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CONFIDENTIAL

SET B

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2011 SESSION

SUBJECT CODE	:	FLD 20302
SUBJECT TITLE	:	OP-AMP & NON LINEAR CIRCUITS
LEVEL	:	DIPLOMA
TIME / DURATION	:	8.00pm – 10.00pm (2 HOURS)
DATE	:	11 MAY 2011

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. This question paper consists of TWO (2) sections. Section A and B. Answer all questions in Section A. For Section B, answer two (2) questions only.
6. Answer all questions in English.
7. Semi-log paper is appended.

THERE ARE 7 PAGES OF QUESTIONS AND 4 PAGES OF APPENDIXES, EXCLUDING THIS PAGE.

SECTION A (Total: 60 marks)

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

Question 1

(a) Define operational amplifier (op-amp).

(4 marks)

(b) List out three (3) applications of op-amp.

(3 marks)

(c) Define Common Mode Rejection Ratio (CMRR). From the data sheet given in Appendix, give the value of CMRR for LM 741.

(3 marks)

(d) Define slew rate (SR). From the data sheet given in Appendix, give the value of SR for op-amp LM741.

(3 marks)

(e) Determine the maximum allowable value of Vin for the circuit shown in **Figure 1**. Assume that the gain of the amplifier is 200.If R_L=5kΩ change to 10kΩ, find the new maximum allowable of Vin. Assume that the gain remain unchanged.

(7 marks)

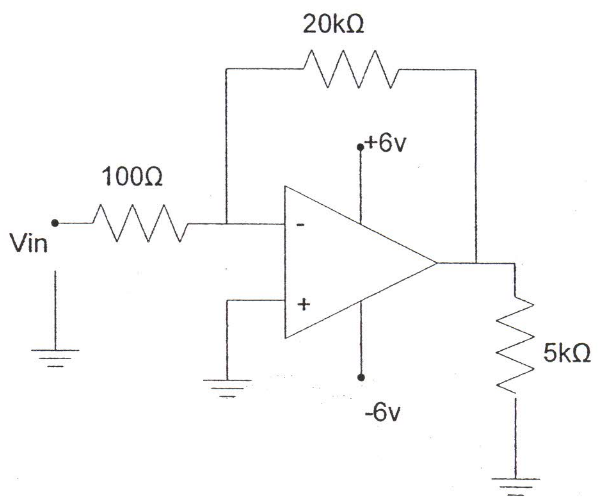


Figure 1

Question 2

Refer to **Figure 2** and answer the following questions:

(a) Give the name of op-amp circuit A and B.

(4 marks)

(b) Calculate the closed-loop gain (A_{CL}) of circuit op-amp A and the output voltage V_A.

(5 marks)

(c) Calculate the closed-loop gain (A_{CL}) of circuit op-amp B and the output voltage V_{out}.

(5 marks)

(d) Sketch the waveform of V_{in}, V_A and V_{out} on the same curve.

(6 marks)

