RANCANG BANGUN
LAMPU OTOMATIS MENGGUNAKAN IC LM 741

PROJEK AKHIR 2

MINDASARI BR KABAN

152411033

PROGRAM STUDI D3 METROLOGI DAN INSTRUMENTASI

DEPARTEMEN FISIKA

FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM

UNIVERSITAS SUMATERA UTARA

MEDAN

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Diajukan untuk melengkapi tugas dan memenuhi syarat memperoleh Ahli Madya

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PERSETUJUAN

JUDUL	: RANCANG BANGUN LAMPU OTOMATIS MENGGUNAKAN IC LM 741
KATEGORI	: TUGAS PROJEK AKHIR 2
NAMA	: MINDASARI BR KABAN
NIM	: 152411033
PROGRAM STUDI	: D3 METROLOGI DAN INSTRUMENTASI
DEPARTEMEN	: FISIKA
FAKULTAS	: FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM (FMIPA) UNIVERSITAS SUMATERA UTARA

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Komisi Pembimbing :

Diketahui/Disetujui oleh

Program Studi D3 Metrologi dan Instrumentasi

Ketua,	Pembimbing
(Dr.Diana Alemin Barus M,Sc)	(Dr.Perdinan Sinuhaji,MS)
NIP.196607291992032002	NIP.195903101987031002

PERNYATAAN

RANCANG BANGUN
LAMPU OTOMATIS MENGGUNAKAN IC LM 741

PROJEK AKHIR 2

Saya mengakui bahwa tugas akhir ini adalah hasil kerja saya sendiri. Kecuali beberapa kutipan dan ringkasan yang masing masing di sebutkan sumbernya.

Medan, Juli 2018

Mindasari br Kaban

152411033

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Medan, Juli 2018

Mindasari br Kaban

152411033

ABSTRAK

Otomatisasi saat ini cukup banyak digunakan untuk berbagai keperluan guna memudahkan pekerjaan manusia. Sistem kendali dalam hal ini sebagai bidang ilmu yang memungkinkan implementasi otomatisasi. Pada rangkaian ini, sistem kendali diterapkan untuk mengendalikan lampu secara otomatis menggunakan sensor cahaya. Pengendali yang digunakan adalah Arduino Uno. Arduino ini berfungsi untuk memproses sinyal masukkan dari sensor cahaya sebagai komponen umpan balik, kemudian menghasilkan keluaran yang ditujukan pada aktuator dalam hal ini adalah relay. Program yang diterapkan pada Arduino berfungsi untuk melakukan inisialisasi dan konfigurasi perangkat keras serta membaca sinyal masukkan dari sensor cahaya yang kemudian memprosesnya dengan diberikan beberapa kondisi sampai menghasilkan keluaran. Hasil akhir rangkaian ini adalah sistem penerangan otomatis untuk mengendalikan lampu berdasarkan pengukuran intensitas cahaya oleh sensor disekitar lampu yang kemudian dikonversi menjadi nilai ADC. Lampu akan menyala secara otomatis jika nilai ADC 0-60 dan sebaliknya lampu akan mati secara otomatis jika nilai ADC 61-102.

Kata Kunci : Sensor Cahaya, Arduino, Relay, Lampu Otomatis

ABSTRACT

Automation is currently widely used for various purposes to facilitate human work. The control system in this case as a field of science that enables the implementation of automation. In this circuit, the control system is applied to control the lamp automatically using the light sensor. The controller used is Arduino Uno. This arduino serves to process the input signal from the light sensor as a feedback component, then produces the output directed at the actuator in this case is the relay. Programs implemented on Arduino function to initialize and configure the hardware and read the input signal from the light sensor which then process it with given some conditions to produce output. The end result of this circuit is the automatic lighting system to control the light based on the measurement of the light intensity by the sensor around the lamp which is then converted to ADC value. The lamp will turn on automatically if the ADC value is 0-60 and the reverse light will automatically turn off if the ADC value is 61-102.

Keywords: Light Sensor, Arduino, Relay, Auto Lamp

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BAB I
PENDAHULUAN

1.1 Latar Belakang

Zaman yang mulai berkembang menjadi lebih modern seperti sekarang ini, membuat perkembangan di bidang Elektronika semakin pesat. Ini membuat kebutuhan manusia akan barang-barang elektronika semakin pesat juga di pasaran. Perkembangan teknologi elektronika saat ini sudah sedemikian pesatnya yang kadang-kadang berawal dari rangkaian-rangkaian sederhana yang biasa kita jumpai dalam buku-buku hobby elektronika. Dalam beberapa perkembangan yang semakin pesat ini, banyak penemuan penemuan dan pengembangan pada bidang Elektronika yang semakin membuming dan berlomba untuk membuat suatu pekerjaan manusia semakin mudah dan praktis. Salah satu contoh pengembangan bidang elektronika tersebut adalah Perancangan Rangkaian Lampu Otomatis. Pernahkah kita ketika ingin meninggalkan rumah atau kontrakan dalam waktu yang lama, kemudian dengan alasan tertentu kita memutuskan untuk menyalakan lampu depan rumah secara terus menerus? Hal tersebut merupakan hal yang biasa, tetapi pada beberapa kasus kita bisa tahu bahwa pemilik rumah atau kontrakan sedang tidak ada dirumah dengan beberapa indikasi, dimana lampu yang mati terus atau lampu yang menyala terus. Apakah itu menjadi masalah? Tidak selalu,sebab tidak semua orang punya niat jahat dan tidak semua orang pula mempunyai niat yang baik. Dengan Lampu Otomatis Lampu Otomatis yang dibuat dengan menggabungkan IC LM471 dan Sensor Cahaya ini, setidaknya kita mendapatkan dua keuntungan, pertama kita bisa menghemat listrik dan yang kedua kita setidaknya menghindari orang yang kita tidak kenal mengintai rumah kita karena rumah atau kontrakan kita tidak berpenghuni. Dengan adanya lampu otomatis, kita bisa menghemat setidanya 50% dari daya yang bisa dihabiskan lampu tersebut. Selain untuk menghemat penggunaan listrik sekitar 50%, juga bisa membuat rumah atau kontrakan tampak hidup dan ada penghuninya. Sebab, jika siang lampunya akan mati, sementara ketika malam tiba lampu akan otomatis hidup, jika ada orang asing, tentu akan mengangap bahwa penghuni rumah atau kontrakan ada didalam. Begitulah prinsip kerja dan manfaat dari ***Rancang Bangun Lampu Otomatis Menggunakan IC LM741.***

1.2 Rumusan Masalah

Permasalahan yang akan dibahas berkaitan mengenai Rangkaian Lampu Otomatis adalah :

1. Pengertian Rancang Bangun Lampu Otomatis ?
2. Komponen apa saja yang diperlukan dalam pembuatan Rancang Bangun Lampu Otomatis ?
3. Bagaimana prinsip kerja pada Rancang Bangun Lampu Otomatis?
4. Bagaimana cara membuat Rancang Bangun Lampu Otomatis ?

1.3 Tujuan Penulisan

Tujuan dilakukannya pembuatan *Rancang Bangun Lampu Otomatis Menggunakan IC LM741* antara lain :

1. Untuk mengetahui pengertian dari *Rancang Bangun Lampu Otomatis Menggunakan IC LM741*.
2. Untuk mengetahui apa saja komponen dan fungsi pada *Rancang Bangun Lampu Otomatis Menggunakan IC LM741*.
3. Untuk mengetahui prinsip kerja pada *Rancang Bangun Lampu Otomatis Menggunakan IC LM741* .

1.4 Manfaat Penulisan

Dari tujuan di atas, manfaat dari pembuatan laporan ini adalah bagaimana kita memanfaatkan pembuatan ***Rancang Bangun Lampu Otomatis Menggunakan IC LM741*** secara mandiri untuk mengembangkan pengetahuan yang telah kita pelajari mengenai komponen dasar pada Rangkaian Elektronika. selain itu manfaat dari Rangkaian ini adalah sebagai alat bantu sederhana untuk membantu atau memudahkan masyarakat untuk menghidupkan/mematikan lampu diruangan tertentu tanpa harus menekan tombol on/off

1.5 Tujuan Pembuatan Alat

Rangkaian Lampu Otomatis ini dibuat dalam rangka memenuhi Tugas Akhir mata kuliah Projek Akhir 2. Tujuan yang ingin dicapai pada pembuatan projek ini adalah:

1. Memperoleh pengenalan dasar tentang*Rancang Bangun Lampu Otomatis Menggunakan IC LM741* serta komponen-komponen dalam perangkatnya.
2. Memperoleh penjelasan dan cara kerja dari rangkaian pada Tugas Akhir yang telah dibuat.
3. Memperoleh alat "*Rancang Bangun Lampu Otomatis Menggunakan IC LM741*" serta implementasinya pada sistem nyata.
4. Untuk menambah pembendaharaan peralatan pada Laboratorium.

1.6 Metode Penulisan

Alasan penulis memilih judul *Rancang Bangun Lampu Otomatis Menggunakan IC LM741* sebagai proyek praktikum yang ditugaskan serta pembuatan makalah yang diberikan ialah karena rangkaian ini merupakan rangkaian yang memiliki manfaat cukup luas untuk orang banyak yang sekarang banyak dipergunakan sebagai alat bantu petani dalam sektor industri, juga secara lebih khusus untuk dapat dipakai langsung dalam menunjang kegiatan persyaratan kelulusan Mata kuliah Tugas Akhir. Dari data-data yang diperoleh, penulis menyajikan dan menjelaskannya dalam makalah ini.

1.7 Sistematika Penulisan

Untuk mempermudah perancangan dan pembuatan alat maka penulis membuat sistematika penulisan Tugas Akhir seperti berikut ini :

BAB I PENDAHULUAN

Pada BAB I PENDAHULUAN, berisi tentang Latar Belakang; Rumusan Masalah; Tujuan; Manfaat; Tujuan Penulisan; Metode Penulisan; serta Sitematika Penulisan.

BAB II LANDASAN TEORI

Pada BAB II LANDASAN TEORI, berisi tentang pembahasan secara umum mengenai komponen komponen yang terdapat pada *"Rancang Bangun Lampu Otomatis Menggunakan IC LM741"*

BAB III METODE PERCOBAAN

Pada BAB III METODE PERCOBAAN, dijelaskan tentang gambaran pada Diagram Blok Rangkaian, Alur Pengujian, Alat dan Bahan, Waktu dan Tempat serta Metode Pendukung Lainnya pada pembuatan Tugas Akhir ini.

BAB IV HASIL PEMBAHASAN DAN ANALISA

Pada BAB IV HASIL PEMBAHASAN DAN ANALISA, berisi tentang pembahasan dan analisa data dari hasil pengujian

BAB V KESIMPULAN DAN SARAN

Pada BAB V KESIMPULAN DAN SARAN, berisi tentang kesimpulan dan saran dari hasil pengujian

BAB II
TINJAUAN PUSTAKA

2.1 Pengertian Sensor

Sensor adalah sesuatu yang digunakan untuk mendeteksi adanya perubahan lingkungan fisik atau kimia. Variabel keluaran dari sensor yang diubah menjadi besaran listrik disebut Transduser. Pada saat ini, sensor tersebut telah dibuat dengan ukuran sangat kecil dengan orde nanometer. Ukuran yang sangat kecil ini sangat memudahkan pemakaian dan menghemat energi.. Sensor Cahaya terdiri dari 3 kategori. Fotovoltaic atau sel solar adalah alat sensor cahaya yang mengubah energi cahaya langsung menjadi energi listrik, dengan adanya penyinaran cahaya akan menyebabkan pergerakan elektron dan menghasilkan tegangan. Demikian pula dengan sensor tipe Fotokonduktif (fotoresistif) yang akan memberikan perubahan tahanan (resistansi) pada sel-selnya, semakin tinggi intensitas cahaya yang terima, maka akan semakin kecil pula nilai tahanannya. Sedangkan Sensor cahaya tipe Fotolistrik adalah sensor yang berprinsip kerja berdasarkan pantulan karena perubahan posisi/jarak suatu sumber sinar (inframerah atau laser) ataupun target pemantulnya, yang terdiri dari pasangan sumber cahaya dan penerima.

2.1.1 Sensor Cahaya Tipe Fotokonduktif

Sensor cahaya tipe fotokonduktif akan memberikan perubahan resistansi pada terminal outputnya sesuai dengan perubahan intensitas cahaya yang diterimanya. Sensor cahaya tipe fotovoltaik ini ada beberapa jenis diantaranya adalah :

2.1.2 LDR (Light Depending Resistor)

LDR adalah sensor cahaya yang memiliki 2 terminal output, dimana kedua terminal output tersebut memiliki resistansi yang dapat berubah sesuai dengan intensitas cahaya yang diterimanya.

Gambar 2.1*LDR (Light Depending Resistor)*

2.1.3 Photo Transistor

Photo transistor adalah suatu transistor yang memiliki resistansi antara kaki kolektor dan emitor dapat berubah sesuai intensitas cahaya yang diterimanya. Photo transistormemiliki 2 terminal output dengan nama emitor dan colektor, dimana nilai resistansi emeitor dan kolektro tersebut akan semakin rendah apabila intensitas cahaya yang diterim photo transistor semnakin tinggi.

Gambar 2.2*Photo Transistor*

2.1.4Photodioda

Photodioda adalah suatu jenis dioda yang resistansinya berubah-ubah kalau cahaya yang jatuh pada dioda berubahubah intensitasnya.Dalam gelap nilai tahanannya sangat besar hingga praktis tidak ada arus yang mengalir.Semakin kuat cahaya yang jatuh pada dioda maka makin kecil nilai tahanannya, sehingga arus yang mengalir semakin besar. Jika photodioda persambungan p-n bertegangan balik disinari, maka arus akan berubah secara linier dengan kenaikan fluks cahaya yang dikenakan pada persambungan tersebut. Photodioda terbuat dari bahan semikonduktor. Biasanya yang dipakai adalah silicon (Si) atau gallium arsenide (GaAs), dan lain-lain termasuk indium antimonide (InSb), indium arsenide (InAs), lead selenide (PbSe), dan timah sulfide (PBS). Bahan-bahan ini menyerap cahaya melalui karakteristik jangkauan panjang gelombang, misalnya: 250 nm ke 1100 untuk nm silicon, dan 800 nm ke 2,0 μm untuk GaAs. Dioda foto adalah jenis dioda yang berfungsi mendeteksi cahaya. Berbeda dengan diode biasa, komponen elektronika ini akan mengubah cahaya menjadi arus listrik. Cahaya yang dapat dideteksi oleh diode foto ini mulai dari cahaya infra merah, cahaya tampak, ultra ungu sampai dengan sinar-X. Aplikasi diode foto mulai dari penghitung kendaraan di jalan umum secara otomatis, pengukur cahaya pada kamera serta beberapa peralatan di bidang medis. Alat yang mirip dengan Dioda foto adalah

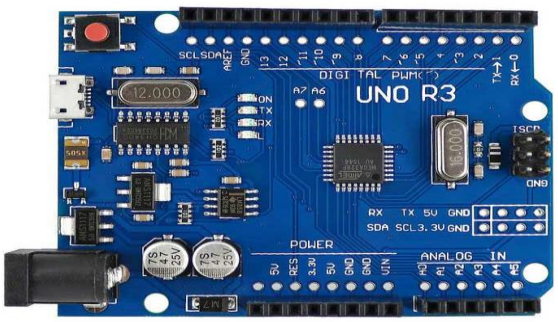
Transistor foto (Phototransistor).Transistor foto ini pada dasarnya adalah jenis transistor bipolar yang menggunakan kontak (junction) base-collector untuk menerima cahaya.Komponen ini mempunyai sensitivitas yang lebih baik jika dibandingkan dengan Dioda Foto.Hal ini disebabkan karena elektron yang ditimbulkan oleh foton cahaya pada junction ini di-injeksikan di bagian Base dan diperkuat di bagian Kolektornya. Namun demikian, waktu respons dari Transistor-foto secara umum akan lebih lambat dari pada Dioda-Foto. Photo dioda digunakan sebagai komponen pendeteksi ada tidaknya cahaya maupun dapat digunakan untuk membentuk sebuah alat ukur akurat yang dapat mendeteksi intensitas cahaya dibawah 1pW/cm2 sampai intensitas diatas 10mW/cm2. Photo dioda mempunyai resistansi yang rendah pada kondisi forward bias, kita dapat memanfaatkan photo dioda ini pada kondisi reverse bias dimana resistansi dari photo dioda akan turun seiring dengan intensitas cahaya yang masuk. Komponen ini mempunyai sensitivitas yang lebih baik jika dibandingkan dengan diodapeka cahaya.Hal ini disebabkan karena electron yang ditimbulkan oleh foton cahaya padajunction ini diinjeksikan di bagian Base dan diperkuat di bagian kolektornya. Namun demikian,waktu respons dari transistor foto secara umum akan lebih lambat dari pada dioda peka cahaya. Jika photo dioda tidak terkena cahaya, maka tidak ada arus yang mengalir ke rangkaian pembanding, jika photo dioda terkena cahaya maka photodiode akan bersifat sebagai tegangan, sehingga Vcc dan photo dioda tersusun seri, akibatnya terdapat arus yang mengalir ke rangkaian pembanding.

