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SET A

UNIVERSITI KALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION

JANUARY 2011 SESSION

SUBJECT CODE	:	FLB 20102
SUBJECT TITLE	:	OP-AMP AND NON-LINEAR CIRCUITS
LEVEL	:	BACHELOR
TIME / DURATION	:	3.30pm – 5.30pm (2 HOURS)
DATE	:	12 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.

THERE ARE 5 PAGES OF QUESTIONS AND 2 PAGES OF APPENDIX, EXCLUDING THIS PAGE.

SECTION A (Total: 50 marks)

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

Question 1

For a class B power amplifier having a input voltage (Vin) of 10 V rms, a power supply (Vcc) of 30 V and providing a output voltage to an 16 Ω load, determine:

(a) Input power, Pi (dc)

(4 marks)

(b) Output power, Po(ac)

(4 marks)

(c) Circuit efficiency, η (%)

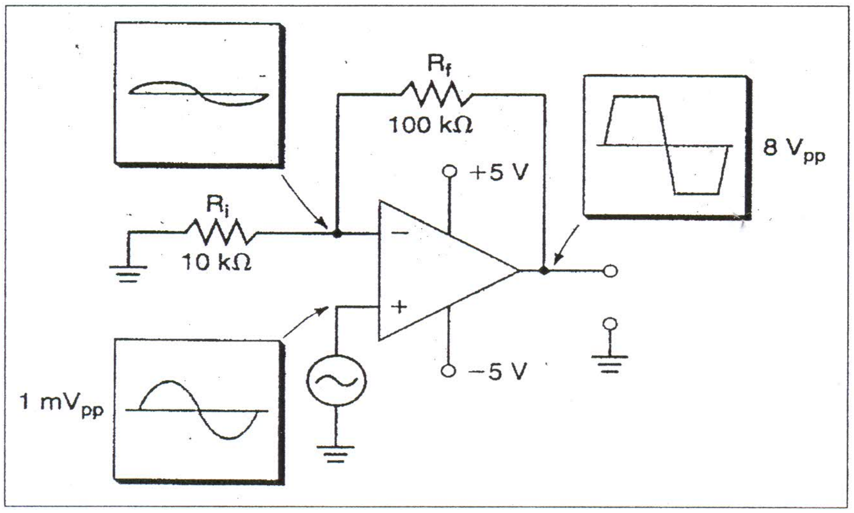
(4 marks)

(d) Power dissipated by both transistors

(3 marks)

Question 2

Figure 1 shows the waveform of the non-inverting amplifier circuit. Explain the possible cause(s) of the problem.



(12 marks)

Figure 1

Question 3

By using the LM741 and its data sheets attached in Appendix, design an inverting amplifier that will deliver a $12V_{pp}$ output voltage to a 15kΩ load resistance with a $50mV_{pk}$ input voltage.

(6 marks)

For this inverting amplifier,

(a) Draw it's schematic diagram and put the 8-pin DIP pin numbers in this diagram.

(3 marks)

(b) Perform a complete analysis by determining the value of A_{CL}, Z_{in}, Z_{out}, CMRR and f_{max}. (Assume, $A_{cm} = 0.01$)

(10 marks)

(c) Determine the maximum allowable input voltage, Vin_{max}.

(2 marks)

(d) Sketch Vin and Vout on the same curve.

(2 marks)

SECTION B (Total: 50 marks)

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

Question 4

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

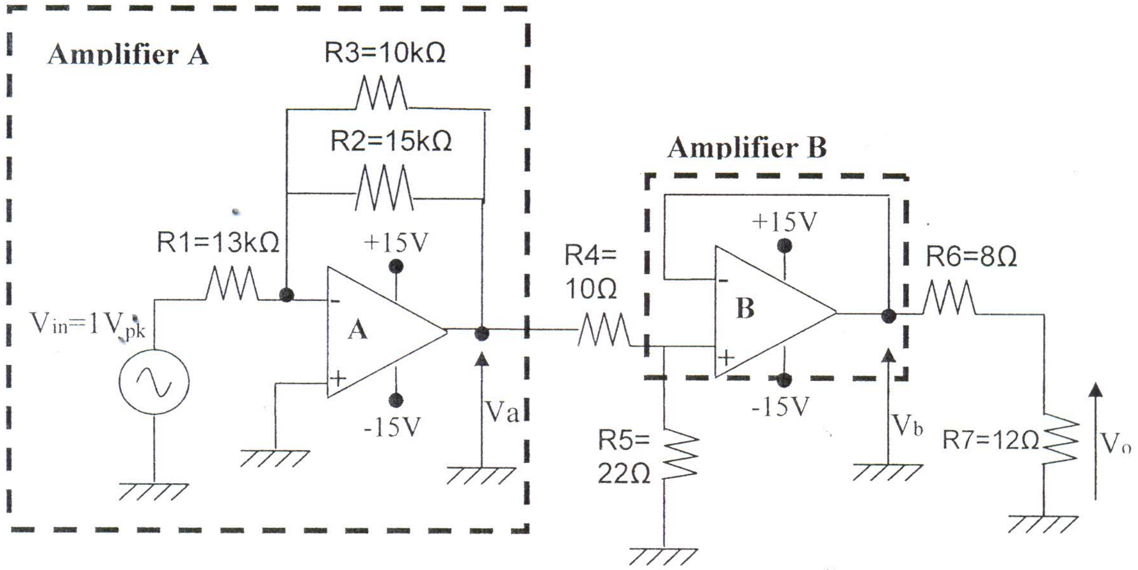


Figure 2

(a) Identify amplifier A and amplifier B.

