MODUL DIGITAL

PRAKTIKUM

POLITEKNIK NEGERI JAKARTA

RISTEKDIKTI

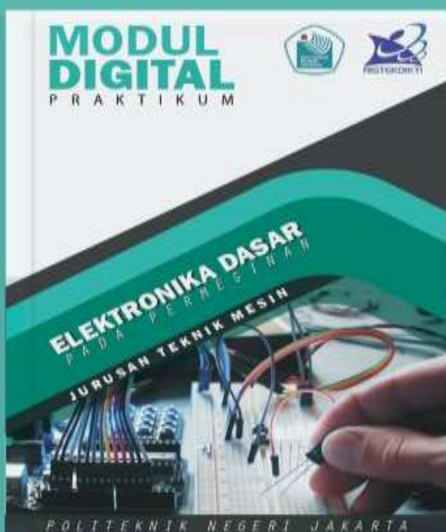
2019

ELEKTRONIKA DASAR

PADA PERMESINAN

JURUSAN TEKNIK MESIN

MODUL DIGITAL
PRAKTIKUM



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MODUL DIGITAL

PRAKTIKUM

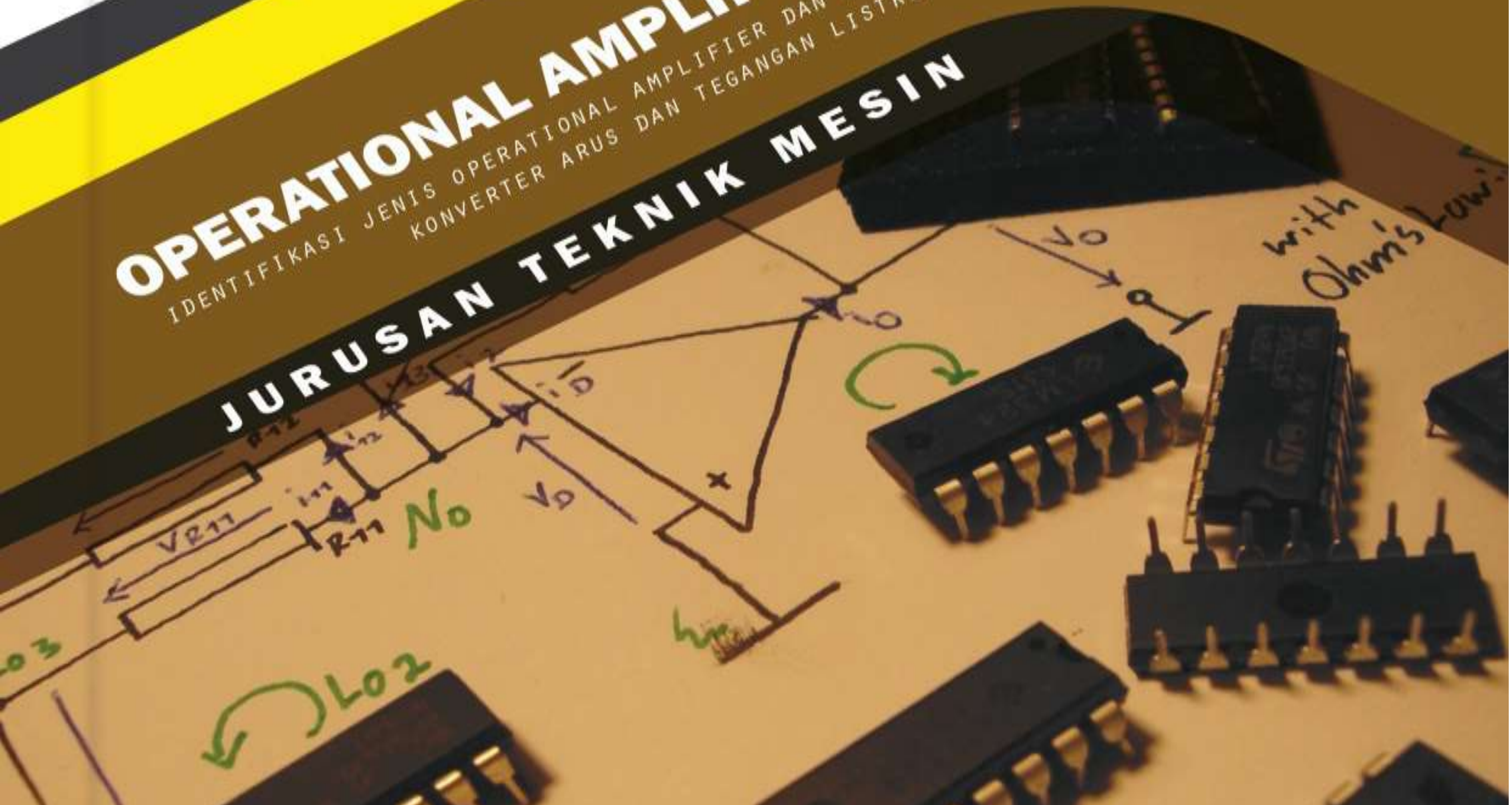
BAB V

2019

OPERATIONAL AMPLIFIER (OP-AMP)

