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CONFIDENTIAL

SET B

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2010 SESSION

SUBJECT CODE	: FLD 20302
SUBJECT TITLE	: OP-AMP & NON LINEAR CIRCUITS
LEVEL	: DIPLOMA
TIME / DURATION	: 8.00pm – 10.00pm (2 HOURS)
DATE	: 07 MAY 2010

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 answer on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. This questions 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 6 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 Common-Mode Rejection Ratio (CMRR).

(2 marks)

(b) Referring to the data sheet attached in Appendix, give the value of CMRR for op-amp LM741.

(2 marks)

(c) Calculate the voltage gain, A_v of an op-amp that has a common-mode gain, A_{CM}=0.006 and a CMRR of 80dB. (5 marks)

(d) For amplifier circuit shown in Figure 1, determine:

i. The value of R_2 if the closed-loop gain, A_{CL} of the amplifier is -50.

(4 marks)

ii. The output voltage, V_{out}.

(4 marks)

iii. The maximum output voltage, V_{outmax}.

(3 marks)

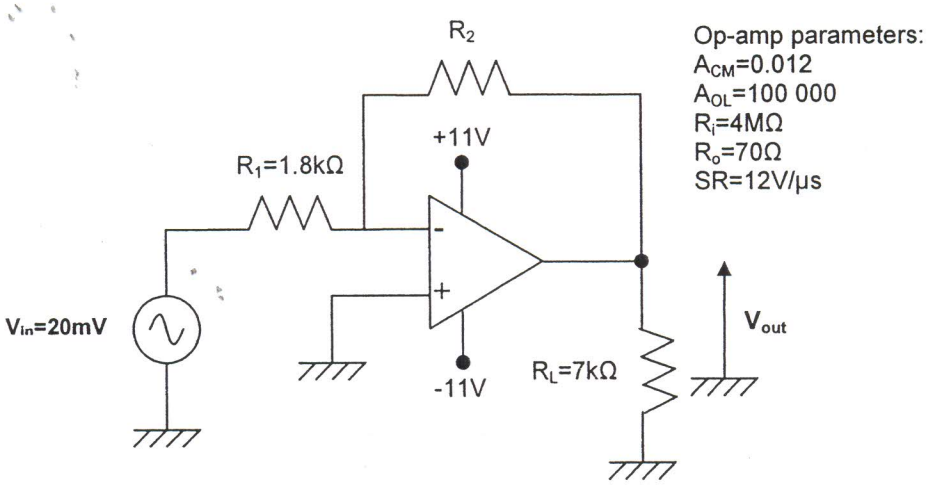


Figure 1

Question 2

(a) Figure 2 (a) and (b) shows two input waveforms and their respective distorted output waveforms.

i. Determine the cause of the problem.

(3 marks)

ii. Propose two solutions to encounter the problem.

(6 marks)

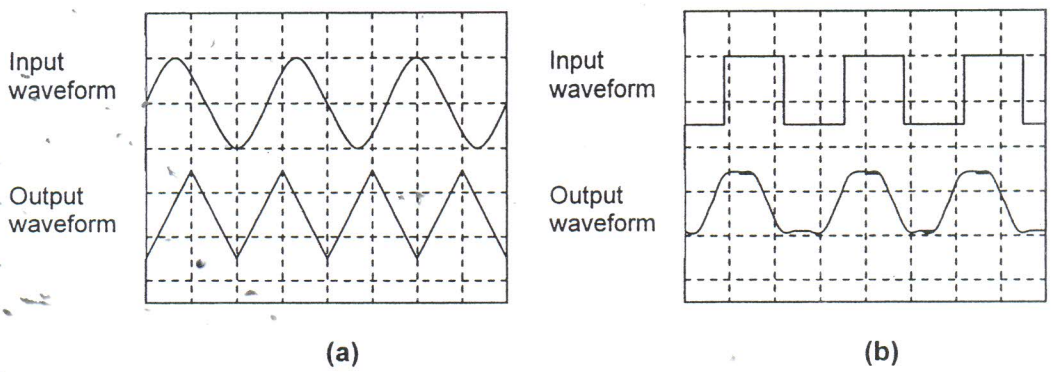


Figure 2

(b) An op-amp has the following parameters: A_{CM} = 0.02, A_{OL}=150 000, R_i=1.5MΩ, R_O=50Ω and slew rate = 0.75V/μs. The op-amp is used in an inverting amplifier with ±12V supply voltages and values of V_{in}=50mV_{pp}, feedback resistor R_2=250kΩ, R_1=1kΩ and R_L=20kΩ. Perform the complete analysis of the circuit.

