HARDWARE OPERATIONS MANUAL

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Introduction

There are major components to the hardware assembly: the case, the printed circuit board (PCB), the voice recorder (ISD), the breadboard, and the interface panel. The PCB, ISD, breadboard, and interface panel are located on standoffs in the case and are all assembled separately and then combined into one assembly. All sections pertain to the audio filtering laboratory activities and are capable of use with a data acquisition device (DAQ).

Section 1: Hardware Component Assemblies

Mechanical Hardware and Case

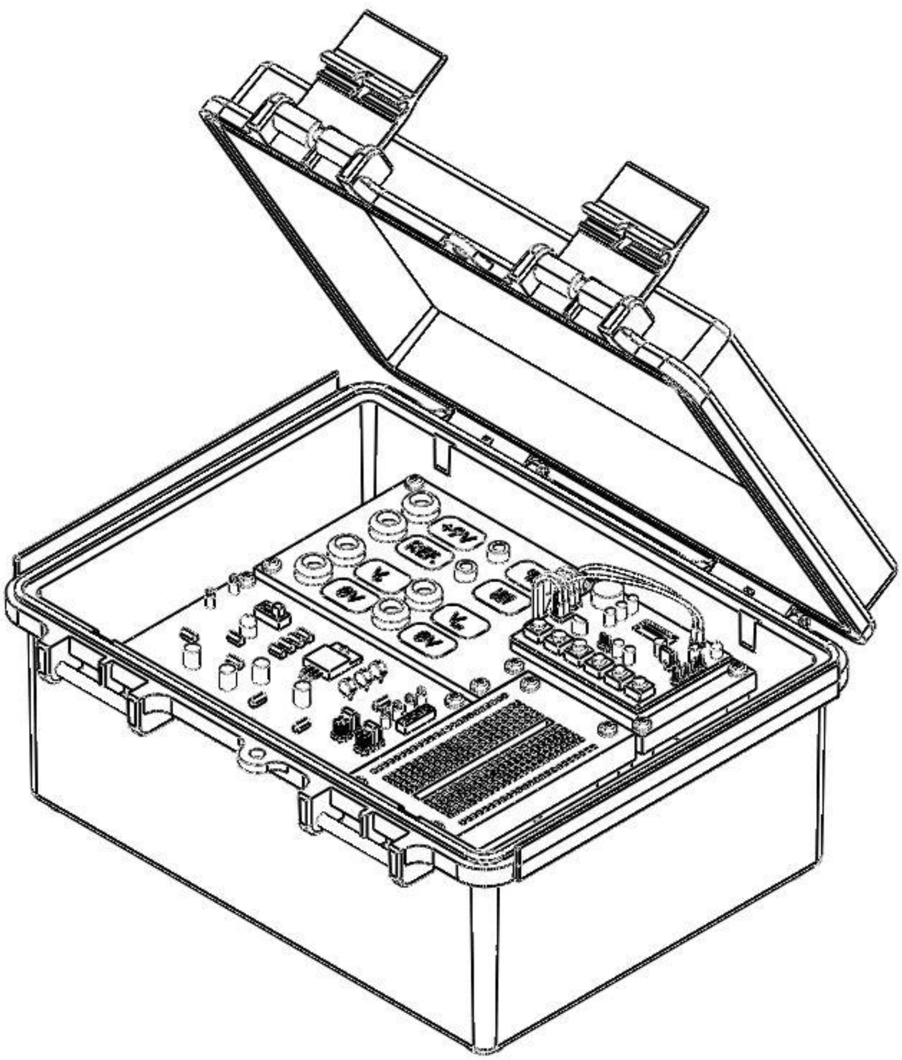

Figure 1: Hardware Activity Kit

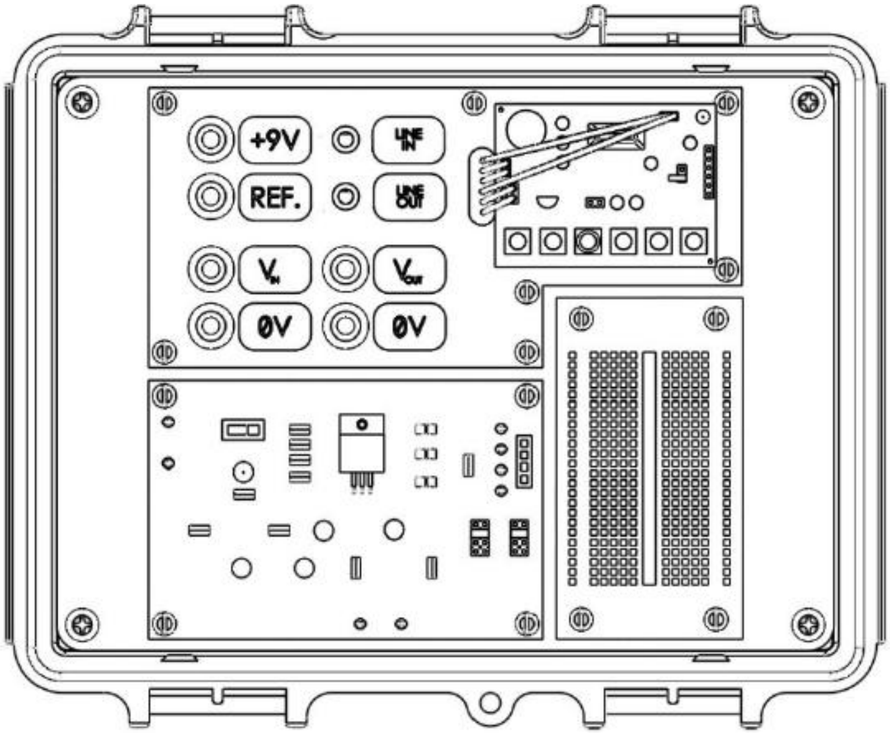

Figure 2: Overhead View of Hardware Activity Kit

The container and housing solution consists of a commercial off-the-shelf Bud Box made of ABS plastic with pre-drilled mounting holes. The electrical components and routing hardware were mounted to a separate piece of 0.25″ thick acrylic (Plexiglas) (referred to as the mounting plate) which provides for an isolated mounting solution for assembly simplification. The component assemblies are mounted on stands-offs to the plate which allows for raised access and easy maintenance.

The mounting screws are 4-40 x ½″with rubber grommets used as spacers on the PCB assembly. The ISD recording board (see section VII) is mounted directly to the interface panel with super glue and strips of soft rubber to serve as a shock absorbance system and allow for flexibility.