IDENTIFIKASI JENIS OPERATIONAL AMPLIFIER DAN APLIKASINYA SEBAGAI KONVERTER ARUS DAN TEGANGAN LISTRIK

JURUSAN TEKNIK MESIN



POLITEKNIK NEGERI JAKARTA

BAB V

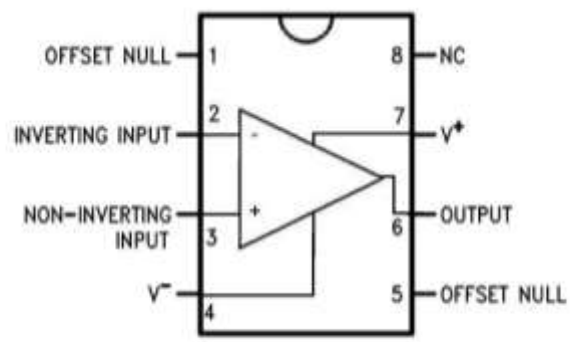
OPERATIONAL AMPLIFIER (OP-AMP)

5.1 TUJUAN

Pada akhir sesi, mahasiswa akan dapat mengidentifikasi jenis operational amplifier dan aplikasinya sebagai konverter arus dan tegangan listrik.

5.2 TEORI PENGANTAR

Dalam rangkaian elektronika, terdapat sebuah 2onver yang memerlukan penguatan agar output yang dihasilkan dapat ditransmisikan ke 2onver lainnya. Komponen yang digunakan untuk menguatkan besaran listrik, yaitu Operational Amplifier (Op-Amp). Komponen tersebut bahkan mampu memberikan penguatan sampai 100 kali. Op-Amp biasanya dipakai pada penguat audio, video, filter, buffer, dan rangkaian analog lainnya. Op-Amp LM 741 yang biasa digunakan memiliki struktur sebagai berikut.



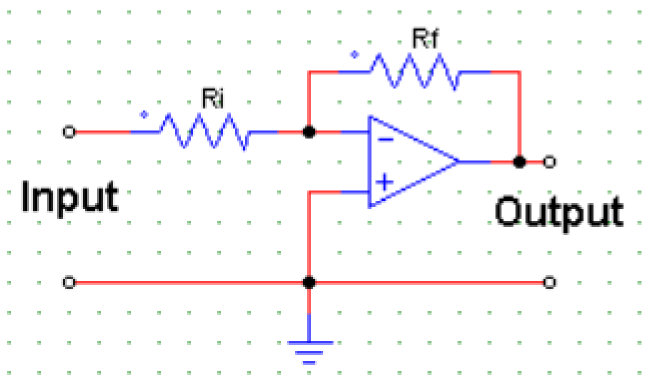
Gambar 5. 1 LM741 Pinout Diagram

Keterangan:

- Pin 1 dan 5 dihubungkan sebagai pengaturan offset
- Pin 2 dihubungkan sebagai masukan terbalik/input inverting
- Pin 3 dihubungkan sebagai masukan tak terbalik/input non-inverting
- Pin 4 dan 7 dihubungkan terhadap catu daya 12VDC
- Pin 6 dihubungkan sebagai keluaran/output
- Pin 8 tidak digunakan (Not Connected)

Op-Amp sebagai Penguat Inverting

Rangkaian penguat inverting merupakan rangkaian elektronika yang memiliki fungsi sebagai penguatan dan pembalik polaritas sinyal input. Berikut bentuk rangkaian elektronika dan persamaan dari penguat inverting.

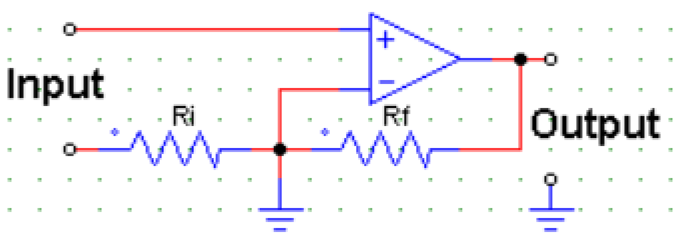


$$\frac{V_{Out}}{V_{in}} = -\frac{R_f}{R_i}$$
$$V_{Out} = -V_{in} \cdot \frac{R_f}{R_i}$$

Gambar 5. 2Op-Amp Penguat Inverting

Op-Amp sebagai Penguat Non-Inverting

Pada rangkaian penguat non-inverting, rangkaian elektronika tersebut akan melakukan penguatan terhadap nilai tegangan input. Hal ini dilakukan sebagai proses rekayasa transmisi listrik menuju rangkaian selanjutnya. Berikut bentuk rangkaian elektronika dan persamaan dari penguatn non-inverting.

