MP212
Principles of Audio Technology II

Black Box Analysis Workstations

Version 2.0, 11/20/06 – revised JMC
Copyright © 2006 – Berklee College of Music. All rights reserved.
Acrobat Reader 6.0 or higher required

http://classes.berklee.edu/mpe
**MP212 Black Box Experimentals**

Please read through this write-up carefully! Then read it again!

You need to UNDERSTAND it thoroughly before going on.

This assignment is an exercise using one of the two “Black Box Analysis Workstations” in the Audio Lab. The workstations are both equipped with internal banks of black box audio devices, each with a different set of inputs, outputs, and controls. Your mission is to experimentally determine the function and signal flow of one randomly generated black box.

The assignment utilizes the A79 Audio Lab, also known as L12 or the tape edit suite. It is located in the rear corridor around the corner from the Music Synthesis Department offices. Across from Studios LB and LC. As before, get the key to the room from the Studio Supervisor in the Studio Office (B08). Don’t forget to sign out headphones.

Sign up for a 2-hour slot in the studio office. You may want to team up with others to benefit from a larger contiguous block of time. Keep in mind that your flows should be generated individually based on the observations that you have made collectively. Turning in identical write-ups is not acceptable.

You should review this handout. If you follow these directions carefully, the assignment is doable. If you don’t follow the directions, you may have difficulty completing the exercise.

When you use the workstations, you will notice that there are many different black box configurations, each represented by a three-letter code. The specific black box you analyze is selected randomly. Some are more difficult than others, so feel free to start over if you are stumped by a particular configuration. In order to generate a random black box configuration, you must first remove all patch cords from J1-J5. Make sure you indicate in your report the three-letter code of the device you analyze.

Submit a detailed lab report describing your experience, in accordance with your teacher’s instructions. The report should contain three sections: a discussion of your experimental procedures; a summary of your observations; and a block diagram of the device. Please use a typewriter or word processor – you will be graded both on the content of your report as well as the presentation.

**Important Reminder - Black box selections may only be changed while no patch cords are inserted into J1-J5.**
THE BLACK BOX WORKSTATION:

How It’s Supposed to Work

- The Black Box panel is right above the patch bay. At the center of the panel is the black box itself. It has five knobs, labeled P1-P5, and five jacks, labeled J1-J5.
- The theory is you put various audio stuff such as music, noise, tones, etc. into the box. Then, you try to figure out what is inside the box by turning the knobs and listening to, or measuring, what comes out.
- A complete analysis would include the function (if any) of each knob and jack, and any other pertinent information about the box such as gain, frequency response, polarity of output vs. input, any delays encountered by the signal, etc.
- Just to save some time: Inputs go into J1, J2, J3.
- Outputs come from J4, J5.
- To make it somewhat more interesting, there are more than 30 different black boxes inside the rack. Some are easy to analyze while some are not quite as easy.
- When you press the SELECT button, one of the available boxes will be picked out at random. A 3-letter ID code will then be displayed next to the SELECT button. However, unless you have the key, this code doesn’t offer any clues to the black box function.
- While you are trying to analyze a black box, you will of course need to have patch cords plugged into one or more of the jacks J1 through J5. Under these conditions, we have automatically disabled the SELECT button to prevent losing the current selection by accident, which would be very frustrating if you were almost but not quite done.

In other words: to change to a different black box, all cords must be disconnected from J1 through J5.

- As described below, the rack provides audio test signals including sine waves, pink noise, a positive pulse for checking polarity or delay, and music of your choice from the CD player, which is located at the top of the rack.
- For measuring and monitoring there’s
  - a dual trace oscilloscope
  - a standard VU meter
  - a Loftech digital dB/frequency meter
  - two headphones jacks.
- The power switch for the Black Box panel is the small toggle switch at the bottom of the rack.
THE TEST SIGNAL PANEL:

Controls and Indicators

This is located just above the Black Box panel. It contains the VU meter, the Loftech dB meter/frequency meter/tone generator, and a small panel, which supplies noise, LFO, pulse, and DC signals.

The VU Meter

The VU meter is the classic type, first specified back in 1939, and still widely used. There’s a switch to select one of two reference levels for the 0 VU indication. Either the standardized Pro Audio level of +4 dBm, or the average consumer-equipment level of -6 dBm, are available.

The input jack for the VU meter is on the patch bay.

The Loftech

The Loftech, for those who haven’t used one, is a very popular piece of test gear. It has a digital meter that can be switch-selected to read frequency or level. Note that since this is a digital meter, it’s only useful for signals that are constant in frequency or level.