PCB Assembly

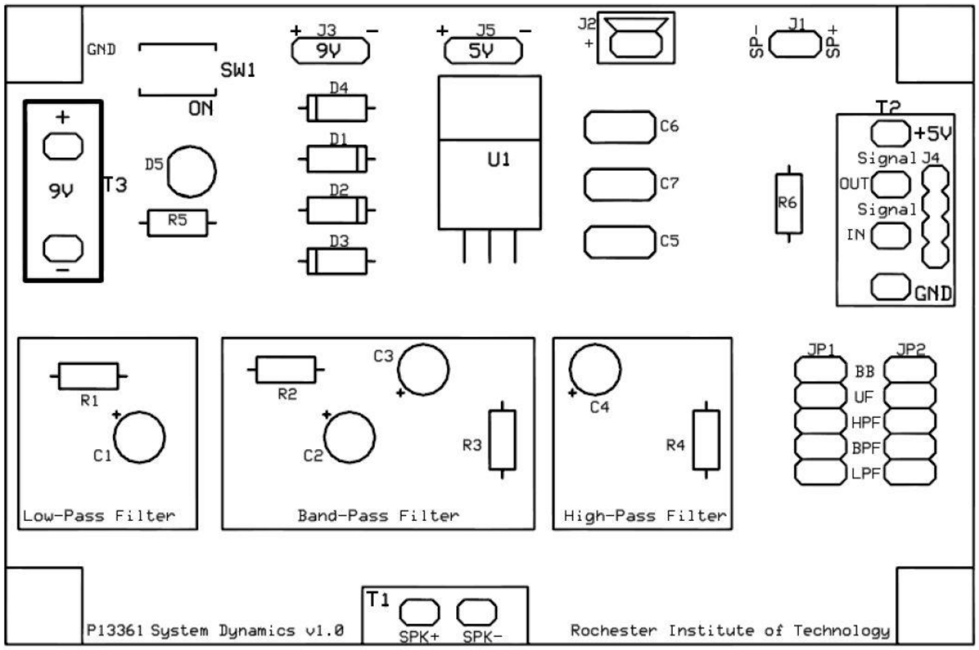

Figure 3: Hardware Activity PCB

The printed circuit board consists of a two-layer (top and bottom) copper trace board with FR4 laminate of 1/16th inch thickness and utilizes only through-hole components, including 6 resistors, 8 capacitors, 4 diodes, a power regulator, and various jumper posts and headers. There are three major sections: the power supply module, the built-in analog filter module, and the various harnessing connections to the interface panel and breadboard.

The power supply module contains diode polarity correction, an LM7805 5 volt power regulator, an LED indicator light for operation notification, and assorted filtering capacitors. The input voltage to the PCB is 9 volts, and can be supplied with a laboratory DC power supply (intended supply method) or through a 9 volt battery and adapter. The four diodes are arranged to correctly route the power polarity even when the device terminals are hooked up in the reverse configurations, which prevents damage to the board through improper wiring.

The analog filter components are laid out according to the general circuit diagram configurations seen in a standard schematic, as this exemplifies the connection between the conceptual and theoretical aspect of signal filtering and the actual implanted devices. The filters consist solely of resistors and capacitors in standard first order low-pass, high-pass, and band-pass configurations. Jumper posts JP1 and JP2 are used to select which signal path is to be used for the output audio (built-in filters, breadboard configuration, etc.).

The routing on the PCB is its main function and serves to power the recording circuit and connect to the breadboard and interface panel. Standard 0.1 inch pitch jumper posts are used to connect with female to male wires on the interface panel, allowing a semi-permanent assembly configuration. A four way female SL connector interfaces with the breadboard, as this allows the use of generic laboratory wires to and from the adjacent breadboard. The connections to the ISD recording circuit are simply female to female socket wires that connect on the same jumper posts as before, and allow for detachability and isolation of the circuits during assembly.

ISD Recording Circuit

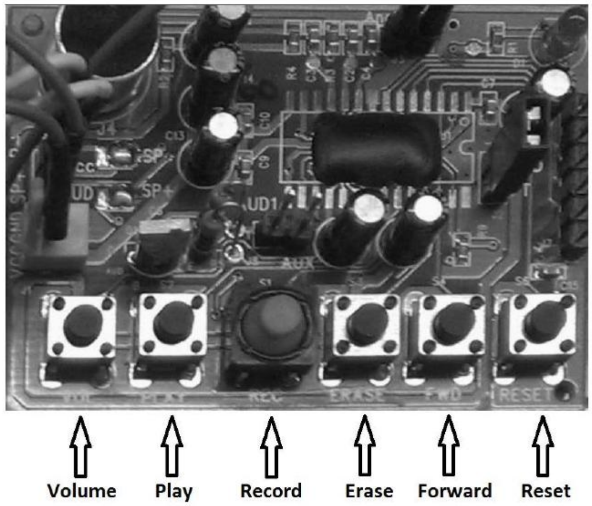

Figure 4: ISD Recording Circuit

The ISD-1760 circuit board allows for recording and playing back of user input audio content. It is a self-contained and total package, with an on-board microphone, amplifier, and recording circuitry. As a whole, it allows for processing of feed-through audio signals that can come from a majority of standard electronic devices, balances them, and then passes them to the board with the right level of amplification to be filtered when the correct jumper is applied. The recording function allows the user to record any voice or sound at the push of a button and is extremely simple to operate. This provides an option for groups with no external audio devices to provide sound to process.