(11 marks)

Question 3

(a) Draw a basic op-amp differentiator circuit.

(4 marks)

(b) Prove that the output voltage of op-amp differentiator is equal to:

$$V_{out} = -RC\frac{d}{dt}V_{in}$$

(8 marks)

(c) Draw the output voltage of an op-amp differentiator for the triangular-wave input shown in Figure 3 with R=5kΩ and C=0.001μF.

(8 marks)

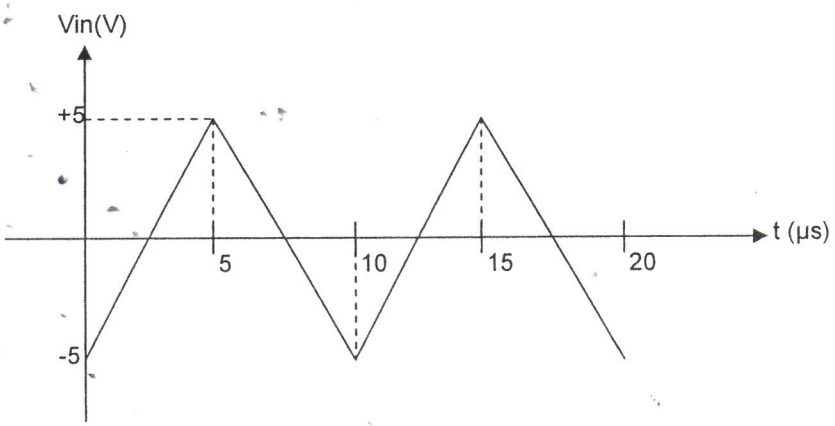


Figure 3

SECTION B (Total: 40 marks)

INSTRUCTION: Answer TWO (2) questions only.

Question 1

A temperature sensor (LM 35DZ) can measure a temperature from 0°C to 100°C. The output voltage of the sensor is connected to the non inverting input terminal of the operational amplifier (op-amp) and it will be amplified by the op-amp. Proofreading of a temperature display is performed by adjusting the gain of an op-amp by variable resistor, R_2 as shown in Figure 4. By referring only to the block amplifier and if **R_2 is maximum value**, answer the following questions:

i. Name the amplifier circuit.

(2 marks)

ii. Calculate the closed-loop gain of the amplifier (A_{cl}).

(4 marks)

iii. Calculate the maximum output voltage (V_{outmax}) of the amplifier.

(4 marks)

iv. Calculate the maximum allowable value of input voltage (V_{inmax}) of the amplifier.

(4 marks)

v. Sketch V_{in}, V_{out} and V_{outmax} waveforms on a same curve.

(6 marks)

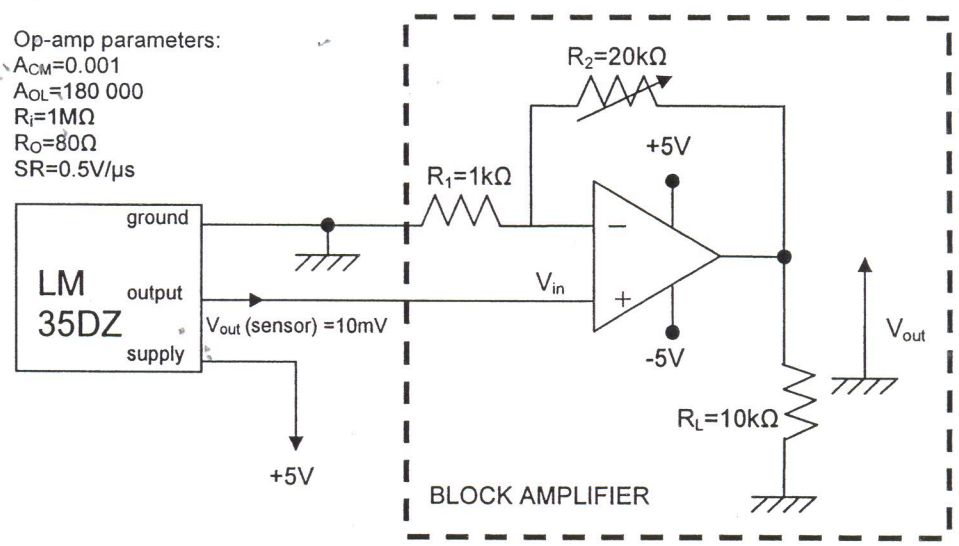


Figure 4

Question 2

Figure 5 shows a frequency response of an op-amp.

(a) Identify on the curve and give the value of open-loop gain (A_{OL}), cut-off frequency (f_c), bandwidth (BW) and f_{unity}.

