VERIFICATION TEST PLAN

P13361: System Dynamics Filtering Laboratory
Release Date: January 22, 2013 Revision: A

PURPOSE

The purpose of this document is to outline testing procedures to be used in order to properly verify that each of the product's Engineering Specifications are satisfied.

TABLE OF CONTENTS

ENGINEERING SPECIFICATIONS, REV B

ID	CN Address	Metric	Unit	Nominal	Ideal	Comments
1	1	Level of understandinig	%	70	100	Open lab quiz will measure understanding of lab activity concepts
2	6	Activity time spent doing "hands-on" work	%	50	100	This includes all lab activity except for reading the lab manual
3	6	Design possibilities/outcomes	#	8	Infinite	H/W: HPF, LPF, BPF, active, inactive, first order, second order, etc.; S/W: Blur, Edge detection, HPF, LPF, etc.
4	9	Storage footprint of hardware	in	12x12x3	6x6x2	
5	9	Maintenance time (minor)	min	10	10	Minor repair such as replacing a wire or simpler
6	9	Repair (major) time	min	90	60	i.e. replacing PCB, audio rec board, breadboard, etc.
7	10	Compatible with laboratory (GLE-2120) support equipment	Y / N	Yes	Yes	i.e. DC power supply, oscilloscope, multimeter, DAQ, computer
8	11	Lab activity duration	min	80	100	Includes reading the lab manual and performing all in lab activities
9	12	Maximum audio level @ 1 ft	dB	80	80	Hearing damage possible (but unlikely) above this level

MASTER LIST OF TEST EQUIPMENT

ID	Qty	Description	Suggested Model	Tests
1	1	Electronics laboratory studio classroom	System Dynamics classroom (GLE-2120)	1, 2, 6
2	1	DC 12V Power Supply	GW Instek Laboratory DC Power Supply (GPS-3303)	1, 2, 6
3	1	Oscilloscope	Agilent Technologies 60MHz Digital Storage Oscilloscope (DSO3062S)	1, 2
4	1	Computer w/ Matlab, Labview, and attached DAQ	Any Electronics laboratory computer	1, 2
5	2	BNC Female-Female Patch Cable	Pamona 48" BNC F-F Patch Cable (4277-C-48)	1, 2
6	2	Stopwatch	http://www.online-stopwatch.com/	1, 4, 5
7	1	System Dynamics Instructor	N/A	1
8	2	ME Student	Current or past System Dynamics Student	1
9	1	Activity Understanding Quiz	N/A	1
10	1	Tape Measure	Stanley Heavy-Duty 12' Tape Measure (30485)	3, 6
11	1	Soldering Iron	Pace 120V PS-90 Soldering Iron (8007-0528)	4, 5
12	1	Lead Free Solder	Multicore 28 Gauge Solder (796065)	4, 5
13	1	Needle Nose Pliers	Stanley 5" Needle Nose Pliers (84-096)	4
14	1	Wire Cutters	Craftsman Wire Cutter-Stripper and Crimper (76575)	4
15	1	Wire Strippers / Crimpers	Craftsman Wire Cutter-Stripper and Crimper (76575)	4
16	1	Phillips Screwdriver	Craftsman 6-in-1 LED Screwdriver (35722)	4, 5
17	1	Slotted Screwdriver	Craftsman 6-in-1 LED Screwdriver (35722)	4, 5
18	1	Replacement Assembled PCB	N/A, See BOM	5
19	1	Replacement Jumper Wire	Jumper Wires Premium 6" F/F (PRT-08430)	4
20	6	Speaker	Coby Portable Mini Stereo Speakers (CSMP16BLK)	6
21	1	Decibel Meter	Decibel Meter TACOTY CN (https://play.google.com/store/apps/details?id=cn.menue.	6

TESTS

TEST 1: PERFORM ACTIVITY

Test Description

The purpose of this test is to verify that the laboratory activity:

1. Lasts an acceptable amount of time
2. Contains enough “hands-on” activity versus background information so a majority of laboratory time is spent doing activities instead of reading the lab manual
3. Is compatible with GLE-2120, the System Dynamics studio classroom
4. A sufficient level of understanding is transmitted to the student user

Engineering Specifications

ID	CN Address	Metric	Unit	Nominal	Ideal	Comments
1	1	Level of understandinig	%	70	100	Open lab quiz will measure understanding of lab activity concepts
2	6	Activity time spent doing "hands-on" work	%	50	100	This includes all lab activity except for reading the lab manual
7	10	Compatible with laboratory (GLE-2120) support equipment	Y / N	Yes	Yes	i.e. DC power supply, oscilloscope, multimeter, DAQ, computer
8	11	Lab activity duration	min	80	100	Includes reading the lab manual and performing all in lab activities

Test Equipment

ID	Qty	Description	Suggested Model
1	1	Electronics laboratory studio classroom	System Dynamics classroom (GLE-2120)
2	1	DC 12V Power Supply	GW Instek Laboratory DC Power Supply (GPS-3303)
3	1	Oscilloscope	Agilent Technologies 60MHz Digital Storage Oscilloscope (DSO3062S)
4	1	Computer w/ Matlab, Labview, and attached DAQ	Any Electronics laboratory computer
5	2	BNC Female-Female Patch Cable	Pamona 48" BNC F-F Patch Cable (4277-C-48)
6	2	Stopwatch	http://www.online-stopwatch.com/
7	1	System Dynamics Instructor	N/A
8	2	ME Student	Current or past System Dynamics Student
9	1	Activity Understanding Quiz	N/A

Test Procedure

1. Ensure functioning hardware, activity software (image processing/phase distortion), and proper support equipment are available for use at test (lab) station
2. Provide test student with laboratory manual and begin first timer (activity duration timer)
3. Allow test student to complete laboratory activity, noting when he/she is performing hands on activities by starting the second timer (hands-on timer) when hands on activities are being performed and stopping when a question is asked or the student is reading
4. Upon the test students completion of the laboratory activity, stop both timers

5. Give test student 10 question multiple choice open laboratory manual quiz that checks his/her understanding of the laboratory (see Appendix of this document)
6. Allow test student 10 minutes to complete quiz (use timer)
7. Grade test student's quiz

Pass/Fail Criteria:

1. Laboratory activity duration does not exceed 100 minutes
2. Laboratory hands-on duration is at least 50% of the laboratory activity duration (i.e. if laboratory activity duration is 100 minutes, laboratory hands-on duration must be at least 50 minutes)
3. Test student scores at least a 70% (C grade) on activity understanding quiz

Test Record Document:

See Appendix of this document

TEST 2: DESIGN POSSIBILITY/OUTCOME

Test Description

The purpose of this test is to verify that the laboratory activity:

1. Contains enough versatility to allow for multiple (8 or more) filter designs

Engineering Specifications

ID	CN Address	Metric	Unit	Nominal	Ideal	Comments
3	6	Design possibilities/ outcomes	#	8	Infinite	H/W: HPF, LPF, BPF, active, inactive, first order, second order, etc.; S/W: Blur, Edge detection, HPF, LPF, etc.

Test Equipment

ID	Qty	Description	Suggested Model
1	1	Electronics laboratory studio classroom	System Dynamics classroom (GLE-2120)
2	1	DC 12V Power Supply	GW Instek Laboratory DC Power Supply (GPS-3303)
3	1	Oscilloscope	Agilent Technologies 60MHz Digital Storage Oscilloscope (DSO3062S)
4	1	Computer w/ Matlab, Labview, and attached DAQ	Any Electronics laboratory computer
5	2	BNC Female-Female Patch Cable	Pamona 48" BNC F-F Patch Cable (4277-C-48)

