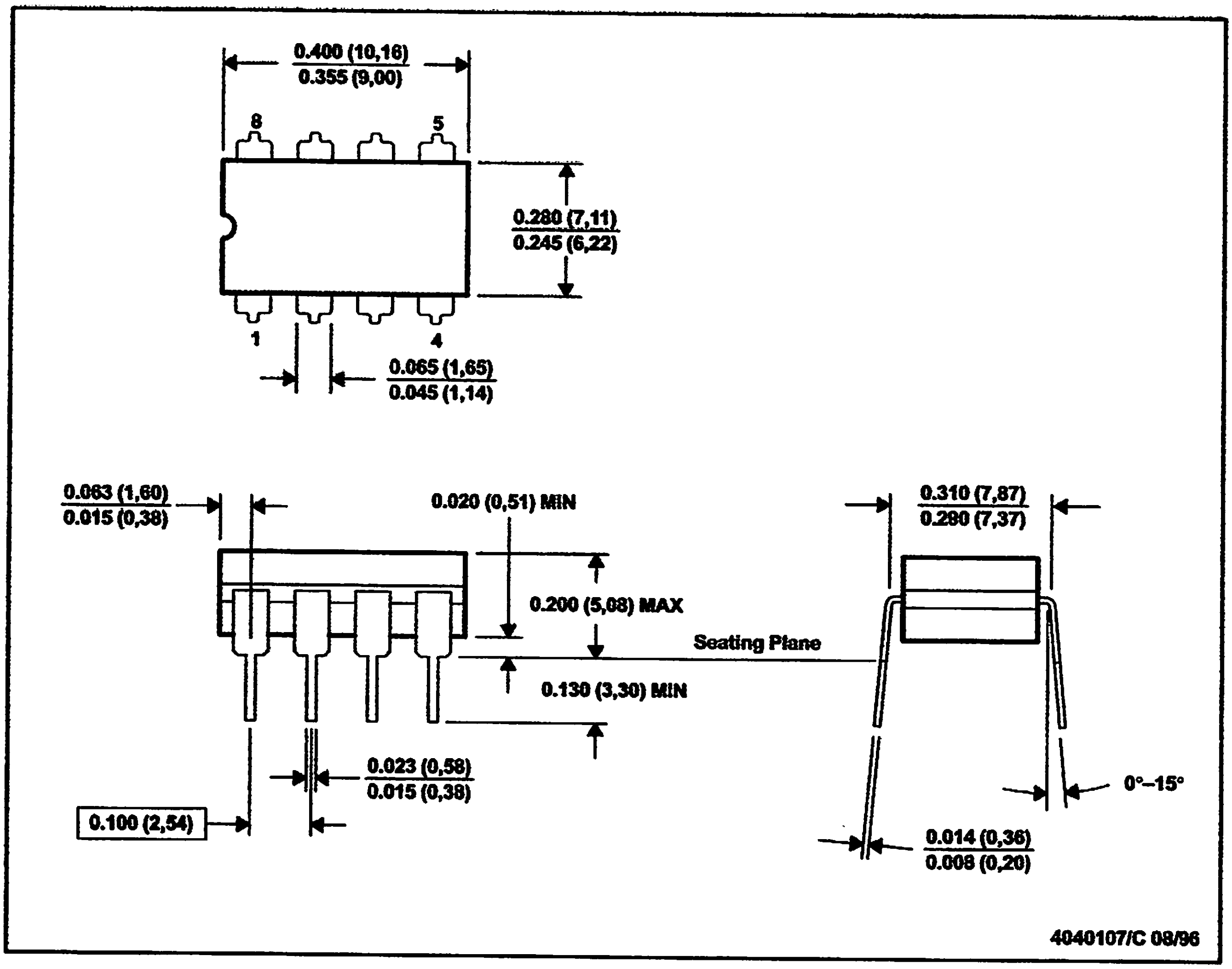
JG (R-GDIP-T8) **CERAMIC DUAL-IN-LINE**

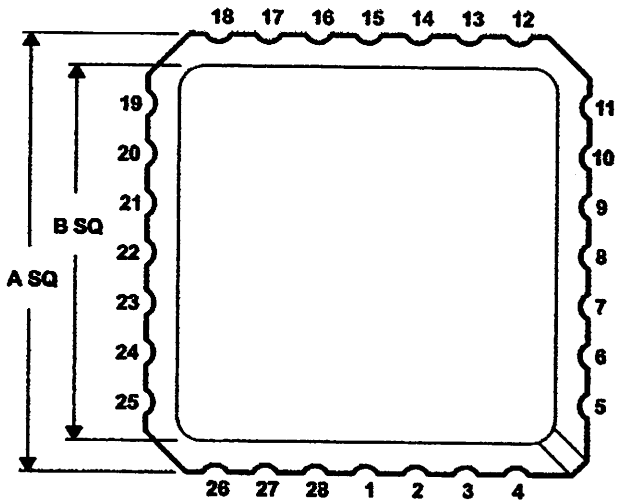


NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification.
E. Falls within MIL STD 1835 GDIP1-T8

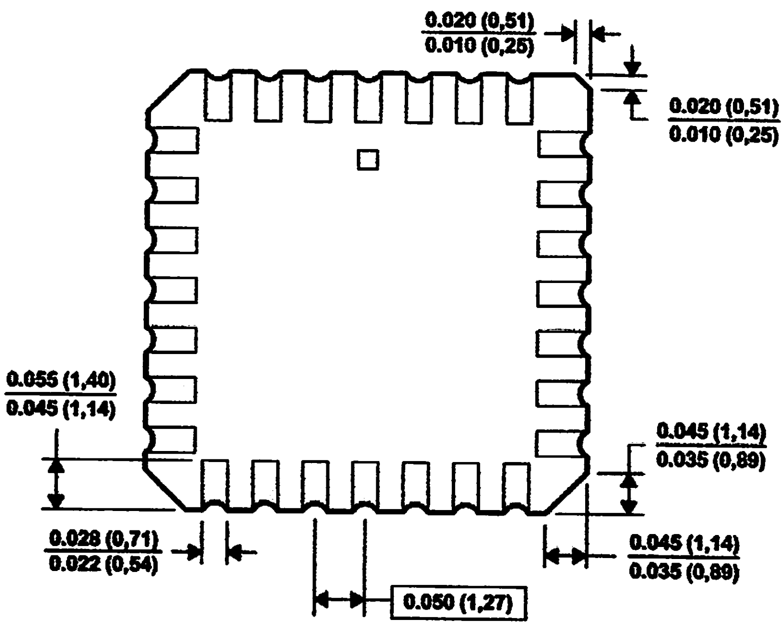
FK (S-CQCC-N)**

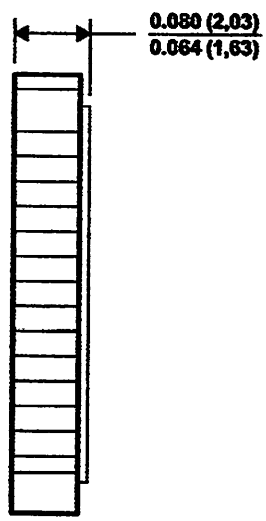
LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



NO. OF TERMINALS **	A		B	
	MIN	MAX	MIN	MAX
20	0.342 (8,69)	0.358 (9,09)	0.307 (7,80)	0.358 (9,09)
28	0.442 (11,23)	0.458 (11,63)	0.406 (10,31)	0.458 (11,63)
44	0.640 (16,26)	0.660 (16,76)	0.495 (12,58)	0.560 (14,22)
52	0.739 (18,78)	0.761 (19,32)	0.495 (12,58)	0.560 (14,22)
68	0.938 (23,83)	0.962 (24,43)	0.850 (21,6)	0.858 (21,8)
84	1.141 (28,99)	1.165 (29,59)	1.047 (26,6)	1.063 (27,0)



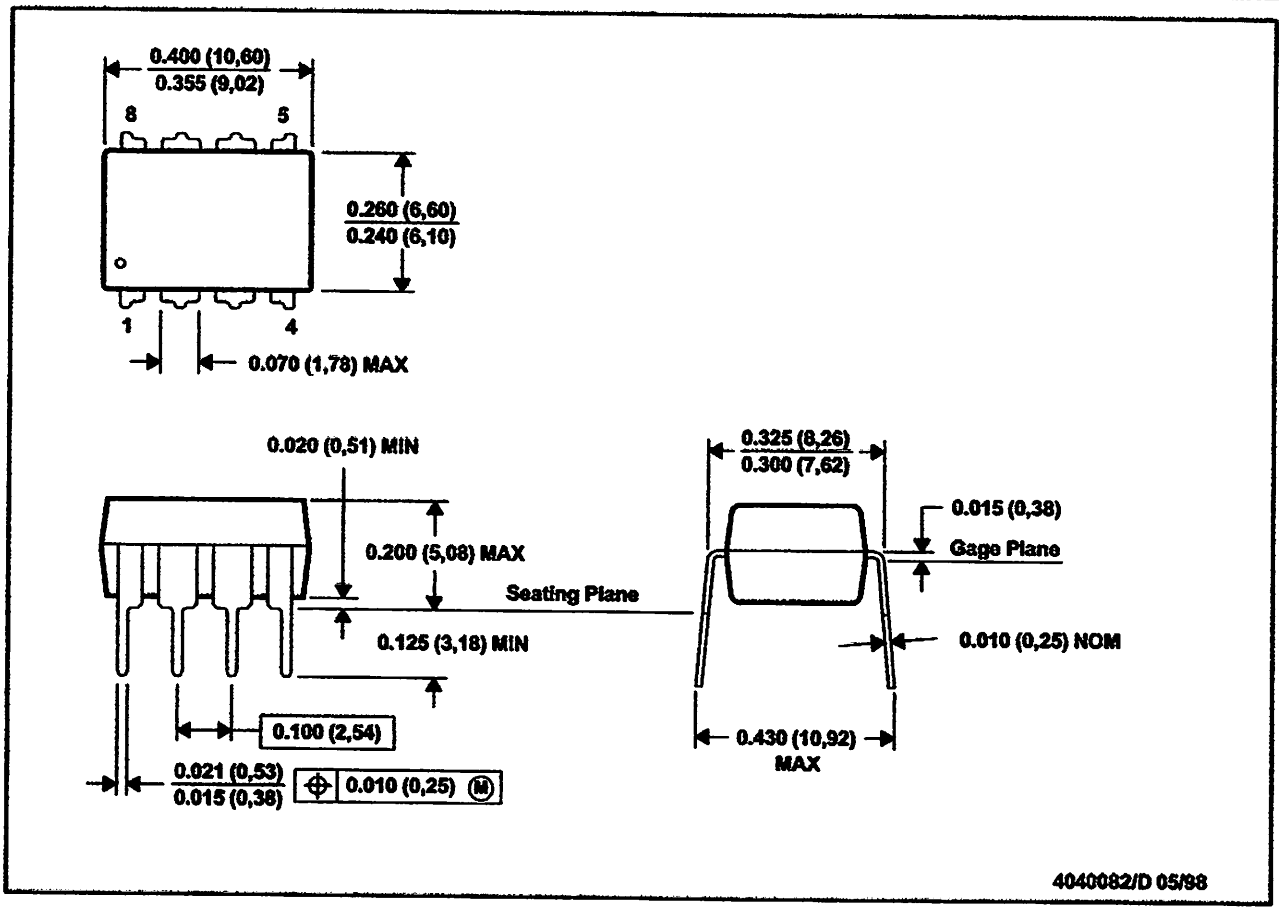


4040140/D 10/96

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a metal lid.
D. The terminals are gold plated.
E. Falls within JEDEC MS-004

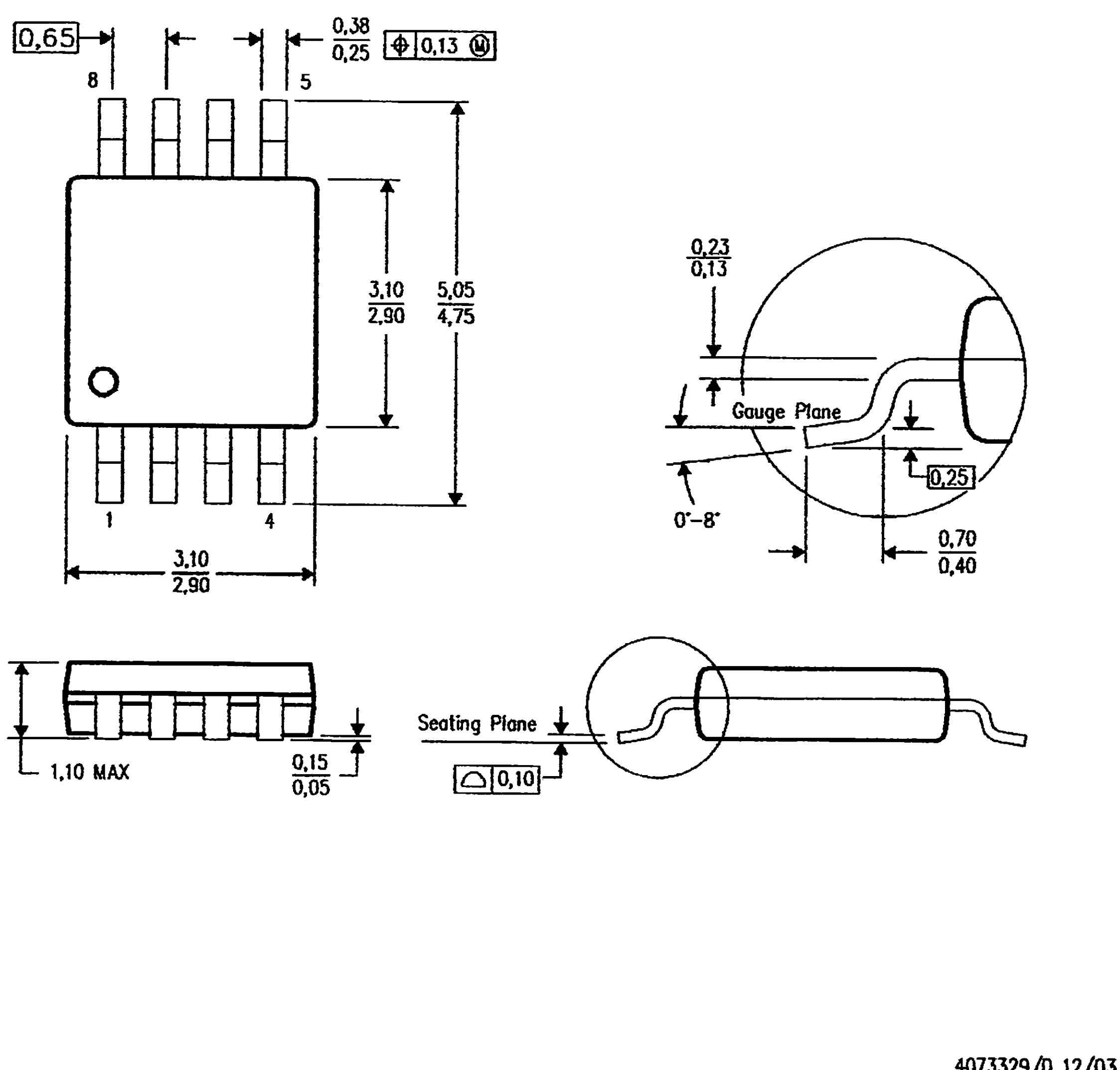
MPDI001A – JANUARY 1995 – REVISED JUNE 1999

P (R-PDIP-T8) **PLASTIC DUAL-IN-LINE**



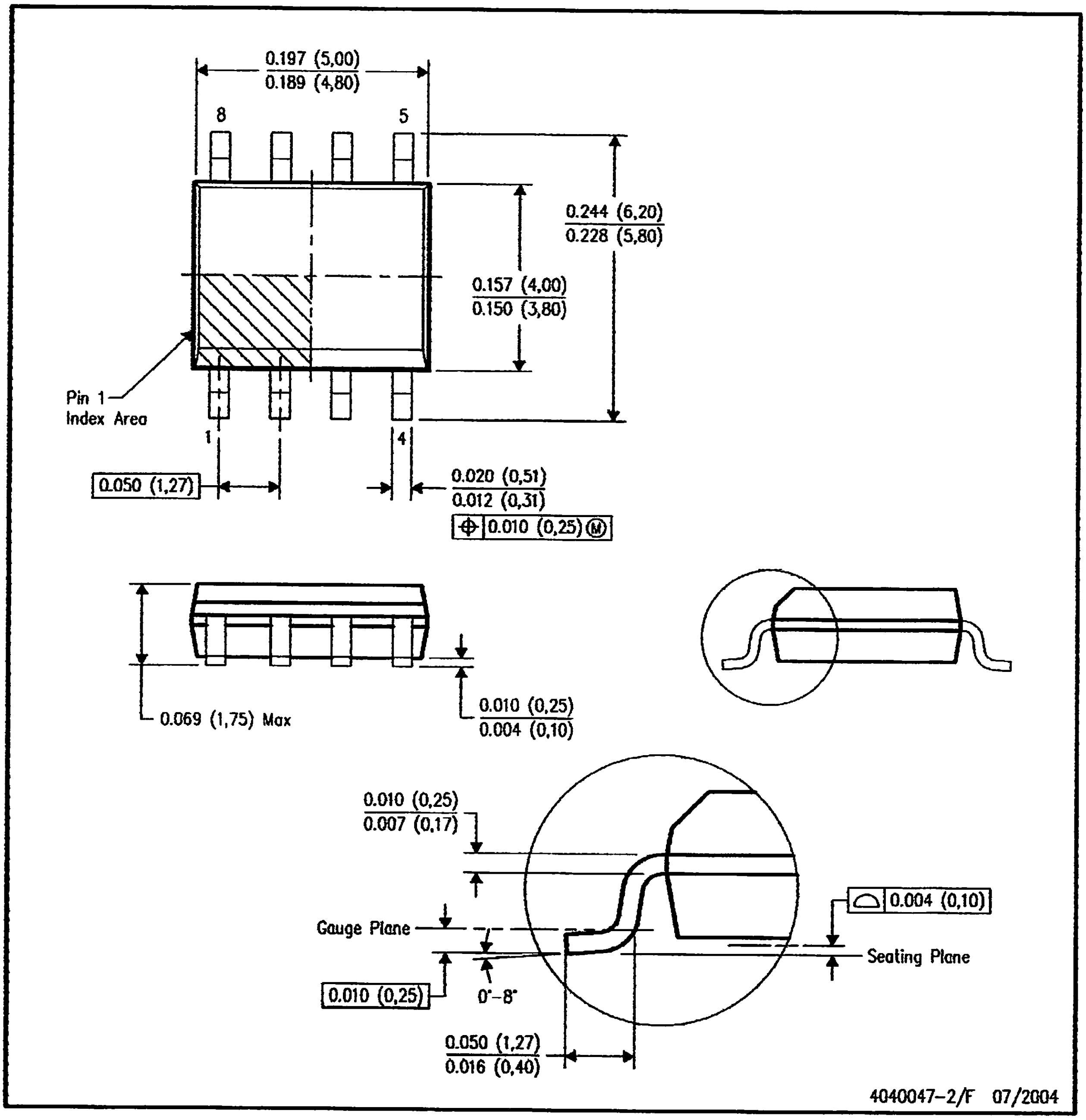
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001

DGK (S-PDSO-G8) PLASTIC SMALL-OUTLINE PACKAGE

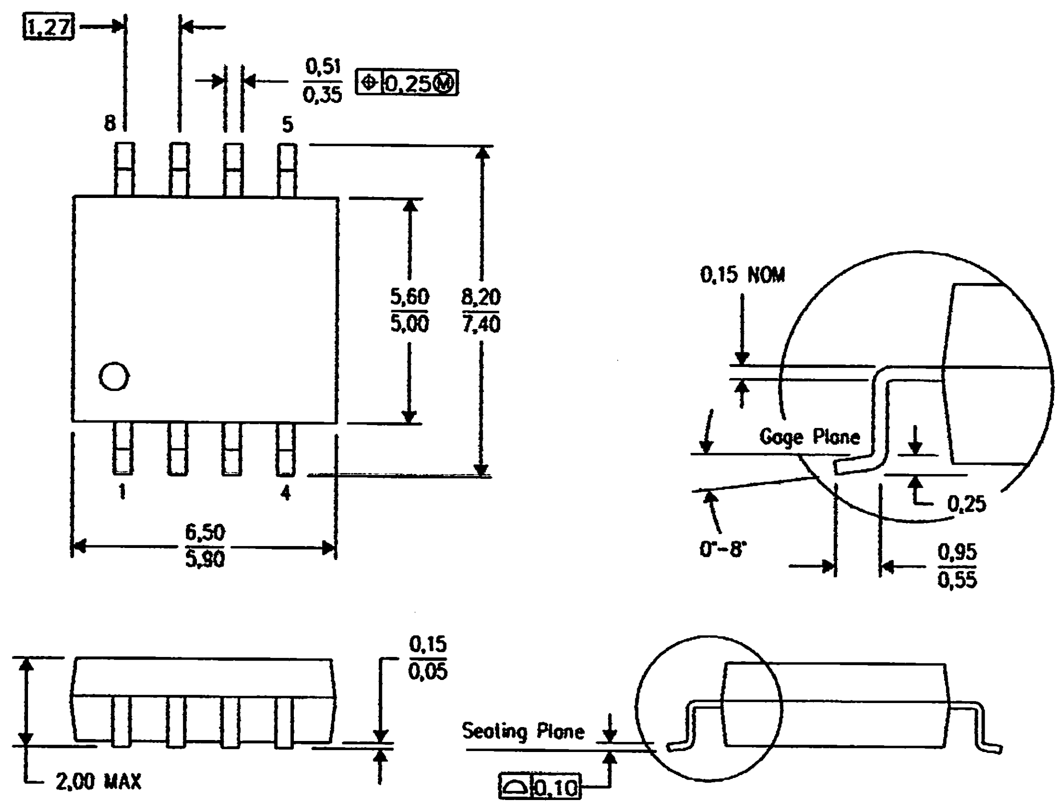


NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion.
- D. Falls within JEDEC MO-187 variation AA.

D (R–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012 variation AA.

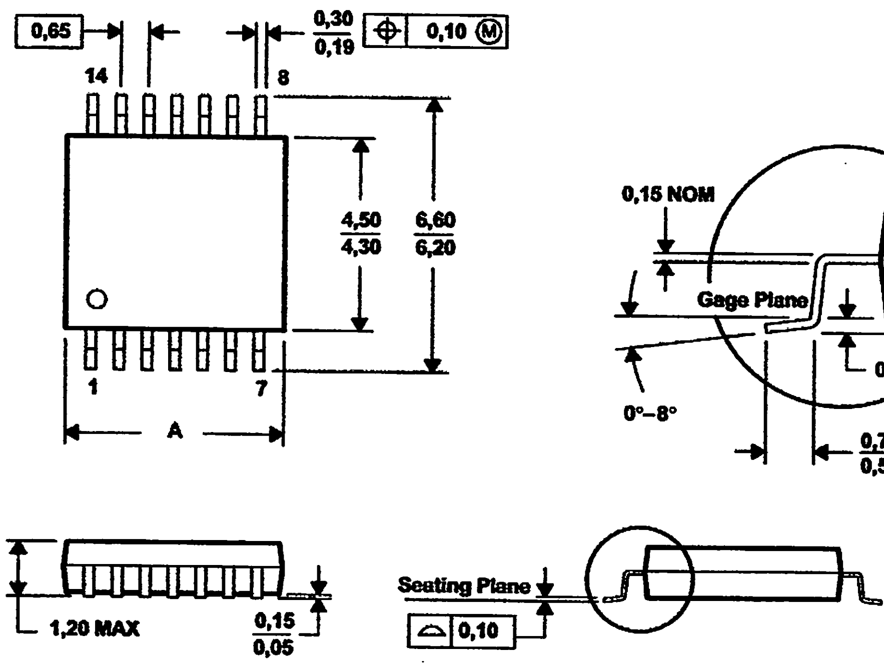


4040063/C 03/03

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

PW (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN



PINS ** / DIM	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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eatures

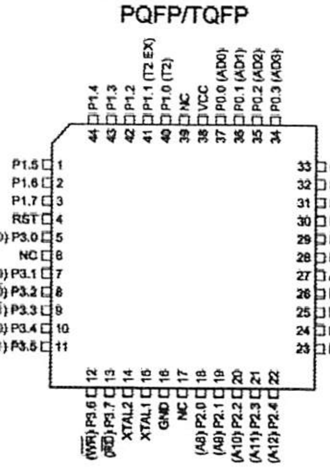
ompatible with MCS-51™ Products
K Bytes of In-System Reprogrammable Flash Memory
ndurance: 1,000 Write/Erase Cycles
ully Static Operation: 0 Hz to 24 MHz
hree-level Program Memory Lock
56 x 8-bit Internal RAM
2 Programmable I/O Lines
hree 16-bit Timer/Counters
ight Interrupt Sources
rogrammable Serial Channel
ow-power Idle and Power-down Modes

escription

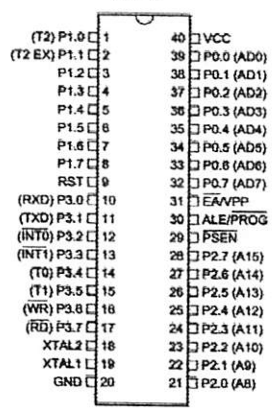
AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K es of Flash programmable and erasable read only memory (PEROM). The device nanufactured using Atmel's high-density nonvolatile memory technology and is npatible with the industry-standard 80C51 and 80C52 instruction set and pinout. on-chip Flash allows the program memory to be reprogrammed in-system or by a ventional nonvolatile memory programmer. By combining a versatile 8-bit CPU Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer ch provides a highly-flexible and cost-effective solution to many embedded control lications.

n Configurations

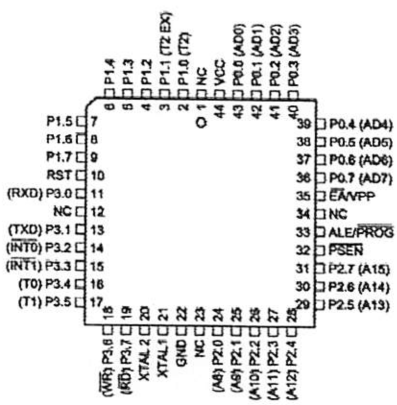
PQFP/TQFP



PDIP



PLCC



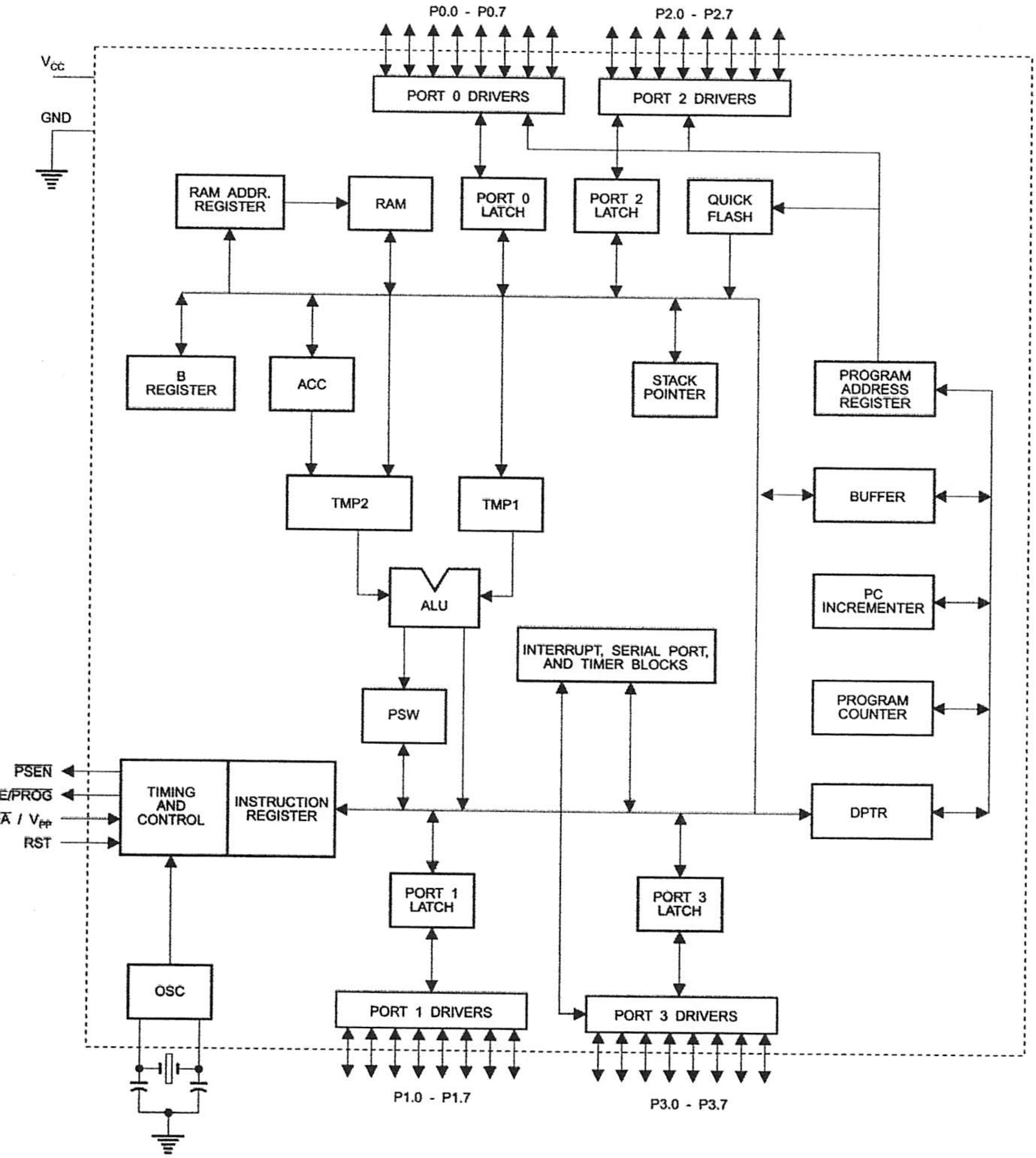
8-bit Microcontroller with 8K Bytes Flash

AT89C52

Not Recommended for New Designs. Use AT89S52.

Rev. 0313H–02/00

lock Diagram



› AT89C52 provides the following standard features: 8K
›s of Flash, 256 bytes of RAM, 32 I/O lines, three 16-bit
›r/counters, a six-vector two-level interrupt architecture,
ıll-duplex serial port, on-chip oscillator, and clock cir-
ry. In addition, the AT89C52 is designed with static logic
operation down to zero frequency and supports two
ware selectable power saving modes. The Idle Mode
›s the CPU while allowing the RAM, timer/counters,
al port, and interrupt system to continue functioning.
› Power-down mode saves the RAM contents but
zes the oscillator, disabling all other chip functions until
next hardware reset.

ı Description

:

ply voltage.

)

und.

t 0

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

: 0 can also be configured to be the multiplexed low-
›r address/data bus during accesses to external pro-
n and data memory. In this mode, P0 has internal
ıps.

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

: 1

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

ddition, P1.0 and P1.1 can be configured to be the
r/counter 2 external count input (P1.0/T2) and the
r/counter 2 trigger input (P1.1/T2EX), respectively, as
vn in the following table.

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

t Pin	Alternate Functions
0	T2 (external count input to Timer/Counter 2), clock-out
1	T2EX (Timer/Counter 2 capture/reload trigger and direction control)

Port 2

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

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

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

Port 3

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

Port 3 also serves the functions of various special features of the AT89C51, as shown in the following table.