(14 marks)

(b) Calculate the gain-bandwidth product (GBW).

(6 marks)

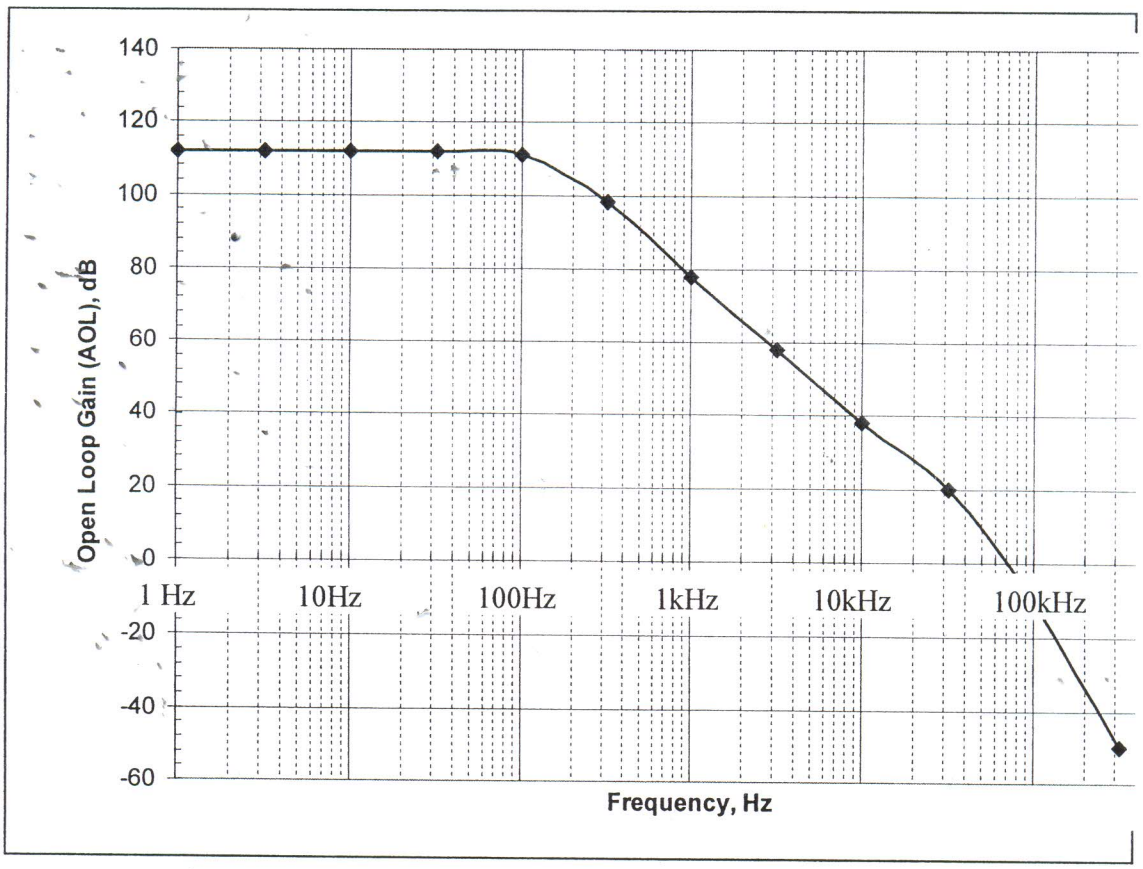


Figure 5

(Attention: Submit this page together with your answer paper)

Question 3

Refer to Figure 6 and answer the following questions.

(a) Identify amplifier A, B and C. (3 marks)

(b) Calculate the closed-loop gain, A_{cl} for amplifier B. (6 marks)

(c) Determine V_{out}. (8 marks)

(d) Calculate the output voltage (V_{out}) if R_6 is 'open' (broken). (3 marks)