Test Procedure

1. Set up hardware kit and open Matlab software
2. Create using hardware (breadboard) the following filters, testing the operation of each per the laboratory manual procedure:
3. 1st order passive high pass filter with a cut-off frequency of XX kHz
4. 1st order passive low pass filter with a cut-off frequency of XX kHz
5. 2nd order passive band pass filter with a high cut-off frequency of XX kHz and low cut-off frequency of XX kHz
6. 1st order active high pass filter with a cut-off frequency of XX kHz
7. 2nd order active high pass filter with a first stage cut-off frequency of XX kHz and second stage cut-off frequency of XX kHz
8. Using the image processing GUI, apply the following filters to a stock image per the laboratory manual procedure:
   a. High pass filter
   b. Low pass filter
   c. Blur filter
9. Document each operating design applied

Pass/Fail Criteria

1. Laboratory hardware and software (combined) provide capability to produce at least 8 different filter designs

Test Record Document

See Appendix of this document

TEST 3: STORAGE SIZE

Test Description

The purpose of this test is to verify that the laboratory activity hardware:

1. Can be stored with a footprint of less than 12 x 12 x 3 inches

Engineering Specifications

ID	CN Address	Metric	Unit	Nominal	Ideal	Comments
4	9	Storage footprint of hardware	in	12x12x3	6x6x2	

Test Equipment

ID	Qty	Description	Suggested Model
10	1	Tape Measure	Stanley Heavy-Duty 12' Tape Measure (30485)

Test Procedure

1. Set up hardware kit in storage posture
2. Measure the kit's length, width, and height, rounding off to the nearest quarter (¼) of an inch

Pass/Fail Criteria

1. Laboratory hardware in storage posture is smaller than 12 long x 12 wide x 3 high inches

Test Record Document

See Appendix of this document

TEST 4: MINOR MAINTENANCE

Test Description

The purpose of this test is to verify that the laboratory activity hardware:

1. Can be maintained (i.e. the replacement of the +7V ground wire between the PCB and white banana jack) in less than 10 minutes

Engineering Specifications

ID	CN Address	Metric	Unit	Nominal	Ideal	Comments
5	9	Maintenance time (minor)	min	10	10	Minor repair such as replacing a wire or simpler

Test Equipment

ID	Qty	Description	Suggested Model
6	2	Stopwatch	http://www.online-stopwatch.com/
11	1	Soldering Iron	Pace 120V PS-90 Soldering Iron (8007-0528)
12	1	Lead Free Solder	Multicore 28 Gauge Solder (796065)
13	1	Needle Nose Pliers	Stanley 5" Needle Nose Pliers (84-096)
14	1	Wire Cutters	Craftsman Wire Cutter-Stripper and Crimper (76575)
15	1	Wire Strippers / Crimpers	Craftsman Wire Cutter-Stripper and Crimper (76575)
16	1	Phillips Screwdriver	Craftsman 6-in-1 LED Screwdriver (35722)
17	1	Slotted Screwdriver	Craftsman 6-in-1 LED Screwdriver (35722)
19	1	Replacement Jumper Wire	Jumper Wires Premium 6" F/F (PRT-08430)

Test Procedure

1. Assure hardware kit is disconnected from power
2. Start timer
3. *Use screwdriver remove mounting plate screws that attach it to the enclosure (see hardware assembly instructions)
4. *Lift mounting plate out of enclosure
5. Use screwdriver to remove interface panel from mounting plate standoffs
6. Disconnect any necessary loose wires (more detail needed) from the interface panel hardware, noting their connections for reassembly
7. Remove +7V ground wire from PCB terminal
8. Use soldering iron to remove ground wire lead from +7V (white) banana jack terminal
9. Clean +7V (white) banana jack wire terminal
10. Solder new wire (of same type) to empty wire terminal
11. Connect loose new wire lead to the PCB +7V ground wire terminal
12. Reconnect any disconnected wires from step 4
13. Replace interface panel (and screws) on mounting plate stand offs
14. Replace mounting plate into enclosure
15. Replace mounting plate screws
16. Stop timer
17. Verify the hardware kit is in working condition by testing the replaced wire for proper operation