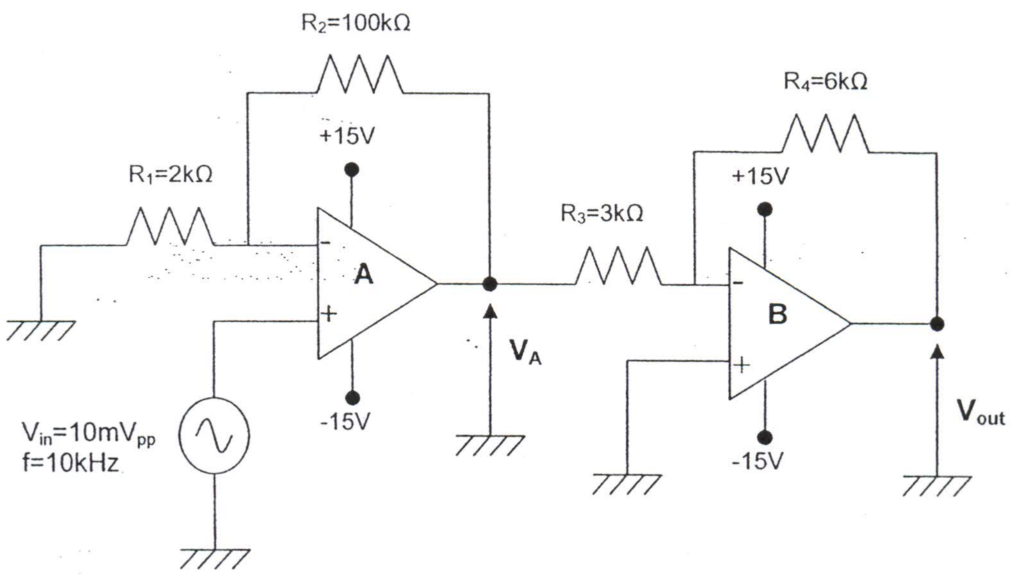


Figure 2

Question 3

(a) If the circuit of inverting amplifier has R_1 = 100 kΩ, R_f = 500 kΩ and input voltage, V_{in} = 2V, determine the output voltage (v_{out}).

(3 marks)

(b) Calculate the output voltage of a noninverting amplifier for values of V_{in} = 2 V, R_f = 500 kΩ and R_1 = 100 kΩ.

(3 marks)

(c) Calculate the output voltage of a summing amplifier with R_f = 1 MΩ for the set of input voltages, V_1= 1 V, V_2 = 2 V, V_3 = 3 V and their respective resistors of R_1 = 500kΩ, R_2 = 1MΩ and R_3 = 1 MΩ.

(3 marks)

(d) Give two (2) reasons why the output of the circuit shown in **Figure 3** is saturated?

(3 marks)

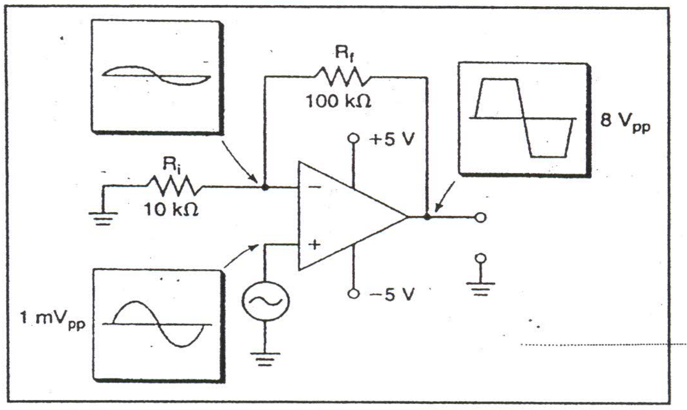


Figure 3

(e) **Figure 4** shows an op-amp differentiator circuit. Prove that the output voltage, V_{out} is equal to: $V_{out} = -RC\frac{d}{dt}V_{in}$

(8 marks)

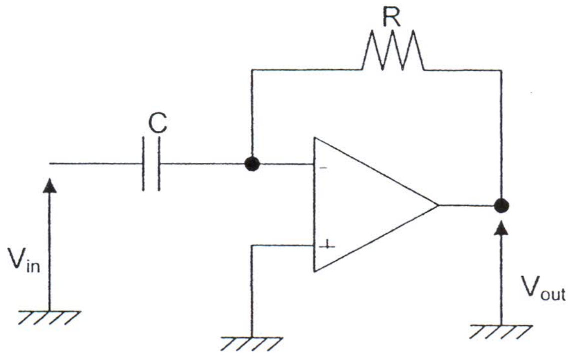


Figure 4

SECTION B (Total: 40 marks)

INSTRUCTION: Answer TWO (2) questions only.

Question 4

Figure 5 is the parts placement diagram for an op-amp circuit. IC's type of packaging is dual-in-line package with 8-pin. Use data sheet attached in Appendix.

(a) Analyze the circuit and draw its schematic (circuit) diagram.

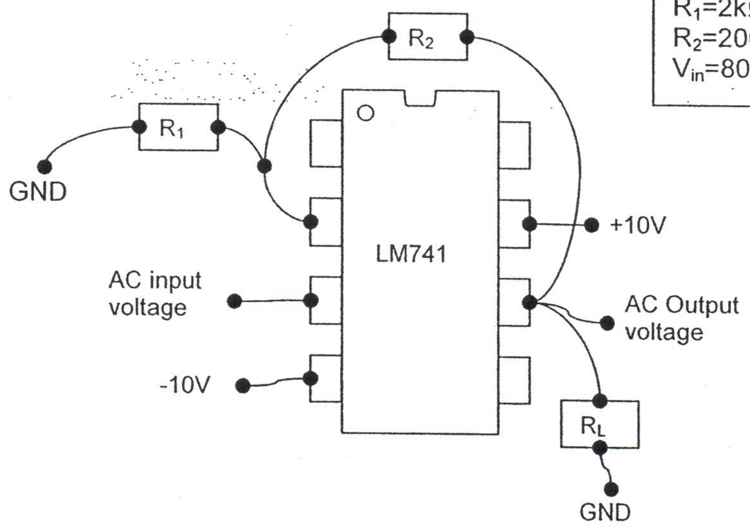
(4 marks)