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

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.

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

Address Latch Enable 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 ng or clocking purposes. Note, however, that one ALE se is skipped during each access to external data nory.

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

EN

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

en the AT89C52 is executing code from external pro- m memory, $\overline{\text{PSEN}}$ is activated twice each machine le, except that two $\overline{\text{PSEN}}$ activations are skipped during h 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 when 12-volt programming is selected.

XTAL1

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

XTAL2

Output from the inverting oscillator amplifier.

le 1. AT89C52 SFR Map and Reset Values

0F8H									0FFH
0F0H	B 00000000								0F7H
0E8H									0EFH
0E0H	ACC 00000000								0E7H
0D8H									0DFH
0D0H	PSW 00000000								0D7H
0C8H	T2CON 00000000	T2MOD XXXXXX00	RCAP2L 00000000	RCAP2H 00000000	TL2 00000000	TH2 00000000			0CFH
0C0H									0C7H
0B8H	IP XX000000								0BFH
0B0H	P3 11111111								0B7H
0A8H	IE 0X000000								0AFH
0A0H	P2 11111111								0A7H
98H	SCON 00000000	SBUF XXXXXXXX							9FH
90H	P1 11111111								97H
88H	TCON 00000000	TMOD 00000000	TL0 00000000	TL1 00000000	TH0 00000000	TH1 00000000			8FH
80H	P0 11111111	SP 00000111	DPL 00000000	DPH 00000000				PCON 0XXX0000	87H

ɔecial Function Registers

ɦap of the on-chip memory area called the Special Func-ı Register (SFR) space is shown in Table 1.

le that not all of the addresses are occupied, and unoc-ɔied addresses may not be implemented on the chip. ad accesses to these addresses will in general return ıdom data, and write accesses will have an indetermi-e effect.

ər software should not write 1s to these unlisted loca-ɪs, 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.

Timer 2 Registers Control and status bits are contained in registers T2CON (shown in Table 2) and T2MOD (shown in Table 4) for Timer 2. The register pair (RCAP2H, RCAP2L) are the Capture/Reload registers for Timer 2 in 16-bit capture mode or 16-bit auto-reload mode.

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

ɔle 2. T2CON – Timer/Counter 2 Control Registe

T2CON Address = 0C8H Reset Value = 0000 0000B

Bit Addressable

Bit	TF2	EXF2	RCLK	TCLK	EXEN2	TR2	C/$\overline{T2}$	CP/$\overline{RL2}$
	7	6	5	4	3	2	1	0

ɾmbol	Function
⁼2	Timer 2 overflow flag set by a Timer 2 overflow and must be cleared by software. TF2 will not be set when either RCLK = 1 or TCLK = 1.
⟨F2	Timer 2 external flag set when either a capture or reload is caused by a negative transition on T2EX and EXEN2 = 1. When Timer 2 interrupt is enabled, EXF2 = 1 will cause the CPU to vector to the Timer 2 interrupt routine. EXF2 must be cleared by software. EXF2 does not cause an interrupt in up/down counter mode (DCEN = 1).
ːLK	Receive clock enable. When set, causes the serial port to use Timer 2 overflow pulses for its receive clock in serial port Modes 1 and 3. RCLK = 0 causes Timer 1 overflow to be used for the receive clock.
ːLK	Transmit clock enable. When set, causes the serial port to use Timer 2 overflow pulses for its transmit clock in serial port Modes 1 and 3. TCLK = 0 causes Timer 1 overflows to be used for the transmit clock.
⟨EN2	Timer 2 external enable. When set, allows a capture or reload to occur as a result of a negative transition on T2EX if Timer 2 is not being used to clock the serial port. EXEN2 = 0 causes Timer 2 to ignore events at T2EX.
ꝛ2	Start/Stop control for Timer 2. TR2 = 1 starts the timer.
$\overline{T2}$	Timer or counter select for Timer 2. C/$\overline{T2}$ = 0 for timer function. C/$\overline{T2}$ = 1 for external event counter (falling edge triggered).
›/$\overline{RL2}$	Capture/Reload select. CP/$\overline{RL2}$ = 1 causes captures to occur on negative transitions at T2EX if EXEN2 = 1. CP/$\overline{RL2}$ = 0 causes automatic reloads to occur when Timer 2 overflows or negative transitions occur at T2EX when EXEN2 = 1. When either RCLK or TCLK = 1, this bit is ignored and the timer is forced to auto-reload on Timer 2 overflow.

ıta Memory

ˈ AT89C52 implements 256 bytes of on-chip RAM. The ɪer 128 bytes occupy a parallel address space to the ɔcial Function Registers. That means the upper 128 ɪs have the same addresses as the SFR space but are sically separate from SFR space.

ən an instruction accesses an internal location above ʼress 7FH, the address mode used in the instruction specifies whether the CPU accesses the upper 128 bytes of RAM or the SFR space. Instructions that use direct addressing access SFR space.

For example, the following direct addressing instruction accesses the SFR at location 0A0H (which is P2).

```
MOV 0A0H, #data
```

ıtructions that use indirect addressing access the upper 8 bytes of RAM. For example, the following indirect dressing instruction, where R0 contains 0A0H, accesses ᵌ data byte at address 0A0H, rather than P2 (whose dress is 0A0H).

```
MOV @R0, #data
```

ıte that stack operations are examples of indirect dressing, so the upper 128 bytes of data RAM are available as stack space.

mer 0 and 1

ner 0 and Timer 1 in the AT89C52 operate the same way Timer 0 and Timer 1 in the AT89C51.

mer 2

ner 2 is a 16-bit Timer/Counter that can operate as either imer or an event counter. The type of operation is ected by bit C/$\overline{T2}$ in the SFR T2CON (shown in Table 2). ner 2 has three operating modes: capture, auto-reload) or down counting), and baud rate generator. The ıdes are selected by bits in T2CON, as shown in Table 3.

ner 2 consists of two 8-bit registers, TH2 and TL2. In the ner function, the TL2 register is incremented every ıchine cycle. Since a machine cycle consists of 12 oscillor periods, the count rate is 1/12 of the oscillator quency.

ɔle 3. Timer 2 Operating Modes

CLK +TCLK	CP/$\overline{RL2}$	TR2	MODE
0	0	1	16-bit Auto-reload
0	1	1	16-bit Capture
1	X	1	Baud Rate Generator
X	X	0	(Off)

the Counter function, the register is incremented in ponse to a 1-to-0 transition at its corresponding external input pin, T2. In this function, the external input is sampled during S5P2 of every machine cycle. When the samples show a high in one cycle and a low in the next cycle, the count is incremented. The new count value appears in the register during S3P1 of the cycle following the one in which the transition was detected. Since two machine cycles (24 oscillator periods) are required to recognize a 1-to-0 transition, the maximum count rate is 1/24 of the oscillator frequency. To ensure that a given level is sampled at least once before it changes, the level should be held for at least one full machine cycle.

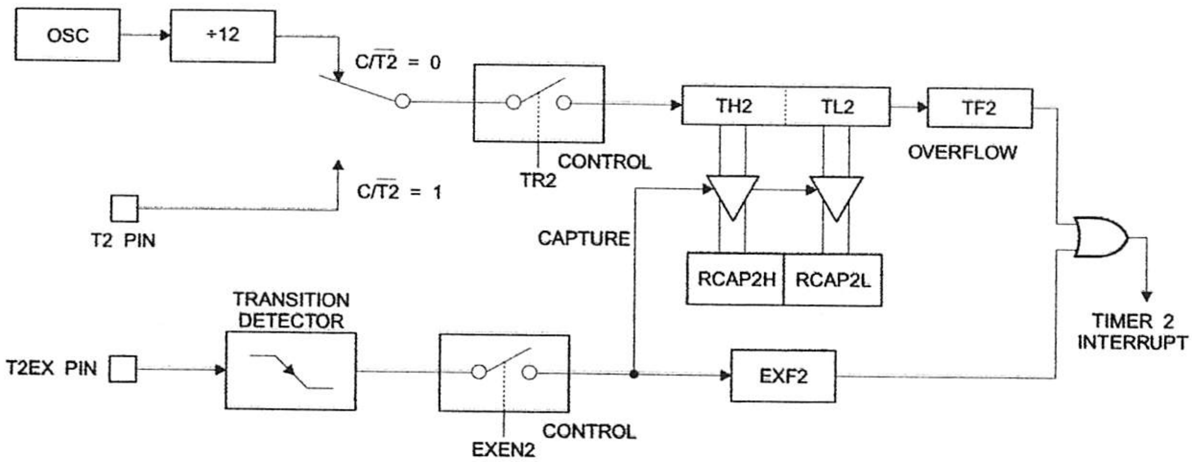
Capture Mode

In the capture mode, two options are selected by bit EXEN2 in T2CON. If EXEN2 = 0, Timer 2 is a 16-bit timer or counter which upon overflow sets bit TF2 in T2CON. This bit can then be used to generate an interrupt. If EXEN2 = 1, Timer 2 performs the same operation, but a 1-to-0 transition at external input T2EX also causes the current value in TH2 and TL2 to be captured into RCAP2H and RCAP2L, respectively. In addition, the transition at T2EX causes bit EXF2 in T2CON to be set. The EXF2 bit, like TF2, can generate an interrupt. The capture mode is illustrated in Figure 1.

Auto-reload (Up or Down Counter)

Timer 2 can be programmed to count up or down when configured in its 16-bit auto-reload mode. This feature is invoked by the DCEN (Down Counter Enable) bit located in the SFR T2MOD (see Table 4). Upon reset, the DCEN bit is set to 0 so that timer 2 will default to count up. When DCEN is set, Timer 2 can count up or down, depending on the value of the T2EX pin.

ure 1. Timer in Capture Mode



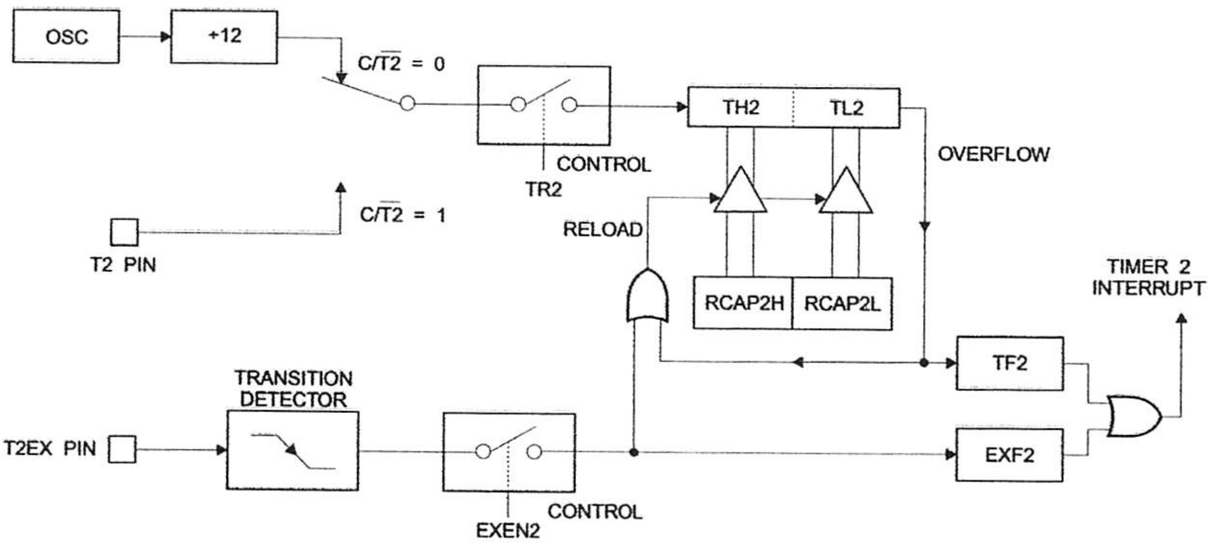
ure 2 shows Timer 2 automatically counting up when EN = 0. In this mode, two options are selected by bit EN2 in T2CON. If EXEN2 = 0, Timer 2 counts up to FFFH and then sets the TF2 bit upon overflow. The rflow also causes the timer registers to be reloaded with 16-bit value in RCAP2H and RCAP2L. The values in er in Capture ModeRCAP2H and RCAP2L are preset software. If EXEN2 = 1, a 16-bit reload can be triggered er by an overflow or by a 1-to-0 transition at external t T2EX. This transition also sets the EXF2 bit. Both the and EXF2 bits can generate an interrupt if enabled.

ting the DCEN bit enables Timer 2 to count up or down, shown in Figure 3. In this mode, the T2EX pin controls the direction of the count. A logic 1 at T2EX makes Timer 2 count up. The timer will overflow at 0FFFFH and set the TF2 bit. This overflow also causes the 16-bit value in RCAP2H and RCAP2L to be reloaded into the timer registers, TH2 and TL2, respectively.

A logic 0 at T2EX makes Timer 2 count down. The timer underflows when TH2 and TL2 equal the values stored in RCAP2H and RCAP2L. The underflow sets the TF2 bit and causes 0FFFFH to be reloaded into the timer registers.

The EXF2 bit toggles whenever Timer 2 overflows or underflows and can be used as a 17th bit of resolution. In this operating mode, EXF2 does not flag an interrupt.

gure 2. Timer 2 Auto Reload Mode (DCEN = 0)

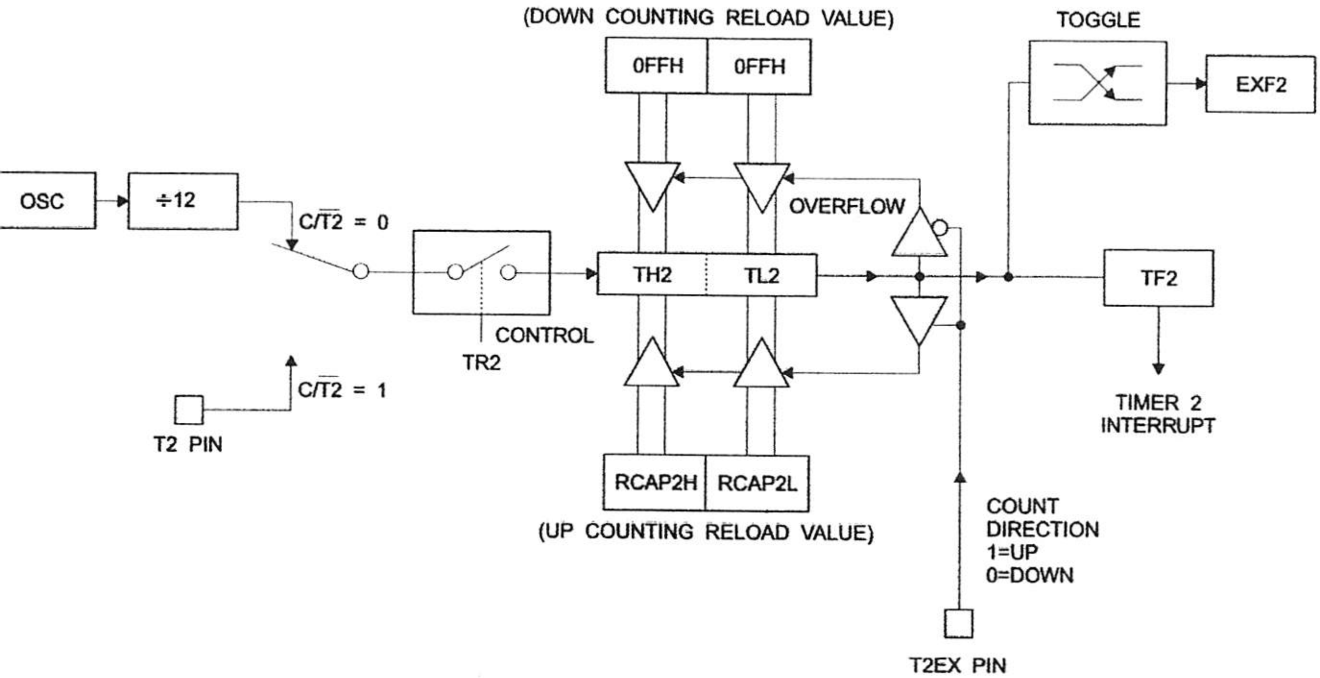


le 4. T2MOD – Timer 2 Mode Control Register

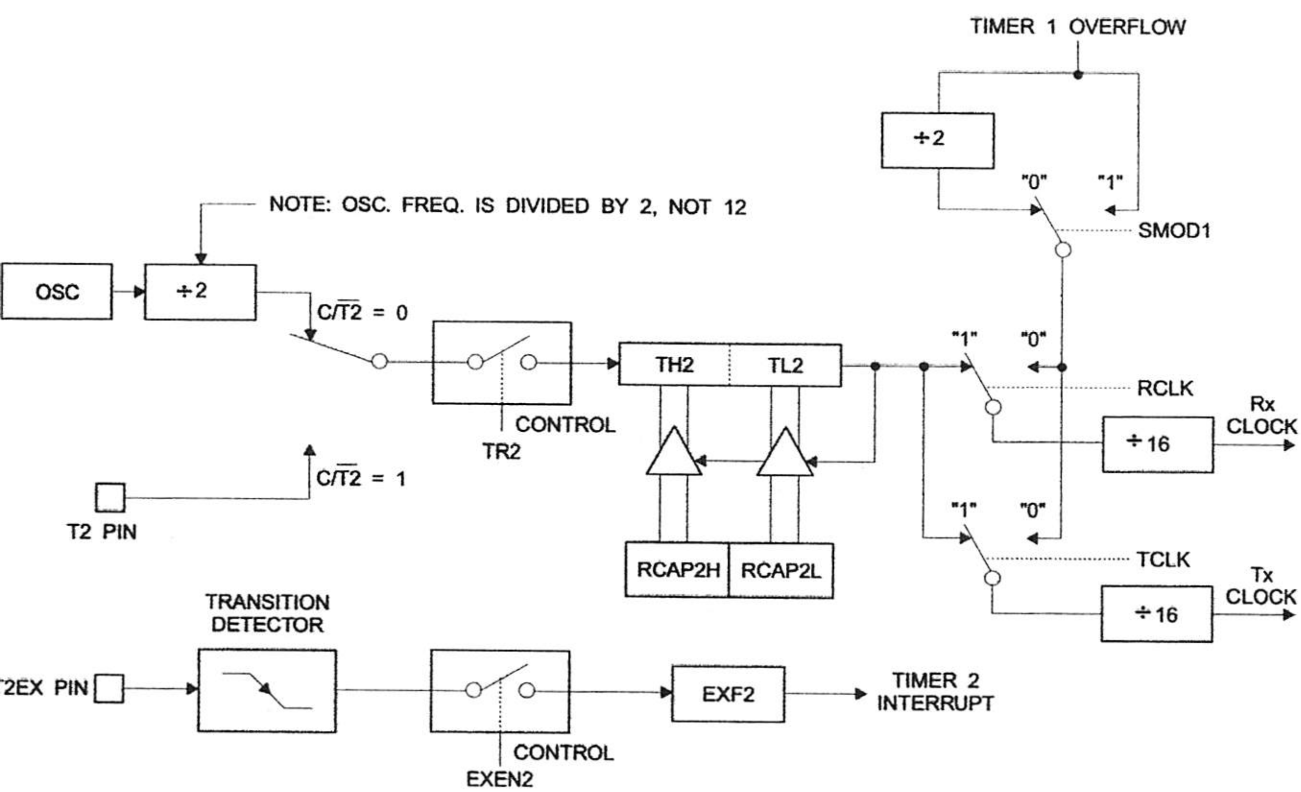
T2MOD Address = 0C9H						Reset Value = XXXX XX00B		
Not Bit Addressable								
	–	–	–	–	–	–	T2OE	DCEN
Bit	7	6	5	4	3	2	1	0

mbol	Function
	Not implemented, reserved for future
OE	Timer 2 Output Enable bit.
CEN	When set, this bit allows Timer 2 to be configured as an up/down counter.

gure 3. Timer 2 Auto Reload Mode (DCEN = 1)



ure 4. Timer 2 in Baud Rate Generator Mode



aud Rate Generator

mer 2 is selected as the baud rate generator by setting CLK and/or RCLK in T2CON (Table 2). Note that the ud rates for transmit and receive can be different if Timer s used for the receiver or transmitter and Timer 1 is used the other function. Setting RCLK and/or TCLK puts mer 2 into its baud rate generator mode, as shown in Fig- e 4.

e baud rate generator mode is similar to the auto-reload de, in that a rollover in TH2 causes the Timer 2 registers be reloaded with the 16-bit value in registers RCAP2H d RCAP2L, which are preset by software.

e baud rates in Modes 1 and 3 are determined by Timer overflow rate according to the following equation.

$$\text{Modes 1 and 3 Baud Rates} = \frac{\text{Timer 2 Overflow Rate}}{16}$$

e Timer can be configured for either timer or counter eration. In most applications, it is configured for timer eration (CP/$\overline{T2}$ = 0). The timer operation is different for mer 2 when it is used as a baud rate generator. Normally, a timer, it increments every machine cycle (at 1/12 the cillator frequency). As a baud rate generator, however, it increments every state time (at 1/2 the oscillator frequency). The baud rate formula is given below.

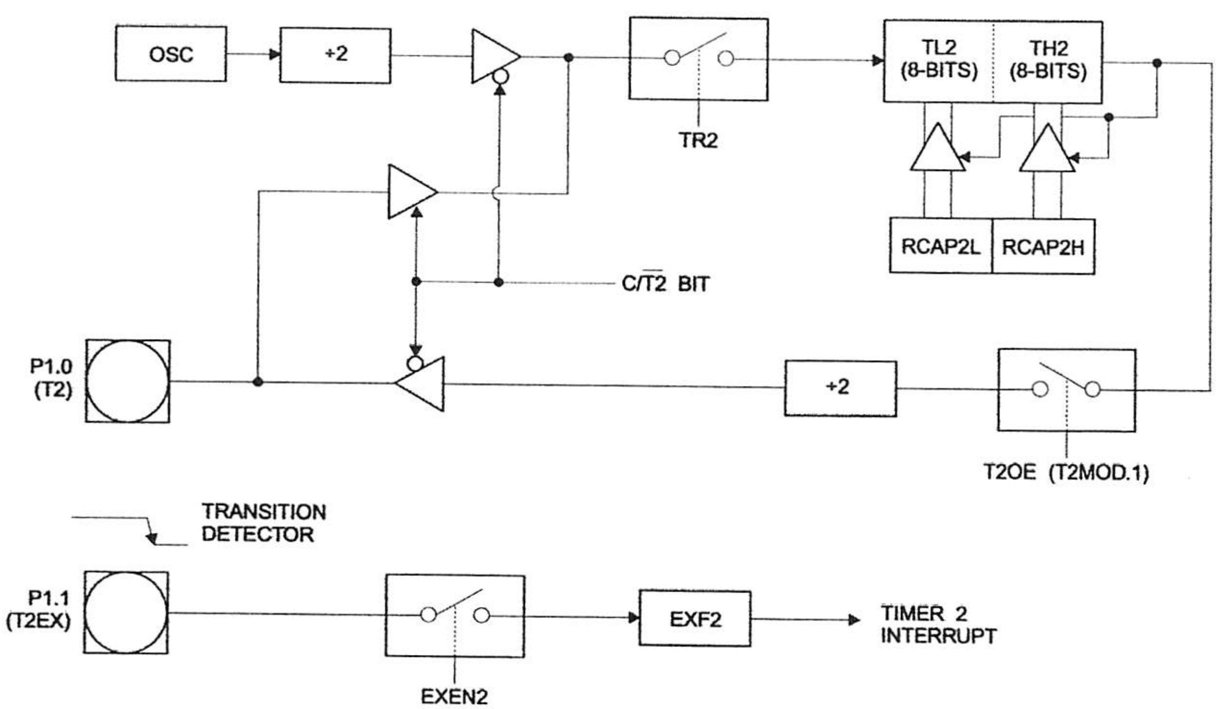
$$\frac{\text{Modes 1 and 3}}{\text{Baud Rate}} = \frac{\text{Oscillator Frequency}}{32 \times [65536 - (\text{RCAP2H,RCAP2L})]}$$

where (RCAP2H, RCAP2L) is the content of RCAP2H and RCAP2L taken as a 16-bit unsigned integer.

Timer 2 as a baud rate generator is shown in Figure 4. This figure is valid only if RCLK or TCLK = 1 in T2CON. Note that a rollover in TH2 does not set TF2 and will not generate an interrupt. Note too, that if EXEN2 is set, a 1-to-0 transition in T2EX will set EXF2 but will not cause a reload from (RCAP2H, RCAP2L) to (TH2, TL2). Thus when Timer 2 is in use as a baud rate generator, T2EX can be used as an extra external interrupt.

Note that when Timer 2 is running (TR2 = 1) as a timer in the baud rate generator mode, TH2 or TL2 should not be read from or written to. Under these conditions, the Timer is incremented every state time, and the results of a read or write may not be accurate. The RCAP2 registers may be read but should not be written to, because a write might overlap a reload and cause write and/or reload errors. The timer should be turned off (clear TR2) before accessing the Timer 2 or RCAP2 registers.

jure 5. Timer 2 in Clock-out Mode



rogrammable Clock Out

50% duty cycle clock can be programmed to come out on .0, as shown in Figure 5. This pin, besides being a regu- I/O pin, has two alternate functions. It can be ogrammed to input the external clock for Timer/Counter 2 to output a 50% duty cycle clock ranging from 61 Hz to 4 Hz at a 16 MHz operating frequency.

configure the Timer/Counter 2 as a clock generator, bit T2 (T2CON.1) must be cleared and bit T2OE (T2MOD.1) ust be set. Bit TR2 (T2CON.2) starts and stops the timer.

e clock-out frequency depends on the oscillator fre- ency and the reload value of Timer 2 capture registers CAP2H, RCAP2L), as shown in the following equation.

$$\text{Clock-Out Frequency} = \frac{\text{Oscillator Fequency}}{4 \times [65536 - (\text{RCAP2H,RCAP2L})]}$$

the clock-out mode, Timer 2 roll-overs will not generate interrupt. This behavior is similar to when Timer 2 is ed as a baud-rate generator. It is possible to use Timer 2 a baud-rate generator and a clock generator simulta- ously. Note, however, that the baud-rate and clock-out quencies cannot be determined independently from one other since they both use RCAP2H and RCAP2L.

ART

e UART in the AT89C52 operates the same way as the RT in the AT89C51.

terrupts

e AT89C52 has a total of six interrupt vectors: two exter- l interrupts ($\overline{\text{INT0}}$ and $\overline{\text{INT1}}$), three timer interrupts mers 0, 1, and 2), and the serial port interrupt. These errupts are all shown in Figure 6.

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

te that Table shows that bit position IE.6 is unimple- nted. In the AT89C51, bit position IE.5 is also mplemented. User software should not write 1s to these positions, since they may be used in future AT89 ducts.

ner 2 interrupt is generated by the logical OR of bits TF2 d EXF2 in register T2CON. Neither of these flags is ared by hardware when the service routine is vectored In fact, the service routine may have to determine ether it was TF2 or EXF2 that generated the interrupt, d that bit will have to be cleared in software.

e Timer 0 and Timer 1 flags, TF0 and TF1, are set at P2 of the cycle in which the timers overflow. The values then polled by the circuitry in the next cycle. However, the Timer 2 flag, TF2, is set at S2P2 and is polled in the same cycle in which the timer overflows.

Table 5. Interrupt Enable (IE) Register

(MSB) (LSB)

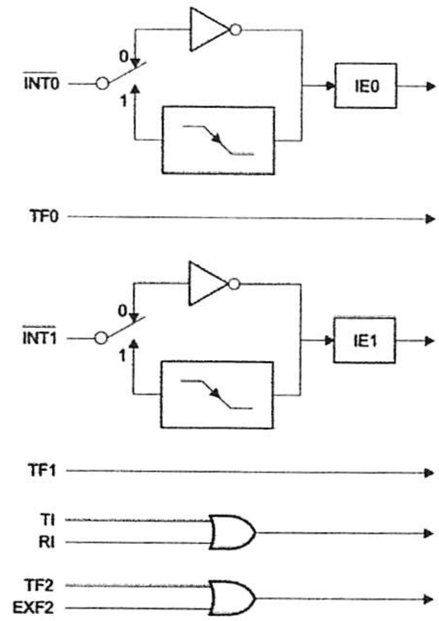
EA	–	ET2	ES	ET1	EX1	ET0	EX0

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.
ET2	IE.5	Timer 2 interrupt enable bit.
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 unimplemented bits, because they may be used in future AT89 products.		

Figure 6. Interrupt Sources



scillator Characteristics

'AL1 and XTAL2 are the input and output, respectively, an inverting amplifier that can be configured for use as on-chip oscillator, as shown in Figure 7. Either a quartz ystal or ceramic resonator may be used. To drive the vice from an external clock source, XTAL2 should be left connected while XTAL1 is driven, as shown in Figure 8. ere are no requirements on the duty cycle of the external ck signal, since the input to the internal clocking circuitry through a divide-by-two flip-flop, but minimum and maxi-ım voltage high and low time specifications must be served.

le Mode

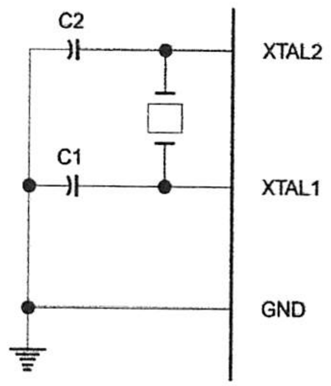
idle mode, the CPU puts itself to sleep while all the on-p peripherals remain active. The mode is invoked by tware. The content of the on-chip RAM and all the spe-l functions registers remain unchanged during this de. The idle mode can be terminated by any enabled errupt or by a hardware reset.

te that when idle mode is terminated by a hardware et, the device normally resumes program execution m where it left off, up to two machine cycles before the ernal reset algorithm takes control. On-chip hardware ibits access to internal RAM in this event, but access to port pins is not inhibited. To eliminate the possibility of unexpected write to a port pin when idle mode is termi-ed by a reset, the instruction following the one that okes idle mode should not write to a port pin or to exter-memory.

wer-down Mode

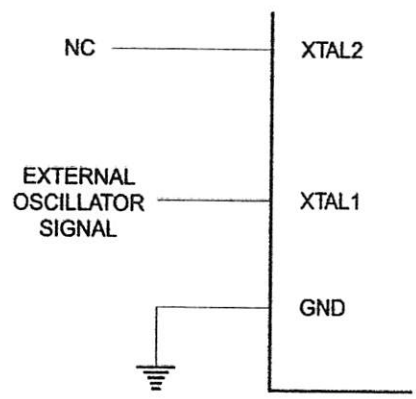
he power-down mode, the oscillator is stopped, and the ruction that invokes power-down is the last instruction ecuted. The on-chip RAM and Special Function Regis-s retain their values until the power-down mode is minated. The only exit from power-down is a hardware et. Reset redefines the SFRs but does not change the 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.

Figure 7. Oscillator Connections



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

Figure 8. External Clock Drive Configuration



atus of External Pins During Idle and Powe-down Modes

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

ogram Memory Lock Bits

: AT89C52 has three lock bits that can be left unpro-
mmed (U) or can be programmed (P) to obtain the
litional features listed in the following table.

ıck Bit Protection Modes

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

ən lock bit 1 is programmed, the logic level at the $\overline{EA}$ pin
ampled and latched during reset. If the device is pow-
1 up without a reset, the latch initializes to a random
ıe and holds that value until reset is activated. The
ıed value of $\overline{EA}$ must agree with the current logic level
ıat pin in order for the device to function properly.