Pass/Fail Criteria

1. Wire replacement procedure (Test Procedure steps 2 – 16) are completed in 10 minutes or less
2. The hardware kit is in working condition after the maintenance

Test Record Document

See Appendix of this document

TEST 5: MAJOR REPAIR

Test Description:

The purpose of this test is to verify that the laboratory activity hardware:

1. Can be repaired (i.e. a major repair) in less than 90 minutes

Engineering Specifications

ID	CN Address	Metric	Unit	Nominal	Ideal	Comments
6	9	Repair (major) time	min	90	60	i.e. replacing PCB, audio rec board, breadboard, etc.

Test Equipment

ID	Qty	Description	Suggested Model
6	2	Stopwatch	http://www.online-stopwatch.com/
16	1	Phillips Screwdriver	Craftsman 6-in-1 LED Screwdriver (35722)
11	1	Soldering Iron	Pace 120V PS-90 Soldering Iron (8007-0528)
12	1	Lead Free Solder	Multicore 28 Gauge Solder (796065)
17	1	Slotted Screwdriver	Craftsman 6-in-1 LED Screwdriver (35722)
18	1	Replacement Assembled PCB	N/A, See BOM

Test Procedure

1. Assure hardware kit is disconnected from power
2. Start timer
3. Assemble new blank PCB as explained in the electrical assembly document
4. Stop timer and record board assembly time
5. Assure hardware kit is disconnected from power
6. Reset timer and start timer
7. *Use screwdriver remove mounting plate screws that attach it to the enclosure (see hardware assembly instructions)
8. *Lift mounting plate out of enclosure
9. Disconnect all wires connected to the top of the PCB, noting their connections (see hardware assembly instructions)
10. Use screwdriver to remove PCB standoff screws
11. Carefully lift the PCB off its standoffs and disconnect wires connected to the bottom of the PCB, again noting their connections (see hardware assembly instructions)
12. Remove the old PCB and discard
13. Connect the bottom wires to the new PCB
14. Attach the new PCB to the standoffs
15. Connect the top wires to the new PCB
16. Replace mounting plate into enclosure
17. Replace mounting plate screws
18. Stop timer
19. Verify the hardware kit is in working condition by testing the replaced wire for proper operation

Pass/Fail Criteria

1. PCB replacement procedure (Test Procedure steps 2 – 18) is completed in 60 minutes or less
2. The hardware kit is in working condition after the maintenance

Test Record Document

See Appendix of this document

TEST 6: AUDIO LEVEL

Test Description

The purpose of this test is to verify that the laboratory activity hardware:

1. Produces sounds less than 80 dB from 1 ft away

Engineering Specifications

ID	CN Address	Metric	Unit	Nominal	Ideal	Comments
9	12	Maximum audio level @ 1 ft	dB	80	80	Hearing damage possible (but unlikely) above this level

Test Equipment

ID	Qty	Description	Suggested Model
1	1	Electronics laboratory studio classroom	System Dynamics classroom (GLE-2120)
2	1	DC 12V Power Supply	GW Instek Laboratory DC Power Supply (GPS-3303)
10	1	Tape Measure	Stanley Heavy-Duty 12' Tape Measure (30485)
20	6	Speaker	Coby Portable Mini Stereo Speakers (CSMP16BLK)
21	1	Decibel Meter	Decibel Meter TACOTY CN (https://play.google.com/store/apps/details?id=cn.menue.