(b) Prove that the closed-loop gain for this amplifier's circuit is $A_{CL} = 1 + \frac{R_2}{R_1}$

(6 marks)

(c) Perform a complete analysis of the circuit to determine its values of A_{cl}, Z_{in}, Z_{out}, CMRR and f_{max}.

(10 marks)



R_1=2kΩ	R_L=10kΩ
R_2=200kΩ	A_{CM}=0.01
V_{in}=80mV	

Figure 5

Question 5

By referring to **Figure 6** and data sheet attached in Appendix, answer the following questions. Op-amp used is LM 741. All op-amp supply is ±15v.

(a) Identify amplifier C and D.

(2 marks)

(b) Calculate Va, Vb, Vc and Vo.

(8 marks)

(c) What will be the output Vo if R2 is broken?

(3 marks)

(d) Perform complete analysis of amplifier B.(Acm=0.01)

(7 marks)

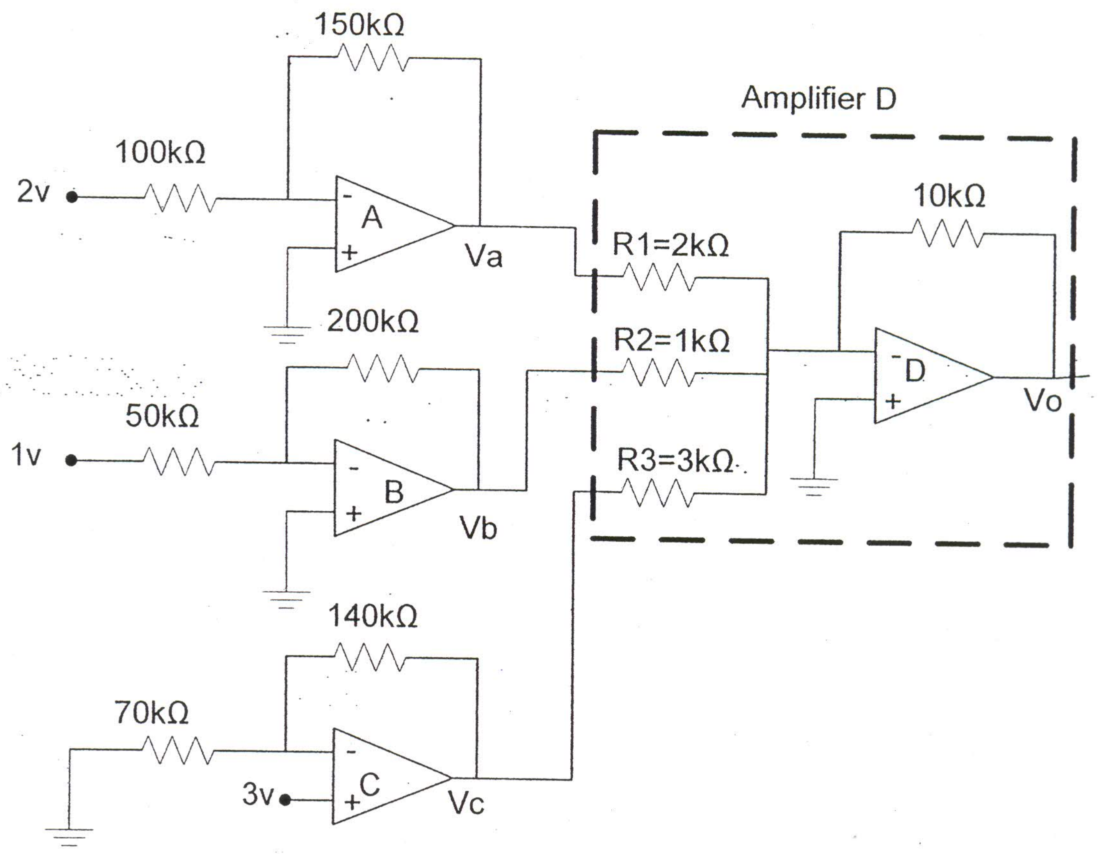


Figure 6

Question 6

An op-amp has an open loop gain of 2×10^5 and the open loop cut-off frequency, fc_{ol} = 10Hz. It is used in an inverting amplifier with input resistance connected to the inverting input terminal, R1=1kΩ and feedback resistance, R2 = 100kΩ. Use the provided semi log paper.