ɔgramming the Flash

AT89C52 is normally shipped with the on-chip Flash
nory array in the erased state (that is, contents = FFH)
ready to be programmed. The programming interface
əpts either a high-voltage (12-volt) or a low-voltage
;) program enable signal. The Low-voltage program-
g mode provides a convenient way to program the
9C52 inside the user's system, while the high-voltage
ıramming mode is compatible with conventional third-
/ Flash or EPROM programmers.

AT89C52 is shipped with either the high-voltage or
voltage programming mode enabled. The respective
side marking and device signature codes are listed in
ollowing table.

	V_{PP} = 12V	V_{PP} = 5V
⊦side Mark	AT89C52 xxxx yyww	AT89C52 xxxx - 5 yyww

	V_{PP} = 12V	V_{PP} = 5V
Signature	(030H) = 1EH (031H) = 52H (032H) = FFH	(030H) = 1EH (031H) = 52H (032H) = 05H

The AT89C52 code memory array is programmed byte-by-byte in either programming mode. *To program any non-blank byte in the on-chip Flash Memory, the entire memory must be erased using the Chip Erase Mode.*

Programming Algorithm Before programming the AT89C52, the address, data and control signals should be set up according to the Flash programming mode table and Figure 9 and Figure 10. To program the AT89C52, take the following steps.

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

Data Polling The AT89C52 features $\overline{Data}$ Polling to indicate the end of a write cycle. During a write cycle, an attempted read of the last byte written will result in the complement of the written data on PO.7. Once the write cycle has been completed, true data is valid on all outputs, and the next cycle may begin. $\overline{Data}$ Polling may begin any time after a write cycle has been initiated.

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

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

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

ading the Signature Bytes The signature bytes are ıd by the same procedure as a normal verification of ations 030H, 031H, and 032H, except that P3.6 and .7 must be pulled to a logic low. The values returned are follows.

(030H) = 1EH indicates manufactured by Atmel
(031H) = 52H indicates 89C52
(032H) = FFH indicates 12V programming
(032H) = 05H indicates 5V programming

Programming Interface

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

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

ash Programming Modes

ode		RST	$\overline{PSEN}$	ALE/$\overline{PROG}$	$\overline{EA}/V_{PP}$	P2.6	P2.7	P3.6	P3.7
rite Code Data		H	L		H/12V	L	H	H	H
ɜad Code Data		H	L	H	H	L	L	H	H
rite Lock	Bit - 1	H	L		H/12V	H	H	H	H
	Bit - 2	H	L		H/12V	H	H	L	L
	Bit - 3	H	L		H/12V	H	L	H	L
ıip Erase		H	L	(1)	H/12V	H	L	L	L
ɜad Signature Byte		H	L	H	H	L	L	L	L

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

ure 9. Programming the Flash Memory

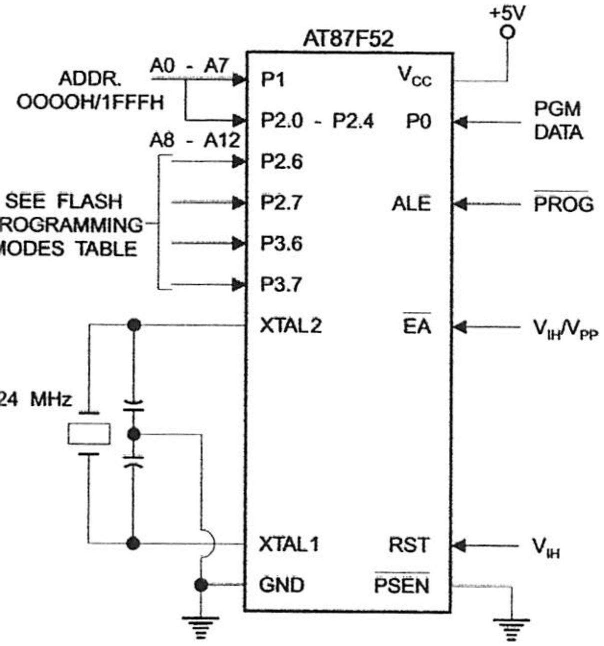
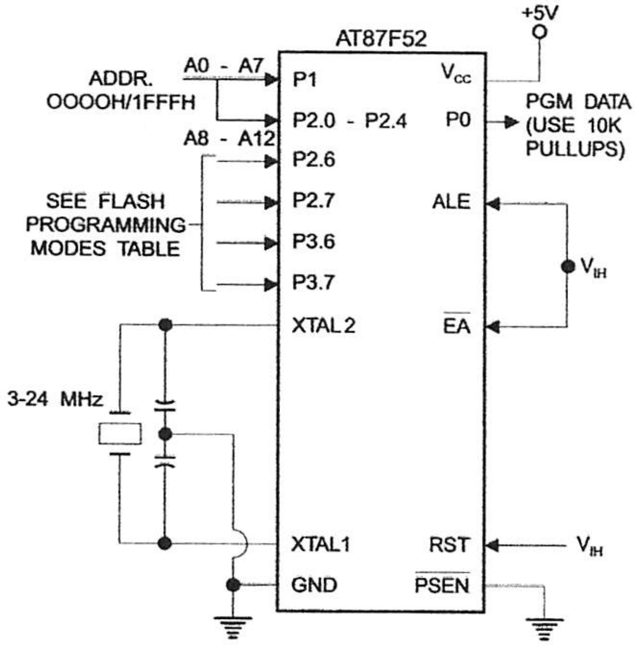


Figure 10. Verifying the Flash Memory



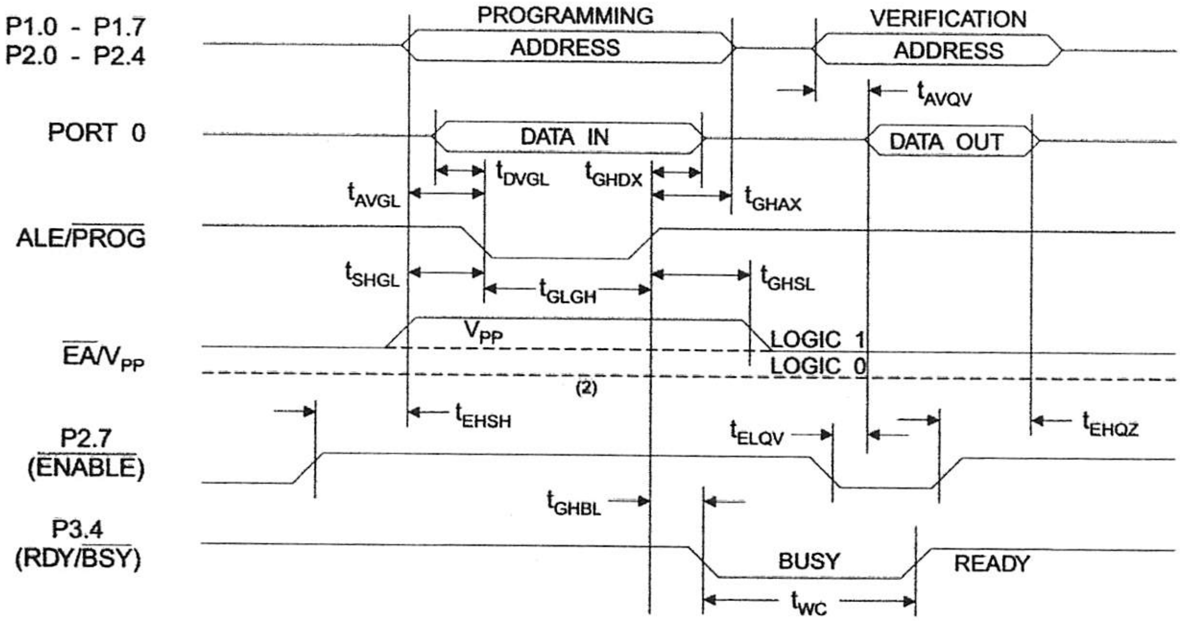
ash Programming and Verification Characteristics

= 0°C to 70°C, V_{CC} = 5.0 ± 10%

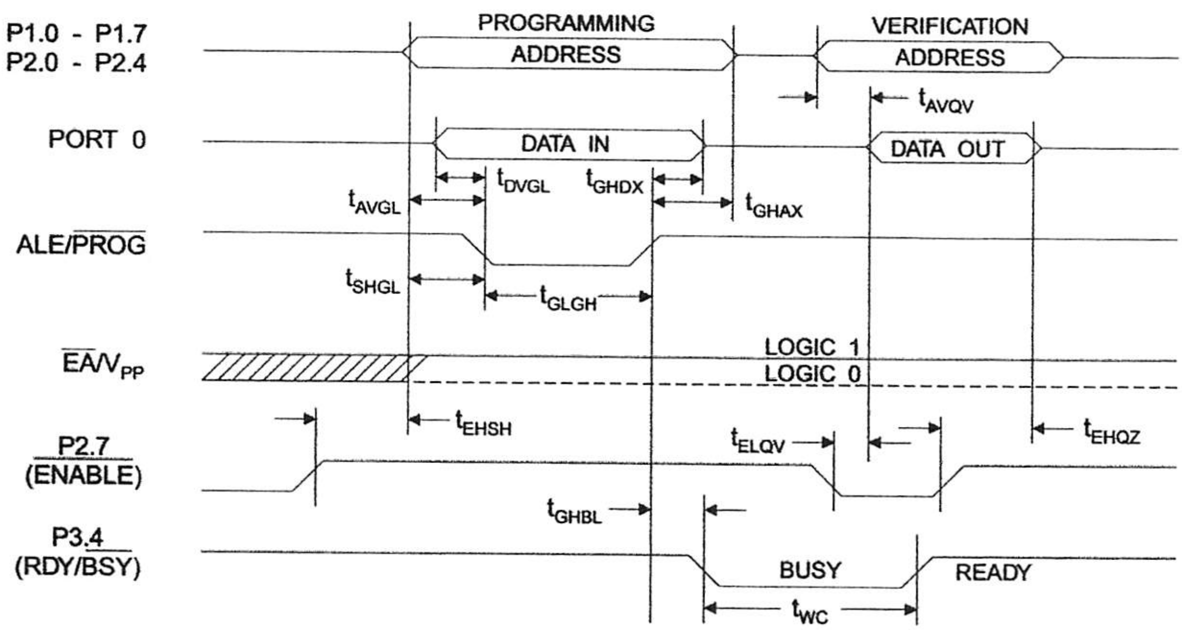
mbol	Parameter	Min	Max	Units
P[1]	Programming Enable Voltage	11.5	12.5	V
[1]	Programming Enable Current		1.0	mA
CLCL	Oscillator Frequency	3	24	MHz
GL	Address Setup to $\overline{\text{PROG}}$ Low	$48t_{CLCL}$		
AX	Address Hold after $\overline{\text{PROG}}$	$48t_{CLCL}$		
DL	Data Setup to $\overline{\text{PROG}}$ Low	$48t_{CLCL}$		
DX	Data Hold After $\overline{\text{PROG}}$	$48t_{CLCL}$		
SH	P2.7 ($\overline{\text{ENABLE}}$) High to V_{PP}	$48t_{CLCL}$		
GL	V_{PP} Setup to $\overline{\text{PROG}}$ Low	10		µs
SL[1]	V_{PP} Hold after $\overline{\text{PROG}}$	10		µs
GH	$\overline{\text{PROG}}$ Width	1	110	µs
QV	Address to Data Valid		$48t_{CLCL}$	
QV	$\overline{\text{ENABLE}}$ Low to Data Valid		$48t_{CLCL}$	
QZ	Data Float after $\overline{\text{ENABLE}}$	0	$48t_{CLCL}$	
BL	$\overline{\text{PROG}}$ High to $\overline{\text{BUSY}}$ Low		1.0	µs
	Byte Write Cycle Time		2.0	ms

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

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



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



bsolute Maximum Ratings*

perating Temperature	-55°C to +125°C
torage Temperature	-65°C to +150°C
oltage on Any Pin ith Respect to Ground	-1.0V to +7.0V
aximum Operating Voltage	6.6V
C Output Current	15.0 mA

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

C Characteristics

e values shown in this table are valid for T_A = -40°C to 85°C and V_{CC} = 5.0V ±20%, unless otherwise noted.

mbol	Parameter	Condition	Min	Max	Units
L	Input Low-voltage	(Except $\overline{EA}$)	-0.5	0.2 V_{CC}-0.1	V
L1	Input Low-voltage ($\overline{EA}$)		-0.5	0.2 V_{CC}-0.3	V
H	Input High-voltage	(Except XTAL1, RST)	0.2 V_{CC}+0.9	V_{CC}+0.5	V
H1	Input High-voltage	(XTAL1, RST)	0.7 V_{CC}	V_{CC}+0.5	V
L	Output Low-voltage(1) (Ports 1,2,3)	I_{OL} = 1.6 mA		0.45	V
L1	Output Low-voltage(1) (Port 0, ALE, $\overline{PSEN}$)	I_{OL} = 3.2 mA		0.45	V
H	Output High-voltage (Ports 1,2,3, ALE, $\overline{PSEN}$)	I_{OH} = -60 µA, V_{CC} = 5V ± 10%	2.4		V
		I_{OH} = -25 µA	0.75 V_{CC}		V
		I_{OH} = -10 µA	0.9 V_{CC}		V
H1	Output High-voltage (Port 0 in External Bus Mode)	I_{OH} = -800 µA, V_{CC} = 5V ± 10%	2.4		V
		I_{OH} = -300 µA	0.75 V_{CC}		V
		I_{OH} = -80 µA	0.9 V_{CC}		V
	Logical 0 Input Current (Ports 1,2,3)	V_{IN} = 0.45V		-50	µA
	Logical 1 to 0 Transition Current (Ports 1,2,3)	V_{IN} = 2V, V_{CC} = 5V ± 10%		-650	µA
	Input Leakage Current (Port 0, $\overline{EA}$)	0.45 < V_{IN} < V_{CC}		±10	µA
RST	Reset Pulldown Resistor		50	300	KΩ
)	Pin Capacitance	Test Freq. = 1 MHz, T_A = 25°C		10	pF
:	Power Supply Current	Active Mode, 12 MHz		25	mA
		Idle Mode, 12 MHz		6.5	mA
	Power-down Mode(1)	V_{CC} = 6V		100	µA
		V_{CC} = 3V		40	µA

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

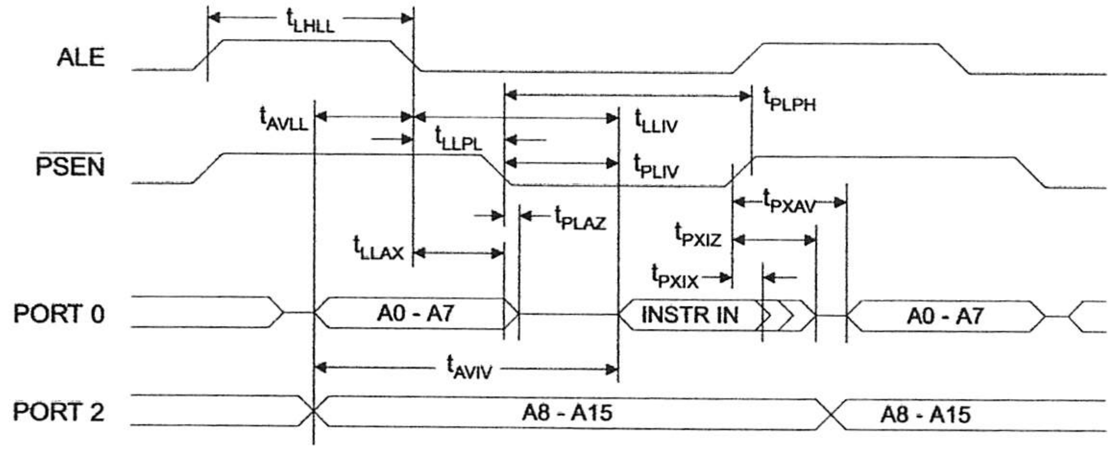
C Characteristics

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

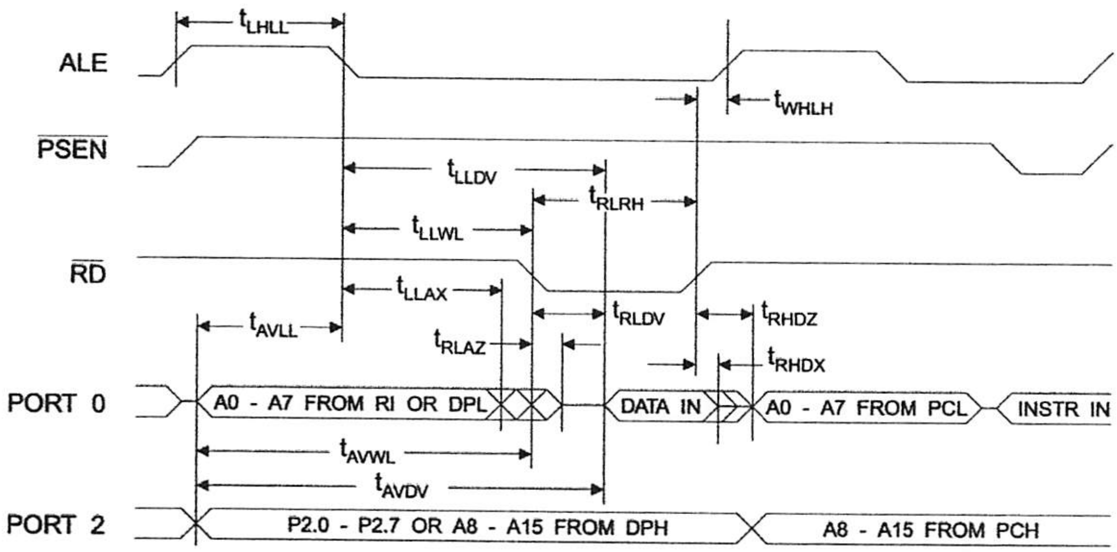
xternal Program and Data Memory Characteristics

ymbol	Parameter	12 MHz Oscillator		Variable Oscillator		Units
		Min	Max	Min	Max	
t_{CLCL}	Oscillator Frequency			0	24	MHz
HLL	ALE Pulse Width	127		$2t_{CLCL}$-40		ns
VLL	Address Valid to ALE Low	43		t_{CLCL}-13		ns
AX	Address Hold After ALE Low	48		t_{CLCL}-20		ns
IV	ALE Low to Valid Instruction In		233		$4t_{CLCL}$-65	ns
PL	ALE Low to $\overline{\text{PSEN}}$ Low	43		t_{CLCL}-13		ns
PH	$\overline{\text{PSEN}}$ Pulse Width	205		$3t_{CLCL}$-20		ns
IV	$\overline{\text{PSEN}}$ Low to Valid Instruction In		145		$3t_{CLCL}$-45	ns
IX	Input Instruction Hold after $\overline{\text{PSEN}}$	0		0		ns
IZ	Input Instruction Float after $\overline{\text{PSEN}}$		59		t_{CLCL}-10	ns
AV	$\overline{\text{PSEN}}$ to Address Valid	75		t_{CLCL}-8		ns
IV	Address to Valid Instruction In		312		$5t_{CLCL}$-55	ns
AZ	$\overline{\text{PSEN}}$ Low to Address Float		10		10	ns
RH	$\overline{\text{RD}}$ Pulse Width	400		$6t_{CLCL}$-100		ns
WH	$\overline{\text{WR}}$ Pulse Width	400		$6t_{CLCL}$-100		ns
DV	$\overline{\text{RD}}$ Low to Valid Data In		252		$5t_{CLCL}$-90	ns
DX	Data Hold After $\overline{\text{RD}}$	0		0		ns
DZ	Data Float After $\overline{\text{RD}}$		97		$2t_{CLCL}$-28	ns
DV	ALE Low to Valid Data In		517		$8t_{CLCL}$-150	ns
DV	Address to Valid Data In		585		$9t_{CLCL}$-165	ns
WL	ALE Low to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ Low	200	300	$3t_{CLCL}$-50	$3t_{CLCL}$+50	ns
WL	Address to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ Low	203		$4t_{CLCL}$-75		ns
WX	Data Valid to $\overline{\text{WR}}$ Transition	23		t_{CLCL}-20		ns
WH	Data Valid to $\overline{\text{WR}}$ High	433		$7t_{CLCL}$-120		ns
QX	Data Hold After $\overline{\text{WR}}$	33		t_{CLCL}-20		ns
AZ	$\overline{\text{RD}}$ Low to Address Float		0		0	ns
LH	$\overline{\text{RD}}$ or $\overline{\text{WR}}$ High to ALE High	43	123	t_{CLCL}-20	t_{CLCL}+25	ns

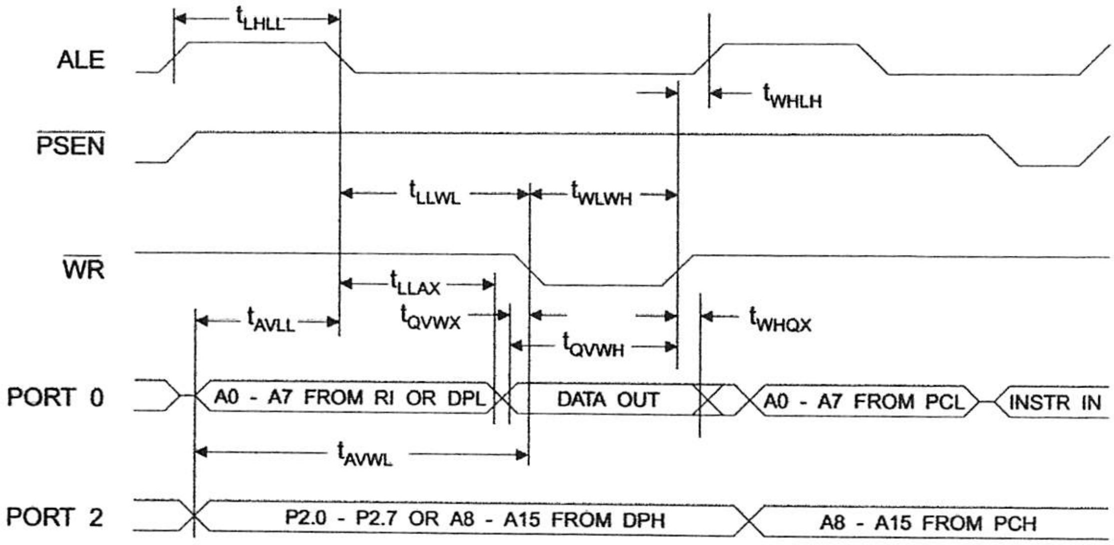
xternal Program Memory Read Cycle



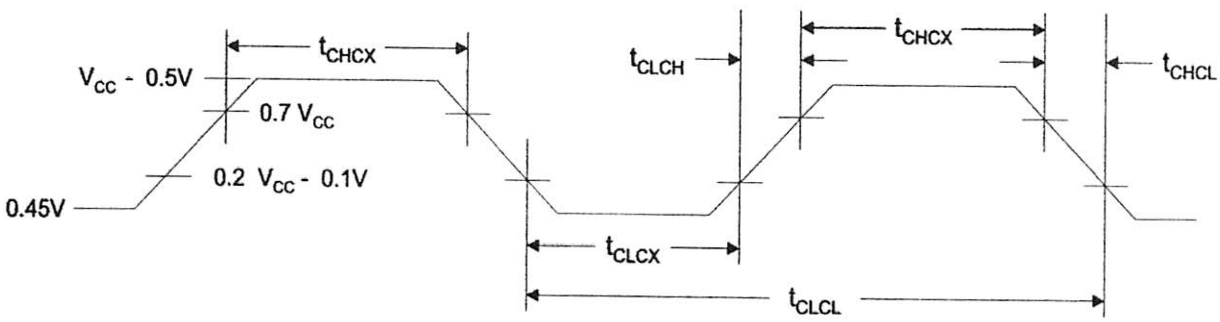
xternal Data Memory Read Cycle



xternal Data Memory Write Cycle



xternal Clock Drive Waveforms



xternal Clock Drive

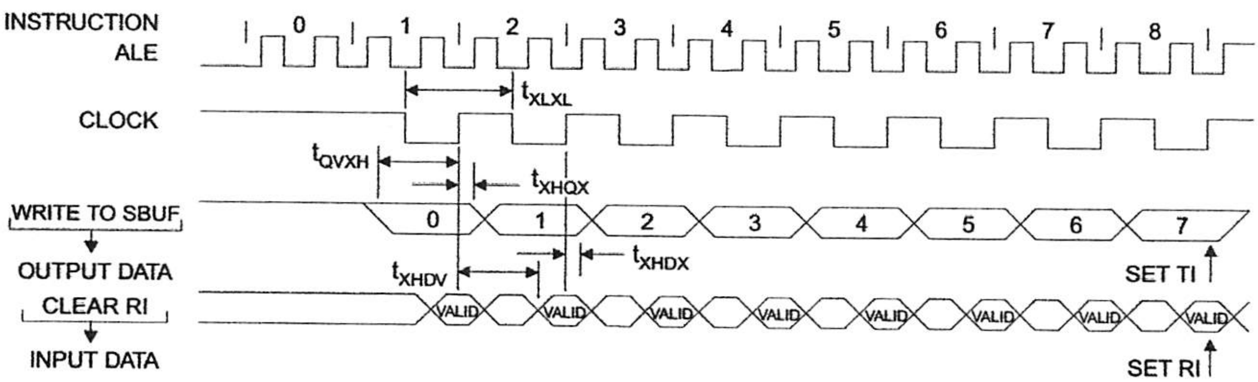
ymbol	Parameter	Min	Max	Units
CLCL	Oscillator Frequency	0	24	MHz
CL	Clock Period	41.6		ns
HCX	High Time	15		ns
CX	Low Time	15		ns
CH	Rise Time		20	ns
HCL	Fall Time		20	ns

erial Port Timing: Shift Register Mode Test Conditions

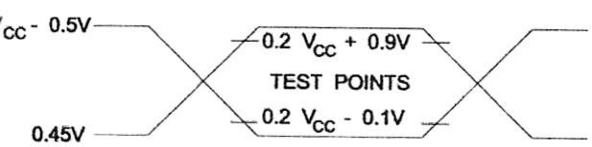
e values in this table are valid for V_{CC} = 5.0V ±20% and Load Capacitance = 80 pF.

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

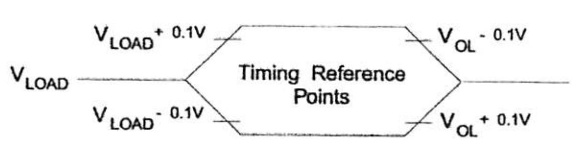
hift Register Mode Timing Waveforms



C Testing Input/Output Waveforms[1]



Float Waveforms[1]



e: 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.

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.