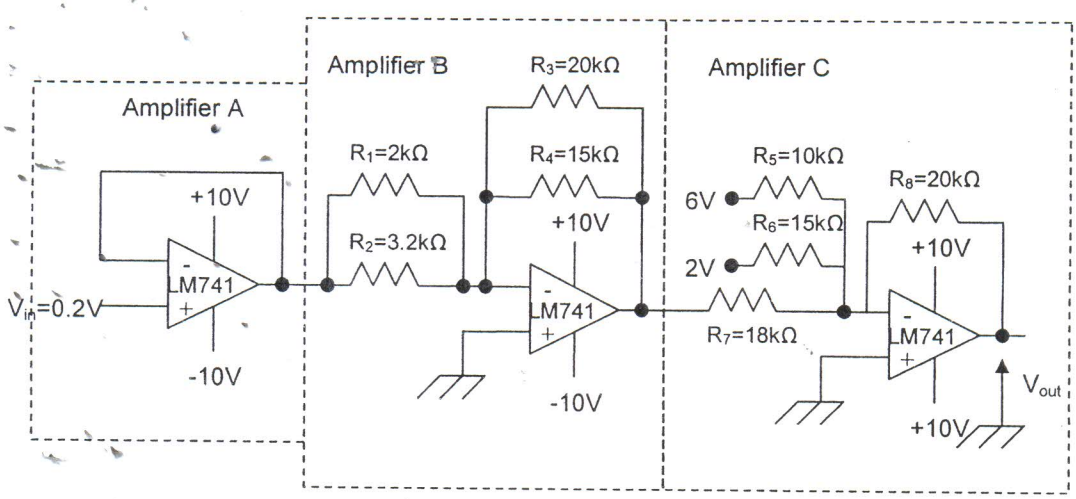


Figure 6

END OF QUESTION PAPER

APPENDIX

National Semiconductor

November 1994

LM741 Operational Amplifier

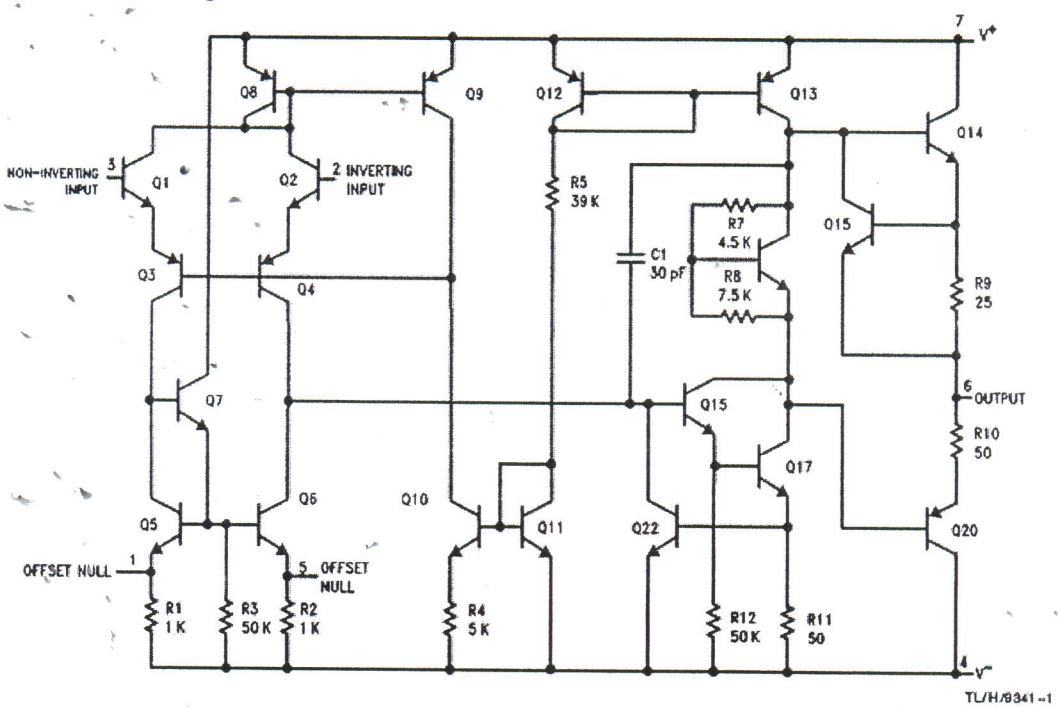
General Description

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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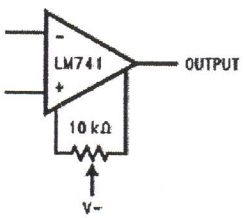
Offset Nulling Circuit