Gambar 2.3 *Photodioda*

2.2 Arduino Uno

Arduino Uno adalah salah satu varian dari produk board mikrokontroller keluaran Arduino. Arduino Uno adalah board Arduino terkecil, menggunakan mikrokontroller

Atmega 328 untuk Arduino Uno 3. Mikrokontroler berbasis ATmega 328(datasheet). Arduino Uno Memiliki 14 pin input dari output digital dimana 6 pin input tersebut dapat digunakan sebagai output PWM dan 6 pin input analog, 16 MHz osilator kristal, koneksi USB, jack power, ICSP header, dan tombol reset. Untuk mendukung mikrokontroler agar dapat digunakan, cukup hanya menghubungkan Board Arduino Uno ke komputer dengan menggunakan kabel USB atau listrik dengan AC yang-ke adaptor-DC atau baterai untuk menjalankannya.Arduino Uno berbeda dari semua papan sebelumnya dalam hal itu tidak menggunakan FTDI chip driver USB-to-serial. Sebaliknya, fitur Atmega 16U2 (Atmega8U2 hingga versiR2) deprogram sebagai converter USB-to-serial. Revisi 2 dari dewan Uno memiliki resistor menarik garis 8U2 HWB ke tanah, sehingga lebih mudah untuk dimasukkan ke dalam mode DFU. ArduinoUno dapat di aktif kan melalui koneksi USB atau dengan satu daya eksternal. Sumber daya dipilih secara otomatis. Eksternal(non-USB) dapat di ambil baik berasaldari AC ke adaptor DC atau baterai. Adaptor ini dapat dihubungkan dengan menancapkan plug jack pusat-positif ukuran 2.1mm konektor POWER. Ujung kepala dari baterai dapat dimasukkan kedalam Gnd dan Vin pin header dari konektor POWER.Kisaran kebutuhan daya yang disarankan untuk board Uno adalah7 sampai dengan 12 volt, jika diberi daya kurang dari 7 volt kemungkinan pin 5v Uno dapat beroperasi tetapi tidak stabil kemudian jikadiberi daya lebih dari 12V, regulator tegangan bisa panas dan dapat merusak board Uno VIN. Tegangan masukan kepada board Arduino ketika itu menggunakan sumber daya eksternal (sebagai pengganti dari 5 volt koneksi USB atau sumber daya lainnya).5V. Catu daya digunakan untuk daya mikrokontroler dan komponen lainnya3v3. Sebuah pasokan 3,3 volt dihasilkan oleh regulator on-board. GND. Ground pin.



Gambar 2.4*Arduino Uno*

2.2.1 Komponen Arduino Uno

Komponen utama di dalam papan Arduino adalah sebuah microcontroller 8 bit dengan merk ATmega yang dibuat oleh perusahaan Atmel Corporation . Berbagai papan Arduino menggunakan tipe ATmega yang berbeda-beda tergantung dari spesifikasinya, sebagai contoh Arduino Uno menggunakan ATmega328 sedangkan Arduino Mega 2560 yang lebih canggih menggunakan ATmega2560.Untuk memberikan gambaran mengenai apa saja yang terdapat di dalam sebuah microcontroller, pada gambar berikut ini diperlihatkan contoh diagram blok sederhana dari microcontroller ATmega328 (dipakai pada Arduino Uno). Blok-blok di atas dijelaskan sebagai berikut:

Universal Asynchronous Receiver/Transmitter (UART) adalah antar muka yang digunakan untuk komunikasi serial seperti pada RS-232, RS-422 dan RS-485. 2KB RAM pada memory kerja bersifat volatile (hilang saat daya dimatikan), digunakan oleh variable-variabel di dalam program. 32KB RAM flash memory bersifat non-volatile , digunakan untuk menyimpan program yang dimuat dari komputer. Selain program, flash memory juga menyimpan bootloader . UART (antar muka serial) 2KB RAM (memory kerja) 32KB RAM Flash memory (program) 1KB EEPROM CPU Port input/output ATmega328 memiliki 32 KB (dengan 0,5 KB digunakan untuk bootloader), 2 KB dari SRAM dan 1 KB EEPROM (yang dapat dibaca dan ditulis dengan EEPROM liberary).

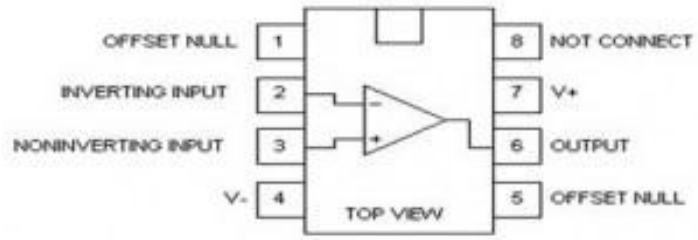
2.2.2 Spesifikasi Arduino Uno

1.	Mikrokontroller	: Atmel ATmega168
2	Tegangan kerja	: 5 Volt
3	Tegangan input	: Optimal : 7 – 12 Volt
4	Minimum	: 6 Volt
5	Maksimum	: 20 Volt
6	Digital pin I/O	: 14 pin yaitu pin D_0 sampai pin D_{13}
7	Analog pin	: 8 pin yaitu pin A_0 sampai pin A_7
8	Arus listrik maksimum	: 40 mA
9	Flash memori	: 32 Mbyte untuk Arduino Uno 3.x
10	SRAM	: 1 KB

11	EEPROM	: 512 B
12	Kecepatan clock	: 16 MHz
13	Ukuran board	: 4,5 mm x 18 mm
14	Berat	: 5 gram

2.3 IC LM741

Penguat operasional (*Op-Amp*) adalah suatu blok penguat yang mempunyai dua masukan dan satu keluaran. Penguat operasional (*Op-Amp*) dikemas dalam suatu rangkaian terpadu (*integrated circuit-IC*). Salah satu tipe operasional amplifier (*Op-Amp*) yang populer adalah LM741. IC LM741 merupakan operasional amplifier yang dikemas dalam bentuk *dual in-line package* (DIP). Kemasan IC jenis DIP memiliki tanda bulatan atau strip pada salah satu sudutnya untuk menandai arah pin atau kaki nomor 1 dari IC tersebut. Penomoran IC dalam kemasan DIP adalah berlawanan arah jarum jam dimulai dari pin yang terletak paling dekat dengan tanda bulat atau strip pada kemasan DIP tersebut. IC LM741 memiliki kemasan DIP 8 pin seperti terlihat pada gambar berikut.



Gambar 2.5 Kaki IC LM741

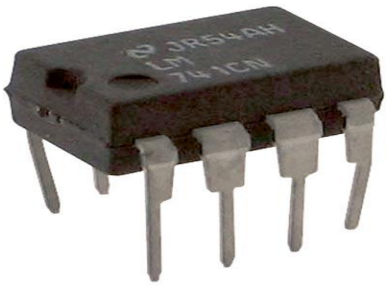
Pada IC ini terdapat dua pin input, dua pin power supply, satu pin output, satu pin NC (*No Connection*), dan dua pin offset null. Pin offset null memungkinkan kita untuk melakukan sedikit pengaturan terhadap arus internal di dalam IC untuk memaksa tegangan output menjadi nol ketika kedua input bernilai nol. IC LM741 berisi satu buah Op-Amp, terdapat banyak tipe IC lain yang memiliki dua atau lebih Op-Amp dalam suatu kemasan DIP. IC Op-Amp memiliki karakteristik yang sangat mirip dengan konsep Op-Amp ideal pada analisis rangkaian. Pada kenyataannya IC Op-Amp terdapat batasan-batasan penting yang perlu diperhatikan.

1. Pertama, tegangan maksimum power supply tidak boleh melebihi rating maksimum, karena akan merusak IC.
2. Kedua, tegangan output dari IC op amp biasanya satu atau dua volt lebih kecil dari tegangan power supply. Sebagai contoh, tegangan swing output dari suatu op amp dengan tegangan supply 15 V adalah ±13V.
3. Ketiga, arus output dari sebagian besar op amp memiliki batas pada 30mA, yang berarti bahwa resistansi beban yang ditambahkan pada output op amp harus cukup besar sehingga pada tegangan output maksimum, arus output yang mengalir tidak melebihi batas arus maksimum.

Pada sebuah peguat operasional (*Op-Amp*) dikenal beberapa istilah yang sering dijumpai, diantaranya adalah :

1. Tegangan ofset masukan (*input offset voltage*) Vio menyatakan seberapa jauh v+ dan v terpisah untuk mendapatkan keluaran 0 volt.
2. Arus offset masukan (*input offset current*) menyatakan kemungkinan seberapa berbeda kedua arus masukan.
3. Arus panjar masukan (*input bias current*) memberi ukuran besarnya arus basis (masukan).
4. Harga CMRR menjamin bahwa output hanya tergantung pada (v+) – (v-), walaupun v+ dan v- masing-masing berharga cukup tinggi.

Untuk menghindari keluaran yang berosilasi, maka frekuensi harus dibatasi, *unity gain frequency* memberi gambaran dari data tanggapan frekuensi. hal ini hanya berlaku untuk isyarat yang kecil saja karena untuk isyarat yang besar penguat mempunyai keterbatasan sehingga output maksimum hanya dihasilkan pada frekuensi yang relative rendah.



Gambar 2.6 IC LM741

2.4 Resistor

Resistor adalah komponen elektronik dua kutub yang didesain untuk menahan arus listrik dengan memproduksi tegangan listrik di antara kedua kutubnya, nilai tegangan terhadap resistansi berbanding dengan arus yang mengalir, berdasarkan. Resistor digunakan sebagai bagian dari jejaring elektronik dan sirkuit elektronik, dan merupakan salah satu komponen yang paling sering digunakan. Resistor dapat dibuat dari bermacam-macam kompon dan film, bahkan kawat resistansi (kawat yang dibuat dari paduan resistivitas tinggi seperti nikel-kromium).Karakteristik utama dari resistor adalah resistansinya dan daya listriknya yang dapat dihantarkan. Karakteristik lain termasuk koefisien suhu, desah listrik, dan induktansi. Resistor dapat diintegrasikan kedalam sirkuit hibrida dan papan sirkuit cetak, bahkan sirkuit terpadu. Ukuran dan letak kaki bergantung pada desain sirkuit, kebutuhan daya resistor harus cukup dan disesuaikan dengan kebutuhan arus rangkaian agar tidak terbakar.Resisitor merupakan salah satu komponen elektronika yang bersifat pasif dimana komponen ini tidak membutuhan arus listrik untuk berkerja. Resisitor memiliki sifat menghambat arus listrik dan resistor sendiri memiliki nilai besaran hambatan yaitu ohm dan dituliskan dengan simbol Ω. Sesuai dengan nama dan kegunaanya untuk membatasi atau menghambat arus listrik yang melewatinya dalam suatu rangkaian maka resistor mempunyai sifat resistif (menghambat) yang umunya terbuat dari bahan karbon. Hal ini bisa terjadi karena resistor yang memiliki dua kutub akan memproduksi tegangan listrik di antara kedua kutubnya. Dengan mengatur besarnya arus yang mengalir, kita dapat mengatur alat elektronik untuk melakukan berbagai hal.Dari hukum Ohm di jelaskan bahwa resistansi akan berbanding terbalik dengan jumlah arus yang melaluinya. Maka untuk menyatakan besarnya resistansi dari sebuah resistor dinyatakan dalam satuan Ohm yang dilambangkan dengan simbol Ω (Omega). Untuk menggambarkanya dalam suatu rangkaian dilambangkan dengan huruf R, karena huruf ini merupakan standart internasional yang sudah disepakati bersama untuk melambangkan sebuah komponen resistor dalam sebuah rangkaian.

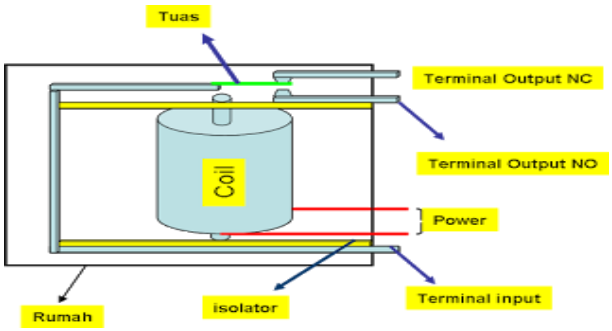
Gambar 2.7 Resistor

Selain untuk membatasi atau menghambat arus listrik, resistor mempunyai kegunaan atau fungsi lainnya, diantara nya adalah sebagai berikut :

1. Sebagai pembagi arus
2. Sebagai pembagi tegangan
3. Sebagai penurun tegangan
4. Sebagai penghambat arus listrik
5. Menghambat arus listrik
6. Pengatur volume (potensiometer)
7. Pengatur kecepatan motor (rheostat), dll.

2.5 Relay

Relay adalah saklar elektronik,yang bekerja karena adanya kontrol yang digerakkan oleh listrik.Relay terdiri dari 2 bagian utama yaitu,Elektromagnet (Coil) dan Mekanikal.Terbuka / tertupnya saklar bergantung pada coil apakah ada listrik yang melewati,sebab koil akan berubah menjadi magnet seketika ada listrik yang melewatinya,sehingga tuas mekanik akan tertarik.Relay mampu menangani daya yang lebih besar dari daya kerjanya.menurut arus listrik kerjanya ,relay dibagi menjadi 2 yaitu Relay AC dan Relay DC.untuk bisa mengetauhi apakah tegangan kerja yang dibutuhkan anda bisa melihat informasi teknis yang tertulis pada body.Relay AC bekerja pada tegangan 220 Volt,sedangkan Relay DC umumnya bekerja pada tegangan 6 Volt 12 Volt, 24 Volt, 48 Volt.



Gambar 2.8 Ilustrasi Cara Kerja Relay

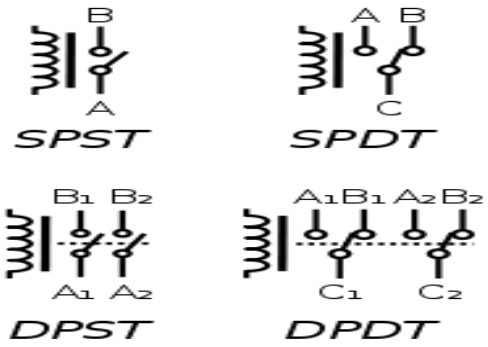
Untuk menjelaskan prinsip kerja secara lebih lengkap,silahkan perhatikan kontruksi relay pada gambar berikut,.relay memilki coil atau lilitan kawat yang berfungsi apabila lilitan tersebut diberikan tegangan kerjanya (power) maka akan berubah

menjadi magnet,sehingga tuas akan tertarik menempel pada coil. Tuas yang awalnya terhubung dengan terminal output Normally Close (NC) akan berpindah ke terminal output normally open (NO),begitu tidak ada power maka tuas akan kembali ke posisi semula.tuas dapat kembali ke posisi semula dikarenakan menggunakan plat yang memilki kelenturan baik,yang mampu menjangkau diantara kedua jarak terminal,oleh kerenanya relay memiliki rumah yang melindungi gangguan luar terhadap sistem kerjanya. Relay dengan kemapuan besar biasanaya di kemas pelindung yang transparan,sehingga masih memungkinkan kita mengetauhi bagaimana sistem mekanik di dalamnya bekerja.Jika tegangan yang di berikan berada di antara kondisi keduanya,maka akan sangat terdengar bunyi perpindahan tuasnya.

Secara umum, keutamaan penggunaan relay adalah kemampunya bekerja pada rangkaian berdaya rendah dan mampu menangani system pensaklaran dengan daya besar.hal inilah yang membedakan sistem pensaklaran menggunakan transistor.Sistem pada transitor menggunakan daya kecil penggunaanya pun untuk daya kecil.Relay dengan arus AC tidak lah berbeda kerjanya,hanya coil yang didesign mampu bekerja pada arus jenis AC. Dikarenakan relay termasuk dalam golongan saklar,maka relay memiliki istlah pole (Terminal) dan Throw (kondisi),oleh kerena itu dibagi menjadi beberapa kelompok diantranya.

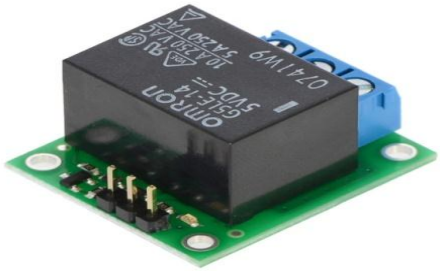
1. Single Pole Single Throw (SPST) : Relay kelompok ini memiliki 1 jenis kontak,dengan 2 terminal 1 terminal input dan satu terminal output
2. Single Pole Double Throw (SPDT) : Relay kelompok ini memiliki 2 jenis kontak,terdiri dari 3 terminal,satu terminal input dan 2 terminal output dengan 2 kondisi normally NO/NC
3. Double Pole Single Throw (DPST) : Relay kelompok ini sama seperti dua relay SPST dalam satu rumah namun dikendalikan oleh hanya satu koil,satu kondisi kontak pada masing masing terminal
4. Double Pole Double Throw (DPDT) : Relay kelompok ini sama dengan relay jenis SPDT dalam satu rumah dan dikendalikan leh hanya satu koil

Untuk mendapatkan gambaran lebih jelasnya silahkan perhatikan symbol relay pada gambar dibawah ini



Gambar 2.9 Simbol Relay

Penggunaan jenis relay sangat bergantung pengaplikasianya dalam peralatan kelistrikan,di karenakan komponen penggunaanya bersifat mekanis,maka tidak cocok di gunakan untuk



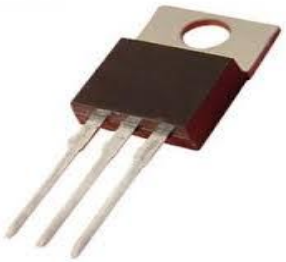
Gambar 2.10 Relay

switching yang sangat cepat.namun kehandalanya untuk menangani daya besar tidak perlu diragukan.Pastikan anda telah mempu dan memahami spesifikasi teknis sebelum menerapkan dalam rangkaian kelistrikan

2.6 Transistor

Transistor adalah alat semikonduktor yang dipakai sebagai penguat, sebagai sirkuit pemutus dan penyambung (switching), stabilisasi tegangan, modulasi sinyal atau sebagai fungsi lainnya. Transistor dapat berfungsi semacam kran listrik, di mana berdasarkan arus inputnya (BJT) atau tegangan inputnya (FET), memungkinkan pengaliran listrik yang sangat akurat dari sirkuit sumber listriknya. Pada umumnya,

transistor memiliki 3 terminal, yaitu Basis (B), Emitor (E) dan Kolektor (C). Tegangan yang di satu terminalnya misalnya Emitor dapat dipakai untuk mengatur arus dan tegangan yang lebih besar daripada arus input Basis, yaitu pada keluaran tegangan dan arus output Kolektor. Transistor merupakan komponen yang sangat penting dalam dunia elektronik modern. Dalam rangkaian analog, transistor digunakan dalam amplifier (penguat). Rangkaian analog melingkupi pengeras suara, sumber listrik stabil (stabilisator) dan penguat sinyal radio. Dalam rangkaian-rangkaian digital, transistor digunakan sebagai saklar berkecepatan tinggi. Beberapa transistor juga dapat dirangkai sedemikian rupa sehingga berfungsi sebagai logic gate, memori dan fungsi rangkaian-rangkaian lainnya Dari banyak tipe-tipe transistor modern, pada awalnya ada dua tipe dasar transistor, bipolar junction transistor (BJT atau transistor bipolar) dan field-effect transistor (FET), yang masing-masing bekerja secara berbeda. Disebut Transistor bipolar karena kanal konduksi utamanya menggunakan dua polaritas pembawa muatan: elektron dan lubang, untuk membawa arus listrik. Dalam BJT, arus listrik utama harus melewati satu daerah/lapisan pembatas dinamakan depletion zone, dan ketebalan lapisan ini dapat diatur dengan kecepatan tinggi dengan tujuan untuk mengatur aliran arus utama tersebut. FET (juga dinamakan transistor unipolar) hanya menggunakan satu jenis pembawa muatan (elektron atau hole, tergantung dari tipe FET). Dalam FET, arus listrik utama mengalir dalam satu kanal konduksi sempit dengan depletion zone di kedua sisinya (dibandingkan dengan transistor bipolar di mana daerah Basis memotong arah arus listrik utama). Dan ketebalan dari daerah perbatasan ini dapat diubah dengan perubahan tegangan yang diberikan, untuk mengubah ketebalan kanal konduksi tersebut. Lihat artikel untuk masing-masing tipe untuk penjelasan yang lebih lanjut.



