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SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION

JULY 2010 SESSION

SUBJECT CODE	:	FLB 20102
SUBJECT TITLE	:	OP-AMP AND NON-LINEAR CIRCUITS
LEVEL	:	BACHELOR
TIME / DURATION	:	9.00 am – 11.00 am (2 HOURS)
DATE	:	16 NOVEMBER 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 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.

THERE ARE 6 PAGES OF QUESTIONS, 4 PAGES OF APPENDICES EXCLUDING THIS PAGE.

SECTION A (Total: 50 marks)

INSTRUCTION: Answer ALL questions.
Please use the answer booklet provided.

Question 1

(a) Attached in Appendix is a data sheet for LM741A/LM741E, LM741 and LM741C op-amp. Define and give the numerical values for the following characteristics/parameters for the LM741.

(i) Open Loop Voltage Gain

(2 marks)

(ii) Output Resistance

(2 marks)

(iii) Output voltage Swing

(2 marks)

(iv) Common-Mode Rejection Ratio

(2 marks)

(v) Slew Rate

(2 marks)

(a) **Figure 1** shows a circuit built for a Smart Continuity Tester. The unit uses two 741 op-amps. Its advantage is that, it offers a short-circuit test current of less than 200μA. It detects resistance values of less than 10 ohms. Analyze the circuit and by referring to the 741 data sheets attached in Appendix, answer the following questions:

(i) Identify amplifier A and B.

(2 marks)

(ii) Perform a complete analysis for both amplifiers. (R_1 = 1kΩ, R_2 = 10kΩ, R_3 = 3.2kΩ, R_4 = 100kΩ, R_{L1} = 18kΩ, R_{L2} = 22kΩ and A_{cm} = 0.01)

(13 marks)

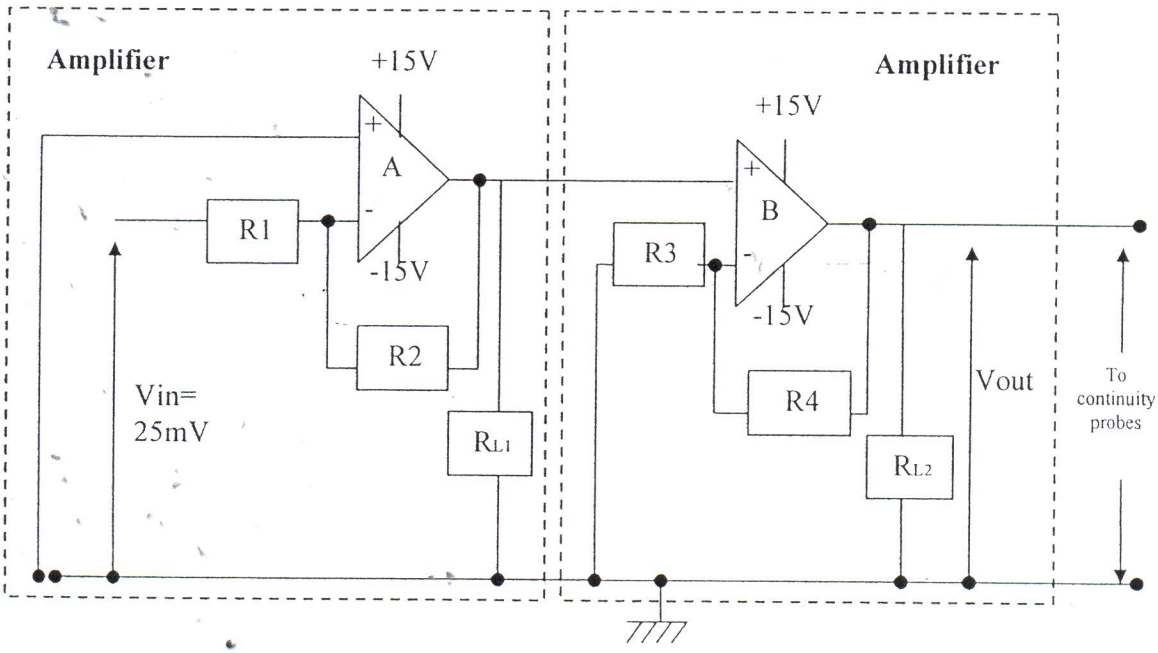


Figure 1

Question 2

(a) **Figure 2** shows an inverting amplifier with the following values; Vin=500mVpk, Rin=100Ω, Rf=15kΩ, Vs=±10v ,RL=10kΩ and Av=150.