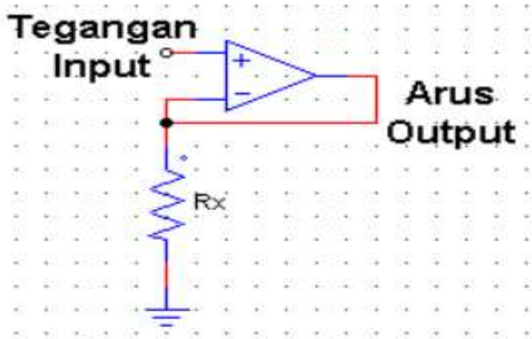


$$\frac{V_{Out}}{V_{in}} = 1 + \frac{R_f}{R_i}$$
$$V_{Out} = V_{in}\left(1 + \frac{R_f}{R_i}\right)$$

Gambar 5. 3Op-Amp Penguat Non-Inverting

Op-Amp Sebagai Konverter Tegangan ke Arus

Pada beberapa kasus sebuah rangkaian elektornik dibutuhkan arus sebagai sumber rangkaian tersebut. Rangkaian Op-amp dapat menjadi solusi sebagai penyedia sumber arus dari rangkaian yang memiliki tegangan listrik. Berikut gambar rangkaian Op-Amp yang digunakan sebagai 4onverter tegangan ke arus beserta persamaannya.

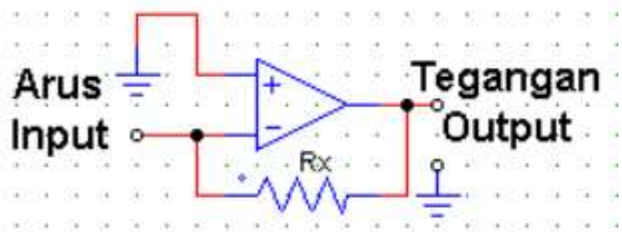


$$I_{out} = \frac{V_{in}}{R_X}$$

Gambar 5. 4Op-Amp Konverter Tegangan ke Arus

Op-Amp Sebagai Konverter Arus ke Tegangan

Rangkaian Op-Amp dapat digunakan sebagai rangkaian yang dapat mengubah arus ke tegangan. Berikut gambar rangkaian Op-Amp tersebut dan persamaannya.



$$V_{out} = V_{in}.R_X$$

Gambar 5. 5Op-Amp Konverter Arus ke Tegangan

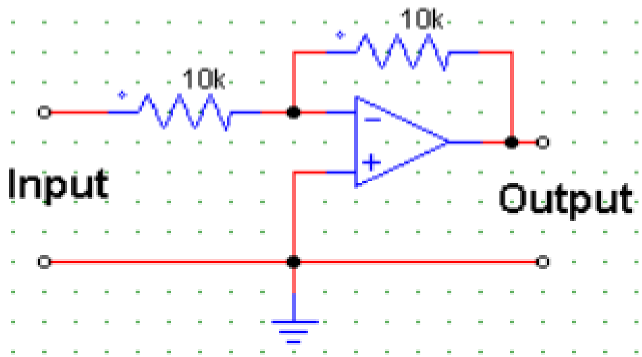
5.3 ALAT DAN BAHAN PRAKTIKUM

1. Multimeter
2. Protoboard
3. Resistor 100Ω, 200Ω, 220Ω, 470Ω, 1kΩ, 10kΩ dan 100kΩ
4. Resistor variabel 1kΩ
5. Kabel penghubung
6. Sumber tegangan DC
7. Op-Amp 741
8. Function Generator

5.4 METODE PRAKTIKUM

1. Penguatan Op-Amp Inverting

a. Buatlah rangkaian sesuai dengan gambar berikut pada protoboard.



Gambar 5. 6 Rangkaian Penguatan Op-Amp Inverting

b. Berikanlah tegangan DC 12V pada V_{CC} Op-Amp 741.

c. Berikanlah input dari function generator sebesar 200-1300 Hz dan $12V_{PP}$

d. Berikanlah pengaturan pada osiloskop sebesar 5 volt/div dan 0,5 time/div.

e. Ukurlah input dan output X(div) menggunakan osiloskop, ubahlah ke tegangan efektif dengan persamaan berikut, kemudian catat hasilnya!

$$V_{eff} = \frac{X \, .Volt/div}{\sqrt{2}}$$

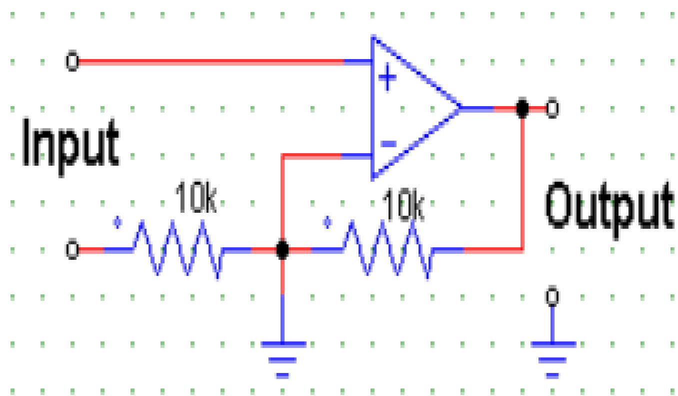
f. Tentukanlah penguatan berdasarkan perbandingan input-output dan kombinasi resistansi!