Gambar 2.11 Transistor

2.7 LED (Light Emiting Dioda)

Led adalah jenis dioda yang memancarkan cahaya. Komponen ini biasa digunakan pada lampu senter atau lampu emergensi. Seperti hal nya dioda yang hanya mengalirkan arus listrik dari satu arah, led juga demikian. Itulah sebab nya, pemasangan led dirangkaian elektronika harus tidak terbalik. Dengan kata lain, led tidak berfungsi jika dipasang terbalik.Led yang umum dipakai berkaki dua. Salah satu kaki berkutub + (disebut anoda) dan yang lain adalah – (disebut katoda). Namun, tidak tanda + atau – secara eksplisit. Pembedanya, led mempunyai kaki dengan panjang berbeda. Kaki yang panjang adalah anoda dan yang pendek adalah katoda.Sekiranya anda menemukan kaki led yang sudah terpotong sehingga kedua panjang kaki tidak bias dibedakan, indikasi yang menyatakan anoda atau katoda masih bias dilakukan.

Gambar 2.12LED *(Light Emiting Dioda)*

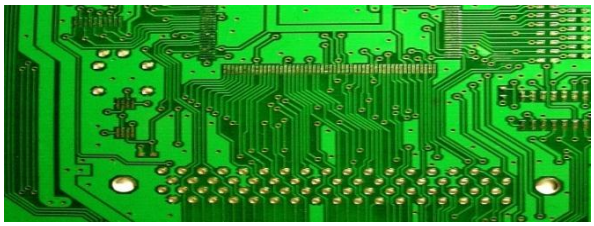
2.8 Pin Header

Header adalah lawan dari konektor black housing, dapat kita andaikan saja jika Black housing adalah Wanita, maka Header adalah Pria. ; Header Female adalah komponen yang berbentuk reperti Black Housing, tetapi jika black housing adalah komponen yang dapat berpindah karena tidak direkatkan pada PCB, sedangkan Header Female adalah komponen tetap, yang menyatu dengan papan sirkuit.

Gambar 2.13*(a) Pin Header Male*; (*b) Pin Header Female*

2.9 PCB(*Printed Circuit Board)*

Papan sirkuit cetak (*printed circuit board* atau PCB) adalah papan yang terbuat dari bahan isolator dan permukaaanya dilapisi tembaga. PCB berguna sebagai tempat pemasangan dan penghubung komponen - komponen elektronika.



Gambar 2.14PCB *(Printed Circuit Board)*

2.10 Lampu dan Fitting Lampu

Fiting dari bahasa Inggris, fitting adalah sebuah tempat untuk menaruh sebuah lampubohlam, yang berbentuk bulat dengan lubang di tengahnya yang digunakan untuk menaruh bohlam. Lampu adalah sebuah peranti yang memproduksi cahaya. Kata "lampu" dapat juga berarti bola lampu. Lampu pertama kali ditemukan oleh Sir Joseph William Swan. Lihat pencahayaan untuk pembahasan lebih lanjut.

(a) **(b)**

Gambar 2.15 (a) Lampu dan ; (b) Fitting Lampu

2.11 Kabel Jumper

Kabel jumper adalah suatu istilah kabel yang ber-diameter kecil yang di dalam dunia elektronika digunakan untuk menghubungkan dua titik atau lebih dan dapat juga untuk menghubungkan 2 komponen atau lebih komponen elektronika. Kabel yang dipakai dalam rangkaian ini adalah kabel jumper jenis *Male to Female*, jumper jenis ini digunakan untuk koneksi *male to female* dengan salah satu ujung kabel dikoneksi *male* dan satu ujungnya lagi dengan koneksi *female*.

BAB III
PERANCANGAN DAN PEMBUATAN SISTEM

3.1 Diagram Blok Rangkaian

Gambar 3.1 Diagram Blok Rangkaian

Fungsi Setiap Blok

1. Supply : Sebagai sumber tegangan
2. Arduino Uno : Sebagai pengolah data dan ditampilkan ke LCD
3. Sensor Cahaya LDR : Sebagai sensor yang mendeteksi masuknya Cahaya
4. Lampu : Sebagai Output tampilan dari instruksi Arduino

Keterangan :

Pada system ini, input atau masukan berasal dari supply atau arus PLN, kemudian proses selanjutnya yaitu dengan diberi atau tidak diberi cahaya sesuai dengan intensitas yang telah di ukur pada sensor cahaya LDR , kemudian data diproses di Arduino, maka output atau keluarannya dapat dilihat ketika lampu menyala atau tidak

3.2 Alat dan Bahan

Adapun alat dan bahan yang digunakan dalam percobaan ini adalah :

3.2.1 Alat

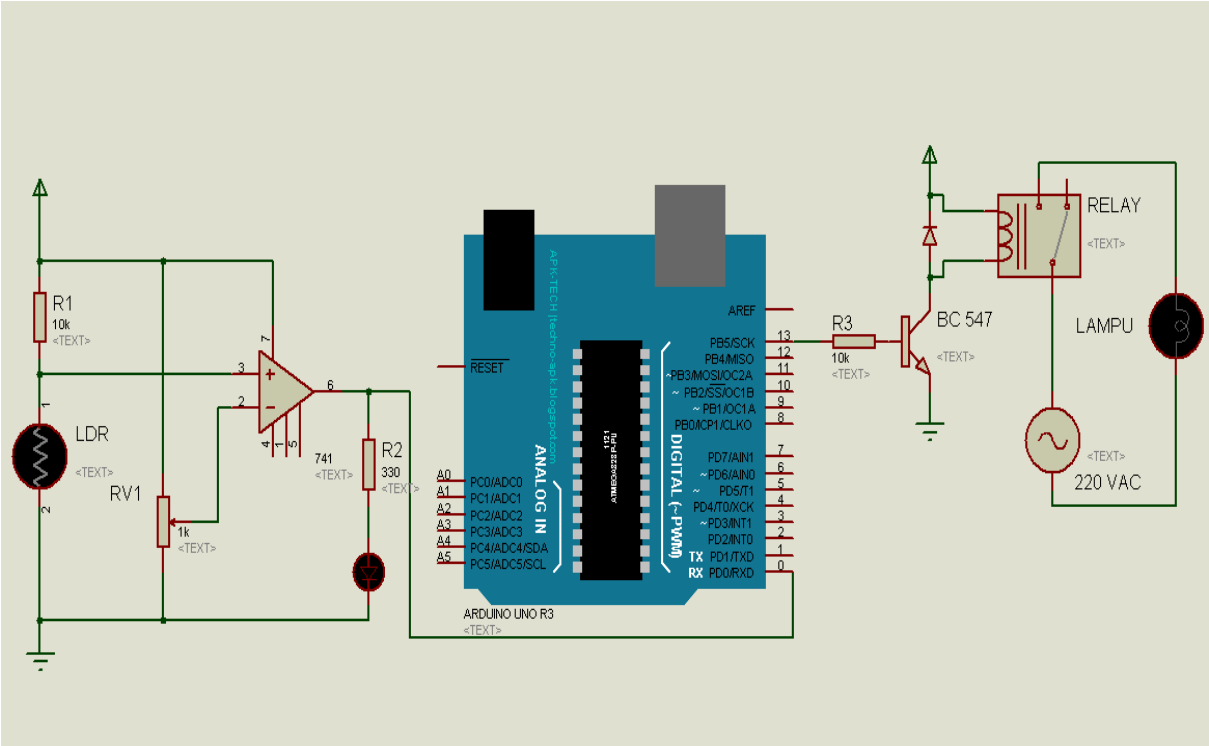
1. Solder : 1 buah
2. Timah : secukupnya
3. Tang Potong : 1 buah
4. Obeng (Plus/Minus) : 1 buah
5. Baut dan Mur : Secukupnya

3.2.2 Bahan

1. Sensor Cahaya LDR : 1 buah
2. Arduino Uno : 1 buah
3. Resistor Variabel 10 k : 1 buah
4. Resistor 10 K : 1 buah
5. Resistor 330 Ω : 2 buah
6. Resistor 1 K : 1 buah
7. Pin Header 16 pin : 1 buah
8. Kabel Jumper Female to Female : secukupnya
9. IC LM 741 : 1 buah
10. PCB Cetak : 2 buah
11. Protoboard : 1 buah
12. Lampu LED 5 watt : 1 buah
13. Fitting Lampu : 1 buah
14. Relay SPDT : 1 buah
15. Dioda Zener : 1 buah
16. Steker : 1 buah
17. Stop Kontak : 1 buah
18. LED : 1 buah
19. Adaptor 12 v : 1 buah

3.3 Prosedur Kerja

1. Siapkan alat dan bahan
2. Siapkan papan rangkaian protoboard yang tersedia, protoboard berfungsi sebagai tempat rangkaian sementara, sehingga setiap bahan hanya perlu dihubungkan satu persatu pada papan rangkaian. seperti gambar berikut :



Gambar 3.2 Rangkaian Lampu Otomatis

3. Hubungkan Arduino ke laptop/PC , setelah Arduino terhubung, input program data yang telah di susun kedalam arduino agar program dapat tersimpan kedalam memori yang tersedia pada arduino dan program dapat di jalankan.
4. Hubungkan IC 741 dengan LDR dan Trimpot
5. Selanjutnya, Output dari rangkaian op amp 741 (pin 6 ic 741) dihubungkan dengan arduino (digital pin 0)
6. Hubungkan Output arduino (digital pin 13) terhubung relay
7. Selanjutnya, hubungkan Fitting lampu ke Relay
8. Selanjutnya, soleder lagi Resistor variabel 10k ke rangkaian menggunakan jumper agar dapat terhubung ke Arduino

9. Terakhir, rapikan sisa-sisa penyolderan dari rangkaian dan bersihkan rangkaian dari debu ketika proses pembuatan rangkaian tersebut
10. Rangkaian*Lampu Otomatis Menggunakan IC LM741 Menggunakan Sensor Cahaya Tipe Foto Konduktif*Siap digunakan dan diuji serta dapat di pasarkan secara luas.

3.4 Prinsip Kerja Rangkaian

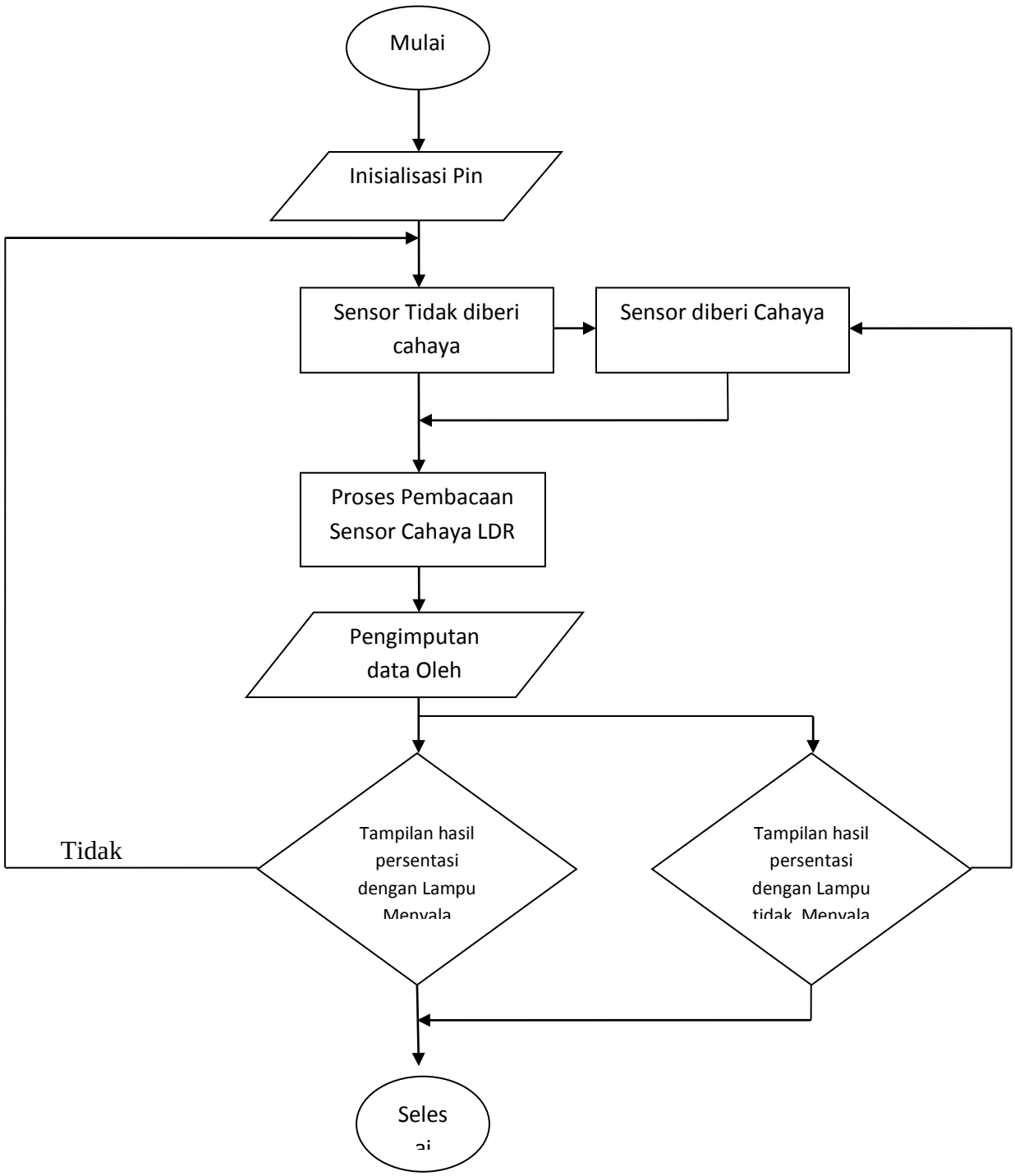
Rangkaian lampu otomatis ini memanfaatkan karakteristik dari salah satu sensor cahaya yaitu sensor LDR (light dependent resistor) yang nilai resistansinya bisa berubah sesuai dengan intensitas cahaya. Karakteristik sensor LDR yaitu "ketika cahaya terang, maka nilai resistansi sensor LDR menjadi sangat kecil, ketika cahaya gelap maka nilai resistansi sensor LDR menjadi sangat besar". Dengan memanfaatkan karakteristik tersebut maka rangkaian ini menggunakan ic op amp 741. Ic op amp 741 akan terhubung dengan LDR dan trimpot. Ic op amp 741 akan mengolah tegangan masukan dari LDR (V 1) dan trimpot (V2) sebagai berikut :

V1 > V2 maka output 741 = 5V

V2 > V1 maka output 741 = 0V

Saat output 741 sebesar 5V maka led indikator dari rangkaian op amp akan menyala dan sebaliknya apabila output 741 sebesar 0V maka led indikator dari rangkaian op amp tidak menyala.Output dari rangkaian op amp 741 (pin 6 ic 741) dihubungkan dengan arduino (digital pin 0). Arduino yang telah diprogram akan membaca input dari rangkaian op amp berupa tegangan 5V = HIGH dan tegangan 0V = LOW. Berdasarkan input tersebut arduino akan mengolahnya dan menghasilkan output (digital pin 13) berupa logika HIGH dan LOW juga. Output arduino (digital pin 13) terhubung dengan relay. Relay adalah saklar elektronik yang berfungsi untuk menghubungkan dan memutuskan ketika coil pada relay dalam kondisi aktif. Saat output dari arduino (digital pin 13) berlogika HIGH maka coil pada relay akan aktif dan lampu akan menyala. Sedangkan saat output dari arduino (digital pin 13) berlogika LOW maka lampu akan padam.