The Loftech frequency indications are in Hz or kHz, which should be simple enough.

The level indications are in dBm, also known as dBs, dBu, etc. This system indicates the number of dB above (+) or below (-) a standard voltage, which is equal to 0.7749 volts AC. While all these decimals may seem unnecessary, this value goes way back into audio history and makes sense if you know the whole story, which, of course, this isn’t the place to tell.

The input jack of the Loftech meter has a very convenient, internal normal connection to the Loftech’s own sine wave generator. So if you don’t plug anything into the meter, it will show you the frequency and level of the sine wave coming out of the other half of the unit.

On the right side of the Loftech is the audio frequency tone generator. The large knob controls the frequency, which can be adjusted from roughly 4 Hz to 28 kHz. There’s also a fine frequency control, to set a precise frequency if you want to. Finally there’s a level control, which adjusts the output level up to a maximum of about +18 dBm.
**The Test Signal Generator**

This is at the right of the panel. It has four outputs on the patch bay, with two jacks each for convenience.

- Pink Noise
- Low Frequency Oscillator (LFO)
- Pulse
- DC

Each signal (except for the pulse, which has constant amplitude) has a level control, as well as some kind of indicator to tell what’s happening. The LFO also has a frequency control (black outer knob). The pulse repetition rate is the same as the LFO frequency. (The little green light that isn’t labeled indicates the pulse rate.)

Experimenting with the test panel knobs will demonstrate how the indicator lights work for each signal.

The pink noise makes it easy to check or compare frequency response by ear.

The LFO and DC are useful for finding out if anything inside the black box is voltage-controlled.

The pulse is positive, about 1/2 volt. Together with the oscilloscope, it can be used to check polarity of output vs. input. It also can be used to measure delay time, if any.

**THE OSCILLOSCOPE PANEL and Headphone Monitoring Scheme:**

The dual-trace oscilloscope, a Hitachi V-212, is located above the Test Signal Panel. Setup instructions are provided below in this write-up.

The two switches to the left of the scope are used to select what is displayed on TRACE 1 and TRACE 2.

The first five switch positions display whatever signals are on Black Box jacks J1 through J5, without having to use patch cords. This is obviously convenient.

For displaying anything other than the Black Box jacks, the PB (patch bay) position of each switch connects to the SCOPE jacks on the patch bay, the left jack for TRACE 1 and the right jack for TRACE 2. These jacks can be patched to anything you want to look at.

Back at the black box panel, there are two headphone jacks (the same signals are on both) with a volume control and a selector switch. You can listen, without using patch cords, to whatever is on TRACE 1 or TRACE 2.

The third switch position, marked 1&2, puts the TRACE 1 signal in the left headphone and the TRACE 2 signal in the right. This should take care of most situations; you hear what you see.

For versatility, the PB (patch bay) position of the selector switch connects the headphones to the PHONES jacks on the patch bay.
PRELIMINARY OSCILLOSCOPE SETTINGS:

Since it’s quite possible that someone has casually entertained himself or herself by turning all the oscilloscope knobs to random positions, here’s a simple procedure to get you started.

1. Take three patch cords, and patch the output of the Loftech oscillator to a MULT, and then to both SCOPE jacks.

2. Turn TRACE 1 and TRACE 2 switches to PB (patch bay).

3. Set the Loftech for approximately 1000 Hz at about 0 dBm.

4. Then set the scope controls as follows:
   - TIME/DIV: .5 ms.
   - SWP VAR: Fully clockwise to CAL Position.
   - MODE: AUTO (Switch to NORM for extremely LOW frequencies, but don’t forget to switch back)
   - LEVEL: Approximately centered
   - SOURCE: INT
   - CH 1 or X, POSITION: Slightly left of center
   - CH 1 or X, VOLTS/DIV: 1 (the red knob in the center should be fully clockwise)
   - AC/GND/DC: DC (Even though we are going to be looking mostly at AC)
   - MODE: ALT (You can also use CHOP mode for low frequencies, to get less flicker)
   - INT TRIG: CH 1 (Later, you can switch to either CH1 or CH 2 as necessary)
   - CH 2 or Y, POSITION: Slightly right of center
   - CH 2 or Y, VOLTS/DIV: 1 (the red knob in the center should be fully clockwise)
   - AC/GND/DC: DC

5. Adjust the horizontal POSITION control (next to the red SWP VAR knob) so that the left side of the display coincides with the leftmost vertical black line on the screen.

   You should now see two sine waves, 5 cycles or so, one above the other. If the display flashes on and off, or moves rapidly, adjust the trigger LEVEL control for a stable display. Also, adjust the INTENSITY and FOCUS controls if necessary.