(i) Determine the peak-to peak output voltage value for the circuit.

(4 marks)

(ii) Also determine the maximum possible output values for the amplifier.

(4 marks)

(iii) If RL=2kΩ, find new maximum possible output values for this amplifier.

(4 marks)

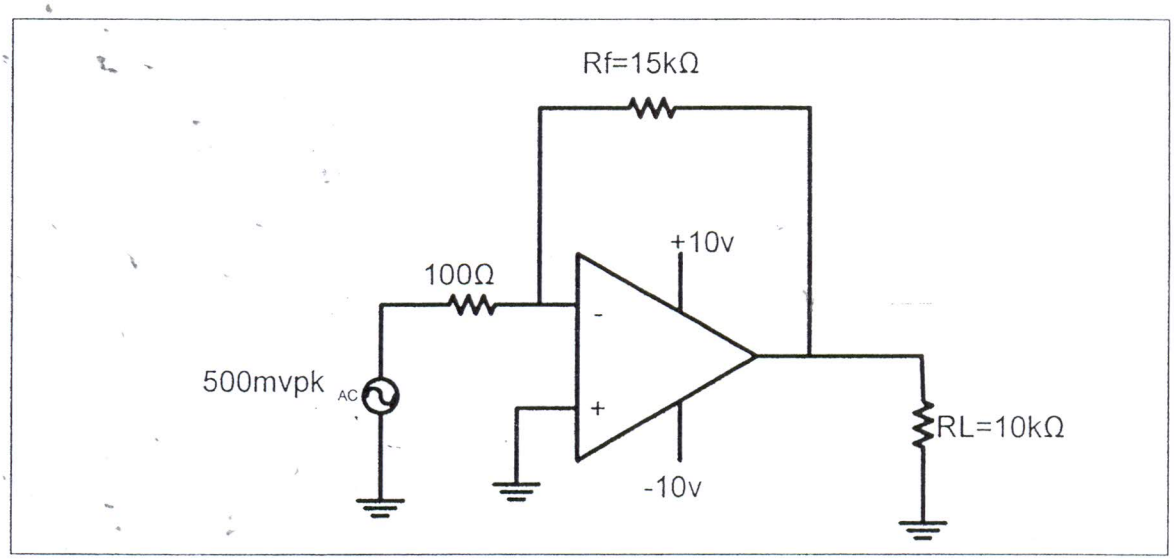


Figure 2

(b) Using the LM741, design a non inverting amplifier that will deliver a 11Vpp output to a 10kΩ load resistance with a 1Vpp input signal. The available supply voltages are ±18Vdc. Prove this voltage supply is an appropriate voltage supply for your design. Include the 8-pin DIP pin numbers in your schematic diagram as shown in data sheets.

(13 marks)

SECTION B (Total: 50 marks)

INSTRUCTION: Answer TWO (2) questions only.
Please use the answer booklet provided.

Question 3

By referring to **Figure 3**, answer the following questions:

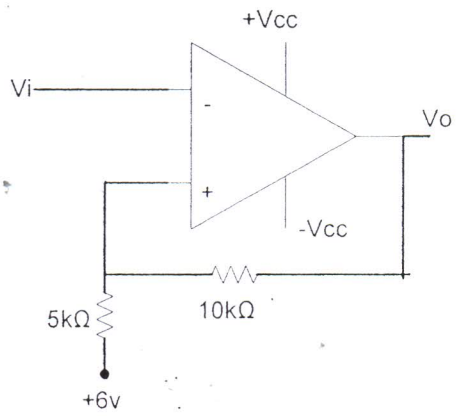


Figure 3

(a) Briefly explain the function of comparator and Schmitt Trigger circuits.

(6 marks)

(b) Find the upper trigger point (UTP) and lower trigger point (LTP). Given the output switches between ±15v.

(8 marks)

(c) Define the meaning of hysteresis and find its value for circuit shown above.

(3 marks)

(d) Find the new upper and lower trigger point if Vref=0v.