3.5 Diagram Alir Rangkaian Lampu Otomatis



Gambar 3.3 Diagram Alir Rangkaian Lampu Otomatis

Keterangan :

Dari instalasi Pin, kemudian dalam pencahayaan yang dikondisikan, Sensor cahaya LDR tidak diberi cahaya, kemudian Sensor mulai membaca ketetapan program sesuai dengan

intensitas cahaya yang telah deprogram, maka data dari sensor LDR akan diproses dan di input oleh Arduino, kemudian Lampu LED 5 watt menyala. Jika pencahayaan dikondisikan lagi dengan memberikan cahaya ke sensor LDR, maka sensor kembali membaca data yang telah diprogram sesuai dengan intensitas yang telah di atur, maka hasil pengimputan data oleh sensor LDR akan dialirkan ke Arduino, kemudian Arduino mengimput data kembali dan Lampu LED 5 watt tidak menyala

BAB IV
PENGUJIAN DAN HASIL RANGAKAIN

Setelah dilakukan perancangan dan pembuatan alat pada bab sebelumnya, pada bab ini akan dilakukan pengujian alat, pengukuran dan pembahasan dari perancangan tersebut.Pengujian ini dilakukan di :

Tempat : Jl. Pancur Siwa Dalam, No:1B, Padang Bulan,Medan
Tanggal : 10 Juli 2017
Waktu / Pukul : 17:39 – 19:00 WIB

Pengujian ditujukan pada Sensor, Trimpot, dan IC 741 dengan metode pengukuran langsung dengan menggunakan alatukur arus dan teganganyang standar dengan penunjukan pada komponen yang akan diuji.Pengujian pengukuran dilakukan sebanyak 3 kali pada setiap komponen. Sehingga dapat diperoleh data percobaan sebagai berikut.

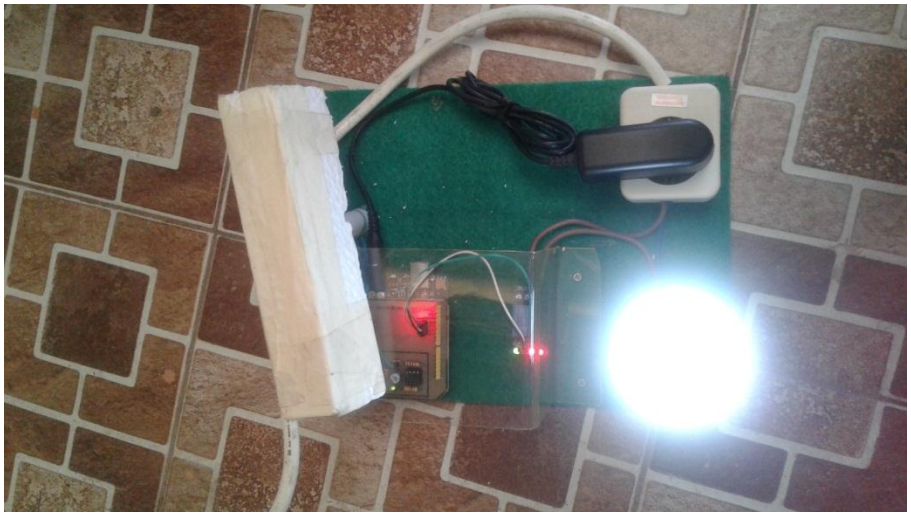
4.1 Data Percobaan

Adapun data percobaan dari hasil pengujian pada saat gelab dan terang:

4.1.1 Pada saat Terang

Gambar 4.1 Pada saat Terang

4.1.2 Pada saat Gelab



Gambar 4.2 pada saat gelab

4.2 Pengujian Arduino dan Sensor

Pengujian Arduino dan Sensor dilakukan dengan mengupload salah satu program ke Arduino. Jika program tersebut berjalan lancar maka dapat dipastikan Arduino dan Sensor dalam keadaan baik. Dalam pengujian Arduino dan Sensor ini dilakukan dengan mengupload kode program seperti pada gambar di bawah ini dan hasilnya terlihat seperti berikut ini :

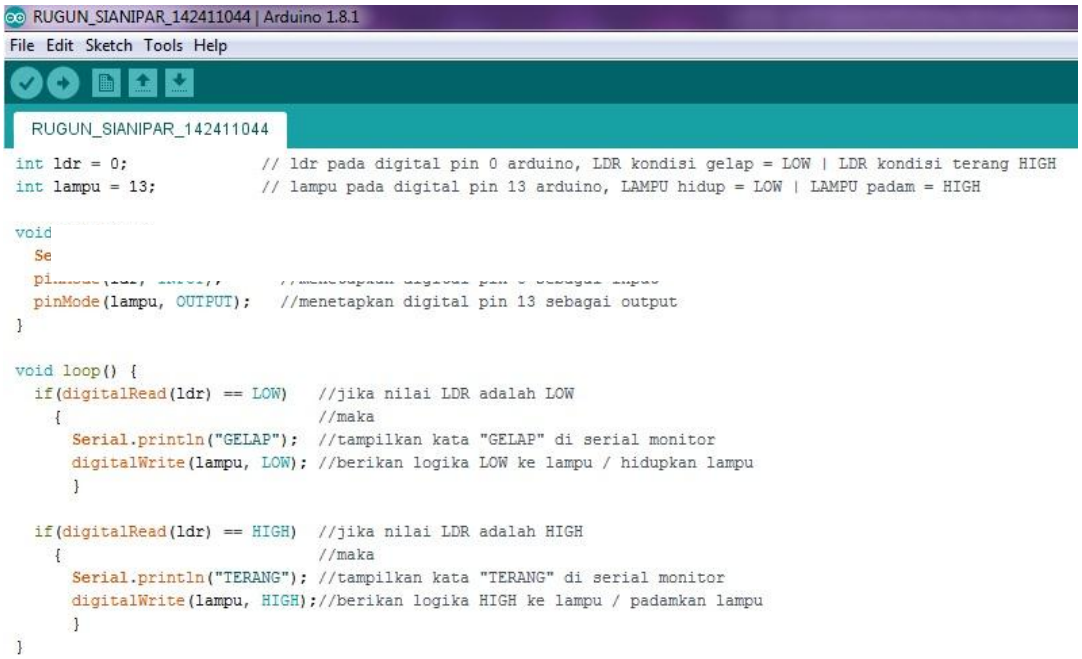
Pembuatan bahasa program dirancang pada software Arduino 1.6.7 dengan menggunakan bahasa C.

Berikut Listing program :

```
int ldr = 0;        // ldr pada digital pin 0 arduino, kondisi gelap = LOW | kondisi terang HIGH
int lampu = 13; // lampu pada digital pin 13 arduino, hidup = LOW | padam = HIGH

void setup()
{
  Serial.begin(9600);                 //untuk pengiriman dan penerimaan data serial
  pinMode(ldr, INPUT);                //menetapkan digital pin 0 sebagai input
  pinMode(lampu, OUTPUT);     //menetapkan digital pin 13 sebagai output
```

```
}

void loop()
{
  if(digitalRead(ldr) = = LOW)   //jika nilai LDR adalah LOW
    {                            //maka
      Serial.println("GELAP");     //tampilkan kata "GELAP" di serial monitor
      digitalWrite(lampu, LOW);   //berikan logika LOW ke lampu / hidupkan
lampu
      }

  if(digitalRead(ldr) = = HIGH)   //jika nilai LDR adalah HIGH
    {                            //maka
      Serial.println("TERANG");  //tampilkan kata "TERANG" di serial monitor
      digitalWrite(lampu, HIGH); //berikan logika HIGH ke lampu / padamkan
lampu
      }
}
```

Program dapat dilihat dari gambar 4.3 berikut :

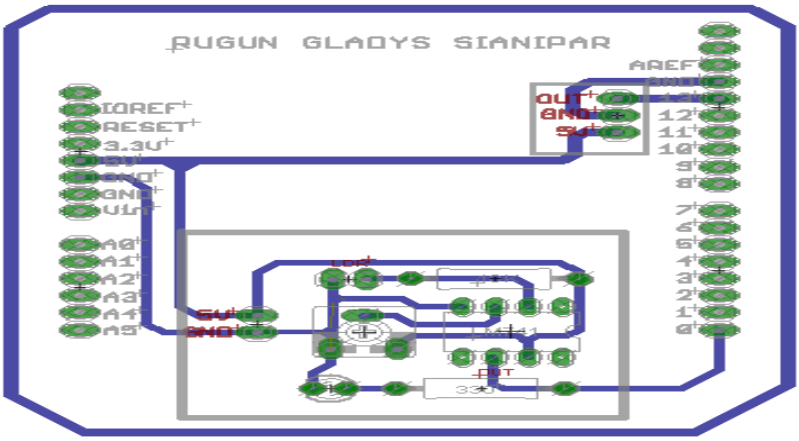


Gambar 4.3 Program Pengujian Arduino dan Sensor

4.3 Rangkaian Keseluruhan

4.3.1 Rangkaian PCB (Printed Circuit Board)

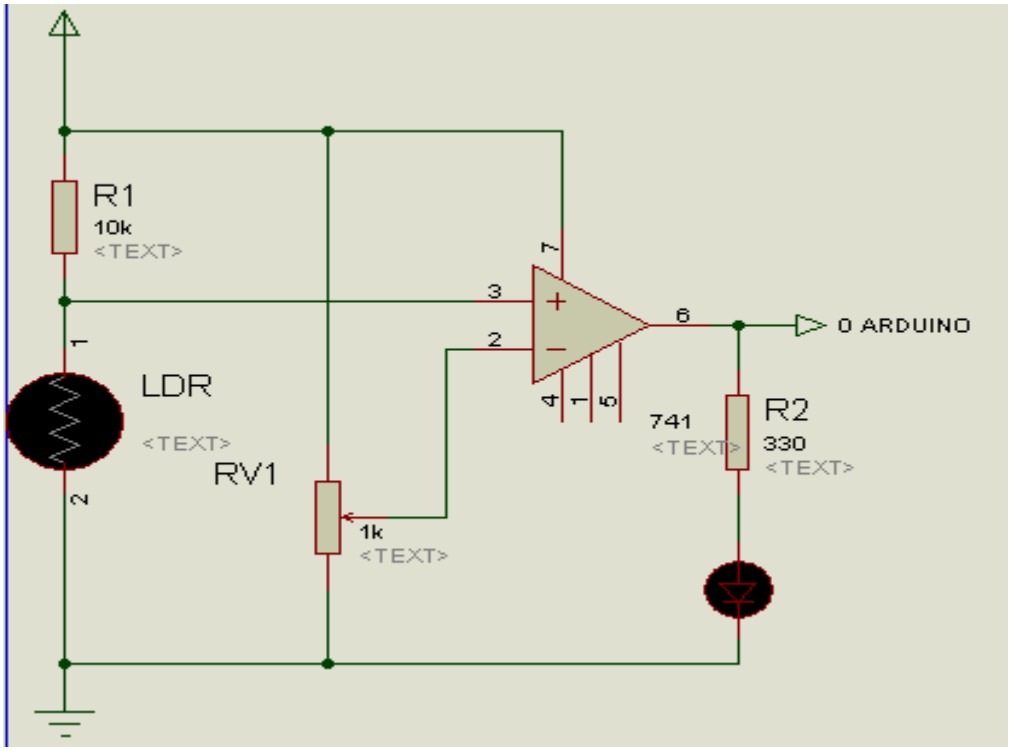
Dalam pembuatan Rancang Bangun Lampu Otomatis Menggunakan IC LM 741 Menggunakan Sensor Cahaya Tipe Fotokonduktif, memerlukan PCB Cetak. Tujuannya adalah untuk menghemat penggunaan kabel dalam pembuatan rangkaian serta menampilkan hasil rangkaian yang lebih rapi ketimbang menggunakan rangkaian PCB polos. Berikut gambar rangkaian PCB Cetak yang digunakan pada Rangkaian



Gambar 4.4 Rangkaian PCB Cetak yang digunakan

4.3.2 Rangkaian IC LM 741 dan Sensor LDR

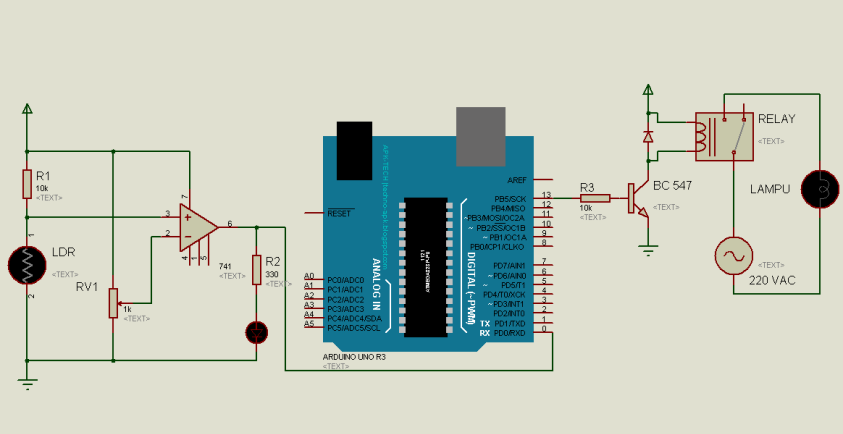
Rangkaian IC LM741 dimulai dari sensor LDR, lalu dibandingkan dengan tegangan yang ada pada trimpot. Setelah itu, akan didapat tegangan keluaran dari IC LM 741 berdasarkan kondisi gelap dan terang dan sensor LDR merespon keluaran dari ic tersebut dan kondisi gelap dan terang tadi di indikatorkan pada keadaan lampu apakah hidup atau mati. Gambar dari Rangkaian IC LM 741 dan Sensor LDR secara keseluruhan dapat kita lihat dari Gambar 4.3 berikut :



Gambar 4.5 Rangkaian keselurah dari IC LM 741 dan Sensor LDR

4.3.3 Rangkaian Keseluruhan Alat

Pada rangkaian keseluruhan alat, dapat kita lihat pada Gambar 4.4 berikut :



Gambar 4.6 Rangkaian Keseluruhan Alat

Dari gambar 4.4 tersebut, dapat kita lihat Sensor LDR membaca kondisi ruangan. Saat kondisi ruangan gelap, maka IC LM 741 akan bekerja dengan cara membandingankan tegangan pada LDR dan Trimpot. Setelah dibandingkan, hasiil dari LDR dan Trimpot, maka IC LM 741 memberikan keluaran kepada Arduino, kemudian Arduino akan membaca tegangan dari IC LM 741 apakah LOW(dalam biner = 0 dan kondisi Lampu aktif) atau

HIGH (dalam biner = 1 Kondisi Lampu tidak aktif). Berdasarkan kondisi tersebut, Arduino akan memproses data sesuai program yang telah dibuat lalu di input kedalam Rangkaian Arduino. Bila input yang masuk ke Arduino adalah LOW, maka Arduino akan mengirimkan Logika LOW juga untuk mengaktifkan Relay yang akan menghidupkan lampu, dan sebaliknya jika kondisi ruangan terang, yang berarti input yang masuk ke Arduino adalah HIGH, maka Arduino akan memberikan Logika HIGH juga untuk menonaktifkan Relay supaya lampu padam.

4.3.4 Spesifikasi Rangkaian

Dari seluruh rangkaian yang telah dibuat, dapat kita lihat spesifikasi dari beberapa komponen inti pada rangkaian Lampu Otomatis. Spesifikasi tersebut dapat kita lihat dari Tabel 4.5 berikut :

Tabel 4.1 Spesifikasi Rangkaian

No	Parameter	Keterangan	Limit			Satuan
			Min	Tipikal	Max	
1	VCC	Arduino Uno	6	5	20	V
		LM 741	±12	±13		V
		Realy SPDT	5	5	12	V
		Lampu LED	90	220	260	V
2	Dimensi	Panjang (p)				mm
		Lebar (l)				mm
		Tinggi (t)				mm
3	Kapasitor Memori Mikrokontrol	Arduino Uno			32	Kb

4.4 Rangkaian Relay

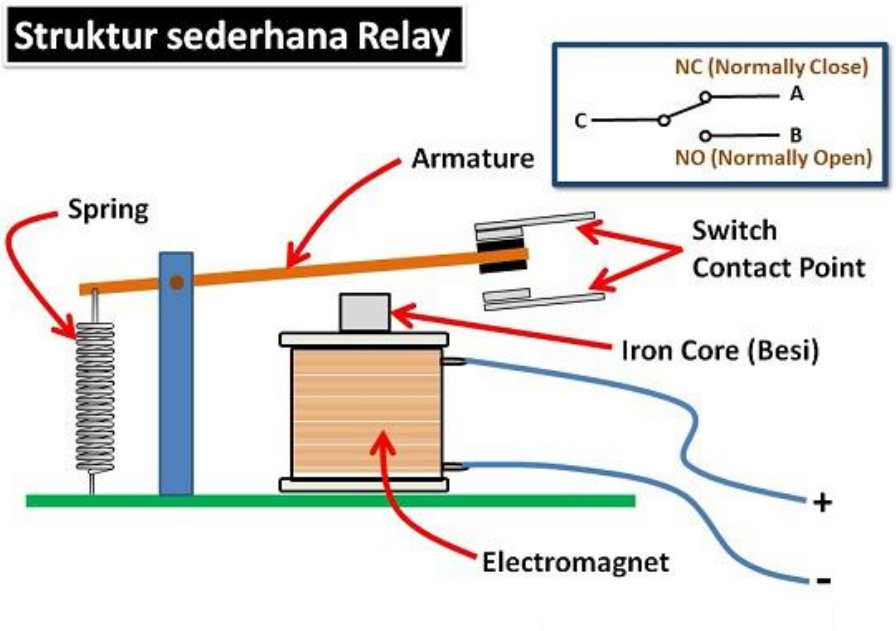
Relay adalah Saklar (*Switch*) yang dioperasikan secara listrik dan merupakan komponen Electromechanical (Elektromekanikal) yang terdiri dari 2 bagian utama yakni Elektromagnet (Coil) dan Mekanikal (seperangkat Kontak Saklar/Switch). Relay menggunakan Prinsip Elektromagnetik untuk menggerakkan Kontak Saklar sehingga dengan arus listrik yang kecil (*low power*) dapat menghantarkan listrik yang bertegangan lebih tinggi. Sebagai contoh, dengan Relay yang menggunakan

Elektromagnet 5V dan 50 mA mampu menggerakan Armature Relay (yang berfungsi sebagai saklarnya) untuk menghantarkan listrik 220V 2A.