Tabel 5. 1 Perbandingan Input-Output Penguatan Op-Amp Inverting

Frekuensi (Hz)	Input		Output		Penguatan (kali)	
	X (div)	Veff (V)	X (div)	Veff (V)	In-Out	Ri – Rf
200						
300						
400						
500						
600						
700						
800						
900						
1000						
1100						
1200						
1300						

2. **Penguatan Op-Amp Non-Inverting**

a. Buatlah rangkaian sesuai dengan gambar berikut pada protoboard.



Gambar 5. 7 Rangkaian Penguatan Op-Amp Non-Inverting

b. Berikanlah tegangan DC 12V pada V_{CC} Op-Amp 741.

c. Berikanlah input dari function generator sebesar 200-1100 Hz dan $12V_{PP}$

d. Berikanlah pengaturan pada osiloskop sebesar 5 volt/div dan 0,5 time/div.

e. Ukurlah input dan output X(div) menggunakan osiloskop, ubahlah ke tegangan efektif dengan persamaan berikut, kemudian catat hasilnya!

$$V_{eff} = \frac{X\ .Volt/div}{\sqrt{2}}$$

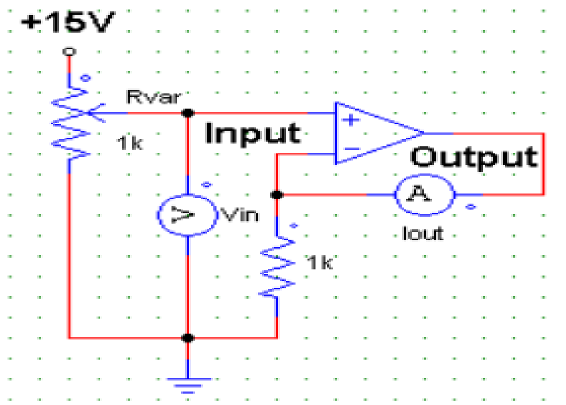
f. Tentukanlah penguatan berdasarkan perbandingan input-output dan kombinasi resistansi!

Tabel 5. 2 Perbandingan Input-Output Penguatan Op-Amp Non-Inverting

Frekuensi (Hz)	**Input**		**Output**		**Penguatan (kali)**	
	X (div)	**Veff (V)**	**X (div)**	**Veff (V)**	**In-Out**	**Resistansi**
200						
300						
400						
500						
600						
700						
800						
900						
1000						
1100						

3. Op-Amp Sebagai Konverter Tegangan ke Arus

a. Buatlah rangkaian sesuai dengan gambar berikut pada protoboard.



Gambar 5. 8 Rangkaian Op-Amp Konverter Tegangan ke Arus

b. Atur R_{var} agar V_{in} memiliki nilai 1-10 V

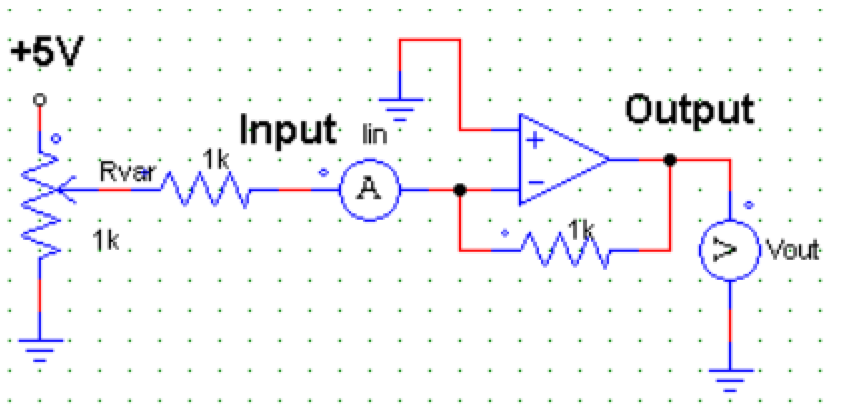
c. Ukurlah I_{out} dengan menggunakan multimeter dan catat hasilnya!

Tabel 5. 3 Pengukuran I_{out}

R_{var} (Ω)	V_{in} (V)	I_{out} (mA)
	0	
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	

4. Op-Amp Sebagai Pengubah Arus ke Tegangan

a. Buatlah rangkaian sesuai dengan gambar berikut pada protoboard.



Gambar 5. 9Rangkaian Op-Amp Pengubah Arus ke Tegangan

b. Atur R_{var} agar I_{in} memiliki nilai 0,1 -10 mA

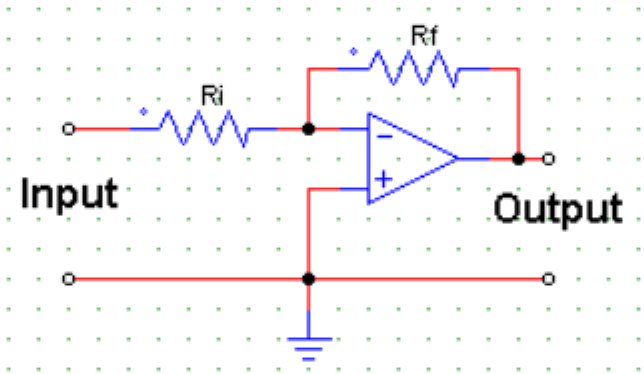
c. Ukurlah V_{out} dengan menggunakan multimeter dan catat hasilnya!