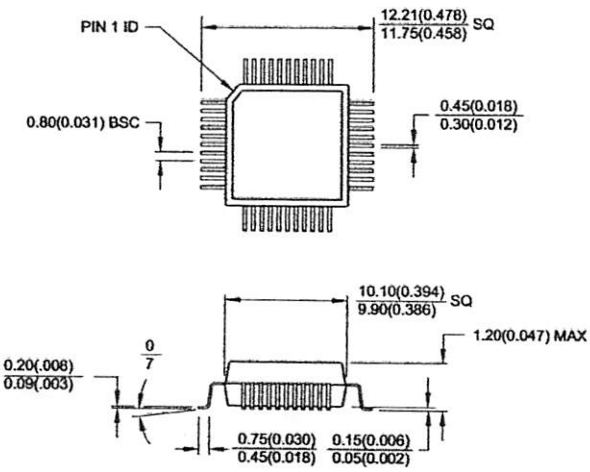
rdering Information

Speed (MHz)	Power Supply	Ordering Code	Package	Operation Range
12	5V ±20%	AT89C52-12AC	44A	Commercial (0° C to 70° C)
		AT89C52-12JC	44J	
		AT89C52-12PC	40P6	
		AT89C52-12QC	44Q	
		AT89C52-12AI	44A	Industrial (-40° C to 85° C)
		AT89C52-12JI	44J	
		AT89C52-12PI	40P6	
		AT89C52-12QI	44Q	
16	5V ±20%	AT89C52-16AC	44A	Commercial (0° C to 70° C)
		AT89C52-16JC	44J	
		AT89C52-16PC	40P6	
		AT89C52-16QC	44Q	
		AT89C52-16AI	44A	Industrial (-40° C to 85° C)
		AT89C52-16JI	44J	
		AT89C52-16PI	40P6	
		AT89C52-16QI	44Q	
20	5V ±20%	AT89C52-20AC	44A	Commercial (0° C to 70° C)
		AT89C52-20JC	44J	
		AT89C52-20PC	40P6	
		AT89C52-20QC	44Q	
		AT89C52-20AI	44A	Industrial (-40° C to 85° C)
		AT89C52-20JI	44J	
		AT89C52-20PI	40P6	
		AT89C52-20QI	44Q	
24	5V ±20%	AT89C52-24AC	44A	Commercial (0° C to 70° C)
		AT89C52-24JC	44J	
		AT89C52-24PC	40P6	
		AT89C52-24QC	44Q	
		AT89C52-24AI	44A	Industrial (-40° C to 85° C)
		AT89C52-24JI	44J	
		AT89C52-24PI	40P6	
		AT89C52-24QI	44Q	

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

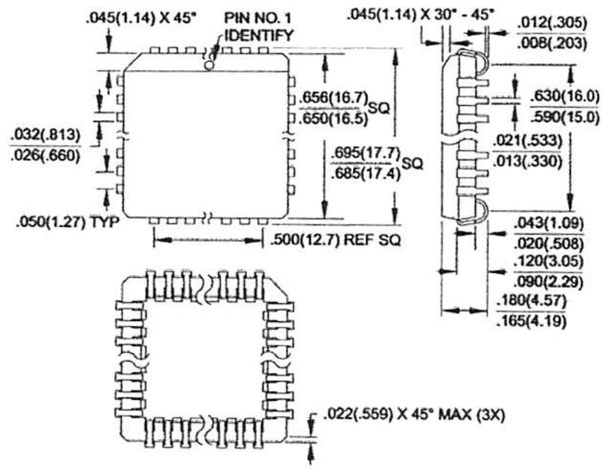
ackaging Information

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

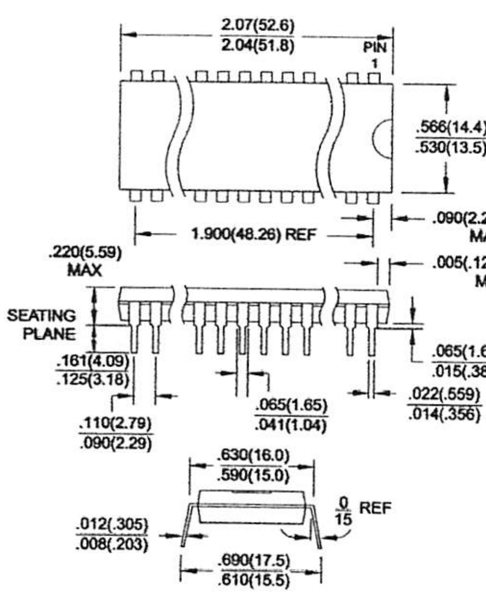


Controlling dimension: millimeters

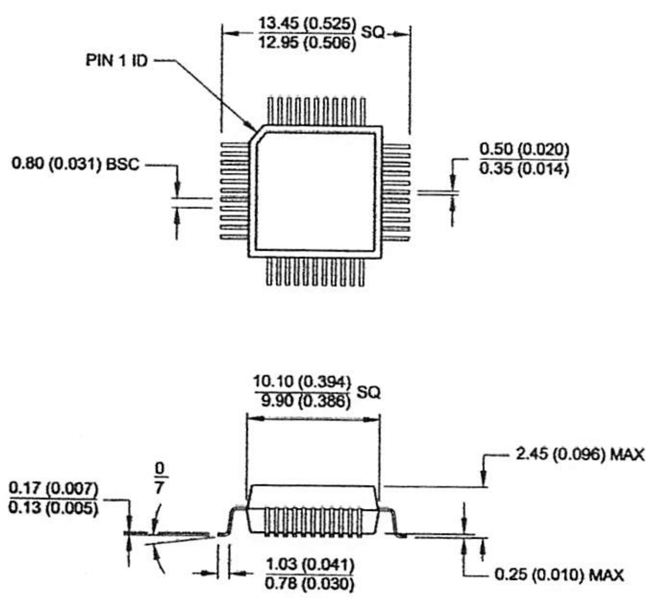
44J, 44-lead, Plastic J-leaded Chip Carrier (PLCC)
Dimensions in Inches and (Millimeters)
JEDEC STANDARD MS-018 AC



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



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



Controlling dimension: millimeters

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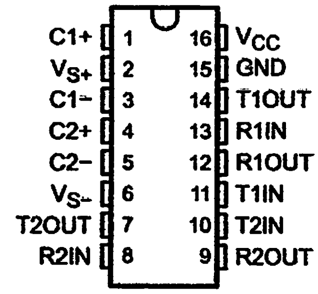
0313H–02/00/xM

- **Meets or Exceeds TIA/EIA-232-F and ITU Recommendation V.28**
- **Operates From a Single 5-V Power Supply With 1.0-μF Charge-Pump Capacitors**
- **Operates Up To 120 kbit/s**
- **Two Drivers and Two Receivers**
- **±30-V Input Levels**
- **Low Supply Current . . . 8 mA Typical**
- **ESD Protection Exceeds JESD 22**
  – **2000-V Human-Body Model (A114-A)**
- **Upgrade With Improved ESD (15-kV HBM) and 0.1-μF Charge-Pump Capacitors is Available With the MAX202**
- **Applications**
  – **TIA/EIA-232-F, Battery-Powered Systems, Terminals, Modems, and Computers**

MAX232 . . . D, DW, N, OR NS PACKAGE
MAX232I . . . D, DW, OR N PACKAGE
(TOP VIEW)



description/ordering information

The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply TIA/EIA-232-F voltage levels from a single 5-V supply. Each receiver converts TIA/EIA-232-F inputs to 5-V TTL/CMOS levels. These receivers have a typical threshold of 1.3 V, a typical hysteresis of 0.5 V, and can accept ±30-V inputs. Each driver converts TTL/CMOS input levels into TIA/EIA-232-F levels. The driver, receiver, and voltage-generator functions are available as cells in the Texas Instruments LinASIC™ library.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP (N)	Tube of 25	MAX232N	MAX232N
	SOIC (D)	Tube of 40	MAX232D	MAX232
		Reel of 2500	MAX232DR	
	SOIC (DW)	Tube of 40	MAX232DW	MAX232
		Reel of 2000	MAX232DWR	
	SOP (NS)	Reel of 2000	MAX232NSR	MAX232
−40°C to 85°C	PDIP (N)	Tube of 25	MAX232IN	MAX232IN
	SOIC (D)	Tube of 40	MAX232ID	MAX232I
		Reel of 2500	MAX232IDR	
	SOIC (DW)	Tube of 40	MAX232IDW	MAX232I
		Reel of 2000	MAX232IDWR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

Function Tables

EACH DRIVER

INPUT TIN	OUTPUT TOUT
L	H
H	L

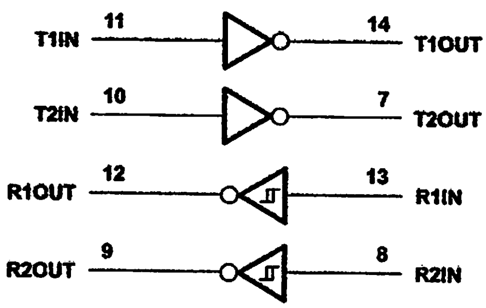
H = high level, L = low level

EACH RECEIVER

INPUT RIN	OUTPUT ROUT
L	H
H	L

H = high level, L = low level

›gic diagram (positive logic)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Input supply voltage range, V_{CC} (see Note 1) .... –0.3 V to 6 V
Positive output supply voltage range, V_{S+} .... V_{CC} – 0.3 V to 15 V
Negative output supply voltage range, V_{S-} .... –0.3 V to –15 V
Input voltage range, V_I: Driver .... –0.3 V to V_{CC} + 0.3 V
Receiver .... ±30 V
Output voltage range, V_O: T1OUT, T2OUT .... V_{S-} – 0.3 V to V_{S+} + 0.3 V
R1OUT, R2OUT .... –0.3 V to V_{CC} + 0.3 V
Short-circuit duration: T1OUT, T2OUT .... Unlimited
Package thermal impedance, θ_{JA} (see Notes 2 and 3): D package .... 73°C/W
DW package .... 57°C/W
N package .... 67°C/W
NS package .... 64°C/W
Operating virtual junction temperature, T_J .... 150°C
Storage temperature range, T_{stg} .... –65°C to 150°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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltages are with respect to network GND.
2. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		4.5	5	5.5	V
V_{IH}	High-level input voltage (T1IN,T2IN)		2			V
V_{IL}	Low-level input voltage (T1IN, T2IN)				0.8	V
R1IN, R2IN	Receiver input voltage				±30	V
T_A	Operating free-air temperature	MAX232	0		70	°C
		MAX232I	–40		85	°C

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER		TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
I_{CC}	Supply current	V_{CC} = 5.5 V, All outputs open, T_A = 25°C		8	10	mA

‡ All typical values are at V_{CC} = 5 V and T_A = 25°C.

NOTE 4: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

DRIVER SECTION

lectrical characteristics over recommended ranges of supply voltage and operating free-air emperature range (see Note 4)

PARAMETER			TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	T1OUT, T2OUT	R_L = 3 kΩ to GND	5	7		V
V_{OL}	Low-level output voltage‡	T1OUT, T2OUT	R_L = 3 kΩ to GND		–7	–5	V
o	Output resistance	T1OUT, T2OUT	$V_{S+} = V_{S-} = 0$, $V_O = \pm 2$ V	300			Ω
$_{OS}$§	Short-circuit output current	T1OUT, T2OUT	V_{CC} = 5.5 V, V_O = 0		±10		mA
$_{IS}$	Short-circuit input current	T1IN, T2IN	V_I = 0			200	µA

All typical values are at V_{CC} = 5 V, T_A = 25°C.
The algebraic convention, in which the least-positive (most negative) value is designated minimum, is used in this data sheet for logic voltage levels only.
Not more than one output should be shorted at a time.
OTE 4: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

witching characteristics, V_{CC} = 5 V, T_A = 25°C (see Note 4)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Driver slew rate	R_L = 3 kΩ to 7 kΩ, See Figure 2			30	V/µs
SR(t)	Driver transition region slew rate	See Figure 3		3		V/µs
	Data rate	One TOUT switching		120		kbit/s

OTE 4: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

RECEIVER SECTION

lectrical characteristics over recommended ranges of supply voltage and operating free-air mperature range (see Note 4)

PARAMETER			TEST CONDITIONS	MIN	TYP†	MAX	UNIT
OH	High-level output voltage	R1OUT, R2OUT	I_{OH} = –1 mA	3.5			V
OL	Low-level output voltage‡	R1OUT, R2OUT	I_{OL} = 3.2 mA			0.4	V
IT+	Receiver positive-going input threshold voltage	R1IN, R2IN	V_{CC} = 5 V, T_A = 25°C		1.7	2.4	V
IT–	Receiver negative-going input threshold voltage	R1IN, R2IN	V_{CC} = 5 V, T_A = 25°C	0.8	1.2		V
hys	Input hysteresis voltage	R1IN, R2IN	V_{CC} = 5 V	0.2	0.5	1	V
	Receiver input resistance	R1IN, R2IN	V_{CC} = 5, T_A = 25°C	3	5	7	kΩ

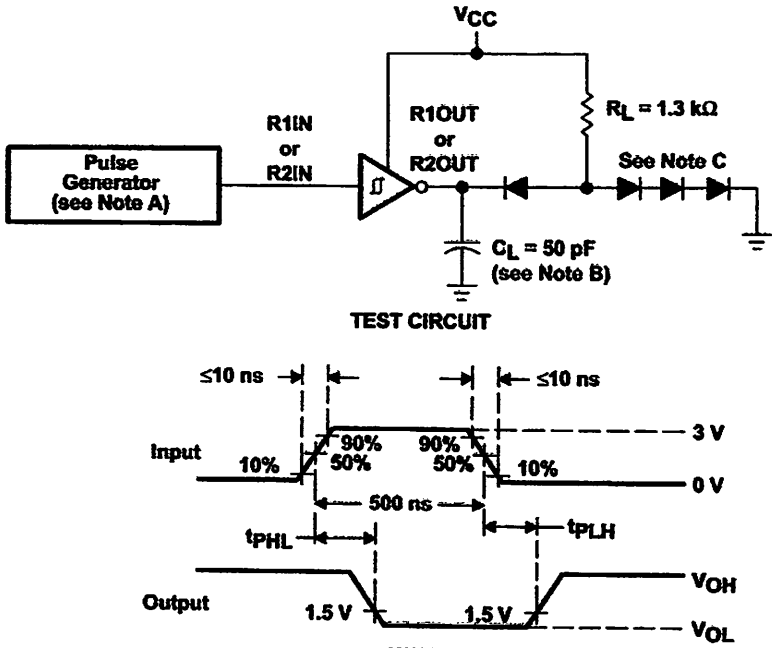
ll typical values are at V_{CC} = 5 V, T_A = 25°C.
he algebraic convention, in which the least-positive (most negative) value is designated minimum, is used in this data sheet for logic voltage evels only.
TE 4: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

vitching characteristics, V_{CC} = 5 V, T_A = 25°C (see Note 4 and Figure 1)

PARAMETER		TYP	UNIT
LH(R)	Receiver propagation delay time, low- to high-level output	500	ns
HL(R)	Receiver propagation delay time, high- to low-level output	500	ns

TE 4: Test conditions are C1–C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

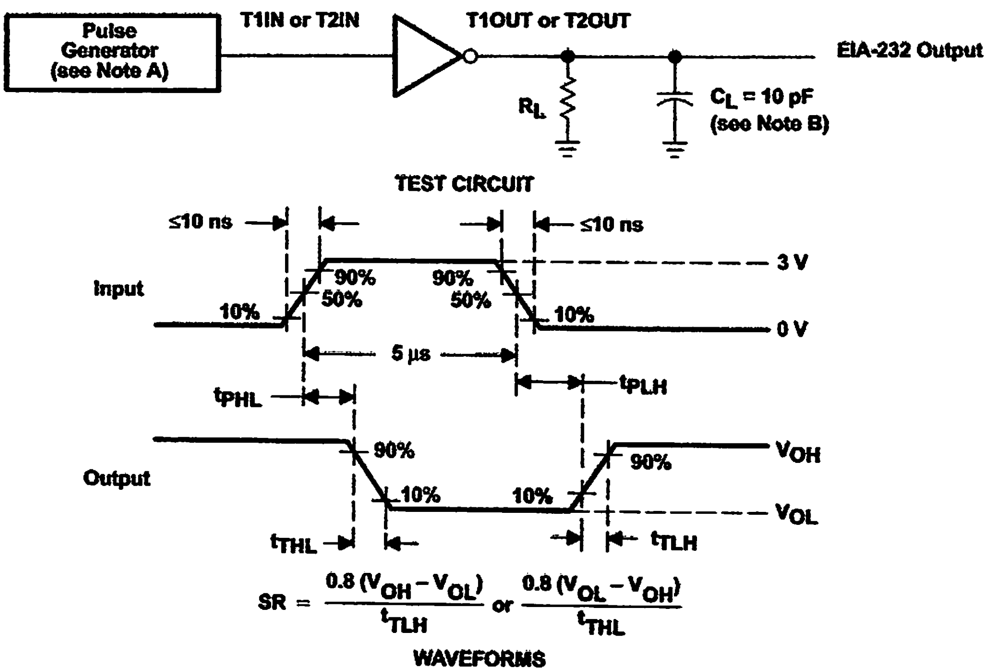
PARAMETER MEASUREMENT INFORMATION



NOTES: A. The pulse generator has the following characteristics: Z_O = 50 Ω, duty cycle ≤ 50%.
B. C_L includes probe and jig capacitance.
C. All diodes are 1N3064 or equivalent.

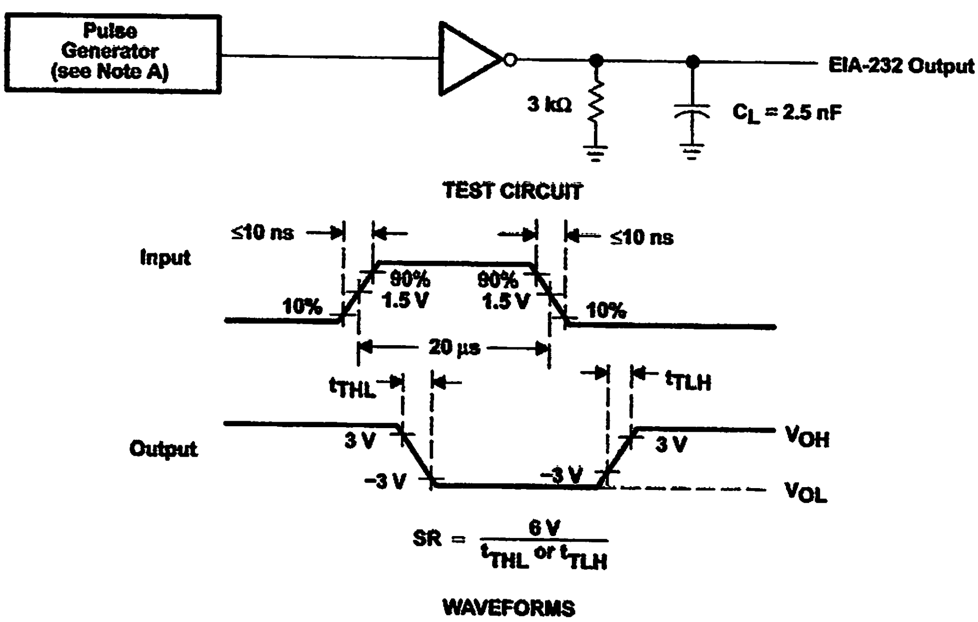
Figure 1. Receiver Test Circuit and Waveforms for t_{PHL} and t_{PLH} Measurements

PARAMETER MEASUREMENT INFORMATION



NOTES: A. The pulse generator has the following characteristics: Z_O = 50 Ω, duty cycle ≤ 50%.
B. C_L includes probe and jig capacitance.

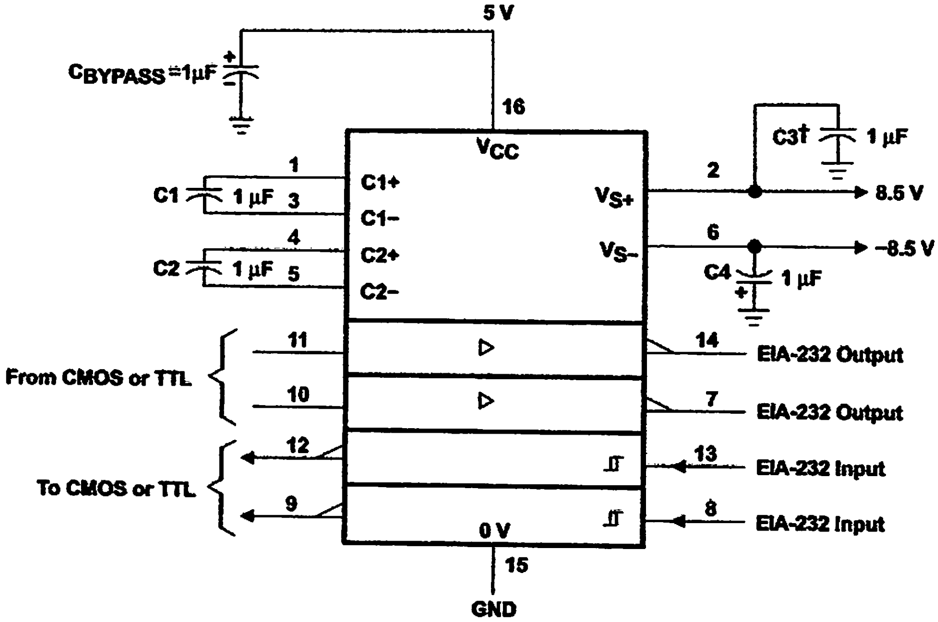
Figure 2. Driver Test Circuit and Waveforms for t_{PHL} and t_{PLH} Measurements (5-µs Input)



NOTE A: The pulse generator has the following characteristics: Z_O = 50 Ω, duty cycle ≤ 50%.

Figure 3. Test Circuit and Waveforms for t_{THL} and t_{TLH} Measurements (20-µs Input)

APPLICATION INFORMATION



† C3 can be connected to V_{CC} or GND.

NOTES: A. Resistor values shown are nominal.

B. Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they should be connected as shown. In addition to the 1-µF capacitors shown, the MAX202 can operate with 0.1-µF capacitors.

Figure 4. Typical Operating Circuit

PACKAGE OPTION ADDENDUM

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
MAX232D	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DE4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DRE4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DWE4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DWRE4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232DWRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232ID	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDE4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDRE4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDWE4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDWRE4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IDWRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232IN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
MAX232INE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
MAX232N	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
MAX232NE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
MAX232NSR	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232NSRE4	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX232NSRG4	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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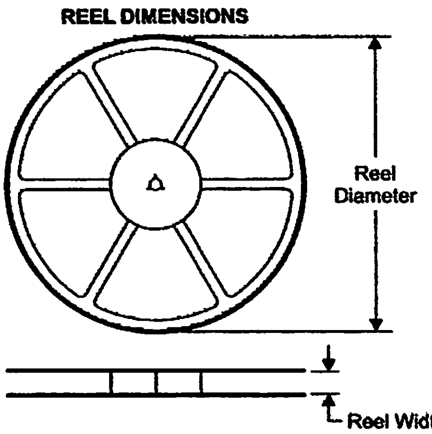
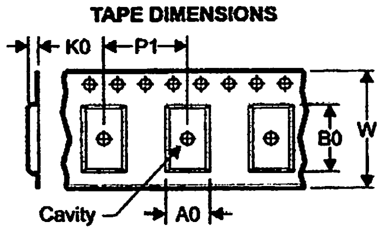
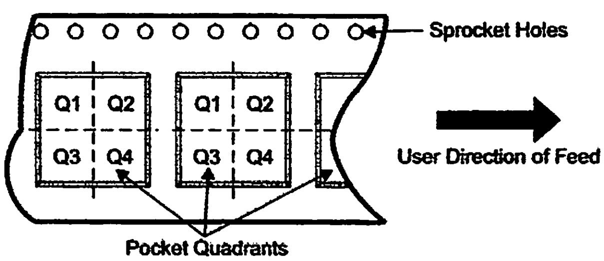
TAPE AND REEL INFORMATION





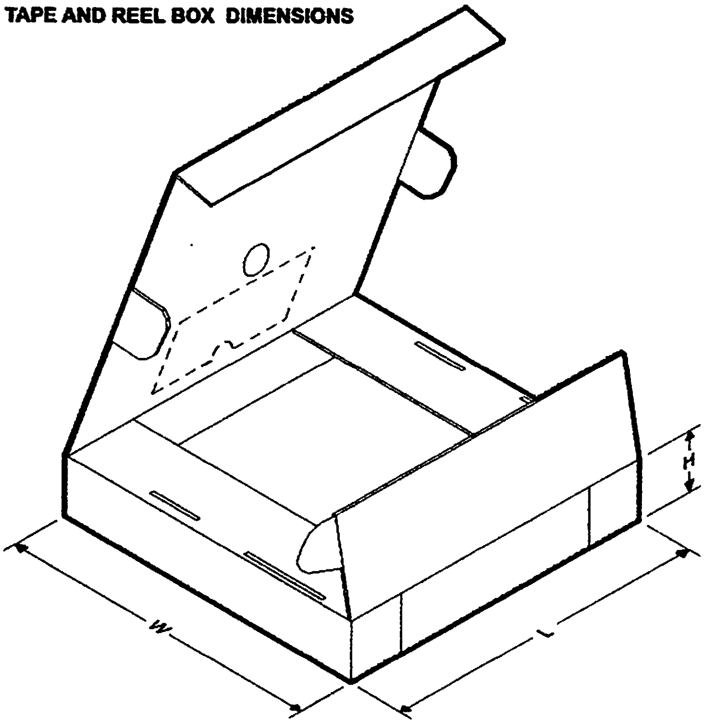
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
MAX232DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
MAX232DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
MAX232DWR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1
MAX232IDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
MAX232IDWR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1
MAX232NSR	SO	NS	16	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS

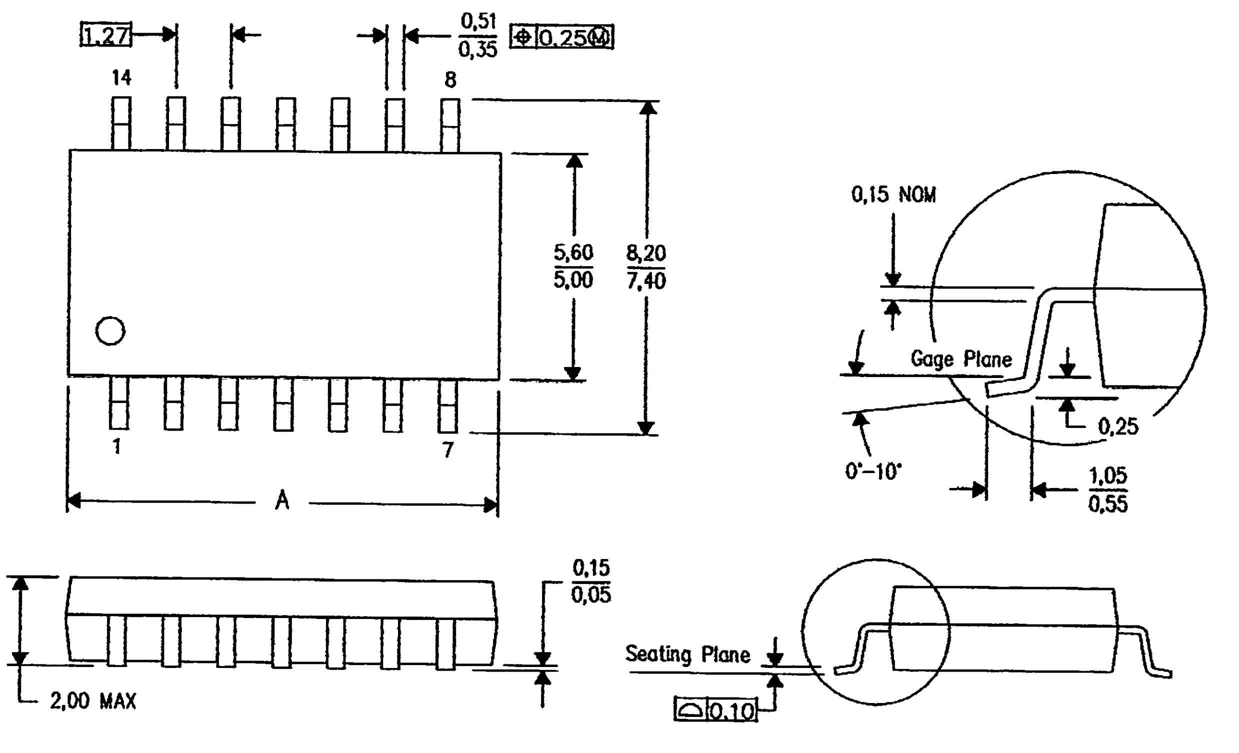


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
MAX232DR	SOIC	D	16	2500	346.0	346.0	33.0
MAX232DR	SOIC	D	16	2500	333.2	345.9	28.6
MAX232DWR	SOIC	DW	16	2000	346.0	346.0	33.0
MAX232IDR	SOIC	D	16	2500	333.2	345.9	28.6
MAX232IDWR	SOIC	DW	16	2000	346.0	346.0	33.0
MAX232NSR	SO	NS	16	2000	346.0	346.0	33.0

NS (R-PDSO-G**) PLASTIC SMALL-OUTLINE PACKAGE

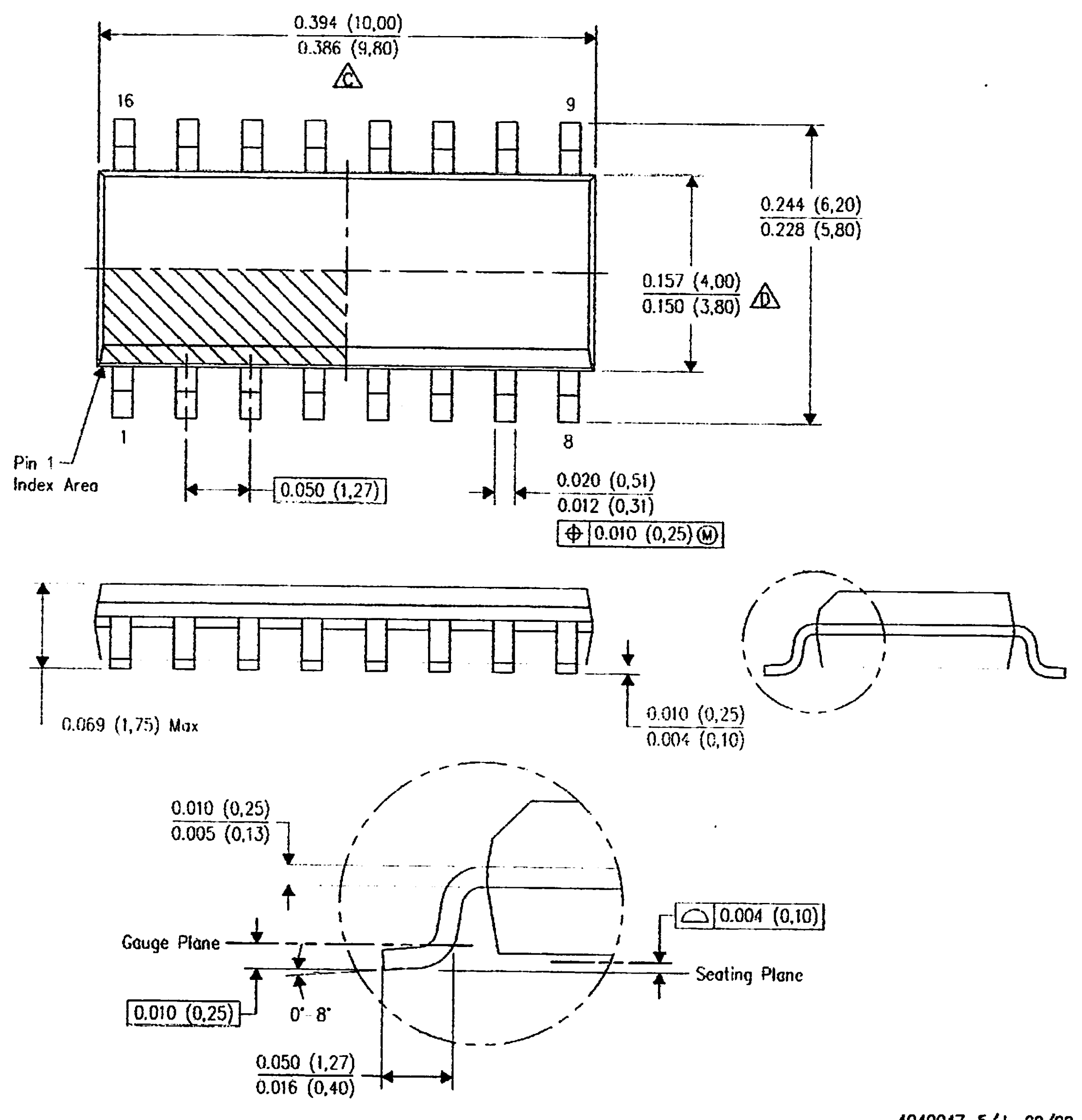
14-PINS SHOWN



PINS ** / DIM	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

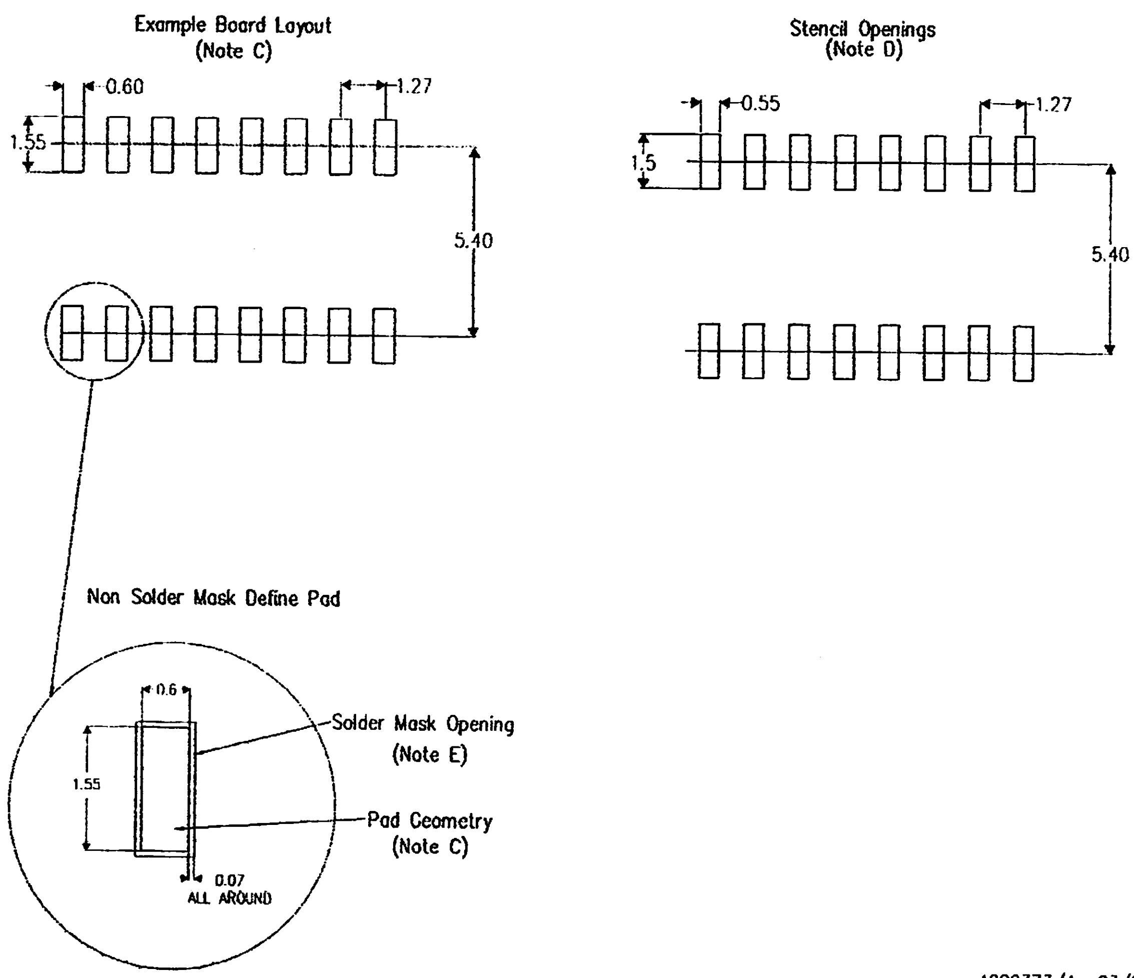
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

D (R–PDSO–G16) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
- D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
- E. Reference JEDEC MS-012 variation AC.