Pada dasarnya, Relay terdiri dari 4 komponen dasar yaitu :

1. Electromagnet (Coil)
2. Armature
3. Switch Contact Point (Saklar)
4. Spring

Berikut ini merupakan gambar dari bagian-bagian Relay :

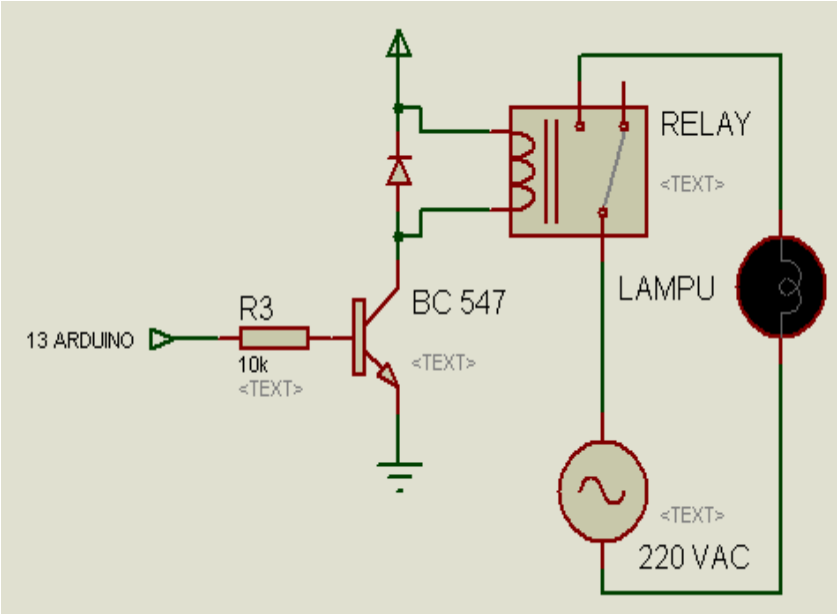


Gambar 4.7 Gambar Rangkaian Relay

Kontak Poin (Contact Point) Relay terdiri dari 2 jenis yaitu :

- Normally Close (NC) yaitu kondisi awal sebelum diaktifkan akan selalu berada di posisi CLOSE (tertutup)
- Normally Open (NO) yaitu kondisi awal sebelum diaktifkan akan selalu berada di posisi OPEN (terbuka)

Rangkaian Relay pada lampu otomatis dapat kita lihat pada gambar 4.6 berikut :



Gambar 4.8 Rangkaian Relay SPDT pada lampu otomatis

Pada Rangkaian Lampu Otomatis ini, penggunaan Relay nya adalah berjenis Relay SPDT atau Single Pole Double Throw. Rangkaian Relay ini memakai kaki common dan kaki NO (Normally Open), kaki common ke salah satu sumber 220V dan kaki NO kesalah satu fitting lampu. Saat relay aktif, maka kaki common akan terhubung dengan kaki NO Relay, tegangan 220V akan mengalir dan lampu hidup.

BAB V
KESIMPULAN DAN SARAN

5.1 Kesimpulan

Dari Percobaan dan pembahasan yang telah dilakukan pada Bab sebelumnya, didapat beberapa kesimpulan, antara lain adalah

1. Rancang Bangun lampu otomatis menggunakan IC 741 menggunakan sensor cahaya tipe fotokonduktif merupakan suatu alat atau rancang bangun yang berupa lampu yang dapat hidup secara otomatis dengan kondisi pencahayaan tertentu. Rangcang bangun ini dibuat menggunakan salah satu perangkat elektronik berupa sensor cahaya tipe fotokonduktif sebagai sensor utama yang fungsi nya untuk menangkap intensitas cahaya gelap maupun terang. Gelap dan terang ini lahh yang disebut sebagai kondisi pencahayaan tertentu, dimana ketika cuaca sedang gelap, maka secara otomatis lampu akan hidup, begitu sebaliknya jika cuaca sedang terang, maka lampu akan otomatis mati, hal tersebut dikarenakan adanya sensor cahaya tipe fotokonduktif tersebut. Sensor cahaya tipe fotokonduktif yag dimaksud adalah Sensor Cahaya LDR atau Light Deppending Resistor. Pada rancang bangun ini ada juga komponen, yaitu IC 741, Relay dan Arduino Uno sebagai otak utama untuk menghidupkan lampu secara otomatis
2. Komponen yang dibutuhkan untuk membuat rancang bangun ini adalah sebagai berikut :
   - Sensor Cahaya LDR (Light Depending Resistor)
   - Arduino Uno adalah
   - Resistor
   - Pin Header atau yang biasa disebut Pin deret
   - Kabel Jumper,
   - IC LM741
   - PCB atau printed circuit board
   - Protoboard
   - Lampu LED
   - Relay.

3. Rangkaian lampu otomatis ini memanfaatkan karakteristik dari salah satu sensor cahaya yaitu sensor LDR (light dependent resistor) yang nilai resistansinya bisa berubah sesuai dengan intensitas cahaya. Karakteristik sensor LDR yaitu “ketika cahaya terang, maka nilai resistansi sensor LDR menjadi sangat kecil, ketika cahaya gelap maka nilai resistansi sensor LDR menjadi sangat besar”. Dengan memanfaatkan karakteristik tersebut maka rangkaian ini menggunakan ic op amp 741. Ic op amp 741 akan terhubung dengan LDR dan trimpot. Saat output 741 sebesar 5V maka led indikator dari rangkaian op amp akan menyala dan sebaliknya apabila output 741 sebesar 0V maka led indikator dari rangkaian op amp tidak menyala. Output dari rangkaian op amp 741 (pin 6 ic 741) dihubungkan dengan arduino (digital pin 0). Arduino yang telah diprogram akan membaca input dari rangkaian op amp berupa tegangan 5V = HIGH dan tegangan 0V = LOW. Berdasarkan input tersebut arduino akan mengolahnya dan menghasilkan output (digital pin 13) berupa logika HIGH dan LOW juga. Output arduino (digital pin 13) terhubung dengan relay. Relay adalah saklar elektronik yang berfungsi untuk menghubungkan dan memutuskan ketika coil pada relay dalam kondisi aktif. Saat output dari arduino (digital pin 13) berlogika HIGH maka coil pada relay akan aktif dan lampu akan menyala.

5.2 Saran

1. Untuk meningkatkan sistem sensitifitas sensor, akan lebih baik apabila melakukan perbandingan sensor dengan sensor cahaya lainnya
2. Disarankan untuk membuat rangkaian lebih baik dan program yang lebih spesifik sehingga dapat di aplikasikan ke penggunaan yang lain.
3. Untuk perancangan alat berikutnya, disarankan untuk menggunkan beberapa sensor cahaya berbeda untuk mendapatkan kepekaan dan keakuratan dalam mendeteksi kondisi cuaca yang berbeda beda.

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pukul : 17.30 WIB

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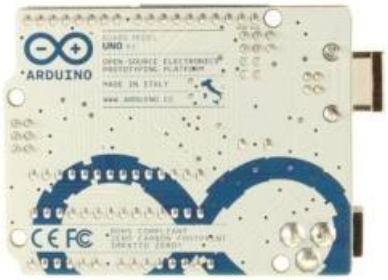
pukul : 11.30 WIB

LAMPIRAN I

(DATA SHEET ARDUINO UNO)

Arduino Uno

Arduino Uno R3 Front



Arduino Uno R3 Back

Arduino Uno R2 Front

Arduino Uno SMD

Arduino Uno Front

Arduino Uno Back

Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.
Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.
Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V

- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication using the SPI library.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- **TWI: A4 or SDA pin and A5 or SCL pin.** Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).
A SoftwareSerial library allows for serial communication on any of the Uno's digital pins.
The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the **Tools > Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials.
The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).
You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.
The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available . The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.
- On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See this user-contributed tutorial for more information.

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload. This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.
The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication using the SPI library.
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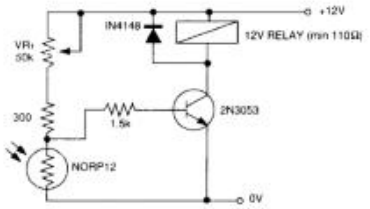
Automatic (Software) Reset

LAMPIRAN II

(DATA SHEET ARDUINO SENSOR LDR)

Figure 7 Light interruption detector



As Figure 6 relay energised when light level drops below the level set by VR_1

Figure 8 Automatic light circuit

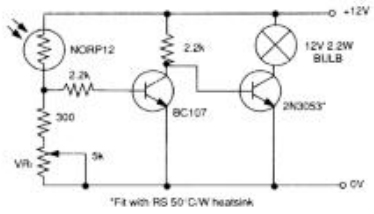
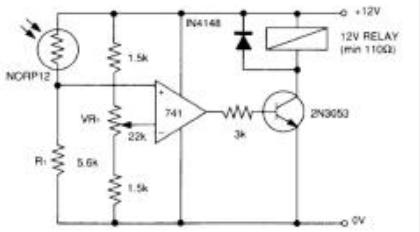
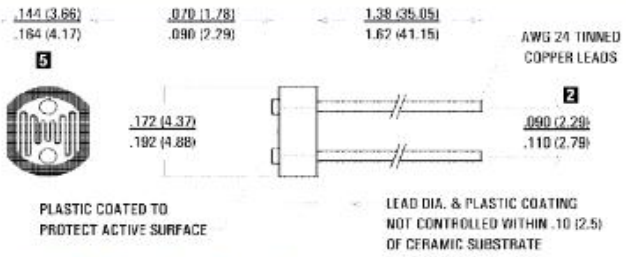


Figure 10 Extremely sensitive light operated relay



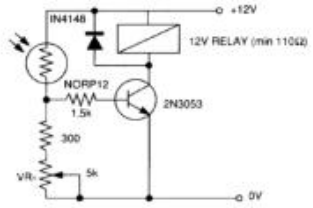
(Relay energised when light exceeds preset level.) Incorporates a balancing bridge and op-amp. R_1 and NORP12 may be interchanged for the reverse function.

Dimensions



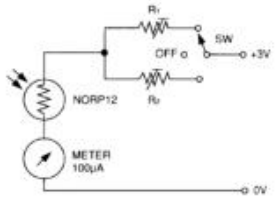
Typical Application Circuits

Figure 6 Sensitive light operated relay



Relay energised when light level increases above the level set by VR_1

Figure 9 Logarithmic law photographic light meter



Typical value $R^1 = 100k\Omega$
$R^2 = 200k\Omega$ preset to give two overlapping ranges.
(Calibration should be made against an accurate meter.)

Guide to source illuminations

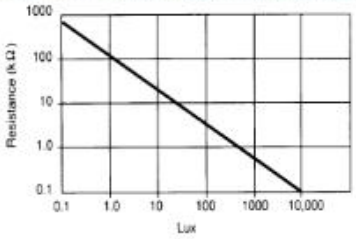
Light source Illumination	LUX
Moonlight	0.1
60W Bulb at 1m	50
1W MES Bulb at 0.1m	100
Fluorescent Lighting	500
Bright Sunlight	30,000

FIGURE 1 CIRCUIT SYMBOL

Sensitivity

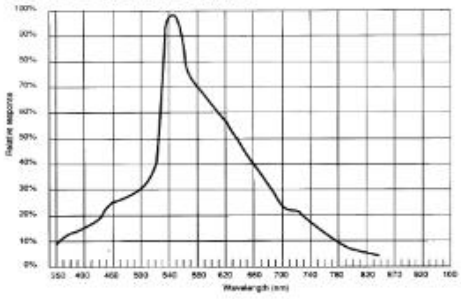
The sensitivity of a photodetector is the relationship between the light falling on the device and the resulting output signal. In the case of a photocell, one is dealing with the relationship between the incident light and the corresponding resistance of the cell.

FIGURE 2 RESISTANCE AS FUNCTION OF ILLUMINATION



Spectral Response

Figure 3 Spectral response



Like the human eye, the relative sensitivity of a photoconductive cell is dependent on the wavelength (color) of the incident light. Each photoconductor material type has its own unique spectral response curve or plot of the relative response of the photocell versus wavelength of light.

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Document: Datasheet Date: 28-Jul-08 Model #: 3190 Product's Page: www.sunrom.com/p-510.html

Light Dependent Resistor - LDR

Two cadmium sulphide(cds) photoconductive cells with spectral responses similar to that of the human eye. The cell resistance falls with increasing light intensity. Applications include smoke detection, automatic lighting control, batch counting and burglar alarm systems.

Applications

Photoconductive cells are used in many different types of circuits and applications.

Analog Applications

- Camera Exposure Control
- Auto Slide Focus - dual cell
- Photocopy Machines - density of toner
- Colorimetric Test Equipment
- Densitometer
- Electronic Scales - dual cell
- Automatic Gain Control – modulated light source
- Automated Rear View Mirror

Digital Applications

- Automatic Headlight Dimmer
- Night Light Control
- Oil Burner Flame Out
- Street Light Control
- Absence / Presence (beam breaker)
- Position Sensor

Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Unit
Cell resistance	1000 LUX 10 LUX	- -	400 9	- -	Ohm K Ohm
Dark Resistance	-	-	1	-	M Ohm
Dark Capacitance	-	-	3.5	-	pF
Rise Time	1000 LUX 10 LUX	- -	2.8 18	- -	ms ms
Fall Time	1000 LUX 10 LUX	- -	48 120	- -	ms ms
Voltage AC/DC Peak		-	-	320	V max
Current		-	-	75	mA max
Power Dissipation				100	mW max
Operating Temperature		-60	-	+75	Deg. C

LAMPIRAN III

(DATA SHEET IC LM 471)

OMRON

■ Approved Standards

UL Recognized (File No. E41643) / CSA Certified (File No. LR31928) - - Ambient Temp. = 40°C

Model	Contact form	Coil ratings	Contact ratings	Number of test operations
G2RL-1A	SPST-NO	3 to 48 VDC	12 A at 250 VAC (General use)	100,000
G2RL-1	SPDT		12 A at 24 VDC (Resistive)	50,000
G2RL-1A-E	SPST-NO	3 to 48 VDC	16 A at 250 VAC (General use)	100,000
G2RL-1-E	SPDT		16 A at 24 VDC (Resistive)	50,000
G2RL-1A-H	SPST-NO	5 to 24 VDC	10 A at 250 VAC (General use) 10 A at 24 VDC (Resistive)	50,000
G2RL-1-H	SPDT			
G2RL-2A	DPST-NO	3 to 48 VDC	8 A at 277 VAC (General use) 8 A at 30 VDC (Resistive)	100,000
G2RL-2	DPDT			

Note: Consult Omron for additional UL / CSA ratings

VDE (EN61810-1) (License No. 119650)

Model	Contact form	Coil ratings	Contact ratings
G2RL-1(A)	1 pole	5, 12, 18, 22, 24, 48 VDC	12 A at 250 VAC (cosϕ=1) 12 A at 24 VDC (L/R=0 ms) AC15: 3 A at 240 VAC DC13: 2.5 A at 24 VDC, 50 ms
G2RL-1(A)-E	1 pole	5, 12, 18, 22, 24, 48 VDC	16 A at 250 VAC (cosϕ=1) 16 A at 24 VDC (L/R=0 ms) AC15: 3 A at 240 VAC (NO) 1.5 A at 240 VAC (NC) DC13: 2.5 A at 24 VDC (NO), 50 ms
G2RL-1(A)-H	1 pole	5, 9, 12, 24 VDC	10 A at 250 VAC (cosϕ=1) 10 A at 24 VDC (L/R=0 ms)
G2RL-2(A)	2 poles	5, 12, 18, 22, 24, 48 VDC	8 A at 250 VAC (cosϕ=1) 8 A at 24 VDC (L/R=0 ms) AC15: 1.5 A at 240 VAC DC13: 2 A at 30 VDC, 50 ms

Note: To achieve approved life cycles on sealed models, the relay should be vented by removing the "knock off vent nib" on top of relay case after the soldering/washing process.

Electrical Life Data

G2RL-1-E	16 A at 250 VAC (cosϕ=1)	30,000 operations min.
	16 A at 24 VDC	30,000 operations min.
	8 A at 250 VAC (cosϕ=0.4)	200,000 operation min. (normally open side operation)
	8 A at 30 VDC (L/R=7 ms)	10,000 operation min. (normally open side operation)
G2RL-1	12 A at 250 VAC (cosϕ=1)	50,000 operations min.
	12 A at 24 VDC	30,000 operations min.
	5 A at 250 VAC (cosϕ=0.4)	150,000 operation min. (normally open side operation)
	5 A at 30 VDC (L/R=7 ms)	20,000 operation min. (normally open side operation)
G2RL-1-H	10 A at 250 VAC (cosϕ=1)	100,000 operations min.
	10 A at 24 VDC	50,000 operations min.
G2RL-2	8 A at 250 VAC (cosϕ=1)	30,000 operations min.
	8 A at 30 VDC	30,000 operations min.

Note: 1. The results shown reflect values measured using very severe test conditions i.e., Duty: 1 s ON/1 s OFF.

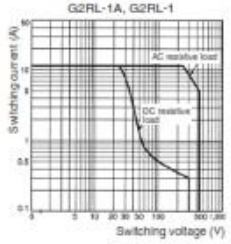
2. In order to obtain the full rated life cycles on the fully sealed models, the relay should be properly vented by removing the "knock off vent nib" on top of the relay case after the soldering/washing process.

3. Electrical endurance will vary depending on the test conditions. Contact your OMRON representative if you require more detailed information for the electrical endurance under your test conditions.