Tabel 5. 4 Pengukuran Vout

R_{var} (Ω)	I_{in} (mA)	V_{out} (V)
	0,1	
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	

5.5 EVALUASI

1. Buatlah rangkaian sesuai dengan gambar berikut pada protoboard.



2. Berikanlah tegangan DC 12V pada V_{CC} Op-Amp 741.
3. Berikanlah input dari function generator sebesar 500 Hz dan $12V_{PP}$
4. Berikanlah pengaturan pada osiloskop sebesar 5 volt/div dan 0,5 time/div.
5. Ukurlah input dan output X(div) menggunakan osiloskop dengan nilai resistor berbeda dan catat hasilnya!

Ri	**Rf**	**Input**		**Output**		**Penguatan (kali)**	
		X (div)	**Veff (V)**	**X (div)**	**Veff (V)**	**In-Out**	**Resistansi**
100	220						
100	470						
100	200						
10k	100k						
1k	10k						

DAFTAR PUSTAKA

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LAMPIRAN

1. Datasheet LM741 Op-Amp

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.

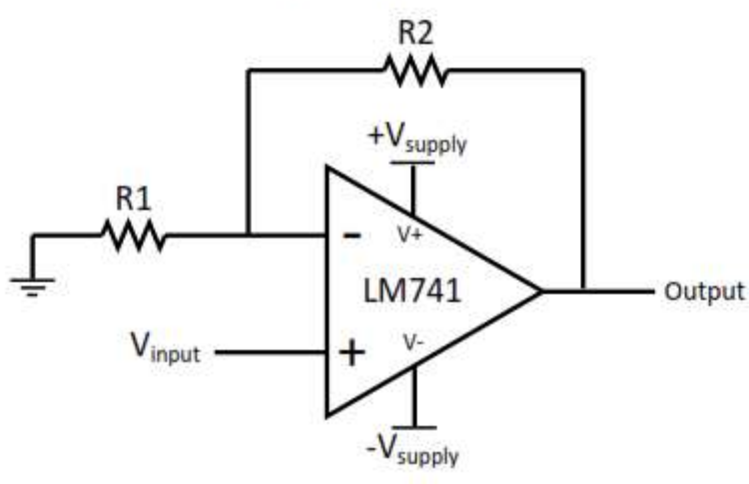
The LM741C is identical to the LM741 and LM741A except that the LM741C has their performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

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



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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**

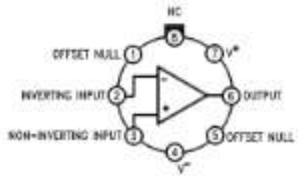
- Added *Applications* section, *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *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

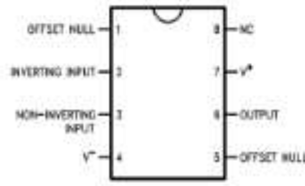
5 Pin Configuration and Functions

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 OFFSET NULL	1, 5	I	Offset null pin used to eliminate the offset voltage and balance the input voltages.
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	–50	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		$R_S \leq 10\ k\Omega$	$T_A = 25°C$		1	5	mV
			$T_{AMIN} \leq T_A \leq T_{AMAX}$			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
		$T_{AMIN} \leq T_A \leq T_{AMAX}$			85	500	
Input bias current		$T_A = 25°C$			80	500	nA
		$T_{AMIN} \leq T_A \leq T_{AMAX}$				1.5	µA
Input resistance		$T_A = 25°C$, $V_S = \pm 20\ V$		0.3	2		MΩ
Input voltage range		$T_{AMIN} \leq T_A \leq T_{AMAX}$		±12	±13		V
Large signal voltage gain		$V_S = \pm 15\ V$, $V_O = \pm 10\ V$, $R_L \geq 2\ k\Omega$	$T_A = 25°C$	50	200		V/mV
			$T_{AMIN} \leq T_A \leq T_{AMAX}$	25			
Output voltage swing		$V_S = \pm 15\ V$	$R_L \geq 10\ k\Omega$	±12	±14		V
			$R_L \geq 2\ k\Omega$	±10	±13		
Output short circuit current		$T_A = 25°C$			25		mA
Common-mode rejection ratio		$R_S \leq 10\ \Omega$, $V_{CM} = \pm 12\ V$, $T_{AMIN} \leq T_A \leq T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		$V_S = \pm 20\ V$ to $V_S = \pm 5\ V$, $R_S \leq 10\ \Omega$, $T_{AMIN} \leq T_A \leq T_{AMAX}$		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 $V_S = \pm 15\ V$, $-55°C \leq T_A \leq +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \leq T_A \leq +70°C$.