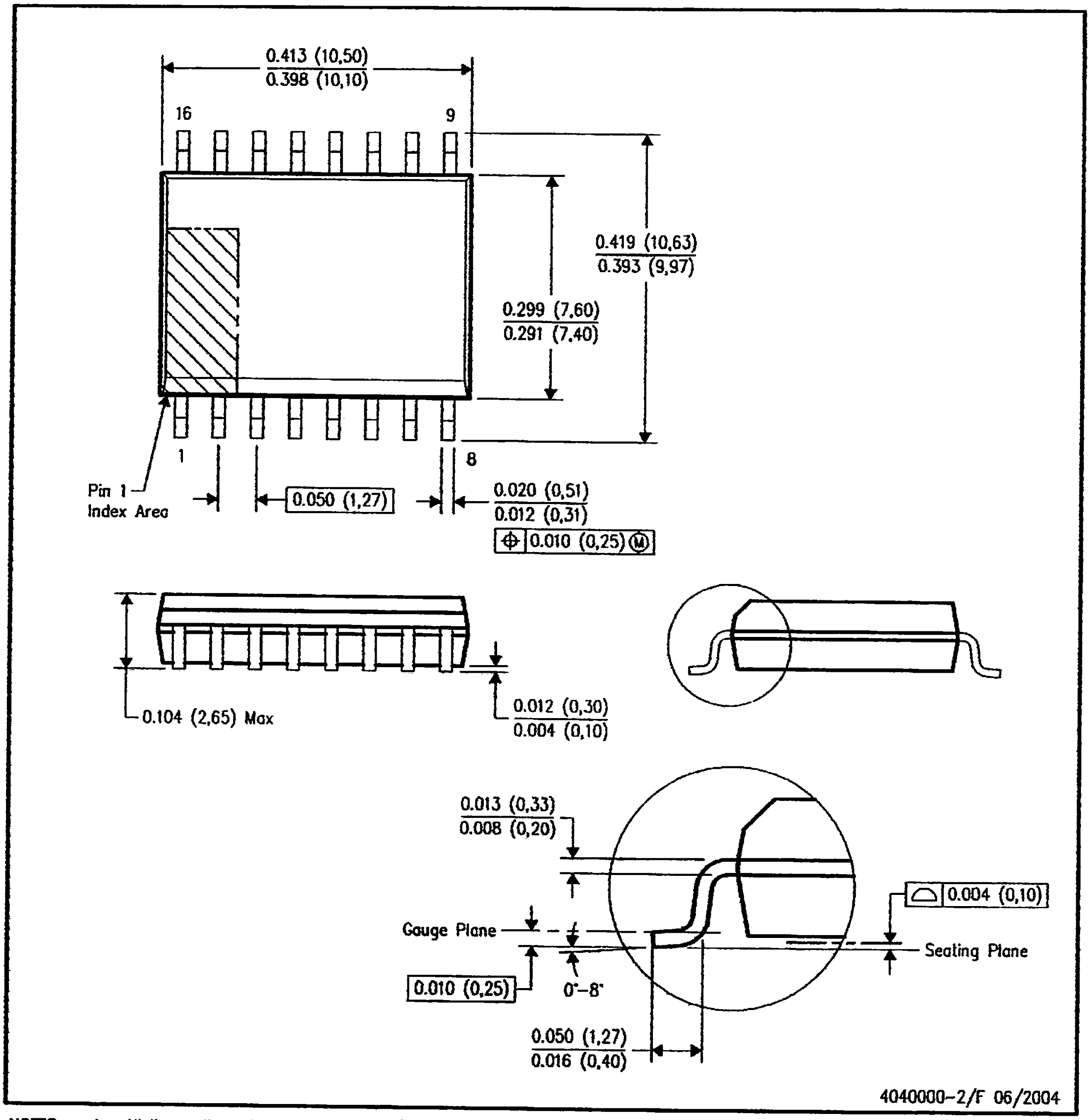
D(R-PDSO-G16)



4209373/A 03/08

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Refer to IPC7351 for alternate board design.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

DW (R-PDSO-G16) PLASTIC SMALL-OUTLINE PACKAGE

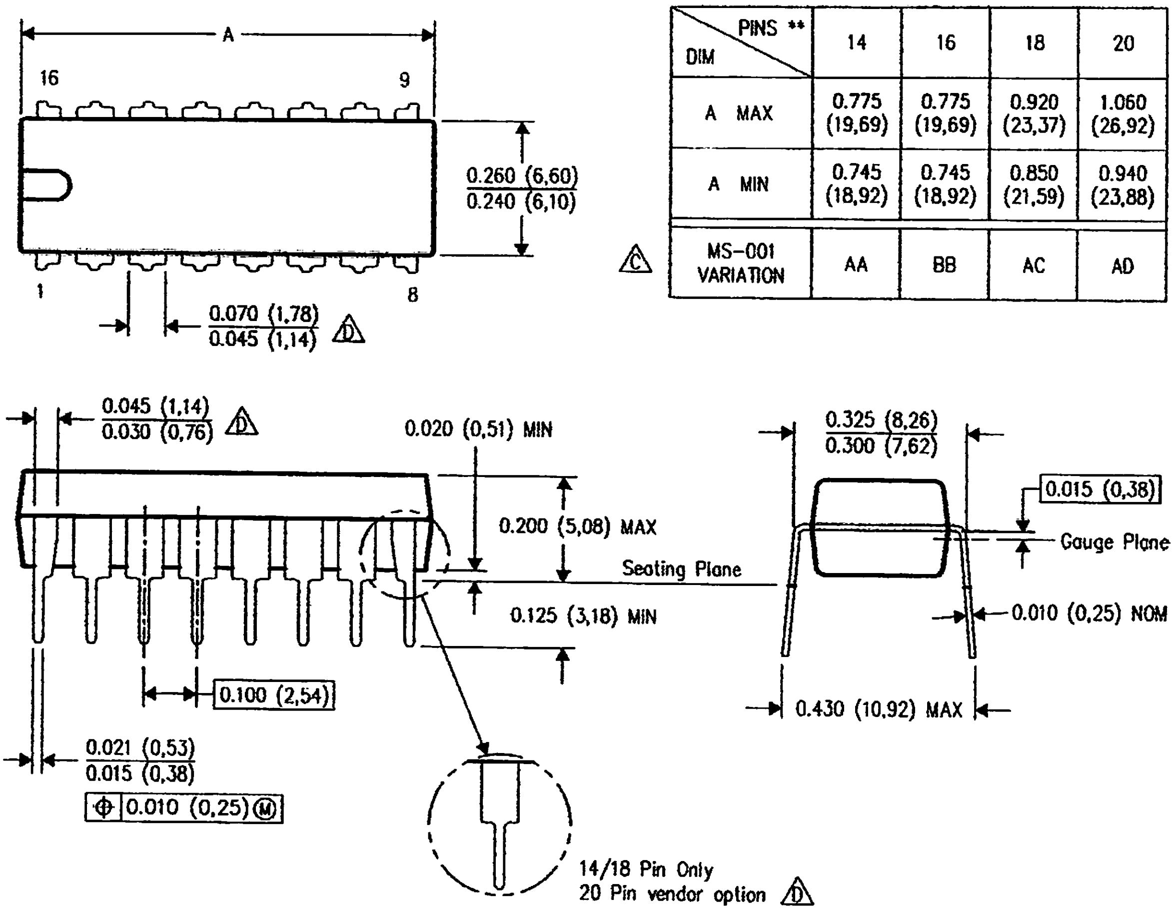


NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS-013 variation AA.

N (R-PDIP-T**) PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN

PINS ** / DIM	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION (C)	AA	BB	AC	AD



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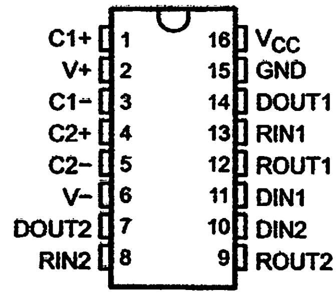
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
(C) Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
(D) The 20 pin end lead shoulder width is a vendor option, either half or full width.

- **RS-232 Bus-Pin ESD Protection Exceeds ±15 kV Using Human-Body Model (HBM)**
- **Meets or Exceeds the Requirements of TIA/EIA-232-F and ITU v.28 Standards**
- **Operates With 3-V to 5.5-V V_{CC} Supply**
- **Operates Up To 250 kbit/s**
- **Two Drivers and Two Receivers**
- **Low Supply Current . . . 300 μA Typical**
- **External Capacitors . . . 4 × 0.1 μF**
- **Accepts 5-V Logic Input With 3.3-V Supply**
- **Alternative High-Speed Pin-Compatible Device (1 Mbit/s)**
  - **SNx5C3232**
- **Applications**
  - **Battery-Powered Systems, PDAs, Notebooks, Laptops, Palmtop PCs, and Hand-Held Equipment**

D, DB, DW, OR PW PACKAGE
(TOP VIEW)



description/ordering information

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−0°C to 70°C	SOIC (D)	Tube of 40	MAX3232CD	MAX3232C
		Reel of 2500	MAX3232CDR	
	SOIC (DW)	Tube of 40	MAX3232CDW	MAX3232C
		Reel of 2000	MAX3232CDWR	
	SSOP (DB)	Tube of 80	MAX3232CDB	MA3232C
		Reel of 2000	MAX3232CDBR	
	TSSOP (PW)	Tube of 90	MAX3232CPW	MA3232C
		Reel of 2000	MAX3232CPWR	
−40°C to 85°C	SOIC (D)	Tube of 40	MAX3232ID	MAX3232I
		Reel of 2500	MAX3232IDR	
	SOIC (DW)	Tube of 40	MAX3232IDW	MAX3232I
		Reel of 2000	MAX3232IDWR	
	SSOP (DB)	Tube of 80	MAX3232IDB	MB3232I
		Reel of 2000	MAX3232IDBR	
	TSSOP (PW)	Tube of 90	MAX3232IPW	MB3232I
		Reel of 2000	MAX3232IPWR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

description/ordering information (continued)

The MAX3232 device consists of two line drivers, two line receivers, and a dual charge-pump circuit with ±15-kV ESD protection pin to pin (serial-port connection pins, including GND). The device meets the requirements of TIA/EIA-232-F and provides the electrical interface between an asynchronous communication controller and the serial-port connector. The charge pump and four small external capacitors allow operation from a single 3-V to 5.5-V supply. The devices operate at data signaling rates up to 250 kbit/s and a maximum of 30-V/μs driver output slew rate.

Function Tables

EACH DRIVER

INPUT DIN	OUTPUT DOUT
L	H
H	L

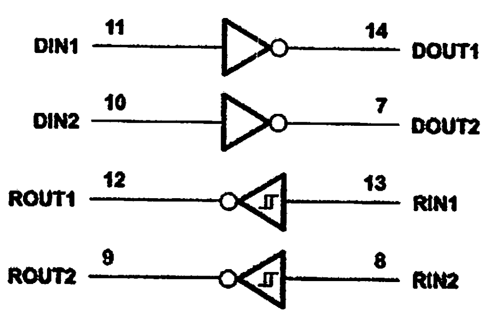
H = high level, L = low level

EACH RECEIVER

INPUT RIN	OUTPUT ROUT
L	H
H	L
Open	H

H = high level, L = low level, Open = input disconnected or connected driver off

logic diagram (positive logic)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CC} (see Note 1)	−0.3 V to 6 V
Positive output supply voltage range, V+ (see Note 1)	−0.3 V to 7 V
Negative output supply voltage range, V− (see Note 1)	0.3 V to −7 V
Supply voltage difference, V+ − V− (see Note 1)	13 V
Input voltage range, V_I: Drivers	−0.3 V to 6 V
Receivers	−25 V to 25 V
Output voltage range, V_O: Drivers	−13.2 V to 13.2 V
Receivers	−0.3 V to V_{CC} + 0.3 V
Package thermal impedance, θ_{JA} (see Notes 2 and 3): D package	73°C/W
DB package	82°C/W
DW package	57°C/W
PW package	108°C/W
Operating virtual junction temperature, T_J	150°C
Storage temperature range, T_{stg}	−65°C to 150°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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltages are with respect to network GND.
2. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 4 and Figure 4)

				MIN	NOM	MAX	UNIT
	Supply voltage		V_{CC} = 3.3 V	3	3.3	3.6	V
			V_{CC} = 5 V	4.5	5	5.5	
V_{IH}	Driver high-level input voltage	DIN	V_{CC} = 3.3 V	2			V
			V_{CC} = 5 V	2.4			
V_{IL}	Driver low-level input voltage		DIN			0.8	V
V_I	Driver input voltage		DIN	0		5.5	V
	Receiver input voltage			−25		25	
T_A	Operating free-air temperature		MAX3232C	0		70	°C
			MAX3232I	−40		85	

NOTE 4: Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER		TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
I_{CC}	Supply current	No load, V_{CC} = 3.3 V or 5 V		0.3	1	mA

‡ All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.

NOTE 4: Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.

DRIVER SECTION

lectrical characteristics over recommended ranges of supply voltage and operating free-air emperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	DOUT at R_L = 3 kΩ to GND,	DIN = GND	5	5.4		V
V_{OL}	Low-level output voltage	DOUT at R_L = 3 kΩ to GND,	DIN = V_{CC}	−5	−5.4		V
I_{IH}	High-level input current	$V_I = V_{CC}$			±0.01	±1	µA
I_{IL}	Low-level input current	V_I at GND			±0.01	±1	µA
I_{OS}‡	Short-circuit output current	V_{CC} = 3.6 V,	V_O = 0 V		±35	±60	mA
		V_{CC} = 5.5 V,	V_O = 0 V				
r_o	Output resistance	V_{CC}, V+, and V− = 0 V,	V_O = ±2 V	300	10M		Ω

All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.
Short-circuit durations should be controlled to prevent exceeding the device absolute power dissipation ratings, and not more than one output should be shorted at a time.
OTE 4: Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.

witching characteristics over recommended ranges of supply voltage and operating free-air emperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER		TEST CONDITIONS		MIN	TYP†	MAX	UNIT
	Maximum data rate	C_L = 1000 pF, One DOUT switching,	R_L = 3 kΩ, See Figure 1	150	250		kbit/s
$t_{sk(p)}$	Pulse skew§	C_L = 150 pF to 2500 pF	R_L = 3 kΩ to 7 kΩ, See Figure 2		300		ns
SR(tr)	Slew rate, transition region (see Figure 1)	R_L = 3 kΩ to 7 kΩ, V_{CC} = 3.3 V	C_L = 150 pF to 1000 pF	6		30	V/µs
			C_L = 150 pF to 2500 pF	4		30	

All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.
Pulse skew is defined as $|t_{PLH} - t_{PHL}|$ of each channel of the same device.
OTE 4: Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.

RECEIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 4)

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	I_{OH} = –1 mA	V_{CC}–0.6V	V_{CC}–0.1 V		V
V_{OL}	Low-level output voltage	I_{OL} = 1.6 mA			0.4	V
V_{IT+}	Positive-going input threshold voltage	V_{CC} = 3.3 V		1.5	2.4	V
		V_{CC} = 5 V		1.8	2.4	
V_{IT-}	Negative-going input threshold voltage	V_{CC} = 3.3 V	0.6	1.2		V
		V_{CC} = 5 V	0.8	1.5		
V_{hys}	Input hysteresis (V_{IT+} – V_{IT-})			0.3		V
r_i	Input resistance	V_I = ±3 V to ±25 V	3	5	7	kΩ

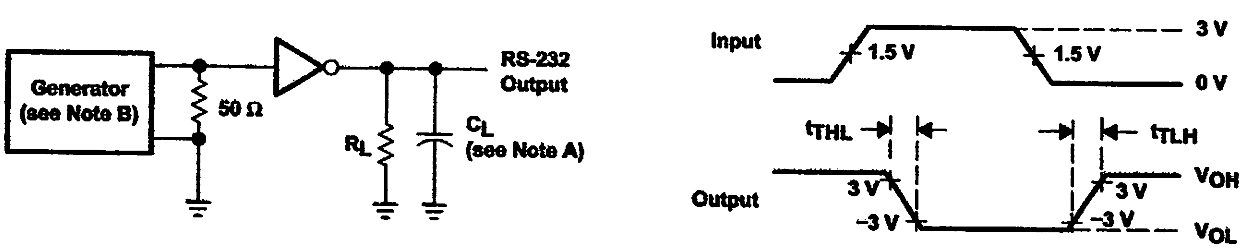
† All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.
NOTE 4: Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Note 4 and Figure 3)

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
t_{PLH}	Propagation delay time, low- to high-level output	C_L = 150 pF		300		ns
t_{PHL}	Propagation delay time, high- to low-level output			300		ns
$t_{sk(p)}$	Pulse skew‡			300		ns

† All typical values are at V_{CC} = 3.3 V or V_{CC} = 5 V, and T_A = 25°C.
‡ Pulse skew is defined as $|t_{PLH} - t_{PHL}|$ of each channel of the same device.
NOTE 4: Test conditions are C1–C4 = 0.1 µF at V_{CC} = 3.3 V ± 0.3 V; C1 = 0.047 µF, C2–C4 = 0.33 µF at V_{CC} = 5 V ± 0.5 V.

PARAMETER MEASUREMENT INFORMATION

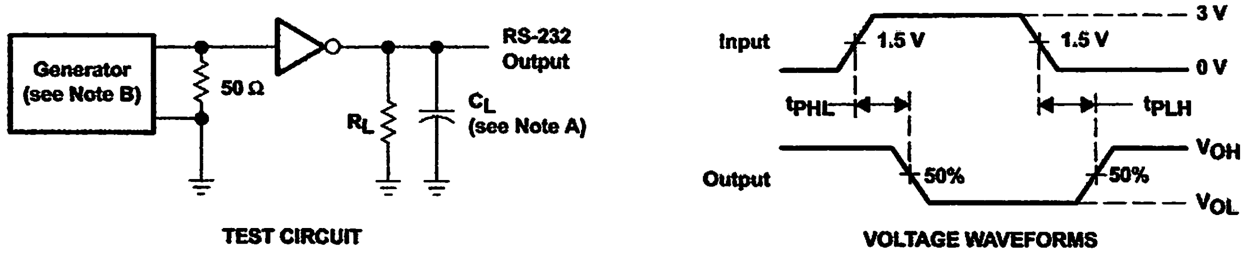


$$SR(tr) = \frac{6\ V}{t_{THL}\ or\ t_{TLH}}$$

NOTES: A. C_L includes probe and jig capacitance.
B. The pulse generator has the following characteristics: PRR = 250 kbit/s, Z_O = 50 Ω, 50% duty cycle, t_r ≤ 10 ns, t_f ≤ 10 ns.

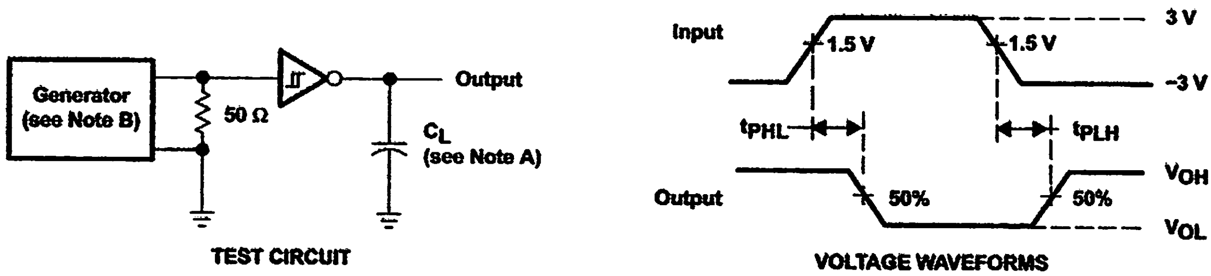
Figure 1. Driver Slew Rate

PARAMETER MEASUREMENT INFORMATION



NOTES: A. C_L includes probe and jig capacitance.
B. The pulse generator has the following characteristics: PRR = 250 kbit/s, Z_O = 50 Ω, 50% duty cycle, $t_r \leq 10$ ns, $t_f \leq 10$ ns.

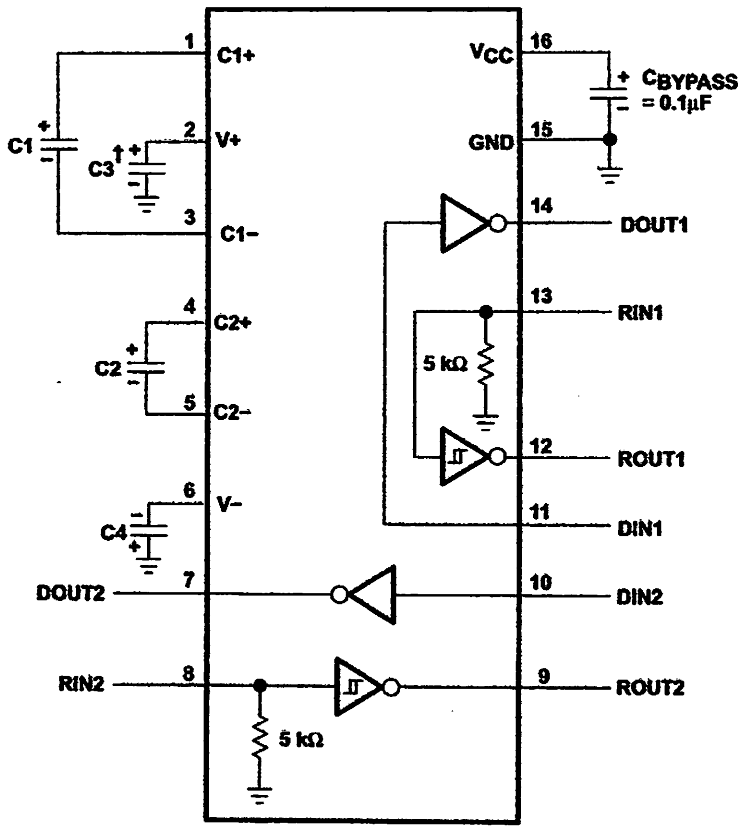
Figure 2. Driver Pulse Skew



NOTES: A. C_L includes probe and jig capacitance.
B. The pulse generator has the following characteristics: Z_O = 50 Ω, 50% duty cycle, $t_r \leq 10$ ns, $t_f \leq 10$ ns.

Figure 3. Receiver Propagation Delay Times

APPLICATION INFORMATION



† C3 can be connected to V_{CC} or GND.

NOTES: A. Resistor values shown are nominal.

B. Nonpolarized ceramic capacitors are acceptable. If polarized tantalum or electrolytic capacitors are used, they should be connected as shown.

V_{CC} vs CAPACITOR VALUES

V_{CC}	C1	C2, C3, C4
3.3 V ± 0.3 V	0.1 µF	0.1 µF
5 V ± 0.5 V	0.047 µF	0.33 µF
3 V to 5.5 V	0.1 µF	0.47 µF

Figure 4. Typical Operating Circuit and Capacitor Values

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
MAX3232CD	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDB	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDBE4	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDBG4	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDBR	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDBRE4	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDBRG4	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDE4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDRE4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CDWRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CPW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CPWE4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CPWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CPWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CPWRE4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232CPWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232ID	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDB	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDBE4	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

PACKAGE OPTION ADDENDUM

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
MAX3232IDBG4	ACTIVE	SSOP	DB	16	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDBR	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDBRE4	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDBRG4	ACTIVE	SSOP	DB	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDE4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDRE4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDRG4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDWE4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDWRE4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IDWRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IPW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IPWE4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IPWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IPWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IPWRE4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
MAX3232IPWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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OTHER QUALIFIED VERSIONS OF MAX3232 :

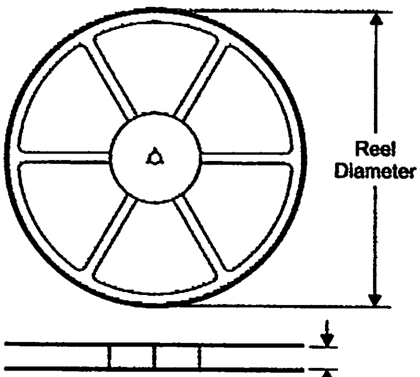
- Enhanced Product: MAX3232-EP

NOTE: Qualified Version Definitions:

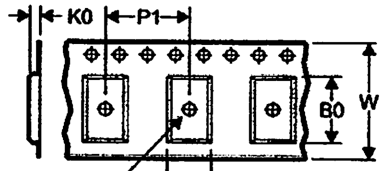
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

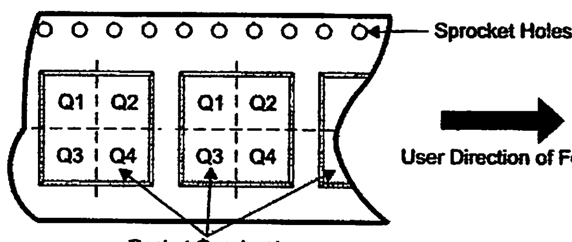


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

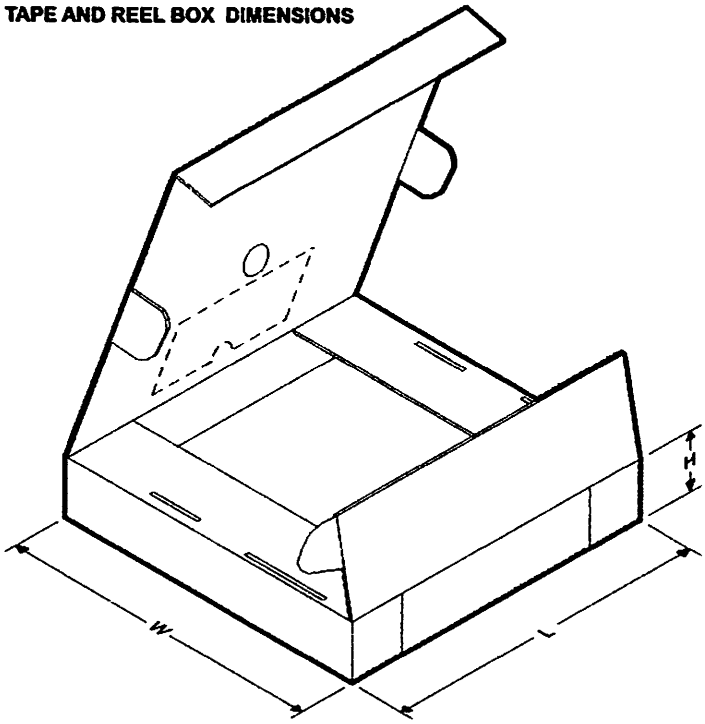
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
MAX3232CDBR	SSOP	DB	16	2000	330.0	16.4	8.2	6.6	2.5	12.0	16.0	Q1
MAX3232CDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
MAX3232CDWR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1
MAX3232CPWR	TSSOP	PW	16	2000	330.0	12.4	7.0	5.6	1.6	8.0	12.0	Q1
MAX3232IDBR	SSOP	DB	16	2000	330.0	16.4	8.2	6.6	2.5	12.0	16.0	Q1
MAX3232IDR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
MAX3232IDWR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1
MAX3232IPWR	TSSOP	PW	16	2000	330.0	12.4	7.0	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

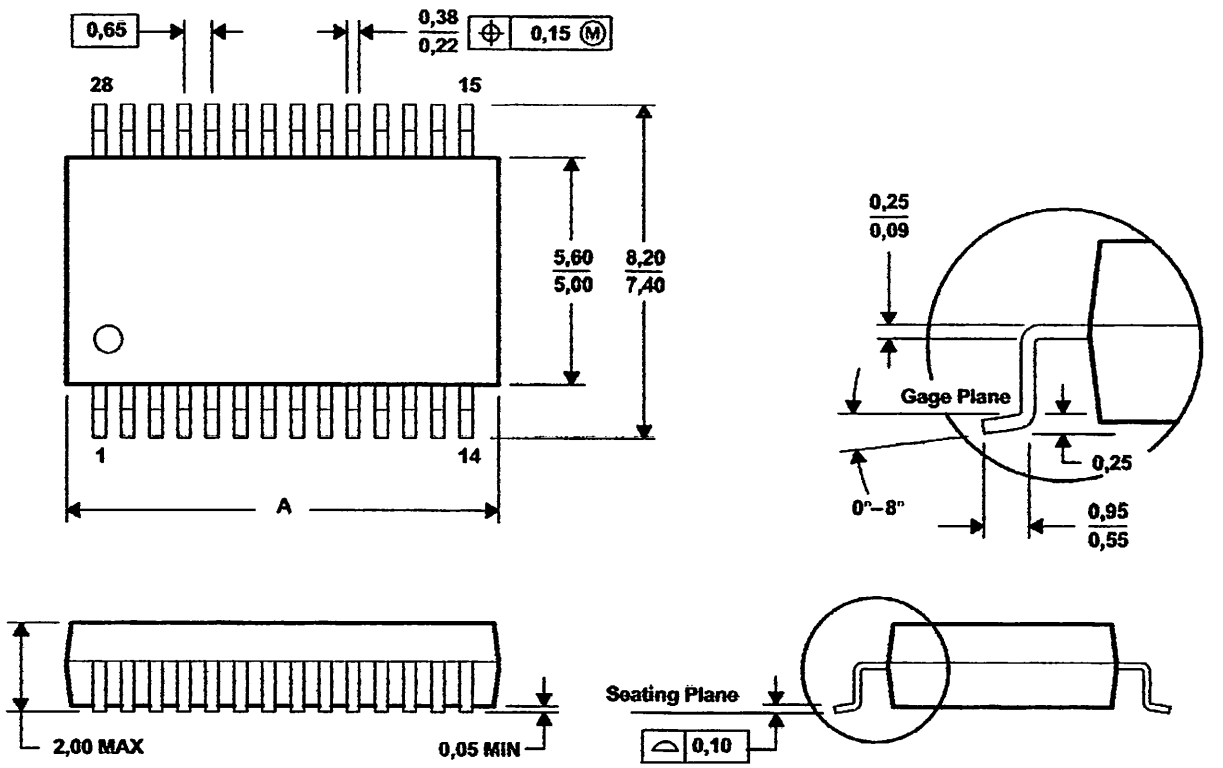


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
MAX3232CDBR	SSOP	DB	16	2000	346.0	346.0	33.0
MAX3232CDR	SOIC	D	16	2500	333.2	345.9	28.6
MAX3232CDWR	SOIC	DW	16	2000	346.0	346.0	33.0
MAX3232CPWR	TSSOP	PW	16	2000	346.0	346.0	29.0
MAX3232IDBR	SSOP	DB	16	2000	346.0	346.0	33.0
MAX3232IDR	SOIC	D	16	2500	333.2	345.9	28.6
MAX3232IDWR	SOIC	DW	16	2000	346.0	346.0	33.0
MAX3232IPWR	TSSOP	PW	16	2000	346.0	346.0	29.0