Breadboard Assembly

The included breadboard is mounted in a similar fashion to the rest of the components and provides a clean palette with which to paint the wonders of custom filters into the tapestry of understanding. The PCB supplies 4 connection points to the breadboard; +5 Volts, Ground, Signal In, and Signal Out. The power and ground connections are for wiring up operational amplifiers for use in active filter circuits. Note: as the ISD centers all audio signals in the positive voltage range and produces no negative voltage, there is no need for a negative power supply to the operational amplifiers in any possible configuration. The Signal Out connection point provides the unfiltered signal to the breadboard, while the Signal In connector receives the filtered output of the custom filter. The ‘Out’ and ‘In’ refer to the signal from the ‘perspective’ of the PCB, as the signal first comes out of the breadboard, is filtered, and then returns to the PCB to be routed to the output.

Interface Panel

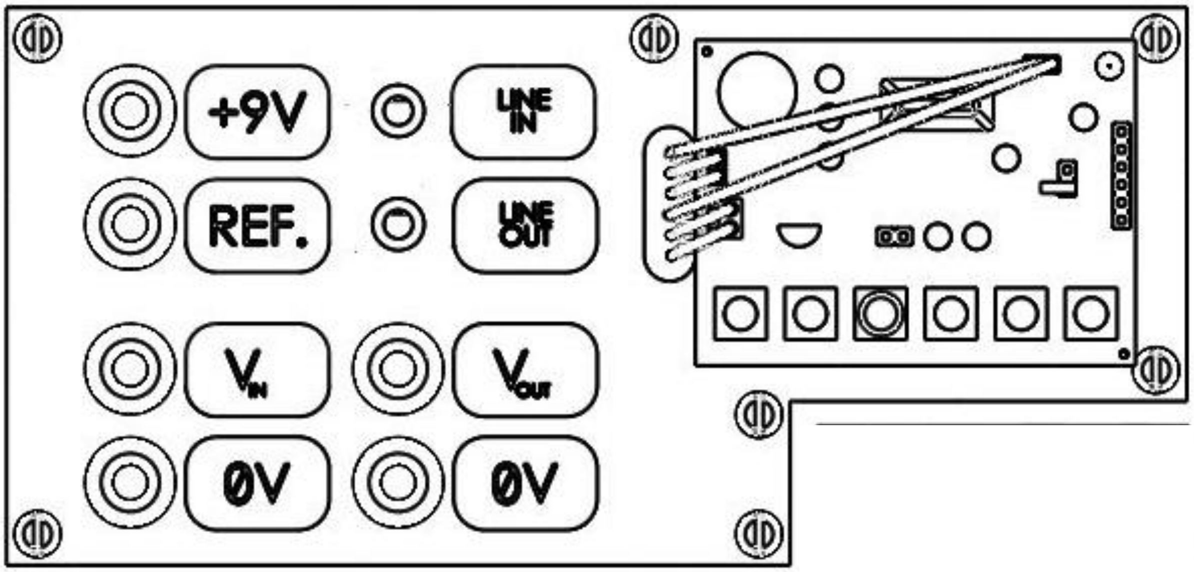

Figure 5: Interface Panel

The interface panel provides a stable and space-efficient means of interacting with the hardware filter module, as it isolates all the major connection points and allows for easy routing and wiring which freed up space on the circuit board. There are four major connection points on the interface panel, including the DC power supply connections, the audio line-in and line out jacks, the input voltage (i.e. function generator input) banana jacks, as well as the output voltage (i.e. oscilloscope out) banana jacks. Female to female socket wires provide the majority of the wiring solutions, and the pins on the ISD and PCB are designed to be compatible with these connectors.