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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.				
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	$T_A = 25°C$ $R_S \le 10\ k\Omega$ $R_S \le 50\Omega$		 0.8	 3.0		1.0	5.0		2.0	6.0	mV mV
	$T_{AMIN} \le T_A \le T_{AMAX}$ $R_S \le 50\Omega$ $R_S \le 10\ k\Omega$			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
	$T_{AMIN} \le T_A \le T_{AMAX}$			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
	$T_{AMIN} \le T_A \le T_{AMAX}$			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
	$T_{AMIN} \le T_A \le T_{AMAX}$, $V_S = \pm 20V$	0.5									MΩ
Input Voltage Range	$T_A = 25°C$							±12	±13		V
	$T_{AMIN} \le T_A \le T_{AMAX}$				±12	±13					V
Large Signal Voltage Gain	$T_A = 25°C, R_L \ge 2\ k\Omega$ $V_S = \pm 20V, V_O = \pm 15V$ $V_S = \pm 15V, V_O = \pm 10V$	50			 50	 200		 20	 200		 V/mV V/mV
	$T_{AMIN} \le T_A \le T_{AMAX}$, $R_L \ge 2\ k\Omega$, $V_S = \pm 20V, V_O = \pm 15V$ $V_S = \pm 15V, V_O = \pm 10V$ $V_S = \pm 5V, V_O = \pm 2V$	 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	$V_S = \pm 20V$ $R_L \geq 10\ k\Omega$ $R_L \geq 2\ k\Omega$	 ±16 ±15									 V V
	$V_S = \pm 15V$ $R_L \geq 10\ k\Omega$ $R_L \geq 2\ k\Omega$				 ±12 ±10	 ±14 ±13		 ±12 ±10	 ±14 ±13		 V V
Output Short Circuit Current	$T_A = 25°C$ $T_{AMIN} \leq T_A \leq T_{AMAX}$	10 10	25	35 40		25			25		mA mA
Common-Mode Rejection Ratio	$T_{AMIN} \leq T_A \leq T_{AMAX}$ $R_S \leq 10\ k\Omega$, $V_{CM} = \pm 12V$ $R_S \leq 50\Omega$, $V_{CM} = \pm 12V$	 80	 95		 70	 90		 70	 90		 dB dB
Supply Voltage Rejection Ratio	$T_{AMIN} \leq T_A \leq T_{AMAX}$, $V_S = \pm 20V$ to $V_S = \pm 5V$ $R_S \leq 50\Omega$ $R_S \leq 10\ k\Omega$	 86	 96		 77	 96		 77	 96		 dB dB
Transient Response Rise Time Overshoot	$T_A = 25°C$, Unity Gain		 0.25 6.0	 0.8 20		 0.3 5			 0.3 5		 µs %
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	$T_A = 25°C$ $V_S = \pm 20V$ $V_S = \pm 15V$		 80	 150		 50	 85		 50	 85	 mW mW
LM741A	$V_S = \pm 20V$ $T_A = T_{AMIN}$ $T_A = T_{AMAX}$			 165 135							 mW mW
LM741E	$V_S = \pm 20V$ $T_A = T_{AMIN}$ $T_A = T_{AMAX}$			 150 150							 mW mW
LM741	$V_S = \pm 15V$ $T_A = T_{AMIN}$ $T_A = T_{AMAX}$					 60 45	 100 75				 mW 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 $0°C \leq T_A \leq +70°C$.

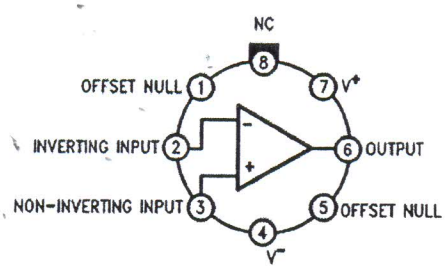
Note 4: Calculated value from: BW (MHz) = 0.35/Rise Time(µs).

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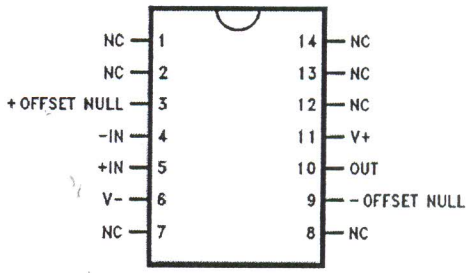
Order Number LM741H, LM741H/883*, LM741AH/883 or LM741CH
See NS Package Number H08C

Ceramic Dual-In-Line Package

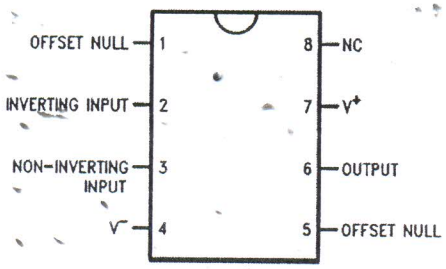


TL/H/9341–5

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

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

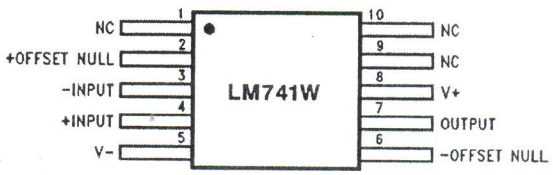
Dual-In-Line or S.O. Package



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