DB (R-PDSO-G)** **PLASTIC SMALL-OUTLINE**

28 PINS SHOWN



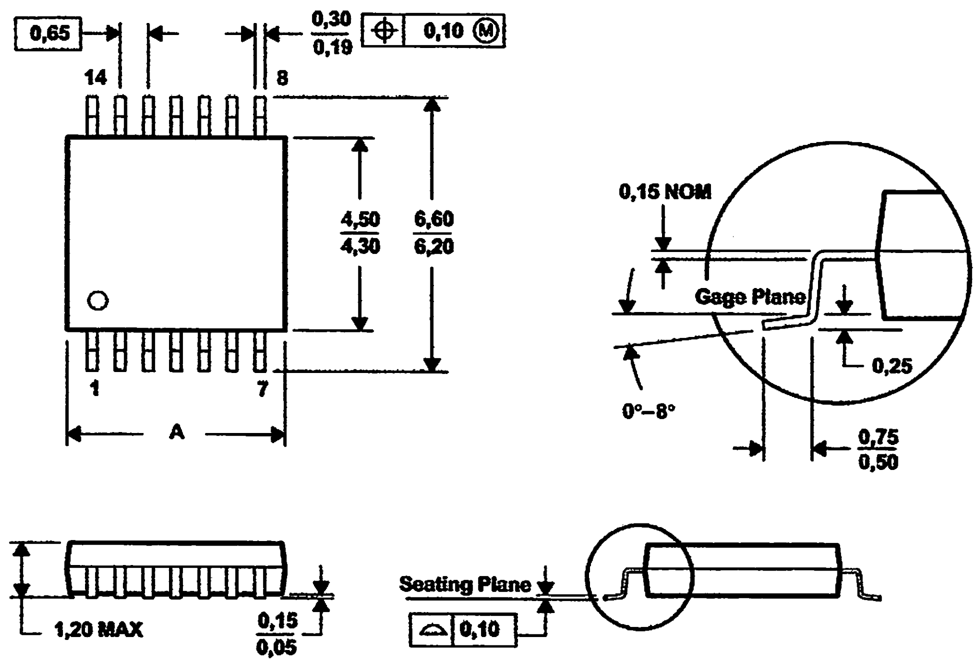
PINS ** / DIM	14	16	20	24	28	30	38
A MAX	6,50	6,50	7,50	8,50	10,50	10,50	12,90
A MIN	5,90	5,90	6,90	7,90	9,90	9,90	12,30

4040065 /E 12/01

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-150

PW (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN

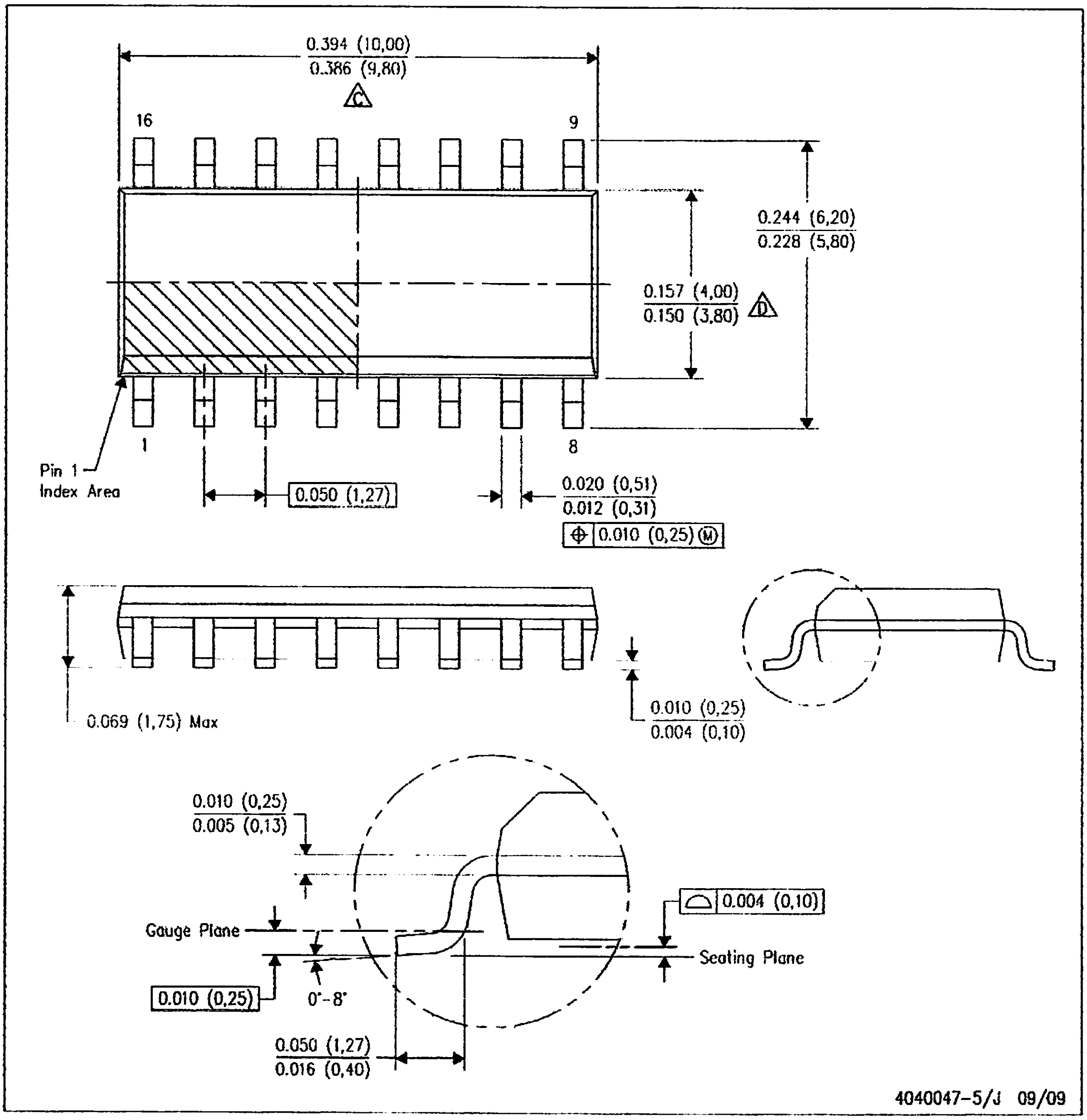


DIM \ PINS **	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

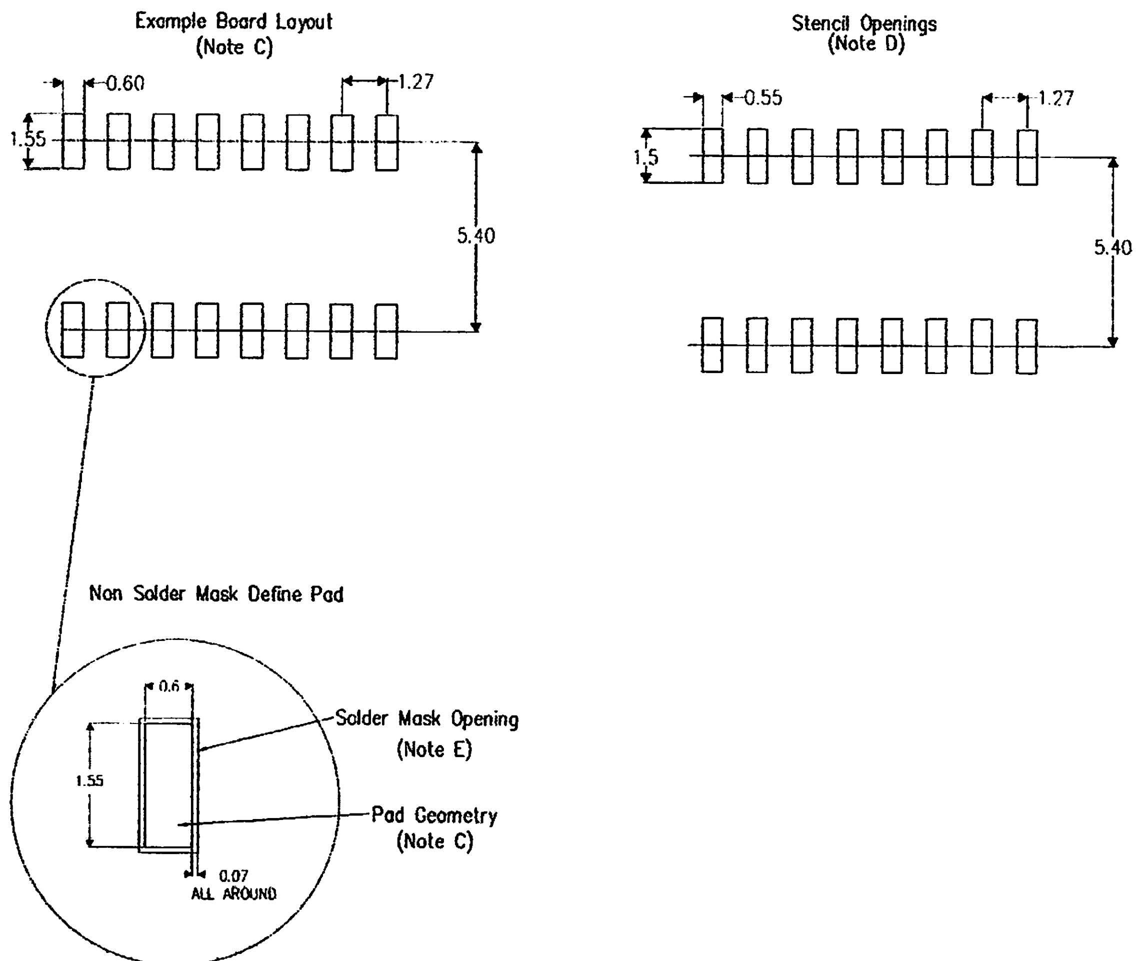
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

D (R-PDSO-G16) PLASTIC SMALL-OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
E. Reference JEDEC MS-012 variation AC.

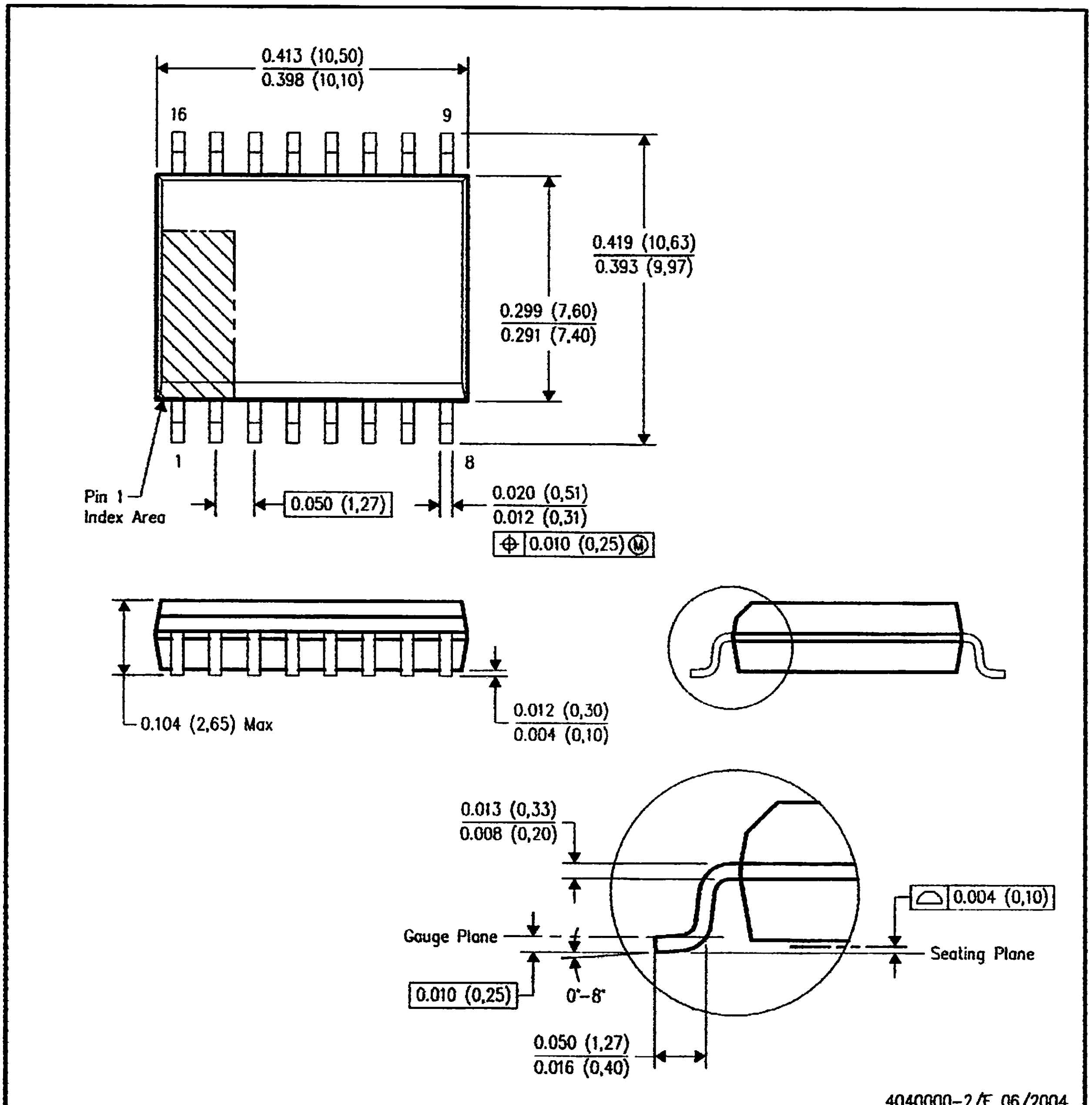
D(R-PDSO-G16)



4209373/A 03/08

NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Refer to IPC7351 for alternate board design.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

DW (R-PDSO-G16) PLASTIC SMALL-OUTLINE PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS-013 variation AA.

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FIGARO

PRODUCT INFORMATION

TGS 2442 - for the detection of Carbon Monoxide

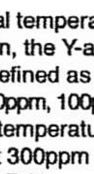
Features:

* Low power consumption
* High sensitivity/selectivity to carbon monoxide (CO)
* Miniature size
* Low sensitivity to alcohol vapor
* Long life and low cost
* Low humidity dependency

Applications:

* CO detectors
* Air quality controllers
* Indoor parking lot ventilation

TGS 2442 utilizes a multilayer sensor structure. A glass layer for thermal insulation is printed between a ruthenium oxide (RuO_2) heater and an alumina substrate. A pair of Au electrodes for the heater are formed on a thermal insulator. The gas sensing layer, which is formed of tin dioxide (SnO_2), is printed on an electrical insulation layer which covers the heater. A pair of Au electrodes for measuring sensor resistance are formed on the electrical insulator. Activated charcoal is filled between the internal cover and the outer cover for the purpose of reducing the influence of noise gases.

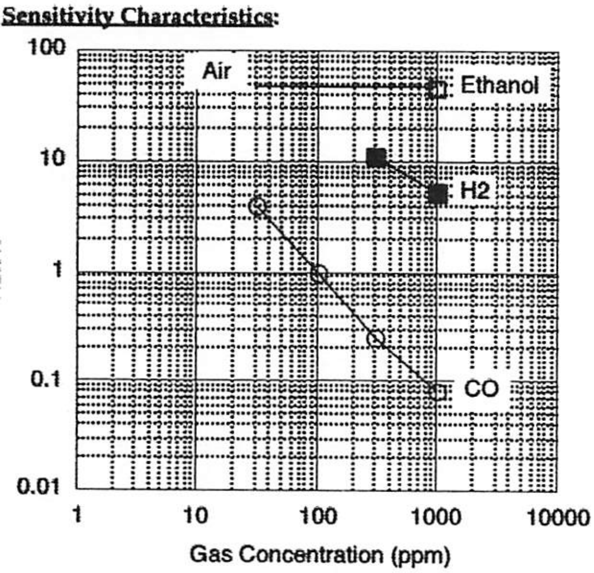


TGS 2442 displays good selectivity to carbon monoxide, making it ideal for CO monitors. In the presence of CO, the sensor's conductivity increases depending on the gas concentration in the air. A simple pulsed electrical circuit operating on a one second circuit voltage cycle can convert the change in conductivity to an output signal which corresponds to gas concentration.

The figure below represents typical sensitivity characteristics, all data having been gathered at standard test conditions (see reverse side of this sheet). The Y-axis is indicated as sensor resistance ratio (Rs/Ro) which is defined as follows:

Rs = Sensor resistance of displayed gases at various concentrations
Ro = Sensor resistance in 100ppm CO

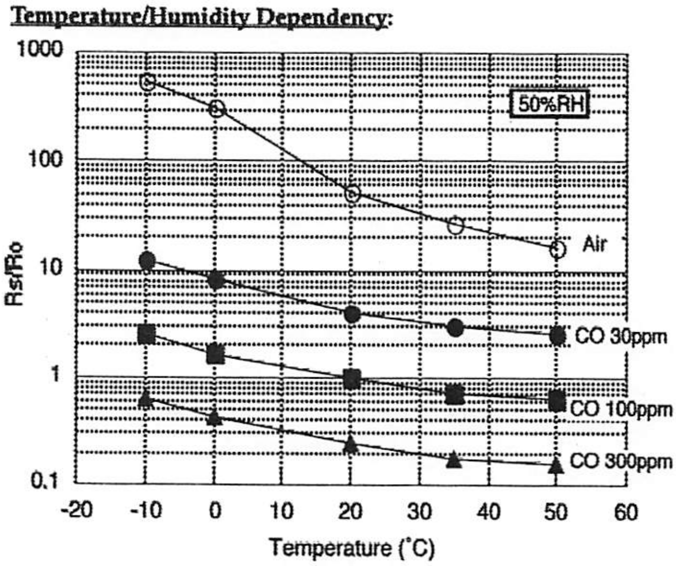
Sensitivity Characteristics:



The figure below represents typical temperature and humidity dependency characteristics. Again, the Y-axis is indicated as sensor resistance ratio (Rs/Ro), defined as follows:

Rs = Sensor resistance at 30ppm, 100ppm and 300ppm of CO at various temperatures and 50%R.H.
Ro = Sensor resistance at 300ppm of CO at 25°C and 50% R.H.

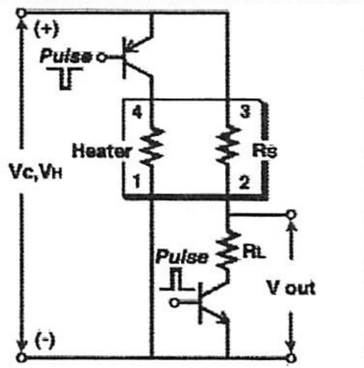
Temperature/Humidity Dependency:

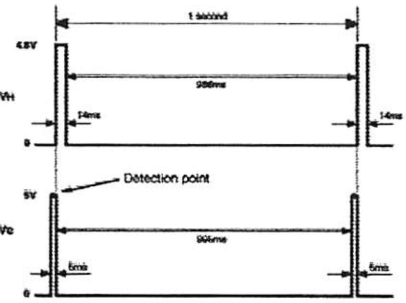


Basic Measuring Circuit:

Circuit voltage (V_C) is applied across the sensing element which has a resistance (R_S) between the sensor's two electrodes (pins No. 2 and No. 3) and a load resistor (R_L) connected in series. The sensing element is heated by the heater which is connected to pins No. 1 and No. 4.

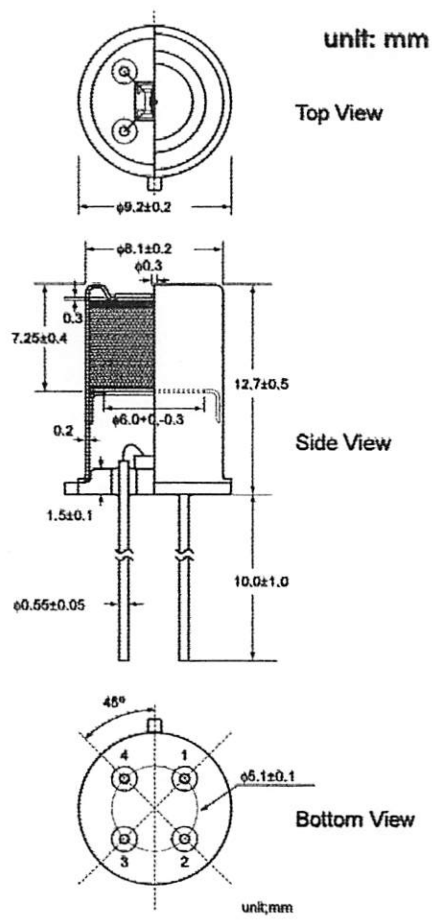
Heating cycle--The sensor requires application of a 1 second heating cycle which is used in connection with a circuit voltage cycle of 1 second. Each V_H cycle is comprised by 4.8V being applied to the heater for the first 14ms, followed by 0V pulse for the remaining 986ms. The Vc cycle consists of 0V applied for 995ms, followed by 5.0V for 5ms. For achieving optimal sensing characteristics, the sensor's signal should be measured after the midpoint of the 5ms Vc pulse of 5.0V (for reference, see timing chart below).





NOTE: Application of a Vc pulse condition is required to prevent possible migration of heater materials into the sensing element material. Under extreme conditions of high humidity and temperature, a constant Vc condition could result in such migration and cause long term drift of Rs to higher values. A 5ms Vc pulse results in significantly less driving force for migration than a constant Vc condition, rendering the possibility of migration negligibly small.

Structure and Dimensions:



Specifications:

Model number			TGS 2442
Sensing element type			M1
Standard package			TO-5 metal can
Target gases			Carbon monoxide
Typical detection range			30 ~ 1000 ppm
Standard circuit conditions	Heater voltage cycle	V_H	V_{HH}=4.8V±0.2V DC, 14ms V_{HL}=0.0, 986ms
	Circuit voltage cycle	V_C	V_C=0V for 995ms, V_C=5.0V±0.2V DC for 5ms
	Load resistance	R_L	variable (≥10kΩ)
Electrical characteristics under standard test conditions	Heater resistance	R_H	17 ± 2.5Ω at room temp.
	Heater current	I_H	approx. 203mA(in case of V_{HH})
	Heater power consumption	P_H	approx. 14mW (ave.)
	Sensor resistance	R_S	13.3kΩ ~ 133kΩ in 100ppm of carbon monoxide
	Sensitivity (change ratio of Rs)	β	0.13 ~ 0.31
Standard test conditions	Test gas conditions		Carbon monoxide in air at 20±2°C, 65±5%RH
	Circuit conditions		Same as Std. Circuit Condition (above)
	Conditioning period before test		2 days or more

Sensor resistance (Rs) is calculated with a measured value of Vout as follows:

$$R_S = \frac{V_C \times R_L}{V_{out}} - R_L$$

The value of sensitivity (β) is calculated with two measured values of Rs as follows:

$$\beta = \frac{R_S\,(CO, 300ppm)}{R_S\,(CO, 100ppm)}$$

For information on warranty, please refer to Standard Terms and Conditions of Sale of Figaro USA Inc.

REV: 07/07

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National Semiconductor

July 1999

LM35
Precision Centigrade Temperature Sensors

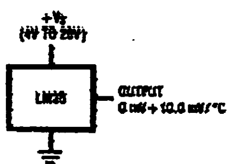
General Description

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 ±¼°C at room temperature and ±¾°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

Features

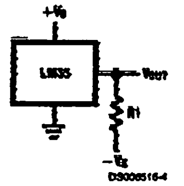
- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guaranteeable (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 μA current drain
-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

Typical Applications



DS005516-3

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



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

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

FIGURE 2. Full-Range Centigrade Temperature Sensor

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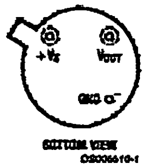
 DS005516

Connection Diagrams

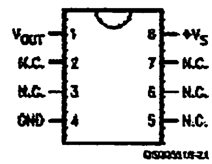
TO-46
Metal Can Package*



*Case is connected to negative pin (GND)

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

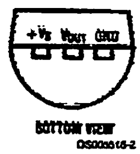
SO-8
Small Outline Molded Package



N.C. = No Connection

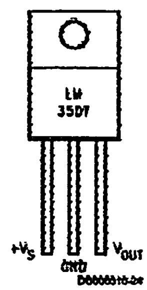
Top View
Order Number LM35DM
See NS Package Number M08A

TO-92
Plastic Package



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

TO-220
Plastic Package*



*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°C	±0.2	±0.5		±0.2	±0.5		°C
	T_A=−10°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}≤T_A≤T_{MAX}	±0.18		±0.35	±0.15		±0.3	°C
Sensor Gain (Average Slope)	T_{MIN}≤T_A≤T_{MAX}	+10.0	+9.9, +10.1		+10.0		+9.9, +10.1	mV/°C
Load Regulation (Note 3) 0≤I_L≤1 mA	T_A=+25°C	±0.4	±1.0		±0.4	±1.0		mV/mA
	T_{MIN}≤T_A≤T_{MAX}	±0.5		±3.0	±0.5		±3.0	mV/mA
Line Regulation (Note 3)	T_A=+25°C	±0.01	±0.05		±0.01	±0.05		mV/V
	4V≤V_S≤30V	±0.02		±0.1	±0.02		±0.1	mV/V
Quiescent Current (Note 9)	V_S=+5V, +25°C	56	67		56	67		µA
	V_S=+5V	105		131	91		114	µA
	V_S=+30V, +25°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≤V_S≤30V, +25°C	0.2	1.0		0.2	1.0		µA
	4V≤V_S≤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°C	±0.4	±1.0		±0.4	±1.0		°C
	T_A=−10°C	±0.5			±0.5		±1.5	°C
	T_A=T_{MAX}	±0.8	±1.5		±0.8		±1.5	°C
	T_A=T_{MIN}	±0.8		±1.5	±0.8		±2.0	°C
Accuracy, LM35D (Note 7)	T_A=+25°C				±0.6	±1.5		°C
	T_A=T_{MAX}				±0.9		±2.0	°C
	T_A=T_{MIN}				±0.9		±2.0	°C
Nonlinearity (Note 8)	T_{MIN}≤T_A≤T_{MAX}	**±0.3**		**±0.5**	**±0.2**		**±0.5**	°C
Sensor Gain (Average Slope)	T_{MIN}≤T_A≤T_{MAX}	**+10.0**	**+9.8, +10.2**		**+10.0**		**+9.8, +10.2**	mV/°C
Load Regulation (Note 3) 0≤I_L≤1 mA	T_A=+25°C	±0.4	±2.0		±0.4	±2.0		mV/mA
	T_{MIN}≤T_A≤T_{MAX}	**±0.5**		**±5.0**	**±0.5**		**±5.0**	mV/mA
Line Regulation (Note 3)	T_A=+25°C	±0.01	±0.1		±0.01	±0.1		mV/V
	4V≤V_S≤30V	**±0.02**		**±0.2**	**±0.02**		**±0.2**	mV/V
Quiescent Current (Note 9)	V_S=+5V, +25°C	56	80		56	80		µA
	V_S=+5V	**105**		**158**	**91**		**138**	µA
	V_S=+30V, +25°C	56.2	82		56.2	82		µA
	V_S=+30V	**105.5**		**161**	**91.5**		**141**	µA
Change of Quiescent Current (Note 3)	4V≤V_S≤30V, +25°C	0.2	2.0		0.2	2.0		µA
	4V≤V_S≤30V	**0.5**		**3.0**	**0.5**		**3.0**	µA
Temperature Coefficient of Quiescent Current		**+0.39**		**+0.7**	**+0.39**		**+0.7**	µA/°C
Minimum Temperature for Rated Accuracy	In circuit of *Figure 1*, I_L=0	+1.5		+2.0	+1.5		+2.0	°C
Long Term Stability	T_J=T_{MAX}, for 1000 hours	±0.08			±0.08			°C

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

Note 2: Thermal resistance of the TO-46 package is 400°C/W, junction to ambient, and 24°C/W junction to case. Thermal resistance of the TO-92 package is 180°C/W junction to ambient. Thermal resistance of the small outline molded package is 220°C/W junction to ambient. Thermal resistance of the TO-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 10mv/°C times the device's case temperature, at specified conditions of voltage, current, and temperature (expressed in °C).

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

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

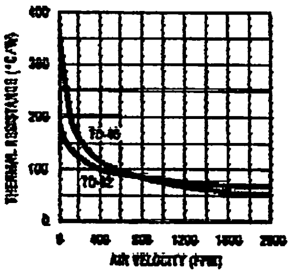
Note 10: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions. See Note 1.

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

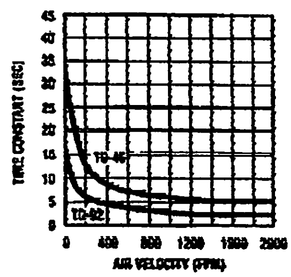
Note 12: See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" or the section titled "Surface Mount" found in a current National Semiconductor Linear Data Book for other methods of soldering surface mount devices.

Typical Performance Characteristics

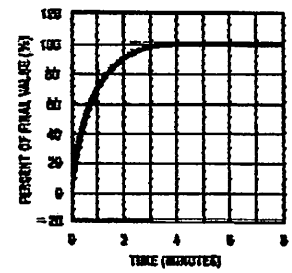
Thermal Resistance Junction to Air



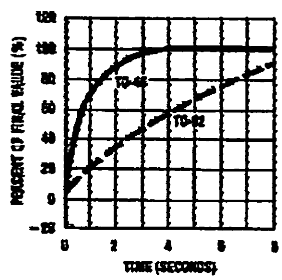
Thermal Time Constant



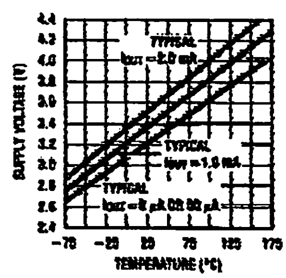
Thermal Response in Still Air



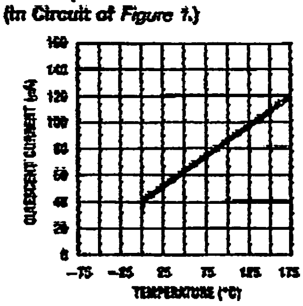
Thermal Response in Stirred Oil Bath



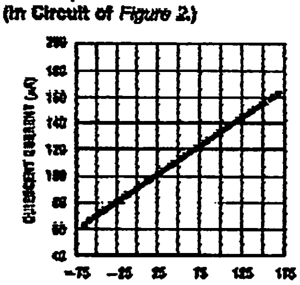
Minimum Supply Voltage vs. Temperature



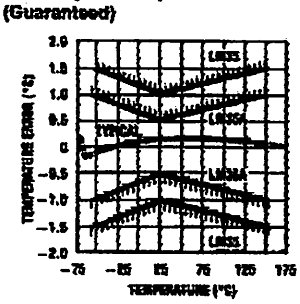
Quiescent Current vs. Temperature (In Circuit of *Figure 1*.)



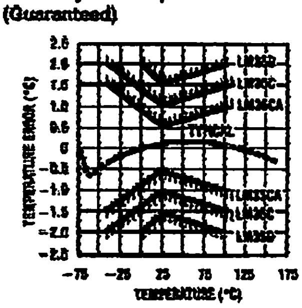
Quiescent Current vs. Temperature (In Circuit of *Figure 2*.)