6. With the CH1 or CH 2 POSITION controls, place trace 1 in the upper part and trace 2 in the lower part of the screen.

   You may have to change the TIME/DIV knob for best viewing of higher or lower frequencies. Change the Loftech frequency to check this out.

7. Try changing the Loftech output level. At low levels, you may lose synchronization and the scope image will flicker or become unstable. If this happens, readjust the trigger LEVEL control for a stable display at as low a level as possible.
8. You can always change the CH1 or CH 2 VOLTS/DIV knob to display different signal amplitudes at a convenient size on the screen. Try this out also.

9. It would be a good idea, at this point, to try patching the various test signals (sine waves, noise, LFO, pulse, DC) into the oscilloscope so that you can see what they look like. Put different signals on each trace and switch INT TRIG between CH 1 and CH 2 to see how the selected trace stabilizes the display. (When triggered by very low LFO or pulse rates, the oscilloscope display will probably become unstable. If so, switch trigger MODE to NORM temporarily; this shuts off the AUTO trace, which occurs every so often whether there is a trigger, or not.

10. Also, change from ALT to CHOP for less flicker at low frequencies. If a grainy-looking display occurs at higher frequencies, return to ALT.)

11. While displaying the various test signals on the scope, you should also check out the headphone selector. Observe how you can listen to what is on either trace, or both at once in left and right ears. (Sine waves, noise, and pulses should be easy to hear, but you won’t hear much from DC or LFO; these frequencies are usually too low to be audible.)

**ANALYSIS SUGGESTIONS:**

The Black Box selections include a 2 in, 2 out mixer, various kinds of filters, delays, a primitive reverb or two, A minus B, electronic switches, gain stages, a couple of limiters, etc. Some of the functions are knob-controlled (by P1-P5), while some are controlled by an external voltage (DC or LFO), which you must patch to the appropriate jack.

This means that to fully test a Black Box, you might have to apply several types of signals simultaneously to the input jacks J1, J2, and J3.

In any case, you’ll find that your choice of signal will be important in figuring out what the Black Box does. If it’s a filter, for example, you will find this out much more easily using music or noise than if you try a single-frequency tone. Once you know that it’s a filter, you can then use a sine wave tone, with the VU meter, to measure its frequency response. If you’ve selected a delay or reverb, you can evaluate the sound best by using music. Switching to the pulse signal will then show you the delay time, number of reflections, etc. if you use the oscilloscope properly. The pulse can also show you whether the Black Box inverts the signal or not. Try everything!

Using the oscilloscope selector knobs (to the left of the oscilloscope): You can select, for example, Trace 1 to observe one of the Black Box inputs, J1-J3, while comparing it with an output, J4 or J5, displayed on Trace 2. Then, you can easily switch your headphones from Trace 1 to Trace 2 to compare the sound of the output against the input.

Many of the Black Boxes have only one output; some have two. These will appear at output jack J4, J5, or both. If you find that there are two outputs, you can observe them simultaneously by selecting J4 and J5. Again, you can listen to one, the other, or both at once with the headphone selector switch.

Other combinations of switch settings may be useful in a particular analysis. Use whatever helps you figure out what’s going on.
The METERS, either the Loftech or the VU, are useful for measuring output levels at J4 or J5. For checking gain or frequency response, the test signal should be a sine wave of known amplitude. Remember that by disconnecting the cord from the Loftech meter, you can read the level (and frequency) of the Loftech’s oscillator.

You will probably find that the VU meter is easier to read than the Loftech when measuring frequency response; just remember to set the level of your sine wave appropriately for either the +4 or -6 VU meter sensitivity.

**BLACK BOX ANALYSIS INSTRUCTIONS:**

**Actually Doing It**

1. Be sure that you have read and understand this write-up.
2. Be sure that you have done the preliminary oscilloscope setup and that your headphones work (both ears!)
3. Check that there are no patch cords plugged into jacks J1-J5 on the Black Box Panel. (Having cords plugged in prevents changing the current Black Box selection)
4. Press the SELECT button. A 3-letter code should be displayed. (This identifies the particular black box, if you have the key)
5. Analyze! (Use the scope and headphone selector switches to monitor what you’re doing.)
6. Write down your conclusions along with the 3-letter code.

On or before the due date, submit a manila envelope, properly labeled, containing your Session Report (appx 2-3 pages), and any other paperwork you generated during this Experimental.

The report should contain three sections:

- a discussion of your experimental procedures
- a summary of your observations
- a block diagram of the device

Please use a typewriter or word processor – you will be graded both on the content of your report as well as the presentation.