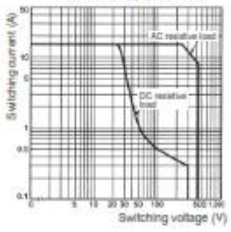
Engineering Data

■ Maximum Switching Capacity

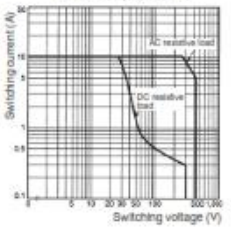
G2RL-1A, G2RL-1



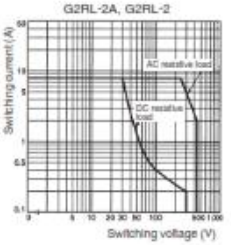
G2RL-1A-E, G2RL-1-E



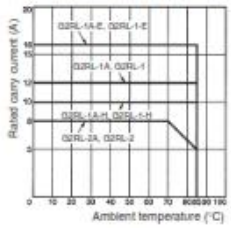
G2RL-1A-H, G2RL-1-H



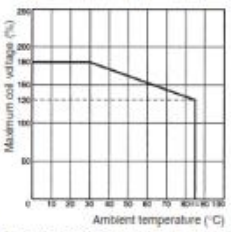
G2RL-2A, G2RL-2



■ Ambient Temperature vs Rated Carry Current



■ Ambient Temperature vs Maximum Coil Voltage



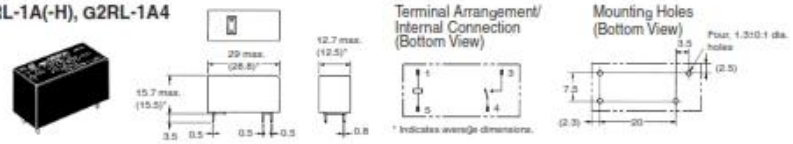
Note: The maximum coil voltage refers to the maximum value in a varying range of operating power voltage, not a continuous voltage.

Note: Contact your OMRON representative for the data on fully sealed models.

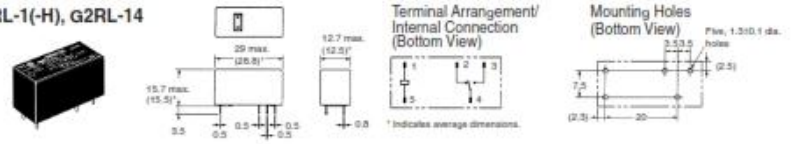
Dimensions

Note: All units are in millimeters unless otherwise indicated.

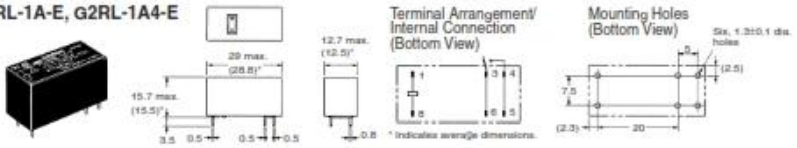
G2RL-1A(-H), G2RL-1A4



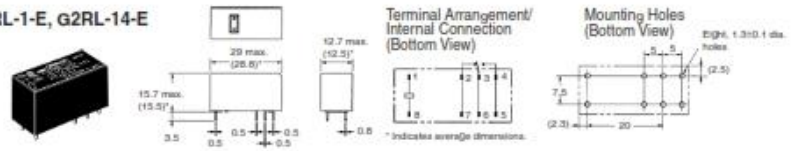
G2RL-1(-H), G2RL-14



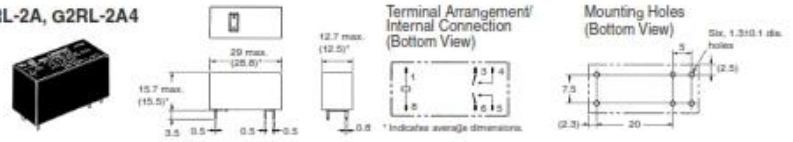
G2RL-1A-E, G2RL-1A4-E



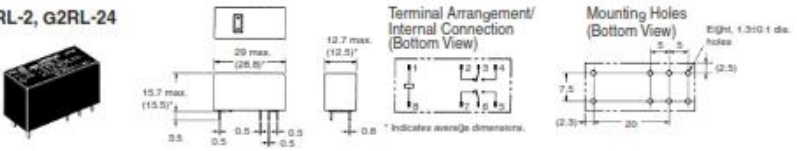
G2RL-1-E, G2RL-14-E



G2RL-2A, G2RL-2A4



G2RL-2, G2RL-24



MEMO

Omron Electronic Components, LLC

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   (a) Terms: These terms and conditions
   (b) Seller: Omron Electronic Components LLC and its subsidiaries
   (c) Buyer: The buyer of Products, including any end user in section III through VI
   (d) Products: Products and/or services of Seller
   (e) Including: Including without limitation
2. Offer; Acceptance: These Terms are deemed part of all quotations, acknowledgments, invoices, purchase orders and other documents, whether electronic or in writing, relating to the sale of Products by Seller. Seller hereby objects to any Terms proposed in Buyer's purchase order or other documents which are inconsistent with, or in addition to, these Terms.
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    (a) All sales and shipments of Products shall be FOB shipping point (unless otherwise stated in writing by Seller), at which point title to and all risk of loss of the Products shall pass from Seller to Buyer, provided that Seller shall retain a security interest in the Products until the full purchase price is paid by Buyer;
    (b) Delivery and shipping dates are estimates only; and
    (c) Seller will package Products as it deems proper for protection against normal handling and extra charges apply to special conditions.
12. Claims: Any claim by Buyer against Seller for shortage or damage to the Products occurring before delivery to the carrier or any claim related to pricing or other charges must be presented in detail in writing to Seller within 30 days of receipt of shipment.

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1. Suitability: IT IS THE BUYER'S SOLE RESPOINSIBILITY TO ENSURE THAT ANY OMRON PRODUCT IS FIT AND SUFFICIENT FOR USE IN A MOTORIZED VEHICLE APPLICATION. BUYER SHALL BE SOLELY RESPONSIBLE FOR DETERMINING APPROPRIATENESS OF THE PARTICULAR PRODUCT WITH RESPECT TO THE BUYER'S APPLICATION INCLUDING (A) ELECTRICAL OR ELECTRONIC COMPONENTS, (B) CIRCUITS, (C) SYSTEM ASSEMBLIES, (D) END PRODUCT, (E) SYSTEM, (F) MATERIALS OR SUBSTANCES OR (G) OPERATING ENVIRONMENT. Buyer acknowledges that it alone has determined that the Products will meet their requirements of the intended use in all cases. Buyer must know and observe all prohibitions of use applicable to the Products.
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   (b) Use in consumer Products or any use in significant quantities.
   (c) Energy control systems, combustion systems, railroad systems, aviation systems, medical equipment, amusement machines, vehicles, safety equipment, and installations subject to separate industry or government regulations.
   (d) Systems, machines, and equipment that could present a risk to life or property.
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4. Indemnities: Buyer shall indemnify and hold harmless Seller, its affiliates and its employees from and against all liabilities, losses, claims, costs and expenses (including attorney's fees and expenses) related to any claim, investigation, litigation or proceeding (whether or not Seller is a party) which arises or is alleged to arise from Buyer's acts or omissions under these Terms or in any way with respect to the Products.

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3. Performance Data: Performance data is provided as a guide in determining suitability and does not constitute a warranty. It may represent the result of Seller's test conditions, and the users must correlate it to actual application requirements.
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5. Errors And Omissions: The information on Seller's website or in other documentation has been carefully checked and is believed to be accurate; however, no responsibility is assumed for clerical, typographical or proofreading errors or omissions.
6. Export Controls: Buyer shall comply with all applicable laws, regulations and licenses regarding (a) export of the Products or information provided by Seller; (b) sale of Products to forbidden or other proscribed persons or organizations; (c) disclosure to non-citizens of regulated technology or information.

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1. Waiver: No failure or delay by Seller in exercising any right and no course of dealing between Buyer and Seller shall operate as a waiver of rights by Seller.
2. Assignment: Buyer may not assign its rights hereunder without Seller's written consent.
3. Law: These Terms are governed by Illinois law (without regard to conflict of laws). Federal and state courts in Cook County, Illinois have exclusive jurisdiction for any dispute hereunder.
4. Amendment: These Terms constitute the entire agreement between Buyer and Seller relating to the Products, and no provision may be changed or waived unless in writing signed by the parties.
5. Severability: If any provision hereof is rendered ineffective or invalid, such provision shall not invalidate any other provision.

LAMPIRAN IV

(DATA SHEET RELAY)

Product Folder | Sample & Buy | Technical Documents | Tools & Software | Support & Community

TEXAS INSTRUMENTS

LM741

SNOSC25D – MAY 1998 – REVISED OCTOBER 2015

LM741 Operational Amplifier

1 Features

- Overload Protection on the Input and Output
- No Latch-Up When the Common-Mode Range is Exceeded

2 Applications

- Comparators
- Multivibrators
- DC Amplifiers
- Summing Amplifiers
- Integrator or Differentiators
- Active Filters

3 Description

The LM741 series are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common-mode range is exceeded, as well as freedom from oscillations.

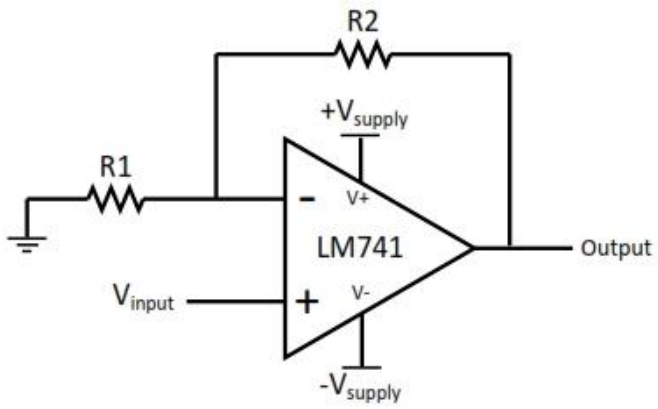
The LM741C is identical to the LM741 and LM741A except that the LM741C has their performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM741	TO-99 (8)	9.08 mm × 9.08 mm
	CDIP (8)	10.16 mm × 6.502 mm
	PDIP (8)	9.81 mm × 6.35 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

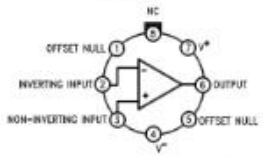
Typical Application



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

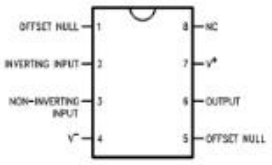
5 Pin Configuration and Functions

LMC Package
8-Pin TO-99
Top View



LM741H is available per JM38510/10101

NAB Package
8-Pin CDIP or PDIP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
INVERTING INPUT	2	I	Inverting signal input
NC	8	N/A	No Connect, should be left floating
NONINVERTING INPUT	3	I	Noninverting signal input
OFFSET NULL	1, 5	I	Offset null pin used to eliminate the offset voltage and balance the input voltages.
OFFSET NULL			
OUTPUT	6	O	Amplified signal output
V+	7	I	Positive supply voltage
V–	4	I	Negative supply voltage

Table of Contents

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision C (October 2004) to Revision D — **Page**

- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1
- Removed NAD 10-Pin CLGA pinout ... 3
- Removed obselete M (S0-8) package from the data sheet ... 4
- Added recommended operating supply voltage spec ... 4
- Added recommended operating temperature spec ... 4

Changes from Revision C (March 2013) to Revision D — **Page**

- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1
- Removed NAD 10-Pin CLGA pinout ... 3
- Removed obselete M (S0-8) package from the data sheet ... 4
- Added recommended operating supply voltage spec ... 4
- Added recommended operating temperature spec ... 4

11 Device and Documentation Support

11.1 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.2 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.3 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.4 Glossary

SLYZ022 — *TI Glossary.*

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1][2][3]

		MIN	MAX	UNIT
Supply voltage	LM741, LM741A		±22	V
	LM741C		±18	
Power dissipation [4]			500	mW
Differential input voltage			±30	V
Input voltage [5]			±15	V
Output short circuit duration		Continuous		
Operating temperature	LM741, LM741A	–55	125	°C
	LM741C	0	70	
Junction temperature	LM741, LM741A		150	°C
	LM741C		100	
Soldering information	PDIP package (10 seconds)		260	°C
	CDIP or TO-99 package (10 seconds)		300	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) For military specifications see RETS741X for LM741 and RETS741AX for LM741A.
(3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(4) For operation at elevated temperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{JA} P_D)$.
(5) For supply voltages less than ±15 V, the absolute maximum input voltage is equal to the supply voltage.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001[1]	±400	V

(1) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
Supply voltage (VDD-GND)	LM741, LM741A	±10	±15	±22	V
	LM741C	±10	±15	±18	
Temperature	LM741, LM741A	–55		125	°C
	LM741C	0		70	

6.4 Thermal Information

THERMAL METRIC[1]		LM741			UNIT
		LMC (TO-99)	NAB (CDIP)	P (PDIP)	
		8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	170	100	100	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	25	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics, LM741[1]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		$R_S \le 10\ k\Omega$	$T_A = 25°C$		1	5	mV
			$T_{AMIN} \le T_A \le T_{AMAX}$			6	mV
Input offset voltage adjustment range		$T_A = 25°C$, $V_S = \pm 20\ V$			±15		mV
Input offset current		$T_A = 25°C$			20	200	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$			85	500	
Input bias current		$T_A = 25°C$			80	500	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				1.5	µA
Input resistance		$T_A = 25°C$, $V_S = \pm 20\ V$		0.3	2		MΩ
Input voltage range		$T_{AMIN} \le T_A \le T_{AMAX}$		±12	±13		V
Large signal voltage gain		$V_S = \pm 15\ V$, $V_O = \pm 10\ V$, $R_L \ge 2\ k\Omega$	$T_A = 25°C$	50	200		V/mV
			$T_{AMIN} \le T_A \le T_{AMAX}$	25			
Output voltage swing		$V_S = \pm 15\ V$	$R_L \ge 10\ k\Omega$	±12	±14		V
			$R_L \ge 2\ k\Omega$	±10	±13		
Output short circuit current		$T_A = 25°C$			25		mA
Common-mode rejection ratio		$R_S \le 10\ \Omega$, $V_{CM} = \pm 12\ V$, $T_{AMIN} \le T_A \le T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		$V_S = \pm 20\ V$ to $V_S = \pm 5\ V$, $R_S \le 10\ \Omega$, $T_{AMIN} \le T_A \le T_{AMAX}$		86	96		dB
Transient response	Rise time	$T_A = 25°C$, unity gain			0.3		µs
	Overshoot				5%		
Slew rate		$T_A = 25°C$, unity gain			0.5		V/µs
Supply current		$T_A = 25°C$			1.7	2.8	mA
Power consumption		$V_S = \pm 15\ V$	$T_A = 25°C$		50	85	mW
			$T_A = T_{AMIN}$		60	100	
			$T_A = T_{AMAX}$		45	75	

(1) Unless otherwise specified, these specifications apply for $V_S = \pm 15\ V$, $-55°C \le T_A \le +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \le T_A \le +70°C$.

6.6 Electrical Characteristics, LM741A[1]

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage	$R_S \le 50\ \Omega$	$T_A = 25°C$		0.8	3	mV
		$T_{AMIN} \le T_A \le T_{AMAX}$			4	mV
Average input offset voltage drift					15	µV/°C
Input offset voltage adjustment range	$T_A = 25°C$, $V_S = \pm 20\ V$		±10			mV
Input offset current	$T_A = 25°C$			3	30	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				70	
Average input offset current drift					0.5	nA/°C
Input bias current	$T_A = 25°C$			30	80	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				0.21	µA
Input resistance	$T_A = 25°C$, $V_S = \pm 20\ V$		1	6		MΩ
	$T_{AMIN} \le T_A \le T_{AMAX}$, $V_S = \pm 20\ V$		0.5			
Large signal voltage gain	$V_S = \pm 20\ V$, $V_O = \pm 15\ V$, $R_L \ge 2\ k\Omega$	$T_A = 25°C$	50			V/mV
		$T_{AMIN} \le T_A \le T_{AMAX}$	32			
	$V_S = \pm 5\ V$, $V_O = \pm 2\ V$, $R_L \ge 2\ k\Omega$, $T_{AMIN} \le T_A \le T_{AMAX}$		10			

(1) Unless otherwise specified, these specifications apply for $V_S = \pm 15\ V$, $-55°C \le T_A \le +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \le T_A \le +70°C$.

Electrical Characteristics, LM741A[1] (continued)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Output voltage swing		V_S = ±20 V	R_L ≥ 10 kΩ	±16			V
			R_L ≥ 2 kΩ	±15			
Output short circuit current		T_A = 25°C		10	25	35	mA
		$T_{AMIN} \le T_A \le T_{AMAX}$		10		40	
Common-mode rejection ratio		R_S ≤ 50 Ω, V_{CM} = ±12 V, $T_{AMIN} \le T_A \le T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 50 Ω, $T_{AMIN} \le T_A \le T_{AMAX}$		86	96		dB
Transient response	Rise time	T_A = 25°C, unity gain			0.25	0.8	µs
	Overshoot				6%	20%	
Bandwidth [2]		T_A = 25°C		0.437	1.5		MHz
Slew rate		T_A = 25°C, unity gain		0.3	0.7		V/µs
Power consumption		V_S = ±20 V	T_A = 25°C		80	150	mW
			$T_A = T_{AMIN}$			165	
			$T_A = T_{AMAX}$			135	

(2) Calculated value from: BW (MHz) = 0.35/Rise Time (µs).