Accuracy vs. Temperature (Guaranteed)

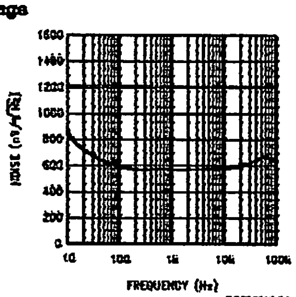


Accuracy vs. Temperature (Guaranteed)



Typical Performance Characteristics (Continued)

Noise Voltage



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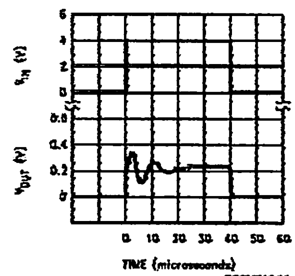
Start-Up Response



DS005516-35

Applications

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

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

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

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

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

Temperature Rise of LM35 Due To Self-heating (Thermal Resistance, 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	90°C/W	70°C/W	105°C/W	90°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

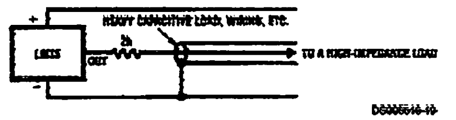


FIGURE 3. LM35 with Decoupling from Capacitive Load

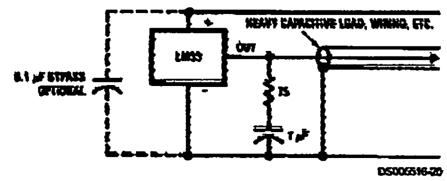


FIGURE 4. LM35 with R-C Damper

CAPACITIVE LOADS

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

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

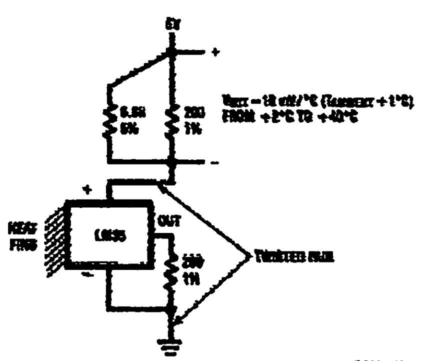


FIGURE 5. Two-Wire Remote Temperature Sensor (Grounded Sensor)

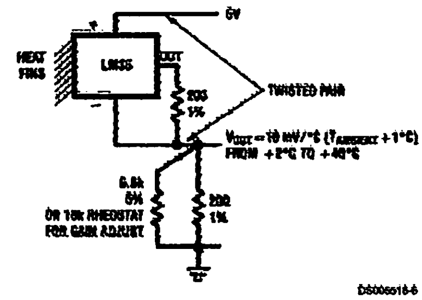


FIGURE 6. Two-Wire Remote Temperature Sensor (Output Referred to Ground)

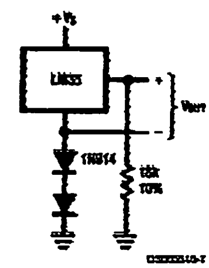


FIGURE 7. Temperature Sensor, Single Supply, −55° to +150°C

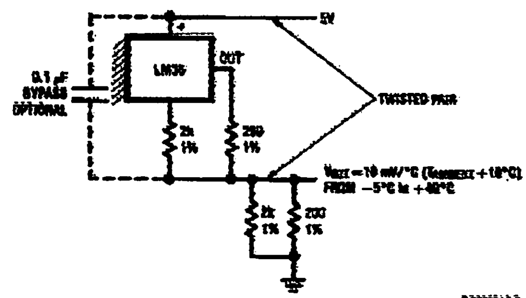


FIGURE 8. Two-Wire Remote Temperature Sensor (Output Referred to Ground)

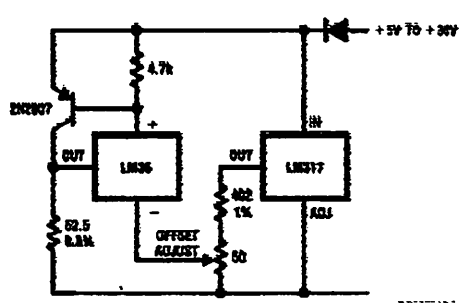


FIGURE 9. 4-To-20 mA Current Source (0°C to +100°C)

Typical Applications (Continued)

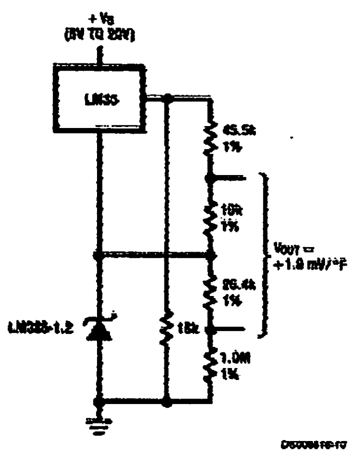


FIGURE 10. Fahrenheit Thermometer

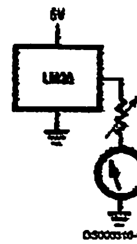


FIGURE 11. Centigrade Thermometer (Analog Meter)

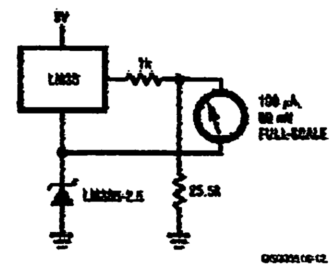


FIGURE 12. Fahrenheit ThermometerExpanded Scale Thermometer
(50° to 80° Fahrenheit, for Example Shown)

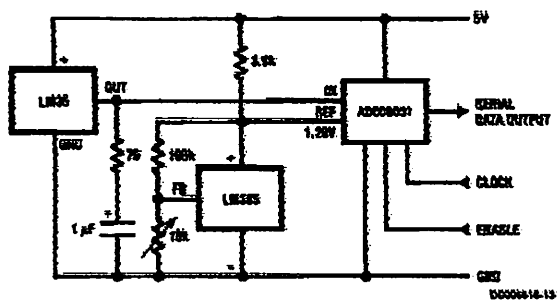


FIGURE 13. Temperature To Digital Converter (Serial Output) (+128°C Full Scale)

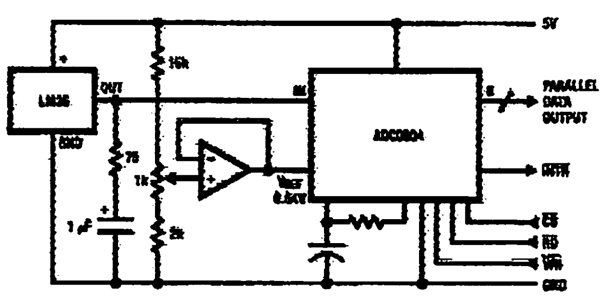
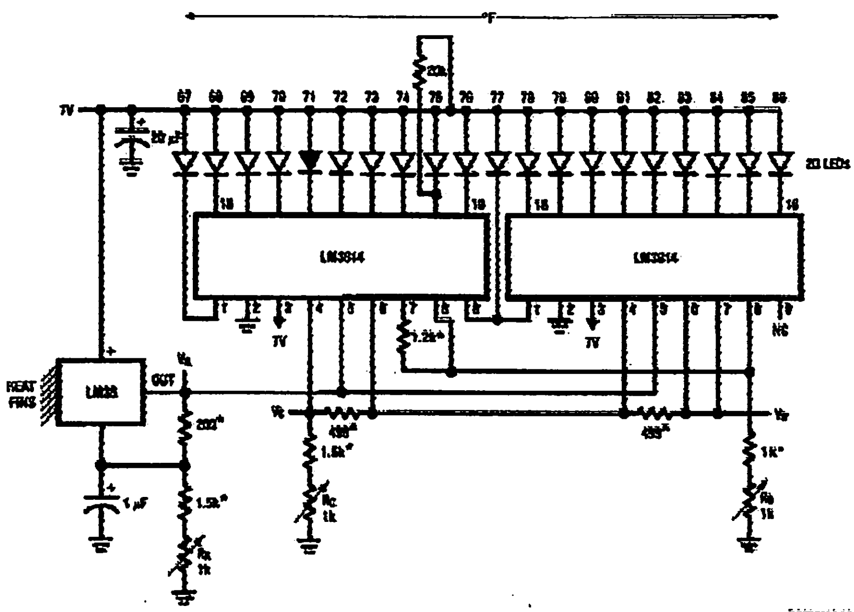


FIGURE 14. Temperature To Digital Converter (Parallel TRI-STATE™ Outputs for Standard Data Bus to µP Interface) (128°C Full Scale)

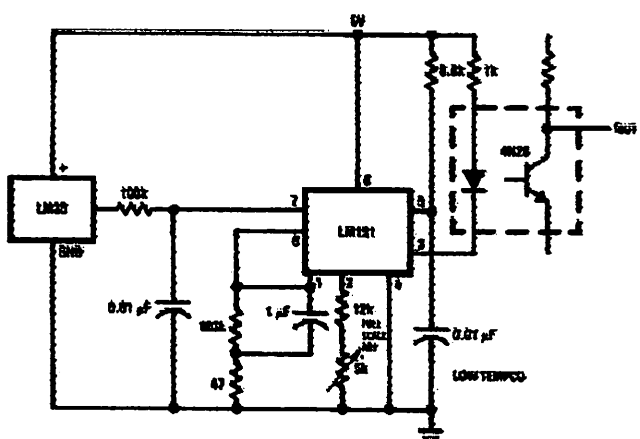
Typical Applications (Continued)



DS005516-16

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

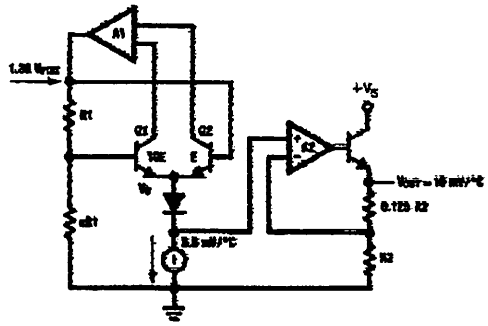
FIGURE 15. Bar-Graph Temperature Display (Dot Mode)



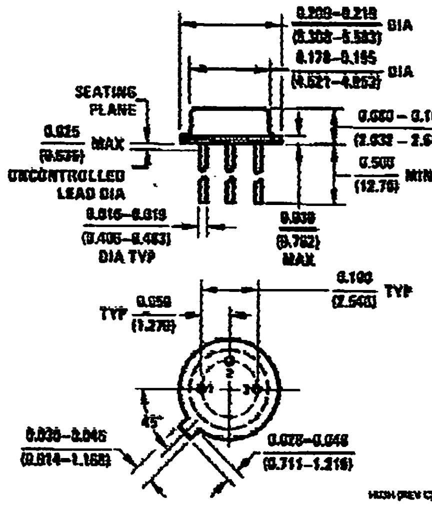
DS005516-16

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

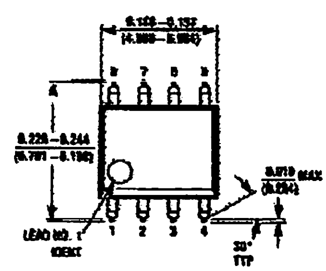
Block Diagram

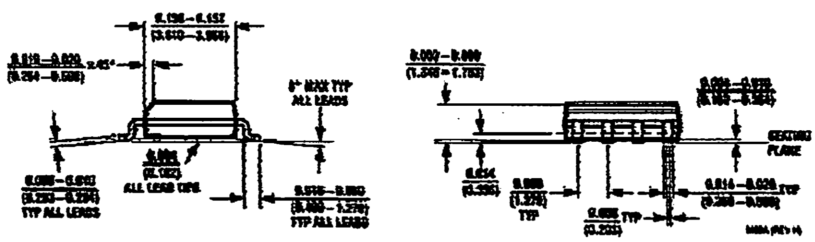


Physical Dimensions inches (millimeters) unless otherwise noted



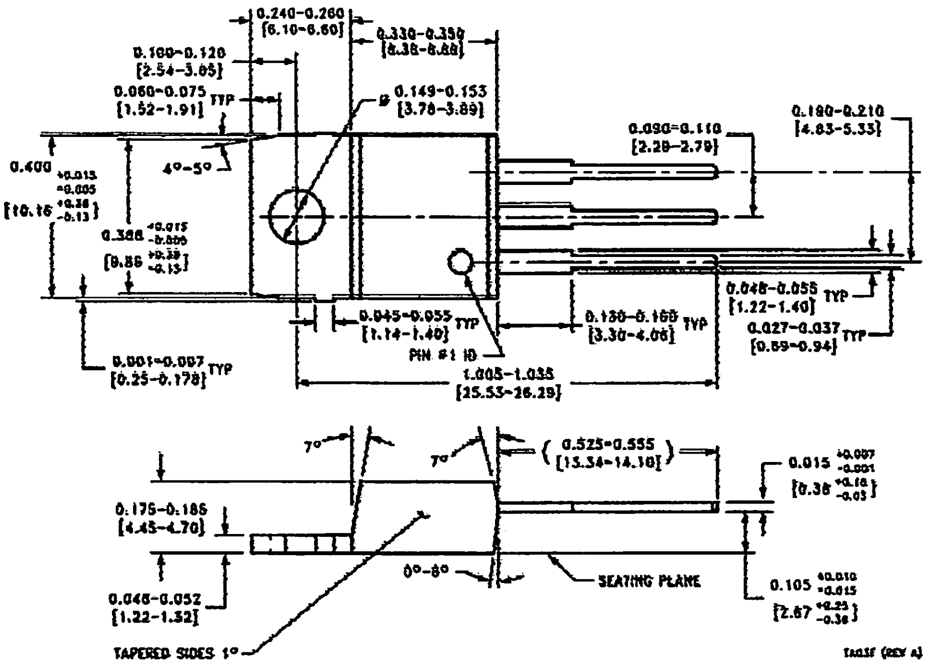
TO-46 Metal Can Package (H)
Order Number LM35H, LM35AH, LM35CH, LM35CAH, or LM35DH
NS Package Number H03H



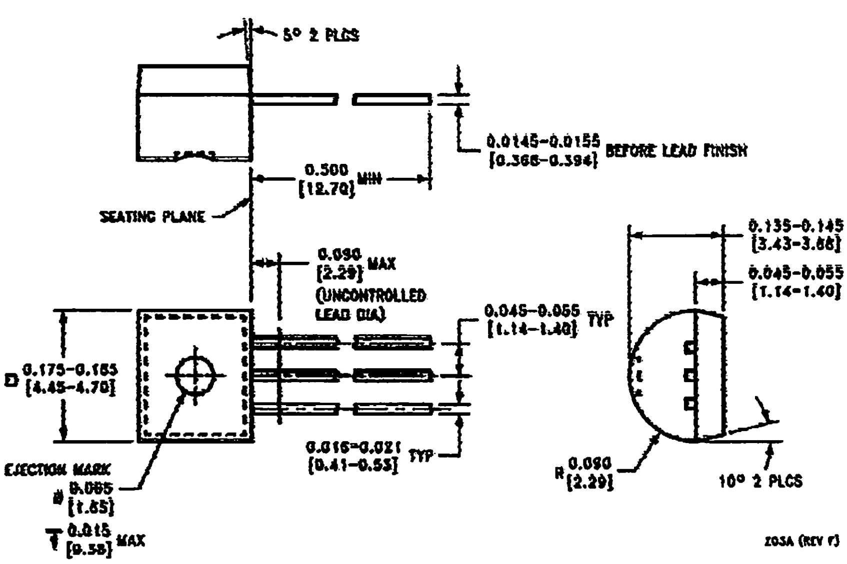


SO-8 Molded Small Outline Package (M)
Order Number LM35DM
NS Package Number M08A

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



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



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

Notes

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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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National Semiconductor

October 1999

ADC0808/ADC0809 8-Bit μP 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.)

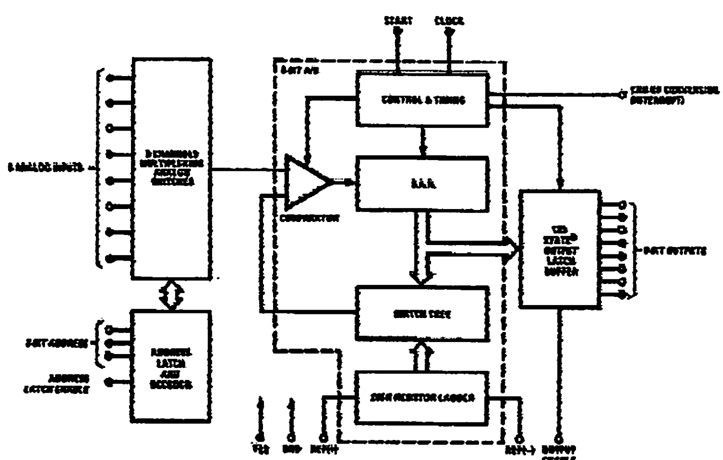
Features

- 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 ±½ LSB and ±1 LSB
- Single Supply 5 V_{DC}
- Low Power 15 mW
- Conversion Time 100 μs

Block Diagram



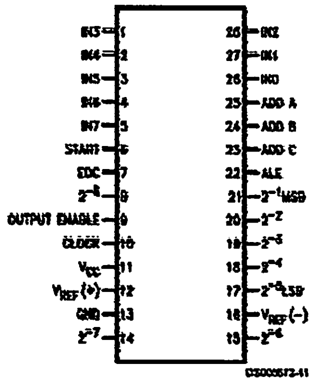
DS005672-1

See Ordering Information

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

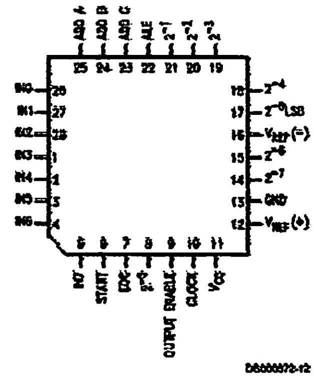
Connection Diagrams

Dual-In-Line Package



Order Number ADC0808CCN or ADC0809CCN
See NS Package J28A or N28A

Molded Chip Carrier Package



Order Number ADC0808CCV or ADC0809CCV
See NS Package V28A

Ordering Information

TEMPERATURE RANGE		−40°C to +85°C			−55°C to +125°C
Error	±½ 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

Absolute Maximum Ratings (Notes 2, 1)

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°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)	$T_{MIN} \le T_A \le T_{MAX}$
ADC0808CCN,ADC0809CCN	$-40°C \le T_A \le +85°C$
ADC0808CCV, ADC0809CCV	$-40°C \le T_A \le +85°C$
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, $T_{MIN} \le T_A \le T_{MAX}$ and f_{CLK}=640 kHz unless otherwise stated.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
	ADC0808					
	Total Unadjusted Error	25°C			±½	LSB
	(Note 5)	T_{MIN} to T_{MAX}			±¾	LSB
	ADC0809					
	Total Unadjusted Error	0°C to 70°C			±1	LSB
	(Note 5)	T_{MIN} to T_{MAX}			±1¼	LSB
	Input Resistance	From Ref(+) to Ref(−)	1.0	2.5		kΩ
	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: ADC0808CCN, ADC0808CCV, ADC0809CCN and ADC0809CCV, $4.75 \le V_{CC} \le 5.25V$, $-40°C \le T_A \le +85°C$ 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°C		10	200	nA
		T_{MIN} to T_{MAX}			1.0	μA
$I_{OFF(-)}$	OFF Channel Leakage Current	V_{CC}=5V, V_{IN}=0,				
		T_A=25°C	−200	−10		nA
		T_{MIN} to T_{MAX}	−1.0			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: ADC0808CCN, ADC0808CCV, ADC0809CCN and ADC0809CCV, $4.75 \le V_{CC} \le 5.25V$, $-40°C \le T_A \le +85°C$ unless otherwise noted

Symbol	Parameter	Conditions	Min	Typ	Max	Units
DATA OUTPUTS AND EOC (INTERRUPT)						
$V_{OUT(1)}$	Logical "1" Output Voltage	$V_{CC} = 4.75V$ $I_{OUT} = -360\mu A$ $I_{OUT} = -10\mu A$		 2.4 4.5		 V(min) V(min)
$V_{OUT(0)}$	Logical "0" Output Voltage	$I_O=1.6$ mA			0.45	V
$V_{OUT(0)}$	Logical "0" Output Voltage EOC	$I_O=1.2$ mA			0.45	V
I_{OUT}	TRI-STATE Output Current	$V_O=5V$ $V_O=0$	 −3		3	μA μA

Electrical Characteristics

Timing Specifications $V_{CC}=V_{REF(+)}=5V$, $V_{REF(-)}=GND$, $t_r=t_f=20$ ns and $T_A=25°C$ 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	$C_L=50$ pF, $R_L=10k$ (*Figure 8*)		125	250	ns
t_{1H}, t_{0H}	OE Control to Hi-Z	$C_L=10$ pF, $R_L=10k$ (*Figure 8*)		125	250	ns
t_c	Conversion Time	$f_c=640$ 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+2 μS	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 othewise 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_{CC}n 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 3*. 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 6*). 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 kΩ resistor.

Functional Description

Multiplexer. The device contains an 8-channel single-ended analog signal multiplexer. A particular input channel is selected by using the address decoder. *Table 1* shows the input states for the address lines to select any channel. The address is latched into the decoder on the low-to-high transition of the address latch enable signal.

TABLE 1.

SELECTED ANALOG CHANNEL	ADDRESS LINE		
	C	B	A
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

CONVERTER CHARACTERISTICS

The Converter

The heart of this single chip data acquisition system is its 8-bit analog-to-digital converter. The converter is designed to give fast, accurate, and repeatable conversions over a wide range of temperatures. The converter is partitioned into 3 major sections: the 256R ladder network, the successive approximation register, and the comparator. The converter's digital outputs are positive true.

The 256R ladder network approach (*Figure 1*) was chosen over the conventional R/2R ladder because of its inherent monotonicity, which guarantees no missing digital codes. Monotonicity is particularly important in closed loop feedback control systems. A non-monotonic relationship can cause oscillations that will be catastrophic for the system. Additionally, the 256R network does not cause load variations on the reference voltage.

The bottom resistor and the top resistor of the ladder network in *Figure 1* are not the same value as the remainder of the network. The difference in these resistors causes the output characteristic to be symmetrical with the zero and full-scale points of the transfer curve. The first output transition occurs when the analog signal has reached +½ LSB and succeeding output transitions occur every 1 LSB later up to full-scale.

The successive approximation register (SAR) performs 8 iterations to approximate the input voltage. For any SAR type converter, n-iterations are required for an n-bit converter. *Figure 2* shows a typical example of a 3-bit converter. In the ADC0808, ADC0809, the approximation technique is extended to 8 bits using the 256R network.

The A/D converter's successive approximation register (SAR) is reset on the positive edge of the start conversion (SC) pulse. The conversion is begun on the falling edge of the start conversion pulse. A conversion in process will be interrupted by receipt of a new start conversion pulse. Continuous conversion may be accomplished by tying the end-of-conversion (EOC) output to the SC input. If used in this mode, an external start conversion pulse should be applied after power up. End-of-conversion will go low between 0 and 8 clock pulses after the rising edge of start conversion.

The most important section of the A/D converter is the comparator. It is this section which is responsible for the ultimate accuracy of the entire converter. It is also the comparator drift which has the greatest influence on the repeatability of the device. A chopper-stabilized comparator provides the most effective method of satisfying all the converter requirements.

The chopper-stabilized comparator converts the DC input signal into an AC signal. This signal is then fed through a high gain AC amplifier and has the DC level restored. This technique limits the drift component of the amplifier since the drift is a DC component which is not passed by the AC amplifier. This makes the entire A/D converter extremely insensitive to temperature, long term drift and input offset errors.

Figure 4 shows a typical error curve for the ADC0808 as measured using the procedures outlined in AN-179.

Functional Description (Continued)

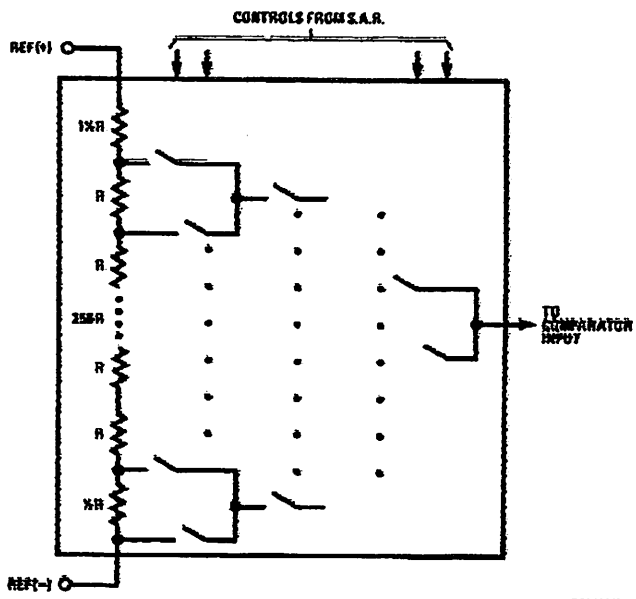


FIGURE 1. Resistor Ladder and Switch Tree

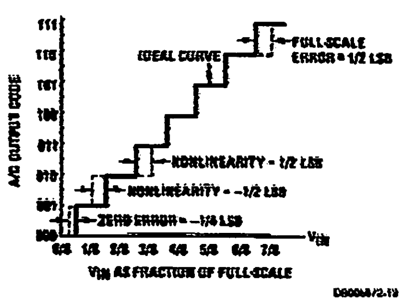


FIGURE 2. 3-Bit A/D Transfer Curve

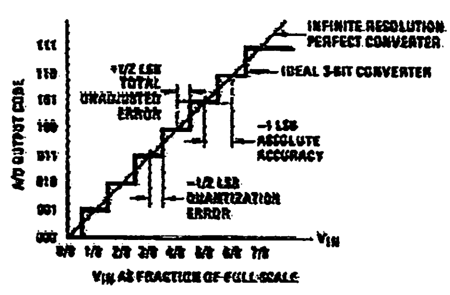


FIGURE 3. 3-Bit A/D Absolute Accuracy Curve

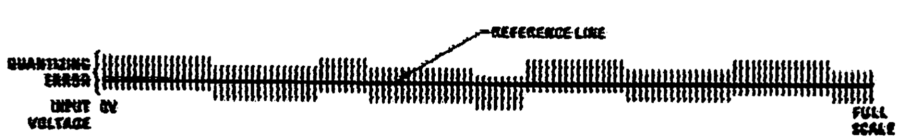


FIGURE 4. Typical Error Curve

Timing Diagram

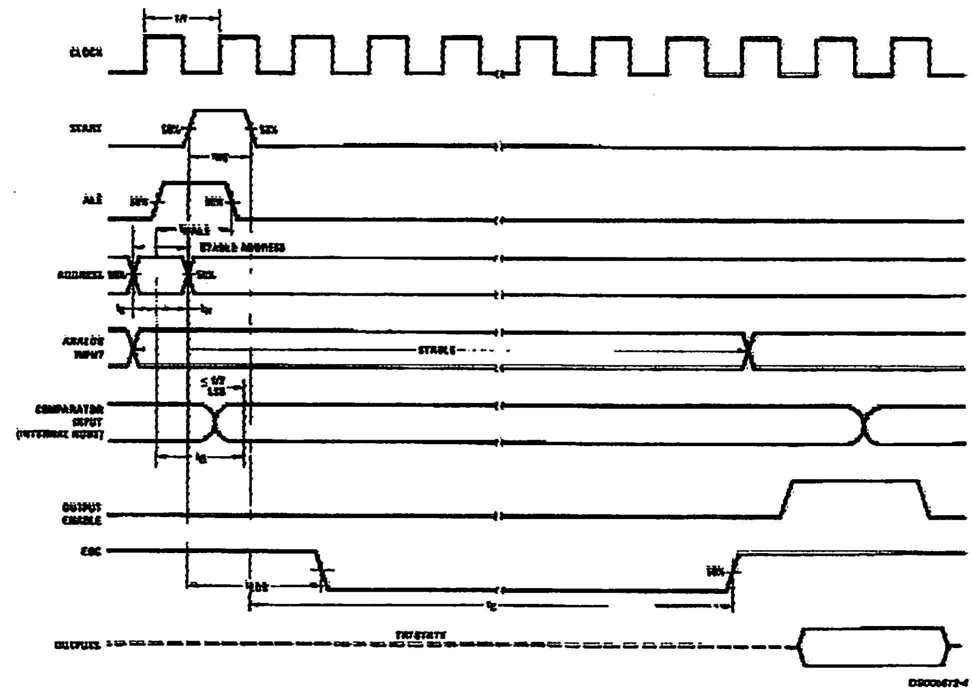


FIGURE 5.

Typical Performance Characteristics

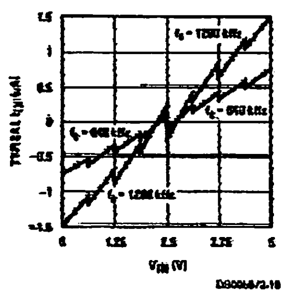


FIGURE 6. Comparator I_{IN} vs V_{IN} ($V_{CC}=V_{REF}=5V$)

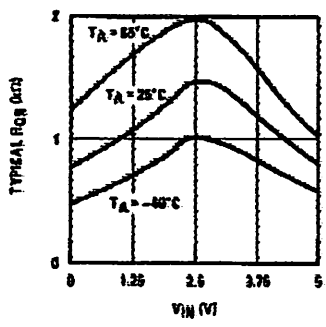


FIGURE 7. Multiplexer R_{ON} vs V_{IN} ($V_{CC}=V_{REF}=5V$)

TRI-STATE Test Circuits and Timing Diagrams

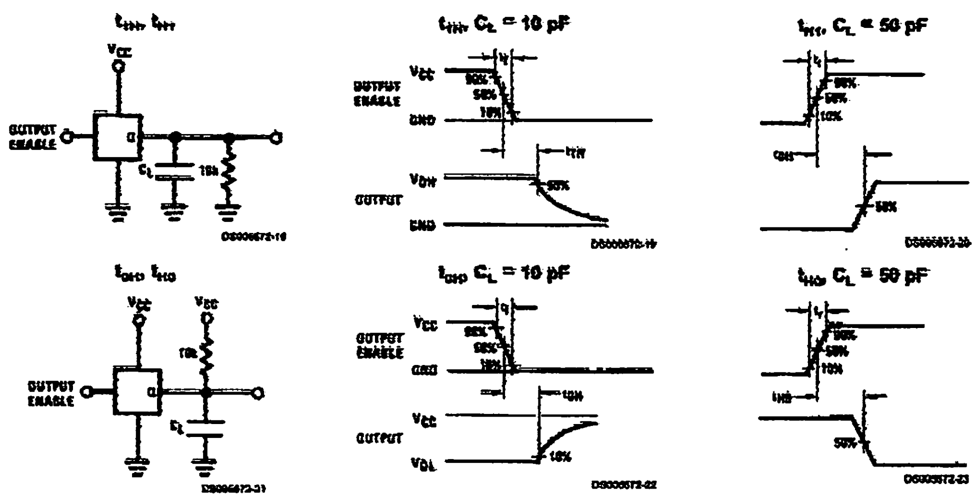


FIGURE 8.

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

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

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 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 sys-

Applications Information (Continued)

tem 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.