(a) Produce a Bode plot for both open loop and closed loop frequency response.

(10 marks)

(b) Show that the slope of this frequency response is approximately to 20dB/decade.

(2 marks)

(c) Mark and determine the funity for the op-amp on your Bode plot.

(2 marks)

(d) Also mark and determine the closed loop cut-off frequency, fc_{cl}.

(2 marks)

(e) Mark and determine the bandwidth of the frequency response.

(2 marks)

(f) Calculate the gain bandwidth product of this response.

(2 marks)

END OF QUESTION PAPER

APPENDIX

National Semiconductor

November 1994

LM741 Operational Amplifier

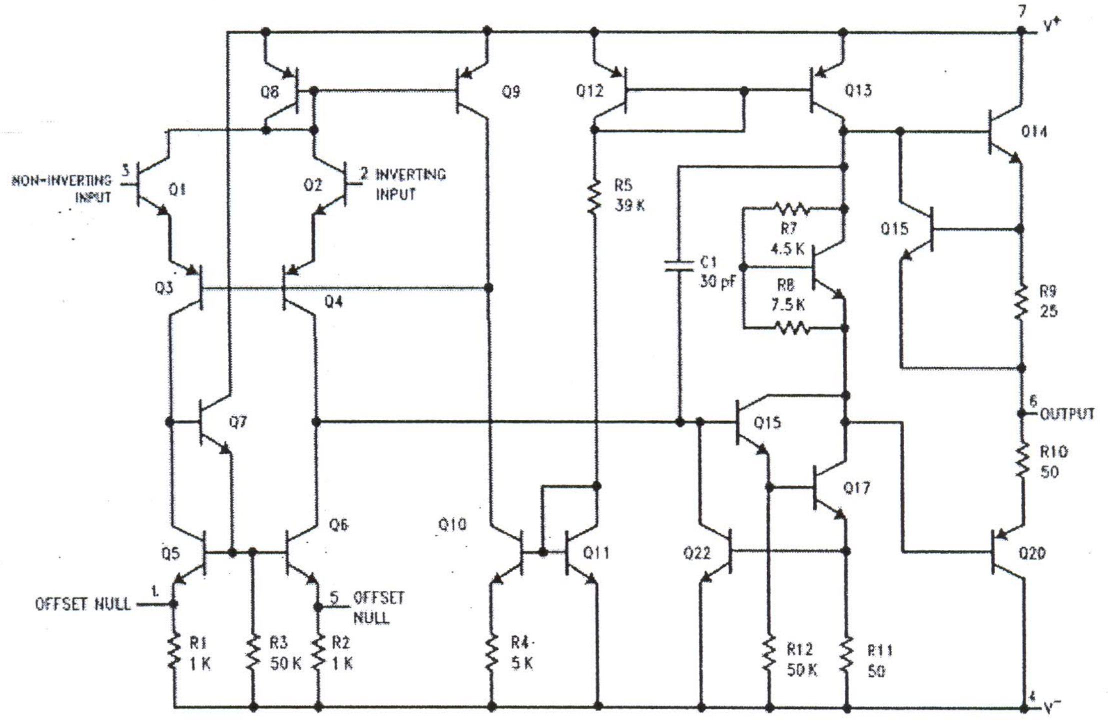
General Description

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/LM741E are identical to the LM741/LM741A except that the LM741C/LM741E have their performance guaranteed over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Schematic Diagram



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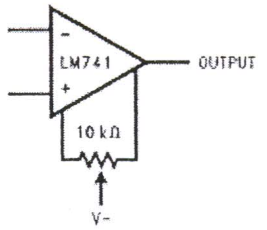
Offset Nulling Circuit



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Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.
(Note 5)