6.7 Electrical Characteristics, LM741C[1]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		R_S ≤ 10 kΩ	T_A = 25°C		2	6	mV
			$T_{AMIN} \le T_A \le T_{AMAX}$			7.5	mV
Input offset voltage adjustment range		T_A = 25°C, V_S = ±20 V			±15		mV
Input offset current		T_A = 25°C			20	200	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				300	
Input bias current		T_A = 25°C			80	500	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				0.8	µA
Input resistance		T_A = 25°C, V_S = ±20 V		0.3	2		MΩ
Input voltage range		T_A = 25°C		±12	±13		V
Large signal voltage gain		V_S = ±15 V, V_O = ±10 V, R_L ≥ 2 kΩ	T_A = 25°C	20	200		V/mV
			$T_{AMIN} \le T_A \le T_{AMAX}$	15			
Output voltage swing		V_S = ±15 V	R_L ≥ 10 kΩ	±12	±14		V
			R_L ≥ 2 kΩ	±10	±13		
Output short circuit current		T_A = 25°C			25		mA
Common-mode rejection ratio		R_S ≤ 10 kΩ, V_{CM} = ±12 V, $T_{AMIN} \le T_A \le T_{AMAX}$		70	90		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 10 Ω, $T_{AMIN} \le T_A \le T_{AMAX}$		77	96		dB
Transient response	Rise time	T_A = 25°C, Unity Gain			0.3		µs
	Overshoot				5%		
Slew rate		T_A = 25°C, Unity Gain			0.5		V/µs
Supply current		T_A = 25°C			1.7	2.8	mA
Power consumption		V_S = ±15 V, T_A = 25°C			50	85	mW

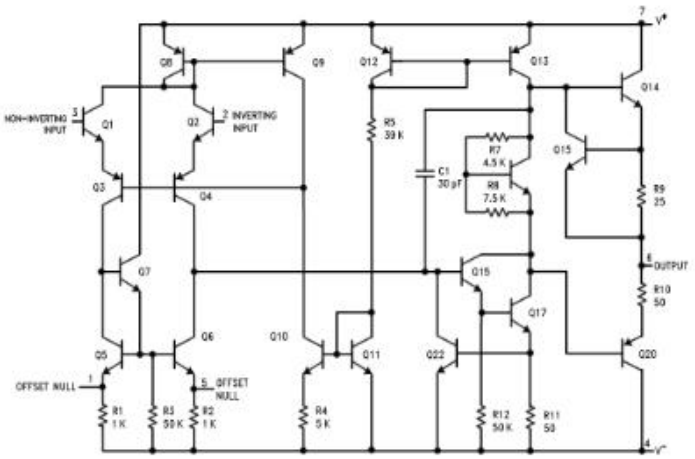
(1) Unless otherwise specified, these specifications apply for V_S = ±15 V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

7 Detailed Description

7.1 Overview

The LM74 devices are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. It is intended for a wide range of analog applications. The high gain and wide range of operating voltage provide superior performance in integrator, summing amplifier, and general feedback applications. The LM741 can operate with a single or dual power supply voltage. The LM741 devices are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Overload Protection

The LM741 features overload protection circuitry on the input and output. This prevents possible circuit damage to the device.

7.3.2 Latch-up Prevention

The LM741 is designed so that there is no latch-up occurrence when the common-mode range is exceeded. This allows the device to function properly without having to power cycle the device.

7.3.3 Pin-to-Pin Capability

The LM741 is pin-to-pin direct replacements for the LM709C, LM201, MC1439, and LM748 in most applications. Direct replacement capabilities allows flexibility in design for replacing obsolete parts.

7.4 Device Functional Modes

7.4.1 Open-Loop Amplifier

The LM741 can be operated in an open-loop configuration. The magnitude of the open-loop gain is typically large thus for a small difference between the noninverting and inverting input terminals, the amplifier output will be driven near the supply voltage. Without negative feedback, the LM741 can act as a comparator. If the inverting input is held at 0 V, and the input voltage applied to the noninverting input is positive, the output will be positive. If the input voltage applied to the noninverting input is negative, the output will be negative.

7.4.2 Closed-Loop Amplifier

In a closed-loop configuration, negative feedback is used by applying a portion of the output voltage to the inverting input. Unlike the open-loop configuration, closed loop feedback reduces the gain of the circuit. The overall gain and response of the circuit is determined by the feedback network rather than the operational amplifier characteristics. The response of the operational amplifier circuit is characterized by the transfer function.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LM741 is a general-purpose amplifier than can be used in a variety of applications and configurations. One common configuration is in a noninverting amplifier configuration. In this configuration, the output signal is in phase with the input (not inverted as in the inverting amplifier configuration), the input impedance of the amplifier is high, and the output impedance is low. The characteristics of the input and output impedance is beneficial for applications that require isolation between the input and output. No significant loading will occur from the previous stage before the amplifier. The gain of the system is set accordingly so the output signal is a factor larger than the input signal.

8.2 Typical Application

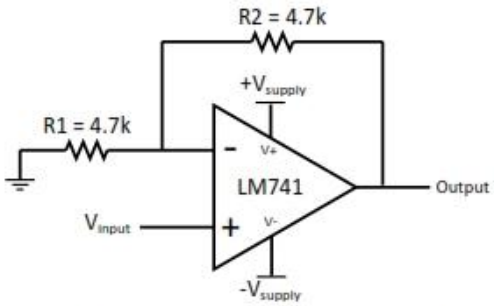


Figure 1. LM741 Noninverting Amplifier Circuit

8.2.1 Design Requirements

As shown in Figure 1, the signal is applied to the noninverting input of the LM741. The gain of the system is determined by the feedback resistor and input resistor connected to the inverting input. The gain can be calculated by Equation 1:

$$\text{Gain} = 1 + (R2/R1) \quad (1)$$

The gain is set to 2 for this application. R1 and R2 are 4.7-k resistors with 5% tolerance.

8.2.2 Detailed Design Procedure

The LM741 can be operated in either single supply or dual supply. This application is configured for dual supply with the supply rails at ±15 V. The input signal is connected to a function generator. A 1-Vpp, 10-kHz sine wave was used as the signal input. 5% tolerance resistors were used, but if the application requires an accurate gain response, use 1% tolerance resistors.

Typical Application (continued)

8.2.3 Application Curve

The waveforms in Figure 2 show the input and output signals of the LM741 non-inverting amplifier circuit. The blue waveform (top) shows the input signal, while the red waveform (bottom) shows the output signal. The input signal is 1.06 Vpp and the output signal is 1.94 Vpp. With the 4.7-kΩ resistors, the theoretical gain of the system is 2. Due to the 5% tolerance, the gain of the system including the tolerance is 1.992. The gain of the system when measured from the mean amplitude values on the oscilloscope was 1.83.

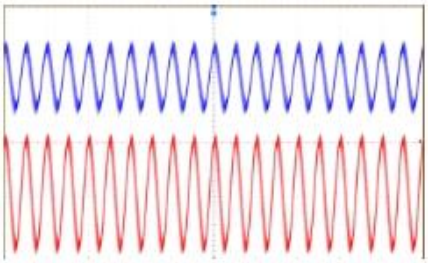


Figure 2. Waveforms for LM741 Noninverting Amplifier Circuit

9 Power Supply Recommendations

For proper operation, the power supplies must be properly decoupled. For decoupling the supply lines, a 0.1-μF capacitor is recommended and should be placed as close as possible to the LM741 power supply pins.

10 Layout

10.1 Layout Guidelines

As with most amplifiers, take care with lead dress, component placement, and supply decoupling in order to ensure stability. For example, resistors from the output to an input should be placed with the body close to the input to minimize pick-up and maximize the frequency of the feedback pole by minimizing the capacitance from the input to ground. As shown in Figure 3, the feedback resistors and the decoupling capacitors are located close to the device to ensure maximum stability and noise performance of the system.

10.2 Layout Example

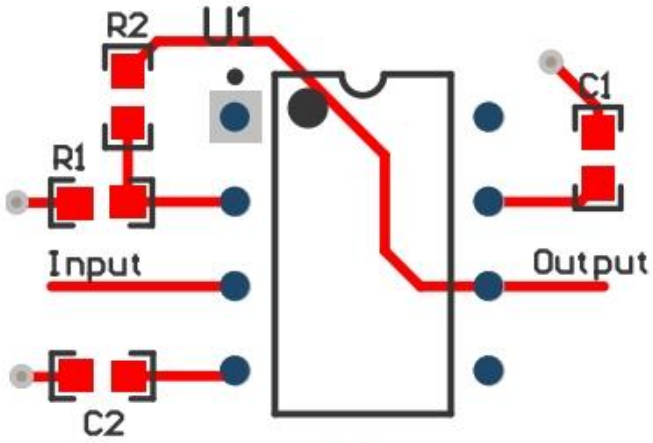


Figure 3. LM741 Layout

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM741C-MWC	ACTIVE	WAFERSALE	YS	0	1	Green (RoHS & no Sb/Br)	CAS TI	Level-1-NA-UNLIM	-40 to 85		Samples
LM741CN/NOPB	ACTIVE	PDIP	P	8	40	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LM 741CN	Samples

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TEXAS INSTRUMENTS

PACKAGE OPTION ADDENDUM

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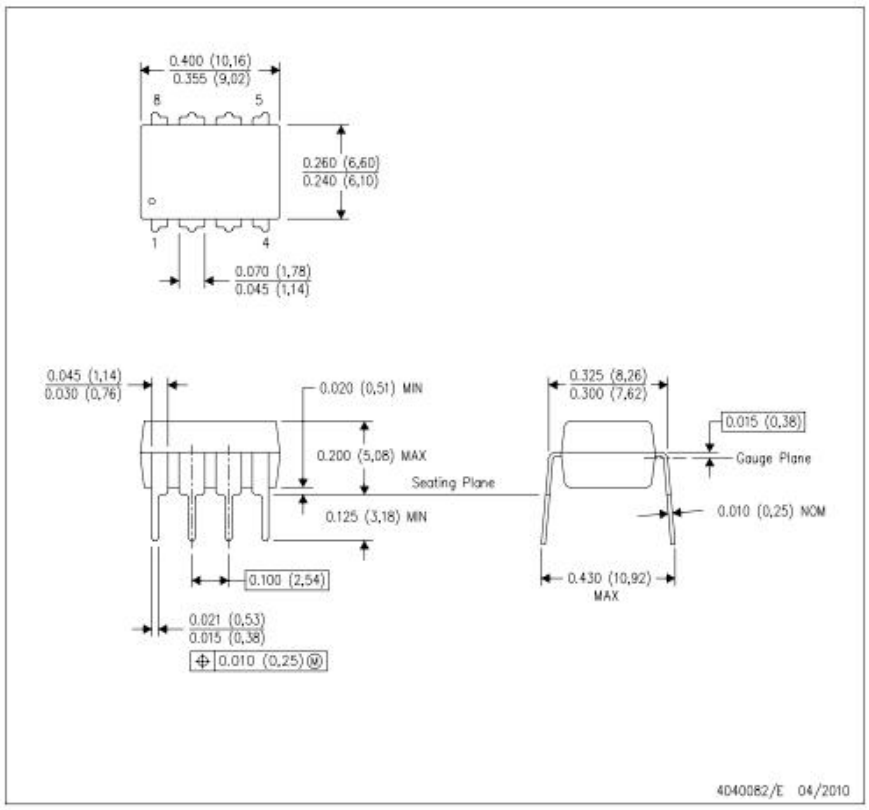
29-Jun-2017

P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE



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

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TEXAS INSTRUMENTS

LM741

SNOSC25D – MAY 1998 – REVISED OCTOBER 2015

LM741 Operational Amplifier

1 Features

- Overload Protection on the Input and Output
- No Latch-Up When the Common-Mode Range is Exceeded

2 Applications

- Comparators
- Multivibrators
- DC Amplifiers
- Summing Amplifiers
- Integrator or Differentiators
- Active Filters

3 Description

The LM741 series are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common-mode range is exceeded, as well as freedom from oscillations.

The LM741C is identical to the LM741 and LM741A except that the LM741C has their performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM741	TO-99 (8)	9.08 mm × 9.08 mm
	CDIP (8)	10.16 mm × 6.502 mm
	PDIP (8)	9.81 mm × 6.35 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Application

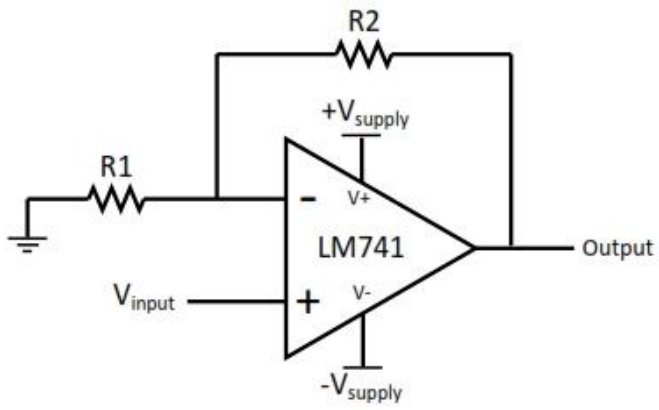


Table of Contents

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision C (October 2004) to Revision D — **Page**

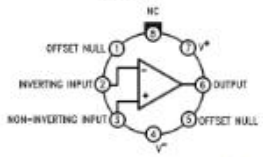
- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1
- Removed NAD 10-Pin CLGA pinout ... 3
- Removed obselete M (S0-8) package from the data sheet ... 4
- Added recommended operating supply voltage spec ... 4
- Added recommended operating temperature spec ... 4

Changes from Revision C (March 2013) to Revision D — **Page**

- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ... 1
- Removed NAD 10-Pin CLGA pinout ... 3
- Removed obselete M (S0-8) package from the data sheet ... 4
- Added recommended operating supply voltage spec ... 4
- Added recommended operating temperature spec ... 4

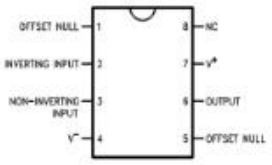
5 Pin Configuration and Functions

LMC Package
8-Pin TO-99
Top View



LM741H is available per JM38510/10101

NAB Package
8-Pin CDIP or PDIP
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
INVERTING INPUT	2	I	Inverting signal input
NC	8	N/A	No Connect, should be left floating
NONINVERTING INPUT	3	I	Noninverting signal input
OFFSET NULL	1, 5	I	Offset null pin used to eliminate the offset voltage and balance the input voltages.
OFFSET NULL			
OUTPUT	6	O	Amplified signal output
V+	7	I	Positive supply voltage
V–	4	I	Negative supply voltage

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1][2][3]

		MIN	MAX	UNIT
Supply voltage	LM741, LM741A		±22	V
	LM741C		±18	
Power dissipation [4]			500	mW
Differential input voltage			±30	V
Input voltage [5]			±15	V
Output short circuit duration		Continuous		
Operating temperature	LM741, LM741A	–55	125	°C
	LM741C	0	70	
Junction temperature	LM741, LM741A		150	°C
	LM741C		100	
Soldering information	PDIP package (10 seconds)		260	°C
	CDIP or TO-99 package (10 seconds)		300	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) For military specifications see RETS741X for LM741 and RETS741AX for LM741A.
(3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(4) For operation at elevated temperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{JA} P_D)$.
(5) For supply voltages less than ±15 V, the absolute maximum input voltage is equal to the supply voltage.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001[1]	±400	V

(1) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
Supply voltage (VDD-GND)	LM741, LM741A	±10	±15	±22	V
	LM741C	±10	±15	±18	
Temperature	LM741, LM741A	–55		125	°C
	LM741C	0		70	

6.4 Thermal Information

THERMAL METRIC[1]		LM741			UNIT
		LMC (TO-99)	NAB (CDIP)	P (PDIP)	
		8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	170	100	100	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	25	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics, LM741[1]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		$R_S \le 10\ k\Omega$	$T_A = 25°C$		1	5	mV
			$T_{AMIN} \le T_A \le T_{AMAX}$			6	mV
Input offset voltage adjustment range		$T_A = 25°C$, $V_S = \pm 20\ V$			±15		mV
Input offset current		$T_A = 25°C$			20	200	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$			85	500	
Input bias current		$T_A = 25°C$			80	500	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				1.5	µA
Input resistance		$T_A = 25°C$, $V_S = \pm 20\ V$		0.3	2		MΩ
Input voltage range		$T_{AMIN} \le T_A \le T_{AMAX}$		±12	±13		V
Large signal voltage gain		$V_S = \pm 15\ V$, $V_O = \pm 10\ V$, $R_L \ge 2\ k\Omega$	$T_A = 25°C$	50	200		V/mV
			$T_{AMIN} \le T_A \le T_{AMAX}$	25			
Output voltage swing		$V_S = \pm 15\ V$	$R_L \ge 10\ k\Omega$	±12	±14		V
			$R_L \ge 2\ k\Omega$	±10	±13		
Output short circuit current		$T_A = 25°C$			25		mA
Common-mode rejection ratio		$R_S \le 10\ \Omega$, $V_{CM} = \pm 12\ V$, $T_{AMIN} \le T_A \le T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		$V_S = \pm 20\ V$ to $V_S = \pm 5\ V$, $R_S \le 10\ \Omega$, $T_{AMIN} \le T_A \le T_{AMAX}$		86	96		dB
Transient response	Rise time	$T_A = 25°C$, unity gain			0.3		µs
	Overshoot				5%		
Slew rate		$T_A = 25°C$, unity gain			0.5		V/µs
Supply current		$T_A = 25°C$			1.7	2.8	mA
Power consumption		$V_S = \pm 15\ V$	$T_A = 25°C$		50	85	mW
			$T_A = T_{AMIN}$		60	100	
			$T_A = T_{AMAX}$		45	75	

(1) Unless otherwise specified, these specifications apply for $V_S = \pm 15\ V$, $-55°C \le T_A \le +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \le T_A \le +70°C$.

6.6 Electrical Characteristics, LM741A[1]

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage	$R_S \le 50\ \Omega$	$T_A = 25°C$		0.8	3	mV
		$T_{AMIN} \le T_A \le T_{AMAX}$			4	mV
Average input offset voltage drift					15	µV/°C
Input offset voltage adjustment range	$T_A = 25°C$, $V_S = \pm 20\ V$		±10			mV
Input offset current	$T_A = 25°C$			3	30	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				70	
Average input offset current drift					0.5	nA/°C
Input bias current	$T_A = 25°C$			30	80	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$				0.21	µA
Input resistance	$T_A = 25°C$, $V_S = \pm 20\ V$		1	6		MΩ
	$T_{AMIN} \le T_A \le T_{AMAX}$, $V_S = \pm 20\ V$		0.5			
Large signal voltage gain	$V_S = \pm 20\ V$, $V_O = \pm 15\ V$, $R_L \ge 2\ k\Omega$	$T_A = 25°C$	50			V/mV
		$T_{AMIN} \le T_A \le T_{AMAX}$	32			
	$V_S = \pm 5\ V$, $V_O = \pm 2\ V$, $R_L \ge 2\ k\Omega$, $T_{AMIN} \le T_A \le T_{AMAX}$		10			

(1) Unless otherwise specified, these specifications apply for $V_S = \pm 15\ V$, $-55°C \le T_A \le +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \le T_A \le +70°C$.