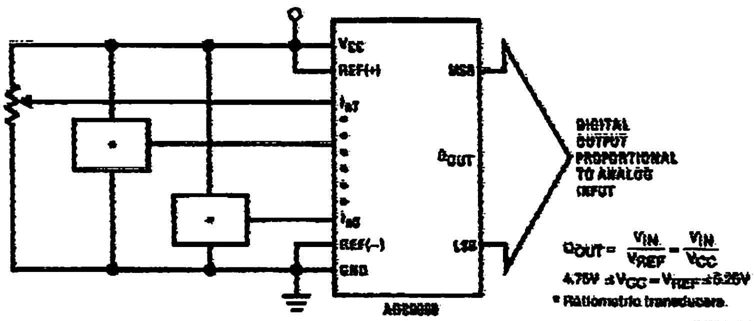
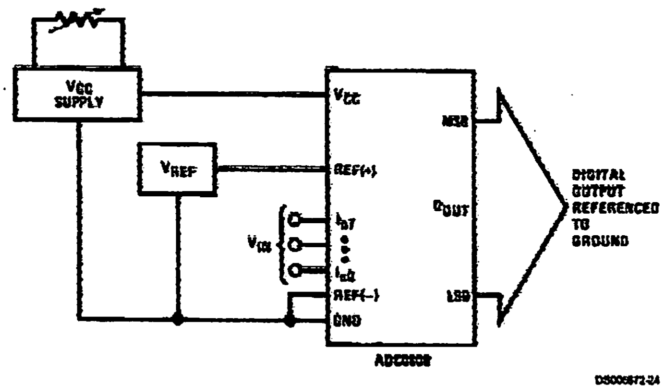


FIGURE 9. Ratiometric Conversion System

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.

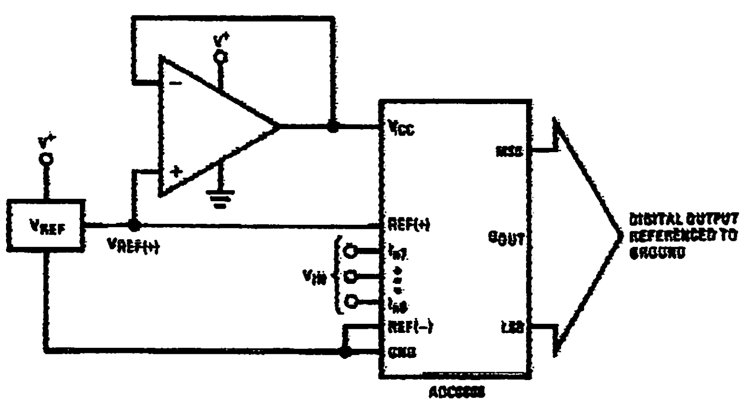
Applications Information (Continued)



$$Q_{OUT} = \frac{V_{IN}}{V_{REF}}$$

$4.75V \le V_{CC} - V_{REF} \le 5.25V$

FIGURE 10. Ground Referenced Conversion System Using Trimmed Supply



$$Q_{OUT} = \frac{V_{IN}}{V_{REF}}$$

$4.75V \le V_{CC} - V_{REF} \le 5.25V$

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

Applications Information (Continued)

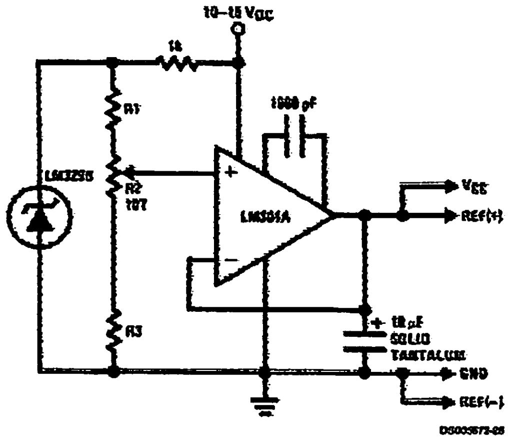
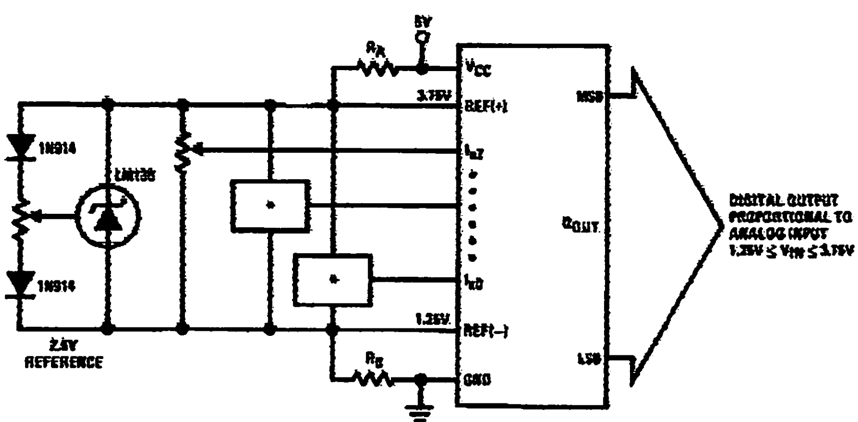


FIGURE 12. Typical Reference and Supply Circuit



$R_A = R_B$

*Ratiometric transducers

FIGURE 13. Symmetrically Centered Reference

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:

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

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

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

Where: V_{IN}=Voltage at comparator input

$V_{REF(+)}$=Voltage at Ref(+)

$V_{REF(-)}$=Voltage at Ref(−)

V_{TUE}=Total unadjusted error voltage (typically $V_{REF(+)} \div 512$)

Applications Information (Continued)

4.0 ANALOG COMPARATOR INPUTS

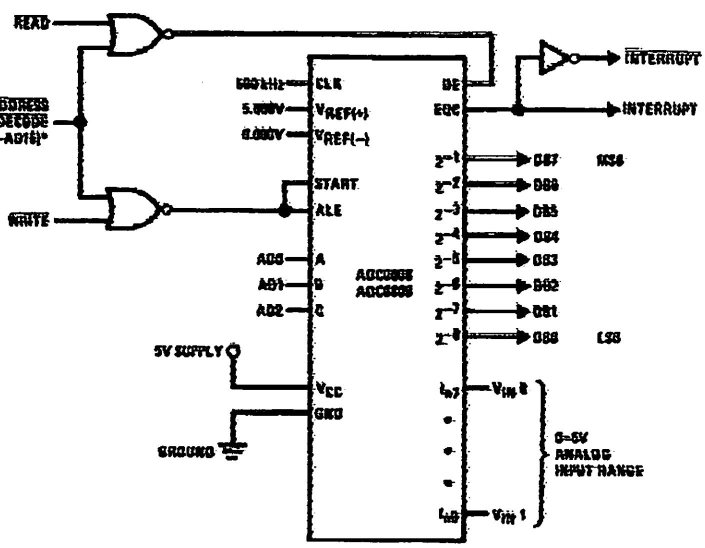
The dynamic comparator input current is caused by the periodic switching of on-chip stray capacitances. These are connected alternately to the output of the resistor ladder/switch tree network and to the comparator input as part of the operation of the chopper stabilized comparator.

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



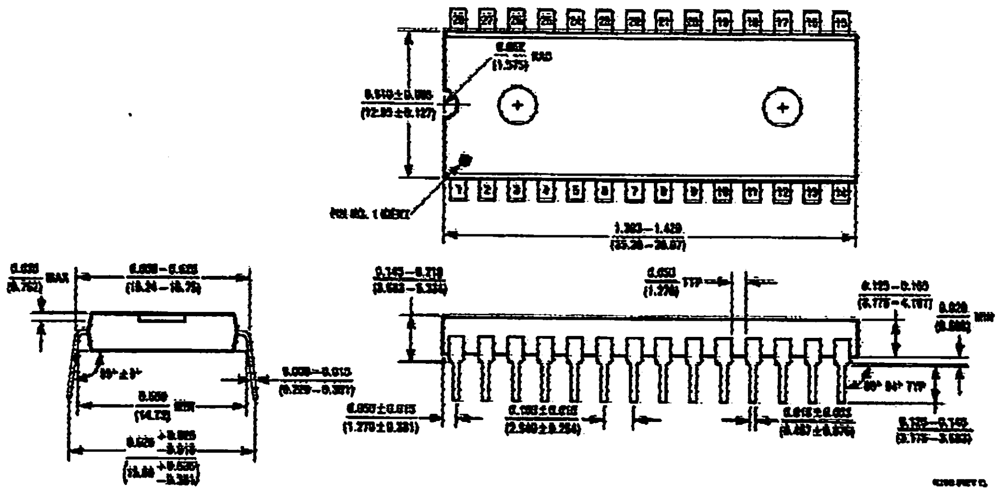
DS005672-10

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

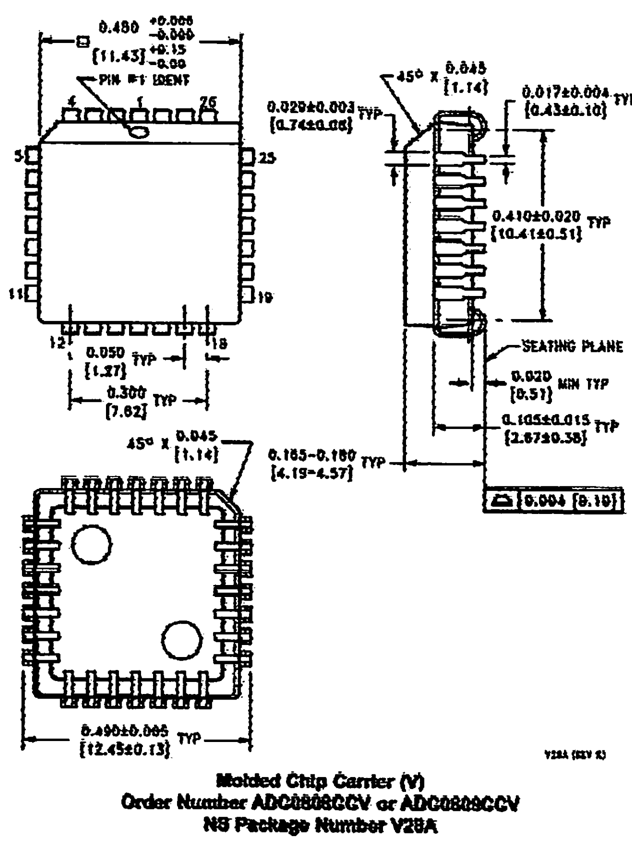
TABLE 2. Microprocessor Interface Table

PROCESSOR	$\overline{READ}$	$\overline{WRITE}$	INTERRUPT (COMMENT)
8080	$\overline{MEMR}$	$\overline{MEMW}$	INTR (Thru RST Circuit)
8085	$\overline{RD}$	$\overline{WR}$	INTR (Thru RST Circuit)
Z-80	$\overline{RD}$	$\overline{WR}$	$\overline{INT}$ (Thru RST Circuit, Mode 0)
SC/MP	NRDS	NWDS	SA (Thru Sense A)
6800	VMA•ϕ2•R/W	VMA•ϕ•$\overline{R/W}$	$\overline{IRQA}$ or $\overline{IRQB}$ (Thru PIA)

Physical Dimensions inches (millimeters) unless otherwise noted



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



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

Notes

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National Semiconductor Japan Ltd.
Tel: 81-3-5639-7560
Fax: 81-3-5639-7507

SOURCECODE PADA KOMPUTER

```
unit Unit1;
interface

uses
  Windows, Messages, SysUtils, Variants, Classes, Graphics, Controls, Forms,
  Dialogs, StdCtrls, ScktComp, ExtCtrls, Menus, ActnList, Buttons,
  sSkinProvider, sSkinManager, jpeg;

type
  TForm1 = class(TForm)
    ClientSocket1: TClientSocket;
    Button1: TButton;
    Label1: TLabel;
    Button2: TButton;
    Label2: TLabel;
    Label3: TLabel;
    Label4: TLabel;
    Label5: TLabel;
    Label6: TLabel;
    Timer1: TTimer;
    Edit1: TEdit;
    Button3: TButton;
    Button4: TButton;
    Timer2: TTimer;
    Label7: TLabel;
    BitBtn1: TBitBtn;
    Label8: TLabel;
    Label9: TLabel;
    Label10: TLabel;
    sSkinManager1: TsSkinManager;
    sSkinProvider1: TsSkinProvider;
    Image3: TImage;
    procedure Button1Click(Sender: TObject);
    procedure Button2Click(Sender: TObject);
    procedure ClientSocket1Read(Sender: TObject; Socket: TCustomWinSocket);
    procedure ClientSocket1Connect(Sender: TObject;
      Socket: TCustomWinSocket);
    procedure ClientSocket1Disconnect(Sender: TObject;
      Socket: TCustomWinSocket);
    procedure Timer1Timer(Sender: TObject);
```

```
    procedure ClientSocket1Connecting(Sender: TObject;
      Socket: TCustomWinSocket);
    procedure Button3Click(Sender: TObject);
    procedure Button4Click(Sender: TObject);
    procedure Timer2Timer(Sender: TObject);
    procedure Button5Click(Sender: TObject);
    procedure BitBtn1Click(Sender: TObject);
    procedure Chart1Click(Sender: TObject);
    procedure Label8Click(Sender: TObject);
    procedure ClientSocket1Error(Sender: TObject; Socket: TCustomWinSocket;
      ErrorEvent: TErrorEvent; var ErrorCode: Integer);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  Form1: TForm1;
implementation
uses unit2;
{$R *.dfm}

procedure delay(lama:longint);
var
ref:longint;
begin
ref:=gettickcount;
repeat
application.ProcessMessages;
until ((gettickcount-ref)>=lama);
end;

procedure TForm1.Button1Click(Sender: TObject);
begin
Timer1.Enabled:=true;
end;

procedure TForm1.Button2Click(Sender: TObject);
begin
ClientSocket1.Active:=False;
Timer1.Enabled:=False;
timer2.Enabled:=false;
```

```
end;

procedure TForm1.ClientSocket1Read(Sender: TObject;
 Socket: TCustomWinSocket);
begin
 Edit1.text:= socket.ReceiveText;
end;

procedure TForm1.ClientSocket1Connect(Sender: TObject;
 Socket: TCustomWinSocket);
begin
Label5.Caption:='Connected With WIZ610wi';
end;

procedure TForm1.ClientSocket1Disconnect(Sender: TObject;
 Socket: TCustomWinSocket);
begin
label5.Caption:='Disconected With WIZ610wi';
end;

procedure TForm1.Timer1Timer(Sender: TObject);
begin
ClientSocket1.Active := True ;
clientsocket1.Socket.SendText('SUHU');
end;

procedure TForm1.ClientSocket1Connecting(Sender: TObject;
 Socket: TCustomWinSocket);
begin
Label5.Caption:='Connecting...';
end;

procedure TForm1.Button3Click(Sender: TObject);
begin
label6.Caption:='SUHU';
label7.Caption:='Derajat Celcius';
timer2.Enabled:=false;
timer1.Enabled:=true;
end;

procedure TForm1.Button4Click(Sender: TObject);
begin
label6.Caption:='CO';
```

```
label7.Caption:='PPM';
timer1.Enabled:=false;
timer2.Enabled:=true;
end;

procedure TForm1.Timer2Timer(Sender: TObject);
begin
clientsocket1.Active:=true;
clientsocket1.Socket.SendText('COCO');
end;

procedure TForm1.Button5Click(Sender: TObject);
begin
form2.show;
end;

procedure TForm1.BitBtn1Click(Sender: TObject);
begin
timer1.Enabled:=false;
timer2.Enabled:=false;
clientsocket1.Active:=false;
end;

procedure TForm1.Chart1Click(Sender: TObject);
begin
label2.Color:=clred;
end;

procedure TForm1.Label8Click(Sender: TObject);
begin
clientsocket1.Active:=false;
timer1.Enabled:=false;
timer2.Enabled:=false;
form2.Show;
end;

procedure TForm1.ClientSocket1Error(Sender: TObject;
  Socket: TCustomWinSocket; ErrorEvent: TErrorEvent;
  var ErrorCode: Integer);
begin
label3.Caption:='Server Error';
end;
end.
```

SOURCECODE PADA MIKROKONTROLER

```
      org    00h
      ljmp   init              ;
      jump                     ;
      org    23h               ;\
      clr    ES                ;|
      jnb    RI,$              ;|
      clr    RI                ;| interupt serial
      mov    R7,SBUF           ;|
      setb   ES                ;|
      reti                     ;/
;
      CoHt   Bit P2.0
      Cosn   Bit P2.1

      Slc0   Bit P3.2
      Slc1   Bit P3.3
      Rest   Bit P3.4
      Enbl   Bit P3.5

      Sbco   Bit 20h.0      ; status baca sensor co

      Bufr   Equ 30h
      Hex0   Equ 31h
      Hex1   Equ 32h
      Dsn0   Equ 33h
      Ds00   Equ 34h
      Ds01   Equ 35h
      Dsn1   Equ 36h
      Ds10   Equ 37h
      Ds11   Equ 38h

      Char   Equ 40h
      Tmo0   Equ 41h
      Tmo1   Equ 42h
      Dly0   Equ 43h
      Dly1   Equ 44h
      Dly2   Equ 45h
      Dly3   Equ 46h
;
init: lcall  lcd_in            ; inisialisasi LCD
      lcall  srl_in            ; inisialisasi serial
      lcall  rstcmd            ; reset command serial
;
mulai: mov   DPTR,#tpnama           ;\
```

```
        lcall   line1                   ;|
        mov     Char,#16        ;|
        lcall   tulis                   ;|
        mov     DPTR,#tpnims            ;|
        lcall   line2                   ;|
        mov     Char,#16        ;|
        lcall   tulis                   ;|
        lcall   delay2                  ;|
        mov     DPTR,#tpjurs            ;|
        lcall   line1                   ;|
        mov     Char,#16        ;|
        lcall   tulis                   ;|
        mov     DPTR,#tpuniv            ;|
        lcall   line2                   ;|
        mov     Char,#16        ;|
        lcall   tulis                   ;|
        lcall   delay2                  ;/
;
        mov     DPTR,#tpsuhu            ;\
        lcall   line1                   ;|
        mov     Char,#16        ;|
        lcall   tulis                   ;|
        mov     DPTR,#tpgsco            ;|
        lcall   line2                   ;|
        mov     Char,#16        ;|
        lcall   tulis                   ;/
measrm: lcall   bcsns0                  ;\
        mov     DPTR,#angka             ;|
        mov     P0,#088h        ;|
        lcall   w_ins                   ;|
        mov     A,Ds00                  ;|
        mov     B,#10                   ;|
        div     AB              ;|
        lcall   wr_chr                  ;|
        mov     A,B                     ;|
        lcall   wr_chr                  ;|
        mov     P0,#'.'                 ;|
        lcall   w_chr                   ;|
        mov     A,Ds01                  ;|
        lcall   wr_chr                  ;|
        mov     P0,#0DFh                ;|
        lcall   w_chr                   ;|
        mov     P0,#0D0h                ;|
        lcall   w_ins                   ;/
;
        lcall   bcsns1                  ;\
```

```
        mov    DPTR,#angka              ;|
        mov    P0,#0C8h                 ;|
        lcall  w_ins                    ;|
        mov    A,R3                     ;|
        lcall  wr_chr                   ;|
        mov    A,R2                     ;|
        lcall  wr_chr                   ;|
        mov    A,R1                     ;|
        lcall  wr_chr                   ;|
        mov    A,R0                     ;|
        lcall  wr_chr                   ;|
        mov    P0,#0D0h                 ;|
        lcall  w_ins                    ;/
;
        mov    Dly1,#1                  ;\
        lcall  delay1                   ;| wait 1 detik
        ljmp   measrm                   ;/
;
bcsns0: clr    Slc0                     ;\
        clr    Slc1                     ;|
        mov    Dly1,#3              ;| select address ADC ch-0
        lcall  delay1                   ;|
        mov    Dsn0,P1                  ;|
        mov    A,Dsn0                   ;|
        mov    B,#10                    ;|
        div    AB                   ;|
        mov    Ds01,B                   ;| kalibrasi suhu
        mov    B,#25                    ;|
        add    A,B                      ;|
        mov    Ds00,A                   ;|
        ret                             ;/
;
bcsns1: setb   Slc0                     ; select address ADC ch-1
        clr    Slc1                     ;
        mov    Dly1,#3                  ;\ wait
        lcall  delay1                   ;/ 2.5ms
        clr    Cosn                     ; nyalakan sensor
        mov    Dly1,#3                  ;\ wait
        lcall  delay1                   ;/ 2.5ms
        mov    Dsn1,P1                  ; baca sensor (adc)
        mov    Dly1,#3                  ;\ wait
        lcall  delay1                   ;/ 2.5ms
        setb   Cosn                     ; matikan sensor
;
        clr    Coht                     ; nyalakan heater
        mov    Dly1,#3                  ;\ wait
```

```
        lcall   delay1                   ;/ 14ms
        setb    Coht                     ; matikan heater
;
        mov     DPTR,#lokup0             ;\
        mov     A,Dsn1                   ;|
        movc    A,@A+DPTR                ;|
        mov     Ds10,A                   ;|
        mov     DPTR,#lokup1             ;|
        mov     A,Dsn1                   ;|
        movc    A,@A+DPTR                ;|
        mov     Ds11,A                   ;|
        mov     Hex0,Ds10                ;|
        mov     Hex1,Ds11                ;|
        lcall   hexdec                   ;|
        ret                              ;/
;
hexdec: mov     R0,#0                    ;\
        mov     R1,#0                    ;|
        mov     R2,#0                    ;|
        mov     R3,#0                    ;|
        mov     A,Hex1                   ;|
        jz      hexdc1                   ;|
        mov     Bufr,#0                  ;| hexa -> decimal
hexdc0: lcall   incdec                   ;|
        djnz    Bufr,hexdc0              ;|
        djnz    Hex1,hexdc0              ;|
hexdc1: mov     A,Hex0                           ;|
        jz      hexdc3                   ;|
hexdc2: lcall   incdec                   ;|
        djnz    Hex0,hexdc2              ;/
hexdc3: ret
;
incdec: inc     R0                       ;\
        cjne    R0,#10,indec             ;|
        mov     R0,#0                    ;|
        inc     R1               ;|
        cjne    R1,#10,indec             ;|
        mov     R1,#0                    ;|
        inc     R2               ;| increment decimal
        cjne    R2,#10,indec             ;|
        mov     R2,#0                    ;|
        inc     R3               ;|
        cjne    R3,#10,indec             ;|
        mov     R3,#0                    ;|
indec:  ret                              ;/
;
```

```
nilai: mov    B,#100                    ;\
       div    AB              ;|
       lcall  wr_chr                    ;|
       mov    A,B                       ;|
       mov    B,#10                     ;| cacah nilai
       div    AB              ;|
       lcall  wr_chr                    ;|
       mov    A,B                       ;|
       lcall  wr_chr                    ;|
       ret                              ;/
;
bc_cmd: cjne   R7,#'S',bccmd0
       lcall  bc_srl
       cjne   R7,#'U',bccmd0
       lcall  bc_srl
       cjne   R7,#'H',bccmd0
       lcall  bc_srl
       cjne   R7,#'U',bccmd0
       mov    A,Ds00                    ;\
       mov    B,#10                     ;|
       div    AB              ;|
       mov    B,#30h                    ;|
       add    A,B                       ;|
       lcall  kr_srl                    ;|
       mov    A,Ds00                    ;|
       mov    B,#10                     ;|
       div    AB              ;|
       mov    A,B                       ;|
       mov    B,#30h                    ;|
       add    A,B                       ;|
       lcall  kr_srl                    ;|
       mov    A,#'.'                    ;|
       lcall  kr_srl                    ;|
       mov    A,Ds01                    ;|
       mov    B,#30h                    ;|
       add    A,B                       ;|
       lcall  kr_srl                    ;|
       mov    A,#0Dh                    ;|
       lcall  kr_srl                    ;/
;
bccmd0: cjne   R7,#'C',bccmd1
       lcall  bc_srl
       cjne   R7,#'O',bccmd1
       lcall  bc_srl
       cjne   R7,#'C',bccmd1
       lcall  bc_srl
```

```
        cjne   R7,#'O',bccmd1
        mov    A,R3                    ;\
        mov    B,#30h                  ;|
        add    A,B                     ;|
        lcall  kr_srl                  ;|
        mov    A,R2                    ;|
        mov    B,#30h                  ;|
        add    A,B                     ;|
        lcall  kr_srl                  ;|
        mov    A,R1                    ;|
        mov    B,#30h                  ;|
        add    A,B                     ;|
        lcall  kr_srl                  ;|
        mov    A,R0                    ;|
        mov    B,#30h                  ;|
        add    A,B                     ;|
        lcall  kr_srl                  ;|
        mov    A,#0Dh                  ;|
        lcall  kr_srl                  ;/
;
bccmd1: lcall  rstcmd
        ret
;
srl_in: mov    Dly3,#1                 ;\
        lcall  delay3                  ;|
        mov    TMOD,#20h               ;|
        mov    TH1,#0FDh               ;|
        mov    SCON,#50h               ;| inisialisasi serial
        setb   TR1                     ;|
        setb   ES                      ;|
        setb   EA                      ;|
        ret                            ;/
;
kr_srl: clr    ES                      ;\
        mov    SBUF,A                  ;|
        jnb    TI,$                    ;|
        clr    TI                      ;| kirim serial
        setb   ES                      ;|
        ret                            ;/
;
bc_srl: lcall  rstcmd                  ;\
        mov    Tmo0,#0                 ;|
        mov    Tmo1,#0                 ;| baca serial
bc_sr0: cjne   R7,#0FFh,bc_sr1         ;| tunggu data bukan FF
        djnz   Tmo1,bc_sr0             ;| sebelum time out
        djnz   Tmo0,bc_sr0             ;|
```

```
bc_sr1: ret                     ;/
;
rstcmd: mov    R7,#0FFh
        ret
;
line1: mov    P0,#080h
        lcall  w_ins
        ret
;
line2: mov    P0,#0C0h
        lcall  w_ins
        ret
;
tulis: clr    A
        lcall  wr_chr
        inc    DPTR
        djnz   Char,tulis
        ret
;
wr_chr: movc   A,@A+DPTR
        mov    P0,A
        lcall  w_chr
        ret
;
w_ins: clr    Enbl
        clr    Rest
        setb   Enbl
        clr    Enbl
        lcall  delay0
        ret
;
w_chr: clr    Enbl
        setb   Rest
        setb   Enbl
        clr    Enbl
        lcall  delay0
        ret
;
lcd_in: mov    Dly3,#1
        lcall  delay3
        mov    P0,#01h          ; Display Clear
        lcall  w_ins
        mov    P0,#38h          ; Function Set
        lcall  w_ins
        mov    P0,#0Dh          ; Display On, Cursor, Blink
        lcall  w_ins
```

```
        mov    P0,#06h                  ; Entry Mode
        lcall  w_ins
        mov    P0,#02h                  ; Cursor Home
        lcall  w_ins
        ret
;
lcdclr: mov    P0,#01h                  ; Display Clear
        lcall  w_ins
        lcall  delay0
        lcall  delay0
        lcall  delay0
        ret
;
delay0: djnz   Dly0,delay0
        ret
;
delay1: lcall  delay0
        cjne   R7,#0FFh,dely10
        ljmp   dely11
dely10: ljmp   bc_cmd
dely11: djnz   Dly1,delay1
        ret
;
delay2: mov    Dly2,#20
dely2:  lcall  delay1
        djnz   Dly2,dely2
        ret
;
delay3: lcall  delay0
        djnz   Dly1,delay3
        djnz   Dly3,delay3
        ret
;
tpnama: DB   '  I R V A N    '
tpnims: DB   ' NIM: 0512207 '
tpjurs: DB   ' Teknik Elektro '
tpuniv: DB   '  ITN Malang  '
tpsuhu: DB   ' Suhu :    C '
tpgsco: DB   ' CO  :   ppm '
angka:  DB   '0123456789     '
;
lokup0: DB   002,004,005,007,009,011,012,014,016,017     ; 000-009
        DB   019,021,022,024,026,027,029,031,032,034     ; 010-019
        DB   036,037,039,041,042,044,046,047,049,050     ; 020-029
        DB   052,054,055,057,059,060,062,063,065,067     ; 030-039
        DB   068,070,071,073,075,076,078,079,081,083     ; 040-049
```

```
        DB      084,086,087,089,090,092,093,095,097,098         ; 050-059
        DB      100,101,103,104,106,107,109,110,112,113         ; 060-069
        DB      115,117,118,120,121,123,124,126,127,129         ; 070-079
        DB      130,132,133,134,136,137,139,140,142,143         ; 080-089
        DB      145,146,148,149,151,152,153,155,156,158         ; 090-099
        DB      159,161,162,164,165,166,168,169,171,172         ; 100-109
        DB      173,175,176,178,179,180,182,183,185,186         ; 110-119
        DB      187,189,190,191,193,194,196,197,198,200         ; 120-129
        DB      201,202,204,205,206,208,209,210,212,213         ; 130-139
        DB      214,216,217,218,220,221,222,223,225,226         ; 140-149
        DB      227,229,230,231,233,234,235,236,238,239         ; 150-159
        DB      240,241,243,244,245,246,248,249,250,251         ; 160-169
        DB      253,254,255,000,002,003,004,005,006,008         ; 170-179
        DB      009,010,011,012,014,015,016,017,018,020         ; 180-189
        DB      021,022,023,024,026,027,028,029,030,031         ; 190-199
        DB      032,034,035,036,037,038,039,040,042,043         ; 200-209
        DB      044,045,046,047,048,049,051,052,053,054         ; 210-219
        DB      055,056,057,058,059,060,062,063,064,065         ; 220-229
        DB      066,067,068,069,070,071,072,073,074,075         ; 230-239
        DB      076,077,078,079,080,082,083,084,085,086         ; 240-249
        DB      087,088,089,090,091,092                         ; 250-255
;
lokup1: DB      000,000,000,000,000,000,000,000,000,000         ; 000-009
        DB      000,000,000,000,000,000,000,000,000,000         ; 010-019
        DB      000,000,000,000,000,000,000,000,000,000         ; 020-029
        DB      000,000,000,000,000,000,000,000,000,000         ; 030-039
        DB      000,000,000,000,000,000,000,000,000,000         ; 040-049
        DB      000,000,000,000,000,000,000,000,000,000         ; 050-059
        DB      000,000,000,000,000,000,000,000,000,000         ; 060-069
        DB      000,000,000,000,000,000,000,000,000,000         ; 070-079
        DB      000,000,000,000,000,000,000,000,000,000         ; 080-089
        DB      000,000,000,000,000,000,000,000,000,000         ; 090-099
        DB      000,000,000,000,000,000,000,000,000,000         ; 100-109
        DB      000,000,000,000,000,000,000,000,000,000         ; 110-119
        DB      000,000,000,000,000,000,000,000,000,000         ; 120-129
        DB      000,000,000,000,000,000,000,000,000,000         ; 130-139
        DB      000,000,000,000,000,000,000,000,000,000         ; 140-149
        DB      000,000,000,000,000,000,000,000,000,000         ; 150-159
        DB      000,000,000,000,000,000,000,000,000,000         ; 160-169
        DB      000,000,000,001,001,001,001,001,001,001         ; 170-179
        DB      001,001,001,001,001,001,001,001,001,001         ; 180-189
        DB      001,001,001,001,001,001,001,001,001,001         ; 190-199
        DB      001,001,001,001,001,001,001,001,001,001         ; 200-209
        DB      001,001,001,001,001,001,001,001,001,001         ; 210-219
        DB      001,001,001,001,001,001,001,001,001,001         ; 220-229
        DB      001,001,001,001,001,001,001,001,001,001         ; 230-239
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        DB      001,001,001,001,001,001,001,001,001,001         ; 240-249
        DB      001,001,001,001,001,001                         ; 250-255
;
        end
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