The power supply jacks are yellow (+9V) and white (Ref.) banana jacks that are directly related to the coloring scheme on the Instek DC power supplies that are used in the System Dynamics studio classroom (GLE/09-2120) where the laboratory activity is performed. This reduces wiring complexity the students would encounter and allows for a color-coordinated approach for simplicity.

The audio interface section consists of 2x 3.5 mm audio jacks, with one each for input and output. These are standard headphone size jacks, and are designed to accommodate mono signals. For design simplicity, only one channel of a stereo input/output is used, as this still reasonably demonstrates the desired filtering concepts. A 3.5 mm male to male cable is included with the activity kit, as this allows for direct audio input from a smart phone, MP3 player, computer, or etc., which may provide adequate audio material to demonstrate signal filtering characteristics.

The voltage input and output banana jacks provide a means to interact with the additional laboratory hardware, such as an arbitrary function generator and oscilloscope. For example, a function generator may be used to provide pure audio tones and the filtered and unfiltered outputs of the activity kit could be viewed on an oscilloscope. The line in audio jack is directly wired to the voltage input (with a similar configuration for the audio out and oscilloscope jacks), so only one can be used at any given time, which must be observed.

Section 2: Operations Instructions

Powering the Device

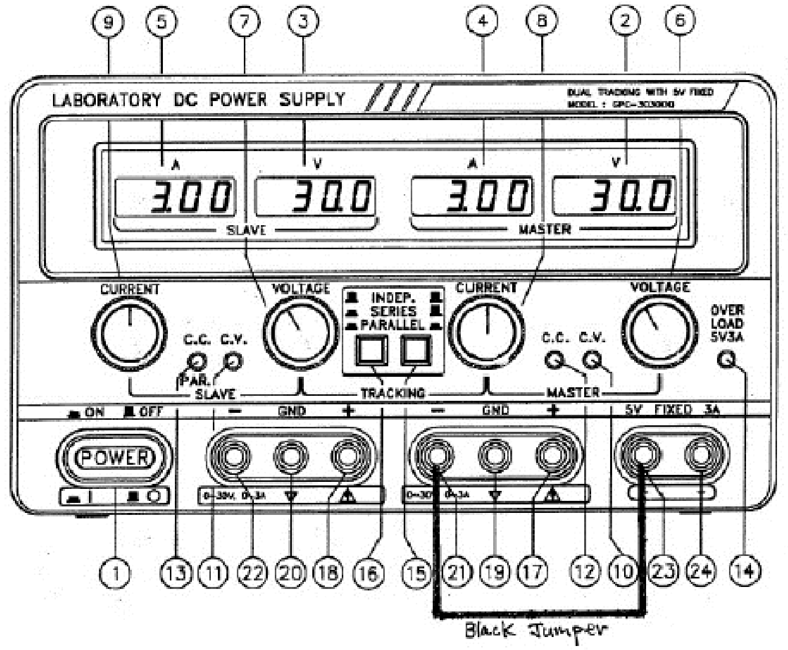

Figure 6: Instek Laboratory DC Power Supply

1) Set up the Instek power supply so the current knob (8) is at approximately 12 o'clock and the voltage knob (6) is at approximately 10 o'clock
2) Make sure the tracking buttons are set so the power supply operates in series (button 16 is 'in', button 15 is 'out')
3) Connect the provided yellow banana patch cable to the positive rail of the Instek power supply (17) and connect the other end of the cable to the yellow +9V jack on the activity kit
4) Connect the provided white banana patch cable to the ground rail (21) of the Instek power supply and connect the other end of the cable to the white Ref. jack on the activity kit.
5) Verify the power switch on the PCB (SW1) is set to 'off'
6) Turn on the Instek power supply and adjust the voltage knob (6) to exactly 9 volts
7) Set the PCB power switch (SW1) in the 'on' position
8) Check the power indicator LED; if it is lit, the device is powered

   Note: To use a 9V battery to power the kit, connect the battery leads to a standard 9V battery connector and connect the red (positive) lead of the battery connector to the yellow +9V jack on the activity kit and the black (negative) lead of the battery connector to the white Ref. jack on the activity kit. Use of male banana to alligator patch cables may be necessary to accomplish this connection.