(3 marks)

(b) Determine the output voltage across R7 (Vo).

(22 marks)

Question 5

(a) Design the Astable Multivibrator circuit using a 555 timer which can produce square waveforms at the desired frequency.

(5 marks)

(b) The above Astable Multivibrator needs to be operated at 350 kHz. Determine the value of capacitor, if both resistors equal to 7.5 kΩ.

(5 marks)

(c) Draw the input and output waveforms of the Astable Multivibrator of question 5(a). Determine the width for each pulse of these square waveforms ($\tau 1$ and $\tau 2$).

(15 marks)

Question 6

(a) The filter in **Figure 3** is evaluated by a student. Calculate the cutoff frequency, f_C and select R_1 such that the filter has Butterworth response.(refer **Table 1**).

(4 marks)

(b) A certain type of active filter has been designed and is shown in **Figure 4**. As a trainee of electronics engineer who have been asked by the manager to evaluate the filter performance.

i. Determine the type of active power filter as shown in **Figure 4**.

(2 marks)

ii. Determine the no of poles and the roll-off rate for the active filter in **Figure 4**.

(4 marks)

iii. Evaluate if the above filter is optimized for Butterworth response.

(5 marks)

iv. Calculate its cut-off frequency, f_C.

(3 marks)

v. As a measure to reduce parts count in the Bill Of Material, your manager has asked you to recalculate R_5,R_6,R_7,R_8 such that $R_5=R_6=R_7=R_8=R$ while perfectly maintaining filter performance. He has also decided that C1=C2=C3=C4=0.22μF. Calculate the R value.

(7 marks)

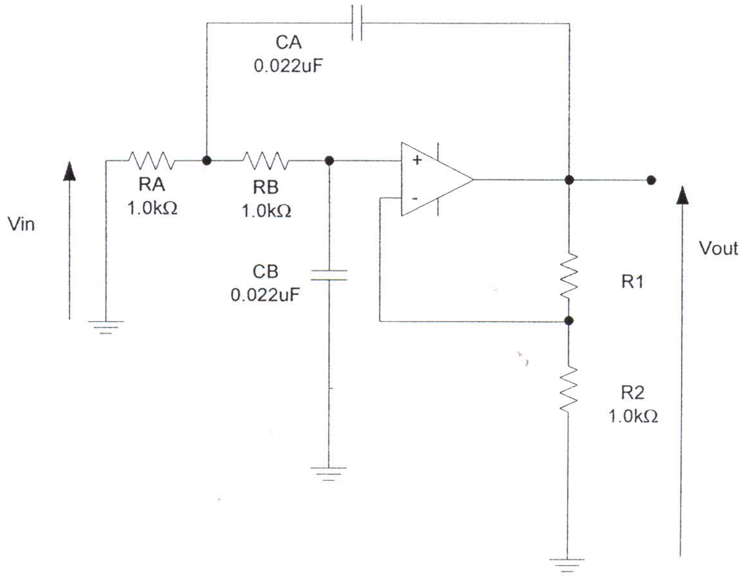


Figure 3

Table 1

No of poles	Overall DC Gain
2	1.586 (4 dB)
3	2 (6 dB)
4	2.58 (8 dB)
5	3.29 (10 dB)
6	4.21 (12 dB)

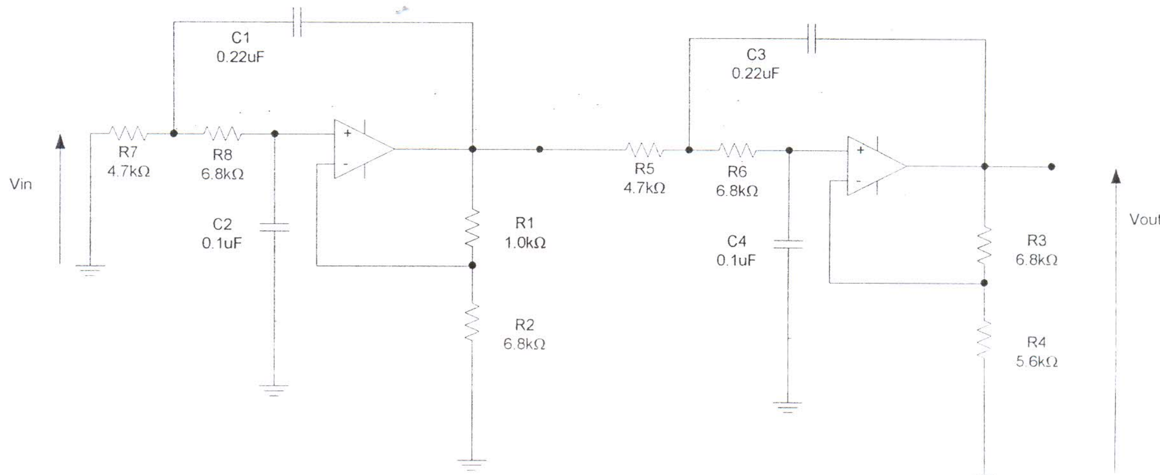


Figure 4

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.

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	$V_S = \pm 20V$ $R_L \geq 10\ k\Omega$ $R_L \geq 2\ k\Omega$	 ±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.