Test Procedure

1. Ensure functioning hardware and proper support equipment are available for use at test (lab) station
2. Set up hardware kit for audio play (see lab activity manual)
3. Use ruler to place the decibel meter 1 foot away from connected speaker
4. Record an audio signal and playback
5. Record the decibel reading for the playback
6. Repeat steps 4 and 5 two more times

Pass/Fail Criteria

1. All three iterations of the test return playback sound less than 80 dB

Test Record Document

See Appendix of this document

APPENDIX

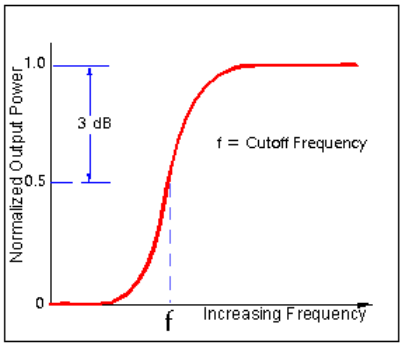
ACTIVITY UNDERSTANDING QUIZ

Name:_____ Date: ____/____/2013 Grade: ／10

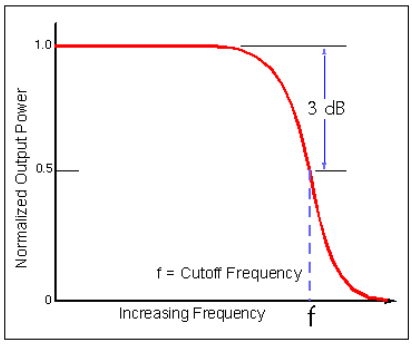
1.) Which of the following filters sharpens an audio signal?
   a. High-Pass filter
   b. Low-Pass filter
   c. Band-Pass filter

2.) Which Bode plot best describes a Low-Pass filter?

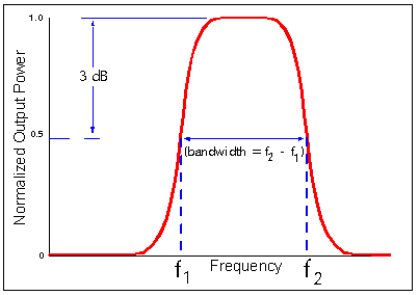
a.



b.



c.



3.) Through which filter will the bass portion of an audio signal be heard the best?
   a. High-Pass filter
   b. Low-Pass filter
   c. Band-Pass filter

4.) What filter is used to accommodate a radio station in a specific frequency bandwidth?
   a. High-Pass filter
   b. Low-Pass filter
   c. Band-Pass filter

5.) What happens to the magnitude of the high frequencies in a signal after it is passed through a Low-Pass filter?
   a. The magnitude of the high frequencies increases while the magnitude of the low frequencies decreases
   b. The magnitude of the high frequencies decreases while the magnitude of the low frequencies remains (ideally) the same
   c. The magnitude of the high frequencies increases as well as the magnitude of the low frequencies

6.) Which of the following contains significantly more information in an image signal?
   a. Magnitude
   b. Phase
   c. Both show equal amounts of the image

7.) Which of the following reveals edges and corners of the image (**circle all that apply**)?
   a. High-Pass filter
   b. Low-Pass filter
   c. Edge Detection filter
   d. Gaussian Blur

8.) Which of the following smoothen/unshapen an image (**circle all that apply**)?
   a. High-Pass filter
   b. Low-Pass filter
   c. Edge Detection filter
   d. Gaussian Blur

9.) Which of the following occurs when the High-Pass image slider is moved to the right?
   a. The image is smoothened, almost blurred
   b. The image is radically blurred and is indistinguishable
   c. More corners and edges are revealed on the image
   d. Less corners and edges are revealed on the image

10.) In the picture with the moon and trees, what happens to the moon when a High-Pass filter is applied to the image?
   a. There is a circle around the moon outlining its edges
   b. The moon and associated clouds are removed from the image, revealing just the trees
   c. The trees are smoothened and the moon’s outline becomes intensified