6.6 Electrical Characteristics, LM741A[(1)]

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

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

Electrical Characteristics, LM741A[(1)] (continued)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Output voltage swing		V_S = ±20 V	$R_L \geq 10$ kΩ	±16			V
			$R_L \geq 2$ kΩ	±15			V
Output short circuit current		T_A = 25°C		10	25	35	mA
		$T_{AMIN} \leq T_A \leq T_{AMAX}$		10		40	mA
Common-mode rejection ratio		$R_S \leq 50$ Ω, V_{CM} = ±12 V, $T_{AMIN} \leq T_A \leq T_{AMAX}$		80	95		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, $R_S \leq 50$ Ω, $T_{AMIN} \leq T_A \leq T_{AMAX}$		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	mW
			$T_A = T_{AMAX}$			135	mW

(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		$R_S \leq 10$ kΩ	T_A = 25°C		2	6	mV
			$T_{AMIN} \leq T_A \leq T_{AMAX}$			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
		$T_{AMIN} \leq T_A \leq T_{AMAX}$				300	nA
Input bias current		T_A = 25°C			80	500	nA
		$T_{AMIN} \leq T_A \leq T_{AMAX}$				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, $R_L \geq 2$ kΩ	T_A = 25°C	20	200		V/mV
			$T_{AMIN} \leq T_A \leq T_{AMAX}$	15			V/mV
Output voltage swing		V_S = ±15 V	$R_L \geq 10$ kΩ	±12	±14		V
			$R_L \geq 2$ kΩ	±10	±13		V
Output short circuit current		T_A = 25°C			25		mA
Common-mode rejection ratio		$R_S \leq 10$ kΩ, V_{CM} = ±12 V, $T_{AMIN} \leq T_A \leq T_{AMAX}$		70	90		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, $R_S \leq 10$ Ω, $T_{AMIN} \leq T_A \leq T_{AMAX}$		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

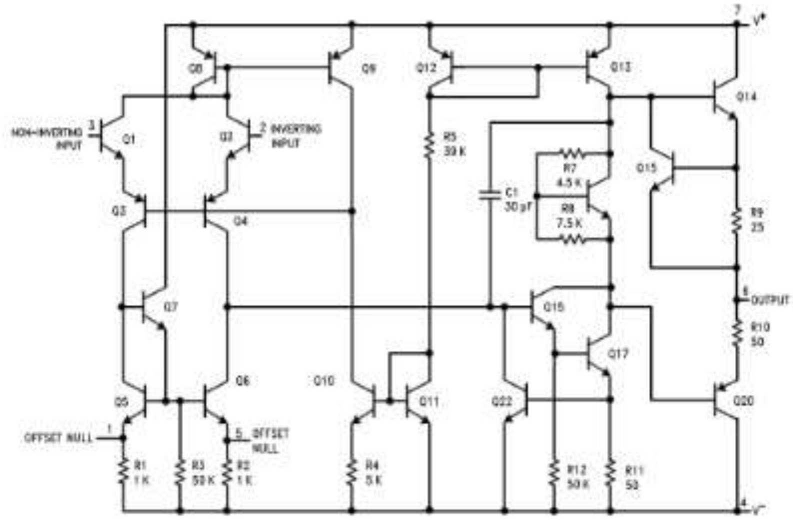
(1) Unless otherwise specified, these specifications apply for V_S = ±15 V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

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.