Electrical Characteristics, LM741A[1] (continued)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Output voltage swing		V_S = ±20 V	R_L ≥ 10 kΩ	±16			V
			R_L ≥ 2 kΩ	±15			
Output short circuit current		T_A = 25°C		10	25	35	mA
		$T_{AMIN} \le T_A \le T_{AMAX}$		10		40	
Common-mode rejection ratio		R_S ≤ 50 Ω, V_{CM} = ±12 V, $T_{AMIN} \le T_A \le T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 50 Ω, $T_{AMIN} \le T_A \le T_{AMAX}$		86	96		dB
Transient response	Rise time	T_A = 25°C, unity gain			0.25	0.8	µs
	Overshoot				6%	20%	
Bandwidth [2]		T_A = 25°C		0.437	1.5		MHz
Slew rate		T_A = 25°C, unity gain		0.3	0.7		V/µs
Power consumption		V_S = ±20 V	T_A = 25°C		80	150	mW
			$T_A = T_{AMIN}$			165	
			$T_A = T_{AMAX}$			135	

(2) Calculated value from: BW (MHz) = 0.35/Rise Time (µs).

6.7 Electrical Characteristics, LM741C[1]

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		R_S ≤ 10 kΩ	T_A = 25°C		2	6	mV
			$T_{AMIN} \le T_A \le T_{AMAX}$			7.5	mV
Input offset voltage adjustment range		T_A = 25°C, V_S = ±20 V			±15		mV
Input offset current		T_A = 25°C			20	200	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				300	
Input bias current		T_A = 25°C			80	500	nA
		$T_{AMIN} \le T_A \le T_{AMAX}$				0.8	µA
Input resistance		T_A = 25°C, V_S = ±20 V		0.3	2		MΩ
Input voltage range		T_A = 25°C		±12	±13		V
Large signal voltage gain		V_S = ±15 V, V_O = ±10 V, R_L ≥ 2 kΩ	T_A = 25°C	20	200		V/mV
			$T_{AMIN} \le T_A \le T_{AMAX}$	15			
Output voltage swing		V_S = ±15 V	R_L ≥ 10 kΩ	±12	±14		V
			R_L ≥ 2 kΩ	±10	±13		
Output short circuit current		T_A = 25°C			25		mA
Common-mode rejection ratio		R_S ≤ 10 kΩ, V_{CM} = ±12 V, $T_{AMIN} \le T_A \le T_{AMAX}$		70	90		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 10 Ω, $T_{AMIN} \le T_A \le T_{AMAX}$		77	96		dB
Transient response	Rise time	T_A = 25°C, Unity Gain			0.3		µs
	Overshoot				5%		
Slew rate		T_A = 25°C, Unity Gain			0.5		V/µs
Supply current		T_A = 25°C			1.7	2.8	mA
Power consumption		V_S = ±15 V, T_A = 25°C			50	85	mW

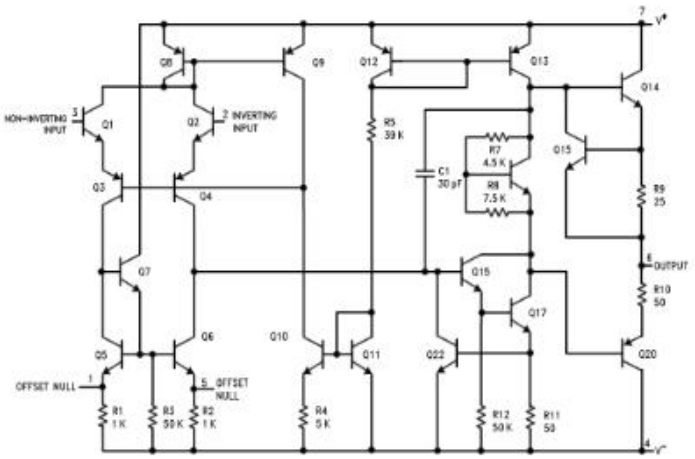
(1) Unless otherwise specified, these specifications apply for V_S = ±15 V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

7 Detailed Description

7.1 Overview

The LM74 devices are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. It is intended for a wide range of analog applications. The high gain and wide range of operating voltage provide superior performance in integrator, summing amplifier, and general feedback applications. The LM741 can operate with a single or dual power supply voltage. The LM741 devices are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Overload Protection

The LM741 features overload protection circuitry on the input and output. This prevents possible circuit damage to the device.

7.3.2 Latch-up Prevention

The LM741 is designed so that there is no latch-up occurrence when the common-mode range is exceeded. This allows the device to function properly without having to power cycle the device.

7.3.3 Pin-to-Pin Capability

The LM741 is pin-to-pin direct replacements for the LM709C, LM201, MC1439, and LM748 in most applications. Direct replacement capabilities allows flexibility in design for replacing obsolete parts.

7.4 Device Functional Modes

7.4.1 Open-Loop Amplifier

The LM741 can be operated in an open-loop configuration. The magnitude of the open-loop gain is typically large thus for a small difference between the noninverting and inverting input terminals, the amplifier output will be driven near the supply voltage. Without negative feedback, the LM741 can act as a comparator. If the inverting input is held at 0 V, and the input voltage applied to the noninverting input is positive, the output will be positive. If the input voltage applied to the noninverting input is negative, the output will be negative.

7.4.2 Closed-Loop Amplifier

In a closed-loop configuration, negative feedback is used by applying a portion of the output voltage to the inverting input. Unlike the open-loop configuration, closed loop feedback reduces the gain of the circuit. The overall gain and response of the circuit is determined by the feedback network rather than the operational amplifier characteristics. The response of the operational amplifier circuit is characterized by the transfer function.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LM741 is a general-purpose amplifier than can be used in a variety of applications and configurations. One common configuration is in a noninverting amplifier configuration. In this configuration, the output signal is in phase with the input (not inverted as in the inverting amplifier configuration), the input impedance of the amplifier is high, and the output impedance is low. The characteristics of the input and output impedance is beneficial for applications that require isolation between the input and output. No significant loading will occur from the previous stage before the amplifier. The gain of the system is set accordingly so the output signal is a factor larger than the input signal.

8.2 Typical Application

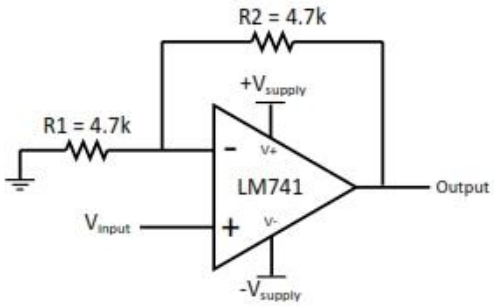


Figure 1. LM741 Noninverting Amplifier Circuit

8.2.1 Design Requirements

As shown in Figure 1, the signal is applied to the noninverting input of the LM741. The gain of the system is determined by the feedback resistor and input resistor connected to the inverting input. The gain can be calculated by Equation 1:

$$\text{Gain} = 1 + (R2/R1) \quad (1)$$

The gain is set to 2 for this application. R1 and R2 are 4.7-k resistors with 5% tolerance.

8.2.2 Detailed Design Procedure

The LM741 can be operated in either single supply or dual supply. This application is configured for dual supply with the supply rails at ±15 V. The input signal is connected to a function generator. A 1-Vpp, 10-kHz sine wave was used as the signal input. 5% tolerance resistors were used, but if the application requires an accurate gain response, use 1% tolerance resistors.

Typical Application (continued)

8.2.3 Application Curve

The waveforms in Figure 2 show the input and output signals of the LM741 non-inverting amplifier circuit. The blue waveform (top) shows the input signal, while the red waveform (bottom) shows the output signal. The input signal is 1.06 Vpp and the output signal is 1.94 Vpp. With the 4.7-kΩ resistors, the theoretical gain of the system is 2. Due to the 5% tolerance, the gain of the system including the tolerance is 1.992. The gain of the system when measured from the mean amplitude values on the oscilloscope was 1.83.

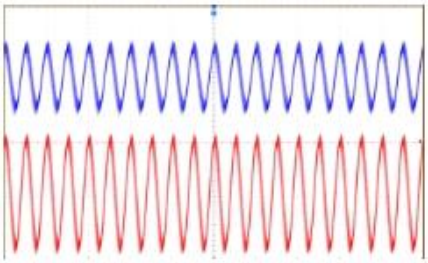


Figure 2. Waveforms for LM741 Noninverting Amplifier Circuit

9 Power Supply Recommendations

For proper operation, the power supplies must be properly decoupled. For decoupling the supply lines, a 0.1-μF capacitor is recommended and should be placed as close as possible to the LM741 power supply pins.

10 Layout

10.1 Layout Guidelines

As with most amplifiers, take care with lead dress, component placement, and supply decoupling in order to ensure stability. For example, resistors from the output to an input should be placed with the body close to the input to minimize pick-up and maximize the frequency of the feedback pole by minimizing the capacitance from the input to ground. As shown in Figure 3, the feedback resistors and the decoupling capacitors are located close to the device to ensure maximum stability and noise performance of the system.

10.2 Layout Example

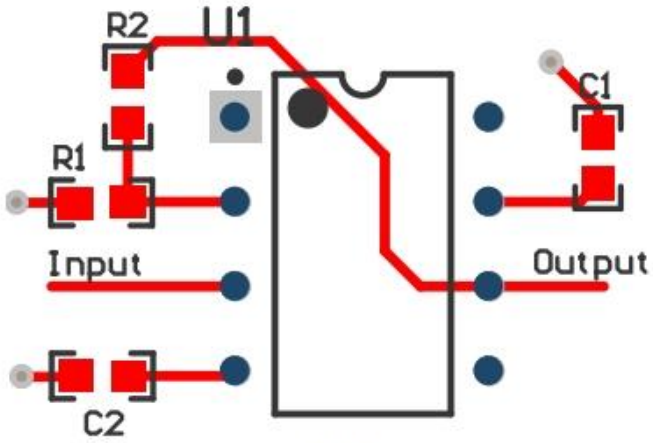


Figure 3. LM741 Layout

11 Device and Documentation Support

11.1 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.2 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.3 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.4 Glossary

SLYZ022 — *TI Glossary.*

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM741C-MWC	ACTIVE	WAFERSALE	YS	0	1	Green (RoHS & no Sb/Br)	CAS TI	Level-1-NA-UNLIM	-40 to 85		Samples
LM741CN/NOPB	ACTIVE	PDIP	P	8	40	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LM 741CN	Samples

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TEXAS INSTRUMENTS

PACKAGE OPTION ADDENDUM

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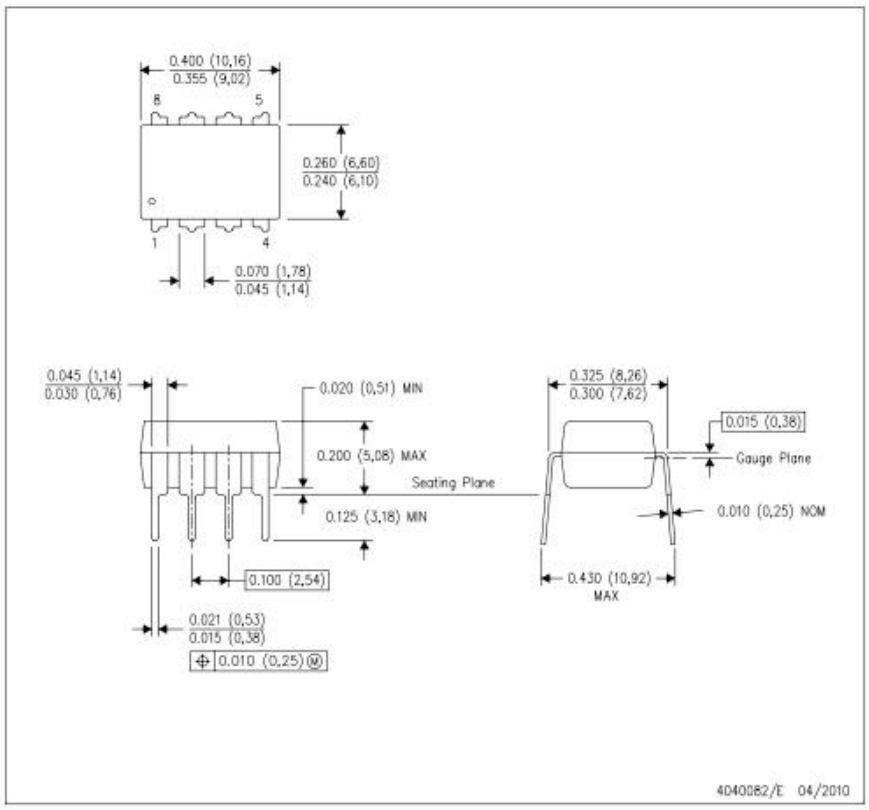
29-Jun-2017

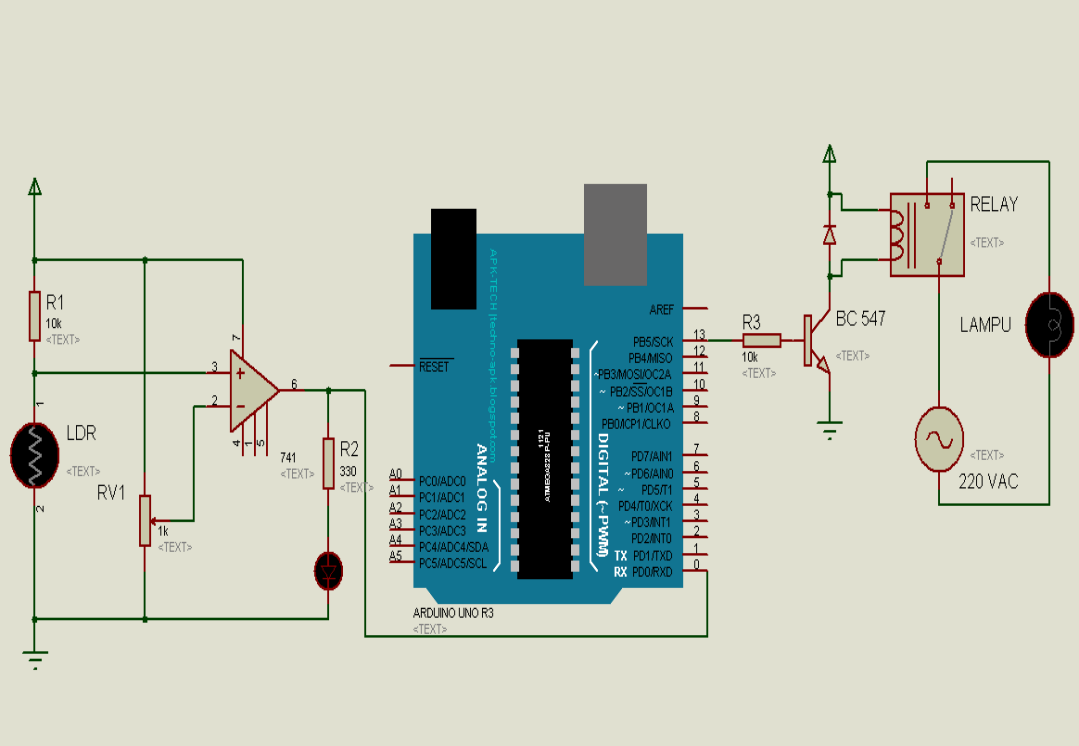
P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE

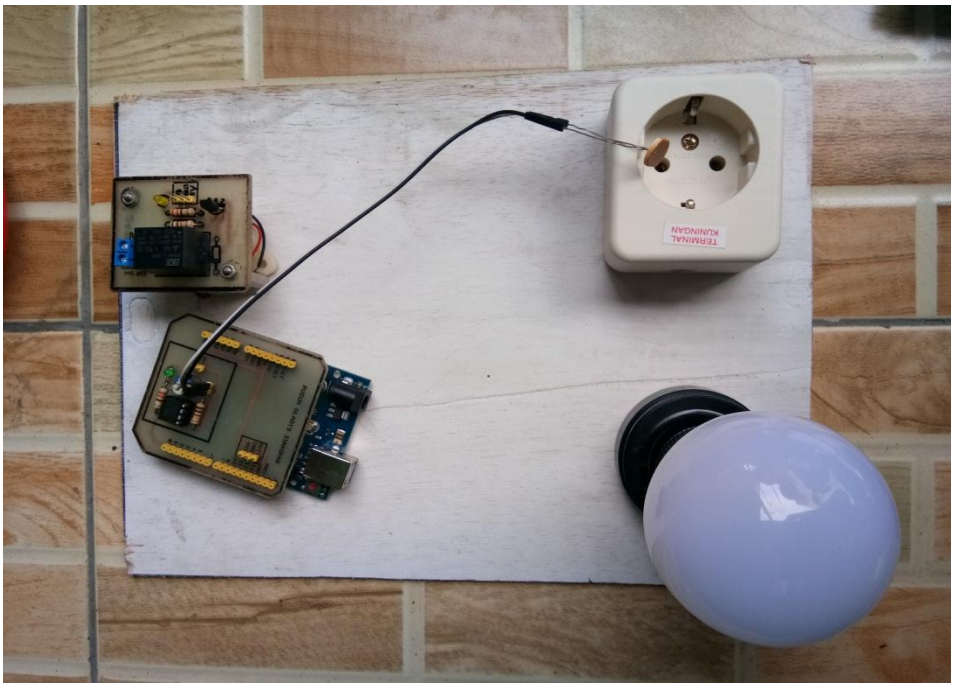


NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001 variation BA.

LAMPIRAN V

(FOTO KESELURUHAN ALAT)





Lampiran 5. Gambar alat keseluruhan setengah jadi

Lampiran 5. Gambar alat keseluruhan jadi