(8 marks)

Question 4

By referring to **Figure 4**, answer the following questions:

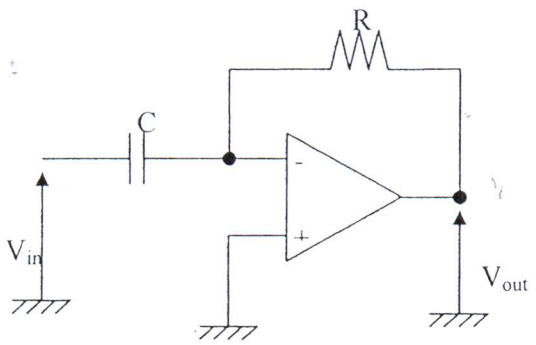


Figure 4

(a) Give the name of the circuit.

(2 marks)

(b) State the function of this circuit.

(3 marks)

(c) Prove that the output voltage (V_{out}) of this circuit is equal to:

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

(10 marks)

(d) Draw the output voltage (V_{out}) for the triangular-wave input shown in **Figure 5** with R = 5kΩ and C = 0.001μF.

(10 marks)

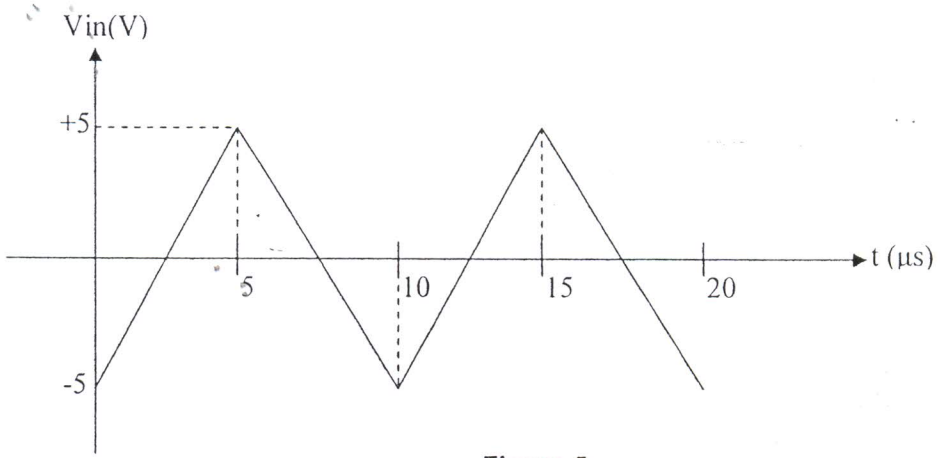


Figure 5

Question 5

(a) List out the four types of active filters.

(4 marks)

(b) Sketch the frequency response curve for each type of active filter.

(8 marks)

(c) What is a pole? Why is the number of poles in an active filter important?

(4 marks)

(d) List out two major differences between Butterworth filter and Chebyshev filter.

(4 marks)

(e) A single-pole low pass Butterworth filter having values of $R_1 = 47k\Omega$, $C_1 = 0.033\mu F$, input resistor connected to op-amp's inverting terminal, $R_2 = 47k\Omega$ and feedback resistor, $R_3 = 27k\Omega$.

i. Determine its bandwidth.

ii. The closed-loop gain for the circuit.

(5 marks)

