MODULE 04

OP-AMPS II

PREREQUISITES: MODULE 03: OP-AMPS I.

OUTLINE OF MODULE 04:

What you will learn about in this Module:

Detailed discussion of Op-Amp performance characteristics
High-order filters
Comparators
Buffers
Op Amp Comparator (Schmidt Trigger) with Hysteresis
Micro-power design

What you will build in the lab:

You will build several more complex Op-Amp circuits, including summing amplifiers and active filters, and you will also build these circuits using different types of Op-Amps, so you can see how they perform differently (linear monolithic BJT vs. JFET).

INTRODUCTION:

In this Module you will read about the important characteristics of Op-Amps, including the open-loop gain, GBW (Gain-Bandwidth Product), CMRR (Common-Mode Rejection Ratio), PSRR (Power Supply Rejection Ratio), input impedance, output impedance and other "non-ideal" characteristics of Op-Amps. Then, you will be introduced to several different types of Op-Amps. Op-amps can be classified by function or by architecture. Function tells you what they do, architecture tells you how they are built. Architecture is important, because it will influence how well an Op-Amp does a particular job. Functional descriptions of Op-Amps include linear, audio, current-feedback (Norton), high-power, high voltage, high speed, rail-to-rail (inputs, outputs), and precision. Architectures (or families) of Op-Amps include linear monolithic, CMOS, and JFET.

READINGS FROM HOROWITZ AND HILL (H&H): *ART OF ELECTRONICS*

1.19-1.22, 4.11-4.12, 4.15-4.16, 4.20-4.26, 4.28, 4.33-4.35
Chapter 5 Introduction, 5.01-5.05

ADDITIONAL READINGS & INTERNET RESEARCH:

Go to the National Semiconductor web page and locate Applications Note 20 (AN-20): "An Applications Guide for Op-Amps". Read this and take note of the different types of functions you can build using Op-Amps (such as summing amplifiers, i.e., voltage adders, etc…).

Then find and read the National Semiconductor Applications Note 31 (AN-31): “Op-Amp Circuit Collection”.

Then find and read the National Semiconductor Applications Note 779 (AN-779): “A Basic Introduction to Filters – Active, Passive, and Switched-Capacitor”.

Then go to the Maxim-IC web page and find and read “A Filter Primer”.

Stay on the Maxim-IC web page and find and read: “Operational Amplifier Inputs”.

Then, go to the Texas Instruments web page and find Application Report SLOA093: “Filter Design in 30 Seconds”.

Stay on the Texas Instruments web page and find Application Report SLOA067: “Op-Amp and Comparators – Don’t confuse them!”.

On the Texas Instruments web page find Application Report SLOA058: “A Single-Supply Op-Amp Circuit Collection”.

On the Texas Instruments web page find Application Report SLOA068A: “Understanding Basic Analog – Ideal Op-Amps”. You may have already read this for the previous module.

Then, finally (still on the Texas Instruments web page) locate the White Paper SLOA011: “Understanding Operational Amplifier Specifications”.

In order to build the circuits in the laboratory, you will need to locate the datasheet for a new type of Op-Amp: the LF444, quad JFET Op-Amp (look on the National Semiconductor web page)

SELF QUIZ

1: Without looking back at your readings, list as many different functions as you can that op-amps can perform in a circuit.

2: Referring to the datasheets for the LM324 and the LF444 op-amps, note as many differences as you can find in the performance of these two different amplifiers.

3: What are the major differences? Why might these be important?

PLEASE ANSWER THE ABOVE QUESTIONS AND E-MAIL TO THE INSTRUCTOR
"I have neither given nor received aid on this examination, nor have I concealed any violation of the Honor Code"

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MODULE 04

LABORATORY PROJECTS

1- Using the circuit you built from Module-03 (Op-Amps I), you will compare two different architectures of Op-Amps: the LM324A vs. the LF444. Check to be sure that the pin functions for each of the two Op-Amps are identical (they should be!). Also, check the LF444 data sheet to be sure that it can accommodate the power that you will be supplying (± 15V).

Plug in and turn on the Signal Generator from Module-02. You will want to check the output from TP-1 and TP-8, just to be sure that you can detect both signals using the O-scope. To do this, connect TP-1 to Ch-1 of the O-scope, and TP-8 to Ch-2 of the O-scope. Then disconnect TP-8 from Ch-2. Then, put the signal from TP-8 into any one of your amplifier circuits that you built in Module-03 and look carefully at the output from your amplifier on Ch-2 of the O-scope (in particular, note the amplitude of the signal…how many volts is it?). Then, go ahead and remove the LM324A Op-Amp from the IC socket very carefully, by prying it up with a small screw driver, or similar tool. Be careful to avoid bending the pins on the LM324A. You can keep the LM324A in your parts box for later use.

In place of the LM324A, insert the LF444, being careful to orient the #1 pin identifier in the same direction that the LM324A was in. Make the same measurements on the test points TP-1 through TP-8 that you made above, but this time using the LF444 Op-Amp instead of the LM324A Op-Amp. Do you notice any differences?

2- Using H&H and the Op-Amp Circuit Collections that you looked up, you will design and build several useful Op-Amp Circuits. Use an LM324A for the circuits that you build. Also, use ExpressSCH to design each of your circuits.

(A) Design and build a Summing Amplifier that will simply add two voltages, each with a gain = -1.

(B) Design & build a Summing Amplifier that will add 3 voltages, with gain = +2

(C) Design and build a first-order Low-Pass Filter with gain = -2 and a cutoff frequency (Fc_{3db}) = 100 Hz. Be sure to use the ceramic chip capacitors (the small flat ones, not large cylindrical ones).

(D) Design and low-pass filter identical to the one above, but set Fc_{3db} = 10,000 Hz.

(E) Now, test your filters using the signal generator. In particular, test TP-1, TP-2, TP-4, and TP-6. Be sure to look at the unfiltered signal on Ch-1, and the filtered signal on Ch-2 of the O-scope. Note the effects that you see.

FEEDBACK

Was this Module useful and informative?

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Is there a topic that should get more or better coverage?

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In what way can this Module be improved:

Content: _____

Depth of Coverage: _____

Style: _____

Any additional comments that will help us to improve this course:

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If you prefer, you may e-mail comments directly to Bob Dennis: yoda@umich.edu