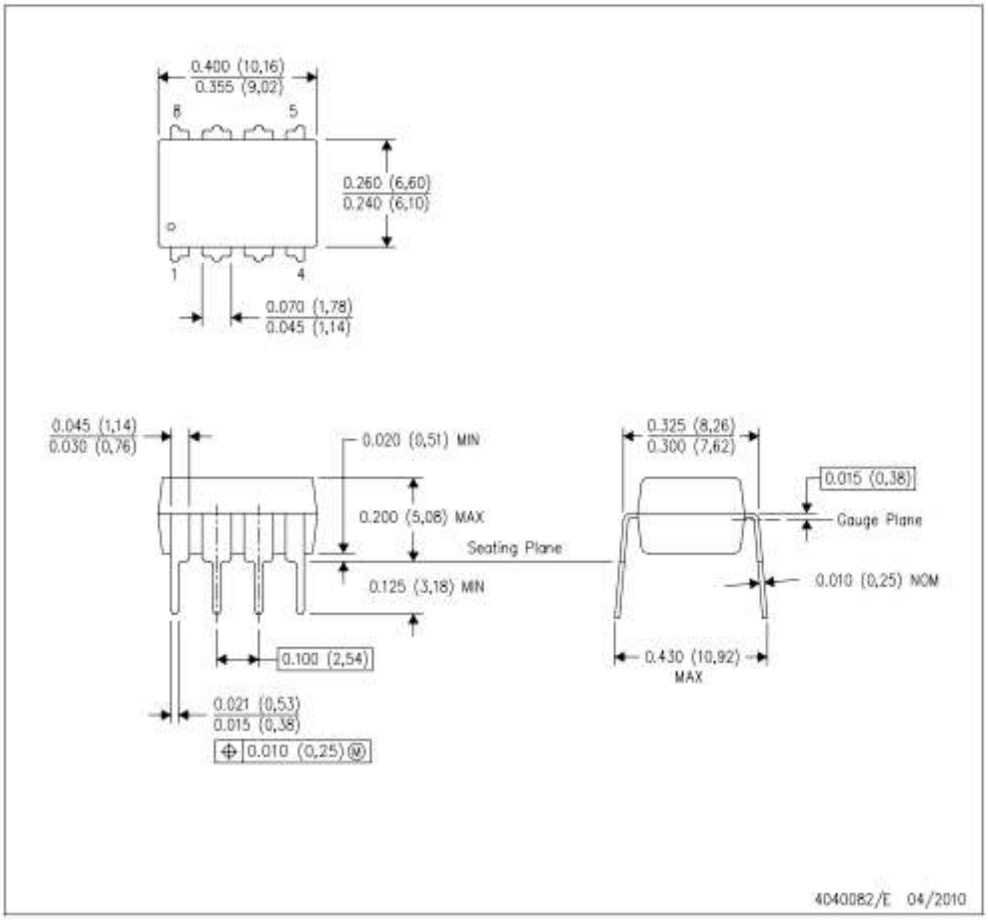
7.3.2 Latch-up Prevention

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

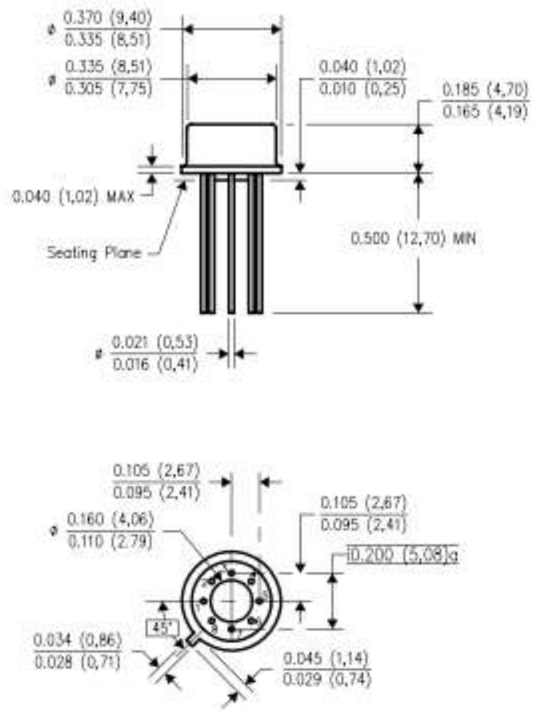
The LM741 is pin-to-pin direct replacements for the LM709C, LM201, MC1439, and LM748 in most applications. Direct replacement capabilities allows flexibility in design for replacing obsolete parts.

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.

LMC (O–MBCY–W8) METAL CYLINDRICAL PACKAGE



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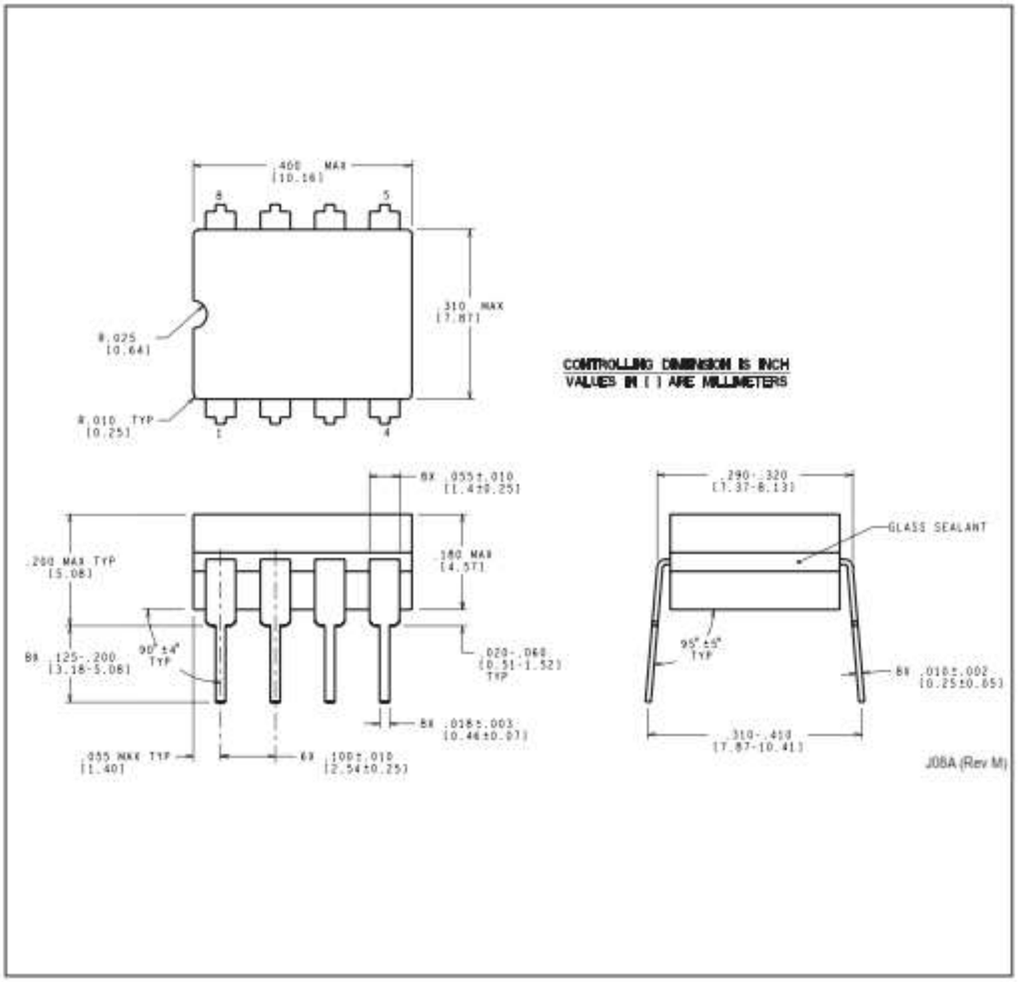
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
- D. Pin numbers shown for reference only. Numbers may not be marked on package.
- E. Falls within JEDEC MO-002/TO-99.