END OF QUESTION PAPER

APPENDIX

National Semiconductor

November 1994

LM741 Operational Amplifier

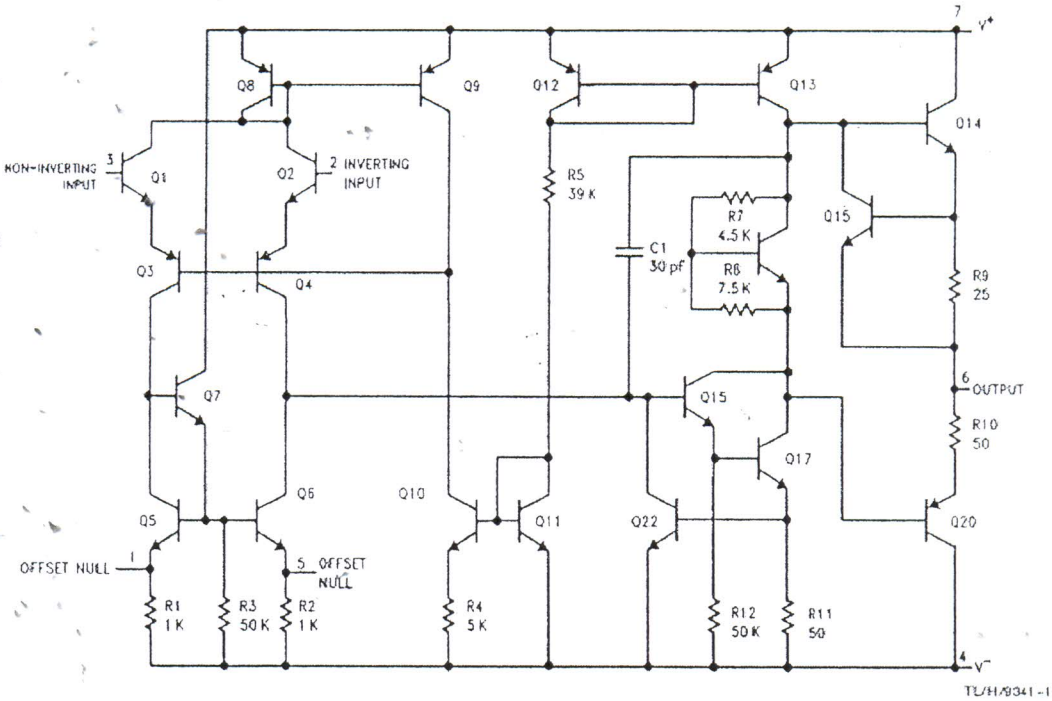
General Description

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.

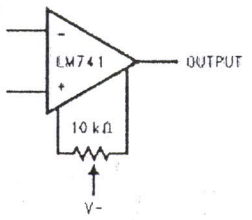
The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

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



Offset Nulling Circuit



TL/H/9341-7

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 = ±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 = ±20V	1.0	6.0		0.3	2.0		0.3	2.0		MΩ
	$T_{AMIN} \le T_A \le T_{AMAX}$, V_S = ±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 = ±20V, V_O = ±15V V_S = ±15V, V_O = ±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 = ±20V, V_O = ±15V V_S = ±15V, V_O = ±10V V_S = ±5V, V_O = ±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 $0°C \leq T_A \leq +70°C$.

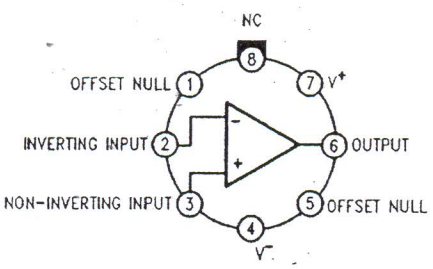
Note 4: Calculated value from: BW (MHz) = 0.35/Rise Time(μs).

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

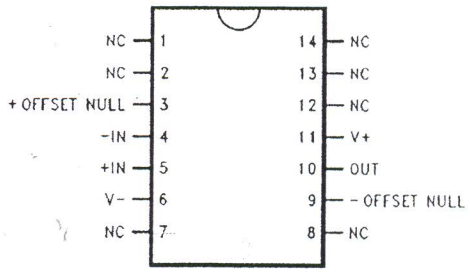
Metal Can Package



TL/H/9341–2

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

Ceramic Dual-In-Line Package

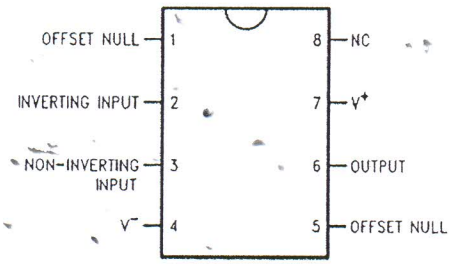


TL/H/9341–5

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

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

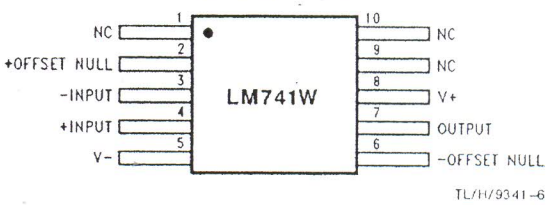
Dual-In-Line or S.O. Package



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