Activity Understanding Quiz Answer Key

1. a
2. b
3. b
4. c
5. b
6. b
7. a & c
8. b & d
9. c
10. b

TEST DATA SHEET

Test 1: Perform Activity

Supervising Engineer: _____

Date Performed: _____

Test Equipment Checklist:

#	Qty	Description	Acquired?	Utilized Model
1	1	Electronics laboratory studio classroom		
2	1	DC 12V Power Supply		
3	1	Oscilloscope		
4	1	Computer w/ Matlab, Labview, and attached DAQ		
5	2	BNC Female-Female Patch Cable		
6	2	Stopwatch		
7	1	System Dynamics Instructor		
8	2	ME Student		
9	1	Activity Understanding Quiz		

Test Documentation:

Student	Laboratory Time	Hands-On Time	Hands-On Percentage % = (H.O. Time / Total Time)

Test Notes:

Pass / Fail? _____

Engineer Signature: _____ Date: _____

TEST DATA SHEET

Test 2: Design Possibility/Outcome

Supervising Engineer: _____

Date Performed: _____

Test Equipment Checklist:

#	Qty	Description	Acquired?	Utilized Model
1	1	Electronics laboratory studio classroom		
2	1	DC 12V Power Supply		
3	1	Oscilloscope		
4	1	Computer w/ Matlab, Labview, and attached DAQ		
5	2	BNC Female-Female Patch Cable		

Test Documentation:

See following page

Test Notes:

Pass / Fail? _____

Engineer Signature: _____ Date: _____

Test Documentation:

#	Implementation Method (H/W or S/W)	Filter Description / Wiring Schematic (include component details)	#	Implementation Method (H/W or S/W)	Filter Description / Wiring Schematic (include component details)
1			6		
2			7		
3			8		
4			9		
5			10		

TEST DATA SHEET

Test 3: Storage Size

Supervising Engineer: _____

Date Performed: _____

Test Equipment Checklist:

#	Qty	Description	Acquired?	Utilized Model
1	1	Tape Measure		

Test Documentation:

Hardware Kit Dimensions		
Legnth	Width	Height

Test Notes:

Pass / Fail? _____

Engineer Signature: _____ Date: _____

TEST DATA SHEET

Test 4: Minor Maintenance

Supervising Engineer: _____

Date Performed: _____

Test Equipment Checklist:

#	Qty	Description	Acquired?	Utilized Model
1	2	Stopwatch		
2	1	Soldering Iron		
3	1	Lead Free Solder		
4	1	Needle Nose Pliers		
5	1	Wire Cutters		
6	1	Wire Strippers / Crimpers		
7	1	Phillips Screwdriver		
8	1	Slotted Screwdriver		
9	1	Replacement Jumper Wire		

Test Documentation:

Repair Time

Test Notes:

Pass / Fail? _____

Engineer Signature: _____ Date: _____

TEST DATA SHEET

Test 5: Major Repair

Supervising Engineer: _____

Date Performed: _____

Test Equipment Checklist:

#	Qty	Description	Acquired?	Utilized Model
1	2	Stopwatch		
2	1	Phillips Screwdriver		
3	1	Soldering Iron		
4	1	Lead Free Solder		
5	1	Slotted Screwdriver		
6	1	Replacement Assembled PCB		

Test Documentation:

PCB Assembly Time	Replacement Time

Test Notes:

Pass / Fail? _____

Engineer Signature: _____ Date: _____

TEST DATA SHEET

Test 6: Audio Level

Supervising Engineer: _____

Date Performed: _____

Test Equipment Checklist:

#	Qty	Description	Acquired?	Utilized Model
1	1	Electronics laboratory studio classroom		
2	1	DC 12V Power Supply		
3	1	Tape Measure		
4	6	Speaker		
5	1	Decibel Meter		

Test Documentation:

Trial	Decibel Rating
1	
2	
3	

Test Notes:

Pass / Fail? _____

Engineer Signature: _____ Date: _____