NAB0008A


.400 MAX
[10.16]
8
5
1
4
.310 MAX
[7.87]
R.025
[0.64]
R.010 TYP
[0.25]
CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
8X .055±.010
[1.4±0.25]
.200 MAX TYP
[5.08]
.180 MAX
[4.57]
90°±4°
TYP
8X .125-.200
[3.18-5.08]
.020-.060
[0.51-1.52]
TYP
8X .018±.003
[0.46±0.07]
.055 MAX TYP
[1.40]
6X .100±.010
[2.54±0.25]
.290-.320
[7.37-8.13]
GLASS SEALANT
95°±5°
TYP
8X .010±.002
[0.25±0.05]
.310-.410
[7.87-10.41]
J08A (Rev M)

[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.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

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)	Call TI	Level-1-NA-UNLIM	-40 to 85		Samples
LM741CH	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	0 to 70	(LM741CH ~ LM741CH)	Samples
LM741CH/NOPB	ACTIVE	TO-99	LMC	8	500	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	0 to 70	(LM741CH ~ LM741CH)	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
LM741H	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	-55 to 125	(LM741H ~ LM741H)	Samples
LM741H/NOPB	ACTIVE	TO-99	LMC	8	500	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125	(LM741H ~ LM741H)	Samples
LM741J	ACTIVE	CDIP	NAB	8	40	TBD	Call TI	Call TI	-55 to 125	LM741J	Samples
U5B7741312	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	-55 to 125	(LM741H ~ LM741H)	Samples
U5B7741393	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	0 to 70	(LM741CH ~ LM741CH)	Samples
U9T7741393	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	0 to 70	LM 741CN	

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

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

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.

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

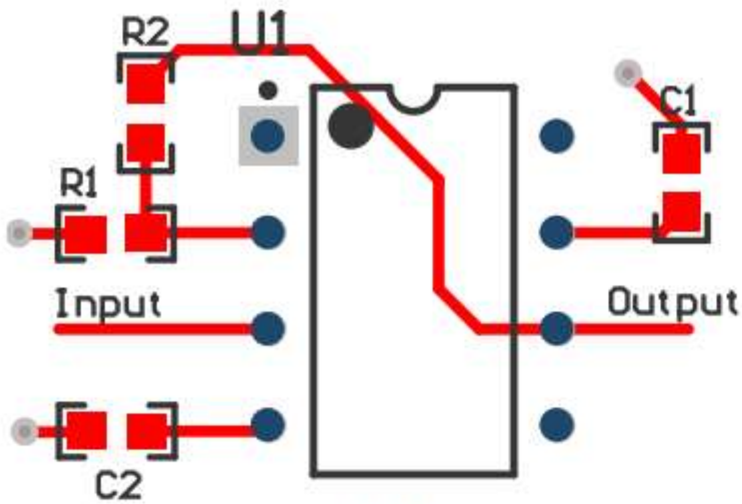

Figure 3. LM741 Layout

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.

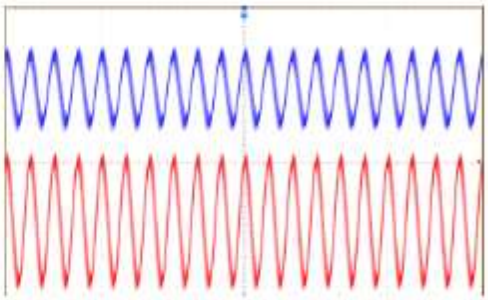

Figure 2. Waveforms for LM741 Noninverting Amplifier Circuit

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.

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

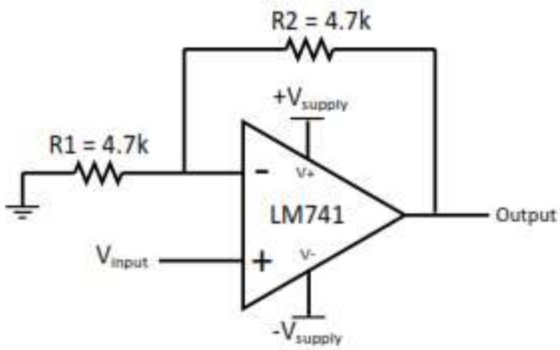

Figure 1. LM741 Noninverting Amplifier Circuit

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:

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

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.

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.