	LM741A	LM741E	LM741	LM741C
Supply Voltage	±22V	±22V	±22V	±18V
Power Dissipation (Note 1)	500 mW	500 mW	500 mW	500 mW
Differential Input Voltage	±30V	±30V	±30V	±30V
Input Voltage (Note 2)	±15V	±15V	±15V	±15V
Output Short Circuit Duration	Continuous	Continuous	Continuous	Continuous
Operating Temperature Range	−55°C to +125°C	0°C to +70°C	−55°C to +125°C	0°C to +70°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C	−65°C to +150°C	−65°C to +150°C
Junction Temperature	150°C	100°C	150°C	100°C
Soldering Information				
N-Package (10 seconds)	260°C	260°C	260°C	260°C
J- or H-Package (10 seconds)	300°C	300°C	300°C	300°C
M-Package				
Vapor Phase (60 seconds)	215°C	215°C	215°C	215°C
Infrared (15 seconds)	215°C	215°C	215°C	215°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

	LM741A	LM741E	LM741	LM741C
ESD Tolerance (Note 6)	400V	400V	400V	400V

Electrical Characteristics (Note 3)

Parameter	Conditions	LM741A/LM741E			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25°C$ $R_S \leq 10\ k\Omega$ $R_S \leq 50\Omega$		 0.8	 3.0		 1.0	 5.0		 2.0	 6.0	 mV mV
	$T_{AMIN} \leq T_A \leq T_{AMAX}$ $R_S \leq 50\Omega$ $R_S \leq 10\ k\Omega$			 4.0			 6.0			 7.5	 mV mV
Average Input Offset Voltage Drift				15							μV/°C
Input Offset Voltage Adjustment Range	$T_A = 25°C, V_S = \pm 20V$	±10				±15			±15		mV
Input Offset Current	$T_A = 25°C$		3.0	30		20	200		20	200	nA
	$T_{AMIN} \leq T_A \leq T_{AMAX}$			70		85	500			300	nA
Average Input Offset Current Drift				0.5							nA/°C
Input Bias Current	$T_A = 25°C$		30	80		80	500		80	500	nA
	$T_{AMIN} \leq T_A \leq T_{AMAX}$			0.210			1.5			0.8	μA
Input Resistance	$T_A = 25°C, V_S = \pm 20V$	1.0	6.0		0.3	2.0		0.3	2.0		MΩ
	$T_{AMIN} \leq T_A \leq T_{AMAX}$, $V_S = \pm 20V$	0.5									MΩ
Input Voltage Range	$T_A = 25°C$							±12	±13		V
	$T_{AMIN} \leq T_A \leq T_{AMAX}$				±12	±13					V
Large Signal Voltage Gain	$T_A = 25°C, R_L \geq 2\ k\Omega$ $V_S = \pm 20V, V_O = \pm 15V$ $V_S = \pm 15V, V_O = \pm 10V$	 50			 50	 200		 20	 200		 V/mV V/mV
	$T_{AMIN} \leq T_A \leq T_{AMAX}$, $R_L \geq 2\ k\Omega$, $V_S = \pm 20V, V_O = \pm 15V$ $V_S = \pm 15V, V_O = \pm 10V$ $V_S = \pm 5V, V_O = \pm 2V$	 32 10			 25			 15			 V/mV V/mV V/mV
Output Resistance						75			75		Ω

Electrical Characteristics (Note 3) (Continued)

Parameter	Conditions	LM741A/LM741E			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Output Voltage Swing	$V_S = \pm 20V$										
	$R_L \geq 10\ k\Omega$	±16									V
	$R_L \geq 2\ k\Omega$	±15									V
	$V_S = \pm 15V$										
	$R_L \geq 10\ k\Omega$				±12	±14		±12	±14		V
	$R_L \geq 2\ k\Omega$				±10	±13		±10	±13		V
Output Short Circuit Current	$T_A = 25°C$	10	25	35		25			25		mA
	$T_{AMIN} \leq T_A \leq T_{AMAX}$	10		40							mA
Common-Mode Rejection Ratio	$T_{AMIN} \leq T_A \leq T_{AMAX}$										
	$R_S \leq 10\ k\Omega$, $V_{CM} = \pm 12V$				70	90		70	90		dB
	$R_S \leq 50\Omega$, $V_{CM} = \pm 12V$	80	95								dB
Supply Voltage Rejection Ratio	$T_{AMIN} \leq T_A \leq T_{AMAX}$, $V_S = \pm 20V$ to $V_S = \pm 5V$										
	$R_S \leq 50\Omega$	86	96								dB
	$R_S \leq 10\ k\Omega$				77	96		77	96		dB
Transient Response	$T_A = 25°C$, Unity Gain										
Rise Time			0.25	0.8		0.3			0.3		μs
Overshoot			6.0	20		5			5		%
Bandwidth (Note 4)	$T_A = 25°C$	0.437	1.5								MHz
Slew Rate	$T_A = 25°C$, Unity Gain	0.3	0.7			0.5			0.5		V/μs
Supply Current	$T_A = 25°C$					1.7	2.8		1.7	2.8	mA
Power Consumption	$T_A = 25°C$										
	$V_S = \pm 20V$		80	150							mW
	$V_S = \pm 15V$					50	85		50	85	mW
LM741A	$V_S = \pm 20V$										
	$T_A = T_{AMIN}$			165							mW
	$T_A = T_{AMAX}$			135							mW
LM741E	$V_S = \pm 20V$										
	$T_A = T_{AMIN}$			150							mW
	$T_A = T_{AMAX}$			150							mW
LM741	$V_S = \pm 15V$										
	$T_A = T_{AMIN}$					60	100				mW
	$T_A = T_{AMAX}$					45	75				mW