Signal Filtering Selection

1) Header jumpers can be placed on the PCB's JP1 and JP2 in the following positions to achieve the following filtering effects
    a. 'BB' – Selects the user defined filter created on the activity kit's breadboard. The unfiltered input signal is fed out to the breadboard through the PCB's J2 'Signal OUT' port and the filtered signal is returned through the PCB's J2 'Signal IN' port
    b. 'UF' – Selects a feed through option, meaning that the audio signal will be output unfiltered
    c. 'HPF' – Selects the premade high-pass filter on the PCB
    d. 'BPF' – Selects the premade band-pass filter on the PCB
    e. 'LPF' – Selects the premade low-pass filter on the PCB

    Note: Header jumpers must be placed on the same selection for both JP1 and JP2 to output a signal. If they do not match, nothing will be output

Recording Audio/ISD Operation

1) Power the activity kit per the procedure in the above 'Powering the Device' section and switch the kit 'on' via the switch (SW1) on the PCB
2) Select desired filtering effect per the procedure in the above 'Signal Filtering Selection' section
3) Ensure that the connection headers labeled 'FT' on the ISD are NOT connected with a header jumper
4) Attach the leads of a speaker cable (using a provided BNC/banana adapter) to 'V_{out}' and the '0V' jack below it OR plug a speaker/headphones into the 'Line Out' 3.5 mm jack on the interface panel
5) Press and hold the soft button labeled 'Record' on the ISD board
6) Speak into the microphone (labeled in the top left hand corner of the ISD)
7) Release the record button
8) Press the 'Play' button on the ISD to hear the recorded sound.
9) To adjust volume, press the 'VOL' button until the desired level is achieved

Audio Feed-through

1) Power the activity kit per the procedure in the above 'Powering the Device' section and switch the kit 'on' via the switch (SW1) on the PCB
2) Select desired filtering effect per the procedure in the above 'Signal Filtering Selection' section
3) Place a header jumper on the ISD headers labeled 'FT'
4) Attach the leads of a speaker cable (using a provided BNC/banana adapter) to 'V_{out}' and the '0V' jack below it OR plug a speaker/headphones into the 'Line Out' 3.5 mm jack on the interface panel
5) Connect an audio source (iPod, computer, etc.) into the 'Line Out' jack on the interface panel using the provided male-male 3.5mm audio cable
6) Play audio with the source device

7) Listen for sound playing through the speaker/headphones

Connecting to a Voltage Source (Function Generator)

1) Power the activity kit per the procedure in the above 'Powering the Device' section and switch the kit 'on' via the switch (SW1) on the PCB
2) Select desired filtering effect per the procedure in the above 'Signal Filtering Selection' section
3) IMPORTANT: Ensure that nothing is attached to the 'Line In' input
4) Connect one of the provided banana to BNC adapters to 'V_{in}' and the '0V'jack below it
5) Connect a BNC cable from the function generator to the adapter attached to 'V_{in}'
6) Attach the leads of a speaker cable (using a provided BNC/banana adapter) to 'V_{out}' and the '0V' jack below it OR plug a speaker/headphones into the 'Line Out' 3.5 mm jack on the interface panel
7) Output a sinusoidal voltage from the function generator that is $1V_{P-P}$ and a frequency ranging from 20 Hz to 20 kHz (the audible spectrum)
8) Listen for sound playing through the speaker/headphones