Note 1: For operation at elevated temperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{jA} P_D)$.

Thermal Resistance	Cerdip (J)	DIP (N)	HO8 (H)	SO-8 (M)
θ_{jA} (Junction to Ambient)	100°C/W	100°C/W	170°C/W	195°C/W
θ_{jC} (Junction to Case)	N/A	N/A	25°C/W	N/A

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Unless otherwise specified, these specifications apply for $V_S = \pm 15V$, $-55°C \leq T_A \leq +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \leq T_A \leq +70°C$.

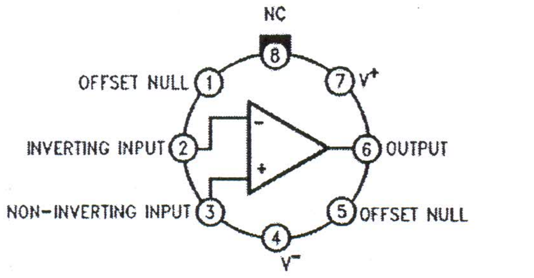
Note 4: Calculated value from: BW (MHz) = 0.35/Rise Time(μs).

Note 5: For military specifications see RETS741X for LM741 and RETS741AX for LM741A.

Note 6: Human body model, 1.5 kΩ in series with 100 pF.

Connection Diagrams

Metal Can Package



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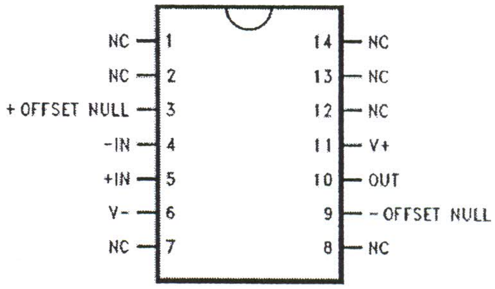
Order Number LM741H, LM741H/883*,
LM741AH/883 or LM741CH
See NS Package Number H08C

Ceramic Dual-In-Line Package

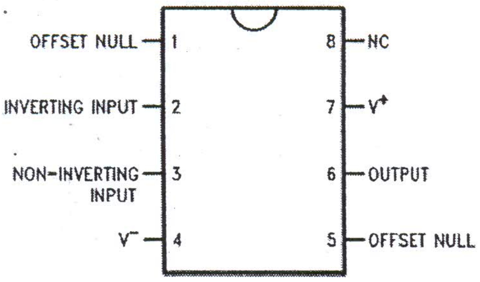


TL/H/9341-5

Order Number LM741J-14/883*, LM741AJ-14/883**
See NS Package Number J14A

*also available per JM38510/10101
**also available per JM38510/10102

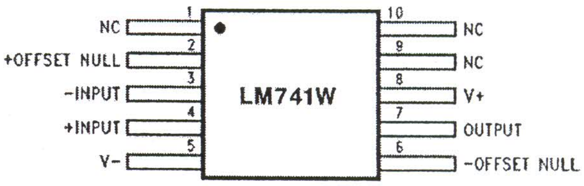
Dual-In-Line or S.O. Package



TL/H/9341-3

Order Number LM741J, LM741J/883,
LM741CM, LM741CN or LM741EN
See NS Package Number J08A, M08A or N08E

Ceramic Flatpak



TL/H/9341-6

Order Number LM741W/883
See NS Package Number W10A

Semi-log Paper