Connecting to an Oscilloscope

1) Power the activity kit per the procedure in the above 'Powering the Device' section and switch the kit 'on' via the switch (SW1) on the PCB
2) Select desired filtering effect per the procedure in the above 'Signal Filtering Selection' section
3) Play audio through either the recording or feed-through option (see above sections)
4) Connect a provided banana to BNC adapter to 'V_{out}' and the '0V' jack below it
5) Connect a BNC cable from the oscilloscope to the adapter attached to 'Vout'
9) OPTIONAL: Attach the leads of a speaker cable to 'V_{out}' and the '0V' jack below by stacking banana jacks it OR plug a speaker/headphones into the 'Line Out' 3.5 mm jack on the interface panel. Because oscilloscopes are high impedance, multiple outputs may be connected

Section 3: Troubleshooting

General Guidance

1) Check that all electrical components on the PCB and ISD appear to functional (i.e. do the diodes/capacitors/resistors/voltage regulator appear to be making connection with the board, do they appear to be damaged, etc.) Replace damaged components on the PCB as necessary and replace the ISD if it is damaged
2) Check that solder joints on the power/input jacks are in good condition. If they are not, re-solder the damaged joints

Issue: The Kit Will Not Turn On

3) Check that all power leads are making contact with both the power supply/9V battery source and with the kit's power input jacks (yellow +9V and white Ref. banana jacks)
4) Verify that the power switch (SW1) on the PCB is in the 'on' position
5) Check that all under-wiring connections are intact (See Hardware Assembly Manual for more information)
6) Check under-wiring connectors for fraying/damage. Replace any suspect wires
7) Check that the power supply is outputting enough voltage and or current. The kit requires approximately 9V of and at least 30mA of current to operate

Issue: No Output is Observed

1) Check that the kit is properly powered (see above section)
2) Verify that the power switch (SW1) on the PCB is in the 'on' position
3) Verify that the signal filtering selections made at JP1 and JP2 on the PCB match (i.e. JP1 and JP2 are both set to 'UF' (unfiltered))
4) Verify that any external volume adjustments are turned up to an adequate level
5) Verify that the ISD volume is at a high enough level. To do this, continually attempt to output a signal while tapping the ISD 'VOL' button
6) If an exterior audio source is being used:
    a. Verify the 'FT' headers on the ISD are connected using a header jumper
    b. Verify that the audio source is properly connected to the kit through the 'Line In' jack
    c. Verify the 'Line In' jack is making contact with the input plug (occasionally, the fin that contacts the plug bends to a position that prevents it from contacting the plug)
    d. Verify that the audio source is providing an input signal (i.e. playing, not paused)
    e. Verify the under-wiring between the input/output jacks, the PCB, and ISD are properly connected (see Hardware Assembly Manual for more information)
    f. Check the under-wiring between the input/output jacks, the PCB, and ISD for fraying/damage. Replace any suspect wires.
7) If user recorded audio is being used:

a. Verify the 'FT' headers on the ISD are not connected using a header jumper
b. Verify that audio has been recorded by the ISD by re-recording, be sure to speak directly into the ISD microphone
c. Verify the under-wiring between the input/output jacks, the PCB, and ISD are properly connected (see Hardware Assembly Manual for more information)
d. Check the under-wiring between the input/output jacks, the PCB, and ISD for fraying/damage. Replace any suspect wires.

8) If an external voltage source (function generator) is being used:
    a. Verify the 'FT' headers on the ISD are connected using a header jumper
    b. Verify that the voltage source is properly connected to the kit through the 'V_{in}' and '0V' jacks
    c. Verify the voltage source is providing an input signal (i.e. output is turned on)
    d. Verify the under-wiring between the input/output jacks, the PCB, and ISD are properly connected (see Hardware Assembly Manual for more information)
    e. Change the pure tone input to a higher/lower frequency, some speakers/headphones may not be able to output an extremely high or low tone due to a lack of adequate amplification
    f. Change the signal filtering selection to 'UF' (unfiltered) to verify that the output signal is not being filtered out by the implemented filter selection

Issue: No Filtering Effect is Observed

1) If recorded audio is being used, try using an audio source to observe the filter. Techno music often works well, as it usually utilizes a broad band of frequencies
2) Change the resistors/capacitors in the filter to another cut off frequency

Section 4: User Notes